

Chapter 4 Sub Area Focusing

4.1 Introduction

A sub area study focuses on a subset of a metropolitan region in greater detail than the long-range regional study. The relative advantage of sub area studies is reduced computational requirements and data collection costs; the caveat is that the transportation improvements under consideration will affect only the location being evaluated and not the entire region. The TRANSIMS regional model is the starting point: a cordon is drawn around the sub area of interest and the demand and the supply applicable to that sub area are extracted. Methodologically, the literature indicates that the sub area approach is similar to the regional approach: the activity regeneration, routing, traffic simulation steps are replicated for the sub area and modified as necessary to match modeled and observed traffic volumes.

Fig. 4.1 illustrates a typical size of sub area study of Blacksburg_Full network. The size of a sub area is much smaller than a regional. This area features a highly utilized multimodal transportation system with significant travel delays during day time.

Section 4.2 mainly presents building a sub area focusing model under TRANSIMS's frame work benefiting from TRANSIMS's fully-represented network, availability of 24 hours activity pattern, stabilized and calibrated simulation output including both summarized data on each link and events of each traveler. Section 4.3 discusses the methods used for interfacing with CORSIM, followed by the testing of different sizes of sub-network on both methodologies. Finally, a conclusion is made based on the assessment of the study.

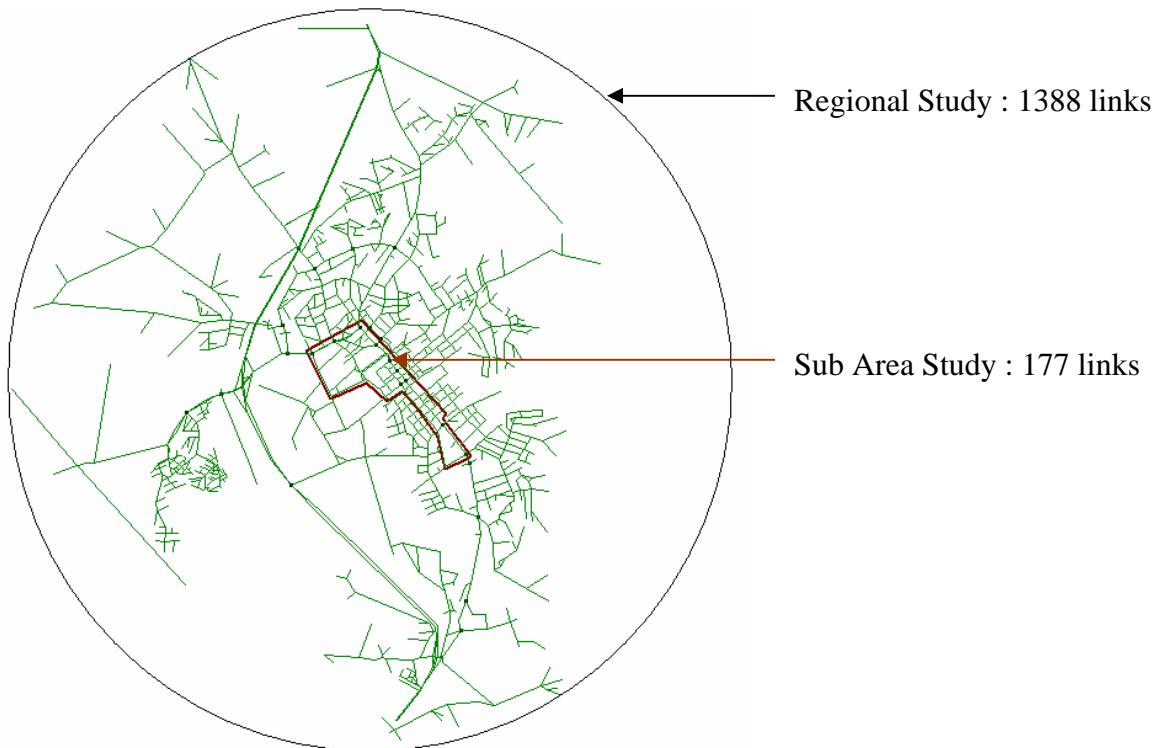


Fig. 4.1 A typical scale of sub area study of a regional network

4.2 TRANSIMS Sub Area Focusing Model

4.2.1 Definitions and Methods

- Boundary: a cordon that is drawn around the sub area of interest
- Boundary Links: links that cross the boundary
- Boundary Incoming Activity Locations: activity locations that are associated with boundary links which generate the traffic into the sub area
- Boundary Outgoing Activity Locations: activity locations that are associated with boundary links which receive the traffic out of the sub area
- Internal Activity Locations: activity locations holding activities inside of the sub area

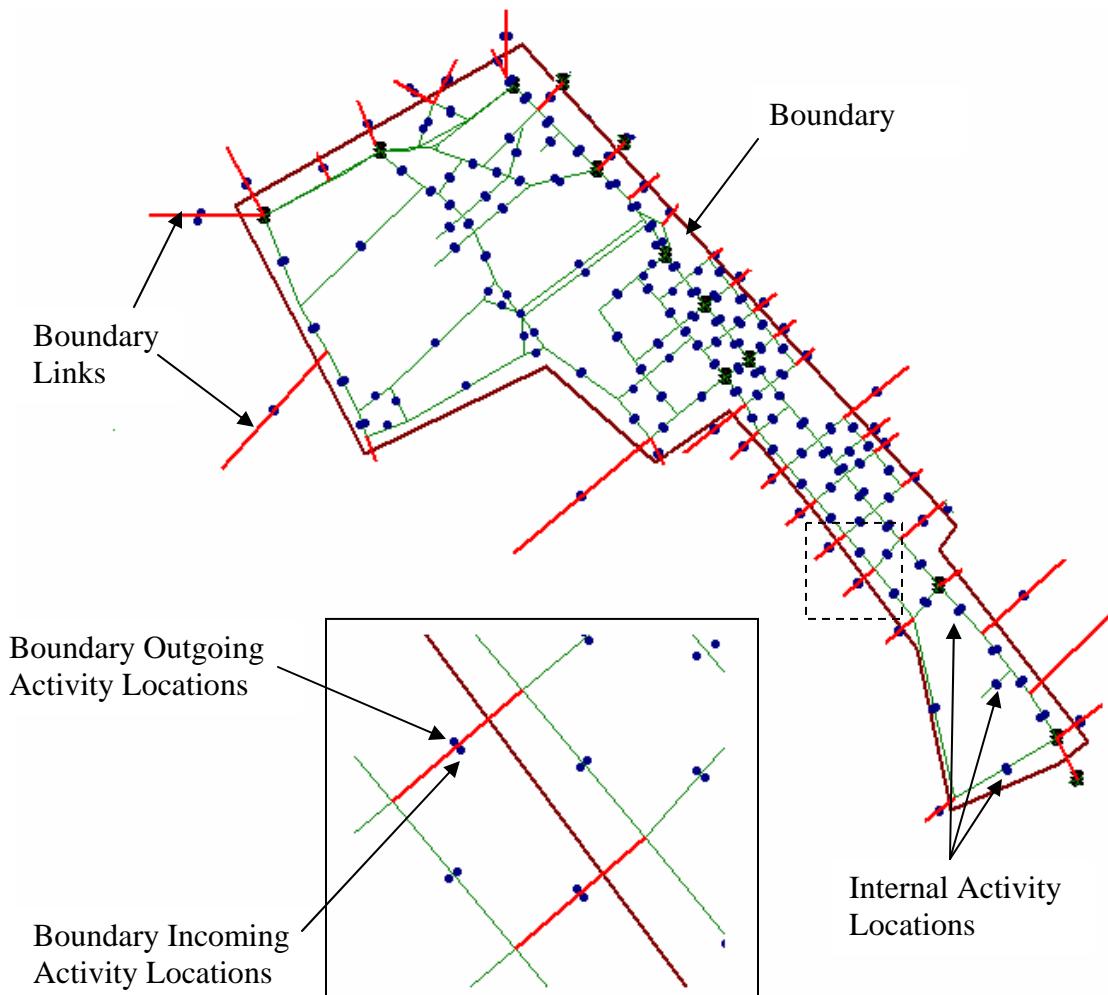


Fig. 4.2 Illustration of sub area network

The sub area focusing modeling method comprised of two main parts: sub area network representation and sub area demand modeling.

1. Sub area network representation

There are two ways of presenting the sub area network. The first way is to use a customized sub area network for sub area study, which means those links that fall outside of the sub area are cut off. The second way is to keep the whole regional network representation, yet only the traffic inside of the sub area is simulated. The second method is adopted in this thesis for two reasons: first, the geographical location of the sub area in the whole region can be shown to the modeler; second, the affected zone or buffer can be identified based on the operational improvement of the sub area.

2. Sub area demand modeling

The demand of the sub area is to be collected based on the stabilized and calibrated simulation output obtained from TRANSIMS regional planning model. Trips that are reflected by the traffic in the sub area are classified into four categories:

- Category-1: External to External
- Category-2: External to Internal
- Category-3: Internal to External
- Category-4: Internal to Internal

For trips that fall into category 1, 2 and 3, boundary incoming activity locations and boundary outgoing activity locations are used to replace the real or true activity locations of the trip in the regional model to avoid simulating trips out of the sub area. The characteristics of those trips will be retrieved, summarized and modeled in the sub area focusing model. For trips in category 4, the trip related information can be borrowed from the regional activity set directly. Section 4.3.2 describes the techniques in detail for sub area demand modeling.

4.2.2 Subarea simulation

Since we keep the whole regional network to simulate a subarea demand, after extracting the subarea demand from the simulation output of the regional planning, the task of TRANSIMS subarea simulation is to create point to point trips using TRANSIMS *ActTripGen* utility program.

The trip table and time table generated from the subarea demand model has the following format:

- Trip Table: <activity location 1> <activity location 2> <number of trips>
- Time Table: <time 1> <time 2> <percentage>

The procedure of simulating subarea demand in a whole regional network is as follows,

1. Change TRANSIMS activity location table so that each activity location is a Transportation Analysis Zone (TAZ) by itself. A utility program *ChgActZoneUniq* is written to replace the TAZ field with each activity location id;
2. Given the Trip Table and Time Table, use TRANSIMS *ActTripGen* utility program to create population file, activity file and vehicle file for those travelers;
3. Change TRANSIMS link delay file (set by key ROUTER_LINK_DELAY_FILE) so that the links fall outside of the subarea has huge travel time (e.g. 999999 seconds) in order to avoid Router choosing paths outside of subarea; A utility program *ChgOutlinksDelayUnlimited* is created for this purpose.
4. Run Router and Microsimulator.

4.3 Interfacing with CORSIM

4.3.1 CORSIM Input Data

Computer simulations use a mathematical representation of the real world. Traffic simulation models are representations of the time-varying processes in traffic flow, and they require accurate descriptions of the characteristics of the vehicles, the transportation network, and the traffic control system. These characteristics vary over the physical network and over time. The structure of the input stream must also reflect the concept of network partitioning.

The characteristics that vary over time include the following:

- Traffic volumes
- Turn movements
- Traffic regulations
- Signal timing.

The characteristics that vary over space include the following:

- Traffic geometry (location of links and nodes, number of lanes, turning pockets, and auxiliary lanes)
- Types of links (such as surface streets or freeways)

Links are one-directional segments of surface streets or freeways, and nodes are usually the intersection of two or more links. Initially, the user must obtain geometric pictures of the network, such as aerial photographs or maps. A basic drawing of the geometry of a single intersection is shown in the following figure.

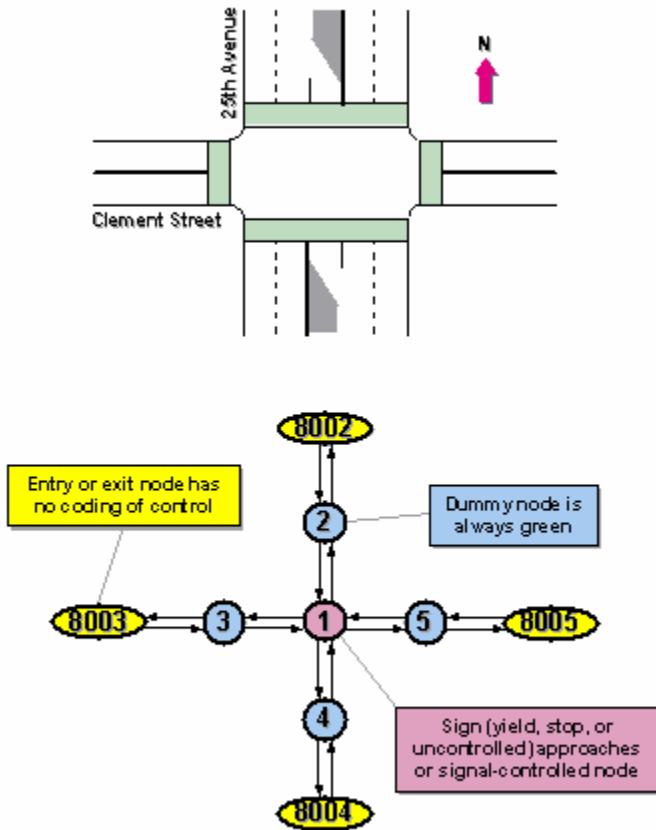


Fig. 4.3 Intersection layout converted to a link-node diagram

The time-varying portion of the simulation analysis is expressed as a sequence of "time periods" specified by the user; that is, the input data specified by the user for a certain time period remains in force unless changed in a subsequent time period. The user can specify up to 19 time periods and must specify the conditions that have changed during

each period. Therefore, the input stream consists of a sequence of "blocks" of data records, with each block defining the conditions that apply to one time period.

Each block of data records for a time period is subdivided into "sections" of data records. Some sections define conditions of one or more subnetworks, including a NETSIM subnetwork and/or a FRESIM subnetwork, while others provide inputs for the specifications that must be specified for the "global" network (such as bus routes).

The input stream of a dataset begins with a basic description of the run being made (run control data), followed by data that is divided into time periods. Each time period contains model-specific data for each subnetwork that is being simulated. Each dataset is divided into a series of 80-column records. The first time period is unique because it contains the data that does not vary from time period to time period. At the end of the model data for the first time period is global network data that is applied to all subnetwork data. This global data describes bus operations, and any other data that applies to both subnetworks. For second and subsequent time periods, only variations in data relative to the previous time periods need to be specified.

CORSIM datasets can be coded with very few record types. Assuming that traffic assignment is not executed, the minimum records that are required to run NETSIM are shown in the proper sequence in the following table for a single time period dataset.

RECORD TYPE	DESCRIPTION	NETSIM	FRESIM
01	Run Identification	Required	Required
02	Run Control	Required	Required
03	Time Period Specification	Required	Required
04	Time Interval and Time Steps per Time Period	Required	Required
05	Reports	Required	Required
11	NETSIM Link Description (NETSIM only)	Required	
21	Surface Street Turn Movements (NETSIM only)	Required	

35	Sign or Pre-timed Signal Control Timing (NETSIM only)	Required	
36	Sign or Pre-timed Signal Control Codes (NETSIM only)	Required	
50 53	Either 50 or 53, or both, can be used to define Entry Link Volumes	Required	Required
51	Traffic Volumes on Source/Sink Links (NETSIM only)	Optional	Optional
170	Sub-network Delimiter	Required	Required
210	Time Period Delimiter	Required	Required

Table 4.1 Minimum coding requirements for the CORSIM models

Some of the characteristics associated with a network are limited to a maximum size, whose limits are summarized in the following table.

CHARACTERISTIC	NETSIM	FRESIM
Actuated Controllers	1000	Not Applicable
Auxiliary Lanes	Not Applicable	3
Bus Routes	500	
Bus Stations	99	Not Applicable
Buses	2000	2000
Data Stations	Not Applicable	2000
Detector Stations	Not Applicable	2000
Detectors	7000	6000
Detectors for a Metering Signal	Not Applicable	10
Disjoint Freeway Segments	Not Applicable	Unlimited
Entries per Segment	Not Applicable	100
Events	200	Not Applicable
Exits per Segment	Not Applicable	100
Incidents	Not Applicable	100
Lane Adds/Drops per Link	Not Applicable	3
Links	Unlimited	Unlimited
Links per Segment	Not Applicable	200
Nodes	8999	8999
Ramp Metering Signals	Not Applicable	4000
Sections of Aggregated Links	100	Not Applicable

Through Lanes	7	5
Through Lanes per Ramp Link	Not Applicable	3
Vehicles	Unlimited	Unlimited

Table 4.2 Size limitations of CORSIM network characteristics

4.3.2 Demand Retrieval

Typical microscale traffic simulation models simulate each vehicle with specific driving behavior. Each vehicle trip is modeled as a driver making a trip between an origin and a destination. The average number of trips made between origins and destinations are specified in advance for each origin-destination pair for each time period, where the interval of the time period can be specified as well.

In CORSIM, there are two types of vehicle volume entry. Record Type 50 describes the volume, in vehicles per hour, entering NETSIM and FRESIM networks on entry links. Entry nodes usually form the outer boundary of the network. After defining entry volumes from entry nodes, internal volumes generated within the network can be defined using Record Type 51. These are usually defined with the source/sink record. Entry/Exit links can be used within the network for locations that have to both generate traffic and have it exit the network.

Two categories of trip types can be defined in terms of trip origins. External origin trips are those starting outside of sub-area and come into or cross the sub-area. Internal origin trips are those starting in side of sub-area. Different methods are adopted to generate the demand for each category.

For external origin trips, TRANSIMS traveler event file is used as the base for sub-area boundary entry volume generation. Utility program - *EventFilter* is written to extract and summarize vehicle counts for Boundary Links. See Appendix-A for detail usage of this utility. The output is a file containing six fields as Table 4.3 shows: boundary link id; the node id from which the vehicle travels; the hourly time period in term of seconds from midnight; total vehicle counts, number of trucks counts, number of carpool counts.

LINK	FNODE	TIME	COUNT	TRUCK	CARPOOL
20022	20022	64800	1245	17	76
20022	20022	68400	852	10	34

Table 4.3 an example of *EventFilter* utility output

For internal origin trips, TRANSIMS activity file is used as the base for sub-area internal volume generation. Utility program – *ActivityFilter* is created to summarize internal vehicle trips. See Appendix-B for detail usage of this utility. Similarly, the output is a file containing four fields as Table 4.4 shows: internal link id; the node id from which the vehicle travels; the 15-minutes time period in terms of seconds from midnight; total vehicle volume generated from associated activity location.

LINK	TNODE	TIME	COUNT
3420	3271	47700	15
3420	3271	48600	19

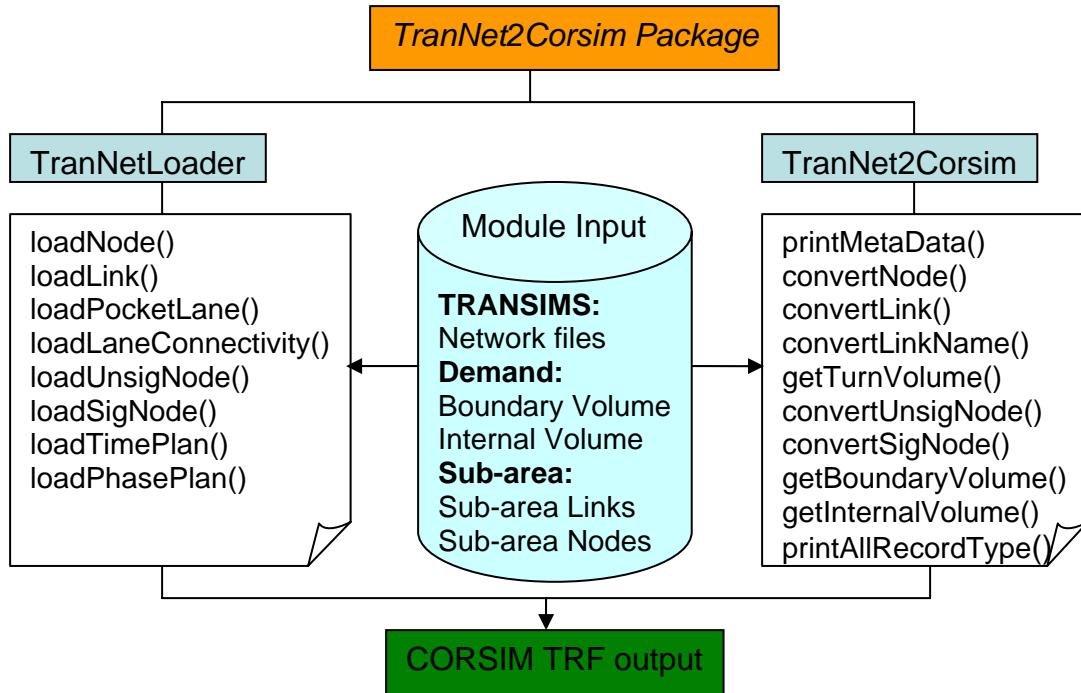
Table 4.4 an example of *ActivityFilter* utility output

These utility outputs will act as inputs for conversion from TRANSIMS to CORSIM, as described in section 4.3.3.

4.3.3 Data Conversion

The core work of interfacing with CORSIM is the creation of software package *TranNet2Corsim*. As its name implies, the *TranNet2Corsim* package converts TRANSIMS demand and network to their CORSIM counterparts. The logic rules and some of main issues encountered during design and implementation of this package are discussed in this section. The detail usage of this package can be found in Appendix C.

Fig. 4.4 shows the structure of the *TranNet2Corsim* package. Sub-module *TranNetLoader* is to load TRANSIMS network files into database and sub-module *TranNet2Corsim* is to execute the conversion functions on both demand and network. The output is a single CORSIM TRF file which contains all the necessary inputs feeding into CORSIM.

Fig 4.4 *TranNet2Corsim* package Structure

Due to different design philosophy between TRANSIMS and CORSIM, several rules need to be defined during the conversion.

1. Coordinates Conversion

Geographic coordinates in TRANSIMS are specified in the Universal Transverse Mercator (UTM) Grid System in meters (e.g. 3332662.78) while the measure unit in CORSIM is feet with a limit of 999999 feet. Thus the extra digits are omitted during the conversion.

2. Link Conversion

TRANSIMS used bi-direction links to represent roadways, while CORSIM defines a link as single-directional from the upstream node to the downstream node as shown in Fig 4.5.

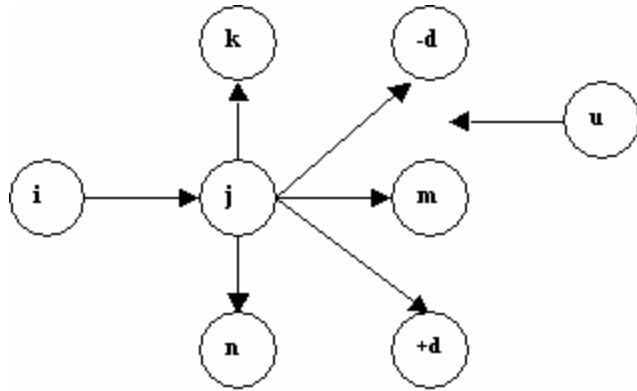


Fig. 4.5 CORSIM Link Configuration

CORSIM Record Type 11 describes the geometry and the traffic characteristics of NETSIM links. Entries 18-22 identify the links that receive vehicles leaving link (i,j) and the link opposing left-turners from link (i,j). They are downstream node receiving left-turning traffic (k), downstream node receiving through traffic (m), downstream node receiving right-turning traffic (n), downstream node receiving diagonal traffic(-d or +d) and upstream node for traffic opposing left-turning traffic(u). If a left-diagonal movement exists, the value of "d" is entered as a negative value. If a right-diagonal movement exists, the value of "d" must be entered with a plus sign. Because only four columns are available for the node number and sign, the node id for downstream node receiving diagonal traffic can hold only 3 digits.

TRANSIMS has a more flexible way to represent link traffic characteristics by using Lane Connectivity table. Lane Connectivity table specifies the node id, the incoming link id, the lane number of incoming lane, the outgoing link id, the lane number of outgoing lane. In order to convert the outgoing links to downstream nodes with correct turn type (i.e. left turn, through, right turn, left or right diagonal traffic), assumptions and rules are made.

The downstream node turn type definition is shown as Fig 4.6 and the following rules are applied if conflicting downstream nodes exist.

- If a through link is defined in TRANSIMS, yet it is calculated to be downstream diagonal node, we switch it to downstream through node;

- If both downstream right diagonal node and left diagonal node exist, we need to switch the one to an according downstream turn node if no such turn downstream node has been found. For example, if there is no downstream right turn node found, we switch the right diagonal node to be right turn and keep the left diagonal node as it is;
- If a through link is defined in TRANSIMS, yet it is calculated to be downstream right turn or left turn node, we switch it to the according turn node;

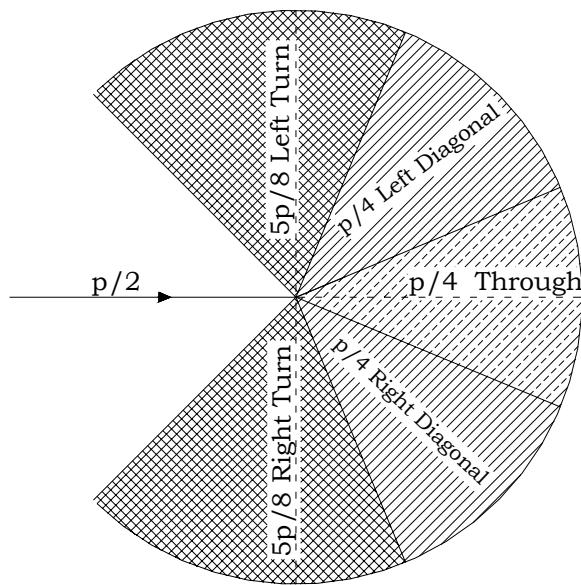


Fig. 4.6 Downstream node turn type definition

3. Unsignalized Node Conversion

Fig 4.7 shows the sign and pre-timed signal control codes. In TRANSIMS Unsignalized Node table, three types of sign are defined including STOP, YIELD and NONE which can be easily converted to CORSIM control type 5, 0 and 1 correspondently.

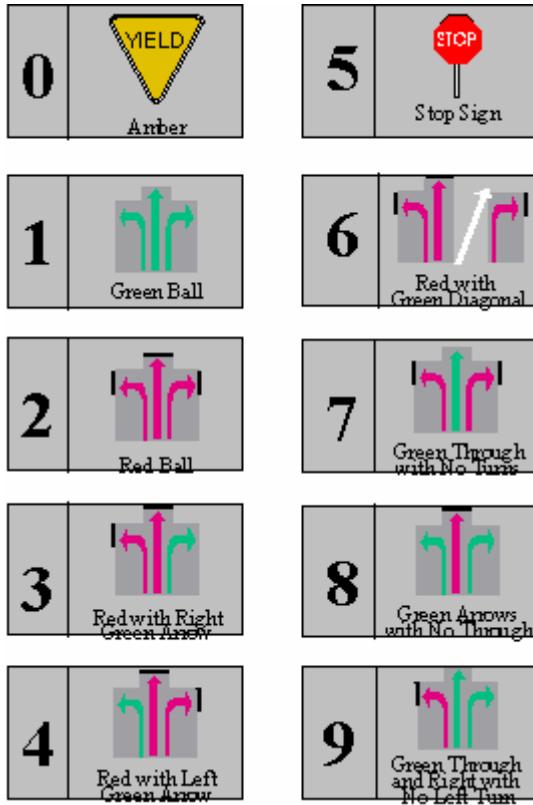


Fig 4.7 CORSIM sign and pre-timed signal control codes

4. Signalized Node Conversion

In TRANSIMS, three interdependent tables are defined to fully represent a signalized node. The Signalized table contains information of the signalized node id, the type of signal (Timed or Actuated), the time plan id etc. The Timing Plan table has information of the time plan id, the phase number, the next phase number, the minimum length (in seconds) of the green interval or fixed green length for timed signal, the maximum length of the green interval, the length of green extension interval, the length of the yellow interval, the length of the red clearance interval, and the GROUPFIRST index to indicate which phase is the first phase in the group. The Phasing Plan table includes information of the node id, the id number of the plan, the phase number, the id number of incoming link, the id number of outgoing link and a movement protection indicator (P – Protected, U – Unprotected, S – unprotected after Stop).

Table 4.5 – 4.7 are examples of the three tables mentioned above to illustrate how a signalized node (See Fig. 4.8) is represented in TRANSIMS.

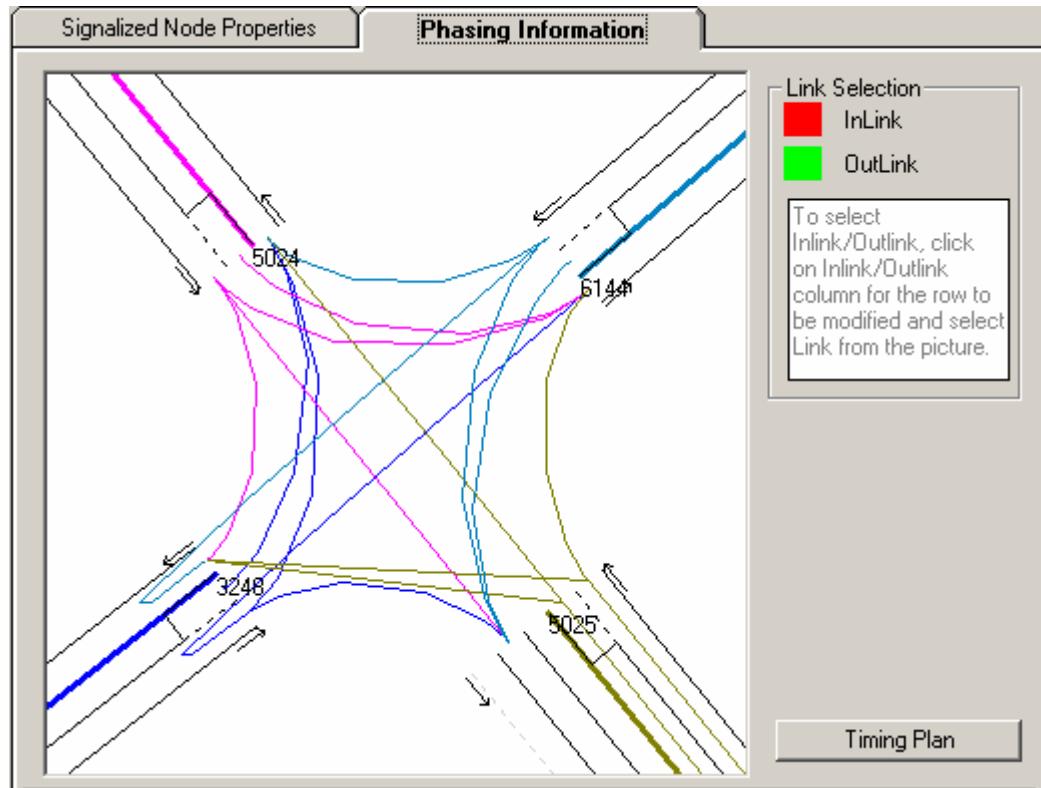


Fig. 4.8 Intersection of South Main St and Washington St

NODE	TYPE	PLAN	OFFSET	STARTTIME	COORDINATE	RING	ALGORITHM	NOTES
5026	T	37	0	ALL0:0	5026	S	0	NONE

Table 4.5 Signaled Node table

PLAN	PHASE	NEXTPHASES	GREENMIN	GREENMAX	GREENEXT	YELLOW	REDCLEAR	GROUPFIRST	NOTES
37	1	2	25	0	10	3	1	1	0
37	2	1	10	0	25	3	1	0	0

Table 4.6 Timing Plan table

NODE	PLAN	PHASE	INLINK	OUTLINK	PROTECTION	DETECTORS	NOTES
5026	37	1	5025	5024	P	0	0
5026	37	1	5025	6144	P	0	0
5026	37	1	5025	3248	U	0	0
5026	37	1	5024	5025	P	0	0
5026	37	1	5024	3248	P	0	0
5026	37	1	5024	6144	U	0	0
5026	37	1	3248	5025	S	0	0
5026	37	1	6144	5024	S	0	0
5026	37	2	3248	6144	P	0	0
5026	37	2	3248	5025	P	0	0
5026	37	2	3248	5024	U	0	0
5026	37	2	6144	3248	P	0	0
5026	37	2	6144	5024	P	0	0
5026	37	2	6144	5025	U	0	0
5026	37	2	5024	3248	S	0	0
5026	37	2	5025	6144	S	0	0

Table 4.7 Phasing Plan Table

The algorithm used to convert signalized node is as follows.

- Protection type in Phasing Plan table

P – Protected, Right Of Way (ROW), either green ball or green arrow;

U – Unprotected, yield to ROW traffic, green ball;

S – Red ball;
- Conversion Procedure for each signalized node for GREEN time interval
 1. Convert each TRANSIMS phasing to CORSIM three time intervals (Green, Yellow, Red Clear);
 2. For each approach in a Green interval, if the protection type is either P or U, the control will be deemed as having ROW, otherwise no ROW is assigned to that approach.
 3. For each pair of incoming link and outgoing link, calculate its turn type (Left Turn, Through, Right Turn, or Diagnal) and obtain the control code with respect to CORSIM sign and pre-timed signal control codes as shown in Fig. 4.7.
 4. Write formatted signal information to CORSIM Record Type 35, 36.
- Conversion Rule for YELLOW time interval
 1. If an approach in the previous GREEN time interval has ROW, assign Yield (Control Type 0) to it in the YELLOW interval.
 2. If an approach in the previous GREEN time interval has no ROW, assign Stop (Control Type 5) to it in the YELLOW interval.
- Conversion Rule for RED time interval

Simply assign Stop (Control Type 5) to each of approaches in this time interval

4.4 Application to Different Network Sizes

In order to examine a broad scope of application outcomes of this subarea focusing model, we run both TRANSIMS and CORSIM on different sizes of network (59 links, 117 links, 568 links and 977 links) using Blacksburg-Full as the test bed. Figs. 4.9-4.10 shows the view of these test cases. We run TRANSIMS subarea model in a Linux cluster and CORSIM subarea model in an IBM Window2000 Laptop. The Linux cluster is currently the featured computing platform in TRANSIMS Lab. The cluster consists of 8

2.4Ghz Intel® Pentium®4 processors, and includes a total of 2 GB of memory and over 400 GB of disk space. The nodes are interconnected by a 100 Mb/s Ethernet network. The IBM Windows2000 laptop has a 1.8Ghz Mobile Intel® Pentium®4 processor with 512MB memory.

The assessment in terms of running time is presented in section 4.5.

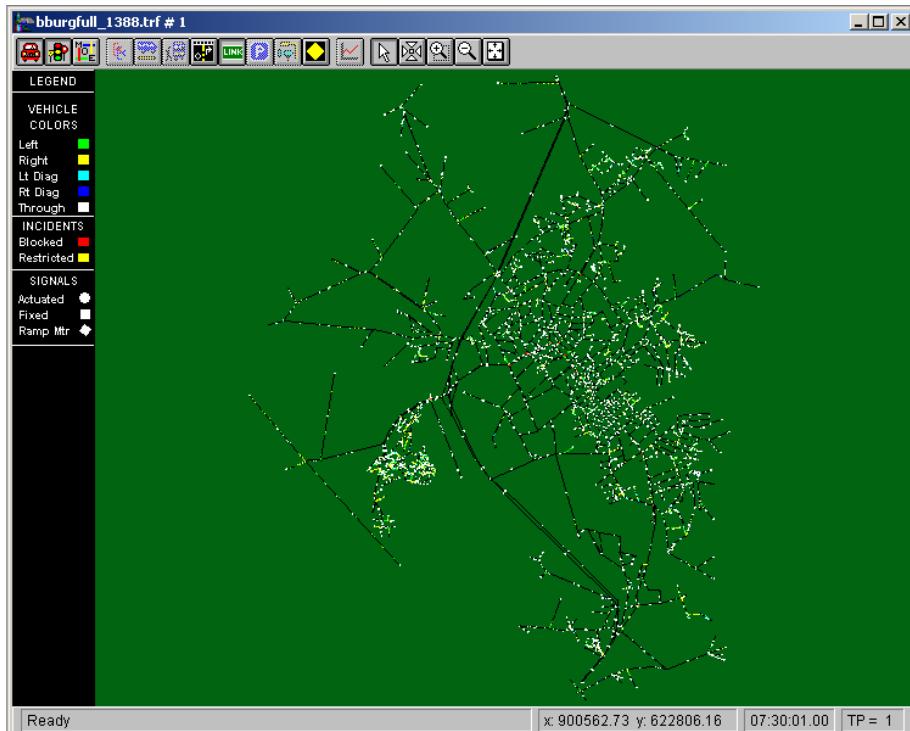


Fig. 4.9 CORSIM Blacksburg-Full View

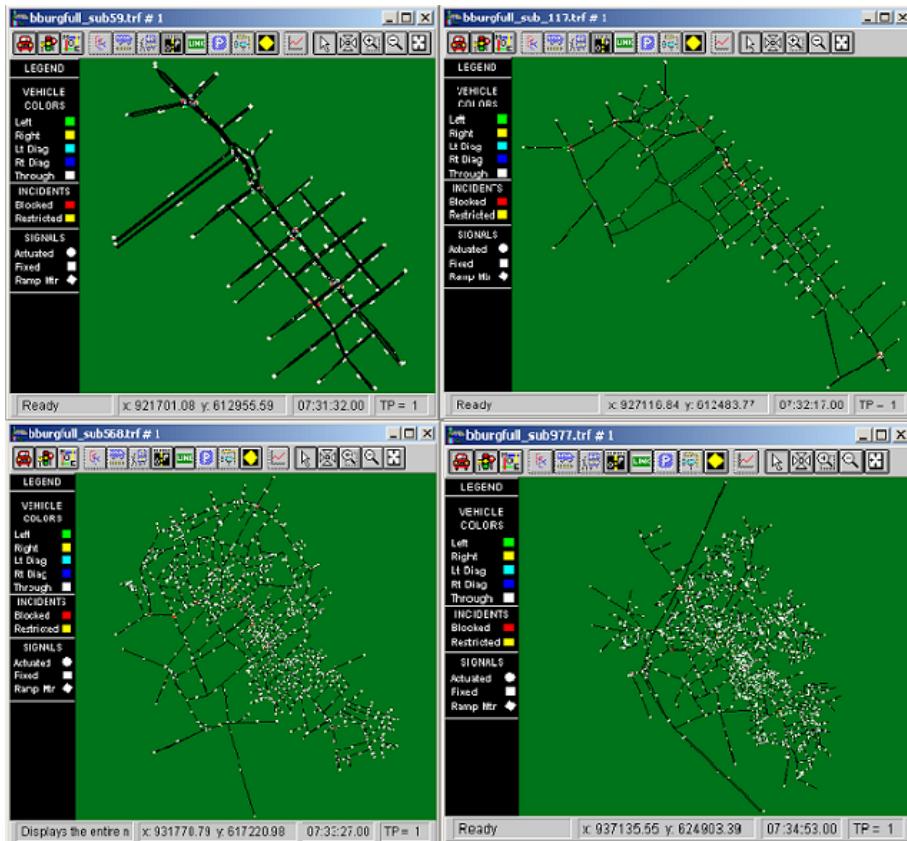


Fig. 4.10 CORSIM four different sizes of network view

4.5 Assessment of the Application Results

The results of the simulation runs in terms of computer time are summarized in Table 4.8.

Test Case	Network Size (# of links in terms of TRANSIMS)	Simulation Time (seconds)		
		TRANSIMS		CORSIM
		1-CPU	4-CPUs	
1	59	267.65	104.11	15.41
2	117	410.12	131.79	38.87
3	568	598.07	172.45	247.95
4	977	733.84	193.24	692.72

Table 4.8 Summarized Running time for different network size

The performance measures of different sizes of subnetworks are presented in Table 4.9 and Table 4.10. The Measure of Effects (MOEs) of a sampled link with a link id 3172 in TRANSIMS and its counterparts in four test cases in CORSIM are compared, i.e.

CORSIM links (1003, 2), (35, 5), (143, 47) and (330, 130) in the four different size of subnetworks are refer to the same link 3172 in TRANSIMS.

Size of Sub-network	CORSIM LINK	Volume(VPH)		Average Spd(MPH)	
		TRANSIMS	CORSIM	TRANSIMS	CORSIM
59	1003, 2	283	338	31.7	26.2
	2, 1003	546	511	24.4	19.2
117	35, 5	283	187	31.7	25.5
	5, 35	546	454	24.4	20.4
568	143, 47	283	276	31.7	26
	47, 143	546	444	24.4	20.4
977	330, 130	283	164	31.7	25.6
	130, 330	546	328	24.4	20.3

Table 4.9 Link Measure of Effects of a sampled link for different network sizes

Size of Sub-network	CORSIM LINK	Control Delay(Sec/Veh)	
		TRANSIMS	CORSIM
59	(2, 1003)	4.5	5.1
117	(5, 35)	4.5	4.1
568	(47, 143)	4.5	4.2
977	(130, 330)	4.5	4.3

Table 4.10 Intersection Measure of Effects of a sampled link for different network sizes

Conclusions can be made from the above results. As far as simulation time is concerned, CORSIM is particular efficient when network size is smaller than 200 links. The performance measures in TRANSIMS and CORSIM are different to some degree due to several reasons. In CORSIM, the volumes are specified as user input for entry links and source/sink links in number of vehicles per hour. The volume of a specific link is determined by the volume of each of its upstream links and their turn percentage. Since the turn percentage is calculated based on the one-hour link summary file of TRANSIMS simulation output, it might not reflect the variations of turn volumes within the peak-hour simulation. The smaller the simulation period is adopted (e.g. 15 minutes instead of one hour), the more accurate volume of each link we obtain. As far as the average speed is concerned, the space mean speed that is calculated from TRANSIMS is about 5 mph higher than the speed obtained from CORSIM. This is because the subnetwork we studied here is Blacksburg downtown area which is composed of short links with very low speed limit, which is 15 meter per second in all cases. TRANSIMS uses Cellular Automata approach and vehicle speed can only be one of the following (in mph): 16.8,

33.6, 50.3, 67.1 and 83.9. The space mean speed that we calculated from TRANSIMS might be overestimated since most vehicles will uses speed 33.6mph when the volume is low. The speed from CORSIM model may be more accurate since the continuous speed is used. The control delay is the time that vehicles spent in the intersection. The control delays for both TRANSIMS and CORSIM are only slightly different. Overall, this subarea modeling is very time efficient and the outputs are acceptable even in one hour simulation period and would be improved if smaller simulation period is adopted.