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Scenario Analyses and Simulations Using TRANSIMS and UrbanSim for the Chittenden County of Vermont

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UVM Transportation Research Center

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Disclaimer

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1. Introduction

Although transportation serves as the foundation of our nation's economy and fulfills indispensable social functions critical to our quality of life, the current state of the nation's transportation system is unsettling. This makes the search for sustainable transportation systems, energy-efficient cities and travel demand reduction strategies a national priority. Further, transportation networks have been found to be a critical driver of land use patterns. So, the transportation system development strategies hinges on our understanding of the complexity inherent in the land-use-transportation system. In turn, a comprehensive understanding of this complex system demands accurate, well-calibrated models. The study using these models is important for evaluating alternative courses of actions and for providing information to the public policy makers. One of the key goals here is to improve the current state-of-practice modeling so that the new models are accurate enough to allow for evaluation of strategies that are of significant policy and planning.

Our research project is a component (Part A) of the Signature Research Project #1, sponsored by the Transportation Research Center (TRC) at the University of Vermont (UVM). The title of the Signature Project #1 is "Integrated Land-use, Transportation and Environmental Modeling: Complex Systems Approaches and Advanced Policy Applications" and the long term objective is to develop, evaluate, calibrate, and validate an integrated framework of agent-based land use model, UrbanSim[1-3], and a transportation model, TRANSIMS[4], for Chittenden County, Vermont. The objective of our component is to test the sensitivity of the models to the level of model complexity through comparative variation in different dynamic processes, submodels, and variables, and to assess how the appropriate level of complexity varies in practical applications. Both TRANSIMS and UrbanSim models are studied and they are described in detail in this report.

It has long been recognized that the traditional four-step travel demand model is not robust enough to analyze adequately many of the issues facing transportation planners. Since 1992, the federal government has sponsored the development of the Transportation Analysis and Simulation System (TRANSIMS) as the next generation of travel modeling, microsimulation and air quality analysis tools. Through employing an agent-based modeling approach which allows for simulating and tracking travel on a person-by-person and second-by-second basis, TRANSIMS is designed to provide transportation planners with increased police sensitivity, more accurate emission estimates, and powerful visualization capabilities[4]. TRANSIMS outputs detailed data on travel, congestion, and emissions; information that are increasingly important to investment decisions and policy setting. Because TRANSIMS tracks travel activities by individuals, the benefit and impact on different geographies and travel markets can be evaluated as well. Furthermore, TRANSIMS has the capability to evaluate highly congested scenarios and operational changes on highways and transit systems.

TRANSIMS has been shown to represent a significant shift in the state of the practice[5]. Converting the existing input files for four-step model is a reasonable first step in the development of a fully functional TRANSIMS planning network and traffic demand. The transportation planning community will need to spend significant amount of human and capital resources preparing for the transition. Some insight into these transitional issues can be provided on the basis of lessons learned from research on actual calibrated transportation networks. Recently, the Federal Highway Administration (FHWA) has made some 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 the recipient of one of those grants. Subsequently, Lawe et al. [6] implemented and calibrated a TRANSIMS model for Chittenden County. They also conducted preliminary sensitivity analyses 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.

UrbanSim[1-3], on the other hand, is a land use model that simulates urban growth for a region based on externally derived estimates of population and employment growth. Using a series of complex algorithms, this expected growth is spatially allocated across the landscape. The landscape is divided into grid cells of a user-defined size, and each simulated development event is assigned to one of those cells based on factors like accessibility, site constraints, and zoning. UrbanSim has been applied to metropolitan areas in Washington, Oregon, Hawaii, and Utah.

A recent review of land use models found UrbanSim to be an excellent choice for integrated land use and transportation modeling[7]. While almost all other urban growth models rely on aggregate cross-sectional equilibrium predictive approaches, UrbanSim is an agent-based behavioral simulation model that operates under dynamic disequilibrium, which allows for more realistic modeling of economic behavior. Other urban growth models simplify reality by assuming agents are price-takers, markets are perfectly competitive and resources are perfectly mobile. UrbanSim operates in an iterative fashion, in which supply-demand imbalances are addressed incrementally in each time period but are never fully satisfied, as they would be in a model assuming full equilibrium. Because of its dynamic nature, UrbanSim can endogenize factors that other models take as exogenous, such as location of employment and the price of land and buildings. Model features include the ability to simulate the mobility and location choices of households and businesses, developer choices for quantity, location and type of development, fluxes and short-term imbalances in supply and demand at explicit locations, and housing price adjustments as a function of those imbalances. Finally, the model also allows for prediction of land market responses to policy alternatives.

In our research, the calibrated TRANSIMS is used to study in more detail the transportation network of Chittenden County, Vermont. Both temporal and spatial analyses of the TRANSIMS simulation will be conducted. Then, comparisons between observation and TRANSIMS simulation at test sites will be carried out. Finally, more extensive scenario experiments will be implemented through running TRANSIMS for a series of cases with different model parameters and traffic demand.

In addition, preliminary scenario analysis of UrbanSim for Chittenden County (without travel model) has been conducted. In collaboration with Austin Troy’s group at the Rubenstein School of Environment and Natural Resources, preliminary results about using Bayesian melding method for the calibration of UrbanSim for Chittenden County have been obtained.

2. Research Methodology

2.1. Scenario Analysis of TRANSIMS and UrbanSim

In order to make the best attainable prediction of the future state of the land use and transportation in Chittenden County, one might choose to initialize the most sophisticated state-of-the-art model with the best available estimate of the current state. However, initial state and model parameters are always "imperfect" due to many factors such as measurement error, sample error and uncertainty. Therefore, the predicted state is never the true state one is predicting. If one component in the initial state is missing, some basic feature(s) in the predicted state might be missing. This can be used for a scenario analysis for our model. Using systematical changes in initial state and/or model parameters, which could represent some adjustment of specific processes in the model, we analyze model predictions to gain some insight into the relative importance of these processes. The study also allows us for a better understanding of the sensitivity of the system to uncertainty.

In particular, by means of the designed scenario study we test the sensitivity of the model outputs to the level of model complexity through comparative variation in different dynamic processes, submodels, and variables. For example, TRANSIMS' activity generator, router and micro-simulator all have several parameters whose impact on the model's results need to be investigated. We carry out numerical experiments with different distributions of a subset of these parameters.

2.2 Calibration of UrbanSim using Bayesian melding

We use Bayesian melding method to calibrate UrbanSim. Bayesian melding is a technique for assessing uncertainties in simulation models. It combines all the available evidence about model inputs and model outputs in a coherent Bayesian way, and can be used in validation/calibration of simulation models. For example, to calibrate a parameter in a model, a prior probability distribution of the parameter may be assumed; and sample values of the parameter can be chosen using Monte Carlo sampling method, then simulations will be carried out for all the parameter values. After estimation of the likelihood using observation data and the simulation results, Bayes' theorem will be used to obtain the posterior distribution of the parameter. The resulting posterior distribution can be considered as a calibration to the prior distribution.

3. Results

3.1 Simulation Results With TRANSIMS

Background

As described by Lawe et al. [6], Chittenden County area encompasses a rapidly growing urban area. It contains Burlington, the largest city in Vermont, and 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 simulation tool used in this paper is a "Track 1" TRANSIMS implementation for Chittenden County, implemented and calibrated by Lawe et al. [6]. Here "Track 1" means implementing only TRANSIMS's Router and Microsimulator, using Origin-Destination (O-D) matrices, for a given area. Transportation network of Chittenden County, prepared for the calibrated TRANSIMS simulation, is briefly illustrated in Figure 3-1, where the term "activity location" represents a place where a traveler's activities can take place, the term "node" denotes a physical location in the TRANSIMS network, such as an intersection, activity location, bus stop, and the term "link" is defined as a unidirectional connection between a pair of nodes[8]. The whole simulation area shown in Figure 3-1 has 535 nodes and 779 links, and is divided into 367 subregions, with total 431406 trips assigned between the subregions.

TRANSIMS has been implemented at Vermont Advanced Computing Center (VACC) located in Farrell Hall at the UVM's Trinity Campus, and is used to study the transportation network of Chittenden County, Vermont. With a set of specified daily transportation parameters obtained by averaging the observation data over a whole year, we build a base case, or case 0, on which different perturbation on parameter or on trip table are tested for the scenario study. It should be noted that in all of our simulations, all random number seed keys in the control files are given to a definite, non-zero constant. Such a non-zero setting for random number seed parameter ensures that the same parameter set gives exactly the same simulation result, and this is necessary for sensitivity study.

Results on the base case

Before investigating perturbation to the base case, we did a detailed analysis of simulation results using the base case parameters. The analysis shows that TRANSIMS is a powerful tool to model the performance of Chittenden County transportation system. It allows us to identify peak hours and congestion sites through conducting temporal and spatial analyses of the TRANSIMS simulation. As a first step of understanding the TRANSIMS model's temporal behavior, we carry out spatial average under the assumption that the spatial dependence of the observations can be omitted. Figure 3-2 illustrates temporal pattern of link speed and link density in the transportation network, averaged over all links. Link density is the average number of vehicles occupying the link during each second of the time increment divided by the number of lane meters. From Figure 3-2 it can be seen the average speed of the whole transportation system reaches its two minimums around 8:00am and 5:00pm. Correspondingly, link density hits its two maximums around the same time indicating that during the peak hours, vehicles move slowly on the roads. On the other hand, maximum speed corresponds to minimum link density occurs around 2:00am.

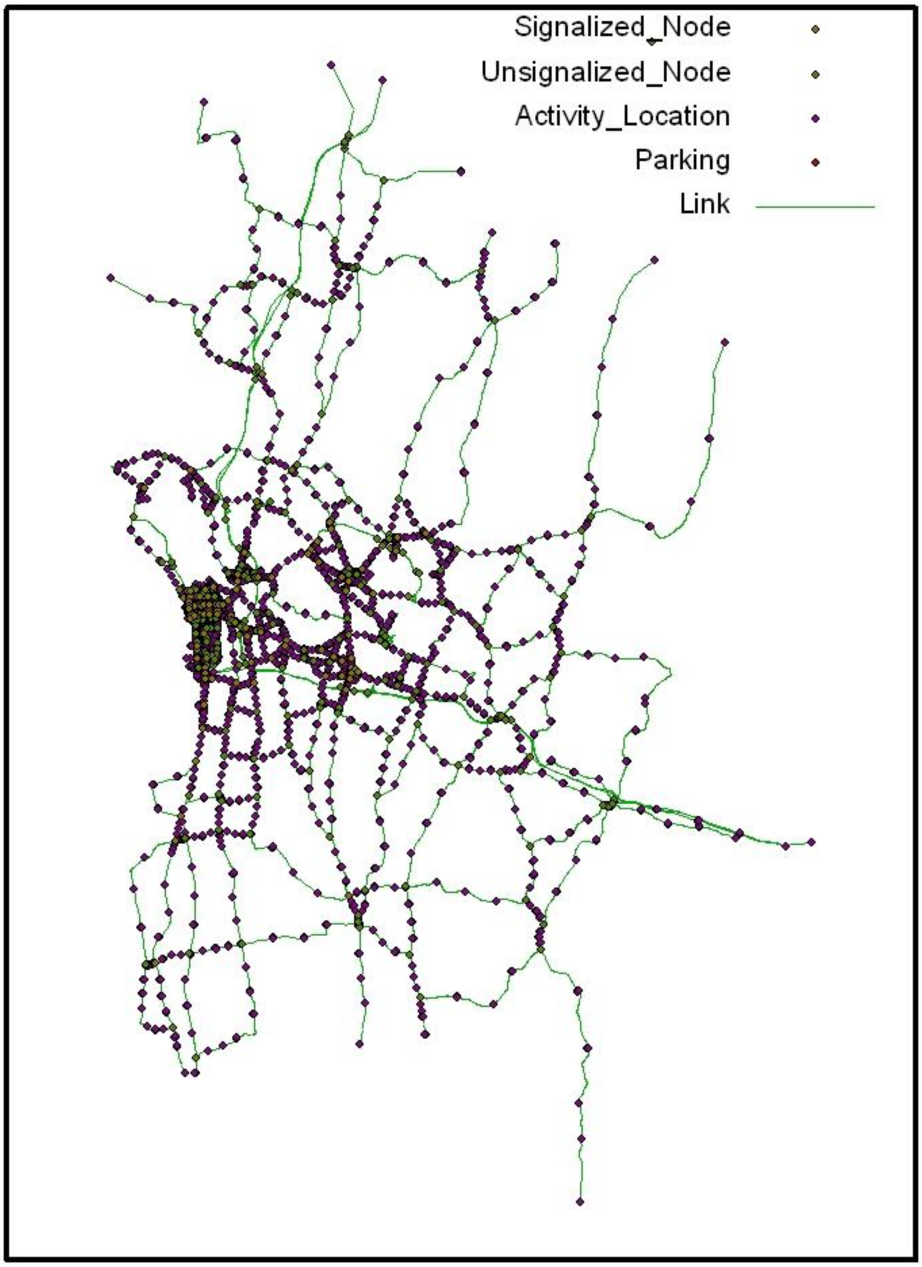


Figure 3-1. Transportation network of Chittenden County, Vermont

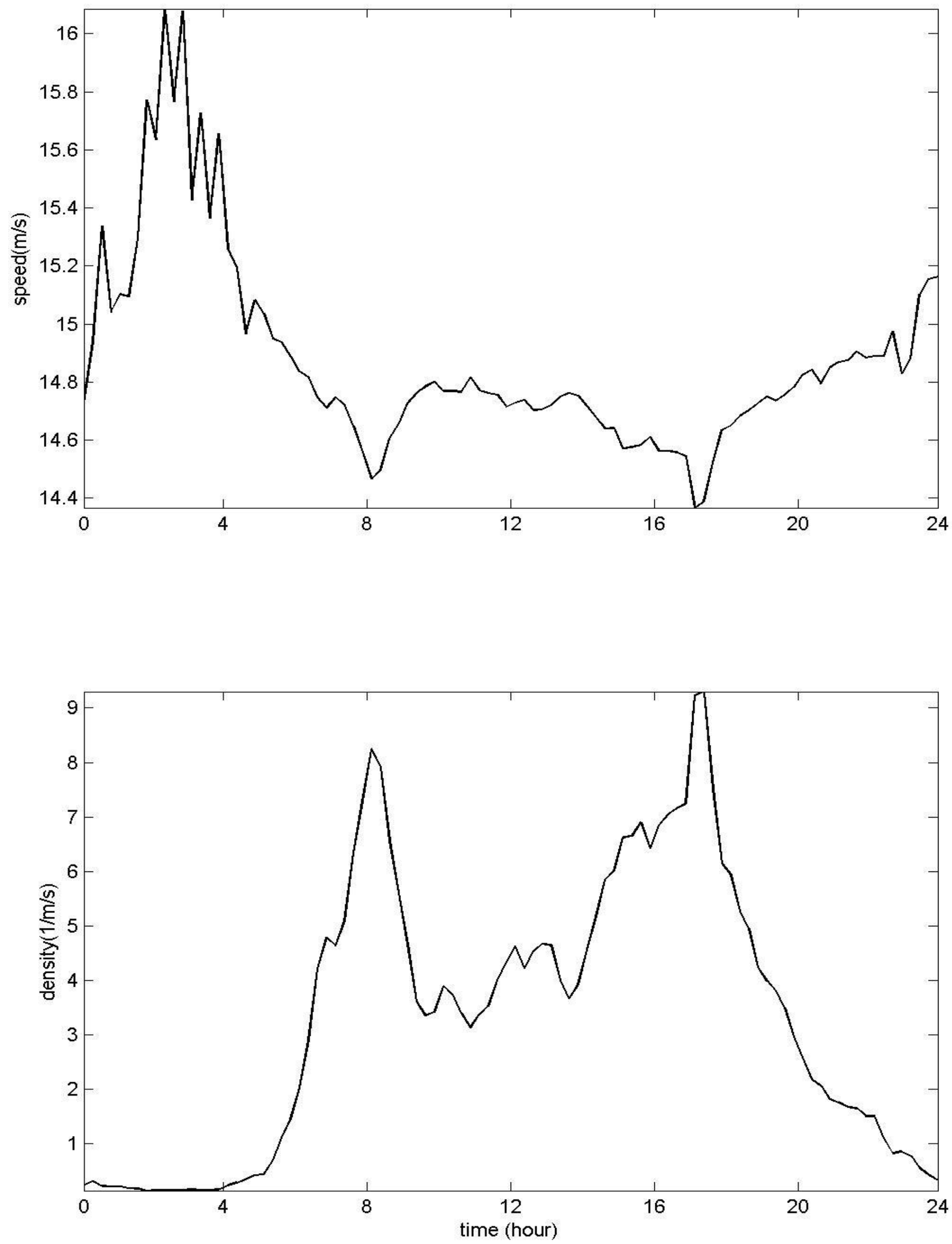


Figure 3-2. Speed and density spatially averaged over all links for the base case.

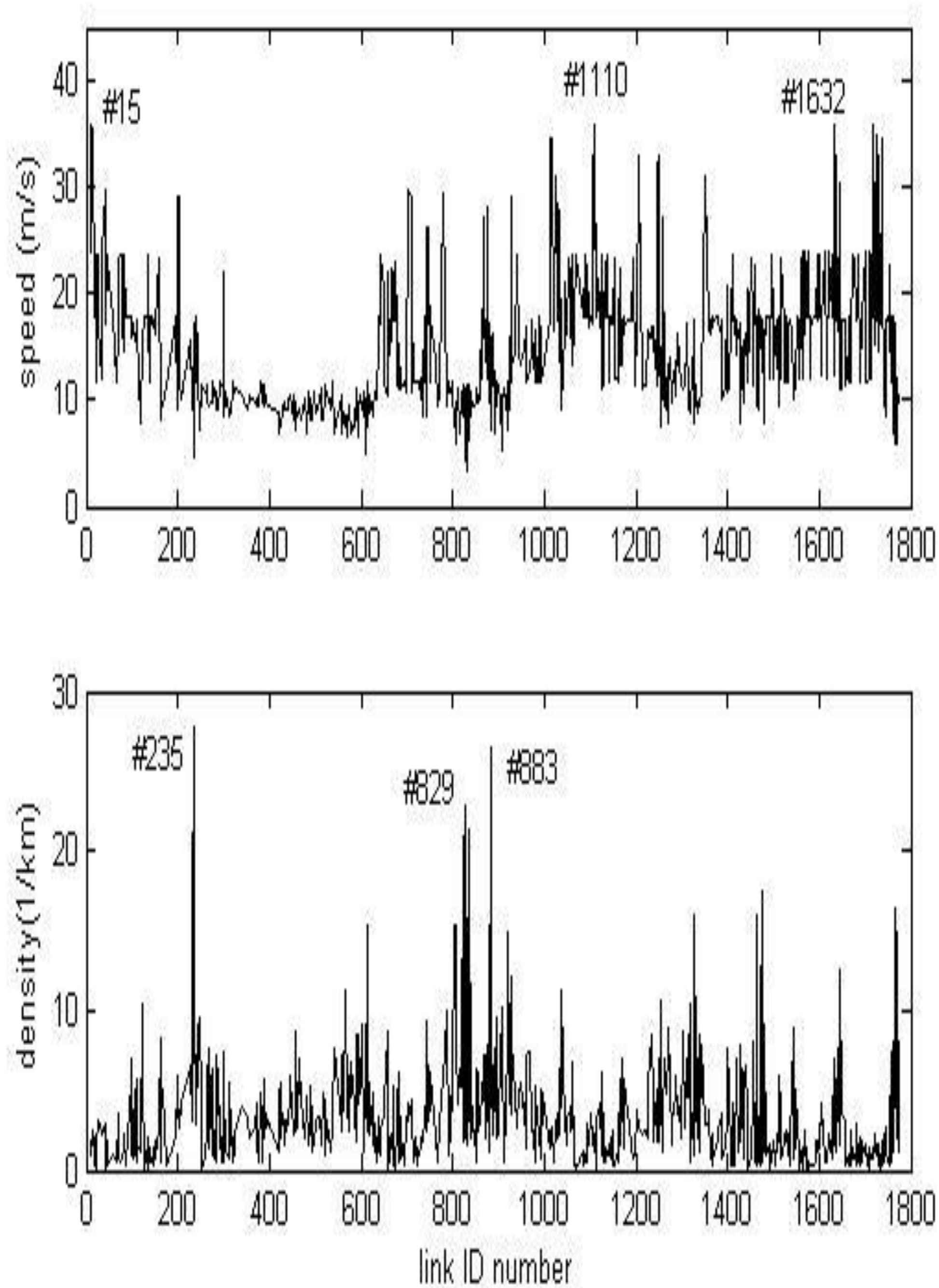


Figure 3-3. Speed and density temporally averaged over whole time for case 0.

In addition to analysis of temporal behavior, spatial distribution of the time averaged link speed and link density are shown in Figure 3-3. It can be seen from Figure 3-3, the links with link ID numbers between 300 to 600 form a cluster of low link speed, and the averaged link speed reaches its minimum value around 10 m/s at these links. Table 3-1is a part of the link table that contains all the data that specifies the characteristics of all the links considered. From Table 3-1 the links with ID number between 300 and 600 are found to be located in downtown Burlington. These links correspond to relatively lower average speed as expected. On the contrary, links with ID numbers between 1060 and 1050 are found to be mainly distributed on suburban regions such as Colchester, Williston, Jericho and Hinesburg, so vehicles run faster on these links, forming a cluster of high link speed. The link property is also identified as the main cause for many sharp peaks in the speed plot; they usually correspond to interstate freeways. For example, links with ID number 15, 1110 and 1632 are parts of Interstate 89, corresponding to three peaks in the speed plot. On the other hand, a sharp peak in the density plot corresponds to a place where heavy traffic is anticipated. For example, link with ID number 235 is a ramp close to the intersection of I-189 and Shelburne Road, and link with ID number 883 is a part of Williston Road. Both these links are well recognized as congestion sites.

Table 3-1. Part of the Link Table used in TRANSIMS for Chittenden County, Vermont.

LINK ID	STREET	NODE A	NODE B	LENGTH (m)	TYPE	FREE SPEED (m/s)
15	INTERSTATE 89 N	731	811	7514	FREEWAY	0
100	SHELBURNE RD	568	567	778.8	MAJOR	18
201	INTERSTATE 189 N	886	717	1641	FREEWAY	25
235	INTERSTATE 189 S	762	1214	51.2	RAMP	18
299	ST PAUL ST	513	895	204.3	MAJOR	13
340	S UNION ST	758	925	115.1	MAJOR	13
395	PEARL ST	905	904	129	MINOR	13
445	COLLEGE ST	755	371	128	COLLECTOR	13
500	ST PAUL ST	892	891	128	COLLECTOR	13
543	MAIN ST	378	377	276.6	MAJOR	13
599	ARCHIBALD ST	835	836	502.6	COLLECTOR	13
701	INTERSTATE 89 N	527	714	1194.7	FREEWAY	0
800	COLCHESTER AV	1209	944	80	MINOR	13
829	MAIN ST	381	380	100.3	MAJOR	16
900	RUSSELL ST	493	495	745	COLLECTOR	11
997	SEVERANCE RD	807	478	246.9	COLLECTOR	18
1054	PEARL ST	705	482	1611.9	MAJOR	20
1060	ROOSEVELT HWY	641	651	3443	MAJOR	22
1064	MILL POND RD	638	476	2575	COLLECTOR	16
1110	INTERSTATE 89 S	767	622	7643	FREEWAY	29
1198	PLEASANT ST	1152	453	554.8	COLLECTOR	11
1300	ROBINSON PKWY	450	447	1915	COLLECTOR	11
1400	MAIN ST	459	454	322	MAJOR	11
1500	OAK HILL RD	592	1003	515	COLLECTOR	16
1600	ROUTE 15	619	616	3041	MINOR	16
1632	INTERSTATE 89 N	729	1241	13628	FREEWAY	29
1701	ROUTE 7 N	674	1238	4940	MINOR	22

Comparison between model simulation and observation

To further demonstrate the capability of TRANSIMS as a simulation tool, comparison between the simulation results and observation data from Chittenden County Metropolitan Planning Organization (CCMPO) for two sites in Chittenden County is carried out.

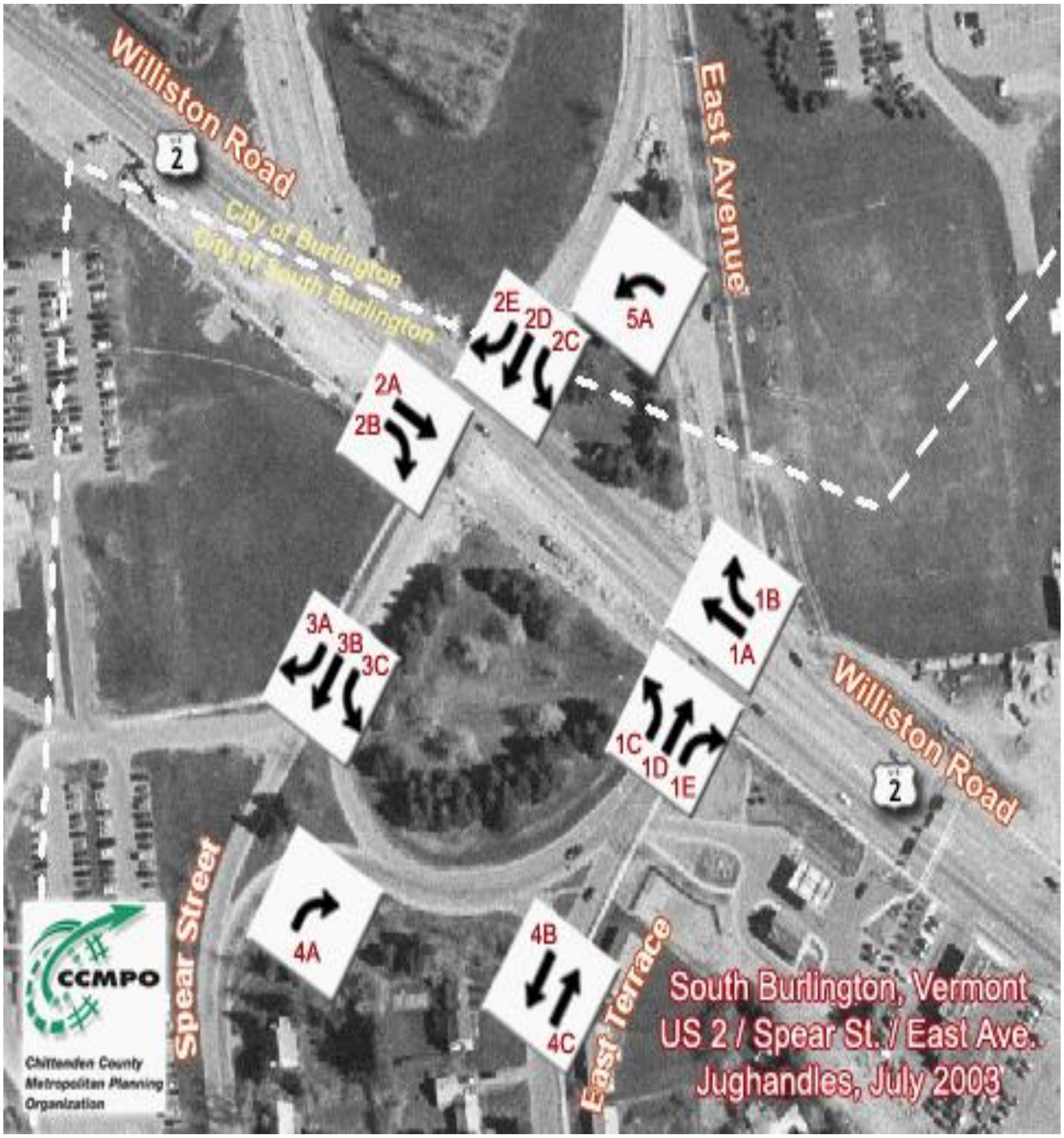


Figure 3-4. Photo of jughandels around the intersection of US 2 / Spear St. / East Ave, South Burlington, download from website of CCMPO.

One site is the jughandels around the intersection of US 2 / Spear St. / East Ave, South Burlington, as illustrated in Figure 3-4, a photo taken from the website of CCMPO (http://www.ccmpo.org/data/ct_7070_jh_2003, it should be noted that although the turning movement is highlighted in the downloaded photo, we actually do not discuss turning movement in this report.) CCMPO conducts traffic studies for this area. Note that link with ID number 829 in our TRANSIMS modeling, as marked in Figure 3-3, corresponds a section of US 2 from 1A to 2A in Figure 3-4. These comparison results are shown in Figure 3-5. Good agreement between observation and TRANSIMS simulation can be observed, although peak hours associated with the simulation occur a little later than the observed ones. Such difference might be explained by the fact that the simulation results is for average behavior over whole year, while observation data is for a typical summer day.

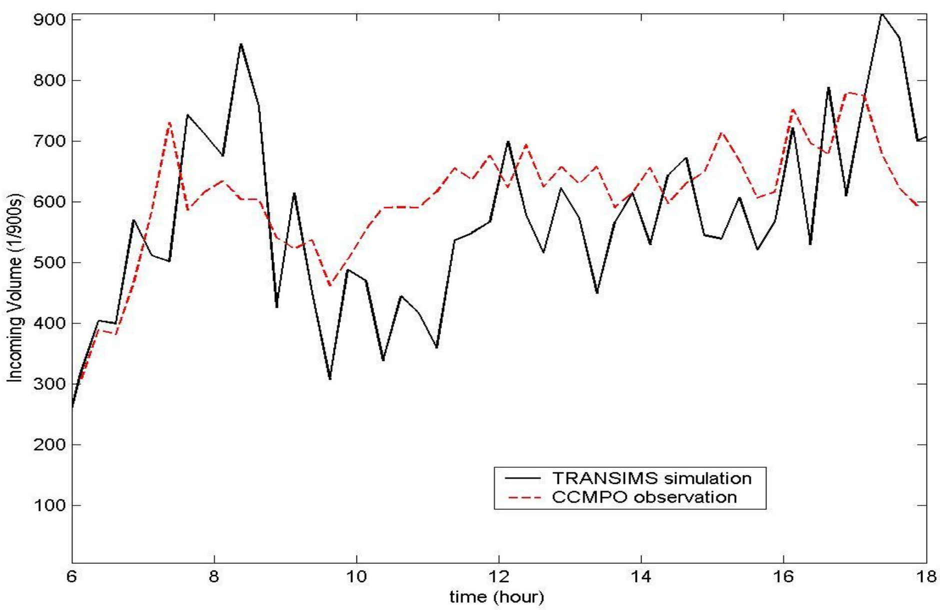


Figure 3-5. Observation by CCMPO on July 31, 2003 and TRANSIMS simulation for Link 829, at jughandels around the intersection of US 2 / Spear St. / East Ave, South Burlington.

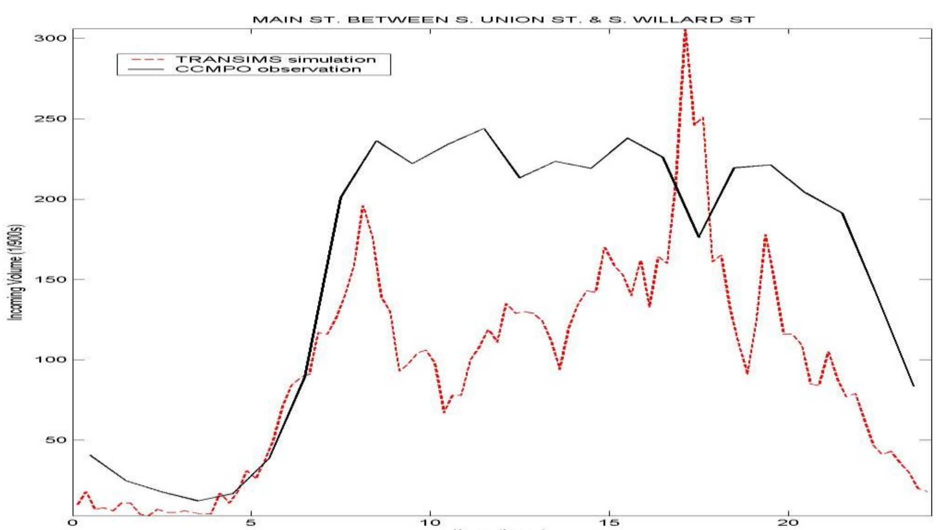


Figure 3-6: Observation by CCMPO on July 25, 2007 and TRANSIMS simulation for Link 543, a part of Main Street between South Union Street and South Williard Street, Burlington.

Figure 3-6 shows a comparison between simulation and observation for a part of Main Street between South Union Street and South Williard Street in Burlington. Again, the agreement is generally good. However, almost for all time, observation data for traffic volume per quarter of hour is a little higher than the simulation results. Such difference may be explained by the increase of transportation demand between 2000 and 2007. The input we used in our simulation is for the year of 2000, while the observation data from CCMPO is for 2007. Variation in transportation demand may have strong influence on performance of the transportation network. Larger trip demand in 2007 may lead to the observation data being higher than the simulation results.

To show more clearly the effect of increased traffic demand, we assumed a 1% annually increase of trip demand, and simulated the transportation network at a time 20 years after. Figure 3-7 gives a comparison between the base case and the future case, labeled as case 24. It can be seen from Figure 3-7 that using a non-improved transportation system to deal with increased future transportation demand will lead to lower transportation quality, with a lower average speed of about 0.5 and a higher link density of about 25, during the whole daytime (from about 7am to about 7pm).

Scenario study

We run TRANSIMS for a series of cases corresponding to different perturbation to the basic input data and parameters. A brief description of these cases is given in Table 3-2.

Table 3-2. Brief description of cases simulated with TRANSIMS in sensitivity studies, values in parentheses represent corresponding values of baseline case.

Case number	description
0	baseline case
1	1% of original-destination matrix is randomly perturbed
2	driver reaction time=0.5s (0.7s)
3	driver reaction time=1.0s (0.7s)
12	all traffic signals are pre-timed (base case for signal related tests)
13	11% of signals are actuated
14	all traffic signals are actuated
17	permission probability=25 (50)
18	permission probability=75 (50)
21	vehicle time value=10 (60)
23	vehicle time value and walk time value et al. = default values
24	20 years of 1% annually increase of trip demand
26	driver reaction time=0.5s, and all traffic signals are pre-timed
28	driver reaction time=0.5s, all traffic signals are actuated
30	driver reaction time=0.5s, permission probability=25, and all traffic signals are actuated

First, the effect of driver reaction time on the performance of the transportation system is investigated. As a first step of studying the TRANSIM model, we use the spatially averaged link speed and link density in this report to indicate the performance of the transportation network. Gap between vehicles is equal to driver reaction time multiplied by vehicle speed. Figure 3-8 shows the percentage difference of speed between cases with driver reaction time being 0.5s, 0.7s, and 1.0s. It can be seen in Figure 3-8 that reducing driver reaction time leads to increase of speed, but the effect is small.

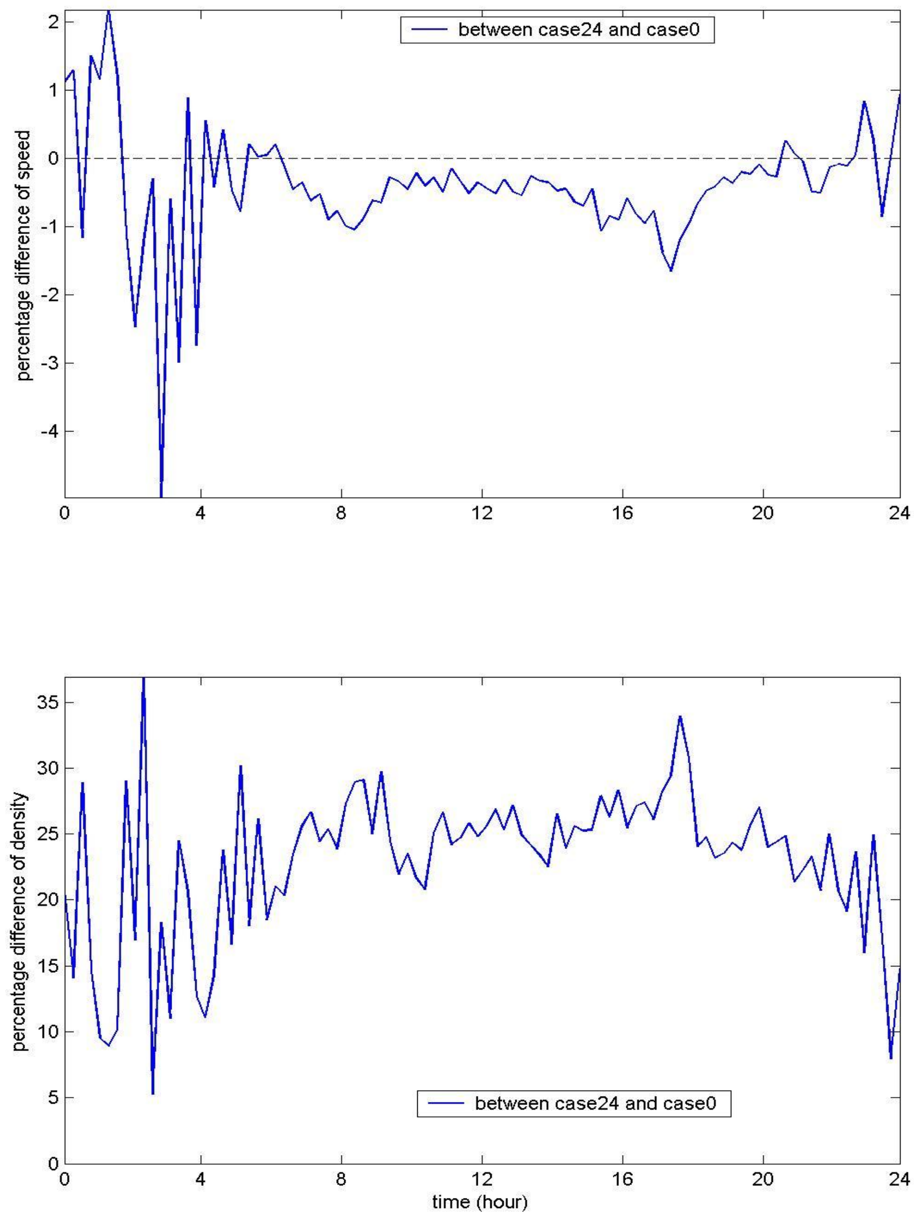


Figure 3-7: Percentage difference of spatially averaged speed and density between the base case and the future case (case 24). Case 24 is the same as the base case 0 except the traffic demand in the model is much larger.

Secondly, we model the transportation system with different permission probability values. The permission probability defines the likelihood that a vehicle will permit another vehicle to change lanes to the cell ahead when the traffic is stopped. Higher permission probability value means that the travelers are friendlier to each other. A driver being friendly to other travelers may spend more time on his/her own trip. However, as shown in Figure 3-9, changing permission probability value from 50 (for the base case) to 25 or 75 has little impact on the performance of the whole transportation system.

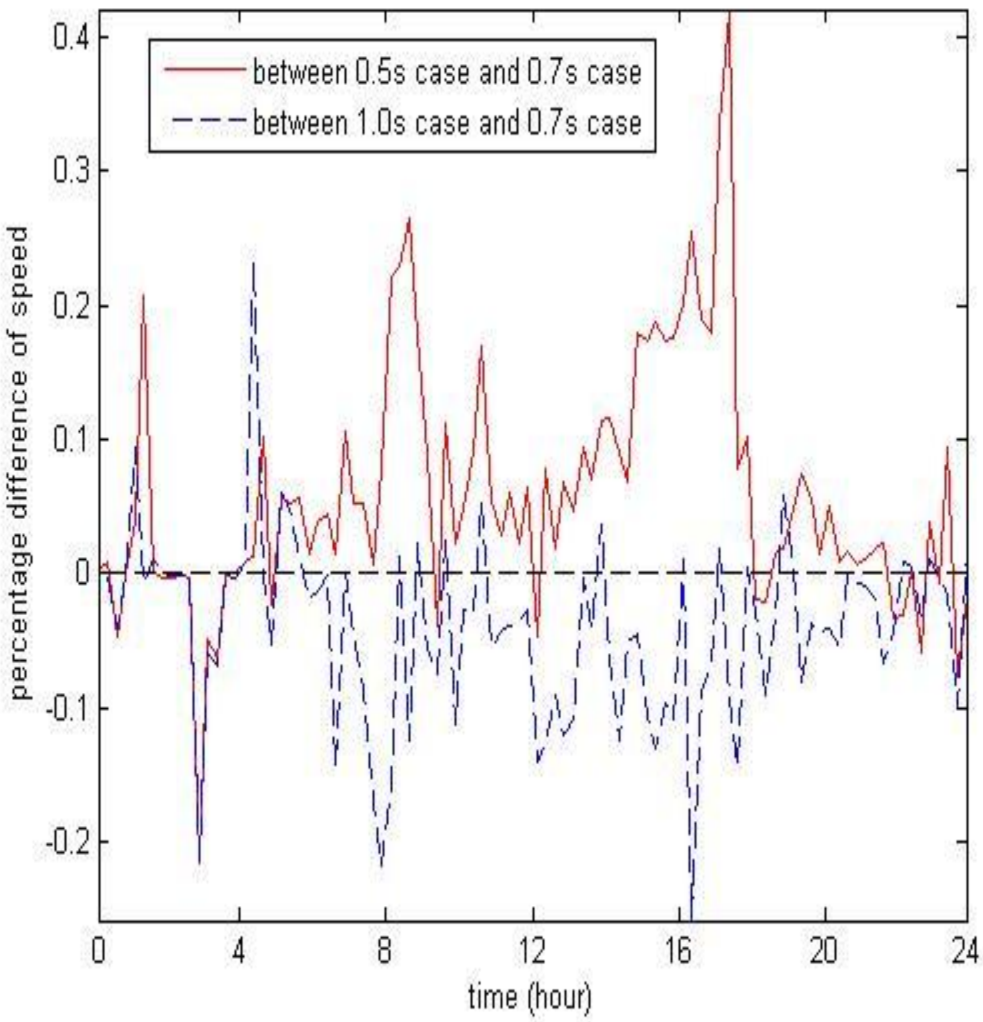


Figure 3-8. Percentage difference of spatially averaged speed between case 2, case 3 and the base case (case 0). Case 2, case 3 and case 0 are same but with driver reaction time given as 0.5s, 1.0s and 0.7s, respectively.

We now study the effect of impedance values on the transportation system. For travel planning in the Router module of TRANSIMS, a traveler is considered to choose a path that has the minimum impedance from a specified starting location to a specified destination. Here the impedance value for each link is determined by the user-defined combination of weighted walking time, waiting time, in-vehicle-travel time, transfer time, and cost. For example, the time spent walking will be assigned 10 impedance units per second, if the parameter walk time value is set as 10; time spent in automobiles will be valued at 60 impedance units per second, if the vehicle time value is chosen as 60, and a 20 impedance unit penalty will be added for each second spent in U turn, if the parameter U turn penalty is given as 20.

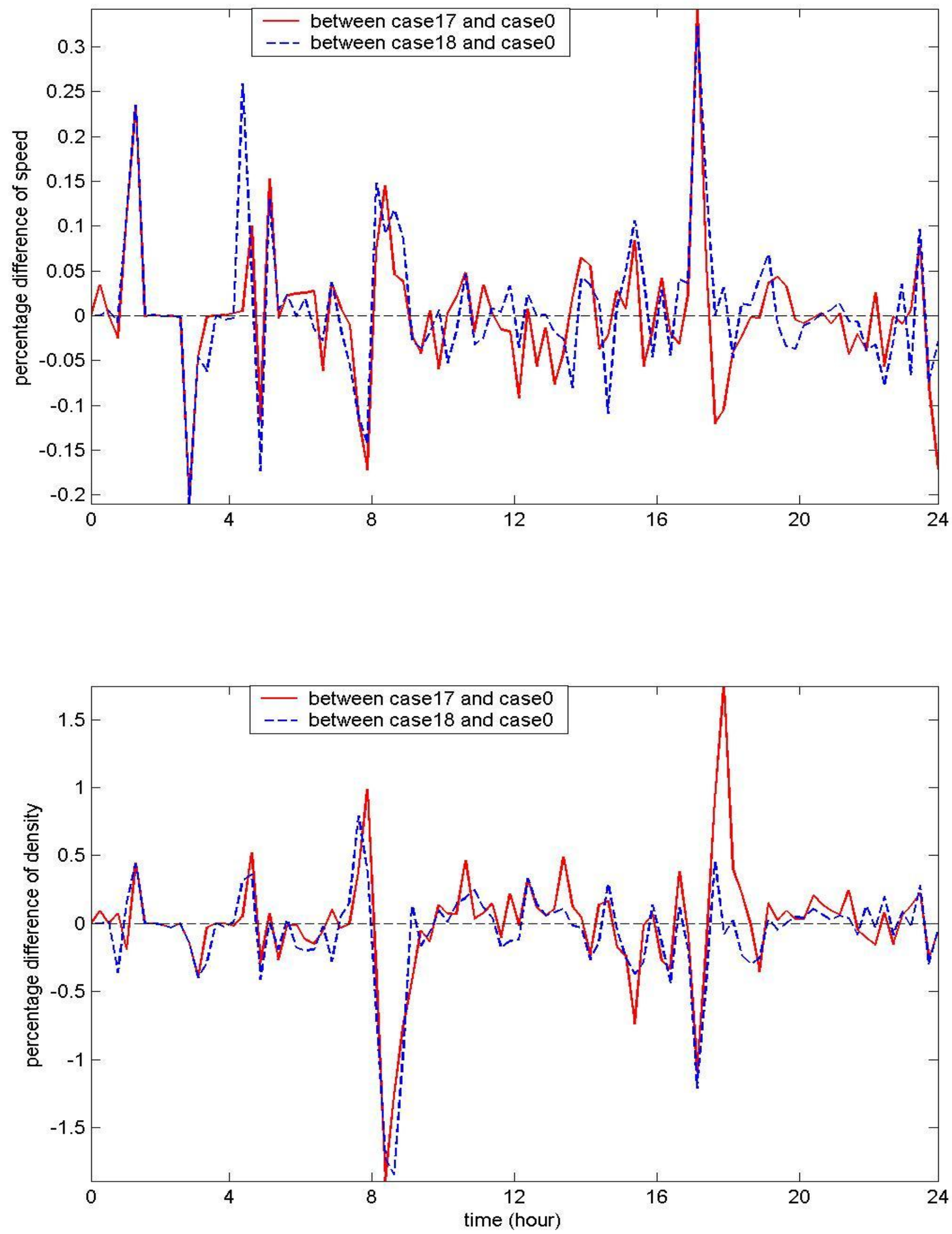


Figure 3-9. Percentage difference of spatially averaged speed and density between case 17, case 18 and the base case (case 0). Case 17, case 18 and case 0 are same but with Permission Probability given as 25, 75 and 50, respectively.

In the base case, we have following parameter setting: walk time value=1, bicycle time value=1, first wait value=1, transfer wait value=1, vehicle time value=60, distance value=1, transfer penalty=1, left turn penalty=15, right turn penalty=5 and U turn penalty = 20. Comparing with the default setting by TRANSIMS developers (walk time value=20, bicycle time value=15, first wait value=20, transfer wait value=20, vehicle time value=10, distance value=0, transfer penalty=0, left turn penalty=0, right turn penalty=0 and U turn penalty= 0), the relative significance of moving around with a car to walking and bicycling et al. is amplified about one hundred times. This means that reduction of the time spent in automobiles is much more desired in the base case than in the default case. Also, there are large penalty for left turn and U turn. We do scenario study through simulations using TRANSIMS for the cases of vehicle time value=10 (case 21) and default parameter setting (case 23). The comparison is shown in Figure 3-10. For case 21 with reduced vehicle time value, travelers pay less attention on reduction time spent in automobiles, and this leads to a decrease of about 0.25% in the average speed during the daytime. For case 23, where the limitation to left turn and U turn is removed, people have more freedom to drive their cars faster, leading to an increase of about 1% in the average speed and a decrease of about 0.5% in the link density during the daytime.

In addition, interesting results can be found from investigating the effect of actuated signal through running the transportation system with different number of actuated signalized nodes. Three cases are considered: case 12, all signalized nodes being timed; case 13, about 11% of all signalized nodes being actuated; and case 14, all signalized nodes being actuated. Simulation results for the three cases are illustrated in Figure 3-11.

It can be seen in Figure 3-11 that more actuated signal nodes results in higher average speed in morning and night time, but has no effect on (or even worsen) the transportation situation during the day time, especially around the peak hours. Only in early morning or late night, when there are not many vehicles on the road, actuated devices help drivers save waiting time at intersections. During peak hours, many vehicles are on the road and people are driving to an intersection from different directions. This results in a lot of conflicting demands to the actuated signal devices and, therefore, increases the possibility of congestion.

We also engage in the scenario analysis of the TRANSIMS model for multiple parameters. A number of simulations using TRANSIMS were carried out for transportation system with more than one parameter changed simultaneously. Figure 3-12 includes simulation results for the system with percentage of actuated traffic signal being changed from 0 to 100, and driver reaction time being changed from 0.7s to 0.5s; while Figure 3-13 includes simulation results for the system with percentage of actuated traffic signal being changed from 0 to 100, driver reaction time being changed from 0.75s to 0.5s, and permission probability being changed from 50 to 25.

Dominant effect of traffic signal type is observed again in Figure 3-12 and Figure 3-13, especially in morning and night times. Finally, we do more investigation on the effect of variation in trip demands by comparing the base case with the case that has 1% of Original Destination Matrix randomly perturbed (case 1). Figure 3-14 shows the simulation results. It can be seen in Figure 3-14 that 1% of variation on transportation demand leads to 5% variation in speed and 10% variation in volume. So variation in transportation demand has strong influence on performance of the transportation network.

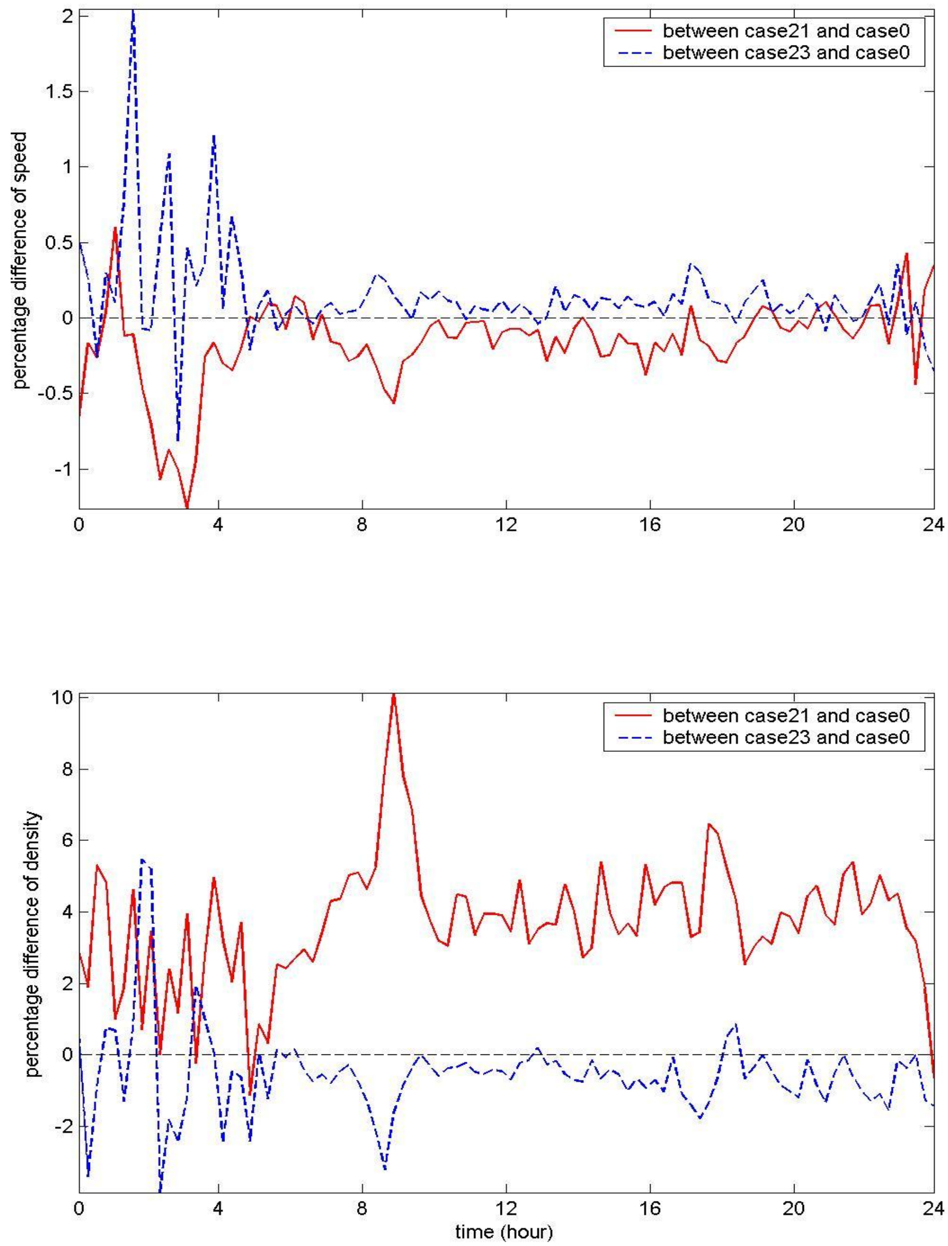


Figure 3-10: Percentage difference of spatially averaged speed and density between case 21, case 23 and the base case (case 0). Case 21 and case 0 are same but with vehicle time value given as 10 and 60, respectively. For case 23, parameters vehicle time value and walk time value et al. are given as default values.

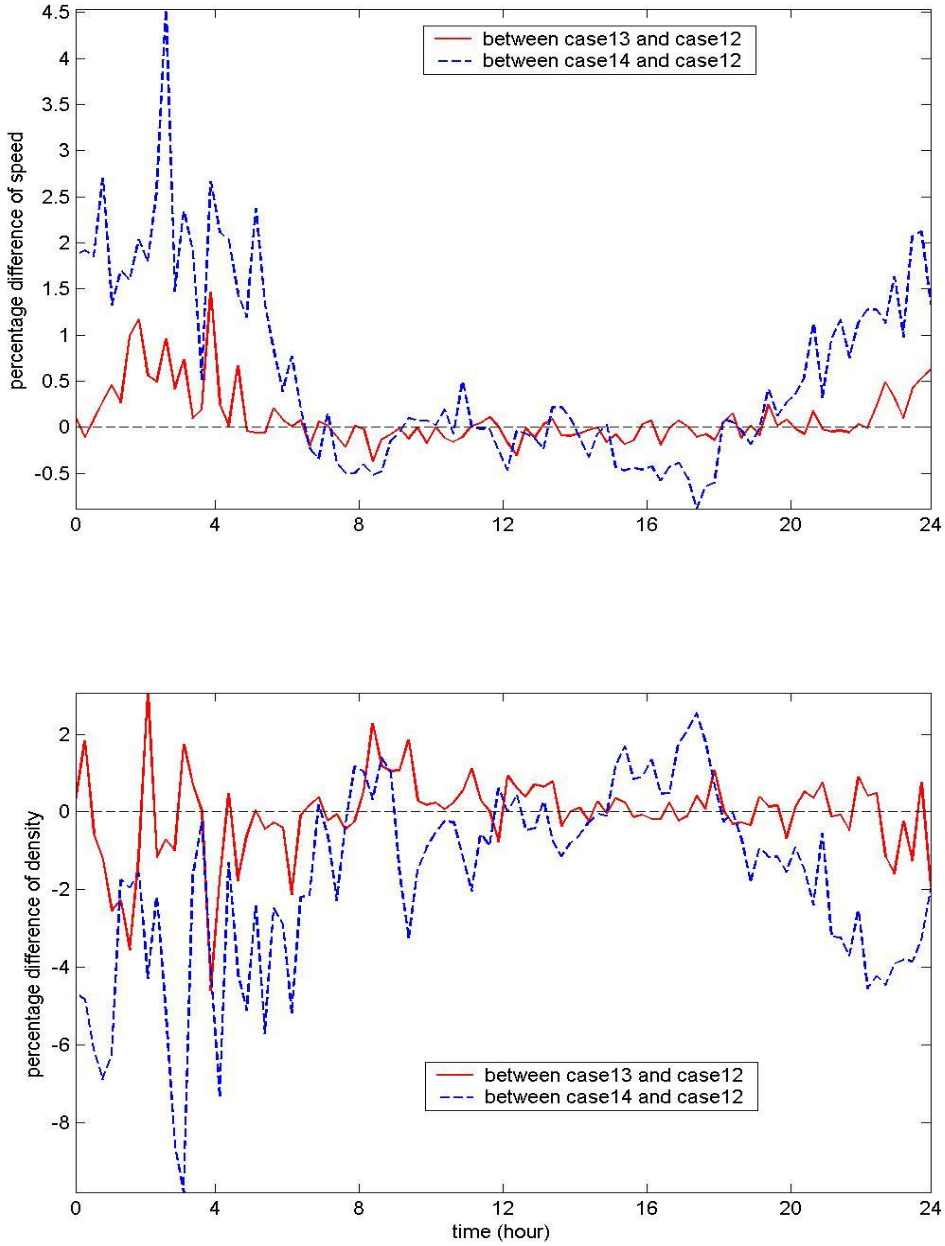


Figure 3-11. Percentage difference of spatially averaged speed and density between case 13, case 14 and case 12. Case 13, case 14 and case 12 are same but with percentage of actuated signalized nodes given as 11, 100 and 0, respectively.

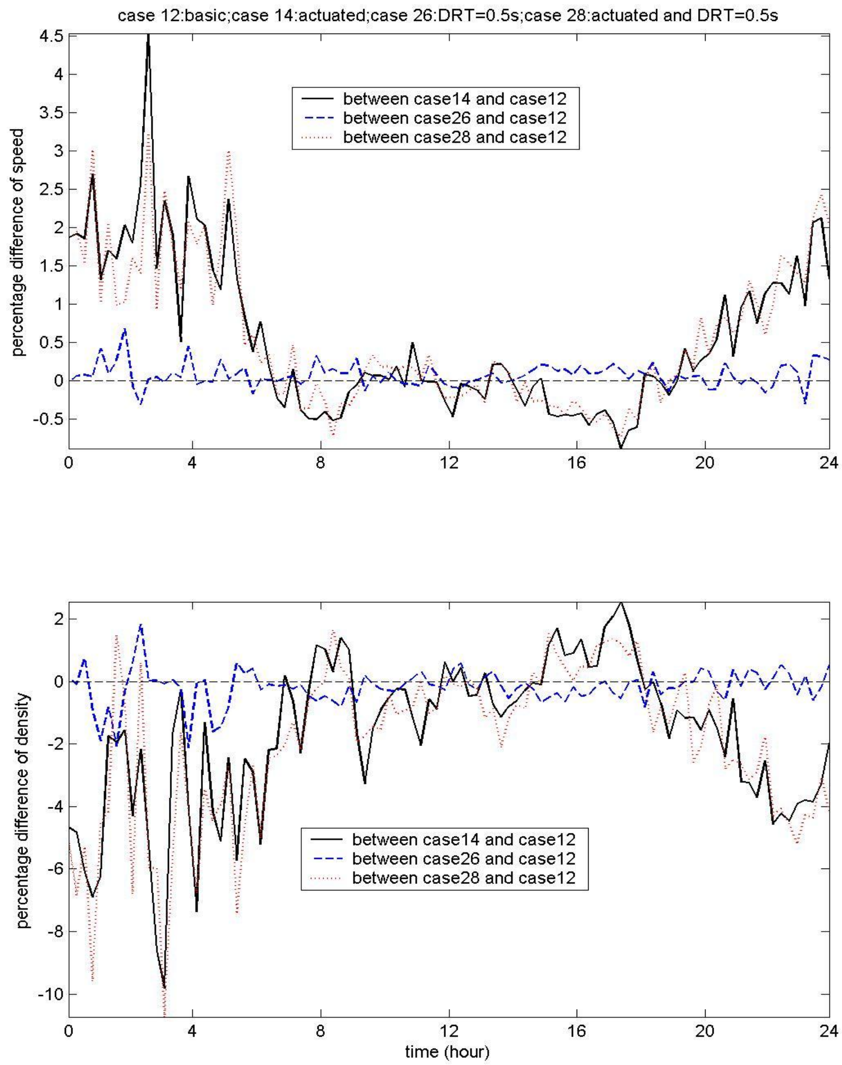


Figure 3-12: Percentage difference of spatially averaged speed and density between cases with (PAS, DRT)=(0, 0.7) for case 12; (100,0.7) for case 14; (0,0.5) for case 26; (100,0.5) for case 28. Here PAS denotes percentage of actuated signal, and DRT is driver reaction time.

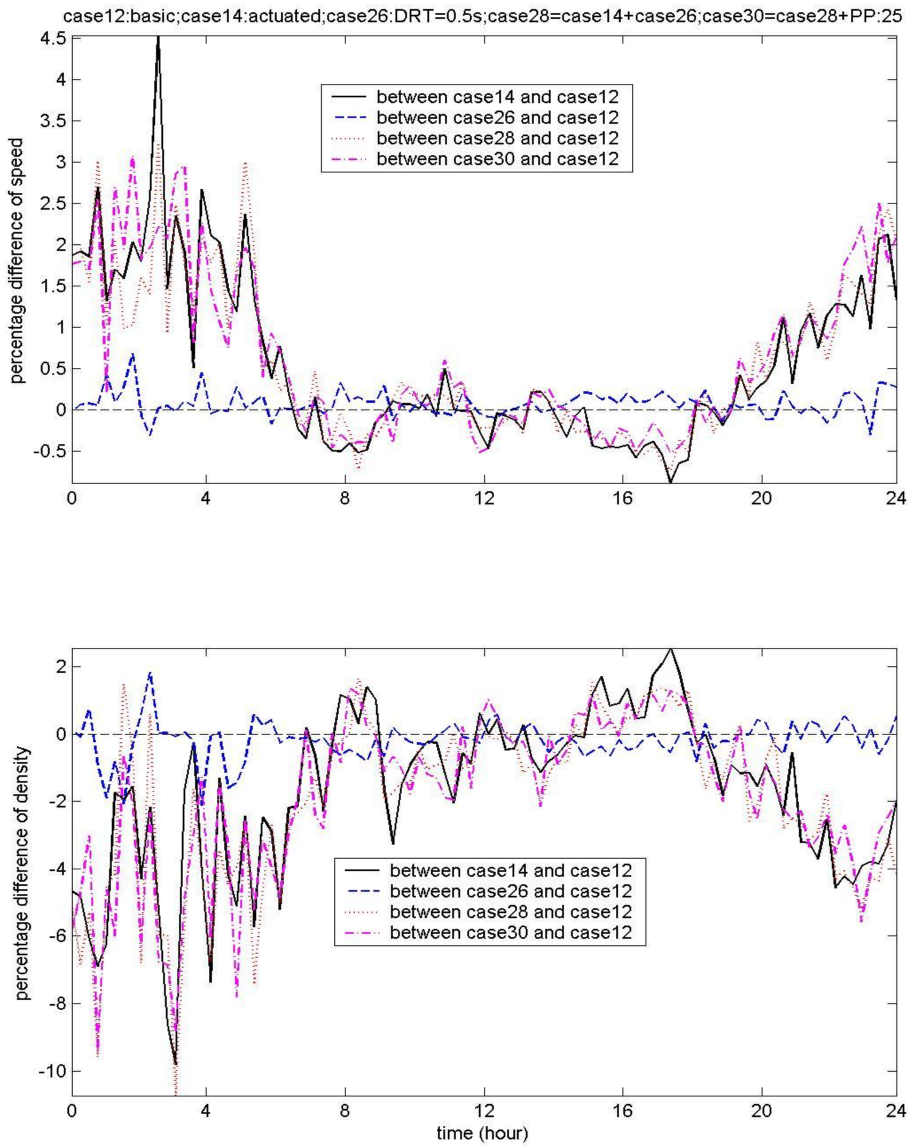


Figure 3-13. Percentage difference of spatially averaged speed and density between cases with (PAS, DRT, PPV)=(0, 0.7,50) for case 12; (100,0.7,50) for case 14; (0,0.5,50) for case 26; (100,0.5,50) for case 28;(100,0.5,25) for case 30. Here PAS denotes percentage of actuated signal, DRT denotes driver reaction time, and PPV denotes permission probability value.

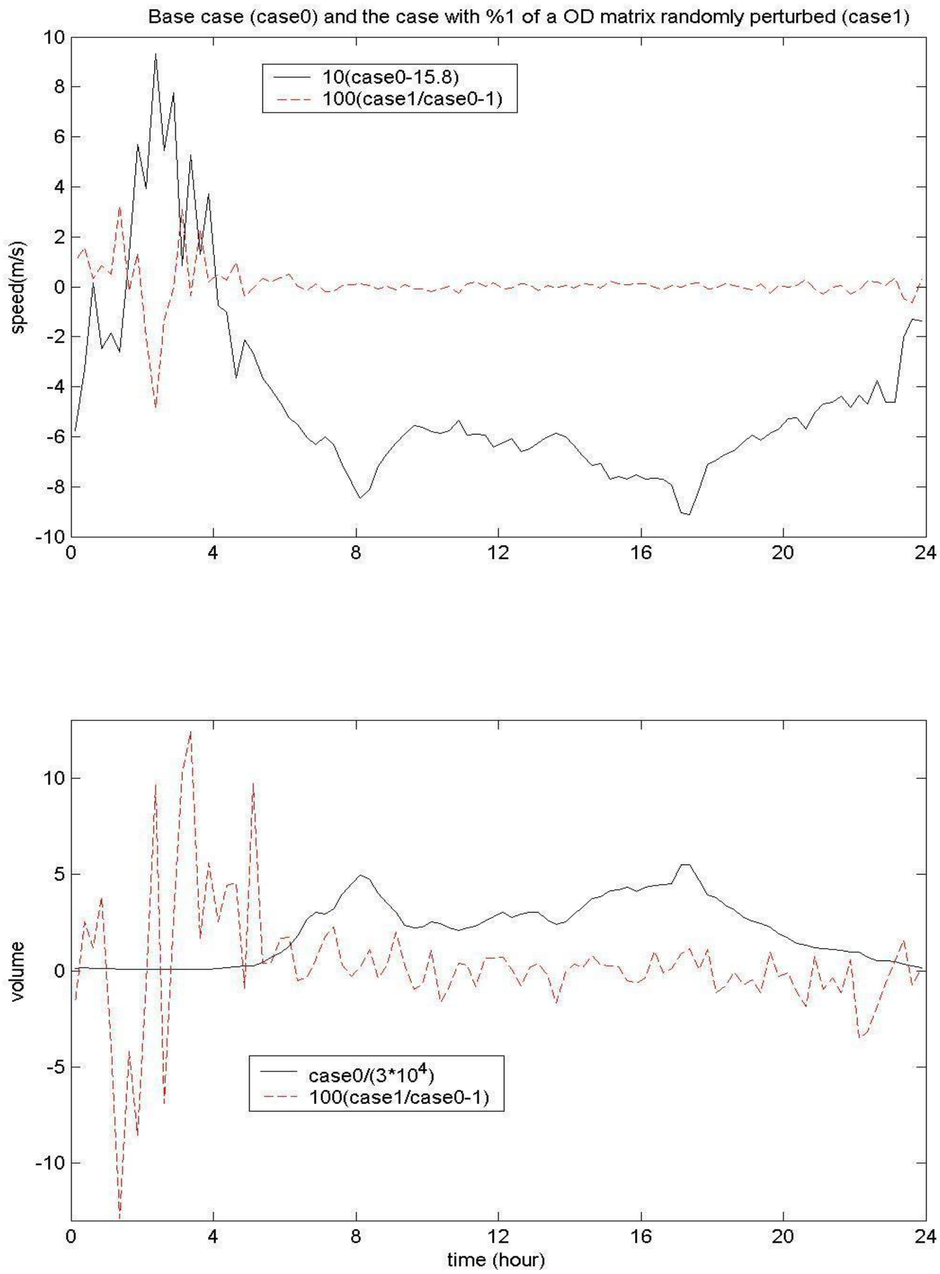
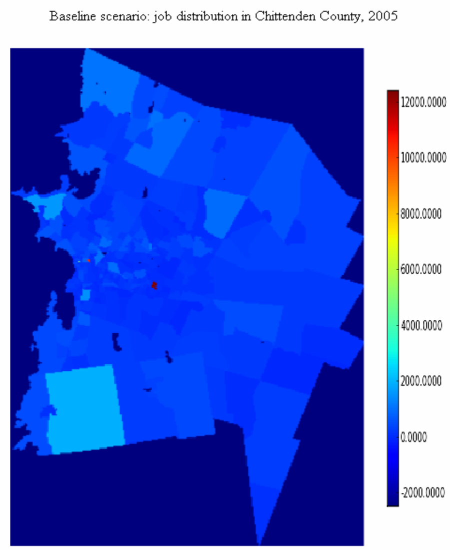


Figure 3-14: Spatially averaged speed and volume for the base case and the case with 1% of Original-Destination Matrix randomly perturbed (case1).

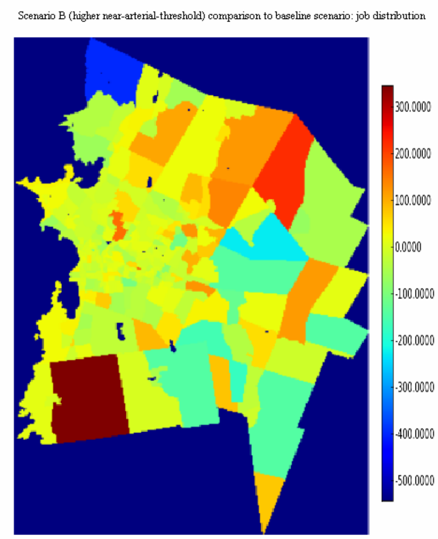
3.2 Simulation Results With UrbanSim

UrbanSim has been installed and compiled on Vermont Advanced Computing Center (VACC) successfully, and UrbanSim for Chittenden County (without travel model) has also been implemented on VACC. As the first step of the sensitivity study, preliminary scenario analysis of UrbanSim for Chittenden County has been conducted. As an example, we focused on scenario study of two model parameters: (1) near-arterial-threshold, which represents the line distance from the centroid of a cell to an arterial for it to be considered nearby, and (2) mid-income-fraction, which indicates the fraction of the total number of households considered to have mid-level incomes. For the scenario study, UrbanSim has been run for many scenarios, including: a baseline scenario, a scenario with doubled near-arterial-threshold (scenario B), a scenario with mid-income-fraction reduced to half (scenario C), and a scenario with doubled near-arterial-threshold and mid-income-fraction reduced to half (scenario D). Figure 3-15 (a) and Figure 3-16 (a) illustrate job distribution and household distribution in Chittenden County for the baseline scenario, respectively, where each colored polygon represents a traffic analysis zone used in a travel model that has been integrated with UrbanSim. Figure 3-15 (b) shows a job number increase in main region of Charlotte when the parameter near-arterial-threshold doubled. This is reasonable as a higher near-arterial-threshold makes the region more suitable for business development. Figure 3-16 (c) demonstrates a household number increase in the northwest of Milton when the parameter mid-income-fraction reduced to half. This is also reasonable. The northwest of Milton is close to Lake Champlain. Smaller mid income fraction means larger high income fraction, and more rich population may lead to more houses nearby the Lake Champlain. Figure 3-15(d) and Figure 3-16(d) illustrate a job number increase in main region of Charlotte, and a household number increase in the northwest of Milton, when the parameters near-arterial-threshold doubled and mid-income-fraction reduced to half jointly. Job number and household number summed spatially over the whole Chittenden County for each year from 1991 to 2005 and averaged temporarily over a time from 1991 to 2005 for each zone in Chittenden County are illustrated in Figure 3-17 and Figure 3-18. Here, as a first step of analyzing the UrbanSim, we omit the spatial dependence of the observation. From Figure 3-17 and Figure 3-18 it can be seen that the spatially summed job number and household number for baseline scenario increase with time, so do, for majority of the time, the spatially summed absolute differences in job numbers and household numbers between scenario B and baseline scenario, scenario C and baseline scenario, and scenario D and baseline scenario.

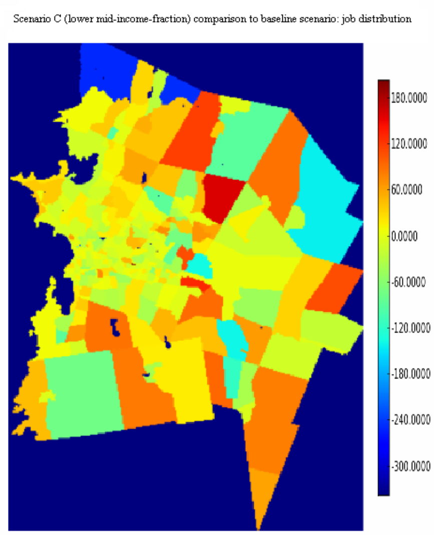
In addition, we keep developing collaborative relationship with Austin Troy and his group at the Rubenstein School of Environment and Natural Resources, on calibration of UrbanSim using Bayesian melding method. Jun Yu, Yi Yang, Austin Troy, and Brian Vogit have met many times to discuss in detail the implementation of Bayesian melding in validation/calibration of UrbanSim for Chittenden County. Jun Yu and Yi Yang have worked out a Matlab program to do Monte Carlo sampling, and Yi Yang has written a DOS batch file to implement Bayesian melding method with UrbanSim. Parameter, mid-income-fraction, is taken as an example to demonstrate schematically how Bayesian melding method can be used in calibration of UrbanSim. Prior probability distribution is assumed to be a normal distribution around the default value (≈ 0.632). Monte Carlo sampling scheme is used to choose 10 test values of the parameter. Then UrbanSim modeling of Chittenden County for the given values of parameter is carried out, and by comparing with observation data of the households distribution in 1991, posterior probability distribution is estimated. The prior and posterior probability distributions of parameter mid-income-fraction are shown in the Figure 3-19. From Figure 3-19 it can be seen that although the posterior probability distribution is much steeper than the assumed prior probability distribution, the peak point of the posterior probability distribution is close to that of the prior probability distribution, indicating that the observation based data support the default value of the parameter mid-income-fraction.



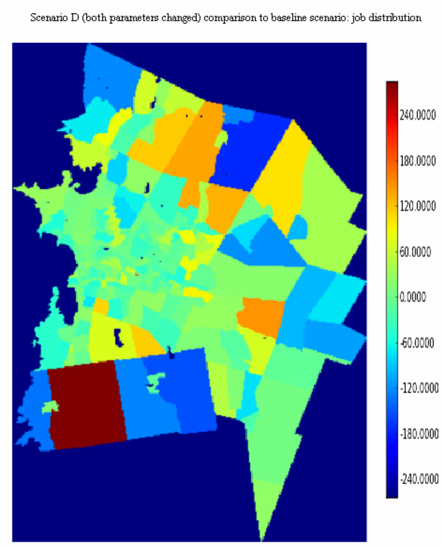
(a)



(b)



(c)



(d)

Figure 3-15. (a) Chittenden job distribution in 2005 for baseline scenario ; (b) the differences of job distribution between scenario B and baseline scenario, (c) scenario C and baseline scenario, and (d) scenario D and baseline scenario.

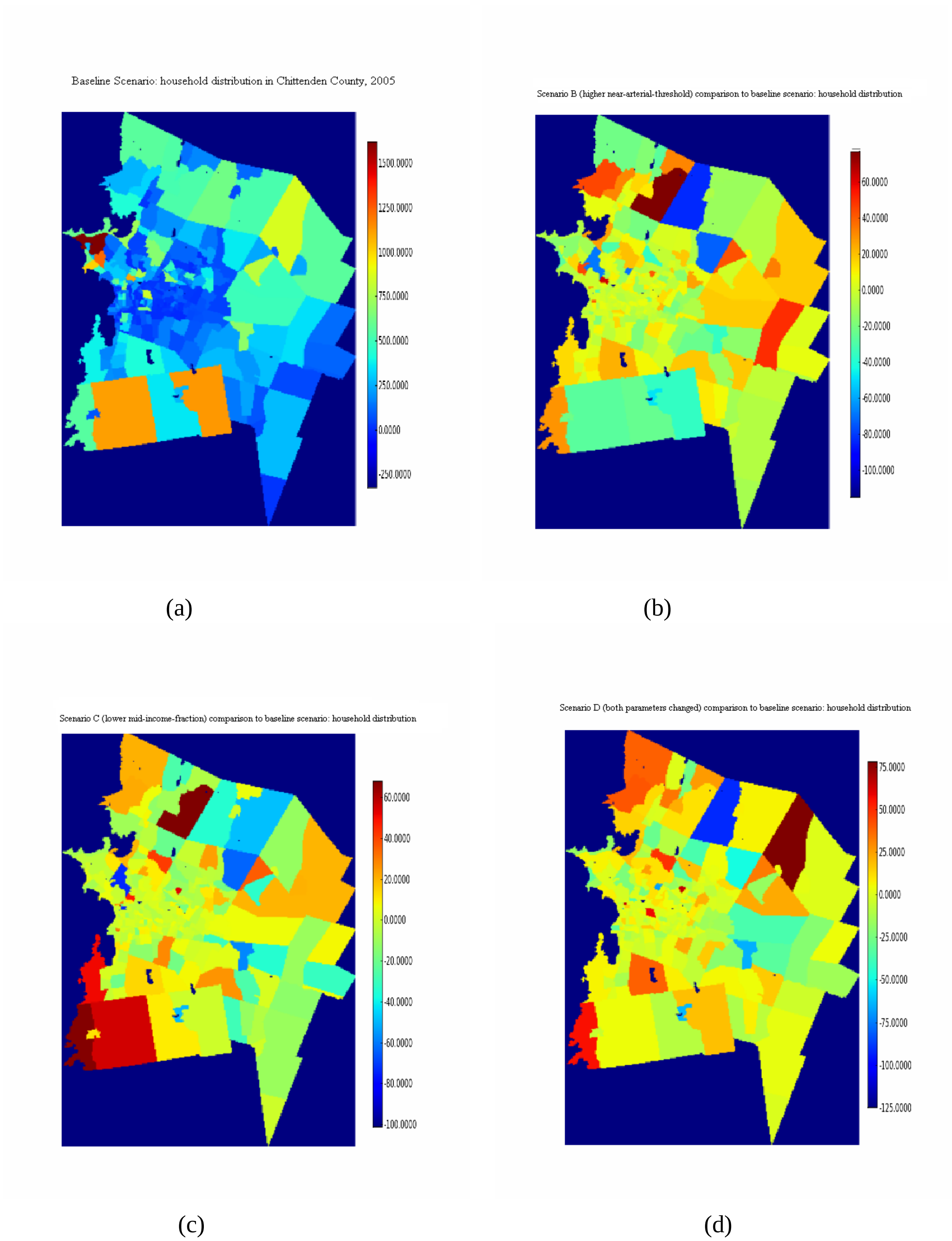


Figure 3-16. (a) Chittenden household distribution in 2005 for baseline scenario; (b) the differences of household distribution between scenario B and baseline scenario, (c) scenario C and baseline scenario, and (d) scenario D and baseline scenario.

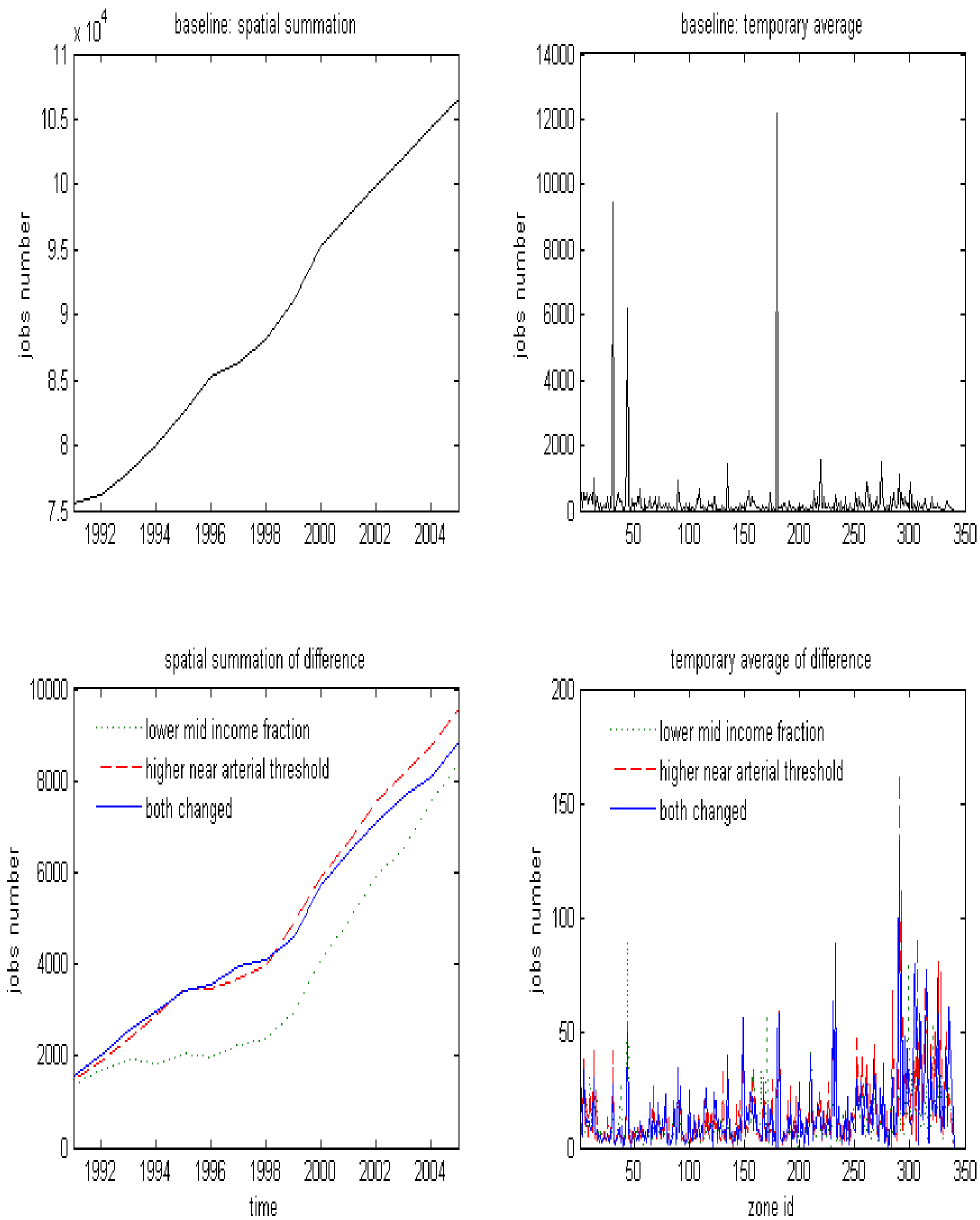


Figure 3-17. Spatial summation (top left corner) and temporary average (top right corner) of the job number for baseline scenario; spatial summations (bottom left corner) and temporary averages (bottom right corner) of the absolute differences in job numbers between scenarios B and baseline scenario, scenarios C and baseline scenario, and scenarios D and baseline scenario.

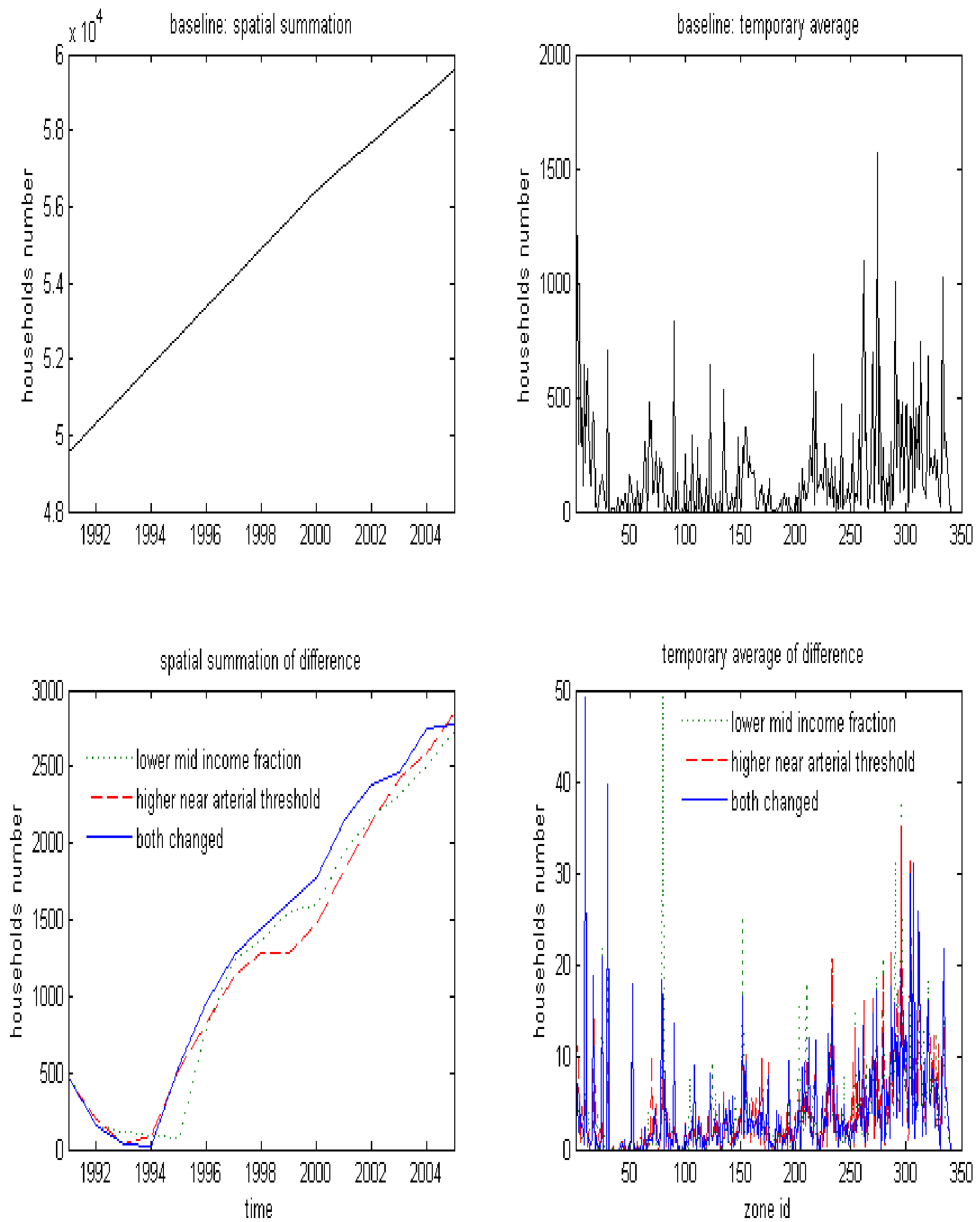


Figure 3-18. Spatial summation (top left corner) and temporary average (top right corner) of the household number for baseline scenario; spatial summations (bottom left corner) and temporary averages (bottom right corner) of the absolute differences in household numbers between scenarios B and baseline scenario, scenarios C and baseline scenario, and scenarios D and baseline scenario.

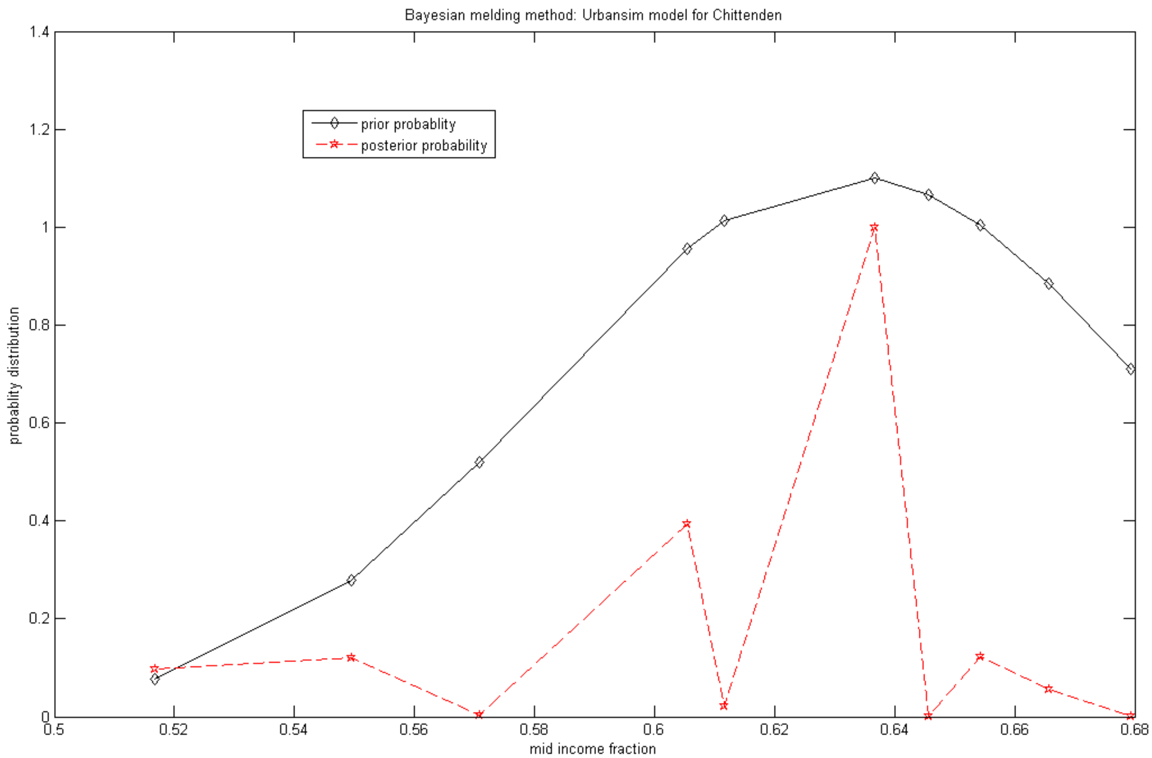


Figure 3-19. Prior (solid black line) and posterior (dashed red line) probability distributions of parameter mid-income-fraction. Diamonds in the black line are obtained from Monte Calo sampling method.

4. Conclusions

TRANSIMS is a powerful tool for evaluating performance of transportation system, as demonstrated by our study for the Chittenden County, Vermont. The simulation is able to capture realistic events such as congestion at specific sites, as well as observed data for volume and speed at chosen sites. In general, comparing with variation of parameters (such as driver reaction time and et al.), variation in transportation demand has stronger influence on performance of the transportation network. In addition, it is found that only for off-peak hour period, the actuated signal devices improve performance of the transportation system significantly.

It should be noted that our research is based on “Track 1” TRANSIMS, a relatively low level of TRANSIMS. We are working on upgrading our simulation tool from “Track 1” TRANSIMS to “Track 2”, in order to conduct scenario analysis for more model parameters such as parking fee, parking lot capacity, travel cost, and walk speed.

In addition to the study of the TRANSIMS model, preliminary scenario analysis of UrbanSim for Chittenden County has been conducted. UrbanSim simulations have been run for many scenarios. The simulation results show a job number increase in the main region of Charlotte when the parameter near-arterial-threshold is doubled; a household number increase in the northwest of Milton when the parameter mid-income-fraction is reduced to half; and a job number increase in main region of Charlotte together with a household number increase in the northwest of Milton when the parameter near-arterial-threshold is doubled and mid-income-fraction is reduced to half.

Finally, preliminary results on using Bayesian melding method for calibration of UrbanSim for Chittenden County are obtained. Mid-income-fraction parameter is taken as an example. Prior probability distribution is assumed to be a normal distribution around the default value (≈ 0.632). Monte Carlo sampling scheme is used to choose 10 test values of the parameter. Then UrbanSim modeling of Chittenden County for the given values of parameter is implemented, and by comparing with observation data of the households distribution in 1991, posterior probability distribution is estimated.

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