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16. Abstract

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FINAL REPORT

DEMONSTRATION OF TRAF-NETSIM FOR TRAFFIC OPERATIONS MANAGEMENT

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(The opinions, findings, and conclusions expressed in this report are those of the authors and not necessarily those of the sponsoring agencies.)

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ABSTRACT

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FINAL REPORT

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INTRODUCTION

Traffic engineers continually face problems with congested facilities and must try to develop strategies to increase vehicular movement via appropriate traffic management strategies. In the field, trial-and-error experiments are very expensive. It is quite time consuming and costly to gather the appropriate data and evaluate the effects of the alteration of a single traffic control.

One technique used to evaluate operational strategies is computer simulation. When a traffic system is represented by a simulation model, the effects of traffic management strategies on the system's performance can be determined.[1] This type of modeling allows the engineer to explore several options before actually choosing the best solution and implementing it. As a result of the flexibility of modeling and the advent of powerful personal computers, simulation has emerged as a powerful tool for transportation professionals to use to study the complex behavior of traffic systems.[2]

BACKGROUND

What is Simulation?

The simulation of a system is the operation of a model that is a representation of the system. The model is amenable to manipulations that would be impossible, too expensive, or impractical to perform on the entity it represents. From a study of the operation of the model, properties concerning the behavior of the actual system can be inferred.[3] Simulation can also be defined as the establishment of a mathematical-logical model of a system and the experimental manipulation of that model on a computer.[4]

TRAF-NETSIM

TRAF-NETSIM is a simulation model that allows the traffic engineer to evaluate complex strategies on a real-time basis for a given network. During the past two decades, the U.S. Department of Transportation and other agencies have sponsored the development and maintenance of computerized models for traffic and transportation engineering and planning. A FORTRAN-based traffic network simulation package known as UTCS-1 (Urban Traffic Control System) was originally developed in 1980 by Peat, Marwick, Mitchell & Co. for the Federal Highway Administration. This model was extended by KLD and Associated (and others) for the FHWA, and the extended model was renamed NETSIM.[5] TRAF-NETSIM has undergone many modifications and enhancements that have added both to the scope of TRAF-NETSIM including its use on a microcomputer. This paper examines TRAF-NETSIM version 3.0. The utility program employed by TRAF-NETSIM, TSIS (Traffic Software Integrated System) is version 2.0.

Applications

TRAF-NETSIM is a microscopic stochastic simulation model, which is a detailed simulation model that involves the use of probability. It is used for evaluating urban roadway networks. It is designed to evaluate alternative network control and management strategies and is particularly appropriate for the analysis of dynamically controlled traffic signal systems based on real-time surveillance of network traffic movements. However, it may also be used to address a variety of other problems, including the effectiveness of conventional traffic engineering measures, bus priority systems, and a full range of standard fixed-time and vehicle-actuated signal control strategies.[6]

Model Description

The TRAF-NETSIM model accurately replicates the flow of traffic through an intersection, arterial network, or grid network. The simulation describes in detail the operational performance of vehicles traversing the network on a microscopic level.[7] For example, each vehicle's position, speed, and amount of time in the network are kept in memory throughout the run. This provides a trajectory for each vehicle throughout the simulation run.

Modularity is a key factor in the development of TRAF-NETSIM. TRAF-NETSIM includes the preprocessor or input module, which reads and checks the input, and the microscopic urban simulation module, which is the main simulation model.[1] Static and animated graphics options are available in the simulation module to display the results of a TRAF-NETSIM run.

OBJECTIVES

The main objective of this study was to demonstrate the use of TRAF-NETSIM for managing traffic congestion. This was accomplished by providing a practical guide for utilizing TRAF-NETSIM and by using TRAF-NETSIM to compare strategies for the reduction of congestion in a case study. Providing a guide included (1) describing the methodology implemented for utilizing TRAF-NETSIM, (2) summarizing the advantages and disadvantages of using TRAF-NETSIM, and (3) estimating resources. Recommending traffic management strategies entailed comparing strategies based on network output. The output was generated by establishing data requirements, collecting the data, entering the data into TRAF-NETSIM, and verifying and validating the information. Comparing traffic management strategies entailed coding and simulating the existing and alternative networks and obtaining and comparing the results. Coding a network included establishing data requirements, collecting the data, entering the data into TRAF-NETSIM, and verifying and validating the network. A graphical representation of these tasks is shown in Figure 1.

BENEFITS

By describing the application of TRAF-NETSIM in a particular case, this study provides a practical guide for traffic engineers. Resource requirements for various tasks are provided to assist others in allocating resources for similar applications. The advantages and disadvantages of working with TRAF-NETSIM are also documented.

METHODOLOGY

The U.S. Route 29 corridor between Hydraulic Road and the South Fork of the Rivanna River in Charlottesville and Albemarle County, Virginia, is used to illustrate the workings of the simulation package. The section of Route 29 under study is an uncontrolled access, four-lane divided highway with a grass median and at-grade signalized intersections. This section of Route 29 is the most heavily travelled highway in the Charlottesville area.[8] Because of rapid development in the area of Route 29 and a surge in traffic volumes, highway users commonly experience congestion and degraded levels of service on this highway.

Through the application of TRAF-NETSIM, assorted traffic management options for enhancing present traffic flow and for alleviating present and future traffic congestion on the Route 29 corridor are explored. The data for the Route 29 corridor is entered into the computer using NEDIT, the input data file editor. TRAF-NETSIM simulation results are related to field data for validation.

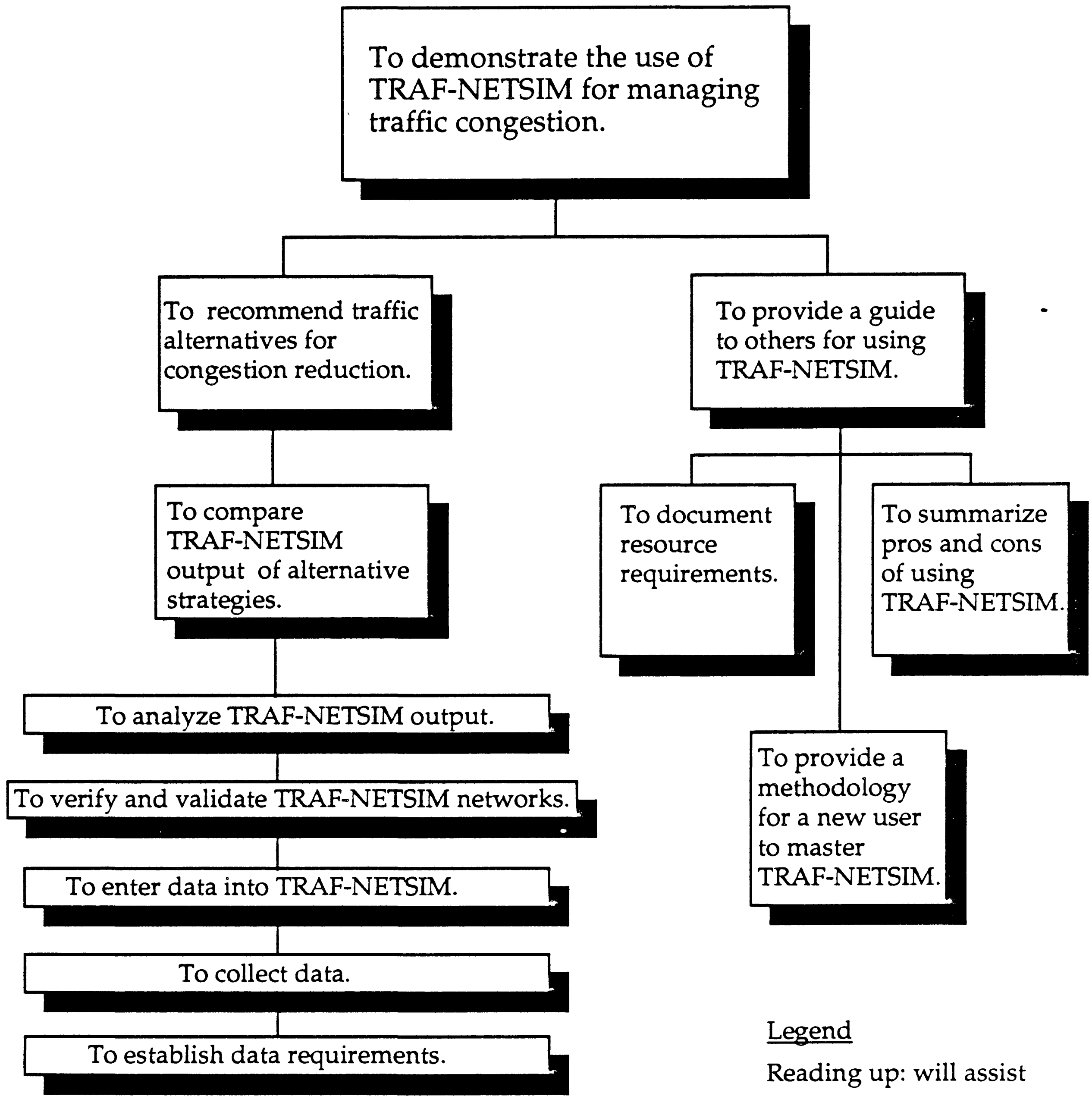


Figure 1. Objectives tree for TRAF-NETSIM project.

To alleviate congestion, a two-phase selection process is used. In Phase I, alternatives based on existing (1990) traffic volumes are examined and in Phase II, alternatives based on projected traffic volumes for the year 2010 are examined. Several measures of effectiveness (MOEs) are used to choose among alternatives. MOEs provide a direct, statistical assessment of proposed solutions.[9]

Options that fare well on move/travel ratio, delay time, and mean speed are selected for assessment. The *move / travel ratio* is the total time a vehicle spends in the network minus the delay time of that vehicle in the network divided by the total time. A single value is found for the average of all vehicles in the network during the simulation period. This average will be known as the *move / travel ratio* throughout this study. *Delay time* is the average time in minutes that vehicles are detained in the network. *Mean speed* is the average speed in miles per hour of vehicles that traversed the network. The number of *phase failures* per link, which is the number of times vehicles already stopped at a red light do not make it through the green light, are investigated to detect "hot spots" that may exist within the network.

USER'S GUIDE TO TRAF-NETSIM

System Requirements

The following is a list of requirements to run TRAF-NETSIM on a microcomputer:

- an IBM XT/AT/PS-2 or compatible microcomputer with at least 640K bytes of memory
- at least one hard disk
- a printer that can print 132 characters per line
- PC-DOS/MS-DOS 2.1 or later operating system
- an 8087/80287/80387 math coprocessor
- a color monitor with a minimum of enhanced graphics capability is required for the graphics software GTRAF. (A monochrome monitor is sufficient if only executing NETSIM.)[1]

Mainframe computer requirements for TRAF-NETSIM can be found in Appendix A of the Netsim *User's Manual.*[1]

Installing The Program

Familiarity with DOS hard disk directory structures in general and the directory structure of the target machine in particular is necessary to install TRAF-NETSIM properly. For correct installation, the installer must identify the locations of certain system files. The installation procedure does not verify the installer's responses for accuracy; thus, if the installer is unsure and ventures a guess as to these locations, the installation can easily progress in spite of these incorrect inputs. This is critical because if an error occurs during the procedure, TRAF-NETSIM must be reinstalled. In order to reinstall TRAF-NETSIM, the existing directory structure and its contents need to be completely deleted to ensure no contamination from the improper installation.

The installer must also locate (manually) certain files, which are called device drivers, selected from a set of seven disks containing dozens of cryptically named files. The installer is expected to know which device drivers are needed to match the particular hardware configuration of the target machine. This is often difficult and can become a trial-and-error process.

Initiating the Study

The first step in mastering TRAF-NETSIM is becoming familiar with the *TRAF-NETSIM User's Manual*,[1] which provides the data and information essential to set up a network. The manual is extremely valuable as a reference.

The *TRAF-NETSIM Mini-Course Manual* (available to attendees of the short course presented in conjunction with VICOR Associates and Barton-Aschman Associates, Inc.) is also an excellent reference guide. The manual includes sample TRAF-NETSIM sessions that permit hands-on experience. Additional documentation, which is listed in the References and Bibliography of this report, will also strengthen overall user comprehension of TRAF-NETSIM.

Card Types

The input stream for TRAF-NETSIM consists of a sequence of data cards that define the conditions of a network. Each card type contains a specific set of data items.

The card types for entering data may be categorized as run specific or network specific. Run specific cards appear at the beginning of the input stream for each case executed. These cards are typically numbered 00 through 05. Network specific cards specify the attributes of the network. These cards are numbered from 10 through 210.

Card types are also defined as required or optional. Required cards must be defined for each network, whereas the use of optional cards is left to the user. The most frequently used card types are summarized below.

Card Types 00 through 05

These cards provide TRAF-NETSIM with basic data needed to control the system. Identification, user name, run number, date, simulation start time, initialization time, time period duration, and number of periods are some of the information items required.

Card Type 10

Link names are entered on Card 10. Common naming conventions are used. For example, the northbound link of Dennison Street, may be labeled NBDennis, and the southbound link may be labeled SBDennis. Card 10 is an optional card.

Card Type 11

Link characteristic information, such as link length, turn pocket information, road grade, and channelization codes, is entered on Card 11. Default values for entries such as discharge headway and discharge code should be used unless local data is available.

Card Type 21

Card 21 is used to input turning movement volumes or percentages. The volumes collected for this card type are also used to determine the entry link volumes required on card 50.

Card Types 35 and 36

Cards 35 and 36 are used to model the control of pretimed controllers and signed intersections. Uncontrolled intersections should be designed with a yield sign facing the minor approaches and a perpetual green facing the major approaches. Node coordinates are also specified here.

Card Types 43 through 48

This set of cards characterize the control of actuated signals. Link approach information and node coordinates are denoted on card 43. Actuated control data, including force-off times and permissive period data, is represented on card 44. Card 45 demonstrates the allowable traffic movements for each phase of actuation. Detector data such as distance from the stop line, delay time, and sensor length are required on card 46. Actual phase operation attributes are defined on Card 47. Pedestrian information is represented on card 48.

Card Type 50

Entry volumes are coded on this card. Entry volumes are calculated from appropriate data from card 21.

Card Types 170 and 210

Card 170 is used to define other TRAF-NETSIM networks that follow the current one. Card 210 defines the existence of additional time periods. These cards must be defined for every network.

All other card types are optional:[1] they are to be added at the user's discretion. The additional cards can portray movements such as parking (short-term events), long-term events, and bus routes.

A printed copy of each blank data card from TRAF-NETSIM will guide the user in collecting germane data and in creating appropriate data-collection worksheets. It is advantageous to design a data collection worksheet with a format similar to the input card.

Network Representation

Numerous features must be assessed when constructing the TRAF-NETSIM network. These include:

- topology of the roadway system
- geometrics of each roadway component
- channelization of traffic on each roadway component
- circulation pattern of traffic on the roadway system
- the behavior of motorists
- specification of the traffic control devices and their operational characteristics
- traffic volumes entering and leaving the roadway
- traffic composition
- specifications of bus transit systems (optional).[1]

Roadway networks are specified in terms of links and nodes. Links are unidirectional segments of roadway that connect nodes. Nodes are points at which vehicles enter, exit, or are controlled, such as at signalized intersections.[10]

The user should begin the network design process by devising a complete drawing of the network under study along with a full enumeration of nodes and links. Nodes should be labeled according to the conventions set forth in the manual: between 8000 and 8999 for entry/exit links and between 1 and 750 for internal links. Program dimensions may not exceed 150 links, 75 nodes, and 18 actuated controllers.[1] An enlargement of a sample internal link is shown in Figure 2. Figure 3 displays a sample link/node drawing.

Route 29 at Hydraulic Road

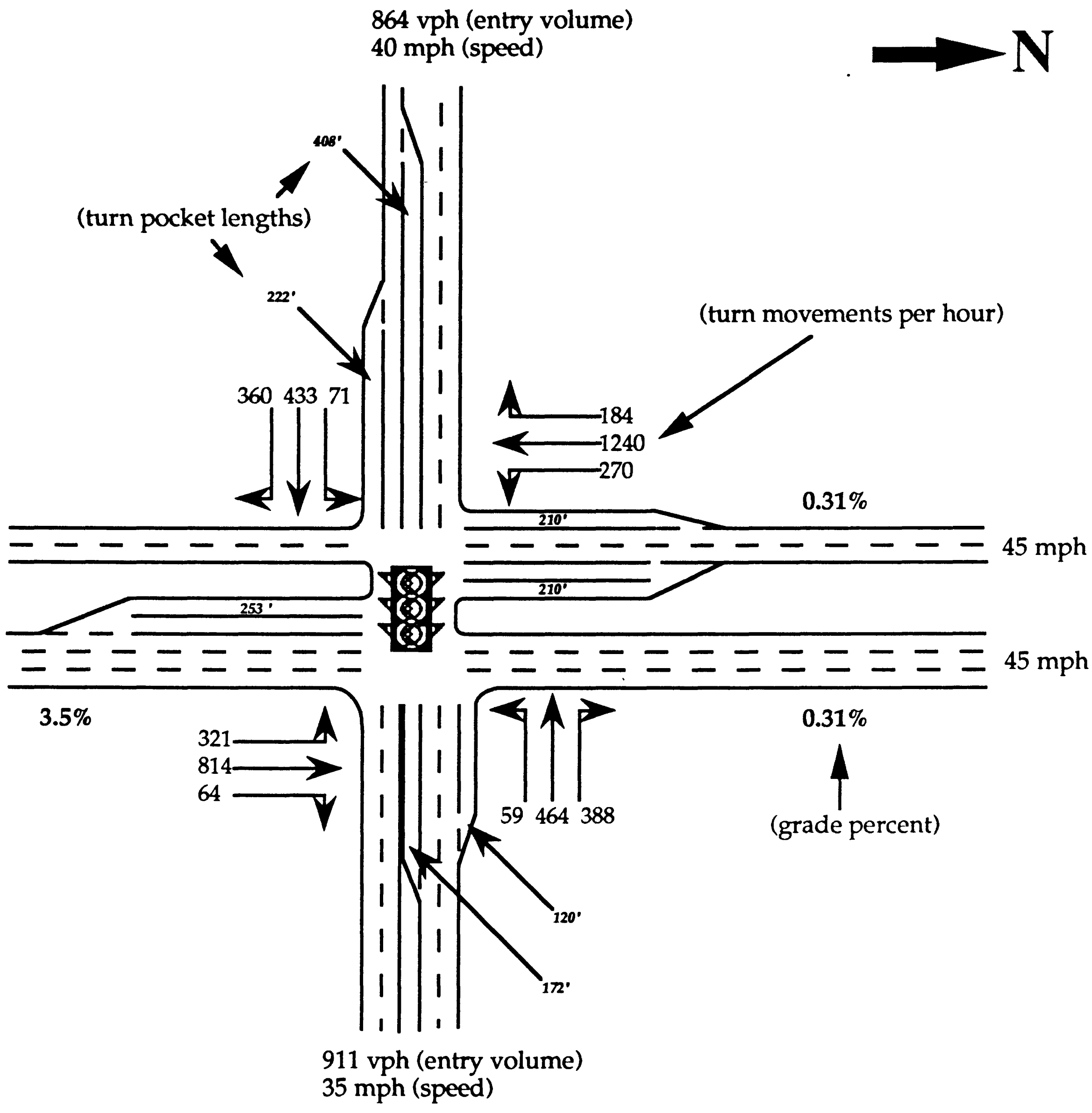


Figure 2. Sample link enlargement (link attributes).

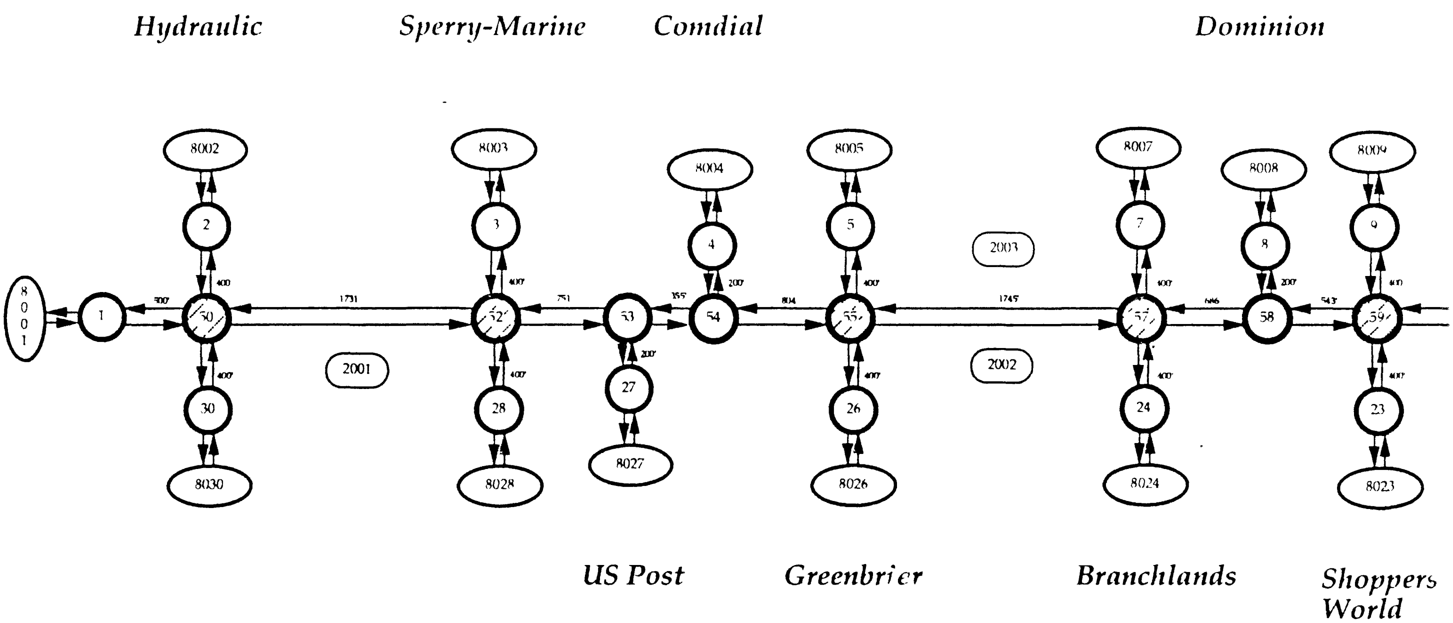
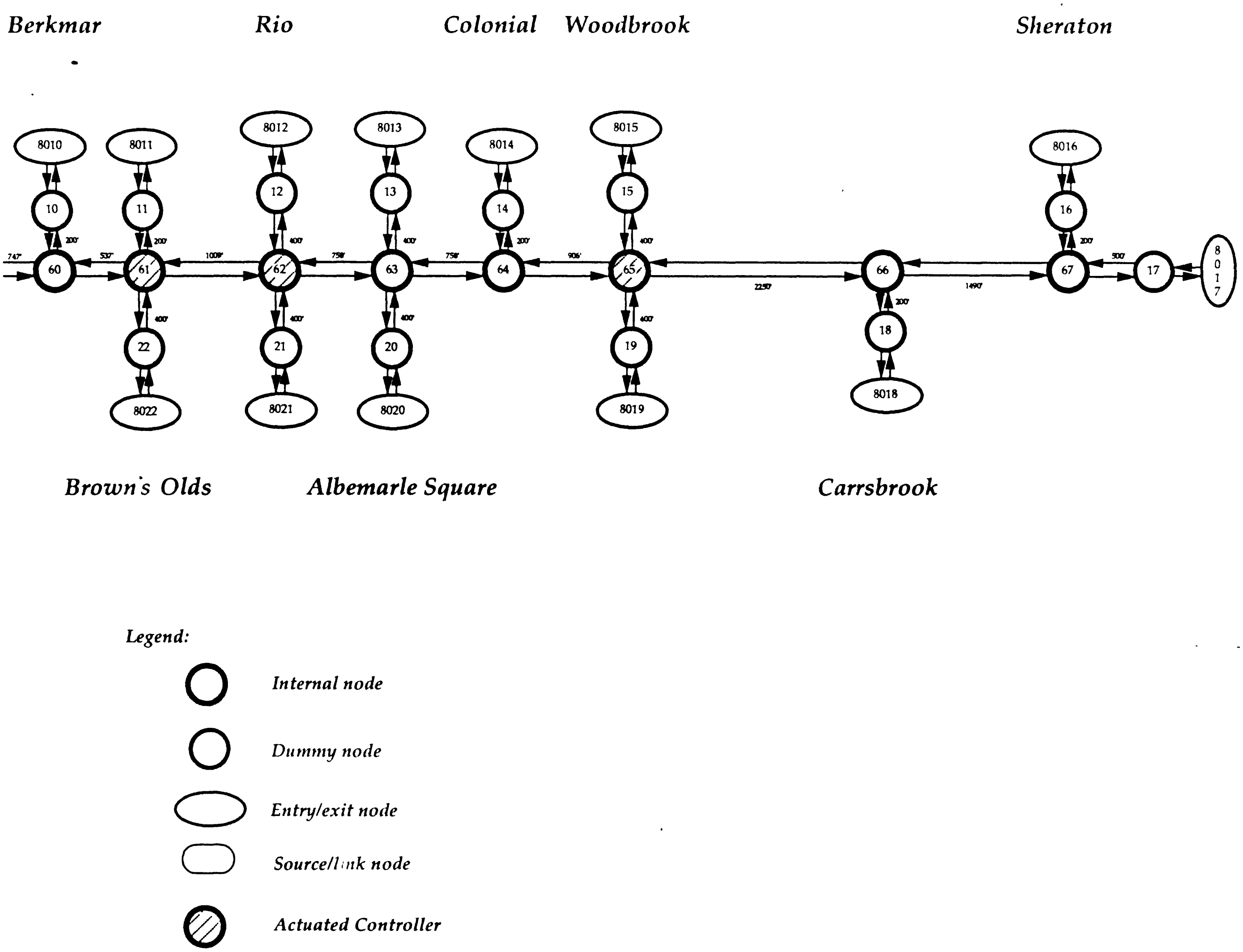


Figure 3. Link/node diagram of Route 29 corridor.


Berkmar
Rio
Colonial
Woodbrook
Sheraton
Brown's Olds
Albemarle Square
Carrsbrook
Legend:
Internal node
Dummy node
Entry/exit node
Source/link node
Actuated Controller

Data Collection

Collecting and arranging the network input data is perhaps the most crucial step in the development of the system. The data gathered must be accurate and properly formatted.

Prior to assembling the data, an itemized list of the required information should be developed. The analyst should then focus on one segment of data collection at a time. First, accumulate the geometric data and then concentrate on compiling the signal and detector data. Bus routes and special-event data should be collected last.

TRAF-NETSIM allows the user to enter data for many activities:

- pretimed controllers
- actuated controllers
- pedestrian activity
- short-term events, such as blockages resulting from illegal parking, stopping, or standing
- long-term events, such as blockages resulting from vehicle breakdowns
- parking activity, where parking activity parameters may be specified
- bus activity
- source/sink node activity, which specify net volumes to reflect intra-link gains or losses.

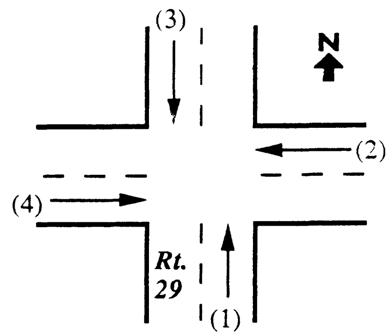
The user only needs to collect and enter the data applicable to the network for the case at hand.

Figure 4 depicts a sample data collection worksheet for Card Type 11, Urban Link Characteristics. Data such as percent grade and link length may also be included on this worksheet. For this worksheet, intersections were surveyed and pockets measured as needed to determine pocket numbers, pocket lengths, right-turn-on-red codes, and lane channelization.

Other types of data must be collected as well. Signal and detector data was for the most part extracted from existing drawings of the intersections. The Virginia Department of Transportation's Culpeper District Traffic Engineer provided the drawings, which included signal phasings and detector lengths and placements. A table was also furnished by the District Traffic Engineer's Office that included details of the actuated signal phase operations. Figure 5 shows a sample phase operations table.

Table 1 exhibits a detailed list of the participants involved in the data collection phase for this project. The table illustrates what information was collected,

Intersection Design and Channelization Data



Route 29 and ______________________

Date ______________

	Northbound (1)	Westbound (2)	Southbound (3)	Eastbound (4)
# of full lanes				
# of lanes in right turn pocket				
length of right turn pocket(s)				
# of lanes in left turn pocket				
length of left turn pocket(s)				
*Channelization Code (by full lane number)				
1				
2				
3				
4				
5				
6				
7				
Right Turn on Red (yes or no)				

Possible Channelization Codes

0 - Unrestricted

1 - Left Turn Only

2 - Busses Only

3 - Closed

4 - Right Turn Only

*Please refer to attached diagram for lane number configurations

Figure 4. Intersection design and geometry.

Routes 29 & 743

	- - - P H A S E - - -							
	1	2	3	4	5	6	7	8
Detector Type	NL	MIN	NL	NL	NL	MIN	NL	NL
Minimum Green	5	12	5	10	5	12	5	10
Pedestrian Clear								
Passage	2.5	5.0	2.5	2.5	2.5	5.0	2.5	2.5
Max Green 1	25	65	15	20	25	65	15	20
Max Green 2	35	65	25	45	35	65	25	45
Yellow	3.0	4.0	3.0	3.5	3.0	4.0	3.0	3.5
Red Clear	2.5	1.5		1.5	2.5	1.5		2.5
Added		1.5				1.5		
Max Initial		30				30		
Time B4 Reduction		20				20		
Time To Reduce		20				20		
Minimum Gap	2.5	2.0	2.5	2.5	2.5	2.0	2.5	2.5
Red Revert		3.0				3.0		

NL: nonlock
MIN: minimum recall

E v e n t s

	Events
M-F	1,2,3,4,5,8
Sat	6,5
Sun	7,5

	Time	Cycle	Offset	Split
1	06:00	140	110	1
2	09:00	150	0	2
3	16:00	150	1	3
4	19:00	140	0	2
5	22:00	Free		
6	08:00	140	0	2
7	08:00	120	0	2
8	21:00	120	0	2

Splits (%)

	1	2	3	4	5	6	7	8
1	49		10	34	49		10	34
2	42		10	25	42		10	25
3	61		15	45	61		15	45

Figure 5. Phase operations sample spreadsheet.

Table 1

DATA COLLECTION LOG

DATA	SOURCE[a]	METHOD
Original network diagram	District Traffic Engineer[b]	Drawing
Link lengths	District Traffic Engineer	Extracted from existing data
Link/ node diagram	User	Computer drawing (MacDraw)
Vehicle counts	District Traffic Crew	Physical (manual) counts of peak hour traffic
Grade (%)	District Traffic Engineer	Extracted from existing data
Free flow speeds	User	Route 29 tour
Turn pocket data	VTRC[c] Field Crew User	Physical (manual) measurements
RTOR data	VTRC Field Crew User	Visual inspection
Detector data	District Traffic Engineer User	Extracted from existing drawings
Signal phase information	District Traffic Crew	Extracted from existing spreadsheets

[a]All sources are Virginia Department of Transportation employees.
[b]All district participants are Culpeper District employees
[c]Virginia Transportation Research Council

who collected the data, and the method employed to obtain it. This is only one example of the variety of strategies that can be used to obtain data for TRAF-NET-SIM applications.

Entering Data

Entering data into TRAF-NETSIM for a first time user is quite simple thanks to the data editor NEDIT. NEDIT is arranged as a hierarchy of menus and options that facilitate user entry of input data. The most favorable attributes of this editor are the on-line help function and the automatic error checking capability. After a user becomes familiar with the format of TRAF-NETSIM input files, it may become more efficient to edit input files using another editor, such as WordPerfect.

Verifying Data Entry

Verification is an integral part of the development of a network. The syntax of the system is examined by the TRAF-NETSIM preprocessor. This inspection yields logic errors and warning messages via the appropriate error message. Each error message will include several parameters denoted by P1, P2, P3, etc. These parameters can be inserted into the explanation of the error message listed in Appendix C of the *User's Manual.* It is common to have a considerable number of errors and/or warnings from the first run through the network.

After all mistakes are corrected, the NETSIM simulation module will run. A sizable amount of disk space is required to run a large network for an extended period of time when employing the graphics option. See page A-7 in the *User's Manual* for the formula to determine disk storage requirements.

The simulation output includes an echo-print of the input card file list, the network validation of the input data, and the output of the network simulation unless otherwise specified on Card 210.[1] The expanded input should be carefully inspected. Even though there may not be any syntactical errors in the system, other errors may exist. Input should also be compared with data collected to ensure accuracy. This includes checking link lengths, lane channelizations, link speeds, turn pocket data, as well as entry volumes, turning percentages, and signal and detector data.

In addition to user verification, the analysis performed by the authors included a verification by a member of the district traffic engineer's office to confirm that actuated signals were coded accurately.

Validating the Network

Validation also plays a significant role in the development of a TRAF-NETSIM network. The user should determine whether the simulated network resembles actual field conditions. Validation can include vehicle counts or other forms of inspection.

Two modes of comparison were used to validate the network used in the case study in the latter half of this report. First, a visual inspection of the corridor under study was made during morning and afternoon hours to determine the "hot spots" (i.e., critically congested links). This information was compared to the "hot links" as determined by the simulation run of TRAF-NETSIM for compatibility. A striking similarity did exist.

Second, a comparison of the number of vehicles per hour on a link basis was generated from two sources: (1) the TRAF-NETSIM output and (2) manual counts made by the District Traffic Engineer's Office. Figure 6 depicts the average number of vehicles per hour (vph) that traveled across the 16 internal nodes as calculated by TRAF-NETSIM versus the vph for the same nodes as determined from traffic counts. The overall percent difference between statistics for the physical counts and the TRAF-NETSIM counts is 8.07 percent. This corresponds to a 3.08 percent difference for the northbound corridor and a 13.06 percent difference for the southbound corridor. The authors find this difference to be acceptable.

Network Output

There are two categories of output data provided by the TRAF-NETSIM simulation model: (1) cumulative output, which provides data accumulated since the beginning of the simulation, and (2) intermediate output, which provides data describing the current status of the traffic environment.[1]

Many measures of effectiveness are output from a TRAF-NETSIM simulation run on an individual link basis and on a network basis. Table 2 is a list of MOEs for link-specific measures.[1] Specific data is also available on bus routes, link aggregations, and turning movements. For the case study described later in this report, four MOEs were chosen to evaluate the alternatives. They are efficiency, mean delay/vehicle, speed, and phase failure.

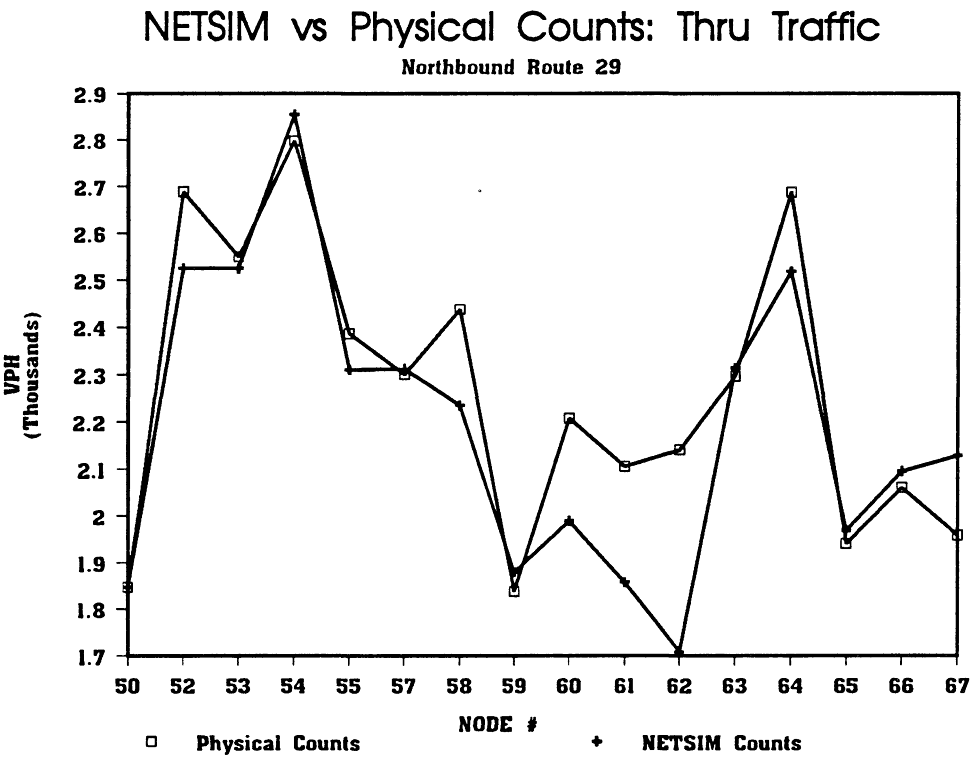
Graphic Options

Both animated (ANETG) and static (SNETG) graphic options are available to users of TRAF-NETSIM. The animated graphics display color-coded vehicles traversing the network. Static graphics allow the user to view node-specific, link-specific, or network-wide characteristics.

Advantages and Disadvantages of TRAF-NETSIM

Advantages of TRAF-NETSIM include

- the capability to address complex analytical stochastic proceses
- the capability to focus on specific aspects of the overall problem



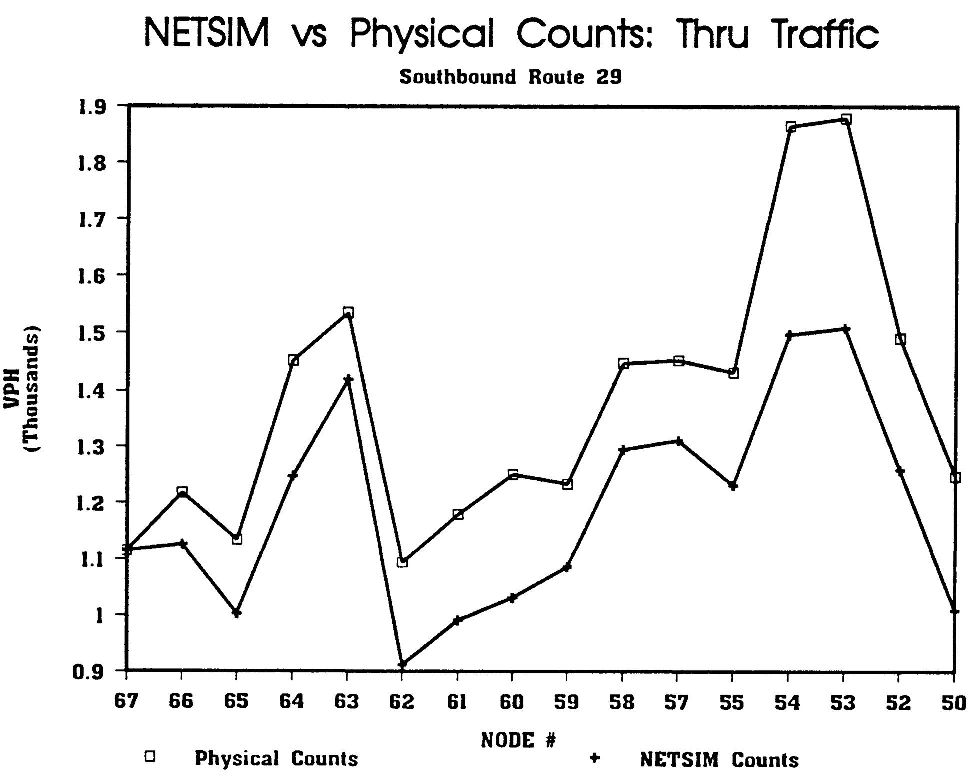


Figure 6. Average number of vehicles per hour for 16 links.

Table 2

LINK-SPECIFIC MEASURES OF EFFECTIVENESS

Travel	Total Travel Time
Moving Time	Delay Time
Efficiency	Mean Travel Time/Vehicle Mile
Mean Delay/Vehicle Mile	Mean Travel Time/Vehicle
Mean Delay/Vehicle	Mean Time in Queue
Mean Stopped Time	Speed
Vehicle Stops	Link Volume Occupancy
Phase Failure	Average Queue Length
Maximum Queue Length	Bus Travel
Bus Travel Time	Bus Moving Time
Bus Delay	Bus Efficiency
Bus Speed	Bus Stops
Fuel Economy	Fuel Consumed
CO Emissions	HC Emissions
NOx Emissions	

- the ability to experiment with ideas otherwise deemed impractical
- the ability to simulate traffic over large areas with a variety of combinations of roadway facilities
- the avoidance of real risk of failure since implementation (of the simulation) is performed entirely in the lab
- real time updates of network measures and traffic controls
- the benefits derived from the evaluation being quick, flexible, and less costly than it would be if the actual project had to be implemented before the evaluation could occur.

Disadvantages of TRAF-NETSIM include

- the simplification of a real life situation in order to fulfill computer requirements
- the risk of error since the package is only as good as the user and the inputs
- the operator/user time of many trial runs
- the need for expertise to ensure complete and effective results.[6]

TRAF-NETSIM Findings

TRAF-NETSIM allows the user to design and implement many traffic options within the office environment. NEDIT can be used to program a base network and different traffic alternatives. It is a comprehensive, user-friendly simulation package.

When developing a TRAF-NETSIM network, the following may be helpful.

- Dedicate two people to the design and implementation of a TRAF-NETSIM network. This allows for necessary verification and validation. One person should be proficient in computer use and the other in traffic engineering and actuated signals.
- Reading and understanding the TRAF-NETSIM *User's Manual* is vital. The manual should be studied thoroughly.
- Reading the manual and attempting to develop a TRAF-NETSIM network before attending the TRAF-NETSIM short course aids the user in developing meaningful questions when attending the short course.
- After the initial case is developed, and one is familiar with the format of a TRAF-NETSIM input stream, it may be more efficient to edit input data using a word processor rather than NEDIT.
- Be thorough when validating the network.
- Constraints on simulation time for a large number of vehicles in the network does exist. Under certain conditions, simulation time must be shortened to accommodate these larger numbers of vehicles.
- Because of computer memory limitations, it may not be possible to run the network with graphics for a long period of time for a large network. If this is the case, run the program without graphics for the desired period of time to gather statistics and then run the program for a short period of time to obtain the graphics displays.
- Warning or error messages detected that are not included in the *User's Manual* should be reported to the McTrans Center at the University of Florida.
- Be alert to any changes that occur in the field while planning the network to ensure accurate, up-to-date information.

CASE STUDY

The U.S. Route 29 case study was performed in two phases. Phase I evaluated the existing network and seven alternatives based on current (1990) volumes for average values of the AM and PM peak hours. Phase II evaluated the best alternatives, as determined in Phase I, based on the forecasted volumes for the year 2010.

Future traffic volumes were based on the ratio of current to projected values from the Route 29 corridor study prepared by the COMSIS Corporation. The projected percentage increase each year for the traffic in and around Route 29 was 2.2 percent.

In determining factors to reduce congestion, several MOEs were considered. Alternatives that fared well on move/total ratio, delay time, and speed at the network level were chosen for further investigation.

The number of phase failures per link was used as an indicator to detect hot spots throughout the network. Hot links are noted in the findings.

Alternative Networks

Alternative Run Times

To compile results, each network in Phase I was run for a duration of one hour starting at 07:30 and for one hour starting at 16:45, representing the morning and afternoon peak hours respectively, and average results were taken.

Each network in Phase II was run for a duration of one half hour starting at 07:30 and 16:45, and average results were taken. The networks in Phase II were run for a shorter period of time than those in Phase I as a result of a vehicle capacity overload of TRAF-NETSIM (since volumes are higher).

Base Case

The link node diagram for the base (existing) case of Route 29 is exhibited in Figure 2. The base network has the following attributes:

Nodes

16 internal nodes	(numbered 50 through 67)
27 dummy nodes	(numbered 1 through 30)
3 source/sink nodes	(numbered 2001 through 2003)
27 entry/exit nodes	(numbered 8001 through 8030)

Controls

8 actuated controllers	(numbered 50,52,55,57,59,61,62,65)
8 signed intersections	(numbered 53,54,58,60,63,64,66,67)
27 uncontrolled nodes (for dummy nodes)	(numbered 1 - 30)

The internal network is 15,070 feet long (in the north/south direction). Dummy links range in length from 200 feet to 600 feet. The speed limit on the north/south corridor is 45 mph.

Link aggregations are maintained to gather output for the northbound and southbound links of Route 29. This option is used if the user wishes the program to treat a set of links as a single entity. Additional output is provided, presenting several MOEs for the aggregations. In this study, two aggregations are used for each direction. In the northbound direction, the aggregations are comprised of links 50-52-53-54-55-57-58-59 and links 59-60-61-62-63-64-65-66. In the southbound direction, aggregations are comprised of links 66-65-64-63-62-61-60-59 and 59-58-57-55-54-53-52-50.

Alternatives presented below are cumulative in effect. For example, when formulating alternative 2, changes are made to alternative 1, not the base case.

Alternative 1

Add or modify base case links to allow for three full lanes on all links in the northbound direction. This entails changing right turn lanes to unrestricted lanes on links (54,55) and (64,65) and adding a third lane on links (55,57), (57,58), (65,66), (66,67), and (67,17). Detectors are placed in the additional lanes as necessary at nodes 55, 57, and 65.

Alternative 2

Add lanes to alternative 1 to allow for three full lanes on all links in the southbound direction. Specifically, lanes will be added on links (17,67), (67,66), (66,65), (65,64), (64,63), (63,62), (62,61), (61,60), (60,59), (59,58), (58,57), (57,55), (55,54), (54,53), (53,52), (52,50), and (50,1). Detectors are also placed in the additional lanes at the nodes with actuated controllers (nodes 65, 62, 61, 59, 57, 55, 52 and 50).

Alternative 3

At node 55, Greenbrier, add left turn pockets and through lanes so two left turn pockets and two full lanes exist in both east and west directions. Left turn and full lanes must be adjusted on the east- and westbound links (5,55) and (26,55), respectively, as appropriate. Detectors are placed in the additional lanes as well. The timing on the controller is modified for additional phases and resembles the timing of the controller at node 50, Hydraulic Road.

Alternative 4

At nodes 50 and 62, Hydraulic Road and Rio Road respectively, add left turn pockets and through lanes so two left turn pockets and two full lanes exist in both east and west directions. Lanes must be added appropriately at the two intersections, and detectors must be placed in the new lanes.

Alternative 5

At node 59, Shoppers World, add left turn pockets so dual left turns exist both northbound and southbound on Route 29. Lanes must be added appropriately at the intersection, and detectors must be placed in the new lanes.

Alternative 6

Add lanes so four full lanes exist on all northbound links of Route 29. Three full lanes exist in the current scenario, so a fourth full lane will be added throughout the northbound direction. Specifically, lanes will be added on links (1,50), (50,52), (52,53), (53,54), (54,55), (55,57), (57,58), (58,59), (59,60), (60,61), (61,62), (62,63), (63,64), (64,65), (65,66), (66,67), and (67,17). Detectors are also placed in the additional lanes at the nodes with actuated controllers (nodes 50, 52, 55, 57, 59, 61, 62, and 65).

Alternative 7

Add lanes so four full lanes exist on all southbound links of Route 29. Three full lanes exist in the current scenario, so a fourth full lane will be added throughout the southbound direction. Specifically, lanes will be added on links (17,67), (67,66), (66,65), (65,64), (64,63), (63,62), (62,61), (61,60), (60,59), (59,58), (58,57), (57,55), (55,54), (54,53), (53,52), (52,50), and (50,1). Detectors are also placed in the additional lanes at the nodes with actuated controllers (nodes 65, 62, 61, 59, 57, 55, 52, and 50).

Comparison of Alternatives

Alternatives were compared in two ways for each phase.

Phase I:

Alternatives considered:	All (1,2,3,4,5,6,7)
Traffic volumes:	Existing - 1990
Methods of comparison:	Network statistics and Route 29 corridor statistics only (excluding side streets)

Phase II:

Alternatives considered:	Those that fare well in Phase I (3,4,5,6,7)
Traffic volumes:	Future - 2010
Methods of comparison:	Network statistics and Route 29 corridor statistics only (excluding side streets)

Phase I

Table 3 is a comparison of the seven alternatives based on the criteria for Phase I for the entire network. A worksheet of other network statistics can be found in Appendix A.

Table 4 is a comparison of the seven alternatives for Phase I depicting percentage increases (decreases) as compared to the base case.

As compared to the base case, all alternatives, except for alternative 1, offer improvement in the three measures of effectiveness. Alternative 7 displays the greatest improvement in all categories. Of the remaining alternatives, 3 and 4 score close together, and 5 and 6 score close together. Alternative 2 achieves the same level as alternatives 5 and 6 in the move time/total time column but is clearly dominated by the same alternatives in the delay and speed categories.

Table 5 is a comparison of the seven alternatives based on the criteria for Phase I for the Route 29 corridor only. A worksheet of other Route 29 statistics can be found in Appendix B.

The results for Route 29 are similar to that of the network. Alternative 7 is the best, and it is followed by the group of alternatives 3, 4, 5, and 6. Alternatives 1 and 2 offer the least improvement to the base case.

Since alternatives 3, 4, 5, 6, and 7 offer the most improvement to the base case both on a network basis and on Route 29 alone, they will be considered in Phase II of this study.

The critical links in terms of number of phase failures greater than or equal to 20 for each alternative for Phase I for the morning and afternoon peak hours are shown in Table 6.

Table 3

PHASE I
COMPARISON OF MOEs FOR SEVEN ALTERNATIVES AND BASE CASE
(Network Wide)

Alternative	Move Time/ Total Time (ratio)	Delay Time (min/veh)	Network Speed (mph)
Base	0.42	2.38	18.20
1	0.42	2.41	18.05
2	0.43	2.36	18.40
3	0.44	2.17	19.15
4	0.44	2.17	19.00
5	0.43	2.21	18.85
6	0.43	2.23	18.80
7	0.46	2.01	19.90

Table 4

PHASE I
PERCENTAGE DIFFERENCES OF SEVEN ALTERNATIVES
AS COMPARED TO THE BASE CASE (Network Wide)

Alternative	Move Time/ Total Time (ratio)	Delay Time (min/veh)	Network Speed (mph)
1	0	1.3 + [a]	0.8 -
2	2.4 +	0.8 -	1.1 +
3	4.8 +	8.8 -	5.2 +
4	4.8 +	8.8 -	4.4 +
5	2.4 +	7.1 -	3.6 +
6	2.4 +	6.3 -	3.3 +
7	9.5 +	15.5 -	9.3 +

[a] – signifies decrease
+ signifies increase

Table 5

PHASE I
COMPARISON OF MOEs FOR SEVEN ALTERNATIVES AND BASE CASE
(Route 29 Only)

Alternative	Move Time/ Total Time (ratio)	Network Speed (mph)
Base	0.51	22.86
1	0.51	23.01
2	0.52	23.46
3	0.53	23.99
4	0.54	24.26
5	0.53	24.11
6	0.53	23.98
7	0.57	25.51

The critical links surround nodes 50 and 62 (Hydraulic and Rio roads) in all PM alternatives and surround nodes 50 and 62 in several AM alternatives. Node 55 (Greenbrier) has critical links about it in the first few PM alternatives, but the problem is alleviated in PM alternatives 3 and higher.

Table 6

PHASE I CRITICAL LINKS

Alternative	AM Critical Links	AM Phase Failures	PM Critical Links	PM Phase Failures
Base			(1,50)	38
			(5,55)	24
			(26,55)	23
			(21,62)	34
1			(1,50)	34
			(5,55)	24
			(26,55)	22
			(21,62)	34
2			(1,50)	23
			(5,55)	24
			(26,55)	21
			(21,62)	33
3			(1,50)	31
			(21,62)	30
4	(2,50)	25	(1,50)	33
	(30,50)	35	(30,50)	22
	(21,62)	42	(12,62)	25
			(21,62)	40
5	(2,50)	29	(1,50)	34
	(30,50)	31	(30,50)	23
	(21,62)	43	(12,62)	28
			(21,62)	38
6	(2,50)	29	(30,50)	23
	(30,50)	34	(12,62)	30
	(21,62)	40	(21,62)	38
7	(2,50)	26	(30,50)	23
	(30,50)	38	(12,62)	27
	(21,62)	38	(21,62)	37

Table 7

PHASE II
COMPARISON OF MOEs FOR FIVE ALTERNATIVES AND BASE CASE
(Network Wide)

Alternative	Move Time/ Total Time (ratio)	Delay Time (min/veh)	Network Speed (mph)
Base	0.28	4.32	12.10
3	0.36	3.09	15.75
4	0.36	2.90	16.15
5	0.37	3.03	15.85
6	0.38	2.92	16.20
7	0.38	2.87	16.45

Phase II

The alternatives considered in Phase II were alternatives 3, 4, 5, 6, and 7. These five alternatives have the same basic characteristics as the alternatives of Phase I except that these alternatives reflect future traffic volumes for the year 2010. These volumes were forecast from information provided by COMSIS, in the *Traffic and Transportation Analysis of the Route 29 Corridor*.[11] The projected volumes for both the morning and afternoon hours for Phase II can be found in Appendix C.

Recall that networks in Phase I were simulated for a period of one hour. As a result of high volumes of traffic in the networks in Phase II, the networks were run for periods of one half hour to avoid vehicle capacity overload of TRAF-NETSIM. Both morning and afternoon simulations were run, and average statistics were used.

Table 7 is a comparison of the five alternatives (and the base case) based on the criteria for Phase II. A worksheet of other network statistics can be found in Appendix D. Table 8 is a comparison of five alternatives to the base case depicting the percentage of increase or decrease using the criteria for Phase II. All alternatives offer greater than 28 percent improvement to the base case in all categories. However, alternative 7 scores best in each area. Alternatives 6, 4, 5, and 3 follow.

Table 9 is a comparison of the five alternatives based on the criteria for Phase II for the Route 29 corridor only. A worksheet of other Route 29 statistics can be found in Appendix E. The results for the Route 29 corridor are similar to those of the network. Alternative 7 rates highest followed by alternatives 4, 6, 5, and 3, respectively. In this instance though, alternative 4 gives better results than 3, 5, and 6.

The critical links in terms of number of phase failures greater than or equal to 10 for each alternative are shown in Table 10. The critical links in the AM alternatives surround node 50 (Hydraulic Road), and node 62 (Rio Road) in all cases

Table 8

PHASE II
PERCENTAGE DIFFERENCES OF FIVE ALTERNATIVES
AS COMPARED TO THE BASE CASE (Network Wide)

Alternative	Move Time/ Total Time (ratio)	Delay Time (min/veh)	Network Speed (mph)
3	28.6 +[a]	28.5 -	30.2 +
4	32.1 +	32.9 -	33.5 +
5	32.1 +	29.9 -	31.0 +
6	35.7 +	32.4 -	33.9 +
7	35.7 +	33.6 -	36.0 +

[a] – signifies decrease
+ signifies increase

Table 9

PHASE II
COMPARISON OF MOEs FOR FIVE ALTERNATIVES AND BASE CASE
(Route 29 Only)

Alternative	Move Time/ Total Time (ratio)	Network Speed (mph)
Base	0.36	17.43
3	0.44	19.86
4	0.46	20.76
5	0.44	20.01
6	0.45	20.74
7	0.46	21.08

and additionally appear about node 55 (Greenbrier Road) in the base case and alternatives 3 and 5. In the PM alternatives, the critical links appear around node 50 (Hydraulic Road), node 59 (Shoppers World), node 62 (Rio Road), and node 65 (Woodbrook Road). The additional volumes of Phase II (as compared to Phase I) add significantly more phase failures to the network.

Human Resource Requirements

Table 11 represents the approximate time spent on each phase of this project. The times shown are for an application by a systems engineer with little knowledge of actuated control using TRAF-NETSIM for the first time. This provides an agency with no TRAF-NETSIM experience with an indication of human resource requirements for training personnel to conduct a network study.

Table 10

PHASE II CRITICAL LINKS

Alternative	AM Critical Links	AM Phase Failures	PM Critical Links	PM Phase Failures
Base	(1,50)	12	(1,50)	16
	(30,50)	12	(52,50)	17
	(5,55)	14	(5,55)	12
	(54,55)	12	(26,55)	12
	(26,55)	14	(23,59)	11
	(21,62)	10	(21,62)	18
			(15,65)	12
3	(1,50)	12	(1,50)	15
	(30,50)	11	(52,50)	10
	(54,55)	11	(23,59)	12
			(21,62)	16
			(15,65)	12
4	(1,50)	12	(1,50)	17
	(2,50)	21	(2,50)	11
	(30,50)	23	(30,50)	11
	(21,62)	23	(23,59)	12
			(12,62)	24
			(21,62)	24
			(15,65)	12
5	(1,50)	12	(1,50)	15
	(2,50)	18	(52,50)	12
	(30,50)	21	(30,50)	11
	(54,55)	12	(23,59)	12
	(21,62)	22	(12,62)	24
			(21,62)	24
			(15,65)	12
6	(1,50)	13	(1,50)	12
	(2,50)	20	(2,50)	11
	(30,50)	22	(30,50)	11
	(21,62)	21	(23,59)	12
			(12,62)	22
			(21,62)	24
			(15,65)	12
7	(1,50)	13	(1,50)	12
	(2,50)	18	(52,50)	11
	(30,50)	19	(2,50)	10
	(21,62)	22	(30,50)	11
			(23,59)	12
			(12,62)	24
			(21,62)	24
			(15,65)	11

Table 11

WEEKS PER TASK

Task	Weeks
1. Reading TRAF-NETSIM *User's Manual* and other literature to gain background information on TRAF-NETSIM, simulation, and actuated control.	3
2. Attending TRAF-NETSIM short course.	1
3. Collecting and formalizing data.	4
4. Practicing TRAF-NETSIM using abbreviated networks.	2
5. Coding and debugging base network.	5
6. Coding alternative networks (28 in this case).	4
TOTAL	19

Subsequent applications by trained personnel will take significantly much less time for two reasons: (1) tasks 1, 2, and 4, (gaining information on TRAF-NETSIM, attending the short course, and practicing with TRAF-NETSIM) will be eliminated and (2) tasks 3, 5, and 6 (collecting data and coding the network) will lessen as the user becomes more familiar with the operation and manipulation of TRAF-NETSIM.

The time required to format a TRAF-NETSIM network is dependent on (1) user familiarity with TRAF-NETSIM, (2) the size of the network being modeled, (3) the availability of data, and (4) user knowledge of actuated controllers. A study of a single actuated interchange took one of the authors less than one week to collect the data and code the network.

Case Study Data

A copy of the input file for the base case and for alternative seven for the afternoon peak hour is available upon request from the Traffic and Transportation Planning Team of the Virginia Transportation Research Council. Directions for use of the diskette are in Appendix F.

Case Study Summary

The effectiveness of TRAF-NETSIM has been evaluated by comparing seven alternative networks and a base case for the Route 29 corridor in Charlottesville. A two phase procedure was used to determine the best alternative. In each phase, the ranking was based on move/total ratio, delay/vehicle (minutes), and speed (mph).

Phase I, an elimination phase, examined alternatives based on current traffic volumes. Since the analysis indicated that alternatives 1 and 2 were dominated by all other alternatives, they were eliminated from further study.

In Phase II, the remaining alternatives (3 through 7) were studied using projected future traffic volumes. The top ranking alternatives were 7, followed by alternatives 6, 5, 4, and 3.

Alternative 7 was found to be the most effective in reducing congestion in the Route 29 network in both phases. This alternative entailed constructing four full lanes in both the north- and southbound directions of Route 29 as well as geometric modifications to the intersections at Greenbrier, Hydraulic, and Rio Roads.

Case Study Conclusions

1. Alternative 7 was found to be the most effective in reducing congestion in the Route 29 network in both phases.
2. The addition of through lanes northbound and southbound on Route 29 does not eliminate spillback (the backup that occurs from one link to another). This phenomenon occurs at intersections such as Hydraulic and Rio Roads and is a result of insufficient capacity for left turn vehicles in the northbound and southbound directions. The left turn lanes should be lengthened to accommodate more vehicles.
3. At high volume intersections, such as Hydraulic and Rio Roads, the modifications made in the eastbound and westbound directions (the reconfiguration and rechannelization of lanes) do not eliminate phase failures as expected. Since the left turn lanes are not lengthened and the rightmost lane is channelized for right turn only, the left-turning vehicles are mixed in with the through vehicles in the center lane and cannot get into the left turn lanes as needed. Left turn lanes should be lengthened, or two through lanes should be added.
4. Network analyses can take many forms since the output provided by TRAF-NETSIM is so extensive. This study provides one of many possible ways to examine alternatives. A thorough analysis of the output should be conducted to better understand the advantages and disadvantages associated with each alternative network. An in-depth investigation of the output will reveal hot spots in the networks not only by link but by lane as well.
5. Longer dummy links should be used to gather more relevant statistics on the side streets.
6. Instead of building cumulative alternatives, modifications should be made to the base case. This allows for the mixing of alternatives and more creative alternatives in the long-run.

CONCLUSIONS

TRAF-NETSIM

TRAF-NETSIM allows the user to design and implement within the office environment the simulation of many traffic options. The network editor NEDIT can be used to program and edit these traffic alternatives.

After a base or existing case is entered into TRAF-NETSIM, changes can be made to produce alternative networks. Alternative networks may be as simple as the addition of a lane or complex enough to reflect phase operation changes or the alteration of bus routes.

TRAF-NETSIM attempts to be as realistic as possible. Lanes can be channelized for turns only or designated for carpool or bus activity. Percent grade and driver characteristics are among the other kinds of information that can be represented by TRAF-NETSIM. Pedestrian activity, long- and short-term events and bus routes can be simulated as well by the use of the appropriate cards. Creativity permits the engineer to design unusual networks.

The output of TRAF-NETSIM provides the user with a host of MOEs to compare traffic networks. Delay time/vehicle, number of phase failures, speed, vehicle miles, stops/vehicle trip are some of the MOEs that can be used to evaluate networks. From these statistics, the user can formulate what effect an alternative has on the network (or on a particular link). Auto emission and fuel consumption results are available as well.

Overall, TRAF-NETSIM is a comprehensive, user-friendly simulation package that is flexible enough to be adapted to specific needs.

Developing A TRAF-NETSIM Network

1. Dedicate two people to the design and implementation of a TRAF-NETSIM network. This allows for necessary verification and validation. One person should be proficient in computer use, and the other should be proficient in traffic engineering and actuated signals.
2. The TRAF-NETSIM *User's Manual* should be studied thoroughly.
3. Reading the manual and attempting to develop a TRAF-NETSIM network before attending the TRAF-NETSIM short course aids the user in developing meaningful questions when attending the short course.
4. After the initial case is developed, and one is familiar with the format of a TRAF-NETSIM input stream, it is more efficient to edit input data using a word processor rather than NEDIT.

5. Be thorough when validating the network.

6. Constraints on simulation time for a large number of vehicles in the network do exist. Under certain conditions, simulation time must be shortened to accommodate the vehicles.

7. Because of computer memory limitations, it may not be possible to run the network with graphics for a long period of time for a large network. If this is the case, run the program without graphics for the desired period of time to gather statistical data and then run the program for a short period of time to obtain the graphics displays.

8. Warning or error messages detected that are not included in the User's Manual should be reported to the McTrans Center at the University of Florida.

9. While planning the network, to ensure accurate, up-to-date information,be alert to any changes that occur in the field.

RECOMMENDATIONS

1. The Virginia Department of Transportation's District Traffic Engineers should have two employees trained in the use of TRAF-NETSIM. This will provide local capability to develop efficient traffic management strategies.

2. All district traffic engineers should be provided the hardware and software necessary to run TRAF-NETSIM on a microcomputer.

3. All District offices should develop a TRAF-NETSIM database of the important roadways and intersections within the district.

4. The results of TRAF-NETSIM simulation runs should be utilized to address public controversy in order to explain the rationale behind decisions for traffic management.

5. The Central Office should consider designating a TRAF-NETSIM coordinator within the Information Systems Division. The responsibilities of the coordinator would be to inform TRAF-NETSIM users of recent updates, to catalog TRAF-NETSIM applications, and maintain a list of user experiences.

6. A TRAF-NETSIM Short Course, designed to introduce state traffic engineers to TRAF-NETSIM, should be developed through the Technology Transfer Center at the Virginia Transportation Research Council.

7. The effectiveness of TRAF-NETSIM versus the *Highway Capacity Manual* for intersection analysis especially for actuated traffic signals should be investigated.

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APPENDIX A

Phase I Network Statistics

COMPARISON OF TRAF-NETSIM ALTERNATIVES
(Based on MOEs)

CURRENT NETWORK RESULTS

Alt.		Total Travel		Vehicle Hours			Ratio	Min/Veh Trip		Avg Values	
		Vehicle Miles	Vehicle Trips	Move Time	Delay Time	Total Time	Move/ Travel	Total Time	Delay Time	Stops/ Trip	Speed mph
Base	AM	9572.67	7280	218.12	238.41	456.53	0.48	3.76	1.96	1.7	21.0
1	AM	9538.75	7252	217.29	243.04	460.34	0.47	3.81	2.01	1.6	20.7
2	AM	9556.49	7308	217.74	221.87	439.61	0.50	3.61	1.82	1.5	21.7
3	AM	9546.83	7264	217.47	225.01	442.48	0.49	3.65	1.86	1.6	21.6
4	AM	9461.40	7262	215.57	234.80	450.38	0.48	3.72	1.94	1.6	21.0
5	AM	9345.09	7221	212.90	237.09	449.99	0.47	3.74	1.97	1.6	20.8
6	AM	9458.42	7268	215.54	234.56	450.09	0.48	3.72	1.94	1.5	21.0
7	AM	9386.49	7168	213.78	226.79	440.57	0.49	3.69	1.90	1.5	21.3

CURRENT NETWORK RESULTS

Alt.		Total Travel		Vehicle Hours			Ratio	Min/Veh Trip		Avg Values	
		Vehicle Miles	Vehicle Trips	Move Time	Delay Time	Total Time	Move/ Travel	Total Time	Delay Time	Stops/ Trip	Speed mph
Base	PM	11431.23	10258	264.48	478.09	742.56	0.36	4.34	2.80	1.9	15.4
1	PM	11499.41	10298	265.99	481.66	747.65	0.36	4.36	2.81	1.9	15.4
2	PM	11487.89	10281	265.69	497.07	762.76	0.35	4.45	2.90	1.9	15.1
3	PM	11507.38	10310	266.19	424.79	690.97	0.39	4.02	2.47	1.9	16.7
4	PM	11195.44	10005	258.92	398.15	657.07	0.39	3.94	2.39	1.8	17.0
5	PM	11226.51	9963	259.58	405.59	665.16	0.39	4.01	2.44	1.8	16.9
6	PM	11401.00	10085	263.48	423.71	687.19	0.38	4.09	2.52	1.8	16.6
7	PM	11499.58	10170	265.74	357.44	623.18	0.43	3.68	2.11	1.7	18.5

CURRENT NETWORK RESULTS
AM/PM Averages

Alt.		Total Travel: Vehicle Miles	Total Travel: Vehicle Trips	Vehicle Hours: Move Time	Vehicle Hours: Delay Time	Vehicle Hours: Total Time	Ratio: Move/ Travel	Min/Veh Trip: Total Time	Min/Veh Trip: Delay Time	Avg Values: Stops/ Trip	Avg Values: Speed mph
Base	AM/ PM	10501.95	8769.00	241.30	358.25	599.55	0.42	4.05	2.38	1.80	18.20
1	AM/ PM	10519.08	8775.00	241.64	362.35	604.00	0.42	4.09	2.41	1.75	18.05
2	AM/ PM	10522.19	8794.50	241.72	359.47	601.19	0.43	4.03	2.36	1.70	18.40
3	AM/ PM	10527.11	8787.00	241.83	324.90	566.73	0.44	3.84	2.17	1.75	19.15
4	AM/ PM	10328.42	8633.50	237.25	316.48	553.73	0.44	3.83	2.17	1.70	19.00
5	AM/ PM	10285.80	8592.00	236.24	321.34	557.58	0.43	3.88	2.21	1.70	18.85
6	AM/ PM	10429.71	8676.50	239.51	329.14	568.64	0.43	3.91	2.23	1.65	18.80
7	AM/ PM	10443.04	8669.00	239.76	292.12	531.88	0.46	3.69	2.01	1.60	19.90

APPENDIX B

Phase I Route 29 Statistics

CURRENT ROUTE 29 RESULTS

Alt.		Total Travel Veh Miles	Total Travel Veh Trips	Vehicle Minutes Delay Time	Vehicle Minutes Total Time	Ratio Move/ Total	Avg Values Stops/ Trip	Avg Values Speed mph
		Northbound						
Base	AM	2858.84	2225	3041.75	6853.54	0.56	1.30	25.1
1	AM	2806.59	2184	2886.77	6628.88	0.56	1.25	25.4
2	AM	2848.78	2216	2927.00	6725.37	0.56	1.20	25.5
3	AM	2837.17	2208	2767.65	6550.55	0.58	1.20	26.0
4	AM	2767.59	2154	2697.05	6387.17	0.58	1.15	26.0
5	AM	2712.45	2111	2698.18	6314.78	0.57	1.15	25.8
6	AM	2750.01	2141	2519.57	6186.25	0.59	1.10	26.7
7	AM	2736.43	2130	2525.39	6173.97	0.59	1.15	26.6
		Southbound						
Base	AM	4594.87	3569	5222.98	11349.48	0.54	1.25	24.30
1	AM	4630.65	3598	5317.24	11491.43	0.54	1.25	24.15
2	AM	4587.32	3564	4407.22	10523.65	0.58	1.15	26.15
3	AM	4601.54	3575	4521.08	10656.47	0.58	1.15	25.85
4	AM	4588.00	3564	4506.55	10623.89	0.58	1.20	25.90
5	AM	4545.68	3531	4450.18	10511.08	0.58	1.15	25.90
6	AM	4608.48	3580	4418.00	10562.65	0.58	1.20	26.15
7	AM	4579.11	3557	3998.60	10104.09	0.60	1.10	27.20

CURRENT ROUTE 29 RESULTS

Alt.		Total Travel Veh Miles	Total Travel Veh Trips	Vehicle Minutes Delay Time	Vehicle Minutes Total Time	Ratio Move/ Total	Avg Values Stops/ Trip	Avg Values Speed mph
		Northbound						
Base	PM	5537.96	4315	7961.16	15345.10	0.48	1.40	21.8
1	PM	5594.01	4359	8045.13	15503.80	0.48	1.30	21.9
2	PM	5578.59	4347	9054.39	16492.52	0.45	1.40	20.7
3	PM	5563.45	4334	7281.29	14699.23	0.50	1.30	22.7
4	PM	5342.74	4162	6477.85	13601.50	0.52	1.20	23.6
5	PM	5356.62	4174	6899.32	14041.48	0.51	1.30	22.9
6	PM	5541.65	4321	8384.20	15773.09	0.47	1.30	21.4
7	PM	5627.37	4386	5898.92	13402.08	0.56	1.10	25.3
		Southbound						
Base	PM	3346.99	2605	5557.37	10020.02	0.45	1.90	20.4
1	PM	3365.27	2621	5416.96	9903.98	0.45	1.90	20.7
2	PM	3357.60	2614	4912.22	9389.03	0.48	1.80	21.6
3	PM	3370.01	2625	5119.83	9613.19	0.47	1.85	21.4
4	PM	3359.36	2617	5040.33	9519.46	0.47	1.85	21.6
5	PM	3384.90	2636	4898.81	9412.00	0.48	1.80	21.9
6	PM	3379.89	2633	4970.73	9477.25	0.48	1.80	21.7
7	PM	3338.85	2600	4330.03	8781.83	0.51	1.70	23.0

CURRENT ROUTE 29 RESULTS

AM/PM Averages

Alt.		Total Travel: Veh Miles	Total Travel: Veh Trips	Vehicle Minutes: Delay Time	Vehicle Minutes: Total Time	Ratio: Move/ Total	Avg Values: Stops/ Trip	Avg Values: Speed mph
				Northbound				
Base	AM/ PM	4198.40	3270.00	5501.46	11099.32	0.52	1.35	23.40
1	AM/ PM	4200.30	3271.50	5465.95	11066.34	0.52	1.28	23.63
2	AM/ PM	4213.69	3281.50	5990.70	11608.95	0.51	1.30	23.08
3	AM/ PM	4200.31	3271.00	5024.47	10624.89	0.54	1.25	24.35
4	AM/ PM	4055.17	3158.00	4587.45	9994.34	0.55	1.18	24.78
5	AM/ PM	4034.54	3142.50	4798.75	10178.13	0.54	1.23	24.33
6	AM/ PM	4145.83	3231.00	5451.89	10979.67	0.53	1.20	24.05
7	AM/ PM	4181.90	3258.00	4212.16	9788.03	0.58	1.13	25.93
				Southbound				
Base	AM/ PM	3970.93	3087.00	5390.18	10684.75	0.49	1.58	22.33
1	AM/ PM	3997.96	3109.50	5367.10	10697.71	0.50	1.58	22.40
2	AM/ PM	3972.46	3089.00	4659.72	9956.34	0.53	1.48	23.85
3	AM/ PM	3985.78	3100.00	4820.46	10134.83	0.52	1.50	23.63
4	AM/ PM	3973.68	3090.50	4773.44	10071.68	0.52	1.53	23.75
5	AM/ PM	3965.29	3083.50	4674.50	9961.54	0.53	1.48	23.90
6	AM/ PM	3994.19	3106.50	4694.37	10019.95	0.53	1.50	23.90
7	AM/ PM	3958.98	3078.50	4164.32	9442.96	0.56	1.40	25.10

APPENDIX C

Forecasted Traffic Volumes

Link	1990 Volume	2010 Volume
(8001, 1)	2399	3707
(8002, 2)	992	1533
(8003, 3)	46	71
(8004, 4)	12	19
(8005, 5)	369	570
(8006, 7)	28	43
(8007, 8)	118	182
(8008, 9)	172	266
(8009, 10)	149	230
(8010, 11)	68	105
(8011, 12)	494	763
(8012, 13)	20	31
(8013, 14)	263	406
(8014, 15)	284	439
(8015, 16)	15	23
(8016, 17)	1122	1734
(8017, 18)	44	68
(8018, 19)	246	380
(8019, 20)	235	363
(8020, 21)	901	1392
(8021, 22)	207	320
(8022, 23)	253	391
(8023, 24)	48	74
(8024, 26)	223	345
(8025, 27)	229	354
(8026, 28)	437	675
(8027, 30)	1497	2313

APPENDIX D

Phase II Network Statistics

FUTURE NETWORK RESULTS

Alt.	Total Travel Vehicle Miles	Total Travel Vehicle Trips	Vehicle Hours Move Time	Vehicle Hours Delay Time	Vehicle Hours Total Time	Ratio Move/ Travel	Min/Veh Trip Total Time	Min/Veh Trip Delay Time	Avg Values Stops/ Trip	Avg Values Speed mph
Base AM	6206.68	4858	141.66	335.78	477.44	0.30	5.90	4.15	2.30	13.0
3 AM	6978.51	5109	158.98	223.07	382.05	0.42	4.49	2.62	1.90	18.3
4 AM	6739.07	4925	153.48	218.72	372.20	0.41	4.53	2.66	1.90	18.1
5 AM	6764.90	4944	154.02	216.05	370.07	0.42	4.49	2.62	1.90	18.3
6 AM	6801.22	4964	154.83	208.10	362.93	0.43	4.39	2.52	1.80	18.7
7 AM	6807.94	4976	154.94	195.82	350.76	0.44	4.23	2.36	1.70	19.4

FUTURE NETWORK RESULTS

Alt.	Total Travel Vehicle Miles	Total Travel Vehicle Trips	Vehicle Hours Move Time	Vehicle Hours Delay Time	Vehicle Hours Total Time	Ratio Move/ Travel	Min/Veh Trip Total Time	Min/Veh Trip Delay Time	Avg Values Stops/ Trip	Avg Values Speed mph
Base PM	6577.20	5781	152.20	432.91	585.11	0.26	6.07	4.49	2.30	11.2
3 PM	6853.88	6117	158.82	362.34	521.16	0.30	5.11	3.55	2.20	13.2
4 PM	6997.79	6299	162.06	329.84	491.90	0.33	4.69	3.14	2.00	14.2
5 PM	6848.03	6159	158.54	351.82	510.36	0.31	4.97	3.43	2.10	13.4
6 PM	6971.36	6285	161.40	348.21	509.61	0.32	4.86	3.32	2.00	13.7
7 PM	6955.73	6280	160.98	353.54	514.53	0.31	4.92	3.38	2.00	13.5

FUTURE NETWORK RESULTS

AM/PM Averages

Alt.		Total Travel		Vehicle Hours			Ratio	Min/Veh Trip		Avg Values	
		Vehicle Miles	Vehicle Trips	Move Time	Delay Time	Total Time	Move/ Travel	Total Time	Delay Time	Stops/ Trip	Speed mph
Base	AM/ PM	6391.94	5319.50	146.93	384.35	531.28	0.28	5.99	4.32	2.30	12.10
3	AM/ PM	6916.20	5613.00	158.90	292.71	451.61	0.36	4.80	3.09	2.05	15.75
4	AM/ PM	6868.43	5612.00	157.77	274.28	432.05	0.37	4.61	2.90	1.95	16.15
5	AM/ PM	6806.47	5551.50	156.28	283.94	440.22	0.37	4.73	3.03	2.00	15.85
6	AM/ PM	6886.29	5624.50	158.12	278.16	436.27	0.38	4.63	2.92	1.90	16.20
7	AM/ PM	6881.84	5628.00	157.96	274.68	432.65	0.38	4.58	2.87	1.85	16.45

APPENDIX E

Phase II Route 29 Statistics

FUTURE ROUTE 29 RESULTS

Alt.		Total Travel		Vehicle Minutes		Ratio	Avg Values	
		Veh Miles	Veh Trips	Delay Time	Total Time	Move/ Total	Stops/ Trip	Speed mph
		Northbound						
Base	AM	1969.34	1534	2830.84	5456.64	0.48	1.50	21.8
3	AM	1923.46	1496	2567.38	5132.00	0.50	1.45	22.6
4	AM	1768.96	1376	2390.27	4748.86	0.50	1.50	22.4
5	AM	1779.84	1385	2528.99	4902.10	0.48	1.50	21.9
6	AM	1831.67	1426	2303.12	4745.35	0.51	1.45	23.2
7	AM	1842.88	1434	2299.57	4756.75	0.52	1.45	23.3
		Southbound						
Base	AM	2838.98	2208	8715.96	12501.28	0.30	2.05	15.4
3	AM	3529.93	2742	5440.47	10147.03	0.46	1.80	20.9
4	AM	3493.20	2713	5280.61	9938.21	0.47	1.65	21.1
5	AM	3503.59	2721	4994.70	9666.15	0.48	1.60	21.7
6	AM	3483.65	2705	4775.67	9420.54	0.49	1.55	22.2
7	AM	3470.49	2695	4088.81	8716.13	0.53	1.35	23.9

FUTURE ROUTE 29 RESULTS

Alt.		Total Travel Veh Miles	Veh Trips	Vehicle Minutes Delay Time	Total Time	Ratio Move/ Total	Avg Values Stops/ Trip	Speed mph
		Northbound						
Base	PM	2825.60	2202	7403.47	11170.94	0.34	1.95	16.8
3	PM	2908.40	2266	6547.56	10425.43	0.37	1.90	17.1
4	PM	2984.72	2323	4973.10	8952.73	0.44	1.65	20.1
5	PM	2906.85	2264	5960.66	9836.45	0.39	1.80	18.1
6	PM	3005.93	2342	6518.70	10526.62	0.38	1.75	18.0
7	PM	3000.65	2338	6900.56	10901.42	0.37	1.80	17.3
		Southbound						
Base	PM	2291.25	1783	6016.45	9071.45	0.34	2.30	15.8
3	PM	2412.49	1878	4571.12	7787.77	0.41	2.05	19.0
4	PM	2426.50	1888	4415.51	7650.85	0.42	2.10	19.5
5	PM	2400.45	1869	4906.98	8107.58	0.39	2.10	18.5
6	PM	2413.99	1879	4307.52	7526.16	0.43	2.00	19.6
7	PM	2398.58	1867	4172.77	7370.87	0.43	1.90	19.9

FUTURE ROUTE 29 RESULTS
AM/PM Averages

Alt.		Total Travel Veh Miles	Total Travel Veh Trips	Vehicle Minutes Delay Time	Vehicle Minutes Total Time	Ratio Move/Total	Avg Values Stops/Trip	Avg Values Speed mph
		Northbound						
Base	AM/PM	2397.47	1868.00	5117.16	8313.79	0.41	9.13	19.25
3	AM/PM	2415.93	1881.00	4557.47	7778.72	0.44	1.68	19.80
4	AM/PM	2376.84	1849.50	3681.69	6850.80	0.47	1.58	21.23
5	AM/PM	2343.35	1824.50	4244.83	7369.28	0.44	1.65	19.95
6	AM/PM	2418.80	1884.00	4410.91	7635.99	0.45	1.60	20.58
7	AM/PM	2421.77	1886.00	4600.07	7829.09	0.44	1.63	20.28
		Southbound						
Base	AM/PM	2565.12	1995.50	7366.21	10786.37	0.32	2.18	15.60
3	AM/PM	2971.21	2310.00	5005.80	8967.40	0.44	1.93	19.93
4	AM/PM	2959.85	2300.50	4848.06	8794.53	0.45	1.88	20.30
5	AM/PM	2952.02	2295.00	4950.84	8886.87	0.44	1.85	20.08
6	AM/PM	2948.82	2292.00	4541.60	8473.35	0.46	1.78	20.90
7	AM/PM	2934.54	2281.00	4130.79	8043.50	0.48	1.63	21.88

APPENDIX F

Directions for Use of TRAF-NETSIM Input

To copy files from diskette to hard drive:

1. Insert TRAF-NETSIM Input diskette into disk drive A
2. Type COPY A:*.* C:\TSIS\TRAF\IO. This will copy two files from the diskette (BASE.TRF and 7ALT.TRF) onto the hard drive, assuming C is the hard drive and A is the disk drive.

To run NETSIM module for BASE.TRF and 7ALT.TRF:

1. At the C:> prompt, type CD TSIS
2. At the C:\TSIS> prompt, type TSIS
3. From the menu, select TRAF, hit return
4. From the menu select NETSIM, hit return
5. At the Enter case # 1 prompt>, type BASE Enter additional information as required
6. At the Enter case # 2 prompt>, type 7ALT Enter additional information as required
7. Hit END