Paper No: 09-1996

TRANSIMS Implementation in Chittenden County, Vermont: Development, Calibration and Preliminary Sensitivity Analysis

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Transportation Research Board
88th Annual Meeting
Washington, D.C.

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Word Count: 5,202 text words + 5 Figures + 4 Tables = 7,452 equivalent words

ABSTRACT

In an effort to advance the state of the practice of travel forecasting, the federal government has, since 1992, sponsored the development of the Transportation Analysis and Simulation System (TRANSIMS). The purpose of this paper is to describe and document the authors' experience with the implementation and calibration of the TRANSIMS model in Chittenden County Vermont, a medium-sized urban area with a population of about 145,000. In developing the TRANSIMS model, the study attempted to primarily rely on readily available data that would be easily accessible to the majority of Metropolitan Planning Organizations (MPOs) around the country. Following model development, several validation experiments were conducted to assess the extent to which the model after calibration replicated observed traffic counts. Preliminary sensitivity analyses were also performed to assess the sensitivity of the model results to changes in the random seed number, and to evaluate the impact of changing pre-timed signals to actuated controllers. The study demonstrates that the TRANSIMS Track 1 structure, and the tools currently available in the model, can be used to develop and calibrate a reasonably working model with a relatively modest effort for a small to medium size MPO. Moreover, for medium-sized areas with little to no congestion, the model does not appear to be quite sensitive to variations in the seed number, which should increase confidence in the model's results.

Keywords: TRANSIMS, micro-simulation, travel demand forecasting, model calibration

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INTRODUCTION

In an effort to advance the state of the practice of travel forecasting, the federal government has, since 1992, sponsored the development of the Transportation Analysis and Simulation System (TRANSIMS). TRANSIMS, initially developed by the Los Alamos National Lab (LANL), was envisioned as representing the “next generation” of transportation planning models, and was designed to provide transportation planners with increased policy sensitivity, more accurate emission estimates, and powerful visualization capabilities *(1)*. To do this, TRANSMIS employed an agent-based modeling approach which allows for simulating and tracking travel on a person-by-person and second-by-second basis.

From 1992 to 2003, the federal Government made significant financial investments in the TRANSIMS model, primarily focused on the development of the model’s core functionalities and algorithms *(2)*. More recently, the Federal Highway Administration (FHWA) has made grant money available to support TRANSIMS implementation and test deployment by Metropolitan Planning Organizations (MPOs) and other operating agencies. In 2006, Chittenden County, Vermont was a recipient of one of those grants.

The purpose of this paper is to describe and document the authors’ experience with the implementation and calibration of the TRANSIMS model in Chittenden County, to present the extent to which the model after calibration was capable of replicating observed counts, and to conduct preliminary sensitivity analyses. The paper is organized as follows. First, some background information about Chittenden County and its existing four-step planning model is provided. The next section provides a brief overview of the TRANSIMS model and describes how it was implemented to model the Chittenden County transportation system. The model’s calibration results are then presented, followed by the sensitivity analyses’ results. The paper concludes by summarizing the main conclusions derived from the study.

BACKGROUND

Chittenden County

The Chittenden County Metropolitan Planning Organization (CCMPO) planning area encompasses a rapidly growing urban area which contains Burlington, the largest city in Vermont. It is bound to the west by Lake Champlain and to the east by the Green Mountains. The Lake and Mountains have limited crossings and create natural screen lines for the County’s transportation model. Chittenden County has the largest population and employment in the state with 145,000 residents and over 120,000 jobs. The City of Burlington is the traditional urban core. Like most regions in the Country, the urban core has spread into neighboring municipalities. A suburban development pattern now surrounds the urban core.

Overview of the existing CCMPO Four-step model

The current CCMPO planning model is based on a four-step modeling platform, but offers several extensions and includes a land use allocation model based on the Lowry model. The model forecasts travel for the AM (7-8 AM) and PM (5-6 PM) peak hours independently. Forecasts represent a mid-week day (Tuesday, Wednesday, and Thursday) in September which was chosen because it is a time period during which public schools and colleges are in session, while seasonal (summer) traffic is still observed. Much of the TRANSIMS data shown throughout this paper are for the PM peak hour which is a close approximation of the design hour conditions. The AM and PM Model calibration statistics for the CCMPO four-step planning model are shown in Table 1 below, which as can be seen are well within the FHWA guidelines for transportation planning model calibration.

Table 1. CCMPO Four-step Model Calibration Statistics

	AM Model	**PM Model**	**FHWA Guidelines**
Correlation Coefficient	0.913	0.917	0.88
Percent Error Regionwide	0.4%	0.7%	5%
RMSE	37.1	33.1	
Percent Error by Functional Class			
Freeways	-1.2%	-0.29%	7%
Principal Arterials	6.9%	2.1%	10%
Minor Arterials	-4.4%	-8.0%	15%
Collectors	7.5%	5%	25%

TRANSIMS IMPLEMENTATION

Brief Overview of TRANSIMS

The TRANSIMS model can conceptually be viewed as consisting of four modules: (1) Synthetic Population Generator; (2) Activity Generator; (3) Router; and (4) Micro-simulator. TRANSIMS starts by creating a synthetic population based on census and land use data, among other data sets. The Activity Generator then creates an activity list for each synthetic traveler, which could include activities such as work, shopping, school, etc. This is done based on the demographic characteristics of the individuals as determined from survey data. Activity times and locations are also determined for each individual. The Activity Generator and the Router then compute combined route and mode trip plans to accomplish the desired activities. Finally, the Micro-simulator simulates the resulting traffic dynamics based on a cellular automata model, yielding detailed, second-by-second trajectories of every traveler in the system over a 24-hour period.

It should be noted that while TRANSIMS is designed to allow for using an activity-based approach to transportation demand modeling (using its Population Synthesizer and Activity Generator), the model's Router and Micro-simulator modules can still be applied using standard trip tables (i.e. Origin-Destination (O-D) matrices). This provides for a cost-effective approach for regional planning organizations to take advantage of the increased resolution of the TRANSIMS micro-simulator, while primarily depending upon standard O-D matrices with which they have dealing for several years. Implementing only TRANSIMS's Router and Micro-simulator, using O-D matrices, for a given area is typically referred to as a "Track 1" TRANSIMS implementation *(3)*. "Track 1" TRANSIMS implementation is the focus of the current paper.

TRANSIMS-related Previous Studies

A review of the literature reveals a handful of previous studies which attempted to extend, calibrate or validate various aspects of the TRANSIMS model. However, the majority of those studies, with the notable exception of the Portland, Oregon effort *(3)*, have focused on small or hypothetical networks. A brief overview of those studies is provided below.

Kikuchi and Pilko *(4)* describe a feasibility study for evaluating the performance and application feasibility of TRANSIMS in Delaware using an early version of the TRANSIMS model. Kim and Rilett *(5)* describe a methodology for calibrating micro-simulation models, and illustrate its application on both the CORSIM and TRANSIMS models. The test network used consisted of a 23-km section of Interstate 10 in Houston, Texas. Rilett and Kim *(6)* also assess the accuracy of TRANSIMS in modeling diamond interchange networks against both empirical observations and CORSIM results. Jeihani et al. *(7)* develop a new heuristic algorithm for determining dynamic user equilibria and apply the algorithm to a subnetwork of the Portland, Oregon model and to the Blacksburg, Virginia network. Given the scope of that work, however, no detailed effort is made to compare the results to field measurements. Dixon et al. *(8)*, after developing a traffic data extractor tool, compared TRANSIMS delay estimates for signalized and unsignalized intersections to delay values obtained from the field and estimates from the Highway Capacity Software (HCS). They conclude that TRANSIMS performed very well for signalized intersections, but tended to overestimate the delay for unsignalized intersections. Finally, Lee and Hobeika *(9)* describe an extension of the TRANSIMS model to allow for dynamic value pricing, and illustrate the approach on a hypothetical network.

CCMPO TRANSIMS Model Implementation

Network Development

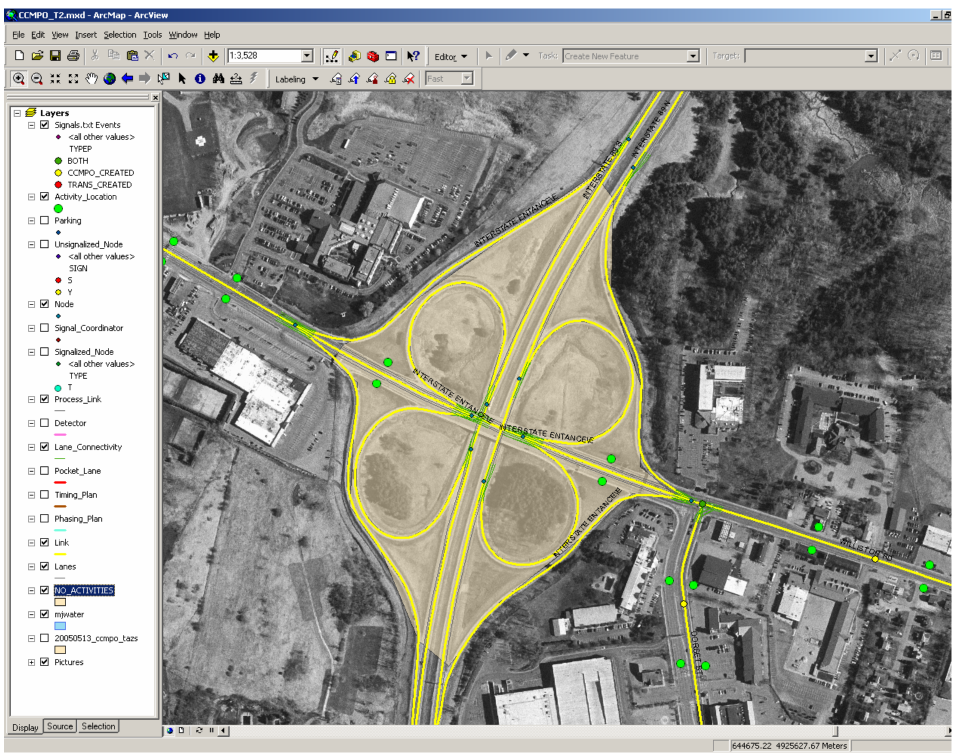
The current study had access to a calibrated microscopic traffic simulation model of Chittenden County which had been previously developed by one of the authors using PARAMICS *(10)*. Given this, the initial plan was to convert the PARAMICS model for use in TRANSIMS, and, in fact, a computer program was written that successfully generated a TRANSIMS network from a PARAMICS network. However, the authors later decided to move away from this approach, in an attempt to maintain connection between the four-step model and the Track 1 TRANSIMS model. With this connection, it was hoped that the CCMPO would be able to run the new model with either an aggregate assignment (four-step model) or a disaggregate assignment-simulation approach (TRANSIMS).

The FHWA-sponsored efforts of developing and testing the TRANSIMS over the course of the last 10 or 15 years, have resulted in the development of several utility programs or tools that can facilitate the deployment of TRANSIMS. Among those programs are routines for translating multi-modal link-node databases for use in TRANSIMS and for estimating traffic control characteristics, called TransimsNet. The approach taken to build the Chittenden County TRANSIMS network, therefore, was to start with the four-step network, apply TransimsNet, and then enhance the network integrity manually during calibration. The following paragraphs briefly describe both the automated and subsequent manual steps taken to build the TRANSIMS network.

Activity locations (i.e. the points where trips start and end) were built using TransimsNet. This program creates activity locations along every block face separated by (n) meters. In this study, the authors specified a minimum block length of 30 meters and that no more than 3 activity locations should be assigned to a block face. This process worked very well but had two problems which needed to be corrected. The first was that in the more rural areas of the County, there were traffic analysis zones (TAZs) in the four-step model which were not associated with activity locations. This occurred in instances where the TAZ represented open land with very little road frontage. To correct this, we used an ArcMap overlay of the TAZs to determine the associated activity locations. Those TAZs that remained unassociated were then given activity locations on the nearest appropriate road.

The second challenge with automated activity locations occurred where there is obviously not loading points; for example, in the middle of interchanges such as shown in Figure 1. Rather than manually remove these activity locations, the authors built a polygon layer representing the areas where this occurred and then applied a GIS rule for automatically removing these locations. This allowed for importing a new 4-step network and automatically generating activity locations.

Figure 1. Example of Activity Locations in Interchanges



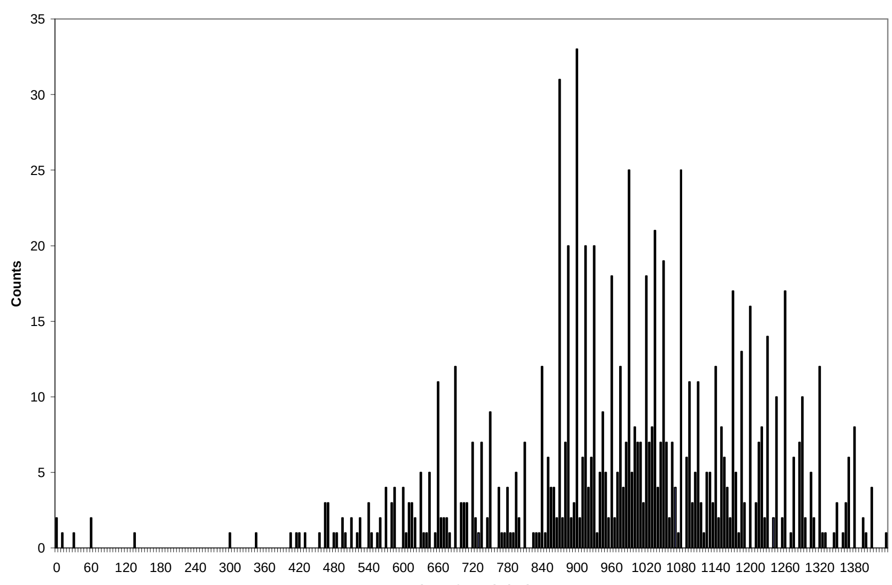
The remaining network parameters generated by TransimsNet included: (1) pocket lane locations; (2) lane connectivity definitions; and (3) signal timing. The study's initial goal was to refine TRANSIMS' default logic regarding these three parameters, with the rules available within TransimsNet, and then use the resulting network unchanged to provide for an easy link between the four-step model and the TRANSIMS model. This obviously would require very little work on the part of the CCMPO when modeling scenarios using the disaggregate TRANSIMS approach.

As it turned out, however, there were too many invariants in the network which required special coding in order to reach a satisfactory calibration. To correct these problems, the TRANSIMS model was run, and the areas where unexpected congestion was occurring were identified. Using aerial photography and ground validation, anomalies were manually corrected and documented. The most common of these corrections were signal timing changes where minor roads were receiving an undue amount of the total cycle. Other examples included adding and removing pocket lanes and adding or removing signals. The study also came across several places where a left turn phase had been automatically added to an intersection by the model's default logic, but which did not have dedicated left turn bays. For these scenarios, the protected left turn phase was manually changed into a permitted phase. The PARAMICS model previously mentioned, proved to be a good resource throughout the process.

Trip Table Matrix Development

With the TRANSIMS network coded, the second task was to develop the trip tables needed to run the TRANSIMS track 1 implementation. To develop the required trip tables for TRANSIMS, the first step was to extract the following PM vehicle trip tables from the CCMPO PM model, after the mode choice step: (1) Home origin; (2) Work to Home; (3) Non-work to Home; (4) Work to non-home; (5) Non-work to non-home; (6) Medium truck trips; (7) Heavy truck trips; and (8) External to external trips. The extracted PM trip tables were then expanded to the full day using time-of-day distribution factors determined from the CCMPO household trip diary survey performed in 1998. The results were also checked against NHTS data and permanent vehicle count data. Figure 2 shows the raw CCMPO household survey data for the diurnal distribution of home based other trips, as an example. Because household trip diary data can be "lumpy" (these are discrete observations that suggest a continuous relationship), the data were smoothed using a TRANSIMS smoothing tool before being used to grow the PM trips.

Figure 2. Example of CCMPO Raw Survey Data Diurnal Distribution



For external-to-external trips, given that the primary external-to-external flow through the region is on Interstate 89, the permanent traffic counters on I-89 were used to generate diurnal patterns for these trips. Finally, the diurnal distribution for non-home-based trips was used to generate daily truck traffic.

Model Structure

In order to appreciate how the Chittenden County TRANSIMS model was structured, a brief overview of TRANSIMS routing logic is required. TRANSIMS router builds travel paths or plans for either household activities (in case of a Track 2 implementation) or trips (Track 1 implementation). Given the origin and destination for a trip, its start time, and travel mode, the Router builds a minimum impedance path based on travel conditions at the specified time of day. Link travel times used for constructing the shortest or minimum impedance path are summarized for a user-specified time interval, typically around 15 minutes. Obviously, the most accurate method to estimate these time-dependent link travel times in TRANSIMS would be from the Microsimulator output. However, TRANSIMS also provides methods for estimating travel times using traditional volume-to-capacity relationships (such as the traditional Bureau of Public Roads (BPR) formula), similar to those used in a four-step planning model. These approximate travel times can be used to obtain reasonable initial travel paths, which can then be further refined using the Microsimulator. In addition to avoiding shocking the Microsimulator with excessive volumes that it cannot handle, this approach is also more computationally efficient, since the runtime for the Microsimulator is orders of magnitude that of the Router.

TRANSIMS routing is based on the concept of iterative feedback, according to which the travel times derived from a given iteration, are used to repeatedly adjust the travel paths until the paths and travel times stabilize. As opposed to traditional four-step planning models however, TRANSIMS, in moving from a given iteration to the next, does not re-route all travelers based on updated travel speeds. Instead, TRANSIMS reroutes only a subset of the travelers, in order to avoid oscillation effects, and then combines their travel planes with all the rest of the plans in a new simulation. The user has the option of selecting a subset of households as candidate for rerouting based on volume-to-capacity ratio thresholds, time of the day, select link or node, or travel time difference thresholds.

The study's implementation of TRANSIMS Router and Microsimulator involved running the following three steps: (1) Router stabilization; (2) Micro-simulator stabilization; and (3) user equilibrium. For router stabilization, only TRANSIMS Router was run and travel times were calculated based on the BPR formula (i.e. the Microsimulator was not run in the first step). Router stabilization involved running router for a total of 20 iterations. After each one of those first 10 iterations, a subset of travelers was selected for rerouting based on travel time differences from the previous iteration. For the next 10 iterations (i.e. iterations 11-20), selecting travelers for re-routing was based upon congestion in the sense that travelers on links having a volume-to-capacity ratio greater than 1.50 were selected as candidates for re-routing.

The second step, Microsimulator stabilization, used the Micro-simulator to more accurately estimate travel times. Estimated travel times were then used by Router and candidate travelers for re-routing were selected based on travel time differences from the previous iteration. The Microsimulator stabilization step involved running Router and Microsimulator for another 10 iterations. Finally, the third sub-process, user equilibrium, also involved using Micro-simulator to estimate travel times. However, in this step, all travelers are rerouted, instead of only a sample as in the previous two steps, before comparing travel times against the previous iteration. Once the travel times based on a complete rerouting of everyone are compared, only a subset is actually re-routed. This allows for approximating user equilibrium. User equilibrium also involved running another 10 iterations of Router and Microsimulator. In other words, the whole process involved a total of 40 iterations, the first 20 of which only used Router, whereas the second 20 used both Router and Microsimulator.

MODEL CALIBRATION

The model was calibrated to a mid weekday (Tuesday, Wednesday, or Thursday) in September for the year 2000 (the same period and year of calibration as the CCMPO four-step model). This was done by comparing the model results to actual field AM and PM counts that covered an extensive portion of the model boundary. Ground counts were adjusted to the model period but no effort was made to balance or account for inconsistencies. Performing this effort would have improved calibration statistics but not necessarily improved the reasonableness of the model. The primary calibration was performed against the PM peak hour while other hours were checked but no detailed adjustments were made to calibrate. The calibration exercise focused on the following items:

1. System-wide calibration comparisons to ground counts;
2. Use of three directional screen lines throughout the county;
3. Diurnal volume distribution for several critical links in the county;
4. Limited Turn-movement comparisons; and
5. Scenario testing.

The calibration steps largely included a continued refinement of the network including representation of signal timings, lane connectivity and pocket lanes. The authors also revisited the method of developing the diurnal trip pattern which results in the distribution of traffic throughout the hours of the day.

Regional Calibration Statistics

Table 2 shows the system-wide calibration statistics, categorized by facility type. As can be seen, the percent difference in volume ranged from -2.1% for minor arterials to -10.5% for major arterials. The corresponding average absolute percent error was lowest for freeways (7.9%) and highest for collectors (45.9%). The total relative error over the whole network was only -0.3%. These calibration statistics were quite comparable to the statistics for the four-step CCMPO model previously outlined in Table 1.

Table 2. Summary Statistics by Facility Type

Facility Type	No of Observations	Estimated Volume	Observed Volume	Percent Difference	Avg. Absolute % Error
Freeway	28	147585	143217	3.0%	7.9%
Major Arterial	262	120211	134270	-10.5%	29.1%
Minor Arterial	170	87890	89765	-2.1%	31.3%
Collector	376	119513	110136	8.5%	45.9%
Ramp	36	8310	7744	7.3%	26.8%

Screen Line Comparisons

Three screen lines, shown in Figure 3, were created to account for variations caused by parallel routes and to be used for model validation. Locations of the screen lines were chosen based on the most significant flows in and out of downtown Burlington and on the availability of count data. The results of the comparisons are shown in Table 3 below for the two directions for each screen line. As can be seen, with the exception of two directions the TRANSIMS results are very close to observed counts across the screen-lines (3% or less). The two comparisons that are worse are both around 23% error. Table 3 also compares the TRANSIMS results and the four-step model results for those three screen lines. The results of the two models appear to be quite close to one another.

Figure 3. Screen Lines Used for Calibration

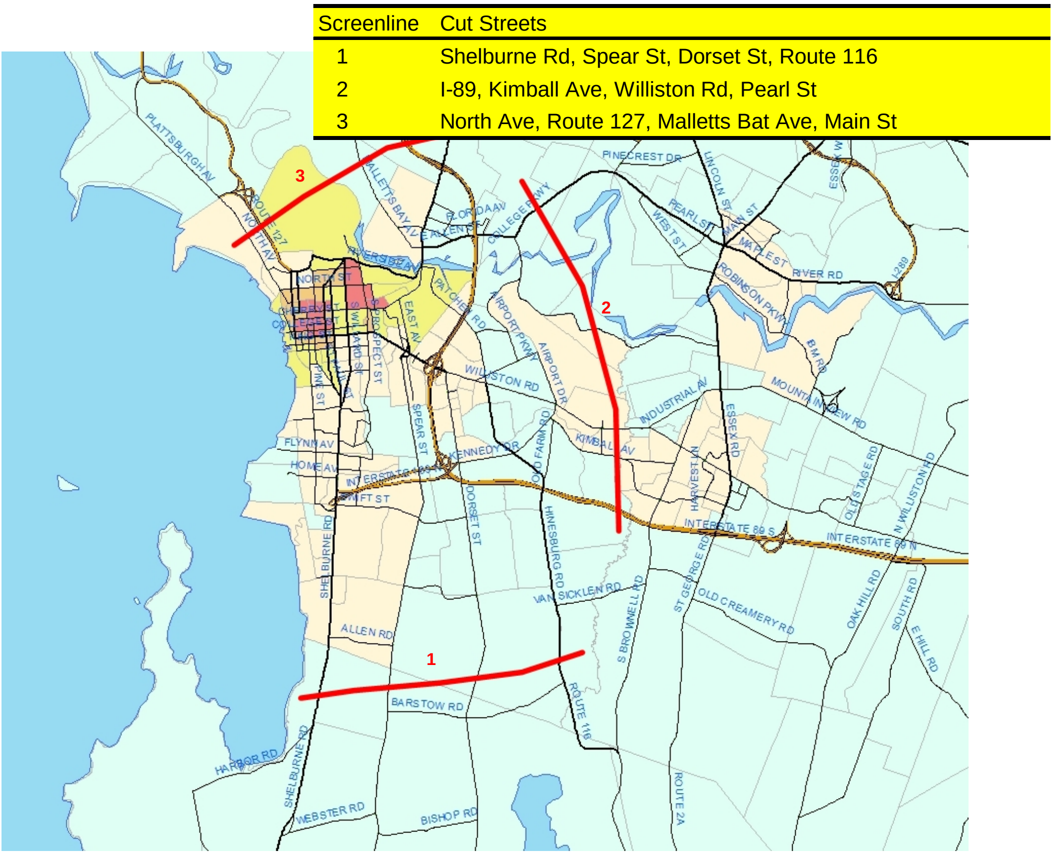


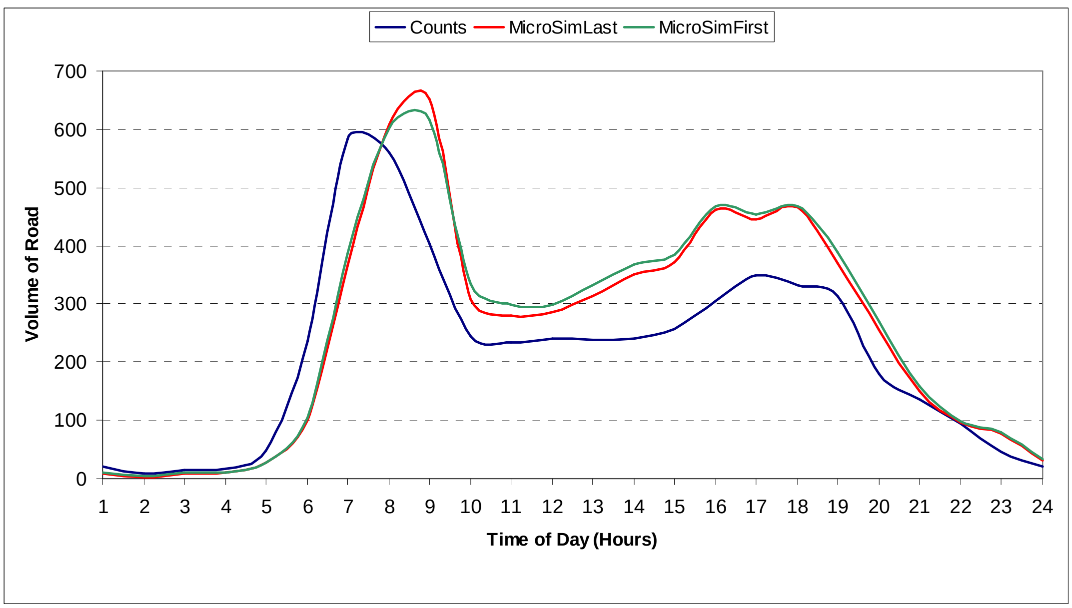
Table 3. Summary of Screen line Differences by Direction

Screen Line	Observed Volume	TRANSIMS		Four-step Model	
		Estimated	% Diff.	Estimated	% Diff
1. Shelburne Rd, Spear St.	1637	1675	2.3%	1657	1.2%
1. Shelburne Rd, Spear St.	2011	2460	22.3%	2445	21.6%
2. I-89N, Kimball Ave.	4120	5076	23.2%	4797	16.4%
2. I-89S, Kimball Ave.	5166	5063	-2.0%	4851	-6.1%
3. North Ave., Route 127	2128	2208	3.8%	2159	1.5%
3. North Ave., Route 127	3213	3191	-0.7%	3276	2.0%

Diurnal Volume Distribution

The third calibration check on the model results included comparisons of actual traffic counts and simulation results over a 24 hour period for select links across the Chittenden County network. For illustration, Figure 4 shows the results for one link. The blue line represents the actual traffic counts, the green line shows the results of the first iteration using the Microsimulator (i.e. iteration number 21 for the overall CCMPO TRANSIMS model), and the red line shows the last iteration using the Microsimulator (i.e. iteration number 40 for the CCMPO model). As can be seen, the model appears to do a fairly good job in replicating the diurnal distribution of traffic. However, there are still both horizontal and vertical shifts between the field and model counts which are somewhat significant, especially during peak periods. It should be noted that some of the differences in Figure 4 may be the result of inaccuracies at the trip table level. The researchers are currently investigating the use of heuristic search techniques (e.g. Genetic Algorithms) to adjust the trip table so as to improve the calibration results.

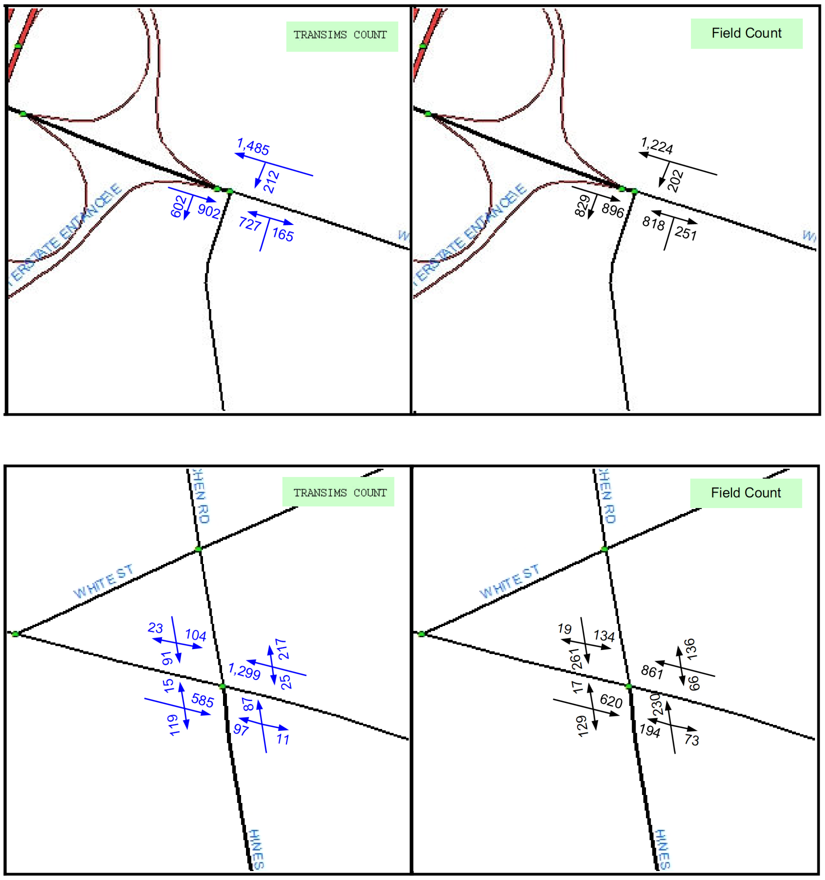
Figure 4. Main Street (Major Arterial)



Turning Movement Validation

Some limited validation of turning movement volumes was also conducted, by comparing the TRANSIMS model volumes against field counts. An example is shown in Figure 5 below which compares turning movements at two key intersections. The average error in turning movements for the volumes at those two intersections is about 21% which is extremely accurate considering no attempt was made to calibrate to the turning movement level.

Figure 5. Turning Movements at the Two Key Intersections on Route 2



Scenario Testing

The plausibility of the TRANSIMS model results was also evaluated in a scenario test that involved introducing a new interchange, called Exit 12B, currently under consideration by the CCMPO. For this scenario, the TRANSIMS model results were compared to those of the existing four-step model. Both models performed reasonably well, and yielded results that agreed with intuition. Specifically, the likely changes in volume patterns indicated by the two models were quite similar. There were differences, however, between the two models when it came to vehicle speeds, where the four-step planning model predicted larger speed changes as a result of the new interchange.

PRELIMINARY SENSITIVITY ANALYSIS

Two types of preliminary sensitivity analyses were performed in this study. The first focused on assessing the sensitivity of the model results to changes in the seed number. Several researchers have recently pointed out the significance of investigating the variability in transportation modeling results caused by random simulation error, and proposed methods to control it *(11,12)*. The second analysis involved assessing the impact of replacing a set of pre-timed signals with actuated controllers, and ascertaining whether the change in the model results agreed with intuition. There are obviously a whole set of other sensitivity analyses that could be performed, but the above two analyses are the ones the authors have performed so far.

Sensitivity to Variations in the Seed Number

As a stochastic model, TRANSIMS results are expected to change with variations in the random seed number used to control the probability distributions used within the model. However, a large variation in the model results with variations in the seed number is not desirable, since this would require the analyst to perform a large number of runs in order to gain confidence in the results, and would mean that the model is too sensitive to the seed number used.

In order to gauge the extent to which the TRANSIMS model results varied with the seed number, the study performed 5 different runs with 5 different seed numbers, and the variation in the model results (in terms of traffic volumes and average speeds) along a total of 10 links on the network was examined. The average value of the coefficient of variation (C_v) for each link hourly volume, defined as the ratio of the standard deviation of the volume across the five runs to the mean, was calculated for each hour in the day. The results are shown in Table 4, which lists the average, minimum and maximum values (out of the 24 values calculated for each link) of the coefficient of variation. As can be seen from Table 4, there seems to be very little variations among the 5 different seed numbers. The average value for C_v ranged from 0 to 2.59%.

Table 4. Average, Minimum and Maximum Coefficient of Variation by Link

	AB Direction			BA Direction		
Link	**Avg. C_v**	**Min. C_v**	**Max. C_v**	**Avg. C_v**	**Min. C_v**	**Max. C_v**
Dorset St.	0.16%	0	1.75%	0.05%	0	0.12%
Shelburne Rd.	0.04%	0	0.15%	0.57%	0	2.5%
I89	0.09%	0	0.23%	0.05%	0	0.16%
North Ave.	0.06%	0	0.23%	0.11%	0	0.63%
Main St.	1.57%	0	13.6%	2.59%	0	6.78%
Route 15	0.06%	0	0.22%	0.04%	0	0.27%
Route 2	0.04%	0	0.06%	0	0	0
Route 7S	0.003%	0	0.08%	0.07%	0	0.19%
Route 7N	0.009%	0	0.07%	0	0	0

Sensitivity to the Use of Actuated versus Pre-timed Controllers

Owing to the lack of accurate information about the setting for the actuated controllers in the county, the base TRANSIMS model implemented in this study was developed assuming pre-timed controllers at all signalized intersections. This section investigates how travel times on the approach legs to an intersection would change when a pre-timed signal is replaced by an actuated controller, and whether the observed change intuitively agrees with what one would normally expect to happen. To conduct this test, a total of 15 key intersections around the County were selected. Those intersections were located along two of the major corridors in the region Road (Route 2) and Shelburne Road (Route 7). The signal timing plans for those 15 intersections were then changed from pre-timed to actuated, using the following parameters for the actuated controllers:

(1) a minimum green time of 4 seconds for exclusive left-turn phases;
(2) a minimum green time of 8 seconds for through phases;
(3) a unit extension of 3 seconds; and
(4) a maximum green equal to between 1.25 and 1.5 the pre-timed green

Intuitively, one also should expect actuated controllers to be more effective in reducing the delay for the side streets, versus the main road. This is precisely what the TRANSIMS results showed. For example, the coding of an actuated controller in TRANSIMS for one specific intersection in the Chittenden County model resulted in a reduction of around 15 seconds/vehicle for traffic on the side street for the hour between 7:00 and 8:00 pm (an off-peak hour was selected for this analysis because actuated controller are likely to be more effective in reducing the delay during off-peak periods). At the same time, travel times on the main street were reduced by 2.6 seconds/vehicle for one approach, and actually increased by 2.5 seconds/vehicle for the other approach. There were some minor changes in the traffic volumes on the intersection's approaches owing to the changes in travel times. These changes, however, were not significant for the majority of the cases tested.

CONCLUSIONS AND FUTURE RESEARCH

This paper has described an effort to implement and calibrate a TRANSIMS model for Chittenden County. The purpose was to demonstrate the feasibility of doing this while primarily depending upon readily available data, to illustrate how close the model results after calibration were to field counts, and to conduct some preliminary sensitivity analyses. Among the main conclusions of the study are:

1. TRANSIMS Track 1 structure and the tools currently available in the model can be used to develop and calibrate a reasonably working model with a relatively modest effort for a small to medium size MPO. Furthermore, this work can be performed within a reasonable budget by competent modelers with only limited TRANSIMS experience.
2. The CCMPO TRANSIMS model also illustrated that the Track 1 approach is stable both in its ability to converge during calibration, and in providing reasonable results that agree with intuition.
3. For medium-sized areas with little to no congestion (similar to Chittenden County), the model does not appear to be quite sensitive to variations in the seed number. This should increase confidence in the model's results.

However, at the time of writing this paper, there remained three impediments to the CCMPO adopting this tool for their internal policy use. These are:

1. The first impediment relates to the lack of a network editor, which would simplify tasks such as adding signals, making timing changes, and changing lane connectivity. Such a system would provide checks against user errors and would facilitate consistent changes in multiple files.
2. The TRANSIMS documentation is still not feature complete, although it is improving. During the course of this work, the authors ran into cases where columns in some of the input and output files from TRANSIMS did not appear to be properly described in the

documentation. Moreover, it appeared that some of the model's available functionalities were known only to the developers.

3. A third impediment to the wide-scale adoption of TRANSIMS at the moment involves the challenges of visualizing the results from the Micro-simulator. At the time of writing the paper, TRANSIMS lacked an open source visualizer that users can use for a visual animation of how traffic flows over the network.

The FHWA is well aware of these challenges and is working actively to remedy them. Fortunately, now that the core of the TRANSIMS Track 1 system is active and stable, these appear to be relatively simple issues.

The research team is currently working on a Track 2 TRANSIMS implementation for Chittenden County. This would include implementing the population synthesizer and activity generator modules. Once completed, the researchers plan to compare the results from the two implementations to see how the performance of the model differs.

ACKNOWLDGEMENTS
Funding for this work has been provided by a grant from FHWA for the test deployment of TRANSIMS, and by the U.S. DOT through the University of Vermont Transportation Research Center. The authors would like to thank Brian Gardner and Supin Yoder of FHWA for their support and insightful comments throughout the project.

REFERENCES

1. Los Alamos National Lab. *TRANSIMS: Transportation Analysis Simulation System.* Version 3.0. Report LA-UR-00-1724. Los Alamos, New Mexico, 2004.

2. Wachs, M., L.L. Cove, T.B. Dean, G.B. Dresser, R.W. Eash, R.A. Johnson, E.J. Miller, M.R. Morris, R.H. Pratt, C.L. Purris, G. Rousseau, M.J. Tischer, and R.E. Wallker. Metropolitan Travel Forecasting: Current Practice and Future Direction. *Transportation Research Board Special Report 288,* Transportation Research Board of the National Academies, Washington, D.C., 2007.

3. DMJM Harris | AECOM. *Using Traditional Model Data as Input to TRANSMIS Micro-simulation.* Draft Technical Report prepared for the Federal Highway Administration. Available on-line at http://transims-opensource.net/. Last accessed on July 31, 2008.

4. Kikuchi, S. and P. Pilko. TRANSIMS Evaluation and Feasibility; Applications in Delaware. University of Delaware, Newark, 2004.

5. Kim, K-O. and L.R. Rilett. Simplex-based Calibration of Traffic Micro-simulation Models using ITS Data. *82nd Annual TRB Meeting Proceedings (on CD-ROM),* 2003.

6. Kim, K-O. and L.R. Rilett. Comparison of TRANSIMS and CORSIM Traffic Signal Simulation Modules. In *Transportation Research Record: Journal of the Transportation*

Research Board, No. 1748, TRB, National Research Council, Washington, D.C., 2001, pp. 18-25.

7. Jeihani, M., H.D. Sherali, and A.G. Hobeika. Computing Dynamic User Equilibria for Large-Scale Transportation Networks. *Transportation: Planning, Policy, Research and Practice,* Vol. 33(6), 2006, pp. 589-604.

8. Dixon, M., K. Chang, S. keecheril, and B. Orton. Applying the TRANSIMS Model Paradigm to the Simulation and Analysis of Transportation and Traffic Control Systems. Final Report, National Institute for Advanced Transportation Technology, 2007.

9. Lee, K-S. and A.G. Hobeika. Application of Dynamic Value Pricing through Enhancements to TRANSIMS. In *Transportation Research Record: Journal of the Transportation Research Board, No. 2003,* TRB, National Research Council, Washington, D.C., 2007, pp. 7-16.

10. Smith, M., A. W. Sadek and S. Huang. Large-scale Microscopic Simulation: Toward an Increased Resolution of Transportation Models. *ASCE Journal of Transportation Engineering*, Vol. 134(7), pp. 273-281, 2008.

11. Gibb, J. and J.L. Bowman. Convergence of an Activity-based Travel Model System to Equilibrium: Experimental Designs and Findings. *11th TRB National Transportation Planning and Applications Conference Proceedings,* Daytona Beach, Florida, 2007.

12. Castiglione, J., J. Freedman, and M. Bradley. Systematic Investigation of Variability due to Random Simulation Error in an Activity-based Micro-simulation Forecasting Model. *82nd Annual TRB Meeting Proceedings (on CD-ROM),* 2003.