EL PASO METROPOLITAN PLANNING ORGANIZATION

Technical Memorandum

DATE: October 9, 2017
TO: Michael Medina, Executive Director/EPMPO

FROM: Salvador González-Ayala **SERIAL:** TDMvalid-01c
SUBJ: Re-validation of 2007 TDM / El Paso Horizon MTP.
Update of the Highway Assignment section of the Validation Report prepared by HNTB

Overview

The present Tech Memo reproduces the text prepared by HNTB on their Trip Assignment chapter/Validation Report (July 2013), and updates the tables and graphs based on the MPO's running of the 2007 base year with coding changes needed to fully reflect roadway operating conditions. Trip assignment which is the final step in the travel demand process, assigns trips to the highway network of the Horizon Model. Validation of the model to observed flows is important to the modeling effort in two regards. First, the validation shows whether the calibration tools used in the model process and assumptions were reasonable. Second, the validation shows what level of confidence the user can have in the forecast results. The process used to validate highway assignment is described below.

Highway Assignment

The typical comparison for highway validation, when sufficient data is available, is between highway traffic assignments and actual traffic volumes derived from traffic count data. A similar measure, vehicle miles of travel (VMT), is calculated from the same traffic counts and the length of the roadway on which the count is located. Fairly extensive traffic counts were available to validate the Horizon Model.

The Horizon Model assigns trips to the roadway network by time period AM, MD, PM, and NT in order to reflect the constraints of roadway capacity that vary substantially by time of day. In order to compare to the available 24-hour traffic counts, the results from these four traffic assignments are totaled to reflect a daily modeled volume.

Although the principle of comparing traffic assignments to traffic count data is intuitively straightforward, subjective review of the travel demand model results and the observed traffic counts is not adequate. The comparative analysis must be carried out in a structured manner using clearly defined benchmarks, or measures of success. That process allows the results of the validation analysis

to be tabulated and quantitatively analyzed in a way that provides the user with a degree of confidence in the statistical foundation and structure of the model.

The model validation procedure used for the Horizon Model was similar to the procedure used by state DOTs and MPOs throughout the country. The locations of year 2007 traffic counts provided by TxDOT were coded to the roadway networks. Traffic assignment results for the validation year (2007) were compared to these traffic counts by three indices: **Percent of Count, Correlation Coefficient,** and **Percent Root Mean Squared Error (%RMSE)**, each of which was aggregated and tabulated across a variety of categories. Percent of Count was used to measure the overall difference between modeled and counted flows. The Correlation Coefficient estimated the correlation between the actual ground counts and the estimated traffic volumes. Percent Root Mean Squared Error (%RMSE) was used to measure the difference between modeled flows and counted volumes on a link-by-link basis, which gave a better picture of the "closeness" between model flows versus counts. The Percent of Count and Percent RMSE calculation are described by the following equations:

$$\text{Pct of count} = \frac{\sum_{j=1}^{n} \text{Modeled}_j}{\sum_{j=1}^{n} \text{Counted}_j}$$

$$\%\ \text{RMSE} = \frac{\sqrt{\sum_{j=1}^{n} \frac{(\text{Modeled}_j - \text{Counted}_j)^2}{(n-1)}}}{\left(\frac{\sum_{j=1}^{n} \text{Counted}_j}{n}\right)} \times 100$$

Where $\boldsymbol{j}$ represents the individual network link with count, and $\boldsymbol{n}$ is the total number of links with counts in the network for the specific categories.

When applied to model volumes versus counts, RMSE values are reported as percentages with lower values superior to higher values.

The Correlation Coefficient (R) represents the linear relationship between modeled flows and counts. The mathematical formula for computing R is:

$$R = \frac{(n\sum \text{Modeled}_j \times \text{Counted}_j) - (\sum \text{Modeled}_j \times \sum \text{Counted}_j)}{\sqrt{n(\sum \text{Modeled}_j{}^2) - (\sum \text{Modeled}_j)^2} \times \sqrt{n(\sum \text{Counted}_j{}^2) - (\sum \text{Counted}_j)^2}}$$

The value of R is between -1 and 1. An R-value close to 1 indicates a strong positive linear relationship between modeled flows and counts while an R-value close to -1 indicates a strong negative linear

relationship between modeled flows and counts. FHWA suggested that the region-wide correlation coefficient should be more than 0.88.

Number of count links, centerline miles and average count values are also presented to provide a frame for interpreting the results in addition to the three indices described above.

The El Paso MPO and TxDOT require that the following criteria be met in order to call the Horizon model validated.

- Overall VMT (vehicle miles traveled) shall match within 5%.
- Area type volume shall match to count within 10%.
- Facility type volume shall match to counts within 10%.
- Screenline volumes shall match counts within 15%.

Validation results are presented by different categories as listed below:

- Model area
- Functional Classification
- Area Type
- Screenline, and
- Validation district

The model results and the outcomes of the validation comparisons for each of these categories are discussed in the following sections.

Model Area Statistics

Starting with a high level conceptual snapshot of the Horizon Model, the first set of comparisons presented are for the full model study area, which is standard practice. These comparisons attempt to show how well the model can replicate travel throughout the study area. The study area statistics presented below include comparison to total VMT and comparison to total counts. These comparisons show a "big picture" snapshot of how well the model is replicating travel across the area's transportation system.

Vehicle Miles Traveled

First, overall traffic flow and vehicle miles of travel (VMT) in the study area were analyzed. VMT is a calculated variable using link length multiplied by count or model volume for the link.

Table 9 compares modeled VMT to Highway Performance Monitoring System (HPMS) VMT(2007) for the El Paso County portion of the model area. From Table 9, it can be seen that the modeled VMT accounts for 101.38% of the HPMS VMT for the study area, which is within the TxDOT TPP standard of +/- 5%.

Table 9. PMS VMT vs. Modeled VMT

	HPMS VMT 2007	Modeled VMT (new)	%HPMS VMT (new)
El Paso County only	15,084,326	15,313,803	101.52

Total vehicles miles of travel (VMT) for the study area compares well with estimates of VMT from TxDOT. The Horizon model produces a total of 15,313,803 VMT within El Paso County for 2007. TxDOT TPP's 2007 estimate of VMT is 15,084,326 for roads within El Paso County.

Comparison to counts

The direct comparison of counts to model volumes removes the bias of link length inherent in the VMT comparison and only considers the actual count and model volume. In many ways, this direct comparison may be a better measure of how well the model is replicating travel.

Table 10 compares the traffic counts vs. the Horizon Model assignment results for the transportation system in El Paso as a whole.

Table 10. Counted vs. Modeled Volume

	Pct of count	Count links	Ctr Line Miles	Avg Counted	%RMSE	Correlation
System wide	97.28	1,062	412.09	14,776	38.79	0.94

The modeled volume within the El Paso area compares well to the counted volume, with the modeled volume forecasted at 97.28% of the counted volume. Figure 1 shows the scatter plot of the traffic counts vs. the Horizon model assignment results.

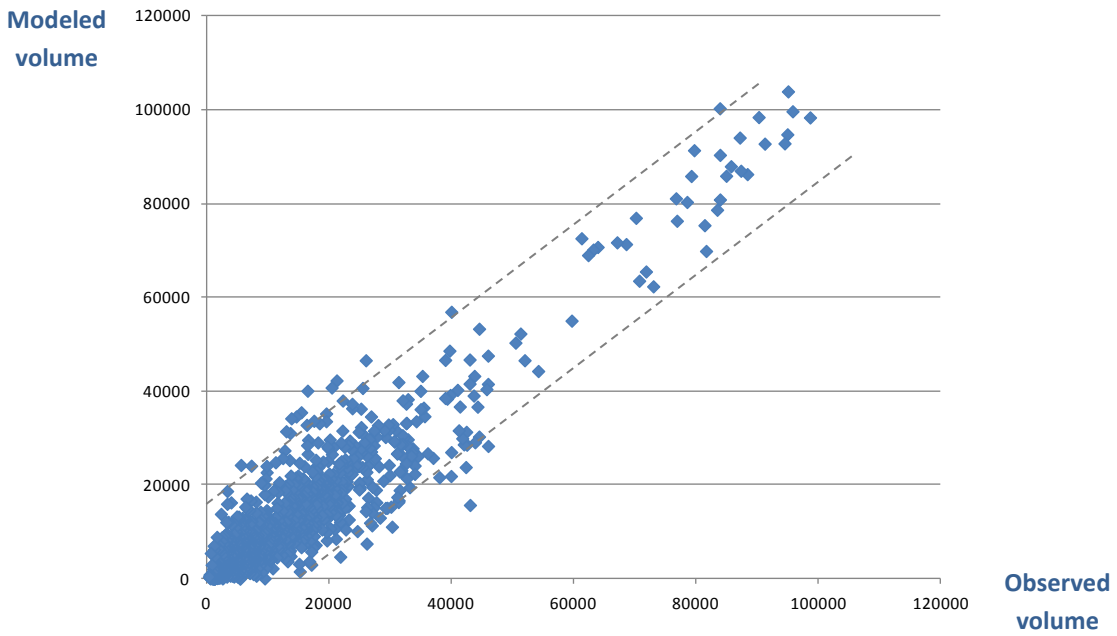

Figure 1. Scatter Plot-Modeled vs. Observed Link Traffic Volume

The scatter plot shows a strong correlation between the modeled volumes and the observed traffic counts. As the traffic volumes increase, there is slightly more variation between the modeled volumes and observed volumes.

Comparison by Functional Class

The Horizon Model uses the Federal Highway Administration's (FHWA) facility types as its functional classifications. While the previous section detailed "big picture" validation data, this section provides a more detailed look at the model validation. The count comparisons by functional class seen below are sub-sets contained within the previous section data above, thereby providing a more discriminating look at the model validation.

Counts

Another criterion used for model validation is to compare assigned traffic volume to traffic counts aggregated by functional class. The comparison of assigned volumes to counted volumes is considered successful if the value for percent error falls within the ranges suggested by FHWA (Federal Highway Administration, 2010), as shown in the table below. The FHWA targets presented can be used to judge the success of the Horizon Model validation.

Table 11. FHWA Functional Class Validation Targets

	FHWA targets	Ohio	Florida	Michigan
Freeway	+/-7%	+/-7%	+/-7%	+/-6%
Principal Arterial	+/-10%	+/-10%	+/-15%	+/-7%
Minor Arterial	+/-15%	+/-10%	+/-15%	+/-10%
Collector	+/-20%	+/-15%	+/-25%	+/-20%

The total modeled volume from the Horizon model compare well to counts aggregated by functional class, most of which are within the FHWA targets, as shown in Table 12.

Table 12. Total Count vs. Modeled by Functional Class

	Pct of count	Count links	Ctr Line Miles	Avg Counted	%RMSE	Correlation
Interstate	102.44	60	55.68	58,212	9.26	0.98
Other Fwys or Expwys	102.76	69	38.76	18,724	31.42	0.78
Principal Arterial	101.34	329	110.45	18,615	40.31	0.76
Minor Arterial	89.88	328	81.04	9,800	51.58	0.68
Major Collector	82.68	230	108.84	6,058	66.11	0.68
Local	74.40	38	16.07	2,371	109.19	0.43

Comparison by Area Types

The FHWA does not provide explicit criterion to compare assigned traffic volume to traffic counts aggregated by area type, but TxDOT TPP does. Because different area types have different travel patterns, analyzing the modeled versus count volumes by area type can allow for the identification of

issues related to network coding. The comparison of assigned volumes is considered successful if the value for percent error falls within 10%.

The Horizon model also performs well for each area type. Table 13 summarizes the comparison of total traffic volumes to traffic counts by area type. The Horizon model accurately models traffic volumes; the less accurate being the suburban area type (but still with a correlation of .89).

Table 13. Total Count vs. Modeled by Area Type

	Pct of count	Count links	Ctr Line Miles	Avg Counted	%RMSE	Correlation
Business District	109.53	53	7.56	18,714	46.11	0.94
Urban Intense	96.50	299	69.43	20,315	33.26	0.94
Urban Central	96.47	315	87.30	13,970	35.97	0.92
Suburban	97.18	215	83.01	11,060	47.42	0.89
Rural	95.36	180	164.80	10,268	43.51	0.94

Comparison by Screenline

A screenline is a boundary transecting a set of roadway facilities at points where traffic counts are available on the individual facilities. Screenlines allow the user to aggregate the total travel on all available facilities in a corridor, or travel market, so that the model performance for the entire travel market can be assessed and analyzed. By providing an overview of corridor activity, the screenline comparisons provide insight into how to calibrate and validate model performance on individual facilities within the given travel market. TxDOT's typical target for this criterion is for the aggregate modeled volume to be within 15% of the aggregate observed volume for each screenline.

The screenline for the Horizon model generally separate areas of the study area and cross groups of key roadways. A map of the screenlines is shown is shown in Figure 4 in Appendix A. The modeled volume is compared to the counted volume on each Horizon model screenline in Table 14 below.

Table 14. Total Count vs. Total Modeled by Screenline

	Pct of count	Count links	Ctr Line Miles	Avg Counted	%RMSE	Correlation
Screenline #1	103.32	5	7.38	12,942	36.82	0.99
Screenline #2	111.40	6	6.48	33,449	14.53	1.00
Screenline #3	105.85	9	0.87	27,130	26.14	1.07
Screenline #4	105.72	5	1.32	14,578	11.77	0.97
Screenline #5	113.07	6	2.50	15,454	20.98	1.00
Screenline #6	113.32	7	2.50	37,310	19.32	0.99
Screenline #7	90.09	9	4.51	18,665	28.41	0.95
Screenline #8	96.03	7	2.63	10,473	28.74	0.94
Screenline #9	88.59	12	4.84	21,769	42.77	0.68
Screenline #10	95.80	5	4.48	21,957	27.13	0.92
Screenline #11	102.31	3	0.17	13,630	61.24	0.57
Screenline #12	86.98	9	2.64	15,250	49.20	0.90
Screenline #13	90.40	6	1.32	17,183	21.39	0.98
Screenline #14	92.49	5	2.91	20,295	11.91	0.99
Screenline #15	93.73	4	0.95	7,845	22.84	0.30

Figure 2 shows how the Horizon model is performing relative to the NCHRP 225 (Transportation Research Board, National Research Council, 1982) screenline deviation guidelines. The graph shows the percent deviation of each screenline.

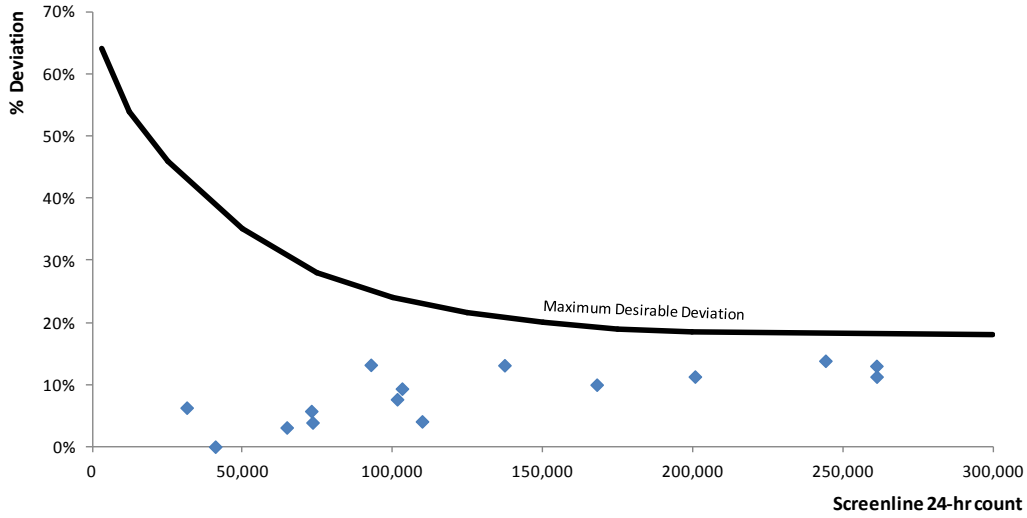

Figure 2. Screenline Percent Deviation, NCHRP 225 Guidelines

Comparison by Validation District

A set of districts (validation districts) has been created from the TAZ layer of the Horizon model. These districts are used to analyze the results of the modeling process. A validation district in another way to group the comparison to counts. These geographic areas can be constructed to isolate (highlight) areas of concern or specific interest. The validation districts for the Horizon model have been created by using the districts provided with the Mission Model. A map of the validation districts is provided in Figure 5, Appendix A.

Below is a table comparing counts to modeled volumes by district. Modeled volumes compare to counted volume well in most districts. Districts with higher percent RMSE typically have fewer count links.

Table 15. Total Count vs. Total Modeled by Validation District

	Pct of count	Count links	Ctr Line Miles	Avg Counted	%RMSE	Correlation
District #1	104.09	2	0.11	17,992	7.28	-1.00
District #3	119.44	142	24.94	12,533	51.84	0.95
District #4	98.59	375	103.42	20,386	32.43	0.94
District #5	82.00	76	47.73	11,160	43.84	0.84
District #6	87.84	9	19.07	3,561	30.62	0.93
District #7	74.05	83	76.54	9,341	45.51	0.90
District #8	96.98	217	74.46	10,913	47.40	0.89
District #9	73.05	3	2.84	9,997	44.41	0.97
District #11	70.93	29	13.03	6,297	49.86	0.88
District #12	91.21	126	49.95	15,841	31.86	0.95

Conclusions

The criteria used for validation of the Horizon model were based on current TxDOT, FHWA, and NCHRP standards, and represents reasonable measures for determining the accuracy and reliability of the model. The validation of the model described in this Tec Memo accomplishes two goals. First, it demonstrates that the calibration tools and assumptions used in the modeling process are reasonable. Second, the validation provides the Horizon model users and transportation professionals with confidence in the accuracy and reliability of forecast results obtained from the Horizon model.

Appendix A

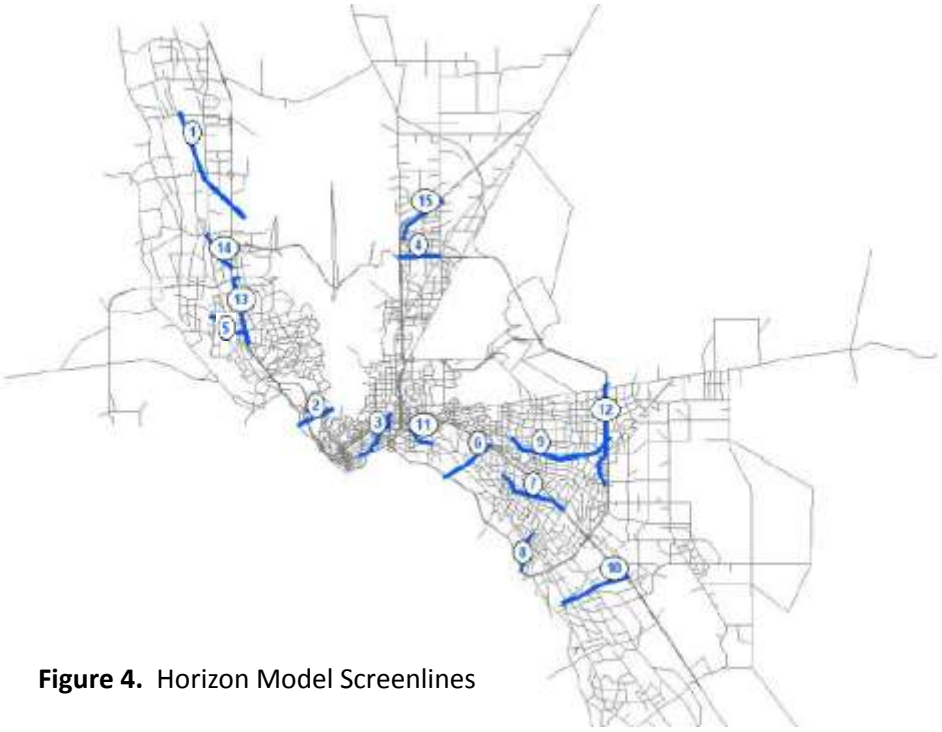

Figure 4. Horizon Model Screenlines

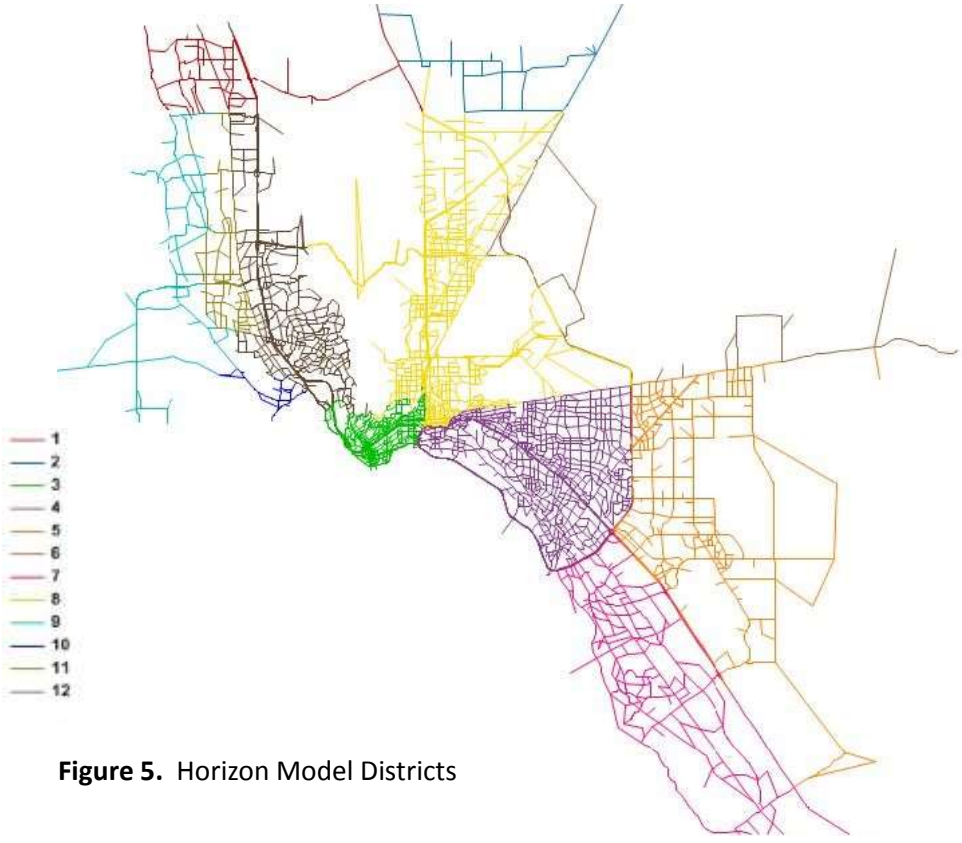

Figure 5. Horizon Model Districts

El Paso MPO Horizon Model

Validation Report

July 2013

Prepared for:

HNTB.

On behalf of the

El Paso MPO and

Texas Department of Transportation,

Prepared by:

Alliance Transportation Group, Inc.

Version History

Release Date	Version Number	Description
May 17, 2013	1.0	Original Submission
July 17, 2013	1.1	Revised based on Network Coding Changes

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APPENDICES

VALIDATION OVERVIEW

This report documents the validation of the El Paso Horizon Travel Demand Model (Beta Version1.0). Validation refers to the process of using a calibrated model to estimate travel for the base year, and then comparing the model's output to observed travel data. This report is focused on the validation of trip generation, trip distribution, mode choice, and trip assignment.

Care was taken with each model step to ensure that the Travel Demand Model maintained a high level of predictive value. To this end, the model contains no K-factors or other subjective adjustment factors. All changes and adjustments to model parameters were performed in a comprehensive and systemic manner, and were applied uniformly and consistently across the entire model. The resulting model provides a realistic and reliable predictor of magnitude and pattern of future travel in the El Paso area; and should serve as a useful and informative tool for performing travel forecasts and analyses of proposed transportation projects.

DATA FOR MODEL VALIDATION

In order for travel demand models forecasts to be judged as reasonable, the models must be able to produce reasonable volumes for the model's base year. The quality of the data used in validation largely influences the reasonableness and confidence of the observed volumes. Several sources of data and travel surveys were used to validate the steps of the Horizon model. These data sources are summarized below.

2009 El Paso Household Survey

The El Paso Household Travel Survey was completed in 2009 by TxDOT to provide comprehensive data on travel patterns within the El Paso study area, including portions within El Paso County and areas in New Mexico. The survey collected the household characteristics, personal information, vehicle information, and trip characteristics in significant detail. Because the trip characteristics were collected with geocodable addresses, the trips were aggregated to the Traffic Analysis Zone (TAZ) level for all trip purposes.

Census Transportation Planning Product (CTPP)

The Census Transportation Planning Product (CTPP) is a set of special tabulations that use large sample surveys conducted by the Census Bureau. The CTPP provides residence-based tabulations, workplace-based tabulations, and worker flows between home and work for the specific geographic units. Because the CTPP excludes secondary work trips, the number of trips reported is typically less than actual volumes. Two different versions of the CTPP were used in the validation of the Horizon Model, as discussed below.

CTPP – 2000

The first version of the CTPP used for validation of the Horizon Model was derived from the 2000 Census Long Form. The CTPP based on the 2000 Census provides data at the state level down to the tract level. However, only the home to work (HBW) flows for 2000 were used to calculate an average trip length in minutes, which was compared to the Horizon model HBW trip length in validation.

CTPP – 2006-2008 ACS

The second version of the CTPP used for validation of the Horizon Model was based on the 2006-2008 American Community Survey (ACS). The CTPP using the 2006-2008 ACS data is restricted to larger geographic units, including places and counties, are only for counties with a population greater than 20,000. The home to work (HBW) flows were used to calculate an average trip length in minutes, which was compared to the Horizon model HBW trip length in validation.

Traffic Counts

The 2007 traffic counts transferred to the Horizon Model roadway network layer were obtained from TxDOT's Transportation Planning and Programming Division.

Three types of counts were transferred to the network:

- Annual 24-hour counts,
- Urban counts, and
- Vehicle classification counts (AVC and ATR).

The annual counts are collected on TxDOT maintained roads for each TxDOT district every year, while the urban counts are collected every five years on TxDOT maintained roads, county roads, and city streets. Alliance obtained annual counts for in a *TransCAD* point format which contained the location information of each count station and the average daily traffic flow at each station for year 2007.

TRIP GENERATION MODEL

Trip generation, which is the first of the four primary steps in the travel demand model process, utilizes TripCAL5 to produce a set of trip productions and trip attractions for each TAZ by trip purpose. This section describes how the results of TripCAL5 were validated.

Trip Generation Validation

The 2009 El Paso household survey was used to develop the Horizon Model trip rates. The percentage of trips by trip purpose as calculated from the household survey was similar to the percentage reported in the National Household Transportation Survey (NHTS) and was input directly into TripCAL5. Five trip purposes are identified in TripCAL5 for the Horizon Model:

- Home based work (HBW),
- Home based non-work (HBNW),
- Non-home based (NHB),
- Non-home based visitor (NXLO), and
- Truck-taxi (TRTX).

Table 1 compares the percentage of trips of several trip purposes between the Horizon Model and the El Paso household survey. The trips by trip purpose for the Horizon Model are close to those reported for the El Paso household survey. The El Paso household survey only includes internal trips, so the percentage of total trips from the Horizon model and survey only include internal passenger trips.

Table 1: Percentages of Trips by Purpose

Trip Purposes	Horizon Model Number of Trips 2007	Horizon Model % of Total Trips	El Paso HH Survey % of Total Trips
HBW	347,682	15%	16.1%
HBNW	1,325,829	57%	60.6%

Trip Purposes	Horizon Model Number of Trips 2007	Horizon Model % of Total Trips	El Paso HH Survey % of Total Trips
NHB	663,195	28%	23.3
NXLO	283,749	N/A	N/A
TRTX	216,873	N/A	N/A
Total	**2,837,328**	**100%**	**100%**

The average person trips per person and per household were also evaluated in comparison to the survey data to ensure the trip generation model was validated. The Horizon Model produced an average of 2.92 person trips per person. As shown in Table 2, this compared with an average of 2.9 person trips per person for the El Paso area in 2009 and an average of 3.43 person trips per person in the Texas NHTS data in 2009. It should be noted that the NHTS includes both internal and external travel, while the El Paso household survey only includes internal trips. The Horizon model is reported as only internal travel in order to compare to the El Paso household survey.

Table 2: Average Person Trips Per Person

	El Paso HH Survey 2009	NHTS 2009	Horizon Model 2007
Average person trips per person	2.9	3.43	2.92

The average person trips per household were compared by trip purpose in Table 3 below. It was determined that the Horizon Model was producing trips in line with the reported travel volumes from the 2009 El Paso household survey and the urban areas within the state of Texas from the 2009 NHTS.

Table 3: Average Person Trips per Household by Trip Purpose

	HBW	HBNW	NHB	Total
El Paso HH Survey 2009	1.41	5.3	2.4	9.11
NHTS 2009	-	-	-	9.78
Horizon Model 2007	1.36	5.18	2.59	9.12

TRIP DISTRIBUTION MODEL

Trip Distribution, which is the second step in the traditional four-step model, takes the production and attraction trip ends developed during trip generation and connects them, in origin – destination pairs, based on the trip length frequency curves for each trip purpose using the ATOM2 software.

Trip Length

The first measure to check in the trip distribution model is the trip length by trip purpose between the model and the observed data. The trip length is checked for time (in minutes) to ensure the model is performing reasonably across all trip purposes, as all the purposes have different travel characteristics. Table 4 below depicts the average trip length, by trip purpose, as reported in the El Paso Household survey and both sets of CTPP data (for HBW trips only).

Table 4: Observed Average Trip Length

Purpose	Unit	El Paso HH Survey 2009	2006-2008 CTPP	2000 CTPP
HBW	Minutes	19.06	23.3	21.8
HBNW	Minutes	12.69	-	-
NHB	Minutes	13.1	-	-
NXLO	Minutes	13.1	-	-

The same surveyed trip lengths are presented in Table 5 below comparing the observed trip lengths to the trip lengths achieved by the Horizon Model for each trip purpose. The table includes two measures of the model's ability to match the observed data: percent of difference (between the modeled and surveyed trip lengths) and coincidence ratio. A coincidence ratio of 1.0 would indicate an identical distribution of the modeled trip length to the observed trip length.

Table 5: Modeled Vs. El Paso HH Survey Observed Trip Length

Trip Purpose	Modeled Trip Length (min)	Surveyed Trip Length (min)	% of Difference	Coincidence Ratio
HBW	18.92	19.06	-0.7%	0.78
HBNW	12.22	12.69	-3.7%	0.9
NHB	12.75	13.1	-2.6%	0.87
NXLO	12.73	13.1	-2.8%	0.87

MODE SHARE

The Horizon mode share application, which is the third step in the travel demand model process, uses production and attraction person trip tables produced by the ATOM2 trip distribution program combined with traveler characteristics, origin, and destination data from the TAZ layer and zone to zone travel impedances to allocate the trips to the available modes of travel. Validation and reasonableness checking of mode shares involve comparison of mode shares by trip purpose produced by the Horizon Model to observed survey data.

Mode Share Target

The El Paso Household survey was used for the mode share development. There are three highway modes: drive alone, share ride 2, and share ride 3+. There are a total of four trip purposes that mode shares are applied by: HBW, HBNW, NHB, and NXLO. Furthermore, because income is a household characteristic that often has significant impact on travelers' mode choice, the trips are segmented into five income market segments. The thresholds for income segmentation are shown in Table 6.

Table 6: Thresholds for Household Income Segmentation

Income Segment	Household Income (2007 $)
Group 1	<= 14,220
Group 2	14,221 – 28,440
Group 3	28,441 – 47,400
Group 4	47,401 – 71,100
Group 5	>=71,101

Although the trips are segmented into five income markets, the mode shares are applied to an aggregate of these income groups where the groups had similar mode share characteristics. The same mode shares are used for income groups one through three, which had similar travel behavior patterns, while a different set of mode

shares are applied for income groups four and five which were alike in their travel behavior, but differed from the first three groups. Furthermore, different values of mode shares are applied based on the bus service within the study area. If both ends of the OD pair are within the bus service area, one set of the mode shares will apply. If either end of the OD pair is not within bus service area, another set will apply. The trips are split among auto only for outside of the bus service area, while they are split among auto and transit for bus service areas. However, for validation purposes, the overall mode share targets are evaluated, as shown in Table 7 below.

Table 7: Target Mode Share

Trip Purpose	Drive Alone	Share Ride 2	Share Ride 3+	Transit
HBW	91.29%	7.06%	1.38%	0.27%
HBNW	33.49%	32.24%	30.11%	4.16%
NHB	42.83%	30.98%	21.72%	4.47%

Mode Share Results

Table 8 shown below documents the mode share output from the Horizon model, which were compared to the targets provided above. As shown, the actual mode shares match the target mode shares very well.

Table 8: Output Mode Share

Trip Purpose	Drive Alone	Share Ride 2	Share Ride 3+	Transit
HBW	91.34%	7.08%	1.38%	0.21%
HBNW	33.88%	32.62%	30.46%	3.04%
NHB	43.33%	31.07%	21.78%	3.82%

TRIP ASSIGNMENT

Trip assignment, which is the final step in the travel demand process, assigns trips to the highway network of the Horizon Model. Validation of the model to observed flows is important to the modeling effort in two regards. First, the validation shows whether the calibration tools used in the model process and assumptions were reasonable. Second, the validation shows what level of confidence the user can have in the forecast results. The process used to validate all modes of travel is described below.

Highway Assignment

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Although the principle of comparing traffic assignments to traffic count data is intuitively straightforward, subjective review of the travel demand model results and the observed traffic counts is not adequate. The comparative analysis must be carried out in a structured manner using clearly defined benchmarks, or measures of success, that process allows the results of the validation analysis to be tabulated and quantitatively analyzed in a way that provides the user with a degree of confidence in the statistical foundation and structure of the model.

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counts by three indices: **Percent of Count**, **Correlation Coefficient,** and **Percent Root Mean Squared Error (%RMSE)**, each of which was aggregated and tabulated across a variety of categories. Percent of Count was used to measure the overall difference between modeled and counted flows. The Correlation Coefficient estimated the correlation between the actual ground counts and the estimated traffic volumes. Percent Root Mean Squared Error (%RMSE) was used to measure the difference between modeled flows and counted volumes on a link-by-link basis, which gave a better picture of the "closeness" between model flows versus counts. The Percent of Count and Percent RMSE calculation are described by the following equations:

$$Percent\ of\ Count = \frac{\sum_{j=1}^{n} Modeled_j}{\sum_{j=1}^{n} Counted_j}$$

$$\%RMSE = \frac{\sqrt{\sum_{j=1}^{n} \frac{(Modeled_j - Counted_j)^2}{n-1}}}{\frac{\sum_{j=1}^{n} Counted_j}{n}} \times 100$$

Where *j* represents the individual network link with count, and *n* is the total number of links with counts in the network for the specific categories.

When applied to model volumes versus counts, RMSE values are reported as percentages with lower values superior to higher values.

The Correlation Coefficient (R) represents the linear relationship between modeled flows and counts. The mathematical formula for computing R is:

$$R = \frac{n\sum Modeled_j \times Counted_j - (\sum Modeled_j) \times (\sum Counted_j)}{\sqrt{n(\sum Modeled_j^2) - (\sum Modeled_j)^2} \times \sqrt{n(\sum Counted_j^2) - (\sum Counted_j)^2}}$$

The value of R is between -1 and 1. An R Value close to 1 indicates a strong positive linear relationship between modeled flows and counts while an R value close to -1 indicates a strong negative linear relationship between modeled flows and counts. FHWA suggested that the region-wide correlation coefficient should be more than 0.88.

Number of count links, center line miles and average count values are also presented to provide a frame for interpreting the results in addition to the three indices described above.

The El Paso MPO and TxDOT require that the following criteria be met in order to call the Horizon model validated.

- Overall VMT (vehicle miles traveled) shall match within 5%.
- Area type volume shall match to count within 10%.
- Facility type volume shall match to counts within 10%
- Screen lines volumes shall match counts within 15%.

Validation results are presented by different categories as listed below:

- Model Area
- Functional Classification
- Area Type
- Screenline, and
- Validation District

The model results and the outcomes of the validation comparisons for each of these categories are discussed in the following sections.

Model Area Statistics

Starting with a high level conceptual snapshot of the Horizon Model, the first set of comparisons presented are for the full model study area, which is standard practice. These comparisons attempt to show how well the model can replicate travel throughout the study area. The study area statistics presented below include comparison to total VMT and comparison to total counts. These comparisons show a "big picture" snapshot of how well the model is replicating travel across the area's transportation system.

Vehicle Miles Traveled

First, overall traffic flow and vehicle miles of travel (VMT) in the study area were analyzed. VMT is a calculated variable using link length multiplied by count or model volume for the link.

Table 9 compares modeled VMT to Highway Performance Monitoring System (HPMS) VMT (2007) for the El Paso County portion of the model area. From Table 9, it can be seen that modeled VMT accounts for 101.38% of the HPMS VMT for the study area, which is within the TxDOT TPP standard of +/- 5%..

Table 9: HPMS VMT vs. Modeled VMT

County	HPMS VMT (2007)	Modeled VMT	% of HPMS VMT (Observed)
El Paso	15,084,326	15,292,582	101.38%

Total vehicle miles of travel (VMT) for the study area compares well with estimates of VMT from TxDOT. The Horizon model produces a total of 15,292,582 VMT within El Paso County for 2007. TxDOT TPP's 2007 estimate of VMT is 15,084,326 for roads within El Paso County.

Comparison to Counts

The direct comparison of counts to model volumes removes the bias of link length inherent in the VMT comparison and only considers the actual count and model volume. In many ways, this direct comparison may be a better measure of how well the model is replicating travel.

Table 10 compares the traffic counts vs. the Horizon Model assignment results for the transportation system in El Paso as a whole.

Table 10: Counted vs. Modeled Volume

System Wide	Percent of Count Σ	Count Links	Center Line Miles	Average Counted	% RMSE	Correlation
Total Volume	97.61	1063	412.39	14,786	38.9	0.93

The modeled volume within the El Paso area compares well to the counted volume, with the modeled volume forecasted at 97.61% of the counted volume. Figure 1 shows the scatter plot of the traffic counts vs. the Horizon model assignment results.

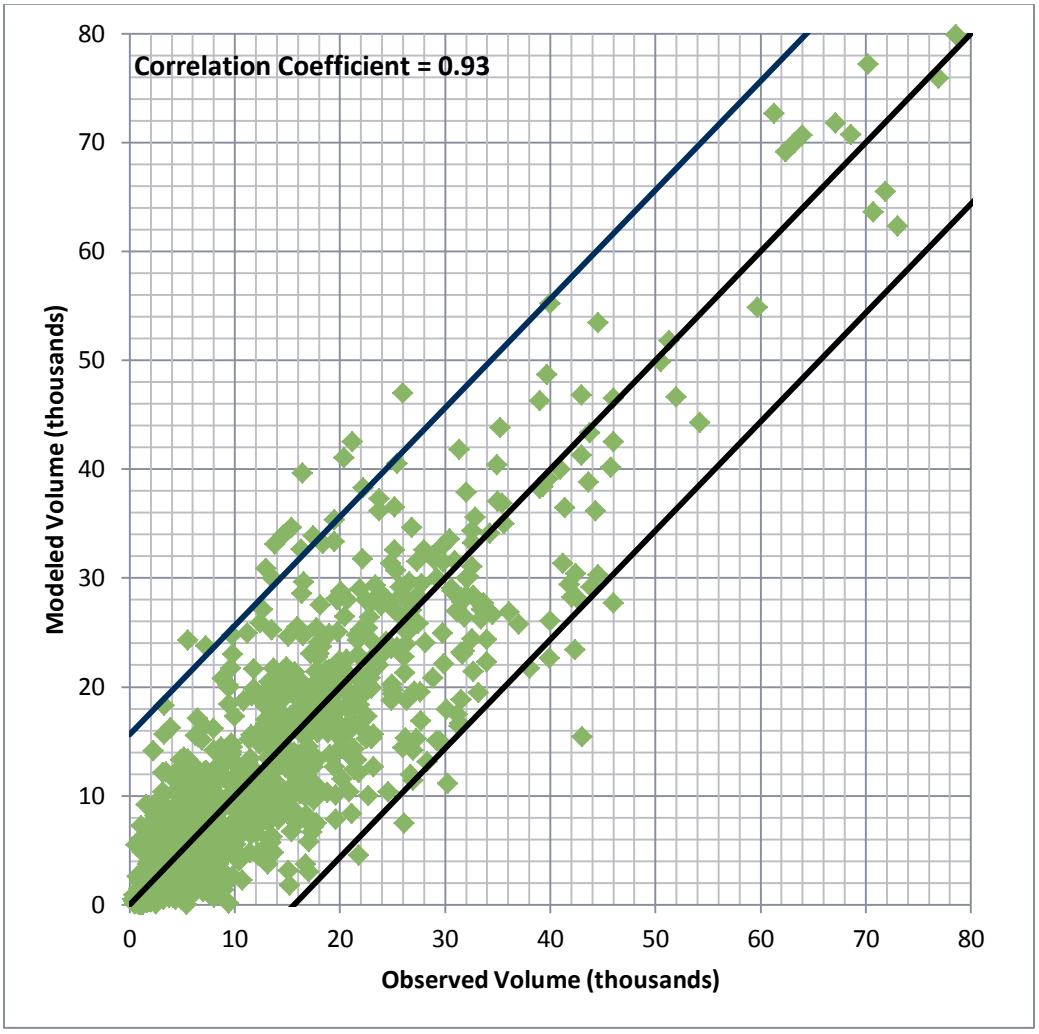

Figure 1: Scatter Plot - Modeled vs. Observed Link Traffic Volume

The scatter plot shows a strong correlation between the modeled volumes and the observed traffic counts. As the traffic volumes increase, there is slightly more variation between the modeled volumes and observed volumes.

Comparison by Functional Class

The Horizon Model uses the Federal Highway Administration's (FHWA) facility types as its functional classifications. While the previous section detailed "big picture" validation data, this section provides a more detailed look at the model validation. The count comparisons by functional class seen below are sub-sets contained within the previous section data above, thereby providing a more discriminating look at the model validation.

Counts

Another criterion used for model validation is to compare assigned traffic volume to traffic counts aggregated by functional class. The comparison of assigned volumes to counted volumes is considered successful if the value for percent error falls within the ranges suggested by the FHWA (Federal Highway Administration, 2010), as shown in the table below. The FHWA targets presented can be used to judge the success of the Horizon Model validation.

Table 11: FHWA Functional Class Validation Targets

Functional Class	FHWA Targets	Ohio	Florida (Acceptable)	Michigan
Freeway	+/- 7%	+/- 7%	+/- 7%	+/- 6%
Principal Arterial	+/-10%	+/-10%	+/-15%	+/-7%
Minor Arterial	+/- 15%	+/- 10%	+/- 15%	+/- 10%
Collector	+/- 20%	+/- 15%	+/- 25%	+/- 20%

The total modeled volume from the Horizon model compare well to counts aggregated by functional class, most of which are within the FHWA targets, as shown in Table 12.

Table 12: Total Count vs. Modeled by Functional Class

Functional Class	Percent of Count Σ	Count Links	Center Line Miles	Average Counted	% RMSE	Correlation
Interstate	101.86	60	55.68	58,212	9.71	0.98
Other Freeways or Expressways	102.71	69	38.78	18,724	31.04	0.79
Principal Arterial	101.10	332	111.17	18,633	40.06	0.76
Minor Arterial	91.26	328	81.04	9,800	52.16	0.67
Major Collector	82.97	230	108.8	6,058	66.18	0.68
Local	75.23	38	16.07	2,371	108.74	0.43

Comparison by Area Types

The FHWA does not provide explicit criterion to compare assigned traffic volume to traffic counts aggregated by area type, but TxDOT TPP does. Because different area types have different travel patterns, analyzing the modeled versus count volumes by area type can allow for the identification of issues related to network coding. The comparison of assigned volumes to counted volumes is considered successful if the value for percent error falls within 10%.

The Horizon Model also performs well for each area type. Table 13 summarizes the comparison of total assigned traffic volumes to traffic counts by area type. The Horizon Model most accurately models traffic volumes in business and urban areas and less accurately models volumes in suburban and rural areas.

Table 13: Total Count vs. Modeled by Area Type

Area Type	Area Type Name	Percent of Count Σ	Count Links	Center Line Miles	Average Counted	% RMSE	Correlation
1	Business District	110.26	53	7.56	18,714	46.59	0.94
2	Urban Intense	96.49	299	69.43	20,315	33.47	0.94
3	Urban Central	97.25	316	87.68	14,004	35.82	0.91
4	Suburban	97.50	215	82.98	11,060	47.37	0.89
5	Rural	95.47	180	164.74	10,268	43.72	0.94

Comparison by Screenline

A screenline is a boundary transecting a set of roadway facilities at points where traffic counts are available on the individual facilities. Screenlines allow the user to aggregate the total travel on all available facilities in a corridor, or travel market, so that the model performance for the entire travel market can be assessed and analyzed. By providing an overview of corridor activity, the screenline comparisons provide insight into how to calibrate and validate model performance on individual facilities within the given travel market. TxDOT's typical target for this criterion is for the aggregate modeled volume to be within 15% of the aggregate observed volume for each screenline.

The screenlines for the Horizon Model generally separate areas of the study area and cross groups of key roadways. A map of the screenlines is shown in Figure 4 in Appendix A. The modeled volume is compared to the counted volume on each Horizon Model screenline in Table 14 below.

Table 14: Total Count vs. Total Modeled by Screenline

Screenline	Percent of Count Σ	Count Links	Center Line Miles	Average Counted	% RMSE	Correlation
1	102.97	5	7.38	12,942	33.97	0.99
2	111.31	6	6.48	33,449	15.86	1
3	113.85	9	0.87	27,130	29.72	0.98

Screenline	Percent of Count Σ	Count Links	Center Line Miles	Average Counted	% RMSE	Correlation
4	105.73	5	1.32	14,578	11.69	0.98
5	108.16	6	2.5	15,454	11.97	1
6	112.72	7	2.5	37,310	19.01	0.99
7	90.16	9	4.51	18,665	28.26	0.95
8	96.06	7	2.63	10,473	28.58	0.94
9	88.64	12	4.84	21,769	42.81	0.68
10	96.19	5	4.48	21,957	26.7	0.93
11	102.47	3	0.17	13,630	57.23	0.62
12	86.81	9	2.62	15,250	49.27	0.9
13	90.48	6	1.32	17,183	19.08	0.99
14	89.14	5	2.91	20,295	14.77	0.99
15	93.34	4	0.95	7,845	22.17	0.22

Figure 2 shows how the Horizon model is performing relative to the *NCHRP 255* (Transportation Research Board, National Research Council, 1982) screenline deviation guidelines. The graph shows the percent deviation of each screenline.

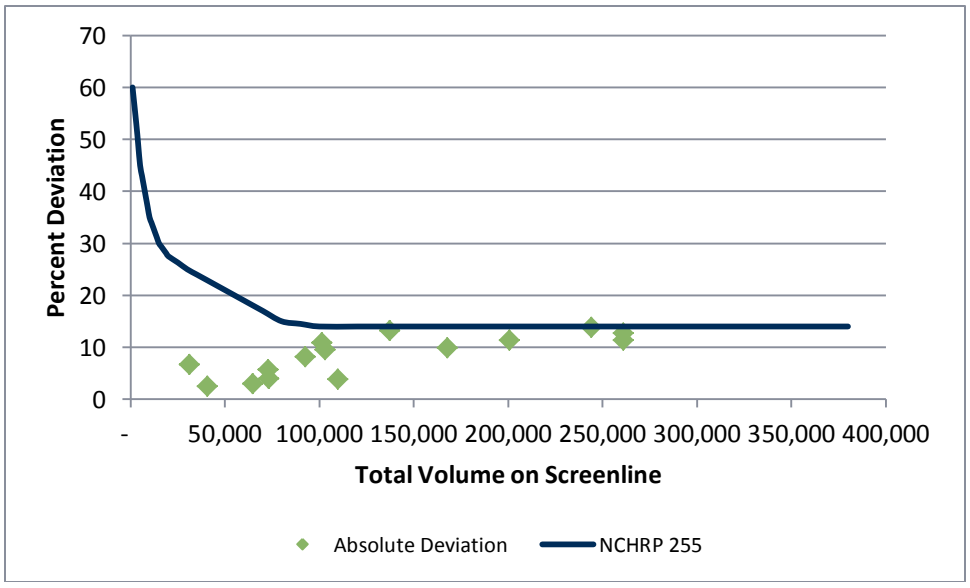

Figure 2: Screenline Percent Deviation, NCHRP 255 Guidelines

Comparison by Validation District

A set of districts (validation districts) has been created from the TAZ layer of the Horizon model. These districts are used to analyze the results of the modeling process. A validation district is another way to group the comparison to counts. These geographic areas can be constructed to isolate (highlight) areas of concern or specific interest. The validation districts for the Horizon Model have been created by using the districts provided

with the Mission Model. A map of the validation districts is provided in Figure 5 in the Appendix and a legend providing a description of the validation districts is provided in Table 16 in the Appendix.

Below is a table comparing counts to modeled volumes by district. Modeled volumes compare to counted volume well in most districts. Districts with higher percent RMSE typically have fewer count links.

Table 15: Total Count vs. Total Modeled by Validation District

District	Percent of Count Σ	Count Links	Center Line Miles	Average Counted	% RMSE	Correlation
1	103.39	2	0.11	17,992	6.23	-1
3	122.08	142	24.93	12,533	53.67	0.95
4	98.31	375	103.4	20,386	32.31	0.94
5	81.96	77	48.08	11,338	43.43	0.84
6	87.88	9	19.06	3,561	30.64	0.93
7	74.01	83	76.54	9,341	45.14	0.9
8	98.11	217	74.45	10,913	47.34	0.89
9	75.07	3	2.84	9,997	41.27	0.97
11	72.97	29	13.03	6,297	48.35	0.88
12	91.14	126	49.95	15,841	31.75	0.95

CONCLUSIONS

This report provides a description of the Horizon Model and its validation. Throughout the development process, focus was maintained on providing a flexible tool that could be used for travel demand forecasting of various future year scenarios. At each stage of the model development process, priority was given to optimizing the predictive value of the model sets. The model was calibrated and validated using a strategic approach based on consistent architecture resulting in a planning tool with predictive value and credibility for use in future year analysis Network assumptions and parameters are systemically and consistently applied across all facilities of similar type and character. There are no bias factors or subjective adjustments contained in the model.

The criteria used for validation of the Horizon Model were based on current TxDOT, FHWA and NCHRP standards and represent reasonable measures for determining the accuracy and reliability of the model. The validation of the model described in the previous sections accomplishes two goals. First, it demonstrates that the calibration tools and assumptions used in the modeling process are reasonable. Second, the validation provides the Horizon Model users and transportation professionals with confidence in the accuracy and reliability of forecast results obtained from the Horizon Model. The model's results were confirmed by rerunning the model and its reports several times.

Travel demand models often continue to evolve as analysis needs and policy objectives change. For this reason, the Horizon Model was designed to be a flexible dynamic tool that could evolve and grow along with the needs of the MPO. As implemented, the Horizon Model is a complete set of planning tools capable of performing the required transportation systems planning analyses, as well as providing inputs for air quality analysis, policy analysis, economic analysis and evaluation of alternative infrastructure investments. The model will assist the El Paso MPO and TxDOT in consistently carrying out all required transportation system planning activities, and performing implementation scenario analyses for Texas.

Appendix A | Attribute Keys

The following tables and maps are provided as an attribute key to the geographic stratifications referenced in this report. The following pages contain maps and tables of:

- Area Type patterns,
- Screenline location, and
- Validation district configuration.

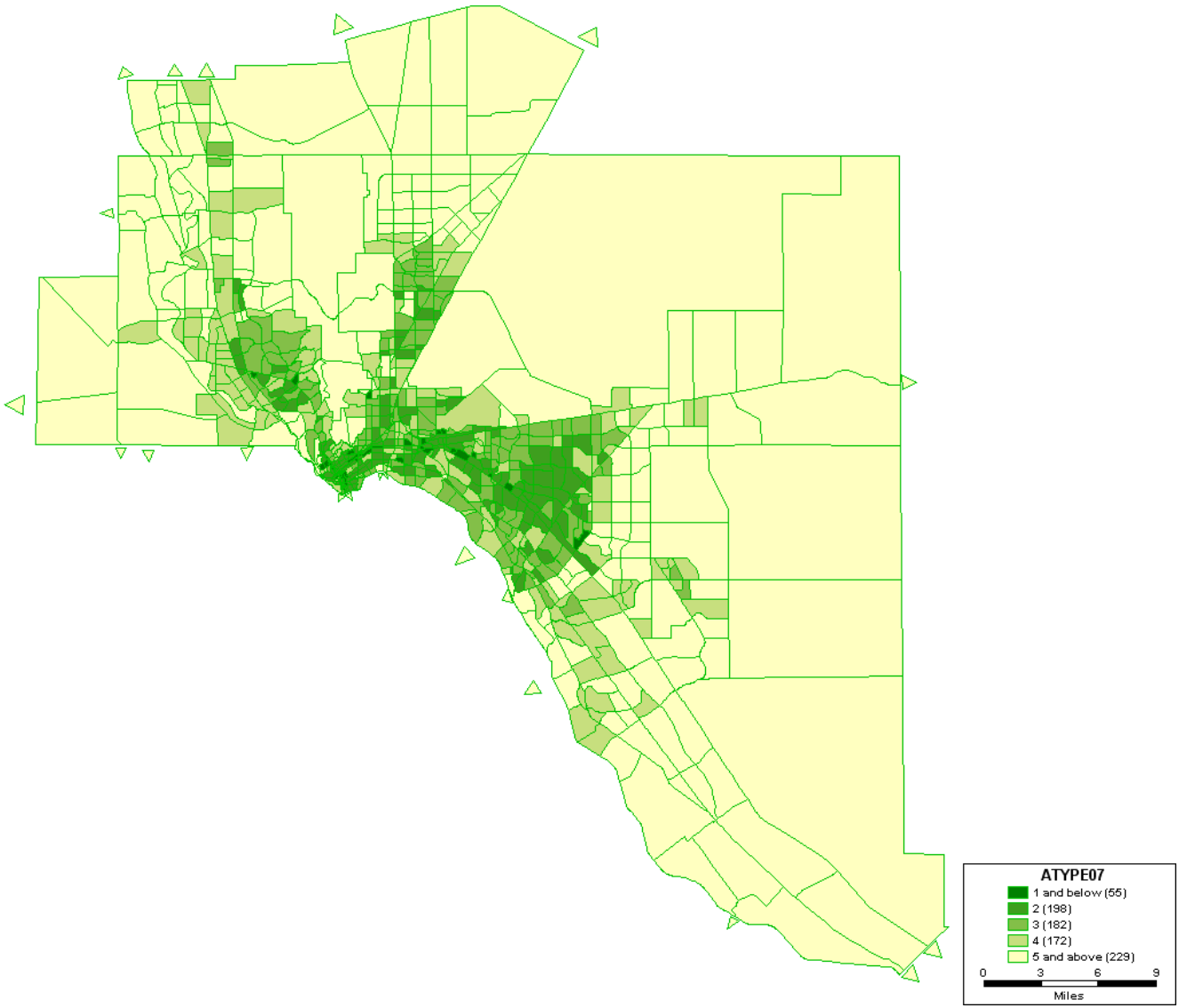

Figure 3: 2007 Area Type

Figure 4: Horizon Model Screenlines

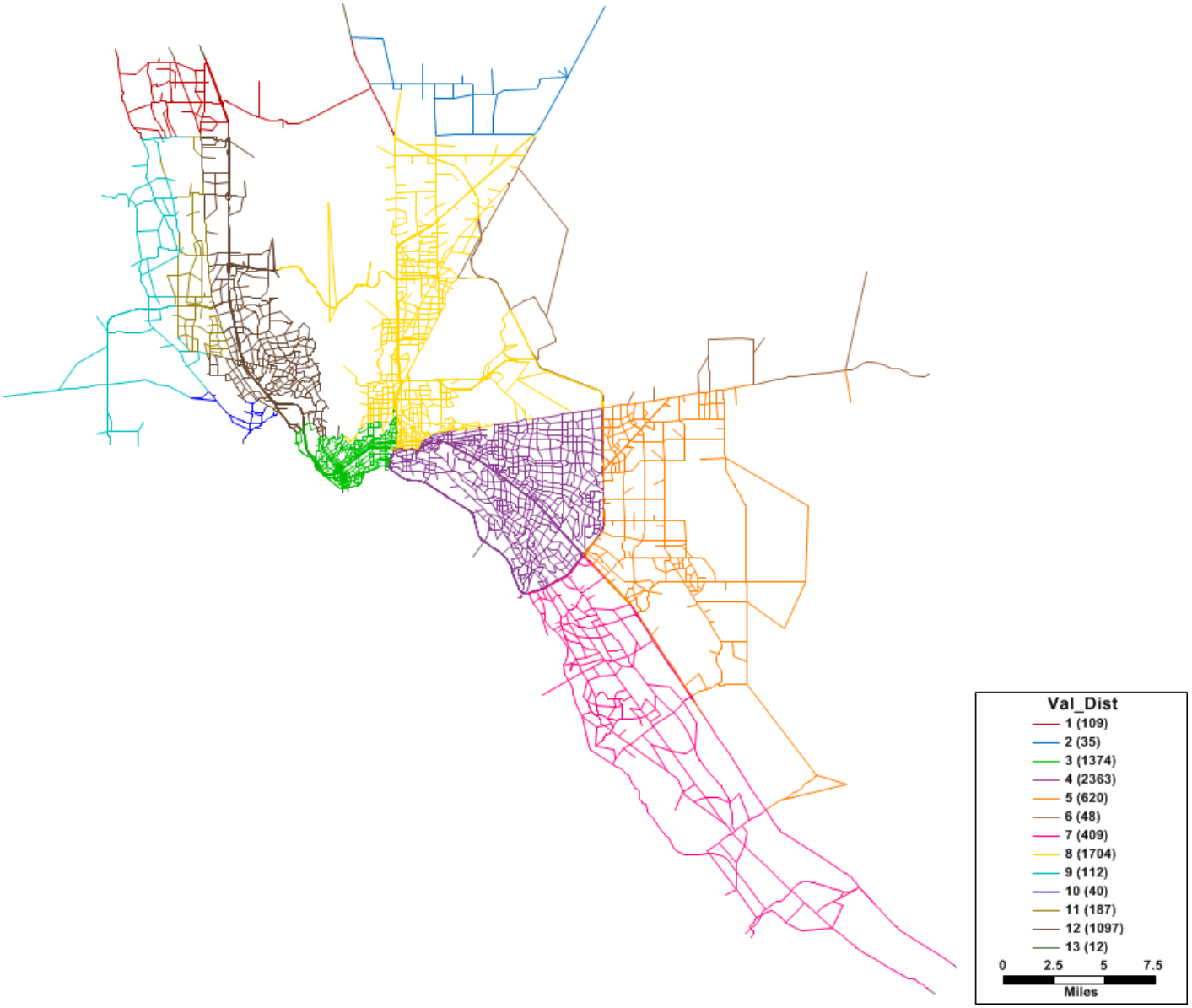

Figure 5: Horizon Model Districts

Table 16: Validation District Legend

Validation District Number	Validation District Name
1	Anthony, NM
2	Chaparral
3	Downtown
4	East Side
5	Far East
6	Hueco Tanks
7	Mission Valley
8	Northeast Central
9	Santa Teresa
10	Sunland Park
11	Upper Valley
12	West Side
13	Externals

Works Cited

Federal Highway Administration. (2010). *Travel Model Valisation and Reasonableness Checking Manual, 2nd Edition*.

Transportation Research Board, National Research Council. (1982). *National Cooperative Highway Research Program Report 255*. Washington, D.C.