Integrated Activity Based Model and Traffic Simulation in the Sacramento Region – the Home Stretch

Thomas Rossi, Cambridge Systematics, Inc.

Introduction

This paper describes the work conducted for Project C10 of the Strategic Highway Research Program (SHRP2) titled “Partnership to Develop an Integrated, Advanced Travel Demand Model and a Fine-Grained, Time-Sensitive Network.” Project C10 consists of two projects: one which includes simulation of both highway and non-highway modes, and one in which choices of non-highway modes are limited. This paper discusses the former project (labeled “C10B”), which focuses on the Sacramento, California region, due to be completed in 2012.

Project C10 is an important step in the evolution of travel modeling from an aggregate, trip-based approach to a completely dynamic, disaggregate methodology. At the same time that travel demand models have been evolving, traffic simulation models, which simulate the movements of vehicles through a highway network, have become more sophisticated due to improvements in computing. The product of C10B is a true integrated model that simulates individuals’ activity patterns and travel and their vehicle and transit trips as the move on a real time basis through the transportation system. It produces a true regional simulation of the travel within a region, for the first time using individually simulated travel patterns as input rather than aggregate trip tables to which temporal and spatial distributions have been applied to create synthetic patterns. The product is intended to be able to be used in any urban area with a significant amount of multimodal travel and is implemented in an open source software framework. The progress of this project is of great interest to planners in such urban areas.

The goals of C10 were developed by the project’s Expert Task Group (ETG) consisting of researchers and agency transportation planning practitioners. These goals are intended to improve the travel modeling process to address key transportation policy and investment questions, to facilitate further development, deployment, and application of the procedures, and to make operational an advanced travel demand model integrated with a fine-grained, time-dependent network. Goals include:

- Production of a portable, transferable product;
- Incorporation of products from other SHRP projects;
- Incorporation of travel time reliability into the modeling capabilities;
- Demonstration of the application of outputs of the integrated model to estimate greenhouse gas emissions using MOVES, the new EPA air quality analysis model; and
The objectives of SHRP C10 include developing tools to accurately analyze the effects of policy and investment questions that are critical to planning in urban areas today. These questions require a model that:

- Reflects the sensitivity of travel choices to the continuous changes in traffic characteristics throughout the day;
- Considers the full range of choices that each traveler encounters, including whether to travel, activity location, mode, route, and departure time, and their effects on other activity decisions the person makes;
- Is fully disaggregate to properly consider the effects of individual choices and to provide results at any relevant level of aggregation; and
- Is sensitive to the important variables affecting travel decisions, including transportation level of service, reliability of travel time, traveler and household demographics, and land use.

SHRP C10B has generated significant interest within the transportation planning and modeling communities over the past two years. This presentation differs from earlier presentations on this project in that the completed integrated model is discussed, along with the model validation process and validation results.

The Integrated Model

The structure of the integrated model is shown in Figure 1. The project team has completed the integration of an activity based model (DAYSIM, within the regional model SACSIM) with the traffic microsimulation model DynusT. The integrated model links individual person records with vehicle and transit trips in the microsimulation, and transit tours are simulated. The integrated model also runs the Motor Vehicle Emission Simulator (MOVES), the mobile source emission model developed by the U.S. Environmental Protection Agency (EPA), using the outputs from the demand and traffic simulation models.

SACSIM (Sacramento Area Council of Governments, 2008) is the travel demand model used by the Sacramento Area Council of Governments (SACOG), the metropolitan planning organization (MPO) for the Sacramento region. It is one of only six activity based models currently in use by MPOs in the U.S. although several other agencies are currently developing such models. Internal person trips are modeled using a complete activity based approach that simulates each person’s set of daily activities by purpose, expressed as tours, and their sequence, locations, and times, as well as the modes used to travel between activity based locations. DynusT is a true disaggregate simulation model that can track individual vehicles and transit travelers through the network—consistent with tracking traveler activities in a travel demand model. Furthermore, DynusT is a dynamic traffic assignment model that takes into account both the spatial and temporal effects of
congestion. The model development followed a detailed model design plan developed at the beginning of the project and approved by the ETG (Cambridge Systematics, Inc. et al., 2010).

Model Features

This section briefly discusses some of the unique and innovative features of the integrated model. These features were developed as part of the C10B project and represent enhancements to individual components such as DAYSIM or DynusT or methods to ensure compatibility of the information being passed between model components.

Transit simulation

A unique feature of the integrated model is the simulation of individual tours and trips made by transit as estimated by DAYSIM. The simulation includes walk or auto access between the trip origin and the transit stop, waiting for the transit vehicle, travel on a specific transit vehicle run, any applicable transfers, and walk or auto egress between the transit stop and the trip destination. This requires the simulation of every transit vehicle run in the Sacramento region. The transit vehicles are simulated in DynusT along with the auto and truck trips and tours from SACSIM (Hickman et al., 2011).

Figure 2 displays the transit passenger simulation process. The simulation of passenger movements in the transit network is handled within a module called Flexible Assignment and Simulation Tool for Transit and Intermodal Passengers (FAST-TrIPs). FAST-TrIPs computes the least cost transit “hyperpath” (a sub-network of the transit network describing the passenger’s possible paths from origin to destination) for each transit traveler. Once a passenger has an assigned path or hyperpath, he/she is loaded into the queue at the departure stop at an appropriate time. In the case of transit with auto access, the passenger is not loaded into the queue at the park-and-ride lot until the vehicle arrives at the lot and any terminal access time is counted.

Feedback of travel times between DynusT and DAYSIM

To achieve consistency between the highway travel time outputs and inputs of the integrated model, the model is run iteratively, with travel time outputs from one iteration used as inputs to the next. This feedback of travel times is common practice in travel demand models for larger areas where congestion levels can affect travel choices. This process is somewhat more complicated for the integrated model since the choice models of demand in SACSIM require as inputs origin-to-destination travel times for aggregate periods (half hours for DAYSIM, longer periods for other components) while DynusT produces travel time estimates only for the specific paths used in the simulation at the precise times the travel occurs. The process used to create the necessary travel time inputs for SACSIM examines all simulated highway link travel times over a period for which origin-destination time data are needed and uses this information to create travel time “skim matrices.”
Incorporation of variable value of time

To more accurately simulate route choices when tradeoffs between cost savings and time savings (or travel time reliability) are involved, it is necessary to make assumptions about each simulated traveler’s value of time. In existing traffic simulation models that obtain their origin-destination information from aggregate travel demand models (i.e., trip tables), the best that can be done is to segment groups of travelers by assumed value of time levels. Since the new integrated model simulates each traveler individually, it is possible to simulate his or her individual value of time (Lemp et al., 2011).

The value of time for each traveler is simulated using a probability distribution. This was achieved in DAYSIM by reestimating the new mode choice models, specifying a distribution for the in-vehicle time coefficient, in this case a log-normal distribution. With a fixed cost coefficient, the value of time distribution can be described easily. Instead of estimating a fixed coefficient for out-of-vehicle time in the new models, the ratio of out-of-vehicle time to in-vehicle time was estimated. This means the coefficient for out-of-vehicle time also follows a log-normal distribution but is determined by the in-vehicle time distribution and the ratio of out-of-vehicle time to in-vehicle time.

It proved impossible to estimate good variable value of time distributions using the available survey data for Sacramento. This difficulty seems to stem from the lack of variation in costs paid by survey respondents, due to the lack of priced roads in the Sacramento region, the fact that the vast majority of travelers paid nothing to park, and the low incidence of transit use in the survey. This is an important realization since the same issues likely apply to household survey data sets from other regions. To deal with this, value of time distributions were transferred from the San Francisco region, where a stated preference survey data set was available. The Sacramento mode choice models were reestimated using the transferred value of time distributions. Ratios of out-of-vehicle time to in-vehicle time were not taken from the San Francisco model, nor was the scale of that model. All parameters related to non-level of service variables were estimated as normal from the Sacramento data.

Implementation

The integrated model can be accessed and executed using any web browser, with the major model components running on shared servers. The model interface allows users to create scenarios, choose to run various model components (e.g., transit simulation, MOVES), select parameter settings, execute the model, and produce various reports. Figure 3 shows one of the user input screens in the interface, which shows the status of various model runs.

Virtually the entire set of programs and components that comprise the integrated model are available under open source licenses, including SACSIM/DAYSIM and DynusT. The integrated model therefore does not depend on any commercial travel demand modeling or simulation software. The entire modeling system—both executable programs and source code—are being made available to the planning community, enabling public agencies to use and customize the software to meet their needs. Researchers can modify or enhance the system, or create new modeling system components that interact with the proposed framework.
Project Status

By spring 2012, the project team will have validated the integrated model for the base year of 2005 for Sacramento, according to a detailed model validation plan prepared in 2010 (included in Cambridge Systematics, Inc. et al., 2010). The main work remaining before the model can be declared ready for use in Sacramento is a set of sensitivity tests in which the model will be run for a set of project and policy analyses developed by SACOG to reflect the types of analyses they perform in their planning process. These analyses may include freeway and arterial improvements, transit service increases and cutbacks, corridor management studies, road pricing approaches such as HOT lanes, and transit pricing strategies. These will be conducted over the summer of 2012. The final model and documentation are expected to be available by the end of 2012.

Further Information

The C10B research team maintains a publicly accessible project web site, http://www.shrp2c10.org/SHRPC10Portal/Home.aspx. Over the past two years, the team has continuously uploaded documents and other information related to model features, software, and other points of interest to the planning community.

Acknowledgments

The development of the integrated model has been performed by a large team of modeling experts. Key staff involved in the work described in this paper include Thomas Rossi (Principal Investigator), Vassili Alexiadis, Eric Ziering, Scott Meeks, Gerard Vaio, Jason Lemp, David Kurth, Lawrence Liao, Tazeen Mahtab, and Moshe Ben-Akiva of Cambridge Systematics; Eric Petersen, formerly of Cambridge Systematics; Yi-Chang Chiu, Mark Hickman, and Brenda Bustillos of the University of Arizona; Jane Lin and Suriyapiyri Vallamsundar of the University of Illinois, Chicago; Song Bai of Sonoma Technology; David Robinson of Fehr & Peers; and Bruce Griesenbeck, Gordon Garry, and Binu Abraham of SACOG.

References


Figure 1. Model Structure
Figure 2. Transit Passenger Simulation

Figure 3. Model Interface