TECHNICAL REPORT OF NCTCOG 2022 LIMITED ACCESS FACILITY USER SURVEY AND DATA COLLECTION

Prepared for

Texas Department of Transportation

Prepared by

Model and Data Development Team

North Central Texas Council of Governments

What is NCTCOG?

The **North Central Texas Council of Governments** (NCTCOG) is a voluntary association of, by, and for **local governments** within the 16-county North Central Texas Region. The agency was established by state enabling legislation in 1966 to assist local governments in **planning** for common needs, **cooperating** for mutual benefit, and **coordinating** for sound regional development. Its purpose is to strengthen both the individual and collective power of local governments, and to help them recognize regional opportunities, resolve regional problems, eliminate unnecessary duplication, and make joint regional decisions – as well as to develop the means to implement those decisions.

North Central Texas is a 16-county **metropolitan region** centered around Dallas and Fort Worth. The region has a population of more than 7 million (which is larger than 38 states), and an area of approximately 12,800 square miles (which is larger than nine states). NCTCOG has 228 member governments, including all 16 counties, 169 cities, 19 independent school districts, and 24 special districts.

NCTCOG's **structure** is relatively simple. An elected or appointed public official from each member government makes up the **General Assembly** which annually elects NCTCOG's **Executive Board**. The Executive Board is composed of 17 locally elected officials and one ex-officio non-voting member of the legislature. The Executive Board is the policy-making body for all activities undertaken by NCTCOG, including program activities and decisions, regional plans, and fiscal and budgetary policies. The Board is supported by policy development, technical advisory and study **committees** – and a professional staff led by **R. Michael Eastland**, Executive Director.

NCTCOG's offices are located in Arlington in the Centerpoint Two Building at 616 Six Flags Drive (approximately one-half mile south of the main entrance to Six Flags Over Texas).

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NCTCOG's Department of Transportation

Since 1974 NCTCOG has served as the Metropolitan Planning Organization (MPO) for transportation for the Dallas-Fort Worth area. NCTCOG's Department of Transportation is responsible for the regional planning process for all modes of transportation. The department provides technical support and staff assistance to the Regional Transportation Council and its technical committees, which compose the MPO policy-making structure. In addition, the department provides technical assistance to the local governments of North Central Texas in planning, coordinating, and implementing transportation decisions.

Prepared in cooperation with the Federal Highway Administration, US Department of Transportation, and the Texas Department of Transportation.

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August 2023

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Executive Summary

The North Central Texas Council of Governments (NCTCOG) conducted a study of the users of Limited Access Facilities (LAF) in the region. LAF refers to freeways, toll roads, and managed lanes. The funding was sponsored by the Texas Department of Transportation (TxDOT). The primary reason to do this survey was to evaluate the social fairness of LAF facilities for users. The second objective was to understand the travel behavior of users such as trip purpose, trip length, and value-of-time (VOT); this was achieved by analyzing the trip characteristics of LAF users.

The users were characterized based on various socioeconomic groups. These groups were defined by characteristics such as age, gender, and race for persons; and income, number of children, and number of employees for households. These dimensions allowed for a detailed analysis of the user base, providing insights into the diverse range of users who rely on LAFs for their travel needs.

The survey covered six strategically-selected LAF facilities in Dallas-Fort Worth (DFW) Metroplex. These included traditional toll roads, managed lanes, and general purpose freeways. Altogether, the facilities selected spanned a wide geographical area, serving a broad spectrum of users that represented various regions and socioeconomic backgrounds. The following table lists the selected LAF facilities.

LAF Facilities	**Type**	**Length (mile)**
1. President George Bush Turnpike	Toll Road	6
2. Dallas North Tollway	Toll Road	6
3. North Tarrant Express	Managed Lane	5
4. IH 820 Freeway	Freeway	5
5. IH 35E TEXpress Lanes	Managed Lane	8
6. IH 35E Freeway	Freeway	8

The study began with traffic counts at the selected LAF facilities. These counts provided valuable data on the traffic volume across these facilities, offering insights into usage patterns. This information was crucial in the design and expansion of the survey. After the traffic counts, license plates were captured, which served as the primary sampling pool for the survey. The survey respondents primarily conducted the questionnaire online. The surveys collected were cleaned and checked for accuracy and consistency. As a result, 5,878 validated surveys were obtained. The survey data was then expanded to be statistically representative of the entire LAF user population. The expansion process was carefully managed to maintain the integrity of the survey data.

The expanded survey data shed light on the trip dynamics, as well as the socioeconomic and demographic profiles of LAF users. Notably, the income distribution of LAF users mirrored that of the overall population in the region, suggesting income does not play a pivotal role in the decisions of LAF users. This indicates no prevailing issue of social fairness, with LAFs serving a diverse section of the community. The income distribution of users of each managed lane and toll road was also compared to that of the residents of the travel areas of these facilities. The comparison showed no statistically significant difference. This means neither toll roads nor managed lanes have created social equity disparity.

As to the LAF user travel characteristics, the trip purpose distribution of LAF users was similar to that of the regional travel. The trip share of home-based nonwork (HBNW) trips was 63 percent, while the share of home-based work (HBW) was about 20 percent. The usage of LAF for commute trips increased to 50 percent in the AM peak period (from 6:30 to 9:00). HBNW trips dominated other time periods.

Compared to the 14 minutes estimated average trip length in 2019, the average trip length of LAF users was longer at 39 minutes. The average trip length on managed lanes was 43 minutes, which was higher than 35 minutes on toll roads. According to the survey respondents, more than 80 percent believed that 10 minutes or more were saved using managed lanes instead of the parallel freeways. Average time savings of managed lane users was around 16 minutes.

Regarding toll awareness, only 14 percent of respondents knew the exact toll amount they paid. This lack of awareness led many users to significantly underestimate their toll payments, resulting in a notable difference in the value-of-time (VOT) between the two groups. The group aware of their toll payments had a median VOT of $34 per hour, compared to a median of $14 per hour for the unaware group.

This report also details other important findings. Neither the number of children in a household nor its income significantly influenced the trip flexibility of LAF users. Frequent LAF users predominantly took HBW trips, and household income did not impact trip frequency. Additionally, higher vehicle occupancy was primarily associated with HBNW trips.

This survey stands out due to its breadth and detail, capturing a myriad facets of user behaviors and journeys on LAF facilities, thereby offering a holistic view of LAF user patterns. As a pivotal reference, this survey can guide future transport planning and policymaking. Insights gleaned from this research can enhance LAF utilities and services, ensuring they cater to the full spectrum of user needs.

Chapter 1. Introduction

1.1 Background

Dallas-Fort Worth (DFW) metropolitan planning area (MPA) covers approximately 10,000 square-miles with a population of about 7.5 million in 2019. The roadway transportation network consists of 18,000 centerline miles of roadway facilities, of which nearly 1,000 are classified as limited access facilities (LAF) including freeways, toll roads, and managed lanes. Providing vital connectivity for every resident as well as pass-through traffic in the region, almost 27 percent of LAF is associated with toll facilities. Approximately, 15 percent of the LAF system consists of traditional fixed toll road facilities with electronic toll collection instrumentation. Of the freeway system, about 120 miles (12 percent) are covered by managed-lane facilities within the right-of-way of the corresponding freeway. All managed lane corridors provide a tolled choice for the users, virtually guaranteeing 50 mph average speed on the managed lanes. The speed guarantee is achieved by variable tolls.

The variety of the limited access facilities demands understanding of the characteristics of the facility users. The clear possibility of reducing travel time by passing through the LAF raises the question of equity along with complexity of travel behavior.

North Central Texas Council of Governments (NCTCOG) has served as the Metropolitan Planning Organization (MPO) for transportation in DFW. NCTCOG's Transportation Department is responsible for regional transportation planning for all modes of transportation. The Department provides technical support and staff assistance to the Regional Transportation Council (RTC) and its technical committees, which compose the MPO policy-making structure. NCTCOG had aimed to gain an understanding of travel behavior and characteristics of the users of LAF system in the region. The performance of these facilities is generally monitored with travel time and traffic volume measurements. The toll facilities maintain a detailed accounting system for toll collection that could be used for performance monitoring and other infrastructure evaluations. However, these measures provide limited data about the user characteristics, travel pattern, origin/destinations, and other conditions that affect the user experiences. These insights are referred to as travel behavior. Understanding the decision-making process of the users enables NCTCOG to forecast future performance and congestion management strategies for the LAF system.

1.2 Study Objectives

Sponsored by the funding of Texas Depart of Transportation (TxDOT), NCTCOG conducted the survey project including several selected facilities in the region to understand the trip-making and socio-economic characteristics of the LAF users. The usage of the system can be monitored passively, but the trip characteristics must be collected through interaction with the users.

The results of the study could also shed light in understanding the travel behavior regarding toll, congestion, reliability, and convenience, as well as consideration of transportation facilities as a consumer product. The user behavior regarding toll and travel time can be characterized by value of time or willingness-to-pay in some degrees. However, it is unclear if the extent of other factors such as reliability of travel time and convenience can be similarly formulated. An even more unknown aspect of the travel behavior is hidden within the consumerism of some of these facilities; this point refers to the use of managed lane facilities despite the logical disadvantage that they provide in some periods of time. Passive observations have shown that some users use the managed lanes regardless of travel

timesaving. This behavior indicates a negative value of time, which is irrational. Therefore, issues such as advertisement and habits as well as aesthetics may play an important role alongside quantifiable factors such as travel time and price.

For these reasons, the project includes a voluntary survey of LAF users. The survey form included questions about trip purpose, origin, destination, time of travel, household, workplace, and socio-economic characteristics of the users. The survey was conducted with utmost consideration for privacy of the users. To ensure high responses, the survey also provided the participants with appropriate incentives.

In addition to the user survey, traffic data collection at the mainlines and ramps were conducted contemporaneously. Traffic volume data may also be extracted from transaction statistics collected by the toll agencies, when applicable.

Another type of data to be collected was entry-to-exit data. This piece of information would be derived from the path information of the participants and helped to provide the base data for survey expansion. It was possible that this data was available from toll agencies, though this means was not employed. One consideration was that this data source was not available for general-purpose freeways. The trajectory data can also be acquired in the form of sample vehicles on the LAF system through several data vendors, but this study did not use those alternatives.

To incorporate the major types of LAF facilities, the study considered general-purpose freeways, traditional toll roads, and managed lanes. The project included two facilities from each type of LAF with lengths ranging from six to eight miles. Observing the geographical limits, the facilities were evenly distributed in both western Fort Worth and eastern Dallas sides in the region. The selection of these facilities was done through consultation with North Texas Tollway Authority (NTTA), Texas Department of Transportation and other managed lane operators. The size of the project was mainly limited by the budget, but all facilities selected were believed to be sufficiently representative for both sides of Fort Worth and Dallas in the region.

Table 1-1. Six LAF Segments to Conduct User Survey

LAF Facilities	Acronym	Type	Segment	Length (mi.)
1. President George Bush Turnpike Toll Road between	PGBT	Toll Road	IH 35E ~ DNT	6
2. Dallas North Tollway	DNT	Toll Road	PGBT ~ SH-121	6
3. North Tarrant Express - 183 Toll Road	NTE	Managed Lane	I-35W ~ SH-121	5
4. IH 820 Freeway	IH820	Freeway	I-35W ~ SH-121	5
5. IH 35E TEXpress Lane	IH 35E TEX	Managed Lane	I-635 ~ SH-121	8
6. IH 35E Freeway	IH 35E	Freeway	I-635 ~ SH-121	8

Table 1-1 presents the details of the six LAF facilities that were chosen for the survey. The six segments were taken from the following facilities: President George Bush Turnpike (PGBT), Dallas North Tollway (DNT), North Tarrant Express (NTE), IH 820, IH35E TEXpress Lanes (IH 35E TEX), and IH 35E Freeway. PGBT and DNT are two essential toll facilities serving the northeastern region of DFW metroplex. NTE is a managed lane with dynamic tolling connecting north Fort Worth to the center of DFW, while IH 820 is the parallel freeway. IH 35E TEXpress Lane is another managed lane connecting Dallas County and Denton County, along with the parallel IH 35E freeway.

The products of this project include implementation of the project steps, documentation of the user survey processes, expansion of the surveys, and a summary report of expanded survey results. In addition, an analytical process will be conducted to answer the questions of travel behavior regarding the relationship among trip purpose, household and person characteristics, time of travel, and socioeconomic information.

1.3 Scope of the Work

As the purpose of the project aimed at understanding travel behavior of the LAF users in the region, the project may break down into the following tasks. A comprehensive user survey should provide unique and informative insights on LAF users' travel behavior. The survey covered six segments selected from managed lanes, traditional toll roads, and general-purpose freeway with approximate length ranging from 5-mile to 8-mile segments. To serve the survey expansion, traffic counts were collected on 24 freeway mainline locations and 93 ramps of LAF, which essentially included at all entrance and exit ramps and mainlines of these LAF facilities. The raw sample data were expanded with the traffic count being control totals to remove potential biases from the raw survey samples.

To provide a sample pool for the LAF travel survey, another task was to collect license plates of the LAF users along the selected segments. NCTCOG used an internal database to extract a list of home addresses based on the captured licenses. The address list was used by the consultant to recruit participants for the survey. The address list was prepared strictly observing the privacy of users.

An implementation plan was made on the design of survey questionnaire, the pilot survey as well as the main one. The feedback from the pilot survey was evaluated and used to modify the survey instrument and programming logic. The main survey data collection began in early December 2021 and was conducted during the weekdays excluding special event dates such as the holiday season.

The consultant compiled the completed surveys and performed cleaning and error-checking. The cleaned database of surveys was delivered with documentation of the table fields. Based on the deliverables from the consultant, NCTCOG developed a SQL server database to accommodate the complete LAF survey responses. As the original database contained only raw, unweighted survey samples, a survey expansion was performed so that each sample in the survey received a weighting factor. These weights may greatly reduce the bias introduced by the raw samples of the survey.

The survey database then became ready to answer various research questions and study needs. Since the survey questions covered the origin and destination information of surveyed trips, it was plausible to estimate the travel time based on another data source named "National Performance Management Research Data Set" (NPMRDS). As a result, the LAF trip time estimates were added into the LAF database.

In the following chapters, the document will elaborate on the Survey Methodology, LAF Survey Database, Survey Findings, and Conclusions.

Chapter 2. Methodology

2.1 Preparation Prior to Implementation

The LAF survey consisted of multiple tasks. Therefore, a project management plan was the first thing co-developed by the consultant and the NCTCOG staff. The plan needed to cover the methodology, deliverables, schedule, staffing, and quality control measures. In the plan, specifications were clearly defined for survey segments, survey design(questionnaire), survey conducting, traffic counts, license plates to capture, and communications of all parties, which was demanded by the NCTCOG project team. In addition, the project plan went in length to define the following preparative and preventive elements:

- Confirmation of project goals and objectives.
- Equipment proposed to collect the traffic counts at each location.
- Equipment proposed to capture license plates.
- Coordinating with TxDOT, NTTA and TEXPRESS to request permission to install the necessary equipment.
- Confirmation of the approval of managed lane operators.
- Case of action to be followed when incidents, accidents, road closures and other events could affect the installation of the equipment or jeopardize the reliability of the data collected.

2.2 Tasks of Implementation

The whole study may be divided into several major operational tasks that sequentially led to the final full survey. They are described in this section.

2.2.1 Traffic Counts

In order to conduct survey expansion at a later stage as well as learn the traffic profile of the LAF segments, classification traffic counts were collected by the consultant at 117 locations (93 ramps and 24 mainlines). These counts were later applied as the constraint totals in the survey expansion process. Table 2-1 presents the traffic counts conducted on the six LAF segments.

Table 2-1. Traffic Counts Collected on Six LAF Segments

Facilities	Mainline Counts	Ramp Counts
PGBT	4	16
DNT	4	18
NTE	4	8
IH 820	4	13
IH 35E TEX	4	9
IH 35E	4	29

All the counts were collected from automatic video counters that run continuously for a 24-hour period during weekdays excluding the holidays like Labor Day or Thanksgiving of 2021. However, the delivered counts were at 15-minute intervals. It would be ideal to conduct traffic counts and travel surveys within the same period. However, in real practice, the two tasks were completed within four months sequentially due to the limit of project resources, which was still acceptable.

2.2.2 License Plates Capturing

To develop a sample pool of survey participants, the consultant and NCTCOG cooperated to capture license plates on the surveyed segments. The locations, camera setup, field testing, and initial video samples were fully communicated and examined. Video cameras were usually positioned on both sides of a segment to capture the license plates of vehicles on all lanes. From 7:00 AM to 8:00 PM of a field day, the cameras usually operated for several hours covering morning peak period, noon, and afternoon peak period. More than 105,000 eligible license plates were captured. The consultant applied an automated video recognition program to identify the license plates and passed the license plates to NCTCOG. NCTCOG then verified each license plate and attempted to match it with a registration address using an internal vehicle registration database. License plates were eliminated from use in the project if they did not match a record in the database or registered to a business instead of a resident or registered in a state other than Texas. About 78,000 license plates identified were matched with residential addresses; the list of usable household addresses extracted by facility are listed in Table 2-2. The addresses database was then used by the consultant so that survey recruitment may be conducted using these addresses. During the recruiting process, private information such as names and contacts were confidentially kept by the consultant. The whole survey recruitment consumed all household addresses. In Table 2-2, the bi-directional daily volumes that were counted at each segment during the survey period were also provided as a reference. Because of the considerable difference in the volume of these segments, the captured licenses were not uniformly distributed across the facilities. The two managed lane facilities, NTE and IH 35E TEX captured relatively lower proportions of users.

Table 2-2. The Proportion of Usable Addresses Extracted from Captured Licenses

Facility	Daily Volume	Usable Addresses	% Facility
PGBT	106,517	15,533	20%
DNT	119,546	18,809	24%
NTE	43,379	8,368	11%
IH 820	110,783	12,183	16%
IH 35E TEX	11,278	6,285	8%
IH 35E	121,586	17,038	22%
Grand Total		**78,216**	**100%**

One essential task was to examine the users of these six LAF segments, to learn and compare their characteristics and travel patterns. The NCTCOG research team conducted a geographical analysis of the registration addresses that were retrieved based on the captured licenses. The geographic distribution of these addresses was of great importance when evaluating the differences and potential bias among the captured users since they were survey samples.

Figure 2-1 used varied bubble sizes to demonstrate the proportion (in percentage) of addresses based on which the video-captured vehicles were registered. The maps used zip code zones to summarize the addresses.

The most obvious characteristic of these GIS layouts is that there are more users from the northern section of the region than from the southern. The observation is understandable considering that both Dallas downtown and Fort Worth downtown are south to these segments and the segments are generally near the dense residential northern region.

Having recognized the weight on the northern side, the geographical distribution of the users apparently follows the geographical location of the facility. The users of PGBT and IH 35E segments were seen to spread all over the northern/eastern of DFW region as these two facilities are relatively long and dominant in the region.

The differences in ML users' geographical distribution and FWY users' do exist, but they are not significant enough to raise our concerns on sampling bias as well as social fairness/equity. As to the factors leading to the differences, one might reason that a user when traveling for longer distance tends to choose the ML option instead of the parallel freeway since it is evident that both NTE and IH 35E TEX had more long-distance trip makers.

Figure 2-1. Influence Area of PGBT Segment by Percent Registration Addresses (of Captured Licenses)

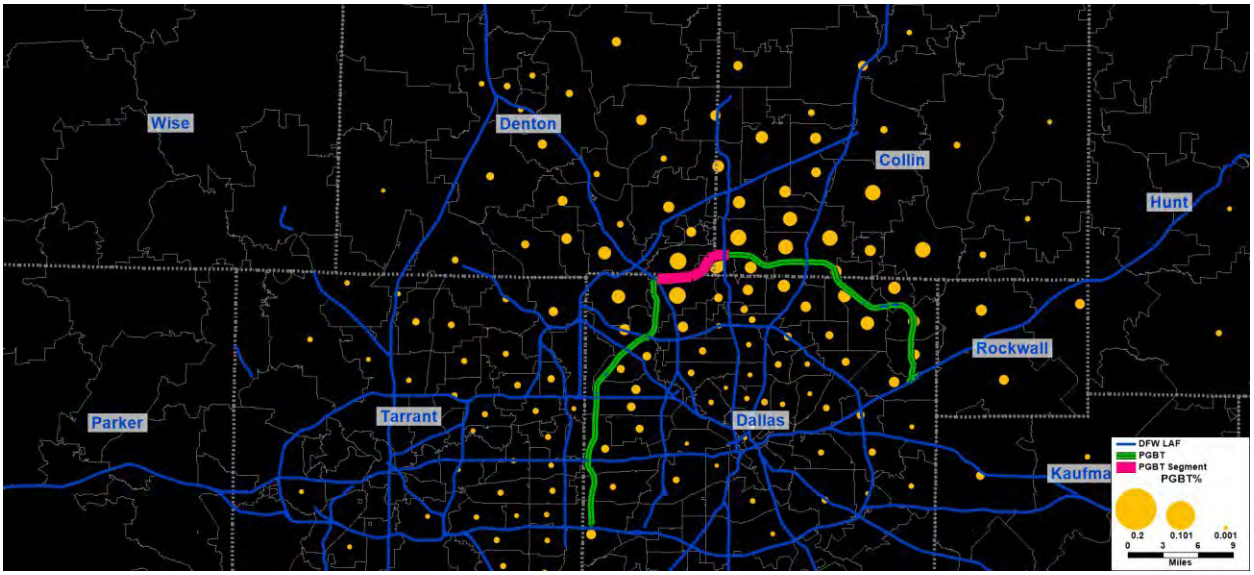


Figure 2-2. Influence Area of DNT Segment by Percent Registration Addresses (of Captured Licenses)

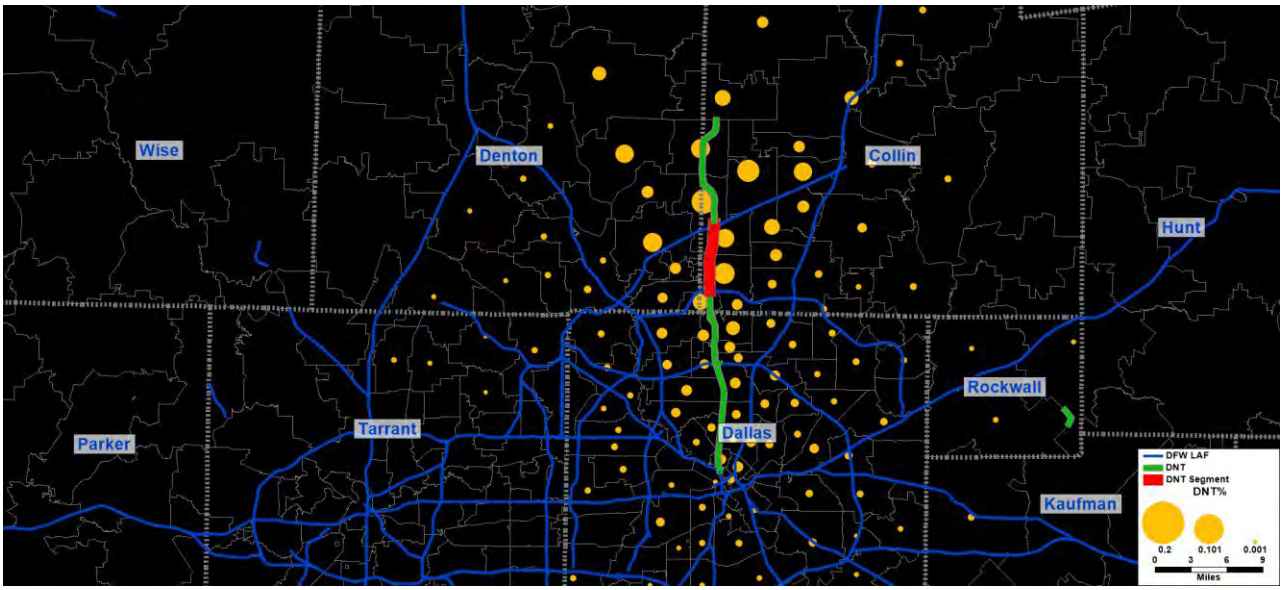


Figure 2-3. Influence Area of NTE Segment by Percent Registration Addresses (of Captured Licenses)

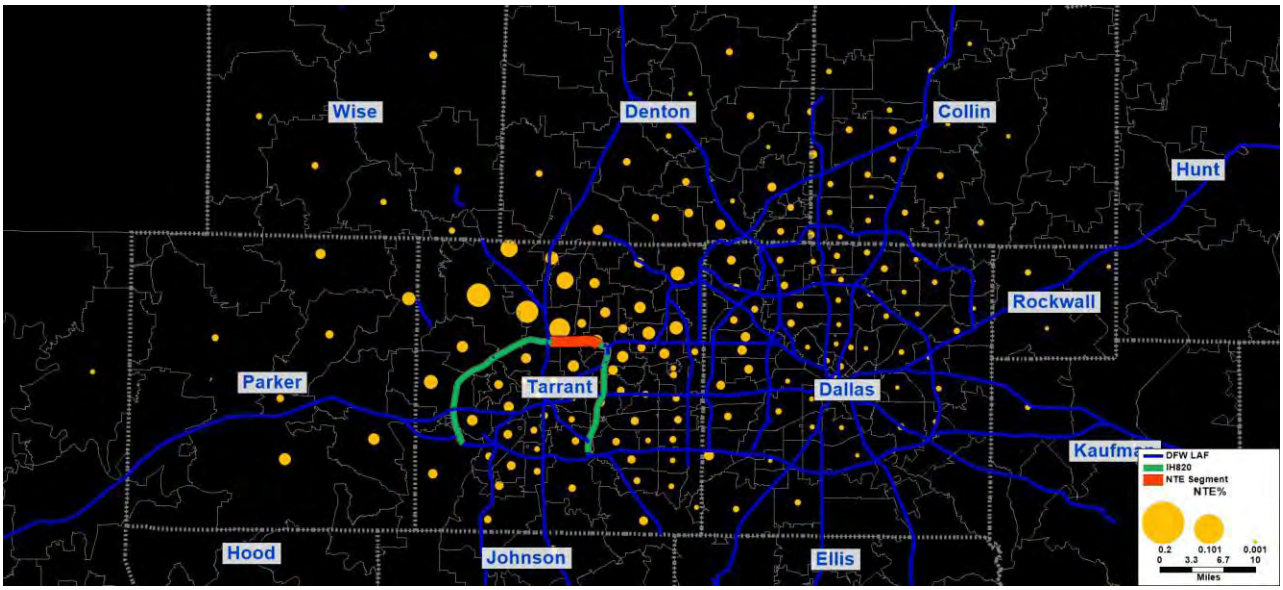


Figure 2-4. Influence Area of IH 820 Segment by Percent Registration Addresses (of Captured Licenses)

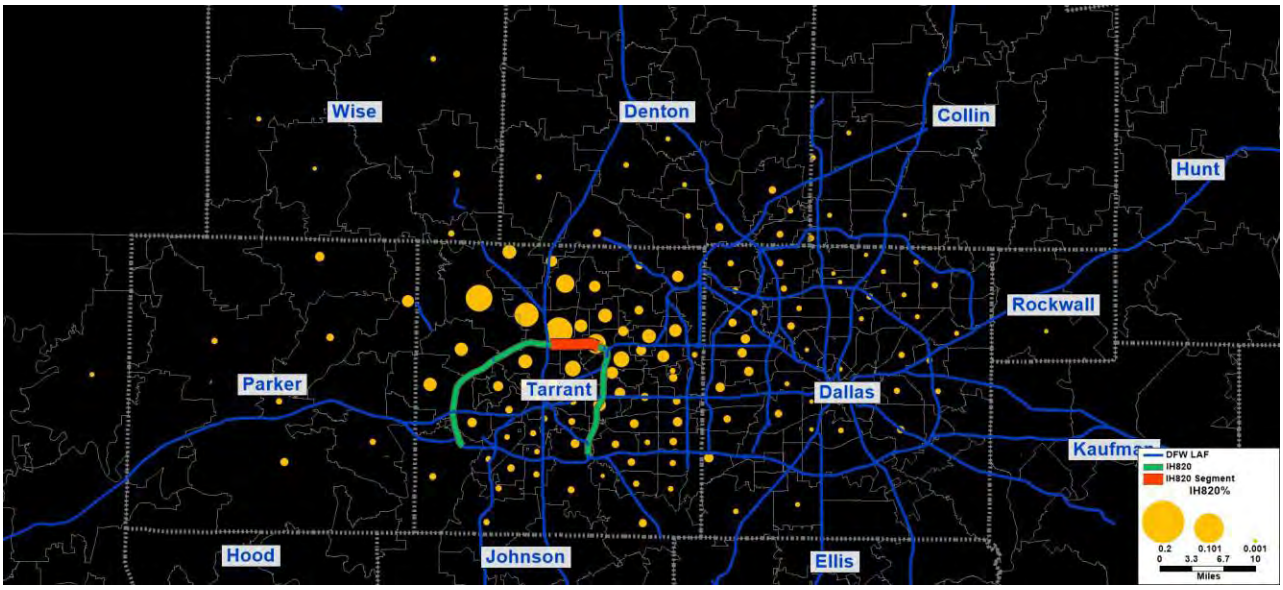


Figure 2-5. Influence Area of IH 35E TEX Segment by Percent Registration Addresses (of Captured Licenses)

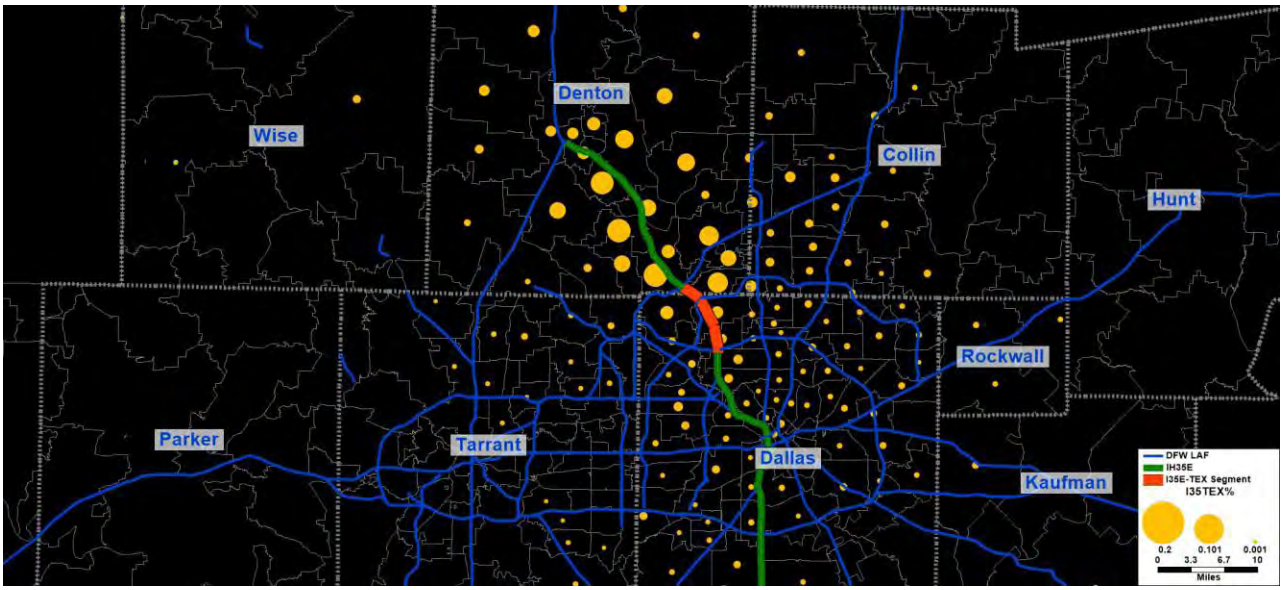
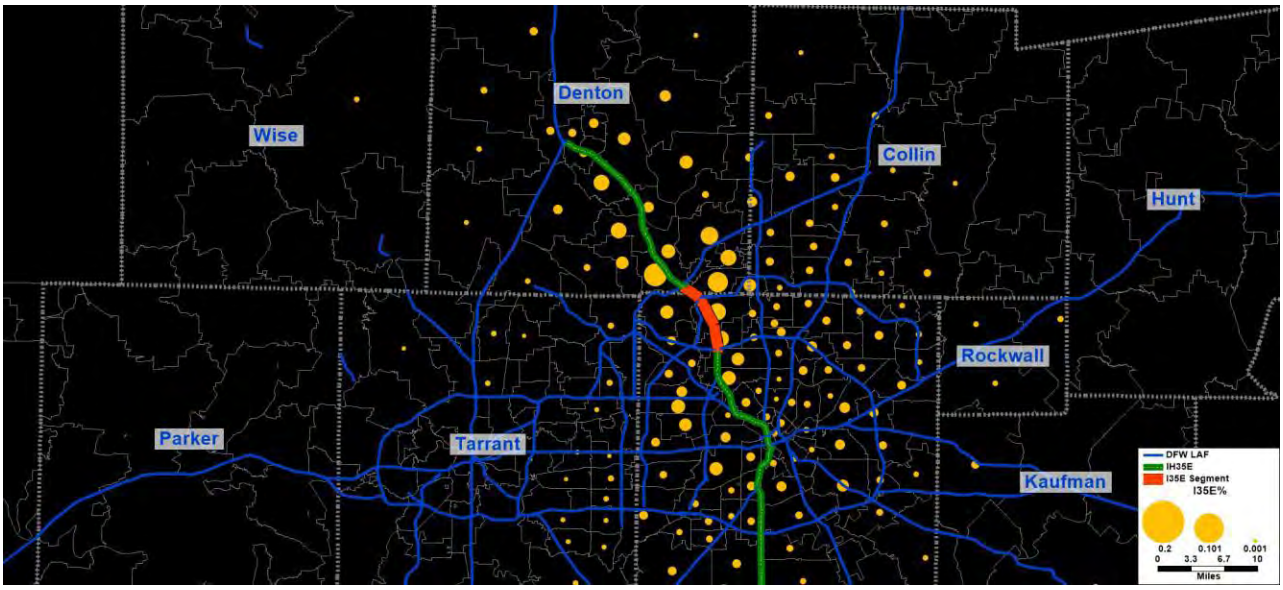


Figure 2-6. Influence Area of IH 35E Segment by Percent Registration Addresses (of Captured Licenses)



2.2.3 Survey Design

The consultant received the survey questions and required data from NCTCOG. In NCTCOG's specifications of the survey questionnaire, there are 29 survey questions that mainly fall into two categories, namely trip-making and user demographics.

In the first half of the survey, twenty questions covered many key elements of trips made on LAF segments including trip purpose, time period, toll awareness, toll paid/estimates, time savings, vehicle occupancy, trip frequency, and vehicle type. The survey's second half contained nine questions that focused on demographics and socioeconomics of LAF users. To draw their profile, age, household income, employment status, vehicle ownership, and number of children/employees/adults in a household were inquired. Because of the differences among the managed lanes (ML), toll roads, and freeway, there were specific questions designed to ask ML users on time savings as the ML segments have parallel alternatives. On the other hand, freeway users would not receive questions on toll amount as well as time savings.

Based on these 29 questions, the consultant designed the survey questionnaire form and tested the logic of the survey programming in a pilot survey to spot and correct the potential issues. The design of each data collection instrument was submitted to the NCTCOG Project Team for review and approval before final use in the full survey.

The survey questionnaire is provided in Appendix 6.3.

2.2.4 Pilot Survey and Findings

The consultant conducted a pilot test during November and early December 2021 to evaluate the survey methods and improve the survey programming including the questionnaire.

Since the sample of license plates that were captured by NCTCOG were limited, the consultant decided to keep the license samples for the full survey. For the pilot survey, the consultant used their own resident database and selected a random sample in the same region of the LAF segments. Six thousand households were randomly selected from a four-county area, which included Collin, Dallas, Denton, and Tarrant Counties. As part of the pilot, the three survey methods of postcard, email, and text were tested separately and in combination in the following ways:

1) Postcard alone
2) Email alone
3) Text alone
4) Combination of Text, Postcard, and Email
5) Combination of Text and Postcard

A total of 184 surveys were completed during the pilot test (Table 2-3). The combination of a postcard and text messaging with a $500 random drawing award extracted most responses in the pilot survey, therefore, it was chosen as the primary method of administration. Once recruited, the respondents may finish the survey questionnaire online using a mobile phone or computer. The consultant may still send emails and place phone calls as follow-up methods.

Table 2-3. The Pilot Survey Distribution by Facility

Facility	Completed Pilot Surveys	% by Facility
PGBT	19	10%
DNT	50	27%
NTE 183 ML	21	11%
IH 820	18	10%
IH 35E TEX	14	8%
IH 35	62	34%
Grand Total	**184**	**100%**

2.2.5 Conducting Full Survey

To conduct the full survey, about 147,000 households in the region were selected from two sources.

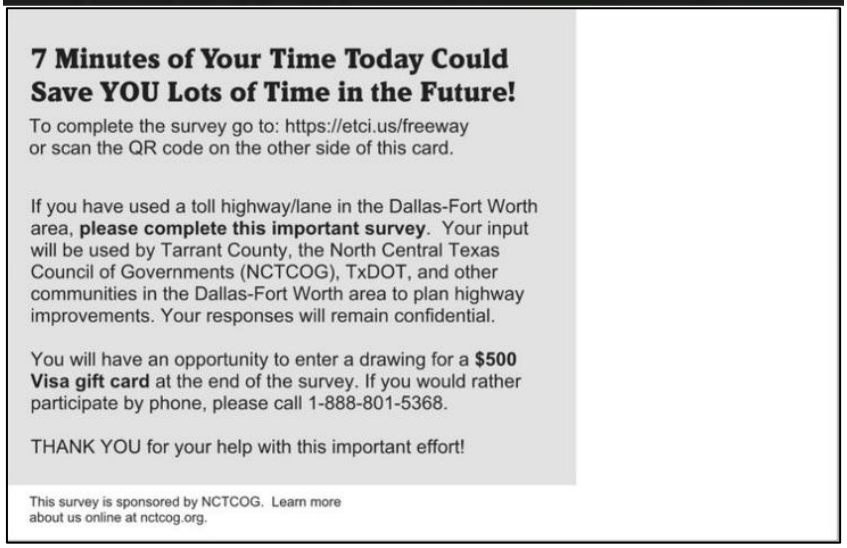
- Source 1 consists of 78,216 addresses that were validated from the addresses that were obtained from the license plates that were collected at the six LAF segments. These addresses were contacted by postcards during the period from late December 2021 to the end of January 2022. In the following week, the consultant also managed to send text messages and emails as follow-ups to nearly half of these households.

- Source 2 consists of 60,000 households that have were selected randomly from all households in Collin, Dallas, Denton, and Tarrant Counties. These households were selected with equal probability from a database owned by the consultant. Considering the possibility that the sampling goal was not met by the first source, the consultant prepared this second source.

The goal was to obtain 6,000 completed responses with at least 600 surveys (300 per direction) from each of the six LAF segments. The survey was conducted using the four means described below in different combinations. The invitation in the form of postcards and text messages were the primary methods.

Figure 2-7. The Front of Postcard to Recruit Survey Respondents

Figure 2-8. The Back of Postcard to Recruit Survey Respondents



Phase 1 of the survey was administered between December 20, 2021 and January 31, 2022. The postcards were mailed to the household addresses. All 78,219 households that were extracted by NCTCOG based on the captured license plates were sent a postcard by the consultant. The contents of the postcards were tailored to the county where the respondent lives. An example of the postcard to residents of Tarrant County is presented in Figure 2-7 and Figure 2-8.

Recipients of the postcards can participate in the survey in one of three manners:

- Scanning the QR code on the postcard
- Entering the URL printed on the postcard into any browser
- Calling a toll-free number provided

Based on the results of the pilot test, ETC Institute decided to have a random drawing for a $500 gift card as an incentive to participate after testing a $10 award and a drawing for a $1,000 gift card in the pilot survey phase.

In addition to sending households a postcard about the survey, the consultant also sent up to two texts to 44 percent of the households in the sample pool seven days after mailing the postcard. Tailored for different county's residents, the texts simply contained a link to the online survey's landing page as well as an "opt out" choice.

Figure 2-9. A Screen Shot of Survey Landing Page (for Smartphone Users)

The consultant also managed to obtain emails from 38 percent of the sample households. As the follow-up invitation, two emails were sent ten days after mailing the post cards. The email contained a link to the online survey along with a phone number so that the respondents could complete the survey by going online or by phone. The email was in both English and Spanish format.

To ensure that people who have no internet access can participate in the survey, the consultant offered the option of completing the survey by phone and mail. Respondents can call a toll-free number on the postcards and either complete the survey or request a printed copy with a return envelope. The consultant also sponsored ads on social media like Facebook and Instagram to raise awareness of the survey from January 17 to March 15, 2022. These ads targeted residents in Collin, Dallas, Denton, and Tarrant Counties. The ads raised awareness of the survey which increased the likelihood that residents responded to the postcards, texts, and emails.

2.2.6 Statistics and Deliverables of the Survey

The consultant achieved the goals of the survey. The survey was conducted in two phases. As of the end of Phase 1, ETC Institute had collected survey data for 4,736 trips from the 78,216 addresses (based on captured license plates). However, only two segments reached the goal of 600 surveys, PGBT and DNT. The goals had not been met on the four other facilities. Therefore, an additional sample pool was necessary for Phase 2. The consultant prepared another sample pool of 60,000 households that were selected at random in Collin, Dallas, Denton, and Tarrant Counties. These households were selected using an address-based selection process to ensure an equal probability of being selected. The consultant also supplemented 9,000 households randomly selected from a 5-mile buffer along the facilities to help guarantee the sampling goals. In the end, the consultant successfully collected 7,646 survey responses by the end of March 2022.

After the survey database was cleaned and ineligible respondents were removed, a total of 6,513 complete trips were ready and legible to the further research as shown in the table below.

Table 2-4. The Complete Surveys After Preliminary Check

Facility	Complete	Disqualified Pro Driver	Partial	Grand Total
1. President George Bush Turnpike Toll Road between I-35E and DNT	1867	47	342	2256
2. Dallas North Tollway between PGBT and SRT	1745	25	245	2015
3. North Tarrant Express - 183 Toll Road between I-35W and Highway 121	782	17	125	924
4. Interstate 820 between I-35W and Highway 121 (parallel to NTE 183 Toll Road	522	9	85	616
5. The TOLL LANES on I-35E between I-635 and Highway 121	734	14	95	843
6. The FREE LANES on I-35E between I-635 and Highway 121	863	18	111	992
Grand Total	**6513**	**130**	**1003**	**7646**

During the full survey, it was observed that the overall response rate to the survey recruitment was 6.4 percent, which was slightly better than that of the pilot survey (5.2 percent). The response rate of the samples from the license plate collection was 6.9 percent. The response rate of the four-county random samples of Phase 2 was 5.5 percent. These are within the expectation.

Since ETC Institute contacted most respondents using more than one method, it is difficult to identify which method contributed most to the completion of the survey. For example, a person may be more likely to respond to a text invitation about the survey due to getting the postcard beforehand.

As to the means of survey responses, among the 7,646 raw surveys collected, 3,455 surveys were completed by respondents via scanning the QR code on postcards or manually entering the survey URL. Text had the second highest level of response. After clicking a survey link sent as a text, 3,251 respondents completed the survey. Email was third. Only 456 people responded to this survey from a link sent in an email. The consultant also identified significant decreases in responses based on their experiences in the past years as concerns about email security keep rising. Social media ads were fourth.

A total of 311 people who had a verifiable address completed the survey as the result of clicking on Facebook or Instagram advertisement. Phone was last. All 172 people who completed the survey by phone called the consultant and spoke with an interviewer.

Table 2-5. The Proportions of Raw Survey by Completion Method

Method of Completion	# Received	% Proportion
Postcard QR Code or URL	3,456	45.20%
Text Link	3,251	42.50%
Email Link	456	6.00%
Phone	172	2.20%
Social Media Ad	311	4.10%
TOTAL	**7,646**	**100.00%**

Note that the 7,646 returned survey samples were not 100 percent eligible for research purposes because of various reasons. Firstly, the check was on the completeness of the survey samples, including two aspects:

- **Trip Completeness:** The questions involving origin, destination, time of travel, and facility name must be answered for a survey record to be legit.
- **Data Completeness:** For the rest of survey questions other than forementioned trip ones, at least 80 percent of them needed to be completed to be accepted as completed surveys.

As a result, 1,003 surveys were classified as “partial”.

Secondly, 130 surveys were completed by professional drivers (Uber, Lyft, etc). Because the value-of-time of their trips had different nature from the rest of the respondents, these surveys were excluded as well. At this phase, 6,513 complete surveys were deemed complete.

The next step was to run a quality-control check on these 6,513 complete surveys to evaluate if they are reliable for the study. Having visualized the survey records in GIS maps, the consultant conducted a logical review of the survey trips. It was found that 635 surveys were filled with apparent errors or missing information so that they reported an invalid trip path. For example, trips that lack entry and exit ramp information or have infeasible entry and exit locations may not be used for travel pattern or toll valuation analysis, since the trip time and distance cannot be estimated. In other words, the conflicting logical origin and destination relative to the surveyed facility was the primary reason why these surveys failed to pass the quality-control check. As a result, 5,878 complete surveys passed the quality-control check and were incorporated into the final database as the survey deliverable.

Table 2-6. The Breakdown of Final Survey Samples by LAF Segments

Facilities	Final Verified	Failed	Complete Survey
1. PGBT	**1,544**	323	1,867
2. DNT	**1,606**	139	1,745
3. NTE	**724**	58	782
4. IH 820	**492**	30	522
5. IH 35E TEX	**699**	35	734
6. IH 35E	**813**	50	863
Total	**5,878**	635	6,513

Prior to conducting the survey, NCTCOG and the consultant had planned to obtain 6,000 complete surveys, with at least 600 (or 300 in each direction, ideally) for each facility. However, the real world did not respond as planned. Two fixed-toll facilities, PGBT and DNT, generated many more survey samples than the rest. About half of all usable survey samples were from these two facilities. On the other hand, two managed lane facilities, NTE and IH 35E TEX, also meet the planned target. As to the freeway facilities, while IH 35E returned 813 surveys, IH 820 generated only 492 samples, making itself the least sampled segment.

Chapter 3. Limited Access Facilities Survey Database

3.1 Cleaning & Checking

After the consultant did a preliminary data cleaning and correction on the 7,646 raw survey responses. There were 5,878 verified surveys that were delivered to NCTCOG together with the documentation of the process.

NCTCOG then imported the surveys into a SQL database. The NCTCOG Project Team then conducted error-checking and corrected two erroneous surveys that the consultant overlooked.

3.2 Survey Expansion

There are 5,878 complete surveys in the Limited Access Facilities user survey database that was developed using SQL Server.

Table 3-1. The Number and Percentage of Completed Surveys for Study by Facility

Facilities	1. PGBT	2. DNT	3. NTE	4. IH 820	5. IH 35E TEX	6. IH 35E	Total
Verified Completed	1,544	1,606	724	492	699	813	5,878
%	26%	27%	12%	8%	12%	14%	100%

Prior to studying the data, the bias carried by these survey samples need to be solved by a survey expansion. The bias existed at two levels. Firstly, some LAF segments collected far more surveys than the others did (Table 3-1). Secondly, for a specific LAF segment, the users taking different paths took different proportions. In other words, these surveys cannot be compared to each other directly. To expand the data, the samples will be aggregated by direction using the corresponding entrance and exit ramps and expanded using the traffic counts collected at each entrance and exit ramp. The process of the expansion is discussed in this section.

For each LAF segment, an origin-destination (OD) matrix was created based on the entry and exit ramps used by each survey sample. The rows correspond to the entrance ramps and the columns correspond to the exit ramps of the LAF Segment. Figure 3-1 shows the surveys collected from the PGBT westbound segment in the form of an OD matrix of entrance and exit ramps; the abbreviation ML in the row and column headings of the figure correspond to “mainline”. The number in each cell represents how many samples travelled in the corresponding combination of entry and exit. For example, on Frankford Rd. (Row 5) and mainline west of Old Denton (Column 1), the consultant collected 33 surveys submitted by users who entered the PGBT segment from Frankford Rd. ramp and traveled to the west along the main line. As the figure shows, a total of 750 surveys were completed by the users of the PGBT westbound segment; this number is shown in the lower right corner as the sum of the Totals column as well as the sum of the Totals row.

Figure 3-1. The Distribution of PGBT Survey based on Entrances and Exits

PGBT Westbound	Exit Ramps	ML w of Old Denton	Old Denton	Josey	Trinity Mills/Kly	Frankford	Midway	ML east of Midway	
Entrance Ramps		1	2	3	4	5	6	7	Totals
ML west of Old Denton	1								0
Old Denton	2	25							25
Josey	3	23	7						30
Trinity Mills/Kelly	4	30	8	6					44
Frankford	5	33	6	6	4				49
Midway	6	29	4	6	4	5			48
ML east of Midway	7	390	41	35	32	38	18		554
Totals		530	66	53	40	43	18	0	750

Note that Figure 3-1 also indicates the need for aggregation of survey records. For example, seven surveys were collected which entered on Josey and exited on Old Denton. It is not statistically sound to treat a small number of surveys the same way as tens of surveys using the mainline. They are not supposed to carry identical weights in the observation. To solve each collected survey's unknown weight, or in other words, to make sure each sample equally represents the LAF users, NCTCOG staff applied traffic counts collected along the surveyed segments as the constraints for the row totals and columns to facilitate the expansion.

Due to the very low number of raw samples of some pairs of entry-exit combinations, the values of weight would be too high to be reliable. To prevent this issue, each cell was required to contain at least 30 surveys before running survey expansion. In order to make this happen, neighboring entrances or neighboring exits had to be aggregated in any case where a cell had insufficient raw survey samples available, which was defined as less than 30. Using these rules, the ramps of PGBT westbound segment sample counts were aggregated as shown in Figure 3-2.

Figure 3-2. The Aggregation of PGBT Surveys based on Nearby Entrances and Exits

PGBT Westbound Surveys	Exit Ramps	ML + Old Denton	Josey + Trinity/Kelly	Frank + Midway	ML, E of Midway		
Entrance Ramps		1	2	3	4	Totals	Counts
ML + Old Denton	1					0	
Josey + Trinity/Kelly	2	99				99	21942
Frankford + Midway	3	72	25			97	7766
ML, E of Midway	4	431	67	56		554	52441
Totals		602	92	56		750	
Counts		58417	4610	16109			

As described in Chapter 2, all entry and exit ramps as well as the mainlines of a LAF segment were counted. Like the sample records, the traffic counts were aggregated to correspond to the survey samples; the totals by entrance and exit are shown in the Counts row and Counts column shown in Figure 3-2 as well. Observing the counts as constraints for each row and column, the surveys were grown following the relative proportions among themselves, which is essentially the core of survey expansion methodology. The Iterative Proportional Fitting (IPF) was then applied, which aims at distributing the traffic counts to each cell of the OD matrix according to relative proportions of the survey samples in all cells, thus creating survey samples for all plausible OD paths. Figure 3-3 was in fact the output of the IPF process.

Westbound PGBT's final survey weights were shown by Figure 3-3. As a benchmark, the overall expansion factor would be 107.5 if we simply treated each survey sample equally. However, after the survey expansion, specific weights can be assigned to each cell (entrance and exit combination) to better reflect the users' proportions in the real world. Apparently, those who entered or exited mainline received much higher weights (213.4 and 293.1) since they represented a larger group of the users of

PGBT. On the other hand, those pairs of ramps that shouldered little traffic were assigned much lower weights. One example is a weight value of 55.8 assigned to those who entered at “Frankford and Midway” and exited at “Josey and Trinity/Kelly”.

Figure 3-3. The Survey Expansion Factors for PGBT Surveys (Westbound)

PGBT WB Expansion Factors	Exit Ramps	ML + Old Denton	Josey + Trinity/Kly	Frank + Midway	ML, E of Midway	
Entrance Ramps		1	2	3	4	
ML + Old Denton	1					
Josey + Trinity/Kelly	2	213.4				
Frankford + Midway	3	84.8	55.8			
ML, E of Midway	4	74.9	49.3	293.1		
Overall Expansion Factor						107.5

Using the same method, the survey expansion was conducted on all 5,878 survey samples for all six LAF segments. As Chapter 2 described, all entry and exit ramps as well as the mainlines of a LAF segment had traffic counts. All 5,878 survey samples were arranged to fill the OD matrices for their corresponding LAF Segment by direction, entrance ramp, and exit ramp in this way. Readers may refer to the Appendix in Chapter 6.5 on all the steps of survey expansion as well as the weights derived for all six LAF segments by direction. However, the survey expansion did compromise due to some limitations that may not be easily overcome. In the initial step of survey expansion, all the OD matrices of six LAF segments reduced the initial dimensions in order to aggregate at least 30 samples for the cells of matrices. Therefore, overall, 48 sample weights were derived and assigned to the survey samples of all six facilities.

In the following step, all the survey samples in the SQL database were then updated by all the sample weights according to the entry and exit combinations. The 5,878 raw samples were expanded to 839,000 trips on six LAF segments as shown by Table 3-2.

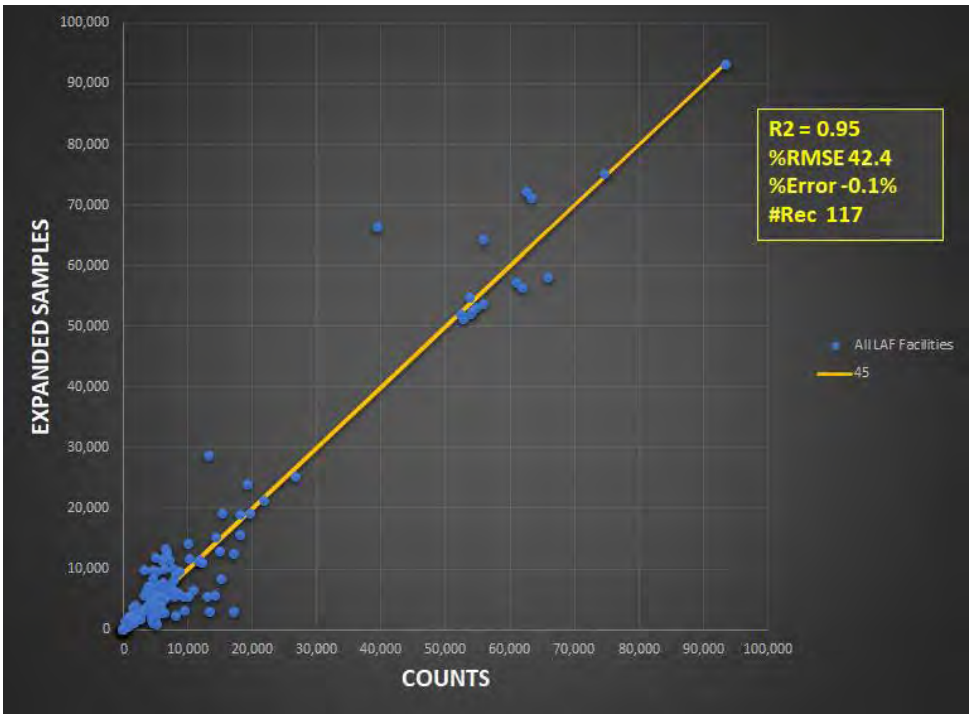
Table 3-2. The Expanded Survey Samples by LAF Facilities

LAF Facilities	PGBT	DNT	NTE	IH 820	IH 35E TEX	IH 35E	**Total**
Surveys	163,200	198,509	57,329	189,998	19,136	211,097	**839,269**

To evaluate the quality of the expansion process, the weighted samples by locations, including both the ramps and the mainlines were summarized. It was expected that the sum of weighted samples would be substantially close to the counts collected from LAF facilities. A comparison was made for each LAF facility as well as overall.

Figure 3-4 depicts the counts on the x-axis and the corresponding expanded sample weight on the y- axis. Since many points are close to the 45-degree line illustrated in orange, it shows that in general the weighted samples had a statistically good match to the traffic counts for all six LAF facilities. There are some data points that are somewhat distant from the 45-degree line, which appears to have been caused by the lack of raw samples in certain location since the aggregation of nearby counts cannot convey the proportion of traffic counts to the corresponding expanded samples. Considering that these problematic data points can be attributed to the limit of too few raw surveys samples, the results were acceptable.

Figure 3-4. The Comparison of Expanded Sample Sums and 117 Traffic Counts of LAF Facilities



Based on this review, we gained confidence in applying the expanded survey database to further research and inquiries.

Chapter 4. LAF Survey Findings

With the limited access facility user database in place, many questions to the regional LAF users may be answered simply by querying the database. NCTCOG found many observations that were unique and unexpected as the study like the LAF survey has been rarely done. NCTCOG had raised questions, analyzed the causes and factors, and made conclusions, which were presented in this chapter.

When designing the survey questionnaire, NCTCOG staff had put the most essential yet unknown questions into the survey. Naturally, the first batch of queries was to find out the answers to each question in the survey for the LAF users.

The most desirable information generally falls into two categories: trip-related, and demographic/socioeconomic. Each question from the survey essentially provided a dimensional variable for us to investigate. For example, "How much toll did you pay on the segment of PGBT?" The answers to this question were for a dimensional variable of the ***toll***. Many dimensional variables may provide fresh and insightful observation based on the survey database. These dimensional variables include trip purposes, time period, toll amount, etc. Queries using these variables brought in interesting observations that were discussed in this chapter. In addition, some key variables may be jointly queried to dig the deeper cross-classification profile of the LAF users. Several exploring experiments were also presented.

4.1 Trip Characteristics of LAF Users

From the perspective of travel demand modeling, the trip purposes of LAF users were of important reference. Were the home-based work (HBW) trips dominating? Was the trip purpose distribution vastly different across different facilities? Such questions may be answered by the survey database.

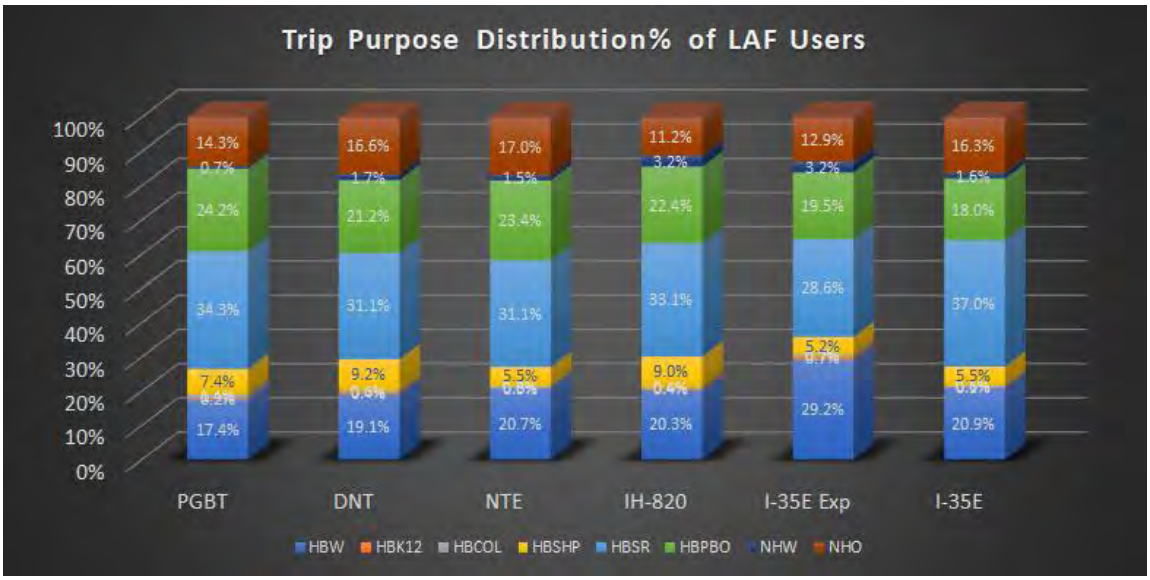
The trip purposes used by the survey aligned with those in the NCTCOG regional travel demand model, and they are: Home-based Work (HBW), Home-based K-12 drop/pickup (HBK12), Home-based College (HBCOL), Home-based Shopping (HBSHP), Home-based Social/Recreational (HBSR), Home-based Personal Business/Other (HBPBO), Non-home-based Work (NHW), and Non-Home-based Other (NHO).

Table 4-1. The LAF User Distribution by Trip Purposes

Facility	HBW	HBK12	HBCOL	HBSHP	HBSR	HBPBO	NHW	NHO
PGBT	28,455	304	2,292	12,117	56,012	39,540	1,219	23,260
DNT	37,964	874	1,250	18,169	61,693	42,158	3,362	33,040
NTE	11,865	0	484	3,156	17,852	13,392	861	9,719
IH 820	38,587	773	773	17,013	62,897	42,551	6,167	21,236
IH 35E TEX	5,580	143	143	991	5,469	3,725	613	2,470
IH 35E	44,206	233	1,224	11,651	78,066	37,953	3,446	34,318
Total	166,657	2,327	6,165	63,097	281,989	179,320	15,669	124,044
Purpose %	**HBW**	**HBK12**	**HBCOL**	**HBSHP**	**HBSR**	**HBPBO**	**NHW**	**NHO**
PGBT	17.4%	0.2%	1.4%	7.4%	34.3%	24.2%	0.7%	14.3%
DNT	19.1%	0.4%	0.6%	9.2%	31.1%	21.2%	1.7%	16.6%
NTE	20.7%	0.0%	0.8%	5.5%	31.1%	23.4%	1.5%	17.0%

IH 820	20.3%	0.4%	0.4%	9.0%	33.1%	22.4%	3.2%	11.2%
IH 35E TEX	29.2%	0.7%	0.7%	5.2%	28.6%	19.5%	3.2%	12.9%
IH 35E	20.9%	0.1%	0.6%	5.5%	37.0%	18.0%	1.6%	16.3%
Total	19.9%	0.3%	0.7%	7.5%	33.6%	21.4%	1.9%	14.8%

Figure 4-1. Percent Trip Purpose Distribution of LAF Users by Facilities



The distribution of trip purpose presented some insights that may be different from usual opinion/expectation. It is evident that home-based social recreational activities were dominant, and remained consistently at 30 percent or more, while home-based work trips were around 20 percent, often lower than home-based personal business. Another interesting observation was that except for IH 35E TEX, the trip purpose distribution is similar/uniform among all facilities regardless the facility is tolled or not. Overall, we gained an impression that work-purpose trips were not as many as expected. If aggregating all the home-based trips that were not work-related (HBK12, HBCOL, HBSHP, HBSR, HBPBO), one may find that home-based nonwork (HBNW) trips consistently dominating at more than 50 percent.

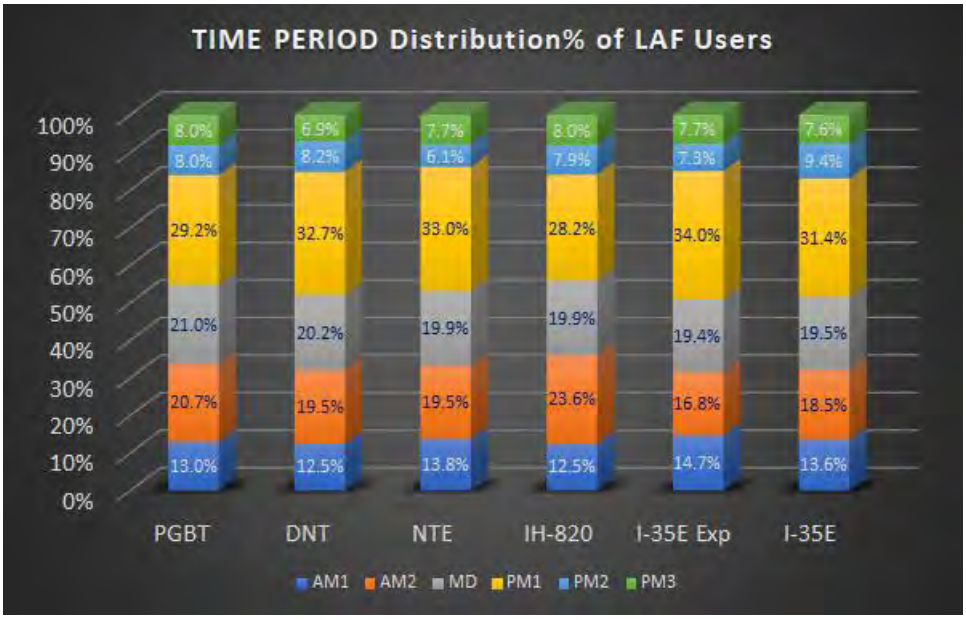
Next we investigated the distribution of survey trips across different time periods of a weekday. It was observed that the trips made in AM1 (6:00AM~9:00AM) were less than those in AM2 (9:00AM~12:00PM), which was unexpected considering the two time periods with equally three hours. The PM1 (3:00PM~7:00PM) was clearly the most congested period with about 30 percent daily traffic. These distributions were relatively consistent across all six segments. Note that the 4-hour PM1 carried more than twice survey responses than the 3-hour AM1.

Table 4-2. The LAF User Distribution by Time Periods

Facility	AM1	AM2	MD	PM1	PM2	PM3	Sum
PGBT	21,294	33,731	34,332	47,659	13,109	13,076	163,200
DNT	24,793	38,685	40,048	64,867	16,323	13,793	198,509
NTE	7,897	11,166	11,407	18,924	3,494	4,442	57,329

IH 820	23,673	44,793	37,736	53,598	15,089	15,109	189,998
IH 35E TEX	2,817	3,220	3,722	6,509	1,397	1,472	19,136
IH 35E	28,670	39,044	41,234	66,339	19,828	15,982	211,097
Total	109,145	170,639	168,478	257,895	69,240	63,872	839,269
%	**AM1**	**AM2**	**MD**	**PM1**	**PM2**	**PM3**	**Sum**
PGBT	13.0%	20.7%	21.0%	29.2%	8.0%	8.0%	100.0%
DNT	12.5%	19.5%	20.2%	32.7%	8.2%	6.9%	100.0%
NTE	13.8%	19.5%	19.9%	33.0%	6.1%	7.7%	100.0%
IH 820	12.5%	23.6%	19.9%	28.2%	7.9%	8.0%	100.0%
IH 35E TEX	14.7%	16.8%	19.4%	34.0%	7.3%	7.7%	100.0%
IH 35E	13.6%	18.5%	19.5%	31.4%	9.4%	7.6%	100.0%
Total	13.0%	20.3%	20.1%	30.7%	8.3%	7.6%	100.0%

Figure 4-2. Percent Distribution of LAF Users by Time Periods



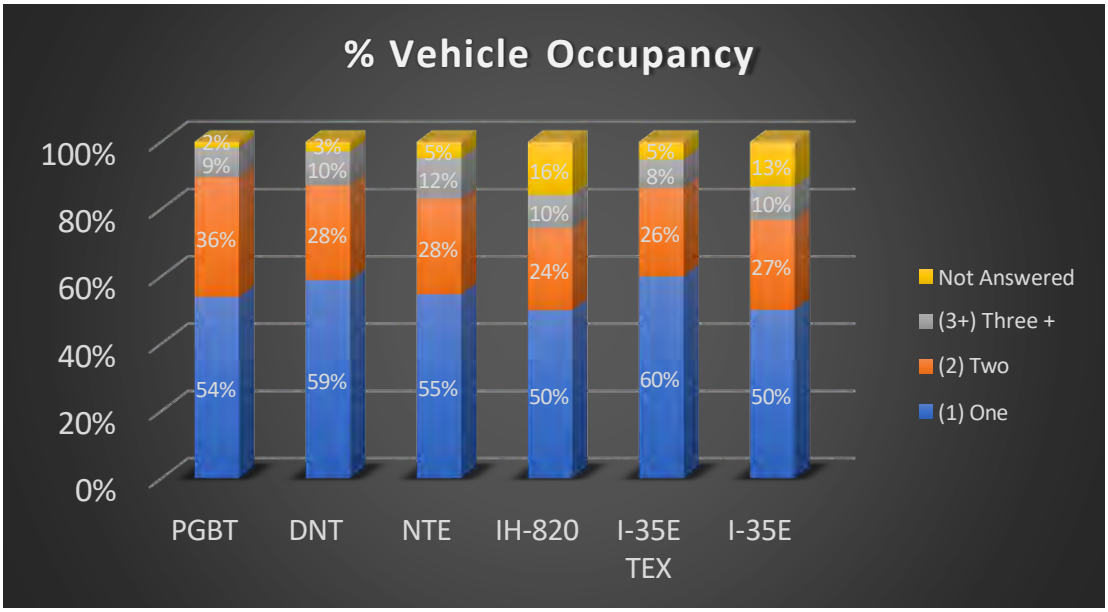
Another perspective to learn the trips on these LAF segments was the vehicle occupancy. It was examined and presented by Table 4-3. Apparently, drive-alone was dominant with at least 50 percent across the six segments.

Table 4-3. The Proportion of Vehicle Occupancy by Facilities

Vehicle Occupancy	(1) One	(2) Two	(3+) Three+	No Answer	Sum
PGBT	88,021	58,144	14,236	2,800	163,200
DNT	116,875	56,067	19,793	5,775	198,509
NTE	31,347	16,284	6,886	2,813	57,329
IH 820	94,999	46,300	18,540	30,159	189,998
IH 35E TEX	11,489	5,017	1,608	1,022	19,136

IH 35E	105,645	56,398	21,096	27,958	211,097
Total	448,375	238,210	82,158	70,525	839,269

Figure 4-3. Percent Distribution of LAF Trips by Vehicle Occupancy



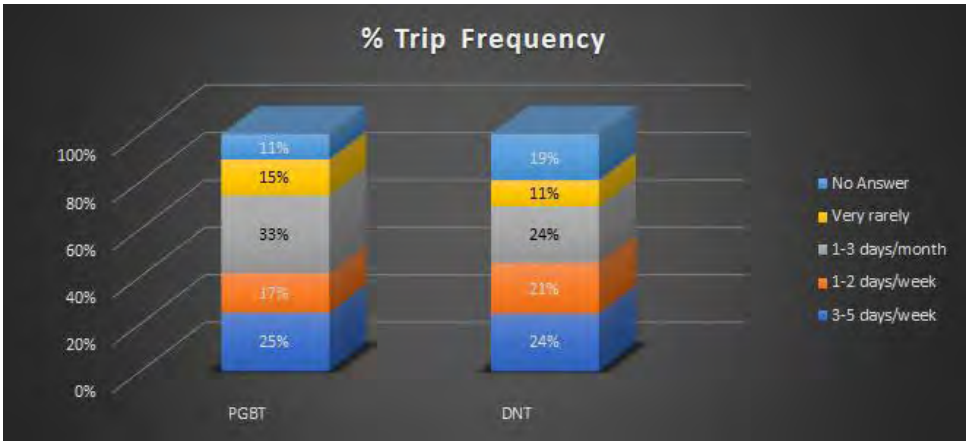
The categories of vehicles used in these LAF trips were considered. The vehicle types were summarized. It turned out that the regular cars with two axles were dominant (amounting to 98 percent). The rest were mainly 3-axle or 4-axle trucks. As shown by Table 4-4, this distribution was essentially consistent across all LAF segments.

Table 4-4. The LAF User Distribution by Vehicle Types

Vehicle Type	Surveys	%
2-axle Vehicle (cars, SUVs, pickups, motorcycles)	822,131	98.0%
3-axle Truck	2,945	0.4%
3-axle Truck with a Trailer	773	0.1%
3-axle Vehicle and Vehicle Combination	777	0.1%
4-axle Truck with a Trailer	806	0.1%
4-axle Vehicle and Vehicle Combination	6,342	0.8%
5-axle Truck with a Trailer	839	0.1%
5-axle Vehicle and Vehicle Combination	487	0.1%
6+ axle Vehicle and Vehicle Combination	607	0.1%
Bus and RV	3,357	0.4%
Heavy Truck or Special Permit Vehicle	203	0.0%
Total	839,269	

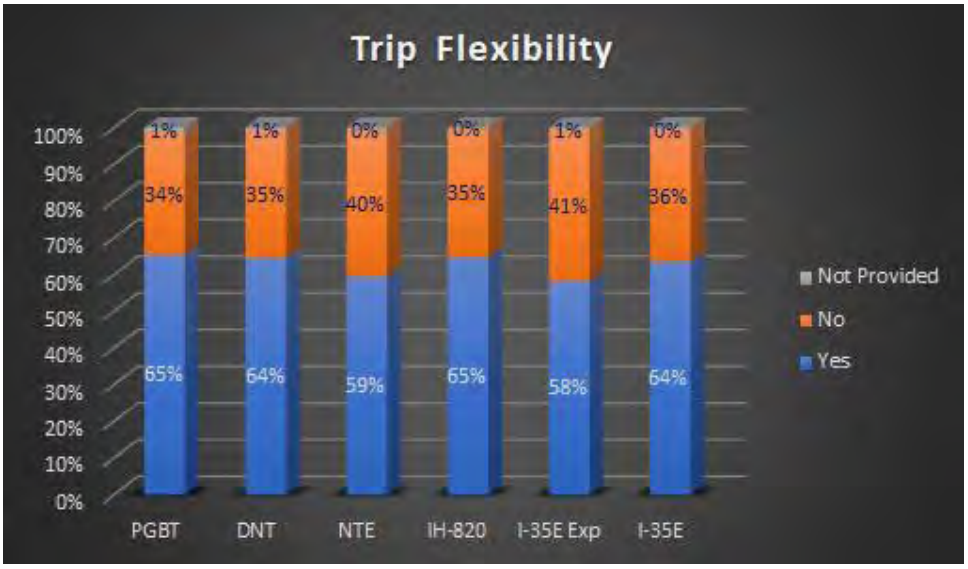
Other than vehicles, “How often do you use the facility?” was also an essential question regarding the utility to LAF users. As shown by Figure 4-4, the users of two toll roads (PGBT and DNT) demonstratedthat more than 40 percent of trips happened in at least a couple of days per week. It was also noteworthy that the low-frequency users (1~3 times per month or fewer) taking considerable proportions, amounting to 35 percent for DNT, and 48 percent for PGBT respectively. However, due to an error in survey implementation, the survey failed to collect the trip frequency responses from the users of two managed lane facilities (NTE and IH 35E TEX) and two parallel freeways (IH 820 and IH 35E).

Figure 4-4. Percent Distribution of LAF Users by Trip Frequency



Like trip frequency, the flexibility of making these trips was also studied. It was found that about 60 percent of travelers were flexible about when to initiate their trips, which is somewhat surprising (Figure 4-5). Whether a facility charges a fee or not did not seem to affect this percentage, since two freeway segments (IH 820 and IH 35E) demonstrated little difference.

Figure 4-5. Percent Distribution of LAF Users by Trip Flexibility



As one of the most important topics in transportation studies, trip length distribution was summarized and examined. Figure 4-6 drew the trip length distribution in terms of trip time (minute) for respondents from all six segments. It clearly suggested that about 0.69 million surveyed trips took time that ranged

from 15 minutes to 60 minutes. Those who made trips in the '30~60 minute' bracket occupied 44 percent of all respondents. One may also conclude that under 10 percent of respondents needed to make trips longer than 60 minutes (Figure 4-7).

Figure 4-6. Trip Length Distribution of LAF Users (minute)

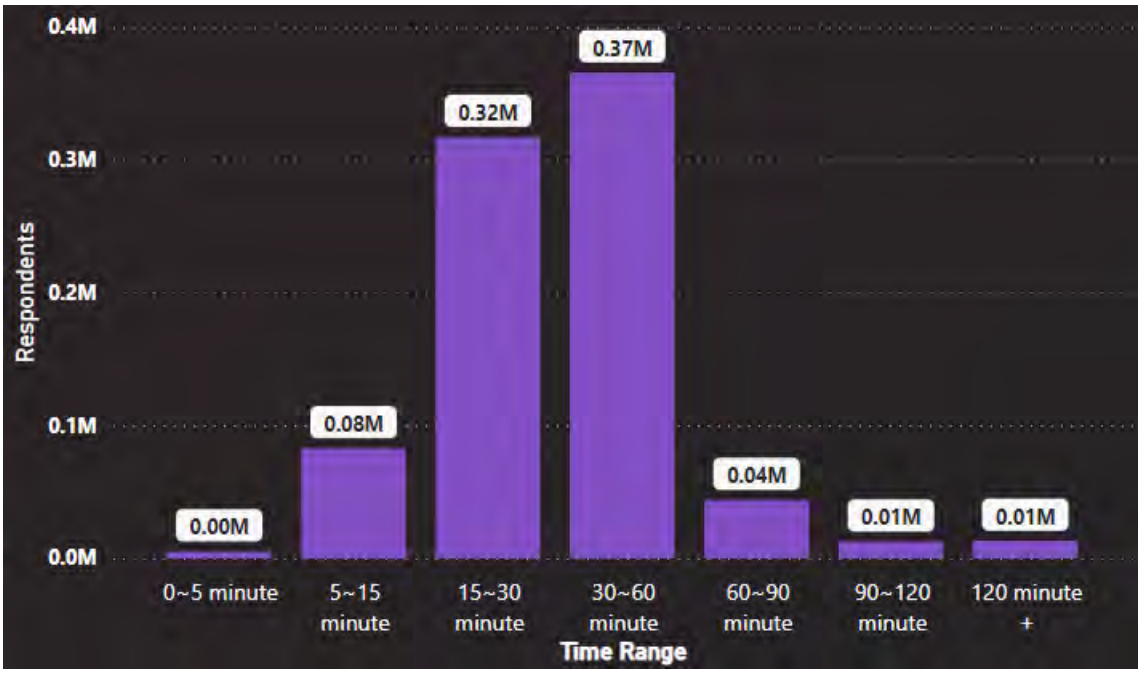
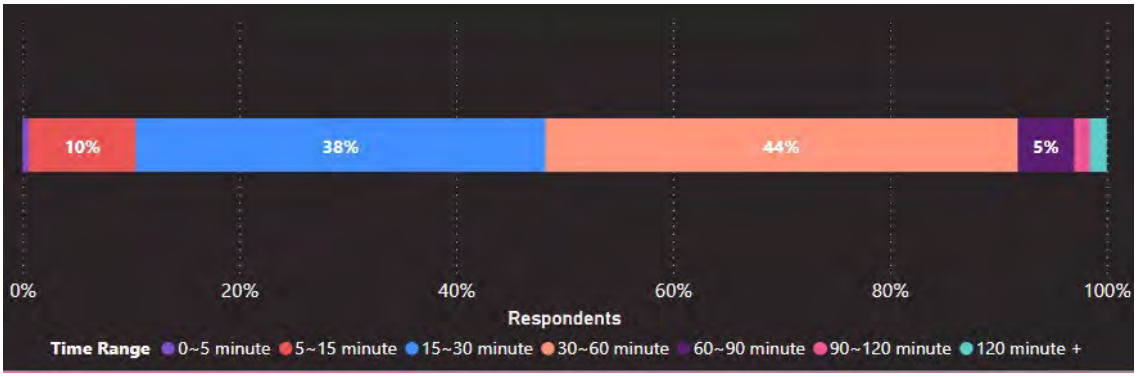


Figure 4-7. The Percentage of LAF Users by Trip Length Distribution (minute)



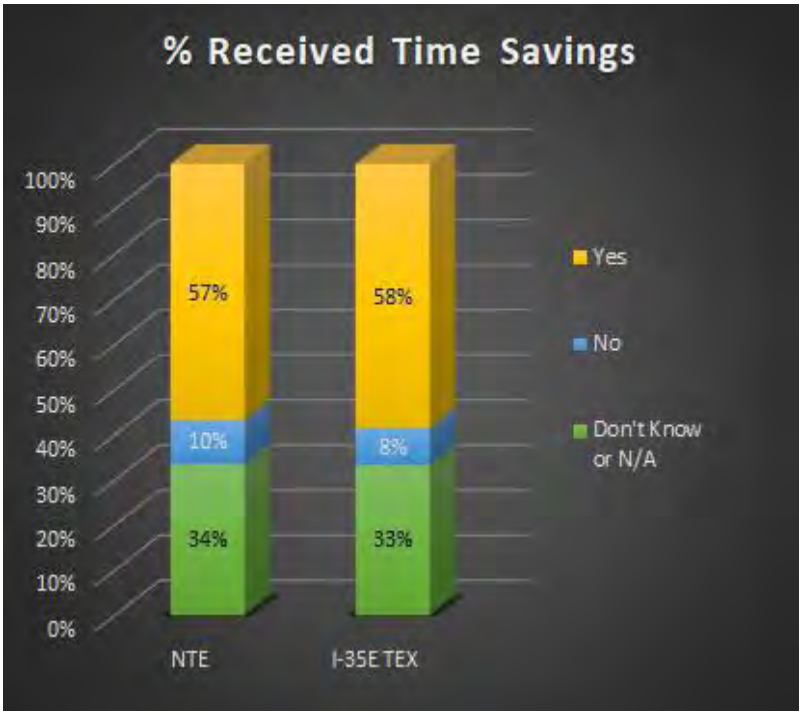
To be specific, the average trip lengths were summarized and presented in Table 4-5. For all respondents, 39 minutes were the average trip time.

Table 4-5. Average and Median of Trip Length of LAF Users

Facilities	Trip Length (minute)	
	Average	Median
PGBT	36.5	30
DNT	34.0	30
NTE	42.9	40
IH 820	45.5	35
IH 35E TEX	43.1	40
IH 35E	44.4	36
All	**39.0**	**35**

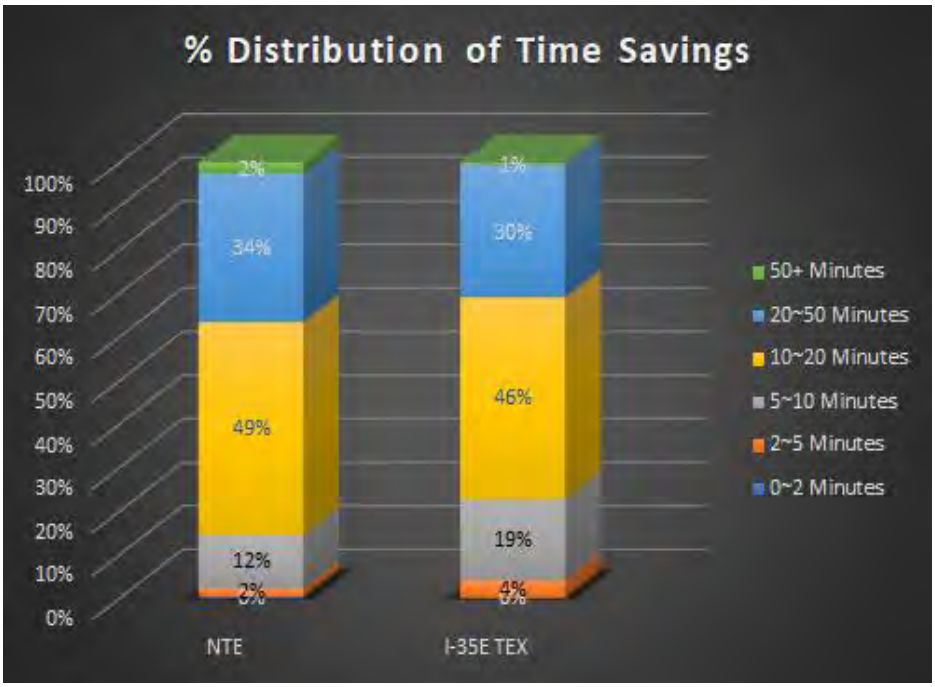
Time savings for the LAF users was another question that needs to be answered. Since the two managed lane (ML) facilities, NTE and IH 35E TEX both have parallel corridors (IH 820 and IH 35E, respectively). We attempted to quantify the perception of time savings of the ML users. Figure 4-8 showed that nearly 60 percent of ML users saved time when using the segment. Ten percent or less of users did not identify time savings. Speculating the nature of the third answer "Don't Know or N/A", it seemed that these users cannot easily identify time savings, likely because they seldom took the parallel freeway and thus cannot evaluate.

Figure 4-8. Percent Distribution of LAF Users by Recognition of Time Savings



To dig deeper in the time savings, Figure 4-9 presented the distribution of the ML users' time savings. If combining the 10~20 minutes group with the 20~50 minutes group, we may conclude that at least 80 percent users saved 10 minutes or more using the managed lanes.

Figure 4-9. Percent Distribution of LAF Users by Time Savings



The average time savings were summarized for the NTE and IH 35E TEX respondents and presented in Table 4-6. The 6-mile NTE segment saved the users on average nearly 18 minutes, while the 8-mile IH 35E TEX saved about 16 minutes.

Table 4-6. Average Time Savings of Managed Lane Users

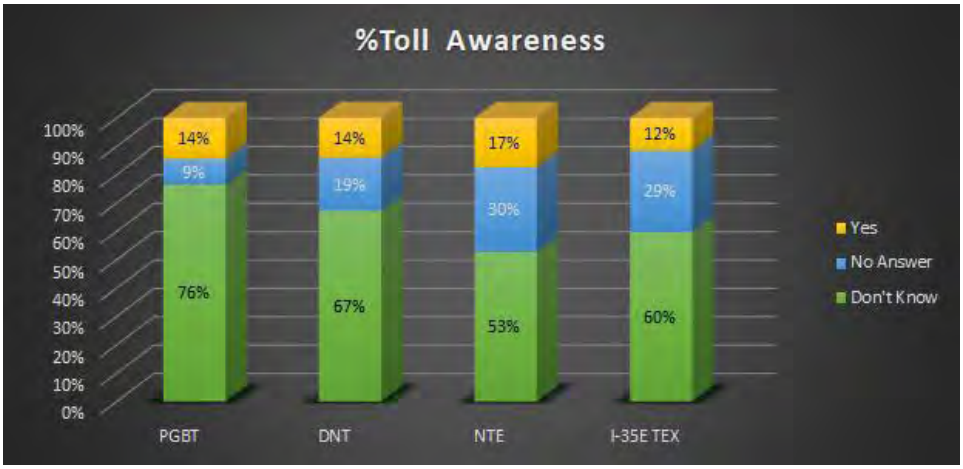
Average Time Saved (Minutes)	
NTE	17.6
IH 35E TEX	15.8

As this study was for LAF users, a series of fundamental questions focused on the toll-related information. In the six segments, there were four segments charging tolls: PGBT, DNT, NTE, and IH 35E TEX. The latter two are managed lanes conducting dynamic tolls, while the former two charge fixed tolls. The first question was "Do you know how much toll you paid for using the segment?". The users who were aware of the toll amount merely constitute from 12 percent to 17 percent of all users across four segments, which was lower than what were expected (Table 4-7). Considering the nature of "No Answer" neither probe the user privacy nor be offensive, it seems appropriate if we take "No Answer" as unknowing and assume that more than 80 percent LAF users were uncertain the toll amount they paid.

Table 4-7. The LAF User Distribution by Toll Awareness

Toll Awareness	Don't know	No Answer	Yes	Sum
PGBT	124,820	14,845	23,535	163,200
DNT	133,472	37,232	27,805	198,509
NTE	30,224	17,125	9,980	57,329
IH 35E TEX	11,424	5,510	2,202	19,136
Total	299,941	74,713	63,521	438,175
%	**Don't Know**	**No Answer**	**Yes**	**Sum**
PGBT	76%	9%	14%	100%
DNT	67%	19%	14%	100%
NTE	53%	30%	17%	100%
IH 35E TEX	60%	29%	12%	100%
Total	68%	17%	14%	100%

Figure 4-10. Percent Distribution of LAF Users by Toll Awareness

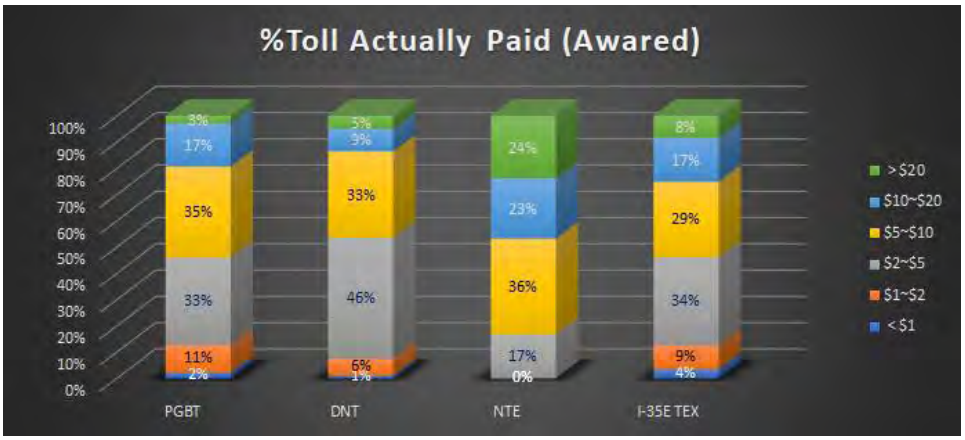


Based on different answers to this binary question, a different question was followed-up. To the users who answered "yes", the next question would be "How much toll did you pay?". Figure 4-11 showed the distribution of users in various toll amount ranges. Clearly the NTE segment was the most expensive facility, which aligned with our impression. Twenty-four percent of users paid over $20. While around 30 percent of users fall in the bracket of $5~$10 across four segments, it was apparent that the two MLs were more expensive than the two toll roads.

Table 4-8. The LAF User Distribution by Range of Tolls (Actually Paid)

Toll Amount Range	< $1	$1~$2	$2~$5	$5~$10	$10~$20	> $20	Total
PGBT	503	2,462	7,694	8,015	3,832	636	23,141
DNT	314	1,778	12,613	9,020	2,372	1,332	27,429
NTE	0	0	1,665	3,615	2,281	2,352	9,914
IH 35E TEX	77	197	729	621	365	179	2,166
Total	893	4,436	22,700	21,271	8,850	4,500	62,650

Figure 4-11. Percent Distribution of LAF Users by Toll (Actually Paid)



An important statistic was the average paid toll of each segment as shown by Table 4-9 below. It was clear that for similar length (all segments are from 5 to 8 miles long.), NTE is the most expensive facility. An average user might pay nearly twice to travel on NTE compared to the other three facilities. Combined with the time saving (or travel time), we can derive a more accurate estimate of value-of-time (VOT) of these LAF users.

Table 4-9. Average Paid Toll of LAF Users

Average Paid Toll ($)	
PGBT	7.8
DNT	7.2
NTE	14.0
IH 35E TEX	7.2

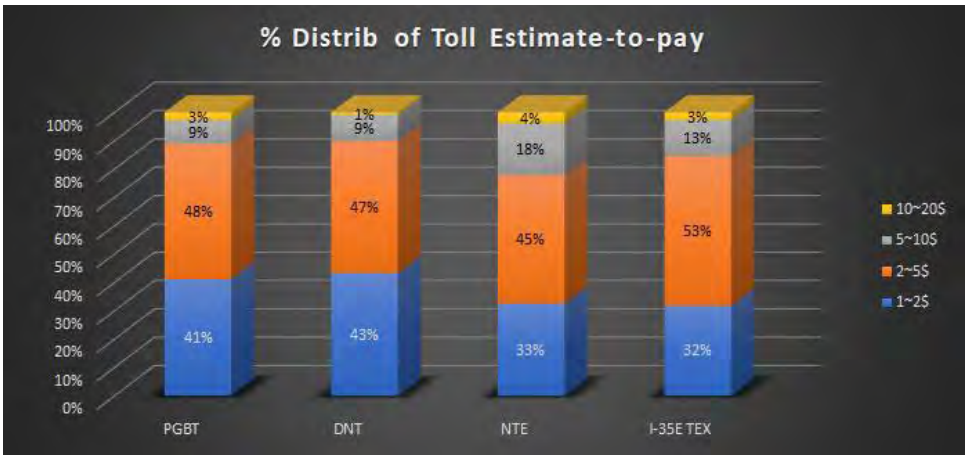
However, when the users chose "No Answer" or "Don't know" to the forementioned question, a different follow-up question was "How much do you estimate that you paid?". Based on the users' estimates, an interesting comparison was then brought up. Figure 4-12 demonstrated an interestingly different distribution compared to Figure 4-11. One observation may be easily derived that the toll that the LAF users estimated to pay were consistently lower than what they actually paid. For example, to the PGBT users, 35 percent of the users paid a toll in the $5~$10 bracket. However, to those who were unaware but estimated the toll they paid, merely nine percent chose the bracket $5~$10. If we assume there is no significant demographic or socioeconomic difference between the two groups PGBT users (those who were aware vs those who were unaware of toll amount), it is apparent that the users of PGBT underestimated the toll that they paid. And this observation remains consistent across all four LAF segments as the two figures suggest. This implication may have an impact on how to specify the value-of-time, since the discrepancy between the actual toll charge and estimated values was significant.

Table 4-10. The LAF User Distribution by Range of Tolls (Estimate-to-pay)

Toll Estimate-to-pay	$1~$2	$2~$5	$5~$10	$10~$20	Total
PGBT	51,368	59,530	10,688	3,234	124,820
DNT	57,785	62,204	12,502	982	133,472

NTE	9,847	13,680	5,560	1,138	30,224
IH 35E TEX	3,632	6,043	1,462	287	11,424
Total	122,632	141,457	30,211	5,641	299,941

Figure 4-12. Percent Distribution of LAF Users by Toll Estimated-to-pay



4.2 Socioeconomics and Demographics of LAF Users

The second part of the survey questionnaire collected the demographic and socioeconomic information of the LAF users. The survey respondents provided their information including but not limited to gender, age, race, and household income.

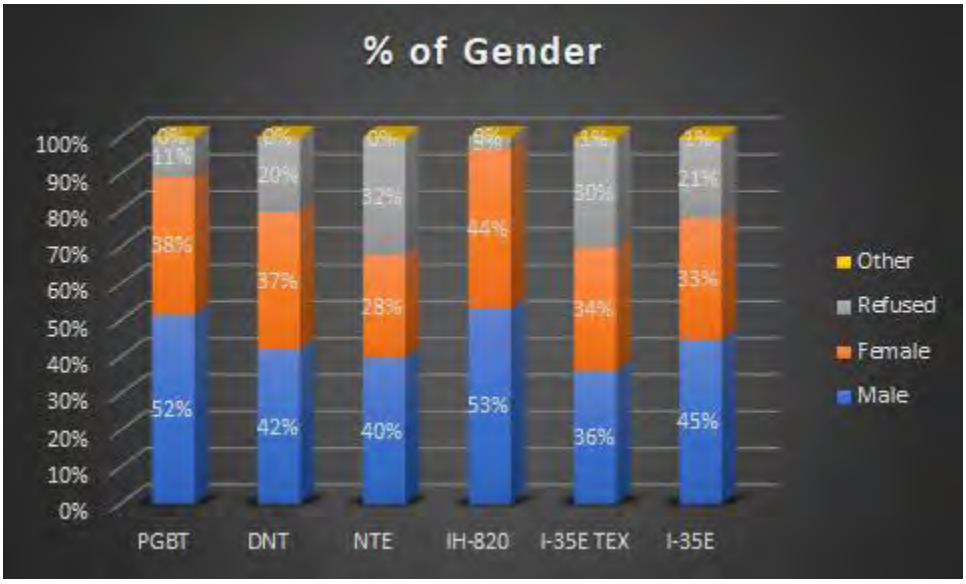
4.2.1 Personal Information

For all six LAF segments, there were consistently more male respondents than female ones.

Table 4-11. The LAF User Distribution by Gender

Facility Code	**Male**	**Female**	**Refused**	**Other**	**Total**
PGBT	84,084	61,380	17,155	582	163,200
DNT	83,537	74,135	40,291	547	198,509
NTE	22,856	15,988	18,245	240	57,329
IH 820	101,224	82,983	5,413	377	189,998
IH 35E TEX	6,916	6,466	5,646	108	19,136
IH 35E	94,334	70,087	44,968	1,707	211,097
Total	392,952	311,039	131,717	3,561	839,269

Figure 4-13. Percent Distribution of LAF Users by Gender

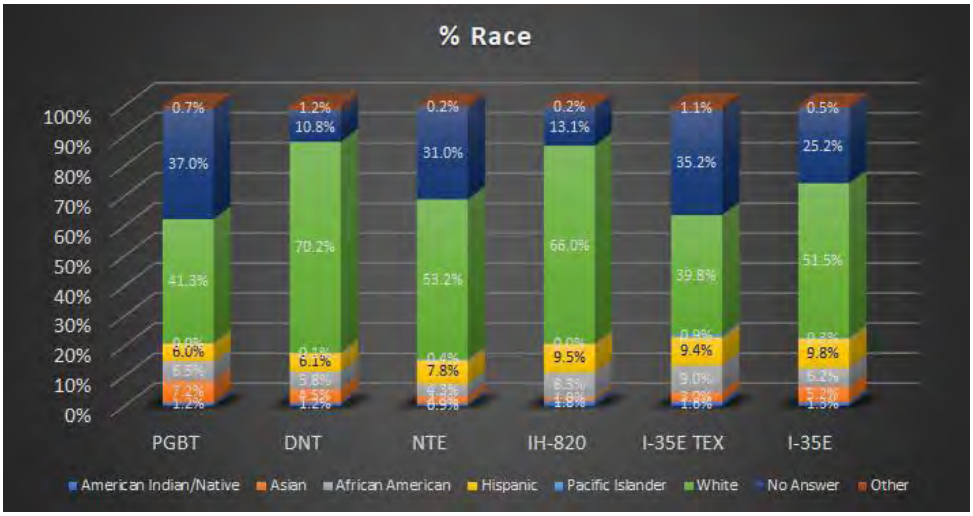


As to the racial distribution, white users were usually more than half except for IH 35E TEX. It was noteworthy that about 138,000 respondents refused to answer this question, which was 16 percent of all respondents.

Table 4-12. The LAF User Distribution by Race

Facility Code	American Indian/Native	Asian	African American	Hispanic	Pacific Islander	White	No Answer	Other	Sum
PGBT	1,913	11,787	10,632	9,766	75	67,456	60,378	1,194	163,200
DNT	2,301	9,006	11,536	12,193	276	139,449	21,413	2,335	198,509
NTE	501	1,321	2,460	4,495	229	30,485	17,747	92	57,329
IH 820	3,470	1,943	15,823	18,124		125,432	24,829	377	189,998
IH 35E TEX	301	572	1,729	1,796	167	7,614	6,742	216	19,136
IH 35E	2,819	10,994	13,037	20,613	600	108,685	53,233	1,115	211,097
Total	11,304	35,623	55,217	66,987	1,347	479,121	184,341	5,328	839,269

Figure 4-14. Percent Distribution of LAF Users by Race

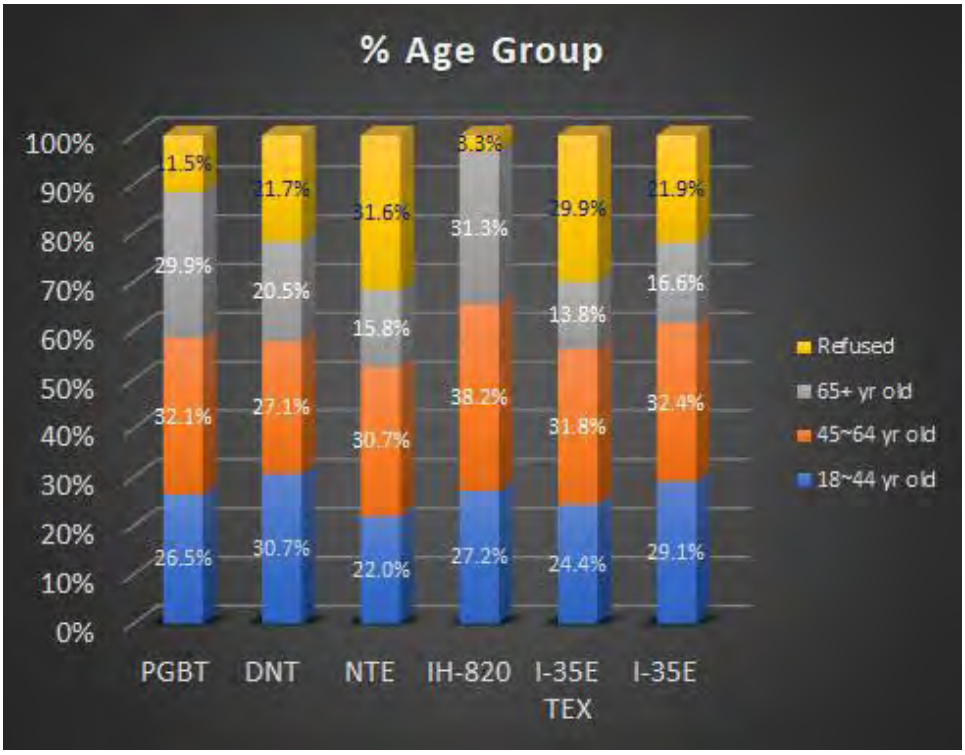


The age distribution of LAF users were grouped into four categories as Table 4-13. Based on Figure 4-15, the group of 45~64-year-old was the largest portion of LAF users. The second large group was the 18~44-year old.

Table 4-13. The LAF User Distribution by Age Group

Facility Code	18~44 yr old	45~64 yr old	65+ yr old	Refused	Total
PGBT	43,174	52,465	48,765	18,796	163,200
DNT	61,006	53,803	40,620	43,081	198,509
NTE	12,614	17,576	9,030	18,109	57,329
IH 820	51,733	72,593	59,486	6,186	189,998
IH 35E TEX	4,672	6,093	2,650	5,720	19,136
IH 35E	61,473	68,318	35,145	46,161	211,097
Total	234,672	270,848	195,696	138,053	839,269

Figure 4-15. Percent Distribution of LAF Users by Age Group

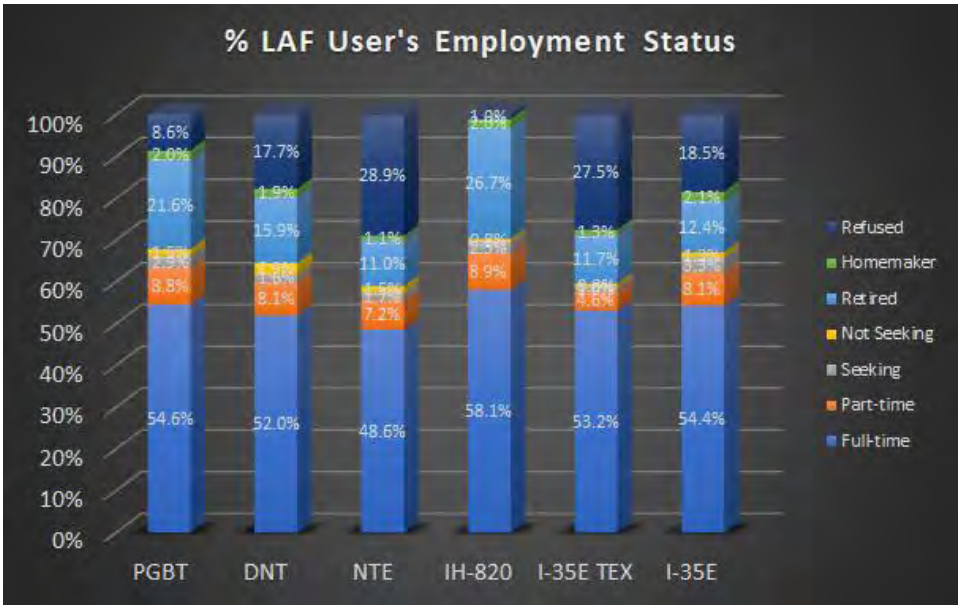


We were also interested in the employment status of the LAF users. Note that both seeking and not-seeking groups were minimal compared to the rest of the respondents. It seemed to agree to the labor market situation since the pandemic started.

Table 4-14. The LAF User Distribution by Their Employment Status

Employment Status	Full-time	Part-time	Seeking	Not Seeking	Retired	Homemaker	Refused	Total
PGBT	89,088	14,325	4,753	2,494	35,187	3,329	14,025	163,200
DNT	103,280	16,015	3,131	5,753	31,521	3,676	35,132	198,509
NTE	27,864	4,100	974	881	6,315	610	16,585	57,329
IH 820	110,406	16,954	4,659	1,547	50,641	3,866	1,923	189,998
IH 35E TEX	10,176	877	195	151	2,235	240	5,261	19,136
IH 35E	114,744	17,192	6,906	2,712	26,193	4,361	38,988	211,097
Total	455,559	69,463	20,619	13,538	152,093	16,083	111,915	839,269

Figure 4-16. Percent Distribution of LAF Users by the Employment Status



It may be noteworthy that the LAF users that were employed and employable (those seeking employment) added up to nearly 70 percent. On the other hand, the retired users constituted an unignorable portion that ranged from 10 percent to 20 percent for the LAF segments, while the homemakers seemed too underrepresented. In retrospect, the survey may be improved by adding a self-employed choice to the employment status.

4.2.2 Household Information

A significant part of socioeconomic conditions of LAF users was household related. In this section, the household size, number of adults, number of employees, household income, and vehicle ownership were summarized and presented below.

For the household size, we identified that usually the combined one-person households and two-people households may be more than 50 percent, except that the two ML only had 40 percent.

Table 4-15. The LAF User Distribution by Household Size

Facility Code	One Person	Two People	Three People	Four People	Five People	Six or More	Refused	Total
PGBT	24,928	65,654	27,819	16,780	9,672	4,322	14,025	163,200
DNT	27,990	70,180	24,998	25,745	9,697	4,768	35,132	198,509
NTE	4,747	18,299	7,212	6,463	2,121	1,903	16,585	57,329
IH 820	32,855	77,213	32,082	24,726	11,957	9,241	1,923	189,998
IH 35E TEX	2,632	4,593	2,829	2,353	852	615	5,261	19,136
IH 35E	29,218	70,085	34,446	24,398	8,764	5,199	38,988	211,097
Total	122,370	306,024	129,386	100,465	43,062	26,048	111,915	839,269

Figure 4-17. Percent Distribution of LAF Users by Household Size

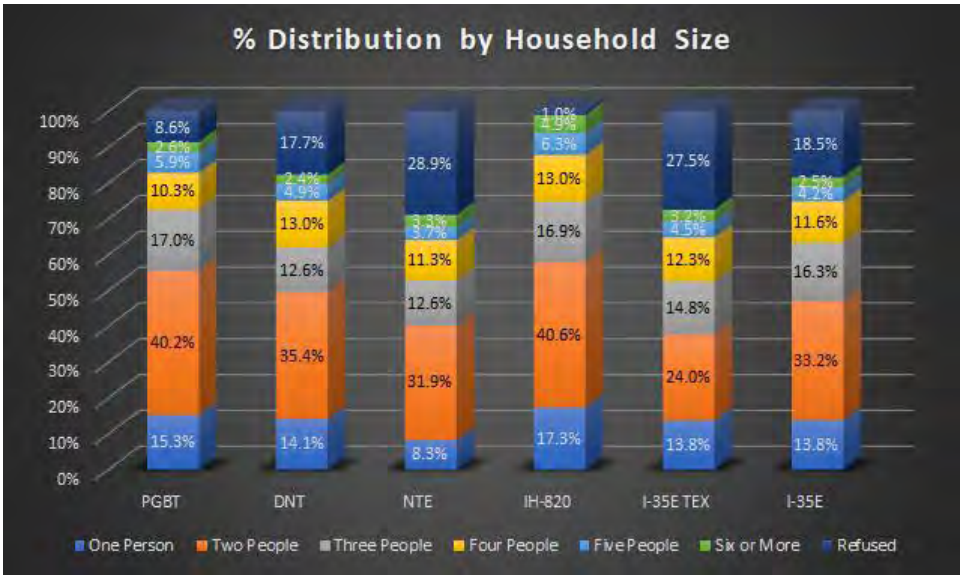
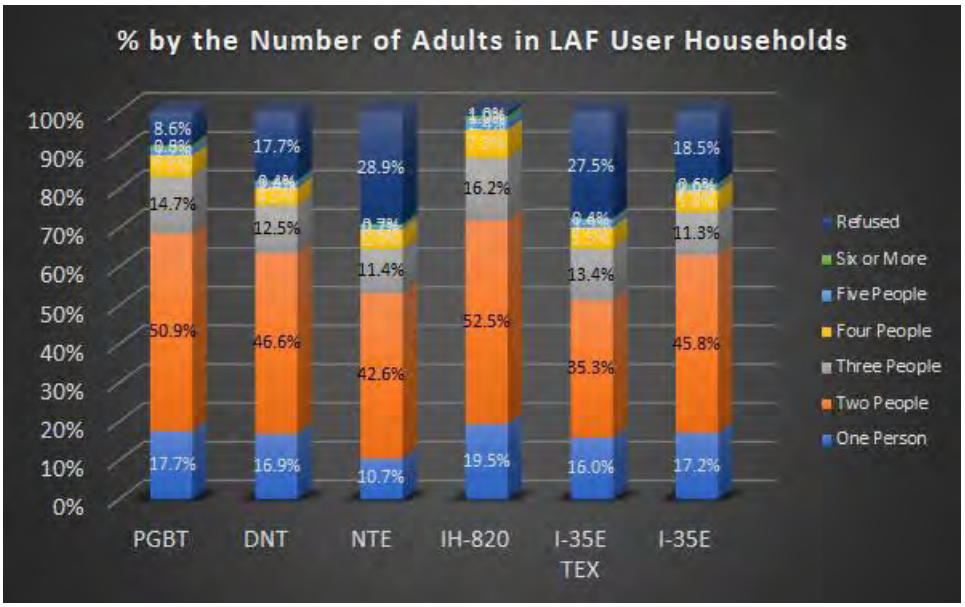


Table 4-16 showed how many adults in their households. The distribution turned out to be highly aligned to the distribution of household size (Figure 4-18).

Table 4-16. The LAF User Distribution by the Number of Adults in Their Households

Facility Code	One Person	Two People	Three People	Four People	Five People	Six or More	Refused	Total
PGBT	28,940	83,067	24,022	9,057	2,734	1,355	14,025	163,200
DNT	33,611	92,407	24,827	8,871	2,817	845	35,132	198,509
NTE	6,119	24,434	6,520	2,876	387	410	16,585	57,329
IH 820	37,079	99,658	30,873	13,900	4,640	1,923	1,923	189,998
IH 35E TEX	3,063	6,753	2,566	1,058	361	74	5,261	19,136
IH 35E	36,312	96,614	23,850	11,799	2,181	1,354	38,988	211,097
Total	145,124	402,933	112,659	47,560	13,120	5,960	111,915	839,269

Figure 4-18. Percent Distribution of LAF Users by the Number of Household Adults

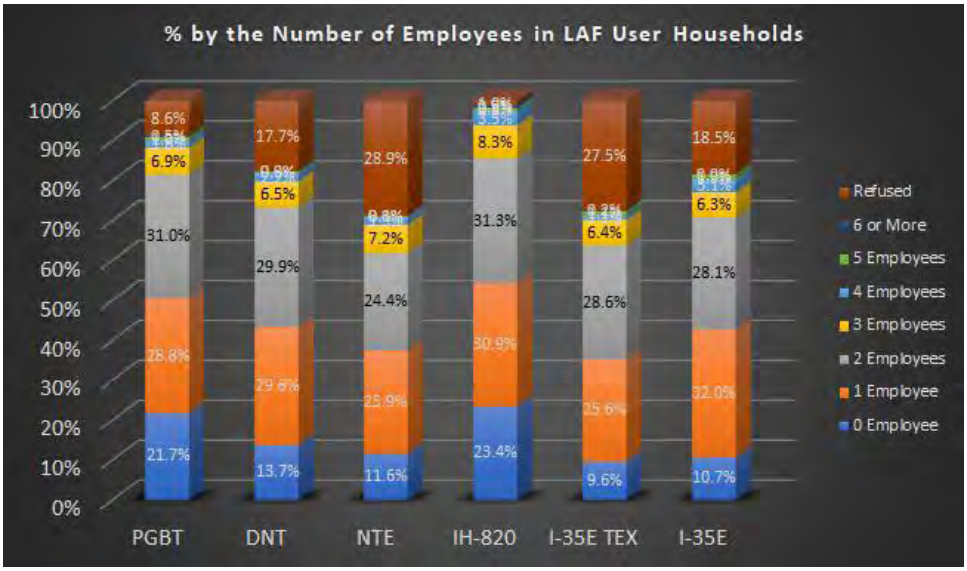


Another important aspect of a household was the number of employees. Clearly the households with one or two employees were the majority of the LAF users, amounting to around 60 percent for all LAF segments. One surprising finding was that households with zero employee occupied a proportion that was at least 10 percent and can reach as high as 23 percent (IH 820), as shown by Figure 4-19. Note that two ML (NTE and IH 35E TEX) had nearly 30 percent users who refused to answer this question. It is more likely that many of them belong to 0-employee households considering that ML users who chose zero-employee household group were lowest among all segments (11.6 percent and 9.6 percent respectively).

Table 4-17. The LAF User Distribution by the Number of Employees in Their Households

Employees	0	1	2	3	4	5	6 or More	Refused	Subtotal
PGBT	35,464	46,997	50,513	11,186	2,598	1,641	776	14,025	163,200
DNT	27,276	58,770	59,410	12,963	4,275	683		35,132	198,509
NTE	6,622	14,830	13,993	4,103	1,111	85		16,585	57,329
IH 820	44,435	58,751	59,408	15,823	6,583	1,527	1,547	1,923	189,998
IH 35E TEX	1,835	4,905	5,466	1,224	202	204	38	5,261	19,136
IH 35E	22,604	67,538	59,304	13,327	6,634	2,701		38,988	211,097
Total	138,237	251,791	248,095	58,627	21,402	6,841	2,360	111,915	839,269

Figure 4-19. Percent Distribution of LAF Users by the Number of Household Employees

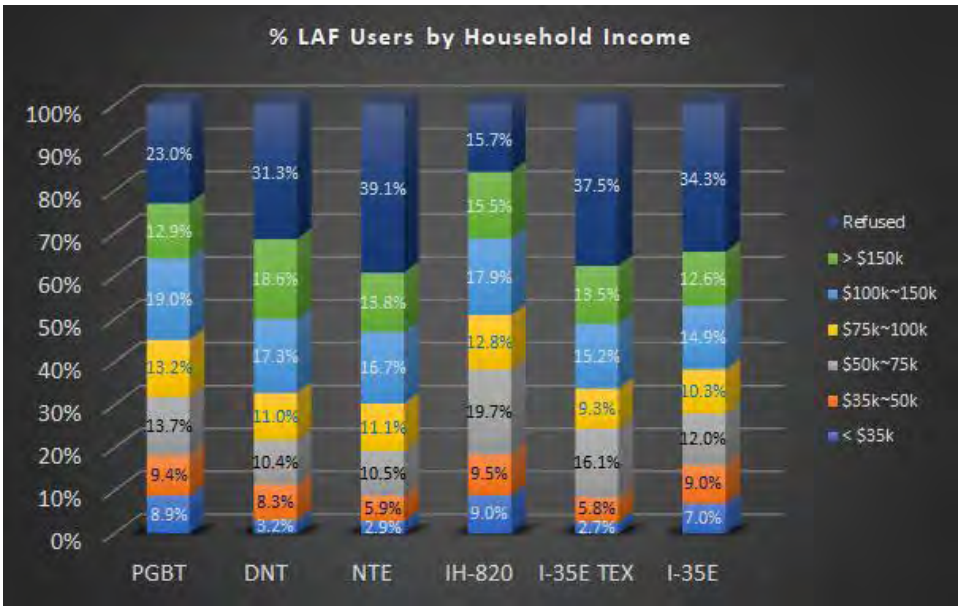


Closely related to a household's employment, another indispensable piece of information is the household income of LAF users. As Figure 4-20 suggested, the higher income households were more likely to pay to use the LAF. There were more users whose household income was more than $75,000 than those with lower numbers. Speaking of user proportions, higher income group ($100k~150k and more than $150k) were often more than 30 percent of all LAF users, which was more than the combined group of $75k~100k and $50k~75k. Based on 2020 census data, the City of Fort Worth and the City of Dallas respectively have median household income at $64,567 and $54,747. The household income distribution of LAF users might suggest that higher income families used the LAF more than the lower income families did.

Table 4-18. The LAF User Distribution by Their Household Income Group

Household Income ($)	< $35k	$35k~50k	$50k~75k	$75k~100k	$100k~150k	> $150k	Refused	Total
PGBT	14,482	15,291	22,330	21,617	30,947	21,047	37,486	163,200
DNT	6,253	16,489	20,552	21,769	34,243	37,010	62,194	198,509
NTE	1,654	3,395	6,000	6,346	9,577	7,925	22,433	57,329
IH 820	17,013	18,104	37,495	24,291	33,967	29,366	29,762	189,998
IH 35E TEX	512	1,101	3,073	1,785	2,904	2,579	7,182	19,136
IH 35E	14,774	19,034	25,330	21,660	31,390	26,520	72,388	211,097
Total	54,687	73,414	114,781	97,467	143,027	124,447	231,445	839,269

Figure 4-20. Percent Distribution of LAF Users by Household Income

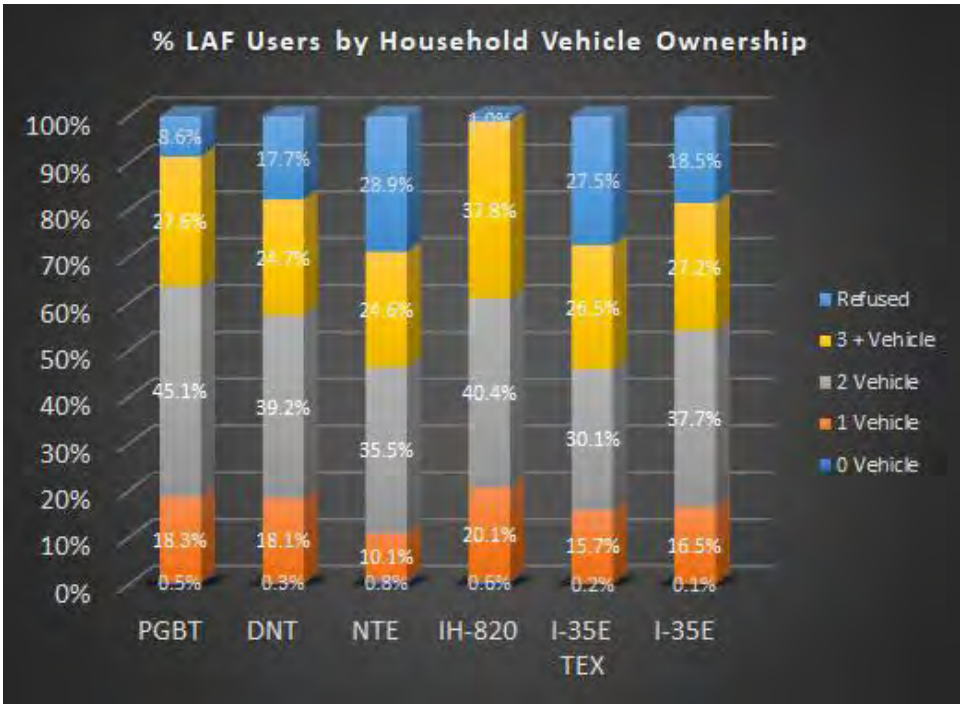


The vehicle ownership of a LAF user's household was also inquired by the survey. The number of vehicles owned may be highly correlated with the household size considering the characteristics of DFW region. The households with two vehicles were dominant (Figure 4-21), which agreed to the fact that the proportion of households with two adults was dominant relative to the other household size groups (Figure 4-17).

Table 4-19. The LAF User Distribution by Their Household Vehicle Ownership

Facility Code	0 Vehicle	1 Vehicle	2 Vehicles	3 + Vehicles	Refused	Total
PGBT	755	29,795	73,562	45,063	14,025	163,200
DNT	629	35,891	77,797	49,061	35,132	198,509
NTE	468	5,788	20,365	14,124	16,585	57,329
IH 820	1,170	38,230	76,817	71,858	1,923	189,998
IH 35E TEX	35	3,010	5,756	5,073	5,261	19,136
IH 35E	240	34,771	79,673	57,424	38,988	211,097
Total	3,297	147,485	333,969	242,604	111,915	839,269

Figure 4-21. Percent Distribution of LAF Users by Household Vehicle Ownership



The LAF survey database contains rich information on travel patterns, trip-making behavior, and socioeconomics of users. The summaries presented in this chapter were results from simple one-variable queries. However, there are abundant insights hidden deep in the database, which have to be queried with combined variables.

Chapter 5. Conclusion

5.1 The limited access facility (LAF) user survey was designed with the following objectives:

1. to describe travel behavior of the users of different types of LAF, and
2. to evaluate the social fairness of LAF facilities for users

Travel behavior refers to trip characteristics of the various LAF users. Trip characteristics include features such as trip purpose, trip departure time, trip length, and vehicle occupancy. The users are usually characterized by the socioeconomic (SE) segments. SE segments are based on characteristics such as age, gender, and race for persons as well as income, number of children, and number of employees. Chapter 4 summarized the travel behavior of the users of all facilities and the survey for main segmentation variables of the person and households. In this chapter, we will compare some of these characteristics with other travel surveys to create a contextual understanding of the limited access facility users versus the general population and transit users.

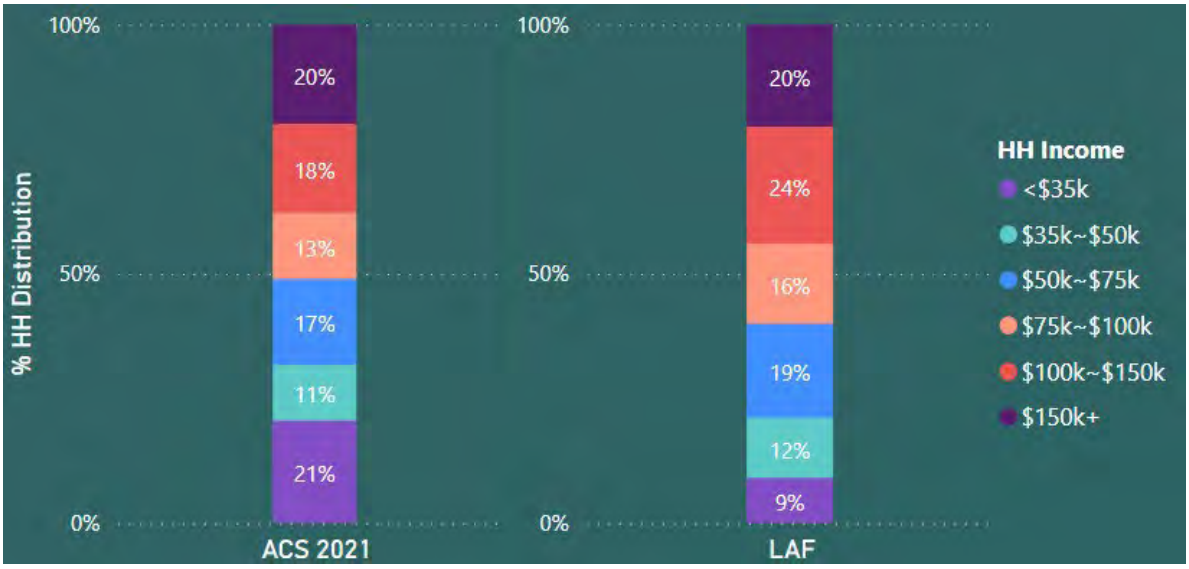
Evaluation of regular toll roads for fairness cannot be done without inclusion of travel behavior and network modeling because of the lack of clear alternative free path in the tolled corridor. The Dallas-Fort Worth regional travel model will be enhanced through using LAF survey data. In the following sections, the first perspective to be examined is household income.

5.2 Distribution of Household Income

Being the likely foremost essential factor, the household income of the LAF users and the household income of the NCTCOG region were carefully investigated and compared to determine if the LAF users' income distribution demonstrated statistically significant differences compared to that of the region. The regional household income distribution was obtained from the 2017-2021 5-year estimates of American Community Survey (ACS). The LAF users' household income distribution for all LAF facilities was presented side by side with that of the region as Figure 5-1 shows; from a visual inspection, the two distributions appear quite similar.

To determine if the LAF respondents' household income distribution was statistically different from that of the regional households, a Chi-squared test was conducted on the two distributions. For this test, the income distribution of LAF users was the observed set, and the income distribution from the ACS for the region regional was the expected set. In the Chi-squared test, the null hypothesis is that the LAF respondents' household income distribution is identical to that of the region, while the alternative hypothesis is that the LAF distribution is different from that of the region. The Chi-squared test obtained a p-value of 0.999 that implied the failure to reject the null hypothesis even at 0.01 significance level. In other words, the LAF respondents did not show differences in their household income when compared to that of the overall region. The same test was performed for each LAF facility, and the result remained unchanged. Therefore, it may be concluded with confidence that the household income level did not make the LAF respondents execute the trip-making choice differently compared to the region's overall residents.

Figure 5-1. Percent Distribution of Households by Household Income, LAF Users vs ACS 2021



The notion of social fairness is a crucial consideration in assessing the utilization of toll facilities. Having conducted a comparative analysis of the household income distribution of the LAF users with that of the regional residents, our findings indicated no significant difference in the household income distribution, thus suggesting that LAF facilities are equitable to the regional residents. It is also concluded that these facilities are likely both necessary and affordable to the majority of the regional residents. Such outcomes provide insights into the nature of social fairness in the usage of LAF facilities, with implications for policy-making and future research. Our examination of the household income above was performed at census block group geographical level.

5.3 Distribution of Trip Purposes

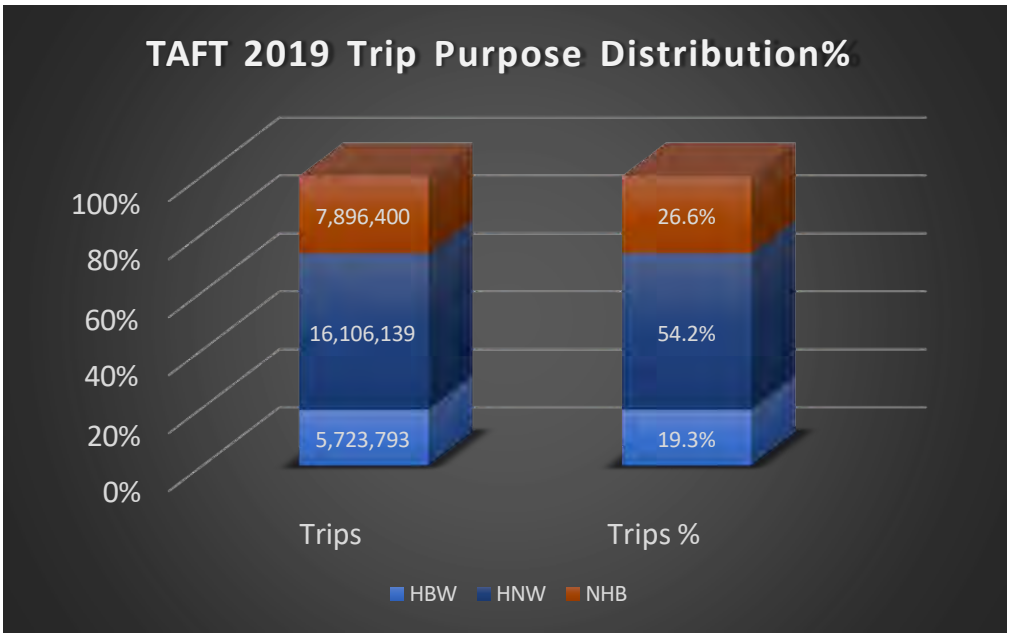
The LAF user survey provided an opportunity to examine the trip purposes of the users of the high-quality facilities in the region. Prior to this survey, our knowledge about trip purpose comes only from the household travel survey and the workplace survey for the region. These surveys are generally done with a small sample of the household and business universes, and therefore cannot provide facility-specific information. The overall trip purpose distribution of households indicates approximately 19 percent are Home-Based Work (HBW), 54 percent are Home-Based Non-Work (HBNW), and 27 percent are Non-Home-Based) (NHB) based on the regional travel model run for 2019, as Figure 5-2 suggests. It is preferable to use the calibrated regional travel model to consolidate various surveys and bring the results to a more recent year; Transportation Analytical Forecasting Tool (TAFT) is the regional travel model for NCTCOG. Another survey data source is the 2014 North Central Texas Regional Transit Travel Survey that showed the breakdown percentage of HBW, HBNW and NHB trips were 46 percent, 44 percent, and 10 percent respectively. The pattern of transit user trip purposes is almost the same across the country based on similar transit studies across the nation.

The LAF survey indicates that the users of freeways, toll roads, and managed lanes in 2022 had a similar trip purpose distribution compared to TAFT household trip shares with HBW of about 20 percent. On the other hand, they had a modestly higher share of HBNW trips with 63 percent, and marginally lower trip

share for NHB trips of about 17 percent. This observation is interesting because one may think that the most important function of the freeway system is providing accessibility for work trips. The survey showed that the most dominant trips are HBNW trips on the freeway system. HBNW trips consist of social/recreational, personal business, shopping, and education trips with one end of the trip being home.

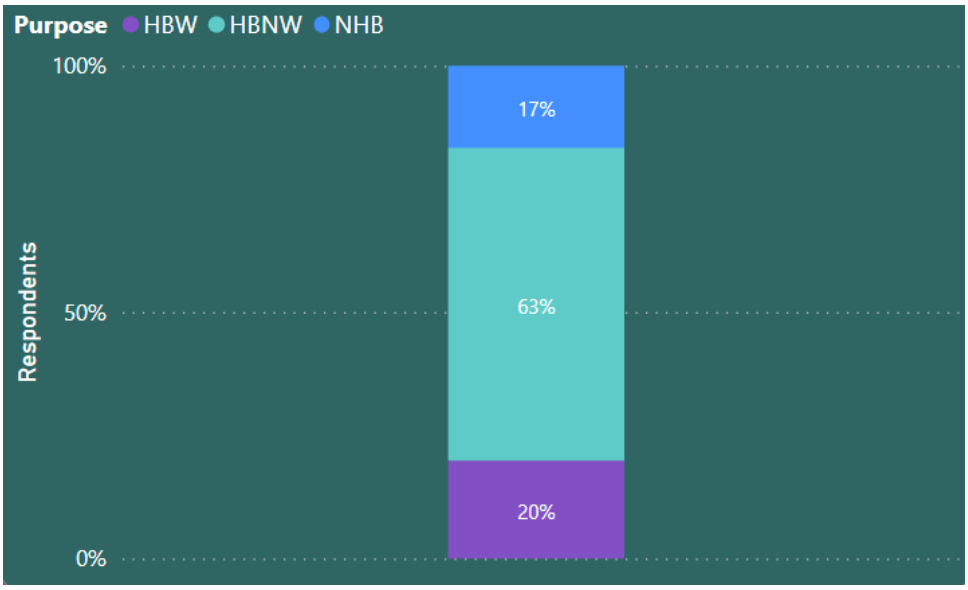
When comparing all data together, TAFT's 2019 model run trip purposes reflected notably similar distribution to that of the LAF survey. Note that what Figure 5-2 depicted is for the region regardless of the usage of facility or transit.

Figure 5-2. Percent Distribution of Aggregated Trip Purposes of 2019 TAFT Model Run



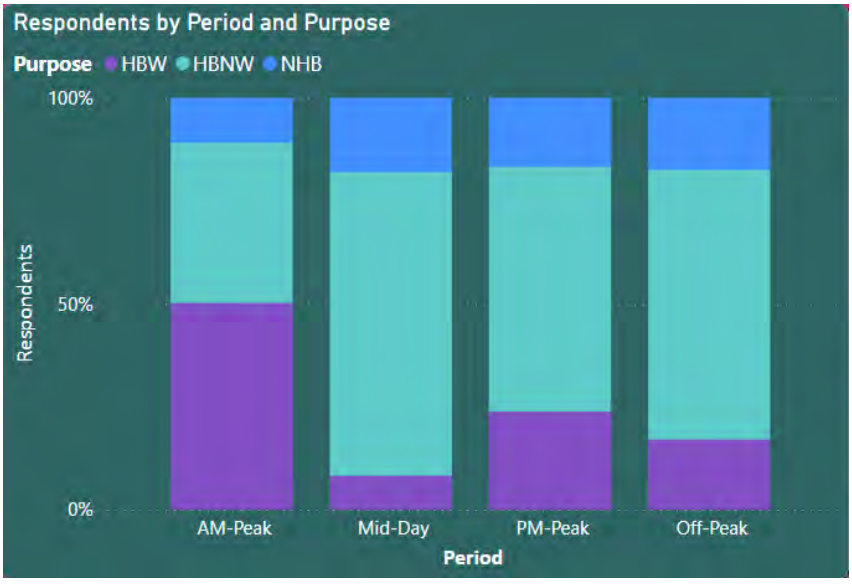
Based on Figure 5-3, it may be concluded that the LAF facilities perform a resembling function as the regional transportation system does, since both LAF users and TAFT 2019 trips demonstrated similar proportions by trip purposes.

Figure 5-3. Percent Distribution of Daily LAF Trips by Trip Purpose



We investigate further by incorporating the time periods of LAF trips (Figure 5-4). Apparently, AM-peak with 50 percent HBW trips had the highest portion compared to the other periods. The other time periods were dominated by HBNW respondents.

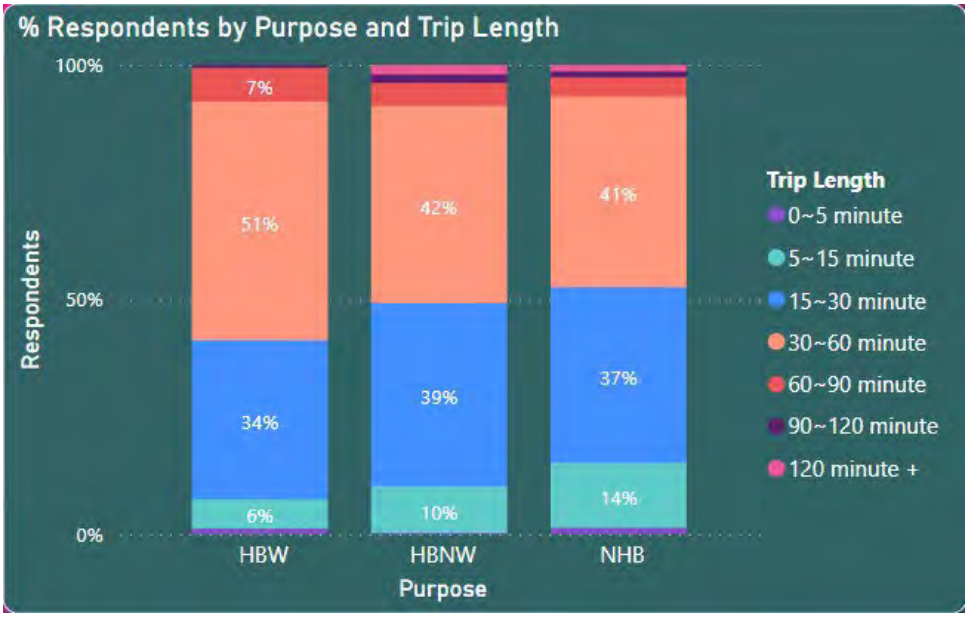
Figure 5-4. Percent Distribution of Trip Purposes of LAF Users by Time Period



5.4 Distribution of Trip Length by Trip Purpose and Income

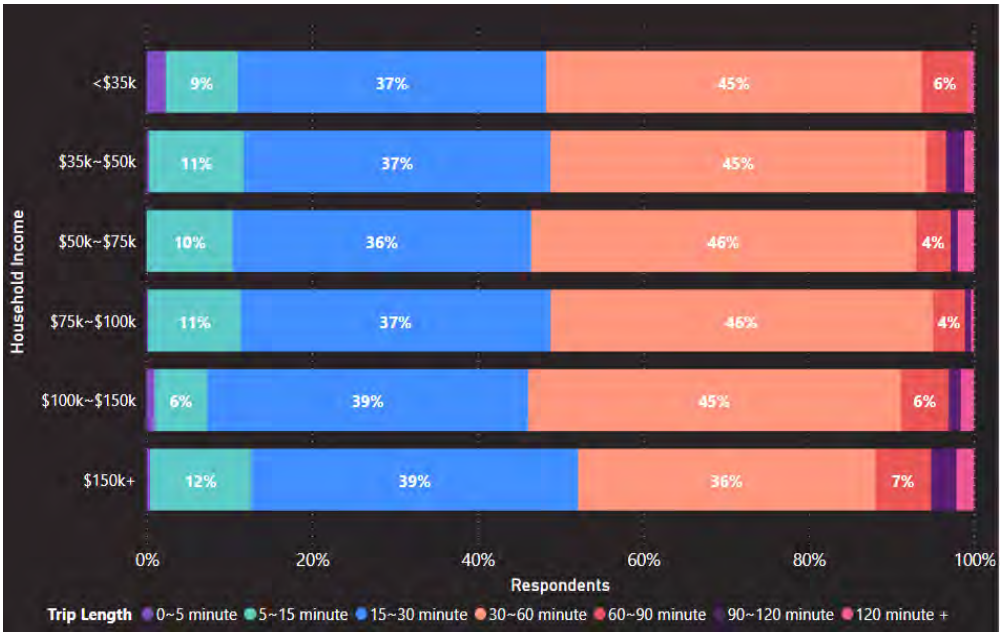
In addition to the discussion of trip length distribution that was described in Chapter 4, it was further investigated how other factors might affect trip length. The first comparison was how trip purposes affected the trip length. Based on Figure 5-5, it may be identified different trip purposes did not cause significant variances in overall trip length distribution. But HBW trips had more than 50 percent share of 30-60-minute trips, while long distance (more than 120 minutes) trips were almost impossible for HBW.

Figure 5-5. Percent Distribution of LAF Trip Length by Trip Purpose



The second investigation was trip length distribution by household income. When checking trip lengths under different household income group, it was apparent that overall household income did not affect trip length distribution based on Figure 5-6. The one exception was the $150K+ household income group made fewer 30-60 minute trips.

Figure 5-6. Percent Distribution of LAF User Trip Length by Household Income

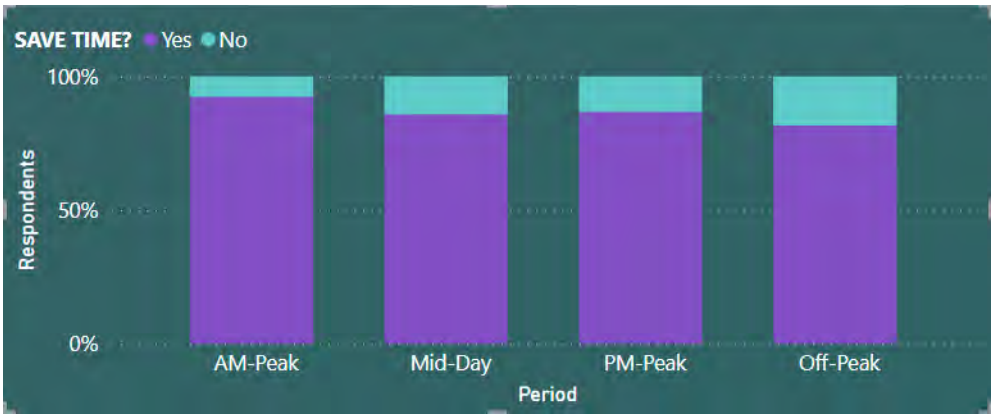


5.5 Time Saving, Toll, and Value of Time

The next topic of investigation focused on the perception of time saving. Time saving was one of the key issues that was identified by the majority of respondents. To understand the fairness of these facilities for the users, we need to compare the differences between users of two types of facilities that provide almost the same accessibility. Since the managed lanes (NTE and IH 35E TEX) of this study were built alongside the general-purpose freeway lanes included in this study, we can compare the users of these parallel facilities for similar accessibility characteristics. We will examine whether the introduction of the variable toll in exchange of travel time under the same geographical accessibility provides benefit for a specific user at the cost of the others, by having the general-purpose lanes serve as a benchmark when asked how much time was saved.

Prior to the LAF survey, it was expected that the potential factors including, but not limited to, trip purposes, time periods, and household income might affect time savings. Per our investigation, none of the three factors demonstrated a significant effect on time saving perceptions, although the majority of respondents confirmed the time savings. Figure 5-7, for example, showed that regardless of time periods, the distribution of time saving perceptions was consistent.

Figure 5-7. Percent Distribution of ML Users by Time Period and Time Saving



For deeper insights on toll facilities, in addition to time savings on the two MLs, the study also examined distribution of toll that were actually paid and toll that were estimated to pay. Therefore, the research considered the users of PGBT, DNT, NTE and IH 35E TEX, who were divided into two groups: the users who were aware of the amount of toll payments paid, and the respondents who were unaware. The survey collected both actual and estimated toll payment from the two groups.

Figure 5-8. $ Median of Actual Toll ($) by Trip Purpose

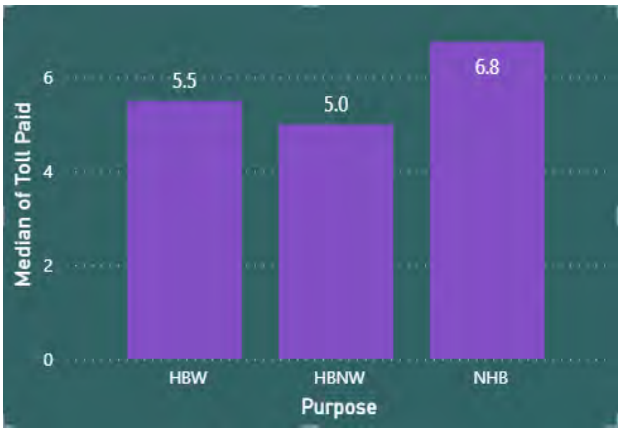


Figure 5-9. $ Median of Actual Toll ($) by Time Period

Figure 5-10. $ Median of Actual Toll ($) by Household Income

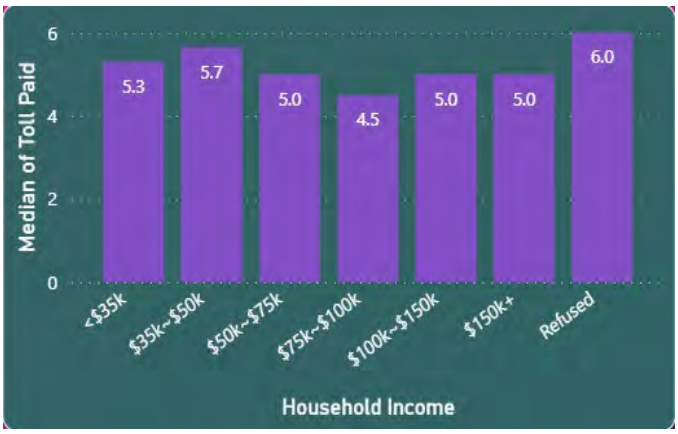


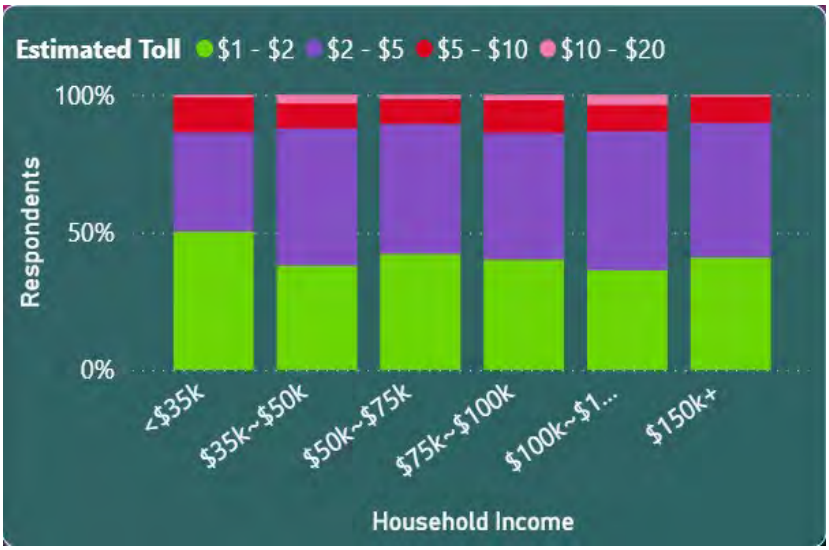
Figure 5-8, 9, and 10 demonstrated the median toll amount that the respondents remembered. There were not significant variations across various trip purposes, time periods, and household income levels. The median toll amounts that were actually paid were consistently around $5 except for NHB trips. On the other hand, for the respondents who did not remember the toll payment, they were asked to estimate their toll payment. The estimated toll was similarly investigated if there were variances related

to factors like trip purpose, time period, and household income (as Figure 5-11, 12, and 13 showed). The observation clearly suggested that none of the three factors had impact on the distribution of estimated toll.

Figure 5-11. Percent Distribution of Estimated Toll by Trip Purpose

Figure 5-12. Percent Distribution of Estimated Toll by Time Period

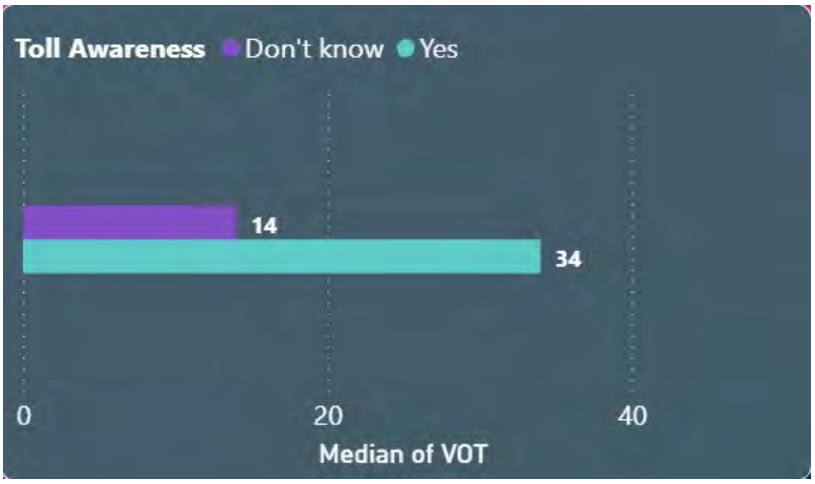
Figure 5-13. Percent Distribution of Estimated Toll by Household Income



When examining the time saving and the toll, the Value of Time (VOT) was derived by dividing the toll by the time saving. Since the estimated toll were ranges like $2-$5 or $5-$10, the median values of the ranges were taken as the estimated toll value. For example, if one user on a ML answered that her estimated toll was within $5-$10, her estimated toll would be taken as $7.50. As previously discussed in Chapter 4, LAF users overall underestimated the toll they paid. Similarly, this underestimation happened to the VOT.

It was also noticed that the LAF users who were aware of their toll payment(actual) demonstrated more than double of VOT estimated by those who did not know the actual toll payment(estimated). This comparison is depicted in Figure 5-14.

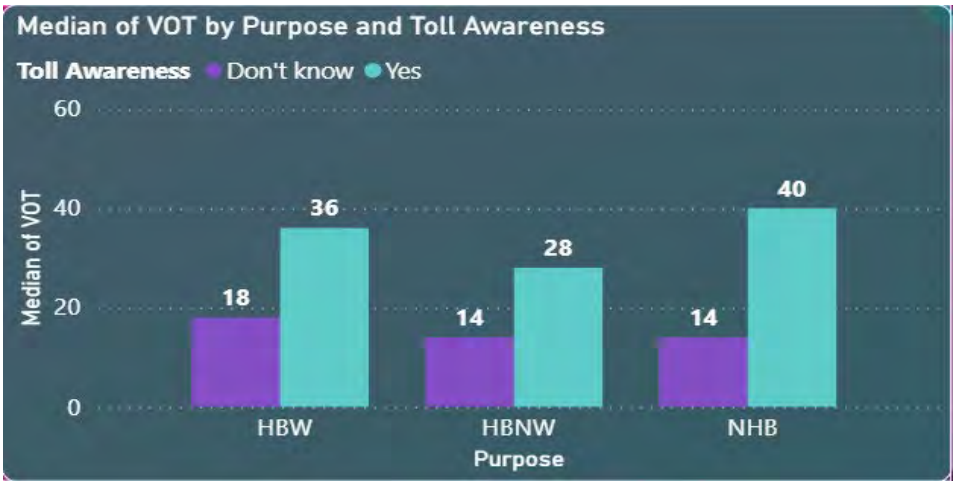
Figure 5-14. Median of VOT ($/hour) of Respondents by Toll Awareness (Actual vs Estimated)



One further look at the VOT on the trip purposes (Figure 5-15) compared those who were aware of their toll (actual VOT) against those were did not know their toll (estimated VOT). In this figure, it can be seen that the estimated VOT presented negligible differences across the trip purposes with the HBW VOT being

marginally higher than the HBNW and NHB. The people who were aware of their toll showed more variation in the actual VOT with NHB having the highest actual VOT of 40.

Figure 5-15. Median of VOT ($/hour) of Respondents by Toll Awareness and Trip Purpose



The effects of trip length and time saving on VOT were evaluated next. Figure 5-16 shows that there was variation of actual VOT and estimated VOT with trip length. The actual VOT showed more variance with high VOT at the 0-5 minute and 90–120-minute groups; this might be due in part to the fewer number of respondents in those groups. In Figure 5-17, we see that both the estimated and the actual VOT decreased with increased time savings of 1-40 minutes.

Figure 5-16. Median of VOT ($/hour) of Respondents by Trip Length (time)

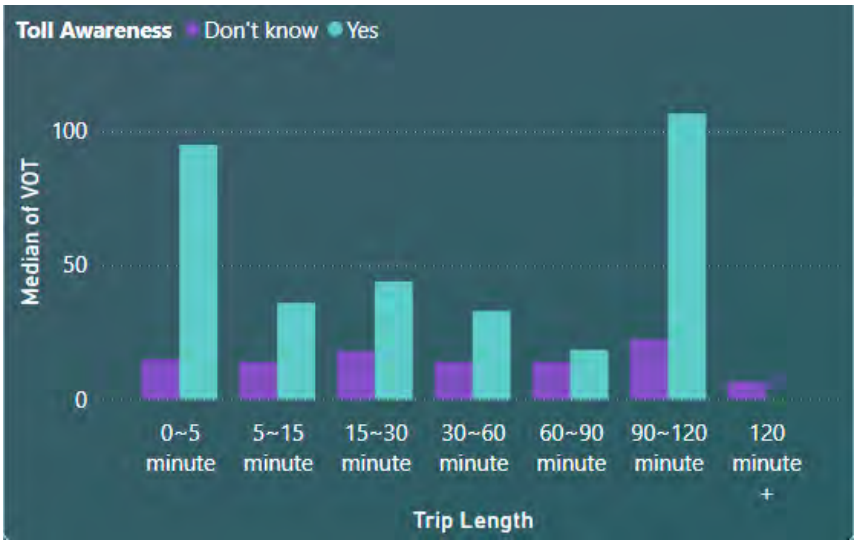


Figure 5-17. Median of VOT ($/hour) of Respondents by Time Savings (minute)

However, when categorized by the household income, the actual VOT showed little noticeable variances or patterns, while the estimated VOT slowly grew with the household income (Figure 5-18).

Figure 5-18. Median of VOT ($/hour) of Respondents by Household Income

To sum up for VOT, compared to the actual VOT, the estimated VOT was more insensitive to factors including trip purpose and trip length. It might imply that many LAF users were convinced of low (estimated) toll payment, and hence did not care to consider the other factors. From the perspective of travel demand modeling, perhaps the estimated VOT is of no less references than the actual VOT, if not more, because ultimately it is a traveler's perception (estimated VOT) playing a more decisive role in making a trip.

When considering both the VOT and time saving perceptions of LAF users, Chapter 4 has shown that over 80 percent of LAF users were unaware of the exact amount of their toll payment. We retrieved toll payment amounts from both those who remembered and the unaware users who simply estimated

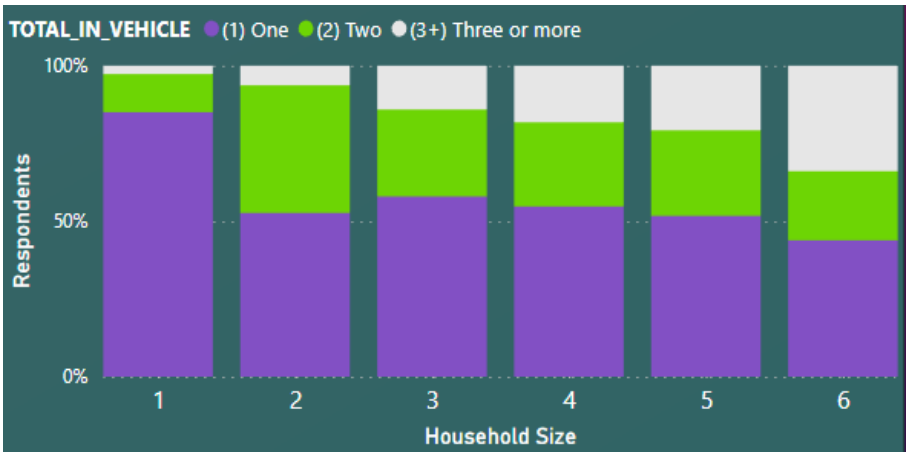
their toll paid. The results indicated that the estimated toll payments were much lower than the actual payments, which led to a significant difference of VOT between the two groups. If our analysis of VOT assumed that the trip-making behavior of LAF users was heavily based on their recognition of the toll amount, the LAF users' trip-making behavior might vary if their recognition of the toll payment were adjusted by reality. In other words, it is likely that the majority of LAF users underestimate their VOT. The study raised a question regarding how LAF users would react if they discovered that they had paid a much higher toll. However, this aspect remains unexplored and requires further investigation. Toll awareness is a critical issue that requires attention in the future.

5.6 What Affects Vehicle Occupancy

Vehicle occupancy, or carpool, is another interesting issue that might be related to the trip purpose, time period, household size, or household income. Figure 5-19 showed that HBW trips, which are prominent in the AM-peak period, were dominantly drive-alone. Figure 5-20 indicated that the household size did have some causal effects on share-riding as the number of three-plus passenger trips grew with household size, while the portion of drive-alone remained consistent with household size. As to time periods and household income, they did not show noticeable variances on vehicle occupancy.

Figure 5-19. Percent Distribution of Vehicle Occupancy by Trip Purpose

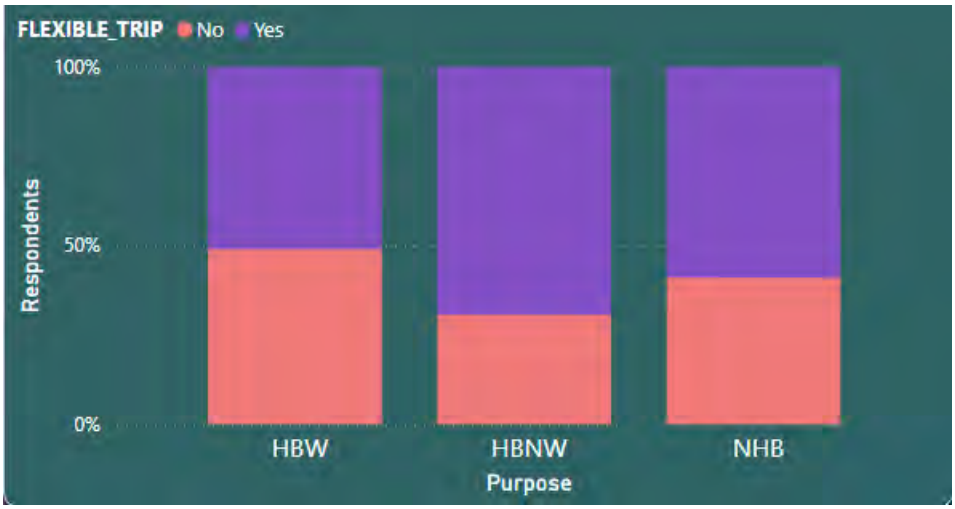
Figure 5-20. Percent Distribution of Vehicle Occupancy by Household Size



5.7 Effect of Trip Purpose on Trip Flexibility

We also examined several factors that were likely contributive to trip flexibility. Among these factors, it was evident that household income or children of a household did not affect the trip flexibility. On the other hand, as displayed in Figure 5-21, there was a difference in trip flexibility with trip purpose. HBNW seems to be the most flexible. HBW was the least flexible, with almost half or respondents saying they were not flexible.

Figure 5-21. Percent Distribution of Trip Flexibility by Trip Purposes



5.8 Trip Frequency vs Trip Purpose, Time Period, and Employment Status

Trip frequency did vary between different trip purpose and time of day periods as shown in Figure 5-22 and Figure 5-23 respectively. HBW trips were dominant in those respondents who used LAF 3-5 times per week. Also, the most frequent LAF users were more likely to travel in the AM-peak period. On the other hand, those who travel on LAF merely 1-3 times per month less likely chose the AM-peak period and mostly belong to HBNW and NHB. It was from another perspective suggested that the frequent users were mainly HBW trip takers. It was also evaluated that trip frequency was not closely related to the factors including household income level and children in a household.

Figure 5-22. Percent Distribution of Trip Frequency by Trip Purposes

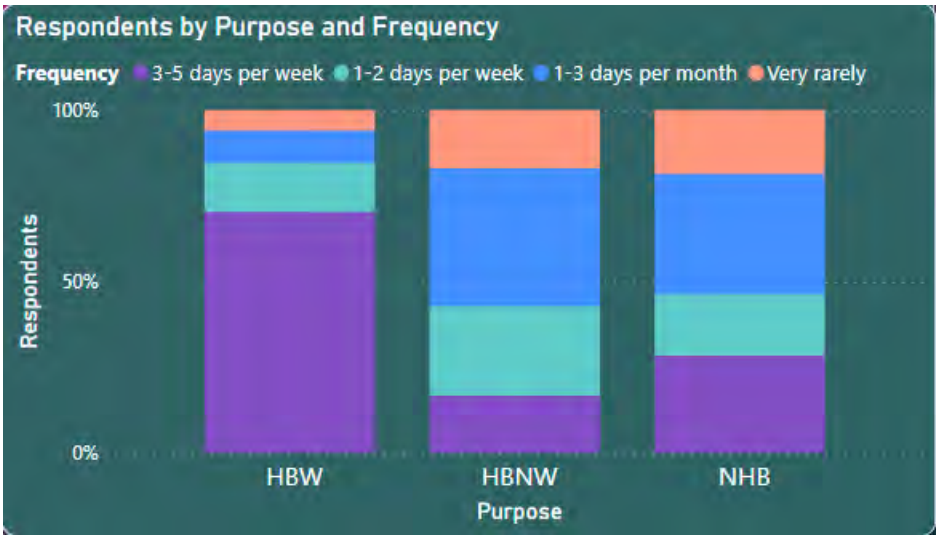
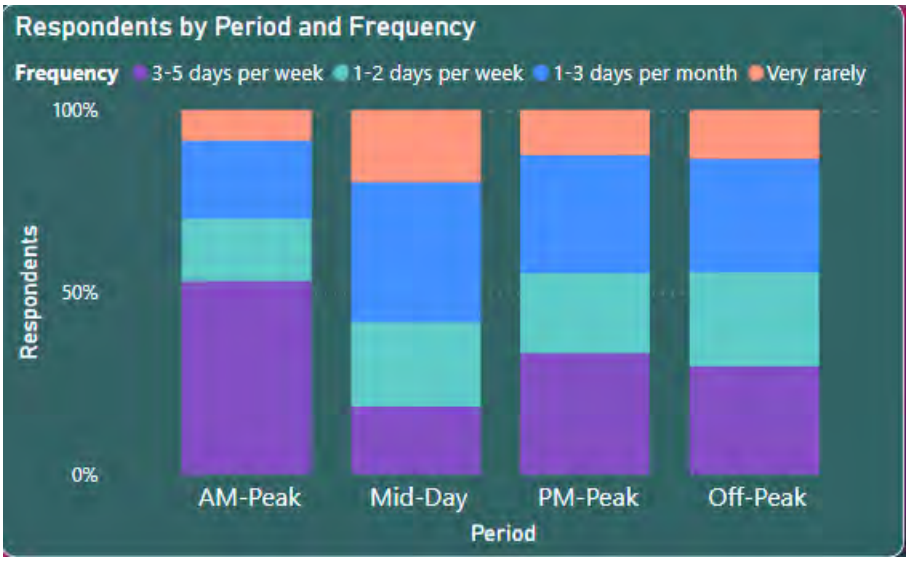
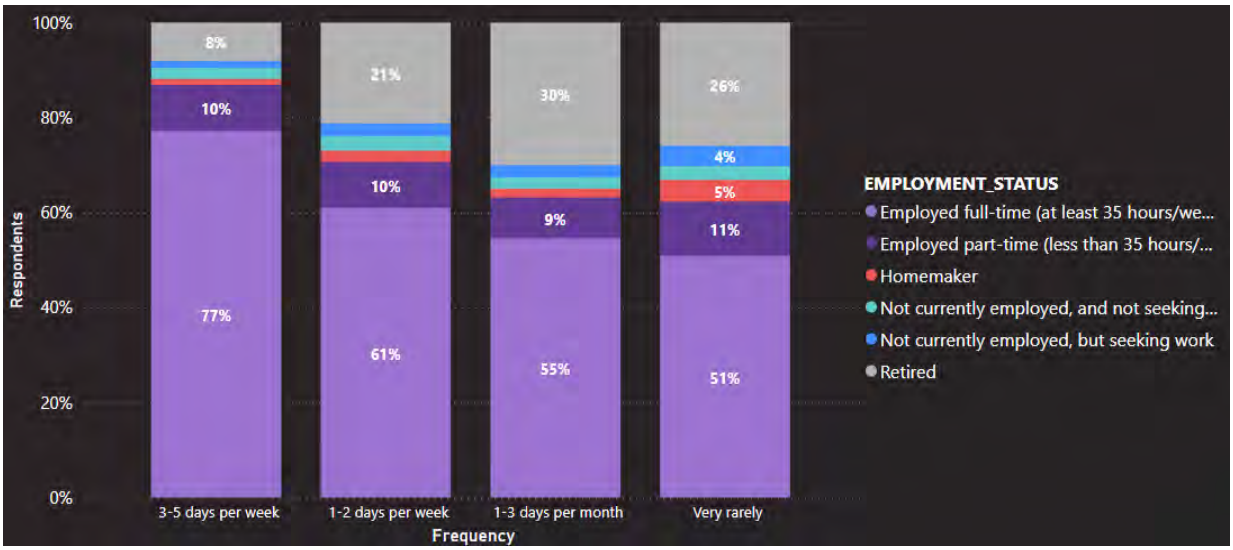


Figure 5-23. Percent Distribution of Trip Frequency by Time Periods



The Trip Frequency was analyzed with employment status in Figure 5-24. The most apparent takeaway was that almost 90 percent of frequent travelers (3-5 days per week) were employed, which was logically expected.

Figure 5-24. Percent Distribution of Trip Frequency by Employment Status



5.9 Summary - What Was Investigated

The NCTCOG Limited Access Facility Survey was a unique survey which collected information on many aspects of users and their trips on these facilities. These variables include household income, trip purpose, time period, toll amount, time savings, vehicle occupancy, trip frequency, and demographics including household income, household size, number of children, and employment status. Many of these variables were evaluated in order to determine if they caused statistical differences among various groups of LAF users or LAF facilities. Notably, the household income was carefully examined with focus as well as combined with the other factors. Multiple dimensional variables were cross-checked to interpret if any underlying connection exists. The toll amount and time savings were incorporated into the VOT analysis.

While NCTCOG has made many observations from various dimensions available in the LAF survey, the abundant information collected in the LAF survey may offer more insights than this report was able to cover which may be enlightening for the future policy making and transportation research related to the region as well as the other metroplex in the US. Some potential future study topics on this survey may include, but are not limited to, trip expense analysis, trip time evaluation using the regional travel model, and trip-making patterns based on gender or race.

Chapter 6. Appendix

6.1 Appendix 1 – Survey Implementation Plan

6.2 Appendix 2 – Questionnaire of the Survey

6.3 Appendix 3 – Database Lookup Table

6.4 Appendix 4 – Survey Expansion Process