Travel Demand Model Validation

Executive Summary

January 2015

Executive Summary Contents

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Introduction

The primary goal in developing a regional travel demand model is to provide a means for making informed decisions regarding proposed transportation improvements. Travel Demand Models have been used for many years to assess mobility issues for virtually all large urban areas. Substantial time and effort are invested in developing and validating a base year model to ensure its reliability.

Model validation is the process whereby the model’s credibility is verified based on replicating observed conditions (e.g. traffic counts, vehicle miles of travel & transit ridership). This Executive Summary reviews the Alamo Area MPO (AAMPO) Travel Demand Model (TDM) development process and demonstrates the validity of the resulting model.

As outlined in Figure 1, development of the 2010 TDM was a cooperative process between several entities. The 2010 AAMPO TDM is actually a series of models and sub models known as the traditional 4-step travel demand model. The TDM has been developed as part of the 2040 Metropolitan Transportation Plan (MTP) update and will provide the primary means for identifying existing and future transportation system deficiencies and assessing proposed regional mobility improvements. The model may also be used in conjunction with EPA’s Mobile6 or Moves emissions software to perform regional air quality analyses.

![Figure 1. Model Development - A Cooperative Process](image)

The AAMPO TDM provides an effective tool that offers regional planning agencies numerous potential uses, including the ability to:

- Provide technical analysis to support the development of the 2040 MTP.
- Evaluate proposed transportation system improvements or enhancements.
- Identify transportation system deficiencies.
- Conduct alternatives analysis.
- Conduct corridor studies.
• Interface with Mobile6 to estimate on-road mobile source emissions for both urban airshed modeling and air quality conformity analyses.

Texas Department of Transportation (TDOT) – Transportation Planning Process (TPP) also uses the model as the primary basis for developing future design level traffic within the (San Antonio District) Alamo Area Region.

Executive Summary Purpose

The methodology for developing and validating a regional travel demand model involved a number of distinct steps:

• Develop the 2010 base year zonal demographic database
• Develop the 2010 base year roadway and transit networks
• Develop trip generation model
• Develop trip distribution model
• Develop the mode choice model
• Develop traffic & transit assignment models
• Validate the 2010 travel demand model

The purpose of this summary is to provide a brief overview of the approach used in accomplishing each of these steps. This document will address model development methodology as well as supporting analytical procedures applied during model validation. Emphasis will be placed on demonstrating that the model performs within acceptable parameters and that the AAMPO TDM is a credible tool to support the local transportation decision-making process.

Demographic Database

The demographic database is one of two essential databases (the other being the network database) required to apply travel demand models. The accuracy of model results is directly correlated to the validity of the demographic database. The demographic database has a direct impact on the number and type of trips produced by the model; it also influences regional travel patterns. Thus, the accuracy of the demographic data has extensive impact on model performance.

Traffic Analysis Zone Definition

The 2010 demographic database is composed of population, households, household income and employment inventories for each traffic analysis zone (TAZ) comprising the study area. TAZs, as shown in Figure 2, are the geographic units used to inventory existing and future demographic data required for modeling purposes. Typically, a TAZ structure is developed that is consistent with the defined roadway structure. This is accomplished by allowing network roadways to be the primary
definition of TAZ boundaries and attempting to minimize roadways that traverse individual TAZs. The rationale for such a structure definition is that the model will perform better by providing trips comparable access opportunities to adjacent streets and transit lines.

For the 2010 Travel Model update, the study area continued to encompass all of Bexar, Comal, Guadalupe, Kendall and Wilson Counties. Total internal Traffic Analysis Zones now number 1,317. These however, include “dummy” or extra zones which can be used for splitting zones or other forecast applications. The TAZ numbering sequence by county is as follows:

- Bexar: 1 to 963
- Comal: 974 to 1074
- Guadalupe: 1094 to 1210
- Kendall: 1232 to 1270
- Wilson: 1290 to 1317

The numbering “gaps” between the counties represent the “dummy” zones.

Population

As part of the cooperative model development effort, AACOG in cooperation with the AAMPO developed the 2010 base year and forecast year demographic database for input to the TDM. Table 1 summarizes the 2010 5-county totals for each database element provided. Population estimates for the Alamo Area study area were based upon information from the Texas State Data Center. Disaggregations of the population and employment totals to TAZ level geography were based upon the TELUM (formerly known as Metropilus) demographic model.

| Table 1. Summary of 2010 Demographic Data for the Five County Modeling Area |
|-----------------------------|-----------------------------|
| Population                  | 2,023,702                   |
| Households                  | 721,621                     |
| Household Size              | 2.80                        |
| Median HH Income            | $47,890                     |
| Basic Employment            | 267,393                     |
| Retail Employment           | 204,339                     |
| Service Employment          | 339,432                     |
| Educ. Employment            | 65,866                      |
| Total Employment            | 877,030                     |

Travel demand models weigh the relationship between people and households (HH size) and between people and employment (Pop/Empl. ratio) to determine the extent and type of travel within the urban area; thus it is critical that the population element of the demographic database be an accurate reflection of base year conditions.

Households/Income

Within a model, households produce the region’s home based trips, which always begin or end at the zone of residence. Individuals within households also produce non home based trips, which by definition cannot originate or terminate at the zone of residence. The travel associated with household trips accounts for 91% of daily regional trip making. For 2010, each household produced an average of 9.9 daily person trips.
Median household income is also specified for each TAZ. Income is important in estimating household travel because higher income usually means more vehicles and greater disposable income. Conversely, transit usage usually goes down as income rises.

Employment

Employment type is used by the model to determine the destination of most trips. So, for example, home based work trips would be destined for a TAZ that contained any type of employment, but home based retail trips would be destined for a TAZ containing retail employment. Also, each TAZ's density factor, calculated as (population + (2.21* employment) / acres contributes to the destination decision. The 2.21 is the regionally constant ratio of total population to total employment. Figure 3 below illustrates the regional TAZ densities that determine area type.

![Figure 3. TAZ Densities](image)

Highway and Transit Networks

The highway and transit networks represent a second important database required to apply travel demand models. Essentially, these networks are a description of the study area's roadway and transit systems for all significant roads and bus lines. In describing travel demand, the networks can be considered the supply side of the equation when comparing existing and future traffic to available roadway capacity. Thus, the relationship of traffic volumes and transit ridership to roadway and transit capacity (demand vs. supply) provides the foundation for any analysis designed for assessing regional mobility and determining transportation system deficiencies.
Network Development

The AAMPO, in cooperation with TxDOT performed the initial step in roadway network development. Together, they inventoried and identified which facilities should comprise the base year roadway network. Generally, all facilities functionally classified as a collector, or higher functional classification, were included in the roadway description provided by both agencies. The transit network, which usually operates on the roadway network was developed in cooperation with VIA Metropolitan Transit. In general, the 2010 transit network consists of five bus modes and 56 individual or combination routes with daily ridership of 127,000 boardings. A sample of the 2010 AAMPO networks are shown in Figure 4.

Figure 4. Sample AAMPO Roadway/Transit Network

For the roadway network, both physical and operational characteristics are coded for each link. These include Facility Type, Area Type, Lanes, Access (divided or undivided), Direction, Speed, Capacity and Count data. For the transit network, Routes, Headways, Stops, Access (walk or park) and Fares are coded.

Facility Types

The following standard Facility Type Codes are used for the 2010 (and future) roadway networks:

1. Radial IH Freeway
2. Radial IH Managed/Tolled
3. Loop IH Freeway
4. Loop IH Managed/Tolled
5. Radial Other Freeway
6. Radial Other Managed/Tolled
7. Loop Other Freeway  8. Loop Other Managed/Tolled
9. Radial Expressway  10. Loop Expressway
11. Principal Arterial-Divided  12. Principal Arterial-Center Turn Lane
13. Principal Arterial-Undivided  14. Minor Arterial-Divided
15. Minor Arterial-Center Turn Lane  16. Minor Arterial-Undivided
17. Collector-Divided  18. Collector-Center Turn Lane
19. Collector-Undivided  20. Frontage Road
21. Freeway Ramp  22. Direct (Flyover) Ramp
23. Tollway Ramp

Area Types

In addition to facility type, each network link was associated with one of five area types as follows:

1. Central Business District (CBD)
2. CBD Fringe (Urban Dense)
3. Urban Residential
4. Suburban Residential
5. Rural

Area types as defined by TAZ density are used to set roadway speeds and capacities. Changes in densities and area types over time enable the model networks to properly represent roadway and transit performance within various types of urban settings. Generally, as urban density increases, speeds decline and capacities increase.

Model Development & Recent Enhancements

In essence, a Travel Demand Model (TDM) is a set of mathematical formulas that emulate human travel behavior based upon observed rationale underlying any trip making. The TDM estimates regional travel demand that would occur as part of a specific demographic scenario and a given roadway and transit structure. Recent model enhancements include the replacement of the gravity distribution model with a Destination Choice model and the introduction of a speed feedback loop. These changes are designed to improve the model's ability to better estimate and forecast transit patronage.

Because model development relies on the observed travel behavior within the San Antonio region, the following comprehensive travel surveys were conducted during 2005/2006 to update travel behavior parameters used in the models. These included the following surveys:

- Household Travel Survey
- Workplace Survey
- Commercial Truck Survey
- Vehicle Classification Survey
- External Vehicle Survey
- On-board Transit Survey
- Saturation Traffic Count Survey
Similar travel surveys have been scheduled for 2015/2016, which will be used to update the 2015 base year models.

The AAMPO Travel Demand Model was developed using TransCAD 6.0 and is comprised of four distinct steps or sub-models: Trip Generation, Trip Distribution, Mode Choice and Trip Assignment. Each of these sub-models and their relation to the overall modeling process are shown in Figure 5.

**Figure 5. Travel Demand Model Process Chart**

The Trip Generation model (Tripcal5) estimates trip productions and trip attractions by trip purpose for each TAZ (1,317) in the region. The various trip purposes as used in the AAMPO model are as follows:

- Home-based Work
- Home-based non-work Retail
- Home-based non-work Other
- Home-based non-work Education (1-12)
- Home-based non-work Educ. (College)
- Non-work Airport
- Non home-based
- Non home-based (Visitor/Commuter)
- Commercial Truck & Taxi
- External-local Commercial Truck
- External-local Non-commercial
- External Through

The Trip Distribution model (Destination Choice) matches trip productions to trip attractions to form trip interchanges among TAZs. Trips are allocated to competing destinations based on observed trip length frequencies and the attractiveness (number of trip attractions) of each TAZ. Using the trip “market segmentation” by income, to inform the destination choice model of the relative affluence of the traveler, the model attempts to send the work trips to work sites that tend to match appropriate employment.

The Mode Choice (Nested Logit) model determines the mode of travel that is selected by the traveler. These decisions are based upon characteristics of (1) the trip maker (income, auto sufficiency), (2) the trip (purpose, length, orientation) and (3) the utility of the competing transportation modes. The mode choice model produces travel for both peak and off-peak times of day for the following modes:

1. Drive Alone
2. Shared Ride 2
3. Shared Ride 3+
4. Bus (walk access)
5. Bus (drive access)
6. Bicycle
7. Walk

The Traffic Assignment model (TransCAD user equilibrium) loads the travel demand (trips) to the roadway network, calculates delay for congested links and re-assigns as necessary to achieve network equilibrium. For future year networks (containing tolled or managed lanes), additional steps are necessary to properly assign travel to the tolled facilities. The TransCAD multi-class, multi-modal equilibrium assignment option is used for this application.

Based upon the Regional Toll Plan document, the roadway tolls are routinely set at $.17 per mile for cars and $.50 per mile for large commercial vehicles. Tolled flyovers are set at $.50 per car and $1.00 per commercial truck. Values of Time (VOT) are set to $16.50 per hour for cars and $40.00 per hour for commercial trucks. The traffic assignment routine calculates the total toll cost for the trip and then uses VOT to estimate whether total time savings would warrant the payment of the toll.

The Transit Assignment model (TransCAD) simply assigns the transit riders to the appropriate routes, according to access/egress (stops) and the need for possible transfers between or among modes.
One very useful product of the Travel Demand Models is the regional traffic loads and transit demand. Analyses of vehicle flow and congestion (Figure 7) are often used to examine a variety of alternatives for future transportation systems.

Figure 7. Vehicle Flow and V/C Ratio Map

Model Validation

Models are validated through a process that proves the model’s ability to replicate existing travel conditions. This is done through comparisons of 2010 modeled traffic volumes and transit ridership to actual traffic counts and bus boardings. Modeled Vehicle Miles Traveled (VMT) vs. observed VMT are compared for each Facility Type and further stratified by Area Type. The results from the 2010 model validation for highways are shown in Table 2. Percent Root Mean Square (%RMS) is a frequently used measure of the difference between observed and estimated values. It provides a single statistic that indicates the models ability to accurately match link based traffic counts. The %RMS for the 2010 model was 28.83% for matching counts and 37.34% for matching VMT. These indicate a quite good link based match and a significant improvement over the 2005 base year models.
The Mode Choice model, which estimates transit usage is also validated to observed bus riders for each type of bus access (walk & drive), bus mode (metro, frequent, express, skip & downtown trolley) and individual bus lines (57 routes). The 2008 Bus ridership validations are shown in Table 3a for comparative purposes. The 2008 mode choice model was recalibrated to account for higher fuel prices with corresponding higher auto operating costs, but as these costs stabilized in 2010, overall transit usage declined. The results of the most recent 2010 transit validation are shown in Table 3b.

<table>
<thead>
<tr>
<th>Area Type</th>
<th>Observed</th>
<th>Assigned</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBD</td>
<td>905,126</td>
<td>850,808</td>
<td>94.0%</td>
</tr>
<tr>
<td>CBD Fringe</td>
<td>14,325,612</td>
<td>14,325,650</td>
<td>100.0%</td>
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<tr>
<td>Urban</td>
<td>13,655,654</td>
<td>13,109,428</td>
<td>96.0%</td>
</tr>
<tr>
<td>Suburban</td>
<td>12,640,437</td>
<td>11,913,415</td>
<td>95.0%</td>
</tr>
<tr>
<td>Rural</td>
<td>7,511,368</td>
<td>8,562,959</td>
<td>114.0%</td>
</tr>
<tr>
<td>Total</td>
<td>48,938,197</td>
<td>48,762,260</td>
<td>99.6%</td>
</tr>
</tbody>
</table>

**Functional Class**

<table>
<thead>
<tr>
<th>Class</th>
<th>Observed</th>
<th>Assigned</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>IH Freeways</td>
<td>17,440,808</td>
<td>17,615,216</td>
<td>101.0%</td>
</tr>
<tr>
<td>Other Freeways</td>
<td>4,927,206</td>
<td>4,976,478</td>
<td>101.0%</td>
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<tr>
<td>Expressways</td>
<td>1,723,805</td>
<td>1,641,981</td>
<td>71.0%</td>
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<tr>
<td>Principal Arterials</td>
<td>7,988,093</td>
<td>8,351,248</td>
<td>105.0%</td>
</tr>
<tr>
<td>Minor Arterials</td>
<td>7,690,983</td>
<td>7,236,428</td>
<td>92.0%</td>
</tr>
<tr>
<td>Collectors</td>
<td>4,603,739</td>
<td>5,269,884</td>
<td>121.0%</td>
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<td>Frontage Roads</td>
<td>2,553,012</td>
<td>2,391,038</td>
<td>63.0%</td>
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<tr>
<td>Ramps</td>
<td>2,013,935</td>
<td>1,934,449</td>
<td>88.0%</td>
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<tr>
<td>Transit Links</td>
<td>841</td>
<td>698</td>
<td>83.0%</td>
</tr>
<tr>
<td>Total</td>
<td>48,938,197</td>
<td>48,762,260</td>
<td>99.6%</td>
</tr>
</tbody>
</table>
Table 3a. Validation of Transit Ridership (2008)

<table>
<thead>
<tr>
<th>Mode</th>
<th>Mode #</th>
<th>Observed</th>
<th>Modeled</th>
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<tbody>
<tr>
<td>Metro</td>
<td>1</td>
<td>70,184</td>
<td>70,227</td>
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<tr>
<td>Frequent</td>
<td>2</td>
<td>42,136</td>
<td>41,177</td>
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<tr>
<td>Express</td>
<td>3</td>
<td>3,477</td>
<td>3,425</td>
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<tr>
<td>Skip</td>
<td>4</td>
<td>12,636</td>
<td>12,848</td>
</tr>
<tr>
<td>N/A</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBD Trolley</td>
<td>6</td>
<td>3,408</td>
<td>3,804</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>131,841</td>
<td>131,482</td>
</tr>
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</table>

Table 3b. Validation of Transit Ridership (2010)

<table>
<thead>
<tr>
<th>Mode</th>
<th>Mode #</th>
<th>Observed</th>
<th>Modeled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metro</td>
<td>1</td>
<td>67,351</td>
<td>73,284</td>
</tr>
<tr>
<td>Frequent</td>
<td>2</td>
<td>42,459</td>
<td>36,506</td>
</tr>
<tr>
<td>Express</td>
<td>3</td>
<td>4,132</td>
<td>3,974</td>
</tr>
<tr>
<td>Skip</td>
<td>4</td>
<td>10,709</td>
<td>10,944</td>
</tr>
<tr>
<td>CBD Trolley</td>
<td>6</td>
<td>2,248</td>
<td>2,327</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>126,898</td>
<td>127,035</td>
</tr>
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</table>

Conclusion

In conclusion, the AAMPO travel demand model replicates base year travel conditions. The model should be a useful tool for identifying existing and future transportation system deficiencies and assessing proposed regional mobility improvements. The MPO, in cooperation with the Alamo Area Council of Governments, VIA Metropolitan Transit, the City of San Antonio, Bexar County and TxDOT District Planning, has developed the base and future year demographic data and corresponding regional roadway and transit network attributes required for model development and forecast applications.