   

The Travel Model *Improvement* Program

# A Snapshot of Travel Modeling Activities: The State of Texas

*Helping Agencies Improve Their Planning Analysis Techniques*

TMIP

Travel Model Improvement Program

# A Snapshot of Travel Modeling Activities: The State of Texas

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# Executive Summary

# Executive Summary

The Texas Department of Transportation (TxDOT) has been involved in model development and travel model activities since the early 1960s. With the implementation of the Surface Transportation Act in 1962, TxDOT became the lead travel demand model developer in the state for all urban areas greater than 50,000 in population and continues to be the lead model developer for 23 of the 25 urban areas in the state.

There are three main aspects in TxDOT's approach to modeling that have been an underlying motif throughout the ensuing decades and that inform the structure of this report; these are:

- *Software Independence*. What may be unique to Texas is the commitment to remain independent of externally developed software. The philosophy at TxDOT has been to support university-based research to shape software development and model approaches by the department.
- *Commitment to Data Collection*. TxDOT places a marked emphasis on a variety of data collection activities to support its travel demand forecasting program. Counts are collected annually in every TxDOT District as well as on a five-year cycle for each urbanized area in the state. Comprehensive travel surveys are conducted on a 10-year cycle for all 25 urban areas and coincide with the five-year urban area count collection program.
- *Support of Research and Model Enhancements*. During the previous four decades TxDOT has been a leading travel model practitioner by implementing periodic model enhancements to maintain their state of the practice. TxDOT's support of research to improve their travel forecasting practice continues to be an on-going commitment.

These three themes form the basis for a snapshot of modeling activities in Texas. Beginning with a brief history of modeling in the state, this snapshot focuses on TxDOT's current activities and is comprised of the following sections:

- A Brief History of Modeling in Texas
- The Current State of Modeling in Texas
- Data Collection Activities to Support Travel Models
- Highlights of Texas Model Applications
- Texas Statewide Analysis Model

## A Brief History of Modeling in Texas

TxDOT has been involved in model development since the early 1960s when it was initially responsible for the development and application of models for all urban areas in the state. In 1962, TxDOT performed the first large sample size home interview origin-destination (O-D) survey in Harris County, Texas. Using the results from this survey, Houston became the original travel model in the state. By the end of the decade, TxDOT had completed large sample-size surveys for every urban area exceeding or approaching 50,000 in population. This was a significant accomplishment at the time and may have been unprecedented in the scale and commitment demonstrated by the department. Nevertheless, TxDOT recognized that they could not afford to continue routinely conducting the large sample size surveys of the 1960s due to funding limitations. To that end, in 1970 TxDOT developed their first "synthetic" travel model for the Houston-Galveston eight-county region. The significance of the 1970 Houston model was to demonstrate that a large urban area model could be developed without the benefit of a large sample survey. In 1990, TxDOT instituted a comprehensive travel survey program to collect data for Texas urban areas and continues to conduct travel surveys around the state to support the development of urban area travel models.

## The Current State of Modeling in Texas

TxDOT centrally develops and deploys the urban area models for 23 of the 25 MPOs in the state. In cooperation with the Texas Transportation Institute, TxDOT has developed the Texas Package Suite of Travel Demand Models. The Texas Package standardizes the approach for model development in the state and has been utilized in some form or another for more than five decades. Because most of the urban areas in Texas are small-to-medium sized urban areas, the Texas Package is maintained as a sequential three-step 24-hour vehicle trip-based model – trip generation, trip distribution, and traffic assignment

In an effort to promote the continued use of travel models to conduct alternatives analysis within each MPO and to support the development of the Metropolitan Transportation Plans, TxDOT sponsors a number of outreach programs to support this philosophy and provides a variety of technical support and assistance programs including:

- Statewide Travel Demand Model Software Support
- Travel Demand Model and TransCAD Help Desk
- Model Application Training
- Air Quality Conformity Support

## Data Collection Activities to Support Travel Models

One of the unique aspects of the TxDOT travel forecasting program is the emphasis placed on a variety of data collection activities to support model development. Evidence of TxDOT's commitment can be found in the magnitude of the annual traffic data collection program. The data collection program includes thousands of traffic counts as well as a commitment to conduct urban area travel surveys on a regular basis. Traffic counts are collected annually in every TxDOT District and on a five-year cycle for each urbanized area in the state. Travel surveys are collected on a 10-year cycle and coincide with the five-year count collection program in an urban area.

There are two separate count collection programs in the state:

- *Continuous Operations*. Using permanent automatic traffic recorders (ATRs), TxDOT collects traffic data for each hour of the day and for each day of year at 162 locations throughout the state.
- *Short-term Traffic Monitoring*. Approximately 75,000 to 95,000 locations are counted annually in the state, depending on the count collection cycle for each individual TxDOT District. The counts are collected on both on-system (TxDOT maintained) and off-system facilities.

TxDOT uses travel surveys as the primary means to obtain current localized travel behavior information as well as travel characteristics. In 1990, TxDOT instituted a comprehensive travel survey program to collect data for the other urban areas in Texas. Under this program, the household travel surveys used random samples stratified by household size and income. Workplace, special generator, external station, and commercial vehicle surveys would also eventually be implemented under this program. The first two surveys conducted under this program were in Amarillo and San Antonio of that same year. Three additional surveys (Brownsville, Sherman-Denison, and Tyler) were conducted in the following year. Notably, since 2001 TxDOT has conducted more than 40 different travel surveys around the state to support the development of a wide array of input variables used in the development and application of travel models.

The travel survey data is used to support urban area travel model development. The statewide travel survey program encompasses all 25 Texas MPOs and is performed on a re-occurring ten-year cycle for each urban area. The travel survey program, depending on budget, may include any of the following surveys for a particular urban area:

- Household survey
- Workplace survey
- External station survey
- Commercial vehicle survey
- Special generator survey

TxDOT has also supported the development and collection of on-board public transit surveys but these are typically funded and coordinated locally.

## Highlights of Texas Model Applications

There have been a number of significant examples of model application in the state of Texas in recent years. Some of these are unique to the state while others, such as the combined regional approaches to modeling, offer similar experiences to what may be occurring in other parts of the country. Two examples that are unique to the state are the Houston-Galveston Area Council hurricane evacuation models and the Texas Metropolitan Mobility Plans. In both instances, specific software was developed to supplement the existing urban area models – one to improve the planning associated with natural disasters and the second to help quantify the actual cost of overcoming congestion throughout the state.

## Texas Statewide Analysis Model

TxDOT developed and maintains the Texas Statewide Analysis Model (SAM). This tool is used to analyze cross-state and cross-regional transportation improvements, to study the effects of statewide policy decisions related to passenger and freight travel, and to better understand the impact of the evolving trade environment beyond the state's borders. In addition, the SAM model may be used to generate external-through and external-local input data for the state's 25 urban-area travel demand models. The current version of SAM model development began in 2008 and was completed in 2011. Fundamentally based upon a prior version, the current version substantially advances the usability, analysis capability, flexibility, and reporting features of the model.

## Conclusion

This TMIP snapshot report offers a means of delineating and documenting the travel modeling activities of various planning agencies. As such, this snapshot report provides an overview of modeling activities in Texas as of 2011. Acknowledging that TxDOT is the lead model developer for 23 of the 25 Texas urban areas, the snapshot of modeling activities focuses on TxDOT's role in model development in Texas. It offers a comprehensive snapshot of Texas modeling activities by summarizing the current state of modeling in Texas, discussing on-going data collection activities and providing an overview of recent and unique Texas model applications. The model applications discussion illustrates that in response to specific needs, modeling activities in Texas continue to improve and evolve. Likewise, TxDOT's support of research to improve their travel forecasting practice continues to be an on-going commitment. The report also cites a number of outreach programs that TxDOT sponsors to promote the continued use of travel models to conduct alternatives analysis within each MPO and to support the development of the Metropolitan Transportation Plans. These efforts acknowledge that a prerequisite for enhancing the state of travel demand modeling practice in Texas, as elsewhere, is to ensure that a commensurate improvement in travel demand model user's knowledge, skills, and abilities occurs in unison with the development of new ideas and methodologies.

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# Introduction

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The Texas Department of Transportation (TxDOT) has been involved in model development and travel model activities since the early 1960s. With the implementation of the Surface Transportation Act in 1962, TxDOT became the lead travel demand model developer in the state for all urban areas greater than 50,000 in population and continues to be the lead model developer for 23 of the 25 urban areas in the state.

There are three main aspects in TxDOT's approach to modeling that have been an underlying motif throughout the ensuing decades and that inform the structure of this report; these are:

- Software independence
- Commitment to data collection
- Support of research and model enhancements

## Software Independence

What may be unique to Texas is the commitment to remain independent of externally developed software. TxDOT did not even utilize federally sponsored software that had been available in earlier decades because the department had developed and successfully implemented trip generation, trip distribution, and traffic assignment models on its own. The philosophy at TxDOT has been to support university-based research to shape software development and model approaches by the department. Since the inception of modeling in the state, TxDOT has developed and applied software specifically tailored to meet the needs and philosophies of the department. This software is commonly referred to as "The Texas Package Suite of Travel Demand Model" software, or merely the "Texas Package".

## Commitment to Data Collection

TxDOT places a marked emphasis on a variety of data collection activities to support its travel demand forecasting program. Evidence of TxDOT's commitment to data collection is demonstrated by the magnitude of the annual traffic data collection program that includes thousands of traffic counts. Counts are collected annually in every TxDOT District as well as on a five-year cycle for each urbanized area in the state. Further evidence of their commitment to data collection is shown in its schedule to update urban area travel surveys on a periodic basis. For the majority of Texas urban areas, comprehensive travel surveys are conducted on a 10-year cycle and coincide with the five-year urban area count collection program.

## Support of Research and Model Enhancements

During the previous four decades TxDOT has been a leading travel model practitioner implementing periodic model enhancements to maintain their state of the practice. Major model improvement milestones have included:

- During the early 1970s, TxDOT sponsored and implemented the development of its own mainframe based travel demand modeling software in lieu of waiting for the federal government to complete the Urban Transportation Planning System (UTPS).
- During the 1980s, TxDOT supported research to continue enhancing the Texas Package. Moreover, in response to Texas MPOs desiring to apply their own travel models, TxDOT integrated numerous Texas Package mainframe capabilities with personal computer platforms. TRANPLAN was subsequently disseminated to Texas metropolitan planning organizations (MPOs) to support local urban area long-range planning efforts. To that end, TxDOT also provided model application training to MPOs and TxDOT Districts throughout the state on the use of the Texas Package within the TRANPLAN environment.
- Acknowledging that urban travel patterns were changing considerably compared to the 1960s, TxDOT initiated a comprehensive travel survey program in the early 1990s. The primary goal of the comprehensive travel survey program was to collect new travel behavior data to support the development of Texas urban area travel models.
- During the late 1990s, TxDOT became one of the first state transportation agencies to adopt TransCAD. The adoption of TransCAD was in recognition of the benefits of integrating transportation planning and the model development process with geographic information system (GIS) technology.

TxDOT's support of research to improve their travel forecasting practice continues to be an on-going commitment. For example, TxDOT has recently supported research to assess the benefits of implementing advanced model practices into their travel models, including implementation of feedback loops and tour-based models.

## Report Content and Structure

These three themes then, form the basis for this modeling snapshot. Acknowledging that TxDOT is the lead model developer for 23 of the 25 Texas urban areas, the snapshot of modeling activities focuses on TxDOT's role in model development in Texas. Neither the Dallas-Fort Worth or Houston-Galveston models will be discussed in their current role in relation to TxDOT. The Dallas-Fort Worth region was one of five urban areas that were previously highlighted by the Travel Model Improvement Program (TMIP) report, *A Snapshot of Travel Modeling Activities*, August 2008. This report is not intended to replace or supplement that report with additional information regarding the North Central Texas Council of Governments (NCTCOG) models. Rather, this snapshot will focus on TxDOT's current activities and will begin with a brief history of modeling in the state. Following the brief history, the current state of modeling in Texas is summarized followed by a discussion of on-going data collection activities that support travel model development in the state. That is followed by an overview of recent and unique Texas model applications. The final section of the report offers a summary of the Texas statewide analysis model (SAM).

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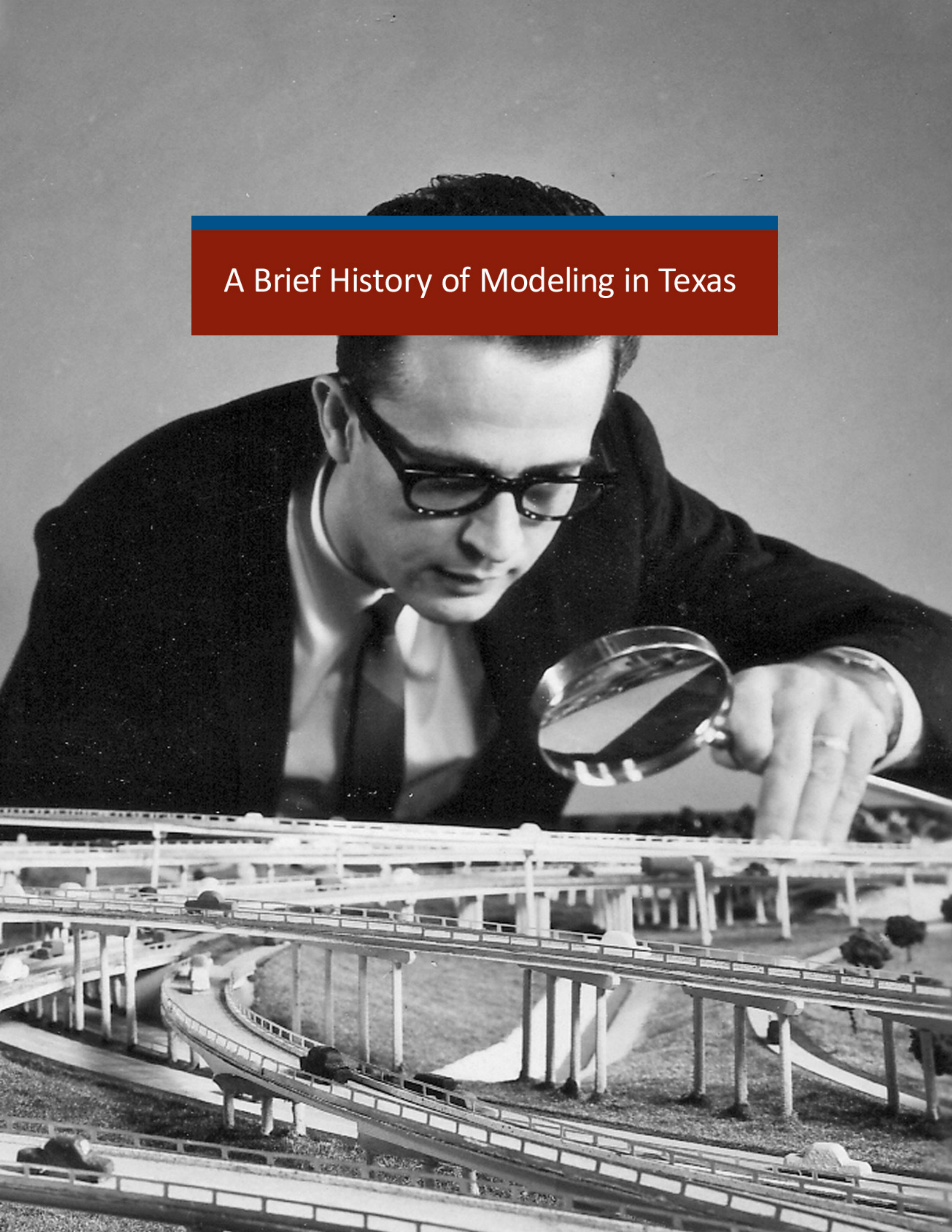
# A Brief History of Modeling in Texas



# A Brief History of Modeling in Texas

The Transportation Planning and Programming (TPP) Division of TxDOT has been involved in model development since the early 1960s, when it was previously known as the Planning-Survey Division of the Texas Highway Department. TxDOT was initially responsible for the development and application of models for all urban areas in the state. Today, TxDOT-TPP is responsible for model development in 23 of the 25 urban areas in the state; the two largest Texas urban areas are no longer under TxDOT's purview. NCTCOG maintains responsibility for the Dallas-Fort Worth (DFW) travel models and the Houston-Galveston Area Council of Governments (H-GAC) is responsible for the Houston-Galveston regional models. Some responsibilities, such as mode choice development and approaches to modeling toll facilities, have been migrated to two other large urban areas – Austin (Capital Area Metropolitan Planning Organization [CAMPO]) and San Antonio-Bexar County (San Antonio Metropolitan Planning Organization [SAMPO]). TxDOT however, still coordinates trip generation, trip distribution, and traffic assignment development activities with these two respective regions.

## Travel Surveys

In 1962, TxDOT performed the first large sample size home interview origin-destination (O-D) survey in Harris County, Texas. Using the results from this survey, Houston became the original travel model in the state. Shortly thereafter, the initial Dallas-Fort Worth (DFW) models were developed also utilizing full-scale home interview O-D travel surveys. The initial DFW models represented Dallas and Tarrant Counties. The sample size for the Dallas-Fort Worth survey was four percent of the households in the region, which is unprecedented by today's standards in terms of size and magnitude. Some of the sample sizes were as large as 12.5 percent (approximately one in every eight households was surveyed). Table 1 lists some of the sampling rates that were achieved for selected urban areas during the decade.

**Table 1: Historical Sampling Rates**

| Urban Area | Sampling Rate (Percent) | Year |
|---|---|---|
| Austin | 10.00 | 1962 |
| Brownsville | 12.50 | 1970 |
| Dallas-Fort Worth | 4.00 | 1964 |
| El Paso | 6.67 | 1970 |
| San Antonio | 5.00 | 1969 |
| Waco | 12.50 | 1964 |

*Source: Texas Department of Transportation*

By the end of the decade, TxDOT had completed large sample size surveys for every urban area exceeding or approaching 50,000 in population (e.g., Victoria had not quite reached 50,000 at that time). This was a significant accomplishment at the time and may have been unprecedented in the scale and commitment demonstrated by the department. Nevertheless, TxDOT recognized that they could not afford to continue routinely conducting the large sample size surveys of the 1960s due to funding limitations. To that end, TxDOT developed in 1970 it's first "synthetic" travel model for the Houston-Galveston eight-county region. The synthetic models relied on recent travel survey results from other large urban areas in Texas. A sizeable number of traffic counts were collected in the region to provide the observed data for validating the models. The synthetic models developed were a three-step model set without a mode choice component. The significance of the 1970 Houston model was in demonstrating that a large urban area model could be developed without the benefit of a large sample survey. The success of this approach thus allowed TxDOT to temporarily discontinue the collection of large sample household travel surveys.

While TxDOT and Texas MPOs realized major cost savings by avoiding the collection of household travel surveys for more than 10 years, by the early 1980s it was clear that their travel model database was becoming dated and required current data. In 1985, travel surveys were performed in the Houston-Galveston region and in the Dallas-Fort Worth region. Small sample stratified random surveys were conducted for these regions rather than the previous large sample surveys of the 1960s. In 1990, TxDOT instituted a comprehensive travel survey program to collect data for the other urban areas in Texas. Under this program, the household travel surveys used random samples stratified by household size and income. Workplace, special generator, external station, and commercial vehicle surveys would also eventually be implemented under this program. The first two surveys conducted under this program were in Amarillo and San Antonio of that same year. Three additional surveys (Brownsville, Sherman-Denison, and Tyler) were conducted in the following year. Notably, since 2001 TxDOT has conducted more than 40 additional travel surveys around the state to support the development of a wide array of input variables used in the development and application of travel models.

## Trip Generation

TxDOT trip generation modeling in the 1960s focused primarily on developing forecasted zonal trip end estimates for the development of growth factors in the trip distribution model. The early trip production models used by TxDOT stratified zonal households by income groups and auto ownership. For the early trip attraction models the non-residential activities were input as acres by type of activity (e.g., commercial, industrial, etc.). In the early 1970s, the Texas Transportation Institute (TTI) developed a suite of mainframe software to process travel survey data, develop trip generation models, and apply the models. This suite of programs was called TripCAL 1, 2, 3, and 4.

In the late 1970s and 1980s, Texas began to transition over to trip production models stratified by income and household size rather than income and auto ownership. In addition, Texas began to transition to the use of employment to describe non-residential activities at the zonal level. By the late 1980s, a new trip generation software package was developed for TxDOT to facilitate these new trip generation procedures. This package was called TripCal5 (since it was replacing the prior TripCAL 1, 2, 3, and 4 suite of programs. A micro-computer version of

TripCAL5 was subsequently developed in the early 1990s to be compatible with TRANPLAN software. Currently, TripCAL5 is still the trip generation program utilized by TxDOT.

## Trip Distribution

Based on 1960 survey data, TxDOT initially used a trip distribution procedure known as the "Texas Pattern Trip Procedure." The Texas Pattern Trip Procedure used FRATAR as the principle means to expand the base year trip tables (e.g., using simple growth rates) to develop forecast trip tables. In the application of FRATAR however, there was an issue with zones that initially had minimal or no trips yet experienced growth in the forecast scenario. In these instances, the growth patterns in adjacent zones were utilized and the trip tables were manually adjusted.

In the late 1960s, the Texas Pattern Trip Procedure was replaced with a "Constrained Interactance Model for Trip Distribution," which would simply be referred to as the "Texas Model," from that point forward. The Texas Model was adopted for all trip purposes with the exception of external-through trips, which continues to use a FARTAR model. The Texas Model, which was also developed by TTI under contract with TxDOT, used a basic gravity analogy but differed from a traditional gravity formulation in several aspects:

- The model provided for the direct input of desired trip length frequency distributions instead of friction factors. The philosophy within the Department at that time was trip lengths could be measured and observed whereas friction factors could not. Since average trip lengths were observed to be correlated with city size, the Department felt comfortable directly forecasting changes in average trip length based on the forecasted regional population control total.
- An interaction constraint was permitted, which essentially limited the number of attraction zones that were eligible for trips from a production zone. This was implemented because it was observed that with zonal production volume increases there was a corresponding increase in the potential number of zonal interactions.
- While most of the gravity model software in the late 1960s provided the users with the option of inputting K-Factors at the zonal interchange level, the Texas Model software was one of the first to allow the user to input the K-factors at the sector or district interchange level rather than a zonal interchange level.

Since a desired trip length frequency distribution was a model input in lieu of friction factors, the Texas Model was essentially a self-calibrating model. Unlike traditional gravity models, which are doubly constrained, the Texas Model was triply constrained (i.e., constrained to productions, attractions, and trip length frequency). Based on the input desired zonal attractions and desired trip length frequency by separation, attraction factors by zone and friction factors by separation were estimated and adjusted between iterations. The Texas Model, therefore, was simultaneously iterating on both attractions and trip length frequency. This was dissimilar to the traditional gravity model because only attraction factors are updated between iterations, while friction factors are held constant. Similar to traditional gravity models, trip matrix row totals were constrained to the input desired zonal productions.

In 1977, the Texas Model (trip distribution) was replaced by a "Spatially Disaggregate Trip Distribution Model," also known as the "Atomistic Model." The replacement model was developed by TTI under contract with TxDOT and was formally adopted by TxDOT for operational use during this time. The key features of the Atomistic Model are:

- The model explicitly accounts for zone size.
- The interaction constraint previously implemented in the Texas Model was removed.
- Zonal radii records were used to help estimate intra-zonal trips. Prior to the Atomistic Model, intra-zonal trips were manually estimated.
- The Atomistic Model retains the option to input the desired trip length frequency distribution, which, similar to the Texas Model, can be a triply constrained model.

In the 1980s, an updated Atomistic model, commonly referred to as ATOM2 was developed. ATOM2 was implemented as part of the Dallas-Fort Worth Joint Model Set that was cooperatively developed by TxDOT and NCTCOG. The cooperative development of the Joint Model set was initiated by the Federal Highway Administration (FHWA) noting that the NCTCOG and TxDOT models for the Dallas-Fort Worth region, which were independently maintained by the two respective agencies, had different assignment results. The key resulting enhancements included in ATOM2 are:

- Friction factors can be input and held constant during the iteration process.
- Terminal times can be input into the trip distribution process.

During the early 1990s, a micro-computer version of the ATOM2 software was created to interface with the TRANPLAN software. The ATOM2 software is still the chosen trip distribution procedure used by TxDOT.

## Traffic Assignment

Similar to trip generation and trip distribution, TxDOT successfully developed and applied its own traffic assignment software. Combined with trip generation, trip distribution and traffic assignment, this suite of programs became known as the "Texas Package."

Initially, traffic assignment was accomplished using TTI developed software for the Highway Department in the 1960s called "Texas BIGSYS." The software was developed for the IBM 7090 and IBM 7094 mainframe computer systems. The IBM 7094 only had 32k "words" of addressable memory (a word of memory consisted of 36 bits). Currently, memory is measured in terms of bytes (a byte of memory consists of 8 bits). Consequently, the IBM 7094 computers could only handle four bytes of information or about 128k of memory in today's standards. Interestingly in 1965, Texas A&M University and MIT were the only two universities at the time that had that level of computing power.

Due to memory limitations of the IBM 7090 and 7094 computers, an innovative "partitioned" network assignment modeling technique was developed and implemented in the Texas BIGSYS package. The ability of the BIGSYS package to partition networks facilitated modeling of large networks (e.g., Dallas-Fort Worth, Houston-Galveston, and San Antonio Bexar County) in greater detail (e.g., greater number of small zones). This feature was implemented because available memory at that time limited the scope and size of networks that could be implemented.

In the late 1960s, two new traffic assignment packages (the Texas Large Network Package and the Texas Small Network Package) were developed for use with the new IBM 360 mainframe computers. The new IBM 360 systems were third generation mainframe computers which were replacing second generation mainframe computers like the IBM 7094. The Texas Large Network Package was operational approximately two years prior to the federal package (UTPS) being developed for the IBM 360 computer systems. The Texas Large Network Package represented the state of the practice in assignment technology at that point in time. It utilized separate sequential "build tree" and "load tree" steps in the assignment process. The package also provided an iterative capacity restraint assignment procedure which adjusted the speeds of links exceeding capacity. Developed for use with smaller urban areas, the Texas Small Network Package had the same functional capabilities of the Large Network Package; however, it required less memory and incorporated a computationally efficient, simultaneous build-and-load algorithm. The reduced memory requirements and computational efficiency of the Texas Small Network Package thus allowed TXDOT to run assignments for small urban areas during the day rather than waiting for overnight runs.

In the mid to late 1970s, changes were made to capacity restraint procedures in both the Texas Large and Small Network Packages. The iterative capacity restraint procedure was modified to include the following improvements:

- The speeds for all links with a capacity were adjusted between each iteration.
- A modified version of the Bureau of Public Roads (BPR) volume-delay function was developed to allow for the input of representative 24-hour speeds rather than free-flow speeds.
- Volume-to-capacity (V/C) ratios were computed using a weighted average of the volumes from a current iteration and all preceding iterations.
- The user specified the number of iterations and desired iteration weights.

The mainframe traffic assignment procedures were maintained and updated through the mid-1990s when micro-computers became more common. In the late 1990s, TxDOT-TPP selected TransCAD software to perform network editing and traffic assignment.

## Travel Forecasting Software

As previously described, TxDOT has developed and applied software specifically tailored to meet their needs and philosophies since the inception of modeling in the state.

In the late 1980s, TxDOT obtained a statewide TRANPLAN license agreement to provide TRANPLAN to Metropolitan Planning Organizations (MPOs) and TxDOT Districts in the state. TRANPLAN software was developed and distributed by the Urban Analysis Group (UAG). This was the first time TxDOT made a commitment to software that was not related to the Texas Package Suite of programs. Even with the purchase of the TRANPLAN software, TxDOT continued to maintain and operate the Texas Package Suite of Travel Demand Model Programs available on the Texas Mainframe System. Model calibration was performed on the mainframe system while the calibrated files were eventually distributed to Texas MPOs and TxDOT Districts in TRANPLAN format. The intent in distributing TRANPLAN model networks and trip tables to the individual MPOs was to foster greater use and application of the travel models locally. Several unique programs were created to automate the file conversion process from the Texas mainframe format to TRANPLAN format to create the files necessary for distribution to the individual MPOs. TxDOT also provided the appropriate control files in TRANPLAN format (e.g., LOAD HIGHWAY NETWORK) to help facilitate local area application associated with analyzing various highway alternatives. The incremental assignment procedure available in TRANPLAN closely approximated the results previously implemented in the Texas Package mainframe software. TxDOT also sponsored TRANPLAN training throughout the state that was conducted by TTI under contract with TxDOT.

In the late 1990s, TxDOT completely migrated away from the Texas Mainframe platform to a microcomputer platform. To facilitate this transition, many of the elements that form the mainframe Texas Package were integrated into the microcomputer platform. This initially included making the trip generation and trip distribution software compatible with the TRANPLAN package.

Currently, TxDOT utilizes the TransCAD software (a commercially available package developed and distributed by the Caliper Corporation) as the base platform. Similar to the practices that occurred when TRANPLAN was used by the MPOs and TxDOT Districts in the late 1980s and mid-1990s, TxDOT still utilizes unique programs to develop and apply the trip generation and trip distribution portions of the sequential model chain. The programs have been integrated with the TransCAD software to take advantage of the geo-spatial capabilities afforded by TransCAD.

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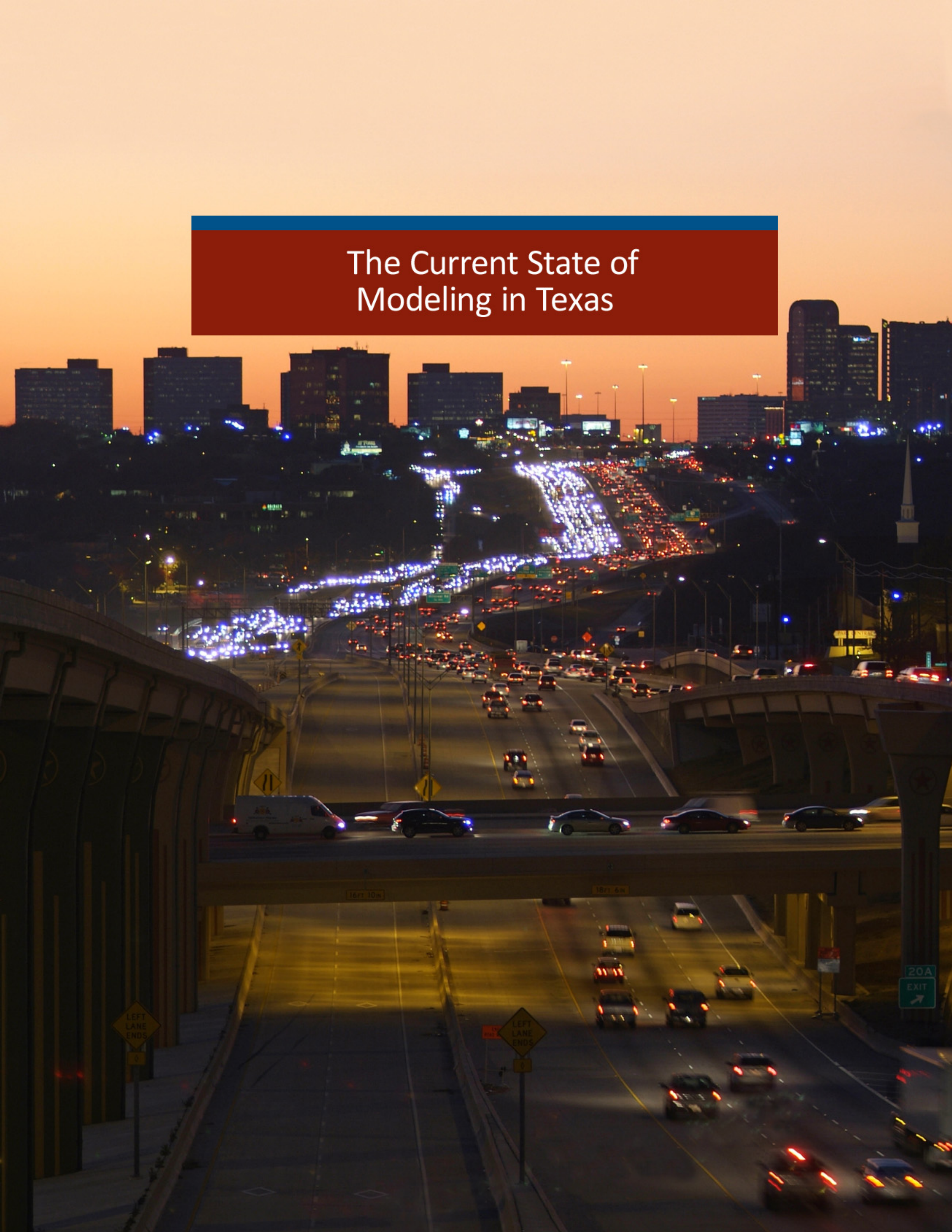
# The Current State of Modeling in Texas



# The Current State of Modeling in Texas

As noted earlier, TxDOT's Transportation Planning and Programming Division (TxDOT-TPP) is responsible for developing 23 of the 25 urban area models in the state of Texas, with the exception of Dallas-Fort Worth and Houston-Galveston. The North Central Texas Council of Governments (NCTCOG) and the Houston-Galveston Council of Governments (H-GAC) are responsible for the Dallas-Fort Worth and Houston regions respectively.

TxDOT-TPP maintains cooperative model development agreements with two other large urban areas – the Capital Area Metropolitan Planning Organization (CAMPO) and the San Antonio-Bexar County Metropolitan Planning Organization (SA-BC MPO). TxDOT-TPP is still responsible for certain aspects of these models (i.e., trip generation and trip distribution); however, the MPOs, thru consulting contracts, develop and apply the remaining steps – mode choice and traffic assignment. The current base year model for each urban area model in conjunction with the planned count collection cycle is listed in Table 2.

Several of the MPOs in the state have either expanded or are planning to extend the model area boundary (MAB) to the county line in an effort to capture the synergies associated with modeling to their respective county line (e.g. population control total estimates by county, external stations surveys conducted at the county line). MPOs that have expanded the MAB beyond the official MPO boundary include: Amarillo, Lubbock, Tyler, Longview, Sherman-Denison, and Brownsville/Harlingen-San-Benito. Waco officially expanded the urban area boundary to represent all of McLennan County in time for the 2005 count collection cycle. For Corpus Christi, the models represent all of San Patricio and Nueces counties and a small portion of Aransas County to accurately capture external stations that merge just beyond the San Patricio County line. Figure 1 depicts the location of the MPOs in the state relative to the model area boundaries.

## Table 2: Model Development Status by MPO

| Metropolitan Planning Organizations | Current Model Year | Next Count Year |
|---|---|---|
| Abilene | 1998 | 2010 |
| Amarillo | 2005 | 2010 |
| Austin – Campo | 2005 | 2010 |
| Brownsville | 2004 | 2010 |
| Bryan-College Station | 2006 | 2011 |
| Corpus Christi | 1996 | 2011 |
| Dallas-Fort Worth | N/A | 2009 |
| El Paso | 2002 | 2012 |
| Harlingen-San Benito | 2004 | 2009 |
| Hidalgo County | 2004 | 2009 |
| Houston-Galveston | N/A | 2011 |
| Jefferson-Orange-Hardin (JORHTS) | 2002 | 2011 |
| Killeen-Temple (KTUTS) | 1997 | 2010 |
| Laredo | 2003 | 2012 |
| Longview | 2002 | 2012 |
| Lubbock | 2000 | 2011 |
| Midland-Odessa | 2002 | 2012 |
| San Angelo | 2003 | 2013 |
| San Antonio | 2008 | 2010 |
| Sherman-Denison | 2003 | 2012 |
| Texarkana | 1995 | 2012 |
| Tyler | 2002 | 2012 |
| Victoria | 1996 | 2011 |
| Waco | 1997 | 2010 |
| Wichita Falls | 2000 | 2010 |

*Source: Texas Department of Transportation*

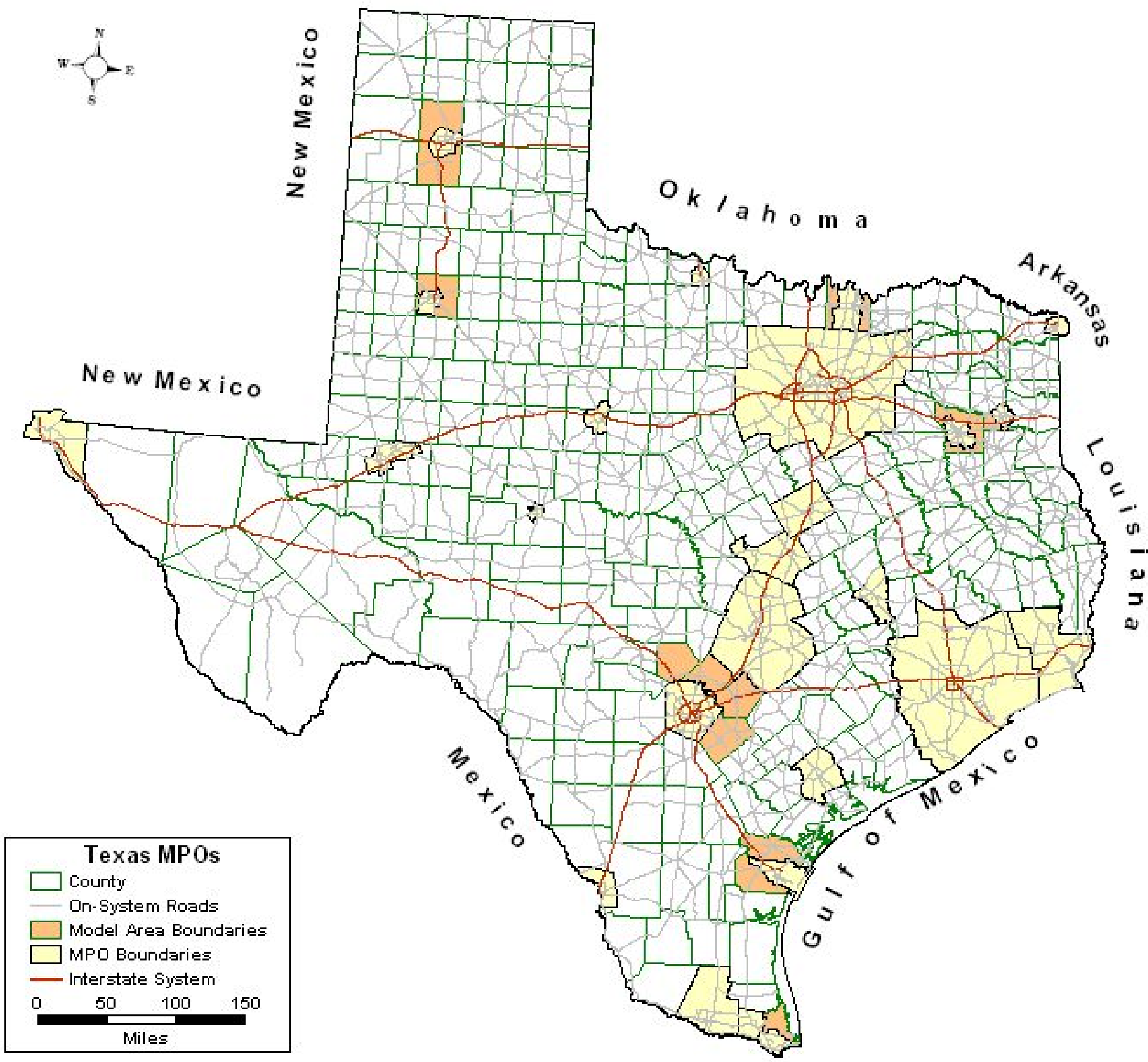



**Figure 1: Texas MPO Urban Area and Model Area Boundaries**

Within TxDOT, there are 25 Districts that are responsible for project development, maintenance, and oversight in their respective regions. Each of the 25 TxDOT Districts has a planning office that is responsible for providing support with the regional long-range plan update and associated long-range planning activities at the local MPO(s). The individual TxDOT Districts are typically the foremost source of highway projects to be included in the financially constrained plans. Of the 25 Districts, only three do not have an urbanized area that exceeds 50,000 in population. Consequently, there are no MPOs in the Lufkin, Brownwood, and Childress Districts. Some of the Districts have multiple MPOs with which to coordinate planning activities. The Dallas and Fort Worth Districts coordinate with NCTCOG. Table 3 provides a list of the Texas MPOs with the corresponding District. Information regarding attainment status (with National Ambient Air Quality Standards) as well as Transportation Management Area (TMA) status is also contained in the table.

**Table 3: Texas Metropolitan Planning Organizations**

| Metropolitan Planning Organization | TxDOT District | Attainment Status | TMA/ Non-TMA* |
|---|---|---|---|
| Abilene | Abilene | Attainment | Non-TMA |
| Amarillo | Amarillo | Attainment | Non-TMA |
| Austin – Campo | Austin | Attainment | TMA |
| Brownsville | Pharr | Attainment | Non-TMA |
| Bryan-College Station | Bryan | Attainment | Non-TMA |
| Corpus Christi | Corpus Christi | Attainment | TMA |
| Dallas-Fort Worth | Dallas & Fort Worth | Non-Attainment | TMA |
| El Paso | El Paso | Non-Attainment | TMA |
| Harlingen-San Benito | Pharr | Attainment | Non-TMA |
| Hidalgo County | Pharr | Attainment | TMA |
| Houston-Galveston | Houston | Non-Attainment | TMA |
| Jefferson-Orange-Hardin (JORHTS) | Beaumont | Non-Attainment | Non-TMA |
| Killeen-Temple (KTUTS) | Waco | Attainment | Non-TMA |
| Laredo | Laredo | Attainment | Non-TMA |
| Longview | Tyler | Attainment | Non-TMA |
| Lubbock | Lubbock | Attainment | TMA |
| Midland-Odessa | Odessa | Attainment | Non-TMA |
| San Angelo | San Angelo | Attainment | Non-TMA |
| San Antonio | San Antonio | Attainment | TMA |
| Sherman-Denison | Paris | Attainment | Non-TMA |
| Texarkana | Atlanta | Attainment | Non-TMA |
| Tyler | Tyler | Attainment | Non-TMA |
| Victoria | Yoakum | Attainment | Non-TMA |
| Waco | Waco | Attainment | Non-TMA |
| Wichita Falls | Wichita Falls | Attainment | Non-TMA |

**Based on 2000 Census Information*

Figure 2 illustrates the location of current MPO boundaries relative to the individual TxDOT Districts in the state. A majority of the Districts match the name of the MPO inside the District. There are a few instances (e.g., the Victoria MPO is in the Yoakum District) where the District and MPO names do not correspond. In those instances, the name of the MPO listed is distinguished with a pull-out arrow in the map.

Two Texas MPOs, El Paso and Texarkana, have model area boundaries that extend into neighboring states. The El Paso MPO models a portion of Dona Ana, New Mexico, for air quality purposes. The City of Texarkana is split in half by the Texas-Arkansas state line. Consequently, the Texarkana MPO represents portions of Bowie County, Texas, and Miller, County, Arkansas. Table 4 provides a list of individual MPOs and corresponding Texas Counties and TxDOT Districts.

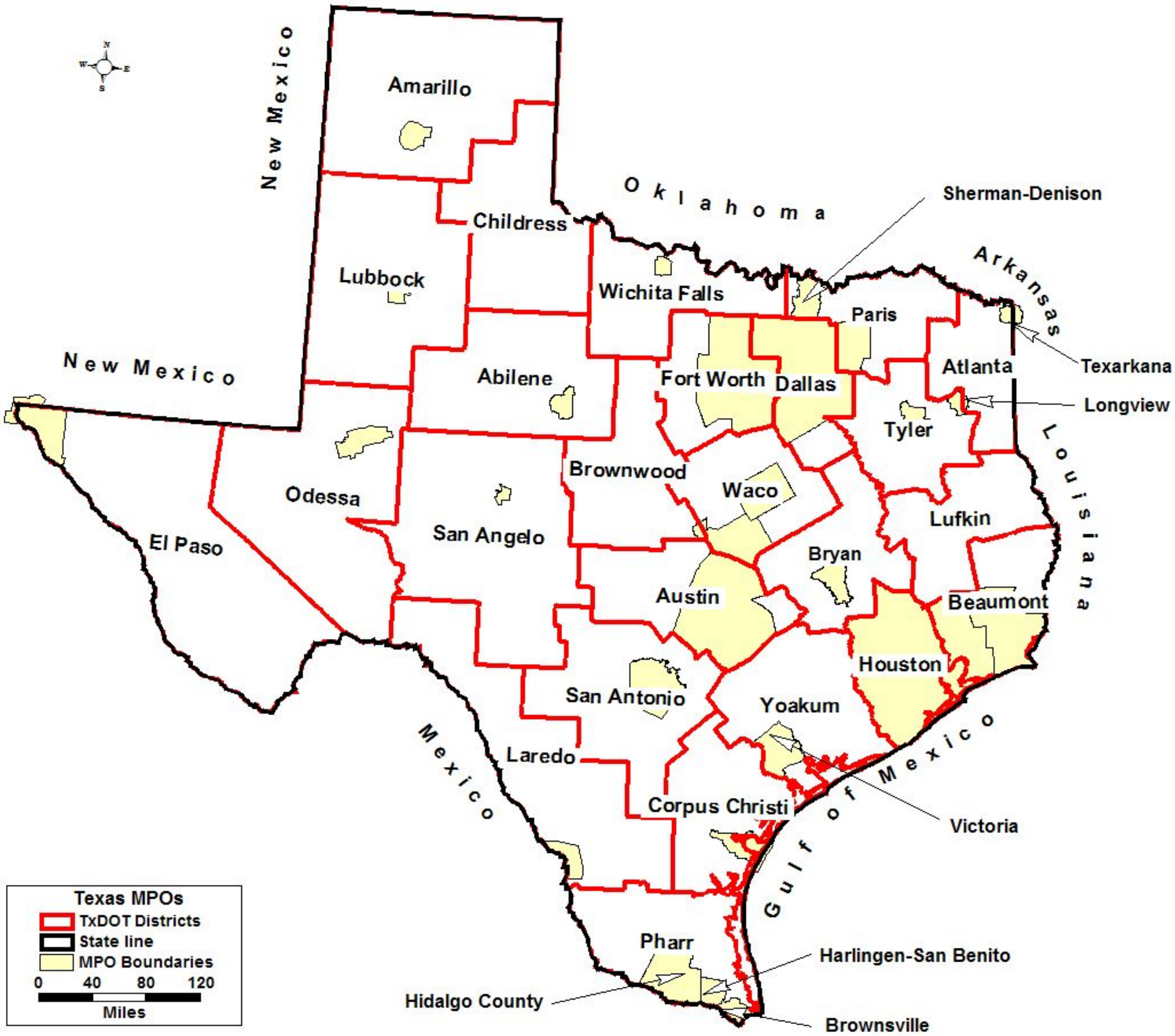



**Figure 2: Current MPO Boundaries Relative to TxDOT Districts**

*Source: Texas Department of Transportation*

**Table 4: List of Texas MPOs and the Counties Modeled**

| Metropolitan Planning Organization | TxDOT District | Current Counties Modeled* |
|---|---|---|
| Abilene | Abilene | Taylor*, Jones* and Callahan* |
| Amarillo | Amarillo | Potter and Randall |
| Austin – Campo | Austin | Travis, Williamson, Hays, Caldwell, and Bastrop |
| Brownsville | Pharr | Cameron** |
| Bryan-College Station | Bryan | Brazos |
| Corpus Christi | Corpus Christi | San Patricio, Nueces and Aransas* |
| Dallas-Fort Worth | Dallas & Fort Worth | 12 Counties in North-Central Texas |
| El Paso | El Paso | El Paso, Texas* and Dona Ana, New Mexico* |
| Harlingen-San Benito | Pharr | Cameron** |
| Hidalgo County | Pharr | Hidalgo |
| Houston-Galveston | Houston | Harris, Galveston, Chambers, Liberty, Montgomery, Waller, Fort Bend, and Brazoria |
| Jefferson-Orange-Hardin (JORHTS) | Beaumont | Hardin, Orange and Jefferson* |
| Killeen-Temple (KTUTS) | Waco | Bell*, Lampasas* and Coryell* |
| Laredo | Laredo | Webb* |
| Longview | Tyler | Gregg, Upshur*, Harrison*, and Rusk* |
| Lubbock | Lubbock | Lubbock* |
| Midland-Odessa | Odessa | Midland* and Ector* |
| San Angelo | San Angelo | Tom Green* |
| San Antonio | San Antonio | Kendall, Comal, Guadalupe, Wilson, and Bexar |
| Sherman-Denison | Paris | Grayson |
| Texarkana | Atlanta | Bowie County* and Texas, Miller County Arkansas* |
| Tyler | Tyler | Smith |
| Victoria | Yoakum | Victoria |
| Waco | Waco | McLenann* |
| Wichita Falls | Wichita Falls | Wichita* |

**Denotes county that is partially modeled    **Shared county between Harlingen-San Benito and Brownsville*
*Source: Texas Transportation Institute*

The Killeen-Temple and Lubbock urban areas will be expanding their model area boundaries to include the entire county within which they reside during their next planned model update.

# Current Trends Impacting Modeling in Texas

## *Population Trends by TxDOT District in Texas*

Six of the 23 MPOs that TxDOT-TPP supports represent metropolitan areas that exceed 200,000 in population. It is anticipated that the list of TMAs in the state will be expanded when the 2010 Census estimates of population are released (i.e., Amarillo, Brownsville, Killeen-Temple, and Laredo). The remaining 17 MPOs represent small-to-medium sized urban areas.

The four largest urbanized areas in the state are: Dallas-Fort Worth, Houston-Galveston, Austin, and San Antonio. According to 2009 population estimates from the Texas State Data Center (TSDC), the Dallas-Fort Worth-Arlington and Houston-Sugar Land-Baytown Metropolitan Statistical Areas (MSAs) have approximately 5.1 and 4.7 million people, respectively. The five TxDOT Districts that experienced the most growth in population between 2000 and 2008 are Dallas, Fort Worth, Houston, Austin, and Pharr with greater than 20 percent increase. Figure 3 depicts by TxDOT District the 2000 to 2008 population growth in percentage terms.

Five other TxDOT Districts experienced growth that exceeded nine percent during the same period – Waco, Bryan, San Antonio, Laredo, and El Paso. The Pharr, Laredo, and El Paso Districts represent the three primary border Districts with Mexico. These regions have cumulatively experienced substantial growth in terms of population and jobs the past few decades.

By county the growth is concentrated in and around existing urbanized areas while rural counties are experiencing declining population. Five counties (Rockwall, Williamson, Collin, Hays, and Fort Bend) experienced population growth that exceeded 50 percent between 2000 and 2008. Williamson and Hays Counties are part of the five county Austin region. Collin and Rockwall County are just north and east of Dallas County respectively and are included in the NCTCOG travel models. Fort Bend County is a part of the high growth region west of Houston along the Interstate 10 corridor and is one of the eight counties modeled in the H-GAC travel models. Figure 4 graphically depicts the population change between 2000 and 2008 by county in the state.

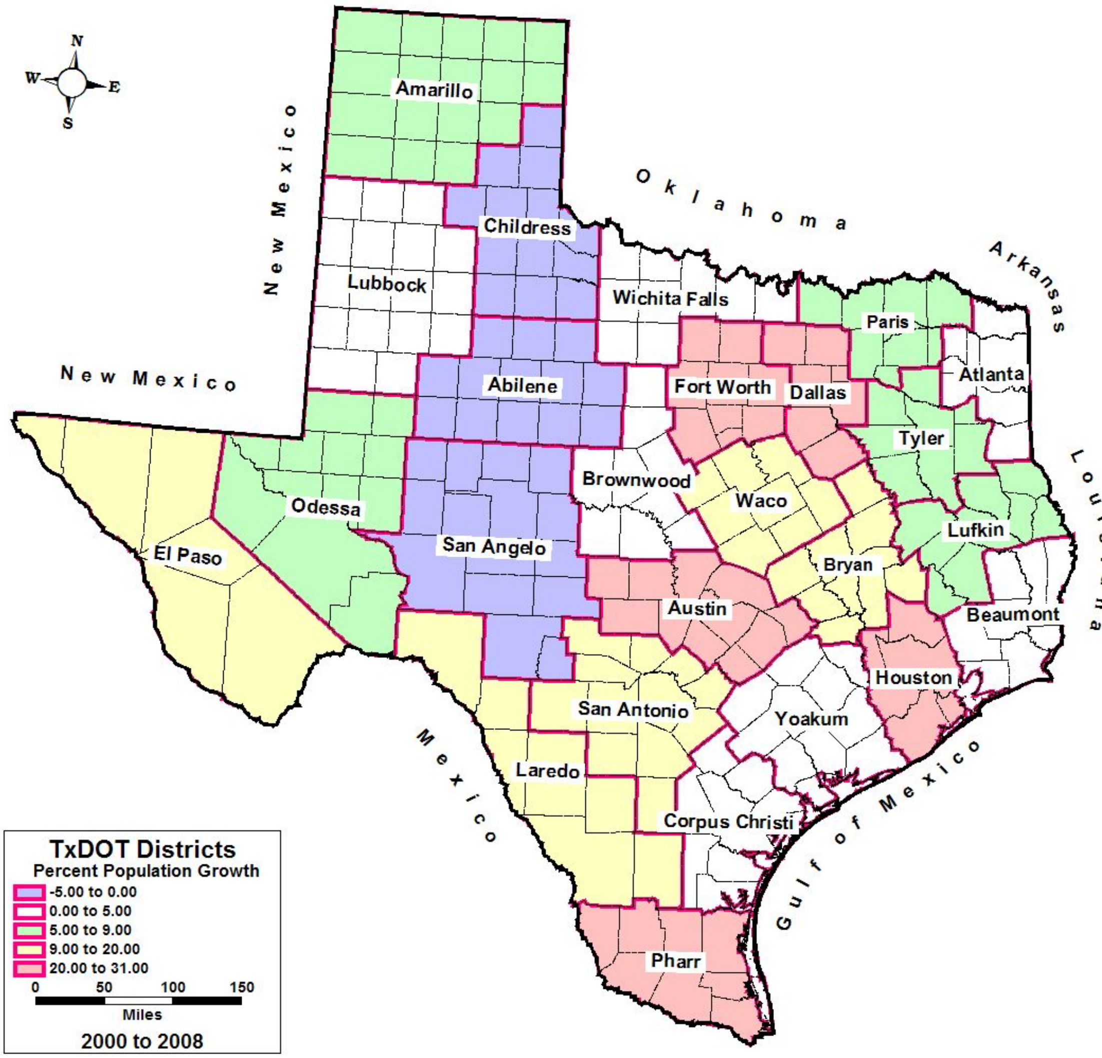



**Figure 3: Population Growth (2000–2008) by TxDOT District**

*Source: Texas State Data Center*

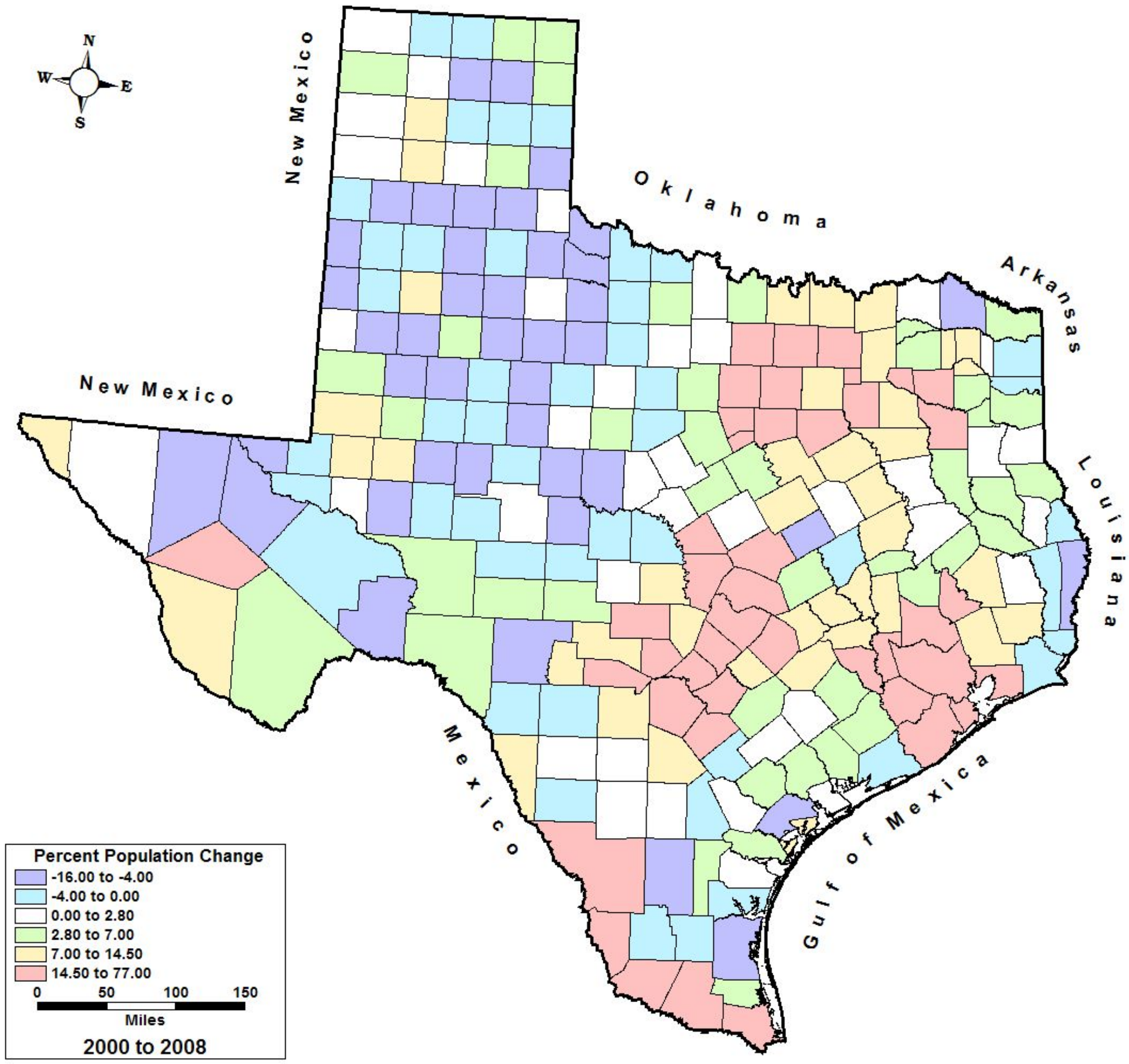



**Figure 4: Population Growth in Texas by County (2000–2008)**

*Source: Texas State Data Center*

## *Vehicle Miles of Travel (VMT) Trends*

Using the same 2000–2008 period that was previously used to describe recent population changes in the state, the TxDOT Districts with the greatest increases in VMT are the same as those that experienced the greatest growth in population. Using the *TxDOT Annual Reports* (2008 is the last published report available), the entire state has seen a nearly nine percent increase in vehicle miles of travel between 2000 and 2008. Similar to population, the largest growth in terms of absolute numbers are associated with the four largest urbanized areas in the state (if the Dallas and Fort Worth Districts are combined). According to Table 5, the Houston District experienced the largest increase in VMT during this eight-year period.

**Table 5: Five Highest Regions (VMT Growth)**

| TxDOT District | Growth 00 to 08 | VMT Growth Rank |
|---|---|---|
| Houston | 16,426,304 | 1 |
| Dallas-Fort Worth* | 10,124,827 | 2 |
| Austin | 7,566,371 | 3 |
| San Antonio | 5,205,367 | 4 |
| Pharr | 4,051,527 | 5 |

**Combined*
*Source: Texas Department of Transportation (Annual Reports)*

In fact, the four largest Districts by VMT have a disproportionate share of the statewide VMT – accounting for 61% of the total 2008 counted daily VMT in the state (see Figure 5).

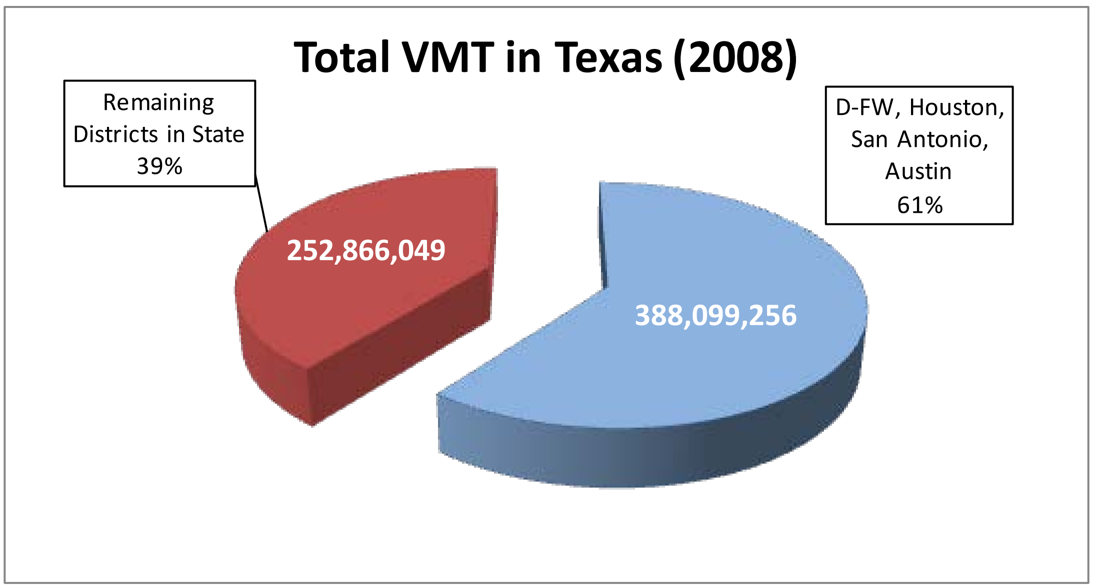



**Figure 5: Proportion of VMT in State**
*Source: Texas Department of Transportation (2008 Annual Report)*

According to the data presented in Table 6, only four Districts in the state experienced a decline in travel (as measured in terms of VMT trends between 2000 and 2008). The data presented in the table is ranked based on absolute growth during the eight-year period.

**Table 6: VMT Trends by TxDOT District (2000–2008)**

| VMT Growth Rank | District Name | 2000 Daily Veh. Miles | 2008 Daily Veh. Miles | % Growth 00 to 08 | Growth per yr. 00 to 08 | Absolute Growth 00 to 08 | TxDOT District Number |
|---|---|---|---|---|---|---|---|
| 1 | Houston | 111,674,251 | 128,100,555 | 14.71% | 1.84% | 16,426,304 | 12 |
| 2 | Austin | 37,274,799 | 44,841,170 | 20.30% | 2.54% | 7,566,371 | 14 |
| 3 | Dallas | 97,834,043 | 103,480,997 | 5.77% | 0.72% | 5,646,954 | 18 |
| 4 | San Antonio | 49,193,439 | 54,398,806 | 10.58% | 1.32% | 5,205,367 | 15 |
| 5 | Fort Worth | 52,799,856 | 57,277,729 | 8.48% | 1.06% | 4,477,873 | 2 |
| 6 | Pharr | 19,786,593 | 23,838,120 | 20.48% | 2.56% | 4,051,527 | 21 |
| 7 | Bryan | 13,655,363 | 15,825,729 | 15.89% | 1.99% | 2,170,366 | 17 |
| 8 | Tyler | 18,196,375 | 19,687,178 | 8.19% | 1.02% | 1,490,803 | 10 |
| 9 | El Paso | 15,837,293 | 17,259,815 | 8.98% | 1.12% | 1,422,522 | 24 |
| 10 | Odessa | 9,534,234 | 10,672,119 | 11.93% | 1.49% | 1,137,885 | 6 |
| 11 | Beaumont | 17,820,827 | 18,682,599 | 4.84% | 0.60% | 861,772 | 20 |
| 12 | Yoakum | 12,891,385 | 13,744,012 | 6.61% | 0.83% | 852,627 | 13 |
| 13 | Corpus Christi | 17,006,093 | 17,841,599 | 4.91% | 0.61% | 835,506 | 16 |
| 14 | Abilene | 8,877,273 | 9,331,750 | 5.12% | 0.64% | 454,477 | 8 |
| 15 | Lufkin | 8,951,336 | 9,397,749 | 4.99% | 0.62% | 446,413 | 11 |
| 16 | San Angelo | 5,629,778 | 6,050,688 | 7.48% | 0.93% | 420,910 | 7 |
| 17 | Waco | 19,426,135 | 19,845,836 | 2.16% | 0.27% | 419,701 | 9 |
| 18 | Atlanta | 11,654,575 | 11,937,195 | 2.42% | 0.30% | 282,620 | 19 |
| 19 | Childress | 2,693,799 | 2,969,723 | 10.24% | 1.28% | 275,924 | 25 |
| 20 | Paris | 11,388,633 | 11,406,474 | 0.16% | 0.02% | 17,841 | 1 |
| 21 | Brownwood | 4,548,404 | 4,413,085 | -2.98% | -0.37% | -135,319 | 23 |
| 22 | Lubbock | 13,199,394 | 12,957,846 | -1.83% | -0.23% | -241,548 | 5 |
| 23 | Wichita Falls | 8,184,026 | 7,741,219 | -5.41% | -0.68% | -442,807 | 3 |
| 24 | Amarillo | 12,350,451 | 11,567,291 | -6.34% | -0.79% | -783,160 | 4 |
| 25 | Laredo | 8,647,731 | 7,696,023 | -11.01% | -1.38% | -951,708 | 22 |
| **State** | | **589,056,086** | **640,965,305** | **8.81%** | **1.10%** | **51,909,219** | |

*Source: Texas Department of Transportation (Annual Reports)*

The general trend for the entire state has been increasing VMT. Recently though, overall VMT experienced a slight decline (probably due in large part to the economic crisis that was beginning to unfold in 2008 along with increasing gasoline prices). Figure 6 depicts recent annual VMT trends for the state between 2000 and 2008.

## *Forecast Population Trends in the State by MSA*

Preliminary projections from the Texas State Data Center (TSDC) and Office of the State Demographer (University of Texas – San Antonio) indicate that the top three largest metropolitan areas in the state (i.e., Dallas-Fort Worth, Houston-Galveston, and Austin-Round Rock) will continue to experience the greatest growth in population in terms of absolute numbers between 2000 and 2040. The San Antonio MSA is displaced in the top four by McAllen-Edinburg-Pharr, which is located in the Lower Rio Grande Valley region.

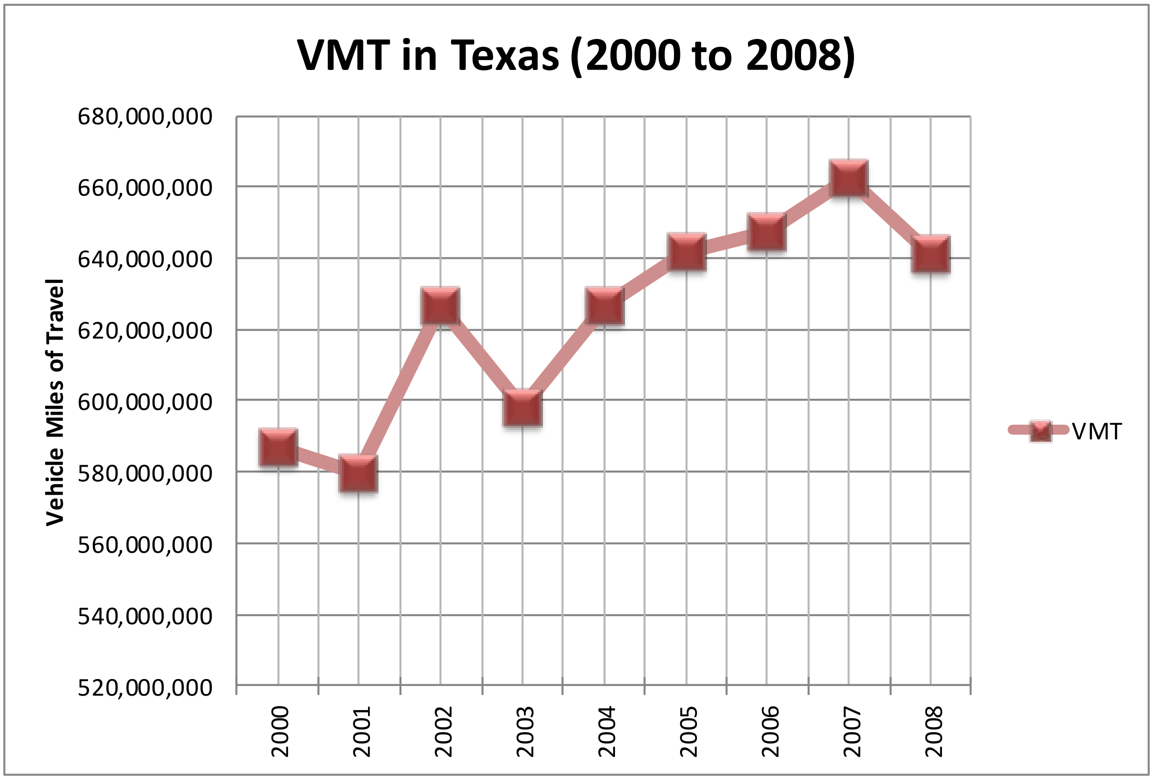



**Figure 6: Annual VMT Trend in Texas**

*Source: Texas Department of Transportation (Annual Reports 2000 to 2008)*

If current trends continue, the entire Lower Rio Grande Valley region (i.e., McAllen, Brownsville, and Harlingen-San Benito) will add 2.1 million new people by 2040 (based on 2000 Census estimates of population). In fact the entire region is anticipated to grow by 133% between 2000 and 2040. This represents an annual growth rate of 3.33%.

Similarly, the entire Texas-Mexico border area, including the Lower Rio Grande Valley, Laredo, and El Paso will add 3.8 million people by 2040, which is greater than the 2010 combined total for the Austin and San Antonio urbanized area. Table 7 on the following page provides a summary of population projections for the 25 MSAs in the state. The data are presented by the 2000–2040 absolute growth rank order.

The entire state is expected to experience a 71% population increase using the 2040 TSDC population projections (0.5 migration scenario). The travel demand models developed by TxDOT will be the primary tool for analyzing the effects of the population and VMT trends highlighted in the previous section.

**Table 7: Texas Population Projections by MSA**

| MSA | 00 to 40 Growth Rank | Population | | | Absolute Growth 00 to '10 | Absolute Growth 00 to '40 | % Growth 00 to '40 | Growth per yr. 00 to '40 |
|---|---|---|---|---|---|---|---|---|
| | | Year 2000 | Year 2010 | Year 2040 | | | | |
| Dallas-Fort Worth | 1 | 5,161,544 | 6,197,626 | 10,107,348 | 1,036,082 | 3,909,722 | 95.82% | 2.40% |
| Houston-Sugar Land-Baytown | 2 | 4,715,407 | 5,545,836 | 8,398,069 | 830,429 | 2,852,233 | 78.10% | 1.95% |
| Austin-Round Rock | 3 | 1,249,763 | 1,565,051 | 2,661,842 | 315,288 | 1,096,791 | 112.99% | 2.82% |
| McAllen-Edinburg-Pharr | 4 | 569,463 | 750,714 | 1,434,632 | 181,251 | 683,918 | 151.93% | 3.80% |
| San Antonio | 5 | 1,711,703 | 1,953,572 | 2,514,097 | 241,869 | 560,525 | 46.88% | 1.17% |
| El Paso | 6 | 679,622 | 804,087 | 1,150,619 | 124,465 | 346,532 | 69.30% | 1.73% |
| Laredo | 7 | 193,117 | 263,727 | 545,292 | 70,610 | 281,565 | 182.36% | 4.56% |
| Brownsville-Harlingen | 8 | 335,227 | 415,304 | 675,777 | 80,077 | 260,473 | 101.59% | 2.54% |
| Killeen-Temple-Fort Hood | 9 | 330,714 | 391,281 | 553,624 | 60,567 | 162,343 | 67.40% | 1.69% |
| Corpus Christi | 10 | 403,280 | 460,003 | 606,563 | 56,723 | 146,560 | 50.41% | 1.26% |
| Amarillo | 11 | 226,522 | 254,676 | 330,723 | 28,154 | 76,047 | 46.00% | 1.15% |
| Bryan-College Station | 12 | 184,885 | 208,258 | 271,579 | 23,373 | 63,321 | 46.89% | 1.17% |
| Waco | 13 | 213,517 | 231,538 | 285,484 | 18,021 | 53,946 | 33.71% | 0.84% |
| Tyler | 14 | 174,706 | 188,519 | 240,263 | 13,813 | 51,744 | 37.52% | 0.94% |
| Beaumont-Port Arthur | 15 | 385,090 | 405,139 | 454,226 | 20,049 | 49,087 | 17.95% | 0.45% |
| Longview | 16 | 194,042 | 207,577 | 249,812 | 13,535 | 42,235 | 28.74% | 0.72% |
| Odessa | 17 | 121,123 | 132,775 | 163,093 | 11,652 | 30,318 | 34.65% | 0.87% |
| Victoria | 18 | 111,663 | 124,336 | 153,826 | 12,673 | 29,490 | 37.76% | 0.94% |
| Lubbock | 19 | 249,700 | 271,221 | 298,162 | 21,521 | 26,941 | 19.41% | 0.49% |
| Midland | 20 | 116,009 | 124,575 | 145,132 | 8,566 | 20,557 | 25.10% | 0.63% |
| Sherman-Denison | 21 | 110,595 | 118,011 | 133,290 | 7,416 | 15,279 | 20.52% | 0.51% |
| Wichita Falls | 22 | 151,524 | 159,225 | 171,356 | 7,701 | 12,131 | 13.09% | 0.33% |
| San Angelo | 23 | 105,781 | 113,236 | 124,823 | 7,455 | 11,587 | 18.00% | 0.45% |
| Abilene | 24 | 160,245 | 171,018 | 181,506 | 10,773 | 10,488 | 13.27% | 0.33% |
| Texarkana | 25 | 89,306 | 90,972 | 84,244 | 1,666 | -6,728 | -5.67% | -0.14% |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **State** | **20,851,820** | **24,330,646** | **35,761,165** | **3,478,826** | **11,430,519** | **71.50%** | **1.79%** |

Source: Texas State Data Center

## Texas Package Travel Demand Modeling Software

As noted earlier, the Transportation Planning and Programming (TPP) Division of the Texas Department of Transportation (TxDOT) centrally develops and deploys the urban area models for 23 of the 25 MPOs in the state. The TPP Division, in cooperation with TTI, has developed the Texas Package Suite of Travel Demand Models for use in the state. The Texas Package standardizes the approach for model development in the state and has been utilized in some form or another for more than five decades. Because most of the urban areas in the state are small-to-medium sized urban areas, the Texas Package is maintained as a sequential three-step 24-hour vehicle trip based model – trip generation, trip distribution, and traffic assignment.

The trip generation program in Texas is called TripCAL5, while the trip distribution program is referred to as ATOM2. A mezzo-level HOV model is available in the Texas Package but has only been used sparingly (i.e., El Paso, Beaumont, and initially in Houston). The TransCAD user equilibrium procedure is used for the trip assignment step. With few exceptions, TxDOT uses a sequential three-step model. The San Antonio and Austin travel models have implemented mode choice models that have time-of-day considerations. In both urban areas, person trips are generated and distributed. The resulting person trip tables are input into the individual mode choice models to create vehicle and transit trip matrices. The El Paso models also generate and distribute person trips prior to applying the mezzo-level HOV model. The remaining urban areas examine 24-hour vehicle trips through the sequential three-step process. Figure 7 illustrates the standard three-step Texas Package without the accompanying suite of supporting utilities necessary to apply the models.

When TxDOT-TPP made the decision to migrate from the mainframe Texas Suite of programs to the TransCAD software in the late 1990s, several existing Texas Package functions were successfully instituted within the micro-computer platform. The use of an add-on menu item invokes the entire Texas Package within TransCAD. Actual use of the TransCAD software is limited to the following model application activities:

- Network and traffic analysis zone definition and specification
- Minimum travel time (expressed in minutes) calculation for trip distribution
- External-thru trip matrix creation (Growth factor model)
- PA to OD conversion
- Traffic assignment

All other model related activities are maintained in the Texas Package. The philosophy of the department has been to maintain the Texas trip generation and trip distribution portions of the suite independently of any commercially available software. The primary reasons are to continue to promote in-house capability and knowledge as well as preserve portability. Figure 8 on the following page is an example flow-chart of the Texas Package Suite of Programs used for model applications in El Paso. The flow chart includes the mezzo-level HOV model that is applied as a part of the travel models in El Paso. Additional utilities are used for model development but these are not illustrated in Figure 8.

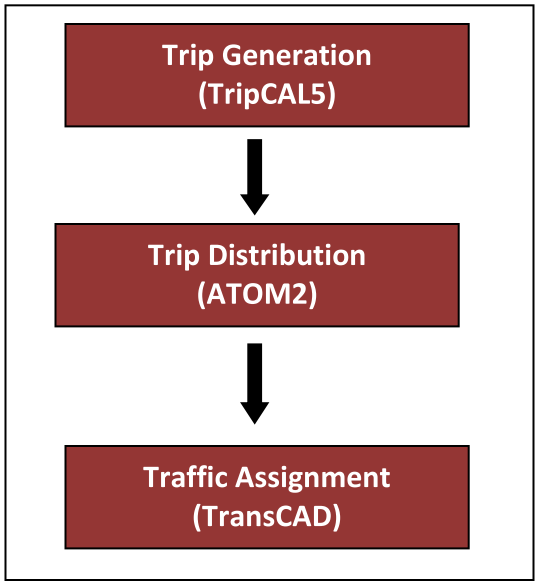



**Figure 7: Texas Travel Demand Model Package**

## *Trip Generation (TripCAL5)*

The zonal trip generation estimates for urban areas in Texas are derived using the TripCAL5 software. This software is a multifunctional and flexible trip generation program that allows the urban areas in Texas to estimate zonal trip productions and attractions for each of the typical trip purposes modeled in the state.

Although there are three potential production models available in the TripCAL5 software (e.g., two-way cross-classification, three-way cross-classification and linear regression model), the standard approach is a two-way cross-classification. The typical independent variables are five household size and income categories. Two exceptions are the Austin and San Antonio models which use a third variable – workers in the household – for the home-base work trip purpose.

The standard trip attraction models are also cross-classification models that apply attraction rates stratified by area type and either households or four employment types. Typically four or five area types are used in most of the Texas urban area models (e.g., CBD, Urban, Suburban, and Rural). However TripCAL5 has the capability to apply five different trip attraction model procedures.

The four employment categories used in the Texas models are:

- Basic employment
- Retail employment
- Service employment
- Education

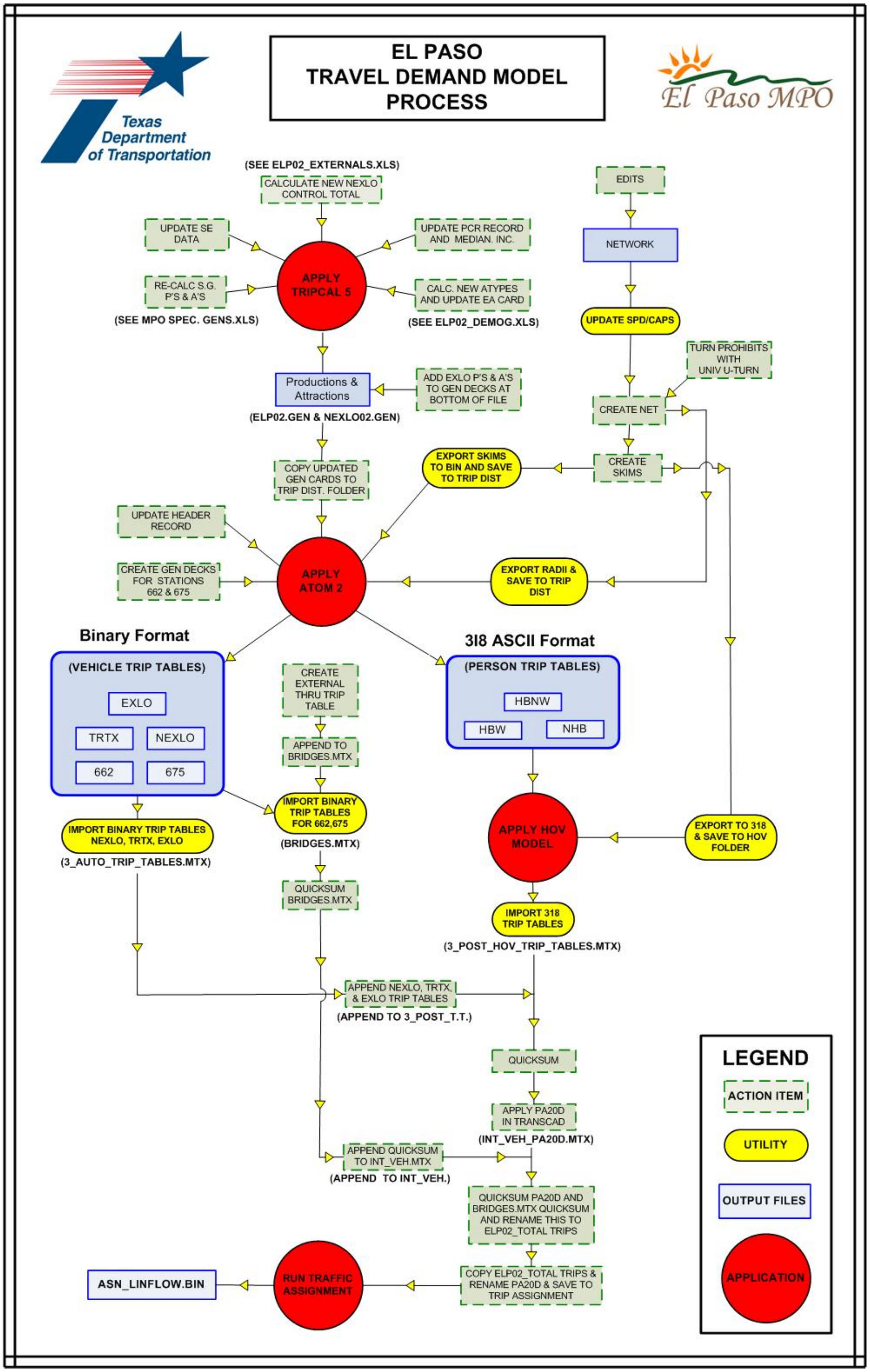



**Figure 8: Texas Package Suite of Program (El Paso Model Application Example)**

In this manner, Texas MPOs are only required to provide zonal base year inventories and forecast year estimates of population, households, and median household income to estimate trip productions; while zonal household and employment by category totals are needed for trip attractions. The zonal household incomes are typically consistent with the year for which household survey data were collected in the region and are expressed in terms of constant dollars for forecast applications.

Because the data provided at the zonal level to TxDOT by the MPOs are aggregate, the application of the trip generation models in the state requires estimates of the distribution of households by five size and income ranges. A regional matrix of households by size and income is estimated for each urban area in the state (typically based on Census data) and is treated as a regional constraint in the development of individual estimates of travel at the zonal level. The distribution of households by size and income are estimated for each zone in the TripCAL5 software based on the regional distribution. The zonal estimates are arrived at through an iterative process in the software.

TripCAL5 can handle up to ten internal trip purposes. The typical internal trip purposes used in Texas are:

- Home-base work (HBW)
- Home-based non-work (HBNW)
- Non-home based (NHB)
- Truck-taxi (TRTX)
- Non-home based non-resident external (NEXLO – discussed below)

Additional trip purposes have been used in other urban areas. For instance, the Austin region trip generation models have three different types of home based work trip purposes. In other instances, education related travel has been included as individual trip purposes (e.g., K-12 and University) and airport related travel has also been segregated as an individual trip purpose. An option to estimate truck travel (TRTX) is available in TripCAL5; however, a regional production control total is typically derived from a regional commercial vehicle survey.

The attraction rates for the internal trip purposes (HBW, HBNW, NHB, and TRTX) are applied at the zonal level to estimate the un-scaled attractions for each of the internal trip purposes. The un-scaled attractions are eventually scaled to match the production control total by trip purpose for the region (minus trips independently estimated for special generators). The scaling process is automatically performed by the TripCAL5 software.

Base year external travel is directly derived from the traffic counts and roadside intercept travel surveys conducted at each external station. The proportion of external-local (external-internal or internal-external) and external-through (external-external) are determined using external travel survey data that have been collected at the urban area cordon boundary (typically the county line in most instances). External travel is further disaggregated into non-commercial and commercial (truck) vehicle classes. Consequently, there are four external trip purposes in the TxDOT models:

- External-local auto (EXLO-A)
- External-local commercial (EXLO-T)
- External-through auto (THRU-A)
- External-through commercial (THRU-T)

External-local auto and truck productions are both input to the TripCAL5 software. For external-local auto, internal attractions are based on NHB attractions, while TRTX attractions are the basis for the external-local truck trip purpose. The external-through trip tables are created using the FRATAR growth factor model available in TransCAD. A seed matrix for each of the external through trip matrices is developed from external station survey data (when available) and the desired totals for each station are derived from the external through and external local percentage of trips obtained from the surveys as well.

TxDOT also estimates additional trips made by non-residents while visiting the urban area. These trips are defined as non-home based non-resident external (NEXLO) trips. In other words, NEXLO trips are non-home based internal trips made by non-residents to the urban area. When a visitor/commuter enters or exits the urban area, this type of trip is classified as external-local (i.e., trips with one trip end at an external station and one end in an internal zone). If the trip maker continues to make additional internal trips before leaving the urban area, then these trips are considered to be NEXLO trips. The proportion of visitors or commuters making these trips as well as the typical number of extra trips is derived from external station surveys. Urban areas, such as San Antonio, which has a number of tourist destinations, as well as the areas along the U.S.-Mexico border tend to have a large number of NEXLO trips.

In addition to the zonal employment estimates, MPOs are required to identify special generators of traffic. Special generators are locations that have unique travel characteristics that would differ from those developed by the trip generation model. TxDOT makes individual determinations as to whether to incorporate these data in the zonal socio-economic data or to segregate the data. If the data are segregated, TxDOT will independently estimate the total number of trips by trip purpose for each special generator. If a special generator survey was conducted, these survey rates will be applied and the control total will be achieved by matching the traffic counts collected during the survey. Since these trips are not a part of the trip production-attraction scaling process, TxDOT prefers to limit the use of special generators in the trip generation models.

## *Trip Distribution (ATOM2)*

Trip distribution is performed using the ATOM2 software. ATOM2, which was developed by TTI for TxDOT, is a spatially disaggregate trip distribution model. Unique to the software, ATOM2 considers zone size within the gravity analogy. The basic inputs to the ATOM2 software are:

- Productions and attractions by zone for each of the trip purposes.
- A separation matrix of network travel times based on the minimum time path from one zone to every other zone for each zone in the network geography. The travel times are based on estimated 24-hour speeds by facility type and area type.
- Zonal radii values for each zone (surrogate for zone size).
- Calibrated friction factors for each trip purpose.
- Bias factors (i.e. K-factors in traditional gravity models). These are optional and TxDOT typically discourages wide-spread application of bias factors in urban area models.

For each urban area, TxDOT will initially constrain to two constraint variables in the ATOM2 model (zonal productions and attractions) while attempting to replicate survey trip length frequency distributions (TLFD) by trip purpose. The individual TLFDs by trip purpose are created by applying the survey expanded trip tables to the latest network speed logic. This is accomplished within the Texas Package by applying a specific utility (GET2), which produces an unsmoothed trip length frequency distribution as well as the average trip length.

Using the ATOM2 software, friction factors are estimated by trip purpose and are calibrated so that the trip distribution model closely replicates the expected average trip length by trip purpose and reasonably estimates the shape of the TLFD. The friction factors are calibrated for the base year condition and are held constant for forecast applications. TxDOT will typically include both the TLFD and calibrated friction factors in the ATOM2 control files. In this manner, changes to urban form or in the highway networks themselves will be evident in the reported changes to the average trip length and forecast trip length frequencies distributions.

In preparation for traffic assignment, the individual trip tables produced by ATOM2 are imported into the TransCAD software using an import matrix utility available in the Texas Package. Once the trip tables have been imported and the external-through matrices have been appended to the imported trip matrices, the individual trip purpose matrices are summed and converted to an origin and destination (OD) matrix in TransCAD to create the 24-hour vehicle trip table.

### *Traffic Assignment*

Using the final 24-hour OD trip table from trip distribution, TxDOT assigns the trips applying the user equilibrium procedure available in TransCAD. The standard approach is to converge on 24 iterations or on 0.001 convergence criteria. Since the models represent daily travel, 24-hour level of service (LOS) E capacities and 24-hour “estimated” speeds and travel times are key variables in the traffic assignment process.

None of the 24-hour models developed by TxDOT currently has a feedback procedure to resolve the resulting traffic assignment speeds/times with those that are used as input into trip distribution. For many of the small urban areas, there simply is not the peak period congestion typically encountered in the larger urban areas (i.e., Dallas-Fort Worth, Houston, and Austin). The Austin and San Antonio models have a feedback mechanism. The Austin model has two separate feedback mechanisms – one for the home-based work (HBW) purpose and another for the remaining trip purposes. The HBW purpose is used as a surrogate for peak period travel, while the remaining trip purposes use the resulting congested 24-hour travel times. San Antonio simply feeds back the HBW trip purpose to the mode choice step. The feedback procedures as well as the mode choice models were developed by the MPOs using consultant contracts.

## Travel Model Support Activities

In an effort to promote the continued use of travel models to conduct alternatives analysis within each MPO and to support the development of the Metropolitan Transportation Plans (MTPs), TxDOT sponsors a number of outreach programs to support this philosophy. TxDOT provides software support and deployment, training, and other technical assistance that is highlighted below.

### *Statewide Travel Demand Model Software Support*

TxDOT-TPP is responsible for the statewide distribution and installation of the selected travel model software – TransCAD (Caliper Corporation). Through the original statewide purchase of the TransCAD software, TxDOT-TPP purchased one license for each MPO and TxDOT District in the state. As the years have passed, many of the District Planning Offices have ceded their respective license to the local MPO since planners in these agencies are more likely to utilize this tool. TxDOT-TPP continues to pay the annual license fees for each of the 25 MPOs and Districts in the state.

### *Travel Demand Model and TransCAD Help Desk*

In addition to TxDOT-TPP modeling staff being available to assist with model application questions, TxDOT-TPP has also contracted with the TTI to staff a travel demand modeling and TransCAD help desk to assist MPOs, TxDOT Districts and municipal staff working for MPOs with model application and development issues. The help desk is available to answer general modeling questions and to provide assistance with standard TransCAD software applications issues. As a matter of practice, the help desk is staffed Monday thru Friday for the entire year.

### *Model Application Training*

In addition to developing the models, TxDOT-TPP has been committed to providing model application training throughout the state for the last 20+ years. Training is typically provided regionally for multiple agencies simultaneously, but when warranted, TxDOT-TPP has provided in-house training of MPO staff to address specific concerns.

Regional training began with the use of TRANPLAN datasets to support network alternatives analysis. The alternatives analysis and model application training utilizes the TransCAD software, the officially adopted software platform in the state. The courses are intended to provide TxDOT District and Texas MPO planning staff with hands-on training in the use of local area models within the framework of the current software platform. The various training courses, delivered by the TTI under contract to TxDOT, have been tailored to provide a thorough overview and review of the standard practices and procedures used in Texas. Course content typically includes some of the following topics:

- Evaluating proposed transportation system improvement or enhancements based on travel model results.
- Identifying transportation system deficiencies using traffic assignments.
- Evaluating and comparing competing proposed transportation system improvements (e.g., highway) based on alternative travel model runs.
- Developing technical information, charts, and maps for policy board and public involvement meetings using model output data.
- Reviewing demographic data input into the travel models.
- Understanding aspects of the Texas Package Suite of Programs.

TxDOT has also been the host agency for two National Highway Institute (NHI) training courses: Introduction to Travel Demand Modeling and Estimating Regional Mobile Source Emissions.

## *Air Quality Conformity Support*

Local area support does not end with model development, deployment, and training. For those areas that are in non-attainment of the National Ambient Air Quality Standards (NAAQs), TxDOT provides two primary means of technical support. The first is developing estimates of mobile emissions

As a part of the requirements of the Clean Air Act Amendments (CAAAs), the Environmental Protection Agency (EPA) defines the limits on the amount of certain pollutants allowed. The three primary pollutants of concern in Texas are oxides of nitrogen (NOx), carbon monoxide (CO) and volatile organic compounds (VOCs). For some areas, particulate matter (PM) is an issue.

Since Texas has four areas that are currently in “non-attainment” of the NAAQs, the state is required to develop a state implementation plan (SIP), which details how the urban areas in violation of the NAAQs will implement measures, enforce those measures and maintain those standards defined in the SIP. The consequences are a loss of federal funding for failure to comply. There are another five urban areas that are “near” attainment for one or more of the criteria pollutants – meaning, these areas have not violated the current standards but are relatively close to having an air quality problem as defined by the U.S. EPA (see Figure 9).

To assist the non-attainment areas achieve or determine compliance, the state of Texas must first estimate future on-road vehicle emissions. These resulting data are used to support SIP development. In the state of Texas, TxDOT provides the mechanism to estimate urban area’s mobile source emissions using an inter-agency contract with TTI. TxDOT provides TTI with key model output files (e.g., loaded networks, trip tables, intra-zonal travel times) once the models have been developed. Standard procedures and methodologies developed through the consultative partner process have provided the means for local areas to assess compliance or develop appropriate measures to reduce emissions.

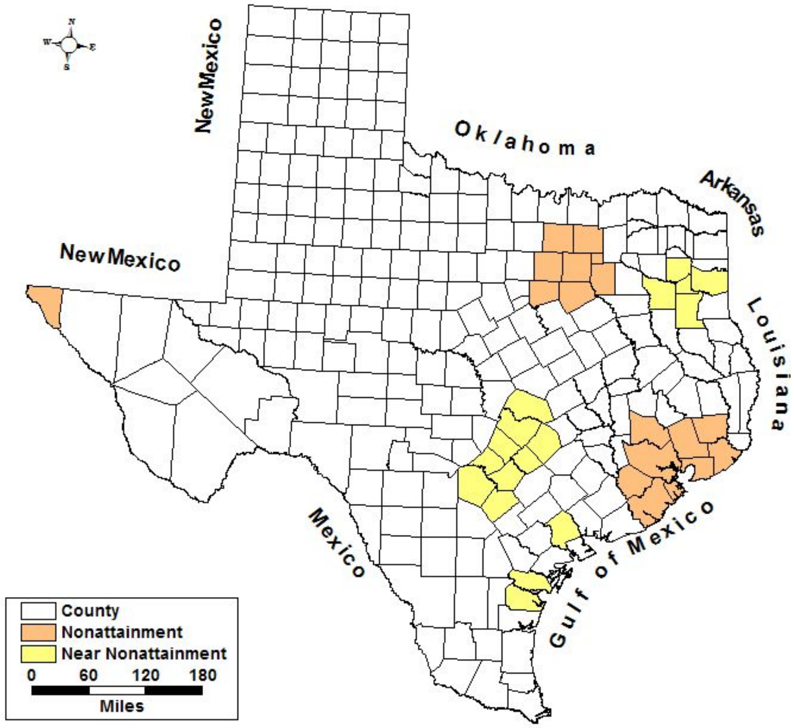



**Figure 9: Attainment Status by Texas Counties**

Currently, the MOBILE6 software is the standard software application, but that is about to change. The EPA has been planning for quite some time to transition from MOBILE6 to the Motor Vehicle Emissions Simulator (MOVES) model to estimate vehicle emissions. On behalf of TxDOT and the Texas Commission on Environmental Quality (TCEQ), TTI has developed application protocols to test MOVES to compare with MOBILE6 results. Similar to the challenge associated with migrating the modeling platform to TransCAD, the intent is to accomplish this activity without interrupting existing commitments.

TxDOT also manages the *Technical Working Group for Mobile Source Emissions* (TWG). This commitment began in the early 1990s in response to the 1990 CAAAs. The TWG meets on a fairly regular basis to discuss strategies for modeling mobile source emissions. The meetings are facilitated by TTI. Discussions are no longer restricted to technical mechanisms and concerns associated with mobile source emissions. Policy issues are now regularly discussed among the participating agencies. Participating agencies include TxDOT, TTI, EPA, FHWA, FTA, TCEQ, local-owned and operated transit agencies in nonattainment and near nonattainment areas, and local air quality agencies in nonattainment and near nonattainment areas.

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# Data Collection Activities to Support Travel Models

# Data Collection Activities to Support Travel Models

One of the unique aspects of the TxDOT travel forecasting program is the emphasis placed on a variety of data collection activities to support model development. Evidence of TxDOT's commitment can be found in the magnitude of the annual traffic data collection program. The data collection program includes thousands of traffic counts and as well as a commitment to conduct urban area travel surveys on a regular basis. Traffic counts are collected annually in every TxDOT District as well as on a five-year cycle for each urbanized area in the state. Travel surveys are collected on a 10-year cycle and coincide with the five-year count collection program in an urban area. A detailed review of data collection programs to support travel model development in the state follows.

## Traffic Data Collection Program

The Texas Department of Transportation collects a wide array of traffic count data to support numerous activities in the state. There are two separate count collection programs in the state – continuous and short-term traffic monitoring. With respect to travel forecasting, the short-term traffic monitoring program is used as the primary source of traffic count data. The data are one of the primary benchmarks used to determine travel model performance.

### *Continuous Operations*

Using permanent automatic traffic recorders (ATRs), TxDOT collects traffic data for each hour of the day and for each day of year at 162 locations throughout the state. Traffic is recorded by direction and in total for each station. These data are used to develop seasonal adjustment factors, directional factors (peak-hour factors, percent trucks) and estimates of vehicle miles of travel for the state.

In addition to the permanent volume sites, there are 129 permanent vehicle classification sites located throughout the state. These locations were previously used to develop the axle-factors by facility type and area type to adjust the total axle counts that are initially annotated in travel model network databases to account for vehicle mix. Because there are a limited number of collection sites in any given urban area (e.g., typically less than 10 total sites for any one urban area), developing axle-factor look-up tables stratified by facility type and area type proved to be challenging. This process has since been supplanted by the implementation of vehicle classification survey data noted later in this section of the report. TxDOT plans to expand the permanent count collection program for fiscal years 2012 and 2013, though the initial estimate of additional sites are purely preliminary at this time.

### *Short-Term Traffic Monitoring*

The second more comprehensive count collection program in the state is the short-term traffic monitoring program. Approximately 75,000 to 95,000 locations are counted annually in the state, depending on the count collection cycle for each individual TxDOT District. The counts are collected on both on-system (TxDOT maintained) and off-system facilities and are collected by contractors to TxDOT. The counts are performed Monday through Thursday in either the spring or the fall (when schools are in session) on non-holiday weekdays. The 24-hour traffic counts are collected using accumulative count recorders (ACRs) or pneumatic tubes. The 24-hour count data are used as one of the primary benchmarks for assessing base year model performance, in addition to metrics that are obtained from travel survey data (e.g., average trip lengths by trip purpose).

TxDOT annually performs counts at Highway Performance Monitoring (HPMS) sample locations and on-system roads in each TxDOT District. The annual District counts are presented as annual average daily traffic (AADT) since these are adjusted for axles and seasonal variations. Notably, the annual District counts are the source for the 20-year regressions performed to produce the growth rates at external stations to support development of forecast external trip tables.

Another annual count collection program product for each urbanized area is referred to as the "ramp books." The ramp books provide detailed traffic count information for freeway directional mainlanes, frontage roads, and entrance and exit ramps in an urbanized area. Unlike the annual TxDOT District counts, the ramp book traffic counts represent axles divided by two.

The annual counts are augmented with off-system counts that are collected in urbanized areas every five years. Designated as saturation counts, these are a more extensive number of traffic counts collected to support travel model development and typically provide a count for approximately 50 percent of the network links. The saturation count cycle is initiated with a traffic count map delivery meeting which typically signifies the beginning of the travel model update process. The traffic count map identifies the locations of previously located count sites in the urbanized area that are to be counted again. The saturation counts, once published, represent axles divided by two and are referred to as average daily traffic (ADT) by TxDOT. The annual, or AADT, counts are converted to ADT prior to annotating these counts on the network to achieve consistency in the counts posted in the travel model networks. Figure 10 is an example of vehicle count data that traffic analysts at TxDOT-TPP use during the model update process.

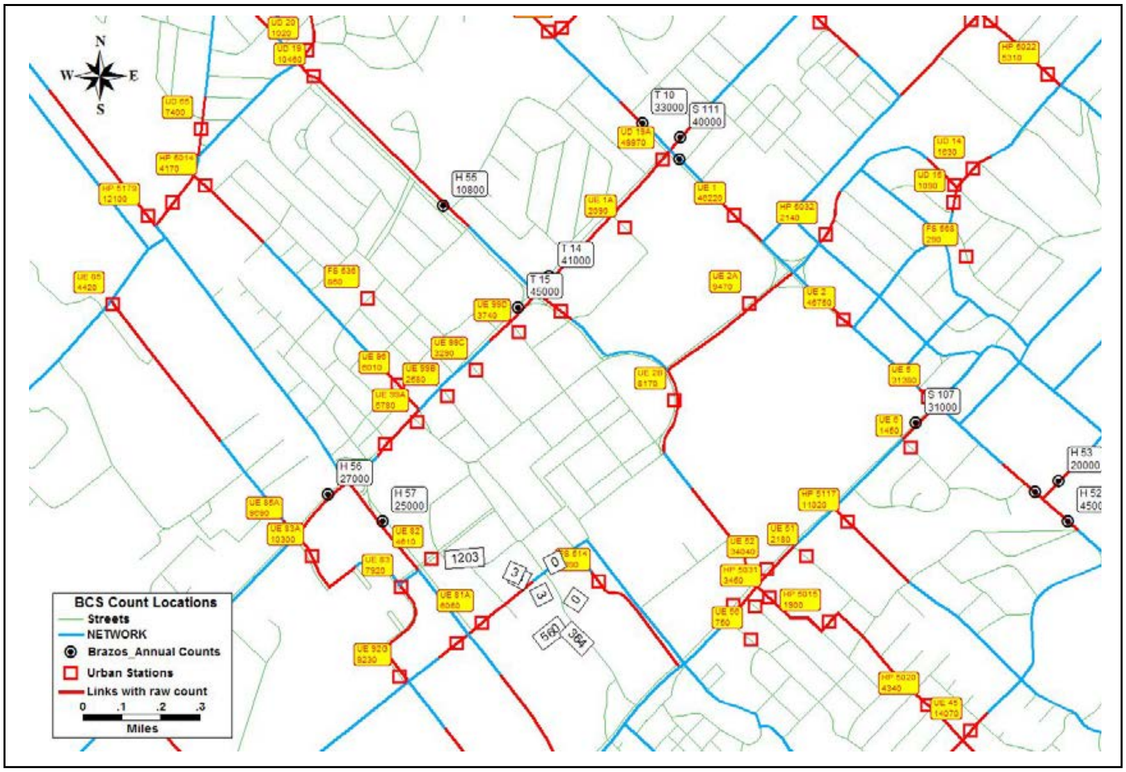



**Figure 10: Example Count Coverage (Bryan-College Station near Texas A&M University)**

Counts posted in black are the annual counts converted to ADT and the counts posted in red are the five-year ADT saturation counts.

Since TxDOT strives to achieve travel model network link count coverage of greater than 50 to 60 percent for all links in any given model network, TxDOT permits each urbanized area to increase the total number of previous counted locations by ten percent during the saturation count location update process. MPO and TxDOT District personnel will review the count maps that are delivered during the count map delivery meeting to determine coverage needs by facility type and area type. This is especially important in high growth areas of a region or in portions of the urban area that previously had limited count coverage. Once the annual and saturation counts have been collected, processed, and published as maps, TxDOT will utilize both sets of traffic counts as a key model validation criterion.

Table 8 provides a listing of the previous two traffic count collection cycles by urban area in the state as well as the planned count collection cycle. The year corresponds to when the annual District and urban saturation counts are collected simultaneously.

In addition to the counts noted above, TxDOT also collects approximately 700 manual traffic counts annually. These are primarily used to collect vehicle classification data but are also used to verify automated vehicle classification site counts. Manual counts are also conducted at all port-of-entry (POE) locations (i.e., international bridge crossings) and for those urban areas tend to be the source of external station count data.

**Table 8: Count Collection Cycle in Texas**

| Urban Area | Previous | Previous | Planned |
|---|---|---|---|
| Brownsville | 1999 | 2004 | 2009 |
| Dallas-Ft Worth | 1999 | 2004 | 2009 |
| Harlingen-San Benito | 1999 | 2004 | 2009 |
| Hidalgo County (McAllen-Pharr-Edinburgh) | 1999 | 2004 | 2009 |
| Abilene | 1998 | 2005 | 2010 |
| Amarillo | 2000 | 2005 | 2010 |
| Austin - CAMPO | 2002 | 2005 | 2010 |
| Killeen-Temple-Belton (KTUTS) | 2002 | 2005 | 2010 |
| San Antonio | 2000 | 2005 | 2010 |
| Waco | 2002 | 2005 | 2010 |
| Wichita Falls | 2000 | 2005 | 2010 |
| Bryan-College Station | 2001 | 2006 | 2011 |
| Corpus Christi | 2001 | 2006 | 2011 |
| Houston-Galveston | 2001 | 2006 | 2011 |
| Beaumont-Port Arthur (JOHRTS) | 2001 | 2006 | 2011 |
| Lubbock | 2000 | 2006 | 2011 |
| Victoria | 2001 | 2006 | 2011 |
| El Paso | 2002 | 2007 | 2012 |
| Longview | 2002 | 2007 | 2012 |
| Midland-Odessa (MORTS) | 2002 | 2007 | 2012 |
| Texarkana | 2002 | 2007 | 2012 |
| Tyler | 2002 | 2007 | 2012 |
| Laredo | 2003 | 2008 | 2012 |
| Sherman-Denison | 2003 | 2008 | 2012 |
| San Angelo | 2003 | 2008 | 2013 |

*Source: Texas Department of Transportation*

## Travel Survey Program

The Texas Department of Transportation uses travel surveys as the primary means to obtain current localized travel behavior information as well as travel characteristics. When available, survey data are used to support urban area travel model development.

TxDOT first used stratified random survey procedures in the 1990 Amarillo travel survey. Houston and Dallas had previously conducted travel surveys in the mid-1980s employing this methodology. The statewide travel survey program encompasses all 25 Texas MPOs and is performed on a re-occurring ten-year cycle for each urban area. Up until the mid-2000s, the travel surveys were coordinated with the five-year traffic count collection and model update cycle. Due to a desire to rewrite the data collection specifications, the travel survey program was temporarily halted until revised specifications were developed. The survey program has since resumed but the data are no longer collected in concert with the urban saturation counts. It is anticipated however, that in the near future the program will be realigned with the urban saturation count cycle.


**Figure 11: External Station Survey Signage**

TxDOT-TPP utilizes consultant contracts as the means to collect travel survey data. TTI, via an inter-agency contract (IAC) with TxDOT-TPP, analyzes the data. TTI's involvement includes:

- Development of statistically valid sample sizes
- Development of survey instruments
- Development of a public information campaign
- Review of the collected data
- Expansion of the sample data to produce person and vehicle trip rates

The travel survey program, depending on budget, may include any of the following surveys for a particular urban area:

- Household
- Workplace
- External station
- Commercial vehicle
- Special generator

TxDOT has also supported the development and collection of on-board public transit surveys but these are typically funded and coordinated locally. TxDOT-TPP prefers that these surveys be conducted in conjunction with the other regional travel surveys and utilizes the TTI IAC to provide technical assistance with survey design and data analysis. In 1996, TxDOT also supported a stated preference survey of transportation issues pertinent to Corpus Christi.

The following information is provided and published as a result of the travel survey program and is used to support travel model development:

- Trip production rates (person and vehicle) by trip purpose.
- Trip attraction rates (person and vehicle) by trip purpose.
- External travel distinguished by local or through trips and by vehicle classification (i.e., auto and commercial vehicles).
- Special generator trip rates.
- Auto occupancy factors.
- Mode of travel.

In addition, TxDOT-TPP will utilize the latest network speed logic along with the survey expanded trip tables by trip purpose to develop the initial trip length frequency distributions by trip purpose as well as calculate the average trip lengths by trip purpose.

As summarized in Table 9, between 2001 and 2010, TxDOT completed 49 travel surveys. Some of these surveys have been specifically conducted to support additional activities not related to the development of urban area models, such as special corridor projects (e.g., the 2007 Presidio/Marfa external survey) or the Texas border survey. The entire Texas border was surveyed twice – in 2001 and again in 2006 – to support the development of the statewide travel model. Another 60 travel surveys are either pending or planned by 2014 (depending upon available funding). Table 9 provides specific information by year regarding the travel survey program in the state of Texas between 2001 and 2010.

## *Household Surveys*

For household surveys, the vendor is required to collect a minimum number of observations for two primary household variables – household size and income. For larger urban areas, the data may be further stratified by the number of employees in the household (e.g., San Antonio). Consequently, households are randomly selected to participate in the survey based on those two stratification categories. For individual urban areas, 1,500 to 2,000 households are typically selected, depending on urban area size. For combined urban areas, such as the Austin-San Antonio region and Dallas-Fort Worth, approximately 3,000 households are surveyed, with an equal apportionment for both regions – 1,500 households for each urban area.

Participating households are asked to record a travel diary of activities and travel for each person in the household over the age of five. The travel diary is for a 24-hour period during a typical weekday (e.g., a non-holiday Monday thru Thursday in the fall or spring when schools are in session). For each trip, the participant is supposed to record the departure and arrival time, trip purpose, the beginning and ending location of the trip, and number of passengers for each trip. In addition to relevant travel information, household characteristics are also collected (e.g., number of people residing in the household, number of people employed, auto availability, household income, etc.). To then retrieve the survey data the vendor employs a computer aided telephone interview (CATI) procedure.

### Table 9: Travel Survey Program (2001–2010)

| Year | Surveys | |
|---|---|---|
| 2001 | • Texas/Mexico external survey (non-commercial)<br>• Texas/Mexico external survey (commercial)<br>• Texas border external survey (entire state) | • Laredo household survey<br>• Sanderson County external survey (Truck traffic on US 90) |
| 2002 | • Laredo external survey<br>• Laredo work place survey (phase I)<br>• Laredo work place survey (phase II) | • El Paso external survey<br>• Midland-Odessa external survey<br>• Bryan-College Station external survey |
| 2003 | • Laredo commercial vehicle survey<br>• Tyler/Longview external survey* | • Tyler/Longview household survey*<br>• Tyler/Longview commercial vehicle survey* |
| 2004 | • San Angelo external survey<br>• Rio Grande Valley commercial vehicle survey*<br>• Rio Grande Valley household survey* | • Rio Grande Valley external survey*<br>• Amarillo/Lubbock commercial vehicle survey* |
| 2005 | • Dallas/Fort Worth external survey*<br>• Sherman-Denison external survey<br>• Wichita Falls external survey<br>• Abilene external survey<br>• Austin/San Antonio external survey*<br>• Amarillo/Lubbock external survey*<br>• Rio Grande Valley work place survey (Phase I)* | • Austin/San Antonio household survey*<br>• Rio Grande Valley work place survey (Phase II)*<br>• Amarillo/Lubbock household survey*<br>• Austin/San Antonio work place survey (Phase I)* |
| 2006 | • Austin/ San Antonio work place survey (Phase II)*<br>• Austin/San Antonio commercial vehicle survey* | • Texas border external survey (entire state)** |
| 2007 | • Waco/Killeen/Temple household survey*<br>• Waco/Killeen/Temple commercial vehicle survey* | • Presidio/Marfa external survey |
| 2008 | • Corpus Christi/Victoria household survey* | • El Paso household survey (pending completion) |
| 2009 | • Amarillo/Lubbock work place survey (pending completion)*<br>• Houston/Galveston/Beaumont/Port Arthur work place survey (pending completion)*<br>• Waco/Killeen/Temple work place survey* | • Corpus Christi/Victoria work place survey (pending completion)*<br>• Corpus Christi/Victoria commercial vehicle (pending completion)* |
| 2010 | • Abilene/Wichita Falls household survey (pending completion)*<br>• Abilene/Wichita Falls work place survey (pending completion)*<br>• Abilene/Wichita Falls commercial vehicle (pending completion)* | • El Paso work place survey (pending completion)<br>• El Paso commercial vehicle survey (pending completion) |

*Source: Texas Department of Transportation*
**Combined region*
***Expanded to include Dalhart, Childress, and Midland FM 1776 corridor survey*

Recently, a small subset of surveyed households have agreed to participate in having a global positioning system (GPS) device placed in their car to log travel data during the same 24-hour survey period. An incentive (i.e., money) is offered to encourage participation in this part of the survey program. The data are collected to compare the results to the diary-based travel survey information and retrieved via the CATI process. The additional GPS information is subsequently used to determine the degree or magnitude of under-reporting of trips. Under reporting of trips is becoming increasingly evident in the household survey results as is the evidence that suggests that a larger proportion of the data provided represents proxy data, rather than accurate data provided by the appropriate person in the household.

### *Workplace Surveys*

The workplace survey collects travel information regarding the destination end of the trip. Similar to the household survey, the survey sample is stratified by employment type and area type. Surveyed establishments are also selected randomly. Given the cost to conduct an individual workplace survey, the sample size tends to be a function of available survey funds.

The surveys are designed to distinguish between employees and visitors to the workplace (non-employees). For employees, information regarding household characteristics is collected in addition to travel information associated with the employee. Visitors provide specific information regarding travel to the surveyed workplace, such as trip origin, trip purpose, mode, vehicle occupancy, and arrival/departure times. The employee and visitor survey data in combination with person and/or vehicle counts collected at the surveyed work sites will then be used to develop attraction rates for the four standard employment categories: basic, service, retail and education by area type.

### *Special Generator Surveys*

TxDOT has been supporting the collection and processing of travel survey data associated with special traffic generators since 1973. When funding is available and the need articulated, TxDOT-TPP continues to collect information regarding special generator locations. Special generators are locations that do not exhibit typical trip making characteristics associated with similar work places. The total number of trips for a special generator can be significantly lower or higher than those produced using survey derived attraction rates. Therefore it is necessary to capture these facilities in the travel survey program and to distinguish these locations in the trip generation portion of the modeling process.

Examples include universities, hospitals, military installations, and regional malls. Military installations can represent significant challenges when accounting for existing or forecasted travel. Depending on base realignment plans and deployments, counts and collected travel survey information may be unintentionally influenced. A sample list of urban areas in the state with significant military installations is included in the Table 10.

Other examples of special generators in the state include major universities, such as the University of Texas in Austin and Texas A&M University in Bryan-College Station (B-CS). Perhaps in no other urban area in the state does a major university influence a region’s travel patterns more than Texas A&M University, as it is the most significant employer and generator of trips in the B-CS urbanized area.

To collect special generator information, TxDOT-TPP will coordinate with the local MPO and TxDOT District office to identify potential candidate sites within an urban area that may not have been previously captured. Typically, the MPO will provide matching funds if a significant number of sites are requested during the travel survey collection cycle since the cost can be rather prohibitive on a case-by-case basis.

**Table 10: Urban Areas with Military Installations**

| Urban Area | Military Installation |
|---|---|
| Abilene | Dyess Air Force Base |
| Corpus Christi | Corpus Christi Naval Air Station |
| El Paso | Fort Bliss |
| Killeen-Temple-Belton | Fort Hood |
| San Antonio | Brooks Air Force Base<br>Camp Bullis<br>Fort Sam Houston<br>Lackland Air Force Base<br>Randolph Air Force Base |
| San Angelo | Goodfellow Air Force Base |
| Wichita Falls | Sheppard Air Force Base |

Source: Texas Transportation Institute

## *External Station Surveys*

External related travel can have a significant impact on modeled VMT. Texas is not unique to this condition and there are number of examples in the state that support this finding. In Longview, for instance, external travel is responsible for more than 60 percent of the total urban area's VMT because of the shape of the urban area and the juxtaposition of the interstate highway (IH-20) relative to the urban area boundary. Other urban areas, including those along the Texas-Mexico border, have sizeable interactions between adjacent cities along the Rio Grande River as well as neighboring cities across the river. Consequently, for more than two decades TxDOT has supported the conduct of external station surveys to estimate the amount of external related travel.

TxDOT conducts the surveys on roadways that intercept the model area boundary (MAB) for the purpose of determining the number of trips that originate outside the urban area and continue through the urban area without stopping (through trips), as well as trips that originate inside the urban area but depart the urban area and trips that begin outside the urban area but travel to a destination inside the urban area (external-local).

For external roadside surveys, a detailed traffic control plan (TCP) is developed for all vehicle intercepts. Surveyors randomly select outbound vehicles and collect information on the purpose of the trip, origin and destination, and vehicle occupancy. Figure 12 shows an example of an external station survey that was recently conducted in the Bryan-College Station urban area.

In addition, the surveyors will also collect information regarding additional trips made by external-local commuters or visitors. Urban areas, such as San Antonio with various tourist attractions (e.g., River Walk, Alamo, Sea World, and Six Flags) and those along the Texas-Mexico border, tend to have a significant amount of non-resident associated travel.

**Figure 12: External Station Survey**

## *Commercial Vehicle Surveys*

Between 2001 and 2008, six commercial vehicle (truck) surveys have been collected among the 25 urban areas in the state with four additional surveys currently pending completion. Several more are tentatively scheduled between 2011 and 2013. The commercial vehicle survey not only provides truck production rates for use in the travel models, but also provides a means to estimate a control total for truck trips in a region.

A database of businesses with fleets of vehicles is used as the initial point for randomly selecting commercial vehicles to survey. Once businesses are selected, the vendor calls the establishment to recruit the site. If the site agrees, one day's worth of travel data is collected for each of the business' commercial vehicles that participate in the survey.

Two separate truck surveys are conducted in the state – cargo and service. For cargo trucks, information about vehicle type, cargo and weight of the cargo are collected. One of 23 cargo options is identified during the survey process, including whether the vehicle is empty, non-cargo is being delivered, or the vehicle is traveling to a pick up. TxDOT typically tries to capture strictly internal freight movements within a region. Despite this, there are a small percentage of vehicles that do eventually leave the urban area in the course of the data being collected. Figure 13 shows a commercial vehicle survey being collected on U.S. 83 in the Rio Grande Valley.

**Figure 13: Example of a Commercial Vehicle Survey**

The second category – service – deals with vehicles that are traveling within an urban area conducting business (e.g., air conditioning repair, flower delivery, plumbers, etc.). Travel surveys in the state reveal that there is substantial service related commercial vehicle travel in any given urban area. Traffic counts are used to expand the data but this proves to be challenging since tube counts do not distinguish between freight and service categories.

In conjunction with the commercial vehicle and external station surveys, TxDOT collects a sample of vehicle classification counts. The data from the vehicle classifications counts are used to assist in the estimation of total commercial vehicles operating within an urban area. The data also provide valuable information for the development of axle-factors by facility type and area type to adjust the 24-hour ADT traffic counts.

Since 2002, 22 vehicle classification count surveys have been collected around the state. The collected data are provided on a CD to each TxDOT District. The CD invokes a website (ref. Figure 14) that contains an interactive map that displays the classification counts by four facility classes: freeway, arterial, collector, and local. Vehicle classification counts are collected at external station locations as well to help determine the mix of commercial and non-commercial vehicles at those locations. Individual sites can also be selected as well. Table 11 provides an inventory of urban areas by year for which vehicle classification data have been collected.

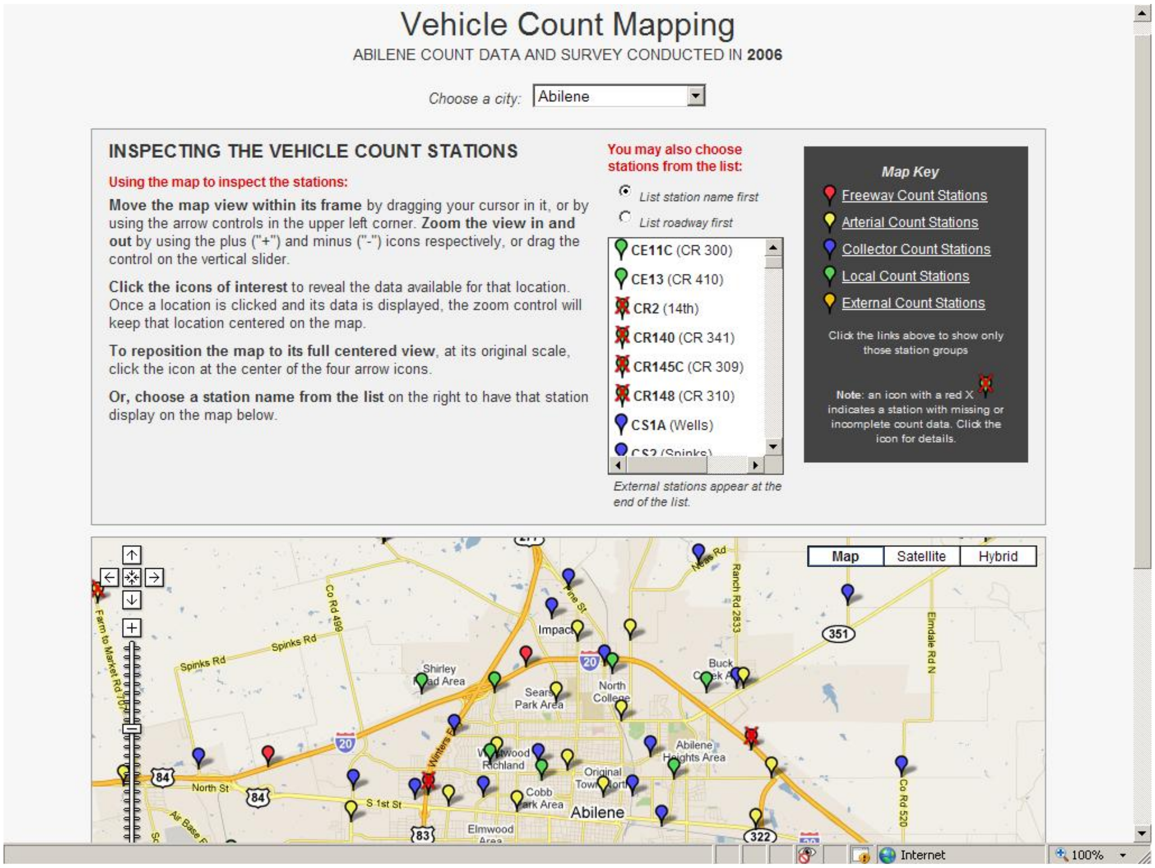



**Figure 14: Vehicle Classification Count Data**

To assist the modeling staff, TTI provides the data in excel format with each count collection location containing coordinate information. In this manner, TxDOT-TPP can import the data directly to TransCAD to develop the axle-factor look-up tables stratified by facility type and area type. Information about directional freeway mainlanes and frontage roads are further distinguished as individual sites. The directional data is also combined to present the entire cross-section as a single value.

## Demographic Data Collection Support

In Texas, the MPO is responsible for inventorying and forecasting demographic data for each traffic analysis zone (TAZ) in an urban area. MPOs in the state either compile these data themselves or seek third-party assistance via consulting contracts.

To ensure that the data are delivered in a consistent manner from all MPOs, TxDOT has established guidelines and criteria for data formats. TxDOT-TPP also provides support and guidance regarding the collection and assembly of socio-economic data. Information about specific inputs, such as population and employment data, as well as the support and guidance provided by TxDOT are discussed in further detail below.

**Table 11: Vehicle Classification Information by Urban Area**

| Study Area | Year Data Collected |
|---|---|
| Abilene | 2006 |
| Amarillo | 2006 |
| Austin | 2007 |
| Beaumont-Port Arthur | N/A |
| Brownsville | 2004 |
| Bryan-College Station | 2002 |
| Corpus Christi | N/A |
| Dallas-Fort Worth | 2005 |
| El Paso | 2002 |
| Harlingen-San Benito | 2004 |
| Hidalgo County (McAllen) | 2004 |
| Houston-Galveston | N/A |
| Killeen-Temple | 2008 |
| Laredo | 2002 |
| Longview | 2003 |
| Lubbock | 2002 |
| Midland-Odessa | 2002 |
| San Angelo | 2004 |
| San Antonio | 2007 |
| Sherman-Denison | 2005 |
| Texarkana | 2003 |
| Tyler | 2003 |
| Victoria | N/A |
| Waco | 2008 |
| Wichita Falls | 2006 |

*Source: Texas Department of Transportation* **N/A Data have yet been collected*

## Texas State Data Center (Population Data)

TxDOT recommends that each MPO in the state use Texas State Data Center (TSDC) county population forecasts when developing base and forecast year(s) population control totals (ref. Figure 15). The TSDC and Office of the State Demographer provide population estimates and projections for the state by counties, place, Metropolitan Statistical Areas (MSAs), and Council of Governments (COGs). The Institute for Demographic and Socioeconomic Research (IDSER), located at the College of Public Policy at the University of Texas at San Antonio (UTSA) maintains and compiles the information. Each MPO is responsible for allocating the region's control total to individual TAZs.

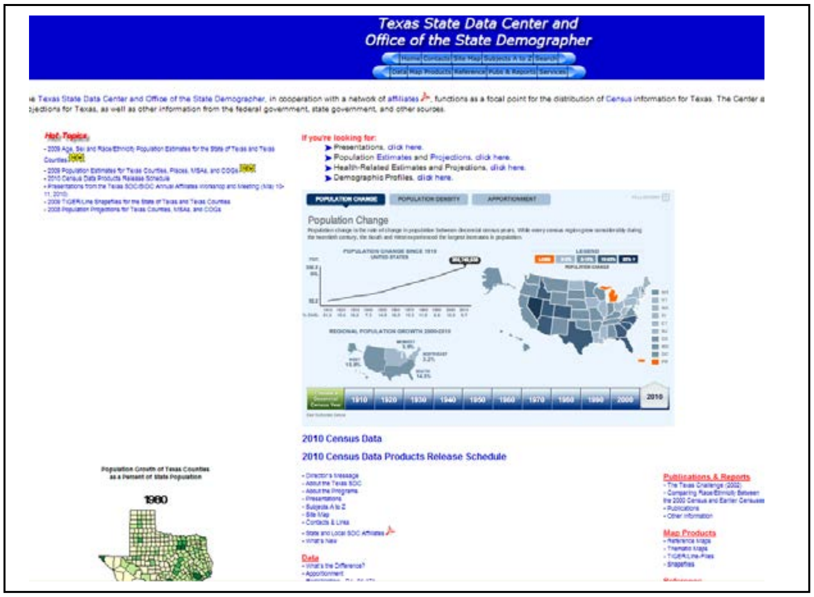



**Figure 15: TSDC Website**

For the forecast, TSDC provides three different growth scenarios based largely on migration and emigration rates:

- 0.0 – The population represents births and deaths only with no migration.
- 0.5 – One half of the migration rates between 1990 and 2000.
- 1.0 – The migration rate is equal to the migration rate between 1990 and 2000.

In addition, a 2000 to 2004 trend scenario is available also. TxDOT recommends that MPOs use the 0.5 migration rate when developing forecast control total unless there is specific local knowledge that warrants deviation from that scenario.

## Texas Workforce Commission (Employment Data)

Under a unique arrangement the Texas Workforce Commission (TWC) annually provides TxDOT quarterly employment data. The data, which are referred to by the TWC as the Enhanced Quarterly U-1 Address File, contain quarterly and monthly employment data for all 254 Texas counties. As a part of the agreement, TxDOT post-processes the data to remove unnecessary or sensitive information. The appropriate county or counties are grouped to form individual files for each of the 25 urban areas in the state (including Houston and Dallas-Fort Worth). These data are typically delivered to an MPO as a part of a model coordination meeting, which initiates the model update process in individual urban areas, and is used as a critical resource for developing the base year employment inventory for input into the travel demand models. The data provided to an MPO represent the 3$^{rd}$ month of the 3$^{rd}$ quarter of the designated model update year and typically correspond with the year in which the saturation traffic counts were collected. Figure 16 is an example of TWC data geo-coded to the El Paso, Texas, TAZ geography with each employment location by type distinguished in individual zones.

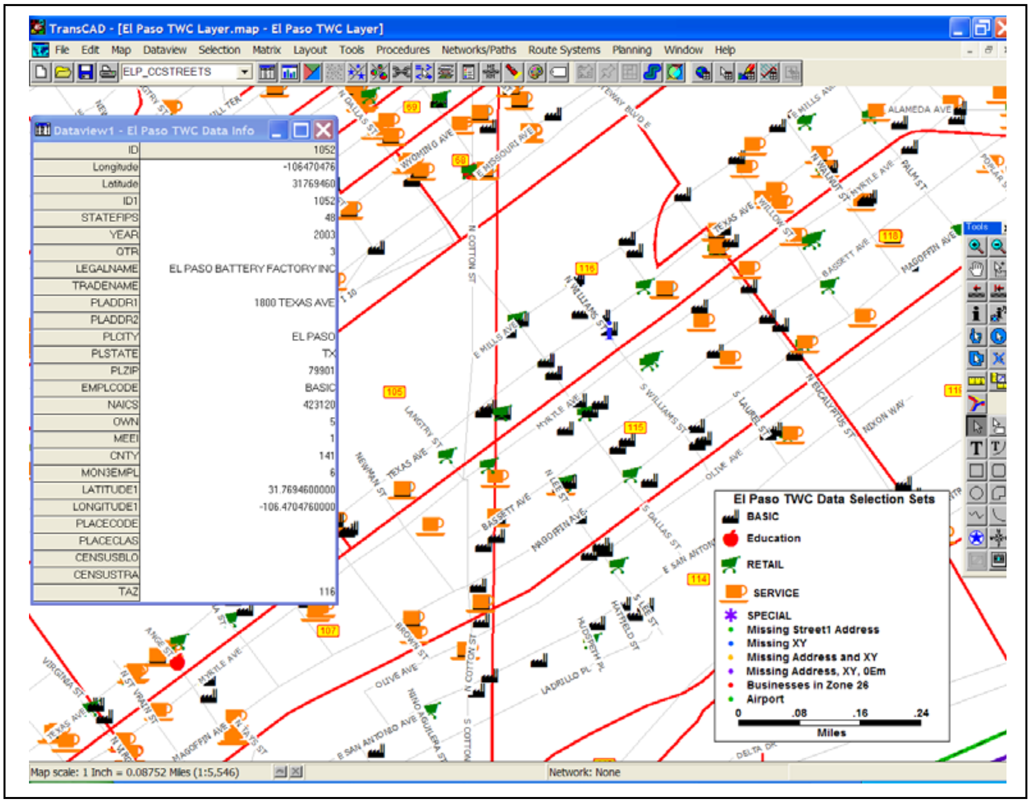



**Figure 16: Geo-coded Texas Workforce Commission Employment Data (El Paso, Texas)**

Beginning with the 2002 TWC data release, several changes were adopted in the format and type of information provided to the MPOs by TxDOT. Two of the more significant changes included the conversion from the Standard Industrial Classification (SIC) codes to the North American Industry Classification System (NAICS) and the inclusion of X-Y coordinates in the database. As a part of the data post-processing, TxDOT aggregates the NAICS classified data into the four employment categories used by TxDOT and the MPOs – basic, retail, service, and education. The majority of the employment sites now contain a geographic X-Y coordinate in addition to a physical or mailing address. This is noteworthy because it provides a mechanism to geo-code establishments with X-Y coordinates to individual TAZs. In this manner, each of the MPOs can aggregate the total number of employees by employment category for each TAZ.

Another salient feature associated with the TWC database is the inclusion of a Multiple Establishment Employer Indicator (MEEI) code. This is used to identify parent-child relationships within the database. For example, each independent school district (ISD) will often associate the total number of employees for their respective ISD with one location – typically the administration building. As a result, individual school campuses are not properly accounted for in the TAZ in which they physically reside. MPOs are responsible for disaggregating the total, identifying correct TAZ locations when these cases arise and are also responsible for identifying workplace locations that could not be geo-coded.

## Demographic Handbook

Obtaining quality socio-economic data that provide sound estimates of travel continues to be a challenge in the state of Texas. Many of the MPOs in the state represent small to medium sized urban areas. For those areas, staff size tends to be limited (e.g., one to two people) and staff typically fulfill multiple roles, such as those associated with MPO requirements and those that are devoted to the cities in which they are employed. Because of staff size and the multiple dedicated roles associated with their positions, it is rare to have staff at the MPOs in Texas with a background in travel forecasting, demographics, land use, or urban economics. Despite clearly defined formats and recommendations, the development of a socioeconomic database continues to represent a challenge in the TDM update process.

To further assist MPOs in Texas, TxDOT-TPP has produced a guidebook entitled, "*Developing Network and Demographic Inputs for Travel Demand Modeling*" (ref. Figure 17). The guidebook provides information and data that can be used to develop the socioeconomic inputs required for trip generation. Information on developing and allocating data inputs, reasonableness checks, as well as documenting the general process and timeline associated with this aspect of the process are also included in the guidebook. The guidebook was created by the Texas Transportation Institute under an inter-agency agreement with TxDOT-TPP.

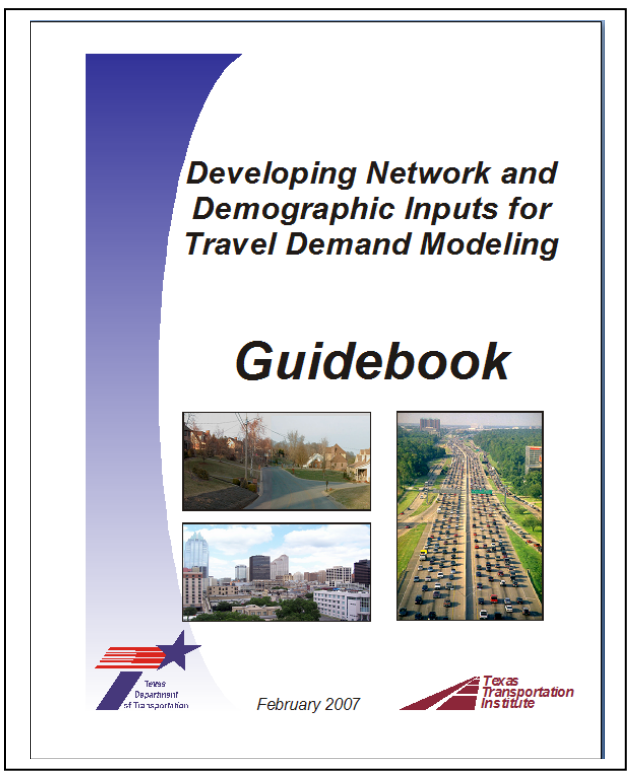



**Figure 17: Demographic Guidebook**

## Demographic Assistance Tool

In addition to the demographic guidebook, TxDOT-TPP provides a "One-Stop Demographic Data Analysis Tool." The data analysis tool was created by the Institute for Demographic and Socioeconomic Research (IDSR) at the University of Texas at San Antonio as part of a TxDOT sponsored research project. The final product is an interactive webpage that is designed to provide quick access to general demographic information by county, TxDOT District, tract, and place. Reports can be generated for multiple geographies of the same type or for the entire state. Data currently include several demographic and transportation related resources:

- Census 2000 data
- Census Transportation Planning Package (CTPP) for 2000
- Texas State Data Center (TSDC) population estimates for 2006
- TSDC population projections to 2040
- TxDOT information on miles of travel, lane miles, and vehicle registrations
- Department of Public Safety (DPS) data on licensed drivers

Historical data, including 1980 and 1990 population information, are also included. Trend data are available for the four separate TSDC migrations scenarios (i.e., 0.0, 0.5, 1.0, and the 2000 to 2004 trend). Table 12 lists the data available by county, TxDOT District, Census tract, and Census Place.


**Figure 18: Demographic Assistance Tool**

**Table 12: Select Reports**

| Reports | Description | |
|---|---|---|
| General Trends | • Population<br>• Vehicle miles traveled | • Registered vehicles<br>• State road network |
| Demographic Characteristics | • Age<br>• Race/ethnicity<br>• Poverty | • Language spoken at home<br>• Households/group quarters |
| Household Characteristics | • Size<br>• Vehicles available<br>• Income<br>• Linguistically isolated | • Housing type<br>• Vehicles by housing type<br>• Occupancy by housing type |
| Commuting | • Commute mode<br>• Travel time to work | • Employment by location |
| Employment and Schooling | • Employment status<br>• Employment status, disabled<br>• Workers by industry | • Workers by occupation<br>• School enrollment |

*Source: IDSR UTSA Website*

Population projections are also available in five year increments (2000 to 2040) for the four separate migration scenarios noted above. Projections are available in four levels of geography. These include Texas Counties, TxDOT Districts, MSAs, and COGs. Table 13 presents the reports that are available using the population projection tool for each of the four migration scenarios noted above. The information noted in Table 12 and Table 13 is currently available at the following address (http://idser.utsa.edu/projects/txdot/onestop/Default.aspx). Figure 19 shows an example of a select population trend and workers by industry report available for Brazos County, Texas.

**Table 13: Available Population Projection Reports**

| Reports |
|---|
| Disabilities |
| Specialized Age Groups |
| Population by Age Group |
| Households |
| Civilian Labor Force |
| Household Income (Median) |

*Source: IDSR UTSA Website*

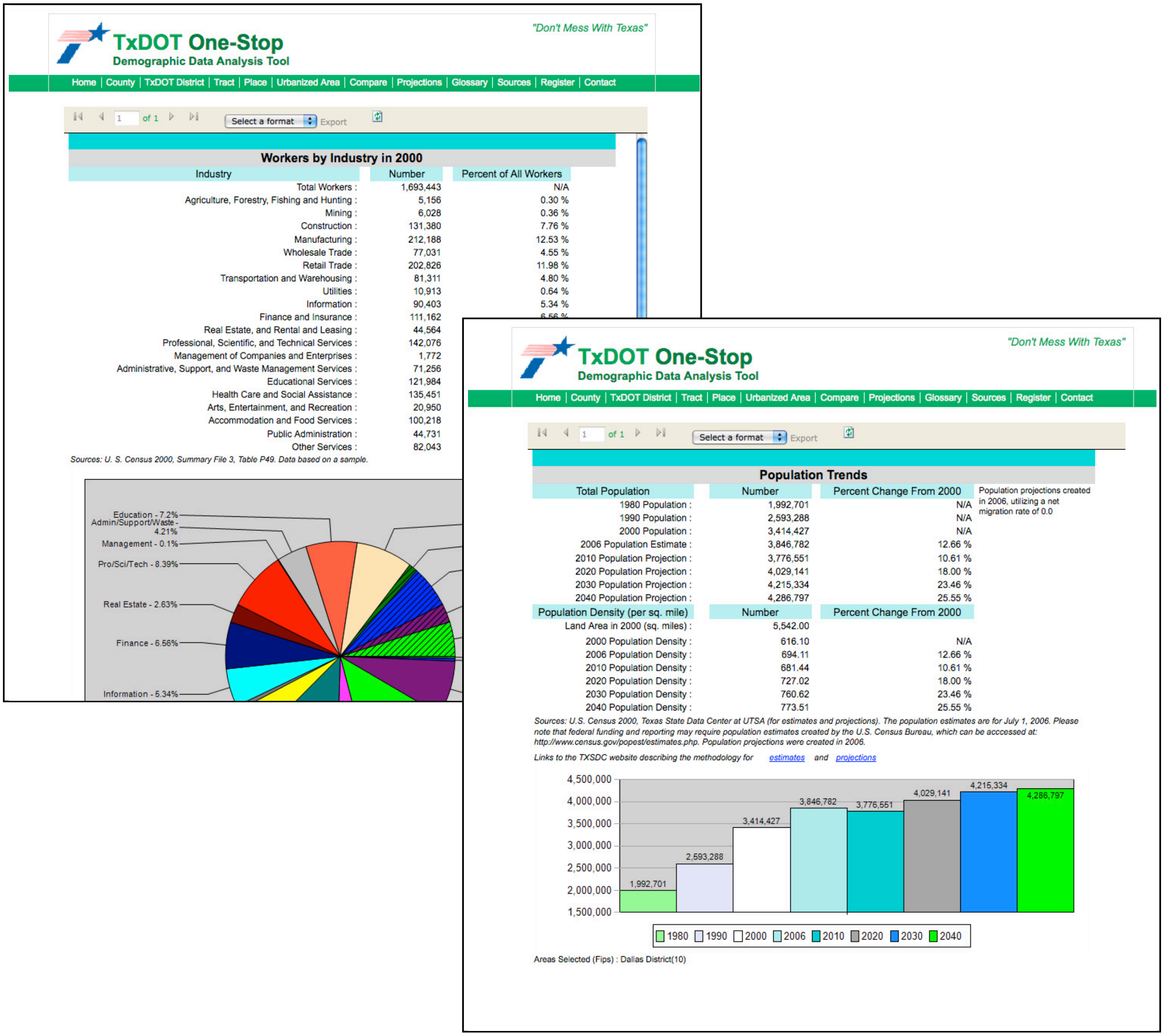



**Figure 19: Example Socioeconomic Trend Reports**

# Highlights of Texas Model Applications

# Highlights of Texas Model Applications

There have been a number of significant examples of model application in the state of Texas in recent years. Some of these are unique to the state while others, such as the combined regional approaches to modeling, offer similar experiences to what may be occurring in other parts of the country. Two examples discussed below that are unique to the state are the Houston-Galveston Area Council (H-GAC) hurricane evacuation models and the Texas Metropolitan Mobility Plans (TMMP). In both instances, specific software was developed to supplement the existing urban area models – one to improve the planning associated with natural disasters and the second to help quantify the actual cost of overcoming congestion in the state. These along with other examples of recent model applications in the state are discussed below.

## Houston-Galveston Hurricane Evacuation Models

In September 2005, Hurricane Rita made landfall along the gulf coast of Texas, near Houston, Texas. Prior to the arrival of the storm, mandatory and voluntary evacuation warnings were given in the region. The ensuing evacuation resulted in hundreds of thousands of people leaving the southeast Texas region during a three day period in advance of landfall. The effort to evacuate the region prior to an impending natural disaster caught the attention of the national media and brought into focus the logistical and planning magnitude associated with evacuating a large metropolitan area in a safe and efficient manner. The manifestation of thousands of people attempting to leave an urbanized area either simultaneously or incrementally resulted in images of stranded motorists and long lines of vehicles that stretched for several hundred miles.

**Figure 20: Hurricane Rita Evacuation**
*Source: yourweatherblog.com*

In response to this, the Houston-Galveston Area Council (H-GAC) undertook an extensive hurricane evacuation planning process in an attempt to overcome the issues associated with the unprecedented event that occurred in September 2005. To support the evacuation planning process, the H-GAC determined that is was necessary to develop and implement a set of evacuation models to quantify the magnitude of congestion and resulting delays that residents in the region could anticipate to encounter under multiple evacuation scenarios. TxDOT conducted a post-Rita evacuation survey of approximately 6,000 residents in the Houston region to determine individual responses/actions that occurred during the evacuation period. These data were used to develop the trip generation and trip distribution evacuation models. The trip generation models are structured to provide the flexibility and capability to study alternative evacuation approaches. Within trip distribution, evacuation trips that remained in the region were distributed using a unique constrained interaction model. External distributions were performed using traditional approaches.

The resulting hurricane evacuation models utilized the existing eight-county H-GAC regional travel models, which had 2,954 traffic analysis zones and 46 external stations. The principle focus of the project was to simulate a three day evacuation event and to study alternative evacuation scenarios for potential future events. The resulting models estimated that 1.25 million vehicle evacuations occurred during the three day evacuation period. Nearly 83% of the vehicle trips left the eight-county region while the remaining trips evacuated to a destination further from the coast but within the eight-county region.

## Texas Metropolitan Mobility Plans

In April 2003, Governor Rick Perry requested that TxDOT develop a plan to address the growing metropolitan congestion problems outlined in a report by the Governor's Business Council (GBC). TxDOT collaborated with the 25 MPOs to develop an innovative procedure for estimating the transportation needs necessary to achieve locally identified mobility goals. The product of several joint working sessions between TxDOT, the 25 MPOs and TTI was the development of a "needs-based" plan or mobility plan for each of the 25 urban areas.

The initial effort only involved urban areas that exceeded 200,000 or more in population (i.e., TMAs). The process now includes each MPO in the state, regardless of size, and has been expanded to estimate rural needs in the state as well. Unlike MTPs, mobility plans do not provide a list of projects that will be built based on available funding. Rather, the mobility plan could be described as a return to vision-oriented planning that communicates the cost of implementing various congestion relief programs to eliminate an agreed-upon congestion threshold (for this project, severe congestion is defined as links or corridors with a volume-to-capacity ratio greater than or equal to one). The strategies discussed in the strategic plan could only be pursued if greater funding levels above a financially constrained plan were actually available. The Texas Mobility Plan process identifies the benefits of implementing such a plan and enumerates the costs associated with implementing these strategies to achieve the prescribed benefits. The mobility goals for each region were intended to be achieved with a mix of multi-modal corridor solutions that include pedestrian, transit and freight solutions, in addition to those specifically designed to address highway congestion.

Although MPOs in the state are no longer required to produce a "needs-based" plan, the process described below is still implemented as a primary means of communicating transportation related funding shortfalls in the state. The latest product of this process is the *2030 Needs Report*, which specified the funding gap between available funds for transportation related activities versus the cost of addressing mobility needs identified in the needs-based planning process for the entire state. The costs for implementing the "needs-based" plans are derived from the latest construction costs available from TxDOT.

The primary analytical tool and value that is used to develop a mobility plan is the Texas Congestion Index (TCI). The TCI value is simply a ratio of the value of congested travel time (peak period) to the value of free-flow travel time (off-peak travel) for the same trip. As such, a TCI value of 1.0 indicates that travel is occurring in free-flow conditions. Whereas a TCI value of 1.3 means that a trip that would normally take 20 minutes in the off-peak or free-flow period would take 26 minutes during the peak period. In this manner, travel time becomes the surrogate measure for communicating and expressing congestion and resulting delay.

The TCI value is derived by applying the urbanized travel demand models available in each of the 25 urban areas in the state for several scenarios that primarily include the base year condition, the forecast or MTP condition, a needs-based condition, and a no-build condition. Interim year conditions are also applied as a part of this process where available.

The modeling process, which is accomplished with an add-on menu item in TransCAD specifically created for this project by TTI, involves five distinct steps:

Step 1: Apply the long-range (or financially constrained scenario).

Step 2: Apply an all-or-nothing assignment using the forecast network to identify the needs beyond the financially constrained plan.

Step 3: Edit the links in the forecast network that exceed a V/C ratio of 1.0 by adding the appropriate number of lanes and associated capacity to the links.

Step 4: Apply the "needs-based" scenario utilizing the updated number of lanes and capacities from step three.

Step 5: Calculate the assignment differences between the financially constrained scenario and the needs-based scenario. A compressed example of the results from the Corpus Christi urban area illustrate the vehicle miles of travel (VMT) and vehicle hours of travel (VHT) differences that can be achieved by implementing the mobility plan.

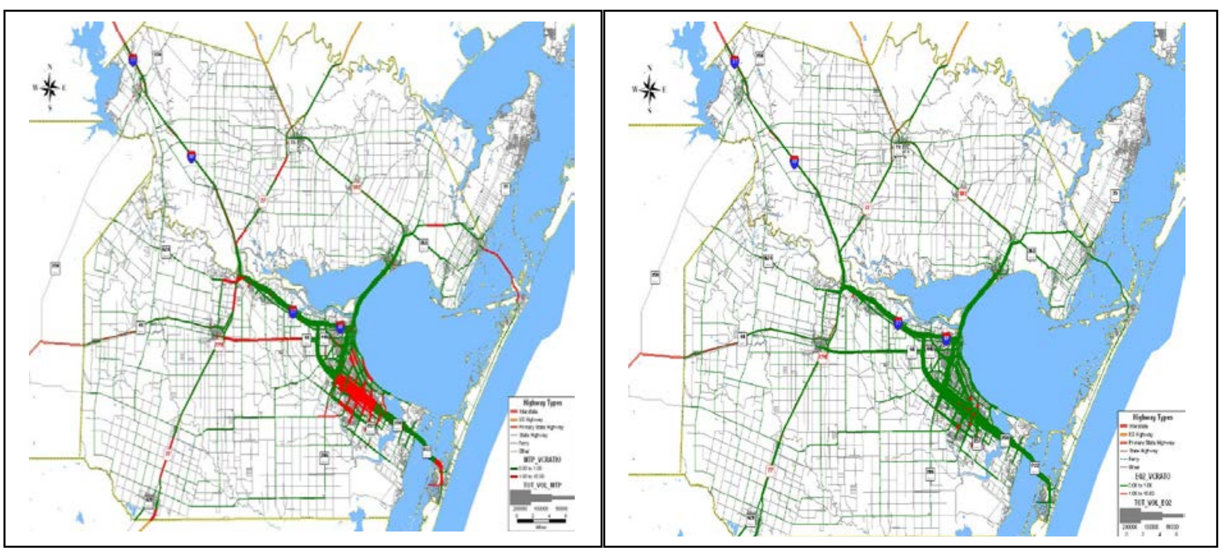
**Table 14: Example Mobility Plan Application Results**

| Functional Classification | VMT Differences | VHT Differences | Lane-Miles Differences |
|---|---|---|---|
| Interstate | -8,436 | -241 | 0 |
| Freeway | 89,387 | 1,907 | 21.5 |
| Principal Arterial | 112,580 | 2,011 | 157.6 |
| Minor Arterial | -272,845 | -6,345 | 100.6 |

*Source: Texas Transportation Institute*

The all-or-nothing assignment in step two is intended to replicate the path that travelers would probably choose if congestion did not influence their route (recurring or incident delay). The number of lanes added in step three are used as the means to express the magnitude of the mobility needs across individual links or within corridors and it is these additional lanes that are used as the primary determinate for estimating the cost of implementing the needs-based plan. Figure 21 illustrates the differences between the Corpus Christi MTP results versus the needs-based plan that eliminates most severe congestion.

Once the TCI values are calculated for each of the model scenarios mentioned previously, a chart illustrating the results are produced for each urban area. An example chart is shown in Figure 22. The chart is also the initial basis for expressing the unfunded gap between achieving acceptable levels of mobility and the level of mobility that is being achieved through the implementation of the financially-constrained plan.



MTP Assignment Needs-Based Assignment

**Figure 21: MTP Assignment versus "Needs-Based" Assignment (Corpus Christi, Texas)**

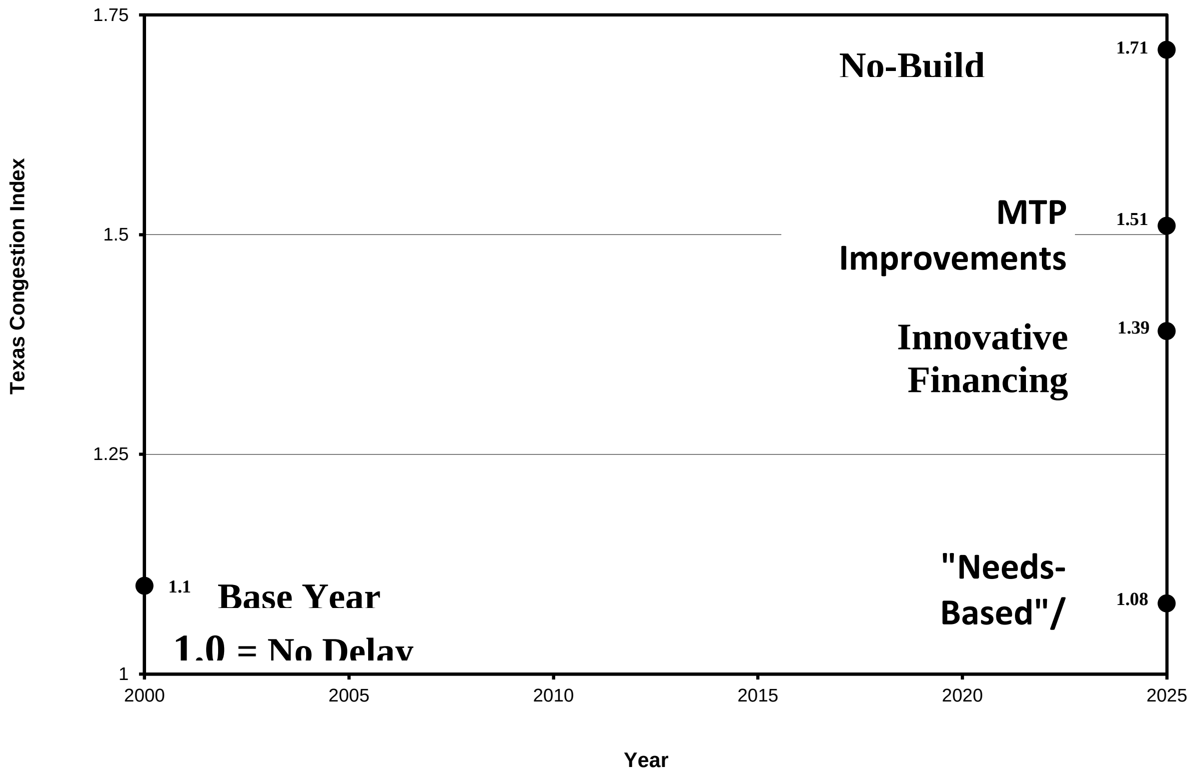



**Figure 22: Example TCI Chart**

## Lower Rio Grande Valley Regional Model

Prior to the advent of the 2004 urban saturation counts, the Brownsville, Harlingen-San Benito (HSB) and Hidalgo County (McAllen-Edinburg-Mission) urban areas were maintained and developed as separate models by the Texas Department of Transportation. The three urban areas are located in Cameron County and Hidalgo County. Both the Brownsville and Harlingen-San Benito urban areas are located in Cameron County. The entire region serves as a major point of entry for international trade between the United States and Mexico. Container trucks destined for ports in Houston and beyond regularly use the Valley as the port-of-entry (POE). Based on 2009 statistics from the Bureau of Transportation Statistics (BTS), approximately 420,000 trucks entered the U.S. at Hidalgo and another 190,000 entered in Brownsville. Figure 24 provides a general image of the Lower Rio Grande Valley, commonly referred to as the "Valley" in Texas.

**Figure 23: International Crossing (McAllen, Texas)**

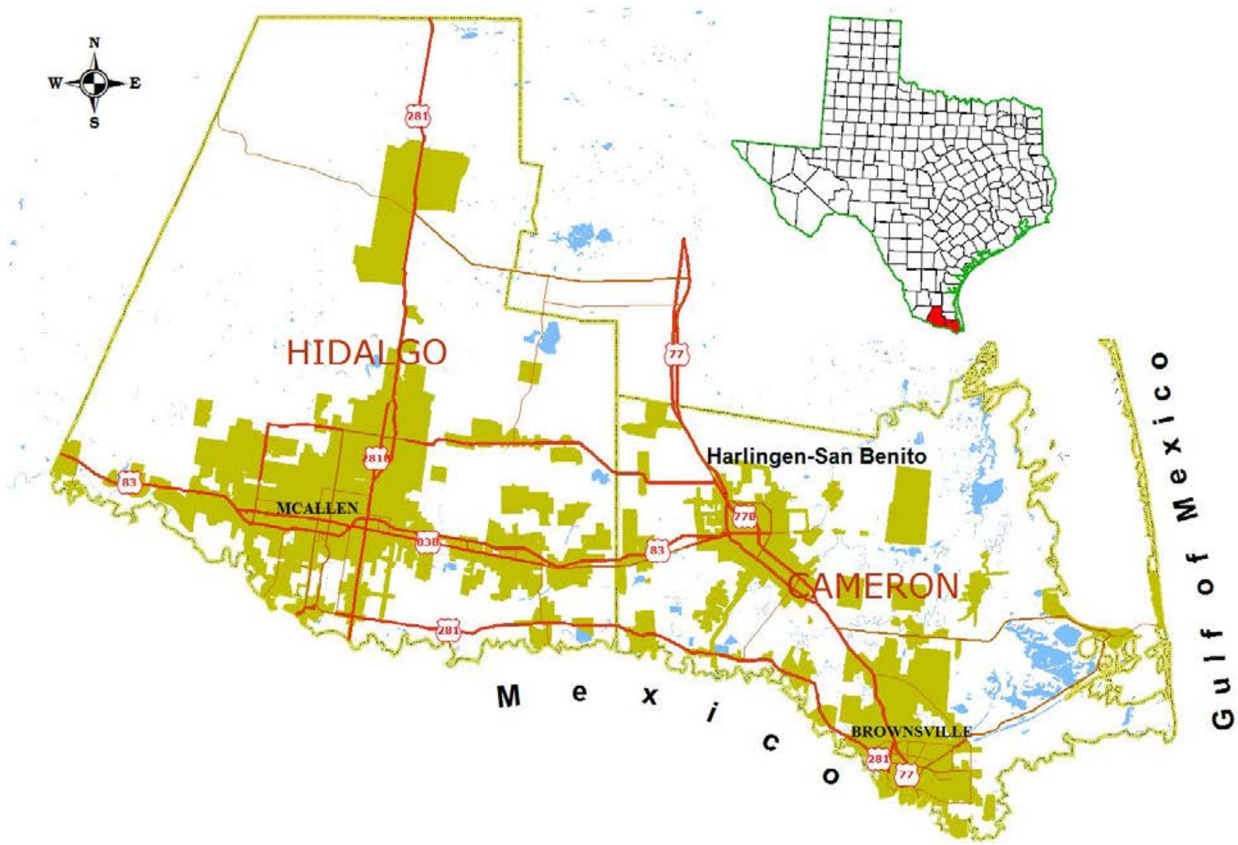



**Figure 24: Lower Rio Grande Valley, Texas**

The Lower Rio Grande Valley has experienced substantial growth in the past two decades. According to population estimates from the Texas State Data Center, the combined counties of Cameron and Hidalgo are projected to have a population of 2.1 million in 2040. A total population of 2.1 million is only exceeded by the current populations in Dallas-Fort Worth and Houston-Galveston. Using 2008 U.S. Census Bureau data, the combined MSAs of McAllen-Edinburg-Mission and Brownsville-Harlingen would have ranked 5$^{th}$ in total population in the state of Texas just behind the Austin-Round Rock MSA and well ahead of the El Paso MSA. Table 15 provides the 2008 U.S. Census population estimates for the ten largest MSAs in the state.

**Table 15: Top Ten 2008 MSA Population Estimates**

| Rank | Metropolitan Statistical Area | 2008 Population |
|---|---|---|
| 1 | Dallas-Fort Worth-Arlington | 6,201,114 |
| 2 | Houston-Sugar Land-Baytown | 5,657,840 |
| 3 | San Antonio | 2,002,944 |
| 4 | Austin-Round Rock | 1,589,135 |
| 5 | El Paso | 749,721 |
| 6 | McAllen-Edinburg-Mission | 725,978 |
| 7 | Corpus Christi | 415,163 |
| 8 | Brownsville-Harlingen | 391,857 |
| 9 | Beaumont-Port Arthur | 381,731 |
| 10 | Killeen-Temple-Fort Hood | 375,556 |

*Source: U.S. Census Bureau*

The combined regional population and growth trends along with the desire to study a potential reliever route for the region motivated the three MPOs in the Valley, along with the Pharr TxDOT District Planning Office, to request that TxDOT-TPP model the entire region rather than as three individual urban areas. There were three principal objectives:

1. To create a model with the ability to forecast travel patterns for the entire region.
2. To create a model that retained the ability to model each urban area separately.
3. To create a model with the ability to assess the impact of new regionally significant projects (e.g., reliever route).

TxDOT-TPP agreed to the request and to better study the entire region, expanded the model area boundary (MAB) to the Cameron and Hidalgo County lines. To support such an effort, TxDOT-TPP, through an inter-agency contract with TTI, conducted a two-county comprehensive travel survey. The travel survey included 2,607 randomly selected households (stratified by household size and income), 20 external roadside surveys at the county lines, 510 commercial vehicle surveys, and workplace surveys. Average trip length results from the regional survey are listed by trip purpose in Table 16.

Rather than creating three separate trip generation and trip distribution models and combining the results post-trip distribution, a decision was made to create unified trip generation and trip distribution models. Trip tables could be extracted by urban area thereafter if the desire arose to model an individual urban area.

**Table 16: Average Trip Lengths (Rio Grande Valley)**

| Trip Purpose | ATL (Minutes) | ATL (Miles) |
|---|---|---|
| Home Based Work | 12.27 | 8.86 |
| Home Based Non-Work | 8.94 | 6.02 |
| Home Based Non-Work Other | 10.26 | 7.01 |
| Home Based Non-Work School (K through 12) | 6.80 | 4.37 |
| Non-Home Based Work | 10.20 | 7.05 |
| Non-Home Based Other | 8.08 | 5.22 |
| All Purposes | 9.18 | 6.22 |

*Source: Texas Department of Transportation*

## Trans-Border Travel Demand Model (El Paso – Ciudad Juarez)

As noted in the discussion above, TxDOT-TPP has recognized the interaction of travel activities that occur among neighboring urban areas on the U.S. side of the international border with Mexico. The El Paso MPO has taken this a step further. Similar to other border towns along the U.S.–Mexico border, the cities of El Paso, Texas and Ciudad Juarez, Mexico function approximately as one large urbanized area.

On a daily basis, thousands of vehicles and pedestrians regularly move between both cities. Despite declining border crossings, Texas still leads the nation in truck and personal vehicle crossings from Mexico (source: Bureau of Transportation Statistics). In 2009, 35,585,141 personal vehicles crossed from Mexico while 3.1 million trucks made the crossing. Nearly 650,000 trucks made the crossing between Juarez, Mexico and El Paso, Texas in 2009 according to the BTS. Figure 25 above is an example of the truck traffic entering the United States at the Zaragosa Bridge international bridge crossing (also known as the Ysleta Bridge) while Figure 26 captures the congestion delay at the El Paso Street Bridge in downtown El Paso, Texas entering the United States.

**Figure 25: Zaragosa Bridge (El Paso, Texas)**

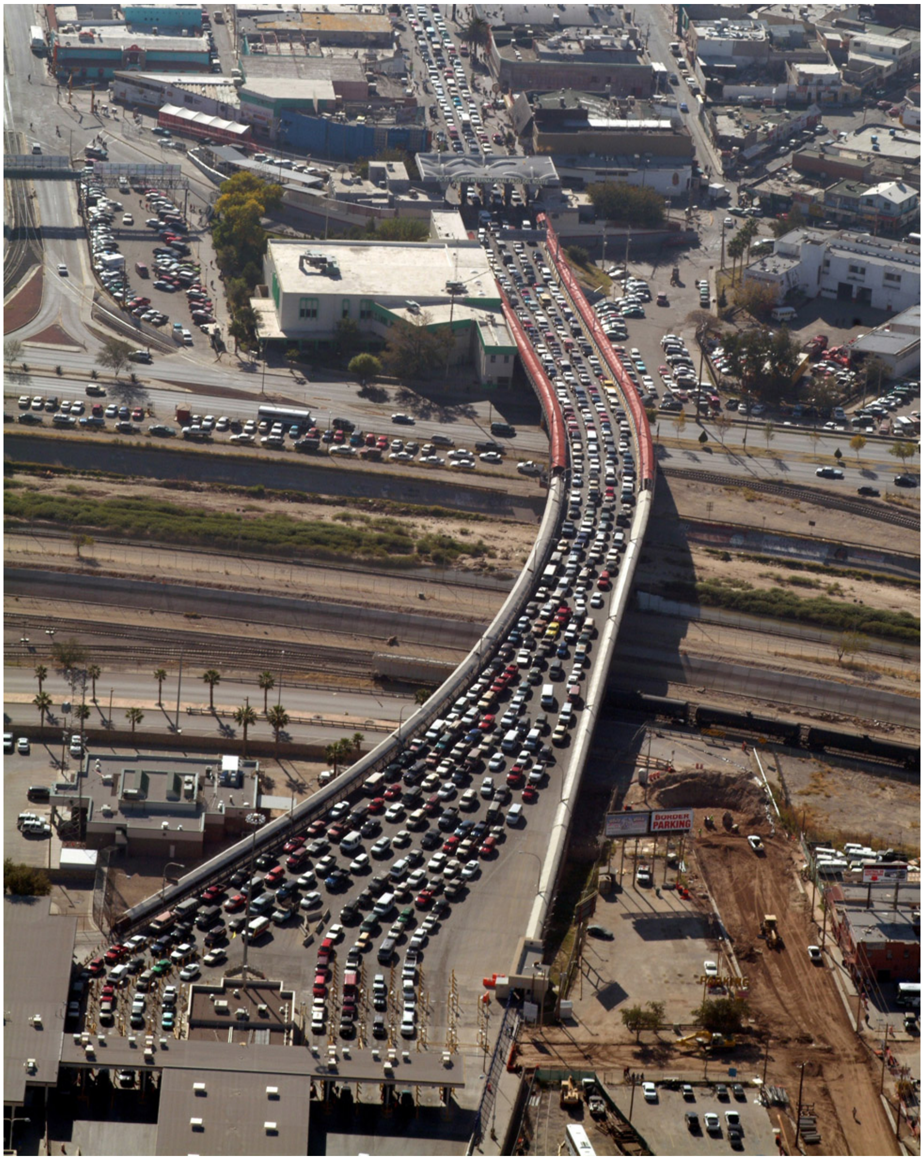


**Figure 26: El Paso Street Bridge (Downtown El Paso, Texas)**

Despite this symbiotic relationship, the two urbanized areas were modeled separately – one maintained and cooperatively developed by the El Paso MPO and TxDOT and the other maintained and jointly developed by the El Paso MPO and IMIP (Instituto Municipal de Investigacion y Planeacion), through ICRC (International Communities Research Center, a branch of IMIP dedicated to trans-border issues). The conventional approach was to treat the international ports-of-entries (POEs) as external stations for the two urbanized areas (see Figure 27 below). Determining that this was insufficient and potentially led to inaccurate portrayals associated with pedestrian and vehicular interactions, the El Paso MPO undertook a research effort to join the two urban area models.

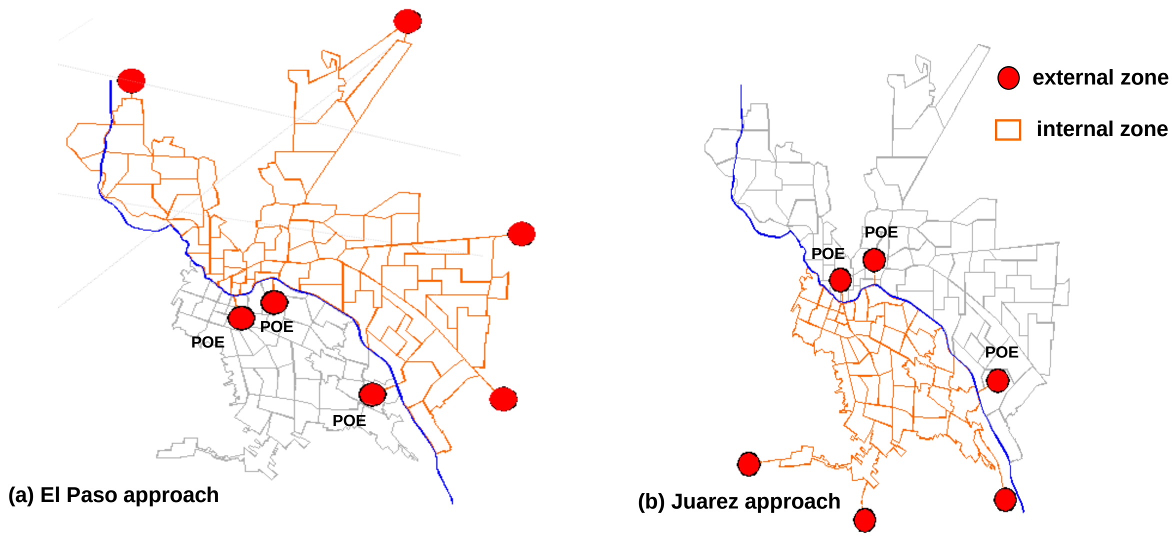



**Figure 27: El Paso-Juarez Bi-National Treatment of External Stations**

The new approach extended the model area boundaries beyond the international boundary limits. By joining the two urbanized areas, the POEs are no longer treated as external stations and the independent treatment of these important regional features is eliminated (as depicted in Figure 28).

Joining the two areas involved a number of considerations:

- Mode choice treatments and practices are very different on either side of the border. For example, there are a number of informal transit providers on the Juarez side of the border that may or may not utilize existing roadways (e.g., jitneys travel along spillways or arroyos).
- Nearly 30 percent of the transit riders on the El Paso side of the border originate as pedestrian traffic that has crossed over from Ciudad Juarez.
- Border inspection times differ depending upon the direction of crossing at individual POEs.
- Household travel data are scarce on the Mexican side of the border because of the high proportion of non-telephone households in Mexico. The 1994 El Paso household survey and a 1996 Juarez household survey (failed to yield robust data regarding trans-border travel between the two cities.

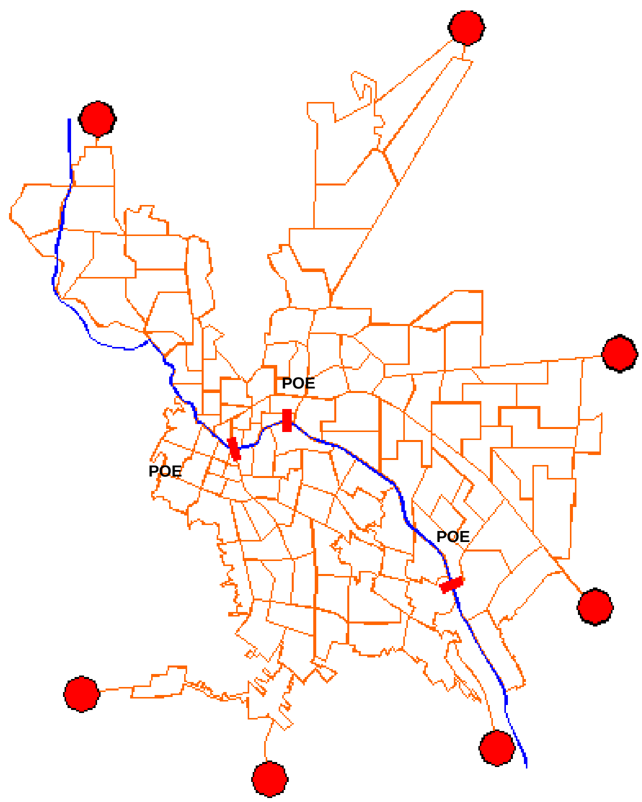



**Figure 28: Bi-National Approach for Modeling**

To support the development of a conjoined model, the El Paso MPO conducted a POE intercept study. Approximately 3,400 trip records were obtained and used for the development of the joint area model. The most significant improvement associated with the bi-national model is the inclusion of multi-modal aspects associated with international crossing that did not previously exist in the El Paso travel models.

The initial set of models has verified the need for greater refinement of data to accurately capture travel within and between the two regions. Examples include:

- Consider implementing a separate pedestrian crossing time variable in the mode choice model. Although this was not an issue that was addressed in the 1996 travel surveys, delay for pedestrians has increased in the post-9/11 environment.
- Consider further refinements to the delay estimation procedures estimated for POEs. Delay is typically consistent and shows very little variability on a daily basis. There are however short-term instances when there are great inconsistencies that are encountered by daily travelers.
- Carefully enhance the POE intercept survey to collect household information (e.g., household income, size, and travel behavior pre and post-POE arrival/departure). This is particularly challenging in the region.
- Consider further refinements to auto-occupancy estimation and the effects of delay at the POEs on auto-occupancy.

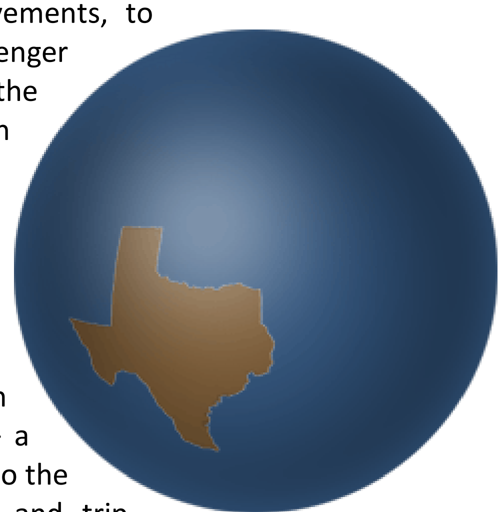

**Figure 29: Traffic Moving toward El Paso, Texas, from Juarez, Mexico**

# Texas Statewide Analysis Model

# Texas Statewide Analysis Model

## General Description

TxDOT developed and maintains the Texas Statewide Analysis Model (SAM). This tool is used to analyze cross-state and cross-regional transportation improvements, to study the effects of statewide policy decisions related to passenger and freight travel, and to better understand the impact of the evolving trade environment beyond the state's borders. In addition, the SAM model may be used to generate external-through and external-local input data for the state's 25 urban-area travel demand models.



Model development for the original SAM (henceforth "SAM Version 1" or "SAM-V1") was well underway by the late 1990s. Developed using TransCAD software, SAM-V1 was similar in structure to the typical urban model of the time for Texas – a traditional four-step model, motorized travel only. Also similar to the typical Texas urban models, passenger-side trip generation and trip distribution utilized the Texas-developed and proprietary packages called TripCal5 and ATOM2, respectively. SAM-V1's freight component was based upon both TRANSEARCH data (proprietary data purchased by TxDOT for this purpose) and input from a separate model called the Texas-North American Freight Flow Model (TX-NAFF) to provide freight origin and destination for the rest of the U.S. and Mexico.

SAM Version 2 (SAM-V2) model development began in 2008 and was completed in 2011. Fundamentally based upon SAM-V1, SAM-V2 substantially advances the usability, analysis capability, flexibility, and reporting features of the tool. SAM-V2, run in TransCAD version 5.0, represents a significant advance with respect to various assignment aspects, added a feedback loop to the model stream, and now incorporates TX-NAFF directly into the user interface. The standard SAM-V2 distribution package includes data for the validated base year 2003 and forecast years 2010, 2020, 2030, and 2035, and the model has the flexibility to interpolate and analyze additional forecast years. No external or proprietary packages are required to run SAM-V2: the individual model components have each been implemented as part of TransCAD.

## Model Inputs

### *Zone Structures and Data*

For the SAM model itself, demographic and employment data are analyzed according to a traffic analysis zone (TAZ) geography. This geography includes 4,400 zones internal to Texas and 142 external stations along the Texas state line. The approach taken to develop this TAZ structure considered the best approach for flexibility and transferability in the future: the procedures to estimate both population and employment variables in the SAM-V2 are based upon the year 2000 U.S. Census block geography, enabling alternate applications of the SAM-V2 with TAZ structures aggregated from different configurations of Census blocks.

The population and employment variables are used for both the passenger and freight trip generation models. Demographic and data inputs necessary to run the model (or interpolate an alternate forecast year) are provided as part of the standard SAM distribution package for the base year 2003 and forecast years 2010, 2020, 2030, and 2035. The development and preparation of demographic and employment data inputs were intentionally performed outside of the SAM-V2 environment. These data inputs were derived using a variety of sources including TSDC Population Projections, socio-economic data from each of the 25 Texas urban-area models, the Woods & Poole 2010 Complete Economic and Demographic Data Source, and Texas Workforce Commission data.

The TX-NAFF model component considers freight movement both inside Texas and beyond its borders. As shown in Figure 30 below, the TX-NAFF TAZ structure is based upon the 254 Texas Counties and the remaining continental states of the United States, Canada, and Mexico. The input data for TX-NAFF are based upon Texas-specific TRANSEARCH data purchased by TxDOT.

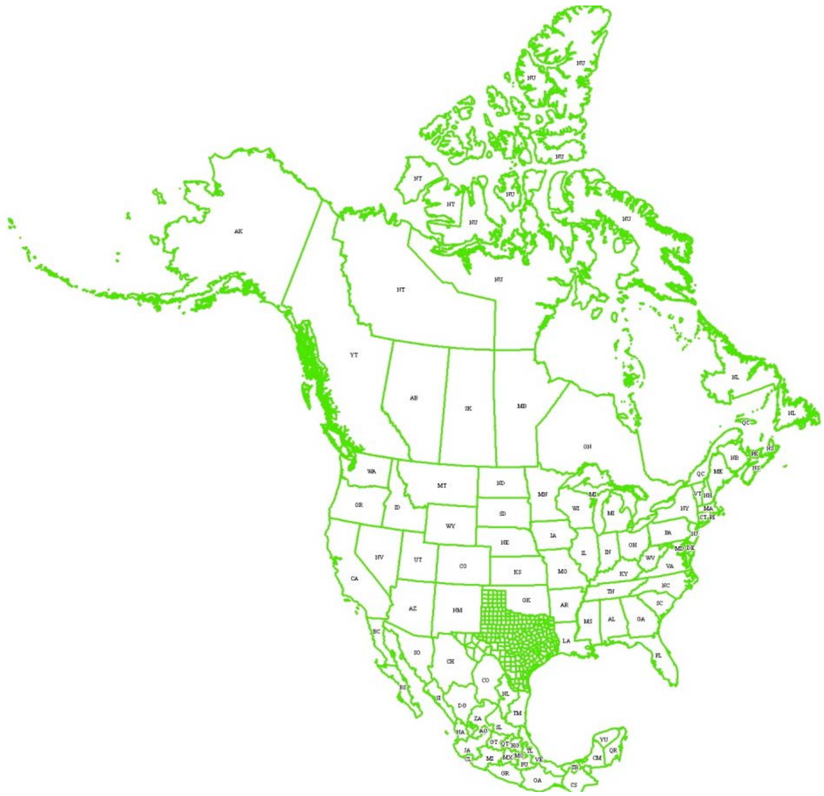


**Figure 30: NX-NAFF Component TAZ Structure**

## *Combined Modal Network*

SAM-V2 network geography is maintained in a "master" framework, selected and extracted for use by year or mode. This master network geography is comprised of the following mode-specific networks by base year 2003 and forecast years 2010, 2020, 2030, and 2035:

- Roadway
- Passenger rail
- Passenger air routes
- Passenger high-speed rail
- Freight rail
- Freight waterways

The version 2 update to SAM merged all modal networks into a combined network. As part of this effort, the passenger and freight roadway networks, separate under SAM-V1, were merged into one roadway network, for which speeds and capacities are based on the Highway Capacity Manual (2004). The roadway network includes all state system highways, as well as county roads and urban arterials as necessary for connectivity. For other freight movements, the network includes rail lines, rail facilities, port facilities, and their interconnections. The passenger air network is defined for direct service, transfer, and terminal access.

# Model Structure

## General Model Structure

The SAM-V2 model structure is a four-step sequential model with feedback from assignment to trip distribution. The trip generation, trip distribution, and mode choice steps are implemented separately for passenger and freight travel. The combined modal network structure enables a combined passenger highway and freight assignment and a feedback loop from assignment back to trip distribution. As mentioned above, the individual model components are each implemented entirely in TransCAD.

# Passenger Travel Models

## Trip Types and Purposes

On the passenger side, SAM-V2 considers two types of motorized person-trips, daily trips (comparable to what is modeled in typical trip-based urban-area models) and "long trips." Long trips are those trips that may occur over a period of several days, given the size of the State of Texas. Long trips, also called infrequent long distance trips, are distinguished from daily trips by being trips longer than 150 miles in distance. Passenger travel encompasses seven internal trip purposes, shown in Table 17.

**Table 17: SAM Internal Trip Purposes**

| Intra-city trips | Inter-city trips |
|---|---|
| • Home based work (HBW)<br>• Home based other (HBO)<br>• Home based school (HBS)<br>• Non-home based other (NHBO)<br>• Non-home based visitor (NHBV) | • Infrequent long distance business trips (ILDB)<br>• Infrequent long distance other trips (ILDO) |

*Source: Alliance Transportation Group, Inc.*

## Trip Generation

For trip generation, production rates were estimated from the 20,000 sample add-on surveys sponsored by TxDOT as part of the 2009 National Household Survey (NHTS). Using year 2000 U.S. Census Transportation Planning Package data, trip productions are stratified by four household size categories and four income categories. These rates are further stratified by eight area type categories.

Trip attraction rates, derived from work place surveys of four urban areas in Texas and data from the 2009 NHTS, are stratified by trip purpose, employment type, income group, and area type (the income stratifications allows income segments to be maintained throughout the model stream for the purpose of mode choice utilities and toll assignment).

### Trip Distribution

SAM-V2 distributes the motorized person-trips by trip purpose and income segment using a traditional gravity-type model with friction factors. Resulting trip lengths (in minutes) are calibrated by trip purpose to year 2009 NHTS observations.

### Mode Choice

On the passenger side, available modes are all motorized: auto driver, auto passenger, intercity rail passenger, high speed rail passenger, or air passenger. Following state of practice, the nested logit model is run separately for each trip purpose, with peak travel times being used for work-related trip purposes and mid-day travel times used for the remaining trip purposes.

## Freight Travel Models

### SAM Freight Models

The SAM-V2 freight models express output as annual tons for 15 commodity types:

- Agriculture
- Mining
- Coal
- Nonmetallic Minerals
- Food
- Consumer Manufacturing
- Non-Durable Manufacturing
- Lumber
- Durable Manufacturing
- Paper
- Chemicals
- Petroleum
- Clay, Concrete, Glass
- Primary Metal
- Secondary & Misc. Mixed

Modes available under the incremental logit choice model include truck, carload rail, and intermodal rail. The resulting flow tables are expressed by mode and the above commodity types. The TxDOT-purchased Texas-specific TRANSEARCH database provides the baseline for applying modal increments. Payload factors by commodity group are applied to daily flows of truck tonnages to derive freight truck trip tables.

### TX-NAFF

The TX-NAFF direct commodity-type model complements the SAM freight model by considering additional modes and freight movements between Texas and the continental states across the United States, Canada, and Mexico. TX-NAFF freight trip tables are based upon TRANSEARCH-derived freight flows for the truck, rail, air, and water modes. TX-NAFF is equipped to perform two types of rail assignment: by tonnage or by train.

## Trip Tables and Assignment

Time-of-day factors were derived from the 2009 NHTS for passenger travel and from Texas vehicle classification count data for truck travel. Following the mode choice steps of both the passenger- and freight-side models, these time-of-day factors are applied to split the trip tables into AM peak, mid-day, PM peak, and overnight periods.

Passenger and freight trip tables are then combined for the roadway mode and assigned using the TransCAD multi-class assignment procedure. Assignment may be performed either for a 24-hour period or by time-of-day. Tolls are represented by a generalized cost function.

Following advanced state of practice principles, SAM-V2 incorporates multiple volume delay functions according to roadway functional classification to account for both link and intersection delay.

## Feedback

To address consistency between the travel times used under trip distribution and those resulting from traffic assignment, roadway travel times are “fed back” from traffic assignment to the trip distribution step for multiple iterations. The feedback procedure follows TransCAD’s recommended approach of the method of successive averages applied to link volumes of successive iterations until model output has stabilized.

## Model Operation and Reporting

SAM-V2 was developed and is run in TransCAD, with no external or proprietary packages required. Version 2 has increased usability with an improved user interface, shown in Figure 31, and incorporation of the TX-NAFF component.

A series of reports, exhibits, and maps are generated automatically for each model scenario run. These are immediately available to the user for analysis purposes and also serve as a record of the model scenario, including statistics for each step of the model.

Model scenarios may be compared using an “audit” procedure provided as part of the user interface. Potential uses for this procedure include examining changes to model outputs by scenario for analysis purposes and identifying changes to model inputs. These uses enable TxDOT to verify intended changes or perform quality control.

SAM-V2 was developed under contract to Alliance Transportation Group, Inc., with assistance from Cambridge Systematics, Inc.

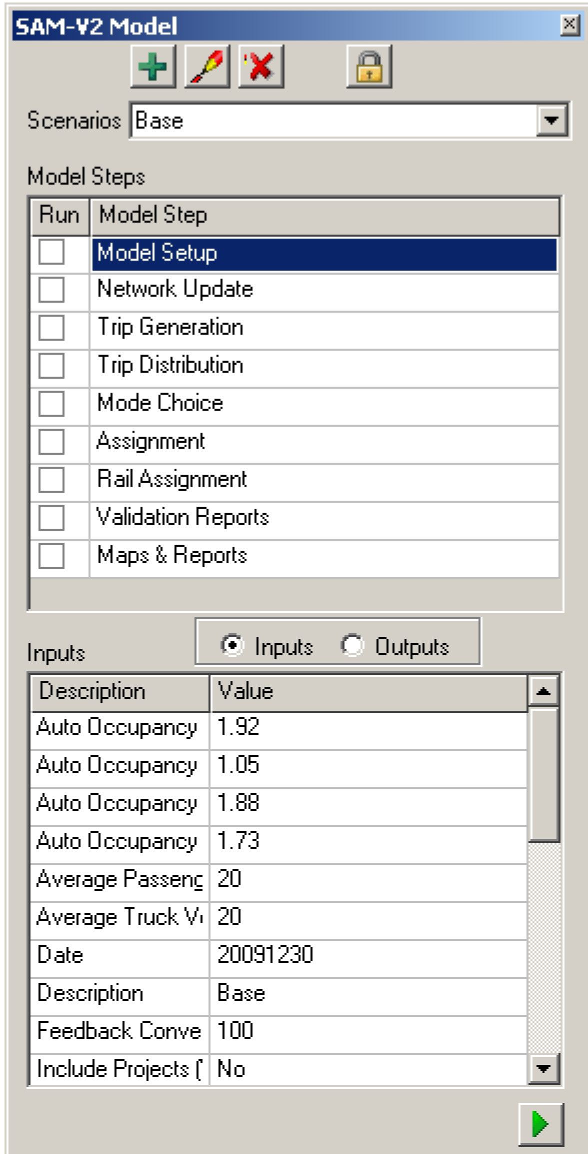



**Figure 31: SAM-V2 User Interface**

# Conclusion

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Funded by the Federal Highway Administration's Office of Planning, Environment and Realty's Surface Transportation Environment and Planning Cooperative Research Program (STEP), TMIP conducts research as well as delivering technical assistance and training to transportation planning professionals. As such, it shares many of its objectives with other stakeholder groups and national organizations. Moreover, TMIP's effectiveness and success is dependent on having direct knowledge of the technical and policy issues that are of concern to its stakeholders. Consequently, reports such as this one and its predecessor, *A Snapshot of Travel Modeling Activities*, August 2008 offer a means of delineating and documenting the travel modeling activities of various planning agencies. These reports offer an opportunity to keep abreast of the state of the practice and ensure that various modeling activities, methodologies and advances explain the technical assistance provided by TMIP.

As such, this snapshot report provides an overview of modeling activities in Texas as of 2011. Acknowledging that TxDOT is the lead model developer for 23 of the 25 Texas urban areas, the snapshot of modeling activities focuses on TxDOT's role in model development across Texas. It offers a comprehensive snapshot of Texas modeling activities by summarizing the current state of modeling in Texas, discussing on-going data collection activities and providing an overview of recent and unique Texas model applications. The model applications discussion illustrates that in response to specific needs, modeling activities in Texas continue to improve and evolve. Likewise, TxDOT's support of research to improve their travel forecasting practice continues to be an on-going commitment. The report also cited a number of outreach programs that TxDOT sponsors to promote the continued use of travel models to conduct alternatives analysis within each MPO and to support the development of the Metropolitan Transportation Plans. These efforts acknowledge that a prerequisite for enhancing the state of travel demand modeling practice in Texas, as elsewhere, is to ensure that a commensurate improvement in travel demand model user's knowledge, skills, and abilities occurs in unison with the development of new ideas and methodologies.

## NOTICE



**FHWA-HEP-12-005**