Sensitivity Testing of the SHRP2 C10A DaySim-TRANSIMS Model System in Jacksonville, Florida

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Introduction

The purpose of this paper is to describe the sensitivity tests that are being performed in the Jacksonville, Florida region in support of the SHRP2 C10A project. The primary objective of the C10A project is to make operational a dynamic integrated model—an integrated, advanced travel-demand model with a fine-grained, time-dependent network, and to demonstrate the model’s performance through validation tests and policy analyses. This integrated model system is necessary because most current travel models are not sufficiently sensitive to the dynamic interplay between travel behavior and network conditions, and are unable to reasonably represent the effects of transportation policies such as variable road pricing and travel demand management strategies.

The model system is comprised of two primary components: DaySim, and the TRANSIMS Router and Microsimulator. DaySim simulates 24-hour itineraries for individuals with spatial resolution as fine as individual parcels and temporal resolution as fine as single minutes, so it can generate outputs at the level of resolution required as input to dynamic traffic simulation. The Jacksonville DaySim implementation incorporates some unique features such as a synthetic sample population that includes seasonal households as well as permanent households, which enables the model to support seasonal analyses. In addition, the project team has also enhanced the DaySim and TRANSIMS components to implement findings from the SHRP 2 C04 project “Improving Our Understanding of How Highway Congestion and Pricing Affect Travel Demand” in a manner that retains as much behavioral detail as possible while also remaining practical for model application.

The TRANSIMS network and travel assignment components of the model system are used to represent the performance of the transportation networks in the integrated model system. TRANSIMS assigns a sequence of trips or tours for individual household persons between specific activity locations (smaller than travel analysis zones but larger than individual parcels) to roadways, walkways, and transit modes on a second-by-second basis for a full travel day. TRANSIMS implements a dynamic user equilibrium network assignment for trip and activity files that define the demand by detailed time of day.

Model Sensitivity Testing

Travel demand forecasting model systems are only able to test the effects of policies and assumptions which have been explicitly included when designing and implementing the model system, and are not
intrinsically sensitive to the increasingly broad range of transportation policies and improvements of interest to decision-makers. While most regional models are sensitive to large-scale assumptions about land use and demographics, few are sensitive to more detailed assumptions about pricing policies, or to traffic or travel demand management strategies. Even where models have the capability to address these types of policies, they are typically not sufficiently sensitive to the dynamic interplay between travel behavior and network conditions by time-of-day, and are unable to reasonably represent the effects of road pricing, travel demand management, and other policies. In addition to making operational a dynamic integrated model—an integrated, advanced travel-demand model with a fine-grained, time-dependent network, a fundamental goal of the SHRP2 C10A project is to demonstrate the model’s performance through sensitivity tests and policy analyses.

A motivating force behind the SHRP2 C10A project is to develop tools to evaluate policies that cannot be adequately addressed using current state of the practice travel forecasting models. In order to assess the increased sensitivity of the integrated model system and illustrate the unique capabilities of the model system, a set of tests were designed which included:

- **Pricing**: Pricing strategies are costs that are imposed on travelers using certain roads, traversing certain screenlines, or travelling to certain areas (tolling, cordon pricing or area pricing). These costs may be either fixed or vary by time-of-day or in response to congestion. Two types of pricing tests are being evaluated as part of this effort. In the first, a number of scenarios were defined in which freeway tolls that varied by time of day. In the second, a number of scenarios were defined in which auto operating costs were modified from the “baseline” condition. The initial pricing sensitivity testing was performed using the Burlington implementation of the model system, and a revised round of pricing sensitivity tests are being performed in Jacksonville using the revised model system described below that features a pricing-enhanced version of DaySim and better integration with the faster version 5 TRANSIMS network simulation tools.

- **Travel Demand Management**: TDM approaches incorporate a wide range of strategies aimed at changing travel behavior to reduce congestion and improve mobility, such as increasing the frequency and numbers of people who work at home, adjusting work schedules to travel in off-peak, less congested conditions, or increasing the number of people who carpool to work. The initial sensitivity testing focused the impacts of a flexible work schedule in which workers worked fewer days but longer hours on those days, and in which the overall time spent in work activities was held fixed. This analysis revealed interesting tradeoffs and implications for network performance and the distribution of travel by detailed time-of-day as the workers who did not participate in work activities participated in more discretionary shopping, social/recreation and other activities, while those workers who did participate in work activities worked longer hours. This test is being revisited in the new integrated Jacksonville model.

- **Operations**: Operational strategies, also known as transportation system management (TSM) also address a wide range of projects and changes, including bottleneck improvements, corridor improvements and parking strategies. For this project, the sensitivity testing was focused on a
scenario in which signals were coordinated along three primary regional corridors with the goal of reducing bottlenecks and improving the overall traffic flow. These initial sensitivity tests revealed a number of challenges with evaluating operational strategies that will inform the further testing of such strategies in Jacksonville. Extensive re-timing of signals using both observed and synthesized data was necessary in order to establish a reasonably well-performing base case scenario, and the alternative scenarios often produced ambivalent results, in which benefits on some links along key corridors appeared to have offsetting disbenefits on other links, or in some cases where the operational improvements led to overall declines in corridor performance.

As described, the initial sensitivity tests were performed using the Burlington implementation of the model system in order to facilitate more rapid testing and debugging of a greater number of scenarios. The final set of sensitivity tests will be performed using the Jacksonville implementation of the model system. The Jacksonville model system is considerably larger in scope than Burlington and is subject to greater congestion effects along key facilities and areas during peak periods than Burlington. This provides a more interesting modeling context, in addition to revealing challenging computational demands that would be expected to be faced in modeling any larger region.

**Convergence, Consistency, Stability**

As part of model sensitivity testing, the project team particularly focused on achieving levels of network assignment and model system convergence and stability that are sufficiently robust to support policy and project alternative analyses. The assessment of convergence and stability has involved use of a number of measures. The basic, traditional link-based relative gap used by the project team is a convergence statistic that quantifies the difference between the simulated performance of the traffic on each link by time of day and the vehicle hours of travel that would result from each traveler taking the minimum impedance path based on the simulated travel times. In addition to the link-based relative gap, the project team has also extensively tested a “trip gap” measure. This measure exploits the fact that TRANSIMS builds a unique path or travel plan for each trip based on the origin and destination activity locations, the trip start time, and other travel mode attributes (e.g., HOV or truck restrictions, etc.). In its simplest form, a trip-gap is computed by comparing the generalized costs for every traveler from their path in the travel plan file to their path in the all-or-nothing plan file. However, there are a number of variations and complexities in calculating this measure depending on whether the only the Router is used in assignment, or whether the Microsimulator is used, as well as arising from the nature of traffic microsimulation. Finally, the project team has been developing new measures that address key model concerns beyond convergence and stability. For example, the project team has developed measures of schedule consistency that assess at a disaggregate level the difference between the original schedule output by the DaySim activity-based demand model to the final schedules manifest in the regional network microsimulation.

**Model System Improvements**

One of the primary challenges in making the fully disaggregate DaySim-TRANSIMS model system useful for practitioners has been the long runtimes associated with the regional microsimulation. In order to
address these runtime issues, more closely link the DaySim demand model and the TRANSIMS network model components, and to provide additional policy sensitivities, in the final phase of the project the model system is being updated to exploit the capabilities of the new TRANSIMS v5 tools and a reengineered DaySim. Transitioning to these new tools will provide a number of advantages, including:

- Reduced Runtimes: The current single-threaded version 4 TRANSIMS Microsimulator is the greatest performance bottleneck in the current model system. The new version 5 TRANSIMS Microsimulator is multi-threaded and distributed and will greatly reduce model system runtimes by allowing regional traffic microsimulations to be simultaneously processed by multiple computing cores. Overall model system runtimes are expected to be reduced by a factor of 4 or 5, which will make the model system more attractive and useful to users by providing the ability to implement and debug tests significantly more quickly than is currently possible.

- Enhanced Gap Calculation and Convergence Methods: As described earlier, a primary focus of the DaySim-TRANSIMS model integration effort has been the testing of convergence methods and metrics. However, efforts to implement and evaluate convergence in the current model system have been complicated by the specific methods used by v4 TRANSIMS tools to calculate link volumes and costs from disaggregate Microsimulator and Router outputs, as well as issues associated with “problem” trips in that arise in microsimulation. Transitioning to the v5 TRANSIMS tools will resolve many of these complications, while enhancements to the new DaySim will support implementation of advanced system convergence methods and measures. Specifically, the version 5 Microsimulator provides the ability to “restart” trips that are “lost” during the simulation at the next link in the path. This capability has the potential to significantly improve the calculation of Microsimulator-based gap measures, which were distorted by these lost trips.

- Incorporating Trip-Specific Value of Time Segmentation: A key goal of the C10A DaySim-TRANSIMS model system is to provide greater sensitivity to pricing alternatives. A limitation of the version 4 TRANSIMS Router is that it only supports household-level value-of-time (VOT) classes. Recent SHRP2 C04 project findings indicate that VOT varies not only by household income, but also by trip purpose, occupancy, and trip distance, which necessitates the use of trip-specific values of time. The version 5 TRANSIMS Router provides trip-specific value-of-time (VOT) capabilities.

- Supporting Further Temporal and Spatial Disaggregation: The new version 5 TRANSIMS PathSkim tool simultaneously increases the flexibility in specifying network skim generation while reducing the amount of time required to generate these skims. Integration of these new TRANSIMS capabilities with the new re-engineered DaySim application capabilities provides the opportunity to significantly realize further temporal and spatial disaggregation in the model system – from the TAZ-level to the activity location-level, and from 22 time periods to 48 time periods.