Ohio-Kentucky-Indiana (OKI) Regional Council of Governments Peer Review Report

June 2014

TMIP

Better Methods. Better Outcomes.

U.S. Department of Transportation
Federal Highway Administration

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TMIP
Better Methods. Better Outcomes.

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List of Acronyms

AADT	Average Annual Daily Traffic
ACS	American Community Survey
ATRI	American Transportation Research Institute
BEA	Bureau of Economic Analysis
BLS	Bureau of Labor Statistics
CBP	County Business Patterns
CTPP	Census Transportation Planning Product
CT-RAMP	Coordinated Travel - Regional Activity-Based Modeling Platform
CVG	Cincinnati/Northern Kentucky International Airport
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GE	General Electric
GIS	Geographic Information Systems
GPS	Global positioning system
HBO	Home-based other
HBS	Home-based school
HBSH	Home-based shopping
HBSR	Home-based social recreation
HBU	Home-based university
HBW	Home-based work
HCM2010	Fifth edition of the Highway Capacity
HOV	High-occupancy vehicle
HPMS	Highway Performance Monitoring System
IDOT	Indiana Department of Transportation
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
KYTC	Kentucky Transportation Cabinet
LEHD	Longitudinal Employer-Household Dynamics
LRT	Light rail transit
MORPC	Mid-Ohio Regional Planning Commission
MOVES	Motor Vehicle Emission Simulator
MPO	Metropolitan planning organization
MVRPC	Miami Valley Regional Planning Commission
NAICS	North American Industry Classification System
NCTCOG	North Central Texas Council of Governments
NHB	Non-home-based
NOACA	Northeast Ohio Areawide Coordinating Agency
OD	Origin-destination
ODOT	Ohio Department of Transportation
OKI	Ohio-Kentucky-Indiana Regional Council of Governments
OSU	Ohio State University
P&G	Procter and Gamble
PDA	Personal digit assistant
QCEW	Quarterly Census of Employment and Wages

QRFM2	Quick Response Freight Manual II
RFG	Reformulated gasoline
RVP	Reid vapor pressure
STEAM	Surface Transportation Efficiency Analysis Model
TAZ	Traffic analysis zones
TDFM	Travel demand forecast model
TLF	Trip length frequency
TMIP	Travel Model Improvement Program
TSD	True-shape display
UC	University of Cincinnati
VMC	Vehicle miles of capacity
VMT	Vehicle miles traveled
WBO	Work-based other

1.0 Introduction

1.1 Disclaimer

The views expressed in this document do not represent the opinions of the Federal Highway Administration (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 Ohio-Kentucky-Indiana (OKI) Regional Council of Governments. OKI is responsible for the allocation of federal transportation funds within the three-state region.

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 OKI travel demand forecast model (TDFM) and for sharing their valuable experience.

The peer review panel members were:

- Rebekah Anderson – Ohio Department of Transportation (ODOT),
- Lei Zhang - National Center for Strategic Transportation Policies, Investments and Decisions at the University of Maryland,
- Keith Lawton - Keith Lawton Consulting,
- Arash Mirzaei – North Central Texas Council of Governments (NCTCOG), and
- Mark Bryam – Ohio Department of Transportation (ODOT).

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

1.3 Report Purpose

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. Given the increasing complexities of travel demand forecasting practice and the growing demands by decision-makers for information about policy alternatives, it is essential that travel forecasting practitioners have the opportunity to share experiences and insights. The TMIP-supported peer review provides a forum for this knowledge exchange.

The objective of the current TMIP peer review was to seek guidance and recommendations on the following features of OKI's travel demand model, which is planned to be updated from a trip-based to a tour-based model:

- Reaffirm that the current trip-based model structure, procedures and results meets the needs of the agency.
- Identify any improvements that can be quickly implemented within OKI's existing data resources or suggest data that can be easily collected for application in the model; and
- Obtain guidance regarding their effort to transition to a tour-based model.

The peer review panel spent one and a half days, April 14 and 15, 2014, responding to specific questions from OKI and its planning partners. The results of those discussions and recommendations from the panel are presented in this report.

1.4 Report Organization

This report is organized into the following sections:

- *Overview of OKI* – this section gives an introduction to the demographics and transportation characteristics of the region, and *OKI*'s planning responsibilities.
- *Development of the OKI Model* – this section provides a historical context of travel modeling at OKI, the agency's current model improvement program, and their goals for the peer review.
- *Transportation Model Improvement Plan* – this section provides an assessment of OKI's improvement plan prior to the peer review session.
- *Peer Review Discussion* – this section provides details regarding each topic discussed during the peer review session.
- *Peer Review Panel Recommendations* – this section provides the peer review panel's recommendations to OKI.

In addition, the report includes Number of 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

2.0 Overview of OKI

2.1 OKI Responsibilities

The OKI Regional Council of Governments was designated in 1973 as the metropolitan planning organization (MPO) for the Cincinnati region, which is home to two million people, an international airport, and a major amusement park. Two projects of national and regional significance are underway, the Brent Spence Bridge and the Eastern Corridor studies.

2.2 Regional Characteristics

In 2010, OKI's eight county region's population was 1,999,474. This eight county region includes four counties in Ohio: Butler, Clermont, Hamilton, and Warren; three counties in Kentucky: Boone, Campbell, and Kenton; and one county in Indiana, Dearborn County. By 2040, OKI and the state data centers expect the region to grow to 2.23 million people.

Much of the regional growth is contained in Warren, Butler, and Boone County.

The region's industry drivers include: Procter and Gamble (P&G), new General Electric (GE) technology centers, University of Cincinnati Medical Center and associated health care facilities, Fifth Third Bank, Citibank, Macy's, Great American Insurance, and Kroger Supermarkets. There are also a multitude of smaller manufacturing firms in Mason in Warren County, a city ranked 24 in the top 100 best places to live by CNN.

The OKI region alone contains about 500 lane miles of freeways, over 200 lane miles of limited access expressways, a major north-south freight corridor that moves truck and rail vehicles, the Ohio River barge corridor, and one international airport. Most congestion in the area occurs on facilities moving vehicles in and out of the downtown area.

Within the region, most large residences are located in the suburbs. Young adult populations are primarily centered in the Over-the-Rhine neighborhood and Newport, KY. Elderly populations are more concentrated in areas like Clermont County and in other suburban areas. Fewer than nine percent of the households are zero-car households, and the median housing costs range from $200 to $220 thousand. Property sales taxes are considered low throughout the region.

3.0 Development of the OKI Model

3.1 Introduction

The OKI model includes two MPOs, the Miami Valley Regional Planning Commission (MVRPC) and OKI, spanning eleven counties: seven in Ohio, three in Kentucky, and one in Indiana. The program runs on Cube Voyager and custom programs, most of which are run through FORTRAN. Figure 1: OKI Modeling Areaprovides an illustration of the modeling area. Table 1: OKI Model Statistics provides a basic model statistical summary.

Figure 1: OKI Modeling Area

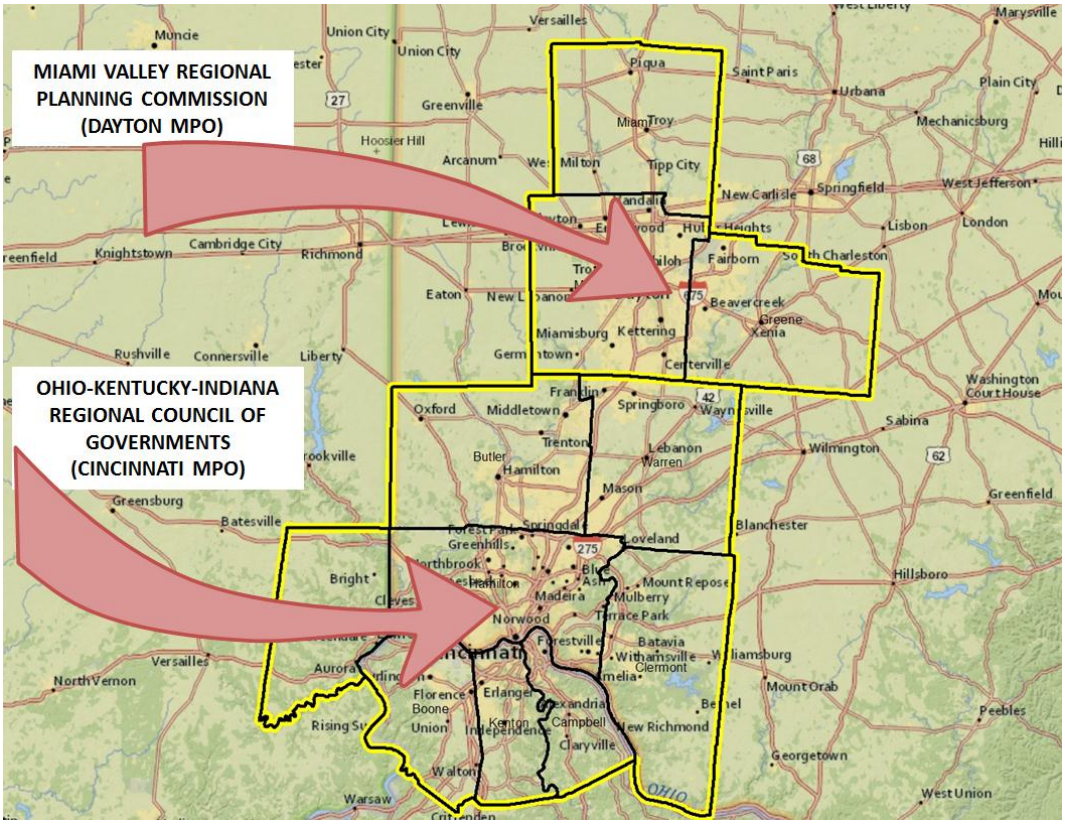


Table 1: OKI Model Statistics

Model Characteristic	Statistics
Population (2010)	OKI: 1,999,474 MVRPC: 823,257 TOTAL: 2,822,731
Households (2010)	OKI: 781,953 MVRPC: 327,630 TOTAL: 1,109,583
Lane-Miles of Roads (OKI)	6,555
Traffic Analysis Zones (Model)	OKI: 2,067 MVRPC: 890 Externals: 106 Total: 3,063
Traffic Analysis Zones (OKI)	2,299 (includes 232 expansion zones)

The OKI model was created in 1968 and first applied in 1971. The following list provides a timeline of the OKI model's development and enhancement. It also includes various factors that have influenced the model building environment:

- 1978: First trip origin-destination surveys conducted;
- Early 1980s: Model was enhanced with logit mode choice model, and emissions model;
- Early 1990s: Model was converted to PC based platform (OS/2 and TranPlan);
- 1994: First OKI Peer Review conducted;
- 1995: Second round of surveys conducted;
- Late 1990s: Model was calibrated to 1995 data;
- Early 2000s: MVRPC model, Cincinnati/Northern Kentucky International Airport (CVG), and Kings Island were added to the structure;
- 2003: Peer Review conducted;
- 2004: Peer Review conducted;
- 2010: Third round of surveys conducted; and
- Current: Model calibrated to 2010 data.

The model is applied to a variety of study types, such as bridge and toll diversion analysis; rail and streetcar corridor analysis; long range transportation planning, specifically 2004 and 2008 regional plans; express and local bus planning for four different transit operators, Metro, Tank, Clermont, and Dayton; and attainment estimation for ozone and fine particulates.

OKI was the first MPO to implement the Motor Vehicle Emission Simulator (MOVES) and has also collaborated with FHWA to apply the Surface Transportation Efficiency Analysis Model (STEAM) for economic analysis of large transportation projects.

3.2 Existing Transportation Model

In the existing structure, OKI runs a modified trip-based model. This model performs a household classification process that provides input to trip generation estimation by wealth classes based on the number of workers per household compared to the number of vehicles (for home-based work trips) or the number of people in the household compared to the number of vehicles (for home-based other trips). The distribution is an un-stratified gravity model. Mode choice is a nested-logit process that is based on wealth classes. Assignment is a bi-conjugate equilibrium assignment. The model performs a feedback procedure for trip distribution and mode choice by time of day.

Prior to the OKI peer review, the OKI model applied 1995 household and transit surveys and validated to 2005 traffic counts and transit ridership. By the time of the peer review in spring 2014, OKI calibrated the model using 2010 household and transit on-board surveys combined with data from the 2010 decennial census and 2005-2010 American Community Survey (ACS). In the last five years, OKI also has collected a massive number of traffic counts and has enhanced the highway network file to include more variables. Additionally, OKI has improved model output reports and streamlined the model process.

OKI is currently working with the Ohio Department of Transportation (ODOT) to develop an activity-based model, using the Coordinated Travel - Regional Activity-Based Modeling Platform (CT-RAMP).This development is expected to take at least until June of 2015.

3.3 Previous Peer Reviews

As referenced in Section 3.1, OKI has conducted three other peer reviews in the past. The first peer review was in 1996 to assess the then-current TDFM in view of the regulations and policies established by the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). Two years later in 1998, the panel was reconvened to review progress and provide suggestions for model use in then-active transportation studies. The third peer review panel was convened in 2003 to comment on several factors surrounding the model's adequacy and consistency with the state of the practice. Several recommendations from the 2003 peer review have been completed or have been investigated prior to this peer review. Table 2 summarizes the status of those items.

Table 2: Status of 2003 Model Peer Review Action Items

Action Item	Completed	Definite TODO in 2010 Trip Based Model	Investigate in 2010 Trip Model	Tour Based Model	Being Monitored	Unclear
Melding OKI and MVRPC into one model	X					
Further analysis of the consistency of highway and transit path building parameters vis-a-vis the utility functions			X	X		
The factors used in the trip generation functions		X				
The use of significant k-factors			X			
Mode choice constants in submodes and transit system specific factors			X	X		
The use of passenger car equivalents for trucks in the assignment process	X					
Allowing the area type designations used in various portions of the model to vary over time	X					
Worker productivity factors used in the truck model were noted as they may over-state growth.					X	
Tour based models				X		
Incorporating land use factors into the forecasting process						X
Generating person trips by all modes		X				
Incorporating a density measure in the modal utility functions			X	X		
Use of a destination choice model rather than a gravity model			X	X		
Use of significantly more graphics in the analysis and presentation of model forecasts		X		X		
Development of an auto ownership model			X	X		
Income based market stratification in distribution and mode choice			X	X		
More detailed demographic and employment data		X				
Consideration of household life-cycle based generation models				X		

3.4 OKI's Goals for the Current Peer Review

OKI identified three reasons for the peer review in their application. First was to reaffirm that the current trip-based model structure, procedures, and results meet the needs of the agency. In areas where the need is not met, OKI requested the suggestion of short term improvements. Second, OKI requested that the panelists identify any improvements that can be quickly implemented utilizing data or data that can be easily collected. Finally, the OKI staff sought guidance on their effort to transition to a tour-based model. The tour-based model is targeted for summer of 2015, but it is expected that both the trip-based and tour-based models will run parallel for a couple of years. OKI emphasized the importance of ensuring that the trip-based model meet the needs of regional transportation planning activities and the key projects until the transition is complete.

At the time of the peer review, OKI identified the following additional areas of priority for the panel to address:

- Model needs for the following major projects including the Brent Spence Bridge, Eastern Corridor Highway and Rail Transit, and Long Range Plan;
- Guidance for moving to the tour-based model structure, including methods for effectively testing the model;
- The introduction of price modeling for tolling and managed lane project forecasting; and
- Multimodal, specifically non-motorized, modeling.

4.0 Transportation Model Improvement Plan

4.1 OKI's Improvement Plan

In their peer review application, the OKI Transportation Modeling Department identified the following a short-, medium-, and long-term plans for the OKI model's enhancement. The short term plan for the OKI model focuses on upgrades to the trip-based model. These upgrades will include removing as much TranPlan code as possible, reducing model data storage overhead, inclusion of the fifth edition of the Highway Capacity Manual (HCM2010) methods, a full recalibration of the model using the 2010 data that have been collected, and the implementation of a more detailed zone structure. In addition, certain parts of the model will be significantly overhauled, including Home-Based School trips, taxi trips (which may be removed due to the lack of data), and truck trips. Other parts may undergo minor changes, such as the trip generation model, which will gain additional trip purposes.

Short-Term Trip Generation Improvements:

- Recalibrate the household classifier, considering the addition of an auto ownership model;
- Recalibrate trip generation rates;
- Investigate adding home-based shopping and home-based social-recreational trip types;
- Recalibrate trip attraction rates; and
- Update EI/IE and EE trips and the process to forecast those trips.

Short-Term Trip Distribution and Mode Choice Improvements:

- Purchase wireless travel data to provide observed trip distribution information;
- Investigate stratification of trip distribution based on wealth class or income class;
- Investigate revision to destination choice;
- Calibrate distribution, re-estimate and recalibrate mode choice; and
- Re-introduce non-motorized modes (bicycle and walk) into the mode choice model.

Short-Term Other Improvements:

- Investigate quick revisions to the truck model;
- Investigate replacement of current time-of-day model (fixed factors) with a time-of-day choice model;
- Update the transit speed estimation methodology; and
- Update the highway capacity methodology to 2010.

The medium-term plan is to move to the CT-RAMP model. This move is supported by Ohio DOT, and will be in conjunction with an upgrade of CT-RAMP at the Mid-Ohio Regional Planning Commission (MORPC) and a similar move to CT-RAMP at the Northeast Ohio Areawide Coordinating Agency (NOACA). This will put the three models on a common code base and enable the three MPOs to share work, such as model enhancements, reports, and post-processes, as well as to share work with other CT-RAMP users in other states.

Since the OKI trip-based and tour-based models will be calibrated to 2010 data and will use many of the same formats of files, the OKI staff will be able to compare runs from each. This

would allow for an easier transition from the trip-based model to the tour-based model. It will also facilitate ensuring that the new model system works correctly and that any major issues may be investigated without impacts to scheduled project work.

Some of the more interesting features of the tour-based model include better representation of commercial vehicles throughout the region, as well as enhanced ability to answer questions about the model and what it forecasts, particularly where major improvements are concerned. The tour-based model will also be set up to use dynamic traffic assignment (DTA). Additionally, the tour-based model will have enhanced output visualization features.

The long-term plan is to build the capability to analyze problems using both macro and meso-level simulation, and to provide a pathway to micro-simulation. Over the long term, the OKI Transportation Modeling Department will focus efforts on better and more automated data collection in order to develop and/or enhance the non-motorized portions of the model.

Several years ago, OKI staff members investigated the potential of adding a land use model to the model stream. At that time, it was determined that no existing model is as good as the current non-model approach to forecasting socioeconomic data. However, with the increased data archiving by the Transportation, Transportation Modeling, and Geographic Information Systems (GIS) departments, OKI will revisit the potential of developing a land-use model that reflects the development patterns of the region.

5.0 Peer Review Discussion

The following section details the discussions that occurred between the OKI modeling staff and the panelists as OKI described their modeling processes in the peer review session. The discussion was broken down into the following topic areas: survey data, traffic count data, highway network updates, socioeconomic data, trip generation, external trips, trip distribution/friction factors, mode choice, freight, non-home based trips, temporal factors, assignment, post processing, air quality, horizon 2040 forecasting, improvements underway, and lessons learned.

5.1 Survey Data

The 2010 household travel survey was a large-scale GPS research project conducted by ODOT. There were an estimated 750,000 households in the area to be surveyed. The target number of households to be surveyed was 3,500, but the resulting sample was 2,051. It was noted that trip purpose imputation was conducted poorly, given that 34% of responses indicated "new place" and "other" as the place types for origin-destination (OD). Many of the coded stop locations were also questionable. Further, 24% of the responses included at-home activity, while home-based work (HBW) trips comprised just 9% of trips. For comparison, the panelists noted that in the most recent OKI survey, prior to this one, home-based work trips comprised about 17% of trips. OKI noted that they had not yet analyzed the tours and also noted that the economic recession could have been the genesis for this variation. OKI did not conduct a separate external station survey. The data from the 1995 external data was replaced with the purchase of AirSage data in 2012.

One panelist noted that the survey did not include weekends, but included Spring Break, which could have explained why the response rate was lower than diary surveys conducted in the Dayton and Columbus areas circa 2000. As a suggestion for future data sources, another panelist noted that ODOT plans to spend $1 million in the design and implementation of the next statewide survey with a 100% prompted recall.

The transit onboard survey conducted in the fall of 2010 and spring of 2011 was conducted via personal digit assistant (PDA) interviews on local buses, while a survey form was provided on express buses. The survey resulted in 6,623 completed records. OKI geocoded the results and performed the initial weighting.

OKI obtained AirSage data for March 2013 for the OKI region, covering resident, non-resident, and through trips. They found that the external-external trip data and the county-level flows were very reasonable, but trip lengths were slightly off when compared to the household survey data. The AirSage data included more of the minor county flows, which they found to be better than the expanded household survey. The AirSage external station summaries were also found to be different along the northern-axis leading in/out of the region. OKI noted that a combination of OD data from household travel surveys with the OD patterns found in the AirSage data would be useful. One of the panelists suggested that AirSage data are better suited to smaller geographies.

5.2 Traffic Counts

There are 3,430 count stations located in the OKI region. The distribution of count stations by county in the modeling region is summarized in Table 3, below. It was noted that while some counters are permanent, many of them can be affected by construction. Radar counts on local roads are used throughout the OKI region, and it was expressed that this technology should be applied to regional freeways, as well, for more accurate, durable counts with greater range.

MVRPC maintains their own count database. Additionally, OKI uses ArcGIS published on-line Average Annual Daily Traffic (AADT) count data, which is available to the public at http://traffic.oki.org. There are 678 planned count locations for inclusion in the count system in 2015. These locations will cover all freeways, river bridges, and screenlines.

Table 3: Count Stations by County

County	Stations
Boone	166
Butler	543
Campbell	130
Clermont	407
Dearborn	64
Hamilton	1524
Kenton	192
Warren	404

OKI's traffic count database contained 5,081 counts dating back to 2003 from multiple sources, including counts taken by OKI. In the data obtained by OKI, 73% provided counts by vehicle, and 27% of counts were volume-only. Counts that span multiple years comprise 67% of count locations. OKI applied a seasonal adjustment factor to the counts to obtain the AADT.

OKI recently cleaned up this count database, eliminating estimates for locations where data were not available. It was resolved that only recent, post-2008, counts would be used for validating models.

5.3 Highway Network Updates

OKI indicated that they wanted a true-shape display (TSD) for the highway network. TSD is preferred to the stick network, as it provides better visualization, is less error-prone in data maintenance, and facilitates data transfer between the street and centerline network. OKI also noted a preference for a geodatabase network over the stick or conflated networks, as TSD could be achieve in both the input and output of the network.

In the 2010 updates, OKI expanded the number of traffic analysis zones (TAZs) from 1,608 to 2,299, and maintains 232 TAZs tagged for further expansion. Each city block in the downtown area is an individual TAZ. The zone sizes become larger further from the urban core. Dummy zones were allocated for future expansion options. Table 4 provides a summary of the TAZ structure statistics for the OKI model.

Table 4: TAZ Statistics

Model Area	2,639 square miles
Number of Zones	2,067
Average Zone Size	1.28 square miles
Maximum Zone Size	24 square miles
Minimum Zone Size	0.004 square miles

One panelist commented that the average TAZ size was relatively small, which is good and should support transit access connections. OKI noted that all transit routes go downtown along major routes. OKI also noted that they split a significant number of zones in Dearborn and Butler counties to logically support new development in these areas. OKI attempted to keep TAZ sizes toward the lower end of Census Transportation Planning Product (CTPP) recommendations. OKI was cognizant of employment centers in the zonal splits, as well as water features and railroads.

It was noted that OKI does minimal review of the MVRPC model. OKI does not consciously match TAZ sizes at the county boundaries near MVRPC, but they did conduct various small splits in Warren and Butler counties near the Montgomery County line so the current TAZ size is more consistent than it has been in the past.

Five networks were developed: four time periods and an all-day sum of assigned volumes. The structural differences in these networks include variation in street-parking by time-of-day and one reversible lane bridge.

All link fields required by ODOT were included in the network update. All core fields were updated, including intersection turn lanes, intersection control types, area types, number of lanes, and traffic counts. Stub links that connected centroid connectors to real links were provided for intersection junction modeling.

One of the panelists noted that Cube dynamic turn penalties at junctions, also known as intersection delays, are an ODOT standard. It was additionally noted that the stub links should be created prior to the intersection.

There is no non-motorized mode network, but OKI wrote a Python process for transit walk access connections. There are also about 20 park-and-ride lots, but the parking supply is not used by the model.

5.4 Socioeconomic Data

For base year 2010, five socioeconomic variables were sourced from the 2010 decennial Census: total population, household population under 18, group quarters institutionalized, group quarters non-institutionalized, and total households.

Census block-level data were converted to each TAZ using the “Tabulate Intersection” analysis tool in ArcMap. In instances where census block boundaries and TAZ boundaries did not overlay exactly, the area proportion feature in Tabulate Intersection apportioned values from the block to the intersecting TAZs. For institutionalized and non-institutional group quarters, the block to zone conversion was handled differently. Using a spatial join in ArcMap, the group quarter population associated with a census block was assigned to a TAZ based on the location of the block centroid. The TAZ in which the block centroid was located was assigned the whole group quarter’s population. The locations of the largest group quarters populations, such as prisons, were reviewed manually to verify the accuracy of the assignment.

For the employed labor force variable, block group is the smallest Census geography for which data are tabulated. The Census Bureau prepared a special tabulation known as “Labor Force Statistics” based on the five-year 2006-2010 ACS. Employed labor force participation rates were calculated from the data provided, and OKI allocated Census block group labor force rates to TAZ, using a spatial join in ArcMap similar to that conducted for group quarters populations. The TAZ in which the block group’s centroid fell was assigned that block group’s labor force participation rate, which was then multiplied by the population aged 16 and older to arrive at a labor force estimate for that TAZ. Population aged 16 and older was derived from the 2010 decennial Census block data previously converted to TAZs.

Data on vehicles per household by TAZ were also derived from five-year 2006-2010 ACS block group data. Vehicles per block group were divided by the number of households in the block group to arrive at a ratio. The ratio was assigned to a TAZ block group using a spatial join in ArcMap in a fashion similar to the development of the employed labor force. The TAZ in which the block group’s centroid fell was assigned that block group’s vehicle ratio. The vehicle ratio was then multiplied by the number of households in each TAZ to arrive at a vehicle estimate for

that TAZ. Households per TAZ had been previously determined in the conversion of households from blocks to TAZs.

The primary source for identification and location of hotel rooms in the OKI region was Reference USA, a free version of InfoUSA available on-line from a local library. Data on the number of rooms were gleaned mainly from AAA tour books and the Directory of Hotel and Lodging Companies. OKI also searched the facility's website and trade association websites or called the facility directly.

Elementary and high school enrollment in each TAZ was developed from data provided by the Ohio, Kentucky, and Indiana departments of education. The address for each school was geocoded and then the geocoded schools were aggregated by TAZ. Enrollments for each TAZ were summed by grade range.

To establish post-secondary school enrollment, OKI first accessed the National Center for Education Statistics website. However, a number of for-profit universities were not included in that database. Some were listed in the Cincinnati chamber of commerce website, known as the Cincinnati USA Regional Chamber. The few schools for which enrollment data could not be found through research were contacted directly. OKI included in its enrollment database only those post-secondary schools which had enrollments of 100 or more under the assumption that those with lower enrollments would have negligible impact on traffic patterns.

For employment, the transportation departments in Ohio and Kentucky provided OKI with individual business records which included name, street address, number of employees, and North American Industry Classification System (NAICS) code. OKI identified employers missing from the provided lists and added them to the database. Missing employers included some churches, libraries, schools, and government offices. Employer data were purchased from InfoUSA for Dearborn County, Indiana, as no data were available from the Indiana Department of Transportation (IDOT). Once all employers were identified to the extent possible, the 45,000 employers were geocoded.

Employment categories were created by grouping similar industries together. The 12 categories are defined by NAICS industry codes.

5.5 Trip Generation

For trip generation, data were developed for years 2010, 2020, 2030, and 2040. Data were then interpolated using the closest data years for any years in between. Household classification used a seed table employing 2006 to 2009 CTPP data. The socioeconomic data file was used to establish the control numbers for area type, persons per household, workers per household, and vehicles per household. The output was a list of households.

The following trip types are used in home-based trip generation: home-based work (HBW), home-based university (HBU), home-based shopping (HBSH), home-based social recreation (HBSR), and home-based other (HBO). Home-based school (HBS) trips are not estimated by the model.

Trip productions were calculated using a cross-classification table for HBW trips using the following survey variables: area type, workers, and auto ownership. Home-based other trips were estimated by area type, persons, and auto ownership. Three different functions: linear, exponential, and natural log, were used for both average (average of all trip rates) and disaggregate estimation. The line of best fit was calculated using R and tested in Excel to select the best fitting function.

A panelist questioned the appropriateness of the four variables, area type, workers, population, and auto ownership, used in determining trip productions and whether the forecast process supports this level of disaggregation.

Trip attraction rates were based on regression using the following variables: employment, hotel rooms, and households. University trips were difficult due to a lack of data, but OKI will be receiving more data from the University of Cincinnati (UC) with which to re-estimate the model. A panelist stated that university trips are often modeled as special generators, for example in Oregon.

5.6 External Trips

Two input files were used in trip generation: the external-external percentage at each external station and zonal trip flow between external stations and annual growth rate. An external station survey has not been conducted since 1996, but AirSage data were applied to update the trip table during the model update. Four AirSage zones were used for externals: north, south, west, and east. The AirSage data trip matrix included: the origin zone (external zone or internal OKI TAZ), destination zone (external zone or internal OKI TAZ), start date, end date, time of day (either 24-hour or AM peak), and resident class (resident, non-resident, or through-traveler).

In addition to the AirSage data, OKI collected traffic counts at external stations in 2013, including trucks. This effort included 63 external stations, versus the four AirSage external zones. Four sets of annual growth percentages were applied to the 63 by 63 zonal pairs.

A panelist asked if comparisons were made between the 2013 counts and the AirSage data. OKI noted that comparisons were conducted at an aggregate level. It was found that AirSage slightly undercounted total traffic.

A panelist noted that there could be a variation between growth rates in the north-south regional corridor versus the west-east regional corridor. It was also noted that both positive and negative trends in count data were observed. The panelists recommended that the lack of current external data be supplemented by and compared with the data from 1996 external station survey.

5.7 Trip Distribution/Friction Factors

Friction factors were developed following guidance from the National Cooperative Highway Research Program (NCHRP) and Philip Viton, a director of The Ohio State University's Joint Program in Urban Transportation. The model's impedance function uses top-level log-sum from the mode choice model. The functional form is the gamma function, which is calculated using R and adjusted iteratively.

OKI compared the results to observed county flows and calculated new K-factors. A panelist noted that this method essentially pivots off of observed data, and recommended that OKI link the K-factors to actual geographic features. OKI identified that trips crossing the Ohio River, as well as trips commuting between Cincinnati and Dayton, require further control.

One panelist noted that a small area of employment data can bias the calculations. If there are not enough data from the household survey, there can be a significant amount of aggregation error. The panelist suggested that developing destination choice models, estimated from disaggregate survey records, rather than an aggregate gravity model, is one way of reducing aggregation error. Another panelist suggested that the log-sums could be part of the problem. OKI responded that log-sums have been used in the past, but they will try to apply only travel times in the future. It was noted that ACS data could be used to review inter-county travel.

OKI provided graphs of trip length frequencies by trip purpose and time-of-day. The following list provides the panelists' reactions to the trip length frequency (TLF) model estimates by trip purpose and time-of-day:

- HBW Peak TLFs: Modeled frequencies are shorter than observed. The market segments in trip generation were not carried forward to trip distribution, only trip purposes. The model does not currently include income, but OKI needs to separate low and high income workers, so workers are not sent to the wrong places.
- HBU Peak TLFs: Modeled frequencies are significantly longer than observed. It was suggested that some of these trips may be occurring off peak.
- HBSH Peak TLFs: The model estimates look very close to observed.
- HBSR Peak TLFs: The model estimates look very close to observed.
- HBO Peak TLFs: The model estimates look okay.
- HBW Off-Peak TLFs: The model estimates look good.
- HBU Off-Peak TLFs: The model estimates are very far off from the observed.
- HBSH Off-Peak TLFs: The model estimates look okay, but are not as good as those modeled in the peak period.
- HBSR Off-Peak TLFs: The model estimates are slightly longer than observed.
- HBO Off Peak TLFs: The model estimates look okay.

The county-to-county flow estimates by trip purpose were each within 5% of the observed data, including the MVRPC area. The panelists commented that results should be within 10% or less and suggested that OKI could easily bring the percentages closer to zero through the use of K-factors. It was noted that further adjustment is required in the three MVRPC counties.

A panelist recommended NCHRP 365 and 716 as a reference for trip rate and length comparisons, and suggested that OKI look at comparable cities in the Midwest for guidance. The panelist also suggested that the results of the 2010 GPS household survey (e.g., HBW trip rates, misidentified locations and purposes) were not trustworthy and recommended that OKI fund an analysis of the methods and sources of error in the survey to identify and hopefully correct for these shortcomings.

5.8 Mode Choice

Mode choice is implemented as a nested logit model designed in Cube Voyager based off of a nested-logit program created by Parsons Brinckerhoff. The nested logit model includes four household categories and seven walk segments. The model outputs log sums for use with distribution output. The mode choice model maintains consistency with trip distribution in that utilities are computed in the distribution step, are saved and read into the mode choice step, and control files are the same between trip distribution and mode choice.

A non-motorized nest is not used in the model. Light rail transit (LRT) and high-occupancy vehicle (HOV) facility nests are also not used in the model. Market segments defined for home-based trips are shown in Table 5. Walk market segments are defined by walk access in Table 6.

Table 5: Market Segments for Home-Based Trips

Classification	HBW Trips	Other HB Trips
1	Autos = 0	Autos = 0
2	Autos < Workers	Autos = 1
3	Autos = Workers	Autos = 2
4	Autos > Workers	Autos > or = 3

Table 6: Market Segments for Walking Trips Defined by Distance Thresholds (miles)

Origin/Destination	Short Walk	Long Walk	No Access
Short Walk	1	2	7
Long Walk	3	4	
Drive Access	5	6	
No Walk Access	7		

Auto cost is set at $0.604 per mile based on the AAA driving cost report. A panelist noted that this value seemed too high. The HOV time savings threshold is set at five minutes based on prior model calibration.

The mode choice estimation process involved the following three steps:

1. Estimated base model in Biogeme by purpose and period with no constants, applying nest coefficients fixed at 1.0;
2. Coefficients were then set to the results of step one, and estimation was run to calculate constants by market segment; and
3. These results were found to be entirely inadequate. Therefore, OKI applied a self-calibration mode choice using PB's methodology and estimated constants using Cube.

A panelist commented that OKI should know how many trips are observed for each submode and within each market segment. The panelists also noted that the mode choice calibration looked good.

The panelists strongly recommended that OKI not continue to use the 2010 GPS-based household survey data, until they can conduct additional analyses to corroborate workplace destinations. CTPP and Longitudinal Employer-Household Dynamics (LEHD) data were referenced as potential sources for this comparison. It was also suggested that OKI compare rates with NCHRP guidance documents as well as other model regions in Ohio and elsewhere.

5.9 Truck Model

OKI noted the issues that they experienced with the first truck model employed in the OKI model. The new truck model adopted in the model update used Quick Response Freight Manual II (QRFM2) methods to develop single- and multi-unit productions and attractions. Medium and heavy truck impedance factors were incorporated, and a temporal split from the traffic count data was added to the truck model structure. The model does not currently separate trucks by external-external or external-internal, but this will be incorporated into the new model.

The panelists noted apprehension based on the single- and multi-unit split, but noted that the numbers looked reasonable. One panelist suggested that the truck model methodology was simple but told a consistent story. It was recommended that the model results be compared with truck counts. Specifically, counts outside of the region on the interstate will provide a benchmark for truck percentages. American Transportation Research Institute (ATRI) data could also be used for corroboration.

OKI noted that classifications by time-of-day were used for the time period splits. A panelist noted that many deliveries are not conducted at night due to restrictions, so night truck traffic may actually be composed of a higher proportion of through traffic.

5.10 Non-Home-Based Trips

Trip generation, distribution, and mode choice were conducted separately for non-home-based trips. Home-based trips were used as an input to generation. Non-home-based trips include work-based other (WBO) and non-home-based (NHB). These trip purposes use linear production equations. The NHB distribution and mode choice models are similar to those used for home-based trips. Mode choice does not use market or walk segments, as there are not many non-home-based transit trips.

A panelist commented that trips should be related to TAZs and not the households themselves. Another panelist noted that, in tours, NHB trips tend to be close to home or work.

There were questions about the GPS survey accuracy and what would constitute a stop. In theory, a stop threshold would be around two-minutes, but many short stops can be recorded in GPS surveys that are not actually stops. For example, vehicles stopped at traffic lights over the threshold could be considered as a stop. Cambridge Systematics used data cleaning methods to fix some of these long pauses. A panelist noted that the cost of analyzing and cleaning the GPS data may not be worth the results, and it may be more effective to pay more for higher quality data, perhaps even 100% prompted recall. A panelist cited that the Northeast Ohio Coordinating Agency (NOACA), the Cleveland regional MPO, finished a similar survey last February, for which they developed logit-based models to assign trip purposes and modes rather than the decision tree algorithm that was developed for OKI. It was also suggested that 1995 data could continue to be used if nothing better is readily available.

OKI provided graphs of trip length frequencies by trip purpose and time-of-day. The following list provides the panelists' reactions to the TLF model estimates by trip purpose and time-of-day:

- NHB Peak and Off-Peak TLF: The model estimates were much longer than the observed and
- WBO Peak and Off-Peak TLF: The errors here look like they could be a software bug.

The panelists also commented on the significant discrepancy between intra-zonal trip frequencies in the survey data and the model estimates. This discrepancy also applied to home-based trips. The survey data report much higher intra-zonal flows than the model, especially for non-work trips. It also was recognized that the average TAZ size was relatively small, so these trip frequencies were most likely incorrect. OKI acknowledged that in the last peer review they conducted, a large number of intra-zonal trips were also recognized. One panelist suggested that the high intra-zonal trip frequencies could be the result of a problem in the survey data related to the way stops were recorded. Another panelist added that work-related travel for transportation, for example postal worker routes, should not be included in the data sample.

After non-home-based trip distribution, the mode choice model applies a factor to the calculated intra-zonal log-sums. The panelists noted that the mode choice model needs much more work.

5.11 Temporal Factors

The temporal factors used to determine the proportion of trips within a day are broken down by 48 half-hour periods. These trips are then further disaggregated by trip purpose, modes, and direction for production-to-attraction or attraction-to-production.

Based on the 2010 GPS-based household survey, the data were expanded by eight purposes: HBW, HBU, HBO, HBSH, HBSR, HBS, WBO, and NHB. OKI provided graphs of the percentage of auto mode trips by half-hour intervals of time in motion. The following list provides the panelists' reactions to the trip percentages model estimates by trip purpose:

- HBW: Trip percentages look good.
- HBU: Trip percentages look okay, but percentages may be too high for early morning hours.
- HBO: Trip percentages look fine.
- HBSH: Trip percentages look fine.
- HBSR: Trip percentages look fine.
- NHB: Trip percentages look fine.

One panelist recommended that percentages be compared with data from the 2010 transit on-board survey. According to OKI, there were sharper peaks observed in the transit on-board survey.

Another panelist voiced concern regarding the peak spreading observed throughout the region. OKI agreed that they were also concerned with the peak spreading, particularly in the I-75/I-71 corridor. Personal vehicles tend to avoid trucks, and trucks typically avoid peak travel periods, creating a conflict in this corridor. Another panelist replied that the peak spreading was not enough to alter the peak period from 6:30AM to 9:00AM, as the percentage of HBW trips in the morning comprises less than one third of total trips. Therefore, mandatory tours are not a significant enough part of the morning peak, meaning the vast majority of trips are flexible. OKI said that they would go further to look at totals by purpose using additional methods (e.g., stacked bar charts) to further evaluate the time-of-day factors.

5.12 Assignment Results

Preliminary assignment results were available at the time of the peer review for analysis. The OKI model applies a standard equilibrium assignment process. Attributes in the network such as number of lanes and area types have been thoroughly assessed for correctness, and speed curves have been compared on a large scale to INRIX and HERE, network data. OKI noted that the large-scale comparisons have been generally comparable to the 2005 model runs, and that trip distribution and mode choice results have been generally reasonable.

Table 7 provides a summary of the assignment results for the 2010 model run versus the former 2005 model run.

Table 7: Assignment Results Comparison 2005 and 2010

ADMCLASS	2005			2010			ΔVMC	ΔVMT
	VMC	VMT	Lane Miles	VMC	VMT	Lane Miles		
1	2,647,347	4,050,961	497	2,430,330	7,806,078	484	-217,017	3,755,117
2	750,718	724,495	231	748,896	1,029,169	234	-1,822	304,674
3	276,205	322,580	236	286,168	542,749	244	9,963	220,169
4	4,447,444	3,832,897	3,208	4,516,776	7,820,834	3,222	69,332	3,987,936
5	1,275,935	910,798	2,343	1,294,899	2,378,254	2,370	18,964	1,467,456
Total	9,397,650	9,841,731	6,515	9,277,069	19,577,084	6,555	-120,581	9,735,353

Some of the problems that OKI noted in the assignment results were high vehicle miles traveled (VMT) estimates, changes in vehicle miles of capacity (VMC), and decreases in freeway lane miles and VMC from the 2005 model runs. OKI suggested that some of these discrepancies could be attributed to the change to the TSD network and subsequently reduced lane mileage, which would provide more accurate output. OKI acknowledged, however, that the high VMT in 2010 could not be accurate, as the VMT was more than double that of the 2005 run.

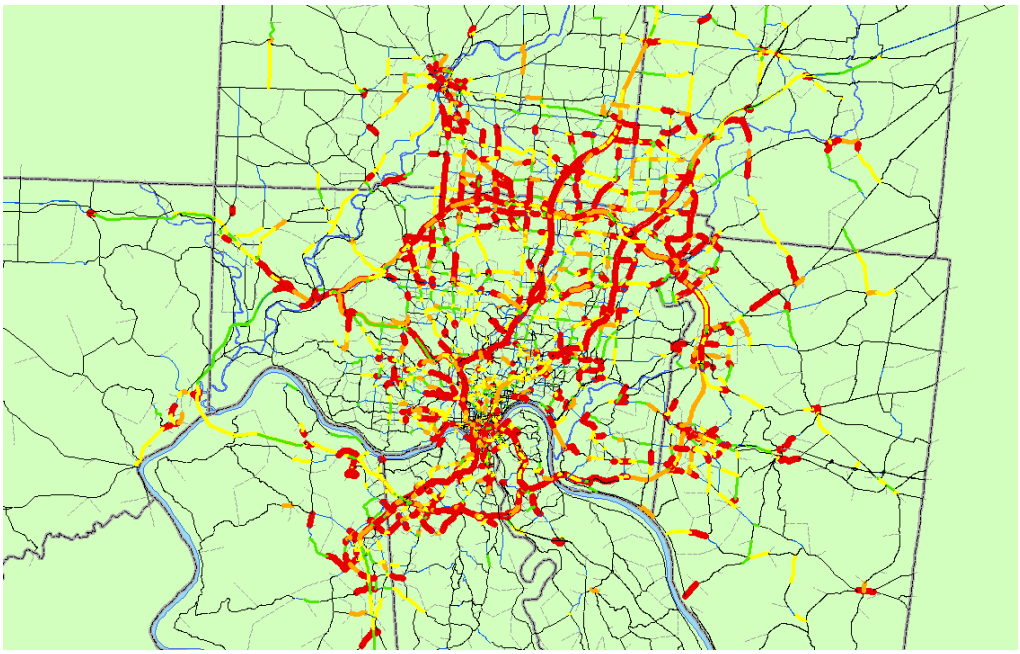
It was observed that the number of trips only increased slightly in the 2010 runs. The trip length, however, increased dramatically.

The model only runs feedback on morning trip assignment. Feedback is run until fewer than 5% of volumes or fewer than 5% of origin-destination districts do not change by less than 10%, which typically converges in either two or three iterations. The user equilibrium assignment method attempts to achieve closure using a relative gap of 0.00001, or 999 maximum iterations.

One panelist wanted to know how green-cycle times at intersections affected link capacities.

Figure 2 maps congestion using modeled volume-to-capacity ratios. The red symbology on the map indicates a level of service "F" on many freeways and some roads leading up to freeways. The map shows daily volumes based on ten times the hourly capacity. The panelists agreed that level service "F" was worrisome, but questioned whether these results as depicted were accurate, given that they were supposed to represent a daily assignment. They concluded that the extremely high 2010 VMT shown in Table 7 were out of line with reality.

Figure 2: Congestion Map – Volume-to-Capacity Ratios



5.13 Model Post Processing

The last of the final Cube catalog steps describe the OKI model post processing steps:

- Step 76: Prepare Model Data Summary Reports
- Step 77: Prepare Highway Assignment Validation Reports
- Step 78: Prepare Social, Economic, and Environmental Impact Reports
- Step 79: Prepare STEAM Cost Benefit Model Data Files
- Step 80: Prepare Study Area Impact Reports
- Step 82: Validation Reporting

Step 78, the preparation of social, economic, and environmental impact reports, is performed separately for the OKI region and the MVRPC region. MOVES post-processing calculates inputs by county in both Ohio and Kentucky. Information then goes to the emissions spreadsheet for

further analysis. The Environmental Justice Zone impact analysis program focuses on low-income zones, minority zones, and elderly zones and calculates average estimated times to hospitals, shopping, and universities from these areas. The application of MOVES is further detailed in "Section 5.14: Air Quality."

Step 79, the preparation of STEAM cost-benefit model data files, involves the use of the following input files: socio-economic, network files, daily person highway and transit trip tables, travel times and cost variables, and regional transit VMT/VHT. STEAM's resulting output files are reported in person trips by zone for each purpose and mode, as well as transit time tables formatted for STEAM.

OKI applies STEAM 2.02, the latest version of the program. One panelist noted that STEAM does not include reliability estimates. They suggested that OKI could consider some of the new methods that estimate changes in reliability, for example, INRIX data.

For certain special studies, OKI will conduct a sub-area analysis, often supplementing it with traffic microsimulation analysis of the sub-area. Sub-area-modeling has been applied in various corridor studies, such as:

- Uptown and new Martin Luther King Junior interchange conducted in 2007;
- Kentucky Route 8 in Bellevue and Dayton conducted in 2009;
- Brent Spence Bridge and I-71 impacts conducted in 2012; and
- Brent Spence Bridge and I-74 impacts conducted in 2013.

For these recent studies, OKI also has used Cube DynaSim to microsimulate corridor traffic. To apply DynaSim, the full-model base year must be run, the sub-area corridor must be extracted and refined by splitting TAZs and adding links for local streets, and zonal vehicle trips must be distributed to a sub-zonal vehicle trip table. Sub-area vehicle assignment is then run and exported to DynaSim. Sub-area networks and zone systems are extracted from the full regional model using Cube scripts. Signal timing and intersection details must then be incorporated and calibrated to observed conditions using traffic counts and travel times. Once this process is complete, DynaSim's three-dimensional imagery may be incorporated.

A panelist suggested that OKI save the paths rather than using static model outputs and splitting them up. The panelists lauded OKI's effort to integrate macro- and micro-simulation. OKI responded that a significant amount of work went into junction modeling in DynaSim, for example, projects like the Brent Spence Bridge/I-74 interchange 2040 traffic simulation required a lot of hands-on work.

OKI noted that all microsimulation has been conducted for the 2040 forecast year and not the current year simulation. A panelist commented that to perform microsimulation for the current year would reveal problems with the model because the simulation is not as forgiving and may result in the findings that signal timing and other assumptions are not reasonable.

5.14 Air Quality

The Cincinnati region was not within ozone attainment levels in 2012 in Butler, Hamilton, Warren, Clinton, and Clermont Counties. Portions of Dearborn, Boone, Kenton, and Campbell Counties were also designated ozone nonattainment. Fine particulates are also designated in non-attainment in summer months.

OKI runs MOVES for the counties in Ohio and Indiana. A separate analysis is run for Kentucky counties. OKI runs the most current model: MOVES 2010b, but anticipates using MOVES 2014, which will include new Tier 3 standards, when the new analysis year is required.

The Kentucky Transportation Cabinet (KYTC) and ODOT provide local vehicle registration data. A default is established for intercity buses and trucks. Based on regional household growth, vehicle population growth is estimated at 0.44% annually. The MOVES default daily mileage rate is applied by source type to travel model VMT. Daily VMT by Highway Performance Monitoring System (HPMS) source type is then converted to annual VMT using the Environmental Protection Agency (EPA) converter. Other inputs that are required for MOVES estimation include:

- Meteorology, which utilizes historical averages from the National Weather Service;
- Age distribution, which utilizes age fraction by state and source type and local vehicle registration data from ODOT and KYTC;
- Fuel parameters based on Reid vapor pressure (RVP) and reformulated gasoline (RFG);
- Road type distribution using daily and annual VMT by state, source type, and MOVES roadway types, as well as local street VMT and speeds as represented by network centroids; and
- Average speed distribution, measured in VHT fraction by state, source type, road type, hour, and MOVES speed bins.

The VB.NET program is the MOVES post-processor in the OKI model. The post process generates annual and summer VMT by source type, hour, road type and speed bin. It also generates annual and summer VHT distribution by source type, hour, road type and speed bin, and then applies emission rates from lookup tables to complete emission calculations.

The emission rate tables are provided in the following forms: rate per distance, rate per vehicle, and rate per profile. The final output report includes the following information:

- Kentucky counties and partial county emissions output;
- Ohio counties with the partial Indiana County emissions output;
- Annual and daily running emissions by pollutant;
- Annual and daily non-running emissions by pollutant;
- Annual and daily total emissions by pollutant; and
- Error checks for annual VMT, daily VMT, source type population, model run directory and location, and date.

5.15 Horizon 2040 Forecasting

A top-down approach was used to develop values for several variables for horizon year 2040. The Ohio, Kentucky, and Indiana state data centers provide county-level population projections by five-year age cohorts. OKI uses these projections as control totals. To project the population under age 18 in households in 2040, the percent of persons under age 18 who resided in households from the 2010 census was applied to the 2040 total number of persons under 18 to arrive at the population in households under age 18 for 2040, by county. The base-year percent of population under 18 in households for each TAZ was factored for 2040 so that the sum of the children across all zones equaled the county control total.

One panelist asked if the long-range plan, specifically one including a significant transit improvement like LRT would affect household allocation. OKI noted that factors like this example are part of the forecasts. There is no land use component in the model structure. It was determined that manual judgment was more effective than utilizing a land use model after attempting to incorporate one in a previous model update.

Future year households at the county level were derived from the "Householder" methodology. The ratio of persons in various age cohorts who are heads of household in 2010 was applied to the total number of people in those age cohorts as projected by the state data centers. The sum of 2040 households across all age cohorts is equal to the number of households in each county in 2040. Households are then allocated to TAZs within each county based on several factors including: historic trends, existing/future land use plans, existing/future water and sewer service, topography, build-out scenarios, and input from local planners. OKI emphasized that local planner input has proved to be the best source of data.

In Table 8 there are several more age cohorts in the actual calculations. OKI found that 10.3% of persons aged 15-24 in 2010 were heads of household. It is projected that 5,764 persons would be between the ages of 15 and 24 in 2040; therefore, 10.3% of those persons, would be heads of household in 2040 assuming the ratio remained the same over time.

Table 8: Future Year Household Calculation Summary

Age Cohort	2010 Ratio	2040 Population	2040 Households
15-24	10.3%	5,764	594
25-64	59.5%	46,028	27,387
65+	76.7%	6,124	4,697
Total			32,678

A panelist commented that often in growing areas, local governments can overstate growth and suggested identifying constant behavior trends for model updates. OKI noted that they develop their own control totals and use local planners is to assist in identifying where in each county the growth or loss is anticipated to occur.

Another panelist provided examples in Columbus and elsewhere in Ohio, in which demographers derive land use predictions using internal models and contacts within the development community. They noted that members of the development industry often have a better awareness of developing infrastructure than planners.

The future year labor force by county was calculated based on the projected population by age cohort provided by the state data centers and a locally-adjusted projected national labor force participation rate for each age cohort. In Table 9, 52% of persons aged 16-19 are projected to be in the labor force, and the 2040 population aged 16-19 is projected to be about 5,000. Therefore, the labor force among persons aged 16-19 totals about 2,800. A percent of unemployed persons was applied to each county's labor force based on an average of historical county unemployment rates as only working persons would be making work trips. The base year labor force participation rate in each TAZ was factored for 2040, so that the sum of the labor force across all TAZs in a county equals the county-level labor force control total. Base year employment data sources include: County Business Patterns (CBP) and the Bureau of Labor Statistics (BLS).

Table 9: Future Year Labor Force Calculation Summary

Age Cohort	2040 Ratio	2040 Population	2040 Labor Force
16-19	52.3%	5,422	2,836
25-64	86.2%	23,954	20,648
65+	35.2%	7,127	2,509
Total			25,993

Future year employment was approached from a "supply side" perspective, beginning with the projected labor force within the OKI region. Historical data from the 1990, 2010, and 2006-2010

journey to work special tabulations provide information on the percent of persons both living and working in the region, as well as those who live in the region and travel outside to work and those who live outside the region and commute to work within the region. The regional employment was allocated to the counties in accordance with those historical trends. Allocation of employment to the TAZs is based on the same criteria as applied to the allocation of households. The type of employment is then adjusted to reflect anticipated future distributions. The projected change in employment type developed by Woods & Poole Economics from 2010 to 2040 was applied to the 2040 employment.

A panelist asked whether OKI had contacted the state economic development cabinet. OKI said that they had not but would do so in the future. Another panelist suggested that OKI review data from the Bureau of Economic Analysis (BEA), which tends to have more information on employment than BLS. The panelist noted that the population to employment ratio from the data in the current OKI model was 2.0, which was slightly higher than reasonable.

Another panelist noted that Ohio State University (OSU) created a tool to perform employment allocation using regional employment and labor force estimates that can be implemented in Cube. The tool may be available for use.

It was also noted by a member of the panel that OKI should look more into land use in the model. For example, as businesses emerge throughout the region, households will also be attracted as a response to the new business facilities. OKI is not currently taking advantage of this two-way relationship in their future land use projections.

Vehicles for the future year were calculated by applying the base year vehicles-to-households ratio to the 2040 number of households for each TAZ. No adjustments were made to the vehicle ratio. Hotel rooms for 2040 were derived from the addition of lodging facilities built since 2010 and planned construction. For future year university enrollment, OKI researched the master plans of the large universities in the region. For smaller colleges lacking projections, OKI carried over the 2010 enrollment figure.

5.16 Improvements Underway & Future Plans

In the presentation of their current improvement efforts, OKI grouped their efforts into three categories: trip-based model improvements; Ohio Disaggregate Modeling System improvements involving ODOT and the development of a regional tour-based model; and data improvements. Figure 3 provides a projected timeline for these improvements.

Figure 3: OKI Model Improvement Timeline

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Trip Model											
Tour Model											
						HHTS					
						TOBS					
				Airport Survey							
				Kings Island Survey							
Traffic Counts	*				*	*	*			*	*

OKI intends for the trip-based model to phase out by 2020 but run in parallel with the developing tour-based model until that point. Future data collection efforts outlined in the timeline include: a CVG airport survey and a survey of Kings Island in the late 2010s, as well as household and transit on-board surveys in 2020. It was noted that the household travel survey plan may change, depending on ODOT's continuous survey. Traffic counts will be obtained for 2015, 2019, 2020, 2021, and 2025.

One panelist noted that the Federal Transit Administration (FTA) New Starts guidance requires that a transit on-board survey must be conducted within five years prior to the application submittal, which should be taken into account when considering timing for the transit on-board survey. OKI responded that they are not sure whether they will be applying to the New Starts program, specifically in the next several years, but are aware of this requirement from the FTA. The panelist also suggested that OKI obtain boarding and alighting data from transit agencies.

Trip-Based Model Improvements

To improve the trip-based model in the short term, adjustments will be made for university trips, trip distribution, and the Dayton region. Truck model updates may include revision to rates and distribution. It was also noted that tolls, enhanced non-motorized modeling integration, dynamic traffic assignment, and other potential improvements were also desired in the short- to mid-term.

One panelist recommended that the following two factors also be considered in the short-term trip-based model improvement process: (1) the inclusion of special generators like universities, large malls, and industrial areas that have unusual trip rates and (2) the acquisition and application of survey data that captures external and pass-through traffic. OKI noted that they replaced shopping corridors with mall special generators in the 2010 model update.

When questioned on speed data sources, OKI noted that they were provided with free INRIX data from ODOT, and therefore are less reliant on HERE speed data from Citilabs.

One panelist applauded OKI's efforts to validate external trip data, but recommend obtaining more truck counts. The panelists also recommended that OKI look into the possibility of special generator surveys, which may be necessary for validation of the tour-based model structure.

Another panelist noted current OSU research on transit on-board survey expansion to current boarding and alighting counts and the validity of these expansions. The panelist also recommended review of the FTA STOPS model and comparison of AirSage data with intercept studies for possible replacement of cordon surveys. The panelist also noted that INRIX and ATRI data are good considerations for the development of truck trip tables.

It was noted that the ODOT statewide model is not currently integrated with the regional models. Currently, ODOT applies a sub-area extraction for regional analysis, and it is intended that regional models use the statewide model to provide external-internal trips. It was also acknowledged that there is not as much confidence in statewide land use modeling in comparison to MPO demographer predictions. The tour-based model will have a commercial vehicle model that will replace the QRFM-based model.

The panelists also advocated for segmentation by income in the trip-based model to help in destination choice and potentially carry through to mode choice. The panelists noted that auto ownership is not a surrogate for income. The panelists also suggested that OKI look at trip length distributions for different market segments to observe statistical differences. OKI responded that they had not used income for segmentation in the model before, but would consider it in their revised specifications.

OKI noted that they were aware that Version 8.0 of their model was not fully functional, so the agency will continue using Version 7.6 until Version 8.0 is validated. However, the peer review session was focused on Version 8.0, which is the version to which they would like improvement suggestions aimed.

Tour-Based Model Development

In the development of the tour-based model in conjunction with the Ohio Disaggregate Modeling System, the model will be delivered in parts so that OKI staff can both pick the model apart but also assemble it back together to develop a deeper understanding of the underlying methods in

the model structure. This process will also allow OKI to look for bugs, identify data needs, check model assumptions, and analyze calibration items.

In the tour-based model development, the model geography will most likely be increased from two MPO areas to three MPO areas, with the addition of Springfield by 2020. This will increase the level of coordination necessary for the model's development and analysis of reporting. The final stages of the tour-based model development effort will involve testing the model against the data slated for collection in Figure 3.

Data Improvement

OKI's data enhancement strategies include taking advantage of the institutional support for traffic counts. OKI does traffic counting in-house but also contracts out a significant portion to the counties. There are many different efforts currently geared toward data organization, and OKI intends to further directly effort toward display and dissemination of this data. OKI will also be adding Bluetooth transponders to its next contract for traffic count collection.

In addition to the airport survey, Kings Island survey, 2020 household survey for all three MPOs, and 2020 transit on-board survey for all MPOs noted by OKI, the agency also listed surveys of the private industry, like GE, P&G, UC, and Miami University of Ohio. OKI also noted the possibility of purchasing AirSage external data for 2020 when available. OKI requested that the panelists provide additional recommendations for data advancement related to trucks and freight movement.

ODOT is moving toward a continuous survey statewide over the next ten years that would have a 100% prompted recall. The intent is that every single trip made by residents between 13 and 75 years of age will be recorded by GPS using a smart phone app or stand-alone GPS receiver to facilitate tracking.

By combining the current GPS data sets with the current, traditional Columbus and Dayton surveys, there will be enough data for the OKI model development. A concern with the current OKI survey is that it is an annual survey rather than a typical day tour-based survey. An additional issue is that the traditional diary survey format will not catch as many "on-the-way" trips as a GPS survey, so there may be discrepancies in merging these data sources.

5.17 Lessons Learned

From the 2010 model update effort, OKI identified lessons learned that will be applicable as they move forward with improvements to their trip-based model and move into the tour-based model development effort. The lessons identified by OKI emphasized both resources and software intricacies.

OKI identified that they did not have enough time or training to calibrate the model within the timeframe allotted. OKI noted that the availability of materials and resources to assist in model calibration were not easy to find. OKI staff noted that they learned more from the first day of this peer review than through reading any publications on the model calibration process.

OKI also emphasized the importance of documentation and knowledge management. OKI noted that sharing codes and methods with other agencies is extremely helpful, as is using open formats.

Finally, OKI noted that their staff learned a lot during the transition from an in-house coded model to an in-house coded model operating on a locked commercial product. The shift in vendors and platforms is difficult, particularly with closed format files and licensing issues.

6.0 Peer Review Panel Recommendations

6.1 Recommendations Corresponding to Specific Issues

The following section describes the panelists' recommendations pertaining to OKI's three major topics for review.

Review of the Current Trip-Based Model

The following suggestions were made based on the review and discussion of OKI's current trip-based model's structure, procedures, and forecasts:

- The roadway network file should be shared with ODOT for review and commentary, particularly for the identification of coding errors.
- Market segmentation in trip generation should be focused on significant travel behavior differences and less reliant on workers and auto-ownership. The panelists recommended that income be used for segmentation.
- Trip distribution model testing should be conducted through simple travel time impedance tests rather than log-sums.
- Trip distribution needs to be calibrated based on the chosen segmentation, i.e. income, and carried through mode choice to help with the tolling element of the model.
- An auto-ownership model is recommended for mode choice and auto sufficiency.
- Mode choice coefficients and nesting structure should be revisited, and different nesting structures should be considered. FTA best practice documentation was identified as a primary resource for this transition, including NCHRP 716, Appendix A (http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_716.pdf) and a presentation on Travel Forecasting for New Starts presented at a workshop in St. Louis, Missouri in September of 2007: (http://www.fta.dot.gov/documents/Sessions_01-04.pdf).The panelists noted that nesting coefficients should not be set to one (1.0) unless a multinomial logit model structure is desired.
- New mode choice coefficients should be reviewed by plotting the transit assignment results of the sensitivity tests for a light-rail scenario, a scenario that OKI has analyzed in the recent past and with which they are familiar.
- Survey findings related to peaking effects and traffic counts by time-of-day should be compared to the temporal factors developed for the model to confirm that the time period lengths accurately represent regional peaking phenomena.
- Trip assignment and validation should be revisited and adjusted in accordance with documentation of best practices, including NCHRP Reports 255, 365 and 716, as well as the ODOT Certified Traffic Manual.
- Additional validation for DynaSim should be conducted, specifically by saving the paths of the model. It was suggested that traffic counts also be used.

Data Improvements and Collection Efforts

The following list provides the panelists' reactions to the data sources currently employed by the OKI model, as well as the identification of additional, readily-available data sources for consideration in the existing model and for planned improvements.

- A consistent transit boarding and alighting data resource should be identified and implemented.
- The 2010 transit on-board sample requires summary and refinement. Before the survey is incorporated into the model, trip table assignment should be checked and compared to FTA path finding standards.
- Additional analysis of the 2010 OKI household survey results:
    - The household survey should be compared to data from the survey conducted in 1995 at a comparable level, i.e. - trips or tours, and any significant variation should be reviewed and explained. The survey should also be compared with other recently conducted surveys in the state and in peer areas.
    - Results should be summarized in production-attraction format and recalculated based on trip length distributions. It was suggested that, at a minimum, home-to-work distances be tabulated.
    - The processes used in the household survey data mining work should be revisited to potentially enhance trip-purpose categorizations. For example, rather than applying block group average vehicles per household, distribution could be performed by distributing results into bins of zero, one, two, and three-or-more vehicles per household.
- BEA and LEHD sources should be used to distribute employment by NAICS code to provide a comparison to the current employment data in the model. It was noted that the OKI model relied heavily on detailed employment categories for attraction rates; therefore, this data check is critical. BEA data will also be helpful to provide consistency in data across the three states. When employment is allocated to TAZs, it should be expanded to match the BEA data totals. Additionally, InfoUSA data should be purchased for year 2015, as well as each subsequent year. The InfoUSA data can be compared with Quarterly Census of Employment and Wages (QCEW) data and LEHD data.

    OKI Response to Employment Data-Related Panelist Suggestions:

    OKI's employment data for seven of it's eight counties is developed from actual business records and supplemented as necessary with information from other sources so all employers are included. For the eigth county (Dearborn) OKI purchases InfoGroup data which consists of individual business records. OKI geocodes all of these records and aggregates employment to each TAZ. OKI has found that many businesses in the raw data have been associated with the wrong county, particularly where the business location is near a county border.OKI catches and corrects these errors in the geocoding process.

    OKI does review and compare county-level employment data from the BEA, as well as the Bureau of Labor Statistics (BLS). OKI feels that its data is more accurate for trip modeling purposes than either of the other sources. BLS data is built on QCEW data which only includes employment covered by unemployment insurance. BEA data is comprised mainly of QCEW data supplemented with administrative records to include sole proprieters. As stated in the methodology, BEA assumes that place-of-work and place-of-residence are identical for both farm and non-farm proprieters. Therefore, the BEA data is inflated for trip modeling purposes as only commuting employment is

pertinent. Both BLS and BEA county-level data contain the inaccuracies of businesses associated with the wrong county.

OKI looked at the LEHD in the past and found it lacking. However, OKI is happy to revisit the source.

OKI will continue to utilize whatever employment data sources are provided by the Ohio and Kentucky departments of transportation. OKI is reliant on InfoGroup data for Dearborn County and will continue to acquire employment data from that source.

- If OKI would like to include HBU as an individual trip type trip type, a survey of local universities should be administered. If this type of survey is not feasible, university trips should be incorporated as an HBO trip type or included in special generators.
- Land use data should be obtained from county tax assessor geodatabases or economic development agencies and subsequently used for household and employment allocation.
- Information from the available statewide models should be used at exchange points for external-external trips and external-internal trips. It may also be used strategically for freight purposes.
- Average growth rates from AirSage should be used at all external stations. Growth rates should be distributed by directional axes.
- While current freight estimation practice was considered sufficient, a truck or commercial survey in the region was recommended to improve estimation.

Guidance Regarding Transition to Tour-Based Model

The panelists' primary guidance with regard to the transition to the tour-based model was to improve their data resources available, as described in the "Data Improvements and Collection Efforts" bulleted list above. In the long-term, the panelists recommended consideration of region-wide DTA to support further simulation efforts and support tour-based modeling.

6.2 Next Steps

In the near-term, OKI will continue to work with the current GPS household data to overcome some of the shortcomings in data processing and address the issues described above regarding the assignment validity.

Specific model improvements are likely to include development of a university-trip model; improvements to trip distribution models, possibly including destination choice models; calibration adjustments in the Dayton region (MVRPC). OKI is also considering updating the regional truck model, adding toll modeling capabilities, dynamic traffic assignment, and integration of non-motorized trip making.

Appendix A List of Peer Review Panel Participants

This section contains a list of the peer review participants, including the panel members, local agency staff, and TMIP documentation support staff.

A.1 Peer Review Panel Members

Panel Member	Affiliation
Rebekah Anderson	Ohio Department of Transportation (ODOT)
Lei Zhang	National Center for Strategic Transportation Policies, Investments and Decisions at the University of Maryland
Keith Lawton	Keith Lawton Consulting
Arash Mirzaei	North Central Texas Council of Governments (NCTCOG)
Mark Byram	Ohio Department of Transportation (ODOT)

A.2 Local Agency and Partner Agency Staff

Name	Affiliation
Andrew Rohne	Ohio-Kentucky-Indiana Regional Council of Govts. (OKI)
Adam Evans	Ohio-Kentucky-Indiana Regional Council of Govts. (OKI)
Hui Xie	Ohio-Kentucky-Indiana Regional Council of Govts. (OKI)
Mary Luebbers	Ohio-Kentucky-Indiana Regional Council of Govts. (OKI)
Andy Reser	Ohio-Kentucky-Indiana Regional Council of Govts. (OKI)
Bob Koehler	Ohio-Kentucky-Indiana Regional Council of Govts. (OKI)
Larry Buckler	Ohio-Kentucky-Indiana Regional Council of Govts. (OKI)
Bernadette Dupont	Federal Highway Administration (FHWA)

A.3 TMIP Peer Review Support Staff

Name	Affiliation
John Gliebe	RSG

Appendix B Peer Review Panel Meeting Agenda

This section contains the agenda of the peer review.

Day 1: April 14, 2014

8:30AM - 9:00AM	Welcome, Introductions, and Logistics
9:00AM - 10:00AM	Background and History • Brief History of OKI Model • Prior Peer Review Recommendations and Improvements • Purpose and Applications of the Model • Issues OKI is interested in the panel addressing Model Methodology Overview
10:00AM – 10:15AM	Break
10:15AM - 12:00PM	Technical Overview Part 1 • OKI Data Collection Efforts and Model Inputs • Home-Based Trip Generation Recalibration Process and Results • EE/EI/IE Trip Recalibration
12:00PM - 1:00PM	Working Lunch - Discussion and Q&A
1:00PM - 2:00PM	Technical Overview Part 2 • Home-Based Distribution Process and Results • Home-Based Mode Choice Process and Results
1:00PM - 2:00PM	Break
2:15PM - 3:30PM	Technical Overview Part 3 • Non-home-based Travel Forecasting Process and Results • Temporal Factor Process and Results • Assignment Results Discussion and Q&A
3:30PM - 3:45PM	Break
3:45PM - 5:00PM	Model Post Processing • MOVES Emission Modeling • STEAM cost-benefit modeling • Subarea Processing and Output visualization Discussion and Q&A

Date 2: April 15, 2014

8:30AM - 10:00AM	Improvements Underway • CT-RAMP Model Development Participation • Initial CT-RAMP Improvements Final Thoughts and Lessons Learned
10:00AM - 12:00PM	Panel Caucus
12:00PM - 1:00PM	Panel Report
1:00 PM	Adjourn

Appendix C Peer Review Panel Biographies

C.1 Rebekah Anderson (Ohio Department of Transportation)

Ms. Anderson is a Transportation Engineer for the Ohio Department of Transportation, which she joined in 2005. She is involved with the development of the Ohio Statewide Travel Forecasting Model. In addition to the statewide model, Ms. Anderson also works with the Columbus/Newark disaggregate tour-based model, and the Dayton/Cincinnati aggregate model, including the review of the Dayton re-estimation and combined model conversion. She also provides assistance to Ohio MPOs on the modeling of transit alternatives, air quality conformity analyses, certified design traffic requests, and has assisted on the Ohio Standard Small/Medium MPO Travel Forecasting Models. She has instructed courses in transit modeling and the use of the Ohio Standard Models to MPO staff. She has also conducted roadside Origin-Destination Surveys for the Department and maintained the state's employment data for use in the Department's travel models. She has provided modeling assistance to the Ohio Rail Development Commission on their High Speed Passenger Rail Study.

Prior to joining ODOT, Ms. Anderson was a Principal Engineer for the Mid-Ohio Regional Planning Commission (MORPC), the Columbus, Ohio MPO. She was the Project Manager for the MORPC Travel Model Improvement Project, which included the development and implementation of the new disaggregate tour-based travel forecasting model. While at MORPC, she reviewed the patronage forecasting and model updates for the North Corridor Transit Project New Starts Submittal and DEIS. She also managed the Major/New Construction Program priorities and the selection of projects for STP, CM/AQ and TEP funding for the Transportation Improvement Program. Ms. Anderson holds Masters and Bachelors degrees from The Ohio State University in Civil and Transportation Engineering. She is licensed by the state of Ohio as a Professional Engineer.

C.2 Lei Zhang (Department of Civil and Environmental Engineering, University of Maryland)

Lei Zhang is an Associate Professor in the Department of Civil and Environmental Engineering at the University of Maryland, College Park. He earned his Ph.D. (major: Transportation Engineering; minor: Operations Research in 2006) and M.S. (Applied Economics in 2005; Civil Engineering in 2002) degrees from the University of Minnesota, and B.S. (Civil Engineering in 2000) from Tsinghua University in China. Dr. Zhang's research program focuses on transportation systems analysis; transportation and land use planning; transportation economics and policy; mathematical, statistical, and agent-based modeling; and integration of transportation operations and planning.

C.3 Keith Lawton (Keith Lawton Consulting)

Keith Lawton is an independent consultant based in Newberg, Oregon. Mr. Lawton was previously Director of Technical Services with the Metro Planning Department in Portland, Oregon, and has been active in model development for over 40 years. He was involved with the application of TRANSIMS in Portland, led the development of the first tour-based activity model set at an MPO, which was used in a road pricing study at Metro, and he has been a leader in developing an integrated land-use and transportation model, which has seen project application in Portland. He has also led the move to include the effects of urban design on transport demand, and to embed these model elements in the Portland trip-based models. He has served on a number of modeling peer and expert review committees. Mr. Lawton has a BSc. in Civil Engineering from the University of Natal (South Africa), and an MS in Civil and Environmental

Engineering from Duke University. He is a member emeritus and past Chair of the TRB Committee on Travel Demand Forecasting.

C.4 Arash Mirzaei (North Central Texas Council of Governments)

Arash Mirzaei is the Senior Program Manager (Lead) of the Travel Model Development Program at the North Central Texas Council of Governments (NCTCOG), the MPO serving the Dallas-Fort Worth region. Mr. Mirzaei has worked with NCTCOG for the past 13 years.

C.5 Mark Bryam (Ohio Department of Transportation)

Mark Bryam, P.E., has been employed by the Ohio Department of Transportation full time for 28 years, since 1986. At present, he is serving as section manager of the Modeling & Forecasting Section within the Office of Statewide Transportation Planning, in the Division of Planning at central office. He has been a registered professional engineer since 1989. He holds a BS in Engineering from Ohio State University. Mark has performed travel demand forecasting modeling related work for 27 years and served as section manager for 15 of those years. Work related to travel demand modeling has include MPO model technical support, model maintenance, model updates, model validation, travel surveys, initiation of statewide model development, air quality conformity, computer programming, project level analyses, special studies, performance measures, etc. Participated with OKI & MVRPC and consultants to develop the combined area, OKI & MVRPC, travel demand model.

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