Chapter 14 - Travel Demand Forecasting

The Richmond/Tri-Cities (RTC) travel demand model utilizes Citilabs software using the CUBE Catalog modeling platform. Using this modeling platform, VDOT has developed a regional travel demand model for the Richmond and Tri-Cities metropolitan areas. The RTC model is a four-step model that includes trip generation, trip distribution, mode split and traffic assignment. The model includes feedback between highway assignment and trip distribution. The coverage area of the model includes the Richmond 8-hour ozone maintenance area as well as parts of Goochland, Powhatan and Dinwiddie counties, and all of Charles City and New Kent counties.

Modeling Process

The following is a brief description of the modeling process as it relates to the RTC model based on documentation currently available from VDOT modeling staff and updated to reflect the current model:

Highway and transit system data were coded by the model developers to create a representation of the regional transportation network. Attributes coded into the network include highway features such as road segment length, capacity, number of lanes, and free-flow speed, and transit operating characteristics such as fares, bus stops, and hours and frequency of service. The networks include all available motorized modes of travel, including single-occupant automobiles, multiple-occupant (“high occupancy”) automobiles, park-and-ride express bus service, and standard bus service. Based on the coded network, travel time and cost data are tabulated for use in subsequent model steps.

Trip making activity is estimated during the trip generation and trip distribution steps. Trip generation uses summary information from each transportation analysis zone (TAZ) to compute the number of trips produced in and attracted to each TAZ. The summary information includes number of households, total population, group-quarters population, retail and non-retail employment, and number of automobiles available to households. These socio-economic data are prepared by RRPDC staff in consultation with area local planning staffs and compiled for use in the model. Trips are generated by purpose (home to work, home to non-work locations, and non-home trips). Commercial vehicle activity is accounted for through the non-home trip purpose. Trips that start or end outside the RTC modeled area, as well as trips that simply pass through the region, are treated as separate trip purposes. These external trips were estimated from traffic counts observed at major exit stations in the year 2008 and then expanded for future years using growth trend estimates of traffic at the external stations.

The trip distribution step joins the production and attraction end of each trip using factors designed to reproduce observed traffic volumes and trip times in the base year. The trip
distribution step uses a standard gravity model, with different factors for each trip purpose. Both the previous and revised CUBE model were designed to use feedback from the highway assignment into trip distribution to better approximate observed traffic conditions (and, in the future years, to better estimate the differential effects of additional trips and transportation facilities). The feedback takes into account the effect of congestion on route choice, since the most commonly chosen route to a destination will depend on whether or not a particular route is congested or free-flowing, and the level of congestion in turn depends on what route travelers are most inclined to choose.

Trip tables from trip distribution, along with network-based travel time and cost data, are input to the mode split step to estimate trip tables by trip purpose, travel period (peak or off-peak) and mode. The mode split step uses a nested logit model to allocate trips between automobile, regular bus and express bus, based on differences in time and cost among the modes. Auto-occupancy rates that vary by trip purpose are applied to automobile trips, and the trip tables are assembled for assignment to the highway and transit networks.

During the highway assignment step, trips between each zone pair are loaded onto the highway network and balanced with congestion effects. Highway assignment uses a capacity restraint formula that limits how many trips can be assigned to each roadway link based on its practical capacity. During assignment, routes are assembled between each zone pair based on the shortest routes under congested conditions. A feedback loop prior to the final assignment adjusts the trip distribution to account for the effect of congestion on travelers’ likely choice of destination, so the number of trips between zones may be altered due to congestion in addition to the actual routes taken.

In transit assignment, trips are assigned to the most efficient transit route available, taking into account waiting time, travel time, transfers required, and fare. Transit assignment is based on the best route, and does not have a capacity restraint or congestion balancing component.

The output of the highway assignment process is a network file that includes forecast traffic volumes on each roadway segment, as well as an estimate of congested travel speed. That file is referred to as a “loaded network”.

This overall modeling process is applied for each analysis year.

**Richmond/Tri-Cities Model Update**

In 2011/2012, the Richmond/Tri-Cities travel demand model was updated from a 2000 base year and 2031 horizon year to a 2008 base year and 2035 horizon year using socioeconomic data and forecasts developed by the Socioeconomic Data Workgroup over the past several years. The model update included a number of improvements over the previous model version (from the Draft Richmond Tri-Cities Model Methodology Report, 2012):
- The highway network has been enhanced and provides significantly more detail in terms of streets and their alignments. The freeway interchanges are coded in the network to more closely reflect the way they actually exist on the ground.
- The transit networks and their processes were converted into CUBE Public Transport (PT) module. The networks were updated to accurately represent 2008 GRTC Transit Company and PATS transit services.
- The model has been refined to conduct full time-of-day modeling. The first three steps in the model (trip generation, trip distribution and mode choice) are stratified for the peak period and the off-peak period. The highway assignments are further stratified into four time periods – AM peak, Midday, PM peak and Night.
- The refined trip generation and distribution models make extensive use of the 2009 National Household Travel Survey (NHTS) Virginia Add-On. Key relationships such as trip rates by purpose, average trip lengths, and trip frequency distributions are derived from that survey. Additional surveys were also conducted for four large Virginia universities, including Virginia Commonwealth University (VCU).
- The mode choice model was developed using a variety of data sources including the fall 2009 GRTC On-Board transit survey, NHTS data (automobile occupancy) and model parameters from FTA “national experience”. The mode choice model is executed using the CUBE XCHOICE module.
- The highway assignment procedures include a variety of enhancements. These include the use of Conical Volume-Delay functions (VDF) built on research done at the Virginia Modeling, Analysis and Simulation Center (VMASC) at Old Dominion University, refinements to the speed-capacity tables and the use of enhanced toll procedures.
- A new heavy truck model was developed and validated.
- The model has been updated to include a feedback loop, which ensures that speeds from the resulting highway assignments are fed back through the forecasting process.

The current version of the RTC model as prepared for the 2035 LRTP update includes a 2008 base year, 2018 and 2028 interim years, and a 2035 horizon year. The 2008 base year is calibrated and validated to 2008 traffic counts and other available real-world data to ensure that the model is producing results that are within an acceptable range of known data.

Map 14-1 shows the 2008 base-year road network covered by the updated RTC model. As is apparent from the map, the model does not cover all of the Region’s roads, instead covering those roads that are “regionally significant” from an air quality conformity standpoint and those roads needed to ensure proper connectivity for accurate travel demand modeling.
Model Application for the 2035 LRTP/CMP Update

As of the April 2012, the revised RTC model was still in the final stages of development by VDOT. Although the updated model was available to be run for the purpose of generating output files for federally required further air quality conformity analysis, the model was not used for further LRTP and CMP analyses.

It was decided by RRPDC staff that the modeling effort for the 2035 plan update would be focused on air quality conformity, with the understanding that the subsequent 2040 plan update would benefit more fully from the improvements made to the RTC model during the update process.

Potential Model Application for the 2040 LRTP/CMP Update

Vast improvements, detailed previously in this section, have been made in the most recent update to the RTC model. These improvements will provide additional opportunities for data analysis and citizen participation in the 2040 LRTP/CMP update process. Additionally, it is anticipated that the model will be updated to a 2010 base-year using 2010 Census data and will undergo conversion to a new 2010 Census-based TAZ structure as part of the 2040 plan update process.

The following are some of the possible uses of the updated model for the 2040 LRTP/CMP update:

- Use of the model for generating multiple regional transportation “scenarios” to aid in the plan visioning process
- Help determine future transportation infrastructure needs
- Potential to analyze regional effects of different groups of transportation projects to aid in the project selection process
- Provide improved future traffic congestion forecasts for the CMP network analysis
- Opportunity to validate other CMP data sources
- Possibility to analyze driver route choices and better inform scope of CMP network
Map 14-1: Richmond/Tri-Cities Travel Demand Model Network