

CHAPTER 9 • TRAVEL DEMAND MODEL SUMMARY

This chapter describes the OKI / MVRPC regional travel demand model, used to support traffic and transit forecasts for the NSTI study. This model is based on version 5.4 of the OKI Regional Council model, and includes several features developed specifically for the NSTI. The OKI/MVRPC model applies to the entire study area (Hamilton, Clermont, Warren, Butler, Montgomery, Greene and Miami counties in the state of Ohio, as well as Boone, Kenton and Campbell in the state of Kentucky and Dearborn in the state of Indiana). It includes several model enhancements, among them time-of-day trip distribution, logsum trip distribution impedances, updated truck trip tables and regionally-estimated mode choice models.

The next subsections describe the characteristics of the major model components. All major components of the OKI/MVRPC model have been estimated and calibrated using locally available data. Please refer to the Technical Appendices for complete documentation of the NSTI model development effort.

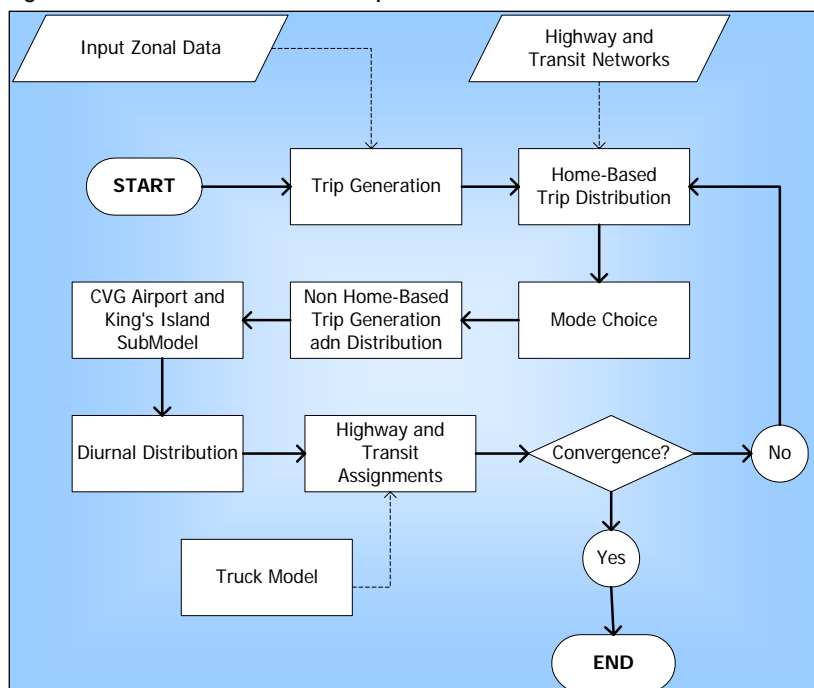
The OKI / MVRPC Regional Travel Demand model is based upon the conventional trip-based four-step modeling approach, complemented with a sub-model to forecast trips at two regionally important trip generators, the Greater Cincinnati/Norther Kentucky International (CVG) airport and the King's Island amusement park.

9.1 Model Overview

Broadly, the main model components fall within the following five categories:

- **Trip Generation** - The process of estimating the number of person trip productions and attractions at each traffic analysis zone (TAZ).
- **Trip Distribution** - The process of creating joined person trips, (i.e., OD trips), by linking trip productions and attractions across the combined region.
- **Modal Choice** - The process of estimating the number of person trips using a particular mode for each OD interchange.
- **CVG Airport and King's Island Sub-model** -
- **Trip Assignment** - The process of accumulating auto and transit trips onto specific highway and transit facilities in the region.

Figure 9-1: OKI/MVRPC Model Components



As indicated in Figure 9-1, updated peak period speeds are fed back to trip distribution, and the entire process is repeated until the model converges. The OKI / MVRPC model uses the method of successive averages, applied to the estimated AM period traffic volumes, to calculate and feed back peak period speeds. Convergence is achieved when the AM period highway volumes and vehicle trip tables from the previous and current iterations are reasonably similar.

9.2 Zone System & Input Zonal Data

The combined zone system consists of 2531 traffic analysis zones (2425 internal zones and 106 external stations). Of the internal zones, 1608 zones correspond to the OKI Regional Council region; the remainder 817 zones belong to the MVRPC region (Miami County included). In both regions the zonal level of detail is finer than that used in previous modeling and planning efforts. For summary reporting purposes, zones are grouped into the nine regional counties plus the Cincinnati Central Business District.

Like most regional travel demand models, the OKI / MVRPC model relies on explicit input of socio-economic characteristics at a zonal level. These zonal data may vary with the year of analysis and may be used to represent alternative regional growth scenarios. The input zonal data include area type, number of households, population, employment, auto ownership, average number of workers, persons and autos per zone, peak and off-peak parking costs, university enrollment, high school enrollment, shopping mall employment and major recreation center attendance, among others.

9.3 Highway & Transit Networks

Highway Network

The highway network provides fairly detailed coverage of the existing and committed highway infrastructure in the OKI Regional Council and the MVRPC areas. The combined highway network consists of approximately 14,000 nodes and 35,000 one-way links. The original 1995 OKI and MVRPC highway networks were edited to ensure that attributes such as capacity, free-flow speed and facility type were consistent across the combined region. Additional roads were added to the three existing networks so as to merge the gaps between them and to increase the road density near the former external cordon lines. The network includes a fine, explicit representation of all freeway interchanges and ramps, and is able to handle HOV lanes and truck-only lanes.

Link capacities and free-flow speeds are based on a system of approximately 25 different facility types, including freeways, expressways, arterials, major and minor roads. Capacities and free-flow speeds are adjusted to account for road and local characteristics such as the percent and length of grades, urbanization density, type of signal control, proportion of truck traffic and road width.

Transit Network

The base year (1995) and existing + committed transit networks (2030) include bus routes from the following transit systems: Southwest Ohio Regional Transit Authority (SORTA), Transit Authority of Northern Kentucky (TANK), Miami Valley Regional Transit Authority (MVRTA), the City of Hamilton Transit, and Middletown Transit. The transit network includes both local and express routes, with separate representation of route coverage, headways, average speeds and fares for peak and off-peak periods. In addition to the transit systems themselves, access and egress networks and transit station infrastructure are explicitly represented in the OKI / MVRPC model, in the form of walk and drive access links, sidewalk networks, park and ride lots and rail station nodes.

To support the NSTI study, the following additional transit systems can be handled by the model: intercity express buses, light rail transit, inter-regional commuter rail service and bus rapid transit. The OKI / MVRPC mode choice model and transit assignment procedures were explicitly designed to accommodate these proposed transit systems. The operational characteristics of these systems were dictated by the needs of the study, and may vary depending on the specific alternative being evaluated. Please refer to the Technical Appendices for a complete description of the various alternatives studied.

9.4 Trip Generation

The model considers the following nine trip purposes:

1. Home-Based Work (HBW)
2. Home-Based University (HBU)
3. Home-Based School (HBSC)
4. Home-Based Other (HBO)
5. Non Home-Based (NHB)
6. External-Internal (EI)

7. External-External (EE)
8. Truck
9. Taxi

The OKI / MVRPC model uses cross-classification trip production models for most of the home-based trip purposes, that is, trip rates that vary by household type applied at the zonal level. For the non-home-based purpose the model applies a cross-classification model to the HBW and HBO attractions by mode. The trip attraction models are linear regression equations that relate zonal employment, households and / or student enrollment to trip attractions. Additional equations are used for uncommon generators, such as shopping mall and recreational areas. The EI trip generation model is a set of regression equations that relate households, employment and proximity to the external cordon line to EI trip ends. The taxi, EE and HBSC trip generation models are fratar (growth factor) models, which rely on an initial or seed matrix. Truck trip generation is estimated outside the model stream; that is, truck trip tables representative of the year of analysis are input to the model at a later step. Productions and attractions are balanced at the super-regional level for all trip purposes.

9.5
Trip
Distribution

Gravity models are used to distribute HBW, HBU, HBO, NHB and EI trips. The first four purposes use logsums, stratified by peak and off-peak periods, as the measure of travel impedance in the gravity model formulation. EI trips are also distributed using a gravity model, yet based on highway travel times and applied at the daily trip level. HBSC, EE, Taxi and Truck trips do not require distribution models because they are already in trip table format out of trip generation. As part of the NSTI travel model development effort, two weaknesses of the original OKI gravity model formulation were addressed. First, instead of using a composite daily impedance to distribute both peak and off-peak trips, the model developed for the NSTI study uses separate impedances for each time period. This allows the model to explicitly represent and account for time-specific differences in the distribution of trips, whether resulting from variations in the highway and transit networks, composition of the travel population or differences in travel times or costs. Second, the OKI / MVRPC gravity models use logsums instead of highway travel time as the measure of travel impedance. The logsum is a term derived from the mode choice model that measures the spatial separation between zones giving adequate consideration to travel time, travel cost and other variables included in the mode choice model. This impedance also gives weight to household characteristics of the traveler, such as income or auto ownership, through the use of these characteristics in the stratification of mode-specific constants.

Due to the use of logsums in the gravity models, the OKI / MVRPC model can account for the effects that transit service and costs, in addition to highway travel times and costs, have on the spatial distribution of trips in the region. This is of critical importance when assessing the impact of new transit service, because it provides a more accurate representation of the improved regional or local accessibility resulting from the additional service than what would be obtained by solely relying on highway travel times for trip distribution.

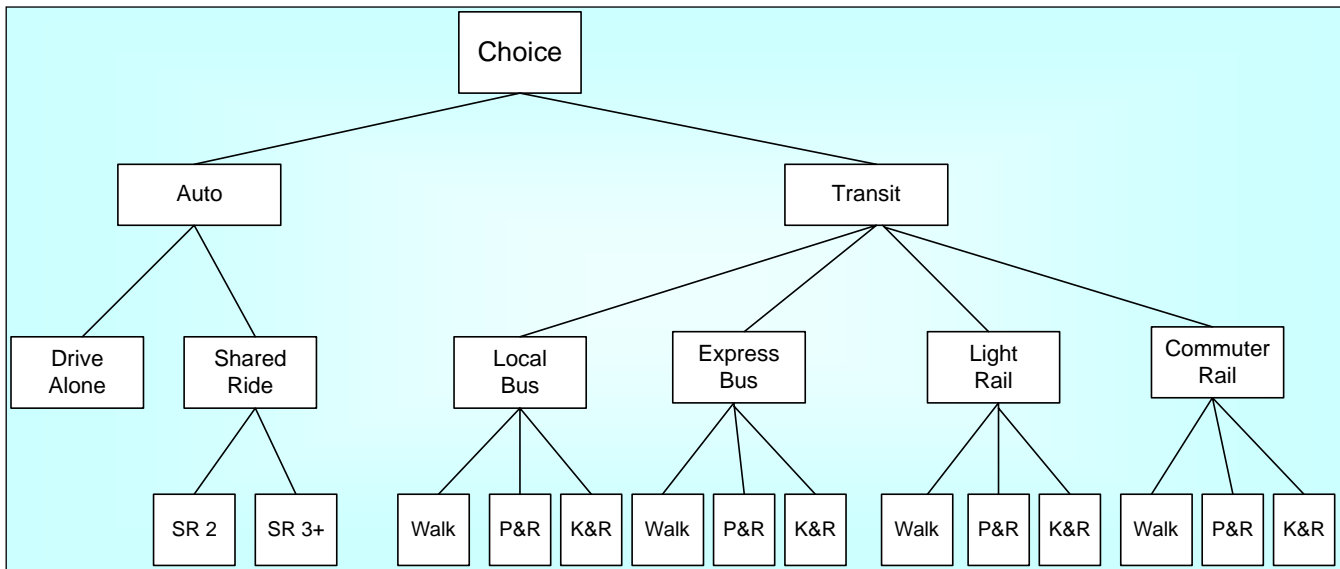
Please refer to Technical Appendices F and G for a detailed description of the trip distribution calibration and validation results.

9.6
Modal Choice

As part of the NSTI model development effort, the OKI/MVRPC mode choice models were originally estimated and calibrated using data from the 1995 OKI Region Home Interview Survey and the 1995 SORTA/TANK On-Board Survey. Transit ridership data from MVRTA and the other local transit systems were incorporated in the model calibration process.

The structure of the OKI/MVRPC mode choice model is depicted in Figure 9-2. In this structure, a choice is first made between auto and transit. Under the transit side, the first level nest distinguishes between local bus, express bus, light rail and commuter rail. The second level transit nest models the choice between walk access, park and ride access and kiss and ride access to each transit mode. The highway side is divided into drive alone and shared ride, with shared ride further subdivided into 2-person and 3+ person carpools.

Figure 9-2: Mode Choice Model Structure



The primary market segmentation variable for mode choice is trip purpose. Four different mode choice models are used in the OKI / MVRPC model: home-based work, home-based university, home-based other and non-home based. All home-based school trips out of trip generation are transit trips, so no mode split is required. The other trip purposes all represent vehicle trips.

Time-of-day is also an important market segmentation variable. For model estimation, peak period levels of service and cost are appended to trips that start during the peak period, while off-peak characteristics are appended to trips that start during the off-peak period. This allows for the estimation of a single set of model coefficients per trip purpose. However, in model calibration separate mode-specific constants are calculated for the peak and the off peak periods.

Another element of the market segmentation strategy is the stratification of alternative specific constants (i.e., bias coefficients) by an indicator of wealth or socio-economic status. Historically, either auto ownership or income has been used for this purpose. In the OKI / MVRPC model, the HBW mode choice model is stratified by car sufficiency, while the HBO model is stratified by car ownership. Car sufficiency specifically captures whether an automobile is available for all or only some of the workers in the household.

The final element of the market segmentation strategy is the use of the potential for walking to transit to calculate walk times. This segmentation stems not from behavioral considerations, as is for example the use of auto ownership, but from the need to better represent actual walking times at the origin and destination ends of a trip. This segmentation recognizes that on any given zone, some trip-makers will have easy access to transit, others will require a long walk, and yet others will start or end their trip too far to walk to transit. Consequently, the walking time to transit will vary within each market segment. This is a considerable improvement over the practice of assuming that everyone is at the same average distance to transit.

Given that light rail and commuter rail do not currently operate in the combined OKI / MVRPC region, the mode choice models were estimated and calibrated ignoring these branches of the tree structure. For evaluating the introduction of these services in the NSTI alternative analysis study, the light rail branch was given mode split characteristics similar to the local bus branch, while the commuter rail branch was given mode split characteristics similar to the express bus branch. Each particular service, however, was represented with its own operational characteristics. This approach is consistent with observed behavior in regions where these types of rail services operate, and it conforms to FTA regulations for New Starts Applications.

9.7
CVG Airport &
King's Island
Sub-Model

Please refer to the Technical Appendices for a detailed description of the mode choice model estimation and calibration results, as well as for a description of the specific assumptions used to model light rail and commuter rail transit.

The CVG Airport and King's Island (PKI) sub-model performs trip generation, distribution and mode split separate from the other trip purposes and particularly for trips that start or end at either of these locations. Adjustments are made to the regional trip tables to avoid double-counting these trips. The CVG and PKI trip tables are assembled into the highway and transit trip tables just prior to assignment.

9.8
Diurnal
Distribution

Diurnal distribution is the process of allocating daily trips (by purpose and mode) into the time periods used for highway assignment. The allocation is achieved via use of time of day or diurnal factors.

A time of day factor gives the proportion of total trips (by purpose) that are in-motion during a certain period of the day. These factors are typically developed separately for the production to attraction direction of travel (P-to-A) and the attraction to production direction of travel (A-to-P). This consideration is necessary to ensure that the trips loaded to the networks are in Origin-Destination format, and not in the Production-Attraction format used in all previous modeling steps.

After mode choice, the peak and off-peak person trip tables are combined into single, daily trip tables and then split into four periods in preparation for highway assignment. This time of day split is based on diurnal factors derived from the 1995 OKI Region Home Interview Survey. The four assignment time periods are:

- Morning Peak Period: 6:00 AM to 8:30 AM
- Midday Period: 8:30 AM to 3:00 PM
- Evening Peak Period: 3:00 PM to 6:30 PM
- Night Period: 6:30 PM to 6:00 AM

9.9
Truck Model

The truck model developed for the OKI / MVRPC model system produces truck trip tables for two types of commercial vehicles: single-unit (six-tire trucks) and multi-unit (three-plus axle combination trucks).

The generation of daily truck trips for each vehicle type assumes that businesses of different types have a propensity to produce and attract single-unit (SU) and multi-unit (MU) truck trips at rates proportional to the amount of commercial activity being generated by the business. It is further assumed, in the absence of revenue data, that employment totals are good indicators of the amount of commercial activity being generated by businesses. Likewise, households generate some amount of commercial vehicle traffic for the pick up and delivery of goods and provision of services. These assumptions are implemented in the OKI / MVRPC model at an aggregate level by applying truck trip generation equations to the zonal totals for households and employees, by industry grouping, to estimate SU and MU truck trip ends. The trip ends are then distributed using a gravity-type formulation.

The trip generation equations and gravity model impedance functions use modified versions of parameters published in the Quick Response Freight Manual (USDOT 1996) to produce initial estimates of SU and MU truck trip tables. The truck model is then calibrated using a synthetic matrix estimation (SME) method. SME uses the initial trip table estimate as a "seed matrix," which is then adjusted such that assignment of the table to the highway network results in truck trip flows that come close to matching observed truck traffic counts, through successive iterations. SME adjusts not only the flow pattern, but also the number of trips produced, effectively calibrating both trip generation and distribution stages simultaneously. The resulting daily trip table is split into four time periods and then loaded to the highway network simultaneously with the personal auto trip tables.

To support the analysis of alternatives in the year 2030, a truck model forecasting procedure was developed to project the base year truck tables into the future. This procedure uses a growth factor matrix adjustment method to generate future-year daily truck trip tables based

9.10 Trip Assignment

on forecast growth in zonal employment and households. Based on time series data, the procedure assumes that SU and MU truck trip generation rates per employee will increase over time because of forecasted improvements in productivity, varying by industry sector. This assumption is reflected in the development of productivity deflation factors, which are then applied in the growth factor calculations.

Highway Assignment

The combined OKI / MVRPC consolidated model uses multi-class equilibrium assignment to load trips onto the highway networks. Five trip classes or modes are considered, three for passenger traffic (single-occupant cars, two-occupant cars, three or more occupant cars) and two for truck traffic (single unit trucks and multiple unit trucks). This class separation allows the modeling of restrictions in network usage, to represent for example HOV lanes, which should be used only by multiple occupant vehicles, or truck prohibitions, to keep multiple unit trucks from using certain streets.

An important new feature was added to the OKI / MVRPC model that did not exist in version 5.4 of the OKI model: feedback iteration until model convergence. The previous version of the OKI model applied a constant number of feedback loops. No checks were made in the course of the model application to ensure that the estimated morning peak period speeds approximated well the initial, assumed morning peak speeds. Now, the convergence algorithm added to the OKI / MVRPC model checks, at the end of each feedback loop, whether the model has converged. If it has not, then the estimated speeds are fed back to the beginning of the model application chain and the full model run is repeated until convergence is reached. The method of successive averages is used to calculate the feedback speeds.

The OKI / MVRPC model development effort included a full, detailed validation of the highway assignment based on 1995 count data. The final model conforms to the validation criteria recommended by the Ohio Department of Transportation and by the Federal Highway Administration. Please refer to the Technical Appendices for a detailed description of the highway assignment procedures and model validation results.

Transit Assignment

Transit assignment is performed separately for peak and off-peak trips. The transit trip tables include all trips forecasted by the regional mode choice model, as well as all transit trips forecasted by the CVG and PKI sub-model.

The OKI / MVRPC model development effort included a detailed comparison of 1995 observed and estimated boardings. It was found that the model estimated regional boardings with an error of 6 percent. Higher, though still acceptable errors were obtained for each transit authority. Please refer to the Appendix F for additional details.