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16. Abstract

External station travel surveys collect important information on local travel needed by districts and Metropolitan Planning Organizations (MPOs) in Texas for travel demand modeling. For roadways with low to moderate traffic levels, external surveys can be safely conducted using a roadside interview method. This 'intercept' method cannot be utilized on high volume facilities due to unsafe conditions and unacceptable levels of delay that it creates. Since high volume facilities often carry the majority of traffic going into and out of urbanized areas, research is needed to develop a safe and acceptable method for conducting external surveys on these facilities.

The objective of this project was to develop a standardized methodology(s) for collecting external survey data on high volume facilities that can be utilized in TxDOT's travel survey program. The research assesses the importance of collecting data on high volume facilities in Texas, assesses the state of the practice and technologies for conducting these surveys, and evaluates techniques and methods currently being used. The project also researches legal and privacy issues related to the use of video in high volume surveys and establishes volume criteria for when external surveys should be conducted using a high volume method.

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EVALUATION OF EXTERNAL STATION SURVEY METHODOLOGIES FOR HIGH VOLUME LOCATIONS

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DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the Federal Highway Administration (FHWA) or the Texas Department of Transportation (TxDOT). This report does not constitute a standard, specification, or regulation. The research supervisors in charge of this project were Edwin N. Hard and Stephen P. Farnsworth.

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- Mr. Jim Neidigh, Transportation Planning and Programming Division, Texas Department of Transportation;
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1.0 INTRODUCTION

1.1 PROJECT OBJECTIVE

External station travel surveys collect important information on local travel needed by districts and Metropolitan Planning Organizations (MPOs) in Texas for travel demand modeling. For roadways with low to moderate traffic levels, external surveys can be safely conducted using a roadside interview method. This 'intercept' method cannot be utilized on high volume facilities due to unsafe conditions and unacceptable levels of delay that it creates. Since high volume facilities often carry the majority of traffic going into and out of urbanized areas, research is needed to develop a safe and acceptable method for conducting external surveys on these facilities.

The objective of this project is to develop a standardized methodology(s) for collecting external survey data on high volume facilities that will be utilized in TxDOT's travel survey program. The research assessed the importance of collecting data on high volume facilities in Texas, assessed the state of the practice and technologies for conducting these surveys, and evaluated techniques and methods currently being used. The project also researched the legal and privacy issues related to the use of video and state motor vehicle records in high volume surveys and analyzed volume criteria for when external surveys should be conducted using a high volume method.

1.2 BACKGROUND AND SIGNIFICANCE OF WORK

Origin-destination travel surveys were first used in Texas in the 1950s to develop trip tables of zone to zone trip movements. In the 1960s, they served as the foundation for early travel models used in transportation planning and programming. Essentially no large travel surveys were performed in Texas during the 1970s and early 1980s. By the mid 1980s, there was a push to revive travel survey data collection efforts using small sample techniques. In 1989-90, the Texas Department of Transportation (TxDOT) initiated several major travel surveys in urban areas to provide information to update their travel demand models. This effort has since evolved into TxDOT's current-day travel

survey program (TSP), which represents one of the most comprehensive continuing data collection efforts in the nation.

TxDOT Travel Survey Program

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 TSP consolidates the MPOs into 14 travel survey regions in order to consolidate effort and combine areas with similar travel characteristics. Figure 1 shows the travel survey regions.

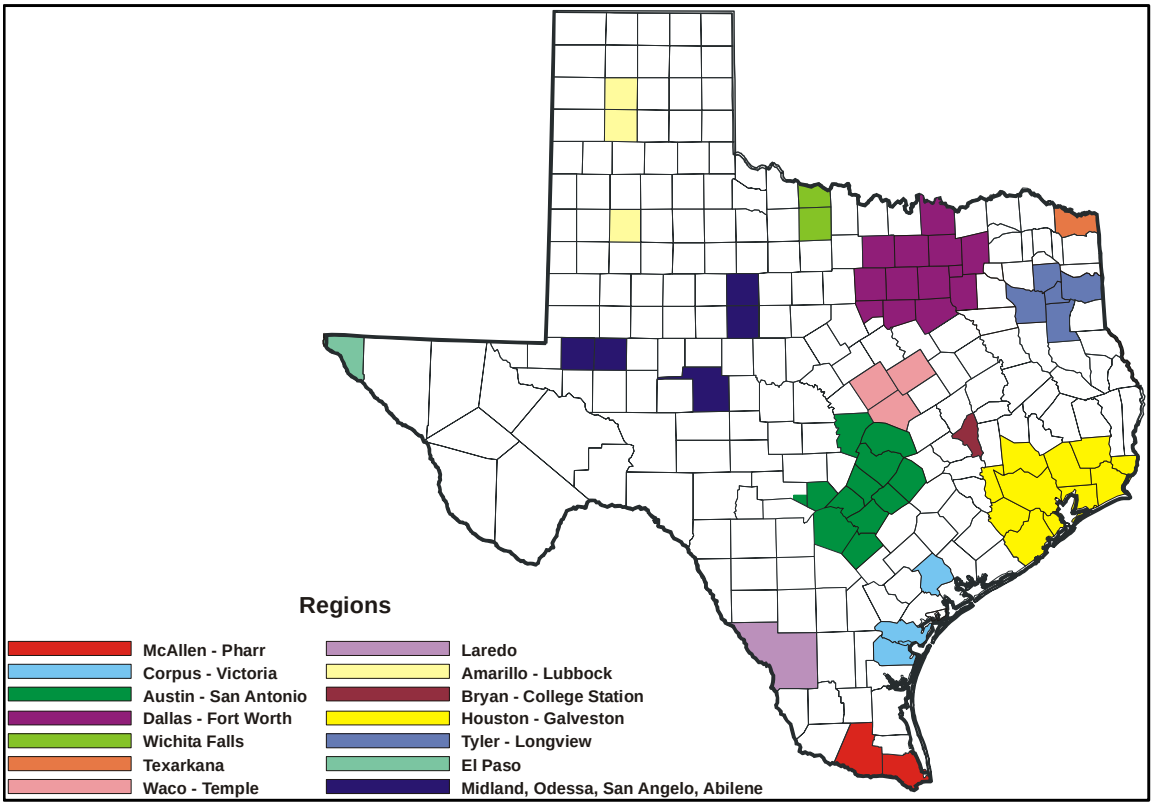

Figure 1. Travel Survey Regions.

The TSP employs the use of four major survey types including household, workplace, commercial vehicle, and external travel surveys. Additionally, travel time and delay surveys are conducted in non-attainment and near non-attainment areas to provide supplemental information. The TSP is set up such that surveys are conducted in each region about every 10 years. To the extent possible, the program is coordinated with TxDOT's saturation count program and model development schedule of each MPO. The

purpose for the surveys is to collect data to support transportation planning and travel demand models of MPOs throughout the state. Travel models are an important tool for MPOs in developing and evaluating transportation plans, plan alternatives, and project priorities.

The TSP is administered and funded through TxDOT's Transportation Planning and Programming Division (TPP). In concert with travel surveys, TPP also provides crucial support and assistance to MPOs throughout the state for the development and calibration of travel models. As part of this assistance, TPP conducts travel surveys to collect data on local travel demand, patterns, and characteristics for use in area models. The surveys provide a base level of up-to-date 'real-world' travel data that is needed to develop and calibrate models representative of each local area. External travel surveys, and high volume travel surveys in particular, play an essential role in supporting these models.

External Travel Surveys

The external travel survey, often termed 'roadside' survey, is an essential component of TxDOT's travel survey program. External surveys are typically conducted at or near the boundaries of urbanized areas to collect information on the amount and characteristics of vehicles traveling into, out of, and through a defined study area. More specifically, the surveys collect data on internal-external 'local' trips and external-external 'through' trips by non-commercial and commercial vehicle categories. These data are important inputs to the travel demand model.

When external surveys are performed, they are designed to capture certain key data elements that are needed for transportation planning purposes and travel model input. These key data elements include the following:

- vehicle information such as occupancy, model, make, and mileage;
- trip information such as origin, destination, and purpose; and
- route information.

When conducting an external survey, roadway facilities from low volume farm-to-market roads to high volume freeways are included in the survey, if possible. The external survey 'stations' are located at or near the MPO's study area boundary or cordon line. The objective of this set-up is to encompass the MPO area and survey traffic that crosses the study area boundary. Figure 2 shows an example of how an external survey is typically set up for an urban area.

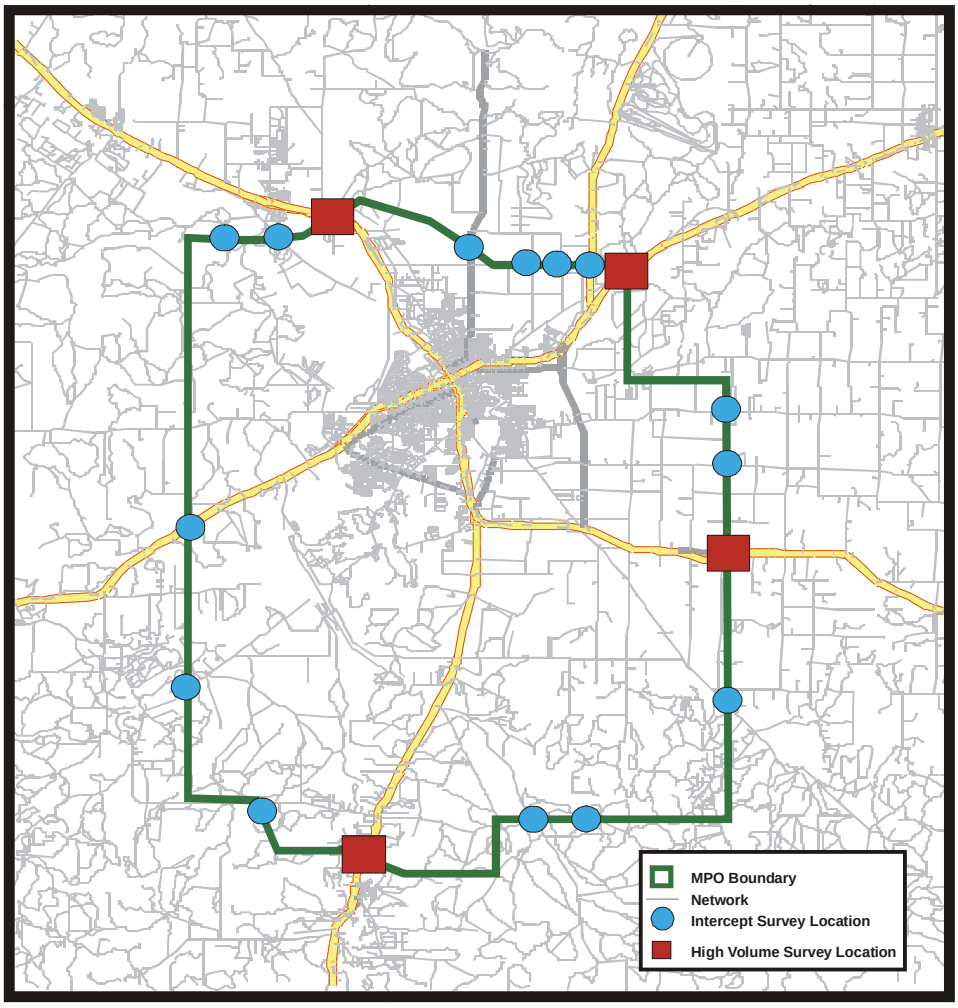

Figure 2. Example External Survey Area.

When used in aggregate, survey data elements provide profiles of travel and trip making that are unique to each survey area. Data collected from the survey are expanded using 24-hour vehicle classification counts performed at each survey location on the day

of the survey. All data elements (both counts and survey data) assist in determining the amount and characteristics of travel out of, into, and through a particular study area. If certain data elements are not collected, a void is created and analysts make assumptions using an 'educated guess' to compensate for the missing data.

Low Volume Survey Method

For roadways with low to moderate traffic levels, external surveys can be safely and effectively conducted using a roadside intercept interview method. Under this method, field personnel establish a traffic control plan (TCP), and then randomly stop and request motorists' participation in the study at roadside survey 'stations'. Figure 3 shows an example of an intercept interview survey. However, this intercept method cannot be utilized on high volume facilities (e.g., 20,000 plus vehicles per day) due to unsafe conditions and unacceptable levels of delay that it creates.

Figure 3. External Survey Using Intercept Interview Method.

High Volume Survey Methods

For roadways with high levels of traffic, such as that shown in Figure 4, license match and license mailout methods are commonly used for external surveys. With the license match method, vehicle license plates are recorded at all locations where high volume facilities cross the study area boundary, and a computer program is used to match license plates between locations. License plates can be recorded manually, by video camcorders as shown in Figure 5, or by other similar technology. This method provides sufficient data to estimate the percentage of through trips on these facilities, but other key data such as external local trip length, trip purpose, and residency information must be estimated using data from other (lower volume) surveyed stations.

Figure 4. High Volume Facility.

Figure 5. Video Recording on High Volume Facility.

With the license mailout method, vehicle license plates are recorded, and a voluntary survey is mailed to the owners of vehicles. Using the license number and state of registration, the names and addresses of registered owners of vehicles are obtained from the state's vehicle registration database, and surveys are mailed to the owners of these vehicles. In addition to obtaining estimates of through traffic, this method allows for the collection of other key data such as the trip origin and destination, trip length, trip purpose, and residency information.

The license mailout method using video is a common high volume external method used throughout the country. However, the practice of using this method in Texas has raised serious concerns in the public with respect to privacy and legality issues.

1.3 UNDERSTANDING THE PROBLEM

How to properly collect travel survey data on high volume facilities has been a challenge and issue since TxDOT's reinstatement of travel surveys in the late 1980s. It is not an issue unique to Texas and TxDOT, but an issue being faced by many state DOTs and jurisdictions throughout the country. As Texas' urban areas continue to grow and expand, so do the traffic volumes on roadways throughout the state. As a result, the proportion of high volume to low-volume sites as part of external travel surveys will continue to increase as time goes on.

The majority of traffic going into and out of urbanized areas is often on high volume facilities. The inability to survey vehicles traveling on high volume facilities in an MPO area leaves a void in key data that are needed to provide the model with local travel characteristics. These data are needed to provide profiles and percentages of local and through trips that are essential for the model development and calibration.

An example of the importance of the high volume external survey to TxDOT's TSP can be shown using the Dallas-Fort Worth / Sherman-Denison study area. The 2005 external survey for this 13 county area included 93 external stations located around the perimeter of this region. Of these 93 external locations, nine facilities have an annual average daily traffic (AADT) of over 20,000 (according to 2003 TxDOT district traffic maps). More importantly, however, is

that these nine sites represent approximately 52 percent of the AADT for all of the 93 sites combined. Due to safety and public privacy concerns, TxDOT utilized a license match method on high volume facilities in the Dallas/Fort Worth region. The inability to survey vehicles on high volume facilities using a more comprehensive method means that key characteristics of more than 50 percent of the traffic traveling into and out of the region will have to be estimated using assumptions to account for missing data elements. These assumptions can result in an inaccurate representation of key information such as trip length, trip purpose, and percentage of local verses through trips into the model for this region.

As described in the example, since the majority of traffic going into and out of an urbanized area can be on high volume facilities, it is imperative that a safe and effective method for conducting external surveys on high volume facilities be established in order to ascertain the local-through profiles of trip making on these facilities that is needed for the model development and calibration.

2.0 PROJECT TASKS AND RESEARCH METHODS

The scope of work for the project was made up of seven major tasks. Researchers completed tasks over a 1 year time period beginning in September of 2004 and ending in August of 2005. The following sections provide a description of each task and the research methods used in accomplishing each task.

2.1 ASSESS DATA IMPORTANCE

The first task of the project was to assess the importance of collecting data at high volume external stations within Texas. The research team examined the influence that high volume facilities have on the total traffic traveling into and out of each of the TSP regions. Under current TSP practice, roadways with an AADT of 20,000 or more are considered high volume for external survey purposes. As part of this task, the research team determined which survey regions are most influenced by high volume facilities based on the current criteria for high volume.

Additionally, the task evaluated the impacts of capturing survey responses on high volume facilities as it relates to model development and calibration. The research team identified data elements that are currently collected in external surveys using intercept, license match, and license mailout methods. The team also examined how each of the data elements are used in the modeling process and assessed the impacts to the modeling process for each data element that was not collected. Additionally, model input assumptions that analysts must make relative to each data element not collected were also identified.

2.2 ASSESS STATE OF THE PRACTICE

Many cities in Texas and around the country perform external station surveys. The data that are collected are important to these locales regardless of their size either in terms of population or geography. The second task involved researching and documenting the 'state of

the practice' for agencies around the country that are involved in conducting external station surveys.

The research team evaluated a wide cross-section of external station surveys in the United States. Additionally, the research team attempted to find relevant external survey practices in the United Kingdom and Australia that could potentially be applied in TxDOT's TSP. These survey efforts involved a range of facility types and volumes, survey methodologies, and agency or jurisdictional policies.

For each external station survey that was identified, a research team member contacted a key individual from the sponsoring agency or agency that performed the data collection. The individual was then interviewed in order to acquire information on the survey relative to key elements, relevant issues, and conflicts and resolutions as encountered during the conduct of the survey. The research team began with a pre-determined list of elements/issues to inquire about, and if additional areas of interest came up during the interview, those issues were addressed as well. The key issues that were identified prior to the phone interview include:

- date of the survey,
- number of survey locations,
- method(s) used during conduct of survey,
- type of technology utilized during conduct of survey (if any),
- AADT levels for surveyed locations and what was considered 'high volume', and
- policy and/or legal issues.

2.3 ASSESS AVAILABLE TECHNOLOGIES

The third task of this research project was comprised of identifying, assessing, and evaluating technologies that have been or could be utilized during the conduct of external station surveys. For each technology that was identified, the research team looked at key aspects of each technology, and those elements include:

- cost,
- capabilities,

- ease of use,
- data processing requirements, and
- hardware/software requirements.

The interview process, the literature review, and professional contacts and affiliations identified the types of technologies utilized in survey efforts. If an individual indicated that specific technologies were utilized while conducting external surveys, follow-up questions were asked in order to assess the experience with the technology that was used.

2.4 ASSESS PRIVACY AND LEGAL ISSUES

Video camcorders and other technology to capture and record license plates have been utilized for many years as part of external surveys and various types of corridor studies. A video license mailout method is often the most desired method to use on high volume facilities because it can capture many of the key data elements that are obtained via a roadside intercept survey. However, many survey sponsors and governmental jurisdictions are reluctant to use a video mailout method due to public concern and political sensitivity of this issue. As part of Task 4, the research team contacted numerous state DOTs, MPOs, and other related agencies and jurisdictions that have conducted external station surveys within the past 10 years. Representatives of these agencies described how the sponsoring agency provided for and responded to perceived privacy violations as well as the legal and/or administrative (policy) framework under which the agency was operating. This portion of the task investigated these considerations as they applied to all external surveys, but special attention was paid to those survey efforts where data were collected on high volume facilities.

An additional component of this task included the query of various legal research databases such as Lexis/Nexis and WestLaw. The research team reviewed and analyzed state statutes and applicable case law in order to ascertain the legal basis for performing external station surveys.

2.5 ESTABLISH CRITERIA FOR IDENTIFYING HIGH VOLUME FACILITIES

The fifth task involved the development of threshold values of traffic volume levels by various roadway cross-sections that can be used to determine when a facility should be considered 'high volume' for external survey purposes. The task included two elements. For the first element, the research team contacted representatives from state DOTs, MPOs, and consultants that have overseen the conduct of external surveys. Researchers obtained information on the criteria they used, if any, to assess a facility as high volume and the method used to collect data at high volume locations. Additionally, researchers requested copies of reports that documented the survey effort and any anecdotal comments and lessons learned.

For the second element of this task, queuing analyses were performed for various roadway cross-sections. In the analyses, the impact that lane reductions and lane blockages have on traffic queues was identified. The analyses considered the maximum queue length that is allowed per TxDOT's standard bid specification for external travel surveys. In an effort to account for the various road cross-sections, the research team developed a systematic approach for evaluating a potential survey location.

2.6 EVALUATE METHODOLOGIES FOR SURVEYS ON HIGH VOLUME FACILITIES

Using the findings from Tasks 1 through 5, alternative methodologies for conducting surveys on high volume facilities were identified. The alternatives were then evaluated by the research team and the project director for TxDOT to identify and remove those which were not considered viable. The remaining methods were evaluated in detail with respect to data elements collected, cost, safety, ease or difficulty of implementation, and types of facilities the method could be adapted to. The research team also weighed public sensitivity and privacy concerns in the evaluation and considered the degree of coordination that the method would require. Based on the evaluations and findings from Tasks 1 through 5, several methodologies have been recommended for incorporation into TxDOT's travel survey program.

Development of a final recommended methodology(s) involved input and feedback from the project director and project coordinator to ensure that the final recommendations and project deliverables are suited to the needs and policies of TxDOT. Recommended wording for the implementation of the recommended methodology(s) was prepared for incorporation into the external survey bid specifications used by TxDOT when selecting vendors to perform external surveys in Texas.

2.7 DEVELOP RESEARCH PRODUCTS AND SUMMARY REPORTS

For the final task, the research team developed two research reports and one product to document the findings and recommendations of the research effort. These reports and products are described below:

- 0-4869-1: The main research report that comprehensively documents all project tasks and findings. The report's recommendations include specific modifications to the current external survey bid specification related to methods for conducting high volume surveys and criteria for what constitutes a high volume site. The report provides TxDOT with documentation and justification for recommended methodologies and for conducting external surveys at high volume sites;
- 0-4869-S: A project summary report summarizing the research and findings; and
- 0-4869-P2: An informational pamphlet on external surveys that highlights the purpose and use of these surveys in developing and improving transportation systems in Texas. This pamphlet is intended for immediate use in the travel survey program and can be distributed to districts and MPOs prior to the conduct of external surveys in their areas.

The deliverables from the 0-4869 research project will serve to support, justify, and facilitate the conduct of high volume external surveys as part of TxDOT's travel survey program.

3.0 IMPACT OF HIGH VOLUME SURVEY LOCATIONS

3.1 INVENTORY OF EXTERNAL STATIONS IN TEXAS

In order to ascertain the influence of high volume external stations in Texas, an inventory of all of the external stations for each urban area and survey region was compiled and analyzed. For each of the 25 MPOs in the state, a table that detailed pertinent information was developed. Information such as the facility name, county name, and 2003 AADT was compiled for each external location within each of the MPOs. Table 1 provides an example of the information that was assembled for each MPO study area.

Table 1. Example of Summary Information Assembled for Each MPO.

Waco				
Facility Name	**County**	**Direction (outbound)**	**AADT (2-way)**	**Date of Count**
FM 2114	McLennan	East	630	2003
FM 308	McLennan	Northeast	1,150	2003
SH 31	McLennan	Northeast	6,300	2003
US 84	McLennan	East	4,800	2003
FM 342	McLennan	East	300	2003
SH 164	McLennan	East	4,500	2003
FM 2603	McLennan	South	380	2003
SH 6	McLennan	South	10,200	2003
FM 434	McLennan	South	760	2003
US 77	McLennan	South	7,100	2003
FM 2643	McLennan	South	680	2003
IH 35	McLennan	South	51,000	2003
SH 317	McLennan	South	5,100	2003
FM 107	McLennan	South	870	2003
FM 2671	McLennan	South	430	2003
US 84	McLennan	West	6,400	2003
FM 185	McLennan	Southwest	210	2003
SH 317	McLennan	North	1,850	2003
SH 6	McLennan	Northwest	7,000	2003
FM 1637	McLennan	West	1,200	2003
FM 2490	McLennan	North	2,500	2003
FM 933	McLennan	North	1,650	2003
FM 2114	McLennan	West	1,650	2003
IH 35	McLennan	North	50,000	2003
Total			166,660	

There are a total of 645 external station locations in the state, of which 50 (7.75 percent) are considered high volume (using TxDOTs current criteria of more than 20,000 vehicles per day). Although fewer than 8 percent of the external stations are categorized as high volume, these locations account for over 46 percent of the total traffic volumes for all of the external stations combined. Therefore, it can be stated that the impact that high volume external stations have within Texas is significant.

El Paso is the urban area most noticeably impacted, with 75 percent of the external station traffic on high volume facilities. A major influence on El Paso having such a high percentage of vehicles on high volume externals is due to the international border crossings shared with Mexico. El Paso is followed by Waco (60.6 percent), Cameron County (59.0 percent), and Houston/Galveston (58.9 percent) as urban areas that are most influenced by high volume external stations.

After tables were developed for each of the 25 MPOs, the information was aggregated and organized by the survey regions developed for the TSP. The tables included the following categories for comparative purposes:

- total number of sites;
- total volume;
- number of high volume sites;
- volume of the high volume sites; and
- percent of total AADT carried on high volume facilities.

Table 2 provides the aggregated information for each of the 25 MPO urban areas and 14 travel survey regions.

With regards to survey regions, El Paso (75.4 percent) is most significantly impacted by high volume facilities. Nearly one-quarter (26.7 percent) of the El Paso region external locations are high volume sites. Following El Paso in the total amount of AADT present on high volume

facilities is Waco/Temple/Killeen (59.6 percent), Austin/San Antonio (56.2 percent), and Houston/Galveston/Beaumont/Port Arthur (55.5 percent).

Table 2. Impact of High Volume Sites on Travel Survey Regions.

Survey Region	Urban Area	Total # Sites	Total AADT	# of HV Sites	HV AADT	HV Percent of Total
Amarillo/Lubbock	Amarillo	21	76,530	0	0	0.0
	Lubbock	23	73,980	0	0	0.0
	Region Total	**44**	**150,510**	**0**	**0**	**0.0**
Austin/San Antonio	Austin	44	288,960	4	156,000	54.0
	San Antonio	43	310,730	5	181,000	58.2
	Region Total	**87**	**599,690**	**9**	**337,000**	**56.2**
Bryan/College Station						
	Region Total	**14**	**85,400**	**2**	**44,000**	**51.5**
Corpus Christi/Victoria	Corpus Christi	20	111,550	1	21,000	18.8
	Victoria	11	82,490	1	25,000	30.3
	Region Total	**31**	**194,040**	**2**	**46,000**	**23.7**
Dallas/Fort Worth	DFW	79	463,710	7	232,000	50.0
	Sherman-Denison	20	119,850	2	64,000	53.4
	Region Total	**99**	**583,560**	**9**	**296,000**	**50.7**
El Paso						
	Region Total	**15**	**181,270**	**4**	**136,670**	**75.4**
Houston/Galveston/ Beaumont/Port Arthur	Houston/Galveston	45	299,000	5	176,000	58.9
	Beaumont/Port Arthur	19	151,760	2	74,000	48.8
	Region Total	**64**	**450,760**	**7**	**250,000**	**55.5**
Midland/Odessa/ San Angelo/Abilene	Midland/Odessa	19	50,850	0	0	0.0
	San Angelo	23	50,300	0	0	0.0
	Abilene	20	79,010	1	23,000	29.1
	Region Total	**62**	**180,160**	**1**	**23,000**	**12.8**
Laredo						
	Region Total	**14**	**77,510**	**1**	**29,180**	**37.6**
Texarkana						
	Region Total	**16**	**94,060**	**2**	**42,500**	**45.2**
Tyler/Longview	Tyler	32	189,320	2	61,000	32.2
	Longview	60	225,160	2	62,000	27.5
	Region Total	**92**	**414,480**	**4**	**123,000**	**29.7**
Rio Grande Valley	Cameron County	13	169,510	2	100,000	59.0
	Hidalgo County	20	155,800	2	79,000	50.7
	Region Total	**33**	**325,310**	**4**	**179,000**	**55.0**
Waco/Temple/Killeen	Waco	24	166,660	2	101,000	60.6
	Temple/Killeen	31	166,970	2	98,000	58.7
	Region Total	**55**	**333,630**	**4**	**199,000**	**59.6**
Wichita Falls						
	Region Total	**19**	**76,660**	**1**	**20,000**	**26.1**
HV is defined as a volume of 20,000+						

The percent of total external AADT that is carried on high volume externals provided in Table 2 is summarized and shown graphically in Figure 6. The results are provided on a TSP region basis.

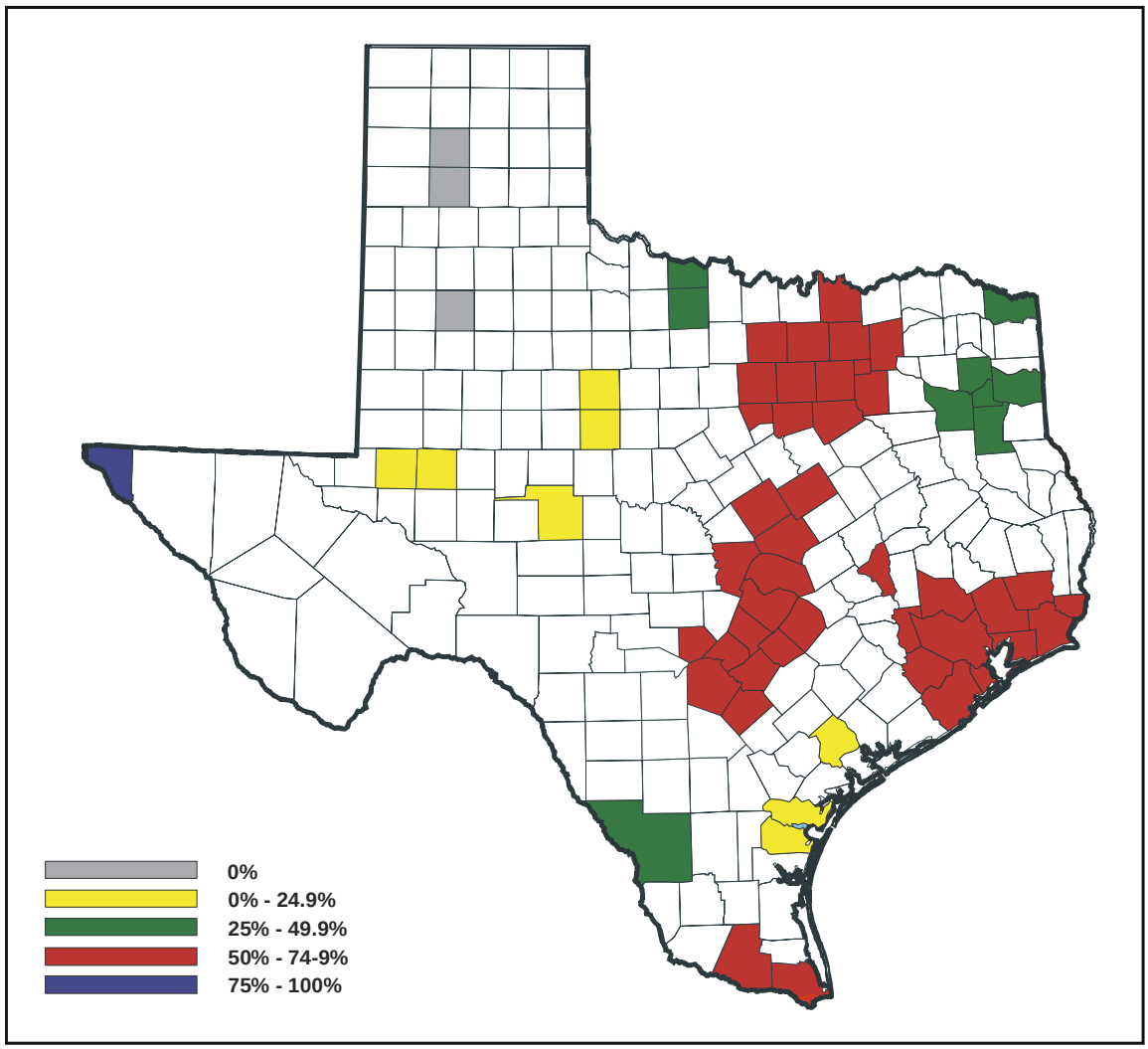

Figure 6. Percent of External AADT on High Volume Facilities by Survey Region.

Seven of the 14 TSP regions (50 percent) had more than half of the external-related AADT on high volume facilities. Four regions had between 25 and 50 percent, and three regions had less than 25 percent. One region (Amarillo/Lubbock) had no high volume external stations. Those regions that had more than half of the external-related AADT on high volume externals are:

- El Paso (75.4 percent)
- Waco/Temple/Killeen (59.6 percent)
- Austin/San Antonio (56.2 percent)
- Houston/Galveston/Beaumont/Port Arthur (55.5 percent)
- Rio Grande Valley (55.0 percent)
- Bryan/College Station (51.5 percent)
- Dallas/Fort Worth/Sherman/Denison (50.7 percent)

An additional assessment was performed that identified the average volume per site in each of the urban areas. For the state, the average AADT per external station is approximately 5,800. The average AADT per external station for each urban area is provided in Figure 7.

The Cameron County study area had the highest average AADT per external station with over 13,000 vehicles, followed by El Paso with just over 12,000 vehicles, and Beaumont/Port Arthur with approximately 8,000 vehicles. The urban areas with the lowest average AADT per external station were San Angelo (2,200), Midland/Odessa (2,700), and Lubbock (3,200).

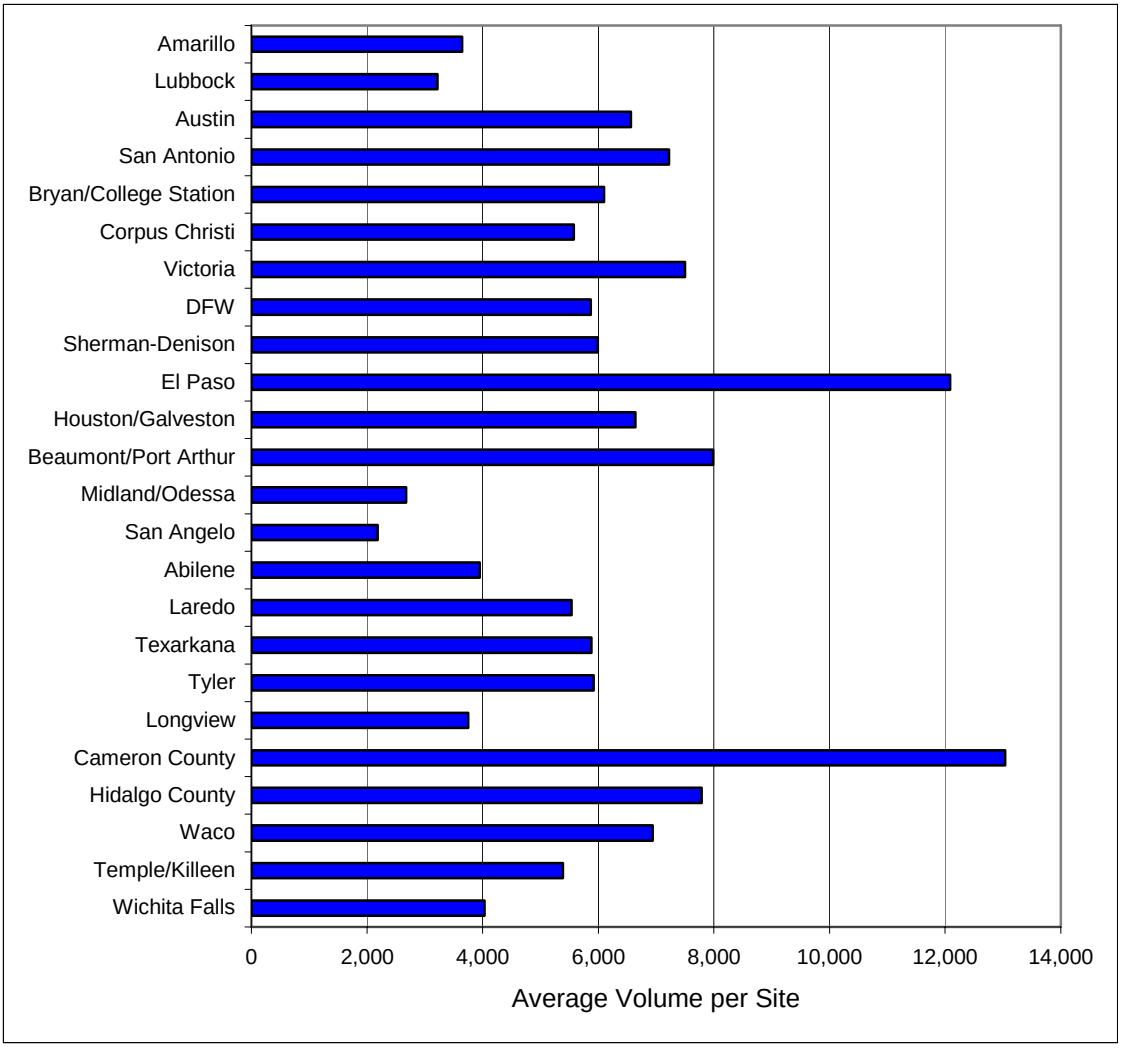

Figure 7. Average AADT per External Station.

3.2 IMPACT OF HIGH VOLUME SURVEY DATA IN THE MODELING PROCESS

The external station survey provides valuable data that are used in the development of trip tables and trip length frequency distributions for the travel demand modeling process. Although there are numerous methods for conducting external station surveys, each method is designed to collect specific data that assist in the development of the trip tables. The purpose of this section is to examine the data that are collected with three methods currently used in external station surveys and describe how those data are used in travel demand models. The methods that were compared are intercept interview, license match, and license mailout.

The amount of data actually used in the travel demand model is dependent on the urban area being modeled. In most urban area models, the majority of data collected is not used directly in the urban travel demand model. In nearly all urban area models, the external survey data that are a key element in the model are the information on vehicle origins and destinations and the split of vehicles that are local trips (i.e., one end of the trip is in the study area and one end is outside the study area) versus those that are through trips (i.e., both ends of the trip are outside the study area). The origins and destinations are geocoded to longitude, latitude, and traffic analysis zone (TAZ). The vehicle trip data (derived from the origin and destination data) provide information that when combined with the transportation network for the urban area yields average trip length and trip length frequency distributions for input to the travel demand models. These data are also used as the basis for developing the external local and external through trip tables that are used as direct inputs to the base year travel demand models.

The split between external local and external through trips observed in the external surveys is the basis for estimating the total local and through trips at each external station. The number of trips and trip lengths are the basis for estimates of vehicle miles of travel within the urban area due to external related travel. Data from the external surveys are also used to estimate the number of internal trips made by persons that do not live in the urban area. These data are developed using the information on trips made prior to being surveyed.

Table 3 and Table 4 present a listing of the types of data/information typically collected in intercept interview, license match, and license mailout methods for non-commercial and commercial vehicles, respectively.

Table 3. Non-Commercial Vehicle External Survey Data Elements.

Data Element(s)	External Survey Method		
	Intercept	License Match	License Mailout
Time/Date/Location	✓	✓	✓
Occupancy	✓		✓
Vehicle Information/Classification	✓		
Residence Location	✓		✓
Overnight Information	✓		
Out of State Information	✓		
Location of Trip Origin	✓		✓
Time Left Origin	✓		
Type of Place at Origin	✓		
Purpose for Being at Origin	✓		✓
Local Trip Indicator	✓	✓	✓
Through Trip Indicator	✓	✓	✓
Location of Trip Destination	✓		✓
Purpose for Traveling to Destination	✓		✓
Information on Travel out of State	✓		
Information on Travel in State	✓		
Information on Trips Made Prior to Being Surveyed	✓		

While the non-commercial and commercial vehicle surveys capture some of the same data elements, the commercial vehicle survey has additional data elements that have been added to the TSP in an effort to collect information to supplement the Statewide Analysis Model (SAM). The SAM was developed in order to assist in the estimating and forecasting of state, regional, and national movements of passengers, commodities, and freight which impact the state of Texas. Examples of these data elements include whether or not the cargo was picked up in or destined to Mexico, the type of cargo container, and information pertaining to the cargo pickup and drop-off location. So while these particular data elements may not be directly applicable to urban travel demand models, they are important to TxDOT for other planning purposes.

Table 4. Commercial Vehicle External Survey Data Elements.

Data Element(s)	External Survey Method		
	Intercept	License Match	License Mailout
Time/Date/Location	✓	✓	✓
Occupancy	✓		✓
Vehicle Information/Classification	✓		
Cargo Being Carried	✓		✓
Vehicle Type	✓		
Cargo Weight	✓		✓
Type of Container	✓		
Mexican Cargo Indicator	✓		
Cargo Pickup Location Information	✓		
Cargo Drop-Off Location Information	✓		
Vehicle Information	✓		
Location Vehicle Traveling From	✓		
Information on Location Being In/Out of Texas	✓		
Location of Trip Origin	✓		✓
Time Left Origin	✓		
Type of Place at Origin	✓		
Purpose for Being at Origin	✓		✓
Local Trip Indicator	✓	✓	✓
Through Trip Indicator	✓	✓	✓
Location of Trip Destination	✓		✓
Purpose for Traveling to Destination	✓		✓
Information on Travel out of State	✓		
Information on Travel in State	✓		
Information on Trips Made Prior to Survey	✓		

The intercept interview method provides all of the data elements used in travel demand models while the license mailout method provides all of the data except for any information on trips made within the urban area prior to the trip being surveyed. The license match method only provides data on the estimates of local and through trips. For the license match method, data relative to travel patterns within the urban area and trip length information must be estimated using secondary data sources and/or survey data from external stations where either the intercept method or the license mailout method were used. While estimating is done in areas where the license match is used (such as high volume locations), it may introduce bias in the results simply because the high volume stations may represent a disproportionate share of the movement of vehicles into and through urban areas. The assumption that the travel patterns from low and medium volume facilities is representative of the travel patterns for high volume facilities may or may not be true. It may also vary between urban areas as well.

In order to gain a better understanding of the role that the individual survey elements have in the modeling process, Table 5 and Table 6 delineate the function of each of the primary data elements and the assumptions that must be made if the data element is not obtained, respectively.

Table 5. Function of Survey Data Elements in the Modeling Process.

Data Element(s)	Function in Modeling Process
Time/Date/Location	Administrative and statistical summary purposes only
Occupancy	Estimates of number of persons traveling in urban area
Vehicle Information/Classification	Distribution of vehicle fleet mix operating in urban area
Residence Location	Distribution of trips by residents vs. visitors
Overnight Information	Statistical purposes
Out of State Information	Statistical purposes
Location of Trip Origin	Average trip length, trip length frequency distribution, trip table development
Time Left Origin	Estimate of travel times
Type of Place at Origin	Attraction models
Purpose for Being at Origin	Disaggregation of trips by purpose (home-based work, home-based non-work, non-home based)
Local Trip Indicator	Trip table development
Through Trip Indicator	Trip table development
Location of Trip Destination	Average trip length, trip length frequency distribution, trip table development
Purpose for Traveling to Destination	Disaggregation of trips by purpose (home-based work, home-based non-work, non-home based)
Information on Travel out of State	Statistical purposes
Information on Travel in State	Statistical purposes
Information on Trips Made Prior to Being Surveyed	Estimate of the number of non-resident internal trips
(Commercial Vehicle Survey Only)	
Cargo Being Carried	Commodity freight model
Cargo Weight	Commodity freight model
Type of Container	SAM
Mexican Cargo Indicator	SAM
Cargo Pickup Location Information	SAM
Cargo Drop-Off Location Information	SAM
Location Vehicle Traveling From	SAM and Attraction models
Information on Location Being In/Out of Texas	SAM

Table 6. Assumptions Required When Data Are Not Collected.

Data Element(s)	Assumption to be Made
Time/Date/Location	None
Occupancy	Average occupancy
Vehicle Information/Classification	Distribution of vehicles by class
Residence Location	Split between resident and non-resident
Overnight Information	None
Out of State Information	None
Location of Trip Origin	Split between local and through trips
Time Left Origin	None
Type of Place at Origin	Distribution of trips by type of place
Purpose for Being at Origin	Distribution of trips by trip purpose
Local Trip Indicator	Split between local and through trips
Through Trip Indicator	Split between local and through trips
Location of Trip Destination	Distribution of trips by destination
Purpose for Traveling to Destination	Distribution of trips by trip purpose
Information on Travel out of State	Distribution of trips by state
Information on Travel in State	Distribution of trips by state
Information on Trips Made Prior to Being Surveyed	Number of non-resident trips
(Commercial Vehicle Survey Only)	
Cargo Being Carried	Distribution of trips by cargo being transported
Cargo Weight	Distribution of trips by cargo and cargo weight
Type of Container	Distribution of trips by type of container
Mexican Cargo Indicator	Distribution of trips by cargo source
Cargo Pickup Location Information	Distribution of trips by cargo pickup location
Cargo Drop-Off Location Information	Distribution of trips by cargo drop-off location
Location Vehicle Traveling From	Distribution of local and through trips
Information on Location Being In/Out of Texas	Distribution of trips by location in/out of Texas

4.0 EXTERNAL SURVEYS AND HIGH VOLUME LOCATIONS: STATE OF THE PRACTICE

This chapter assesses the state of the practice of external station travel surveys and other similar traffic studies as they relate to the methods used to conduct origin-destination type travel surveys on high volume roadways. Surveys and other relevant studies were identified through the Transportation Research Information System (TRIS) online search function, the Travel Model Improvement Program (TMIP) modeling list-serv, literature reviews, computer searches using various search engines, Transportation Research Board (TRB) contacts, and professional contacts in both the public and private sectors. This chapter also discusses the current state of the practice as it relates to technology and the application of technology in the conduct of external surveys as well as legal and privacy issues as they relate to external travel surveys.

The contents of this chapter were developed through the review of reports and write-ups of completed travel surveys and corridor studies, and telephone interviews and/or e-mail correspondence with representatives from state departments of transportation (DOTs), MPOs, and private transportation consulting firms. All individuals contacted were directly involved in the travel survey (or surveys) for their agency or region. For travel surveys in Texas, the contents are based on the experience of researchers who have developed, overseen, and analyzed over two dozen travel surveys for TxDOT since 1995.

4.1 REVIEW OF O-D SURVEYS INVOLVING HIGH VOLUME METHODS

To determine the types of high volume survey methods and their frequency of use, researchers examined a cross-section of external station surveys having a range of survey methodologies utilized on high volume facilities. They also reviewed high volume survey methods used in a small sample of corridor studies, toll feasibility studies, and user/attitudinal studies. The assessment is based primarily on high volume survey methods that have been used in external station surveys in the United States over the past 10 years. It should be reiterated that this assessment only represents findings for a cross-section of surveys that have been conducted during this time period.

The researchers identified and reviewed over 25 origin-destination (O-D) travel surveys from 16 different states, including 18 external station surveys and 11 of the aforementioned 'other' types of O-D surveys. All surveys had at least two or more sites where a high volume survey method was used. The nine remaining surveys (e.g., corridor, rail/toll feasibility, etc.) used a high volume survey method exclusively. Surveys included in the assessment are listed in Table 7 and Table 8. Table 7 shows the sponsoring agency, the year the survey was conducted, and the high volume survey method used for external station surveys.

Table 7. High Volume Survey Methods in External Surveys.

Sponsoring Agency	High Volume Survey Method Used
Texas DOT, TPP Division. 2002-2005, (7 urban areas).	Video license match. Intercept interviews of commercial vehicles at weigh stations, rest areas, and truck stops.
Capital Region Planning Commission (CRPC), Baton Rouge, LA, 2005.	Video license match. Intercept interviews for commercial vehicles at weigh stations, rest areas, truck stops.
Florida DOT, Regional Transportation Authority (RTA) Tampa, FL, 2003.	Video license mailout using high speed cameras and voice recorders.
Chattanooga/ Hamilton County Regional Planning Agency. Chattanooga, TN, 2002.	Intercept postcard mailback at diamond interchanges near freeway entrance and exit ramps. Intercept interviews at rest areas and weigh stations. *(1)*
Delaware Valley Regional Planning Commission (DVRPC). Philadelphia, PA, 2001.	Intercept interviews on shoulders of freeway mainlanes. *(2, 3, 4)*
Texas DOT, TPP Division, Statewide Border Crossing Survey. 2001.	Video license mailout. Intercept interviews of commercial vehicles at weigh stations, rest areas, and truck stops near state borders.
Southern California Area Council (SCAG) Los Angeles, CA, 2001.	Video license mailout. Included reminder postcards and brochure sent with survey. *(5)*
North Carolina DOT, Triangle Modeling Area. Raleigh - Durham, NC, 2001.	Primarily video license match/mailout. Postcard mailbacks at some sites. Intercept interviews at rest areas and weigh stations.
North Carolina DOT with South Carolina DOT. City of Charlotte, Metrolina Region. 2001.	Video license match. *(6)*
Knoxville MPO, Knoxville, TN, 2000-2001.	Video license mailout and telephone survey. *(7)*
Crittenden County, Little Rock, AR, 2000.	License mailout using binoculars and handheld computers. Interviews at weigh stations.
Maricopa Association of Governments (MAG) Phoenix, AZ, 1999.	Intercept interviews on freeway exit ramps, rest areas, and weigh stations. *(8)*
Denver Regional Council of Governments (DRCOG). Denver, CO, 1998.	Intercept interviews at interchanges near interstate off-ramps and ports of entry. *(9)*
Chicago Area Transportation Study (CATS), Chicago, IL, 1998.	Video license mailout. Postcard mailback used on interstates with toll plazas. *(10)*
Nashville Area MPO, Nashville, TN, 1997.	License mailout using both video camcorders and audio recording of license plates at all external survey locations (including low volume). *(11)*
Ohio DOT with West Virginia DOT. Steubenville-Weirton, OH, 1997.	Video license mailout and intercept postcard mailback. *(12)*
Ohio DOT, Various External Surveys, 1996-1997.	Video license mailout surveys. *(13)*
Caltrans, Numerous Districts, various cordon surveys, 1990-1997.	Video license mailout. *(14)*

Table 8 provides this same information, but for the other types of O-D surveys reviewed in the research.

Table 8. High Volume Survey Methods in Other O-D Surveys.

Sponsoring Agency	Survey Date and Type	High Volume Survey Method Used
Texas DOT, Texas Turnpike Authority (TTA)	2004-2005 Various Toll Feasibility Studies	Video license mailout. Intercept postcard mailback on freeway entry/exit ramps.
North Carolina DOT, Transportation Planning Branch	2004 US 64 – NC 49 Corridor Study, Video O-D Survey	Video license match and video license mailout. *(15, 16)*
Florida DOT, High Speed Rail Authority	2002 Rail Feasibility	Intercept interview. Troopers used to pull motorists off freeway for researchers to ask O&D questions. *(17)*
Pennsylvania Turnpike	2001 Motorist Attitude	Intercept postcard mailback. Motorists were randomly selected as they exited turnpike. *(18)*
Dakota County, Mn. Cedar Avenue Corridor Transitway O-D Study	2000 Corridor Study	Video license mailout. *(19)*
Orlando-Orange County Expressway Authority (OOCEA)	1999 Study of Toll Verses Non-Toll Users	Intercept postcard mailback at toll plazas. Survey also mailed to E-pass users. *(20)*
Washington DOT, Hood Canal Survey	1998	Video license mailout. *(21)*
Caltrans, Between San Joaquin Valley and San Francisco	1998 Corridor Study	Video license mailout. Study referenced 5 other license mailout surveys conducted by Caltrans in previous years. *(14)*
Caltrans, Numerous Districts	1990-1997 External Station and Corridor	Various video license mailout surveys. *(14)*
Wisconsin DOT	1995 Motorist Attitude	License mailout. Licenses recorded manually. *(22)*
Santa Barbara County Association of Governments	1995 Corridor Study	Video license mailout. *(23)*

A review of Table 7 and Table 8 shows the following high volume survey methods used in a cross-section of O-D travel surveys conducted in the United States:

- intercept interviews on the shoulders of freeway mainlanes;
- intercept interviews on or near freeway exit ramps;
- intercept interviews at weigh stations, rest areas, and truck stops (primarily commercial vehicles only);
- intercept postcard mailback at interchanges near freeway ramps;
- postcard mailback at toll plazas;
- surveys mailed to electronic toll tag/pass users;

- license match (point-to-point match only); and
- license mailout (without point to point matching).

With the exception of intercept interviews at weigh stations, rest areas, and truck stops, the large majority of methods listed above were used for non-commercial vehicles only (e.g., passenger cars and light trucks). The research found that a video license mailout method for non-commercial vehicles in combination with intercept interview surveys at weigh stations, rest areas, and/or truck stops for commercial vehicles (e.g., medium and heavy trucks, tractor-trailors) was the most frequently used high volume method in the sample of external surveys that were reviewed. It found that the large majority of commercial vehicle surveys on high volume facilities are conducted using an intercept interview method at weigh stations, rest areas, and truck stops along the high volume route.

The high volume survey methods identified in the cross-section of O-D surveys included in Table 7 and Table 8 can be consolidated into the following four primary categories:

- intercept interview methods,
- intercept postcard mailback methods,
- license match (point-to-point) methods, and
- license mailout methods.

In the majority of surveys, a combination of two more of these methods were used, particularly if both non-commercial and commercial vehicles were being surveyed. The following sections discuss in detail the high volume survey methods in each of the four categories of high volume survey methods.

4.2 INTERCEPT INTERVIEW METHODS

Several major external surveys in the United States in recent years have used an intercept interview method to survey non-commercial vehicles on or along high volume freeways and interstates. These intercept interviews were conducted at interchanges on or near freeway exit ramps and on the shoulders of the freeway mainlanes. For commercial vehicles, intercept

interview surveys at rest areas, weigh stations, and truck stops were found by to be the most common way of conducting O-D surveys on high volume facilities. Some reports cited this method as the only means of conducting commercial surveys on freeways and interstates.

Intercept Interviews on or near Freeway Exit Ramps

For the high volume locations in the Denver and Phoenix external surveys, non-commercial vehicles were surveyed using intercept interviews on or near freeway exit ramps. In both cases, the high volume surveys were located on the periphery of the urban areas where traffic volumes were lower and the freeway cross-sections were only two lanes in each direction. In the Denver survey, it was stipulated that surveys could only be conducted at ramp locations that would not require a lane reduction on the mainlanes.

In a 2002 Rail Feasibility Study conducted by the Florida High Speed Rail Authority, state troopers directed motorists off the freeway so that their participation in an interview survey could be requested *(17)*. As a result of this effort, the Florida DOT suspended (at least temporarily) the use of intercept survey methods on freeways and interstates.

Details on how the Phoenix and Denver external surveys were conducted and why the sponsoring agency chose this survey method are provided in the sections to follow:

Phoenix, Arizona, Maricopa Association of Governments (MAG), 1999

The Phoenix external survey included three high volume freeway locations where a personal intercept interview method was used on freeway exit ramps and rest areas *(8)*. Two high volume intercept sites were located on IH 10, and a third was on IH 17. To conduct the surveys, traffic control plans (TCPs), which would allow platoons of vehicles to be flagged from the freeway and into the survey sites, were prepared and installed. The number of vehicles flagged into the survey site at one time never exceeded the number of interviewers. All freeway survey sites were located on the outskirts of the Phoenix area, where traffic volumes were lower. The intercept interview surveys were conducted using a paper survey instrument.

Prior to conducting the survey, permits were obtained from affected counties, municipalities, and several districts of the Arizona DOT. TCPs were prepared for each site, and all jurisdictions and agencies were afforded the opportunity to review the TCPs prior to the conduct of the survey. According to the MAG representative contacted, getting the necessary approvals and permits from all affected agencies and jurisdictions was very difficult (Mark Schlappi, April 21, 2005). It was also noted that the conduct of the survey was announced ahead of time to the local press (though specific survey locations were not provided), and the survey did not generate many complaints. Key aspects and policies of the Phoenix survey were as follows:

- Arizona state troopers declined to participate due to concerns that the survey could be considered an illegal search and seizure; and
- MAG did not use a license mailout method at high volume locations, at least in part, because the Arizona DOT would not allow licenses to be identified using state motor vehicle records.

Denver, Colorado, Denver Regional Council of Governments (DRCOG), 1998

The DRCOG conducted an external survey for the Denver region in 1998. For the high volume locations, personal intercept interview surveys of smaller vehicles were conducted at low volume interstate off-ramps near the survey area boundary *(9)*. A TCP was established on the freeway and handheld radios were used to coordinate the flagging of random platoons of vehicles to exit the freeway. Freeway sampling was generally from the outside lane, although a few vehicles from the inside lane responded to flaggers. Flagged vehicles were then surveyed at the interchange immediately downstream from the ramp, and only vehicles in the right lanes were surveyed. Due to grade and deceleration concerns, commercial vehicles were not surveyed at off-ramps, but were surveyed at weigh stations using an intercept interview method. The survey took 2 to 3 minutes to complete and was conducted using a paper survey instrument. The 1998 DRCOG survey included five interstate highway locations. Key elements and policies of the Denver surveys were as follows:

- Intercept surveys were prohibited on freeway mainlanes as part of the effort.
- The Colorado State Police declined to provide officers at survey sites, but provided patrol and enforcement near sites.

- The DRCOG chose not to use a video license mailout method, *not* because it was deemed too intrusive, but because of concerns for reduced reliability of results due to the 'self selection' aspect of the method, and because out-of-state license plates would be lost in the process.
- The time to conduct the survey was kept to a minimum (e.g., about 2 to 3 minutes).
- Due to the complexity of the safety issues associated with the survey method, it took over a year to resolve problems, develop TCPs, and obtain approval from the Colorado DOT to conduct the surveys.

The DRCOG used several measures to help publicize the survey, cast it in a positive light, and improve survey response. For the survey, they established a 1-888 toll-free hotline which had a series of pre-recorded messages. They also developed a brochure that was handed out with the survey, which explained the survey's purpose and contained coupons from local merchants.

Intercept Interviews on Freeway Mainlanes

In the late 1980s and the early 1990s, TxDOT used an intercept interview method on freeway mainlanes in numerous areas around the state, including Houston, El Paso, and San Antonio, among others. The freeway intercept interview surveys were conducted with the assistance of law enforcement using a TCP which merged the traffic into one lane and extended for 1.5 to 2 miles. TxDOT ended the use of intercept interview surveys on freeways in the early 1990s due to long traffic delays and queues and safety concerns for the public and surveyors.

The research found one recent external travel survey, the External and Through Trip Survey for the Delaware Valley located in the Philadelphia, Pennsylvania, area, where intercept interview surveys were conducted on the shoulders of freeway mainlanes. Details on this survey are provided in the following subsection.

Philadelphia, Pennsylvania, Delaware Valley Regional Planning Commission (DVRPC), 2001

For the DVRPC external survey, an intercept interview method was used on some of its high volume facilities. With the use of a TCP and state troopers, intercept surveys were conducted on the shoulders of two-lane sections of IH 95 between Philadelphia, Pennsylvania, and Wilmington, Delaware *(2, 3, 4)*. Troopers were used to flag motorists into the survey sites, and no freeway mainlanes were taken out of service. The survey took 2 to 3 minutes to complete and was conducted using paper surveys color coded by time of day (AM and PM peak periods) and direction of travel.

According to a DVRPC representative, surveys were conducted in-house with assistance from Pennsylvania, New Jersey, and Delaware DOTs, and local and state police departments (Joseph F. Hacker, DVRPC, May 17, 2005). The effort took over 1 year to coordinate. The survey was in progress when the terrorist attacks of September 11, 2001, occurred. The survey was suspended for a short period and then resumed after a meeting of all agencies and jurisdictions involved in the effort. DVRPC had excellent response to the surveys and little negative public and political feedback. Officials at DVRPC believed the fact that they had precedence in conducting these surveys helped to gain acceptance of the project. Key policies and aspects of the survey were as follows:

- DVRPC chose not to use a license mailout method, not because of privacy concerns, but because of a lower quality of response and a bias in survey results it experienced with this method in their 1988 survey;
- good coordination and cooperation between all state DOTs and law enforcement agencies; and
- the survey's short duration of 2 to 3 minutes and color coding of survey forms.

4.3 INTERCEPT POSTCARD MAILBACK METHODS

This method is conducted the same way as the intercept interview method, except that instead of motorists being asked questions, they are handed a survey form to be completed once

their final destination is reached. The driver is then responsible for completing the survey and mailing it back. Key aspects of this method include the following:

- It introduces a self selection bias, and data quality may be reduced since the driver is forced to recall details about past travel.
- The response rate for this type of mailback method is often under 15 percent.
- Most handout mailback survey forms use business reply postal permits, which eliminate postal costs for respondents.

Handing out postcard mailback surveys in lieu of conducting a personal interview has also been used for intercept surveys on low volume facilities. Utilizing this method on low volume facilities is usually not the best option due to drawbacks such as low sampling rates and quality of responses. The intercept postcard mailback method gets increased consideration on high volume facilities since it is less prone to creating traffic delays and queues than an interview survey. However, DRCOG chose not to use this method for its 1998 survey because of its low sampling rates and high costs.

Intercept Postcard Mailbacks on or near Freeway Ramps

Chattanooga, Tennessee, Chattanooga/Hamilton County Regional Planning Agency (CHCRPA), 2002

High volume facilities in the 2002 Chattanooga-Hamilton County area external travel survey were conducted using roadside surveys and distributing mailback postcard questionnaires at diamond interchanges near interstate entrance and exit ramps *(1)*. Postcards were distributed at intersections downstream from freeway exit ramps or near entrance ramps when vehicles were yielding to oncoming traffic. Respondents had the option of completing and mailing back the postcard or completing the survey online. In addition to postcards, personal intercept interview surveys of both non-commercial and commercial vehicles were conducted at rest areas along the interstates. Commercial vehicles were also surveyed at weigh stations.

According to a subsequent regional transportation planning report for the Chattanooga area, the percentages of internal-external (local) and external-external (through) trips developed

from the survey were determined to not be reliable. It indicated that for the surveys which were conducted on ramps at interchanges and rest areas, vehicles were not flagged from the freeway mainlanes where most of the through trips occur. The vehicles that were surveyed were already stopping at the interchange or rest area. Therefore, through trips were underestimated, and there was a significant bias toward internal-external trips.

According to a CHCRPA representative, postcard distribution at interchanges was not the original method that they had planned to use for the survey (R.C. Hoff, December 20, 2005). The agency had planned to set up survey stations at rest stops and weigh stations at key locations along the interstate and hire law enforcement to assist in flagging samples of motorists into the stations. However, prior to beginning the survey, a major fog-related traffic pileup occurred on one of the interstates. Additionally, the September 11, 2001, terrorist attacks occurred, and this precluded support for the survey from state troopers. Key policies and aspects of the Chattanooga-Hamilton County External surveys included the following:

- The Tennessee state police declined to participate in the survey due to safety concerns and concerns that stopping vehicles for the purpose of a survey may constitute an illegal search and seizure.
- The state's Title and Registration division would not release license information to the DOT, thus removing the option of license capture mailout surveys.
- Estimates of through trips from interstate survey sites were subsequently reported not to be reliable due to the survey method used.

For non-interstate survey sites, non-commercial and commercial vehicles were interviewed at roadside intercept sites. Certified flaggers and law enforcement officers were used to direct traffic into survey areas at non-interstate sites.

Postcard Mailback Surveys at Toll Plazas

Orlando, Florida, Orlando-Orange County Expressway User Study, 1999

In 1999, the Orlando-Orange County Expressway Authority (OOCEA) conducted a study comparing the travel characteristics of Orlando-Orange County Expressway System users in the

Orlando area *(20)*. For non-users of the electronic toll collection system, E-PASS, a total of 100,960 survey forms were distributed at 10 toll plazas. A total of 7,529 surveys were returned by mail, resulting in a response rate of 7.5 percent. For E-PASS users on the Orange County Expressway, a total of 66,189 surveys were mailed, and 13,608 surveys were returned (a response rate of 20.6 percent). Surveys were mailed to almost one-third of E-PASS users on the system. The survey also included the option of completing the survey via the internet. A total of 504 surveys were completed on the internet, representing approximately 2.5 percent of all survey responses.

4.4 VIDEO LICENSE MATCH METHODS

Video license match methods involve video recording license plate information of vehicles at two or more video survey locations around the perimeter of a study area (or along a corridor) and then matching them to identify vehicle movements between the different locations. This 'point-to-point' matching is then used to determine the percentages of internal-external (local) trips and external-external (through) trips within a study area or along a corridor.

The most common reasons stated for using this method were (1) because traffic volumes were too high to safely stop motorists and (2) because it was an unobtrusive means of collecting the data. An upside to the license 'match only' method is that it does not involve accessing state motor vehicle records and mailing a survey to registrants of captured license plates. The downside is that it only collects one data element (i.e., local and through trip movements) and cannot be used to collect other needed data elements such as specific origin and destination information, residency, trip purpose, trip length, and others.

In order to more accurately identify through trips as part of a license match survey, travel time runs between each video survey location are conducted to determine reasonable times it takes for vehicles to travel between survey locations. Vehicle classification counts are also conducted at each video survey site in order to determine the percent of vehicle license plates recorded relative to the total traffic that went through the site during the survey time period.

The research found that high speed, high specification video cameras and camcorders with ample zoom capabilities are most commonly used to conduct video license match surveys. The information needed to perform license matching includes the following:

- license plate number,
- state of registration of the plate,
- time of day when the plate was recorded, and
- direction of travel.

The license match survey should be conducted for an entire day during daylight hours or, depending on the study objectives, it can be conducted during peak periods or other periods of interest. To conduct the survey, license plates are recorded for all high-volume survey locations in a defined study area on the same day. The method can become costly in areas with multiple locations because all lanes of traffic in each direction at all locations must be surveyed at the same time. For example, an external survey with four high volume locations and three lanes in both directions at each of the four locations would require the use of 24 video cameras (not to mention other accompanying equipment). In order to capture the clearest images of plates, experienced video survey contractors indicate that, if possible, video cameras should be placed on overpasses (or other overhead structures, where possible). However, for divided facilities with two lanes in each direction, they indicate that good license plate images can also be obtained from placement on the side of the roadway (Trey Gamble, Alliance Transportation Group and George Nassour, Gram Traffic Counting, Inc., December 20, 2005).

For non-commercial vehicles, rear license plates should be recorded since 19 states currently do not require a front license plate. Depending on the type of survey, license information for commercial vehicles may need to be recorded on the front of the vehicle for the following reasons:

- Rear license numbers have a higher probability of being obscured by a trailer or a trailer hitch.
- For tractor-trailer combinations, the rear license plate may be that of a leased trailer and not that of the true registrant (or state) of the vehicle.

Other methods have been used to capture license data. However, the use of high specification video cameras and camcorders is by far the most common and was the method used for the license match method in the large majority of surveys identified in this research. Other methods identified included the following:

- using high speed cameras in combination with voice recorders (Tampa, Florida, 2001);
- using binoculars in combination with hand-held computers (Little Rock, Arkansas, 2000); and
- audio recording license plates using hand-held cassette recorders (Nashville, Tennessee, 1997).

Processing Video License Data and Optical Character Recognition (OCR)

Once license plates are recorded on videotape, they need to be transferred to an electronic database for processing and analysis. The most time-consuming and labor-intensive method for performing the transfer is manually viewing the videotapes on a frame-by-frame basis and recording the plate number, state of registration, and time the vehicle passed the video survey.

The majority of the external station surveys using a license match method for their high volume facilities used some form of a video license plate data reduction (VLPDR) software. These specialized proprietary programs are used to identify the frames that contain vehicles and to remove the remaining empty frames *(24)*. The programs are designed to read and associate the frames with video images with a time stamp. Once the videotapes are reduced, it significantly facilitates and speeds up manual data transcription and development of electronic license data files.

For the surveys reviewed in the research, OCR technology was used to transcribe license data in most of the corridor type surveys but in only a few external station surveys. The majority of corridor surveys reviewed used a proprietary OCR system, while only a few of the external station surveys identified used this technology.

OCR is not more commonly used in external surveys because of its high cost and low degree of accuracy, particularly when applied in a 1-day temporary setup such as a high volume roadside survey site. In order for accuracy rates to approach acceptable levels, OCR software must first be 'trained' to better recognize typical occurrences of license plates in a state or particular region. This training is done by modifying the font templates in the software's algorithms to increase recognition rates. With the present state of technology constantly changing, the need to modify font templates for OCR software will be on-going. Additionally, each of the 50 states have different license plates, it is not uncommon for plates to change, and the growing popularity of specialty plates such as those permitted in Texas all pose potential limitations to the ability of OCR technology to recognize license plate characters and digits.

OCR technology in video license capture is currently not well suited for single event, single day temporary applications such that of an external survey. It is better suited for 'fixed' applications where video license capture is done continuously or for longer periods, such as in security, parking, and toll enforcement applications. The accuracy of plate recognition in fixed applications of OCR is significantly better than that of temporary applications for the following reasons:

- Font templates in the software algorithms have been trained to better recognize the license plates that occur in the area.
- The cameras are in a fixed position, usually overhead, and the vehicles are better channeled into lanes where a clearer image of the plate can be obtained.
- The quality of cameras and video equipment is superior due to a more permanent nature of use and greater importance of enforcement (e.g., toll e-tags, security).
- Vehicle speeds are often lower which allows for better clarity of plate images.

In order for OCR to be more commonly used in external surveys, its cost will need to be reduced and its rate of accurately recognizing plates increased; particularly with respect to correctly recognizing *all* characters of license plates. The ability to accurately recognize all characters in the plate is important in license mailout surveys where state motor vehicle records are used to obtain addresses.

Case Studies of Video License Match Surveys

This section provides details on surveys that have used a video license match method where 'point-to-point' movements of vehicles between survey stations are determined by matching captured license plates. This method does not include accessing state motor vehicle records and mailing out a survey to motorists passing the survey station.

TxDOT's Travel Survey Program to Support Modeling

TxDOT's TPP division currently uses a video license match method on high volume facilities as part of its ongoing travel survey program. This 'match only' method does not require accessing motor vehicle records and mailing a survey. Since 2002, TxDOT's TPP division has used this method in external station surveys of seven urban areas in Texas. TxDOT has developed detailed specifications that contractors are required to follow when conducting video license surveys.

The video surveys are conducted using high-end digital camcorders with ample zoom capability. At each high volume location, rear license plates are recorded for all lanes of traffic in both directions during daylight hours. Once removed from the field, a customized VLPDR program is used to condense the video by removing all footage on the tape lacking a vehicle image. Once the tapes are reduced, databases of license plates for each site (by direction) are developed by manually reviewing the video images of recorded plate numbers. Using this method, one TxDOT vendor indicated that approximately four to seven plates per minute can be transcribed (Trey Gamble, Alliance Transportation Group, December 20, 2005). It was added that up to 10 computer monitoring stations at a time are used to transcribe videotapes to create license plate data files.

TxDOT conducted external station surveys for the Dallas/Fort Worth and Austin/San Antonio regions in 2005. In the Dallas/Fort Worth area, 34 low volume sites were surveyed using roadside interviews, and nine high volume sites were surveyed using a video license match method to determine through movements between video sites. In order to videotape all lanes of traffic in both directions at the nine sites, it required the use of 36 video cameras. A total of 176,331 license plates were captured for the 12-hour recording period. Approximately

72 percent of the plates were from non-commercial vehicles, and 28 percent were from commercial vehicles.

The Austin/San Antonio region external survey included 42 low volume roadside interview sites and eight high volume sites where the license match methods were used. In this study area, a total of 34 cameras were utilized to videotape all lanes of traffic in both directions.

Metrolina Region External Travel Survey, 2001

In 2001, a video license match survey was sponsored by the NCDOT, the SCDOT, and the City of Charlotte. The survey included the use of 43 high specification video cameras to capture license plate data on 43 lanes of traffic in and around the Charlotte, North Carolina, area for a 12-hour period *(6)*. Approximately 400,000 license plates were recorded, and video data was transcribed using a proprietary OCR system. The license data was matched and analyzed to determine O-D patterns within the area as well as travel time and average speed data between all camera locations. The travel time data was analyzed separately for non-commercial and commercial vehicles.

4.5 VIDEO LICENSE MAILOUT METHODS

A video license mailout method was the most frequently used method of O-D surveys reviewed in the research. The license mailout method is typically used for mailing surveys only to registrants of non-commercial vehicles. Commercial, rental, and government vehicles are usually removed from the license plate data files. Unlike the license match method, the license mailout method does not require the data to be collected at multiple locations on the same day. Each survey location is treated independently.

A key aspect of a license mailout survey is the use of state motor vehicle records to obtain address information of license registrants. This element of the survey can raise right-to-privacy concerns and be a source of survey disapproval and negative feedback. Many surveys reviewed encountered negative feedback regarding the use of state motor vehicle records, but relative to the number of surveys that were mailed, the percentage of complaints was minimal.

To help curtail potential negative feedback and improve response rates, license mailout surveys typically include some or all of the following aspects and/or elements:

- Enclose simple survey instrument that can be completed easily.
- Avoid asking personal questions (e.g., income).
- Provide pre-addressed postage paid envelope.
- Send only one survey per address.
- To ensure confidentiality, use a detachable survey form that allows respondent to remove their address.

Additionally, providing a cover letter or informational brochure and a toll-free number for questions or complaints are important components of this method. The letter or brochure explains the survey purpose and importance, and provides contact information. In order to be able to accurately respond to public officials concerning the amount of complaints, some survey sponsors kept a record of the number of surveys mailed by the highway facility and maintained a log of all calls received, including the purpose of the calls. Other important aspects regarding the license mailout method are as follows:

- A short turnaround time between license capture and survey mailout is very important, but difficult to accomplish.
- Out-of-state plates require special consideration and pose challenges such as:
  - Increased difficulty in gaining approval to use out-of-state motor vehicle records.
  - Turnaround times for processing license data will likely be greater.
  - Depending on the proportion of in-state to out-of-state plates, it may not be economical or worth the effort to mail surveys to small groups of out-of-state plates.
- Survey return rates are typically under 15 percent. The return rates for O-D surveys reviewed as part of the research ranged from 9 to 17 percent.

Seventeen of the 27 O-D surveys cited in Table 7 and Table 8 included a license capture/mailout component where state Department of Motor Vehicle (DMV) records were used to acquire address information. In most cases, license data was transmitted to the state DMV and then returned by the DMV with the needed address information. The 17 surveys using DMV

records were from 12 different states. Reasons cited for using the license mailout method include:

- High traffic volumes limit or preclude the ability to safely conduct roadside interviews, and the license match mailout is a safer option.
- It permits the collection of needed information in a non-obtrusive manner.

The use of a license mailout method is also influenced by policies which do not allow intercept surveys on interstates, will not allow the use of DMV records for survey purposes, or when state or local law enforcement (typically state) will not provide assistance for and/or agree to participate in the survey. Surveys reviewed in three states indicated DMV records could not be accessed. These states are Arizona, Tennessee, and Louisiana.

The following survey sponsors chose not to use a license capture mailout method for the reasons provided below:

- In the 2001 DVRPC survey in the Philadelphia area, the method was not chosen because they had used a mailout method in their 1988 survey and found bias in the survey results. In addition, some of the mailout survey questions were misunderstood and others not completed by respondents;
- The Ohio DOT used license mailout surveys in the mid to late 1990s, but no longer does so. This is because a separate commercial survey is still needed, and because of the difficulty of matching out-of-state plates and getting a short turnaround time between license capture and survey mailout; and
- For the 1998 DRCOG survey in the Denver region, the method was not chosen because it introduces a self-selection bias, has lower data quality (compared to the interview method), and is difficult to handle out-of-state plates.

Several license mailout surveys reviewed cited difficulties in getting the early approvals needed and in coordinating license data transfers necessary to obtain addresses with the state DMV(s). Some survey contacts reported that the turnaround time between recording license plates and mailing a survey to a registrant was too long. In these surveys, the turnaround time was greater than two weeks which was cited as too long for plate registrants to accurately recall

their trip. However, in the 2003 external survey for the Tampa RTA, recorded plates were processed overnight so the survey mailout could be turned around very quickly.

Another common finding in the review of license mailout surveys was the difficulty in handling out-of-state plates. Some survey efforts mailed surveys only to in-state registrants and did not mail surveys to out-of-state persons; though they did keep track of them. A few surveys coordinated with DMVs from other states to mail surveys, but cited the difficulty in this coordination and generally cited a greater turnaround time in receiving addresses for these plates.

Tampa, Florida, Regional Transportation Authority (RTA), Florida DOT, 2003

This external survey utilized a license mailout method using DMV records on its high volume facilities. Surveyors using voice recorders and photographers with high speed cameras gathered license data during daylight hours. Separate data collectors were used to verbally record and photograph license plates. License data was processed overnight to ensure that surveys were mailed and received by motorists in an expeditious manner. Six categories of license plates were recorded. These included commercial vehicles, temporary tags, out of state, unable to identify, partially readable Florida tag, and readable Florida tag.

Records were kept on the number of surveys going out and a toll-free 1-800 number was established to handle questions and complaints about the survey. The toll-free number was manned 24-hours a day, and all calls were logged and categorized by type. The use of the 1-800 number along with good record keeping allowed the survey's sponsor to show politicians and other public officials that the actual amount of complaints was very low. For this survey, arterials with traffic volumes greater than 40,000 AADT were considered high volume.

According to a survey contact with the Florida DOT, the DOT does not perform intercept interview surveys on freeways, and most areas in Florida have done license mailout surveys (Danny Lamb, April 21, 2005). It was noted that the DOT has had good luck with license mailout surveys, but the main drawbacks in Florida were the number of out-of-state tags and rental cars. The contact offered the following tips to help minimize or preclude negative public relations regarding license mailout surveys:

- Have a 1-800 number and keep it manned at all times.
- Make survey forms look as official as possible and keep the cover letter as colloquial as possible. Have many people review the letter and make sure it does not have the feel of 'big brother'.
- Provide space on the survey for comments. They received numerous positive comments.

Although a press release regarding the survey was made in advance, no information was released prior to the survey taking place. It was decided not to call attention to the survey.

Texas Border Crossing Travel Survey, TxDOT, 2001

In 2001, TxDOT's Transportation Planning and Programming Division conducted a statewide border crossing study where travel surveys were conducted at 46 highway crossings around the state's perimeter. Surveys on highways with low to moderate traffic levels were conducted using a roadside intercept interview method for both non-commercial and commercial vehicles. At five high volume locations (those in excess of 20,000 AADT), non-commercial vehicles were surveyed using a video license mailout survey, and commercial vehicles were surveyed via intercept interviews at rest areas and truck stops near the Texas border.

As part of the border crossing study, TxDOT mailed out 19,382 surveys to motorists identified as traveling on the five high volume facilities. A total of 2,934 surveys were returned, resulting in a response rate of 15.14 percent. The survey form included the date and location where the vehicle license was recorded. The mailer also included a cover letter stating the purpose of the survey and provided a telephone number for persons to call if they had questions. TxDOT received an estimated 65 calls from persons who were mailed surveys. The nature of the calls was as follows:

- individuals who said that they did not make the trip (the majority),
- inquiries about the legitimacy of the survey,
- individuals saying they no longer owned the vehicle with that license, and
- those voicing anger and/or disapproval of the survey due to privacy and civil liberties concerns.

With only 65 calls out of 19,000 plus surveys mailed, TxDOT received very little feedback from motorists who were mailed surveys. Despite a very low percentage of negative feedback from those surveyed, the study received negative publicity and created a public relations challenge for TxDOT's TPP division. As a result of their experience with the border crossing surveys, the TPP division suspended the use of video license mailout surveys in 2002.

Los Angeles, California, Southern California Council of Governments (SCAG), 2003

This survey involved the use of a video license mailout method at the 17 highest volume external stations around the perimeter of the SCAG modeling area *(5)*. After license plates were recorded, the videotapes were read and addresses for the survey mailout were obtained using the state's DMV database. Proprietary computer software was used to process the videotapes and create license plate databases for each external location. As part of this process, out-of-state, commercial, government, and rental vehicles were removed from the license plate database. Permits were obtained from Caltrans prior to the start of any videotaping. The greatest challenge during the initial stages was getting appropriate approvals, documents, and data transfer processes established with the DMV.

High speed, high specification camcorders were used to collect the license plate data. Surveys were generally conducted for a 12-hour period at each site, beginning at 7AM and ending at 7 PM. Combining all sites, a total of 326,421 vehicles were videotaped. Once government, out-of-state, and rental vehicles were removed, the number of valid plates for the survey totaled 286,649. However, in order to reduce costs and stay within budget only 200,960 surveys were mailed. A total of 17,874 surveys were returned resulting in a response rate of 9 percent.

Reminder postcards were sent out for some of the lower volume sites in order to increase response rates. At several locations, more plates and addresses were obtained than anticipated, and the survey mailout was reduced by approximately 30 percent to stay within budget. SCAG also developed a brochure explaining the purpose of the survey, and this brochure was mailed with the survey. The survey form and the brochure contained both English and Spanish text.

Ohio DOT, Various External Surveys, 1995-present

The Ohio DOT has a long history of conducting O-D roadside travel surveys. Ohio DOT uses various methods of roadside surveying and has surveyed approximately 800-900 locations over the past 10 years *(25)*. According to an ODOT representative, when ODOT updated its external surveys in 1996-1997, a license mailout method was used at all locations with an AADT of more than 25,000 vehicles (G. Giaimo, November 17, 2005). ODOT used a consultant to collect the license data via video and then did the processing and matching of the plates in-house. ODOT no longer conducts license mailout surveys as its experience has shown that they are not effective. The ODOT representative noted the following downsides to the use of the license mailout method:

- A separate (commercial) truck survey is still needed since it is extremely difficult to get a survey to the appropriate person via vehicle registration information.
- Matching out-of-state plates is burdensome, yet important in a state like Ohio that has a lot of out-of-state vehicles on its interstates.
- Many states will not allow the use of or access to their vehicle registration data to obtain address information.
- The time between recording vehicle licenses and getting a survey to the registrant is often too long for the motorist to remember the trip.

ODOT checks and comparisons of data at locations where both intercept interview and license mailout surveys were conducted indicated that the license data were biased toward longer trips.

ODOT has temporarily suspended O-D surveys on high volume facilities until a better high volume method can be found. They are currently looking into the use of an Automatic License Plate Recognition System (ALPR) using OCR technology for use in developing through trip tables on high volume facilities.

Raleigh, North Carolina, North Carolina Department of Transportation, 2003

In 2003, the NCDOT conducted an O-D survey of US 64/NC 49 for the Raleigh to Statesville and Raleigh to Charlotte corridors. The survey included roadside interview surveys,

video license 'point-to-point' matching surveys, and video license mailout surveys *(15, 16)*. The video license surveys utilized high specification video camcorders positioned on overpasses to record license plates. A proprietary OCR software was used to transcribe plates to an electronic database.

A total of 246,587 license plates were recorded out of a total of 285,179 vehicles passing the survey locations, resulting in a capture rate of 86.5 percent. For the 'point-to-point' matching survey, license plates of each origin survey location were matched against those of destination survey locations to determine movements into and through the study area. In addition, a record was also kept on the in-state and out-of-state plates at each video survey location.

For the video license mailout survey, a total of 32,953 postcard surveys were mailed out to motorists on pre-addressed postage paid cards. The primary data collected from the postcard survey were trip origins and destinations, trip purposes, and vehicle occupancies. A total of 3,384 surveys were returned, resulting in a 10 percent return rate. Excluding incomplete surveys from the total, the return rate for usable surveys was approximately 8.9 percent.

Chicago, Illinois, Chicago Area Transportation Study (CATS), 1998

For the 1997-1998 CATS external survey, high volume facilities were surveyed using a combination of license mailout and postcard mailback distribution methods *(10)*. On interstate highways that also served as tollways, postcard mailback surveys were handed out to passenger cars and light trucks at toll plazas. On non-toll interstate facilities, a video license mailout survey was used for passenger cars and light trucks, while medium and heavy duty trucks were distributed mailback surveys at weigh stations. Permission to stop traffic on non-toll facilities could not be obtained. Surveys at weigh stations were determined to be the only viable means of collecting O-D data from commercial vehicles. Non-interstate facilities were surveyed using a roadside intercept interview method wherever the station could be safely set-up and operated.

The CATS external survey was for the 10 county Chicago metropolitan region. The survey included seven sites with two-way AADT volumes in excess of 25,000 vehicles. Five of the sites had AADT volumes in the direction of the survey in excess of 15,000 vehicles. A total

of 147,345 surveys were distributed and 22,063 surveys were returned, yielding a response rate of 15 percent. With invalid returned surveys removed, the response rate for valid surveys was 11.7 percent.

Raleigh-Durham-Chapel Hill, North Carolina, NCDOT, 1997

Information for the Raleigh-Durham-Chapel Hill (triangle area) travel survey was provided by a representative from the Institute for Transportation and Education at North Carolina State University (Leta Huntsinger, November 14, 2005). As part of this survey, the NCDOT used a combination of video license mailout and intercept interview methods to conduct surveys at 27 locations. The effort included the conduct of video license mailout surveys at seven locations, which included four video survey sites on Interstates 40 and 85. State DMV records were used to obtain ownership and address information to mail surveys. The turnaround time between license capture and subsequent survey mailout, sometimes 2 to 3 weeks, was cited as a drawback to the video mailout method. Approximately 77,800 surveys were mailed and 13,250 surveys returned, yielding a return rate of 17 percent. Trucks (e.g., large, commercial) in the Triangle area were surveyed via an intercept interview method at rest areas and weigh stations.

Two key policies for the 1997 Triangle Area travel survey were that (1) traffic could not be stopped on interstates and (2) intercept interview surveys had to be temporarily suspended if queues became too long. At non-interstate survey locations, a personal intercept interview method and/or an intercept postcard mailback method was utilized for the survey. At some sites, the intercept interview method was used during off-peak periods and then surveyors changed to distributing postcards in higher traffic/peak periods in order to avoid excessive queue lengths.

TCPs were developed and approved for all survey locations. Law enforcement personnel, primarily the North Carolina State Highway Patrol, were cooperative and assisted in the conduct on intercept surveys.

Dakota County, Minnesota, 2000

Dakota County, Minnesota, conducted the Cedar Avenue Transit Origin-Destination Survey in 2000. The purpose of the survey was to study travel characteristics in the Cedar

Avenue corridor to aid in planning for alternative transit options being considered for the corridor. The survey used a video license mailout method because of high traffic volumes, limited opportunities to pull over traffic and perform roadside interviews, and because it was a non-obtrusive method *(19)*. The survey included questions to ascertain trip origins and destinations, trip purpose and frequency, trip length, and vehicle occupancy.

License plates were recorded using a video camera for each lane of traffic in one direction for an 11-hour period on a weekday. Video license data was processed using OCR technology, which converted license images to an electronic database listing. Converted database listings of captured plates were then queried against Minnesota DMV records to obtain addresses. Over 90 percent of the plates of vehicles passing through the survey point were captured. However, it is unknown if plates not having all characters recognized are included in this percentage. Steps were taken to remove leased vehicles from the mailout and to ensure only one survey was mailed to each address.

A total of 15,351 surveys were mailed and the response rate was 13 percent. Both the state police and the Minnesota DOT were notified in advance of the video data collection. To increase survey response rates, the survey emphasized the importance of the survey to the addressee. The survey was kept simple so it could be completed quickly, no personal questions were asked (e.g., income), and postage was paid for the return of the survey.

Washington DOT, 1998

In 1998, the Washington DOT conducted an origin-destination survey of users on the Hood Canal Bridge to determine trip patterns, frequency, and purpose. The purpose of the survey was to determine the routes to be most impacted by the bridge's pending closure. The survey was conducted using a video license mailout method using OCR technology to transcribe plates *(21)*. Surveys were mailed to registrants of captured plates within 2 days of recording. Over 18,000 surveys were mailed and over 7,000 were returned, resulting in a response rate of over 39 percent. The survey included a zone map where respondents could record their own origins and destinations. It also included a tear-off panel to ensure confidentiality of the

respondent. The response rate for this survey was high because the bridge's closure was an issue that had significant impact in the community.

Wisconsin DOT, 1995

In 1995, the Wisconsin DOT conducted a motorist attitude survey of Wauwatosa Road users in Ozaukee County to determine if they were in favor of or opposed to the widening of the roadway. WisDOT used a license mailout method to conduct the survey *(22)*. A total of 4,000 surveys were mailed to a sample of road users. Approximately 1,300 surveys were returned resulting in a return rate of 32.5 percent.

4.6 TECHNOLOGY IN HIGH VOLUME SURVEYS

Technology, in general terms, is the application of knowledge in a particular area. As various technologies become more sophisticated, the breadth of the capabilities of these technologies increases immensely. A challenge of transportation engineers and planners is to capture the capabilities of various technologies and apply them in a fashion that will address their needs. The utilization of new and emerging technologies in the collection of travel survey data is ongoing and also offers opportunities to explore new avenues for gathering information.

At the present time, there are a variety of developing technologies capable of offering non-intrusive, "point" sensor traffic data. With regards to external stations, the term "point" sensor is used because the survey data is collected at a single location, with no further detection of vehicle average speed, travel time, etc. This differs from "link" sensors, which is a series of "point" sensors used in coordination with one another in order to detect vehicle average speed, travel time, and other characteristics along a roadway *(26)*. This "link" sensor technology is increasingly found in Intelligent Transportation Systems (ITS), where it is effective in providing drivers with real-time traffic data.

Link sensors, however, are not normally used to detect and extract vehicle and driver information for the purposes of contacting that individual later. This part of the process is unique to external station surveys. Because of the difficulty in obtaining specific trip-related information, especially at high volume locations, the variety of devices/techniques presently

available is still limited. Additionally, the current public and political responses to the implementation of some of these devices could potentially present additional problems. The following sections present a discussion of the various technologies that might be available for implementation at external station locations in the future.

Video/Infrared

The use of video recording for license plate matching (with and without OCR technology), has been shown to be effective in identifying vehicles for the purposes of contacting that individual at a later time *(26, 27, 28)*. Infrared illumination has also been shown to be useful in correctly identifying dirty license plates, license plates with a very high reflectivity, and license plates with a non-uniform background *(29)*.

In recent years, increasing capabilities in OCR hardware and software have significantly lowered the time required to process the data. In addition to the standard video recording, the use of infrared illumination along with the video recording is also effective in performing license plate recognition at night. Claims of OCR accuracy in recent years have ranged from 90 percent to 99 percent, depending on weather conditions, license plate lettering format, and the assistance of additional technologies such as inductive loop detectors *(29, 30, 31)*. It should be noted, however, that these high accuracy rates were not taken from external station surveys or other similar O/D-type surveys. From 2002 to 2003, a license plate matching survey using high-speed video camcorders in Southern California was administered by the Southern California Association of Governments. At a cost of $685,000, over 200,000 vehicles were successfully matched to a database from the California Department of Motor Vehicles. As shown by ETC Institute, almost 18,000 of those persons contacted responded to the survey, yielding an average cost of over $38 per completed survey. In May 2004, an origin-destination study using video camcorders was used on major highways in North Carolina. It was found that on average, 86.5 percent of license plates were collected from vehicles, and hourly samples always exceeded 70 percent *(32)*.

This technology is also effective in that it is relatively easier to set up than many other methods, it is capable of dealing with different styles of license plates at the same time, and it

requires minimal human interaction while running. As with any type of video-based technology, poor weather conditions can severely affect the machine accuracy. Additionally, these devices are typically mounted in areas very close to the roadway, potentially causing interference with drivers, especially at high volume locations *(33, 34)*.

Cellular Phone Tracking

The use of cellular phone tracking around an external station location in order to obtain origin-destination data relating to that location has not yet been shown to be an effective method of data collection. Although cellular phone tracking has been used with ITS applications to monitor congestion on high volume roadways, this technology has not reached a point where it can facilitate conducting external station surveys at the single vehicle scale *(35)*.

In 2001, the Florida Department of Transportation conducted a thorough analysis of the use of "cellular probes" as a means of data collection. From this analysis, they concluded that "FDOT should proceed cautiously" in this area for three main reasons: 1) slow implementation of the E-911 standard; 2) technological uncertainty; and 3) business and implementation issues. It was also found that these issues would remain present for years after the federally mandated deadline for E-911 implementation, which was October 1, 2001 *(26)*.

Recently, the use of cellular phones for monitoring congestion and tracking vehicles on heavily traveled roadways has been implemented in two areas, and plans for additional areas are in progress. In early 2005, the State of Maryland began testing the Multi-Modal Travelers Information System on 1,000 miles of roads around the Baltimore area *(36, 37)*. Currently, Cingular Wireless is the only cellular phone company to get on board for providing the location data, and even they have announced that they will not continue to do so forever *(38)*.

The second agency to recently adopt the use of cellular phones for monitoring traffic and congestion is the Missouri Department of Transportation, which plans to use the system on all 5,500 miles of major roads in the state *(37)*. The DOT claims that the reason cellular tracking was chosen as the best option to monitor conditions is because it does not require the purchase of new equipment and it also requires no maintenance *(39)*. The costs of this form of tracking will

only be a small fraction of the cost required for installing traffic cameras or embedding traffic flow sensors in the pavement *(40)*.

In both of these implementations, the cellular phone does not have to be in use, only turned on, to be detected. This is an improvement over a similar system used in the Washington D.C. area in 1999, when drivers were required to be talking on the phone to be detected *(40)*.

Toll Tags/Radio Frequency Identification (RFID)

Similar to cellular phones, the use of radio frequency identification tags such as those used in toll tag systems, are also being implemented in systems around the United States for the purpose of traffic and congestion monitoring. In the city of San Francisco, a $35 million program, named FasTrak, has been initiated to install roadside RFID readers to monitor vehicles that have electronic toll passes. The traffic-related RFID readers are designed to destroy the anonymous, encrypted information they collect on a daily basis *(40,41)*. Similar systems have also been developed in Houston, San Antonio, and New York City *(42)*. Despite the success of these projects, the use of these devices for O-D surveys has not been shown to be effective at this time.

Vehicle Telematics

Vehicle telematics can be defined as the use of global positioning systems technology integrated with information and communications technology in road vehicles for the purpose of providing such features as remote diagnostics, on-demand navigation, and audio-visual entertainment content *(43)*. The large-scale integration of vehicle telematics into urban transportation planning presents the potential for the development of a seemingly unlimited data source, well beyond the simple origin-destination data commonly obtained in external station surveys.

Recently, this technology has seen an increased usage in fleet management of commercial vehicles, but still remains a luxury to most non-commercial vehicle owners. However, as vehicle telematics continues to penetrate the marketplace in the coming years, its use as a viable means of collecting travel data will increase *(26)*.

4.7 LEGAL AND PRIVACY ISSUES

As discussed previously in this chapter, various methods are utilized to collect traveler information on high volume facilities around the country. This includes variations of intercept type surveys as well as videotaping of vehicle license plates. While the practice of collecting motorist travel data is common around the country, there have been challenges to some of these survey efforts in parts of the United States. In some instances, the challenges have come in the form of court cases and/or legal opinions, and in other instances, the suspension of survey programs have been the result of policy decisions made within the institution that oversees and administers the surveys.

Critics of intercept interview surveys contend that establishing roadblocks for the purpose of collecting travel survey data are analogous to unreasonable search and seizure, which is in violation of the Fourth Amendment to the Constitution. The legal issue related to intercepting vehicles on roadways for the purpose of conducting travel surveys is whether such 'seizure' is unreasonable. In other words, does the government's (state DOT) intrusion (intercept of vehicle for travel survey data) outweigh the motorists' reasonable expectation of privacy under the Fourth Amendment? In *Delaware v. Prouse* 440 U.S. 648, 653, 59 L.Ed.2d 660, 99 S.Ct. 1391 (1979), the court of record concluded, "There can be no question that the stopping of a vehicle and the detention of its occupants constitutes a 'seizure' within the meaning of the Fourth Amendment, even though the purpose of the stop is limited and the resulting detention quite brief."

In 1994, the Attorney General (AG) for the State of Kentucky concluded intercept surveys illegal (1994 Ky. AG LEXIS 37, OAG 94-26). The Kentucky AG's opinion held that the governmental units involved in the proposed survey could not show a legitimate governmental interest sufficient to overcome motorists' legitimate expectation of privacy in their vehicles. The AG concluded that the information sought in the survey could be obtained through less obtrusive means.

In some instances, policy changes are made at the institutional level before legal challenges are brought forth. In 2002, the Florida High-Speed Rail Authority sponsored an

intercept survey intended to gauge motorists' interest in a high-speed rail network. Approximately 7,000 intercept surveys were administered and nearly 100 individuals complained about being pulled over to be surveyed. Despite the small number of complaints (approximately 1 percent of the total people surveyed), the Florida Department of Transportation put the practice of intercept surveys on hold "indefinitely" *(17)*.

While there are relatively few states that have determined that intercept type surveys are illegal, the majority of case studies reviewed showed that this methodology is an acceptable and legal process for collecting survey data. The justification for the collection of survey data is provided in the Code of Federal Regulations (CFR). In Texas, travel surveys are conducted under a cooperative agreement between TxDOT and MPOs within the state. As part of this agreement, TxDOT conducts travel surveys, performs traffic counts, and maintains travel demand models for the MPOs within the state. The data collected as part of travel surveys and traffic counts serve as inputs to local and regional travel demand models. As specified in 23 CFR 500.202, traffic data is defined as:

"…data used to develop estimates of the amount of person or vehicular travel, vehicle usage, or vehicle characteristics associated with a system of highways or with a particular location on a highway."

The travel demand models are utilized, in part, to meet local and state planning requirements specified in the CFR. Planning requirements at the local level are specified in 23 CFR 134 and state level requirements are provided in 23 CFR 135. Under Title 23 of the CFR, metropolitan and statewide planning are required to "encourage and promote the safe and efficient management, operation, and development of surface transportation systems that will serve the mobility needs of people and freight and foster economic growth and development within and through urbanized areas, while minimizing transportation-related fuel consumption and air pollution."

Therefore, the traffic data that is collected as part of the TSP assists in meeting the planning needs and requirements at both the state and local level.

Another methodology for collecting survey data is the video license mailout. This method involves recording license plate numbers as vehicles go by, matching the numbers against motor vehicle registration databases, and mailing surveys to vehicle owners. While the main advantages are that traffic is not disrupted and the method is safe (especially on higher volume facilities), there have been concerns with regards to privacy issues. The potential for privacy concerns exists on two levels with this methodology:

- The feeling of the motorists that they are being "spied upon," or under ever-increasing surveillance, and
- Whether personal information (addresses) maintained by the Vehicle Titles and Registration (VTR) Division of TxDOT and subject to the "Drivers' Personal Privacy Act" can be released to a 3rd party without the driver's consent.

As part of the research, a query of Attorney General Opinions for all states concluded that this survey methodology is neither illegal nor unconstitutional. In Texas, Attorney General Opinion No. M-692, September 14, 1970, concluded that:

"There is no actionable invasion of the right of privacy of a person whose photograph is taken on a public highway by a traffic surveillance system when such a photo is used solely for speed enforcement or *traffic surveying purposes*. Such photographs would be admissible in evidence as proof of identification of defendants and their speed of driving, provided they comply with the rules of evidence applicable thereto (emphasis added)."

Video cameras are used to capture license plate information precisely because intercept surveys at high volume locations would prove to be unduly burdensome to motorists as well as potentially dangerous for staff and motorists alike.

The research reviewed literature documenting motorists' reactions to these surveys in various states within the United States. When survey questionnaires requesting information on a vehicle owner's whereabouts on a given day were received in the mail, a small number reacted to this practice as intrusive, unnerving, and like 'big brother' *(44, 45, 46)*.

The second privacy concern regarding this methodology involves the VTR Division's release of the selected motorists' addresses to the agency administering the surveys. 'Permitted uses' to disclose such information (motorists' addresses to mail survey cards) to perform travel surveys are provided for in 18 U.S.C 2721 (I) A.

For use in connection with *any matter* of:
(1) motor vehicle or motor vehicle operator safety; …
(3) motor vehicle emissions

In addition, 'permitted uses' allows for DOTs and their contracted entities to obtain the information under 18 U.S.C. 2721 (I) B.

Use of information will be strictly limited to use by:

- a government agency, including any court or law enforcement agency, in carrying out its functions; or
- a private person or entity acting on behalf of a governmental agency in carrying out the functions of the agency.

The work of a state DOT (in this case, TxDOT) and its contracted entities to carry out its function to prepare travel surveys for the state are within this category.

The question of whether a state DOT was prohibited from disclosing personal information from motor vehicle records to other agencies of the same state was addressed by the Attorney General's office for the State of Oregon in 1998 Ore. AG LEXIS 12; 49 Op. Atty Gen. Ore. 127. The opinion held that Oregon DOT may disclose personal information from motor vehicle records to state agencies as mandated by ORS 802.179(1) or as permitted by 18 USC 2721 (b) (discussed supra).

Therefore, both elements of privacy concerns for video license mailout surveys are legally permissible constitutionally and with respect to specific federal regulation. However, as

history has shown, informing a wary public of this fact is the challenge that remains for many DOTs.

5.0 IDENTIFYING HIGH VOLUME FACILITIES

5.1 BACKGROUND ON DETERMINING HIGH VOLUME THRESHOLD VALUES

The research sought to obtain information on the traffic level(s) or criteria that agencies sponsoring travel surveys used in determining when a high volume survey method should be used, particularly in lieu of a low volume intercept interview method. Extensive research and communication with survey sponsors found only a small number of agencies with specific documentation or a policy addressing this topic. In many surveys reviewed, there was a policy that intercept interview surveys could not be conducted on freeways or interstate highways, which resulted in the use of a high volume survey method on these facilities.

Texas DOT Policy

For many years, TxDOT has had an unwritten policy that facilities with two or more lanes in each direction, and an AADT in excess of 20,000 vehicles, are considered high volume. This threshold was arrived at based on years of field experience and observation of traffic queues and delays at roadside travel survey stations. TxDOT rarely (if ever) has a problem with high traffic volumes on two-lane facilities (e.g., one lane in each direction), since its surveys are typically conducted around the periphery of urban areas where volumes on these facilities are low. To this end, TxDOT has not encountered the need to use a high volume survey method on a two-lane facility and has not developed a policy addressing high traffic volumes on these facilities.

High Volume Thresholds from Various Jurisdictions

For roadside survey purposes, the Ohio DOT defines high volume locations as those with an AADT greater than 25,000 vehicles *(13)*. This volume is based on a calculation of achievable survey station through-traffic per hour (1,500 per hour max on two lanes in one direction). At survey locations with volumes above this number, a license mailout method was used for non-truck traffic. ODOT no longer uses a license mailout method, citing numerous problems with the procedure. They have temporarily suspended O-D surveys on high volume facilities until a

better high volume method can be found. ODOT is currently looking into the use of an Automatic License Plate Recognition System using OCR technology for use in determining through trips on high volume facilities.

The 1994 external station survey for the Hampton Roads Planning District Commission in Chesapeake, Virginia, used the following traffic volume criteria for its roadside surveys:

- Low volume roads were defined as those with less than 16,000 AADT. On these facilities, roadside interviews using paper surveys were conducted.
- For roadways between 16,000 and 18,000 AADT, surveyors handed out survey cards on the roadway.
- For roadways over 18,000 AADT (up to 73,000 AADT), in-state license plate numbers were recorded, and a survey was mailed.

In the travel survey report for the Front Range Travel Survey conducted by the Denver COG in 1998, a high volume facility is defined as a roadway with greater than 500 vehicles per lane per hour. In the final report for Tampa RTA External Survey conducted in 2003, it indicates arterials with an AADT over 40,000 are considered high volume for travel survey purposes.

5.2 QUEUING ANALYSES OF TXDOT INTERCEPT SURVEYS

Based on years of field observation, TxDOT has had a long-standing policy that roadways with two-way volumes greater than 20,000 AADT should be surveyed using a high volume method. To evaluate this policy, the research analyzed traffic volume levels on various roadway facility types in order to quantify the correlation between traffic volumes, queuing, and delay as part of intercept surveys. Researchers conducted queuing analyses based on TxDOT TCPs used for travel surveys. TxDOT's bid specifications include TCPs for the following roadway cross-sections:

- two-lane undivided with shoulders;
- two-lane undivided without shoulders;
- three-lane (includes turning lane);

- four-lane undivided with shoulders;
- four-lane undivided without shoulders;
- four-lane divided with shoulders; and
- four-lane divided without shoulders.

The analyses evaluated the impact of lane reductions and lane blockages, and identified maximum traffic volumes levels that could be surveyed without creating unacceptable levels of queuing and delay at survey sites.

For the purpose of queuing analysis, TxDOT's TCPs can be grouped into two categories. These categories are (1) a total block of a traffic lane and (2) a bottleneck or lane reduction. A total block of a traffic lane calls for a complete stop of arriving traffic. In this case, surveys are typically carried out in platoons to minimize the delay and inconvenience to the road users. The second category, lane reductions, creates a bottleneck that reduces the capacity of a roadway.

5.3 ANALYSES OF BLOCKED LANE SCENARIO

For situations where there are two-way, two or three-lane roadways, the roadside intercept survey TCP calls for a complete block of traffic in the direction in which the survey is being conducted. The queue discipline for this scenario is first-in-first-out (FIFO). However, not all the vehicles in the queue are surveyed. Surveys are typically carried out in platoons or groups for those vehicles with short inter-arrival times. Vehicles that join the queue after the survey has begun have no ability to bypass the queue and must wait until the survey of the platoon is complete before proceeding through the survey station. Figure 8 shows an example of the blocked lane scenario.

Figure 8. Typical Blocked Lane Configuration.

A factor in the determination of the queue that results from the conduct of the survey is the service time. The service time is defined as the time it takes to complete the questionnaire. For the purpose of the queuing analyses, the service time is assumed to be normally distributed. Since the normal distribution can take a wide range of real values, the range of service times used in the simulation was checked to ensure that no invalid values were generated. In practice, the survey durations range from 180 to 360 seconds. The mean is about 270 seconds (4.5 minutes). The standard deviation is approximately 30 seconds. The number of surveyors generally varies from two to five people depending on the traffic conditions.

As part of the research effort, two types of performance measures were derived for the queuing simulation of the blocked traffic lane scenario. The first group of performance measures quantifies the level of impedance in terms of delay and queue length that is caused by the survey.

The second group of measures delineates the efficiency of the survey procedure with respect to the number of surveyors and traffic volume conditions. Since both surveyed and non-surveyed vehicles are impacted by the survey station, the delay associated with the survey station is quantified for both categories. The following performance measures were used in determining the level of impedance created by the survey:

- Average delay for surveyed vehicles
- Average delay for non-surveyed vehicles
- Average delay for all vehicles
- 85^{th} percentile of delay for all vehicles
- Maximum delay
- Total delay in vehicle-hours
- Average queue length
- Percent of queue length greater than 10 vehicles (including vehicles being surveyed)
- 85^{th} percentile of queue length
- Maximum queue length

Performance of a survey procedure with respect to the traffic conditions and number of surveyors is quantified using the following measures:

- Percent of surveys completed for a given traffic volume and number of surveyors
- Average number of surveys completed per hour
- Average number of surveys completed per person-hour

The queuing analyses simulation for the roadside survey procedure was performed using a wide range of parameters. The traffic volume in the direction of the survey was varied from 30 to 300 vehicles per hour (vph), and the number of surveyors was varied from two to seven. Additionally, the thresholds for the survey platoon and the non-survey platoon vehicles were set at 30 and 20 seconds, respectively.

Table 9 provides an example of the simulation results using two surveyors.

Table 9. Simulation Results for Blocked Lane Scenario.

Simulation Parameters								
Traffic volume (vph)	30	60	90	120	150	180	240	300
Average headway (sec)	120	60	40	30	24	20	15	12
Same-platoon threshold (sec)	30	30	30	30	30	30	30	30
Next-platoon threshold (sec)	20	20	20	20	20	20	20	20
Mean survey duration (sec)	270	270	270	270	270	270	270	270
SD of survey duration (sec)	30	30	30	30	30	30	30	30
Number of surveyors	2	2	2	2	2	2	2	2
Performance Measures								
Average delay for all vehicles (sec)	171.6	155.5	148.7	144.6	141.9	140.7	136.2	132.0
Average delay for surveyed vehicles (sec)	272.1	273.3	274.1	274.5	275.0	276.0	276.2	276.1
Average delay for non-surveyed vehicles (sec)	118.5	121.6	123.5	124.5	125.2	126.7	125.5	123.5
85th percentile of delay for all vehicles (sec)	279.1	269.2	263.3	259.2	256.4	254.9	251.2	247.9
Maximum delay (sec)	392.0	391.1	398.5	392.0	398.5	391.1	370.6	378.0
Average queue length	1.9	3.1	4.2	5.4	6.5	7.6	9.6	11.6
85th percentile of queue length for all vehicles (sec)	4.0	6.0	8.0	10.0	12.0	14.0	18.0	21.4
Maximum queue length (veh)	13.0	17.0	23.0	28.0	30.0	37.0	42.0	46.0
Percent of queue length greater than 10 vehicles	0.0	0.0	0.0	0.1	0.2	0.3	0.4	0.5
Percent of surveys completed	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Average number of surveys completed per hour	10.4	13.4	15.1	16.1	16.7	16.9	17.0	16.7
Average number of surveys completed per person-hour	5.2	6.7	7.5	8.0	8.3	8.4	8.5	8.3
Total traffic delay per hour (vph)	1.4	2.6	3.7	4.8	5.9	7.0	9.1	11.0

Researchers performed simulations while varying the number of surveyors from two to seven in an attempt to quantify the impact that the number of surveyors had on delay and queue length. Figure 9 provides the average delay for surveyed vehicles. The average delay increases slightly as the traffic volume increases. An increase in the number of surveyors will slightly increase the average delay for the surveyed vehicles. Generally, the surveyed vehicles are delayed only by the time that it takes to decelerate, participate in the survey, and accelerate out of the survey station. However, as the number of surveyors increase, the volume in the queue increases and thus takes more time to clear after the survey has been administered.

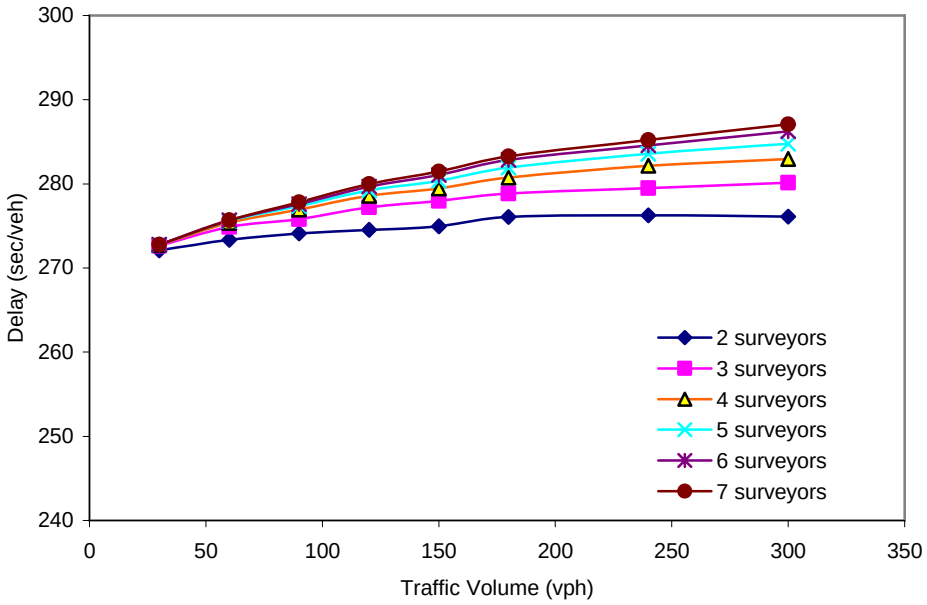

Figure 9. Average Delay for Surveyed Vehicles.

Figure 10 shows the average delay for non-surveyed vehicles. It shows a tendency for the delay to increase as traffic volumes increase. The increase in delay occurs up to a certain point, and then the level of delay stabilizes or drops. This pattern of delay is created because non-surveyed traffic is randomly delayed by survey queues. However, queue build-up at a survey station depends on the ability of surveyors to stop the traffic for surveys. As traffic volumes increase, the ability of surveyors to disrupt the traffic flow for survey purposes decreases, thus resulting in a drop in the average delay for non-surveyed traffic. In other words, more vehicles proceed through the survey station without being stopped for surveys, so the resulting average delay is reduced.

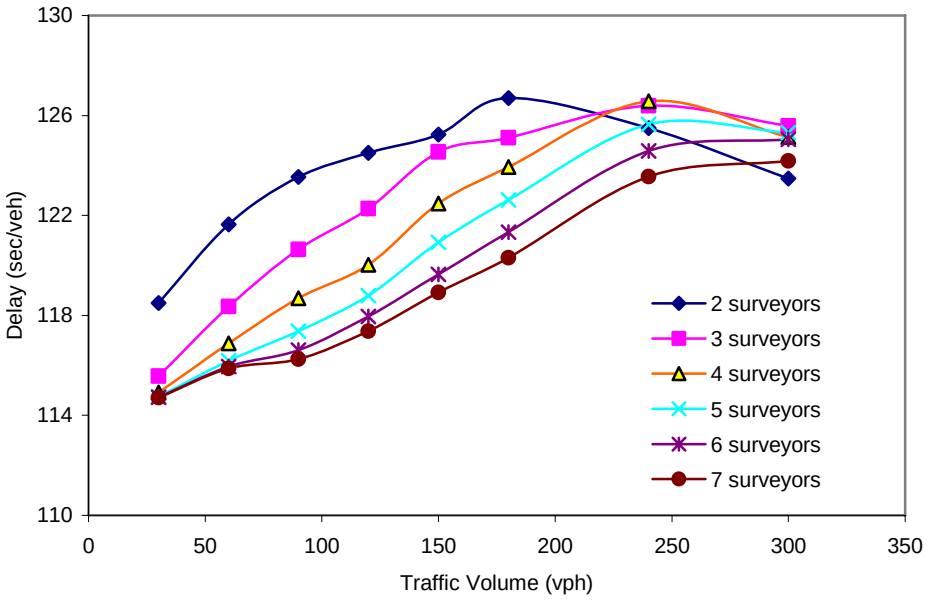

Figure 10. Average Delay for Non-Surveyed Vehicles.

Figure 11 provides the average delay for all vehicles. There is a decrease in the average delay for all vehicles as the traffic volume increases. This decrease in average delay occurs due to the number of surveyors being static while the number of vehicles passing through the survey station is increasing. Additionally, increasing the number of surveyors increases the average delay. The increase in average delay is attributed to the fact that more vehicles are stopped for the survey, thus resulting in additional delay.

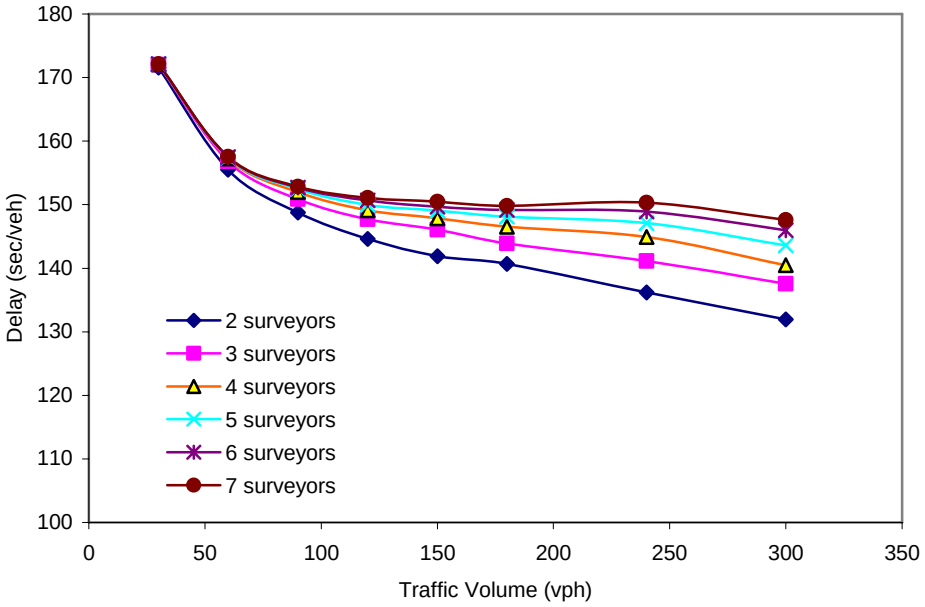

Figure 11. Average Delay for All Vehicles.

In addition to the average delay of vehicles traveling through a survey station, the analyses also quantified queue lengths created as a result of the conduct of the roadside survey. The average queue length and 85th percentile of queue length with respect to traffic volume and number of surveyors are presented in Figure 12 and Figure 13, respectively. Both figures illustrate the correlation between queue length and traffic volumes. However, the number of surveyors has minimal impact on queue length because surveys are conducted in platoons. When vehicles are stopped for surveys, a queue will build up depending on arriving traffic pattern regardless of the number of surveyors. Looking at these two performance measures by themselves, it would appear that more questionnaires can be completed with more surveyors with a minimal impact of the resulting queue length.

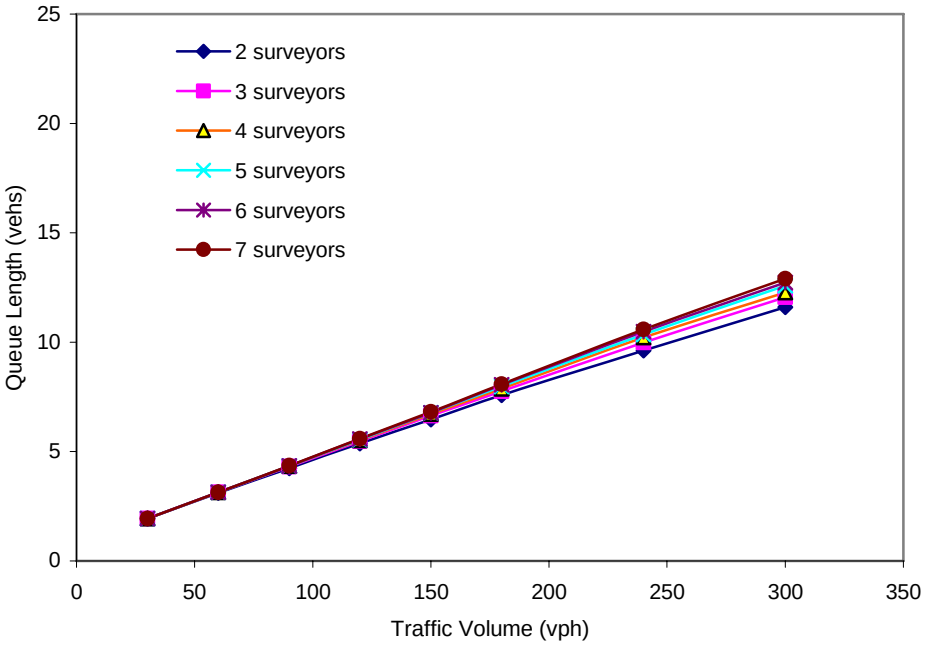

Figure 12. Average Queue Length.

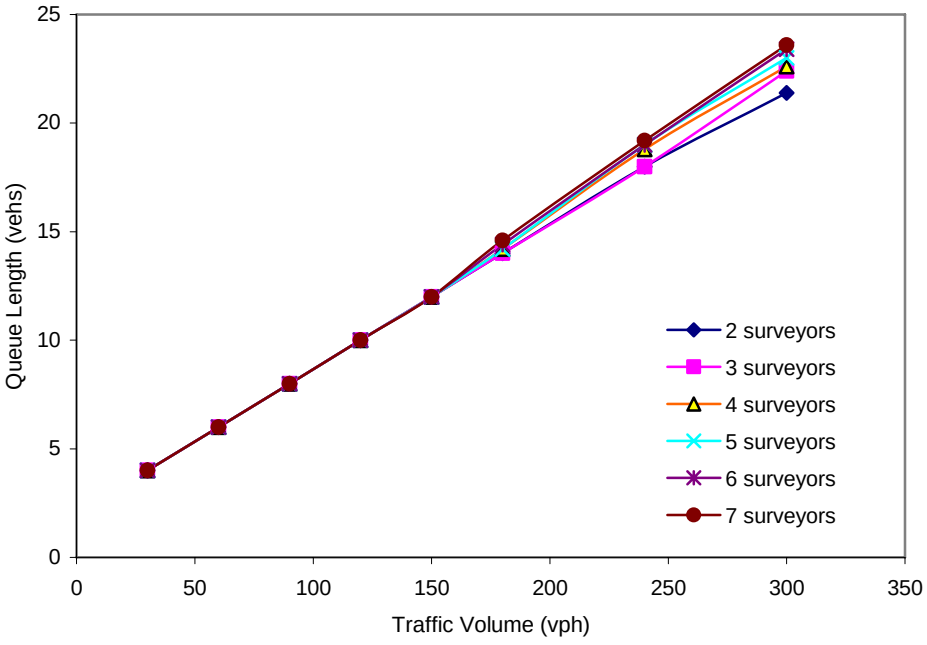

Figure 13. 85th Percentile of Queue Length.

Several factors can affect the number of surveys completed. In the analyses of the roadside survey procedure, the traffic volumes and number of surveyors were varied during the simulation in order to ascertain their impacts on survey efficiency. The percent of vehicles stopped for surveys, the average number of surveys completed per hour, and the average number of surveys completed per person-hour are presented in Figure 14 through Figure 16.

Figure 14 shows the percent of vehicles stopped for surveys versus traffic volume. As traffic volume increases, time headways of arriving vehicles become shorter thus reducing the possibility to find large enough headways to interrupt traffic flows. In addition, the number of surveyors has a significant impact on the percent of vehicles stopped for surveys. A size of survey platoon is limited by the number of surveyors on site. For example, if there are four surveyors, only four vehicles at most can be stopped for surveys at the same time. Therefore, it can be observed that the percent of vehicles stopped for surveys increases with the addition of the number of surveyors. Moreover, the increase is more pronounced at high volume conditions. The implication here is that additional surveyors should be deployed only on high volume two-lane facilities.

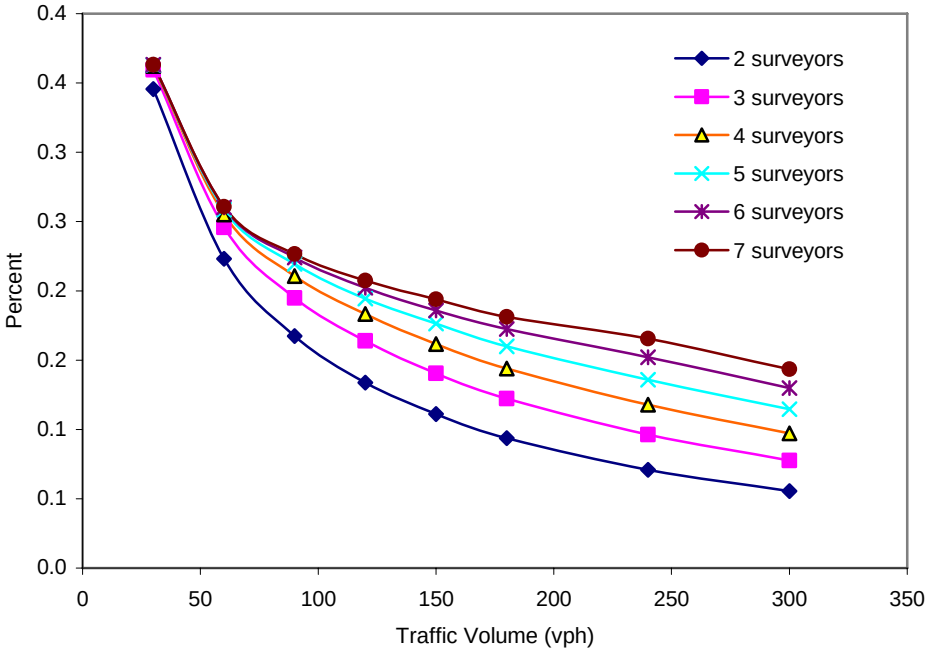

Figure 14. Percent of Vehicles Stopped for Surveys.

The average number of surveys completed per hour increases with increases in traffic volume and number of surveyors (see Figure 15). However, as traffic volume increases, it has a tendency to stabilize given that the number of surveyors is fixed. That is, there is a maximum threshold that can be achieved under optimal conditions. As the number of surveys completed per hour gets closer to this threshold, the curve starts to stabilize or flatten. For example, if there were optimal survey conditions and each survey took 5 minutes, each surveyor could complete 12 surveys per hour. If there were a two-person survey station, then the maximum number of surveys that could be completed per hour would be 24. In Figure 15, the curve indicates that between 10 and 15 surveys can be completed in an hour with two surveyors regardless of traffic volume conditions. So as the number of completed surveys approaches this maximum threshold, the curve flattens out. It is possible to increase the number of surveys completed by increasing the number of surveyors, but this strategy may not be cost-effective for low volume conditions (below 100 vph in the direction being surveyed).

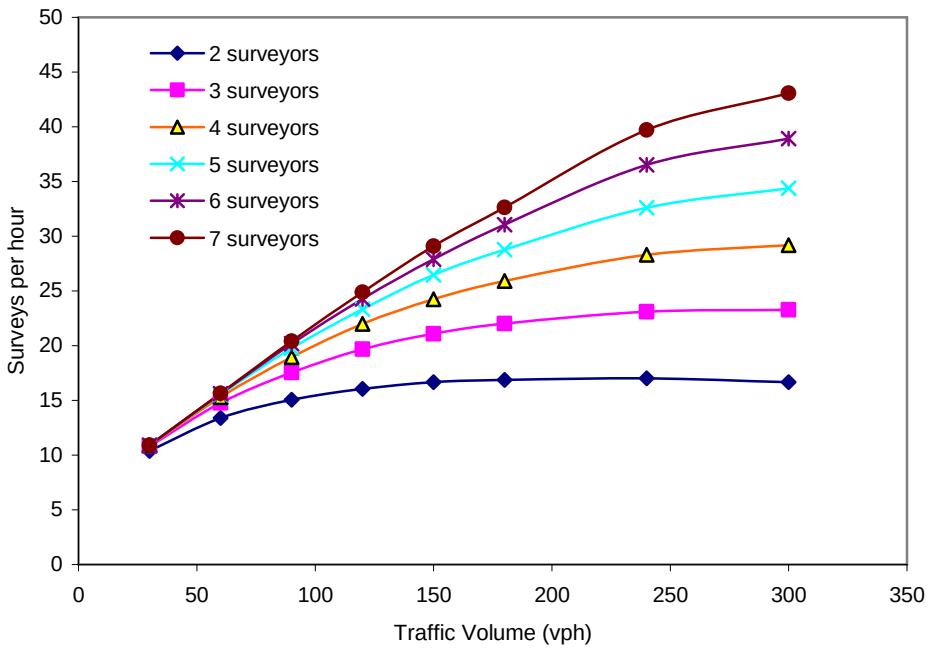

Figure 15. Average Number of Completed Surveys.

An assessment of the efficiency of the survey station was also performed. Survey efficiency is defined as the average number of surveys completed per person-hour. Figure 16 provides the survey efficiency based on a varied number of surveyors and traffic volume levels. Surveys are the most efficient when a minimal number of surveyors are deployed as it means less idling time, especially for lower volume facilities. However, more surveyors may occasionally be needed in order to meet a required sample size. Figure 15 may be used in conjunction with Figure 16 to estimate the required number of surveyors needed for data collection.

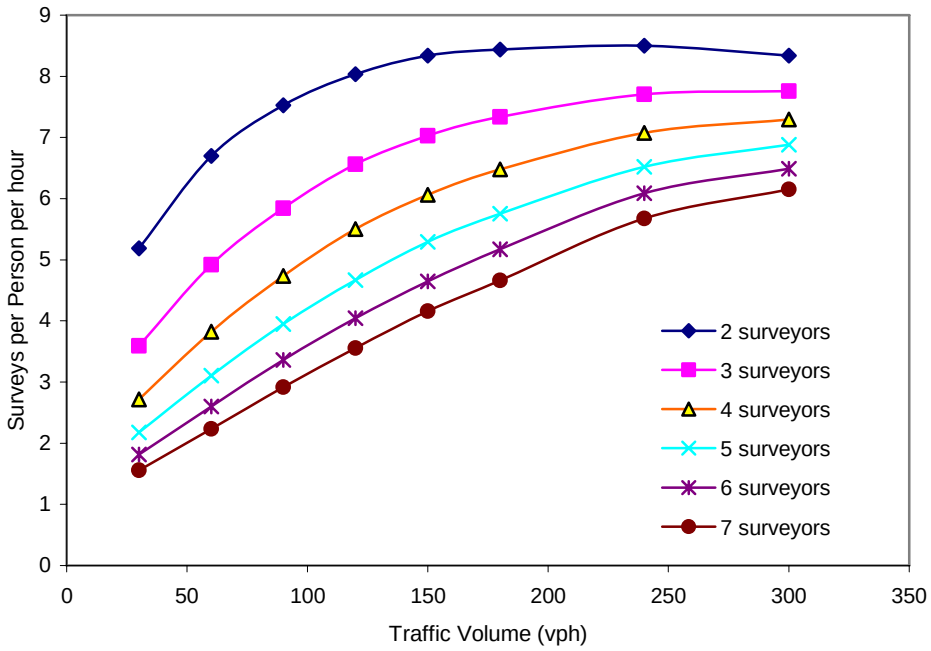

Figure 16. Survey Efficiency.

5.4 SUMMARY OF BLOCKED LANE SCENARIO

The TCPs for two-lane divided and undivided highways call for a complete stop of traffic in the direction that the survey is being conducted. The impacts of the survey on the traveling public can be quantified both in terms of delay and queue length. The average delay tends to decrease with more traffic volume because the ability to stop the traffic for surveys is limited by shorter headways between successive arriving vehicles. The total delay, however, still increases with higher traffic volume. Queue length was found to be a more critical measure for this type of

survey station. The queue steadily becomes longer with more traffic volume regardless of the number of surveyors on site.

With regards to survey efficiency, increasing the number of surveyors at low volume locations only slightly increases the percent of surveys completed. For example, increasing the number of surveyors from three to five will result in only a 5 percent increase in the total number of completed surveys. However, increasing the number of surveyors at moderate volume survey locations appears to be a favorable strategy. While the delays remain nearly unchanged, increasing the number of surveyors from three to five will result in an approximate 20 percent increase in the number of surveys completed.

When conducting sensitivity analyses of the platoon thresholds, it was found that both average delay and queue length are relatively insensitive to changes in the survey platoon thresholds. Average delay and queue length were found to be more sensitive to changes in the non-survey platoon thresholds. The number of surveys that can be collected was found to be sensitive to both survey and non-survey platoon thresholds. Therefore, the actual number of surveys that can be collected is largely dependent on the methodology utilized to stop the traffic for the purpose of conducting the surveys.

Planners and administrators of external surveys often deal in terms of AADT when deciding whether roadside surveys can be conducted for a particular facility using the blocked lane methodology. The queuing analyses provided in this section were performed using traffic volumes in terms of vehicles per hour. The hourly volumes utilized in the analyses can be converted to AADT that is acceptable for the conduct of a survey in a few steps. For example, assume that the 85th percentile of queue length (see Figure 13) is set at no more than 10 vehicles, and the survey is being conducted with three surveyors. For these conditions, Figure 13 shows a peak hour traffic volume of 125 vph. In order to convert vehicles per hour to AADT, two parameters must be assumed. Those parameters are directional split and percent of peak hour traffic. Using past survey data, these figures can be estimated for similar roadways. In this

example, the assumption is that the directional split is 50/50 and the peak-hour volume is 10 percent of daily total (AADT). The AADT can be calculated as follows:

(125/0.5)/0.10 = 2,500 vehicles per day.

Therefore, for this example with three surveyors, the blocked lane roadside survey can be conducted with 85th percentile of queue length capped at a maximum of 10 vehicles if the facility has an AADT of 2,500 or less.

5.5 ANALYSES OF BOTTLENECK SCENARIO

For situations where a survey station is located on a roadway that has two or more lanes of traffic in the direction of the survey, the TCP is structured so that the traffic is channeled from two lanes to one (or three lanes to two in certain circumstances). For the purpose of the analyses, the two lanes merged to one is the scenario that is described. Once traffic is merged into a single lane, random vehicles are flagged into the survey station so that a questionnaire can be administered to the operator of the vehicle. Vehicles that are not selected to participate in the survey are permitted to bypass the survey station in the lane that remains open for through traffic. Figure 17 provides an example of a survey station where some vehicles are being surveyed, and non-surveyed vehicles are allowed to pass through the survey station.

Figure 17. Typical Survey Station for the Bottleneck Scenario.

Since the traffic on the roadway is being channeled into one lane, the resulting effect is that the capacity of the roadway is being reduced. The sudden reduction in capacity and the accompanying reduction in speed may result in the development of a queue. The system by which the queue develops is usually discrete in nature. That is, the system changes its state on an event by event basis. Which in this case refers to the arrivals of vehicles and the completion of the surveys. In a discrete simulation, the analysis model focuses on survey event periods since these are the times that the system will change its state.

For the purpose of conducting the analyses, bottleneck capacity was estimated for the specification of average time headway. Work zones and survey stations share similar characteristics such as lane channelization, temporary lane closure, and the presence of activities inside the closure lane. The 2000 Highway Capacity Manual (HCM) recommends that a capacity of 1,600 vehicles/hour/lane be used for short-term freeway work zones, regardless of lane closure configurations *(47)*. Additionally, the HCM provides a capacity value of 1,550 vehicles/hour/lane be used for a long-term construction zone where the number of normal lanes

is reduced from two to one lane. As a result, the average of the two values (1,575 vehicles/hour/lane) was used in the analyses as the bottleneck capacity.

The HCM also provides guidelines for adjusting the capacity value under certain conditions. The effect of lane widths less than 12 feet must be accounted for in estimating a capacity value. According to the HCM, for traffic with passenger cars only, headways increase approximately 10 percent when going from 11 foot widths to 10.5 or 10 foot widths and by an additional 6 percent when going to 9 foot widths. The increases in headways translate to a 9 and 14 percent drop in capacity for the narrower lane widths within construction zones. The TCPs in the TxDOT bid specification call for a 10 foot minimum travel lane at the survey station. This width represents a 9 percent reduction in the capacity value.

A second adjustment to the capacity value is needed in order to account for the disruption to the bottleneck traffic caused by random flagging of vehicles into the survey station. This value was assumed to be 5 percent. Therefore, the final capacity value used in the bottleneck queuing analysis is $1,575 \times 0.91 \times 0.95 = 1,362$. A rounded value of 1,350 vehicles/hour/lane was used for simplicity. The equivalent average time headway is $3,600/1,350 = 2.67$ seconds. Finally, a coefficient of variation (CV) of time headways of 0.3 was used for the time headways in order to account for random disruption to the bottleneck traffic when vehicles are flagged into a survey queue.

As with the blocked lane scenario, performance measures were derived to quantify the impacts of the traffic control and survey on motorists. The performance measures are quantified in terms of queue length and delay. Additionally, as part of its travel survey program bid specification, TxDOT utilizes a queue length of 10 vehicles or more as a threshold for excessive inconvenience incurred to road users. Another measure is the amount of delay caused by the traffic control for the survey station and the conduct of the survey. As a result, the following performance measures were obtained from the queuing analyses:

- Average delay for non-surveyed vehicles
- 85^{th} percentile of delay for non-surveyed vehicles
- Maximum delay

- Average queue length
- 85th percentile of queue length
- Maximum queue length
- Percent of queue length greater than 10 vehicles
- Total hourly traffic delay

Only the delay for non-surveyed vehicles is measured for the bottleneck analyses since the survey queue is separated from the non-surveyed traffic. Eighty-fifth percentiles as well as maxima of average delay and queue length were obtained as representative measures of worst-case scenarios at different traffic volumes.

The queuing analyses simulation for the bottleneck scenario was performed using various traffic volumes. The volumes ranged from 300 vph to 1,200 vph. For each traffic volume, the average headway was adjusted to reflect the spacing of the vehicles. Table 10 provides the results of the simulation.

Table 10. Simulation Results for Bottleneck Scenario.

Simulation Parameters							
Traffic volume (vph)	300	600	900	1000	1100	1175	1200
Average headway (sec)	12.0	6.0	4.0	3.6	3.3	3.1	3.0
Bottleneck capacity (vph)	1350	1350	1350	1350	1350	1350	1350
Coefficient of variation of bottleneck time headway	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Performance Measures							
Average delay for non-surveyed vehicles (sec)	3.3	4.1	6.3	8.1	11.6	18.2	23.3
85th percentile of delay (sec)	4.5	6.2	10.5	13.8	20.6	33.0	43.0
Maximum delay (sec)	15.6	24.6	40.6	54.3	72.5	112.3	136.9
Percent of vehicles delayed for 2 minutes or more	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average queue length (veh)	0.8	1.2	2.1	2.7	4.1	6.5	8.3
85th percentile of queue length	1.0	2.0	4.0	5.0	7.4	11.8	15.2
Maximum queue length (veh)	5.6	8.6	15.0	19.4	25.6	40.8	49.4
Percent of queue length greater than 10 vehicles	0.0	0.0	0.0	0.0	0.1	0.2	0.3
Total traffic delay per hour (veh-hr)	0.3	0.7	1.6	2.2	3.6	6.0	7.8

The relationship between the traffic volume and the average delay to non-surveyed vehicles is shown in Figure 18. As shown in the figure, the delay increases rapidly after the traffic volumes reach approximately 1,000 vph.

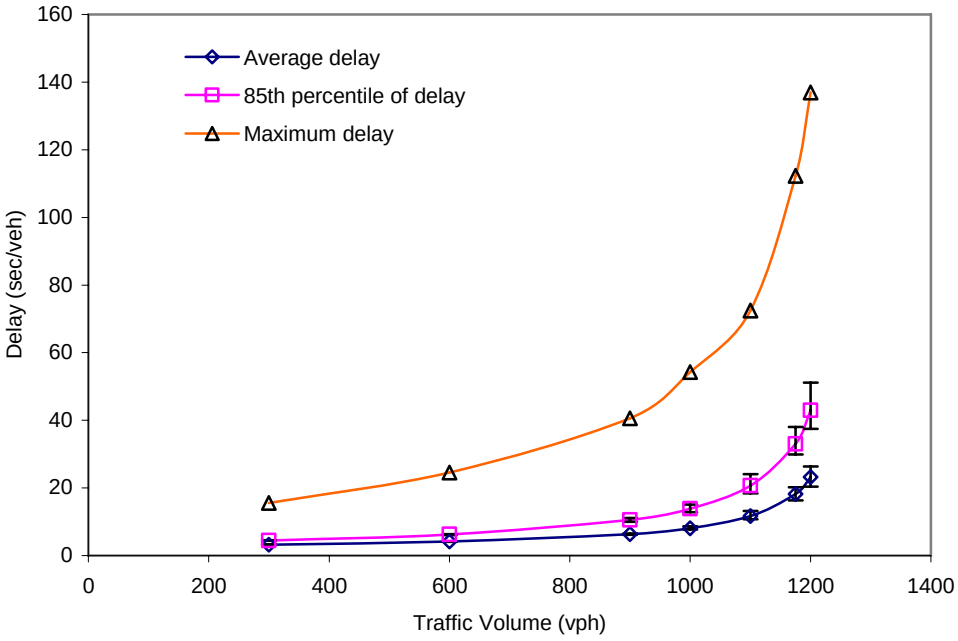

Figure 18. Average Delay Caused by Bottleneck.

The amount of delay for each vehicle is relatively small (typically less than 1 minute). However, the total delay to the entire population of traffic can be significant as the traffic volume increases, particularly during the peak periods. A modest increase in the average vehicular delay will increase the total delay considerably when the traffic volume is high. Figure 19 provides the effect of a bottleneck survey station configuration on the total delay to motorists.

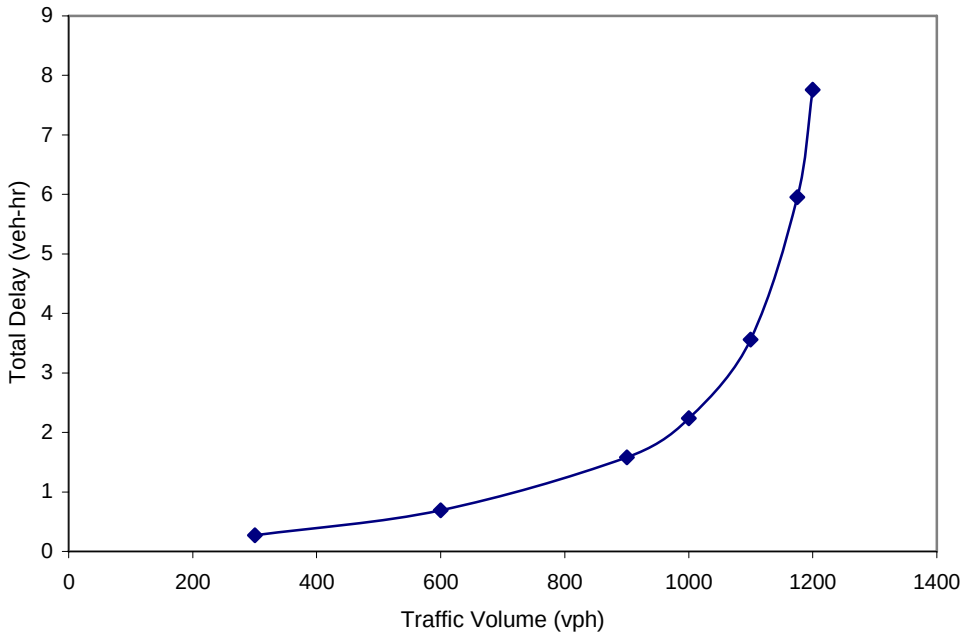

Figure 19. Total Delay Created by Bottleneck.

The effects of the survey station on the queue length are presented in Figure 20. The queue length increases substantially after traffic volumes reach approximately 1,000 vph. This figure can be used to help determine critical volume conditions where queue lengths exceed acceptable levels. For example, if a survey station is structured to limit the queue length to no longer than 10 vehicles for no more than 15 percent of the time, this can be accomplished by determining the maximum peak hour volume that satisfies this criterion using Figure 20. This volume is approximately 1,150 vph. Then, assuming peak-hour traffic equals 10 percent of the AADT, and a 50/50 directional split, the peak volume of 1,150 vph can be converted to AADT as follows:

$$(1{,}150 \times 2)/0.10 = 23{,}000$$

Therefore, a facility with an AADT of approximately 23,000 can handle a survey station using the bottleneck configuration with the expectation that the queue length will not exceed 10 vehicles 85 percent of the time. For those times when the queue begins to exceed the acceptable threshold, the survey can be suspended to allow the queue to dissipate.

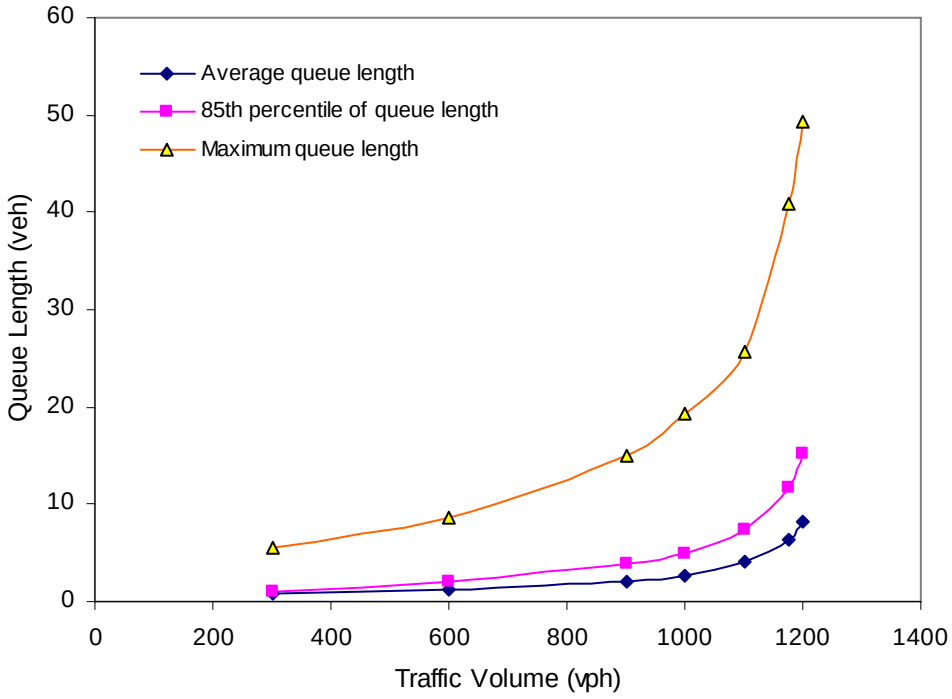

Figure 20. Effect of Bottleneck on Queue Length.

5.6 SUMMARY OF BOTTLENECK SCENARIO

The TCPs for roadways that have two or more lanes in the direction of the survey call for a lane reduction that channels motorists into fewer lanes before reaching the survey station area. The result of the channeling of vehicles into fewer lanes is, in effect, a reduction in the capacity of the roadway. The analyses utilized a discrete event simulation since the manner in which a queue develops occurs on an event by event basis.

Results from the analyses indicate that a survey being conducted using a bottleneck configuration can be performed without causing excessive disruption to motorists if the traffic level is less than 1,000 vph. For traffic levels greater than 1,000 vph, the survey station may cause unacceptable levels of delay to road users. However, it is possible that traffic volumes may attain the level of 1,000 vph (or more) for only a short period. In cases like this, a temporary suspension of the survey process may be appropriate.

Planners and administrators of external surveys typically deal in terms of AADT when deciding whether intercept surveys can be conducted on a particular facility using a bottleneck configuration. The queuing analyses were performed using traffic volumes in terms of vehicles per hour. The hourly traffic volumes can be converted to AADT in the same manner as the blocked lane configuration. The conversion can be made as follows:

(Vehicles per Hour / Directional Split) / Percent of Peak Hour Traffic = AADT

For example, for a volume of 1,000 vehicles per hour, a 50/50 directional split, and an assumption that 10 percent of the daily traffic occurred during the peak period, the result would be:

(1,000 vph / 0.5) / 0.1 = 20,000

Sensitivity analyses on simulation inputs indicate that delay and queue length are relatively insensitive to simulation inputs if the traffic volume is not considerably higher than 1,000 vph. The TSP has historically utilized an AADT of 20,000 in determining whether or not a roadway is considered high volume. The queuing analyses confirm that this threshold value is a reasonable guideline in general terms.

6.0 RECOMMENDATIONS ON HIGH VOLUME SURVEY METHODS

Upon review and evaluation of over 25 origin and destination type travel surveys from around the country, the research found that there is no easy solution to the problem, and no one survey method that can be applied for any and all high volume locations. The findings of the study lead researchers to conclude that collecting origin/destination information on high volume facilities should be handled using a flexible approach where a variety of options are available. The approach should allow for use of the most viable method or combination of methods that best suit the physical conditions of the location and policies of the survey sponsor and other affected agencies. The primary factors considered in selecting the most suitable high volume method or methods for a location typically include:

- the type of facility, roadway cross-section, physical conditions, etc.;
- policies of state DOTs and/or affected agencies or jurisdictions;
- the level of traffic (AADT);
- data elements collected and quality of data;
- cost and/or resources of the sponsoring agency; and
- potential for negative feedback/relations.

The review of survey efforts from around the country demonstrates that there are numerous methods being used to conduct travel surveys on high volume facilities. In many instances, the conduct of such surveys in an urban area or corridor involved more than one survey methodology. The research found nine different high volume survey methods which, as previously discussed, fall into the following four general categories:

- Intercept Interview Surveys;
- Intercept Postcard Mailback Surveys;
- License Match Surveys; and
- License Mailout Surveys.

The advantages and disadvantages of each of the four categories are evaluated separately in the following sections. Research recommendations and conclusions on the use of specific high volume methods in TxDOT's travel survey program are provided in each section. It should be

noted that the evaluations and subsequent recommendations in the sections to follow are from the standpoint of potential application in TxDOT's TSP with consideration of the legal, policy, and operational framework under which the program is carried out. The recommendations may or may not be suitable for other state DOTs or agencies outside of Texas.

6.1 INTERCEPT INTERVIEW SURVEYS

Several major external surveys in the United States in recent years have used intercept interview surveys for high volume facilities. The types of surveys that fall into the intercept interview category include those conducted at intersections or interchanges near freeway exit ramps, on freeway shoulders, and at weigh stations, rest areas, and truck stops. The primary advantages and disadvantages of surveys in the intercept interview category are shown in Table 11.

Table 11. Advantages and Disadvantages of Intercept Interview Surveys.

Advantages	Disadvantages
• High data quality and response rate • Ability to clarify and follow up on responses • All needed data elements can be collected • More control of sampling • Does not require use of state motor vehicle records • Data available much sooner	• Safety • Requires TCP and vehicles to be stopped • Requires extensive coordination within and between agencies for permits, TCP approval • TCPs dependent on willingness of law enforcement to participate • Typically more expensive • Weather sensitive

The primary advantages of an intercept interview survey method are that motorists' information is collected at the time of the interview, and that all data elements needed for modeling purposes can be collected. Trained interviewers are also able to clarify responses that may be vague or illogical. The primary disadvantages of this method relate to the safety of the surveyors and the traveling public and the extensive coordination that is often needed within and between government agencies and private contractors. The intercept interview method, despite the use of TCPs and reduced speeds, often places surveyors near travel lanes, which increase safety risks for both the surveyors and motorists.

Along high volume locations where safety issues and logistical challenges can be addressed, the intercept interview is the optimal method for use in TxDOT's travel survey program in light of its accuracy, high response rates, and ability to collect all needed data elements. More specific recommendations and conclusions on the use of intercept interview surveys by TXDOT are included in the two following subsections.

Intercept Interviews on or near Freeway Exit Ramps

This form of interview intercept method was successfully used in the Phoenix and Denver external survey conducted in 1998 and 1999, respectively. Researchers believe it is a viable non-commercial survey method for limited application in TxDOT's TSP if the following criteria are followed:

- Use only around the periphery of urban areas in locations that are more rural in nature where freeway traffic volumes are low. To this end, locations meeting this criteria may not exist around Texas' major urban regions (e.g. Houston, Dallas, San Antonio/Austin) so the method may only be viable in TxDOT's less populated travel survey regions.
- Use only at minor off-ramps where there are low traffic volumes on the frontage road and at the cross-street, and where ramp and frontage geometry will allow for a survey site to be safely set-up and operated.
- Freeway 'sampling' should only take place from the right (outside) lane and the number of vehicles flagged to exit and enter the survey site should never exceed the number of surveyors. Furthermore, the survey station should be completely clear of all vehicles before more vehicles are flagged to exit the freeway.
- The survey instrument should be simplified such that the interview takes no more than 2 minutes to complete.
- Ample public relations measures should be included such as a brochure handout, a toll-free hotline, and coupons or giveaways for surveyed motorists.

Because of its elevated safety concerns and potential for negative public relations, it is recommended that TxDOT proceed cautiously with the use of intercept interview surveys at/near exit ramps. Researchers recommend that TxDOT conduct one or more pilot surveys using this

method and incorporate it as part of a future external travel survey in one of the state's least populated travel survey regions. One or more pilots using this method would serve as a test trial(s) to determine if TxDOT should include it as a permanent method to be used (where conditions allow) in the travel survey program.

Since it is unlikely that all high volume locations in one TSP region could be surveyed using an intercept interview method at/near off-ramps, researchers see this method as only being supplemental to other methods.

Intercept Interviews on the Shoulders of Freeway Mainlanes

As discussed in Chapter 4, researchers found only one major external survey in recent years where intercept interview surveys were conducted on a freeway. This method was successfully used on two-lane sections of IH-95 in the Philadelphia area as part of the external survey for the Delaware Valley Regional Planning Commission. The DVRPC survey was conducted in-house, took over a year to coordinate, and required extensive planning and coordination between various DOTs and law enforcement agencies. Unlike the DVRPC effort, TxDOT contracts out its survey projects and may have numerous major surveys around the state being conducted at the same time.

TxDOT ended the use of intercept interview surveys on freeways in the early 1990s due to long traffic delays, safety concerns, and the negative public relations this method generated. These same factors and concerns hold true today, but to a far greater degree of sensitivity than in the early 1990s. While the DVRPC surveys shows that intercept surveys can be conducted on freeways, researchers do not believe that this method is a viable option for TxDOT due primarily to its elevated safety risks and potential for negative public relations.

Intercept Interviews at Weigh Stations, Rest Areas, and Truck Stops

The research found that intercept interview surveys at weigh stations, rest areas, and truck stops were the most common way of conducting O-D surveys on high volume facilities for commercial vehicles. Over the past several years, TxDOT has used this method for commercial vehicles on high volume facilities in nine urban areas around the state. Additionally, external

surveys in Denver, Colorado, Phoenix, Arizona, Chattanooga, Tennessee, Raleigh-Durham, North Carolina, Little Rock, Arkansas, and Baton Rouge, Louisiana, among others, have all used this method for commercial vehicles on high volume facilities. Research findings support continuing this method as TxDOT's most viable option for surveying commercial vehicles on high volume facilities.

6.2 INTERCEPT POSTCARD MAILBACK SURVEYS

This category of surveys consists primarily of postcards distributed at interchanges near freeway exit ramps and at toll plazas. The primary difference between this method and the intercept interview method is that motorists are not interviewed by surveyors when they are stopped. Instead, motorists are handed a postcard with questions that can be filled out and returned in the mail once they reach their destination. Table 12 provides the main advantages and disadvantages of intercept postcard mailback surveys.

Table 12. Advantages and Disadvantages of Intercept Postcard Mailback Surveys.

Advantages	Disadvantages
• Less disruption to traveling public than intercept interview • Traffic delays are shorter • Method does not require the use of state motor vehicle records • Collects key data elements needed for model updates • Method usually less expensive than intercept interview	• Safety • Requires TCP and vehicles to be stopped • Introduces self-selection bias, no ability to follow up • Potential for low response rate • Requires extensive coordination with and between agencies for permits, TCP approval • TCPs dependent on willingness of law enforcement to participate • Delay in getting survey responses • Weather sensitive

Although the postcard contains fewer questions than the intercept interview method, the method still is able to obtain origin/destination, trip purpose, and vehicle occupancy information. The postcard method typically also allows for a small number of additional questions that are suited to meet the needs of the particular survey. Primary disadvantages include safety issues related to having traffic control and personnel distributing the postcards, the potential for low

response rates, and no ability to follow up or clarify respondent answers. The amount of coordination needed between and within government agencies and for permits and approvals of the TCP may also be a disadvantage.

Intercept Postcard Mailback Surveys at Interchanges near Freeway Ramps

The research found three major external travel surveys within the past 10 years where postcard mailback surveys were distributed at interchanges near freeway ramps. These surveys included the Chattanooga, Tennessee, external in 2002, the Raleigh-Durham, North Carolina, external in 2001, and the Steubenville-Weirton, Ohio, external in 1997. For the Chattanooga survey, the postcard distributions at/near ramps was not their first option, but rather one they resorted to due to last minute withdrawals of cooperation from state officials. For the Raleigh-Durham survey, the method was used at a few sites, but a license match mailout was their primary method used. The Denver Regional COG chose not to use a postcard mailback method in their 1998 survey, citing its low sampling rates and high costs.

Based on research findings, intercept postcard mailback surveys at or near freeway ramps appear to be a method better suited to corridor or attitudinal surveys than for external surveys. Unlike external surveys, postcard distribution at or near ramps can be conducted more easily for corridor and attitudinal surveys since typically these types of studies do not require that samples of vehicles be flagged from the freeway and into the survey site.

On the other hand, since a key data element of external surveys is the breakdown of internal and external trips, the use of a postcard mailback method on or near freeway ramps for an external survey would require that it be conducted near the regions survey area boundary and that only vehicles flagged from the freeway be included in the survey. In other words, the method would need to be conducted just like the intercept method previously described, except that instead of interviewing the motorists, a postcard survey would be distributed.

Researchers conclude that the postcard mailback method on or near ramps is a viable non-commercial survey method for limited application in TxDOT's TSP, if the same criteria specified for intercept interviews are followed. However, while this method is viable,

researchers believe that (barring special circumstances) the use of intercept interviews on ramps is a better option than distributing postcards. The expense and level of effort required to install TCPs and flag motorists to exit the freeway may be more justifiable for the higher quality data obtained from intercept interviews than for lesser quality data and marginal responses of mailback surveys.

Intercept Postcard Mailback Surveys at Toll Plazas

The external survey for the Chicago area in 1998 included postcard mailback surveys at toll plazas on interstates in combination with video license mailout surveys. The use of mailback surveys at toll plazas is a viable option for TxDOT when the tolling facility is in close proximity to the study area boundary. As done in Chicago, this method would be one that could be used only when logistically feasible as a supplement to the primary high volume method used in the travel survey region.

A similar method identified in the research was a mailout survey sent to electronic toll tag users (e.g., EZ Tag or E-PASS). This method was used in the Orlando, Florida, area to study travel habits of users and non-users of their electronic toll collection system. The use of mailout surveys to electronic toll users is not a viable option for TxDOT to use in conducting external travel surveys. Users of the system would overwhelmingly be residents of the region being surveyed and would represent a highly non-representative and inaccurate sample for estimating internal/external trips, among other data elements. Mailout surveys to electronic toll users are better suited to corridor and user/attitudinal surveys, as they are currently being used.

6.3 LICENSE MATCH SURVEYS

The license match method involves the video recording of license plates at two or more locations in or around the perimeter of the study area and then matching them to identify movements between locations. This method is used to estimate internal-external (local) and external-external (through) trips in a study area or corridor. Table 13 shows the advantages and disadvantages of license match surveys.

Table 13. Advantages and Disadvantages of License Match Surveys.

Advantages	Disadvantages
• Safety • No disruption or delay to traveling public • Does not require use of state motor vehicle records • No TCP required • Can be collected on 24-hour basis (with certain technologies)	• Only one needed data element collected • All sites must be recorded on the same day • Weather sensitive

The primary advantages of the license match method are that it is a non-disruptive way to collect travel data and it does not require the use of state motor vehicle records. The method does not require a TCP, and motorists are not contacted about their travel. Despite these advantages, this method also is one of the least productive in terms of travel information that can be collected. The only data element for modeling purposes that can be estimated from the license match method is the number of internal-external (local) trips and the number of external-external (through) trips that are made. An additional disadvantage is that in order for the 'point-to-point' matching to be effective, all survey locations must be videotaped on the same day.

Despite the limited data that is obtained, license match surveys have been performed in numerous areas around the country. TxDOT has used the license match surveys as its primary high volume method since the mid 1990s. Recent travel surveys in Baton Rouge, Louisiana, and North Carolina have also used this method.

Research findings support the continued use of license match surveys as a mainstay in TxDOT's TSP. However, in light of its limited data collected, it is recommended that the license match method be used as a backup or fall-back method to license mailout surveys and intercept interview surveys.

6.4 LICENSE MAILOUT SURVEYS

The license mailout method is similar to the license match method in that license plates of motorists are recorded as they pass external survey locations around the periphery of a study

area. However, unlike the license match method, with this method recorded plates are queried against state motor vehicle databases, the vehicle registrant's address is determined, and they are mailed a survey questionnaire. When used in an external survey, the license mailout method is used only for non-commercial vehicles. In addition to the questionnaire, the survey mailout typically provides information on the survey's purpose, ensures that responses will be anonymous, gives toll-free numbers for questions, and includes a pre-paid postage return envelope. Table 14 provides the main advantages and disadvantages of the license mailout survey method.

Table 14. Advantages and Disadvantages of License Mailout Surveys.

Advantages	Disadvantages
• Safety • All key data elements needed for model updates can be collected • No disruption or delays to traveling public • Does not require all high volume locations to be recorded on the same day • No TCP required	• Lower data quality than intercept interview method • Requires approval and coordination with DMV for data transfers • Quick turnaround needed between license capture and survey mailout • Difficulty in handling out-of-state plates • Commercial vehicle surveys must be handled using a different survey method • Potential for low response rate • Commercial, rental, and government plates must be removed from the dataset • Potential for negative public relations and right to privacy concerns • Cost • Weather-sensitive

As with the license match method, the license mailout method collects license data in a non-disruptive manner with no delay to motorists. Compared to intercept interview surveys, the primary advantage of this method is that it allows for data to be collected safely, without the use of TCPs, and without stopping motorists. Unlike the license match method, the license mailout method allows for the collection of key data elements needed for model updates. These elements include trip origins and destinations, trip purpose, vehicle occupancy, and trip length. The primary disadvantage to the method is the use of DMV records and the potential negative feedback due to privacy concerns. Other significant drawbacks include the difficulty in

achieving quick turnaround times between collecting license plate data and mailing out the surveys as well as the potential for lower quality of responses.

Based on research findings, a video mailout survey appears to be the most common method used throughout the country to conduct origin-destination type surveys on high volume facilities. Seventeen of the 29 travel studies reviewed in this research used a video mailout method. In recent years, this method has been used in external surveys in many metropolitan areas throughout the United States. Among others, these locations include Tampa, Florida (2003), Los Angeles, California (2001), Raleigh-Durham, North Carolina (2001), Charlotte, North Carolina (2001), Knoxville, Tennessee (2001), Phoenix, Arizona (1999), and Chicago, Illinois (1998). The license mailout method has also been frequently used in corridor and user/attitudinal throughout the country.

TxDOT last used a license mailout method as part of its 'Texas Border Crossing Survey' in 2001. Despite experiencing a very low percentage of negative feedback from the public, TxDOT suspended the use of the license mailout survey method. It is believed that the primary source of negative feedback for TxDOT's 2001 survey was the wording of the cover letter that was mailed with the survey.

Considering the advantages and disadvantages mentioned in Tables 11 through 14, it becomes clear that determining which method or combination of methods to use in TxDOT's TSP requires trade-offs between key elements such as safety, data quality, traffic disruption/delay, data elements collected, cost/benefits, and negative feedback. Table 15 provides a comparison of these elements by high volume survey method, and shows which elements have positive or negative attributes. A '✓' represents a positive attribute and an '*x*' denotes a negative attribute.

Table 15. Comparison of Key Factors for Viable High Volume Methods.

Factor/Method	Safety	Disruption/ Delay	Use of DMV Records	Data Elements Collected	Data Quality	Negative Public Relations	Cost/ Benefit
Intercept Interview*	*x*	*x*	✓	✓	✓	*x*	✓
Intercept Mailout*	*x*	*x*	✓	✓	*x*	*x*	*x*
License Match	✓	✓	✓	*x*	*x*	✓	*x*
License Mailout	✓	✓	*x*	✓	*x*	*x*	*x*

* at/near ramps, weigh stations, or rest areas near survey area boundaries

Considering the trade-offs between the elements shown in Table 15, researchers believe the license mailout survey is a necessary and viable method for non-commercial vehicles for the following reasons:

- Safety is the most important element. Though data quality is a trade-off, the license mailout survey is safer than the intercept survey, and it provides all the key data elements needed for model updates.
- High traffic volumes and roadway geometry often preclude the ability to safely conduct intercept surveys, and the license mailout method is safer, less disruptive, and the most viable replacement option.
- Despite being safe and causing no disruption to motorists, license match surveys are arguably not cost-effective and not worth the high level of effort required since the method only provides one data element.
- While the data quality of mailout surveys is inferior to that of intercept surveys, enough complete and usable mailout survey responses can be obtained by adjusting sample levels. In addition, mailout survey forms can be simplified to improve accuracy and response rates.
- Negative feedback/relations can be addressed and minimized through a combination of proactive public relation measures performed prior to and during the survey.

In light of the reasons provided above, it is recommended that TxDOT reinstate the use of license mailout surveys as part of its TSP, and incorporate many of the 'lessons learned' from this research. Researchers recommend that license mailout surveys be carried out as follows:

- Use a simplified survey form that can be completed quickly and easily. Also, provide space on the survey for comments.
- Require a turnaround time of no more than two days between license capture and survey mailout.
- Include a cover letter that is on agency letterhead and is signed by an appropriate official. Have several individuals review the letter, and make it as colloquial as possible.
- Provide/use a pre-addressed postage paid envelope or postcard. Provide assurance that return responses are anonymous (e.g., such as detachable survey form that allows respondent to remove their address).
- Ensure only one survey is sent per address.
- Have a toll-free number for questions and complaints, and keep it manned 24 hours per day.
- Keep accurate records of all calls received. Record the date, time, nature/purpose of call, and the city/region from which the respondent is calling.

The requirement for a turnaround time of no more than two days between license capture and survey mailout is imperative for obtaining quality data and acceptable survey response rates. The content and tone of the cover letter included with the survey mailout is also important. The letter should convey the important purpose and need for the survey, cast a positive light on the survey, and stress the importance of the recipient's input. TxDOT may also elect to include information in the survey mailout that informs the survey recipient that addresses were ascertained via a computerized query, and all records related to recorded license plates have already been destroyed.

6.5 OVERVIEW OF RECOMMENDED METHODS FOR THE TSP

It is recommended that TxDOT's external travel surveys on high volume facilities be carried out using a flexible approach where a variety of survey methods are available. The approach should allow for the use of the most viable method or combination of methods that best suit the physical conditions of the location and consider the policies and needs of TxDOT

districts and other affected agencies. As part of this flexible approach, recommendations for non-commercial and commercial survey methods, as well as the use of supplemental survey methods, are provided below.

For non-commercial vehicle surveys, it is recommended that TxDOT use a license mailout survey method as the primary method to collect the key data elements needed for model updates. In the event a license mailout survey cannot be conducted in a particular survey area, district, or region, researchers recommend that a license match survey in combination with intercept interview surveys at or near low-volume exit ramps be used.

For commercial vehicles on high volume facilities, TxDOT should continue to use intercept interview surveys at rest areas, truck stops, and weigh stations located at or near the survey area boundary. In certain areas of the state, highway border patrol checkpoints may also be used for commercial vehicle surveys.

There are a number of high volume survey methods that are viable, but typically not feasible, for widespread use. These methods may be used to supplement data collection efforts of the license match and mailout survey methods recommended for TxDOT's TSP. Supplemental high volume methods recommended for potential use include the following:

- Intercept postcard mailback surveys at or near freeway exit ramps. While an intercept interview survey is recommended over a postcard mailback at these locations, site specific conditions or local policies could make postcard distribution the preferred method. This method should only be used for non-commercial surveys.
- Intercept interview or postcard mailback surveys at rest areas. When a rest area that is conducive to operating a survey station is located near a survey area boundary, either an intercept or postcard mailback survey method may be utilized. The use of this method is contingent upon the development of a TCP which allows for platoons of vehicles to be safely flagged from the freeway and into the site. Depending on the amount of deceleration and queuing space available, these facilities may allow for the conduct of both non-commercial and commercial vehicle surveys. In the

absence of sufficient space, this method should only be used for non-commercial surveys.

- Intercept postcard mailback surveys at toll plazas. This method is limited to only a few survey regions, and it will only be viable for external surveys when the toll collection facility is at or near the survey area boundary.

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