Title

Potential Benefits Of In-vehicle Information Systems In A Real Life Freeway Corridor Under Recurring And Incident-induced Congestion

Author
Al-deek, Haitham

Publication Date
1988

Institute of Transportation Studies
University of California, Berkeley

PROGRAM ON ADVANCED TECHNOLOGY
FOR THE HIGHWAY

Potential Benefits of In-Vehicle Information Systems in a Real Life Freeway Corridor under Recurring and Incident-Induced Congestion

Haitham Al-Deek
Michael Martello
Adolf May
Wiley Sanders

PATH Research Report UCB-ITS-PRR-88-2

Prepared in cooperation with the State of California, Business and Transportation Agency, Department of Transportation.

July I988

PATH GOAL STATEMENT

The research reported herein is a part of the program on Advanced Technology for the Highway, PATH, which aims to obtain better productivity from the State's most used urban highway segments. PATH centers on opportunities that advanced technologies may contribute to the relief of traffic congestion, with related problems of air pollution and parking, and on cleaner energy for transportation.

ACKNOWLEDGEMENTS

The research in this paper would not have been possible without the aid of numerous people.

The authors wish to thank Goro Endo and Robert Masuda of District 7, California Department of Transportation, Los Angeles: Ed Rowe, James Okazaki, Kang Hu, and Glenn Ogura of the City of Los Angeles Department of Transportation; Paul Fowler of the Automobile Club of Southern California; and Kathy Gerwig of Commuter Transportation Services, Inc.

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EXECUTIVE SUMMARY

Optimal use of existing transportation facilities has become a major priority in congested urban areas. Providing real-time in-vehicle traffic information to drivers is one possibility of achieving this goal. This report documents an initial attempt to ascertain the potential benefits of a real-time in-vehicle traffic information system under recurring and non-recurring congestion conditions.

As opposed to creating a hypothetical network, an actual real-life network in the Santa Monica freeway corridor in Los Angeles, California, was simulated via the FREQS and TRANSYT-7F simulation models. The Santa Monica freeway corridor represented a typical congested freeway and was the focus of interest of the sponsoring agencies for this project namely CALTRANS and the City of Los Angeles Department of Transportation or LADOT. The freeway study limits were: San Diego freeway in the west to Harbor freeway in the east; Venice boulevard in the north to Adams boulevard in the south. The study period was from 6:00 a.m to 10:00 a.m. and covers the morning peak period. The four hour time period was divided into sixteen time slices fifteen minutes each. The traffic counts provided by CALTRANS and LADOT were gathered from several years of data (1984-1988) and based on meetings with CALTRANS and LADOT it was assumed that these traffic counts represent traffic counts of a "typical day" on which the analysis in this report was based.

The output of the FREQS and TRANSYT-7F simulation was travel times on the freeway links and the surface street links. Travel times for both the freeway links and surface street links from these models were transformed to a network model developed entitled PATHNET. PATHNET was utilized to determine the travel times for the "shortest path" between any origin and destination point in the network or for any other path in the network so desired (examples are "freeway-biased path", "arterial-biased path", "user-specified path"). A survey was conducted to determine typical routes used by actual commuters in the Santa Monica freeway corridor in the home to work trip. The survey suggested that the preferred route for those drivers is to enter and leave the corridor on the freeway. The survey sample size was small and was taken from a selected group of drivers. The results should not be interpreted as a random sample of commuters but rather as a preliminary indication of the typical routes taken by local commuters in the Santa Monica freeway corridor.

The shortest path is assumed to be the perfect information path. Comparisons between the "shortest path" travel time and the travel times of the other paths listed were made for a set of four origin points and three destination points. These comparisons of travel times were the basis of determining

potential benefits of an in-vehicle information system.

Under the recurring, non-incident congestion scenario, the travel time savings when utilizing the "shortest path" were generally negligible (less than three minutes for a 20-25 minute trip) when compared to the least travel time of the other paths (usually the freeway-biased path). Under the non-recurring, incident congestion scenario (where the incident was created on the freeway), travel time savings were found to be significant (greater than three minutes for a particular trip), when comparing the "shortest path" to the least travel time of the other paths (usually the freeway-biased path) during certain times in the study period (the entire study period extended from 6:00 a.m to 10:00 a.m). The greatest travel time savings occur during the time slices following the introduction of the freeway incident, from 6:45 to 7:15 a.m, with a maximum savings of 10 minutes for a 30 minute trip.

The incident scenario introduced did not capture the maximum time savings under incident induced conditions, however. Incident sensitivity analysis, an immediate goal for future research, is needed to estimate the potential benefits by varying traffic demand level, incident severity level, and network or corridor structure.

The results of this study are specific to the corridor under investigation and other limitations and constraints, e.g time of the study and the 12 O-D pairs selected and the routing strategy used.

A key assumption in this study was that an incident on the freeway system does not affect travel times on the surface street system because the percentage of vehicles diverting to the surface street system is small.

The authors of this report think that this study is only a first step in the process of the overall assessment of potential benefits. Chapter - VI in this report discussed the pros and cons of this study and the need for refinement of the obtained estimates of the potential benefits, It has also addressed future research in the area of vehicle navigation. The next step in this research is thought to be in the release of some restraining assumptions in this report, e.g to increase the percentage of diverting drivers equipped with the in-vehicle information technology from the freeway to the surface street system and recalculate the potential benefits. An integrated FREQS-TRANSYT-7F and PATHNET model will be needed to reduce the time of analysis. An equilibrium model will then have to be incorporated. The simulation can then be applied to a numerous number of networks with different sizes, structures, and the estimation of benefits can indicate in what type of network the technology can be best applied.

CHAPTER I - INTRODUCTION

A. PATH

This report describes the efforts of a study team investigating the potential benefits of in-vehicle information systems. This is one of the studies related to vehicle navigation systems which is a part of the "Program On Advanced Technology for the Highway" or (PATH). This program has three main components: Automation, Electrification and Navigation. Work in Vehicle Navigation started with Kanafani [1987] [l] and Gosling [1988] [Z].

B. THE PROBLEM

Urban congestion has been the daily problem facing California drivers and it is estimated that Californians suffer 300,000 hours of traffic delay per day. Congestion is increasing at a rate of 15-20 & per year throughout the state. It has been estimated that the demand measured by VMT is growing at the rate of 5-6 % per year, while facilities (in lane miles) are increasing at a rate less than 1% per year [3].

Even if it is financially possible to cope with this demand by the construction of new highway facilities, it is currently impossible to satisfy environmental, land use and other requirements. Technology based systems for the management of traffic operations is necessary. The use of traffic information systems has the objective of helping drivers to arrive at their destinations without having to suffer excess travel (if they are not familiar with the network) or congestion delay. There have been studies in the U.S. that estimated the contribution of excess travel (relative to the total travel time) for work trips. The paper of Mast and King [4] estimated a $45 billion dollars loss per year caused by excess travel time which could be recovered if there was a navigational system.

There is a substantial wastage of time and other resources (e.g fuel) because of excessive delay at intersections and congestion on the freeways. However, there has not been a large research effort (in U.S.) directed to estimate travel time savings that could be accrued by a real time traffic information system that diverts drivers around bottlenecks (recurring and non-recurring) and consequently avoid congestion delay.

C. BACKGROUND

In his paper of [1987] [l], Kanafani talked about current technology in navigational aids, route guidance and route control systems. Kanafani also made a brief comparison between current navigation and route guidance systems. Examples of navigation systems are the U.S. ETAK and the Japanese **JNPA** Amtics. Examples of the route guidance systems are the German ALI-SCOUT and the British AUTOGUIDE. Also, definitions of route guidance, route control and navigation systems can be found in Kanafani's paper.

The paper of Yumoto. et al, [l979] **[5],** estimated travel time savings of 9-15 % (in a thousand trials made between 7 pairs of O-D's). More work has been done by Jeffery, et al, TRRL, England, [1987] [6]. Jefferg's estimation of benefits was even more comprehensive, including estimations of user and system benefits rather than just stating the travel time savings. Jeffery estimated costs of the in-vehicle units (IVU) and the system hardware costs (i.e burried loops in the network). The general outcome of Jefferg's cost/benefit analysis was that the system is feasible.

It is important not to forget that all of the above estimates were made for a traffic system under recurring traffic congestion conditions, i.e traffic congestion is not caused by an incident. <u>There was no work related to the estimation of benefits under non-recurring traffic congestion conditions.</u> Also, previous international estimates of benefits were related to the network in question, in other words they were network specific, and these estimates or magnitudes do not necessarily apply to the network system in the U.S. per se.

D. PURPOSE OF THE STUDY

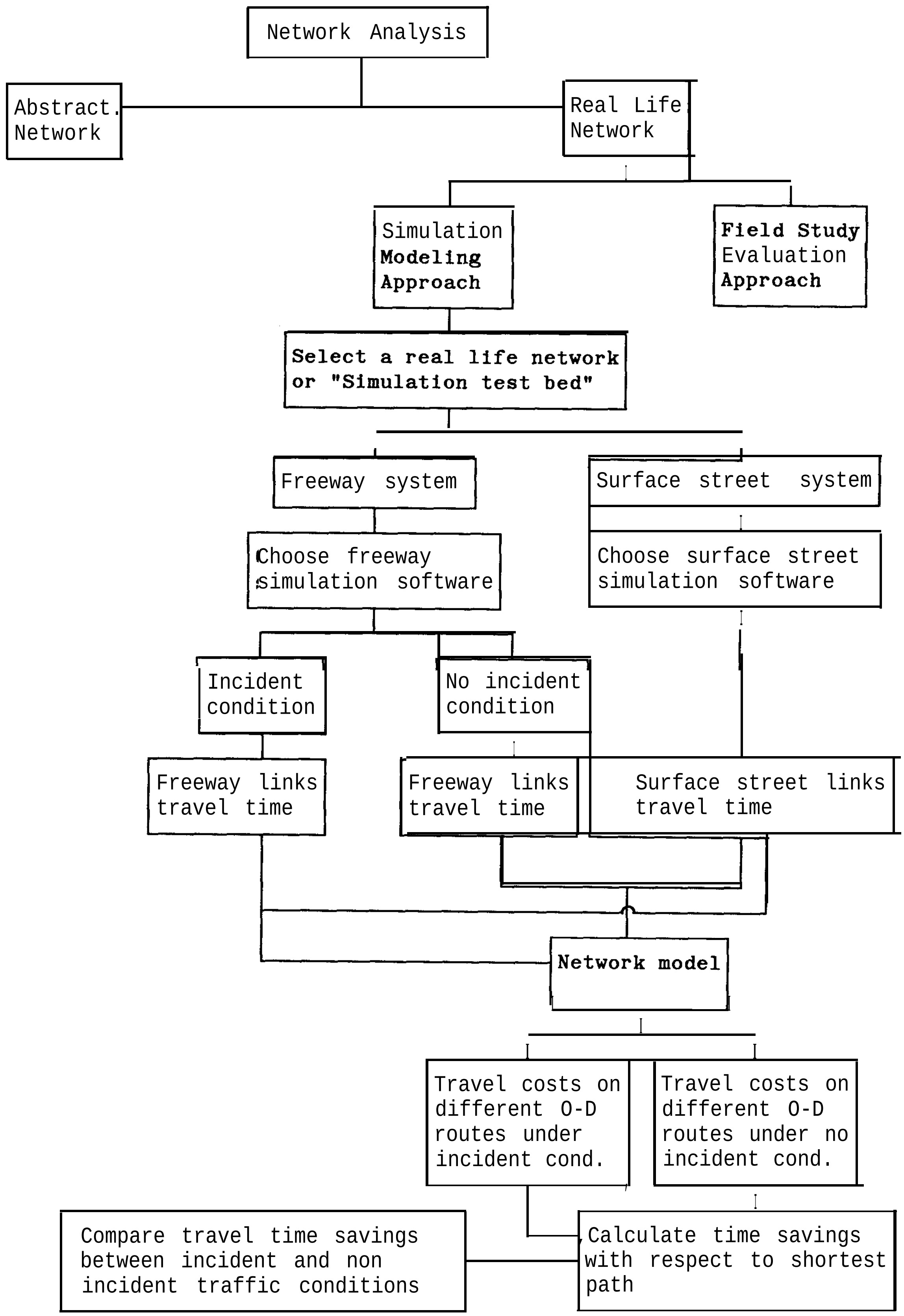
The purpose of this study is to evaluate the potential benefits that could be accrued by an in-vehicle information system that is able to provide real time traffic information in an actual network to the driver under Incident and non-incident traffic conditions.

A real time traffic information system is one that would have the capability of providing information about travel time on the shortest route and any other route between each origin and destination pair in the network.

E. STUDY APPROACH

The flow chart page - 3 -, explains the logical steps that this study went through.

Network Flow Chart



When one wants to analyze a network, one usually has two options. One option is to develop an abstract network which incorporates the visualization of a hypothetical network with flows on its links. The other option is to work with a real life network. When considering a real life network, two kinds of approaches are available: the simulation modeling approach and the field study and evaluation approach. Since the field study and evaluation approach does not give the ability to calculate benefits in an incident induced condition and makes it very difficult to answer "what if?" questions, the simulation modeling approach is the most desirable. The first step in the simulation modeling approach is to select a simulation test bed, obviously a real life network. In selecting the site location for the real life network, a number of factors were taken into consideration. These factors are listed as follows:

- -Interests of the sponsoring agencies; the California Department of Transportation or CALTRANS and the city of Los Angeles Department of Transportation or LADOT.
- -The location for the PATHFINDER experiment anticipated to take place in the Los Angeles SMART corridor next year.
- -Availability of traffic counts database.
- -Existing traffic congestion.
- -Size of the network.

It was decided in a meeting held on September 25, 1987 between CALTRANS, LADOT, and the Institute of Transportation Studies (ITS) that the network location for this project would be in the SMART corridor in Los Angeles. The SMART corridor is composed of the Santa Monica freeway and the surrounding surface street facilities. There are several advantages in choosing the SMART corridor. One, the SMART corridor has been the focus of CALTRANS' and LADOT's current and future traffic improvement projects. Two, the SMART corridor is the candidate corridor for the future PATHFINDER experiment. Three, the relative availability of traffic counts at CALTRANS and LADOT which could be used in the simulation process when needed. And four, the traffic congestion and the size of the corridor is sufficient to give, drivers with information, maneuvering ability when they want to divert around bottlenecks and avoid congestion. This is important so that the size of the benefits (e.g time savings) of an in-vehicle information system will be sound and conceivable.

The question of defining the general spatial and temporal boundaries were also addressed In the September 25th meeting. It was agreed that the spatial boundaries would extend from the San Diego freeway (I-405) on the west end to the Harbor freeway (I-110) on the east end. The north and the south limits would extend from Adams Boulevard on the south end to Venice Boulevard on the north end.

Concerning the time period in which the study would take place, it was suggested to choose the most congested periods of the day, i.e either morning peak period or evening peak period or both. Because of time and budget constraints only one of the two peak periods was choosen for analysis. The decision was made to analyze the A.M. peak period. There are several advantages seen in choosing the A.M. peak period and they are listed as follows:

- People are more concious about travel time In the morning in order to not arrive at work late, assuming that most trips in the morning are work trips.

- Evening trips may be multi-purpose trips or "chain" trips and they may not be consistent throughout the week as morning trips are.

- The morning typically has a tighter and higher peak period.

- Generally there is more capacity on the parallel surface streets in the morning peak period.

The morning peak period extends approximately from 6:30 A.M. to 9:30 A.M. However, as will be explained in later chapters, the limitations of the computer software selected required that the analysis begin and end in free flow traffic conditions. In order to assure this, the period between 6:OO A.M. and 1O:OO A.M. was chosen for the simulation analysis.

The simulation of the corridor is divided into two systems, the freeway system and the surface street system. For each system, as will be explained in chapters II and III, the exact boundaries were defined and also a simulation software was selected. The input for each simulation package is generally formed of three different inputs: supply, demand and control. The output of simulation will be travel time on the system links (i.e freeway links and surface street links). The input and output of each software are discussed in chapters II and III.

As stated previously, traffic congestion can either be of a recurring type or a non-recurring, incident type of congestion. Recurring congestion is a result of the daily formation of bottlenecks on a facility due to traffic demand exceeding the full physical capacity of the facility. Non-recurring congestion is a result of bottlenecks developing on a facility due to a reduction in the full physical capacity of the facility because of an incident (i.e. accidents, breakdowns). It is easier to predict the deterministic recurring congestion based on known past traffic experiences while the non-recurring congestion is stochastic in nature and thus difficult to predict.

For this study, only incidents on the freeway facility will be considered because freeway links are more critical in the changes of the network travel times than Incidents on the surface street links. An important assumption being made in this study is that an incident on the freeway system will not affect travel times on the arterial system because It is assumed that the percentage of vehicles diverting to the surface street system is small.

As the flow chart shows there will be two sets of costs: the incident and the non-incident costs. In the non-incident case travel time savings could be calculated based on the comparison of travel time between a certain O-D pair, using different routes, and the travel time of the shortest route between the same O-D pair. In the incident case it is assumed that travel time on the surface streets will not change, so the same travel time on the surface street links will be used as in the non-incident case, but the freeway links will have their link travel time changed (and that is only in the direction where the incident is introduced, e.g eastbound). With revised freeway link costs for the Incident case, travel costs will be calculated as in the non-incident case. All these calculations are performed In chapters IV and V.

Chapter VI talks about a broader assessment of potential benefits of the in-vehicle information system and future research in this field.

CHAPTER II - FREQSPC SIMULATION OF THE SANTA MONICA FREEWAY

A. INTRODUCTION

1. Objective

The objective of the simulation of the Santa Monica freeway is to determine realistic travel times for each subsection of the freeway within the study area for the duration of a peak traffic period under incident free situation and with a typical incident situation. Travel times are then to be used as freeway link costs input to the network model.

2. Process

In order to accomplish the above objective it was necessary to:

- -determine freeway east and west study boundaries.
- -select modeling approach to simulate the freeway.
- -collect data (supply, demand, and control).
- -simulate existing conditions on the freeway.
- -calibrate input (by cross checking with real life observations).
- -generate and simulate incident scenario on the freeway.
- -provide travel time data on the freeway links with incident and with no incident situation for the network model.

B. FREEWAY STUDY BOUNDARIES

1. Spatial Boundary Considerations

a. Eastbound

In addition to the considerations in chapter-I for the selection process of the corridor and its general boundaries, the following considerations were used to define the final freeway limits:

(1) Upstream Boundary

It was desirable for the upstream limit, to include the San Diego-Santa Monica freeway interchange so as to determine travel times from the San Diego freeway to any destination (off-ramp) in the eastbound direction of the Santa Monica freeway.

(2) Downstream Boundary

It was desirable for the downstream limit, to include the Harbor-Santa Monica freeway interchange so as to determine travel times from any origin (on-ramp) in the eastbound direction of the Santa Monica freeway to the Harbor freeway.

Based on above upstream and downstream boundaries the length of the freeway to be simulated was roughly 10 miles.

(3) Subsection Identification

Except for the first and last subsections of the freeway, each freeway subsection is identified by two ends: an upstream ramp and a downstream ramp. The upstream end in the first subsection of the freeway is the starting point of study on the freeway (or mainline origin) and the downstream end in the last subsection of the freeway is the ending point of study on the freeway (or mainline destination). The length of a subsection is the distance between the nose of the upstream ramp and the nose of the downstream ramp. Throughout each subsection the capacity should be constant (i.e number of lanes in the subsection does not change). If the number of lanes in the subsection changes then this subsection is split into two subsections.

(4) C-D Roads Consideration

The Collector-Distributer (or C-D) roads which exist on both eastbound and westbound directions of the Santa Monica freeway are used by through traffic to avoid congestion and therefore Increase the capacity of subsections parallel to the C-D road. This may enhance the role of information systems and provide more flexibility for drivers who like to divert and return to the freeway without continuing their trip using the surface street system. C-D roads were considered as auxiliary lanes for the freeway subsections and the capacity of the C-D lanes was less than the capacity of the mainline lanes. It will be shown later in this report that subsections of the freeway with mainline lanes parallel to the C-D road were found to be natural bottlenecks, bottlenecks that drivers can avoid during congestion periods and use the C-D roads If they are not congested.

(5) Simulation Software Limitations

The simulation software selected have some limitations that play a role in selecting the freeway boundary for analysis, this will be discussed later on in this chapter.

b. <u>Westbound</u>

All considerations in the westbound direction are identical to those in the eastbound direction of the Santa Monica freeway.

2. Temporal Boundaries Considerations

In chapter-I we have discussed the selection of the peak period used for simulation which was decided to be the morning peak period 6:OO a.m to 1O:OO a.m. The choice of the time slice period will depend on how frequently traffic fluctuates. Experience shows that within a 15 minute period, there are usually not many abrupt changes occurring in the traffic conditions and one could observe stationary flow conditions within a 15 minute time period. It has also been observed that within a 15 minute period and at a speed of 65 mph or even 55 mph (free flow conditions), time will be more than sufficient for any driver to traverse the freeway between mainline origin and mainline destination (or between San Diego freeway and Harbor freeway).

Selecting a 15 minute time slice period, a four hour time period (6:OO a.m - 1O:OO a.m) will have 16 time slices. Also, it will be explained later that setting the starting time at 6:OO a.m and the ending time at 1O:OO a.m for simulation is related to limitations of the software that will be used for the simulation process.

C. MODELING APPROACH

It has been explained in chapter-I that the simulation approach is the approach to be used for the purpose of this study. This chapter will discuss the simulation of the Santa Monica freeway, while the next chapter (chapter-III) will discuss the simulation of the arterial or surface street network.

1. Freeway Simulation Models

There are several freeway simulation models which can be used for different freeway corridor analysis. The paper of May [1987] [7] described five families of currently available models used for the purpose of freeway simulation. The reader is referred to this paper for a comprehensive classification, historical development of these models and their real life applications. One of the five families is the FREQ family. The FREQ model is a deterministic demand-supply model at the macroscopic level that includes simulation, optimization and user response. Shock wave analysis is used for analyzing queues. For more details on how the model works, the reader is referred to May and Wong [l987] [S], and Imada and May [1985] [9]. A user-friendly interactive PC version of FREQ called FREQSPC (now version 3.0 has been released) was used in this study [S].

a. <u>FREQSPC limitations</u>

The FREQSPC has a number of constraints which are necessary to be taken into consideration when applying FREQSPC to any freeway analysis:

* the space boundaries of the freeway have to be free of congestion, i.e free flow conditions on both ends of the freeway. This is important to assure accurate and reliable output results and travel times on the freeway links.

* the time boundaries (i.e starting and ending time of the analysis) also have to be congestion free.

* the length of the freeway should be such that the maximum number of subsections is 40, this is approximately 10-15 miles.

* the maximum number of inputs and outputs to the freeway section are each limited to 20.

* the maximum number of time slices is 20.

The FREQSPC limitation of congestion free time boundaries implies that the time period of analysis should start and end with free flow conditions. This is necessary to attain accurate results. Therefore, the study period extends from 6:OO a.m to 10:OO a.m. It is assumed that vehicles entering the freeway anywhere will be able to leave it within 15 minutes under free flow conditions in the subsections of study. This is an outcome of FREQSPC free flow boundary assumptions and space limitiations.

Given the above constraints, objectives and practical considerations, it was decided that limits may start just west of the San Diego freeway and extends just east of the Harbor freeway, approximately 10 miles in length. Figure II-1 shows the study limits.

D. DATA COLLECTION

The data required for this model is divided into three different categories: supply, demand and freeway performance data.

1. Supply Data

a. Data for the Geometric Design of the Freeway

Physical dimensions of the freeway subsections, ramp locations and number of lanes were determined by strip maps with post mileage for the freeway corridor under study and the aerial photographs for the freeway between the eastern and the western limits. The strip maps and the aerial photographs were provided by CALTRANS District-7. The strip maps and the aerials were helpful to notice bad curvatures, nature of the subsections, further checking on lengths of subsections and field capacities which were given by CALTRANS.

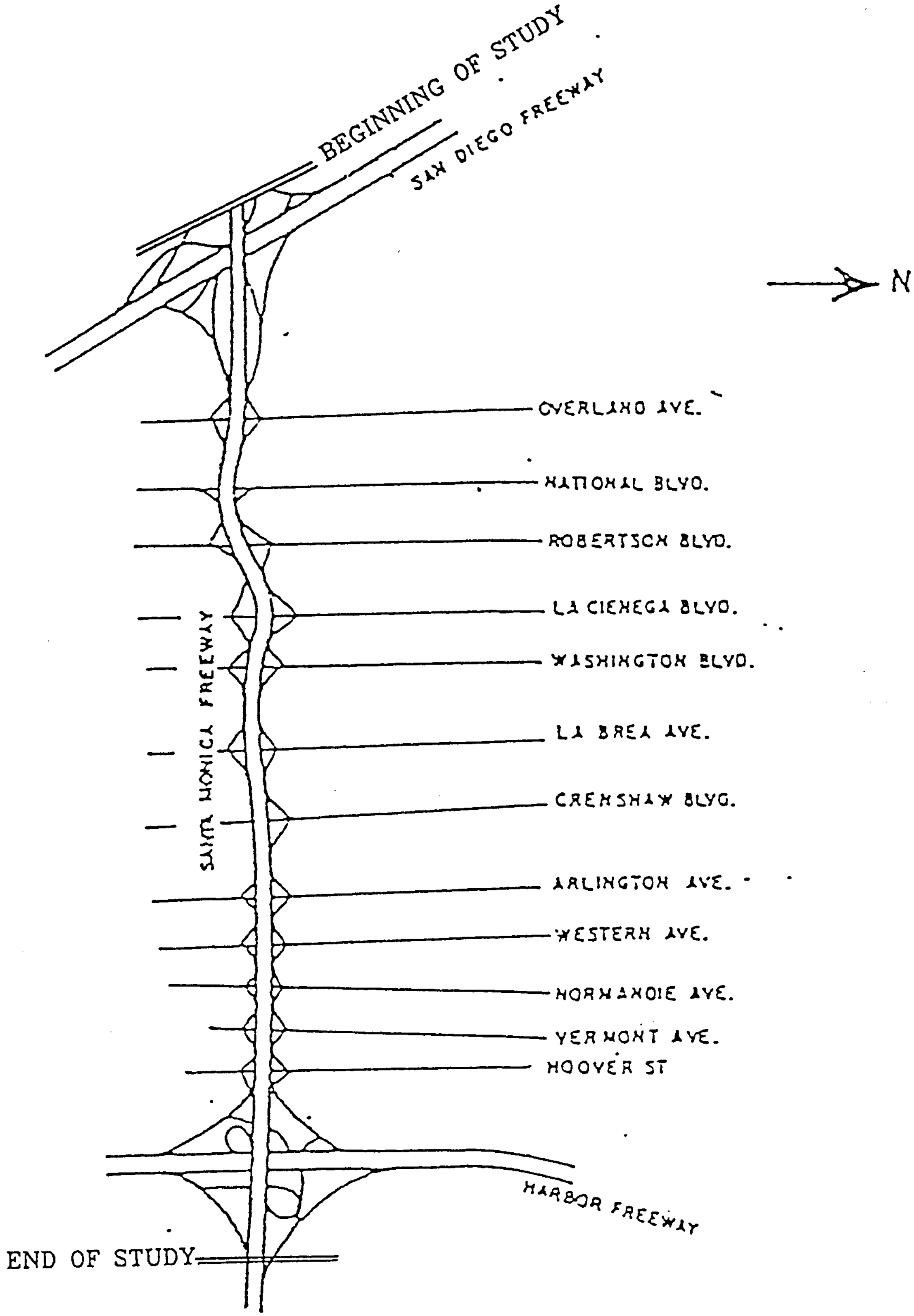
b. Sunnested Field Capacities for Freeway Ramps and Subsections

Net capacities including merge and weaving effects were provided by CALTRANS. In addition to these, C-D road capacities and on/off ramp capacities were supplied ".

C. Speed-Flow Relationshins

After consultations with CALTRANS about the nature of the speed-flow relationship for the Santa Monica freeway, the 65 mph speed-flow curve was used in this analysis.

Y Capacities of all single lane on-ramps were taken as 1500 vph, while capacity of connectors and especialy designed on-ramps were different and were given by CALTRANS.



THE SANTA MONICA FREEWAY STUDY LIMITS

FIGURE II-1

2. Demand Data

a. Ramp and Mainline Counts

For the period of analysis 6:00 a.m - 10:00 a.m, FREQ8PC requires 16 time slice traffic counts (each time slice is a 15 minute period) for all on and off ramps as well as mainline origin and mainline destination of the freeway (within the study limits). This information was obtained from the following sources:

(1) Existing Database at CALTRANS

CALTRANS has counts for most of the on and off ramps within the area of study. The traffic counts dated from 1983 to 1988. These ramp counts were either manually collected or machine counts (tube counts). All on ramps were controlled within the study limit. New 15 minute counts were collected at some of the C-D road locations.

(2) Mainline Counts and Connectors * Counts

In January 1988, Video cameras were already installed by CALTRANS at the two major freeway interchanges: San Diego-Santa Monica freeway interchange in the west and Harbor-Santa Monica freeway interchange in the east. These cameras recorded traffic between 6:00 a.m- 10:OO a.m, and the tapes were then analyzed manually at ITS to attain the 15 minute counts for the mainline origin and destination as well as for all in and out connector traffic of the San Diego and Harbor freeways.

(3) Missing On/Off Ramp Counts

CALTRANS was not able to supply counts at some of the on/off ramps. These ramp counts were obtained from the city of Los Angeles Department of Transportation (LADOT).

It is important to remember that counts used were gathered at different times of the year and sometimes even from different years. This of course affects the accuracy of the results. However, the count database obtained was the best available at

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* Connectors are those highway segments that connect one freeway to another freeway.

the time when this research was carried out.

(4) Occupancy Data

Occupancy for each origin (on-ramp) in each direction of the freeway is needed for FREQSPC input. Occupancy is needed in the form of the proportion of l-passenger, a-passenger, and 3 or more passenger autos, and also the proportion of buses. In addition to that, the average car pool and bus occupancies are needed for each origin. Occupancy data was obtained from CALTRANS.

(5) Freeway Performance Data Needed for the Calibration Process

(a). Bottleneck Location and Travel Time

Real life speed contour map is needed to locate bottleneck locations and durations and then to compare with the FREQ speed contour map and queue diagram.

Field measurement speed contour maps as shown in figure II-2 and figure II-3 (for east and westbound Santa Monica freeway respectively) were obtained by analysis of one day traffic tachographs (for the same study period, i.e 6:00 a.m -10:00 a.m) provided by CALTRANS. Real life travel times in minutes between mainline origin and mainline destination were analyzed from the tachographs and were plotted against time slices (1 through 16) as shown in figure II-4 and figure II-5 for eastbound and westbound directions of the Santa Monica freeway respectively.

Also some descriptive statements about the existing traffic conditions, congestion, and bottleneck locations and durations were given by CALTRANS engineers, for example:

* During the morning peak period, traffic is always congested at subsections of the LaCienega C-D road on eastbound direction of the Santa Monica freeway and the LABREA C-D road on the westbound direction of the Santa Monica freeway.

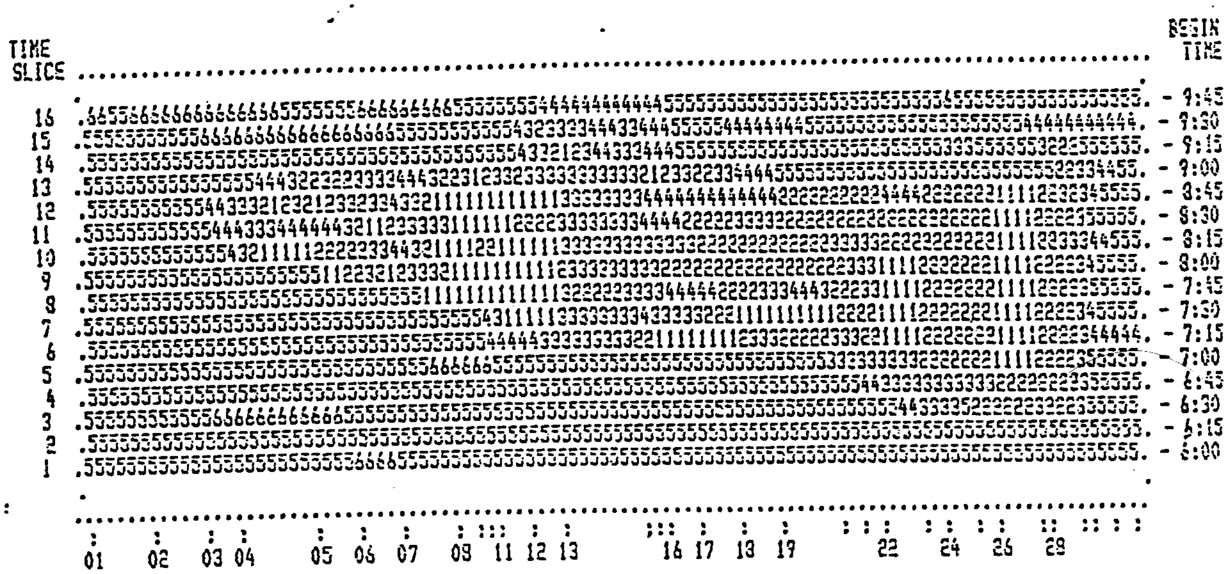
E. SIMULATION PROCESS

1. Code Input

The freeway subsections were coded into FREQBPC using its interactive processor. The first step taken was to code the

EASTBOUND SANTA MONICA FREEWAY
SPEED CONTOUR MAPS FROM TACHOGRAPH ANALYSIS

"REAL LIFE SPEED CONTOUR MAP"



Subsection Number

FIGURE II-2

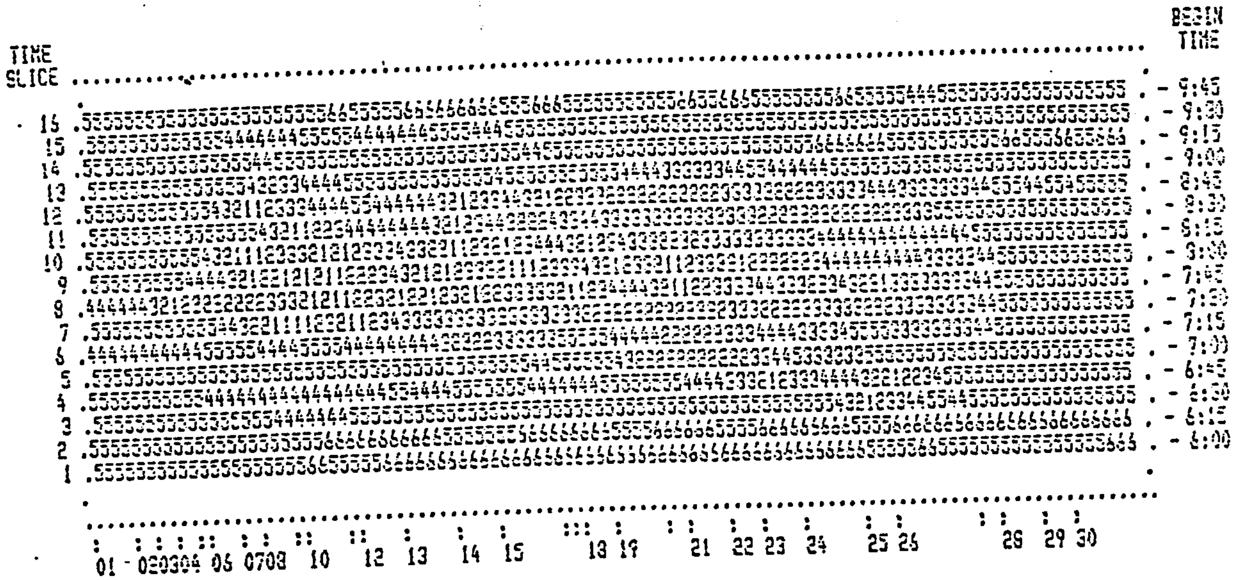
* THE DIGIT LEVELS DENOTE THE FIRST DIGIT OF THE OPERATING SPEED (EX. 4 MEANS 40-49 MPH).

* CONTOURS OF 30-39 MPH SPEED DENOTE BOTTLENECKS

* CONTOURS OF 10-19 MPH AND 20-29 MPH SPEED DENOTE CONGESTION EFFECT BEHIND THE BOTTLENECKS.

WESTBOUND SANTA MONICA FREEWAY
SPEED CONTOUR MAPS FROM TACHOGRAPH ANALYSIS

"REAL LIFE SPEED CONTOUR MAP"



Subsection Number

FIGURE II-3

* THE DIGIT LEVELS DENOTE THE FIRST DIGIT OF THE OPERATING SPEED (EX. 4 MEANS 40-49 MPH).

* CONTOURS OF 30-39 MPH SPEED DENOTE BOTTLENECKS

* CONTOURS OF 10-19 MPH AND 20-29 MPH SPEED DENOTE CONGESTION EFFECT BEHIND THE BOTTLENECKS.

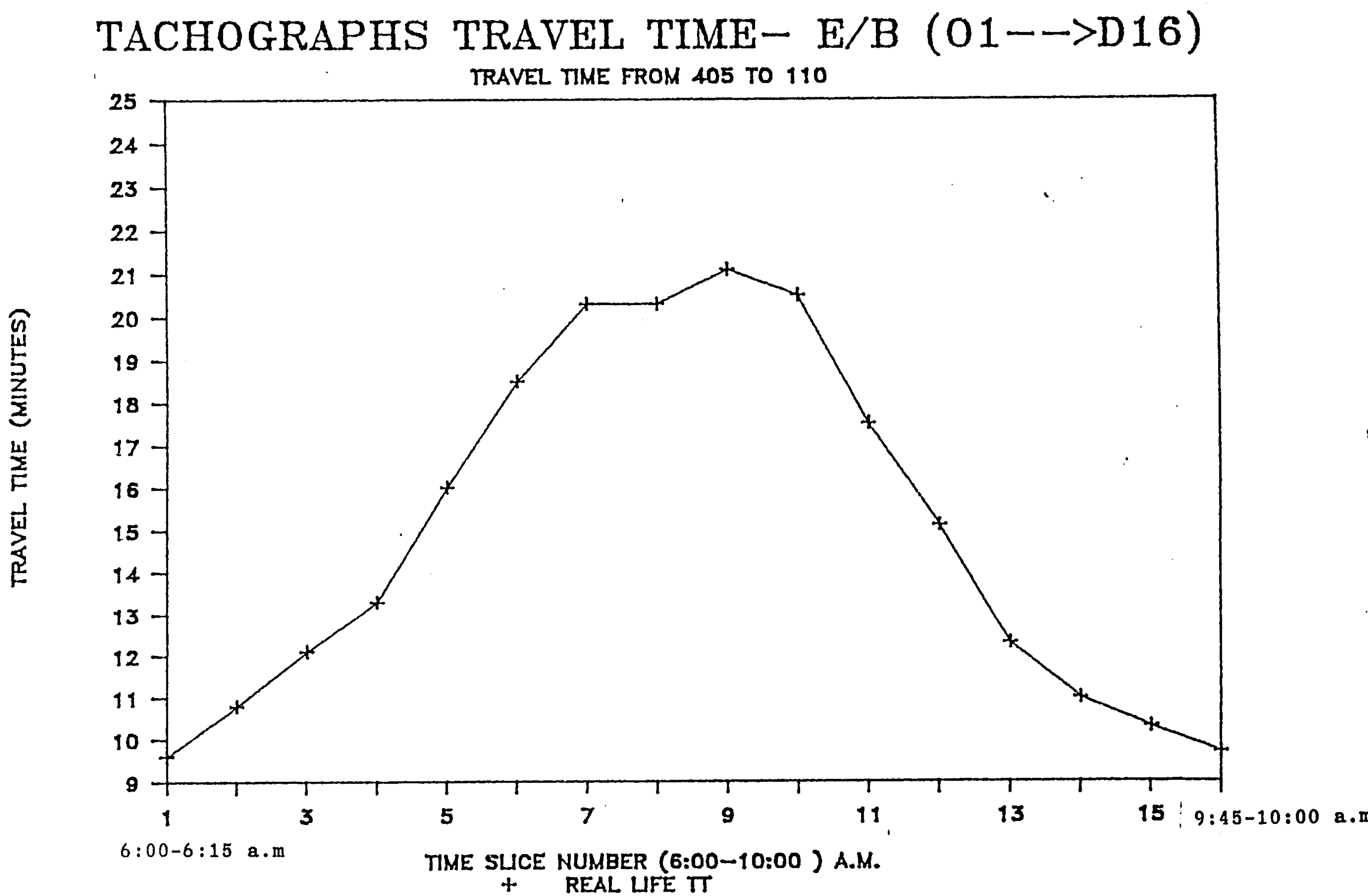
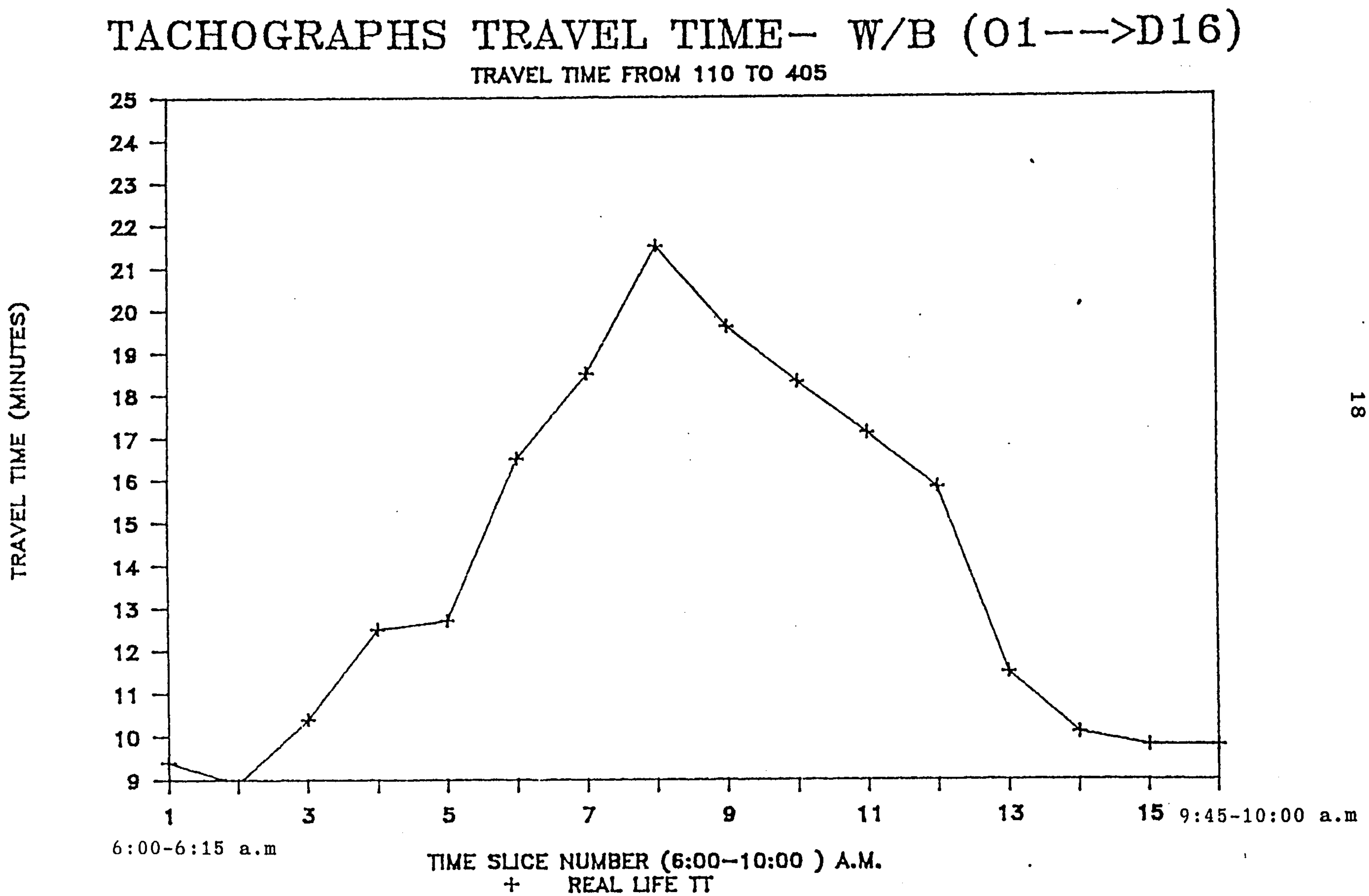

TACHOGRAPHS TRAVEL TIME- E/B (O1-->D16)
TRAVEL TIME FROM 405 TO 110
TRAVEL TIME (MINUTES)
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
1
3
5
7
9
11
13
15
6:00-6:15 a.m
9:45-10:00 a.m
TIME SLICE NUMBER (6:00-10:00) A.M.
+ REAL LIFE TT

FIGURE II-4



TACHOGRAPHS TRAVEL TIME- W/B (O1--->D16)
TRAVEL TIME FROM 110 TO 405
TRAVEL TIME (MINUTES)
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
1
3
5
7
9
11
13
15
6:00-6:15 a.m
9:45-10:00 a.m
TIME SLICE NUMBER (6:00-10:00) A.M.
+ REAL LIFE TT

FIGURE II-5

geometric design features of the freeway for both eastbound and westbound directions. For each direction there was a separate FREQ file (each direction will have its own simulation). The next step was to add the time slice demand data or the 15 minute traffic counts to each file. Finally occupancy data was also coded.

2. Check Coded Input

Printouts of the input data before simulation were obtained for both directions and then were checked with strip maps and aerial photographs. Counts on the time slice demand output were rechecked to make sure the correct data was input. Further automatic checking for the consistency of the number of lanes of the mainline subsection and the number of lanes of the on/off ramp is provided by FREQSPC through warning messages.

3. Samples of the Input Printout

In different appendices at the end of this report, the reader will find sample pages of the geometric design maps, the time slice demand maps, and the vehicle occupancy maps. Complete maps for both directions eastbound and westbound of the Santa Monica freeway are available at ITS, Berkeley.

Appendix -A- entitled "Geometric Design of the Santa Monica Freeway" shows two sample pages of the output of the freeway design maps for each direction of the freeway with subsection name and its number of lanes, length, capacity, speed-flow curve used (the 65 mph curve) as well as on/off ramp capacities and their number of lanes. It should be mentioned that all capacities shown in the complete maps are those capacities after final calibration. In the eastbound direction of the Santa Monica freeway, there was a total of 32 subsections, 17 origins (including mainline origin) and 16 destinations (including mainline destination). In the westbound, there was a total of 30 subsections, 15 origins (including mainline origin) and 16 destinations (including mainline destination).

Appendix -B- entitled "Time Slice Demand Data" for the eastbound and westbound directions of the Santa Monica freeway, shows two sample pages of the time slice counts that are entered in FREQSPC in hourly rates (i.e each 15 minute count is multiplied by 4). This is optional, however, because in FREQ8PC it is possible to enter the counts either on the basis of time slice rate or as hourly rate.

Appendix -C- entitled "Occupancy Data" shows the occupancy data at each subsection for both eastbound and westbound directions.

Occupancy is given as the proportion of l-passenger, 2-passenger, and 3 or more passenger autos. The proportion of buses is negligible. In addition, the average car pool and bus occupancies are given for each origin. Because there was only one on ramp occupancy data available, the same occupancy values were used for all on ramps as well.

4. Base Run

Once the input was completed two base runs were made, one for the eastbound direction and one for the westbound direction of the Santa Monica freeway. However, the two base runs showed severe congestion in both directions. Later, in the calibration process, these runs will be compared to real life data.

F. FREQSPC CALIBRATION

1. Calibration Criteria

The acceptable criteria for FREQSPC calibration was based on reasonable identification of the freeway bottlenecks and that the freeway link travel times calculated by FREQSPC would have to be comparable with the real life freeway link travel times.

a. <u>Bottleneck Identification</u>

The speed contour map was used to identify bottlenecks. In FREQSPC a speed contour map shows the number 3 in the bottlenecks to indicate that the speed in the location shown is between 30 and 39 mph. Speeds of 20-29 mph and l0-19 mph usually appear upstream of the bottleneck. One has to differentiate between cause and effect. The bottleneck is the cause of the congestion while the queue behind the bottleneck is the effect. For final calibration, the advise of CALTRANS was needed to correctly identify eastbound and westbound bottlenecks locations and durations.

b. <u>Travel Time</u>

Travel time between mainline origin and mainline destination (which is the longest distance that one can travel on the freeway within study limits) was used as the basis for comparison between FREQ travel times and real life travel times. Since travel times fluctuate among time slices, a plot between travel time and time slice number shows the fluctuation. Comparison is then made between these two curves.

2. Calibration Process

Since the traffic counts were taken in different times of the year (different seasons) and some were taken even at different years, (e.g in some cases, a difference of 3-4 years), the counts have a problem of lack of consistency. Severe congestion was shown in the output of FREQ8PC. When the output was checked and compared with real life freeway performance data, it was not compatible in terms of the size of congestion caused by bottlenecks. The traffic counts and the capacities were then checked again with CALTRANS, but the results were still the same. CALTRANS explained this by pointing to the observation of their engineers that traffic flow exhibits multi-level congestion patterns under recurring traffic conditions and perhaps the data analyzed was for a heavy traffic day. This observation was true for both east and westbound directions of the freeway. Capacities were then modified and revised based upon the advice from CALTRANS and reference to the 1985 Highway Capacity Manual [l0]. Finally it was decided to use growth factors of .92 for eastbound direction of the Santa Monica freeway counts and 0.90 for westbound counts. This was an essential part of the calibration process and what will be discussed in the following paragraphs is the final calibrated runs for the non-incident situation.

3. Final Results

a. <u>Eastbound Final Calibrated Run</u>

The portions of the output needed for the purpose of the following discussion are included in appendix -D- entitled "Non-incident Final Calibrated Run for Eastbound Direction of the Santa Monica Freeway" (FREQ8PC output file called EB-FINAL.OUT complete output is available at ITS). In page -Dl- and page -D2- of the output there is a complete geometric design description for all freeway eastbound subsections. Pages -D3- to -DS- show the sequence of important eastbound freeway events under non-incident congestion conditions. The important freeway events are summarized in table II-l. The total length of the eastbound direction of the Santa Monica freeway under study is 52,500 feet shown at the bottom of page -D3-, this is about 9.9 miles length. The average speed in the bottleneck subsection is 35 mph.

The queuing diagram page -D9- shows the congestion pattern. There are three bottlenecks of which two are major ones: SS#29 bottleneck (Hoover On to Southbound Route 11 Off) which causes

Table II-1

Important E/B freeway events
under "non-incident" simulation conditions

Freeway event and its sequence	Ref. PP# *	Time Slice Number	Current Bottleneck Location	Queue build up caused by SS botleneck	Queue length (miles)
1.Congestion commenced	D3	3	SSt29 **	SS#28-->SS#26	0.5
2.New bottlenecks form.	D4	4	1) SS#29 2) SS#Zl 3) SS#13	SS#28-->SS#23 SS#20-->SS#19 part of SS#13	1.3 0.5 0.1
3.Queues caused by SS#29 and SS#Zl collided.	D5	6	1) SS#29 2) SS#13	SS#28-->SS#17 SS#12-->SS#7	3.3 1.4
4.All queues collided and maximum queue length occurs.	D6	8	SS#29 a major bottleneck	SS#28-->SS#6	6.2
5.Queues start to dissipate	D7	9	1) SS#29 2) SS#l3	SS#28-->SS#l6 SS#13-->SS#7	3.8 1.9
6.Free flow condition	DS	14			

* See Appendix -D-

** SS#29 is a symbol that denotes subsection 29. This symbol will be used so frequently in this chapter.

congestion that extends from time slice 3 to time slice 13, and SS#13 bottleneck (Washington On to Southbound LaBrea Off) which begins in time slice 4 and ends in time slice 13. The third bottleneck SS#2l (Arlington On to Western Off) is less severe than the other two, its effect starts in time slice 4 and ends in time slice 12. It is noticed that all vehicles are being served during peak hour flow (i.e no queuing exists at the end of the analysis period).

Travel times in minutes on freeway links (or subsections) in each time slice are summarized in FREQSPC output. For example, page -DlO- shows travel time matrix for time slice 1 (6:00 a.m - 6:15 a.m) between origins and destinations. This matrix is repeated for the next fifteen time slices.

Superimposing of the travel time from mainline origin to mainline destination of both the final FREQSPC calibrated run and the real life data for eastbound direction of the Santa Monica freeway is shown in figure 11-6. The two curves are close (difference is about 10% of the travel time). Superimposed speed contour maps are shown in figure 11-7. When looking at the two comparisons, it should be remembered that the FREQSPC output results are compared with only one day real life data.

b. <u>Westbound Final Calibrated Run</u>

The portions of the output needed for the purpose of the following discussion are included in appendix -E- entitled "Non-incident Final Calibrated Run for Westbound Santa Monica Freeway" (FREQSPC output file called WB-FINAL.OUT), complete output is available at ITS. In page -El- and page -E2- of the output there is a complete geometric design description for all freeway westbound subsections. Pages -E3- to -E9- show the sequence of important westbound freeway events under non-incident congestion conditions. The important freeway events are summarized in table 11-2.

The total length of the westbound Santa Monica freeway under study is 53,860 feet, shown at the bottom of page -E3- , this is about 10.2 miles.

The queue diagram page -ElO- of the output (appendix -E-) shows the major bottleneck SS#26 (National Off to Overland Off) with congestion extending from time slice 5 to time slice 13 and another three bottlenecks: SS#22 (Fairfax On to LaCienega On) where congestion starts in time slice 4 and ends in time slice 12, SS#24 (Robertson Off to Robertson On) which causes congestion from time slice 6 to time slice 12, and SS#l5 (Crenshaw On to Northbound LaBrea Off) i.e the C-D road bottleneck which starts in time slice 3 and ends in time slice 10.

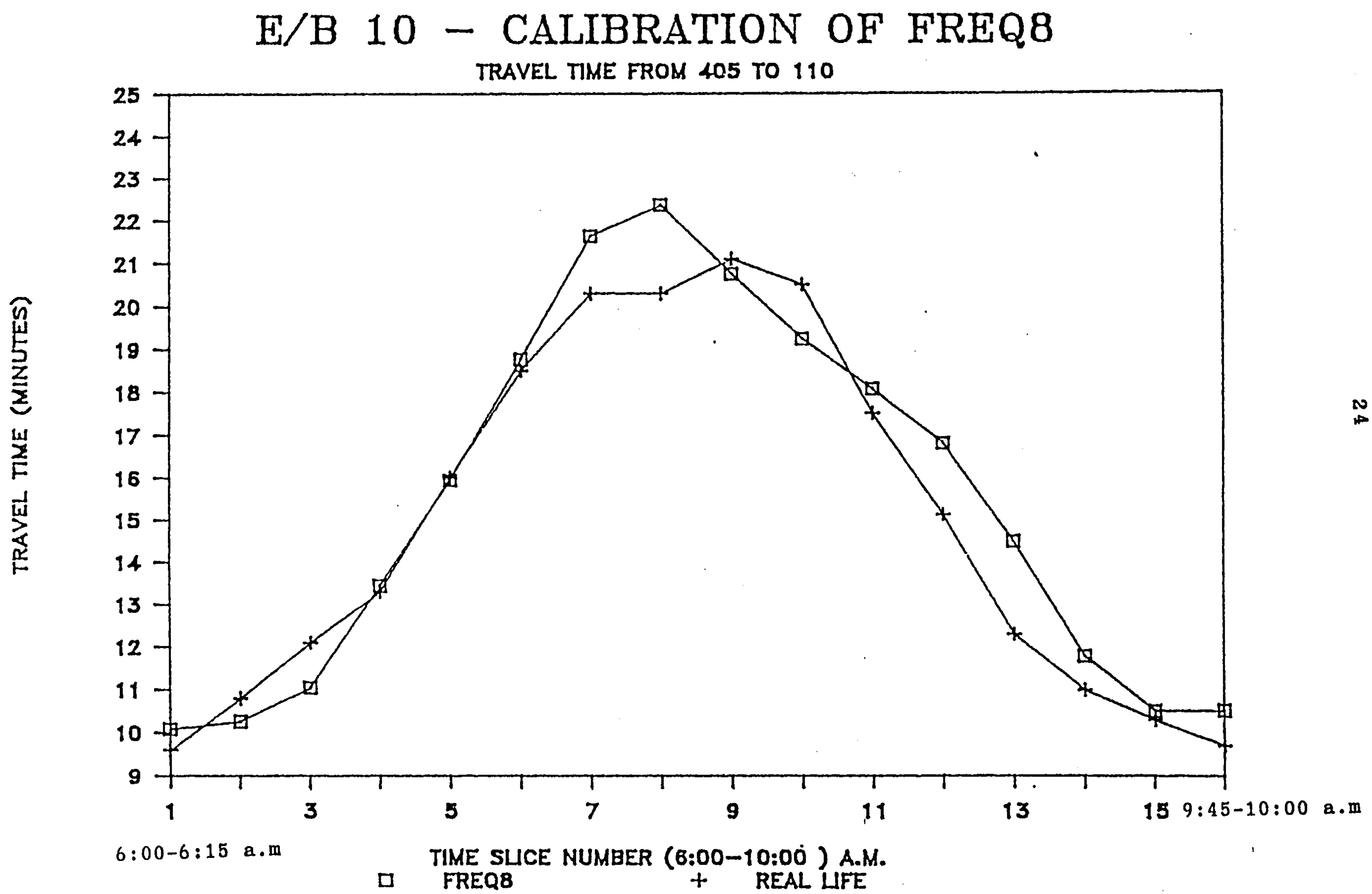

E/B 10 – CALIBRATION OF FREQ8
TRAVEL TIME FROM 405 TO 110
TRAVEL TIME (MINUTES)
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
1
3
5
7
9
11
13
15
6:00-6:15 a.m
9:45-10:00 a.m
TIME SLICE NUMBER (6:00–10:00) A.M.
FREQ8
REAL LIFE

FIGURE II-6

EASTBOUND SANTA MONICA FREEWAY
SUPERIMPOSED SPEED CONTOUR MAPS

FREQ8 FINAL CALIBRATED RUN COMPARED WITH REAL LIFE DATA

_____ FREQ8 - - - - REAL LIFE

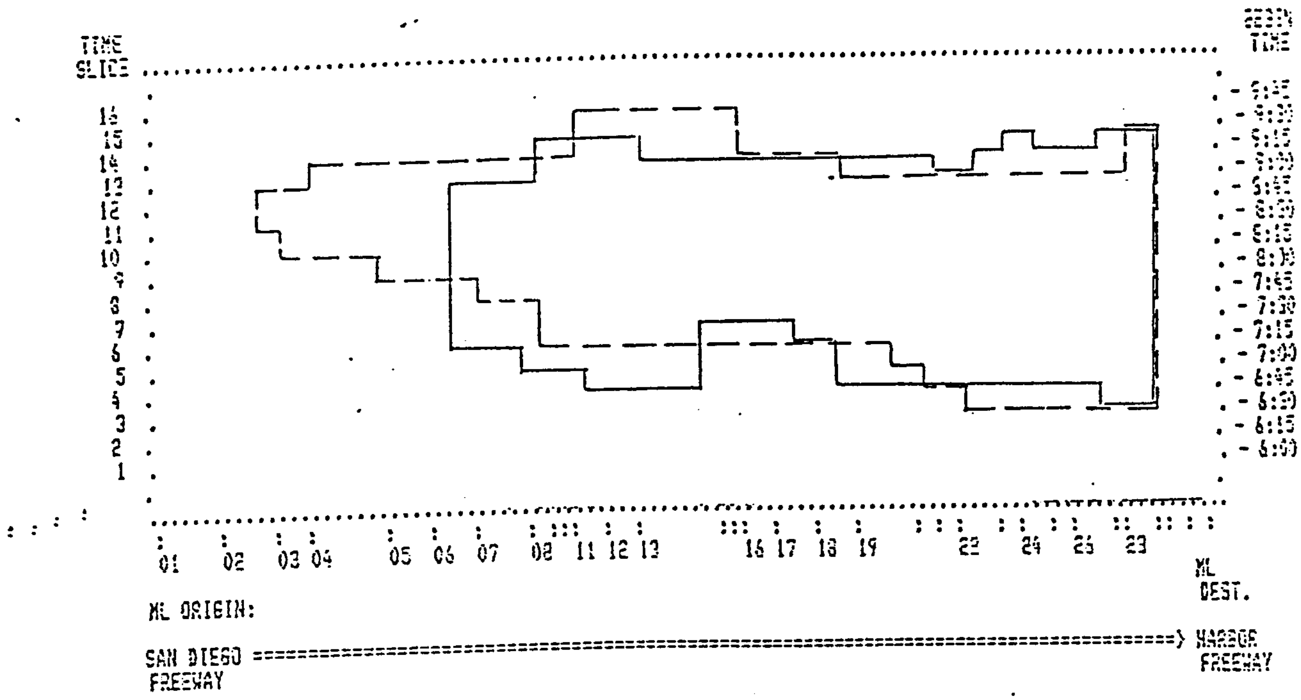


FIGURE II-7

Table II-2

Important W/B freeway events
under non-incident simulation conditions

Freeway event and its sequence	Ref. PP# *	Time Slice Number	Current Bottleneck Location	Queue build up caused by SS bottleneck	Queue length (miles)
1l.Congestion commenced	E3	3	ss#15	part of SS#14	0.2
2!.New bottlenecks	E4	4	1) SS#22 2) SS#l5	part of SS#21 SS#14-->SS#13	0.2 0.8
3s.New bottlenecks	E5	6	1) SS#26 2) SS#24 3) SS#22 4) SS#l5	part of SS#25 part of SS#23 SS#21-->SS#19 SS#14-->SS#12	0.2 0.2 1.1 1.2
4.All queues collided	E6	8	SS#26	SS#25-->SS#13	4.4
5.Maximum queue length occurs.	E7	9	SS#26 (major bot.)	SS#25-->SS#13	4.5
6).Queues start to dissipate	ES	10	1) SS#26	SS#25-->SS#14	4.0
6.Free flow condition	E9	14			

* See Appendix -E-

Superimposing of the travel time from mainline origin to mainline destination of both the final FREQSPC calibrated run and the real life data for westbound direction of the Santa Monica freeway is shown in figure 11-S. The two curves are close (difference is about l0% of the travel time). Superimposed speed contour maps are shown in figure 11-9. The fit results were not as good as those of the eastbound direction of the Santa Monica freeway.

G. FREEWAY INCIDENT SIMULATION PROCESS

The overall objective of the freeway incident scenario is to illustrate the potential benefits of an information equipped vehicle under incident situation. The purpose of this section is then to demonstrate an incident situation in one of the freeway subsections in only one direction of travel. Since calibration results of the non-incident situation have shown to be a better fit between FREQSPC output and real life data, and provided that traffic is likely to be heavier in the eastbound direction (going to down-town Los Angeles) in the morning, the eastbound direction was the candidate for introducing the incident.

1. Incident Scenario

a. Incident Location

In order to select the subsection in which to introduce the incident. The following criteria was used:

- It is not favored to have the subsection location at or near to either end of the freeway study limits. Because that is more likely to cause boundary congestion, which gives inaccurate results and makes it difficult to simulate the freeway traffic conditions.

- Increase the opportunity for drivers to divert from and return to the freeway.

- For demonstration purposes, it is desirable to select a subsection which is not already congested.

Given the above constraints, a number of trials were made and it was decided that subsection 12 (Venice On to Washington On) is a good candidate for this demonstration. It is theoretically possible to demonstrate an incident situation in any subsection of the freeway, however, travel time savings and the diverting

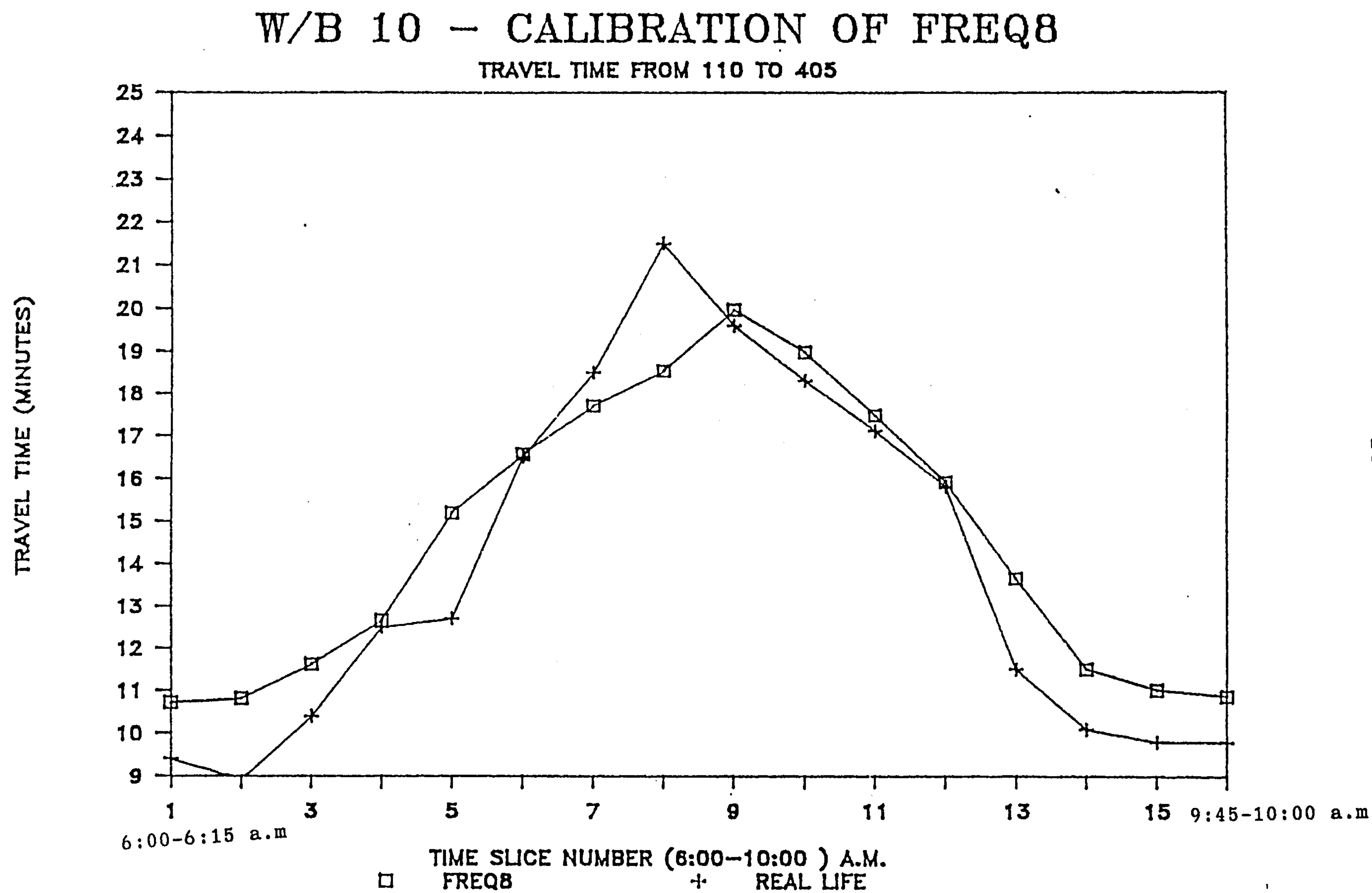

W/B 10 — CALIBRATION OF FREQ8
TRAVEL TIME FROM 110 TO 405
TRAVEL TIME (MINUTES)
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
1
3
5
7
9
11
13
15
6:00-6:15 a.m
9:45-10:00 a.m
TIME SLICE NUMBER (6:00–10:00) A.M.
FREQ8
REAL LIFE

FIGURE II-8

WESTBOUND SANTA MONICA FREEWAY
SUPERIMPOSED SPEED CONTOUR MAPS

FREQ8 FINAL CALIBRATED RUN COMPARED WITH REAL LIFE DATA

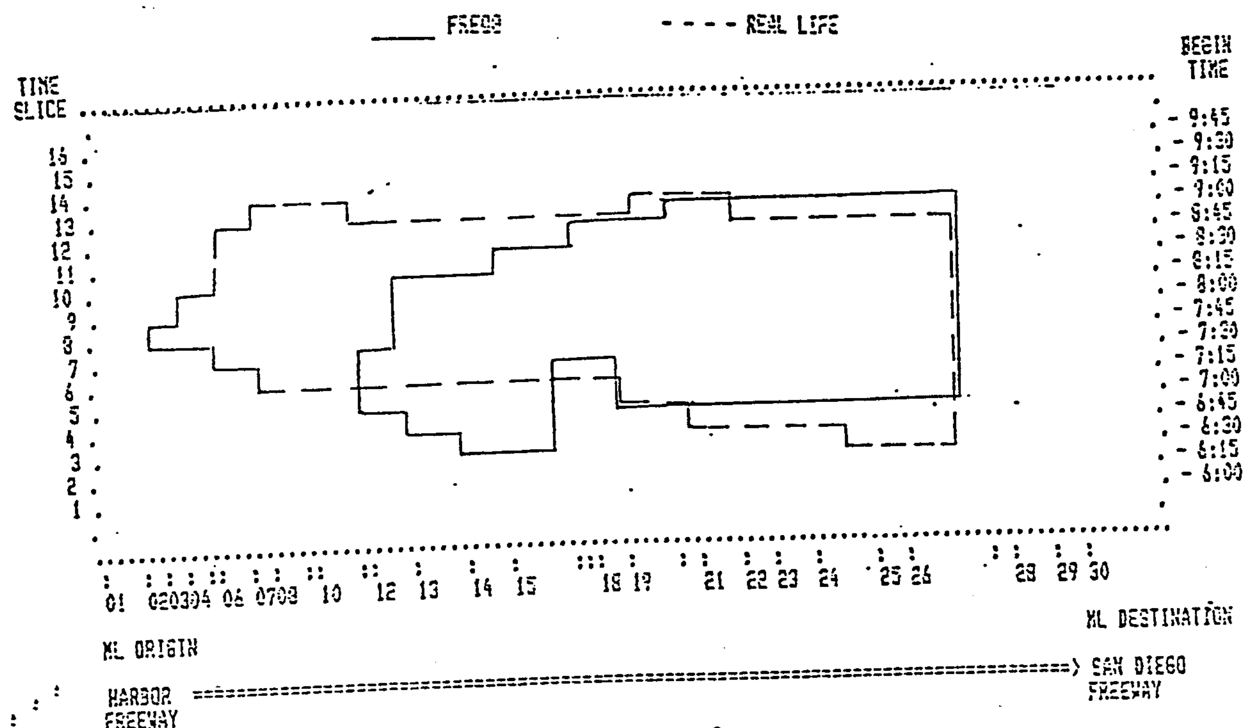


FIGURE II-9

ability will be different.

The incident on the freeway can take many forms. For example a vehicle stopped in one of the lanes, a rear end collision accident, or freeway surveillance blocking one lane...etc. When an Incident occurs in one of the freeway lanes, it causes a certain reduction in the capacity of the subsection which contains that lane. The reduction in capacity is instantaneous in the time slice in which the incident occurs. The capacity gradually increases, when the incident is cleared by police and emergency, until the capacity of the subsection retains its original level.

b. Incident Severity

FREQSPC space and time limitations (i.e congestion free boundaries) does not allow to introduce a major incident, for example an accident that blocks two or more lanes in a four lane subsection for more than one hour. Also the introduction of the incident in a time slice when the freeway is heavily congested is desirable, because the flow will be critical and close to capacity. Introducing the incident in free flow conditions, e.g time slice 1,2 or 15, will not have a major effect in the formation of the new bottlenecks or making significant travel time differences between incident and non-incident situation.

C. Incident Duration

Finally, it was decided that an incident would be introduced In SS#l2 in time slice 3 (6:30-6:45), just before traffic starts to get heavy, and continues for 45 minutes for a total of three time slices. It is an incident with capacity changes as the following table II-3 suggests:

Table II-3

Time slice	Net capacity after reduction (Vph)
3	5000
4	5000
5	5500

Subsection 12 is a five lane subsection with physical capacity of 9300 vph in the natural and non-incident condition. After the incident occurs, there is a 4300 vph loss of capacity (for half an hour), this is about 46.2% loss in capacity, i.e more than two lanes are blocked. In time slice 5, capacity starts recovering (5500 vph) because police and emergency are in the process of clearing the incident and by time slice 6, SS#l2 retains its original capacity of 9300 vph.

2. Final Incident Simulation Run

Portions of the output run EB-FINC.OUT are in appendix -E- entitled "Incident Final Run for Eastbound Direction of the Santa Monica Freeway". In time slice 3, page -Fl-, SS#l2 (Venice On to Washington On) became a new bottleneck causing queue to build up from SS#ll (Fairfax Off to Venice On) to SS#7 (National On to Southbound LaCienega Off). In time slice 5 the queue reaches part of SS#l (Mainline Origin to Route 405 On) but does not cover it all, therefore still not violating FREQ8PC limitations.

In time slice 6 page -F2- SS#l2 is no longer a bottleneck (demands7559 vph and less than subsection capacity of 9300 vph). New three bottlenecks form: SS#13 (Washington On to Southbound LaBrea Off), SS#21 (Arlington On Western Off) and SS#29 (Hoover On to Southbound Route11 Off). Subsection 29 was known to be a major bottleneck from the recurring congestion analysis of table II-l. Subsection 13 makes the congestion even worse for vehicles that already suffered from the incident delay. As soon as drivers get out of SS#l2 , vehicles are hit by another natural bottleneck in SS#l3 and drivers suffer from further delay again.

In time slice 8, page -F4-, the queue caused by the bottleneck of SS#13 starts to dissipate but builds up again In time slice 11, page -F7- and dissipates again in time slice 12, page -F8-. In time slice 9. page -F5- the queue caused by SS#2l starts to dissipate and disappears completely in time slice 10. The queue caused by bottleneck SS#29 also starts to dissipate In time slice 10 and disappears completely in time slice 13. In time slice 12 queues caused by bottleneck in SS#12 begins to dissipate and disappears completely by time slice 16. In time slice 16, page -F9-, the freeway is almost congestion free. The above analysis is summarized in table 11-4.

The queue diagram page -FlO- graphically summarizes the previous discussion and shows the four bottleneck locations: SS#12, SS#13, SS#2l, SS#29 with their durations. Since SS#13, SS#2l and SS#29 were also bottlenecks in the recurring congestion condition, it might be helpful to compare their durations under non-incident and incident FREQ8PC simulation conditions. The comparison is shown in table 11-5.

3. Final Results

From table 11-5, it can be seen that bottlenecks of SS#2l and SS#29 have less congestion effects in the incident simulation than in the non-incident simulation, but the congestion In the

Table II-4

Important E/B freeway events
under "incident" simulation conditions

Freeway event and its sequence	Ref. pp# *	Time Slice Number	Current Bottleneck Location	Queue build up caused by SS bottleneck	Queue length (miles)
1.Congestion starts suddenly as incident occurs in SS#12	F1	3	**SS#12**	SS#11-->SS#17	0.8
2.Queue reaches SS#1 but does not cover it all.	F2	**5**	**SS#12**	SS#11-->SS#1	**3.7**
3.New bottlenecks	F3	6	1) SS#29 2) SS#21 3) SS#13	SS#28-->SS#26 SS#20-->SS#19 SS#12-->SS#1	0.6 0.4 4.1
4.Queues caused by starts to dissipate	F4	8	1) SS#29 2) SS#21 3) SS#13	SS#28-->SS#22 SS#20-->SS#19 SS#12-->SS#1	1.6 0.7 3.9
5.Queue caused by bottleneck SS#21 starts to dissipate	F5	**9**	1) SS#29 2) SS#21 3) SS#13	SS#28-->SS#22 SS#20-->SS#19 SS#12-->SS#2	1.7 0.3 3.5
6.Queue caused by SS#29 starts to dissipate.	F6	**10**	1) SS#29 2) ss#13	SS#28-->SS#22 SS#12-->SS#3	**1.5** **3.3**
7.Free flow condition	F9	16	-	-	-

* See Appendix -F-

Table II-5

Comparison between duration of common E/B bottlenecks under non-incident and under incident simulation conditions

Non-incident Congestion				Incident Congestion		
SS#	Starting Time Slice	Ending Time Slice	Congestion Duration	Starting Time Slice	Ending Time Slice	Congestion Duration (minutes)
13	4 6:45 - 7:00	13 9:00-9:15	150 min. (2.5 hrs)	6 7:15 - 7:30	16 9:45 - 10:00	165 min. (2.75 hrs.)
21	4 6:45 - 7:00	12 8:45-9:00	135 min. (2.25 hrs)	6 7:15 - 7:30	9 8:00 - 8:15	60 min. (1 hr)
29	3 6:30 - 6:45	12 8:45-9:00	165 min. (2.75 hrs)	6 7:15 - 7:30	12 8:45 - 9:00	105 min. (1.75 hrs)

non-incident simulation lasts longer (this can be verified by comparison of incident and non-incident queue diagrams previously discussed for the eastbound direction). Conversely SS#13 has longer congestion effects in the incident simulation condition than in the non-incident simulation condition. This is expected since the new incident induced in SS#12 created a dam for the upstream traffic that prohibited vehicles to proceed to the downstream natural bottlenecks in SS#21 and SS#29. Since SS#13 is located downstream of SS#l2, immediately after the the incident location, then obviously it is going to be worse than everyday congestion, because this bottleneck must handle the traffic that suffered from the incident delay which rushes through it after the traffic is released.

H. SUMMARY RESULTS OF THE FREEWAY SIMULATION PROCESS

1. Input Requirements of the Network Model

The main output of this chapter was the travel times on both directions of the Santa Monica freeway links under non- Incident situation and also the travel times for eastbound direction of the Santa Monica freeway links under incident induced situation. These are the input requirements for the network model discussed in chapter IV.

a. <u>Non-incident Situation</u>

(1) Eastbound Direction of the Santa Monica Freeway Travel Time Matrix:

For each time slice one through sixteen, in the non-incident situation, travel time between origins and destinations was estimated for each of the 164 cells shown In the travel time matrix, page -DlO- of the output for non-incident simulation of eastbound direction of the Santa Monica freeway, appendix -D-. Producing this matrix for 16 time slices yields a total of 2624 cells to be filled with estimated travel times between any upstream origin and any downstream destination.

(2) Westbound Direction of the Santa Monica Freeway Travel Time Matrix:

Similarly, for each time slice one through sixteen, In the non-incident situation, travel times between origins and destinations were estimated for each of the 160 cells shown In the travel time matrix, page -Ell- of the output for non-incident simulation of westbound direction of the Santa Monica freeway, appendix -E-. Producing this matrix for 16 time slices yields a total of 2560 cells to be filled with estimated travel times between any upstream origin and any downstream destination.

There will be a total of 5184 travel time cells for both directions with non-incident situation, this number represents all possible travel times on freeway links, and the cells of the matrices are the input for the network model under non-incident simulation conditions.

b. Incident Situation

This will be done only for the eastbound direction and the same total number of cells in the travel time matrices for 16 time slices as in the non-incident case, i.e 2624, will have to be calculated again using FREQ under incident situation. Westbound freeway link costs are assumed to stay as they were In the non-incident condition, because the incident is Introduced only In the eastbound direction. Figure II-10 shows the stack of 16 matrices for the eastbound direction with each matrix composed of 164 cells for the two cases under incident and under non-incident congestion conditions.

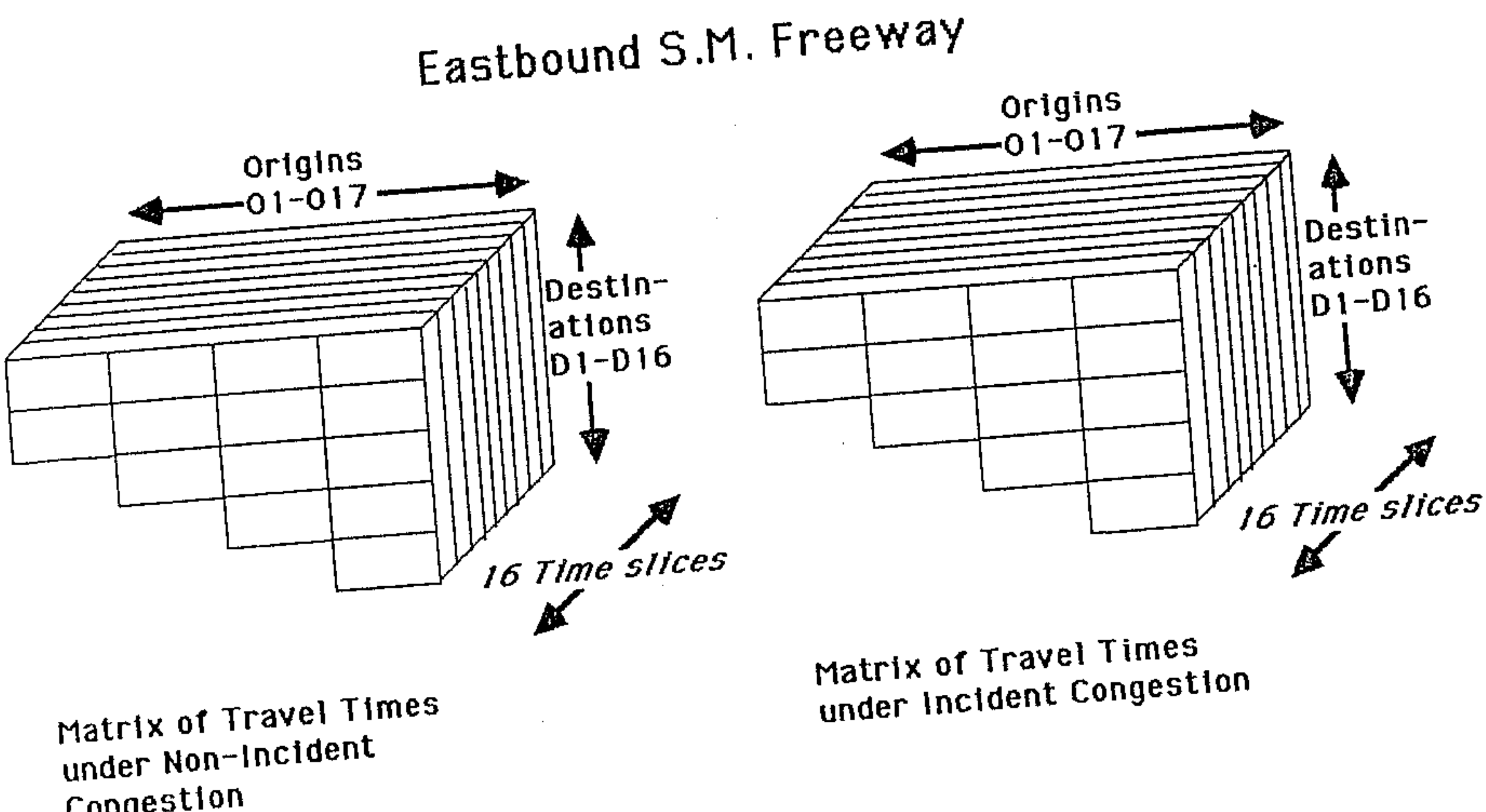

Eastbound S.M. Freeway
Origins
01-017
Destin-
ations
D1-D16
16 Time slices
Matrix of Travel Times
under Non-Incident
Congestion
Origins
01-017
Destin-
ations
D1-D16
16 Time slices
Matrix of Travel Times
under Incident Congestion

Figure II-10

CHAPTER III - SURFACE STREET TRAVEL TIMES

A. INTRODUCTION

This chapter discusses the processes undertaken for the in-vehicle navigation project In estimating vehicle travel times on individual links of the arterial network. Figure III-1 outlines these processes. The objective in selecting the appropriate arterial network was to choose an adequate network of surface street facilities adjacent to the Santa Monica freeway (I-10) that would provide alternate routes for freeway travellers. These alternate routes are either actually utilized by local drivers today or have the potential of being utilized by local drivers equipped with an in-vehicle information system.

The arterial network was chosen In conjunction with the City of Los Angeles' Department of Transportation (LADOT), without whose cooperation this portion of the project would not have been possible. The overall size of the network was limited by data availability and manpower constraints.

A computer simulation model was utilized (see "MODELING APPROACH", p.41) in order to create and save for possible uses in the future a simulation test bed for the arterial network (see chapter I). A speed/delay study would provide link travel times just as the simulation model does. However, possible future studies of looking at corridor equilibrium, for Instance, will require a computerized simulation test bed. Also, the simulation test bed can be used for future ATSAC (Automated Traffic Surveillance and Control) planning and demonstration studies of in-vehicle information systems In Los Angeles. A speed/delay study was performed by LADOT for model calibration purposes (see "CALIBRATION PROCESS", p.46).

B. STUDY NETWORK

Three major east/west surface arterials parallel to the Santa Monica freeway were selected along with the major north/south arterials intersecting the east/west arterials at signalized intersections and intersecting the Santa Monica freeway at signalized on/off ramps (see Figure 111-S).

The three major east/west parallel arterials chosen were:

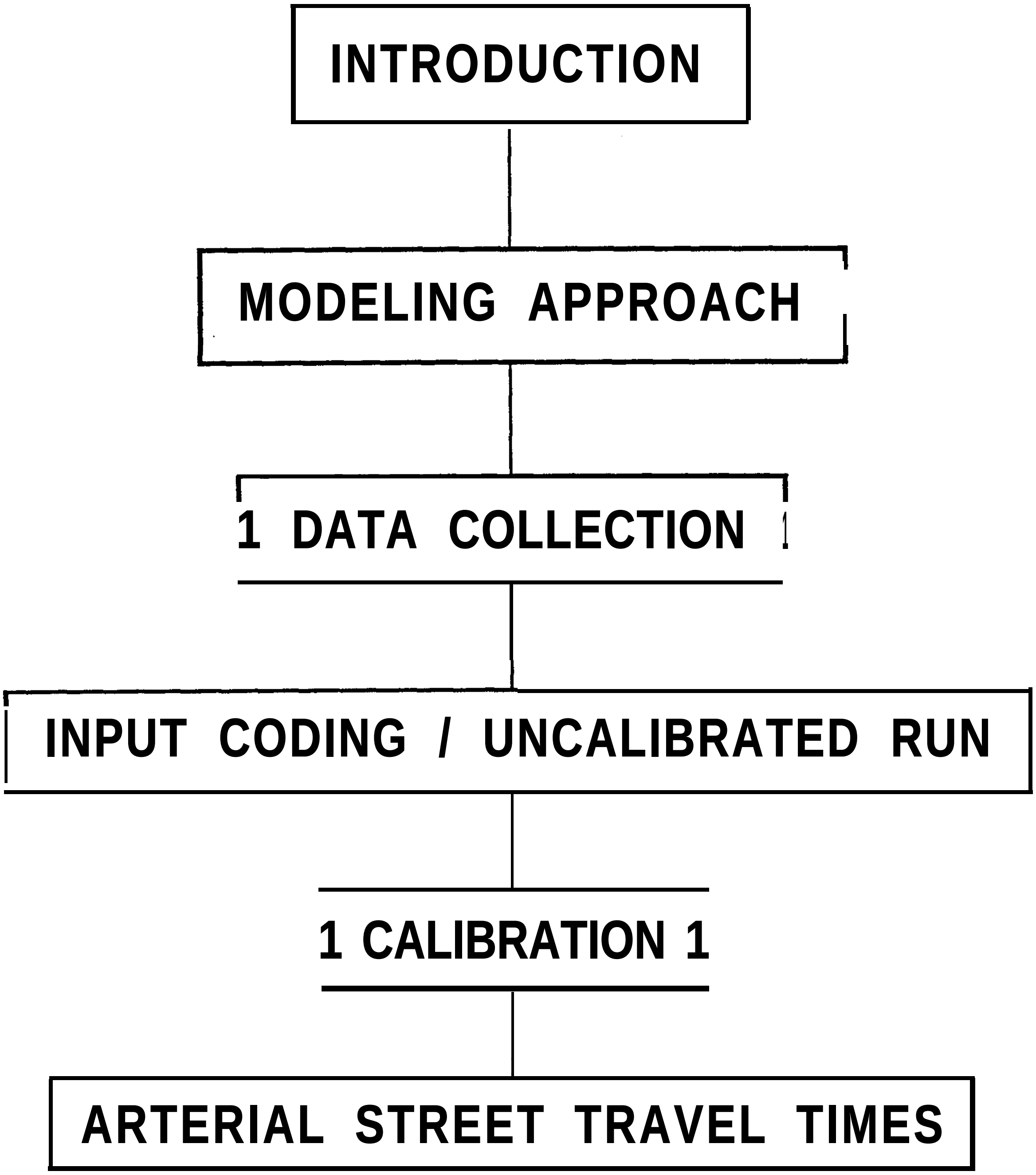

INTRODUCTION
MODELING APPROACH
DATA COLLECTION
INPUT CODING / UNCALIBRATED RUN
CALIBRATION
ARTERIAL STREET TRAVEL TIMES

FIGURE III-1

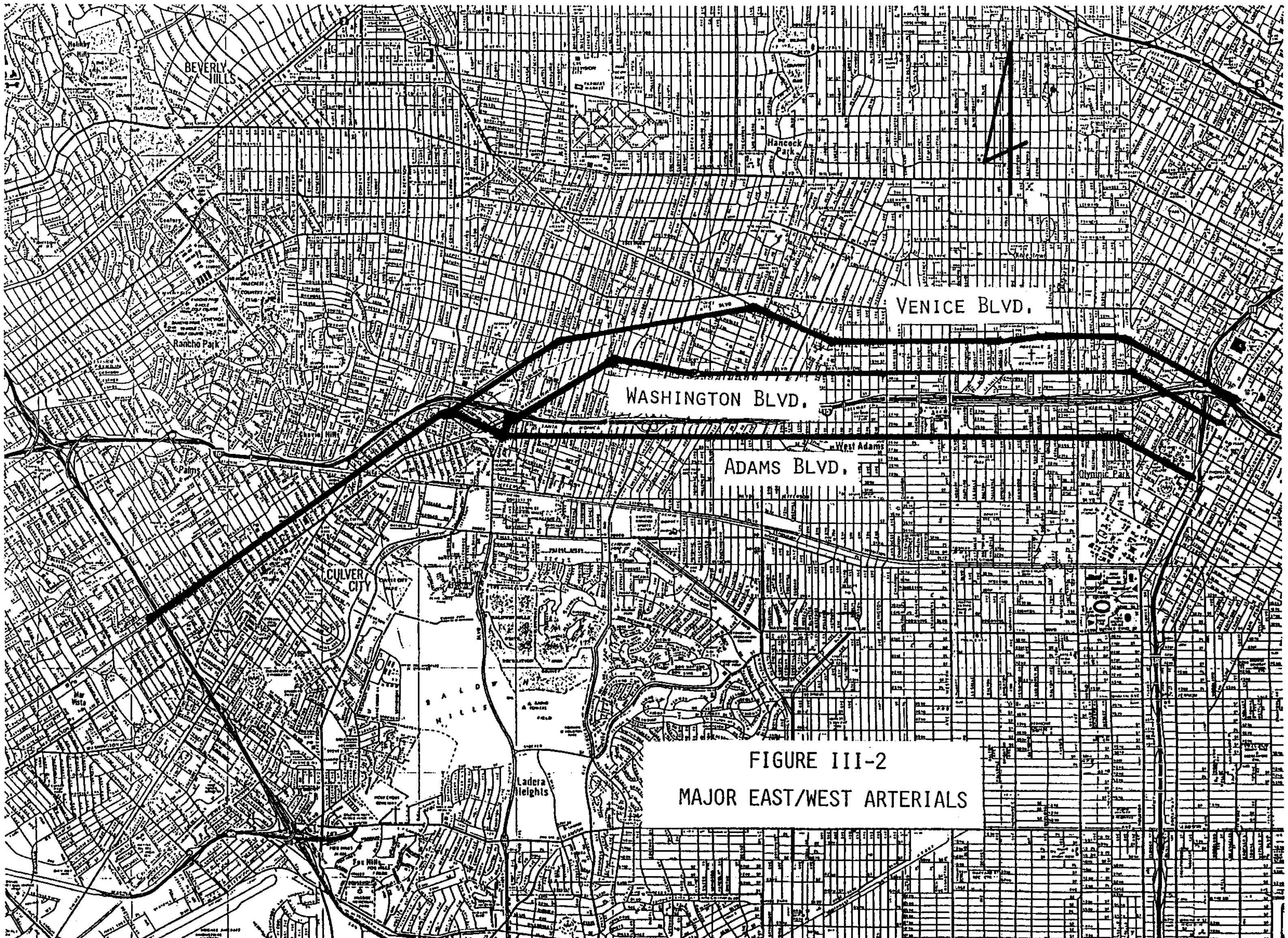


FIGURE III-2

MAJOR EAST/WEST ARTERIALS

1. Adams Boulevard:

Approximately 0.1 - 0.4 mile south of the Santa Monica freeway, traversing 5.5 miles from Fairfax Avenue on the west end to Flower Street on the east end of the project.

2. Washington Boulevard:

Approximately 0.2-0.5 mile north of the Santa Monica freeway, traversing 5.9 miles from Fairfax Avenue on the west end to Figueroa Street on the east end of the project.

3. Venice Boulevard:

Extending south of the Santa Monica freeway from the San Diego freeway (I-405) on the west end of the project at Sawtelle Boulevard, to north of the Santa Monica freeway on the east end of the project at Figueroa Street, traversing a distance of 9.5 miles. Also, Palms Boulevard and National Boulevard on the west end of the project south of the Santa Monica freeway were chosen to be included in the network in order to provide continuity in the network on the west end.

Twenty one major north/south arterials selected to be included in the network are (from west to east):

1)Sawtelle Blvd.
2)Sepulveda Blvd.
3)Overland Ave.
4)Hughes Ave.
5)Robertson Blvd.
6)National Blvd.
7)La Cienega Blvd.
8)Cadillac Ave.
9)Fairfax Ave.
10)Apple St.
ll)Hauser Blvd.
12)La Brea Ave.
13)Vinyard/San Vicente Blvd.
14)Crenshaw Blvd.
15)Arlington Ave.
16)Western Ave.
17)Normandie Ave.
18)Vermont Ave.
19)Hoover St.
20)Figueroa St.
21)Flower St.

The network is composed of eighty (80) signalized intersections or nodes and over five hundred sixty (560) links. Due to the constraints on selecting the size of the network (see "MODELING APPROACH",p.43) there are signalized intersections ("minor" intersections) not chosen to be included in the network located in between the eighty nodes selected to comprise the network. Table III-1 is presented showing the average link distances between the signalized intersections included in the network and the proportion of signalized intersections in-between that are not included.

The added delays for the "minor" signalized intersections not included in the TRANSYT model were analyzed separately (i.e. speed/delay study) and later added to the link travel times utilized by the network model described in chapter four.

Due to time constraints, the final analysis deals only with eastbound trips occurring in the morning peak period (6-10 A.M.).

C. MODELING APPROACH

The computer model used for this in-vehicle navigation project to simulate the arterial network is the TRANSYT model, version 7F release 5.0, modified to provide for a one hundred node capability and for an actuated signal capability (see description below). The acronym "TRANSYT-7F" stands for TRAffic Network Study Tool, version 7F where the "F" indicates that this is the FHWA version of TRANSYT-7.

Another project ongoing concurrently in the Institute of Transportation Studies at the University of California, Berkeley during the time of this project was the modification of TRANSYT-7F, release 5.0, the purpose of which was to enable the model to simulate actuated signals in a network. This modified version of TRANSYT-7F is entitled TRANSYT-7FC. A preliminary working version of TRANSYT-7FC (November 1987) was utilized for this project. The preliminary working version of TRANSYT-7FC was deemed to be in satisfactory working order to be utilized for the in-vehicle navigation project. See Appendix G for a description of this modification to TRANSYT-7F.

The standard dimensions of TRANSYT-7F can handle up to fifty nodes and two hundred fifty links. In order to analyze a network larger than this two options are available: expand the dimensions of the program or divide the network into two or more smaller sections.

TABLE III-1
AVERAGE LINK DISTANCES AND
NUMBER OF NODES EXCLUDED

E/W Arterial	No. of Nodes Included In Network	Average TRANSYT Link Distance (mi)	* "Minor* Nodes Not Included In Network	
			No.	Percent
Adams Blvd	9	0.69	10	53%
Washington Blvd	11	0.59	11	50%
Venice Blvd	19	0.53	17	47%

* These nodes are the signalized intersections included in the LADOT speed/delay field study but not included in the TRANSYT network and only those with a measured stop delay in the LADOT field study greater than zero.

For this in-vehicle navigation project, the dimensions of the TRANSYT-7F model modified to handle actuated signals were expanded to accommodate one hundred nodes and six hundred links (hereafter simply referred to as the TRANSYT model). Theoretically, the dimensions of the program could be expanded further. However, the size of the network is limited due to time, budget, and data availability constraints.

The specific output from the TRANSYT model that is needed to calculate trip costs are the link distances, cruise speeds, and the link average delay. The total travel time for a particular vehicle from an upstream node to a downstream node is the non-delay travel time at cruise speed over the length of the link plus the average delay for that particular link at the downstream node. A particular trip cost through the arterial network is thus the summation of the total travel times for each link that the trip traverses.

D. DATA COLLECTION

The data required for the TRANSYT model can be summarized as follows:

- -Demand Parameters
- -Supply Parameters
- -Control Parameters

All data required for the TRANSYT model was provided by the city of Los Angeles' Department of Transportation (LADOT).

1. Demand Parameters

The demand parameters consist of traffic volumes per link in the network. Turning movement counts were provided for eighty (80) signalized intersections. The counts utilized consist of hourly passenger car and pedestrian volumes extending from 7-10 A.M. in the morning for all four approaches to the intersection. Traffic volumes for the 6-7 A.M. period were estimated by reducing the 7-8 A.M. counts by twenty percent.

Heavy vehicle counts provided consist of the total number of dual wheeled vehicles and buses observed over the peak period for each approach. Heavy vehicle volumes were generally less than five percent of the total volumes per approach and thus were not converted to passenger car equivalents as per the TRANSYT user's manual. The dates of the counts taken ranged from January 1985 to December 1987.

2. Supply Parameters

The SUPPLY parameters consist of the number of lanes and the ideal saturation flows per link for each intersection approach. The saturation flows used for each link come as a result of recommendations from the TRANSYT user's manual and from discussions with LADOT over a period of several months during the calibration of the model (see "CALIBRATION PROCESS", p.46). Table III-2 summarizes the general guidelines established for saturation flows. Other network data required are link distances and cruise speeds along links.

TABLE III-2
IDEAL SATURATION FLOWS

Movement Type	Ideal Saturation Flow (vphgpl)
Exclusive Thru	1700
Exclusive Left (Protected)	1600
Exclusive Right	1450
Shared Thru-Right	1700
Shared Thru-Left	(See Note 1)
Exclusive Left (Permitted)	(See Note 2)

Note 1

Saturation Flows for shared thru-left movements were calculated by reducing the ideal saturation flow for an exclusive thru movement (1700) by applying a left turn factor. The left turn factor was calculated utilizing procedures in the 1985 Highway Capacity Manual (chapter 9) via the Highway Capacity Software package for signalized intersections. An absolute minimum of 450 vphgpl is used as a result of advice from the city of Los Angeles' Department of Transportation.

Note 2

Saturation flows for exclusive left turning movements with permitted phasing was calculated based upon the relationship of the exclusive left permitted saturation flow rate versus the opposing flow rate. This relationship was depicted in a 1988 Transportation Research Board paper entitled "CALSIG - An Introduction of Methodologies for the Design and Analysis of Signalized Intersections"; written by Michael J. Cassidy and Professor A.D. May of the Institute of Transportation Studies, University of California, Berkeley.

This saturation flow rate versus opposing flow rate relationship is taken directly from procedures outlined in the 1985 Highway Capacity Manual. Again, an absolute minimum of 450 vphgpl is used.

3. Control Parameters

The control parameters required for the TRANSYT model consist of signal timing data such as interval lengths, minimum phase durations, cycle lengths, offsets/yield points, reference intervals, type of signal control (i.e. pretimed, semi-actuated, or fully actuated), and phase sequencing.

E. SIMULATION PROCESS

The initial pre-calibrated simulation of the arterial network simply involves the data collection as described in the previous section and the coding of the data into the TRANSYT model.

The data collection procedures began on September 25, 1987 with a "kick-off" meeting in Los Angeles, California with representatives from the three major parties in this project being present, namely; the Institute of Transportation Studies at the University of California, Berkeley (ITS), the City of Los Angeles' Department of Transportation (LADOT), and the State Department of Transportation (CALTRANS) . At this meeting, the scope of this project and the data requirements and collection responsibilities were agreed upon between the major parties listed above.

Specifically for the arterial network, data began to be received at ITS from LADOT in October/November of 1987. Data input into the TRANSYT model began concurrently in November of 1987. By February 18, 1988, seventy four (74) intersections (or nodes) had been coded into the TRANSYT model and the first of two meetings with LADOT concerning calibration of the TRANSYT simulation had been held.

F. CALIBRATION PROCESS

After the coding of the network into the TRANSYT model and the initial simulation run is made, calibration of the model is required if the results from the TRANSYT simulation do not portray real-life conditions to the degree of accuracy desired.

The calibration of the TRANSYT simulation was based upon the resultant travel times from the TRANSYT simulation for the eastbound and westbound thru links for the three major east/west arterials included in this study (Adams Blvd., Washington Blvd., and Venice Blvd.) and the results from a speed/delay study performed by LADOT from September 1987 to March 1988 on the same thru links for the same three major east/west arterials. Calibration was also based upon the knowledge of local traffic conditions by experienced LADOT engineers.

For comparison purposes, the LADOT field study link travel times were adjusted for the "minor" intersections along the east/west arterials that were not included in the coding of the TRANSYT network (see "STUDY NETWORK", p.37). The adjustment consisted of subtracting the average stopped delay at the "minor" intersections (as measured in the field study) and the deceleration/acceleration delay per stop (estimated at 10 set/stop) at the "minor" intersections from the field study average link travel time. These adjusted field study link travel times were then compared to the TRANSYT simulation link travel times as a basis for the determination of accuracy of the TRANSYT simulation.

As stated earlier in the "Study Network" section on page 41, the delays at the "minor" intersections were added to the TRANSYT link travel times before downloading the link travel times into the network model.

Comparisons between the field study and TRANSYT simulation eastbound link travel times for Adams Blvd., Washington Blvd., and Venice Blvd. can be found in figures III-3 through III-5 on page 50-52.

As stated in the previous section, by February 18, 1988, seventy four nodes had been coded in the network and the first of two meetings with LADOT concerning calibration was held. By April 8, 1988, eighty (80) nodes had been coded into the TRANSYT model and the second meeting with LADOT concerning calibration had been held.

The first calibration meeting with LADOT on February 18, 1988 consisted of reviewing various output from the TRANSYT simulation with LADOT personnel and evaluating the output based on the knowledge and experience of the local LADOT personnel. The TRANSYT output primarily reviewed was the degree of saturation, or v/c ratio, per link. Links from the TRANSYT simulation with degrees of saturation greater than or equal to ninety percent (906) were particularly addressed to check with known existing field conditions. There were no known oversaturated links in the field that were not depicted in the TRANSYT simulation. A weakness with the TRANSYT model is that when an intersection becomes oversaturated, the estimations of intersection delay become less accurate. After the final calibration was completed, intersections with oversaturated links did exist, particularly left turning movements.

Before the calibration meeting on April 8, 1988, the results from the LADOT speed/delay field study had been forwarded to the

Institute of Transportation Studies and the average link travel times from the field study had been compared with the TRANSYT simulation link travel times for the eastbound and westbound thru movement links for the three major east/west arterials. These comparisons were the primary focus of this calibration meeting.

A TRANSYT optimization run (7-8 A.M.) was made as a check for any gross errors in coding the input data that might have occurred improvements in the performance index (and thus travel times) were to exceed certain percentage, say fifteen to twenty percent (15%-20>), then this could be an indication that erroneous data had been coded in the TRANSYT model. For the network a whole there was an approximately twenty percent (20%) improvement in the performance index. For the eastbound (and westbound) thru movements specifically, generally no significant improvement was made in the optimization run. By May 6, 1988, final calibration adjustments had been made and the final TRANSYT simulation results had been sent to LADOT.

G. RESULTS

The specific output of interest from the TRANSYT simulation model IS the total travel time per link in seconds per vehicle (sec/veh). The total travel time per link is composed of the free flow travel time upstream of an intersection plus the turning movements delay at the intersection. Since the TRANSYT output is in vehicle-hours per hour (veh-hr/hr), it is converted to sec/veh by dividing the link total travel time in veh-hr/hr by the link flow in veh/hr and multiplying by 3600 sec/hr. A total trip cost is the summation of travel times for all links traversed in a particular trip.

Eastbound (and westbound) thru link travel time comparisons were made between the LADOT field study (7-9 A.M.) and the TRANSYT model (7-8 A.M.) results for the three major east/west arterials. The results are shown on figures 111-3, 111-4, and III-5 on pages 50-52 (and figures H-l, H-2, and H-3 in appendix H). An explanation of these figures is as follows. Tables III-3 thru III-7 on pages 53 thru 56 accompany figures III-3,4 and 5.

PS : LADOT field study eastbound (or westbound) thru link travel times including delays at "minor" intersections not coded in the TRANSYT model.

FS (-1 : LADOT field study eastbound (or westbound) thru link travel times adjusted by subtracting delays at the "minor" intersections not included in the TRANSYT network.

T7F SIM : The TRANSYT simulation (7-8 A.M.) eastbound thru link travel times.

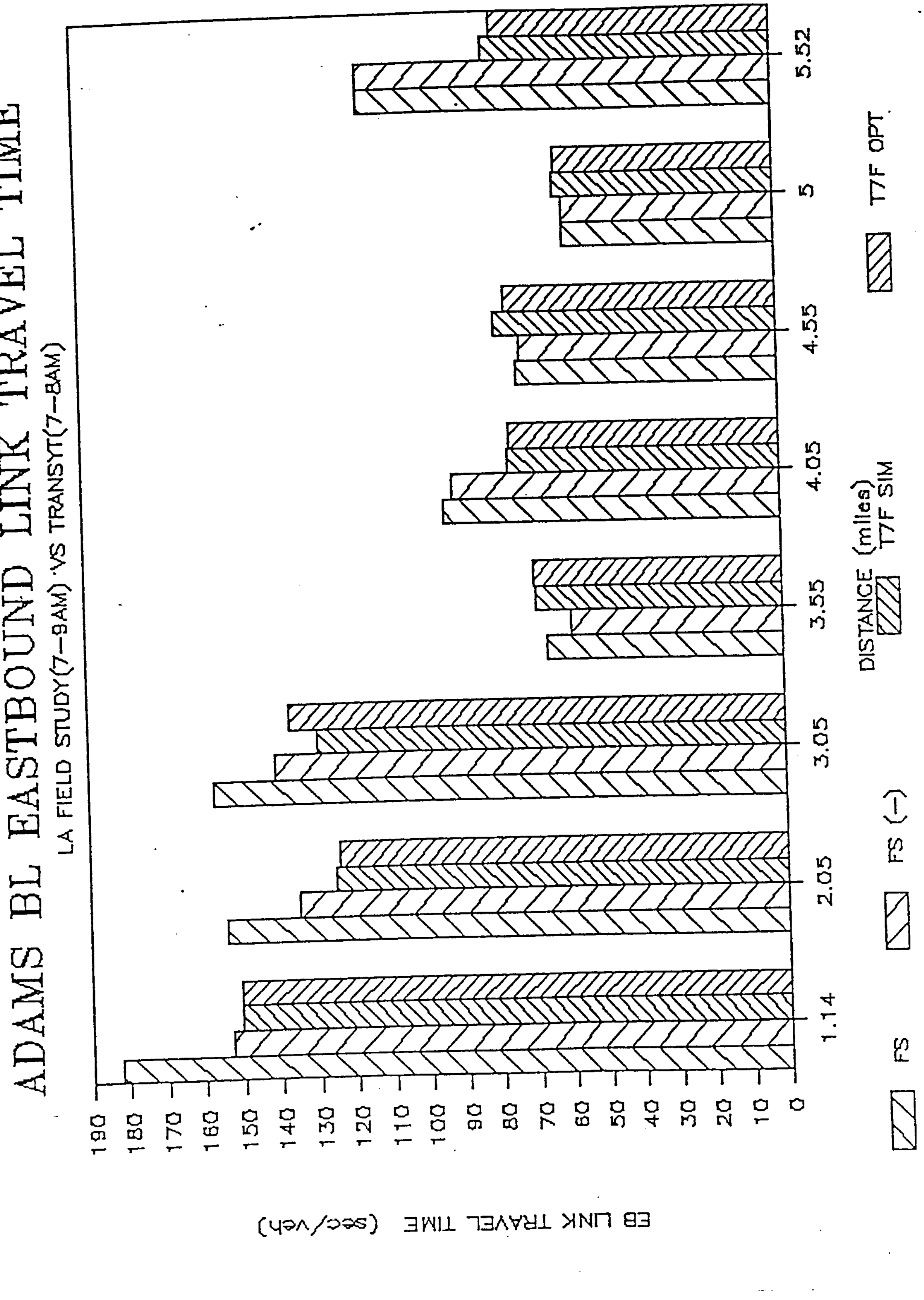
T7F OPT : The TRANSYT optimization (7-8 A.M.) eastbound thru link travel times.

The TRANSYT simulation was compared to the adjusted field study for model calibration purposes. Tables III-3,4, and 6 on pages 54 thru 56 show the actual arithmetic differences in eastbound thru link travel times between the adjusted LADOT field study and the final calibrated TRANSYT simulation for Adams, Washington, and Venice Boulevards. Table III-7 summarizes the differences between these travel times. As noted in the title, the values in table III-3 are absolute values.

Traversing the entire length of Adams Blvd. on the eastbound thru links from Fairfax Ave. to Figueroa St. (5.5 ml), the TRANSYT simulation cumulative travel time is approximately 55 seconds (0.92 min) or 7% less than the adjusted LADOT field study. Traversing the entire length of Washington Blvd. on the eastbound thru links from Fairfax Ave. to Figueroa St. (5.9 ml). the TRANSYT simulation cumulative travel time is approximately 19 seconds (0.32 min) or 2$ greater than the adjusted LADOT field study. Traversing the entire length of Venice Blvd. on the eastbound thru links from Sawtelle Blvd. to Figueroa St. (9.5 ml), the TRANSYT simulation cumulative travel time is approximately 170 seconds (2.8 min) or 11% less than the adjusted LADOT field study.

Also, as shown on figures 111-3, 4, and 5, the eastbound thru link travel times did not significantly vary between the TRANSYT optimization and the TRANSYT simulation.

The results of the TRANSYT simulation (i.e. link travel times) were considered to be within the degree of accuracy needed for the purposes of this study.



ADAMS BL EASTBOUND LINK TRAVEL TIME
LA FIELD STUDY(7—9AM) VS TRANSYT(7—8AM)
EB LINK TRAVEL TIME (sec/veh)
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1.14
2.05
3.05
3.55
4.05
4.55
5
5.52
DISTANCE (miles)
FS
FS (—)
T7F SIM
T7F OPT

FIGURE III-3

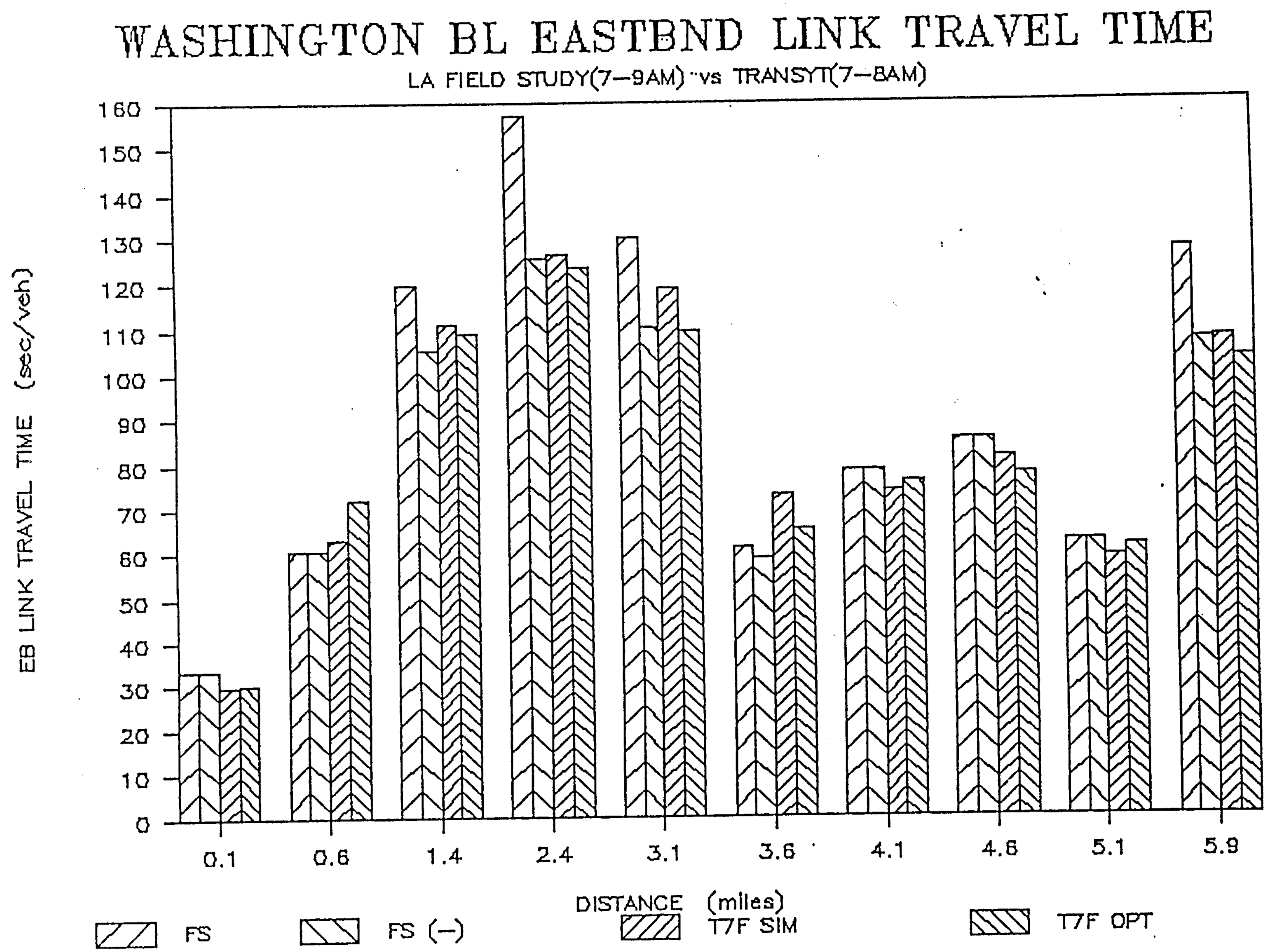

WASHINGTON BL EASTBND LINK TRAVEL TIME
LA FIELD STUDY(7–9AM) vs TRANSYT(7–8AM)
EB LINK TRAVEL TIME (sec/veh)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0.1
0.6
1.4
2.4
3.1
3.6
4.1
4.6
5.1
5.9
DISTANCE (miles)
FS
FS (–)
T7F SIM
T7F OPT

FIGURE III-4

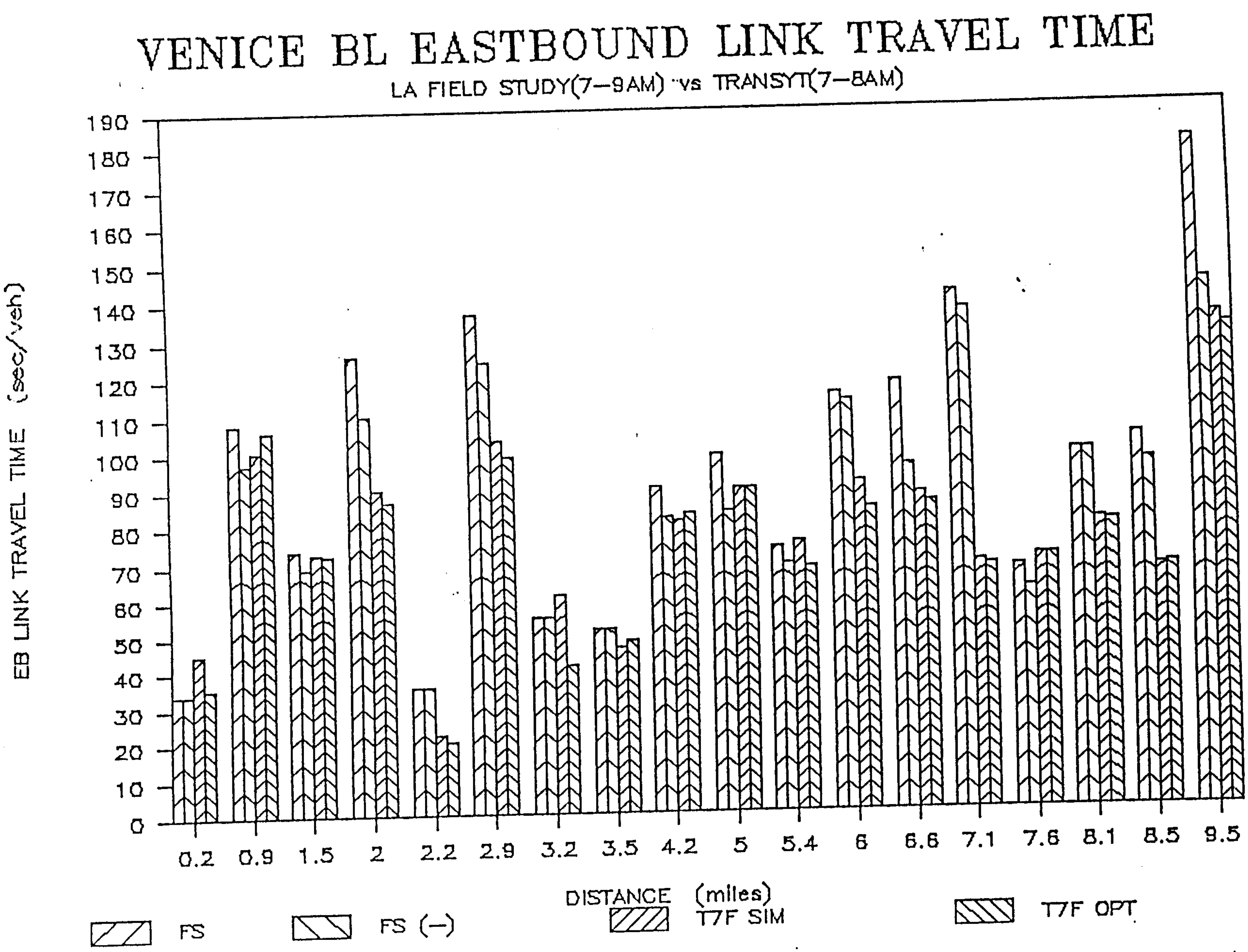

VENICE BL EASTBOUND LINK TRAVEL TIME
LA FIELD STUDY(7–9AM) vs TRANSYT(7–8AM)
EB LINK TRAVEL TIME (sec/veh)
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0.2
0.9
1.5
2
2.2
2.9
3.2
3.5
4.2
5
5.4
6
6.6
7.1
7.6
8.1
8.5
9.5
DISTANCE (miles)
FS
FS (–)
T7F SIM
T7F OPT

FIGURE III-5

TABLE III-3
CROSS STREET IDENTIFICATION

ARTERIAL	EASTBOUND CUMULATIVE DISTANCE (mi)	CROSS STREET	TRANSYT INTERSECTION NODE NUMBER
Adams Blvd.	0.0	Fairfax Ave.	49
	1.1	La Brea Ave.	44
	2.1	Crenshaw Blvd.	38
	3.1	Arlington Ave.	33
	3.6	Western Ave.	28
	4.1	Normandie Ave.	23
	4.6	Vermont Ave.	18
	5.0	Hoover St.	13
	5.5	Figueroa St.	7
Washington Blvd.	0.0	Fairfax Ave.	48
	0.1	Apple St.	46
	0.6	Hauser Blvd.	76
	1.4	La Brea Ave.	41
	2.4	Crenshaw Blvd.	35
	3.1	Arlington Ave.	30
	3.6	Western Ave.	25
	4.1	Normandie Ave.	20
	4.6	Vermont Ave.	15
	5.1	Hoover St.	9
	5.9	Figueroa St.	2
Venice Blvd.	0.0	Sawtelle Blvd.	73
	0.2	Sepulveda Blvd.	72
	0.9	Overland Ave.	66
	1.5	Hughes Ave.	60
	2.0	Robertson Blvd.	58
	2.2	National Blvd.	57
	2.9	La Cienega Blvd.	53
	3.2	Cadillac Ave.	50
	3.5	Fairfax Ave.	45
	4.2	Hauser Blvd.	75
	5.0	La Brea Ave.	40
	5.4	Vinyard/San Vicente Blvd.	39
	6.0	Crenshaw Blvd.	34
	6.6	Arlington Ave.	29
	7.1	Western Ave.	24
	7.6	Normandie Ave.	19
	8.1	Vermont Ave.	14
	8.5	Hoover St.	8
	9.5	Figueroa St	1

TABLE III-4
ADAMS BOULEVARD
EASTBOUND THRU LINK TRAVEL TIMES

EB THRU LINK TRAVEL TIMES (sec/veh)
FOR INDIVIDUAL INTERSECTIONS

CUMULATIVE DISTANCE (mi)	ADJUSTED L.A. FIELD STUDY	TRANSYT SIMULATION INAL CALIBRATION	ARITHMETIC DIFFERENCE
1.1	153.1	150.6	-2.5
2.1	134.8	125.1	-9.7
3.1	140.9	129.5	-11.4
3.6	59.4	69.0	+9.6
4.1	91.4	76.0	-15.4
4.6	71.9	78.6	t6.7
5.0	59.3	61.5	t2.2
5.5	114.7	80.2	-34.5
	825.5	770.5	

TABLE III-5
WASHINGTON BOULEVARD
EASTBOUND THRU LINK TRAVEL TIMES

EB THRU LINK TRAVEL TIMES (sec/veh)
FOR INDIVIDUAL INTERSECTIONS

CUMULATIVE DISTANCE (mi)	ADJUSTED L.A. FIELD STUDY	TRANSYT SIMULATION INAL CALIBRATION	ARITHMETIC DIFFERENCE
0.1	33.6	29.8	-3.8
0.6	58.3	63.2	t4.9
1.4	105.3	111.1	t5.8
2.4	125.6	126.3	to.7
3.1	110.2	119.1	t8.9
3.6	58.5	72.9	t14.4
4.1	78.3	73.9	-4.4
4.6	85.2	81.3	-3.9
5.1	62.2	58.5	-3.7
5.9	106.8	107.2	to.4
	824.0	843.3	

TABLE III-6
VENICE BOULEVARD
EASTBOUND THRU LINK TRAVEL TIMES

CUMULATIVE DISTANCE (ml)	EB THRU LINK TRAVEL TIMES (sec/veh) FOR INDIVIDUAL INTERSECTIONS: ADJUSTED L.A. FIELD STUDY	TRANSYT SIMULATION FINAL CALIBRATION	ARITHMETIC DIFFERENCE
0.2	33.6	44.9	+11.3
0.9	97.2	100.8	+3.6
1.5	68.9	72.7	+3.8
2.0	110.1	90.2	-19.9
2.2	35.3	22.0	-13.3
2.9	124.4	103.0	-21.4
3.2	55.0	61.0	+6.0
3.5	51.6	46.1	-5.5
4.2	81.7	80.8	-0.9
5.0	82.9	89.4	+6.5
5.4	68.9	75.0	+6.1
6.0	113.0	91.0	-22.0
6.6	95.4	87.6	-7.8
7.1	136.8	69.2	-67.6
7.6	61.8	70.3	+8.5
8.1	98.9	79.6	-19.3
8.5	96.0	67.0	-29.0
9.5	143.3	134.2	-9.1
	1554.2	1384.8	ABS=261.6 TOT

TABLE III-7
EASTBOUND THRU LINK TRAVEL TIME DIFFERENCE BETWEEN ADJUSTED LADOT FIELD STUDY AND FINAL CALIBRATED TRANSYT SIMULATION (Absolute Value) (sec/veh)

ARTERIAL	Average	Maximum	Minimum
Adams Blvd. (8 intersections)	11.5	34.5	2.2
Washington Blvd. (10 intersections)	5.1	14.4	0.4
Venice Blvd. (18 intersections)	14.5	67.6	0.9

CHAPTER IV - NETWORK MODEL

A. INTRODUCTION

This section describes the project task in which:

1. Data from the TRANSYT and FREQ models were incorporated into a network database.

2. The costs of various routes through the network are compared.

The computer programs were developed to merge output files from TRANSYT and FREQ with the network data base, and to find shortest and user-specified path costs through the network. The database itself was maintained in a spreadsheet format.

B. NETWORK DESIGN

The network used in this part of the project is similar to the network specified in the TRANSYT and FREQ models. It incorporates the arterial streets included in the TRANSYT model, and all freeway sections and ramps included in the FREQ model, into a single network representation of the corridor.

A computer program, called PATHNET, was used to find minimum cost routes through the corridor, and to tabulate the cost of user-specified routes. PATHNET is a prototype version of a generalized network analysis package written in Macintosh Fortran. Since PATHNET was designed to handle fully-directed, “generic" networks, as well as networks that are representations of urban traffic, the network representation in the PATHNET format is different from the TRANSYT and FREQ network representation in several respects.

PATHNET uses a fully directed graph (unidirectional links) to facilitate the representation of turn movements, the implementation of turn prohibitions or penalties, and the super-imposition of different values of stopped delay for different time slices. This representation requires eight nodes and twelve internal turning movement links to make up a single intersection. This group of links and nodes is equivalent to the 12-link arrangement well known to users of TRANSYT, (see appendix I).

These clusters of nodes and links, representing intersections, are combined with nodes and links representing segments of arterials between signalized intersections, freeway sections, and ramps, into a complete network model of the corridor. In a combined network, illustrated in Figure IV-l, some of the links

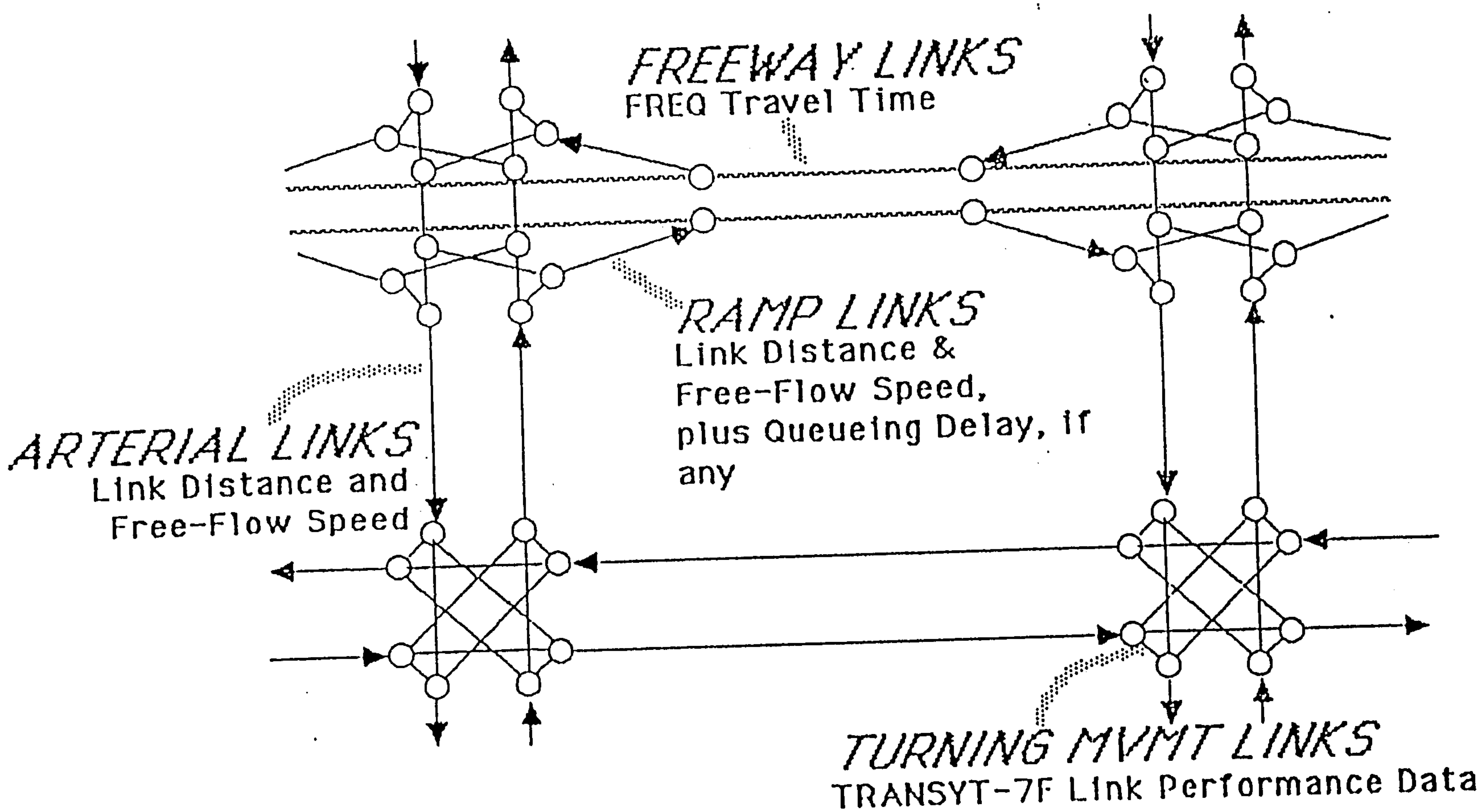

FREEWAY LINKS
FREQ Travel Time
RAMP LINKS
Link Distance &
Free-Flow Speed,
plus Queueing Delay, if
any
ARTERIAL LINKS
Link Distance and
Free-Flow Speed
TURNING MVMT LINKS
TRANSYT-7F Link Performance Data

FIGURE IV-1

represent arterial through movements, others represent freeway sections, and others represent ramps. A travel cost is associated with each link in the network. This cost is the travel time; the source for each link travel time is different, depending on the link type.

Each node in the network is numbered. Each link in the network has several attributes associated with it.

- Origin node number and destination node number.
- A travel cost, determined in various ways.
- A link type.

Although this type of representing the street network adds to the number of nodes and links, the added complexity of the database is offset by a decrease in the complexity of the algorithms required to compute minimum cost routes and travel times .

The generic, fully-directed network allows a generalized minimum cost algorithm to find its way through the network without producing inadvertent loops or U-turns. In addition, at intersections, it allows each link representing a turning movement to be assigned a separate cost.

As mentioned above, a travel cost is associated with each link in the network. This travel time is obtained by different means, depending on the link type:

1. Turning Movement Links

The travel time for these links was obtained directly from the TRANSYT model link performance output statistic "average delays*', with additional travel time added to certain links to account for mid-link signalized intersections not included in the TRANSYT model. Since TRANSYT calculates average delay by taking the average total link travel time, which includes average traffic signal delays, and subtracting the average free-running travel time, the average delay statistic can be incorporated directly into the PATHNET model as the travel time for turning movement links. If the free-running travel time is used as the travel time for arterial through links in PATHNET, then the travel cost of successive pairs of arterial through and turning movement links in PATHNET will be the total travel time between intersections. The value of the arterial through link cost will represent the free-running component of the travel time, and the turning movement link cost will represent the delay part of the travel time.

2. Arterial Through Links

The cost for these links was the free-speed travel time, obtained by dividing the length of the link by its operating speed. The operating speed was assumed to be 30 mph for all arterial links in the network. Lengths of the links were obtained from maps.

3. Freeway Links

The cost of these links is obtained directly from FREQ model output, which prints the travel time for each freeway section. The network model is constructed so that each PATHNET freeway link corresponds directly to a FREQ model freeway section. In this way the freeway links in the PATHNET model can be updated directly from FREQ data for each of the 16 time slices in both the recurring and non-recurring congestion scenarios.

4. Entrance and Exit Ramps

Travel times for these link types were calculated using a constant acceleration/deceleration model. A value of 5 feet/sec^2 was used. For an entrance ramp, the time was calculated for the vehicle to travel the length of ramp while accelerating from 20 towards a maximum of 60 mph, and, if any distance remained on the ramp, for traveling the remaining distance at a constant speed of 60 mph. For exit ramps, the time was calculated for the vehicle to travel the length of the ramp while decelerating from 60 to a minimum of 20 mph, and, if any distance remained, to traverse the remaining distance at 20 mph. In both cases the length of the ramp was obtained from maps.

C. UPDATING LINK TRAVEL TIMES

The network database was replicated 32 times, once for each different 15-minute time slice in each of the recurring and non-recurring congestion scenarios. Freeway travel times were different for each time slice, and turning movement travel times were different for each hour (set of four time slices). A computer program, PATHMOD, was created for this task and used to update the database for each replicant.

Travel times for arterial through links and ramp links remained constant for all time slices. (Recall that arterial through links reflect only the free-speed travel time for streets, and that delays are represented by travel costs of the turning movement links.)

D. TABULATING ROUTE COSTS

PATHNET prints a report, listing sequentially the links in the minimum cost path and the cumulative route cost for each link. Minimum cost paths are calculated by PATHNET using Dijkstra's algorithm. This algorithm is described in most elementary operation research textbooks. Given origin node and a destination node, Dijkstra's algorithm finds the minimum cost route through a network if one exists, but is not capable of determining whether multiple minimum cost routes exist. However, due to the complexity of the network model of the corridor, it is unlikely that multiple minimum cost paths exist.

In this network model, link costs are fixed in time within one time slice, rather than dynamically adjusted for changing traffic conditions during the course of a vehicle's progress along a route. Most routes through the corridor are on the order of 20 minutes long. Since time slices are 15 minutes long, this means that a 20-minute route that begins in time slice N will end in time slice N+l. PATHNET does not consider this effect; the decision whether to make link costs fixed or dynamic for a given route is beyond the scope of this report, and is a worthy subject for future research.

The cost of user-specified routes are tabulated by entering a series of node numbers. PATHNET generates a printed report giving the cumulative path cost [19].*

"Freeway-biased" and "arterial-biased" routes are generated by using a combination or PATHNET's minimum cost and user-specified route cost functions. The way in which these routes were specified is described in Section F, "Route Costs."

E. SURVEY

A survey was conducted to determine typical routes used by actual commuters in the corridor. Designed in cooperation with Commuter Transportation Services, Inc., the quasi-public agency coordinating van and car pooling services for the Los Angeles area, and Paul Fowler of the Southern California Auto Club, the

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* See: Deo, Narsingh, 1936-. Graph theory with applications to engineering and computer science. Englewood Cliffs, N.J., Prentice-Hall (1974). Series title: Prentice-Hall series in automatic computation. CSL Main Lib TA 338 G7 D46 General Collection. Also see Hillier and Lieberman.

survey was designed to identify drivers who use the Santa Monica Freeway Corridor, determine their primary route to work, and what route, if any, was used when diversion took place due to traffic congestion or some other reason.

The database used for the survey was Commuter Transportation Services's sizable data base of van and car pool riders and drivers. Potential respondents were pre-selected by identifying members from the data base living and working in certain zones likely to result in corridor use. (The zone system used by C.T.S. coincides with the coordinate system used in the popular Thomas Brothers map of Los Angeles County.) Origin zones used were relatively close to the corridor, primarily in the Santa Monica, southern Beverly Hills, and Culver city areas. Destination zones were in downtown Los Angeles at the eastern terminus of the corridor.

These relatively close-in zones were selected, rather than further-out zones, because the probability of finding a SMART Corridor user was greater in a close-zone. In further-out zones, the likelihood that a commuter was a corridor user was much smaller, and a great deal more telephone screening would have been necessary to separate corridor users from commuters using other routes.

Once potential users were selected on the basis of origin and destination zones, questions were used to filter out non-drivers, and identify commuters using the corridor on a more or less daily basis. Based on these criteria, 78 drivers were eventually surveyed. Only travel to work in the morning peak was discussed in the survey.

Due to the pre-selection criteria used to select interviewees for this survey, the results should not be interpreted as a random sample of commuters. The primary purposes of this survey were to determine which routes frequently corridor users normally take, why they divert, if ever, from the usual route, the reason for diversion, and which routes are used in the diversion process. Particularly, since corridor users were pre-selected from certain zones, the locations of respondents' trip origins and destinations should not be taken as indicative of trip origins and destinations for the corridor.

Another reason limiting the extrapolation of these answers is that the drivers who stated that they divert from their usual route may be more aggressive or traffic-conscious ("savvy" is a good term) than drivers who do not divert. This could imply fundamental differences in the psychology of route-choosing between diverting drivers and non-diverting drivers. Also, all drivers in the Transportation Services database are probably more traffic conscious than the general population since they are active participants in a ride sharing program.

Even if survey respondents are more route-conscious than most drivers, it is not provable from the data in the survey that the routes chosen for diversion are superior to the old routes diverted from. Portions of most of the routes given in the survey responses lay outside the SMART Corridor, and no travel time data is available there. However, the assumption, that a diversion route is shorter than the original route, is consistent with the paradigm of user equilibrium, which assumes that, except for some random variations, no driver can unilaterally improve his travel time by changing routes. This is the same as saying that a driver always takes what is perceived to be the shortest route to a destination.

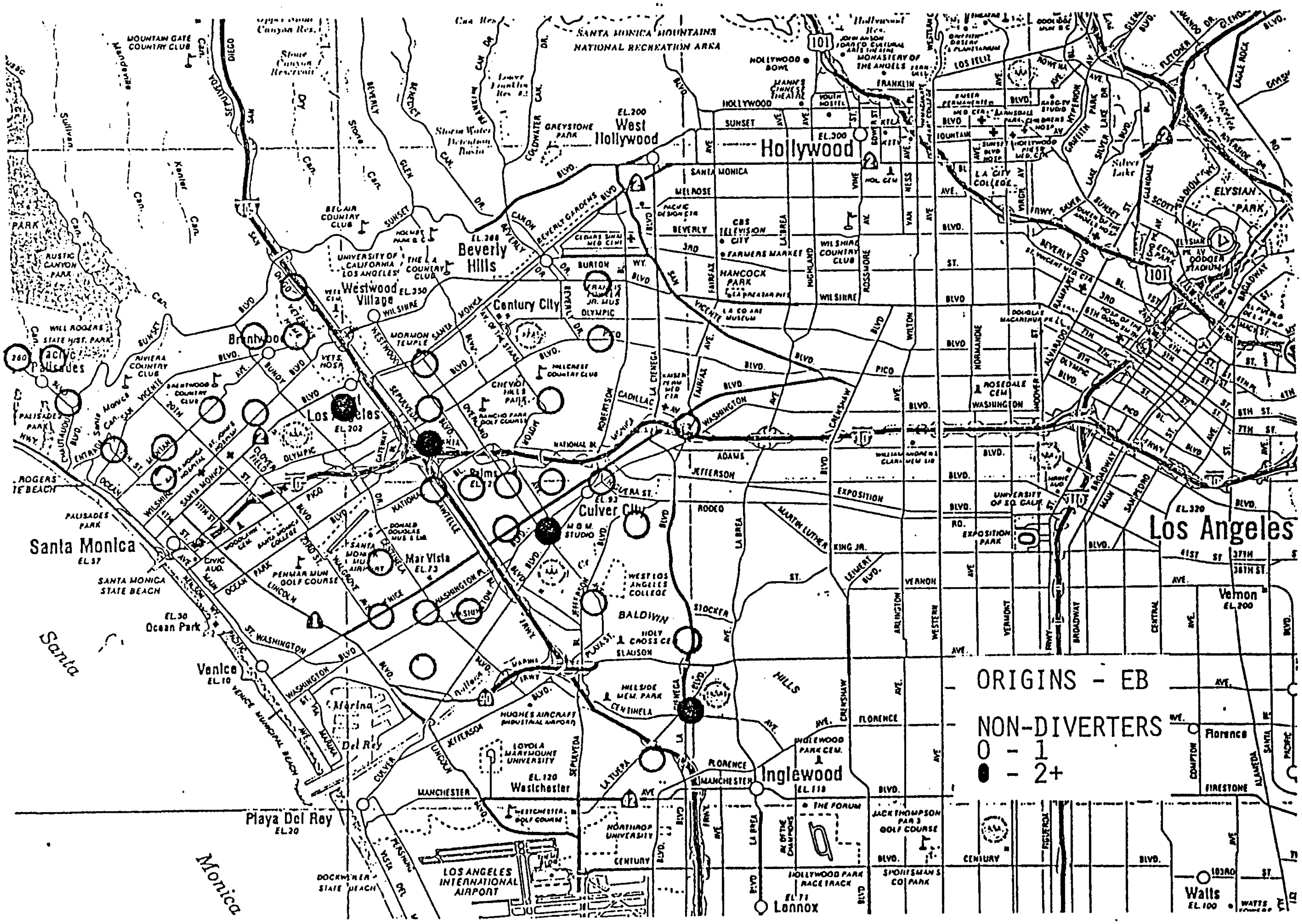
The user equilibrium assumption stated in the paragraph above is the underlying reason for evaluating the paths generated by shortest-path and other heuristics in this report. The assumption is that driver will attempt to save time by taking a shorter route than the usual route if the information about that shorter path is made available. The purpose of in-vehicle navigation systems is to respond to real-time traffic information and provide information about potential shorter routes.

Seventy two out of the seventy eight respondents to the survey were users of the corridor in the eastbound direction. Forty of these eastbound drivers told interviewers they never diverted from their usual routes. (This set of respondents will be referred to as "non-diverters.") All but six of the non-diverting eastbound drivers used the Santa Monica Freeway for the entire duration of their travel in the corridor. Five of these six used Olympic, Pico, Venice, and Washington, in addition to the freeway, along their route. The sixth driver used Jefferson, without using the freeway; this driver was the only non-diverting eastbound driver not to use the freeway at all.

Of the remaining 32 eastbound drivers who stated that they diverted from their usual routes, 25 used the freeway exclusively as their usual means of getting to work. The other seven used a variety of routes. Four were not freeway users: three used Olympic exclusively, and one used Jefferson exclusively. The remaining three used Venice, Washington, and Olympic in addition to the freeway as their usual route.

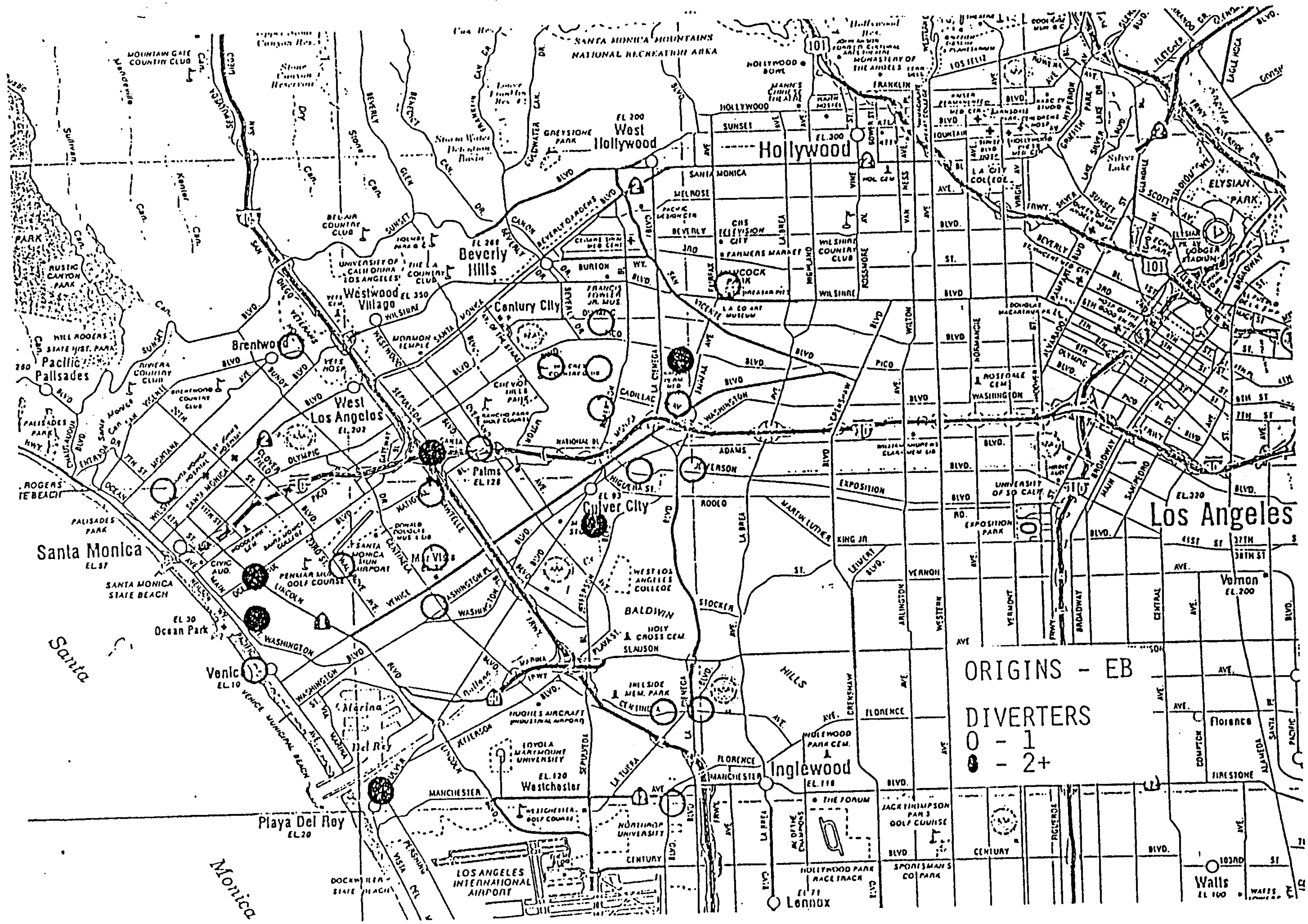
Origin locations for surveyed users in the eastbound direction only are shown in Figures IV-2 and IV-3. Figure IV-2 shows origin points for drivers who stated that they never diverted from their usual route; the other figure shows origin points for diverters. Figure IV-4 shows destination locations for all eastbound commuters surveyed.

Some answers given in the survey can be summarized statistically. The average departure time and average trip length for the diverting, as compared to non-diverting drivers, varied little. Average trip length, 32 minutes, was the same for both grouped. Diverting drivers departed for work at 7:07 AM, on the average, while non-diverting drivers departed at an average time of



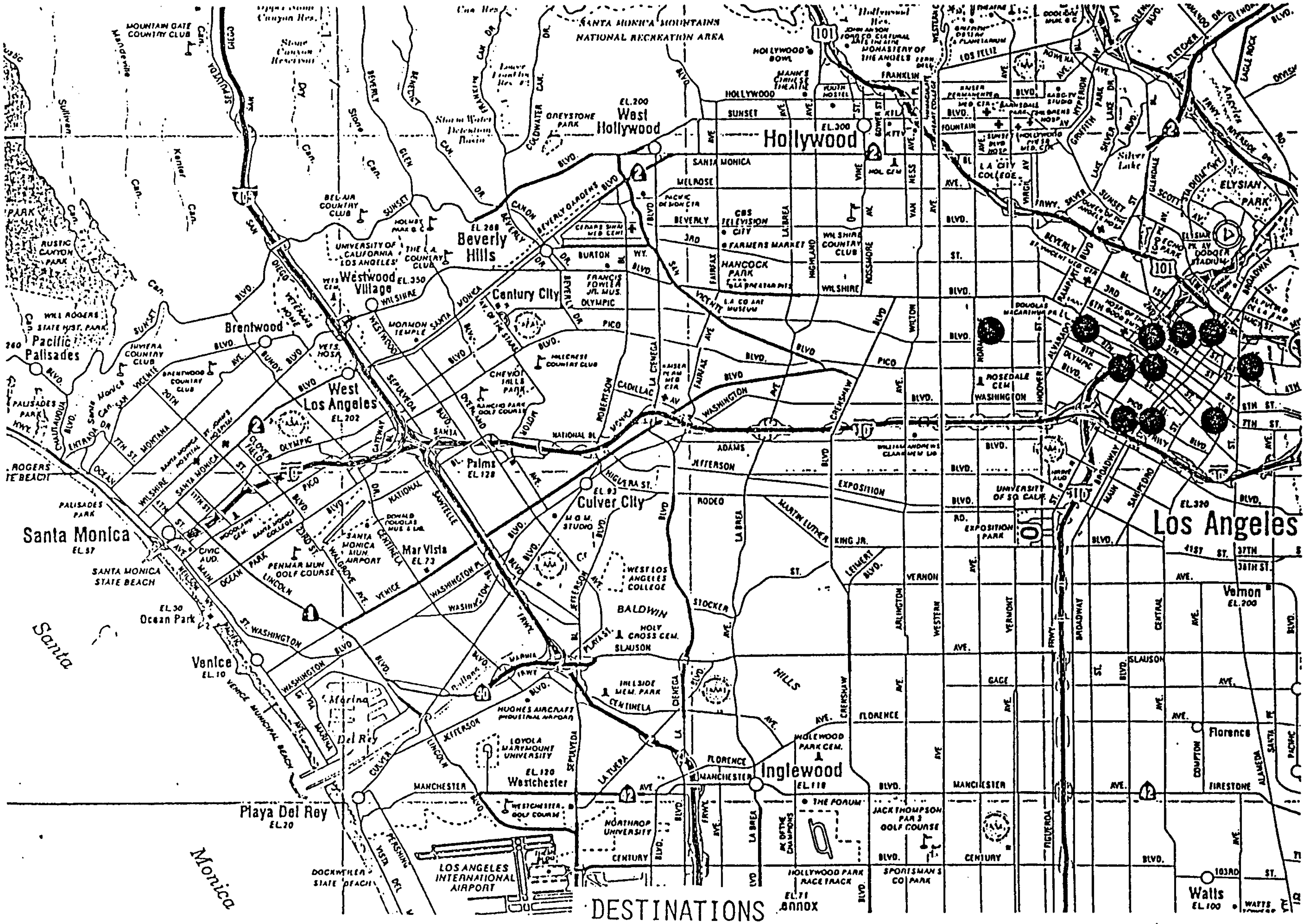
ORIGINS - EB
NON-DIVERTERS
0 - 1
● - 2+
Santa Monica
Beverly Hills
West Hollywood
Hollywood
Los Angeles
Culver City
Century City
Westwood Village
Brentwood
Pacific Palisades
Mar Vista
Venice
Ocean Park
Marina Del Rey
Playa Del Rey
Westchester
Inglewood
Lennox
Watts
Vernon
Florence
LOS ANGELES INTERNATIONAL AIRPORT
Santa Monica

FIGURE IV-2



ORIGINS - EB
DIVERTERS
0 - 1
● - 2+
Los Angeles
Hollywood
West Hollywood
Beverly Hills
Century City
Westwood Village
West Los Angeles
Brentwood
Pacific Palisades
Santa Monica
Ocean Park
Venice
Culver City
Palms
Inglewood
Westchester
Playa Del Rey
Lennox
Walls
Vernon
Florence
Santa Monica

FIGURE IV-3



Santa Monica Mountains National Recreation Area
Hollywood
West Hollywood
Beverly Hills
Westwood Village
Century City
Brentwood
West Los Angeles
Pacific Palisades
Santa Monica
Palms
Culver City
Mar Vista
Ocean Park
Venice
Playa Del Rey
Westchester
Inglewood
Los Angeles
Vernon
Florence
Watts
Silver Lake
Elysian Park
Dodger Stadium
Baldwin Hills
Los Angeles International Airport
Santa Monica State Beach
Santa
Monica
DESTINATIONS

FIGURE IV-4

6:56AM. Sample sizes varied slightly because some respondents did not give specific values for their travel time or departure time. The table below summarizes these statistics about EB survey respondents:

TABLE : Trip Lengths and Departure Times: EB Travelers Only

	Avg Trip (minutes)	N	Avg Dep Time	N
Non-Diverters	32	38	6:56	38
Diverters	32	32	7:07	26

Exact tabulation of the reasons for diverting was not practical because of the fuzzy nature of the question and responses. All but about six of the eastbound diverting drivers gave "freeway congestion", "accident", "traffic report of congestion", or some similar answer as their reason for diverting. Other non-traffic-related reasons for diverting included varying work hours, "change of scenery", or the need for a chained trip on the route, such as a trip to a day care center, gas station or a field appointment for work.

The choices of diversion routes was as numerous as the number of responses. No two interviewees reported using the same route when diverted from the freeway. Why this is so unclear from the survey; the result could be due to randomness, or to a strong correlation between the place of origin and destination and the diversion and the diversion route.

The main conclusion to be drawn from the responses to the survey is that most corridor users do not deviate from their usual route in the face of traffic congestion, accidents,, or other adverse traffic conditions. The preferred route for these drivers is to enter and leave the corridor on the freeway. This is reasonable, as one would normally assumed that, in addition to the slower speeds and increased delay, some sort of penalty is associated with leaving the freeway.

F. ROUTE COSTS

PATHNET was used to compute the cost of several different routes for a combination of four origin intersections and three destination intersections in the corridor. These different routes are described by the following three terms:

- "Shortest-path"
- "Freeway-biased"
- "Arterial-biased"

The "shortest-path" route is that route specified by the Dijkstra minimum cost algorithm. This route represents the quickest route through the corridor based on the given set of link costs for that time slice.

It is important to note that in this section, as in previous sections, the term "nearest" is used synonymously with "quickest" and "minimum-cost", since the metric used in all route tabulations in this project is travel time.

The "freeway-biased" route is a route designed to reflect the behavior of the majority of corridor users. As noted in the section covering results of the survey of corridor users, in the absence of travel time information, most drivers tend to strike out from their origin to the nearest freeway entrance, then stay on the freeway until close to their destination, and then exit the freeway and travel to the final destination.

The heuristic used to tabulate costs for the freeway-biased route, then, is as follows:

For each time slice:

1. Find the shortest path from the origin node to the nearest freeway node.

2. Find the shortest path from the freeway node nearest the destination to the destination node.

3. Calculate the travel time incurred between these two points on the freeway, using a route that does not exit the freeway.

4. Add these three travel times; this is the travel time of the "freeway-biased" route.

During conditions of light flow (low congestion), the freeway biased route will almost always be the same as the minimum-cost route through the corridor. As congestion increases and freeway speeds decrease, the freeway-biased route will always take longer than the minimum cost route. This is because the minimum-cost route can take advantage of faster travel times on parallel streets; drivers can reduce their travel time by delaying entry onto the freeway past their usual entry point, exiting the freeway early, or exiting the freeway and reentering, thus bypassing congestion. In the real world, drivers have difficulty accurately gauging where to correctly make these entrances and exits, largely as a result of a lack of information (or past experiences with bad information!) about travel times on adjacent parallel streets. As with the psychology of the diversion decision itself, under what conditions such diversion takes place is not in the scope of this report, but is the objective of current research elsewhere.

The difference between the freeway-biased and minimum-cost routes, therefore, represents the time savings that might be available to a driver who has "perfect" information about travel times in the rest of the corridor.

The "arterial-biased" route is found by tabulating costs along an arterial parallel to the freeway, without venturing onto the freeway itself. Since the corridor under study was fairly narrow, when applicable, each of three arterial-dominated routes were tabulated for each origin-destination pair: one each for travel primarily on Adams, Washington, and Venice Avenues.

The origin and destination points for the routes were chosen to reflect driver preferences revealed in the survey of corridor users. Since almost all of the surveyed drivers used the entire length of the corridor in their normal day-to-day travel, origin and destination points were chosen close to the ends of the corridor. Origin points were:

- Origin 1: EB Santa Monica Freeway at San Diego Freeway
- Origin 2: National Blvd. at Sawtelle
- Origin 3: Venice Blvd. at Sawtelle
- Origin 4: LaCienega at Adams Blvd

Origin 1 through 3 represent "gateways" into the corridor model. Most trips through the corridor originate to the west of these origin points, so Origins 1 through 3 represent the usual entry on to the majority of corridor users. Origin 4 represents a gateway for travelers using the corridor in a more diagonal route; this route represents a route for drivers entering the corridor from more southerly points than the Santa Monica-Venice areas.

Destination points were selected in downtown locations, reflecting the downtown destinations of survey respondents:

- Destination 1: EB Santa Monica Freeway at Harbor Freeway
- Destination 2: Venice Blvd. at Figueroa Street
- Destination 3: Venice Blvd at Western Avenue

Destinations 1 and 2 were selected as gateways to the downtown area, while destination 3 was selected in order to represent corridor users choosing a more diagonal route.

Travel times were evaluated for a fully factorial combination of these 4 origin and 3 destination points. Shortest paths, freeway-biased, and arterial-biased routes, where applicable, were computed for all 12 combinations.

CHAPTER V - ASSESSMENT OF POTENTIAL BENEFITS

A. INTRODUCTION

This chapter will assess potential benefits found in this study of an in-vehicle information system providing "perfect" real-time traffic information to the driver under non-incident and incident scenarios. It should be noted that the analysis in this study is performed with traffic conditions on the freeway and surface streets for a "typical day". Heavier or lighter traffic conditions would possibly yield different results.

First, travel times will be compared under each scenario separately and then a comparison will be made between the two scenarios. Travel time is the only measure of effectiveness being considered in this study. The assessment of potential benefits will be based upon the comparison of travel times for several paths for each origin/destination pair being considered.

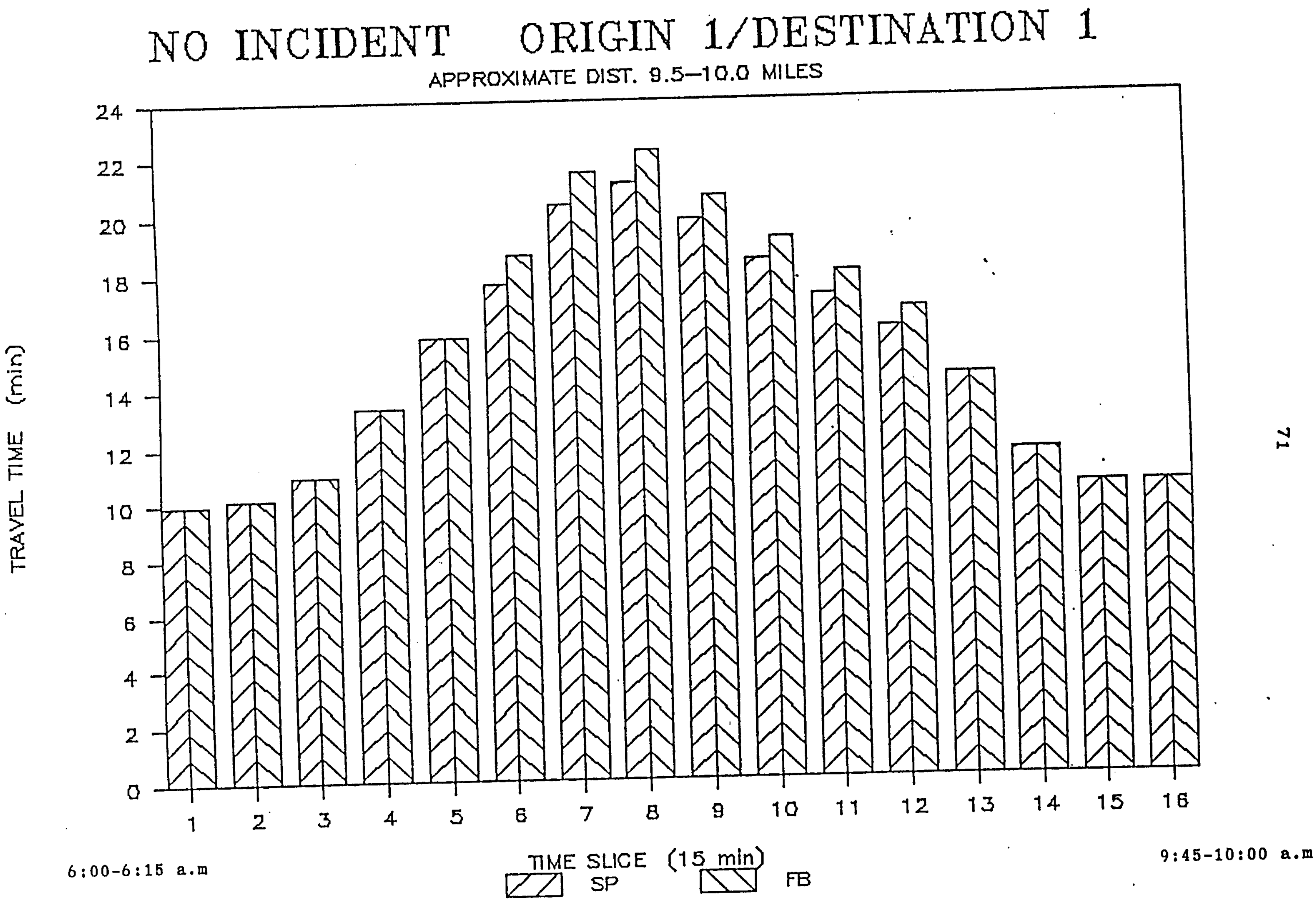
As described in chapter IV, there are four different origins and three different destinations being analyzed for a total of twelve origin/destination pairs. There are a maximum of five possible routes that can be compared for each origin/destination pair in each time slice. The location of each origin and destination and the five possible routes that can be utilized between the origin/destination pairs are described in chapter IV.

B. NON-INCIDENT SCENARIO

1. Origin 1 - Santa Monica Freeway Mainline Origin

Figures V-l, 2, and 3 depict the travel times for trips beginning at origin one and traversing to destinations one, two, and three respectively via the shortest path and the freeway biased-path. Surface street biased paths are not included as possible path options for trips from origin one since this origin is on the Santa Monica Freeway mainline.

As shown in figures V-l, 2, and 3, the shortest path deviates from the freeway-biased path and reduces the travel time for all three destinations during a one hour and forty five minute period between 7:15 A.M. and 9:00 A.M. (time slices 6-12). From 6:00 A.M. to 7:15 A.M. and from 9:00 A.M. to 10:00 A.M. the shortest path is the freeway biased path.


NO INCIDENT ORIGIN 1/DESTINATION 1
APPROXIMATE DIST. 9.5–10.0 MILES
TRAVEL TIME (min)
0
2
4
6
8
10
12
14
16
18
20
22
24
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
6:00-6:15 a.m
9:45-10:00 a.m
TIME SLICE (15 min)
SP
FB

NO INCIDENT ORIGIN 1/DESTINATION 2

APPROXIMATE DIST. 10.0–10.5 MILES

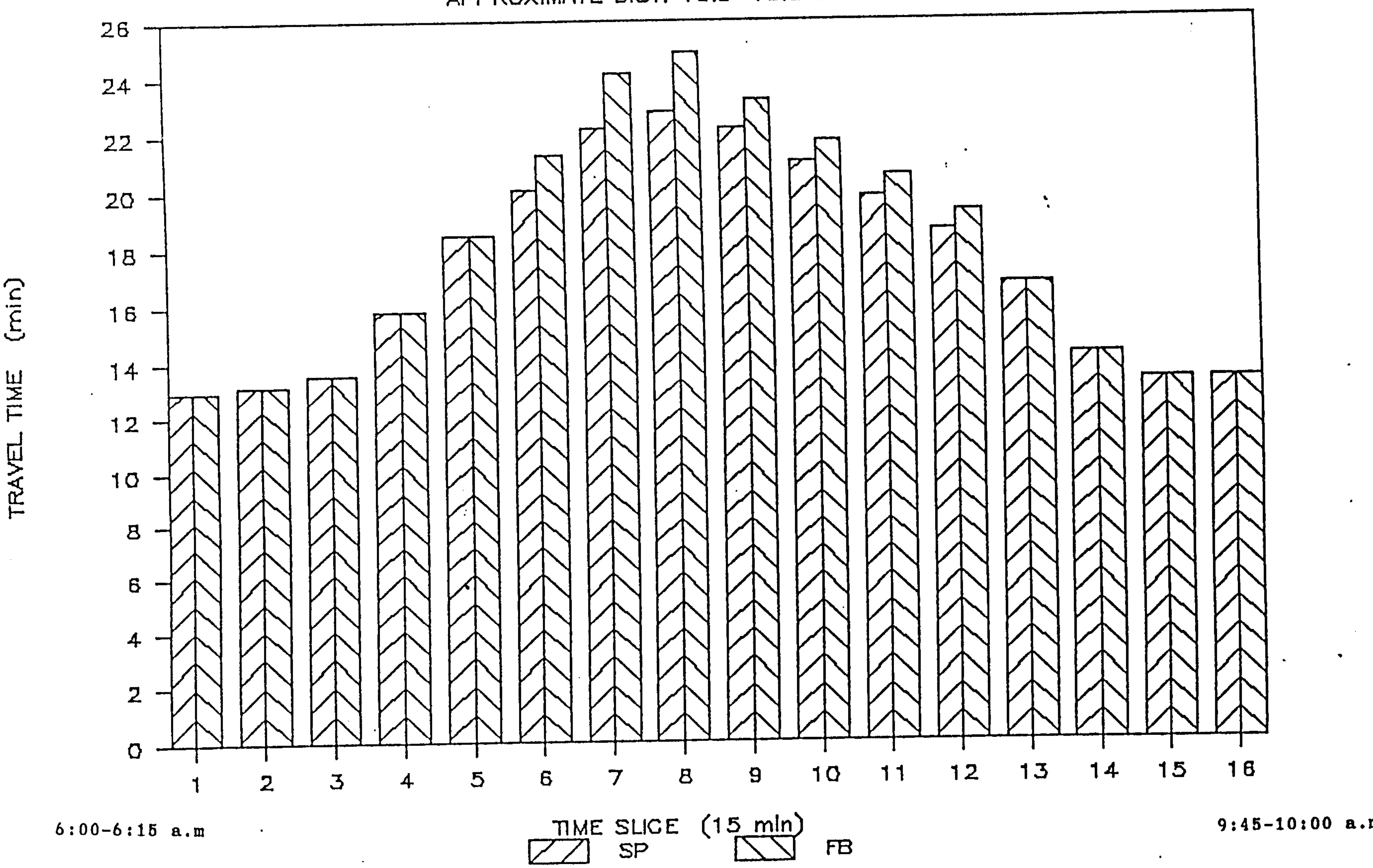


FIGURE V.

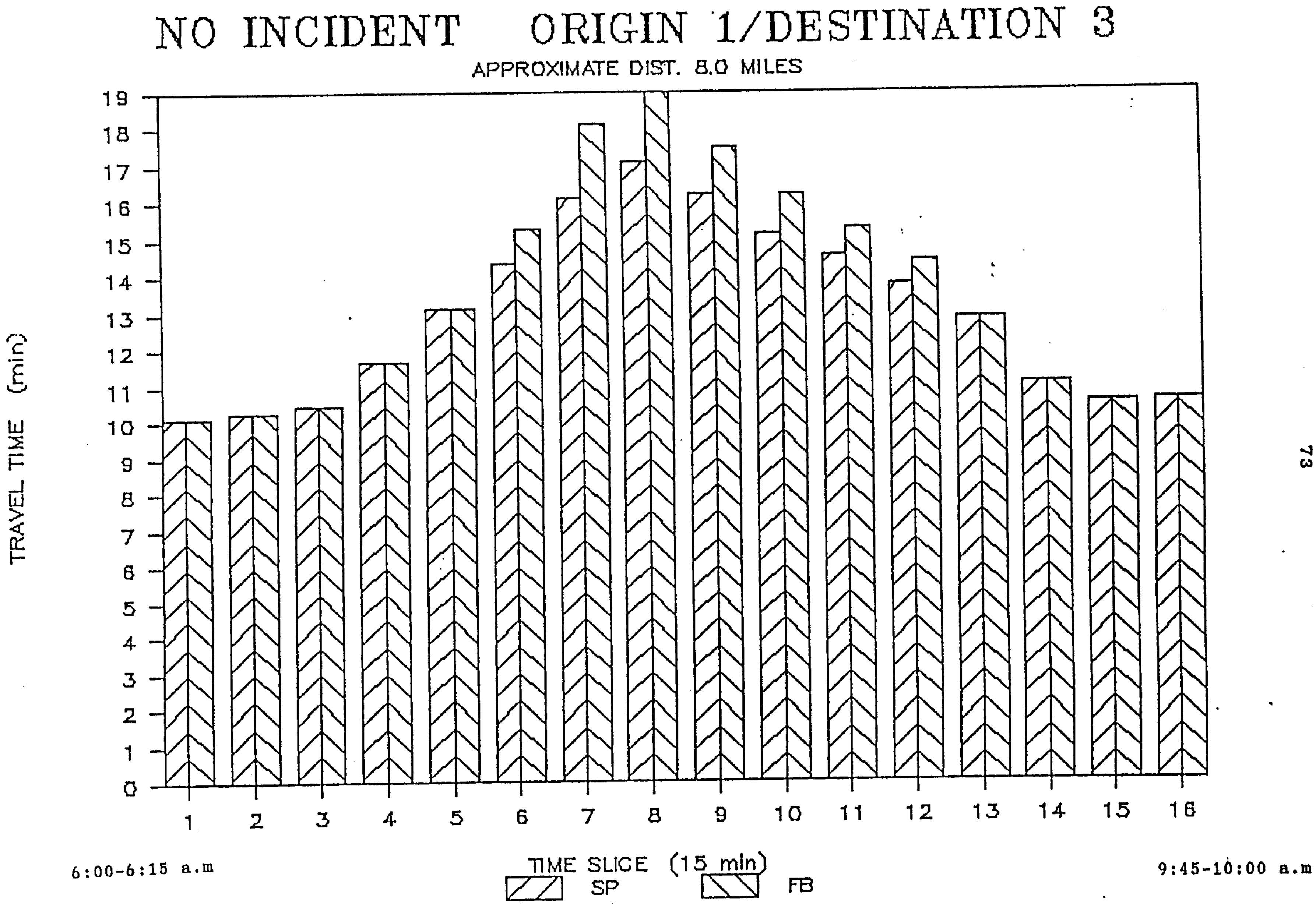

NO INCIDENT ORIGIN 1/DESTINATION 3
APPROXIMATE DIST. 8.0 MILES
TRAVEL TIME (min)
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
6:00-6:15 a.m
TIME SLICE (15 min)
9:45-10:00 a.m
SP
FB

FIGURE V-3

The maximum time savings when utilizing the shortest path occur during time slices seven and/or eight (7:30 - 7:45 A.M. and 7:45 - 8:00 A.M.) for trips to all three destinations. The maximum travel time savings to destination one is approximately one minute or a 5% reduction in travel time. The maximum time savings to destinations two and three is approximately two minutes or 8% and 11% reductions in travel time respectively.

2. Origin 2 - National at Sawtelle

Figures V-4, 5, and 6 depict the travel times for trips beginning at origin two and traversing to destinations one, two, and three respectively via the shortest path, the freeway-biased path, and three surface street biased paths, namely National/Venice; National/Adams; and National/Washington paths.

As shown in figures V-4, 5, and 6, the shortest path deviates from the freeway biased path and reduces the travel time for all three destinations during a one hour and forty five period between 7:15 A.M. and 9:00 A.M. (time slices b-12). From 6:00 A.M. to 7:15 A.M. and from 9:00 A.M. to 10:00 A.M. the shortest path is the freeway biased path. This is identical to origin one trips previously described. The shortest paths from origin two deviate from all surface street biased paths and reduces the travel time in all sixteen time slices (6:00 A.M. - 10:00 A.M.) for all three destinations.

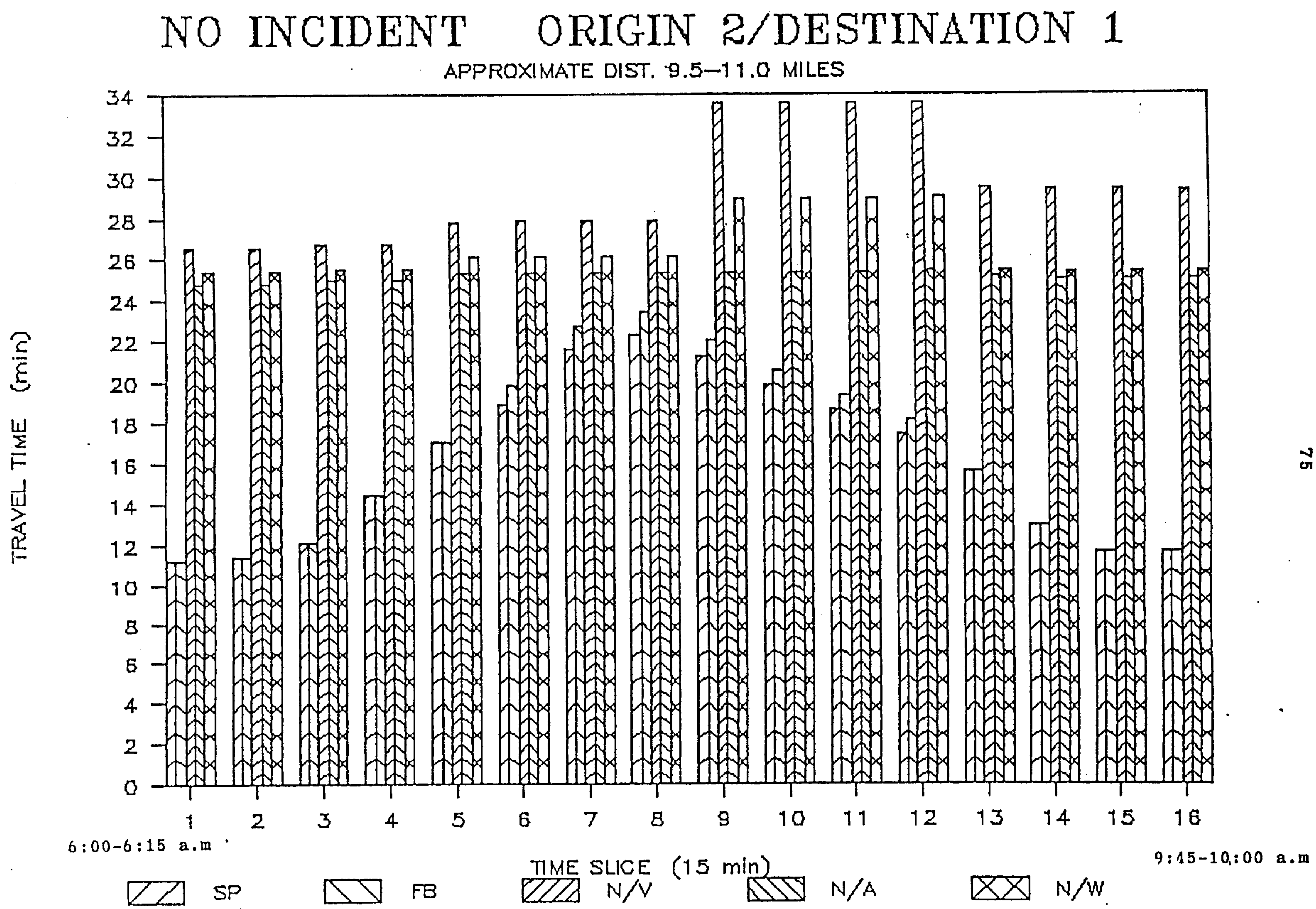
As far as the freeway biased path is concerned, the maximum time savings when utilizing the shortest path occur during the same time periods and have the same values as that of origin one trips with respect to each destination. The individual shortest path and freeway-biased path travel times from origin two do vary from origin one trips but the differences in travel times for the shortest path and freeway-biased path are equal for each respective destination.

As far as the surface street biased paths are concerned, the maximum time savings when utilizing the shortest path occurs during time slice fifteen (9:30-9:45 A.M.) on the National/Venice path to destination 1 and has a value of approximately eighteen minutes or 6l% reduction in travel time.

3. Origin 3 - Venice at Sawtelle

Figures V-7, 8, and 9 depict the travel times for trips beginning at origin three and traversing to destinations one, two, and three respectively via the shortest path, the freeway-biased path, and three surface street biased paths, namely Venice; Venice/Adams; and Venice/Washington paths.

As shown in figures V-7, 8, and 9, the shortest path deviates



NO INCIDENT ORIGIN 2/DESTINATION 1
APPROXIMATE DIST. 9.5–11.0 MILES
TRAVEL TIME (min)
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
6:00-6:15 a.m
9:45-10:00 a.m
TIME SLICE (15 min)
SP
FB
N/V
N/A
N/W

FIGURE V-4

NO INCIDENT ORIGIN 2/DESTINATION 2

APPROXIMATE DIST. 9.5–11.5 MILES

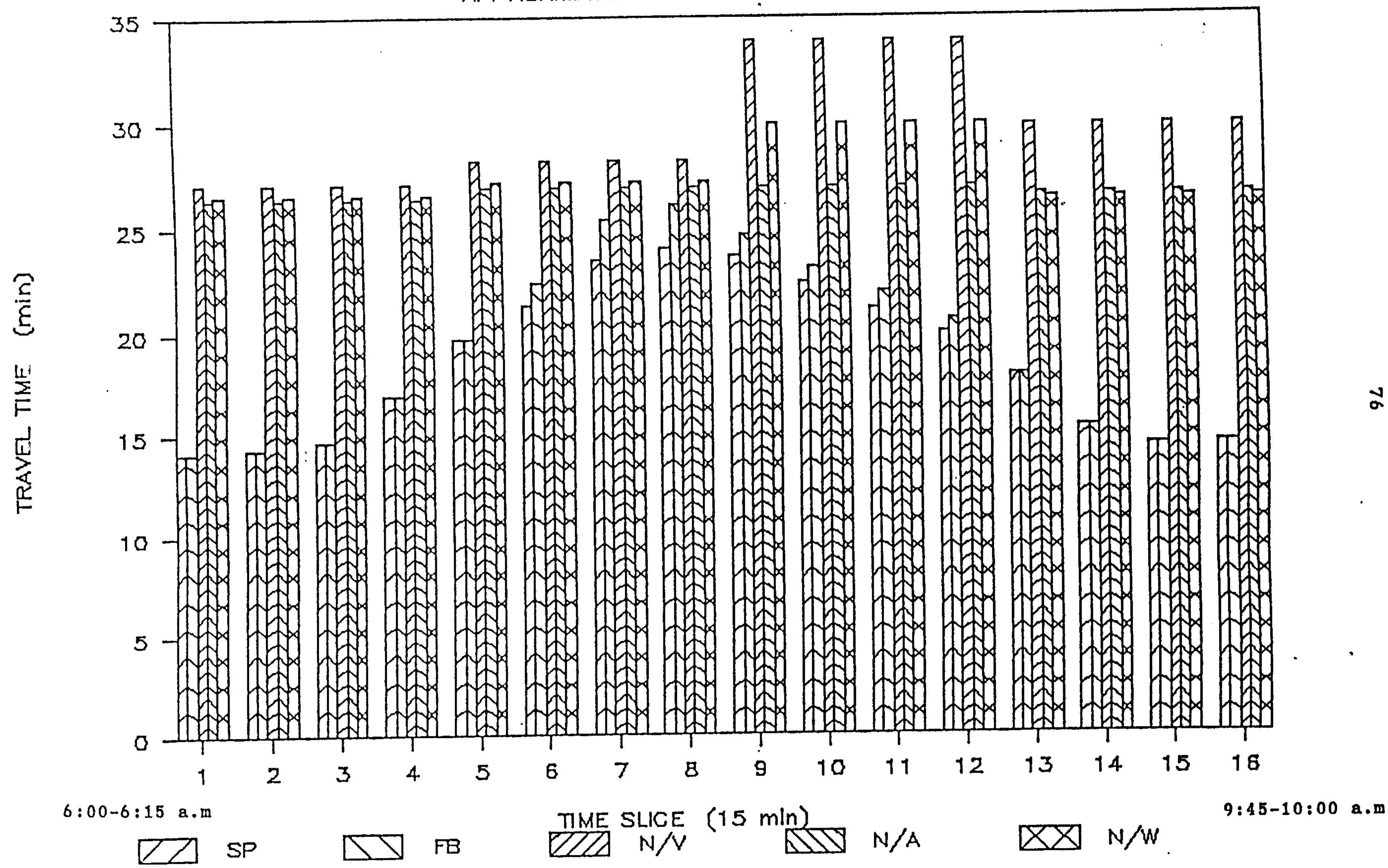


FIGURE V-5

NO INCIDENT ORIGIN 2/DESTINATION 3

APPROXIMATE DIST. 7.0–9.0 MILES

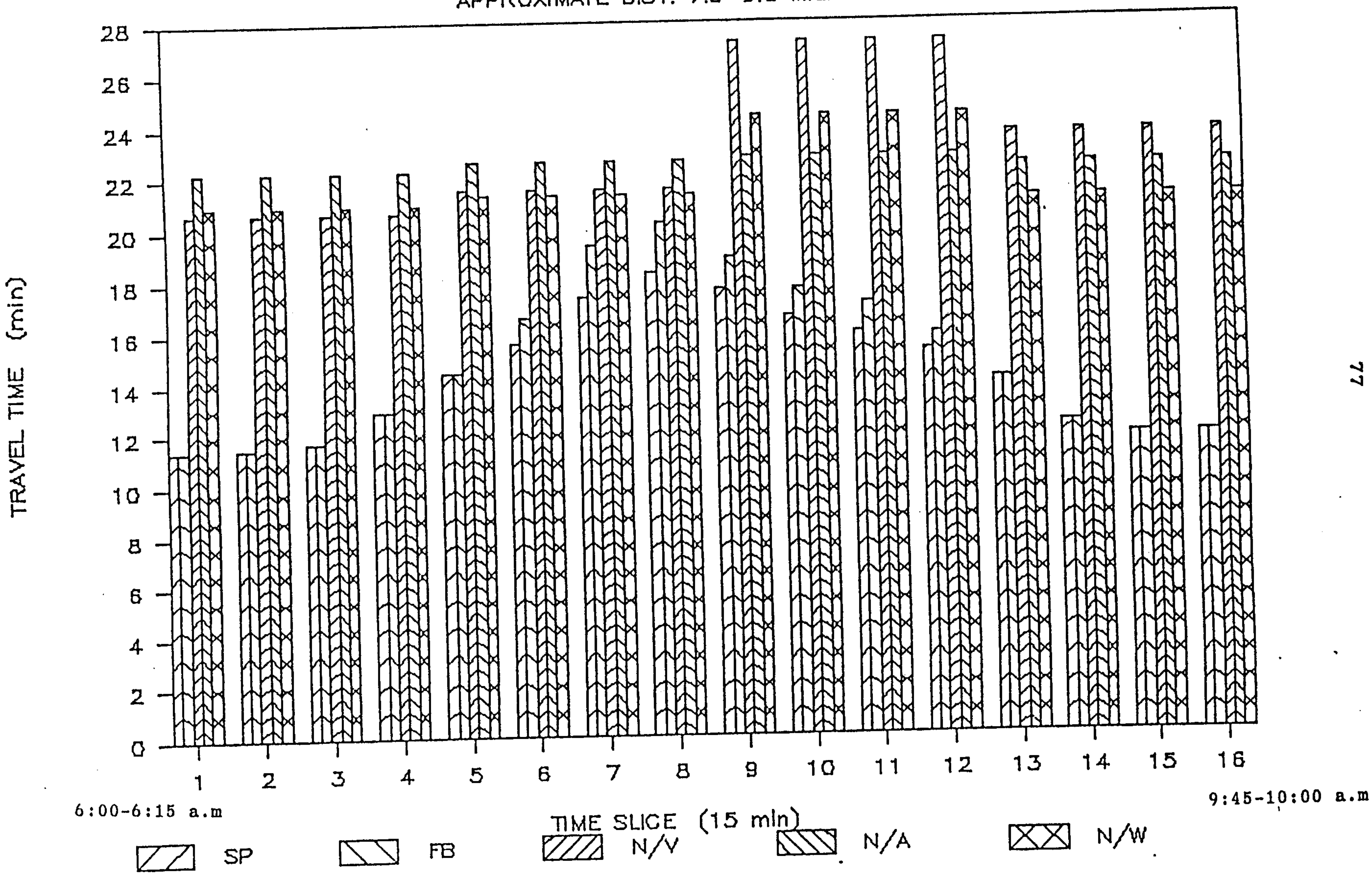


FIGURE V-6

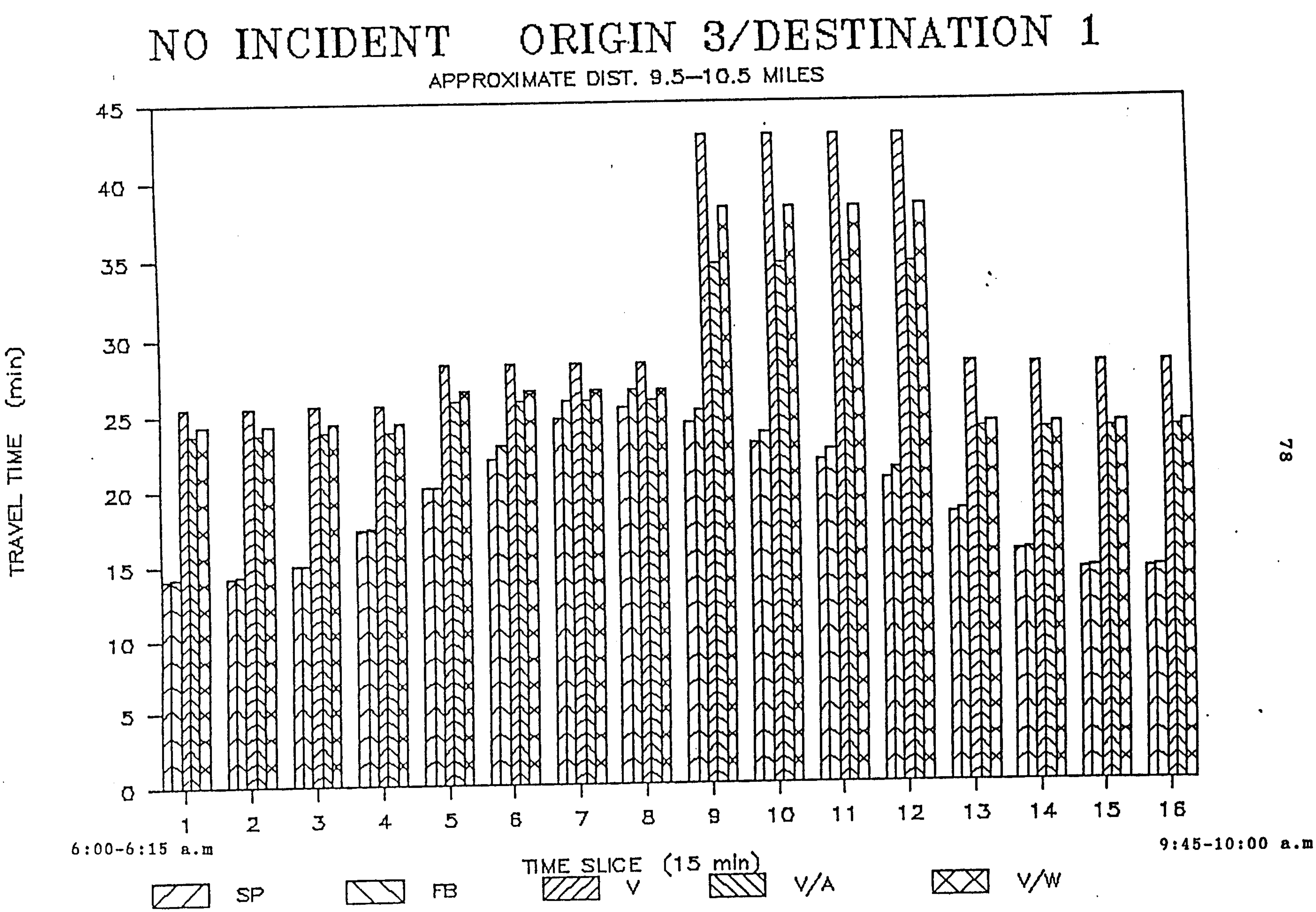

NO INCIDENT ORIGIN 3/DESTINATION 1
APPROXIMATE DIST. 9.5–10.5 MILES
TRAVEL TIME (min)
45
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
6:00-6:15 a.m
9:45-10:00 a.m
TIME SLICE (15 min)
SP
FB
V
V/A
V/W

FIGURE V.7

NO INCIDENT ORIGIN 3/DESTINATION 2

APPROXIMATE DIST. 10.0–10.5 MILES

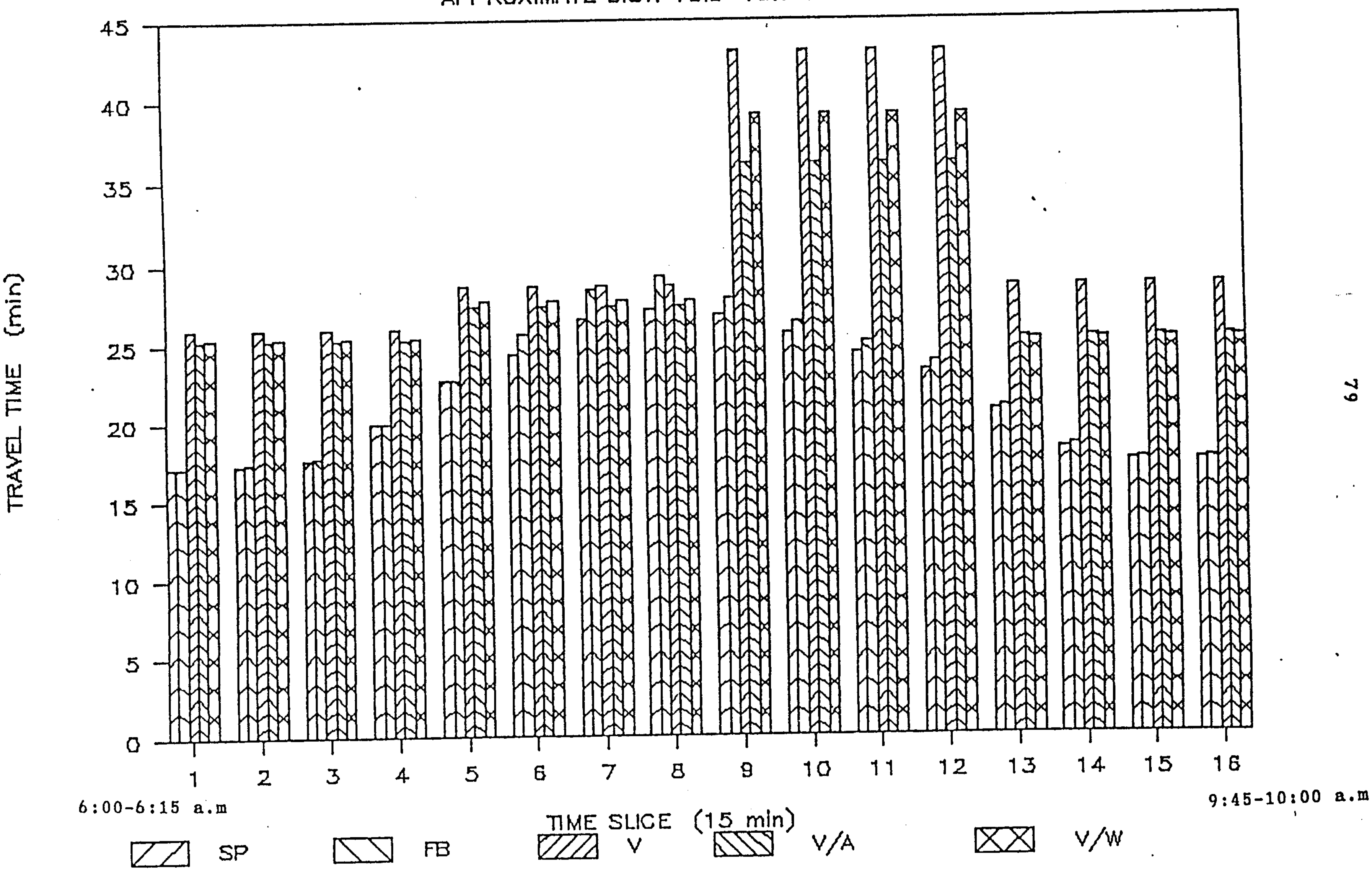


FIGURE V-8

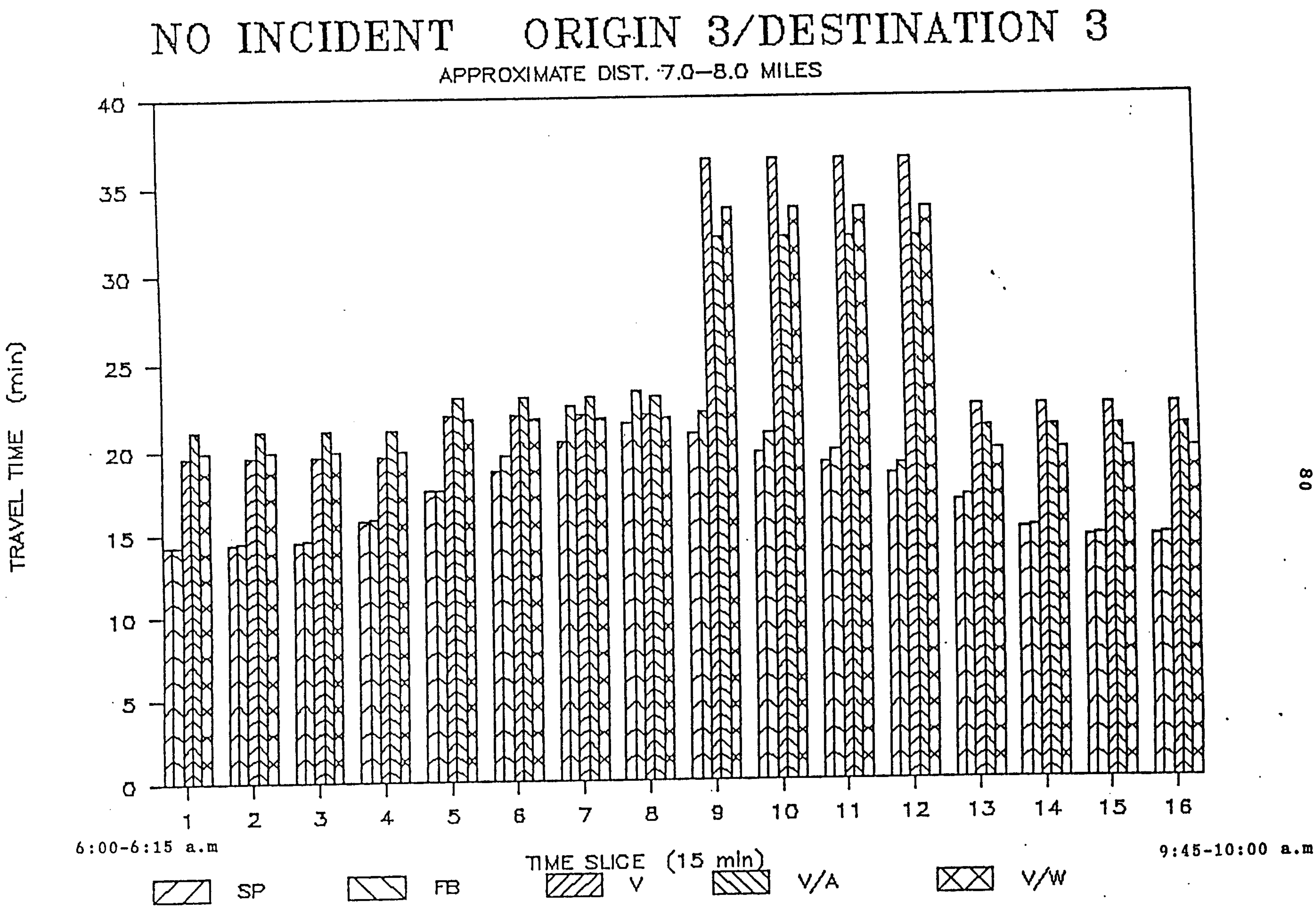

NO INCIDENT ORIGIN 3/DESTINATION 3
APPROXIMATE DIST. 7.0–8.0 MILES
TRAVEL TIME (min)
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
6:00-6:15 a.m
9:45-10:00 a.m
TIME SLICE (15 min)
SP
FB
V
V/A
V/W

FIGURE V-9

from the freeway-biased path and reduces the travel times for all three destinations for all time slices except time slice five. The larger travel time savings occur during time slices six thru twelve (7:15-9:00 A.M.), as is the case for trips from origin one and two. The shortest paths from origin three deviate from all three surface street biased paths and reduces the travel time in all sixteen time slices for all three destinations.

As far as the freeway-biased path is concerned, the maximum time savings when utilizing the shortest path occur during the same time periods and have the same values as that of origin one and origin two trips with respect to each destination. The individual shortest path and freeway-biased path travel times from origin three do vary from origin one and origin two trips but the differences in travel times for the shortest path and freeway-biased path are equal for each respective destination.

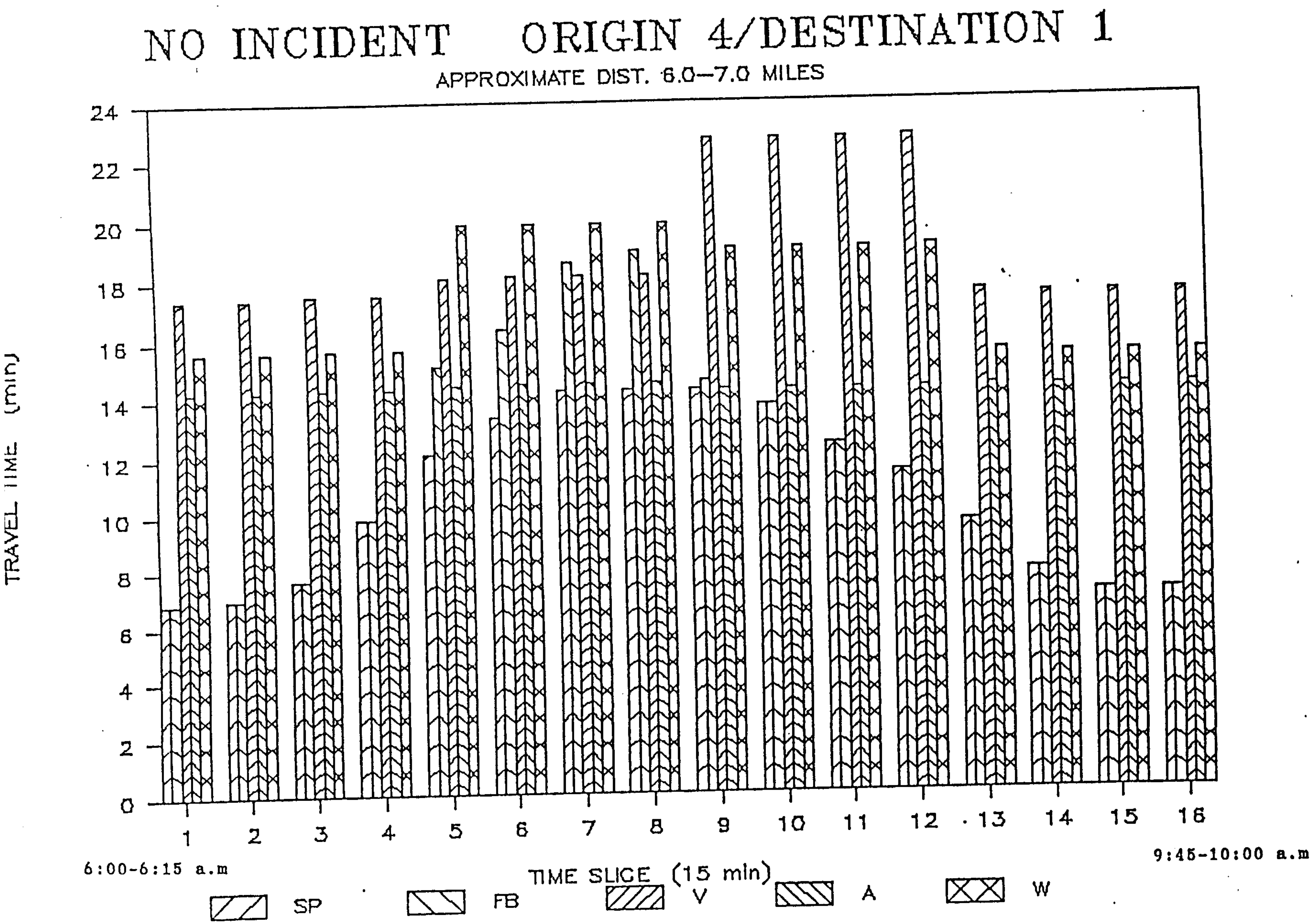
As far as the surface street biased paths are concerned, the maximum time savings when utilizing the shortest path occurs during time slice twelve (8:45-9:00 A.M.) on the Venice path to destination 1 and has a value of approximately twenty two minutes or a 52% reduction in travel time.

4. Origin 4 - Adams at Fairfax

Figures v-10, 11, and 12 depict the travel times for trips beginning at origin four and traversing to destinations one, two, and three respectively via the shortest path, the freeway-biased path, and three surface street biased paths, namely Venice; Adams; and Washington paths. It should be noted that no route descriptions exist for origin four in the origin/destination survey taken and therefore no Information exists in the survey for trips from origin 4 to suggest that the freeway-biased path IS the user-defined path. However, the route choice survey did suggest that user-specified trips from origins 1, 2, and 3 are freeway-biased. Therefore, the same was assumed for trips from origin 4.

As shown in figures VI-l0, 11, and 12, the shortest path deviates from the freeway-biased path and reduces the travel times during time slices five thru nine (7:00-8:15 A.M.) for trips to destination one. For trips to destinations two and three, the shortest path deviates from the freeway-biased path during time slices four thru ten. The larger travel time savings for trips to all three destinations occur during time slices five thru eight (7:00-8:00 A.M.).

The shortest paths from origin four do not deviate from all surface street biased paths for all time slices. During time slices seven thru ten (7:30-8:30 A.M.), the surface street biased path on Adams Boulevard is the shortest path for trips to destination two.



NO INCIDENT ORIGIN 4/DESTINATION 1
APPROXIMATE DIST. 6.0–7.0 MILES
TRAVEL TIME (min)
24
22
20
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
6:00-6:15 a.m
9:45-10:00 a.m
TIME SLICE (15 min)
SP
FB
V
A
W

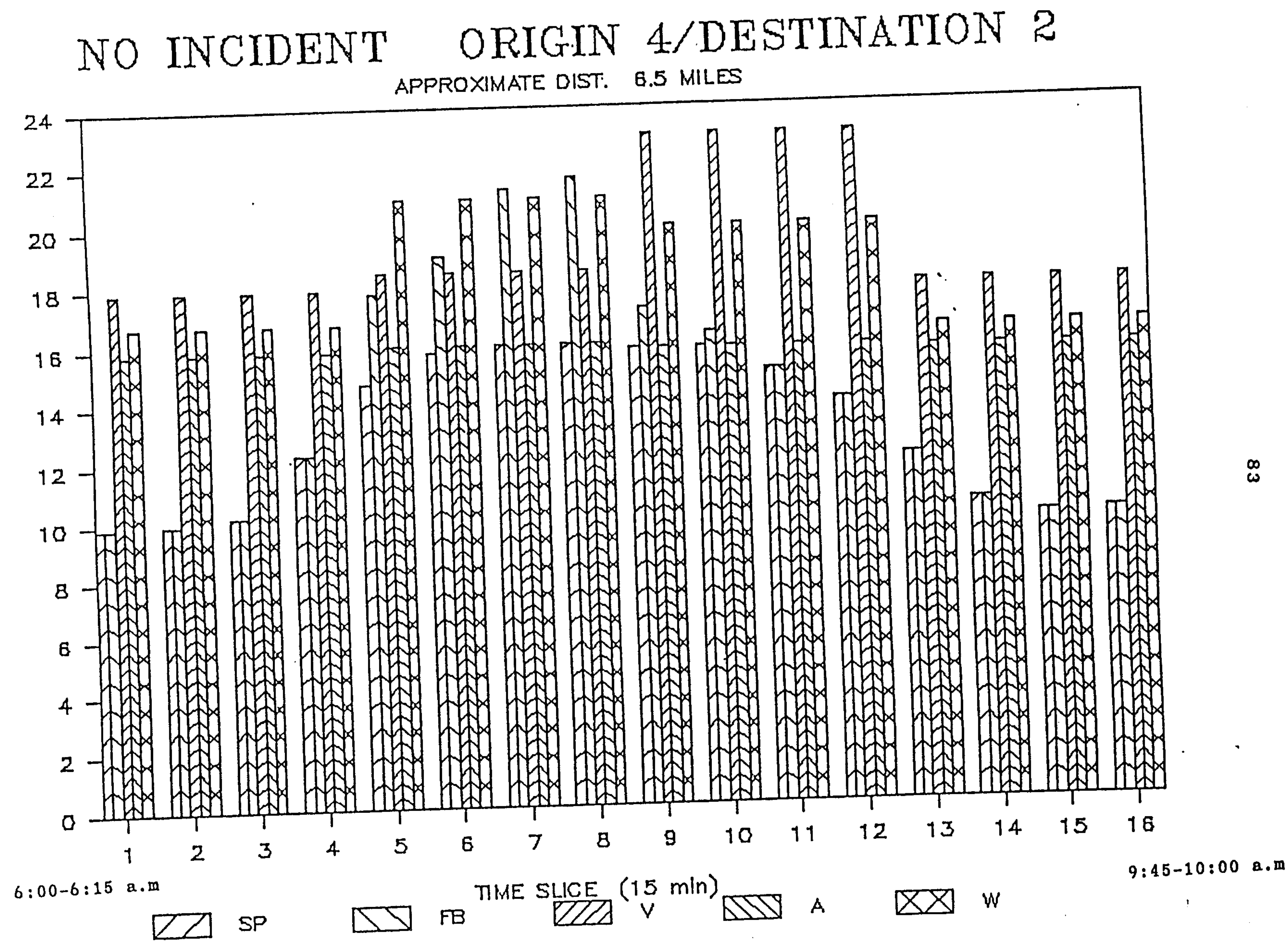

NO INCIDENT ORIGIN 4/DESTINATION 2
APPROXIMATE DIST. 6.5 MILES
TRAVEL TIME (min)
24
22
20
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
6:00-6:15 a.m
9:45-10:00 a.m
TIME SLICE (15 min)
SP
FB
V
A
W

FIGURE V-11

NO INCIDENT ORIGIN 4/DESTINATION 3

APPROXIMATE DIST. 4.5 MILES

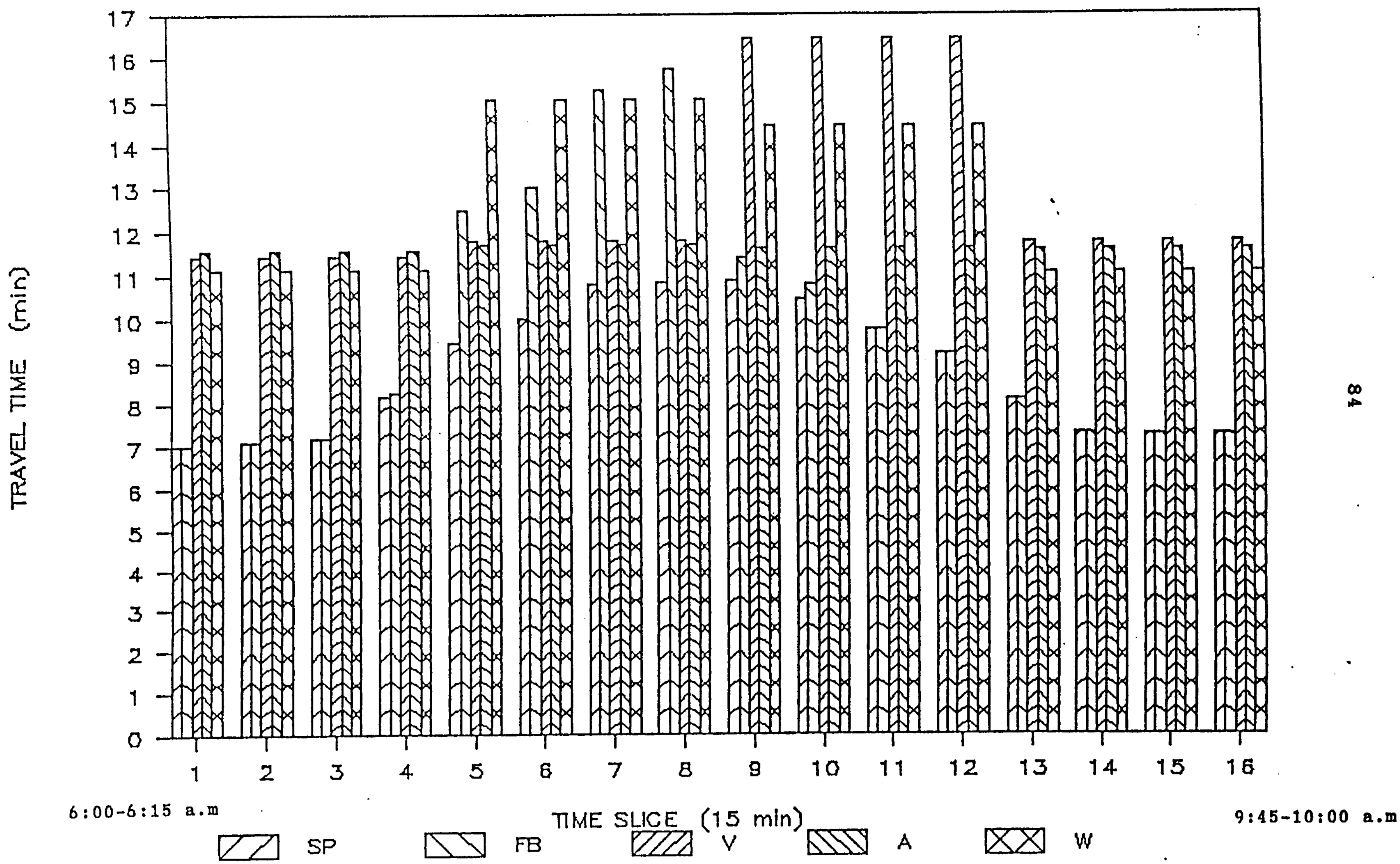


FIGURE V-12

As far as the freeway-biased path is concerned, the maximum time savings when utilizing the shortest path occur during time slice eight (7:45-8:00 A.M.) for trips to all three destinations. The maximum travel time savings to destination one is approximately five minutes or a 25% reduction in travel time; to destination two is approximately six minutes or a reduction of 26% in travel time; and to destination three is approximately five minutes or a 31% reduction in travel time.

As far as the surface street biased paths are concerned, the maximum time savings when utilizing the shortest path occur during time slice twelve (8:45-9:00 A.M.) and has a value of approximately eleven minutes. It should be noted that the freeway biased path is the worst path to take for trips to destinations two and three during time slices seven and eight (7:30-7:45 A.M. and 7:45-8:00 A.M.).

C. SUMMARY: NON-INCIDENT SCENARIO

Two assumptions made in this analysis are that the freeway-biased path is the predominant local user-specified path and travel time savings less than three minutes when utilizing the shortest path are not considered significant. Thus, only trips from origin four (to all three destinations) utilizing the shortest path information have significant travel time savings for the local driver In the non-incident scenario and only during the time period from 7:00-8:00 A.M. (time slices 5-8).

The freeway-biased path is actually the path with the longest travel time for four origin/destination pairs, namely origin three to destinations two and three during time slice eight (7:45-8:00 A.M.) and origin four to destinations two and three during time slices seven and eight (7:30-8:00 A.M.).

For trips to destination one and two from all four origins during time slice eight (7:45-8:00 A.M.), Adams Boulevard is the shortest path east of the southbound La Cienega off ramp. Of course trips to destination one must reenter the freeway. Figures v-13, 14, and 15 depict the shortest path routes taken during time slice eight for all origin/destination combinations.

D. INCIDENT SCENARIO

The second set of routing results are for the "incident scenario", in which a freeway incident was introduced in the eastbound direction between Venice and WaShingtOn during time slices 3, 4, and 5.

In general, the incident scenario yields substantially higher

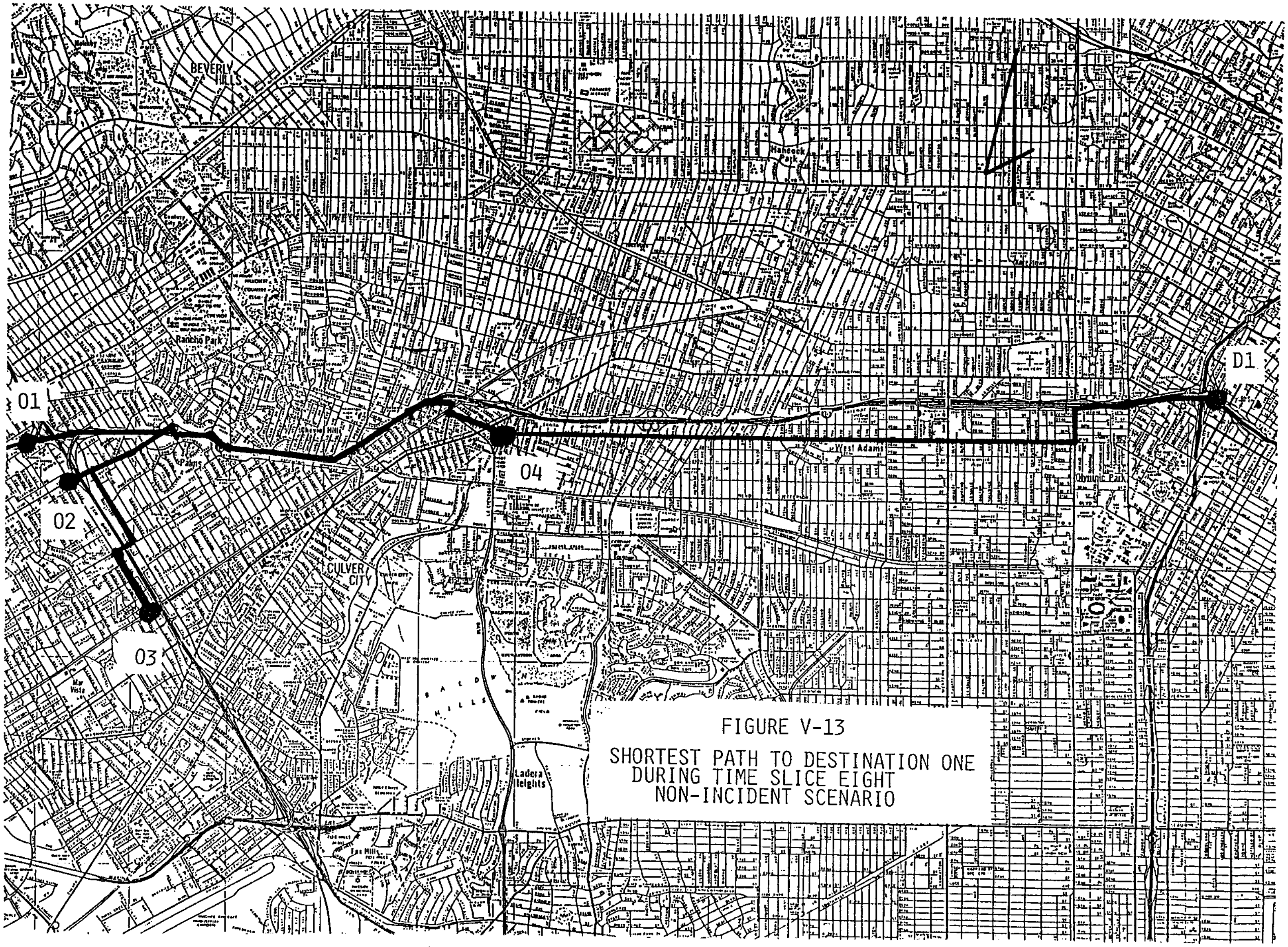


FIGURE V-13

SHORTEST PATH TO DESTINATION ONE
DURING TIME SLICE EIGHT
NON-INCIDENT SCENARIO

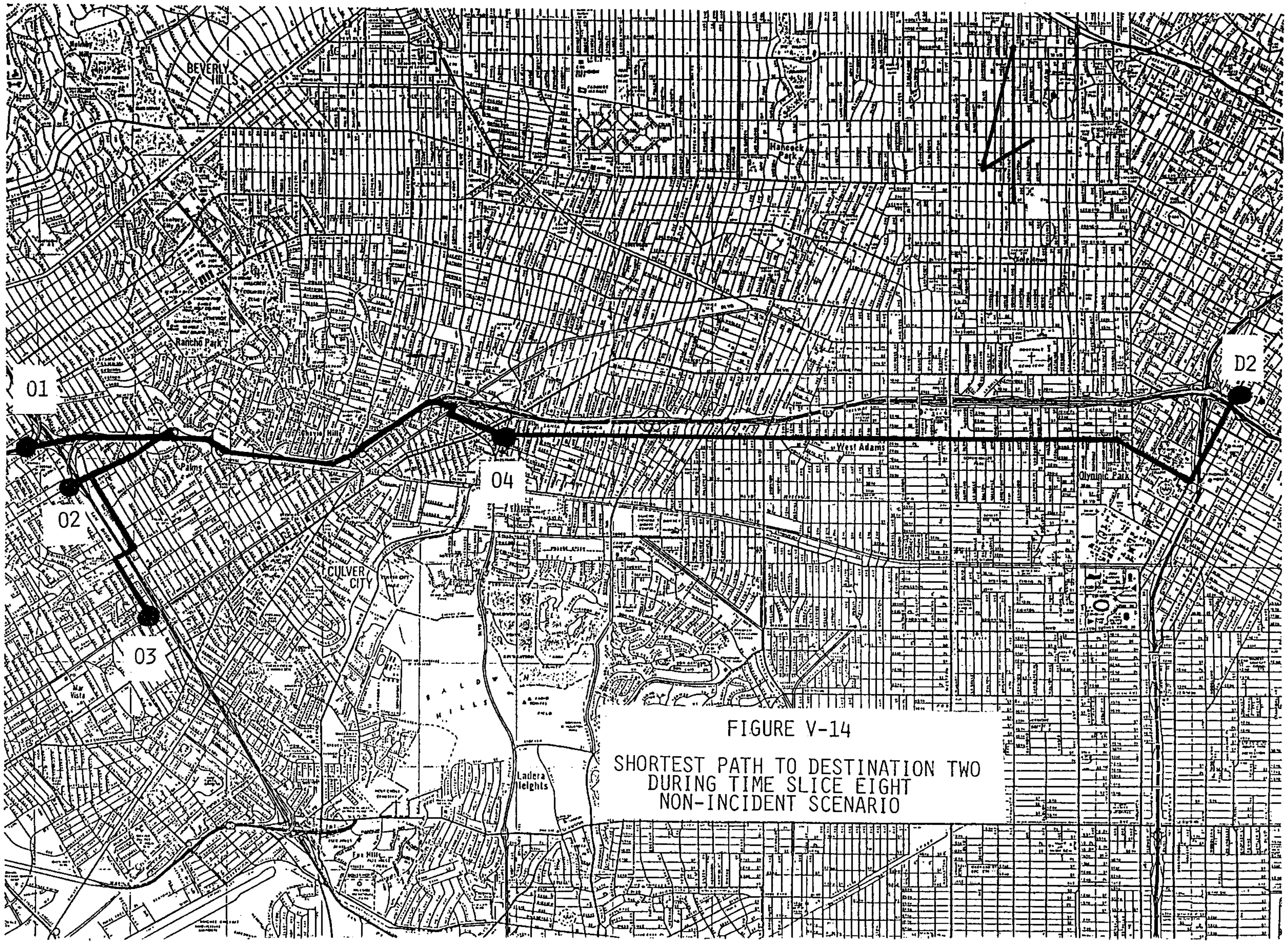


FIGURE V-14

SHORTEST PATH TO DESTINATION TWO
DURING TIME SLICE EIGHT
NON-INCIDENT SCENARIO

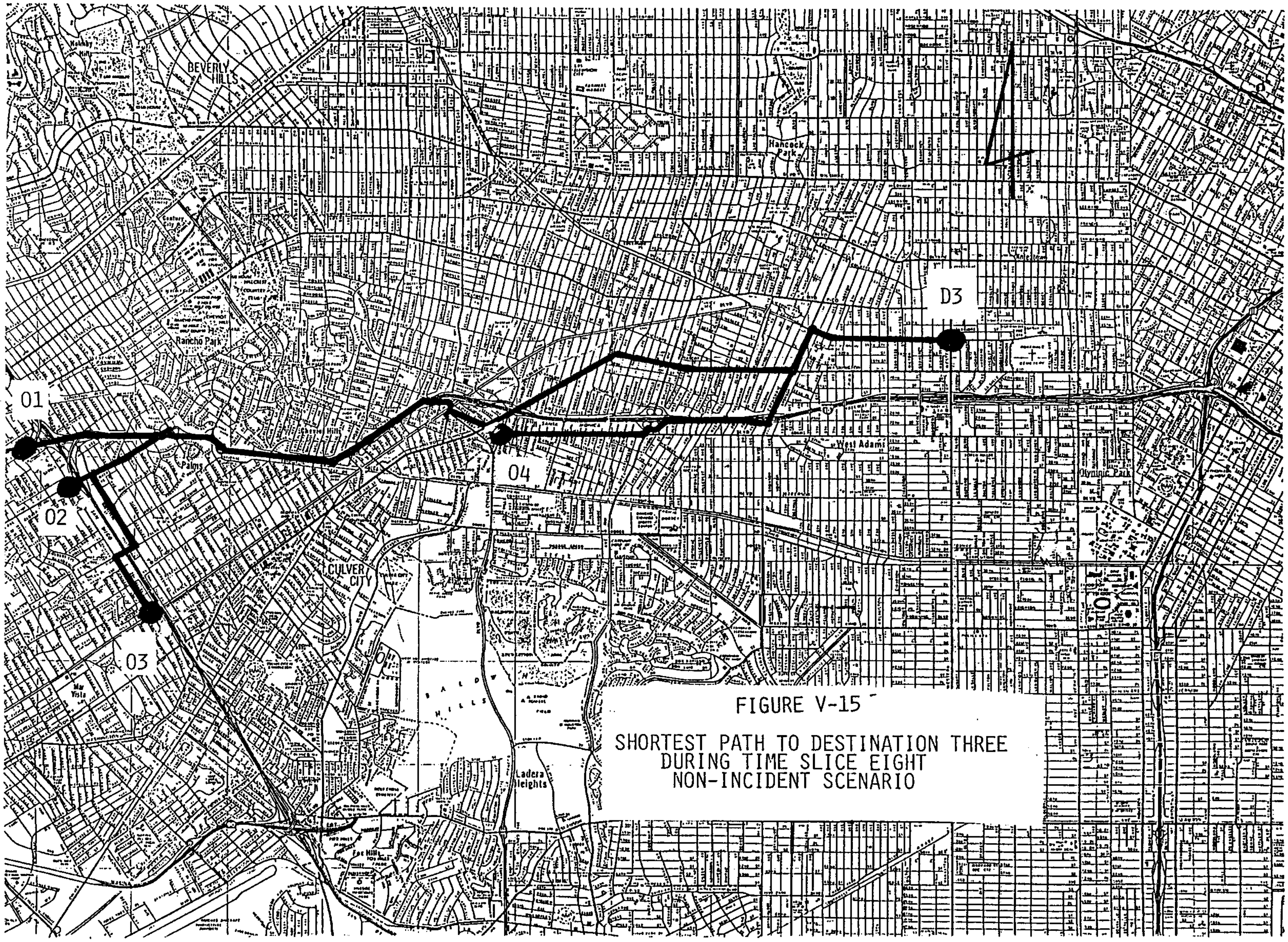


FIGURE V-15

SHORTEST PATH TO DESTINATION THREE
DURING TIME SLICE EIGHT
NON-INCIDENT SCENARIO

travel times for the freeway-biased routes, as compared to the set of model runs with no incident (the "non-incident scenario.") During time slices 3, 4, and 5, travel times for most shortest-path routes in the incident scenario are longer than shortest-path routes for the non-incident scenario, but the difference is not as great as between the freeway-biased routes for the two scenarios. The result is that, for most routes through the corridor, the potential benefits of using the shortest path are greater in the incident scenario than in the non-incident scenario.

There is no difference between the two scenarios in travel times on arterial streets since the effects of the incident were not incorporated into the TRANSYT model used to calculate arterial delays. Also, no effects that might occur as a result of traffic diverting off the freeway onto arterial streets were Included in the model. Therefore, there is no difference between travel times on arterial-biased routes between the incident and non-incident scenarios, except for routes ending at Destination 1, where freeway links are included on part of the routes. When the cost of freeway links differs between the two scenarios, so does the cost of any arterial-biased route including any of the links.

The principal difference between the two scenarios is that the incident affects the spatial and temporal location of bottlenecks on the freeway. As discussed in detail in Chapter 11, the introduction of the incident between Venice and Washington resulted immediately in much slower speeds upstream of the blockage, but also metered traffic downstream of the incident, resulting in higher speeds in downstream freeway sections further east. This phenomenon results in higher travel times for routes using the freeway west of the incident, but lower travel times for routes using freeway sections east of the incident location.

1. Origin/Destination Pairs Comparisons

The costs of shortest, freeway-biased, and arterial-biased routes were computed under the incident scenario for the same 12 origin-destination pairs as under the non-incident scenario. Potential benefits reach their peak during the most congested time slices, during the presence of the incident in time slices 4 and 5. A second rise in benefits in the incident scenario, paralleling the peak period of benefits in the non-incident scenario, is reached at the time that recurring congestion reaches a maximum in the non-incident scenario, during time slices 7 and 8. This second rise is smaller in magnitude but broader than the first peak, because effects of the incident linger throughout the study period, and because much of the benefits in the second rise are due to the same recurring congestion as In the non-incident scenario.

a. <u>Origin l/Destination 1, Origin l/Destination 2. Origin l/Destination 3</u>

As in the non-incident scenario, only the shortest and freeway-biased paths through the corridor were found for these OD pairs because the origin point is on the freeway itself. In the non-incident scenario during time slices 3, 4, and 5, the shortest path remained entirely on the freeway. With the incident introduced in time slices 3. 4, and 5, travel times increased a great deal on freeway sections. As a result, the shortest path involves diverting from the freeway onto parallel side streets. As the speeds on the freeway section affected by the incident drop In successive time slices, the diversion path involves less and less freeway travel. The routes given in the shortest paths between Origin 1 and Destination 1 serve as a typical example of how the diversion point from the freeway moves westward along with the area of congested freeway traffic:

Time Slice 3: Divert from Freeway via LaCienega Exit LaCienega, Venice, return to freeway on Venice on-ramp.

Time Slice 4: Divert from Freeway via Robertson Exit, Robertson, Venice, return to freeway on Venice on-ramp.

Time slice 5: Divert from Freeway via Overland Exit, National, Overland, Palms/National, Venice, return to freeway on Venice on-ramp.

Figures V-16, 17, and 18 depict the travel times for trips beginning at origin one and traversing to destinations one, two, and three respectively via the shortest path and the freeway biased path. The maximum travel time savings (shortest path versus freeway biased path) were approximately six minutes for trips to all three destinations or a 25% reduction in travel time.

b. <u>Origin a/Destination 1. Origin 2/Destination 2. Origin 2/Destination 3</u>

Origin 2, on eastbound National at Sawtelle, is close to a freeway entrance. During light traffic, the shortest path enters the freeway on the Overland on-ramp, the closest one available. However, as freeway congestion increases due to the incident, the point of entry onto the freeway is displaced further east. Time savings are realized by delaying entry onto the freeway; for time slice 5, the shortest-path routing delays entry on the freeway until the Venice on-ramp. (The route follows National to Venice up to this point). For these three O-D pairs, the freeway-biased route is always shorter than the arterial-biased route. Pairs originating from origin 3 exhibit similar characteristics to the O-D pairs from origin 2.

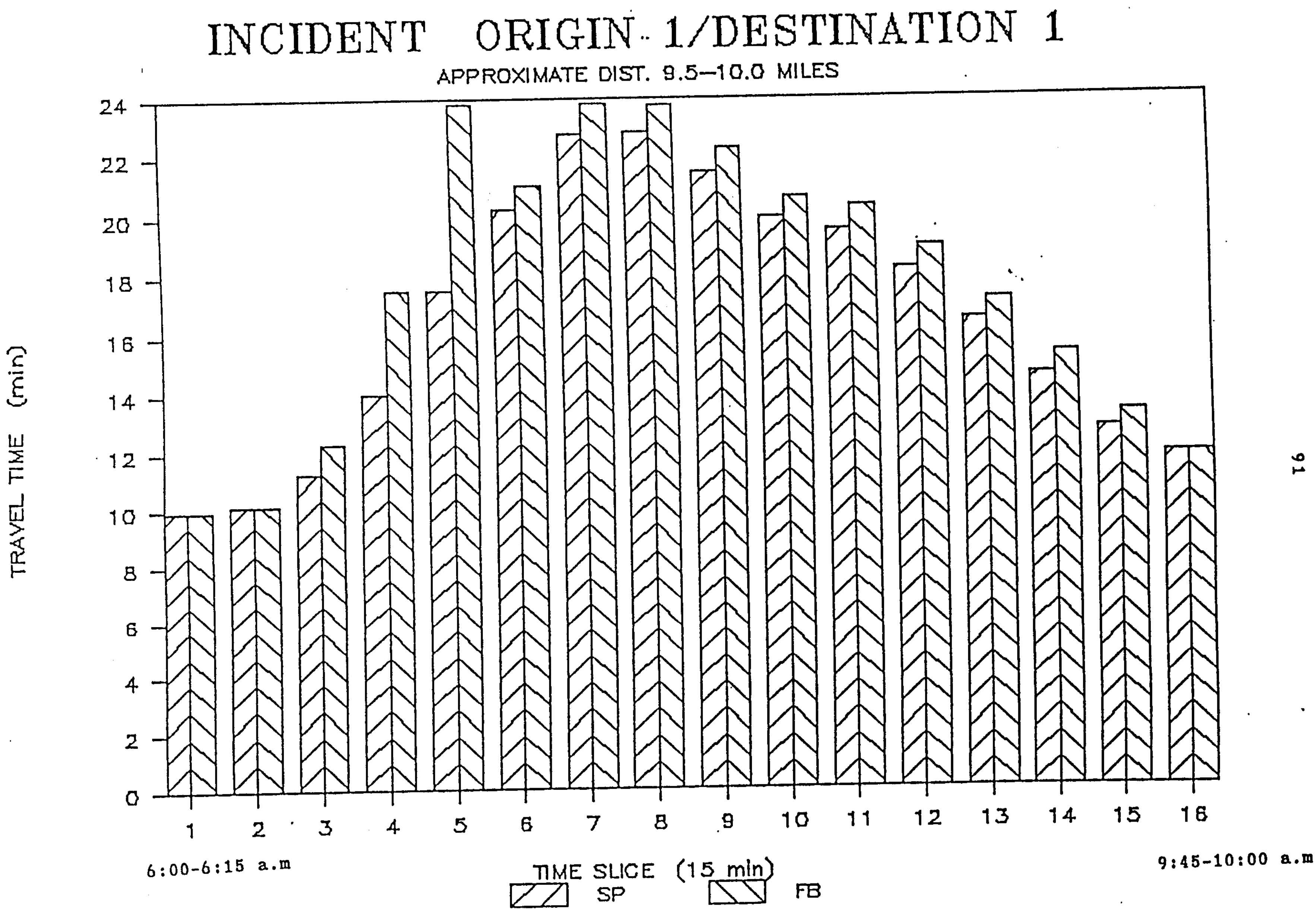

INCIDENT ORIGIN 1/DESTINATION 1
APPROXIMATE DIST. 9.5–10.0 MILES
TRAVEL TIME (min)
0
2
4
6
8
10
12
14
16
18
20
22
24
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
6:00-6:15 a.m
9:45-10:00 a.m
TIME SLICE (15 min)
SP
FB

FIGURE V-16

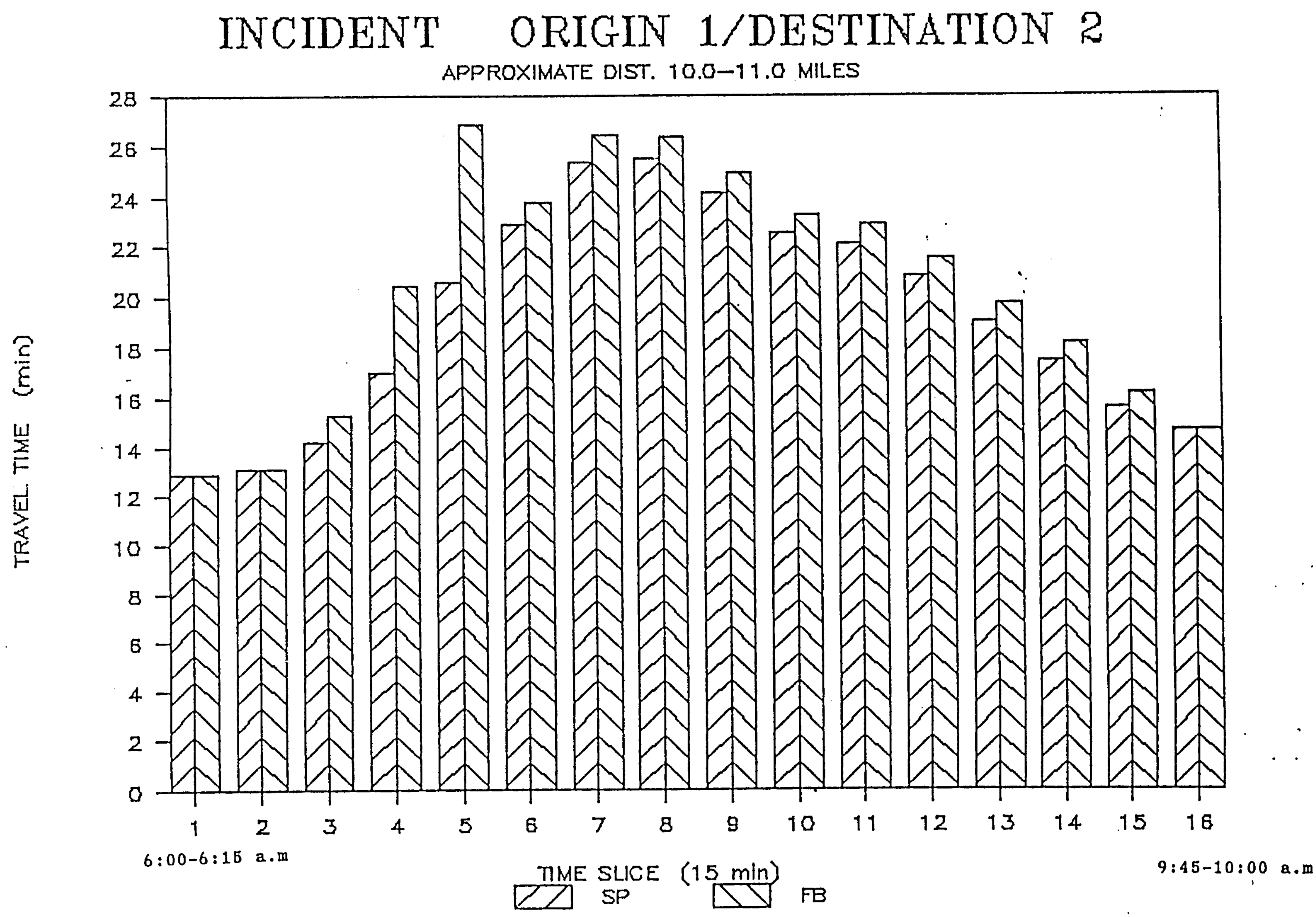

INCIDENT ORIGIN 1/DESTINATION 2
APPROXIMATE DIST. 10.0–11.0 MILES
TRAVEL TIME (min)
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
6:00-6:15 a.m
9:45-10:00 a.m
TIME SLICE (15 min)
SP
FB

FIGURE V-17

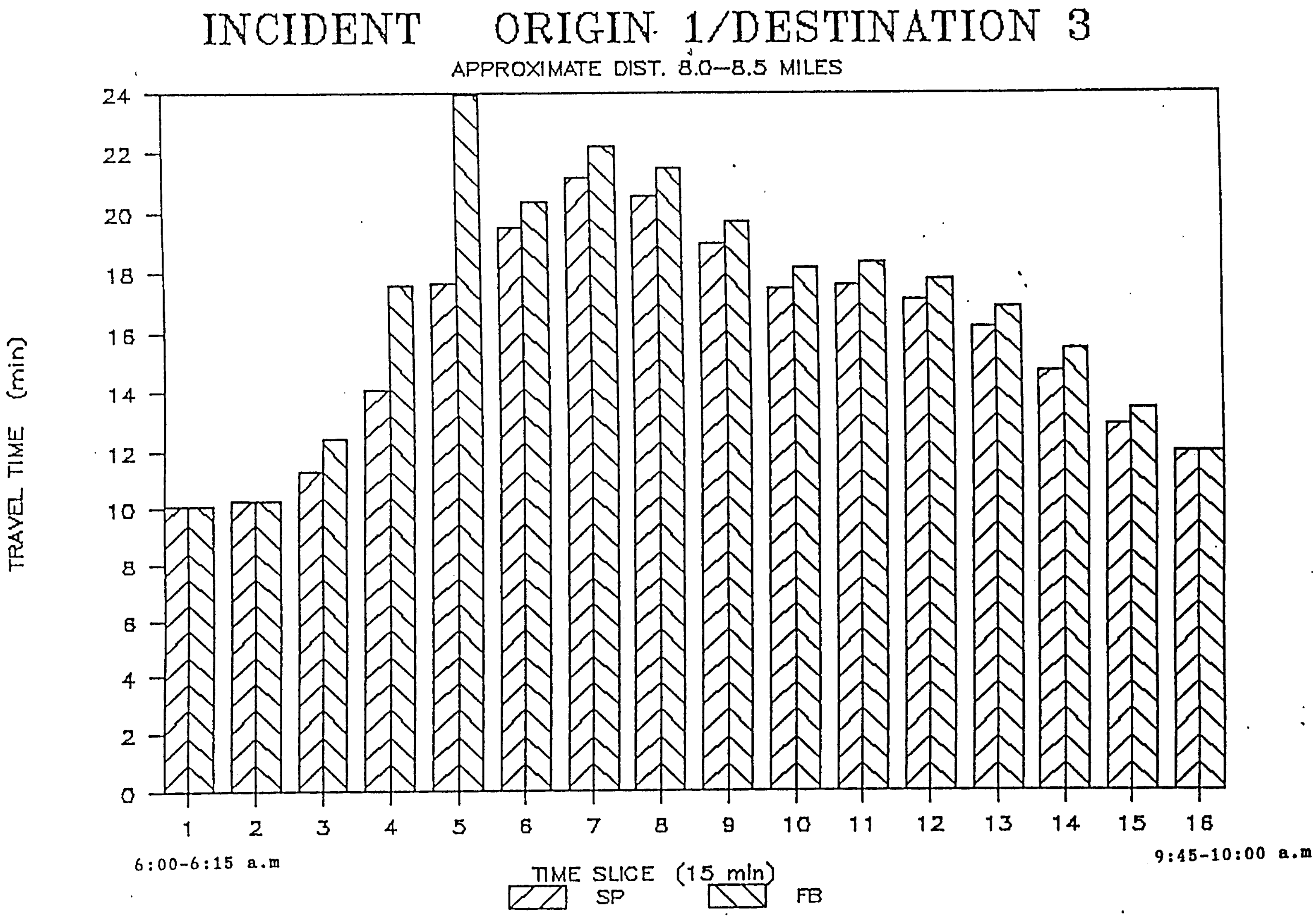

INCIDENT ORIGIN 1/DESTINATION 3
APPROXIMATE DIST. 8.0—8.5 MILES
TRAVEL TIME (min)
0
2
4
6
8
10
12
14
16
18
20
22
24
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
6:00-6:15 a.m
9:45-10:00 a.m
TIME SLICE (15 min)
SP
FB

FIGURE V-18

Figures V-19 through 24 on pages 96 thru 101 depict the travel times for O/D pairs described in this section via the shortest path, freeway biased path, and three surface street biased paths, namely National/Venice; National/Adams; and National/Washington paths.

The maximum travel time savings (shortest versus freeway-biased path) for trips from origin 2 to destination 1 is approximately 8 minutes or a 33% reduction in travel time:

-To destination 2 is approximately 8 minutes or a 29% reduction in travel time.

-To destination 3 is approximately 8 minutes or a 32% reduction in travel time.

The maximum travel time savings for trips from origin 3:

-To destination 1 is approximately 10 minutes or a 37% reduction in travel time.

-To destination 2 is approximately 10 minutes or a 33% reduction in travel time..

-To destination 3 is approximately 10 minutes or a 37% reduction in travel time.

C. Origin 4/Destination 1, Origin 4/Destination 2. Origin 4/Destination 3

In this set of results, the incident scenario results in shorter travel times. This is because, for these routes, the bottleneck created by the incident results in faster travel on the freeway downstream of the incident, and all freeway travel is downstream of the location of the Incident. Shortest-path routes from Origin 4 actually experience a decrease in travel time in the Incident as opposed to the non-incident scenario for this reason.

There are no differences between the scenarios for travel times on the arterial-biased routes because these routes do not travel on the freeway, and only freeway travel times are affected by the incident.

Figures V-25, 26, and 27 on pages 102 thru 104 depict the travel times for the O/D pairs described in this section via the shortest path, freeway biased path, and three surface street biased paths, namely Venice; Adams; and Washington paths.

The maximum travel time savings for trips from origin 4:

-To destination 1 is approximately 3 minutes or a 25% reduction in travel time.

-To destination 2 is approximately 3 minutes or a 20% reduction in travel time.

-To destination 3 is approximately 3 minutes or a 25% reduction in travel time.

2. Differences Between Shortest Paths And Typical Routes

The differences between shortest paths and freeway-biased or arterial-biased routes are summarized In Tables V-l and V-2 on pages 105 and 106. These tables show the differences, rounded off to the nearest minute, between the travel time for the shortest path and the travel time for the freeway biased path. The freeway biased path is usually the path with the least travel time among the freeway-biased and the arterial-biased paths, but in some cases it is an arterial-biased path. In the non-incident scenario, the greatest savings occur during time slices 7 and 8, from 7:30 to 8:00 AM. For the incident scenario, the greatest savings occur during the time slices following the introduction of the freeway Incident, from 6:45 to 7:15 AM. The time period during which large savings occur is broader for the incident scenario.

Time savings of less than 3 minutes are of questionable significance. Not only might the savings be masked by random variations in travel times and driver behavior, but the threshold at which drivers might perceive benefits from optimum routing is unknown. Both of these topics are good opportunities for further research.

Also, the interpretation of the routes from this study should consider that:

- Only twelve origin/destination pairs have been analyzed
- Only traffic conditions for a "typical" day have been analyzed.
- Some turning movements on the surface streets are oversaturated, causing TRANSYT to possibly overestimate average delays for those turning movements.
- As verified by the survey, the typical corridor user chooses a freeway-biased path.
- For the incident scenario, only one incident, with its' particular characteristics, has been analyzed.

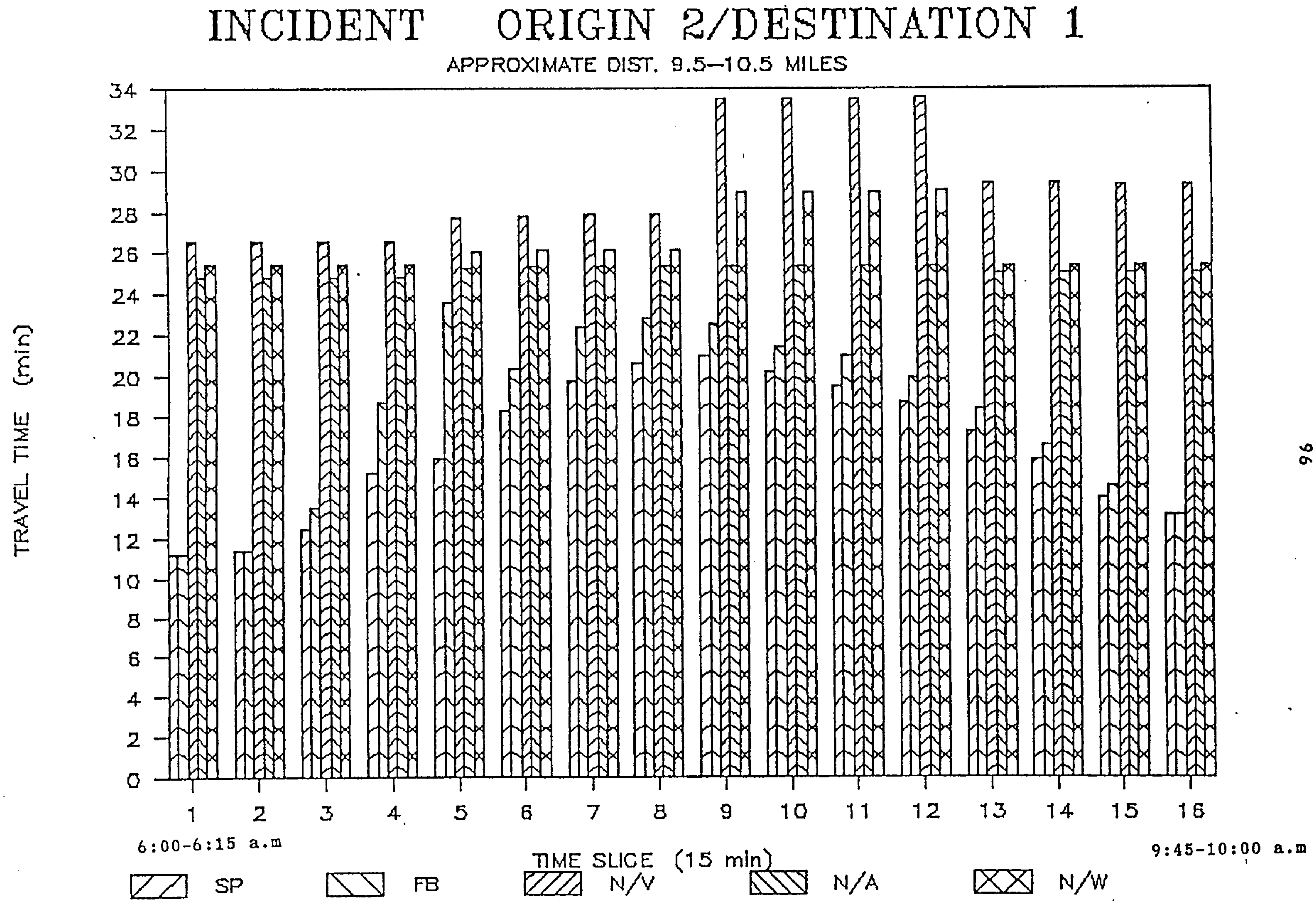

INCIDENT ORIGIN 2/DESTINATION 1
APPROXIMATE DIST. 9.5–10.5 MILES
TRAVEL TIME (min)
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
6:00-6:15 a.m
9:45-10:00 a.m
TIME SLICE (15 min)
SP
FB
N/V
N/A
N/W

FIGURE V-19

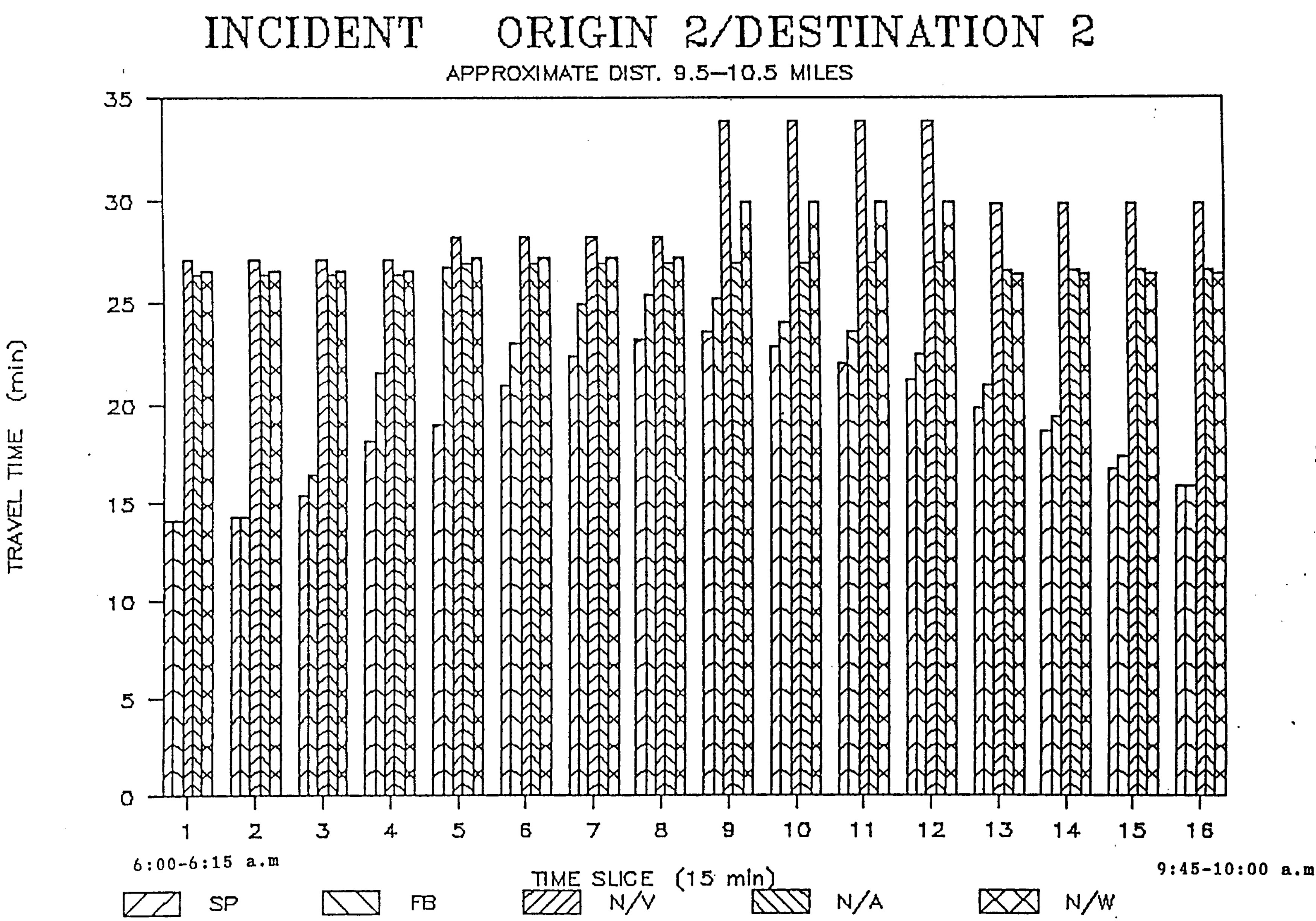

INCIDENT ORIGIN 2/DESTINATION 2
APPROXIMATE DIST. 9.5–10.5 MILES
TRAVEL TIME (min)
35
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
6:00-6:15 a.m
9:45-10:00 a.m
TIME SLICE (15 min)
SP
FB
N/V
N/A
N/W

FIGURE V-20

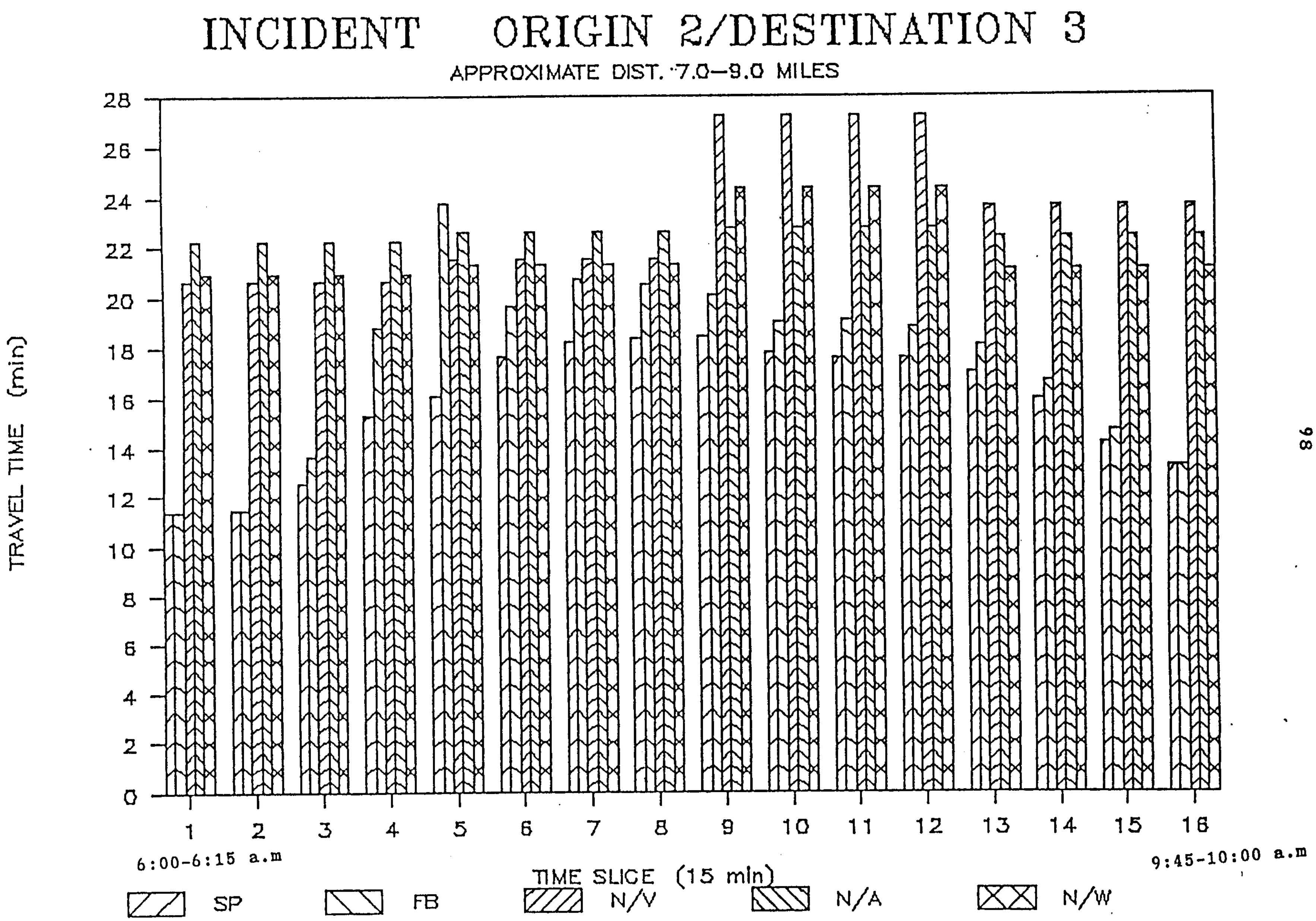

INCIDENT ORIGIN 2/DESTINATION 3
APPROXIMATE DIST. 7.0–9.0 MILES
TRAVEL TIME (min)
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
6:00-6:15 a.m
9:45-10:00 a.m
TIME SLICE (15 min)
SP
FB
N/V
N/A
N/W

FIGURE V-21

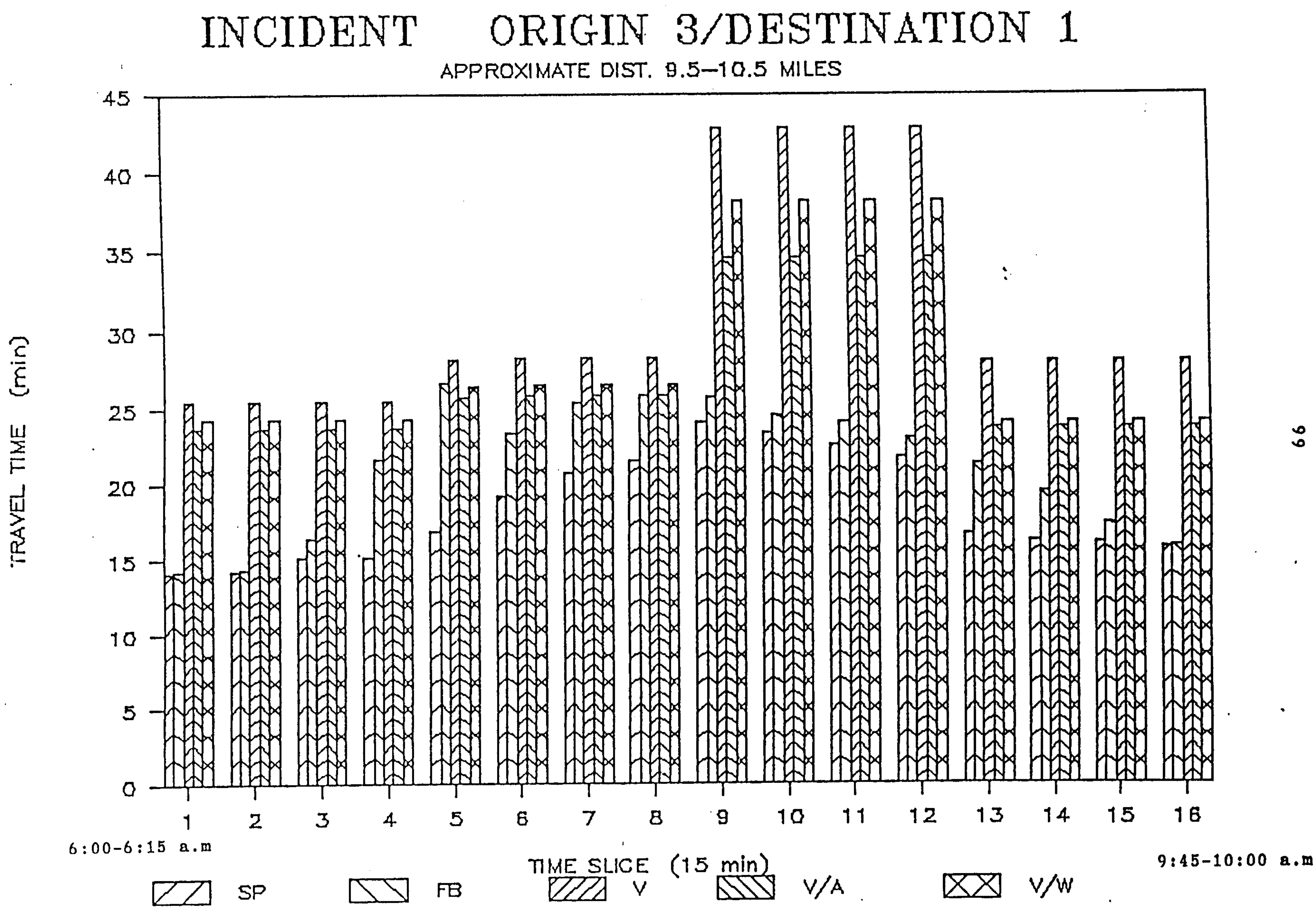

INCIDENT ORIGIN 3/DESTINATION 1
APPROXIMATE DIST. 9.5–10.5 MILES
TRAVEL TIME (min)
45
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
6:00-6:15 a.m
9:45-10:00 a.m
TIME SLICE (15 min)
SP
FB
V
V/A
V/W

FIGURE V-22

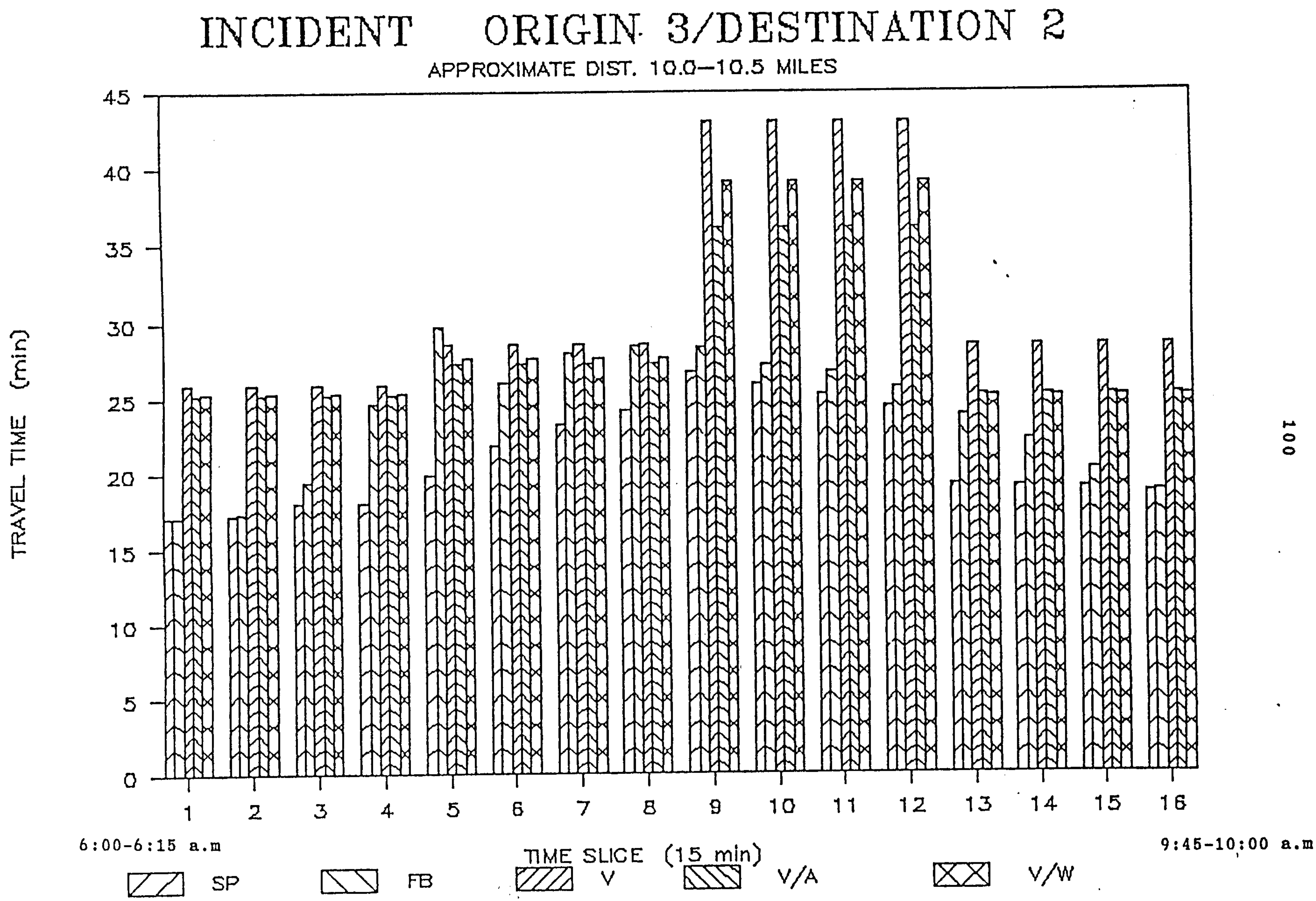
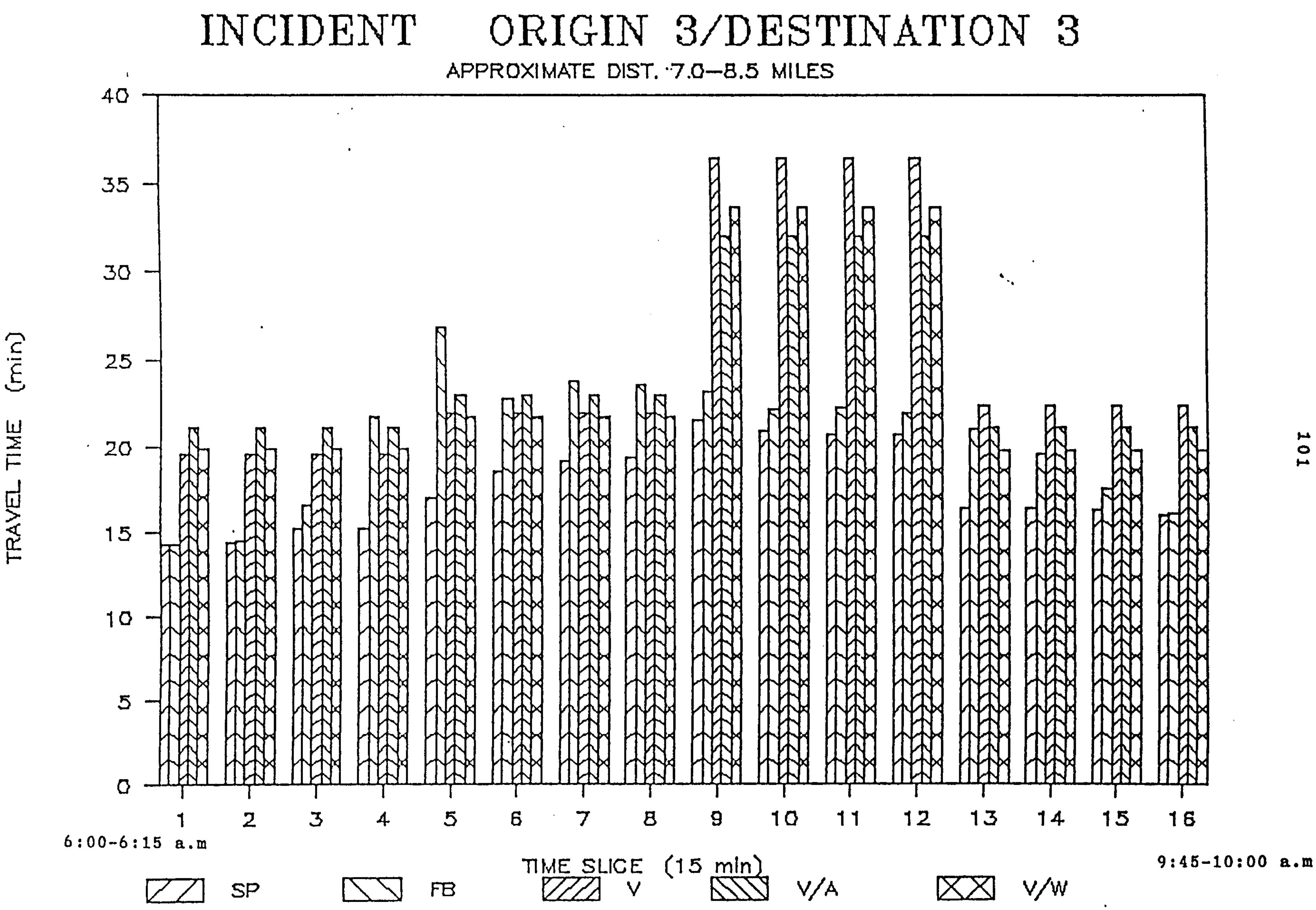

INCIDENT ORIGIN 3/DESTINATION 2
APPROXIMATE DIST. 10.0–10.5 MILES
TRAVEL TIME (min)
45
40
35
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
6:00-6:15 a.m
9:45-10:00 a.m
TIME SLICE (15 min)
SP
FB
V
V/A
V/W

FIGURE V-23



INCIDENT ORIGIN 3/DESTINATION 3
APPROXIMATE DIST. 7.0–8.5 MILES
TRAVEL TIME (min)
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
6:00-6:15 a.m
9:45-10:00 a.m
TIME SLICE (15 min)
SP
FB
V
V/A
V/W

FIGURE V-24

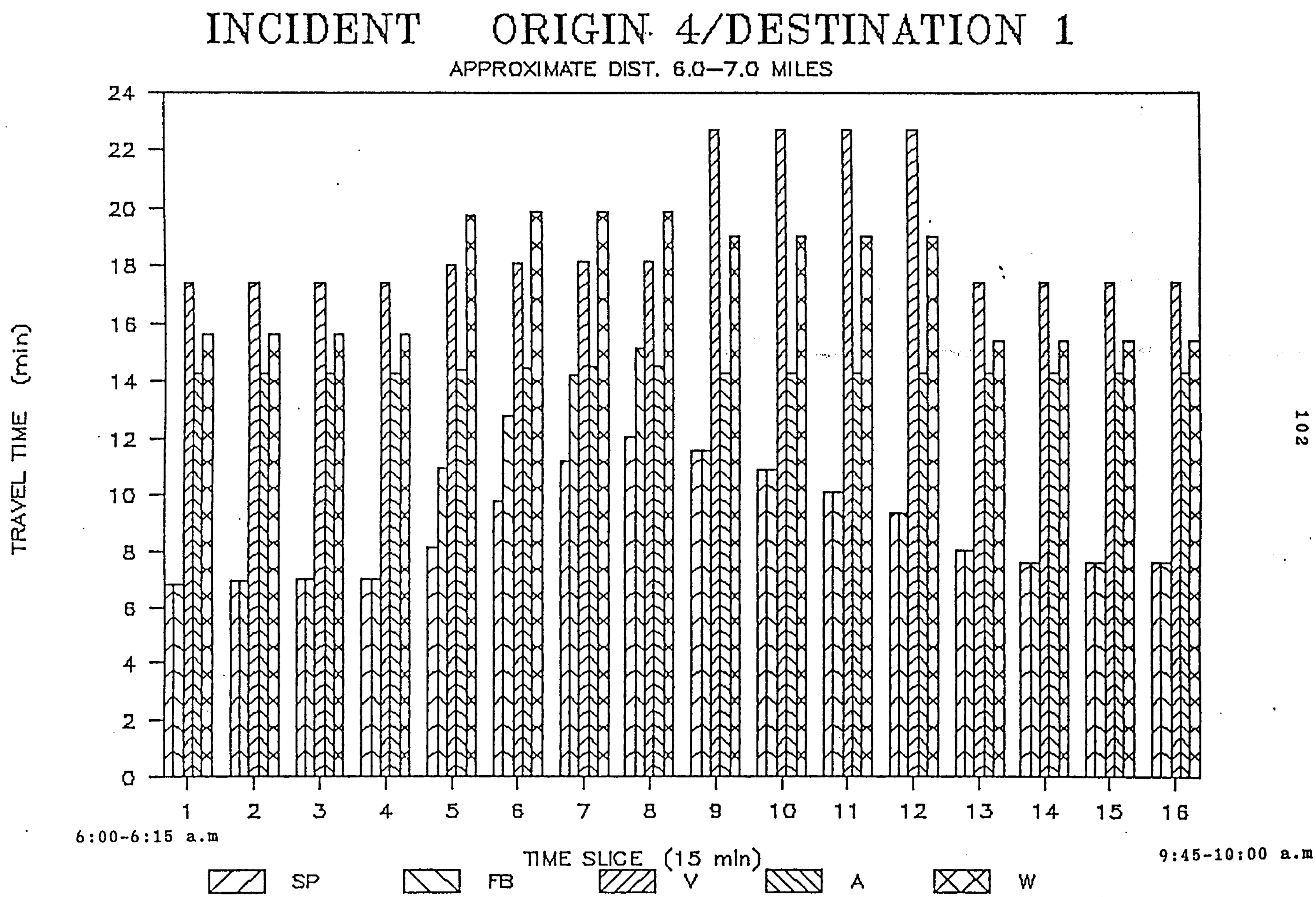

INCIDENT ORIGIN 4/DESTINATION 1
APPROXIMATE DIST. 6.0–7.0 MILES
TRAVEL TIME (min)
24
22
20
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
6:00-6:15 a.m
9:45-10:00 a.m
TIME SLICE (15 min)
SP
FB
V
A
W

FIGURE V-25

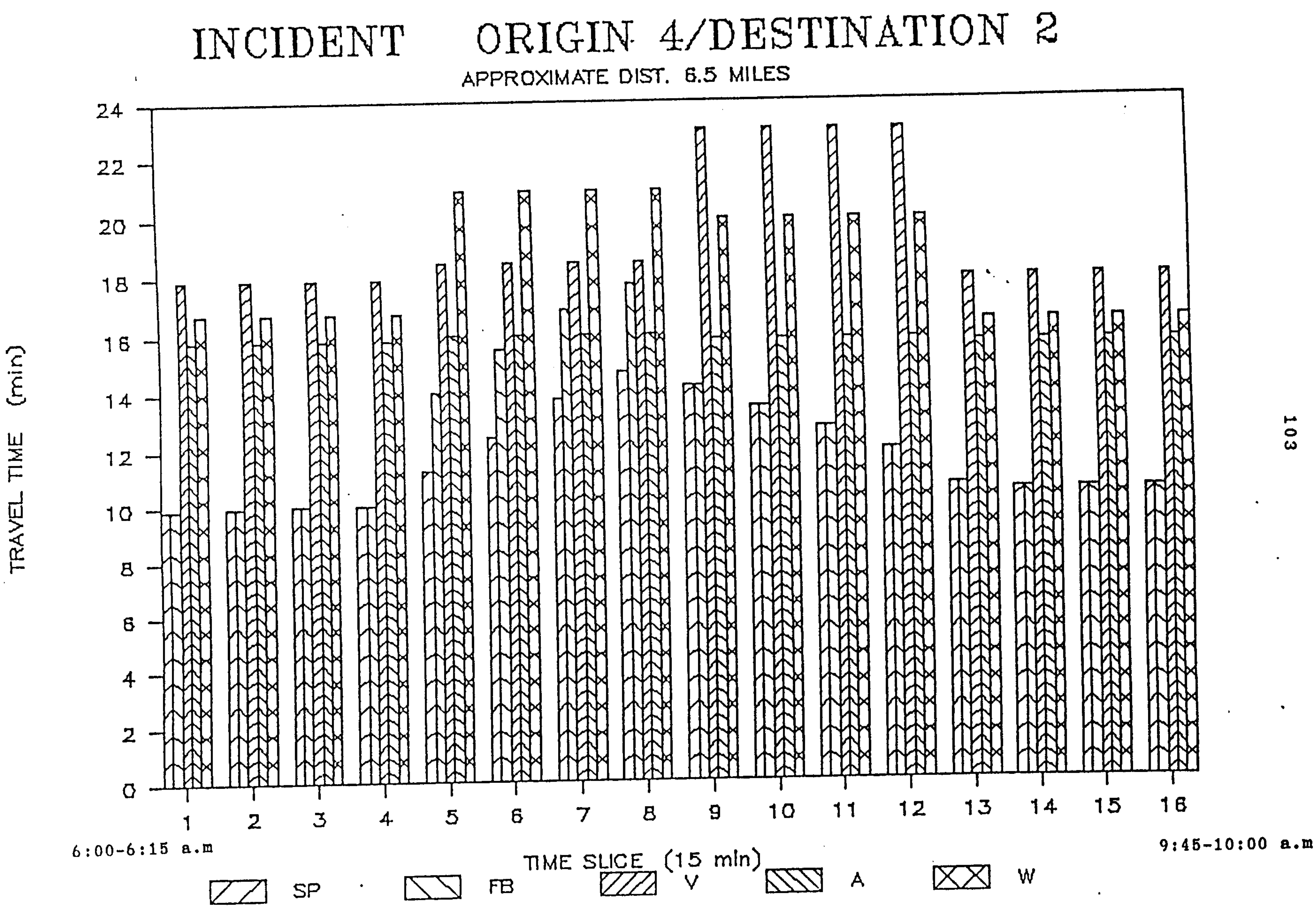

INCIDENT ORIGIN 4/DESTINATION 2
APPROXIMATE DIST. 6.5 MILES
TRAVEL TIME (min)
24
22
20
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
6:00-6:15 a.m
9:45-10:00 a.m
TIME SLICE (15 min)
SP
FB
V
A
W

FIGURE V-26

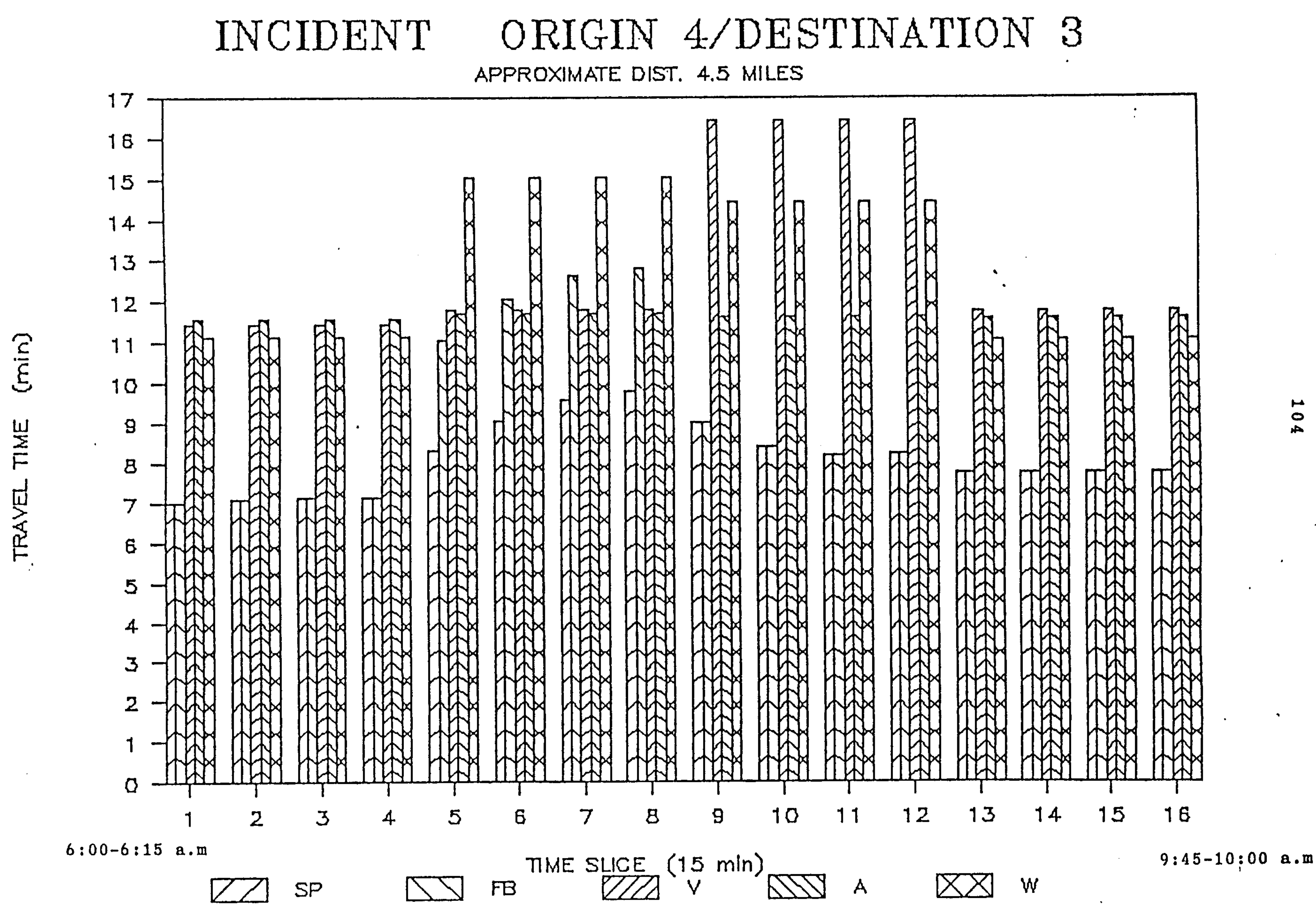

INCIDENT ORIGIN 4/DESTINATION 3
APPROXIMATE DIST. 4.5 MILES
TRAVEL TIME (min)
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
6:00-6:15 a.m
TIME SLICE (15 min)
9:45-10:00 a.m
SP
FB
V
A
W

FIGURE V-27

TABLE V-l

Travel Time Savings in Minutes (Rounded to Nearest Minute)
Non-Incident Scenario (Shortest Path vs. Freeway-Biased Path)

From	D l	O	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	
01	D2	0	0	0	0	0	1	2	2	1	1	1	1	0	0	0	0	
to:	D3	0	0	0	0	0	1	2	2	1	1	1	1	0	0	0	0	
Time:		0600		0630		0700		0730		0800		0830		0900		0930		1000

From	D l	O	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	
02	D2	0	0	0	0	0	1	2	2	1	1	1	1	0	0	0	0	
to:	D3	0	0	0	0	0	1	2	2	1	1	1	1	0	0	0	0	
Time:		0600		0630		0700		0730		0800		0830		0900		0930		1000

From	D l	O	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	
03	D2	0	0	0	0	0	1	2	2	1	1	1	1	0	0	0	0	
to:	D3	0	0	0	0	0	1	2	2	1	1	1	1	0	0	0	0	
Time:		0600		0630		0700		0730		0800		0830		0900		0930		1000

From	D l	O	0	0	0	3	3	4	5	0	0	0	0	0	0	0	0
04	D2	0	0	0	0	3	3	5	6	1	1	0	0	0	0	0	0
to:	D3	0	0	0	0	3	3	4	5	1 0		0	0	0	0	0	0

TABLE V-2

Travel Time Savings in Minutes (Rounded to Nearest Minute)
Incident Scenario (Shortest Path vs. Freeway-Biased Path)

From	Dl	0	01	4	6	1	1	1	1	1	1	1	1	1	1	0	
01	D2	0	01	4	6	1	1	1	1	1	1	1	1	1	1	0	
to:	D3	0	01	3	6	1	1	1	1	1	1	1	1	1	1	0	

Time: 0600 0630 0700 0730 0800 0830 0900 0930 1000

From	Dl	0	0	1	4	8	2	3	2	2	1	2	1	1	1	1	0
02	D2	0	0	1	4	8	2	3	2	2	1	2	1	1	1	1	0
to:	D3	0	0	1	4	8	2	3	2	2	1	2	1	1	1	1	0

Time: 0600 0630 0700 0730 0800 0830 0900 0930 1000

From	D l	O	0	1	7	1	0	4	5	4	2	1	2	1	5	3	1	0
03	D2	0	0	1	7	1	0	4	5	4	2	1	2	1	5	3	1	0
to:	D3	0	0	1	7	1	0	4	5	4	2	1	2	1	5	3	1	0

Time: 0600 0630 0700 0730 0800 0830 0900 0930 1000

From	D l	O	0	0	0	3	3	3	3	0	0	0	0	0	0	0	0
04	D2	0	0	0	0	3	3	3	3	0	0	0	0	0	0	0	0
to:	D3	0	0	0	0	3	3	3	3	0	0	0	0	0	0	0	0

CHAPTER - VI OVERALL ASSESSMENT OF POTENTIAL BENEFITS AND FUTURE RESEARCH

A. INTRODUCTION

Chapter V has shown a sample estimation of benefits expressed as time savings to the user of the information equipped vehicle. This is only the first step in the overall assessment of potential benefits. In addition to classifying the user benefits, this chapter will also try to identify other benefits, quantitative or qualitative, like benefits to non-users and to society. A discussion of the assumptions, constraints and conditions of the previous estimates of benefits will follow. Refinement of these estimates and economic assessment will be needed for the complete assessment of the in-vehicle information technology. Further work is needed for the evaluation of cost effectiveness and the economic feasibility of the information equipped vehicle technology. Finally, phases for technology implementation in the real world are discussed at the end of this chapter as visualized by the team performing this study.

B. TAXONOMY OF POTENTIAL BENEFITS [l]

Benefits can be either quantitative or qualitative. Quantitative benefits are those which can be calculated. Quantitative benfits are classified as: user benefits, non-user benefits and system benefits.

1. Quantitative Benefits

a. User Benefits

User benefits are those accrued by the driver who has an information equipped vehicle. For simplicity, benefits in chapter V have been analyzed as savings in travel time with respect to travel time on the shortest path (for incident and non incident situations). Savings in travel time is just one of many savings that could be gained by drivers using the information equipped vehicles. For example, savings in operating costs (like fuel consumption, vehicle wear and tear) were not considered. However, these savings are related to and they increase with travel time and VMT and they are not as easy to calculate as savings in travel time. User benefits can be further subdivided into benefits to users who are familiar with the network area, benefits to users who are not familiar with the network area, and special types of benefits which are benefits to institutional users.

Users who are familiar with the network will gain time savings under non-incident and under incident travel conditions. They will avoid congestion and their vehicles can be routed around the bottlenecks.

It has been found in chapter V that savings were much higher under incident induced conditions than savings under non-incident conditions.

There are savings of excess travel time and distance for drivers who are unfamiliar with the area. In the literature these savings are also called savings in navigational wastage. In chapter I, it was mentioned that some studies estimated this wastage to be close to $45 billion per year [4]. This estimate represents costs to individual drivers and to society and includes time costs, operating costs and other costs.

In addition to the benefits of time savings under recurring and non-recuring cogestion, drivers unfamiliar with the network area can get an extra benefit of knowing how to get where they want to go.

Different users will have different values of travel time. Institutional users like police, delivery vehicles and emergency vehicles are usually more sensitive to values of time savings and it is easier to identify the benefit in their case. In the case of emergency vehicles a minute savings may be equivalent to the saving of lives.

It is possible that institutional users will be the first markets for such technology. An interesting problem for future research is the problem of optimally routing emergency vehicles according to real time traffic information so that they can reach the emergency location in the shortest time possible. The network can be divided into subnetworks with each subnetwork covering a smaller urban area with depots of emergency vehicles located in it. An emergency routing center can be equipped with a central computer and have the cability of providing accurate traffic information (e.g shortest path), preferably using voice communication, to the drivers of emergency vehicles. The computer system will calculate dynamic (minute by minute) shortest paths. If one has several emergency depots in the subnetwork and an accident occurs in time slice X in subnetwork I, the question will be what is the best strategy to dispatch the emergency vehicle? Which depot and what route to use to reach the accident location and to return as fast as possible to the closest hospital in case if any injuries ? Of course the best depot to dispatch the emergency vehicle from may or may not be the closest emergency depot to the accident location (in terms of distance) because the shortest path will be changing by time.

Institutional usage of the system can also create secondary benefits (indirect benefits) to other non-users in the society. For example, when delivery vehicles improve their routing service industry will improve and served parties will gain and~overall economy can improve. However, these secondary benefits are difficult to quantify.

b. Non-user Benefits

Drivers who do not have the equipment will get benefit when users start to divert from the freeway especially around bottlenecks. Since bottleneck queues are very sensitive to small changes in traffic volumes, diversion of a small percentage of users from the bottlenecks can cause substantial reductions in the bottleneck queues and hence improve speed and travel time on the freeway. Therefore, non-diverted drivers (or non-users if we assume that all vehicle equipped drivers will use their machines during the congestion) will benefit from congestion relief on the freeway links they are using. This is particularly anticipated under the incident congestion situation.

The policy question is that if the number of users (i.e drivers with information equipped vehicles) was large enough to relieve congestion from the freeway, then the freeway will become less congested than before the diversion. Non-users who choose to stay on the freeway will then get the benefit of driving in less congested freeway links without paying for it. Consequently this may discourage others from buying the information equipment. This question of a fair cost recovery scheme is an area for future research.

c. System Benefits

(1) Traffic Counts

The system will have up-to-date travel times on the network links where traffic counts are collected automatically and continuously by the system itself since vehicles act like moving detectors. Vehicles equipped with the information device will be located by the system and their time-progress can be determined. Therefore, the system will be accurate and complete and consequently, the travel time will be reliable. The up-to-date travel times could be used as a feedback for a central control to help the authorities in monitoring the network.

(2) Optimization of the Overall Network in Question

Can be achieved by distributing the congestion over the entire network, however, in some cases there are network limitations that makes diversion not practical, examples are bridges and tunnels , where there is only one way to get through. Benefits will greatly depend on the structure of the network in question.

2. Qualitative Benefits

These are benefits which are hard to quantify, if not impossible sometimes. Examples of such benefits are:

-Driver safety and potential reduction in the number of accidents (especially rear end collisions) and consequently reducing the number of injuries and fatalities caused by these types of accidents.

-Environmental benefits gained by reduction of the concentration of carbon monoxide and toxic gases in the atmosphere. Also a reduction in noise, driver stress, frustration and lack of comfort.

-Hazard warnings, (e.g fog, bad weather, bad curvature...etc).

C. GENERAL EVALUATION OF THE PREVIOUS ESTIMATES OF POTENTIAL BENEFITS

Other than limitations of the simulation models for the freeway system and surface street system, and network model, estimates of potential benefits in chapter V were also based on several assumptions, constraints, conditions and also some other limitations.

1. Assumptions

It should be emphasized that the following assumptions were made in order to attain the previous estimates of potential benefits:

*The SMART corridor is considered to be a typical corridor.

*The percentage of drivers diverting to the surface streets under the incident and non-incident induced situation is not large enough to cause significant increases in travel time on the freeway and the surface street links of the network; those drivers divert either on the basis of their own experience in routes or by using an information-equipped vehicle system. Sometimes this assumption may not be realistic, later on, in the section of modeling improvement, the need for releasing this constraint is discussed.

*With a mature information system any driver who buys the information-equipment is going to use it under recurring or non-recurring traffic congestion conditions. It is assumed that the driver who buys the equipment is going to use it when it is needed, otherwise he would have incurred the cost of buying the information for no benefit. However, this is only true if there is a complete confidence in the equipment and the efficiency of using it is very high. This assumption is very important and reflects directly into the magnitudes of benefits for both the user and the system. As will be discussed later on, a rich area for future research is the driver-information equipment interface.

*In estimating travel time savings, it has been implicitly assumed that travel time in congested links of the freeway has the same cost unit value as travel time in free flow links of the freeway. Usually this is not true, because people perceive travel time in congestion of being longer than travel time in free flow movement. If travel time through congested links is given more weight, then benefits could be higher than estimated.

*Benefits (or time savings) were only calculated for one person who is the driver. Passengers were not considered because at this moment there is no data available on occupancy of information equipped vehicles. Passengers of the information-equipped vehicles will benefit from the time savings as well.

*The freeway biased route was assumed to be the user-selected route (as found from the O-D survey in chapter-V).

2. Constraints

The potential benefits are microscopic and problem specific in nature and actually depend on:

-The structure of the network in question.

-The incident location, time it occurs, magnitude (capacity reduction), duration, and the time slice when the benefits are calculated. The time savings seem to be greatest during the period of the incident itself and fluctuates after the incident is cleared.

-The simulation results in this report apply only to the peak period.

-The length and nature of the trip. For example, if the trip is too short, the driver may not use the information system.

3. Conditions and Limitations

*The estimated benefits in chapter V were assumed to be for traffic flow volumes in a typical day where traffic is neither light or heavy. It is observed by CALTRANS District-7 engineers, that under non-incident traffic conditions, traffic exhibits multi-level congestion. This means that potential benefits may vary with the level of congestion.

*Similarly under incident congestion conditions, incidents in heavy traffic days will yield larger benefit estimates, while those in lighter traffic days will yield less benefit estimates.

*Since the objective of the study was to give a clear picture of the magnitude of benefits gained under an incident situation, the incident scenario has introduced the incident on the freeway rather than on the surface streets. Network link costs are more sensitive to changes in the freeway travel time than changes in the surface street travel time. It is also possible to introduce an incident in a major parallel arterial street to the freeway and see how the level of benefit changes.

*Because one of the purposes of this study was the illustration of benefits under an incident situation, and because of time and budget constraints, estimates were done only for 12 O-D pairs using different routing strategies such as: freeway biased, surface street biased, and shortest path.

The outcome of the above discussion is that further study and more simulation effort will be needed on the spatial and temporal nature of the potential benefits. Examples of spatial considerations are the size of the network and the variability of benefits according to the location investigated. Temporal characteristics of the benefits are related to time of the day the benefits are calculated. Variables that contribute to the benefits need to be identified, after which, sensitivity analysis could be carried out.

*Accuracy of the traffic surveillance system and its updating capability are necessary for the reliability of the Information given to the driver and for the reliability of the estimates of benefits.

D. MODELING IMPROVEMENTS

1. Refinement of the Estimates

From the discussion in the previous section (evaluation of the estimates), one can see that further research work will be needed in order to refine the obtained estimates of benefits.

2. User Equilibrium Analysis

The user equilibrium issue was not addressed in our study because of the assumption made that the percentage of users diverting is small enough not to affect the equilibrium condition on the surface street system. The question is what if the percentage diverting has increased to the extent that it begins affecting the equilibrium conditions in the network? As long as some routes are still better than others, then the information system will be sound and effective because there will always be benefits gained by diverting drivers to the best routes. This is particularly true for the incident situation, where flow on the network links become disturbed by the incident and it takes a long time to return to the equilibrium condition.

There is the need to develop an information-driver simulation model that will incorporate the user equilibrium criteria [11]. The model will define a more realistic approach to the assessment of potential benefits accrued by an in-vehicle Information system. The information-driver simulation model can be calibrated using the results of a real life experiment like the PATHFINDER experiment or possibly through a navigation simulation model which can be experimented on driver subjects in a simulation lab [12].

3. Trip Cost Characteristics

Trip cost parameters or trip cost characteristics that have been considered in our previous analysis included travel time as the only cost parameter. There are other cost parameters which, if incorporated, will increase the magnitude of the benefits because they usually increase by the increase in travel time, for instance, vehicle operating costs (wear and tear). This is still a quantitative benefit but more difficult to calculate accurately.

4. Route Choice

Factors affecting the route selection may vary from one driver to another. Because each driver has a different utility function in selecting his own optimal route (which he/she thinks that it is the best route). Unfortunately, the information provided about the driver route choice behavior is very limited in the literature, therefore more studies will be needed to understand the driver behavior in route selection.

E. INFORMATION-DRIVER INTERFACE

As stated earlier, one of the assumptions made about the previous estimates of benefits was that drivers will interact with the information system in the most effective manner so that no confusion will occur and the driver's confidence will increase in the system through a learning process. However, it is important to know what is the most effective manner in which information could be conveyed to the driver. First, simulation experiments as in Kitamura [1988] [12] will be needed to determine the most effective route guidance system In transferring informatlon to the driver. Secondly, the effect of this information system or the response of the driver to the information given needs to be studied. Driver response is going to be reflected into route choice behavior which has been discussed in the previous section.

Further study is needed to address the safety component of the information system [13], this also Interacts with liability questions. For example, in case of a traffic accident, caused by wrong information given to the driver from the information system, who is going to be held responsible in front of law for this accident?

F. ECONOMIC ASSESSMENT OF THE POTENTIAL BENEFITS

One major issue is the economic feasibility of the information equipped vehicles. Unless this system is cost effective people will not buy it and it will not be able to break through the market. Therefore demand analysis, marketing research, and cost effectiveness are to be studied before the technology implementation process.

1. Demand Analysis for the In-vehicle Information System and Marketing Research

First, marketing research will be necessary to know if this system will ever be able to break through the market. Marketing research Includes marketing surveys which will take into consideration O-D surveys and existing O-D patterns. Pricing the information technology will play a major role In determining its market size. The demand for an in-vehicle traffic Information system depends on many factors of which the most two important are the pricing strategy and the number of users (or the number of customers).

Let us assume that the technology will be able to break through the market. If the number of users increases and hence the information about the best routes is spread out to a large number of users, best routes will no longer be best routes. Benefits accrued by diversion of users will be small If not negligible and the system will be at or near equilibrium condition. That is true under the recurring congestion situation. It is assumed in the recurring congestion situation that drivers usually distribute themselves on routes so that the benefit of shifting from one route to another is negligible (Wardrop conventional principle in traffic assignment). However, in the non-recurring congestion situation, it will take a long time to reach equilibrium in the network once an incident occurs. The incident creates disturbance in the link costs, and consequently there will be always routes which are better than others for different O-D pairs In the network. How big the disturbance in link costs will be depends on the incident characteristics in question.

2. Integrated Technology Assessment and cost Benefit Analysis

The flow chart, figure VI-l, shows an integrated technology assessment process.

The technology implementation will go through a sequence of phases which will be described later in this chapter. For each of these phases, the process shown in figure VI-l will be repeated. Basically the process is a five step process:-

a. <u>Technology Updates</u>

Each time the technology of in-vehicle information system is updated there is a new cost, and consequently the price of the equipment will be updated.

(TECHNOLOGY ASSESSMENT FLOW CHART)

PHASE (I), WHERE 1=1,2,....,X

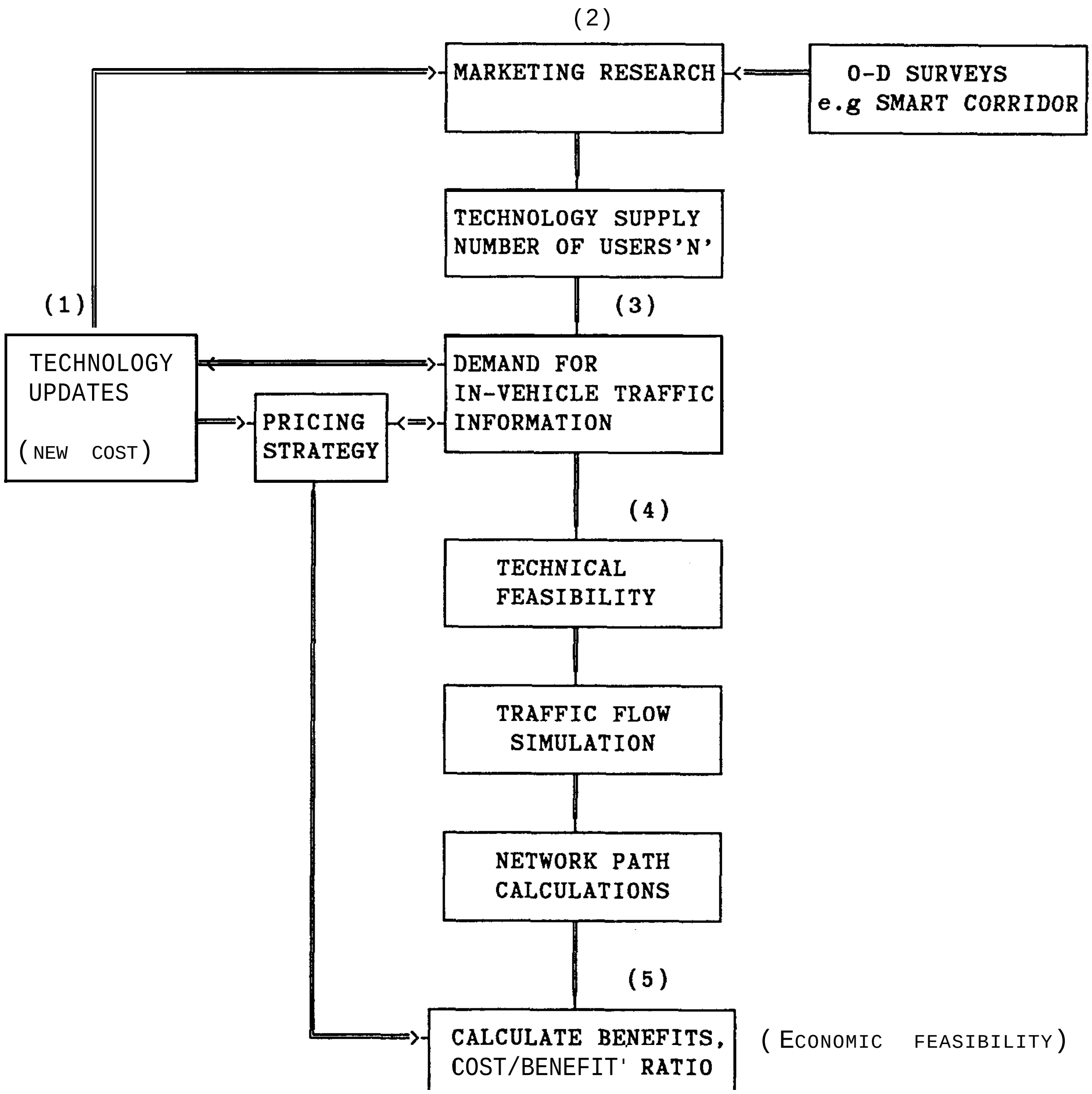


FIGURE V-1

(1) Pricing the Information Equipped Vehicle Technology :

Pricing the technology of information equipped vehicles will also play a major role in determining the cost effectiveness of this technology from both the user perspective and system perspective. Each pricing strategy, e.g average cost pricing or marginal cost pricing, results in a different benefit/cost ratio and affects the overall economic feasibility. Pricing strategy will depend on whether there will be subsidies to the in-vehicle information technology from public money or not? And if yes how much?

If developers think that the use of this technology can be considered as part of the Transportation System Management (TSM) plan and therefore it is not only confined to individual or even institutional users, then one could justify the subsidy issue.

There is a two way effect between demand and technology updating: as the technology updates, demand also is updated and if demand increases the effect reflects back on updating the technology. Thus, demand will also be a function of a technology Index variable which represents the merits of the technology at its different levels.

b. Marketing Research

Marketing research is needed after each technology updates to predict the number of users "N" of the new technology, and therefore determines the supply of the information equipped vehicles. The use of O-D surveys might be helpful in this context. With the price of the technology determined there will be a supply demand model which also determines the final number of users in the market equilibrium.

c. Technical Feasibilitv

Once the demand is determined, technical feasibility is reviewed through traffic simulation and path calculations just as the work done in this report (chapters II to V). With an integrated navigation simulation model, traffic simulation and network path calculations can be summarized into one phase.

d. Economic Feasibility

Cost/benefit ratio and cost effectiveness of the updated technology needs to be reviewed form the user perspective

(1) Pricing the Information Equipped Vehicle Technology :

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d. Economic Feasibility

Cost/benefit ratio and cost effectiveness of the updated technology needs to be reviewed form the user perspective and from the system perspective. As discussed before, final cost/benefit estimates will be sensitive to the pricing strategy and cost recovery scheme used.

G. MORE ON THE FUTURE RESEARCH IN TEE AREA OF VEHICLE NAVIGATION

1. Traffic Impact Studies on the Surface Street Network

Studies on the adverse effects of diverting traffic from the freeway to the surface street system should be envisaged. It might be that diverting too much traffic from the freeway to the surface street system causes the traffic volumes to reach the capacity of the arterial network. This is possible when a lot of drivers are equipped with the information technology. The practicality of traffic control strategies that can accommodate this diversion of traffic will also need to be discussed [14].

2. Application of Artificial Intelligence

As the size of the network gets larger and becomes too complicated, the limitations of existing computation techniques threaten the technical feasibility of the in-vehicle information system, a problem which the artificial intelligence might be the solution [15].

3. Feasibility of Routing Algorithms with Multiple Stops and Time Windows

If the driver has to make multiple stops with time constraints, a study is needed on the technical feasibility, and later on the economic feasibility of different routing algorithms used. This idea can be applied for the rent-a-car businesses **[16].**

H. FUTURE USES OF THE SIMULATION TEST-BED RESULTS OF THE SMART CORRIDOR

1. The Freeway/ATSAC System

At the present time, the system of ATSAC or (Automated Traffic Surveillance and Control) has been implemented for parts of the down town area of the city of Los Angeles. The ATSAC system is an advanced system and the plan is to expand it through the SMART corridor. The ATSAC provides on line minute by minute traffic speed, flow and occupancy data to the information database in the ATSAC computer center located in the LADOT. CALTRANS detectors on the Santa Monica freeway are being upgraded and once the upgrading process is completed, freeway detectors will also provide complete on-line traffic speed, flow and occupancy data to CALTRANS central database. There is a need for linking the two databases of the city of Los Angeles and CALTRANS so that an overall and accurate picture of the SMART corridor is obtained. Linking the two databases will make it easier for applying different control strategies needed to handle the diverted traffic from the freeway to the arterial network. Traffic diverted from the freeway to the arterial may cause congestion and extra delay to the surface streets, a problem which might be solved by changing the signal timing plans. The simulation results of this report can be used, in a *sense,* to help authorities in the control of the freeway and the surface street systems.

Currently operators of the ATSAC system can detect incidents and detector malfunctions in the ATSAC area by looking at the updated data provided by the ATSAC system. Nevertheless, when the data from the freeway system and surface street system is integrated into one databank, or even if the surface street system expands and gets more complicated, it will become very difficult for ATSAC operators to continuously detect the incidents manually. Artificial intelligence can be applied using the experience of the operators in detecting the incidents, this experience will continuously be updated. An artificial intelligence system provides easier, faster and more effective way of detecting the incidents.

2. The PATHFINDER Experiment

The simulation test-bed results in this report can be used in the design of the PATHFINDER experiment that is going to take place in the SMART corridor at full scale in the early 1990's [12].

In this experiment, driver subjects will be tested in a real life corridor to assess the user quantitative benefits accrued by the driver information systems.

I. PHASES OF TECHNOLOGY IMPLEMENTATION:

Table VI-1 visualizes the logical phases of technology implementation that may take place in U.S in the future:

Table VI-l

PHASES OF TECHNOLOGY IMPLEMENTATION

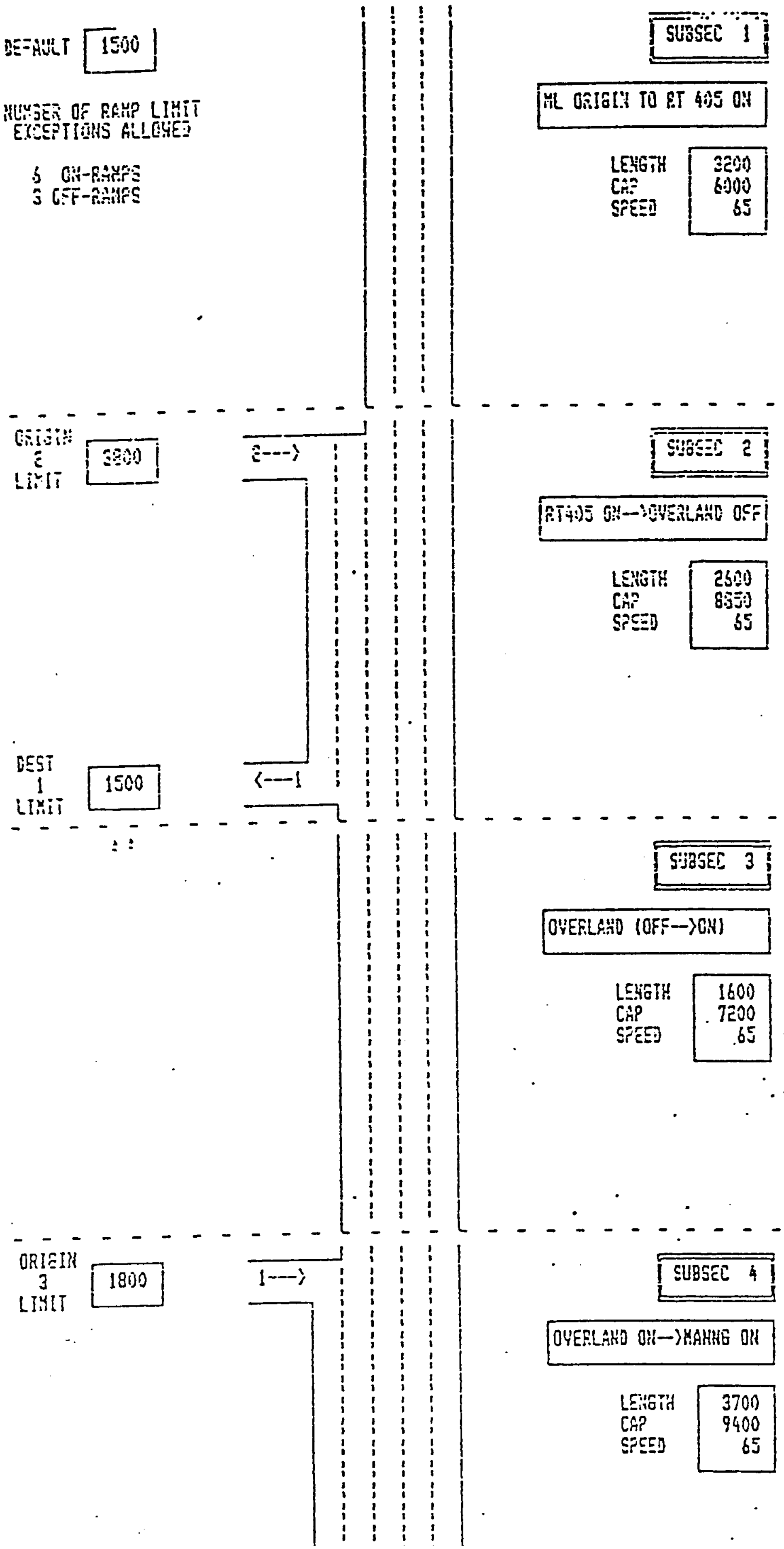
PHASE NUMBER	LEVEL OF INFORMATION	EXAMPLES OF CURRENT TECHNOLOGIES
PHASE (1)	Map display only	ETAK
PHASE (2)	Real time information: -congestion red bars on maps in the vehicle. -Voice communication to allert drivers of congestion.	Japanese JNPA AMTICS system. Improved ETAK system
PHASE (3)	Recommended routes to follow with their travel time.	-----------
PHASE (4)	Exact route instructions for driver to follow.	ALI-SCOUT German system
- :		
PHASE (X)	Fully automated highways	Not Available

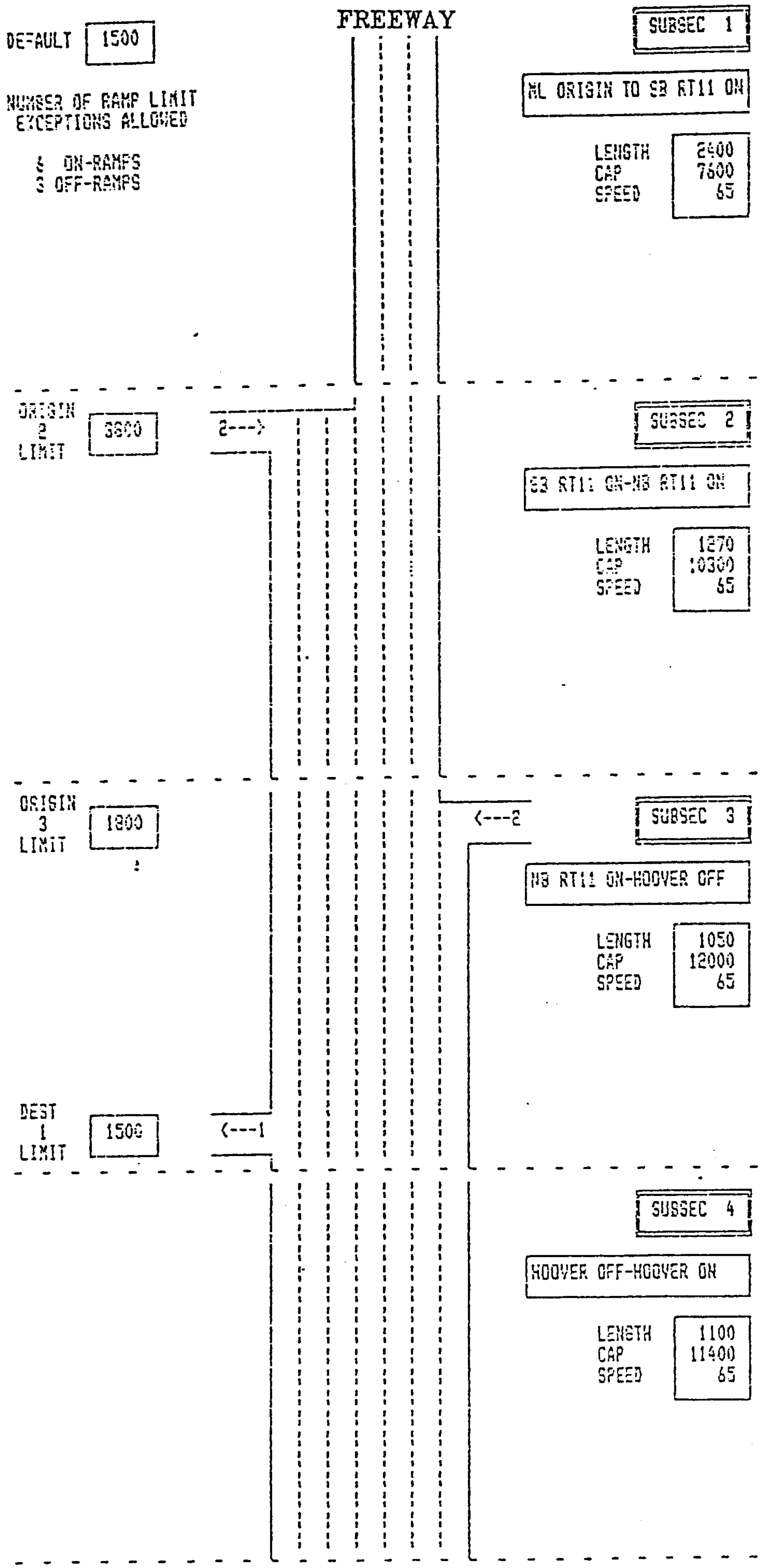
It should be mentioned that these phases are not necessarily going to occur in the sequence they are presented. However, these phases and their sequence were based on current and previous research, literature review and the experience of the in-vehicle information technology in other countries.

APPENDIX -A-

GEOMETRIC DESIGN OF THE SANTA MONICA FREEWAY

EASTBOUND DIRECTION OF THE SANTA MONICA FREEWAY




DEFAULT 1500
NUMBER OF RAMP LIMIT EXCEPTIONS ALLOWED
6 ON-RAMPS
3 OFF-RAMPS
FREEWAY
SUBSEC 1
ML ORIGIN TO SB RT11 ON
LENGTH 2400
CAP 7600
SPEED 65
ORIGIN 2 LIMIT 3600
2--->
SUBSEC 2
SB RT11 ON-NB RT11 ON
LENGTH 1270
CAP 10300
SPEED 65
ORIGIN 3 LIMIT 1800
<---2
SUBSEC 3
NB RT11 ON-HOOVER OFF
LENGTH 1050
CAP 12000
SPEED 65
DEST 1 LIMIT 1500
<---1
SUBSEC 4
HOOVER OFF-HOOVER ON
LENGTH 1100
CAP 11400
SPEED 65

APPENDIX -B-

TIME SLICE DEMAND DATA

EASTBOUND DIRECTION OF THE SANTA MONICA FREEWAY

TS DEMANDS

SUBSEC 1

MAINLINE ORIGIN

1	1376	13	4032
2	1894	14	4252
3	2956	15	4188
4	3248	16	3764
5	3832		
6	4100		
7	4208		
8	4176		
9	4460		
10	4924		
11	4900		
12	4684		

ML ORIGIN TO RT 405 ON

TS DEMANDS

SUBSEC 2

ORIGIN 2 LIMIT 3300

1	2180	13	3700
2	2764	14	3592
3	3108	15	3416
4	3608	16	3620
5	3488		
6	3648		
7	3264		
8	3244		
9	3316		
10	3164		
11	3392		
12	3332		

2--->

RT405 ON-->OVERLAND OFF

<---1

DEST 1 LIMIT 1500

1	440	13	1128
2	480	14	1344
3	520	15	1204
4	560	16	992
5	600		
6	848		
7	890		
8	970		
9	1122		
10	1050		
11	1110		
12	1216		

TS DEMANDS

SUBSEC 3

OVERLAND (OFF-->ON)

TS DEMANDS

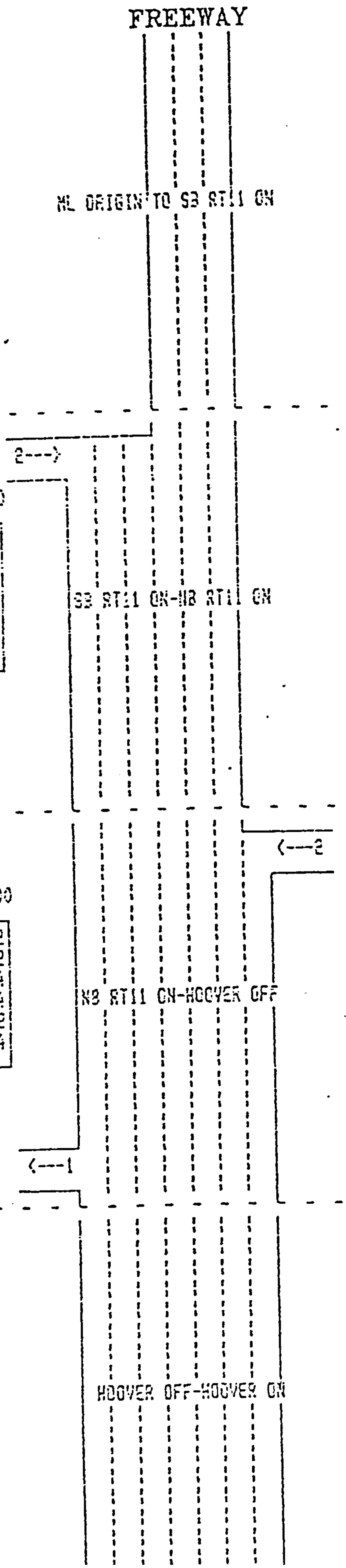
SUBSEC 4

1--->

ORIGIN 3 LIMIT 1800

1	600	13	844
2	640	14	840
3	720	15	830
4	960	16	810
5	1176		
6	1020		
7	1008		
8	1092		
9	964		
10	996		

OVERLAND ON-->MANNG ON



SUBSEC 1

TS DEMANDS

MAINLINE ORIGIN

1	4492	11	6204
2	4988	12	6164
3	5980	13	6284
4	6060	14	6284
5	6320	15	6136
6	6258	16	5976
7	6248		
8	6060		
9	6204		
10	6300		

SUBSEC 2

TS DEMANDS

ORIGIN 2 LIMIT 3200

1	2472	11	2780
2	2772	12	2572
3	2856	13	2620
4	3016	14	3152
5	3160	15	3024
6	2904	16	2964
7	2672		
8	2708		
9	2544		
10	2416		

SUBSEC 3

TS DEMANDS

ORIGIN 3 LIMIT 1800

1	1048	11	772
2	1040	12	832
3	1004	13	984
4	1100	14	1004
5	1072	15	1212
6	844	16	964
7	876		
8	708		
9	764		
10	772		

DEST 1 LIMIT 1500

1	200	11	560
2	208	12	584
3	224	13	520
4	264	14	480
5	348	15	432
6	428	16	380
7	460		
8	476		
9	520		
10	552		

SUBSEC 4

TS DEMANDS

APPENDIX -C-

OCCUPANCY DATA

EASTBOUND DIRECTION OF THE SANTA MONICA FREEWAY

SUBSEC 1

OCCUPANCY DATA

MAINLINE

1 OCC. AUTO	0.877
2 OCC. AUTO	0.110
3+ OCC. AUTO	0.013
BUSES	0.000

ML ORIGIN TO RT 405 ON

AVG. OCC.

3+ OCC. AUTO	3.200
BUSES	40.000

SUBSEC 2

OCCUPANCY DATA

ORIGIN 2 LIMIT 3300

1 OCC. AUTO	0.877
2 OCC. AUTO	0.110
3+ OCC. AUTO	0.013
BUSES	0.000

2--->

RT405 ON-->OVERLAND OFF

<---1

AVG. OCC.

3+ OCC. AUTO	3.200
BUSES	40.000

SUBSEC 3

OCCUPANCY DATA

OVERLAND (OFF-->ON)

SUBSEC 4

OCCUPANCY DATA

ORIGIN 3 LIMIT 1900

1--->

1 OCC. AUTO	0.877
2 OCC. AUTO	0.110
3+ OCC. AUTO	0.013
BUSES	0.000

OVERLAND ON-->HAWKG ON

AVG. OCC.

3+ OCC. AUTO	3.200
BUSES	40.000

FREEWAY

SUBSEC 1

OCCUPANCY DATA

MAINLINE

1 OCC. AUTO	0.877
2 OCC. AUTO	0.110
3+ OCC. AUTO	0.013
BUSES	0.000

ML ORIGIN TO SB RT11 ON

AVG. OCC.

3+ OCC. AUTO	3.200
BUSES	40.000

SUBSEC 2

OCCUPANCY DATA

2--->

ORIGIN 2 LIMIT 3800

1 OCC. AUTO	0.877
2 OCC. AUTO	0.110
3+ OCC. AUTO	0.013
BUSES	0.000

SB RT11 ON-NB RT11 ON

AVG. OCC.

3+ OCC. AUTO	3.200
BUSES	40.000

SUBSEC 3

OCCUPANCY DATA

<---2

ORIGIN 3 LIMIT 1800

1 OCC. AUTO	0.877
2 OCC. AUTO	0.110
3+ OCC. AUTO	0.013
BUSES	0.000

NB RT11 ON-HOOVER OFF

AVG. OCC.

3+ OCC. AUTO	3.200
BUSES	40.000

<---1

SUBSEC 4

OCCUPANCY DATA

HOOVER OFF-HOOVER ON

APPENDIX -D-

NON-INCIDENT FINAL CALIBRATED RUN FOR EASTBOUND DIRECTION-SANTA MONICA FREEWAY

INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, BERKELEY
(415)-642-7390

FREEWAY AND ARTERIAL DESIGN FEATURES

SUB SEC	NO. LNS	SSEC CAP	SSEC LENGTH	DESIGN SPEED	GRG DES	TRK FAC	SSEC GRAD	PCT TRK	PCT DES TRUCKS	SPECIAL RAMP	FF.SPD. ALT.RTE	CAP. ALT.RTE	ART TYPE	GRADE ALT.RTE	SUBSECTION LOCATION
1	3	6000.	3200.	65	0	0.93	0.0	3	30	NO	0.0	0.	6000	0.0	ML ORIGIN TO RT 405 ON
2	5	8350.	2600.	65	00	0.95	0.0	3	30	YES	0.0	0.	6000	0.0	RT405 ON--)OVERLAND OFF
3	4	7200.	1600.	65		0.93	0.0	3	30	NO	0.0	0.	6000	0.0	OVERLAND (OFF--)ON)
4	5	9400.	3700.	65	0	0.93	0.0	3	30	YES	0.0	0.	6000	0.0	OVERLAND ON--)MANNG ON
5	5	9250.	2000.	65	00	0.93	0.0	2	30	YES	0.0	0.	6000	0.0	MANNG ON--)ROBERTSON OF
6	5	9000.	2200.	65		0.93	0.0	2	30	NO	0.0	0.	6000	0.0	ROBERTSON OFF--)NAT. ON
7	5	9000.	2300.	65	00	0.93	0.0	2	30	YES	0.0	0.	5000	0.0	NATIONAL ON-SB LAC. OFF
8	5	8700.	1100.	65		0.93	0.0	2	30	YES	0.0	0.	6000	0.0	SB LAC. OFF-SB LAC. ON
9	6	9200.	400.	65	00	0.93	0.0	2	30	YES	0.0	0.	6000	0.0	SB LAC. ON-NB LAC. OFF
10	5	8600.	500.	65	0	0.93	0.0	2	30	YES	0.0	0.	6000	0.0	NB LAC. OFF-FAIRFAX OFF
11	5	9000.	1500.	65		0.93	0.0	2	30	YES	0.0	0.	6000	0.0	FAIRFAX OFF-VENICE ON
12	5	9200.	1700.	65	0	0.93	0.0	2	30	YES	0.0	0.	6000	0.0	VENICE ON-WASHINGTON ON
13	5	8000.	3350.	65	00	0.93	0.0	2	30	YES	0.0	0.	6000	0.0	WASHIN. ON-SB LAB. OFF
14	5	8100.	600.	65		0.93	0.0	2	30	YES	0.0	0.	6000	0.0	SB LAB. OFF-SB LAB. ON
15	6	9000.	400.	65	00	0.95	0.0	2	30	YES	0.0	0.	6000	0.0	SB LAB. ON-NB LAB. OFF
16	5	8500.	1450.	65		0.93	0.0	2	30	YES	0.0	0.	6000	0.0	NB LABREA (OFF--)ON)
17	5	9500.	2200.	65	00	0.93	0.0	2	30	YES	0.0	0.	5000	0.0	NB LAB. ON-CRENSHAW OFF
18	5	9450.	2300.	65		0.98	0.0	2	30	YES	0.0	0.	6000	0.0	CRENSHAW (OFF--)ON)
19	6	10900.	2900.	65	00	0.93	0.0	2	30	YES	0.0	0.	6000	0.0	CRENSHAW ON-ARLING. OFF
20	5	9500.	1200.	65		0.93	0.0	2	30	YES	0.0	0.	6000	0.0	ARLINGTON (OFF--)ON)

INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, BERKELEY
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FREEWAY AND ARTERIAL DESIGN FEATURES

SUB SEC	NO. LNS	SSEC CAP	SSEC LENGTH	DESIGN SPEED	ORG DES	TRK FAC	SSEC GRAD	PCT TRK	PCT DES TRUCKS	SPECIAL RAMP	FF.SPD. ALT.RTE	CAP. ALT.RTE	ART TYPE	GRADE ALT.RTE	SUBSECTION LOCATION
21	6	10100.	1050.	65	00	0.93	0.0	2	30	YES	0.0	0.	6000	0.0	ARLINGTON ON-WESTERN OF
22	7	12100.	2150.	65		0.93	0.0	2	30	YES	0.0	0.	6000	0.0	WESTERN OFF-WESTERN ON
23	7	12100.	1100.	65	00	0.93	0.0	2	30	YES	0.0	0.	6000	0.0	WESTERN ON-NORMANDIE OF
24	6	10500.	1500.	65		0.93	0.0	2	30	YES	0.0	0.	6000	0.0	NORMANDIE (OFF-->ON)
25	7	11900.	1000.	65	00	0.95	0.0	2	30	YES	0.0	0.	6000	0.0	NORMANDIE ON-VERMONT OF
26	7	12500.	1900.	65		0.93	0.0	2	30	NO	0.0	0.	6000	0.0	VERMONT (OFF-->ON)
27	7	11350.	700.	65	00	0.93	0.0	2	30	YES	0.0	0.	6000	0.0	VERMONT ON-HOOVER OFF
28	6	10150.	1550.	65		0.93	0.0	2	30	YES	0.0	0.	6000	0.0	HOOVER (OFF-->ON)
29	6	9350.	700.	65	00	0.93	0.0	2	30	YES	0.0	0.	6000	0.0	HOOVER ON-SB RT11 OFF
30	6	9000.	950.	65	D	0.93	0.0	2	30	NO	0.0	0.	6000	0.0	SB RT11 OFF-NB RT11 OFF
31	5	7500.	900.	65		0.93	0.0	2	30	NO	0.0	0.	6000	0.0	NB RT11 OFF-SB RT11 ON
32	6	9300.	700.	65	00	0.93	0.0	2	30	YES	0.0	0.	6000	0.0	SB RT11 ON-XL DEST.

2049 RECORDS OF EXTENDED CORE STORAGE REQUIRED

RAMP LIMITS =1500.
OFF-RAMP 4 LIMIT= 750.
OFF-RAMP 14 LIMIT=1600.
OFF-RAMP 15 LIMIT=3800.

INSTITUTE OF TRANSPORTATION STUDIES
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FREQ8
SIMULATION BEFORE ENTRY CONTROL
TIME SLICE 3 OF 16

FREEWAY PERFORMANCE TABLE

SUB SEC	NO. LNS	SSEC LENGTH	O-D DATA DEMANDS ORG.	DES.	DEM.	ADJUSTED VOLUMES ORG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GS/VM	CO GS/VM	NOX GS/VM
1	3	2200.	2720.	0.	2720.	2720.	0.	2720.	6000.	0.	0.	0.	.45	59.	17.16	2.49	9.75	3.21
2	5	2500.	2850.	497.	5591.	2850.	497.	5591.	3550.	0.	0.	0.	.63	53.	16.71	2.61	12.51	3.53
3	4	1600.	0.	0.	5084.	0.	0.	5084.	7200.	0.	0.	0.	.71	57.	17.57	2.58	10.97	3.06
4	5	3700.	662.	0.	5746.	662.	0.	5746.	9400.	0.	0.	0.	.61	58.	17.42	2.54	10.51	3.11
5	5	2000.	297.	497.	6033.	297.	497.	6023.	9350.	0.	0.	0.	.65	58.	17.47	2.55	10.69	3.09
6	5	2200.	0.	0.	5537.	0.	0.	5537.	9000.	0.	0.	0.	.62	53.	17.42	2.55	10.53	3.11
7	5	2200.	355.	73.	5902.	355.	73.	5902.	9000.	0.	0.	0.	.66	57.	17.49	2.56	10.73	3.09
8	5	1100.	0.	0.	5829.	0.	0.	5829.	8700.	0.	0.	0.	.67	57.	17.51	2.57	10.80	3.03
9	6	400.	289.	153.	6117.	288.	153.	6117.	9200.	0.	0.	0.	.66	57.	17.50	2.57	10.77	3.08
10	5	500.	0.	157.	5964.	0.	157.	5964.	8600.	0.	0.	0.	.69	57.	17.55	2.59	10.91	3.05
11	5	1500.	0.	0.	5807.	0.	0.	5807.	9600.	0.	0.	0.	.65	58.	17.47	2.56	10.69	3.09
12	5	1700.	358.	0.	6165.	359.	0.	6165.	9300.	0.	0.	0.	.66	57.	17.50	2.57	10.76	3.03
13	5	2250.	917.	85.	7082.	917.	85.	7092.	8900.	0.	0.	0.	.89	56.	17.83	2.66	11.23	2.95
14	5	600.	0.	0.	6998.	0.	0.	6998.	8100.	0.	0.	0.	.95	56.	17.24	2.65	11.73	2.96
15	6	400.	500.	177.	7497.	500.	177.	7497.	9000.	0.	0.	0.	.83	56.	17.79	2.64	11.53	2.93
16	5	1450.	0.	0.	7320.	0.	0.	7320.	8500.	0.	0.	0.	.86	55.	17.63	2.65	11.72	2.96
17	5	2200.	811.	150.	8131.	811.	150.	8131.	9500.	0.	0.	0.	.86	55.	17.83	2.65	11.69	2.97
18	5	2300.	0.	0.	7921.	0.	0.	7921.	9450.	0.	0.	0.	.94	55.	17.81	2.64	11.34	2.97
19	6	2900.	531.	73.	8912.	931.	73.	8912.	10900.	0.	0.	0.	.92	56.	17.76	2.63	11.51	2.99
20	5	1200.	0.	0.	8839.	0.	0.	8839.	9500.	0.	0.	0.	.93	55.	17.95	2.63	12.05	2.92
21	6	1050.	737.	156.	9576.	737.	156.	9576.	10100.	0.	0.	0.	.95	55.	17.92	2.69	12.14	2.91
22	7	2150.	0.	0.	9420.	0.	0.	9420.	12100.	0.	0.	0.	.78	56.	17.69	2.61	11.32	3.01
23	7	1100.	548.	151.	9968.	545.	151.	9968.	12100.	0.	0.	0.	.92	56.	17.77	2.63	11.54	2.99
24	6	1500.	0.	0.	9817.	0.	0.	9817.	10300.	0.	0.	0.	.95	55.	17.97	2.63	12.10	2.92
25	7	1600.	405.	293.	10223.	405.	293.	10223.	11900.	0.	0.	0.	.85	56.	17.53	2.65	11.71	2.97
26	7	1900.	0.	0.	9930.	0.	0.	9452.	12500.	0. *	524.	479.	.76	52.	17.50	2.69	12.20	2.96
27	7	700.	422.	395.	10353.	422.	325.	9874.	11250.	0. **	700.	479.	.57	33.	17.77	3.20	18.76	2.59
28	6	1550.	0.	0.	9968.	0.	0.	9439.	10150.	0. **	1550.	479.	.93	29.	19.90	3.47	22.03	2.30
29	6	700.	361.	1502.	10329.	361.	1433.	9850.	9850.	0.	0.	0.	1.00	35.	21.77	3.06	16.28	2.42
30	6	950.	0.	3617.	9926.	0.	3450.	9417.	9000.	0.	0.	0.	.94	55.	17.96	2.63	12.03	2.92
31	5	900.	0.	0.	5209.	0.	0.	4958.	7500.	0.	0.	0.	.66	57.	17.50	2.57	10.76	3.08
32	6	720.	769.	5773.	5978.	769.	5737.	5737.	9300.	0.	0.	0.	.22	58.	17.43	2.55	10.54	3.11

TOTAL 52500.

MAX(V/C) = 1.00 AVG = 53. 17.73 2.67 12.07 2.97

INSTITUTE OF TRANSPORTATION STUDIES
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(415)-642-7390

FREQ8
SIMULATION BEFORE ENTRY CONTROL
TIME SLICE 4 OF 16

FREEWAY PERFORMANCE TABLE

SUB SEC	NO. LNS	SEC LENGTH	O-D DATA DEMANDS ORG.	DES.	DEM.	ADJUSTED VOLUMES ORG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GM/VM	CO GM/VM	NOX GM/VM
1	3	3200.	2927.	0.	2987.	2987.	0.	2987.	6600.	0.	0.	0.	.50	59.	17.23	2.50	9.97	3.12
2	5	2100.	3220.	561.	6305.	3220.	561.	6302.	8550.	0.	0.	0.	.71	57.	16.84	2.54	12.53	3.47
3	4	1500.	0.	0.	5746.	0.	0.	5746.	7200.	0.	0.	0.	.80	56.	17.73	2.62	11.41	3.20
4	5	3700.	682.	0.	6429.	682.	0.	6429.	9400.	0.	0.	0.	.71	57.	17.57	2.53	10.97	3.32
5	5	2900.	624.	561.	7053.	624.	561.	7052.	9350.	0.	0.	0.	.75	57.	17.65	2.64	11.30	3.03
6	5	2200.	0.	0.	6472.	0.	0.	6472.	9000.	0.	0.	0.	.72	57.	17.50	2.57	11.04	3.05
7	5	2900.	366.	123.	6973.	366.	123.	6978.	9000.	0.	0.	0.	.76	57.	17.67	2.51	11.25	3.05
8	5	1100.	0.	0.	6750.	0.	0.	6750.	8700.	0.	0.	0.	.78	56.	17.69	2.61	11.21	3.02
9	6	400.	266.	201.	7016.	266.	201.	7015.	9200.	0.	0.	0.	.76	57.	17.57	2.51	11.24	3.02
10	5	500.	0.	201.	6815.	0.	201.	6815.	8600.	0.	0.	0.	.79	56.	17.72	2.62	11.39	3.01
11	5	1500.	0.	0.	6615.	0.	0.	6615.	9000.	0.	0.	0.	.73	57.	17.62	2.59	11.11	3.04
12	5	1700.	403.	0.	7018.	403.	0.	6852.	9200.	0.	* 739.	159.	.74	33.	16.22	3.00	15.34	2.31
13	5	3750.	1142.	91.	8159.	1142.	89.	8000.	8000.	0.	0.	0.	1.00	35.	21.77	3.06	15.53	2.42
14	5	600.	0.	0.	8053.	0.	0.	7311.	8100.	0.	0.	0.	.93	49.	18.57	2.76	13.25	2.70
15	6	400.	457.	224.	8526.	457.	219.	8353.	9000.	0.	0.	0.	.93	55.	17.95	2.59	12.05	2.92
16	5	1450.	0.	0.	8302.	0.	0.	8149.	8500.	0.	0.	0.	.96	55.	18.06	2.57	12.34	2.87
17	5	2200.	847.	180.	9149.	847.	177.	8995.	9500.	0.	0.	0.	.95	55.	17.93	2.55	12.13	2.91
18	5	2200.	0.	0.	8969.	0.	0.	8819.	9450.	0.	0.	0.	.93	55.	17.96	2.53	12.07	2.92
19	6	2900.	942.	126.	9911.	942.	124.	9470.	10900.	0.	* 1167.	291.	.87	45.	17.54	2.85	14.27	2.82
20	5	1200.	0.	0.	9735.	0.	0.	9246.	9500.	0.	** 1200.	156.	.93	29.	21.17	3.41	21.17	2.30
21	6	1050.	754.	183.	10540.	754.	175.	10100.	10100.	0.	0.	0.	1.00	35.	21.77	3.06	16.33	2.42
22	7	2150.	0.	0.	10356.	0.	0.	9925.	12100.	0.	0.	0.	.82	56.	17.76	2.63	11.52	2.99
23	7	1100.	661.	233.	11019.	661.	226.	9779.	12100.	0.	* 411.	722.	.81	54.	17.80	2.69	12.18	2.94
24	6	1500.	0.	0.	10735.	0.	0.	9575.	10300.	0.	** 1500.	725.	.93	34.	21.52	3.12	17.59	2.40
25	7	1000.	412.	414.	11192.	412.	356.	9999.	11900.	0.	** 1000.	725.	.84	36.	17.47	3.11	17.53	2.33
26	7	1900.	0.	0.	10784.	0.	0.	9592.	12500.	0.	** 1900.	725.	.77	21.	14.40	4.06	27.14	2.21
27	7	700.	354.	450.	11135.	354.	460.	9946.	11350.	0.	** 700.	725.	.88	22.	17.77	3.57	27.32	2.14
28	6	1550.	0.	0.	10653.	0.	0.	9486.	10150.	0.	** 1550.	664.	.93	25.	20.01	3.56	24.43	2.21
29	6	700.	364.	1272.	11023.	364.	1142.	9550.	9550.	0.	0.	0.	1.00	35.	21.77	3.06	16.55	2.42
30	6	950.	0.	3559.	9745.	0.	3151.	8705.	9000.	0.	0.	0.	.97	53.	18.34	2.72	12.64	2.82
31	5	900.	0.	0.	6185.	0.	0.	5527.	7500.	0.	0.	0.	.74	57.	17.62	2.60	11.12	3.34
32	6	700.	850.	7035.	7035.	850.	6377.	6377.	9300.	0.	0.	0.	.69	57.	17.54	2.59	10.57	3.07
TOTAL		52500.											MAX(V/C) = 1.00	AVG = 43.	18.16	2.32	14.71	2.79

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INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, BERKELEY
(415)-642-7390

FREQ8
SIMULATION BEFORE ENTRY CONTROL
TIME SLICE 6 OF 16

FREEWAY PERFORMANCE TABLE

SUB SEC	NO. LNS	SEC LENGTH	O-D DATA DEMANDS ORG.	DES.	DEM.	ADJUSTED VOLUMES ORG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GS/VM	CO GS/VM	NOX GS/VM
1	3	3200.	3773.	0.	3773.	3773.	0.	3773.	6000.	0.	0.	0.	.63	59.	17.45	2.55	10.60	3.10
2	5	2600.	3353.	833.	7126.	3353.	833.	7126.	8850.	0.	0.	0.	.81	56.	17.00	2.63	13.29	3.40
3	4	1600.	0.	0.	6294.	0.	0.	6294.	7200.	0.	0.	0.	.87	56.	17.56	2.65	11.73	2.96
4	5	3700.	939.	0.	7233.	939.	0.	7233.	9400.	0.	0.	0.	.77	57.	17.63	2.61	11.23	3.03
5	5	2000.	341.	563.	7574.	341.	563.	7574.	8350.	0.	0.	0.	.91	56.	17.75	2.63	11.47	2.93
6	5	2200.	0.	0.	7011.	0.	0.	7011.	9000.	0.	0.	0.	.78	56.	17.70	2.61	11.32	3.01
7	5	2300.	275.	130.	7286.	275.	130.	6719.	9000.	0.	* 2097.	567.	.75	35.	16.23	3.10	17.50	2.74
8	5	1100.	0.	0.	7157.	0.	0.	6590.	8700.	0.	** 1100.	567.	.76	19.	13.76	4.20	31.70	2.11
9	6	400.	330.	256.	7427.	330.	256.	6920.	9200.	0.	** 400.	567.	.75	17.	13.23	4.40	34.23	2.09
10	5	500.	0.	294.	7221.	0.	294.	6664.	8600.	0.	** 500.	567.	.77	18.	14.07	4.29	32.90	2.02
11	5	1500.	0.	0.	6937.	0.	0.	6370.	9000.	0.	** 1500.	567.	.71	16.	11.91	4.61	37.04	1.76
12	5	1700.	622.	0.	7559.	622.	0.	6992.	9300.	0.	** 1700.	567.	.75	17.	13.22	4.41	34.35	2.06
13	5	3950.	1003.	118.	8567.	1003.	110.	8000.	8000.	0.	0.	0.	1.00	35.	21.77	3.06	16.22	2.42
14	5	600.	0.	0.	8449.	0.	0.	7890.	8100.	0.	0.	0.	.97	50.	18.67	2.75	13.10	2.73
15	6	400.	514.	243.	8934.	514.	229.	8404.	9000.	0.	0.	0.	.93	55.	17.96	2.65	12.67	2.52
16	5	1450.	0.	0.	8721.	0.	0.	8177.	8500.	0.	0.	0.	.96	54.	18.14	2.70	12.35	2.37
17	5	2200.	807.	275.	9529.	807.	259.	9169.	9500.	0.	* 234.	795.	.96	55.	17.92	2.69	12.15	2.51
18	5	2300.	0.	0.	9252.	0.	0.	7930.	8450.	0.	** 2300.	795.	.94	33.	17.57	3.04	16.64	2.76
19	6	2900.	1016.	203.	10233.	1016.	197.	8945.	10900.	0.	** 2900.	795.	.82	25.	16.67	3.62	24.21	2.35
20	5	1200.	0.	0.	10060.	0.	0.	8705.	9500.	0.	** 1200.	795.	.92	25.	19.94	3.65	24.34	2.21
21	6	1050.	824.	183.	10825.	824.	170.	9530.	10100.	0.	** 1050.	570.	.94	23.	20.66	3.45	21.77	2.23
22	7	2150.	0.	0.	10701.	0.	0.	9340.	12100.	0.	** 2150.	570.	.77	19.	14.10	4.25	32.34	2.05
23	7	1100.	667.	340.	11359.	667.	317.	10047.	12100.	0.	** 1100.	570.	.83	20.	16.41	4.04	29.43	2.09
24	6	1500.	0.	0.	11043.	0.	0.	9730.	10300.	0.	** 1500.	570.	.94	25.	20.23	3.63	24.02	2.2
25	7	1000.	446.	546.	11474.	446.	510.	10176.	11900.	0.	** 1000.	570.	.86	21.	17.12	3.93	28.33	2.11
26	7	1900.	0.	0.	10947.	0.	0.	9666.	12500.	0.	** 1900.	570.	.77	18.	14.00	4.30	33.60	2.03
27	7	700.	359.	535.	11317.	359.	549.	10034.	11350.	0.	** 700.	570.	.88	23.	18.05	3.54	26.34	2.15
28	6	1550.	0.	0.	10732.	0.	0.	9486.	10150.	0.	** 1550.	570.	.93	25.	20.01	3.66	24.43	2.2
29	6	700.	364.	1445.	11096.	364.	1293.	9950.	9850.	0.	0.	0.	1.00	35.	21.77	3.06	16.32	2.43
30	6	950.	0.	3165.	9651.	0.	2309.	8567.	9000.	0.	0.	0.	.95	55.	17.96	2.63	12.06	2.9
31	5	900.	0.	0.	6465.	0.	0.	5752.	7500.	0.	0.	0.	.77	57.	17.63	2.61	11.27	3.03
32	6	700.	659.	7145.	7145.	659.	6416.	6416.	9200.	0.	0.	0.	.69	57.	17.35	2.53	10.59	3.0

TOTAL 52500. MAX(V/C) = 1.00 AVG = 31. 17.12 3.30 20.03 2.5

INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, BERKELEY
(415)-642-7390

FREQ8
SIMULATION BEFORE ENTRY CONTROL
TIME SLICE 8 OF 16

FREEWAY PERFORMANCE TABLE

SUB SEC	NO. LNS	SSEC LENGTH	O-D DATA DEMANDS ORG.	DES.	DEM.	ADJUSTED VOLUMES ORG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GS/VM	CO GS/VM	NOX GS/VM
1	3	3200.	3342.	0.	3342.	3342.	0.	3342.	6000.	0.	0.	0.	.64	58.	17.46	2.55	10.55	3.10
2	5	2600.	2934.	875.	6826.	2934.	875.	6826.	8850.	0.	0.	0.	.77	57.	16.94	2.67	13.14	3.42
3	4	1600.	0.	0.	5751.	0.	0.	5751.	7200.	0.	0.	0.	.83	56.	17.78	2.63	11.55	3.33
4	5	3700.	1003.	0.	6953.	1003.	0.	6953.	9400.	0.	0.	0.	.74	57.	17.53	2.60	11.13	3.04
5	5	2000.	330.	874.	7274.	330.	874.	7274.	9350.	0.	0.	0.	.78	56.	17.69	2.61	11.33	3.21
6	5	2200.	0.	0.	6400.	0.	0.	6330.	9000.	0.	* 57.	179.	.69	57.	17.57	2.59	11.02	3.25
7	5	2300.	341.	187.	6741.	341.	187.	6563.	9000.	0.	** 2300.	179.	.73	18.	13.17	4.35	33.37	2.11
8	5	1100.	0.	0.	6614.	0.	0.	6435.	8700.	0.	** 1100.	179.	.74	17.	13.10	4.42	34.39	2.00
9	6	400.	337.	497.	7010.	337.	497.	6831.	9300.	0.	** 400.	179.	.74	17.	13.18	4.41	34.44	2.00
10	5	500.	0.	253.	6524.	0.	253.	6345.	8600.	0.	** 500.	179.	.74	17.	13.04	4.43	34.70	2.00
11	5	1500.	0.	0.	6271.	0.	0.	6092.	9000.	0.	** 1500.	179.	.68	15.	11.17	4.73	38.87	1.94
12	5	1700.	641.	0.	6912.	641.	0.	6733.	9300.	0.	** 1700.	179.	.72	17.	12.59	4.50	35.59	1.98
13	5	3950.	876.	67.	7783.	876.	69.	7609.	9000.	0.	** 3950.	391.	.85	26.	20.39	3.59	23.5-	2.33
14	5	600.	0.	0.	7721.	0.	0.	7540.	8100.	0.	** 600.	391.	.93	25.	19.85	3.67	24.62	2.30
15	6	400.	324.	253.	8044.	324.	260.	7863.	9000.	0.	** 400.	391.	.87	22.	17.70	3.88	27.44	2.14
16	5	1450.	0.	0.	7791.	0.	0.	7604.	8500.	0.	** 1450.	391.	.89	23.	18.42	3.31	26.43	2.16
17	5	2200.	590.	284.	8481.	690.	270.	8294.	9500.	0.	** 2200.	391.	.87	22.	17.68	3.88	27.47	2.13
18	5	2300.	0.	0.	8217.	0.	0.	8033.	9450.	0.	** 2300.	391.	.85	21.	16.94	3.97	28.61	2.11
19	6	2900.	1030.	268.	9249.	1030.	268.	9054.	10900.	0.	** 2900.	391.	.83	20.	16.42	4.03	29.47	2.09
20	5	1200.	0.	0.	8786.	0.	0.	8786.	9500.	0.	** 1200.	391.	.92	25.	19.59	3.69	24.93	2.20
21	6	1050.	960.	172.	9946.	960.	175.	9747.	10100.	0.	** 1050.	353.	.97	26.	20.65	3.56	23.19	2.34
22	7	2150.	0.	0.	9774.	0.	0.	9572.	12100.	0.	** 2150.	353.	.79	19.	14.74	4.22	31.86	2.04
23	7	1100.	700.	335.	10474.	700.	340.	10272.	12100.	0.	** 1100.	353.	.85	21.	16.94	3.97	28.62	2.11
24	6	1500.	0.	0.	10139.	0.	0.	9932.	10300.	0.	** 1500.	353.	.96	26.	20.61	3.57	23.32	2.34
25	7	1000.	361.	533.	10500.	361.	546.	10293.	11500.	0.	** 1000.	353.	.86	22.	17.42	3.91	27.36	2.13
26	7	1900.	0.	0.	9962.	0.	0.	9747.	12500.	0.	** 1900.	353.	.78	18.	14.26	4.27	32.59	2.03
27	7	700.	339.	635.	10251.	339.	643.	10136.	11350.	0.	** 700.	353.	.89	22.	18.36	3.81	26.50	2.15
28	6	1550.	0.	0.	9716.	0.	0.	9493.	10150.	0.	** 1550.	353.	.94	25.	20.04	3.65	24.40	2.21
29	6	700.	357.	1193.	10073.	357.	1171.	9850.	9850.	0.	0.	0.	1.00	35.	21.77	3.06	16.68	2.42
30	6	950.	0.	2370.	8875.	0.	2307.	8679.	9000.	0.	0.	0.	.96	53.	18.21	2.71	12.47	2.83
31	5	900.	0.	0.	6005.	0.	0.	5972.	7500.	0.	0.	0.	.78	56.	17.70	2.62	11.34	3.01
32	6	700.	769.	6774.	6774.	769.	6641.	6641.	9300.	0.	0.	0.	.71	57.	17.59	2.59	11.01	3.05
TOTAL		52500.											MAX(V/C) = 1.00	AVG = 26.	16.80	3.59	23.66	2.40

FREEWAY PERFORMANCE TABLE

SUB SEC	NO. LNS	SSEC LENGTH	O-D DATA DEMANDS ORG.	DES.	DEM.	ADJUSTED VOLUMES OFG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GS/VM	CO GS/VM	NOX GS/VM
1	3	3200.	4103.	0.	4103.	4103.	0.	4103.	6000.	0.	0.	0.	.68	57.	17.54	2.57	10.96	3.07
2	5	2500.	3050.	975.	7153.	3050.	975.	7153.	8650.	0.	0.	0.	.81	56.	17.00	2.63	12.30	3.40
3	4	1200.	0.	0.	6178.	0.	0.	6178.	7200.	0.	0.	0.	.86	56.	17.82	2.65	11.70	2.77
4	5	3700.	888.	0.	7066.	888.	0.	7066.	9400.	0.	0.	0.	.75	57.	17.65	2.60	11.19	3.03
5	5	2000.	295.	943.	7261.	295.	943.	7361.	9350.	0.	0.	0.	.79	56.	17.71	2.62	11.26	3.01
6	5	2200.	0.	0.	6418.	0.	0.	6418.	9000.	0.	0.	0.	.71	57.	17.53	2.59	11.02	3.05
7	5	2800.	336.	125.	6754.	336.	125.	7096.	9000.	0.	* 1122.	-342.	.79	23.	15.36	3.77	26.21	2.33
8	5	1100.	0.	0.	6629.	0.	0.	6971.	8700.	0.	** 1100.	-342.	.80	19.	15.20	4.17	31.20	2.05
9	6	400.	336.	437.	7015.	336.	437.	7357.	9200.	0.	** 400.	-342.	.80	19.	15.12	4.17	31.30	2.05
10	5	500.	0.	247.	6529.	0.	247.	6270.	8600.	0.	** 500.	-342.	.80	19.	15.07	4.13	31.33	2.05
11	5	1500.	0.	0.	6231.	0.	0.	6623.	9000.	0.	** 1500.	-342.	.74	17.	12.71	4.48	35.24	1.97
12	5	1700.	515.	0.	6795.	515.	0.	7139.	9300.	0.	** 1700.	-342.	.77	18.	13.73	4.33	33.37	2.02
13	5	3950.	862.	115.	7553.	862.	115.	8000.	8000.	0.	** 3950.	-342.	1.00	28.	21.35	3.46	21.75	2.28
14	5	600.	0.	0.	7543.	0.	0.	7885.	8100.	0.	0.	0.	.97	45.	18.96	2.55	14.20	2.57
15	6	400.	325.	247.	7868.	325.	258.	8210.	9000.	0.	0.	0.	.91	36.	18.77	3.09	17.28	2.62
16	5	1450.	0.	0.	7620.	0.	0.	8161.	8500.	0.	* 724.	-209.	.96	28.	20.22	3.45	22.17	2.31
17	5	2200.	655.	259.	8275.	655.	258.	8916.	9500.	0.	** 2200.	-209.	.93	25.	19.73	3.68	24.76	2.20
18	5	2300.	0.	0.	8018.	0.	0.	8549.	9450.	0.	** 2300.	-209.	.90	24.	18.78	3.77	25.94	2.17
19	6	2900.	958.	292.	8976.	958.	292.	9506.	10900.	0.	** 2900.	-209.	.87	22.	17.65	3.39	27.52	2.13
20	5	1200.	0.	0.	8694.	0.	0.	9214.	9500.	0.	** 1200.	-209.	.97	27.	20.73	3.55	22.59	2.25
21	6	1050.	673.	166.	9367.	673.	171.	9888.	10100.	0.	** 1050.	-209.	.98	27.	20.91	3.58	22.62	2.25
22	7	2150.	0.	0.	9202.	0.	0.	9717.	12100.	0.	** 2150.	-209.	.80	19.	15.29	4.16	31.08	2.06
23	7	1100.	551.	330.	9753.	551.	341.	10258.	12100.	0.	** 1100.	-209.	.85	21.	16.33	3.97	28.83	2.11
24	6	1500.	0.	0.	9423.	0.	0.	9927.	10300.	0.	** 1500.	-209.	.96	26.	20.60	3.57	23.24	2.24
25	7	1000.	428.	592.	9850.	429.	610.	10355.	11900.	0.	** 1000.	-209.	.87	22.	17.39	3.90	27.61	2.13
26	7	1900.	0.	0.	9258.	0.	0.	9745.	12500.	0.	** 1900.	-209.	.78	19.	14.25	4.27	32.60	2.02
27	7	700.	384.	592.	9642.	384.	609.	10128.	11350.	0.	** 700.	-209.	.89	23.	18.34	3.81	26.54	2.16
28	6	1550.	0.	0.	9049.	0.	0.	9519.	10150.	0.	** 1550.	-209.	.94	25.	20.10	3.65	24.29	2.21
29	6	700.	331.	1163.	9380.	331.	1221.	9850.	9850.	0.	0.	0.	1.00	35.	21.77	3.06	16.38	2.42
30	6	950.	0.	2631.	8217.	0.	2763.	8629.	9000.	0.	0.	0.	.96	55.	18.06	2.69	12.25	2.59
31	5	900.	0.	0.	5586.	0.	0.	5866.	7500.	0.	0.	0.	.78	56.	17.70	2.62	11.34	3.01
32	6	700.	607.	6193.	6193.	607.	6473.	6473.	9300.	0.	0.	0.	.70	57.	17.56	2.59	10.92	3.06

TOTAL 53500. MAX(V/C) = 1.00 AVG = 23. 17.33 3.47 22.24 2.43

INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, BERKELEY
(415)-642-7390

FREQ8
SIMULATION BEFORE ENTRY CONTROL
TIME SLICE 14 OF 15

FREEWAY PERFORMANCE TABLE

SUB SEC	NO. LNS	SSEC LENGTH	O-D DATA DEMANDS ORG.	DES.	DEM.	ADJUSTED VOLUMES ORG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GR/VM	CO GR/VM	NOX GR/VM
1	3	3200.	3912.	0.	3912.	3912.	0.	3912.	6000.	0.	0.	0.	.65	58.	17.48	2.55	10.71	3.09
2	5	2600.	3121.	1097.	7032.	3121.	1097.	7032.	8350.	0.	0.	0.	.79	54.	16.98	2.63	13.24	3.41
3	4	1600.	0.	0.	5936.	0.	0.	5936.	7200.	0.	0.	0.	.82	56.	17.77	2.63	11.54	2.99
4	5	3700.	774.	0.	6710.	774.	0.	6710.	9400.	0.	0.	0.	.71	57.	17.59	2.59	11.01	3.05
5	5	2000.	397.	1139.	7106.	397.	1139.	7106.	9350.	0.	0.	0.	.76	57.	17.66	2.61	11.23	3.02
6	5	2200.	0.	0.	5967.	0.	0.	5967.	9000.	0.	0.	0.	.66	57.	17.50	2.57	10.75	3.03
7	5	2900.	430.	159.	6397.	430.	159.	6397.	9000.	0.	0.	0.	.71	57.	17.59	2.59	10.99	3.05
8	5	1100.	0.	0.	6237.	0.	0.	6237.	8700.	0.	0.	0.	.72	57.	17.59	2.59	11.02	3.05
9	6	400.	475.	555.	6702.	475.	555.	6702.	9200.	0.	0.	0.	.73	57.	17.61	2.59	11.08	3.04
10	5	500.	0.	346.	6147.	0.	345.	6147.	8600.	0.	0.	0.	.71	57.	17.59	2.59	11.01	3.05
11	5	1500.	0.	0.	5502.	0.	0.	5502.	9000.	0.	0.	0.	.64	55.	17.34	2.59	11.05	3.05
12	5	1700.	357.	0.	6159.	357.	0.	6674.	9500.	0.	0.	-506.	.72	24.	14.10	3.57	24.93	3.47
13	5	3950.	845.	121.	7015.	845.	130.	7521.	8000.	0.	0.	0.	.94	55.	17.97	2.68	12.10	2.92
14	5	600.	0.	0.	6894.	0.	0.	7391.	8100.	0.	0.	0.	.91	55.	17.92	2.67	11.97	2.93
15	6	400.	437.	403.	7331.	437.	435.	7329.	9600.	0.	0.	0.	.87	56.	17.55	2.65	11.75	2.94
16	5	1450.	0.	0.	6923.	0.	0.	7392.	8500.	0.	0.	0.	.87	56.	17.25	2.65	11.76	2.96
17	5	2200.	563.	339.	7485.	563.	361.	7955.	9500.	0.	0.	0.	.84	56.	17.79	2.64	11.60	2.92
18	5	2500.	0.	0.	7147.	0.	0.	7595.	9450.	0.	0.	0.	.90	56.	17.74	2.62	11.44	3.00
19	6	2900.	785.	235.	7931.	785.	248.	8379.	10900.	0.	0.	0.	.77	57.	17.63	2.61	11.27	3.02
20	5	1200.	0.	0.	7697.	0.	0.	8131.	9500.	0.	0.	0.	.86	55.	17.83	2.65	11.59	2.97
21	6	1050.	569.	225.	8266.	569.	237.	8701.	10100.	0.	0.	0.	.86	56.	17.84	2.65	11.72	2.96
22	7	2150.	0.	0.	8041.	0.	0.	8464.	12100.	0.	0.	0.	.70	57.	17.56	2.58	10.94	3.06
23	7	1100.	477.	299.	8519.	477.	314.	8941.	12100.	0.	0.	0.	.74	57.	17.63	2.60	11.13	3.04
24	6	1500.	0.	0.	8219.	0.	0.	8575.	10200.	0.	0.	-232.	.86	31.	17.53	3.03	19.20	2.53
25	7	1000.	254.	607.	8473.	254.	656.	9149.	11900.	0.	0.	0.	.77	57.	17.68	2.61	11.27	3.02
26	7	1900.	0.	0.	7866.	0.	0.	8494.	12500.	0.	0.	0.	.69	52.	17.23	2.66	11.95	2.82
27	7	700.	345.	613.	8211.	345.	660.	8239.	11350.	0.	0.	0.	.79	33.	17.25	3.18	18.51	2.54
28	6	1550.	0.	0.	7598.	0.	0.	8853.	10150.	0.	0.	-479.	.87	26.	17.57	3.56	23.30	2.35
29	6	700.	261.	1035.	7330.	261.	1189.	9119.	9850.	0.	0.	0.	.93	55.	17.95	2.68	12.08	2.93
30	6	950.	0.	2483.	6835.	0.	2385.	7930.	9000.	0.	0.	0.	.92	56.	17.87	2.66	11.81	2.95
31	5	900.	0.	0.	4347.	0.	0.	5044.	7500.	0.	0.	0.	.67	57.	17.52	2.57	10.81	3.08
32	6	700.	523.	4370.	4670.	523.	5565.	5566.	9300.	0.	0.	0.	.60	58.	17.40	2.54	10.45	3.12

MAX(V/C) = 0.94 AVG = 50. 17.50 2.72 12.57 2.77

TOTAL 52500.

INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, BERKELEY
(415)-642-7390

FREQ8
SIMULATION BEFORE ENTRY CONTROL
TIME SLICE 1 OF 16

FREEWAY TRAVEL TIME (MINUTES)

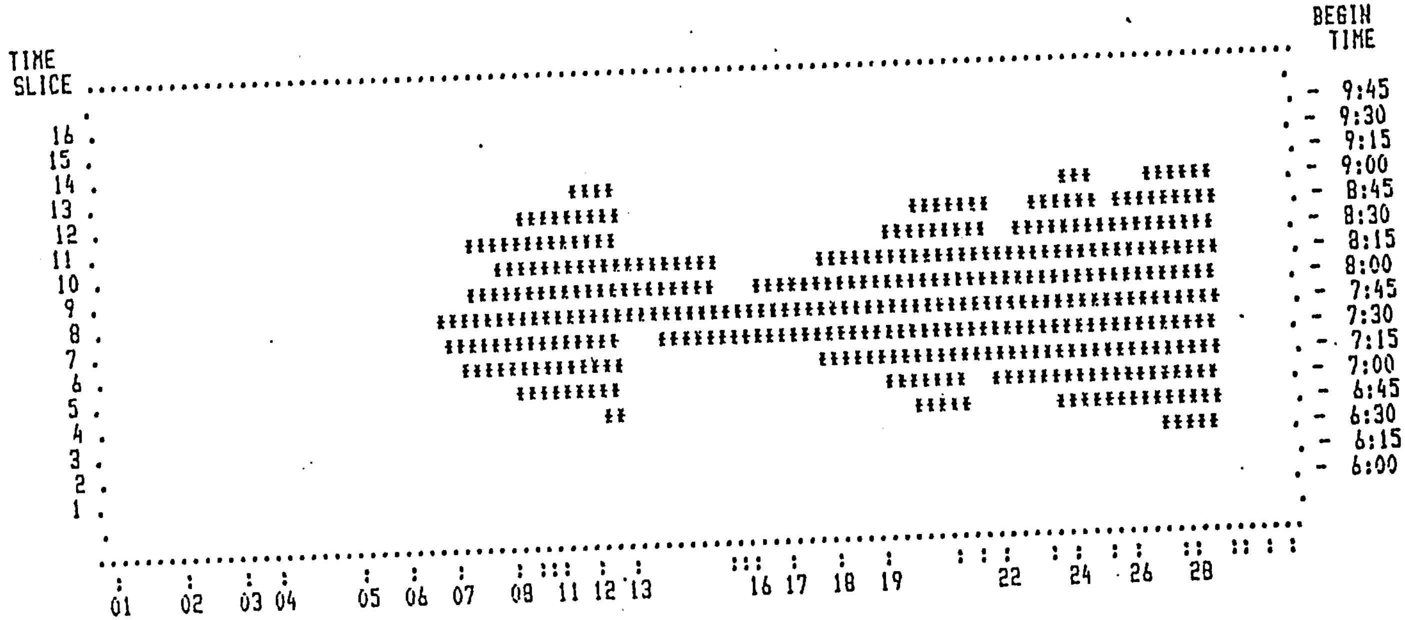
ORIGINS DOWN / DESTINATIONS ACROSS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1.09	2.47	3.42	3.71	3.80	5.17	5.37	6.07	7.08	7.52	8.15	8.64	9.15	9.59	9.78	10.09
2	0.49	1.83	2.83	3.11	3.21	4.58	4.77	5.48	6.49	6.93	7.56	8.05	8.55	9.00	9.18	9.49
3	0.00	1.08	2.03	2.32	2.41	3.78	3.98	4.68	5.69	6.13	6.76	7.25	7.75	8.20	8.39	8.69
4	0.00	0.38	1.33	1.61	1.71	3.08	3.27	3.98	4.99	5.43	6.05	6.55	7.06	7.50	7.69	7.99
5	0.00	0.00	0.53	0.82	0.91	2.29	2.48	3.18	4.19	4.63	5.26	5.75	6.26	6.70	6.89	7.20
6	0.00	0.00	0.00	0.08	0.17	1.54	1.74	2.44	3.45	3.89	4.52	5.01	5.52	5.96	6.15	6.45
7	0.00	0.00	0.00	0.00	0.00	1.09	1.28	1.99	2.99	3.44	4.07	4.56	5.06	5.51	5.69	6.00
8	0.00	0.00	0.00	0.00	0.00	0.76	0.95	1.66	2.67	3.11	3.74	4.23	4.74	5.18	5.37	5.68
9	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.73	1.79	2.23	2.86	3.35	3.86	4.30	4.49	4.80
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	1.43	1.88	2.51	3.00	3.50	3.95	4.13	4.44
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	1.00	1.63	2.12	2.63	3.07	3.26	3.57
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.84	1.33	1.83	2.29	2.46	2.77
13	0.00	0.00	0.00	0.00	0.00	0:00	0.00	0.00	0.00	0.00	0.21	0.70	1.21	1.65	1.64	2.15
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.70	1.14	1.33	1.64
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.58	0.77	1.07
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.33	0.63
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13

FREQ8

INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, BERKELEY
(415)-642-7390

CONTOUR DIAGRAM OF
QUEUE LENGTH
BEFORE OPTIMIZATION



BLANK DENOTES MOVING TRAFFIC. ASTERISK DENOTES QUEUED VEHICLES DUE TO MAINLINE CONGESTION.
M DENOTES QUEUED VEHICLES DUE TO MERGING. B DENOTES QUEUED VEHICLES DUE TO MAINLINE CONGESTION AND MERGING. (WHEN BOTH QUEUES EXIST, LENGTH OF DISPLAY REPRESENTS MAINLINE CONGESTION.)

A P P E N D I X - E -

NON-INCIDENT FINAL CALIBRATED RUN FOR WESTBOUND DIRECTION-SANTA MONICA FREEWAY

INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, BERKELEY
(415)-642-7350

FREEWAY AND ARTERIAL DESIGN FEATURES

SUB SEC	NO. LNS	SSEC CAP	SSEC LENGTH	DESIGN SPEED	ORG DES	TRK FAC	SSEC GRAD	PCT TRK	PCT DES TRUCKS	SPECIAL RAMP	FF.SPD. ALT.RTE	CAP. ALT.RTE	ART TYPE	GRADE ALT.RTE	SUBSECTION LOCATION
1	3	7600.	2400.	65	O	0.93	0.0	2	30	NO	0.0	0.	GOOD	0.0	ML ORIGIN TO SB RT11 ON
2	6	10300.	1270.	65	O	0.93	0.0	2	30	YES	0.0	0.	GOOD	0.0	SB RT11 ON-NB RT11 ON
3	7	12000.	1050.	65	OD	0.95	0.0	2	30	YES	0.0	0.	GOOD	0.0	NB RT11 ON-HOOVER OFF
4	7	11400.	1100.	65		0.93	0.0	2	30	NO	0.0	0.	GOOD	0.0	HOOVER OFF-HOOVER ON
5	7	10900.	400.	65	OD	0.95	0.0	2	30	YES	0.0	0.	GOOD	0.0	HOOVER ON-VERMONT OFF
6	7	12500.	1700.	65		0.92	0.0	2	30	NO	0.0	0.	GOOD	0.0	VERMONT OFF-VERMONT ON
7	7	11300.	950.	65	OD	0.93	0.0	2	30	YES	0.0	0.	GOOD	0.0	VERMONT ON-NORMANDIE OF
8	6	10300.	1600.	65		0.92	0.0	2	30	NO	0.0	0.	GOOD	0.0	NORMANDIE (OFF-->ON)
9	6	9800.	600.	65	OD	0.95	0.0	2	30	YES	0.0	0.	GOOD	0.0	NORMANDIE ON-WESTERN OF
10	6	10600.	2200.	65		0.93	0.0	2	30	NO	0.0	0.	GOOD	0.0	WESTERN OFF-WESTERN ON
11	6	9500.	600.	65	OD	0.93	0.0	2	30	YES	0.0	0.	GOOD	0.0	WESTERN ON-ARLINGTON OF
12	5	9450.	1900.	65		0.92	0.0	2	30	NO	0.0	0.	GOOD	0.0	ARLINGTON (OFF-->ON)
13	6	11550.	2950.	65	OD	0.95	0.0	2	30	YES	0.0	0.	GOOD	0.0	ARLINGTON ON-CRENSH.OFF
14	5	9500.	2150.	65		0.93	0.0	2	30	NO	0.0	0.	GOOD	0.0	CRENSHAW (OFF-->ON)
15	5	8800.	3050.	65	OD	0.92	0.0	2	30	YES	0.0	0.	GOOD	0.0	CRENSHAW ON-NB LAB. OFF
16	5	9100.	650.	65		0.95	0.0	2	30	YES	0.0	0.	GOOD	0.0	NB LAB. OFF-NB LAB. ON
17	6	9500.	330.	65	OD	0.93	0.0	2	30	YES	0.0	0.	GOOD	0.0	NB LAB. ON-SB LAB. OFF
18	5	9100.	1550.	65		0.93	0.0	2	30	YES	0.0	0.	GOOD	0.0	SB LAB. OFF-SB LAB. ON
19	5	9150.	2550.	65	OD	0.92	0.0	2	30	YES	0.0	0.	GOOD	0.0	SB LAB. ON-WASHING. OFF
20	5	9100.	550.	65	D	0.92	0.0	2	30	YES	0.0	0.	GOOD	0.0	WASHING. OFF-VENICE OFF

INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, BERKELEY
(415)-642-7390

FREEWAY AND ARTERIAL DESIGN FEATURES

SUB SEC	NO. LNS	SSEC CAP	SSEC LENGTH	DESIGN SPEED	ORG DES	TRK FAC	SSEC GRAD	PCT TRK	PCT DES TRUCKS	SPECIAL RAMP	FF.SPD. ALT.RTE	CAP. ALT.RTE	ART TYPE	GRADE ALT.RTE	SUBSECTION LOCATION
21	4	7600.	2400.	65		0.93	0.0	2	30	NO	0.0	0.	6000	0.0	VENICE OFF-FAIRFAX ON
22	4	7550.	1750.	65	0	0.93	0.0	2	30	YES	0.0	0.	6000	0.0	FAIRFAX ON-LACIENEGA ON
23	5	9500.	2300.	65	00	0.93	0.0	2	30	YES	0.0	0.	6000	0.0	LACIENEGA ON-ROBERT.OFF
24	4	7500.	3200.	65		0.93	0.0	2	30	YES	0.0	0.	6000	0.0	ROBERTSON (OFF-->ON)
25	5	9450.	1400.	65	00	0.93	0.0	2	30	YES	0.0	0.	6000	0.0	ROBERTSON ON-NATION.OFF
26	4	7550.	4350.	65	0	0.93	0.0	2	30	NO	0.0	0.	6000	0.0	NATION. OFF-OVERLAND OF
27	4	7200.	1050.	65		0.93	0.0	2	30	NO	0.0	0.	6000	0.0	OVERLAND (OFF-->ON)
28	5	9400.	2250.	65	00	0.93	0.0	2	30	YES	0.0	0.	6000	0.0	OVERLAND ON-SB 405 OFF
29	4	7500.	1700.	65	0	0.93	0.0	2	30	NO	0.0	0.	6000	0.0	SB 405 OFF-NB 405 OFF
30	3	6000.	2100.	65	0	0.93	0.0	2	30	NO	0.0	0.	6000	0.0	NB 405 OFF-ML DEST.

1921 RECORDS OF EXTENDED CORE STORAGE REQUIRED

RAMP LIMITS =1500.
OFF-RAMP 14 LIMIT=2400.
OFF-RAMP 15 LIMIT=3000.
ON-RAMP 2 LIMIT=3900.
ON-RAMP 3 LIMIT=1800.

FREEWAY PERFORMANCE TABLE

SUB SEC	NO. LNS	SSEC LENGTH	O-D DATA DEMANDS ORG.	DES.	DEM.	ADJUSTED VOLUMES ORG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GS/VM	CO GS/VM	NOX GS/VM
1	3	2400.	5442.	0.	5442.	5442.	0.	5442.	7600.	0.	0.	0.	.72	57.	17.57	2.57	11.02	3.05
2	6	1270.	2600.	0.	8042.	2600.	0.	8042.	10300.	0.	0.	0.	.75	56.	17.70	2.61	11.22	3.01
3	7	1050.	915.	212.	8956.	915.	212.	8955.	12000.	0.	0.	0.	.75	57.	17.64	2.60	11.17	3.03
4	7	1100.	0.	0.	8744.	0.	0.	8744.	11400.	0.	0.	0.	.77	57.	17.63	2.61	11.26	3.02
5	7	400.	362.	254.	9136.	362.	254.	9106.	10900.	0.	0.	0.	.84	56.	17.79	2.64	11.59	2.93
6	7	1700.	0.	0.	8822.	0.	0.	8822.	12500.	0.	0.	0.	.71	57.	17.37	2.52	10.77	3.09
7	7	950.	364.	255.	9156.	364.	255.	9156.	11300.	0.	0.	0.	.81	56.	17.73	2.63	11.49	2.97
8	6	1600.	0.	0.	8922.	0.	0.	8922.	10500.	0.	0.	0.	.85	55.	17.84	2.65	11.74	2.92
9	6	600.	363.	379.	9265.	363.	379.	9295.	9500.	0.	0.	0.	.95	55.	17.92	2.65	12.12	2.91
10	6	2200.	0.	0.	8906.	0.	0.	8906.	10600.	0.	0.	0.	.84	56.	17.80	2.64	11.82	2.93
11	6	600.	259.	340.	9166.	259.	340.	9166.	9900.	0.	0.	0.	.93	55.	17.95	2.66	12.03	2.91
12	5	1500.	0.	0.	8825.	0.	0.	8825.	9450.	0.	0.	0.	.93	55.	17.96	2.66	12.07	2.92
13	6	2950.	343.	632.	9173.	343.	632.	9173.	11550.	0.	0.	0.	.79	56.	17.72	2.62	11.40	3.00
14	5	2150.	0.	0.	8541.	0.	0.	8392.	9500.	0. *	910.	149.	.88	43.	17.93	2.91	13.05	2.73
15	5	3050.	408.	253.	8949.	405.	247.	8800.	8800.	0.	0.	0.	1.00	35.	21.77	3.06	16.66	2.42
16	5	650.	0.	0.	8676.	0.	0.	8551.	9100.	0.	0.	0.	.94	55.	17.97	2.68	12.10	2.92
17	6	330.	298.	511.	8994.	278.	503.	8850.	9600.	0.	0.	0.	.92	55.	17.94	2.67	12.01	2.93
18	5	1550.	0.	0.	8463.	0.	0.	8347.	9100.	0.	0.	0.	.92	55.	17.93	2.67	11.99	2.93
19	5	2950.	248.	936.	8731.	248.	922.	8594.	9150.	0.	0.	0.	.94	55.	17.97	2.68	12.09	2.92
20	5	950.	0.	424.	7794.	0.	477.	7672.	9100.	0.	0.	0.	.84	56.	17.80	2.64	11.63	2.93
21	4	2400.	0.	0.	7310.	0.	0.	7196.	7600.	0.	0.	0.	.95	55.	17.98	2.68	12.13	2.91
22	4	1750.	331.	0.	7641.	331.	0.	7527.	7750.	0.	0.	0.	.97	38.	21.52	2.98	15.72	2.46
23	5	2300.	345.	631.	7926.	345.	641.	7872.	9500.	0.	0.	0.	.83	56.	17.78	2.64	11.56	2.93
24	4	2200.	0.	0.	7336.	0.	0.	7231.	7500.	0.	0.	0.	.96	54.	18.20	2.71	12.46	2.85
25	5	1400.	411.	490.	7747.	411.	483.	7642.	9450.	0.	0.	0.	.81	56.	17.75	2.62	11.47	3.00
26	4	4350.	0.	554.	7257.	0.	547.	7159.	7850.	0.	0.	0.	.91	55.	17.92	2.67	11.96	2.93
27	4	1050.	0.	0.	6703.	0.	0.	6612.	7200.	0.	0.	0.	.92	55.	17.93	2.67	11.99	2.93
28	5	2250.	248.	1920.	6951.	248.	1895.	6860.	9400.	0.	0.	0.	.73	57.	17.61	2.59	11.09	3.04
29	4	1700.	0.	1541.	5030.	0.	1519.	4965.	7500.	0.	0.	0.	.66	57.	17.50	2.57	10.76	3.09
30	3	3100.	0.	3390.	3390.	0.	3345.	3345.	6000.	0.	0.	0.	.56	58.	17.32	2.52	10.25	3.14

TOTAL 53960. MAX(V/C) = 1.00 AVG = 52. 18.13 2.59 12.25 2.91

FREEWAY PERFORMANCE TABLE

SUB SEC	NO. LNS	SSEC LENGTH	O-D DATA DEMANDS ORG.	DES.	GEN.	ADJUSTED VOLUMES ORG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GS/VM	CO GS/VM	NOX GS/VM
1	3	2400.	5515.	0.	5515.	5515.	0.	5515.	7600.	0.	0.	0.	.73	57.	17.61	2.59	11.07	3.04
2	6	1270.	2746.	0.	8251.	2746.	0.	8251.	10300.	0.	0.	0.	.80	56.	17.73	2.52	11.43	3.00
3	7	1050.	1000.	246.	9251.	1000.	246.	9251.	12000.	0.	0.	0.	.77	57.	17.59	2.51	11.29	3.02
4	7	1100.	0.	0.	9015.	0.	0.	9015.	11400.	0.	0.	0.	.79	55.	17.72	2.52	11.33	3.01
5	7	400.	473.	299.	9429.	473.	299.	9429.	10900.	0.	0.	0.	.87	55.	17.85	2.55	11.76	2.95
6	7	1700.	0.	0.	9189.	0.	0.	9129.	12500.	0.	0.	0.	.74	57.	17.62	2.50	11.11	3.04
7	7	950.	392.	298.	9551.	392.	298.	9551.	11300.	0.	0.	0.	.85	56.	17.81	2.54	11.65	2.97
8	5	1600.	0.	0.	9233.	0.	0.	9233.	10300.	0.	0.	0.	.90	55.	17.90	2.57	11.91	2.94
9	6	600.	336.	551.	9669.	336.	551.	9669.	9800.	0.	0.	0.	.99	44.	20.03	2.81	13.81	2.57
10	5	2200.	0.	0.	9102.	0.	0.	9108.	10600.	0.	0.	0.	.86	56.	17.83	2.55	11.71	2.97
11	6	500.	310.	469.	9418.	310.	469.	9418.	9900.	0.	0.	0.	.95	55.	17.95	2.58	12.02	2.92
12	5	1900.	0.	0.	8950.	0.	0.	8950.	9450.	0.	0.	0.	.95	55.	17.99	2.60	12.13	2.91
13	6	2950.	553.	670.	9502.	553.	670.	8847.	11550.	0.	* 1333.	656.	.77	37.	16.77	2.98	15.97	2.75
14	5	2150.	0.	0.	8933.	0.	0.	9175.	9500.	0.	** 2150.	656.	.86	22.	17.35	3.81	26.55	2.30
15	5	3050.	622.	253.	9456.	622.	235.	8300.	8300.	0.	0.	0.	1.00	35.	21.77	3.05	16.55	2.42
16	5	650.	0.	0.	9203.	0.	0.	8565.	9100.	0.	0.	0.	.94	55.	17.97	2.60	12.10	2.92
17	6	330.	336.	524.	9539.	336.	487.	8900.	9600.	0.	0.	0.	.93	55.	17.95	2.62	12.04	2.93
18	5	1550.	0.	0.	9014.	0.	0.	8411.	9100.	0.	0.	0.	.92	55.	17.94	2.58	12.02	2.93
19	5	2950.	295.	935.	9309.	295.	874.	8706.	9150.	0.	0.	0.	.95	55.	17.95	2.69	12.05	2.92
20	5	950.	0.	523.	8375.	0.	489.	7832.	9100.	0.	0.	0.	.86	56.	17.83	2.55	11.73	2.95
21	4	2400.	0.	0.	7831.	0.	0.	7207.	7600.	0.	* 1251.	136.	.95	42.	18.76	2.95	15.47	2.68
22	4	1750.	343.	0.	8195.	343.	0.	7550.	7550.	0.	0.	0.	1.00	35.	21.77	3.05	16.83	2.42
23	5	2300.	356.	659.	8550.	356.	609.	7906.	9500.	0.	0.	0.	.83	56.	17.79	2.54	11.58	2.98
24	4	3200.	0.	0.	7892.	0.	0.	7297.	7500.	0.	0.	0.	.97	51.	18.60	2.74	13.00	2.75
25	5	1400.	563.	603.	8455.	563.	561.	7860.	9450.	0.	0.	0.	.83	56.	17.78	2.64	11.53	2.98
26	4	4360.	0.	550.	7851.	0.	511.	7299.	7850.	0.	0.	0.	.93	55.	17.95	2.62	12.05	2.92
27	4	1050.	0.	0.	7302.	0.	0.	6789.	7200.	0.	0.	0.	.94	55.	17.98	2.62	12.11	2.92
28	5	2250.	483.	1672.	7790.	499.	1561.	7275.	9400.	0.	0.	0.	.77	56.	17.69	2.61	11.30	3.02
29	4	1700.	0.	1996.	6118.	0.	1864.	5714.	7500.	0.	0.	0.	.76	57.	17.67	2.61	11.24	3.02
30	3	3100.	0.	4122.	4122.	0.	3850.	3850.	6000.	0.	0.	0.	.64	58.	17.47	2.56	10.65	3.09

TOTAL 53260. MAX(V/C) = 1.00 AVG = 43. 18.14 2.77 13.30 2.54

FREEWAY PERFORMANCE TABLE

SUB SEC	NO. LNS	SSEC LENGTH	O-D DATA DEMANDS ORG.	DES.	DEM.	ADJUSTED VOLUMES ORG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GS/VM	CO GS/VM	NOX GS/VM
1	3	2400.	5704.	0.	5704.	5704.	0.	5704.	7500.	0.	0.	0.	.75	57.	17.65	2.60	11.13	3.02
2	6	1270.	2352.	0.	8256.	2352.	0.	8256.	10300.	0.	0.	0.	.80	56.	17.73	2.62	11.43	3.00
3	7	1050.	765.	413.	9024.	765.	413.	9024.	12000.	0.	0.	0.	.75	57.	17.65	2.60	11.13	3.02
4	7	1100.	0.	0.	8610.	0.	0.	8610.	11400.	0.	0.	0.	.76	57.	17.66	2.60	11.21	3.03
5	7	400.	622.	247.	9238.	622.	247.	9238.	10900.	0.	0.	0.	.85	56.	17.81	2.64	11.63	2.97
6	7	1700.	0.	0.	8992.	0.	0.	8992.	12500.	0.	0.	0.	.72	57.	17.60	2.59	11.03	3.05
7	7	750.	464.	444.	9456.	464.	444.	9456.	11500.	0.	0.	0.	.84	56.	17.79	2.64	11.62	2.98
8	6	1500.	0.	0.	9012.	0.	0.	9194.	10300.	0.	0.	-132.	.89	41.	17.95	2.93	15.23	2.73
9	6	600.	454.	915.	9466.	454.	932.	9348.	9500.	0.	0.	0.	.98	46.	19.77	2.81	13.22	2.61
10	6	2200.	0.	0.	8551.	0.	0.	8716.	10600.	0.	0.	0.	.82	55.	17.77	2.62	11.52	2.99
11	6	600.	217.	655.	8759.	217.	633.	8933.	9900.	0.	0.	0.	.90	55.	17.91	2.67	11.92	2.94
12	5	1900.	0.	0.	8113.	0.	0.	8220.	9450.	0.	* 1451.	44.	.87	27.	17.66	3.33	22.77	2.33
13	6	2950.	571.	725.	8884.	571.	733.	8792.	11550.	0.	** 2950.	44.	.76	16.	13.55	4.36	33.77	2.01
14	5	2150.	0.	0.	7559.	0.	0.	8054.	9500.	0.	** 2150.	44.	.85	21.	16.50	3.77	28.67	2.11
15	5	3050.	746.	255.	8705.	746.	253.	8300.	8300.	0.	0.	0.	1.00	35.	21.77	3.06	16.68	2.42
16	5	650.	0.	0.	8450.	0.	0.	8542.	9100.	0.	0.	0.	.94	55.	17.97	2.68	12.09	2.92
17	6	330.	509.	607.	8959.	509.	613.	9051.	9600.	0.	0.	0.	.94	55.	17.99	2.68	12.11	2.92
18	5	1550.	0.	0.	8352.	0.	0.	8438.	9100.	0.	0.	0.	.93	55.	17.95	2.68	12.04	2.93
19	5	2950.	414.	696.	8766.	414.	703.	8340.	9150.	0.	* 2440.	512.	.91	40.	18.51	2.99	15.98	2.63
20	5	950.	0.	771.	8070.	0.	778.	7637.	9100.	0.	** 950.	512.	.84	24.	16.50	3.73	25.58	2.27
21	4	2400.	0.	0.	7299.	0.	0.	6853.	7600.	0.	** 2400.	512.	.90	24.	15.70	3.75	26.02	2.17
22	4	1750.	692.	0.	7991.	692.	0.	7550.	7550.	0.	0.	0.	1.00	35.	21.77	3.06	16.68	2.42
23	5	2300.	683.	555.	8674.	683.	555.	8055.	8500.	0.	* 1009.	173.	.95	41.	17.63	2.94	15.39	2.73
24	4	3200.	0.	0.	8099.	0.	0.	7500.	7500.	0.	0.	0.	1.00	35.	21.77	3.06	16.68	2.42
25	5	1400.	928.	470.	9017.	928.	439.	8239.	9430.	0.	* 975.	139.	.88	35.	17.96	3.13	17.30	2.63
26	4	4360.	0.	771.	8546.	0.	705.	7250.	7250.	0.	0.	0.	1.00	35.	21.77	3.06	16.68	2.42
27	4	1050.	0.	0.	7777.	0.	0.	7142.	7200.	0.	0.	0.	.99	41.	20.96	2.88	14.49	2.52
28	5	2250.	921.	1352.	8698.	921.	1254.	8063.	9400.	0.	0.	0.	.86	55.	17.83	2.65	11.70	2.97
29	4	1700.	0.	2319.	7346.	0.	2235.	6809.	7500.	0.	0.	0.	.91	55.	17.92	2.67	11.94	2.94
30	3	3100.	0.	4227.	4827.	0.	4474.	4474.	6000.	0.	0.	0.	.75	57.	17.64	2.60	11.15	3.03

TOTAL 53260.

MAX(V/C) = 1.00 AVG = 37. 18.29 3.05 15.31 2.64

INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, BERKELEY
(415)-642-7390

FREQ9
SIMULATION BEFORE ENTRY CONTROL
TIME SLICE 8 OF 16

FREEWAY PERFORMANCE TABLE

SUB SEC	NO. LNS	SSEC LENGTH	O-D DATA DEMANDS ORG.	DES.	DEM.	ADJUSTED VOLUMES ORG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GM/VM	CO GM/VM	NOX GM/VM
1	3	2400.	5515.	0.	5516.	5515.	0.	5515.	7500.	0.	0.	0.	.73	57.	17.61	2.59	11.07	3.04
2	6	1270.	2465.	0.	7961.	2445.	0.	7961.	10300.	0.	0.	0.	.77	56.	17.69	2.51	11.30	3.02
3	7	1050.	644.	467.	8625.	644.	467.	8625.	12000.	0.	0.	0.	.72	57.	17.57	2.57	11.03	3.05
4	7	1100.	0.	0.	8158.	0.	0.	8153.	11600.	0.	0.	0.	.72	57.	17.59	2.59	11.03	3.05
5	7	400.	459.	431.	8647.	457.	431.	8647.	10900.	0.	0.	0.	.79	56.	17.72	2.62	11.39	3.00
6	7	1700.	0.	0.	8815.	0.	0.	8815.	12500.	0.	0.	0.	.66	57.	17.49	2.56	10.74	3.08
7	7	950.	439.	510.	8704.	469.	510.	8704.	11500.	0.	0.	0.	.77	57.	17.63	2.61	11.23	3.02
8	6	1500.	0.	0.	8195.	0.	0.	8195.	10300.	0.	0.	0.	.90	56.	17.72	2.62	11.40	3.00
9	6	600.	393.	1027.	8588.	393.	1027.	8588.	9500.	0.	0.	0.	.93	56.	17.35	2.65	11.73	3.06
10	6	2200.	0.	0.	7560.	0.	0.	7560.	10600.	0.	0.	0.	.71	57.	17.57	2.57	11.01	3.05
11	6	600.	306.	884.	7866.	306.	884.	7866.	9900.	0.	0.	0.	.79	56.	17.72	2.62	11.40	3.00
12	5	1900.	0.	0.	7002.	0.	0.	7002.	9450.	0.	0.	0.	.74	57.	17.83	2.60	11.14	3.04
13	6	2550.	484.	754.	7457.	424.	754.	7599.	11550.	0.	* 320.	-112.	.66	35.	15.55	3.07	17.24	2.82
14	5	2150.	0.	0.	6732.	0.	0.	6044.	9500.	0.	** 2150.	-112.	.72	17.	13.36	4.39	34.10	2.61
15	5	3050.	798.	248.	7530.	798.	288.	7642.	8800.	0.	** 3050.	940.	.97	27.	17.92	3.52	22.84	2.32
16	5	650.	0.	0.	7282.	0.	0.	7357.	9100.	0.	** 650.	940.	.81	21.	16.60	4.00	27.05	2.10
17	6	330.	620.	463.	7902.	620.	523.	7979.	9600.	0.	** 330.	940.	.83	22.	17.31	3.93	23.03	2.12
18	5	1550.	0.	0.	7433.	0.	0.	7456.	9100.	0.	** 1550.	940.	.92	21.	16.97	3.97	23.56	2.11
19	5	2950.	397.	629.	7835.	397.	705.	7953.	9150.	0.	** 2950.	940.	.96	23.	18.12	3.84	25.53	2.15
20	5	950.	0.	982.	7206.	0.	1103.	7147.	9100.	0.	** 950.	940.	.79	20.	15.49	4.13	30.70	2.07
21	4	2400.	0.	0.	6223.	0.	0.	6044.	7600.	0.	** 2400.	940.	.80	20.	15.99	4.05	30.04	2.39
22	4	1750.	1055.	0.	7278.	1055.	0.	7079.	7550.	0.	** 1750.	451.	.94	28.	20.69	3.44	21.55	2.29
23	5	2300.	520.	574.	8095.	620.	593.	7919.	9500.	0.	** 2300.	451.	.83	21.	16.87	3.93	23.73	2.10
24	4	3200.	0.	0.	7524.	0.	0.	7325.	7500.	0.	** 2200.	175.	.93	29.	21.12	3.40	20.79	2.20
25	5	1400.	1002.	479.	8555.	1002.	477.	8327.	9450.	0.	** 1400.	175.	.89	23.	17.95	3.56	27.03	2.14
26	4	4360.	0.	947.	8047.	0.	923.	7250.	7550.	0.	0.	0.	1.00	35.	21.77	3.06	16.63	2.42
27	4	1050.	0.	0.	7195.	0.	0.	7022.	7200.	0.	0.	0.	.93	50.	18.74	2.76	13.19	2.71
28	5	2250.	1132.	1055.	8330.	1132.	1033.	8154.	9400.	0.	0.	0.	.67	56.	17.95	2.65	11.75	2.96
29	4	1700.	0.	2419.	7275.	0.	2332.	7121.	7500.	0.	0.	0.	.95	55.	17.99	2.67	12.14	2.91
30	3	3100.	0.	4356.	4856.	0.	4753.	4753.	6000.	0.	0.	0.	.75	56.	17.72	2.62	11.37	3.01

MAX(V/C) = 1.00 AVG = 33. 17.74 2.19 18.67 2.57

TOTAL 53860.

INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, BERKELEY
(415)-642-7390

FREQ8
SIMULATION BEFORE ENTRY CONTROL
TIME SLICE 9 OF 16

FREEWAY PERFORMANCE TABLE

SUB SEC	NO. LNS	SSEC LENGTH	O-D DATA DEMANDS ORG.	DES.	DEM.	ADJUSTED VOLUMES ORG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GS/VM	CO GS/VM	NOX GS/VM
1	3	2400.	5546.	0.	5546.	5546.	0.	5546.	7600.	0.	0.	0.	.74	57.	17.62	2.60	11.15	3.03
2	6	1270.	2405.	0.	8051.	2405.	0.	8051.	10300.	0.	0.	0.	.78	56.	17.70	2.62	11.34	3.01
3	7	1050.	695.	468.	8746.	695.	438.	8746.	12000.	0.	0.	0.	.73	57.	17.61	2.59	11.02	3.04
4	7	1100.	0.	0.	8278.	0.	0.	8273.	11400.	0.	0.	0.	.73	57.	17.61	2.59	11.07	3.04
5	7	400.	542.	417.	8821.	542.	417.	8821.	10700.	0.	0.	0.	.81	56.	17.75	2.63	11.47	3.00
6	7	1700.	0.	0.	8404.	0.	0.	8404.	12500.	0.	0.	0.	.67	57.	17.52	2.57	10.81	3.03
7	7	950.	463.	486.	8873.	463.	436.	8872.	11300.	0.	0.	0.	.77	56.	17.71	2.62	11.35	3.01
8	6	1600.	0.	0.	8335.	0.	0.	8335.	10300.	0.	0.	0.	.81	56.	17.73	2.63	11.49	2.99
9	6	600.	281.	954.	8707.	281.	954.	8707.	9300.	0.	0.	0.	.93	55.	17.92	2.66	11.85	2.95
10	6	2200.	0.	0.	7753.	0.	0.	7753.	10600.	0.	0.	0.	.73	57.	17.62	2.59	11.09	3.04
11	6	600.	236.	828.	7989.	236.	828.	7789.	9600.	0.	0.	0.	.81	56.	17.74	2.63	11.46	3.00
12	5	1900.	0.	0.	7161.	0.	0.	7161.	9450.	0.	0.	0.	.76	57.	17.66	2.61	11.22	3.03
13	5	2950.	474.	864.	7655.	474.	854.	7453.	11550.	0.	* 941.	197.	.65	34.	15.07	3.09	17.55	2.54
14	5	2150.	0.	0.	6791.	0.	0.	6594.	9500.	0.	** 2150.	197.	.69	15.	11.56	4.57	37.34	1.95
15	5	3050.	727.	278.	7318.	727.	278.	7321.	8600.	0.	** 3050.	197.	.83	20.	16.46	4.05	29.41	2.09
16	5	650.	0.	0.	7241.	0.	0.	7044.	9100.	0.	** 650.	197.	.77	18.	14.02	4.30	32.95	2.03
17	6	330.	553.	419.	7304.	553.	419.	7607.	9600.	0.	** 330.	197.	.79	19.	14.80	4.31	31.77	2.05
18	5	1550.	0.	0.	7286.	0.	0.	7182.	9100.	0.	** 1550.	197.	.79	19.	14.69	4.22	31.93	2.04
19	5	2950.	408.	603.	7793.	408.	603.	7596.	9150.	0.	** 2950.	197.	.83	20.	16.41	4.04	29.49	2.09
20	5	950.	0.	918.	7190.	0.	918.	6993.	9100.	0.	** 950.	197.	.77	18.	13.92	4.33	33.31	2.03
21	4	2400.	0.	0.	6272.	0.	0.	6075.	7600.	0.	** 2400.	197.	.80	19.	15.11	4.17	31.32	2.05
22	4	1750.	874.	0.	7145.	874.	0.	6948.	7550.	0.	** 1750.	197.	.92	24.	19.40	3.71	25.15	2.19
23	5	2300.	874.	597.	8019.	874.	597.	7822.	9500.	0.	** 2300.	197.	.82	20.	16.23	4.06	29.80	2.08
24	4	3200.	0.	0.	7422.	0.	0.	7225.	7500.	0.	** 3200.	197.	.96	26.	20.59	3.57	23.26	2.24
25	5	1400.	1013.	395.	8435.	1013.	333.	8238.	9450.	0.	** 1400.	197.	.87	22.	17.64	3.89	27.54	2.13
26	4	4350.	0.	800.	8047.	0.	780.	7250.	7250.	0.	0.	0.	1.00	35.	21.77	3.05	16.68	2.42
27	4	1050.	0.	0.	7247.	0.	0.	7070.	7200.	0.	0.	0.	.98	47.	19.44	2.73	13.49	2.33
28	5	2250.	957.	976.	8205.	957.	954.	8027.	9400.	0.	0.	0.	.85	56.	17.83	2.65	11.55	2.97
29	4	1700.	0.	2300.	7229.	0.	2250.	7073.	7500.	0.	0.	0.	.94	55.	17.98	2.69	12.11	2.92
30	3	3100.	0.	4929.	4929.	0.	4823.	4823.	6000.	0.	0.	0.	.80	56.	17.74	2.62	11.44	3.00

TOTAL 53360. MAX(V/C) = 1.00 AVG = 31. 17.12 3.27 19.71 2.55

FREEWAY PERFORMANCE TABLE

SUB SEC	NO. LNS	SSEC LENGTH	O-D DATA DEMANDS ORG.	DES.	DEM.	ADJUSTED VOLUMES ORG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GS/VM	CO GS/VM	NOX GS/VM
1	3	2400.	5542.	0.	5542.	5542.	0.	5542.	7600.	0.	0.	0.	.74	57.	17.63	2.60	11.15	3.04
2	6	1270.	2155.	0.	7340.	2155.	0.	7340.	10300.	0.	0.	0.	.76	57.	17.57	2.61	11.24	3.03
3	7	1050.	702.	477.	8541.	702.	477.	8541.	12000.	0.	0.	0.	.71	57.	17.58	2.59	11.00	3.05
4	7	1100.	0.	0.	8054.	0.	0.	8054.	11400.	0.	0.	0.	.71	57.	17.53	2.55	10.93	3.02
5	7	400.	441.	449.	8506.	441.	449.	8566.	10900.	0.	0.	0.	.73	56.	17.70	2.61	11.33	3.01
6	7	1700.	0.	0.	8057.	0.	0.	8057.	12500.	0.	0.	0.	.64	58.	17.47	2.56	10.57	[illegible]
7	7	950.	325.	482.	8392.	325.	482.	8395.	11300.	0.	0.	0.	.74	57.	17.63	2.60	11.15	3.03
8	6	1500.	0.	0.	7910.	0.	0.	7910.	10300.	0.	0.	0.	.77	57.	17.58	2.61	11.27	3.03
9	6	600.	373.	932.	8287.	373.	932.	8287.	9500.	0.	0.	0.	.85	56.	17.91	2.64	11.64	2.97
10	6	2200.	0.	0.	7355.	0.	0.	7355.	10600.	0.	0.	0.	.69	57.	17.55	2.58	10.91	3.06
11	6	500.	207.	863.	7562.	207.	863.	7562.	9900.	0.	0.	0.	.76	57.	17.57	2.61	11.22	3.03
12	5	1300.	0.	0.	6599.	0.	0.	6599.	9450.	0.	0.	0.	.71	57.	17.53	2.55	10.93	3.05
13	5	2950.	416.	344.	7115.	416.	544.	7115.	11550.	0.	0.	0.	.62	47.	16.65	2.72	12.75	3.02
14	5	2150.	0.	0.	6271.	0.	0.	6942.	9500.	0.	* 556.	-671.	.73	19.	13.37	4.13	30.37	2.19
15	5	3050.	654.	309.	6925.	654.	309.	7576.	8800.	0.	** 3050.	-671.	.86	22.	17.37	3.92	27.94	2.12
16	5	650.	0.	0.	6616.	0.	0.	7237.	9100.	0.	** 650.	-671.	.80	19.	15.15	4.17	31.23	2.05
17	6	230.	321.	389.	6997.	391.	389.	7658.	9600.	0.	** 230.	-671.	.80	19.	15.09	4.18	31.36	2.05
18	5	1550.	0.	0.	6508.	0.	0.	7279.	9100.	0.	** 1550.	-671.	.80	19.	15.14	4.17	31.22	2.05
19	5	2950.	452.	519.	7051.	452.	519.	7732.	9150.	0.	** 2950.	-671.	.84	21.	16.52	3.98	28.20	2.10
20	5	950.	0.	906.	6542.	0.	906.	7213.	9100.	0.	** 950.	-671.	.79	19.	14.91	4.21	31.76	2.05
21	4	2400.	0.	0.	5636.	0.	0.	6307.	7600.	0.	** 2400.	-671.	.83	20.	16.40	4.04	29.51	2.09
22	4	1750.	723.	0.	6364.	723.	0.	7035.	7550.	0.	** 1750.	-671.	.93	25.	19.39	3.57	24.53	2.20
23	5	2300.	810.	597.	7174.	810.	597.	7845.	9500.	0.	** 2300.	-671.	.83	20.	16.29	4.05	29.67	2.08
24	4	3200.	0.	0.	6577.	0.	0.	7248.	7500.	0.	** 3200.	-671.	.97	26.	20.65	3.56	23.14	2.24
25	5	1400.	1019.	417.	7596.	1019.	417.	8267.	9450.	0.	** 1400.	-671.	.87	22.	17.74	3.83	27.37	2.14
26	4	4350.	0.	789.	7179.	0.	863.	7350.	7350.	0.	0.	0.	1.00	35.	21.77	3.06	16.63	2.42
27	4	1050.	0.	0.	6390.	0.	0.	6987.	7200.	0.	0.	0.	.97	52.	18.47	2.73	12.63	2.73
28	5	2250.	1005.	943.	7395.	1005.	1019.	7992.	9400.	0.	0.	0.	.85	56.	17.22	2.64	11.57	2.97
29	4	1700.	0.	1991.	6453.	0.	2141.	6974.	7500.	0.	0.	0.	.93	55.	17.95	2.68	12.05	2.92
30	3	3100.	0.	4472.	4472.	0.	4833.	4833.	6000.	0.	0.	0.	.81	58.	17.74	2.63	11.45	3.01

TOTAL 52850. MAX(V/C) = 1.00 AVG = 32. 17.52 3.22 19.05 2.57

FREEWAY PERFORMANCE TABLE

SUB SEC	NO. LNS	SSEC LENGTH	O-D DATA DEMANDS ORG.	DES.	DEM.	ADJUSTED VOLUMES ORG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GS/VM	CO GS/VM	NOX GS/VM
1	5	2400.	5719.	0.	5719.	5719.	0.	5719.	7600.	0.	0.	0.	.75	57.	17.65	2.60	11.19	3.03
2	6	1270.	2337.	0.	8537.	2337.	0.	8537.	10300.	0.	0.	0.	.83	56.	17.79	2.64	11.59	2.93
3	7	1050.	913.	416.	9499.	913.	416.	9499.	12000.	0.	0.	0.	.79	55.	17.72	2.62	11.33	3.01
4	7	1160.	0.	0.	9034.	0.	0.	9034.	11400.	0.	0.	0.	.80	55.	17.78	2.62	11.41	3.03
5	7	400.	479.	302.	9542.	479.	302.	9542.	10900.	0.	0.	0.	.88	55.	17.85	2.66	11.50	2.92
6	7	1700.	0.	0.	9260.	0.	0.	9260.	12300.	0.	0.	0.	.74	57.	17.63	2.60	11.14	[illegible]
7	7	950.	402.	469.	9662.	402.	467.	9662.	11300.	0.	0.	0.	.86	56.	17.22	2.65	11.67	2.97
8	6	1200.	0.	0.	9194.	0.	0.	9194.	10500.	0.	0.	0.	.89	55.	17.89	2.66	11.87	2.95
9	6	500.	238.	763.	9431.	238.	763.	9431.	9900.	0.	0.	0.	.95	54.	18.15	2.70	12.38	2.87
10	6	2200.	0.	0.	8668.	0.	0.	8668.	10600.	0.	0.	0.	.82	56.	17.76	2.63	11.51	2.99
11	6	600.	220.	521.	9388.	220.	521.	9385.	9900.	0.	0.	0.	.90	55.	17.90	2.66	11.59	2.94
12	5	1900.	0.	0.	8857.	0.	0.	8857.	9450.	0.	0.	0.	.93	55.	17.83	2.66	11.84	2.95
13	6	2750.	414.	913.	8781.	414.	919.	8781.	11350.	0.	0.	0.	.76	57.	17.56	2.61	11.23	3.02
14	5	2150.	0.	0.	7862.	0.	0.	7862.	9500.	0.	0.	0.	.83	56.	17.73	2.63	11.56	2.93
15	5	3050.	510.	440.	8372.	510.	440.	8372.	8800.	0.	0.	0.	.95	55.	17.95	2.66	12.05	2.92
16	5	650.	0.	0.	7932.	0.	0.	7932.	9100.	0.	0.	0.	.87	56.	17.85	2.65	11.77	2.76
17	6	320.	217.	457.	8149.	217.	457.	8149.	9600.	0.	0.	0.	.85	56.	17.81	2.64	11.68	2.97
18	5	1550.	0.	0.	7692.	0.	0.	7692.	9100.	0.	0.	0.	.85	56.	17.81	2.64	11.64	2.97
19	5	2950.	358.	609.	8050.	358.	609.	8050.	9150.	0.	0.	0.	.88	55.	17.27	2.66	11.81	2.95
20	5	950.	0.	391.	7442.	0.	391.	7442.	9100.	0.	0.	0.	.92	55.	17.76	2.63	11.51	2.97
21	4	2400.	0.	0.	6551.	0.	0.	6551.	7600.	0.	0.	0.	.86	55.	17.84	2.65	11.72	2.96
22	4	1750.	470.	0.	7022.	470.	0.	7022.	7550.	0.	0.	0.	.93	55.	17.95	2.63	12.05	2.92
23	5	2300.	692.	846.	7704.	692.	846.	7704.	9500.	0.	0.	0.	.81	53.	17.74	2.63	12.17	2.96
24	4	3200.	0.	0.	6858.	0.	0.	7412.	7500.	0.	0.	-535.	.99	35.	19.65	3.15	17.95	2.34
25	5	1400.	757.	539.	7615.	757.	632.	8356.	9450.	0.	0.	-56.	.87	45.	17.82	2.93	14.04	2.54
26	4	4350.	0.	324.	7026.	0.	593.	7624.	7830.	0.	0.	0.	.97	51.	18.31	2.74	12.83	2.77
27	4	1050.	0.	0.	6202.	0.	0.	6729.	7200.	0.	0.	0.	.92	55.	17.96	2.68	12.07	2.92
28	5	2250.	965.	1512.	7166.	965.	1624.	7694.	9400.	0.	0.	0.	.82	55.	17.76	2.63	11.51	2.93
29	4	1700.	0.	1820.	5654.	0.	2019.	6070.	7500.	0.	0.	0.	.91	56.	17.75	2.63	11.47	3.00
30	3	3100.	0.	3774.	3774.	0.	4052.	4052.	6000.	0.	0.	0.	.63	57.	17.52	2.57	10.82	3.07

TOTAL 53960.   MAX(V/C) = 0.99 AVG = 53.   17.94   2.63   12.15   2.93

INSTITUTE OF TRANSPORTATION STUDIES
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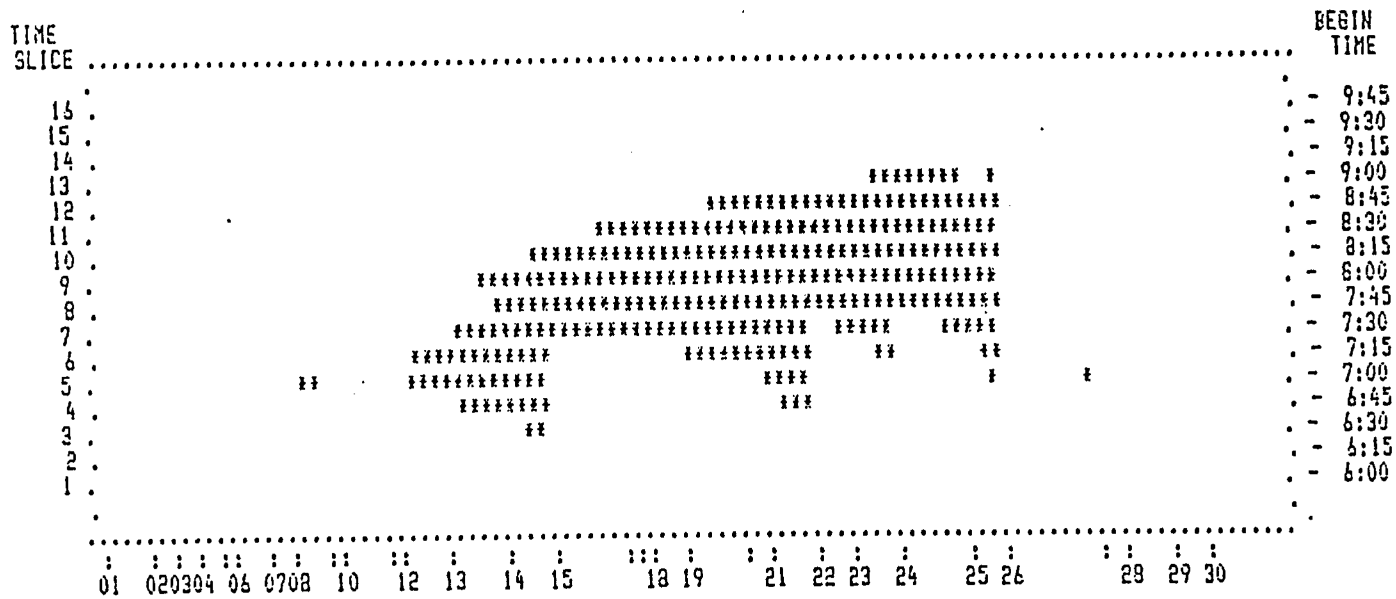
FREQ8

CONTOUR DIAGRAM OF
QUEUE LENGTH
BEFORE OPTIMIZATION



BLANK DENOTES MOVING TRAFFIC. ASTERISK DENOTES QUEUED VEHICLES DUE TO MAINLINE CONGESTION.
M DENOTES QUEUED VEHICLES DUE TO MERGING. B DENOTES QUEUED VEHICLES DUE TO MAINLINE CONGESTION AND MERGING. (WHEN BOTH QUEUES EXIST, LENGTH OF DISPLAY REPRESENTS MAINLINE CONGESTION.)

INSTITUTE OF TRANSPORTATION STUDIES
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FREQ8
SIMULATION BEFORE ENTRY CONTROL
TIME SLICE 1 OF 16

FREEWAY TRAVEL TIME (MINUTES)

ORIGINS DOWN / DESTINATIONS ACROSS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0.92	1.22	1.74	2.18	2.74	3.70	4.76	4.95	5.86	6.05	7.34	8.27	9.14	9.79	10.12	10.72
2	0.46	0.75	1.27	1.71	2.27	3.24	4.29	4.49	5.29	5.58	6.88	7.80	8.69	9.33	9.65	10.26
3	0.21	0.50	1.02	1.46	2.02	2.99	4.04	4.24	5.14	5.33	6.63	7.55	8.43	9.08	9.41	10.01
4	0.00	0.08	0.60	1.04	1.60	2.57	3.62	3.85	4.72	4.91	6.20	7.13	8.00	8.65	8.98	9.58
5	0.00	0.00	0.19	0.63	1.19	2.15	3.21	3.40	4.31	4.50	5.79	6.72	7.59	8.24	8.57	9.17
6	0.00	0.00	0.00	0.12	0.69	1.65	2.70	2.90	3.80	3.99	5.29	6.21	7.08	7.74	8.07	8.67
7	0.00	0.00	0.00	0.00	0.12	1.09	2.14	2.34	3.24	3.43	4.73	5.65	6.53	7.18	7.51	8.11
8	0.00	0.00	0.00	0.00	0.00	0.58	1.54	1.85	2.74	2.93	4.22	5.15	6.02	6.67	7.00	7.60
9	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.82	1.72	1.91	3.21	4.13	5.01	5.66	5.99	6.59
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.97	1.16	2.46	3.38	4.25	4.91	5.24	5.84
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.78	2.08	3.00	3.89	4.53	4.86	5.46
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.81	1.74	2.61	3.26	3.59	4.19
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	1.38	2.26	2.91	3.24	3.84
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	1.15	1.80	2.13	2.73
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.77	1.37

APPENDIX -F-

INCIDENT FINAL, RUN FOR EASTBOUND DIRECTION-SANTA MONICA FREEWAY

FREEWAY PERFORMANCE TABLE

SUB SEC	NO. LNS	SSEC LENGTH	O-D DATA DEMANDS ORG.	DES.	DEM.	ADJUSTED VOLUMES ORG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GS/VM	CO GS/VM	NOX GS/VM
1	3	3200.	2720.	0.	2720.	2720.	0.	2720.	6000.	0.	0.	0.	.45	59.	17.16	2.43	9.73	3.21
2	5	2600.	2360.	497.	5581.	2360.	497.	5581.	8850.	0.	0.	0.	.63	58.	16.71	2.61	12.51	3.53
3	4	1600.	0.	0.	5084.	0.	0.	5084.	7200.	0.	0.	0.	.71	57.	17.57	2.58	10.97	3.05
4	5	3700.	662.	0.	5746.	662.	0.	5746.	9400.	0.	0.	0.	.61	58.	17.42	2.54	10.51	3.11
5	5	2000.	287.	497.	6033.	287.	497.	6033.	9350.	0.	0.	0.	.65	58.	17.47	2.55	10.68	3.09
6	5	2200.	0.	0.	5537.	0.	0.	5537.	9000.	0.	0.	0.	.62	58.	17.42	2.55	10.53	3.11
7	5	2200.	365.	73.	5902.	365.	73.	4737.	9000.	0.	* 592.	1165.	.53	54.	17.19	2.61	11.32	3.07
8	5	1100.	0.	0.	5329.	0.	0.	4664.	8700.	0.	** 1100.	1165.	.54	27.	13.35	3.35	21.15	2.79
9	6	400.	288.	153.	6117.	288.	153.	4952.	9200.	0.	** 400.	1165.	.54	20.	11.41	3.93	22.56	2.58
10	5	500.	0.	137.	5964.	0.	137.	4799.	8600.	0.	** 500.	1165.	.56	13.	10.50	4.21	32.16	2.45
11	5	1500.	0.	0.	5207.	0.	0.	4542.	9000.	0.	** 1500.	1165.	.52	12.	8.22	5.50	43.35	2.13
12	5	1700.	353.	0.	5165.	353.	0.	5000.	5000.	0.	0.	0.	1.00	35.	21.77	3.03	15.38	2.42
13	5	3950.	917.	85.	7032.	917.	71.	5917.	8000.	0.	0.	0.	.74	57.	17.63	2.60	11.13	3.04
14	5	600.	0.	0.	6793.	0.	0.	5846.	8100.	0.	0.	0.	.72	57.	17.50	2.59	11.05	3.05
15	6	400.	500.	177.	7497.	500.	150.	6346.	9000.	0.	0.	0.	.71	57.	17.57	2.53	10.97	3.06
16	5	1450.	0.	0.	7320.	0.	0.	6196.	8500.	0.	0.	0.	.73	57.	17.61	2.59	11.08	3.04
17	5	2200.	811.	150.	8131.	811.	127.	7007.	9500.	0.	0.	0.	.74	57.	17.53	2.60	11.12	3.04
18	5	2300.	0.	0.	7981.	0.	0.	6878.	9450.	0.	0.	0.	.73	57.	17.61	2.59	11.08	3.04
19	6	2900.	931.	73.	8912.	931.	64.	7809.	10900.	0.	0.	0.	.72	57.	17.59	2.59	11.02	3.05
20	5	1200.	0.	0.	8839.	0.	0.	7745.	9500.	0.	0.	0.	.82	56.	17.76	2.63	11.50	2.99
21	6	1050.	737.	156.	9576.	737.	139.	8482.	10100.	0.	0.	0.	.84	56.	17.80	2.64	11.62	2.93
22	7	2150.	0.	0.	9420.	0.	0.	8344.	12100.	0.	0.	0.	.69	57.	17.55	2.53	10.59	3.07
23	7	1100.	548.	131.	9968.	548.	135.	8892.	12100.	0.	0.	0.	.73	57.	17.62	2.60	11.11	3.04
24	6	1500.	0.	0.	9317.	0.	0.	8757.	10300.	0.	0.	0.	.85	56.	17.62	2.64	11.67	2.97
25	7	1000.	406.	293.	10223.	406.	262.	9163.	11900.	0.	0.	0.	.77	57.	17.69	2.61	11.33	3.02
26	7	1900.	0.	0.	9930.	0.	0.	8901.	12500.	0.	0.	0.	.71	57.	17.59	2.59	11.00	3.05
27	7	700.	422.	385.	10353.	422.	346.	9323.	11350.	0.	0.	0.	.82	56.	17.77	2.63	11.53	2.99
28	6	1550.	0.	0.	9968.	0.	0.	8977.	10150.	0.	0.	0.	.88	56.	17.87	2.66	11.83	2.95
29	6	700.	361.	1502.	10329.	361.	1353.	9337.	9850.	0.	0.	0.	.95	55.	17.98	2.68	12.14	2.91
30	6	950.	0.	3617.	8823.	0.	3270.	7979.	9000.	0.	0.	0.	.89	56.	17.83	2.66	11.84	2.95
31	5	900.	0.	0.	5209.	0.	0.	4709.	7500.	0.	0.	0.	.63	58.	17.44	2.55	10.59	3.10
32	6	700.	769.	5978.	5978.	769.	5478.	5478.	9300.	0.	0.	0.	.57	58.	17.33	2.53	10.41	3.13
TOTAL		52500.											MAX(V/C) = 1.00	AVG = 49.	16.93	2.70	12.57	3.08

INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, BERKELEY
(415)-642-7290

FREQ8
SIMULATION BEFORE ENTRY CONTROL
TIME SLICE 5 OF 16

FREEWAY PERFORMANCE TABLE

SUB SEC	NO. LNS	SSEC LENGTH	O-D DATA DEMANDS ORG.	DES.	DEM.	ADJUSTED VOLUMES ORG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GS/VM	CO GS/VM	NOX GS/VM
1	3	2300.	3525.	0.	3525.	3525.	0.	1235.	6000.	0.	* 1067.	2290.	.21	48.	17.03	2.60	11.28	3.12
2	5	2600.	3207.	537.	6732.	3207.	537.	4442.	9550.	0.	** 2600.	2290.	.50	26.	12.57	3.70	26.12	3.14
3	4	1600.	0.	0.	6145.	0.	0.	3355.	7200.	0.	** 1600.	2290.	.54	19.	11.20	4.07	30.27	2.49
4	5	3700.	1052.	0.	7227.	1052.	0.	4937.	9400.	0.	** 3700.	2290.	.53	12.	8.33	5.41	47.77	2.10
5	5	2000.	435.	594.	7662.	435.	594.	5372.	9350.	0.	** 2000.	2290.	.57	11.	8.17	5.66	50.95	1.87
6	5	2200.	0.	0.	7057.	0.	0.	4772.	9000.	0.	** 2200.	2290.	.53	10.	7.43	6.05	56.19	1.83
7	5	2900.	389.	130.	7457.	389.	130.	5167.	9000.	0.	** 2900.	2290.	.57	11.	8.17	5.66	50.39	1.87
8	5	1100.	0.	0.	7327.	0.	0.	5037.	8700.	0.	** 1100.	2290.	.58	11.	8.26	5.62	50.43	1.87
9	6	400.	294.	214.	7621.	294.	214.	5332.	9200.	0.	** 400.	2290.	.58	11.	8.27	5.62	50.43	1.87
10	5	500.	0.	213.	7407.	0.	213.	5117.	8600.	0.	** 500.	2290.	.60	12.	8.59	5.47	48.73	1.83
11	5	1500.	0.	0.	7194.	0.	0.	4905.	9000.	0.	** 1500.	2290.	.54	10.	7.66	5.95	53.97	1.85
12	5	1700.	595.	0.	7790.	595.	0.	5500.	5500.	0.	0.	0.	1.00	35.	21.77	3.05	15.88	2.48
13	5	3950.	937.	90.	8727.	937.	67.	6437.	8000.	0.	0.	0.	.80	56.	17.74	2.62	11.45	3.03
14	5	600.	0.	0.	8637.	0.	0.	6371.	8100.	0.	0.	0.	.79	55.	17.71	2.62	11.35	3.01
15	6	400.	336.	234.	8973.	336.	175.	6707.	9000.	0.	0.	0.	.75	57.	17.54	2.60	11.15	3.03
16	5	1450.	0.	0.	8739.	0.	0.	6532.	8500.	0.	0.	0.	.77	57.	17.53	2.61	11.27	3.02
17	5	2200.	887.	253.	9626.	887.	195.	7419.	9500.	0.	0.	0.	.78	56.	17.70	2.62	11.33	3.01
18	5	2300.	0.	0.	9373.	0.	0.	7224.	9450.	0.	0.	0.	.76	57.	17.57	2.61	11.25	3.02
19	6	2500.	994.	169.	10367.	994.	134.	8217.	10900.	0.	0.	0.	.75	57.	17.55	2.60	11.20	3.03
20	5	1200.	0.	0.	10197.	0.	0.	8083.	9500.	0.	0.	0.	.85	56.	17.82	2.64	11.57	2.97
21	6	1050.	766.	179.	10964.	766.	145.	8949.	10100.	0.	0.	0.	.88	55.	17.86	2.65	11.79	2.96
22	7	2150.	0.	0.	10794.	0.	0.	8805.	12100.	0.	0.	0.	.72	57.	17.60	2.59	11.04	3.05
23	7	1100.	659.	300.	11453.	659.	245.	9372.	12100.	0.	0.	0.	.77	56.	17.69	2.61	11.30	3.02
24	6	1500.	0.	0.	11153.	0.	0.	9123.	10300.	0.	0.	0.	.89	56.	17.88	2.66	11.84	2.95
25	7	1800.	379.	505.	11532.	379.	416.	9507.	11900.	0.	0.	0.	.80	55.	17.73	2.62	11.42	3.00
26	7	1900.	0.	0.	11027.	0.	0.	9091.	12500.	0.	0.	0.	.73	57.	17.61	2.59	11.07	3.04
27	7	700.	364.	586.	11391.	364.	486.	9455.	11350.	0.	0.	0.	.83	56.	17.79	2.64	11.58	2.98
28	6	1550.	0.	0.	10805.	0.	0.	8969.	10150.	0.	0.	0.	.88	56.	17.87	2.66	11.83	2.95
29	6	700.	368.	1451.	11173.	368.	1212.	9337.	9850.	0.	0.	0.	.95	55.	17.98	2.68	12.14	2.91
30	6	950.	0.	3473.	9723.	0.	2906.	8124.	9000.	0.	0.	0.	.90	55.	17.91	2.67	11.92	2.94
31	5	900.	0.	0.	6245.	0.	0.	5219.	7500.	0.	0.	0.	.70	57.	17.56	2.53	10.92	3.06
32	6	700.	681.	6926.	6926.	681.	5899.	5899.	9300.	0.	0.	0.	.63	58.	17.45	2.55	10.63	3.10

TOTAL 52500. MAX(V/C) = 1.00 AVG = 28. 13.86 3.35 20.37 2.76

FREEWAY PERFORMANCE TABLE

SUB SEC	NO. LNS	SSEC LENGTH	O-D DATA DEMANDS ORG.	DES.	DEM.	ADJUSTED VOLUMES ORG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GS/VM	CO GS/VM	NOX GS/VM
1	3	3200.	3773.	0.	3773.	3773.	0.	3241.	6000.	0.	* 1394.	432.	.56	35.	15.13	3.00	16.41	2.9
2	5	2600.	3353.	833.	7126.	3353.	833.	6694.	8350.	0.	** 2600.	432.	.76	19.	14.21	4.43	34.36	2.3
3	4	1600.	0.	0.	6294.	0.	0.	5262.	7200.	0.	** 1600.	432.	.81	21.	17.05	3.93	28.00	2.1
4	5	3700.	939.	0.	7233.	939.	0.	6301.	9400.	0.	** 3700.	1239.	.72	18.	13.26	4.35	32.66	2.0
5	5	2000.	341.	563.	7574.	341.	627.	7142.	9350.	0.	** 2000.	1282.	.76	19.	14.54	4.20	31.70	2.0
6	5	2200.	0.	0.	7011.	0.	0.	6516.	9000.	0.	** 2200.	1282.	.72	17.	13.29	4.37	33.91	2.0
7	5	2300.	275.	130.	7296.	275.	144.	6791.	9000.	0.	** 2300.	1283.	.75	17.	14.24	4.24	32.17	2.0
8	5	1100.	0.	0.	7157.	0.	0.	6647.	9700.	0.	** 1100.	1283.	.76	19.	14.59	4.19	31.55	2.0
9	6	400.	330.	236.	7467.	330.	232.	6777.	9200.	0.	** 400.	1239.	.76	19.	14.35	4.23	31.99	2.0
10	5	500.	0.	294.	7231.	0.	325.	6695.	8600.	0.	** 500.	1286.	.73	20.	15.14	4.13	30.67	2.0
11	5	1500.	0.	0.	6937.	0.	0.	6370.	9000.	0.	** 1500.	1905.	.71	17.	12.75	4.43	34.74	2.0
12	5	1700.	622.	0.	7559.	622.	0.	6992.	9300.	0.	** 1700.	2139.	.75	18.	12.37	4.27	32.57	2.0
13	5	3950.	1008.	118.	8567.	1009.	110.	8000.	8000.	0.	0.	0.	1.00	35.	21.77	3.06	16.62	2.4
14	5	600.	0.	0.	8449.	0.	0.	7890.	8100.	0.	0.	0.	.97	50.	18.67	2.75	13.10	2.7
15	6	400.	514.	243.	8966.	514.	228.	8404.	9000.	0.	0.	0.	.93	55.	17.76	2.68	12.07	2.9
16	5	1450.	0.	0.	8721.	0.	0.	8177.	8500.	0.	0.	0.	.96	54.	18.14	2.70	12.36	2.8
17	5	2200.	807.	275.	9528.	807.	259.	8923.	9500.	0.	0.	0.	.95	55.	17.92	2.62	12.13	2.9
18	5	2300.	0.	0.	9252.	0.	0.	8724.	9450.	0.	0.	0.	.92	55.	17.94	2.67	12.02	2.9
19	6	2900.	1016.	208.	10268.	1016.	197.	9473.	10900.	0.	* 1032.	257.	.87	45.	17.35	2.82	13.91	2.8
20	5	1200.	0.	0.	10060.	0.	0.	9276.	9500.	0.	** 1200.	224.	.98	29.	20.99	3.46	21.79	2.2
21	6	1050.	824.	183.	10235.	824.	170.	10100.	10100.	0.	0.	0.	1.00	35.	21.77	3.06	16.66	2.4
22	7	2150.	0.	0.	10701.	0.	0.	9930.	12100.	0.	0.	0.	.82	56.	17.77	2.63	11.52	2.9
23	7	1100.	667.	340.	11259.	667.	317.	10617.	12100.	0.	0.	0.	.88	56.	17.36	2.66	11.80	2.9
24	6	1500.	0.	0.	11046.	0.	0.	10500.	10500.	0.	0.	0.	1.00	35.	21.77	3.06	16.67	2.4
25	7	1000.	446.	546.	11494.	446.	510.	10746.	11900.	0.	0.	0.	.90	55.	17.91	2.67	11.92	2.9
26	7	1900.	0.	0.	10949.	0.	0.	9656.	12500.	0.	* 1027.	570.	.77	45.	17.19	2.84	14.17	2.8
27	7	700.	368.	535.	11317.	368.	548.	10036.	11350.	0.	** 700.	570.	.89	30.	16.01	3.36	20.72	2.4
28	6	1550.	0.	0.	10732.	0.	0.	9426.	10150.	0.	** 1550.	570.	.93	27.	20.12	3.54	22.90	2.3
29	6	700.	354.	1445.	11096.	354.	1223.	9850.	9850.	0.	0.	0.	1.00	35.	21.77	3.06	16.62	2.4
30	6	950.	0.	3165.	9631.	0.	2209.	8567.	9000.	0.	0.	0.	.95	55.	17.96	2.62	12.06	2.8
31	5	900.	0.	0.	6426.	0.	0.	5758.	7500.	0.	0.	0.	.77	57.	17.69	2.61	11.27	3.0
32	6	700.	659.	7145.	7145.	659.	6416.	6416.	9300.	0.	0.	0.	.69	57.	17.55	2.53	10.39	3.1
TOTAL		52500.									MAX(V/C) = 1.00			AVG = 29.	16.91	3.36	20.79	2.5

FREEWAY PERFORMANCE TABLE

SUB SEC	NO. LNS	SSEC LENGTH	O-D DATA DEMANDS ORG.	DES.	DEM.	ADJUSTED VOLUMES ORG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GS/VM	CO GS/VM	NOX GS/VM
1	3	3200.	3342.	0.	3342.	3342.	0.	4054.	6000.	0.	* 352.	-212.	.68	29.	14.52	3.32	20.46	2.70
2	5	2600.	2764.	676.	6925.	2764.	676.	7039.	8550.	0.	** 2600.	-212.	.80	19.	14.58	4.43	34.35	2.30
3	4	1600.	0.	0.	5951.	0.	0.	6163.	7200.	0.	** 1600.	-212.	.86	22.	17.14	3.35	28.29	2.12
4	5	3700.	1003.	0.	6953.	1003.	0.	7166.	9400.	0.	** 3700.	-212.	.76	18.	13.57	4.36	33.70	2.01
5	5	2000.	320.	874.	7274.	320.	874.	7485.	9350.	0.	** 2000.	-212.	.80	19.	15.17	4.17	31.24	2.05
6	5	2200.	0.	0.	6400.	0.	0.	6612.	9000.	0.	** 2200.	-212.	.73	17.	12.67	4.49	35.42	1.99
7	5	2900.	341.	127.	6741.	341.	127.	6953.	9000.	0.	** 2900.	-212.	.77	18.	13.97	4.31	33.05	2.02
8	5	1100.	0.	0.	6614.	0.	0.	6826.	8700.	0.	** 1100.	-212.	.78	19.	14.46	4.25	32.23	2.04
9	6	400.	397.	487.	7010.	397.	487.	7223.	9200.	0.	** 400.	-212.	.79	19.	14.42	4.24	32.25	2.04
10	5	500.	0.	253.	6524.	0.	253.	6736.	8600.	0.	** 500.	-212.	.78	19.	14.40	4.25	32.36	2.04
11	5	1500.	0.	0.	6271.	0.	0.	6483.	9000.	0.	** 1500.	-212.	.72	16.	12.25	4.55	36.29	1.97
12	5	1700.	641.	0.	6912.	641.	0.	7124.	9300.	0.	** 1700.	-212.	.77	13.	13.73	4.34	33.46	2.02
13	5	3950.	576.	67.	7798.	576.	69.	8000.	8000.	0.	0.	0.	1.00	35.	21.77	3.06	16.63	2.42
14	5	600.	0.	0.	7721.	0.	0.	7931.	8100.	0.	0.	0.	.98	46.	19.12	2.77	13.36	2.67
15	6	400.	324.	253.	8044.	324.	260.	8255.	9000.	0.	0.	0.	.92	35.	17.93	2.57	11.99	2.93
16	5	1450.	0.	0.	7791.	0.	0.	7995.	8500.	0.	0.	0.	.94	55.	17.97	2.63	12.10	2.92
17	5	2200.	690.	264.	8481.	690.	270.	8685.	9500.	0.	0.	0.	.91	55.	17.93	2.57	11.97	2.93
18	5	2300.	0.	0.	8217.	0.	0.	8415.	9450.	0.	0.	0.	.89	56.	17.89	2.66	11.56	2.95
19	6	2700.	1030.	262.	9249.	1030.	268.	9407.	10900.	0.	* 2742.	38.	.86	23.	17.40	3.81	26.53	2.20
20	5	1200.	0.	0.	8786.	0.	0.	9140.	9500.	0.	** 1200.	38.	.96	26.	20.57	3.57	23.31	2.24
21	6	1050.	960.	172.	9946.	960.	175.	10100.	10100.	0.	0.	0.	1.00	35.	21.77	3.06	16.62	2.42
22	7	2150.	0.	0.	9774.	0.	0.	9572.	12100.	0.	* 434.	353.	.79	53.	17.66	2.38	12.13	2.96
23	7	1100.	700.	335.	10474.	700.	340.	10272.	12100.	0.	** 1100.	353.	.85	27.	17.25	3.51	22.67	2.41
24	6	1500.	0.	0.	10139.	0.	0.	9932.	10300.	0.	** 1500.	353.	.95	24.	20.61	3.37	23.22	2.24
25	7	1000.	361.	538.	10500.	361.	546.	10293.	11700.	0.	** 1000.	353.	.88	22.	17.42	3.91	27.86	2.13
26	7	1900.	0.	0.	9962.	0.	0.	9747.	12500.	0.	** 1900.	353.	.78	12.	14.26	4.27	32.59	2.03
27	7	700.	389.	635.	10351.	389.	643.	10136.	11350.	0.	** 700.	353.	.89	23.	18.36	3.81	26.50	2.16
28	6	1550.	0.	0.	9716.	0.	0.	9493.	10150.	0.	** 1550.	353.	.94	25.	20.04	3.65	24.40	2.21
29	6	700.	357.	1158.	10073.	357.	1171.	9850.	9850.	0.	0.	0.	1.00	35.	21.77	3.06	16.62	2.42
30	6	950.	0.	2570.	8875.	0.	2307.	8679.	9000.	0.	0.	0.	.96	53.	18.21	2.71	12.47	2.55
31	5	500.	0.	0.	6005.	0.	0.	5372.	7500.	0.	0.	0.	.72	56.	17.70	2.62	11.34	3.01
32	6	700.	759.	6774.	6774.	759.	6641.	6641.	9300.	0.	0.	0.	.71	57.	17.59	2.59	11.01	3.05

TOTAL 55500. MAX(V/C) = 1.00 AVG = 25. 16.55 3.61 23.93 2.37

FREEWAY PERFORMANCE TABLE

SUB SEC	NO. LNS	SSEC LENGTH	O-D DATA DEMANDS ORG.	DES.	DEM.	ADJUSTED VOLUMES ORG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GS/VM	CO GS/VM	NOX GS/VM
1	3	3200.	4103.	0.	4103.	4103.	0.	4103.	6000.	0.	0.	0.	.68	56.	17.47	2.59	11.12	3.06
2	5	2600.	3050.	975.	7152.	3050.	975.	7495.	8850.	0.	* 938.	-342.	.85	25.	16.62	3.79	26.61	2.62
3	4	1600.	0.	0.	6173.	0.	0.	6520.	7200.	0.	** 1600.	-342.	.91	24.	18.82	3.77	25.39	2.17
4	5	3700.	833.	0.	7066.	833.	0.	7408.	9400.	0.	** 3700.	-342.	.79	19.	14.61	4.23	32.06	2.04
5	5	2000.	295.	943.	7361.	295.	943.	7703.	9350.	0.	** 2000.	-342.	.82	20.	16.34	4.06	27.72	2.02
6	5	2200.	0.	0.	6418.	0.	0.	6760.	9000.	0.	** 2200.	-342.	.75	17.	13.20	4.41	34.40	2.00
7	5	2200.	336.	125.	6754.	336.	125.	7096.	9000.	0.	** 2200.	-342.	.77	19.	14.62	4.22	32.33	2.04
8	5	1100.	0.	0.	6629.	0.	0.	6971.	8700.	0.	** 1100.	-342.	.80	19.	15.20	4.17	31.36	2.05
9	6	400.	336.	437.	7015.	336.	437.	7357.	9200.	0.	** 400.	-342.	.80	19.	15.13	4.17	31.30	2.05
10	5	500.	0.	247.	6528.	0.	247.	6870.	8600.	0.	** 500.	-342.	.80	19.	15.09	4.18	31.35	2.05
11	5	1500.	0.	0.	6281.	0.	0.	6623.	9000.	0.	** 1500.	-342.	.74	17.	12.71	4.46	35.34	1.99
12	5	1700.	515.	0.	6796.	515.	0.	7138.	9300.	0.	** 1700.	-342.	.77	18.	13.73	4.33	33.27	2.02
13	5	3950.	862.	115.	7658.	862.	120.	8000.	8000.	0.	0.	0.	1.00	35.	21.77	3.06	16.63	2.42
14	5	600.	0.	0.	7543.	0.	0.	7880.	8100.	0.	0.	0.	.97	51.	18.59	2.74	13.00	2.75
15	6	400.	335.	247.	7868.	335.	253.	8205.	9000.	0.	0.	0.	.91	55.	17.92	2.67	11.96	2.93
16	5	1450.	0.	0.	7620.	0.	0.	7947.	8500.	0.	0.	0.	.93	55.	17.96	2.68	12.07	2.92
17	5	2200.	655.	259.	8275.	655.	263.	8603.	9500.	0.	0.	0.	.91	55.	17.91	2.67	11.93	2.94
18	5	2300.	0.	0.	8018.	0.	0.	8334.	9450.	0.	0.	0.	.88	56.	17.37	2.66	11.52	2.95
19	6	2900.	958.	232.	8976.	958.	231.	9713.	10900.	0.	* 539.	-426.	.89	31.	18.10	3.32	20.27	2.50
20	5	1200.	0.	0.	8694.	0.	0.	9487.	9500.	0.	** 1200.	-426.	.99	23.	21.19	3.45	22.07	2.27
21	6	1050.	673.	166.	9367.	673.	179.	10100.	10160.	0.	0.	0.	1.00	35.	21.77	3.06	16.59	2.42
22	7	2150.	0.	0.	9202.	0.	0.	9773.	12100.	0.	* 1020.	144.	.81	34.	16.95	3.13	17.96	2.83
23	7	1100.	551.	230.	9753.	551.	255.	10329.	12100.	0.	** 1100.	144.	.85	21.	17.07	3.95	28.40	2.11
24	6	1500.	0.	0.	9423.	0.	0.	9974.	10300.	0.	** 1500.	144.	.97	27.	20.39	3.55	23.06	2.24
25	7	1000.	423.	592.	9850.	423.	634.	10402.	11900.	0.	** 1000.	144.	.87	22.	17.71	3.33	27.42	2.14
26	7	1900.	0.	0.	9258.	0.	0.	9768.	12500.	0.	** 1900.	144.	.73	18.	14.33	4.26	32.48	2.03
27	7	700.	384.	592.	9642.	384.	633.	10151.	11350.	0.	** 700.	144.	.89	23.	19.41	3.91	26.44	2.15
28	6	1550.	0.	0.	9049.	0.	0.	9519.	10150.	0.	** 1550.	144.	.94	25.	20.10	3.65	24.39	2.21
29	6	700.	331.	1163.	9380.	331.	1231.	9850.	9850.	0.	0.	0.	1.00	35.	21.77	3.06	16.63	2.42
30	6	950.	0.	2631.	8217.	0.	2753.	8629.	9000.	0.	0.	0.	.96	55.	18.06	2.69	12.35	2.39
31	5	900.	0.	0.	5556.	0.	0.	5966.	7500.	0.	0.	0.	.78	55.	17.70	2.58	11.34	3.01
32	6	700.	607.	6193.	6193.	607.	6473.	6473.	9200.	0.	0.	0.	.70	57.	17.56	2.58	10.92	3.06

TOTAL 52500. MAX(V/C) = 1.00 AVE = 27. 17.05 3.33 22.39 2.40

INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, BERKELEY
(415)-642-7390

FREQ3
SIMULATION BEFORE ENTRY CONTROL
TIME SLICE 10 OF 15

FREEWAY PERFORMANCE TABLE

SUB SEC	NO. LNS	SEC LENGTH	O-D DATA DEMANDS ORG.	DES.	DEM.	ADJUSTED VOLUMES ORG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GS/VM	CO GS/VM	NOX GS/VM
1	3	3200.	4438.	0.	4438.	4438.	0.	4438.	6000.	0.	0.	0.	.74	57.	17.63	2.60	11.13	3.04
2	5	2600.	2911.	911.	7349.	2911.	911.	7504.	8250.	0.	0.	-155.	.85	43.	16.94	2.97	15.74	3.19
3	4	1500.	0.	0.	6432.	0.	0.	6593.	7200.	0.	** 1500.	-155.	.92	24.	19.22	3.73	23.33	2.18
4	5	3700.	917.	0.	7355.	917.	0.	7511.	9400.	0.	** 3700.	-155.	.80	19.	15.09	4.18	31.24	2.05
5	5	2000.	451.	906.	7906.	451.	906.	7961.	9350.	0.	** 2000.	-155.	.55	21.	17.01	3.96	28.50	2.11
6	5	2200.	0.	0.	6900.	0.	0.	7055.	9000.	0.	** 2200.	-155.	.73	19.	14.43	4.25	32.32	2.04
7	5	2300.	308.	130.	7208.	308.	130.	7362.	9000.	0.	** 2300.	-155.	.82	20.	16.05	4.06	30.08	2.07
8	5	1100.	0.	0.	7078.	0.	0.	7234.	9700.	0.	** 1100.	-155.	.83	20.	16.44	4.03	29.43	2.09
9	6	400.	372.	493.	7450.	372.	493.	7605.	9200.	0.	** 400.	-155.	.83	20.	16.32	4.05	29.65	2.08
10	5	500.	0.	353.	6957.	0.	353.	7112.	8600.	0.	** 500.	-155.	.83	20.	16.33	4.05	29.54	2.08
11	5	1500.	0.	0.	6604.	0.	0.	6759.	9000.	0.	** 1500.	-155.	.75	17.	13.19	4.41	34.41	2.00
12	5	1700.	510.	0.	7112.	510.	0.	7259.	9300.	0.	** 1700.	-155.	.78	18.	14.33	4.26	32.47	2.03
13	5	3950.	731.	191.	7845.	731.	195.	8000.	8000.	0.	0.	0.	1.00	35.	21.77	3.06	16.68	2.42
14	5	500.	0.	0.	7664.	0.	0.	7815.	9100.	0.	0.	0.	.96	53.	18.23	2.71	12.49	2.85
15	6	400.	316.	248.	7930.	316.	253.	8132.	9000.	0.	0.	0.	.90	55.	17.91	2.67	11.98	2.94
16	5	1450.	0.	0.	7732.	0.	0.	7679.	8500.	0.	0.	0.	.93	55.	17.55	2.68	12.04	2.93
17	5	2200.	600.	243.	8332.	600.	247.	8478.	9500.	0.	0.	0.	.89	55.	17.39	2.66	11.87	2.95
18	5	2300.	0.	0.	9099.	0.	0.	8231.	9450.	0.	0.	0.	.87	56.	17.55	2.65	11.77	2.96
19	6	2900.	912.	239.	9000.	912.	293.	9143.	10900.	0.	0.	0.	.84	53.	17.79	2.58	12.14	2.95
20	5	1200.	0.	0.	8711.	0.	0.	9167.	9500.	0.	0.	-318.	.96	33.	19.52	3.23	13.95	2.50
21	6	1050.	850.	158.	9562.	850.	166.	10017.	10100.	0.	0.	0.	.99	41.	20.93	2.83	14.47	2.52
22	7	2150.	0.	0.	9403.	0.	0.	10027.	12100.	0.	* 286.	-176.	.83	36.	17.31	3.06	17.84	2.71
23	7	1100.	520.	357.	9933.	520.	373.	10557.	12100.	0.	** 1100.	-176.	.87	22.	17.66	3.89	27.50	2.13
24	6	1500.	0.	0.	9576.	0.	0.	10184.	10300.	0.	** 1500.	-176.	.99	27.	21.12	3.49	22.22	2.27
25	7	1600.	328.	611.	9904.	328.	638.	10512.	11900.	0.	** 1000.	-176.	.88	23.	19.02	3.65	25.97	2.15
26	7	1900.	0.	0.	9293.	0.	0.	9874.	12500.	0.	** 1900.	-176.	.79	17.	14.67	4.22	31.93	2.04
27	7	700.	305.	599.	9598.	305.	624.	10180.	11350.	0.	** 700.	-176.	.90	23.	18.50	3.80	26.31	2.16
28	6	1550.	0.	0.	8999.	0.	0.	9556.	10150.	0.	** 1550.	-176.	.94	25.	20.17	3.64	24.15	2.22
29	6	700.	294.	1129.	9294.	294.	1195.	9850.	9850.	0.	0.	0.	1.00	35.	21.77	3.06	16.68	2.42
30	6	950.	0.	2525.	8165.	0.	2782.	8654.	9000.	0.	0.	0.	.96	54.	18.12	2.70	12.34	2.87
31	5	900.	0.	0.	5340.	0.	0.	5872.	7500.	0.	0.	0.	.78	55.	17.70	2.62	11.34	3.01
32	6	700.	579.	6118.	6118.	575.	6450.	6450.	9500.	0.	0.	0.	.69	57.	17.55	2.59	10.91	3.05
TOTAL		55500.											MAX(V/C) = 1.00	AVG = 29.	17.39	3.41	21.43	2.47

FREEWAY PERFORMANCE TABLE

SUB SEC	NO. LNS	SSEC LENGTH	O-D DATA DEMANDS ORG.	DES.	DEM.	ADJUSTED VOLUMES ORG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GS/VM	CO GS/VM	NOX GS/VM
1	3	3200.	4507.	0.	4507.	4507.	0.	4507.	6000.	0.	0.	0.	.75	57.	17.65	2.60	11.19	3.03
2	5	2600.	3120.	1001.	7627.	3120.	1001.	7394.	8550.	0.	* 1390.	233.	.84	39.	15.84	2.10	15.32	3.0
3	4	1600.	0.	0.	6626.	0.	0.	6393.	7200.	0.	** 1600.	233.	.89	23.	13.18	3.83	26.75	2.15
4	5	3700.	977.	0.	7603.	977.	0.	7370.	9400.	0.	** 3700.	233.	.78	19.	14.44	4.25	32.31	2.0
5	5	2000.	419.	931.	8021.	419.	931.	7788.	9350.	0.	** 2000.	233.	.83	21.	16.49	4.03	29.35	2.09
6	5	2200.	0.	0.	7090.	0.	0.	6857.	9000.	0.	** 2200.	233.	.76	18.	13.53	4.36	32.72	2.01
7	5	2800.	310.	136.	7400.	310.	136.	7167.	9000.	0.	** 2800.	233.	.80	19.	14.97	4.19	31.51	2.05
8	5	1100.	0.	0.	7264.	0.	0.	7031.	8700.	0.	** 1100.	233.	.81	20.	15.54	4.13	30.74	2.0
9	5	400.	477.	515.	7742.	477.	515.	7509.	9200.	0.	** 400.	233.	.82	20.	15.94	4.09	30.21	2.07
10	5	500.	0.	270.	7227.	0.	270.	6994.	8600.	0.	** 500.	233.	.81	20.	15.79	4.11	30.41	2.0
11	5	1500.	0.	0.	6956.	0.	0.	6723.	9000.	0.	** 1500.	233.	.75	17.	13.06	4.43	34.66	2.09
12	5	1700.	493.	0.	7449.	493.	0.	7216.	9300.	0.	** 1700.	233.	.78	18.	14.11	4.29	32.83	2.0
13	5	2950.	784.	68.	8233.	784.	66.	8000.	8000.	0.	0.	0.	1.00	35.	21.77	3.06	16.68	2.42
14	5	800.	0.	0.	8165.	0.	0.	7934.	8100.	0.	0.	0.	.98	48.	19.16	2.77	13.37	2.61
15	6	400.	383.	262.	8548.	383.	255.	8317.	9000.	0.	0.	0.	.92	55.	17.94	2.57	12.02	2.93
16	5	1450.	0.	0.	8286.	0.	0.	8061.	8500.	0.	0.	0.	.95	55.	17.99	2.59	12.14	2.91
17	5	2200.	553.	249.	8832.	553.	243.	8614.	9500.	0.	0.	0.	.91	55.	17.91	2.57	11.94	2.94
18	5	2300.	0.	0.	8583.	0.	0.	8371.	9450.	0.	0.	0.	.89	56.	17.88	2.56	11.84	2.9
19	6	2900.	904.	314.	9493.	904.	307.	9276.	10900.	0.	0.	0.	.85	56.	17.82	2.54	11.57	2.97
20	5	1200.	0.	0.	9180.	0.	0.	8969.	9500.	0.	0.	0.	.94	55.	17.93	2.68	12.32	2.9
21	6	1050.	631.	160.	9651.	631.	157.	9650.	10100.	0.	0.	0.	.96	55.	18.00	2.59	12.16	2.91
22	7	2150.	0.	0.	9700.	0.	0.	9493.	12100.	0.	0.	0.	.78	56.	17.69	2.53	11.51	3.00
23	7	1100.	523.	380.	10223.	523.	372.	10016.	12100.	0.	0.	0.	.83	36.	17.76	3.09	17.21	2.68
24	6	1500.	0.	0.	9843.	0.	0.	9644.	10200.	0.	0.	0.	.94	31.	20.34	3.30	19.84	2.42
25	7	1000.	270.	642.	10113.	270.	630.	10475.	11900.	0.	* 694.	-562.	.88	23.	17.92	3.36	27.09	2.16
26	7	1900.	0.	0.	9470.	0.	0.	9945.	12500.	0.	** 1900.	-562.	.79	19.	14.59	4.23	32.08	2.04
27	7	700.	331.	627.	9802.	331.	617.	10177.	11350.	0.	** 700.	-562.	.90	23.	18.49	3.20	26.32	2.16
28	6	1550.	0.	0.	9172.	0.	0.	9559.	10150.	0.	** 1550.	-562.	.94	25.	20.18	3.63	24.13	2.22
29	6	700.	291.	1186.	9463.	291.	1224.	9850.	9850.	0.	0.	0.	1.00	35.	21.77	3.06	16.68	2.42
30	6	950.	0.	2495.	8277.	0.	2598.	8616.	9000.	0.	0.	0.	.96	55.	18.02	2.67	12.21	2.9
31	5	900.	0.	0.	5781.	0.	0.	6018.	7500.	0.	0.	0.	.80	56.	17.72	2.62	11.43	3.00
32	6	700.	578.	6359.	6359.	578.	6595.	6595.	9300.	0.	0.	0.	.71	57.	17.58	2.59	10.99	3.05
TOTAL		52500.											MAX(V/C) = 1.00	AVE = 30.	17.06	3.36	20.35	2.51

FREEWAY PERFORMANCE TABLE

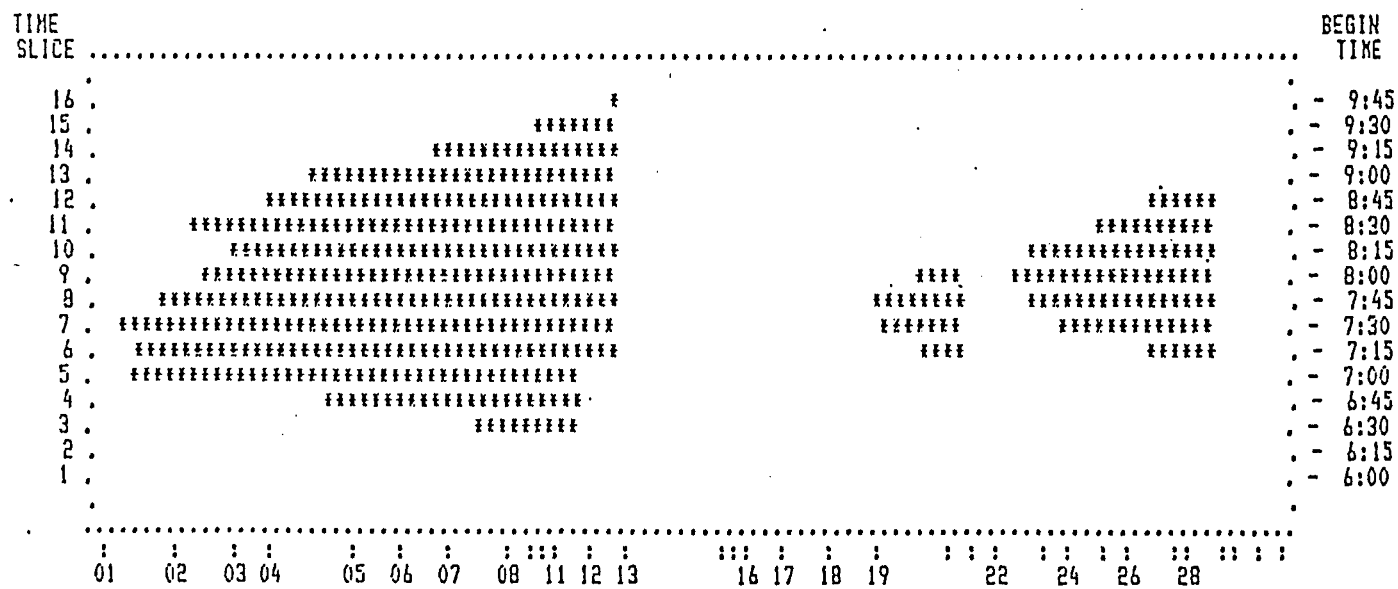
SUB SEC	NO. LNS	SSEC LENGTH	O-D DATA DEMANDS ORG.	DES.	DEM.	ADJUSTED VOLUMES ORG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GS/VM	CO GS/VM	NOX GS/VM
1	3	3200.	4309.	0.	4309.	4309.	0.	4309.	6000.	0.	0.	0.	.72	57.	17.59	2.59	11.03	3.05
2	5	2600.	3066.	1022.	7376.	3066.	1022.	7375.	8350.	0.	0.	0.	.83	46.	17.12	2.33	15.69	3.24
3	4	1600.	0.	0.	6348.	0.	0.	6348.	7200.	0.	0.	0.	.88	30.	19.52	3.57	20.79	2.41
4	5	3700.	794.	0.	7142.	794.	0.	7584.	9400.	0.	* 3542.	-442.	.81	19.	15.47	4.13	30.30	2.06
5	5	2000.	391.	1085.	7533.	391.	1085.	7975.	9350.	0.	** 2000.	-442.	.85	21.	17.05	3.96	28.43	2.11
6	5	2200.	0.	0.	6448.	0.	0.	6890.	9000.	0.	** 2200.	-442.	.77	18.	13.71	4.34	32.49	2.08
7	5	2300.	366.	132.	6815.	368.	132.	7258.	9000.	0.	** 2300.	-442.	.81	19.	15.45	4.14	30.35	2.06
8	5	1100.	0.	0.	6685.	0.	0.	7127.	8760.	0.	** 1100.	-442.	.82	20.	16.10	4.07	30.01	2.07
9	6	400.	523.	457.	7203.	523.	427.	7650.	9200.	0.	** 400.	-442.	.83	20.	16.45	4.03	29.43	2.09
10	5	500.	0.	365.	6722.	0.	365.	7154.	8600.	0.	** 500.	-442.	.83	21.	16.49	4.03	29.36	2.09
11	5	1500.	0.	0.	6356.	0.	0.	6798.	9000.	0.	** 1500.	-442.	.76	17.	13.34	4.39	34.13	2.01
12	5	1700.	452.	0.	6808.	452.	0.	7250.	9300.	0.	** 1700.	-442.	.78	18.	14.25	4.27	32.60	2.03
13	5	3950.	750.	85.	7558.	750.	91.	8000.	8000.	0.	0.	0.	1.00	35.	21.77	3.06	16.68	2.42
14	5	600.	0.	0.	7472.	0.	0.	7909.	8100.	0.	0.	0.	.98	49.	18.55	2.76	13.24	2.70
15	6	400.	405.	271.	7577.	405.	285.	8314.	9000.	0.	0.	0.	.92	55.	17.94	2.67	12.02	2.93
16	5	1450.	0.	0.	7606.	0.	0.	8023.	8500.	0.	0.	0.	.94	55.	17.95	2.63	12.12	2.92
17	5	2200.	776.	226.	8352.	776.	233.	8804.	9500.	0.	0.	0.	.93	55.	17.95	2.69	12.03	2.93
18	5	2200.	0.	0.	8156.	0.	0.	8567.	9450.	0.	0.	0.	.91	55.	17.91	2.57	11.54	2.94
19	6	2700.	877.	234.	9033.	877.	297.	9443.	10900.	0.	0.	0.	.87	56.	17.84	2.65	11.74	2.95
20	5	1200.	0.	0.	8748.	0.	0.	9166.	9500.	0.	0.	0.	.96	54.	19.16	2.70	12.40	2.86
21	6	1050.	681.	132.	9429.	691.	137.	9827.	10100.	0.	0.	0.	.97	51.	18.60	2.75	13.01	2.75
22	7	2150.	0.	0.	9298.	0.	0.	9690.	12100.	0.	0.	0.	.80	56.	17.73	2.62	11.43	3.00
23	7	1100.	522.	357.	9819.	522.	382.	10211.	12100.	0.	0.	0.	.84	56.	17.81	2.64	11.64	2.97
24	6	1500.	0.	0.	9452.	0.	0.	9830.	10300.	0.	0.	0.	.95	55.	17.99	2.69	12.14	2.91
25	7	1000.	309.	609.	9761.	309.	633.	10139.	11900.	0.	0.	0.	.85	45.	17.93	2.88	14.06	2.84
26	7	1300.	0.	0.	9152.	0.	0.	10043.	12500.	0.	* 559.	-537.	.80	23.	15.75	3.32	26.77	2.27
27	7	700.	243.	679.	9395.	243.	705.	10286.	11350.	0.	** 700.	-537.	.91	24.	18.85	3.76	25.35	2.17
28	6	1550.	0.	0.	8716.	0.	0.	9581.	10150.	0.	** 1550.	-537.	.94	25.	20.22	3.63	24.05	2.22
29	6	700.	269.	929.	8955.	269.	1083.	9850.	9850.	0.	0.	0.	1.00	35.	21.77	3.06	16.63	2.42
30	6	950.	0.	2739.	7397.	0.	3035.	8767.	9000.	0.	0.	0.	.97	50.	18.67	2.75	12.19	2.73
31	5	900.	0.	0.	5233.	0.	0.	5742.	7500.	0.	0.	0.	.77	57.	17.67	2.61	11.26	3.02
32	6	700.	622.	5959.	5257.	622.	6334.	6344.	9300.	0.	0.	0.	.68	57.	17.54	2.57	10.37	3.07
TOTAL		52500.									MAX(V/C) = 1.00			AVG = 32.	17.32	3.25	19.45	2.57

FREEWAY PERFORMANCE TABLE

SUB SEC	NO. LNS	SECT LENGTH	O-D DATA DEMANDS ORG.	DES.	DEM.	ADJUSTED VOLUMES ORG.	DES.	VOL.	FRWY CAP.	WEAVE EFF	QUEUE LENGTH	STORAGE RATE	V/C	SPEED MPH	FUEL MPG	HC GS/VM	CO GS/VM	NOX GS/VM
1	3	3200.	3463.	0.	3463.	3463.	0.	3463.	6000.	0.	0.	0.	.58	58.	17.36	2.53	10.35	3.13
2	5	2600.	3330.	769.	6793.	3330.	769.	6793.	8550.	0.	0.	0.	.77	57.	16.93	2.66	13.12	3.43
3	4	1600.	0.	0.	6024.	0.	0.	6024.	7200.	0.	0.	0.	.84	56.	17.79	2.64	11.60	2.93
4	5	3700.	744.	0.	6769.	744.	0.	6769.	9400.	0.	0.	0.	.72	57.	17.60	2.59	11.04	3.05
5	5	2000.	323.	746.	7091.	323.	746.	7091.	9350.	0.	0.	0.	.76	57.	17.66	2.61	11.22	3.03
6	5	2200.	0.	0.	6345.	0.	0.	6345.	9000.	0.	0.	0.	.71	57.	17.57	2.58	10.97	3.06
7	5	2200.	372.	153.	6717.	372.	153.	6717.	9000.	0.	0.	0.	.75	57.	17.64	2.60	11.16	3.03
8	5	1100.	0.	0.	6534.	0.	0.	6534.	8700.	0.	0.	0.	.75	57.	17.65	2.60	11.19	3.03
9	6	400.	530.	558.	7064.	530.	558.	7064.	9200.	0.	0.	0.	.77	57.	17.68	2.61	11.27	3.02
10	5	500.	0.	362.	6506.	0.	362.	6506.	8600.	0.	0.	0.	.76	55.	17.63	2.63	11.54	3.01
11	5	1500.	0.	0.	6144.	0.	0.	6144.	9000.	0.	0.	0.	.68	32.	15.30	3.20	16.55	2.71
12	5	1700.	347.	0.	6491.	347.	0.	7123.	9300.	0. *	437.	-637.	.77	20.	14.19	4.08	30.13	2.17
13	5	3750.	872.	105.	7363.	872.	115.	8000.	8000.	0.	0.	0.	1.00	35.	21.77	3.06	16.68	2.42
14	5	600.	0.	0.	7257.	0.	0.	7835.	8100.	0.	0.	0.	.97	51.	18.63	2.75	13.05	2.74
15	6	400.	458.	449.	7715.	458.	485.	8343.	9000.	0.	0.	0.	.93	55.	17.95	2.68	12.04	2.93
16	5	1450.	0.	0.	7266.	0.	0.	7858.	8500.	0.	0.	0.	.92	55.	17.94	2.68	12.02	2.92
17	5	2200.	427.	350.	7593.	427.	377.	8295.	9500.	0.	0.	0.	.87	56.	17.85	2.65	11.77	2.95
18	5	2300.	0.	0.	7343.	0.	0.	7908.	9450.	0.	0.	0.	.84	56.	17.79	2.64	11.60	2.99
19	6	2900.	769.	154.	8113.	769.	157.	8677.	10900.	0.	0.	0.	.80	56.	17.72	2.62	11.40	3.00
20	5	1200.	0.	0.	7929.	0.	0.	8430.	9500.	0.	0.	0.	.89	55.	17.89	2.66	11.87	2.95
21	6	1050.	408.	248.	8337.	408.	265.	8839.	10100.	0.	0.	0.	.88	56.	17.87	2.66	11.81	2.95
22	7	2150.	0.	0.	8087.	0.	0.	8624.	12100.	0.	0.	0.	.71	57.	17.58	2.59	11.00	3.05
23	7	1100.	405.	267.	8492.	405.	284.	9029.	12100.	0.	0.	0.	.75	57.	17.64	2.60	11.15	3.03
24	6	1500.	0.	0.	8227.	0.	0.	8745.	10300.	0.	0.	0.	.85	56.	17.81	2.64	11.65	2.97
25	7	1000.	282.	581.	8448.	282.	617.	8957.	11900.	0.	0.	0.	.75	57.	17.65	2.60	11.20	3.03
26	7	1300.	0.	0.	7867.	0.	0.	8350.	12500.	0.	0.	0.	.67	57.	17.51	2.57	10.79	3.08
27	7	700.	328.	535.	8194.	328.	567.	8677.	11350.	0.	0.	0.	.76	57.	17.67	2.61	11.25	3.02
28	6	1550.	0.	0.	7659.	0.	0.	8110.	10150.	0.	0.	0.	.80	56.	17.73	2.62	11.42	3.00
29	6	700.	254.	1021.	7913.	254.	1079.	8364.	9850.	0.	0.	0.	.85	55.	17.81	2.64	11.66	2.97
30	6	950.	0.	2613.	6892.	0.	2762.	7285.	9000.	0.	0.	0.	.81	56.	17.75	2.63	11.47	3.00
31	5	900.	0.	0.	4279.	0.	0.	4523.	7500.	0.	0.	0.	.60	58.	17.40	2.54	10.47	3.12
32	6	700.	596.	4875.	4875.	596.	5119.	5119.	9300.	0.	0.	0.	.55	58.	17.32	2.52	10.22	3.15

TOTAL 52500. MAX(V/C) = 1.00 AVG = 50. 17.75 2.71 12.63 2.95

CONTOUR DIAGRAM OF
QUEUE LENGTH
BEFORE OPTIMIZATION



BLANK DENOTES MOVING TRAFFIC. ASTERISK DENOTES QUEUED VEHICLES DUE TO MAINLINE CONGESTION.
M DENOTES QUEUED VEHICLES DUE TO MERGING. B DENOTES QUEUED VEHICLES DUE TO MAINLINE CONGESTION AND MERGING. (WHEN BOTH QUEUES EXIST, LENGTH OF DISPLAY REPRESENTS MAINLINE CONGESTION.)

INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, BERKELEY
(415)-642-7390

FREQ8
SIMULATION BEFORE ENTRY CONTROL
TIME SLICE 1 OF 16

FREEWAY TRAVEL TIME (MINUTES)

ORIGINS DOWN \ DESTINATIONS ACROSS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1.09	2.47	3.42	3.71	3.80	5.17	5.37	6.07	7.08	7.52	8.15	8.64	9.15	9.59	9.78	10.09
2	.49	1.85	2.83	3.11	3.21	4.58	4.77	5.48	6.49	6.93	7.56	8.05	8.55	9.00	9.18	9.49
3	.00	1.08	2.03	2.32	2.41	3.78	3.98	4.66	5.69	6.13	6.76	7.25	7.76	8.20	8.39	8.69
4	.00	.38	1.33	1.61	1.71	3.08	3.27	3.98	4.99	5.43	6.06	6.55	7.06	7.50	7.69	7.99
5	.00	.00	.53	.82	.91	2.25	2.48	3.18	4.19	4.63	5.26	5.75	6.26	6.70	6.89	7.20
6	.00	.00	.00	.08	.17	1.54	1.74	2.44	3.45	3.89	4.52	5.01	5.52	5.96	6.15	6.45
7	.00	.00	.00	.00	.00	1.09	1.28	1.99	2.99	3.44	4.07	4.56	5.06	5.51	5.69	6.00
8	.00	.00	.00	.00	.00	.76	.96	1.65	2.67	3.11	3.74	4.23	4.74	5.18	5.37	5.68
9	.00	.00	.00	.00	.00	.00	.08	.76	1.79	2.23	2.86	3.35	3.86	4.30	4.49	4.80
10	.00	.00	.00	.00	.00	.00	.00	.43	1.43	1.88	2.51	3.00	3.50	3.95	4.13	4.44
11	.00	.00	.00	.00	.00	.00	.00	.00	.56	1.00	1.63	2.12	2.63	3.07	3.26	3.57
12	.00	.00	.00	.00	.00	.00	.00	.00	.00	.21	.84	1.33	1.83	2.28	2.46	2.77
13	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.21	.70	1.21	1.65	1.84	2.15
14	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.20	.70	1.14	1.33	1.64
15	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.14	.58	.77	1.07
16	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.14	.33	.63
17	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.13

APPENDIX -G-

TRANSYT-7FC USER'S GUIDE
(APRIL 1988)

TRANSYT-7FC

TRANSYT MODEL FOR ACTUATED SIGNALS

USER'S GUIDE

Alexander Skabardonis
Aaron Weinstein

Institute of Transportation Studies
University of California, Berkeley
Berkeley, CA 94720

April 1988

1. INTRODUCTION

This document describes the enhancements made to the TRANSYT model at the Institute of Transportation Studies-Berkeley (ITS) to better handle actuated signals on arterials and networks. All of these enhancements were incorporated to the latest version of the TRANSYT Program (TRANSYT-7F Release 5) available from the McTrans Center (1). The work performed by ITS was sponsored by Caltrans as part of the FETSIM Program.

Section 2 of the report describes briefly the methodology used to model the operation of actuated signals into TRANSYT. Section 3 provides input coding instructions for using the enhanced version (called TRANSYT-7FC). Section 4 explains the new output features. Appendix A provides details on the computational methodology and, Appendix B includes revised coding instructions in tabular form for quick reference.

This enhanced version of the model is fully compatible with TRANSYT-7F Rel. 5 distributed, by the McTrans. Existing data sets will still run without any modifications and produce identical results with the standard version.

It should be noted that this User's Guide describes only the changes to the model performed by ITS. A complete documentation on the use of TRANSYT-7F can be found in the TRANSYT-7F User's . Manual and the FETSIM Orientation Workbook (2).

2. OVERVIEW OF THE METHODOLOGY

TRANSYT-7FC calculates the controller timings for actuated signals based on the results from earlier research work performed at ITS (3,4). A brief description of the methodology is given below (Refer also to Appendix A for more details about the computational methodology).

First, the average green times for the actuated phases are estimated for a desired degree of saturation for the critical links moving on each phase (default value 85 percent). The estimated values are adjusted as appropriate to satisfy the minimumphases length requirements for vehicles andpedestrians specified by the user.

Next, the average green time for the non-actuated (sync) phase is estimated by subtracting the sum of the actuated phase lengths from the background cycle length. The program checks and adjusts the estimated green time to satisfy minimum phase lengths and avoid oversaturation for the sync phase. In case of more than one non-actuated phases (for example, through phases on grid networks) the program automatically determines the extra time to distribute to each non-actuated phase based on the specified phase sequence.

If all the phases are specified as actuated ("free" signal operation), then the program computes the average green times to equalize the degree of saturation on the conflicting critical approaches.

The methodology has been incorporated in TRANSYT with a minimum amount of additional input coding and at the same time provides considerable flexibility to the model Users. Users can easily designate which phases are actuated, and they can override the default value for estimating the green times for either i) the entire network, or ii) a specific phase. Changes were also made to the output to assist the user interpreting the simulation results.

3. INPUT CODING MODIFICATIONS

To use the enhanced version of TRANSYT changes should be made on the following Card Types: 2,10,1X and 2X. (Refer also to Appendix B for a description of coding instructions in tabular form).

Actuated nodes should be listed on Card Type 2. The values of the variable intervals should normally be left blank on Card Type 1X. The type of each signal phase (pretimed/actuated) is specified on Card Type 2X. Users have the option to override the default value for the degree of saturation either for the entire network on Card Type 10, or for a specific phase on card Type 2X.

Card Type 2--Optimization Node List--Fields 2 through 16

The actuated nodes for which you would like TRANSYT to compute the average green times, must be listed on Card Type 2 under the list of nodes to be optimized. This is optional for pretimed nodes. However, since all the nodes need to be listed for an optimization run it is good practice to list all the nodes in the simulation data deck to avoid making changes later to perform an optimization run.

Card Type 10 -- NETWORK MASTER CARD -- Field 11

Users can specify a network wide value for the degree of saturation to be used in the computation of green times for the actuated phases. The program uses 85% as the default value for this parameter. Users wishing to override this default value may code the desired value in this field. This value must be within the range 50-100. No decimal points are allowed. TRANSYT reads this value as a percentage.

Note that this value applies to the entire network. Users wishing to change the desired degree of saturation for a particular phase may do so in Card Type 2X, Field 16.

Card Type 1X -- CONTROLLER TIMING CARD -- Fields 5 through 15

A node having at least one phase coded as actuated on Card Type 2X (see below) then there is no need to code into TRANSYT the duration of the variable intervals on fields 5-15, Leave them zero or blank. TRANSYT will override any values for the variable intervals coded. Fixed intervals (yellow, all reds, and ped clearance if any) can still be coded in those fields.

Note

If an existing data set-is used with the value of the variable intervals already coded and is desired to determine average green times for actuated control but at the same time maintain the same offset, then the yield point coded on Field 3 of Card Type 1X should be adjusted. This is' illustrated through the following example:

Suppose you have the following Card Type 1X in an existing data file:

CONTROLLER TIHING DATA

IE 10.	CARD TYPE	NODE NO.	OFFSET/ YLD.PT.	REF IN1	INTI	INTZ	INT3	INT4	INTJ	INT6	INT7	INTB	INT9	INTlO	INTll	DOUBLE CYCLE
II	12	1	50	3	36	4	ib	4	0	0	0	0	0	0	0	0

INTERVAL DURATIONS (SEC% .OR PERCENT) . . . .a.................................

The yield point is referenced to interval 3, hence the offset (referenced to interval 1) is 50-4-36. = 10 seconds. If you now alter the data set by coding zeros for the variable intervals, and if you want to preserve the 10 'second offset, then you must also modify the input yield point value, as follows:

Yield Point = offset + interval 1 + interval 2
Yield Point = 10 + 0 + 4 = 14

The modified Card Type 1X is shown below:

CiiiliOLLER TIMNG ~MTA

E IO.	CARD TYPE	NODE NO.	OFFSET/ YLD.PT.	REF INT	INTl	IN'12	INT3	INT4	INT5	INT6	INT7	INTB	INT9	INTIO	INTll	DOUBLE CYCLE
II	12	1	14	3	0-	4	0	4	0	0	0	0	0	0	0'	0

INTERVAL DURATIONS (SECS. OR PERCENT) . . . .*...........................*.*......

Card Type 2X - Phase Sequence Card - Fields 16

Field 16 is now the location for not only the 2X continuation flag, but also for a flag indicating whether a phase is actuated. The new hybrid flag is coded as follows;

CODING	INTERPRETATION
"0"	The phase is non-actuated (e.g., sync phase); no continuation card 2Y will follow.
"1"	The phase is non-actuated; a continuation card 2Y will follow.
"3"	Actuated phase; green times will be estimated based on the degree of saturation entered on Card Type 10, Field 11, or the default value (85 percent).
"50-100"	Actuated phase; green time will be estimated based on the degree of saturation value entered in this field.

Note that a continuation card 2Y is required for a phase in which there are more than 8 links moving. Thus, in most practical applications, this field should be coded as "0" (non-actuated phase), or "3" (actuated phase). Users have the flexibility to code a desired degree of saturation to estimate the green time for the specific phase.

Card Type 2X- Phase Sequence Card - Field 7

Here, the minimum phase length for a phase is specified. Normally, this value represents the minimum phase duration for vehicles and pedestrians to safely clear the intersection and it should be at least equal to the sum of the fixed interval lengths plus one second.

Simulation of actuated signals with TRANSYT requires to give special consideration to the phase minimum entered in this field. For example, suppose that the pedestrian signal is pushrbutton actuated for a particular phase and 18 seconds are required to satisfy the minimum pedestrian clearance time for the actuated .-Phase X, but only 10 seconds are needed to. serve the traffic demand. If pedestrian traffic is so light that the-push-button is activated only once every 15 cycles, then most of the time, phase x needs to be at least 10 second long. Thus, to accurate simulate average traffic conditions using TRANSYT it is appropriate to code the minimum phase length required for vehicles and ignore minimum pedestrian requirements. If, however, pedestrians frequently use the intersection then the minimum phase length for peds is the appropriate value to code in field 7. Users, therefore, should be familiar with the field conditions to appropriately code this value.

4. OUTPUT FEATURES

Several features were added to the TRANSYT-7F output to assist the user correctly interpret; the results of a simulation, run. Notice that next to the TRANSYT 7F Release Number on the top left side of the Input Data Report appear the words "Enhanced Actuated Signals Version" (Figure 1).

Input Data Report

Within the Input Data Report, several field headings have been changed or added. For Card Type 10, Field 11 (previously blank) now has-the heading "Degree Sat". As it is shown in Figure 1, the system-wide value for the degree of saturation for actuated phases is coded as 90% for the sample problem. For Card Type 2X, Field 16 (previously entitled "Continuation Flag") now has the heading "Phase Type". Note that phases 1 and 3 are actuated (Figure 2).

Signal Controller Tables

There are several new features within the "TRANSYT 7F SIGNAL CONTROLLER SETTINGS" output (Figure 3). First, a message is printed indicating that the network includes actuated signals. Each intersection is labeled with "Actuated" or "Pretimed" as appropriate. (In the example output shown in Figure 3, the signal is "Actuated"). Also, phase splits (in seconds and in % of cycle) are provided, and the phases which are actuated are identified with the letter "A". At the bottom of the table, the new yield point is printed.

If the estimated average green time is lower that the specified minimum phase length, the green time is adjusted and a letter M is, printed in the, Signal Controllers Table to indicate this program action (Figure 4).

Note that in the enhanced actuated signals version of TRANSYT 7F the terminology "yield point" is always used for actuated signals and "offset" for pretimed signals, regardless of the reference interval.

TRANSYT-7F -- TRAFFIC SI6NAL SYSTEH OPTIMIZATION PROGRAM

RELEASE 5 JULY, 1987 ENHANCED ACTUATED SIGNALS VERSION VERSION 1. i

SPONSORED BY:
FEDERAL HIGHWAY ADMIN!STRATION
OFFiCE OF TRAFFIC OPERATIONS

DEVELOPED BY*
TRANSPORT AND ROAD RESEARCH LABORATORY
UNITED KINGDOM AND
TRANSPORTATION RESEARCH CENTER
UN!VERSITY OF FLORIDA

INPUT DATA REPORT FOR RUN 1

FIELDS: ! 2 3 4 5 t 7 8 9 10 11 12 13 14 15 16

LINE NO. TITLE — RUN TITLE CARD

2) SAMPLE RUN FOR USERS' GUIDE SUPPLERENT

NETWORK CONTROL CARD

LINE NO.	CARD TYPE	C!:E	C!:E	;;;kE	SEC! STEP CYCLE	SEC/ STEP NORRAL	LOSi TIRE	GREEN EXTEN.	STOP PENALTY	OUTPUT LEVEL	INITIAL TItIINSS	PERIOD LENGT!!	SEC(V) PERC(II	SPDiO! TItIEII!	ENSL!O! HETR!!!	PNSH DECK
3!	1	120	120	0*'	0	2	2	2	-1'	1	0	60	0	0	0	0

ttt 107 ttt YARN!NS t A STOP PENALTY OF "-1' WILL RESULT IN AUTO#A?IC
CALCULATION OF THE PI TO MNIHIZE FUEL COHSU!tPTION.
LINK SPECIFIC DELAY OR STOP WEIGHTS ON CARD
TYPE 37 t 38 WILL STILL BE APPLIED, HOWEVER.

LIST OF NODES TO BE OFTIfiIZED

LINE NO.	CARD TYPE															
4!	2	1	0	0	0	0	0	0	0	0	0 J	0	0	0	0	0

SYSTEM MASTER DATA

LINE NO.	CARD' TYPE	MASTER NODE	SYSTEM YELLOW	DEFAULTS ALL-RED	SYSTEM SATFLOW	EXTERNAL SPEED	SYSTEM PDF	FUEL -FACTOR	VEHICLE LENGTH	ORiEN-TATION	DEGREE SAT.					
5!	10	0	0	0	0	0	0	0	0	0	90	0	0	0	0	0

FIGURE 1. INPUT DATA REPORT -- TRANSYT-7FC

IELDS:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
							PHASE	TIMING	DATA							
.INE NO.	CARD TYPE	NODE NO.	START INTVL	VARIAB. INTVL	YELLOW INTVL	ALL-RED INTVL	MINIM. SECS.	LINKS MOVING IN THIS PHASE								PHASE TYPE
7)	21	1	1	1	2	0	10	102	104	0	0	0	0	0	0	3
8)	22	1	3	3	4	0	20	101	103	0	0	0	0	0	0	0
9)	23	1	5	5	6	0	24	105	106	107	108	0	0	0	0	55

								LINK	DATA							
							FIRST INPUT LINK....			SECOND INPUT LINK....			THIRD INPUT LINK....			QUEUE
.INE NO.	CARD TYPE	LINK NO.	LINK LENGTH	SAT. FLOW	TOTAL VOL.	MID-BLK. VOL.	NO.	VOL.	SPD/TT	NO.	VOL.	SPD/TT	NO.	VOL.	SPD/TT	CAP.
10)	28	101	400	3400	900	0	0	0	0	0	0	0	0	0	0	0
11)	28	102	400	1600	46	0	0	0	0	0	0	0	0	0	0	0
12)	28	103	766	3400	906	0	0	0	0	0	0	0	0	0	0	0
13)	28	104	766	1600	110	0	0	0	0	0	0	0	0	0	0	0
14)	28	105	200	3400	530	0	0	0	0	0	0	0	0	0	0	0
15)	28	106	200	950	49	0	0	0	0	0	0	0	0	0	0	0
16)	28	107	625	3400	334	0	0	0	0	0	0	0	0	0	0	0
17)	28	108	625	750	86	0	0	0	0	0	0	0	0	0	0	0

FIGURE 2. INPUT DATA REPORT--CARD TYPE 2X--TRANSYT-7FC

```
--------------------------------------
TRANSYT-7F SIGNAL CONTROLLER SETTINGS
--------------------------------------


-------------------------------
NETWORK-WIDE SIGNAL TIMING DATA
-------------------------------

SYSTEM CYCLE LENGTH =  120 SECONDS .

NO MASTER OFFSET REFERENCE CONTROLLER SPECIFIED

ALL OFFSETS ARE REFERENCED TO AN ARBITRARY TIME BASE.

NETWORK INCLUDES ACTUATED SIGNAL - GREEN TIMES ARE ESTIMATED.


--------------------------------
INTERSECTION CONTROLLER SETTINGS
--------------------------------


------------------------------
INTERSECTION    1 ACTUATED
------------------------------

INTERVAL  NUMBER :     1   2   3   4   5   6

INTVL LENGTH(SEC):    10   4  76   4  22   4

INTVL LENGTH  (%):     8   3  65   3  18   3

SPLITS      (SEC):    14      80      26

SPLITS        (%):    11      68      21

PIN SETTINGS  (%): 100/0   8  11  76  79  97

PHASE START (NO.):    1A       2      3A

INTERVAL   TYPE  :     V   Y   V   Y   V   Y


LINKS  MOVING  :     102     101     105
                     104     103     106
                                     107
                                     108

YIELD POINT =  16 SEC.  13 %; REFERENCED TO START OF INTERVAL NO.   4
```

A: ACTUATED PHASE

FIGURE 3. REVISED SIGNAL CONTROLLER TABLES--TRANSYT-7FC

INTERSECTION 3 ACTUATED

INTERVAL NUMBER :	1	2	3	4	5	6	7	8
INTVL LENGTH(SEC):	21	4	33	4	13M	4	37	4
INTVL LENGTH (%):	18	3	28	3	11	3	31	3
SPLITS (SEC):	25		37		17		41	
SPLITS (%):	21		31		14		34	
PIN SETTINGS (%):	100/0	18	21	49	52	63	66	97
PHASE START (NO.):	1A		2		3		4	
INTERVAL TYPE :	V	Y	V	Y	V	Y	V	Y
LINKS MOVING :	302 304		301 303		306 308		305 307	

YIELD POINT = 90 SEC. 75 %.

GREEN TIMES SET EQUAL TO MIN. GREENS.

FIGURE 4. SIGNAL CONTROLLER TABLES (PHASE MINIMUM)

REFERENCES

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APPENDIX A

COMPUTATIONAL METHODOLOGY

Actuated signals along arterials and on grid networks operate on a common background cycle length; synchronization is provided through the yield point, which is a fixed point in the cycle, normally at the end of the synchronization (sync) phase. The sync phase is non-actuated and has a minimum green time. The green times on the actuated phases, however, vary on each cycle between a minimum green and a maximum green time, depending on the arrival rate of vehicles and the value of the extension interval. Fixed force-off points in the background cycle are used to terminate the duration of the actuated phases. If an actuated phase terminates early then the extra green time is transferred to the next phase, and in many cases the sync phase receives the extra time.

TRANSYT is designed for pretimed signals. To simulate the operation of coordinated actuated signals the average phasing and green times should be first estimated. The phasing can be determined from traffic volume information and the average green times can be obtained from field measurements on the duration of the green times for a number of cycles. Field data collection, however, is expensive and time-consuming, since data should be collected for every time period that a plan is to be simulated. Therefore, TRANSYT has been modified to automatically estimate the average green times.

First, the average effective green time for each actuated phase is computed as follows:

$$g = \frac{VC}{S \cdot DS} \quad (1)$$

where:
C: Background cycle (sec)
V: Link Volume (vph)
S: Saturation Flow (vphg)
DS: Degree of Saturation (user specified--default 0.85)

Next, the average effective green time for the sync phase is computed as follows:

$$g_M = C - \sum_{i=1}^{n} g_i - L \quad (2)$$

APPENDIX B

REVISED INPUT CODING INSTRUCTIONS

TABLE G.4. CARD TYPE 2: OPTIMIZATION NODE LIST CARD

FIELD	COL.	VARIABLE NAME	DESCRIPTION	UNITS	RANGE	DEFAULT VALUE
1	5		"2"		2	REQ
2-16	10-80	NLIST(I)	Node numbers to be optimized. If two or more nodes are grouped, the secondary node number(s) must be negative and must immediately precede the primary node number (which has a positive number) in the list. Negative node numbers need not be negative in references to these nodes on later card types. Note: In a simulation run where the initial timings flag has been set to "1", this card contains the list of nodes eligible for initial timings. Note: If more than one cycle length is to be evaluated, all nodes must be included on Card Type 2, and there may be no grouped nodes. Note: In a simulation run with some actuated signals, this card contains the list of nodes eligible for estimated average timings.		(+)1-(+)9999	REQ for nodes to be optimized or for nodes where initial timings are requested (blank fields ignored)

TABLE G.9. CARD TYPE 10: NETWORK MASTER CARD

FIELD	COL.	VARIABLE NAME	DESCRIPTION	UNITS	RANGE	DEFAULT VALUE
1	5	—	"10"		10	REQ
2	10	MASTER	The node number of the system master controller. All offsets (or yield points) will be referenced to the start of Interval 1 on this controller.		1-9999	No intersection master
3	15	IYELOW	A network-wide yellow change interval length. Applies only when Field 11 on Card Type 1 has been coded as "1".	sec	1-10	4
4	20	IARED	A network-wide all-red clearance interval length. Applies only when field 11 on Card Type 1 has been coded as "1".	sec	1-10	1
5	25	INSATF	A network-wide saturation flow rate.	vphg/lane	1000-2000	1,700
6	30	VEXT	A network-wide approach speed for external links.	mph, km/hr	5-60 mph 8-97 km/hr	30 mph 48 km/hr
7	35	MPDF	A network-wide Platoon Dispersion Factor, given as the factor times 100.		1-100	35
8	40	FFACT	A scalar multiplier to adjust the fuel consumption estimate, expressed as a number times 100.		50-200	100
9	45	VEHLEN	An average vehicle spacing used in the calculation of queue capacity.	ft, m	15-50 ft. 45-150 m	25 ft 78 m
10	50	ORIENT	The orientation flag (applies to "primary" orientation). 0 = not specified 2 = southbound 1 = northbound 3 = eastbound 4 = westbound		0-4	0
11	55	IDSAT	Default degree of saturation for actuated phases	percent	50-100	85%
12-16	60-80	—	Not used.			

TABLE G.12. CARD TYPE 2X: PHASE TIMING CARD

FIELD	COL.	VARIABLE NAME	DESCRIPTION	UNITS	RANGE	DEFAULT VALUE
1	5	IPHASE	"2X" (X = phase number). The 2X cards must be in ascending order.		21-27	REQ
2	10	NLIST(I)	Node number.		1-9999	REQ
3	15	ISTIN(I,J)	Interval number which starts the green for this phase.		1-(n-1)*	REQ
4	20	IVARIN(I,J)	Variable interval number for this phase.		1-(n-1)	ISTIN(I,j)
5	25	ICLIN(I,J)	Yellow interval number for this phase.		2-n	REQ
6	30	IREDIN(I,J)	All-red interval number for this phase, if one exists.		2-n	no interval
7	35	LMIN(I)	Minimum phase duration (includes yellow and all-red).	sec	see text	REQ
8-15	40-75	LNUM(I)	Numbers of the links which receive green in this phase. A negative link number indicates a permitted (i.e., opposed) movement.		(±)1-(±)9999	no link
16	80	FLAG IPACT NASAT	Continuation/Actuated Hybrid Flag: 0 = no continuation card/non-actuated phase. 1 = continuation card follows/non-actuated phase. 3 = (no continuation flag necessary)/actuated phase. 50-100 = (no continuation flag necessary)/actuated phase Note: If the node is single phase, leave fields 3-7 blank. Note: A maximum of 10 links may move in each phase except for single phase nodes, where a maximum of 50 links may move in the one "phase". *n = number of intervals indicated by Card Type(s) 1X/18.	none or percent	0,1,3,or 50-100	0

APPENDIX -H-

WESTBOUND THRU LINK
TRAVEL TIME COMPARISONS

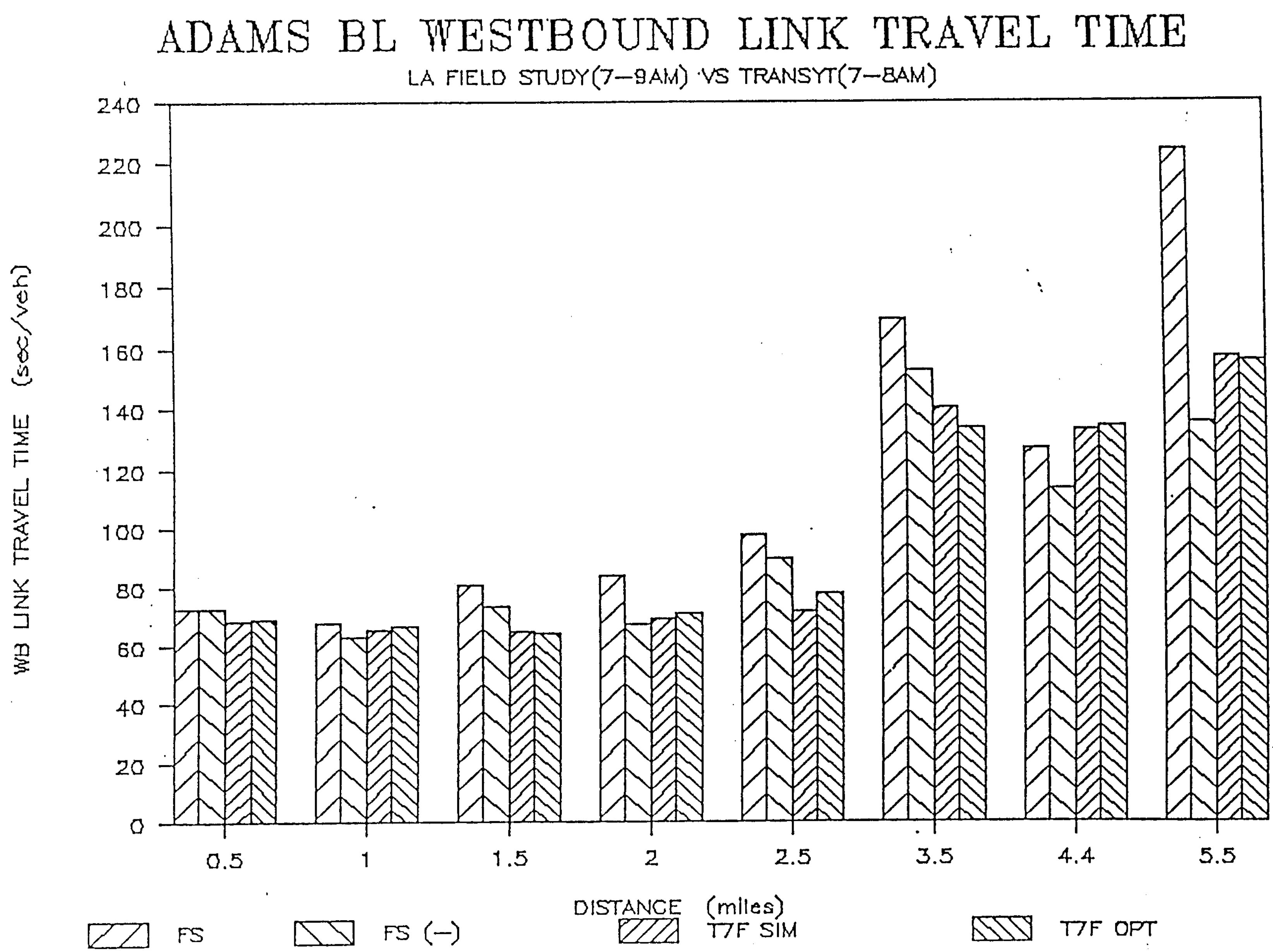

ADAMS BL WESTBOUND LINK TRAVEL TIME
LA FIELD STUDY(7—9AM) VS TRANSYT(7—8AM)
WB LINK TRAVEL TIME (sec/veh)
240
220
200
180
160
140
120
100
80
60
40
20
0
0.5
1
1.5
2
2.5
3.5
4.4
5.5
DISTANCE (miles)
FS
FS (—)
T7F SIM
T7F OPT

FIGURE H-1

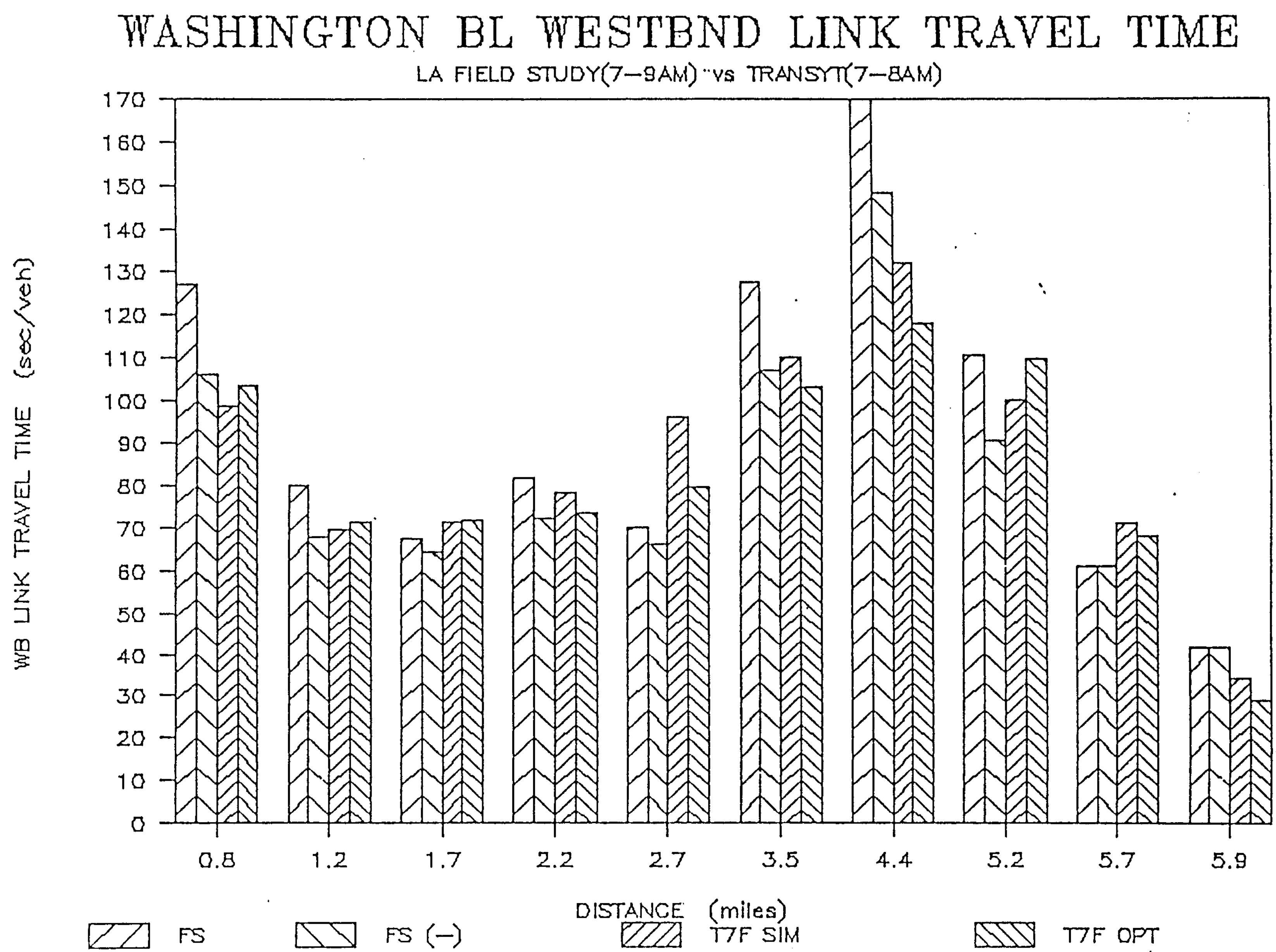

WASHINGTON BL WESTBND LINK TRAVEL TIME
LA FIELD STUDY(7—9AM) vs TRANSYT(7—8AM)
WB LINK TRAVEL TIME (sec/veh)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0.8
1.2
1.7
2.2
2.7
3.5
4.4
5.2
5.7
5.9
DISTANCE (miles)
FS
FS (—)
T7F SIM
T7F OPT

FIGURE H-2

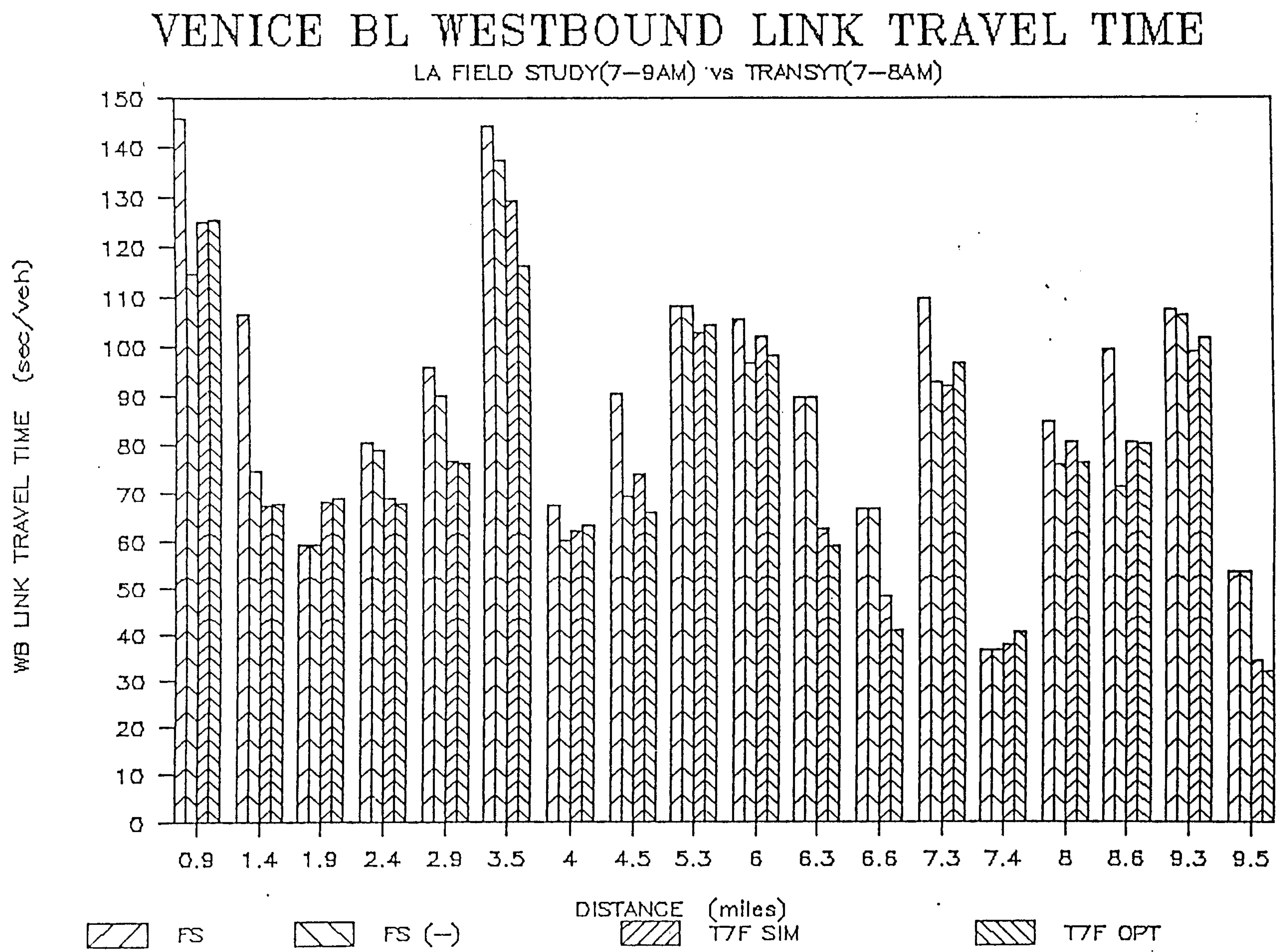
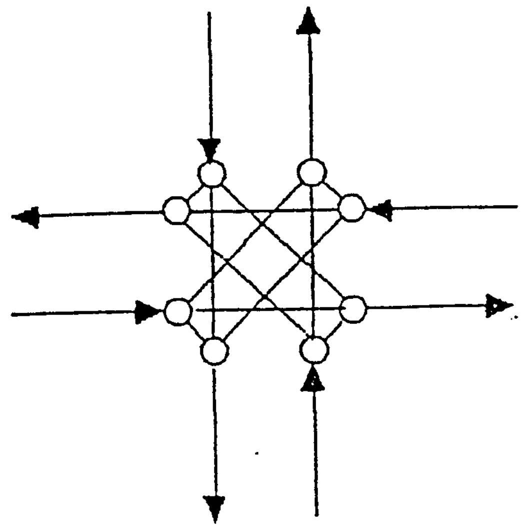

VENICE BL WESTBOUND LINK TRAVEL TIME
LA FIELD STUDY(7—9AM) vs TRANSYT(7—8AM)
WB LINK TRAVEL TIME (sec/veh)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0.9
1.4
1.9
2.4
2.9
3.5
4
4.5
5.3
6
6.3
6.6
7.3
7.4
8
8.6
9.3
9.5
DISTANCE (miles)
FS
FS (—)
T7F SIM
T7F OPT

FIGURE H-3

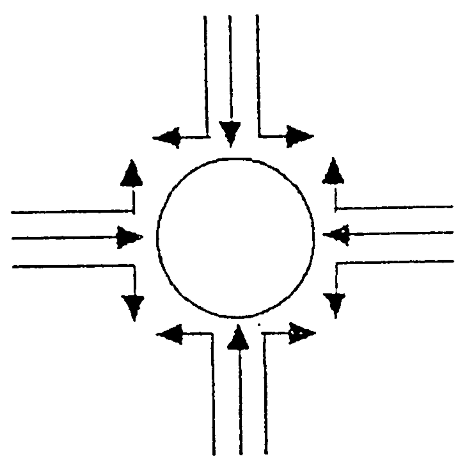
APPENDIX -I-

PATHNET AND TRANSYT
INTERSECTION REPRESENTATIONS



PATHNET INTERSECTION REPRESENTATION

FIGURE I-1



TRANSYT INTERSECTION REPRESENTATION

FIGURE I-2

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