A Comparative Analysis of Weaving Areas in HCM, TRANSIMS, CORSIM, VISSIM and INTEGRATION

Nanditha Koppula

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Antoine Hobeika
Antonio A.Trani
Sam Tignor

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Abstract

Traffic simulation is a powerful tool that provides transportation engineers with the ability to test the feasibility and performance of a system before it is implemented and also helps in optimizing the proposed system. Over the past twenty years significant amount of work has been conducted on improving the quality and accuracy of transportation simulation models. Much of this work has been concentrated on microscopic simulation models because they provide traffic engineers greater opportunity to examine the inherently complex, stochastic, and dynamic nature of transportation systems when compared to traditional macroscopic models. In order to test the performance of some of the simulation models, a study is conducted on freeway weaving sections, which are considered to be one of the most complex regions to be modeled and analyzed. The intent of the research is to evaluate TRANSIMS, CORSIM, VISSIM and INTEGRATION and compare them with Highway Capacity Manual, which adopts a traditional methodology for carrying out the operational analysis of a highway system. The statistics collected for the simulation runs include weaving speeds, non-weaving speeds and density of the weaving section.

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Chapter 1 : Introduction

1.1 Background

Simulation is a valuable tool that is widely used in a variety of fields due to its ability to provide realistic results. Simulation modeling has gained recognition as an effective approach for quantifying traffic operations as transportation systems have become more complex. Traffic simulation is a powerful tool that provides transportation engineers with the ability to test the feasibility and performance of a system before it is implemented, and also helps in optimizing the proposed system. Traffic simulation models are established tools for assessing the network and freeway issues and are used for analyzing traffic. Several different types of simulation packages are available, from detailed microscopic models to macroscopic flow models, each with a particular role depending upon the type of analysis desired. Some of the various simulation models that can be used for traffic modeling and analysis are CORSIM (CORridor SIMulation), VISSIM, INTEGRATION and TRANSIMS (TRansportation ANalysis and SIMulation System). There is little information available to analysts applying these tools to simulate freeway weaving sections, about the most appropriate models to choose. To address this need, a detailed and technical comparison of the above mentioned simulation models is provided.

CORSIM, VISSIM and INTEGRATION adopt microscopic modeling approach. A microscopic modeling approach is adopted where there is a need to obtain the system entities and their interactions at a high level of detail. The microscopic approach possessing the potential to be more accurate than its less detailed counterparts, involves a lot of complexity in the logic of the core algorithms, as a large number of parameters need to be calibrated. The core algorithm logic includes various factors like car following logic, lane change behavior and vehicle movements at intersections, which are discussed in detail later. Early car following theory of microscopic simulation models is based on research first conducted at the General Motors Research Labs in the middle and late 1950's.

In order to obtain a less computationally intensive and complex modeling approach, unlike microscopic models, mesoscopic approach is used which generally represents most entities at a high level of detail but describes their activities and interactions at a much lower level of detail. TRANSIMS uses this approach. It uses particle hopping theory, where vehicle movements take place by hopping from one cell to another. This kind of approach is used where a large network has to be simulated as it adopts simple rule based algorithms.

1.2 Problem Definition

On freeways, weaving areas are the most complex regions to be modeled. Weaving sections require intense lane changing maneuvers, as drivers must access lanes appropriate to their desired exit point. It is important to model weaving behavior accurately, as the overall performance of networks can be influenced by traffic behavior at weave sections. There is little information available in literature regarding the performance of different simulation models at freeway weave sections, and therefore, the most appropriate model to use for analyzing these areas.

1.3 Thesis Objective

The objective of the thesis is to compare the core algorithm logics of the simulation models, TRANSIMS, CORSIM, VISSIM and INTEGRATION. A comparative analysis of weaving areas is then conducted using these models. The methodology adopted in Highway Capacity Manual (HCM) is taken as the basis for the comparison of models. This methodology evolved from a wide range of empirical research conducted since 1960’s. The different configurations of weaving areas, Type A, Type B and Type C are considered for analysis. The statistics collected for the simulation runs include weaving speeds, non-weaving speeds and density of the weaving section. The models are calibrated by conducting a sensitivity analysis taking the HCM results as a base. The simulation model giving best results with respect to HCM is identified.

1.4 Organization of Thesis

The thesis is organized as follows: Chapter 2 presents a literature review of previous studies related to this research. It discusses the modeling of vehicular traffic using car following theory and particle hopping theory. Specific characteristics of each simulation model being considered in this research are described. The methodologies used by HCM for analysis of freeway weaving sections are then discussed.

The different configurations of weaving sections are compared, analyzed and modeled in Chapter 3. A discussion of the modeling strategies adopted to model these configurations is then presented.

Chapter 4 presents a sensitivity analysis conducted for the models and then a comparison of results. The conclusions and recommendations for future research are detailed in chapter 5.

Appendix A shows the data used for analysis and validation. The data used for plotting various graphs is shown in Appendix B.

Chapter 2 : Literature Review

2.1 Introduction

The main focus of this thesis is to carry out a comparative analysis of weaving sections of configuration types A, B and C on freeways using TRANSIMS, CORSIM, VISSIM and INTEGRATION. Hence, it is important to understand the treatment of vehicle movements in weaving sections in the models.

A coarse simulation modeling approach, "Cellular Automata" is adopted by TRANSIMS to keep up with the fast computational speed necessary to simulate a whole region. The Cellular Automata approach divides every link on the network into a finite number of cells. It incorporates particle-hopping theory where the vehicle movements take place by hopping from one cell to another. Vehicles in the network follow simple rules that govern their movements. At the core, the rules for a vehicle movement in the same lane could be put simply as "Acceleration whenever possible, Deceleration only if necessary and sometimes for no reason". The decision by a vehicle to accelerate or decelerate depends on its current speed and the gap between it and the immediate vehicle ahead in the same lane. Lane change maneuver is considered by a vehicle based on either passing slower vehicle or based on following its plan. The central idea of lane changing logic is the availability of forward and backward gaps in the adjacent lanes. TRANSIMS does not have a separate logic for weaving sections but incorporates algorithms based on 'vehicle movement logic in the same lane' and 'lane changing logic'.

CORSIM uses the Pitts car-following model, developed by University of Pittsburgh. The basic concept of this model is vehicle movements take place considering the headway between the follower car and the lead car. The model includes a comprehensive lane changing logic representing different sides of lane changing process namely gap evaluation, gap acceptance and the driver decision to perform a lane change. Gap evaluation refers to the process of evaluating the lead gap and trailing gap sizes. Gap acceptance refers to the process of determining whether the lead and trailing gaps are acceptable to the lane changer and putative follower. In CORSIM there is no separate treatment for weaving areas.

VISSIM uses a psychophysical car following model for longitudinal vehicle movement, and a rule-based algorithm for lateral movements. The basic concept of this model is that the driver of a faster moving vehicle starts to decelerate as he reaches his individual perception threshold to a slower moving vehicle. Since he cannot exactly determine the speed of that vehicle, his speed will fall below that vehicle's speed until he starts to slightly accelerate again after reaching another perception threshold. This results in an iterative process of acceleration and deceleration. Lane changing behavior forms a part of core algorithm logic, which considers acceptable gaps in neighboring lanes. VISSIM simulates traffic flow by moving "driver- vehicle- units" through a network. As a consequence, the driver behavior corresponds to the technical capabilities of the vehicle. In VISSIM there is no separate logic for weaving movements but the behavior is emergent from the car following and lane changing logic.

INTEGRATION uses a steady state car following model that combines Pipes and Greenshields models into a single regime model, which is a four-parameter model. The car-following model selects the desired speeds of vehicles by considering only the attributes of other vehicles ahead of it in the same lane. It provides separate deceleration and acceleration logic. Lane changing behavior that incorporates gap evaluation and gap acceptance logic forms a part of core algorithm logic. Within INTEGRATION the impact of a weaving section is a direct function of the interaction between the prevailing car-following and lane-changing behavior but it has no separate weaving logic. The weaving logic is sensitive to the type of weave that takes place, as different numbers of lane changes are required per vehicle for different weave types. The model is also sensitive to the length of the weave, as a longer weaving section permits the impact of the lane changes to be spread out over a longer length of road segment. The weaving logic and impacts are emergent features of the default model logic, and therefore do not require the modeler to tag specific sections as being weaving sections. Therefore, any area in which a large number of mandatory lane changes are necessary will automatically experience weaving impacts. Furthermore, the magnitude of the capacity reduction will dynamically depend upon the mix of weaving versus non-weaving flows. *(Integration user's guide)*

2.2 Purpose of this chapter

In this chapter, the literature behind the core algorithm logic for the simulation models is discussed. As a part of core algorithm logic vehicle movements, car following logic and lane changing logic in all the models is detailed. The various analytical models, which led to the development of the current version of the simulation models, are discussed. The specific characteristics of these models are brought out and a comparative analysis is provided. Past and current research on these factors is also elaborated.

2.3 Traffic Simulation Packages

A brief description of the models that are used for the comparative analysis of freeway weaving sections in this study is provided here.

2.3.1 TRANSIMS

TRANSIMS is a mesoscopic simulation model, which consists of mutually supporting simulations, models, and databases that employ advanced computational and analytical techniques to create an integrated regional transportation system analysis environment. By applying advanced technologies and methods, it simulates the dynamic details that contribute to the complexity inherent in transportation issues. The integrated results from the detailed simulations help address environmental pollution, energy consumption, traffic congestion, land use planning, traffic safety, intelligent vehicle efficiencies, and the transportation infrastructure effect on quality of life, productivity, and economy.

TRANSIMS was developed by The Los Alamos National Laboratory (LANL). It is a part of the Travel Model Improvement Program sponsored by the U.S. Department of Transportation, the Environmental Protection Agency, and the Department of Energy. TRANSIMS operates on Unix and Linux operating systems only. *(TRANSIMS website).*

2.3.2 CORSIM

CORSIM is a microscopic simulation model of the TRAF system designed for the analysis and modeling of freeways, surface streets, corridors or networks and basic transit operations. The model includes two predecessor models that operate on a one-second time step:

- NETSIM, a microscopic stochastic simulation model for street networks
- FRESIM, a microscopic stochastic simulation model for freeway networks

CORSIM's capabilities include simulating different intersection controls (e.g., actuated and pre-time signals); almost any surface geometry including number of lanes and turn pockets and a wide range of traffic flow conditions. It is based on a link-node network model. The links represent the roadway segments while the nodes mark a change in the roadway, an intersection, or entry points.

CORSIM was developed in the mid-1970's through the Federal Highway Administration (FHWA). It is run within a software environment called the Traffic Software Integrated System (TSIS), which provides an integrated, Windows-based interface and environment for executing the model. A key element of TSIS is the TRAFVU output processor, which allows the analyst to view the network graphically and assess its performance using animation.

2.3.3 VISSIM

VISSIM is a microscopic, time step and behavior based simulation model developed to analyze the full range of functionally classified roadways and public transportation operations. It can model integrated roadway networks found in a typical corridor as well as various modes consisting of general purpose traffic, buses, light rail, heavy rail, trucks, pedestrians, and bicyclists.

The model was developed at the University of Karlsruhe, Germany during the early 1970s. The model is based on the continued work of Wiedemann. The network coding and editing is done using Graphical User Interface, which runs in various versions of Microsoft Windows.

2.3.4 INTEGRATION

INTEGRATION is a microscopic simulation model. The name INTEGRATION stems from the fact that the model integrates a number of unique capabilities. It integrates traffic assignment and microscopic simulation, and then the model integrates freeway and arterial modeling within a single logic. The model performs simulations by explicitly tracking the movement of individual vehicles within a transportation network every deci-second. This detailed tracking of vehicles movements allows the model to conduct detailed analyses of lane changing movements, shock wave propagations along transportation links, as well as gap acceptance, merge and weaving behaviors at intersections and freeway entrances and exits.

The INTEGRATION model was conceived as an integrated simulation and traffic assignment model (M.Van Aerde and Associates, 2000). The Windows version of INTEGRATION model provides on-screen graphics that continuously reflect the network status and all versions of INTEGRATION run in Windows 95/98/2000 or Windows NT.

2.4 Simulation

Simulation methodology is an essential element in the design, evaluation and operation of transportation systems. Transportation researchers have developed models and simulators for use in the design and operation of effective traffic management systems. The simulation techniques are adopted to solve dynamical problems, which cannot be usually described in analytical terms as they are characterized by many system components. The mathematical and logical forms cannot be quite well described by complex and simultaneous interactions of many system components. The simulation models then come into picture, which integrate separate entity behaviors and interactions to produce a detailed, quantitative description of system performance.

The categories into which simulation models can be classified are described here: *Continuous* simulation models describe how the elements of a system change *state* continuously over time in response to continuous stimuli whereas *Discrete* simulation models represent real-world systems (that are either continuous or discrete) by asserting that their *states* change abruptly at points in time.

Simulation models can be further classified according to the level of detail with which they represent the system to be studied, which is shown as follows:

- Microscopic (high fidelity)
- Mesoscopic (mixed fidelity)
- Macroscopic (low fidelity)

A *microscopic* model describes both the system entities and their interactions at a high level of detail. A *mesoscopic* model generally represents most entities at a high level of detail but describes their activities and interactions at a much lower level of detail than would a microscopic model. A *macroscopic* model describes entities and their activities and interactions at a low level of detail.

The simulation models can again be classified as high-fidelity and low-fidelity models. High-fidelity microscopic models, and the resulting software, are costly to develop, execute and to maintain, relative to the lower fidelity models. While these detailed models possess the potential to be more accurate than their less detailed counterparts, this potential may not always be realized due to the complexity of their logic and the larger number of parameters that need to be calibrated. Lower-fidelity models are easier and less costly to develop, execute and to maintain. They carry a risk that their representation of the real-world system may be less accurate, less valid or perhaps, inadequate. Use of lower-fidelity simulations is appropriate if the results are not sensitive to microscopic details.

Another classification of the simulation models, which addresses the processes, represented by the model: (1) Deterministic and (2) Stochastic.

Deterministic models have no random variables; all entity interactions are defined by exact relationships (mathematical, statistical or logical). *Stochastic* models have processes, which include probability functions. *(Srinivas Jillella et al)*

2.5 Vehicular Traffic Theory

Vehicular traffic theory can broadly be classified into three groups: Traffic flow model (Macroscopic model), car-following model (Microscopic model) and particle hopping model (Mesoscopic model).

The macroscopic approach considers flow density relationships, whereas the microscopic approach considers spacings between and speeds of individual vehicles. "Microscopic modeling" is concerned with individual time and space headway between vehicles while "macroscopic modeling" is concerned with macroscopic flow characteristics, which are expressed as flow rates, where attention is given to temporal, spatial and modal flows" (Adolph May, 1990). Particle hopping models fit between microscopic models for driving and fluid dynamical models for traffic flow. For a weaving analysis, a microscopic analysis approach is considered to be a better choice over macroscopic approach, as this model depicts the traffic flow patterns like acceleration/deceleration, merging etc. for each individual vehicle within a stream more vividly than a macroscopic model.

2.5.1 Traffic Flow Theory - Macroscopic Model

The macroscopic approach considers traffic streams and develops algorithms that relate flow to density and space mean speeds.

The fundamental traffic flow relationship is given by

$$q = u_s k \qquad [2\text{-}1]$$

where

q = flow in vehicles/hour

u_s = space speed in miles/hour

k = density in vehicles/mile

The different macroscopic models are Greenshields model, Greenberg model, Underwood's model and Drew's model, Greenshields and Greenberg models being the most commonly used.

2.5.1.1 Greenshields Model

Greenshields studied the relationship between speed and density. According to him a linear relationship existed between speed and density, which he expressed as

$$u = u_f - \left(\frac{u_f}{k_j}\right)k \qquad [2\text{-}2]$$

where

u = Velocity at any time

u_f = Freeflow Speed

k = Density at that instant

k_j = Maximum density

Substituting u from the general equation of a traffic stream,

$$\frac{q}{k} = u_f - \left(\frac{u_f}{k_j}\right)k \qquad [2\text{-}3]$$

$$q = u_f k - \left(\frac{u_f}{k_j}\right)k^2 \qquad [2\text{-}4]$$

As the flow increases, density increases and the speed decreases which is obtained by interchanging the relationships between the variables velocity, flow and density by successive elimination of one of these variables. Flow becomes maximum at optimum density. Thus, flow increases from zero as the speed increases from zero, until it becomes q_m (maximum density) at $u = u_f/2$ and $k = k_j/2$.

Hence,

$$Q_m = \frac{u_j k_j}{4} \qquad [2\text{-}5]$$

Highway Capacity Manual and all traditional codes use this set of equations. However, this relationship is not accurately followed by the practical field data. Hence, over the past six decades a number of theoretical models have cropped up.

2.5.1.2 Greenberg Model

Greenberg, using a fluid flow analogy, developed a macroscopic traffic flow model. This is a non-linear model where a hydrodynamic analogy is combined with equations of motion in mechanics. The velocity is governed by

$$u = u_o \ln\left(\frac{k_j}{k}\right) \qquad [2\text{-}6]$$

where

u = speed at any time

u_0 = optimum speed

2.5.1.3 Underwood's Model

To account for the problem of free-flow reaching infinity value during free flow conditions in the above model, a new single regime model was proposed. According to this theory,

$$u = u_f e^{-\left(\frac{k}{k_o}\right)} \qquad [2\text{-}7]$$

where

u = speed at any time

k_0 = optimum density

k = Density at any time

u_f = Free flow speed

2.5.1.4 Drew's Model

Drew proposed a formulation, which modified Greenshields model by introducing a parameter called 'n'.

$$u = u_f \left[1 - \left(\frac{k}{k_j} \right)^{n+\frac{1}{2}} \right] \qquad [2\text{-}8]$$

where

$n = 1$ ~ Linear Model

$n = 2$ ~ Parabolic Model

$n = 3$ ~ Exponential Model

2.5.2 Car Following Theory - Microscopic Models

The microscopic approach, which is sometimes referred to as the car-following theory, considers spacing between and speeds of individual vehicles. A characteristic about the car following approach is the way in which all of the models model the behavior of each vehicle in relation to the vehicle ahead. This theory is mainly accurate for single lane situations where in reality every driver reacts only to the vehicle in front of him/her. Most of the car following models use the equation of the form given below for interaction between the vehicle and the leading car.

$$a(t+T)\,\alpha\,\frac{\mathrm{v(t)}^{\mathrm{m}}}{[\Delta x(t)]^{l}}.\Delta v(t) \qquad [2\text{-}9]$$

Where

a represents the acceleration of the car under consideration;

v represents the velocity of the car under consideration;

Δx represents distance of the two vehicles; (car under observation and leading vehicle)

Δv is the velocity difference between the car under observation and the leading vehicle;

T represents the delay time between stimulus and the response time; and

m and l being constants.

Theories describing how one vehicle follows another vehicle were developed primarily in the 1950s and 1960s. Reuschel and Pipes were pioneers in the development of car following theories in early 1950s.Three parallel efforts were undertaken in the late 1950s and continued to the mid 1960s. Kometani and sasaki in Japan, Forbes at the Institute for Research and Michigan state University and a group of researchers associated with General Motors made significant contributions to car following theory. There were a series of car following theories proposed by professor Adolph May, 1990 in publication " traffic flow theory". The basic form of these theories was:

Response = f{sensitivity, Stimuli}

where

Response = Acceleration or Deceleration of the vehicle which is dependent on the sensitivity of the automobile and the driver himself

Sensitivity = Ability of the driver to perceive and react to the stimuli

Stimuli = Visual and auditory inputs that influence driver's decision

Consider two vehicles moving from left to right as shown in Figure 1. Let these be denoted by 'n' and 'n+1' having a length of L_n and L_{n+1} respectively, moving at the same time with the distance between them at any time being 't'. Since the vehicles change distance positions, speeds, and acceleration rates (or deceleration times) over time, the subscript t is used to specify time.

The acceleration rate of the following vehicle (x_{n+1}) is specified as occurring at time t + Δt, not t. The Δt represents an interval of time between the time a unique car following situation occurs (t) and the time the driver of the following vehicle decides to apply a specified acceleration rate (or deceleration rate) at (t + Δt). This interval of time is often referred to as the reaction time. The distance headway between the lead vehicle and the following vehicle is denoted as $[x_n(t) - x_{n+1}(t)]$. The relative velocity of the lead vehicle and the following vehicle is denoted by $[\dot{x}_n(t) - \dot{x}_{n+1}(t)]$. If the relative velocity is positive, the lead vehicle has a higher speed and the distance headway is increasing. A negative value implies that the following vehicle has a higher speed and the distance headway is decreasing. Finally, the acceleration rate (or deceleration rate) [$\ddot{x}_{n+1}(t+\Delta t)$] can be positive or negative, with a positive value indicating that the following vehicle is accelerating and increasing its speed while a negative value indicates the reverse. *(Adolf D.May, Traffic Flow Fundamantals)*

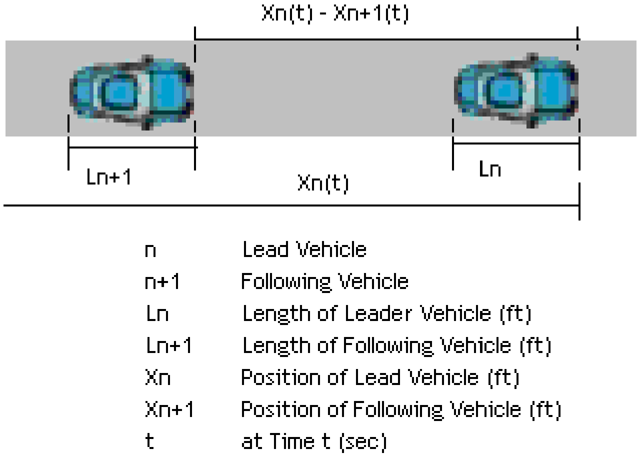


Figure 1: A Car Following Theory

2.5.2.1 Pipes' theory of car-following

Pipes proposed a theory of car following behavior based on what he referred to as the ***"idealized law of separation",*** which is explained as, *A good rule for following another vehicle at a safe distance is to allow yourself the length of a car for every ten miles per hour you are traveling.* Such a model implies that the actions of following vehicle are only affected by the relative speed between the leading vehicle (LV) and the following vehicle (FV).

The resulting equation for distance headway as a function of speed is shown in the equation [2-10],

$$d_{MIN} = [x_n(t) - x_{n+1}(t)]_{MIN} = L_n[\frac{\dot{x}_{n+1}(t)}{(1.47)(10)}] + L_n \qquad [2\text{-}10]$$

Assuming a vehicle length of 20 feet, equation [2-10] can be expressed as shown in equation [2-11],

$$d_{MIN} = 1.36[\dot{x}_{n+1}(t)] + 20 \qquad [2\text{-}11]$$

Distance headway can be obtained by calculation based on time headway and individual speed measurements, as shown in equation [2-12],

$$d_{n+1} = h_{n+1}\,\dot{x}_n \qquad [2\text{-}12]$$

Selecting speeds from 0 to 88 feet per second (60 miles per hour), the minimum safe distance headways can be computed. Associated minimum safe time headways can be determined by combining equations [2-11] and [2-12] as shown in equation [2-13],

$$h_{MIN} = 1.36 + \frac{20}{\dot{x}_{n+1}(t)} \qquad [2\text{-}13]$$

Again selecting speeds from 0 to 88 feet per second (60 miles per hour), the minimum safe time headways can be computed.

According to Pipes' car following theory, the minimum safe distance headway increases linearly with speed. The associated minimum safe time headway continuously decreases with speed and theoretically reaches absolute minimum time headway of 1.36 seconds at a speed of infinity. As speed increases the minimum safe distance headway increases but the minimum safe time headway decreases. Since the flow rate is the reciprocal of the time headway, the possible flow rate increases with increasing speeds. *(Adolf D.May, Traffic Flow Fundamantals)*

2.5.2.2 Forbes' theory of car-following

Forbes' modeled car following behavior by assuming that drivers choose to keep a minimum time gap from the rear end of LV. Forbes' model of car following also implies that the actions of FV is only affected by the relative speed between the LV and FV.

Forbes approached car-following behavior by considering the reaction time needed for the following vehicle to perceive the need to decelerate and apply the brakes. That is, the time gap between the rear of the lead vehicle and the front of the following vehicle should always be equal to or greater than the reaction time. Therefore, the minimum time headway is equal to the reaction time (minimum time gap) and the time required for the lead vehicle to traverse a distance equivalent to its length. This, relationship is shown mathematically in the equation [2-14],

$$h_{MIN} = \Delta t + \frac{L_n}{\dot{x}_n(t)} \qquad [2\text{-}14]$$

Forbes conducted many field studies of minimum time gaps and found considerable variations between drivers and sites. Minimum time gaps varied from 1 to 2 or 3 seconds. Assuming a reaction time of 1.5 seconds and a vehicle length of 20 feet, equation [2-14] can be rewritten as follows:

$$h_{MIN} = 1.50 + \frac{20}{\dot{x}_n(t)} \qquad [2\text{-}15]$$

Selecting speeds from 0 to 88 feet per second (60 miles per hour) the minimum safe time headway can be computed. Associated minimum distance headways can be determined by combining equations [2-12] and [2-15] as shown in equation [2-16],

$$d_{MIN} = 1.50[\dot{x}_n(t)] + 20 \qquad [2\text{-}16]$$

Again selecting speeds from 0 to 88 feet per second (60 miles per hour), the minimum safe distance headways can be computed.

The results of Forbes' car following theory is very similar to Pipes' results with minimum safe distance headway increasing linearly with speed while the minimum safe time headway continuously decreases with speed. There is very close agreement between Forbes' model and the field study results in the midspeed range, but at lower and higher speeds there is considerable difference in a pattern similar to Pipe's model. *(Adolf D.May, Traffic Flow Fundamantals)*

2.5.2.3 GM-model of car-following

The car following theories developed by researchers associated with the General Motors group was much more extensive and are of particular importance because of the accompanying comprehensive field experiments, and the discovery of the mathematical bridge between microscopic and macroscopic theories of traffic flow. The research team developed five generations of car following models, all of which took the form,

Response = func(sensitivity, stimuli)

The response was always represented by the acceleration (or deceleration) of the following vehicle, while the stimuli was always represented by the relative velocity of the lead and following vehicle. The difference in the different levels of models was the representation of the sensitivity.

The first model assumed that the sensitivity term was a constant and the model formulation is shown in the equation [2-17],

$$\ddot{x}_{n+1}(t+\Delta t) = \alpha[\dot{x}_n(t) - \dot{x}_{n+1}(t)] \qquad [2\text{-}17]$$

The stimuli term could be positive, negative or zero, which could cause the response to be an acceleration, deceleration, or constant speed. This is shown in the equations [2-18], [2-19] and [2-20],

If $\dot{x}_n(t) > \dot{x}_{n+1}(t)$ then $\ddot{x}_{n+1}(t+\Delta t)$ is positive [2-18]

If $\dot{x}_n(t) < \dot{x}_{n+1}(t)$ then $\ddot{x}_{n+1}(t+\Delta t)$ is negative [2-19]

If $\dot{x}_n(t) = \dot{x}_{n+1}(t)$ then $\ddot{x}_{n+1}(t+\Delta t) = 0$ [2-20]

Field experiments were conducted on the General Motors test track to quantify the parameter values for the reaction time (Δt) and the sensitivity parameter (α). The significant range in the sensitivity value alerted the investigators that the spacing between vehicles should be introduced into the sensitivity term. This led to the development of the second model, which proposed that the sensitivity term should have two states. That is, when the two vehicles were close together, a high sensitivity value (α_2) should be used. This formulation can be shown by equation [2-21],

$$\ddot{x}_{n+1}(t+\Delta t) = \int_{\alpha_2}^{\alpha_1} [\dot{x}_n(t) - \dot{x}_{n+1}(t)] \qquad [2\text{-}21]$$

Very quickly the investigators saw the difficulty in selecting the α_1 and α_2 values and the difficulty associated with discontinuous states. This led to further field experiments to determine means of incorporating the distance headway, into the sensitivity term. The relationship was determined for α_o, d, and α as shown in the equation [2-22],

$$\alpha_o = \frac{\alpha}{1/d} = \alpha d \qquad [2\text{-}22]$$

$$\alpha = \frac{\alpha_0}{d} = \frac{\alpha_o}{x_n(t) - x_{n+1}(t)} \qquad [2\text{-}23]$$

Then equation [2-23] for α was substituted into equation [2-17], and the third model resulted as shown in the equation [2-24].

$$\ddot{x}_{n+1}(t+\Delta t) = \frac{\alpha_o}{x_n(t) - x_{n+1}(t)} [\dot{x}_n(t) - \dot{x}_{n+1}(t)] \qquad [2\text{-}24]$$

The fourth model was a further development towards improving the sensitivity term by introducing the speed of the following vehicle. The concept was that as the speed of the traffic stream increased, the driver of the following vehicle would be more sensitive to the relative velocity between the lead and following vehicle. The formulation of this fourth model is shown in the equation [2-25],

$$\ddot{x}_{n+1}(t+\Delta t) = \frac{\alpha'[\dot{x}_{n+1}(t+\Delta t)]}{x_n(t) - x_{n+1}(t)}[\dot{x}_n(t) - \dot{x}_{n+1}(t)] \qquad [2\text{-}25]$$

where

α′ = Speed of the following vehicle

The fifth and the final model was a continued effort to improve and generalize the sensitivity term. The question was raised whether the speed and distance headway components should be raised to the first power or whether an improved and more generalized approach could be accomplished by introducing generalized exponents. This was implemented by introducing m and l exponents as shown in the equation [2-26],

$$\dot{x}_{n+1}(t+\Delta t) = \frac{\alpha_{l,m}[\dot{x}_{n+1}(t+\Delta t)]^m}{[x_n(t) - x_{n+1}(t)]^l}[\dot{x}_n(t) - \dot{x}_{n+1}(t)\,] \qquad [2\text{-}26]$$

where

m = Speed exponent

l = Distance headway

Ranges of values: *m* = -2 to 2 and l = -1 to 4

It can be found that upon substitution of different combinations of *m* and *1* terms, the resultant microscopic general motors formulae take the shape of various macroscopic models, proposed by various researchers. The model is widely accepted as a generalized car following model, which can be modified and applied to a particular case. *(Adolf D.May, Traffic Flow Fundamantals)*

2.5.3 Particle Hopping Theory – Mesoscopic Model

This is one of the approaches for modeling traffic. Considering a one-dimensional chain of cells, each cell either empty, or occupied by exactly one particle, movement of particles is achieved by particles jumping from one cell to another according to specific movement rules. In the context of vehicular traffic, one can imagine a road represented by cells, which can fit exactly one car. A rough representation of car movements then is given by moving cars from one cell to another.

In general all particle-hopping models are defined on a lattice. The lattice being made up of a certain number of sites, each of which is either empty or occupied by a particle. Another characteristic of the model is that only one particle can occupy each site and all the movement of these particles is to be in one direction. This model adheres to the laws of conservation of total mass, which states that the total particles in the system are conserved except at boundaries where particles can either enter or exit. In traffic models the road segments are generally thought of as a lattice and each vehicle represents particles. *(Nagel, K. et al, LA-UR 96-659).* These models are sometimes called cellular automata (CA). Particle hopping models and CA are not exactly the same, although the definitions are overlapping.

This section starts out with the Stochastic Traffic Cellular Automaton (STCA), which has been proposed for traffic flow and which is currently implemented as a microsimulation option for large scale traffic simulation projects. The STCA includes strong randomness in the rules. Setting this randomness to zero reduces the STCA to be a much simpler, deterministic model, which, when restricting oneself to maximum velocity $v_{max} = 1$, turns out to a well-known cellular automaton model. In the third model of this section, randomness is re-introduced, but in this case by changing the update algorithm: Whereas in the first two models all particles are updated synchronously based in “old" information, in this third model, particles are selected in random sequence for individual updates.

2.5.3.1 The Stochastic Traffic Cellular Automaton (STCA)

The characteristics of the Stochastic Traffic Cellular Automaton are defined below. Each particle (in traffic sense referring to a vehicle) has a velocity that is either 0 or an integer. The speed constrained by a maximum of v_{max}. This means that every vehicle can only take integer values of velocity between 0 and v_{max}. The configuration of timestep t+1 is computed from the stored configuration of timestep t, using either parallel or synchronous updates. The decisions for the timestep t+1 entirely depend on the configuration at timestep t. Briefed below are the update procedures executed by every particle/vehicle in parallel. *(Nagel,K. et al, LA-UR 95-2098)*

- The gap ahead of the particle/vehicle is computed
- If the velocity of the particle is greater than the gap, a need for slowing down the particle is observed and its velocity changed so it equals the gap ahead. Else if there is enough headway in front of the vehicle and the vehicle is not moving at the maximum speed allowed then its velocity is incremented so as to represent acceleration. This acceleration is however gradual so as to represent daily behavior.
- To capture the realistic behavior of traffic, some randomness is introduced. This models the idea of particles/vehicles slowing down without reason, fluctuations at maximum speed, overreactions at breaking and noisy accelerations. For such a condition to occur, the velocity of the particle should clearly be positive and non-zero. With a probability *p,* the velocity of such a particle is thus reduced by one.
- Once these decisions have been taken the particle/vehicle is moved ahead depending on the velocity computed as listed above.

It is interesting to note in this model if the maximum velocity is set to one, i.e., $v_{max} =1$, then the model behaves very differently from what it would when the maximum velocity is greater than two. All the conditions stated above reduce to a singular statement that states a particle to move ahead to the next cell with a probability of p, should it be free. The analysis for STCA/2 (STCA with $v_{max} >= 2$) shows that there is a very dynamic and a different flow regime that does not have an exact solution. Inspection of the space-time plots visually confirmed that the dynamics of this model was very similar to STCA-CC/2 (which is discussed later) more than to the ASEP (discussed later). It was observed that multiple jams could exist simultaneously. Jams in such a models start simultaneously and independently of other jams attributed to the velocity fluctuations at maximum speed and depended on the parameter p_{free} (not equal to zero).

2.5.3.2 The Deterministic Limit of the STCA (CA-184)

The deterministic limit of the STCA models unprobabilistic nature of the STCA i.e., taking the randomness out of the randomness step. This is, when the maximum velocity equal to one, equivalent to cellular automaton rule 184 in Wolfram's notation. *(Nagel,K. et al, LA-UR 95-2098)* It is interesting to note that most Cellular Automaton Traffic models are based on this model.

2.5.3.3 The Asymmetric Stochastic Exclusion Process (ASEP)

The Asymmetric Exclusion Process or ASEP for short is probably the most investigated particle-hopping model. The ASEP models behavior that can be generalized by two simple rules stated below

- Selection of a random particle/vehicle;
- Movement of the particle to the right should the space on that site be empty.

The ASEP model is closely related to the STCA and CA models that were discussed earlier. The ASEP model behaves just the same way that STCA/1 and CA-184/1 do. This is because in rule two of ASEP, particles are only updated to the next site and not further. The basic difference though between them would be the way in which the particles are updated.

STCA/1 and CA-184/1 particles are all updated once and synchronously while ASEP does random updates of particles in a sense that these updates are a random serial sequence. However comparisons can be made between these models after defining the quantity timestep for the ASEP model. The definition of a timestep is clear and understood for the STCA and the CA-184 models as being the time between two successive updates of particles. In ASEP at an average a particle is updated after n single-particle updates, a timestep is thus completed after N single-particle updates.

It can also be observed that the randomness in the updates of the particles can be reduced i.e., reduction in the noise by techniques discussed by Wolf and Kertesz. They stated that using a counter associated with every particle could considerably reduce the noise if the updates are only made after *k* trials. It can also be seen that as *k* increases to a very large value the ASEP model slowly tends to behave as a CA-184. *(Nagel,K. et al, LA-UR 95 2098).*

2.6 Specific Characteristics of the Simulation Packages

The vehicle movements with the car following logic, lane changing logic and movements at the intersections, in all the four simulation models is discussed in the following sections.

2.6.1 TRANSIMS

TRANSIMS is a five-module software package; each module dealing with a specific task. The modules are Population Synthesizer, Activity Generator, Route Planner, Microsimulator and a Selector. Another module is the Emissions Estimator, which as the name suggests calculates the amount of emissions for the region in analysis using the outputs of the above-mentioned previous five modules.

A very brief description of what each module does is presented next starting with the Population Synthesizer. This module of TRANSIMS uses the PUMS data and the STF-3A data provided by the Census to create synthetic population having the same aggregate characteristics to those in the census data. This module also locates this synthetic population on transportation network using a suitable algorithm. The Activity Generator then assigns activities to these synthetic population based on the activity survey data depending on the household and demographic characteristics using the CART algorithm. Once the synthetic population is in place with their respective activities the Route Planner designates to each traveler his travel plans, i.e., how he/she goes about doing his/her activities. Should the activity of synthetic household include activities that require travel on the transportation network, the Route Planner finds the shortest path using various shortest path algorithms and assigns the traveler his exact itinerary detailing the links and nodes he travels on to reach his destination. On having these plans and the transportation network, the Microsimulator simulates the plans for all travelers on the network, their movements being governed by some simple rules. The Microsimulator uses a cellular automata approach for simulating vehicles on the network. Traffic behavior that the analyst wants to study is collected as the simulation progresses. The selector module provides the feedback for the whole process so that any unrealistic data such as an infeasible plan or an unlocatable household can be dealt by redoing his plan or relocating him with changed household characteristics or demographics.

The TRANSIMS Microsimulator module simulates the movement and the interactions of travelers in the transportation system of the study area. In this module every traveler tries to execute his/her travel movements according to plan. These movements and interactions produce key data that is output from the Microsimulator, bringing about more macroscopic quantities like volume, flow etc by aggregation of these individual interactions. The Microsimulator imitates realistic traffic behavior in decisions about lane changes, passing slow vehicles and evaluating interactions with other vehicles. As this research mainly deals with analyzing weaving areas, it is noted that the Microsimulator is the only module that affects it. *(Jillella et al., 2001)*

This section highlights how the Microsimulator conducts the movements of the travelers encompassing vehicle movements, lane changes and traversal across intersections.

2.6.1.1 Vehicle Movement In The Same Lane

Vehicles in the TRANSIMS network follow simple rules that govern their movements. These rules are intentionally kept simple to enhance the computation speed considering the millions of interactions taking place in the system. At the core, the rules for a vehicle movement in the same lane could be put simply as "Acceleration whenever possible, Deceleration only if necessary and sometimes for no reason".

The decision by a vehicle to accelerate or decelerate depends on its current speed, and the gap between it and the immediate vehicle ahead in the same lane. Another factor that influences the movement of a vehicle is the deceleration probability (P_d), which can be thought of as the probability of a vehicle decelerating in the timestep. All the vehicles in the TRANSIMS network are constrained by a maximum attainable speed that is specified ($V_{GlobalMax,}$ which is 5 cells/timestep or about 80 mph).

Consider a vehicle traveling at a certain speed at a given timestep. Now if the vehicle speed is greater than the gap ahead, the vehicle needs to reduce its speed to avoid a collision. The amount of deceleration being subject to, depends on how large or small the current gap (Gc) is compared to the current speed. To model aggressive breaking an element of randomness in the form of P_d is used. If the probability of decelerating is greater than a certain threshold value (P_{noise}), the speed of the vehicle is further reduced than what can be actually attainable based on gap (G_c). Considering the scenario where the gap ahead of the vehicle is larger than its current speed, then the vehicle can possibly accelerate. The magnitude of acceleration is specified differently for each type of vehicle. All velocity and acceleration changes are integer values based on the number of cells/second or cells/second/second respectively.

In the case that the vehicle is traveling at maximum allowable speed and having enough gap ahead to accelerate, the vehicle stays at maximum speed. As explained earlier the probability for deceleration is randomly activated and the vehicles speed may be reduced by 1 cell/second. A flowchart, illustrating the logic for the vehicles movement in the same lane, is outlined in Figure 4.

To illustrate the above rules for general movement in a lane, the following pictorial examples on speeds are provided including their calculations.

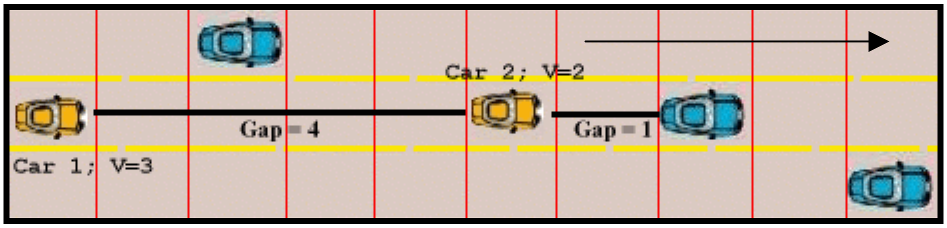


Figure 2: In-Lane Movement Of Car1 Based On Gaps At T=t

Consider the movement of car 1 shown in Figure 2. The gap ahead of it is 4 cells, and its current speed is 3 cells per timestep or second. Since the gap ahead is more than the speed of the vehicle, acceleration is attempted. A random number is generated and for the sake of this example assume that this number is greater than the deceleration probability. Hence, the vehicle (car 1) will not maintain its speed. Now, the speed of car 1 in the next timestep would be equal to the gap ahead, which is 4 cells per timestep. Car 1 would also move by an amount of the speed computed in the direction of motion i.e., by 4 cells as shown in Figure 3.

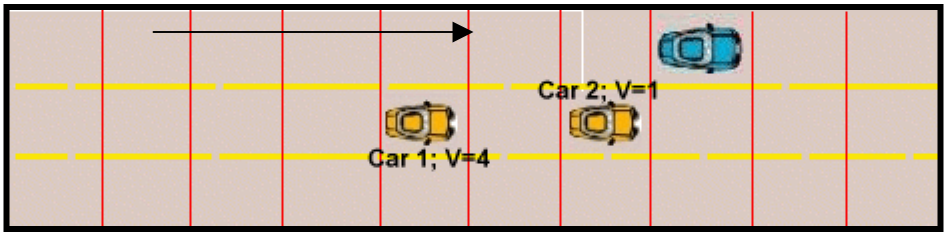


Figure 3: Position And Speed Of Car 1 Based On Gaps At T=t+1

The analysis for in-lane movements of car 1 and car 2 is presented in an algorithmic manner to provide a better understanding of the rules.

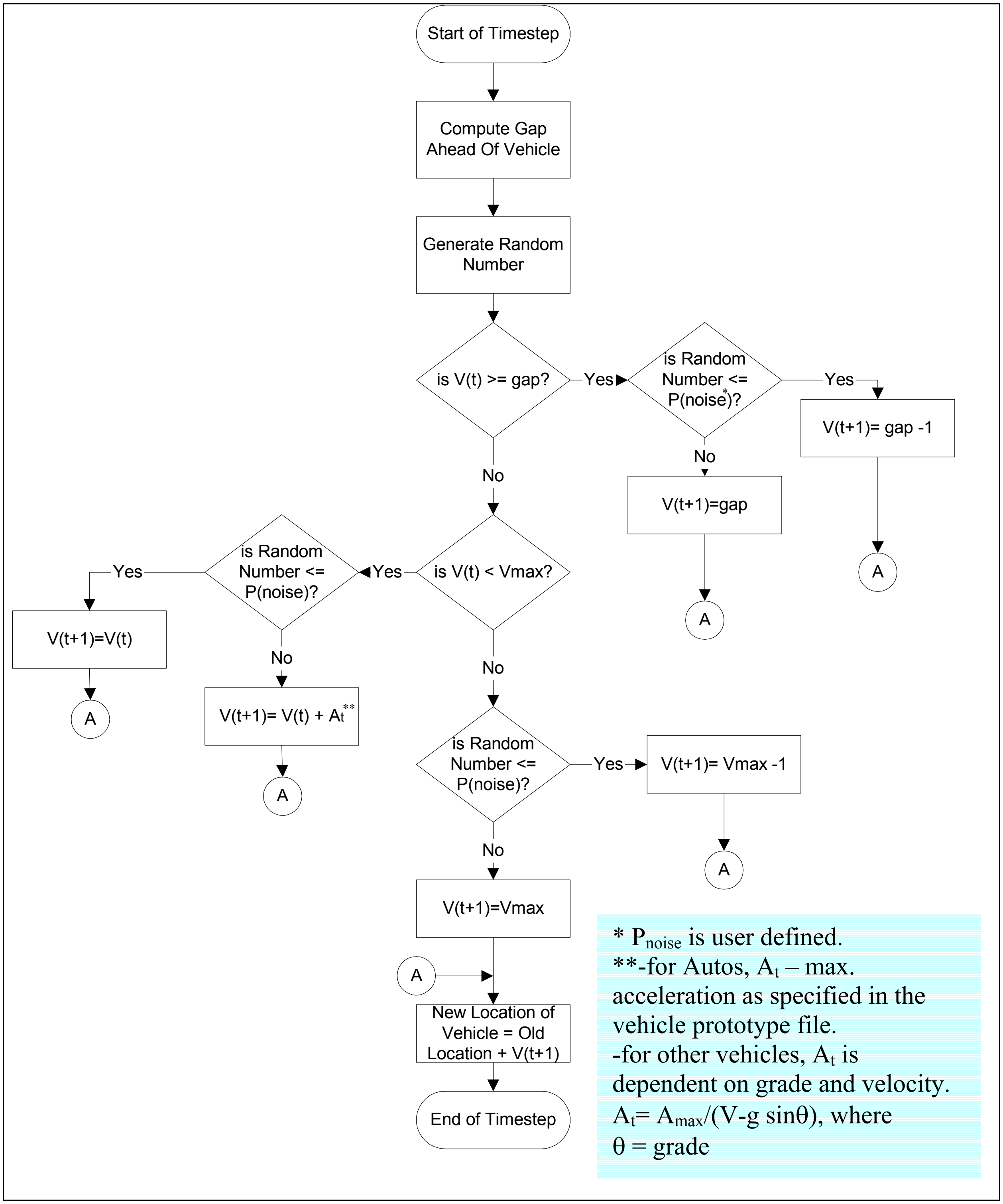
For Car 1: Current Velocity, V(t)=3 cells per timestep.

Compute gap ahead	Gap ahead =4 cells
Generate random number	Random number = 0.78 ; P_{noise} = 0.05 (assumed)
If V_t >= gap	V_t = 3 cells/timestep and gap ahead = 4 cells
If random number <=P_{noise}	
Then V_{t+1} = gap –1	Since (V_t < gap) AND (V_t < V_{max}) AND random number > P_{noise}
Else V_{t+1} = gap	
Else If V_t < V_{max}	$V_{t+1}=V_t+A_t$ (A_t is assumed to be 1 for this vehicle)
If random number <=P_{noise}	
Then V_{t+1} = V_t	V_{t+1} = 3 + 1 = 4 cells/timestep
Else if V_{t+1} = V_t+ A_t	
Else If ((V_t = V_{max}) and (V_t < gap))	Location at time t+1 = current cell + V_{t+1}
If random number <=P_{noise}	= current cell + 4 cells
Then V_{t+1} =V_{max} – 1	
Else V_{t+1} = V_{max}	

For Car 2: Current Velocity, V(t)=2 cells per timestep

Compute gap	Gap =1 cell
Generate random number	Random number = 0.57; P_{noise} = 0.05
If V_t >= gap	V_t = 2 cell/timestep
If random number <=P_{noise}	
Then V_{t+1} = gap –1	Since (V_t >= gap) and random number > P_{noise}
Else V_{t+1} = gap	
Else If V_t < V_{max}	V_{t+1} = gap = 1 cell/timestep
If random number <=P_{noise}	
Then V_{t+1} = V_t	Location at time t+1 = current cell + V_{t+1}
Else if V_{t+1} = V_t+ A_t	= current cell + 1 cell
Else If ((V_t = V_{max}) and (V_t < gap))	
If random number <=P_{noise}	
Then V_{t+1} =V_{max} – 1	
Else V_{t+1} = V_{max}	

The positions and the speeds of car 1 and car 2 at the timestep t+1 are shown in Figure 3.



* P_{noise} is user defined.
**-for Autos, A_t – max. acceleration as specified in the vehicle prototype file.
-for other vehicles, A_t is dependent on grade and velocity.
$A_t = A_{max}/(V - g \sin\theta)$, where
θ = grade

Figure 4: Flowchart For General Movement Of Vehicles In The Same Lane

2.6.1.2 Lane Changing logic

The lane-changing maneuver of a vehicle in TRANSIMS Microsimulator occurs to pass a slower vehicle immediately ahead or to make turns at intersections following its current plan. The decisions for lane changes take place before the in-lane movement of the vehicles on the links occur. This ensures that the in-lane movement of the vehicles takes into account the effect of lane changes.

Lane changes into the left lane and into the right lane are treated by the Microsimulator on alternating timesteps. The left lane changes are made on even timesteps while the right ones are made on odd timesteps. Multilane roadways are processed from left to the right during left lane changing and from the right to the left during right lane changing procedures. It should be noted that these lane change procedures are only explored if the cell on the adjacent lane in which the vehicle is trying to change into is vacant.

The above mentioned lane changing procedures are discussed in detail below under two separate categories. One category is for lane changing based purely on passing a slower vehicle, and the other one is based on making turns at intersections to follow plan.

Lane changes based on passing slower vehicles

The lane changes based on this criterion occur only if the speed of the vehicle under consideration is more than or equal to the gap ahead of it in the current lane (G_c). Another important consideration is the magnitude of the gaps in the adjacent lane to which the vehicle is attempting a lane change into. The gap ahead of the vehicle in the new adjacent lane (G_f) should be larger than the one in the current lane (G_c). The vehicle, before making the necessary lane change, should also consider if the vehicle behind it in the new lane is sufficiently far away (G_b) to avoid any kind of collision.

The above ideas are captured into the TRANSIMS Microsimulator using three variables Weight1, Weight2 and Weight 3. The values of these weights are computed as shown in

Table 1. For a vehicle to make a lane change the following three criterions should be satisfied: Weight1 be greater than zero; Weight1 be greater than Weight2, and Weight1 be greater than Weight 3.

Parameter	**Description**	**Equation**
Weight 1	An integer value based on the gap in the current vehicle, the potential speed of the vehicle in this timestep, and the gap forward in the new lane	Weight1= $(V+1>G_c)$ AND $(G_f > G_c)$
Weight 2	An integer value based on the gap forward in the new lane and the speed of the vehicle	Weight2= $V-G_f$
Weight 3	An integer value based on the gap backward and the maximum speed of a vehicle in the simulation	Weight3= $V_{GlobalMax} - G_b$

Table 1: Computation Of Weights For Lane Changes For Passing Slower Vehicles

An example on the lane changing procedures based on passing slower vehicles is shown in Figure 5 and Figure 6. The example shows car 1 moving at a speed of 2 cells per timestep. Consider a timestep when left lane changes are done first at time t and then right lane changes are made at time t+1.

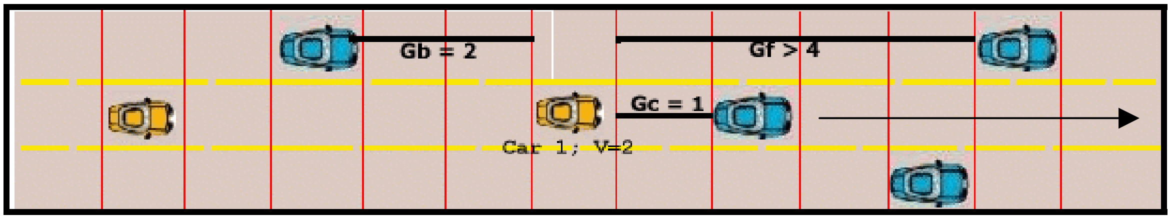


Figure 5: Left Lane Change Considerations For Car 1 At T=t

These calculations are done in an algorithmic manner and provided in a tabular form below.

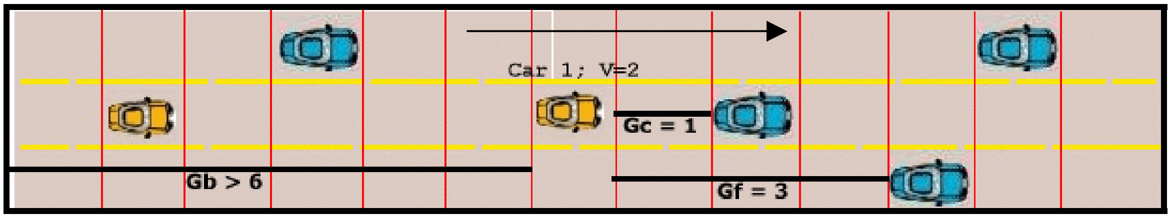


Figure 6: Right Lane Change For Car1

The analysis for in-lane movements of car 1 and car 2 is presented in an algorithmic manner and provided in a tabular form below to provide a better understanding of the rules.

Lane change to get into the left lane for Car 1

If neighboring position in adjacent lane is empty Calculate gap in current lane G_c Calculate gap forward in new lane G_f Calculate gap backward in new lane G_b Using G_c, G_f, G_b calculate Weight1= $(V+1>G_c)$ AND $(G_f > G_c)$ Weight2= $V-G_f$ Weight3= $V_{GlobalMax} - G_b$ If weight 1 > 0 And weight1> weight2 and Weight1> weight3 And lane change probability is affirmative And lane change not merge, turn or next link Move vehicle to new lane	Neighboring position in adjacent lane empty G_c = 1 cell G_f = 4 cells G_b = 2 cells Weight1 = 1 = ((2+1 > 1) AND (4>1)) Weight2 = -2 = (2-4) Weight3 = 3 = (5-2) Weight1 =1 (TRUE) Weight1 > Weight 2 (TRUE) Weight 1 > Weight 3 (FALSE) Since the three conditions are not satisfied, lane change into the left lane is not allowed.

Lane change to get into the right lane for Car 1

If neighboring position in adjacent lane is empty Calculate gap in current lane G_c Calculate gap forward in new lane G_f Calculate gap backward in new lane G_b Using G_c, G_f, G_b calculate Weight1= $(V+1>G_c)$ AND $(G_f > G_c)$ Weight2= $V-G_f$ Weight3= $V_{GlobalMax} - G_b$ If weight 1 > 0 And weight1> weight2 and Weight1> weight3 And lane change probability is affirmative And lane change is not a merge, turn or next link Move vehicle to new lane	Neighboring position in adjacent lane empty G_c = 1 cell G_f = 3 cells G_b = 7 cells (not shown clearly in figure) Weight1 = 1 = ((2+1 > 1) AND (3>1)) Weight2 = -1 = (2-3) Weight3 = -2 = (5-7) Weight1 =1 (TRUE) Weight1 > Weight 2 (TRUE) Weight 1 > Weight 3 (TRUE) Lane change probability affirmative and Lane is not a merge or turn or next link one. Hence lane change into the right lane is allowed based on passing a slower vehicle.

Performing Lane changes based on plan following

As a vehicle enters a link, acceptable lanes for transition to the next link in its plan are determined. From this, a particular lane is chosen to be the preferred destination lane. The preferred destination lane is generally the current lane if allowed onto the next link. In the event that the current lane is not being acceptable, a preferred destination lane is chosen at random from the allowable set of lanes.

Lane changes based on plan following are triggered only when the vehicle is within a set distance from the intersection. This distance is specified by D_{pf}, the point on the link where a vehicle starts to consider lane changes to follow its plan. It can be easily understood that the urgency for a lane change to get into the desired lane based on plan following increases with the vehicle getting closer and closer to the intersection. It can also be understood that this urgency also increases with the number of lanes between the current lane and the preferred lane. Microsimulator uses these two factors in modeling a parameter (Weight 4) which represents the bias to make a lane change based on plan following. This is shown below in the form of a mathematical equation that the Microsimulator uses.

$$Weight4 = V_{\max} - \frac{(V_{\max} - 1) * D_i}{n * D_{pf}} \qquad [2\text{-}27]$$

Where,

V_{max} is the max speed attainable by vehicle

D_i is the distance of the vehicle from the intersection

D_{pf} is the set distance from intersection where a vehicle starts to consider lane changes to follow its plan (specified in configuration file).

N is the number of lanes change necessary to get into the preferred lane.

It can be seen from the above equation that, as D_i goes from $n.D_{pf}$ to 0, the values of Weight4 goes from 1 to V_{max} indicating that it should always be a positive value.

Weight4 is initially set to 0. However if it is set to –1, it will prevent any passing lane changes based on gaps. As discussed earlier, left and right lane changes occur on alternating timesteps even for lane changes based on plan following.

The overall decision to change lane considers both plan following and gaps. The parameters are adjusted to reflect these conditions.

Weight1 = Weight1 (based on Gaps) + Weight 4.

The overall conditions for lane change remain the same as those based on passing slower vehicles i.e., Weight1 >0; Weight 1> Weight 2 and Weight 1 > Weight 3.

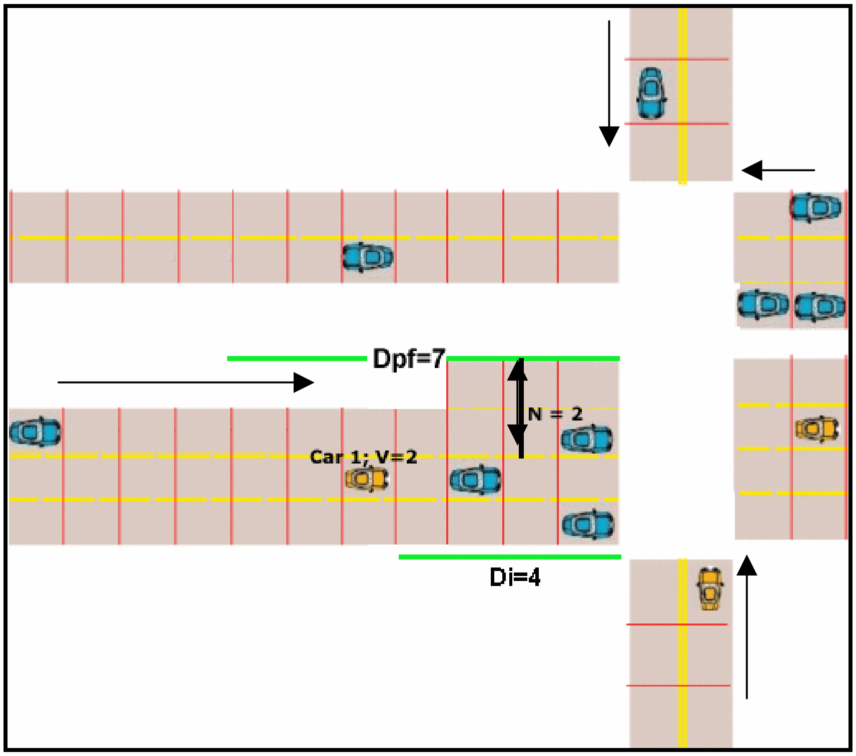


Figure 7: Example For Lane Change Based On Plan Following

An illustration of a lane change based on plan following is shown in Figure 7. In this example, the analysis for lane change is presented for Car 1, which is moving with a velocity of 2 cells per timestep. Let us assume at this point that this vehicle needs to make a left turn at the intersection, and hence needs to get into the left pocket lane. To get into the left pocket lane, two left lane changes need to occur i.e., n=2. It can also be clearly seen that car 1 is 4 cells away from the intersection or $D_i = 4$. For this particular example let us also consider that the lane change for plan following in considered when a vehicle is within 7 cells from the intersection i.e., D_{pf} = 7 cells. Taking into consideration all these factors, Weight 4 is calculated using the equation defined earlier.

$$Weight4 = V_{\max} - \frac{(V_{\max} - 1) * D_i}{n * D_{pf}} \qquad [2\text{-}28]$$

= 5 – (5-1)*4/(2*7) =5- 1.14 = 3.87

Using Weight 4, Weight 1 is calculated as Weight1 = Weight 1 + Weight 4; The analysis then continues exactly as that for lane change based on gaps. For Example;

Weight 1 = 1+3.87 = 4.87
Weight 2 = 2 –3 = -1
Weight 3 = 5 –5 = 0

Since Weight 1>0, and Weight 1> Weight 2, and Weight 1 > Weight 3, the lane change into the adjacent lane is approved. It is important to note that a car making 2 lane changes to reach its desired plan following lane, it needs to calculate again Weight 4 and the other three weights at timestep t+1, after the in-lane movement in the adjacent lane is carried in this timestep. For this example, the car needs to execute a turn pocket lane change at time t+1.

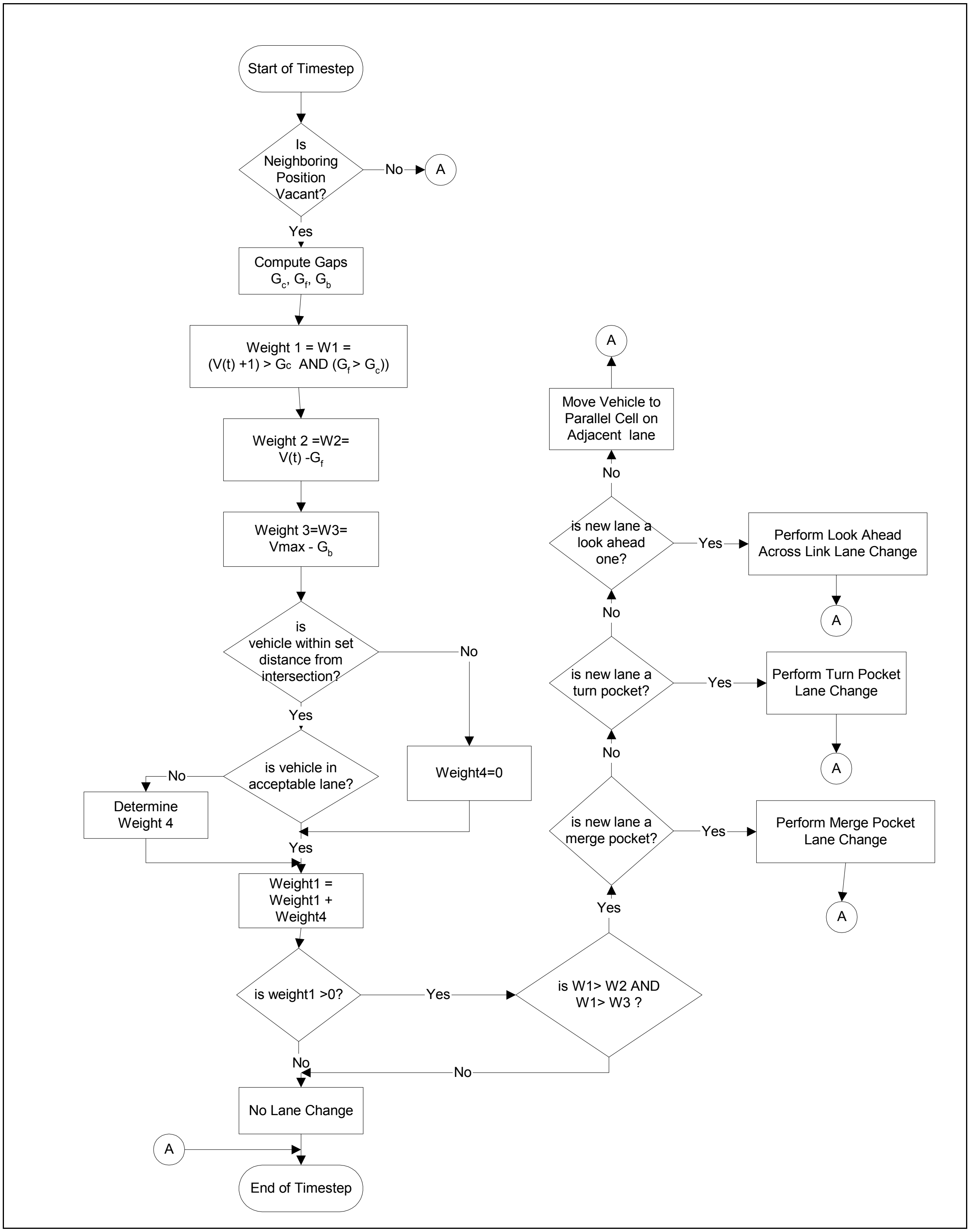


Figure 8: A Flowchart Representing the Lane Change Procedures

2.6.1.3 Vehicle Movements at Intersections

TRANSIMS Microsimulator uses a separate set of rules to model the vehicles leaving a link and passing through an intersection. Every vehicle arriving at an intersection, determines a destination lane on the next link onto which it will travel considering the lane use and HOV restrictions. By default the current lane is chosen if allowed on the next link, else a lane is picked randomly from the set of allowable lanes.

Vehicles at signalized intersections have different behaviors from those at unsignalized intersections. The Microsimulator handles vehicles differently at signalized and unsignalized intersections, though they share some common features. This section presents the way the Microsimulator handles both these cases. But first, the six conditions to be satisfied for a vehicle to enter an intersection are provided below.

Condition One: The vehicle has to be the first one on the link going toward the intersection. This is necessary since the Microsimulator allows only one vehicle per lane to enter an intersection in a single timestep.

Condition Two: The speed of the vehicle trying to enter the intersection must be greater than or equal to the number of empty cells between it and the end of the link.

Condition Three: The vehicle entering the intersection should satisfy the conditions of the traffic control at the intersection. The state of the Traffic Control indicates if a vehicle must consider oncoming traffic gaps. This would ensure that a vehicle facing a red does not enter the intersection. For unsignalized intersections the traffic control would specify a condition of yield or stop. For signalized intersections it would represent a protected, permitted, or a wait traffic control state. This would specify if the oncoming traffic has to be considered for an entry into the intersection. The traffic controls and conditions at an intersection are shown in Table 2.

Traffic Control State	**Action**	**Conditions**
S* - Protected	Proceed	None
S – Wait	Stop	None
S - Permitted	Evaluate	G_i on IL (Interfering Lanes)
S - Caution	Proceed	None
U** -None	Proceed	None
U – Stop	Wait Evaluate	Stopped < 1 Timestep G_i on IL, Stopped ≥ 1 Timestep
U – Yield	Evaluate	G_i on IL

Table 2: Traffic Control States And Corresponding Actions

* S = Signalized intersection

** U = Unsignalized intersection

Condition Four: If the traffic control specifies that the oncoming traffic has to be considered then this condition checks to ensure that there is an acceptable gap between the turning vehicle and oncoming traffic. This is generally important for unsignalized intersections and permitted movements in signalized intersections.

Condition Five: This condition is only checked for vehicles trying to enter a signalized intersection. The intersection buffer for the signalized intersection is checked to verify if it can accommodate the entering vehicle. This is explained more in detail later in the section. Practically this would represent a check to see if there is any space in the intersection to accommodate another vehicle.

Condition Six: A last check before a vehicle enters the intersection is to check if the destination cell on the destination link to which the vehicle will move into is unoccupied. In the case that the destination cell is unoccupied and all other conditions are satisfied, the vehicle leaves the intersection buffer and follows the procedures pertaining to the destination link.

The remaining section looks at the procedures followed for signalized and unsignalized intersections separately.

Unsignalized Intersections

A major difference in the way in which Signalized and Unsignalized intersections are handled is the way vehicles can enter and exit an unsignalized intersection in a single timestep. An unsignalized intersection with stop/yield type *traffic controls* requires the vehicle to consider oncoming traffic before it can move onto the next link. The TC (Traffic Control) state may require that the distance between the intersection and the on-coming traffic (interfering lane gap) meet certain criteria before the vehicle can enter the intersection. The turning vehicle uses the gap between the oncoming vehicles and the intersection to determine whether the intersection can be entered. If the gap is acceptable, the vehicle traverses the intersection and arrives on the destination link during a single update step in the Microsimulator.

The interfering lane gap (G_i) is the distance between the oncoming vehicle and the intersection, as shown in Figure 9. The oncoming vehicle must be on a link connected to the intersection, which limits the look-back distance for oncoming traffic to the length of a single link. The speed of the oncoming vehicle (V_{OV}) and the Gap Velocity Factor (GVF) are used to calculate the Desired Gap. The Gap Velocity Factor is specified by the configuration key, and has a default value of 3.

$$\text{Desired Gap } (G_d) = V_{OV} * \text{GVF}$$

On links where the desired gap is greater than the number of cells on the link, the number of cells on the link is used as the desired gap. If

$G_i \geq G_d$, then Interfering Gap is Acceptable
$G_i < G_d$, then Interfering Gap is Not Acceptable

It is important to note that for an oncoming vehicle with a speed of 0, G_d will also be 0, which allows movement through intersections in congested conditions where both G_d and $G_i = 0$.

For the example shown in Figure 9, Car 1 is not allowed to enter the intersection because its interfering gap (G_i) for the oncoming car 4 on link 4 is 4, which is less than the required G_d of 6 obtained by multiplying the car 4 velocity of 2 by the Gap Velocity Factor of 3.0.

If the interfering gap is not acceptable and the vehicle is at a stop or yield sign and the interfering lane is also controlled by a stop/yield sign, there will be a deadlock resolution in which the vehicle will proceed with probability determined by the value of the configuration key CA_IGNORE_GAP_PROBABILITY.

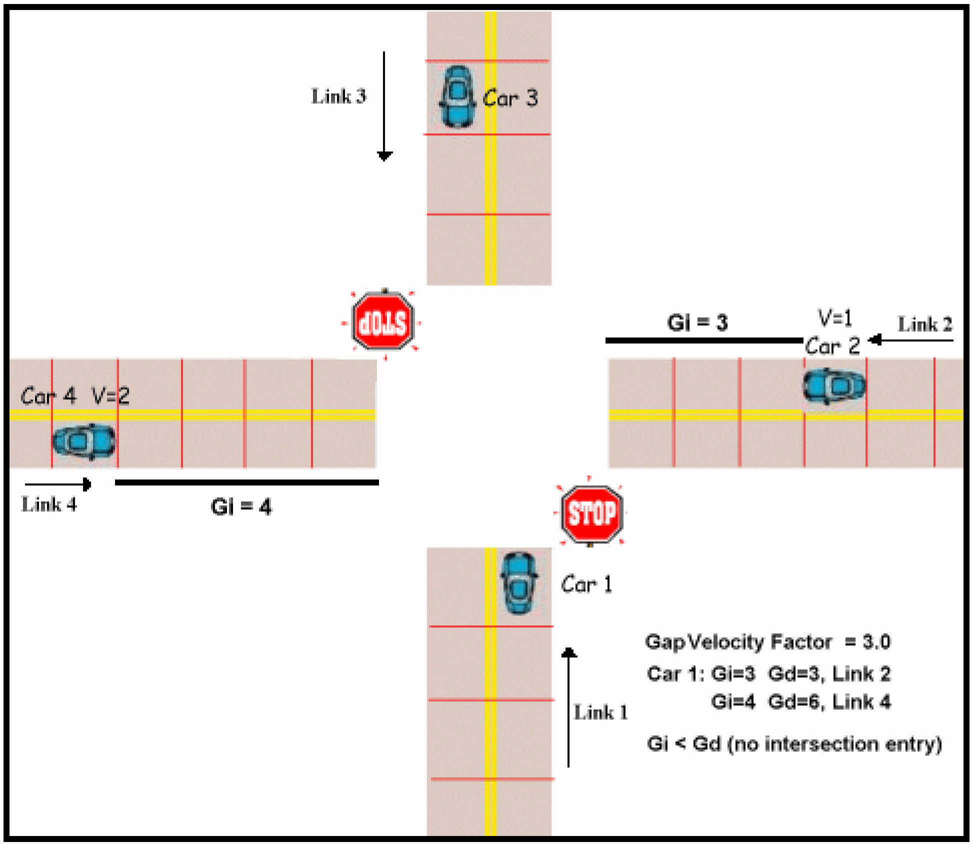


Figure 9: Vehicle Movement At An Unsignalized Intersection.

The primary destination cell on the destination link to which the vehicle will exit from the intersection is determined by considering the current speed of the vehicle. In case the primary destination cell is occupied, a cell closer to the intersection is tried. Should it be occupied, a cell bit closer to the intersection is tried until an unoccupied one between the intersection and the primary destination cell is found. Upon finding a vacant cell, a marker is placed on the cell to reserve the position and an internal state variable is set to indicate that the vehicle can proceed. This variable is further used during the movement procedure to determine whether to remove a vehicle from a link or decrease its speed. Vehicles traversing unsignalized intersections are placed on their destination link during the clean-up procedure at the end of a timestep.

Signalized Intersections

At signalized intersections the vehicles do not traverse the intersection in the current Microsimulation timestep. Instead they are placed in the *internal queued buffers* maintained by the signalized intersection. Each intersection has one queued buffer for each incoming lane. If the conditions of the signalized traffic control have been satisfied, a vehicle must check whether the appropriate buffer has space to receive the vehicle, which is one of the conditions for entry into the intersection.

The time that the vehicle spends in the queued buffer models the time necessary to traverse the intersection. Also the state of the traffic control (TC) at the intersection is an important factor in the decision on whether the vehicle can enter the intersection. The TC must indicate a permitted, protected, or caution movement for the current lane in order for the vehicle to enter the intersection. Vehicles with permitted, but not protected traffic control at a signalized intersection consider the oncoming traffic before entering the intersection just as in an unsignalized intersection.

After the specified time period has expired in the intersection buffer, the vehicle exits from the buffer to the first cell on the destination link if the cell is vacant. If not, the vehicle waits in the intersection buffer until the cell becomes vacant. Also these buffers have a fixed size and so that if the buffer is full, the vehicle cannot enter the intersection and must wait on the link. *(TRANSIMS manual, 2001)*

2.6.2 CORSIM

Corsim combines Netsim and Fresim simulation models into an integrated package providing comprehensive simulation capabilities in the areas of traffic operational analysis, geometric design evaluations, congestion assessment and mitigation strategies. Both Netsim and Fresim components of Corsim model simulate the traffic behavior at a microscopic level with detailed representation of individual vehicles and their interaction with their physical environment and other vehicles. Netsim simulates traffic on urban street portion of the traffic network and the Fresim model simulates the traffic behavior on the freeway segments. The interface between the two components is transparent to the users with the only requirement being the initial partitioning of the traffic network into separate surface street and freeway subnetworks and identification of interface points between the two adjoining subnetworks.

2.6.2.1 FRESIM Model

The vehicle movement logic explaining the lateral and longitudinal movements of the vehicles on the freeways and at the intersections, both signal controlled and sign controlled (both stop and yield signs) are explained in detail in the following sections.

Vehicle Movement Logic

The traffic flow distributions in CORSIM are based on continuous speed and distance variables. The vehicle movements is based on the interaction between three factors which are stated as follows:

- Car-following
- Emergency requirements

- Vehicle performance capabilities

Car Following

Fresim model uses the Pitts car-following model. The space headway between the leader and the follower vehicles is given by the following equation which is also shown in the Figure 10:

$$L+10+kv_t+bk(u_t-v_t)^2$$

where:

L = lead vehicle length

k = driver sensitivity factor for the follower vehicle

v_t = speed of the follower vehicle at time t

u_t = speed of the lead vehicle at time t

b = calibration constant defined as:

$$b = \begin{cases} 0.1 & u_t < v_t \\ 0 & \text{otherwise} \end{cases}$$

The follower vehicle acceleration is determined using the following equation:

$$a = \frac{2(x_{t+T} - y_t - L - 10 - v(k+T) - bk(u_{t+T} - v_t)^2)}{T^2 + 2kT}$$

where:

x = lead vehicle position at time t+T

y = follower vehicle position at time t

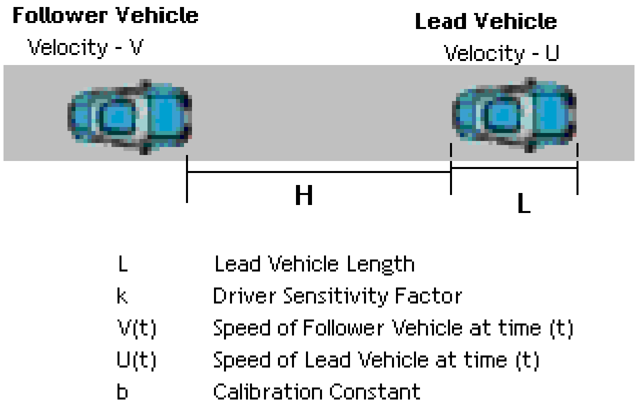


Figure 10: Car Following

Emergency Requirements

The acceleration by the car following model as discussed above is not considered in the case of emergency as in the case of emergency the first priority for the vehicles is to stop safely behind the leader with the lead vehicle having a provision to decelerate at the maximum allowable emergency deceleration, which enables it to come to a complete stop and also the follower vehicle being able to stop behind the lead vehicle within its maximum emergency deceleration limit.

Vehicle Performance Capability

There are certain unique performance capabilities associated with a vehicle and the corresponding driver in terms of maximum acceleration at current traveling speed, maximum acceleration on grade, maximum emergency and non-emergency decelerations, maximum attainable speed, maximum jerk, response lag times, etc. In order to satisfy the vehicle's performance capabilities vehicle acceleration as determined from car following is adjusted.

Lane changing logic

Fresim model involves a lane changing process considering gap evaluation and the gap acceptance side as well as the behavioral issues related to the driver decision to perform a lane change. The various parameters associated with the lane changing process is shown in the Figure 11. Gap evaluation refers to the process of evaluating the lead gap and the trailing gap sizes, which enable the lane changer to remain in a safe position relative to the putative leader and the putative follower.

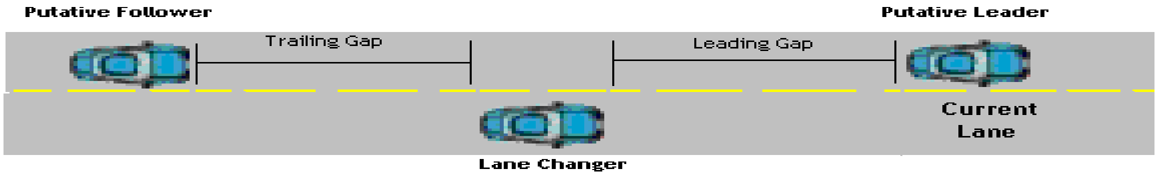


Figure 11: Lane Change Parameters

The required deceleration by the lane changer to be in a safe position relative to its new leader is given by:

$$a^2 + a\left[e + \frac{2eR}{(h-R)} + \frac{2v_t}{(h-R)}\right] - \left[\frac{2e}{(h-R)^2}\right]\left[x_{t+T} - y_t - v_t h - L - Rv_t - \frac{v_t^2 - u_{t+T}^2}{2e}\right] \geq 0$$

when

$$a \geq \frac{\sqrt{u_{t+T}^2 + e^2R^2} - eR - v_t}{(h-c)} > 0$$

or

$$a \leq 2\left[\frac{x_{t+T} - y_t - v_t h - L}{(h-R)^2}\right]$$

when

$$\frac{\sqrt{u_{t+T}^2 + e^2R^2} - eR - v_t}{(h-R)} > a > \frac{-v_t}{(h-R)}$$

or

$$a \leq \frac{-v_t^2}{2(x_{t+T} - y_t - L)}$$

when

$$a \leq \frac{-v_t}{(h-R)}$$

where:

L = length of the putative leader

h = lane changing period

R = driver response lag time

e = maximum emergency deceleration rate

x_{t+T} = position of the putative leader at time t+T

y_t = position of the lane changer at time t

v_t = speed of the lane changer at time t

u_{t+T} = speed of the putative leader at time t+T

a = lane changer acceleration to remain in safe position

Gap acceptance refers to the process of determining whether the lead and trailing gaps are acceptable to the lane changer and putative follower. The required deceleration should not exceed the acceptable level of risk by the lane changer for the lead gap to be acceptable and similarly the trailing gap becomes acceptable if the required deceleration for the putative follower does not exceed its acceptable risk. The acceptable levels of risk for both the lane changer vehicle and the putative follower is manifested as the maximum acceptable deceleration in performing the lane change. *(Halati et al, 1997)*

Types of lane changing

Three distinct types of lane changing is recognized in the Fresim model which are as follows:

- Mandatory
- Discretionary
- Anticipatory

Mandatory lane change

Lane Changing is considered mandatory in the situations when traffic is merging from the on-ramp, when traffic is trying to reach the proper lane to exit the freeway, when vacating a lane blocked by an incident and also when vacating a lane which is dropped further downstream.

For the driver to perform a lane change, to get out of the auxiliary lane and merge with the mainline traffic, the acceptable level of risk is obtained as follows:

$$a_l = a_{min} + (e - a_{min})\sqrt{\frac{d}{l}} \qquad [2\text{-}29]$$

where:

a_l = acceptable deceleration rate
a_{min} = minimum acceptable deceleration
e = emergency deceleration rate
d = distance between the vehicle and the on-ramp gore
l = length of the acceleration auxiliary lane

The acceptable deceleration for a vehicle considering exiting the freeway and trying to get off ramp is shown as follows:

$$a_l = \begin{cases} e & d > 200 \\ a_{min} + (e - a_{min})\sqrt{\frac{d}{l}} & d \le 200 \end{cases} \qquad [2\text{-}30]$$

where:

d = distance between the vehicle and the upstream off-ramp warning sign
l = distance between the off-ramp and its advanced warning sign

Discretionary lane change

It refers to lane changes performed to bypass other slow moving vehicles, to obtain a more favorable position, and to attain a higher speed. The discretionary lane change logic involves three behavioral factors on the part of the driver namely motivation, advantage and urgency.

Motivation refers to the desire for performing the discretionary lane change, which is a function of vehicles present speed and driver's characteristics. Each vehicle is assigned an "intolerable" speed below which the driver is highly motivated to perform the lane change.

Advantage refers to the benefits gained by performing the lane change and is modeled in terms of the disadvantage of remaining in the current lane and the gain in moving to a new lane. The putative factor which represents the perceived gain in performing a lane change is computed for both lanes adjacent to the current lane. The lane with the largest putative factor is selected as the target lane.

Urgency in making the lane change refers to the strength of the desire for the lane change. It is based on the assumption that the driver who is motivated to perform a lane change but is unable to do so would gradually become impatient and accept higher levels of risk in performing the lane change.

Anticipatory lane change

It refers to the lane changes performed upstream of the on-ramps in anticipation of potential slowdown caused by traffic entering the freeway and merging with the mainline traffic. According to the field observations many a time vehicles on the freeway vacate the lane when they encounter an on ramp merging. To incorporate this feature in the model anticipatory lane changing logic was adopted. There are basically two differences between the anticipatory and discretionary lane change logic in the Fresim model. Firstly the advantage in performing the lane change is based on the volume and prevailing average speed in the vicinity of the on-ramp gore and secondly the desire to perform the lane change, as characterized by the impatience factor, is always set to 1 indicating a high level of desire.

2.6.2.2 NETSIM Model

The vehicle movement logic explaining the lateral and longitudinal movements of the vehicles at the intersections, both signal controlled and sign controlled (both stop and yield signs) are discussed in detail in the following sections.

Vehicle Movement Logic

Netsim model deals with the movement of traffic on the surface street portion of the transportation network. Vehicle status in each processing time step is classified as either a lead, follower, or independent. The vehicle is identified as independent when it is outside the car-following influence zone as determined by:

$$s \geq v^2 / 8 + v + 4$$

or [2-31]

$$s > 2u + v + 4 \text{ and } v > u$$

where:

s = front bumper to rear bumper separation distance

v = follower vehicle speed

u = lead vehicle speed

For free flow conditions the lead and the independent vehicles attempt to attain their desired free-flow speed subject to their performance capability restrictions. The lead vehicle in an approach lane which is within the influence zone of the intersection traffic control device (sign or signal) will begin to decelerate in anticipation of stopping at the approach stop bar.

Car-Following

The car following logic in CORSIM follows a behavior which deals with avoiding collision between the vehicles. A collision is considered unavoidable if:

$$s < v - \frac{d_f}{2} \qquad [2\text{-}32]$$

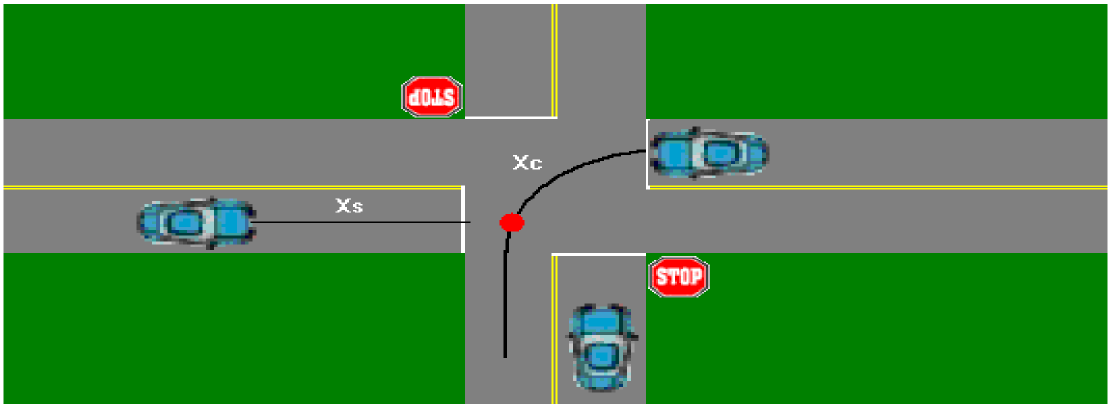
where:

d_f = the maximum emergency deceleration of the follower vehicle (default value is 12 ft/sec^2)

If collision between the follower and the leader is unavoidable, the vehicle will be stopped at the rear bumper of the lead vehicle and is given a deceleration of -15 ft/sec^2. When collision is avoidable, the follower vehicle will car-follow it’s leader and the vehicle’s acceleration is framed from a set of equations.

Gap Acceptance and Gap Evaluation

Gap acceptance model is used in Netsim at sign controlled, both stop and yield signs, and at signalized intersections for right and permissive left-turning vehicles. The model compares the available gap in the opposing traffic to the acceptable gap to determine if the vehicle can be discharged. Available gap in the opposing traffic is evaluated only for the through moving vehicles (turning vehicles are assumed not to impede each other movement) and is measured for the first vehicle in each lane of the opposing traffic stream, unless the first vehicle can clear the intersection prior to the arrival of the turning vehicle in which case it is measured with respect to the second vehicle. If the opposing vehicle is in a queue state, the available gap is computed as the remaining time of the vehicle’s queue discharge headway otherwise the available gap (G) is computed as shown in the Figure 12. *(Halati et al, 1997)*



$$G = (Xs - Xc) / V$$

G	Available Gap
Xs	Distance Between the Opposing Vehicle and Stop Line
Xc	Distance Betweeb the Stop Line and the Conflict Point
V	Opposing Vehicles Speed

Figure 12: Gap Acceptance

Table 3 shows the default values for the range of acceptable gaps for stop sign and signal controlled intersections. The acceptable gap size for yield sign controlled intersections is 1.5 seconds less than the corresponding values for stop sign controlled intersections.

Type of Control	**Turning Movement**	**Acceptable Gap Size (sec.)**
Stop Sign	Right-turn	3.6-10.0
Stop Sign	Through, Left, Diagonal	0.5-4.1
Signalized	Right-turn-on-red	3.6-10.0
Signalized	Permissive Left, Diagonal Left	2.7-2.8

Table 3: Acceptable Gap Size

Lane Changing

The Netsim model identifies two types of lane changes as follows:

- Mandatory
- Discretionary

The idea of the lane changing logic is same for this model as the FRESIM model except for the fact that they do not have anticipatory lane changing environment here. *(Halati et al, 1997)*

2.6.3 VISSIM

VISSIM is a microscopic, time step and behavior based simulation model developed to model urban traffic and public transit operations. The program can analyze traffic and transit operations under constraints such as configuration, traffic composition, traffic signals, transit stops etc, thus making it a useful tool for the evaluation of various alternatives based on transportation engineering.

The model consists of two primary components: (1) simulator and (2) signal state generator (SSG). The simulator generates traffic and is where the user graphically builds the network. Although links are used in the simulator, VISSIM does not have a traditional node structure. The lack of nodes provides the user with the flexibility to control traffic operations (e.g., yield conditions) and vehicle paths within an intersection or interchange.

The simulation system consists of two separate programs. The first program is the traffic flow model (the kernel of VISSIM), second the signal control model. VISSIM is the master program, which sends second by second detector values to the signal control program (slave). The quality of the traffic flow model properties are a major concern as the traffic flow model used by VISSIM is a discrete, stochastic, time step based (1s) microscopic model, with driver-vehicle-units (DVU) as single entities. The quality of a traffic simulation system depends highly on the quality of the traffic flow model at its core. The car-following and the lane-changing model are part of this kernel. *(VISSIM user manual, 2000)*

2.6.3.1 Car Following Logic

VISSIM uses a psychophysical car following model for longitudinal vehicle movement, and a rule-based algorithm for lateral movements (lane changing). The basic concept of this model is that the driver of a faster moving vehicle starts to decelerate as he reaches his individual perception threshold to a slower moving vehicle. Since he cannot exactly determine the speed of that vehicle, his speed will fall below that vehicle's speed until he starts to slightly accelerate again after reaching another perception threshold. This results in an iterative process of acceleration and deceleration.

VISSIM simulates traffic flow by moving "driver- vehicle- units" through a network. Every driver with his specific behavior characteristics is assigned to a specific vehicle. As a consequence, the driver behavior corresponds to the technical capabilities of his vehicle. Attributes characterizing each driver - vehicle - unit can be discriminated into three categories:

1. Technical specifications of the vehicle
    - Length
    - Maximum speed
    - Potential acceleration
    - Actual position within the network
    - Actual speed and acceleration
2. Behavior of driver- vehicle- unit
    - Psychophysical sensitivity thresholds of the driver (ability to estimate, aggressiveness)
    - Memory of driver
    - Acceleration based on current speed and driver's desired speed
3. Interdependence of driver- vehicle- units
    - Reference to leading and following vehicles on own and adjacent travel lanes

- Reference to current link and next intersection
- Reference to next traffic signal

The basic idea of the Wiedemann model is the assumption that a driver can be in one of four driving modes:

- ***Free drivin*g** – In this mode, for a vehicle, there is no influence of preceding vehicles. The driver tries to maintain his individually desired speed.
- ***Approaching*** - In this mode, the driver adapts a speed as that of lower speed of the preceding vehicle. The driver while approaching decelerates so that the speed difference is zero in the moment he reaches his desired safety distance.
- ***Followin*g** – In this kind of mode the driver follows the preceding car without any conscious acceleration or deceleration. He keeps the safety distance more or less constant, but again due to imperfect throttle control and imperfect estimation the speed difference oscillates around zero.
- ***Brakin*g** – This refers to an application of medium to high deceleration rates if the distance falls below the desired safety distance. This can happen if the preceding car changes speed abruptly, or if a third car changes lanes in front of the observed driver. *(VISSIM User Manual, 2000).*

For each mode, the acceleration is described as a result of speed, speed difference, distance and the individual characteristics of driver and vehicle. The driver switches from one mode to another as soon as he reaches a certain threshold that can be expressed as a combination of speed difference and distance. The ability to perceive speed differences and to estimate distances varies among the driver population, as well as the desired speeds and safety distances. Because of the combination of psychological aspects and physiological restrictions of the driver's perception, the model is called a psychophysical car-following model.

Vehicles follow each other in an oscillating process. As a faster vehicle approaches a slower vehicle on a single lane it has to decelerate. The action point of conscious reaction depends on the speed difference, distance and driver depended behaviour. Figure 13 indicates the oscillating process of this approach. The thresholds of Figure 13 are explained in an abbreviated form. Driver specific perception abilities and individual risk behaviour is modelled by adding random values to each of the parameters as shown for AX

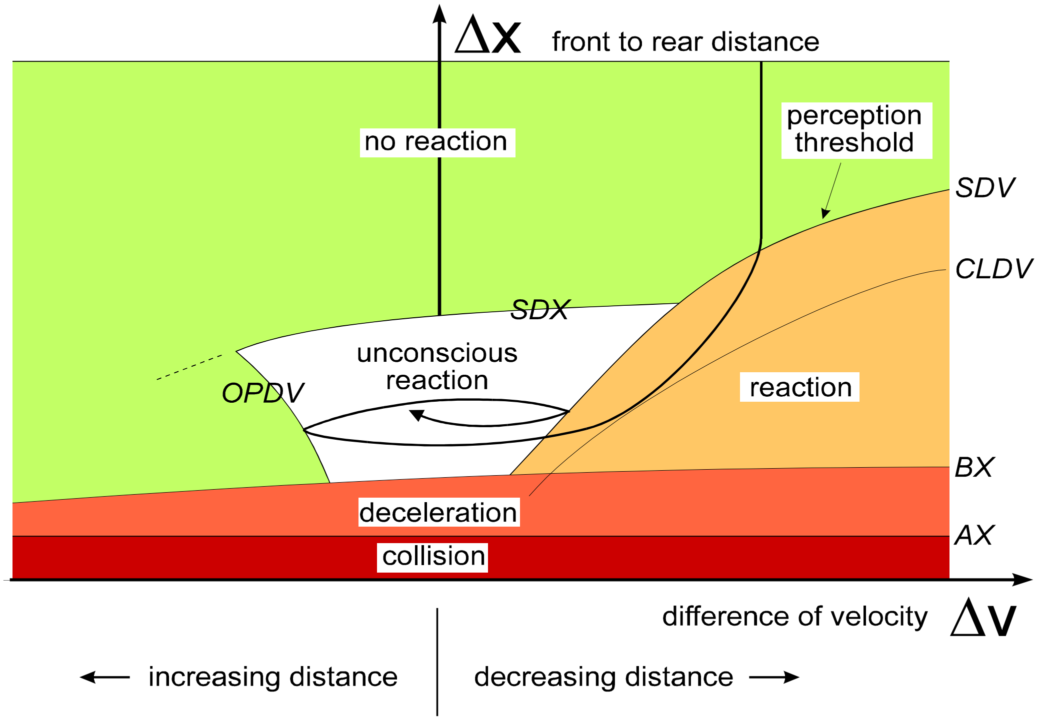


Figure 13: Car Following Logic (Source VISSIM User Manual, 2000).

AX : Desired distance between the fronts of two successive vehicles in a standing queue. $AX = VehL + MinGap + RND1 \cdot AXMult$ with RND1 normally distributed N(0.5, 0.15)

ABX : Desired minimum following distance which is a function of AX, a safety delta distance BX and the speed

$ABX := AX + BX \cdot \sqrt{v}$

SDV: Action point where a driver consciously observes that he approaches a slower car in front. SDV increases with increasing speed differences ($\sqrt{\Delta v}$).

OPDV: Action point where the following driver notices that he is slower than the leading vehicle and starts to accelerate again. The variation of OPDV is large.

SDX: Perception threshold to model the maximum following distance which is about 1.5 - 2.5 times ABX.

A following driver reacts to a leading vehicle on up to a certain distance, which is about 150 m. The minimum acceleration and deceleration rate is set to be 0.2 m/s^2. Maximum rates of acceleration depend on technical features of vehicles, which are usually lower for trucks than the personal desire of its driver. The model includes a rule for exceeding the maximum deceleration rate in case of emergency. This happens if ABX is exceeded. The values of the thresholds depend on the present speed of the vehicle. *(VISSIM User Manual, 2000)*

2.6.3.2 Lane Changing Logic

On multi-lane links vehicles check whether they improve by changing lanes and if so, they check the possibility of finding acceptable gaps on neighboring lanes. Thus a hierarchical set of rules is formulated to model lane changes. A driver has a desire to change lane if he has to drive slower than his desired speed due to a slow leading vehicle or in case of an upcoming junction with a special turning lane. Then the driver checks whether he improves his present situation by changing lanes. Last he checks whether he can change without generating a dangerous situation. In case of multi-lane approaches towards intersections this method will lead to evenly used lanes unless routing information forces vehicles to keep lanes.

The basis for lane changing logic is to define time-distance relationships and times of start and end of lane changing maneuvers. The combination of both data types is allowed to determine speeds and distances between vehicles.

There are two types of lane changing in VISSIM

- Changes to faster lane

Further the changes to faster lane can be classifies as

  - FREE lane changes
  - LEAD lane changes
  - LAG lane changes
  - GAP lane changes

- Changes to slower lane

  These are further classified as

  - FREE lane changes
  - ACCEL lane changes

2.6.4 INTEGRATION

The INTEGRATION model is a trip-based microscopic traffic simulation model. It is a continuous model, which is based on speed and distance variables. The model is designed to trace both the lateral and longitudinal movements of an individual vehicle from a vehicle's origin to its destination at a level of resolution of one status update every 1/10th of a second, or deci-second. INTEGRATION uses a steady state car following model proposed by Van Aerde that combines the Pipes and Greenshields models into a single regime model, which is a four-parameter model.

2.6.4.1 Vehicle Movement Logic

The vehicle movement logic deals with a discussion on how the model has been designed to estimate the steady-state speeds of vehicles that are driving at constant speeds within different traffic conditions. This discussion emphasizes the relationship between the macroscopic fundamental diagrams for the traffic flow of groups of vehicles, to the microscopic car-following logic of individual vehicles. Macroscopic traffic flow theory describes the flow rate, speed, density of the traffic flow and the rate of propagation of any queues that form when the traffic demand exceeds the available capacity. Microscopic traffic flow theory deals with the speeds and headways which individual vehicles maintain at various times and at different locations. *(INTEGRATION user's guide, 2001)*

2.6.4.2 Car Following Logic

INTEGRATION's microscopic car-following model is a forward-looking one, as it selects the desired speeds of vehicles by considering only the attributes of other vehicles ahead of it in the same lane. The general equation that is utilized to determine a vehicle's headway every deci-second is provided in Equation below.

$$h = c_1 + \frac{c_2}{u_f - u} + c_3 u \qquad [2\text{-}33]$$

Where:

h = vehicle distance headway (km)

u = speed (km/h)

u_f = free speed (km/h)

c_1 = fixed distance headway constant (km)

c_2 = first variable headway constant (km 2 /h)

c_3 = second variable distance headway constant (h -1)

INTEGRATION provides separate deceleration and acceleration logic. The deceleration logic recognizes speed differentials between the vehicle that is making desired speed decisions, and the vehicle ahead of it. It is simplest to first describe how this logic applies to a vehicle approaching a stationary object. In this case, a vehicle will first estimate the excess headway between itself and the vehicle ahead of it. This excess headway is defined as the residual that remains when the currently available headway is reduced by the minimum headway. Based on this residual headway, the vehicle will next compute the time it has to comfortably decelerate from its current speed to the speed of the object/vehicle in front of it. This time is, for constant deceleration rates, equal to the residual headway divided by the average speed of the leading vehicle and the following vehicle. Subsequently, the following vehicle computes the required deceleration rate as the speed differential divided by the deceleration time.

The following vehicle will select a constant deceleration rate that allows it to just come to a stop at jam density headway behind a following vehicle. If the leading vehicle is actually moving, the following vehicle would attempt to decelerate at a constant rate in such a manner as to attain the speed of the leading vehicle when it reached the location that is single jam density headway behind its current location. By the time the following vehicle would reach this location, the lead vehicle would already have moved ahead on the highway, resulting in an asymptotic deceleration of the follower vehicle to the lead vehicle's speed, rather than a constant deceleration. Similarly, if the lead vehicle were accelerating, the follower vehicle would only continue to decelerate until it was traveling at the same speed as the lead vehicle. From that point onwards, the follower vehicle would likely begin to accelerate again, as the increasing gap to the lead vehicle would cause the follower vehicle to perceive increasing desired speeds.

While deceleration is governed primarily by kinematics, the acceleration rate of vehicles is governed by dynamics. Specifically, a vehicle with a desired speed that is greater than its current speed will attempt to accelerate at the maximum possible rate. This maximum possible rate can be constrained using one of two different mechanisms. Within the first mechanism, the maximum acceleration rate of a vehicle is set to be linearly dependent upon the vehicle's current speed. This results in vehicles being able to achieve higher acceleration rates at lower speeds, and lower acceleration rates at high speeds. *("Microsimulation of Traffic with and without Adaptive Cruise Control: Model Logic", Paper submitted to ITS America).*

2.6.4.3 Lane Changing Logic

Two distinct types of lane changing is recognized in the INTEGRATION which are as follows:

- Mandatory
- Discretionary

When a vehicle travels down a particular link, it may make discretionary lane changes, mandatory lane changes, or both. Discretionary lane changes are a function of the prevailing traffic conditions, while mandatory lane changes are usually a function of the prevailing network geometry.

In order to determine if a discretionary lane change should be made, each vehicle computes three speed alternatives each deci-second. The first alternative represents the potential speed at which the vehicle could continue to travel in its current lane, while the second and third choices represent the potential speeds that this vehicle could travel in the lanes immediately to the left and to the right of its current lane. These speed comparisons are made on the basis of the available headway in each lane, and pre-specified biases for the vehicle to remain in the lane in which it is already traveling or to move to the shoulder lane. A vehicle will then elect to try to change into that lane which will permit it to travel at the highest of these three potential speeds.

While discretionary lane changes are made by vehicles in order to maximize their speed, mandatory lane changes arise primarily from a need for vehicles to maintain lane connectivity at the end of each link. The lane connectivity requires that eventually every vehicle must be in one of the lanes that are directly connected to the relevant downstream link onto which the vehicle anticipates turning. A unique feature of INTEGRATION's lane changing model is that the lane connectivity at any diverge or merge is computed internally.

Once a lane-changing maneuver has been initiated, a subsequent lane change is not permitted until a pre-specified minimum amount of time has elapsed. In the first instance, this minimum interval ensures that lane changes usually involve a finite length of time to materialize, and that two consecutive lane changes cannot be executed one immediately after the other. Furthermore, while an actual lane-changing maneuver is in progress, the vehicle is modeled as if it partially restricts the headway in both the lane it is moving from and the lane it is changing into. This concurrent presence in two lanes will result in an effective capacity reduction. *(INTEGRATION User's Guide, 2001).*

2.6.4.4 Vehicle Movements at Intersections

The main roadway element within most urban areas is the presence of signalized intersections. Within INTEGRATION, a signalized link is identical in virtually all respects to a freeway link. When the traffic light is red, vehicles must still obey the link's car-following logic, except that a red traffic signal is now considered as an additional vehicle positioned just beyond the stop line at the end of each lane on the link. This *virtual* vehicle creates a reduction in the vehicle's perceived headway, and causes vehicles that approach a red signal to slow down as their headway to the traffic signal decreases. Eventually, the first vehicle to approach the red signal comes to a complete stop upstream of the stop line. Subsequent vehicles then automatically queue upstream of the first vehicle in a horizontal queue, where the minimum spacing of vehicles in this horizontal queue is governed by the user-specified jam density.

When the effective green indication commences, the *virtual* object at the signal stop line of each lane is removed and the first vehicle in queue faces an uninterrupted headway down the next downstream link. The initial acceleration of the first vehicle in the queue, together with the subsequent impact of the model's car-following logic on any additional vehicles, causes two shock waves to form concurrently. *(INTEGRATION user's guide, 2001).*

2.7 Comparison and Contrast Between TRANSIMS, CORSIM VISSIM and INTEGRATION

The following discussion will compare the TRANSIMS, CORSIM, VISSIM and INTEGRATION models in more detail.

- The models are similar as they are designed to model any combination of surface street and freeway facilities, including most signal control and other operational strategies. The models provide detailed and focused output, in tabular format and via animated graphics. The main differences between the models are in vehicle and driver behavior, primarily in the car-following and gap acceptance logic.

- VISSIM, CORSIM and INTEGRATION are stochastic microscopic computer simulation programs while TRANSIMS is a mesoscopic simulation program. All the models are capable of modeling individual vehicle interactions on complex roadway networks. The models use inputs such as lane assignments and geometries, intersection turning movement volumes, vehicle speeds, percentages of vehicles by type, and pretimed and/or actuated signal timing. And the programs produce output that contains measures of effectiveness commonly used in the traffic engineering profession, including total delay, stopped delay, and queue lengths.
- VISSIM is more capable of modeling the interaction of various modes of transit with automobile traffic while CORSIM, INTEGRATION and TRANSIMS can effectively model simple bus routes within a roadway network. VISSIM and TRANSIMS can model light rail transit and can model more bus routes and bus stops than CORSIM and INTEGRATION. In addition, unlike CORSIM, INTEGRATION and TRANSIMS, VISSIM is capable of modeling gates at rail crossings as well as complex traffic control strategies such as preemption and priority systems.
- *User Interface:* CORSIM input files can be quickly created either through ITRAF or Synchro. In order to take full advantage of CORSIM's capabilities, it is often necessary to use a text editor to adjust the input file. The input data files for INTEGRATION can be generated/modified using any standard editor, spreadsheet or word processor. The Windows version of INTEGRATION model provides on-screen graphics that continuously reflect the network status. The input files in TRANSIMS can be created using any text editor such as vi, gvim, gnotepad, pico etc. It has the capability of viewing the output using the output visualizer provided with TRANSIMS in the XWindows. VISSIM network editing is done completely through the use of its Graphical User Interface, which runs in various versions of Microsoft Windows. VISSIM can also import scaled versions of background bitmap files, which can be used to build the model upon.
- *Network Structure:* Unlike CORSIM, INTEGRATION and TRANSIMS, which use a link-node network structure, VISSIM uses links and connectors. These links

and connectors allow VISSIM to be very flexible when working with complex geometries allowing it to accurately model curvature while CORSIM, INTEGRATION and TRANSIMS have a tendency to show strange loops or other graphical misrepresentations based upon limited input options.

- *Vehicle Entry:* CORSIM generates vehicles using a uniform distribution at its entry points. VISSIM generates vehicles randomly. It follows Poisson arrival distribution. The movement of vehicles in TRANSIMS follows the distributions as specified in traveler plans.
- *Mid-Block Source/Sinks:* CORSIM Source and Sink nodes add or remove vehicles from a link without regard to lane position, acceleration, or deceleration. Specifically, when using source nodes, vehicles just appear on the roadway in any lane, traveling at full speed. When using sink nodes, vehicles just disappear from the roadway in any lane, traveling at full speed. This does not accurately represent the effect of entering and exiting vehicles would have on the link. In contrast, VISSIM's flexible link capabilities can be used to create mid-block source and sink locations where vehicles accelerate, decelerate, and use lanes more realistically when they enter or exit. In addition, VISSIM can more easily account for these vehicles in the statistics if desired. In TRANSIMS parking places model the Source or Sinks on the network. These parking places are placed anywhere on the links and the vehicles are ejected from the parking places and placed on the link with a velocity depending on the gap ahead. And in the same way vehicles are removed from the network and placed in the parking lots without any deceleration.
- *Output:* CORSIM provides detailed output in a series of standardized tables contained in one output file. This output is usually easy to read and has been summarized to a great extent. The output in VISSIM, INTEGRATION and TRANSIMS is present in separate files. The user or analyst can specify the amount and the type of data to be collected. An advantage of VISSIM and TRANSIMS is that they can produce very detailed results on any time interval
- *Driver Characteristics:* CORSIM and VISSIM provide a wide variety of configurable parameters that model a driver behavior in a traffic stream.

TRANSIMS, on the other hand provides very few driver characteristic configurable parameters. INTEGRATION provides driver characteristics on a lane-by-lane basis through adjustable flow density relationships.

2.8 Description of the Weaving Sections

Weaving is defined as the crossing of two streams traveling in the same direction along a significant length of the highway without the aid of traffic control devices. Weaving areas are formed when a merge area is closely followed by a diverge area, or when an on ramp is closely followed by an off ramp and the two are joined by an auxiliary lane. Weaving areas require intense lane changing maneuvers, as drivers must access lanes appropriate to their desired exit point.

As a result, traffic in a weaving area is subject to turbulence in excess of that normally present on the basic highway sections. The drivers from two upstream lanes compete for space and merge into a single lane and then diverge into two different upstream lanes because of which capacity is reduced in these weaving areas. Configuration (number of entry lanes and exit lanes and relative placement) is one of the important geometric factors that need to be considered, as lane changing is a complex component of the weaving areas. Some of the other factors to be considered are speed, level of service, volume distribution etc. The operational problems and special design requirements are often presented by the turbulence created by the "weaving" of vehicles. *(HCM 2000*)

Weaving length

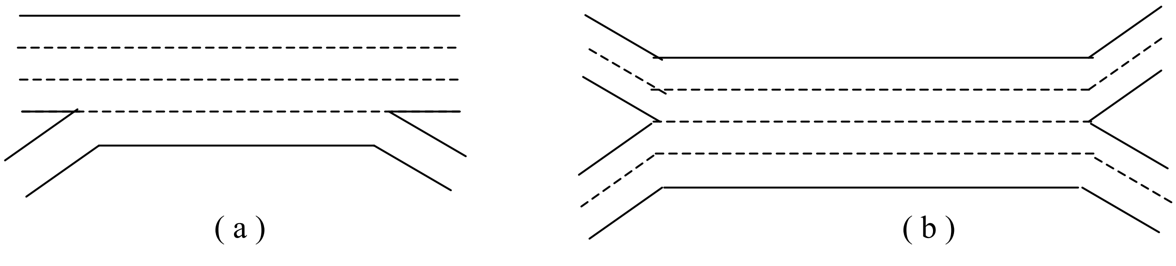
The weaving area length is measured from the merge gore area at a point where the right edge of the freeway shoulder lane and the left edge of the merging lane(s) are 2 ft apart to a point at the diverge gore area where the two edges are 12 ft apart. The time and space are constrained by the length of the weaving area, in which the drivers have to make the necessary and the required lane changes. The intensity of the lane changing as well as the turbulence increases as the length of the weaving area decreases, other factors remaining a constant. There is also a reduction in the average speed of the vehicles in the weaving area *(HCM 2000)*

Configuration

Configuration of a weaving area refers to the relative placement and the number of entry lanes and exit lanes for the section. The performance of a weaving section is drastically affected by this critical geometric characteristic feature. The number of lane changes required of each weaving movement is an influential factor for the weaving segment configuration. The primary types of weaving configuration are categorized as Type A, Type B and Type C, according to the Highway Capacity Manual. The types are defined in terms of the minimum number of lane changes that must be made by weaving vehicles as they traverse the section. *(HCM 2000)*

Type A Weaving Areas

According to this type of configuration weaving vehicles in both the directions must make one lane change to successfully complete a weaving maneuver. The two types of weaving areas for Type A configuration are shown in Figure 14. An on-ramp followed by an off-ramp, with a continuous auxiliary lane between the ramps, is shown in Figure 14a. In this configuration one lane change needs to be performed by all on ramp vehicles out of the auxiliary lane into the shoulder lane of the freeway, and all off-ramp vehicles must make a lane change from the shoulder lane of the freeway to the auxiliary lane.



(a) (b)

Figure 14 a & b: Type A Weaving Sections (Source HCM)

Ramp-weave sections are those that are formed by on-ramp/off-ramp sequences joined by continuous auxiliary lanes. A major weaving section characterized by three or more entry and exit roadways having multiple lanes is shown in the Figure 14(b). To get into the desired lanes all weaving vehicles in this type of configuration need to make at least one lane change. The crown line (the line connecting the nose of the entrance gore area to the nose of the exit gore area) is a characteristic feature of this type of weaving configuration. This crown line is crossed over by every weaving vehicle that makes a lane change. The impact of ramp geometrics on speed, the ramp weave model having its vehicle to accelerate or decelerate as they move from the on to the off-ramp is identified as the primary difference between the two types of movements as shown in the Figure 14. The weaving vehicles are usually confined to the two lanes adjacent to the crown line in the weaving section as they cross the crown lane in this type of configuration. A significant effect of this configuration on operations is the maximum number of lanes that weaving vehicles occupy while traversing the section. *(HCM 2000)*

Type B Weaving Areas

In this type of configuration weaving vehicles in one direction may complete a weaving maneuver without making a lane change, whereas other vehicles in the weaving segment must make one lane change to successfully complete a weaving maneuver. Three different types of Type B configurations are shown in Figure 15 a, b and c. A lane change is not required by the movement B-C while one lane change is required for A-D. This is achieved by lane balancing as shown in Figure 15(a), while in b this is achieved by a lane in Leg A merging with a lane from leg B at the entrance gore area.

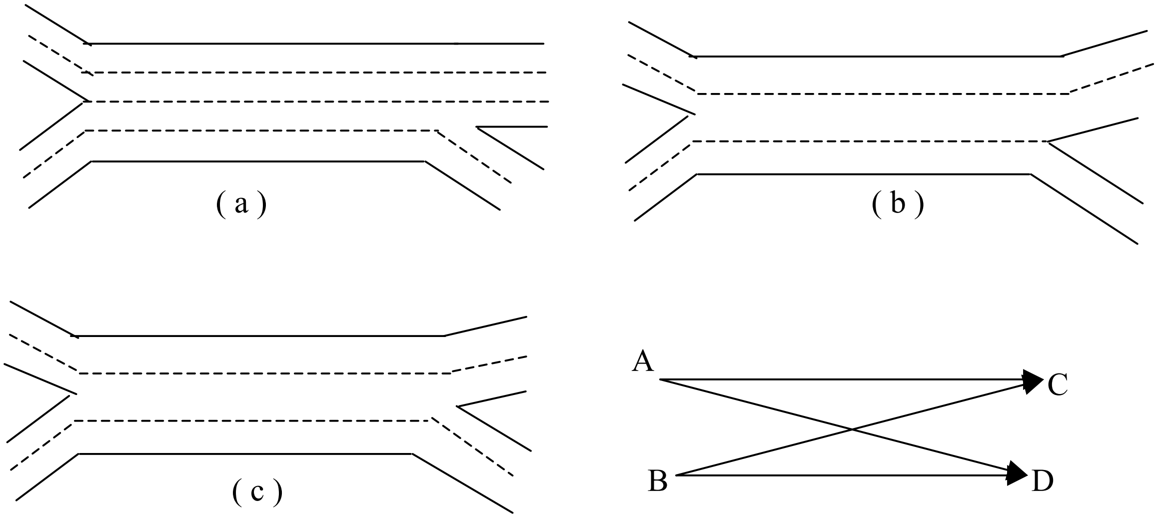


Figure 15: Type B Weaving Sections (Source HCM)

This kind of a weaving configuration is found to be more efficient in carrying large weaving volumes much attributed to the provision of a through lane from one weaving movement. The weaving vehicles are allowed to occupy a substantial number of lanes in the weaving section for this type of configuration and not restricted as in Type A configuration sections. *(HCM 2000)*

Type C Weaving Areas

In this weaving vehicles in one direction may complete a weaving maneuver without making a lane change, whereas other vehicles in the weaving segment must make two or more lane changes to successfully complete a weaving maneuver. The weaving areas in Type C configuration are very similar to those of Type B. The difference crops up in the number of lane changes necessary for the other weaving movement. Figure 16 shows different types of movements for this type of configuration. A lane change is not required for the movement B-C while the movement A-D requires two lane changes.

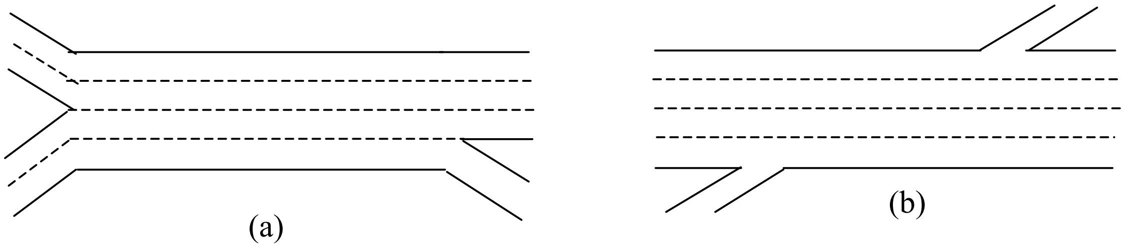


Figure 16: Type C Weaving Sections (Source HCM)

A two-sided weaving area, which is formed by a right-hand on-ramp followed by a left side off-ramp, is shown in Figure 16(b). A lane change is not required by the through volume of the freeway, functionally a weaving movement. But the other movement, the ramp-to-ramp flow, would require vehicles to change lanes three times. *(HCM 2000)*

The Table 4 shown below identifies the configuration type based on lane changing characteristics

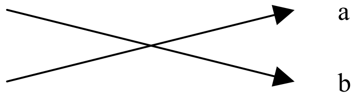
			
MINIMUM NUMBER OF REQ'D LANE CHANGES FOR WEAVING MVT. A	MINIMUM NUMBER OF REQ'D LANE CHANGES FOR WEAVING MVT. b		
	0	1	>1
0	Type B	Type B	Type C
1	Type B	Type A	N/A
>1	Type C	N/A	N/A

Table 4: Configuration Type versus Minimum Number of Required Lane Changes

Weaving Width And Type of Operation

Width of a weaving area is an important geometric characteristic with a significant impact on the weaving area operations, which is measured as the number of lanes in the section. The weaving area operations are affected by the proportional use of the lanes by weaving and non-weaving vehicles more than the number of lanes in the weaving section.

Traffic stream turbulence and a consumption of more of the available roadway space by a weaving vehicle than a non-weaving vehicle is caused by the weaving movements.

Type A configuration is the most impacted by configuration where all weaving vehicles must cross a crown line but it is felt the least in Type B sections. Vehicles in the weaving area will make use of the available lanes in a way such that all component flows achieve approximately the same average running speeds, with weaving flows somewhat slower than non-weaving flows. The ability of weaving vehicles to occupy the proportion of available lanes required to achieve this equivalent or balanced operation is limited by this configuration type. A smaller proportion of the available lanes is occupied by the weaving vehicles than desired and non-weaving vehicles take a larger proportion of lanes than required for a balanced operation. The operation of the weaving area is then classified as constrained by the configuration. The constrained operation results in the non-weaving vehicles operating at significantly higher speeds than weaving vehicles. *(HCM 2000)*

2.8.1 HCM Methodology

The methodology adopted for the analysis of weaving sections as identified by the HCM has four distinct components. It includes equations predicting the average weaving and non weaving speeds, configuration type, type of operation, definition of limiting values of key parameters for each type of configuration and then the definition of level of service criteria. (*Transportation Research Record, Washington D.C., 1997)*

Prediction of Weaving and Non-weaving Speeds

The prediction of weaving and non-weaving speeds is stated in general terms as follows:

$$S_i = S_{\min} + \frac{S_{\max} - S_{\min}}{1 + W}$$

Where

S_i = speed of weaving (i=w) or non-weaving (i=nw) vehicles (mph),

S_{min} = minimum speed expected in the section (mph),

S_{max}= maximum speed expected in the section (mph), and

W = weaving intensity factor.

The minimum speed is generally taken as 15 mph and the maximum speed is taken to be 5 mph more than the average of the free-flow speeds of the freeway segments entering and leaving the section. The new equation would then be represented as

$$S_i = 15 + \frac{S_{FF} - 10}{1 + W}$$ Where,

S_{FF} = average free flow speed of the freeway segments entering and leaving the weaving area

The weaving intensity factor *W*, a measure of weaving activity and its intensity is computed as shown below

$$W = \frac{a(1 + VR)^b (v / N)^c}{L^d}$$ Where,

VR = volume ration v_w/v;

v = total flow rate in weaving area (equivalent pcph);

v_w = weaving flow rate in weaving area (equivalent pcph);

N = number of lanes in the weaving area; and L = length of the weaving area.

Table 5 shows constants a, b, c and d and these constants primarily determined depending on whether the weaving speed S_w or the non-weaving speed S_{nw} is being predicted, or whether the configuration type of the weaving area is A, B or C and whether the type of operation is constrained or unconstrained.

GENERAL FORM

$$W = \frac{a(1 + VR)^b (v / N)^c}{L^d}$$

TYPE OF CONFIGURATION	CONSTANTS FOR WEAVING SPEED, S_w				CONSTANTS FOR NONWEAVING SPEED, S_{nw}			
	A	B	C	d	a	b	c	d
TYPE A								
Unconstrained	0.226	2.2	1.00	0.90	0.020	4.0	1.30	1.00
Constrained	0.280	2.2	1.00	0.90	0.020	4.0	0.88	0.60
TYPE B								
Unconstrained	0.100	1.2	0.77	0.50	0.020	2.0	1.42	0.95
Constrained	0.160	1.2	0.77	0.50	0.015	2.0	1.30	0.90

TYPE C								
Unconstrained	0.100	1.8	0.80	0.50	0.015	1.8	1.10	0.50
Constrained	0.100	2.0	0.85	0.50	0.013	1.6	1.00	0.50

Table 5: Type of Configuration vs Constant Values

Determination of Type of Operation

The type of operation for a weaving section whether constrained or unconstrained is based on the number of lanes that must be used by weaving vehicles in order to achieve balanced or unconstrained operation and the maximum number of lanes that may be used by weaving vehicles for a given configuration. If $N_w \leq N_w(max)$ the type of operation is considered as unconstrained as weaving vehicles have no impediments to using the required number of lanes. The operation is constrained when $N_w > N_w(max)$ as the weaving vehicles are constrained by the configuration to a smaller number of lanes that are required for balanced operation. The average speeds of the non-weaving vehicles are higher than the average speeds of the weaving vehicles in the constrained operations.

Table 6 gives the equations from which the values N_w and $N_w(max)$ are computed each varying with the type of configuration. From the data and equations shown in Table 4 the Type A sections seem to be most restrictive in terms of the maximum number of lanes that can be used by weaving vehicles. In the usage of the available lanes Type B and Type C sections do not generally restrict weaving vehicles. The weaving vehicles in Type A sections require more lanes for balanced operations because for these sections the length increases which is attributed to the substantial segregation of weaving and non-weaving flows in such sections.

TYPE OF CONFIGURATION	NO. OF LANES REQ'D FOR UNCONSTRAINED OPERATION, N_w	MAX. NO. OF WEAVING LANES, N_w *(max)*
Type A	$2.19\ N\ VR^{0.571} L_H^{0.234} / S_w^{0.438}$	1.4
Type B	$N\ [\ 0.085 + 0.703\ VR + (234.8/L) - 0.018\ (S_{nw} - S_w)]$	3.5
Type C	$N\ [\ 0.761 - 0.011 L_H - 0.005\ (S_{nw} - S_w) + 0.047\ VR\ ]$	3.0[a]

[a] For two-sided weaving areas, *all* freeway lanes may be used as weaving lanes.

Table 6: Criteria For Unconstrained versus Constrained Operation Of Weaving Areas

Level of Service Criteria

The Level of Service is related to the average density of all vehicles in the section in the HCM methodology. The average density in the weaving area is computed as the total flow divided by the average (space mean) speed of all vehicles in the weaving section.

The density is found using the equation,

$$D = \frac{v / N}{S}$$

Where, *D= density in passenger cars per mile per lane.*

$$S = \frac{v_w + v_{nw}}{\frac{v_w}{S_w} + \frac{v_{nw}}{S_{nw}}}$$

Where,

S = average (space mean) speed of all vehicles in the weaving section in miles per hour.

The Table 7 as shown below helps to determine the level of service corresponding to the density in the weaving area. The table specifies the LOS for both freeways as well as multilane highways and collector-distributor (C-D) roadways.

LEVEL OF SERVICE	MAXIMUM DENSITY (PC/MI/LN)	
	FREEWAY WEAVING AREA	MULTILANE AND C-D WEAVING AREAS
A	10	12
B	20	24
C	28	32
D	35	36
E	<=43	<=40
F	>43	>40

Table 7: LOS Criteria for Weaving Areas

Procedure For Application

The procedure for the analysis of simple weaving areas is highlighted in this section. First a weaving diagram depicting the weaving and non-weaving flows in a weaving area is constructed. To ensure the proper placement of weaving and non-weaving flows relative to each other, the relative placement of entry and exit points (A, B, C, and D) in the diagram are seen to be matching with the actual site. The following steps are used to accomplish the evaluations of the level of service in an existing or projected weaving area.

Step 1. Establish roadway and traffic conditions

In the first place all the existing roadway and traffic conditions are noted and then collected. The length, number of lanes and the type of configuration for the weaving area under study are studied as a part of the roadway conditions. Traffic conditions include the distribution of vehicle types in the traffic stream as well as peak hour factor. The weaving area is then analyzed on the basis of peak flow rates for a 15-min interval.

Step 2. Convert all traffic volumes to peak flow rates

As the speed and lane use algorithms are based on peak flow rates, all component flows must be converted to flow rate for peak 15 min, by using following equation:

$$v = \frac{V}{PHFxf_{HV}xf_{w}xf_{p}}$$

Where,

v=flow rate for peak 15 min under ideal conditions (pcph);
V=hourly volume under prevailing conditions (veh/hr);
PHF= peak-hour Factor;
f_{HV}*=heavy-vehicle adjustment factor;*
f_p*=driver population adjustment factor.*

Step 3. Construction of Weaving Diagram

It is necessary and helpful to construct a weaving diagram that shows all flows indicated at peak flow rates under ideal conditions in passenger cars per hour.

Step 4. Computation of Unconstrained Weaving and Non-weaving Speeds

In this step it is assumed that the operation is unconstrained. The weaving intensity factor for the appropriate configuration is read from Table 4. The average (space mean) speed is then computed for the weaving and non-weaving vehicles.

Step 5. Check for Constrained operation

Using the speeds computed in the previous step, an estimate of the number of lanes used by weaving vehicles to achieve unconstrained operation is made using the equations specified in the Table 6. This computed value of N_w is then compared with N_w(max) (read from Table 6). If N_w(max) is less than or equal to N_w then the operation is constrained as per definition and hence the assumption that this is an unconstrained operation is accurate. If the condition is not satisfied then the operation is constrained and the values of the weaving and non-weaving speeds are recomputed using the constrained weaving intensity factor for the appropriate configuration.

Step 6. Computation of Average (Space Mean) Speed and Density in Weaving Area

The equation stated earlier in the methodology is used to compute the average (space mean) speed of all vehicles in the weaving section. Then this average speed (space mean) is used in the equation to compute the density of the weaving area.

Step 7. Check for Weaving Area Limitations

As a final check to see if the whole analysis is acceptable the table specifying the limitations on the weaving sections is consulted and is made sure that none of the parameters have exceeded their limits specified by the table.

Step 8. Determination of Level of Service

The estimated value of density, *D*, in the weaving area is compared with the criteria in the Table 7 to determine the prevailing Level of Service.

2.9 Past Research Related to Freeway Weaving Analysis

The methodology adopted in the comparative analysis is to model different kinds of weaving configurations using TRANSIMS, CORSIM, VISSIM and INTEGRATION. To adjust the simulation model, various factors such as capacity of the weaving section, driver characteristics, roadway geometrics, parameters influencing the weaving behavior etc need to be studied. As the scope of the research is to identify various parameters, which affect the result of simulation and methods to improve them, the next few paragraphs talk about some earlier research done on some of the various parameters, which might affect the calibration of the model and their resulting conclusions.

A study on capacity and level of service at ramp freeway junctions by Roger P. Roess and Jose M. Ulerio found that if some parameters such as volume distribution, speed variance can be improved, its use could augment field data and allow more consistent and thorough calibration of regression/simulation models. The importance of the driver population to the freeway traffic operation analysis also should not be neglected. In analyzing freeway capacity, one of the most important factors is speed because service flow rate can be obtained from the value of density multiplied by the value of average speed. Most traditional weaving analysis methods use roadway geometry and traffic volumes as inputs and provide an estimate of speed as an output. The use of speed for assessing the capacity and level of service for weaving has proved to be a poor choice. One reason is that speed is not very sensitive to flow at saturation level. A study conducted by Halati et al has shown that the concept of a stable relationship between speed and flow is fundamentally flawed. As flow nears capacity, it begins a series of fast and unstable jumps from the smooth flow to an unstable one. With this approach, traffic only flows at capacity speed while transitioning from fast sub capacity flow to a slow congested flow. In effect, capacity speed is ephemeral and can be quantified in averages.

Since speed has been identified as one of the important factors that might affect the calibration of the model, the variance of speed in the output results needs to be studied. The next few paragraphs talk about the impact of speed limit on a freeway.

Nicholas J. Garber and Ravi Gadijaru conducted a study on factors affecting speed variance. They found that the difference between the design speed and the posted speed limit had a statistically significant effect on speed variance. Furthermore they found that drivers tend to drive at increasing speeds as the roadway geometrics improved, regardless of the posted speed limits.

Another study was conducted by Adolph D. May., to determine the congestion causes in weaving areas. One of the important observations that came out from this research was that vehicles tend to reduce speed in weaving areas depending upon the merging characteristics of the driver, number of lanes and volume distribution. These observations were made based on several factors such as interrelationships between volume, occupancy and speed, the measurement of the effect of congestion on traffic flow and travel time and a comparison of traffic characteristics just before and after congestion

Essam Radwan and Sylvester A. F. Kalevela conducted an investigation of the effect of change in vehicular characteristics on the highway capacity. The results from analyzing traffic flow models and time headway's showed that despite the change in vehicular characteristics there has not been a discernible corresponding change in highway parameters. This research clearly shows that by altering various vehicular parameters, there has been no influence on highway parameters. (*Ramachandran et al.,*)

Chapter 3: Description of the Ramp-Weave Model

3.1 Introduction

The research uses TRANSIMS, CORSIM, VISSIM and INTEGRATION as the analysis models. A flow chart depicting the methodology adopted for the purpose of this research is shown in Figure 17. The principal aim is to model different types of weaving configurations using various simulation models, TRANSIMS, CORSIM, VISSIM and INTEGRATION and compare the results to HCM.

The various assumptions made in conducting simulations using the models are discussed more at depth in the following sub-sections. Further, the modeling methodology adopted is highlighted. The three different types of configurations along with their geometric characteristics for all the models are also described. For the ease of understanding, tables listing various configuration values used in TRANSIMS, CORSIM, VISSIM and INTEGRATION are shown along with the link node diagrams used in each model.

3.2 Assumptions

To model a similar type of weaving configuration as the one conducted in HCM, the following assumptions are made in TRANSIMS, CORSIM, VISSIM and INTEGRATION.

- All vehicles adhere to the specifications, shape and performance.
- Each vehicle follows a particular behavioral pattern which is quantifiable
- All standard assumptions such as the freeway speed limits and ramp speed limits are used for each type of configuration.
- The models are simulated for 30 minutes. A 30-minute simulation represents a one point of the data sample while HCM method may represent an average value of samples. Hence, more than one simulation run is necessary for a statistically meaningful comparison.

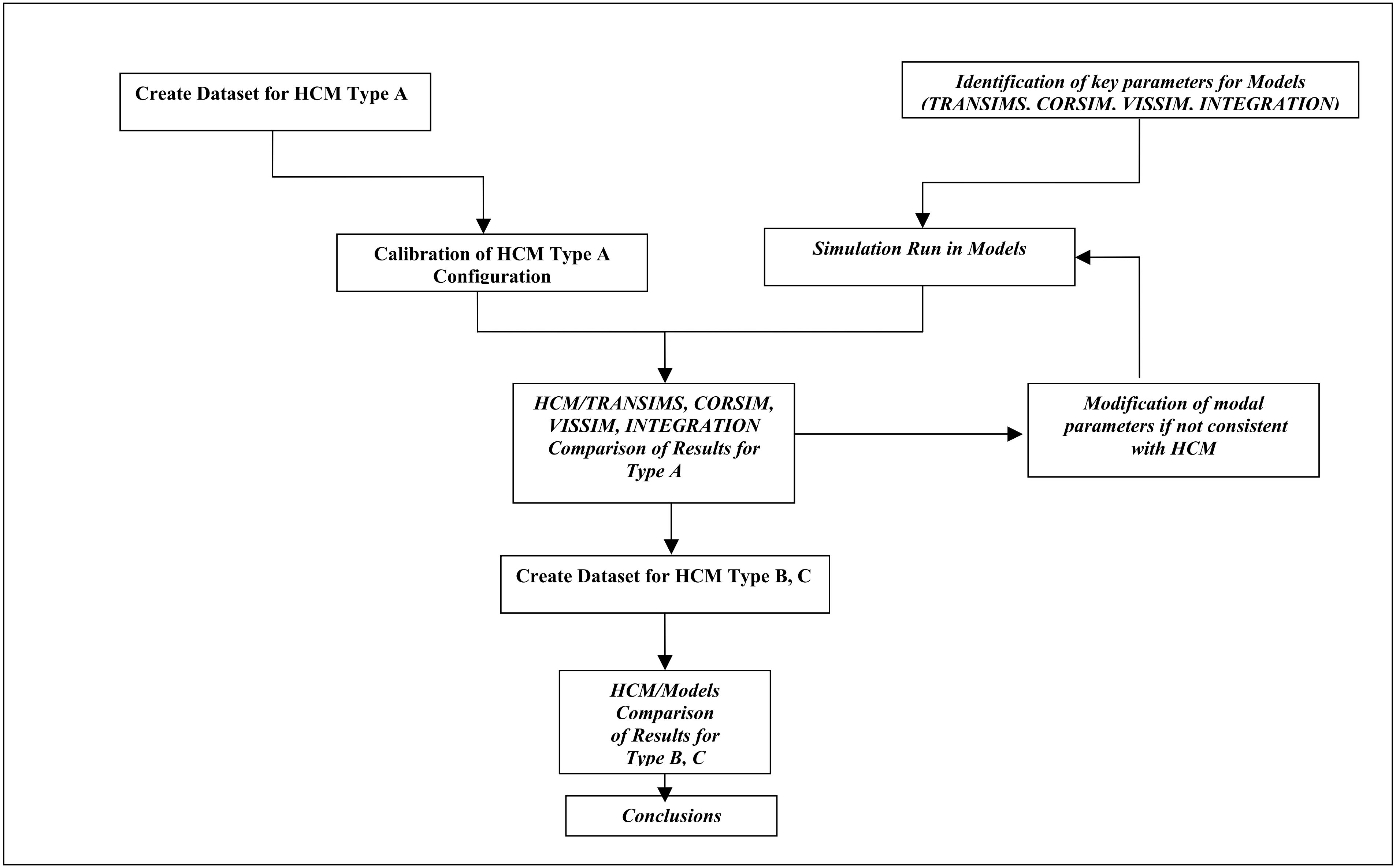


Figure17: Methodology Adopted in the Research

3.3 The Modeling Concepts

3.3.1 HCM

The traditional models like HCM predict volumes immediately upstream of the ramp junction. The prediction is based upon full hour volumes and is calculated in mixed vehicles per hour (vph). Such models, while simple and straightforward in prediction of volumes, are complex, when applied to capacity analysis.

- Traditional HCM models focus on volume as input and evaluate the speed as an output for the entire weaving section.
- The HCM is based upon analysis of flow rates within 30-minutes periods of time. To conform to other methodologies in HCM, 30-minute data periods are used in all the models studied.
- All calibrations are made in passenger car equivalents (pce's).

In the context of the proposed model, several changes have been made to incorporate a similar model existing in HCM as described in the following subsections.

3.3.2 TRANSIMS

Some of the standard assumptions made in TRANSIMS

- The link is divided into 7.5-meter cells.
- The vehicles moving on the links are of the types specified by the vehicle prototype file. They comprise of autos that occupy one cell or trucks that occupy two cells. The file also states their maximum acceleration and speeds possible for each vehicle type.
- HCM predicts the weaving speed and non-weaving speed per vehicle. The result is obtained from the TRANSIMS Microsimulator in the form of the snapshot data. Thus snapshot data is processed to interpret the results.

To develop a scenario similar to Highway Capacity Manual, all of the necessary tables for the network are coded manually. The network is split into a combination of nodes and links, parking being provided at each entry and exit point of the links, from where vehicles are generated and absorbed. The travel plans for all vehicles, both weaving and non-weaving are generated for the necessary volume in the simulation. The lane, which connects the on-ramp and the off-ramp on each lane of the weaving link, is modeled as a full-length auxiliary lane. The rate at which vehicles are generated at the entry links is made to follow a random normal distribution.

3.3.3 CORSIM

To develop a configuration as described in the Highway Capacity Manual, a link node structure is used to code the network. Following this, the notion of origin and destination is used based on the travel route. The entry volumes at freeway origins and exiting fractions at freeway destinations are specified in the input file. Geometrically, the lane connecting both the on ramp and the off ramp gore is modeled as a full-length auxiliary lane. Detectors are placed (near the on ramp, mid weaving section, near the off ramp) on each lane of the weaving link to observe the vehicle behavior (speed, density, and headway) on each lane within the link. Again, the rates at which vehicles are generated at the entry link on the freeway follow a random normal distribution. The input and the output data set for all the different configurations are shown in the Appendix.

3.3.4 VISSIM

VISSIM network editing is completely achieved through the use of its Graphical User Interface, which is available for various versions of Microsoft Windows Operating System. It is interesting to note that VISSIM uses links and connectors. The basic element of a VISSIM traffic/transit network is a link representing a single or multiple lane roadway segments. Connecting multiple links, thus creates a network. The time variable traffic volumes to enter the network are defined as input to the model. These traffic volumes are entered for a specific link and for a certain time period in vehicles/hr even if the corresponding time period is different from an hour. Within this time period, the model simulates vehicles entering the link based on a Poisson distribution.

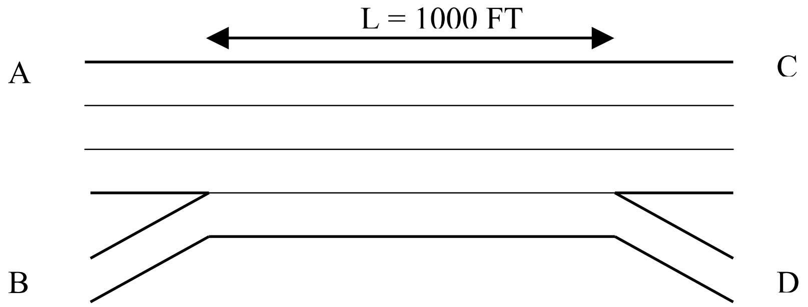
3.3.5 INTEGRATION

The input data files for INTEGRATION are generated/modified using a standard editor, spreadsheet or word processor. The Windows version of INTEGRATION model provides on-screen graphics that continuously reflect the network status. The traffic demand is specified as a time series histogram of O-D departure rates for each possible O-D pair within the entire network. INTEGRATION model executes simulation run based on various traffic network and traffic flow parameters as specified in the Master Control File. The Master Control File provides general simulation parameters to the model and defines which input data files are to be used. The file also contains information as to where these inputs are located, defines which output files are to be produced, and where these output files are to be stored. The model like most of the models discussed defines network as a combination of nodes and links. The inputs and the outputs for all the configurations are listed in the Appendix.

3.3 Description of Configurations

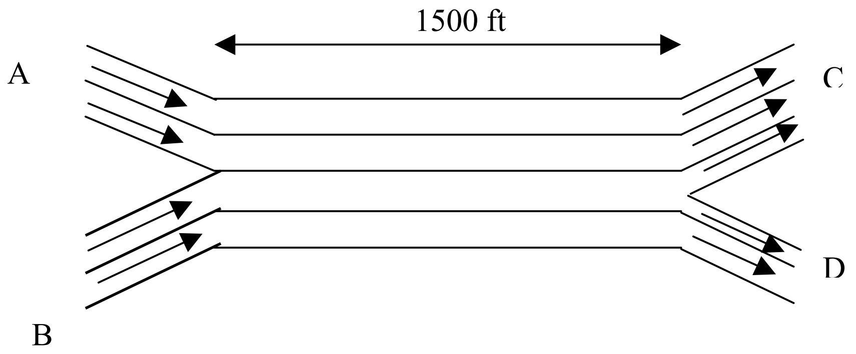
As stated earlier the configurations used for analysis are adopted from Highway Capacity Manual, which were arrived at by doing a lot of field observations and hence are used for analysis here. The geometric characteristics of the sections show that the lane widths are 12 ft and the sections are located in a level terrain. There are no lateral obstructions. For conveniences, all traffic flow conditions are given in terms of peak flow rates for ideal conditions, expressed in passenger cars per hour. The ramp weave sections for all the configuration types A, B and C considered for study here, are shown in Figures 18, 21 and 24 respectively.

To test the performance of the models when the total flows reached saturation, the volumes in the weaving sections are increased and thus the behavior is tested for five different types of volumes for each configuration type. The configurations are modeled in TRANSIMS, CORSIM and INTEGRATION as a series of links and nodes, and in VISSIM as links and connectors. Figure 19 and Figure 20 show the exact configuration of the network coded in the models for the Type A configuration. Type B and Type C configurations also follow the same node link structure as shown in Figures 22, 23, 25 and 26. The reason for representing the network such a way is to allow for the vehicles to come to equilibrium with each other so as to behave as freeway traffic.



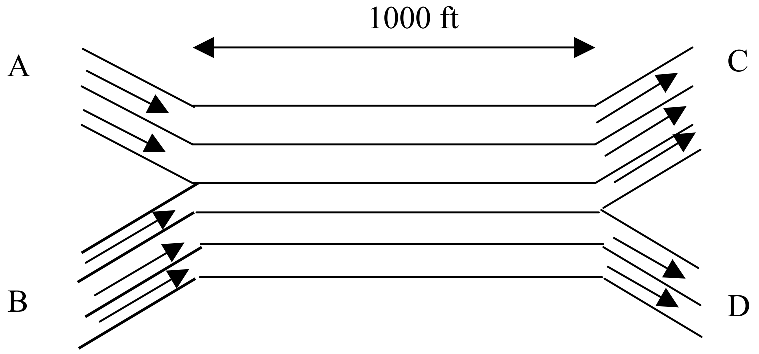
Traffic Characteristics for Type A	Volume 1	Volume 2	Volume 3	Volume 4	Volume 5
• Main Line Volume (AC)	4000	5000	6000	6000	4500
• On Ramp Volume (BC)	600	800	1000	1200	1800
• Off Ramp Volume (AD)	300	450	600	800	1200
• Ramp-Ramp Volume (BD)	100	100	100	300	300
Type of operation	Unconstrained	Unconstrained	Unconstrained	Unconstrained	Constrained
Total Flow	5000	6350	7700	8300	7800
% of Weaving Vehicles	18	19.7	20.8	24.1	38.5

Figure 18: Analysis of Ramp-Weave section



Traffic Characteristics for Type B	Volume 1	Volume 2	Volume 3	Volume 4	Volume 5
• Main Line Volume (AC)	2095	2300	2500	3000	1000
• On Ramp Volume (BC)	1197	1500	1700	2000	2500
• Off Ramp Volume (AD)	799	1100	1200	1500	2800
• Ramp-Ramp Volume (BD)	1497	1700	1800	2000	1000
Type of operation	Unconstrained	Unconstrained	Unconstrained	Unconstrained	Constrained
Total Flow	5588	6600	7200	8500	7300
% of Weaving Vehicles	35.7	39.4	40.3	41.2	72.6

Figure 19: Analysis of major weaving segment



Traffic Characteristics for Type B	Volume 1	Volume 2	Volume 3	Volume 4	Volume 5
• Main Line Volume (AC)	2000	3500	4000	1200	1600
• On Ramp Volume (BC)	1500	300	350	900	1300
• Off Ramp Volume (AD)	1450	200	300	850	1250
• Ramp-Ramp Volume (BD)	2000	3500	4000	1200	1600
Type of operation	Unconstrained	Unconstrained	Constrained	Constrained	Constrained
Total Flow	7500	8650	4150	5750	6950
% of Weaving Vehicles	6.7	7.5	42.2	44.3	42.4

Figure 20: Analysis of Alternative Major Weaving Segments

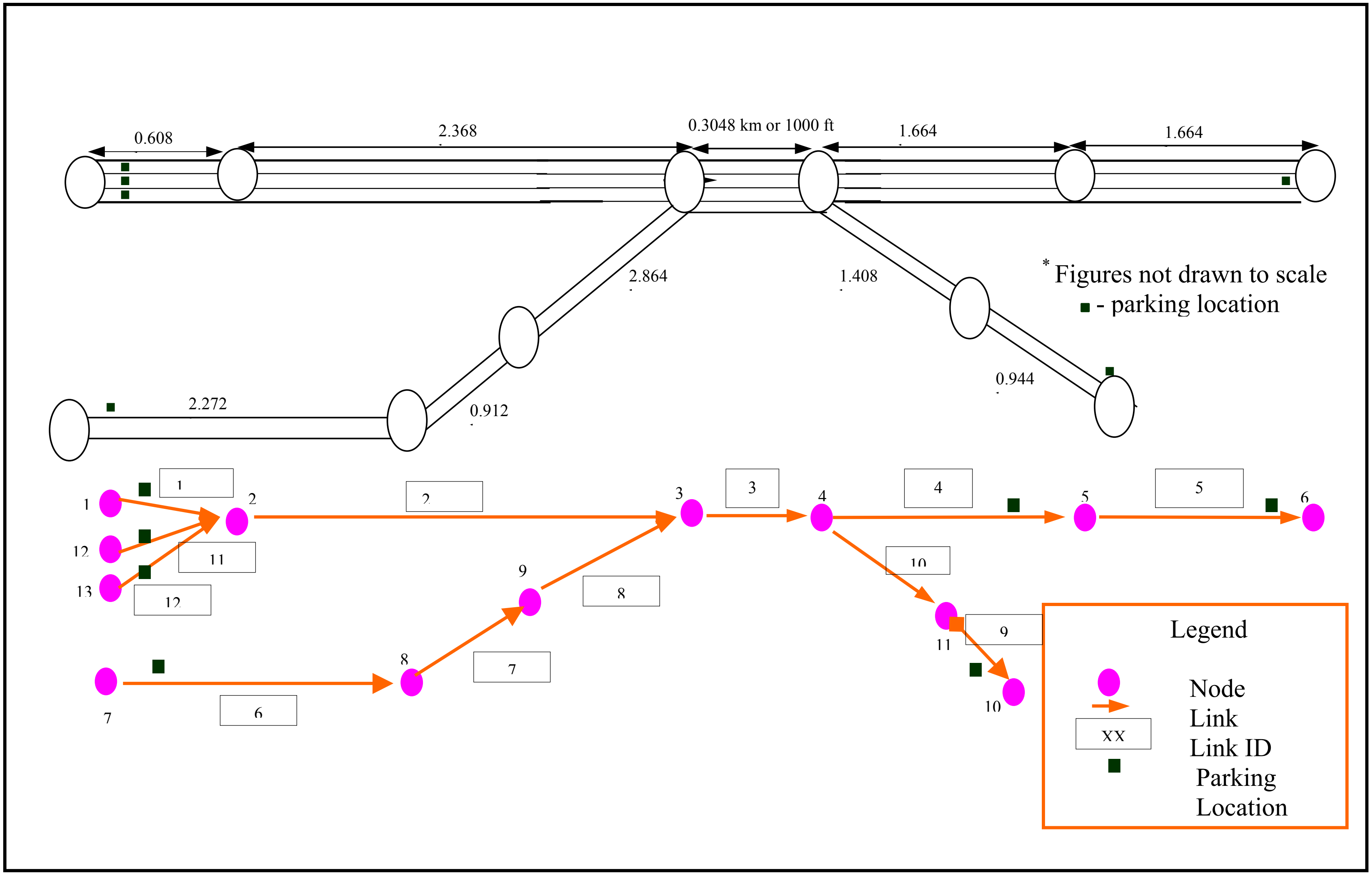
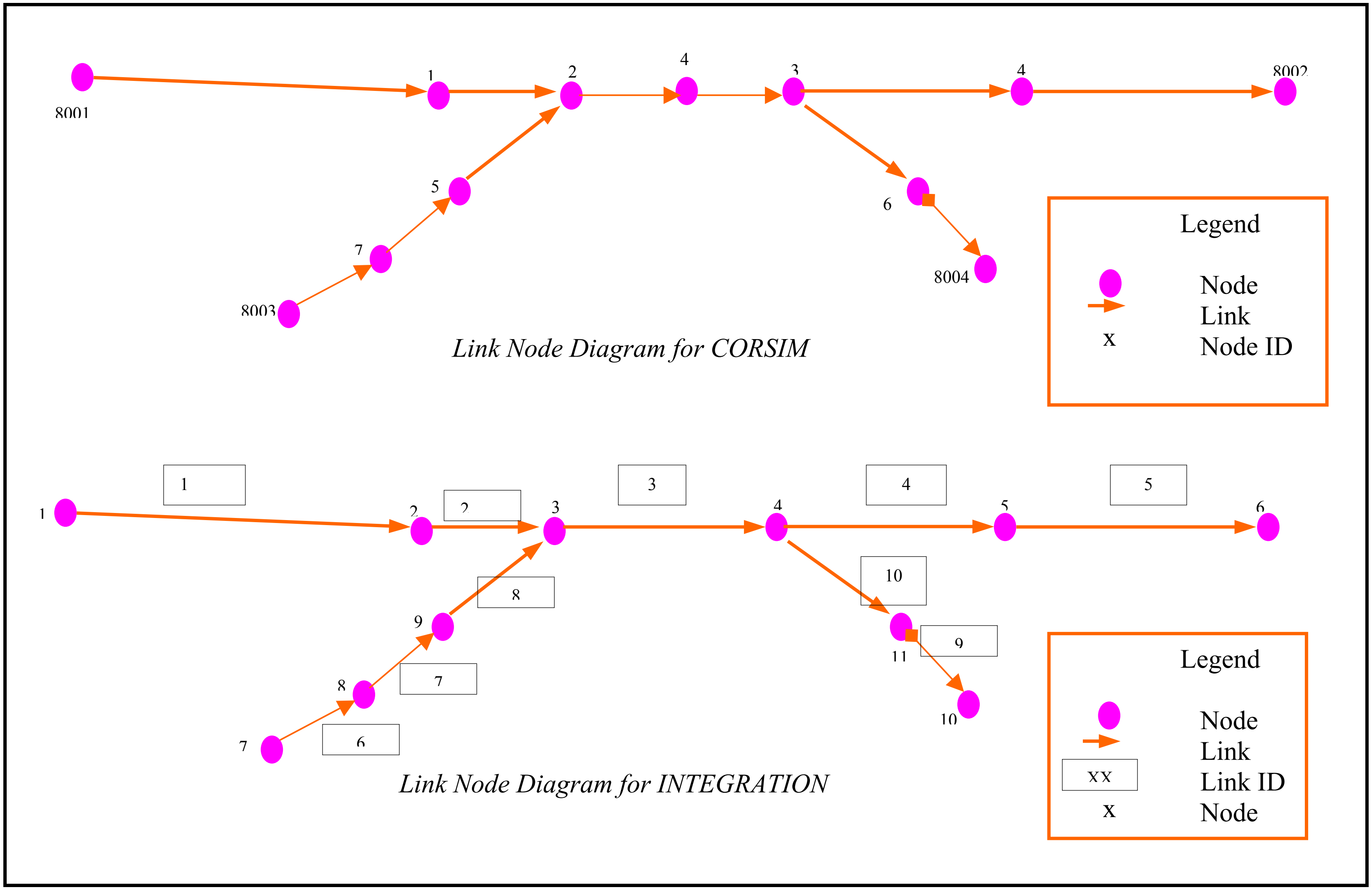


Figure 21: Node Representation of Type A for TRANSIMS



Link Node Diagram for CORSIM

Link Node Diagram for INTEGRATION

Figure 22: Node Representation of Type A for CORSIM and INTEGRATION

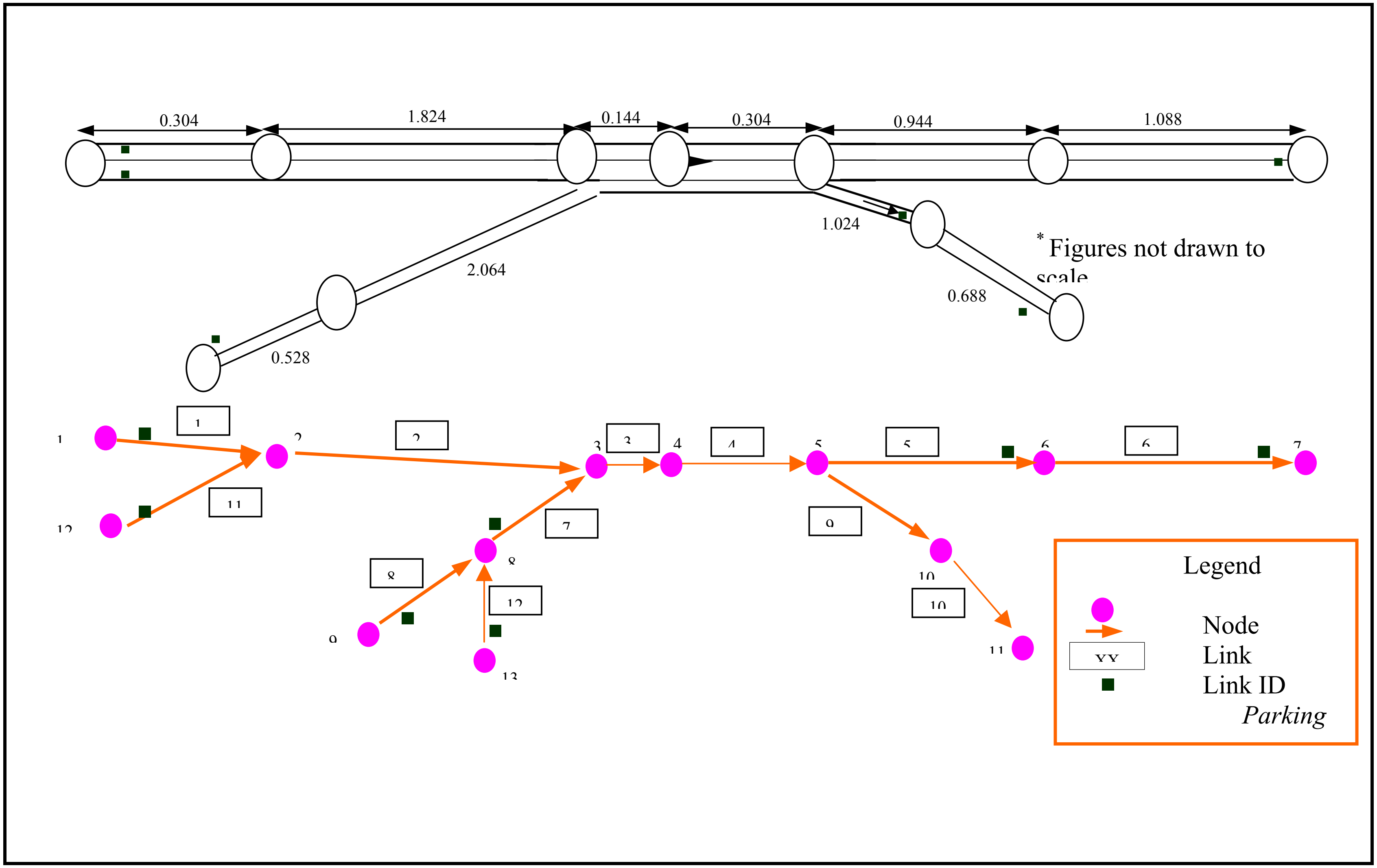
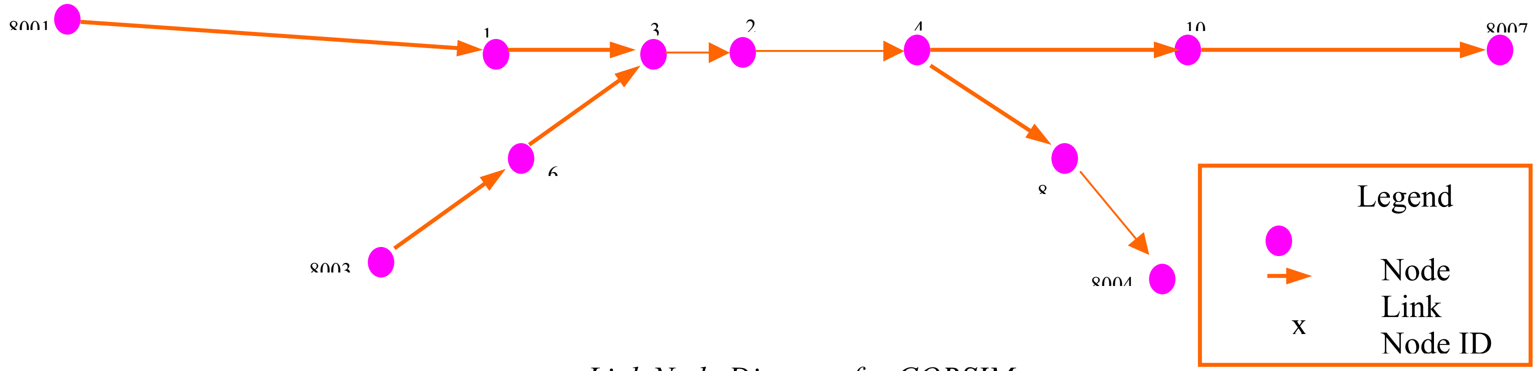
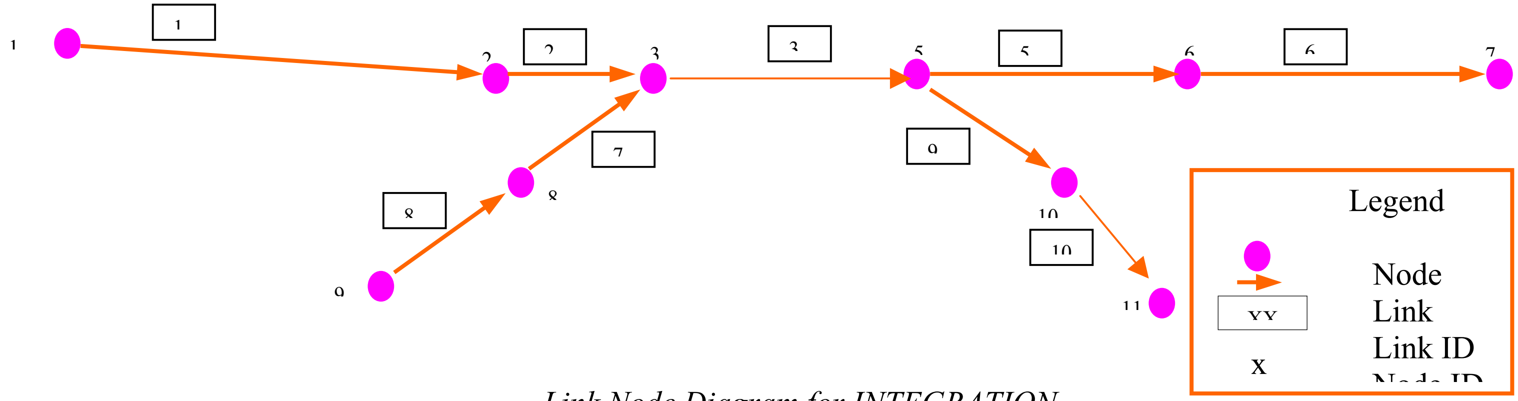


Figure 23: Node Representation of Type B for TRANSIMS



Link Node Diagram for CORSIM



Link Node Diagram for INTEGRATION

Figure 24: Node Representation of Type B for CORSIM and INTEGRATION

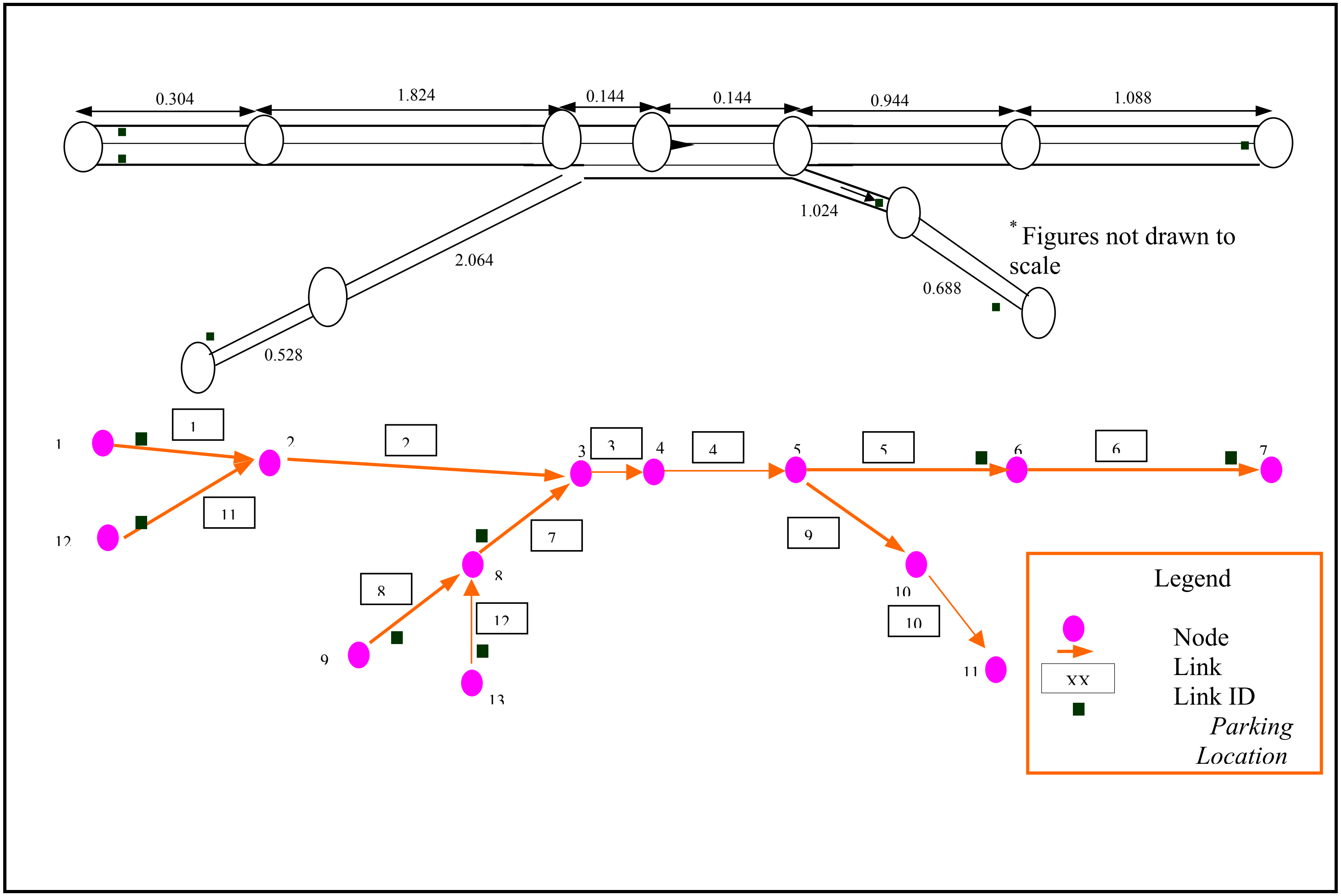


Figure 25: Node Representation of Type C for TRANSIMS

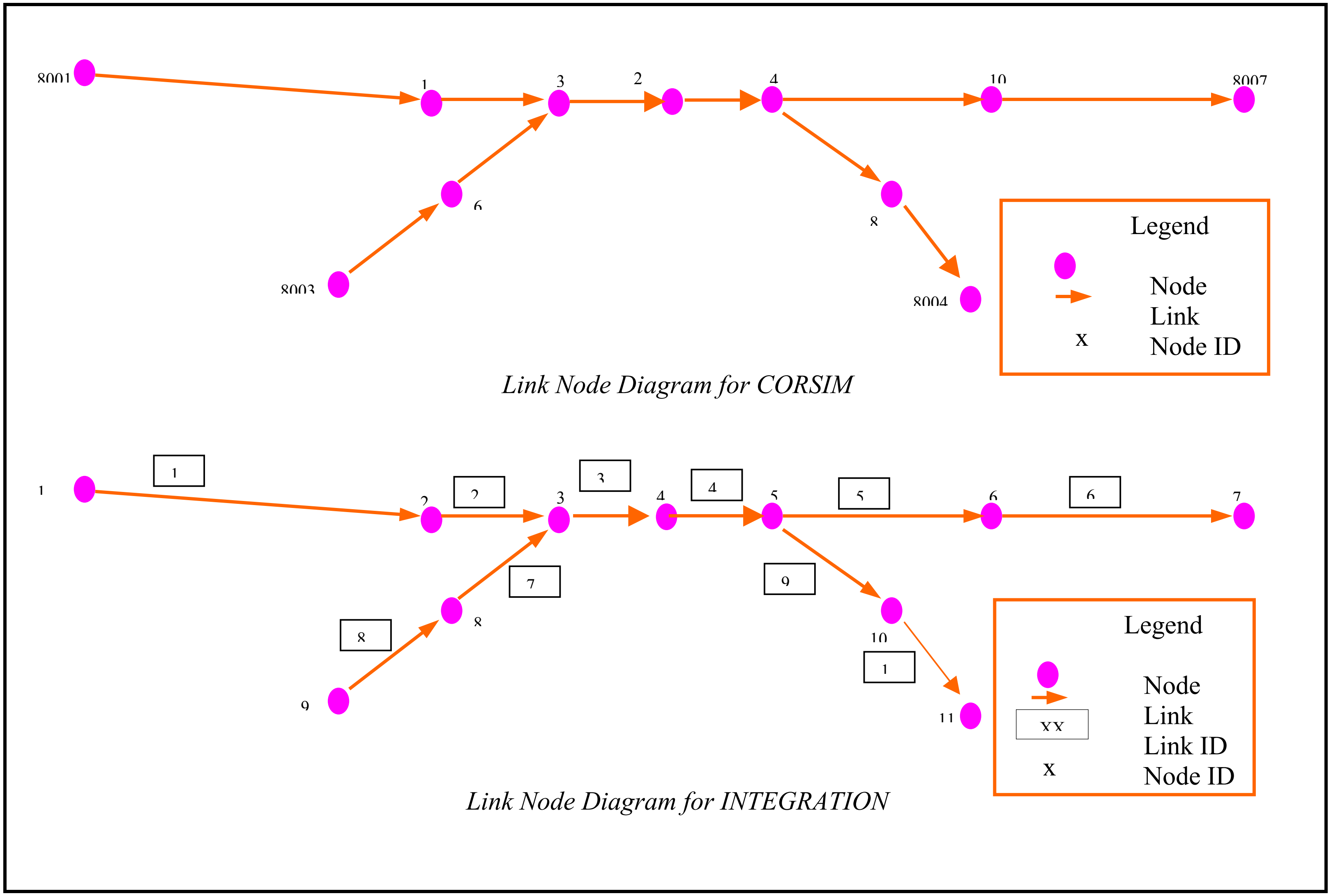


Figure 26: Node Representation of Type C for CORSIM and INTEGRATION

Chapter 4: Comparing HCM, TRANSIMS, CORSIM, VISSIM and INTEGRATION Results

A basis for the comparison of results between HCM, TRANSIMS, CORSIM, VISSIM and INTEGRATION is needed, and hence a common data set is created for all the models. Taking HCM as the base model and assuming similar traffic and geometric conditions for all the models, sensitivity analysis is conducted for Type A configuration of the weaving section. This is done to assess the applicability of all the models to the model in HCM and then the same values are used for the other two types of configurations. Although it is not recommended to use the HCM results as baseline, this is done only for the model validation of this experimental study, as there is no field data available to calibrate the model. The results obtained for all the models are then compared to the base model.

4.1 Calibration Parameters for the Models

The following sections identify the key parameters or configuration keys for the models. A series of test simulations are conducted changing each of the parameters identified, then studying the results and interpreting how they affect the model. The Type A configuration of the ramp-weave section is used for model calibration and sensitivity analysis. After these runs, the model with calibrated parameters that best describes the scenario is chosen and the other types of configurations simulated. For every case three simulation runs are considered so as to average out the error or bring them closer to the true expected values. The statistics collected over these tests include the average speeds of weaving and non-weaving vehicles and the average densities given by each of these configurations.

4.1.1 TRANSIMS

The parameters influencing the behavior of vehicles in the freeway weaving sections in TRANSIMS are identified as deceleration probability, lane change probability and planning ahead for a lane change which are discussed in detail in the following subsections.

Deceleration Probability

The configuration key CA_DECELERATION_PROBABILITY defines the probability of a driver to decelerate for no reason. This enhances the traffic variation as each automobile driver randomly decides whether to decelerate for no apparent reason at each timestep. This configuration key is defined by the user and it assumes a value between 0.0 and 1.0. If the configuration key is set to 0, it would mean that a driver would never decelerate without a reason. The only time he/she would decelerate would be when the gap ahead of him/her is less than the velocity at which he/she is driving. If this key is set to 1 it would imply that a driver would always decelerate at every timestep where the gap ahead of him/her is more than the velocity.

This configuration key is important as it replicates human behavior for not accelerating all the time. As stated earlier for a model to depict reality, it is very important to capture such kind of data and calibrate the model. For the sake of this study, since no real world data on weaving sections was present the model was calibrated to that of a default value of 0.2. This implies that one-fifth of the time a driver would decelerate for no apparent reason. This value is also justified as the default value was arrived at in TRANSIMS based on several studies conducted by the research team headed by Kai Nagel. *(Jillella et al., 2001)*

Lane Change Probability

The configuration key that controls a lane-changing maneuver is the CA_LANE_CHANGE_PROBABILTIY. Should all the conditions be satisfied for a driver to lane change into the adjacent lane, this configuration key specifies the probability of the driver to lane change i.e., should a slower vehicle be ahead of a vehicle whose gap ahead is less than the velocity at which it is traveling and the gap ahead in the adjacent lane is more than in the current lane while the gap behind in the new lane is more than the $V_{GlobalMax}$, then all the conditions are satisfied for a lane change. It should also be noted that right and left lane changes occur on alternate timesteps. Having all the condition satisfied for a lane change a driver would still only lane change with a probability given by this configuration key. This configuration key is quite crucial for the simulation to perform close to reality. An example to emphasize the importance of this key would be to consider a two-lane roadway with all the vehicles in one lane next to each other. This would mean that every vehicle would have its conditions for lane change based on gaps fulfilled. So in the next time step each of the vehicles would move into the adjacent lane. This continues at every timestep and would result in very unrealistic scenario. Introducing this configuration key helps stabilize this maneuver.

As the configuration key suggests, it represents the probability of lane change and so the permissible values lie between 0 and 1. A default value of 0.99 was arrived at after a lot of experimental studies at the Los Alamos National Laboratories and is used in this research too.

Planning ahead for a lane change

For this study it is important that drivers plan ahead for a lane change as the drivers are constrained by time and distance to get into the right lanes. The configurations keys discussed in this subsection could be thought of as off-ramp information signs for drivers that have to go off-ramp.

TRANSIMS Microsimulator uses two configuration keys for modeling this behavior. The first of which is the CA_PLAN_FOLLOWING_CELLS. This configuration key specifies the number of cells preceding the intersection within which a vehicle will make a lane change to get into the appropriate lane and thus transition into the next link in its plan. Beyond this distance any lane changes are based only on vehicle speed and gaps in the traffic. Within this distance, the lane required by vehicle’s plan is also taken into account. As the vehicle nears the intersection, the bias to be in the lane required to stay on plan is increased. The valid values for this configuration key are positive values or zero.

The second configuration key that helps in planning ahead for a lane change is the CA_LOOK_AHEAD_CELLS. To understand the significance of this configuration key it should be noted that the preferred lane for a vehicle to be in as it approaches an intersection depends on the connectivity from the current link to the next link in the plan. In certain cases it would be advantageous for the driver to look beyond the next link to the subsequent links in the plan when deciding the preferred lane. This configuration key controls how far ahead the driver will look beyond the next link. A positive value set for the configuration key indicates that the driver would look at least one additional step beyond the next step in the plan. The number of additional links considered is determined by the lengths of the subsequent links.

These configuration keys again have to be calibrated for the study. Since the study area configuration of the network is known, sensitivity analysis on these configuration keys is performed. *(Jillella et al., 2001)*

4.1.2 CORSIM

The parameters considered to influence the lane changing behavior, thus affecting the weaving maneuvers of the vehicles in the weaving sections in CORSIM, are off-ramp warning sign distance, driver characteristics like time required to maneuver to correct lane, and percentage of drivers yielding to lane change.

Off-ramp warning sign distance

The off - ramp warning sign distance is defined as the distance from the point where the warning sign is positioned in relation to the downstream end of the link, at which drivers begin to react to the off – ramp exiting from the link. Hence this parameter details how far of the upstream from the downstream end of the link the vehicles are destined to exit at the off-ramp, begin to react to the exit's presence. The vehicle will start to enter the lane when it is at this distance. The default value used in CORSIM is 2500 ft. This value is specified in Record Type 20.

As the warning sign distance increases, the average speed of the weaving vehicles decreases. This is because, as the warning sign distance increases, the vehicles can take more time do perform a lane change. Thus the possibility of the vehicles doing a lane changing maneuvers much earlier before reaching the ramp increases. This contributes to the fact that as the warning sign distance increases the speed reduces.

Maneuver time

Maneuver time is defined as the time taken by a vehicle to do a lane change maneuver. The vehicles operate in an unsafe mode during the process of lane changing. The default value used in CORSIM is 3 sec. This value is specified in record type 70.

As the maneuver time decreases, the time required to change lanes decreases. A vehicle would consider performing a lane change only when the gap in the adjacent lane into which the vehicle is trying to enter is acceptable, that is, if the gap is greater than the critical gap. The probability of gap acceptance increases as the time required to lane change decreases. More number of vehicles will be able to merge on to a freeway from on ramp with the reduction in time for a lane change maneuver thus increasing the freeway throughput.

Percentage of drivers yielding to lane change

The percentage of drivers yielding to the lane change represents the number of drivers yielding their right of way to the vehicles entering the freeway. This parameter ensures that the cooperative vehicles move to the left most lanes allowing the traffic coming from the ramps to merge. The default value used in CORSIM is 20%. The value is specified in Record Type 70.

As the percentage of vehicles yielding to lane change increases the speed of vehicles entering the weaving section increases. An increase in the value of the percentage results in a lot of lane changing movements as the percentage of cooperative drivers increases.

4.1.3 VISSIM

The parameters influencing the weaving behavior of vehicles in weaving sections in VISSIM include link connection and time steps per simulation second.

Link Connection

This parameter defines the distance at which vehicles will begin to attempt to change lanes in order to exit a ramp. The default value used in VISSIM is 200 m. A value of 1000 m is used in all the simulation runs after having consulted with the VISSIM software development research group at itc-world who arrived at this figure after a lot of field observations.

Time steps per simulation second

The parameter indicates the number of times the position of the vehicle will be calculated within one simulated second (it follows a range of 1 to 10). An input of 1 will result in the movement of vehicles once a simulated second. An input of 10 will result in the movement of the vehicles to be more smooth as all vehicle movements will be calculated 10 times per simulation second. It has been found out that the change of simulation speed is inversely proportional to the time steps. A default value of 1 is used in VISSIM but for the present study a value of 10 is considered as per the recommendation of the VISSIM software development group.

4.1.4 INTEGRATION

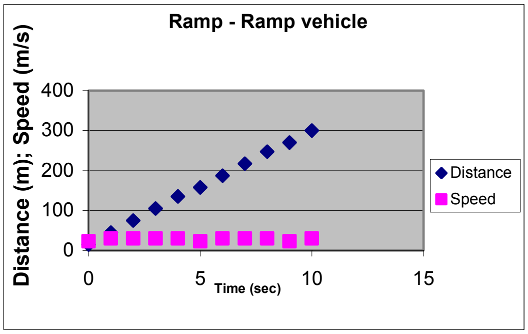
Lane Bias File

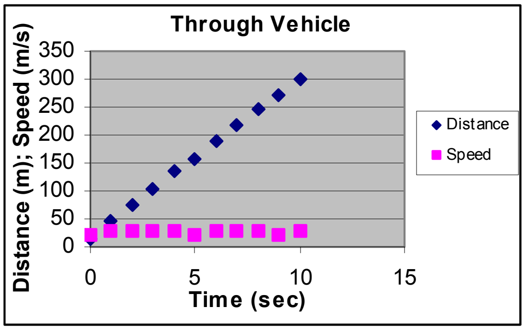
A lane bias file is an optional file that biases vehicles to change lanes within a specified distance of a downstream link. The optional input file is named as ‘lanebias.dat’. The parameters included in the file will override the lane bias internal to the model. The file is important as it replicates the usage of a particular lane, thus governing the behavior of the movement of the vehicles. As stated earlier for a model to depict reality, it is very important to capture such kind of data. For the sake of this study, since no real world data on weaving sections is present this optional file is not specified. The lane bias internal to the model is used for simulation runs.

Time-Space diagrams for a typical vehicle for TRANSIMS, CORSIM, VISSIM and INTEGRATION

A better understanding of the particle hopping theory, car following theory as well as the actual movements of the vehicles could be understood with time-space figures. The time-space diagrams for the Type A configuration is presented below for all the models and since the distance of vehicle movements is closely related to the velocity, a plot of the velocity on the same figure is shown. The data for the figures plotted is attached in the Appendix.

The figures shown below depict a single vehicles path as it traverses the weaving section for through, offramp, onramp and ramp-ramp vehicles. The x-axis on these graphs represents the time. It is assumed that the time at which the vehicle enters the weaving section is 0 and the trajectory is presented till the time it moves off the weaving section. The data is shown in points in accordance with the car following theory.





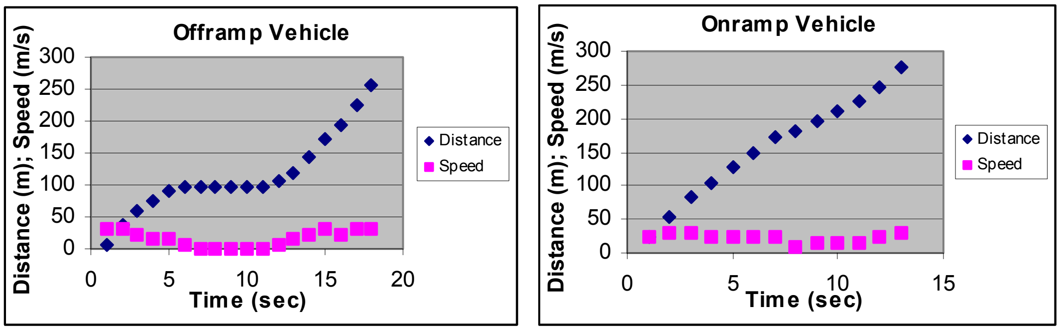


Figure 27: Time-Space Diagrams for a typical vehicle in TRANSIMS

It can be observed that the velocity is always in discrete steps of 7.5 m/s. A close examination of these plots suggest that the velocities of the vehicles generally tend to get lower as they reach a point when lane change decisions are affected by plan following.

Although looking at a single vehicle one cannot make a conclusion, the statement about the velocity dip was arrived at after careful observation of the vehicles in the simulation. Another point that becomes very evident about the Microsimulator theory is about the coarseness of the simulation. Though TRANSIMS is a microscopic simulation, it is also coarse owing to the trade off between it and resolution.

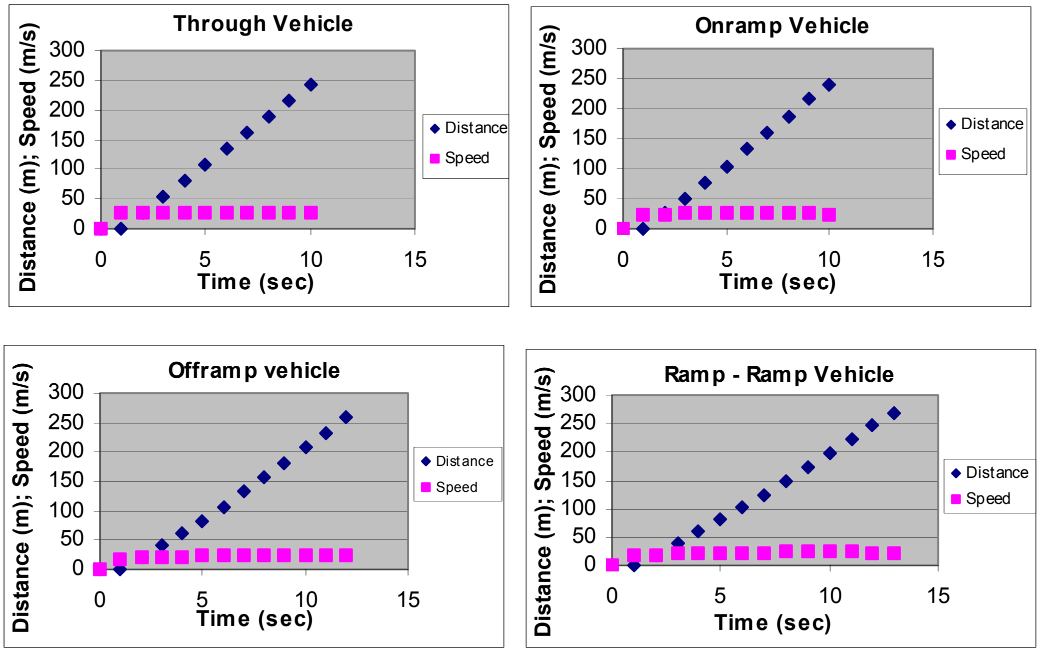


Figure 28: Time-Space Diagrams for a typical vehicle in CORSIM

The time space plots for a single vehicle in CORSIM show that the speeds of the vehicles are almost constant during their travel in the weaving section. It does not demonstrate any queue built up in the section thus representing a smooth flow of traffic. Although the behavior of a single vehicle is not representative of the performance of the considered volume of vehicles being simulated, it was noticed from the simulation that there was no erratic behavior of the vehicles traveling on these sections.

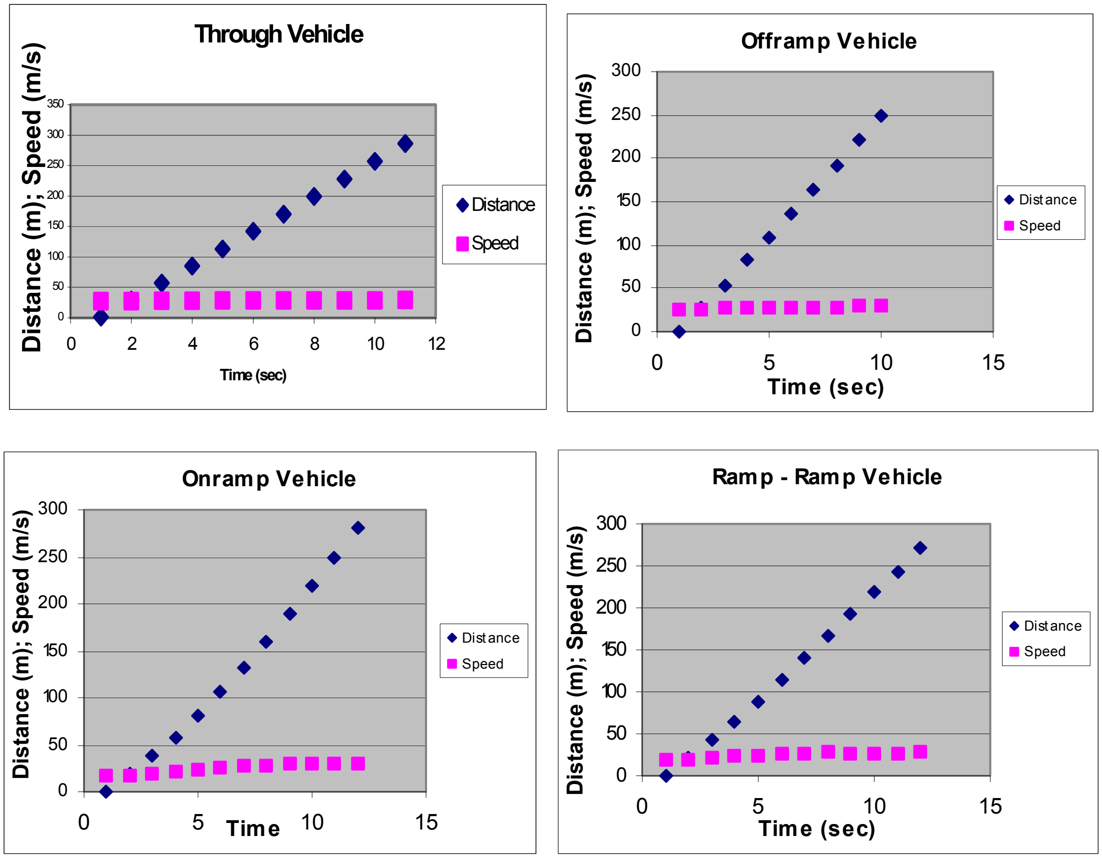


Figure 29: Time-Space Diagrams for a typical vehicle in VISSIM

The time space plots for a single vehicle in VISSIM show that the speeds of the vehicles are increasing and decreasing with a very slight variation which is very much representative of the real world scenario considering the lane changing maneuvers and anticipatory lane changes and weaving movements.

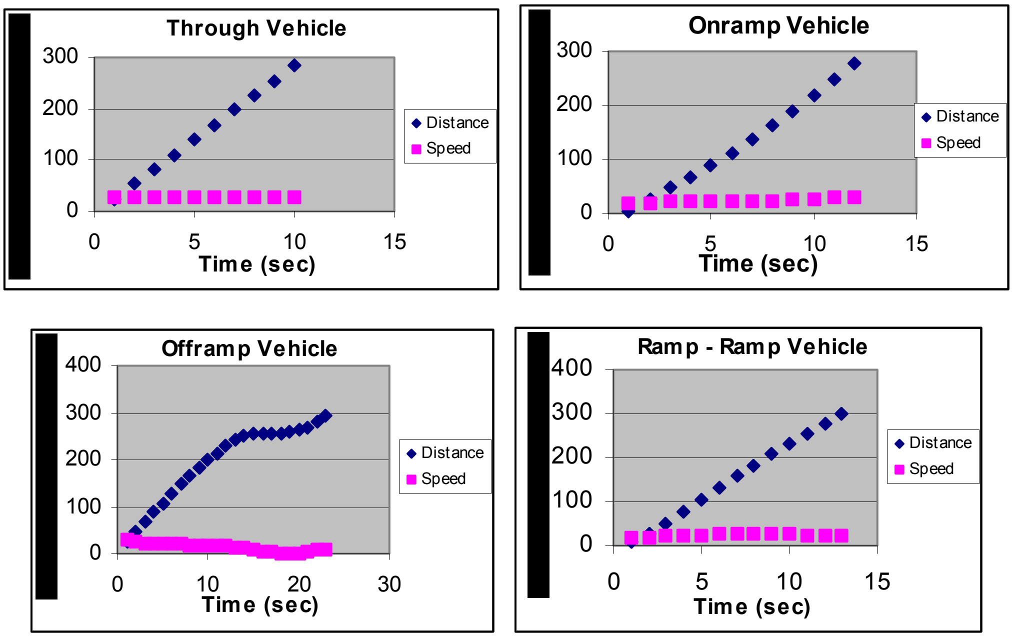


Figure 30: Time-Space Diagrams for a typical vehicle in INTEGRATION

The time space plots for a single vehicle in INTEGRATION show that the speeds of the vehicles are almost constant during their travel in the weaving section except that for vehicles going off ramp where there is a much variation in the speeds of the vehicle as it traverses the section. The behavior shows queue formation.

4.2 Calibration Tests and Sensitivity Analysis

Two key areas for comparison of the models are the weaving, non-weaving speeds and the average density of the section. For the calibration tests performed for Type A configuration, the speeds of each movement are aggregated. Further since HCM does not predict the velocities based on the individual movement type, statistics of speeds for weaving and non-weaving vehicles is collected.

TRANSIMS

The key configuration parameters altered other than the RANDOM_SEED_n that only have an affect on the internal random number generation in TRANSIMS include, the CA_PLAN_FOLLOWING_CELLS and CA_LOOK_AHEAD_CELLS. A series of test simulations are conducted changing each of the two parameters and studying the results and interpreting how they affect the model. Briefly the statistics collected over these tests include the average velocities of weaving and non-weaving vehicles and the average densities given by each of the configurations.

The first test included using a CA_PLAN_FOLLOWING_CELLS of 70 cells i.e., 70x7.5 mts or 525 mts or 1725 ft. The CA_LOOK_AHEAD_CELLS was set to 0 implying that the preferred lane is determined only with respect to the set of acceptable lanes for transition into the next link.

The second test included keeping the CA_PLAN_FOLLOWING_CELLS at 70 cells i.e., 70x7.5 mts or 525 mts or 1725 ft. The CA_LOOK_AHEAD_CELLS was set to 40 cells implying that the preferred lane is determined considering a look ahead distance of 40x7.5 mts or 300 mts.

The third test included keeping the CA_PLAN_FOLLOWING_CELLS at 100 cells i.e., 100x7.5 mts or 750 mts or 2460 ft while the CA_LOOK_AHEAD_CELLS was set to 40 cells.

The fourth test included keeping the CA_PLAN_FOLLOWING_CELLS at 30 cells i.e., 30x7.5 mts or 225 mts or 740 ft. The CA_LOOK_AHEAD_CELLS was set to 40 implying that the preferred lane is determined only with respect to the set of acceptable lanes for transition into the next link.

The fifth calibration test used a value of 50 cells for CA_PLAN_FOLLOWING_CELLS. The CA_LOOK_AHEAD_CELLS was set to 40 implying that the preferred lane is determined only with respect to the set of acceptable lanes for transition into the next link. The tests are shown in Table 8.

	CA_LOOK_AHEAD_CELLS	CA_PLAN_FOLLOWING_CELLS	
Test 1	0	70 cells = 70x7.5 mts or 525 mts or 1725 ft	0_70
Test 2	40 cells Look ahead distance = 40x7.5 mts or 300 mts	70 cells = 70x7.5 mts or 525 mts or 1725 ft	40_70
Test 3	40 cells	100 cells = 100x7.5 mts or 750 mts or 2460 ft	40_100
Test 4	40 cells	30 cells = 30x7.5 mts or 225 mts or 740 ft	40_30
Test 5	40 cells	50 cells = 50x7.5 mts = 375 mts or 1238 ft	40_50

Table 8: Sensitivity analysis using configuration keys

Having described the tests performed on Type A configuration the results are presented in the later sections but grouped in a way so as to allow for comparison. Figure 31 shows the results of the sensitivity analysis. It gives the average velocities for ramp to ramp, through, off ramp and on ramp vehicles for the different test cases as discussed above.

	40_100	**40_70**	**40_30**	**0_70**
Ramp-Ramp	24.76	25.59	26.38	24.26
Thru	26.21	26.34	26.95	23.47
Off Ramp	21.52	22.34	24.75	17.45
On Ramp	19.16	19.62	20.92	17.51

Table 9: Comparison of Velocities by Movement Type for different Test Cases in TRANSIMS

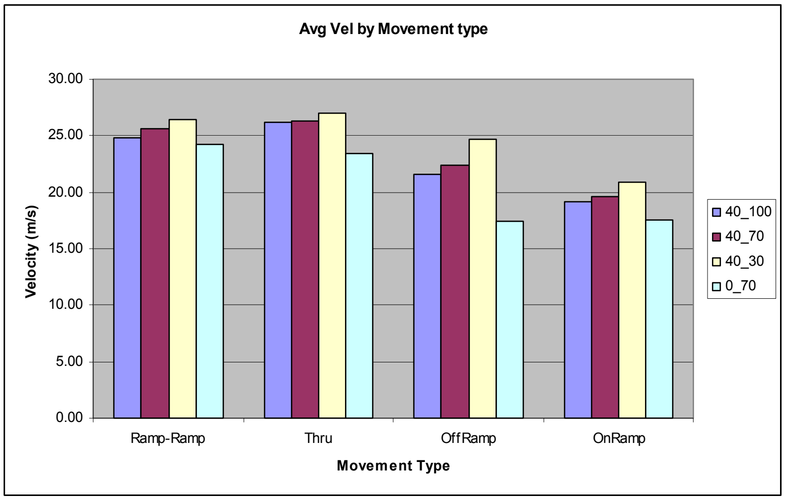


Figure 31: Comparison of Velocities by Movement Type for different Test Cases in TRANSIMS

Although HCM does not predict the individual movements, average velocities over the weaving section is presented here to better understand the simulation model. It can be seen from the above graph that the velocities of all the movements for the test case 0_70 are the lowest and the velocities increase if the plan following cells are increased keeping the look ahead distance the same.

Test	Non-Weaving Velocity	Weaving Velocity
0_70	48.72	37.06
40_30	59.22	47.89
40_50	58.17	45.57
40_70	57.50	44.31
40_100	56.89	42.48
HCM	53.96	45.37

Table 10: Comparison of Velocities for different Test Cases in TRANSIMS and HCM

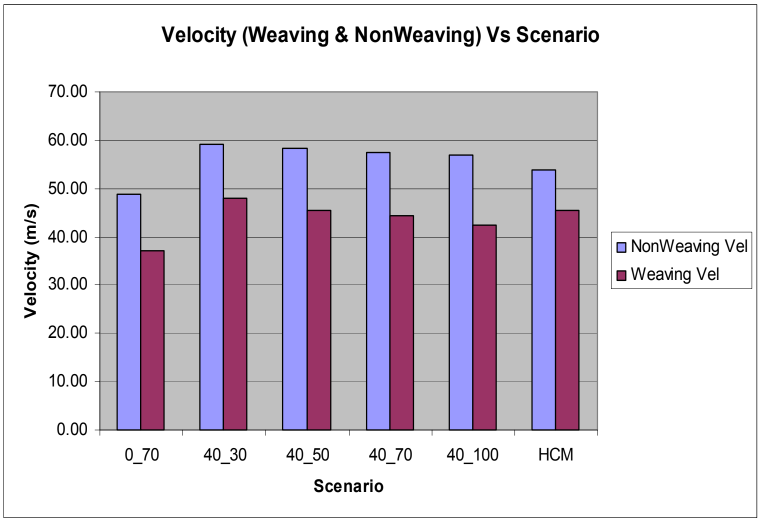


Figure 32: Comparison of Velocities for different Test Cases in TRANSIMS and HCM

A more interesting statistic that allows for the direct comparison between both the models deals with the weaving and the non-weaving speeds. Figure 32 shows this data collected from the simulation model as well as that predicted by HCM.

When there was no look ahead across links allowed, both the weaving and the non-weaving speeds predicted by the simulation model were less than that predicted by HCM. Both values were less by 5 mph. However if the look ahead across links was set so as to consider the next link, there was found to be considerable difference in velocities than when it is not allowed. The average non-weaving velocity shot up by as much as 10 mph for the same plan following cells such as 40_70. The general trend observed by increasing the plan following cells keeping the look ahead distance the same is that the non-weaving and the weaving speeds are reduced. For all the test cases considered the non-weaving speeds were slightly higher in the simulation than those predicted by HCM while the weaving speeds were slightly less than those predicted by HCM.

The second output variable where the simulation model is compared to HCM is the average density. The results aggregated from the simulation runs and the values predicted by HCM are shown in Figure 33.

	Average Density
0_70	26.60
40_30	21.53
40_50	21.79
40_70	22.19
40_100	22.88
HCM	23.96

Table 11: Comparison of Densities for Test Cases in TRANSIMS and HCM

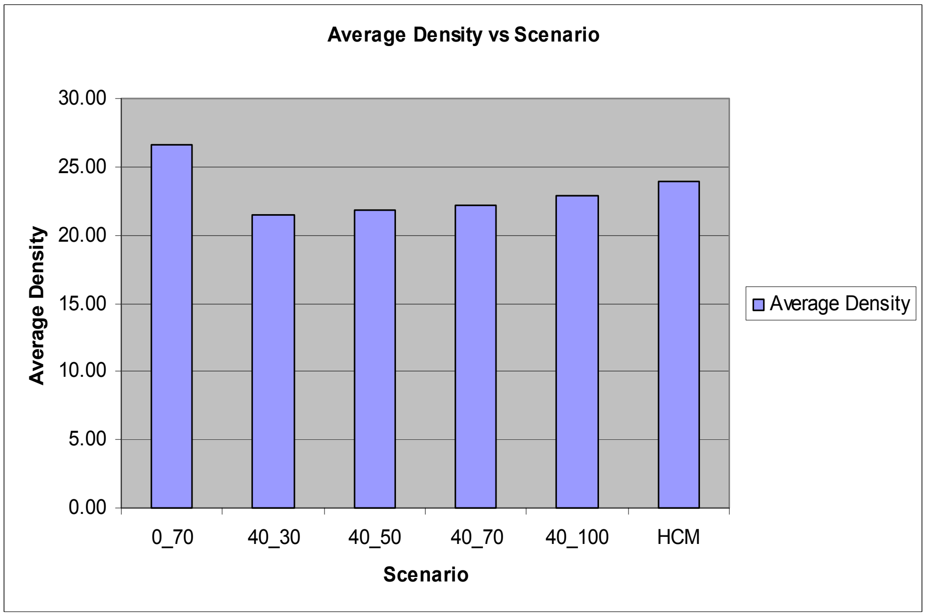


Figure 33: Comparison of Densities for different Test Cases in TRANSIMS and HCM

The average density for the first calibration test (0_70) had the highest density among all the tests. The value was found to be higher than the one predicted by HCM. For the rest of the tests with look ahead distance being one link more than the current link the average values seemed to increase with the increase of the plan following cells configuration key. However, all of the average density values from the simulation were lower than that predicted by HCM, though not by a very large margin.

It is seen that the best-calibrated TRANSIMS model for this study would be the test case where the configuration keys CA_LOOK_AHEAD_CELLS and CA_PLAN_FOLLOWING_CELLS are set to 40 and 70 cells respectively.

CORSIM

The default values used for off ramp warning sign distance, maneuver time and driver yielding percentage are shown in Table 12. These default values were obtained after several field observations. But sensitivity analysis is conducted to calibrate the model so that a common data set is created for the model and HCM.

Description	Default Values	Record Type
Off-ramp Warning Sign Distance (ft)	**2500**	**20**
Maneuver Time (sec)	**3**	**70**
Driver Yielding Percentage	**20 %**	**70**

Table 12: Default values used in CORSIM.

A series of tests were conducted by varying the warning sign distance from 2500 ft to 9000 ft. The maneuver time is varied from 1 sec to 3 sec and the driver yielding percentage is varied from 10% to 30 % to investigate the effect of the driver yielding characteristics on the merging vehicles. These values are chosen by considering a range of values around the defaults.

Maneuver Time (sec)	Non Weaving Velocity	Weaving Velocity
1	61.43	55.87
1.5	61.77	52.15
2	60.77	51.03
2.5	61.64	50.43
3	60.41	50.26
HCM	54	44.25

Table 13: Comparison of Velocities for different Test Cases in CORSIM and HCM

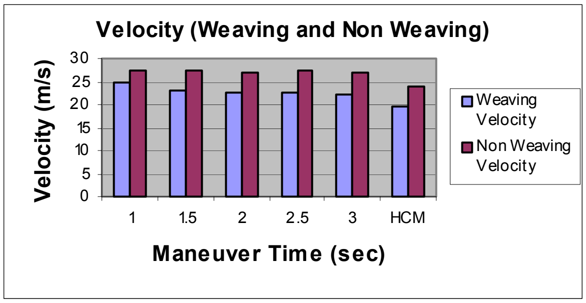


Figure 34: Comparison of Velocities for different Test Cases in CORSIM and HCM

Figure 34 shows that when the maneuver time is increased from 1 to 3 seconds, the weaving and non-weaving velocities decreased although observed to be higher than those of HCM. The maneuver time of 2 seconds is giving results closer to that of HCM. Hence the value of 2 sec is chosen for simulation.

% of Drivers Yielding	Non Weaving Velocity	Weaving Velocity
10	61.62	58.31
20	60.55	56.32
30	60.12	53.69
HCM	54	44.25

Table 14: Comparison of Velocities for different Test Cases in CORSIM and HCM

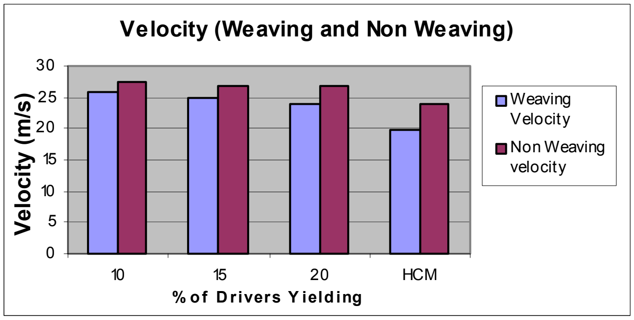


Figure 35: Comparison of Velocities for different Test Cases in CORSIM and HCM

Figure 35 shows that when the percentage of drivers yielding is increased from 10 % to 30 %, the weaving and non weaving velocities decreased although they are observed to be higher in comparison to HCM. When the driver yielding percentage is 30 %, the simulation run gave a result closer to HCM but 20 % is chosen for simulation, considering the fact that it is unlikely for 30 % of drivers to yield in a real life scenario.

Warning Sign Distance	Non Weaving Velocity	Weaving Velocity
2500	61.47	55.8
3500	61.55	55.03
4000	60.54	53.89
4750	60.59	52.98
5400	59.71	51.93
6000	59.33	51.5
7000	59.22	50.03
HCM	54	44.25

Table 15: Comparison of Velocities for different Test Cases in CORSIM and HCM

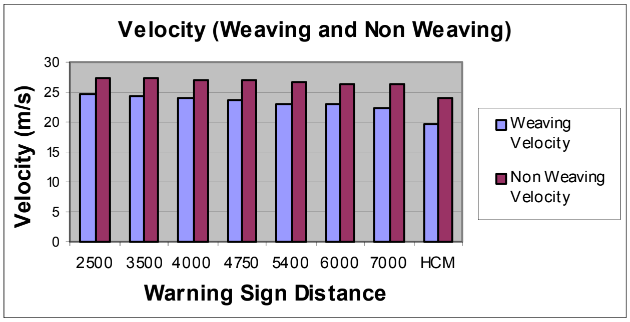


Figure 36: Comparison of Velocities for different Test Cases in CORSIM and HCM

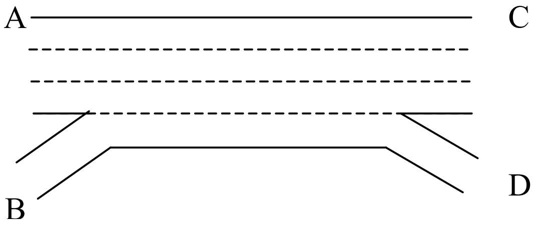
The figure above shows that when the off–ramp warning sign distance is increased from 2500 ft to 7000 ft, the weaving and non weaving velocities decreased although they were observed to be higher on comparison with HCM. When the distance is 5400 ft the simulation run gave a result closer to HCM. In real world situations this distance starts a mile before the vehicle has to exit or before the vehicle realizes that it has to merge. Hence this value is set to 5280 ft, which is roughly equivalent to one mile.

Sensitivity analysis was performed for the older version of VISSIM, VISSIM 3.5 where the parameters did not prove to be sensitive to the weaving behavior. Default values were used in running the simulations using the new version of VISSIM, VISSIM 3.6, after communication with the VISSIM software development group and on their suggestion.

No sensitivity analysis is done for INTEGRATION as the model performed well with the default values.

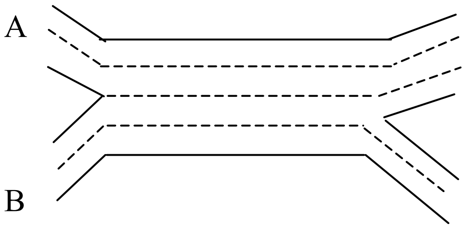
4.3 Final Results of Analysis in HCM, CORSIM, VISSIM, INTEGRATION and TRANSIMS

The simulation statistics were collected over 15 minute intervals while the runs made for 30 minutes starting from 0 seconds. This statistic was collected only after simulation model had reached equilibrium and steady state achieved. For every case in all the simulation models three simulation runs were considered so as to average out the error or bring them closer to the true expected values. The comparison of the results for the Type A, Type B and Type C configuration is presented as follows:

Type A Configuration						
		V1	V2	V3	V4	V5
	AC	4000	5000	6000	6000	4500
	AD	300	450	600	800	1200
	BC	600	800	1000	1200	1800
	BD	100	100	100	300	300
Type of operation		Unconstrained	Unconstrained	Unconstrained	Unconstrained	Constrained
Total Flow		5000	6350	7700	8300	7800
% of Weaving Vehicles		18	19.7	20.8	24.1	38.5
V1		Hcm	Corsim	Vissim	Integration	Transims
	Non Weaving Speed (mph)	54	60.77	56.47	58.73	57.5
	Weaving Speed (mph)	44.25	51.03	47.7	43.58	44.31
	Average Speed (mph)	51.95	58.75	57.15	55.16	55.13
	Density (veh/mi/la)	24.06	21.3	14.42	22.67	22.19
V2	Non Weaving Speed (mph)	50.27	59.84	54.01	50.6	53.84
	Weaving Speed (mph)	41.09	49.76	46.1	38.58	38.52
	Average Speed (mph)	48.15	57.61	52.17	47.83	50.82
	Density (veh/mi/la)	32.97	27.3	19.93	30.62	27.72
V3	Non Weaving Speed (mph)	46.99	59.4	38.55	46.45	51.35
	Weaving Speed (mph)	38.55	47.5	36.52	35.00	34.26
	Average Speed (mph)	44.95	56.13	43.53	43.57	47.8
	Density (veh/mi/la)	42.83	29	27.46	30.69	31.13
V4	Non Weaving Speed (mph)	45.68	59.64	35.42	47.04	50.35
	Weaving Speed (mph)	37.57	46.18	32.13	34.45	31.24
	Average Speed (mph)	43.43	55.32	39.46	43.29	45.74
	Density (veh/mi/la)	47.78	31.2	30.66	31.83	34.05

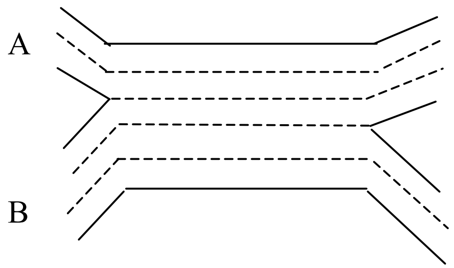
V5	Non Weaving Speed (mph)	45.69	58.7	35.98	48.2	52.58
	Weaving Speed (mph)	25.02	45.1	30.67	33.14	30.02
	Average Speed (mph)	34.68	53.94	40.28	41.96	43.89
	Density (veh/mi/la)	56.23	33.4	30.22	35.16	35.82

Table 16: Comparison of Velocities and Density in HCM, TRANSIMS, CORSIM, VISSIM and INTEGRATION for Type A Configuration

Type B Configuration						
		V1	V2	V3	V4	V5
	AC	2095	5000	6000	6000	4500
	AD	799	450	600	800	1200
	BC	1197	800	1000	1200	1800
	BD	1497	100	100	300	300
Type of operation		Unconstrained	Unconstrained	Unconstrained	Unconstrained	Constrained
Total Flow		5588	6600	7200	8500	7300
% of Weaving Vehicles		35.7	39.4	40.3	41.2	72.6
V1		Hcm	Corsim	Vissim	Integration	Transims
	Non Weaving Speed (mph)	52.83	60.57	66.53	47.63	59.76
	Weaving Speed (mph)	48.37	37.8	64.85	39.3	49.28
	Average Speed (mph)	51.14	52.91	61.86	44.21	56.8
	Density (veh/mi/la)	27.32	23.75	14.02	30.33	23.26
V2	Non Weaving Speed (mph)	48.74	59.02	63.32	37.4	56.57
	Weaving Speed (mph)	46.02	39.22	59.63	30.89	39.16
	Average Speed (mph)	47.63	51.78	62.89	34.37	50.91

	Density (veh/mi/la)	34.64	29.3	16.43	28.74	30.92
V3	Non Weaving Speed (mph)	47.07	58.98	56.08	36.34	56.58
	Weaving Speed (mph)	45.01	38.64	51.88	29.99	39.76
	Average Speed (mph)	46.22	51.78	55.01	33.33	51.03
	Density (veh/mi/la)	38.94	31.6	20.59	30.25	30.53
V4	Non Weaving Speed (mph)	43.35	59.03	21.06	36.5	57.27
	Weaving Speed (mph)	43.22	37.4	10.32	3026	39.24
	Average Speed (mph)	43.29	51.21	20.96	33.44	50.79
	Density (veh/mi/la)	49.08	32.1	46.09	28.32	30.09
V5	Non Weaving Speed (mph)	39.38	58.58	52.25	35.29	50.67
	Weaving Speed (mph)	30.77	37.68	46.37	29.18	28.76
	Average Speed (mph)	32.72	51.19	50.07	30.56	43.46
	Density (veh/mi/la)	55.76	31.9	22.88	26.47	35.49

Table 17: Comparison of Velocities and Density in HCM, TRANSIMS, CORSIM, VISSIM and INTEGRATION forType B Configuration

Type C Configuration						
		V1	V2	V3	V4	V5
	AC	3500	4000	1200	1600	2000
	AD	200	300	850	1250	1450
	BC	300	350	900	1300	1500
	BD	3500	4000	1200	1600	2000
Type of operation		Unconstrained	Unconstrained	Constrained	Constrained	Constrained
Total Flow		7500	8650	4150	5750	6950
% of Weaving Vehicles		6.7	7.5	42.2	44.3	42.4

V1		Hcm	Corsim	Vissim	Integration	Transims
	Non Weaving Speed (mph)	62.95	58.24	35.26	49.51	62.11
	Weaving Speed (mph)	51.28	34.66	12.93	40.19	54.3
	Average Speed (mph)	62.01	49.48	37.28	46.67	61.84
	Density (veh/mi/la)	24.19	29.75	34.06	28.53	10.82
V2	Non Weaving Speed (mph)	61.6	55.54	22.79	37.59	62.18
	Weaving Speed (mph)	49.6	30.45	13.65	30.39	54.74
	Average Speed (mph)	60.5	46.57	26.56	34.24	61.92
	Density (veh/mi/la)	28.6	35.05	58.62	28.86	10.75
V3	Non Weaving Speed (mph)	60.28	62.46	66.2	56.82	58.3
	Weaving Speed (mph)	41.33	43.19	59.87	46.38	47.15
	Average Speed (mph)	50.51	59.37	65.67	51.43	54.82
	Density (veh/mi/la)	16.43	13.9	7.87	15.54	11.99
V4	Non Weaving Speed (mph)	56.14	60.24	63.22	44.64	58.24
	Weaving Speed (mph)	37.32	38.47	55.32	36.38	47.26
	Average Speed (mph)	45.88	52.43	62.73	40.3	54.7
	Density (veh/mi/la)	25.06	20.1	11.34	23.39	12.01
V5	Non Weaving Speed (mph)	54.76	59.2	61.1	39.7	52.64
	Weaving Speed (mph)	35.74	35.99	48.66	32.83	40.45
	Average Speed (mph)	44.67	50.87	60.91	36.18	50.02
	Density (veh/mi/la)	31.12	26.7	14.44	22.88	12.57

Table 18: Comparison of Velocities and Density in HCM, TRANSIMS, CORSIM, VISSIM and INTEGRATION for Type C Configuration

The results are presented in a graphical manner as follows:

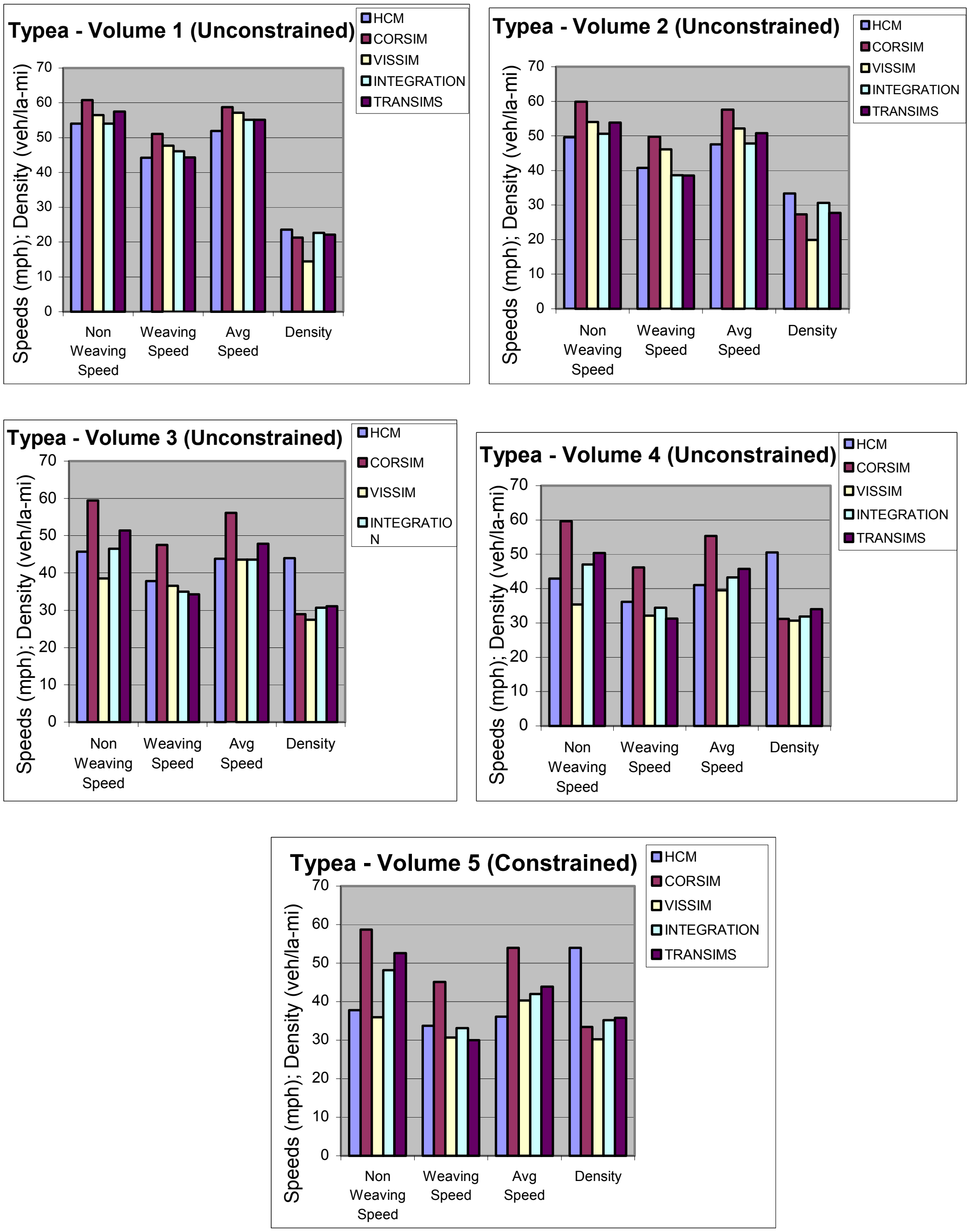
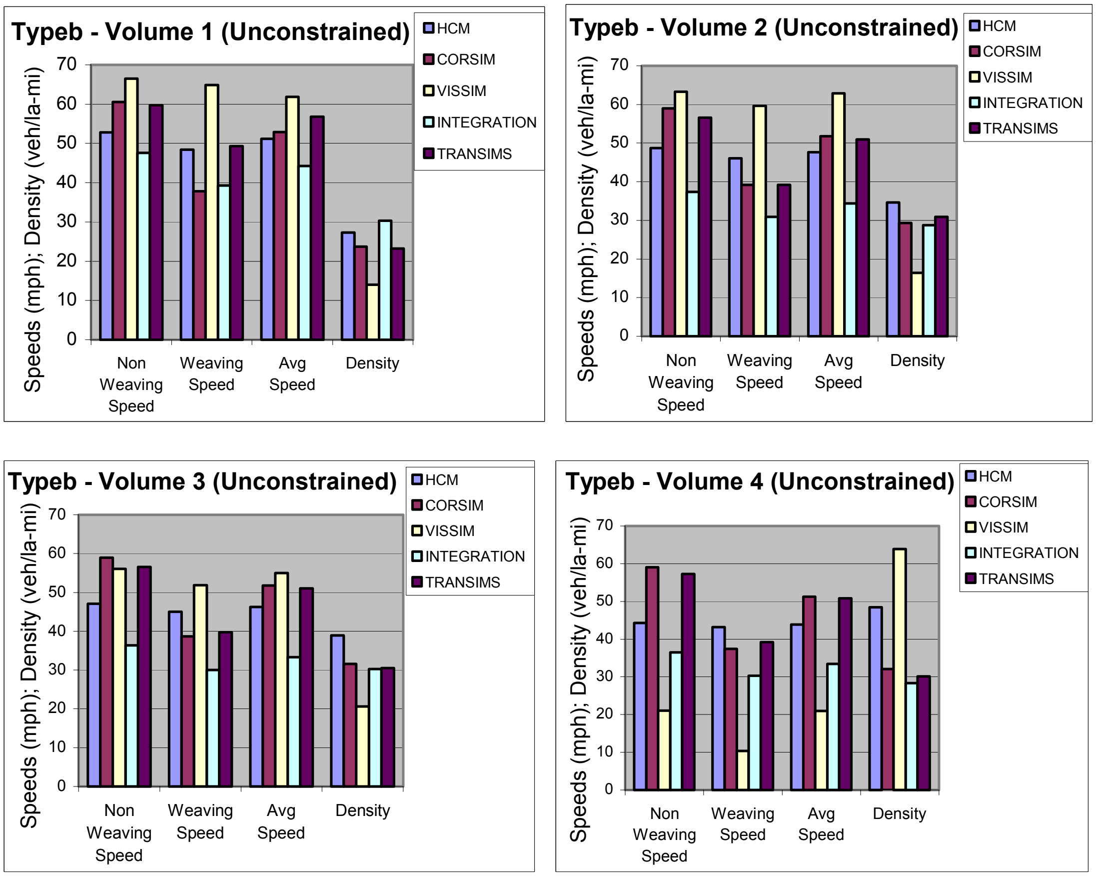


Figure 37: Results for Type A Configuration

Before comparing the results, it should be noted that the calibrated parameters for CORSIM and TRANSIMS for Type A weaving configuration were used *(HCM 2000).* VISSIM and INTEGRATION, on the other hand did quite well with their default values. It is therefore hardly surprising to note that all of the models have done quite well in comparison to HCM and with each other. A key point with respect to CORSIM is its consistent prediction of higher values for both weaving and non-weaving sections. This behavior is noticed to increase with increasing volumes on the section and as the type of operation becomes constrained. The values predicted by other three models, VISSIM, INTEGRATION and TRANSIMS are quite close to each other in the density predictions and in weaving speeds. Although none of the models have separate weaving logic, they have performed well with the weaving sections in comparison to HCM. The densities predicted, however, for all the simulation models are lower than those obtained for HCM.

The results for Type B configuration are shown in Figure 38:



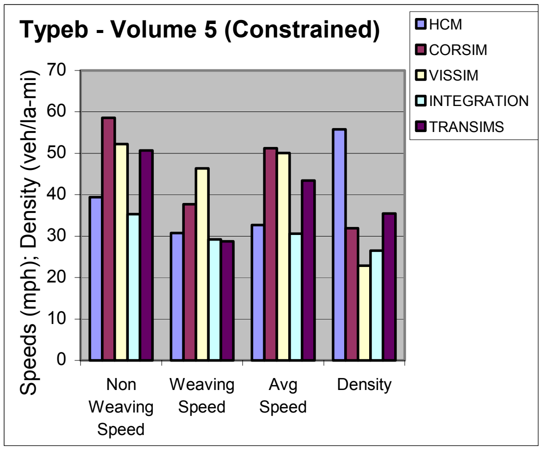


Figure 38: Results for Type B Configuration

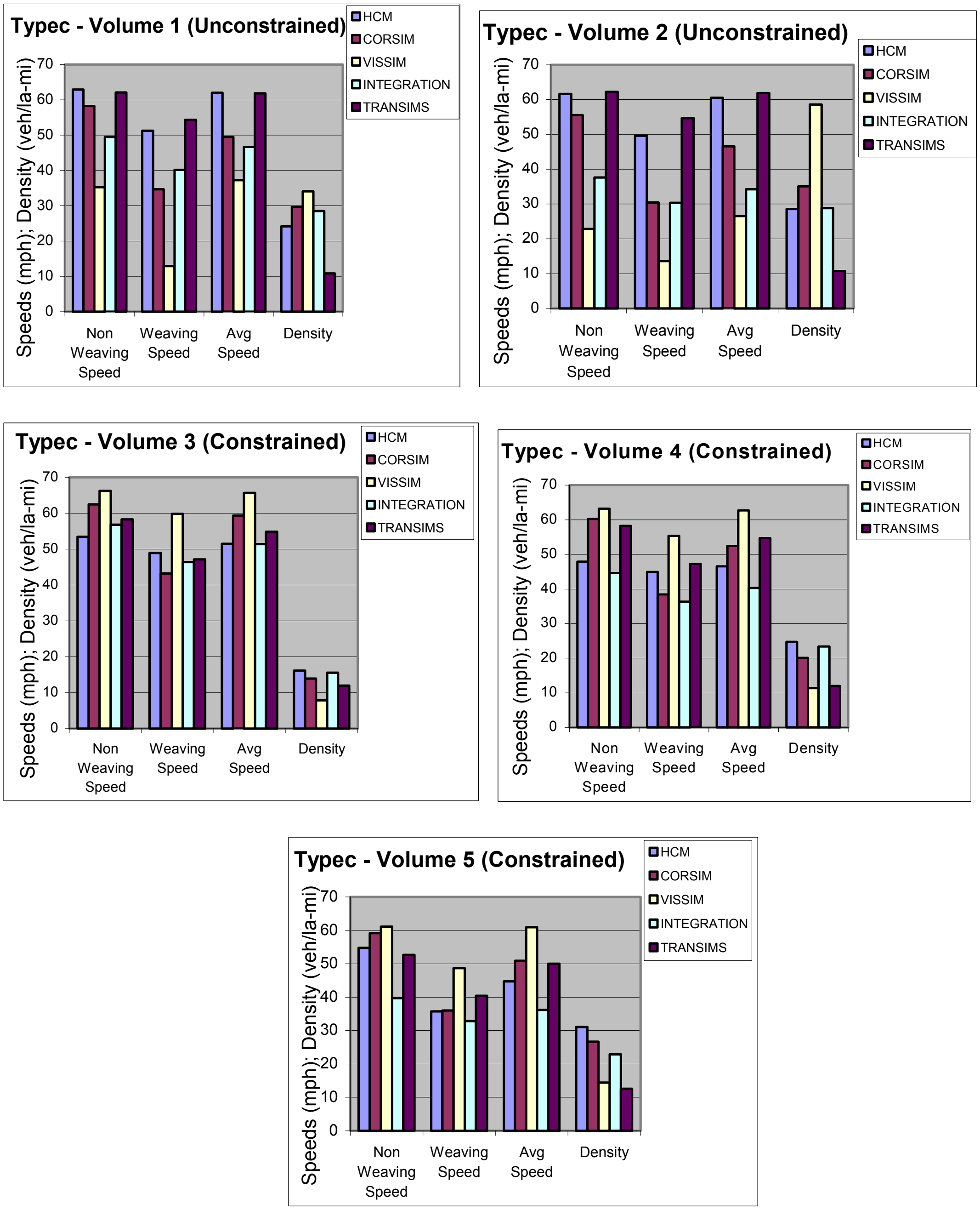
Although CORSIM cannot model the behavior of two freeways merging or two freeways diverging, a design concept using a ramp with a high speed limit acting as a freeway was used for modeling the Type B configuration. The results obtained from CORSIM were studied and close inspection revealed a trend of the model predicting higher non-weaving and lower weaving speeds for the unconstrained operation while predicting a little higher values for the constrained operation in both non-weaving and weaving speeds as compared to HCM. The density predictions compared well with HCM, it was also noted that as the total flow on the section increased the density values tended to drop.

In all cases except for one case, VISSIM predicted considerably higher values of both weaving and nonweaving speeds and lower values for density in comparison to HCM. These predicted values were among the highest (for speeds) even among the simulation models. An interesting phenomenon observed about VISSIM was that it is sensitive to the total flow rather than to the type of operation (contained or unconstrained). This is particularly seen in the case type-B configuration volume 4 when the predicted speeds are very low and the density of the section high. It was observed during the simulation for the case when the flow was high the vehicles destined to go off ramp made lane changes very close to the exit (although a large lane change distance was specified) resulting in the build up of a queue resulting in low speeds and high density.

Unlike the other simulation models, INTEGRATION under predicted the weaving and non-weaving speeds in comparison to HCM for all of the Type-B weaving section scenarios. It is also interesting to note that the predictions for constrained type were closer to HCM than for unconstrained flow. INTEGRATION was fairly consistent in capturing the changes shown by HCM i.e., on increase in volumes the changes in the speeds predicted by HCM and INTEGRATION were same. Another observation about INTEGRATION just like HCM is the fact that the model did not show great differences between weaving and non-weaving speeds in this configuration type B.

TRANSIMS probably fares the best in comparison to all the other simulation models discussed considering all the cases. Although the model predicts higher non-weaving speeds, the weaving speeds predicted are lower than those of HCM but very close. The density values observed are also the closest to HCM and comparable to other models. The biggest difference between HCM and TRANSIMS happens to be the difference in the weaving and non-weaving speeds as predicted by the two. HCM for the scenarios presented does not show a considerable difference in the weaving and the non-weaving speeds however TRANSIMS predicts a larger difference between the two. A possible reason for this behavior may be the handling of speeds in the model, as vehicles travel at speeds that are multiples of 7.5 m/sec. It is also seen during the simulation that some weaving vehicles stop for a second or two trying to lane change to get into the appropriate lane. This behavior may also bring about the large difference in the weaving and non-weaving speeds.

The results for Type C configuration are shown in Figure 39:



Typec - Volume 1 (Unconstrained)

Typec - Volume 2 (Unconstrained)

Typec - Volume 3 (Constrained)

Typec - Volume 4 (Constrained)

Typec - Volume 5 (Constrained)

Figure 39: Results for Type C Configuration

As mentioned earlier, since CORSIM cannot model the behavior of two freeways merging or diverging, a design concept using a ramp with a high speed limit acting as a freeway was used for modeling the Type C configuration. CORSIM yielded considerably lower values for weaving speeds in unconstrained operations while the speeds in constrained operations compared fairly well with HCM. The non-weaving speeds in both cases (constrained and unconstrained) were fairly close to those predicted by HCM, the values being slightly lower for unconstrained and higher for constrained. The density values obtained were higher than those predicted by HCM for unconstrained operations while for constrained operations the density values were lower. It was also observed that the density values were closest to HCM probably second only to INTEGRATION.

Even for the Type C configuration VISSIM showed the same behavior as in Type B that is of weaving and non-weaving speeds dropping down drastically and the density values rising sharply for higher flows. For flows that are not very high the weaving and non-weaving velocities were both a little higher than HCM but nonetheless comparable. The densities corresponding to these flows were although considerably lower than those predicted by HCM.

Probably the best model to replicate the density values close to HCM is INTEGRATION, which yielded values close to HCM in both constrained and unconstrained operations. The weaving and non-weaving speeds however are not tallying well for high flows or for sections operating at their capacity. Both the velocity and the density predictions were close to HCM for constrained type of operations for flows that were not very high.

TRANSIMS compared very well with HCM even for Type C configuration by giving the speeds, which are much similar to HCM, but the densities obtained were much lower than those of HCM.

Chapter 5 : Conclusions and Recommendations

5.1 Conclusions

There have been a lot of studies involving simulation models and their applications in various transportation operations. However the performance of these models considering the critical maneuvers of the vehicles in particular sections of the roadways called the weaving sections is a concern as they are the most critical regions to be modeled by any simulation software. Hence the weaving sections involving intense lane changing maneuvers are considered for study here.

The fundamental difference between HCM and the simulation models TRANSIMS, CORSIM, VISSIM and INTEGRATION is that HCM is a deterministic model in which the results are based on traditional data collected while the other models are stochastic simulation models, which can model results based on several driver behavior parameters. A 30-minute simulation run for all the models only represents one point of the data sample while HCM may represent an average value of samples. Although a series of simulation runs were performed for every configuration and an average collected for all the models, it only reduces the average error and gets the results closer to the true convergence value of the simulation.

The objective of the research was to carry out a comparative analysis of the models so as to be able to judge the performance of the models. In the course of the analysis the following conclusions were drawn.

CORSIM did not compare well with HCM probably because of the fact that it cannot model the behavior of two freeways merging or two freeways diverging, the way in which the Type B and Type C configurations are modeled. It yielded lower values of speeds for unconstrained operations and a little higher value of speeds for constrained operations.

VISSIM predicted higher values of speeds and lower values of densities. The model proved to be sensitive to the total flows rather than the type of operation (constrained or unconstrained). The model did not show a behavior consistent with HCM.

Although INTEGRATION performed well for the Type A and Type B configurations it did not do well with sections operating at high flows for unconstrained operations. But it was especially good in predicting the densities and fairly accurate with speeds. Overall it can be concluded that it performed well with the weaving sections with respect to HCM.

TRANSIMS gave good results in comparison to all the other models discussed. The model predicted the speeds and densities very close to HCM although densities did not compare very well with HCM for the Type C configuration. A major difference between HCM and TRANSIMS proved to be the difference in the weaving and non-weaving speeds as predicted by the two. HCM did not show a considerable difference in the weaving and the non-weaving speeds however TRANSIMS showed a greater difference between the two. This kind of behavior can be attributed to the 'cellular automata' kind of simulation used by TRANSIMS Microsimulator. Even though TRANSIMS did not give a wide range of microscopic characteristics that can be changed such as driver characteristics, the effect had been brought out by properly adjusting the parameters provided by the model.

5.2 Recommendations

The following recommendations are suggested to the models:

In TRANSIMS, the vehicles when considering a lane change should consider the speeds of the lead and the following car in the adjacent lane into which the vehicle is trying to do a lane change. TRANSIMS considers a lane changing movement when the gap backward is more than 5 cells irrespective of the speeds of the vehicle. This is not true in the real life scenario. Also the vehicles are considered to have a fixed length. TRANSIMS follows same logic for simulating freeways and arterials, which may not replicate the real life scenario when simulating either of them.

In CORSIM when the vehicles are trying to merger on to freeway from on ramp they immediately get into the lane adjacent to the auxiliary lane within 100 ft of the gore area, which is very unlikely in the real life. The merging logic could be altered to make a realistic behavior possible.

VISSIM is not able to perform lane changes in the weaving sections realistically. Vehicles start to do a lane change within 100 ft of the gore area at the exit ramp trying to exit the freeway, which results in queue formation throughout the section. There is no anticipatory lane changing logic, which disables the user to input the percentage of vehicles yielding to the entering traffic.

HCM does not consider the various driver characteristics, which play an important role while evaluating the weaving speeds of the vehicles. And also it gives out an approximated weaving speed of the vehicles in a section rather than considering the varying speeds of the vehicles in that section.

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APPENDIX A

HCM calculations

Type A – Volume 1

Establish Roadway and Traffic Conditions

All the traffic conditions are specified in the calculation description and Figure below

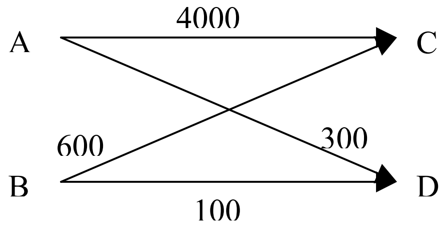
Convert All Traffic Volumes to Peak Flow Rates Under Ideal Conditions

A-C = 4000 pcph

A-D = 300 pcph

B-C = 600 pcph

B-D = 100 pcph



Construct Weaving Diagram

The weaving diagram is shown in Figure above. Critical ratios may be computed as follows:

V_w= 600+300 = 900 pcph

V = 900+4000+100= 5000 pcph

VR = 900/5000 = 0.18

R = 300/900 = 0.33

Compute Unconstrained Weaving and Nonweaving Speeds

Weaving intensity factors are computed from Table 3.

For assumed unconstrained conditions on a Type A weaving section:

$W = a(1+VR)^b(V/N)^c/(3.28*L)^d$

$W_w = 0.15(1+0.18)^{2.2}(5000/4)^{0.97}/(3.28*300)^{0.8} = 0.879$

$W_{nw} = 0.0035(1+0.18)^{4.0}(5000/4)^{1.3}/(3.28*300)^{0.75} = 0.41$

Then, on the basis of a free-flow speed, S_{FF} , of 65 mph, the weaving and nonweaving vehicle speeds can be estimated:

$S_i = 24 + (S_{FF} - 10)/(1+W)$

S_w = 24+ (104-10)/(1+0.879) = 70.84 km/h = 44.28 mph

S_{nw} =24 + (104-10)/(1+0.41) = 86.41 km/h = 54.01 mph

Check for Constrained Operation

$N_w = 1.21(N)VR^{0.571}L^{0.234}/S_w^{0.438}$

$N_w = 1.21(4)(0.18^{0.571})(300^{0.234})/70.84^{0.438} = 1.06$ lanes

As this is lesser than N_w (max) of 1.4 lanes for a Type A weaving section, the section operates in an **unconstrained** mode.

Compute Average (Space Mean) Speed and Density of All Vehicles in Weaving Area

$S = (v_w + v_{nw})/(v_w/S_w + V_{nw}/S_{nw})$

$S = (900+4100)/(900/70.84+4100/86.41) = 83.12$ km/h $= 51.95$ mph

$D= (v/N)/S$

$D= (5000/4)/51.95 = 24.06$ veh/hr/ln

After consultation with Table 7 the LOS C.

Check Weaving Area Limitations

None of the limitations have been violated, and the results seem to be appropriate.

Type A – Volume 2

Establish Roadway and Traffic Conditions

All the traffic conditions are specified in the calculation description and Figure below

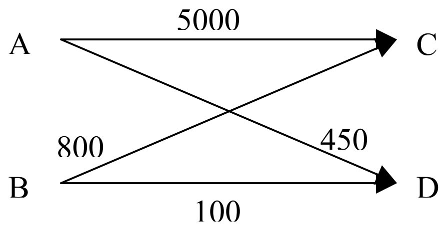
Convert All Traffic Volumes to Peak Flow Rates Under Ideal Conditions

A-C = 5000 pcph

A-D = 450 pcph

B-C = 800 pcph

B-D = 100 pcph



Construct Weaving Diagram

The weaving diagram is shown in Figure above. Critical ratios may be computed as follows:

V_w= 800+450 = 1250 pcph

V = 1250+5000+100= 6350 pcph

VR = 1250/6350 = 0.197

R = 450/1250 = 0.36

Compute Unconstrained Weaving and Nonweaving Speeds

Weaving intensity factors are computed from Table 3.

For assumed unconstrained conditions on a Type A weaving section:

$W = a(1+VR)^b(V/N)^c/(3.28*L)^d$

$W_w= 0.15(1+0.197)^{2.2}(6350/4)^{0.97}/(3.28*300)^{0.8} = 1.108$

$W_{nw}= 0.0035(1+0.197)^{4.0}(6350/4)^{1.3}/(3.28*300)^{0.75} = 0.559$

Then, on the basis of a free-flow speed, S_{FF} , of 65 mph, the weaving and nonweaving vehicle speeds can be estimated:

$S_i = 24 + (S_{FF} - 10)/(1+W)$

S_w = 24+ (104-10)/(1+1.108) = 65.75 km/h = 41.09 mph

S_{nw} =24 + (104-10)/(1+0.559) = 80.43 km/h = 50.27 mph

Check for Constrained Operation

$N_w = 1.21(N)VR^{0.571}L^{0.234}/S_w^{0.438}$

$N_w = 1.21(4)(0.197^{0.571})(300^{0.234})/65.75^{0.438}$ = 1.16 lanes

As this is lesser than N_w (max) of 1.4 lanes for a Type A weaving section, the section operates in an **unconstrained** mode.

Compute Average (Space Mean) Speed and Density of All Vehicles in Weaving Area

$S = (v_w + v_{nw})/(v_w/S_w + V_{nw}/S_{nw})$

S = (1250+5100)/(1250/65.75+5100/80.43) = 77.04 km/h = 48.15 mph

D= (v/N)/S

D= (6350/4)/48.15 = 32.97 veh/hr/ln

After consultation with Table 7 the LOS D.

Check Weaving Area Limitations

None of the limitations have been violated, and the results seem to be appropriate.

Type A – Volume 3

Establish Roadway and Traffic Conditions

All the traffic conditions are specified in the calculation description and Figure below

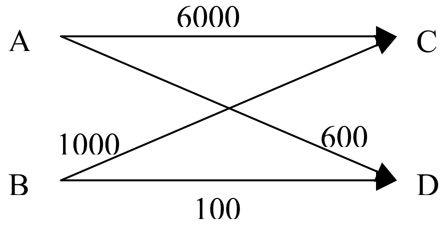
Convert All Traffic Volumes to Peak Flow Rates Under Ideal Conditions

A-C = 6000 pcph

A-D = 600 pcph

B-C = 1000 pcph

B-D = 100 pcph



Construct Weaving Diagram

The weaving diagram is shown in Figure above. Critical ratios may be computed as follows:

V_w= 1000+600 = 1600 pcph

V = 1600+6000+100= 7700 pcph

VR = 1600/7700 = 0.208

R = 600/1600 = 0.375

Compute Unconstrained Weaving and Nonweaving Speeds

Weaving intensity factors are computed from Table 3.

For assumed unconstrained conditions on a Type A weaving section:

$W = a(1+VR)^b(V/N)^c/(3.28*L)^d$

$W_w= 0.15(1+0.208)^{2.2}(7700/4)^{0.97}/(3.28*300)^{0.8} = 1.336$

$W_{nw}= 0.0035(1+0.208)^{4.0}(7700/4)^{1.3}/(3.28*300)^{0.75} = 0.719$

Then, on the basis of a free-flow speed, S_{FF} , of 65 mph, the weaving and nonweaving vehicle speeds can be estimated:

$S_i = 24 + (S_{FF} - 10)/(1+W)$

$S_w = 24 + (104-10)/(1+1.336) = 61.67$ km/h = 38.55 mph

$S_{nw} = 24 + (104-10)/(1+0.559) = 75.19$ km/h = 46.99 mph

Check for Constrained Operation

$N_w = 1.21(N)VR^{0.571}L^{0.234}/S_w^{0.438}$

$N_w = 1.21(4)(0.208^{0.571})(300^{0.234})/61.67^{0.438} = 1.23$ lanes

As this is lesser than N_w (max) of 1.4 lanes for a Type A weaving section, the section operates in an **unconstrained** mode.

Compute Average (Space Mean) Speed and Density of All Vehicles in Weaving Area

$S = (v_w + v_{nw})/(v_w/S_w + V_{nw}/S_{nw})$

$S = (1600+6100)/(1600/61.67+6100/75.19) = 71.92$ km/h = 44.95 mph

$D = (v/N)/S$

$D = (7700/4)/44.95 = 42.82$ veh/hr/ln

After consultation with Table 7 the LOS E.

Check Weaving Area Limitations

None of the limitations have been violated, and the results seem to be appropriate.

Type A – Volume 4

Establish Roadway and Traffic Conditions

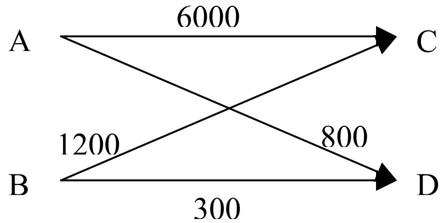
All the traffic conditions are specified in the calculation description and Figure below

Convert All Traffic Volumes to Peak Flow Rates Under Ideal Conditions

A-C = 6000 pcph

A-D = 800 pcph

B-C = 1200 pcph



B-D = 300 pcph

Construct Weaving Diagram

The weaving diagram is shown in Figure above. Critical ratios may be computed as follows:

V_w= 1200+800 = 2000 pcph

V = 2000+6000+300= 8300 pcph

VR = 2000/8300 = 0.241

R = 800/2000 = 0.4

Compute Unconstrained Weaving and Nonweaving Speeds

Weaving intensity factors are computed from Table 3.

For assumed unconstrained conditions on a Type A weaving section:

$W = a(1+VR)^b(V/N)^c/(3.28*L)^d$

$W_w= 0.15(1+0.241)^{2.2}(8300/4)^{0.97}/(3.28*300)^{0.8} = 1.437$

$W_{nw}= 0.0035(1+0.241)^{4.0}(8300/4)^{1.3}/(3.28*300)^{0.75} = 0.792$

Then, on the basis of a free-flow speed, S_{FF} , of 65 mph, the weaving and nonweaving vehicle speeds can be estimated:

$S_i = 24 + (S_{FF} -10)/(1+W)$

S_w = 24+ (104-10)/(1+1.437) = 60.12 km/h = 37.57 mph

S_{nw} =24 + (104-10)/(1+0.792) = 73.09 km/h = 45.68 mph

Check for Constrained Operation

$N_w = 1.21(N)VR^{0.571}L^{0.234}/S_w^{0.438}$

$N_w = 1.21(4)(0.241^{0.571})(300^{0.234})/60.12^{0.438}$ = 1.36 lanes

As this is lesser than N_w (max) of 1.4 lanes for a Type A weaving section, the section operates in an **unconstrained** mode.

Compute Average (Space Mean) Speed and Density of All Vehicles in Weaving Area

$S = (v_w + v_{nw})/(v_w/S_w + V_{nw}/S_{nw})$

S = (2000+6300)/(2000/60.12+6300/73.09) = 69.48 km/h = 43.43 mph

$D = (v/N)/S$

$D = (8300/4)/43.43 = 47.78$ veh/hr/ln

After consultation with Table 7 the LOS F.

Check Weaving Area Limitations

None of the limitations have been violated, and the results seem to be appropriate.

Type A – Volume 5

Establish Roadway and Traffic Conditions

All the traffic conditions are specified in the calculation description and Figure below

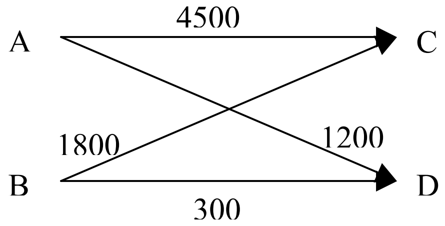
Convert All Traffic Volumes to Peak Flow Rates Under Ideal Conditions

A-C = 4500 pcph

A-D = 1200 pcph

B-C = 1800 pcph

B-D = 300 pcph



Construct Weaving Diagram

The weaving diagram is shown in Figure above. Critical ratios may be computed as follows:

$V_w = 1800+1200 = 3000$ pcph

$V = 3000+4500+300 = 7800$ pcph

$VR = 3000/7800 = 0.385$

$R = 1200/3000 = 0.4$

Compute Unconstrained Weaving and Nonweaving Speeds

Weaving intensity factors are computed from Table 3.

For assumed unconstrained conditions on a Type A weaving section:

$W = a(1+VR)^b(V/N)^c/(3.28*L)^d$

$W_w = 0.15(1+0.385)^{2.2}(7800/4)^{0.97}/(3.28*300)^{0.8} = 1.923$

$W_{nw} = 0.0035(1+0.385)^{4.0}(7800/4)^{1.3}/(3.28*300)^{0.75} = 1.386$

Then, on the basis of a free-flow speed, S_{FF} , of 65 mph, the weaving and nonweaving vehicle speeds can be estimated:

$S_i = 24 + (S_{FF} - 10)/(1+W)$

$S_w = 24 + (104-10)/(1+1.923) = 54.11$ km/h = 33.82 mph

$S_{nw} = 24 + (104-10)/(1+1.386) = 60.89$ km/h = 38.05 mph

Check for Constrained Operation

$N_w = 1.21(N)VR^{0.571}L^{0.234}/S_w^{0.438}$

$N_w = 1.21(4)(0.385^{0.571})(300^{0.234})/54.11^{0.438} = 1.855$ lanes

As this is greater than N_w (max) of 1.4 lanes for a Type A weaving section, the section operates in a **constrained** mode.

Repeat the step for constrained Weaving and Nonweaving Speeds

Weaving intensity factors are computed from Table 3.

For constrained conditions on a Type A weaving section:

$W_w = 0.35(1+0.385)^{2.2}(7800/4)^{0.97}/(3.28*300)^{0.8} = 4.487$

$W_{nw} = 0.002(1+0.385)^{4.0}(7800/4)^{1.3}/(3.28*300)^{0.75} = 0.792$

Then, on the basis of a free-flow speed, S_{FF} , of 65 mph, the weaving and nonweaving vehicle speeds can be estimated:

$S_i = 24 + (S_{FF} - 10)/(1+W)$

$S_w = 24 + (104-10)/(1+4.487) = 40.04$ km/h = 25.02 mph

$S_{nw} = 24 + (104-10)/(1+1.386) = 73.11$ km/h = 45.69 mph

Compute Average (Space Mean) Speed and Density of All Vehicles in Weaving Area

$S = (v_w + v_{nw})/(v_w/S_w + V_{nw}/S_{nw})$

$S = (3000+4800)/(3000/40.04+4800/73.11) = 55.48$ km/h = 34.68 mph

$D = (v/N)/S$

$D = (8300/4)/34.68 = 56.23$ veh/hr/ln

After consultation with Table 7 the LOS F.

Check Weaving Area Limitations

None of the limitations have been violated, and the results seem to be appropriate.

Type B – Volume 1

Establish Roadway and Traffic Conditions

All the traffic conditions are specified in the calculation description and Figure below

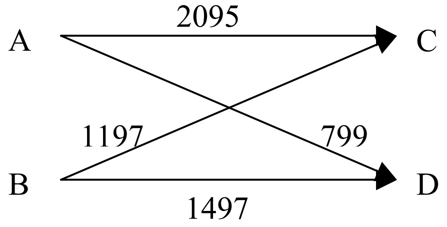
Convert All Traffic Volumes to Peak Flow Rates Under Ideal Conditions

A-C = 2095 pcph

A-D = 799 pcph

B-C = 1197 pcph

B-D = 1497 pcph



Construct Weaving Diagram

The weaving diagram is shown in Figures above. Critical ratios may be computed as follows:

V_W= 1197 + 799 = 1996 pcph

V = 1197 + 2095 + 1497 = 5588 pcph

VR = 1996 / 5588 = 0.357

R = 799 / 1996 = 0.400

Compute Unconstrained Weaving and Nonweaving Speeds

Weaving intensity factors are computed from Table 5.

For assumed unconstrained conditions on a Type B weaving section:

$$W_i = \frac{a(1+VR)^b\left(\frac{v}{N}\right)^c}{(3.28L)^d}$$

$$W_w = \frac{0.08(1+0.357)^{2.2}\left(\frac{5588}{4}\right)^{0.70}}{(3.28*450)^{0.50}} = 0.647$$

$$W_{nw} = \frac{0.0020(1+0.357)^{6.0}\left(\frac{5588}{4}\right)^{1.0}}{(3.28*450)^{0.50}} = 0.454$$

Then, on the basis of a free-flow speed, S_{FF}, of 65 mph, the weaving and nonweaving vehicle speeds can be estimated:

$S_i = 24 + (S_{FF} - 16)/(1+W)$

$S_w = 24 + (104 - 16) / (1+0.649) = 77.38$ km/h = 48.36 mph

$S_{nw} = 24 + (104 - 16) / (1+ 0.454) = 84.52$ km/h = 52.82 mph

Check for Constrained Operation

$N_w = N[0.085 + 0.703VR + (71.57/L) - 0.0112 (S_{nw} - S_w)]$

$N_w = 4[0.085 + 0.703(0.357) + (71.57/450) - 0.0112 (52.82 - 48.36)]$

$N_w = 1.78$

As this is lesser than N_w (max) of 3.5 lanes for a Type B weaving section, the section operates in an **unconstrained** mode.

Compute Average (Space Mean) Speed and Density of All Vehicles in Weaving Area

$S = (v_w + v_{nw})/(v_w/S_w + V_{nw}/S_{nw})$

$S = (1996 + 3592) / (1996 / 77.38 + 3592 / 84.52) = 81.82$ km/h = 51.14 mph

$D= (v/N)/S$

$D= (6600 / 4) / 51.14 = 27.32$ veh/mi/ln

After consultation with Table 7 the LOS C.

Check Weaving Area Limitations

None of the limitations have been violated, and the results seem to be appropriate.

Type B – Volume 2

Establish Roadway and Traffic Conditions

All the traffic conditions are specified in the calculation description and Figure below

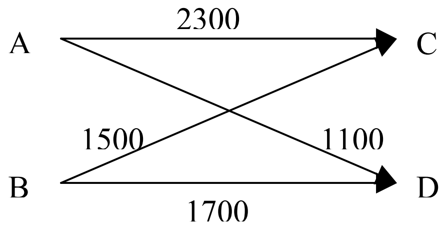
Convert All Traffic Volumes to Peak Flow Rates Under Ideal Conditions

A-C = 2300 pcph

A-D = 1100 pcph

B-C = 1500 pcph

B-D = 1700 pcph



Construct Weaving Diagram

The weaving diagram is shown in Figures above. Critical ratios may be computed as follows:

V_w= 1500 + 1100 = 2600 pcph

V = 2600 + 2300 + 1700 = 6600 pcph

VR = 2600 / 6600 = 0.394

R = 1100 / 2600 = 0.423

Compute Unconstrained Weaving and Nonweaving Speeds

Weaving intensity factors are computed from Table 5.

For assumed unconstrained conditions on a Type B weaving section:

$$W_i = \frac{a(1+VR)^b \left(\frac{v}{N}\right)^c}{(3.28L)^d}$$

$$W_w = \frac{0.08(1+0.394)^{2.2}\left(\frac{6600}{4}\right)^{0.70}}{(3.28*450)^{0.50}} = 0.773$$

$$W_{nw} = \frac{0.0020(1+0.394)^{6.0}\left(\frac{6600}{4}\right)^{1.0}}{(3.28*450)^{0.50}} = 0.63$$

Then, on the basis of a free-flow speed, S_{FF}, of 65 mph, the weaving and non-weaving vehicle speeds can be estimated:

$S_i = 24 + (S_{FF} - 16)/(1+W)$

$S_w = 24 + (104 - 16) / (1+0.773) = 73.64$ km/h = 46.02 mph

$S_{nw} = 24 + (104 - 16) / (1+ 0.63) = 77.98$ km/h = 48.74 mph

Check for Constrained Operation

$N_w = N[0.085 + 0.703VR + (71.57/L) - 0.0112 (S_{nw} - S_w)]$

$N_w = 4[0.085 + 0.703(0.394) + (71.57/450) - 0.0112 (48.74 - 46.02)]$

$N_w = 1.96$

As this is lesser than N_w (max) of 3.5 lanes for a Type B weaving section, the section operates in an **unconstrained** mode.

Compute Average (Space Mean) Speed and Density of All Vehicles in Weaving Area

$S = (v_w + v_{nw})/(v_w/S_w + V_{nw}/S_{nw})$

$S = (2600 + 4000) / (2600 / 73.64 + 4000 / 77.98) = 76.21$ km/h = 47.63 mph

$D = (v/N)/S$

$D = (6600 / 4) / 47.63 = 34.64$ veh/mi/ln

After consultation with Table 7 the LOS D.

Check Weaving Area Limitations

None of the limitations have been violated, and the results seem to be appropriate.

Type B – Volume 3

Establish Roadway and Traffic Conditions

All the traffic conditions are specified in the calculation description and Figure below

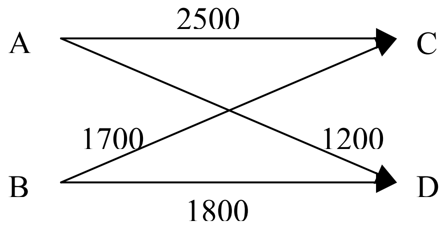
Convert All Traffic Volumes to Peak Flow Rates Under Ideal Conditions

A-C = 2500 pcph

A-D = 1200 pcph

B-C = 1700 pcph

B-D = 1800 pcph



Construct Weaving Diagram

The weaving diagram is shown in Figures above. Critical ratios may be computed as follows:

V_w= 1500 + 1100 = 2600 pcph

V = 2600 + 2300 + 1700 = 6600 pcph

VR = 2600 / 6600 = 0.394

R = 1100 / 2600 = 0.423

Compute Unconstrained Weaving and Nonweaving Speeds

Weaving intensity factors are computed from Table 5.

For assumed unconstrained conditions on a Type B weaving section:

$$W_i = \frac{a(1+VR)^b \left(\frac{v}{N}\right)^c}{(3.28L)^d}$$

$$W_w = \frac{0.08(1+0.403)^{2.2}\left(\frac{7200}{4}\right)^{0.70}}{(3.28*450)^{0.50}} = 0.833$$

$$W_{nw} = \frac{0.0020(1+0.403)^{6.0}\left(\frac{7200}{4}\right)^{1.0}}{(3.28*450)^{0.50}} = 0.714$$

Then, on the basis of a free-flow speed, S_{FF} , of 65 mph, the weaving and nonweaving vehicle speeds can be estimated:

$S_i = 24 + (S_{FF} - 16)/(1+W)$

$S_w = 24 + (104 - 16) / (1+0.833) = 72.01$ km/h = 45.07 mph

$S_{nw} =15 + (104 - 16) / (1+ 0.714) = 75.34$ km/h = 47.09 mph

Check for Constrained Operation

$N_w = N[0.085 + 0.703VR + (71.57/L) – 0.0112 (S_{nw} - S_w)]$

$N_w = 4[0.085 + 0.703(0.403) + (71.57/450) – 0.0112 (47.09 – 45.07)]$

$N_w = 2.02$

As this is lesser than N_w (max) of 3.5 lanes for a Type B weaving section, the section operates in an **unconstrained** mode.

Compute Average (Space Mean) Speed and Density of All Vehicles in Weaving Area

$S = (v_w + v_{nw})/(v_w/S_w + V_{nw}/S_{nw})$

$S = (2900 + 4300) / (2900 / 72.01 + 4300 / 75.34) = 73.96$ km/h = 46.23 mph

$D= (v/N)/S$

$D= (7200/4) / 46.23 = 38.94$ veh/mi/ln

After consultation with Table 7 the LOS E.

Check Weaving Area Limitations

None of the limitations have been violated, and the results seem to be appropriate.

Type B – Volume 4

Establish Roadway and Traffic Conditions

All the traffic conditions are specified in the calculation description and Figure below

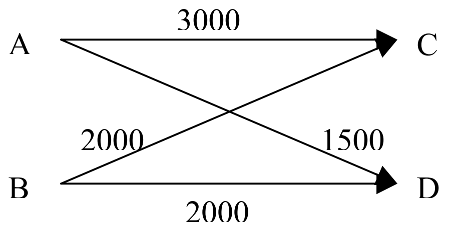
Convert All Traffic Volumes to Peak Flow Rates Under Ideal Conditions

A-C = 3000 pcph

A-D = 1500 pcph

B-C = 2000 pcph

B-D = 2000 pcph



Construct Weaving Diagram

The weaving diagram is shown in Figures above. Critical ratios may be computed as follows:

V_w= 2000 + 1500 = 3500 pcph

V = 3500 + 3000 + 2000 = 8500 pcph

VR = 3500 / 8500 = 0.412

R = 1500 / 3500 = 0.429

Compute Unconstrained Weaving and Nonweaving Speeds

Weaving intensity factors are computed from Table 5.

For assumed unconstrained conditions on a Type B weaving section:

$$W_i = \frac{a(1+VR)^b\left(\frac{v}{N}\right)^c}{(3.28L)^d}$$

$$W_w = \frac{0.08(1+0.412)^{2.2}\left(\frac{8500}{4}\right)^{0.70}}{(3.28*450)^{0.50}} = 0.949$$

$$W_{nw} = \frac{0.0020(1+0.411)^{6.0}\left(\frac{8500}{4}\right)^{1.0}}{(3.28*450)^{0.50}} = 0.94$$

Then, on the basis of a free-flow speed, S_{FF} , of 65 mph, the weaving and nonweaving vehicle speeds can be estimated:

$S_i = 24 + (S_{FF} - 16)/(1+W)$

S_w = 24 + (104 - 16) / (1+0.948) = 69.16 km/h = 43.22 mph

S_{nw} =15 + (104 - 16) / (1+ 0.94) = 69.35 km/h = 43.35 mph

Check for Constrained Operation

$N_w = N[0.085 + 0.703VR + (71.57/L) - 0.0112 (S_{nw} - S_w)]$

$N_w = 4[0.085 + 0.703(0.412) + (71.57/450) - 0.0112 (43.34 - 43.22)]$

$N_w = 2.13$

As this is lesser than N_w (max) of 3.5 lanes for a Type B weaving section, the section operates in an **unconstrained** mode.

Compute Average (Space Mean) Speed and Density of All Vehicles in Weaving Area

$S = (v_w + v_{nw})/(v_w/S_w + V_{nw}/S_{nw})$

$S = (3500 + 5000) / (3500 / 69.16 + 5000 / 69.35) = 69.27$ km/h = 43.29 mph

$D= (v/N)/S$

$D= (5588 / 4) / 43.29 = 49.08$ veh/mi/ln

After consultation with Table 7 the LOS F.

Check Weaving Area Limitations

None of the limitations have been violated, and the results seem to be appropriate.

Type B – Volume 5

Establish Roadway and Traffic Conditions

All the traffic conditions are specified in the calculation description and Figure below

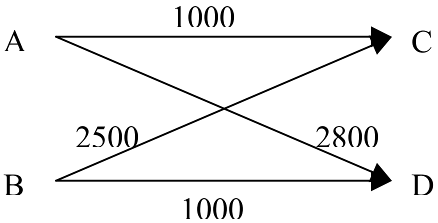
Convert All Traffic Volumes to Peak Flow Rates Under Ideal Conditions

A-C = 1000 pcph

A-D = 2800 pcph

B-C = 2500 pcph

B-D = 1000 pcph



Construct Weaving Diagram

The weaving diagram is shown in Figures above. Critical ratios may be computed as follows:

$V_w= 2500 + 2800 = 5300$ pcph

$V = 5300 + 1000 + 1000 = 7300$ pcph

$VR = 5300 / 7300 = 0.726$

$R = 2800 / 5300 = 0.528$

Compute Unconstrained Weaving and Nonweaving Speeds

Weaving intensity factors are computed from Table 5.

For assumed unconstrained conditions on a Type B weaving section:

$$W_i = \frac{a(1+VR)^b\left(\frac{v}{N}\right)^c}{(3.28L)^d}$$

$$W_w = \frac{0.08(1+0.726)^{2.2}\left(\frac{7300}{4}\right)^{0.70}}{(3.28*450)^{0.50}} = 1.327$$

$$W_{nw} = \frac{0.0020(1+0.726)^{6.0}\left(\frac{7300}{4}\right)^{1.0}}{(3.28*450)^{0.50}} = 2.51$$

Then, on the basis of a free-flow speed, S_{FF} , of 65 mph, the weaving and nonweaving vehicle speeds can be estimated:

$S_i = 24 + (S_{FF} - 16)/(1+W)$

$S_w = 24 + (104 - 16) / (1+1.327) = 61.81$ km/h = 38.63 mph

$S_{nw} = 24 + (104 - 16) / (1+ 2.512) = 49.05$ km/h = 30.66 mph

Check for Constrained Operation

$N_w = N[0.085 + 0.703VR + (71.57/L) – 0.0112 (S_{nw} - S_w)]$

$N_w = 4[0.085 + 0.703(0.357) + (71.57/450) – 0.0112 (30.66 – 38.63)]$

$N_w = 3.54$

As this is greater than N_w (max) of 3.5 lanes for a Type B weaving section, the section operates in a **constrained** mode.

Repeat the step for constrained Weaving and Nonweaving Speeds

Weaving intensity factors are computed from Table 5.

For constrained conditions on a Type B weaving section:

$$W_w = \frac{0.15(1+0.726)^{2.2}\left(\frac{7300}{4}\right)^{0.70}}{(3.28*450)^{0.50}} = 2.488$$

$$W_{nw} = \frac{0.0010(1+0.726)^{6.0}\left(\frac{7300}{4}\right)^{1.0}}{(3.28*450)^{0.50}} = 1.256$$

Then, on the basis of a free-flow speed, S_{FF} , of 65 mph, the weaving and nonweaving vehicle speeds can be estimated:

$S_i = 24 + (S_{FF} - 16)/(1+W)$

$S_w = 24 + (104 - 16) / (1+2.488) = 49.23$ km/h = 30.77 mph

$S_{nw} = 24 + (104 - 16) / (1+ 1.256) = 63.01$ km/h = 39.38 mph

Compute Average (Space Mean) Speed and Density of All Vehicles in Weaving Area

$S = (v_w + v_{nw})/(v_w/S_w + V_{nw}/S_{nw})$

$S = (5300 + 2000) / (5300 / 49.23 + 2000 / 63.01) = 52.36$ km/h = 32.73 mph

$D = (v/N)/S$

$D = (7300 / 4) / 32.73 = 55.76$ veh/mi/ln

After consultation with Table 7 the LOS F.

Check Weaving Area Limitations

None of the limitations have been violated, and the results seem to be appropriate.

Type C – Volume 1

Establish Roadway and Traffic Conditions

All the traffic conditions are specified in the calculation description and Figure below

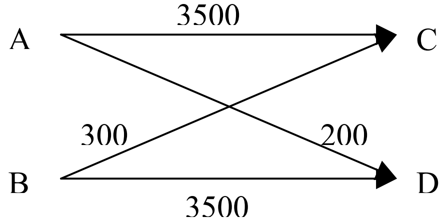
Convert All Traffic Volumes to Peak Flow Rates Under Ideal Conditions

A-C = 3500 pcph

A-D = 200 pcph

B-C = 300 pcph

B-D = 3500 pcph



Construct Weaving Diagram

The weaving diagram is shown in Figures above. Critical ratios may be computed as follows:

$V_w = 300 + 200 = 500$ pcph

$V_{nw} = 3500 + 3500 = 7000$ pcph

$V = 500 + 7000 = 7500$ pc/h

$VR = 500 / 7500 = 0.067$

$R = 200 / 500 = 0.400$

Compute Unconstrained Weaving and Nonweaving Speeds

Weaving intensity factors are computed from Table 5.

For assumed unconstrained conditions on a Type B weaving section:

$$W_i = \frac{a(1+VR)^b \left(\frac{v}{N}\right)^c}{(3.28L)^d}$$

$$W_w = \frac{0.08(1+0.067)^{2.3}\left(\frac{7500}{5}\right)^{0.80}}{(3.28*300)^{0.60}} = 0.516$$

$$W_{nw} = \frac{0.0020(1+0.067)^{6.0}\left(\frac{7500}{5}\right)^{1.1}}{(3.28*300)^{0.60}} = 0.147$$

Then, on the basis of a free-flow speed, S_{FF} , of 65 mph, the weaving and nonweaving vehicle speeds can be estimated:

$S_i = 24 + (S_{FF} - 16)/(1+W)$

$S_w = 24 + (104 - 16) / (1+0.516) = 82.05$ km/h $= 51.28$ mph

$S_{nw} = 24 + (104 - 16) / (1+ 0.147) = 100.73$ km/h $= 62.95$ mph

Check for Constrained Operation

$N_w = N\,[0.761 + 0.047VR - 0.00036L - 0.0031(S_{nw} - S_w)]$

$N_w = 5\,[0.761 + 0.047*0.0.067 - 0.00036*300 - 0.0031\,(100.73 - 82.05)]$

$N_w = 2.99$

As this is lesser than N_w (max) of 3.0 lanes for a Type C weaving section, the section operates in an **unconstrained** mode.

Compute Average (Space Mean) Speed and Density of All Vehicles in Weaving Area

$S = (v_w + v_{nw})/(v_w/S_w + V_{nw}/S_{nw})$

$S = (500 + 7000) / (500 / 82.05 + 7000 / 100.73) = 99.22$ km/h = 62.01 mph

$D= (v/N)/S$

$D= (7500 / 5) / 62.01 = 24.19$ v/mi/ln

After consultation with Table 7 the LOS C.

Check Weaving Area Limitations

None of the limitations have been violated, and the results seem to be appropriate.

Type C – Volume 2

Establish Roadway and Traffic Conditions

All the traffic conditions are specified in the calculation description and Figure below

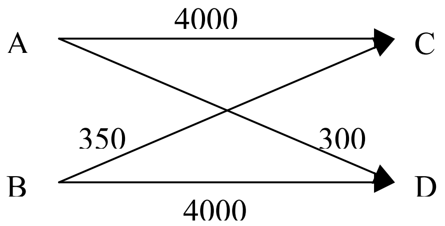
Convert All Traffic Volumes to Peak Flow Rates Under Ideal Conditions

A-C = 4000 pcph

A-D = 300 pcph

B-C = 350 pcph

B-D = 4000 pcph



Construct Weaving Diagram

The weaving diagram is shown in Figures above. Critical ratios may be computed as follows:

$V_w = 350 + 300 = 650$ pcph

$V_{nw} = 4000 + 4000 = 8000$ pcph

$V = 650 + 8000 = 8650$ pc/h

$VR = 650 / 8650 = 0.075$

R = 300 / 650 = 0.462

Compute Unconstrained Weaving and Nonweaving Speeds

Weaving intensity factors are computed from Table 5.

For assumed unconstrained conditions on a Type B weaving section:

$$W_i = \frac{a(1+VR)^b \left(\frac{v}{N}\right)^c}{(3.28L)^d}$$

$$W_w = \frac{0.08(1+0.075)^{2.3}\left(\frac{8650}{5}\right)^{0.80}}{(3.28*300)^{0.60}} = 0.589$$

$$W_{nw} = \frac{0.0020(1+0.075)^{6.0}\left(\frac{8650}{5}\right)^{1.1}}{(3.28*300)^{0.60}} = 0.18$$

Then, on the basis of a free-flow speed, S_{FF}, of 65 mph, the weaving and nonweaving vehicle speeds can be estimated:

$S_i = 24 + (S_{FF} - 16)/(1+W)$

$S_w = 24 + (104 - 16) / (1+0.589) = 79.38$ km/h = 49.61 mph

$S_{nw} = 24 + (104 - 16) / (1+ 0.18) = 98.56$ km/h = 61.6 mph

Check for Constrained Operation

$N_w = N\,[0.761 + 0.047VR - 0.00036L - 0.0031(S_{nw} - S_w)]$

$N_w = 5\,[0.761 + 0.047*0.075 - 0.00036*300 - 0.0031\,(98.56 - 79.38)]$

$N_w = 2.99$

As this is greater than N_w (max) of 3.0 lanes for a Type C weaving section, the section operates in an **unconstrained** mode.

Compute Average (Space Mean) Speed and Density of All Vehicles in Weaving Area

$S = (v_w + v_{nw})/(v_w/S_w + V_{nw}/S_{nw})$

$S = (650 + 8000) / (650 / 79.38 + 8000 / 98.56) = 96.8$ km/h = 60.5 mph

$D = (v/N)/S$

D= (8650/5) / 60.5 = 28.59 veh/mi/ln

After consultation with Table 7 the LOS D.

Check Weaving Area Limitations

None of the limitations have been violated, and the results seem to be appropriate.

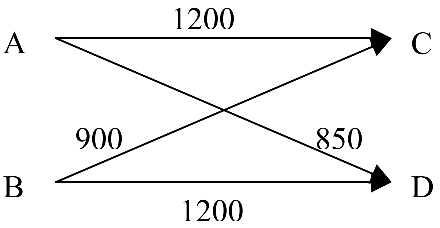
Type C – Volume 3

Establish Roadway and Traffic Conditions

All the traffic conditions are specified in the calculation description and Figure below

Convert All Traffic Volumes to Peak Flow Rates Under Ideal Conditions

A-C = 1200 pcph
A-D = 850 pcph
B-C = 900 pcph
B-D = 1200 pcph



Construct Weaving Diagram

The weaving diagram is shown in Figures above. Critical ratios may be computed as follows:

$V_w = 900 + 850 = 1750$ pcph

$V_{nw} = 1200 + 1200 = 2400$ pcph

$V = 1750 + 2400 = 4150$ pc/h

$VR = 1750 / 4150 = 0.422$

$R = 850 / 1750 = 0.486$

Compute Unconstrained Weaving and Nonweaving Speeds

Weaving intensity factors are computed from Table 5.

For assumed unconstrained conditions on a Type B weaving section:

$$W_i = \frac{a(1+VR)^b \left(\frac{v}{N}\right)^c}{(3.28L)^d}$$

$$W_w = \frac{0.08(1+0.422)^{2.3}\left(\frac{4150}{5}\right)^{0.80}}{(3.28*300)^{0.60}} = 0.622$$

$$W_{nw} = \frac{0.0020(1+0.422)^{6.0}\left(\frac{4150}{5}\right)^{1.1}}{(3.28*300)^{0.60}} = 0.429$$

Then, on the basis of a free-flow speed, S_{FF} , of 65 mph, the weaving and nonweaving vehicle speeds can be estimated:

$S_i = 24 + (S_{FF} - 16)/(1+W)$

$S_w = 24 + (104 - 16) / (1+0.622) = 78.24$ km/h = 48.9 mph

$S_{nw} = 24 + (104 - 16) / (1+ 0.429) = 85.56$ km/h = 53.47 mph

Check for Constrained Operation

$N_w = N [0.761 + 0.047VR - 0.00036L - 0.0031(S_{nw} - S_w)]$

$N_w = 5 [0.761 + 0.047*0.424 - 0.00036*300 - 0.0031 (85.56 - 78.24)]$

$N_w = 3.25$

As this is greater than N_w (max) of 3.0 lanes for a Type C weaving section, the section operates in a **constrained** mode.

Repeat for Constrained Operation

Weaving intensity factors are computed from Table 5.

For constrained conditions on a Type C weaving section:

$$W_w = \frac{0.14(1+0.422)^{2.3}\left(\frac{4150}{5}\right)^{0.80}}{(3.28*300)^{0.60}} = 1.089$$

$$W_{nw} = \frac{0.001(1+0.422)^{6.0}\left(\frac{4150}{5}\right)^{1.1}}{(3.28*300)^{0.60}} = 0.215$$

$S_w = 24 + (104 - 16) / (1+1.089) = 66.13$ km/h = 41.33 mph

$S_{nw} = 24 + (104 - 16) / (1+ 0.215) = 96.44$ km/h = 60.28 mph

Compute Average (Space Mean) Speed and Density of All Vehicles in Weaving Area

$S = (v_w + v_{nw})/(v_w/S_w + V_{nw}/S_{nw})$

S = (1750 + 2400) / (1750 / 66.13 + 2400 / 96.44) = 80.82 km/h = 50.51 mph

D= (v/N)/S

D= (4150 / 5) / 50.51 = 16.43 veh/mi/ln

After consultation with Table 7 the LOS B.

Check Weaving Area Limitations

None of the limitations have been violated, and the results seem to be appropriate.

Type C – Volume 4

Establish Roadway and Traffic Conditions

All the traffic conditions are specified in the calculation description and Figure below

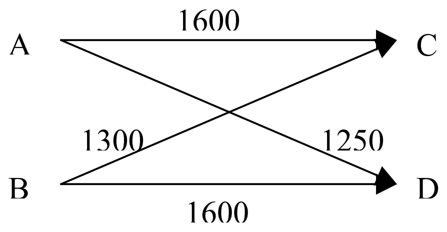
Convert All Traffic Volumes to Peak Flow Rates Under Ideal Conditions

A-C = 1600 pcph

A-D = 1250 pcph

B-C = 1300 pcph

B-D = 1600 pcph



Construct Weaving Diagram

The weaving diagram is shown in Figures above. Critical ratios may be computed as follows:

V_w = 1300 + 1250 = 2550 pcph

V_{nw} = 1600 + 1600 = 3200 pcph

V = 2550 + 3200 = 5750 pc/h

VR = 2550 / 5750 = 0.443

R = 1250 / 2550 = 0.49

Compute Unconstrained Weaving and Nonweaving Speeds

Weaving intensity factors are computed from Table 5.

For assumed unconstrained conditions on a Type B weaving section:

$$W_i = \frac{a(1+VR)^b\left(\frac{v}{N}\right)^c}{(3.28L)^d}$$

$$W_w = \frac{0.08(1+0.443)^{2.3}\left(\frac{5750}{5}\right)^{0.80}}{(3.28*300)^{0.60}} = 0.837$$

$$W_{nw} = \frac{0.0020(1+0.443)^{6.0}\left(\frac{5750}{5}\right)^{1.1}}{(3.28*300)^{0.60}} = 0.674$$

Then, on the basis of a free-flow speed, S_{FF}, of 65 mph, the weaving and non-weaving vehicle speeds can be estimated:

$S_i = 24 + (S_{FF} - 16)/(1+W)$

$S_w = 24 + (104 - 16) / (1+0.837) = 71.92$ km/h = 44.95 mph

$S_{nw} = 24 + (104 - 16) / (1+ 0.674) = 76.58$ km/h = 47.86 mph

Check for Constrained Operation

$N_w = N [0.761 + 0.047VR - 0.00036L - 0.0031(S_{nw} - S_w)]$

$N_w = 5 [0.761 + 0.047*0.443 - 0.00036*300 - 0.0031 (76.58 - 71.92)]$

$N_w = 3.29$

As this is greater than N_w (max) of 3.0 lanes for a Type C weaving section, the section operates in a **constrained** mode.

Repeat for Constrained Operation

Weaving intensity factors are computed from Table 5.

For constrained conditions on a Type C weaving section:

$$W_w = \frac{0.14(1+0.443)^{2.3}\left(\frac{5750}{5}\right)^{0.80}}{(3.28*300)^{0.60}} = 1.464$$

$$W_{nw} = \frac{0.001(1+0.443)^{6.0}\left(\frac{5750}{5}\right)^{1.1}}{(3.28*300)^{0.60}} = 0.337$$

S_w = 24 + (104 - 16) / (1+1.464) = 59.72 km/h = 37.32 mph

S_{nw} = 24 + (104 - 16) / (1+ 0.337) = 89.83 km/h = 56.14 mph

Compute Average (Space Mean) Speed and Density of All Vehicles in Weaving Area

$S = (v_w + v_{nw})/(v_w/S_w + V_{nw}/S_{nw})$

S = (2550 + 3200) / (2550 / 59.72 + 3200 / 89.83) = 73.41 km/h = 45.88 mph

D= (v/N)/S

D= (5750/5) / 45.88 = 25.06 veh/mi/ln

After consultation with Table 7 the LOS C.

Check Weaving Area Limitations

None of the limitations have been violated, and the results seem to be appropriate.

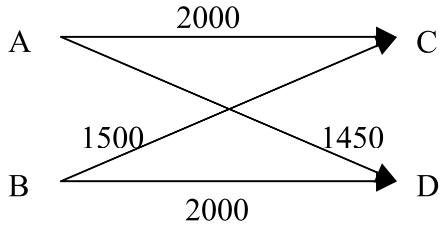
Type C – Volume 5

Establish Roadway and Traffic Conditions

All the traffic conditions are specified in the calculation description and Figure below

Convert All Traffic Volumes to Peak Flow Rates Under Ideal Conditions

A-C = 2000 pcph
A-D = 1450 pcph
B-C = 1500 pcph
B-D = 2000 pcph



Construct Weaving Diagram

The weaving diagram is shown in Figures above. Critical ratios may be computed as follows:

$V_w = 1500 + 1450 = 2950$ pcph

$V_{nw} = 2000 + 2000 = 4000$ pcph

$V = 4000 + 2950 = 6950$ pc/h

$VR = 2950 / 6950 = 0.424$

$R = 1450 / 2950 = 0.492$

Compute Unconstrained Weaving and Nonweaving Speeds

Weaving intensity factors are computed from Table 5.

For assumed unconstrained conditions on a Type B weaving section:

$$W_i = \frac{a(1+VR)^b\left(\frac{v}{N}\right)^c}{(3.28L)^d}$$

$$W_w = \frac{0.08(1+0.424)^{2.3}\left(\frac{6950}{5}\right)^{0.80}}{(3.28*300)^{0.60}} = 0.944$$

$$W_{nw} = \frac{0.0020(1+0.424)^{6.0}\left(\frac{6950}{5}\right)^{1.1}}{(3.28*300)^{0.60}} = 0.765$$

Then, on the basis of a free-flow speed, S_{FF}, of 65 mph, the weaving and nonweaving vehicle speeds can be estimated:

$S_i = 24 + (S_{FF} - 16)/(1+W)$

$S_w = 24 + (104 - 16) / (1+0.944) = 69.27$ km/h = 43.29 mph

$S_{nw} = 24 + (104 - 16) / (1+ 0.765) = 73.86$ km/h = 46.16 mph

Check for Constrained Operation

$N_w = N [0.761 + 0.047VR - 0.00036L - 0.0031(S_{nw} - S_w)]$

$N_w = 5 [0.761 + 0.047*0.424 - 0.00036*300 - 0.0031 (73.82 - 69.26)]$

$N_w = 3.29$

As this is greater than N_w (max) of 3.0 lanes for a Type C weaving section, the section operates in a **constrained** mode.

Repeat for Constrained Operation

Weaving intensity factors are computed from Table 5.

For constrained conditions on a Type C weaving section:

$$W_w = \frac{0.14(1+0.424)^{2.3}\left(\frac{6950}{5}\right)^{0.80}}{(3.28*300)^{0.60}} = 1.651$$

$$W_{nw} = \frac{0.001(1+0.424)^{6.0}\left(\frac{6950}{5}\right)^{1.1}}{(3.28*300)^{0.60}} = 0.382$$

S_w = 24 + (104 - 16) / (1+1.651) = 57.2 km/h = 35.75 mph

S_{nw} =24 + (104 - 16) / (1+ 0.382) = 87.68 km/h = 54.8 mph

Compute Average (Space Mean) Speed and Density of All Vehicles in Weaving Area

$S = (v_w + v_{nw})/(v_w/S_w + V_{nw}/S_{nw})$

S = (2950 + 4000) / (2950 / 57.2 + 4000 / 87.68) = 71.51 km/h = 44.69 mph

D= (v/N)/S

D= (6950 / 5) / 44.69 = 31.1 v/mi/ln

After consultation with Table 7 the LOS D.

Check Weaving Area Limitations

None of the limitations have been violated, and the results seem to be appropriate.

APPENDIX B

TRANSIMS FILES

Type A

Node File

```
ID    EASTING     NORTHING    ELEVATION   NOTES
1     -2968 0     0
2     -2368 0     0
3     0     0     0
4     304   0     0
5     2000  0     0
6     3664  0     0
7     -4900 -2650 0
8     -2650 -2650 0
9     1304  -1000 0
10    2350  -2050 0
11    1304  -1000 0
12    -2968 0     1
13    -2968 0     2
```

Link File

```
ID    NAME  NODEA NODEB PERMLANESA  PERMLANESB  LEFTPCKTSA  LEFTPCKTSB  RGHTPCKTSA  RGHTPCKTSB  TWOWAYTURN
      LENGTH      GRADE SETBACKA    SETBACKB    CAPACITYA   CAPACITYB   SPEEDLMTA   SPEEDLMTB   FREESPDA
      FREESPDB    FUNCTCLASS  THRUA THRUB COLOR VEHICLE     NOTES
1     [unknown]   2     1     0     1     0     0     0     0     0     608   0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     0     1     AUTO
11    [unknown]   2     11    0     1     0     0     0     0     0     608   0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     0     1     AUTO
12    [unknown]   2     12    0     1     0     0     0     0     0     608   0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     0     1     AUTO
```

```
2     [unknown]   2     3     0     3     0     0     0     0     0     2368  0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     0     1     AUTO
3     [unknown]   3     4     0     4     0     0     0     0     0     304   0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     0     1     AUTO
4     [unknown]   4     5     0     3     0     0     0     0     0     1664  0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     0     1     AUTO
5     [unknown]   5     6     0     3     0     0     0     0     0     1664  0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     0     1     AUTO
6     [unknown]   7     8     0     1     0     0     0     0     0     2272  0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     0     1     AUTO
7     [unknown]   8     9     0     1     0     0     0     0     0     912   0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     0     1     AUTO
8     [unknown]   9     3     0     1     0     0     0     0     0     2864  0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     0     1     AUTO
9     [unknown]   11    10    0     1     0     0     0     0     0     944   0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     0     1     AUTO
10    [unknown]   4     11    0     1     0     0     0     0     0     1404  0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     0     1     AUTO
```

Lane Connectivity File

```
NODE  INLINK      INLANE      OUTLINK     OUTLANE     NOTES
2     1     1     2     1
2     11    1     2     2
2     12    1     2     3
3     2     1     3     1
3     2     2     3     2
3     2     3     3     3
3     8     1     3     4
4     3     1     4     1
4     3     2     4     2
4     3     3     4     3
4     3     4     10    1
5     4     1     5     1
5     4     2     5     2
5     4     3     5     3
8     6     1     7     1
9     7     1     8     1
```

```
11    10    1     9     1

Parking File

ID    NODE  LINK  OFFSET      STYLE CAPACITY    GENERIC     VEHICLE     STARTTIME   ENDTIME     NOTES
1     2     1     600   LOT   0     T     AUTO  ALL00:00    ALL24:00
2     2     11    600   LOT   0     T     AUTO  ALL00:00    ALL24:00
3     2     12    600   LOT   0     T     AUTO  ALL00:00    ALL24:00
4     8     6     2250  LOT   0     T     AUTO  ALL00:00    ALL24:00
5     6     5     10    LOT   0     T     AUTO  ALL00:00    ALL24:00
6     5     4     10    LOT   0     T     AUTO  ALL00:00    ALL24:00
7     10    9     10    LOT   0     T     AUTO  ALL00:00    ALL24:00

Unsignalised Nodes file

NODE  INLINK      SIGN  NOTES
2     1     N
2     11    N
2     12    N
3     2     N
3     8     N
4     3     N
5     4     N
8     6     N
9     7     N
11    10    N
10    9     N
6     5     N
```

Type B

```
Node File

ID    EASTING     NORTHING    ELEVATION   NOTES
1     448   2736  0
2     752   2720  0
3     2720  2720  0
```

```
8     1360  1056  0
9     1056  608   0
5     3184  2720  0
6     4096  3024  0
10    4096  2272  0
7     5008  3632  0
11    4704  1968  0
12    448   2736  1
13    1056  608   1
```

Link File

```
ID    NAME  NODEA NODEB PERMLANESA  PERMLANESB  LEFTPCKTSA  LEFTPCKTSB  RGHTPCKTSA  RGHTPCKTSB  TWOWAYTURN
      LENGTH      GRADE SETBACKA    SETBACKB    CAPACITYA   CAPACITYB   SPEEDLMTA   SPEEDLMTB   FREESPDA
      FREESPDB    FUNCTCLASS  THRUA THRUB COLOR VEHICLE     NOTES
1     [unknown]   1     2     0     1     0     0     0     0     0     304   0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     2     1     AUTO
2     [unknown]   2     3     0     2     0     0     0     0     0     1824  0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     3     2     AUTO
3     [unknown]   3     5     0     4     0     0     0     0     0     448   0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     4     3     AUTO
7     [unknown]   8     3     0     2     0     0     0     0     0     2064  0     0     0     1     1
      20.13 20.13 37.5  37.5  FREEWAY     0     3     0     AUTO
8     [unknown]   9     8     0     1     0     0     0     0     0     528   0     0     0     1     1
      20.13 20.13 37.5  37.5  FREEWAY     0     7     0     AUTO
5     [unknown]   5     6     0     3     0     0     0     0     0     944   0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     6     5     AUTO
9     [unknown]   5     10    0     2     0     0     0     0     0     1024  0     0     0     1     1
      20.13 20.13 37.5  37.5  FREEWAY     0     10    0     AUTO
6     [unknown]   6     7     0     3     0     0     0     0     0     1088  0     0     0     1     1
      29.08 29.08 37.5  37.5  RAMP  0     0     6     AUTO
10    [unknown]   10    11    0     2     0     0     0     0     0     688   0     0     0     1     1
      29.08 29.08 37.5  37.5  RAMP  0     0     0     AUTO
11    [unknown]   12    2     0     1     0     0     0     0     0     304   0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     2     1     AUTO
12    [unknown]   13    8     0     1     0     0     0     0     0     528   0     0     0     1     1
      20.13 20.13 37.5  37.5  FREEWAY     0     7     0     AUTO
```

Lane Connectivity File

```
NODE  INLINK      INLANE      OUTLINK     OUTLANE     NOTES
2     1     1     2     1
2     11    1     2     2
3     2     1     3     1
3     2     2     3     2
3     7     1     3     3
3     7     2     3     4
8     8     1     7     1
8     12    1     7     2
5     3     1     5     1
5     3     2     5     2
5     3     3     5     3
5     3     3     9     1
5     3     4     9     2
6     5     1     6     1
6     5     2     6     2
6     5     3     6     3
10    9     1     10    1
10    9     2     10    2
```

Parking File

```
ID    NODE  LINK  OFFSET      STYLE CAPACITY    GENERIC     VEHICLE     STARTTIME   ENDTIME     NOTES
1     2     1     300   LOT   0     T     AUTO  ALL00:00    ALL24:00
2     8     8     520   LOT   0     T     AUTO  ALL00:00    ALL24:00
3     7     6     10    LOT   0     T     AUTO  ALL00:00    ALL24:00
4     11    10    10    LOT   0     T     AUTO  ALL00:00    ALL24:00
5     2     11    300   LOT   0     T     AUTO  ALL00:00    ALL24:00
6     8     12    520   LOT   0     T     AUTO  ALL00:00    ALL24:00
7     7     6     500   LOT   0     T     AUTO  ALL00:00    ALL24:00
```

Unsignalised Nodes file

```
NODE  INLINK      SIGN  NOTES
2     1     N
2     11    N
```

```
3     2     N
3     7     N
5     3     N
6     5     N
7     6     N
8     8     N
8     12    N
10    9     N
11    10    N
```

Type C

```
Node File

ID    EASTING     NORTHING    ELEVATION   NOTES
1     448   2736  0
2     752   2736  0
3     2720  2736  0
4     2880  2736  0
5     3024  2736  0
6     11936 3024  0
7     20848 3632  0
8     1360  1056  0
9     1056  608   0
10    11936 2272  0
11    20544 1968  0
12    448   2736  1
13    1056  608   1
14    1056  608   2

Link File

ID    NAME  NODEA NODEB PERMLANESA  PERMLANESB  LEFTPCKTSA  LEFTPCKTSB  RGHTPCKTSA  RGHTPCKTSB  TWOWAYTURN
      LENGTH      GRADE SETBACKA    SETBACKB    CAPACITYA   CAPACITYB   SPEEDLMTA   SPEEDLMTB   FREESPDA
      FREESPDB    FUNCTCLASS  THRUA THRUB COLOR VEHICLE     NOTES
1     [unknown]   1     2     0     1     0     0     0     0     0     304   0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     2     1     AUTO
```

```
2     [unknown]   2     3     0     2     0     0     0     0     0     1824  0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     3     2     AUTO
3     [unknown]   3     4     0     5     0     0     0     0     0     144   0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     4     3     AUTO
4     [unknown]   4     5     0     5     0     0     0     0     0     144   0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     5     4     AUTO
5     [unknown]   5     6     0     3     0     0     0     0     0     8917  0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     6     5     AUTO
6     [unknown]   6     7     0     3     0     0     0     0     0     8933  0     0     0     1     1
      29.08 29.08 37.5  37.5  RAMP  0     0     6     AUTO
7     [unknown]   8     3     0     3     0     0     0     0     0     2064  0     0     0     1     1
      20.13 20.13 37.5  37.5  FREEWAY     0     3     0     AUTO
8     [unknown]   9     8     0     1     0     0     0     0     0     528   0     0     0     1     1
      20.13 20.13 37.5  37.5  FREEWAY     0     7     0     AUTO
9     [unknown]   5     10    0     2     0     0     0     0     0     8924  0     0     0     1     1
      20.13 20.13 37.5  37.5  FREEWAY     0     10    0     AUTO
10    [unknown]   10    11    0     2     0     0     0     0     0     8613  0     0     0     1     1
      20.13 20.13 37.5  37.5  FREEWAY     0     0     0     AUTO
11    [unknown]   12    2     0     1     0     0     0     0     0     304   0     0     0     1     1
      29.08 29.08 37.5  37.5  FREEWAY     0     2     1     AUTO
12    [unknown]   13    8     0     1     0     0     0     0     0     528   0     0     0     1     1
      20.13 20.13 37.5  37.5  FREEWAY     0     7     0     AUTO
13    [unknown]   14    8     0     1     0     0     0     0     0     528   0     0     0     1     1
      20.13 20.13 37.5  37.5  FREEWAY     0     7     0     AUTO
```

Lane Connectivity File

```
NODE  INLINK      INLANE      OUTLINK     OUTLANE     NOTES
2     1     1     2     1
2     11    1     2     1
3     2     1     3     1
3     2     2     3     2
3     7     1     3     3
3     7     2     3     4
3     7     3     3     5
4     3     1     4     1
4     3     2     4     2
4     3     3     4     3
```

```
4     3     4     4     4
4     3     5     4     5
5     4     1     5     1
5     4     2     5     2
5     4     3     5     3
5     4     3     9     1
5     4     4     9     2
5     4     5     9     3
6     5     1     6     1
6     5     2     6     2
6     5     3     6     3
8     8     1     7     1
8     12    1     7     1
8     13    1     7     1
10    9     1     10    1
10    9     2     10    2
10    9     3     10    3
```

Parking File

```
ID    NODE  LINK  OFFSET      STYLE CAPACITY    GENERIC     VEHICLE     STARTTIME   ENDTIME     NOTES
1     2     1     300   LOT   0     T     AUTO  ALL00:00    ALL24:00
2     8     8     520   LOT   0     T     AUTO  ALL00:00    ALL24:00
3     7     6     10    LOT   0     T     AUTO  ALL00:00    ALL24:00
4     11    10    10    LOT   0     T     AUTO  ALL00:00    ALL24:00
5     2     11    300   LOT   0     T     AUTO  ALL00:00    ALL24:00
6     8     12    520   LOT   0     T     AUTO  ALL00:00    ALL24:00
7     8     13    520   LOT   0     T     AUTO  ALL00:00    ALL24:00
```

Unsignalised Nodes file

```
NODE  INLINK      SIGN  NOTES
2     1     N
2     11    N
3     2     N
3     7     N
4     3     N
5     4     N
```

```
6     5     N
7     6     N
8     8     N
8     12    N
8     13    N
10    9     N
11    10    N
```

APPENDIX C

CORSIM FILES

Type A – volume 1

```
                                                     TRAF SIMULATION MODEL

                                                          DEVELOPED FOR

                                                U. S. DEPARTMENT OF TRANSPORTATION
                                                  FEDERAL HIGHWAY ADMINISTRATION
              FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

   1                                       Input CARD FILE LIST

0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

     1 :ITRAF 2.0                                                                    00
     2 :                                                                               1
     3 :       1   1      15                               8 8        7781    7581     2
     4 :1800                                                                           3
     5 :                  60                                                           4
     6 :                                                                               5
     7 :8001   1   2     0 3                         1                                19
     8 :   2   3   4 10000 3 93 1000                 1 9                              19
     9 :   3   48002 55000 3                         1                                19
    10 :   5   2   3 94861 1                         9                                19
    11 :   3   68004 46491 1                         1                                19
    12 :   7   5   2 30001 1                         1                                19
    13 :8003   7   5     1 1                         1                                19
    14 :   1   2   3 78100 3                         1                                19
    15 :8001   1         1  65                                                        20
    16 :   2   3         12265       5280                                             20
    17 :   3   4         1  65                                                        20
    18 :   5   2         1  45                                                        20
    19 :   3   6         1  45                                                        20
    20 :   7   5         1  45                                                        20
    21 :8003   7         1  45                                                        20
    22 :   1   2         12265                                                        20
    23 :8001   1   24300                                                              25
    24 :   2   3   44600   6 400                                                      25
    25 :   3   480024600                                                              25
    26 :   5   2   3 700                                                              25
    27 :   3   68004 400                                                              25
```

```
    28 :   7   5   2 700                                                              25
    29 :8003   7   5 700                                                              25
    30 :   1   2   34300                                                              25
    31 :   2   3   9  40  20  10   2   1                                              28
    32 :   2   3   1  40  20  10   2   2                                              28
    33 :   2   3   2  40  20  10   2   2                                              28
    34 :   2   3   3  40  20  10   2   2                                              28
    35 :   2   3   9 200  20  10   2   3                                              28
    36 :   2   3   1 200  20  10   2   4                                              28
    37 :   2   3   2 200  20  10   2   4                                              28
    38 :   2   3   3 200  20  10   2   4                                              28
    39 :   2   3   9 500  20  10   2   5                                              28
    40 :   2   3   1 500  20  10   2   6                                              28
    41 :   2   3   2 500  20  10   2   6                                              28
    42 :   2   3   3 500  20  10   2   6                                              28
    43 :   2   3   9 980  20  10   2   7                                              28
    44 :   2   3   1 980  20  10   2   8                                              28
    45 :   2   3   2 980  20  10   2   8                                              28
    46 :   2   3   3 980  20  10   2   8                                              28
    47 :8001   14300                                                 20 40 40         50
    48 :8003   7 700                                                                  50
    49 :       1 900  60                                      17   1                  64
    50 :   1 2 3 4 5 6 7 8                                                            67
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

1                                   CARD FILE LIST (CONT.)
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

    51 :  15  14  13  12  11  10   9   8   7   6                                      68
    52 :  16  16  16  16   3   1                                                      69
    53 :  20  16   1  20                                                              70
    54 :   1  14   7 150  25               1                                          71
    55 :   2   3  14   2   4  86   1   3   7   1   4  93                              74
    56 :   0                                                                         170
    57 :   1       0   16000                                                         195
    58 :   2    6000   11000                                                         195
    59 :   3    7000   11000                                                         195
    60 :   4   12500   11000                                                         195
    61 :   5    3000    2000                                                         195
    62 :   6   10500    7500                                                         195
    63 :8001       0   14000                                                         195
    64 :8002   15500   11000                                                         195
    65 :8003    1000    9500                                                         195
    66 :8004   11500    4500                                                         195
    67 :   7       0    2000                                                         195
    68 :   1                                                                         210
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
```

OUTPUT RESULTS

```
                                                          TRAF SIMULATION MODEL

                                                             DEVELOPED FOR

                                                   U. S. DEPARTMENT OF TRANSPORTATION
                                                     FEDERAL HIGHWAY ADMINISTRATION
                                        FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

0                          ITRAF 2.0

 ***********************************************************************************************************************************
1
                                            CUMULATIVE FRESIM STATISTICS AT TIME  8 30  0
                                        -----------------------------------------------------

                                                          LINK STATISTICS
                                                                                         VEH-MIN/
                                                            SECONDS/VEHICLE              VEH-MILE
                                                           ------------------         -----------
                 VEHICLES  LANE  CURR  AVG    VEH-     VEH-    TOTAL  MOVE DELAY                          VOLUME     DENSITY         SPEED   LINK
   LINK          IN   OUT  CHNG  CONT  CONT  MILES      MIN     TIME  TIME  TIME   M/T  TOTAL DELAY VEH/LN/HR VEH/LN-MILE   MILE/HR  TYPE
----------- ----- ----- ---- ----- ----- ------- ------- ------ ----- ----- ----- ----- -----  -------   ---------  ---------- ----

(   2,    3)  2496  2492  727    12  15.7  472.7   471.3   11.3  10.6    .8   .93  1.00   .07   1248.0      20.7          60.18   FRWY

(   3,    4)  2295  2303 1110    74  77.2 2397.0  2317.2   60.4  57.9   2.5   .96   .97   .04   1534.1      24.7          62.07   FRWY

(   5,    2)   352   352    0    30  30.1  627.6   902.6  155.0 144.7  10.3   .93  1.44   .10    698.6      16.7          41.72   RAMP

(   3,    6)   197   198    0    12   8.0  173.9   240.2   73.0  70.7   2.2   .97  1.38   .04    395.0       9.1          43.44   RAMP

(   7,    5)   349   352    0     7   9.1  199.9   271.6   46.3  45.7    .6   .99  1.36   .02    703.5      15.9          44.15   RAMP

(   1,    2)  2148  2144 1248   106 101.3 3185.1  3038.8   84.7  82.3   2.4   .97   .95   .03   1435.6      22.8          62.89   FRWY
```

Type A – Volume 2

```
                                                      TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

1                                       INPUT CARD FILE LIST
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

     1 :ITRAF 2.0                                                                     00
     2 :                                                                               1
     3 :       1   1      15                               8 8        7781    7581     2
     4 :1800                                                                           3
     5 :                  60                                                           4
     6 :                                                                               5
     7 :8001   1   2     0 3                         1                                19
     8 :   2   3   4 10000 3 93 1000                 1 9                              19
     9 :   3   48002 55000 3                         1                                19
    10 :   5   2   3 94861 1                         9                                19
    11 :   3   68004 46491 1                         1                                19
    12 :   7   5   2 30001 1                         1                                19
    13 :8003   7   5     1 1                         1                                19
    14 :   1   2   3 78100 3                         1                                19
    15 :8001   1         1  65                                                        20
    16 :   2   3         12265       5280                                             20
    17 :   3   4         1  65                                                        20
    18 :   5   2         1  45                                                        20
    19 :   3   6         1  45                                                        20
    20 :   7   5         1  45                                                        20
    21 :8003   7         1  45                                                        20
    22 :   1   2         12265                                                        20
    23 :8001   1   25450                                                              25
    24 :   2   3   45800   6 550                                                      25
    25 :   3   480025800                                                              25
    26 :   5   2   3 900                                                              25
    27 :   3   68004 550                                                              25
    28 :   7   5   2 900                                                              25
    29 :8003   7   5 900                                                              25
    30 :   1   2   35450                                                              25
    31 :   2   3   9  40  20  10   2   1                                              28
    32 :   2   3   1  40  20  10   2   2                                              28
```

```
    33 :   2   3   2  40  20  10   2   2                                              28
    34 :   2   3   3  40  20  10   2   2                                              28
    35 :   2   3   9 200  20  10   2   3                                              28
    36 :   2   3   1 200  20  10   2   4                                              28
    37 :   2   3   2 200  20  10   2   4                                              28
    38 :   2   3   3 200  20  10   2   4                                              28
    39 :   2   3   9 500  20  10   2   5                                              28
    40 :   2   3   1 500  20  10   2   6                                              28
    41 :   2   3   2 500  20  10   2   6                                              28
    42 :   2   3   3 500  20  10   2   6                                              28
    43 :   2   3   9 980  20  10   2   7                                              28
    44 :   2   3   1 980  20  10   2   8                                              28
    45 :   2   3   2 980  20  10   2   8                                              28
    46 :   2   3   3 980  20  10   2   8                                              28
    47 :8001   15450                                                 20 40 40         50
    48 :8003   7 900                                                                  50
    49 :       1 900  60                                      17   1                  64
    50 :   1 2 3 4 5 6 7 8                                                            67
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

1                                   CARD FILE LIST (CONT.)
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

    51 :  15  14  13  12  11  10   9   8   7   6                                      68
    52 :  16  16  16  16   3   1                                                      69
    53 :  20  16   1  20                                                              70
    54 :   1  14   7 150  25               1                                          71
    55 :   2   3  14   2   4  86   1   3   7   1   4  93                              74
    56 :   0                                                                         170
    57 :   1       0   16000                                                         195
    58 :   2    6000   11000                                                         195
    59 :   3    7000   11000                                                         195
    60 :   4   12500   11000                                                         195
    61 :   5    3000    2000                                                         195
    62 :   6   10500    7500                                                         195
    63 :8001       0   14000                                                         195
    64 :8002   15500   11000                                                         195
    65 :8003    1000    9500                                                         195
    66 :8004   11500    4500                                                         195
    67 :   7       0    2000                                                         195
    68 :   1                                                                         210
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
```

OUTPUT RESULTS

```
                                                        TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

0                          ITRAF 2.0
0
 ***********************************************************************************************************************************
1                                                    FRESIM LINK CHARACTERISTICS


                                           CUMULATIVE FRESIM STATISTICS AT TIME  8 30  0
                                       -----------------------------------------------------
                                                        LINK STATISTICS
                                                                                    VEH-MIN/
                                                          SECONDS/VEHICLE           VEH-MILE
                                                         ------------------       -----------
              VEHICLES  LANE  CURR  AVG    VEH-     VEH-    TOTAL  MOVE DELAY                    VOLUME     DENSITY      SPEED   LINK
   LINK       IN    OUT  CHNG  CONT  CONT  MILES     MIN    TIME   TIME  TIME  M/T  TOTAL DELAY VEH/LN/HR VEH/LN-MILE   MILE/HR  TYPE
----------- ----- ----- ---- ----- ----- ------- ------- ------ ----- ----- ----- ----- -----  -------   ---------  ---------- ----

(   2,   3)  3180  3171  992    21  20.2  600.9   605.1   11.4   10.6    .9   .92  1.01   .08   1586.3      26.6        59.58  FRWY

(   3,   4)  2895  2895 1337   101  98.4 3021.1  2952.2   61.1   57.9   3.1   .95   .98   .05   1933.5      31.5        61.40  FRWY

(   5,   2)   450   454     0    38  38.8  808.8  1164.3  155.2 143.7  11.5   .93  1.44   .11    900.4      21.6        41.68  RAMP

(   3,   6)   276   280     0    10  11.3  243.0   339.9   73.9   70.9   3.0   .96  1.40   .06    552.0      12.9        42.90  RAMP

(   7,   5)   450   450     0    11  11.6  257.2   348.0   46.1   45.4    .7   .98  1.35   .02    905.4      20.4        44.35  RAMP

(   1,   2)  2724  2726 1544   129 129.8 4038.4  3892.9   85.6   82.4   3.2   .96   .96   .04   1820.1      29.2        62.24  FRWY
```

Type A – Volume 3

```
                                                      TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

1                                       INPUT CARD FILE LIST
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

     1 :ITRAF 2.0                                                                     00
     2 :                                                                               1
     3 :       1   1      15                               8 8        7781    7581     2
     4 :1800                                                                           3
     5 :                  60                                                           4
     6 :                                                                               5
     7 :8001   1   2     0 3                         1                                19
     8 :   2   3   4 10000 3 93 1000                 1 9                              19
     9 :   3   48002 55000 3                         1                                19
    10 :   5   2   3 94861 1                         9                                19
    11 :   3   68004 46491 1                         1                                19
    12 :   7   5   2 30001 1                         1                                19
    13 :8003   7   5     1 1                         1                                19
    14 :   1   2   3 78100 3                         1                                19
    15 :8001   1         1  65                                                        20
    16 :   2   3         12265       5280                                             20
    17 :   3   4         1  65                                                        20
    18 :   5   2         1  45                                                        20
    19 :   3   6         1  45                                                        20
    20 :   7   5         1  45                                                        20
    21 :8003   7         1  45                                                        20
    22 :   1   2         12265                                                        20
    23 :8001   1   26600                                                              25
    24 :   2   3   47000   6 700                                                      25
    25 :   3   480027000                                                              25
    26 :   5   2   31100                                                              25
    27 :   3   68004 700                                                              25
    28 :   7   5   21100                                                              25
    29 :8003   7   51100                                                              25
    30 :   1   2   36600                                                              25
    31 :   2   3   9  40  20  10   2   1                                              28
    32 :   2   3   1  40  20  10   2   2                                              28
```

```
    33 :   2   3   2  40  20  10   2   2                                              28
    34 :   2   3   3  40  20  10   2   2                                              28
    35 :   2   3   9 200  20  10   2   3                                              28
    36 :   2   3   1 200  20  10   2   4                                              28
    37 :   2   3   2 200  20  10   2   4                                              28
    38 :   2   3   3 200  20  10   2   4                                              28
    39 :   2   3   9 500  20  10   2   5                                              28
    40 :   2   3   1 500  20  10   2   6                                              28
    41 :   2   3   2 500  20  10   2   6                                              28
    42 :   2   3   3 500  20  10   2   6                                              28
    43 :   2   3   9 980  20  10   2   7                                              28
    44 :   2   3   1 980  20  10   2   8                                              28
    45 :   2   3   2 980  20  10   2   8                                              28
    46 :   2   3   3 980  20  10   2   8                                              28
    47 :8001   16600                                                 20 40 40         50
    48 :8003   71100                                                                  50
    49 :       1 900  60                                      17   1                  64
    50 :   1 2 3 4 5 6 7 8                                                            67
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

1                                   CARD FILE LIST (CONT.)
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

    51 :  15  14  13  12  11  10   9   8   7   6                                      68
    52 :  16  16  16  16   3   1                                                      69
    53 :  20  16   1  20                                                              70
    54 :   1  14   7 150  25               1                                          71
    55 :   2   3  14   2   4  86   1   3   7   1   4  93                              74
    56 :   0                                                                         170
    57 :   1       0   16000                                                         195
    58 :   2    6000   11000                                                         195
    59 :   3    7000   11000                                                         195
    60 :   4   12500   11000                                                         195
    61 :   5    3000    2000                                                         195
    62 :   6   10500    7500                                                         195
    63 :8001       0   14000                                                         195
    64 :8002   15500   11000                                                         195
    65 :8003    1000    9500                                                         195
    66 :8004   11500    4500                                                         195
    67 :   7       0    2000                                                         195
    68 :   1                                                                         210
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
```

OUTPUT RESULTS

TRAF SIMULATION MODEL

```
                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

0                          ITRAF 2.0

 ***********************************************************************************************************************************

                                           CUMULATIVE FRESIM STATISTICS AT TIME  8 30  0
                                       -----------------------------------------------------

                                                        LINK STATISTICS
                                                                                    VEH-MIN/
                                                          SECONDS/VEHICLE           VEH-MILE
                                                         ------------------       -----------
              VEHICLES  LANE  CURR  AVG    VEH-    VEH-   TOTAL  MOVE DELAY                    VOLUME     DENSITY      SPEED   LINK
   LINK       IN   OUT  CHNG  CONT  CONT  MILES    MIN    TIME   TIME  TIME  M/T  TOTAL DELAY VEH/LN/HR VEH/LN-MILE   MILE/HR  TYPE
----------- ----- ----- ---- ----- ----- ------- ------- ------ ----- ----- ----- ----- -----  -------   ---------  ---------- ----

(   2,   3)  3837  3859 1131    16  24.8  728.6   744.7    11.6  10.6   1.0   .91  1.02   .09   1923.6      32.8         58.71   FRWY

(   3,   4)  3556  3548 1530   119 121.9 3695.9  3656.1    61.8  58.1   3.7   .94   .99   .06   2365.4      39.0         60.65   FRWY

(   5,   2)   551   550    0    47  47.9  985.4  1438.5   157.4 145.0  12.4   .92  1.46   .12   1096.9      26.7         41.10   RAMP

(   3,   6)   303   302    0    13  12.4  266.6   372.1    73.7  70.7   3.0   .96  1.40   .06    605.6      14.1         43.00   RAMP

(   7,   5)   550   551    0    14  14.4  314.0   433.4    47.0  45.9   1.2   .98  1.38   .03   1105.4      25.4         43.48   RAMP

(   1,   2)  3299  3287 1899   166 158.6 4888.1  4759.3    86.4  82.5   3.9   .95   .97   .04   2203.1      35.8         61.62   FRWY
```

Type A – Volume 4

```
                                                      TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY
1                                       CARD FILE LIST
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

     1 :ITRAF 2.0                                                                     00
     2 :                                                                               1
     3 :       1   1      15                               8 8        7781    7581     2
     4 :1800                                                                           3
     5 :                  60                                                           4
     6 :                                                                               5
     7 :8001   1   2     0 3                         1                                19
     8 :   2   3   4 10000 3 93 1000                 1 9                              19
     9 :   3   48002 55000 3                         1                                19
    10 :   5   2   3 94861 1                         9                                19
    11 :   3   68004 46491 1                         1                                19
    12 :   7   5   2 30001 1                         1                                19
    13 :8003   7   5     1 1                         1                                19
    14 :   1   2   3 78100 3                         1                                19
    15 :8001   1         1  65                                                        20
    16 :   2   3         12265       5280                                             20
    17 :   3   4         1  65                                                        20
    18 :   5   2         1  45                                                        20
    19 :   3   6         1  45                                                        20
    20 :   7   5         1  45                                                        20
    21 :8003   7         1  45                                                        20
    22 :   1   2         12265                                                        20
    23 :8001   1   26800                                                              25
    24 :   2   3   47200   61100                                                      25
    25 :   3   480027200                                                              25
    26 :   5   2   31500                                                              25
    27 :   3   680041100                                                              25
    28 :   7   5   21500                                                              25
    29 :8003   7   51500                                                              25
    30 :   1   2   36800                                                              25
    31 :   2   3   9  40  20  10   2   1                                              28
```

```
    32 :   2   3   1  40  20  10   2   2                                              28
    33 :   2   3   2  40  20  10   2   2                                              28
    34 :   2   3   3  40  20  10   2   2                                              28
    35 :   2   3   9 200  20  10   2   3                                              28
    36 :   2   3   1 200  20  10   2   4                                              28
    37 :   2   3   2 200  20  10   2   4                                              28
    38 :   2   3   3 200  20  10   2   4                                              28
    39 :   2   3   9 500  20  10   2   5                                              28
    40 :   2   3   1 500  20  10   2   6                                              28
    41 :   2   3   2 500  20  10   2   6                                              28
    42 :   2   3   3 500  20  10   2   6                                              28
    43 :   2   3   9 980  20  10   2   7                                              28
    44 :   2   3   1 980  20  10   2   8                                              28
    45 :   2   3   2 980  20  10   2   8                                              28
    46 :   2   3   3 980  20  10   2   8                                              28
    47 :8001   16800                                                20 40 40          50
    48 :8003   71500                                                                  50
    49 :       1 900  60                                      17   1                  64
    50 :   1 2 3 4 5 6 7 8                                                            67
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

1                                   CARD FILE LIST (CONT.)
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

    51 :  15  14  13  12  11  10   9   8   7   6                                      68
    52 :  16  16  16  16   3   1                                                      69
    53 :  20  16   1  20                                                              70
    54 :   1  14   7 150  25               1                                          71
    55 :   2   3  14   2   4  86   1   3   7   1   4  93                              74
    56 :   0                                                                         170
    57 :   1       0   16000                                                         195
    58 :   2    6000   11000                                                         195
    59 :   3    7000   11000                                                         195
    60 :   4   12500   11000                                                         195
    61 :   5    3000    2000                                                         195
    62 :   6   10500    7500                                                         195
    63 :8001       0   14000                                                         195
    64 :8002   15500   11000                                                         195
    65 :8003    1000    9500                                                         195
    66 :8004   11500    4500                                                         195
    67 :   7       0    2000                                                         195
    68 :   1                                                                         210
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
```

OUTPUT RESULTS

```
                                                               TRAF SIMULATION MODEL

                                                                  DEVELOPED FOR

                                                        U. S. DEPARTMENT OF TRANSPORTATION
                                                          FEDERAL HIGHWAY ADMINISTRATION
                                             FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

0                          ITRAF 2.0
0
 ************************************************************************************************************************************

                                                 CUMULATIVE FRESIM STATISTICS AT TIME  8 30  0
                                              -----------------------------------------------------

                                                               LINK STATISTICS
                                                                                                  VEH-MIN/
                                                                 SECONDS/VEHICLE                  VEH-MILE
                                                                ------------------              -----------
                    VEHICLES  LANE  CURR  AVG    VEH-     VEH-    TOTAL  MOVE DELAY                           VOLUME     DENSITY      SPEED   LINK
   LINK            IN   OUT  CHNG  CONT  CONT  MILES     MIN     TIME   TIME  TIME  M/T  TOTAL DELAY VEH/LN/HR VEH/LN-MILE  MILE/HR  TYPE
----------- ----- ----- ---- ----- ----- ------- ------- ------ ----- ----- ----- ----- -----  -------   ---------  ---------- ----

(    2,    3)  4120  4119 1361    30  27.1  780.8   811.5    11.8  10.6   1.2   .90  1.04   .11   2061.4      35.7        57.73   FRWY

(    3,    4)  3781  3783 1580   122 129.9 3939.7  3896.2    61.8  57.9   3.9   .94   .99   .06   2521.4      41.6        60.67   FRWY

(    5,    2)   747   750    0    62  65.5 1345.5  1964.6   157.4 143.6  13.8   .91  1.46   .13   1497.9      36.5        41.09   RAMP

(    3,    6)   338   336    0    14  13.9  297.6   417.0    74.0  70.8   3.2   .96  1.40   .06    676.0      15.8        42.82   RAMP

(    7,    5)   750   747    0    22  19.7  428.3   590.7    47.0  45.5   1.5   .97  1.38   .05   1507.6      34.7        43.51   RAMP

(    1,    2)  3373  3370 1876   164 162.3 4998.5  4870.2    86.5  82.4   4.1   .95   .97   .05   2252.8      36.6        61.58   FRWY
```

Type A – Volume 5

```
                                                      TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

1                                       INPUT CARD FILE LIST
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

     1 :ITRAF 2.0                                                                     00
     2 :                                                                               1
     3 :       1   1      15                               8 8        7781    7581     2
     4 :1800                                                                           3
     5 :                  60                                                           4
     6 :                                                                               5
     7 :8001   1   2     0 3                         1                                19
     8 :   2   3   4 10000 3 93 1000                 1 9                              19
     9 :   3   48002 55000 3                         1                                19
    10 :   5   2   3 94861 1                         9                                19
    11 :   3   68004 46491 1                         1                                19
    12 :   7   5   2 30001 1                         1                                19
    13 :8003   7   5     1 1                         1                                19
    14 :   1   2   3 78100 3                         1                                19
    15 :8001   1         1  65                                                        20
    16 :   2   3         12265       5280                                             20
    17 :   3   4         1  65                                                        20
    18 :   5   2         1  45                                                        20
    19 :   3   6         1  45                                                        20
    20 :   7   5         1  45                                                        20
    21 :8003   7         1  45                                                        20
    22 :   1   2         12265                                                        20
    23 :8001   1   25700                                                              25
    24 :   2   3   46300   61100                                                      25
    25 :   3   480026300                                                              25
    26 :   5   2   32100                                                              25
    27 :   3   680041100                                                              25
    28 :   7   5   21500                                                              25
    29 :8003   7   51500                                                              25
    30 :   1   2   35700                                                              25
    31 :   2   3   9  40  20  10   2   1                                              28
```

```
    32 :   2   3   1  40  20  10   2   2                                              28
    33 :   2   3   2  40  20  10   2   2                                              28
    34 :   2   3   3  40  20  10   2   2                                              28
    35 :   2   3   9 200  20  10   2   3                                              28
    36 :   2   3   1 200  20  10   2   4                                              28
    37 :   2   3   2 200  20  10   2   4                                              28
    38 :   2   3   3 200  20  10   2   4                                              28
    39 :   2   3   9 500  20  10   2   5                                              28
    40 :   2   3   1 500  20  10   2   6                                              28
    41 :   2   3   2 500  20  10   2   6                                              28
    42 :   2   3   3 500  20  10   2   6                                              28
    43 :   2   3   9 980  20  10   2   7                                              28
    44 :   2   3   1 980  20  10   2   8                                              28
    45 :   2   3   2 980  20  10   2   8                                              28
    46 :   2   3   3 980  20  10   2   8                                              28
    47 :8001   15700                                                 20 40 40         50
    48 :8003   72100                                                                  50
    49 :       1 900  60                                      17   1                  64
    50 :   1 2 3 4 5 6 7 8                                                            67
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

1                                   CARD FILE LIST (CONT.)
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

    51 :  15  14  13  12  11  10   9   8   7   6                                      68
    52 :  16  16  16  16   3   1                                                      69
    53 :  20  20   1  20                                                              70
    54 :   1  14   7 150  25               1                                          71
    55 :   2   3  14   2   4  86   1   3   7   1   4  93                              74
    56 :   0                                                                         170
    57 :   1       0   16000                                                         195
    58 :   2    6000   11000                                                         195
    59 :   3    7000   11000                                                         195
    60 :   4   12500   11000                                                         195
    61 :   5    3000    2000                                                         195
    62 :   6   10500    7500                                                         195
    63 :8001       0   14000                                                         195
    64 :8002   15500   11000                                                         195
    65 :8003    1000    9500                                                         195
    66 :8004   11500    4500                                                         195
    67 :   7       0    2000                                                         195
    68 :   1                                                                         210
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
```

OUTPUT RESULTS

```
                                                        TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

0                          ITRAF 2.0

 ***********************************************************************************************************************************

                                           CUMULATIVE FRESIM STATISTICS AT TIME  8 30  0
                                       -----------------------------------------------------

                                                        LINK STATISTICS
                                                                                    VEH-MIN/
                                                          SECONDS/VEHICLE           VEH-MILE
                                                         ------------------       -----------
              VEHICLES  LANE CURR  AVG     VEH-    VEH-   TOTAL  MOVE DELAY                     VOLUME     DENSITY     SPEED  LINK
   LINK         IN   OUT  CHNG CONT  CONT   MILES     MIN   TIME   TIME  TIME  M/T  TOTAL DELAY VEH/LN/HR VEH/LN-MILE   MILE/HR TYPE
----------- ----- ----- ---- ----- ----- ------- ------- ------ ----- ----- ----- ----- -----  -------   ---------   ---------- ----

(   2,   3)  3592  3598 1388    17  23.5   680.6   706.1   11.8  10.6   1.2   .90  1.04   .11   1796.7      31.1        57.83  FRWY

(   3,   4)  3308  3308 1405   119 113.1  3444.8  3392.6   61.6  58.1   3.5   .94   .98   .06   2204.7      36.2        60.92  FRWY

(   5,   2)   902   896    0    82  80.0  1618.5  2399.4  159.8 145.0  14.8   .91  1.48   .14   1801.8      44.5        40.47  RAMP

(   3,   6)   290   294    0     9  11.8   258.0   355.4   72.8  70.4   2.4   .97  1.38   .04    586.1      13.5        43.56  RAMP

(   7,   5)   901   902    0    23  24.1   514.6   724.4   48.0  45.9   2.1   .96  1.41   .06   1811.4      42.5        42.62  RAMP

(   1,   2)  2697  2696 1505   128 128.6  3996.2  3856.7   85.7  82.4   3.2   .96   .97   .04   1801.1      29.0        62.17  FRWY
```

Type B – Volume 1

```
                                                      TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

1                                       CARD FILE LIST
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

     1 :ITRAF 2.0                                                                     00
     2 :                                                                               1
     3 :       1   1      15     7981                  1   8 8          7781    7581   2
     4 :1800                                                                           3
     5 :                  60                                                           4
     6 :                                               1                               5
     7 :8003   6   3     1 2                         1                                19
     8 :   6   3   2 68001 2                        10                                19
     9 :8001   1   3     0 2                         1                                19
    10 :   1   3   2 60000 2                         1                                19
    11 :   3   2   4  5000 2 93  500103   500         2                                19
    12 :   2   4  10 10000 3 93 1000                 1 9                              19
    13 :   4  108007 31620 3                         1                                19
    14 :   4   88004 33541 2                         1                                19
    15 :8003   6         12265                                                        20
    16 :   6   3         12265                                                        20
    17 :8001   1         12265                                                        20
    18 :   1   3         12265                                                        20
    19 :   3   2         12265                                                        20
    20 :   2   4         12265       2500                                             20
    21 :   4  10         12265                                                        20
    22 :   4   8         12265                                                        20
    23 :8003   6   32694                                                              25
    24 :   6   3   22694                                                              25
    25 :8001   1   32894                                                              25
    26 :   1   3   22894                                                              25
    27 :   3   2   45588                                                              25
    28 :   2   4  103292   82296                                                      25
    29 :   4  1080073292                                                              25
    30 :   4   880042296                                                              25
    31 :   3   2  10  30  20  10   2   1                                              28
    32 :   3   2   9  30  20  10   2   1                                              28
    33 :   3   2   1  30  20  10   2   2                                              28
```

```
    34 :   3   2   2  30  20  10   2   2                                              28
    35 :   3   2  10 460  20  10   2   3                                              28
    36 :   3   2   9 460  20  10   2   3                                              28
    37 :   3   2   1 460  20  10   2   4                                              28
    38 :   3   2   2 460  20  10   2   4                                              28
    39 :   2   4   9  30  20  10   2   5                                              28
    40 :   2   4   1  30  20  10   2   6                                              28
    41 :   2   4   2  30  20  10   2   6                                              28
    42 :   2   4   3  30  20  10   2   6                                              28
    43 :   2   4   9 200  20  10   2   7                                              28
    44 :   2   4   1 200  20  10   2   8                                              28
    45 :   2   4   2 200  20  10   2   8                                              28
    46 :   2   4   3 200  20  10   2   8                                              28
    47 :   2   4   9 500  20  10   2   9                                              28
    48 :   2   4   1 500  20  10   2  10                                              28
    49 :   2   4   2 500  20  10   2  10                                              28
    50 :   2   4   3 500  20  10   2  10                                              28
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

1                                   CARD FILE LIST (CONT.)
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

    51 :   2   4   9 940  20  10   2  11                                              28
    52 :   2   4   1 940  20  10   2  12                                              28
    53 :   2   4   2 940  20  10   2  12                                              28
    54 :   2   4   3 940  20  10   2  12                                              28
    55 :8003   62694                                                                  50
    56 :8001   12894                                                                  50
    57 :       1 900  60                                      71   1                  64
    58 :   1 2 3 4 5 6 7 8 9101112                                                    67
    59 :  15  14  13  12  11  10   9   8   7   6                                      68
    60 :  16  16  16  16   3   1                                                      69
    61 :  20  16   1  20                                                              70
    62 :   1  10  73   1   4  27   3  10  45   3   4  55                              74
    63 :   0                                                                         170
    64 :8003    3500    2000                                                         195
    65 :8004   15500    6500                                                         195
    66 :   6    4500    3500                                                         195
    67 :   8   13500    7500                                                         195
    68 :8007   16500   12000                                                         195
    69 :   3    9000    9000                                                         195
    70 :8001    1500    9000                                                         195
    71 :  10   13500   10000                                                         195
    72 :   1    2500    9000                                                         195
    73 :   2    9500    9000                                                         195
    74 :   4   10500    9000                                                         195
    75 :   1                                                                         210
```

OUTPUT RESULTS

```
                                                        TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

0                          ITRAF 2.0
***********************************************************************************************************************

                                          CUMULATIVE FRESIM STATISTICS AT TIME  8 30  0
                                       -----------------------------------------------------
```

LINK STATISTICS

```
                                                                                    VEH-MIN/
                                                          SECONDS/VEHICLE           VEH-MILE
                                                         ------------------       -----------
              VEHICLES  LANE  CURR  AVG    VEH-    VEH-   TOTAL  MOVE DELAY                    VOLUME   DENSITY        SPEED   LINK
   LINK       IN   OUT  CHNG  CONT  CONT  MILES    MIN    TIME   TIME  TIME  M/T  TOTAL DELAY VEH/LN/HR VEH/LN-MILE   MILE/HR  TYPE
----------- ----- ----- ---- ----- ----- ------- ------- ------ ----- ----- ----- ----- -----  -------   ---------  ---------- ----

(   6,   3)  1346  1350  575    54  55.3 1738.2  1658.0    73.7  71.6   2.1   .97   .95   .03   1349.7     21.5        62.91   RAMP

(   1,   3)  1445  1446  655    53  52.4 1647.6  1571.9    65.1  63.3   1.8   .97   .95   .03   1449.9     23.1        62.89   FRWY

(   3,   2)  2796  2793  887     5   8.6  264.7   258.8     5.6   5.3    .3   .95   .98   .05   1397.5     22.8        61.36   FRWY

(   2,   4)  2793  2793  223    21  17.1  529.0   511.7    11.0  10.6    .4   .96   .97   .04   1396.6     22.5        62.03   FRWY

(   4,  10)  1635  1630  390    35  31.2  977.8   936.1    34.4  33.4   1.0   .97   .96   .03   1088.5     17.4        62.67   FRWY

(   4,   8)  1158  1163  285    17  23.4  735.9   702.4    36.4  35.3   1.1   .97   .95   .03   1158.5     18.4        62.86   RAMP
```

Type B – Volume 2

```
                                                      TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

1                                       CARD FILE LIST
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

     1 :ITRAF 2.0                                                                     00
     2 :                                                                               1
     3 :       1   1      15     7981                  1   8 8          7781    7581   2
     4 :1800                                                                           3
     5 :                  60                                                           4
     6 :                                               1                               5
     7 :8003   6   3     1 2                         1                                19
     8 :   6   3   2 68001 2                        10                                19
     9 :8001   1   3     0 2                         1                                19
    10 :   1   3   2 60000 2                         1                                19
    11 :   3   2   4  5000 2 93  500103  500         2                                19
    12 :   2   4  10 10000 3 93 1000                 1 9                              19
    13 :   4  108007 31620 3                         1                                19
    14 :   4   88004 33541 2                         1                                19
    15 :8003   6         12265                                                        20
    16 :   6   3         12265                                                        20
    17 :8001   1         12265                                                        20
    18 :   1   3         12265                                                        20
    19 :   3   2         12265                                                        20
    20 :   2   4         12265       2500                                             20
    21 :   4  10         12265                                                        20
    22 :   4   8         12265                                                        20
    23 :8003   6   33200                                                              25
    24 :   6   3   23200                                                              25
    25 :8001   1   33400                                                              25
    26 :   1   3   23400                                                              25
    27 :   3   2   46600                                                              25
    28 :   2   4  103800   82800                                                      25
    29 :   4  1080073800                                                              25
    30 :   4   880042800                                                              25
    31 :   3   2  10  30  20  10   2   1                                              28
    32 :   3   2   9  30  20  10   2   1                                              28
    33 :   3   2   1  30  20  10   2   2                                              28
    34 :   3   2   2  30  20  10   2   2                                              28
```

```
    35 :   3   2  10 460  20  10   2   3                                              28
    36 :   3   2   9 460  20  10   2   3                                              28
    37 :   3   2   1 460  20  10   2   4                                              28
    38 :   3   2   2 460  20  10   2   4                                              28
    39 :   2   4   9  30  20  10   2   5                                              28
    40 :   2   4   1  30  20  10   2   6                                              28
    41 :   2   4   2  30  20  10   2   6                                              28
    42 :   2   4   3  30  20  10   2   6                                              28
    43 :   2   4   9 200  20  10   2   7                                              28
    44 :   2   4   1 200  20  10   2   8                                              28
    45 :   2   4   2 200  20  10   2   8                                              28
    46 :   2   4   3 200  20  10   2   8                                              28
    47 :   2   4   9 500  20  10   2   9                                              28
    48 :   2   4   1 500  20  10   2  10                                              28
    49 :   2   4   2 500  20  10   2  10                                              28
    50 :   2   4   3 500  20  10   2  10                                              28
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

1                                   CARD FILE LIST (CONT.)
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

    51 :   2   4   9 940  20  10   2  11                                              28
    52 :   2   4   1 940  20  10   2  12                                              28
    53 :   2   4   2 940  20  10   2  12                                              28
    54 :   2   4   3 940  20  10   2  12                                              28
    55 :8003   63200                                                                  50
    56 :8001   13400                                                                  50
    57 :       1 900  60                                      71   1                  64
    58 :   1 2 3 4 5 6 7 8 9101112                                                    67
    59 :  15  14  13  12  11  10   9   8   7   6                                      68
    60 :  16  16  16  16   3   1                                                      69
    61 :  20  16   1  20                                                              70
    62 :   1  10  73   1   4  27   3  10  45   3   4  55                              74
    63 :   0                                                                         170
    64 :8003    3500    2000                                                         195
    65 :8004   15500    6500                                                         195
    66 :   6    4500    3500                                                         195
    67 :   8   13500    7500                                                         195
    68 :8007   16500   12000                                                         195
    69 :   3    9000    9000                                                         195
    70 :8001    1500    9000                                                         195
    71 :  10   13500   10000                                                         195
    72 :   1    2500    9000                                                         195
    73 :   2    9500    9000                                                         195
    74 :   4   10500    9000                                                         195
    75 :   1                                                                         210
```

OUTPUT RESULTS

```
                                                        TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

0                          ITRAF 2.0
***********************************************************************************************************************
1

                                           CUMULATIVE FRESIM STATISTICS AT TIME  8 30  0
                                       -----------------------------------------------------

                                                        LINK STATISTICS
                                                                                    VEH-MIN/
                                                          SECONDS/VEHICLE           VEH-MILE
                                                         ------------------       -----------
              VEHICLES  LANE  CURR  AVG    VEH-    VEH-   TOTAL  MOVE DELAY                    VOLUME     DENSITY     SPEED    LINK
   LINK       IN   OUT  CHNG  CONT  CONT  MILES    MIN    TIME   TIME  TIME  M/T  TOTAL DELAY VEH/LN/HR VEH/LN-MILE   MILE/HR  TYPE
----------- ----- ----- ---- ----- ----- ------- ------- ------ ----- ----- ----- ----- -----  -------   ---------  ---------- ----

(   6,   3)  1600  1601  714    68  66.0 2064.3  1979.9    74.1  71.6   2.5   .97   .96   .03   1602.9     25.6        62.56   RAMP

(   1,   3)  1698  1699  820    62  62.1 1934.8  1861.7    65.6  63.3   2.3   .97   .96   .03   1702.6     27.3        62.35   FRWY

(   3,   2)  3300  3296 1122    10  10.2  312.5   307.3     5.6   5.3    .3   .94   .98   .06   1649.8     27.0        61.01   FRWY

(   2,   4)  3296  3302  321    18  20.2  624.6   606.5    11.0  10.6    .5   .96   .97   .04   1649.0     26.7        61.79   FRWY

(   4,  10)  1941  1939  482    38  37.1 1160.4  1113.8    34.5  33.3   1.2   .97   .96   .03   1291.8     20.7        62.51   FRWY

(   4,   8)  1361  1358  302    27  27.6  863.2   829.0    36.6  35.3   1.3   .96   .96   .03   1358.8     21.8        62.47   RAMP
```

Type B – Volume 3

```
                                                      TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

1                                       CARD FILE LIST
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

     1 :ITRAF 2.0                                                                     00
     2 :                                                                               1
     3 :       1   1      15     7981                  1   8 8          7781    7581   2
     4 :1800                                                                           3
     5 :                  60                                                           4
     6 :                                               1                               5
     7 :8003   6   3     1 2                         1                                19
     8 :   6   3   2 68001 2                        10                                19
     9 :8001   1   3     0 2                         1                                19
    10 :   1   3   2 60000 2                         1                                19
    11 :   3   2   4  5000 2 93  500103  500         2                                19
    12 :   2   4  10 10000 3 93 1000                 1 9                              19
    13 :   4  108007 31620 3                         1                                19
    14 :   4   88004 33541 2                         1                                19
    15 :8003   6         12265                                                        20
    16 :   6   3         12265                                                        20
    17 :8001   1         12265                                                        20
    18 :   1   3         12265                                                        20
    19 :   3   2         12265                                                        20
    20 :   2   4         12265       2500                                             20
    21 :   4  10         12265                                                        20
    22 :   4   8         12265                                                        20
    23 :8003   6   33500                                                              25
    24 :   6   3   23500                                                              25
    25 :8001   1   33700                                                              25
    26 :   1   3   23700                                                              25
    27 :   3   2   47200                                                              25
    28 :   2   4  104200   83000                                                      25
    29 :   4  1080074200                                                              25
    30 :   4   880043000                                                              25
    31 :   3   2  10  30  20  10   2   1                                              28
    32 :   3   2   9  30  20  10   2   1                                              28
    33 :   3   2   1  30  20  10   2   2                                              28
    34 :   3   2   2  30  20  10   2   2                                              28
```

```
    35 :   3   2  10 460  20  10   2   3                                              28
    36 :   3   2   9 460  20  10   2   3                                              28
    37 :   3   2   1 460  20  10   2   4                                              28
    38 :   3   2   2 460  20  10   2   4                                              28
    39 :   2   4   9  30  20  10   2   5                                              28
    40 :   2   4   1  30  20  10   2   6                                              28
    41 :   2   4   2  30  20  10   2   6                                              28
    42 :   2   4   3  30  20  10   2   6                                              28
    43 :   2   4   9 200  20  10   2   7                                              28
    44 :   2   4   1 200  20  10   2   8                                              28
    45 :   2   4   2 200  20  10   2   8                                              28
    46 :   2   4   3 200  20  10   2   8                                              28
    47 :   2   4   9 500  20  10   2   9                                              28
    48 :   2   4   1 500  20  10   2  10                                              28
    49 :   2   4   2 500  20  10   2  10                                              28
    50 :   2   4   3 500  20  10   2  10                                              28
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

1                                   CARD FILE LIST (CONT.)
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

    51 :   2   4   9 940  20  10   2  11                                              28
    52 :   2   4   1 940  20  10   2  12                                              28
    53 :   2   4   2 940  20  10   2  12                                              28
    54 :   2   4   3 940  20  10   2  12                                              28
    55 :8003   63500                                                                  50
    56 :8001   13700                                                                  50
    57 :       1 900  60                                      71   1                  64
    58 :   1 2 3 4 5 6 7 8 9101112                                                    67
    59 :  15  14  13  12  11  10   9   8   7   6                                      68
    60 :  16  16  16  16   3   1                                                      69
    61 :  20  16   1  20                                                              70
    62 :   1  10  73   1   4  27   3  10  45   3   4  55                              74
    63 :   0                                                                         170
    64 :8003    3500    2000                                                         195
    65 :8004   15500    6500                                                         195
    66 :   6    4500    3500                                                         195
    67 :   8   13500    7500                                                         195
    68 :8007   16500   12000                                                         195
    69 :   3    9000    9000                                                         195
    70 :8001    1500    9000                                                         195
    71 :  10   13500   10000                                                         195
    72 :   1    2500    9000                                                         195
    73 :   2    9500    9000                                                         195
    74 :   4   10500    9000                                                         195
    75 :   1                                                                         210
```

OUTPUT RESULTS

```
                                                        TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

0                          ITRAF 2.0
0

 ***********************************************************************************************************************************
                                           CUMULATIVE FRESIM STATISTICS AT TIME  8 30  0
                                       -----------------------------------------------------

                                                        LINK STATISTICS
                                                                                    VEH-MIN/
                                                          SECONDS/VEHICLE           VEH-MILE
                                                         ------------------       -----------
              VEHICLES  LANE  CURR  AVG    VEH-     VEH-   TOTAL  MOVE DELAY                    VOLUME     DENSITY      SPEED   LINK
   LINK       IN   OUT  CHNG  CONT  CONT  MILES     MIN    TIME   TIME  TIME  M/T  TOTAL DELAY VEH/LN/HR VEH/LN-MILE   MILE/HR  TYPE
----------- ----- ----- ---- ----- ----- ------- ------- ------ ----- ----- ----- ----- -----  -------   ---------  ---------- ----

(   6,   3)  1750  1747  753    74  72.5 2258.4  2176.4    74.5  71.8   2.7   .96   .96   .03   1753.6     28.2        62.26   RAMP

(   1,   3)  1849  1849  813    68  67.7 2107.3  2029.8    65.7  63.2   2.5   .96   .96   .04   1854.4     29.8        62.29   FRWY

(   3,   2)  3596  3597 1253     4  11.3  340.7   337.7     5.6   5.3    .4   .94   .99   .06   1798.9     29.7        60.53   FRWY

(   2,   4)  3597  3598  348    26  22.2  680.7   665.6    11.1  10.6    .5   .95   .98   .05   1796.9     29.3        61.36   FRWY

(   4,  10)  2138  2150  570    34  41.1 1284.0  1233.8    34.5  33.4   1.1   .97   .96   .03   1429.3     22.9        62.44   FRWY

(   4,   8)  1460  1450  335    36  29.6  923.7   888.6    36.7  35.3   1.4   .96   .96   .04   1454.1     23.3        62.37   RAMP
```

Type B – Volume 4

```
                                                      TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

1                                       CARD FILE LIST
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

     1 :ITRAF 2.0                                                                     00
     2 :                                                                               1
     3 :       1   1      15     7981                  1   8 8          7781    7581   2
     4 :1800                                                                           3
     5 :                  60                                                           4
     6 :                                               1                               5
     7 :8003   6   3     1 2                         1                                19
     8 :   6   3   2 68001 2                        10                                19
     9 :8001   1   3     0 2                         1                                19
    10 :   1   3   2 60000 2                         1                                19
    11 :   3   2   4  5000 2 93  500103  500         2                                19
    12 :   2   4  10 10000 3 93 1000                 1 9                              19
    13 :   4  108007 31620 3                         1                                19
    14 :   4   88004 33541 2                         1                                19
    15 :8003   6         12265                                                        20
    16 :   6   3         12265                                                        20
    17 :8001   1         12265                                                        20
    18 :   1   3         12265                                                        20
    19 :   3   2         12265                                                        20
    20 :   2   4         12265       2500                                             20
    21 :   4  10         12265                                                        20
    22 :   4   8         12265                                                        20
    23 :8003   6   34000                                                              25
    24 :   6   3   24000                                                              25
    25 :8001   1   34500                                                              25
    26 :   1   3   24500                                                              25
    27 :   3   2   49500                                                              25
    28 :   2   4  105000   83500                                                      25
    29 :   4  1080075000                                                              25
    30 :   4   880043500                                                              25
    31 :   3   2  10  30  20  10   2   1                                              28
    32 :   3   2   9  30  20  10   2   1                                              28
    33 :   3   2   1  30  20  10   2   2                                              28
    34 :   3   2   2  30  20  10   2   2                                              28
```

```
    35 :   3   2  10 460  20  10   2   3                                              28
    36 :   3   2   9 460  20  10   2   3                                              28
    37 :   3   2   1 460  20  10   2   4                                              28
    38 :   3   2   2 460  20  10   2   4                                              28
    39 :   2   4   9  30  20  10   2   5                                              28
    40 :   2   4   1  30  20  10   2   6                                              28
    41 :   2   4   2  30  20  10   2   6                                              28
    42 :   2   4   3  30  20  10   2   6                                              28
    43 :   2   4   9 200  20  10   2   7                                              28
    44 :   2   4   1 200  20  10   2   8                                              28
    45 :   2   4   2 200  20  10   2   8                                              28
    46 :   2   4   3 200  20  10   2   8                                              28
    47 :   2   4   9 500  20  10   2   9                                              28
    48 :   2   4   1 500  20  10   2  10                                              28
    49 :   2   4   2 500  20  10   2  10                                              28
    50 :   2   4   3 500  20  10   2  10                                              28
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

1                                   CARD FILE LIST (CONT.)
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

    51 :   2   4   9 940  20  10   2  11                                              28
    52 :   2   4   1 940  20  10   2  12                                              28
    53 :   2   4   2 940  20  10   2  12                                              28
    54 :   2   4   3 940  20  10   2  12                                              28
    55 :8003   64000                                                                  50
    56 :8001   14500                                                                  50
    57 :       1 900  60                                      71   1                  64
    58 :   1 2 3 4 5 6 7 8 9101112                                                    67
    59 :  15  14  13  12  11  10   9   8   7   6                                      68
    60 :  16  16  16  16   3   1                                                      69
    61 :  20  16   1  20                                                              70
    62 :   1  10  73   1   4  27   3  10  45   3   4  55                              74
    63 :   0                                                                         170
    64 :8003    3500    2000                                                         195
    65 :8004   15500    6500                                                         195
    66 :   6    4500    3500                                                         195
    67 :   8   13500    7500                                                         195
    68 :8007   16500   12000                                                         195
    69 :   3    9000    9000                                                         195
    70 :8001    1500    9000                                                         195
    71 :  10   13500   10000                                                         195
    72 :   1    2500    9000                                                         195
    73 :   2    9500    9000                                                         195
    74 :   4   10500    9000                                                         195
    75 :   1                                                                         210
```

OUTPUT RESULTS

```
                                                        TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

0                          ITRAF 2.0
0

 ***********************************************************************************************************************************


                                          CUMULATIVE FRESIM STATISTICS AT TIME  8 30  0
                                       -----------------------------------------------------

                                                        LINK STATISTICS
                                                                                    VEH-MIN/
                                                          SECONDS/VEHICLE           VEH-MILE
                                                         ------------------       -----------
              VEHICLES  LANE  CURR  AVG    VEH-    VEH-   TOTAL  MOVE DELAY                        VOLUME     DENSITY      SPEED   LINK
   LINK       IN   OUT  CHNG  CONT  CONT  MILES    MIN    TIME   TIME  TIME  M/T  TOTAL DELAY VEH/LN/HR VEH/LN-MILE   MILE/HR  TYPE
----------- ----- ----- ---- ----- ----- ------- ------- ------ ----- ----- ----- ----- -----  -------   ---------  ---------- ----

(   6,   3)  1999  1999  824    81  83.4 2581.8  2500.6    74.8  71.7   3.2   .96   .97   .04   2004.7     32.4        61.95   RAMP

(   1,   3)  2248  2245  953    86  83.3 2560.6  2498.4    66.5  63.3   3.2   .95   .98   .05   2253.3     36.6        61.49   FRWY

(   3,   2)  4244  4252 1456     7  13.5  402.2   405.1     5.7   5.3    .5   .92  1.01   .08   2123.5     35.6        59.57   FRWY

(   2,   4)  4252  4252  445    26  26.6  805.4   798.9    11.3  10.6    .7   .94   .99   .06   2126.2     35.2        60.49   FRWY

(   4,  10)  2543  2527  634    60  49.1 1519.0  1472.7    34.8  33.4   1.5   .96   .97   .04   1691.0     27.3        61.89   FRWY

(   4,   8)  1709  1709  406    33  35.1 1085.7  1052.9    37.0  35.4   1.6   .96   .97   .04   1709.1     27.6        61.87   RAMP
```

Type B – Volume 5

```
                                                      TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

1                                       CARD FILE LIST
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

     1 :ITRAF 2.0                                                                     00
     2 :                                                                               1
     3 :       1   1      15     7981                  1   8 8          7781    7581   2
     4 :1800                                                                           3
     5 :                  60                                                           4
     6 :                                               1                               5
     7 :8003   6   3     1 2                         1                                19
     8 :   6   3   2 68001 2                        10                                19
     9 :8001   1   3     0 2                         1                                19
    10 :   1   3   2 60000 2                         1                                19
    11 :   3   2   4  5000 2 93  500103  500         2                                19
    12 :   2   4  10 10000 3 93 1000                 1 9                              19
    13 :   4  108007 31620 3                         1                                19
    14 :   4   88004 33541 2                         1                                19
    15 :8003   6         12265                                                        20
    16 :   6   3         12265                                                        20
    17 :8001   1         12265                                                        20
    18 :   1   3         12265                                                        20
    19 :   3   2         12265                                                        20
    20 :   2   4         12265       2500                                             20
    21 :   4  10         12265                                                        20
    22 :   4   8         12265                                                        20
    23 :8003   6   33500                                                              25
    24 :   6   3   23500                                                              25
    25 :8001   1   33800                                                              25
    26 :   1   3   23800                                                              25
    27 :   3   2   47300                                                              25
    28 :   2   4  103500   83800                                                      25
    29 :   4  1080073500                                                              25
    30 :   4   880043800                                                              25
    31 :   3   2  10  30  20  10   2   1                                              28
    32 :   3   2   9  30  20  10   2   1                                              28
    33 :   3   2   1  30  20  10   2   2                                              28
    34 :   3   2   2  30  20  10   2   2                                              28
```

```
    35 :   3   2  10 460  20  10   2   3                                              28
    36 :   3   2   9 460  20  10   2   3                                              28
    37 :   3   2   1 460  20  10   2   4                                              28
    38 :   3   2   2 460  20  10   2   4                                              28
    39 :   2   4   9  30  20  10   2   5                                              28
    40 :   2   4   1  30  20  10   2   6                                              28
    41 :   2   4   2  30  20  10   2   6                                              28
    42 :   2   4   3  30  20  10   2   6                                              28
    43 :   2   4   9 200  20  10   2   7                                              28
    44 :   2   4   1 200  20  10   2   8                                              28
    45 :   2   4   2 200  20  10   2   8                                              28
    46 :   2   4   3 200  20  10   2   8                                              28
    47 :   2   4   9 500  20  10   2   9                                              28
    48 :   2   4   1 500  20  10   2  10                                              28
    49 :   2   4   2 500  20  10   2  10                                              28
    50 :   2   4   3 500  20  10   2  10                                              28
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

1                                    CARD FILE LIST (CONT.)
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

    51 :   2   4   9 940  20  10   2  11                                              28
    52 :   2   4   1 940  20  10   2  12                                              28
    53 :   2   4   2 940  20  10   2  12                                              28
    54 :   2   4   3 940  20  10   2  12                                              28
    55 :8003   63500                                                                  50
    56 :8001   13800                                                                  50
    57 :       1 900  60                                      71   1                  64
    58 :   1 2 3 4 5 6 7 8 9101112                                                    67
    59 :  15  14  13  12  11  10   9   8   7   6                                      68
    60 :  16  16  16  16   3   1                                                      69
    61 :  20  16   1  20                                                              70
    62 :   1  10  73   1   4  27   3  10  45   3   4  55                              74
    63 :   0                                                                         170
    64 :8003    3500    2000                                                         195
    65 :8004   15500    6500                                                         195
    66 :   6    4500    3500                                                         195
    67 :   8   13500    7500                                                         195
    68 :8007   16500   12000                                                         195
    69 :   3    9000    9000                                                         195
    70 :8001    1500    9000                                                         195
    71 :  10   13500   10000                                                         195
    72 :   1    2500    9000                                                         195
    73 :   2    9500    9000                                                         195
    74 :   4   10500    9000                                                         195
    75 :   1                                                                         210
```

OUTPUT RESULTS

```
                                                        TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

0                          ITRAF 2.0
0

 ***********************************************************************************************************************************

                                          CUMULATIVE FRESIM STATISTICS AT TIME  8 30  0
                                       -----------------------------------------------------

                                                        LINK STATISTICS
                                                                                    VEH-MIN/
                                                          SECONDS/VEHICLE           VEH-MILE
                                                         ------------------       -----------
              VEHICLES  LANE  CURR  AVG    VEH-    VEH-   TOTAL  MOVE DELAY                    VOLUME     DENSITY      SPEED   LINK
   LINK       IN   OUT  CHNG  CONT  CONT  MILES     MIN   TIME   TIME  TIME  M/T  TOTAL DELAY VEH/LN/HR VEH/LN-MILE   MILE/HR  TYPE
----------- ----- ----- ---- ----- ----- ------- ------- ------ ----- ----- ----- ----- -----  -------   ---------   ---------- ----

(   6,    3)  1750  1747  761    73  72.3 2258.1  2169.6    74.2  71.6   2.6   .96   .96   .03   1753.3     28.1        62.45   RAMP

(   1,    3)  1900  1898  848    71  69.8 2164.0  2093.3    66.0  63.4   2.5   .96   .97   .04   1904.3     30.7        62.03   FRWY

(   3,    2)  3645  3646 1195    14  11.4  345.3   341.4     5.6   5.3    .3   .94   .99   .06   1823.1     30.0        60.69   FRWY

(   2,    4)  3646  3642  339    24  22.4  689.0   673.3    11.1  10.6    .5   .95   .98   .05   1819.0     29.6        61.40   FRWY

(   4,   10)  2190  2187  531    45  42.2 1310.0  1264.6    34.7  33.4   1.3   .96   .97   .04   1458.3     23.5        62.15   FRWY

(   4,    8)  1452  1463  320    24  29.5  924.5   885.1    36.5  35.3   1.2   .97   .96   .03   1455.3     23.2        62.67   RAMP
```

Type C – Volume 1

```
                                                      TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

1                                       CARD FILE LIST
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

     1 :ITRAF 2.0                                                                     00
     2 :                                                                               1
     3 :       1   1      15     7981                  1   8 8          7781    7581   2
     4 :1800                                                                           3
     5 :                  60                                                           4
     6 :                                               1                               5
     7 :8003   6   3     1 3                         1                                19
     8 :   6   3   2 68001 3                        11                                19
     9 :8001   1   3     0 2                         1                                19
    10 :   1   3   2 60000 2                         1                                19
    11 :   3   2   4  5000 2 93  500103  500113  500 2                                19
    12 :   2   4  10  5000 3 93  500103  500         110                              19
    13 :   4  108007 31620 3                         1                                19
    14 :   4   88004 33541 3                         1                                19
    15 :8003   6         12265                                                        20
    16 :   6   3         12265                                                        20
    17 :8001   1         12265                                                        20
    18 :   1   3         12265                                                        20
    19 :   3   2         12265                                                        20
    20 :   2   4         12265       2500                                             20
    21 :   4  10         12265                                                        20
    22 :   4   8         12265                                                        20
    23 :8003   6   33800                                                              25
    24 :   6   3   23800                                                              25
    25 :8001   1   33700                                                              25
    26 :   1   3   23700                                                              25
    27 :   3   2   47500                                                              25
    28 :   2   4  103800   83700                                                      25
    29 :   4  1080073800                                                              25
    30 :   4   880043700                                                              25
    31 :   3   2  11  30  20  10   2   1                                              28
    32 :   3   2  10  30  20  10   2   1                                              28
```

```
    33 :   3   2   9  30  20  10   2   1                                              28
    34 :   3   2   1  30  20  10   2   2                                              28
    35 :   3   2   2  30  20  10   2   2                                              28
    36 :   3   2  11 200  20  10   2   3                                              28
    37 :   3   2  10 200  20  10   2   3                                              28
    38 :   3   2   9 200  20  10   2   3                                              28
    39 :   3   2   1 200  20  10   2   4                                              28
    40 :   3   2   2 200  20  10   2   4                                              28
    41 :   3   2  11 460  20  10   2   5                                              28
    42 :   3   2  10 460  20  10   2   5                                              28
    43 :   3   2   9 460  20  10   2   5                                              28
    44 :   3   2   1 460  20  10   2   6                                              28
    45 :   3   2   2 460  20  10   2   6                                              28
    46 :   2   4  10  30  20  10   2   7                                              28
    47 :   2   4   9  30  20  10   2   7                                              28
    48 :   2   4   1  30  20  10   2   8                                              28
    49 :   2   4   2  30  20  10   2   8                                              28
    50 :   2   4   3  30  20  10   2   8                                              28
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

1                                   CARD FILE LIST (CONT.)
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

    51 :   2   4  10 200  20  10   2   9                                              28
    52 :   2   4   9 200  20  10   2   9                                              28
    53 :   2   4   1 200  20  10   2  10                                              28
    54 :   2   4   2 200  20  10   2  10                                              28
    55 :   2   4   3 200  20  10   2  10                                              28
    56 :   2   4  10 460  20  10   2  11                                              28
    57 :   2   4   9 460  20  10   2  11                                              28
    58 :   2   4   1 460  20  10   2  12                                              28
    59 :   2   4   2 460  20  10   2  12                                              28
    60 :   2   4   3 460  20  10   2  12                                              28
    61 :8003   63800                                                                  50
    62 :8001   13700                                                                  50
    63 :       1 900  60                                      71   1                  64
    64 :   1 2 3 4 5 6 7 8 9101112                                                    67
    65 :  15  14  13  12  11  10   9   8   7   6                                      68
    66 :  16  16  16  16   3   1                                                      69
    67 :  20  16   1  20                                                              70
    68 :   1  10  73   1   4  27   3  10  45   3   4  55                              74
    69 :   0                                                                         170
    70 :8003    3500    2000                                                         195
    71 :8004   15000    6500                                                         195
    72 :   6    4500    3500                                                         195
    73 :   8   13000    7500                                                         195
    74 :8007   16000   12000                                                         195
```

```
    75 :   3    9000    9000                                                         195
    76 :8001    1500    9000                                                         195
    77 :  10   13000   10000                                                         195
    78 :   1    2500    9000                                                         195
    79 :   2    9500    9000                                                         195
    80 :   4   10000    9000                                                         195
    81 :   1                                                                         210
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
```

OUTPUT RESULTS

```
                                                        TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

0                          ITRAF 2.0
0

 ***********************************************************************************************************************************

                                          CUMULATIVE FRESIM STATISTICS AT TIME  8 30  0
                                       -----------------------------------------------------

                                                        LINK STATISTICS
                                                                                    VEH-MIN/
                                                          SECONDS/VEHICLE           VEH-MILE
                                                         -------------------       -----------
              VEHICLES  LANE  CURR  AVG    VEH-    VEH-   TOTAL  MOVE DELAY                    VOLUME     DENSITY      SPEED   LINK
   LINK       IN   OUT  CHNG  CONT  CONT  MILES    MIN    TIME   TIME  TIME  M/T  TOTAL DELAY VEH/LN/HR VEH/LN-MILE   MILE/HR  TYPE
----------- ----- ----- ---- ----- ----- ------- ------- ------ ----- ----- ----- ----- -----  -------   ---------  ---------- ----

(   6,   3)  1900  1896  848    80  77.6 2451.2  2327.2    73.4  71.6   1.7   .98   .95   .02   1268.9     20.1          63.20 RAMP

(   1,   3)  1849  1842  820    69  67.6 2106.6  2027.0    65.6  63.1   2.6   .96   .96   .04   1853.8     29.7          62.36 FRWY

(   3,   2)  3738  3743 1655    10  11.6  354.1   346.6     5.6   5.3    .3   .95   .98   .05   1495.6     24.4          61.30 FRWY

(   2,   4)  3743  3740  227    11  11.6  354.3   347.1     5.6   5.3    .3   .95   .98   .05   1496.8     24.4          61.25 FRWY

(   4,  10)  2252  2258  589    37  43.3 1353.2  1298.7    34.5  33.2   1.3   .96   .96   .04   1506.4     24.1          62.51 FRWY

(   4,   8)  1488  1485  355    35  29.9  945.8   896.0    36.1  35.3    .8   .98   .95   .02    992.6     15.7          63.33 RAMP
```

Type C – Volume 2

```
                                                      TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

1                                       CARD FILE LIST
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

     1 :ITRAF 2.0                                                                     00
     2 :                                                                               1
     3 :       1   1      15     7981                  1   8 8          7781    7581   2
     4 :1800                                                                           3
     5 :                  60                                                           4
     6 :                                               1                               5
     7 :8003   6   3     1 3                         1                                19
     8 :   6   3   2 68001 3                        11                                19
     9 :8001   1   3     0 2                         1                                19
    10 :   1   3   2 60000 2                         1                                19
    11 :   3   2   4  5000 2 93  500103  500113  500 2                                19
    12 :   2   4  10  5000 3 93  500103  500         110                              19
    13 :   4  108007 31620 3                         1                                19
    14 :   4   88004 33541 3                         1                                19
    15 :8003   6         12265                                                        20
    16 :   6   3         12265                                                        20
    17 :8001   1         12265                                                        20
    18 :   1   3         12265                                                        20
    19 :   3   2         12265                                                        20
    20 :   2   4         12265       2500                                             20
    21 :   4  10         12265                                                        20
    22 :   4   8         12265                                                        20
    23 :8003   6   34350                                                              25
    24 :   6   3   24350                                                              25
    25 :8001   1   34300                                                              25
    26 :   1   3   24300                                                              25
    27 :   3   2   48650                                                              25
    28 :   2   4  104350   84300                                                      25
    29 :   4  1080074350                                                              25
    30 :   4   880044300                                                              25
    31 :   3   2  11  30  20  10   2   1                                              28
    32 :   3   2  10  30  20  10   2   1                                              28
```

```
    33 :   3   2   9  30  20  10   2   1                                              28
    34 :   3   2   1  30  20  10   2   2                                              28
    35 :   3   2   2  30  20  10   2   2                                              28
    36 :   3   2  11 200  20  10   2   3                                              28
    37 :   3   2  10 200  20  10   2   3                                              28
    38 :   3   2   9 200  20  10   2   3                                              28
    39 :   3   2   1 200  20  10   2   4                                              28
    40 :   3   2   2 200  20  10   2   4                                              28
    41 :   3   2  11 460  20  10   2   5                                              28
    42 :   3   2  10 460  20  10   2   5                                              28
    43 :   3   2   9 460  20  10   2   5                                              28
    44 :   3   2   1 460  20  10   2   6                                              28
    45 :   3   2   2 460  20  10   2   6                                              28
    46 :   2   4  10  30  20  10   2   7                                              28
    47 :   2   4   9  30  20  10   2   7                                              28
    48 :   2   4   1  30  20  10   2   8                                              28
    49 :   2   4   2  30  20  10   2   8                                              28
    50 :   2   4   3  30  20  10   2   8                                              28
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

1                                   CARD FILE LIST (CONT.)
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

    51 :   2   4  10 200  20  10   2   9                                              28
    52 :   2   4   9 200  20  10   2   9                                              28
    53 :   2   4   1 200  20  10   2  10                                              28
    54 :   2   4   2 200  20  10   2  10                                              28
    55 :   2   4   3 200  20  10   2  10                                              28
    56 :   2   4  10 460  20  10   2  11                                              28
    57 :   2   4   9 460  20  10   2  11                                              28
    58 :   2   4   1 460  20  10   2  12                                              28
    59 :   2   4   2 460  20  10   2  12                                              28
    60 :   2   4   3 460  20  10   2  12                                              28
    61 :8003   64350                                                                  50
    62 :8001   14300                                                                  50
    63 :       1 900  60                                      71   1                  64
    64 :   1 2 3 4 5 6 7 8 9101112                                                    67
    65 :  15  14  13  12  11  10   9   8   7   6                                      68
    66 :  16  16  16  16   3   1                                                      69
    67 :  20  16   1  20                                                              70
    68 :   1  10  73   1   4  27   3  10  45   3   4  55                              74
    69 :   0                                                                         170
    70 :8003    3500    2000                                                         195
    71 :8004   15000    6500                                                         195
    72 :   6    4500    3500                                                         195
    73 :   8   13000    7500                                                         195
    74 :8007   16000   12000                                                         195
```

```
    75 :   3    9000    9000                                                         195
    76 :8001    1500    9000                                                         195
    77 :  10   13000   10000                                                         195
    78 :   1    2500    9000                                                         195
    79 :   2    9500    9000                                                         195
    80 :   4   10000    9000                                                         195
    81 :   1                                                                         210
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
```

OUTPUT RESULTS

```
                                                        TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

0                          ITRAF 2.0

 ***********************************************************************************************************************************

                                           CUMULATIVE FRESIM STATISTICS AT TIME  8 30  0
                                       -----------------------------------------------------

                                                        LINK STATISTICS
                                                                                    VEH-MIN/
                                                          SECONDS/VEHICLE           VEH-MILE
                                                         ------------------       -----------
              VEHICLES  LANE  CURR  AVG     VEH-    VEH-   TOTAL  MOVE DELAY                   VOLUME     DENSITY     SPEED    LINK
   LINK        IN   OUT CHNG  CONT  CONT  MILES     MIN    TIME  TIME  TIME   M/T  TOTAL DELAY VEH/LN/HR VEH/LN-MILE   MILE/HR  TYPE
----------- ----- ----- ---- ----- ----- ------- ------- ------ ----- ----- ----- ----- ----- -------   ---------  ---------- ----

(   6,   3)  2175  2174 1015    88  89.3 2808.3  2679.2   73.7  71.6   2.1   .97   .95   .03  1453.7      23.1         62.89  RAMP

(   1,   3)  2148  2150  951    76  79.2 2448.0  2376.6   66.2  63.2   3.0   .96   .97   .04  2154.2      34.9         61.80  FRWY

(   3,   2)  4324  4313 1830    25  13.5  408.6   404.0    5.6   5.3    .3   .94   .99   .06  1726.0      28.4         60.68  FRWY

(   2,   4)  4313  4321  324    11  13.6  409.1   407.4    5.7   5.3    .4   .94  1.00   .06  1727.8      28.7         60.24  FRWY

(   4,  10)  2520  2524  660    46  48.6 1506.7  1456.6   34.7  33.3   1.4   .96   .97   .04  1677.3      27.0         62.07  FRWY

(   4,   8)  1801  1810  466    28  36.5 1147.5  1095.8   36.4  35.3   1.1   .97   .95   .03  1204.3      19.2         62.83  RAMP
```

Type C – Volume 3

```
                                                      TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

1                                       CARD FILE LIST
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

     1 :ITRAF 2.0                                                                     00
     2 :                                                                               1
     3 :       1   1      15     7981                  1   8 8          7781    7581   2
     4 :1800                                                                           3
     5 :                  60                                                           4
     6 :                                               1                               5
     7 :8003   6   3     1 3                         1                                19
     8 :   6   3   2 68001 3                        11                                19
     9 :8001   1   3     0 2                         1                                19
    10 :   1   3   2 60000 2                         1                                19
    11 :   3   2   4  5000 2 93  500103  500113  500 2                                19
    12 :   2   4  10  5000 3 93  500103  500         110                              19
    13 :   4  108007 31620 3                         1                                19
    14 :   4   88004 33541 3                         1                                19
    15 :8003   6         12265                                                        20
    16 :   6   3         12265                                                        20
    17 :8001   1         12265                                                        20
    18 :   1   3         12265                                                        20
    19 :   3   2         12265                                                        20
    20 :   2   4         12265       2500                                             20
    21 :   4  10         12265                                                        20
    22 :   4   8         12265                                                        20
    23 :8003   6   32100                                                              25
    24 :   6   3   22100                                                              25
    25 :8001   1   32050                                                              25
    26 :   1   3   22050                                                              25
    27 :   3   2   44150                                                              25
    28 :   2   4  102100   82050                                                      25
    29 :   4  1080072100                                                              25
    30 :   4   880042050                                                              25
    31 :   3   2  11  30  20  10   2   1                                              28
```

```
    32 :   3   2  10  30  20  10   2   1                                              28
    33 :   3   2   9  30  20  10   2   1                                              28
    34 :   3   2   1  30  20  10   2   2                                              28
    35 :   3   2   2  30  20  10   2   2                                              28
    36 :   3   2  11 200  20  10   2   3                                              28
    37 :   3   2  10 200  20  10   2   3                                              28
    38 :   3   2   9 200  20  10   2   3                                              28
    39 :   3   2   1 200  20  10   2   4                                              28
    40 :   3   2   2 200  20  10   2   4                                              28
    41 :   3   2  11 460  20  10   2   5                                              28
    42 :   3   2  10 460  20  10   2   5                                              28
    43 :   3   2   9 460  20  10   2   5                                              28
    44 :   3   2   1 460  20  10   2   6                                              28
    45 :   3   2   2 460  20  10   2   6                                              28
    46 :   2   4  10  30  20  10   2   7                                              28
    47 :   2   4   9  30  20  10   2   7                                              28
    48 :   2   4   1  30  20  10   2   8                                              28
    49 :   2   4   2  30  20  10   2   8                                              28
    50 :   2   4   3  30  20  10   2   8                                              28
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

1                                   CARD FILE LIST (CONT.)
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

    51 :   2   4  10 200  20  10   2   9                                              28
    52 :   2   4   9 200  20  10   2   9                                              28
    53 :   2   4   1 200  20  10   2  10                                              28
    54 :   2   4   2 200  20  10   2  10                                              28
    55 :   2   4   3 200  20  10   2  10                                              28
    56 :   2   4  10 460  20  10   2  11                                              28
    57 :   2   4   9 460  20  10   2  11                                              28
    58 :   2   4   1 460  20  10   2  12                                              28
    59 :   2   4   2 460  20  10   2  12                                              28
    60 :   2   4   3 460  20  10   2  12                                              28
    61 :8003   62100                                                                  50
    62 :8001   12050                                                                  50
    63 :       1 900  60                                      71   1                  64
    64 :   1 2 3 4 5 6 7 8 9101112                                                    67
    65 :  15  14  13  12  11  10   9   8   7   6                                      68
    66 :  16  16  16  16   3   1                                                      69
    67 :  20  16   1  20                                                              70
    68 :   1  10  73   1   4  27   3  10  45   3   4  55                              74
    69 :   0                                                                         170
    70 :8003    3500    2000                                                         195
    71 :8004   15000    6500                                                         195
    72 :   6    4500    3500                                                         195
    73 :   8   13000    7500                                                         195
```

```
    74 :8007   16000   12000                                                         195
    75 :   3    9000    9000                                                         195
    76 :8001    1500    9000                                                         195
    77 :  10   13000   10000                                                         195
    78 :   1    2500    9000                                                         195
    79 :   2    9500    9000                                                         195
    80 :   4   10000    9000                                                         195
    81 :   1                                                                         210
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
```

OUTPUT RESULTS

```
                                                        TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

0                          ITRAF 2.0
0
 ***********************************************************************************************************************************

                                           CUMULATIVE FRESIM STATISTICS AT TIME  8 30  0
                                       -----------------------------------------------------

                                                        LINK STATISTICS
                                                                                    VEH-MIN/
                                                          SECONDS/VEHICLE           VEH-MILE
                                                         ------------------       -----------
              VEHICLES  LANE  CURR  AVG    VEH-    VEH-   TOTAL  MOVE DELAY                    VOLUME     DENSITY       SPEED   LINK
   LINK       IN   OUT  CHNG  CONT  CONT  MILES    MIN    TIME   TIME  TIME  M/T  TOTAL DELAY VEH/LN/HR VEH/LN-MILE   MILE/HR  TYPE
----------- ----- ----- ---- ----- ----- ------- ------- ------ ----- ----- ----- ----- -----  -------   ---------  ---------- ----

(   6,   3)  1049  1050  411    42  42.4 1354.9  1271.7    72.5  71.7    .8   .99   .94   .01    701.4      11.0        63.93   RAMP

(   1,   3)  1025  1027  465    37  36.9 1167.6  1106.4    64.6  63.5   1.1   .98   .95   .02   1027.5      16.2        63.32   FRWY

(   3,   2)  2077  2070  912     9   6.2  196.3   187.5     5.4   5.3    .1   .97   .96   .03    829.0      13.2        62.81   FRWY

(   2,   4)  2070  2070  117     6   6.3  196.1   187.6     5.4   5.3    .1   .98   .96   .02    828.3      13.2        62.72   FRWY

(   4,  10)  1216  1219  238    24  23.0  729.1   689.3    34.0  33.4    .6   .98   .95   .02    811.6      12.8        63.46   FRWY

(   4,   8)   854   854  160    16  17.0  542.3   511.1    35.9  35.4    .5   .99   .94   .01    569.2       8.9        63.67   RAMP
```

Type C – Volume 4

```
                                                      TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

1                                       CARD FILE LIST
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

     1 :ITRAF 2.0                                                                     00
     2 :                                                                               1
     3 :       1   1      15     7981                  1   8 8          7781    7581   2
     4 :1800                                                                           3
     5 :                  60                                                           4
     6 :                                               1                               5
     7 :8003   6   3     1 3                         1                                19
     8 :   6   3   2 68001 3                        11                                19
     9 :8001   1   3     0 2                         1                                19
    10 :   1   3   2 60000 2                         1                                19
    11 :   3   2   4  5000 2 93  500103  500113  500 2                                19
    12 :   2   4  10  5000 3 93  500103  500         110                              19
    13 :   4  108007 31620 3                         1                                19
    14 :   4   88004 33541 3                         1                                19
    15 :8003   6         12265                                                        20
    16 :   6   3         12265                                                        20
    17 :8001   1         12265                                                        20
    18 :   1   3         12265                                                        20
    19 :   3   2         12265                                                        20
    20 :   2   4         12265       2500                                             20
    21 :   4  10         12265                                                        20
    22 :   4   8         12265                                                        20
    23 :8003   6   32900                                                              25
    24 :   6   3   22900                                                              25
    25 :8001   1   32850                                                              25
    26 :   1   3   22850                                                              25
    27 :   3   2   45750                                                              25
    28 :   2   4  102900   82850                                                      25
    29 :   4  1080072900                                                              25
    30 :   4   880042850                                                              25
    31 :   3   2  11  30  20  10   2   1                                              28
```

```
    32 :   3   2  10  30  20  10   2   1                                              28
    33 :   3   2   9  30  20  10   2   1                                              28
    34 :   3   2   1  30  20  10   2   2                                              28
    35 :   3   2   2  30  20  10   2   2                                              28
    36 :   3   2  11 200  20  10   2   3                                              28
    37 :   3   2  10 200  20  10   2   3                                              28
    38 :   3   2   9 200  20  10   2   3                                              28
    39 :   3   2   1 200  20  10   2   4                                              28
    40 :   3   2   2 200  20  10   2   4                                              28
    41 :   3   2  11 460  20  10   2   5                                              28
    42 :   3   2  10 460  20  10   2   5                                              28
    43 :   3   2   9 460  20  10   2   5                                              28
    44 :   3   2   1 460  20  10   2   6                                              28
    45 :   3   2   2 460  20  10   2   6                                              28
    46 :   2   4  10  30  20  10   2   7                                              28
    47 :   2   4   9  30  20  10   2   7                                              28
    48 :   2   4   1  30  20  10   2   8                                              28
    49 :   2   4   2  30  20  10   2   8                                              28
    50 :   2   4   3  30  20  10   2   8                                              28
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

1                                   CARD FILE LIST (CONT.)
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

    51 :   2   4  10 200  20  10   2   9                                              28
    52 :   2   4   9 200  20  10   2   9                                              28
    53 :   2   4   1 200  20  10   2  10                                              28
    54 :   2   4   2 200  20  10   2  10                                              28
    55 :   2   4   3 200  20  10   2  10                                              28
    56 :   2   4  10 460  20  10   2  11                                              28
    57 :   2   4   9 460  20  10   2  11                                              28
    58 :   2   4   1 460  20  10   2  12                                              28
    59 :   2   4   2 460  20  10   2  12                                              28
    60 :   2   4   3 460  20  10   2  12                                              28
    61 :8003   62900                                                                  50
    62 :8001   12850                                                                  50
    63 :       1 900  60                                        71   1                  64
    64 :   1 2 3 4 5 6 7 8 9101112                                                    67
    65 :  15  14  13  12  11  10   9   8   7   6                                      68
    66 :  16  16  16  16   3   1                                                      69
    67 :  20  16   1  20                                                              70
    68 :   1  10  73   1   4  27   3  10  45   3   4  55                              74
    69 :   0                                                                         170
    70 :8003    3500    2000                                                         195
    71 :8004   15000    6500                                                         195
    72 :   6    4500    3500                                                         195
    73 :   8   13000    7500                                                         195
```

```
    74 :8007   16000   12000                                                         195
    75 :   3    9000    9000                                                         195
    76 :8001    1500    9000                                                         195
    77 :  10   13000   10000                                                         195
    78 :   1    2500    9000                                                         195
    79 :   2    9500    9000                                                         195
    80 :   4   10000    9000                                                         195
    81 :   1                                                                        210
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
```

OUTPUT RESULTS

```
                                                        TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

0                          ITRAF 2.0

 ***********************************************************************************************************************************

                                           CUMULATIVE FRESIM STATISTICS AT TIME  8 30  0
                                       -----------------------------------------------------
                                                        LINK STATISTICS
                                                                                    VEH-MIN/
                                                          SECONDS/VEHICLE           VEH-MILE
                                                         ------------------       -----------
              VEHICLES  LANE  CURR  AVG    VEH-    VEH-   TOTAL  MOVE DELAY                    VOLUME     DENSITY      SPEED   LINK
   LINK       IN   OUT  CHNG  CONT  CONT  MILES    MIN    TIME   TIME  TIME  M/T  TOTAL DELAY VEH/LN/HR VEH/LN-MILE   MILE/HR  TYPE
----------- ----- ----- ---- ----- ----- ------- ------- ------ ----- ----- ----- ----- -----  -------   ---------  ---------- ----

(   6,   3)  1449  1447  596    60  58.9 1870.3  1768.3    73.1  71.9   1.2   .98   .95   .02    968.1      15.3         63.46   RAMP

(   1,   3)  1424  1429  625    48  51.7 1623.9  1549.6    65.1  63.2   1.8   .97   .95   .03   1429.0      22.7         62.87   FRWY

(   3,   2)  2876  2876 1192    14   8.8  272.3   263.3     5.5   5.3    .2   .96   .97   .04   1150.2      18.5         62.06   FRWY

(   2,   4)  2876  2873  157     7   8.8  272.3   263.6     5.5   5.3    .2   .96   .97   .03   1150.3      18.6         62.00   FRWY

(   4,  10)  1690  1699  389    25  32.2 1013.4   967.4    34.3  33.4    .9   .97   .95   .03   1128.1      17.9         62.85   FRWY

(   4,   8)  1183  1180  252    28  23.7  750.0   710.8    36.1  35.4    .7   .98   .95   .02    787.1      12.4         63.31   RAMP
```

Type C – Volume 5

```
                                                      TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

1                                       CARD FILE LIST
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

     1 :ITRAF 2.0                                                                     00
     2 :                                                                               1
     3 :       1   1      15     7981                  1   8 8          7781    7581   2
     4 :1800                                                                           3
     5 :                  60                                                           4
     6 :                                               1                               5
     7 :8003   6   3     1 3                         1                                19
     8 :   6   3   2 68001 3                        11                                19
     9 :8001   1   3     0 2                         1                                19
    10 :   1   3   2 60000 2                         1                                19
    11 :   3   2   4  5000 2 93  500103  500113  500 2                                19
    12 :   2   4  10  5000 3 93  500103  500         110                              19
    13 :   4  108007 31620 3                         1                                19
    14 :   4   88004 33541 3                         1                                19
    15 :8003   6         12265                                                        20
    16 :   6   3         12265                                                        20
    17 :8001   1         12265                                                        20
    18 :   1   3         12265                                                        20
    19 :   3   2         12265                                                        20
    20 :   2   4         12265       2500                                             20
    21 :   4  10         12265                                                        20
    22 :   4   8         12265                                                        20
    23 :8003   6   33500                                                              25
    24 :   6   3   23500                                                              25
    25 :8001   1   33450                                                              25
    26 :   1   3   23450                                                              25
    27 :   3   2   46950                                                              25
    28 :   2   4  103500   83450                                                      25
    29 :   4  1080073500                                                              25
    30 :   4   880043450                                                              25
    31 :   3   2  11  30  20  10   2   1                                              28
    32 :   3   2  10  30  20  10   2   1                                              28
```

```
    33 :   3   2   9  30  20  10   2   1                                              28
    34 :   3   2   1  30  20  10   2   2                                              28
    35 :   3   2   2  30  20  10   2   2                                              28
    36 :   3   2  11 200  20  10   2   3                                              28
    37 :   3   2  10 200  20  10   2   3                                              28
    38 :   3   2   9 200  20  10   2   3                                              28
    39 :   3   2   1 200  20  10   2   4                                              28
    40 :   3   2   2 200  20  10   2   4                                              28
    41 :   3   2  11 460  20  10   2   5                                              28
    42 :   3   2  10 460  20  10   2   5                                              28
    43 :   3   2   9 460  20  10   2   5                                              28
    44 :   3   2   1 460  20  10   2   6                                              28
    45 :   3   2   2 460  20  10   2   6                                              28
    46 :   2   4  10  30  20  10   2   7                                              28
    47 :   2   4   9  30  20  10   2   7                                              28
    48 :   2   4   1  30  20  10   2   8                                              28
    49 :   2   4   2  30  20  10   2   8                                              28
    50 :   2   4   3  30  20  10   2   8                                              28
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

1                                   CARD FILE LIST (CONT.)
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

    51 :   2   4  10 200  20  10   2   9                                              28
    52 :   2   4   9 200  20  10   2   9                                              28
    53 :   2   4   1 200  20  10   2  10                                              28
    54 :   2   4   2 200  20  10   2  10                                              28
    55 :   2   4   3 200  20  10   2  10                                              28
    56 :   2   4  10 460  20  10   2  11                                              28
    57 :   2   4   9 460  20  10   2  11                                              28
    58 :   2   4   1 460  20  10   2  12                                              28
    59 :   2   4   2 460  20  10   2  12                                              28
    60 :   2   4   3 460  20  10   2  12                                              28
    61 :8003   63500                                                                  50
    62 :8001   13450                                                                  50
    63 :       1 900  60                                      71   1                  64
    64 :   1 2 3 4 5 6 7 8 9101112                                                    67
    65 :  15  14  13  12  11  10   9   8   7   6                                      68
    66 :  16  16  16  16   3   1                                                      69
    67 :  20  16   1  20                                                              70
    68 :   1  10  73   1   4  27   3  10  45   3   4  55                              74
    69 :   0                                                                         170
    70 :8003    3500    2000                                                         195
    71 :8004   15000    6500                                                         195
    72 :   6    4500    3500                                                         195
    73 :   8   13000    7500                                                         195
    74 :8007   16000   12000                                                         195
```

```
    75 :   3    9000    9000                                                         195
    76 :8001    1500    9000                                                         195
    77 :  10   13000   10000                                                         195
    78 :   1    2500    9000                                                         195
    79 :   2    9500    9000                                                         195
    80 :   4   10000    9000                                                         195
    81 :   1                                                                         210
0SEQ.# :----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
```

OUTPUT RESULTS

```
                                                        TRAF SIMULATION MODEL

                                                           DEVELOPED FOR

                                                 U. S. DEPARTMENT OF TRANSPORTATION
                                                   FEDERAL HIGHWAY ADMINISTRATION
                                    FHWA OFFICE OF OPERATIONS RESEARCH, DEVELOPMENT AND TECHNOLOGY

                                          CUMULATIVE FRESIM STATISTICS AT TIME  8 30  0
                                       -----------------------------------------------------

                                                        LINK STATISTICS
                                                                                     VEH-MIN/
                                                          SECONDS/VEHICLE            VEH-MILE
                                                         ------------------       -----------
              VEHICLES  LANE  CURR  AVG    VEH-    VEH-   TOTAL  MOVE DELAY                     VOLUME     DENSITY      SPEED   LINK
   LINK       IN   OUT  CHNG  CONT  CONT  MILES    MIN    TIME   TIME  TIME   M/T TOTAL DELAY VEH/LN/HR VEH/LN-MILE   MILE/HR   TYPE
----------- ----- ----- ---- ----- ----- ------- ------- ------ ----- ----- ----- ----- -----  -------    ---------  ---------- ----

(   6,   3)  1750  1744  849    73  71.5 2257.8  2144.5    73.4  71.9   1.5   .98   .95   .02   1168.7      18.5        63.17   RAMP

(   1,   3)  1724  1720  695    65  62.8 1964.9  1884.4    65.4  63.2   2.2   .97   .96   .03   1729.1      27.6        62.56   FRWY

(   3,   2)  3464  3473 1477    10  10.7  328.3   320.3     5.5   5.3    .3   .95   .98   .05   1386.8      22.5        61.50   FRWY

(   2,   4)  3473  3472  239    12  10.7  328.8   322.3     5.6   5.3    .3   .95   .98   .05   1388.8      22.7        61.21   FRWY

(   4,  10)  2110  2102  565    42  40.4 1262.0  1212.2    34.5  33.3   1.2   .97   .96   .03   1404.9      22.5        62.47   FRWY

(   4,   8)  1362  1366  302    25  27.5  866.9   824.2    36.2  35.5    .8   .98   .95   .02    909.8      14.4        63.11   RAMP
```

APPENDIX D

INTEGRATION FILES

Type A – Volume 1

TYPEA Master File

```
120  900   900     1     1
typea\
typea\output\
TYPEA1.dat
TYPEA2.dat
TYPEA3.dat
TYPEA4.dat
TYPEA5.dat
none
none
none
none
none
TYPEA11.out
TYPEA12.out
TYPEA13.out
TYPEA14.out
TYPEA15.out
TYPEA16.out
none
none
none
none
detector.dat
none
□
```

Typea1 Node Characteristic File

```
 11    1.0     1.0
  1    0.1     2.65     3        0        0
  2    0.1     3.03     4        0        0
  3    1.24    2.08     4        0        0
  4    1.43    2.08     4        0        0
  5    2.47    2.08     4        0        0
  6    3.04    2.08     2       -1        0
```

```
 7    0.29    1.80    3        0        0
 8    0.1     0.38    4        0        0
 9    0.67    0.38    4        0        0
10    2.28    0.85    2       -2        0
11    2.09    1.42    4        0        0
□
```

Typea Link Characteristic File

```
 10     1.6     1.0     1.0     1.0     1.0
  1    1    2  0.38  104.0 2200.0  3.0  0.00 103.9 125.0   0  0    0   0   0     0   0   0 00000 11111
  2    2    3  1.48  104.0 2200.0  3.0  0.00 103.9 125.0   0  0    0   0   0     0   0   0 00000 11111
  3    3    4  0.19  104.0 2200.0  4.0  0.00 103.9 125.0   0  0    0   0   0     0   0   0 00000 11111
  4    4    5  1.04  104.0 2200.0  3.0  0.00 103.9 125.0   0  0    0   0   0     0   0   0 00000 11111
  5    5    6  1.04  104.0 2200.0  3.0  0.00 103.9 125.0   0  0    0   0   0     0   0   0 00000 11111
  6    7    8  1.42   72. 0 1600.0  1.0  0.00  71.9  125.0   0  0    0   0   0     0   0   0 00000 11111
  7    8    9    0.57   72.0 1600.0  1.0  0.00  71.9 125.0   0  0    0   0   0     0   0   0 00000 11111
  8    9    3    1.79   72.0 1600.0  1.0  0.00  71.9 125.0   0  0    0   0   0     0   0   0 00000 11111
  9   11   10  0.59   72.0 1600.0  1.0  0.00  71.9 125.0   0  0    0   0   0     0   0   0 00000 11111
 10    4   11  0.88   72.0 1600.0  1.0  0.00  71.9 125.0   0  0    0   0   0     0   0   0 00000 11111
□
```

Typea Signal Timing Plan File

```
 0    0
□
```

Typea O-D Traffic Demand File

```
 4    0      0    1.0
 1    1    6  4000  1.0     0  1800   1.0   0.0   0.0   0.0   0.0 100.0     1.0
 2    1  10    300  1.0     0  1800   0.0   0.0   1.0   0.0   0.0 100.0     1.0
 3    7    6   600   1.0     0  1800   0.0   0.0   0.0   1.0   0.0 100.0     1.0
 4    7  10    100  1.0     0  1800   0.0   1.0   0.0   0.0   0.0 100.0     1.0
□
```

Typea Incident File - Type 1

```
  0
 □
```

typeav2 detector file

```
3 0
1 1 3 0.01 0.005 300
2 1 3 0.09 0.005 300
3 1 3 0.19 0.005 300
```

Output File

Average Traffic conditions

```
120     1
   1 0.608  6600  3630  3360    0  270    0    0  21.0   21.1   21.1   21.0   21.1   21.0   21.0  0.00   0.00   0.00   0.00   0.00 23.3  20.8  0.0    7.496    14.599  365.648    28.377     67.1     31.0      0.7
1.9     32.7     19.3
   2 2.368  6600   480   420    0   60    0    0  82.0   82.2   82.1   82.0   82.9   82.0   82.0  0.00   0.00   0.00   0.00   0.00 48.3  41.6  0.1   14.186    15.023  283.866    51.210    139.1     64.3      1.5
4.0     65.9     41.0
   3 0.304  8800   210   180    0   30    0    0  10.5   10.9   10.6   10.5   13.1   10.5   10.5  0.00   0.00   0.00   0.00   0.00  1.1   0.9  0.1    0.359     1.047   21.177     1.295      3.2      1.5      0.0      0.1
1.5      0.9
   4 1.664  6600     0     0    0    0    0    0  57.6   57.6   57.6   57.6   57.6   57.6   57.6  0.00   0.00   0.00   0.00   0.00  0.2   0.1  0.0    0.057     0.061    1.109     0.217      0.6      0.3      0.0      0.0      0.3
0.2
   5 1.664  6600     0     0    0    0    0    0  57.6   57.6   57.6   57.6   57.6   57.6   57.6  0.00   0.00   0.00   0.00   0.00  0.0   0.0  0.0    0.000     0.000    0.000     0.000      0.0      0.0      0.0      0.0      0.0
0.0
   6 2.272  1600    30     0    0    0   30    0 113.6  113.7  113.6  113.6  113.6  113.7  113.6  0.00   0.00   0.00   0.00   0.00 12.9   0.4  0.9    2.425     2.133   34.262     4.740     55.6     26.8      0.2
3.2     24.1     16.9
   7 0.912  1600     0     0    0    0    0    0  45.6   45.6   45.6   45.6   45.6   45.6   45.6  0.00   0.00   0.00   0.00   0.00  0.1   0.0  0.0    0.009     0.008    0.133     0.017      0.2      0.1      0.0      0.0      0.1
0.1
   8 2.864  1600     0     0    0    0    0    0 143.2  143.2  143.2  143.2  143.2  143.2  143.2  0.00   0.00   0.00   0.00   0.00  0.0   0.0  0.0    0.000     0.000    0.000     0.000      0.0      0.0      0.0      0.0
0.0      0.0
   9 0.944  1600     0     0    0    0    0    0  47.2   47.2   47.2   47.2   47.2   47.2   47.2  0.00   0.00   0.00   0.00   0.00  0.0   0.0  0.0    0.000     0.000    0.000     0.000      0.0      0.0      0.0      0.0      0.0
0.0
  10 1.408  1600     0     0    0    0    0    0  70.4   70.4   70.4   70.4   70.4   70.4   70.4  0.00   0.00   0.00   0.00   0.00  0.0   0.0  0.0    0.001     0.001    0.015     0.001      0.0      0.0      0.0      0.0      0.0
0.0
```

Type A – Volume 2

TYPEAV2 Master File

```
1800  900   900     1     1
typeav2\
typeav2\output\
TYPEAV21.dat
TYPEAV22.dat
TYPEAV23.dat
TYPEAV24.dat
TYPEAV25.dat
none
none
none
```

```
none
none
TYPEAV211.out
TYPEAV212.out
TYPEAV213.out
TYPEAV214.out
none
none
none
none
none
none
detector.dat
none

```

typea O-D Traffic Demand File

```
 4    0      0    1.0
 1   1   6  5000  1.0     0  1800   1.0   0.0   0.0   0.0   0.0 100.0    1.0
 2   1  10   450  1.0     0  1800   0.0   0.0   1.0   0.0   0.0 100.0    1.0
 3   7   6   800  1.0     0  1800   0.0   0.0   0.0   1.0   0.0 100.0    1.0
 4   7  10   100  1.0     0  1800   0.0   1.0   0.0   0.0   0.0 100.0    1.0

```

Output File

Average Traffic conditions

```
   1800      1
    1 0.608  6600  5378  4936     0   442     0     0   21.0   21.2   21.2   21.0   21.2   21.0   21.0   0.00   0.00   0.00   0.00   0.00  32.0  30.7   0.1   161.056   320.430  8225.957   646.615   1381.0    636.6
13.0     40.2    686.3    390.7
    2 2.368  6600  5064  4648     0   416     0     0   82.0   86.6   86.4   82.0   89.7   82.0   82.0   0.00   0.00   0.00   0.00   0.00 126.2 122.4   0.4   561.421  1073.019 24062.955  2037.327   5444.4   2517.1
59.6    155.6   2587.5   1602.3
    3 0.304  8800  5734  4608    88   414   624     0   10.5   14.3   13.5   14.4   16.8   18.3   10.5   0.00   0.00   0.00   0.00   0.00  23.0  22.9   0.2   169.143  1051.534 23077.895   594.617    991.7    462.8
5.3      41.2    478.7    280.1
    4 1.664  6600  5044  4444     0     0   600     0   57.6   57.7   57.7   57.6   57.6   58.1   57.6   0.00   0.00   0.00   0.00   0.00  82.4  80.6   0.0   400.943   722.696 14243.964  1476.557   3556.5   1657.2
29.6    125.1   1726.3   1020.9
    5 1.664  6600  4862  4286     0     0   576     0   57.6   57.5   57.5   57.6   57.6   57.5   57.6   0.00   0.00   0.00   0.00   0.00  79.1  77.3   0.0   350.127   340.359  6139.452  1271.369   3414.7   1579.7
37.2     97.4   1625.0   1003.5
    6 2.272  1600   832     0    94     0   738     0  113.6  113.7  113.6  113.7  113.6  113.8  113.6   0.00   0.00   0.00   0.00   0.00  27.4   1.1   0.1    76.862    67.662  1084.634   148.736   1768.3    853.9
7.7     104.6    755.2    543.2
    7 0.912  1600   812     0    90     0   722     0   45.6   45.5   45.6   45.5   45.6   45.5   45.6   0.00   0.00   0.00   0.00   0.00  10.4   0.5   0.0    28.881    25.503   405.708    54.010    671.4    323.0      2.9
38.4    294.8    202.7
```

```
   8 2.864  1600   722     0    88     0   634     0  143.2  143.4  143.2  143.5  143.2  143.4  143.2   0.00   0.00   0.00   0.00   0.00  30.9   0.7   0.1    85.228    75.558  1197.940   158.633   1995.4    960.2
8.7    114.0    877.6    602.2
   9 0.944  1600   464     0    84   380     0     0   47.2   47.0   47.2   47.0   47.0   47.2   47.2   0.00   0.00   0.00   0.00   0.00   6.2   0.3   0.0    17.337    15.314   243.306    32.370    403.7    194.1      1.8
23.0    177.5    121.8
  10 1.408  1600   486     0    86   400     0     0   70.4   70.5   70.4   70.6   70.5   70.4   70.4   0.00   0.00   0.00   0.00   0.00   9.7   0.5   0.1    27.866    29.741   543.681    56.667    625.9    301.5      2.7
36.3    269.8    191.0
```

Type A – Volume 3

TYPEAV3 Master File

```
  1800  900   900     1     1
typeav3\
typeav3\output\
TYPEAV31.dat
TYPEAV32.dat
TYPEAV33.dat
TYPEAV34.dat
TYPEAV35.dat
none
none
none
none
none
TYPEAV311.out
TYPEAV312.out
TYPEAV313.out
TYPEAV314.out
none
none
none
none
none
none
detector.dat
none
□
```

typea O-D Traffic Demand File

```
 4   0     0   1.0
 1   1   6  6000  1.0    0  1800   1.0   0.0   0.0   0.0   0.0 100.0    1.0
 2   1  10   600  1.0    0  1800   0.0   0.0   1.0   0.0   0.0 100.0    1.0
 3   7   6  1000  1.0    0  1800   0.0   0.0   0.0   1.0   0.0 100.0    1.0
 4   7  10   100  1.0    0  1800   0.0   1.0   0.0   0.0   0.0 100.0    1.0
```

Output File

Average Traffic conditions

```
   1800      1
    1 0.608  6600  5732  5204    0   528    0    0   21.0   35.6   35.6   21.0   35.2   21.0   21.0   0.00   0.00   0.00   0.00   0.00  57.8  57.7   0.4   134.169   155.336  2560.181   262.724   2494.7   1152.2
19.5    78.9   1275.9   686.0
    2 2.368  6600  5170  4680    0   490    0    0   82.0  151.5  150.7   82.0  159.7   82.0   82.0   0.00   0.00   0.00   0.00   0.00 232.8 232.8   1.0   716.385  1692.751 38533.410  1964.148  10074.4   4751.0
34.2   497.8   4400.5   3025.8
    3 0.304  8800  6030  4640   90   490   810    0   10.5   15.7   14.7   16.4   18.4   20.3   10.5   0.00   0.00   0.00   0.00   0.00  26.6  26.5   0.2   238.804  1606.733 35272.684   855.954   1146.3    516.9
3.0    36.7    660.9   265.1
    4 1.664  6600  5264  4490    0     0   774    0   57.6   57.7   57.7   57.6   57.6   57.8   57.6   0.00   0.00   0.00   0.00   0.00  85.9  84.7   0.0   409.945   640.371 12753.462  1527.088   3705.7   1718.6
32.6   119.1   1825.9   1054.3
    5 1.664  6600  5080  4336    0     0   744    0   57.6   57.5   57.5   57.6   57.6   57.5   57.6   0.00   0.00   0.00   0.00   0.00  82.7  81.7   0.0   366.567   356.702  6431.008  1333.099   3570.6   1651.9
38.7   101.7   1703.2   1047.7
    6 2.272  1600  1034    0    98    0   936    0 113.6  113.8  113.6  113.8  113.6  113.9  113.6   0.00   0.00   0.00   0.00   0.00  33.8   1.7   0.1    95.342    83.796  1347.680   186.276   2183.8   1056.1
9.5   131.2    919.8   676.2
    7 0.912  1600  1018    0    94    0   924    0   45.6   45.5   45.6   45.5   45.6   45.5   45.6   0.00   0.00   0.00   0.00   0.00  13.0   0.6   0.0    36.153    31.928   508.459    67.645    839.6    404.0     3.7
48.1   368.3   253.6
    8 2.864  1600   912    0    90    0   822    0 143.2  148.1  143.2  147.6  143.2  148.1  143.2   0.00   0.00   0.00   0.00   0.00  39.9   3.2   0.4   106.818    95.561  1498.392   195.934   2577.8   1240.3
11.2   147.4   1132.2   778.3
    9 0.944  1600   532    0    80   452    0    0   47.2   47.0   47.2   47.0   47.0   47.2   47.2   0.00   0.00   0.00   0.00   0.00   7.2   0.3   0.0    19.863    17.548   278.875    37.083    462.5    222.4     2.0
26.4   203.3   139.5
   10 1.408  1600   558    0    86   472    0    0   70.4   70.5   70.4   70.7   70.5   70.4   70.4   0.00   0.00   0.00   0.00   0.00  11.1   0.6   0.1    31.983    33.148   595.084    65.037    720.0    347.1     3.1
42.1   308.9   220.4
```

Type A – Volume 4

TYPEAV4 Master File

```
 1800  900   900    1    1
typeav4\
typeav4\output\
```

```
TYPEAV41.dat
TYPEAV42.dat
TYPEAV43.dat
TYPEAV44.dat
TYPEAV45.dat
none
none
none
none
none
TYPEAV411.out
TYPEAV412.out
TYPEAV413.out
TYPEAV414.out
none
none
none
none
none
none
detector.dat
none
□
```

typeav4 O-D Traffic Demand File

```
 4   0      0   1.0
 1   1   6  6000  1.0     0  1800   1.0   0.0   0.0   0.0   0.0 100.0    1.0
 2   1  10   800  1.0     0  1800   0.0   0.0   1.0   0.0   0.0 100.0    1.0
 3   7   6  1200  1.0     0  1800   0.0   0.0   0.0   1.0   0.0 100.0    1.0
 4   7  10   300  1.0     0  1800   0.0   1.0   0.0   0.0   0.0 100.0    1.0
□
```

Output File

Average Traffic conditions

```
  1800      1
   1 0.608  6600  5658  4990    0   668    0    0   21.0   37.3   37.4   21.0   36.4   21.0   21.0   0.00   0.00   0.00   0.00   0.00  59.7  59.7   0.5   132.196   151.730  2455.347   238.604   2580.1   1192.3
19.8     82.7   1321.1    708.6
   2 2.368  6600  5126  4518    0   608    0    0   82.0  156.4  155.4   82.0  164.2   82.0   82.0   0.00   0.00   0.00   0.00   0.00 236.2 236.1   1.1   751.025  2064.852 47104.160  2083.406  10218.3   4824.4
31.3    510.9   4354.1   3117.6
   3 0.304  8800  6162  4482   234   602   844    0   10.5   15.8   14.4   18.1   19.5   20.1   10.5   0.00   0.00   0.00   0.00   0.00  27.3  27.3   0.2   248.863  1682.238 37167.281   882.347   1179.0    527.1
2.5     34.0    696.5    264.6
```

```
   4 1.664  6600  5128  4316     0     0   812     0   57.6   57.7   57.6   57.6   57.6   57.8   57.6   0.00   0.00   0.00   0.00   0.00  83.8  82.0   0.0   398.083   606.258 11965.169  1480.123   3616.6   1677.9
31.8    116.5   1780.5   1029.5
   5 1.664  6600  4936  4156     0     0   780     0   57.6   57.5   57.5   57.6   57.6   57.5   57.6   0.00   0.00   0.00   0.00   0.00  80.4  78.6   0.0   356.239   346.556  6248.720  1295.182   3470.8   1605.6
37.7     98.9   1653.5   1019.3
   6 2.272  1600  1398     0   288     0  1110     0  113.6  114.4  113.6  114.4  113.6  114.4  113.6   0.00   0.00   0.00   0.00   0.00  46.0   4.3   0.1   130.575   114.001  1838.889   258.993   2973.1   1443.6
12.9    186.1   1204.5    940.8
   7 0.912  1600  1338     0   282     0  1056     0   45.6   54.5   45.6   54.0   45.6   54.7   45.6   0.00   0.00   0.00   0.00   0.00  21.0   9.6   0.2    48.675    44.513   674.068    76.961   1353.6    653.1      5.9
79.6    579.1    415.3
   8 2.864  1600  1092     0   238     0   854     0  143.2  241.5  143.2  237.7  143.2  242.5  143.2   0.00   0.00   0.00   0.00   0.00  84.8  70.5   0.8   157.018   147.111  2031.604   193.210   5491.0   2551.7
14.0    231.3   2638.5   1545.3
   9 0.944  1600   772     0   210   562     0     0   47.2   47.1   47.2   47.1   47.1   47.2   47.2   0.00   0.00   0.00   0.00   0.00  10.3   0.5   0.0    28.599    25.276   402.263    53.408    664.8    319.8      2.9
38.0    292.1    200.6
  10 1.408  1600   796     0   216   580     0     0   70.4   70.9   70.4   71.1   70.9   70.4   70.4   0.00   0.00   0.00   0.00   0.00  16.1   1.3   0.1    48.174    59.059  1200.728   105.149   1043.2    500.0      4.1
58.6    453.2    316.3
```

Type A – Volume 5

TYPEAV5 Master File

```
1800  900   900     1     1
typeav5\
typeav5\output\
TYPEAV51.dat
TYPEAV52.dat
TYPEAV53.dat
TYPEAV54.dat
TYPEAV55.dat
none
none
none
none
none
TYPEAV511.out
TYPEAV512.out
TYPEAV513.out
TYPEAV514.out
none
none
none
none
none
none
detector.dat
none
```

typeav5 O-D Traffic Demand File

```
 4   0     0   1.0
 1   1   6  4500  1.0     0  1800   1.0   0.0   0.0   0.0   0.0 100.0    1.0
 2   1  10  1200  1.0     0  1800   0.0   0.0   1.0   0.0   0.0 100.0    1.0
 3   7   6  1800  1.0     0  1800   0.0   0.0   0.0   1.0   0.0 100.0    1.0
 4   7  10   300  1.0     0  1800   0.0   1.0   0.0   0.0   0.0 100.0    1.0
□
```

Output File

Average Traffic conditions

```
   1800      1
    1 0.608  6600  5532  4352     0  1180     0     0   21.0   23.2   23.1   21.0   23.3   21.0   21.0   0.00   0.00   0.00   0.00   0.00  36.8  35.9   0.2   160.572   320.377  8080.864   614.416   1589.3    732.4
14.5    46.7    794.9    446.7
    2 2.368  6600  4962  3928     0  1034     0     0   82.0  141.5  139.3   82.0  150.0   82.0   82.0   0.00   0.00   0.00   0.00   0.00 210.9 210.0   1.6   750.998  2459.014 56611.859  2318.463   9109.9   4213.0
79.0    299.7   4296.8   2662.9
    3 0.304  8800  6028  3890   164  1028   946     0   10.5   16.3   13.9   20.7   20.7   20.6   10.5   0.00   0.00   0.00   0.00   0.00  27.6  27.5   0.2   235.996  1535.637 33214.973   828.986   1190.9    544.5
3.1     44.0    626.6    306.0
    4 1.664  6600  4668  3756     0     0   912     0   57.6   57.7   57.6   57.6   57.6   57.8   57.6   0.00   0.00   0.00   0.00   0.00  76.1  72.6   0.0   365.810   608.095 11764.261  1347.044   3286.5   1525.3
29.2    106.9   1607.2    940.1
    5 1.664  6600  4490  3620     0     0   870     0   57.6   57.5   57.5   57.6   57.6   57.5   57.6   0.00   0.00   0.00   0.00   0.00  73.2  69.6   0.0   323.974   315.110  5683.804  1176.599   3160.3   1461.5
34.5     90.1   1503.4    928.7
    6 2.272  1600  1414     0   200     0  1214     0  113.6  130.8  113.6  129.2  113.6  131.0  113.6   0.00   0.00   0.00   0.00   0.00  56.2  29.3   0.3   136.986   122.863  1913.422   231.634   3629.3   1766.3
15.7    231.3   1439.9   1161.6
    7 0.912  1600  1346     0   194     0  1152     0   45.6   63.0   45.6   63.8   45.6   62.8   45.6   0.00   0.00   0.00   0.00   0.00  24.4  17.0   0.1    52.058    48.067   713.856    72.168   1579.3    740.8      3.9
72.5    726.5    459.8
    8 2.864  1600  1124     0   164     0   960     0  143.2  244.4  143.2  245.5  143.2  244.2  143.2   0.00   0.00   0.00   0.00   0.00  85.4  76.0   0.7   161.143   150.786  2135.880   195.670   5527.9   2565.3
10.8    230.4   2609.2   1573.7
    9 0.944  1600  1102     0   146   956     0     0   47.2   47.1   47.2   47.1   47.1   47.2   47.2   0.00   0.00   0.00   0.00   0.00  14.6   0.7   0.0    40.581    35.858   571.550    75.871    941.9    453.3      4.1
54.0    413.1    284.6
   10 1.408  1600  1130     0   150   980     0     0   70.4   71.7   70.4   72.2   71.6   70.4   70.4   0.00   0.00   0.00   0.00   0.00  23.1   2.9   0.2    74.351   117.892  2712.285   180.205   1496.2    704.5      4.6
73.0    684.3    436.5
```

Type B – Volume 1

TYPEB Master File

```
  1800  900  900     1     0
typeb\
typeb\output\
TYPEB1.dat
```

```
TYPEB2.dat
TYPEB3.dat
TYPEB4.dat
TYPEB5.dat
none
none
none
none
none
TYPEB11.out
TYPEB12.out
TYPEB13.out
TYPEB14.out
TYPEB15.out
TYPEB16.out
none
none
none
none
detector.dat
none
□
```

```
typeb O-D Traffic Demand File

 4    0      0    1.0
 1   1   7  2095  1.0     0  1800   1.0   0.0   0.0   0.0   0.0 100.0    1.0
 2   1  11   799  1.0     0  1800   0.0   0.0   1.0   0.0   0.0 100.0    1.0
 3   9   7  1197  1.0     0  1800   0.0   0.0   0.0   1.0   0.0 100.0    1.0
 4   9  11  1497  1.0     0  1800   0.0   1.0   0.0   0.0   0.0 100.0    1.0
□
```

Output File

Average Traffic conditions

```
   1800      1
    1 0.304  4400  2862  2074    0   788    0    0   10.5   10.6   10.6   10.5   10.6   10.5   10.5   0.00   0.00   0.00   0.00   0.00   8.5   7.1   0.0    45.762   125.187  3419.396   185.933    368.1    169.9      3.6
10.7    181.5    104.9
    2 1.824  4400  2762  2016    0   746    0    0   63.1   63.7   63.7   63.1   63.7   63.1   63.1   0.00   0.00   0.00   0.00   0.00  49.8  40.2   0.1   213.484   212.391  3792.219   764.153   2152.4    994.0
23.6     61.4   1018.8    633.5
    3 0.144  8800  5314  2014  1412   744  1144    0    5.0    7.0    6.9    6.5    8.1    7.0    5.0   0.00   0.00   0.00   0.00   0.00  10.3  10.2   0.2    36.254   139.040  3428.452   117.859    446.1    206.4      3.0
15.6    225.2    122.6
```

```
   4 0.304  8800  5262  1998  1400   734  1130    0   10.5   15.8   13.7   15.6   19.0   17.9   10.5   0.00   0.00   0.00   0.00   0.00  23.3  23.1   0.3   198.846  1378.380 27594.912   648.572   1008.3    471.4
4.8     43.2    491.2    282.6
   5 0.944  6600  3084  1974     0     0  1110    0   32.7   32.7   32.7   32.7   32.7   32.9   32.7   0.00   0.00   0.00   0.00   0.00  28.3  22.6   0.0   153.925   399.960  7182.982   558.394   1222.2    567.2
10.6     40.7    596.6    349.4
   6 1.088  6600  3008  1920     0     0  1088    0   37.7   37.5   37.5   37.7   37.7   37.5   37.7   0.00   0.00   0.00   0.00   0.00  31.8  25.3   0.0   140.256   136.807  2470.736   508.353   1375.2    635.1
15.1     39.2    650.8    405.4
   7 2.064  4400  2564     0  1416     0  1148    0   71.4   71.5   71.4   71.5   71.4   71.5   71.4   0.00   0.00   0.00   0.00   0.00  51.8  40.2   0.1   225.464   222.490  4001.528   810.460   2239.4   1034.7
24.8     63.9   1056.7    660.9
   8 0.528  4400  2662     0  1474     0  1188    0   18.3   18.3   18.3   18.3   18.3   18.3   18.3   0.00   0.00   0.00   0.00   0.00  13.7  10.8   0.0    67.628   144.372  3730.930   260.991    590.0    272.4      5.8
17.2    289.3    169.0
   9 1.024  4400  2090     0  1372   718     0    0   35.4   35.6   35.4   35.5   35.8   35.4   35.4   0.00   0.00   0.00   0.00   0.00  20.9  12.2   0.0   121.368   375.303  6599.429   434.443    901.0    419.9      7.0
32.7    440.3    256.6
  10 0.688  4400  2068     0  1354   714     0    0   23.8   23.7   23.8   23.7   23.7   23.8   23.8   0.00   0.00   0.00   0.00   0.00  13.7   8.0   0.0    60.352    59.088  1066.339   218.996    591.1    273.2      6.5
16.9    279.9    174.2
```

Type B – Volume 2

TYPEBV2 Master File

```
  1800  900  900    1     0
typebv2\
typebv2\output\
TYPEBV21.dat
TYPEBV22.dat
TYPEBV23.dat
TYPEBV24.dat
TYPEBV25.dat
none
none
none
none
none
TYPEBV211.out
TYPEBV212.out
TYPEBV213.out
TYPEBV214.out
TYPEBV215.out
TYPEBV216.out
none
none
none
none
detector.dat
none
□
```

typebv2 O-D Traffic Demand File

```
 4   0     0   1.0
 1   1   7  2300  1.0     0  1800   1.0   0.0   0.0   0.0   0.0 100.0    1.0
 2   1  11  1100  1.0     0  1800   0.0   0.0   1.0   0.0   0.0 100.0    1.0
 3   9   7  1500  1.0     0  1800   0.0   0.0   0.0   1.0   0.0 100.0    1.0
 4   9  11  1700  1.0     0  1800   0.0   1.0   0.0   0.0   0.0 100.0    1.0
□
```

Output File

Average Traffic conditions

```
  1800     1
   1 0.304  4400  3176  2162     0  1014     0     0   10.5   18.6   18.5   10.5   18.9   10.5   10.5  0.00  0.00  0.00  0.00  0.00  16.9  16.2   0.3    51.753   126.046  3243.208   177.006    728.3    339.7     5.4
27.0    354.9    207.6
   2 1.824  4400  2718  1864     0   854     0     0   63.1  183.2  180.6   63.1  188.8   63.1   63.1  0.00  0.00  0.00  0.00  0.00 156.9 154.9   0.9   281.717   278.554  3651.361   497.387   6767.8   2962.4
35.1    113.5   4482.1   1304.7
   3 0.144  8800  5430  1854  1456   848  1272     0    5.0   12.9   11.9   12.8   15.0   13.2    5.0  0.00  0.00  0.00  0.00  0.00  19.6  19.6   0.1   108.072   518.881 12925.935   375.866    848.3    361.2
0.5     11.3    621.5    127.2
   4 0.304  8800  5402  1838  1452   846  1266     0   10.5   16.4   13.8   16.5   18.3   18.7   10.5  0.00  0.00  0.00  0.00  0.00  24.7  24.5   0.2   250.842  1790.457 34136.824   814.492   1065.2    493.1
3.0     45.0    535.9    285.8
   5 0.944  6600  3050  1812     0     0  1238     0   32.7   32.7   32.6   32.7   32.7   32.7   32.7  0.00  0.00  0.00  0.00  0.00  27.9  22.7   0.0   146.563   348.790  6549.957   536.208   1206.2    558.6
10.9    38.4    590.7    344.6
   6 1.088  6600  2986  1772     0     0  1214     0   37.7   37.5   37.5   37.7   37.7   37.5   37.7  0.00  0.00  0.00  0.00  0.00  31.5  25.4   0.0   139.134   135.731  2451.100   504.445   1363.8    629.9
15.0    38.9    645.6    402.0
   7 2.064  4400  2746     0  1470     0  1276     0   71.4  127.4   71.4  127.7   71.4  126.9   71.4  0.00  0.00  0.00  0.00  0.00 110.9 104.7   1.0   284.592   281.962  4356.235   760.405   4784.8   2214.4
52.7    136.8   2269.2   1410.8
   8 0.528  4400  3170     0  1682     0  1488     0   18.3   18.4   18.3   18.4   18.3   18.4   18.3  0.00  0.00  0.00  0.00  0.00  16.3  14.1   0.1    82.468   181.091  4727.898   326.794    703.2    324.5     6.6
20.6    348.9    199.3
   9 1.024  4400  2246     0  1422   824     0     0   35.4   35.5   35.4   35.4   35.6   35.4   35.4  0.00  0.00  0.00  0.00  0.00  22.4  14.2   0.0   121.491   315.368  5847.985   443.097    968.6    449.3     8.2
32.0    477.4    275.0
  10 0.688  4400  2218     0  1404   814     0     0   23.8   23.7   23.8   23.7   23.7   23.8   23.8  0.00  0.00  0.00  0.00  0.00  14.7   9.2   0.0    64.973    63.566  1147.186   235.865    636.0    293.9     7.0
18.1    301.1    187.5
```

Type B – Volume 3

TYPEBV3 Master File

```
  1800  900  900    1    0
typebv3\
typebv3\output\
```

```
TYPEBV31.dat
TYPEBV32.dat
TYPEBV33.dat
TYPEBV34.dat
TYPEBV35.dat
none
none
none
none
none
TYPEBV311.out
TYPEBV312.out
TYPEBV313.out
TYPEBV314.out
TYPEBV315.out
TYPEBV316.out
none
none
none
none
detector.dat
none
□
```

typebv3 O-D Traffic Demand File

```
 4   0      0    1.0
 1   1   7  2500  1.0     0  1800   1.0   0.0   0.0   0.0   0.0 100.0    1.0
 2   1  11  1200  1.0     0  1800   0.0   0.0   1.0   0.0   0.0 100.0    1.0
 3   9   7  1700  1.0     0  1800   0.0   0.0   0.0   1.0   0.0 100.0    1.0
 4   9  11  1800  1.0     0  1800   0.0   1.0   0.0   0.0   0.0 100.0    1.0
□
```

Output File

Average Traffic conditions

```
   1800      1
    1 0.304  4400  3208  2164     0  1044     0     0   10.5   26.1   25.7   10.5   26.9   10.5   10.5   0.00   0.00   0.00   0.00   0.00  23.8  23.6   0.5    49.988    92.221  2063.776   125.322   1025.3    480.6      6.7
41.7    498.2    291.8
    2 1.824  4400  2776  1882     0   894     0     0   63.1  211.0  209.2   63.1  214.6   63.1   63.1   0.00   0.00   0.00   0.00   0.00 179.6 179.0   0.7   295.118   288.290  3570.568   407.126   7741.8   3278.7
19.2     62.8   5762.3   1167.8
    3 0.144  8800  5562  1870  1448   886  1358     0    5.0   13.8   12.6   13.8   15.9   14.3    5.0   0.00   0.00   0.00   0.00   0.00  21.5  21.5   0.1   107.175   476.082 12328.047   378.106    930.5    392.8
0.4      9.9    701.7    129.5
```

```
   4 0.304  8800  5512  1860  1434   870  1348     0   10.5   16.4   13.7   16.7   18.3   18.6   10.5   0.00   0.00   0.00   0.00   0.00  25.3  25.2   0.2   262.507  1901.766 36734.961    856.968    1091.7    508.2
3.0     48.8    527.3    303.2
   5 0.944  6600  3152  1828     0     0  1324     0   32.7   32.7   32.6   32.7   32.7   32.7   32.7   0.00   0.00   0.00   0.00   0.00  28.9  23.3   0.0   151.190   352.952  6578.758   552.651    1250.4    579.0
11.4     39.7    611.4    357.6
   6 1.088  6600  3090  1788     0     0  1302     0   37.7   37.5   37.5   37.7   37.7   37.5   37.7   0.00   0.00   0.00   0.00   0.00  32.6  26.2   0.0   143.672   140.114  2530.057   520.739    1408.5    650.5
15.5     40.2    666.5    415.2
   7 2.064  4400  2832     0  1462     0  1370     0   71.4  190.0   71.4  190.2   71.4  189.9   71.4   0.00   0.00   0.00   0.00   0.00 167.9 165.4   0.9   318.187   311.150  4216.849   565.871    7238.3   3181.1
36.6    129.1   4452.6   1590.9
   8 0.528  4400  3296     0  1698     0  1598     0   18.3   29.4   18.3   29.6   18.3   29.1   18.3   0.00   0.00   0.00   0.00   0.00  28.0  26.7   0.3    86.121   174.211  4266.500   278.238    1209.6    561.9
9.6     41.9    597.6    341.7
   9 1.024  4400  2248     0  1394   854     0     0   35.4   35.5   35.4   35.5   35.6   35.4   35.4   0.00   0.00   0.00   0.00   0.00  22.5  14.4   0.0   123.754   333.645  6206.657   451.897     971.8    451.1      8.2
32.6    478.0    276.2
  10 0.688  4400  2212     0  1376   836     0     0   23.8   23.7   23.8   23.7   23.7   23.8   23.8   0.00   0.00   0.00   0.00   0.00  14.7   9.2   0.0    64.938    63.671  1149.036   236.040     635.3    293.6      7.0
18.1    301.2    187.1
```

Type B – Volume 4

TYPEBV4 Master File

```
  1800  900  900    1    0
typebv4\
typebv4\output\
TYPEBV41.dat
TYPEBv42.dat
TYPEBv43.dat
TYPEBv44.dat
TYPEBv45.dat
none
none
none
none
none
TYPEBv411.out
TYPEBv412.out
TYPEBv413.out
TYPEBv414.out
TYPEBv415.out
TYPEBv416.out
none
none
none
none
detector.dat
none
```

typebv4 O-D Traffic Demand File

```
 4   0     0   1.0
 1   1   7  3000  1.0    0  1800   1.0   0.0   0.0   0.0   0.0 100.0    1.0
 2   1  11  1500  1.0    0  1800   0.0   0.0   1.0   0.0   0.0 100.0    1.0
 3   9   7  2000  1.0    0  1800   0.0   0.0   0.0   1.0   0.0 100.0    1.0
 4   9  11  2000  1.0    0  1800   0.0   1.0   0.0   0.0   0.0 100.0    1.0
```

Output File

Average Traffic conditions

```
  1800     1
   1 0.304  4400  3178  2138    0  1040    0    0   10.5   30.1   29.9   10.5   30.5   10.5   10.5   0.00   0.00   0.00   0.00   0.00  27.0  27.0   0.6    46.632    61.388  1014.178    89.433   1165.9    547.1      7.3
48.6    565.2    331.8
   2 1.824  4400  2736  1846    0   890    0    0   63.1  227.1  226.1   63.1  229.3   63.1   63.1   0.00   0.00   0.00   0.00   0.00 190.8 189.6   0.6   293.984   285.903  3344.378   338.254   8228.1   3452.3
8.0     59.7   6501.9   1024.2
   3 0.144  8800  5522  1828  1404   884  1406    0    5.0   13.9   13.1   13.5   15.7   14.2    5.0   0.00   0.00   0.00   0.00   0.00  21.5  21.5   0.1   113.410   525.827 13669.019   402.206    928.3    391.1
0.3      9.3    705.9    125.9
   4 0.304  8800  5484  1818  1394   880  1392    0   10.5   16.2   13.7   16.1   18.0   18.4   10.5   0.00   0.00   0.00   0.00   0.00  24.8  24.7   0.2   260.860  1878.227 35750.379   844.580   1069.5    498.8
2.9     48.5    510.7    300.0
   5 0.944  6600  3154  1788    0     0  1366    0   32.7   32.7   32.6   32.7   32.7   32.8   32.7   0.00   0.00   0.00   0.00   0.00  28.9  23.6   0.0   153.062   371.160  6752.865   555.942   1250.3    579.7
11.3    40.6    608.0    358.9
   6 1.088  6600  3076  1750    0     0  1326    0   37.7   37.5   37.5   37.7   37.7   37.5   37.7   0.00   0.00   0.00   0.00   0.00  32.6  26.4   0.0   143.605   140.000  2528.235   520.327   1408.2    650.4
15.5    40.1    666.3    415.2
   7 2.064  4400  2828    0  1408    0  1420    0   71.4  219.0   71.4  220.4   71.4  217.6   71.4   0.00   0.00   0.00   0.00   0.00 191.1 190.3   0.7   326.631   317.788  4033.686   457.883   8237.4   3503.5
21.4    73.3   5700.2   1481.9
   8 0.528  4400  3308    0  1672    0  1636    0   18.3   42.8   18.3   43.2   18.3   42.5   18.3   0.00   0.00   0.00   0.00   0.00  40.4  40.0   0.5    87.201   130.589  2660.843   211.966   1744.9    814.2
11.7    67.2    862.9    489.7
   9 1.024  4400  2232    0  1376   856    0    0   35.4   35.5   35.4   35.5   35.6   35.4   35.4   0.00   0.00   0.00   0.00   0.00  22.3  13.7   0.0   122.623   332.103  6051.813   445.087    960.9    446.2      8.0
32.5    473.3    272.7
  10 0.688  4400  2200    0  1350   850    0    0   23.8   23.7   23.8   23.7   23.7   23.8   23.8   0.00   0.00   0.00   0.00   0.00  14.6   9.0   0.0    64.487    63.163  1139.916   234.172    631.3    291.7      6.9
18.0    299.1    186.0
```

Type B – Volume 5

```
TYPEBV5 Master File

  1800  900  900     1     0
typebv5\
typebv5\output\
TYPEBV51.dat
TYPEBV52.dat
TYPEBV53.dat
TYPEBV54.dat
TYPEBV55.dat
none
none
none
none
none
TYPEBV511.out
TYPEBV512.out
TYPEBV513.out
TYPEBV514.out
TYPEBV515.out
TYPEBV516.out
none
none
none
none
detector.dat
none
```

```
typebv5 O-D Traffic Demand File
 4    0      0    1.0
 1   1   7  1000  1.0     0  1800   1.0   0.0   0.0   0.0   0.0 100.0    1.0
 2   1  11  2800  1.0     0  1800   0.0   0.0   1.0   0.0   0.0 100.0    1.0
 3   9   7  2500  1.0     0  1800   0.0   0.0   0.0   1.0   0.0 100.0    1.0
 4   9  11  1000  1.0     0  1800   0.0   1.0   0.0   0.0   0.0 100.0    1.0
□
```

Output File

Average Traffic conditions

```
   1800     1
```

```
   1 0.304  4400  2672   728     0  1944     0     0   10.5   39.4   38.8   10.5   39.6   10.5   10.5  0.00   0.00   0.00   0.00   0.00  30.1  29.8   0.6    50.390    86.948  1795.962   112.599   1298.1    612.1      7.4
58.7    601.1    380.4
   2 1.824  4400  2144   592     0  1552     0     0   63.1  323.5  322.1   63.1  324.0   63.1   63.1   0.00   0.00   0.00   0.00   0.00 225.5 224.7   0.8   295.564   290.755  2849.866   354.580   9749.9  4006.8
17.3     58.2   8740.5    554.7
   3 0.144  8800  4502   588   682  1526  1706     0    5.0   15.4   14.6   13.5   17.3   14.8    5.0  0.00   0.00   0.00   0.00   0.00  19.5  19.5   0.2   101.563   456.538 12174.867   362.006    841.7    343.5
0.1      2.7    755.7     50.4
   4 0.304  8800  4460   586   676  1510  1688     0   10.5   17.5   13.3   16.7   18.3   18.5   10.5  0.00   0.00   0.00   0.00   0.00  21.8  21.6   0.3   222.303  1526.395 28390.725   701.447    942.5    435.9
2.5     40.1    476.8    250.8
   5 0.944  6600  2224   570     0     0  1654     0   32.7   32.7   32.6   32.7   32.7   32.7   32.7  0.00   0.00   0.00   0.00   0.00  20.4  13.7   0.0   108.967   267.760  4812.959   394.802    883.1    409.3      8.0
28.3    430.8    253.2
   6 1.088  6600  2180   564     0     0  1616     0   37.7   37.5   37.5   37.7   37.7   37.5   37.7  0.00   0.00   0.00   0.00   0.00  23.0  15.4   0.0   101.127    98.619  1781.055   365.732    992.8    458.7     11.0
28.3    469.4    293.2
   7 2.064  4400  2416     0   690     0  1726     0   71.4  277.2   71.4  278.6   71.4  276.6   71.4  0.00   0.00   0.00   0.00   0.00 212.0 209.9   1.0   327.585   320.005  3685.260   500.329   9157.8   3897.6
33.2    106.4   7286.3   1057.3
   8 0.528  4400  2922     0   830     0  2092     0   18.3   47.8   18.3   48.0   18.3   47.7   18.3  0.00   0.00   0.00   0.00   0.00  40.6  39.7   0.4    85.368   149.910  3289.031   217.870   1757.0    823.1
11.7     71.7    840.2    505.1
   9 1.024  4400  2134     0   658  1476     0     0   35.4   35.5   35.4   35.5   35.6   35.4   35.4  0.00   0.00   0.00   0.00   0.00  21.4  13.3   0.0   120.483   346.575  6230.090   434.467    922.9    428.9      7.6
31.7    452.8    262.6
  10 0.688  4400  2102     0   644  1458     0     0   23.8   23.7   23.8   23.7   23.7   23.8   23.8  0.00   0.00   0.00   0.00   0.00  13.9   8.7   0.0    61.466    60.103  1084.715   222.892    602.1    278.3      6.6
17.2    285.0    177.6
```

Type C – Volume 1

TYPECV1 Master File

```
  1800  900  900    1    0
typecv1\
typecv1\output\
TYPECV11.dat
TYPECV12.dat
TYPECV13.dat
TYPECV14.dat
TYPECV15.dat
none
none
none
none
none
TYPECV111.out
TYPECV112.out
TYPECV113.out
TYPECV114.out
TYPECV115.out
TYPECV116.out
```

```
none
none
none
none
detector.dat
none
□
```

typecv1 O-D Traffic Demand File

```
 4   0     0   1.0
 1   1   7  3500  1.0     0  1800   1.0   0.0   0.0   0.0   0.0 100.0    1.0
 2   1  11   200  1.0     0  1800   0.0   0.0   1.0   0.0   0.0 100.0    1.0
 3   9   7   300  1.0     0  1800   0.0   0.0   0.0   1.0   0.0 100.0    1.0
 4   9  11  3500  1.0     0  1800   0.0   1.0   0.0   0.0   0.0 100.0    1.0
□
```

Output File

Average Traffic conditions

```
  1800     1
   1 0.304  4400  3678  3482    0   196    0    0   10.5   10.8   10.8   10.5   10.8   10.5   10.5   0.00   0.00   0.00   0.00   0.00  11.0  10.3   0.1    63.751   164.370  4539.904   285.740    477.3    220.1      4.3
14.0    240.2    133.7
   2 1.824  4400  3536  3346    0   190    0    0   63.1   66.2   66.2   63.1   66.9   63.1   63.1   0.00   0.00   0.00   0.00   0.00  66.4  60.7   0.2   273.023   283.824  5151.901   957.361   2866.5   1324.7
30.7     81.7   1372.0    837.9
   3 0.144 11000  7108  3334  3300   190   284    0    5.0    6.3    6.0    6.4    7.9    7.3    5.0  0.00   0.00   0.00   0.00   0.00  12.5  12.4   0.2    56.749   274.963  6437.654   194.504    538.2    251.2      4.0
20.4    258.4    154.9
   4 0.304 11000  7046  3314  3260   188   284    0   10.5   15.3   11.2   19.2   20.0   16.2   10.5   0.00   0.00   0.00   0.00   0.00  30.2  30.1   0.3   226.883  1436.266 30473.047   786.391   1304.5    607.4
7.3      52.5    646.4    361.0
   5 0.944  6600  3528  3246    0     0   282    0   32.7   32.6   32.6   32.7   32.7   32.8   32.7   0.00   0.00   0.00   0.00   0.00  32.3  27.9   0.0   148.401   190.227  3463.931   542.241   1395.5    644.8
14.6     40.9    666.5    408.0
   6 1.088  6600  3450  3172    0     0   278    0   37.7   37.5   37.5   37.7   37.7   37.5   37.7   0.00   0.00   0.00   0.00   0.00  36.4  31.4   0.0   160.950   157.076  2834.823   584.529   1574.9    727.2
17.2     44.9    746.7    463.4
   7 2.064  6600  3594    0  3308    0   286    0   71.4   71.4   71.4   71.4   71.4   71.4   71.4   0.00   0.00   0.00   0.00   0.00  72.9  62.1   0.0   317.777   312.168  5616.411  1141.846   3146.2   1455.8
34.9     90.0   1485.8    929.8
   8 0.528  6600  3756    0  3460    0   296    0   18.3   18.2   18.3   18.2   18.3   18.3   18.3   0.00   0.00   0.00   0.00   0.00  19.2  16.5   0.0    90.844   163.133  3985.027   339.657    829.3    383.0      8.6
24.0    400.7    240.5
   9 1.024  4400  3376    0  3192   184    0    0   35.4   35.8   35.4   35.8   35.9   35.4   35.4   0.00   0.00   0.00   0.00   0.00  33.9  30.1   0.0   200.133   658.854 13362.428   745.014   1466.1    685.5
9.6      58.0    719.4    413.9
  10 0.688  4400  3330    0  3148   182    0    0   23.8   23.7   23.8   23.7   23.7   23.8   23.8   0.00   0.00   0.00   0.00   0.00  22.1  19.3   0.0    98.020    96.469  1740.658   358.123    955.8    441.5     10.4
27.2    454.9    280.8
```

Type C – Volume 2

TYPECV2 Master File

```
  1800  900  900     1     0
typecv2\
typecv2\output\
TYPECV21.dat
TYPECV22.dat
TYPECV23.dat
TYPECV24.dat
TYPECV25.dat
none
none
none
none
none
TYPECV211.out
TYPECV212.out
TYPECV213.out
TYPECV214.out
TYPECV215.out
TYPECV216.out
none
none
none
none
detector.dat
none
□
```

typecv2 O-D Traffic Demand File

```
 4    0      0    1.0
 1    1   7  4000  1.0     0  1800   1.0   0.0   0.0   0.0   0.0 100.0    1.0
 2    1  11   300  1.0     0  1800   0.0   0.0   1.0   0.0   0.0 100.0    1.0
 3    9   7   350  1.0     0  1800   0.0   0.0   0.0   1.0   0.0 100.0    1.0
 4    9  11  4000  1.0     0  1800   0.0   1.0   0.0   0.0   0.0 100.0    1.0
□
```

Output File

Average Traffic conditions

```
  1800     1
   1 0.304  4400  3554  3300    0   254    0    0   10.5   22.2   22.1   10.5   23.1   10.5   10.5   0.00   0.00   0.00   0.00   0.00  22.2  22.2   0.5    45.199    63.007  1119.099    99.747    959.6    446.9      6.6
35.3    481.1    267.2
   2 1.824  4400  3134  2914    0   220    0    0   63.1  162.9  162.9   63.1  163.2   63.1   63.1   0.00   0.00   0.00   0.00   0.00 156.4 156.3   0.6   309.578   334.463  5573.373   538.576   6744.7   2953.0
12.6    138.9   4348.6   1350.1
   3 0.144 11000  6990  2896  3570   218   306    0    5.0   13.4   10.2   15.5   17.0   17.1    5.0   0.00   0.00   0.00   0.00   0.00  26.2  26.2   0.2   143.081   756.480 17449.912   484.900   1131.4    478.9
0.9     15.3    875.3    142.5
   4 0.304 11000  6910  2874  3524   210   302    0   10.5   16.0   11.6   19.4   20.2   15.1   10.5   0.00   0.00   0.00   0.00   0.00  31.0  31.0   0.2   291.798  2067.837 43645.484  1024.917   1338.9    607.7
3.5     47.3    760.6    313.8
   5 0.944  6600  3132  2832    0     0   300    0   32.7   32.6   32.6   32.7   32.7   32.6   32.7   0.00   0.00   0.00   0.00   0.00  28.5  23.3   0.0   129.726   155.808  2869.579   474.604   1233.3    569.7
13.1     35.7    589.2    360.7
   6 1.088  6600  3084  2792    0     0   292    0   37.7   37.5   37.5   37.7   37.7   37.5   37.7   0.00   0.00   0.00   0.00   0.00  32.5  26.5   0.0   143.291   139.892  2525.321   520.203   1402.9    647.8
15.4     40.0    664.9    413.1
   7 2.064  6600  3910     0  3600     0   310    0   71.4  115.0   71.4  114.8   71.4  116.6   71.4   0.00   0.00   0.00   0.00   0.00 136.1 129.8   0.9   394.815   402.131  6688.046  1176.466   5867.8   2712.0
65.1    168.0   2773.5   1733.2
   8 0.528  6600  4312     0  3964     0   348    0   18.3   18.3   18.3   18.3   18.3   18.3   18.3   0.00   0.00   0.00   0.00   0.00  22.0  20.1   0.0   106.531   207.815  5230.410   405.238    951.6    439.3      9.6
27.5    463.0    274.5
   9 1.024  4400  3662     0  3458   204     0    0   35.4   35.7   35.4   35.7   35.9   35.4   35.4   0.00   0.00   0.00   0.00   0.00  36.7  34.2   0.0   203.126   545.310 11201.993   773.231   1587.0    738.8
11.2     58.5    787.5    445.0
  10 0.688  4400  3612     0  3410   202     0    0   23.8   23.7   23.8   23.7   23.7   23.8   23.8   0.00   0.00   0.00   0.00   0.00  24.0  22.3   0.0   106.392   105.079  1895.477   389.569   1036.3    478.6
11.2     29.5    494.4    303.9
```

Type C – Volume 3

TYPECV3 Master File

```
 1800  900  900    1    0
typecv3\
typecv3\output\
TYPECV31.dat
TYPECV32.dat
TYPECV33.dat
TYPECV34.dat
TYPECV35.dat
none
none
none
none
```

```
none
TYPECV311.out
TYPECV312.out
TYPECV313.out
TYPECV314.out
TYPECV315.out
TYPECV316.out
none
none
none
none
detector.dat
none
□
```

typecv3 O-D Traffic Demand File

```
 4    0      0    1.0
 1    1    7  1200  1.0     0  1800    1.0    0.0    0.0    0.0    0.0 100.0     1.0
 2    1  11    850  1.0     0  1800    0.0    0.0    1.0    0.0    0.0 100.0     1.0
 3    9    7    900  1.0     0  1800    0.0    0.0    0.0    1.0    0.0 100.0     1.0
 4    9  11  1200  1.0     0  1800    0.0    1.0    0.0    0.0    0.0 100.0     1.0
□
```

Output File

Average Traffic conditions

```
   1800      1
    1 0.304  4400  2038  1190     0   848     0     0   10.5   10.6   10.6   10.5   10.6   10.5   10.5   0.00   0.00   0.00   0.00   0.00   6.0   4.2   0.0    29.803    67.162  1745.743   114.027    259.5    119.8      2.7
7.5    125.7     75.1
    2 1.824  4400  1988  1154     0   834     0     0   63.1   63.2   63.2   63.1   63.2   63.1   63.1   0.00   0.00   0.00   0.00   0.00  35.4  22.8   0.1   153.377   152.671  2756.135   550.892   1528.7    706.1
16.9     43.6    721.6    451.5
    3 0.144 11000  3962  1150  1124   830   858     0    5.0    6.1    5.7    5.6    7.3    6.0    5.0   0.00   0.00   0.00   0.00   0.00   6.8   6.4   0.2    30.317   152.215  3741.075   105.435    292.7    136.3      2.3
10.5    143.3     83.3
    4 0.304 11000  3940  1148  1118   826   848     0   10.5   13.5   11.3   13.0   16.4   14.2   10.5   0.00   0.00   0.00   0.00   0.00  14.9  14.0   0.2   123.088   813.155 15894.519   407.453    641.6    302.7
4.0     28.5    301.4    186.8
    5 0.944  6600  1958  1132     0     0   826     0   32.7   32.6   32.6   32.7   32.7   32.8   32.7   0.00   0.00   0.00   0.00   0.00  18.0  10.6   0.0    89.376   172.603  3027.903   321.649    775.8    359.5      7.8
24.0    370.5    226.6
    6 1.088  6600  1916  1118     0     0   798     0   37.7   37.5   37.5   37.7   37.7   37.5   37.7   0.00   0.00   0.00   0.00   0.00  20.2  11.9   0.0    89.023    86.825  1567.923   321.784    874.3    404.0      9.7
24.9    413.1    258.3
    7 2.064  6600  1992     0  1128     0   864     0   71.4   71.4   71.4   71.4   71.4   71.4   71.4   0.00   0.00   0.00   0.00   0.00  40.3  25.1   0.0   175.672   173.139  3129.476   631.873   1740.1    803.9
19.3     49.7    819.4    514.7
    8 0.528  6600  2070     0  1182     0   888     0   18.3   18.2   18.3   18.2   18.3   18.2   18.3   0.00   0.00   0.00   0.00   0.00  10.6   6.9   0.0    47.128    55.777  1141.356   171.350    455.5    210.5      5.0
13.1    216.1    134.0
```

```
   9 1.024  4400  1906     0  1092   814     0     0   35.4   35.6   35.4   35.5   35.7   35.4   35.4   0.00   0.00   0.00   0.00   0.00  19.0  11.2   0.0   106.577   304.596  5440.942   381.533    821.6    382.3     7.1
28.5    396.3    237.0
  10 0.688  4400  1880     0  1084   796     0     0   23.8   23.7   23.8   23.7   23.7   23.8   23.8   0.00   0.00   0.00   0.00   0.00  12.5   7.5   0.0    54.983    53.674   968.775   199.073    539.1    249.2     6.0
15.4    254.8    159.2
```

Type C – Volume 4

TYPECV4 Master File

```
  1800  900  900     1     0
typecv4\
typecv4\output\
TYPECV41.dat
TYPECV42.dat
TYPECV43.dat
TYPECV44.dat
TYPECV45.dat
none
none
none
none
none
TYPECV411.out
TYPECV412.out
TYPECV413.out
TYPECV414.out
TYPECV415.out
TYPECV416.out
none
none
none
none
detector.dat
none
□
```

typecv4 O-D Traffic Demand File

```
 4    0      0    1.0
 1    1    7  1600  1.0     0  1800   1.0   0.0   0.0   0.0   0.0 100.0    1.0
 2    1  11   1250  1.0     0  1800   0.0   0.0   1.0   0.0   0.0 100.0    1.0
 3    9    7  1300  1.0     0  1800   0.0   0.0   0.0   1.0   0.0 100.0    1.0
 4    9  11   1600  1.0     0  1800   0.0   1.0   0.0   0.0   0.0 100.0    1.0
□
```

Output File

Average Traffic conditions

```
  1800     1
   1 0.304  4400  2834  1594     0  1240     0     0   10.5   10.6   10.6   10.5   10.6   10.5   10.5   0.00   0.00   0.00   0.00   0.00   8.4   7.0   0.0    44.966   124.394  3403.713   181.374    363.0    167.5      3.5
10.6    178.6    103.6
   2 1.824  4400  2730  1536     0  1194     0     0   63.1   68.7   68.8   63.1   68.5   63.1   63.1   0.00   0.00   0.00   0.00   0.00  53.1  43.5   0.5   211.073   214.017  3761.269   736.107   2297.6   1061.4
25.2     65.5   1087.5    676.6
   3 0.144 11000  5442  1524  1516  1182  1220     0    5.0    9.9    9.9    8.3   12.7    9.2    5.0   0.00   0.00   0.00   0.00   0.00  15.1  15.0   0.3    99.898   589.104 13964.335   337.827    651.1    288.6
1.6     16.4    407.1    135.2
   4 0.304 11000  5394  1516  1500  1168  1210     0   10.5   15.1   12.6   14.7   18.0   16.1   10.5   0.00   0.00   0.00   0.00   0.00  22.9  22.7   0.3   220.897  1550.735 28796.059   706.575    987.9    473.1
4.6     53.9    433.5    298.8
   5 0.944  6600  2682  1492     0     0  1190     0   32.7   32.7   32.6   32.7   32.7   32.8   32.7   0.00   0.00   0.00   0.00   0.00  24.6  18.4   0.0   128.720   304.570  5468.230   464.637   1060.2    491.6
9.8     34.2    513.6    305.6
   6 1.088  6600  2604  1444     0     0  1160     0   37.7   37.5   37.5   37.7   37.7   37.5   37.7   0.00   0.00   0.00   0.00   0.00  27.6  20.5   0.0   121.611   118.572  2142.046   440.038   1194.2    551.6
13.2     34.1    564.4    352.6
   7 2.064  6600  2752     0  1528     0  1224     0   71.4   71.9   71.4   71.9   71.4   71.9   71.4   0.00   0.00   0.00   0.00   0.00  56.0  42.5   0.2   239.928   240.707  4326.166   857.241   2418.3   1118.0
26.9     69.1   1139.5    714.9
   8 0.528  6600  2862     0  1578     0  1284     0   18.3   18.2   18.3   18.2   18.3   18.2   18.3   0.00   0.00   0.00   0.00   0.00  14.6  11.3   0.0    67.001    99.421  2265.163   246.382    630.9    291.5      6.7
18.1    301.5    184.6
   9 1.024  4400  2612     0  1470  1142     0     0   35.4   35.7   35.4   35.6   35.8   35.4   35.4   0.00   0.00   0.00   0.00   0.00  26.2  19.3   0.0   152.982   487.456  8870.809   549.761   1131.8    529.1
8.3     43.7    547.1    324.2
  10 0.688  4400  2568     0  1444  1124     0     0   23.8   23.7   23.8   23.7   23.7   23.8   23.8   0.00   0.00   0.00   0.00   0.00  17.1  12.5   0.0    75.299    73.669  1329.757   273.527    736.9    340.5      8.1
21.0    349.0    217.2
```

Type C – Volume 5

TYPEC Master File

```
 1800  900  900    1    0
typec\
typec\output\
TYPEC1.dat
TYPEC2.dat
TYPEC3.dat
TYPEC4.dat
TYPEC5.dat
none
none
none
none
none
TYPEC11.out
```

```
TYPEC12.out
TYPEC13.out
TYPEC14.out
TYPEC15.out
TYPEC16.out
none
none
none
none
detector.dat
none
```

typec O-D Traffic Demand File

```
 4   0      0   1.0
 1   1   7  2000  1.0     0  1800   1.0   0.0   0.0   0.0   0.0 100.0    1.0
 2   1  11  1450  1.0     0  1800   0.0   0.0   1.0   0.0   0.0 100.0    1.0
 3   9   7  1500  1.0     0  1800   0.0   0.0   0.0   1.0   0.0 100.0    1.0
 4   9  11  2000  1.0     0  1800   0.0   1.0   0.0   0.0   0.0 100.0    1.0
□
```

Output File

Average Traffic conditions

```
   1800      1
    1 0.304  4400  2938  1726     0  1212     0     0   10.5   28.3   27.5   10.5   29.5   10.5   10.5   0.00   0.00   0.00   0.00   0.00  23.7  23.3   0.4    49.656    94.271  2139.829   132.107   1023.5    480.8      6.5
43.2    487.4    295.2
    2 1.824  4400  2458  1450     0  1008     0     0   63.1  245.4  241.3   63.1  251.4   63.1   63.1   0.00   0.00   0.00   0.00   0.00 192.3 191.1   0.9   290.131   284.932  3235.239   415.044   8293.3   3509.1
27.5     80.0   6620.4    961.9
    3 0.144 11000  5566  1444  1786   990  1346     0    5.0   13.0   11.0   12.9   14.7   14.2    5.0   0.00   0.00   0.00   0.00   0.00  20.4  20.3   0.1   156.140   870.411 20732.791   528.811    878.8    361.7
0.3      4.8    762.1     67.1
    4 0.304 11000  5516  1434  1770   980  1332     0   10.5   14.8   12.1   15.2   17.5   15.2   10.5   0.00   0.00   0.00   0.00   0.00  22.9  22.6   0.2   227.578  1618.719 29536.051   729.496    986.8    473.3
4.5     54.7    432.6    298.5
    5 0.944  6600  2716  1408     0     0  1308     0   32.7   32.7   32.6   32.7   32.7   32.8   32.7   0.00   0.00   0.00   0.00   0.00  24.9  19.0   0.0   128.253   281.852  5048.744   462.824   1076.0    499.2
10.1     34.8    516.9    312.3
    6 1.088  6600  2654  1372     0     0  1282     0   37.7   37.5   37.5   37.7   37.7   37.5   37.7   0.00   0.00   0.00   0.00   0.00  28.0  21.3   0.0   123.380   120.302  2173.406   446.522   1211.5    559.6
13.4     34.6    572.6    357.7
    7 2.064  6600  3164     0  1808     0  1356     0   71.4  106.3   71.4  106.3   71.4  106.2   71.4   0.00   0.00   0.00   0.00   0.00 100.2  89.7   1.0   317.453   315.940  5286.514  1016.365   4321.0   2001.4
48.1    123.7   2043.1   1277.5
    8 0.528  6600  3474     0  1984     0  1490     0   18.3   18.2   18.3   18.2   18.3   18.2   18.3   0.00   0.00   0.00   0.00   0.00  17.7  14.8   0.0    82.856   138.666  3314.715   308.711    764.6    353.1      8.0
22.0    367.7    222.6
    9 1.024  4400  2702     0  1744   958     0     0   35.4   35.7   35.4   35.6   35.8   35.4   35.4   0.00   0.00   0.00   0.00   0.00  27.0  20.7   0.0   157.175   496.002  9165.565   567.693   1169.3    546.4
8.6     44.7    566.0    334.7
   10 0.688  4400  2672     0  1724   948     0     0   23.8   23.7   23.8   23.7   23.7   23.8   23.8   0.00   0.00   0.00   0.00   0.00  17.7  13.6   0.0    78.274    76.643  1383.254   284.605    765.4    353.7      8.4
21.8    362.9    225.5
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Vita

Nanditha Koppula was born on February 20, 1979 in Hyderabad, India. She graduated with a Bachelor in Engineering degree in Civil Engineering from Osmania University, University College of Engineering, Hyderabad, India in 2000. She started her work towards her Masters Degree in Civil Engineering at Virginia Polytechnic Institute and State University in the fall of 2000. Nanditha is currently working with Michael Baker Corporation at Baltimore, Maryland since May 2002.