

# **El Paso MPO TDM22/52**

## *Model Technical Documentation*

*prepared for*

**El Paso Metropolitan Planning Organization**

*prepared by*

**Cambridge Systematics, Inc.**



# El Paso MPO TDM22/52

## *Model Technical Documentation*

*prepared for*

**El Paso Metropolitan Planning Organization**

*prepared by*

**Cambridge Systematics, Inc.**  
505 East Huntland Drive, Suite 550  
Austin, TX 78752

*date*

**October 31, 2025**

---



# Table of Contents

- 1.0 Introduction ..... 1-1**
- 1.1 Data Sources ..... 1-3
- 2.0 Networks ..... 2-4**
- 2.1 Roadway Network..... 2-4
- 2.1.1 Roadway Network Structure ..... 2-4
- Input and Output Networks ..... 2-5
- 2.1.2 Network Attributes..... 2-5
- Functional Classification ..... 2-7
- Bicycle Facility Type ..... 2-9
- Area Type ..... 2-9
- Link Speeds ..... 2-10
- Link Capacities..... 2-11
- Period Capacities..... 2-12
- Toll and HOV Coding ..... 2-12
- Routable Network ..... 2-13
- 2.2 Transit Network..... 2-13
- 2.2.1 Transit / Roadway Linkage ..... 2-13
- 2.2.2 Transit Route System ..... 2-14
- Route System Attributes ..... 2-14
- Transit Modes ..... 2-15
- Transit Stops..... 2-15
- Base Year Transit Routes..... 2-16
- 2.2.3 Transit Roadway Network..... 2-16
- Transit Travel Time ..... 2-17
- Walk Access and Egress ..... 2-17
- Walk Access/Egress Adjustment ..... 2-17
- Drive Access ..... 2-18
- 2.2.4 Transit Pathbuilding ..... 2-18
- 3.0 Traffic Analysis Zones ..... 3-20**
- 4.0 External Travel..... 4-23**

4.1	External Station Locations .....	4-23
4.2	Base Year External Travel .....	4-24
4.2.1	External Station Volumes .....	4-24
4.2.2	Internal-External and External-Internal Trips .....	4-25
4.2.3	External-External Trips .....	4-25
4.2.4	External Station Forecasting.....	4-26
<b>5.0</b>	<b>Trip Generation.....</b>	<b>5-28</b>
5.1	Socio-Economic and Demographic Input .....	5-28
5.1.1	Household and Population Data .....	5-28
5.1.2	Employment Data .....	5-29
5.1.3	Socio-Economic and Demographic Data Summary .....	5-30
5.2	Trip Purposes.....	5-30
5.3	Production Rates .....	5-31
5.4	Attraction Rates .....	5-38
5.5	Income Segmentation .....	5-39
5.6	Special Generators .....	5-40
5.6.1	University of Texas at El Paso (UTEP).....	5-40
	University Trip Purposes.....	5-41
	Employment and Enrollment Data .....	5-42
5.6.2	Fort Bliss .....	5-42
5.6.3	El Paso International Airport .....	5-42
5.6.4	Special Generator Forecasting .....	5-43
5.7	Trip Balancing .....	5-44
<b>6.0</b>	<b>Trip Distribution .....</b>	<b>6-45</b>
6.1	Peak and Off-Peak Period Definitions .....	6-45
6.2	Gravity Model.....	6-45
6.2.1	Friction Factors .....	6-46
<b>7.0</b>	<b>Vehicle Availability Model .....</b>	<b>7-47</b>
7.1	Variables .....	7-47
7.2	Model Estimation .....	7-48
7.3	Model Calibration .....	7-49
<b>8.0</b>	<b>Mode Choice .....</b>	<b>8-51</b>

8.1	Observed Mode Shares .....	8-51
8.1.1	Non-Transit Mode Shares.....	8-51
8.1.2	Observed Transit Trips .....	8-52
8.2	Mode Choice Model Structure .....	8-55
8.2.1	Market Segmentation.....	8-57
8.2.2	Production and Attraction Density Variables .....	8-59
8.2.3	Model Specification.....	8-59
8.2.4	Auto Occupancy.....	8-64
<b>9.0</b>	<b>Trip Assignment .....</b>	<b>9-65</b>
9.1	Time of Day.....	9-65
9.1.1	Time Period Definitions.....	9-65
9.1.2	Peak Hour Definition .....	9-65
9.1.3	Directional Time of Day Factors .....	9-66
9.2	Traffic Assignment .....	9-67
9.2.1	Closure Criteria .....	9-67
9.2.2	Impedance Calculations .....	9-68
9.2.3	Volume-Delay Functions.....	9-68
9.2.4	Multi-Class Assignment .....	9-69
9.2.5	Peak Hour Assignment .....	9-70
9.3	Speed Feedback.....	9-71
9.3.1	Method of Successive Averages .....	9-72
9.3.2	Initial Speeds and Borrowed Feedback Results .....	9-73
9.3.3	Convergence Criteria .....	9-73
9.3.4	Shortest Path Root Mean Square Error.....	9-73
9.3.5	Application of Speed Feedback for Alternatives Analysis .....	9-74
9.4	Transit Assignment .....	9-75
<b>10.0</b>	<b>Calibration and Validation .....</b>	<b>10-76</b>
10.1	Trip Generation Calibration.....	10-76
10.2	Trip Distribution Calibration .....	10-76
10.2.1	Trip Distribution Calibration .....	10-76
10.3	Mode Choice Calibration .....	10-80
10.4	Traffic Assignment Validation .....	10-81

10.4.1	Overall Activity Level.....	10-81
10.4.2	Measures of Error .....	10-82
10.4.3	Screenline Analysis.....	10-84
10.5	Transit Assignment Validation .....	10-87
<b>Appendix A.</b>	<b>LOCUS Location Based Services Data.....</b>	<b>10-90</b>
	Data Description .....	10-90
	Key Analytics Steps .....	10-91
<b>Appendix B.</b>	<b>Transit Delay Parameters.....</b>	<b>10-92</b>

## List of Tables

Table 2.1	Input Network Link Fields .....	2-6
Table 2.2	Input Network Node Fields .....	2-7
Table 2.3	Functional Classes .....	2-7
Table 2.4	Bicycle Facility Type .....	2-9
Table 2.5	Area Type Ranges .....	2-10
Table 2.6	Free-flow Speed Lookup Table .....	2-11
Table 2.7	Hourly Lane Capacity Lookup Table .....	2-11
Table 2.8	Toll Table Fields .....	2-12
Table 2.9	Route Attributes .....	2-14
Table 2.10	Transit Network Mode Values .....	2-15
Table 2.11	Route Stop Attributes.....	2-15
Table 2.12	Key fields in Transit Line Layer .....	2-17
Table 2.13	Minimum Walk Access/Egress Times by Market Segment.....	2-18
Table 2.14	Transit Pathbuilding Weights.....	2-19
Table 3.1	Data Dictionary for TDM22/52 TAZ file.....	3-20
Table 4.1	External Travel Assumptions.....	4-24
Table 4.2	External Trip Truck Classification Shares .....	4-25
Table 4.3	External Trip Seed Matrix .....	4-26
Table 4.4	External Station Forecasts .....	4-26
Table 5.1	Income Group Definitions .....	5-29
Table 5.2	Employment Type Categories .....	5-30
Table 5.3	Socio-Economic Data Summary.....	5-30
Table 5.4	HBW Trip Production Rates (Work).....	5-31
Table 5.5	HNWR Trip Production Rates (Retail).....	5-33
Table 5.6	HNWE1 Trip Production Rates (Kindergarten to Grade 12).....	5-34
Table 5.7	HNWE2 Trip Production Rates (College/University) .....	5-35
Table 5.8	HNWO Trip Production Rates (Other).....	5-36
Table 5.9	NHB Trip Production Rates .....	5-37
Table 5.10	Trip Attraction Rates .....	5-38
Table 6.1	Trip Distribution Time of Day Factors .....	6-45
Table 6.2	Gravity Model Friction Factors (Peak).....	6-46

Table 6.3	Gravity Model Friction Factors (Off-Peak) .....	6-46
Table 7.1	Utility Parameters for Accessibility Variables .....	7-48
Table 7.2	Vehicle Availability Model Estimation Results .....	7-49
Table 7.3	Theta Values for the Vehicle Availability Model .....	7-50
Table 7.4	Vehicle Sufficiency Validation.....	7-50
Table 8.1	Non-Transit Trip Targets .....	8-52
Table 8.2	2022 Fixed Route Boardings .....	8-53
Table 8.3	Observed Walk and Drive Access Shares .....	8-53
Table 8.4	Resulting Transit Trip Targets .....	8-55
Table 8.5	Walk Access and Egress Market Segments .....	8-58
Table 8.6	Walk Segments Sample Output .....	8-59
Table 8.7	Mode Choice Model Coefficients.....	8-61
Table 8.8	Peak Mode Choice Model Constants by Income .....	8-62
Table 8.9	Off-Peak Mode Choice Model Constants by Income .....	8-63
Table 8.10	Mode Choice Model Constants by Vehicle Sufficiency .....	8-64
Table 9.1	Travel Model Time Periods.....	9-65
Table 9.2	Pre-Assignment Directional Time of Day Factors .....	9-67
Table 9.3	Volume Delay Function Lookup Table (Alpha / Beta) .....	9-69
Table 9.4	Perceived Value of Time by Vehicle Class.....	9-70
Table 10.1	Average Daily Travel Times by Trip Purpose .....	10-77
Table 10.2	Mode Choice Calibration Targets – Number of Trips .....	10-80
Table 10.3	Mode Choice Model Results – Number of Trips.....	10-81
Table 10.4	Mode Choice Calibration Results – Percent Difference .....	10-81
Table 10.5	Regional Modeled Volumes and VMT vs. Counts.....	10-82
Table 10.6	RMSE Statistics by Link Type .....	10-84
Table 10.7	RMSE Statistics, by Volume Group.....	10-84
Table 10.8	TDM22/52 Screenline Analysis .....	10-85
Table 10.9	Transit Assignment Results.....	10-88
Table 10.10	Peak Local Transit Delay Factors.....	10-92
Table 10.11	Peak Express Transit Delay Factors .....	10-92
Table 10.12	Peak Premium Transit Delay Factors.....	10-92
Table 10.13	Off-Peak Local Transit Delay Factors.....	10-93
Table 10.14	Off-Peak Express Transit Delay Factors .....	10-93

Table 10.15 Off-Peak Premium Transit Delay Factors ..... 10-93



# List of Figures

Figure 1.1	El Paso MPO Travel Demand Model Structure .....	1-2
Figure 2.1	Example Model Run Directory Structure .....	2-5
Figure 2.2	Connections between the Route System and Transit Line Layer .....	2-14
Figure 2.3	El Paso Base Year Transit Routes .....	2-16
Figure 4.1	El Paso External Station Locations .....	4-23
Figure 5.1	UTEP Traffic Analysis Zones .....	5-41
Figure 5.2	Fort Bliss and Airport Zones (Overview).....	5-43
Figure 5.3	Fort Bliss and Airport Zones (Detail) .....	5-43
Figure 8.1	2022 Park-n-Ride Locations .....	8-54
Figure 8.2	Nested Logit Mode Choice Structure.....	8-57
Figure 9.1	Diurnal Curve of 15-Min Interval Counts .....	9-66
Figure 9.2	Feedback Process .....	9-72
Figure 10.1	Home-Based Work Trip Length Frequency Distribution .....	10-77
Figure 10.2	Home-Based Non-Work Education Trip Length Frequency Distribution .....	10-78
Figure 10.3	Home-Based Non-Work Retail Trip Length Frequency Distribution.....	10-78
Figure 10.4	Home-Based Non-Work Other Trip Length Frequency Distribution .....	10-79
Figure 10.5	Non-Home Based Trip Length Frequency Distribution.....	10-79
Figure 10.6	Mode Choice Calibration Methods .....	10-80
Figure 10.7	Model Volume/Count Comparison.....	10-83
Figure 10.8	TDM22/52 Model Screenlines .....	10-86
Figure 10.9	TDM22/52 Model Screenline Analysis.....	10-87
Figure 10.10	Route Group Definitions .....	10-89



## 1.0 Introduction

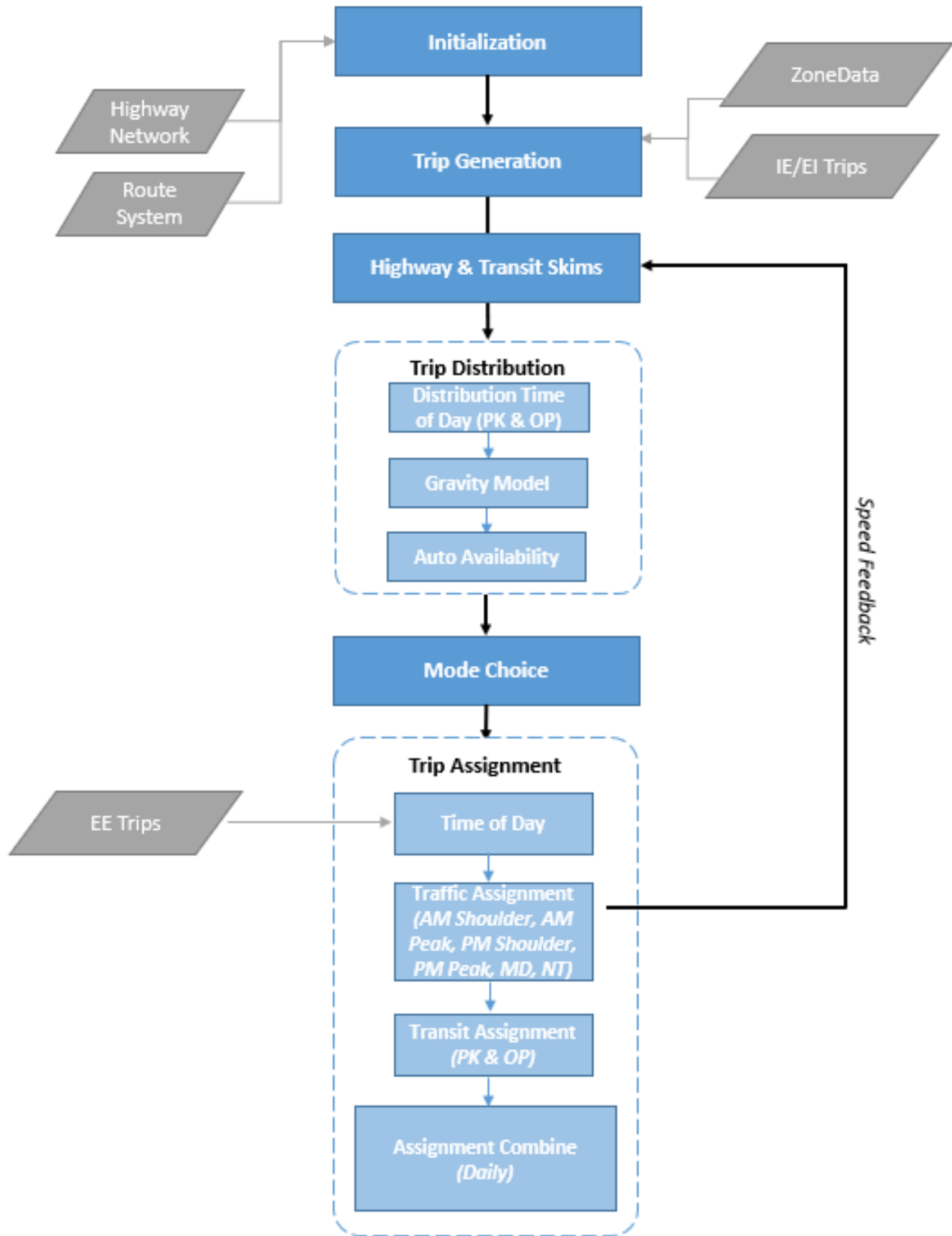
The El Paso MPO and its affiliated stakeholders use the El Paso MPO Regional Travel Demand Model as a tool to forecast traffic and travel in communities throughout the region. The primary purpose of the travel model is to support the Metropolitan Transportation Plan (MTP). The model can support evaluation of proposed roadway and transit projects, help evaluate potential impacts of proposed development projects, and support various other studies of the region, subareas, corridors, and other planning activities. The current version of the model, named TDM22/52, has been calibrated to reflect a base year of 2022.

The previous version of the model, named the Regional Mobility Strategy (RMS) Model, featured a 2017 base year and 2050 forecast year. The El Paso MPO TDM22/52 includes minor changes to the 2017 base year RMS Model. Changes include updating the model base year to 2022, implementing peak hour assignment, and calibrating and validating the various model components to the new base year.

Data sources include available census packages, a 2010-2011 Household Travel Survey, and 2022 transit boardings. All of these data sources were accounted for in the 2017 base year RMS travel model with the exception of the more recent route ridership data used to update the transit trip targets. This version of the model has also employed location based services (LBS) data in the calibration and validation of the trip generation and distribution models.

The El Paso MPO TDM 22/52's process and functions, shown in the model flow diagram in Figure 1.1, follow a standard 4-step modeling process that is prevalent among travel models in small and medium-sized regions throughout the U.S.

Figure 1.1 El Paso MPO Travel Demand Model Structure



## 1.1 Data Sources

Travel behavior represented in The El Paso MPO TDM22/52 was estimated during development of the 2012 base year Destino Model using data from a household travel survey (HTS) conducted in 2010-2011. HTS data were combined with data from an on-board transit survey conducted at a similar time. Because new HTS data were not available for this effort, other data sources have been used to calibrate and validate model components to the new 2022 base year.

1. **El Paso Household Travel Survey Data (2010-2011)** were provided by the MPO for the development of the Destino Model and for reference in the RMS and TDM22/52 model development. The data were used extensively in Destino model development and were frequently referenced in confirming or updating parameters in development of the RMS and TDM22/52 models.
2. **Transit On-Board Survey Data (2012)** were provided by the MPO for the development of the Destino Model and for reference in RMS and TDM22/52 model development. The data were used along with base year transit boarding data to develop observed transit by purpose, time period, and income group.
3. **Traffic Counts (2022)** were obtained by the MPO and attached to the highway network for use in model validation. Traffic counts by time of day and vehicle class were also provided by TxDOT for peak hour factor determination.
4. **Transit Boarding Data (September and October 2022)** were provided by transit operators in the region. Total boardings by route were used in calibration of mode choice, as well as validation of transit assignment.
5. **LOCUS Location Based Services (LBS) Data (2023)** served as an additional calibration and validation data source, supplementing the HTS dataset. LBS data is a licensed data product that provides trip patterns at the Census block group level. More information about the LOCUS data is provided in 0.
6. **Longitudinal Employer-Household Dynamics Origin-Destination Employment Statistics (LODES; 2021)** served as an additional data source for the calibration of the trip distribution model.

In addition, data from the American Community Survey (ACS) and proprietary employer data obtained from Data Axle were used to support development of demographic data.

## 2.0 Networks

### 2.1 Roadway Network

The roadway network contains basic input information for use in the travel demand model and represents real-world conditions for the 2022 base year and expected conditions for future years or tested alternatives. The roadway networks are used in the model to distribute and route vehicle trips. The model networks provide a foundation for system performance analysis including vehicle miles of travel, congestion delay, level of service, and other performance measures. This section provides a description of the network attributes and lookup tables for the roadway networks. The assumptions and parameters identified herein are relevant for the model's 2022 base year network, but generally apply to interim and forecast year networks as well.

The roadway network is a GIS-based representation of the street and highway system in the El Paso MPO modeling area. It also has designations for bicycle facilities including bike routes, bike lanes, and multi-use paths. It is one of the foundational components of the travel model as it serves to represent the supply side of the travel demand/transportation system relationship. As such, the establishment and review of detailed network attribute data was very important to the model's development. The network serves as:

- An input database containing roadway and non-motorized facility characteristics (such as facility type, number of lanes, area type, etc.);
- A foundation for the transit route system; and
- A data repository that can be used to store and view travel model results.

The roadway network is structured to contain data across multiple years. The roadway network prepared for the TDM 22/52 is designed to maintain information about existing, as well as planned and proposed roadway, transit, and non-motorized projects. This allows the network to represent the 2022 base year, existing plus committed networks, planned forecast year networks, interim horizon year networks, and any other network scenarios desired within a single network database.

#### 2.1.1 Roadway Network Structure

The El Paso MPO TDM22/52 roadway network structure is a flexible data repository that hosts input and output data required by the travel model. This section describes the network file structure and defines attributes populated on the network. Input attributes and some output attributes are discussed herein. Additional output variables created by subsequent model steps are discussed in the associated sections of this report.

Input network attributes used by the travel model include functional class, area type (populated based on TAZs), number of lanes, and direction of flow. Each of these variables is addressed in the sections that follow. Values for these attributes have been populated on the roadway network file for the years 2022, 2052, and various interim years.

## Input and Output Networks

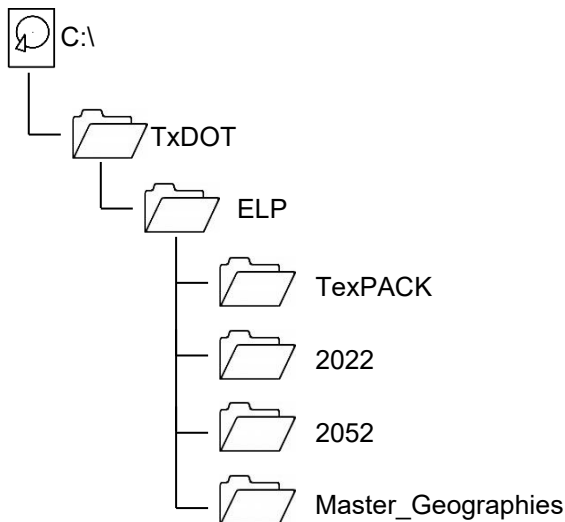
The roadway network file contains travel model input data and also acts as a repository for both intermediate (e.g., speed and capacity) and final (e.g., traffic volumes) model data. For this reason, a separate output model network is created for each model scenario. This output network is created by making a copy of the input network, then modifying this network to contain data and results specific to each model run. This copy of the roadway network is created and modified automatically by a network initialization step when the travel model is run.

The model's directory structure, as shown in Figure 2.1, allows for a single input and output folder for each model scenario. When the travel model is run, files located in the input directory are not modified by model macros. Instead, when a file needs to be modified, a copy is created in the output directory, and only the copy is modified. An exception, though, is the transit route system, which is modified in-place. This approach has several benefits, including:

All input files relevant to the scenario are stored inside the scenario folder making locating files easier; and

Because input files are not modified by the travel model macros, it is unlikely that important data present within input files will be inadvertently overwritten by travel model macros.

**Figure 2.1 Example Model Run Directory Structure**



### 2.1.2 Network Attributes

The roadway network contains input attributes listed in **Table 2.1**. Using standard tools available within the TransCAD software, additional fields can be added to the network, as desired, by MPO staff or other users. These additional fields will not be referenced by the travel model but can be used to aid in analysis of results.

In addition to link attributes, several attributes are included on the node layer of the roadway network file. Centroid nodes are identified by the ZONE attribute on the node layer. Node attributes are listed in **Table 2.2**.

**Table 2.1 Input Network Link Fields**

Field Name	Description	Comments
ID	TransCAD Unique ID	Maintained automatically by TransCAD
Dir	Link Direction of Flow	Direction of Flow
Length	Link Length in miles	Maintained automatically by TransCAD
TAZ	TAZ where link is located	
County	County where link is located	
Local_Stre	Optional Field indicating street name	
State_Syst	State system roadway name	
District	El Paso MPO District Assignment	
FUNCL_yy	Scenario-specific functional class (see <b>Table 2.3</b> for definition)	
LANES_AB/BA_yy	Scenario-specific directional number of through lanes	
DIV_yy	Flag denoting divided or undivided roadway (0=undivided; 1=divided) – not currently used in model	
ATYPE_yy	Link area type (populated during the model run)	
PKFB_AB/BA_yy	Peak directional speed from feedback loop	“yy” represents a two-digit year code (e.g., 17, 50) or a string representing a scenario (e.g., CE)
OPFB_AB/BA_yy	Off-peak directional speed from feedback loop	
TrkProhib_yy	Truck Prohibition: null/0= Trucks Allowed; 1=Med/Hvy Trucks Prohibited	
HOV_yy	HOV Restriction (no trucks allowed): 2=HOV2+; 3=HOV3+; null/0=no restriction	
Toll_SOV/HOV2/HOV3_PK/OP_yy	Tolls to be paid by vehicle class in 2017 dollars (SOV, HOV2,HOV3) and period (PK,OP), allowing testing of HOT lane concepts.	
Toll_LTK/MTK/HTK_PK/OP_yy	Tolls to be paid by vehicle class in 2017 dollars (LTK,MTK,HTK) and period (PK,OP), allowing testing of HOT lane concepts.	
BIKEFT_yy	Bicycle facility type representing bicycle comfort index.	
VAL_COUNT	Traffic count selected for use in validation	
VC_Auto/MT/HT	Vehicle class counts used to validate by vehicle class – not directly used by the model.	
MergelD	ID used to merge volumes on mainline and HOV/managed lanes when comparing to counts.	

Notes: Additional fields not included in this table may be present on the network but are not referenced by the travel model. The model creates numerous additional fields at runtime and places them on the output network. Examples include fields for Capacity, Alpha, and Beta. If such fields exist on the input network, their contents are overwritten in the output copy of the network.

**Table 2.2 Input Network Node Fields**

Field Name	Description	Comments
ID	Unique TransCAD ID	Maintained automatically by TransCAD.  Note: The node ID value should be set to match the Zone number. This can be accomplished by either exporting the network file after modifying the ZONE field or running the Update Input Network utility available from the model interface.
TAZ	Traffic Analysis Zone Number	Populated only for centroid nodes (including external station nodes). Null for all non-centroid nodes.
ModelArea	Distinguishes between external nodes, internal nodes, and internal centroids	

### Functional Classification

The Functional Class (FUNCL) variable on the roadway network is used to look up speed, capacity, and volume delay parameters. Functional class values used in the TDM 22/52 are listed in **Table 2.3**. Functional classifications 51 and 61 are included for use in future scenario coding, though are not present in the base year network.

**Table 2.3 Functional Classes**

Value	Functional Class
0	Centroid Connector
1	Interstate
2	Expressway
3	Principal Arterial
4	Minor Arterial
5	Collector & Frontage Road
6	(Not Used)
7	Local
20	Ramp
51	Transit Only
61	Bicycle Only

The following bullets provide a description of each functional class:

- **Centroid Connector** – These facilities are the means by which the trip and other data at the traffic analysis zone (TAZ) level are attached to the street system. Centroid connectors are an approximate representation of local streets, most of which are not included in the travel model.

- **Interstate** – Freeways are divided, restricted access facilities with no direct land access and no at-grade crossings or intersections. Freeways are intended to provide the highest degree of mobility serving higher traffic volumes and longer-length trips.
- **Expressway** – Expressway facilities are sometimes classified as divided principal arterials but include many features common to freeways. Expressways use a higher level of access control than other arterials and may include grade-separated intersections. Expressways have higher speed limits than other principal arterials (e.g., 55 or 65 MPH), provide little or no direct access to local businesses, may have frontage roads or access roads, and limit signal spacing to at least ½ mile.
- **Principal Arterial** – Principal arterials permit traffic flow through and within urban areas and between major destinations. These are important to the transportation system since they provide local land access by connecting major traffic generators, such as central business districts and universities, to other major activity centers. Principal arterials carry a high proportion of the total urban travel on a minimum of roadway mileage. They typically receive priority in traffic signal systems (i.e., have a high level of coordination and receive longer green times than other functional classes). Divided principal arterials have turn bays at intersections, include medians or center turn lanes, and sometimes contain grade separations and other higher-type design features. State and US highways are typically designated as principal arterials unless they are classified as freeways.
- **Minor Arterial** – Minor arterials collect and distribute traffic from principal arterials and freeways to streets of lower classification and, in some cases, allow traffic to directly access destinations. They serve secondary traffic generators, such as community business centers, neighborhood shopping centers, multifamily residential areas, and traffic between neighborhoods. Access to land use activities is generally permitted, but should be consolidated, shared, or limited to larger-scale users. Minor arterials generally have slower speed limits than principal arterials, may or may not have medians and center turn lanes, and receive lower signal priority than other functional classes (i.e., are only coordinated to the extent that principal arterials are not disrupted and receive shorter green times than principal arterials).
- **Collector**– Collectors provide for land access and traffic circulation within and between residential neighborhoods and commercial and industrial areas. They distribute traffic movements from these areas to arterial streets. Except in rural areas, collectors do not typically accommodate long through trips and are not continuous for long distances. The cross-section of a collector street may vary widely depending on the scale and density of adjacent land uses and the character of the local area. Left turn lanes sometimes occur on collector streets adjacent to non-residential development. Collector streets should generally be limited to two lanes, but sometimes have 4-lane sections.
- **Frontage Road** – Frontage roads are identified as facilities similar to minor arterials or collectors but specifically provide local access alongside a freeway or expressway.
- **Local** – Local streets directly serve residential neighborhoods and some commercial uses. The model includes only a small number of local streets in order to properly represent connectivity in and between neighborhoods. Most local streets are instead represented by centroid connectors.
- **Ramp** – Ramps provide connections between freeways and other non-freeway roadway facilities. On freeway-to-non-freeway ramps, traffic usually accelerates or decelerates to or from a stop. Therefore, the free-flow speed on freeway to arterial ramps is often coded as much slower than the ramp speed limit.

- **Transit Only** – Transit only links represent right-of-ways designated exclusively for transit use. These are particularly important when including routes for premium modes, such as Bus Rapid Transit (BRT) or Light Rapid Transit (LRT), in the transit system. General traffic is prohibited from using these links, and speeds can be adjusted in the speed lookup table to represent transit operating speeds.
- **Bicycle Only** – Bicycle only links can be used to represent bicycle facilities that are not associated with a roadway. These are especially useful when bicycle connections allow for a shorter travel route than would be possible using roadway links.

### Bicycle Facility Type

Bicycle facility type defines the bicycle facilities available on the roadway network. Bicycle pathbuilding prioritizes higher level bicycle facilities (i.e., facilities with a lower Bike FT value) and excludes facilities where bicycles are prohibited. Bicycle facility types are defined by the network variable BikeFT, as defined in **Table 2.4**. Bicycle facilities include roadways and other non-motorized facilities such as bike paths. Bike paths not directly adjacent to a roadway can be assigned a roadway functional class value of 61.

**Table 2.4 Bicycle Facility Type**

BikeFT	Bicycle Facility Type
1	Bike trails / mixed use paths
2	Bike lanes
3	Bike routes / bikeable shoulders
4	No specific treatment, but bikes allowed
-1	Bikes prohibited

### Area Type

Area type is an attribute assigned to each TAZ and roadway, determined by the zone’s activity level and/or the zone’s character. Terminal times, free-flow speeds, roadway capacity, and volume-delay characteristics are dependent on area type. Area type is first defined at the TAZ level based on socio-economic characteristics, then transferred to the roadway network.

Area type values are maintained in the TAZ dataset for each model year. Using an automated process, area type is then transferred from the TAZ layer to the roadway network layer. This process assigns links along an area type boundary to the denser area type and ensures consistent area type values are assigned to links within interchanges. This automated process uses buffering to prevent links from alternating between area types along borders, removing the need to manually review results of the zone to link area type transfer procedure.

Both employment and household density was calculated for each TAZ using a buffer of 0.75 miles. These density variables are calculated for each TAZ as employment per acre and households per acre for all zones that are at least partially within 0.75 miles of a TAZ centroid.

Area type for each TAZ is then calculated based on activity densities as defined in **Table 2.5**. There are five area types: Central Business District (CBD), CBD Fringe, Urban, Suburban and Rural. The CBD area type is not based on activity density, but rather on the historical definition of the CBD boundary. Results of the area

type model were reviewed and parameters adjusted until manual smoothing of area type model results became unnecessary.

**Table 2.5 Area Type Ranges**

Area Type	Area Type Name	Lower Limit Household Density	Lower Limit Employment Density
1	CBD	n/a (fixed)	n/a (fixed)
2	CBD Fringe	n/a	9
3	Urban	4	3.5
4	Suburban	0.3	1.2
5	Rural	n/a	n/a

Note: Each zone is assigned the densest area type for which it exceeds **either** the household or employment density specified.

### Link Speeds

Network speeds are used to calculate travel times, which inform the trip distribution model for distributing trips throughout the model area and in the trip assignment model for routing traffic on the roadway network.

Link free-flow speeds represent average travel time, including intersection delay, needed to traverse the distance of a link with little or no traffic (i.e., no congestion effects). These speeds are generally similar to the posted speed and are calculated based on functional class and area type. Free-flow speeds are typically lower than the speed limit to account for intersection delay on arterials, collectors, and ramps but may be higher than the posted speed on freeways.

During this model update, free-flow speeds for certain functional class/area type destinations were revised. This was done based on a review of model volumes and traffic counts in each category, followed by review of example links using aerial photography and Google Street View. The resulting free-flow speeds are tabulated in **Table 2.6**.

**Table 2.6 Free-flow Speed Lookup Table**

	Functional Class	CBD (1)	CBD Fringe (2)	Urban (3)	Suburban (4)	Rural (5)
0	Centroid Connector	20	20	20	20	20
1	Freeway	65	65	70	70	75
2	Expressway	50	50	50	50	50
3	Principal Arterial	20	27	35	40	50
4	Minor Arterial	18	23	30	35	35
5	Collector	15	20	27	32	35
7	Local	20	20	23	23	24
20	Ramp	15	20	22	24	25
51	Transit Only	n/a	n/a	n/a	n/a	n/a
61	Non-Motorized	n/a	n/a	n/a	n/a	n/a

Source: Destino Travel Model, reviewed and updated for use in The El Paso MPO TDM22/52.

### Link Capacities

Capacity constrained traffic assignment requires roadway capacity values on each network link. The model uses link capacity to measure congestion and determine route diversion due to slower travel speeds associated with increasing congestion. This is accomplished through volume-delay equations that are further documented in **Section 9.2.3**.

In the model, per-lane capacity values are retrieved from a lookup table based on the functional class and area type of each link in the roadway network, shown in **Table 2.7**. This approach eliminates opportunities for error in defining link-level capacities and enforces consistent application of capacity values. These hourly lane capacities, combined with the number of lanes present in the network, define hourly directional capacity.

**Table 2.7 Hourly Lane Capacity Lookup Table**

	Functional Class	CBD (1)	CBD Fringe (2)	Urban (3)	Suburban (4)	Rural (5)
0	Centroid Connector	10,000	10,000	10,000	10,000	10,000
1	Freeway	1,950	1,950	2,000	2,000	2,000
2	Expressway	1,900	1,900	1,900	1,900	1,900
3	Principal Arterial	820	840	860	880	1,000
4	Minor Arterial	730	740	750	760	760
5	Collector	720	730	740	750	760
7	Local	640	640	650	650	650
20	Ramp	500	500	550	560	580
51	Transit Link	n/a	n/a	n/a	n/a	n/a
61	Non-Motorized	n/a	n/a	n/a	n/a	n/a

Source: Destino Travel Model, reviewed and retained for use in The El Paso MPO TDM22/52.

## Period Capacities

While hourly capacity is useful for most applications, the traffic assignment model requires time period-specific capacities. Both mid-day and night-time capacity are calculated by multiplying the number of hours in the time period by the hourly capacity. The mid-day capacity represents 5.5 hours, while the off-peak capacity represents 11.5 hours. For peak periods, higher traffic volumes in the peak hour must be considered. Peak period capacity can be calculated using the equation below.

$$PeriodCapacity = \frac{HourlyCapacity}{PeakHourTrafficShare}$$

The survey reveals that 41% of the 3-hour AM period traffic occurs during the peak hour. Consequently, the AM peak period capacity is 2.44 times the hourly lane capacity. Similarly, the survey reveals that 26% of the 4-hour PM period traffic occurs during the peak hour. Consequently, the PM peak period capacity is 3.85 times the hourly lane capacity.

## Toll and HOV Coding

Tolling is indicated on the highway network using a toll value which identifies a specific set of per-mile toll rates and/or flat cost toll values at specified locations. In typical application, tolls are specified as either per-mile (e.g., \$0.05/mile for long segments), or flat rate (e.g., a \$2.50 toll at a toll plaza or access link). Fields present in the toll table are defined in **Table 2.8**. However, since The El Paso MPO TDM22/52 does not feature any toll facilities in the base year, toll functionality is only implemented in forecast year networks. Toll cost data for all years are entered in 2017 dollars for consistency with other costs in the travel model.

**Table 2.8 Toll Table Fields**

Field Name	Field Description
Toll_SOV_PK_22	Tolls to be paid by single occupancy vehicles in the peak periods
Toll_HOV2_PK_22	Tolls to be paid by shared ride 2 vehicles in the peak periods
Toll_HOV3_PK_22	Tolls to be paid by shared ride 3+ vehicles in the peak periods
Toll_SOV_OP_22	Tolls to be paid by single occupancy vehicles in the off-peak periods
Toll_HOV2_OP_22	Tolls to be paid by shared ride 2 vehicles in the off-peak periods
Toll_HOV3_OP_22	Tolls to be paid by shared ride 3+ vehicles in the off-peak periods
Toll_LTK_PK_22	Tolls to be paid by light truck vehicles in the peak periods
Toll_MTK_PK_22	Tolls to be paid by medium truck vehicles in the peak periods
Toll_HTK_PK_22	Tolls to be paid by heavy truck vehicles in the peak periods
Toll_LTK_OP_22	Tolls to be paid by light truck vehicles in the off-peak periods
Toll_MTK_OP_22	Tolls to be paid by medium truck vehicles in the off-peak periods
Toll_HTK_OP_22	Tolls to be paid by heavy truck vehicles in the off-peak periods

The HOV field indicates whether the link is an HOV lane, and assigns restrictions to certain vehicle classes prohibiting them from using the HOV lanes. An HOV value of 2 (indicating a 2+ HOV lane) prohibits trucks and SOVs, while an HOV value of 3 (indicating a 3+ HOV lane) prohibits SOVs, SR2 vehicles, and trucks.

## Routable Network

Many functions in TransCAD require the creation of a routable network file, identified by a “.net” extension. For The El Paso MPO TDM22/52, the path building/skimming and traffic assignment procedures require a routable network. A routable network is also required when editing transit route systems. Routable network files store link length, turn penalty information, and travel time information for each link. An appropriate routable network file is automatically created during network initialization.

Specific turn prohibitions are initially stored in a separate file, which is referenced during the creation of the routable network. The El Paso MPO TDM22/52 uses turn penalties exclusively to represent localized delays caused by queuing border crossings. This queuing related turn penalties are removed from forecast year models to account for roadway improvements that mitigate the issue.

The routable network file contains information about centroid connectors to prevent pathbuilder and traffic assignment algorithms from routing trips through centroids. The model automatically creates a selection of centroid nodes and identifies nodes as centroids in the routable network file.

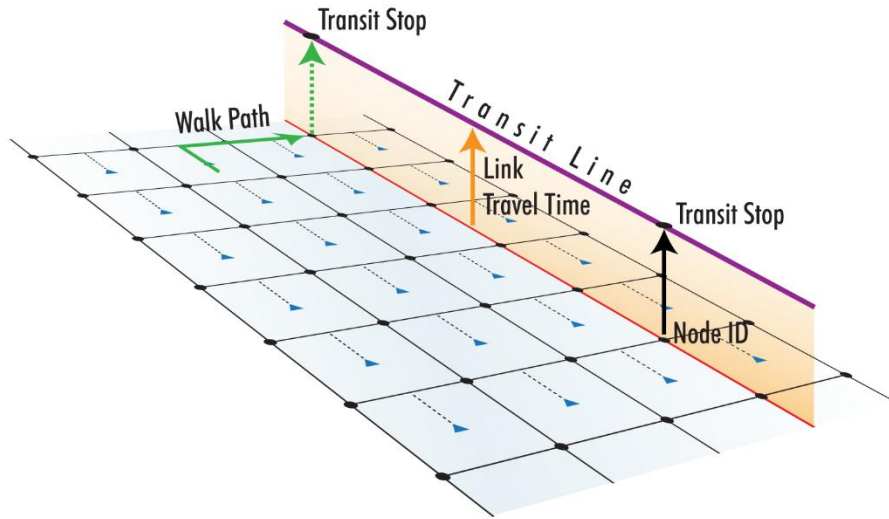
## 2.2 Transit Network

The travel model uses transit networks to build the shortest paths between each zone pair for transit trips. Shortest paths are determined by minimizing a weighted combination of costs, times, and penalties encountered during a trip. Variables representing the resulting shortest paths are used as inputs to the mode choice model. The El Paso MPO TDM22/52 uses information stored on the roadway network layer, including congested travel times, and a TransCAD route system to represent the transit networks. For transit pathbuilding, The El Paso MPO TDM22/52 uses the “Pathfinder” method provided by the TransCAD software.

### 2.2.1 Transit / Roadway Linkage

Transit networks in TransCAD are made up of two separate, but connected, parts: the transit route system and the transit roadway network. The transit route system includes two layers - routes and stops. The transit roadway network includes link and node layers and is a copy of the roadway network used for vehicle modeling. **Figure 2.2** shows how information from these four layers is combined to represent both the walk and in-vehicle components of a transit trip. Indicated in **Figure 2.2**, drive access to transit can be represented in a similar manner, with drive access replacing the walk access. Because these layers are connected, information on the roadway network, such as link travel times and centroid data, is available to the route system. This connection requires the roadway and transit networks to be maintained in a manner that prevents them from becoming inconsistent with one another.

**Figure 2.2** Connections between the Route System and Transit Line Layer



### 2.2.2 Transit Route System

Transit routes and stops are represented within the TransCAD route system. Contents of the route system are based on schedule data from Sun Metro and El Paso County.

#### Route System Attributes

Each route is represented as a unique feature in the route system layer. Like the line layer, the route system layer includes attributes for each feature. These attributes contain route-specific information, such as route name and headway. Notably absent from the list of route system attributes is travel time. The TransCAD model computes stop-to-stop travel time using attributes on the underlying link layer rather than attributes stored directly on the route system. **Table 2.9** includes a list of route attributes.

**Table 2.9** Route Attributes

Field Name	Description	Comments
Route_ID	TransCAD Unique ID	Maintained automatically by TransCAD
Route_Name	Short descriptive route name	Unique route name used for route identification
Mode	Transit Mode ID	See <b>Table 2.10</b> .
Dwell	Stop dwell time	Stop dwell time has been set to 0.25 minutes for all routes
PK_HDWY	Peak route headway	Peak and off-peak headways from transit operator.
OP_HDWY	Off-peak route headway	
Fare	Indicates the fare used in pathbuilding and mode choice	This value represents the average fare paid by transit riders (in 2022 dollars)

## Transit Modes

The El Paso MPO TDM22/52 features four primary types of transit service: local bus, circulator, express bus, and premium transit. Premium transit can represent bus rapid transit (BRT) service or can be used to represent proposed rail service. Each mode is coded with a separate Mode value, allowing different speed, in-vehicle travel time weights, and other attributes to be specified at the mode level. **Table 2.10** specifies mode values available in The El Paso MPO TDM22/52.

Transit routes are coded directly onto roadway links and may also use local streets or dedicated transit facilities, such as BRT lanes or rail, that are not included in the roadway model. These transit-only streets or lanes are coded using the *Transit Link* functional class, 51. Transit links are not available for use by vehicles, even though they may represent local streets.

**Table 2.10 Transit Network Mode Values**

Mode ID	Mode Description
1	Local Bus
2	Circulator
3	Express Bus
4	Premium Transit (e.g. BRT)

## Transit Stops

The transit route system includes transit stop locations coded at all locations where transit access may be possible. For local bus routes, transit stops were not coded based on actual stop locations, rather they are designed to represent good access to all routes. For other types of service, such as limited stop, express, or BRT, stops can be coded based on actual or proposed stop locations.

Routes can only be boarded or alighted at stops. To facilitate a connection to the transit line layer, all transit stops must be coded to coincide with a distinct node on the input roadway network. Furthermore, only one stop can be coded per direction, per route, per node. At stations and transfer points, multiple stops are coded on the same node, but each is associated with a different route. **Table 2.11** lists attributes maintained on the route stop layer.

The TransCAD route system structure does not require transit stops to be located at nodes on the transit line layer. However, during the transit network processing model step, each transit stop is matched to the nearest node on the transit line layer. If the route system contains stops that cannot be matched to nodes, the model will fail to run.

**Table 2.11 Route Stop Attributes**

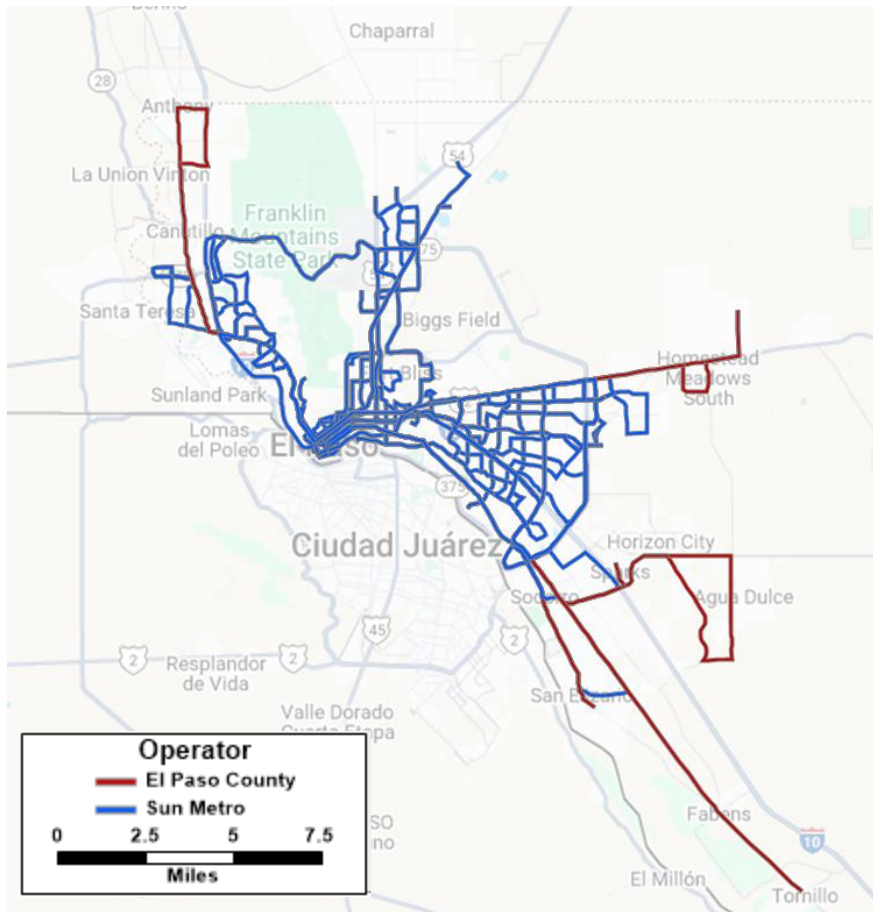
Field Name	Description	Comments
ID	TransCAD Unique ID	
Longitude	Longitude coordinate of the stop	These fields are all maintained automatically by TransCAD and are read-only.
Latitude	Latitude coordinate of the stop	
Route_ID	ID of the route associated with the stop	

Pass_Count	Used to associate a stop with one of multiple times a route passes a particular node.	
Milepost	Distance from the route starting point	
STOP_ID	Unique stop ID (identical to ID)	
NodeID	Identifies the ID of the node on the network layer that matches the route stop	This field is filled automatically when the model is run.

### Base Year Transit Routes

Figure 2.3 shows the base year 2022 transit routes.

**Figure 2.3 El Paso Base Year Transit Routes**



### 2.2.3 Transit Roadway Network

Some transit variables are maintained on the output copy of the roadway network rather than the route system, allowing for interaction between the roadway and transit networks. Transit travel time is calculated as a function of vehicle travel time on each link. The transit line layer also provides a connection between TAZ centroids and route stops in the form of centroids, roadway links, and non-motorized links in the roadway network.

## Transit Travel Time

Transit travel time is computed by applying area type and functional class specific delays shown in **Appendix B** to congested travel time. These adjustments represent the observed difference between transit route times and congested network times. Transit times are calculated according to the equation below.

$$\text{TransitTime} = \text{DelayFactor} \cdot \text{LinkLength} + \text{CongestedTime}$$

During roadway and transit network processing, the fields listed in **Table 2.12** are populated with data required for transit and non-motorized modeling. When running speed feedback (discussed in detail in Section 9.3), the model calculates transit speeds based on the congested speeds generated from speed feedback.

**Table 2.12 Key fields in Transit Line Layer**

Field Name	Description	Comments
TrnTimePKL_[AB/BA]	Peak period transit time – local bus and circulators	
TrnTimePKE_[AB/BA]	Peak period transit time – express bus	
TrnTimePKS_[AB/BA]	Peak period transit time – premium transit	Based on the off-peak link time resulting from speed feedback
TrnTimeOPL_[AB/BA]	Off-peak period transit time – local bus and circulators	
TrnTimeOPE_[AB/BA]	Off-peak period transit time – express bus	
TrnTimeOPS_[AB/BA]	Off-peak period transit time – premium transit	
WalkTime_[AB/BA]	Walk travel time	Used for transit walk access
WalkMode	Flag identifying the mode value for walk links	Must match the walk model in the MODE table.

## Walk Access and Egress

The transit line layer also represents the connection between TAZ centroids and transit route stops. With the exception of park-n-ride trips, all transit trips must start and end with walking<sup>1</sup>. Walk access and egress occurs using the roadway network, including centroid connectors and most roadways. Walk access cannot occur on freeway and expressway links.

## Walk Access/Egress Adjustment

Walk access and egress times generated in the pathbuilding process represent the walk time to and from the zone centroid to the transit stop used by the trip maker. Consistent network coding practices ensure this value is reasonable, and more importantly, consistent for all zones with access to transit. During model application, walk times are adjusted to account for variations in walk access and egress times across different areas within each TAZ.

Walk access and egress times are segmented into short (less than ¼ mile), medium (more than or equal to ¼ and less than ¾ mile), and long (over ¾ mile) distance from transit. The 24-minute walk time used for

<sup>1</sup> Bicycle access and egress to transit is not modeled explicitly, but is instead modeled as walk access and egress.

transit trips in the long market segment significantly limits walk access to transit from areas further than  $\frac{3}{4}$  of a mile from a transit stop. The model computes access and egress times for each walk distance market segment included in a zone. The rules outlined below are used to compute walk access and egress times by market segment.

- If a zone falls completely within one market segment, walk times are read directly from the network.
- If a zone falls in two or more market segments, the following procedure is used:
- The minimum walk times specified for each market segment in **Table 2.13** are used; and
- For each zone pair, if the stop on the first route is not the closest stop to the zone centroid, the distance between the stop and the closest stop is added to the minimum walk time. This prevents the model from assuming an unreasonably short walk time in cases where the route used for a path does not make use of the closest stop to a zone.

**Table 2.13 Minimum Walk Access/Egress Times by Market Segment**

Market	Minimum Walk Time
Short	3 minutes
Medium	12 minutes
Long	24 minutes

**Section 8.2.1** further describes transit market segmentation related to walk access adjustments.

### Drive Access

The transit network connects TAZs to route stops to represent park-n-ride transit. Drive access connectivity is only provided in the direction from TAZs to route stops. The model allows trips from a production zone to a park-n-ride but does not permit trips from a park-n-ride to an attraction zone. This restriction aligns with the mode choice and transit modeling convention, in which transit pathbuilding and assignment follow a *Production/Attraction* format rather than *Origin/Destination* format. By following this convention, drive access to transit is limited to the production (or home) end of each trip, reflecting the reality that transit riders do not have vehicle access at the attraction (or non-home) end of a trip. Consequently, transit egress is limited to walking.

Drive access to transit is provided using centroid connectors and roadway links, with zone to park-n-ride travel times computed using peak and off-peak roadway network travel times. Drive access is only provided to designated park-n-ride nodes, identified by the input park and ride table.

### 2.2.4 Transit Pathbuilding

Transit networks are built in the TransCAD software for use with the Pathfinder transit shortest path method. The Pathfinder method is unique to the TransCAD software and builds paths using a weighted generalized cost approach, in which each component of a transit trip is converted into a common unit, allowing application of different weights to each trip component. Pathfinder weights have been set for consistency with coefficients in the mode choice model.

The Pathfinder evaluates possible transit paths between each zone pair and identifies the path with the lowest generalized cost. **Table 2.14** lists path components considered by the Pathbuilder setup in The El Paso MPO TDM22/52 are along with pathbuilding weights.

**Table 2.14 Transit Pathbuilding Weights**

Variable	Description	Weight
Walk Access Time	Time spent walking from the production TAZ centroid to the transit stop (for walk access trips only)	2.5
Drive Access Time	Time spent driving from the production TAZ centroid to a park-n-ride (for drive access trips only)	1
Drive Access Cost	Auto operating cost associated with drive access (for drive access trips only)	1
Initial Wait Time	Time spent waiting for the first bus to arrive, computed as one-half of the route headway.	2.5
In-Vehicle Travel Time	Time spent riding or waiting in a transit vehicle	1
Transfer Wait Time	Time spent walking between stops for a transfer (if applicable)	1.5
Transfer Walk Time	Time spent walking between stops for a transfer (if applicable)	1.5
Transfer Penalty Time	Additional transfer penalty (calibration parameter)	10
Egress Walk Time	Time spent walking from the transit stop to the attraction TAZ centroid	2.5
Fare	Transit fare paid for the trip	1

Note: Travel time variables are converted for consistency with cost variables using the value of time documented in the mode choice model specification.

### 3.0 Traffic Analysis Zones

Traffic analysis zones (TAZ) are geographic boundaries that contain socio-economic data used as the foundation for trip-making in the travel model. The TAZ layer is formatted as a polygon layer and is based on US Census Block geography. The size and number of TAZs in a particular area is primarily driven by the density of development but planned or expected future development also plays a role. Developed areas require a greater number of smaller zones, while rural un-developed areas are represented with larger zones. TAZs are attached to the roadway networks using zone centroids and centroid connectors that allow travelers access to the transportation system by simulating local and neighborhood streets.

TAZs are ideally, though not always, sized and shaped to provide a relatively homogeneous amount and type of activity within each zone. TAZ delineations traditionally follow the natural and manmade boundaries that tend to segregate different land uses. These boundaries include water features, bridges, roads, railroads, and other lines that form logical boundaries. Jurisdictional and Census boundaries often do not make for good TAZ delineations because they can be arbitrary in relation to the needs of the model; but they are usually desirable for data development and reporting functions.

The 2022 TAZ layer is based on the 2017 TAZ layer from the RMS model. Consequently, zone numbering has not changed between the two models. The zone system totals 869 TAZs, 848 of which are internal and 21 are external. The TAZ layer is contained in a TransCAD geographic file and is a required input to the travel model. A listing of required fields in the TAZ geographic file can be found in **Table 3.1**. By design, the geographic file contains all required socio-economic and demographic information used by the trip generation model.

All demographic data read by the model is contained directly in the TAZ geographic file. More details about demographic data development are provided in separate documents.

**Table 3.1 Data Dictionary for TDM22/52 TAZ file**

TAZ Fields	Description	Comment
ID	Unique TransCAD identifier	Must match the TAZ number
Area	Total TAZ area (square miles)	Maintained by TransCAD
TAZ	TAZ number	
Acres	Total TAZ area (acres)	
County	Texas or New Mexico	
Municipal	Jurisdiction (city or county) containing the TAZ	
District	District name for analysis	Used for Delphi Process
MPO_Boundary	Distinguishes between internal and external zones	
ATYPE_yy	Numeric area type ID (See <b>Section 0</b> )	
POP_yy	Non-special generator population	“yy” represents a two-digit analysis year code (e.g., 22, 52)
HHPOP_yy	Non-special generator household population	
GQPOP_yy	Non-special generator group quarter population	
HH_yy	Number of non-special generator households	

TAZ Fields	Description	Comment
HHSIZE_yy	Average household size	
MEDINC_yy	Median household income	
AVGWRK_yy	Average number of workers per household	
EMP_yy	Non-special generator total employment	
BASIC_yy	Non-special generator basic employment	
RETAIL_yy	Non-special generator retail employment	
SERVICE_yy	Non-special generator service employment	
EDY_yy	Non-special generator education employment	
K12_ENROLL_yy	Non-special generator school enrollment	
COLL_ENROLL_yy	Non-special generator college enrollment	
SGEN_yy	Includes a 1 to indicate internal special generator or external station zones	
SGZ_yy	Includes a 1 to indicate internal special generator zones	
SGZ_POP_yy	Special generator population	
SGZ_HH_yy	Special generator households	
SGZ_AVGHH_yy	Special generator average household size	
SGZ_MEDINC_yy	Special generator median household income	
SGZ_AVGWRK_yy	Special generator average number of workers per household	
SGZ_EMP_yy	Special generator total employment	
SGZ_BAS_yy	Special generator basic employment	
SGZ_RET_yy	Special generator retail employment	
SGZ_SER_yy	Special generator service employment	
SGZ_EDU_yy	Special generator education employment	
SGZ_K12ENR_yy	Special generator school enrollment	
SGZ_COLENR_yy	Special generator college enrollment	
AOP_NHB_yy	Add-on NHB trip productions (not used by The El Paso MPO TDM22/52, set to zero)	
AOA_NHB_yy	Add-on NHB trip attractions (not used by The El Paso MPO TDM22/52, set to zero)	
AOP_HBW_yy	Add-on HBW trip productions (not used by The El Paso MPO TDM22/52, set to zero)	
AOA_HBW_aa	Add-on HBW trip attractions (not used by The El Paso MPO TDM22/52, set to zero)	
AOP_HNW_yy	Add-on HNW trip productions (not used by The El Paso MPO TDM22/52, set to zero)	
AOA_HNW_yy	Add-on HNW trip attractions (not used by The El Paso MPO TDM22/52, set to zero)	
CMT_yy	Special generator description	
TOT_POP_yy	Total population	
TOT_HH_yy	Total households	

TAZ Fields	Description	Comment
TOT_EMP_yy	Total employment	
TOT_BAS_yy	Total basic employment	
TOT_RET_yy	Total retail employment	
TOT_SER_yy	Total service employment	
TOT_EDU_yy	Total education employment	
SGP_HBW_yy	Special generator home-based work productions	
SGP_HNWE1_yy	Special generator home-based education 1 productions	
SGP_HNWE2_yy	Special generation home-based education 2 productions	
SGP_HNWR_yy	Special generator home-based retail productions	
SGP_HNWO_yy	Special generator home-based other productions	
SGP_NHB_yy	Special generator non-home based productions	
SGP_LT_yy	Special generator light truck productions	
SGP_MT_yy	Special generator medium truck productions	
SGP_HT_yy	Special generator heavy truck productions	
SGP_EXTINT_yy	Special generator EI/IE productions	
SGA_HBW_yy	Special generator home-based work attractions	
SGA_HNWE1_yy	Special generator home-based education 1 attractions	
SGA_HNWE2_yy	Special generator home-based education 2 attractions	
SGA_HNWR_yy	Special generator home-based retail attractions	
SGA_HNWO_yy	Special generator home-based other attractions	
SGA_NHB_yy	Special generator non-home based attractions	
SGA_LT_yy	Special generator light truck attractions	
SGA_MT_yy	Special generator medium truck attractions	
SGA_HT_yy	Special generator heavy truck attractions	
SGA_EXTINT_yy	Special generator EI/IE attractions	

Note: The TAZ structure adopted by the El Paso MPO model differs from the standard TexPACK format used by some models in the state of Texas.

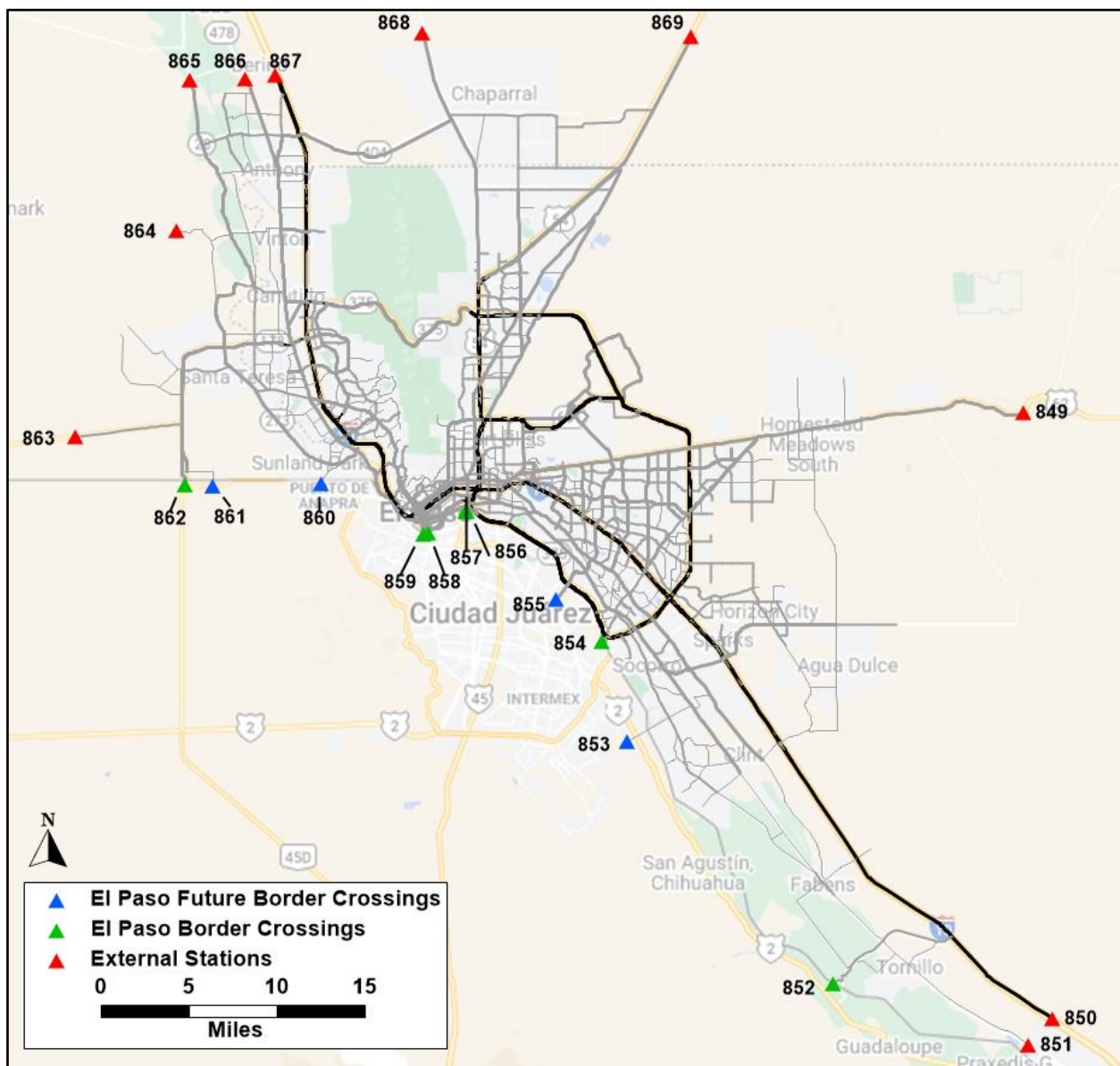
## 4.0 External Travel

Separate from internal-internal (II) trips that occur entirely within the modeling area, the model includes external travel from outside of the region. Trips with one end inside the modeling area and the other outside of the area are called Internal-External and External-Internal (IE/EI) trips. Through trips, or External-External (EE) trips, are those which pass through the modeling area without stopping (or with only short convenience stops). External travel is modeled at the external stations where roadways cross the model boundary.

### 4.1 External Station Locations

Figure 4.1 shows the 21 external stations used when running the model for the MPO only.

**Figure 4.1 El Paso External Station Locations**



## 4.2 Base Year External Travel

### 4.2.1 External Station Volumes

The first step in estimating external travel for the model is to determine the average weekday traffic at each location in the base year. This process begins with traffic count data for all external stations. Counts represent an average weekday in March, April, September, October, and November (i.e. an “average weekday when school is in session”).

The model also requires information about the split between autos and trucks, as well as the split between EE and IE/EI trips at each external station. Vehicle class shares were determined by vehicle classification counts at external stations where data was available. Where such counts were unavailable, nearby counts or assumptions based on external station facility type were used. The splits between EE and IE/EI trips were determined based on a combination of assumptions in the Destino Model and a review of major routes through the region. **Table 4.1** lists external stations along with total volumes, truck shares, and EE trip shares.

**Table 4.1 External Travel Assumptions**

ID	Name	Volume	% Truck	% EE
849	US 62 East	2,381	30%	18%
850	I-10 East	22,620	13%	22%
851	SH 20 / Alameda Ave. East	1,030	22%	0%
852	Tornillo-Guadalupe Border Crossing	1,620	0%	5%
853	Proposed Border Crossing	0	0%	0%
854	Ysleta Border Crossing	19,640	13%	10%
855	Proposed Border Crossing	0	0%	0%
856	Bridge of the Americas Truck	550	100%	46%
857	Bridge of the Americas PSS	32,430	0%	5%
858	Stanton Street Border Crossing	11,560	0%	5%
859	El Paso Street Border Crossing	7,360	0%	5%
860	Proposed Border Crossing	0	0%	0%
861	Santa Teresa Border Crossing (not used)	0	0%	0%
862	Santa Teresa Border Crossing	3,580	20%	8%
863	SH-9 West	850	2%	5%
864	CR A-020 West	201	20%	0%
865	SH-28 Lou Henson Hwy. North	2,180	12%	0%
866	SH-478 North	2,800	14%	0%
867	I-10 North	22,160	36%	29%
868	SH-213 Martin Luther King Jr Blvd. North	1,960	5%	0%
869	US 54 North	5,540	10%	9%

Source: Cambridge Systematics analysis of traffic count data combined with Destino Model assumptions.

Due to limited available data, the share of trucks classified as light commercial vehicles, medium trucks (FHWA vehicle classes 6-7) and heavy trucks (FHWA vehicle classes 8-13) is generally estimated for external stations bordering Mexico and for all other external stations. At the border, light commercial vehicles must use commercial vehicle lanes and, therefore, are included in the commercial vehicle totals. At domestic external stations, light commercial vehicles are not distinguishable from personal vehicles since trucks are defined by vehicle class. Shown in **Table 4.2**, these assumptions, based on analysis of vehicle class counts, are available at some, but not all, border crossings. Truck type shares can be updated if additional data is obtained.

**Table 4.2 External Trip Truck Classification Shares**

External Station Type	Light Commercial	Medium Trucks	Heavy Trucks
International	5%	30%	65%
Domestic	n/a	35%	65%

Note: 5% of light duty vehicles and busses (FHWA vehicle classes 1-5) are assumed to be commercial vehicles at domestic external stations.

**4.2.2 Internal-External and External-Internal Trips**

Internal trip ends for IE/EI are represented by trip productions at external stations and by trip attractions at internal TAZs. Internal trip-ends are generated as the EXTINT trip purpose, while IE/EI trips are distributed using friction factors defined for the NHB trip purposes. More information on generation and distribution of external trips is included in the relevant sections that follow.

**4.2.3 External-External Trips**

The external to external trip process matches through trip-ends from each external station with through trip-ends at another external station. The model applies an iterative proportional fitting process that estimates an EE trip matrix based on an input seed. The resulting through trip matrix is included in the vehicle trip tables assigned to the highway network. The external trip seed matrix for autos and trucks, shown in **Table 4.3**, was developed using passive OD data processed by TTI.

**Table 4.3 External Trip Seed Matrix**

ID	849	850	852	853	854	855	856	857	858	859	860	861	862	863	867	869
849	0	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1
850	0	0	1	1	1	1	1	1	1	1	1	1	1	0	2	1
852	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
853	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
854	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
855	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
856	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
857	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
858	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
859	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
860	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
861	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
862	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
863	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
867	1	2	1	1	1	1	1	1	1	1	1	1	1	1	0	0
869	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0

**4.2.4 External Station Forecasting**

Forecast year model runs require traffic volume forecasts at each external station. These forecasts can be developed using a number of available procedures, listed below.

- Direct scaling of all external station volumes based on population growth within the modeling area.
- Growth of external station values individually based on analysis of the Texas Statewide Model.
- Growth of external station values using trend analysis from historical traffic count volumes.

The forecast model uses a combination of historical trend analysis (for domestic external stations) and growth based on regional population and employment growth (for border crossings). **Table 4.4** shows the external station forecasts for the base, interim and forecast years for the El Paso MPO TDM22/52.

**Table 4.4 External Station Forecasts**

ZONE	Description	2022	2027	2032	2042	2052
849	US 62 East	2,381	2,571	2,762	3,714	4,095
850	I-10 East	22,620	24,430	26,239	35,287	38,906
851	SH 20 / Alameda Ave. East	1,030	1,082	1,133	1,391	1,494
852	Tornillo-Guadalupe Border Crossing	1,620	2,041	2,463	2,349	2,592
853	Proposed Border Crossing	0	0	0	0	0
854	Ysleta-Zaragoza Border Crossing	19,640	21,113	22,586	29,951	32,897

855	Proposed Border Crossing	0	0	0	0	0
856	Bridge of the Americas Truck	550	578	605	743	798
857	Bridge of the Americas Non-truck	32,430	34,052	35,673	43,781	47,024
858	Good Neighbor Bridge (Stanton St.)	11,560	12,169	12,778	13,996	15,215
859	Paso Del Norte Bridge (El Paso St.)	7,360	8,574	9,789	13,947	15,419
860	Proposed Border Crossing	0	0	0	0	0
861	Santa Teresa Border Crossing (Livestock)	0	0	0	0	0
862	Santa Teresa Border Crossing	3,580	3,759	3,938	4,833	5,191
863	SH-9 West	850	893	935	1,148	1,233
864	CR A-020 West	201	211	221	271	291
865	SH-28 Lou Henson Hwy. North	2,180	2,289	2,398	2,943	3,161
866	SH-478 North	2,800	2,940	3,080	3,780	4,060
867	I-10 North	22,160	23,268	24,376	29,916	32,132
868	SH-213 Martin Luther King Jr Blvd. North	1,960	2,058	2,156	2,646	2,842
869	US 54 North	5,540	6,149	6,759	8,476	9,030

Source: TxDOT external station regressions of historical traffic counts and external station values from the Texas Statewide Analysis Model.

## 5.0 Trip Generation

Trip generation is the first step of the traditional four-step travel demand modeling process. It identifies trip ends (productions and attractions) that correspond to places where activities occur, represented by socio-economic data (households and employment). Trip generation estimates productions and attractions by trip purpose for each TAZ, then balances trips at the regional level to ensure total productions are equal to attractions. The resulting productions and attractions by trip purpose and TAZ are subsequently used by the Trip Distribution model to estimate zone-to-zone travel patterns.

The primary data source for estimating trip productions and attractions in the El Paso MPO modeling area is the 2010-2011 El Paso Household Travel Survey. Since the survey is household-based, it provides excellent information with regard to household trip-making and is especially well suited for estimating trip production rates. The survey also provides good information for estimating trip attraction rates based on participant employment type and attraction place information. Detailed analysis of the household survey was conducted in development of the Destino Model (base year 2012). Since a new household travel survey is not available, trip rates from the Destino model were carried forward with only minor adjustments made during model calibration and validation.

The trip generation model uses TripCAL6, the latest generation model developed by the Texas Transportation Institute (TTI) for the Texas Department of Transportation (TxDOT). This version of TripCAL replicates functionality available in the previous version, but is run entirely from within the TransCAD software. An overview of the model and its operation can be found in the TexPACK Model Documentation, Version 2.6.

### 5.1 Socio-Economic and Demographic Input

Trip generation requires household and employment data at the TAZ level. This information, referred to as socio-economic data (SED) or demographic data, has been developed in coordination with UrbanSim. Regional household and population totals were developed based on guidance from the Institute for Demographic and Socio-economic Research (IDSER) at the University of Texas at San Antonio (UTSA).

#### 5.1.1 Household and Population Data

Household and population input data is provided to the model at a TAZ level, with the following variables included for each TAZ:

- Total number of Households.
- Population in Households
- Group Quarters Population
- Total Population (population in households plus group quarters population).
- Average household size (population in households divided by number of households)
- Median household income in 2022 dollars.

- Average workers per household.

Additionally, the model requires a tri-variate regional joint distribution of households by income, size, and number of workers. Joint distributions are generated at the TAZ level based on the input SED using household disaggregation TripCAL6 procedures.

The tabulated household resulting from the household disaggregation model includes the following categories:

- Household sizes categorized into 1-person households through 5+ person households.
- Number of resident workers categorized into 0-worker households through 2+ worker households.
- Income groups classified into the five categories shown in **Table 5.1**.

**Table 5.1 Income Group Definitions**

Income Group	Income Range (2012 dollars)	Income Range (2017 dollars)	Income Range (2022 dollars)
Low	\$14,999 and lower	\$16,861 and lower	\$19,559 and lower
Medium-low	\$15,000 to \$24,999	\$16,862 to \$28,102	\$19,560 to \$32,598
Medium	\$25,000 to \$39,999	\$28,103 to \$44,963	\$32,599 to \$52,157
Medium-high	\$40,000 to \$69,999	\$44,964 to \$78,687	\$52,158 to \$91,277
High	\$70,000 and higher	\$78,688 and higher	\$91,278 and higher

Source: Destino Travel Model, reviewed and adjusted for use in The El Paso MPO TDM22/52.

### 5.1.2 Employment Data

The trip generation model uses employment data at the TAZ level based on the categories shown in **Table 5.2**. Employment types are defined based on North American Industrial Classification System (NAICS) codes listed in this table. Enrollment data is required for K-12 and college/university categories.

**Table 5.2 Employment Type Categories**

Employment Type	NAICS Codes
Basic	11, 21- 23, 31-33, 42, 48-49, 5111, 5112, 512, 5151, 5152, 5174
Retail	44-45, 491, 51213, 71, 722
Service	5171, 5179, 518, 519, 52-56, 6114, 6115, 6116, 6117, 62, 81, 92, 721
Education	6111, 6112, 6116

**5.1.3 Socio-Economic and Demographic Data Summary**

SED summary for the 2022 base year is shown in **Table 5.3**.

**Table 5.3 Socio-Economic Data Summary**

Socio-Economic Data	2022
Total Households	319,453
Household Population	919,220
Group Quarters Population	17,851
Total Population	937,071
Total Employment	375,479
Basic Employment	70,043
Retail Employment	81,575
Service Employment	186,559
Education Employment	37,246
School Enrollment (K-12)	212,842
College/University Enrollment	59,719

**5.2 Trip Purposes**

Trip purpose is used in travel models to categorize various types of trips with similar characteristics, such as trip rates, trip length, and auto occupancy. A separate set of trip generation rates has been developed for each individual trip purpose. The trip purposes in the El Paso MPO TDM22/52 are listed below.

- 1. Home-Based Work (HBW):** Commute trips between home and work.
- 2. Home-Based Non-Work Education 1 (HNWE1):** Trips between home and K-12 school locations for students in these schools.
- 3. Home-Based Non-Work Education 2 (HNWE2):** Trips between home and colleges/universities by people not employed by these institutions.
- 4. Home-Based Non-Work Retail (HNWR):** Trips between home and retail locations for the purpose of shopping.

5. **Home-Based Non-Work Other (HNWO):** All other trips that have one end at home.
6. **Non-Home-Based Work (NHBW):** Trips starting or ending at work, but without an end at home; represented by non-home based (NHB) trips in Trip Generation and Trip Distribution.
7. **Non-Home-Based Other (NHBO):** Trips with neither an end at home nor a work-related purpose; represented by non-home based (NHB) trips in Trip Generation and Trip Distribution.
8. **External Internal (EXTINT or IE/EI):** All trips that have one end outside the modeling area.
9. **Light Trucks (LT):** Light truck trips (Commercial vehicles under FHWA Vehicle classes 2-5)
10. **Medium Trucks (MT):** Medium-heavy truck trips (FHWA Vehicle classes 6-7)
11. **Heavy Trucks (HT):** Heavy truck trips (FHWA Vehicle classes 8-13)

The two non-home-based (NHB) trip purposes are generated and distributed as a single NHB purpose. Prior to mode choice, NHB trips are separated into NHBW (19.4%) and NHBO (80.6%) purposes. Conversion from NHB to NHBW and NHBO trips is based on analysis of household survey data, aligning with the Destino model approach.

### 5.3 Production Rates

Production rates for the El Paso MPO TDM22/52 are based on a detailed analysis of household survey data conducted during development of the Destino Model. This analysis produced trip production rates that vary by household size, income, and number of workers. The Destino Model development process included a calibration procedure in which trip rates were applied and adjusted by market segment to match expanded household survey data. These trip rates were then adjusted as part of the 2017 base year RMS model development.

During model validation, the 2017 trip rates were factored down by 7% to better align the 2022 modeled volumes with the observed 2022 traffic counts.

As shown in **Table 5.4** through **Table 5.9**, trip rates generally increase with increasing household size, income, and number of workers.

**Table 5.4 HBW Trip Production Rates (Work)**

Worker and Income Group	Household Size				
	1	2	3	4	5+
<b>0 Workers</b>					
Low	0.0000	0.0000	0.0000	0.0000	0.0000
Medium-low	0.0000	0.0000	0.0000	0.0000	0.0000
Medium	0.0000	0.0000	0.0000	0.0000	0.0000
Medium-high	0.0000	0.0000	0.0000	0.0000	0.0000
High	0.0000	0.0000	0.0000	0.0000	0.0000

<b>1 Worker</b>					
Low	0.8587	0.7736	1.5510	1.4920	1.8372
Medium-low	0.9911	0.8026	1.4504	1.4504	1.7405
Medium	1.0153	0.8316	1.3963	1.4214	1.6438
Medium-high	1.0965	0.9940	1.2087	1.3924	1.6206
High	1.1981	0.9960	1.0801	1.2571	1.5297
<b>2+ Workers</b>					
Low	0.0000	1.6438	2.2240	2.5973	2.9009
Medium-low	0.0000	1.7405	2.2898	2.6108	3.0943
Medium	0.0000	1.8372	2.4281	2.7288	3.1910
Medium-high	0.0000	2.0306	2.6398	3.2673	3.4521
High	0.0000	2.0621	2.6997	3.3505	3.7008

Source: Destino Travel Model, reviewed and updated for use in the El Paso MPO TDM22/52.

**Table 5.5 HNWR Trip Production Rates (Retail)**

Worker and Income Group	Household Size				
	1	2	3	4	5+
<b>0 Workers</b>					
Low	0.5173	1.4504	1.7405	1.5471	3.3080
Medium-low	0.5802	1.5471	1.8372	1.6177	3.4811
Medium	0.6430	1.7405	1.9610	1.7405	3.6745
Medium-high	0.7736	1.9339	2.0567	1.8372	3.8679
High	0.8799	2.0567	2.1273	1.9610	4.2566
<b>1 Worker</b>					
Low	0.3578	0.6372	1.3837	1.0637	1.4572
Medium-low	0.3723	0.9583	1.4969	1.2300	2.4290
Medium	0.3868	1.2600	1.5471	1.8372	2.6563
Medium-high	0.4023	1.4504	1.6429	2.1090	2.7733
High	0.4322	1.5984	2.0799	2.2289	4.2024
<b>2+ Workers</b>					
Low	0.0000	0.5840	0.8538	2.3110	2.7085
Medium-low	0.0000	0.8703	1.3460	2.2724	2.5209
Medium	0.0000	1.0231	1.4504	2.2095	1.8372
Medium-high	0.0000	1.1604	1.6148	2.1728	1.6593
High	0.0000	1.4002	1.8034	2.0306	1.3238

Source: Destino Travel Model, reviewed and updated for use in the El Paso MPO TDM22/52.

**Table 5.6 HNWE1 Trip Production Rates (Kindergarten to Grade 12)**

Worker and Income Group	Household Size				
	1	2	3	4	5+
<b>0 Workers</b>					
Low	0.1151	0.2031	1.1584	4.9402	7.2522
Medium-low	0.0919	0.2224	1.3538	2.1728	7.7357
Medium	0.0677	0.2321	1.5820	4.5302	8.2192
Medium-high	0.0580	0.2562	2.1273	7.4834	8.9657
High	0.0280	0.2901	2.3217	6.5570	9.0895
<b>1 Worker</b>					
Low	0.0097	0.0967	1.6052	4.9054	7.9098
Medium-low	0.0483	0.1170	1.7405	5.0640	9.7664
Medium	0.0822	0.1654	1.9339	5.3183	9.9597
Medium-high	0.1199	0.2127	2.0306	5.5891	10.1783
High	0.1450	0.2514	2.1273	6.1886	10.4432
<b>2+ Workers</b>					
Low	0.0000	0.3868	1.3538	2.9009	6.0919
Medium-low	0.0000	0.2901	1.2571	3.1910	6.1886
Medium	0.0000	0.2417	0.9670	3.4811	6.2853
Medium-high	0.0000	0.1934	0.8703	3.7044	6.6614
High	0.0000	0.1547	0.7736	4.2488	6.7204

Source: Destino Travel Model, reviewed and updated for use in the El Paso MPO TDM22/52.

**Table 5.7 HNWE2 Trip Production Rates (College/University)**

Worker and Income Group	Household Size				
	1	2	3	4	5+
<b>0 Workers</b>					
Low	0.0000	0.0000	0.2901	0.7736	0.3713
Medium-low	0.0000	0.0000	0.3868	0.8703	0.6556
Medium	0.0000	0.0097	0.5376	1.0221	1.0637
Medium-high	0.0000	0.0290	0.6459	1.0637	1.1178
High	0.2466	0.0580	0.8703	1.1971	1.1604
<b>1 Worker</b>					
Low	0.1044	0.0164	0.2901	0.3288	0.1934
Medium-low	0.3868	0.0435	0.3868	0.3868	0.2901
Medium	0.5802	0.0532	0.5318	0.5454	0.3868
Medium-high	0.7736	0.0928	0.6285	0.6769	0.5986
High	0.1064	0.0967	0.6769	0.8867	0.6769
<b>2+ Workers</b>					
Low	0.0000	0.9177	0.8703	1.1604	0.8780
Medium-low	0.0000	0.8993	0.7968	0.9718	0.8567
Medium	0.0000	0.8780	0.6769	0.9186	0.8219
Medium-high	0.0000	0.5753	0.4864	0.8703	0.7736
High	0.0000	0.3636	0.3752	0.8509	0.7513

Source: Destino Travel Model, reviewed and updated for use in the El Paso MPO TDM22/52.

**Table 5.8 HNWO Trip Production Rates (Other)**

Worker and Income Group	Household Size				
	1	2	3	4	5+
<b>0 Workers</b>					
Low	0.9979	1.3915	1.7889	2.6079	4.1580
Medium-low	1.0027	1.4031	1.8372	2.8042	4.3513
Medium	1.1729	1.4311	1.8846	3.1910	4.4480
Medium-high	1.2087	1.6438	1.9707	3.4811	4.5447
High	1.2280	1.8701	2.1273	3.7093	4.6414
<b>1 Worker</b>					
Low	0.4796	0.7388	0.9863	1.3808	2.4377
Medium-low	0.5028	1.0617	1.2571	1.5471	2.4493
Medium	0.5444	1.1604	1.3538	1.7135	3.2877
Medium-high	0.5608	1.2571	1.4514	2.5605	3.4492
High	0.5802	1.4011	1.6438	2.7520	6.2804
<b>2+ Workers</b>					
Low	0.0000	0.4835	0.6827	1.4388	1.4882
Medium-low	0.0000	0.5318	0.9969	1.7405	1.7405
Medium	0.0000	0.5995	1.1604	1.9339	2.6263
Medium-high	0.0000	0.8625	1.1874	2.3343	2.7075
High	0.0000	1.0008	1.6168	2.4164	2.7472

Source: Destino Travel Model, reviewed and updated for use in the El Paso MPO TDM22/52.

**Table 5.9 NHB Trip Production Rates**

Worker and Income Group	Household Size				
	1	2	3	4	5+
<b>0 Workers</b>					
Low	0.7104	1.3505	1.2996	2.4909	2.9241
Medium-low	0.9130	1.5530	1.6245	2.7075	3.1071
Medium	1.0830	2.0382	2.0187	2.8158	3.6768
Medium-high	1.2671	2.0577	2.1660	2.9241	4.5486
High	1.2996	2.1660	2.3826	3.0097	6.4341
<b>1 Worker</b>					
Low	0.4332	0.9325	1.4566	2.7996	3.3010
Medium-low	0.7581	1.1079	1.7328	2.8158	3.4656
Medium	1.0169	1.1913	2.1660	2.9241	3.7039
Medium-high	1.0743	1.2032	2.3382	3.0801	4.7165
High	1.0830	2.6176	2.3967	4.6396	7.3428
<b>2+ Workers</b>					
Low	0.0000	0.7581	1.0722	2.1660	4.1154
Medium-low	0.0000	1.1913	1.1989	2.3891	4.8735
Medium	0.0000	1.2065	1.8671	2.9241	5.2190
Medium-high	0.0000	1.5498	2.4454	3.5122	5.8482
High	0.0000	2.8819	3.9508	5.6219	6.1309

Source: Destino Travel Model, reviewed and updated for use in the El Paso MPO TDM22/52.

## 5.4 Attraction Rates

Attractions identify ends of trips located at places other than the trip-maker's home. For home-based trips, the attraction end of a trip occurs at a non-residential location, or occasionally at another person's home. For NHB trips, both trip productions and attractions occur at non-home locations. As documented previously, IE/EI trip attractions represent the internal trip-ends for all IE/EI trips, regardless of purpose. Attraction rates are defined for total households, employment by type, and school enrollment by type, and vary by area type. The attraction model structure and rates were carried over from the Destino model and remain unchanged during the model validation process. Trip rates are shown in **Table 5.10**.

**Table 5.10 Trip Attraction Rates**

Trip Purpose	ATYPE	HH	BASIC EMP	RETAIL EMP	SERVICE EMP	EDUC EMP	K-12 ENROLL	COLL ENROLL
Home-Based Work (HBW)	1	0.0000	1.2388	1.3688	0.5631	1.0569	0.0000	0.0000
	2	0.0000	1.9839	0.9876	1.1002	1.0569	0.0000	0.0000
	3	0.0000	1.1349	1.8539	1.7673	1.1089	0.0000	0.0000
	4	0.0000	1.8713	2.0878	1.8020	1.1609	0.0000	0.0000
	5	0.0000	2.4257	5.7697	0.9876	0.9010	0.0000	0.0000
Home-Based Non Work Retail (HNWR)	1	0.0000	0.0000	1.9300	0.0000	0.0000	0.0000	0.0000
	2	0.0000	0.0000	3.5500	0.0000	0.0000	0.0000	0.0000
	3	0.0000	0.0000	5.7100	0.0000	0.0000	0.0000	0.0000
	4	0.0000	0.0000	7.8700	0.0000	0.0000	0.0000	0.0000
	5	0.0000	0.0000	8.0300	0.0000	0.0000	0.0000	0.0000
HBNW School (HNWE1)	1	0.0000	0.0000	0.0000	0.0000	0.0000	3.0000	0.0000
	2	0.0000	0.0000	0.0000	0.0000	0.0000	3.0000	0.0000
	3	0.0000	0.0000	0.0000	0.0000	0.0000	3.0000	0.0000
	4	0.0000	0.0000	0.0000	0.0000	0.0000	3.0000	0.0000
	5	0.0000	0.0000	0.0000	0.0000	0.0000	3.0000	0.0000
HBNW College (HNWE2)	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.2000
	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.2000
	3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.2000
	4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.2000
	5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.2000
HBNW Other (HNWO)	1	0.5400	0.2309	0.9984	0.7363	1.4664	0.0000	0.0000
	2	0.5400	0.1810	0.8923	0.8237	1.4664	0.0000	0.0000
	3	0.5400	0.0562	1.4290	1.1170	1.4664	0.0000	0.0000
	4	0.5400	0.4493	1.8221	0.9235	1.4664	0.0000	0.0000
	5	0.5400	0.6677	2.2320	0.7301	1.1107	0.0000	0.0000
	1	0.0000	2.9078	9.1978	0.6115	2.7955	0.0000	0.0000

Trip Purpose	ATYPE	HH	BASIC EMP	RETAIL EMP	SERVICE EMP	EDUC EMP	K-12 ENROLL	COLL ENROLL
Non-Home Based (NHB)	2	0.0000	0.5366	7.0013	0.6989	2.7955	0.0000	0.0000
	3	0.0000	0.5366	7.0013	0.6989	2.7955	0.0000	0.0000
	4	0.0000	0.5366	7.0013	0.6989	2.7955	0.0000	0.0000
	5	0.0000	0.5366	7.0013	0.6989	2.7955	0.0000	0.0000
	1	0.3770	0.1375	0.3142	0.1375	0.1375	0.0000	0.0000
Light Trucks (LT)	2	0.3770	0.1375	0.3142	0.1375	0.1375	0.0000	0.0000
	3	0.3770	0.1375	0.3142	0.1375	0.1375	0.0000	0.0000
	4	0.3770	0.1375	0.3142	0.1375	0.1375	0.0000	0.0000
	5	0.3770	0.1375	0.3142	0.1375	0.1375	0.0000	0.0000
	1	0.3829	0.1192	0.4618	0.1192	0.1192	0.0000	0.0000
Medium Trucks (MT)	2	0.3829	0.1192	0.4618	0.1192	0.1192	0.0000	0.0000
	3	0.3829	0.1192	0.4618	0.1192	0.1192	0.0000	0.0000
	4	0.3829	0.1192	0.4618	0.1192	0.1192	0.0000	0.0000
	5	0.3829	0.1192	0.4618	0.1192	0.1192	0.0000	0.0000
	1	0.0119	0.0356	0.0901	0.0356	0.0356	0.0000	0.0000
Heavy Trucks (HT)	2	0.0119	0.0356	0.0901	0.0356	0.0356	0.0000	0.0000
	3	0.0119	0.0356	0.0901	0.0356	0.0356	0.0000	0.0000
	4	0.0119	0.0356	0.0901	0.0356	0.0356	0.0000	0.0000
	5	0.0119	0.0356	0.0901	0.0356	0.0356	0.0000	0.0000
	1	0.0000	0.8008	1.8512	0.0520	0.0000	0.0000	0.0000
External Internal (EXTINT)	2	0.0000	0.3016	2.1424	0.1456	0.0208	0.0000	0.0000
	3	0.0000	0.4472	3.1200	0.1040	0.1560	0.0000	0.0000
	4	0.0000	0.2600	0.6032	0.0416	0.1456	0.0000	0.0000
	5	0.0000	0.0000	8.2576	0.1352	0.0000	0.0000	0.0000

Source: Destino Travel Model, reviewed and retained for use in the El Paso MPO TDM22/52.

## 5.5 Income Segmentation

TripCAL6 outputs productions and attractions by trip purpose for each zone. However, the trip distribution and mode choice models include market segmentation by income group. This requires separation of home-based trips into the five previously described income groups. The El Paso MPO TDM22/52 post-processes TripCAL6 production and attraction tables to include market segmentation. For productions, trips are segmented into income groups using the share of households by income in each TAZ. For attractions, trip-ends are segmented uniformly in all TAZs based on the regional distribution of households by income group.

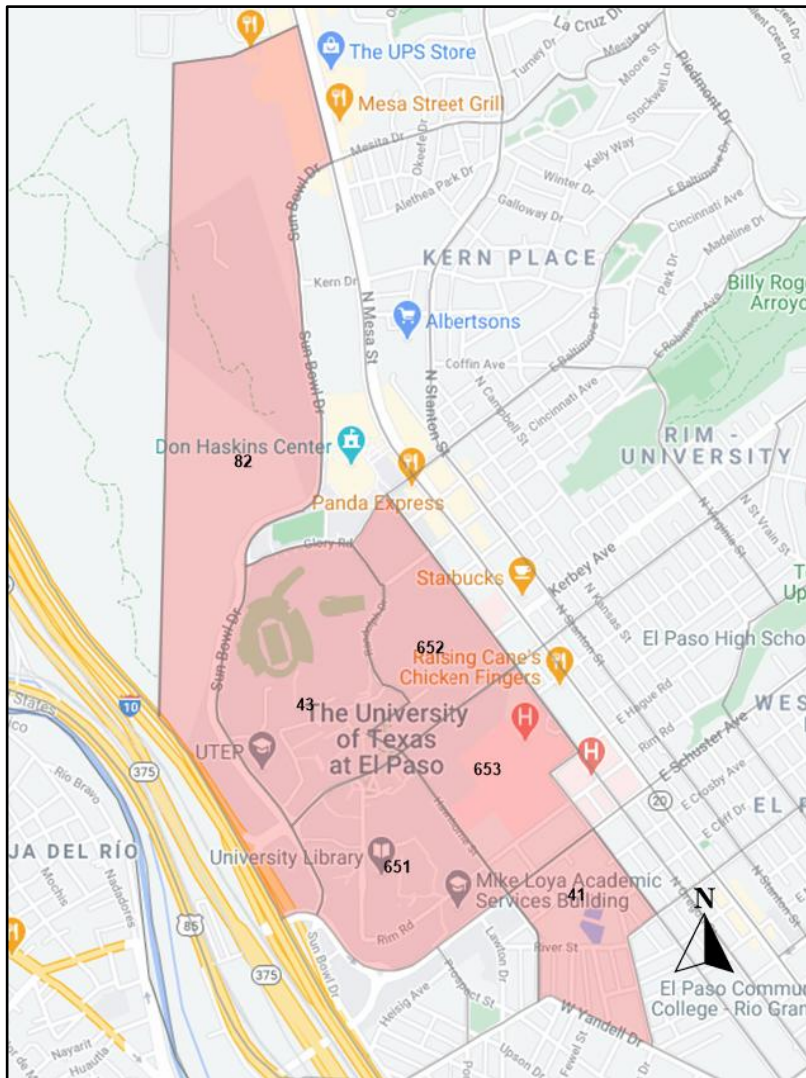
## 5.6 Special Generators

The RMS Model uses special generators to account for locations with high activity levels that are not well represented by the standard Trip Generation model. Special generators include the University of Texas at El Paso (UTEP), the El Paso International Airport, and Fort Bliss Military Base. Other colleges and universities in the region are smaller in size, have limited or no on-campus housing, and are reasonably represented by the trip generation rates described in **Section 5.3** and **Section 5.4**.

### 5.6.1 University of Texas at El Paso (UTEP)

Located just northwest of downtown El Paso, UTEP is a four-year university with enrollment of nearly 25,000 students. UTEP students tend to live on or near campus, resulting in unique trip generation patterns. The university is made up of the six traffic analysis zones shown in Figure 5.1. The university is made up of the six TAZs shown in **Figure 5.1**. The TAZs contain a combination of classrooms, offices, and on-campus housing. Some university zones also contain other non-university uses, such as off-campus housing and commercial activities.

**Figure 5.1 UTEP Traffic Analysis Zones**



### University Trip Purposes

Since UTEP does not fall into the normal trip patterns used by the model in the remainder of the region, some special considerations are given to trip types at universities. In particular, the Home-Based Non-Work Education 2 (HBNWE2) trip purpose is defined as a trip by a university student or visitor between an off-campus home and any location on the university campus. Other trip ends at the university are associated with university faculty and staff, students living on campus, and students and visitors living off campus. Descriptions of how each trip purpose are addressed at university special generators are presented below.

- **HBW, HNWR, and HNWO Productions:** These production trip ends at the University can occur only for students living on campus.
- **HBW Attractions and NHBW Productions:** These trip ends at the University can occur only for University faculty and staff.

- **NHBW Attractions and all NHBO Trips:** These trip ends at the University can only occur for students and visitors living off campus.
- **HNWR and HNWO Attractions:** These trip ends cannot occur at the university. All home-based trips to the university by students and visitors are considered HBNWE22 trips and all home-based trips to the university by faculty and staff are considered HBW trips.
- **HNWE2 Productions:** Trips within the university campuses are not modeled, so HBNWE2 productions cannot occur on campus.
- **HNWE2 Attractions:** HBNWE2 on-campus attractions can occur only for students and visitors living off campus and traveling to campus.

## Employment and Enrollment Data

UTEP special generator trip generation is based on 2022 employment and enrollment totals. For the 2022 base year, UTEP is modeled as having 2,565 employees and 22,880 enrolled students.

### 5.6.2 Fort Bliss

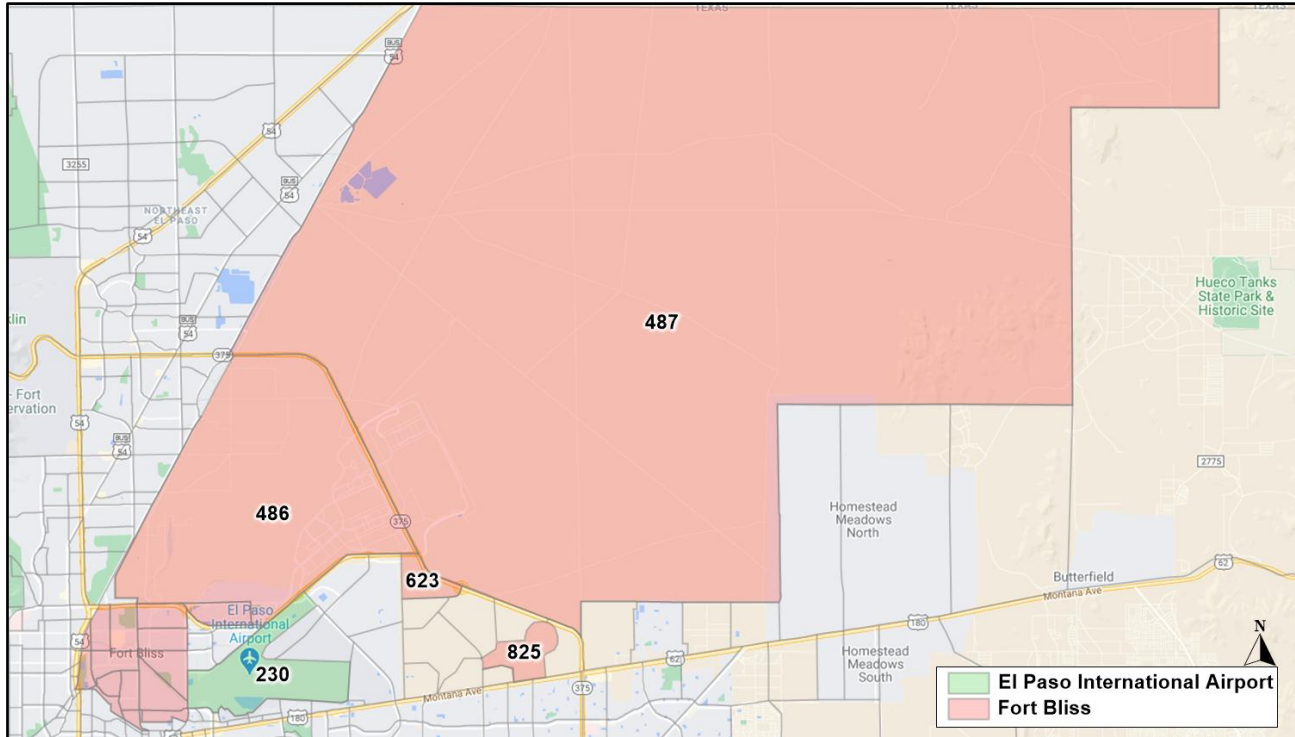
Fort Bliss consists of 19 TAZs, shown in **Figure 5.2** and **Figure 5.3**. Access to Fort Bliss is limited to a select number of gates, represented in the model by connections to the highway network outside of the base. Total Fort Bliss activity has been defined based on total base employment of 44,233 multiplied by a calibrated special generator trip rate of 0.65 trips per employee. This trip rate was maintained from the Destino model, and the results were then compared to LBS and traffic count data.

Employment data at Fort Bliss does not coincide with places where activity occurs, nor is it particularly useful in defining trip purposes. Instead, special generator trip-ends were assigned to trip purposes and distributed to Fort Bliss TAZs based on an analysis of LBS data.

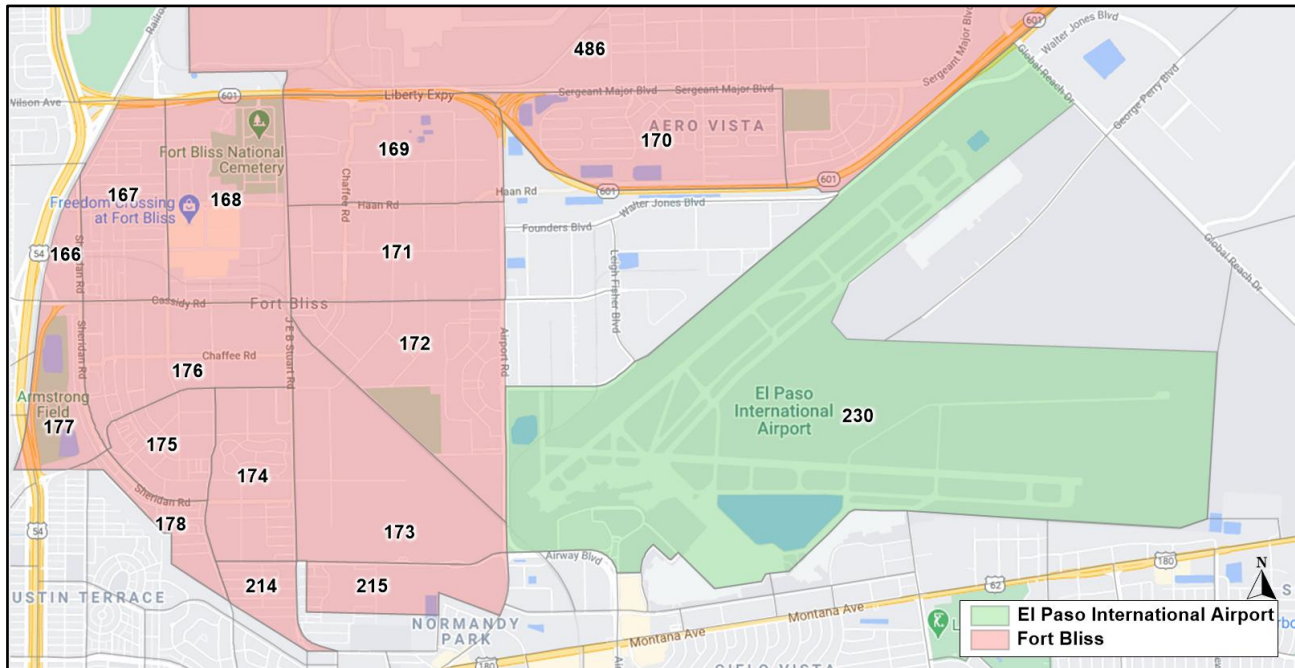
### 5.6.3 El Paso International Airport

El Paso International Airport is represented by TAZ 230, identified in **Figure 5.2** and **Figure 5.3**. Due to the unique nature of airport trips, the airport is modeled as a special generator and represented by an overall special generator trip rate of 2.5 trips per employee, carried over from the Destino Model. This value was adjusted to match traffic counts immediately near airport entrances and exits.

**Figure 5.2 Fort Bliss and Airport Zones (Overview)**



**Figure 5.3 Fort Bliss and Airport Zones (Detail)**



**5.6.4 Special Generator Forecasting**

Special generators can be difficult to forecast due to the unique nature of special generator uses. The following assumptions have been made for special generators in the El Paso MPO TDM22/52.

- **UTEP** is assumed to grow at the same rate as population in the region.
- **Fort Bliss** is assumed to remain the same in interim and forecast years.
- **El Paso International Airport** is assumed to grow at the same rate as population in the region.

## 5.7 Trip Balancing

After application of production and attraction rates, the total number of trip productions and attractions may not be equal, especially when considering the trip production rate increase introduced to match total VMT. It is necessary to scale or “balance” either productions or attractions so that production and attraction totals are equal for each trip purpose. For most trip purposes, trips are balanced to productions. This approach is taken due to the higher level of confidence in the U.S. Census-based household data that underpins the trip production models. Described below are several deviations and caveats to this approach.

- HNWE2 (College/university) trips are balanced to trip attractions. This method has been chosen due to the high level of confidence in enrollment data at colleges and universities. This approach also allows the model to vary the amount of traffic to and from these isolated locations by changing enrollment input data.
- While NHB trips are balanced to productions, they are re-allocated to non-home locations.
- Because truck trips are not generated by the household-based trip production models, truck trips are balanced to attractions.

## 6.0 Trip Distribution

Trip distribution is the second step of the traditional four step travel model and is the process through which trip productions and attractions from the trip generation model are apportioned between all zone pairs in the modeling domain. The resulting trip table matrix contains both intrazonal trips (i.e., trips that do not leave the zone) on the diagonal and interzonal trips in all other zone interchange cells for each trip purpose.

### 6.1 Peak and Off-Peak Period Definitions

The El Paso MPO TDM22/52 uses TransCAD’s built-in gravity model to distribute trips. The model distributes trips occurring during the AM and PM peak periods using peak congested speeds, and distributes trips occurring during mid-day and overnight periods using off-peak congested speeds. Trip distribution is performed in Production-Attraction (PA) format rather than Origin-Destination (OD) format because the majority of trips in the AM peak period travel from production to attraction (e.g., to work) and the majority of trips in the PM peak period travel from attraction to production (e.g., from work). The model uses congested travel times to distribute productions and attractions using a doubly constrained gravity model.

To implement trip distribution by time of day, factors are required to represent the portion of trips occurring in the combined AM and PM peak periods, as well as separately during the off-peak time period. Trips are further separated into more detailed peak periods during the time of day step prior to traffic assignment. Trip distribution time of day factors based on the 2010-2011 Household Travel Survey data are shown in **Table 6.1**.

**Table 6.1 Trip Distribution Time of Day Factors**

	HBW	HNWE1	HNWE2	HNWR	HNWO	NHB	LT	MT	HT	EXTINT
Peak	62.7%	92.9%	40.0%	35.9%	42.7%	53.1%	53.1%	53.1%	53.1%	53.1%
Off-Peak	37.3%	7.1%	60.0%	64.1%	57.3%	46.9%	46.9%	46.9%	46.9%	46.9%

Source: Destino Travel Model, reviewed and updated for use in the El Paso MPO TDM22/52.

### 6.2 Gravity Model

The gravity model applies friction factors to represent the effects of impedance between zones. As the impedance between zones increases, the number of trips between those zones decreases as represented by a decreasing friction factor. The gravity model also assumes that the number of trips between two zones is directly proportional to the number of productions and attractions contained in those zones. The gravity model is defined in the equation below.

$$T_{ij} = P_i \cdot \frac{A_j \cdot F_{ij} \cdot K_{ij}}{\sum_{i=1}^n (A_j \cdot F_{ij} \cdot K_{ij})}$$

Where:

- $T_{ij}$  = trips from zone i to zone j
- $P_i$  = productions in zone i
- $A_j$  = attractions in zone j
- $K_{ij}$  = K-factor adjustment from i to zone j
- $i$  = production zone
- $j$  = attraction zone
- $n$  = total number of zones
- $F_{ij}$  = friction factor (a function of impedance between zones i and j)

Doubly constraining the gravity model means that the total number of productions and attractions resulting from trip generation is maintained at the TAZ level.

### 6.2.1 Friction Factors

Friction factors represent the impedance to travel between each zone pair. The El Paso MPO TDM22/52 applies friction factors in the form of gamma functions, defined by the equation below. Gamma function parameters are defined in **Table 6.2** and **Table 6.3** and calibration of these parameters is described in **Section 10.2**.

$$F_{ij} = \alpha t^{-\beta} e^{-\gamma t}$$

Where:

- $F_{ij}$  = friction factor between zones i and j
- $t$  = travel time
- $\alpha, \beta, \gamma$  = calibration parameters

**Table 6.2 Gravity Model Friction Factors (Peak)**

	HBW	HNWE1	HNWE2	HNWR	HNWO	NHB	LT	MT	HT	EXTINT
Alpha	99.9999	999.9859	999.9859	1671.9790	999.9859	999.8991	155.6592	155.6592	155.6592	999.8991
Beta	0.8100	0.9500	0.9500	0.1900	0.7200	0.5500	0.0000	0.0000	0.0000	0.4099
Gamma	0.0460	0.1020	0.0510	0.2495	0.098	0.0880	0.0885	0.0885	0.0885	0.1600

Source: El Paso MPO TDM22/52.

**Table 6.3 Gravity Model Friction Factors (Off-Peak)**

	HBW	HNWE1	HNWE2	HNWR	HNWO	NHB	LT	MT	HT	EXTINT
Alpha	99.9999	999.9859	999.9859	1671.979	999.9859	999.8991	155.6592	155.6592	155.6592	999.8991
Beta	0.7800	1.1200	1.1200	0.1900	0.7800	0.6200	0.0000	0.0000	0.0000	0.4099
Gamma	0.0580	0.2500	0.1250	0.2495	0.0930	0.0850	0.0885	0.0885	0.0885	0.1600

Source: El Paso MPO TDM22/52.

## 7.0 Vehicle Availability Model

The vehicle availability, applied after trip generation, allows consideration of auto availability in the mode choice model. The model is specified as a discrete choice model with five alternatives:

- 0-vehicles available;
- 1-vehicle available;
- 2-vehicles available;
- 3-vehicles available; and
- 4-vehicles or more available.

Because the dependent variable (vehicles) demonstrates a natural ordering, the ordered logit (ORL) model form was chosen to model the choice. The ORL model is specifically suited for choice contexts where the alternatives follow a natural ordering. Whereas a multinomial logit (MNL) treats each choice alternative distinctly and estimates the coefficients of linear (latent) utility functions specific for each alternative, the ORL assumes a single latent function (modeled as a linear function of explanatory variables, similar to MNL), which measures the propensity for a household to own more or less vehicles. The higher the latent variable for a specific household, the more likely that household is to own a higher number of vehicles.

### 7.1 Variables

Household characteristic variables available for this model are limited to those variables that are generated by TripCAL6, including income, household size, and number of workers. Each of these variables was tested during model estimation and included in the final model.

Two locational attributes of a household's zone are included in the model. The first is the land use density at the home zone, which takes the following function form:

$$Density = Ln \left( 1 + \frac{Population + 2.0 \times Employment}{Acres} \right)$$

The second variable is a measure of relative transit accessibility. Transit accessibility is important to vehicle ownership, since having transit accessibility allows for lower auto ownership rates than areas with more limited transit accessibility. Transit accessibility is measured relative to roadway accessibility since transit networks and highway networks typically share many characteristics spatially.

$$Acc_i = A_{i,DA} - A_{i,TW}$$

Here,  $Acc_i$  is the relative transit accessibility,  $A_{i,DA}$  is the absolute highway accessibility, and  $A_{i,TW}$  is the absolute transit accessibility. The absolute accessibilities are computed as follows:

$$A_{im} = \ln \left[ \sum_j S_j \times \exp(U_{ijm}) \right]$$

Here, the sum is across all zones in the region,  $S_j$  is the size of the zone (measured as total employment in the zone), and  $U_{ijm}$  is an idealized mode utility from zone  $i$  to zone  $j$  by mode  $m$ . **Table 7.1** shows the parameters assumed for the utility function for this variable. These parameter values are based on values typically found in similar regions across the U.S. Separate accessibilities are computed for low and high income households. Shown in **Table 7.1**, the variable differs in the cost coefficient used in the utility function.

**Table 7.1 Utility Parameters for Accessibility Variables**

Mode	Variable	Value
All	In-Vehicle Travel Time	-0.025
All	Cost – Low Income (Cat = 1,2)	-0.200
All	Cost – High Income (Cat = 3,4,5)	-0.100
TW	Transfers	-0.100
TW	Local Bus Used (0/1)	-1.000
TW	OVT Ratio	2.500

Source: Destino Travel Model, reviewed and retained for use in the El Paso MPO TDM22/52.

The estimation results are presented in **Table 7.2**. Some of the key findings of the vehicle availability model estimation are as follows:

- All else being equal, higher income households have higher propensity to own vehicles;
- Household size and number of workers both positively impact vehicle availability propensity;
- Land use density in the home zone negatively correlates with vehicle ownership propensity. This is expected, as denser areas typically feature more closely spaced employment centers, making non-auto modes more viable.
- Relative transit accessibility has a positive effect on the propensity to own vehicles. This is expected, as relative transit accessibility is defined as the difference between highway and transit accessibility. The better the highway accessibility, the higher the value of the variable. We would expect when highway accessibility is high, households will own more vehicles.

## 7.2 Model Estimation

Vehicle availability model estimation results are shown in **Table 7.2**.

**Table 7.2 Vehicle Availability Model Estimation Results**

Variable		Coefficient	t-stat
Income Category	Medium-low	0.32	2.5
	Medium	0.97	7.8
	Medium-high	1.38	11.2
	High	1.80	13.8
Household Size	2 persons	1.58	12.1
	3 persons	2.35	17.0
	4 persons	2.50	17.8
	5 persons	2.81	19.0
Workers	1 worker	0.29	3.3
	2 workers	1.28	11.9
Zonal	Relative Transit Access	0.11	1.6
	Land Use Density	-0.17	-2.9
Thetas	0 1	-1.31	-6.3
	1 2	1.95	9.6
	2 3	4.61	21.2
	3 4	6.35	27.9
Number of Observations		2892	
Log Likelihood of Model		-3205.0	
Log Likelihood of Constants Only		-3842.1	
Rho Squared		0.166	

Source: Destino Travel Model, reviewed and retained for use in the El Paso MPO TDM22/52.

### 7.3 Model Calibration

The Theta parameters shown in **Table 7.2** serve the same purpose as alternative specific constants in an MNL model, but are the ORL model’s equivalent. They ensure that the model replicates the alternative shares represented in the survey data. The ORL uses only a single latent variable and the thetas assign the breakpoints at which a household’s propensity to own more or less vehicles actually manifests in changing auto ownership level. The first theta (0|1) represents the breakpoint between 0 and 1 vehicles, the second (1|2) represents the breakpoint between 1 and 2 vehicles, and so on. To illustrate how the model works, consider shifting from a propensity of 1.5 to 2.0, which will result in a shift of owning 1 vehicle to 2 vehicles. However, shifting from a propensity of 1.0 to 1.5 results in no change in auto ownership (one vehicle is owned at both propensity levels). The calibrated theta parameters are provided in **Table 7.3**.

**Table 7.3 Theta Values for the Vehicle Availability Model**

Coefficient	Estimated Value	Calibrated Value
Theta 1	-1.31	-0.92
Theta 2	1.95	1.91
Theta 3	4.61	4.71
Theta 4	6.35	6.86

Source: Destino Travel Model, reviewed and retained for use in the El Paso MPO TDM22/52. Model validation results, presented in **Table 7.4**, evaluate three vehicle sufficiency categories which combine auto ownership model results with household size. The following vehicle sufficiency values are used in the mode choice model.

- 12. Zero vehicles;
- 13. Vehicles less than household size, greater than zero; and
- 14. Vehicles greater than or equal to household size and greater than zero.

**Table 7.4** shows the expanded survey versus modeled vehicle availability shares.

**Table 7.4 Vehicle Sufficiency Validation**

Vehicle Category	Expanded Survey	2022 ACS <sup>2</sup>	Modeled
Zero Vehicles	3.5%	6.2%	6.2%
Vehicles < Household size	52.9%	41.5%	41.5%
Vehicles >= Household size	43.6%	52.3%	52.3%

Source: Cambridge Systematics analysis of 2010-2011 Household Travel Survey data, 2022 ACS, El Paso MPO TDM22/52 results.

<sup>2</sup> Table B08201 in the 2022 (1 Year) American Community Survey

## 8.0 Mode Choice

The El Paso MPO TDM22/52 produces and distributes all person trips including non-motorized, auto, and transit trips. The mode choice model separates the resulting person trip tables into drive alone, shared ride by occupancy (2 and 3+ occupancy), transit (walk access and drive access), and non-motorized (bicycle and walk) modes. Roadway and transit networks provide important input to the mode choice model and include information about bicycle facilities. The mode choice model considers trip lengths produced by the trip distribution model, resulting in sensitivity to higher density and mixed-use areas. Such areas produce shorter trips which are more likely to be made using non-motorized modes.

### 8.1 Observed Mode Shares

#### 8.1.1 Non-Transit Mode Shares

The mode choice model has been calibrated to reproduce observed mode shares. Observed mode share values for auto trips and non-motorized trips are based on data from the 2010-2011 Household Travel Survey. **Table 8.1** shows the non-transit trip calibration targets.

A review of the household travel survey revealed that 9.6% of school trips happen on school buses. Consequently, school trips were factored down by 9.6% before mode choice, as school bus is not a mode considered in the El Paso MPO TDM22/52 mode choice model.

**Table 8.1 Non-Transit Trip Targets**

Purpose	SOV	HOV2	HOV3+	Bike	Walk
HBW Low Inc	86%	7%	6%	0%	1%
HBW Med-Low Inc	86%	7%	3%	0%	4%
HBW Med Inc	90%	9%	1%	0%	1%
HBW Med-High Inc	91%	8%	1%	0%	0%
HBW High Inc	93%	5%	1%	0%	0%
HNWE1 Low Inc	14%	32%	41%	2%	11%
HNWE1 Med-Low Inc	12%	27%	43%	1%	17%
HNWE1 Med Inc	14%	27%	47%	0%	11%
HNWE1 Med-High Inc	15%	31%	43%	0%	11%
HNWE1 High Inc	18%	32%	43%	1%	6%
HNWE2 Low Inc	70%	28%	2%	0%	0%
HNWE2 Med-Low Inc	79%	21%	0%	0%	0%
HNWE2 Med Inc	66%	25%	5%	1%	4%
HNWE2 Med-High Inc	67%	24%	10%	0%	0%
HNWE2 High Inc	72%	17%	11%	0%	0%
HNWR Low Inc	38%	37%	24%	0%	1%
HNWR Med-Low Inc	34%	35%	27%	0%	4%
HNWR Med Inc	39%	39%	21%	0%	1%
HNWR Med-High Inc	41%	33%	25%	0%	1%
HNWR High Inc	40%	31%	28%	0%	1%
HNWO Low Inc	29%	40%	26%	0%	4%
HNWO Med-Low Inc	33%	27%	30%	1%	9%
HNWO Med Inc	37%	32%	24%	0%	7%
HNWO Med-High Inc	36%	34%	26%	0%	3%
HNWO High Inc	36%	26%	32%	1%	6%
NHBW	83%	12%	3%	0%	2%
NHBO	30%	37%	30%	0%	3%

Source: Cambridge Systematics analysis of 2010-2011 Household Travel Survey data.

### 8.1.2 Observed Transit Trips

For transit trips, total transit boardings were obtained from Sun Metro and El Paso County, as shown in **Table 8.2**. Transit boarding data cannot be directly used as mode choice calibration targets because they include transfers and must be converted into complete origin-to-destination trips, or linked transit trips. In addition, transit boardings must be separated by trip purpose and income to support model calibration. The 2010-2011 Household Travel Survey did not contain enough records to convert boardings to trips or to

separate transit trips by purpose or income. This data is sometimes available from on-board surveys conducted by transit agencies, but not all agencies collect this data.

For The El Paso MPO TDM22/52, boardings were converted to linked trips using an average transfer rate of 1.45, as provided by Sun Metro for the 2017 base year RMS model development. Since the 2012 El Paso on-board survey data were not sufficient for segmenting transit trips by income, income-based targets were derived from a 2014 on-board survey conducted by VIA Transit in San Antonio, TX. This distribution was maintained during the development of the 2022 targets.

**Table 8.2 2022 Fixed Route Boardings**

Operator	Average Weekday Boardings
Sun Metro	20,936 <sup>3</sup>
El Paso County	1,327 <sup>4</sup>
<b>Total</b>	<b>22,263</b>

Source: Data provided by SunMetro as well as Cambridge Systematics analysis of NTD ridership of El Paso County routes.

The El Paso MPO TDM22/52 represents two transit access modes: Walk access<sup>5</sup> and drive access. Walk access includes all non-motorized transit access and implicitly includes kiss-n-ride access to stops that are not formal park-n-rides. Drive access includes transit trips that make use of one of the formal park-n-rides shown in **Figure 8.1**. Transit trips were separated into walk and drive access based on survey data, resulting in the shares shown in **Table 8.3**.

**Table 8.3 Observed Walk and Drive Access Shares**

Access Mode	Share of Trips
Walk and bike	94%
Drive	6%

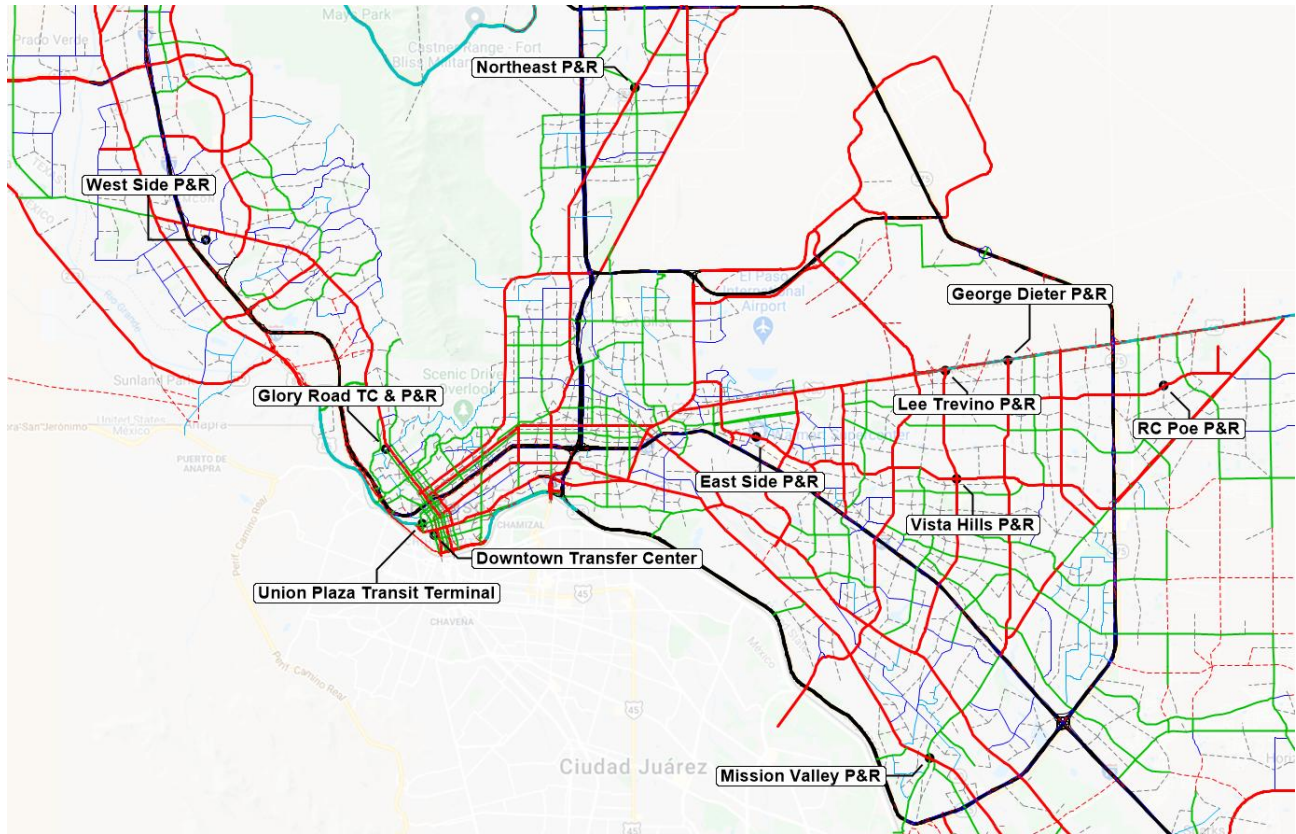
Source: Cambridge Systematics analysis of 2010-2011 Household Travel Survey data

<sup>3</sup> Average weekday ridership in September and October 2022.

<sup>4</sup> Estimated by dividing the annual unlinked trips in the National Transit Database by an annualization factor of 300. ([https://www.transit.dot.gov/sites/fta.dot.gov/files/transit\\_agency\\_profile\\_doc/2022/60179.pdf](https://www.transit.dot.gov/sites/fta.dot.gov/files/transit_agency_profile_doc/2022/60179.pdf))

<sup>5</sup> Bicycle access and egress to transit is not modeled explicitly but is instead modeled as walk access and egress.

**Figure 8.1 2022 Park-n-Ride Locations**



Based on the analysis described above, regional transit trip targets can be prepared based on income, trip purpose, and transit access mode. Transit calibration targets are shown in **Table 8.4**, expressed as the number of linked trips. Transit targets are computed in the number of linked trips rather than as a percentage of overall travel. This approach ensures that small changes in total trips during model calibration do not change the transit targets, which are based on observed data. These targets are combined with the previously discussed auto and non-motorized mode share targets to form a complete set of mode choice calibration targets.

**Table 8.4 Resulting Transit Trip Targets**

Purpose	Drive to Transit	Walk to Transit	Total Transit Linked Trips
HBW Low Inc	92	1,678	<b>1,770</b>
HBW Med-Low Inc	50	764	<b>814</b>
HBW Med Inc	17	119	<b>136</b>
HBW Med-High Inc	5	23	<b>28</b>
HBW High Inc	8	18	<b>26</b>
HNWE1 Low Inc	49	543	<b>591</b>
HNWE1 Med-Low Inc	9	112	<b>121</b>
HNWE1 Med Inc	1	29	<b>30</b>
HNWE1 Med-High Inc	0	4	<b>4</b>
HNWE1 High Inc	0	4	<b>4</b>
HNWE2 Low Inc	95	1,105	<b>1,199</b>
HNWE2 Med-Low Inc	46	411	<b>457</b>
HNWE2 Med Inc	16	109	<b>125</b>
HNWE2 Med-High Inc	0	41	<b>41</b>
HNWE2 High Inc	0	4	<b>4</b>
HNWR Low Inc	194	2,370	<b>2,563</b>
HNWR Med-Low Inc	20	537	<b>558</b>
HNWR Med Inc	2	62	<b>64</b>
HNWR Med-High Inc	0	8	<b>8</b>
HNWR High Inc	0	3	<b>3</b>
HNWO Low Inc	138	2,895	<b>3,034</b>
HNWO Med-Low Inc	48	794	<b>842</b>
HNWO Med Inc	17	94	<b>112</b>
HNWO Med-High Inc	7	24	<b>32</b>
HNWO High Inc	1	10	<b>10</b>
NHBW	29	588	<b>617</b>
NHBO	129	2,032	<b>2,162</b>
<b>Total</b>	<b>974</b>	<b>14,380</b>	<b>15,354</b>

Source: Cambridge Systematics analysis of on-board Survey Data and 2022 Transit Boarding Data

## 8.2 Mode Choice Model Structure

The El Paso MPO TDM22/52 applies a logit-based mode choice model for all internal trip purposes. The general equation describing a multinomial mode choice is shown in the equation below.

$$P_i = \frac{e^{U_i}}{\sum_{m=1}^n e^{U_m}}$$

Where:

- $P_i$  = the probability of using mode i
- $u_i$  = the utility of mode i
- $u_m$  = the utility of mode m
- $n$  = the number of modes

The logit model is based on the concept of utilities (or dis-utilities) that describe the characteristics of travel by each mode. The utility function can be made up of impedance variables such as travel time, wait time, and cost, as well as locational and socio-economic variables. Each variable is multiplied by an estimated coefficient that describes the relative weight (positive or negative) of each variable. A mode constant is added to the utility function to account for mode preferences not measured by the other utility variables. Due to the relative nature of the mode constants, one mode's constant must be set to zero. The utility equation applied to each mode is shown below.

$$u_i = c_1X_{1i} + c_2x_{2i} + c_3x_{3i} + \dots + c_nx_{ni} + K$$

Where:

- $u_i$  = Utility for mode i
- $c_1, c_2, c_3, \dots, c_n$  = Estimated coefficients for variables 1 through n
- $x_{1i}, x_{2i}, x_{3i}, \dots, x_{ni}$  = Values for variables 1 through n
- $K$  = Alternative Specific Constant

The El Paso MPO TDM22/52 uses a mode choice structure that nests multiple multinomial choices. At the bottom level of the nested logit structure, utility values are computed using the method described for multinomial application. Utilities at the upper level are computed as a combination of utilities for the nested modes (i.e., modes below the upper level choice). Walk is an example of a lower level mode, while the corresponding upper level mode is non-motorized. Utilities for intermediate modes are based on the natural log of the sum of exponentiated sub-mode utilities. This term, referred to as the "logsum" variable, is computed as shown below.

$$LS_i = \ln \left( \sum_{j=1}^n e^{u_j} \right)$$

Where:

- $LS_i$  = The logsum of intermediate mode i
- $u_j$  = Utility terms for nested mode j
- $n$  = The number of sub-modes under mode i

Once the logsum variables have been computed for all intermediate modes, mode probabilities are calculated in a manner similar to that described for multinomial logit models. However, for nested modes, utilities are replaced by the product of the logsum and a nesting coefficient, as shown in the equation below. The nesting coefficient has a value between zero and one, where a nesting value of zero indicates sub-modes are identical and do not need to be included as separate modes. A nesting value of one indicates sub-modes are distinctly different and could be represented as separate non-nested modes.

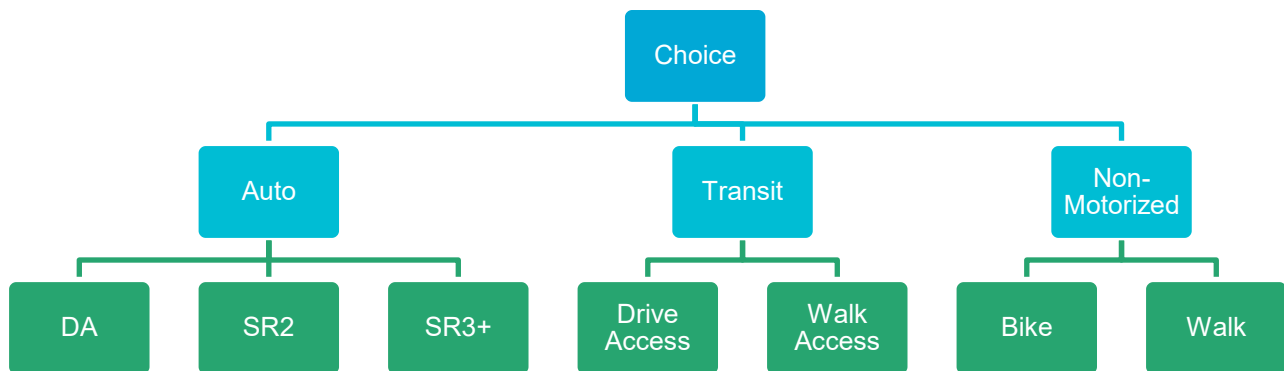
$$P_i = \frac{e^{\theta_i \cdot LS_i}}{\sum_{m=1}^n e^{\theta_m \cdot LS_m}}$$

Where:

- $P_i$  = The probability of selecting intermediate mode  $i$
- $\theta_i$  = The nesting coefficient for intermediate mode  $i$
- $\theta_m$  = The nesting coefficient for mode  $m$
- $n$  = The number of modes at the same level as mode  $i$

The structure for the El Paso mode choice models, shown in **Figure 8.2**, assumes modes, sub-modes, and access modes are distinctly different types of alternatives that present distinct choices to travelers. Within each nest, the model operates as a multinomial logit model, evaluating the modes included within that nest. Similarly, at each specific nesting level, the model operates as a multinomial logit model, evaluating the nests within that level. However, the competition between modes included in different nests or nesting levels is not proportional to initial estimates of the mode shares. As a result, a key difference from multinomial logit models is “lower level” choices exhibit greater elasticity than they would in a multinomial logit model.

**Figure 8.2 Nested Logit Mode Choice Structure**



The nested logit model employs several multinomial logit models. The first is choice among primary modes: Auto, transit, and non-motorized. The second choice is among sub-modes of the chosen primary mode. That is, if the chosen primary mode was auto, the second choice would be between drive alone, shared ride 2 and shared ride 3+; if the chosen primary mode was transit, the second choice would be between walk and drive access to transit; if the chosen primary mode was non-motorized, the second choice would be between walk and bike.

In application, utilities are calculated at the bottom levels first and passed up through the nesting structure. When this is complete, the probabilities are estimated from the top of the structure down. Composite utilities are passed upward using “logsum” variables.

### 8.2.1 Market Segmentation

The El Paso MPO TDM22/52 utilizes market segmentation to more accurately model transit ridership. Market segmentation by walk access and egress distance is used to provide a finer level of detail in the walk to transit modes. Market segmentation by income is used to more accurately identify potential transit riders, as the household travel survey indicated members of low-income households are more likely to use transit.

Segmentation of markets into three walk access categories and three walk egress categories results in nine walk access/egress markets, demonstrated in **Table 8.5**. The mode choice models are applied once for each of these markets.

Segmentation by walk access provides improved model sensitivity to density and transit oriented developments. This can be illustrated by the application of a mode choice model to a 1 square-mile zone with dense development and access to transit along one edge. Without market segmentation, all residents in the zone would be assumed to have access to transit with a ½ mile walk, resulting in minimal transit ridership in this zone. With market segmentation, some residents would be assumed to have very short walk access lengths, some medium access lengths, and the remainder long (over ¾ mile) access lengths. This scenario results in more realistic representation of actual conditions. A similar example could be applied to walk egress market segmentation.

**Table 8.5 Walk Access and Egress Market Segments**

Access/Egress	Short Egress	Medium Egress	Long Egress
Short Access	1	2	3
Medium Access	4	5	6
Long Access	7	8	9

Note: Short, medium, and long access and egresses are defined as less than ¼ mile, ¼ to ¾ mile, and more than ¾ mile, respectively.

The first step of the mode choice model calculates, for each TAZ, the percentage of the area falling within a ¼ mile radius of a transit stop (short access/egress), ¾ mile radius of a transit stop (medium access/egress) and outside of a ¾ mile radius (long access/egress). The transit stations included in this calculation are those belonging to active transit routes. The output from this step looks like the sample in **Table 8.6**. The Activity fields represent a combination of households and employees belonging to each of the access/egress categories. Similarly, the Short, Med, and Long Area fields show the TAZ area belonging to short, medium, and long walk access/egress segments, respectively. The short, medium, and long percentage fields are calculated based on the share of activity in each of the three segments.

Trips in the long walk category are only considered for zone pairs in which transit skims can be built. The skimming procedure uses a maximum walk time of 30 minutes, which equates to a maximum walk distance of 1.25 miles, assuming a walk speed of 2.5 mph. The transit modes are not available for the long walk segment in cases where the long walk time exceeds the maximum.

By default, the activity values are apportioned based on TAZ area, resulting in shares distributed by TAZ area within each market segment. The model features an input table that can be used to override the default calculations. This table has been populated based on a review of aerial photography in selected transit corridors.

This process can also be extended to incorporate sub-TAZ level data (e.g., parcel data) for a more precise allocation of activity shares within each segment.

**Table 8.6 Walk Segments Sample Output**

TAZ	Short Activity	Med Activity	Long Activity	Short Pct	Med Pct	High Pct	Short Area	Med Area	Long Area
81	42	0	0	100%	0%	0%	0.03	0.00	0.00
82	0	0	0	33.0%	33.0%	34.0%	0.14	0.15	0.00
83	717	1600	0	30.9%	69.1%	0%	0.20	0.46	0.00
84	28.8	46.5	0.0173	38.2%	61.8%	0%	0.26	0.42	0.00
85	391	98.0	0	79.9%	20.1%	0%	0.10	0.02	0.00
86	684	1.05	0	100%	0%	0%	0.08	0.00	0.00
87	0	13.3	99.2	0%	11.8%	88.2%	0.00	0.08	0.62
88	918	21.6	0	98%	2.30%	0%	0.22	0.01	0.00
89	15.1	93.8	55.4	9.18%	57.1%	33.7%	0.11	0.68	0.40
90	543	0	0	100%	0%	0%	0.18	0.00	0.00

Source: El Paso MPO TDM22/52 example model run.

### 8.2.2 Production and Attraction Density Variables

To increase sensitivity of the travel model to transit-oriented developments, production and attraction density variables are included in the utility equations. Higher density attraction zones are expected to promote non-SOV modes because of the higher congestion, walkability, and transit service. The density factor is calculated as:

$$Density_i = Ln \left( 1 + \frac{POP_i + 2 \times EMP_i}{Area_i} \right)$$

Where:

- $POP_i$  = total population in zone i
- $EMP_i$  = total employment in zone i
- $Area_i$  = area of zone i in acres

### 8.2.3 Model Specification

The utility equations for mode choice are documented below. The coefficient designations (e.g.,  $C_{ivtt}$  for Coefficient of in-vehicle travel time) rather than the actual model coefficients are shown to aid in the understanding of the model specification. The model coefficients are shown in **Table 8.7**. Note that mode choice constants are divided into those that vary by purpose and vehicle sufficiency, and those that vary by purpose and income group. Model constants ( $K_m$ ) calibrated to reproduce observed mode shares are shown in **Table 8.8** and **Table 8.9**. The vehicle sufficiency constants, shown in **Table 8.10**, were estimated and do not vary with mode choice calibration. Income and vehicle sufficiency mode constants are added to form the alternative specific constants for each mode.

**Drive Alone Utility:**

$$\begin{aligned}
 U_{DA} &= K_{Auto} + K_{DA} + C_{IVTT} \cdot IVTT_{drive} \\
 &+ C_{OVTT} \cdot TTIME \\
 &+ C_{Cost(income)} \cdot (CPM \cdot Dist + ParkCost) + K_{DA\_Dens} \cdot Density
 \end{aligned}$$

**Shared Ride 2 Utility:**

$$\begin{aligned}
 U_{SR2} &= K_{Auto} + K_{SR2} + C_{IVTT} \cdot IVTT_{drive} \\
 &+ C_{OVTT} \cdot TTIME \\
 &+ C_{Cost(income)} \cdot \left( \frac{CPM \cdot Dist + ParkCost}{2} \right) + K_{SR2\_Dens} \cdot Density
 \end{aligned}$$

**Shared Ride 3+ Utility:**

$$\begin{aligned}
 U_{SR3} &= K_{Auto} + K_{SR3} + C_{IVTT} \cdot IVTT_{drive} \\
 &+ C_{OVTT} \cdot TTIME \\
 &+ C_{Cost(income)} \cdot \left( \frac{CPM \cdot Dist + ParkCost}{3.2} \right) + K_{SR3\_Dens} \cdot Density
 \end{aligned}$$

Note: The cost terms are divided by 2 for SR2 and by 3.2 for SR3+.

**Walk to Transit Utilities:**

$$\begin{aligned}
 U_{TRW} &= C_{IVTT} \cdot IVTT_{transit} \\
 &+ C_{OVTT} \cdot WalkAccessTime \\
 &+ C_{OVTT} \cdot WalkEgressTime \\
 &+ C_{OVTT} \cdot InitialWaitTime \\
 &+ C_{OVTT} \cdot (XferWalkTime + XferWaitTime + XferPenTime) \\
 &+ C_{Cost(income)} \cdot Fare \\
 &+ K_{TRW\_Dens} \cdot Density \\
 &+ K_{TRN} + K_{TRW}
 \end{aligned}$$

**Drive to Transit Utilities:**

$$\begin{aligned}
 U_{TRD} &= C_{IVTT} \cdot IVTT_{transit} \\
 &+ C_{OVTT} \cdot DriveAccessTime \\
 &+ C_{OVTT} \cdot WalkEgressTime \\
 &+ C_{OVTT} \cdot InitialWaitTime \\
 &+ C_{OVTT} \cdot (XferWalkTime + XferWaitTime + XferPenTime) \\
 &+ C_{OVTT} \cdot TTIME_P \\
 &+ C_{Cost(income)} \cdot Fare \\
 &+ C_{Cost(income)} \cdot CPM \cdot AccessDriveDistance \\
 &+ K_{TRD\_Dens} \cdot Density \\
 &+ K_{TRN} + K_{TRD}
 \end{aligned}$$

**Walk Utility:**

$$U_{Walk} = C_{WALK} \cdot WALKDist + K_{NM} + K_{WALK} + K_{WALK\_Dens} \cdot Density$$

**Bike Utility:**

$$U_{Bike} = C_{BIKE} \cdot IMP_{bike} + K_{NM} + K_{BIKE} + K_{BIKE\_Dens} \cdot Density$$

Where:

- IVTT<sub>transit</sub>* = Transit in-vehicle travel time
- IVTT<sub>drive</sub>* = Drive in-vehicle travel time
- TTIME* = Terminal time in minutes
- TTIME<sub>P</sub>* = Terminal time in minutes (production end only)
- CPM* = Auto operating cost per mile in cents (Set to \$0.72 per mile)
- Dist* = Distance traveled in miles
- ParkCost* = Parking cost (dollars)
- AccessTime* = Walk or drive access time
- EgressTime* = Walk egress time
- InitialWaitTime* = Initial wait time for transit in minutes
- XferWalkTime* = Transfer walk time in minutes
- XferWaitTime* = Transfer wait time in minutes (1/2 of the headway of the route being boarded)
- XferPenTime* = Transfer penalty time in minutes
- Fare* = Transit fare in dollars (average rate paid by all riders)
- WALKDIST* = Walk Distance
- IMP<sub>bike</sub>* = Bike impedance, weighted by bicycle facility type
- C<sub>x</sub>* = Coefficient for variable “x”
- K<sub>mode</sub>* = Constant for specified mode

**Table 8.7 Mode Choice Model Coefficients**

Coefficient	HBW	HNW	NHB
In-Vehicle Travel Time (IVTT)	-0.0267	-0.0178	-0.0133
Out of Vehicle Travel Time (OVTT)	-0.0667	-0.0444	-0.0333
Cost (low income)	-0.5079	-0.5079	-0.1581
Cost (med-low income)	-0.3048	-0.3048	-0.1581
Cost (med income)	-0.2111	-0.2111	-0.1581
Cost (med-high income)	-0.1385	-0.1385	-0.1581
Cost (high income)	-0.0693	-0.0693	-0.1581
Walk Distance	-1.7394	-1.5308	-2.2937
Bike Impedance	-0.3302	-0.4231	-0.1876
Nesting Coefficient (Theta)	0.75	0.75	0.75

**Table 8.8 Peak Mode Choice Model Constants by Income**

Purpose	Auto	DA	SR2	SR3+	TRN	TRD	TRW	NM	BIKE	WALK
HBW (low inc)	0	0	-3.0759	-5.2934	-4.2904	-3.6284	0	-2.7419	-2.9951	0
HBW (med-low inc)	0	0	-3.0759	-5.2934	-5.5560	-3.6284	0	-2.7419	-2.9951	0
HBW (med inc)	0	0	-3.0759	-5.2934	-6.6863	-3.6284	0	-2.7419	-2.9951	0
HBW (med-high inc)	0	0	-3.0759	-5.2934	-6.6863	-3.6284	0	-2.7419	-2.9951	0
HBW (high inc)	0	0	-3.0759	-5.2934	-6.6863	-3.6284	0	-2.7419	-2.9951	0
HNWE1 (low inc)	0	0	0.3211	0.5331	-2.9707	-2.8912	0	1.8124	-3.9356	0
HNWE1 (med-low inc)	0	0	0.3211	0.5331	-5.6577	-2.8912	0	1.8124	-3.9356	0
HNWE1 (med inc)	0	0	0.3211	0.5331	-9.5905	-2.8912	0	1.8124	-3.9356	0
HNWE1 (med-high inc)	0	0	0.3211	0.5331	-9.5905	-2.8912	0	1.8124	-3.9356	0
HNWE1 (high inc)	0	0	0.3211	0.5331	-9.5905	-2.8912	0	1.8124	-3.9356	0
HNWE2 (low inc)	0	0	-1.8885	-3.2508	-1.0080	-2.9886	0	-1.6255	-3.0034	0
HNWE2 (med-low inc)	0	0	-1.8885	-3.2508	-3.6079	-2.9886	0	-1.6255	-3.0034	0
HNWE2 (med inc)	0	0	-1.8885	-3.2508	-6.6403	-2.9886	0	-1.6255	-3.0034	0
HNWE2 (med-high inc)	0	0	-1.8885	-3.2508	-6.6403	-2.9886	0	-1.6255	-3.0034	0
HNWE2 (high inc)	0	0	-1.8885	-3.2508	-6.6403	-2.9886	0	-1.6255	-3.0034	0
HNWR (low inc)	0	0	-0.5313	-0.9278	-1.9507	-3.0899	0	-1.9660	-2.4493	0
HNWR (med-low inc)	0	0	-0.5313	-0.9278	-5.0493	-3.0899	0	-1.9660	-2.4493	0
HNWR (med inc)	0	0	-0.5313	-0.9278	-6.6705	-3.0899	0	-1.9660	-2.4493	0
HNWR (med-high inc)	0	0	-0.5313	-0.9278	-6.6705	-3.0899	0	-1.9660	-2.4493	0
HNWR (high inc)	0	0	-0.5313	-0.9278	-6.6705	-3.0899	0	-1.9660	-2.4493	0
HNWO (low inc)	0	0	-0.6241	-0.8835	-2.3502	-3.3738	0	0.6104	-3.6951	0
HNWO (med-low inc)	0	0	-0.6241	-0.8835	-4.5643	-3.3738	0	0.6104	-3.6951	0
HNWO (med inc)	0	0	-0.6241	-0.8835	-6.5104	-3.3738	0	0.6104	-3.6951	0
HNWO (med-high inc)	0	0	-0.6241	-0.8835	-6.5104	-3.3738	0	0.6104	-3.6951	0
HNWO (high inc)	0	0	-0.6241	-0.8835	-6.5104	-3.3738	0	0.6104	-3.6951	0
NHBW	0	0	-2.5835	-4.1189	-13.3323	-3.1871	0	-8.2796	1.5717	0
NHBO	0	0	-0.3141	-0.7984	-12.4364	-2.9171	0	-6.3644	3.2582	0

**Table 8.9 Off-Peak Mode Choice Model Constants by Income**

Purpose	Auto	DA	SR2	SR3+	TRN	TRD	TRW	NM	BIKE	WALK
HBW (low inc)	0	0	-3.0299	-5.2072	-3.4289	-4.5955	0	-2.8388	-2.9716	0
HBW (med-low inc)	0	0	-3.0299	-5.2072	-4.8766	-4.5955	0	-2.8388	-2.9716	0
HBW (med inc)	0	0	-3.0299	-5.2072	-6.0249	-4.5955	0	-2.8388	-2.9716	0
HBW (med-high inc)	0	0	-3.0299	-5.2072	-6.0249	-4.5955	0	-2.8388	-2.9716	0
HBW (high inc)	0	0	-3.0299	-5.2072	-6.0249	-4.5955	0	-2.8388	-2.9716	0
HNWE1 (low inc)	0	0	0.4577	0.7533	-0.1847	-2.0522	0	0.7626	-3.6021	0
HNWE1 (med-low inc)	0	0	0.4577	0.7533	-3.4599	-2.0522	0	0.7626	-3.6021	0
HNWE1 (med inc)	0	0	0.4577	0.7533	-7.1430	-2.0522	0	0.7626	-3.6021	0
HNWE1 (med-high inc)	0	0	0.4577	0.7533	-7.1430	-2.0522	0	0.7626	-3.6021	0
HNWE1 (high inc)	0	0	0.4577	0.7533	-7.1430	-2.0522	0	0.7626	-3.6021	0
HNWE2 (low inc)	0	0	-1.8030	-3.1050	-0.8302	-3.0308	0	-2.0051	-2.9172	0
HNWE2 (med-low inc)	0	0	-1.8030	-3.1050	-3.0278	-3.0308	0	-2.0051	-2.9172	0
HNWE2 (med inc)	0	0	-1.8030	-3.1050	-6.5325	-3.0308	0	-2.0051	-2.9172	0
HNWE2 (med-high inc)	0	0	-1.8030	-3.1050	-6.5325	-3.0308	0	-2.0051	-2.9172	0
HNWE2 (high inc)	0	0	-1.8030	-3.1050	-6.5325	-3.0308	0	-2.0051	-2.9172	0
HNWR (low inc)	0	0	-0.5322	-0.9298	-2.0770	-3.0775	0	-1.9635	-2.4532	0
HNWR (med-low inc)	0	0	-0.5322	-0.9298	-5.1523	-3.0775	0	-1.9635	-2.4532	0
HNWR (med inc)	0	0	-0.5322	-0.9298	-6.7746	-3.0775	0	-1.9635	-2.4532	0
HNWR (med-high inc)	0	0	-0.5322	-0.9298	-6.7746	-3.0775	0	-1.9635	-2.4532	0
HNWR (high inc)	0	0	-0.5322	-0.9298	-6.7746	-3.0775	0	-1.9635	-2.4532	0
HNWO (low inc)	0	0	-0.6228	-0.8820	-1.7922	-3.5958	0	0.5638	-3.6761	0
HNWO (med-low inc)	0	0	-0.6228	-0.8820	-4.0940	-3.5958	0	0.5638	-3.6761	0
HNWO (med inc)	0	0	-0.6228	-0.8820	-6.0383	-3.5958	0	0.5638	-3.6761	0
HNWO (med-high inc)	0	0	-0.6228	-0.8820	-6.0383	-3.5958	0	0.5638	-3.6761	0
HNWO (high inc)	0	0	-0.6228	-0.8820	-6.0383	-3.5958	0	0.5638	-3.6761	0
NHBW	0	0	-2.5746	-4.1067	-12.3153	-3.6615	0	-8.4186	1.6734	0
NHBO	0	0	-0.3061	-0.7871	-11.4289	-3.3830	0	-6.5152	3.3701	0

**Table 8.10 Mode Choice Model Constants by Vehicle Sufficiency**

Purpose	Auto	DA	SR2	SR3+	TRN	TRD	TRW	NM	BIKE	WALK
HBW (no auto)	0	0	0.	0	0	0	0	0	0	0
HBW (auto < workers)	0	0	-3.7749	-2.2173	-9.3434	0	0	0	0	0
HBW (auto ≥ workers)	0	0	-3.7749	-2.2173	-9.3434	0	0	0	0	0
HNWE1 (no auto)	0	0	0.	0	0	0	0	0	0	0
HNWE1 (auto < workers)	0	0	0.3348	-0.1369	-4.6588	0	0	0	-1.2496	0
HNWE1 (auto ≥ workers)	0	0	0.3348	-0.1369	-4.6588	0	0	0	-1.2496	0
HNWE2 (no auto)	0	0	0.	0	0	0	0	0	0	0
HNWE2 (auto < workers)	0	0	0.3348	-0.1369	-4.6588	0	0	0	-1.2496	0
HNWE2 (auto ≥ workers)	0	0	0.3348	-0.1369	-4.6588	0	0	0	-1.2496	0
HNWR (no auto)	0	0	0.	0	0	0	0	0	0	0
HNWR (auto < workers)	0	0	0.3348	-0.1369	-4.6588	0	0	0	-1.2496	0
HNWR (auto ≥ workers)	0	0	0.3348	-0.1369	-4.6588	0	0	0	-1.2496	0
HNWO (no auto)	0	0	0.	0	0	0	0	0	0	0
HNWO (auto < workers)	0	0	0.3348	-0.1369	-4.6588	0	0	0	-1.2496	0
HNWO (auto ≥ workers)	0	0	0.3348	-0.1369	-4.6588	0	0	0	-1.2496	0
NHBW	0	0	0.	0	0	0	0	0	0	0
NHBO	0	0	0.	0	0	0	0	0	0	0

### 8.2.4 Auto Occupancy

Once person trips have been separated into the different available modes, it is necessary to convert person trips in vehicles to vehicle trips. This is accomplished through use of an auto occupancy factor. Each drive alone person trip is equivalent to one vehicle trip, and every two SR2 person trips are equivalent to a vehicle trip. The average auto occupancy for SR3+ trips is assumed to be 3.2.

## 9.0 Trip Assignment

Trip assignment is the final step of the four-step travel model. Trip assignment includes a process where person trips in vehicles from mode choice are converted into directional vehicle trips by time of day, followed by identification of specific paths taken by vehicle and transit trips. The resulting traffic volumes and transit boarding data are available for four time period, as well as a 24-hour period. Due to limited data, trips made using non-motorized modes are not assigned to the network.

When the model is run with speed feedback enabled, travel times resulting from traffic assignment are fed back to trip distribution. The model is then run iteratively until speeds input to trip distribution are reasonably consistent with speeds resulting from traffic assignment.

The traffic and transit assignment procedures in this version of the model remain relatively unchanged from the Destino model. Some roadway capacities have been updated, and volume delay function parameters have been revised.

### 9.1 Time of Day

#### 9.1.1 Time Period Definitions

The time period definitions have been retained from the Destino model, and are shown in **Table 9.1**.

**Table 9.1 Travel Model Time Periods**

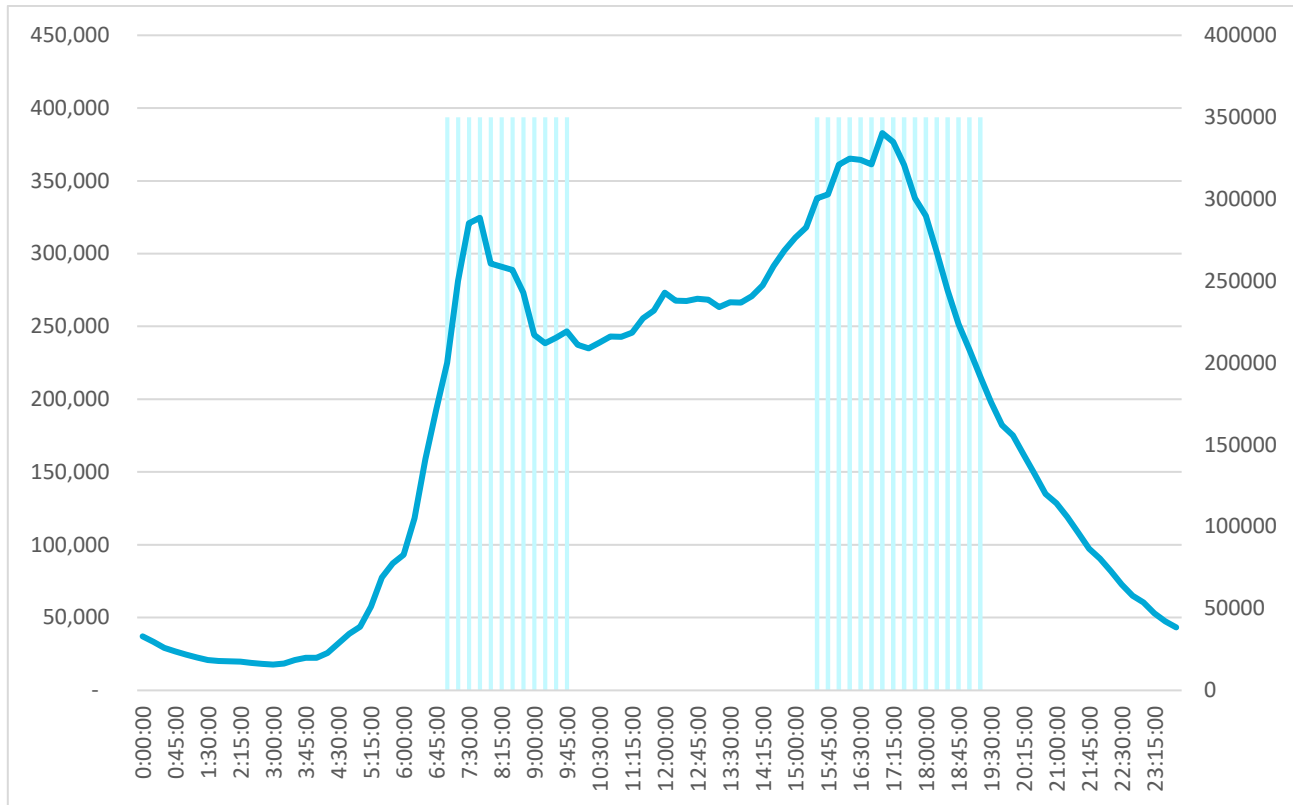
Period Name	Time Period	Description
AM	7:00 AM – 10:00 AM	AM Peak Period
PM	3:30 PM – 7:30 PM	PM Peak Period
MD	10:00 AM – 3:30 PM	Mid-Day Period
NT	7:30 PM – 7:00 AM	Night-Time Period

Source: Destino Travel Model, reviewed and retained for use in the El Paso MPO TDM22/52.

#### 9.1.2 Peak Hour Definition

The temporal distribution of time of day counts available via TxDOT (shown in **Figure 9.1**) identifies 7:30 AM – 8:30 AM as the AM peak hour with 38% of the AM period traffic occurring during the peak hour, and 4:30 PM – 5:30 PM as the PM peak hour with 29% of the PM period traffic occurring during the peak hour. The rest of the hours in the respective peak periods serve as shoulder hours.

**Figure 9.1 Diurnal Curve of 15-Min Interval Counts**



**9.1.3 Directional Time of Day Factors**

The El Paso MPO TDM22/52 uses directional time of day factors to convert trips from production-attraction (PA) format to origin-destination (OD) format and into four time periods. This process is based on data from the household travel survey indicating that trips are made directionally by time of day. For example, HBW trips generally occur from the production to the attraction (i.e., from home to work) in the AM peak and from the attraction to the production (i.e., from work to home) in the PM peak. It is also recognized that some trips are made in the reverse of this pattern and many trips are made outside of peak periods, so the factors represent this activity as well as the predominant movements.

In the travel model, time of day factors are applied directly to purpose-specific vehicle trip tables created by the mode choice model. As described in the **Section 6.1**, daily trip tables are separated into peak period (combined AM and PM peak periods) and off-peak (combined mid-day and off-peak) period trips during trip distribution. The traffic assignment time of day module further separates peak period trips into AM and PM peak period trips and off-peak trips into mid-day trips and other off-peak trips. During this conversion, trip tables are also converted from PA format to OD format. Peak period trips are then separated into sub-periods later in the process.

Time of day factors shown in **Table 9.2** identify the portion of trips by purpose and direction assigned to each time period. These detailed factors are based on the household travel survey, as traffic count data does not contain the trip purpose and direction information necessary to develop this table.

An earlier model step separates peak and off-peak trip tables from trip generation into peak and off-peak trip tables using factors defined in **Table 6.1**. Consequently, all AM and PM factors for each purpose sum to 1, as do MD and NT factors for each purpose. Because truck trips and IE/EI trips are not converted from PA to OD in this step, a single factor is provided for each period.

**Table 9.2 Pre-Assignment Directional Time of Day Factors**

Purpose	AM		PM		MD		NT	
	P to A	A to P	P to A	A to P	P to A	A to P	P to A	A to P
HBW	0.4391	0.0100	0.0598	0.4911	0.298	0.1597	0.2443	0.298
HNWE1	0.4417	0.0878	0.0903	0.3802	0.3852	0.377	0.086	0.1518
HNWE2	0.4463	0.0197	0.1518	0.3822	0.3787	0.3392	0.0508	0.2313
HNWR	0.0764	0.0411	0.3781	0.5043	0.3072	0.3134	0.116	0.2634
HNWO	0.2677	0.0512	0.2846	0.3965	0.2857	0.2413	0.1537	0.3193
NHB	0.1795	0.1799	0.3219	0.3188	0.3942	0.4108	0.1188	0.0762
LT	0.5567		0.4433		0.8973		0.1027	
HT	0.5567		0.4433		0.8973		0.1027	
IE/EI	0.4546		0.5454		0.8888		0.1112	
THRU	0.2273	0.2273	0.2727	0.2727	0.4444	0.4444	0.0556	0.0556

Source: Destino Travel Model, reviewed and retained for use in the El Paso MPO TDM22/52.

## 9.2 Traffic Assignment

The traffic assignment module assigns the time of day vehicle trip tables onto the roadway network, assigns the time of day vehicle trip tables onto the roadway network, distributing the travel demand. The El Paso MPO TDM22/52 assigns traffic with user equilibrium assignment, minimizing travel time for all vehicle trips assigned to the network. This iterative assignment algorithm calculates congested travel time as a function of link volume and shifts travelers to the shortest available path. As a result, user equilibrium traffic assignment represents traffic diversion from congested links.

### 9.2.1 Closure Criteria

After each iteration, the user equilibrium traffic assignment algorithm computes a relative gap corresponding to the difference between the previous and current iteration volumes. The algorithm stops when a pre-selected relative gap has been achieved, indicating the network has reached equilibrium, and users have optimized their paths. The relative gap parameter is set to 0.0001 for The El Paso MPO TDM22/52, providing a sufficient level of convergence for most model applications. Users may elect to specify a higher convergence criterion for specific applications if oscillations between equilibrium iterations result in unstable assignment results. The gap setting may need adjustment for applications where two very similar model runs (e.g., with only one small adjustment to the roadway network) produce non-intuitive results. There may also be cases when the network is extremely congested and the specified relative gap cannot be reached within a reasonable amount of time. This instance is addressed by setting an iteration limit of 500 for The El Paso MPO TDM22/52, and as with the gap criterion, the iteration limit can be adjusted if needed during model application.

### 9.2.2 Impedance Calculations

The impedance used for determining the shortest path in the traffic assignment model includes travel time and tolls. When including variables in addition to travel time, a generalized cost function, as demonstrated in the equation below, converts all variables to a consistent cost using a value of time.

$$\text{Generalized Cost} = \text{Time} * \text{Value Of Time} + \text{Toll Cost}$$

Since the base year model does not include tolls in the network, the toll cost is set to zero.

### 9.2.3 Volume-Delay Functions

During the assignment process, a volume-delay function represents the effect of increasing traffic volume on link travel time. While several volume delay functions are available for consideration, the most commonly used function is the modified Bureau of Public Roads (BPR) function. The modified BPR function is based on the original BPR equation shown below.

$$T_c = T_f \left( 1 + \alpha \left( \frac{V}{C} \right)^\beta \right)$$

Where:

$T_c$	= Congested travel time
$T_f$	= Freeflow travel time
$V$	= Traffic volume
$C$	= Highway design capacity (i.e., upper limit level of service C capacity)
$\alpha$	= Coefficient alpha (0.15)
$\beta$	= Exponent beta (4.0)

The modified BPR equation uses the same form, but replaces design capacity with ultimate capacity (i.e., upper limit LOS E). The modified function also replaces the coefficient alpha and the exponent beta with calibrated values that vary by functional class and area type. Alpha and beta values in The El Paso MPO TDM22/52 are shown in **Table 9.3**. Alpha and beta values were developed by monitoring link speed and VMT balance by functional class during the model validation process. The alpha and beta coefficients for centroid connectors are retained at the default BPR values, as centroid connectors are set with very high capacities of 10,000 vehicles per hour. This prevents the model from showing significant congestion on centroid connectors in particular.

**Table 9.3 Volume Delay Function Lookup Table (Alpha / Beta)**

	Functional Class	CBD (1)	CBD Fringe (2)	Urban (3)	Suburban (4)	Rural (5)
0	Centroid Connector	0.15 / 4.00	0.15 / 4.00	0.15 / 4.00	0.15 / 4.00	0.15 / 4.00
1	Freeway	1.20 / 5.20	1.20 / 5.20	1.20 / 5.20	1.20 / 5.20	1.20 / 5.20
2	Expressway	1.20 / 5.20	1.20 / 5.20	1.20 / 5.20	1.20 / 5.20	1.20 / 5.20
3	Principal Arterial	0.64 / 1.92	0.64 / 1.92	0.64 / 1.92	0.64 / 1.92	0.64 / 1.92
4	Minor Arterial	0.50 / 1.92	0.50 / 1.92	0.50 / 1.92	0.50 / 1.92	0.50 / 1.92
5	Collector	0.35 / 1.73	0.35 / 1.73	0.35 / 1.73	0.35 / 1.73	0.35 / 1.73
7	Local	0.35 / 1.73	0.35 / 1.73	0.35 / 1.73	0.35 / 1.73	0.35 / 1.73
20	Ramp	0.64 / 1.92	0.64 / 1.92	0.64 / 1.92	0.64 / 1.92	0.64 / 1.92
51	Transit Only	n/a	n/a	n/a	n/a	n/a
61	Non-Motorized	n/a	n/a	n/a	n/a	n/a

Source: Destino Travel Model, reviewed and updated for use in the El Paso MPO TDM22/52.

### 9.2.4 Multi-Class Assignment

The El Paso MPO TDM22/52 considers 14 different vehicles classes in the traffic assignment step: Single occupant vehicles (by income group for HBW trips and a single class for non-work trips), shared ride 2 vehicles, shared ride 3+ vehicles, light trucks, medium trucks, heavy trucks, external internal auto trips, through auto trips, and through truck trips. The El Paso MPO TDM22/52 does not assign transit vehicles to the highway network.

During constrained traffic assignment, vehicle classes are assigned simultaneously, but with slightly different settings. Some classes are prohibited from using certain links, and different values of time and toll values are permitted. A description of settings applied for each class is included below in **Table 9.4**, with value of time values. Values of time are divided by a perception factor of 70% which reflects lower perceived toll values associated with automated toll collection.

Once traffic assignment is complete, traffic volumes are available for each individual vehicle class.

- **Single Occupancy Vehicles:** SOVs are excluded from using HOV lanes and can be set to incur toll charges on express lanes or standalone toll facilities.
- **Shared Ride 2 Vehicles:** These vehicles are excluded from HOV links coded with a minimum occupancy requirement of 3 and can be set to incur toll charges on express lanes or standalone toll facilities.
- **Shared Ride 3+ Vehicles:** These vehicles can use any roadway link in the network but can still be set to incur tolls on express lanes or standalone toll facilities.
- **Trucks:** These trucks are excluded from HOV lanes and any link coded with a truck prohibition.

**Table 9.4 Perceived Value of Time by Vehicle Class**

<b>Vehicle Class</b>	<b>Value of Time (2022\$)</b>
SOV low income	\$3/hour (5 cents/min)
SOV med-low income	\$7.5/hour (12.5 cents/min)
SOV med income	\$10.8/hour (18 cents/min)
SOV med-high income	\$16.5/hour (27.5 cents/min)
SOV high income	\$33/hour (55 cents/min)
SOV non-work	\$7.2/hour (12 cents/min)
Shared Ride 2	\$7.2/hour (12 cents/min)
Shared Ride 3+	\$7.2/hour (12 cents/min)
Internal Trucks	\$7.2/hour (12 cents/min)
External Internal	\$7.2/hour (12 cents/min)
External Trucks	\$7.2/hour (12 cents/min)
External Auto	\$7.2/hour (12 cents/min)

Note: These values of time include a perception factor of 70%.

**9.2.5 Peak Hour Assignment**

The link peak hour link capacities are the product of the hourly lane capacities from the speed and capacity lookup table and the number of lanes on the link. The shoulder capacities are the difference between the period capacities and the peak hour capacities.

Before the traffic assignment step, the model splits the AM vehicle trip OD matrices into AM shoulder and AM peak hour matrices using the AM peak hour factor (38% peak hour, 62% shoulder). Similarly, the model splits the PM vehicle trip OD matrices into PM shoulder and PM peak hour matrices using the PM peak hour factor (29% peak hour, 71% shoulder).

AM and PM period flow files are the sum of the peak hour and shoulder flow files for the respective time periods.

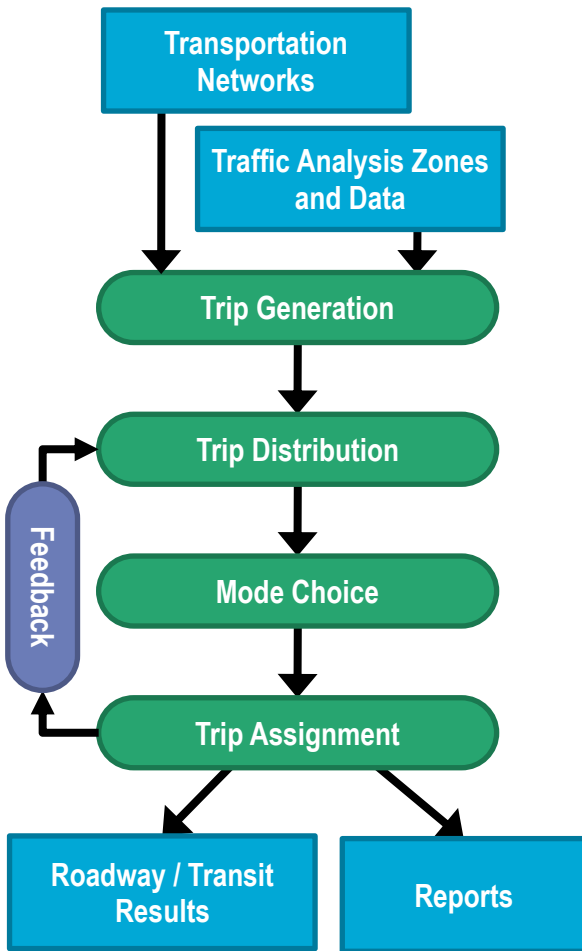
## 9.3 Speed Feedback

The trip distribution and mode choice model steps rely on congested zone-to-zone travel time information to distribute trips and identify mode shares. The traffic assignment step produces estimated congested travel speeds based on traffic flows and application of the volume-delay function. The speed inputs to trip distribution and mode choice are generally not consistent with the speed outputs from traffic assignment. To rectify this inconsistency, results from the AM traffic assignment are used to re-compute peak zone-to-zone travel times, and the results from the MD traffic assignment are used to re-compute off-peak zone-to-zone travel times. The model is, then, re-run, and a comparison is made between the initial and updated zone-to-zone travel times, as depicted in **Figure 9.2**. If the travel times are not reasonably similar, the updated travel times are then fed back to trip distribution and mode choice. This process is repeated iteratively until a convergence criterion or iteration limit is met.

Inclusion of a speed feedback process in the travel model can have interesting and desirable effects on the way the travel model represents the effects of network improvements in congested situations. Without speed feedback, overall regional travel demand remains constant regardless of the amount of roadway network congestion because trip distribution and mode choice patterns are not affected by changing congestion levels.

When speed feedback is incorporated into the model, heavy congestion reduces speeds, resulting in shorter trip patterns in highly congested areas. As roadway improvements are incorporated into the model, the resulting capacity increase results in faster travel speeds by reducing localized congestion. The higher speeds lead to longer trip lengths, which incrementally increases overall vehicle miles traveled. In the mode choice model, slower roadway speeds typically result in slower transit speeds, as well, minimizing the effect of speed feedback on transit results. Speed feedback has a more notable effect on transit results when modeling transit options that do not experience speed degradation as traffic congestion increases. Inclusion of speed feedback is most important from a mode choice perspective when using the model to test options such as BRT, rail, or improvements such as transit signal prioritization or queue jumps.

**Figure 9.2 Feedback Process**



**9.3.1 Method of Successive Averages**

The simplest approach to speed feedback merely feeds link speeds from traffic assignment back to the trip distribution and mode choice model steps. This approach often leads to convergence problems as trip distribution oscillates between long and short trip lengths. Instead, the model uses the method of successive averages (MSA) to implement speed feedback. With this approach, volumes resulting from traffic assignment are averaged over multiple iterations. These average volumes are then used in the volume delay equation to compute speeds for trip distribution and mode choice.

MSA calculates a simple average of all flows from previous assignment runs. MSA flows can be computed using the equations below.

$$MSAFlow_n = \left( MSAFlow_{n-1} - \frac{MSAFlow_{n-1}}{n} \right) + \frac{Flow_n}{n}$$

$$MSAFlow_n = MSAFlow_{n-1} + \frac{1}{n} (Flow_n - MSAFlow_{n-1}) \text{ [Simplified]}$$

Where:

<i>MSAFlow</i>	= Flow calculated using the MSA
<i>n</i>	= current iteration
<i>Flow</i>	= Flow resulting from traffic assignment

The method of successive averages assigns a weight to the traffic volumes from each traffic assignment iteration that is equal to the reciprocal of the iteration number. In other words, the volume results from each previous iteration are weighted equally when computing travel times for trip distribution. After calculating the new MSA-weighted flows, speeds on each roadway network link are re-estimated, and the remainder of the model is executed to complete the iteration.

### 9.3.2 Initial Speeds and Borrowed Feedback Results

Use of the MSA feedback procedure generates results that are sensitive to the initial speeds and travel times used in the first iteration of the trip distribution model. For this reason, caution must be used when comparing results of different model runs that include speed feedback. In cases where different model runs will be compared directly, when speed feedback model is active, initial congested speeds should be initialized using free flow.

In some cases, it may be desirable to test multiple alternatives without running speed feedback for each scenario. In these cases, the model can be run once with speed feedback enabled to establish a baseline forecast scenario (e.g., future growth on existing and committed network). The final model results with speed feedback can then be saved for use in alternative testing runs. Then, the model can be run using the saved speeds without running the speed feedback loop. When using this approach, the baseline scenario should be run a second time using the saved speeds and without feedback, ensuring consistency between all scenarios.

### 9.3.3 Convergence Criteria

It is important to specify a meaningful convergence criterion when running a model with speed feedback. The convergence criterion should be monitored during model runs to prevent unnecessary iterations of the speed feedback process, as the convergence measure will provide diminishing benefits after a certain point. The point at which the best possible convergence has been met will often vary with the level of congestion in a network. Therefore, it is particularly important to monitor speed feedback convergence when first running a dataset that is significantly different than previously considered scenarios.

Traffic assignment convergence settings also affect speed feedback convergence. If traffic assignment does not adequately converge, the speed feedback convergence measure may improve slowly or inconsistently. Alternately, if traffic assignment is set to converge more fully, the speed feedback convergence measure may improve more consistently and more quickly. However, closure settings that are too stringent can result in unreasonably long model run times.

### 9.3.4 Shortest Path Root Mean Square Error

Shortest Path Root Mean Square Error (% RMSE) is a common way to measure speed feedback convergence. This measure compares zone-to-zone travel time matrices between subsequent iterations, so % RMSE provides an indication of how similar the two travel time matrices are to one another. This approach directly satisfies the requirement that inputs to trip distribution and outputs from traffic assignment are

reasonably similar. This method also has the advantage of measuring convergence criteria without the need to run traffic assignment for the final iteration. This facilitates a simpler structure for the speed feedback model. The model uses % RMSE to monitor speed feedback convergence using the equation below.

$$\% RMSE = \frac{100 \cdot \sqrt{\sum_z (t_{z(i)} - t_{z(i-1)})^2}}{\frac{\sum_z t_{z(i)}}{n}}$$

Where:

% RMSE	= Percent Root Mean Square Error
$t_{z(i)}$	= Travel time for zone pair $z$ for feedback iteration $i$
$t_{z(i-1)}$	= Travel time for zone pair $z$ for feedback iteration $i - 1$
$n$	= Number of zone-to-zone pairs

### 9.3.5 Application of Speed Feedback for Alternatives Analysis

Speed feedback ensures travel time consistency within the entire modeling structure. It was conceived as a model enhancement in the early 1990's, largely in response to environmental lawsuits, though, now, it is good practice and considered a necessity. Generally, speed feedback is most sensitive to network changes that provide a significant travel time improvement. These types of alternatives warrant running the feedback process because they can affect regional travel patterns. Less significant improvements can also affect travel times and regional travel patterns to various degrees and should be considered for feedback.

For all interim milestone and horizon years, speed feedback should be executed. For subsequent alternatives analysis, speed feedback should be considered for any of the conditions listed below. Further information on available speed feedback settings is presented in **Section 9.3.2**.

- A significant new roadway alternative (i.e., new or greatly improved access) would likely warrant speed feedback. This applies to cases where new or significantly improved access is provided to areas that are undeveloped, developing, or already developed. For undeveloped areas, it is likely the effect is more significant in later years. Examples include new freeway interchanges, new freeway lanes, new freeways and arterials, and in limited cases new collector roads.
- Minor roadway improvements may justify running speed feedback. These might include roadway widening or corridor improvements which imply functional class, speed, or capacity changes. Improvements limited to a short section of roadway, or, simply, an intersection, generally would not warrant running speed feedback.
- A significant change to socio-economic assumptions when compared to the base case. Speed feedback is more likely necessary for widespread involving significant demographic shifts but may also be warranted after changes to a small number of high-activity zones. Socio-economic changes should also include an update to area type assumptions.
- Significant changes to external trip or special generator assumptions.
- Any model run in which a significant anticipated congestion changes on a corridor could affect regional travel times and travel patterns. This criterion is largely covered by those above.

- Changes to model parameters, factors, coefficients, etc. – *Note: These changes should only be made in conjunction with model calibration and validation, but any tests of changes to parameters should include running the feedback process.*

## 9.4 Transit Assignment

Transit person trips resulting from the mode choice model are assigned to the transit route system. Each trip is assigned from zone centroid to zone centroid using the roadway network (for access and egress) and transit routes. The transit assignment step does not include capacity constraint, so increasing transit volumes does not result in diversion of transit trips to other transit service.

Transit assignment results include the total number of boardings at each transit stop, as well as transit volumes on all stop to stop transit route segments. However, transit results are generally best evaluated at the systemwide or route group level. Individual route, stop, and segment values have not been validated to observed conditions. Prior to using the model to support detailed transit corridor studies, a focused transit model calibration and validation effort is recommended.

## 10.0 Calibration and Validation

The El Paso MPO TDM22/52 has been calibrated to match household travel survey data and location-based services data, and validated to traffic count and transit boarding data. This section documents the stepwise model calibration and validation process.

### 10.1 Trip Generation Calibration

Since new household survey data were not available for this model update, the trip rates estimated and calibrated for the Destino model served as a starting point for the trip distribution model. Trip rates obtained from the Destino Model were factored so that overall travel model volumes match regional VMT totals. Based on analysis of model validation in areas with high and low income households, higher factors were applied to the highest income groups. Trip rates reflect factoring conducted during model calibration.

### 10.2 Trip Distribution Calibration

#### 10.2.1 Trip Distribution Calibration

The trip distribution model was calibrated by comparing observed and modeled average trip lengths and trip length frequency distributions. Observed trip length frequency distributions (TLFDs) were created using trip tables extracted from household survey data and LBS data. These trip tables were combined with congested shortest path matrices generated by the model. The TLFDs resulting from the two different sources were reasonably similar and served as trip distribution calibration targets.

Trip distribution calibration began with friction factors from the Destino Model. Friction factors were converted from table form to gamma functions, represented by the formula described in **Section 6.2**. These friction factors served as a starting condition for initial application in The El Paso MPO TDM22/52. The initial factors were iteratively adjusted to improve the match between modeled and observed TLFDs. This iterative process was repeated several times, as the shortest path matrices are sensitive to other changes in the model such as network, trip rate, and mode choice adjustments. Shortest path matrices for each trip length calibration exercise were generated using results from a full feedback model run.

Three measures of trip length calibration include average trip travel time, coincidence ratio between the observed and modeled TLFDs, and a visual comparison of the observed and modeled TLFDs. The coincidence ratio, representing the portion of area under both the observed and modeled curves, is a value that can range from zero to one, with one indicating a perfect match. A comparison of coincidence ratios and average daily trip travel times by trip purpose is shown in **Table 10.1**, with trip length frequency distributions for each trip purpose shown in **Figure 10.1** through **Figure 10.5**. Calibration was performed separately for peak and off-peak conditions, with results summed to daily for the statistics shown below.

Note that friction factors were refined beyond targets from the survey and the LBS to maintain intrazonal trip shares below 5% for the region as a high share of intrazonal trips has implications on air quality analysis for future years. This is why trip length frequency distribution charts may not match perfectly for some trip purposes.

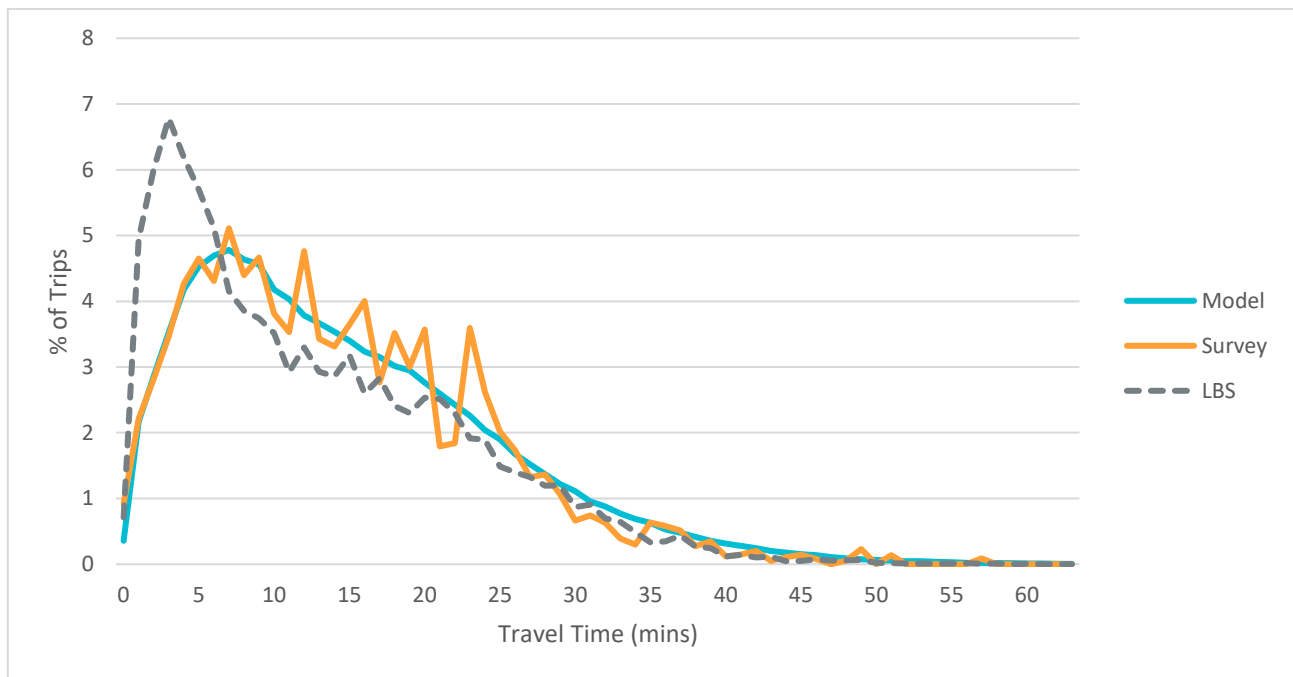
**Table 10.1 Average Daily Travel Times by Trip Purpose**

Purpose	Average Trip Travel Time			Coincidence Ratios	
	Modeled	Target (Survey)	Target (LBS)	Survey	LBS
HBW	9.9	14.7	12.9	0.87	0.77
HNWE	7.0	7.0	-	0.55	-
HNWR	6.0	9.3	10.5	0.79	0.78
HNWO	7.8	10.7	10.5	0.79	0.76
NHB	7.2	8.8	9.8	0.82	0.85

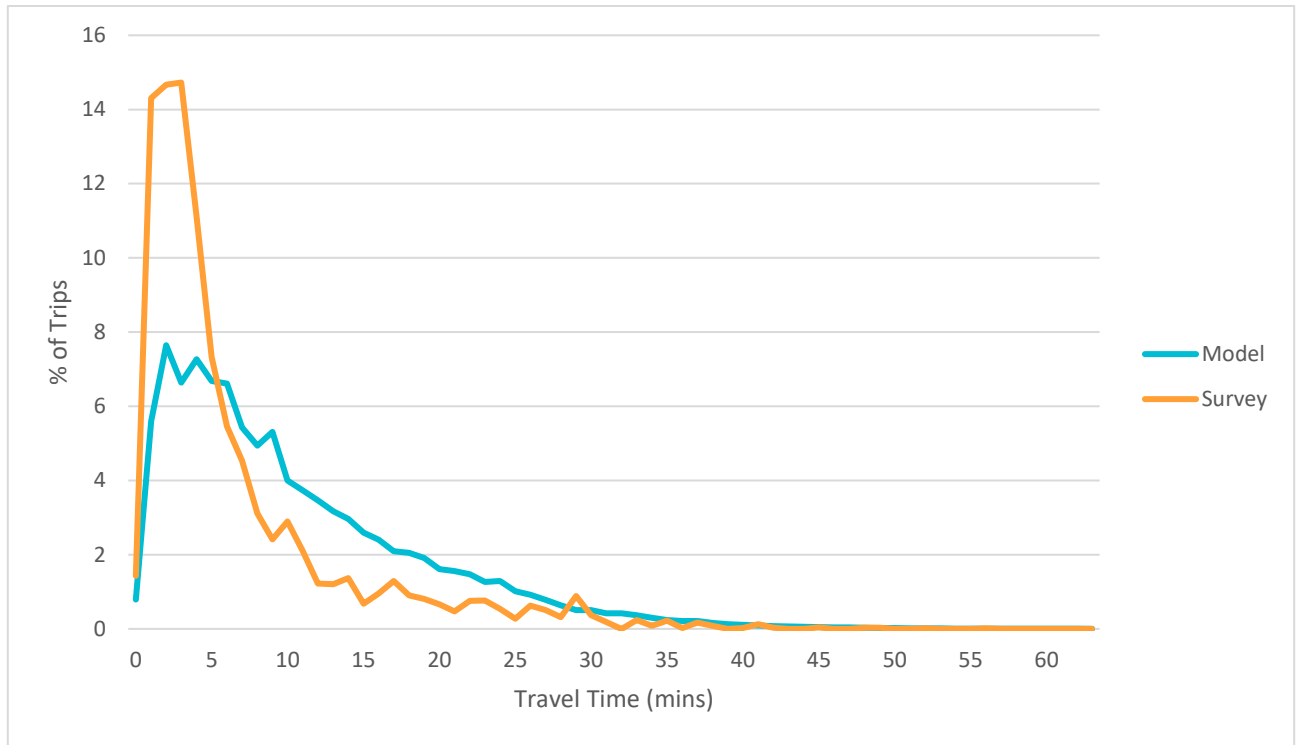
Source: El Paso MPO TDM22/52 Model Output Files, 2010-2011 Household Travel Survey, and 2023 LBS Data

Note: HNWE1 and HNWE2 have been combined from the model to better compare against survey data  
 HNWR and HNWO trips from the model compare against HBO trips from the LBS Data.

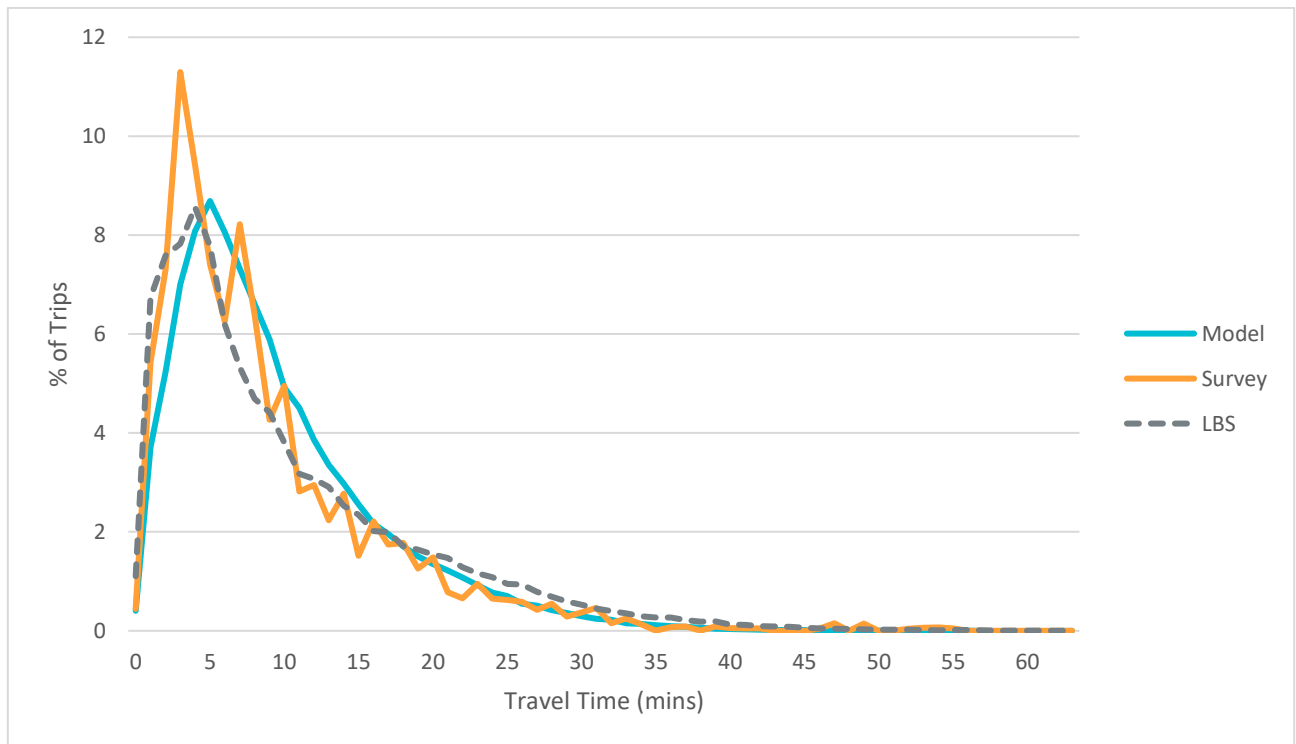
**Figure 10.1 Home-Based Work Trip Length Frequency Distribution**



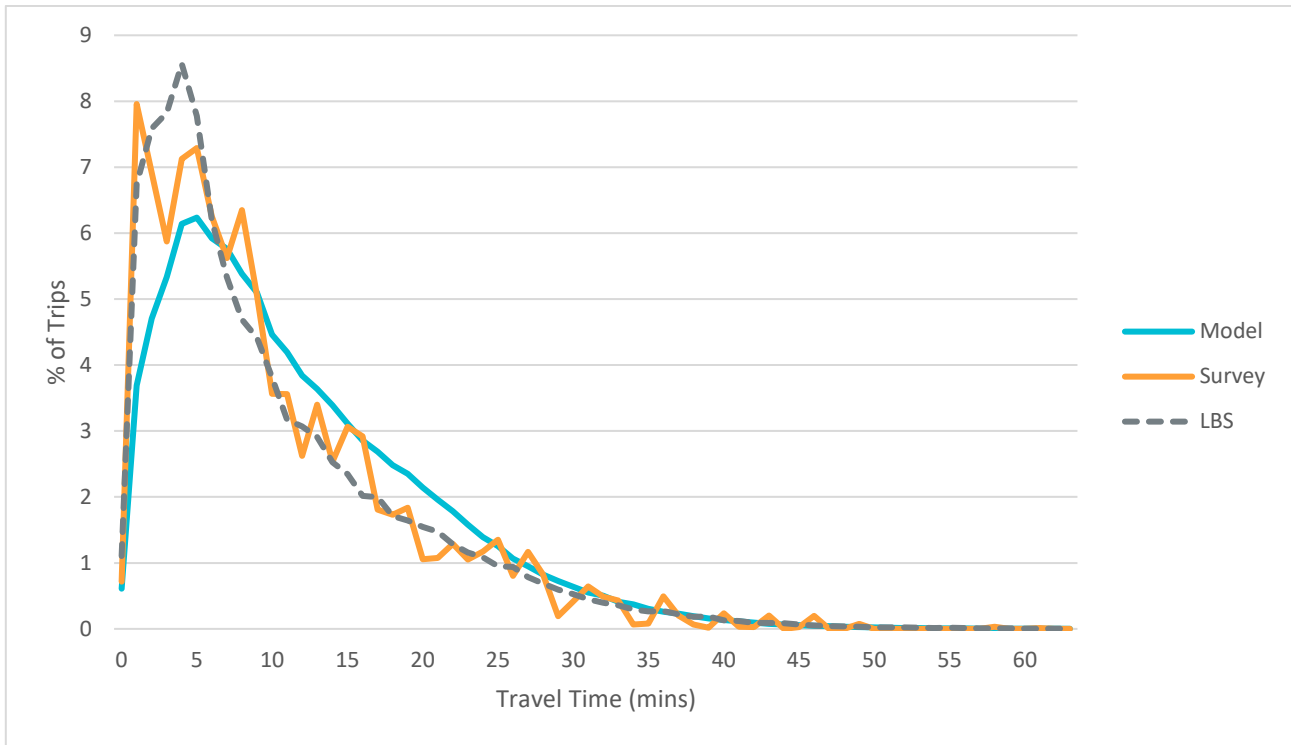
**Figure 10.2 Home-Based Non-Work Education Trip Length Frequency Distribution**



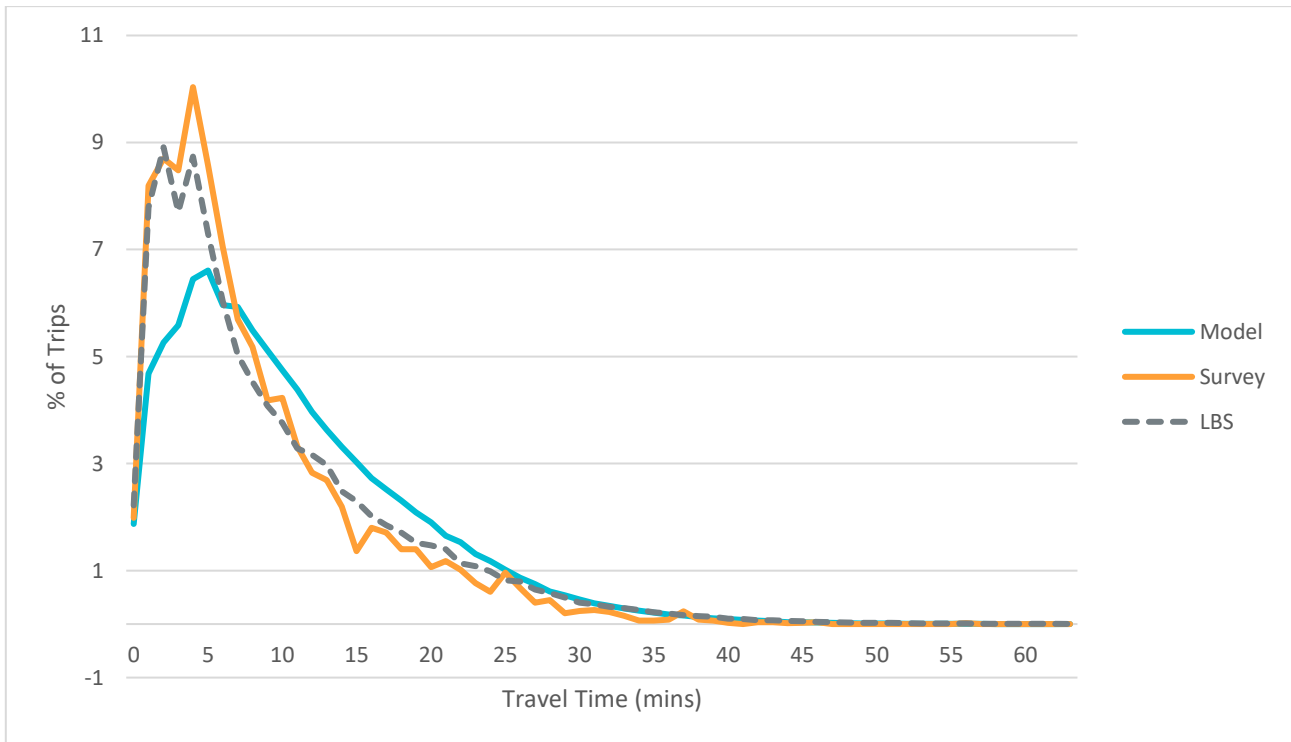
**Figure 10.3 Home-Based Non-Work Retail Trip Length Frequency Distribution**



**Figure 10.4 Home-Based Non-Work Other Trip Length Frequency Distribution**



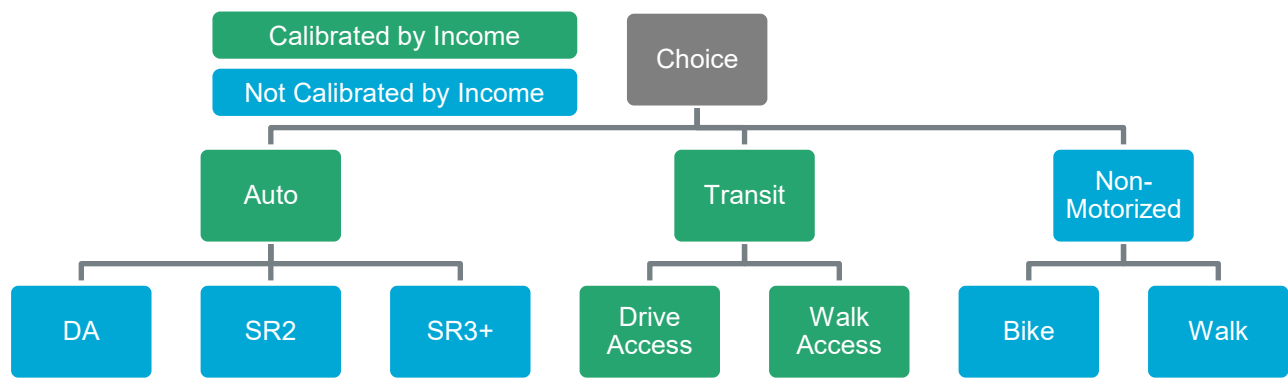
**Figure 10.5 Non-Home Based Trip Length Frequency Distribution**



### 10.3 Mode Choice Calibration

The mode choice model has been calibrated to the targets documented in **Section 8.1**. Calibration was performed by iteratively running the mode choice model, and then adjusting ASCs for each mode and purpose. The El Paso MPO TDM22/52 includes a calibration tool that automatically calibrates mode choice to match a given set of targets. This tool calibrates constants using a tiered approach, considering top-level modes separately from bottom-level modes. This helps prevent over-specification of the model by restricting income group calibration to modes with sufficient data. For certain modes, there are insufficient data or variation to calibrate constants by income. **Figure 10.6** shows which modes and sub-modes in the nested logit structure are calibrated by income, and which are not. A summary of mode choice calibration results is shown in **Table 10.2** through **Table 10.4**.

**Figure 10.6 Mode Choice Calibration Methods**



**Table 10.2 Mode Choice Calibration Targets – Number of Trips**

Purpose	Drive Alone	SR2	SR3	Transit Drive	Transit Walk	Bike	Walk
HBW	444,634	33,883	8,362	172	2,602	889	4,061
HNWE1	80,596	162,700	231,813	59	691	3,006	53,626
HNWE2	38,145	11,476	4,161	157	1,669	73	344
HNWR	167,296	142,550	110,267	216	2,980	1,241	5,219
HNWO	164,614	140,519	132,422	211	3,818	2,035	25,886
NHBW	122,931	17,568	5,114	29	588	15	2,823
NHBO	182,253	231,287	184,297	129	2,032	508	19,360
<b>All Purposes</b>	<b>1,200,469</b>	<b>739,982</b>	<b>676,435</b>	<b>974</b>	<b>14,380</b>	<b>7,766</b>	<b>111,319</b>

Source: Analysis of 2010-2011 Household Survey Data and 2022 Transit Boarding Data

**Table 10.3 Mode Choice Model Results – Number of Trips**

Purpose	Drive Alone	SR2	SR3	Transit Drive	Transit Walk	Bike	Walk
HBW	445,614	32,820	7,917	180	2,667	959	4,517
HNWE1	82,103	160,764	224,919	59	701	3,323	60,630
HNWE2	38,244	11,405	4,120	161	1,684	75	355
HNWR	168,978	141,839	108,769	217	3,020	1,324	5,663
HNWO	166,478	139,007	129,286	213	3,864	2,200	28,504
NHBW	123,522	17,048	4,885	29	589	16	3,112
NHBO	185,853	229,439	180,494	129	2,043	560	21,359
<b>All Purposes</b>	<b>1,210,793</b>	<b>732,323</b>	<b>660,390</b>	<b>987</b>	<b>14,568</b>	<b>8,458</b>	<b>124,141</b>

Source: El Paso MPO TDM22/52 Model Output Files.

**Table 10.4 Mode Choice Calibration Results – Percent Difference**

Purpose	Drive Alone	SR2	SR3	Transit Drive	Transit Walk	Bike	Walk
HBW	0.2%	-3.1%	-5.3%	4.2%	2.5%	7.9%	11.2%
HNWE1	1.9%	-1.2%	-3.0%	-0.4%	1.5%	10.6%	13.1%
HNWE2	0.3%	-0.6%	-1.0%	2.7%	0.9%	3.1%	3.2%
HNWR	1.0%	-0.5%	-1.4%	0.2%	1.4%	6.7%	8.5%
HNWO	1.1%	-1.1%	-2.4%	0.9%	1.2%	8.1%	10.1%
NHBW	0.5%	-3.0%	-4.5%	-0.6%	0.1%	9.2%	10.2%
NHBO	2.0%	-0.8%	-2.1%	-0.2%	0.5%	10.2%	10.3%
<b>All Purposes</b>	<b>0.9%</b>	<b>-1.0%</b>	<b>-2.4%</b>	<b>1.3%</b>	<b>1.3%</b>	<b>8.9%</b>	<b>11.5%</b>

Source: El Paso MPO TDM22/52 Model Output Files, 2010-2011 Household Survey Data, and 2022 Transit Boarding Data.

## 10.4 Traffic Assignment Validation

Traffic assignment validation is the process of comparing modeled traffic volumes to traffic count data. Validation ensures that the model reasonably matches observed traffic patterns in the base year. It uses traffic count data obtained from various sources, which are mapped onto the roadway network. Comparisons were made using a variety of techniques, including regional comparisons and inspection of individual link values.

### 10.4.1 Overall Activity Level

Overall vehicle trip activity was validated by comparing count data to model results on all links where count data is available using two statistics: Model volume to count volume ratio and model VMT as compared to count VMT. These statistics were reviewed at functional class, area type, and regional levels, as shown in **Table 10.5**.

**Table 10.5 Regional Modeled Volumes and VMT vs. Counts**

Link Type	Modeled Volumes/ Counts	Modeled VMT/ Count VMT	Target
Freeways	102.5%	105.8%	+/- 10%
Expressways	99.9%	102.1%	+/- 10%
Principal Arterials	102.1%	100.1%	+/- 10%
Minor Arterials	96.0%	94.5%	+/- 10%
Collectors and Frontage Roads	94.7%	90.9%	+/- 25%
CBD	96.2%	95.7%	n/a
CBD Fringe	100.6%	89.1%	n/a
Urban	100.7%	97.2%	n/a
Suburban	99.3%	97.8%	n/a
Rural	111%	103.8%	n/a
<b>Total</b>	<b>100.1%</b>	<b>98.4%</b>	<b>+/- 5%</b>

Source: El Paso MPO TDM22/52.

Note: Activity level targets are based on industry standard practice guidelines, not a rule or regulation.

### 10.4.2 Measures of Error

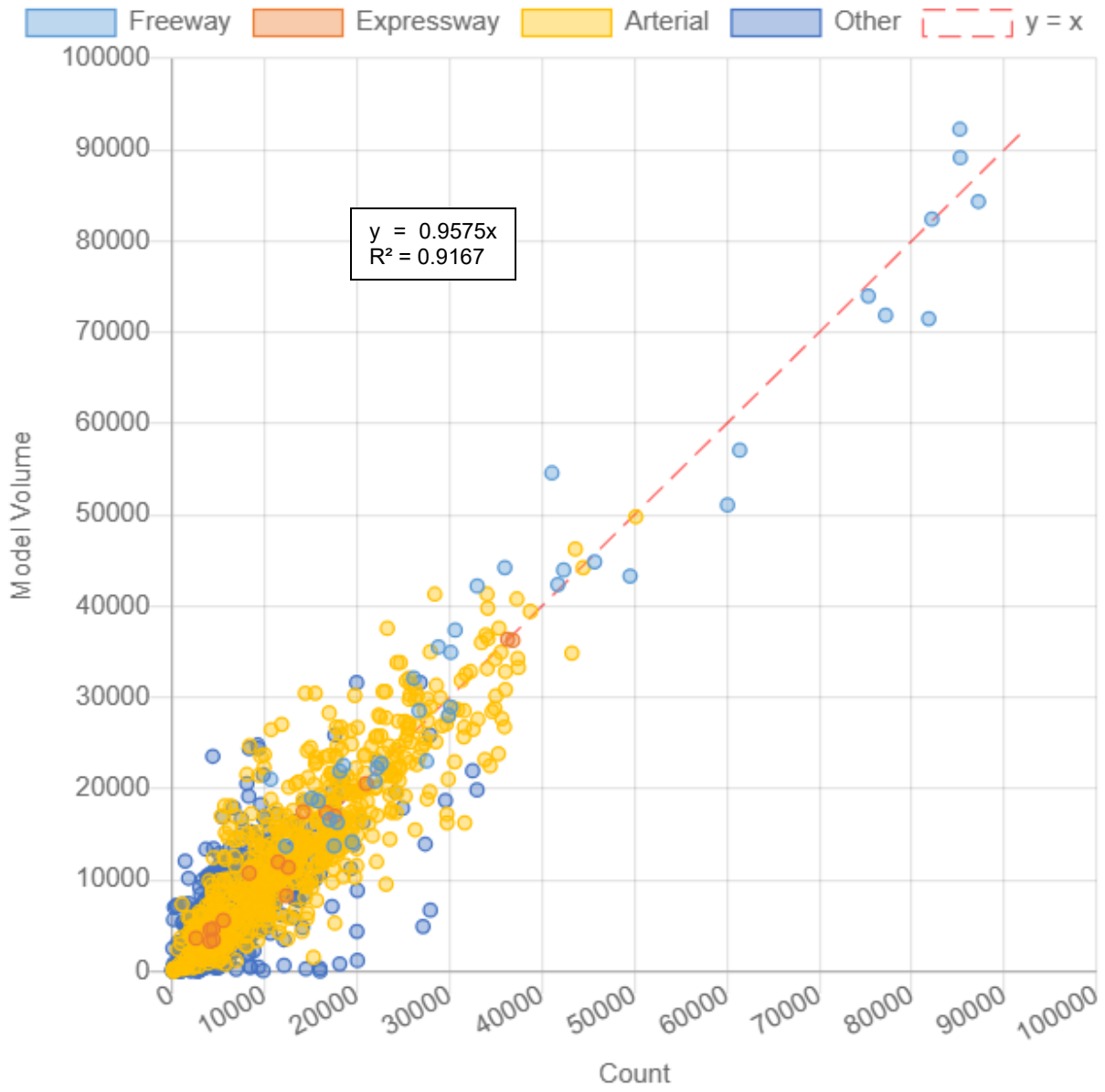
While the model should accurately represent the overall level of activity, it is equally important to verify the model maintains an acceptable level of error. The model is not expected to perfectly reproduce count volumes on every link, but the level of error should be monitored. The plot shown in **Figure 10.7** demonstrates the ability of the El Paso MPO TDM22/52 to match individual traffic count data points.

**Table 10.6** lists RMSE and percent RMSE values along with target values by functional class and area type. General guidelines suggest that percent RMSE should be below 40 percent region-wide, with values near or below 30 percent for high volume facilities such as freeways. The percent RMSE measure tends to over-represent errors on low volume facilities, so values on collectors are not particularly meaningful.

Percent RMSE is expected to be higher on low volume facilities, decreasing as volumes increase.

**Table 10.7** show the percent RMSE values by volume group, demonstrating low percent RMSE values for high volume facilities.

**Figure 10.7 Model Volume/Count Comparison**



**Table 10.6 RMSE Statistics by Link Type**

Link Type	RMSE	% RMSE	Target	Number of Links with Counts
Freeways	5,459	14.0%	10-20%	37
Expressways	1,631	12.3%	20-30%	16
Principal Arterials	4,819	28.6%	< 40%	375
Minor Arterials	3,874	41.6%	< 50%	328
Collectors and Frontage Roads	3,699	67.6%		201
CBD	2,453	35.9%	n/a	39
CBD Fringe	2,360	42.6%	n/a	27
Urban	5,053	41.1%	n/a	373
Suburban	4,399	37.6%	n/a	797
Rural	2,351	50.7%	n/a	121
<b>Total</b>	<b>4,374</b>	<b>39.8%</b>	<b>&lt; 40%</b>	<b>1,357</b>

Source: El Paso MPO TDM22/52.

Note: RMSE targets are based on industry standard practice guidelines, not a rule or regulation.

**Table 10.7 RMSE Statistics, by Volume Group**

Volume Group	Links	RMSE	% RMSE
0 - 1,000	115	4,010	153.5%
1,000 - 5,000	327	3,130	71.8%
5,000 - 10,000	328	3,548	48.5%
10,000 - 20,000	380	4,598	33.9%
20,000 - 30,000	143	6,510	29.6%
30,000 - 50,000	54	6,554	20.4%
50,000 - 100,000	10	7,390	10.0%
100,000 and up	0	0	--
<b>All Links</b>	<b>1,365</b>	<b>4,374</b>	<b>39.8%</b>

Source: El Paso MPO TDM22/52.

### 10.4.3 Screenline Analysis

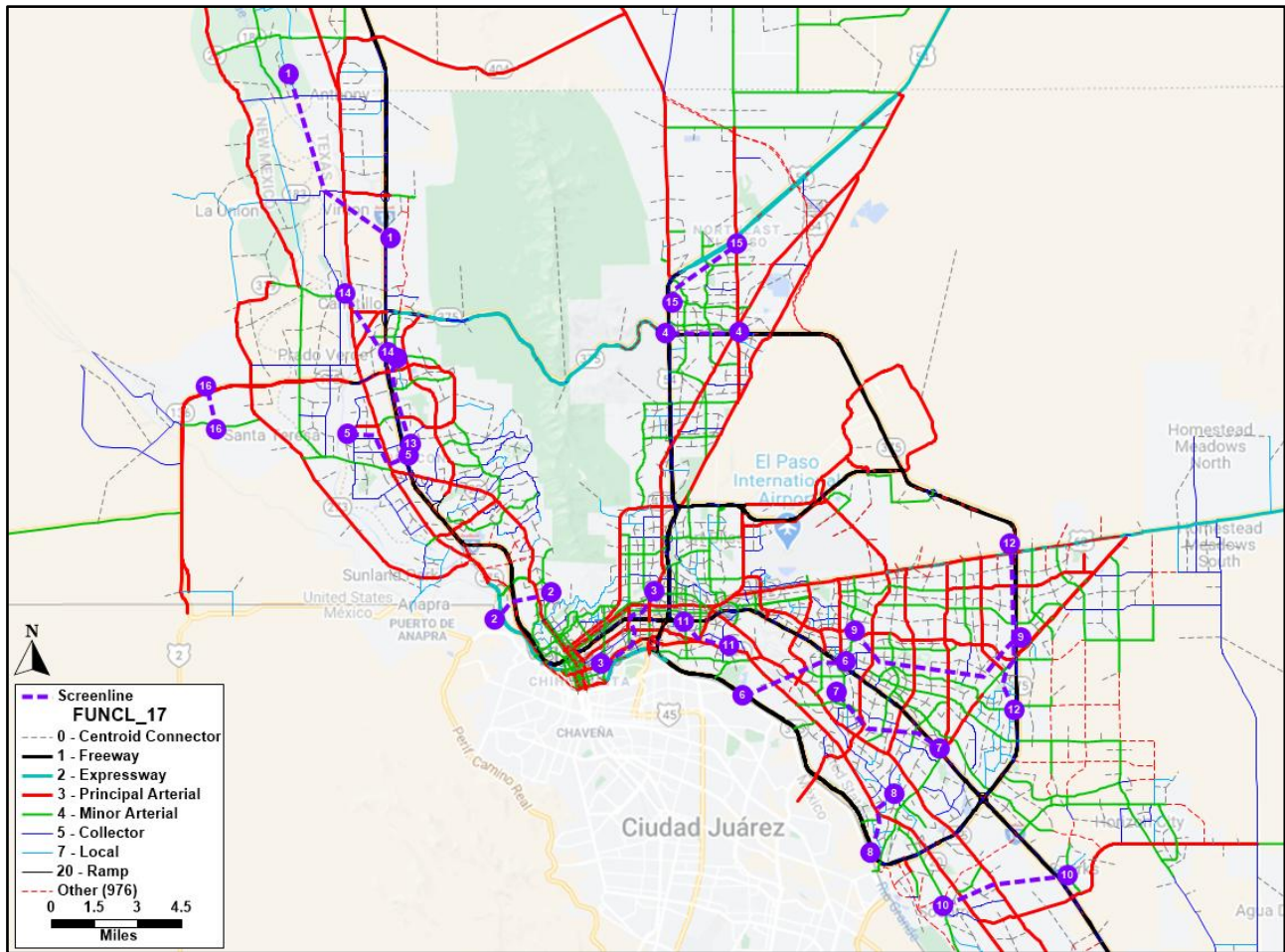
The El Paso MPO TDM22/52 includes 16 screenlines, shown in **Figure 10.8**. Screenlines capture distinct regional or inter-regional travel patterns and can be useful in understanding the model’s trip generation and trip distribution characteristics. Screenlines have been drawn to cover links that either have observed traffic volumes or are known to carry very low traffic volumes. As demonstrated in **Table 10.8** and **Figure 10.9**, error on each screenline falls within the maximum desirable error as defined in NCHRP Report 255, with most falling below 15%.

**Table 10.8 TDM22/52 Screenline Analysis**

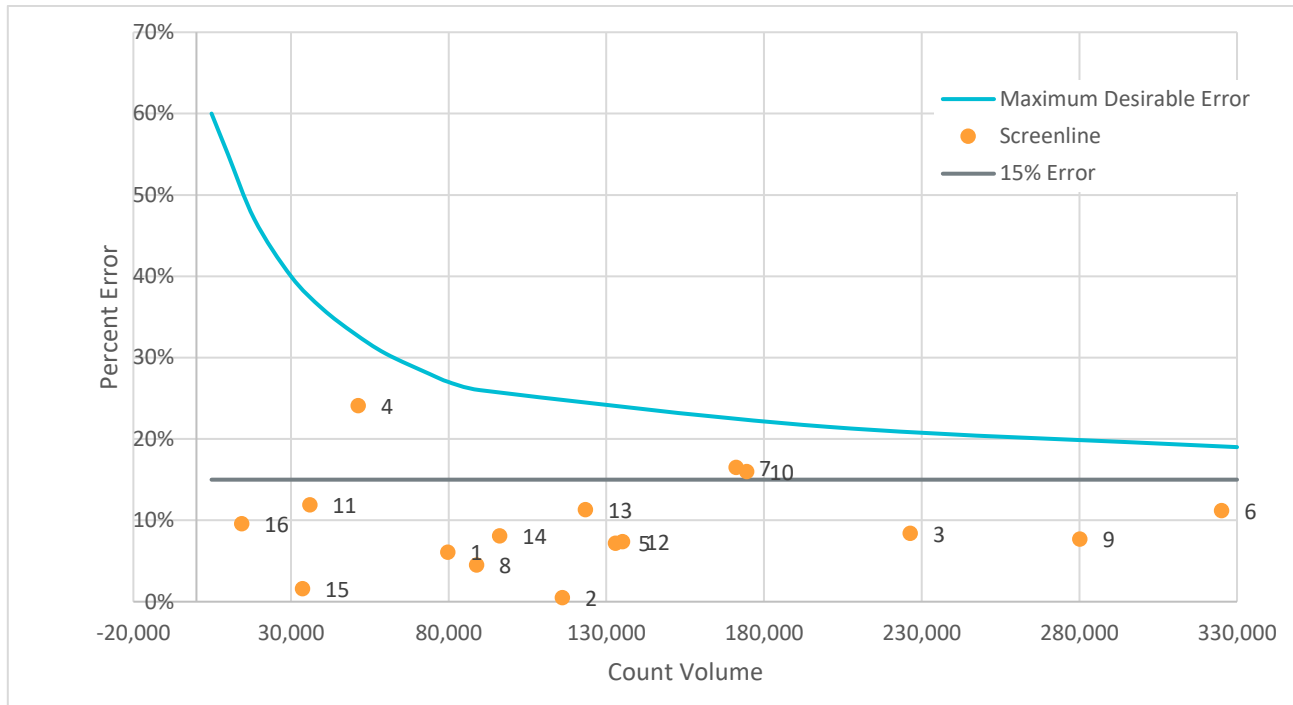
Screenline	Model Volume	Observed Volume	% Error
1	74,860	79,690	-6.10%
2	115,554	116,090	-0.50%
3	245,389	226,370	8.40%
4	63,710	51,350	24.10%
5	142,508	132,920	7.20%
6	288,625	325,104	-11.20%
7	142,967	171,200	-16.50%
8	84,866	88,826	-4.50%
9	258,621	280,160	-7.70%
10	146,556	174,521	-16.00%
11	40,190	35,930	11.90%
12	125,140	135,170	-7.40%
13	109,392	123,360	-11.30%
14	104,024	96,191	8.10%
15	33,070	33,610	-1.60%
16	15,781	14,400	9.60%

Source: El Paso MPO TDM22/52.

Figure 10.8 TDM22/52 Model Screenlines



**Figure 10.9 TDM22/52 Model Screenline Analysis**



### 10.5 Transit Assignment Validation

Transit assignment has been validated to observed route boardings by the route groups shown in **Figure 10.10**. As shown in **Table 10.9**, the overall number of boardings is nearly identical to observed values. The Central/Northeast group is moderately under-predicted, with other groups slightly over-predicted. The County service provides rural connections to the Sun Metro system and is not concentrated in any one geographic area. While the percent error is high for the county system, further adjustments were not performed for the county route group since it carries a relatively small share of overall transit riders.

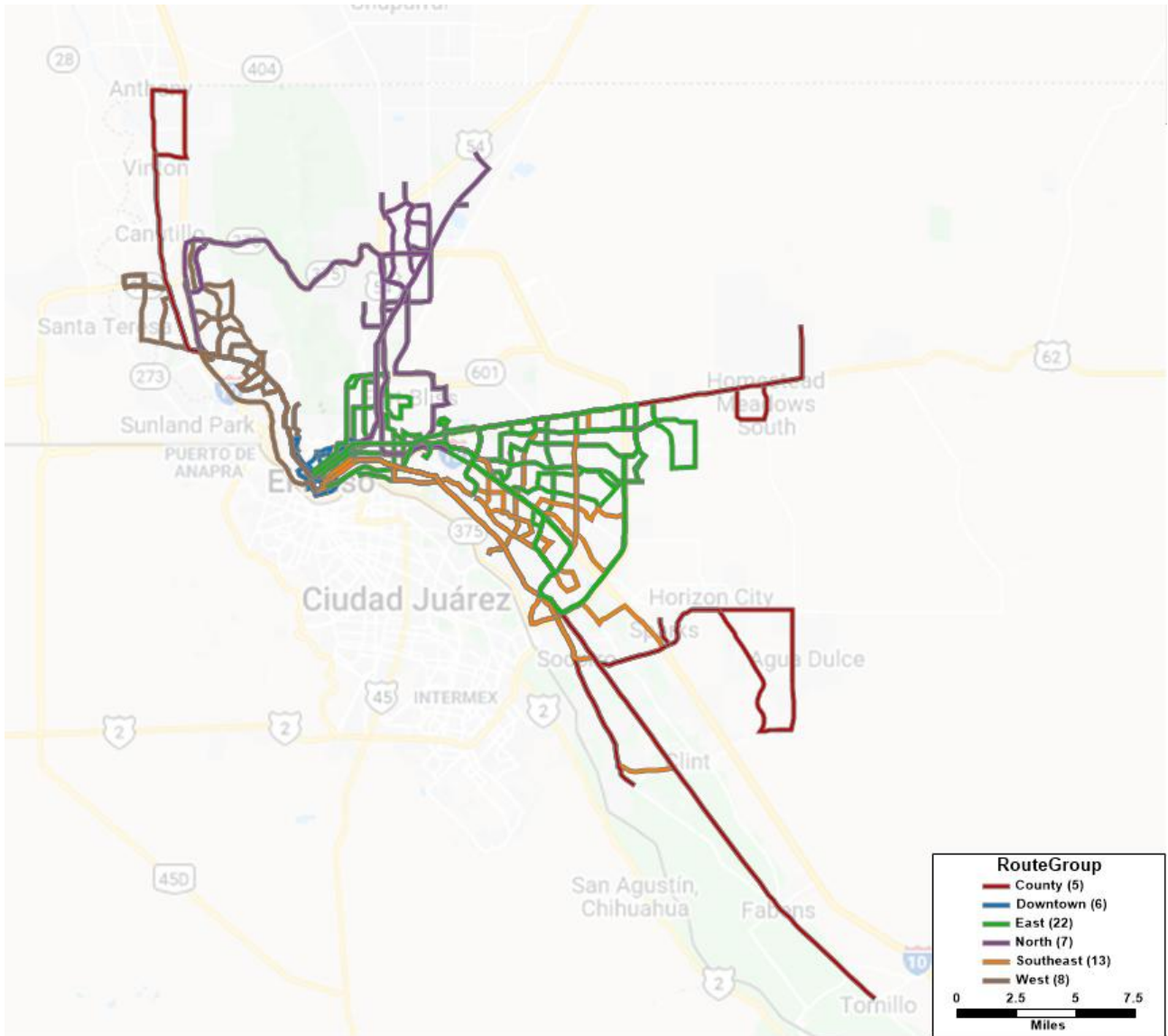
The transit assignment validation results show The El Paso MPO TDM22/52 is sufficiently calibrated to support testing of transit alternatives and scenarios on a regional basis. The model is useful for comparative analysis of different transit improvements and accounts transit as part of the overall transportation system in the region. The model serves as a starting point for detailed transit planning activities, such as corridor studies or New Starts/Small Starts analysis. If the model is used for detailed transit planning, localized calibration and validation efforts should be conducted.

**Table 10.9 Transit Assignment Results**

<b>Route Group</b>	<b>Observed</b>	<b>Modeled</b>	<b>Error</b>	<b>% Error</b>
East	5,814	4,851	-963	-17%
Southeast	5,550	5,350	-200	-4%
Downtown	1,507	945	-562	-37%
West	4,750	3,854	-896	-19%
North	3,315	4,980	1,665	50%
<b>Sun Metro Subtotal</b>	<b>20,936</b>	<b>19,980</b>	<b>-956</b>	<b>-5%</b>
County	1,327	1,252	-75	-6%
<b>Total</b>	<b>22,263</b>	<b>21,232</b>	<b>-1,031</b>	<b>-5%</b>

Source: El Paso MPO TDM22/52 and 2022 transit boardings data obtained from Sun Metro and the National Transit Database.

Figure 10.10 Route Group Definitions



## Appendix A. LOCUS Location Based Services Data

While household travel surveys collect rich information about the traveler and their travel behavior, they are costly, time consuming to conduct, and typically have small sample sizes. Practitioners have also noted declining participation rates in traditional surveys.

In contrast, passively collected location data from mobile devices are increasingly valuable for analyzing travel patterns. These data can provide detailed information about how people are moving, where they are going, and when their travel is occurring. These datasets are also massive in size, often containing millions of records collected over a period of months, rather than the typical 1- to 2-day travel diary often collected by travel surveys. Not only does this generate a larger overall sample, travel patterns can be tracked over the course of days, weeks, or even months to capture more frequent travel patterns. However, location data cannot provide all of the disaggregate household information available from household travel surveys.

A variety of passive mobile device data collection paradigms exist, including call detail records (CDR), Global Positioning Systems (GPS) data, and location-based services (LBS) data from smartphones. LBS data are the newest type of passively collected cell phone data, but are quickly becoming more ubiquitous.

LBS data are collected by GPS applications running either in the background or foreground on smartphones, where the device user has opted to allow access to the app to track the device's geographic location. The data are anonymized so that information cannot be tracked to a particular mobile phone number.

Cambridge Systematics performed a study for National Cooperative Highway Research Program (NCHRP) to estimate origin-destination (O-D) trip matrices with mobile data. The LBS product, LOCUS, used to support the El Paso model update efforts, was developed using analytics developed for the NCHRP study but has been refined to support modeling work.

The data contain a series of events for each smartphone device, where each event represents a cluster of time and location data points. The spacing of the events in the data is not regular; in some cases, events may be closely grouped with only small time gaps in between them, while in other cases, time gaps between events could be several hours or more. Time gaps depend on a variety of conditions, including the frequency with which the device is used and the types of apps running on the device.

Each event is classified as either a visit or a trajectory, depending on whether the device was stationary (resulting in a visit) or moving (resulting in a trajectory). For each event, several data fields exist, including start time, duration, and starting and ending coordinates. We process these events to identify trip stops, measure travel movements, and quantify travel demand.

**LOCUS** has previously been applied to support modeling work in metropolitan areas of varying size, and now for the El Paso region. The analytical framework is described below in greater detail.

### Data Description

The data used for the El Paso region come from a dataset of mobile devices (including residents and visitors) observed in the modeling area. The data collection period includes the full year of 2023. As a consequence of this large sample size, detailed conclusions can be drawn about key aspects of travel, including O-D flows, time of day distribution, day of the week flows, and travel purpose.

## Key Analytics Steps

Three key analytical steps were applied to take the trip data generated from the LBS dataset to convert into a usable dataset for use in travel model calibration and validation. These are described briefly below:

- **Identify Home and Regular Locations** – The first step in processing the raw location information was to filter trajectory events, identify activity stays, and infer trips. Once activity stays and trips were extracted for each device, home and work locations were inferred based on stay durations and time of day/day of the week frequencies.
- **Expand to Match Population and Employment Estimates** – Expansion methods were then applied to the processed LOCUS data to match El Paso population and employment estimates for the region. The weighted metrics provide estimates of person trips rather than index scores that could be biased.
- **Normalize Data to Develop Average Weekday and Weekend Day Travel Patterns** – Devices often provide a different number of valid/usable days. As a final step, multi-day travels were normalized by day of week for each device to capture typical weekday, Saturday, and Sunday daily travel patterns.

## Appendix B. Transit Delay Parameters

**Table 10.10 Peak Local Transit Delay Factors**

Functional Class	CBD (1)	CBD Fringe (2)	Urban (3)	Suburban (4)	Rural (5)
0 Centroid Connector	n/a	n/a	n/a	n/a	n/a
1 Freeway	0	0	0	0	0
2 Expressway	0	0	0	0	0
3 Principal Arterial	0	0	0	0	0
4 Minor Arterial	1.00	0.80	0.70	0.70	0.70
5 Collector	0.50	0.20	0.50	0.10	0.00
7 Local	0.50	0.20	0.10	0.10	0.10
20 Ramp	0.50	0.30	0.30	0.30	0.30

**Table 10.11 Peak Express Transit Delay Factors**

Functional Class	CBD (1)	CBD Fringe (2)	Urban (3)	Suburban (4)	Rural (5)
0 Centroid Connector	n/a	n/a	n/a	n/a	n/a
1 Freeway	0	0	0	0	0
2 Expressway	0	0	0	0	0
3 Principal Arterial	0	0	0	0	0
4 Minor Arterial	0.50	0.10	0.10	0	0
5 Collector	2.50	2.50	2.50	0	0
7 Local	0.10	0.10	0.10	0.10	0
20 Ramp	0.50	0.10	0.50	0	0

**Table 10.12 Peak Premium Transit Delay Factors**

Functional Class	CBD (1)	CBD Fringe (2)	Urban (3)	Suburban (4)	Rural (5)
0 Centroid Connector	n/a	n/a	n/a	n/a	n/a
1 Freeway	0	0	0	0	0
2 Expressway	0	0	0	0	0
3 Principal Arterial	0	0	0	0	0
4 Minor Arterial	0.45	0.09	0.09	0	0
5 Collector	0.45	0.18	0.45	0	0
7 Local	0.09	0.09	0.09	0.09	0
20 Ramp	0.45	0.09	0.27	0	0

**Table 10.13 Off-Peak Local Transit Delay Factors**

Functional Class	CBD (1)	CBD Fringe (2)	Urban (3)	Suburban (4)	Rural (5)
0 Centroid Connector	n/a	n/a	n/a	n/a	n/a
1 Freeway	0	0	0	0	0
2 Expressway	0	0	0	0	0
3 Principal Arterial	0	0	0	0	0
4 Minor Arterial	1.00	1.00	1.00	0.20	0.20
5 Collector	0.50	0.50	0.50	0.10	0
7 Local	0.50	0.50	0.10	0.10	0.10
20 Ramp	0.50	0.50	0.30	0.10	0.10

**Table 10.14 Off-Peak Express Transit Delay Factors**

Functional Class	CBD (1)	CBD Fringe (2)	Urban (3)	Suburban (4)	Rural (5)
0 Centroid Connector	n/a	n/a	n/a	n/a	n/a
1 Freeway	0	0	0	0	0
2 Expressway	0	0	0	0	0
3 Principal Arterial	0	0	0	0	0
4 Minor Arterial	0.50	0.10	0.10	0	0
5 Collector	2.50	2.50	2.80	0	0
7 Local	0.10	0.10	0.10	0.10	0
20 Ramp	0.50	0.10	0.50	0	0

**Table 10.15 Off-Peak Premium Transit Delay Factors**

Functional Class	CBD (1)	CBD Fringe (2)	Urban (3)	Suburban (4)	Rural (5)
0 Centroid Connector	n/a	n/a	n/a	n/a	n/a
1 Freeway	0	0	0	0	0
2 Expressway	0	0	0	0	0
3 Principal Arterial	0	0	0	0	0
4 Minor Arterial	0.45	0.09	0.09	0	0
5 Collector	0.45	0.45	0.45	0	0
7 Local	0.09	0.09	0.09	0.09	0
20 Ramp	0.45	0.09	0.27	0	0