4.0 Chapter 4 – Base CORSIM Model Process

4.1 Base CORSIM Modeling Process Overview

The CORSIM modeling process begins after the data has been assembled and prepared.

A successful simulation model is one that is:

- Verifiable
- Reproducible
- Accurate

The method for developing a CORSIM model that achieves these goals is a simple process that requires the modeler to think in terms of layers. Each individual layer in the model can be broken down into very manageable individual tasks that build towards the completed model. The analogy to consider is building a house. To build a house, you begin with a blueprint, and then you build each element in sequence, with each individual step being relatively straightforward. The construction sequence begins with the foundation, the framing, followed by the roof, walls, and finally the interior details. The development of a successful CORSIM model is similar in that you must begin with a link node diagram (blue print), and then you proceed to build the model in a sequence that breaks down the total model into basic steps. First, the link node structure is created in TRAFED (the frame of the building), followed by the addition of detailed attributes including operational characteristics and traffic volumes (interior details).

Another advantage to the process in this manual is the ability to break the model into independent parts. This will allow you to better utilize staff resources through multi-tasking activities. Parts of the model can be prepared separately and combined at the end to develop the completed model. In brief, the process is a four part process. The first part is the creation of the link node diagram and lane schematic. The second part is the creation of the freeway submodel (FRESIM), and the third part is the creation of the arterial submodel (NETSIM). The final part is combining the two submodels.

4.1.1 Long-Term Benefits to a Standardized Process

The long-term benefit of all CORSIM models in the State of Minnesota prepared using the criteria in this manual is threefold. First of all, the quality control and review of the model will be consistent reducing modeling mistakes and review time. Secondly, less time will be spent debating on how to model and more time will be spent on what is modeled. Finally, it becomes viable to reuse a model. This process and criteria were established so that a minimal amount of effort would be required to add to an existing model or to modify a model with a different design condition. To date, over 30 miles of the metro area freeway have been modeled using this criteria. Building models to the same coordinate correct system allows them to be expanded upon efficiently. Using different project coordinates for models would have the same difficulties that design projects have when different coordinate systems are used, adjoining projects will be incompatible with each other. Using the same coordinate system on recent projects has resulted in significant time and cost savings when new projects have expanded on existing models.

STOP! AND READ THIS!

Before proceeding with any model development, Chapter 5 should be reviewed to clarify file management and the required organizational structure of all files that are developed during the model development process.

4.1.2 Model Development Steps

Part I: Link Node Diagram and Lane Schematic Development

Step 1: Create link node diagram and lane schematic
Step 1a: Balance traffic data sets for the peak period and multiple time periods

Part II: Freeway Coding

Step 2: Code freeway mainline nodes (direction 1)
Step 3: Connect freeway mainline nodes (direction 1)
Step 4: Code freeway ramp nodes (direction 1)
Step 5: Connect freeway ramps with freeway mainline (direction 1)
Step 6: Code physical and operational characteristics (direction 1)
Step 7: Code peak hour traffic volumes (direction 1)
Step7a: Verify the model function and operation and make changes to model structure to accommodate unique features
Step 8: Translate and run direction 1 of model
Step 9: Repeat steps 2-8 for direction 2 of the model
Step 10: Repeat steps 2-8 for intersecting freeways
Step 11: Combine freeway submodels
Step 12: Create Quality Control/Quality Assurance (QA/QC) worksheet
Step 13: Coding O-D information

Part III: Arterial Coding

Step 2: Create a Synchro model of the ramp terminal intersections by interchange (one file for all interchanges).
Step 3: Change node numbers and coordinates.
Step 4: Update signal timings
Step 5: Transfer Synchro file to CORSIM input file *.trf (CAUTION DO NOT NAME THE SYNCHRO FILE THE SAME AS THE FREEWAY FILE).
Step 6: Run Synchro generated CORSIM file.

Part IV: Combining Models

Step 1: Combine freeway and arterial *.trf files.
Step 2: Connect the two models in TRAFED.
Step 3: Run combined model.
Step 4: Finalize QA/QC.
Step 5: Develop input for multiple time periods.
Step 6: Run model.
Step 7: Summarize Measures of Effectiveness (MOEs) outputs.

4.2 Part I: Link Node Diagram Development

Step 1: Create Link Node Diagram and Lane Schematic

The link node diagram should be developed using real coordinates in CAD. The main reason for this is, in the freeway models, the details required to develop a model are not apparent on BMP or JPG files. Details, such as points of curvature, grades, and painted nose locations, are not readily apparent. Also, the modeler needs to “map out” the model ahead of time to ensure the structure of the link node diagram follows a logic that will make reviewing the model inputs efficient. It will also allow for multi-tasking model coding (i.e., there would be no node numbers repeated).

A detailed link node diagram is critical to the modeling process to ensure efficient review, to ensure that the model results are reproducible. Developing a good link node diagram at the beginning of the modeling process is essential to a successful project. The lane schematic or coding diagram is a drawing that when developed properly compliments the link node diagram and facilitates the model coding. The lane schematic diagram, if prepared electronically in CAD (a graphics program) or excel, can be used to illustrate model results. So essential are the link node diagram and lane schematic that a person preparing a model should never begin a model without a link node diagram and lane schematic. The only law to modeling is as follows:

Law # 1: Thou shall not begin a model without a link node and lane schematic.

What does this mean?

A link node diagram is not a sketch on a blank piece of paper that gets discarded after the model is set up. It is a diagram created on a base map in real world coordinates either on an aerial or topographic base mapping, which will be used to construct the CORSIM model. The link node diagram is sent along with the electronic input files when being reviewed. The lane schematic is a representation of the freeway system – not to scale – that allows the modeler to view how lanes are connected through the system and to identify acceleration and deceleration lanes and how they should be coded. Below are examples a link node diagram and lane schematic.

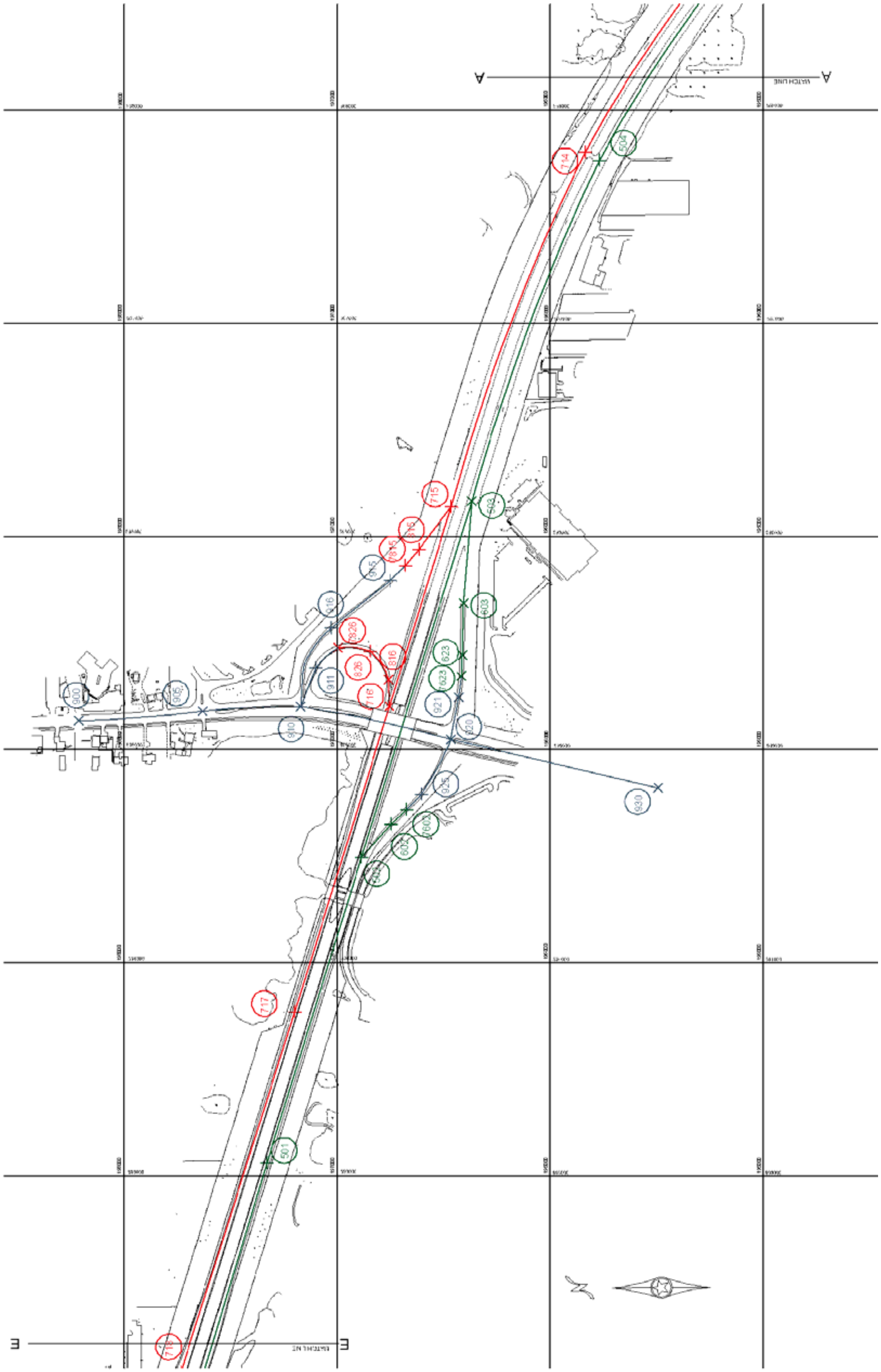


Figure 10 – Link Node Diagram

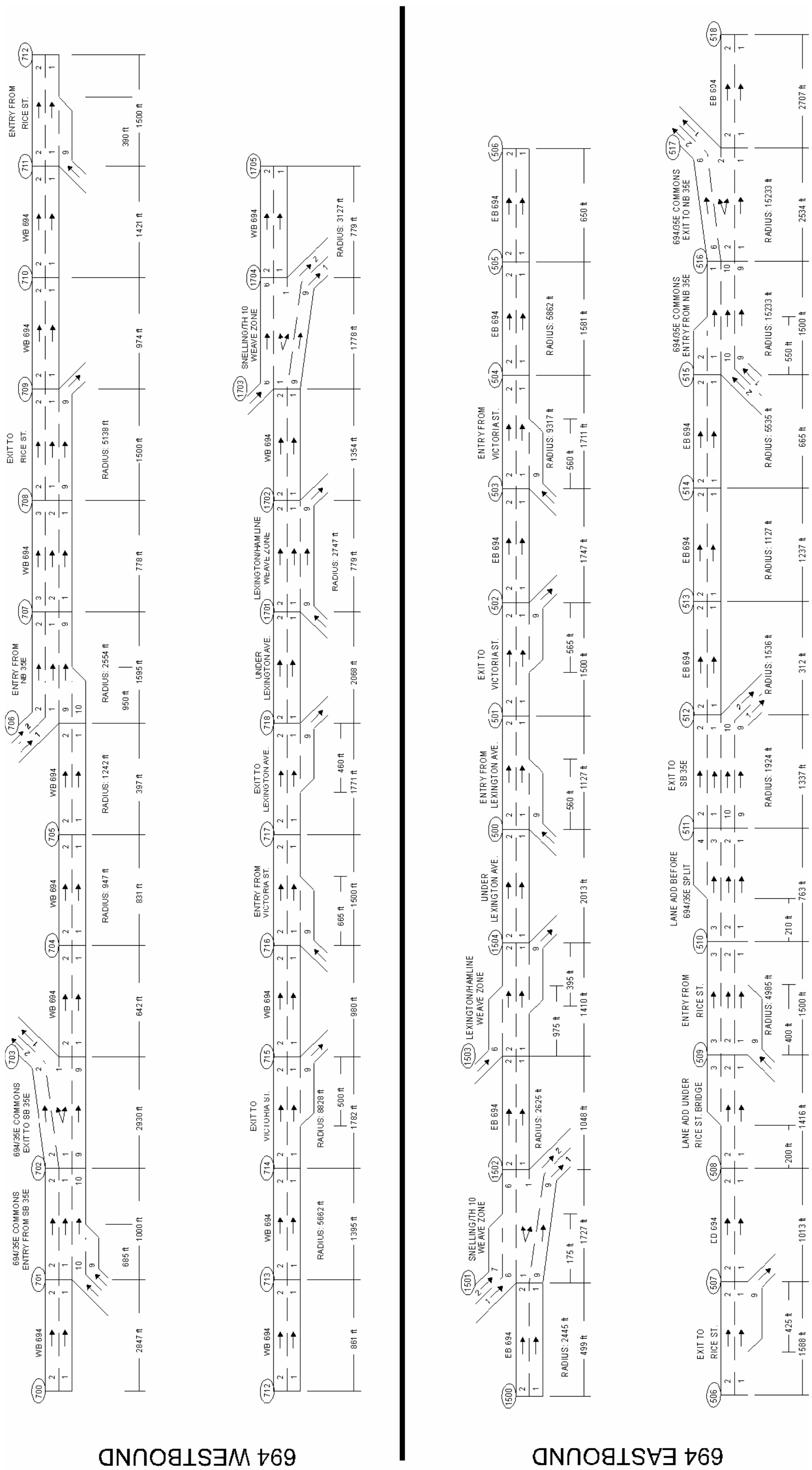


Figure 11 – Lane Schematic

4.2.1 Freeway Node Location Criteria

The freeway and ramp node location criteria in this manual have been developed to assist in the modeling process. These criteria provide a framework and can be modified based on circumstances. However, the criteria are based on replicating Mn/DOT design standards, and they provide practical guidance on developing models from which meaningful results are easier to extract. Generally, all nodes for the freeway model should be located in the center of the roadway and longitudinally using the following criteria:

<u>Mainline Freeway</u>

1. Ramp Junctions

   Nodes are placed at all ramp junctions. **The location of the node should be in the center of the freeway mainline at the painted nose**. Along with coding the location of the freeway mainline node at the ramp junction (painted nose), there needs to be a corresponding length of acceleration or deceleration lane in the model. Mn/DOT's standard single lane ramp designs are taper style ramps; there is a difference in design standards between rural and urban designs.

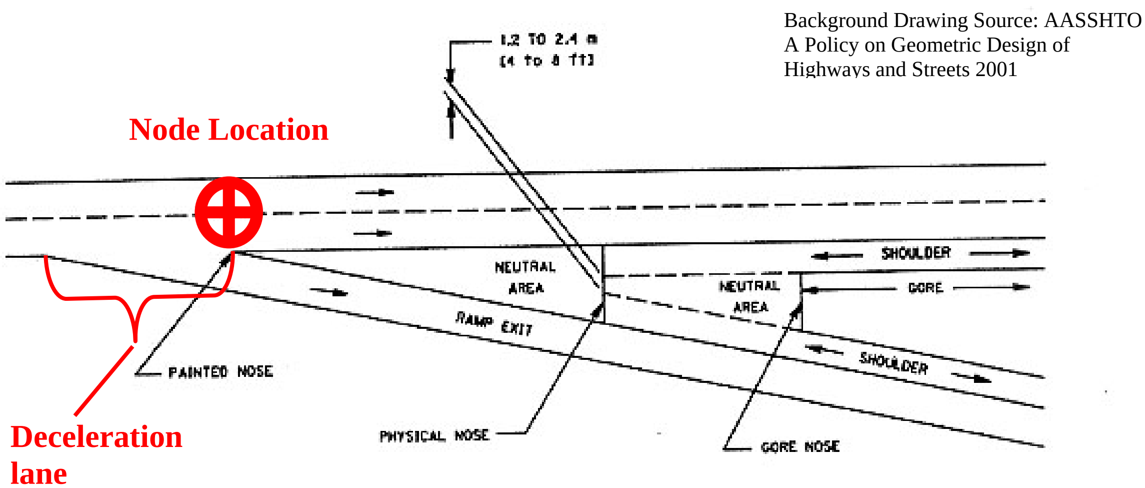


Figure 12 – Ramp Junction Node Location

Within the CORSIM model, it is necessary to include an acceleration or deceleration lane on the mainline to accommodate the transition of vehicles from the mainline to the ramp or to allow entering vehicles to merge onto the mainline. Table 1 shows standard lengths to use in the model on future designs and to provide a frame of reference when estimating acceleration/deceleration lane lengths on an existing freeway. On older freeways or in constrained areas, it is possible that these lengths are less. The distances for the acceleration lanes at on ramps are from 600 to 700 feet; this includes an acceleration lane between 300 to 400 feet plus half of a 600 foot taper. For exit ramps, the deceleration lane begins at the taper.

Table 1
Standard Acceleration and Deceleration Lane Lengths

Type of Ramp	Interchange Type			
	Urban		Rural	
	Standard Plan Sheet 5-297.106		Standard Plan Sheet 5.297.108	
	Loop	Standard	Loop	Standard
On ramp (acceleration lane)	700 feet	600 feet	700 feet	600 feet
Exit (deceleration lane)	350 feet	320 feet	270 feet	240 feet

2. Ramp Exit and Ramp Entrance Links on the Mainline

   CORSIM results include MOEs that are directly relatable to level of service (LOS) criteria published in the HCM. The ramp chapter and analysis techniques in the HCM were based on studies of mainline freeway segments within 1,500 feet of ramp junctions. Figure 13 below illustrates the 1,500-foot influence area for both on and off ramps. **In order to correlate the CORSIM model to the LOS criteria for ramp junctions, a node should be place 1,500 feet away from the ramp junction.**

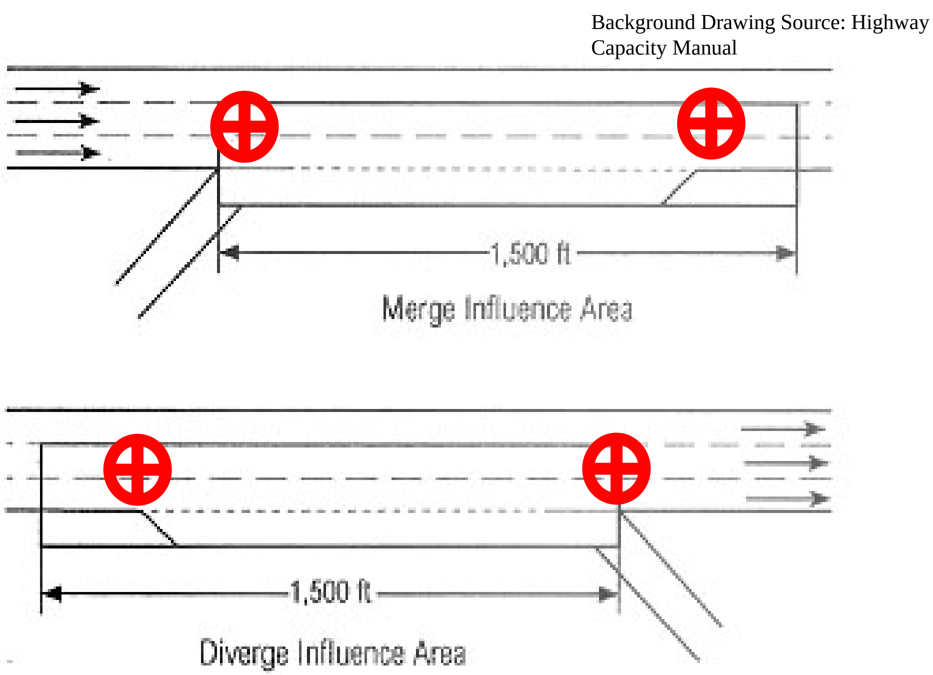


Figure 13 – Node Location Requirements for Ramp Influence Area

3. Points of Curvature

   Nodes should be placed at the beginning and at the end of curves. There are a few reasons for this. The first reason is that the distance around a curve is longer than the straight line distance, accurately reflecting the distance between ramps could be affected if not included properly. Also, the graphics in the animation will be displayed more accurately using the right distance around the curve and the appropriate points of the curve. Secondly, identifying curves is essential to accurately reflect operational characteristics as operating speeds are adversely affected when the radius of curve drops below 2,500 feet. **Curves on freeway alignments need to be identified, especially if the radius of curve is less than 2,500 feet.** Table 2 below summarizes design speed by minimum radius for urban and rural freeways. In summary, curves on mainline freeways less than 2,500 feet have an effect on operations, and these need to be identified on the base map with nodes placed at the beginning and end of curves.

Table 2
Design/Operating Speed by Radius

	Rural Freeways		Urban Freeways	
Design Speed mph	**Limiting Value of Friction factor f**	**Minimum Radius**	**Limiting Value of Friction factor f**	**Minimum Radius**
20	0.17	116	0.3	75
25	0.16	190	0.25	135
30	0.16	273	0.22	215
35	0.15	390	0.2	320
40	0.15	509	0.18	450
45	0.14	677	0.14	677
50	0.14	849	0.14	849
55	0.13	1,042	0.13	1,042
60	0.12	1,348	0.12	1,348
65	0.11	1,637	0.11	1,637
70	0.1	2,083	0.1	2,083
75	0.09	2,546	0.09	2,546

* Source Table 3-2.03A and B, Mn/DOT Road Design Manual

e_{max} = 0.06 ft/ft

4. Grades

Nodes are not usually placed based on grades or profile information; the other mainline criteria will supersede the grade requirement. This is due to the complexity of parabolic curves that are used in transitions between grades; the actual grade on a vertical curve changes at every point along the curve. Also, long straight grades can be added to the model by matching the grade to individual link segments.

The effects that grades have in CORSIM are on the acceleration and deceleration characteristics of heavy trucks. Grades in the field can have other human factors type of effects that cause operational issues; CORSIM will not interpret human factors issues caused by grades. The “calibration” of these conditions is done by other means.

Grades are not a significant factor in most cases in Minnesota because the terrain is mostly flat throughout the state. The desired maximum grade for freeways in Minnesota is 3 percent. The HCM has documented in its methodology that a grade less than 3 percent must be longer than a 0.50 miles to have an effect on truck operations. A grade of 3 percent or greater must be 0.25 miles or longer to have an effect on trucks.

Grades that are significant in HCM Analysis must be coded in CORSIM. Such grades will have an effect on truck performance.

5. Between Interchanges

   Nodes should be spaced an average of 2,000 feet or less throughout the freeway model. Where there are long stretches of basic freeway on tangent sections, multiple nodes should be considered. On long tangent sections, nodes at the beginning of grades should be considered to break up the model into smaller segments. Curvilinear alignments will tend to have enough nodes to break up the freeway into appropriate segments. The reason for this is to facilitate the review of MOEs.

   - If distance is greater than 3,000 feet between ramps – the split should be 1,500 feet downstream of merge and 1,500 feet up stream of diverge (see ramp exit links and ramp entrance link criteria.).
   - 2,500 to 3,000 feet between ramps – the 1,500 feet rule should be applied where possible.
   - Less than 2,500 feet – follow grades and curvature criteria.
   - Less than 1,600 feet between entrance and exit ramps – code as one link.

Ramps

Ramp segments are the links and nodes on the ramp roadway. Because ramps are a transition between facilities, the design includes lower speed curves primary consideration is given to where curves begin. After considering curves, the criteria governing the node locations on ramp links depend on whether it is an exit or entrance ramp or a metered ramp. Another consideration will be if the ramp is a system-to-system ramp (free flow) or if the ramp is a connection to an arterial with at-grade signals. Coding the entire ramp links including the ramp arterial intersections are discussed later in the chapter.

1. Controlling Curve, First Node Away from the Freeway

   Within a standard ramp design, there are provisions for a safe transition of speed. The distance between the physical gore and the painted nose is around 300 feet for both on and off ramps. Figure 14 from the Mn/DOT Road Design Manual illustrates this transition. After this distance, a lower speed curve may be introduced. In the case of loop ramps, this is a very tight curve with a desired minimum radius of 230 feet. On older freeways or locations with other constraints, this radius could be less. **Based on these criteria, the first node for an exit ramp away from the mainline should be at the physical gore.**

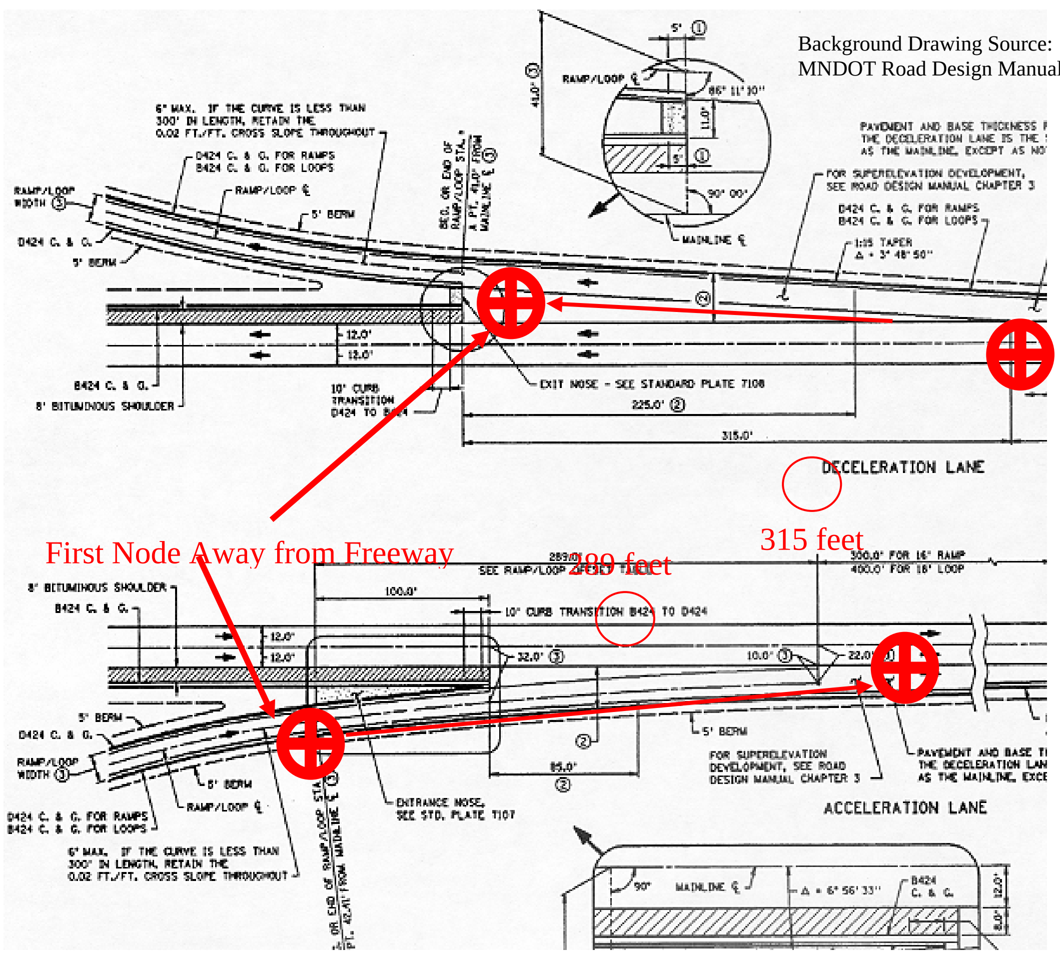


Figure 14 – First Ramp Node Detail

2. Ramp Meters

A node should be located where the ramp meter is located. During ramp-metered conditions, single lane ramps will operate as two-lane ramps; the signals will alternate green lights releasing one car per green. Mn/DOT's ramp metering strategy is system responsive with ramp metering timing set by zone controls and traffic conditions. As a result of the ramp metering study conducted in 2000, there is a limit to the wait that can occur at a ramp meter. If the traffic backs up to a 4-minute wait or greater, the ramp meter will cycle at the fastest rate, releasing all vehicles on the ramp.

Coding the ramp meter timing and control in CORSIM is done on a FRESIM ramp node. There are three basic ramp metering control strategy types that can be modeled in CORSIM. The one that should be used for modeling freeway projects in Minnesota is Clock Time Metering. All ramp meters in CORSIM operate as a dual release (i.e., on each green light two cars will leave the meter). Meter rates provided by the TMC will need to be adjusted to reflect two cars departing per green.

Mn/DOT's ramp metering system is demand responsive. The effort to replicate the demand responsive system and algorithms in CORSIM is not typically necessary for design projects. The traffic management system can provide a report (see below) that will include typical metering rates by ramp. This information is used to code ramp meter rates in CORSIM using the clock-time method.

<u>Coding ramp meter timing example:</u>

- *Mn/DOT's Ramp Meter Timings.* The timings to use for ramp meter timings are collected from the IRIS system. The IRIS system records the actual ramp meter timings that occurred in the field in 30-second intervals. Below are IRIS Ramp Meter Reports Column Descriptions.

Time:	The start time of that rows 30-second interval.
Cycle Time:	The number of seconds to complete the cycle of red, yellow, green.
Green Count:	The number of greens given in that 30 second time interval.
Greens/Merge:	The ratio of the number of greens given to the merge detector volume.
Queue Occupancy:	The occupancy on the queue detector for the 30 second interval.
Queue Volume:	The volume measured by the queue detector for the 30 second interval.
NOTE:	Any numbers that are followed by an "*" indicate that one of the values that the number was derived from was missing. If a number is replaced by a "?", this means that either all of the values for that total were missing or the

result of the calculation was not a number (i.e., division by zero).

- The raw data will be provided in a comma separated excel file (*.csv). The raw data will then need to be averaged into a constant rate to be used during the simulation period. Below is a portion of a sample IRIS report for the southbound on-ramp at I-494 at Carlson Parkway.

Ramp Meter M494E09 Carlson Pkwy October 10, 2002

Time	Cycle Time	Green Count	Ratio	Queue occupancy	Queue volume
7:15:00	10	3	1.5	9.7	5
7:15:30	10	3	1	7.2	4
7:16:00	10	3	1	10.7	5
7:16:30	10	3	1	5.9	3
7:17:00	10	3	0.8	6.9	3
7:17:30	7.5	4	1.3	5.3	3
7:18:00	10	3	0.8	10.8	4
7:18:30	10	3	1	3.8	2
7:19:00	7.5	4	1.3	9.2	3
7:19:30	10	3	0.8	10.9	5
7:20:00	7.5	4	1.3	7.7	3
7:20:30	10	3	1	3.6	2
7:21:00	10	3	0.8	6.7	3

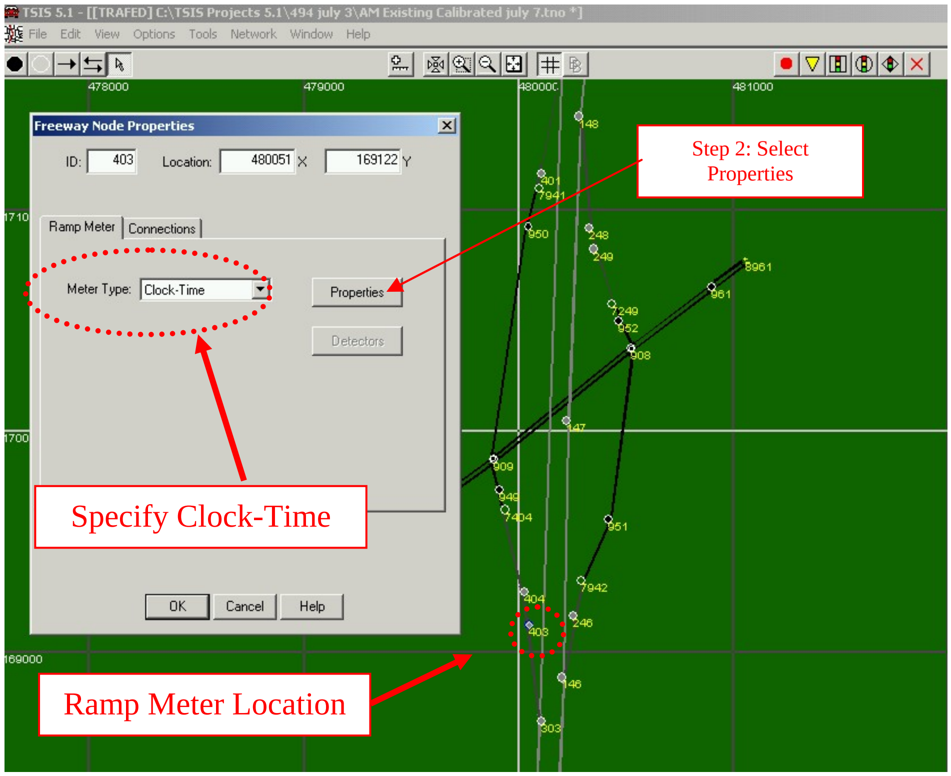
- The cycle time values from the IRIS report are averaged for the duration of the simulation period. All ramp meter timings within the study area should be summarized into a cycle times' table formatted like the I-494 example below.

SP 2785-304 I-494 in Minnetonka, MN Meter Data from October 10, 2002

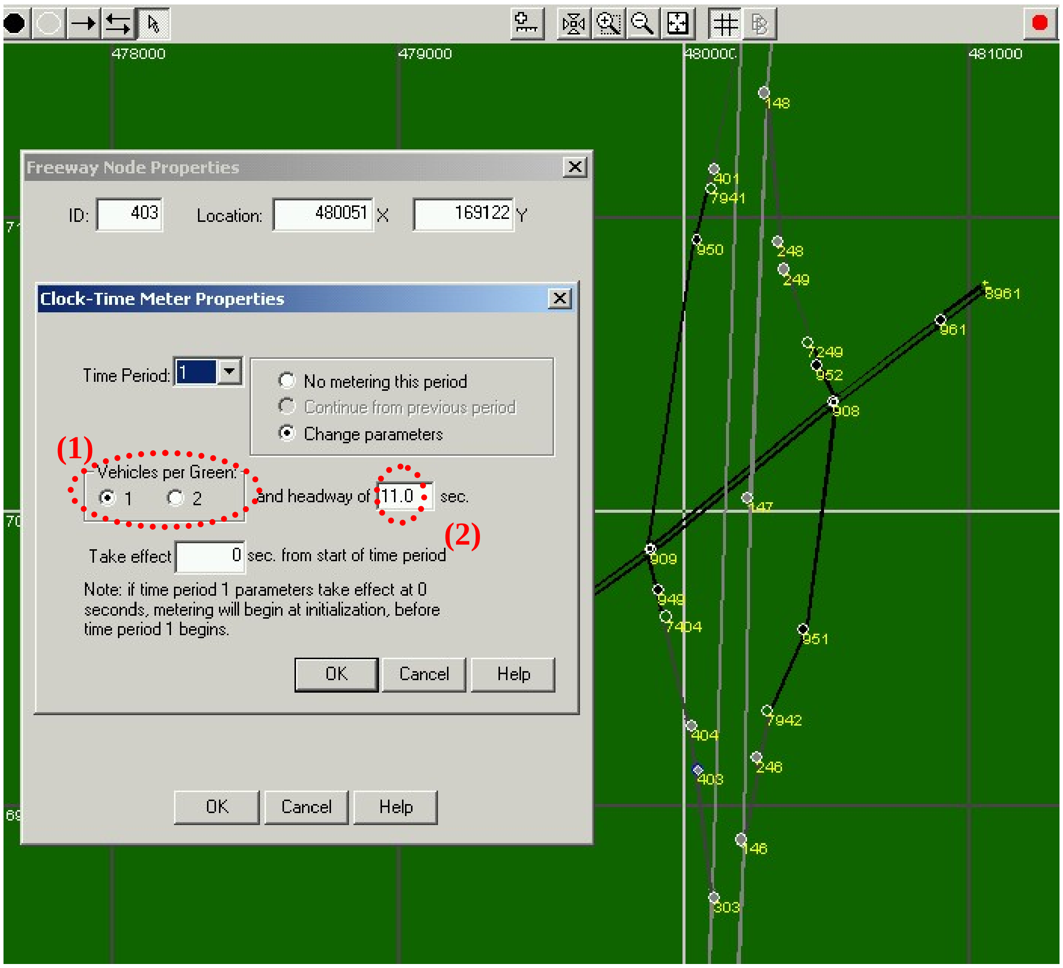
Location	Meter ID	Node	AM Start	AM End	AM Timing (sec/veh)	PM Start	PM End	PM Timing (sec/veh)
Carlson Pkwy.	E09	403	6:15	8:30	11.0	15:30	17:30	6.0
	W65	248	n/a	n/a	0.0	15:05	17:45	5.5
I-394	E10	406	6:15	8:30	7.0	15:10	17:45	3.5
	E11	408	6:10	8:30	4.0	15:10	17:45	6.0
	W63	1617	n/a	n/a	0.0	15:10	17:45	10.0
	W64	244	n/a	n/a	0.0	15:10	17:45	2.0
Minnetonka Blvd.	E13	415	6:15	8:30	10.0	15:30	17:45	10.0
	W61	235	n/a	n/a	0.0	15:10	17:45	8.5
TH 7	E15	419	6:15	8:30	15.0	15:45	17:45	8.0
	E16	421	6:15	8:30	7.5	15:45	17:45	6.5
	W58	228	6:45	8:30	4.5	15:10	17:45	8.0
	W59	230	7:00	8:30	12.0	15:10	17:45	8.5
TH 62	E19	430	6:20	8:30	6.0	15:10	17:45	4.0
	W55	219	6:40	8:30	4.0	15:10	17:45	3.5
Valley View Rd	W53	212	n/a	n/a	0.0	15:30	17:30	4.5

- Coding ramp meter timings into CORSIM can be done using Trafed. The following screen captures illustrate the dialog boxes that appear when a ramp meter is identified for a node.

Step 1: Specify Clock Time Metering.



Step 2: Select properties and identify one-car per green (1). The entered headway time (2) equals the averaged cycle time from the cycle time's table shown above.



3. System-to-System Ramps

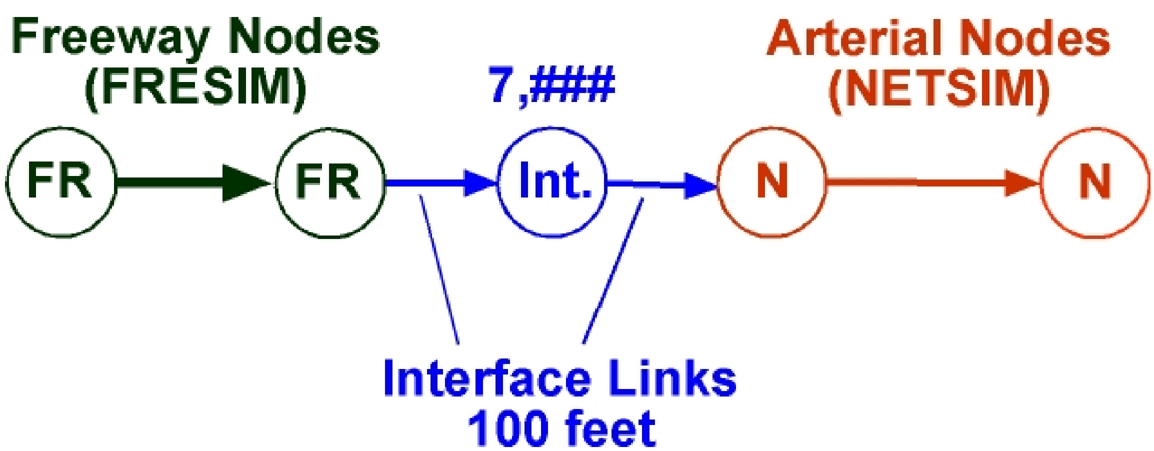
   It is possible in CORSIM to connect freeway-to-freeway directional ramps with a single link connecting the two ramp junctions together. In order to reflect the speed conditions and to facilitate review of results, there should be at least two nodes on these ramps. The node numbering criteria will explain connecting ramps in further detail.

4.2.2 Arterial Node Locations

Arterial node locations are placed based on the location of intersections, transitions from the freeway model, and nodes required to feed the intersections. ***The nodes feeding the approaches to the intersection must be place far enough away so that storage lanes can be accommodated. A rule of the thumb is to place entry exit nodes at the center of adjacent intersections.***

4.2.3 Interfaces Nodes

Interface nodes (7###) are required when the transitioning between a freeway and arterial. These nodes are typically on ramps at service interchanges. ***Generally, at exit ramps, the interface node should be closer to the freeway mainline and at entrance ramps, closer to the arterial.*** The interface links created using interface nodes should be kept as short as possible, 100 feet is a typical distance to use. Statistics on interface links



are not reliable. Figure 15 details how interface links are constructed.

Figure 15 – Interface Link Schematic

4.2.4 Node Numbering Criteria

The purpose of creating a node numbering convention is to create consistency, which allows for easy review by yourself and others. Also combining models becomes an easier process when the likelihood of duplicate node numbers is eliminated. Table 3 below shows the recommended criteria for assigning node numbers. When following this criteria, review of the *.trf file is easier. For instance, if you want to review southbound freeway mainline links, the file is scanned for nodes that are numbered in the 300s.

Table 3
Node Numbering Criteria

Segments	Range		Description
	From	To	
0s	1	99	Miscellaneous
100s	100	199	Northbound Freeway Mainline
200s	200	299	Northbound Freeway Ramps
300s	300	399	Southbound Freeway Mainline
400s	400	499	Southbound Freeway Ramps
500s	500	599	Eastbound Freeway Mainline
600s	600	699	Eastbound Freeway Ramps
700s	700	799	Westbound Freeway Mainline
800s	800	899	Westbound Freeway Ramps
900s	900	999	Arterials

When assigning node numbers, the node value at the beginning of the freeway should be a low value and increased sequentially as you move down the freeway. Allow for gaps in the numbering sequence where there is a potential for new or revised access to the freeway system. Be careful not to be so generous with values that you run out of node numbers before the end of the freeway segment (leaving large gaps between the nodes 100 to 110 to 120 for instance). You will have 99 nodes to work with for one direction of freeway; on average, there will be a node every 1,000 feet. This would create a model 99,000 feet long or 18 miles long. Typical projects are from 3 to 8 miles long.

When assigning node values at entrance ramps, it is useful to "pair" the numbers. For instance, if there is a ramp junction node of 110, the first node on the ramp link should be 210. By "pairing" the last two digits of the ramp junction node and the first node on the ramp, you will have another mechanism for reviewing the input file. Depending on the number of nodes on the ramp link, the pairing sequence may not work. The model will run with any number used as long as it has not been duplicated. The purpose of this "pairing" concept is to make modeling easier, be prepared to move onto the next steps if the model is complicated.

When assigning node numbers on arterials, use the 900 values. The only criterion beyond this that is useful is to assign the lowest numbers to the intersection nodes. So, if you have two intersections in the model, assign the first intersection as 901, the second as 902. By using this numbering sequence for arterials, sorting links in a sequence that facilitates MOEs is a much easier process.

4.2.4.1 Adding to an Existing Model

When adding to an existing model or building a model that exceeds the available numbers within the hundreds criteria, maintain the hundreds criteria by adding a thousands value to it. For example, we want to add to a northbound I-35W model, our existing model stops at node 199. To continue or add to the model, use 1100, 1102, etc. The main reason is to make it clear what is different and to eliminate the possibility of duplicate node numbers. This would also eliminate the need to renumber and recode a completed model.

4.2.5 Typical Link Node Diagram Concepts

There are a number of ways of assigning nodes to a roadway system. The purpose of this manual and the proceeding criteria is to create consistency between modeling efforts and to ensure reproducibility of results. There are a number of interchange areas in the metropolitan area where typical conditions may not be applied. These need to be addressed on a case-by-case basis and may require the modeler to try other methods to determine the best method for modeling the project. Most of the system, however, does fall into a standard arrangement. In these cases, the criteria developed is straightforward. A number of typical link node diagram concepts have been prepared for this manual and are illustrated. This manual can be used as a living document for the modeler. As you encounter unusual modeling areas, make a sketch of the diagram and put into the Mn/DOT web site. If the sample case is very unique or innovative, provide it to Mn/DOT to add to this manual.

Link node concepts illustrated in this chapter:

Diamond Type Interchanges	Diamond interchanges are the most common interchange; however, folded diamonds or partial clover leaf interchanges are quite similar when applying the criteria (see Figures16 and 17).
Single Point Interchanges	Single point interchanges are similar to diamond type interchanges up to the interface links. At the ramp terminal intersection, extra nodes are used to separate the signalized single point from the free flow right turns (see Figure 18).
Freeway Bifurcation	Ramps can only be added to mainline freeway segments in CORSIM. A freeway that splits into two freeways requires special coding. One leg of the freeway split will be coded as a mainline freeway, while the other leg is

coded as a ramp link. Ramp links in CORSIM cannot have other ramp connections; therefore, the freeway split coded as a ramp link needs to be "converted" into a mainline freeway segment. A ramp link is converted into a mainline segment by the use of a "dummy" mainline freeway. Figure 19 illustrates the technique of introducing a dummy mainline freeway.

Collector-Distributor Roads

Collector-distributor (C-D) roads within freeway interchanges are modeled like mini freeways within a freeway. After the freeway exit, the ramp link needs to be converted into a mainline freeway so that the exits and entrances that occur within the C-D road can be modeled. Finally, the C-D road must be converted back into a ramp before it can merge back into the mainline freeway. Figure 20 is an example of a C-D road system for a cloverleaf interchange. This concept can be applied to any C-D road configuration.

On Ramp HOV Bypass Lane

HOV bypass lanes are quite complex when broken down into a link node diagram. The time and effort to model these conditions usually out weighs the benefits. However, if it is necessary to look at a ramp with an HOV bypass lane in greater detail, it is provided in Figure 21.

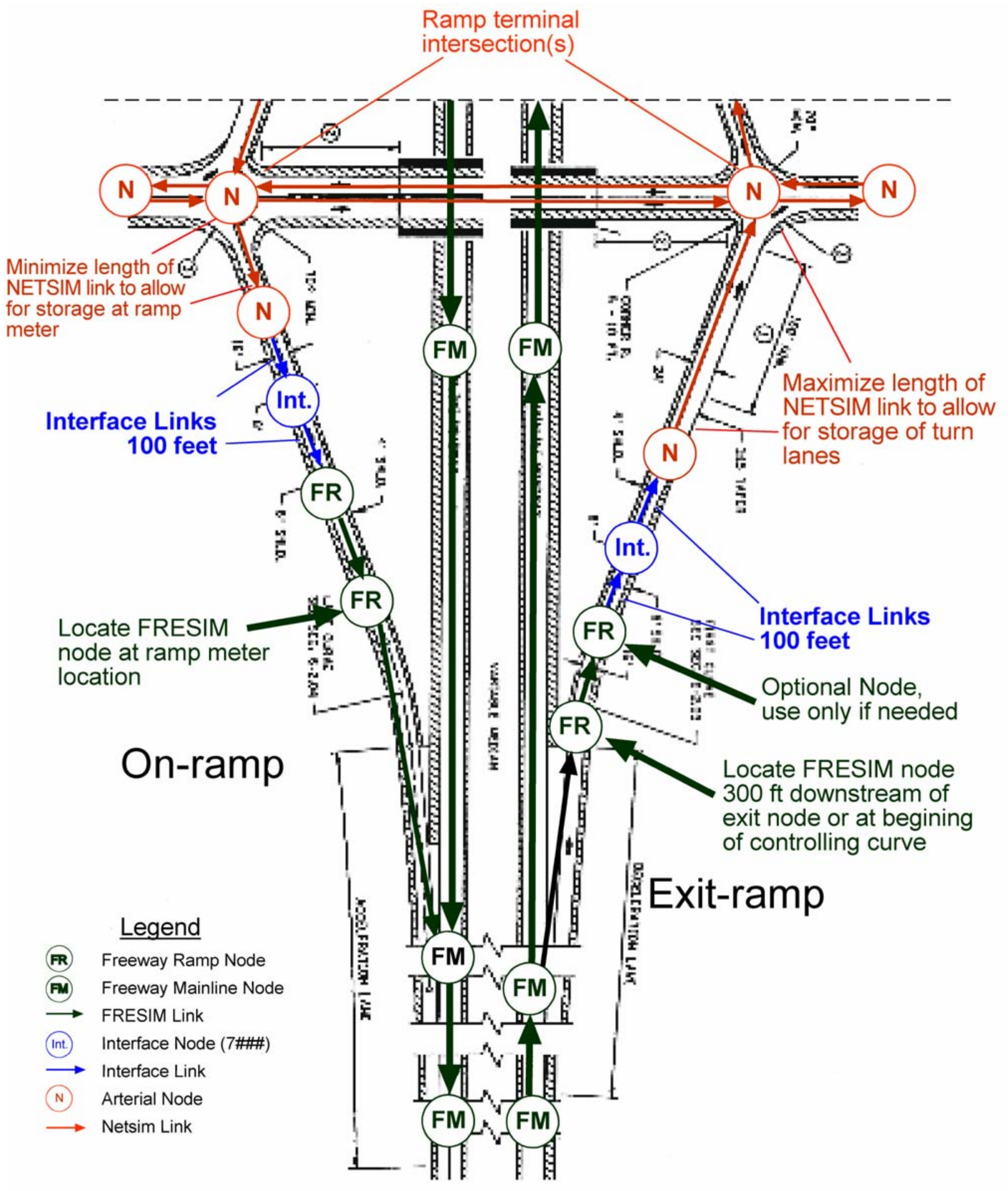


Figure 16 – CORSIM Coding for Standard Diamond Interchange

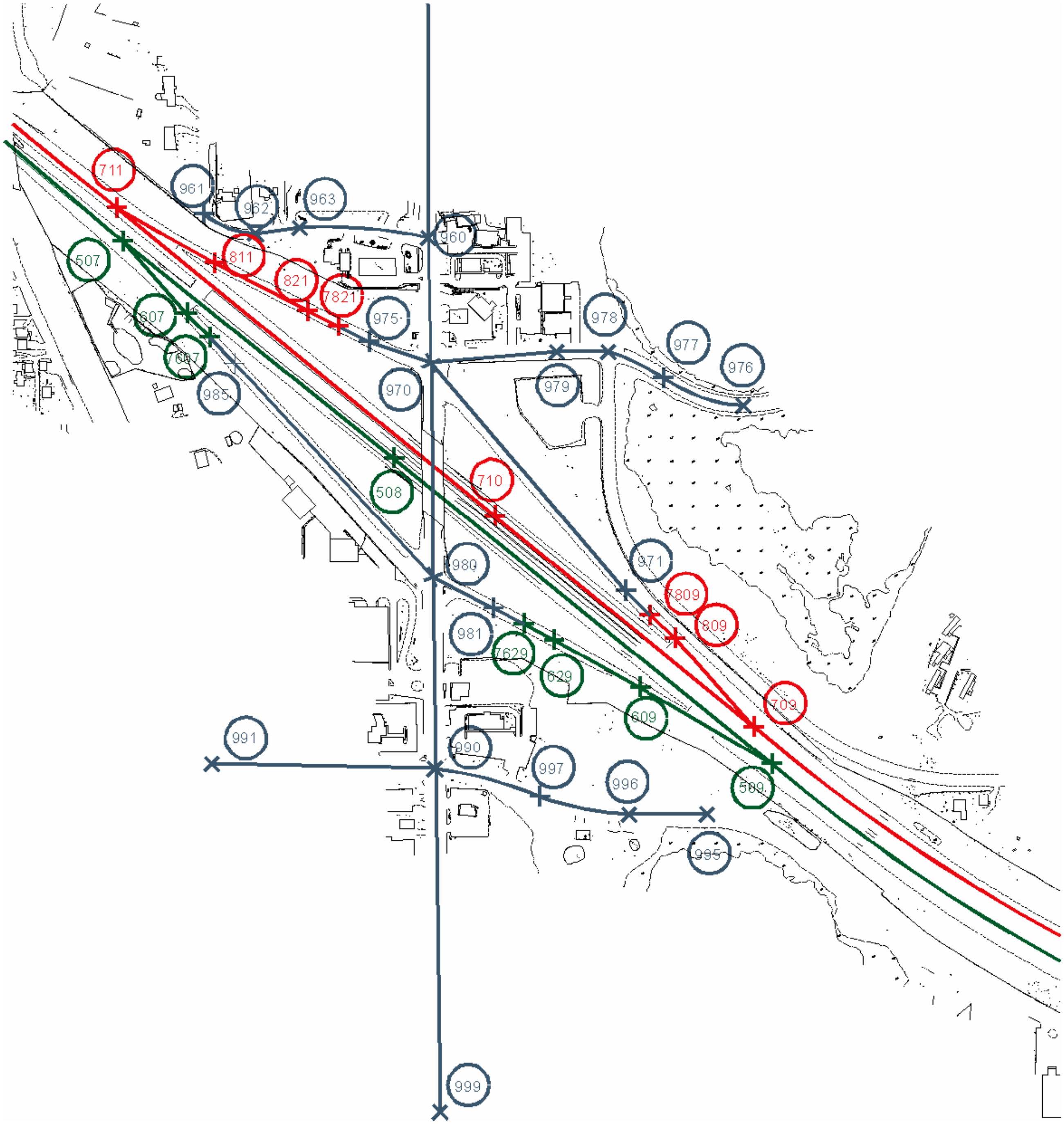


Figure 17 – CORSIM Link Node Diagram Sample: Diamond Interchange

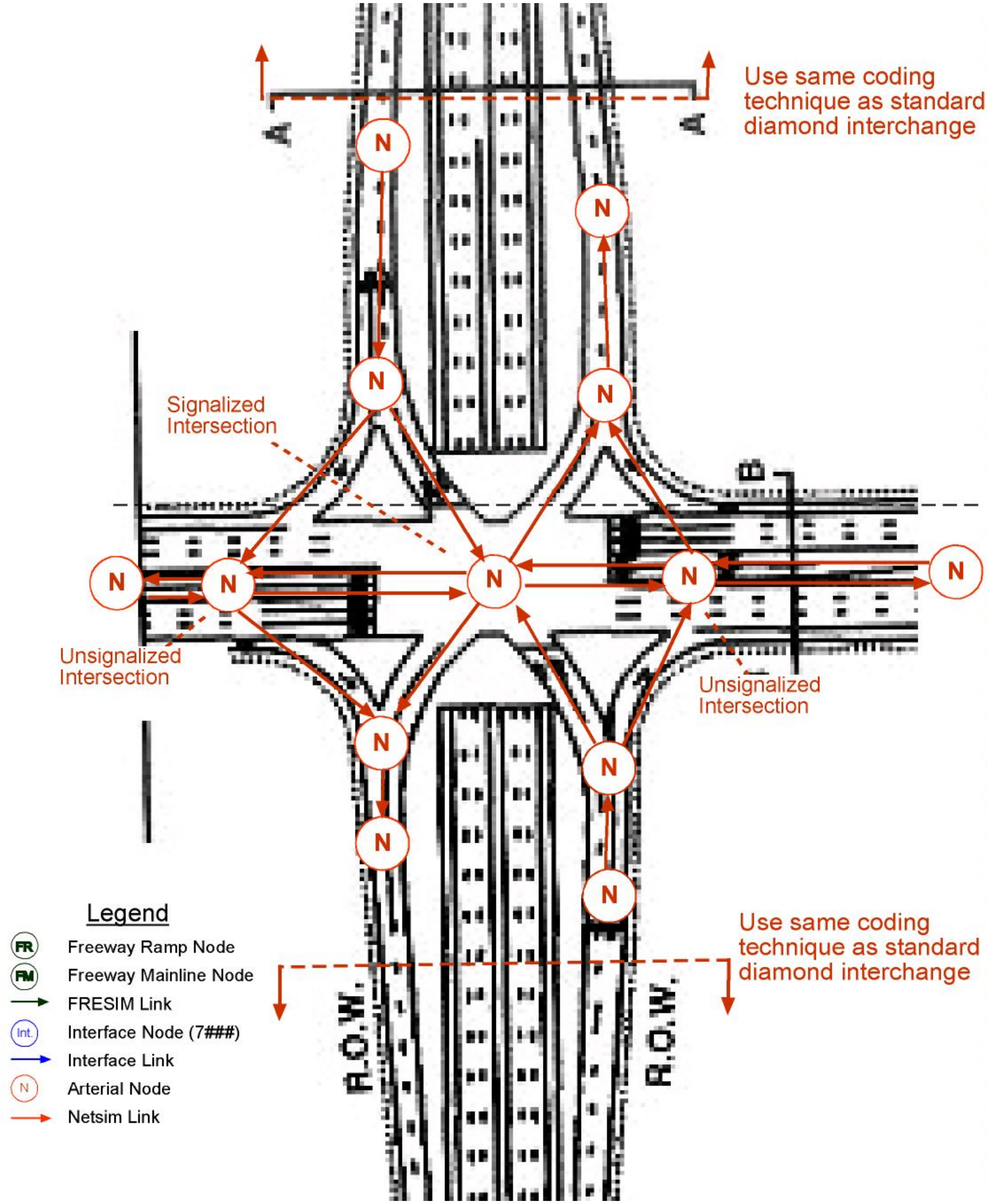


Figure 18 – Single Point Interchange Node Diagram Sample

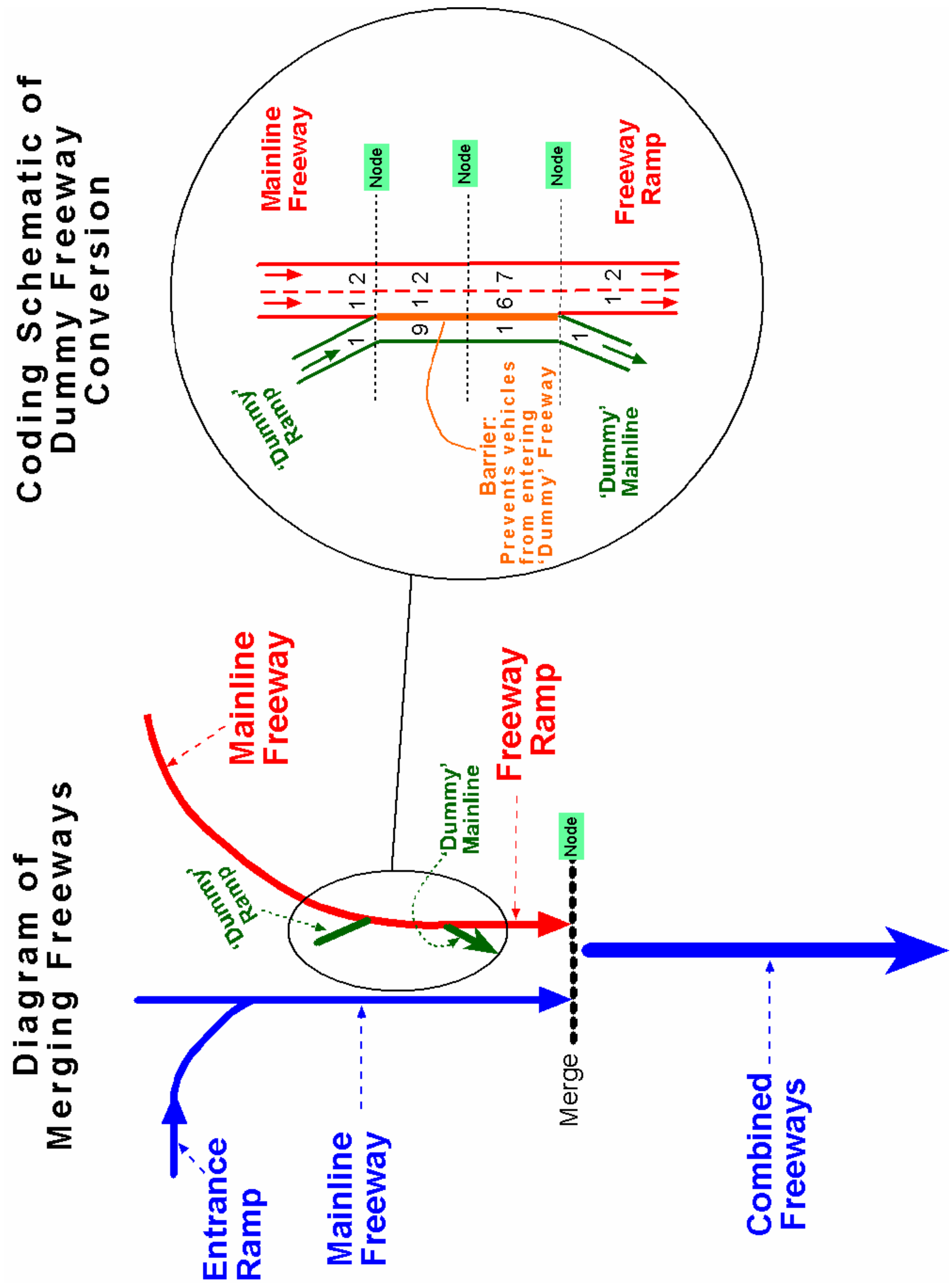


Figure 19 – Freeway Bifurcation Coding Sample

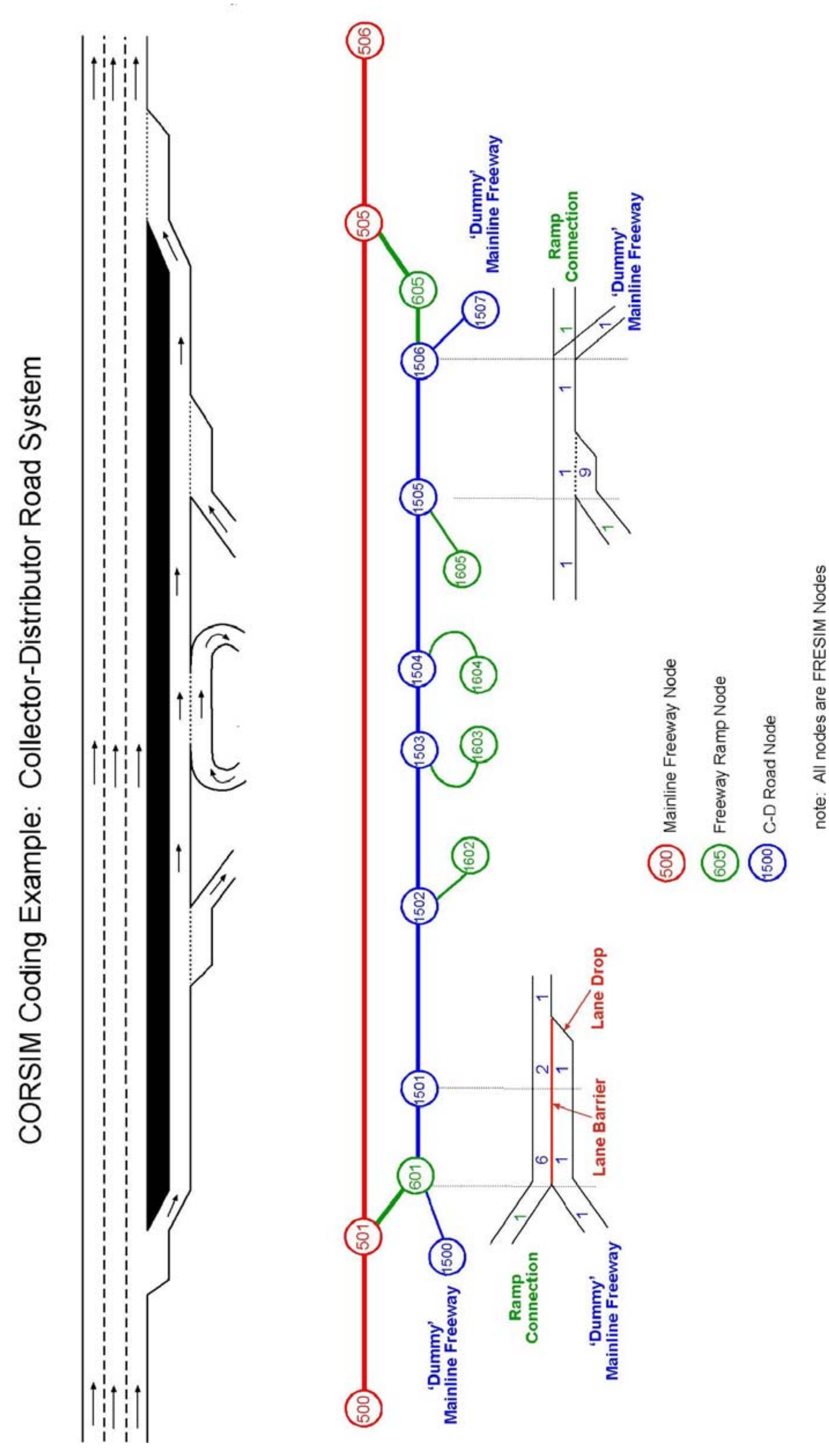


Figure 20 – Collector-Distributor Road System Coding Sample

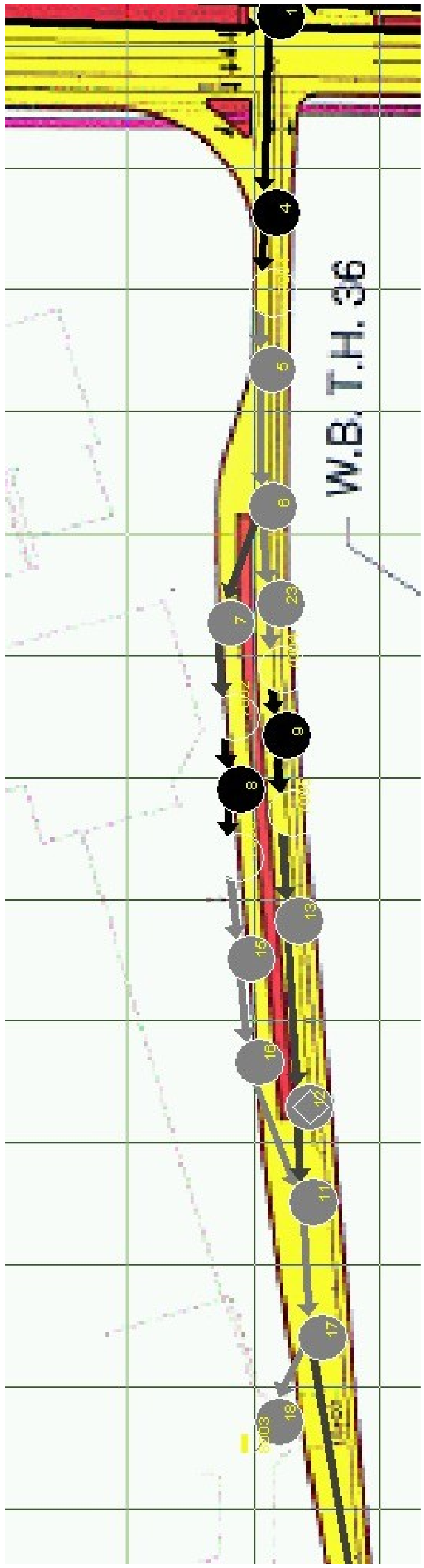


Figure 21 – HOV Bypass Lane at Typical On Ramp Coding Sample

4.2.6 Lane Schematic Development

A lane schematic is a drawing that is prepared with an exaggerated width compared to actual lengths so that lane alignments and lane patterns can easily identified. This schematic aids the modeler in accurately coding CORSIM network. Figure 22 below provides detail lane number diagrams from the TSIS Users Manual. These diagrams provide guidance as to how to develop a lane schematic. Figure 23 is a sample lane schematic from a project. Preparation of the lane schematic should be concurrent with the construction of link node diagram, and both drawings should be reviewed at the same time. If the lane schematic is prepared in an electronic fashion, it can serve as a graphical display of results later on in the modeling process. Features that should be included in the lane schematic include:

- Mainline node numbers
- Distance between nodes
- Length of acceleration and deceleration lanes
- Length of add and drop lanes,
- CORSIM lane assignment numbering scheme
- Radius <2,500 feet
- Grade > 3 degrees
- Label exit and exit ramps
- Label major roadways
- Peak hour volumes (mainline segments and ramps)
- Mainline detector stations

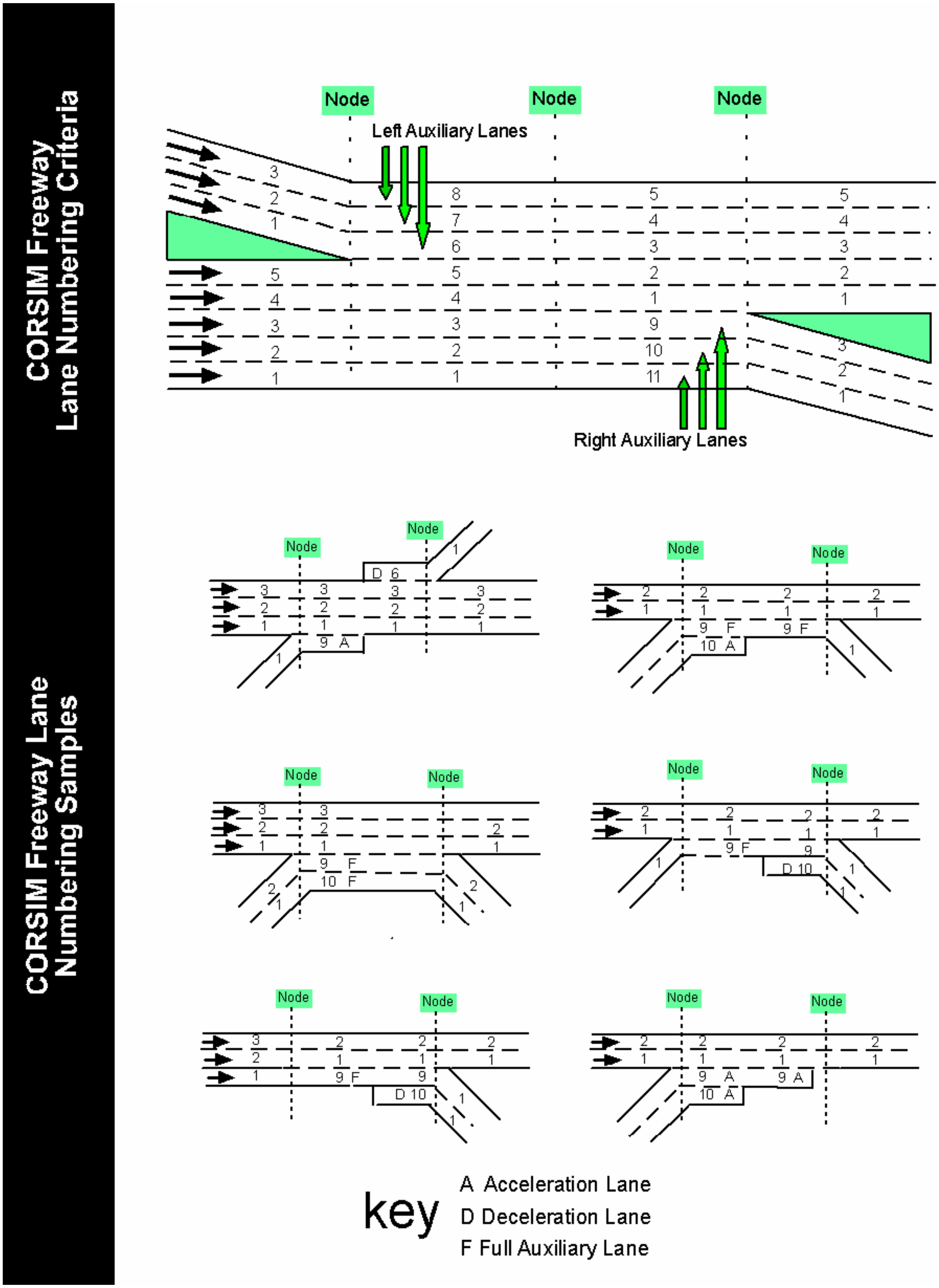


Figure 22 – Lane Schematic Lane Number Criteria

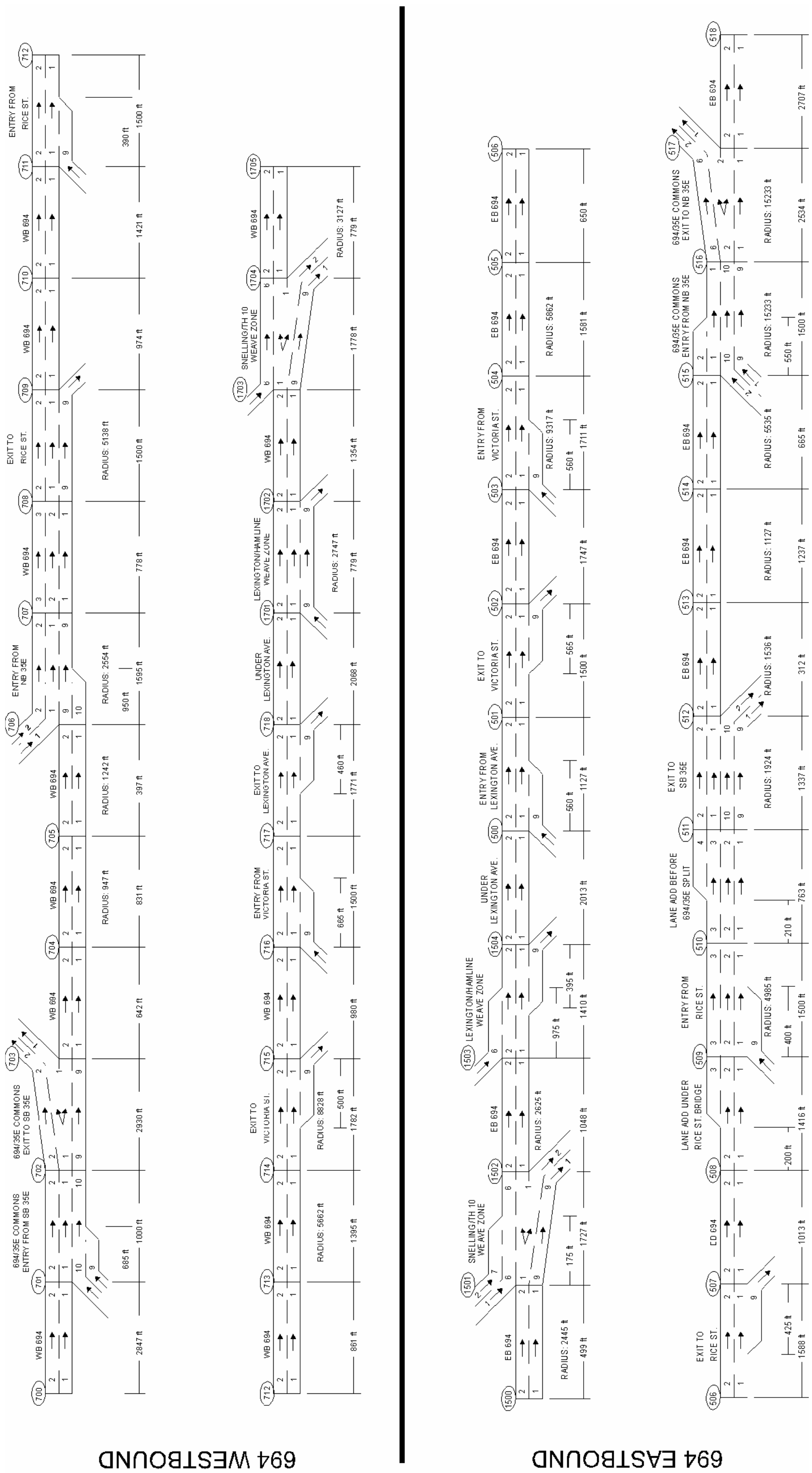


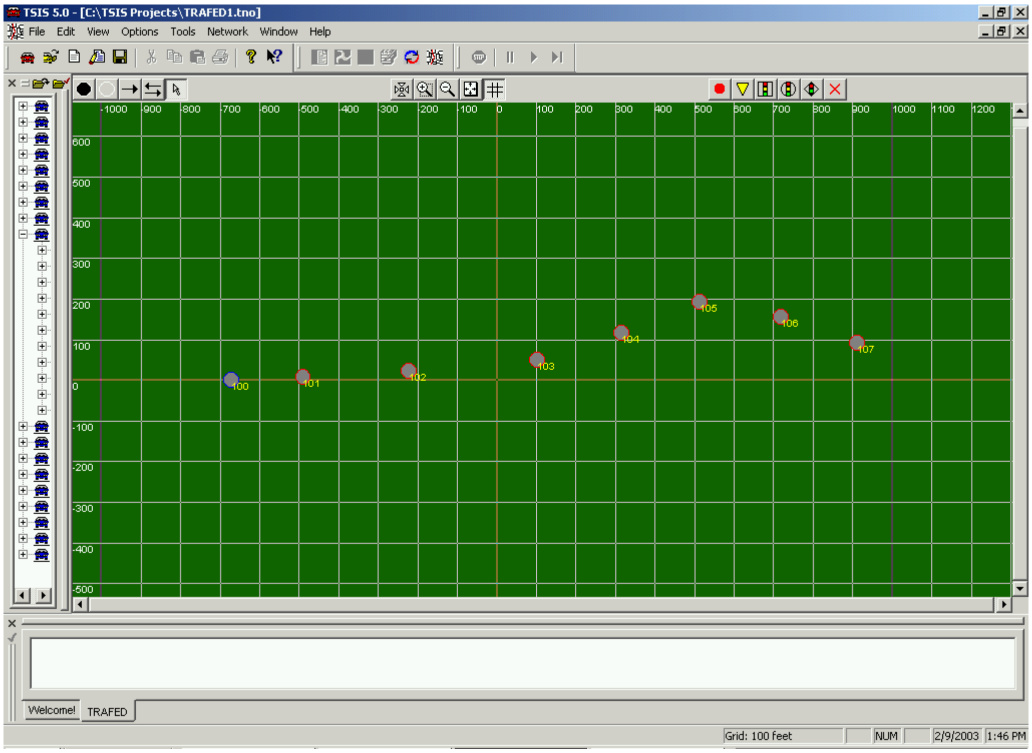
Figure 23 – Lane Schematic Sample

4.3 Part II: Freeway Coding

With the link node diagram, lane schematic, and node coordinates in hand, the actual modeling is a relatively easy process. The initial steps (Steps 2-7) by freeway direction are conducted using TRAFED. TRAFED is the graphical user interface program used for creating CORSIM files. Because the information for coding a model has been prepared to real world coordinates using detailed information, it is not necessary (nor helpful) to use the bitmap background feature in TRAFED.

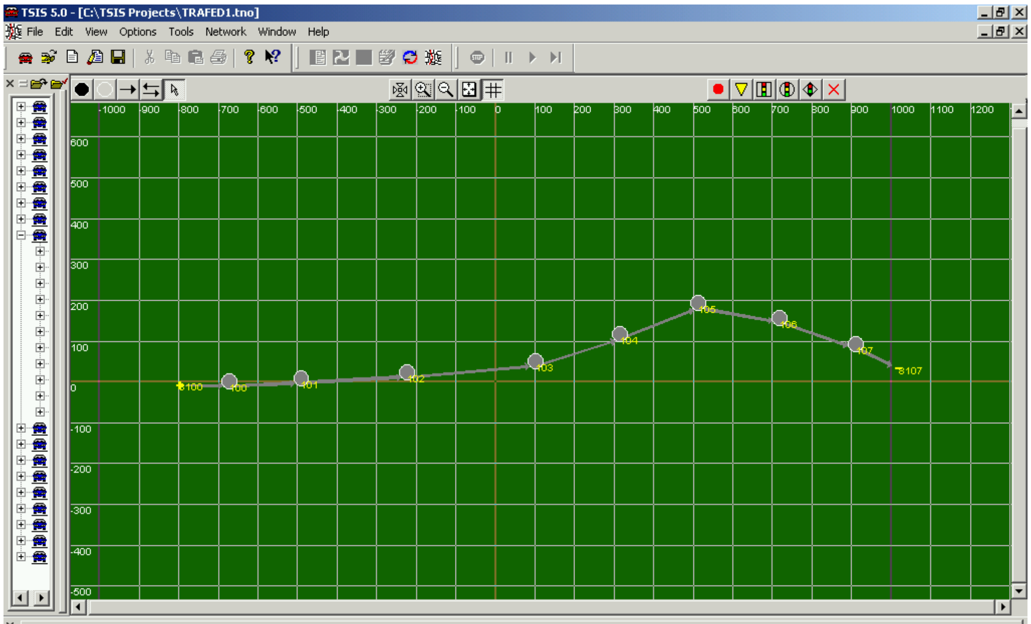
4.3.1 Step 2: Code Freeway Mainline Nodes (Direction 1)

From the link node diagram, the modeler will first place the nodes pertaining to freeway mainline links for one direction of the freeway model in TRAFED.



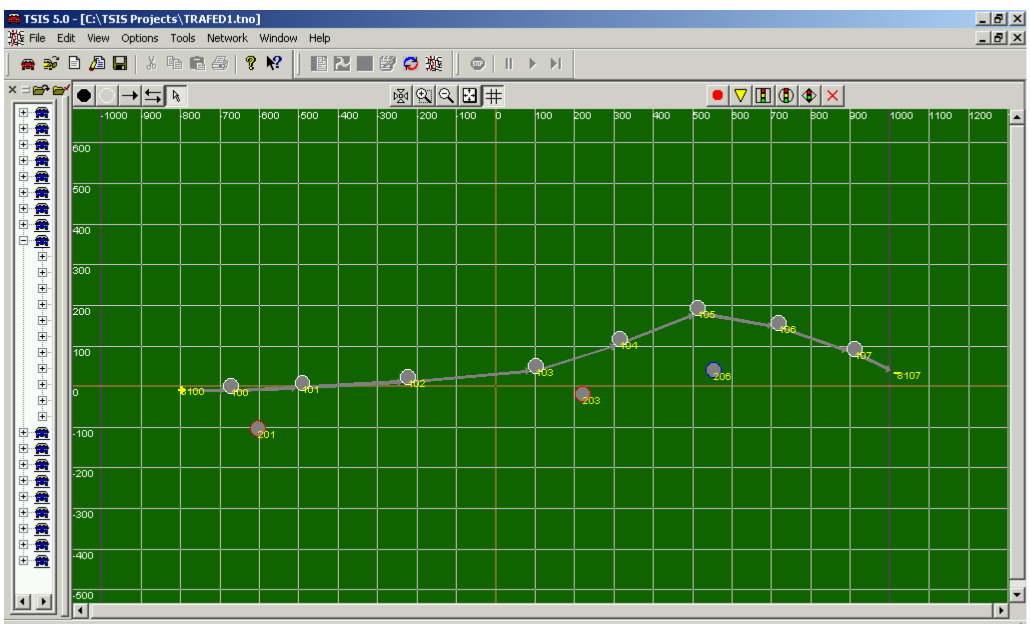
4.3.2 Step 3: Connect Freeway Mainline Nodes (Direction 1)

Beginning where the freeway model starts for direction 1, the modeler will connect each node in sequence in TRAFED.



4.3.3 Step 4: Code Freeway Ramp Nodes (Direction 1)

Similar to Step 2, the modeler will place the freeway ramp nodes required in the freeway model.



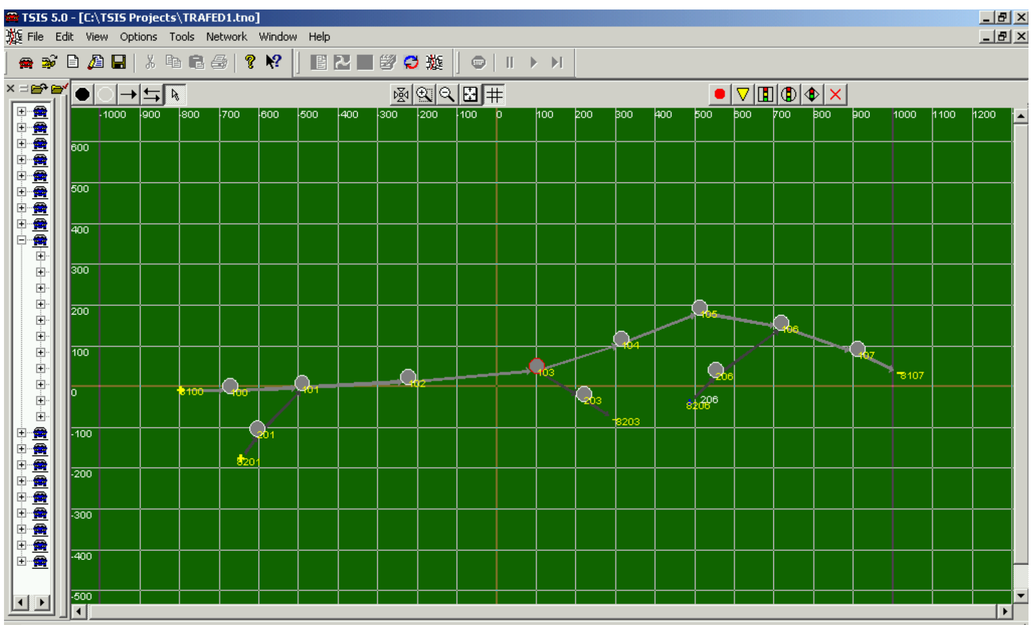
4.3.4 Step 5: Connect Freeway Ramps with Freeway Mainline (Direction 1)

Similar to Step 3, the modeler will connect the ramp nodes to the freeway mainline beginning with the ramps closest to the start of the freeway model. **It is important to understand that the sequence of connecting the nodes can affect the roadway characteristic (whether it is coded as a freeway or ramp).** This condition mostly occurs for modelers at on ramps. You must first connect the on ramp node to the freeway ramp junction node before coding the entry link for the on ramp. If you follow this procedure, the ramp link will be black in the display. If you do not, the ramp link will be light gray in color indicating a FRESIM mainline link. If this does happen, you have two choices:

1) Delete the link and redo the connection in the proper sequence, or

2) Edit the link properties and change from a freeway to ramp designation, remember to change the number of lanes.

Quick Check: Freeway segments and nodes are indicated in gray, while arterial links and nodes are black.

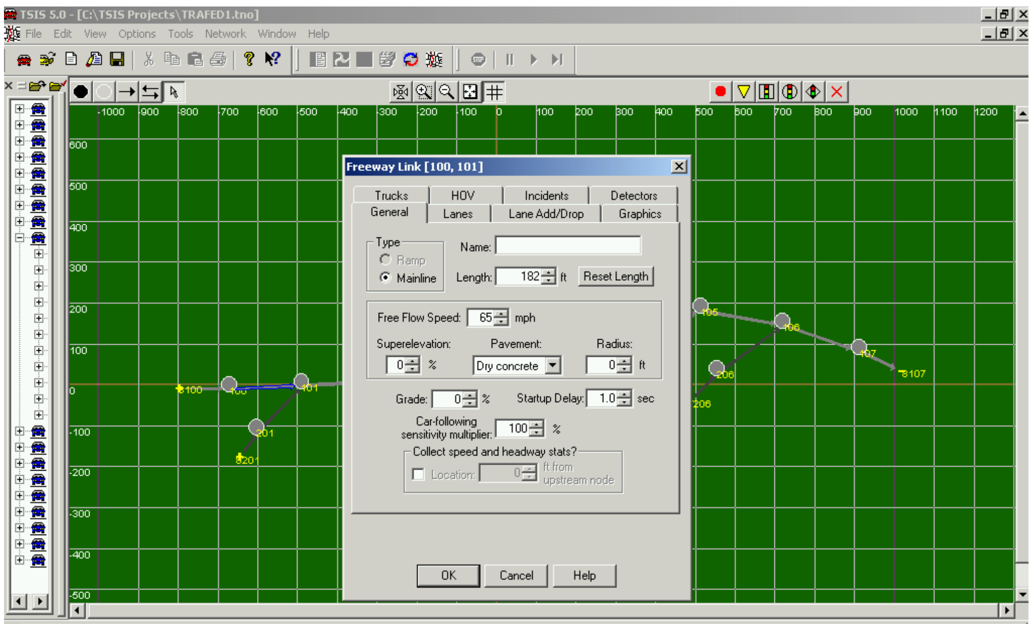


4.3.5 Step 6: Code Physical and Operational Characteristics (Direction 1)

Using the lane schematic developed in Step 1, the modeler will use TRAFED to update the lane geometry and operating characteristics of each link in the model, beginning with the start of the freeway model.

When updating this information in TRAFED, you should use the Lane Schematic Diagram as a reference. The Lane Schematic Diagram will have all the information required to complete this step.

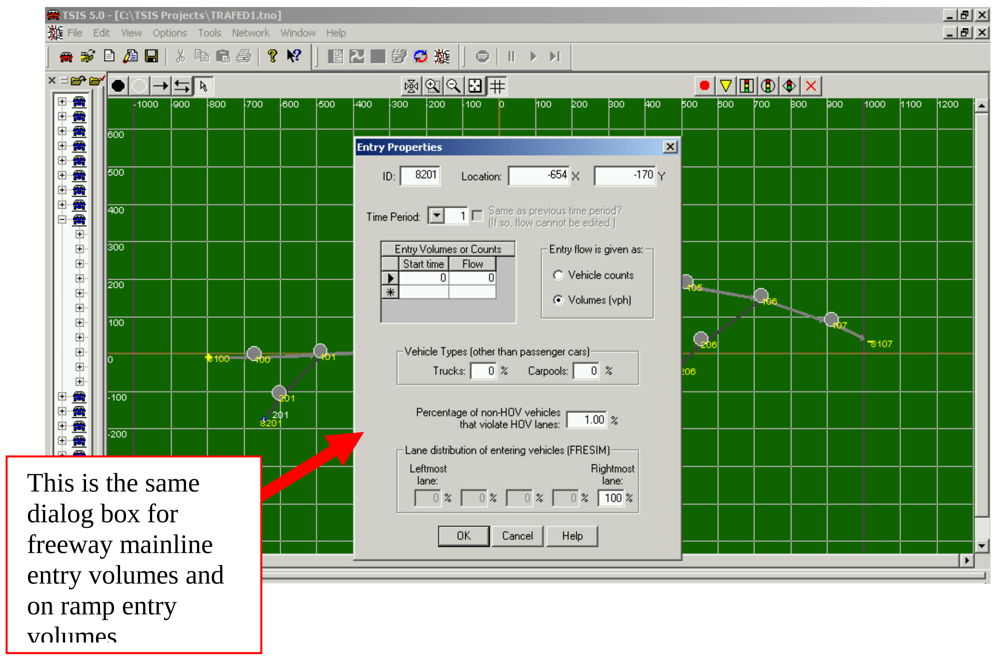
Reminder: When coding Lane Adds or Lane Drops, the designation in the dialog box is not the number of lanes being added or dropped, it is the CORSIM lane number. Only one lane can be added or dropped at a location on a link, up to two lanes can be added or dropped on a link.

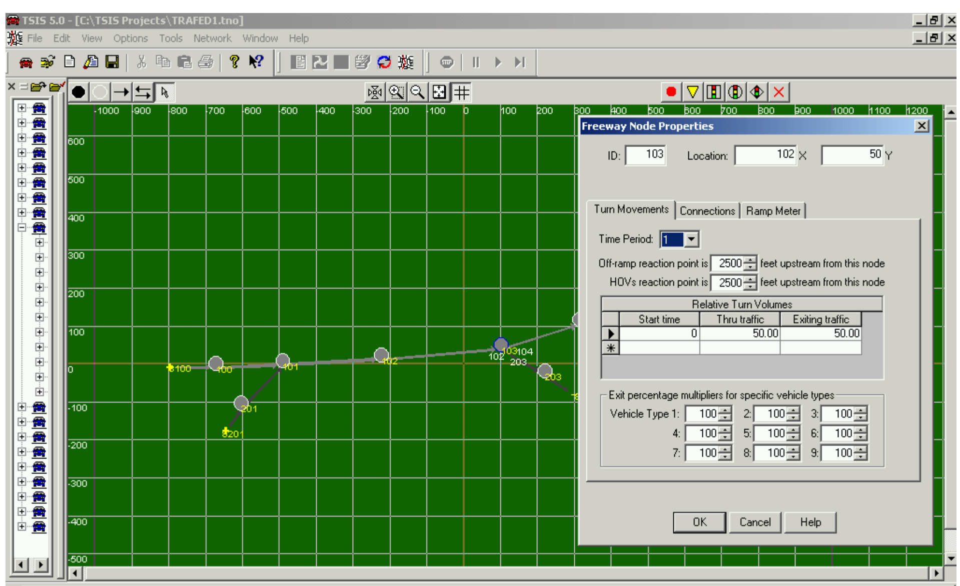


4.3.6 Step 7: Code Peak Hour Traffic Volumes (Direction 1)

Law #2: Do not proceed with modeling without a balanced volume data set of the peak hour.

Coding the peak hour traffic volume allows the creation of a base model that runs and is representative of the condition being modeled. A running model allows for review of the physical inputs in TRAFVU and from the QA/QC form. ***This is a critical point in the model development. Simple mistakes can be found and corrected well before the calibration process. This will reduce and/or eliminate rework***. The base model will be used in later steps to create a start point for multiple time period entries. Volumes at ramps connected to arterials will eventually be replaced with the NETSIM submodel. However, at this stage, on ramp volumes must be entered.





4.3.7 Step 8: Translate and Run Direction 1 of Model

At the end of Step 7, the modeler will have a complete working model of one direction of the freeway submodel. Translate to CORSIM and run the model to verify that it works. Make any edits necessary.

4.3.8 Step 9: Repeat Steps 2-8 for Direction 2 of the Model

Because the link node diagram has been developed for the entire network, it is possible to have another modeler create the model for the opposite direction of the freeway or intersecting freeways. Therefore, a second modeler can start with Part II of the modeling process for the opposite direction. Step 11 will discuss combining the freeway submodels together. If there is only one person working on the model, then Steps 2-8 are conducted in TRAFED using the **SAME** TRAFED file.

4.3.9 Step 10: Repeat Steps 2-8 for Intersecting Freeways

If there are additional freeways included in the model, Steps 2-8 are conducted in the same manner.

4.3.10 Step 11: Combine Freeway Submodels

If there is only one model file for the whole freeway system, then this step is not necessary, and you can proceed to Step 12. Otherwise, the process is as follows.

This step is conducted if a freeway model was prepared by direction in separate files. CORSIM input files are lines of information in an 80 column text format. Each line has a number on the last three columns that is referred to as a record type (RT). Each RT has a different purpose of input. These RTs must be in numerical order by submodel.

All freeway RTs must be grouped together.

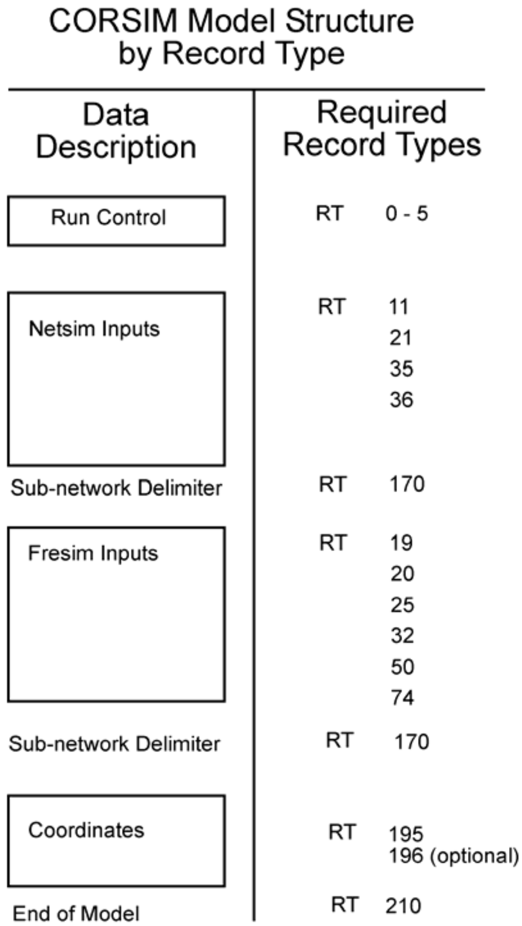


Figure 24 – CORSIM Model Structure by Record Type

Combining different freeway models requires the use of text edit.

- Open all freeway submodel *.trf files in text edit.
- Rename one of the *.trf files. Call it the blank freeway model or a name that identifies it as the complete freeway model.
- Go to the other *.trf file, select all RT 19 information, use the copy command, and return to the main file.
- Place the cursor at the beginning of the RT 19 information. Use the paste command.
- Repeat steps for RT 20, 25, 50, and 195 information.

4.3.11 Step 12: Create QA/QC Worksheet

QA/QC reports are used to verify model inputs and to ensure the organization of the model. The QA/QC reports at this stage are related to the physical geometry and operating characteristics of each link in the model. The modeler needs to create a QA/QC report with the links in a logical order (beginning of freeway to end), and it must include a description of the links (from ramp to ramp, etc.). Figure 25 is a sample QA/QC report, more complete examples of a QA/QC report are available on-line under sample projects.

	Link Description		Link Geometrics												Anticipatory Chg.	
	From	**To**	Node From	Node To	Receiving Node	Length	Type	No. of lanes	Grade	Super-Elev.	Radius	Speed	Car Following Factor	Warning Sign Distance	Min. Speed to Trigger	Distance to Rx Pt.
EB I-694 Mainline Links	EB I-694		530	531	532	1226	0	2				65	100			
		Exit to Victoria Street	531	532	533	1502	0	2				65	100	2500		
	Exit to Victoria Street		532	533	534	633	0	2				65	100			
		Entrance from Victoria Street	533	534	535	1057	0	2				65	100			
	Entrance from Victoria Street		534	535	538	1500	0	2				65	100		43	1500
			535	538	540	1595	0	2				65	100			
			538	540	542	1069	0	2				65	100			
		Exit to Rice Street	540	542	546	1500	0	2				65	100	2500		
	Exit to Rice Street		542	546	548	1059	0	2				65	100			
		Entrance from Rice Street	546	548	550	1141	0	2				65	100			
	Entrance from Rice Street		548	550	551	1500	0	3				65	100		43	1500
			550	551	552	861	0	3				65	100			
		Exit to SB I-35E	551	552	553	1403	0	2				65	100	2500	43	1500
	Exit to SB I-35E		552	553	554	1541	0	2			1152	65	100			
		Entrance from NB I-35E	553	554	555	648	0	2				65	100			
	Entrance from NB I-35E		554	555	556	400	0	2				65	100		43	1500
			555	556	557	1101	0	4				65	100			
		EB I-694 and NB I-35E Commons	556	557	8557	492	0	3				65	100			
EB I-694 Ramp Links		Victoria Street Exit	532	632	8632	262	1	1				65	100			
	Victoria Street Entrance		634	534	535	415	1	1				65	100			
		Rice Street Exit	542	642	7904	431	1	1				55	100			
	Rice Street Entrance		648	548	550	397	1	1				55	100			
		SB I-35E	552	652	8652	1777	1	2				65	100			
	NB I-35E		654	554	555	554	1	2			1912	65	100			

Figure 25 – Sample QA/QC form

At this point, the modeler has a base freeway model that will be further developed to include the arterial networks (created in Part III) and to include multiple time periods for volumes (created in Part IV). ***Note: The data in the QA/QC form should cross-correlate with the input data within the *.trf file.*** The internal and external QA/QC of the model should be based on what was run. Also, the QA/QC sequence should follow a logic that is easy to follow in a tabular format. If the link order is out of sequence, you cannot follow speed and geometry data that continues from segment to segment.

Review Physical Inputs:
Between link node diagram, lane schematic, and QA/QC form

4.3.12 Step 13: Coding Origin-Destination Information

In order to model weaving conditions in any traffic analysis program or methodology, an O-D matrix, which is an estimate of the number of vehicles from the mainline freeway and entrance ramps destined to the exit ramps and the mainline freeway, is required. The HCM methodology requires that a weave diagram be constructed to help estimate weaving percentages. Figure 26 below is a sample weave diagram that illustrates weaving volumes.

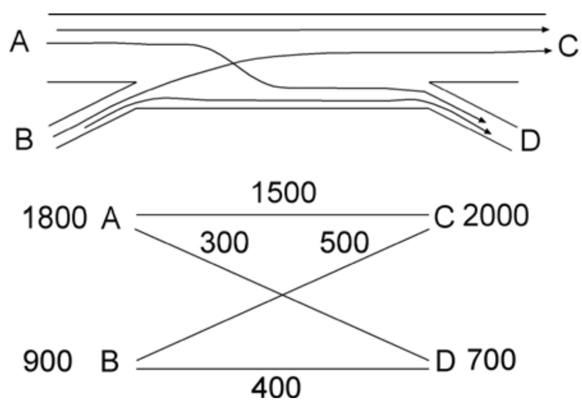


Figure 26 – Weave Volume Illustration

The HCM methodology is only designed to analyze individual weave sections. CORSIM models allow the user to evaluate the effects that different weaving sections have across the entire system. The basic inputs for CORSIM include entering flow rates and exiting percentages. In the absence of user specified O-D percentages, CORSIM will create an estimated O-D. The program also does not come with “built-in” knowledge of the area being modeled. CORSIM will not identify whether a cloverleaf loop ramp weave area is different than any other weave section. In the cloverleaf weave area, the weave percentages are 100 percent – 100 percent of the vehicles entering the freeway are trying to get onto the freeway while 100 percent of the vehicles exiting at the ramp are coming from the freeway mainline.

The cloverleaf interchange area is the most dramatic case of modeling weave section that CORSIM will not interpret for the modeler. If the modeler does not manually create O-D inputs for the model, they will not end up with a valid model, resulting in large numbers of vehicles entering at the on loop and exiting at the off loop. It is possible to model partial O-Ds in CORSIM; however, for consistency and a clear understanding of what the model is doing, O-Ds should be coded for all freeway mainlines in the model. The most efficient way to calculate O-Ds for the model inputs is to create an O-D matrix. The following discussion explains how to set up an O-D matrix that provides the input for CORSIM.

Note: By not manually entering an O-D matrix, you have made an assumption on weaving. You have assumed that the O-D pattern internally calculated by CORSIM reflects reality. CORSIM cannot distinguish between a closely spaced weave section

and a cloverleaf interchange. The unrealistic movements described in the example would occur in the model.

4.3.12.1 <u>Creating an O-D Matrix</u>

An O-D matrix is a table that organizes entering and exit volumes. The preferred way to organize this information is to list entering volumes in rows on the left and exiting volumes in columns across the top. The entrance and exit locations should also be in sequence. The O-D table is populated by estimating the number of vehicles originating from a particular entrance location that exit at a particular downstream destination. The volumes from each entrance and at each exit are divided against the total volume to determine the total percentage. Figure 27 below is a sample O-D matrix. The O-D matrix table provides a back check of balanced traffic volumes. If the sum of the entries and the exits do not equal each other, then there is a problem in the O-D calculations or in the source traffic volumes.

I-94 Eastbound (PM)				Exit Locations												
				SB I-35W			NB I-35W			SB TH 55			end/exit			
Entry Location				812			818			822			826			
Detector				95			2191			2605			465			
Name	Station	Node #	Volume	Volume	Vol %	New Volume	Volume	Vol %	New Volume	Volume	Vol %	New Volume	Volume	Vol %	New Volume	
I-94 Eastbound	108	804	1521	420	0.28	1101	301	0.20	800	210	0.14	590	590	0.39		101%
Hennepin/Lyndale	.241/3150/315	806	436	121	0.28	315	86	0.20	229	60	0.14	169	169	0.39		101%
5th Ave	2604	819	138	0	0.00	138.23	0	0.00	138	36	0.26	102	102	0.74		100%
NB I-35W	2609	825	281	0	0.00	281.11	0	0.00	281	0	0.00	281	281	1.00		100%
			2377	541			387			307			1142			2377
				541			387			306			1142			2376

Figure 27 – Sample Origin-Destination Calculation Worksheet

In brief, the steps are as follows:

1. Identify by ramp name
   - All entrances
   - All exits
2. Identify corresponding node according to the following criteria:
   - Enter volumes for each entry and exit including the end of the freeway.
   - Starting from the beginning, calculate by entering the number of vehicles system by each destination.
   - Calculate the percentages of vehicles entering at the origin node and exiting at the destination node.
   - Convert information in the O-D matrix table into RT 74 input. This includes every entry and exit pair and the corresponding percentage of traffic.

4.3.12.2 <u>Calculating O-D Percentages</u>

Calculating O-D percentages can be as precise as actual weaving based on a license plate O-D study or estimated based a variety of methods. Methods for estimating O-D include assigning obvious weave patterns, such as cloverleaf interchanges, and then estimating the remaining O-D percentages based on a uniform distribution. Another method is to use a select link analysis at each entrance to determine percentages from a regional travel demand model to identify the freeway O-D.

The potential exists for rounding errors in the calculated O-D pattern. There are two potential problems. The first is, if the rounded values for entry location exceed 100 percent, this will result in a fatal error, and the model will not run. The best way to deal with this situation is to leave the last O-D pair out of the model. CORSIM will internally calculate any O-D pairs that are not included in RT 74. The second issue is at low volume exit ramps. If the O-D percentage for multiple entries end up rounding down, then there may be a shortfall in traffic. In this case, you may want to force the equation to round up to account for the exiting traffic.

Regardless of how the O-D matrix is derived, it will be based on more intelligence and engineering judgment than the CORSIM created O-D. If the matrix to model input process is automated, then it is possible to test the model with different O-D patterns. This is especially useful when conducting sensitivity tests on future designs.

4.4 Part III: Base Arterial Model Development Steps

The arterial base model is primarily set up using Synchro (could be TEAPAC as well). The process for modeling intersections includes coding geometrics, signal timings, etc. Synchro is a more efficient tool for modeling intersections than TRAFED. In addition, Synchro is useful when alternatives need to be tested and intersections need to be retimed. Synchro is an optimization tool that should be used in developing timing and improvements. Another person independent of the freeway model can conduct this step, but this should only be started after the link node diagram is created.

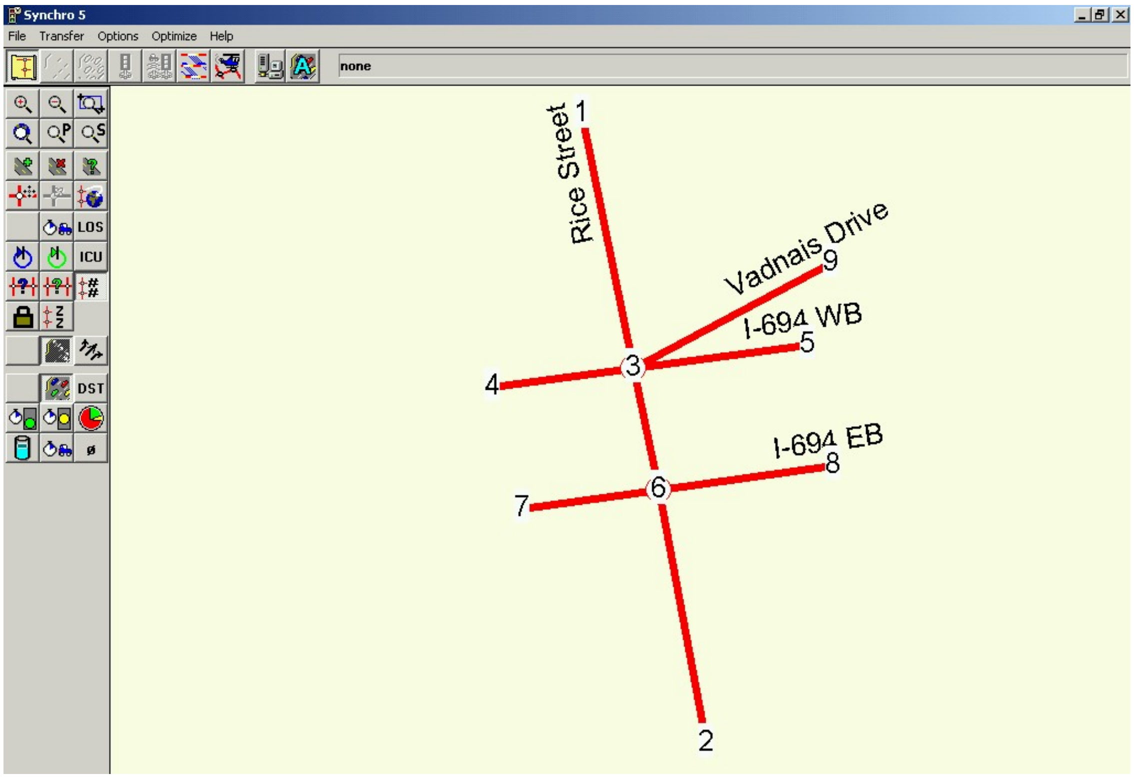
Each intersection in the arterial base model is created in Synchro using the same coordinates and node numbers from the main link node diagram. The inputs for each intersection can be verified using SimTraffic. After the arterial base models are created, the “Transfer CORSIM Analysis” feature in Synchro is used to create the NETSIM submodel. The submodel can be run in CORSIM and viewed in TRAFVU to ensure that the intersections have been coded properly. After the arterial submodel has been verified, the modeler is ready for Part IV, Combining Freeway and Arterial Models.

Details of signal timing and the use of Synchro can be found in the Signal Timing and Coordination Manual located on Mn/DOT’s web site at:

http://www.dot.state.mn.us/trafficeng/

4.4.1 Step 1: Create a Synchro Model of the Ramp Terminal Intersections

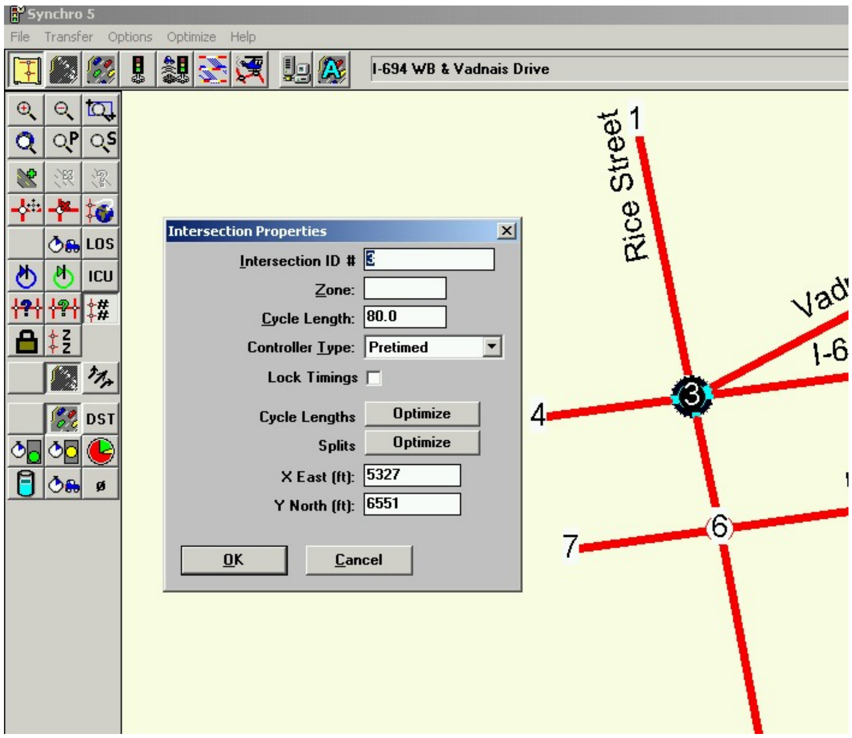
There should be one file for all interchanges in the CORSIM model. The steps following this step will involve updating the Synchro node numbers to match the overall link node diagram and to update the node coordinates. Initially, you are using Synchro to build a basic model that has the correct orientation; intersections spacing should be approximated. The node that leads into and away from the intersections is automatically created by Synchro. You must locate this node using the coordinate information from the main link node diagram.



Step 2: Change Node Numbers and Coordinates

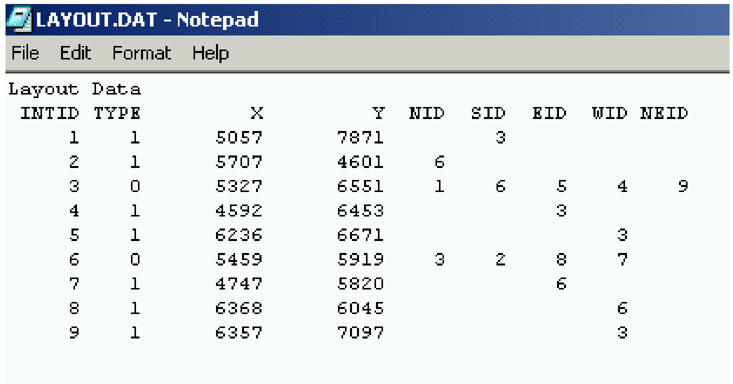
Change node numbers and coordinates to correspond with link node diagram. Transform map to relevant coordinate system.

Change node numbers in the Synchro map view to match the arterial node numbers from the link node diagram. Do not include the interface nodes (7,###) or the entry/exit nodes (8,###) nodes in the Synchro model, only construct the 9## nodes. Synchro will automatically create the entry/exit nodes, and the 7,### nodes will be created in Part IV.



Changing the node coordinates in the Synchro model to match the real-world coordinates from the link node diagram is done using the Uniform Traffic Data Format (UTDF) feature in Synchro. The procedure is outlined below.

- In the map view, either go to the transfer menu and select Data Access or hit CTRL-D, to open the Database Access Menu.
- In the UTDF database select the LAYOUT tab.
- In the LAYOUT menu, use the SELECT file button to ensure that the LAYOUT.DAT file is located in the working directory.
- Using the cursor, select the WRITE button and left click the mouse. You have now created a text file that includes the node numbers and X and Y coordinates. Figure 28 shows what this file looks like in Notepad.



LAYOUT.DAT - Notepad

File Edit Format Help

Layout Data

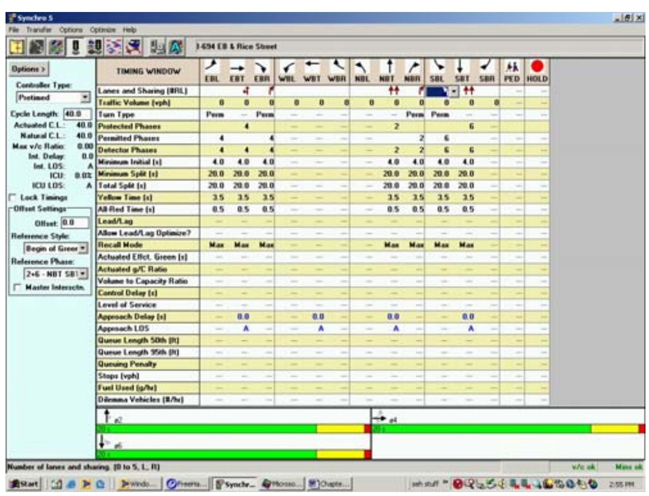
INTID	TYPE	X	Y	NID	SID	EID	WID	NEID
1	1	5057	7871		3			
2	1	5707	4601	6				
3	0	5327	6551	1	6	5	4	9
4	1	4592	6453			3		
5	1	6236	6671				3	
6	0	5459	5919	3	2	8	7	
7	1	4747	5820			6		
8	1	6368	6045				6	
9	1	6357	7097				3	

Figure 28 – Synchro Layout.DAT Sample File

- Open the LAYOUT.DAT file in Notepad. Notepad is a text editor program that comes standard with Microsoft installation. Wordpad is an alternative text editor program that can be used. Replace the X and Y coordinates in this file with the real world coordinates. Maintain the right column position in the text file. The column INTID summarizes the node number. After editing, save the file.
- Return to the Database Access menu and the LAYOUT tab. Select the LAYOUT.DAT file that you just edited. Select the READ button with the cursor and click the left button. The new coordinates will be read into the Synchro file. **DO NOT SELECT THE WRITE BUTTON, YOU WILL LOSE ALL OF YOUR WORK!** The Synchro file is now coordinate correct and ready for the next steps.

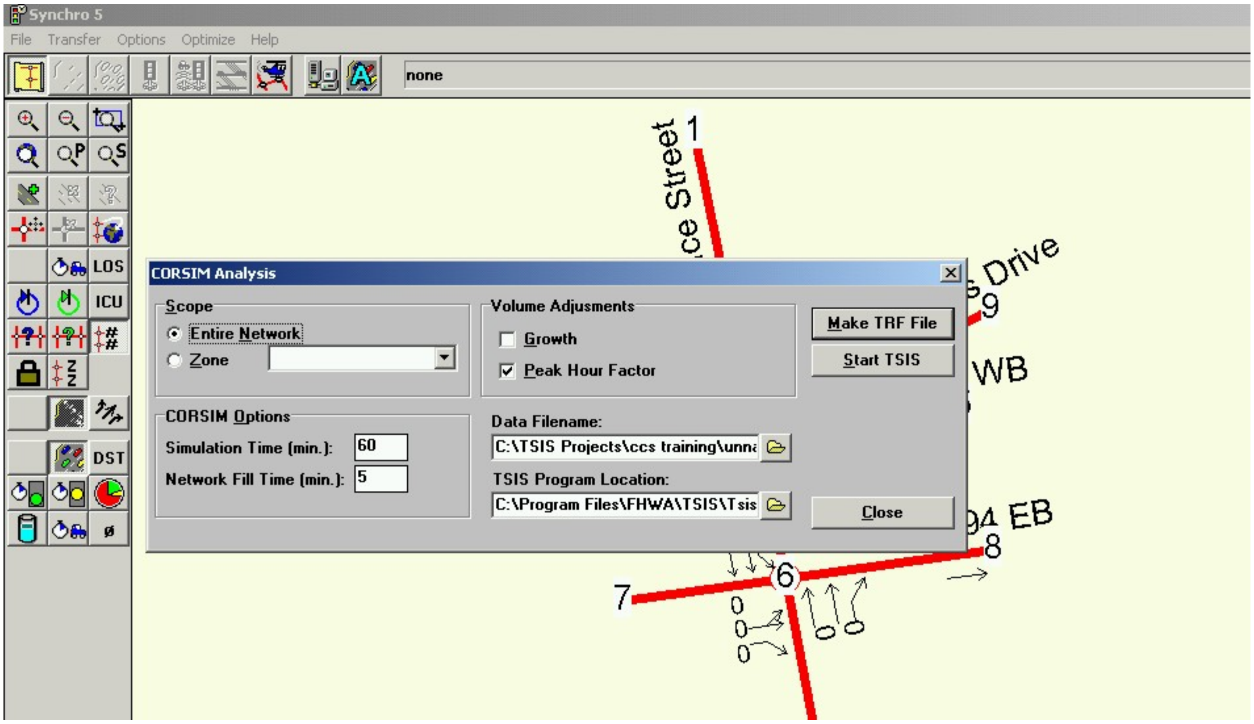
4.4.2 Step 3: Update Signal Timings

During the data gathering stage, signal timing sheets and signal design plans should have been gathered. At this point, the phasing, intervals, and minimum green times should be set based on field reports. Signal timings should be updated to reflect phasing, clearance intervals. Refer to Mn/DOT's Signal Timing and Optimization Manual for signal timing criteria.



4.4.3 Step 4: Transfer Synchro File to CORSIM

(CAUTION – DO NOT NAME THE SYNCHRO FILE THE SAME AS THE FREEWAY FILE!)



4.4.4 Step 5: Run Synchro Generated CORSIM File

Review and make changes to the Synchro file and retransfer to CORSIM as needed. At this point, you should have a NETSIM file that accurately represents the arterial system.

4.5 Part IV: Combining Freeway and Arterial Models

At this point, the modeler has two independent models, a freeway model and an arterial model, for one peak hour period. Part IV is the point in the process where the two different submodels are combined into one main model. After the combined model is working, data entry for the multiple time periods is created. The working model with multiple time periods is run, and an MOE report of the model run is created. With all of this information in hand, a final error check of the model can be conducted before proceeding to the calibration process. Chapter 5 outlines the structure of model materials and the review of the model inputs. The individual steps to combining models are discussed in the following sections.

4.5.1 Step 1: Combine Freeway and Arterial *.TRF Files

This step presumes that all the freeway models have been combined. If this has not happened, refer back to Section 4.3.10. This step also assumes that all intersections in the arterial model are in one *.trf file. If they are not, they must be combined in a similar fashion as combining the freeway models. Presumably, all the signalized intersections at multiple interchanges were developed in one Synchro model and transferred into one *.trf file. The CORSIM input file (*.trf) structure is based on RT numbers that must be in numerical order and grouped by submodel. The following graphic is a reminder of the model structure that must be considered when combining submodel files. A detailed description of the RTs can be found in the TSIS Users Manual, refer to Figure 24 on page 51.

The general process for combining FRESIM and NETSIM models from separate files is as follows:

- In text edit, open the freeway model file and save this file with a different name. Next in Text edit, open the *.trf file for the arterial model and select everything from RT 11 through RT 170. Copy and paste this information back into the renamed file right after RT 5.
- Return to the arterial *.trf file and copy the RT 195 and 196 information. Paste this information at the end of the RT 195 information. Save the combined file. Close the arterial file.
- In RT 2, change entry 15 from 8 to 3.
- In RT 170 at the end of the arterial network, change entry 1 from 0 to 8.

RT 170: Entry-Specific Data

ENTRY	STR COL	END COL	NAME	TYPE	RANGE	UNITS	DEFAULT
1	1	4	Code indicating the Next Section	Integer	0,3,8	Not Applicable	0
2	78	80	Record Type	Integer	170	Not Applicable	None

- Save file.
- To make sure that the models survived this process, go ahead and run the file and view the animation. You should have the interchanges in the proper locations, and traffic should be moving, but not between the freeways and arterials.

4.5.2 Step 2: Connect the Two Models in TRAFED

- Translate the *.trf file to a TRAFED file.
- Open the TRAFED file. Go to each ramp where the freeway and arterials network should be connected, and delete the entry and exit links. After these links are deleted, an interface link is created by selecting "create a one-way link" and selecting the "from" node and dragging and connecting to the "to" node. When one-way links are created between the two model types, an interface node is automatically created.
- Change the interface node to match the master link node diagram.
- Save the file after all interface connections have been created.

4.5.3 Step 3: Run Combined Model

Translate the *.tno file back to a *.trf file. Run the model and review the animation to make sure all connections have been properly made. If not, return to TRAFED and repeat Step 2.

At this point, celebrate; you have achieved a significant milestone in the process.

4.5.4 Step 4: Finalize QA/QC

Celebration is over; you have more work to do.

The *.trf file with the combined models needs to be organized to facilitate the QA/QC of the inputs, to develop an organized output structure, and to facilitate the development of volume inputs for multiple time periods.

<u>Freeway Submodel</u>

Based on the work done to organize the freeway model, this work will be minimal. RT 19 and RT 20 information should be sequenced in the same order with each freeway direction grouped together in order of consecutive mainline links followed by the ramp links.

TRAFED creates a RT 25 entry for every link in the freeway model. This input is only required at exit ramps, delete all RT 25s with 100 percent through traffic and 0 percent exit traffic.

<u>Arterial Submodel</u>

RT 11 and RT 21 information should be resorted in the same sequence. The important links are all links entering intersections. Each link entering an intersection should be grouped together; exit links and dummy links should be at the end.

The raw input from Synchro will not follow a logical sequence conducive for reviewing inputs and MOEs.

The input information should be incorporated into the QA/QC form.

4.5.5 Step 5: Develop Input for Multiple Time Periods

CORSIM allows for the model to be divided into different time periods and within the time periods certain inputs can be modified. The maximum number of intervals that can be modeled is 19, and the maximum time within each interval is 9,999 seconds. The primary information that can be altered from interval to interval is traffic volumes and signal timings.

The main reason for a freeway model to include multiple intervals is to change the volume inputs over the entire time period. Even though CORSIM is a stochastic model, traffic output will closely match the input volumes. So if the peak hour flow rates are coded in the model, the fluctuation within the peak period will not be realized. Mn/DOT requires that traffic conditions are modeled in CORSIM taking into account traffic fluctuations. The interval length that has been decided upon is 15-minute intervals over the course of the peak period. The peak period in the metro area is 3 hours; out-state areas may be less than this depending on prevailing traffic conditions.

Developing inputs for multiple time periods can be accomplished efficiently if the input file has been organized and the traffic volume data is in a database format that can be converted into model input.

The structure of the input file with multiple time periods is illustrated in Figure 29 below. The time period one input occurs in the main input portion of the model. Following the coordinate information are the additional time periods. The arterial model first followed by the freeway model information. A RT 170 and 210 separates each time period.

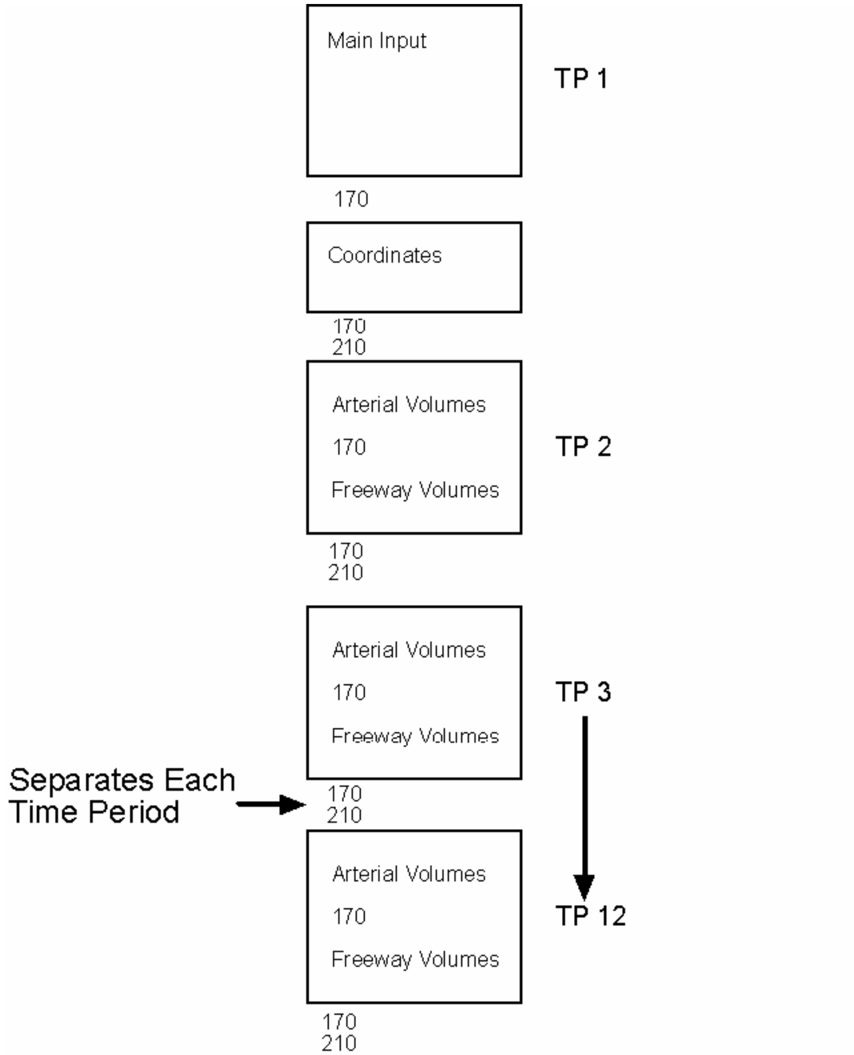


Figure 29 – Multiple Time Period Model Structure

The database for freeway volumes on the instrumented system shall be organized into rows for each station and ramp detector and the volume intervals will occur by columns. If the project is not on the instrumented system, the data should be arranged in a similar fashion and project stations should be created. Figure 30 below is a sample database format. Arranging the freeway data into this format will allow you to more easily cross correlate the volume data, which will be useful during the calibration process.

			Time Period											
	type		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Description	**m, off, on**	**Station**	15:30:00	15:45:00	16:00:00	16:15:00	16:30:00		17:00:00	17:15:00	17:30:00	17:45:00	18:00:00	18:15:00
NB 35W/TH62 before Lyndale on R	m	50	1213	1278	1268	1293	1216	1268	1199	1189	1090	1161	1207	1378
NB - Lyndale on Ramp	on	125	136	112	128	137	147	149	172	173	166	151	142	110
NB 35W/TH62 before EB TH62 off	m	50a	1349	1390	1396	1430	1363	1417	1371	1362	1256	1312	1349	1488
NB - EB TH62 off Ramp	off	167	359	376	407	410	417	480	452	429	392	402	442	398
NB 35W - before WB TH62 on Ramp	m	51	990	1014	989	1020	946	937	919	933	864	910	907	1090
NB - WB TH62 on Ramp	on	126	454	425	450	443	466	458	459	482	446	417	435	417
NB 35W - before 60th St on Ramp	m	52	1444	1439	1439	1463	1412	1395	1378	1415	1310	1327	1342	1507
NB - 60th Street on Ramp	on	127	58	60	60	52	48	52	49	60	56	55	57	57
NB 35W - between 60th and DLR	m	52a	1502	1499	1499	1515	1460	1447	1427	1475	1366	1382	1399	1564
NB - Diamond Lake Rd off Ramp	off	168	42	39	45	46	49	49	54	64	67	70	74	77
NB 35W - at Diamond Lake Rd Bridge	m	53	1460	1460	1454	1469	1411	1398	1373	1411	1299	1312	1325	1487
NB - Diamond Lake Rd on Ramp	on	128	69	71	70	71	65	66	69	67	73	78	86	85
NB 35W - between DLR and 46th	m	54	1529	1531	1524	1540	1476	1464	1442	1478	1372	1390	1411	1572
NB 35W - between DLR and 46th	m	55	1529	1531	1524	1540	1476	1464	1442	1478	1372	1390	1411	1572
NB - 46th Street off Ramp	off	169	84	94	85	84	88	98	87	96	107	115	102	122
NB 35W - at 46th Street	m	56	1445	1437	1439	1456	1388	1366	1355	1382	1265	1275	1309	1450
NB - 46th Street on Ramp	on	129a	143	155	164	146	181	177	174	158	185	187	202	161
NB 35W - between 46th and 36th	m	57	1588	1592	1603	1602	1569	1543	1529	1540	1450	1462	1511	1611
NB 35W - between 46th and 36th	m	58	1588	1592	1603	1602	1569	1543	1529	1540	1450	1462	1511	1611
NB - 36th Street off Ramp	off	170	86	95	93	95	91	95	86	84	86	89	95	97
NB 35W - between 36th and 35th	m	59	1502	1497	1510	1507	1478	1448	1443	1456	1364	1373	1416	1514
NB - 35th Street on Ramp	on	130a	233	203	190	208	203	164	195	171	194	186	207	212
NB 35W - between 35th and 31st	m	59a	1735	1700	1700	1715	1681	1612	1638	1627	1558	1559	1623	1726
NB - 31st Street off Ramp	off	171	170	181	191	197	179	199	168	174	165	168	222	237
NB 35W - after 31st off Ramp	m	60	1565	1519	1509	1518	1502	1413	1470	1453	1393	1391	1401	1489
NB 35W - between 31st and Diverge	m	61	1565	1519	1509	1518	1502	1413	1470	1453	1393	1391	1401	1489
NB 35W - between 31st and Diverge	m	62	1565	1519	1509	1518	1502	1413	1470	1453	1393	1391	1401	1489
NB - TH65 Diverge	off	64	704	748	681	720	744	675	664	647	619	601	620	707
NB 35W - after TH 65 Diverge	m	63	861	771	828	798	758	738	806	806	774	790	781	782
NB - 5th Avenue on Ramp	on	2130	138	124	150	152	149	142	144	129	117	107	103	83
NB 35W - after 5th Ave on Ramp	m	565	999	895	978	950	907	880	950	935	891	897	884	865
NB - EB 94 on Ramp	on	2191	329	324	355	360	354	354	353	356	353	345	327	295

Figure 30 – Sample Freeway Volume Database Structure

Turning movement counts shall be assembled into a database structure to facilitate multiple time period inputs. A sample format for structuring turning movement counts is illustrated in Figure 31 below.

	Rice St.				694 WB Exit				Vadnais Blvd.				Rice St.			
Link	**905-901**				**906-901**				**908-901**				**900-901**			
	SBL	SBT	SBR	DIAG	WBL	WBT	WBR	DIAG	WBL	WBT	WBR	DIAG	NBL	NBT	NBR	DIAG
7:00	2	211	46		64	0	10	28		22	5	54	33	49		18
7:15	2	233	55		51	0	8	30		28	5	75	46	59		16
7:30	1	212	52		78	0	15	46		26	9	75	41	60		19
7:45	1	217	47		81	0	13	45		26	12	77	48	69		19
8:00	4	155	44		79	0	11	41		20	7	53	45	64		17
8:15	5	139	47		80	0	14	42		18	5	71	31	84		28
8:30	5	146	39		51	0	10	26		17	6	37	35	80		29
8:45	3	146	30		52	0	11	38		15	2	28	33	66		18
16:00	5	130	24		79	0	16	114		6	1	36	60	183		26
16:15	6	126	20		65	0	17	122		6	6	40	53	179		25
16:30	10	113	20		62	0	20	109		5	10	29	53	199		36
16:45	6	110	16		75	0	15	142		5	5	25	55	200		21
17:00	7	116	22		85	0	10	121		16	11	42	41	198		16
17:15	3	130	16		89	0	19	134		13	6	33	37	183		26
17:30	6	136	14		58	0	22	103		14	6	30	43	175		38
17:45	3	117	30		79	0	20	128		19	4	34	48	180		28

Figure 31 – Sample Intersection Volume Database Structure

Before using any of the information in the databases above, it is important to ensure that the traffic balances for **<u>all</u>** time periods. If the counts do not balance, the model results will never match the data as it was entered. This may lead you down the wrong path of changing calibration parameters and other settings to achieve the correct outcome.

The freeway inputs that need to be entered for each time interval are RT 25, 50, and 74. RT 25 is straightforward and can be taken directly from the table. RT 50 is the entering volume in vph; each 15-minute volume needs to be converted into hourly flow rates by multiplying the volume by four. RT 74 is the O-D information. The O-D percentages will change from time period to time period. Therefore, the O-D matrix that was developed earlier will need to be used again to calculate the O-D for each time interval.

The arterial inputs that need to be modified from interval to interval include RT 21, 50, and 22 if used. RT 21 is straightforward and is equal to the 15-minute volumes for each turning movement. RT 50s are the entering volumes; the 15-minute volumes must be converted into hourly flow rates by multiplying the 15-minute volumes by four. RT 22 defines discharge turn percentages based on entry movements and is used to correctly model conditions within interchanges. RT 22 is used at ramps to ensure that traffic does not reenter the freeway and that ramp demand volumes are satisfied.

4.5.6 Step 6: Run Model

After the volume data is entered into the model for the multiple time periods, run the model five times with different random number seeds.

4.5.7 Step 7: Summarize MOE Outputs

After the model has been run, the output is processed into tables that summarize output information. For freeway models, the key information is volume throughput, speed, density, and LOS information. Figure 32 below is a partial sample of MOEs from a freeway model. Notice that the node structure flows in sequence and the entire eastbound I-694 freeway segment can be analyzed at a glance. This table is the backbone information for the freeway model. It is from this table that report tables and graphics are prepared (see Chapter 7).

Location		Node		Length (ft)	Volumes			Link Statistics			Aggregate Statistics			Total Thruput		
From	To	From	To		Actual	Simu-lated	Differ-ence	Speed (mph)	Density (vplpm)	LOS	Speed (mph)	Density (vplpm)	LOS	Actual	Simu-lated	Differ-ence
NB I-35W		300	301	1,012	3,300	3,319	19	49	22	C				10465	10,502	37
		301	304	1,973	3,300	3,322	22	49	22	C	49	22	C	10465	10,487	22
	EB TH 62 Entrance	304	305	1,068	3,300	3,328	28	48	23	C				10465	10,482	17
EB TH 62 Entrance	WB TH 62 Entrance	305	306	210	5,200	5,246	46	47	28	C				16047	16,069	22
WB TH 62 Entrance	60th Street Entrance	306	308	1,315	6,900	6,963	63	52	27	C				20999	21,049	50
60th Street Entrance	Diamond Lake Road Exit	308	310	863	7,260	7,326	66	56	22	C				21861	21,902	41
Diamond Lake Road Exit	Diamond Lake Road Entrance	310	315	2,341	7,190	7,271	81	61	24	C				21620	21,649	29
Diamond Lake Road Entrance		315	316	2,634	8,040	8,101	61	57	28	C				23616	23,618	2
	46th Street Exit	316	317	1,461	8,040	8,115	75	61	26	C	58	27	C	23616	23,607	-9
46th Street Exit	46th Street Entrance	317	319	2,426	7,919	7,986	67	56	28	D				23240	23,182	-58
46th Street Entrance		319	321	854	9,489	9,519	30	52	30	D				27058	26,935	-123
		321	323	1,755	9,489	9,521	32	54	29	D	55	28	D	27058	26,913	-145
	36th Street Exit	323	325	1,671	9,489	9,515	26	58	27	C				27058	26,905	-153
36th Street Exit		325	326	1,014	9,338	9,373	35	56	33	D				26594	26,441	-153
	35th Street Entrance	326	327	1,760	9,338	9,356	18	53	36	E	54	35	E	26594	26,416	-178
35th Street Entrance	31st Street Exit	327	328	715	10,759	10,756	-3	43	42	E				30301	30,218	-83
31st Street Exit	Lake Street Transit Exit	328	397	298	10,028	10,008	-20	43	39	E				27852	27,824	-28
Lake Street Transit Exit		397	329	1,242	10,028	9,983	-45	49	40	E				27852	27,777	-75
		329	330	346	10,028	9,977	-51	52	38	E				27852	27,771	-81
	Lake Street Transit Entrance	330	331	1,072	10,028	9,967	-61	52	37	E	51	38	E	27852	27,745	-107
Lake Street Transit Entrance		331	332	125	10,028	9,977	-51	53	32	D				27852	27,775	-77
		332	334	1,367	10,028	9,964	-64	54	36	E				27852	27,757	-95
	Downtown/WB I-94 Exit	334	336	1,875	10,028	9,961	-67	56	35	D				27852	27,718	-134
Downtown/WB I-94 Exit		336	695	228	4,078	4,109	31	60	23	C				11581	11,569	-12
		695	696	150	4,078	4,109	31	59	11	B				11581	11,568	-13
		696	697	153	4,078	4,109	31	57	12	B	54	21	C	11581	11,568	-13
		697	337	299	4,078	4,107	29	52	26	C				11581	11,567	-14
	EB I-94 Exit	337	338	411	4,078	4,106	28	50	22	C				11581	11,564	-17
EB I-94 Exit	5th Avenue Entrance	338	340	740	2,768	2,787	19	45	21	C				8079	8,078	-1
5th Avenue Entrance	EB I-94 Entrance	340	342	1,081	3,438	3,459	21	51	19	B				9760	9,758	-2
EB I-94 Entrance	EB I-94 Exit	342	344	1,394	5,048	4,770	-278	50	24	C				14304	13,616	-688
EB I-94 Exit		344	370	350	4,659	4,386	-273	47	31	D				13374	12,667	-707
	Washington Ave. U of M Exit	370	345	800	4,659	4,384	-275	51	24	C	49	26	C	13374	12,662	-712
Washington Ave. U of M Exit		345	346	336	3,419	3,228	-191	56	19	B				10022	9,522	-500
	NB TH 55 Entrance	346	348	521	3,419	3,226	-193	58	19	B	57	19	B	10022	9,520	-502
NB TH 55 Entrance		348	349	2,490	4,330	4,123	-207	58	18	B				12312	11,799	-513
	NB I-35W	349	350	677	4,330	4,121	-209	58	18	B	58	18	B	12312	11,797	-515
TH 62 EB		400	401	909	1,900	1,907	7	49	20	B				5582	5,598	16
		401	402	1,664	1,900	1,909	9	49	20	B				5582	5,597	15
		402	403	2,052	1,900	1,912	12	46	21	C	47	23	C	5582	5,593	11
		403	404	845	1,900	1,914	14	44	25	C				5582	5,592	10
		404	406	605	1,900	1,914	14	46	42	E				5582	5,589	7
TH 62 EB Entrance	NB I-35W	406	305	125	1,900	1,915	15	46	42					5582	5,588	6
TH 62 WB Entrance	NB I-35W	405	306	1,040	1,700	1,711	11	48	36					4952	4,987	35
60th Street Entrance		407	408	330	360	359	-1	22	8					862	861	-1
	NB I-35W	408	308	682	360	359	-1	37	7					862	861	-1
	Diamond Lake Road Exit	310	410	401	70	67	-3	55	1					241	248	7
Diamond Lake Road Entrance		414	415	68	850	826	-24	8	43					1996	1,988	-8
	NB I-35W	415	315	356	850	825	-25	31	16					1996	1,985	-11
	46th Street Exit	317	417	445	121	139	18	54	2					376	406	30
46th Street Entrance		418	419	84	1,570	1,534	-36	7	89					3818	3,765	-53
	NB I-35W	419	319	559	1,570	1,531	-39	34	30					3818	3,763	-55
	36th Street Exit	325	425	116	151	141	-10	61	2					464	444	-20
35th Street Entrance		426	427	143	1,421	1,414	-7	9	73					3707	3,816	109
	NB I-35W	427	327	426	1,421	1,413	-8	32	31					3707	3,815	108
	31st Street Exit	328	428	134	731	745	14	51	14					2449	2,388	-61
	Lake Street Transit Exit	397	498	332	0	9	9	29	0					0	32	32
Lake Street Transit Entrance	NB I-35W	430	331	746	0	9	9	29	0					0	32	32
	Downtown/WB I-94 Exit*	336	600	339	5,950	5,844	-106	53	35					16271	16,147	-124
	EB I-94 Exit	338	719	540	1,310	1,322	12	50	25					3502	3,480	-22
5th Avenue Entrance	NB I-35W	440	340	375	670	669	-1	54	11					1681	1,681	0
EB I-94 Entrance	NB I-35W	818	342	344	1,610	1,315	-295	50	26					4544	3,867	-677
	EB I-94 Exit	344	825	560	389	382	-7	52	6					930	944	14
	Washington Ave. U of M	345	445	543	1,240	1,156	-84	53	10					3352	3,136	-216
NB TH 55 Entrance	NB I-35W	448	348	360	911	910	-1	54	16					2290	2,290	0

Figure 32 – Sample MOE Report Freeways

Similar to the freeway information, arterial data is processed and summarized into tables. Figure 33 below is a sample table of arterial output. The information includes volume throughput, control delay, and maximum queues. The table should also highlight problem areas that affect arterial and freeway performance, such as ramp intersections operating at LOS E or F and links where queues exceed storage length.

Key arterial MOE include approach and intersection control delay and LOS, throughput, and storage and queue information.

TABLE G-2
riod
Arterial Measures of Effectivness

Select Time Period: 7:00 AM-8:00 AM

Location	Aprch	Link	Demand volumes				Model - Demand		LOS by Approach		LOS by Intersection		Modeled Storage & Maximum Traffic Queueing (feet)					
													Through		Left Turn		Right Turn	
			Lt	Th	Rt	total	Total	%	Delay	LOS	Delay	LOS	Link Length	Queue	Storage	Queue	Storage	Queue
Lake Street at Stevens	SB	545-513	14	169	11	194	0.6	0%	21	C	16	B	586	72				
	WB	514-513	157	548	0	705	159.6	23%	11	B			326	160	80	80		
	EB	512-513	0	619	149	768	-5.6	-1%	21	C			328	156			80	40
Lake Street at 2nd	WB	515-514	0	699	15	714	-3.6	-1%	23	C	13	B	334	176			80	28
	NB	510-514	166	402	133	701	2.8	0%	5	A			618	60				
	EB	513-514	78	699	0	777	-156.4	-20%	12	B			326	168				
31st at Stevens	SB	513-509	15	424	40	479	34	7%	13	B	16	B	618	144			80	20
	WB	510-509	146	189	0	335	75.4	23%	17	B			328	148				
	EB	508-509	0	145	167	312	0.2	0%	20	B			330	120			80	80
31st at 2nd	WB	511-510	0	298	10	308	-1	0%	16	B	13	B	332	80				
	NB	539-510	112	666	152	930	20	2%	14	B			282	288				
	EB	509-510	24	172	0	196	-31.6	-16%	7	A			328	52				
35th at Stevens	SB	522-505	0	469	308	777	44.4	6%	16	B	15	B	292	184			150	76
	WB	506-505	159	235	0	394	-0.6	0%	14	B			332	96	150	128		
35th at 2nd	WB	507-506	0	322	211	533	2	0%	23	C	22	C	351	172				
	NB	502-506	72	1373	0	1445	17.4	1%	21	C			659	356	150	84		
36th at 2nd	NB	525-502	0	409	86	495	-2.4	0%	28	C	29	C	252	236			150	48
	EB	501-502	1290	487	0	1777	-319.2	-18%	29	C			333	312	150	160		

Figure 33 – Sample MOE Report Arterials

It is easier to review model inputs and check for errors when a model that has been run for the full duration of the modeling period has been completed and MOE summaries have been prepared. Large discrepancies in volume outputs can be an indicator of an error in volume inputs. Large discrepancies in volume output and extremely poor operations that are unexpected may indicate incorrect lane geometry or signal timings.