OKI Travel Demand Model, Version 7.6

Introduction

The OKI Travel Demand Model is a tool used by transportation planners and engineers to forecast travel demand and estimate the impacts of travel on highway and transit facilities including congestion, travel time and mobile-source emissions. The OKI Travel Demand Model is a battery of computer programs and algorithms that make use of hundreds of independent variables to predict human travel behavior. The model allows for the identification of current and future transportation needs as well as the testing of the impacts of implementing proposed improvements to the system (i.e. new or widened roadways, additional transit service, etc.). The model covers the Ohio-Kentucky-Indiana Regional Council of Governments (OKI) and Miami Valley Regional Planning Commission (MVRPC) region, with the counties of Hamilton, Butler, Warren, Clermont, Montgomery, Miami, and Greene in Ohio, Boone, Kenton, and Campbell in Kentucky, and Dearborn County Indiana.

The model is a trip-based model, which uses four major steps: trip generation, trip distribution, mode choice, and trip assignment. Additionally, the model is enhanced with special modules for the Greater Cincinnati-Northern Kentucky International Airport, King's Island Amusement Park, the EPA Motor Vehicle Emissions Simulator (MOVES), and many reporting programs.

Model Inputs

Put in its most basic form, transportation is about supply and demand. The model requires a variety of inputs. The most notable include the socioeconomic data (demand), highway and transit inventory data, behavioral data, and travel pattern data (supply).   Each of these items is discussed in more detail below.

Socioeconomic Data

The socioeconomic inputs (where people live and work) are the primary source of predicting travel volumes and patterns. Population, households, and employment data is compiled for the region using the Census, building permits, InfoUSA, ES-202 unemployment data (now QCEW), and other sources. These inputs drive the trip generation and mode choice phases of the model. In addition to the observed base-year data, OKI forecasts the population and households in the future. These forecasts are based on county-level forecasts from the state data centers, which are the Ohio Department of Development, The Kentucky State Data Center at the University of Louisville, and the Indiana State Library. The county forecasts are allocated to traffic analysis zones by OKI staff in consultation with local planning professionals based on a variety of factors including development patterns and the amount of developable land in each traffic analysis zone. A traffic analysis zone is a small area, similar to a Census block group that is used as the primary geographic unit in the model.

Several analysis years are prepared for model applications. This enables the examination of several different scenarios.

Highway and Transit Inventory Data

Highway and transit networks represent the "supply side" of transportation infrastructure in the region. For highways, OKI develops and maintains network data that includes the number of lanes, traffic counts, roadway type (freeway, major arterial, collector, etc), and posted speed. For transit, the network information includes peak and off-peak headways, bus stop locations, and park-n-ride locations and amenities. In addition to the geographic and inventory data specific to the highway and transit networks, OKI integrates data on use - such as traffic counts and transit ridership, and user costs, including cost to own and operate a vehicle and transit fares. OKI also collects data on the parking supply and prices in downtown. The parking cost and supply data is used in the mode choice program to account for travel time to walk from a parking location to a final trip destination.

Networks are developed for multiple scenarios.

Travel Behavior Data

OKI periodically surveys the public, and in August 2010 completed a household survey and transit on-board survey. The data is used to develop and refine the model so that the number of trips (trip generation), the origins and destinations (trip distribution) and how those trips are made (mode choice) reflect behavior of people in the region.

External Station Travel Pattern Data

To get a complete picture of travel within the region, travel that passes through the region requires consideration. To do this, OKI collects travel pattern data at the outer boundaries of the regions and from the Census Transportation Planning Products and American Community Survey.

Model Steps

The OKI Model is a State of the Practice model that includes four phases: trip generation, trip distribution, mode choice, and assignment. In addition, the OKI model uses some extended steps, such as network processing, a truck model, a Kings Island/CVG Airport model, a time-of-day model, the MOVES air quality model, and extensive reporting features. These steps are described below.

Trip generation

The trip generation step estimates the number of person trips based on the socioeconomic data (population and employment) described above by traffic analysis zone and the trip rate table. The trip rate table is developed by performing a cross-classification analysis on the household travel survey. Trip rates are cross-classified over the criteria of the number of people in a household, the number of workers in a household, and the number of vehicles in a household. Every trip must have an origin and a destination. The OKI Model is similar to most other models in that it follows convention that trips are produced at the home end and attracted to the non-home end (usually work, shop, etc.)

During the model run, the input socioeconomic data is classified by different characteristics of households (number of people, number of workers, and number of vehicles to calculate the number of trips produced by purpose including work, university, school, other. Next in the process, the employment data is used to calculate the trip attractions, also by purpose. The attracted trips are based on regression models of trips, and employment by type.

The purposes used in the model are home-based work, home-based university, home-based school, home-based other, and non-home-based. Later in the model, these purposes influence trip lengths in distribution and the probability of choosing one mode over another in the mode choice process.

The output of this step is a table of productions (origins) and attractions (destinations) by purpose for each traffic analysis zone.

Network Processing

The network processing step is executed to determine the capacity and travel time for highways, and the access time, waiting time, riding time, transfer walk time, transfer wait time, and walk egress time for transit.

For highways, the capacity is based on calculations prescribed in the industry standard *Highway Capacity Manual*. The travel time is initially based on the posted speed, but is adjusted during the model run to take into account congestion. The adjustment function uses two parameters that have been calibrated to our region using travel time studies.

For transit, vehicle speeds are a function of the auto speed. The output of this step is several matrices that have the times and distances for highway and transit travel.

Trip Distribution

Trip distribution is the model step where travel destinations are determined. This is done using the "gravity" model, where the attractiveness of a destination is inversely proportional to the 'cost' to get there. In this case, cost includes time, cost to operate a vehicle and cost of parking or the bus fare, and in the case of transit, all the waiting and access times.
The output of this step is a person trip zone to zone person trip matrix.

Mode Choice

Mode choice is the step that answers the "how do I get there?" question. For some zone pairs, trips might only be possible by auto only, while other zones are linked by auto and/or bus. The mode choice model runs through a decision tree that is illustrated below.
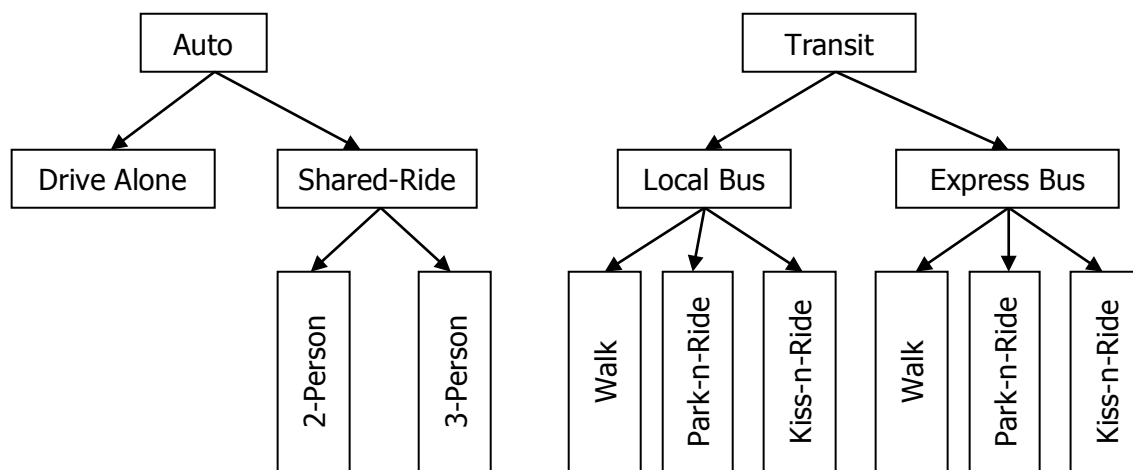
The mode choice model first makes a choice between auto or transit.

If the choice is made for auto, the next choice is between drive-alone or shared ride.

If the choice is made for shared-ride, the next choice is for 2-person or 3-people:

   a. If the choice is made for transit the second choice is local or express bus
   b. If the choice is made for local bus, the next choice is among walk, park-n-ride, and kiss-n-ride (drop-off)
   c. If the choice is made for express bus, the next choice is the same as the final choice for local bus, what is different is the bus path that is ultimately used.

To facilitate the mode choice decision, the economic utility values for each choice are computed. These are based on travel times, travel costs, an alternative-specific constant, and sometimes a system-specific constant (in transit). In these utility equations, coefficients to the travel times, travel costs, etc. are estimated using statistical software. In addition, the software indicates the alternative-specific constant that is used to make adjustments to the utility based on the mode chosen. This alternative specific constant adjusts for immeasurable items such as comfort, feeling of safety, environmentalism, etc. In addition, for transit, there is a system-specific constant that can be used to adjust the ridership because of immeasurable items relating to specific systems (i.e. affinity towards a system, perceived service levels, perceived reliability, etc.).

Truck Model

The truck model uses an observed truck trip table and adjusts traffic to the estimated (or forecasted) truck trips. These truck trips are estimated for the base year and forecasted for future years based on employment data and using national trip rates.

Kings Island and CVG Airport Model

Because of the difference in trip generation, distribution, and modal choices, trips for Kings Island and CVG are treated differently. In both cases, OKI has obtained information regarding attendance (KI) and passengers (CVG) from surveys conducted at the respective agencies. These are adjusted based on those agencies' growth forecasts, which provides the trips generated from those locations.

Time of Day Choice and Trip Assignment

Once the trip modes are determined, the model compiles all of the mode-choice tables (which are still in person trips) and converts the auto person trips to vehicle trips. For drive alone, this means that the person trips and vehicle trips are the same, for shared-ride 2-person, every two person trips is one vehicle trip, and for shared-ride 3+ person, the person trips are converted to vehicle trips using a factor based on household survey data (we collect and compare between our household survey and the national household survey) and Census ACS data (for work trips). Following the conversion to vehicle trips, the vehicle trips by purpose are broken out to individual half-hour segments based on household survey data (in this case, local and national household survey data is used). These half-hour segments are then combined to the four periods we use for assignment, AM, midday, PM, and night.

Once the vehicle-by-period trip tables are completed, vehicle trips are assigned to the network using an equilibrium highway assignment. This means that the assignment process assigns vehicles based on the shortest path. Highway travel times are then recalculated and vehicles are assigned several times until there is balance between travel times across the system.

MOVES Post-Processing

The Motor Vehicle Emissions Simulator (MOVES) model is a model used for the estimation and forecasting of mobile air emissions, such as carbon dioxide, nitrous oxide, and particulate matter. Because OKI is a non-attainment area, the use of MOVES is required to ensure our regional transportation plan conforms with EPA pollution standards. Primary input to the MOVES model is the amount of traffic, the travel speed and the vehicle composition.

Model Reporting

OKI staff has customized the OKI Travel Model to produce several reports that facilitate the review of various performance measures including impacts on the social and natural environment as well as identify predicted congestion or safety problem areas.

Conclusion

The OKI model is a complex tool designed to simulate human travel behavior. It has the capability of estimating base-year traffic and forecasting future year traffic by time of day. It requires several types and sources of data, and runs through a battery of programs and a variety of processes. The model is designed to inform the decision-making process. It can provide valuable information to the public and community leaders in their evaluation of potential transportation solutions.