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RESOURCE SYSTEMS GROUP, INC.

The UNIVERSITY of VERMONT

TRANSIMS IMPLEMENTATION
CHITTENDEN COUNTY VERMONT

Final Report

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1.0 OVERVIEW OF THE STUDY

This project was conducted under a Broad Agency Announcement released by FHWA. The goal of the project was to implement TRANSIMS in Chittenden County, Vermont as a proof of concept for other small and medium sized MPOs. Resource Systems Group, along with the University of Vermont, worked with FHWA and the Chittenden County MPO (CCMPO) to identify a practical implementation of TRANSIMS which the CCMPO may be able to use in its policy work.

After discussions with the CCMPO and FHWA, the project team decided to build and calibrate a Track 1 implementation of TRANSIMS integrating the existing land use, trip generation, distribution and mode choice models with the TRANSIMS traffic assignment modules (i.e. the Router and Microsimulator). The purpose of this tool is to provide transportation systems management (TSM) capabilities for the CCMPO's long range planning efforts and to improve air emissions modeling. The CCMPO is also considering using this tool in their project prioritization process.

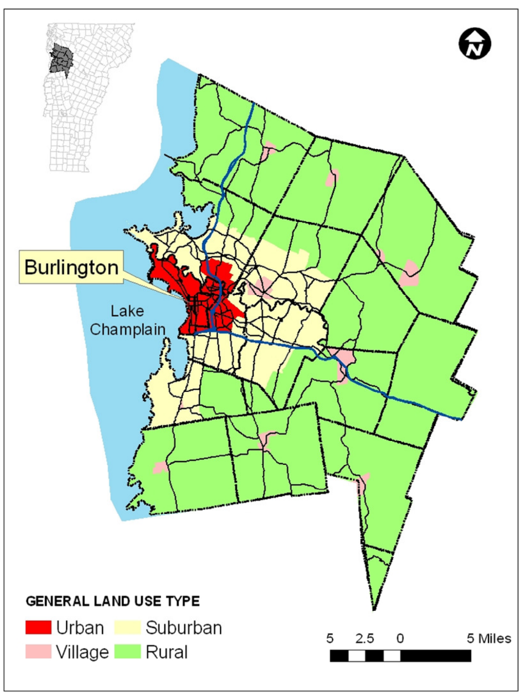
This document provides a description of the TRANSIMS model developed for the CCMPO, the calibration exercise which was conducted and several sensitivity and policy tests which were performed. The initial result of this work was reviewed by a peer group independently established by Volpe. This peer review was valuable in suggesting several additional improvements which were implemented. It should be noted that this document provides merely a cursory overview of TRANSIMS, focusing primarily on the specifics of the CCMPO implementation, including the preparation of the input data and the algorithms and assumptions specified in the implementation. More thorough documentation of TRANSIMS can be found on the TRANSIMS Website (http://transims-opensource.org/index.php).

2.0 OVERVIEW OF THE CHITTENDEN COUNTY REGION

The Chittenden County MPO planning area encompasses a rapidly growing urban area. The county contains Burlington, which is 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. The County has the largest population and employment in the state with 145,000 residents and over 120,000 jobs. It is considered the economic engine for the state and has a commuter shed that extends to the surrounding counties. The County contains the largest employers in the state including IBM, the University of Vermont, and a regional medical center.

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 consisting of auto-oriented residential, office, and retail land uses now surrounds the urban core. Recent big box development in the suburban communities attracts customers from all over northwest Vermont and parts of Upstate New York. The outer ring towns still support some traditional rural activities but also serve as bedroom communities for the jobs located in the suburban and urban areas.

Figure 1: Chittenden County, Vermont



LOOKING EAST FROM LAKE CHAMPLAIN OVER THE CITY OF BURLINGTON TOWARDS THE GREEN MOUNTAINS.

The transportation system consists of a well connected road network that offers multiple routes; a fixed route bus service within the urban core and suburban areas; commuter bus service to the counties in the north, east, and south; an emerging network of multi-use paths and on-road bicycle facilities, and well connected sidewalk systems within the urban core and village areas.

Figure 2: Center of Chittenden County Metropolitan Region

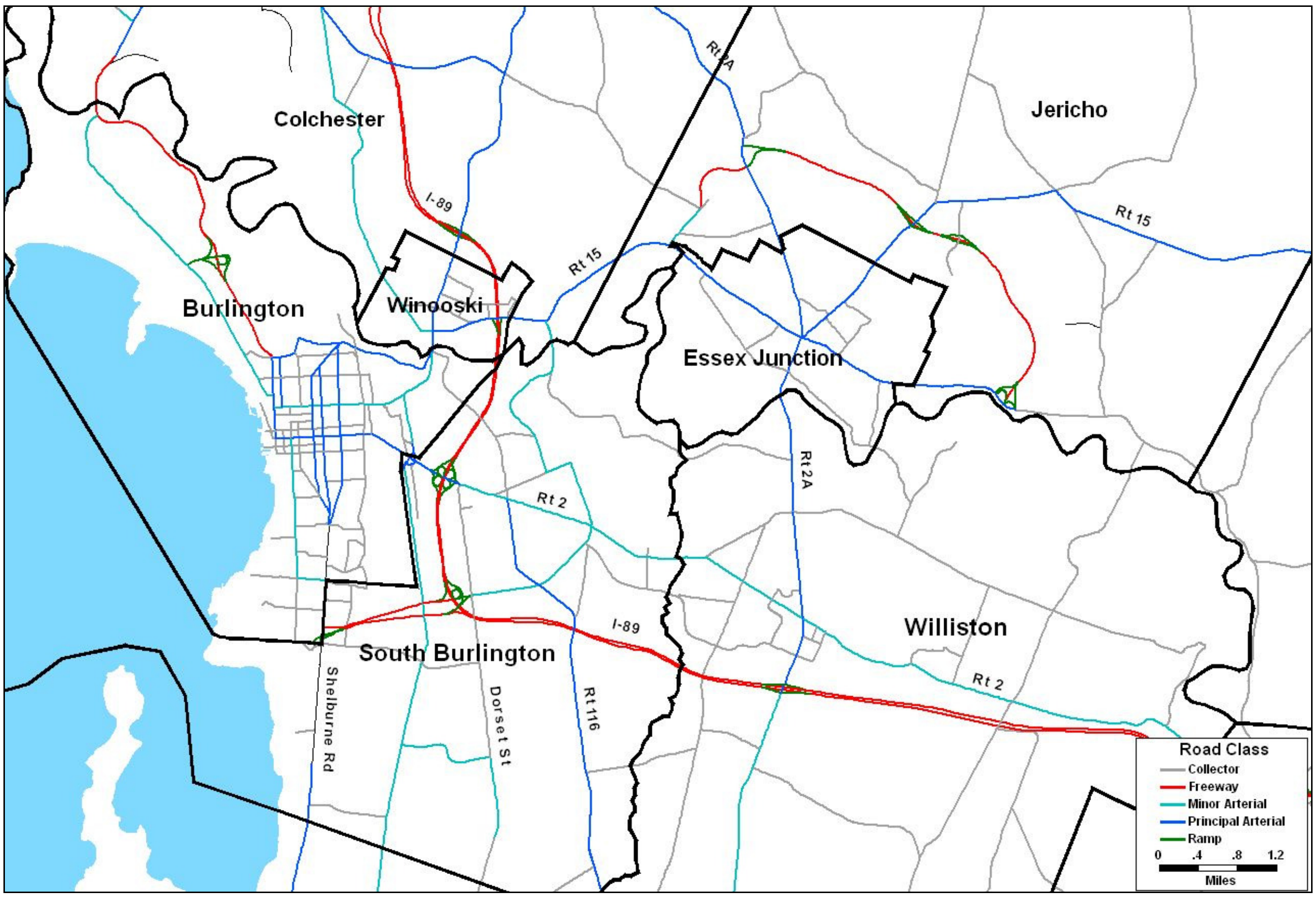


Figure 3: Housing Density per Acre by TAZ (year 2000)

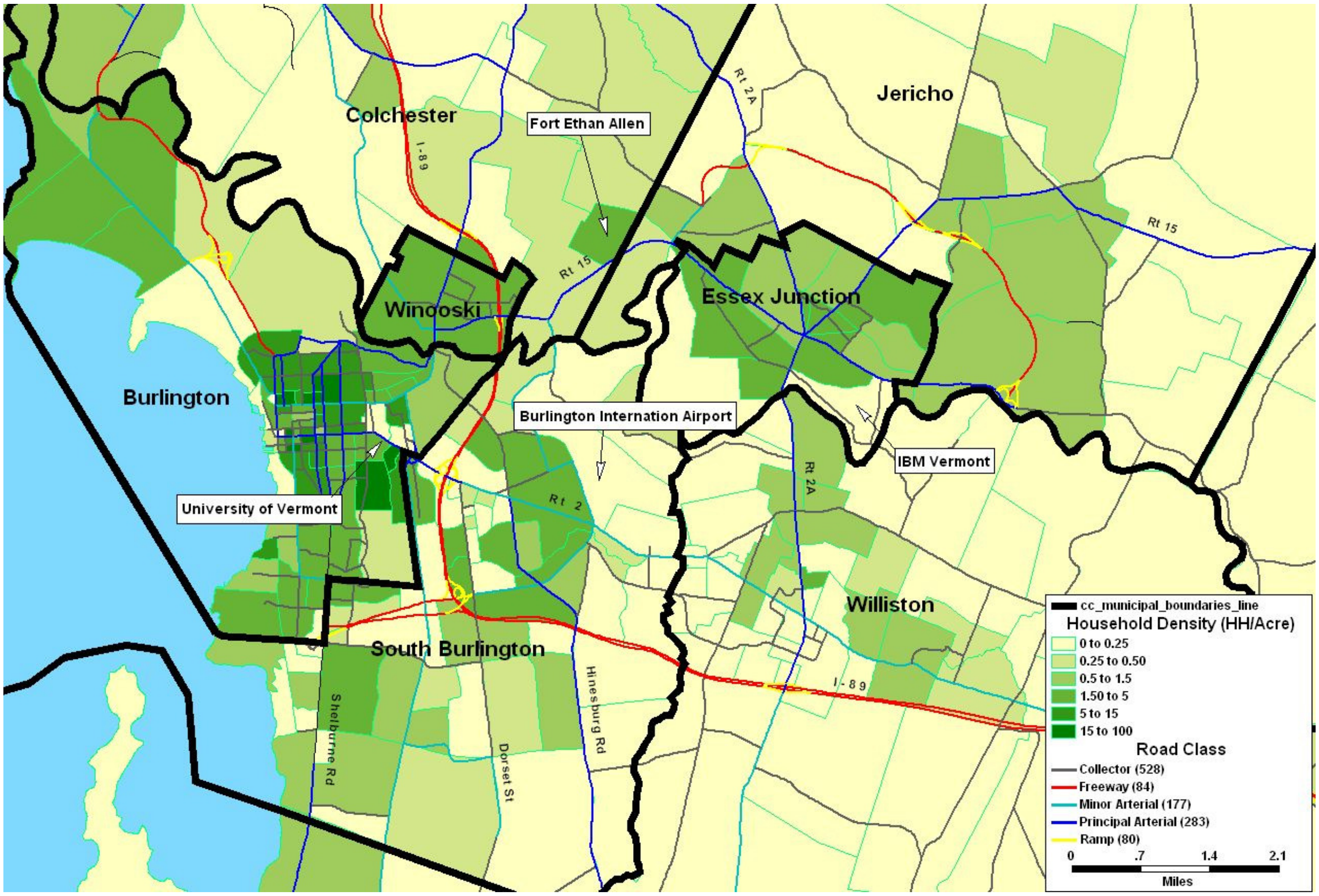
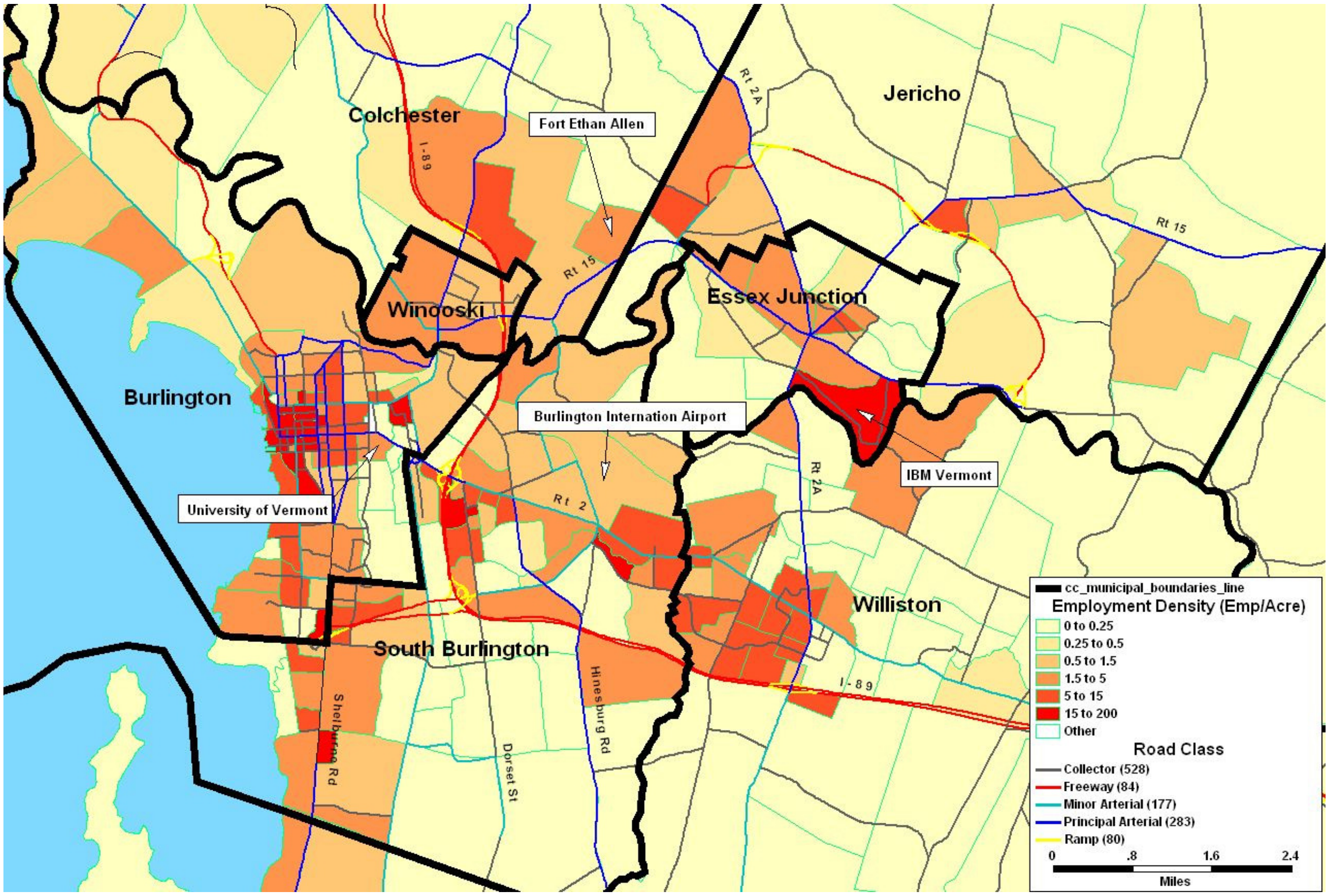


Figure 4: Employment Density per Acre by TAZ (year 2000)



Although Chittenden County is a small urban area, congestion is perceived as notable. According to a recent public opinion survey conducted by the Chittenden County Metropolitan Planning Organization[1], over 80% of residents and employees agree that congestion gets noticeably worse every year. Over 50% of residents and employees agree that congestion affects the majority of their trips. The response to this question is higher than other jurisdictions across the U.S.

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[1] "Chittenden County Metropolitan Planning Organization Transportation Survey Report of Results"; Prepared by National Research Center, Inc.; July 2006

Figure 5: PM Peak Hour Congestion on US 2 Leaving Burlington

Not surprisingly, the worst congestion in the County is located in the urban core and suburban areas. All of the major arterials leading into Burlington experience congestion in the morning and afternoon peak hours. The congestion occurs at the numerous signalized intersection installed as the urban and suburban development pattern spread out along the arterials.

As growth continues to spread into the suburban and rural communities, congestion follows as well. Congestion is now an issue at many of the I-89 interstate ramps, including those located within the rural areas. In some cases, vehicle queues extend back from the arterial to the freeway mainline causing safety concerns and disruptions to traffic flow on the interstate. Congestion is an issue now and will worsen in the future due to growth within the County and as more commuters travel to work from the affordable housing available in surrounding counties. The CCMPO's 2025 Metropolitan Transportation Plan projects an increase in congested VMT that is much greater than anticipated growth in households and employment.

3.0 OVERVIEW OF THE EXISTING CCMPO 4-STEP MODEL

The CCMPO has a long history of building and using advanced transportation models while always focusing on the practical implications such as ability to operate the model and explain the results. For example, the CCMPO has had an integrated land use-transportation model since the early 1990's. The current CCMPO model is based on a 4-step platform but offers several extensions such as peak spreading, intersection modeling, nested logit mode choice models, and parking re-allotment.

The TRANSIMS Model uses the vehicle trip tables produced from the existing CCMPO 4-step model. The existing 4-step transportation model forecasts 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. 7-8 AM and 5-6 PM were chosen as the AM and PM peak time periods based on September data from automatic traffic recorders throughout the region. Much of the TRANSIMS data shown throughout this report are for the PM peak hour which is a close approximation of the design hour conditions.

The model follows a relatively conventional 4-step process and includes an integrated land use allocation model. The general steps of the model include:

- *Land use allocation* allocates future land use (i.e. housing and jobs) based on accessibility, availability of land (through physical constraints and zoning), and location of existing land uses. The process uses a modified Lowry-Putnam model structure.
- *Trip generation* calculates the number of person trip ends (origins and destinations) generated by each zone. Vehicle trip ends for truck trip forecasting are also computed. The model structure uses a cross-classification process. Trip types include:

Table 1: Non-truck Trip Types for the AM and PM Models

Trip Type	AM Model	PM Model	Description
Home Destination	X		Any trip that ends at home (e.g. work to home, or shopping to home)
Home Origin		X	Any trip that begins at home (e.g. home to restaurant, or home to work)
Home-to-Work	X		from home to the workplace
Work-to-Home		X	from the workplace to home
Home-to-School	X		from home to school
Nonwork-to-Home		X	from anywhere other than the workplace to home (e.g. shopping to home)
Home-to-Nonwork	X		from home to anywhere other than the workplace (e.g. home to shopping)
Work-to-Nonhome		X	From the workplace to anywhere but home (e.g. work to shopping)
Nonhome-Based	X		From anywhere other than home to anywhere other than home (e.g. daycare to work)
Nonwork-Nonhome		X	From anywhere other than work to anywhere other than home (e.g. shopping to daycare)

Table 2: Estimated AM Peak Hour Person Trips by Trip Purpose, 2000

	# of Trips	% of Total
Home Destination	2,746	5%
Home to Work	23,250	41%
Home to School	12,213	21%
Home to Other	9,569	17%
Nonhome Based	6,717	12%
Medium Trucks	1,902	3%
Heavy Trucks	442	1%
	56,841	100%

Table 3: Estimated PM Peak Hour Person Trips by Trip Purpose, 2000

	# of Trips	% of Total
Home origin	11,842	17%
Work to home	15,475	22%
Nonwork to home	20,713	29%
Work to nonhome	8,990	13%
Nonwork Nonhome	11,566	16%
Medium Truck	1,535	2%
Heavy Truck	572	1%
	70,694	100%

- *Transit shortest path* skims the transportation network and calculates the travel time and frequency from every zone served by transit to every other zone served by transit.

- *Trip distribution* uses a gravity model structure to pair the origins and destinations for each zone for each of five trip purposes.
- *Mode split* uses a nested logit model structure to estimate which mode the person trips are likely to take based on availability and mode-specific parameters (e.g. time, cost, transit frequency). Modes include walk/bike, drive-alone, shared ride, rail, and bus.
- *Vehicle assignment* uses a user equilibrium multi-class process to assign autos and trucks to the road network.
- *Transit assignment* uses the transit trip table output from mode split and assigns person trips using transit to road segments.

The AM and PM Model calibration statistics appear in the three tables below.

Table 4: AM and PM Calibration Statistics

	AM	PM
Correlation Coefficient	0.913	0.917
RMSE	37.1	33.1
Absolute Error	27.6	24.2
Sum of Differences	0.70%	0.40%

Table 5: AM Peak Hour Model Calibration

	FHWA Guideline	Model
Correlation Coefficient	0.880	0.913
Percent Error Region-Wide	5%	0.4%
Sum of Differences By Functional Class		
Freeways	7%	-1.2%
Principal Arterials	10%	6.9%
Minor Arterials	15%	-4.4%
Collectors	25%	7.5.%

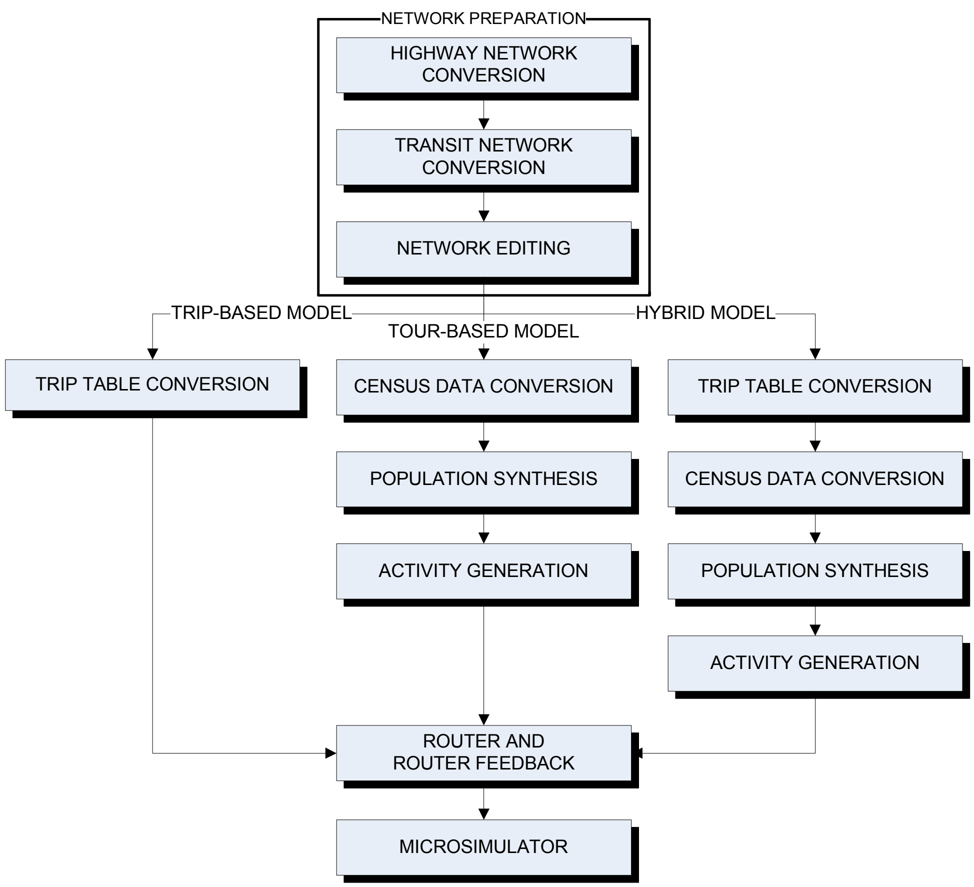
Table 6: PM Peak Hour Model Calibration

	FHWA Guideline	Model
Correlation Coefficient	0.880	0.917
Percent Error Region-Wide	5%	0.7%
Sum of Differences By Functional Class		
Freeways	7%	-0.29%
Principal Arterials	10%	2.1%
Minor Arterials	15%	-8.0%
Collectors	25%	5.0%

4.0 BRIEF OVERVIEW OF TRANSIMS

TRANSIMS is a complex system of travel demand models and traffic assignment models. Each implementation can be customized to the particular needs and available data, as shown in *Figure 6*. The primary difference among the three approaches listed below concerns how the trip matrices are estimated. The "Trip Table Conversion" method relies on fixed trip tables estimated outside of TRANSIMS and converted into TRANSIMS format. This approach is often referred to as a "Track 1" implementation. The "Tour-Based Model" is an implementation of a tour-based model inside the TRANSIMS framework. The "Hybrid Model", is a combination of the two previous approaches (e.g. fixed external and commercial vehicle trip matrices can be read into TRANSIMS). Models that rely on the demand models within TRANSIMS are often called "Track 2" implementations. There are of course many other details that could make an implementation unique.

Figure 6: Three Ways to Implement TRANSIMS (transims-opensource.org, Sbyati/Roden)



For this study we have implemented only the advanced traffic assignment components within TRANSIMS, and not the activity/tour-based demand models, and moreover we are focusing only on assigning vehicle trips. In *Figure 6*, our approach is depicted via the left-most sequence of modules (Track 1). We use trip tables that have been estimated using a standard planning model.

The traffic assignment process within TRANSIMS is fairly complex and requires some introduction. There are two primary components to the assignment process, the Router and the Microsimulator. The Router identifies the best path for each traveler. The Microsimulator assigns travelers and vehicles to the specified path. Link travel times from the Microsimulator are then fed back to the Router for the next iteration. Various strategies can be used for selecting travelers and for manipulating link travel times.

The Router identifies the shortest path based on a user-defined generalized cost function. The routing is done separately for each traveler, and the LOS variables used in the cost function are output from the previous iteration, or averaged over multiple iterations, by time of day. The LOS variables can be measured in whatever time increments the user specifies, and for our implementation we have chosen 15-minute increments. Therefore, the travel time on a link and for specific turning movements varies by time of day in 15-minute increments.

Not all travelers are re-routed during each Router iteration. In order to approximate equilibrium and stabilize the level-of-service estimates, only a portion of all the travelers are rerouted based on user-specified criteria. Travelers can be selected for rerouting based on the difference in their travel time from the previous iteration, or based on the level of congestion on the links they traverse. The thresholds for these criteria are specified by the user, and care must be taken to not reroute too many travelers that have oscillating LOS within each iteration.

5.0 CCMPO TRANSIMS MODEL IMPLEMENTATION

The following section describes the development of the CCMPO TRANSIMS model and the system configuration.

5.1 TRIP TABLE MATRIX DEVELOPMENT

The vehicle trip table used in the TRANSIMS Track 1 model is developed from the PM peak hour CCMPO 4-step model. The first step is to extract the following vehicle trip tables after the mode choice step:

1. Home origin (HBO)
2. Work to Home (HBW)
3. Non-work to Home (HBO)
4. Work to non-home (NHB)
5. Non-work to non-home (NHB)
6. Medium truck trips
7. Heavy truck trips
8. External to external trips

These PM trip tables were expanded to the day using the time-of-day distribution from the CCMPO household trip diary survey performed in 1998. The results were checked against NHTS data and permanent vehicle count data. Because household trip diary data can be "lumpy" (there 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. The following graph shows the raw CCMPO household survey data for home based other trips followed by the smoothed data.

Figure 7: Example of CCMPO Raw Survey Data Diurnal Distribution

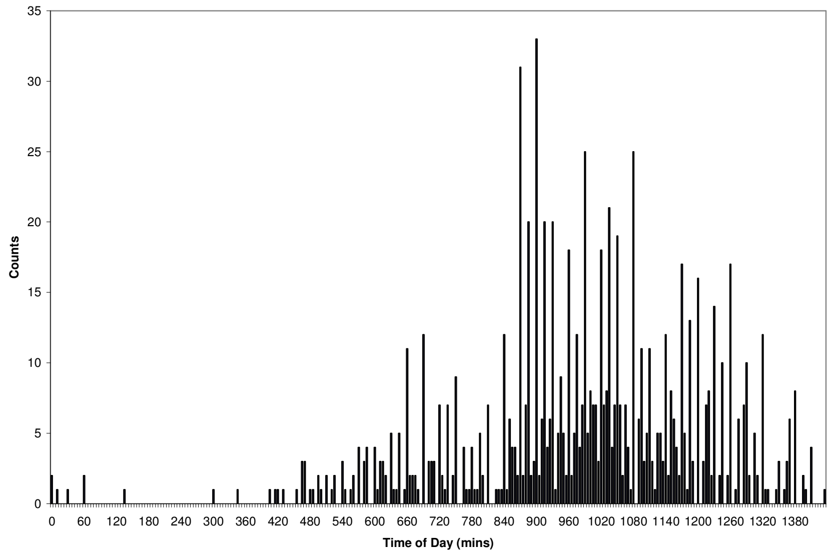
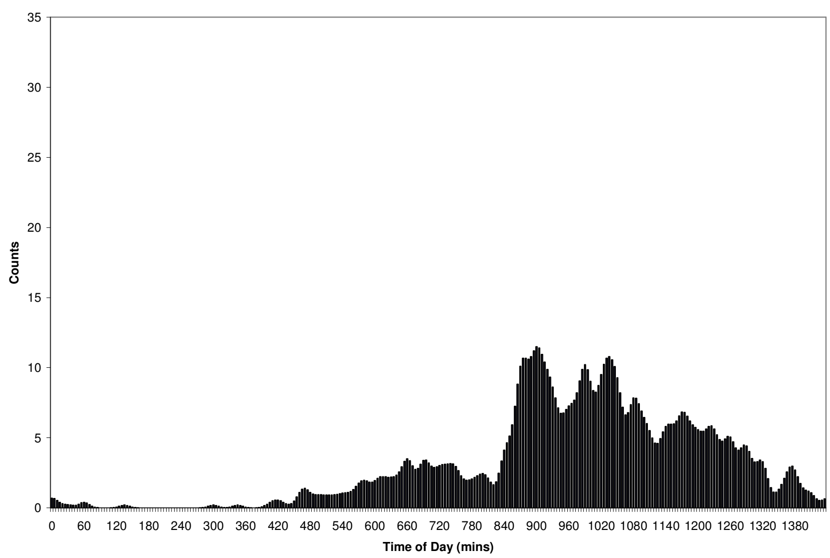
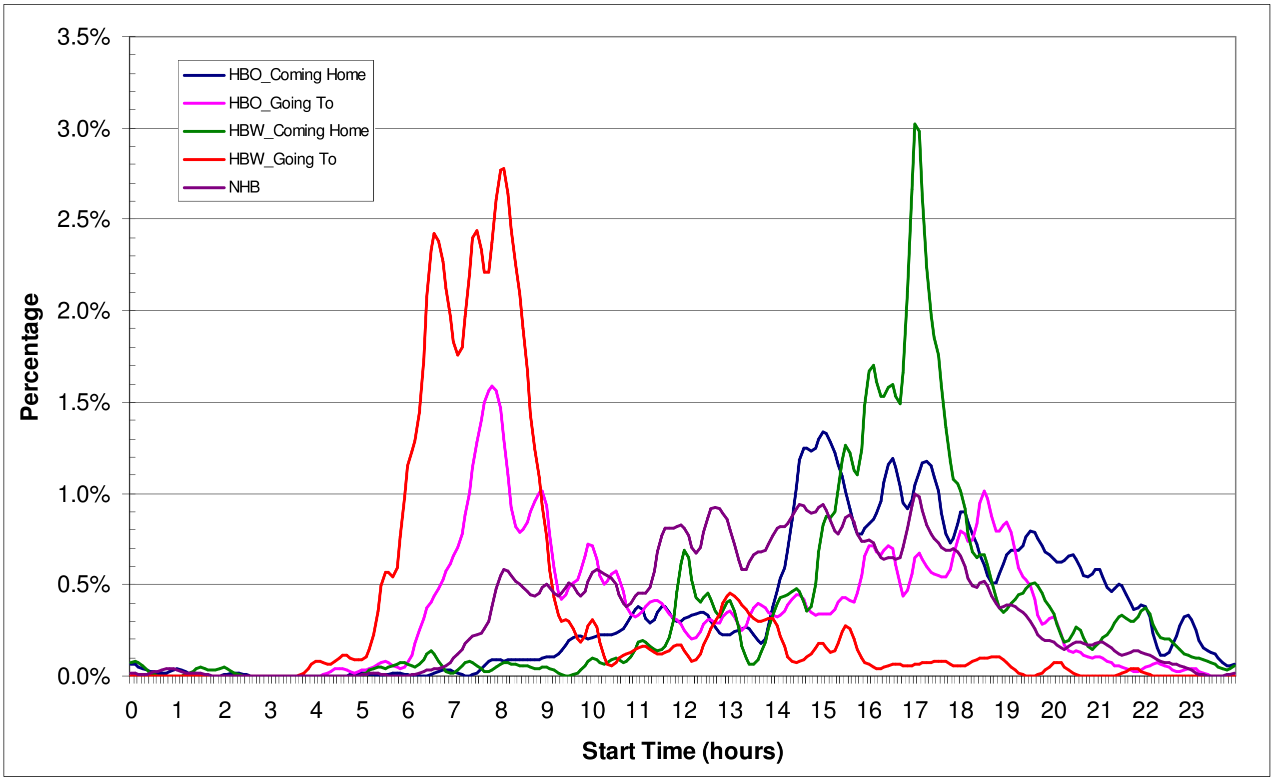


Figure 8: Example of CCMPO Smoothed Survey Data Diurnal Distribution



The following are the resulting smoothed diurnal distributions which were applied to the PM vehicle trip tables to generate daily matrices.

Figure 9: Smoothed Survey Diurnal Data by Trip Type



The primary external-to-external flow through the region is on I-89 where permanent traffic counters exist. These counters were used to generate diurnal patterns for these trips. Finally, non home based trips were used to generate daily truck traffic.

Figure 10: Diurnal Distribution (All Trips)

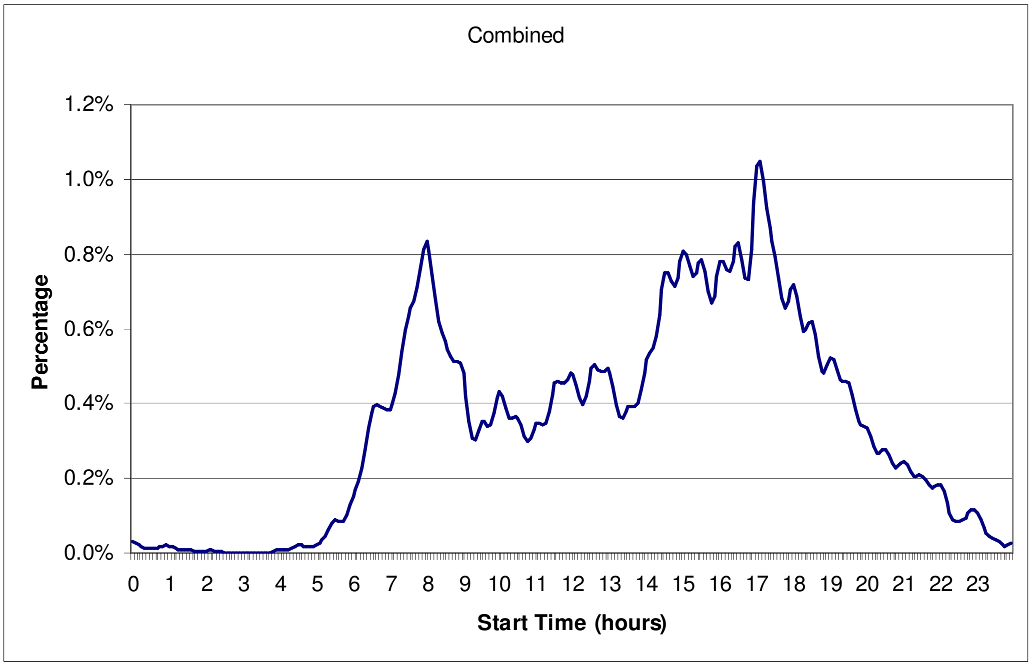


Table 7: Final Diurnal Distribution by Trip Type

Hour	HBW_GT	HBW_CH	HBO_GT	HBO_CH	NHB	Combined
1	0.0%	0.5%	0.0%	0.5%	0.4%	0.3%
2	0.0%	0.3%	0.0%	0.2%	0.2%	0.1%
3	0.0%	0.3%	0.0%	0.1%	0.0%	0.1%
4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5	1.3%	0.0%	0.3%	0.0%	0.0%	0.3%
6	3.8%	0.5%	0.8%	0.2%	0.1%	1.1%
7	22.8%	1.1%	4.0%	0.2%	0.4%	5.7%
8	23.9%	1.1%	13.1%	0.6%	2.5%	8.2%
9	24.3%	0.8%	11.7%	1.1%	6.1%	8.8%
10	3.8%	0.3%	7.3%	2.0%	5.4%	3.8%
11	2.3%	1.1%	6.3%	2.9%	6.2%	3.8%
12	2.3%	2.4%	4.7%	4.4%	7.7%	4.3%
13	2.5%	6.1%	2.9%	3.9%	9.7%	5.0%
14	5.1%	2.4%	4.4%	2.6%	7.9%	4.5%
15	1.8%	4.8%	4.5%	10.7%	10.2%	6.4%
16	2.3%	11.8%	4.7%	12.8%	10.1%	8.3%
17	0.8%	17.6%	7.3%	11.7%	7.9%	9.1%
18	0.9%	24.6%	7.3%	11.0%	9.9%	10.7%
19	1.3%	8.6%	10.1%	8.8%	5.9%	6.9%
20	0.3%	5.6%	6.7%	8.3%	4.1%	5.0%
21	0.5%	2.7%	2.3%	7.3%	2.1%	3.0%
22	0.3%	3.5%	0.9%	5.7%	2.0%	2.5%
23	0.0%	3.2%	0.6%	3.2%	1.2%	1.6%
24	0.0%	0.8%	0.3%	1.8%	0.1%	0.6%

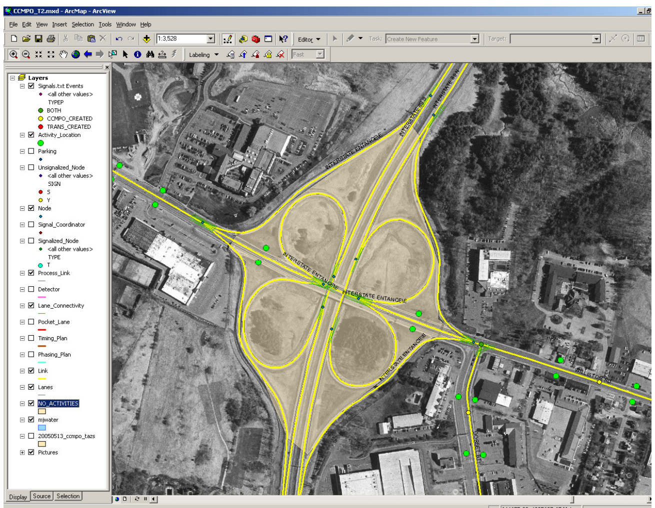
5.2 NETWORK DEVELOPMENT

Because there is a Paramics model of the entire county, we had initially planned on converting that network for use in the TRANSIMS model. We did, in fact, write a program that successfully generated a TRANSIMS network from a Paramics network. We later decided to move away from this approach partly because of the differences in the data storage representation between the two packages (signal timing, as an example, is represented very differently). The primary reason for dropping this approach, however, was the goal of maintaining connection between the 4-step model and the Track 1 model so that the CCMPO can run the new model with either an aggregate assignment (4-step model) or a disaggregate assignment (TRANSIMS).

The approach taken to build the TRANSIMS network, therefore, was to start with the 4-step network, apply the network tools available within TRANSIMS (i.e. TransimsNet) and then enhance the network integrity manually during calibration. The following section describes both the automated and subsequent manual steps taken to build the TRANSIMS network.

Activity locations were built using TransimsNet. This program creates activity locations (loading points for TRANSIMS) along every block face separated by (n) meters (where n is a user defined variable – we used 100 meters). We also 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 as that in the more rural areas, there were zones (TAZs in the 4-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.

Figure 11: Example of Activity Locations in Interchanges

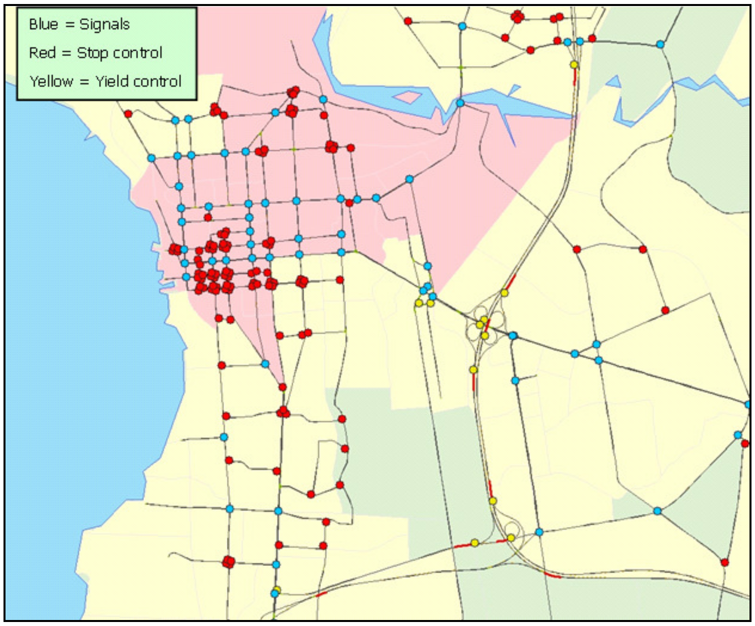


The second challenge with automated activity locations occurred where there is obviously not loading points; for example, in the middle of interchanges such as Exit 14 shown in Figure 11. Rather than manually remove these activity locations, we built a polygon layer representing the areas where this occurred and then applied a GIS rule for automatically removing these locations. This way we can import a new 4-step network and automatically generate activity locations. Obviously, if new interchanges are added or if the TAZ structure changes we would want to perform a check to ensure that these rules were not broken.

The remaining network parameters were generated by TRANSIMS. These include:

1. Pocket lane location
2. Lane connectivity
3. Signal timing

Figure 12: Downtown Intersection Controls



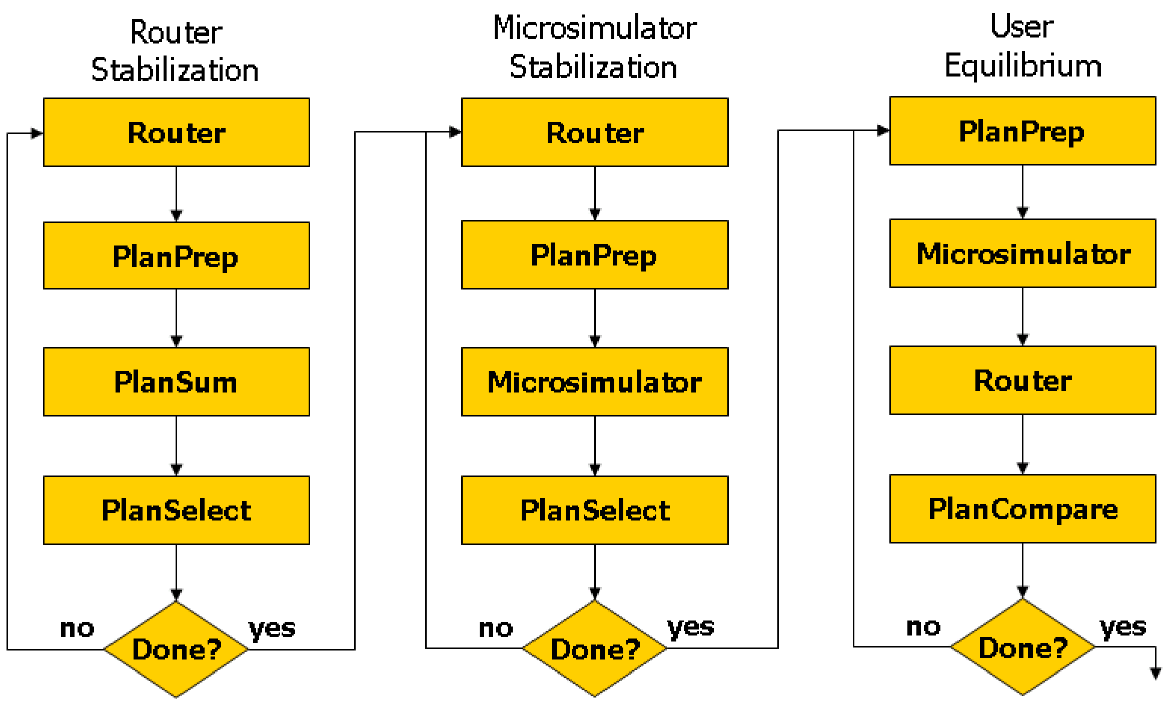
Our initial goal was to refine the defaults with the rules available within TransimsNet and use the resulting network unchanged. Our thinking was that this would make for an easy link between the 4-step model and the TRANSIMS model and require very little work on the part of the CCMPO when modeling scenarios. As it turned out, there were too many invariants in the network which required special coding in order to reach a satisfactory calibration. We performed this exercise by running the model and focusing on areas where unexpected congestion was occurring. Using aerial photography (see **Error! Reference source not found.**) and ground validation we corrected these anomalies manually and recorded the changes. The most common of these were signal timing changes where minor roads were receiving an undue amount of the total cycle. Other examples include adding and removing pocket lanes and adding or removing signals. Finally, we ran across several places where a left turn phase had been automatically added to an intersection with no dedicated left turn bays.

Figure 13: Example of the Use of Imagery for Manual Validation

5.3 CCMPO TRANSIMS MODEL STRUCTURE

In its most general form, Track 1 involves two processes. The first is a Router which locates a route for each vehicle being loaded onto the network. The second step is the Microsimulator which loads the vehicles and simulates their movement on the network. Because microsimulating the whole network for an entire day is time consuming, it is common to start by iterating the Router and recalculating the travel times using a conventional BPR delay. Once a level of convergence has been reached in the Router (the paths generally reflect the congested travel times), the Microsimulator is then introduced. A final step in the process once the Microsimulator has reached a level of convergence (the paths now reflect a more refined set of travel times generated by the Microsimulator), a user equilibrium step is introduced. This process is shown in the following diagram.

Figure 14: CCMPO TRANSIMS Process



The actual process of convergence involves selecting a portion of the assigned trips to be reassigned in the subsequent iteration. Many different rules and criteria can be applied to perform this selection process. Through trial and error we arrived at the following process:

1. **Router Stabilization (rerouting travelers whose travel time is changing measurably):**
   a. Iterations 1 – 10
   b. Utilize BPR equations to measure link travel times
   c. Reroute only a sample of travelers, based on travel time differences from previous iteration
      i. Rerouting Selection Criteria for iterations 1 - 10
         1. Minimum Time Difference = 2 minutes
         2. Maximum Time Difference = 30 minutes
2. **Router Stabilization (rerouting around bottlenecks):**
   a. Iterations 11-20

   b. Utilize BPR equations to measure link travel times
   c. Reroute only a sample of travelers, based on presence of congestion and on travel time differences from previous iteration
      i. Rerouting Selection Criteria for iterations 11 - 20
         1. ***Select travelers using links with V/C Ratios >= 1.50***
         2. Minimum Time Difference = 2 minutes
         3. Maximum Time Difference = 30 minutes
3. **Microsimulator Stabilization (introduce the Microsimulator):**
   a. Iterations 21-30
   b. ***Utilize the Microsimulator to measure link and turning movement travel times***
   c. Reroute only a sample of travelers, based on travel time differences from previous iteration
      i. Rerouting Selection Criteria for iterations 21 – 30
         1. Minimum Time Difference = 2 minutes
         2. Maximum Time Difference = 30 minutes
4. **User Equilibrium using Microsimulator (continue to refine the routing):**
   a. Iterations 31-40
   b. Utilize the Microsimulator to measure link and turning movement travel times
   c. ***Reroute all travelers***
   d. Compare travel times to previous iteration, and select a subset of travelers to actually reroute
      i. Rerouting Selection Criteria for iterations 31 – 40
         1. Minimum Time Difference = 2 minutes
         2. Maximum Time Difference = 30 minutes

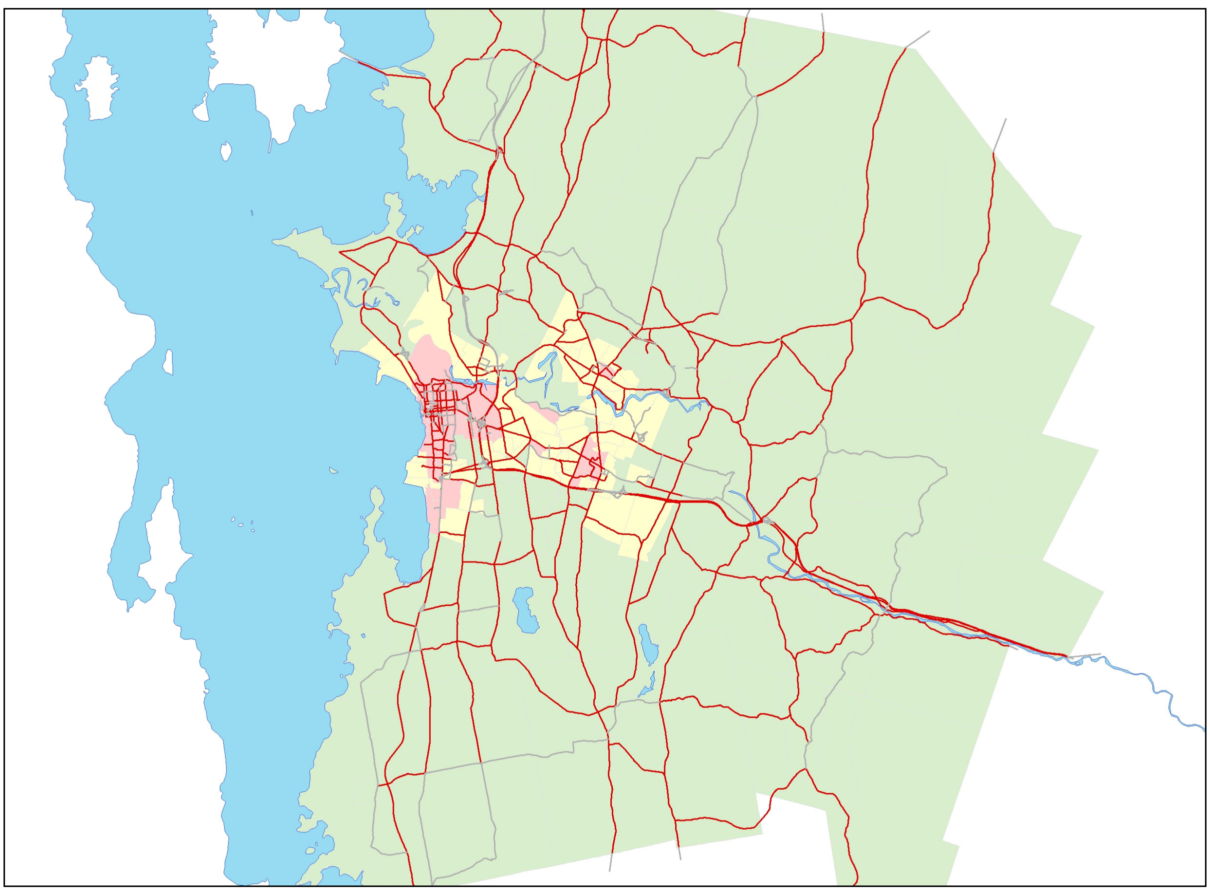
The difference between stage 3 and stage 4 of the simulation is subtle. In stages 1-3 we estimate travel times (using BPR curves or the Microsimulator), and compare travel times against the previous iteration to selectively choose travelers to reroute in the next iteration. In stages 1-3 we only reroute a small sample with each iteration. In stage 4 we reroute all travelers, instead of only a sample, before comparing travel times against the previous iteration. However, once we compare the travel times based on a complete rerouting of everyone, we select a sample to actually reroute. This allows us to begin to approximate user equilibrium.

As a point of context, the model run time is approximately 1 minute per Router iteration and 13 minutes per Microsimulator iteration. This is with loading approximately 430,000 daily trips on the network which includes about 800 links. These model runs are being performed on a T46 IBM Thinkpad (laptop) with 1 GB of ram and a 2 GHz processor.

6.0 TRANSIMS MODEL CALIBRATION

The model is 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 4-step model). AM and PM ground counts were taken from the 4-step model and volumes for other hours of the day were collected from the CCMPO model. As you can see from the following figure, there ground counts 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.

Figure 15: Count Coverage for Calibration Purposes



The calibration exercise focused on the following items:

- The system-wide calibration comparisons to ground counts
- Use of three directional screen lines throughout the county
- Comparison to several critical links in the county
- Review of the operations within TRANSIMS (specifically the convergence of the Microsimulator and the relationship shift in behavior between the Router and Microsimulator.

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

6.1 REGIONAL CALIBRATION STATISTICS

The following two tables show the system-wide statistics. It is clearly shown that the simulated traffic volumes are close to the field traffic count, both by the volume level and by the facility type. The total relative error over the network is -2.9%.

Table 8: Summary Statistics by Volume Level

Summary Statistics by Volume Level

Volume Level	Num. Obs.	Volume Estimate	Volume Observed	Difference Volume	Difference %	Abs.Error Avg.	Abs.Error %	Std. Dev.	% RMSE	R Sq.	V/C Avg.	V/C Max.
0 to 100	99	8630	5939	2691	45.3	44	73.6	50	110.9	0.072	0.16	0.70
100 to 250	203	40214	35027	5187	14.8	77	44.6	79	63.8	0.143	0.33	1.21
250 to 500	274	99142	102470	-3328	-3.2	118	31.4	95	40.5	0.113	0.49	1.72
500 to 750	147	84100	92135	-8035	-8.7	147	23.4	98	28.1	0.031	0.66	1.64
750 to 1000	79	62649	69258	-6609	-9.5	192	21.9	130	26.3	0.053	0.70	1.71
1000 to 2500	73	97477	99582	-2105	-2.1	237	17.4	201	22.7	0.629	0.87	1.79
2500 to 5000	1	3358	3155	203	6.4	203	6.4	0	6.4	0.000	1.12	1.12
TOTAL	876	395570	407566	-11996	-2.9	121	26.1	117	36.3	0.827	0.56	1.79

Table 9: Summary Statistics by Facility Type

Summary Statistics by Facility Type

Facility Type	Num. Obs.	Volume Estimate	Volume Observed	Difference Volume	Difference %	Abs.Error Avg.	Abs.Error %	Std. Dev.	% RMSE	R Sq.	V/C Avg.	V/C Max.
Freeway	28	36018	35551	467	1.3	156	12.3	128	15.8	0.943	0.76	1.29
Major Arterial	262	173122	178912	-5790	-3.2	151	22.1	134	29.5	0.737	0.61	1.78
Minor Arterial	170	79303	88495	-9192	-10.4	144	27.7	127	36.9	0.701	0.59	1.79
Collector	376	87929	84923	3006	3.5	89	39.4	88	55.5	0.558	0.43	1.72
Ramp	36	19069	19505	-436	-2.2	126	23.3	116	31.5	0.755	0.54	1.32
Facility Type 17	4	129	180	-51	-28.3	13	29.4	13	38.3	0.853	0.06	0.12
TOTAL	876	395570	407566	-11996	-2.9	121	26.1	117	36.3	0.827	0.56	1.79

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We further defined an alternative performance measure for the model calibration: the link volume weighted by link length. With this new performance measure, a link with longer length would receive more weight in the system evaluation. The rationale of using this new measure can be justified by both the conceptual and empirical evidence. In our case, the calibration result using the length-weighted volume is shown in Tables 10 and 11. It is clearly shown that a better match is realized between the simulated traffic volumes and field traffic counts. The total relative error over the network is only -0.3%.

Table 10: Summary Statistics by Volume Level (Using the Length-Weighted Volume)

Summary Statistics by Volume Level

Volume Level	Num. Obs.	Volume Estimate	Volume Observed	Difference Volume	Difference %	Abs.Error Avg.	Abs.Error %	Std. Dev.	% RMSE	R Sq.	V/C Avg.	V/C Max.
0 to 100	227	15432	12377	3055	24.7	31	56.5	56	116.7	0.220	0.09	1.10
100 to 250	216	38915	36024	2891	8.0	56	33.8	54	46.9	0.188	0.22	0.87
250 to 500	194	66846	69757	-2911	-4.2	141	39.2	180	63.4	0.114	0.46	3.96
500 to 750	89	56600	55854	746	1.3	235	37.5	247	54.1	0.036	0.80	3.69
750 to 1000	45	40094	38906	1188	3.1	256	29.6	220	38.8	0.020	1.07	2.91
1000 to 2500	84	116689	122448	-5759	-4.7	424	29.1	439	41.8	0.347	1.66	7.60
2500 to 5000	12	35081	39525	-4444	-11.2	879	26.7	728	34.1	0.461	2.47	5.65
5000 to 7500	1	7240	6802	438	6.4	438	6.4	0	6.4	0.000	2.41	2.41
7500 to 10000	4	35447	35436	11	0.0	521	5.9	226	6.3	0.040	4.12	4.74
10000 to 50000	4	71295	68204	3091	4.5	864	5.1	777	6.4	0.984	7.75	9.90
TOTAL	876	483639	485333	-1694	-0.3	150	27.0	263	54.6	0.958	0.68	9.90

Table 11: Summary Statistics by Facility Type Level (Using the Length-Weighted Volume)

Summary Statistics by Facility Type

Facility Type	Num. Obs.	Volume Estimate	Volume Observed	Difference Volume	Difference %	Abs.Error Avg.	Abs.Error %	Std. Dev.	% RMSE	R Sq.	V/C Avg.	V/C Max.
Freeway	28	147585	143217	4368	3.0	404	7.9	412	11.2	0.992	3.11	9.90
Major Arterial	262	120211	134270	-14059	-10.5	149	29.1	308	66.6	0.719	0.42	3.86
Minor Arterial	170	87890	89765	-1875	-2.1	165	31.3	242	55.3	0.842	0.65	5.65
Collector	376	119513	110136	9377	8.5	134	45.9	225	89.3	0.619	0.58	7.60
Ramp	36	8310	7744	566	7.3	58	26.8	52	35.9	0.823	0.24	0.82
Facility Type 17	4	130	201	-71	-35.3	18	35.3	12	41.1	0.366	0.07	0.09
TOTAL	876	483639	485333	-1694	-0.3	150	27.0	263	54.6	0.958	0.68	9.90

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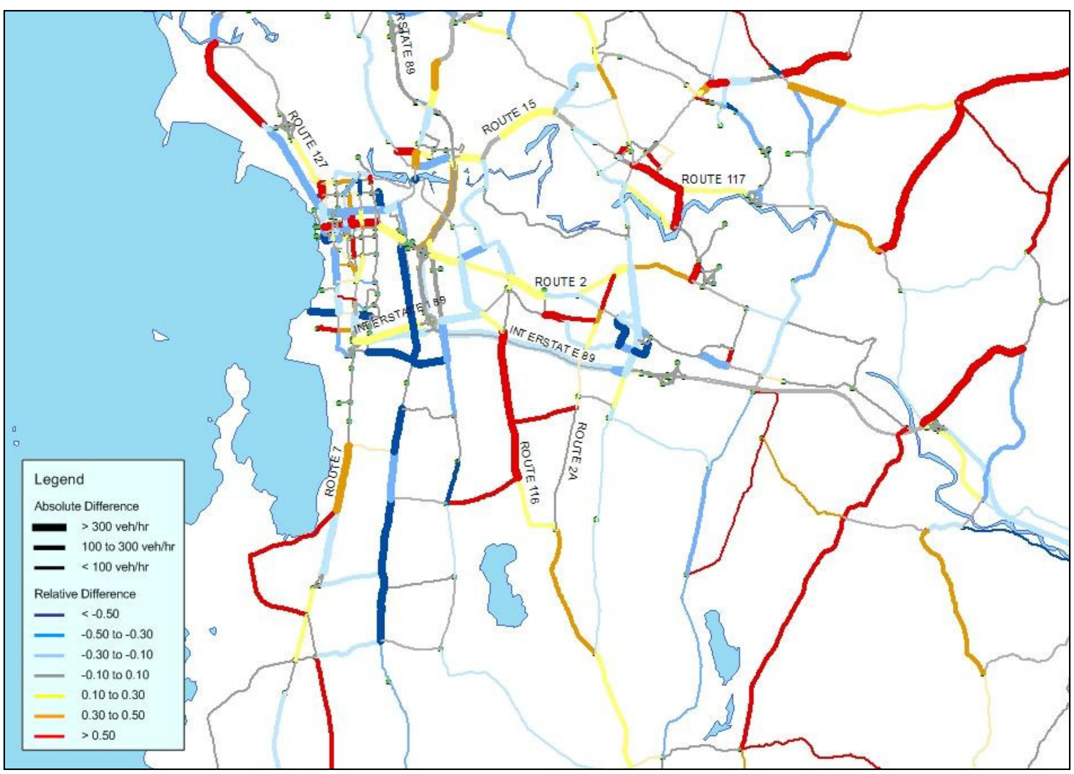
Table 12 shows a comparison between the 4-step and TRANSIMS calibration statistics in the PM Peak.

Table 12: Calibration Statistics for 4-Step and TRANSIMS (PM Peak Hour)

	FHWA Guideline	4-Step	TRANSIMS
Correlation Coefficient	0.88	0.91	0.91
RMSE		0.33	0.36
Percent Difference Region-Wide	5%	-0.8%	-2.9%
Percent Differences by Functional Class			
Freeways	7%	1.2%	1.3%
Principal Arterials	10%	-0.5%	-3.2%
Minor Arterials	15%	-9.1%	-10.4%
Collectors	25%	5.5%	3.5%

Figure 16 shows a link-level comparison between the simulated traffic flow rates and the field traffic counts.

Figure 16: PM Peak Hour Comparison of Counts to Simulated Volumes

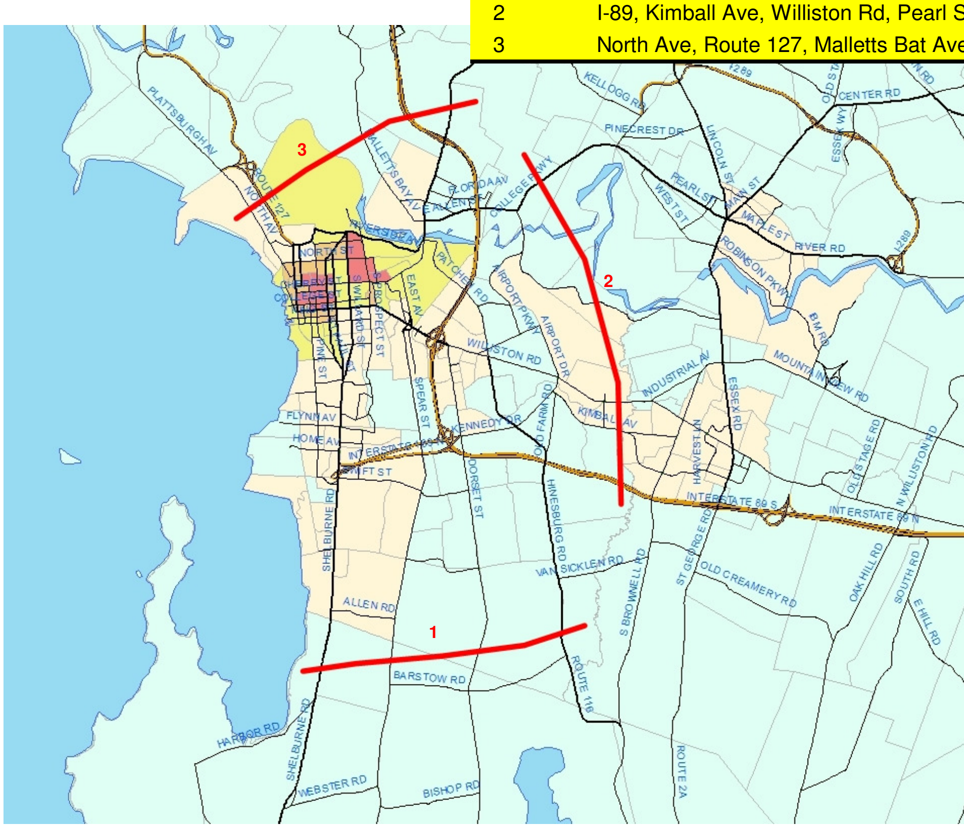


6.2 SCREENLINE COMPARISON

Three screenlines were created to account for variations caused by parallel routes and to be used with the validate program. Locations of the screenlines were chosen based on most significant flows in and out of Downtown Burlington and on the availability of count data. Below is a list of the screenlines, the roads that they cover, and a map of the Chittenden County region showing the geographical location of each screenline.

Figure 17: Screen Lines Used for the Calibration

Screenline	Cut Streets
1	Shelburne Rd, Spear St, Dorset St, Route 116
2	I-89, Kimball Ave, Williston Rd, Pearl St
3	North Ave, Route 127, Malletts Bat Ave, Main St



There are six comparisons (three screenlines and two directions). With the exception of two directions the results are very close (3% or less). The two comparisons that are worse are both around 23% error. Table 13 below shows both the TRANSIMS model and the 4-step model comparisons for the three screenlines. The results are very similar between these two models. This is not surprising since, fundamentally, the same trip table is being used in both models.

Table 13: Summary of Screenline Differences by Direction

Summary Statistics by Link Group

	Link Group	Num. Obs.	------Volume------ Estimate	Observed	---Difference--- Volume	%	--Abs.Error-- Avg.	%	Std. Dev.	% RMSE	R Sq.	----V/C---- Avg.	Max.
1	SHELBURNE RD, SPEAR ST, D	4	1675	1637	38	2.3	117	28.5	61	31.2	0.920	0.58	1.31
	SHELBURNE RD, SPEAR ST, D	4	2460	2011	449	22.3	320	63.6	170	70.0	0.784	0.85	1.71
2	I-89N, KIMBALL AVE, WILLI	4	5076	4120	956	23.2	314	30.4	195	34.6	0.821	1.04	1.79
	I-89S, KIMBALL AVE, WILLI	4	5063	5166	-103	-2.0	172	13.3	140	16.3	0.880	1.03	1.41
3	NORTH AVE, ROUTE 127, MAL	4	2208	2128	80	3.8	180	33.7	122	39.2	0.897	0.55	0.78
	NORTH AVE, ROUTE 127, MAL	4	3191	3213	-22	-0.7	99	12.3	23	12.5	0.993	0.80	1.28
	TOTAL	24	19673	18275	1398	7.6	200	26.3	147	32.4	0.822	0.83	1.79

(a) The Screenline Analysis Results from the TRANSIMS model

Summary Statistics by Link Group

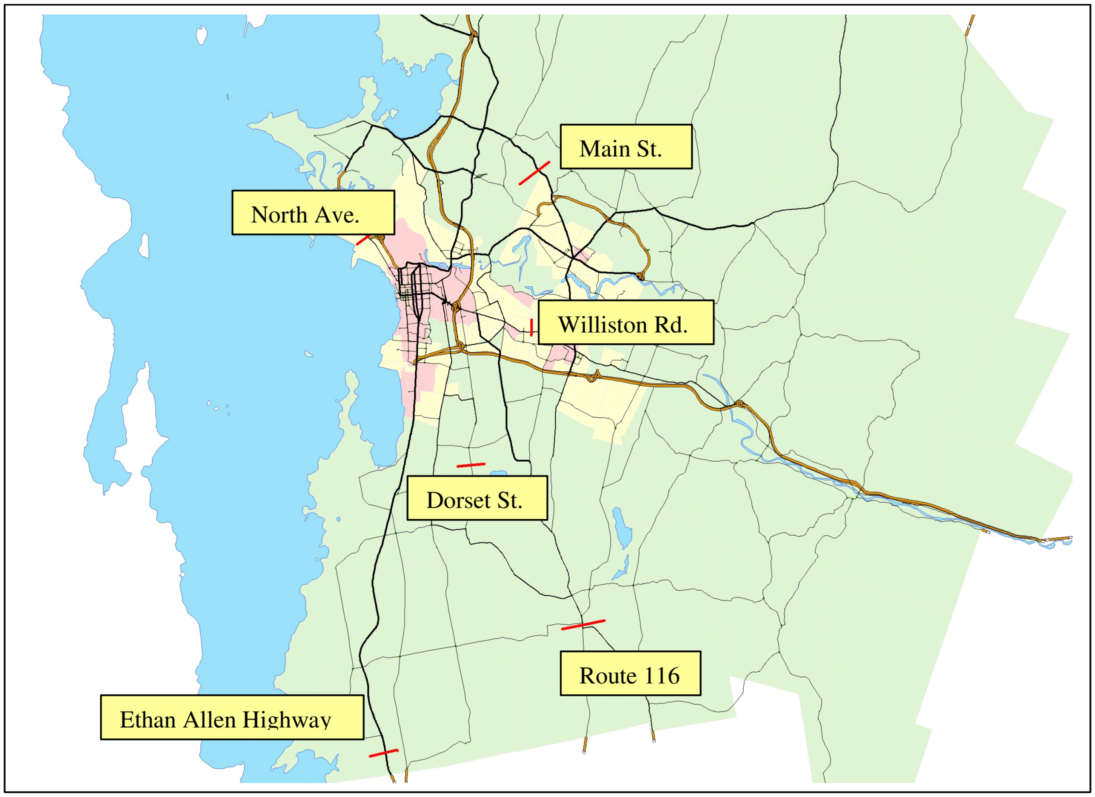
	Link Group	Num. Obs.	------Volume------ Estimate	Observed	---Difference--- Volume	%	--Abs.Error-- Avg.	%	Std. Dev.	% RMSE	R Sq.	----V/C---- Avg.	Max.
1	SHELBURNE RD, SPEAR ST, D	4	1657	1637	20	1.2	133	32.5	62	35.0	0.911	0.57	1.33
	SHELBURNE RD, SPEAR ST, D	4	2445	2011	434	21.6	309	61.4	159	67.2	0.768	0.84	1.67
2	I-89N, KIMBALL AVE, WILLI	4	4797	4120	677	16.4	327	31.7	161	34.5	0.693	0.98	1.74
	I-89S, KIMBALL AVE, WILLI	4	4851	5166	-315	-6.1	167	13.0	166	17.1	0.853	0.99	1.35
3	NORTH AVE, ROUTE 127, MAL	4	2159	2128	31	1.5	170	32.0	111	36.8	0.907	0.54	0.76
	NORTH AVE, ROUTE 127, MAL	4	3276	3213	63	2.0	110	13.7	39	14.3	0.987	0.82	1.31
	TOTAL	24	19185	18275	910	5.0	203	26.6	141	32.2	0.799	0.81	1.74

(b) The Screenline Analysis Results from the 4-Step model

6.3 INDIVIDUAL LINK COMPARISONS

The following several graphs contain comparisons of traffic counts and simulation results over a 24 hour period. Figure 18 shows the comparison locations which contain many of the major roads throughout the county.

Figure 18: Location of Key Links



Figures 19 – 24 contain the 24 hour comparisons for each link segment. The blue line represents the actual traffic counts while the green line shows the results of the first iteration using the Microsimulator and the red line shows the last iteration using the Microsimulator.

Similar to the screenline analysis, the individual link level count comparison by time of day shows some cases where the model matches the existing counts quite well (e.g. Williston Road/Rte. 2), and cases where the fit is relatively poor (Route 116). Generally speaking, however, the modeled diurnal distribution of traffic follows similar patterns as the traffic counts, and the peak traffic volumes tend to approximate the peak traffic counts.

Figure 19: Dorset Street (Collector)

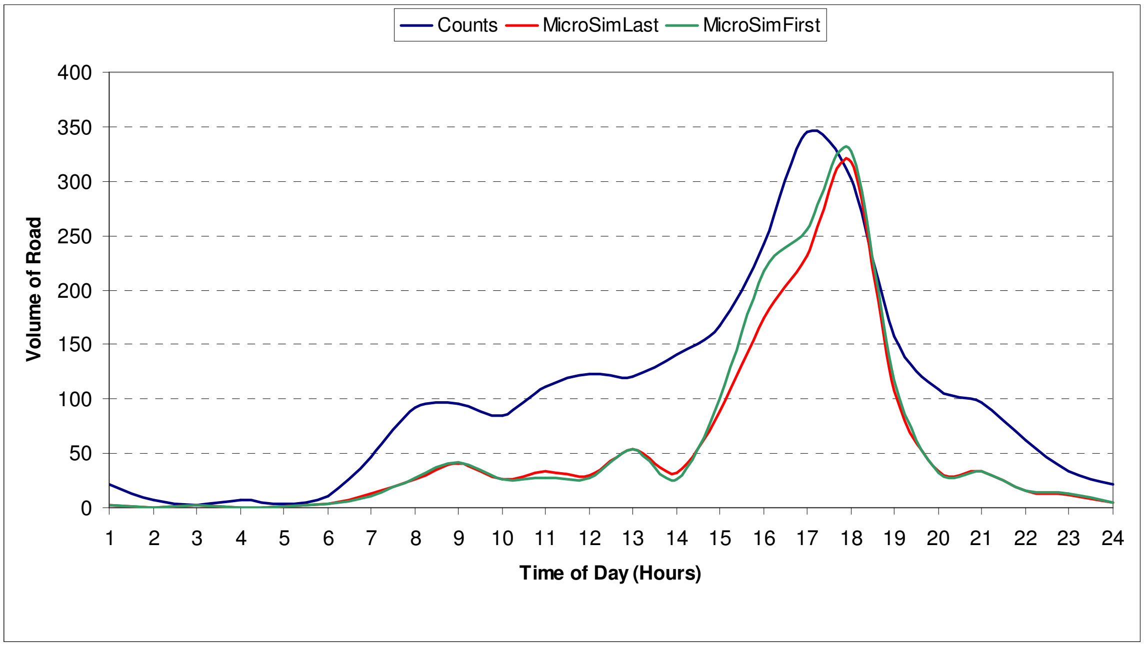


Figure 20: Williston Road (Minor/Major Arterial)

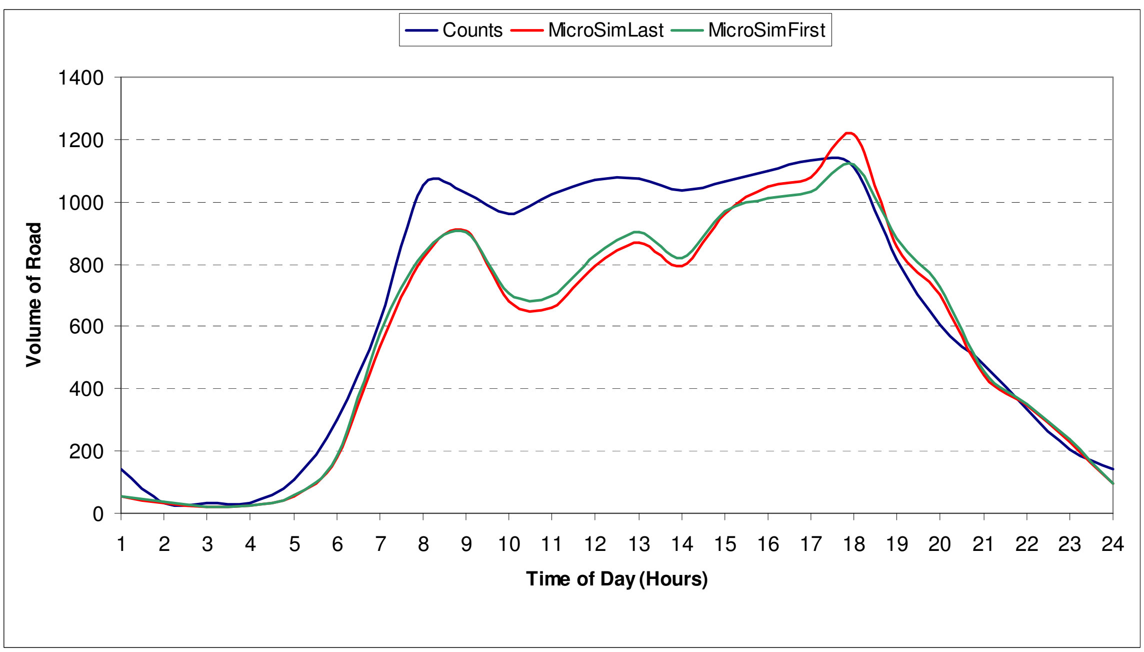


Figure 21: Route 116 (Minor Arterial)

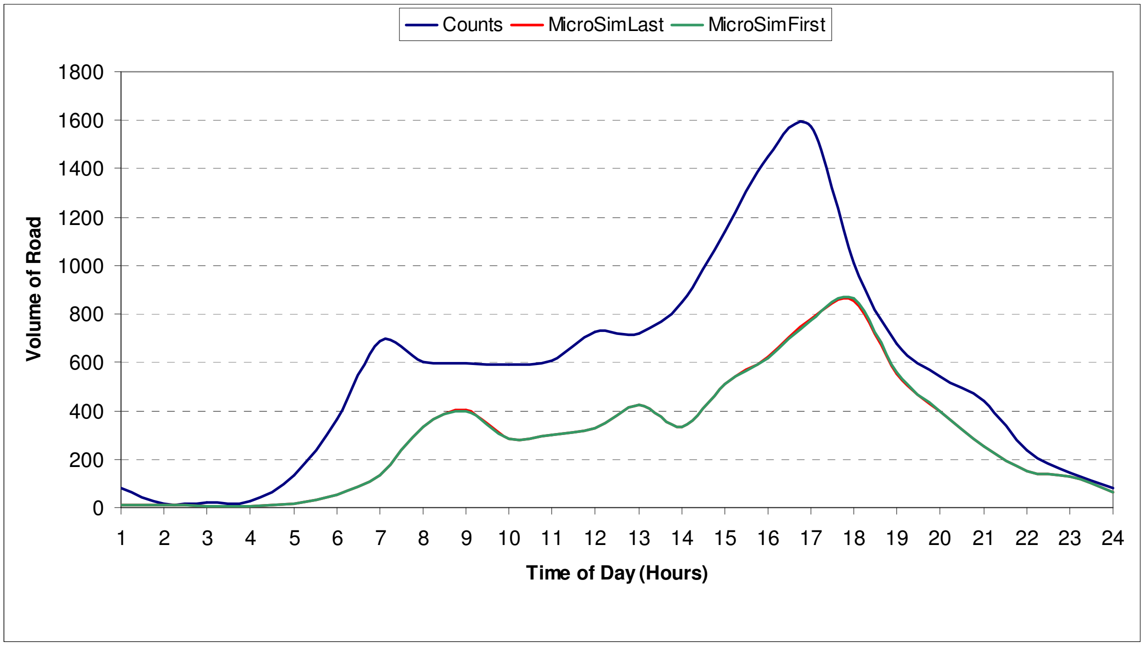


Figure 22: Ethan Allen Highway (Major Arterial)

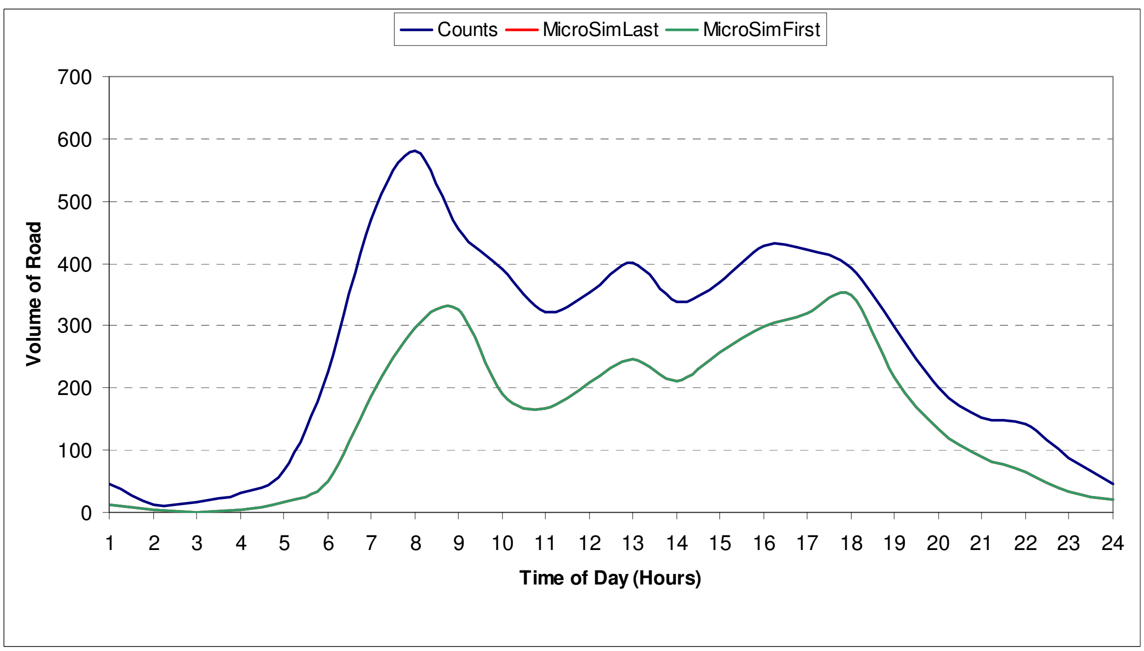


Figure 23: Main Street (Major Arterial)

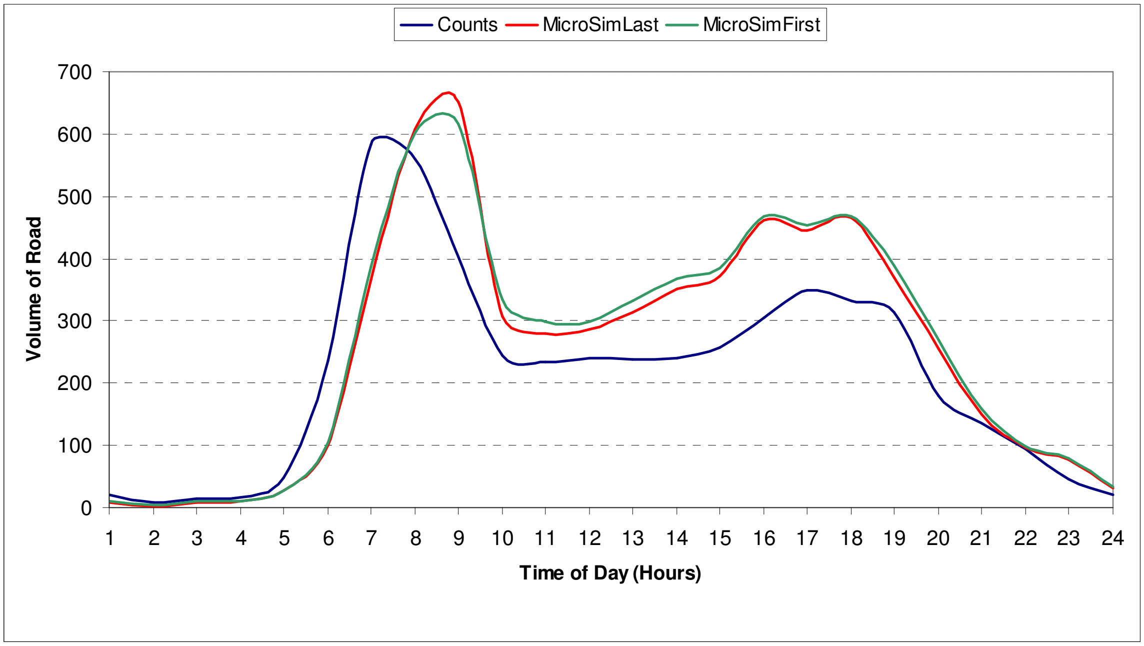
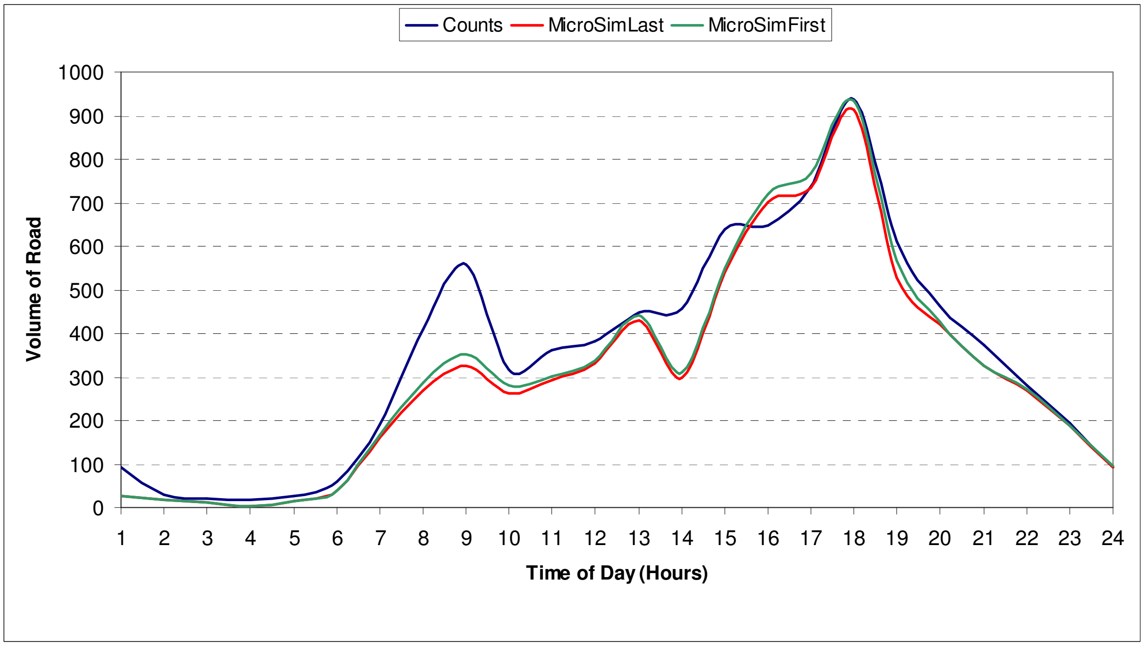


Figure 24: North Avenue (Minor Arterial)



6.4 SPEED COMPARISONS

In addition to individual link-level comparison against counts, we have also compared V/C ratios and operating speeds on two key link segments. The capacities are from the existing CCMPO model, and are LOS C/D capacities. These next two plots show that the average operating speeds are impacted by increases in volume, however, the change in speed by time of day is not dramatic given the large change in volumes by time of day.

Figure 25: Route2 (Williston Road) is a Major East-West Arterial Accessing Downtown

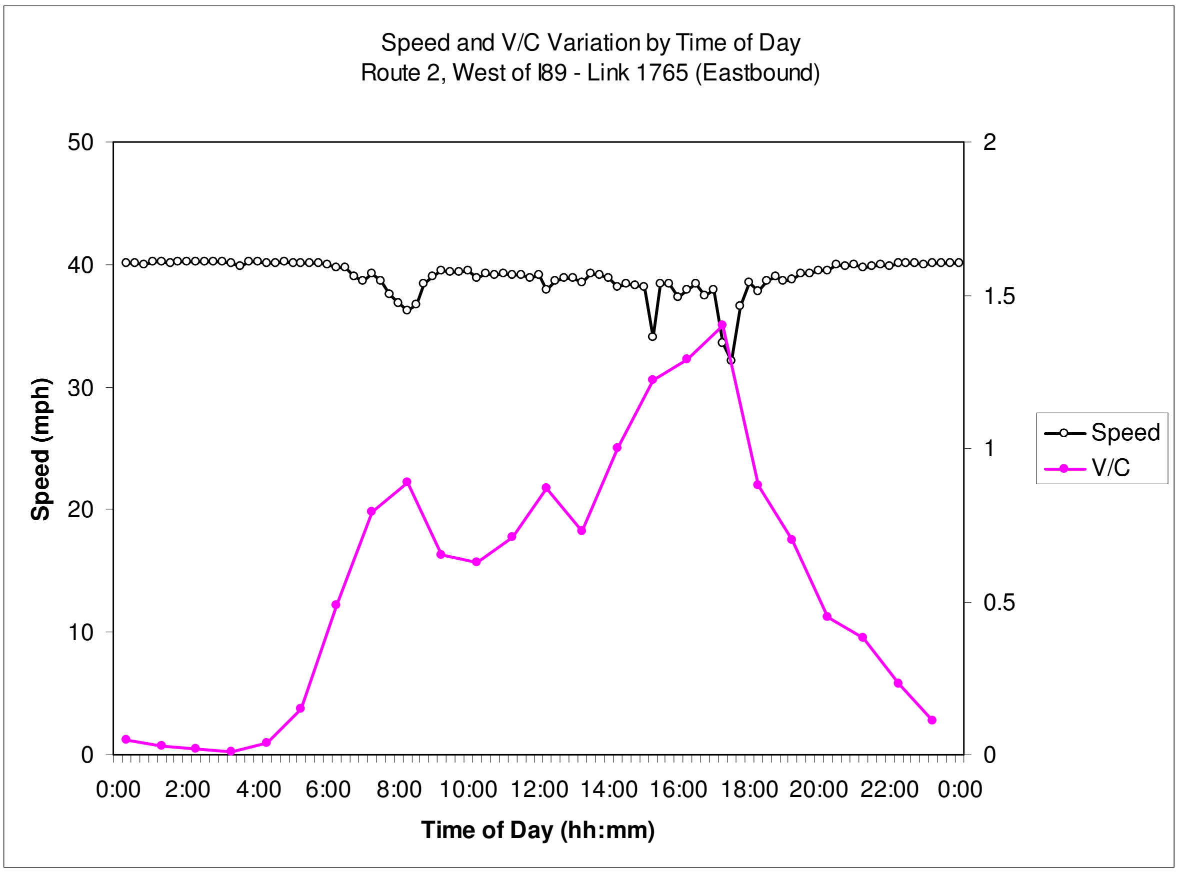
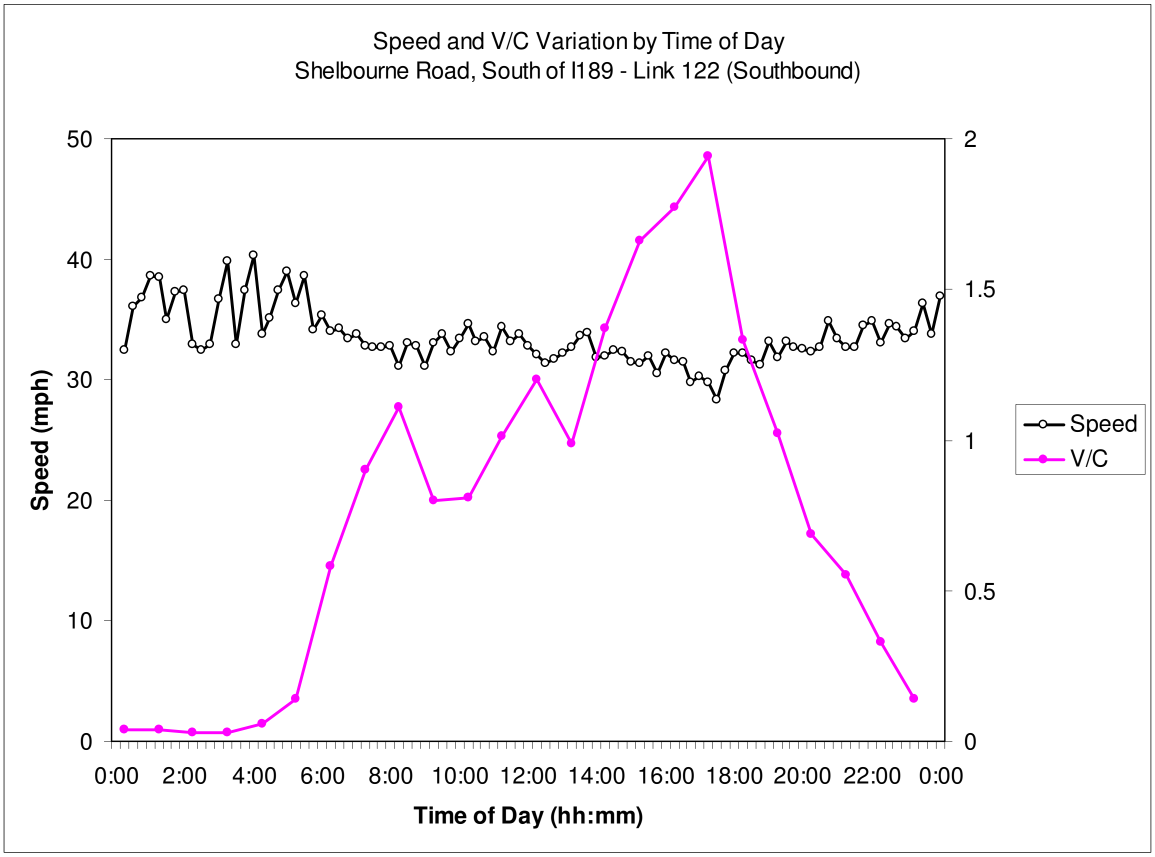


Figure 26: Shelburne Road is a Major North-South Arterial Accessing Downtown



The figures below compare the effects of congestion between the TRANSIMS and 4-step base models. The maps show how the PM Peak congested travel time compares to the travel time computed from the speed limit. Overall the operating speeds are higher in TRANSIMS, in part because the maximum operating speeds are faster in the Microsimulator than the free-flow speeds are in the 4-step model. It is also the case that the change in operating speeds due to congestion is greater in the base 4-step model than in the TRANSIMS model. However, all in all, the congested locations (shown in red) and the most congested locations (shown in black) are similar in the two loaded networks. Also, Interstate 89 experiences little speed deterioration in the PM Peak Hour in the TRANSIMS base case (blue), but shows signs of significant congestion on the 4-step assignment (speeds decrease by at least 33% in many cases).

Figure 27: TRANSIMS Base Year Congestion (ratio of congested time to time if traveling speed limit)

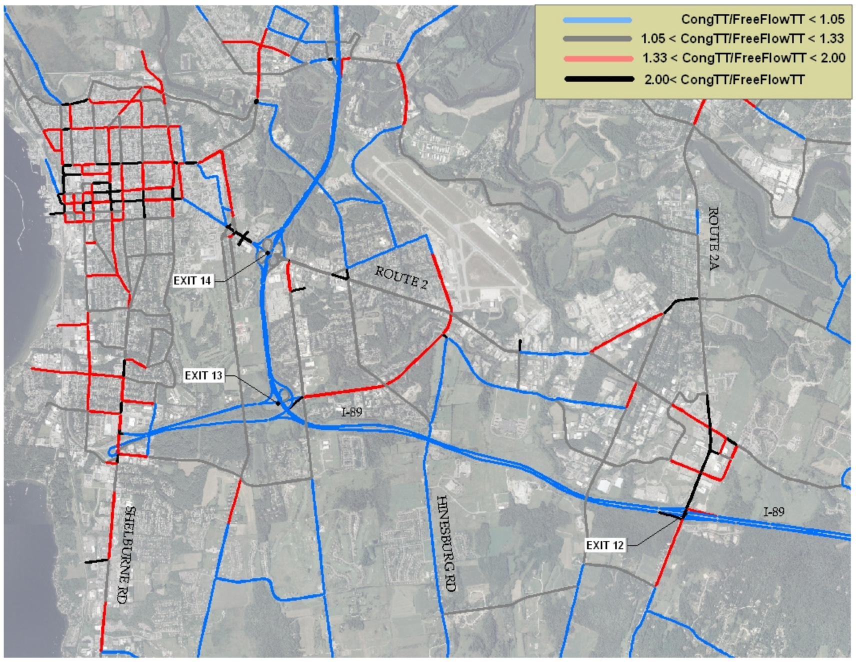
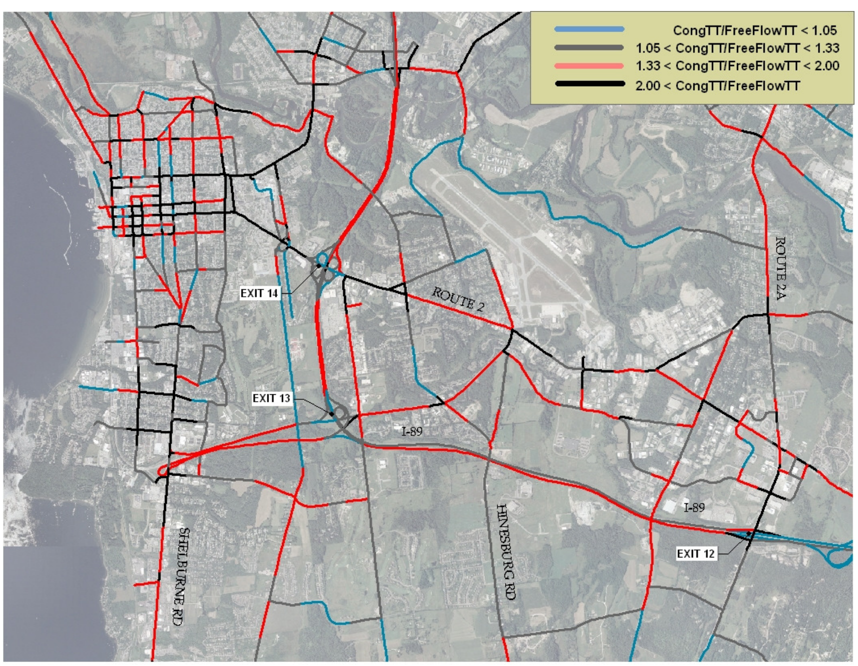


Figure 28: 4-Step Base Year Congestion (ratio of congested time to time if traveling speed limit)



6.5 MODEL CONVERGENCE

Figure 29 shows how regional daily Vehicle Miles Traveled (VMT) and Vehicle Hours Traveled (VHT) converge in the simulation. The graphic shows that as the Microsimulation stabilizes towards user and system equilibrium, the VHT decrease and levels off, while the VMT increases and levels off. Neither statistics changes by more than a few percent overall, but the change appears logical given that the iterative routing will shift travelers onto somewhat faster routes that are often less direct.

Figure 29: Convergence of Regional VMT/VHT

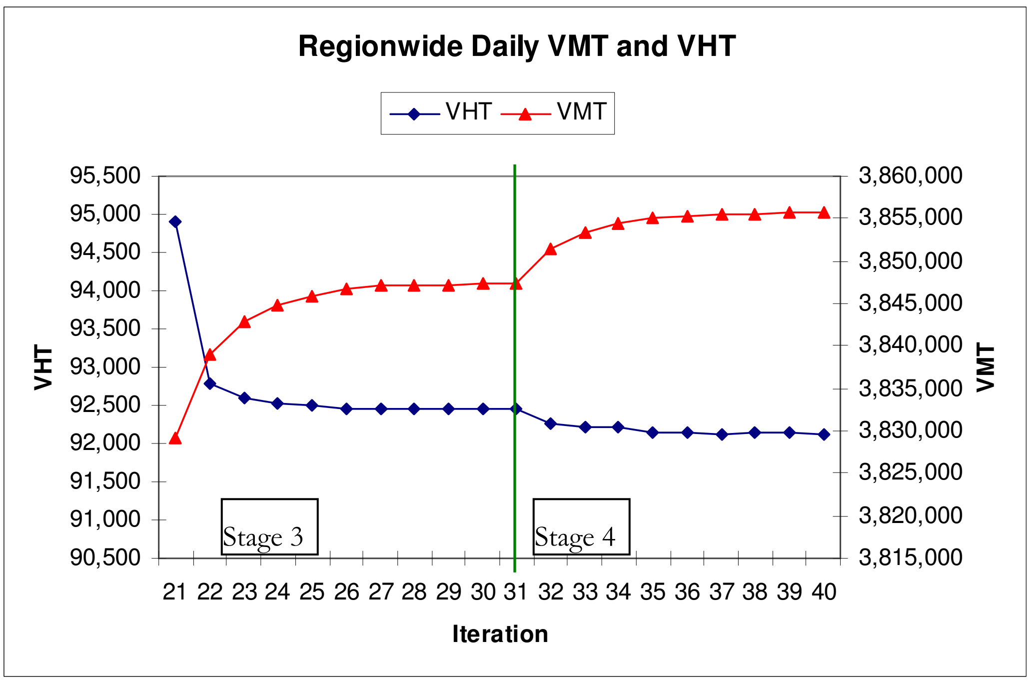
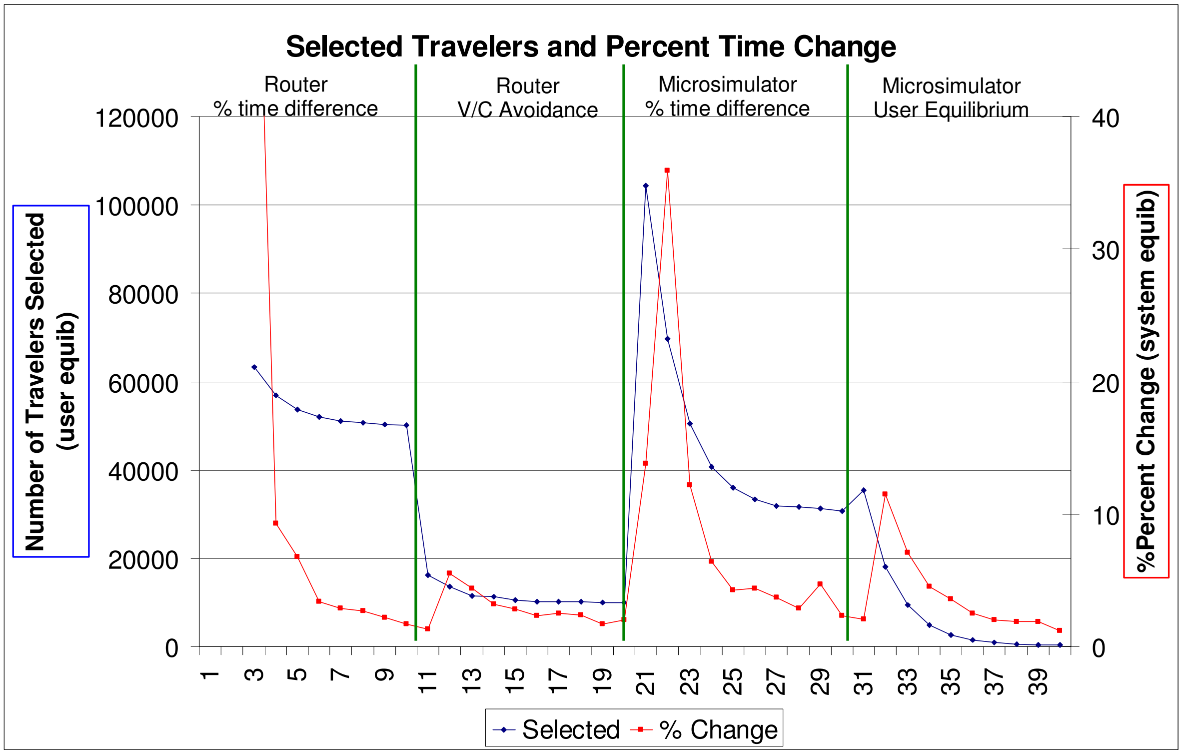


Figure 30 shows the convergence of the model during the phases of the Router and Microsimulator. The blue line represents the number of travelers (cars) that were selected for rerouting given the criteria specified earlier in this report. The red line represents the 99th percentile of travelers whose trip times changed by less than a percentage specified within the model.

Figure 30: CCMPO TRANSIMS Convergence Measurement



To illustrate how to read this graphic, for example, at iteration 23 ninety-nine percent of all travel times changed by 12% or less; the converse is also applicable, one percent of all travelers experience a travel time change of greater than 12%.

In order to assess the how the different values of the V/C criteria impact convergence in the second stage of the convergence process (i.e. router stabilization) we implemented three V/C criteria: 2.0, 1.5 and 1.0, where 1.5 was used for the calibrated model. The influence from these different V/C criterion values on the model convergence property can be seen by comparing the number of selected travelers for re-routing and the travel time change of a certain percentile (99%) of travelers (see Figures 31 and 32).

Figure 31: Convergence Itineraries in Terms of Number of Travelers Selected for Re-routing

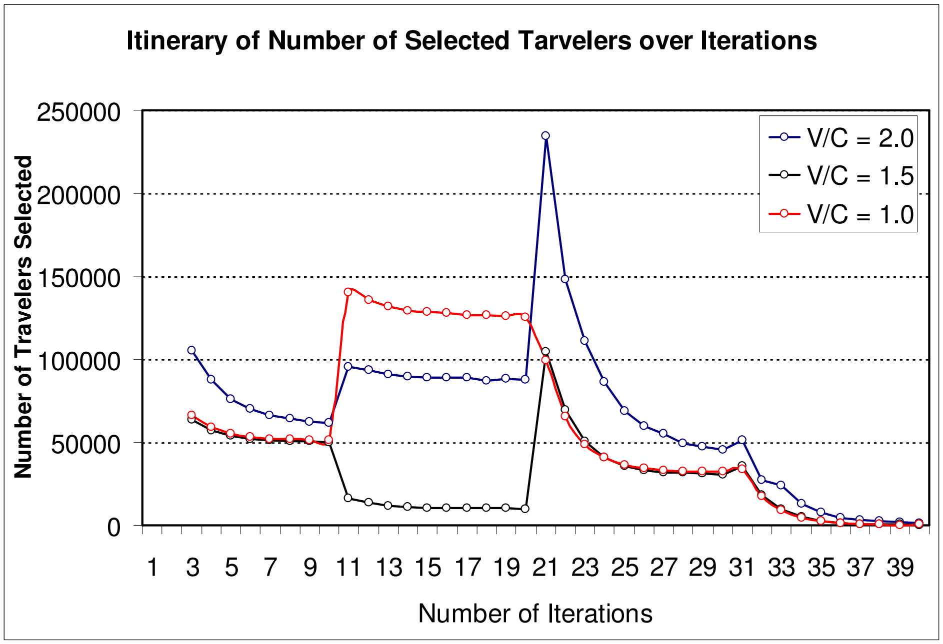
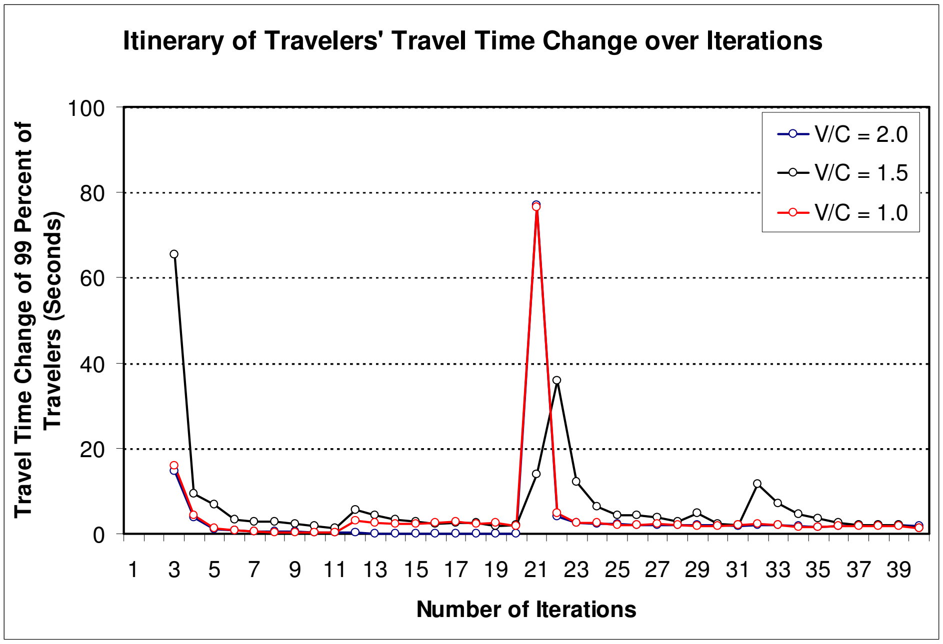


Figure 32: Convergence Itineraries in Terms of Travelers' Travel Time Change



It can be seen from Figures 31 and 32 that all three V/C criterion values result in the final convergence status to almost the same level. This is because the V/C criterion is only applied to the second stage; on the other hand, it also implies that the convergence mechanism in TRANSIMS is rather robust.

It should be noted that the number of selected travelers at each iteration is not only related to the V/C criterion value, but also to the resulting traffic flow conditions over the network. From Figure 31 we can see that the V/C = 1.5 provides the best convergence profile among the three values for the second stage which also means that under this V/C setting the computing time is the least among the three cases.

7.0 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 select number of links on the network was examined. This was performed using both a one hour resolution, as well as a 5-minute resolution.

7.1 RESULTS FOR ONE HOUR RESOLUTION

For the one hour solution, the study focused on looking at variations in the hourly volumes on a total of 10 links distributed across the Chittenden County network. For illustration purposes, Figures 33 and 34 show the hourly volume variations over a 24-hour period for five different seed numbers for 2 representative links. The figures also show the geographic location of each link.

As the plots below illustrate, there seems to be very little variation in the hourly volumes with changes in the seed number used. Visually, the five plots are very close to one another. One possible reason for the seeming lack of randomness is that there are not many things varying randomly in the simulation. The trip table is fixed, and so is the 15-minute diurnal distribution, but individual trip start times can change within a 15-minute interval.

Figure 33: Hourly Variation in Volumes on Dorset Street with Different Seed Numbers

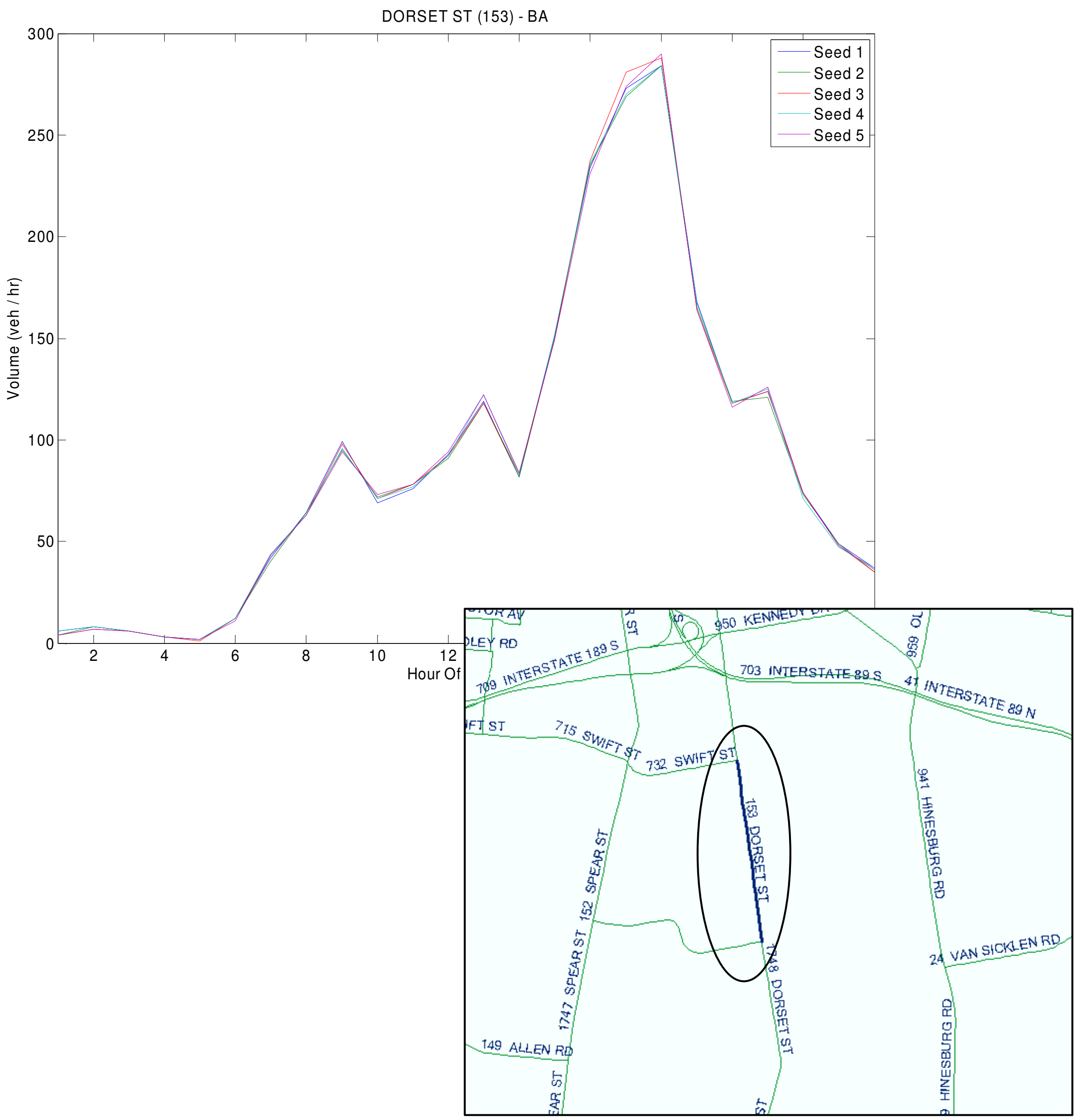
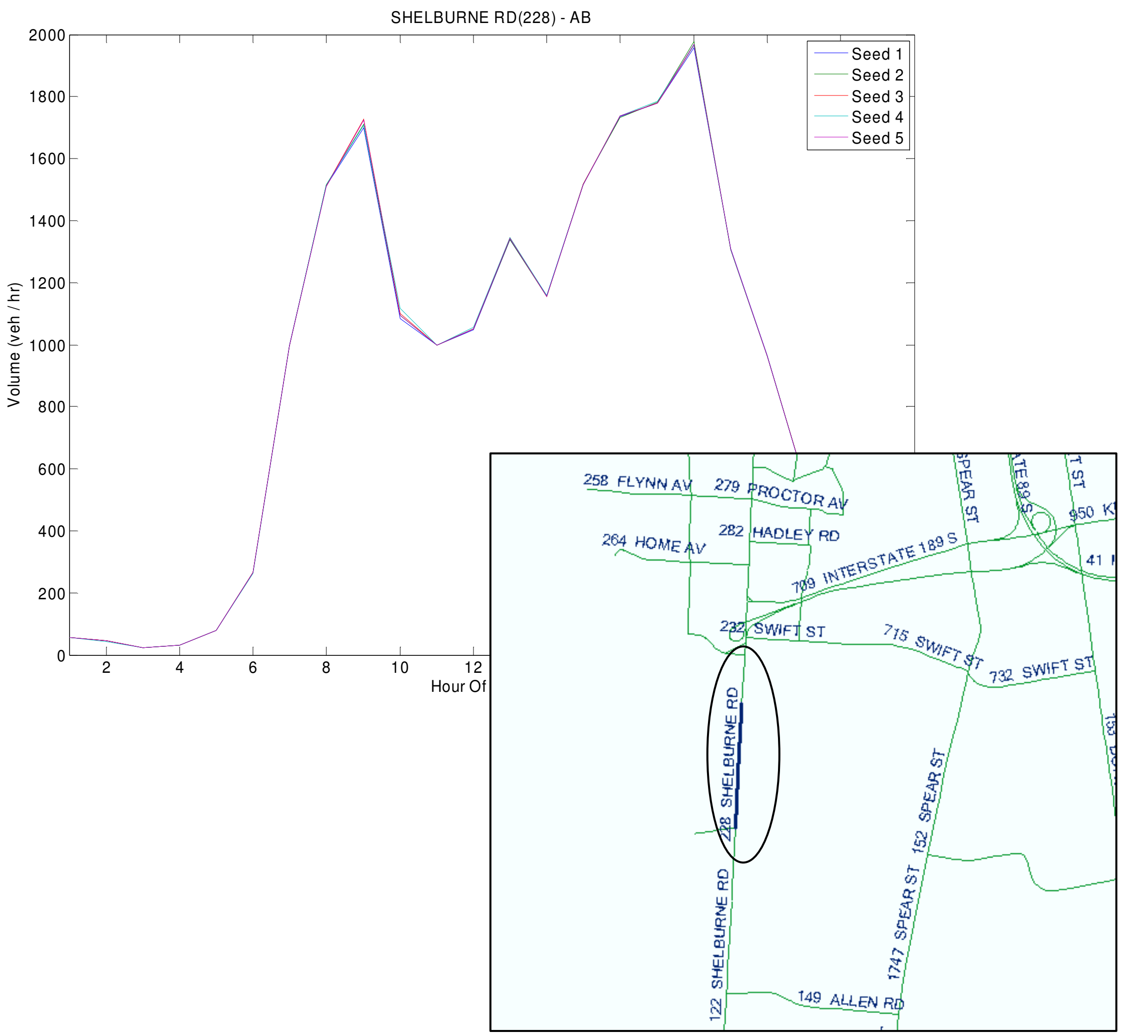


Figure 34: Hourly Variation in Volume on Shelburne Road with Different Seed Numbers



The average value of the coefficient of variation was calculated and the minimum and maximum values reported. As is well-known, the coefficient of variation is defined as the ratio of the standard deviation to the mean, and provides a measure for assessing the degree of variation relative to the mean value. **Error! Reference source not found.**4 lists the average, minimum and maximum values of the coefficient of variation for the different links. As can be seen from Table 14 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 14: 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

7.2 RESULTS FOR 5-MINUTE RESOLUTION

To shed more light into the variation of the model results with the seed number, the study looked into 5 minute volume and speed variations along the 10 selected links referred to above. For illustration purposes, Figure 35 and Figure 36 show the variation on Dorset Street, which is representative of other links. In addition, the values of the coefficient of variation were also examined. In this case, the coefficient of variation was calculated for each 5 minute period, and the average (of 24 * 12 data points), minimum and maximum values were recorded. Once again, the coefficient of variation indicated very slight variations among the different seed numbers for both volumes and speeds. The numbers were similar to the values shown previously, so they are not presented.

You will notice more variance in travel speeds in the early hours of the day than in the peak hours on Shelburne Road. This is due to there being relatively few trips very early in the morning, and the small sample size leads to higher variation in speeds depending on whether delay is incurred at a traffic signal.

Figure 35: Speed Variation on Dorset Street with Different Seed Numbers (5-minute)

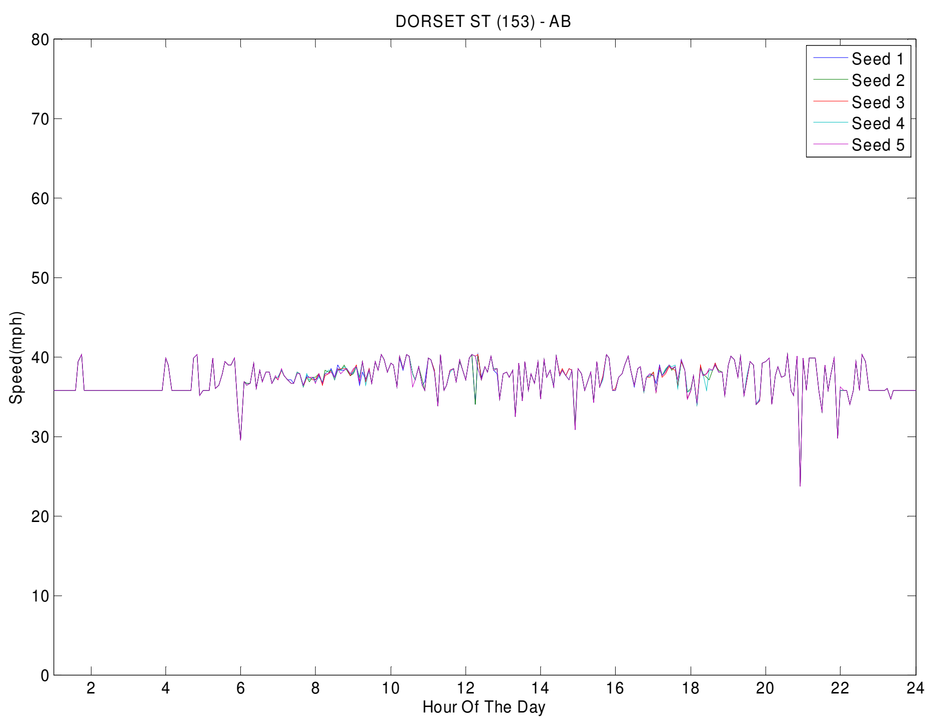


Figure 36: Volume Variation on Dorset Street with Different Seed Numbers (5-minute intervals)

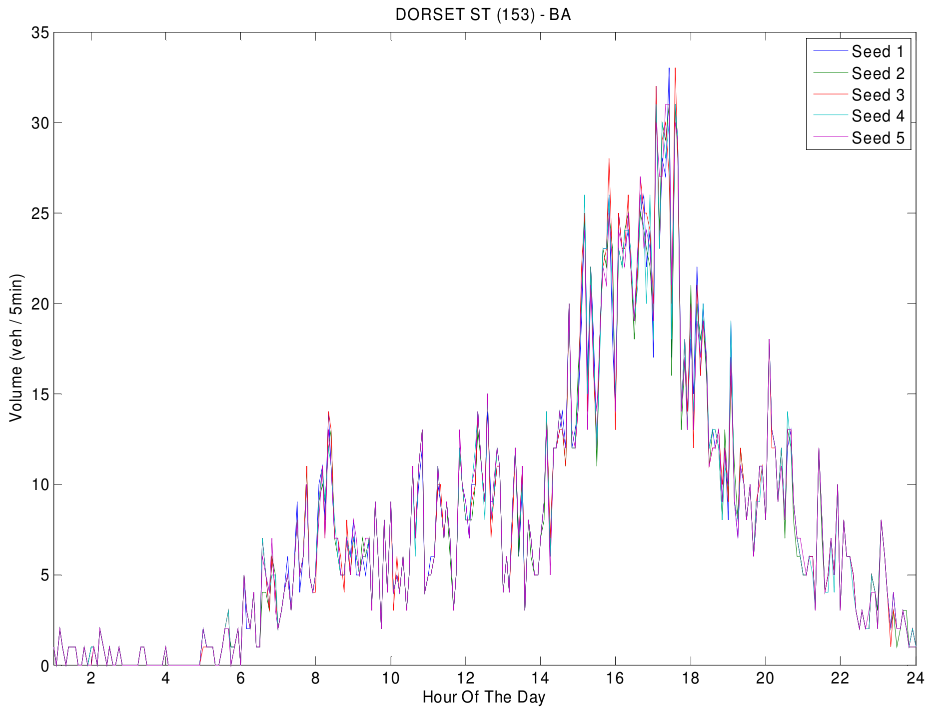


Figure 37: Speed Variation on Shelburne Road with Different Seed Numbers (5-minute)

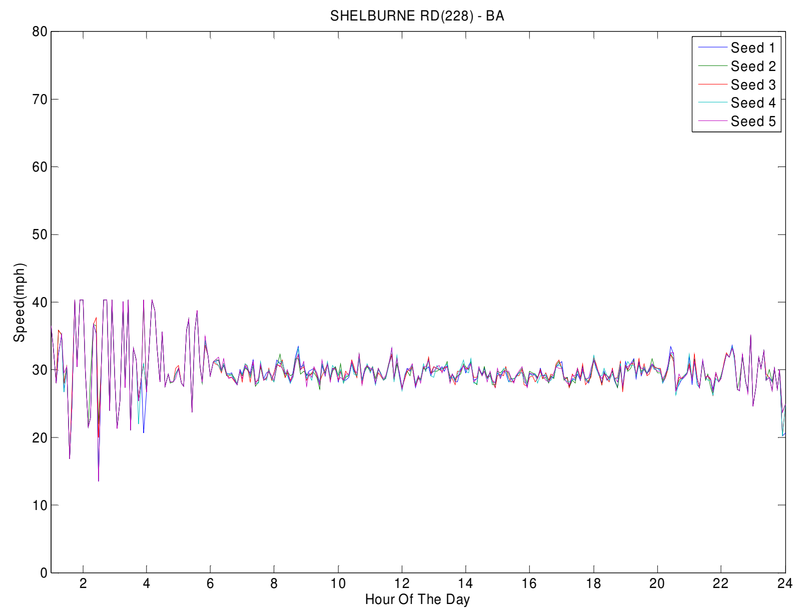
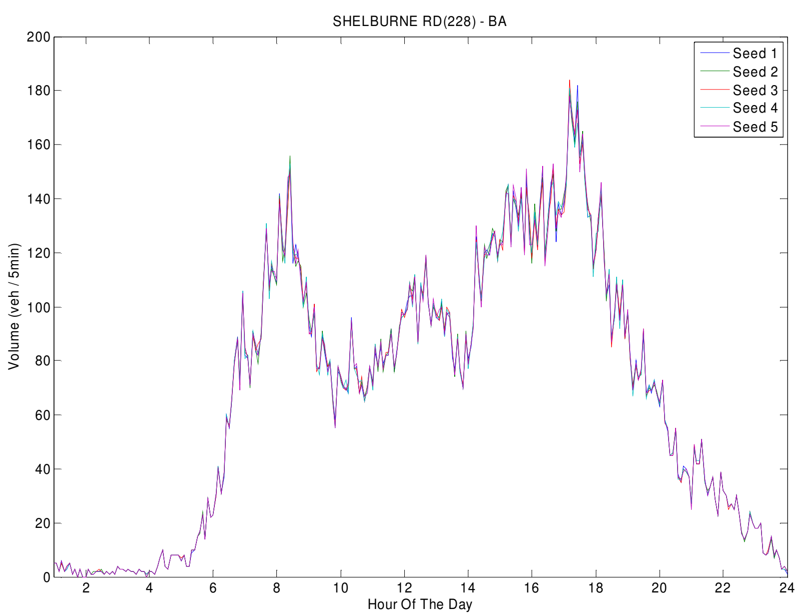


Figure 38: Volume Variation on Shelburne Road with Different Seed Numbers (5-minute)



8.0 SENSITIVITY TO THE USE OF ACTUATED CONTROLLERS VERSUS PRE-TIMED

Owing to the lack of accurate information about the setting for the actuated controllers in the county, the base TRANSIMS model was developed assuming pre-timed controllers at all signalized intersections. Given this, an important sensitivity test was to assess how the results of the model varied with the use of actuated controllers versus pre-timed. To test this, a total of 15 key intersections around the County were selected. Those intersections were located along two corridors in the County, Williston Road (Route 2) and Shelburne Road (Route 7), as shown in Figure 39 and Figure 40.

The signal timing plans for those 15 intersections were changed from pre-timed to actuated. For the actuated controllers, the following parameters were used:

(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

To assess the sensitivity of the model results to those changes, the change in the travel time on the entering links to each intersection, between the actuated case and the pre-timed case, was calculated. The results are shown in Figure 39 through Figure 43 for each of the 15 intersections. Specifically, the difference in travel time (in seconds) is recorded above each link, where this difference is calculated as the travel time for the actuated case minus the travel time for the pre-timed case. In other words, a negative value would indicate that the travel time on the links has decreased as a result of implementing an actuated controller versus a pre-timed one. A simple color scheme was used in generating these plots, with red and green refereeing to negative values (i.e. the actuated controller has reduced the travel time or delay), and blue referring to an increase in travel time.

It should also be noted that the results plotted are those for the hour between 7:00 and 8:00 pm. The reason an off-peak hour was selected to portray the results (versus a peak hour) is the fact that one should expect an actuated controller to be more effective in reducing the delay during off-peak periods, since during peak periods, actuated controllers function quite similarly to pre-timed controllers given the high traffic demand. One also should expect actuated controllers to be more effective in reducing the delay for the side streets, versus the main road, which is also what can be seen from the plots.

Figure 39: Modified Signals along Williston Road (Route 2)

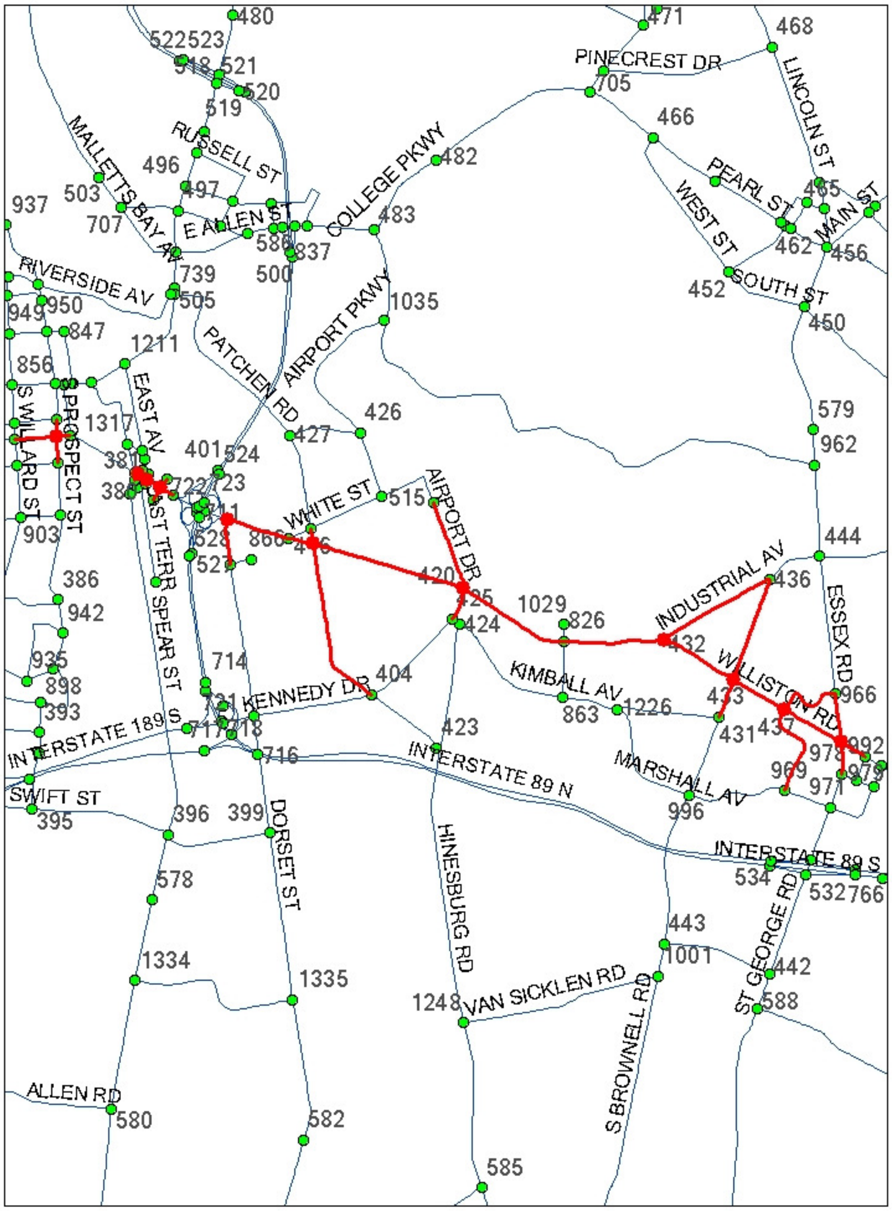


Figure 40: Modified Signals along Shelburne Road

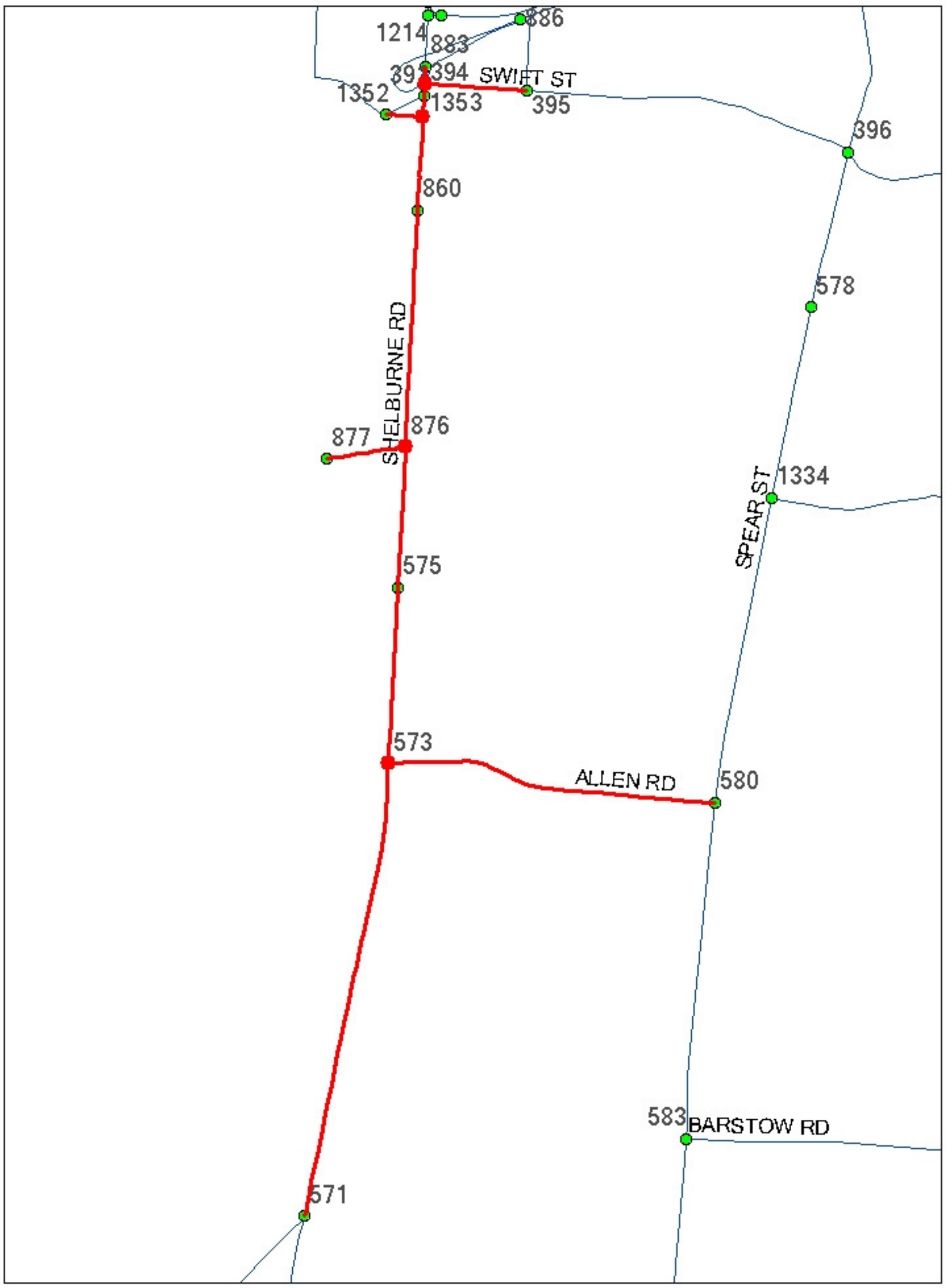


Figure 41: Changes in Travel Time for Select Signals along Shelburne Road (seconds)

Figure 42: Changes in Travel Time for Select Signals along Williston Road (seconds)

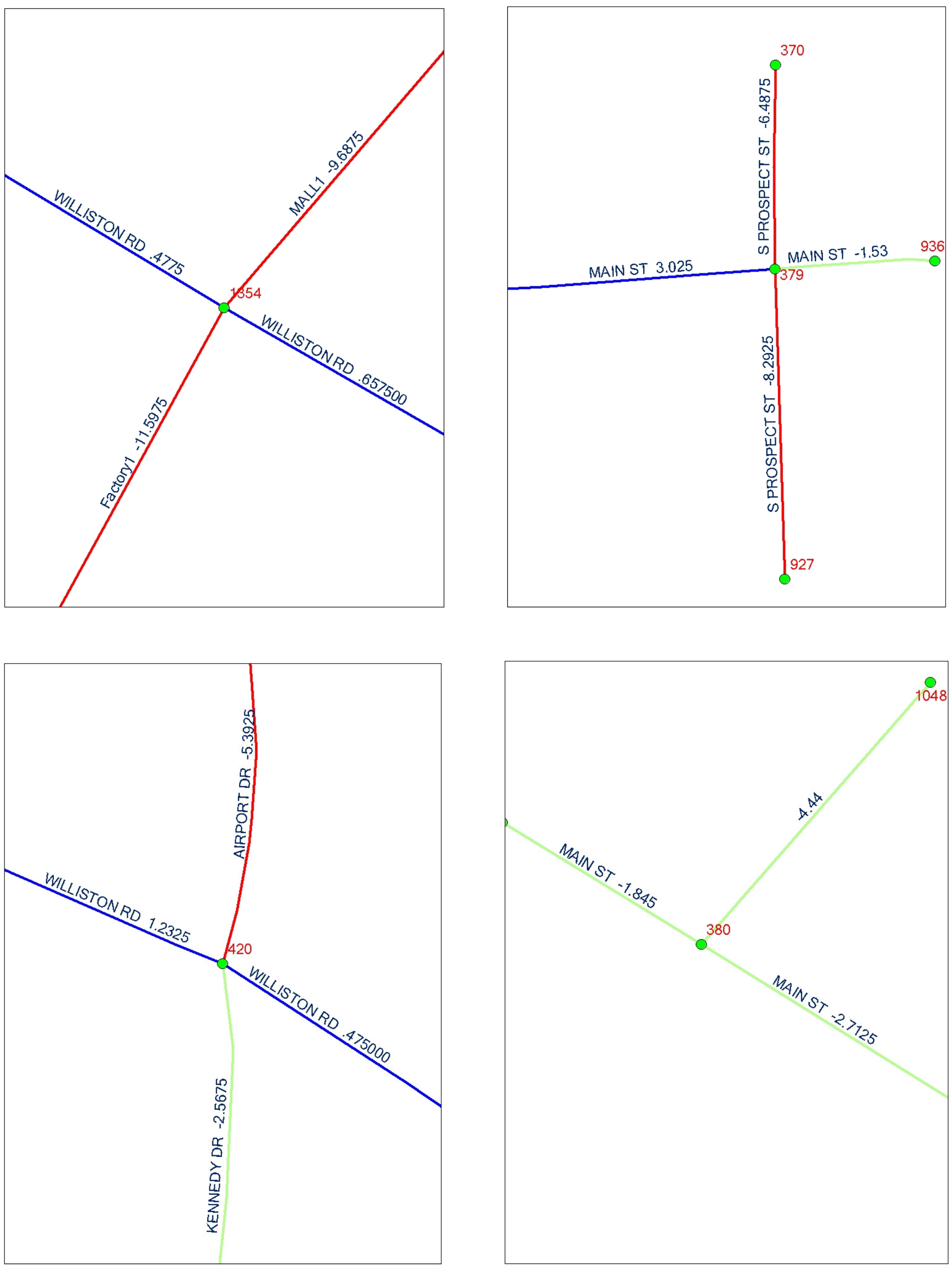
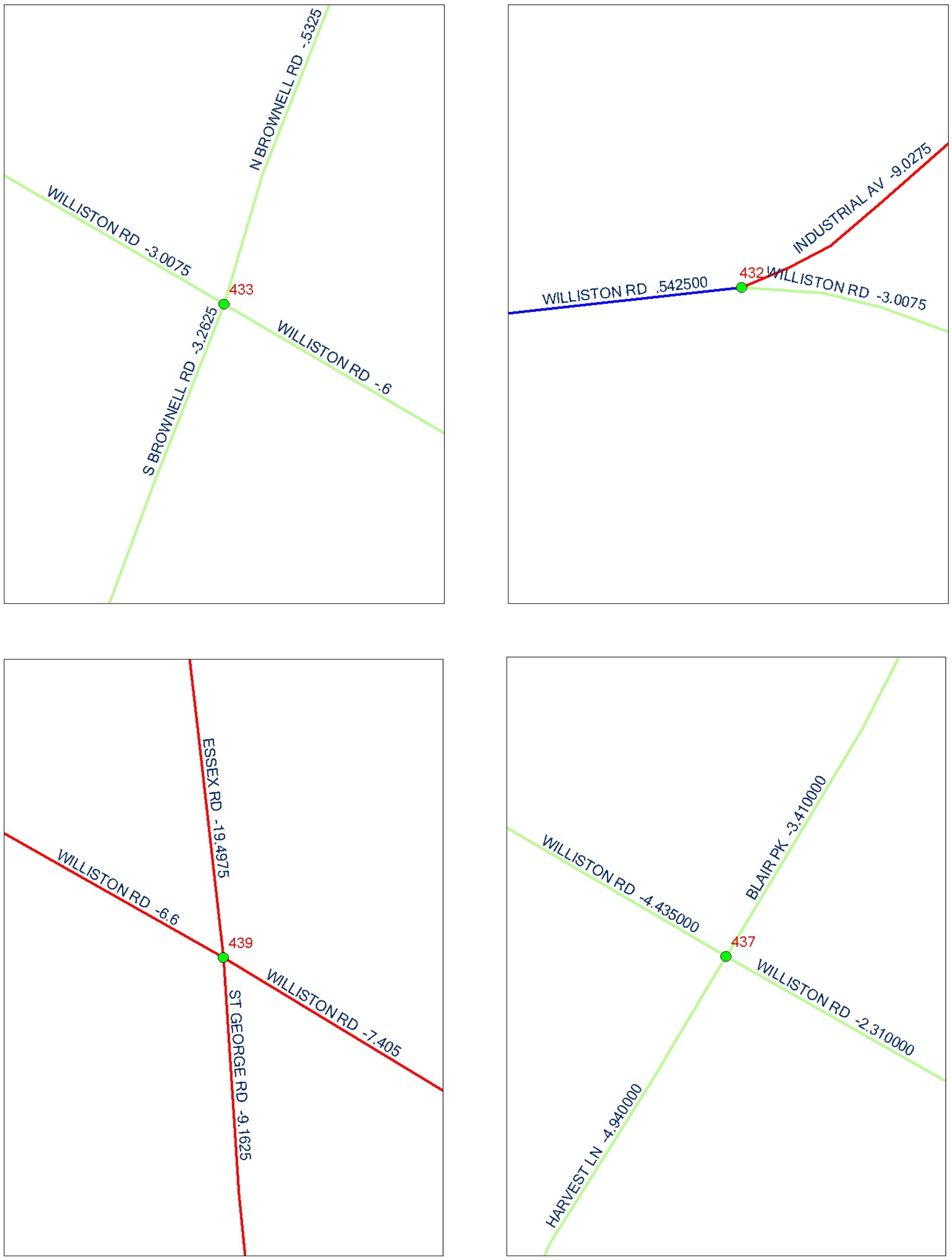


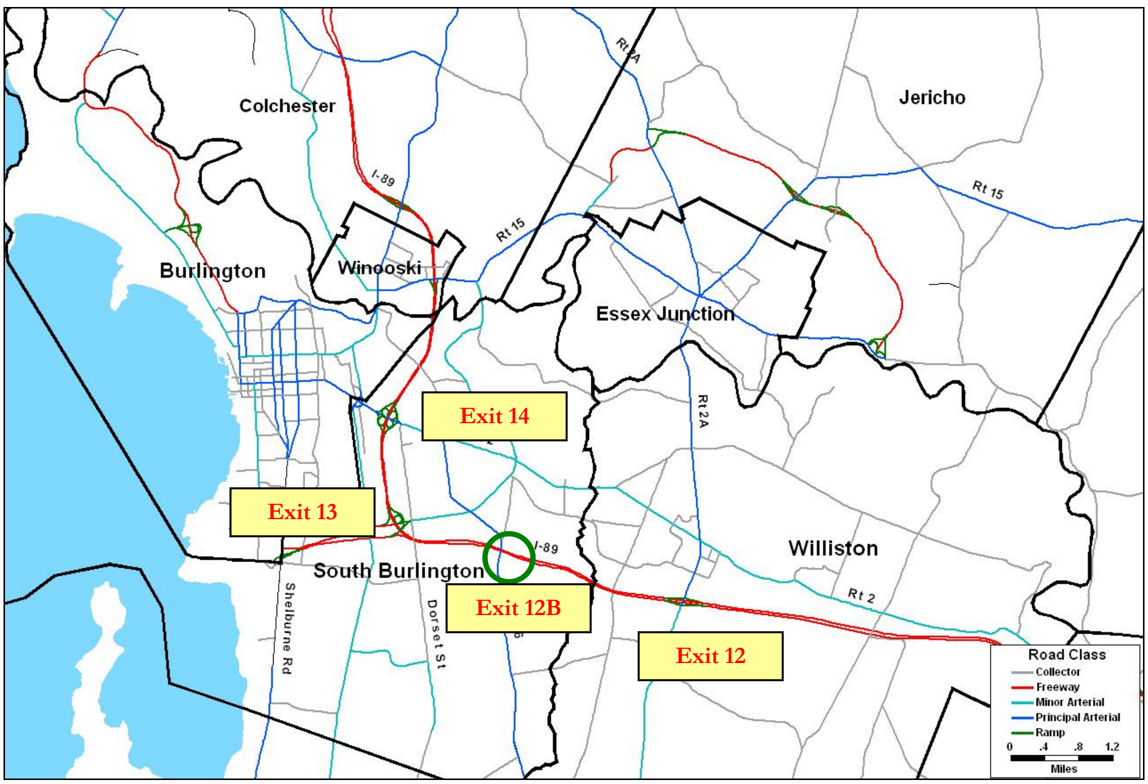
Figure 43: Changes in Travel Time for Select Signals along Williston Road Cont.



9.0 SCENARIO TEST – EXIT 12B

Interstate 89 runs through the heart of Chittenden County from the south-east to the north-west. The interstate is used not only by external traffic accessing places within the county but also by local traffic avoiding congestion on local roads. Exit 14 provides access to the downtown and to major employment centers to the east. Exit 13 only provides access to Interstate 189 which is a small stub that heads to the west and provides access to the Shelburne Road commercial area. This leaves exit 12 to provide access to several communities such as Williston, Essex Junction, and parts of South Burlington.

Figure 44: Location of Exit 12B



Directly off Exit 12 is also the largest "big box" store area in the county. Consequently, Exit 12 is heavily congested and traffic accessing areas to the north must pass through the local traffic generated by the big box stores. For these reasons, an additional interchange, Exit 12B, is being considered by the CCMPO. To test this scenario, we implemented Exit 12B in both the TRANSIMS model and the 4-Step model.

Both models performed reasonably well (keep in mind that the same trip table was used in both models). Both models exhibit two key findings which we expect:

1. Traffic which previously used Hinesburg Road from downtown and other areas north now use Exit 14 to access the interstate and travel to Exit 12B where they get off.
2. Similarly, traffic which used to use Exit 12 now stays on the interstate and gets off at Exit 12B heading north.

When comparing these models side by side one sees very similar results.

Figure 45: : TRANSIMS Absolute Differences in Volumes

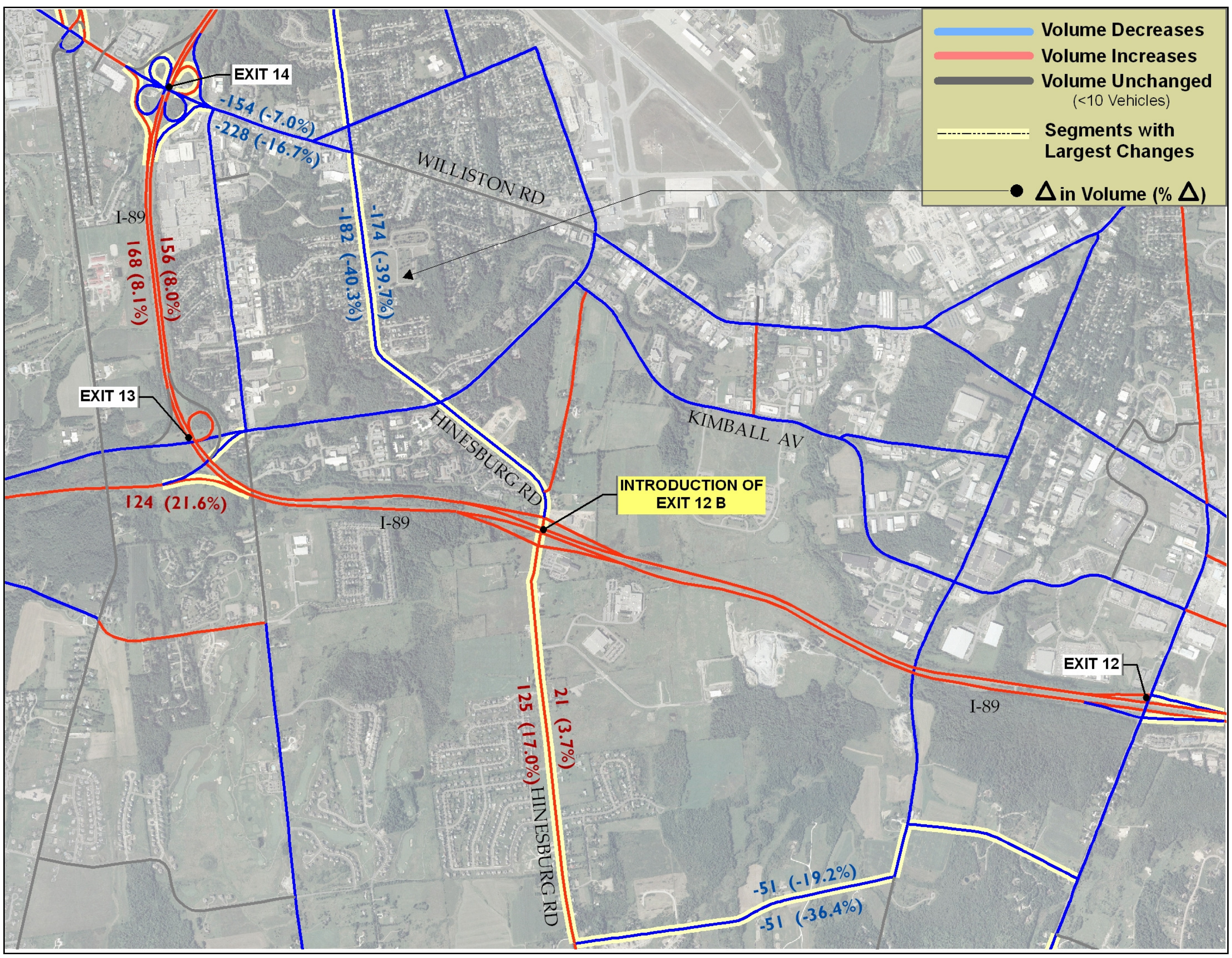
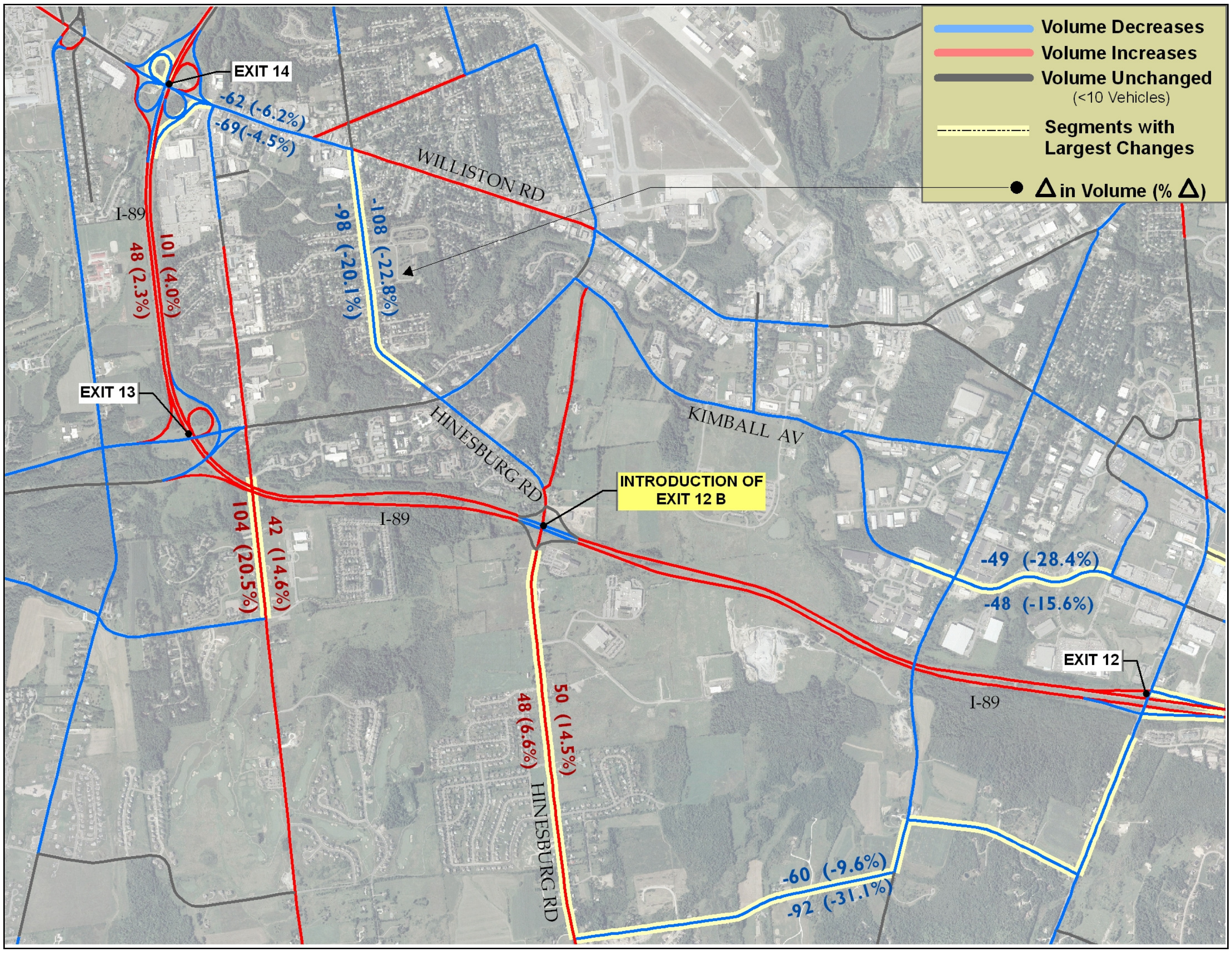
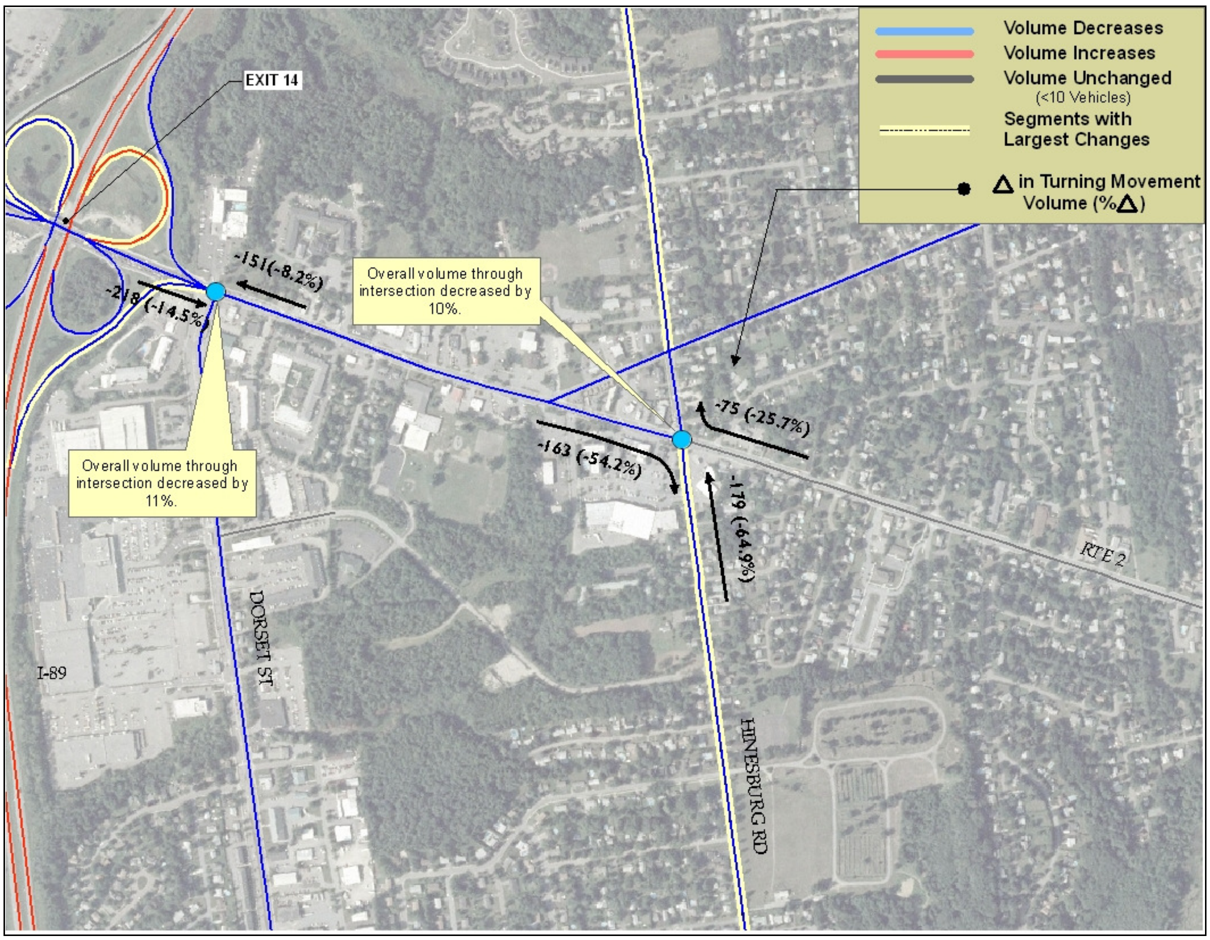


Figure 46: 4-Step Absolute Differences in Volumes



In addition to the decrease in volume on the road, Exit 12B would provide significant reduction in congestions at key intersections. Figure 47 shows two major intersections along Route 2 whose volume would decrease by as much at 10% if the proposed exit were constructed.

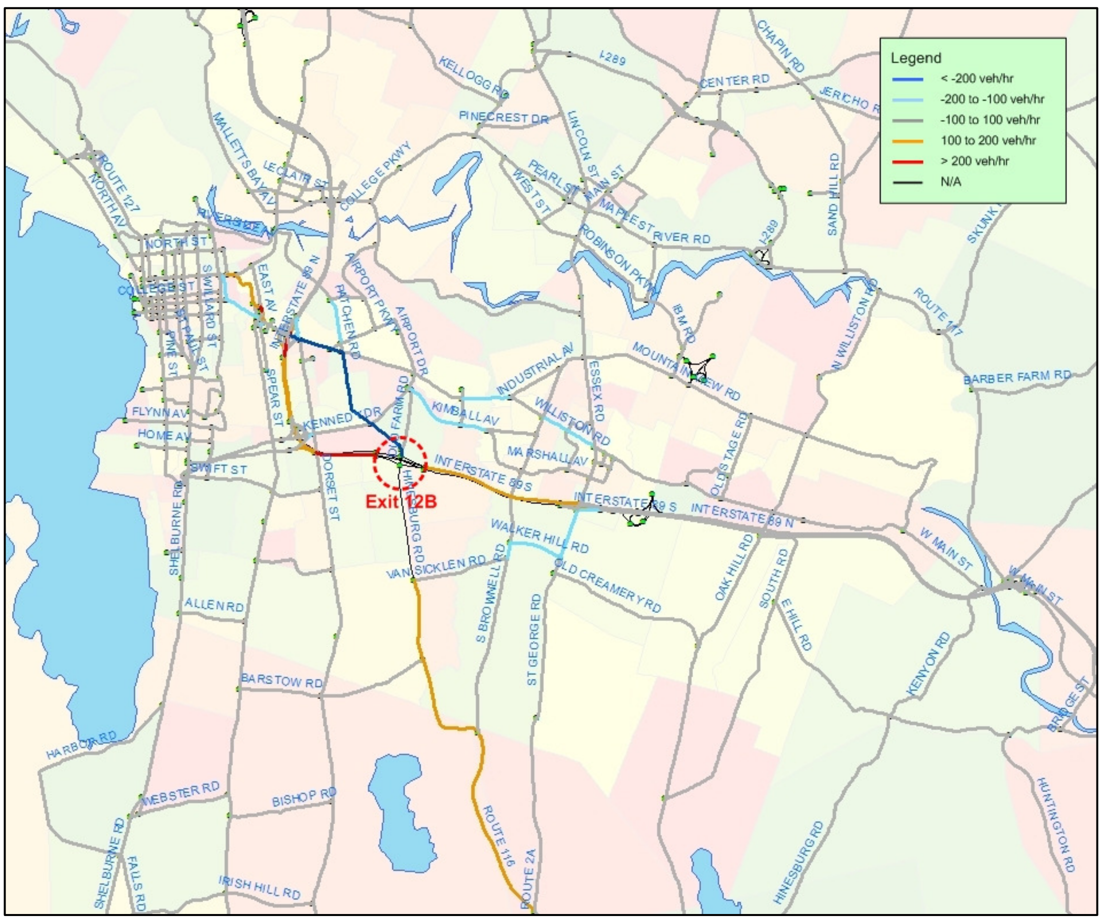
Figure 47: Intersection Volume Change



There is a difference between the two models when it comes to vehicle speeds. This is because the volume/delay curves employed in the 4-step model are continuous and show changes in operating speeds with even minor changes in volume. TRANSIMS, where delays are a function of more accurate representation of signal timing, may not show such delays until queuing reaches a certain level. This is even more important on the interstate with small relative increases in volumes which will not impact TRANSIMS travel times at all until congestion reaches a certain point.

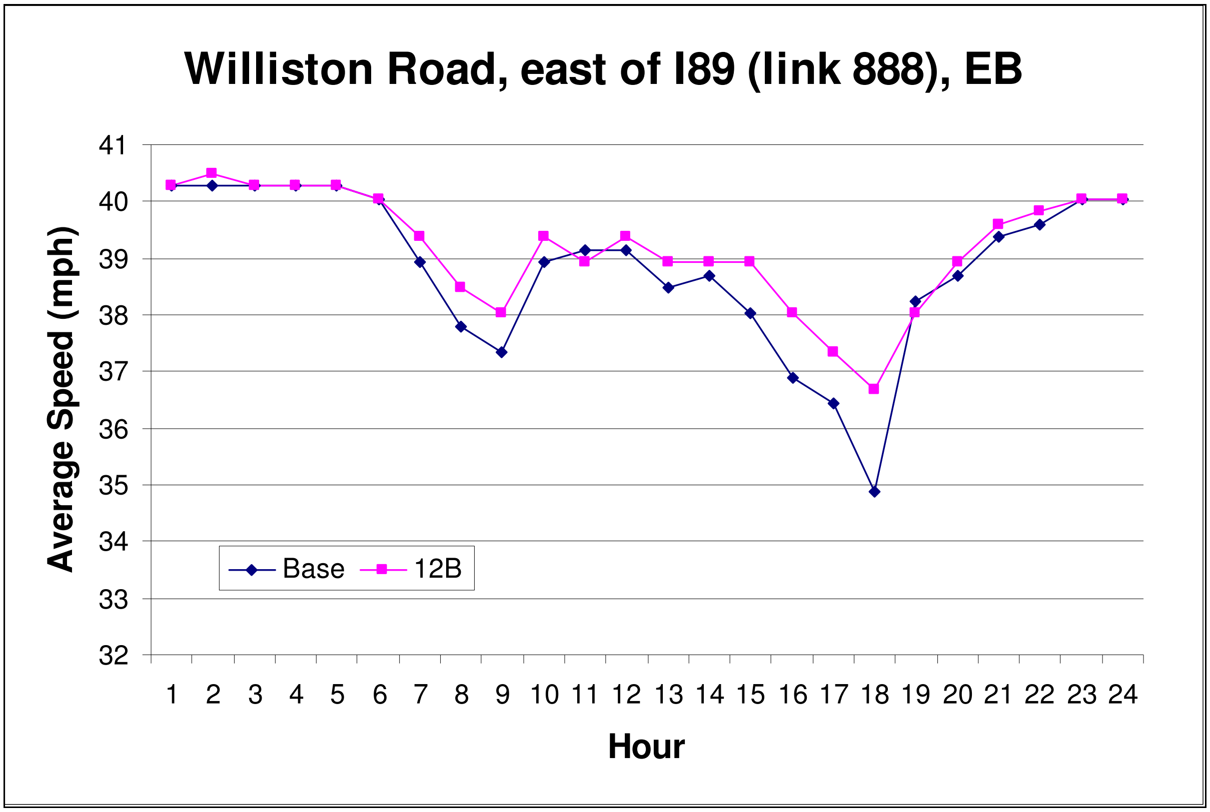
In addition to analyzing the area around Exit 12B, we also were interested in whether the model produced any anomalous changes away from the area where network changes were made. For example, we were interested as to whether the well-known Braess' paradox, in which adding extra capacity to a user-equilibrium system reduces the network performance, might occur. Thus, we evaluated the change of the traffic flow pattern over the whole network. Figure 48 clearly shows that as expected, the significant traffic flow changes merely occur in the vicinity of Exit 12B. For example, it attracts more traffic to use the I-89 section between Exits 12 and 14, while the traffic using Williston Rd and Hinesburg Rd (in the north of I-89) is reduced significantly. The overall impact caused by Exit 12B on the traffic flow outside the study area is marginal.

Figure 48: Traffic Volume Change over the Network



The following figure illustrates that operating speeds are impacted on selected links in the Exit 12B scenario within TRANSIMS. In this case, the average operating speed on Williston Road (Route 2 which connects to I89 at Exit 14) increases notably in the PM peak hour.

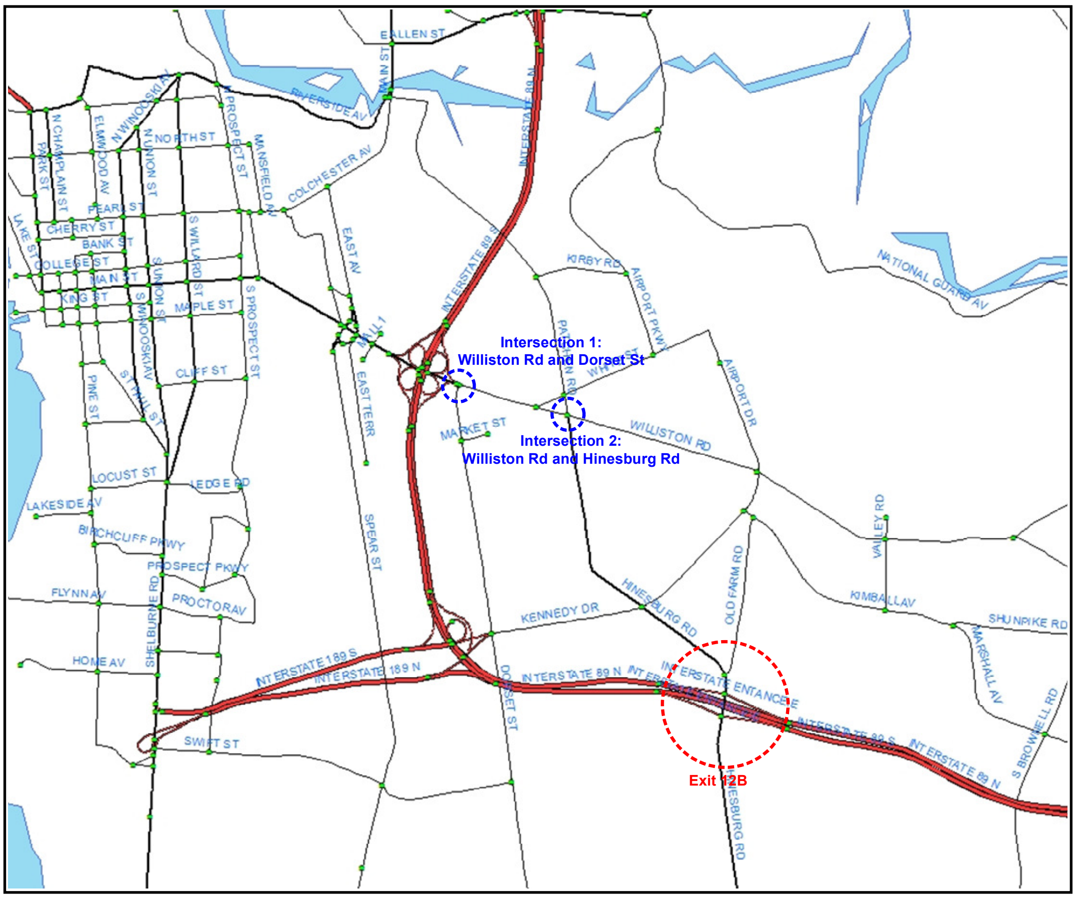
Figure 49: CCMPO TRANSIMS Operating on Williston Road EB with Exit 12B in Place



After comparing the two models at the link-level, we then focused on the intersection level where the signal timing that existed during calibration no longer applies after Exit 12B was implemented. We spent a little time attempting to improve signal timing and concluded that volumes did change but not dramatically. For future use of this tool in general planning studies we suggest that it would be appropriate to identify the signals where timings need to be altered and then to implement fully actuated signal timing during initial scenario testing. Later, the signal timing capability within the Microsimulator could be used to further refine the plan.

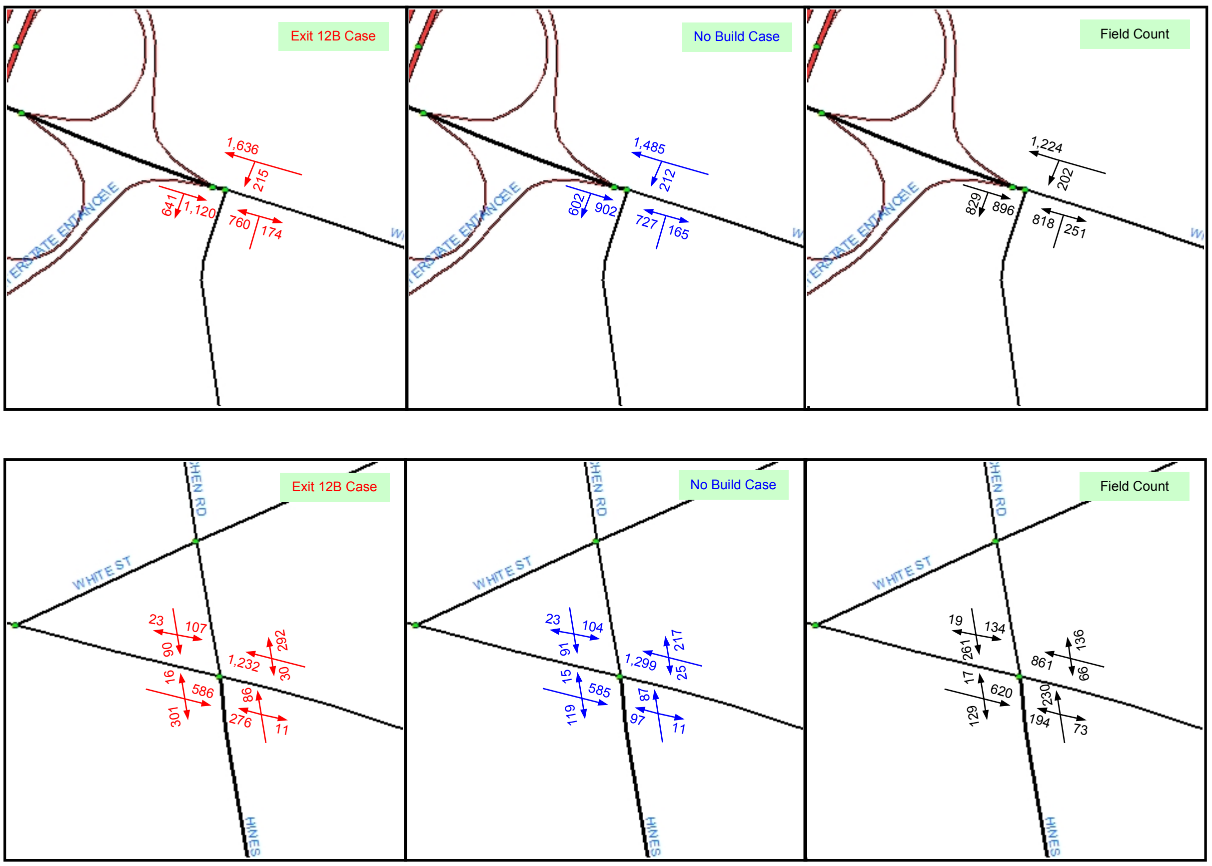
To further quantify the local traffic impacts caused by Exit 12B we evaluated the turning movements at the two selected intersections on Route 2 (Williston Rd), which is one of major roadways on which the introduction of Exit 12B has a significant influence. The locations of the two intersections are shown in Figure 50.

Figure 50: The Locations of Two Selected Intersections for Evaluating Turning Movements



The turning movements at these two intersections are compared between the no-build cases and build case of Exit 12B as well as the observed (counted) turning movement data from the field survey, as shown in Figure 51. The average error in turning movements of the no-build case over the field counts is about 21% which is extremely accurate considering no attempt was made to calibrate to the turning movement level. In comparing the 12B scenario to the no-build scenario, the volumes decreased by 10% and 12% which was also considered plausible.

Figure 51: Turning Movements at the Two Key Intersections on Route 2



Finally, we performed a demand location analysis by tracking the origins and destinations of drivers who use Exit 12B for their trips. The purpose of this analysis is to identify the size and distribution of the residential population that makes a route change due to the introduction of Exit 12B. Figures 52 and 53 respectively provide the information of the origin distribution and destination distribution of travel demands using Exit 12B. These figures reveal that a large number of travelers who use Exit 12B are commuting between the north and south parts of the network, for which Exit 12B provides them with a convenient access to I-89.

Figure 52: The Origin Distribution of Travel Demands Using Exit 12B

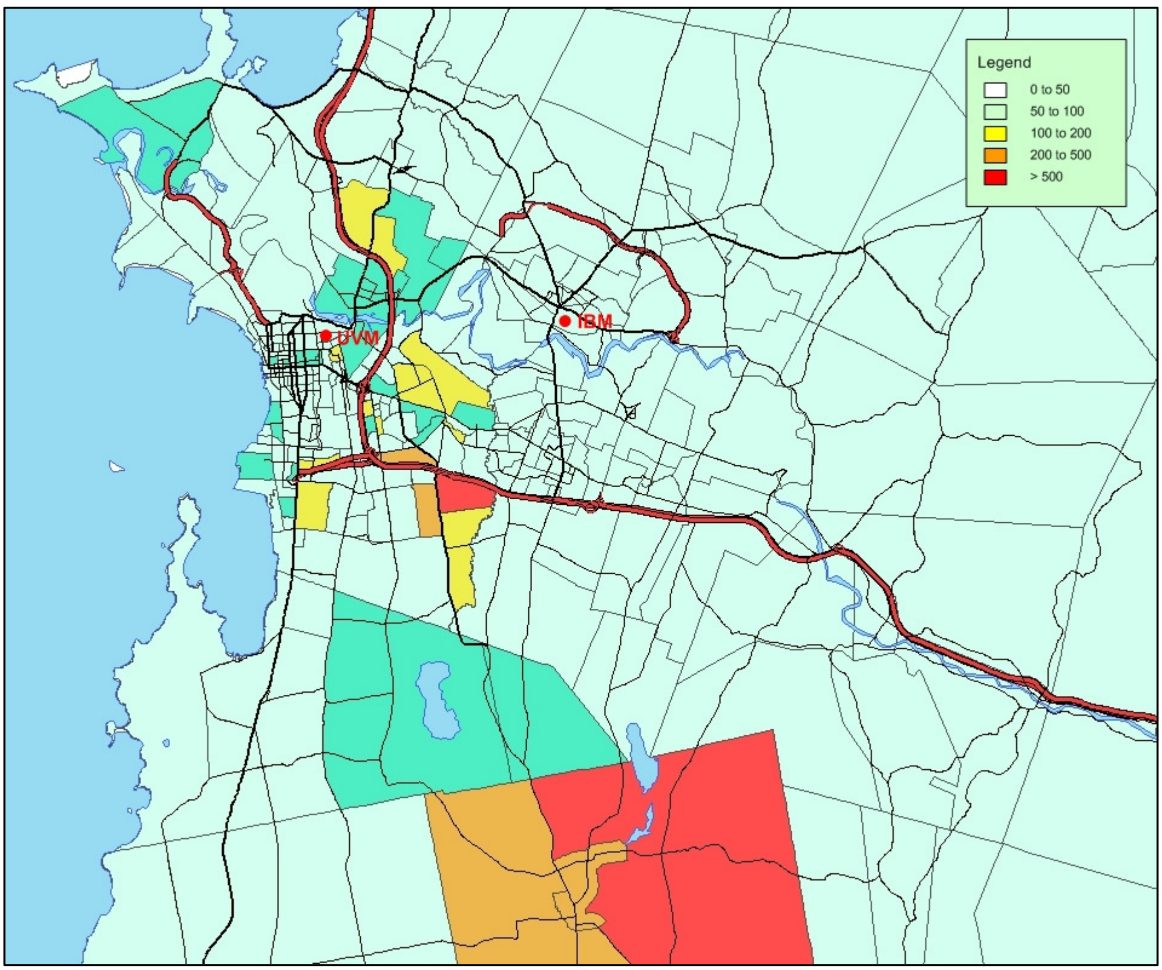
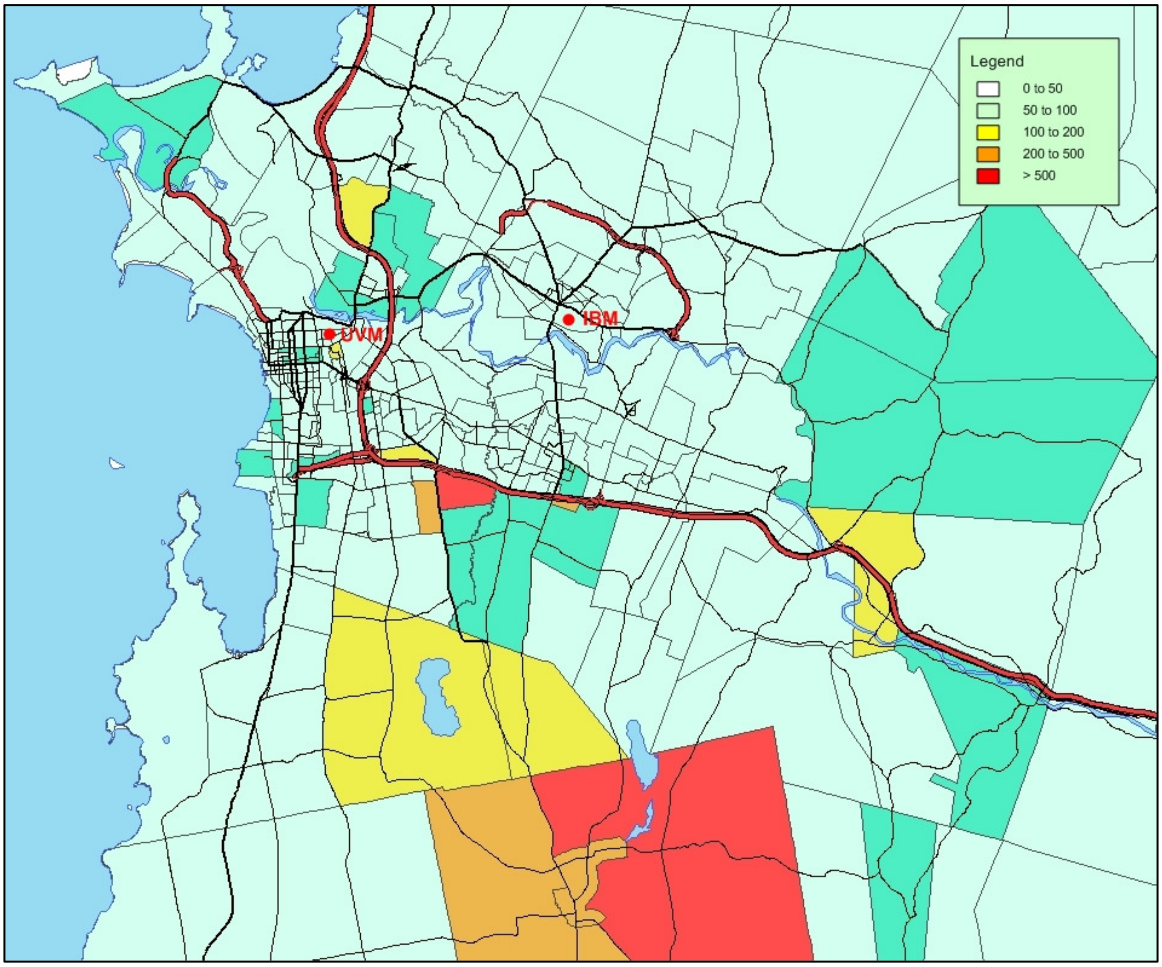


Figure 53: The Destination Distribution of Travel Demands Using Exit 12B



10.0 FUTURE YEAR 2030 TEST

A final test we performed on the TRANSIMS model was to assign a future 2030 trip table on the base year network. The 2030 trip table was generated by running a full 4-step model run on the 2030 Metropolitan Transportation Plan highway network (i.e. the trip distribution is consistent with an expanded network). The 2030 year was iterated through the 4-step distribution-mode choice-assignment steps so that the final trip table represents a convergence with the future travel times. The resulting PM peak hour trip table was then converted to a daily table using the process described earlier (no changes were made to the diurnal distribution).

The following graphic shows that the free flow travel times are significantly impacted by the increase in the number of trips. Interestingly, in the TRANSIMS assignment both interstate 89 and 189 show virtually no decrease in travel times (they continue to operate at or about the posted speed).

Figure 54: TRANSIMS Operating Speeds in the PM Peak Hour (2030 demand on 2000 network)

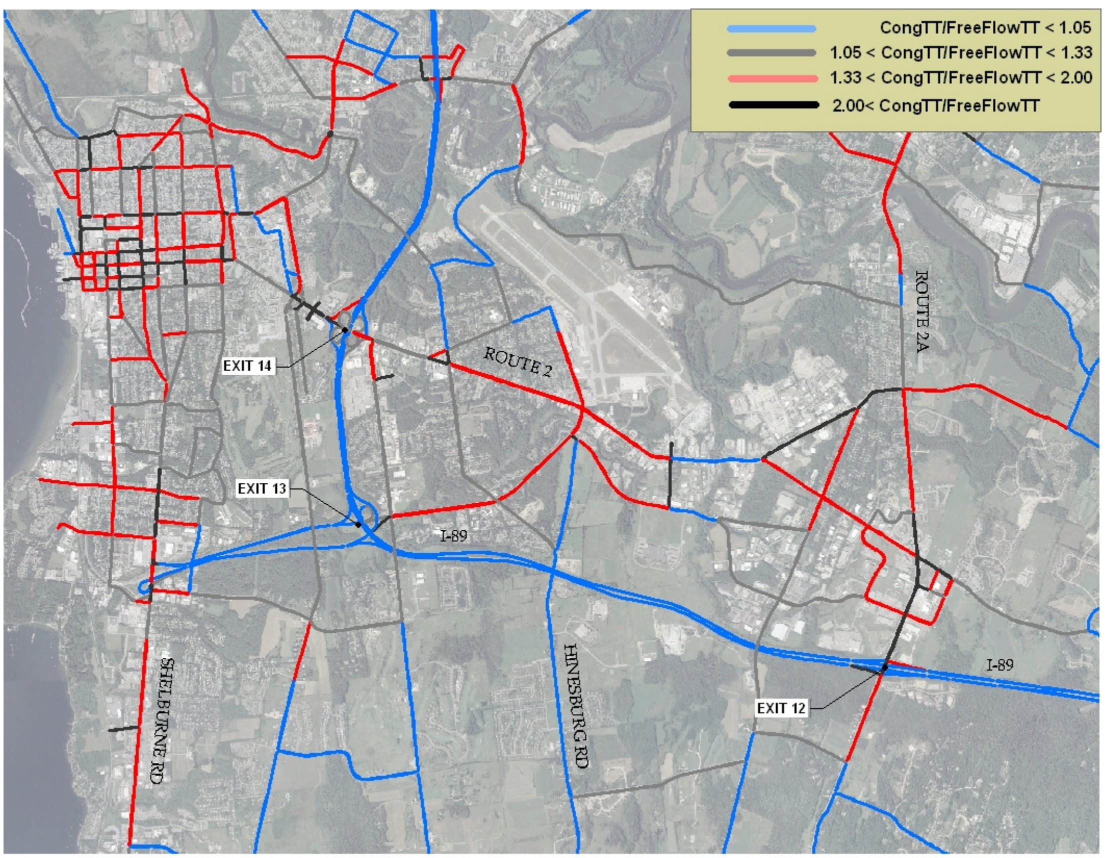
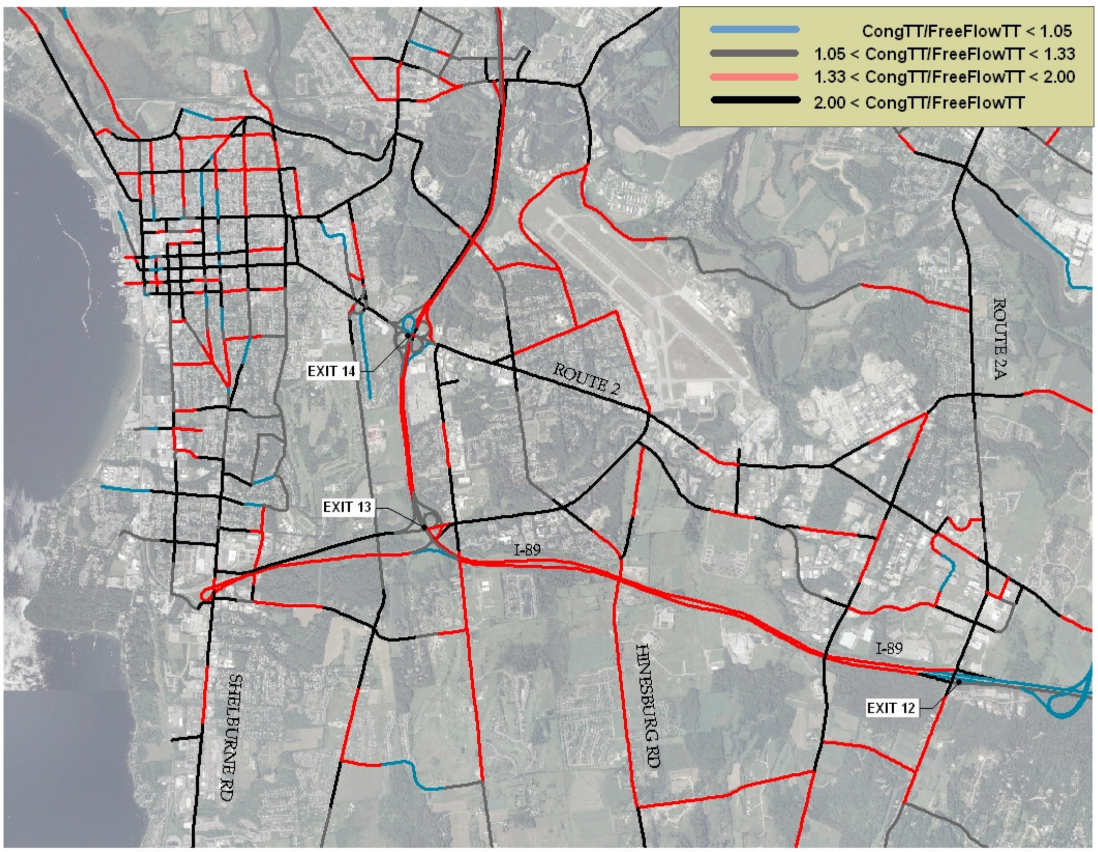


Figure 55 shows the same congested flow using the 4-step model as the forecasting tool. There appears to be significantly more congestion in the 4-step model (particularly on and near route 2, to the south of Burlington on Shelburne/Rte. 7, and northeast of Burlington).

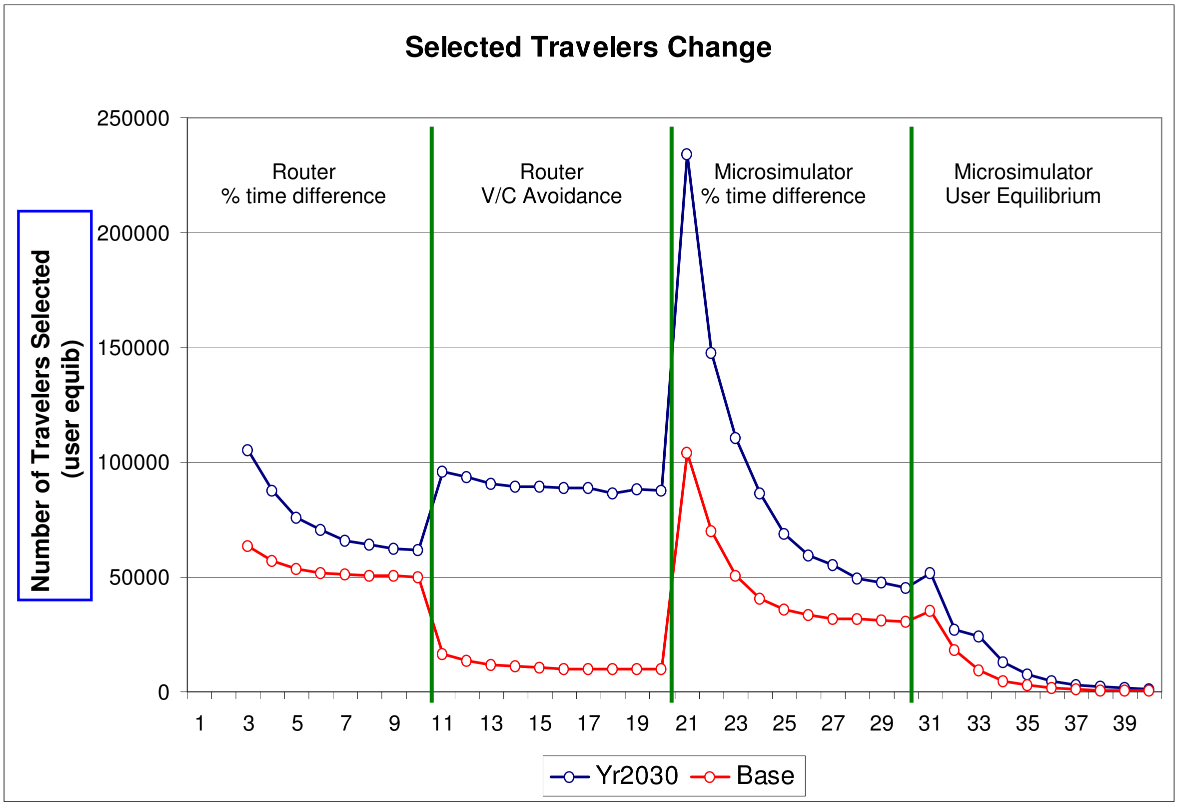
Figure 55: 4-Step Operating Speeds in the PM Peak Hour Period of 2030



In the 2030 trip table there are approximately 30% more trips than in the base year trip table. As expected, the model takes longer to converge in 2030. The following figure shows the user equilibrium convergence (measured in number of individuals selected for rerouting per iteration). This figure suggests that convergence is reached by iteration 40. Note, however, none of the first three phases of the TRANSIMS process converge to the same level as they did in 2000. Furthermore, the V/C criteria used in the second phase of the Router causes an increase in the number of selected travelers (iteration 11) in 2030 while it resulted in a decrease in the year 2000. This, again, is a reflection of the significant congestion on the network.

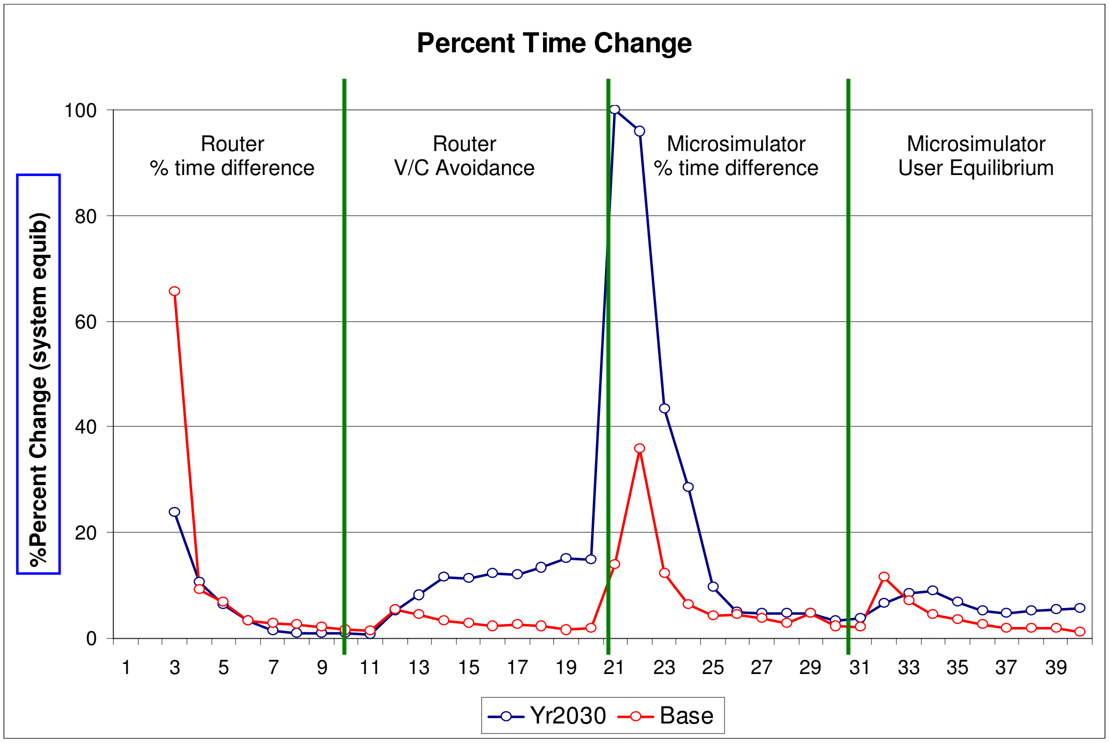
In viewing these results, we are tempted to use a decreasing V/C target between iterations 11 and 20 (for example, 1.5, 1.4, 1.3,…), possibly starting with a higher V/C criteria than 1.5 in the initial iterations. In earlier tests we did, however, we observed nonsensical fluctuations in routing with a low V/C target because many travelers shifted around bottlenecks to create other bottlenecks.

Figure 56: User Equilibrium



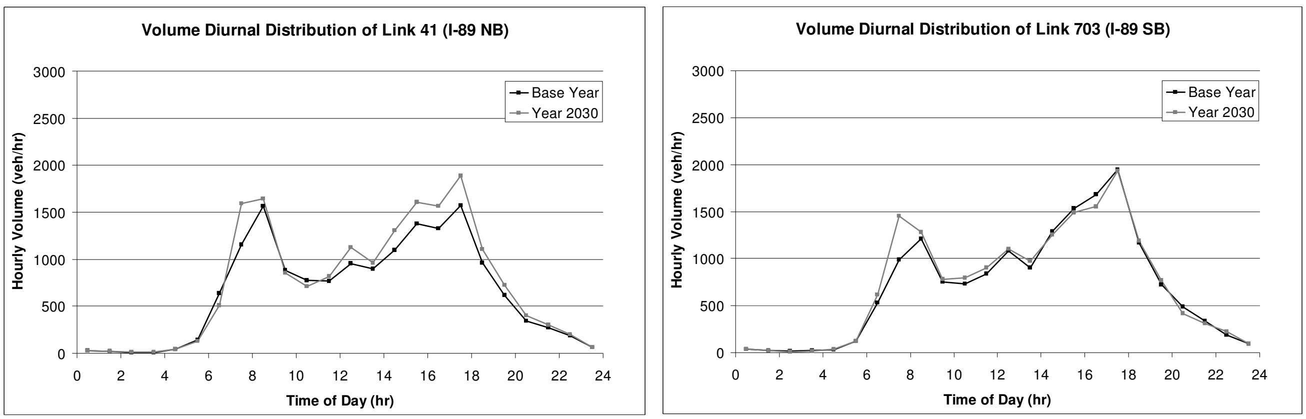
The following graphic illustrates the change in link level travel time in the PM Peak (used to approximate system equilibrium). This graph plots the 99th percentile link travel time change from the previous iteration. As in the figure above, we note that the V/C criterion is not converging. In this case we are actually observing minor increase in total system time. By iteration 40 we are close to system equilibrium in 2030 although we do not appear to be progressing beyond a point where the 99th percentile of links changes by less than approximately 5% from the previous iteration. We believe that with successive averaging of link travel times we can achieve a tighter convergence, which should stabilize the link travel time estimates from one model run to the next.

Figure 57: TRANSIMS % Change in Travel Time between Model Iteration for 2030 and the Year 2000 (Base)

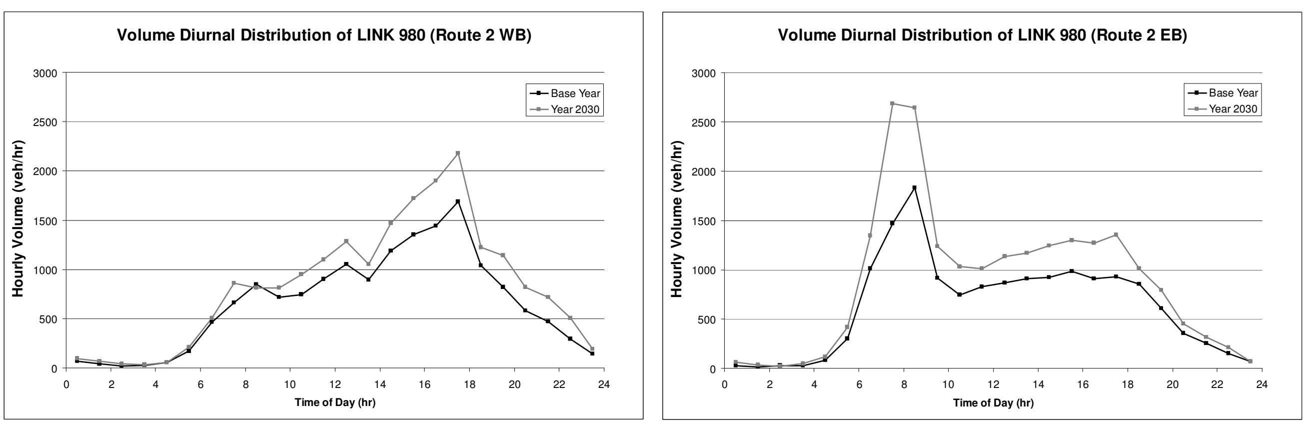


Another interesting question about the performance of the 2030 network is the traffic "spread" effect, which to some degree represents the capability of the network supply to accommodate future demand. To investigate the possible traffic spread effect arising from the 2030 model, we compared the diurnal profiles of traffic volumes in the base case and 2030 case on a number of major roadways, including I-89, Routes 2, 7 and 116. The figures below show a diurnal distribution comparison for several example roadway sections, including I-89, Route 2 and Route 7.

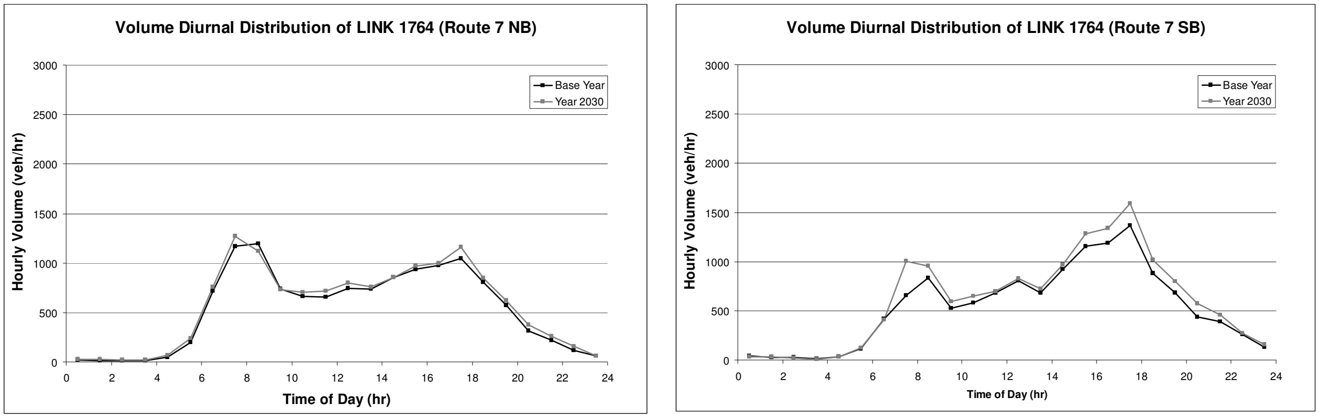
Figure 58: A Comparison of the Diurnal Distributions of Several Example Roadways in the Base and 2030 Networks



(a) Volume Diurnal Distributions of I-89



(b) Volume Diurnal Distributions of Route 2



(c) Volume Diurnal Distributions of Route 7

By examining and comparing the diurnal distributions of the major roadways in the network, we find that, while the 2030 network is more congested during the peak hours, the “spread” effect in the 2030 model is not very apparent in that the diurnal profiles of the 2000 and 2030 models for each of these major roadways show a similar pattern. In all the cases, the peak value of hourly traffic volume over the whole-day is around 10-20%. These results suggest that the expected travel demand in 2030 could be well accommodated by the existing network.

11.0 CONCLUSIONS

The CCMPO TRANSIMS Model implementation has established several important findings:

1. The Track 1 structure and tools currently available in TRANSIMS can be calibrated 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 under policy scenario testing under both network alteration and future growth conditions.
3. Finally, the CCMPO TRANSIMS model performed well in several policy tests and was used in an alternatives analysis project for Exit 12B. Features of the TRANSIMS model, such as the ability to track individual travelers, were used during the study to answer policy questions.

In addition to these findings, the project team has also made a contribution to the technical functionality of the TRANSIMS suit of tools. For example, a software tool was built which successfully converts a Paramics network to a TRANSIMS network. Because this software was only used during a single conversion, it should be considered in Beta level at best. The project team also built a software tool to create and modify a suite of batch files necessary to run an integrated Track 1 system.

The CCMPO has now taken over this model and the University of Vermont continues to make enhancements under its University Transportation Center projects. At this point, there remain three impediments to the CCMPO adopting this tool for their internal policy use. These are:

1. 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. For example, there are columns in some of the input and output files that do not appear to be properly described, as well as available functionality known only to the developers.
3. The challenges of visualizing the traffic simulation. The current commercially available visualization options work with some versions of TRANSIMS but it needs to be updated every time certain TRANSIMS output file formats are changed. This is complicated by the fact that TRANSIMS is open source.

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.