Second Arizona Department of Transportation (ADOT) Travel Model Peer Review Report

March 2014

TMIP
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U.S. Department of Transportation
Federal Highway Administration

FHWA-HEP-14-041


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1.0 Introduction

1.1 Disclaimer

The views expressed in this document do not represent the opinions of FHWA and do not constitute an endorsement, recommendation, or specification by FHWA. The document is based solely on the discussions that took place during the peer review sessions and supporting technical documentation provided by the Arizona Department of Transportation (ADOT).

1.2 Acknowledgements

The FHWA wishes to acknowledge and thank the peer review panel members for volunteering their time to participate in the peer review of the Arizona Statewide Travel Demand Model (AZTDM) and for sharing their valuable experience.

The Peer Review Panel Members included the following individuals:

- Chad Baker, Chief of Statewide Modeling, California Department of Transportation
- Jim Benson, Senior Research Engineer, Texas A&M Transportation Institute
- Karen Faussett, Statewide Model Specialist, Michigan Department of Transportation
- Greg Giaimo, Manager of Travel Demand Modeling, Ohio Department of Transportation

Brief biographies for each of the peer review panel members are presented in Appendix C.

1.3 Report Purpose

This report summarizes the results of the second peer review of the Arizona statewide travel demand model, version 3 (AZTDM3). This review is a follow up to the work performed since the first review conducted in November 2011 (see FHWA-HEP-12-024 for a summary of the first AZTDM peer review).

The peer review was supported by the Travel Model Improvement Program (TMIP), which is sponsored by FHWA. The peer review of a travel model can serve multiple purposes, including identification of model deficiencies, recommendations for model enhancements, and guidance on model applications. It is essential that travel forecasting practitioners have the opportunity to share experiences and insights given the increasing complexities of travel demand forecasting practice and the growing demands by decision-makers for information about policy alternatives. The TMIP-supported peer review provides a forum for this knowledge exchange.

1.4 Report Organization

This report is organized into the following sections:

- Overview of ADOT's goals for this peer review, their model improvement program, and the role of TMIP peer reviews in improving their model.
- Review of the topics posed by ADOT during the first peer review for which ADOT sought specific insight, and guidance from the peer review panel, the panel's recommendations on these topics, and ADOT's response to the recommendations made by the panel.

- Summary of the questions and the peer review panel's comments and recommendations to the topics ADOT sought specific insight and guidance on during the second peer review.

In addition, the report includes four appendices:

- Appendix A—list of peer review participants
- Appendix B—peer review meeting agenda
- Appendix C—biographies for each of the peer review panel members
- Appendix D—summary of the current AZTDM

2.0 ADOT Overview

2.1 Agency's Goals for Peer Review

ADOT has requested this second TMIP peer review to assist ADOT staff in identifying the best practices in statewide travel modeling for implementation in the AZTDM. The goal of the review is to enhance the methods employed in the AZTDM and to improve its utility for planning analyses at state, regional, and municipal levels.

The AZTDM is expected to have a role in a variety of transportation planning studies and projects, including:

- Socioeconomic forecasting;
- Statewide multimodal planning;
- Future scenario evaluations;
- Corridor and sub-area analyses;
- Transportation system planning;
- Project identification and ranking;
- Freight and goods movement studies;
- Air quality and energy analyses;
- Toll and HOV studies; and
- Facility design and operations support.

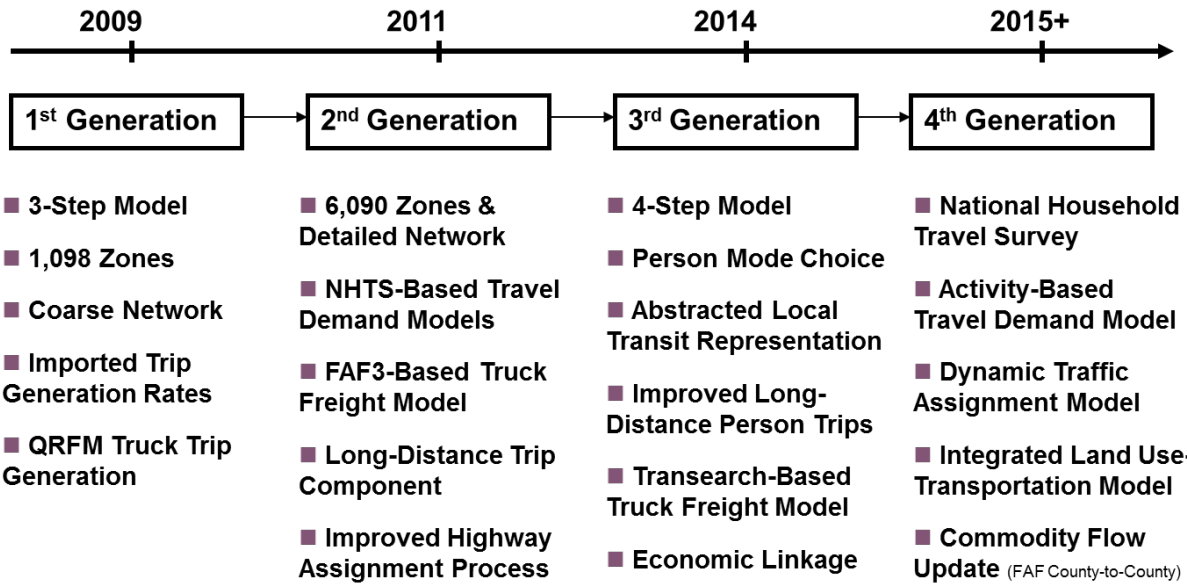
The TMIP peer review summary report will provide useful documentation of the discussion and guidance from the peer review panel of their examination of the AZTDM. To this end, ADOT has prepared a list of specific topics for which they sought the panel's comments and recommendations. The list of topics and the peer review panel's response is presented in Section 4.0 of this report.

ADOT, along with its partner agencies, will assess the feedback from the peers when prioritizing its model development plan. While the advice of the peers is invaluable, there are many factors to work through when considering a model improvement strategy. The panel's recommendations will be regarded as recommendations only and not mandates for ADOT and its partnering agencies.

2.2 ADOT's Model Improvement Plan

The AZTDM currently employs state-of-the-practice techniques for estimating and forecasting statewide travel demand. Over time, ADOT plans to incorporate advanced modeling techniques into the AZTDM, as shown in Figure 1.

Figure 1: AZTDM Phased Model Improvement Plan.



The first generation model (AZTDM1), delivered in 2009, was developed to provide estimates of general statewide performance of alternative system improvement strategies during the visioning activities of the Building a Quality Arizona (bqAZ) framework study. However, the basic structure of the first generation model was aggregate in nature, with a highway network containing only the highest-level roadways. AZTDM1 was determined to have limited suitability for both transportation planning applications and many of the policy questions anticipated in current statewide transportation system planning and development activities.

The second generation model (AZTDM2), initiated in March 2010 and completed in May 2011, focused on implementing personal and freight travel demand model components. The model incorporated considerable additional detail in the transportation analysis zone (TAZ) systems and the transportation networks of the metropolitan planning organizations (MPO) in the state. The personal travel demand model component was calibrated to Arizona travel behaviors by using the 2009 National Household Travel Survey (NHTS) as the primary source of travel behavior information. In addition to the base national sample collected in Arizona through the 2009 NHTS (approximately 500 samples), there were NHTS Add-Ons purchased by the Maricopa Association of Governments (MAG) (4,286 samples) and Pima Association of Governments (PAG) (2,285 samples), which formed the estimation/calibration database totaling approximately 7,000 sample households. The freight and goods movement component of the AZTDM2 was based on available data from public sources, including the FHWA Freight Analysis Framework (FAF3) and the Bureau of Transportation Statistics (BTS) databases.

The third generation model (AZTDM3), initiated in July 2011, seeks to transition the AZTDM to a 4-step model. This has involved incorporating a personal mode choice model component. The abstraction of local transit services during this enhancement provided a realistic representation of local transit while reducing the effort required to maintain and update the statewide model. However, the explicit coding of non-local services (i.e., fixed-guide-way and other line-haul transit services) was retained. The AZTDM3 has capabilities of providing estimates of transit use for major system and service improvements for multimodal planning studies. This transition to a 4-step travel demand model is intended to include feedback interactions with other

AZTDM3 components (e.g., vehicle availability, trip generation, trip distribution, and network assignment) and maintain transit sensitivity to highway network congestion.

2.3 TMIP Peer Reviews Part of ADOT's Model Improvement Plan

The AZTDM2 and the implementation plan for the AZTDM3 were topics of discussion during the first TMIP peer review, which was conducted on November 18, 2011. Section 3.0 of this report includes a summary of the first peer review panel recommendations and ADOT's response.

In this second peer review, ADOT requested assistance from the peer panel to examine aspects of the AZTDM3 and potential advanced modeling techniques for the fourth-generation AZTDM. ADOT's questions to the panel and the panel's responses are included in Section 4.0 of this report. Appendix D of this report contains an overview of the AZTDM3 taken from the model documentation provided by ADOT.

3.0 First TMIP Peer Review Panel Recommendations and ADOT Responses

In the first TMIP-sponsored peer review, ADOT sought feedback and recommendations from a panel of experts on several facets of ADOT's statewide model and model development plan. The following topics were covered, with panel members providing guidance:

- Local Transit Network Abstraction in Mode Choice Model
- Data Needs—Statewide Cordon Count Data and Rural Household Travel Survey
- Commodity-based Freight Model
- Hybrid Statewide/Local Model Application
- Incorporating Advanced Modeling Techniques

The discussion and panel's recommendations on these topics are documented in *Arizona Department of Transportation (ADOT) Travel Model Peer Review Report* (FHWA-HEP-12-024).

During the second peer review, ADOT provided the following summary of the progress made to date on the recommendations from the first peer review.

3.1 Transit

First Review Panel Recommendation

The panel recommended applying a local bus abstraction method in AZTDM3. The panel commented that the use of an abstraction method to estimate local transit in a statewide model was acceptable practice since the model would be used to test regional transit demand and not to estimate local ridership or local transit route choice. Employing a transit abstraction method would reduce network coding at a statewide scale. The panel also recommended following a pre-established structure when developing the local transit abstraction methods. The panel concurred with the practice of only using similar transit service types in an abstraction set when doing transit abstraction. Transit services with different characteristics (e.g., local bus vs. express bus) should not be combined in the same abstraction.

ADOT Response

The third generation statewide model (AZTDM3) has implemented the local transit service abstraction method.

3.2 Travel Data

First Review Panel Recommendation

The panel recommended that ADOT stop vehicles—if they are allowed to do so—in reference to conducting a statewide cordon study. For low-volume roadways, ADOT could stop traffic in the lane. For interstate or higher-volume facilities, ADOT could stop a sample at a designated area, such as a rest stop. If ADOT is not allowed to stop vehicles, then the panel recommended conducting a license plate survey. However, when conducting a license plate survey, the panel strongly recommended that ADOT not conduct a mail-in follow-up survey due to the panel's previous experience with inconsistent data and negative public reaction. The panel also recommended that ADOT review potential new technologies, such as cell phone or Bluetooth,

as these may provide an alternative method to collect important data if vehicles cannot be stopped.

The panel also recommended that ADOT collect better household data in the rural areas of the state and better data for long-distance trips. The panel recommended stratifying the sampling plan by geography (e.g., by county) and by hard-to-reach groups (e.g., minorities or long-distance travelers). The panel suggested that ADOT could conduct a preliminary sample design study as a low-cost method for determining the number of samples needed.

The panel also recommended that ADOT explore opportunities to partner with local MPOs to pool data collection efforts. Partnering with the MPOs would facilitate more efficient data collection and greater consistency between data sources.

ADOT Response

ADOT partners with the MPOs to incorporate MPO model data into the statewide model. For instance, ADOT is using the latest network and socioeconomic data provided by the MPOs in the AZTDM3.

ADOT is planning to participate in the 2015 National Household Travel Survey (NHTS). An add-on of 2,000 samples is being considered to collect travel behavior data for the greater Arizona area residents belonging to smaller MPOs and urbanized areas outside the larger MPOs as well as rural and tribal areas. Consideration will be given to equipping all recruited households with GPS devices. ADOT is also considering conducting a long-distance survey as part of this effort. The add-on to the survey sample will also consider market-augment sampling.

ADOT reported that long-distance travel survey data has been elusive. Trips in existing databases, such as the 1995 American Travel Survey, are higher than counts and needed adjustments have been difficult. Some states do not have data and the 2002 NHTS data has not been good enough for application. ADOT is still searching for a viable, cost-effective approach to collect long-distance travel data. ADOT is considering purchasing cell phone data and is looking for recommendations, especially since much of the long-distance travel is from non-Arizona residents.

ADOT researched whether they would be able to stop vehicles for a state-sponsored cordon survey and were informed that this practice was unlawful. The cordon survey was canceled due to complexity of collecting the data. ADOT will look at the border survey data they have obtained to determine to what degree it may be useful in identifying long-distance trips.

3.3 Enhance Truck Model

First Review Panel Recommendation

The panel liked that the AZTDM2 borrowed MAG's short-distance freight model and recommended that ADOT use MAG's freight data to complement the FAF3 data in recalibrating their freight models.

The panel commented that commodity-based mode choice modeling for freight can be difficult. The panel recommended that ADOT begin by defining the questions they would like to answer with a freight model, such as:

- Is the freight question just about how trucks affect highways?
- Does ADOT need to understand freight movements, such as for a potential rail-mode option?

- How sensitive to different policies does the model need to be?

The panel recommended scaling the complexity of the truck mode choice model to meet their needs based on the questions being asked of the model. The panel also commented that ADOT should be able to take advantage of the TRANSEARCH commodity database purchased regardless of the complexities chosen for the development of the freight mode choice model.

ADOT Response

ADOT reported that the short-distance truck model from MAG was used to recalibrate portions of the statewide freight model. ADOT also reported that the effect of trucks on the highways is addressed by passenger-car equivalents and terrain variables in the statewide truck model.

ADOT is using TRANSEARCH data in place of FHWA FAF3 commodity flow data in the AZTDM3. As of the AZTDM2, the question of which dataset to use had not been decided. FHWA is proposing to release the next FAF dataset version at the county-to-county level (probably in late 2015). ADOT will reassess the FAF/TRANSEARCH issue after the new FAF dataset release. ADOT is also looking at video tracking of trucks (or other technology) to obtain a better estimate of truck flows.

3.4 Hybrid Statewide/Local Model for Focused Analysis

First Review Panel Recommendation

The panel thought that building a hybrid statewide/local model was a good idea and strongly recommended that ADOT pursue this development. The panel concurred with ADOT's recommended approach of maintaining data at a more disaggregate level. The panel also recommended that ADOT look at creating a "window out" tool that could be used to perform the sub-area extraction from the statewide model.

ADOT Response

The AZTDM3 has about 6,100 zones. For the sub-area model development, ADOT has developed a regional analysis zone system that aggregates the AZTDM TAZ to 482 regional analysis zones and 37 super districts to aid in sub-area modeling. Focus area model development is also underway for Central Yavapai MPO (CYMPO) and Central Arizona Governments (CAG).

3.5 Advanced Model Development

First Review Panel Recommendation

The panel recommended that ADOT link the development of advanced modeling techniques to specific needs. They recommended that ADOT consider links to both state and national economic models when looking at connections between the statewide and economic models. The panel also recommended looking into dynamic traffic assignment (DTA) due to the long distances in state travel. However, the panel commented that ADOT needed to specify the functions that would be performed by a DTA and that they would need to be clear on the functional specifications. A statewide DTA application would require development of a simplified approach that extracts the salient portions, such as time of day. The panel also recommended that ADOT consider collecting more detailed highway network data, such as signal locations and timing plans, in anticipation of implementing a DTA.

The panel recommended that ADOT consider an open architecture to implement any activity-based (AB) model platform if ADOT decides to use an AB model. The panel also commented that an AB model approach would most likely also entail an investment in resources and acceptance of longer runtimes.

ADOT Response

As a whole, ADOT seeks to evaluate transportation project impacts with the statewide model with the following quantitative performance measures:

- Mobility
  - Travel Time Delay
  - Reliability
  - Mobility Index
- Accessibility
  - Percent of employment accessible within one hour of travel time
- Economic Impact
  - Migration
  - Value-of-Time (VOT) Cost Savings
  - Gross State Product
- Environmental Quality
  - Mobile Source Air Pollution Index (CO, NOx, SOx, PM, VOC)
- Cost-Effectiveness
  - Cost per hour of travel time saved
  - Return on Investment

ADOT also wishes to use the statewide model for modernization projects affecting traffic flow, including:

- Climbing Lanes;
- Intersection Treatments;
- Managed Lanes;
- Passing Lanes;
- Roundabouts;
- Shoulder Widening; and
- Traffic Interchanges.

ADOT is exploring applying for Strategic Highway Research Program (SHRP2) C10 to help determine which policy options would be inadequately addressed by a traditional 4-step model and that might be better addressed by an AB model or DTA model. MAG's Inner Loop Traffic Operations model and AB model efforts or the FHWA exploratory advanced research in SimTravel may also provide helpful insights.

ADOT is also looking at using the state's REMI TranSight model to quantify the economic contributions of transportation investments.

Regarding collecting more data for DTA, ADOT is planning to collect more detailed network data in the next phase of the AZTDM model improvement.

4.0 Second TMIP Peer Review Topics of Interest and Panel Discussion and Recommendations

ADOT requested that the panel provide insight and guidance related to topics of interest for the AZTDM3 and AZTDM4 development. These topics helped frame the panel discussion and recommendations. The topics provided by ADOT in this peer review are as follows:

1. Any guidance on the minimum requirements for feedback equilibration of travel impedances during both model estimation and calibration?
2. Any guidance on overcoming the absence of long-distance trips in trip distribution when using destination choice?
3. Any guidance on data development and surveys for enhancing long-distance travel demand?
4. Any guidance on the transition to advanced travel models for assessing modernization and congestion management options?

The following text summarizes a point-by-point response by the peer review panel to the topics of interest posed by ADOT.

4.1 Minimum Feedback Requirements in Equilibration

The panel recommended rechecking calibration targets on individual model steps when using updated skims to ascertain if the model is still within validation targets. The panel commented that recalibration should be performed if changes to the impedance matrices prevent individual model steps from meeting the validation thresholds for that step. The panel was not aware of a set of thresholds or criteria governing changes in impedance tables that dictate when to redo a model calibration. The panel also recommended using averaging in feedback loops, if it is not currently being employed. Averaging trip tables or impedances helps to dampen oscillations and/or drifts that may occur in successive iterations of the feedback loop.

4.2 Overcoming the Absence of Long-distance Trips

The panel recommended that ADOT adjust the Census Transportation Planning Products (CTPP) journey-to-work data that was used to calibrate the work-trip purpose in the long-distance model to be in the same units as home-based work trips. CTTP reports on work trips based on the respondents' usual trip patterns and does not account for absenteeism and working from multiple locations. Home-based work trips represent an actual trip made (or not made) on the survey date. The panel commented that the adjustment between these two definitions may be significant.

The panel recognized that many of the limitations to the long-distance model stem from a lack of data. The panel recommended that ADOT first seek to better understand long-distance trips by obtaining more data in order to improve the long-distance model. To do this, the panel offered the following suggestions:

- Conduct a long-distance survey to capture internal long-distance trip behavior.
- Consider obtaining cell phone data to inform long-distance travel movements both in and out of the state.

- Consider contacting tourism agencies to identify location(s) where the non-resident population stays; place(s) of origin; duration of stay(s); and, perhaps, purpose of travel.
- Continue to explore other sources for external long-distance trip data such as the FHWA long-distance model currently under development.

The panel commented that rural areas near urban areas may have different travel patterns because of access to the urban areas. As a result, ADOT may want to consider clustering samples in these cities, or other smaller cities, in order to obtain a sufficient sample size to adequately understand trip behavior. The panel also commented that the NHTS may not conduct long-distance surveys; however, it may be possible to recruit a household during the NHTS for an additional survey if that household took a long-distance trip in the recent past.

The panel commented that ADOT would need to determine the importance of non-resident trips. Since non-resident trips are typically not identified in a household travel survey, assumptions may need to be made about non-resident trips if data cannot be found.

The panel noted that ADOT could apply correct methods to the long-distance model once long-distance trip behavior is better understood. Specifically, the panel recommended considering separating long-distance, home-based work trips from short-distance work trips in the model; this would better account for the long, inter-city commute trips. The panel also suggested that ADOT consider additional terms in the destination choice model to capture intercity interactions, such as between Tucson and Phoenix. The panel also suggested that additional market segmentation in trip distribution, where there is a closer match between employment and job types, may help.

4.3 Data Development & Surveys for Long-distance Travel

The panel commented that many agencies, such as California DOT, have recent experience in collecting data from long-distance surveys. These agencies could provide feedback to ADOT regarding their experience and also advise on potential pitfalls. The panel recommended that ADOT contact agencies that recently completed trip-diary or long-distance surveys to better understand the types of questions they asked and the lessons they learned from their data collection efforts.

The panel also recommended that ADOT investigate the use of other sources to quantify the magnitude of long-distance trips (both resident and non-resident), including through cell phone data, which could then be controlled using other data sources, such as CTPP data. The panel commented that while cell phone data would help to quantify the magnitude of travel, ADOT would probably still need survey data to understand the details about the trips since cell phone data is aggregate in nature. The panel commented that smartphone survey applications with GPS tracking may be the future of trip surveys, but acknowledged these are still in beta testing.

The panel also recommended that ADOT consider vehicle body type identification and location tracking technology at weigh-in-motion (WIM) stations to help identify long-distance truck movements for the freight model.

4.4 Advanced Models for Assessing Modernization & Congestion Management

The panel recommended that ADOT consider an AB model for the long-distance component first and leave the short-distance models as trip-based models. The panel commented that

aggregate-demand models typically work well in evaluating highway projects, which affect all users in the same way. Aggregate-demand models are less effective for projects that affect user groups differently, such as managed lanes, where tolling could affect people in different ways or at different times of the day.

The panel also commented that the traffic modernization evaluations ADOT wishes to perform could be achieved through the use of DTA—whether AB models or trip-based models were being used. Enhancements to the demand models may not be necessary to address operational traffic issues.

In reference to DTA, the panel recommended consideration of zonal-level data in addition to the network detail that ADOT is planning to collect in the AZTDM4. Large zone sizes typically found in statewide models and more moderate zone sizes typically found in MPO models will likely lack sufficient resolution needed to capture the effects of intersection improvements. A much finer spatial resolution and supporting data would be needed. The panel commented that the multi-resolution approach ADOT is proposing for sub-area modeling may be a good way of getting more refined data for traffic operations analyses. The panel recommended that ADOT consider prioritizing updates to the long-distance and freight models before DTA.

4.5 Discussion of Other Modeling Topics

The panel acknowledged ADOT's efforts to improve aspects of the truck model in the AZTDM3. The panel noted that the primary uses of a statewide model are to estimate long-distance and freight trips and that plans for further development of the freight model in the AZTDM model improvement plan were missing (other than an update to incorporate FAF county-to-county data). The panel recommended that ADOT consider further freight model enhancements in their model development plan.

The panel also recommended that ADOT consider adding an auto sufficiency parameter in addition to an auto availability parameter in the model. Auto sufficiency is defined as the ratio of potential drivers to the number of vehicles available in a household. The auto sufficiency variable might also be measured as the number of vehicles versus the number of workers. This measure could be a better parameter to use in the mode choice model.

Appendix A List of Peer Review Panel Participants

Peer Review Panel Members:

Chad Baker	California DOT
Jim Benson	Texas A&M Transportation Institute
Karen Faussett	Michigan DOT
Greg Giaimo	Ohio DOT

Local Agency and Partner Agency Staff:

Keith Killough	Arizona DOT
Deng Bang Lee	Arizona DOT
Baloka Belezamo	Arizona DOT
Tracy Clark	Arizona DOT
Dianne Kresich	Arizona DOT
Michael Gorton	Arizona DOT

Consultant Staff:

Krishnan Viswanathan	Wilbur Smith Associates
Liza Amar	Wilbur Smith Associates

Supporting Staff to Peer Review Panel Members:

Chad Worthen	RSG

Webinar Attendees:

Ken Cervenka	Federal Transit Administration
Eric Pihl	FHWA—Colorado Division
Ed Stillings	FHWA—Arizona Division
Joonwon Joo	Arizona DOT
Darcy Anderson	Arizona DOT
Sooraz Patro	Central Arizona Governments
Arup Dutta	Maricopa Association of Governments
Patrizia Gonella	Jacob Engineering, Inc.
Rama Dhanikonda	Wilson & Company
Holly Hassett	Hexagon Transportation
Ruth Gutierrez	CivTech
Katie Strickland	Citilabs
Hyunsoo Noh	PAG

Appendix B Peer Review Panel Meeting Agenda

ADOT Second TMIP Model Peer Review

March 6, 2014

8:30 a.m.–5:00 p.m.

ADOT Board Room
206 South 17th Avenue
Phoenix, Arizona 85007

1	Welcome and Introduction	ADOT	08:30-08:45
2	Recommendations from the First TMIP Model Peer Review	ADOT	08:45-09:10
3	AZTDM3 Model Specification	CDM-Smith	09:10-10:00
4	Morning Break		10:00-10:15
5	AZTDM3 Model Implementation	CDM-Smith	10:15-12:00
6	Lunch		12:00-01:00
7	AZTDM3 Model Calibration and Validation	CDM-Smith	01:00-02:10
8	ADOT's AZTDM Model Improvement Plan	ADOT	02:10-02:45
9	Afternoon Break		02:45-03:00
10	Peer Review Panel Internal Discussion	TMIP Panel	03:00-04:00
11	Preliminary findings/Recommendations from Panel	TMIP Panel	04:00-05:00

Appendix C Peer Review Panel Biographies

Chad Baker (California Department of Transportation)

Chad Baker has been the Statewide Model Branch Chief for Caltrans since 2009. In this capacity, he is responsible for all aspects of the model, including quality control, operation, scenario development, post-processing, and reporting. In his role as Branch Chief, he provides technical reviews and reports for various planning efforts such as travel surveys, regional demand modeling, freight modeling, and passenger rail modeling. Prior to his current engagement, he has worked for the Department performing design, project study, programming, and macro and microsimulation work.

Prior to working for Caltrans, Mr. Baker worked for a private engineering firm performing design, construction, and open channel flow simulation work. Mr. Baker graduated from the University of California at Davis with both a Bachelor's and a Master's degree in Civil Engineering. Mr. Baker is an active participant with the Transportation Research Board as the Chair for NCFRP Project 38, Improving Freight System Performance in Metropolitan Areas, as well as other panels. He is also a member of the technical expert panel for SHRP2 Project C10B.

Jim Benson (Texas Transportation Institute)

Dr. Benson has more than 45 years of experience in transportation planning and engineering. During his 40+ years with the Texas Transportation Institute (TTI), his research has focused in the areas of transportation planning and travel forecasting. He has served as Principal Investigator or Study Director for numerous projects in these areas. During the past 10 years, Dr. Benson's research and development efforts have focused primarily on the provision of technical support and assistance in the area of travel demand model development, travel demand model applications, and travel model software support. Through his work with the Transportation Planning and Programming Division of the Texas Department of Transportation (TX DOT), he has been directly or indirectly involved with the model development efforts for most of the metropolitan areas in Texas. He played a major role in TX DOT's migration to the TransCAD software platform for travel demand modeling. Through his work with the Houston-Galveston Area Council (H-GAC), he has provided management and technical guidance in the development of the travel demand models for the region for over 30 years.

Dr. Benson has served on various panels and committees, including: the Peer Review Panel for the Development of the Oahu MPO Travel Demand Models and the Texas Statewide Analysis Model Review Panel. He is currently a member of the TMIP Peer Review Panel for the ADOT statewide model.

Karen Faussett (Michigan Department of Transportation)

Karen Faussett is the Statewide Model Specialist at the Michigan Department of Transportation (MDOT). She is responsible for the update and maintenance of the Michigan statewide travel demand model and leads the statewide model team.

Ms. Faussett was also project manager for MDOT's 2004–2005, 2009, and 2015 statewide household travel surveys. Before moving to statewide modeling, she spent several years developing small urban models at MDOT. Prior to MDOT, Ms. Faussett worked at the Southeast Michigan Council of Governments (SEMCOG). She has a Bachelor of Science in Urban Planning from Michigan State University and a Master's Certificate in Project Management from the George Washington University.

Greg Giaimo (Ohio Department of Transportation)

Greg Giaimo graduated from the Ohio State University with BSCE (1989) and MS (1991) degrees. He has worked for Ohio Department of Transportation (ODOT) as a travel modeler for almost two decades and is a registered professional engineer in Ohio. Besides day-to-day project and corridor analyses, he is in charge of new model development, data collection, and development of technical methods related to the planning process. In this role, he develops methods for producing project-level forecasts from models and other inputs and creates those forecasts for complex projects in the northwest quadrant of the state.

Mr. Giaimo estimates/calibrates new travel demand models, or manages consultant contracts, for the statewide model and 17 Ohio MPO models and has actively guided Ohio's adoption of advanced modeling techniques focusing on activity micro-simulation, freight, land use, and integration of traffic operations models. He develops data collection protocols and implements new technologies for household surveys, intercept surveys, and travel time data collection programs and oversees staff and consultants collecting these data. He has also developed various other related planning processes, including the statewide congestion management system, bypass project analysis process, transportation review advisory council scoring factors, planning level Highway Capacity Manual program, and toll revenue forecasting process.

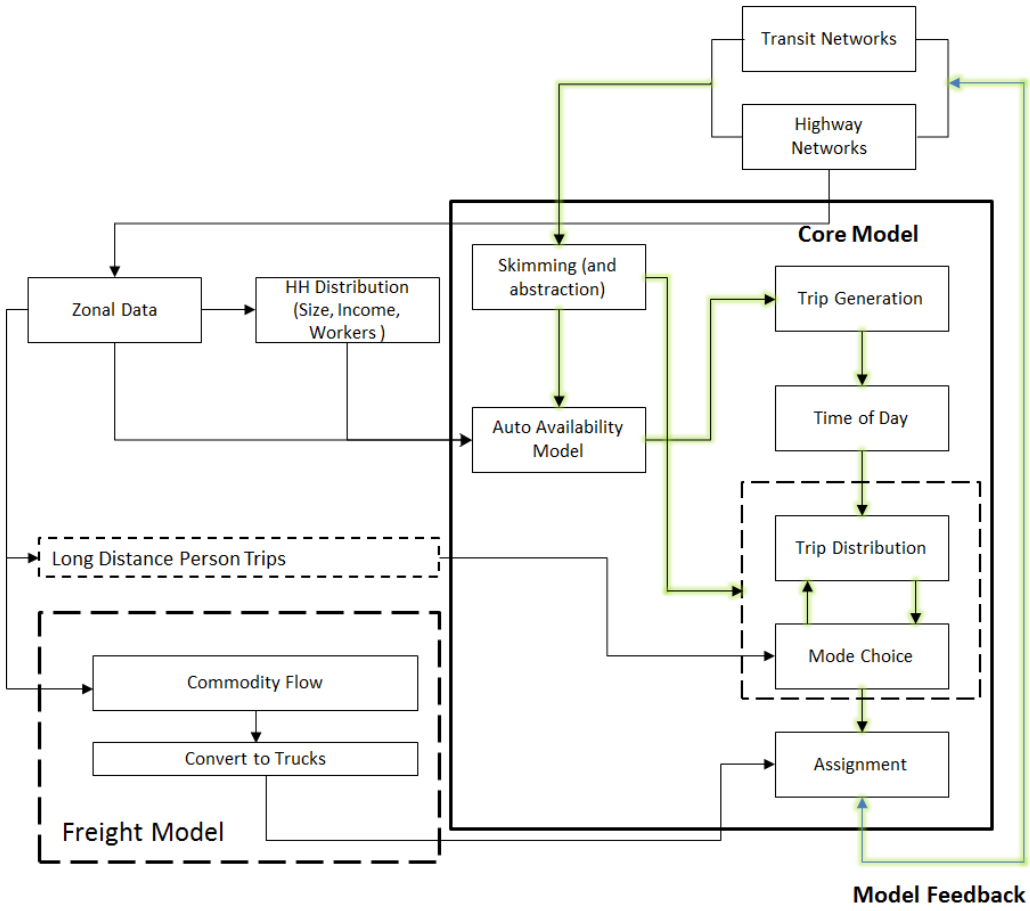
Appendix D Overview of AZTDM3

The following text summarizes the latest version of the Arizona Statewide Travel Demand Model (AZTDM3) at the time of the review, along with data sources used in the development of the model.

Model Components

The AZTDM3 is a traditional 4-step model with feedback, including separate components for passenger travel and truck trips. Also, new to the AZTDM3 structure is an auto-availability model and mode choice (a key change from the AZTDM2), as shown in the following flow chart.

Figure 2: AZTDM3 structure.



Source: ADOT, AZTDM3 Model Report, February 5, 2014

The AZTDM3 has five primary model components as described in the current model documentation:

- Setup and Skimming
- Household Models
- Person Travel

- Trucks/Long Distance
- Assignment

Setup and Skimming

By developing highway networks and updating the network settings, the AZTDM3 creates toll/non-toll skims using a generalized cost that is based on travel time, toll, and distance for the following four vehicle classes:

- Drive alone
- Shared ride 2
- Shared ride 3+
- Truck

Skimming is based on generalized cost (including monetary costs such as toll costs and non-monetary costs such as the cost of time) for a variety of travel characteristics.

Transit skims are created by developing transit networks, updating the transit network settings, and skimming based on highway, transit, and walk time for a variety of travel characteristics.

Transit abstraction methodology is used instead of traditional skimming to represent the local transit system. This methodology has been implemented in the California statewide travel demand model and is known as a hybrid transit abstraction method. The California model's coefficients were used as a starting point and then the AZTDM was calibrated to match the values of coded skims in Arizona network. The advantage of using this methodology instead of traditional skimming is that maintenance of the transit networks can be more easily facilitated.

Household Models

In this stage, trip generation is conducted for short-distance person trips only. Truck and long-distance person trips are processed separately in other stages of the model.

The base year for the model is 2010 and socioeconomic data have been updated from the AZTDM2. Trip generation rates for short-distance person trips were generated based on the 2009 NHTS. For each county, rates were calculated for five trip purposes:

- Home-based work (HBW)
- Home-based university (HBU)
- Home-based school (HBS)
- Home-based other (HBO)
- Non-home-based (NHB)

Person trip generation rates are stratified by area type. Area type definitions were calculated based on an accessibility measure. Area types used by the AZTDM3 include the following:

- Central Business District (CBD)
- Urban
- Suburban
- Rural
- Small Town Central Business District

The 2009 NHTS data were used for the estimation of the mode choice, auto availability, and time-of-day models. Public Use Microdata Sample (PUMS) data from 2006–2010 are used for calibrating the auto availability models.

The auto availability model was estimated for the following three alternatives:

- Household with zero vehicle
- Households with one vehicle
- Households with two or more vehicles

The outputs from the auto availability model are shares of zero, one, and two or more vehicle households and these are input into the trip generation model. A nested logit model is used for model estimation.

Short-Distance Mode Choice Models

The following modal alternatives are considered in estimating the mode choice models:

- Drive alone
- Shared ride 2
- Shared ride 3+
- Walk and drive access to local bus
- Walk, Drive, and Local Bus access to premium transit
- Non-motorized modes (Walk and Bike)

The AZTDM3 is a vehicle model; therefore, non-motorized choices are disabled during model calibration and application process.

Long-Distance Mode Choice Model

A nested logit model is used with an auto nest containing three alternatives (drive alone, shared ride2, and shared ride3+) and a transit nest containing drive and walk access. Air travel within Arizona is almost non-existent and is not considered in the model. The automobile drive alone is considered to be the base alternative. Model coefficients asserted from literature are shown in Table 1 (mainly Ohio statewide model[1] and Florida High Speed Rail study[2]).

Table 1: Proposed Variables in Long-Distance Mode Choice.

Variable	Units	Business	Non-Business
IVTT	Minutes	-0.0103	-0.0087
Walk-Access Time	Minutes	-0.0206	-0.0174
Drive-Access Time	Minutes	-0.0206	-0.0174
Cost	Dollars/log (income/1000)	-0.104	-0.153
Auto Nest Parameter		0.35	0.35
Transit Nest Parameter		0.35	0.35

[1] Ohio DOT, Ohio Statewide Model, 2010.

[2] Wilbur Smith Associates and Steer, Davis, Gleave. Tampa - Orland High Speed Rail Ridership Study - Summary Report, November 2011.

Time-of-Day Models

The time of day component in the AZTDM3 is moved upstream (compared to the AZTDM2) and the factors are applied to trips after the trip generation step. The factors based on trip purposes and mode (separate for Auto and Transit) are developed using the 2009 NHTS and are applied to produce the desired trip tables by purpose and time of day to be assigned to the network.

Person Travel

In this stage, the AZTDM3 performs trip distribution for short-distance person travel using a destination choice logit model. A multinomial logit model is then used to predict auto occupancy. Shares were derived from the NHTS and then smoothed to ensure a logical relationship among modes.

Truck & Long-Distance Person Travel

In this stage, the model separately processes short- and long-distance truck travel and long-distance person travel.

The short-distance truck model is a three-step model without mode choice. Its trip generation is segmented by 12 land use categories:

- Employer (start and end point of any truck trip)
- Retail
- Construction
- Farming
- Mining
- Households
- Governments
- Warehousing
- Transportation
- Office
- Industrial/Manufacturing

A gravity model is applied to distribute short-distance truck trips. Friction factors between zone pairs are calculated dynamically based on congested travel time.

Long-distance truck trips are processed by a Java program that uses a Transearch commodity flow matrix. Long-distance commodity flows are converted to truck trips using payload factors for single-unit and multi-unit trucks. An empty truck rate is used to factor the truck trips for returning empty trucks. Capacity and volume/delay function curve parameters were obtained from MAG. Passenger car equivalent (PCE) values were obtained from the Highway Capacity Manual (HCM 2000).

Long-distance person trips are mainly processed by a Java script, which reads and expands the 2002 NHTS long-distance data to a state-to-state trip table then disaggregated to TAZ using household data, employment, and a weighting scheme. A 10% sample of ticketed air travelers by BTS was also used. After missing NHTS records are synthesized and the NHTS data are expanded, trips are disaggregated to the AZTDM zones based on population and employment. The model also uses national and state parks as special attractions.

Assignment

Highway assignment in the AZTDM3 includes the assignment of auto trips to the highway network with preload of long-distance auto and truck trips as well as local bus vehicles by time of day. The assignment of trips onto the network is done by four time periods:

- AM Peak (6:00 a.m.–9:00 a.m.)
- Mid-Day (9:00 a.m.–3:00 p.m.)
- PM Peak (3:00 a.m.–6:00 p.m.)
- Night (6:00 p.m.–6:00 a.m.)

Highway assignment is implemented using user equilibrium assignment with mode and period specific tolls, PCEs, capacities, and preload volumes. Congested travel times are calculated using a BPR-type volume-delay function. The resulting assignments by time of day are summed into a daily table of assignment statistics by link. Long-distance auto and truck trips are assigned with All-or-Nothing (AON) assignment.

The model performs a feedback loop from trip generation to assignment. In the first feedback loop iteration, long-distance trips (person and truck) are loaded onto the network using an AON assignment. Then, the short-distance trips (person and truck) are loaded onto the network with a user equilibrium traffic assignment. Only the AM and MD travel times are fed back. Convergence is reached when the percent RMSE for the AM and the MD periods are both less than 1%. On the final model iteration, the model assigns PM and NT trips to a highway network.

For transit assignment, transit trips are assigned to the coded premium transit service routes (e.g., rail, BRT, express bus, and intercity routes) for walk, drive, and local bus access by time of day. The local bus vehicles are added to the preload volume in highway assignment and are not assigned in transit assignment. Transit assignment is based on the Pathfinder algorithm for transit networks created in the skimming procedures and origin-destination (O-D) transit trips for premium transit walk, drive, and local bus access.

Model Validation

Model calibration is focused on broad markets and the state highway system at the corridor level. Traffic counts were used to validate the AZTDM3.

Aggregate volume to count comparisons showed that the R-Square for the total flow was approximately 0.92, and the percent RMSE of total flow was 30% slightly above Ohio RMSE totals.

Figure 3: Total flow for the AZTDM3.

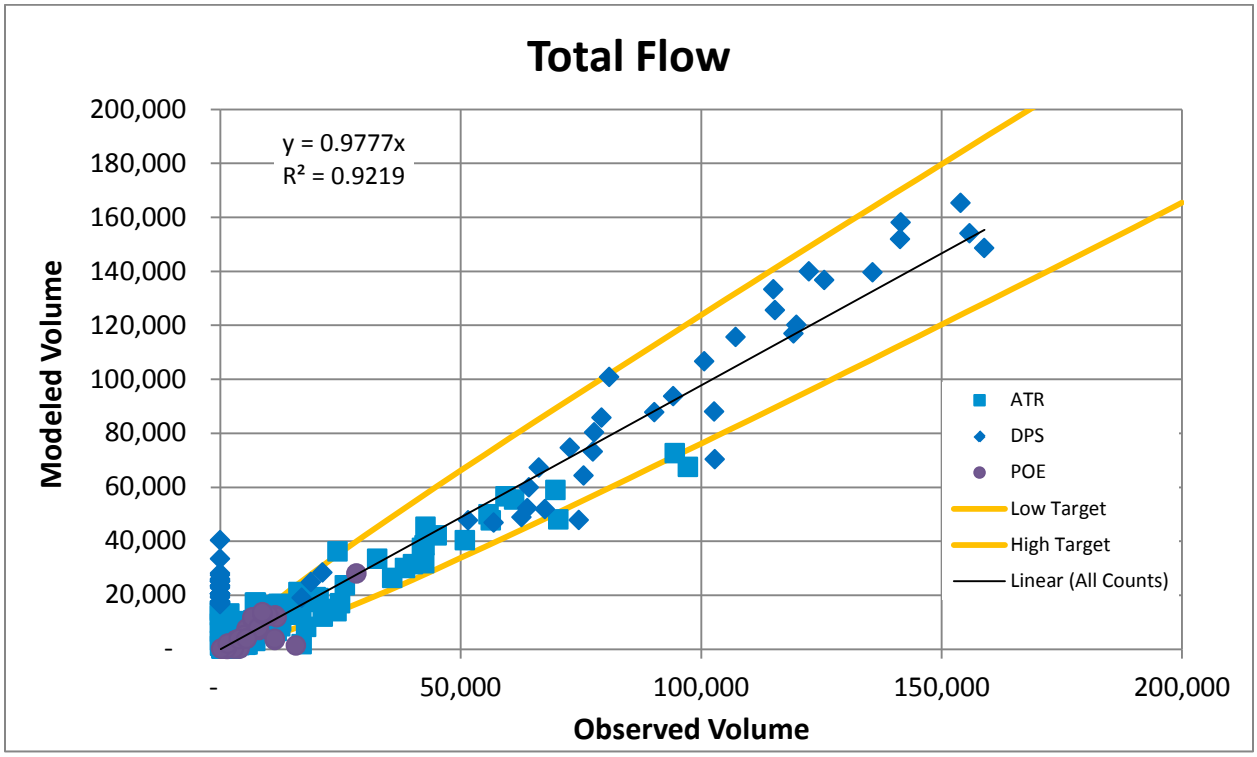
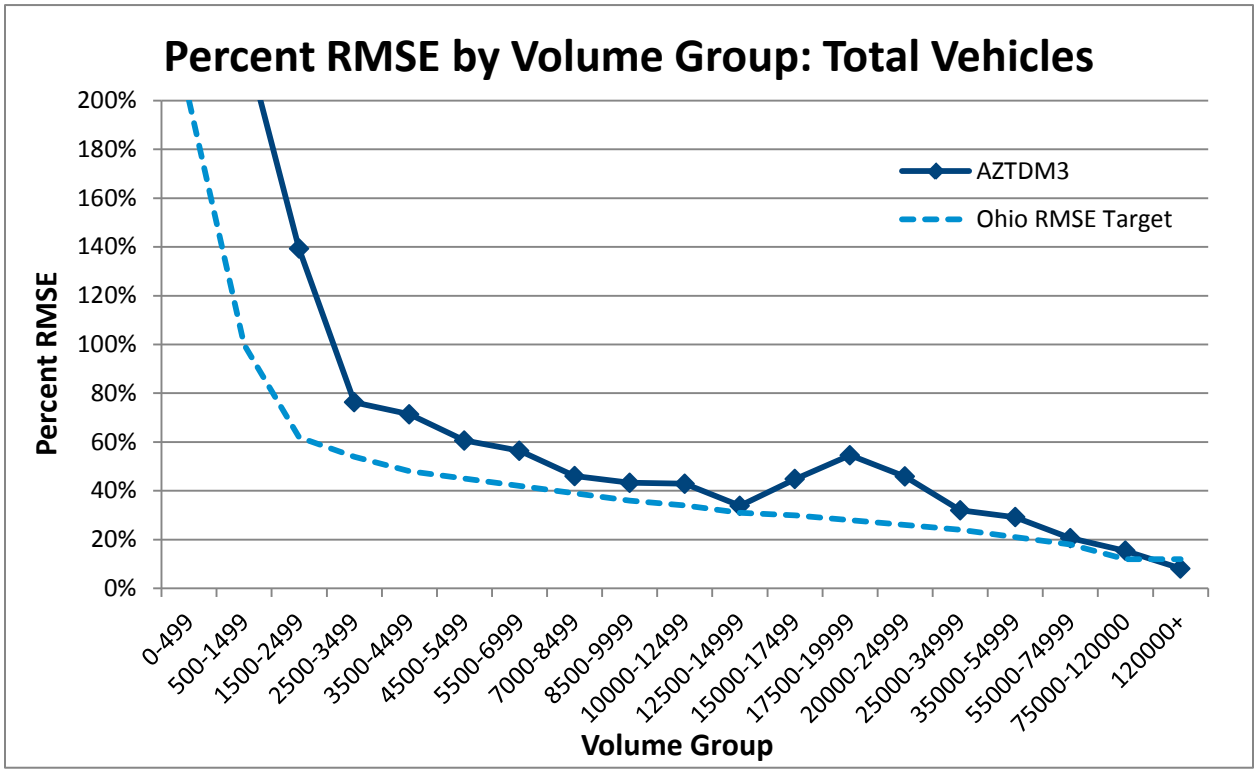


Figure 4: Percent RMSE by Volume Group—Total Vehicles.



Source: ADOT, AZTDM3 Model Report, February 5, 2014

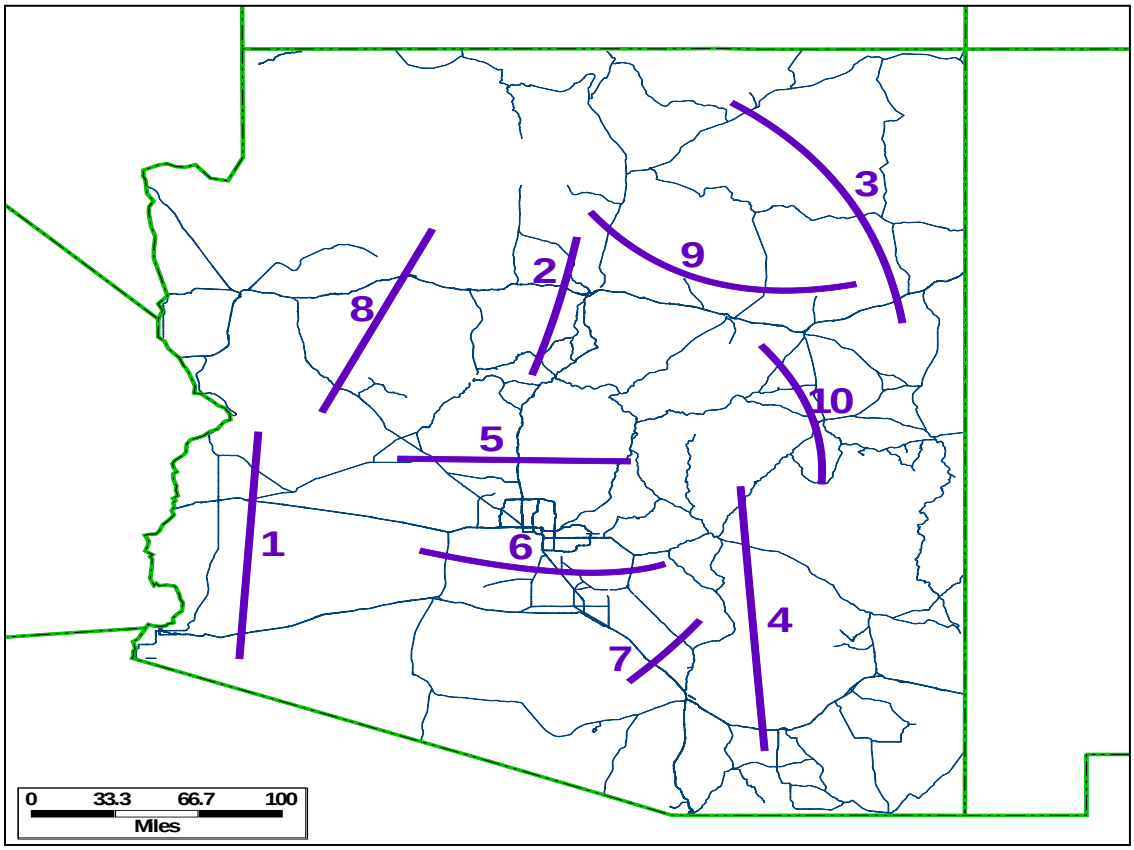
Screenline and cordon validations were also performed. The percent error of volume on 8 of 10 screenlines was within 20%. All screenlines and cordons were within maximum desired deviation.

Table 2: Screenline and cordon validations.

Description	SCREEN LINE2	Number of Counts	ATR	Model	Difference	% Difference	Maximum Desirable Deviation	Within Target?
I-8 & I-10 West	1	6	36,117	43,519	7,402	20.5%	38%	YES
I-40 Mid	2	5	32,667	22,455	-10,212	-31%	40%	YES
I-40 East	3	4	21,014	19,443	-1,571	-7%	46%	YES
I-10 East	4	2	30,049	28,137	-1,912	-6%	40%	YES
MAG-Flagstaff	5	3	47,230	42,652	-4,578	-9.7%	34%	YES
MAG-CAG	6	6	117,979	138,505	20,526	17.40%	22%	YES
CAG-PAG	7	3	53,212	61,096	7,884	14.82%	32%	YES
I-40 West	8	3	15,040	13,491	-1,549	-10.30%	50%	YES
Northeast	9	3	8,836	8,048	-788	-9%	61%	YES
I-10 East--North Split	10	5	16,738	20,722	3,984	23.80%	50%	YES
Total of Screenlines		**40**	**378,882**	**398,068**	**19,186**	**5%**	**17%**	**YES**
MAG Cordon	MAG	14	221,596	253,946	32,350	15%	17%	YES
PAG Cordon	PAG	8	76,274	80,133	3,859	5%	27%	YES
CAG Cordon	CAAG	8	181,780	208,912	27,132	15%	18%	YES
CYMPO Cordon	CYMPO	4	50,599	34,337	-16,262	-32%	32%	YES
Yuma Cordon	YMPO	4	30,322	33,318	2,996	10%	40%	YES
Flagstaff Cordon	FMPO	9	59,572	54,512	-5,060	-8.49%	31%	YES
Total of Cordons		**47**	**620,143**	**665,157**	**45,014**	**7%**	**17%**	**YES**

Screenlines Totals on Links with ATR Counts
Source: ADOT, AZTDM3 Model Report, February 5, 2014

Figure 5: Screenline locations in Arizona.



Screenlines Map

Source: ADOT, AZTDM3 Model Report, February 5, 2014

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