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Model Selection And Initial Application Of CONTRAM Model For Evaluating In-vehicle Information Systems

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

BACKGROUND

The preliminary evaluation of the potential benefits of in-vehicle information systems was conducted by an Institute of Transportation Studies research team in 1988 and 1989 using the computer programs, FREQ and TRANSYT to model the Smart Corridor in Los Angeles, California. Out of that study came recommendations for future research on the need for more realistic simulation of the interaction between the freeway and parallel arterials. A study was conducted in 1990 to assess which models were suitable to evaluate in-vehicle information systems within an integrated freeway/arterial corridor. Twenty-four models were identified as being potentially suitable. Of the 24 models identified, three were recommended for further analysis and application: CONTRAM, SATURN, and INTEGRATION.

OBJECTIVES

The objectives of this study were to select a traffic assignment and simulation model, apply that model to an integrated freeway/arterial network such as the Smart Corridor in Los Angeles, California, and, using the model, make an initial evaluation of in-vehicle information systems and the applicability of the model.

APPROACH

The approach consisted of first evaluating of the CONTRAM, SATURN, and INTEGRATION models and then selecting of one of the models for a detailed analysis of the features which would be best suited to this particular application. The next step was an initial application of the selected model to a generic network and then the Smart Corridor. The final steps in the study were to make an assessment of the model, present major findings of the study, and describe the potential for future research.

RESULTS

After review of the CONTRAM, SATURN, and INTEGRATION models, the CONTRAM model was chosen for further evaluation. Since the CONTRAM model was primarily developed for use in the design of traffic management schemes for urban signalized arterial networks, further analysis into the models ability to model freeway congestion was necessary. In order to gain a more clear understanding of the freeway modelling characteristics within CONTRAM, several test networks were designed and evaluated and as a result problems were discovered regarding the ability of the model to accurately reflect freeway congestion. However, an analysis ensued to evaluate the potential benefits of in-vehicle information systems. The results of the study should be viewed with some caution due to difficulties with the freeway modelling characteristics of CONTRAM, as well as weaknesses within the characteristics of the network and structure of the demand pattern. The results are best considered in a qualitative manner with the findings being, the more vehicles that are equipped with in-vehicle information, the better the system performance. For a severe incident condition on the freeway, as the percentage of vehicles equipped with information increases, the performance of the system improves until the system is at a level of performance that is only slightly less than that before the incident occurred.

1.0 INTRODUCTION

This report describes the results of the study team's efforts to:

1) select a traffic assignment and simulation model;

2) apply that model to an integrated freeway/arterial network such as the Smart Corridor in Los Angeles, California; and,

3) using the model, make an initial evaluation of in-vehicle information systems and the applicability of the model.

1.1 Background

As traffic congestion increases worldwide, attempts are being made at improving the efficiency of the existing systems through the use of information available through computers. Past research has indicated that up to $45 billion per year is lost due to excess travel time which could be recovered if there was a more efficient transportation system that used navigational systems [1].

Several researchers have attempted to make a quantitative assessment of in-vehicle information systems [2]. Most previous studies have been network specific, i.e., the benefits of in-vehicle information systems were related only to the network in question. This holds true for this particular application as well. For this study, the integrated freeway/arterial network chosen for modelling was the Smart Corridor in Los Angeles, California.

1.2 Purpose

The purpose of this study was to select an appropriate traffic assignment and simulation to evaluate in-vehicle information systems. After the appropriate model was selected, an initial application to the Smart Corridor was conducted and a second and third application were undertaken to simulate an incident on the freeway. Varied percentages of in-vehicle information systems were then modelled which permitted an initial evaluation of the applicability of the model.

1.3 Scope and Study Approach

Based on previous research (Al-Deek, Martello, Sanders and May [3]), it was determined that an equilibrium model combining traffic simulation, control, and assignment was desirable for evaluating the potential benefits of in-vehicle information systems in an integrated freeway/arterial corridor. Thus, a study was begun to evaluate the models available for the task of evaluating in-vehicle information systems. This project is an extension of the original work by May in 1986 [3].

Chapter 2 of this report outlines the history and background of this and previous studies. Chapter 3 describes the evaluation of the CONTRAM, SATURN, and INTEGRATION models. Chapter 4 discusses in more detail the features in CONTRAM that were best suited for application in this study. Chapter 5 describes the Smart Corridor and the features that made it particularly attractive to be used in the modelling process. Chapter 6 describes the initial applications of the CONTRAM model to both a generic freeway segment, and the freeway segment to be used in the entire corridor. Chapter 7 outlines the design of the experiment and how a reference-base-run assignment was derived. Chapter 8 gives a description of incident modelling within CONTRAM. Chapter 9 presents the analysis findings and results, while Chapter 10 summarizes an assessment of the model and the modelling effort and discusses the potential for future research.

2.0 PREVIOUS RESEARCH

Since the early 1980's much research has been conducted in the area of in-vehicle information systems **[4 - 9].** One of the primary objectives of much of this research has been to provide a quantitative assessment of in-vehicle information value in a real-world freeway corridor under recurring and non-recurring congestion.

2.1 1987-1989

The history of this study dates back to 1987. PATH Research Report UCB-ITS-PRR-88-2[3] details the initial attempts at understanding ***the Potential Benefits of In-Vehicle Information Systems in a Real Life Freeway Corridor under Recurring and Incident-Induced Congestion.*** This initial attempt was conducted using the simulation models FREQ and TRANSYT-7F. The Santa Monica freeway corridor was simulated based on data collected by the Los Angeles Department of Transportation and Caltrans from 1984 to 1988.

Since TRANSYT-7F and FREQ do not perform traffic assignment, a network model was developed called 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. PATHNET is a prototype version of a generalized network analysis package. PATHNET prints a report listing the links in the minimum-cost path and the cumulative route cost for each link. Thus, the research team was able to assess the potential benefits by comparing travel times between different origin and destination pairs under different scenarios.

The results of the study were as follows [3,10-11]:

- under the recurring, non-incident congestion scenario, the travel time savings were generally negligible (less than three minutes for a 20-25 minute trip);
- under the non-recurring, incident congestion scenario, travel time savings were found to be significant (greater than three minutes);
- the greatest travel time savings occur during the time slices following the introduction of a freeway incident.

One recognized weakness with the earlier study was the fact that the user equilibrium issue was not addressed. To address this weakness, a traffic assignment model which combines traffic assignment with simulation was chosen as the tool for evaluation which achieves user equilibrium through each assignment. Thus, the first objective of this study was to find a model that could model an integrated freeway/arterial network and also combine traffic assignment with simulation.

2.2 1989-1990 RESEARCH

The 1989-1990 research focused on the modelling approaches for evaluating advanced traffic control strategies and in-vehicle information systems within an integrated network of traffic signals and freeways. Efforts included a literature review of candidate freeway/arterial models. An assessment of model suitability was carried out in order to determine if any existing model would be potentially suitable, the specific modifications needed to be included in a reasonable level of effort, or the specifications that would be required for developing a new model.

The approach consisted of a literature review and preliminary assessment of candidate models, an in-depth evaluation of the most promising models, and the selection of a few models for further analysis and testing. The literature review resulted in the identification of twenty-four candidate models, classified into four categories:

1) Transportation planning models: MINUTP, Tmodel, TRANPLAN, CARS, MICROTRIPS, EMME2, MULATM;

2) Freeway operation models: FREQ, INTRAS, MACK-FREFLO-FRECON, KRONOS, FREESIM, ROADRUNNER;

3) Signalized network operation models: TRAFFICQ, MICRO-ASSIGNMENT, SATURN, CONTRAM, JAM;

4) Freeway/arterial operation models: CORQ1C, SCOT, TRAFLO, DYNEV, CORQ-CORCON, INTEGRATION.

A preliminary screening process (summarized in Table 2.1) indicated that only five of the models chosen were capable of simultaneously performing traffic assignment and traffic simulation under oversaturated conditions, which were considered as two essential features for the purposes of this study. For three of these models (INTEGRATION, SATURN and CONTRAM), an in-depth evaluation was carried out, including tabular summaries of the characteristics of each model, rating of the performance of each model and the corresponding strengths and weaknesses, and a discussion on model suitability with regard to our application. A final report describing the 1989/1990 activities was published in June 1990 [12]. It was

TABLE 2.1
PRELIMINARY SCREENING PROCESS

MODEL	OPERATING ENVIRONMENT			TRAFFIC ASSIGNMENT	QUEUING CONDITIONS
	Freeway	Corridor	Arterial		
1) CARS	x	P	P	x	
2) EMME2	x			x	
3) MICROTRIPS	x			x	
4) MINUTP	x			x	
5) MULATM	P	P	P	x	P
6) TMODEL	x	P	P	x	
7) TRANPLAN	x			x	
8) FREESIM	x				
9) FREQ	x	P		P	x
10) INTRAS	x	P	P		
11) KRONOS	x				x
12) MACK-FREFLO	x				x
FRECON2	x	x	P		x
13) ROADRUNNER	x				
14) CONTRAM	P	P	x	x	x
15) JAM	P	P	x	x	x
16) MICRO-ASSIGNMENT			x	x	P
17) SATURN	P	P	x	x	x
18) TRAFFICQ			x		x
19) CORQ1C	x	x	x	x	P
20) CORQ-CORCON	x	x	x	x	x
21) DYNEV	x	x	x	x	
22) INTEGRATION	x	x	x	x	x
23) SCOT	x	x	x	x	
24) TRAFLO	x	x	x	x	

x: Existing P: Partially Existing

recommended that the three selected models be acquired in order to perform a hands-on experiment and assessment.

3.0 MODEL EVALUATION

The main features of the CONTRAM, SATURN and INTEGRATION models are highlighted in this chapter and a demonstration of SATURN and CONTRAM is described.

3.1 CONTRAM

CONTRAM is a traffic assignment model developed by the Transport and Road Research Laboratory for use in the design of traffic management schemes in urban areas. CONTRAM5 (Continuous Traffic Assignment model Version 5) is the latest version of the CONTRAM program which was originally written in the early 1970s. Given the traffic demands between origins and destinations for a network, it predicts routes of vehicles and flows and queues on links. It is a capacity restrained model which takes account of the interactive effects of traffic between intersections and the variation through time of traffic conditions. In particular, CONTRAM models the build up and decay of congestion such as occurs during peak periods.

3.1.1 Basic Structure [13]

The overall structure and suite of programs in CONTRAM is outlined in Figure 3.1. The inputs are the network data, the traffic demand data, and the control data. The bases of the program are the assignment process, which calculates and stores vehicle route information, and the calculation through time of the delays on links derived from the flows and queues of vehicles.

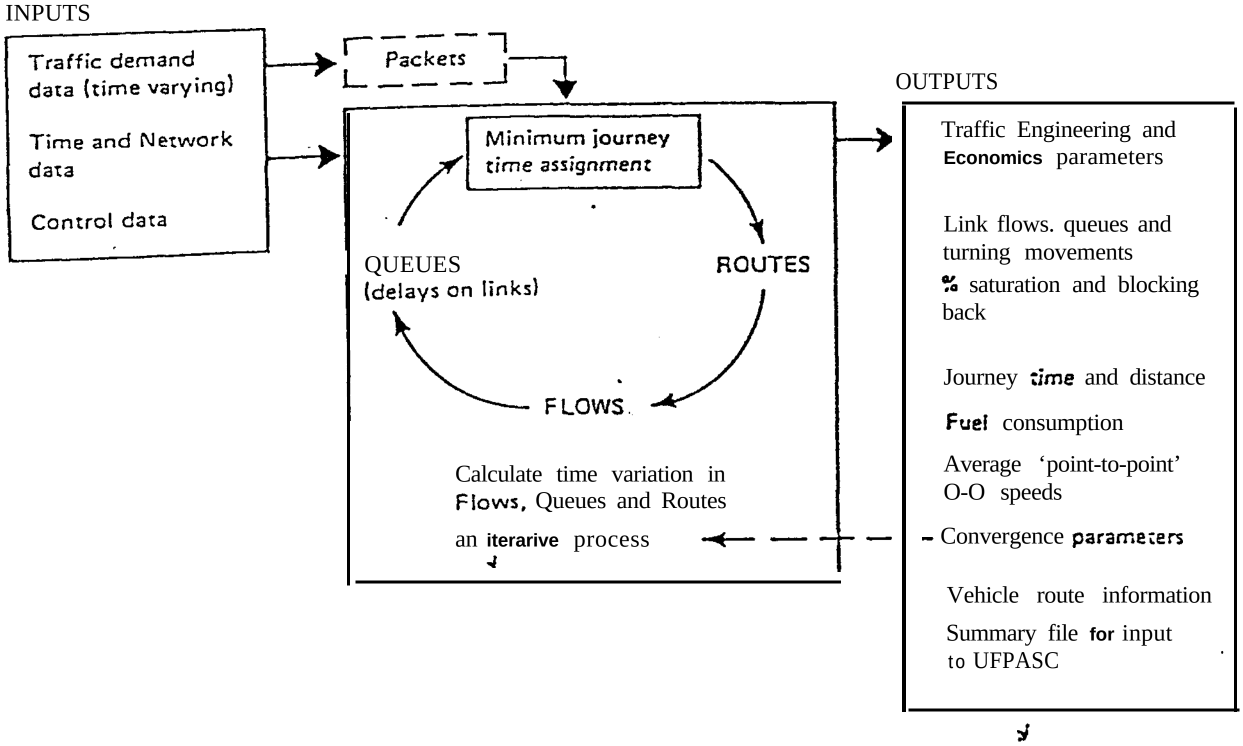
3.1.2 Input Data Requirements [13]

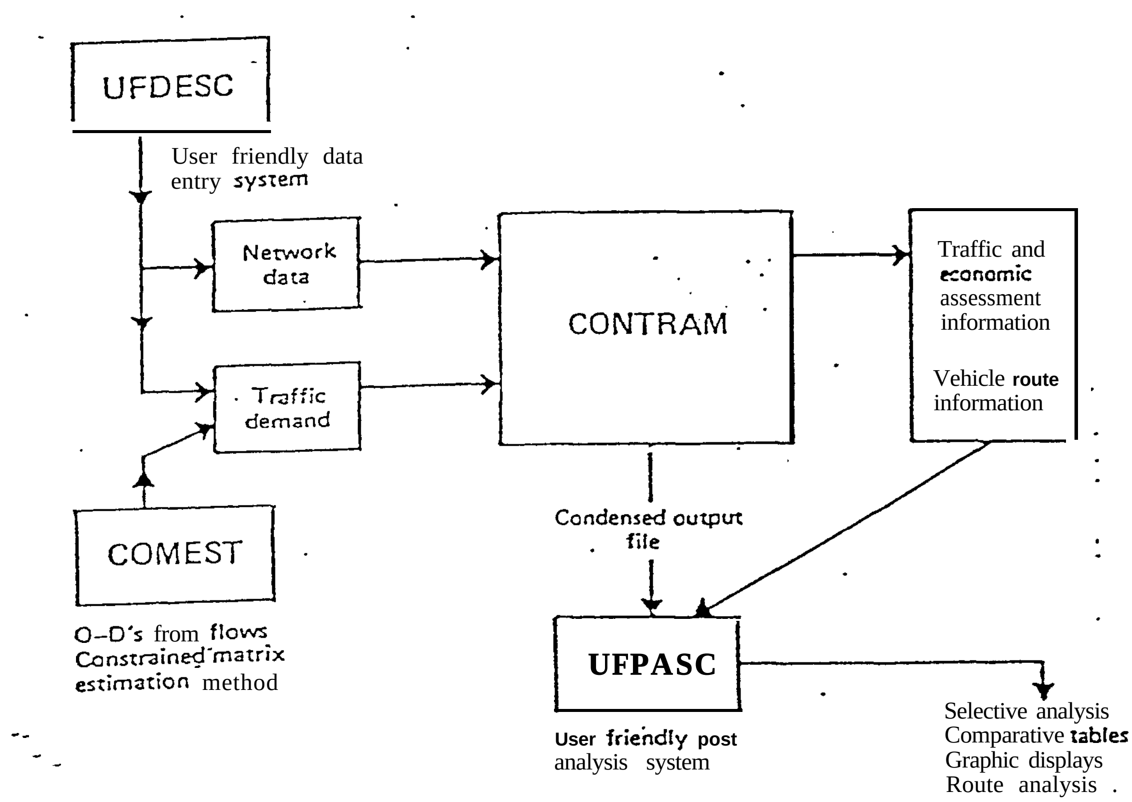
The three major components of input to the model are the network and time data, the demand data, and the control data. The following pages outline the characteristics of these three areas.

3.1.2.1 Network and Time Data

This defines the period to be simulated and the geometric properties of the network. The following provides a description of the basic card types used in the CONTRAM model.

FIGURE 3.1
OVERALL STRUCTURE OF CONTRAM
& SUITE OF PROGRAMS





Card type 1 is the time card which defines the duration of the simulation period and the time intervals into which the period is divided. The maximum number of time intervals is 13 while the maximum duration of a simulation period is eight hours.

Card type 2 defines the general parameters of the network. It sets the values of certain network parameters used for the estimation of storage capacity on a link, to specify signal lost time for capacity calculations and to select the separate calculation of geometric delay at intersections.

Card type 3 defines the links to which an origin is connected.

Card types 4, 5, and 6 define the type of control used at link junctions. Card type 4 represents an uncontrolled link. It gives detail required for an uncontrolled link: cruise time (or cruise speed, or speed-flow relationship to be used), length, saturation flow, storage capacity. Card type 5 represents give-way links. Card type 6 represents signal-controlled links and has the same basic requirements as card type 4 plus percentage green and delay factors.

Card type 7 defines the speed-flow relationships. Speed/flow relationships have been incorporated to be used on roads where cruise time is a significant proportion of total time, e.g. on urban freeways and other limited-access high speed urban roads. The effect of a speed/flow relationship is in addition to explicit queuing at the downstream end of the link to which it applies. The general form of speed/flow relationships used by CONTRAM consists of two linear sections of different slope. The exact form is determined by entering as data three points:

1) the free speed, where flow is zero
2) the break point, where the slope changes
3) the capacity point, which is a point through which the second section passes.

Card type 8 is the change of mind card, which allows the user to vary values of a parameter without changing the original data cards.

Card type 9 defines the vehicle classes used in the simulation. The card specifies passenger car unit equivalents and relative cruise times for each vehicle type. The model distinguishes three classes of vehicle, car, bus, and trucks.

Card type 10 defines the coefficients of the fuel model, which is based on the following formula for fuel consumption per unit distance at steady speed V:

$$F = A + (B / V) + (C * V^2)$$

Card types 11 and 12 allow the saturation flow value on a link to be varied from time interval to time interval, for example to allow the effect of an accident to be simulated.

Card type 13 allows the calculation of a geometric delay due to deceleration and acceleration at an intersection. CONTRAM 5 provides the option to calculate the geometric delay explicitly for each separate turning movement.

Card types 14, 15 and 16 set the speeds for turning movements out of individual links.

Card type 18 defines the range of allowed destination numbers.

3.1.2.2 Traffic Demand Data

The traffic demand data specifies the flow rate during each time interval for each origin-destination movement. The traffic demand for each origin-destination movement in a network is specified as a series of flow rates (veh/h) for each time interval. For a given O-D pair, one data card is used for each classified vehicle demand (C, B or L). The card also contains:

- the packet size, which can be generated automatically;
- the "straight-line" distance between the origin and destination (optional);
- the start-code (time of start of the first packet from the O-D demand to enter the network in the first time interval).

It is possible to model the movements of more than one demand for the same class of vehicle, between the same origin and destination, by using separate cards, or the change of mind card. The change of mind cards can be used to change specified flow rates.

3.1.2.3 **Control Data**

The data in the control data pack has two control functions. The first, describing the running of the program, defines the number of iterations to be carried out and the types of output required. The second provides the additional data required for signalized intersections. The data required for vehicles with fixed routes are also specified in this pack.

- Card type 50: Maximum number of iterations

Selection of outputs:

- Card type 51: Network summary information for assessing convergence
- Card type 52: Change in vehicle arrivals - convergence matrix
- Card type 53: Link-by-link data - all parameters
- Card type 54: Link-by-link values - flows, queues, queue times, average speeds
- Card type 55: Measure of fairness
- Card types 56 and 57: Output of turning movements
- Card type 58: Alternative units of measurement
- Card type 59: Alternative file units for results
- Card type 60: Control of algorithms (used to select variable or constant packet size)
- Card type 154: Selection of tables in output

Cost parameters are specified by the following card types:

- Card type 61: Perceived cost output units
- Card type 62: Perceived cost functions
- Card types 63 and 64: Resource cost functions

The perceived cost is the cost that is perceived by drivers which they seek to minimize by their route choice. The resource cost is assumed to represent the real cost of travel and in CONTRAM, is purely an output quantity which has no effect on route choice. In CONTRAM, the functional form of both perceived and resource cost is $C = Ad + Bt + Cv^2*d$ which expresses cost C in terms of distance d, time t and average speed v.

Additional signal data can be specified by the following card types:

- Card type 70: Common signal coordination factor
- Card type 71: Signal plans - fixed cycle/fixed splits
- Card type 72: Signal plans - fixed cycle/optimized splits
- Card type 73: Signal plans - optimized cycle/optimized splits
- Card type 77: Intersection signal plans schedule

Fixed route data can be specified by the following card types:

- Card type 81: Specification of fixed routes
- Card type 85: O-D movements having fixed routes

3.1.3 outputs [13]

There are six forms of output, any selection of which can be called by the appropriate card types 51 to **56.**

3.1.3.1 Summary Information

The data provided for each time-slice are as follows:

- Total Journey-time (veh.h)
- Total Distance Travelled (veh.kms)
- Overall Network Speed (km/h)
- Total Final Queues (veh)
- Fuel Consumption (litres)
- Total Link Counts (veh)

3.1.3.2 Convergence Monitor

The purpose of these printouts is to provide data for assessing convergence. The convergence indicators are, for all iterations, the total journey-time, the total distance travelled, and the changes in initial queues plus arrivals on links.

3.1.3.3 Link-by-Link Values (All Parameters)

These data contain, for each time slice, the values of the following parameters:

- Link entry flow (veh);
- Mean initial queue (veh): number of vehicles queuing on the link at the start of the time slice;
- Vehicle arrivals (veh): number of vehicles in each class reaching the stopline on the link in the time slice;
- Departures from queue (veh): number of vehicles which leave the link in the time slice;
- Mean final queue (veh): number of vehicle queuing on the link at the end of the time slice;
- Spare throughput capacity (veh): difference between the maximum throughput capacity of the link and the number of vehicles which leave the link in the time slice;
- Mean PCU factor (Passenger Car Units);

- **Rho** = ratio of arrivals to capacity at stop line, to be used in place of degree of saturation;
- Mean total and queue time per vehicle (secs);
- Total delays **by** source (free moving, flow-delay or queuing) (veh.h);
- Percentage of occupancy;
- Measure of the number of stops, as a percentage of arrivals;
- An estimate of the efficiency of signal coordination.

The following information is necessary for signal controlled links:

- Plan type
- Cycle time (secs)
- Green time (secs)

The following network totals for each time interval are printed out:

- Total times by vehicle class (veh.h)
- Total distances travelled (veh.km)
- Total fuel consumption (litres)

3.1.3.4 Link-by-Link All Intervals Tables

The following lists the tables that can be output for each time slice:

- Arrivals (veh/h)
- Capacities (veh/h)
- Mean final queues (veh)
- Mean queuing times per vehicle (sec)
- Mean travel times per vehicle (sec)
- Total delay (veh-hr)
- Average speed of a car (km/h)
- Generalized costs

3.1.3.5 Point to Point Speeds

This output indicates the variation with time of the average straight-line speed (km/h) for selected O-D movements.

3.1.3.6 Turning Movements: For Selected Intersections or For All Links

These data provide detailed information for all time slices of turning movements. The first form of this option is intersection-oriented and contains additional information on flows, signal timings, final queues, and mean queue time for the links feeding the intersection. The second form provides turning movements from all links without any additional information.

3.1.4 Demonstration [14]

3.1.4.1 Test Network

The test network shown on Figure 3.2 has been designed to demonstrate the use of the facilities in CONTRAM [14].

3.1.4.2 Input Data Files

TEST.NET (Appendix A): Network and Time Data
TEST.DEM (Appendix A): Traffic Demand Data
TEST.CON (Appendix A): Control Data

3.1.4.3 Running the Program

The main executable program is called CONTRAM7.EXE. The command CONTRAM7 TEST is used to run the program with the TEST data files.

3.1.4.4 output

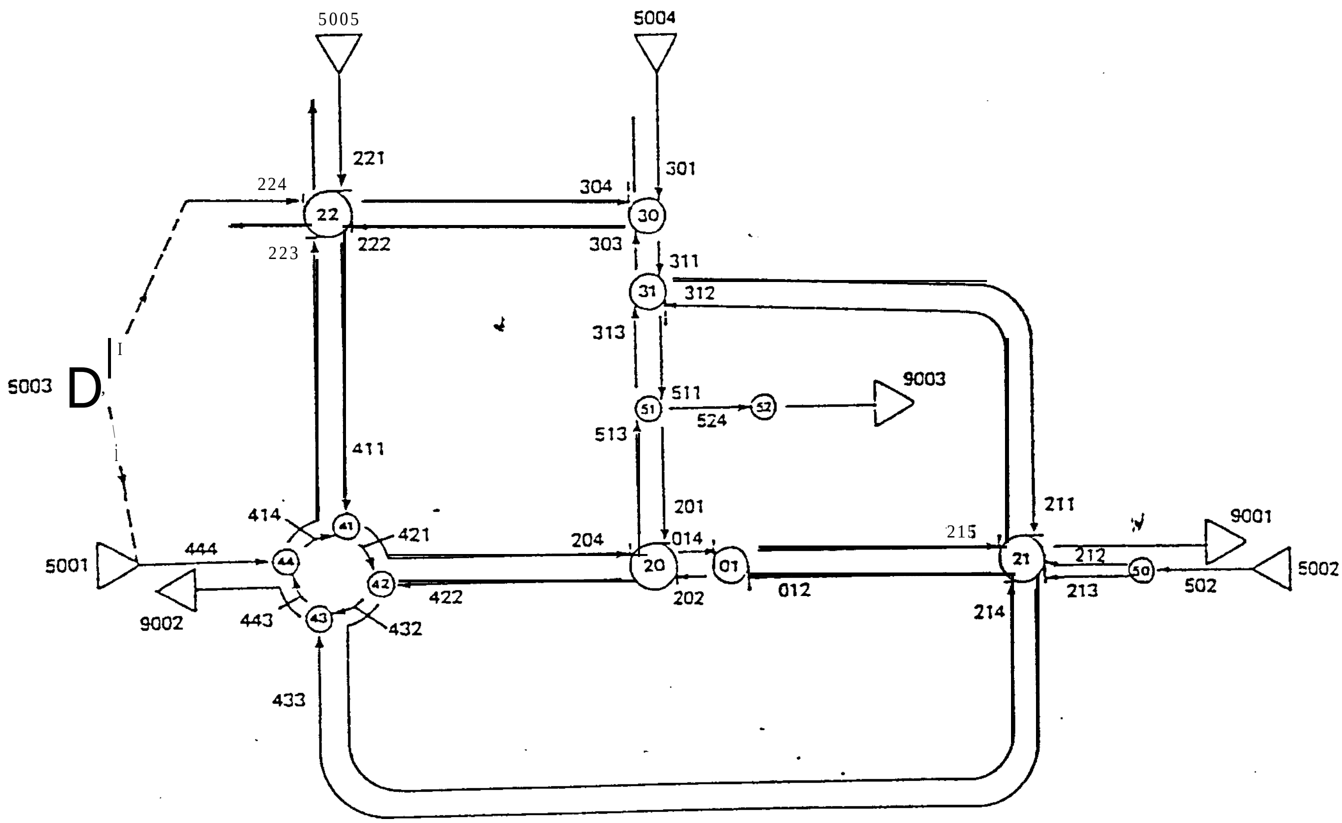
Three output files are created:

1) TEST.RES (Appendix A): Normal Results file (printer file)
2) TEST.RTE (Appendix A): Vehicle Route file (detailed information for each packet path)
3) TEST.PAF: Post Analysis Output File

- Demonstration of UFPASC (User Friendly Post Analysis System for Contram)

Input: TEST.PAF Post Analysis file
TEST.RTE Vehicle Route file

FIGURE 3.2
CONTRAM TEST NETWORK



Output: OUTPUT1 (Appendix A)

- Demonstration of UFDESC5 (User Friendly Data Entry System for Contram)

Input: TEST.NET or TEST.DEM or TEST.CON

- Demonstration of COMEST (Constrained O-D Matrix Estimation)

Input: X2.OBS Observed link counts
X2.RTE Assigned routes and flows in CONTRAM type packet route format
X2.CON Control file

Output: X2.RES Results file

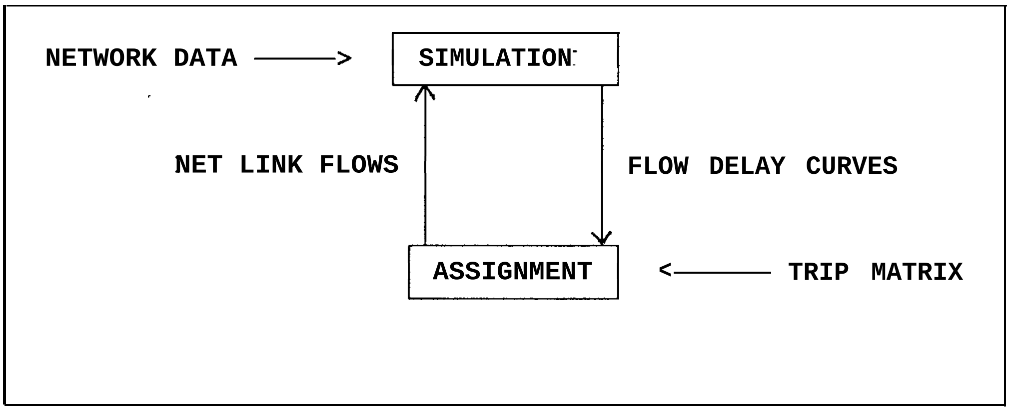
3.2 SATURN

SATURN (Simulation and Assignment of Traffic to Urban Road Networks) is a computer model developed at the Institute for Transportation Studies, University of Leeds, for the analysis and evaluation of traffic management schemes over relatively localized networks (typically of the order of 100 to 150 intersections) [15]. It is primarily intended to be used as a highly sophisticated traffic assignment model. This sophistication is due to a highly detailed simulation of delays at intersections. Unlike conventional assignment models, SATURN places great emphasis on intersections and specific turning movements as opposed to links.

3.2.1 Basic Structure

The basic structure of SATURN incorporates two phases, as shown in Figure 3.3, a simulation and an assignment phase [15].

Figure 3.3
The Simulation and Assignment Phases of SATURN



3.2.1.1 The Simulation Model [15]

The primary objective of the simulation is to determine intersection delays resulting from a given pattern of traftic. Two fundamental assumptions are made to do this:

1) A traffic pattern is constant for time periods of 15 or 30 minutes;
2) A cyclical behavior is imposed on the flows by traffic signals operating with a common cycle time of typically 60 to 120 seconds.

The first assumption restricts analysis to the average behavior of the system within the given time period. However, a quasi-dynamic analysis of traffic patterns may be carried out by modelling a series of successive 15 or 30 minute time periods. By changing the trip matrices for each time period, one can follow, for instance, the growth and decay of traffic over a morning or evening peak period.

The second assumption permits concentration of the simulation effort on one cycle, where traffic is represented as semi-continuous flow profiles, as opposed to individual vehicles or packets of vehicles.

3.2.1.2 The Assignment Model [15]

The simulation model is used to model the flow-delay curves by calculating the delays for each turning movement at zero flow, current flow and capacity, with all other flows (i.e. opposing traffic) fixed.

The model assumes that:

1) the travel time of each link is fixed independent of flow
2) the delay of each turning movement at an intersection is a function of that turning volume.

The flow-delay curves determined by the simulation are fed to the assignment. The objective of the assignment phase is to select minimum time routes through the network for each element in the trip matrix. The model uses an equilibrium technique which optimally combines a succession of all-or-nothing assignments.

3.2.1.3 The Complete Model [15]

As shown in Figure 3.3, the complete mode1 is based on an iterative loop between the assignment and simulation phases. Although described as two separate phases, SATURN appears as a single program for the user. The simulation and assignment stages can be run automatically without user intervention until either convergence has been achieved or a specified number of iterations performed.

3.2.2 Input Data Requirements [15]

Two distinct forms of data input are required. The first is an O/D trip matrix representing the period of interest, or a set of trip matrices. The second is network data.

3.2.2.1 Trip Matrices

The O/D trip matrix is conventional in most respects, but a very fine zoning system is often required in order to perform detailed modelling. The accuracy of the assigned flows will depend critically on the validity of that matrix. The traditional techniques to gather a O/D matrix are direct observations, such as roadside interviews or license plate surveys. However, these techniques are expensive in terms of manpower and data processing, as well as being subject to errors.

To overcome these problems, at least partially, SATURN makes use of a technique which was also developed at the Institute for Transportation Studies, known as ME2. The technique is based on the principles on entropy maximization; in essence, ME2 calculates the most likely trip matrix consistent with all the available information, which may be, in the simplest case, a limited number of traffic counts. Since link counts, as opposed to O/D trips, can be obtained quickly, cheaply and accurately, the method is extremely attractive. ME2 has been an essential component in virtually every application of SATURN to date.

3.2.2.2 Network Data

As usual, the road network is described graphically as a set of nodes and connecting links. SATURN allows networks to be coded at two levels of detail:

1) an "inner" or "simulation" network which is coded and simulated in detail, restricted to 100-150 intersections; and

2) an "outer" or "buffer" network coded in much less detail, in a conventional link-based detail.

Since **SATURN** assumes that virtually all delays to traffic occur at intersection, the simulation network coding is primarily intersection-based. The user is required to supply for each intersection:

1) A node type (basically signals, priority or roundabout);
2) The travel distances and times (or speeds) from the previous intersection for each entry arm;
3) The number of lanes on each entry arm;
4) For each permitted turn, the lanes used and the saturation flow;
5) Information on whether one stream of traffic takes priority over any other;
6) The phase structure of all traffic signals (cycle times, offsets, green splits between different turns, etc.).

3.2.3 Outputs [15]

3.2.3.1 Assignment Stage

Outputs from **the SATURN** assignment stage are essentially conventional, e.g. flows and travel times for both links and turns plus various aggregate measures such as average speeds, total vehicle-kilometers, interzonal travel times, etc.

3.2.3.2 Simulation Stage

Mostly intersection-based, the information provided by the simulation phase is far more detailed. It includes:

1) Capacities, average delays, and average queues for each individual turn;
2) Cyclical flow profiles, as in TRANSYT;
3) The rate of growth of any permanent queues at over-capacity intersections;
4) Estimates of the number of vehicle stops at each intersection (these estimates are used in estimates of fuel consumption);
5) Separate performance measures for buses.

One of the basic programs which comes with the SATURN suite, **SATLOOK,** allows the user to look directly at delays, queues, etc., at a selected intersection, as opposed to having all possible data output to the line printer following each run.

3.2.4 Demonstration **[16]**

The basic model has six components:

- **SATNET:** Network Build Program
- SATASS: Assignment Program
- SATSIM: Simulation Program
- **SATLOOK:** Analysis Program
- SATED: Network Editing Program
- **P1:** Network Plot Program

The demonstration was made in the following way:

1) Build the trip matrix
   Command: **Ml LIVTRIPS**
   Printer Output: **LIVTRIPS.LPM** (Appendix B)
2) Build the network
   Command: **SATNET LIVNET**
   Printer Output: **LIVNET. LPN** (Appendix B)
3) Run first assignment
   Command: **SATASS LIVNET LIVTRIPS**
   Printer Output: **LIVNET.LPA** (Appendix B)
4) Run first simulation
   Command: **SATSIM LIVNET LIVNET1**
   Printer Output: **LIVNET1.LPS** (Appendix B)
5) Run second assignment
   Command: **SATASS LIVNET1 LIVTRIPS**
   Printer Output: **LIVNET1.LPA**

The process may then be repeated to convergence.

3.2.5 References

The following applications have been reported:

- Harrogate, North Yorkshire, England [17]
1980, 45 nodes, 24 zones
Ref: Traffic Engineering & Control, April 1980

- Liverpool, England [18]
1982, 818 nodes, 106 zones
Ref: Traffic Engineering & Control, January 1983

3.3 INTEGRATION [19]

INTEGRATION is a traffic model developed at Queen's University in Kingston, Canada to evaluate the operation of integrated freeway/traffic signal networks during periods of recurring and non-recurring congestion.

The INTEGRATION modelling approach consists of a discrete simulation that traces the path of each vehicle throughout the network. The links that a vehicle uses are selected in accordance with its estimate of the best route, and, along its path, each vehicle's route is further adjusted in view of any changes in the prevailing traffic congestion and traffic controls.

The self-assignment capability circumvents the need to use either an explicit time slice or iterations during the traffic assignment. Consequently, one can consider continuously variable traffic demands and controls, both freeway and signalized networks, as well as any links that join them.

3.3.1 Basic Structure [19]

Figure 3.4 provides an overview of the main steps within the modelling approach and indicates that it basically consists of four stages. The first stage sets up the model by generating the configuration of the network (link-node structure) and specifying the traffic demands (O-D demands). The second stage performs the actual simulation of traffic flows; it enters vehicles into the network; routes them through it; and then remove them upon reaching their destination. This second phase frequently interfaces with the third, which updates the dynamic parameters of the network, and may provide intermediate statistics or graphics. Lastly, the fourth stage generates any final statistics.

Insert Figure 3.4

Figure 3.4 also illustrates that the main simulation consists primarily of a loop, which steps through time in increments of a decisecond. Within this loop, checks are made to see if any vehicles are eligible to enter the network or to be moved forward within it. In addition, checks are made to determine if minimum path trees should be updated or any intermediate statistics provided.

3.3.2 Input Data Requirements [19]

The model requires five basic inputs:

1) Node coordinates file
2) Link descriptor file
3) Traffic demand file
4) Signal timings file
5) Incident descriptor file

3.3.2.1 Node Coordinates File

This file is used to describe the x-y location of the nodes. The coordinates are utilized primarily for purposes of displaying the network and its attributes during the progress of the simulation, but they can also be used to assist in the computation of approximate link lengths.

3.3.2.2 Link Descriptor File

This file provides the attributes of each link that joins the above nodes. The primary data required in this file are:

- link length (meters)
- number of lanes (integer)
- saturation flow per lane (veh/hour/lane)
- saturation flow reduction coefficient for congested conditions (ratio = congested saturation flow/uncongested saturation flow)
- number of traffic signal controlling the link, if any
- signal phase number (phase during which the signal has effective green)
- link descriptor label (character string)

3.3.2.3 Traffic Demand File

The traffic demand to be applied to the network is expressed to the model as a series of origin-destination flow rates for a user-specified time period.

The model internally translates these flow rates into corresponding individual vehicle departures during the specified ‘time period.

3.3.2.4 Signal Timings File

This file identifies the signal control logic that is to be used to set or modify the signal timings at any signalized intersections or ramp meters in the network. This file provides the initial timings as well as the signal timing constraints that cannot be violated by the traffic signal optimizer, if utilized:

- initial, minimum and maximum cycle time (sec)
- offset of phase 1 relative to absolute clock (sec)
- number of phases at intersection (integer)
- phase start/end time and associated lost time

3.3.2.5 Incident Descriptor File

This file indicates the number of incidents that are to be modelled, their severity and duration. Multiple consecutive or concurrent incidents can be modelled. The incident severity is specified as an effective reduction in the number of lanes, while the incident duration is specified in terms of the start and end times of the incident with reference to the master simulation clock.

3.3.3 outputs [19]

At the conclusion of the simulation run, the model produces two types of summary outputs. The first provides user-oriented statistics on the trips between each origin-destination (Appendix C). The second provides system-oriented statistics on the operation of each network link (Appendix C). INTEGRATION was not tested as a copy of the program was not available at the time the evaluations were conducted in November 1990. However, the model is now available.

3.4 MODEL SELECTION

Based on an evaluation of the test runs and further evaluation of previous applications of each of the models, it was determined that CONTRAM was best suited for this particular application. This is not a negative reflection upon the other two models, as both other models could have been used for this project as well. Chapter 4 describes in greater detail the features of CONTRAM that made it most attractive for ‘this application.

4.0 FEATURES OF CONTRAM RELEVANT. TO THIS APPLICATION

CONTRAM 5 is the latest version of the Transport and Road Research Laboratory's traffic assignment program which models time-varying traffic demands on urban and other road networks subject to capacity constraints, and predicts the variation through time of the resulting routes, queues and delays. This chapter summarizes the main features of the model relevant to our specific application.

Two programs, COMEST and RODIN [20], used in our study in relation with CONTRAM are also discussed in this chapter.

4.1 CONTRAM 5

4.1.1 Representation of Traffic

The traffic, for each Origin-Destination movement, is handled in groups called packets. Each packet consists of an integral number of vehicles of the same type, typically in the range l-20, assigned at the same time between the same origin and destination. The grouping of vehicles into packets can be regarded, for assignment purposes, as a process in which the behavior of one vehicle in a packet is taken as typical of the behavior of the other vehicles in that packet.

The default mode of packet generation in CONTRAM 5 is variable packet size. This means that packet size can be adjusted up to a certain maximum value, so as to match the demand specified in the O-D data. The maximum packet size for each O-D movement can be specified in the data or calculated automatically (subject to an optional scaling factor **or** an optional upper limit). The optimum choice of packet size is necessarily a compromise:

- Large packet sizes require fewer assignments leading to shorter run time, but produce a grainy loading and possibly an unrealistic assignment;
- Small packet sizes tend to give a better representation of the demand flow profile.

4.1.2 Assignment

The method of assignment in CONTRAM 5 is a modified form of Dijkstra's algorithm which at any point on a route seeks to minimize the sum of the actual cost from the origin to that point and an estimate of the minimum cost from that point to the destination. Packets are assigned to their minimum cost routes by an iterative procedure shown in Figure 4.1. After the initial loading iteration the sequence of operations for assigning each packet is:

(i) Remove the increment of flow, due to the packet, from the flows stored for each link (in the appropriate time intervals) for the route taken by the packet in the previous iteration;

(ii) Recalculate the queues on links affected by the previous route of the packet;

(iii) Assign the packet to its new minimum cost route;

(iv) Add the flow due to the packet to the links on the new route and recalculate the queues affected by the new route;

(v) Take the next packet and repeat steps (i) through (iv).

The updating of flows and queues on links and the recalculation of delays for the reassignment of each packet is made for the appropriate time intervals during which a packet travels along each link of its journey. The procedure for loading and assigning traffic combines progressive and incremental loading techniques. Although the assignment procedure for an individual packet is all or nothing, it is not all or nothing overall, since different packets for the same O-D movement can be assigned to different routes in response to changes in traffic conditions throughout the period modelled.

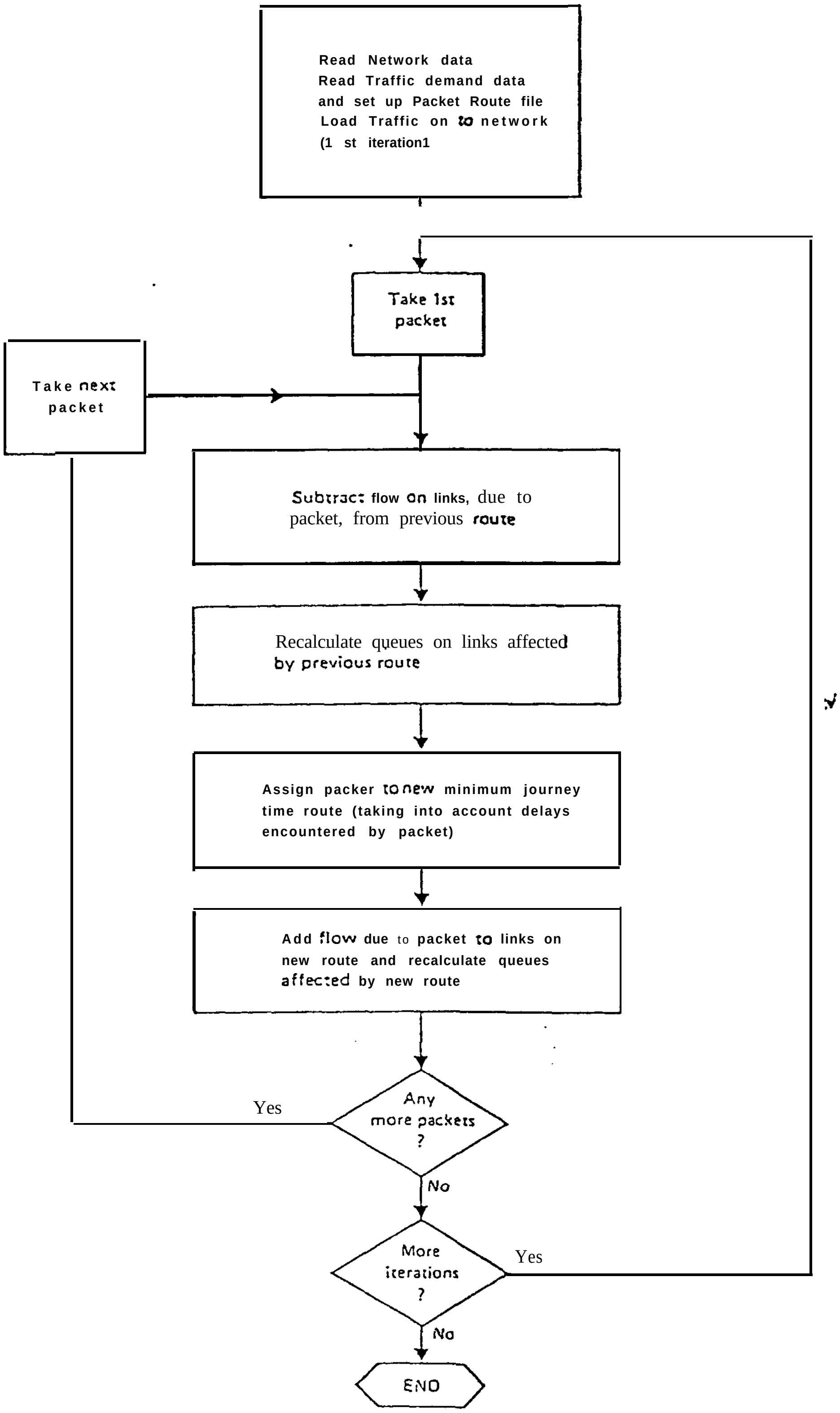
4.1.3 Queue and Delay Model

CONTRAM 5 calculates the lengths of queues using time-dependent stochastic queuing theory. Random-and-oversaturation queues are calculated using the queue formulae developed by Kimber and Hollis (1979) and Kimber and Daly (1986), and other formulae are used to calculate queues due to signals. Vertical queuing is assumed, i.e., the queuing process is formally defined as occurring at the stop line.

Queuing models are compatible with those employed by the intersection modelling programs ARCADY2, PICADY2 and OSCADY2 (Semmens 1985 a,b, Burrow 1987). A queue is calculated either for a particular moment within a time slice, such as the arrival time of a packet, or for the end of a time slice, to provide a size for the initial queue in the next time slice. The size of the queue depends on five variables:

1) the initial queue at the start of the time interval;
2) the mean vehicle arrival rate;

FIGURE 4.1
ITERATIVE PROCEDURE USED BY CONTRAM



3) the throughput capacity (average flow rate at which vehicles discharge from a queue on a link);
4) the length of time during which the queue develops;
5) the intersection type.

4.1.4 Blockirig-Back

Blocking-back occurs when the queue of vehicles on a link extends back to the previous links, thereby blocking free access to the link from the upstream links. The net effect is to reduce the throughput capacity of the upstream links as long as the blocking-back condition persists.

The basis of the blocking-back mechanism is as follows: since the CONTRAM model is based on vertical queuing at a stopline, the onset of blocking-back on a link is detected by comparing the equivalent length of the queue with the storage capacity of the link (number of vehicles which can be stored on the link). The comparison is made immediately after each packet has been assigned to its new route, for each of the links along the packet's route working backwards from the destination to the origin. If the queue on a link calculated, using the current arrivals, is found to exceed its storage capacity, then the throughput of the upstream link is reduced to match the sum of the initial queue on the link and the current arrivals at the stop line, for the rest of the time interval for the remainder of the iteration.

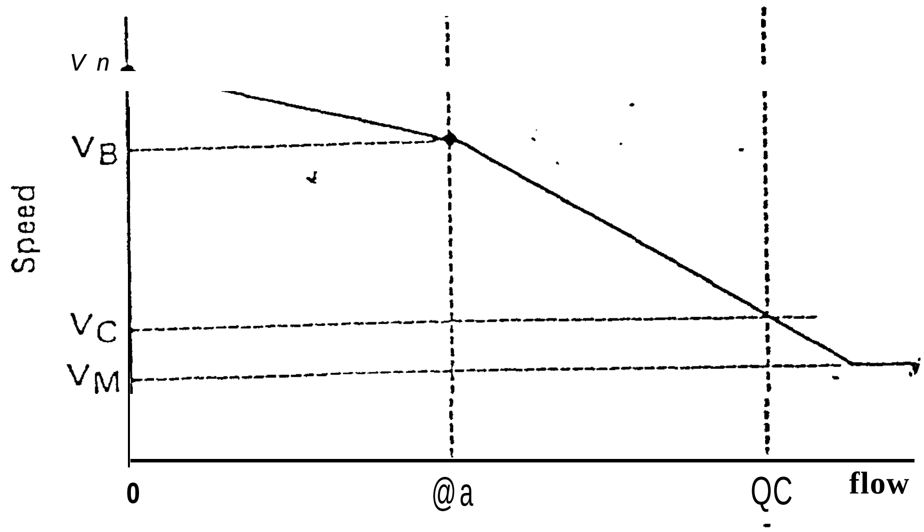
4.1.5 Speed/Flow Relationships

Speed/flow relationships are intended to be used in CONTRAM for two main purposes: to represent cruise speeds on high-speed and limited access roads; and to take account of the aggregate effect of delays in buffer networks, i.e., parts of a network which need not be modelled in detail but which may affect traffic alignment in the areas of main interest.

The effect of a speed/flow relationship is in addition to any delay due to explicit queuing at the downstream end of the link to which it applies. The relatively simple, time-independent, form assumed for speed/flow relationship, presumes that traffic is free-flowing or well under saturation so that any queuing effects can be subsumed by the relationship. The speed/flow relationships are not intended to model congestion.

CONTRAM 5 uses COBA-type speed/flow relationships whose general form consists of two linear sections of different slope (see Figure 4.2). The exact form of each relationship is determined by entering as data three points through which it passes:

FIGURE 4.2
SPEED/FLOW RELATIONSHIP IN CONTRAM



V_0 - The free speed where flow is Zero

V_B - The break point speed where the slope of the line changes

V_C - The capacity point, which is the highest level of traffic flow observed

V_M - The speed at which the inter-vehicle headway equals minimum distance headway input by the user

Q_B - The break point flow

Qc - The capacity flow

1) **the free** speed (where flow is zero);
2) the break point (flow and speed) where the slope changes;
3) the capacity point (flow and speed) which is a point through which the second section passes.

This last point need not actually represent capacity but it is convenient to identify it with the highest level of traffic flow that has been observed. A minimum speed cut-off can also be entered.

4.2 COMEST

COMEST stands for Constrained O-d ESTimation. Its purpose is to fit a time-varying origin-destination matrix to a set of observed link counts and set of routes.

4.2.1 Principles

Due to the difficulty of obtaining detailed origin-destination information, a synthetic O-D matrix generation technique must be used. The COMEST program uses a combination of entropy maximization (Van Zuylen and Willumsen, 1980) and Furness-type balancing (Maher, 1987) to achieve its objectives. The latter acts as a constraint on the way individual O-D flows change so avoiding bias due to the number of times each O-D is counted.

4.2.2 COMEST/CONTRAM Relationship

COMEST is designed to be used with CONTRAM-type data files in which time-variation is represented by specifying O-D and link counts in up to 13 consecutive time slices. A flow diagram of the operation of COMEST in relation with CONTRAM is shown in Figure 4.3.

COMEST loads three sets of data in sequence:

1) a set of control parameters;

RELATIONSHIP BETWEEN COMEST AND CONTRAM

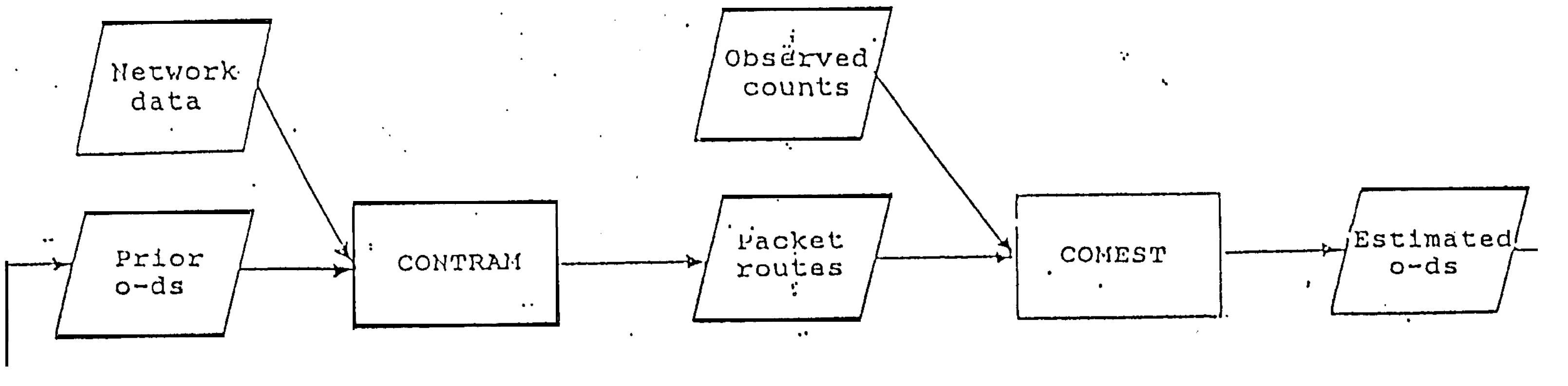


FIGURE 4.3
COMEST-CONTRAM RELATIONSHIP

2) a set of target link counts, which may be time-dependent and disaggregated by the three CONTRAM vehicle classes;

3) a set of prior O-D movements and routes, in the form of a CONTRAM-type route file containing the routes and times of a number of packets.

4.3 RODIN [20]

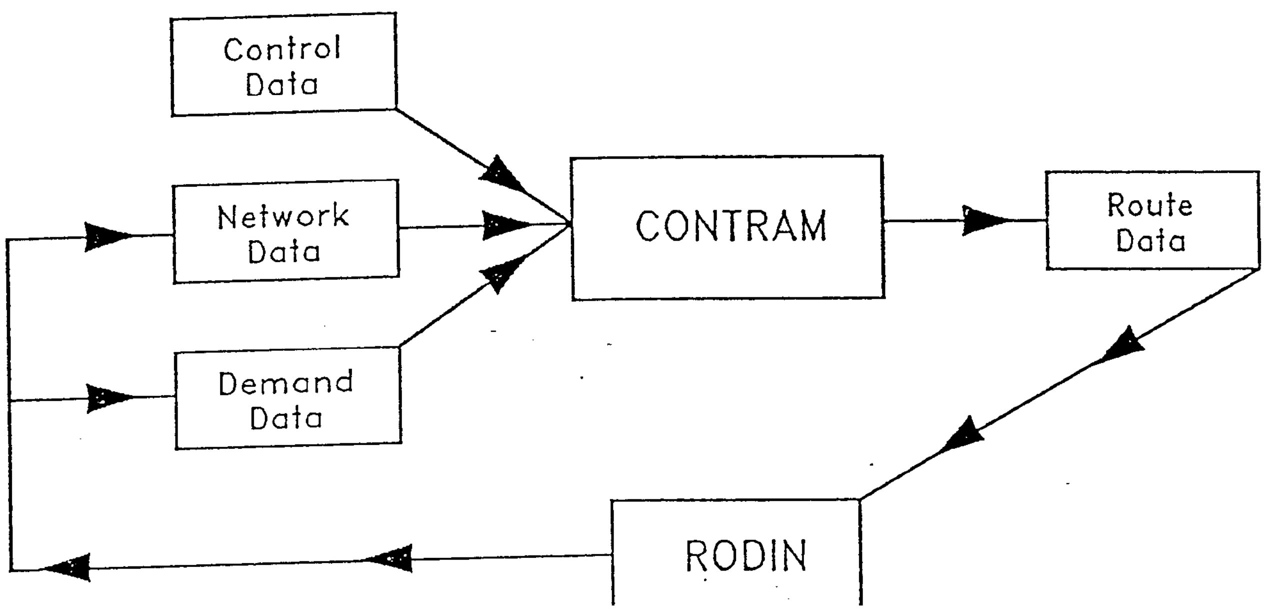
RODIN is an external software developed by Nick Taylor (TRRL) and intended to be used in relation with CONTRAM to simulate route guidance. This program converts a packet route file output by CONTRAM into an O-D matrix and a set of routes which it embeds as fixed routes in a copy of the network file. The O-D movements are duplicated and each set is preceded by a percentage multiplying or split factor.

When rerun using the new network and O-D files as data, the first set of 0-Ds is assigned on the fixed routes (i.e. along the original routes), while the second set is assigned to minimum cost routes in the usual way. This provides a framework in which experiments involving two user classes (guided and unguided vehicles) can be performed.

The use of RODIN in relation with CONTRAM is highlighted in Figure 4.4. RODIN is designed to perform the basic operations described above. In addition to these functions, it provides:

- a choice of methods for setting packet sizes;
- alternate vehicle class for the second set of 0-Ds;
- randomization of the output O-D counts.

FIGURE 4.4
RODIN-CONTRAM RELATIONSHIP



5.0 SMART CORRIDOR

Five key factors led to the decision whereby the Smart Corridor in Los Angeles, California would be used as the integrated freeway/arterial network in the CONTRAM simulation of the potential benefits of in-vehicle information systems.

1) The availability of a good database in terms of traffic counts, arterial geometric considerations, average arterial and freeway travel times, and freeway capacity calibrations.
2) The size of the corridor and the fact that the corridor is experiencing traffic congestion and incidents occur regularly.
3) The interest and continued assistance of CALTRANS and the City of Los Angeles Department of Transportation.
4) The Pathfinder in-vehicle motorist information and road navigation project that is currently underway within the corridor.

5.1 Database

As mentioned previously, this project is a continuance of an earlier project [3]: the database used in the earlier project provided the vast majority of information used in setting up the CONTRAM model. Due to time and resource constraints, and since the earlier project had only evaluated the morning peak period, it was determined that the morning peak period would be used in all analyses. The morning peak period captures mostly work trips; therefore, people are typically more time conscious. Additionally, the morning peak period provides a more defined peak period as well as the fact that the arterials have more available capacity in the morning peak hours. Demand data was provided to the earlier research effort by the City of Los Angeles Department of Transportation and Caltrans.

5.1.1 Supply Parameters

To properly code the network into the CONTRAM model it was important that the supply side of the Smart Corridor be coded properly. These supply parameters consist of the link distance, the cruise speed on each link, and the number of lanes and the ideal saturation flows per link for each intersection approach. The saturation flows used on each link were a result of the earlier research team's effort to calibrate the model. Table 5.1 summarizes the general guidelines established for the saturation flows.

Table 5.1
Ideal Saturation Flows

Movement Type	Ideal Saturation Flow (vphgpl)
Exclusive Through	1700
Exclusive Left (Protected)	1600
Exclusive Right	1450
Shared Through-Right	1700

The ideal saturation flow for a shared through-left movement was calculated by reducing the ideal saturation flow for an exclusive left turn movement by applying a left turn factor. This factor was determined from utilization of Chapter 9 of the 1985 Highway Capacity Manual[21]. An absolute minimum of 450 vphgpl was used as a result of the advice from the City of Los Angeles Department of Transportation.

The ideal saturation flows for exclusive left-turn movements with permitted phasing was calculated based upon the relationship of the exclusive left permitted saturation flow rate versus the opposing flow rate. Once again, the saturation flows were determined from Chapter 9 of the 1985 Highway Capacity Manual [21]. As before for shared through-left movements, an absolute minimum of 450 vphgpl was used on advice of the City of Los Angeles Department of Transportation.

5.1.2 Control Parameters

The control parameters required for the CONTRAM model consist of the signal timing data. Information such as interval lengths, minimum phase durations, cycle lengths, offsets/yield points, reference intervals, type of signal control, and phase sequencing were all obtained from the City of Los Angeles Department of Transportation.

5.2 Size of the Corridor and Traffic Congestion

The Santa Monica Freeway in Los Angeles is considered to be one of the most congested freeways in the world. As one of eight freeways which provides direct access to the downtown Los Angeles area, the

Santa Monica Freeway is also.the only facility which connects the west side of Los Angeles to the central downtown region. The Santa Monica Freeway is the only east-west freeway between the Santa Monica Mountains to the north and the Artesia Freeway to the south, a distance of approximately 13 miles. The five major arterials, Olympic, Pico, Venice, Washington and Adams Boulevards are connected to the freeway by approximately 15 major north-south streets. Figure 5.1 displays a map of the entire corridor.

The principal'cause of traffic congestion is the peak hour(s) travel demands. Although the Santa Monica Freeway is four to five lanes in each direction, the travel demand during the peak hours still exceeds the amount of available freeway capacity. Daily traffic volumes on the freeway range from a low of approximately 180,000 to a high of nearly 315,000 close to the downtown area. Stop-and-go conditions exist daily during the peak hours on the freeway, where the average speeds throughout the corridor on the freeway are often below 35 miles per hour in both directions.

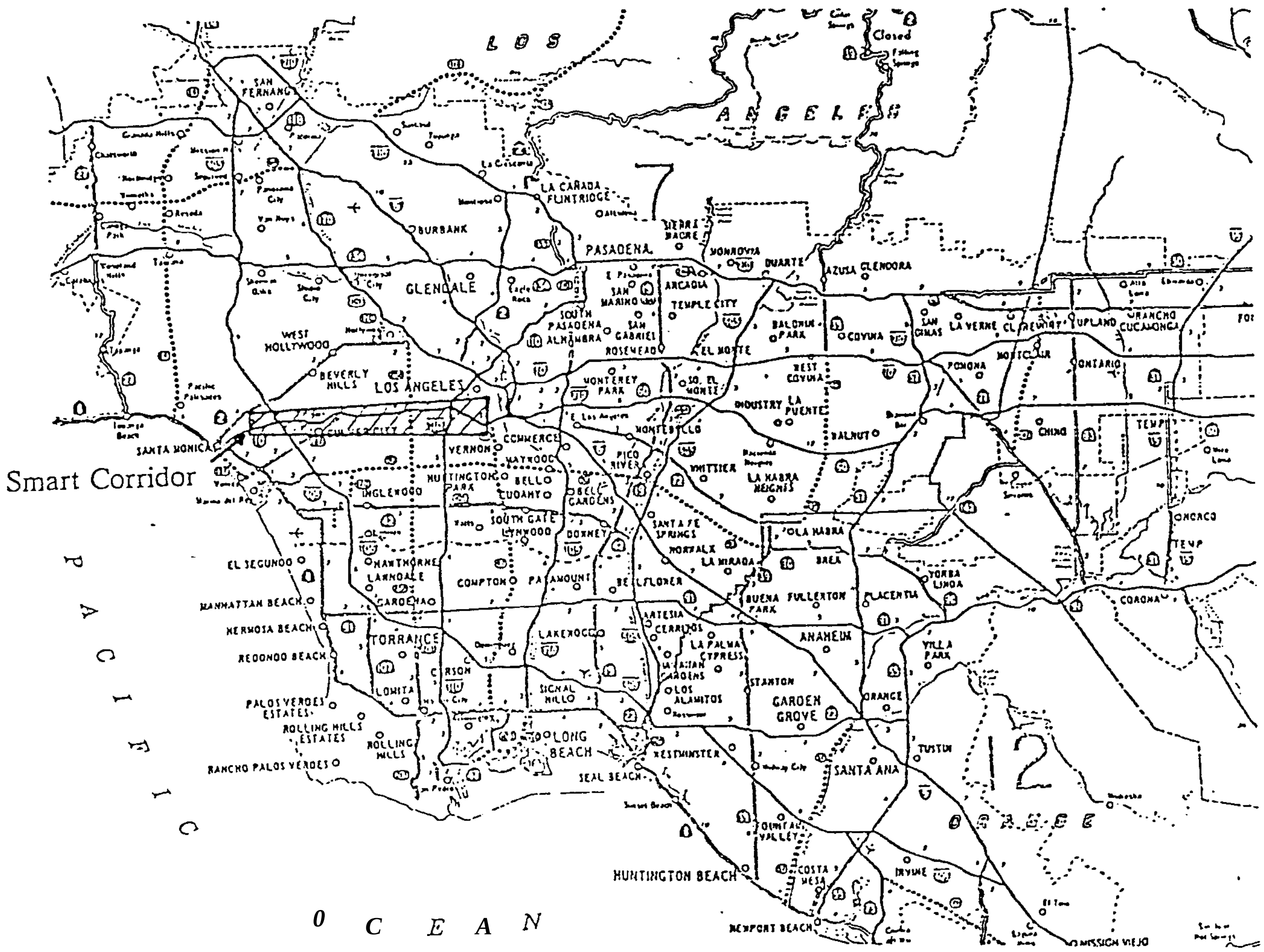
Traffic on the parallel arterials is different from that on the freeway. Olympic Boulevard carries the most traffic of the five parallel arterials with a range of approximately 14,000 vehicles per day to nearly 32,000 vehicles per day near Century City. Adams Boulevard is the least travelled arterial with volumes ranging from 2,600 vehicles per day to nearly 11,000 vehicles per day. Adams, Washington and Venice Boulevards have significant amounts of unused capacity. Therefore, the arterials offer a considerable savings over the freeway in terms of travel time, especially when an incident occurs on the freeway. Thus, diverting freeway traffic to one of the major arterials in an incident scenario is a high priority of the Smart Corridor Demonstration Project.

5.4 Pathfinder

Pathfinder is an experimental project designed to test the feasibility of using the latest technological devices to assist motorists in avoiding traffic congestion. The Smart Corridor is the test bed for the project. The project provides drivers of specially equipped General Motors Oldsmobile Eighty-Eights, real-time information about accidents, congestion, highway construction, and alternate routes. The in-vehicle motorist information and road navigation system demonstration project is being sponsored by Caltrans, the Federal Highway Administration and General Motors.

Since the objective of this research is to determine the potential benefits of in-vehicle information systems using the CONTRAM model, meaningful results may be used at some point to compare with those to come out of the Pathfinder demonstration project. Thus, any results found from this research may be compared with “real-world“ results to make a more definitive determination as to what the potential benefits may be since each project is using the Smart Corridor as its test bed.

FIGURE 5.1
LOCATION MAP - SMART CORRIDOR



Source: California Department of Transportation State Highway Map

6.0 INITIAL MODEL APPLICATION

The purpose of this chapter is to describe the initial applications of the CONTRAM model to the Smart Corridor with particular emphasis on freeway performance modelling. The freeway performance modelling was found to be more difficult than originally anticipated and required a number of modifications which are described in this chapter. The freeway performance modelling undertaken for a simple directional freeway is presented first, and then the modelling of the I-10 Santa Monica Freeway is discussed.

The CONTRAM model was primarily developed for use in the design of traffic management schemes for urban signalized arterial networks. As mentioned in Chapter 4, CONTRAM has the ability to represent limited access and buffer network roads. The speed flow relationships represent the relationship between average speed and flow on roads where cruise time is a significant proportion of total time and journey times on links in a buffer network in order to simulate the general effects of capacity restraint. A standard COBA type speed/flow relationship is used whereby two linear sections of different slopes, one representing the break point speed/flow and the second representing the capacity point speed/flow are used.

In order to gain a more clear understanding of the freeway modelling characteristics within CONTRAM, a linear test segment of freeway was designed. To evaluate the characteristics of the CONTRAM model, both manual calculations and the FREQ model were chosen as tools for calibration. The FREQ family of freeway simulation models has been in existence since the 1960's [22]. Both manual calculations and the FREQ model were used in the I-10 calibration process. FREQ is a macroscopic deterministic simulation model in which time can be broken into equal discrete time-slices and the directional freeway segment divided into homogeneous subsets with demands and capacities remaining constant during each time slice . Merging and weaving analysis, when selected, follows the 1965 Highway Capacity Manual procedures. A limitation to the FREQ model is that freeway congestion can only begin and end at boundaries between time slices. The queue contour maps in FREQ provide a picture of both bottleneck locations and queue lengths over both time and space. The speed contour maps also provide a picture of speeds in the queue in the bottleneck and for every subsection over time and space.

The criteria for freeway calibration were based on three key considerations. The first consideration was that CONTRAM identified the bottlenecks in the same subsections as those determined by manual calculations and shown in FREQ. The second consideration was that of queue length. Once the bottlenecks were identified and located properly, queue lengths were evaluated to see whether CONTRAM had the proper queue lengths as shown in the manual calculations and determined by FREQ. The third consideration in the freeway calibration process was that of freeway speeds in terms of free flow speeds, speeds at the bottleneck, and speeds within the congestion.

6.1 Linear Test Freeway Segment

In an attempt to gain a more comprehensive understanding of the operation of the CONTRAM model as it relates to freeway operations, a simple linear test freeway segment was created as shown in Figure 6.1. The test freeway segment is 8,100 feet long with five subsections and nine time slices. Figure 6.1 also presents the ‘time slice demands as well as the capacities assumed for each subsection. In the test segment, the first subsection through the third subsection is composed of three lanes. The fourth subsection is two lanes with a length of 100 feet. The fifth and last sub-section is composed of three lanes and is 2000 feet long. The capacity of each lane of the freeway is assumed to be 2000 passenger vehicles per hour.

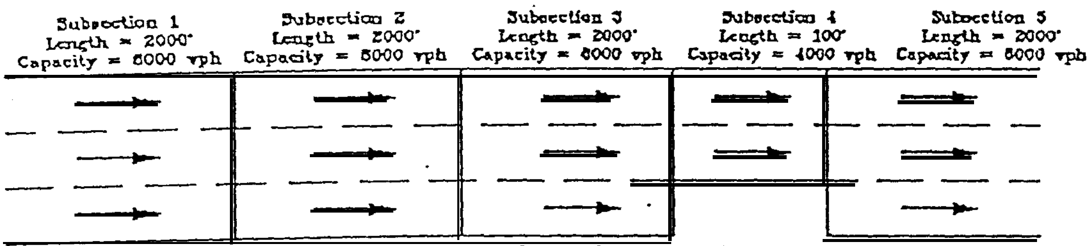
The demands were set to create queuing at the bottleneck in the fourth time slice. All queuing would dissipate by the beginning of the ninth time slice. A manual shock wave analysis was conducted to predict queue lengths and speeds in each subsection during each time slice. The complete results of the analysis are contained in Appendix D. Figure 6.2 displays the shock wave and speed information in km/hr by time slice and subsection. In Figure 6.2 the shock wave can be seen beginning in subsection three at the beginning of time slice four. At the end of time slice six and beginning of time slice seven, the queue reaches its longest at approximately 700 meters. The shock wave ends during time slice eight.

Figure 6.3 presents the speeds and shock wave as predicted by CONTRAM. As seen in the figure, the speeds predicted by CONTRAM do not match those from the manual calculations. The queue pattern does not identically match that of the manual calculations either.

Several key reasons for the differences between the manual analysis and the CONTRAM output deserve mention. It should be noted that because the CONTRAM model is macroscopic and sends vehicles through the system in packets, not all packets make it through each subsection during each time slice. To identify the bottleneck in the proper subsection, the approach used was to code the saturation flow of a link as the capacity of the downstream link. This technique is theoretically correct since the saturation flow of each link is measured as the throughput capacity of that link. Thus, in this particular application the bottleneck was properly identified in sub-section four.

The key input to calibrate queue lengths is the minimum distance headway. Since the CONTRAM model is designed for arterials, an estimated storage capacity is calculated by the program based on a minimum distance headway that is either provided by the program or input by the user. The default provided within the model for the minimum headway distance is 5.75 meters. The minimum distance headway directly determines the densities that are represented on the freeway. Since freeway densities are much lower than those at an intersection, the minimum distance headway in the CONTRAM model must be

FIGURE 6.1
LINEAR TEST FREEWAY INFORMATION



Time Slice	Demand	Demand	Demand	Demand	Demand
1	3000	3000	3000	3000	3000
2	3900	3900	3900	3900	3900
3	4000	4000	4000	4000	4000
4	4100	4100	4100	4100	4100
5	4100	4100	4100	4100	4100
6	4100	4100	4100	4100	4100
7	3800	3800	3800	3800	3800
8	3800	3800	3800	3800	3800
9	3800	3800	3800	3800	3800

FIGURE 6.2
SPEED/SHOCK WAVE INFORMATION - MANUAL CALC.

Time Slice	SS 1	SS 2	SS 3	SS 4	SS 5
1	SPEED 94	SPEED 94	SPEED 94	SPEED 91	SPEED 94
2	SPEED 93	SPEED 93	SPEED 93	SPEED 70	SPEED 93
3	SPEED 91	SPEED 91	SPEED 91	SPEED 68	S-PEED 91
4	SPEED 91	SPEED 91	SPEED 91 27	SPEED 58	SPEED 91
5	SPEED 91	SPEED 91	SPEED 91 27	SPEED 56	SPEED 91
6	SPEED 91	SPEED 91	SPEED 27	SPEED 58	SPEED 91
7	SPEED 33	SPEED 93	SPEED 93 27	SPEED 56	SPEED 91
8	SPEED 93	SPEED 93	SPEED 27 93	SPEED 70	SPEED 93
9	SPEED 93	SPEED. 93	SPEED 93	SPEED 88	SPEED 93

FIGURE 63
SPEED/SHOCK WAVE INFORMATION - CONTRAM

Time Slice	SS 1	SS 2	SS 3	SS 4	SS 5
1	SPEED 95	SPEED 45	SPEED 108	SPEED 91	SPEED 95
2	SPEED 95	SPEED 95	SPEED 108	SPEED 91	SPEED 95
3	SPEED 95	SPEED 95	SPEED 108	SPEED 56	SPEED 95
4	SPEED 95	SPEED 95	SPEED 8	SPEED 89	SPEED 95
5	SPEED 95	SPEED 92	SPEED 7	SPEED 56	SPEED 95
6	SPEED 45	SPEED 88	SPEED 5	SPEED 56	SPEED 95
7	SPEED 95	SPEED 91	SPEED 4	SPEED 90	SPEED 95
8	SPEED 95	SPEED 95	SPEED 17	SPEED 66	SPEED 95
9	SPEED 45	SPEED 95	SPEED 108	SPEED 90	SPEED 95

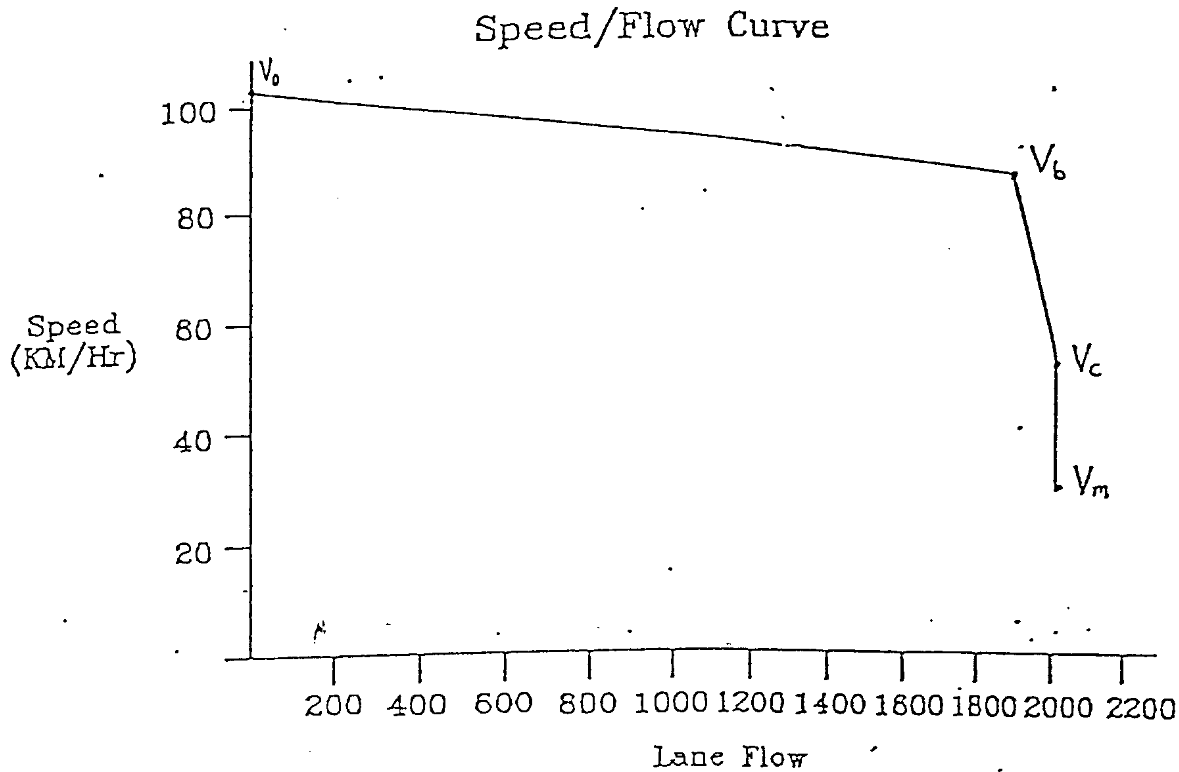
manipulated to create densities that more closely reflect those that are observed on freeway segments. The storage capacity of each link determines the amount of queuing each sub section can handle. Table 6.1 illustrates the conversion of distance headway in meters to densities in vehicles per mile per lane. The minimum distance headway input by the user is universal over all links, thus densities cannot be changed at each link. Through a series of tests for the specific linear freeway segment under investigation in this study, the minimum distance headway of 20 meters was determined to most effectively represent queue lengths as found in the manual calculations.

Table 6.1
Relationship Between Minimum Distance Headway and Density

Minimum Distance Headway (m)	Density (Vehicles/Mile/Lane)
5.75	280
7.50	215
10.00	161
12.50	129
15.00	107
16.00	101
17.00	95
18.00	89
19.00	85
20.00	80

To more realistically represent speeds on the linear test segment as determined in the manual calculations, the speed flow relationship curve as specified in CONTRAM was modified in conjunction with the input cruise speeds. The most effective method of replicating speeds determined by the manual calculations was to use the speed-flow relationships only at the bottleneck and one subsection downstream from the bottleneck. As mentioned previously, CONTRAM has the ability to model high speed limited access roads through the use of a speed-flow curve. Figures 6.4 and 6.5 present the speed flow curves that were

FIGURE 6.4
SPEED FLOW CURVE - TEST FREEWAY (BOTTLENECK)



V_0 - The free speed where flow is zero

V_B - The break point speed where the slope of the line changes

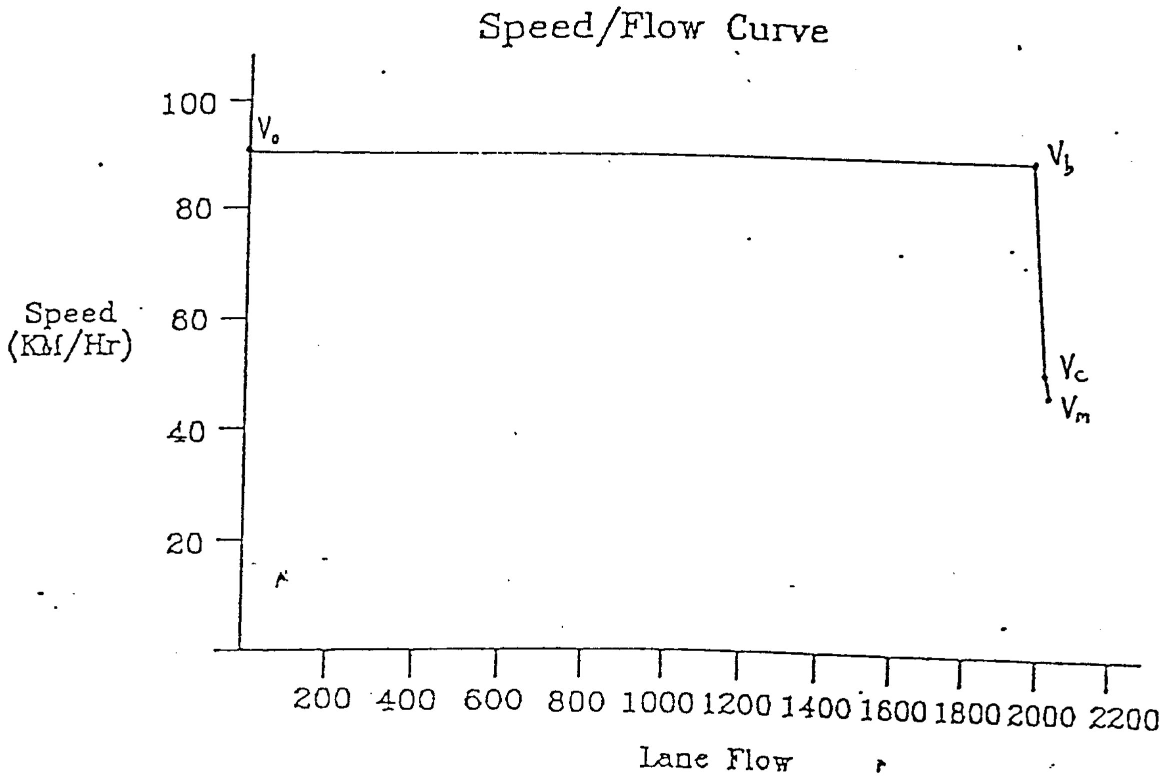
V_C - The capacity point, which is the highest level of traffic flow observed

V_M - The speed at which the inter-vehicle headway equals minimum distance headway input by the user

Q_B - The break point flow

Q_C - The capacity flow

FIGURE 6.5
SPEED/FLOW CURVE - TEST FREEWAY
(ONE SS DOWNSTREAM)



V_0 - The free speed where flow is zero

V_B - The break point speed where the slope of the line changes

V_C - The capacity point, which is the highest level of traffic flow observed

V_M - The speed at which the inter-vehicle headway equals minimum distance headway input by the user

Q_B - The break point flow

Q_C - The capacity flow

used to best replicate the results as found in the manual analysis for the bottleneck and downstream section. The speed flow curve is a replication of the COBA curve used in the CONTRAM model as described in Chapter 4. As shown in the figures, V_c represents the point at which the highest level of flow is observed. V_b represents the break point speed and V_m represents the speed at which the speed-flow relationship predicts an inter-vehicle headway equal to the minimum distance headway as input from the user. The curves shown in Figures 6.4 and 6.5 are those that provided the best results in terms of matching the ‘queue lengths and speeds as derived from the manual calculations. In the subsections without the speed flow relationships the cruise speed of 92 km/hr was used. The free flow speeds on each link do not match because the model truncates the mean time per vehicle in seconds on the link and does not represent a constant free flow speed. The speed flow relationship that CONTRAM uses for modelling high speed limited access roads does not allow for modelling traffic congestion. That is, the speed-flow relationship only obeys the upper limb of the true speed flow relationship on a freeway. Thus, the speeds as output from CONTRAM do not obey the speed-flow relationship as input to the program in congestion. The method CONTRAM uses for calculating free flow speeds does not provide for a constant speed across all free flowing links. Additionally, for congested links, the speeds as represented by the model are much too high. This has been identified as a problem and is something that needs to be addressed in future research efforts if CONTRAM is to be used to represent a freeway segment.

Although freeway conditions could be represented somewhat realistically through the use of the procedures described in the previous paragraphs, a question regarding the influence of freeway ramps on bottlenecks and other sections of the freeway remained unanswered. To help answer some of the remaining questions regarding the operation of the model another linear test freeway segment was introduced. However, this time a real life freeway corridor was used. The Santa Monica Freeway in Los Angeles, California was modelled in the eastbound direction to reach a better understanding of the operations of the CONTRAM model. For comparison purposes, the FREQ model was also applied.

6.2 Smart Corridor Freeway Modelling

The eastbound section of the twelve mile Santa Monica Freeway was the next segment used in the freeway calibration process. The network consists of 32 subsections with 16 on-ramps and 15 off-ramps. The demand data consists of 17 origins and 16 destinations over eight 30 minute time slices. The network and demand information is shown in Figures 6.6 and 6.7. The elements that were given special consideration in this process were; bottleneck location, queue length, and average speeds.

FIGURE 6.6
NETWORK FOR SANTA MONICA EASTBOUND

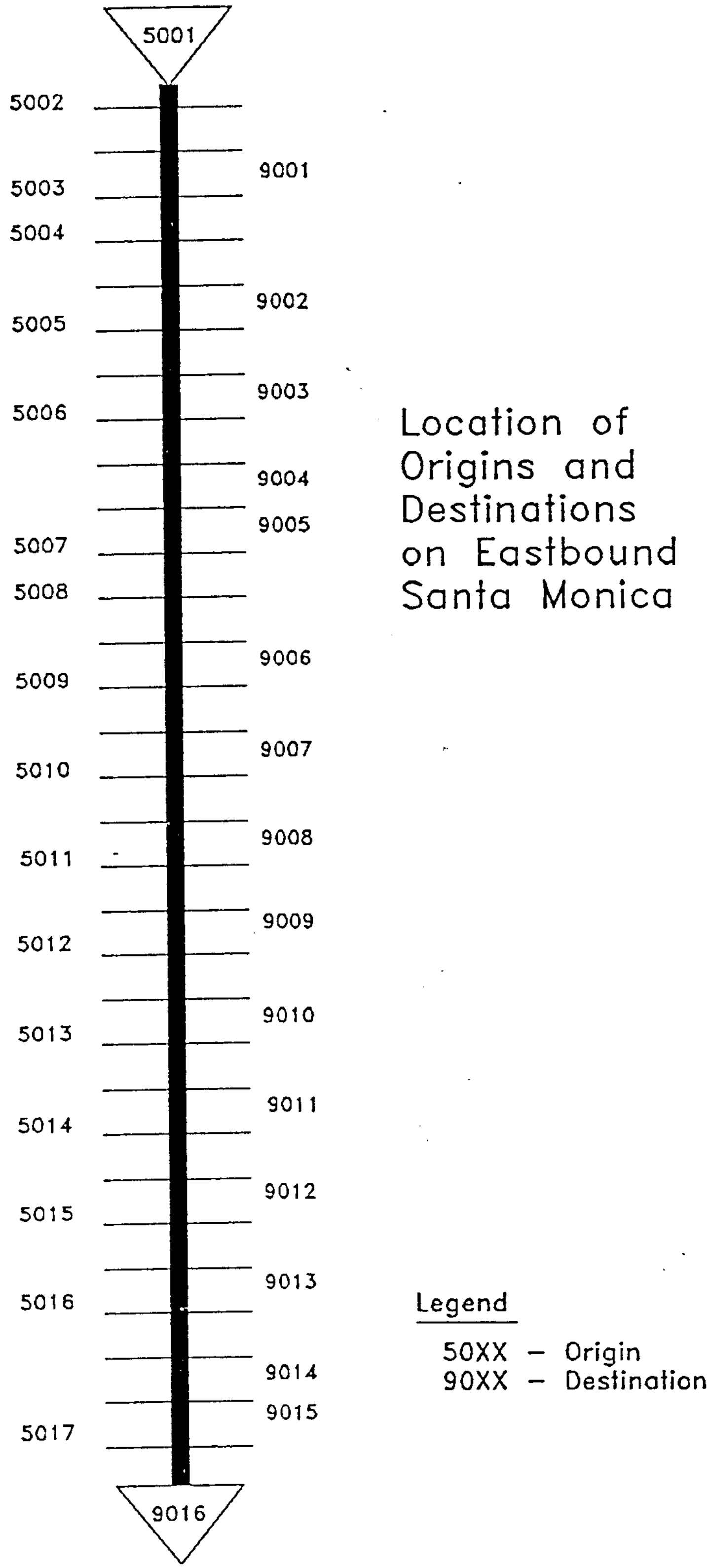


FIGURE 6.7
DEMAND INFORMATION - SANTA MONICA EB

0TOTAL VEHICLE FLOW RATES FROM EACH ORIGIN DURING EACH TIME SLICE (VEH/H)

ORIGINS	FLOWS								
5001	1498	2854	3649	3856	4270	4409	3812	3656	0
5002	2274	3090	3283	2994	2980	3092	3262	3236	0
5003	569	771	1009	1102	899	884	777	757	0
5004	212	357	387	358	374	404	382	336	0
5005	355	377	335	337	327	341	401	403	0
5006	66	280	316	389	382	504	456	508	0
5007	341	384	613	638	515	478	386	347	0
5008	589	1031	976	899	800	768	863	812	0
5009	426	479	427	359	324	398	415	450	0
5010	803	833	849	694	627	665	594	500	0
5011	854	940	1007	1027	936	891	798	773	0
5012	715	748	798	1061	763	683	596	434	0
5013	460	606	678	699	542	523	498	433	0
5014	376	409	413	397	378	289	278	231	0
5015	276	390	367	422	345	288	277	314	0
5016	357	362	367	359	358	280	263	256	0
5017	600	810	670	707	593	600	560	600	0

TOTAL VEHICLE FLOW RATES DIRECTED TOWARDS EACH DESTINATION DURING EACH TIME SLICE (VEH/H)

DESTINATIONS	FLOWS								
9016	4505	6506	7039	6985	6180	6106	5052	4856	0
9003	52	101	130	129	128	134	151	171	0
9006	81	90	104	113	149	78	111	129	0
9008	150	165	265	267	253	236	312	346	0
9009	55	100	193	228	284	300	243	203	0
9010	157	172	185	182	165	148	194	235	0
9011	123	194	321	344	344	375	311	271	0
9012	260	356	526	545	604	627	596	587	0
9013	358	434	591	633	598	656	736	561	0
9001	468	529	710	872	947	1016	993	855	0
9002	448	530	577	864	926	1011	1003	911	0
9004	141	174	237	412	491	500	530	552	0
9005	150	176	252	251	302	321	373	353	0
9007	169	200	242	253	251	268	364	429	0
9014	1301	1399	1449	1330	1150	1086	1021	1013	0
9015	2353	3595	3323	2890	2641	2635	2628	2574	0

'OTAL VEHICLE FLOW RATES ENTERING THE NETWORK DURING EACH TIME SLICE (VEH/H)

10771	14721	16144	16298	15413	15497	14618	14046	0

6.2.1 Bottleneck Location and Queue Length Pattern

Table 6.2 highlights the main freeway events as predicted by FREQ.

Table 6.2
FREQ Main Freeway Events

Time	Bottleneck Location	Queue Length (miles)
6:30 - 7:00	SS 29	1.9
7:00 - 7:30	SS 29	3.7
7:00 - 7:30	SS 13	1.4
7:30 - 8:00	SS 29	8.0
8:00 - 8:30	s s 29	3.6
8:00 - 8:30	ss 14	2.2
8:30 - 9:00	SS 29	1.7
8:30 - 9:00	SS 21	0.8
8:30 - 9:00	SS 14	2.0
9:00 - 9:30	ss 14	0.3

As ***seen*** in the table, the major bottlenecks were identified in subsections 14 and 29. Each freeway subsection was coded as an uncontrolled link in the CONTRAM network while the on-ramps were coded as signalized links with 100 percent green time. The first approach was to code the saturation flow of a link as the capacity of the downstream link. This technique is theoretically correct since the saturation flow of each link is measured as the throughput capacity of that link. The results obtained from this technique did not closely resemble the results provided by FREQ. A possible explanation for the discrepancies could be the ramp merge and diverge points and their influence on capacity.

The second approach was to input the capacity of each subsection from FREQ as the saturation flow. This technique led to the results shown in Table 6.3. As shown in the figure, the bottlenecks were usually identified one subsection downstream from those in the FREQ runs.

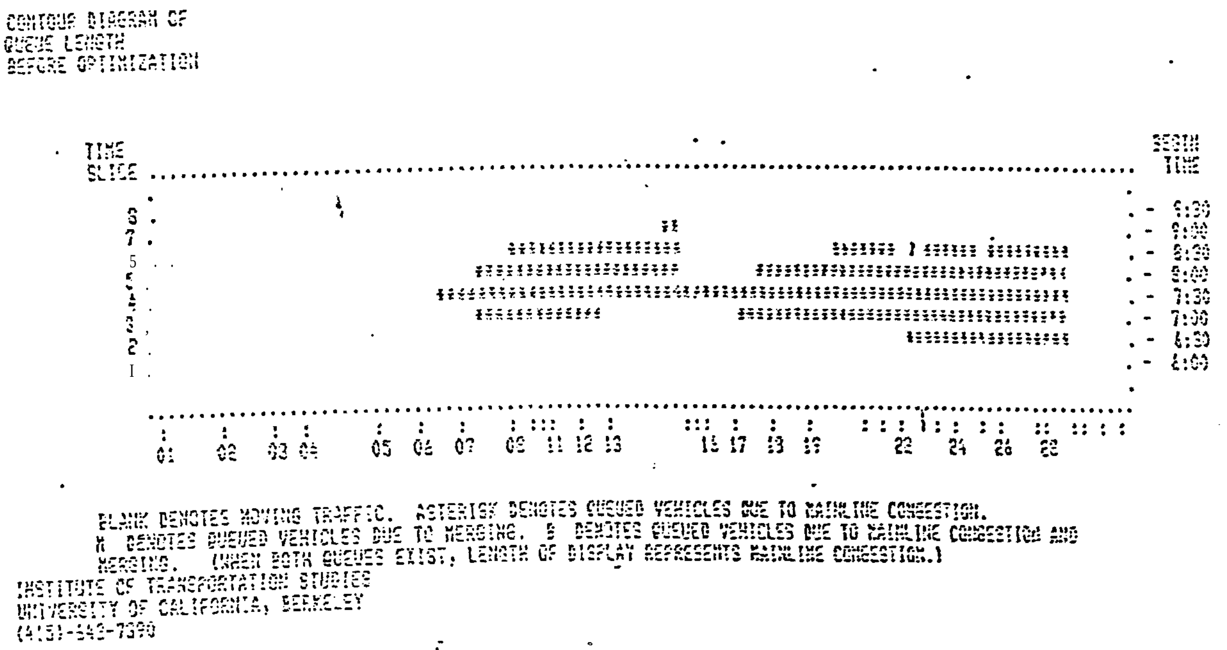
Table 6.3
CONTRAM Main Freeway Events

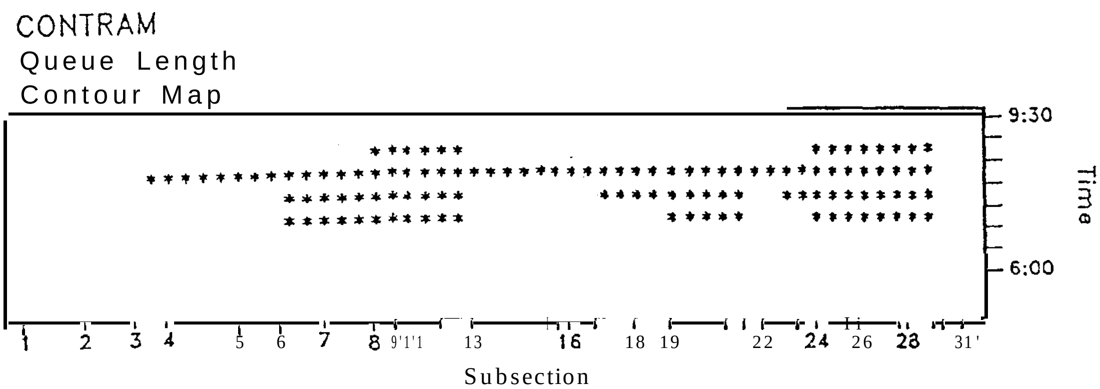
Time	Bottleneck Location	Queue Length (miles)
7:00 - 7:30	SS 30	1.4
7:00 - 7:30	SS 22	0.6
7:00 - 7:30	SS 14	1.7
7:30 - 8:00	SS 30	8.0
8:00 - 8:30	SS 30	1.6
8:00 - 8:30	SS 22	1.0
8:00 - 8:30	SS 14	2.1
8:30 - 9:00	SS 30	1.4
8:30 - 9:00	SS 22	0.7
8:30 - 9:00	SS 14	2.1
9:00 - 9:30	SS 14	0.2

The comparison between Tables 6.2 and 6.3 shows that CONTRAM typically identifies bottlenecks one subsection downstream from those of FREQ, and there does not seem to be a way of modifying CONTRAM to model it correctly.

The next objective was to obtain the queue patterns as produced by FREQ. Queue length patterns are directly affected by the storage capacities input in the CONTRAM network file. As mentioned previously, the minimum distance headway in CONTRAM determines the optimum densities that will be replicated on each link. For this particular application, the minimum distance headway which provided the queue pattern which most closely resembled those provided by FREQ was found to be 50 meters or a density of 32 vehicles per mile per lane. Figure 6.8 shows the queuing patterns from both FREQ and CONTRAM. While not perfect, this was the closest agreement based on modifying the minimum distance headway.

FIGURE 6.8
QUEUING PATTERN - FREQ, CONTRAM COMPARISON





6.2.2 Average Speeds

Figure 6.9 shows the speeds predicted by FREQ. When calibrating the speeds predicted by CONTRAM, two key elements must be considered: free-flow speeds and speed-flow relationships. A uniform freeway free-flow speed of 85 km/h (53 mph) was adopted. Based on the conclusions of Section 6.1 and trial and error, speed-flow relationships were only used in the bottleneck subsections (14, 22 and 30) after the bottleneck locations were identified by a first run. As seen in Figure 6.9, once again CONTRAM predicts speeds within the congestion that are much too high. The speeds one subsection downstream from the bottleneck are too high. It is unclear just how much influence the freeway on-and off-ramps have on the speeds as determined by the model. Further analysis is required to determine the precise amount of influence on-and off-ramps have on average speeds.

6.2.3 Overall Summary Measures

Table 6.4 displays the overall network wide summary results from the FREQ run and the CONTRAM run.

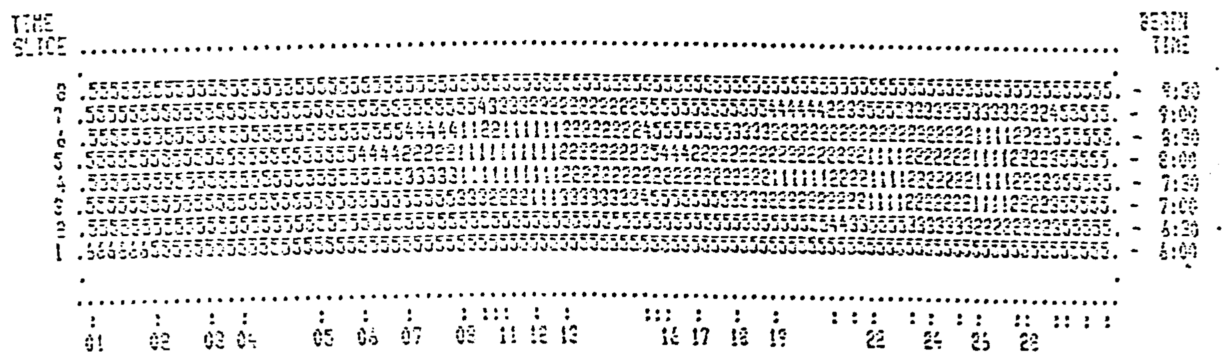
Table 6.4
Overall Network Wide Summary Results Comparison

Network Summary Measure	FREQ	CONTRAM
Total Travel Time (veh-hr)	**8035**	**7546**
Total Travel Distance (veh-mi)	290975	**306388**
Overall Network Speed **(mi/hr)**	**36.2**	**40.6**

As seen in the table, from a system-wide perspective, the results are fairly comparable. Once again, the speed is higher in the CONTRAM model which is consistent with the previous freeway modelling effort.

FIGURE 6.9
SPEED PATTERN - FREQ, CONTRAM COMPARISON

CONTOUR DIAGRAM OF
SPEED
BEFORE OPTIMIZATION



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

CONTRAM
contour Map
Speed

Time
Slice

1	5	5	5	5	5	6	5	5	5	5	5	5	6	5	5	5	5	5	5	5	5	5	6	5	5	5	5	5	5	5	5	6
2	5	5	5	5	5	5	5	5	5	5	5	5	5	6	5	5	6	5	5	5	5	6	6	6	5	5	5	5	5	5	5	6
3	5	5	5	5	5	5	5	5	6	5	5	5	3	3	5	6	5	5	6	3	4	3	5	4	6	6	4	5	1	3	5	5
4	5	5	5	5	5	5	5	5	5	5	5	4	2	3	4	5	5	6	5	4	3	5	4	4	4	4	3	3	1	3	5	6
6	5	5	5	5	6	6	4	4	4	4	5	4	2	12		3	4		4		411	3	4	1	3	4	2	2	1	6	5	5
6	6	6	5	5	6	5	4	4	4	4	5	5	2	3	5	6	5	5	4	1	1	3	6	2	4	6	2	2	,	3	5	5
7	5	5	5	5	6	6	6	4	4	5	5	5	3	3	6	5	5	5	6	6	3	5	6	6	5	6	4	4	,	5	6	5
8	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	5	5	5	5	5	5	5	5
Sub	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32

The digit levels denote the first digit of the operating speed (ex. 4 means 4049 mph)

6.2.4 Conclusions

The freeway calibration process focused on three major elements of freeway operations.

1) The first element consisted of identifying freeway bottlenecks in the appropriate subsection. It was determined that for a simple network with no on-and off-ramps to identify the bottleneck in the proper subsection, it was necessary to code the saturation flow of a link as the capacity of the downstream link. This technique is theoretically correct since the saturation flow of each link is measured as the throughput capacity of that link. However, for a freeway section with a number of on-and off-ramps this technique did not prove effective and the bottlenecks were identified one subsection downstream.

2) Once the bottlenecks were identified and located properly, queue lengths were evaluated to see whether or not CONTRAM had comparable queue lengths to those estimated by the manual calculations and determined by FREQ. The key input to calibrate queue lengths is the minimum distance headway. Since the CONTRAM model is designed for arterials, an estimated storage capacity is calculated by the program based on a minimum distance headway that is either provided by the program or input by the user. The default provided within the model for the minimum headway distance is 5.75 meters. The minimum distance headway directly determines the densities which in turn determine the storage capacity of each link. The storage capacity of each link directly influences the queue lengths found throughout the network. For the first linear test segment a value of 20 meters was used, while in the eastbound Santa Monica Test Segment, a value of 50 meters was used.

3) The third consideration in the freeway calibration process was that of freeway speeds. This is the area of most concern. In free flow conditions, the freeway speeds could be approximated through the use of the speed-flow curve and also as input by the cruise speed. However, for congested conditions, the speeds represented by the CONTRAM model are not realistic. The speeds within the queues are much too high and the speeds at the bottleneck can only be approximated at best through the use of the speed flow relationship.

7.0 DESIGN OF THE EXPERIMENT, REFERENCE BASE ASSIGNMENT, SIMULATION AND VALIDATION

This chapter describes the design of experiment as well as the steps undertaken to develop a reference base assignment. The first section outlines the experiment while the remainder of the chapter is devoted to the development of the base reference assignment.

7.1 Design of Experiment

After several months of attempting to model freeway congestion in a realistic fashion, it was decided that despite the limitations of the model with respect to freeway congestion, attention would be given to modelling the Smart Corridor with the CONTRAM model. With the goal of determination of the benefits of in-vehicle information systems, the experiment was designed as shown in Figure 7.1. The first step was to develop a reference base assignment and simulation that as closely as possible represented the Santa Monica Smart Corridor. The remainder of this chapter is devoted to discussion of this process. Since, from the previous study [3], the benefits for non-incident conditions were found to be relatively small, the next step was to model a freeway incident. Two incidents were created and are discussed in Chapter 8. Once the incidents were created, tests were begun to evaluate the benefits of in-vehicle information systems. Investigations were made with varying percentages of equipped vehicles from 0 to 100 percent. Chapter 9 describes the results of the experiments with varying percentages of equipped vehicles.

7.2 Network Description and Calibration

Figure 7.2 presents the network modelled and used in the analysis. Approximately nine miles of the SMART Corridor with two parallel arterials were coded into the model. The eastern boundary of the network is the Harbor Freeway, while the western boundary is LaCienega Boulevard. In addition to the Santa Monica Freeway, the two parallel arterials coded were Washington Boulevard and Adams Boulevard. Ten major north-south streets connecting Washington, Adams, and the Santa Monica Freeway were coded as well.

As previously mentioned, the previous project (PATH-ITS-UCB-PRR-88-2) provided a comprehensive data base for this analysis, in the form of FREQ and TRANSYT input files. All data provided by the previous project represents the year 1987. Some updated information regarding speed-flow relationships provided by Caltrans was used as well.

FIGURE 7.1
DESIGN OF EXPERIMENT

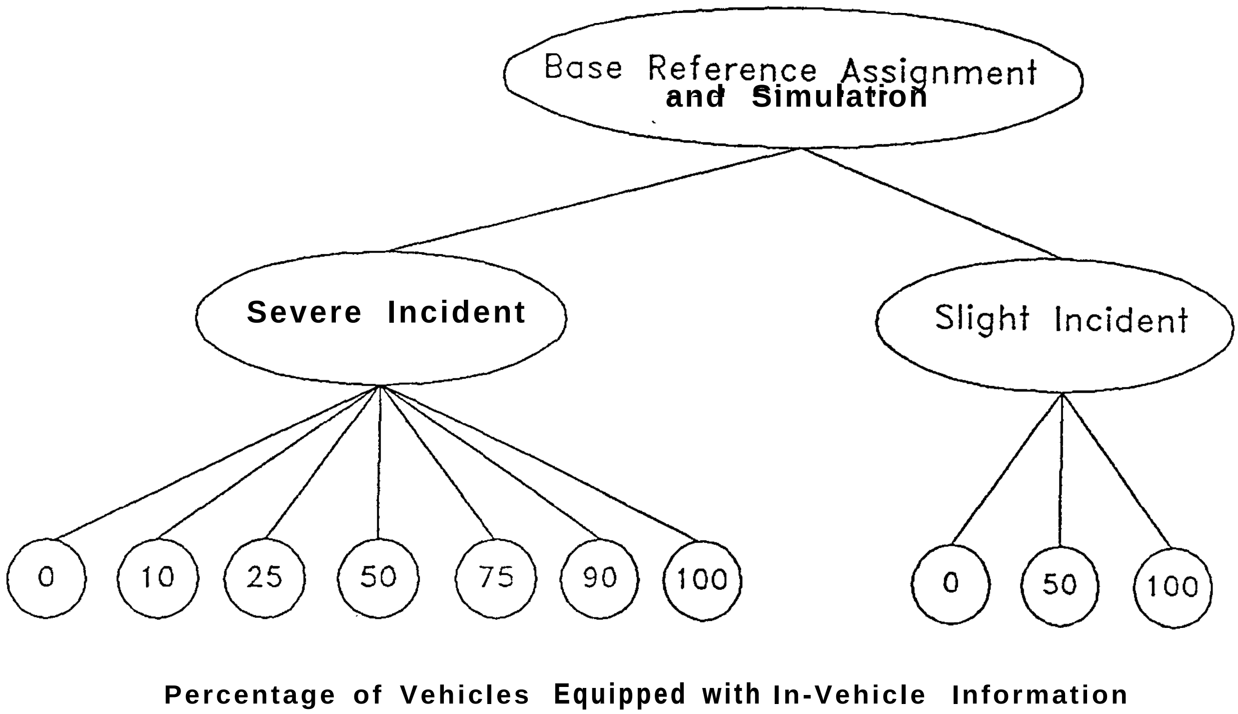
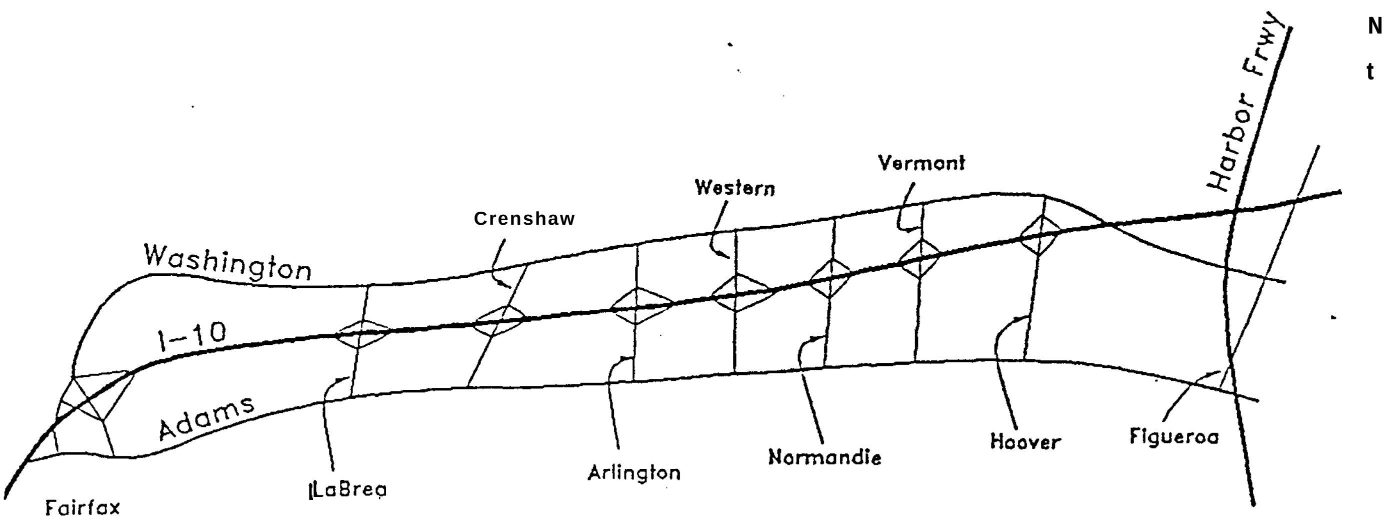


FIGURE 7.2
MAP OF NETWORK MODELLED



The coded network is composed of approximately 200 arterial links. A uniform free-flow speed of 35 miles per hour was adopted for the arterials. The link throughput capacity was determined by the rules described in Section 5.1.1. The signal timing data were taken from the earlier study as well. Some minor modifications were made in the signal timings, especially at freeway ramp intersections, to improve the simulation of the network.

The freeway part of the corridor is composed of 51 uncontrolled links. The westbound direction is represented by 23 uncontrolled links, while the eastbound direction is made up of 26 uncontrolled links. Two additional links were used to represent the Harbor Freeway at the eastern boundary of the system. A uniform free-flow speed of 60 miles per hour was used on all freeway links. On the basis of the experiments described in Chapter 6, no speed-flow relationships were used and each link throughput capacity was input as the corresponding FREQ capacity. The storage capacity was determined by the standard default formula using the minimum distance headway of 20 meters which was found to be optimum after calibration as described in Chapter 6.

The freeway network includes 24 on-ramps (11 for the westbound direction and 13 for the eastbound direction). These links were coded in CONTRAM as signalized links with 100 percent green time. Thus, ramp metering was not modelled as a part of this project. A uniform free-flow speed of 30 miles per hour was used on freeway ramps.

7.3 Corridor Demand

To achieve a realistic demand level and pattern, a three step process was undertaken. The three steps consisted of the following:

1) creation of an origin-destination matrix;

2) using the COMEST program, the origin-destination estimator described in Chapter 4;

3) manipulation of the COMEST output to create a more realistic demand level

The third step, manipulation of the COMEST output, was necessary because of the crude nature of the original origin-destination matrix which was created in step one. The following paragraphs outline the procedures taken to reach a final origin-destination matrix with demand levels similar to those used in the previous study of the SMART Corridor.

7.3.1 Initial Origin-Destination Matrix Generation

As mentioned in Chapter 4, CONTRAM requires the user to input an origin-destination matrix. For this particular application there was not detailed enough origin-destination information available as mentioned in Chapter 5. Although the City of Los Angeles did provide origin-destination information for the vicinity in and around the SMART Corridor, due to the coarse nature of the data and the time and resource considerations, it was decided that the best option was to create a fictitious origin-destination matrix based on traffic counts provided in the previous study and then apply the COMEST program to reach a realistic representation of the demand throughout the corridor.

The first step in creating the fictitious origin-destination matrix was to determine where origins and destinations were to be located. The decision was made to create external origins and destinations as shown in Figure 7.3. This decision was made primarily because information regarding the total number of vehicles entering and exiting each newly created external origin-destination link was readily available for the time period from 7:00 a.m. to 8:00 a.m. No internal origins and destinations were created since the primary sinks and sources within the corridor were not well understood, and they were considered to be less important than the external sinks and sources.

Once the locations of the origins and destinations were decided, the total number of vehicles entering and exiting each link for the time period from 7:00 a.m. to 8:00 a.m. were entered into a spreadsheet as shown in Figure 7.4. Once the row and column sums of the matrix were fixed, the next step was to balance the entries in the matrix. This step was done mostly by trial and error with the assistance of the graph shown in Figure 7.5. The objective of the fictitious origin-destination matrix was to help lead the COMEST program in the proper direction through the use of the observed link counts. A final fictitious matrix was chosen and a CONTRAM run was made. The CONTRAM run provided the COMEST program with the necessary packet route file and an original origin destination matrix from which to work.

7.3.2 Use of the COMEST Program

The second step in the corridor demand analysis was to create an “observed traffic count“ file from the data provided in the Al-Deek, Martello, Sanders and May study [3] on TRANSYT and FREQ runs for the time period from 7:00 a.m. to 8:00 a.m. For the initial application of COMEST every link in the network was input to the observed traffic count file. After many iterations of COMEST and CONTRAM it was discovered that there were too many links for COMEST to balance the traffic counts. The demand

FIGURE 7.3

Location of Origins and Destinations

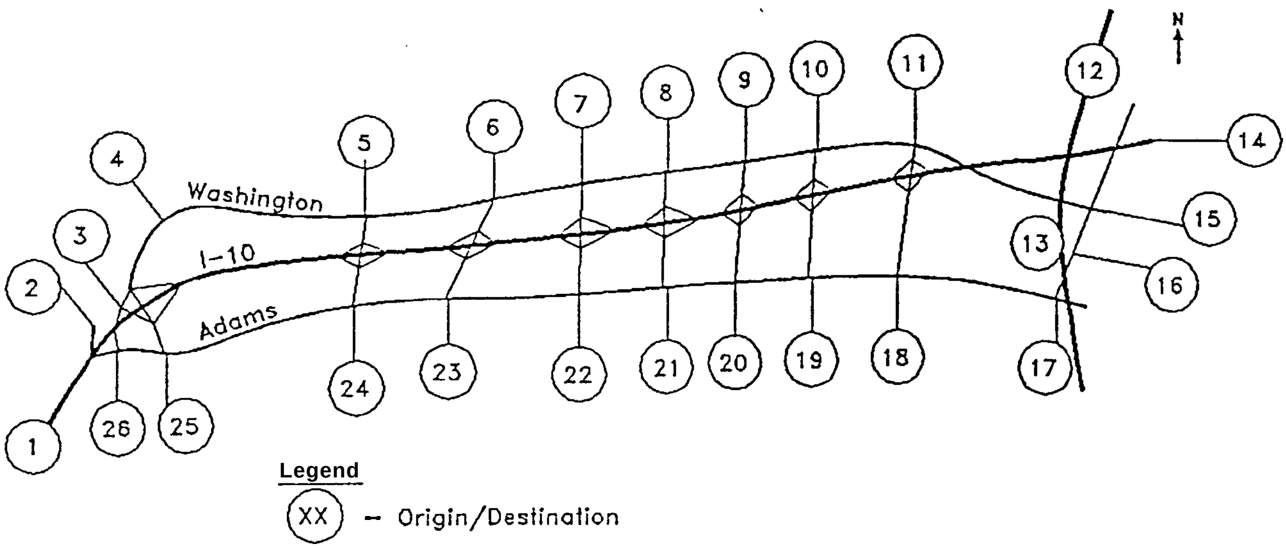
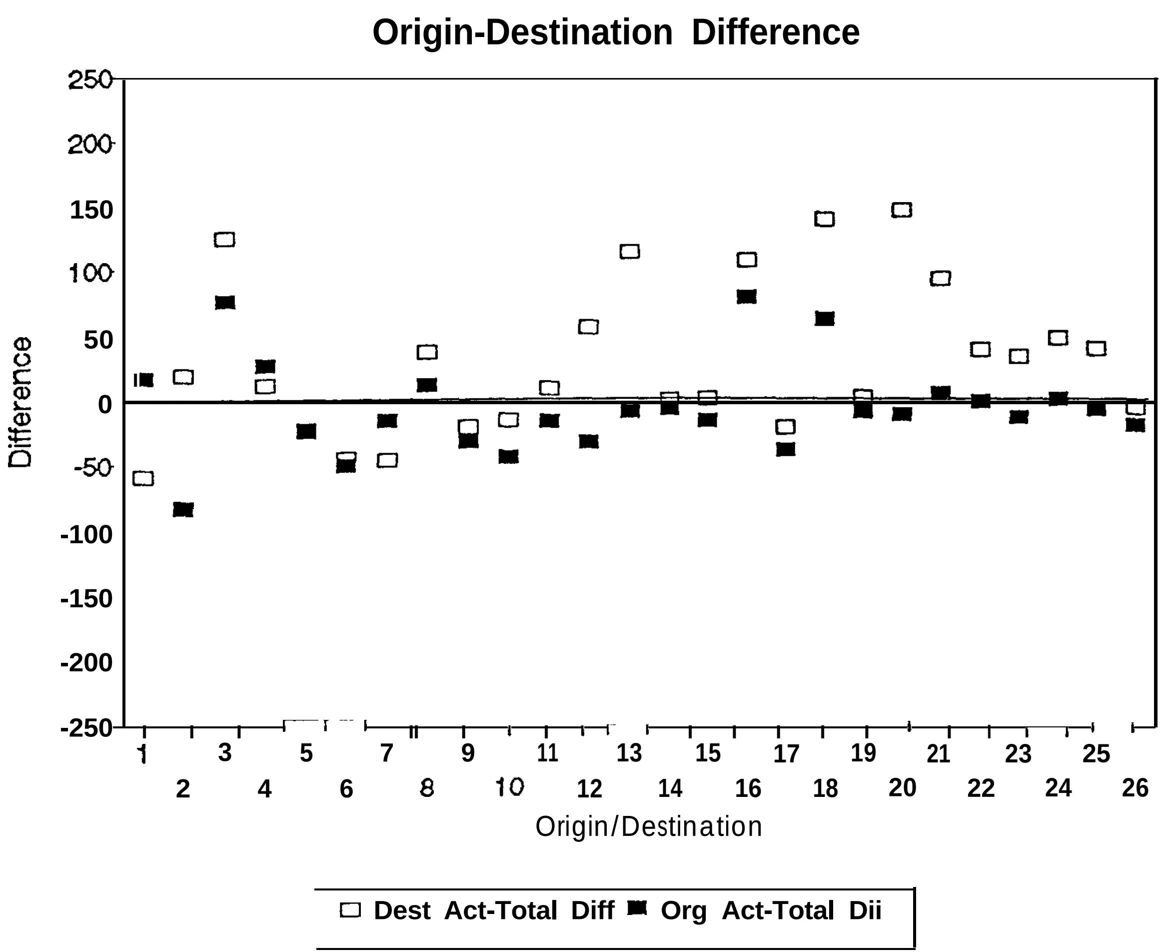


FIGURE 7.4

Origin/Destination Matrix

Dest/Org	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Sum	Obs. Total	
1	0																										0	6880	
2		0																									0	2240	
3			0																								0	713	
4				0																							0	400	
5					0																						0	1694	
6						0																					0	1437	
7							0																				0	972	
8								0																			0	1214	
9									0																		0	1084	
10										0																	0	1450	
11											0																0	1434	
12												0															0	3500	
13													0														0	1000	
14														0													0	6613	
15															0												0	1138	
16																0											0	94	
17																	0										0	1546	
is																		0									0	329	
19																			0								0	1231	
20																				0							0	1193	
21																					0						0	1190	
22																						0					0	1033	
23																							0				0	2158	
24																								0			0	1967	
25																									0		0	1414	
26																										0	0	1046'	
Sum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43970	Total
Obs. Total	8000	1368	741	696	1890	1847	1388	1269	1354	1395	1307	2300	2000	6716	1243	248	631	807	1006	727	761	5 %	1564	1968	1008	1349		43970	Total
																												0	Diff.

FIGURE 7.5


Origin-Destination Difference
250
200
150
100
50
0
-50
-100
-150
-200
-250
Difference
1 3 5 7 9 11 13 15 17 19 21 23 25
2 4 6 8 10 12 14 16 18 20 22 24 26
Origin/Destination
Dest Act-Total Diff
Org Act-Total Dii

pattern created by COMEST. was not very realistic due to the coarse nature of the original "fictitious" origin-destination information.

To achieve a demand pattern representative of those provided by reference [3], the best results were provided by COMEST when the only observed link counts input were those counts on the eastbound freeway and the corresponding ramp junctions. The relationship between CONTRAM and COMEST as explained in 'Chapter 4 was next used to generate a final origin-destination matrix. Four CONTRAM-COMEST iterations were conducted to obtain the final demand pattern for the 7:00 a.m. to 8:00 a.m. time period.

7.3.3 Final Origin-Destination Matrix

Once the demand pattern provided by the COMEST runs was satisfactory for the 7:00 a.m. to 8:00 a.m. time period, the next step in the process was to develop origin-destination information for the eight 30-minute time slices from 6:00 a.m. to 10:00 a.m. Based on information provided by the previous study [3] and information regarding the performance of the system, the demand was manipulated to create an origin-destination matrix for the eight time slices. Table 7.1 displays the time slices and corresponding level of demand factors.

Table 7.1
Corresponding Time Slice Demands

Time Slice	Demand Factor
6:00 - 6:30	30 %
6:30 - 7:00	80 %
7:oo - 7:30	100 %
7:30 - 8:00	100 %
8:00 - 8:30	80 %
8:30 - 9:00	60 %
9:oo - 9:30	40 %
9:30 - lo:oo	30 %

Once the demand factors were applied, a final origin-destination matrix was completed. The resulting sums from each origin and destination per time slice are shown in Figure 7.6. This matrix was then used as the demand information for the base CONTRAM run.

7.4 Base Run Validation

Three key areas were examined **to** validate the model's representation of the Smart Corridor. The first area was that of route choice and travel times/speeds. The second area of concern was that of bottleneck location on the freeway and the corresponding queuing pattern. The final validation process was in the overall network statistics. The following paragraphs describe the three major steps taken in the base run reference assignment validation.

7.4.1 Travel Times/Route Choice

A critical element to the successful modelling of the Smart Corridor is to achieve an equilibrium assignment whereby the travel times via different routes between various sets of origins and destinations are not significantly different. If the travel times differ by a large magnitude then not much diversion will be seen even with a very severe incident. From the work described in Chapter 6, it was recognized that the freeway travel times were slightly lower than real life due to the fact that the speeds within the congested portions of the network are too high. With that in mind, travel time comparisons were made between a route on each parallel arterial only and a route on the freeway only. Figure 7.7 shows the travel time comparisons from Origin 1 to Destination 14, which is a freeway Origin to a freeway Destination. The travel times on the parallel arterials (Adams and Washington) include times on the freeway at the beginning and end of the route as well as the times taken to enter and exit the freeway. Thus, a second comparison was drawn and is shown in Figure 7.8. This comparison is made from freeway link 11 to link 29, which represents the length of Adams and Washington from Fairfax to Hoover. As seen in the figure, travel times on the arterial are much closer to that of the freeway in the heaviest demand time slices. As the demand decreases the difference in travel times increases.

The second key element of travel time/speed is that of route choice. This was done primarily through the use of UFPASC (User Friendly Post Analysis System for CONTRAM) program. The UFPASC is an interactive program for examining the outputs from CONTRAM runs. The UFPASC produces tabular and graphical outputs for selected parameters from the results file produced by CONTRAM. UFPASC uses a menu system to set up the analysis stages for producing the selected outputs. UFPASC allows selective investigations of the results file produced by CONTRAM.

FIGURE 7.6
FINAL DEMAND INFORMATION

0TOTAL VEHICLE FLOW RATES FROM EACH ORIGIN DURING EACH TIME SLICE (VEH/H)

ORIGINS	FLOWS								
5001	2721	7228	9000	9000	7228	5390	3610	2721	0
5002	56	146	185	185	146	113	74	56	0
5003	629	1657	2073	2073	1657	1247	833	629	0
5004	125	335	424	424	335	252	171	125	0
500s	288	771	954	954	771	578	385	288	0
5006	540	1433	1782	1782	1433	1a69	717	540	0
5007	48	128	158	158	128	97	60	48	0
5008	305	802	1004	1004	802	594	404	305	0
5009	159	420	519	519	420	311	207	159	0
5010	309	811	1013	1013	all	604	404	309	0
5011	7	23	26	26	23	14	9	7	0
5012	766	2039	2542	2542	2039	1523	1019	766	0
5013	766	2039	2542	2542	2039	1523	1019	766	0
5014	1801	4831	6016	6016	4831	3583	2410	1801	0
5015	21	68	79	79	68	51	26	21	0
5016	25	72	88	88	72	53	33	25	0
5017	5	14	15	15	14	8	5	5	0
5018	95	267	329	329	267	196	128	95	0
5019	58	151	192	192	151	112	73	57	0
5020	103	272	336	336	272	200	132	103	a
5021	199	519	651	651	519	385	261	199	0
5022	29	79	99	99	79	61	39	29	a
5023	338	933	1153	1153	933	696	462	350	a
5024	319	850	1060	1060	850	632	424	319	a
5025	343	903	1128	1128	903	674	454	343	0
5026	196	524	658	653	524	393	261	196	0

0TOTAL VEHICLE FLOW RATES DIRECTED TOWARDS EACH DESTINATION DURING EACH TIME SLICE (VEH/H)

DESTINATICNS	FLOWS								
9001	2984	7927	9875	9875	7927	5913	3951	2984	0
9014	1777	4715	5874	5874	4715	3523	2350	1777	0
9013	523	1387	1727	1727	1387	1030	693	523	a
9012	1143	3038	3791	3791	3038	2272	1522	1143	0
9017	132	355	450	450	355	267	177	132	0
9018	69	184	224	224	184	138	86	69	0
9019	37	108	128	128	108	74	47	37	a
9020	46	140	172	172	140	106	64	46	0
9021	98	256	321	321	256	1a9	130	98	0
9022	18	51	60	60	51	32	25	18	0
9023	206	578	686	724	578	406	291	206	0
9024	121	314	394	39:	314	237	156	121	0
9025	45	130	159	159	130	97	59	45	0
9015	148	390	490	490	390	293	200	148	a
9011	174	45a	575	575	458	346	234	174	0
9010	553	1471	1830	1830	1471	1102	738	553	0
9009	251	656	818	818	656	490	327	251	0
9008	a2	223	274	274	223	163	108	82	0
9007	230	615	772	772	615	462	310	230	a
9006	77	216	265	265	216	161	103	77	0
9005	314	824	1028	1028	a24	615	415	314	0
9004	419	1112	1380	1380	1112	a27	550	418	0
9003	327	aao	1095	1095	880	659	439	333	0
9002	401	1068	1332	1332	1068	801	535	407	0
9026	43	125	154	154	125	90	59	43	0
9016	33	94	114	114	94	66	45	33	0

0TOTAL VEHICLE FLOW RATES ENTERING THE NETWORK DURING EACH TIME SLICE (VEH/H)

	10251	27315	34026	34026	27315	20359	13620	10262	0

FIGURE 7.7

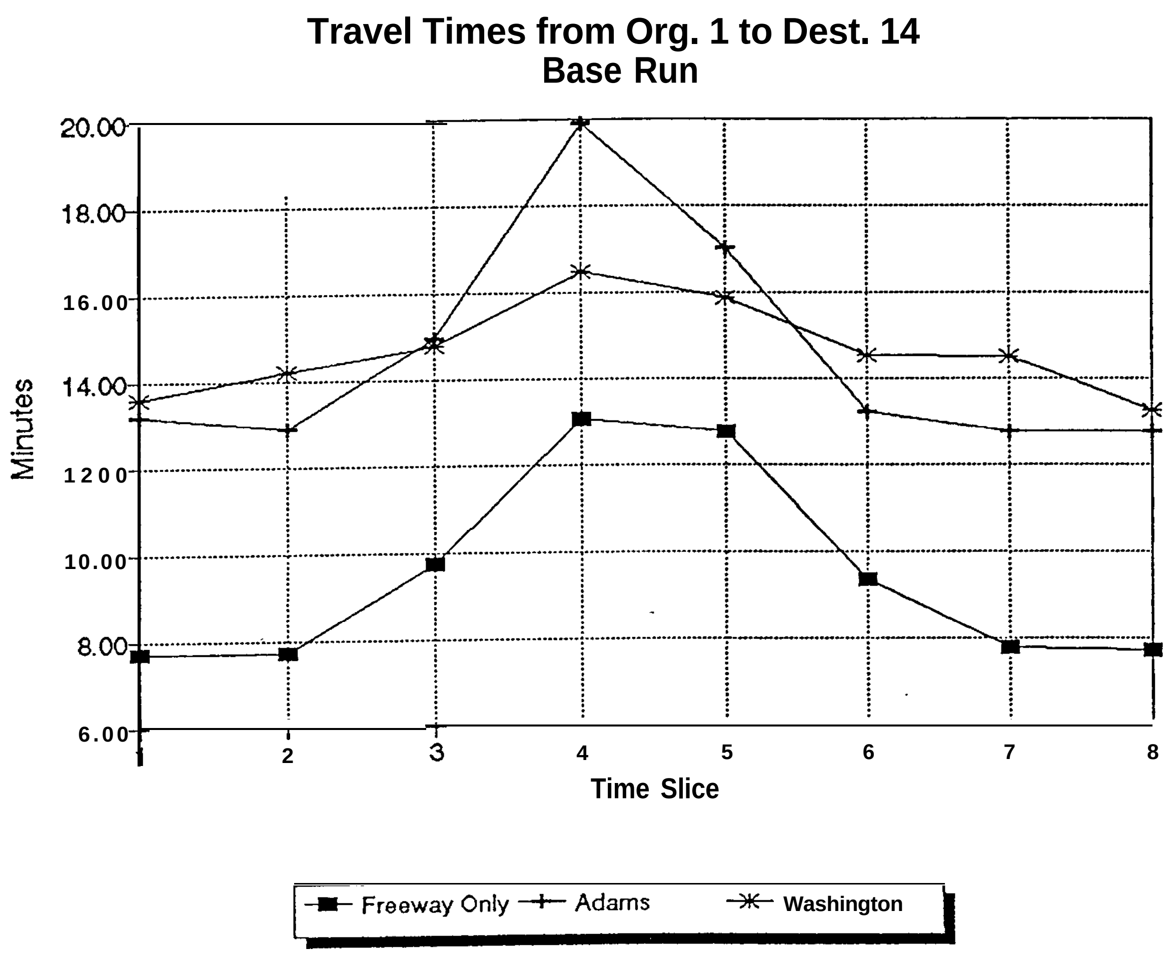
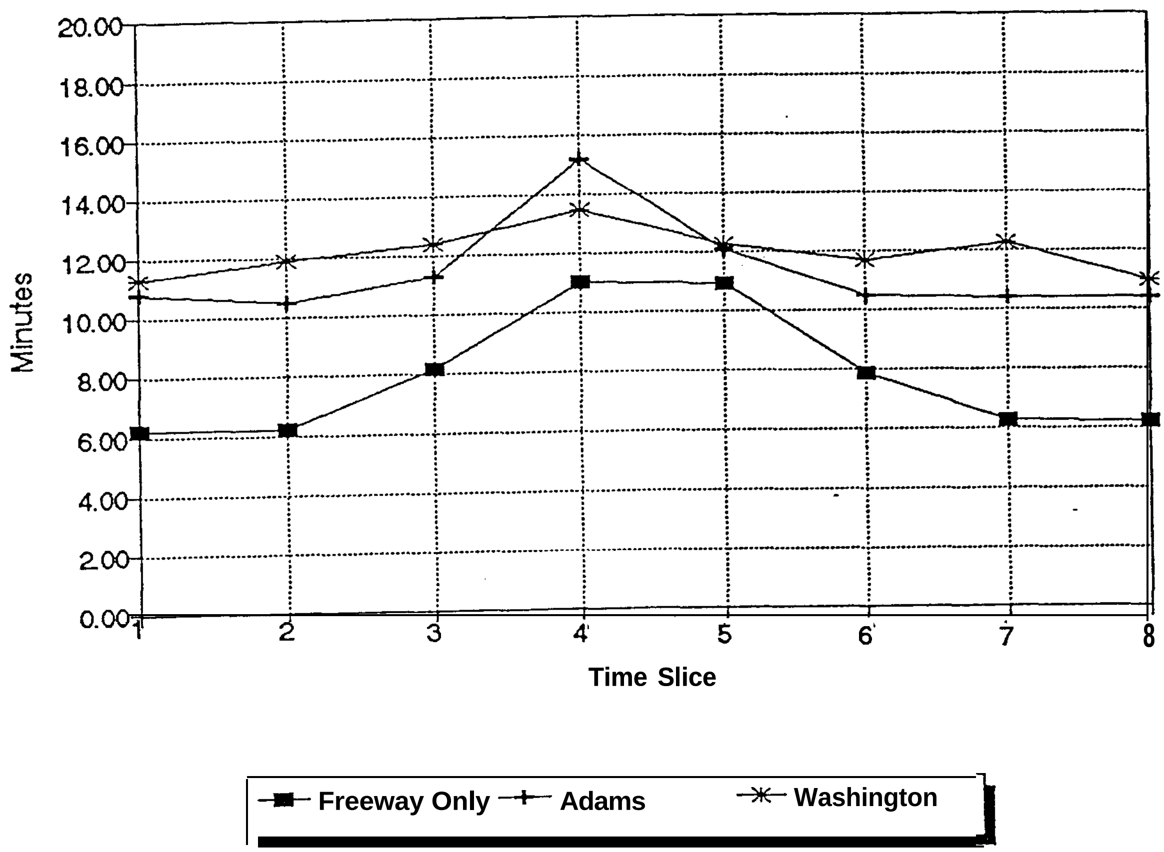

Travel Times from Org. 1 to Dest. 14
Base Run
Minutes
20.00
18.00
16.00
14.00
1200
10.00
8.00
6.00
1
2
3
4
5
6
7
8
Time Slice
Freeway Only
Adams
Washington

FIGURE 7.8

Equal Distance Travel Times
Base Run



Thus, by using UFPASC a number of origin destination pairs were chosen and evaluated. An example of such an output is shown in Figure 7.9. As seen in the figure, the route chosen by most is that of the freeway. The average speeds and travel times shown in the figure represent averages over all time slices. The routes chosen from origin to destination were also examined to make sure they were reasonable.

7.4.2 Bottleneck Location/Queuing Pattern

A key validation measure was that of freeway bottleneck location and queue length. Bottlenecks were identified in subsections 14 and 29 which match the work reported in Chapter 6. While the bottlenecks were identified in the same subsections as before, the queuing pattern was not exactly the same. Since the demand pattern is much more complex, it was not possible to achieve the same queuing pattern as before. However, the pattern as shown in Figure 7.10 does closely match that of the work described in Chapter 6. The main difference between the previous freeway-only work and the corridor base simulation run is that the queues do not back up as far from subsection 29 as before. In the freeway-only work, the queues from subsections 14 and 29 collided. In the base reference assignment, the queuing is not as severe as that described in Chapter 6 where the freeway only is modelled. However, because the bottlenecks were properly identified and the demand patterns were reasonable it was felt that existing queuing pattern shown in Figure 7.10 was acceptable to continue with the experiment. Therefore, it was concluded that comparisons made to the base reference assignments would be acceptable for analysis.

7.4.3 Overall Corridor Wide Summary Information

From a system-wide perspective, the amount of free moving delay compared to the amount of flow delay and delay caused by queuing was examined for its reasonableness. The total distance travelled, the overall network speed, and the total final queues were all examined for reasonableness. Table 7.2 presents the overall network summary information for the base reference corridor assignment. As seen in the table, the overall network speed is approximately 30 miles per hour which is in a reasonable range. The total freemoving time as compared to the delay due to queuing is also in a reasonable range. Appendix E contains a condensed input and output of the base reference assignment.

FIGURE 7.9
UFPASC EXAMPLE OUTPUT

ROUTE INFORMATION

**** Origin 5001 and Destination 9015

TABLE Of ROUTES

```
Route Links on Route ---->
No.

  1     7     8     9    10    11    12    13    14    15    16  --,
-->    17    18    19    20    21    22    23    24    25    26  -->
-->    27  1205  1001   909   205
  2     7     8     9    10    11    12    13  14    15    16  -->
-->    17    18    19    20    21    22    23  2205  2101  2009  -->
-->  1505   905   205
  3     7     8     9    10    11    12    13    14    15    16  -->
-->    17    18    19    20    21  2705  2601  2501  2005  1505  -->
-->   905   205
  4     7  5305  4905  4801  4701  4603  7605  4105  3505  3005  -->
--> .2505  2005  1505   905 -  205
-->
  5     7     8     9    10  4805  4601  7605  4105  3505  3005  -->
-->  2505  2005  1505   905   205
-->
```

TABLE OF FLOWS (Vehicles)

Route NO.	Veh. Type	Time Intervals 1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL FLOW (VEH)	ROUTE DIST. (M)	OVERALL AVE.JOU. TIME	OVERALL AVE. SPEED
1	c	22	59	74	38	19	44	30	22	0	0	0	0	0	308	10532	646	57.6
2	c	0	0	0	14	15	0	0	0	0	0	0	0	0	29	13390	836	57.6
3	C	0	0	0	8	0		0	0	0	0	0	0	0	8	12226	846	50.4
4	C	0	0	0	14	0	0	0	0	0	0	0	0	0	14	11951	1010	39.6
5	C	0	0	0	0	15	0	0	0	0	0	0	0	0	15	12169	843	50.4
TOTALS		22	59	74	74	49	44	30	22	0	0	0	0	0				

0 0 0 0

--

FIGURE 7.10
QUEUING PA'ITERN - REFERENCE BASE ASSIGNMENT

1 LINK-BY-LINK ALL-TIME-SLICES - MEAN FINAL QUEUES (VEH) RUN ON 11/ 6/91

SHART CORRIDOR BASE RUN NETWORK and TIME DATA (6/11/91)
SHART CORRIDOR BASE DEMAND
SHART CORRIDOR COHTROL DATA

ITERATION NUMBER 3

LINK NO.& TYPE	TIME SLICES : 1 600 630	2 630 700	3 700 730	4 730 800	5 800 830	6 830 900	7 900 930	8 930 1000	9 1000 1300	TOTAL FINAL QUEUES
7U	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
au	.0	.0	68.0	334.0	.0	.0	.0	.0	.0	402.0
9U	.0	.0	87.0F	94.0F	20.0	.0	.0	.0	.0	201.0
10U	.0	.0	46.0F	44.0F	74.0F	.0	.0	.0	.0	164.0
11U	.0	.0	110.0F	122.0F	126.0F	.0	.0	.0	.0	358.0
12U	.0	.0	122.0F	137.0F	156.0F	.0	.0	.0	.0	415.0
13u	.0	.0	275.0F	257.0F	251.0F	.0	.0	.0	.0	783.0
14U	.0	.0	37.0F	76.0F	39.0F	.0	.0	.0	.0	152.0
15u	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
16U	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
17U	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
18U	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
19U	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
20U	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
21U	.0	.0	53.0	.0	52.0	.0	.0	.0	.0	105.0
22U	.0	.0	.0	143.0	199.0F	.0	.0	.0	.0	342.0
23U	.0	.0	.0	120.0F	112.0F	.0	.0	.0	.0	232.0
24U	.0	.0	14.0	121.0F	140.0F	.0	.0	.0	.0	275.0
25U	.0	.0	103.0F	144.0F	137.0F	.0	.0	.0	.0	384.0
26U	.0	.0	214.0F	201.0F	193.0F	.0	.0	.0	.0	608.0
27U	.0	.0	67.0F	66.0F	103.0F	71.0F	.0	.0	.0	307.0
28U	.0	.0	154.0F	147.0F	126.0F	120.0F	.0	.0	.0	547.0
29U	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
30U	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
31u	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
32u	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
50U	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
51u	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

TABLE 7.2
BASE REFERENCE ASSIGNMENT SUMMARY INFORMATION

SUMMARY INFORMATION CONTRAM 5.14 (16. 4.91) RUN ON 11/ 6/91

SMART CORR'IDOR BASE RUN NETWORK and TIME DATA (6/11/91)
SMART CORRIDOR BASE DEMAND
SMART CORRIDOR CONTROL DATA

ITERATION NUMBER 3

TIME SLICES :	1	2	3	4	5	6	7	a	9	TOTALS
	600	630	700	730	800	a30	900	930	1000 1300	
0 JOURNEY-TIME (VEH-H)										
OFREEMOVING	456.8	1222.2	1560.4	1650.4	1494.7	1099.3	700.3	520.1	43.1	8747.3
FLOW DELAY	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
QUEUEING	33.8	140.3	543.3	1101.4	1144.8	465.2	65.4	37.4	1.2	3612.9
TOTAL	490.7	1362.5	2103.6	2831.8	2639.5	1564.4	765.8	557.5	44.3	12360.1
0 DISTANCE TRAVELLED (VEH-KM)										
0	36981.5	98906.8	123665.	127436.	115655.	88215.8	56937.3	42310.3	3703.4	693810.9
0 OVERALL NETUORK SPEED (KM/H)										
0	75.4	72.6	58.8	45.0	43.8	56.4	74.4	75.9	83.6	56.1
0 TOTAL FINAL QUEUES (VEH)										
0	69.2	354.4	3425.9	5910.4	4720.9	832.2	109.3	76.7	.0	15499.0
0										
0 FUEL CONSUMPTION (LITRES)										
OTRAVELLING	3952.4	10530.7	13255.3	13395.8	12199.2	9563.2	6140.1	4530.5	408.9	73976.0
QUEUEING	14.3	144.8	702.3	1573.5	1528.3	597.2	49.0	17.6	.0	4627.1
TOTAL	3966.7	10675.5	13957.6	14969.3	13727.5	10160.5	6189.1	4548.1	408.9	78603.1
0 TOTAL LINK COUNTS (VEH)										
OARRIVALS	78446	208733	257975	259595	234424	185418	121677	90337	8483	1445088
PCU FACTOR	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
STOPS	6046	17377	70741	77738	66095	36199	10008	6701	247	291152
% STOPPED	7.7	a.3	27.4	29.9	28.2	19.5	8.2	7.4	2.9	20.1

OPACKET SIZE WITHIN EACH O-D MOVEMENT IS VARIABLE

TOTAL NUMBER OF PACKETS ENTERING THE NETWORK	12735	ROUTES AND ROUTE MEMORY:	
TOTAL NUMBER OF VEHICLES	88529	MEAN LINKS PER ROUTE	16.32
TOTAL NUMBER OF PCUS	88529	WORDS AVAILABLE	3806309 (CUT OF 3808437)
MEAN PCU FACTOR	1 . 0 0	USED PER ITERATION	18927
		CODONS PER WORD	10

8.0 INCIDENT MODELLING

The purpose of this chapter is to describe the techniques applied within the CONTRAM model and to report the results of modelling an incident on the freeway. The incidents modelled, the techniques applied within CONTRAM, and the results of the efforts are discussed within this chapter. The modelling of an incident on the freeway in conjunction with the modelling of in-vehicle information systems illustrates the benefits to both the equipped vehicles and non-equipped vehicles as well as system-wide results which will be reported in Chapters 9 and 10.

8.1 Incident Scenario

Two likely incident scenarios were created to evaluate the potential benefits of in-vehicle information systems. The key elements which comprise the modelling of an incident are:

1) location;
2) severity;
3) duration.

8.1.1 Location

To determine an appropriate location for an incident, the first consideration used was whether or not the location of the incident caused the freeway congestion to back up out of the initial boundary of the freeway or extend beyond the last time slice. If the congestion were to back out of the first subsection on the freeway, the results would be inaccurate as the number of vehicles in the system would not be comparable across different simulation runs.

The second key consideration was to locate an incident in a subsection in such a manner as to cause a congestion pattern quite different from the normal congestion pattern. Thus, the subsections more towards the middle of the freeway section were given consideration as the location of an incident. Two different locations for two separate incident run scenarios were chosen to simulate. The first incident was located in subsection 20. The second run was made with an incident in subsection 22.

8.1.2 Incident Severity and Duration

Many different types of incidents can occur on a freeway section. An incident on the freeway typically reduces the capacity of the subsection where the incident occurred. This capacity reduction can be at various levels and extend over time in different patterns. The following paragraphs describe the two separate incidents modelled.

8.1.2.1 Slight Incident

The first incident (hereafter referred to as the slight incident scenario), was modelled as occurring in subsection 20. The incident began in time slice 4 and reduced the capacity from 10900 vph to 7500 vph for the 30 minutes in time slice 4. The incident was modelled to last into time slice 5. During time slice 5, the capacity was reduced from 10900 vph to 8500 vph. This incident is the equivalent of having approximately one and a half lanes blocked in time slice 4, while in time slice 5, one-half lane is re-opened.

8.1.2.2 Severe Incident

The second incident (hereafter referred to as the severe incident), was modelled as occurring in subsection 22. The incident began in time slice 3 and reduced the capacity from 12100 vph to 6900 vph for the one hour in time slices 3 and 4. This incident is the equivalent of having approximately two and a half lanes blocked.

8.2 Incident Modelling Within CONTRAM

The following sections outline the methodology and results of the slight and severe incident simulation runs. Along with results, conclusions are presented at the end of the chapter.

8.2.1 Methodology

The following procedures were used to model an incident within CONTRAM. The first step in the process was to make a base run in CONTRAM with the capacity reduced in the subsection where the incident has occurred. This was accomplished through the use of Card Type 12. Card Type 12 allows the user to override any capacities calculated by CONTRAM except smaller reduced capacities arising from blocking back. The. link number is entered followed by the capacity of the link in each corresponding time slice.

A three-step process is conducted to model an incident within CONTRAM. The first step in the process is to make a base run (described in Chapter 7), whereby all drivers have 100 percent information and are taking their shortest routes. The second step involves the use of RODIN as described in Chapter 4. A RODIN run is conducted with no vehicles having information systems thereby being set to their fixed routes. The final step in the process is to make another CONTRAM run with the new network where the capacity of the subsection is reduced through the use of Card Type 12.

8.2.2 Results

Figure 8.1 presents the output queuing pattern on the eastbound Santa Monica for the slight incident scenario and the base run (described in Chapter 7). Based on a comparison of Figures 7.10 and 8.1 it can be concluded that the slight incident scenario does not change the queuing pattern substantially. It should also be noted that there is little increase in the amount of congestion as a result of the incident. Table 8.1 presents the network wide summary information for the slight incident as well.

Figure 8.2 presents the output queuing pattern on the eastbound Santa Monica for the severe incident and the base run. As a result of the incident, the more queuing occurs and the pattern changes. There is a significant increase in the amount of congestion as a result of the incident. Table 8.2 presents the network-wide summary information for severe incident as well.

As a result of the incident runs, questions began to arise as to both the severity and duration of the congestion as predicted by CONTRAM in both incident situations. Therefore, a FREQ analysis was conducted to compare the queuing pattern projected by FREQ to that provided by CONTRAM. Figure 8.3 presents the queuing pattern for both the slight and severe incident as predicted by FREQ. As seen in the figure, the congestion predicted by CONTRAM is not nearly as severe or as long lasting as that of FREQ.

Due to time constraints, a thorough investigation as to why the discrepancies occurred could not be conducted. Thus, it was concluded that despite the fact that congestion was much less severe in CONTRAM than as predicted by FREQ, an analysis would be conducted using the severe incident scenario since, as a result of the incident, there was a change in the queuing pattern and an increase in the amount of congestion on the freeway. This deficiency in CONTRAM will be discussed later. Since the slight incident scenario did not result in much change in the queuing pattern on the freeway and not

FIGURE 8.1
QUEUING PATTERN - SLIGHT INCIDENT
(EB SANTA MONICA)

...

1 LINK-BY-LINK ALL-TIME-SLICES - MEAN FINAL QUEUES (VEH) RUN ON 10/ 6/91

SMART CORRIDOR INCIDENT RUN NETWORK and TIME DATA (6/10/91)
SMART CORRIDOR BASE DEMAND (0 % guided)
SMART CORRIDOR CONTROL DATA

ITERATION NUMBER 3

TIME SLICES :

LINK NO.8 TYPE	1	2	3	4	5	6	7	8	9	TOTAL FINAL QUEUES
	600–630	630–700	700–730	730–800	800–830	830–900	900–930	930–1000	1000–1300	
7U	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
8U	.0	.0	191.0	668.0	94.0	.0	.0	.0	.0	953.0
9U	.0	.0	55.0F	35.0F	67.0F	.0	.0	.0	.0	157.0
10U	.0	.0	65.0F	42.0F	37.0F	.0	.0	.0	.0	144.0
11U	.0	.0	103.0F	136.0F	131.0F	.0	.0	.0	.0	370.0
12U	.0	.0	151.0F	136.0F	148.0F	.0	.0	.0	.0	435.0
13u	.0	.0	276.0F	260.0F	250.0F	.0	.0	.0	.0	786.0
14U	.0	.0	44.0F	37.0F	55.0F	.0	.0	.0	.0	136.0
15U	.0	.0	.0	35.0F	47.0F	.0	.0	.0	.0	82.0
16U	.0	.0	1.0	105.0F	105.0F	.0	.0	.0	.0	211.0
17U	.0	.0	.0	160.0F	160.0F	.0	.0	.0	.0	320.0
18U	.0	.0	.0	195.0F	168.0F	.0	.0	.0	.0	363.0
19U	.0	.0	.0	255.0F	244.0F	.0	.0	.0	.0	499.0
20U	.0	.0	.0	122.0F	115.0F	.0	.0	.0	.0	237.0
21U	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
22u	.0	.0	.0	.0	28.0	.0	.0	.0	.0	28.0
23U	.0	.0	.0	82.0	108.0F	.0	.0	.0	.0	190.0
24U	.0	.0	5.0	121.0F	145.0F	.0	.0	.0	.0	271.0
25U	.0	.0	99.0F	109.0F	120.0F	.0	.0	.0	.0	328.0
26U	.0	.0	184.0F	183.0F	182.0F	111.0	.0	.0	.0	660.0
27-U	.0	.0	99.0F	63.0F	107.0F	66.0F	.0	.0	.0	335.0
28U	.0	.0	120.0F	121.0F	160.0F	122.0F	.0	.0	.0	523.0
29U	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
3ou	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
31u	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
32U	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
5ou	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
51U	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

FIGURE 8.2
QUEUING PATTERN - SEVERE INCIDENT
(EB SANTA MONICA)

1 LINK-BY-LINK ALL-TIME-SLICES - MEAN FINAL QUEUES (VEH) RUN ON 8/ 6/91

SMART CORRIDOR INCIDENT RUN NETWORK and TIME DATA (6/8/91)
SMART CORRIDOR INCIDENT RUN NETWORK and TIME DATA (6/8/91)
SMART CORRIDOR CONTROL DATA

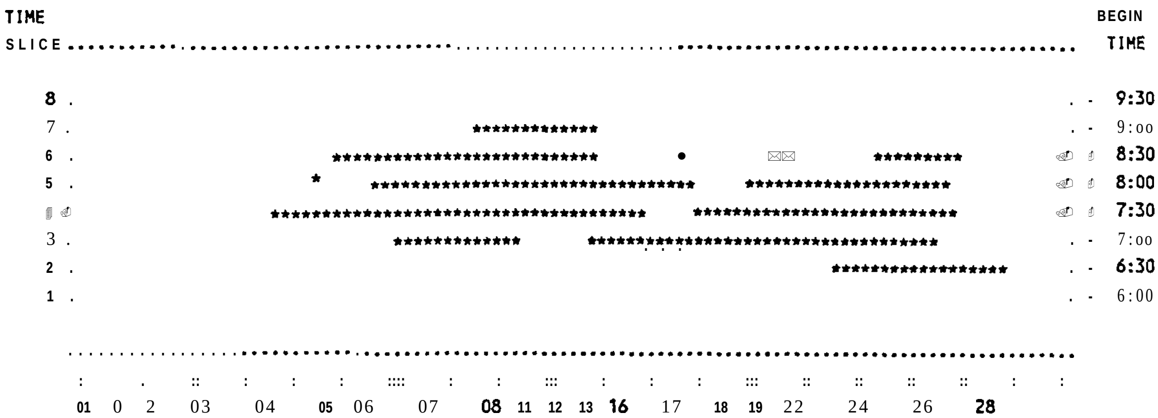
ITERATION NUMBER 3

LINK NO.8 TYPE	TIME SLICES : 1	2	3	4	5	6	7	8	9	TOTAL FINAL QUEUES
	600 630	630 700	700 730	730 800	800 830	830 900	900 930	930 1000	1000 1300	
7u	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
8U	.0	.0	502.0	1803.0	1308.0	398.0	.0	.0	.0	4011.0
9u	.0	.0	44.0F	61.0F	43.0F	38.0F	.0	.0	.0	186.0
10U	.0	.0	42.0F	35.0F	62.0F	37.0F	.0	.0	.0	176.0
11U	.0	.0	107.0F	105.0F	103.0F	117.0F	.0	.0	.0	432.0
12U	.0	.0	121.0F	125.0F	121.0F	120.0F	.0	.0	.0	487.0
13u	.0	.0	273.0F	250.0F	259.0F	250.0F	.0	.0	.0	1032.0
14u	.0	.0	37.0F	37.0F	64.0F	45.0F	.0	.0	.0	183.0
15U	.0	.0	39.0F	51.0F	28.0F	.0	.0	.0	.0	118.0
16U	.0	.0	123.0F	97.0F	94.0F	.0	.0	.0	.0	314.0
17U	.0	.0	177.0F	166.0F	43.0	.0	.0	.0	.0	386.0
18U	.0	.0	173.0F	195.0F	176.0F	.0	.0	.0	.0	544.0
19U	.0	.0	286.0F	254.0F	264.0~	148.0	.0	.0	.0	952.0
20u	.0	.0	96.0F	87.0F	103.0F	94.0F	.0	.0	.0	380.0
21U	.0	.0	108.0F	117.0F	91.0F	99.0F	.0	.0	.0	415.0
22u	.0	.0	200.0F	232.0F	.0	36.0	.0	.0	.0	468.0
23U	.0	.0	.0	.0	.0	129.0F	.0	.0	.0	129.0
24U	.0	.0	.0	.0	71.0	130.0F	.0	.0	.0	201.0
25U	.0	.0	.0	.0	94.0F	98.0F	.0	.0	.0	192.0
26U	.0	.0	.0	.0	186.0F	182.0F	.0	.0	.0	368.0
27U	.0	.0	.0	.0	62.0F	66.0F	.0	.0	.0	128.0
28U	.0	.0	.0	.0	120.0F	137.0F	.0	.0	.0	257.0
29U	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
30u	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
31U	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
32U	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
50U	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
51U	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

FIGURE 8.3
QUEUING PATTERN - SLIGHT AND SEVERE INC. (FREQ)

CONTOUR DIAGRAM OF
QUEUE LENGTH
BEFORE ENTRY CONTROL

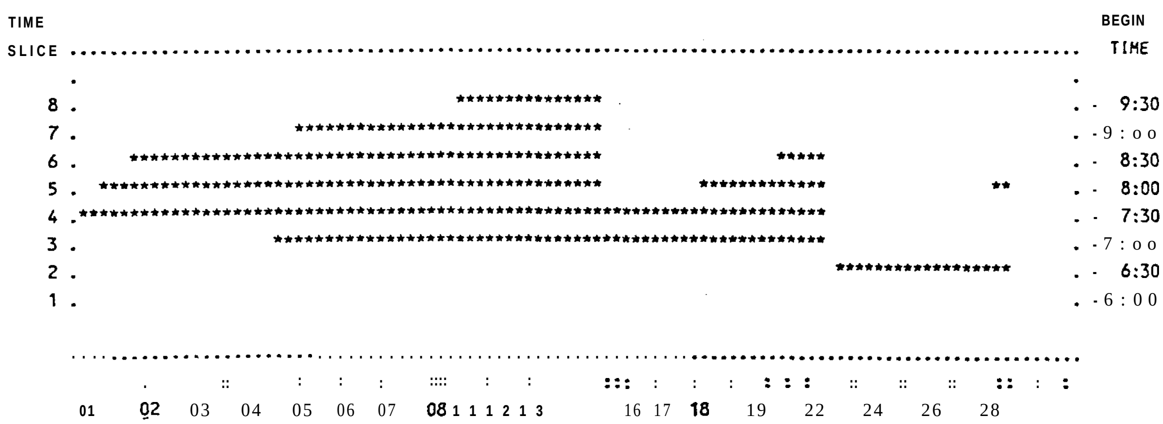
SLIGHT INCIDENT



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

CONTOUR DIAGRAM OF
QUEUE LENGTH
BEFORE ENTRY CONTROL

SEVERE INCIDENT



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.)

TABLE 8.1
SLIGHT INCIDENT ASSIGNMENT
SUMMARY INFORMATION

1 SUMMARY INFORMATION CONTRAM 5.14 (16. 4.91) RUN ON 10/6/91

SMART CORRIDOR INCIDENT RUN NETWORK and TIME DATA (6/10/91)
SMART CORRIDOR BASE DEMAND (0% guided)
SMART CORRIDOR CONTROL DATA

ITERATION NUMBER 3

	1	2	3	4	5	6'	7	a	9	
TIME SLICES :	600	630	700	730	800	a30	900	930	1000	1300

										TOTALS
0 JOURNEY-TINE (VEH-H)										
OFREEMOVING	456.9	1219.3	1565.1	1584.7	1447.5	1188.9	706.7	520.6	43.0	8732.6
FLOW DELAY	.0	.O	.O	.O	.O	.0	.0	.O	.O	.O
OUEUEING	33.9	153.9	610.1	1222.5	1324.3	562.4	84.9	36.8	1.1	4029.9
TOTAL	490.8	1373.2	2175.3	2807.2	2771.0	1751.3	791.5	557.3	44.1	12762.5
0 DISTANCE TRAVELLED (VEH-KM)										
0	36977.0	98592.9	123565.	122527.	112795.	95287.0	57441.4	42351.5	3696.9	693233.3
0 OVERALL NETWORK SPEED (KM/H)										
0	75.3	71.a	56.8	43.6	40.7	54.4	72.6	76.0	83.8	54.3
0 TOTAL FINAL QUEUES(VEH)										
0	68.8	403.1	3301.3	7050.8	6403.4	1334.8	110.5	74.7	.0	18747.4
0										
0 FUEL CONSUMPTION(LITRES)										
OTRAVELLING	3951.3	10i83.3	13110.4	12805.8	11975.5	10304.3	6191.4	4535.1	408.0	73764.9
QUEUEING	14.4	161.7	795.0	1624.2	1765.6	723.0	77.0	16.8	.0	5177.7
TOTAL	3965.6	10645.0	13905.4	14430.0	13741.1	11027.3	6268.4	4551.8	408.0	78942.7
0 TOTAL LINK COUNTS(VEH)										
OARRIVALS	78427	207885	257125	250230	230611	198248	122490	90386	8467	1443869
PCU FACTOR	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
STOPS	6052	17427	65667	70937	68376	45214	11000	6668	242	291582
% STOPPED	7.7	6.4	25.5	28.3	29.6	22.8	9.0	7.4	2.9	20.2

OPACKET SIZE WITHIN EACH O-D MOVEMENT IS VARIABLE

TOTAL NUMBER OF PACKETS ENTERING THE NETWORK	12735	ROUTES AND ROUTE MEMORY:	
TOTAL NUMBER OF VEHICLES	88529	HEAR LINKS PER ROUTE	16.31
TOTAL NUMBER OF PCUS	88529	WORDS AVAILABLE	3806309 (OUT OF 380'3437)
MEAN PCU FACTOR	1.00	USED PER ITERATION	la.561
		CODONS PER WORD	10

TABLE 8.2
SEVERE INCIDENT ASSIGNMENT
SUMMARY INFORMATION

• ·.

1 **SUMMARY INFORMATION** CONTRAM 5.14 (16. 4.91) RUN ON 8/6/91

SMART CORRIDOR INCIDENT RUN NETWORK and TIME DATA (6/8/91)
SMART CORRIDOR INCIDENT RUN NETWORK and TIME DATA (6/8/91)
SMART CORRIDOR CONTROL DATA

ITERATION NUMBER 3

TIME SLICES :	1	2	3	4	5	6	7	8	9	
	600	630	700	730	800	830	900	930	1000	1300

										TOTALS
0 JOURNEY-TIME (VEH-H)										
OFREEMOVING	456.9	1219.3	1482.4	1475.7	1475.9	1256.6	001.8	521.1	43.0	0732.6
FLOW DELAY	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
QUEUEING	33.9	153.9	691.7	1715.0	2275.9	1342.8	202.5	44.0	1.1	6460.8
TOTAL	490.8	1373.2	2174.0	3190.6	3751.8	2599.4	1004.3	565.1	44.2	15193.5
0 DISTANCE TRAVELLED (VEH-KM)										
0	36977.0	98594.2	116480.	113567.	115141.	100840.	65549.4	42385.6	36W.0	693232.6
0 OVERALL NETWORK SPEED (KM/H)										
0	75.3	71.a	53.6	35.6	30.7	38.8	65.3	75.0	83.7	45.6
0 TOTAL FINAL QUEUES(VEH)										
0	68.8	403.1	4417.5	8404.4	7776.9	3594.7	174.6	76.1	.0	24916.1
0										
0 FUEL CONSUMPTION (LITRES)										
OTRAVELLING	3951.3	10486.2	12574.1	12003.8	12574.7	11162.2	7177.9	4539.2	408.2	74877.4
PUEUEING	14.4	161.7	097.3	2281.5	3083.0	1808.7	235.5	26.1	.0	8508.1
TOTAL	3965.6	10647.9	13471.3	14285.2	15657.7	12970.9	7413.4	4565.3	408.2	03385.5
0 TOTAL LINK COUNTS(VEH)										
OARRIVALS	70427	207885	241592	230516	235125	210443	140889	90521	8471	1443869
PCU FACTOR	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
STOPS	6052	17427	57331	60150	84629	66404	15728	6734	243	314700
% STOPPED	7.7	a.4	23.7	26.1	36.0	31.6	11.2	7.4	2.9	21.8

OPACKET SIZE WITHIN EACH O-D MOVEMENT IS VARIABLE

TOTAL NUMBER OF PACKETS ENTERING THE NETWORK	12735
TOTAL NUMBER OF VEHICLES	88529
TOTAL NUMBER OF PCUS	85529
MEAN PCU FACTOR	1.00

ROUTES AND ROUTE MEMORY:

MEAN LINKS PER ROUTE	Ib.31
WORDS AVAILABLE	3806309 (OUT OF 3808437)
USED PER ITERATION	18710
CODONS PER WORD	10

1 CONVERGENCE MONITOR - SUMMARIES OF JOURNEY-TINES. DISTANCES AND CHANGES-FOR ALLITERATIONS RUN ON 8/ b/91

much increase in congestion, it was determined that the remaining analysis would focus on the results provided by the severe incident.

9.0 SIMULATION RESULTS UNDER SEVERE INCIDENT SCENARIO

The purpose of this chapter is to describe the methodology and analysis results of the investigation into the benefits derived from in-vehicle information systems under the severe incident scenario. The first part of the chapter describes the methodology and techniques used to obtain results from the modelling process. The results are then broken down into both system-wide performance measures and benefits for both guided and unguided vehicles.

9.1 Methodology: Modelling Guidance Systems in CONTRAM

In order to model guidance systems within the CONTRAM model the RODIN program as described in Chapter 4 was used. RODIN is external software program developed by Nick Taylor (TRRL) and is intended to simulate route guidance. This program converts a packet route file output produced by a standard CONTRAM into an origin-destination matrix and a set of routes which it embeds as fixed routes in a copy of the network file. The origin-destination movements are duplicated and each set is preceded by a percentage multiplying or split factor. The network and demand files are then rerun in RODIN. The first set of origins-destinations is assigned on the fixed routes (i.e. along the original routes, which are the minimum time path routes before the incident), while the second set is assigned to minimum cost routes. This provides a framework in which experiments involving two user classes (guided and unguided vehicles) can be performed.

RODIN is also designed to provide:

- a choice of methods for setting packet sizes;
- alternate vehicle class for the second set of 0-Ds;
- randomization of the output O-D counts.

An important point about this procedure is that the fixed and free routed trips are dynamically integrated so that each affects the routes of the others in an expected way.

Once a RODIN base run under the severe incident scenario with 0 percent equipped vehicles was complete, a series of CONTRAM runs with varying percentages of equipped vehicles was chosen to be evaluated under the severe incident scenario. The percentages of in-vehicle information equipped vehicles chosen for examination was 0, 10, 25, 50, 75, 90 and 100. It was felt that a range of 0 to 100 with five points in-between would identify where the benefits would be the greatest and/or would describe any trends that may develop.

9.2 Analysis Results

An analysis of system-wide benefits and benefits to the users and non-users of the in-vehicle information system was conducted. The first step in the process was to evaluate the system wide results via the system-wide measures output from each CONTRAM run for the varying percentages of equipped vehicles under the severe incident scenario. The second phase of the evaluation was through the use of UFPASC as described in Chapter 7.

9.2.1 System-Wide Results

Table 9.1 displays the results from a system-wide perspective. As seen in the table, the results of the simulation under the severe incident situation indicate that 100 percent of the vehicles on the road equipped with in-vehicle information systems provides the greatest benefit to the system in terms of total system travel time, travel time per vehicle, and speed.

Total system travel time is perhaps one of the most important measures of system-wide performance. The total system travel was 12,360 vehicle-hours under the non-incident base run. Under the severe incident scenario but with all unguided vehicles, the total system travel time increased to 15,194 vehicle-hours, a difference of 2,834 vehicle-hours. As the percentage of guided vehicles increased under the incident scenario, the total system travel time decreased from 15,194 to 13,101 vehicle-hours, a reduction of 2,093 vehicle-hours. This would indicate that the adverse effect of the incident was significantly reduced under guided vehicle situations.

In addition to the varying percentages of equipped vehicles under the severe incident scenario, the base run without the incident where all vehicles choose their fastest route is shown. As seen in the table, at 100 percent, equipped vehicles under severe incident conditions, the speeds are only slightly lower and the travel times are only slightly higher than those under the no-incident, 100 percent, guided base run. It also appears as though at either 50 percent equipped vehicles, or 75 percent equipped vehicles, a quirk in the data occurred. For all other percentages between 0 and 50 and 75 to 100 the findings were consistent in that the more equipped vehicles, the more benefit was accrued to the system. However, the data between 50 and 75 percent equipped did not follow that trend. The quirk in the data will be pursued in future research as was not possible in this project.

Table 9.1
System-Wide Results

Percent Vehicles Equipped	0	10	25	50	75	'90	100	Base Run
Avg. Travel Time per Veh (min)	10.30	10.00	9.86	9.44	9.52	9.26	8.88	8.38
Avg. Travel Distance per Veh (mi)	12.53	12.48	12.43	12.48	12.45	12.52	12.59	12.54
Average Speed (mph)	28.5	29.2	29.6	31.0	30.7	31.7	33.3	35.1

Figure 9.1 displays the increase in average speed, network-wide under the severe incident scenario. As seen in the figure, an increase of approximately 17 percent is obtained for 100 percent information-system-equipped vehicles.

The average travel time per vehicle is displayed in Figure 9.2. The travel time per vehicle on average is network wide from each O-D pair. As seen in the figure, the average travel time per vehicle decreases from slightly more than 10 minutes to less than 9 minutes for 100 percent equipped. This represents a reduction of approximately 14 percent over the nine-mile-long, two-mile-wide corridor for each vehicle on average, as presented in Figure 9.3. It is difficult to make conclusive remarks regarding the time saved per vehicle because the average trip length is not very long. An average trip length of over 20 to 25 minutes is more desirable. However, the system-wide results provided by this analysis indicate that the greatest benefits are obtained when all vehicles are equipped with in-vehicle information systems. Assuming optimal data is given to all drivers and that all drivers follow their recommendations.

Figure 9.4 presents the percent decrease in total queues, network-wide under the severe incident scenario. As seen in the figure, a decrease of almost 35 percent is obtained with 100 percent of the vehicles having in-vehicle information. From the figure it can be concluded that the guided vehicles are diverting to avoid the major queues.

Whether or not travellers purchase the IVHS equipment and the various percentages of equipped vehicles occur, depends on two major factors. First, do "IVHS" guided vehicles benefit significantly enough to justify their expenditure of funds for such equipment, and second, will all users and the general public be supported by governmental-supported traffic control centers? In order to begin to address these

FIGURE 9.1

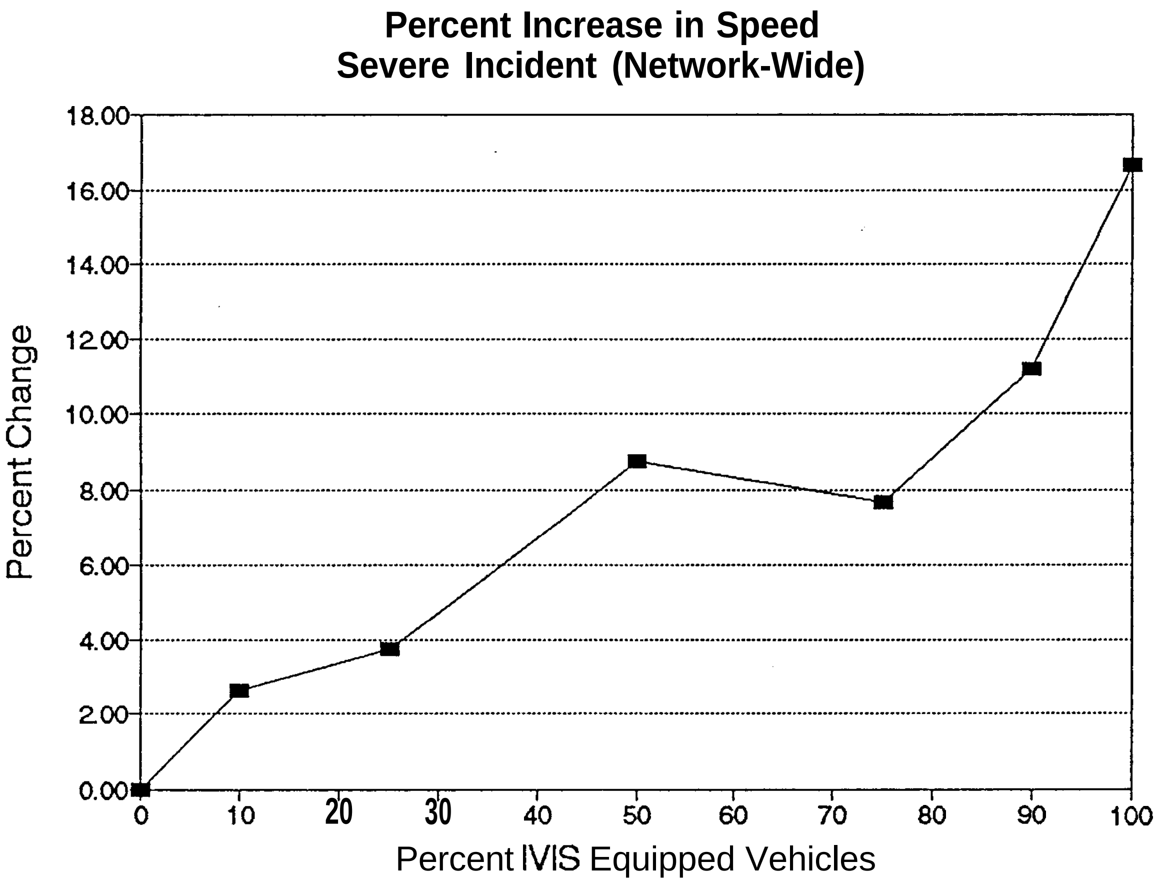

Percent Increase in Speed
Severe Incident (Network-Wide)
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Percent Change
0
10
20
30
40
50
60
70
80
90
100
Percent IVIS Equipped Vehicles

FIGURE 9.2

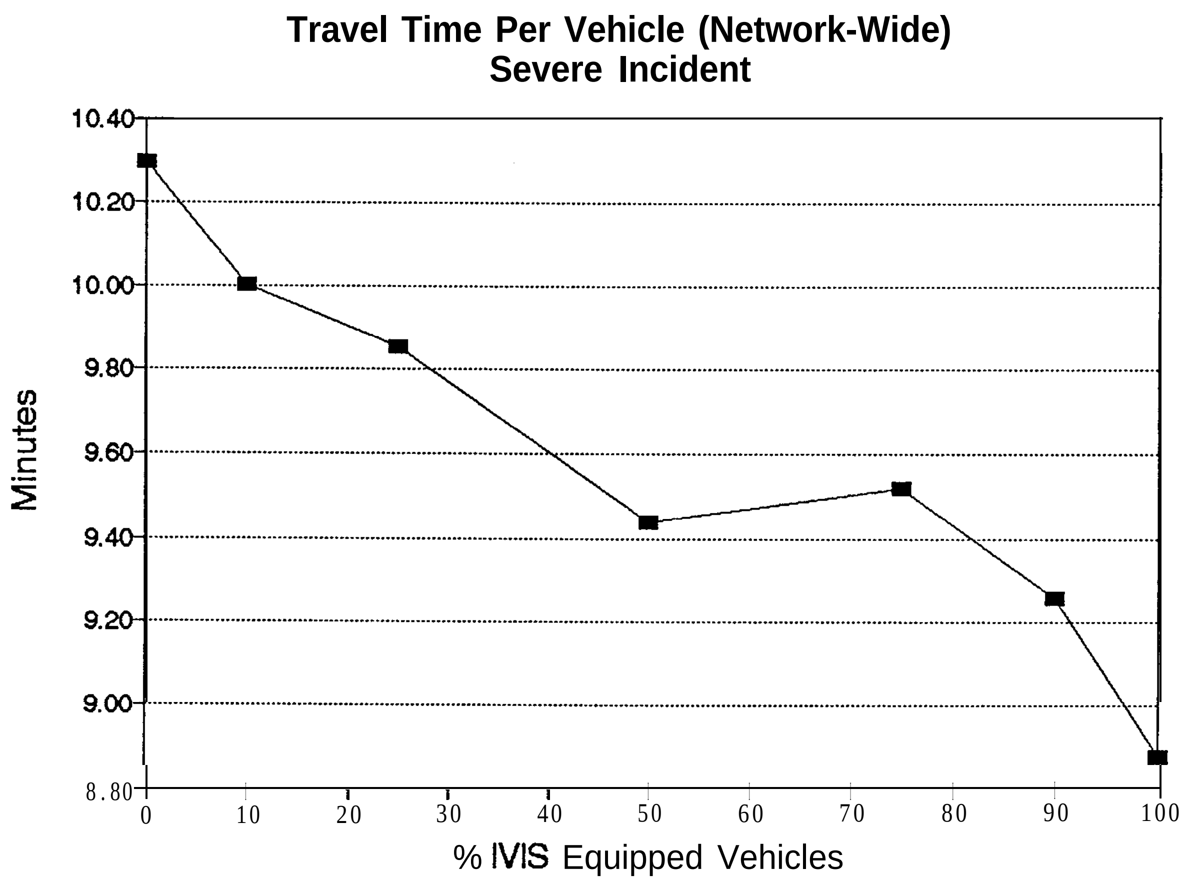

Travel Time Per Vehicle (Network-Wide)
Severe Incident
Minutes
10.40
10.20
10.00
9.80
9.60
9.40
9.20
9.00
8.80
0
10
20
30
40
50
60
70
80
90
100
% IVIS Equipped Vehicles

FIGURE 9.3

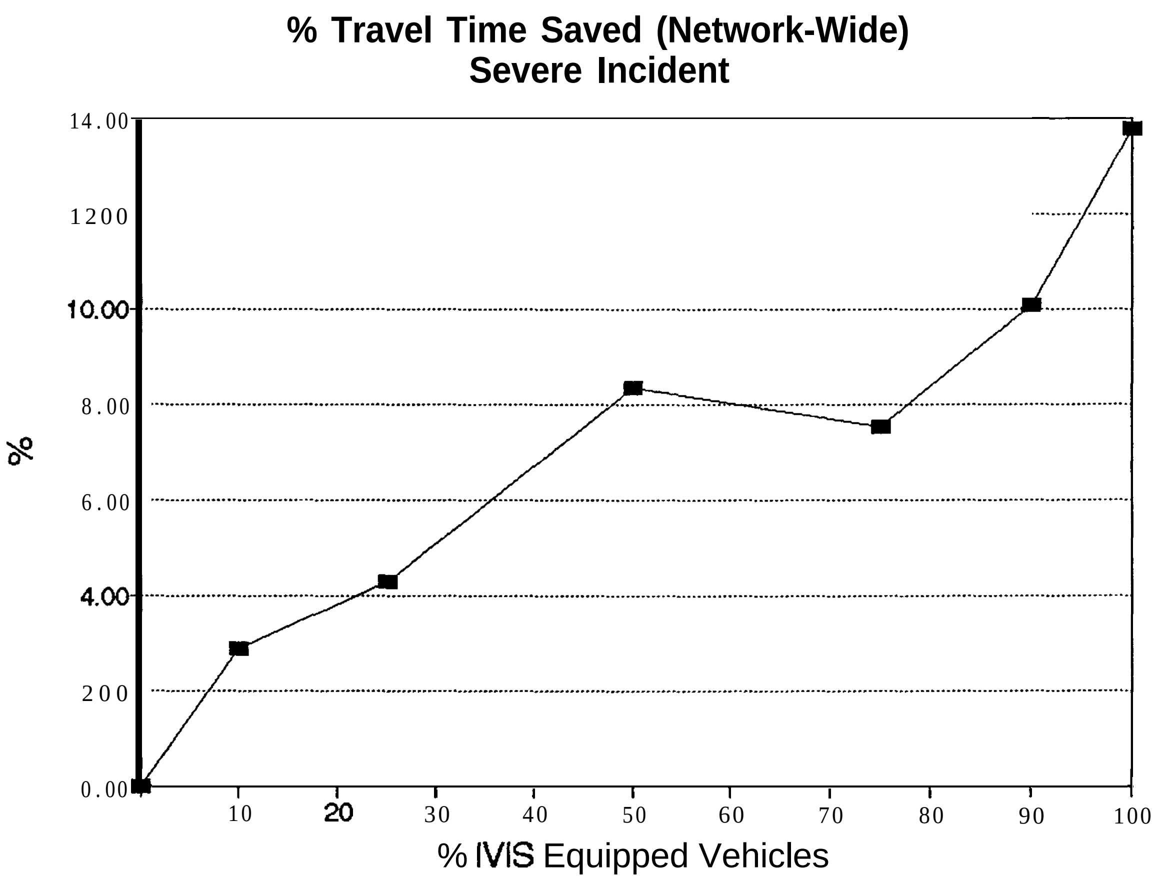
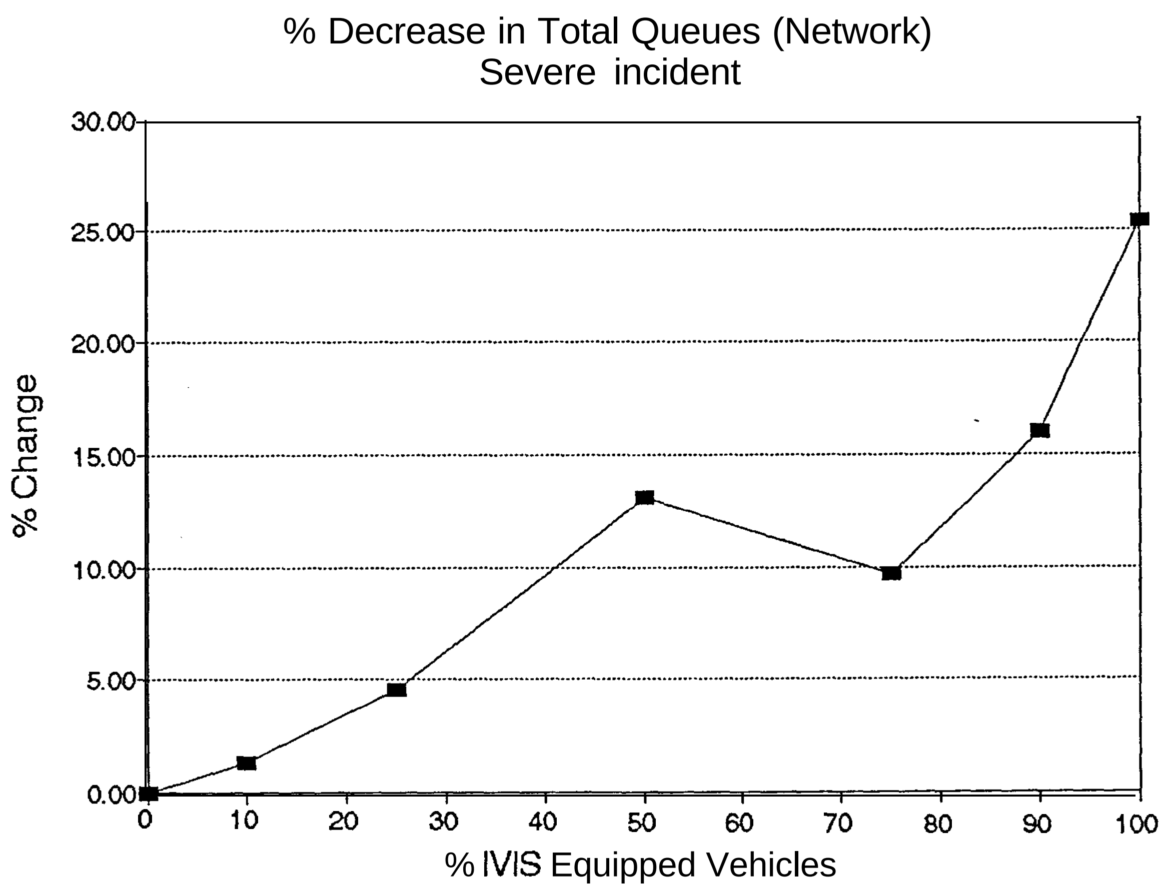

% Travel Time Saved (Network-Wide)
Severe Incident
14.00
1200
10.00
8.00
6.00
4.00
200
0.00
%
10
20
30
40
50
60
70
80
90
100
% IVIS Equipped Vehicles

FIGURE 9.4


% Decrease in Total Queues (Network)
Severe incident
30.00
25.00
20.00
15.00
10.00
5.00
0.00
% Change
0
10
20
30
40
50
60
70
80
90
100
% IVIS Equipped Vehicles

questions, benefits to travellers in guided and unguided vehicles need to be assessed. This initial assessment is discussed in the next section. All benefits are also based on the availability of substantial un-used capacity on the parallel arterials.

9.2.2 Benefits to Guided and Unguided Vehicles

To properly evaluate the benefits to both the guided and non-guided vehicles in the system, a procedure was used whereby two classes of vehicles were set up. The first set of vehicles were those that were considered guided, which were free to be assigned on the fastest routes within CONTRAM. The second class of vehicles were the unguided vehicles, which were the vehicles assigned to the fixed routes that did not change regardless of the incident on the freeway. The primary source of information regarding the benefits that both guided and unguided vehicles obtained with the varying percentages of equipped vehicles under the severe incident scenario on the network came from the UFPASC. The UFPASC (User Friendly Post Analysis System for CONTRAM) is an interactive program for examining the outputs from CONTRAM runs. The UFPASC produces tabular and graphical outputs for selected parameters from the results file produced by CONTRAM. UFPASC uses a menu system to set up the analysis stages for producing the selected outputs. UFPASC allows selective investigations of the .RTE and .PAF files produced by CONTRAM.

Thus, by using the UFPASC, a number of origin-destination pairs were evaluated. The origin-destination pairs were chosen on the basis of three key considerations:

1) The O-D pair had to have a reasonably large demand level, at least enough to draw some reasonable conclusions;

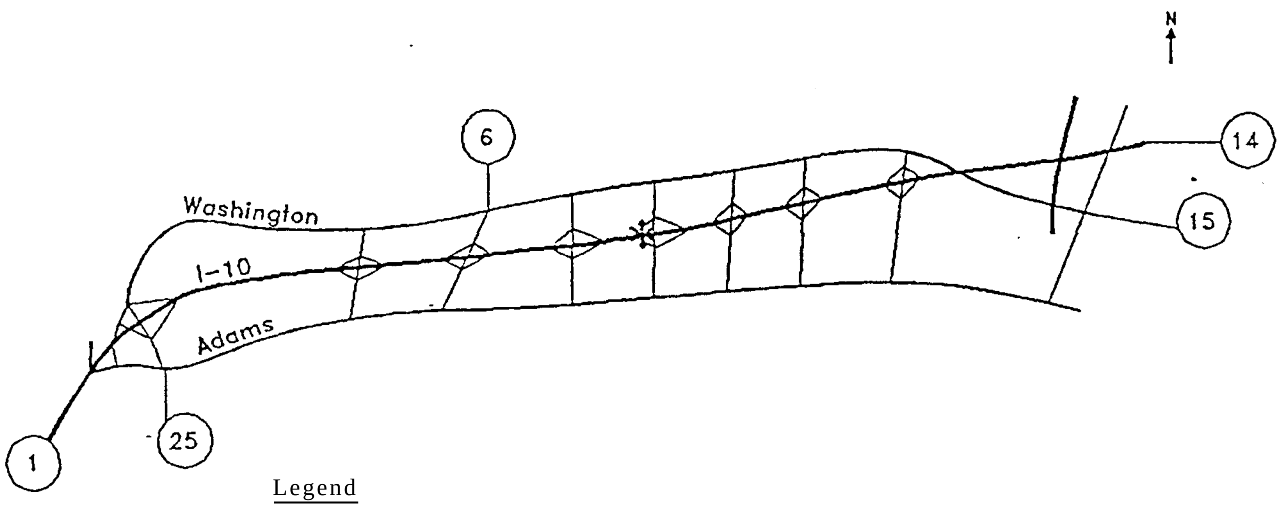
2) The O-D pair had to have the incident on the freeway between the origin and destination. This is a requirement so that there is the opportunity for some significant diversion to occur;

3) Different O-D pairs would be chosen relative to one another so that a cross section of the different areas of the network would be examined and that both Adams Boulevard and Washington Boulevard would have the opportunity to be used.

On this basis three different O-D pairs were chosen. The three different O-D pairs are highlighted in Figure 9.5. The first O-D pair chosen for evaluation was that of origin 6 to destination 14. Origin 6 is off the arterial Washington Boulevard while destination 14 is at the end of the Santa Monica eastbound freeway, The second O-D pair chosen was origin 1 on the western boundary of the Santa Monica

FIGURE 9.5

O/D Pairs Chosen For Evaluation



Legend

(xx) – Origin/Destination

✱ – Location of Severe Incident

freeway to destination 15 at the eastern end of Washington Boulevard off Figueroa. The third origin-destination pair chosen for evaluation was origin 25 off Adams Boulevard to destination 14. Thus, in the three O-D pairs, two originate on the arterial with their final destination being the freeway, while the other pair originates on the freeway and ends on the arterial.

Table 9.2 presents the results for the three origin-destination pairs chosen for evaluation in terms of average speed (mph) and average travel time (min) for both guided and unguided vehicles with the varying percentages of in-vehicle information equipped vehicles. This information is an average over all time slices. Time slice by time slice information is only available for the routes selected, not for the route time, distance, and speed. Figures 9.6 - 11 present the information from Table 9.2 in graphical form.

As seen in the figures, the guided vehicles have a higher speed and shorter travel time to the destination than the unguided vehicles. Once again, as in the system-wide results, the highest benefits in terms of speed and travel time were found to occur with 100 percent in-vehicle information equipped vehicles.

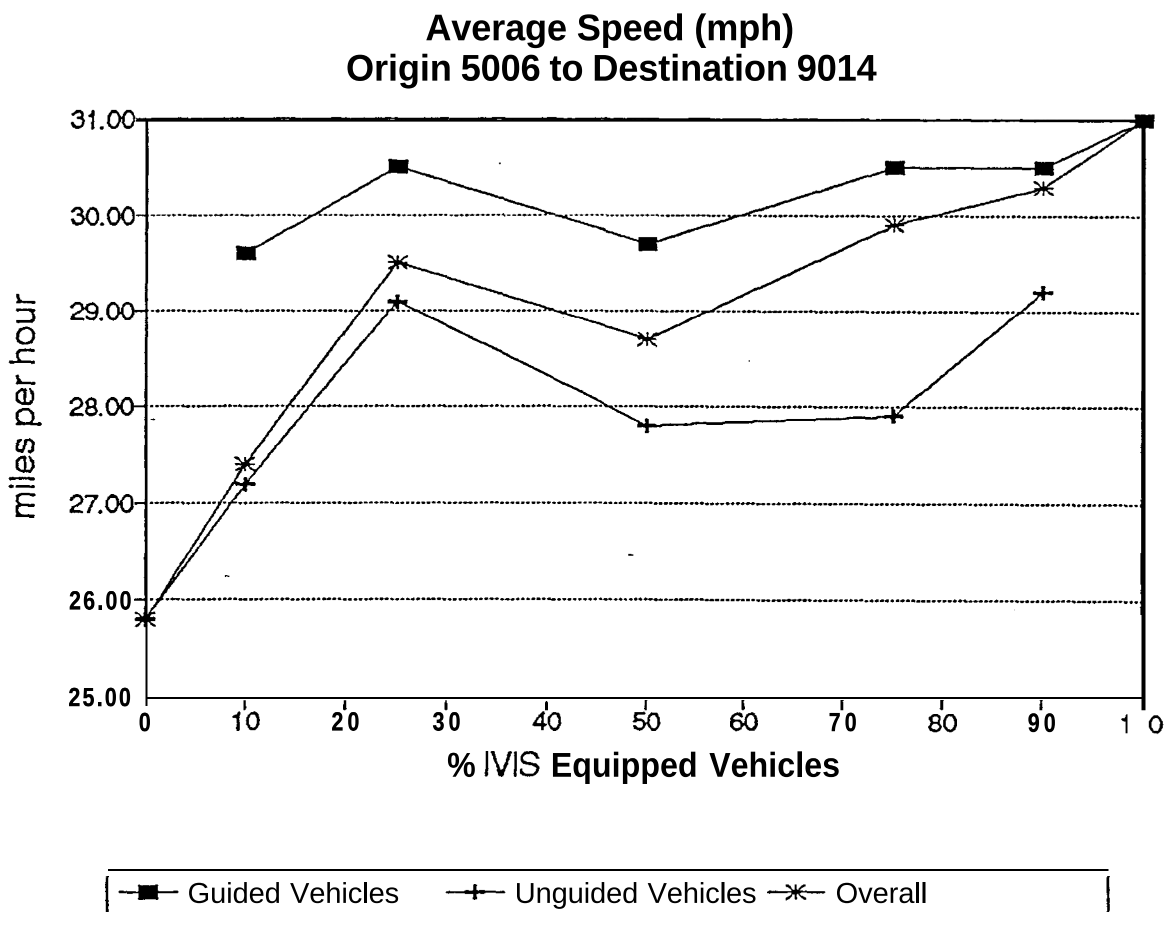
The reliability of the total route distance for both types of vehicles was found to be questionable. It appeared that the same route did not have the same distance in different runs; therefore, the total route distance was not used as part of the analysis. However, analysis was conducted to investigate the routes chosen between different origin-destination pairs for varying percentages of equipped vehicles. Figure 9.12 presents the results of such analysis. The figure shows the two most popular routes chosen for the unguided vehicles and guided vehicles between origin 1 which is on the western boundary of the freeway, and destination 15 which is on the eastern boundary of the network at the end of Washington Boulevard. The figure represents the routes chosen when 75 percent of the vehicles are equipped with in-vehicle information systems under the severe incident scenario.

The two most popular routes for the unguided vehicles both travel through the incident on the eastbound Santa Monica Freeway, while for the guided vehicles, the second route of choice was to exit the freeway at the first possible alternative and use Washington to reach destination 15.

9.3 General Evaluation

The following assumptions need be noted again to cautiously view the results of this analysis:

FIGURE 9.6



Average Speed (mph)
Origin 5006 to Destination 9014
31.00
30.00
29.00
28.00
27.00
26.00
25.00
miles per hour
0
10
20
30
40
50
60
70
80
90
1 0
% IVIS Equipped Vehicles
Guided Vehicles
Unguided Vehicles
Overall

FIGURE 9.7

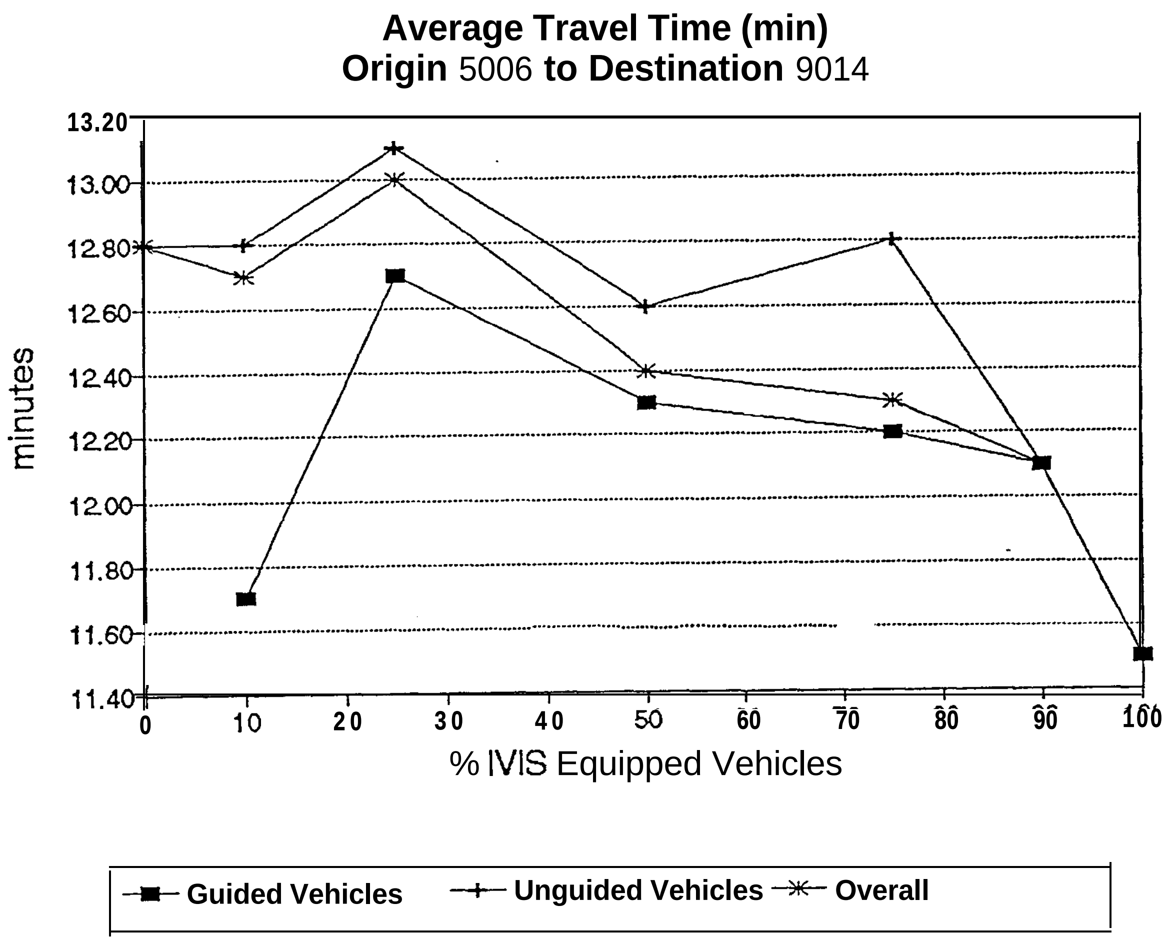

Average Travel Time (min)
Origin 5006 to Destination 9014
minutes
13.20
13.00
12.80
12.60
12.40
12.20
12.00
11.80
11.60
11.40
0
10
20
30
40
50
60
70
80
90
100
% IVIS Equipped Vehicles
Guided Vehicles
Unguided Vehicles
Overall

FIGURE 9.8

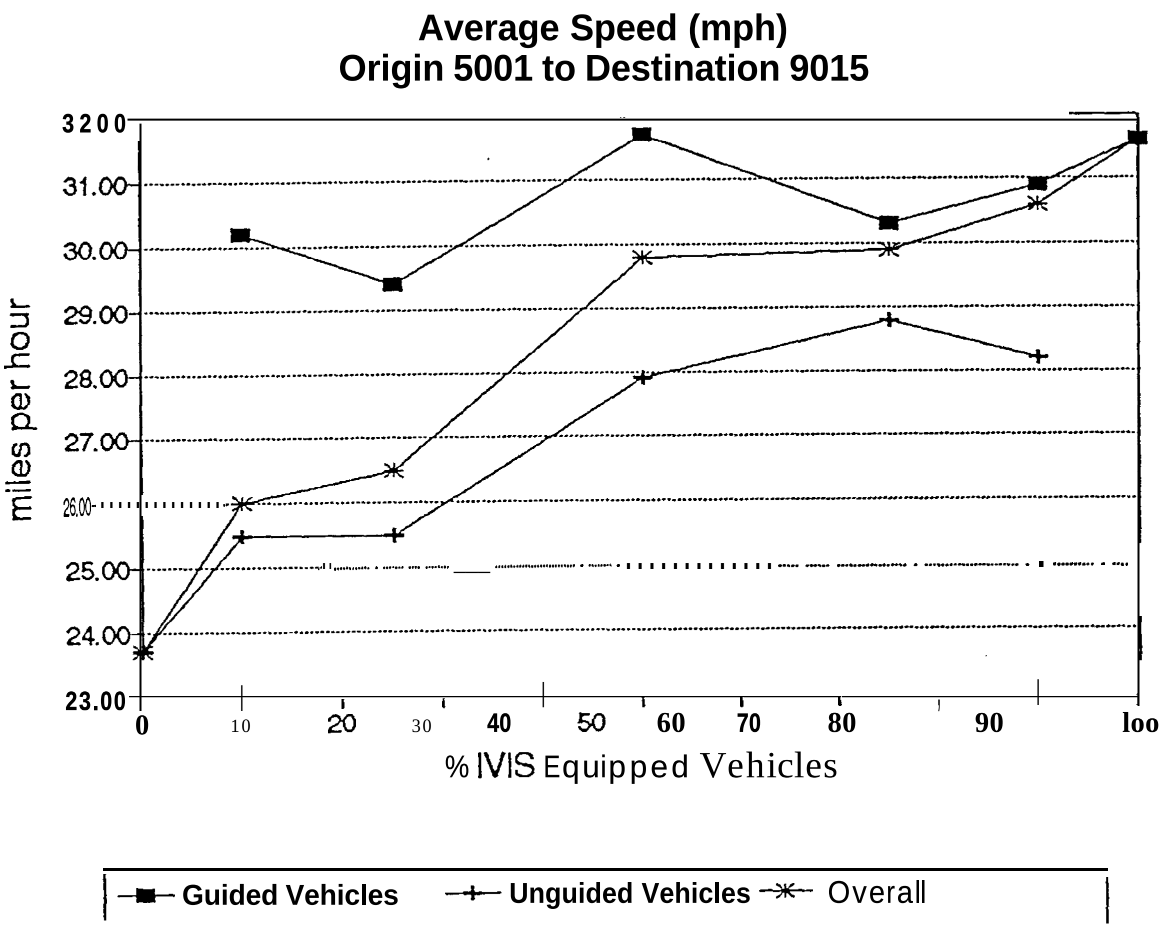
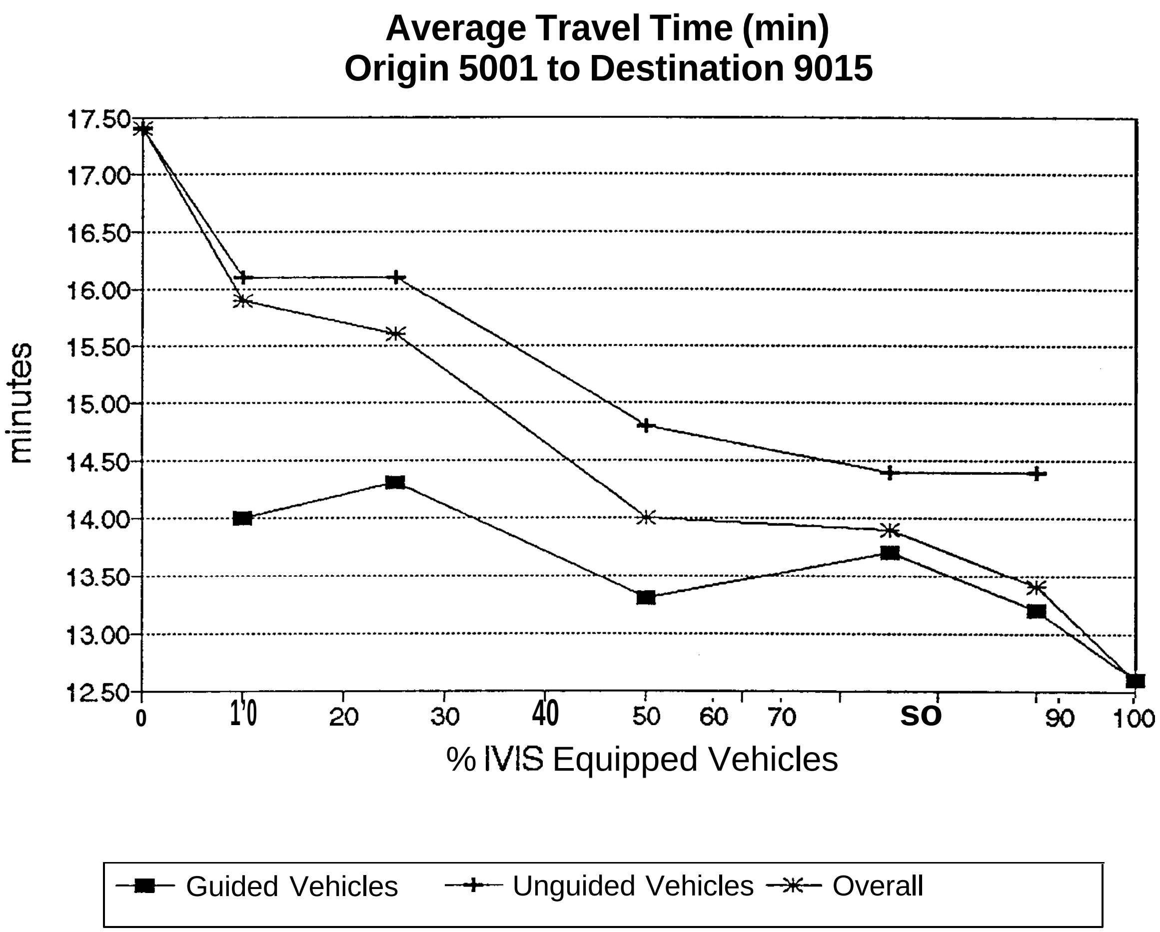

Average Speed (mph)
Origin 5001 to Destination 9015
miles per hour
3200
31.00
30.00
29.00
28.00
27.00
26.00
25.00
24.00
23.00
0
10
20
30
40
50
60
70
80
90
loo
% IVIS Equipped Vehicles
Guided Vehicles
Unguided Vehicles
Overall

FIGURE 9.9



Average Travel Time (min)
Origin 5001 to Destination 9015
17.50
17.00
16.50
16.00
15.50
15.00
14.50
14.00
13.50
13.00
12.50
minutes
0
10
20
30
40
50
60
70
80
90
100
% IVIS Equipped Vehicles
Guided Vehicles
Unguided Vehicles
Overall

FIGURE 9.10

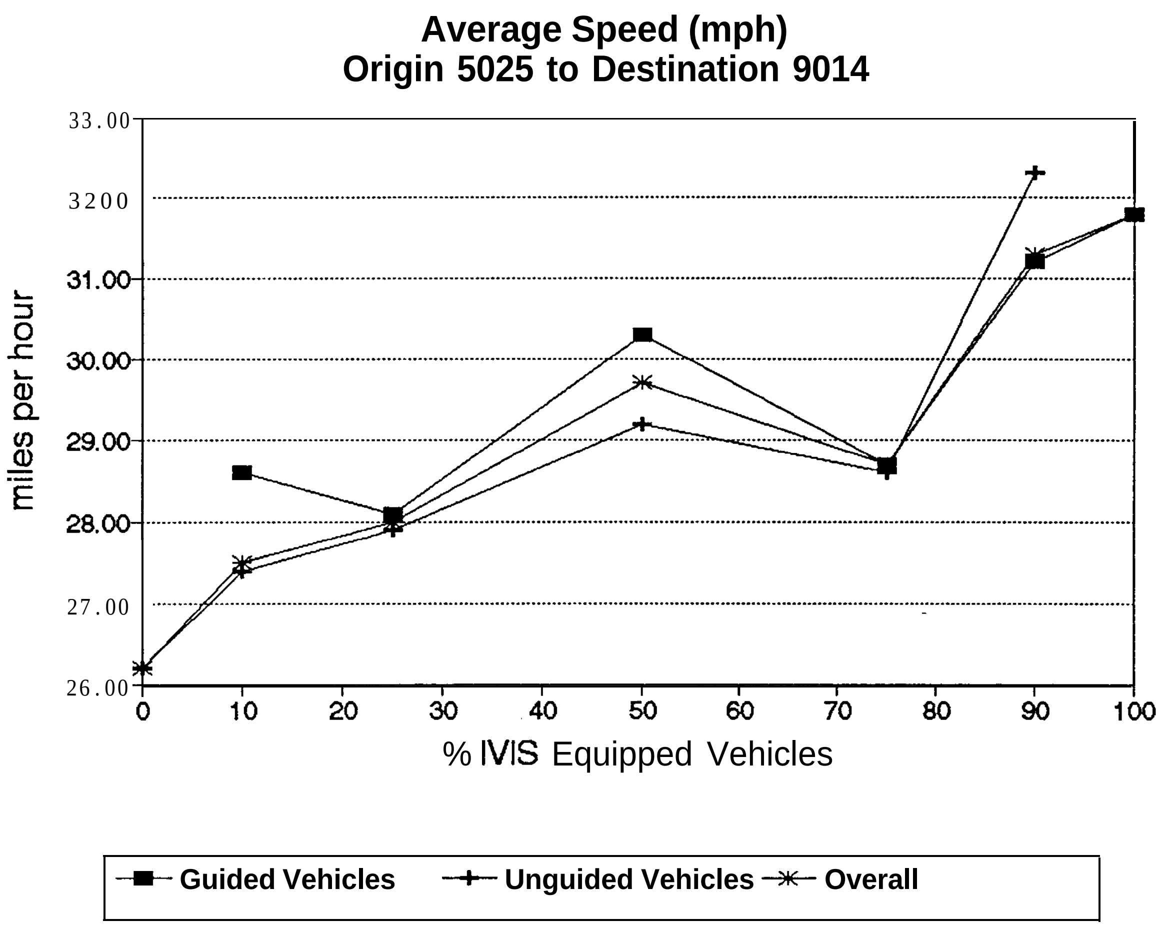

Average Speed (mph)
Origin 5025 to Destination 9014
33.00
3200
31.00
30.00
29.00
28.00
27.00
26.00
miles per hour
0
10
20
30
40
50
60
70
80
90
100
% IVIS Equipped Vehicles
Guided Vehicles
Unguided Vehicles
Overall

FIGURE 9.11

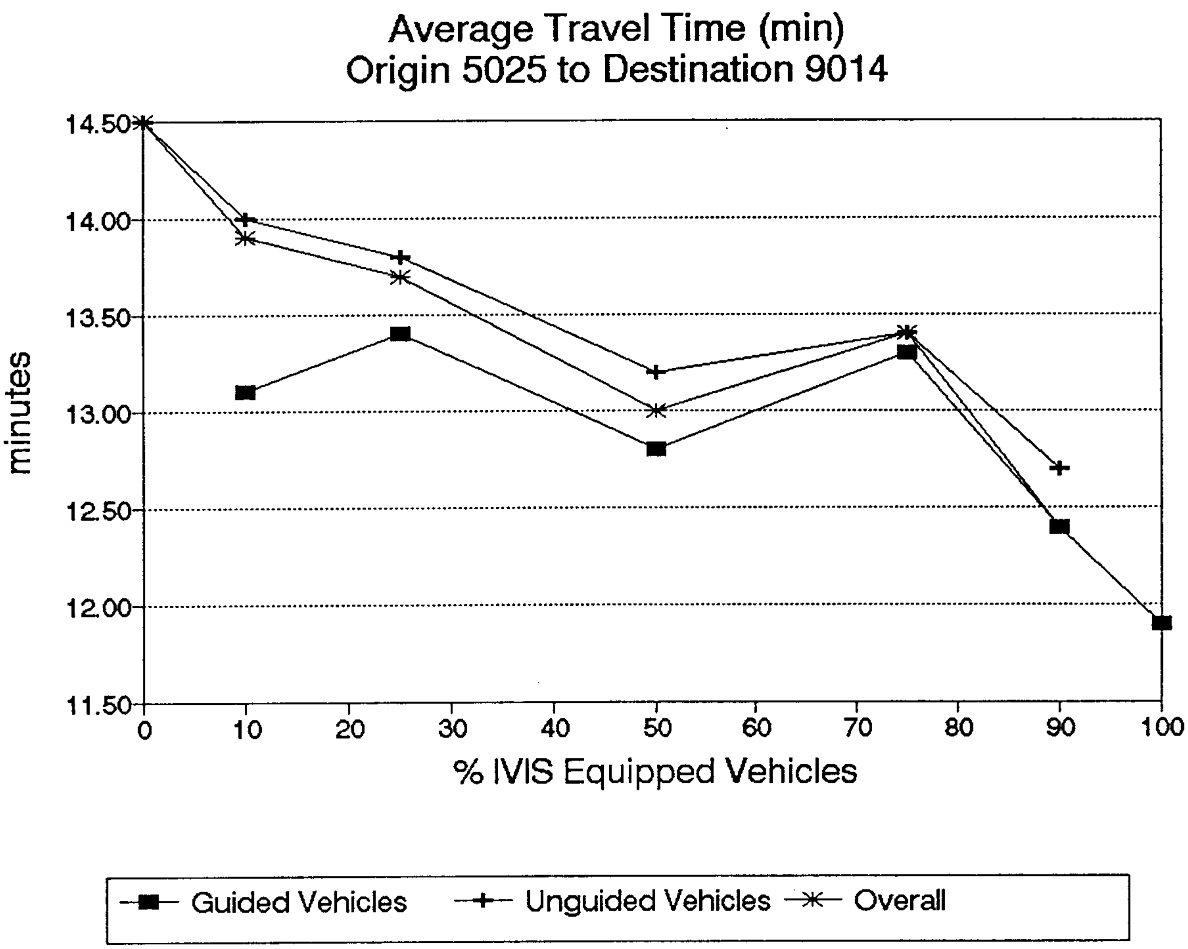
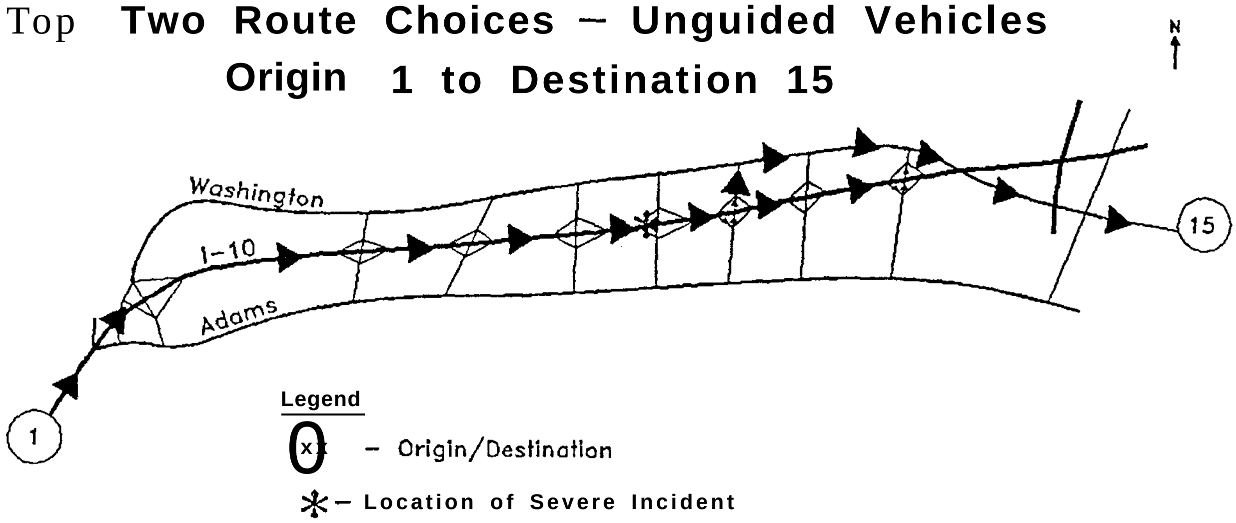

Average Travel Time (min)
Origin 5025 to Destination 9014
14.50
14.00
13.50
13.00
12.50
12.00
11.50
minutes
0
10
20
30
40
50
60
70
80
90
100
% IVIS Equipped Vehicles
Guided Vehicles
Unguided Vehicles
Overall

FIGURE 9.12
ROUTE CHOICE - GUIDED, UNGUIDED VEHICLES

Top Two Route Choices — Unguided Vehicles
Origin 1 to Destination 15



Top Two Route Choices — Guided Vehicles
Origin 1 to Destination 15

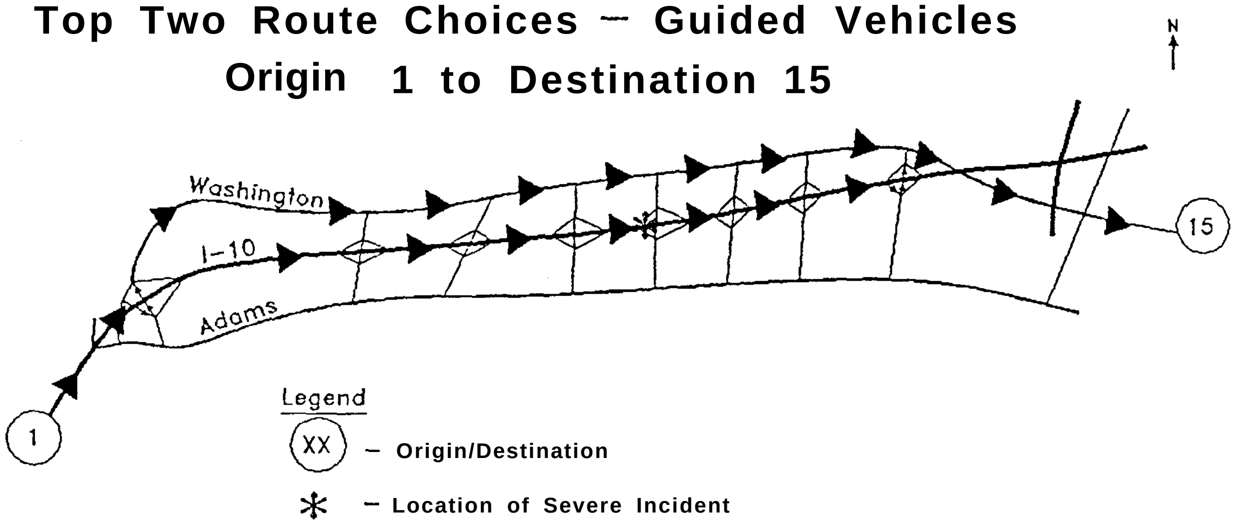


TABLE 9.2
AVERAGE SPEED AND TRAVEL TIME

Origin 5006
Destination 9014

Average Speed (mph)

Percent Equipped

	0	10	25	50	75	90	100
Guided		29.6	30.5	29.7	30.5	30.5	31
Unguide	25.8	27.2	29.1	27.8	27.9	29.2	
Overall	25.8	27.4	29.5	28.7	29.9	30.3	31

Origin 5006
Destination 9014

Average Travel Time (minutes)

Percent Equipped

	0	10	25	50	75	90	100
Guided		11.7	12.7	12.3	12.2	12.1	11.5
Unguide	12.8	12.8	13.1	12.6	12.8	12.1	
Overall	12.8	12.7	13	12.4	12.3	12.1	11.5

Origin 5001
Destination 9015

Average Speed (mph)

Percent Equipped

	0	10	25	50	75	90	100
Guided		30.2	29.4	31.7	30.3	30.9	31.6
Unguide	23.7	25.5	25.5	27.9	28.8	28.2	
Overall	23.7	26	26.5	29.8	29.9	30.6	31.6

Origin 5001
Destination 9015

Average Travel Time (minutes)

Percent Equipped

	0	10	25	50	75	90	100
Guided		14	14.3	13.3	13.7	13.2	12.6
Unguide	17.4	16.1	16.1	14.8	14.4	14.4	
Overall	17.4	15.9	15.6	14	13.9	13.4	12.6

Origin 5025
Destination 9014

Average Speed (mph)

Percent Equipped

	0	10	25	50	75	90	100
Guided		28.6	28.1	30.3	28.7	31.2	31.8
Unguide	26.2	27.4	27.9	29.2	28.6	32.3	
Overall	26.2	27.5	28	29.7	28.7	31.3	31.8

Origin 5025
Destination 9014

Average Travel Time (minutes)

Percent Equipped

	0	10	25	50	75	90	100
Guided		13.1	13.4	12.8	13.3	12.4	11.9
Unguide	14.5	14	13.8	13.2	13.4	12.7	
Overall	14.5	13.9	13.7	13	13.4	12.4	11.9

- Only two of the five parallel arterials within the Smart Corridor were modelled; additionally, three-quarters of the entire length of the Corridor was modelled. Thus, the travel times throughout the corridor are not as large as one would like to evaluate the benefits.

- The structure of the origin-destination pairings was set up so that all origins and destinations were external to the network. The origin and destination data were very coarse and from point to point, each origin and destination could be reached by either the freeway or the arterial, not both. For example, to get to destination 15, a vehicle must exit the freeway and use Washington Boulevard.

- Due to the weaknesses in freeway modelling and incident modelling as described in Chapters 6 and 8, the results presented from this analysis should be viewed with caution. The travel times on the freeway are too low during both incident and non-incident conditions thus, diversion to the arterial is not as attractive as it should be.

- Since this is the first application of RODIN, the results should be viewed with some caution as well.

- The simulation results in this analysis apply only to the morning peak period. Additionally, the type of incident modelled is atypical and extreme, since it is unlikely that two-and-a-half lanes would be blocked for longer than one-half hour. All analysis for guided versus unguided vehicles was conducted on the traffic heading eastbound toward downtown Los Angeles.

10.0 OVERALL ASSESSMENT AND FUTURE RESEARCH

This chapter describes the overall assessment of the completed research. First, the suitability of CONTRAM is described followed by a description of weaknesses of the study outside of the model; then the major findings of the study are presented. Finally, potential future directions regarding the application of a modelling process to evaluate the potential benefits of in-vehicle information systems are discussed.

10.1 Suitability of CONTRAM

The CONTRAM model has many features that are well suited to an application such as this. However, there still remain questions about some of its capabilities. This section outlines the strengths and weakness of the model for this particular application.

10.1.1 Strengths

1) When using the 386 version of CONTRAM 5 and DBOS memory management system, there was no problem in terms of network size limitations and running time for this particular application.

2) CONTRAM provided evidence of accurate representation of oversaturated conditions on arterials.

3) The use of COMEST in developing O-D matrices was very helpful. The difficulty of setting up a realistic time-sliced O-D matrix is traditionally one of the main problems encountered in an experiment such as this one.

4) RODIN provided the capability to distinguish between guided and unguided vehicles. The unguided vehicles were always assigned to the same fixed routes determined by the average daily conditions, without incident. These routes were usually no longer optimum under incident conditions. On the other hand, guided vehicles are assigned to their optimum routes, assuming perfect knowledge of current traffic conditions.

10.1.2 Weaknesses - Suggested Improvements

1) The weakness of CONTRAM in the area of representation of oversaturated conditions on freeways was identified as the most important problem with regard to this application. Although a lot of time was spent in trying to get acceptable results, as described in Chapter 6, many questions were not answered:

   - What type of link (uncontrolled, give-way or signalized) is the most appropriate to code freeway links and on-ramps? As mentioned in Chapter 6, this decision has an effect on the queuing process.

   - How does the concept of "throughput capacity" used by CONTRAM relate to the usual concept of freeway capacity?

   - How can the speed-flow relationships of CONTRAM be used in simulating oversaturation conditions?

   - Is it possible to do any weaving analysis?

   - Some parameters, like the jam headway spacing and points on the speed-flow curve can be calibrated on a simple freeway section. How can the calibration information be used when applying the model to a complex corridor network?

2) The CONTRAM standard assignment assumes that all vehicles take their optimum routes. The base run (no incident) should not be regarded as an accurate representation of average daily conditions. Some drivers do not choose the best route, and this should be accommodated by the model by introducing distortions to the perceived link costs.

3) Under incident conditions, it was assumed that unguided vehicles always take the same route that used to be optimum under non-incident conditions. It would be realistic to model the spontaneous diversion of unguided vehicles due to sources of information other than the guidance system, like radio information or the direct view of queues in front of them.

4) The use of RODIN for varying percentages of guided vehicles led to some discrepancies in the demand structure and the total number of vehicles in the system (in the range of 3%). In order to have some comparable results, the demand should be exactly the same.

5) The truncation of link travel times led to some problems in speed calculations. For example, when using a link free-flow speed of 80 km/h in undersaturated conditions, the resulting average **speed** is not necessarily 80 km/h, as expected.

6) Output information useful for this type of analysis which is not provided by CONTRAM such as:

- aggregate statistics per set of links (Freeway-Arterials);
- aggregate statistics per vehicle type (Guided-Unguided)

7) Although the use of UFPASC (described in Chapter 9) for routing analysis was very helpful, some weaknesses were identified:

- The run time for each O-D pair is a half hour to an hour on a 386 microcomputer;
- The reliability of the total route distance is questionable, as it appeared that the same route did not have the same distance in different runs;
- **A** time slice **by** time slice analysis would be a useful tool in comparing travel times and travel distances;
- A network plot showing the two most popular routes for a given O-D pair, vehicle type and time slice would be very useful as well.

10.2 Weaknesses of the Study

The improvement of modelling freeway congestion does not alone cure the weaknesses of the study. Weaknesses exist on both the supply and demand side of the modelling process as well. With respect to the supply side, as mentioned in Chapter 5, the Smart Corridor consists of five parallel arterials with approximately 15 cross streets, and is approximately 13 miles long. Due to time and resource limitations, approximately nine miles of the SMART Corridor with two parallel arterials was coded into the model instead of the entire 13 miles and five parallel arterials of the corridor. The eastern boundary of the network is the Harbor Freeway, while the western boundary is LaCienega Boulevard. The two parallel arterials coded were Washington Boulevard and Adams Boulevard. Ten of the 15 major north-south streets connecting Washington, Adams, and the Santa Monica Freeway were coded as well. Thus, with only two parallel arterials the opportunity for diversion is not as great as it would normally be in the Smart Corridor. Additionally, since approximately nine miles of the 13 mile corridor were modelled, the travel times throughout the corridor were not as high as they would normally be due to the reduced travel distance, and diversion from the freeway to the arterial was not as attractive as it might be with a longer travel time.

From the demand side, problems exist with both the origin-destination matrix and the structure of the demand over time. The problems with the origin destination information and structure are described in Chapter 7. Only external sinks and sources were used; thus, any major internal sinks and sources within the corridor were neglected. Although using the origin-destinationestimator program, COMEST, assisted in creating a somewhat realistic origindestination matrix, it should be pointed out that the inputs to COMEST are the flows instead of the actual demands. Thus, the demand could be underestimated through use of this program. A second weakness in the demand structure is the variation over time. Based on information provided by the previous study [3] and information regarding the performance of the system, the demand was manipulated to create an origin-destination matrix for eight time slices. Information was only available for the time period of 7:00 a.m. to 8:00 a.m., and all information for the previous and remaining time slices was factored based on spot traffic counts. Thus, for the purposes of this study the highest demand was assumed to occur from 7:00 a.m. to 8:00 a.m. while the demand for the other time slices were factored based on information provided from the previous study. Once again, this is likely not the case and leaves the results of the study open to some question.

10.3 Major Findings

Based on the information provided in the previous two sections, the results of this study should be viewed with some caution. The results should be viewed in a somewhat qualitative manner, the findings being the more vehicles equipped, the better the system performance. As seen in Table 9.1, with a severe incident on the freeway, as the percentage of vehicles equipped with information increases, the performance of the system improves to where the system is at a level of performance that is only slightly less than that before the incident occurred. This degree of improvement is only possible because of the availability of underutilized capacity on the arterials parallel to the freeway. Chapter 9 describes in greater detail the results of the analysis.

10.4 Future Research

1) ***The representation of oversaturated conditions on*** freeways. As previously mentioned, some difficulties were encountered in the modelling of the freeway portion of the

SMART Corridor. Any further application of CONTRAM to this type of network will have to carefully address this question. The authors of the model reported that Southampton University has recently conducted research on modelling congestion on freeways by varying the randomness parameter in the queuing formula [23]. This is similar to the approach suggested some years ago by Davidson [24] and could be repeated using the current version of CONTRAM. However, it is not clear how relevant this method is.

2) ***The*** use ***of ROGUS.*** ROGUS is a program currently under development at TRRL to simulate route guidance based on the CONTRAM model. Because of time constraints it was not possible to use ROGUS in this phase of the study, though it could be used in an extension of the project. ROGUS consists of two main parts: Modified CONTRAM and ROGUS/Ada.

   a) Modified CONTRAM is responsible for generating the base loading of unguided vehicles, and differs from standard CONTRAM5 only in its ability to distort drivers' perception of link costs to simulate their lack of perfect information, and

   b) ROGUS/Ada reassigns a certain proportion of the unguided vehicles to simulate guided vehicles. The method of assignment is event-based using simulated beacon information which itself is based on the historical data and simulated real-time data from detectors and vehicle-to-beacon communications.

3) ***The application and simulation of different traffic management strategies.*** It would be interesting to compare the effects of guidance systems with some other corridor management strategies like signal optimization and coordination to determine how the benefits compare and if the benefits are cumulative.

4) ***The potential re-investigation of the INTEGRATION model. The*** model is now available for investigation. It might be worthwhile to reevaluate the application of the INTEGRATION model to the Smart Corridor.

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APPENDIX A

```
CONTRAM TEST NETWORK
   1    1  700  730  800  815  830  845  900  930 1000 1100
   3 5001 4440
   3 5002 5020
   3 5003 2240 4440
   3 5004 3010
   3 5005 2210
   4  301 3110 2220    0    0    0   40  500 1500    0   30
   4  303 2220    0    0    0    0    1   10 1600    2   30
   4  311 2110 5110    0    0    0    1   10 1600    2   31
   4  313 3030 2110    0    0    0   20  240 1600    0   31
   4  414 2040 4210    0    0    0    4   40 2500    0   41
   4  421 2140 4320    0    0    0    4   40 2500    0   42
   4  43290020 4430    0    0    0    4   40 2500    0   43
   4  443 2230 4140    0    0    0    4   40 2500    0   44
   4  502 2130 2120    0    0    0   60  600 4200    0   50
   4  511 5240 2010    0    0    0   20  240 1600    0   51
   4  513 3130 5240    0    0    0   20  200 1600    0   51
   4  52490030    0    0    0    0    4   30 1500   40   52
   5  304 3110                        75 1000  600  180  303  301   25   30
   5  312 5110 3030    0    0    0  100 1300  600  200  311  313   25   31
   5  411 2040 4210    0    0    0   40  500 2000    0  414    0   70   41
   5  422 2140 4320    0    0    0   80 1000 1500    0  421    0   50   42
   5  43390020 4430    0    0    0  300 5000 3000    0  432    0   95   43
   5  444 2230 4140    0    0    0   80 1000 3000    0  443    0   95   44
   6   12 2024    0    0    0    0   75  900 1500    0    1    2  100  100    0
   6   14 2154    0    0    0    0    4   50 1500    8    1    2  100   60    0
   6  201  144 4220    0    0    0   20  200 1600    0   20    1  100  100    0
   6  202 4220 5130    0    0    0    4   50 1600    8   20    2  100  100    0
   6  204 5130  144    0    0    0   80 1000 1500    0   20    2  100  100    0
   6  21190010 4330  124    0    0  100 1300 1800    0   21    1  100  100    0
   6  212 3120    0    0    0    0   10  100 1500    0   21    2   50  100    0
   6  213 4330  124    0    0    0   10  100 3000    0   21    2  100  100    0
   6  214  124 312090010    0    0  300 5000 3000    0   21    1  100  100    0
   6  215 312090010 4330    0    0   75  900 1600    0   21    2   50   70    0
   6  221 3040 4110    0    0    0   40  500 1500    0   22    1  100  100    0
   6  222 4110    0    0    0    0   75 1000 1800    0   22    2  100  100    0
   6  223 3040    0    0    0    0   40  500 2000    0   22    1  100  100    0
   6  224 3040 4110    0    0    0   90 1000 1500    0   22    2  100  100    0
   7    1   25
   7   20   10
   7   21   10
   7   22   10
   9   10   22   18  140  120    0    0
 -10    1  164  240  200  150  107  340
 -10    2  492  720  600  450  321 1020
 -10    4  492  720  600  450  321 1020
```

```
CONTRAM TEST DEMAND
          1    9  105
 5001 9001  101 3000 5000  375  750 1125 1500 1350 1050  750  375     0
 5001 9001   54 3000 5000   40   80  120  180  160  170  160  100     0
 5001 9003  101 2300 5000  150  300  450  600  525  375  300  150     0
          1    9  100
 5002 9002  101 2700 5000  320  560  800 1200  950  700  600  300     0
 5003 9003  101 2300 5000   50  200  300  350  400  250  150   50     0
 5004 9002  104 2000 5000   40  120  200  300  270  240  210  150     0
 5005 9001   22 2900 5000   10   20   20   20   20   20   20   20     0
 5005 9002  101 1000 5000  100  120  150  200  180  150  120   80     0
```

CONTRAM TEST CONTROL

50	12									
53										
54										
55										
56										
57	1	20	21	22						
71	1	110	50	50						
71	2	110	50	50						
72	6	-110	4	6						
71	3	55	0	30						
71	4	110	40	60						
71	5	110	50	50						
77	1	3	3	3	3	3	3	3	3	3
77	20	2	2	2	2	2	2	2	2	2
77	21	5	5	5	5	5	5	5	5	5
77	22	1	1	1	1	6	6	1	1	1
81	1	7	221	304	311	511	201	14	215	
85	5005	9001	2	1						

SUMMARY INFORMATION

CONTRAM TEST NETWORK
CONTRAM TEST DEMAND
CONTRAM TEST CONTROL

ITERATION NUMBER

TIME SLICES :

	1	2	3	4	5	6	7	8	9	
	700–730	730–800	800–815	815–830	830–845	845–900	900–930	930–1000	1000–1100	TOTALS
0 JOURNEY-TIME (VEH-H)										
0FREEMOVING	31.9	70.5	55.1	85.8	82.7	65.8	90.1	44.6	3.1	529.4
FLOW DELAY	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
QUEUEING	7.4	21.5	18.0	27.8	40.9	40.4	30.4	13.3	.6	200.3
TOTAL	39.3	91.9	73.0	113.5	123.6	106.2	120.5	58.0	3.7	729.8
0 DISTANCE TRAVELLED (VEH-KM)										
0	1360.8	3171.8	2634.7	4380.3	4244.0	3287.9	4198.6	1896.0	128.9	25303.0
0 OVERALL NETWORK SPEED (KM/H)										
0	34.7	34.5	36.1	38.6	34.3	31.0	34.8	32.7	34.6	34.7
0 TOTAL FINAL QUEUES (VEH)										
0	17.3	57.9	77.4	137.1	198.5	156.9	56.4	30.2	.6	732.3
0										
0 FUEL CONSUMPTION (LITRES)										
0TRAVELLING	136.1	313.5	254.2	402.8	392.9	325.3	460.1	238.7	18.4	2541.8
QUEUEING	7.6	35.3	28.9	58.2	88.1	80.9	51.8	24.2	.2	375.3
TOTAL	143.7	348.9	283.1	460.9	481.0	406.2	511.9	262.8	18.6	2917.1
0 TOTAL LINK COUNTS (VEH)										
0ARRIVALS	2662	5282	3656	4539	4341	3884	6224	3645	304	34537
PCU FACTOR	1.07	1.08	1.09	1.11	1.11	1.12	1.13	1.17	1.26	1.11
STOPS	961	2196	1601	1980	1837	1630	2631	1425	96	14359
% STOPPED	36.1	41.6	43.8	43.6	42.3	42.0	42.3	39.1	31.7	41.6

0PACKET SIZE WITHIN EACH O-D MOVEMENT IS VARIABLE

TOTAL NUMBER OF PACKETS ENTERING THE NETWORK	792
TOTAL NUMBER OF VEHICLES	7158
TOTAL NUMBER OF PCUS	7927
MEAN PCU FACTOR	1.11

ROUTES AND ROUTE MEMORY:

MEAN LINKS PER ROUTE	4.82
WORDS AVAILABLE	3985292 (OUT OF 3985293)
USED PER ITERATION	586
CODONS PER WORD	10

LINK-BY-LINK VALUES IN TIME SLICE 3 - FOR TRAFFIC AND ECONOMIC ASSESSMENTS

CONTRAM TEST NETWORK
CONTRAM TEST DEMAND
CONTRAM TEST CONTROL
OTIME SLICE 3 START 800 FINISH 815 DURATION 15 MINUTES ITERATION NUMBER 5

LINK NO. AND TYPE	LINK ENTRY FLOW (VEH)	MEAN INIT. QUEUE (VEH)	ARRIVALS BY CLASS C (VEH)	B	L	DEPART FROM QUEUE (VEH)	MEAN FINAL QUEUE (VEH)	THRU-PUT CAP/Y (VEH)	MEAN PCU FACTOR	ARR/ CAP (RHO)	MEAN-TIME PER VEHICLE TOTAL (SEC)	QUEUE (SEC)	TOTAL-TIME-&-DELAY FREE-MOV/G	FLOW-DELAY (VEH-H)	QUEUE -ING	OCCUP-ANCY//	STOPS (%//%)	AV. SPEED (KM/H)	JUNC. NO.	---SIGNAL--- GREEN: O LIN CYCLE P -IN (SEC) T (%
12S	160	2.0	160			152	10.5	162R		.99*	92	17	3.31		.82	9	88	34.6	1	30: 55
14S	63	.8	58	5		63	.6	187	1.10	.34	9	5	.07		.09	8	67	19.8	1	30: 55
201S	15	.1		5		5	.1	94	1.93	.05	45	17	.08		.03	1	57	19.4	20	50:110
202S	160	5.0	160			157	8.1	182		.88	46	42	.18		1.88	F	94	3.9	20	50:110
204S	197	21.6	166			166	21.9	171		.97*	202	122	3.94		5.99	17	99	17.9	20	50:110
211S	34	1.8	10		14	25	.5	154	1.33	.16	130	18	.75		.12	0	63	36.1	21	50:110
212S								85											21	25:110
213S	200	3.3	190			188	5.0	341		.56	33	23	.53		1.21	19	79	11.0	21	50:110
214S	200	.9	188		9	193	5.4	326	1.05	.60	326	23	16.46		1.34	0	82	54.8	21	50:110
215S	63	9.0	58	4		67	4.1	84	1.08	.74	124	47	1.39		.83	4	95	26.4	21	25:110
221S	43	.7	38	5		43	1.0	150	1.14	.29	62	20	.50		.24	2	68	29.1	22	50:110
222S	40	.7			40	40	1.0	114	1.80	.35	113	23	1.02		.26	1	73	31.9	22	50:110
223S	43	1.5	39		19	58	1.3	180	1.26	.32	60	17	.60		.26	2	69	29.3	22	50:110
224S	57	.7	67			66	1.7	171		.39	108	18	1.43		.33	1	70	32.4	22	50:110
301U	50				50	50		208	1.80	.24	48		.67					37.5	30	
303U								400											30	
304G	130	8.1	77	5	15	97	8.4	107	1.20	.91*	164	85	2.33		2.55	6	92	21.9	30	
311U	106		77	5	24	106		323	1.24	.33	1		.03					36.0	31	
312G								117											31	
313U								400											31	
411G	88	.3	38		50	87	1.4	148	1.45	.59	60	15	1.09		.37	2	63	30.2	41	
414U	397		384		13	397		609	1.03	.65	4		.44					36.0	41	
421U	288		215		63	278		532	1.17	.52	4		.32					36.0	42	
422G	160	.7	180			176	4.8	212		.85	106	26	3.75		1.25	3	87	33.7	42	
432U	248		198		50	248		538	1.16	.46	4		.28					36.0	43	
433G	30							477					1.27		.01			59.6	43	
443U								625											44	
444G	463	.7	413		27	439	1.6	713	1.05	.62	84	3	10.16		.38	1	62	42.8	44	
502U	200		200			200		1050		.19	60		3.31					36.0	50	
511U	72		48	5	10	63		335	1.19	.19	21		.40					40.8	51	
513U	108		108			108		400		.27	20		.60					36.0	51	
524U	156		166			166		375		.44	4		.18					27.0	52	

OTOTAL TIMES BY VEHICLE CLASS

		C	B	L	TOTAL
(VEH-H)	FREEMOVING	48.86	0.45	5.78	55.09
	FLOW DELAY	0.00	0.00	0.00	0.00
	QUEUEING	16.61	0.23	1.12	17.95
	TOTAL	65.47	0.67	6.90	73.04

TOTAL DISTANCES

		C	B	L	TOTAL
(VEH-KM)	TRAVELLING	2384.4	14.2	236.2	2634.7

TOTAL FUEL CONSUMPTION

		C	B	L	TOTAL
(LITRES)	TRAVELLING	184.50	5.45	64.22	254.17

FLAGS:
R = REDUCED CAPACITY
* = RHO EXCEEDING 90%
** = RHO 100% OR GREATER
F = FULL LINK
S = OPTIMISED SPLITS
C = OPTIMISED CYCLE & SPLI

NOTE: FOR FULL DEFINITIONS OF COLUMN HEADINGS SEE USER GU

TOTAL LINK COUNTS (VEH)

ARRIVALS 3656.0

LINK-BY-LINK ALL-TIME-SLICES - AVERAGE SPEED OF A CAR (KM/H)

CONTRAM TEST NETWORK
CONTRAM TEST DEMAND
CONTRAM TEST CONTROL

ITERATION NUMBER

LINK NO.& TYPE	TIME SLICES : 1	2	3	4	5	6	7	8	9	OVERALL AVERAGE SPEEI
	700 730	730 800	800 815	815 830	830 845	845 900	900 930	930 1000	1000 1100	
12S	39.0	36.9	34.6	36.3	39.8	37.3	35.7	38.6	40.5	36.9
14S	19.9	19.9	19.8	22.2	22.3	20.4	19.8	19.9	25.4	20.3
201S	16.4	16.0	19.4	14.4	15.7	16.5	17.0	17.7	16.4	15.9
202S	7.2	5.0	3.9	6.5	8.1	5.9	4.1	6.5	7.9	5.1
204S	33.0	24.0	17.9	14.6	11.1	10.7	20.1	27.7	36.0	18.7
211S	37.5	36.7	36.1	37.5	34.2	34.4	36.8	35.7	35.9	36.4
212S	.0	.0	.0	.0	8.2	8.2	.0	.0	.0	8.2
213S	12.9	11.7	11.0	7.9	9.6	11.0	11.6	12.9	13.8	10.6
214S	.0	56.9	54.8	51.0	41.3	38.0	51.5	57.0	.0	46.5
215S	25.9	23.5	26.4	27.8	29.5	29.1	23.9	21.6	31.5	24.9
221S	30.3	29.4	29.1	28.8	26.2	26.5	29.4	29.4	.0	28.7
222S	33.6	32.8	31.9	32.7	34.4	34.2	31.8	32.8	34.0	32.8
223S	29.4	28.9	29.3	30.1	26.0	29.0	28.8	29.3	.0	29.1
224S	33.6	34.0	32.4	32.5	33.1	34.0	33.3	34.0	.0	33.3
301U	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	.0	37.5
303U	.0	.0	.0	.0	.0	36.0	.0	.0	.0	36.0
304G	39.0	26.5	21.9	17.8	12.9	11.3	20.2	29.9	23.2	19.9
311U	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0
312G	.0	.0	.0	.0	.0	43.7	.0	.0	.0	43.7
313U	.0	36.0	.0	.0	.0	.0	36.0	36.0	36.0	36.0
411G	40.6	37.8	30.2	10.4	11.1	16.5	33.8	36.7	35.3	22.8
414U	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0
421U	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0
422G	43.4	42.8	33.7	22.2	18.1	23.8	39.4	42.7	43.9	33.4
432U	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0
433G	.0	.0	59.6	59.6	59.6	59.6	.0	.0	.0	59.6
443U	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
444G	43.8	43.3	42.8	40.4	41.6	42.5	42.8	43.1	43.3	42.4
502U	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	.0	36.0
511U	40.5	41.5	40.8	39.9	40.4	41.7	41.2	39.0	30.9	40.7
513U	36.0	35.8	36.0	36.0	36.0	36.0	35.8	34.5	33.1	35.7
524U	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
OOVERALL	34.7	34.5	36.1	38.6	34.3	31.0	34.8	32.7	34.6	34.7

TURNING MOVEMENTS (VEH/H) - SELECTED JUNCTIONS

CONTRAM TEST NETWORK
CONTRAM TEST DEMAND
CONTRAM TEST CONTROL

0 JUNCTION NUMBER 20 SIGNAL CONTROLLED ITERATION 5

0 TIME SLICES

LINK TO LINK	1 700 730	2 730 800	3 800 815	4 815 830	5 830 845	6 845 900	7 900 930	8 930 1000	9 1000 1100	AVERA IN T/ 1-
201 - 14	10	16	20	20	16	20	22	20	2	
201 - 422	0	0	0	188	156	40	0	20	0	
202 - 422	280	540	640	280	236	468	598	340	20	4
202 - 513	0	0	0	0	0	0	0	0	0	
204 - 513	138	346	432	552	476	472	344	250	15	3
204 - 14	316	296	232	196	192	200	294	294	20	2

0JUNCTION ENTRY FLOWS (VEH/H)

LINK										
201	10	16	20	208	172	60	22	40	2	
202	280	540	640	280	236	468	598	340	20	4
204	454	642*	664*	748*	668*	672*	638	544	35	6

0SIGNAL PLAN TYPES

FCFS	FCFS	FCFS	FCFS	FCFS	FCFS	FCFS	FCFS	FCFS

0CYCLE TIMES (SECS)

110	110	110	110	110	110	110	110	110

0GREEN TIMES (SECS)

LINK									
201	50	50	50	50	50	50	50	50	50
202	50	50	50	50	50	50	50	50	50
204	50	50	50	50	50	50	50	50	50

0ALL-RED TIMES (SECS)

10	10	10	10	10	10	10	10	10

CONTRAM TEST NETWORK

10	5001	46	1	10	9001	444	414	204	14	215		
5	127	131	240	249	369							
11	5002	57	1	10	9002	502	213	12	202	422	432	
6	117	145	228	253	336	340						
10	5001	114	1	10	9003	444	414	204	513	524		
5	195	199	308	328	332							
10	5001	138	1	10	9001	444	414	204	14	215		
5	219	223	332	341	462							
11	5002	169	1	10	9002	502	213	12	202	422	432	
6	229	257	340	365	448	452						
10	5001	172	3	4	9001	444	223	304	311	211		
5	269	334	435	436	573							
9	5005	180	1	10	9002	221	411	421	432			
4	238	280	284	288								
10	5001	229	1	10	9001	444	414	204	14	215		
5	310	314	423	432	554							
11	5002	282	1	10	9002	502	213	12	202	422	432	
6	342	370	453	478	561	565						
10	5003	288	1	8	9003	224	304	311	511	524		
5	395	481	482	502	506							
10	5001	316	1	9	9001	444	414	204	14	215		
5	397	401	510	519	642							
10	5001	342	1	10	9003	444	414	204	513	524		
5	423	427	536	556	560							
12	5005	360	2	2	9001	221	304	311	511	201	14	215
7	434	550	551	579	623	633	787					
11	5002	394	1	10	9002	502	213	12	202	422	432	
6	454	482	565	590	673	677						
10	5001	403	1	10	9001	444	414	204	14	215		
5	484	488	597	606	729							
10	5004	450	3	10	9002	301	222	411	421	432		
5	498	605	655	659	663							
10	5001	494	1	10	9001	444	414	204	14	215		
5	575	579	688	697	821							
11	5002	507	1	10	9002	502	213	12	202	422	432	
6	567	595	678	703	786	790						
10	5001	515	3	4	9001	444	223	304	311	211		
5	612	677	778	779	916							
9	5005	540	1	10	9002	221	411	421	432			
4	598	640	644	648								
10	5001	570	1	10	9003	444	414	204	513	524		
5	651	655	764	784	788							
10	5001	585	1	10	9001	444	414	204	14	215		
5	666	670	779	788	912							
11	5002	619	1	10	9002	502	213	12	202	422	432	
6	679	707	790	815	898	902						
10	5001	677	1	10	9001	444	414	204	14	215		
5	758	762	871	880	1004							
11	5002	732	1	10	9002	502	213	12	202	422	432	
6	792	820	903	928	1011	1015						
10	5001	768	1	10	9001	444	414	204	14	215		
5	849	853	962	971	1096							
10	5001	787	1	9	9003	444	414	204	513	524		
5	868	872	981	1001	1005							
11	5002	844	1	10	9002	502	213	12	202	422	432	
6	904	932	1015	1040	1123	1127						
10	5001	855	1	9	9001	444	414	204	14	215		
5	936	940	1049	1058	1183							

:MONSTRATION OF UFPASC (USER FRIENDLY POST ANALYSIS)
COLUMNED OUTPUT OPTION

LINKS	FLOWS (VEHS /HR)	DEG OF SAT. (%)	FINAL QUEUE (VEH)	INIT. QUEUE (VEH)	AVE. SPEED (KM/ HR)	AVE. TIME DELAY (SEC)	BLOCK -ING BACK
Time Interval Number 3							
12S	284	23	0	0	39	1	0
14S	92	9	0	0	16	0	0
201S	124	27	1	1	15	20	0
202S	284	40	2	3	5	22	0
204S	552	83	6	4	28	40	0
211S	104	19	1	0	33	18	0
212S	0	0	0	0	0	0	0
213S	804	57	5	3	10	22	0
214S	980	72	8	4	78	27	0
215S	92	44	1	1	24	45	0
221S	172	28	1	1	29	20	0
222S	88	17	0	0	32	14	0
223S	132	22	1	0	25	17	0
224S	180	37	1	1	32	21	0
TOTALS	3888	478	27	18	366	267	0
AVERAGES	299	36	2	2	28	22	0
MINIMUM	0	0	0	0	0	0	0
MAXIMUM	980	83	8	4	78	45	0

APPENDIX B

LIVTRIPS. LPM 6/12/90

```
                    THE SATURN SUITE OF PROGRAMS

           PROGRAM        M1  MATRIX CONVERSION AND PRINTING

           RUN NAME       BUILD THE LIVERPOOL TRIP MATRIX

           DATE 12/ 6/90            TIME 10:55: 0


LISTING OF THE PARAMETER VALUES EITHER INPUT ON &PARAM OR TAKEN AS DEFAULT

DOC     =     F     CHANGE =     F     DOT     =     F
INPUT   =     F     NAMES  =     F     FACTOR  =     F
KARDS   =     T     TAPE   =     F     PRINT   =     T
TOTALS  =     T     TRANF  =     F     PMAPT   =     F
VADAPT  =     T     MFNEXT =     T     LONG    =     F
FLAT    =     F     PART   =     F     CSR1    =     F
CERT    =     F

XF1   =    1.00     XF2    =   1.00    XF11  =    1.00
XF12  =    1.00     ADDR   =   0.00

NROWS =      24     NCOLS  =     24    IROW1   =     0
IROW2 =       0     JCOL1  =      0    JCOL2   =     0
MTYPE =       3     MODET  =     -1    MSTACK  =     0


HEADER RECORD DATA FOR THE MATRIX WRITTEN TO CHANNEL  2

           MATRIX TITLE -  LIVERPOOL CENTRAL AREA O-D (TRAMP CORDON)

           MATRIX SIZE -   24 ROWS X   24 COLUMNS
           TYPE OF ELEMENTS (MTYPE) =  3
           ELEMENT DIMENSIONS - TRIPS
           ELEMENT UNITS - VPH      *10** 0

           FILE ELEMENTS ARE WRITTEN AS [illegible]


N.B. SINCE LONG = F THE FORMAT ASSUMED IS:
                  (F8.0)
```

BUILD THE LIVERPOOL TRIP MATRIX

ROW	ID	SUM	COLUMNS					
			1	2	3	4	5	
			7	8	9	10	11	
			13	14	15	16	17	
			19	20	21	22	23	
1	1	243.	0.000	2.000	0.000	4.000	0.000	0.0
			0.000	0.000	2.000	0.000	0.000	8.0
			147.000	7.000	0.000	0.000	0.000	31.0
			0.000	17.000	6.000	2.000	2.000	15.0
2	2	447.	0.000	0.000	0.000	21.000	21.000	0.0
			44.000	0.000	5.000	0.000	0.000	8.0
			192.000	10.000	0.000	0.000	0.000	40.0
			0.000	31.000	6.000	11.000	2.000	56.0
3	3	0.	0.000	0.000	0.000	0.000	0.000	0.0
			0.000	0.000	0.000	0.000	0.000	0.0
			0.000	0.000	0.000	0.000	0.000	0.0
			0.000	0.000	0.000	0.000	0.000	0.0
4	4	664.	31.000	22.000	0.000	0.000	19.000	0.0
			234.000	0.000	15.000	5.000	0.000	4.0
			38.000	3.000	0.000	0.000	0.000	194.0
			0.000	6.000	26.000	17.000	27.000	83.0
5	5	0.	0.000	0.000	0.000	0.000	0.000	0.0
			0.000	0.000	0.000	0.000	0.000	0.0
			0.000	0.000	0.000	0.000	0.000	0.0
			0.000	0.000	0.000	0.000	0.000	0.0
6	6	817.	0.000	1.000	0.000	0.000	0.000	0.0
			0.000	0.000	99.000	1.000	0.000	3.0
			4.000	3.000	0.000	0.000	0.000	580.0
			0.000	24.000	91.000	1.000	0.000	10.0
7	7	0.	0.000	0.000	0.000	0.000	0.000	0.0
			0.000	0.000	0.000	0.000	0.000	0.0
			0.000	0.000	0.000	0.000	0.000	0.0
			0.000	0.000	0.000	0.000	0.000	0.0
8	8	335.	18.000	17.000	0.000	13.000	0.000	0.0
			0.000	0.000	0.000	0.000	0.000	17.0
			30.000	12.000	0.000	0.000	0.000	27.0
			0.000	87.000	5.000	10.000	55.000	44.0
9	9	0.	0.000	0.000	0.000	0.000	0.000	0.0
			0.000	0.000	0.000	0.000	0.000	0.0
			0.000	0.000	0.000	0.000	0.000	0.0
			0.000	0.000	0.000	0.000	0.000	0.0
10	10	1182.	14.000	12.000	0.000	10.000	0.000	0.0
			0.000	0.000	0.000	0.000	0.000	5.0

LIVNET.LPN

THE SATURN SUITE OF PROGRAMS

PROGRAM S1 -7.1 [redacted]

DATE 13/ 6/90 TIME 10:29:17

LISTING OF THE OPTIONS CHOSEN:

UPDATE = F FASSO = F PLOD = F

LISTING OF THE PARAMETERS USED

A - GENERAL MODEL PARAMETERS: V1.4

MODET =	1	MASL =	1	ISTOP =	90
LTP =	30				

B - SATNET SPECIFIC: V1.4

LIST =	T	PRINT =	F	SPEEDS =	F
AUTOX =	F	AUTOZ =	F		
DUTCH =	F	NOMADS =	1	KNOBS =	0
MAXZN =	500	MINSAT =	500	BCRP =	5.0
MINRED =	10	IFCC =	2	IFRL =	1
RUSPCU =	3.0	KPHMIN =	10	KPHMAX =	100

C - SATSIM SPECIFIC:

PRSFD =	F	NOTUK =	0	NOPD =	0
NITS =	3	LCY =	75	NUC =	15
LRTP =	0				
GAP =	5.0	GAPM =	3.0	GAPR =	4.0
TDEL =	3.0	CAPMIN =	30.	ALEX =	5.75

D - SATASS SPECIFIC:

PRINTF =	F	EXPERT =	T	COMPAR =	F
MIFLOW =	T	SUZIE =	F	SAVEIT =	T
QUANTA =	T	AMY =	F		
PPM =	1.0	PPK =	0.0	SUET =	0.20
WAITU =	1.0	GONZO =	1.00		
NITA =	5				

NETWORK TITLE:
LIVERPOOL MINI NETWORK, WARDROP EQUILIBRIUM, 1 USER CLASS

```
 26     5     6    60 6000   1  4 1600   5 5
       33     6     4    23    25    22    26
       29     7     4    26    23    24    25
 72     1     0     0     0     0     0     0
 22     2     0     0
 30     3     3     2    64     0     0     0     0
 27     3    15    90     0   0  0 4500   1 3
 28     2    18   160 2600   1  2    0   0 0
 31     0    12    60     0   0  0    0   0 0
       38     7     2    27    31
       21     7     2    28    31
 31     3     2     4     2     0     0     0     0
 30     4    12    60 6000   1  4    0   0 0
 32     0    24   140     0   0  0    0   0 0
 52     2    30   110     0   0  0 2600   1 2

****  - WARNING - **** THE MAXIMUM TURN CAPACITY FOR
        ROUNDABOUT NODE     31,  6000 EXCEEDS THE INPUT
        ROUNDABOUT CAPACITY,      2. THE CAPACITY IS THEREFORE
        RE-SET TO  6000
 32     1     0     0     0     0     0     0     0
 31     4    24   140
 44     1     0     0     0     0     0     0     0
 45     4    30   137
 45     4     3     2    42    60     0     0     0
 44     0    30   137     0   0  0    0   0 0     0  0 0
 18     3    18   130     0   0  0 1900   1 1 2400  2 3
 46     3    22   128 1300   1  1 4000   1 3     0  0 0
 53     2    24   140 2300   1  2    0   0 0     0  0 0
       12     7     6    46    53    46    44    46    18

**** - WARNING - **** TURN     46 TO     45 TO     18
        HAS BEEN GIVEN ZERO SATURATION FLOW
        BUT IS CODED AS GREEN DURING STAGE    1
        44     7    12    18    46    18    53    18    44    53    44    53    18
                          53    46

**** - WARNING - **** TURN     18 TO     45 TO     46
        HAS BEEN GIVEN ZERO SATURATION FLOW
        BUT IS CODED AS GREEN DURING STAGE    2

**** - WARNING - **** TURN     53 TO     45 TO     18
        HAS BEEN GIVEN ZERO SATURATION FLOW
        BUT IS CODED AS GREEN DURING STAGE    2

**** - WARNING - **** TURN     53 TO     45 TO     46
        HAS BEEN GIVEN ZERO SATURATION FLOW
        BUT IS CODED AS GREEN DURING STAGE    2

**** - WARNING - **** NODE     45 THE TOTAL TIMES DEFINED
        FOR STAGES AND INTER-GREENS  -   70 -
        DIFFERS FROM THE TOTAL CYCLE TIME OF    60
        ALL (GREEN) STAGE LENGTHS ARE THEREFORE FACTORED BY     0.821
 46     4     1     0     0     0     0     0     0
 45     0    22   128     0   0  0    0   0 0     0  0 0
 19     2    36   200 1700   1  1 3200   1 2 1500X  2 2
 47     2     6    65 1300G  1  1 2000G  1 1 1200G  2 2
 51     3    18   100 1300   1  1 3600   1 3 1500X  3 3
 47     4     1     0     0     0     0    38     0
 46     1     6    65     0   0  0 2000   1 1 1400X  1 1

**** - WARNING - **** LINK     46    47
```

LIVNET . LPA 6/12/90

THE SATURN SUITE OF PROGRAMS

PROGRAM SR-7.1 SATURN ASSIGMENT PROGRAM SATASS

DATE 12/ 6/90 TIME 13:57:18

THE INPUT SATURN MAG TAPE FILE IS READ FROM CHANNEL 1

HEADER DATA FROM THE MAG TAPE FILE READ FROM CHANNEL 1

RUN NAME LIVERPOOL MINI NETWORK, WARDROP EQUILIBRIUM, 1 USER CLASS

CREATED BY PROGRAM S1
DATE AND TIME OF CREATION 12/ 6/90 13/55/55

LISTING OF THE PARAM VALUES TAKEN

```
MODET  =    1    NITA   =    5    MPIJA  =    0
TITLE  =    F    REGO   =    F    COMPAR =    F
PRINTF =    F    EXPERT =    T    CCOUNT =    F
MTFLOW =    T    AMY    =    F    PRPIJA =    F
PRTIJA =    F    SUZIE  =    F    SAVEIT =    T
QUANTA =    T
SUET   = 0.20    PPM    = 1.00    PPK    = 0.00
GONZO  = 1.00
```

ke V.4

HEADER DATA FROM THE MAG TAPE FILE READ FROM CHANNEL 9

RUN NAME BUILD THE LIVERPOOL TRIP MATRIX

CREATED BY PROGRAM M1
DATE AND TIME OF CREATION 12/ 6/90 13/55/ 0

MATRIX TITLE - LIVERPOOL CENTRAL AREA O-D (TRANP CORDON)

MATRIX SIZE - 24 ROWS 24 COLUMNS
TYPE OF ELEMENTS (MTYPE) = 3
ELEMENT DIMENSIONS - TRIPS
ELEMENT UNITS - VPH *10** 0

FILE ELEMENTS ARE WRITTEN AS REAL

LISTING OF THE FLOWS ASSIGNED TO THE SELECTED LINKS

N.B. THE ASSIGNED FLOWS ARE TOTAL FLOWS INCLUDING FIXED FLOWS

LINK NO.	ANODE	BNODE	CNODE	ASSIGNED FLOW	TARGET COUNT	DIFFERENCE (PCU/HR.)	%DIFF.
1	1	58	0	714.0	1252.	538.0	42.97
2	58	1	0	235.0	779.	544.0	69.83
3	46	47	0	250.7	100.	-150.7	-150.72
4	49	48	0	292.1	200.	-92.1	-46.05
5	22	21	0	780.6	900.	119.4	13.27
6	45	53	52	106.9	826.	719.1	87.06
7	32	33	0	1508.3	1500.	-8.3	-0.56
8	33	34	0	1692.4	1600.	-92.4	-5.78
9	7	8	0	689.6	800.	110.4	13.80
10	10	65	0	517.0	400.	-117.0	-29.25
11	69	21	0	981.0	1000.	19.0	1.90

COMPARISON OF THE ASSIGNED (SET 1) AND TARGET FLOWS (SET 2):

TOTAL NUMBER OF ELEMENTS CONSIDERED 11

STATISTIC	SET 1	SET 2	DIFFERENCE
NUMBER OF ZEROS OR NEGATIVES	0	0	
SUM OF ELEMENTS	7768.	9357.	-1589.
AVERAGE ELEMENT	706.15	850.64	-144.49
STANDARD DEVIATION	494.82	463.90	30.92
COEFFICIENT OF VARIATION	0.7007	0.5454	0.1554

REGRESSION OF SET 2 ELEMENTS (Y) AGAINST SET 1 (X)

EQUATION	A	B	R-SQUARED
Y = A + BX	312.201	0.763	0.6615
STANDARD ERRORS -	327.435	0.380	
Y = BX		1.059	0.5123
Y = X			0.5003

LIVNET1.LPS 6/12/90

```
                 THE SATURN SUITE OF PROGRAMS

          PROGRAM       S3 -7.1 SATURN SIMULATION PROGRAM SATSIM

          DATE 12/ 6/90            TIME 13:58:29

 THE INPUT SATURN FILE IS READ FROM CHANNEL  1

 HEADER DATA FROM THE MAG TAPE FILE READ FROM CHANNEL  1

      RUN NAME   LIVERPOOL MINI NETWORK, WARDROP EQUILIBRIUM, 1 USER CLASS

      CREATED BY PROGRAM    S2
      DATE AND TIME OF CREATION 12/ 6/90  13/57/18

          LISTING OF THE PARAMETERS USED

 TITLE =     F   PRSFD =     F   NOTUK =     0
 MODET =     1   MASL  =     8   NITS  =    10
 ISTOP =    90   LRTP  =     0   NOPD  =     0
 TCEL  = 3.00    CAPMIN =  20.   ALEX   = 5.75



          OUTPUT FROM SATSIM (SATURN SIMULATION)
          SIMULATION RUN NUMBER     1

 ITERATION   1 - AVER. ABS. CHANGE =    131.79614 PCU/HR
 NO LINKS BLOCKING BACK

 ITERATION   2 - AVER. ABS. CHANGE =     28.48292 PCU/HR

 BLOCKING BACK CONVERGENCE STATISTICS:
    1 LINKS WITH QUEUE GT STACK - TOTAL EXCESS PCUS       70.46
    0 LINKS WITH QUEUE LT STACK - TOTAL SPARE PCUS         0.00
    0 LINKS WITH QUEUE EQ STACK (TO +- 0.1 PCU)
    1 LINKS WITH BLOCKING BACK; SUM OF
      ABSOLUTE DIFFERENCES BETWEEN QUEUES AND STACKS      70.46 PCUS.

 ITERATION   3 - AVER. ABS. CHANGE =     11.75938 PCU/HR

 BLOCKING BACK CONVERGENCE STATISTICS:
    2 LINKS WITH QUEUE GT STACK - TOTAL EXCESS PCUS      152.86
    0 LINKS WITH QUEUE LT STACK - TOTAL SPARE PCUS         0.00
    0 LINKS WITH QUEUE EQ STACK (TO +- 0.1 PCU)
    2 LINKS WITH BLOCKING BACK; SUM OF
      ABSOLUTE DIFFERENCES BETWEEN QUEUES AND STACKS     152.86 PCUS.
```

APPENDIX C

1. User-Oriented Summary Statistics from Integration-1 Model

Trip Time for Each Vehicle Under Simulated Conditions

Origin Zone	Destination Zone	Number of Arrivals	Average Trip Time (minutes)	Total Trip Time (minutes)
1	2	150	14.8	2222.3
1	3	150	12.6	1890.7
1	4	150	4.9	738.6
1	5	150	6.4	951.8
1	6	150	9.1	1369.6
1	7	150	11.9	1781.7
2	1	150	14.0	2103.4
2	3	150	5.1	764.4
2	4	150	11.4	1712.0
2	5	150	11.1	1664.9
2	6	150	8.6	1286.4
2	7	150	6.1	910.6
3	1	150	11.3	1701.2
3	2	150	4.7	697.9
3	4	675	8.8	5915.6
3	5	150	8.5	1266.3
3	6	150	6.3	944.5
3	7	150	5.2	774.6
4	1	150	4.8	712.1
4	2	150	12.3	1846.3
4	3	1350	9.8	13229.4
5	3	150	8.8	1317.9
5	4	150	4.7	701.7
6	3	150	6.7	998.7
6	4	150	6.2	931.7
7	3	150	5.0	745.2
7	4	150	7.9	1185.

Sum of total trip time = 50364.6
(839.41 hours)

Total demand to enter network = 5775
Vehicles entered network = 5775
Vehicles who completed trip = 5775
Vehicles left on network = 0

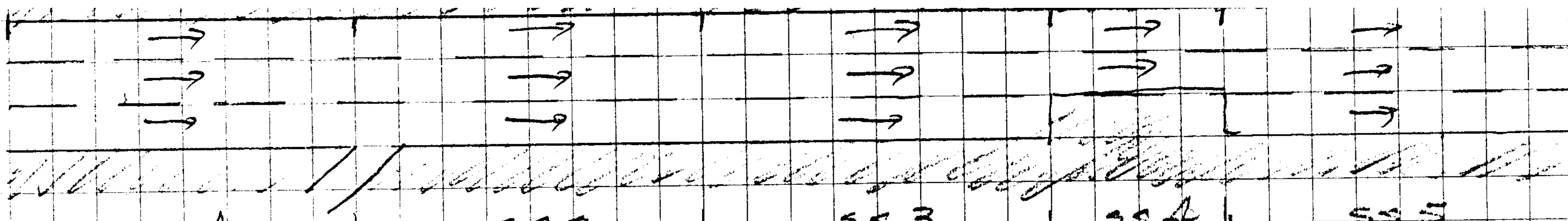
Computer time for simulation run = 00:31:50

Table 2. System-Oriented Summary Statistics from Integration-1 Model

Link Summaries at Time: 10 minutes

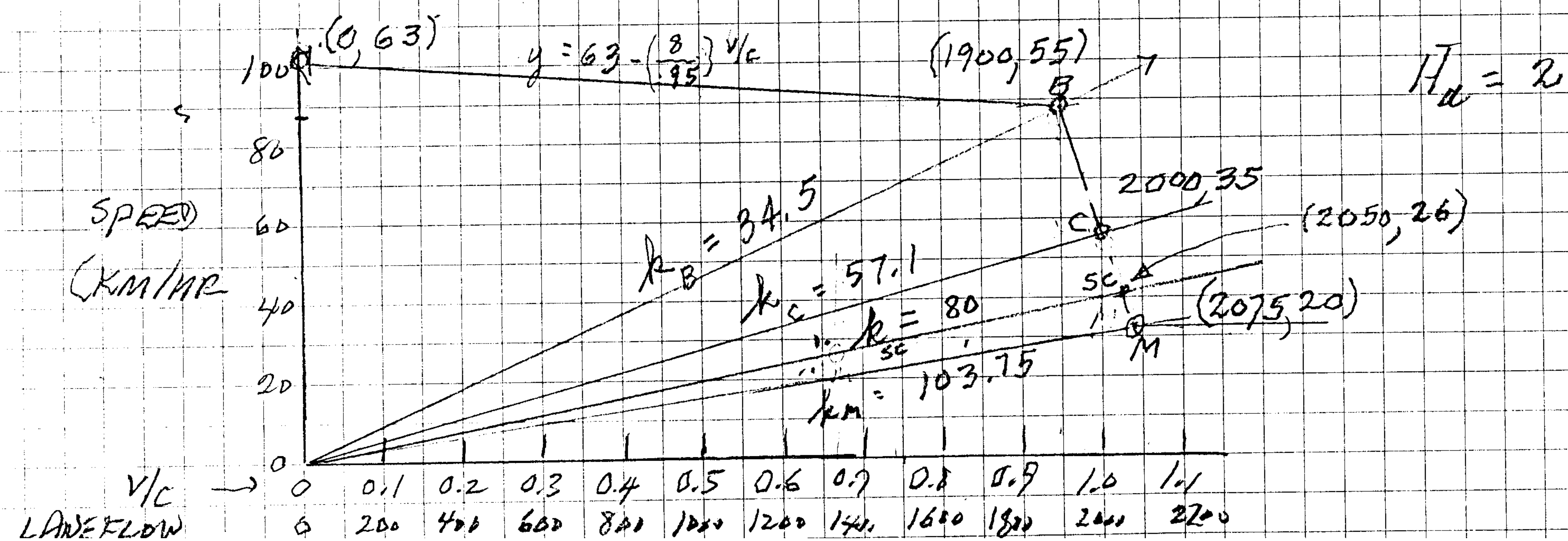
Num	Name	Link Typ S	Link Typ P	Link Speed (kph)	Link Satur (vphg)	Link Ln (#)	Link Lgth (m)	Node from (#)	Node to (#)	Link Flow (vehs)	V/C ratio (#)	Total Time (min)	Av Tir (m
1	To-Zone 1	101	1	70.0	2000	2	1414	10	1	17	0.03	27	1
2	To-Zone 2	101	1	70.0	2000	2	1414	14	2	17	0.03	27	1
3	To-Zone 3	101	1	70.0	2000	2	1000	19	3	108	0.16	130	1
4	To-Zone 4	101	1	70.0	2000	2	1000	15	4	82	0.12	101	1
5	To-Zone 5	101	1	70.0	2000	2	1000	11	5	20	0.03	24	1
6	To-Zone 6	101	1	70.0	2000	2	1000	12	6	21	0.03	28	1
7	To-Zone 7	101	1	70.0	2000	2	1000	13	7	27	0.04	30	1
8	Fr-Zone 1	1	1	70.0	2000	2	1414	1	10	144	0.22	253	1
9	Kingston Rd WB	1	1	60.0	1600	1	2236	11	10	4	0.01	16	4
10	1st Avenue NB	1	2	50.0	1400	2	1500	15	10	19	0.04	46	2
11	Fr-Zone 5	2	2	70.0	2000	2	1000	5	11	54	0.08	62	1
12	Kingston Rd EB	2	1	60.0	1600	1	2236	10	11	45	0.16	163	3
13	Kingston Rd WB	2	1	60.0	1600	1	2000	12	11	0	0.00	0	0
14	2d Avenue NB	2	2	50.0	1400	1	500	16	11	25	0.11	30	1
15	Fr-Zone 6	3	2	70.0	2000	2	1000	6	12	54	0.08	61	1
16	Kingston Rd EB	3	1	60.0	1600	1	2000	11	12	10	0.04	26	2
17	Kingston Rd WB	3	1	60.0	1600	1	2000	13	12	9	0.03	23	2
18	3d Avenue NB	3	2	50.0	1400	1	500	17	12	14	0.06	13	0
19	Fr-Zone 7	4	2	70.0	2000	2	1000	7	13	54	0.08	62	1
20	Kingston Rd EB	4	1	60.0	1600	1	2000	12	13	0	0.00	4	0

APPENDIX D



TS	SS1 (L=2000', C=6000)	SS2 (L=2000', C=6000)	SS3 (L=2000', C=6000)	SS4 (L=1000', C=4000)	SS5 (L=2000', C=6000)
1	3000	3001	3001	3001	3001
2	3900	3901	3901	3901	3901
3	3999	4000	4000	4000	4000
4	4100	4101	4101	4101	4101
5	~~4499~~ 4100	~~4500~~	~~4500~~	~~4500~~	~~4500~~
6	~~4499~~ 4100	~~4500~~	~~4500~~	~~4500~~	~~4500~~
7	~~3449~~ 3850	~~3450~~	~~3450~~	~~3450~~	~~3450~~
8	~~3449~~ 3800	~~3450~~	~~3450~~	~~3450~~	~~3450~~
9	~~3449~~ 3800	~~3450~~	~~3450~~	~~3450~~	~~3450~~

DEMANDS



$H_d = 2$

SLOPE OF BC

$$slope = \frac{55-35}{1900-2000} = -\frac{20}{100} = -0.2 \text{ MPH/VEH}$$

FLOW AT V_m

$$slope = \frac{35-20}{2000-q_M} = -0.2$$

$$2000 - q_M = \frac{15}{-0.2}$$

$$q_M = 2000 + \frac{15}{0.2} = 2000 + 75$$

$$q_M = 2075$$

DENSITIES AT B, C, AND M

$$k_B = \frac{1900}{55} = 34.5 \text{ vpmpl}$$

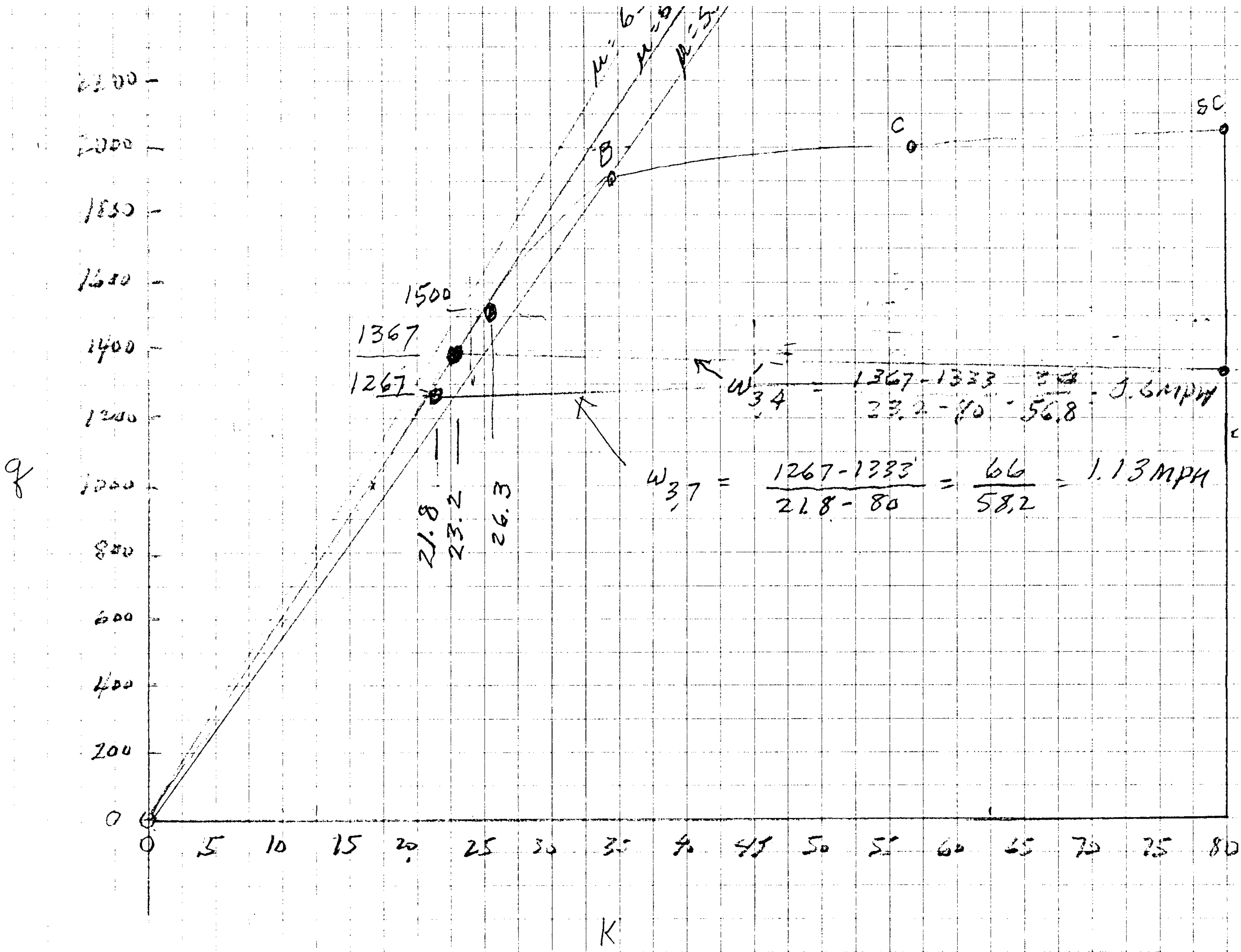
$$k_C = \frac{2000}{35} = 57.1 \text{ vpmpl}$$

$$k_M = \frac{2075}{20} = 103.75 \text{ vpmpl}$$

MAX STORAGE

$$k = \frac{5280}{3.2808\ H_d} = \frac{5280}{3.2808 \times 20} = \frac{5280}{65.616} = 80.$$ vpm

SS 1 L = 2000 C = 6000	SS 2 L = 2000 C = 6000	SS 3 L = 2000 C = 6000	SS 4 L = 100 C = 4000	SS 5 L = 2000 C = 6000
$\frac{3000}{6000} = 0.5$ (59)	$\frac{3001}{6000} = 0.5$ (59)	$\frac{3001}{6000} = 0.5$ (59)	$\frac{3001}{4000} = 0.75$ (57)	$\frac{3001}{6000} = 0.5$ (59)
$\frac{3900}{6000}$ 0.65 (58)	$\frac{3901}{6000} = 0.65$ (58)	$\frac{3901}{6000}$ 0.65 (58)	$\frac{3901}{4000} = 0.975$ (44)	$\frac{3901}{6000}$ 0.65 (58)
$\frac{3999}{6000}$ 0.67 (57)	$\frac{4000}{6000}$ 0.67 (57)	$\frac{4000}{6000}$ 0.67 (57)	$\frac{4000}{4000}$ 1.00 (35)	$\frac{4000}{6000} = 0.67$ (57)
$\frac{4100}{6000} = 0.68$ (57)	$\frac{4101}{6000} = 0.68$ (57)	$\frac{4101}{6000} = 0.68$ (57) $= .67$ $\frac{4000}{6000}$	$\frac{4101}{4000} = 1.00$ (35)	$\frac{\cancel{4101}\ 4000}{6000} = .67$ (57)
$\frac{4100}{6000}$ 0.68 (57)	$\frac{4101}{6000}$ 0.68 (57)	$\frac{4101}{6000}$ .68 (57) $\boxed{1792'}$ $-.67$ (17) $\boxed{1584'}$	$\frac{\cancel{4101}\ 4201}{4000}$ (35)	$\frac{\cancel{4101}\ 4201\ \cancel{4000}}{6000}$ .67 (57)
$\frac{4100}{6000} = 0.68$ (57)	4884' $\frac{4100}{6000} = 0.68$ (57)	$\frac{4100}{6000}$ (17)	$\frac{\cancel{4200}\ \cancel{4100}\ 4000}{4000}$ 1.0 (35)	$\frac{\cancel{4200}\ \cancel{4100}\ 4000}{6000}$ .67 (57)
$\frac{3800}{6000} = 0.63$ (58)	$\frac{3800}{6000} = 0.63$ (58)	(17) (17) $\frac{3800}{6000}$ (17) (58) $\boxed{2376'}$ 3800	$\frac{\cancel{3800}\ 4000}{4000}$ 1.0 (35)	$\frac{\cancel{3800}\ 4000}{6000}$ .67 (57)
$\frac{3800}{6000} = 0.63$ (58)	$\frac{3800}{6000}$ .63 (58)	$\frac{3800}{6000}$ .63 (58) 879' (17) 100	$\frac{3900}{4000}$ 0.975 (44)	$\frac{\cancel{3800}\ 3900}{6000}$ 0.65 (58)
$\frac{3800}{6000}$ 0.63 (58)	$\frac{3800}{6000}$ .63 (58)	$\frac{3800}{6000}$ .63 (58)	$\frac{3800}{4000}$ 0.95 (55)	$\frac{3800}{4000}$ 0.63 (58)



q
K
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
μ = .6
μ = .5
B
C
SC
1500
1367
1267
21.8
23.2
26.3
w'3,4 = 1367-1333 / 23.2-80 = 56.8 = .6 mph
w3,7 = 1267-1333 / 21.8-80 = 66 / 58.2 = 1.13 mph

APPENDIX E

1CONTINUOUS TRAFFIC ASSIGNMENT MODEL VERSION 5 CONTRAM 5.14 (16. 4.91) RUN ON 11/6/91
TRANSPORT AND ROAD RESEARCH LABORATORY (DTP) CROUTHORNE, RG116AU, ENGLAND = TRAFFIC GROUP, 0344-770494 = CROWN COPYRIGHT 1990

NETWORK AND TIME DATA

SMART CORRIDOR BASE RUN NETWORK and TIME DATA (6/11/91)

CARD TYPE	(TIME) (UNIT)	DEFINITION OF TIME SLICES IN SIMULATION PERIOD (24 HOUR CLOCK) TIME SLICE NUMBER : 1	2	3	4	5	6	7	8	9	10	11	12	13	
1	1	600	630	700	730	800	830	900	930	1000	1300	0	0	0	0

CARD TYPE	ORIGIN NUMBER	FEEDS UP TO 5 LINKS : (LETTERS DENOTE BANNED MOVEMENTS)				
3	5001	7	0	0	0	0
3	5002	5303	5304	158	128	0
3	5003	4803	4804	4603	157	0
3	5004	4607	4105	4106	0	0
3	5005	4203	7607	3505	3506	0
3	5006	3603	3610	4107	3005	3011
3	5007	3103	3110	3507	3508	2505
3	5008	2603	2610	3007	2005	2006
3	5009	2103	2110	2507	2508	1505
3	5010	1603	2007	2008	905	0
3	5011	1003	1010	1507	205	211
3	5012	80	82	83	0	0
3	5013	81	84	0	0	0
3	5014	50	0	0	0	0
3	5015	907	908	303	304	0
3	5016	202	209	703	704	0
3	5017	301	309	1307	1308	0
3	5018	8001	705	1807	1808	0
3	5019	1701	1305	1306	2307	0
3	5020	2201	2209	1805	1806	2807
3	5021	2701	2709	2305	2306	3307
3	5022	3201	2805	2806	3807	0
3	5023	3701	3709	3305	3306	4407
3	5024	4201	3805	3806	4907	0
3	5025	4405	4406	5307	4801	4809
3	5026	4905	128	0	0	0

UNCONTROLLED... CARD TYPE	SET	LINK NUMBER	FEEDS UP TO 5 LINKS OR DESTINATIONS : (LETTERS DENOTE BANNED MOVEMENTS)					CRUISE TIME (SECS)	LENGTH (METRS)	SAT/N FLOW (PCU/H)	STORE CAP. (PCUS)	JUNCTION NUMBER	% DELAY
4	1	50	51	0	0	0	0	86V	732	10500	139	136	
4	1	51	52	0	0	0	0	86V	387	10300	100	137	
4	1	52	53	1101	0	0	0	86V	320	12000	96	138	
4	1	53	54	0	0	0	0	86V	335	11400	95	139	
4	1	54	55	1607	0	0	0	86V	122	10900	33	140	
4	1	55	56	0	0	0	0	86V	518	12500	162	141	
4	1	56	57	2107	0	0	0	86V	290	11300	82	142	
4	1	57	58	0	0	0	0	86V	488	10300	126	143	
4	1	58	59	2607	0	0	0	86V	183	9800	45	144	
4	1	59	60	0	0	0	0	86V	671	10600	178	145	

4	1	60	61	3107	0	0	0	86V	183	9900	45	146
4	1	61	62	0	0	0	0	86V	579	9450	137	147
4	1	62	63	3607	0	0	0	86V	899	11550	260	148
4	1	63	64	0	0	0	0	86V	655	9500	156	149
4	1	64	65	4207	0	0	0	86V	930	8800	205	150
4	1	65	66	0	0	0	0	86V	198	9100	45	151
4	1	66	67	0	0	0	0	86V	101	9600	24	152
4	1	67	68	0	0	0	0	86V	472	9100	107	153
4	1	68	69	4601	0	0	0	86V	899	9150	206	154
4	1	69	70	0	0	0	0	86V	290	9100	66	155
4	1	70	71	0	0	0	0	86V	732	7600	139	156
4	1	71	72	0	0	0	0	86V	533	7550	101	157
4	1	72	9001	0	0	0	0	86V	701	9500	166	158
4	1	7	a	5305	5311	0	0	86V	853	15000	469	107
4	1	8	9	0	0	0	0	86V	335	8700	3500	108
4	1	9	10	5205	0	0	0	86V	122	9200	28	109
4	1	10	11	4805	0	0	0	86V	152	8600	33	110
4	1	11	12	0	0	0	0	86V	457	9000	103	111
4	1	12	13	0	0	0	0	86V	518	9300	120	112
4	1	13	14	4305	0	0	0	86V	1204	8000	241	113
4	1	14	15	0	0	0	0	86V	183	8100	37	114
4	1	15	16	4205	0	0	0	86V	122	9000	27	115
4	1	16	17	0	0	0	0	86V	442	8500	94	116
4	1	17	18	3705	0	0	0	86V	671	9500	159	117
4	1	18	19	0	0	0	0	86V	701	9450	166	118
4	1	19	20	3205	0	0	0	86V	884	10900	241	119
4	1	20	21	0	0	0	0	86V	366	9500	87	120
4	1	21	22	2705	0	0	0	86V	320	10100	81	121
4	1	22	23	0	0	0	0	86V	655	12100	198	122
4	1	23	24	2205	0	0	0	86V	335	12100	101	123
4	1	24	25	0	0	0	0	86V	457	10300	118	124
4	1	25	26	1705	0	0	0	86V	305	11900	91	125
4	1	26	27	0	0	0	0	86V	579	12500	181	126
4	1	27	28	1205	0	0	0	86V	213	11350	60	127
4	1	28	29	0	0	0	0	86V	472	8500	120	128
4	1	29	30	85	0	0	0	86V	213	9850	52	129
4	1	30	31	86	0	0	0	86V	290	9000	65	130
4	1	31	32	0	0	0	0	86V	274	7500	51	131
4	1	32	9014	0	0	0	0	86V	213	9300	50	132
4	1	80	9013	0	0	0	0	86V	700	7600	462E	160
4	1	81	9012	0	0	0	0	86V	700	7600	462E	161

SIGNALISED CARD TYPE	SET	LINK NUMBER	FEEDS UP TO 5 LINKS OR DESTINATIONS : (LETTERS DENOTE BANNED MOVEMENTS)					CRUISE TIME (SECS)	LENGTH (METRS)	SAT/N FLOW (PCU/H)	STORE CAP. (PCUS)	SIGNAL/ JUNCTION NUMBER	STAGES UHEN GREEN	% GREEN	% DELAY
6	2	705	301	309	9017	0	0	55v	837	2778	202E	7	1		
6	2	1305	705	0	0	0	0	55v	732	5100	324E	13	1		
6	2	1306	8001	0	0	0	0	55v	732	900	57E	13	1		
6	2	1307	1807	1808	0	0	0	55v	837	5100	371E	13	1		
6	2	1308	9018	0	0	0	0	55v	837	1000	72E	13	1		
6	2	1805	1305	1306	9019	0	0	55v	804	3400	237E	18	1		
6	2	1806	1701	0	0	0	0	55v	804	900	62E	18	1		
6	2	1807	2307	2308	0	0	0	55v	719	3400	212E	18	1		
6	2	1808	9019	0	0	0	0	55v	719	500	31E	18	1		
6	2	2305	1805	1806	9020	0	0	55v	815	3400	240E	23	1		
6	2	2306	2201	2209	0	0	0	55v	815	875	62E	23	1		
6	2	2307	2807	2808	0	0	0	55v	658	3400	194E	23	1		
6	2	2308	9020	0	0	0	0	55v	658	675	38E	23	1		

6	2	2805	2305	2306	0	0	0	55v	802	3400	237E	28	2
6	2	2806	2701	2709	0	0	0	55v	802	700	48E	28	2
6	2	2807	3307	3308	0	0	0	55v	815	3400	240E	28	2
6	2	2808	9021	0	0	0	0	55v	815	600	42E	28	2
6	2	3305	2805	2806	9022	0	0	55v	1591	3400	470E	33	1
6	2	3306	3201	0	0	0	0	55v	1591	955	132E	33	1
6	2	3307	3807	3808	0	0	0	55v	802	3400	237E	33	1
6	2	3308	9022	0	0	0	0	55v	802	1140	79E	33	1
6	2	3805	3305	3306	0	0	0	55v	1478	3400	436E	38	2
6	2	3806	3701	3709	0	0	0	55v	1478	600	77E	38	2
6	2	3807	4407	4408	0	0	0	55v	1591	3400	470E	38	2
6	2	3808	9023	0	0	0	0	55v	1591	825	114E	38	2
6	2	4405	3805	3806	9024	0	0	55v	1829	3400	540E	44	2
6	2	4406	4201	0	0	0	0	55v	1829	600	95E	44	2
6	2	4407	4907	4908	0	0	0	55v	1478	3400	436E	44	2
6	2	4408	9024	0	0	0	0	55v	1478	975	125E	44	2
6	2	4907	5307	5308	0	0	0	55v	1829	3400	540E	49	2
6	2	4908	9025	0	0	0	0	55v	1829	1155	183E	49	2
6	3	205	9015	0	0	0	0	55v	1272	5100	564E	2	1
6	3	206	9015	0	0	0	0	55v	1272	500	55E	2	1
6	3	211	303	304	0	0	0	55v	1272	1450	160E	2	1
6	3	905	206	205	211	0	0	55v	692	5100	306E	9	1
6	3	906	9011	0	0	0	0	55v	692	825	49E	9	1
6	3	907	1507	1508	0	0	0	55v	1201	5100	532E	9	1
6	3	908	1003	1010	0	0	0	55v	1201	1600	167E	9	1
6	3	1505	906	905	0	0	0	55v	814	3400	240E	15	2
6	3	1506	9010	0	0	0	0	55v	814	800	56E	15	2
6	3	1507	2007	2008	0	0	0	55v	692	3400	204E	15	2
6	3	1508	1603	0	0	0	0	55v	692	1600	96E	15	2
6	3	2005	1505	1506	0	0	0	55v	796	3400	235E	20	1
6	3	2006	9009	0	0	0	0	55v	796	800	55E	20	1
6	3	2007	2507	2508	9009	0	0	55v	814	3400	240E	20	1
6	3	2008	2103	2110	0	0	0	55v	814	500	35E	20	1
6	3	2505	2006	2005	0	0	0	55v	805	3400	238E	25	2
6	3	2506	9008	0	0	0	0	55v	805	650	45E	25	2
6	3	2507	3007	9008	0	0	0	55v	796	3400	235E	25	2
6	3	2508	2603	2610	0	0	0	55v	796	500	34E	25	2
6	3	3005	2506	2505	0	0	0	55v	1234	3400	364E	30	1
6	3	3006	9007	0	0	0	0	55v	1234	536	57E	30	1
6	3	3007	3507	3508	0	0	0	56V	805	2600	182E	30	1
6	3	3011	3103	3110	0	0	0	55v	1234	1450	155E	30	1
6	3	3505	3005	3006	3011	0	0	55v	1526	5100	676E	35	2
6	3	3506	9006	0	0	0	0	55v	1526	500	66E	35	2
6	3	3507	4107	4108	9006	0	0	55v	1164	5100	516E	35	2
6	3	3508	3603	3610	0	0	0	55v	1164	625	63E	35	2
6	3	4105	3506	3505	0	0	0	55v	1280	3400	378E	41	3
6	3	4106	9005	0	0	0	0	55v	1280	500	55E	41	3
6	3	4107	7612	7607	0	0	0	55v	1303	3400	385E	41	3
6	3	4108	4203	0	0	0	0	55v	1303	875	99E	41	3
6	3	4605	7606	7605	0	0	0	55v	227	5100	100E	46	1
6	3	4606	4707	0	0	0	0	55v	227	575	11E	46	1
6	3	4607	4707	4807	4808	0	0	55v	792	5100	351E	46	1
6	3	4805	4903	4904	4910	4601	0	55v	300	3400	2000	48	2
6	3	4807	4701	4702	0	0	0	55v	213	3400	62E	48	2
6	3	4808	4903	4904	4910	0	0	55v	213	1600	29E	48	2
6	3	7605	4106	4105	9004	0	0	55v	792	5100	351E	76	1
6	3	7606	9004	0	0	0	0	55v	792	740	50E	76	1
6	3	7607	4607	0	0	0	0	55v	1280	5100	567E	76	1
6	3	7612	9004	0	0	0	0	55v	1280	1450	161E	76	1
6	4	1501	905	906	9010	0	0	55v	280	3400	82E	15	1

6	4	1502	2007	2008	0	0	0	55V	280	500	12E	15	1
6	4	1601	1501	1502	0	0	0	55V	50	5100	22E	16	
6	4	1602	151	0	0	0	0	55V	50	3200	13E	16	2
6	4	1603	1703	1704	151	0	0	55V	280	5100	124E	16	1
6	4	1607	1501	1502	1703	1704	151	55V	250	3400	2000	16	3
6	4	1701	1601	1602	121	0	0	55V	1330	5100	589E	17	
6	4	1703	1803	1804	0	0	0	55V	165	5100	73E	17	1
6	4	1704	121	0	0	0	0	55V	165	1600	22E	17	2
6	4	1705	1803	1804	1601	1602	121	55V	250	3400	2000	17	3
6	4	1803	2307	2308	9019	0	0	55V	1330	3400	393E	18	2
6	4	1804	1305	1306	0	0	0	55V	1330	500	57E	18	2
6	4	2001	9009	0	0	0	0	55V	860	3400	254E	20	2
6	4	2002	2507	2508	0	0	0	55V	860	500	37E	20	2
6	4	2009	1505	1506	0	0	0	55V	860	1450	108E	20	2
6	4	2101	2001	2002	2009	0	0	55V	360	3400	106E	21	2
6	4	2102	152	0	0	0	0	55V	360	1600	50E	21	1
6	4	2103	2203	2204	0	0	0	55V	860	3400	254E	21	2
6	4	2107	2203	2204	2001	2002	2009	55V	240	3400	2000	21	3
6	4	2110	152	0	0	0	0	55V	860	1450	108E	21	2
6	4	2201	2101	2102	0	0	0	55V	1390	3400	410E	22	2
6	4	2203	2303	2304	0	0	0	55V	360	3400	106E	22	2
6	4	2204	122	0	0	0	0	55V	360	1800	56E	22	1
6	4	2205	2303	2304	2101	2102	122	55V	240	3400	2000	22	3
6	4	2209	122	0	0	0	0	55v	1390	1450	175E	22	2
6	4	2303	2807	2808	9020	0	0	55V	1390	3400	410E	23	2
6	4	2304	1805	1806	0	0	0	55V	1390	500	60E	23	2
6	4	2501	2005	2006	9008	0	0	55V	820	3400	242E	25	1
6	4	2502	3007	0	0	0	0	55V	820	500	35E	25	
6	4	2601	2501	2502	0	0	0	55V	400	3400	118E	26	
6	4	2602	153	0	0	0	0	55V	400	1600	55E	26	3
6	4	2603	2703	2704	0	0	0	55V	820	3400	242E	26	1
6	4	2607	2703	2704	2501	2502	153	55V	330	3400	2000	26	2
6	4	2610	153	0	0	0	0	55V	820	1450	103E	26	1
6	4	2701	2601	2602	0	0	0	55V	1400	5100	620E	27	1
6	4	2703	2803	2804	2810	0	0	55V	400	3400	118E	27	1
6	4	2704	123	0	0	0	0	55V	400	1600	55E	27	3
6	4	2705	2803	2804	2810	2601	2602	55V	330	3400	2000	27	2
6	4	2709	123	0	0	0	0	55V	1400	1450	176E	27	
6	4	2803	9021	0	0	0	0	55V	1400	3400	413E	28	
6	4	2804	2305	2306	0	0	0	55V	1400	500	60E	28	
6	4	2810	3307	3308	0	0	0	55V	427	1450	53E	28	
6	4	3001	2505	2506	3507	3508	9007	55V	1076	3400	318E	30	2
6	4	3101	3001	0	0	0	0	55V	300	3400	88E	31	2
6	4	3102	154	0	0	0	0	55V	300	1600	41E	31	
6	4	3103	3203	3204	0	0	0	55V	1076	3400	318E	31	2
6	4	3107	3203	3204	3001	154	0	55V	240	3400	2000	31	3
6	4	3110	154	0	0	0	0	55V	1076	1450	135E	31	2
6	4	3201	3101	3102	124	0	0	55V	1280	3400	378E	32	1
6	4	3203	3303	0	0	0	0	55v	300	3400	88E	32	
6	4	3204	124	0	0	0	0	55V	300	1600	41E	32	1
6	4	3205	3303	3101	3102	124	0	55V	240	3400	2000	32	3
6	4	3303	3807	3808	2805	2806	9022	55V	1280	3215	357E	33	2
6	4	3501	3005	3006	3011	9006	0	55V	1750	5100	776E	35	1
6	4	3502	4107	4108	0	0	0	55V	1750	500	76E	35	
6	4	3601	3501	3502	0	0	0	55V	360	5100	159E	36	1
6	4	3602	155	0	0	0	0	55V	360	1600	50E	36	3
6	4	3603	3703	3704	0	0	0	55V	1750	5100	776E	36	
6	4	3607	3703	3704	3501	3502	155	55V	300	4200	2000	36	2
6	4	3610	155	0	0	0	0	55V	1750	1450	220E	36	1
6	4	3701	3601	3602	0	0	0	55V	805	6800	476E	37	2

6	4	3703	3803	3804	0	0	0	55V	360	5100	159E	37	2
6	4	3704	125	0	0	0	0	55V	360	1800	56E	37	1
6	4	3705	3601	3602	3803	3804	125	55V	300	3400	2000	37	3
6	4	3709	125	0	0	0	0	55V	805	1600	112E	37	2
6	4	3803	4407	4408	9023	0	0	55V	805	5100	357E	38	1
6	4	3804	3305	3306	0	0	0	55V	805	500	35E	38	1
6	4	4101	3505	3506	9005	0	0	55V	1733	5100	768E	41	1
6	4	4102	7607	7612	0	0	0	55V	1733	1600	241E	41	2
6	4	4201	4101	4102	156	0	0	55V	595	5100	263E	42	1
6	4	4203	4303	156	a7	0	0	55V	1733	5100	768E	42	1
6	4	4205	4101	4102	0	0	0	55V	300	3400	2000	42	3
6	4	4207	4101	4102	4303	156	0	55V	500	3400	2000	42	3
6	4	4303	4403	4404	126	0	0	55V	490	6800	289E	43	1
6	4	4305	4403	4404	126	0	0	55V	300	3400	2000	43	2
6	4	4403	4907	4908	9024	0	0	55V	105	5100	46E	44	1
6	4	4404	3805	3806	0	0	0	55V	105	500	4E	44	1
6	5	901	9011	0	0	0	0	55V	212	3400	62E	9	2
6	5	902	1507	1508	0	0	0	55V	212	500	9E	9	2
6	5	909	205	206	211	0	0	55V	212	1700	31E	9	2
6	5	1001	901	902	909	0	0	55V	169	3400	49E	10	2
6	5	1002	1108	0	0	0	0	55V	169	1600	23E	10	1
6	5	1003	1203	1204	0	0	0	55V	212	3400	62E	10	2
6	5	1005	1203	1204	901	902	909	55V	165	3400	48E	10	3
6	5	1010	1108	0	0	0	0	55V	212	1450	26E	10	2
6	5	1101	1005	150	0	0	0	55V	200	3400	2000	11	2
6	5	1108	150	0	0	0	0	55V	165	1325	19E	11	1
6	5	1201	1001	1002	120	0	0	55V	151	5100	66E	12	2
6	5	1203	7803	0	0	0	0	55V	169	5100	74E	12	1
6	5	1204	120	0	0	0	0	55V	169	1600	23E	12	1
6	5	1205	1001	1002	7803	0	0	55V	220	3200	2000	12	3
6	5	1303	9018	0	0	0	0	55V	298	3400	88E	13	2
6	5	1304	705	0	0	0	0	55V	298	1050	27E	13	2
6	5	1310	1807	1808	0	0	0	55V	298	1450	37E	13	2
6	5	7801	1201	0	0	0	0	55V	97	3400	28E	78	1
6	5	7803	8003	0	0	0	0	55V	151	3400	44E	78	1
6	5	8001	7801	0	0	0	0	55V	298	3400	88E	80	1
6	5	8003	1303	1304	1310	0	0	55V	97	3400	28E	80	1
6	6	4601	4807	4808	4707	7605	0	55V	250	3400	2000	46	3
6	6	4603	7605	7606	4807	4808	0	55V	152	3400	44E	46	3
6	6	4701	4603	9003	0	0	0	55V	140	3400	41E	47	1
6	6	4702	157	0	0	0	0	55V	140	660	8E	47	1
6	6	4707	4803	4804	157	9003	0	55V	152	3400	44E	47	2
6	6	4801	4701	4702	0	0	0	55V	213	3400	62E	48	4
6	6	4803	4903	4904	4910	0	0	55V	140	3400	41E	48	4
6	6	4804	4605	4606	127	0	0	55V	140	1600	19E	48	4
6	6	4809	4605	4606	127	0	0	55V	213	1450	26E	48	4
6	6	4903	9025	0	0	0	0	55V	213	3400	62E	49	1
6	6	4904	4405	4406	0	0	0	55V	213	500	9E	49	1
6	6	4905	4801	4405	4406	9025	0	55V	427	3235	120E	49	2
6	6	4910	5307	5308	0	0	0	55V	213	1450	26E	49	1
6	6	5201	9002	0	0	0	0	55V	210	5100	93E	52	3
6	6	5202	158	0	0	0	0	55V	210	1600	29E	52	3
6	6	5205	9002	0	0	0	0	55V	500	3400	2000	52	3
6	6	5303	4.905	9026	0	0	0	55V	210	5100	93E	53	1
6	6	5304	128	0	0	0	0	55V	210	500	9E	53	1
6	6	5307	5201	5202	0	0	0	55V	427	5100	189E	53	3
6	6	5308	9026	0	0	0	0	55V	427	1600	59E	53	3
6	6	5305	5201	5202	4905	128	0	55V	350	3400	2000	53	3
6	6	5311	9026	0	0	0	0	55V	350	1450	2000	53	3
6	7	202	907	908	0	0	0	55V	457	3400	135E	2	2

6	7	209	9015	0	0	0	0	55v	457	1450	57E	2	2
6	7	301	202	209	0	0	0	55v	334	5100	148E	3	1
6	7	303	703	704	0	0	0	55v	457	5100	202E	3	1
6	7	304	9016	0	0	0	0	55v	457	500	19E	3	
6	7	309	9016	0	0	0	0	55v	334	1450	42E	3	
6	7	703	1307	1308	9017	0	0	55v	334	5100	148E	7	2
6	7	704	9017	0	0	0	0	55v	334	500	14E	7	2
4	8	82	51	0	0	0	0	86V	300	9000	234E	136	
4	8	83	32	0	0	0	0	86V	500	9000	391E	131	
4	8	84	52	0	0	0	0	86V	500	9000	391E	137	
4	8	85	9013	0	0	0	0	86V	300	9000	2000	160	
4	8	86	9012	0	0	0	0	86V	500	9000	.2000	161	
4	8	87	15	0	0	0	0	86V	200	9000	156E	114	
6	8	120	29	0	0	0	0	5ov	200	3400	59E	128	
6	8	121	27	0	0	0	0	5ov	250	3400	73E	126	
6	8	122	25	0	0	0	0	5ov	250	3400	73E	124	1
6	8	123	23	0	0	0	0	5ov	300	3400	88E	122	
6	8	124	21	0	0	0	0	5ov	250	3400	73E	120	1
6	8	125	19	0	0	0	0	5ov	300	3400	88E	118	1
6	8	126	17	0	0	0	0	5ov	300	3400	88E	116	1
6	8	127	13	0	0	0	0	5ov	400	3400	118E	112	1
6	8	128	9	0	0	0	0	5ov	400	3400	118E	108	
6	8	150	54	0	0	0	0	50V	200	3400	59E	139	
6	8	151	56	0	0	0	0	5ov	250	3400	73E	141	
6	8	152	58	0	0	0	0	5ov	250	3400	73E	143	1
6	8	153	60	0	0	0	0	5ov	300	3400	88E	145	
6	8	154	62	0	0	0	0	5ov	250	3400	73E	147	1
6	8	155	64	0	0	0	0	5ov	300	3400	88E	149	1
6	8	156	68	0	0	0	0	5ov	300	3400	88E	153	
6	8	157	71	0	0	0	0	5ov	350	3400	103E	156	
6	8	158	72	0	0	0	0	5ov	300	3400	88E	157	1

OFLAGS:- V = SPEED IN KM/H, SF = LANES*1000 + SPEED/FLOW NUMBER, E = ESTIMATED STORAGE CAPACITY, D = DEPARTURES, A = ARRIVAL

CARD TYPE	VEH CLASS	FUEL COEFFICIENTS					
		CRUISE			WEIGHT	EFFICIENCY	
		A (ML/M)	B (M L / S)	C (ML/MV**2)	M (T)	EI (ML/KJ..)	E2
D/F	C	0.024	0.361	0.000057	1.080	0.087	0.025
D/F	B	-0.040	2.272	0.000334	8.000	0.074	0.025
D/F	L	-0.040	2.272	0.000334	5.000	0.074	0.025

CARD TYPE	PCUS PER CLASS CAR	B	L	CRUISE TIMES (% CAR VALUE) CAR	B	L
D/F	1.0	2.0	1.5	100	100	100

NETWORK COMPOSITION DEDUCED FROM DATA:

57 UNCONTROLLED LINKS)
0 GIVE-WAY LINKS) TOTAL OF 275 LINKS OF ALL TYPES
218 SIGNALISED LINKS)
41 SIGNAL JUNCTIONS TOTAL OF 92 JUNCTIONS OF ALL TYPES

NO. OF ORIGINS 26 NO. OF DESTINATIONS 26

OTOTAL VEHICLE FLOW RATES FROM EACH ORIGIN DURING EACH TIME SLICE (VEH/H)

ORIGINS	FLOWS								
5001	2738	7242	9006	9006	6836	5368	3628	2738	0
5002	62	150	190	190	130	116	78	62	0
5003	644	1666	2086	2086	1640	1250	844	644	0
5004	136	348.	438	438	336	254	180	136	0
5005	300	782	962	962	766	594	398	300	0
5006	556	1446	1796	1796	1380	1048	726	556	0
5007	52	134	162	162	118	a4	66	52	0
5008	320	816	1018	1018	762	598	412	320	0
5009	168	428	528	528	402	304	216	168	0
5010	324	822	1024	1024	742	552	420	324	0
5011	12	30	32	32	26	18	14	12	0
5012	778	2048	2554	2554	1948	1430	1026	778	0
5013	778	2048	2554	2554	1992	1332	1026	778	0
5014	1808	4844	5990	6028	4810	3232	2376	1808	0
5015	28	80	92	92	80	58	32	28	0
5016	38	86	106	106	86	58	46	38	0
5017	a	18	18	18	18	12	8	a	0
5018	108	286	346	346	286	186	142	108	0
5019	72	166	204	204	160	120	80	70	0
5020	114	280	346	346	276	206	142	114	0
5021	214	532	662	662	510	390	270	214	0
5022	34	90	110	110	78	68	44	34	0
5023	354	944	1170	1170	916	656	476	366	0
5024	324	862	1066	1066	726	630	432	324	0
5025	358	914	1138	1138	834	654	464	358	0
5026	214	540	670	670	496	400	270	214	0

OTOTAL VEHICLE FLOW RATES DIRECTED TOWARDS EACH DESTINATION DURING EACH TIME SLICE (VEH/H)

DESTINATIONS	FLOWS								
9001	2996	7934	9884	9884	7612	5120	3970	2996	0
9014	1792	4728	5888	5888	4356	3498	2362	1792	0
9013	536	1398	1736	1736	1238	1042	684	536	0
9012	1160	3048	3804	3804	2896	2282	1512	1160	0
9017	146	364	460	460	354	248	178	146	0
9018	78	194	234	234	188	146	98	78	0
9019	46	122	142	142	112	80	56	46	0
9020	50	152	182	182	148	118	68	50	0
9021	112	266	328	328	264	198	142	112	0
9022	26	58	64	64	50	40	34	26	0
9023	218	592	700	738	578	422	300	218	0
9024	132	324	400	400	324	244	162	132	0
9025	48	140	170	170	132	104	66	48	0
9015	162	394	498	498	370	304	210	162	0
9011	186	470	588	588	442	352	244	186	0
9010	564	1486	1844	1844	1472	1058	748	564	0
9009	262	666	830	830	658	500	334	262	0
9008	90	236	284	284	234	176	116	90	0
9007	244	628	784	784	620	476	316	244	0
9006	86	228	274	274	228	178	120	a6	0
9005	328	842	1042	1042	810	622	426	328	0
9004	430	1120	1390	1390	1120	832	560	428	0
9003	340	890	1108	1108	852	604	448	346	0
9002	416	1078	1346	1346	1072	800	544	422	0
9026	50	134	164	164	126	104	64	50	0
9016	44	110	124	124	98	70	54	44	0

OTOTAL VEHICLE FLOW RATES ENTERING THE NETWORK DURING EACH TIME SLICE (VEH/H)

10542	27602	34268	34306	26354	19618	13816	10552	0

ONUMBER OF ORIGIN-DESTINATION (O-D) CARDS 2420
LAST TIME SLICE WITH NON-ZERO O-D DEMAND 8
LENGTH OF "BUSY PERIOD" IN MINUTES 240
ESTIMATED TOTAL DEMAND (VEHICLES) 88529

1 LINK-BY-LINK ALL-TIME-SLICES - MEAN TRAVEL TIMES PER VEHICLE (SEC) RUN ON 11/ 6/91

SMART CORRIDOR BASE RUN NETWORK and TIME DATA (6/11/91)
SMART CORRIDOR BASE DEMAND
SMART CORRIDOR CONTROL DATA

ITERATION NUMBER 3

TIME SLICES :

LINK NO.& TYPE	1	2	3	4	5	6	7	8	9	MEAN QUEUE TIME
	600 630	630 700	700 730	730 800	800 830	830 900	900 930	930 1000	1000 1300	
7u	35	35	35	35	35	35	35	35	0	35
8U	14	14	15	33	31	14	14	14	0	20
9u	5	5	7	14	8	5	5	5	0	7
IOU	6	6	7	10	8	7	6	6	0	7
11U	19	19	24	35	27	21	19	19	0	24
12U	21	21	27	41	32	24	21	21	21	28
13u	50	-50	104	170	163	73	50	50	50	100
14U	7	7	10	23	27	7	7	7	7	13
15U	5	5	5	5	5	5	5	5	5	5
16U	18	18	18	18	18	18	18	18	18	18
17U	28	28	28	28	28	28	28	28	28	28
18U	29	29	29	29	29	29	29	29	29	29
19U	37	37	37	37	37	37	37	37	37	37

20U	15	15	15	15	15	15	15	15	15	15
21U	13	13	27	14	**14**	13	13	13	13	16
22u	27	27	27	31	33	29	27	27	27	29
23U	**14**	14	**14**	19	18	15	14	14	14	16
24U	19	19	19	25	29	21	19	19	19	22
25U	12	12	13	23	23	14	12	12	12	16
26U	24	24	31	44	43	27	24	24	24	32
27U	8	8	10	12	19	11	8	8	8	11
28U	19	19	44	84	86	75	21	19	19	53
29U	8	8	8	8	8	8	8	8	8	8
30u	12	12	12	12	12	12	12	12	12	12
31u	11	11	11	11	11	11	11	11	11	11
32U	8	8	8	8	8	8	8	8	8	8
50u	30	30	30	30	30	30	30	30	0	30
51u	16	16	16	16	16	16	16	16	0	16
52U	13	13	13	13	**13**	13	13	13	0	13
53u	14	14	14	14	**14**	14	14	**14**	14	14
54u	5	5	5	5	5	5	5	5	5	5
55u	21	21	21	21	21	21	21	21	21	21
56U	12	12	12	12	12	12	12	12	12	12
57U	20	20	20	22	22	20	20	20	20	21
58U	7	7	17	25	8	7	7	7	7	13
59U	28	28	28	29	28	28	28	28	28	28
60U	7	7	15	26	8	7	7	7	7	12
61U	24	24	29	33	29	24	24	24	24	27
62U	37	37	37	52	48	40	37	37	37	42
63U	27	27	32	42	39	30	27	27	27	33
64U	38	38	80	119	93	49	38	38	38	69
65U	8	8	8	8	14	8	8	8	8	9
66U	4	4	4	4	12	4	4	4	4	5
67U	19	19	19	30	34	21	19	19	19	23
68U	37	37	38	61	91	59	37	37	37	52
69U	12	12	14	20	24	12	12	12	12	15
70u	30	30	37	62	75	54	32	30	30	47
71u	22	22	51	90	102	93	27	22	22	62
72U	29	29	29	29	29	29	29	29	29	29
80U	29	29	29	29	29	29	29	29	0	29
81U	29	29	29	29	29	29	29	29	0	29
82U	12	12	12	12	12	12	12	12	0	12
83U	20	20	20	20	20	20	20	20	0	20
84U	20	20	20	20	20	20	20	20	0	20
85U	12	12	12	12	12	12	12	12	12	12
86U	20	20	20	20	20	20	20	20	20	20
87U	8	8	8	8	8	8	8	8	0	8
120s	**14**	14	**14**	14	14	14	**14**	14	0	14
121s	18	18	30	88	98	18	18	18	0	41
122s	18	18	20	59	54	21	18	18	0	35
123S	21	21	21	30	34	21	21	21	0	25
124S	18	18	18	18	18	18	18	18	18	18
125S	21	21	21	21	21	21	21	21	21	21
126S	0	21	21	21	21	0	0	0	0	21
127S	28	28	28	32	37	28	28	28	0	30
128S	28	28	32	82	55	28	28	28	0	49
150s	14	14	**14**	14	14	14	14	**14**	0	14
151s	18	18	18	18	18	18	18	18	0	18
152S	18	18	18	18	18	18	18	18	0	18
153s	21	21	21	22	21	21	21	21	0	21
154s	18	18	18	37	20	18	18	18	0	23
155s	21	21	41	41	41	24	21	21	0	33
156S	21	21	21	73	95	33	21	21	0	61

157s	25	25	85	230	292	79	27	25	0
158S	21	21	21	21	21	21	21	21	0
202s	38	38	38	40	40	38	38	38	0
205s	92	92	93	93	92	92	92	92	92
206s	0	0	87	92	90	0	0	0	0
209S	38	38	38	38	38	38	38	38	0
211s	92	93	94	97	97	93	92	92	0
301s	26	26	26	26	26	26	26	26	0
303s	34	34	34	34	34	34	34	34	0
304s	34	35	35	37	37	34	34	34	0
309s	26	26	26	26	26	26	26	26	26
703s	28	28 ,	28	28	28	28	28	28	0
704s	0	0	0	21	25	0	0	0	0
705s	66	67	69	77	73	67	66	66	65
901s	22	23	23	23	22	23	22	22	22
902S	22	22	23	24	22	22	22	22	0
905s	54	54	54	55	55	54	54	54	0
906S	54	57	61	77	100	62	55	54	0
907s	87	87	87	87	87	87	87	87	0
908S	87	88	88	95	100	89	87	87	0
909s	23	24	24	24	23	23	23	23	22
1001s	18	19	19	18	18	19	18	18	18
1002s	31	39	42	43	42	39	32	31	0
1003s	20	20	20	21	21	20	20	20	0
1005s	52	123	207	228	117	83	62	52	0
1010s	20	21	21	20	20	20	20	20	0
1101s	35	37	37	36	35	35	35	35	0
1108S	13	14	15	14	15	14	13	13	0
1201s	27	28	30	32	31	28	27	27	0
1203s	24	24	24	24	24	24	24	24	0
1204s	25	26	26	37	83	60	24	25	0
1205s	29	33	37	31	30	33	30	29	27
1303s	28	28	28	28	28	28	28	28	0
1304s	30	34	37	32	30	32	31	30	28
1305s	56	56	56	57	57	56	56	56	0
1306s	56	57	132	195	211	76	56	56	0
1307s	63	63	63	63	63	63	63	63	0
1308S	63	63	63	64	64	63	63	63	0
1310s	0	28	28	28	28	28	0	0	0
1501s	24	28	29	30	30	28	25	25	23
1502s	23	23	24	24	23	23	23	23	0
1505s	68	68	71	82	79	69	68	68	0
1506s	73	91	214	509	539	296	82	74	0
1507s	59	59	60	60	60	59	59	59	0
1508s	0	59	59	0	0	59	0	0	0
1601s	15	16	17	17	17	16	15	15	14
1602s	16	16	16	16	16	16	16	16	0
1603s	30	32	32	32	31	31	30	30	0
1607s	39	116	199	369	307	128	40	39	0
1701s	97	98	98	98	98	98	97	97	0
1703s	20	20	21	21	21	20	20	20	0
1704s	25	33	29	28	27	28	26	25	0
1705s	42	98	180	300	407	146	55	46	36
1803s	92	. 92	92	92	92	92	92	92	0
1804s	0	0	95	96	95	92	0	0	0
1805s	66	66	70	85	88	67	66	66	0
1806S	66	69	98	167	284	204	66	66	0
1807S	61	61	61	61	61	61	61	61	0
1808S	0	62	67	66	67	62	0	0	0
2001s	63	63	64	64	63	63	63	63	62

2002s	62	62	63	63	64	62	62	62	0
2005s	64	65	67	68	68	65	64	64	0
2006S	65	70	80	95	105	77	67	65	0
2007s	65	65	66	66	66	65	65	65	0
2008s	0	0	0	0	0	0	0	0	0
2009s	0	0	65	68	65	62	0	0	0
2101s	34	35	35	36	36	35	35	34	34
2102s	45	50	50	53	47	47	45	45	0
2103s	67	68	68	68	68	67	67	67	0
2107s	31	34	50	53	39	33	31	31	0
2110s	68	71	72	70	70	69	69	68	0
2201s	104	104	105	105	104	104	104	104	0
2203s	37	37	37	37	37	37	37	37	0
2204s	41	50	58	59	55	48	41	41	0
22059	31	33	34	37	35	34	31	31	30
2209s	104	106	106	107	115	105	104	104	0
2303s	95	95	95	95	95	95	95	95	0
23046	95	96	104	131	118	96	95	95	0
2305s	67	68	73	94	92	69	67	67	0
2306s	0	0	68	120	103	67	0	0	0
23078	57	57	57	57	57	57	57	57	0
2308s	57	58	58	58	58	57	57	57	0
2501s	58	58	58	58	58	58	58	58	0
25026	58	58	60	74	68	58	58	58	0
2505s	66	68	70	74	74	68	67	66	0
2506s	66	69	70	73	74	69	67	66	0
25076	66	66	67	67	67	66	66	66	0
2508s	0	0	67	68	0	0	0	0	0
2601s	37	37	38	38	38	37	37	37	0
2602S	4s	53	53	56	48	48	46	45	0
2603s	64	65	66	66	65	65	65	64	0
2607s	38	39	41	47	40	38	38	38	0
2610s	66	75	75	74	73	70	67	66	0
2701s	104	104	104	104	104	104	104	104	0
2703s	38	39	40	42	40	39	38	38	0
2704s	42	47	48	45	44	45	43	42	0
2705S	41	42	43	44	45	42	41	41	0
2709s	104	107	115	116	120	107	106	104	0
2803s	100	100	101	101	101	100	100	100	0
28049	0	100	105	116	107	102	0	0	0
2805S	61	61	63	66	66	61	61	61	0
28068	0	62	85	89	114	63	58	0	0
2807s	62	62	62	62	62	62	62	62	0
28088	62	63	64	64	63	63	62	62	0
2810s	36	36	36	41	37	36	36	36	0
3001s	76	77	79	80	79	77	77	76	76
3005s	95	97	101	108	106	97	96	95	0
3006s	97	106	123	189	210	120	100	97	0
3007s	66	67	72	87	77	66	66	66	0
3011s	102	129	253	320	235	117	108	102	0
3101s	31	31	32	32	32	31	31	31	31
31025	36	38	39	37	37	37	36	36	0
3103s	83	84	85	84	85	84	83	83	0
3107s	32	35	39	65	60	34	32	32	0
3110s	82	83	82	82	82	82	82	82	0
3201s	94	96	96	96	96	96	95	95	94
3203s	30	30	30	30	30	30	30	30	0
3204s	34	43	52	43	43	41	36	34	30
3205s	28	28	29	29	30	28	28	28	0
3303s	91	91	91	91	91	91	91	91	0

3305s	115	116	123	158	128	116	115	115	0	134
3306s	116	148	164	215	201	147	122	117	0	169
3307s	63	63	64	65	64	62	63	63	0	64
3308S	63	63	63	63	63	63	63	63	0	63
3501s	121	121	121	121	121	121	121	121	0	121
3502S	0	0	123	127	134	0	0	0	0	130
3505s	111	112	113	115	113	112	111	111	0	113
3506s	113	114	119	125	123	116	115	113	0	119
3507s	88	88	90	91	92	88	88	88	0	90
3508S	0	0	0	107	0	0	0	0	0	107
3601s	33	33	34	34	34	33	33	33	0	34
36028	44	57	56	56	45	46	46	44	0	52
3603s	124	125	125	126	125	125	124	124	0	125
3607s	35	36	39	55	42	36	36	35	0	44
3610s	127	135	131	142	143	131	128	127	0	135
3701s	60	60	60	61	60	60	60	60	0	60
3703s	31	32	32	33	33	32	31	31	0	32
3704s	47	81	193	258	214	77	47	47	0	165
3705s	36	38	38	38	38	37	37	36	35	37
3709s	67	125	162	163	79	95	69	67	60	110
3803s	58	58	59	59	59	58	58	58	58	59
38043	0	58	61	70	62	0	0	0	0	66
3805s	109	113	128	217	123	113	110	109	0	147
3806s	165	177	170	258	249	177	162	180	0	194
3807s	117	117	118	119	119	118	117	117	0	118
3808s	117	118	118	121	124	118	118	117	0	121
4101s	122	123	124	124	124	123	122	122	122	123
4102s	0	0	141	147	198	140	0	0	0	170
4105s	97	98	101	113	102	98	97	97	0	104
4106s	129	114	138	175	265	157	126	126	94	156
4107s	99	101	112	155	194	120	100	99	0	143
4108s	0	0	100	210	130	114	0	0	0	168
4201S	49	49	49	50	62	53	49	49	0	53
4203s	125	125	126	127	128	127	125	125	0	126
4205s	31	33	33	33	33	32	32	28	0	33
42078	45	49	55	69	60	49	46	46	44	56
4303s	33	33	34	34	34	34	33	33	0	34
4305s	41	42	41	40	42	41	41	41	0	41
4403s	14	14	15	14	15	14	14	14	0	14
4404s	0	0	0	0	0	0	0	0	0	0
4405s	130	130	133	135	134	128	130	130	0	134
4406s	0	0	132	247	283	0	0	0	0	256
4407s	107	107	109	109	110	108	107	107	0	109
4408S	0	107	108	110	111	108	0	0	0	110
4601S	29	58	70	94	42	45	32	31	25	54
4603S	18	20	24	27	22	19	19	18	0	23
4605S	30	0	0	0	30	0	30	30	0	30
46063	0	0	0	32	31	0	0	0	0	32
4607s	68	69	72	75	77	70	68	68	0	72
4701s	18	21	23	29	24	21	19	18	0	24
4702s	20	25	64	96	110	63	26	20	0	68
4707s	27	35	48	65	99	43	29	28	24	50
4801S	27	30	38	67	47	32	28	27	0	43
4803s	23	25	27	26	26	25	21	23	0	26
4804s	36	151	297	322	145	119	86	37	0	158
4805S	34	33	34	36	35	34	33	34	0	34
4807s	0	28	28	54	42	29	0	0	0	41
4808S	32	58	51	54	65	53	43	35	27	51
4809s	33	130	192	223	97	48	37	33	0	117
4903s	20	20	20	20	20	20	20	20	0	20

4904s	20	26	54	71	56	25	20	20	0	55
4905s	39	40	45	52	45	40	39	39	0	45
4907s	130	131	133	137	136	132	130	130	0	135
4908S	130	130	130	131	132	130	130	130	0	131
4910s	23	36	61	36	42	54	27	24	20	42
5201s	29	32	35	33	33	35	31	30	28	33
5202s	30	37	176	178	480	75	39	30	0	188
5205s	47	48	49	49	49	48	47	47	0	48
5303s	25	25	25	25	25	25	25	25	0	25
5304s	0	0	0	0	0	0	0	0	0	0
5305s	34	35	42	103	47	35	35	34	0	65
5307s	41	43	55	144	267	102	42	41	39	111
5308s	40	41	41	41	41	41	40	40	39	41
5311s	34	35	35	35	35	35	34	34	0	35
7605s	59	60	62	63	61	60	59	59	58	61
7606S	58	59	61	62	60	59	58	58	0	60
7607S	90	91	91	92	92	91	90	90	0	91
7612s	91	92	94	98	100	95	91	91	0	96
7801s	9	10	10	11	11	10	9	9	0	10
7803S	13	13	13	13	13	13	13	12	0	13
8001S	22	22	22	23	23	22	22	22	0	22
8003s	9	9	9	9	9	9	9	9	9	9

1 LINK-BY-LINK ALL-TIME-SLICES TOTAL DELAY (VEH-H) RUN ON 11/6/91

SMART CORRIDOR BASE RUN NETWORK and TIME DATA (6/11/91)
SMART CORRIDOR BASE DEMAND
SMART CORRIDOR CONTROL DATA

ITERATION NUMBER 3

TIME SLICES :

LINK NO.& TYPE	1	2	3	4	5	6	7	8	9	TOTAL DELAY
	600 630	700	730	800	830	900	930	1000	1300	
7u	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
8u	.00	.00	.85	9.73	25.97	.00	.00	.00	.00	36.55
9U	.00	.00	1.63	9.09	3.57	.07	.00	.00	.00	14.35
10U	.00	.00	1.50	4.56	1.73	1.02	.00	.00	.00	8.81
11U	.00	.00	3.99	14.81	8.31	2.19	.00	.00	.00	29.30
12U	.00	.00	5.80	18.07	12.04	4.06	.00	.00	.00	39.97
13U	.00	.01	61.40	134.69	126.31	20.87	.00	.00	.00	343.29
14u	.00	.00	3.52	17.86	22.53	.00	.00	.00	.00	43.90
15U	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
16U	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
17U	.00	.00	.00	.00	.00	.00	.00	.00	.DO	.00
18U	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
19U	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2ou	.00	.00	.00	.DO	.00	.00	.00	.00	.00	.00
21u	.00	.00	19.53	1.10	1.15	.32	.00	.00	.00	22.11
22u	.00	.00	.00	4.08	6.06	4.97	.00	.00	.00	15.12
23U	.00	.00	.00	6.10	5.66	1.59	.00	.00	.00	13.35
24U	.00	.00	.17	6.89	11.53	4.36	.00	.00	.00	22.94
25U	.00	.00	1.59	13.38	13.75	4.15	.00	.00	.00	32.86
26U	.00	.00	5.97	24.02	23.07	6.46	.00	.00	.00	59.51
27U	.00	.00	2.24	5.36	13.09	4.45	.61	.00	.00	25.75
28U	.00	.00	31.12	76.34	78.63	65.69	2.27	.00	.00	254.04
29U	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
3ou	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
31U	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

32U	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
5ou	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
51U	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
52U	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
53u	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
54u	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
55U	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
56U	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
57U	.00	.00	.22	2.44	2.30	.00	.00	.00	.00	4.96
58U	.00	.00	13.48	25.00	1.52	.00	.00	.00	.00	39.99
59U	.00	.00	.08	1.25	.81	.00	.00	.00	.00	2.15
60U	.00	.00	10.86	25.98	.89	.00	.00	.00	.00	37.73
61U	.00	.00	6.04	9.38	7.48	.00	.00	.00	.00	22.91
62U	.00	.00	.59	14.01	16.25	3.48	.00	.00	.00	34.34
63U	.00	.00	3.72	16.34	12.18	4.95	.00	.00	.00	37.19
64U	.00	.00	53.34	99.72	59.50	14.40	.00	.00	.00	226.96
65U	.00	.00	.00	.00	5.24	.31	.00	.00	.00	5.56
66U	.00	.00	.00	.00	7.30	.68	.00	.00	.00	7.98
67U	.00	.00	.00	9.76	13.88	2.79	.00	.00	.00	26.43
68U	.00	.00	1.12	19.93	55.14	28.13	.00	.00	.00	104.32
69U	.00	.00	1.08	7.51	10.80	.54	.00	.00	.00	19.93
7ou	.00	.00	4.37	28.51	40.27	22.34	2.99	.00	.00	98.48
71U	.00	.00	30.96	72.63	83.10	74.82	3.07	.00	.00	264.57
72U	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
80U	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
81U	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
82U	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
83U	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
84U	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
85U	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
86u	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
87U	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
120s	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
121s	.00	.00	.39	2.27	2.43	.33	.00	.00	.00	5.43
122s	.00	.00	.10	2.05	3.92	1.14	.00	.00	.00	7.21
123S	.00	.00	.00	.47	1.04	.13	.00	.00	.00	1.64
124S	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
125S	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
126S	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
127S	.00	.00	.00	.32	.98	.24	.00	.00	.00	1.54
128s	.00	.00	.39	4.12	4.94	.00	.00	.00	.00	9.45
150s	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
151S	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
152S	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
153s	.00	.00	.00	.08	.04	.00	.00	.00	.00	.12
154s	.00	.00	.00	.36	.17	.00	.00	.00	.00	.52
155s	.00	.00	1.14	3.00	2.30	.69	.00	.00	.00	7.13
156S	.00	.00	.00	2.25	6.69	2.60	.00	.00	.00	11.54
157s	.00	.00	5.08	28.29	39.97	19.09	1.14	.00	.00	93.57
158S	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
202s	.05	.11	.12	.76	.78	.09	.06	.05	.00	2.01
205S	.17	.35	.53	.63	.44	.40	.28	.19	.02	3.01
206S	.00	.01	.00	.02	.00	.00	.00	.00	.00	.03
209S	.02	.04	.07	.06	.04	.04	.04	.02	.00	.31
211s	.04	.15	.24	.63	.53	.14	.07	.06	.00	1.86
301s	.01	.03	.05	.34	.32	.03	.02	.01	.00	.82
303s	.02	.06	.09	.18	.17	.06	.03	.02	.00	.64
304s	.01	.03	.03	.07	.07	.01	.01	.01	.00	.25
309s	.02	.05	.05	.04	.03	.04	.03	.02	.01	.28
703s	.03	.09	.15	.26	.24	.10	.05	.04	.00	.96

704s	.00	.00	.00	.00	.01	.00	.00	.00	.00	.01
705s	.24	.60	.91	2.52	1.92	.51	.35	.27	.03	7.35
901s	.19	.42	.45	.38	.26	.38	.29	.21	.02	2.59
902S	.00	.01	.03	.08	.02	.01	.00	.00	.00	.15
905s	.07	.22	.38	.80	.67	.29	.10	.08	.00	2.61
906S	.03	.18	.42	1.34	2.40	.28	.06	.03	.00	4.73
907s	.01	.03	.04	.05	.06	.02	.01	.01	.00	.21
908S	.08	.19	.20	1.07	1.62	.30	.09	.08	.00	3.60
909s	.16	.37	.34	.34	.23	.25	.25	.18	.02	2.15
1001s	.14	.40	.43	.40	.24	.34	.24	.17	.03	2.40
1002s	.24	.88	1.01	.93	1.06	.83	.33	.24	.00	5.53
1003s	.02	.05	.06	.37	.51	.20	.02	.02	.00	1.25
1005s	1.43	5.58	9.42	10.72	4.88	3.08	1.91	1.42	.00	38.44
1010s	.05	.12	.12	.09	.08	.06	.05	.05	.00	.62
1101s	.76	1.21	1.13	1.18	.98	.88	.81	.74	.00	7.69
1108s	.06	.18	.23	.18	.21	.16	.07	.06	.00	1.15
1201s	.30	.83	1.69	2.27	2.29	1.17	.39	.30	.00	9.23
1203s	.14	.20	.18	.25	.24	.18	.18	.14	.00	1.51
1204S	.14	.20	.25	1.19	5.16	2.31	.05	.13	.00	9.44
1205s	.57	1.71	2.37	1.32	.99	1.76	.89	.61	.05	10.28
1303s	.10	.22	.23	.19	.17	.21	.12	.11	.00	1.34
1304s	.18	.46	.72	.37	.23	.33	.26	.19	.02	2.75
1305s	.04	.11	.20	.81	.80	.12	.05	.04	.00	2.18
1306S	.03	.08	4.60	8.84	10.00	.92	.03	.03	.00	24.52
1307s	.01	.03	.04	.06	.03	.02	.01	.01	.00	.19
1308s	.00	.01	.02	.08	.10	.01	.00	.00	.00	.23
1310s	.00	.00	.05	.03	.04	.01	.00	.00	.00	.13
1501s	.36	1.61	2.15	2.59	2.30	1.78	.68	.51	.04	12.02
1502S	.00	.01	.02	.03	.01	.01	.00	.00	.00	.07
1505s	.11	.38	1.16	3.47	2.46	.60	.17	.13	.00	8.49
1506s	.21	.91	6.27	11.66	17.17	6.54	.51	.24	.00	43.51
1507s	.01	.05	.10	.20	.13	.04	.02	.01	.00	.56
1508S	.00	.01	.01	.00	.00	.01	.00	.00	.00	.03
1601s	.43	1.10	1.55	1.94	1.48	1.33	.68	.59	.06	9.16
1602s	.07	.12	.12	.11	.11	.09	.07	.06	.00	.75
1603s	.49	1.48	1.70	1.60	1.11	.91	.64	.49	.00	8.41
1607s	.65	8.95	15.36	28.99	25.62	9.49	.97	.68	.00	90.71
1701s	.07	.24	.50	.67	.61	.43	.08	.07	.00	2.67
1703s	.03	.08	.19	.19	.18	.07	.04	.03	.00	.81
1704s	.22	1.01	.68	.58	.37	.51	.33	.23	.00	3.92
1705s	.95	6.20	13.62	24.76	29.30	9.00	2.29	1.45	.12	87.68
1803s	.03	.04	.04	.03	.02	.03	.04	.04	.00	.26
1804S	.00	.00	.08	.11	.09	.01	.00	.00	.00	.30
1805s	.07	.31	1.51	4.26	4.85	.56	.11	.08	.00	11.75
1806S	.01	.16	1.23	4.75	9.18	4.06	.02	.01	.00	19.42
1807s	.02	.05	.13	.14	.08	.04	.02	.02	.00	.49
1808S	.00	.02	.12	.09	.13	.03	.00	.00	.00	.39
2001s	.17	.43	.59	.59	.42	.38	.27	.19	.03	3.07
2002S	.00	.01	.02	.03	.03	.00	.00	.00	.00	.09
2005S	.19	.60	1.05	1.50	1.42	.60	.29	.21	.00	5.86
2006s	.07	.27	.69	1.48	1.67	.52	.15	.07	.00	4.92
2007S	.04	.11	.33	.50	.27	.09	.06	.04	.00	1.46
2008S	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2009S	.00	.00	.35	.69	.26	.02	.00	.00	.00	1.31
2101s	.13	.37	.50	.69	.55	.30	.24	.16	.05	2.98
2102s	.15	.47	.46	.56	.32	.30	.20	.15	.00	2.61
2103s	.09	.26	.30	.32	.23	.18	.12	.09	.00	1.61
2107s	.24	1.19	4.04	4.58	2.21	1.03	.32	.24	.00	13.85
2110s	.13	.43	.50	.36	.30	.25	.18	.13	.00	2.29
2201s	.11	.27	.35	.38	.27	.21	.14	.11	.00	1.84

22033	.03	.09	.24	.27	.14	.07	.04	.03	.00	.91
22043	.15	1.04	1.65	1.72	1.57	.94	.20	.15	.00	7.42
2205s	.24	.70	1.05	1.83	1.48	1.22	.42	.29	.06	7.28
22093	.07	.20	.22	.48	1.20	.10	.09	.07	.00	2.42
2303s	.03	.06	.08	.08	.06	.05	.05	.03	.00	.45
2304s	.00	.03	.25	1.32	.97	.02	.00	.00	.00	2.59
23055	.06	.43	1.92	5.56	5.04	.78	.10	.07	.00	13.95
2306s	.00	.00	.07	2.55	1.67	.02	.00	.00	.00	4.30
23078	.04	.11	.21	.22	.14	.07	.05	.04	.00	.88
23083	.00	.03	.03	.03	.03	.02	.01	.00	.00	.16
2501s	.05	.12	.12	.16	.13	.08	.07	.06	.00	.78
25029	.00	.00	.07	.71	.17	.00	.00	.00	.00	.96
2505s	.19	.77	1.47	2.28	2.24	.77	.36	.22	.00	8.32
2506s	.02	.10	.13	.23	.26	.10	.03	.02	.00	.89
2507s	.05	.14	.46	.76	.47	.11	.07	.05	.00	2.11
2508s	.00	.00	.03	.04	.00	.00	.00	.00	.00	.07
2601s	.06	.13	.22	.37	.25	.08	.08	.08	.00	1.28
26025	.26	.89	.80	1.01	.52	.51	.36	.26	.00	4.60
2603s	.15	.42	.64	.69	.35	.31	.21	.15	.00	2.93
2607s	.17	.46	.78	2.22	.71	.31	.22	.17	.00	5.04
2610s	.26	1.16	1.13	1.00	.84	.63	.37	.26	.00	5.64
2701s	.20	.50	.51	.62	.43	.31	.25	.20	.00	3.01
2703s	.08	.21	.44	1.20	.50	.15	.10	.08	.00	2.75
27045	.20	.66	.82	.49	.34	.44	.28	.20	.00	3.44
2705s	.26	.55	.70	.85	1.15	.43	.34	.32	.00	4.60
2709S	.13	.41	1.06	1.35	1.47	.33	.24	.13	.00	5.12
28035	.12	.26	.34	.37	.38	.23	.16	.14	.00	1.99
28048	.00	.01	.11	.48	.25	.03	.00	.00	.00	.88
2805s	.02	.19	.85	1.90	1.69	.21	.04	.02	.00	4.93
28065	.00	.05	1.16	1.26	2.50	.12	.00	.00	.00	5.09
28076	.02	.05	.14	.12	.09	.04	.02	.02	.00	.50
2808s	.02	.05	.07	.07	.05	.04	.02	.02	.00	.33
2810s	.01	.02	.09	.61	.16	.02	.02	.01	.00	.94
3001s	.20	.54	.97	1.40	1.26	.52	.36	.22	.02	5.49
3005s	.23	.95	1.85	3.25	2.83	.93	.41	.26	.00	10.71
3006s	.05	.29	.69	2.46	2.39	.52	.11	.05	.00	6.55
3007s	.10	.32	1.20	3.53	1.81	.23	.14	.10	.00	7.42
3011s	.69	2.65	11.04	14.44	8.73	1.72	1.12	.66	.00	41.04
3101s	.14	.35	.43	.39	.47	.26	.21	.18	.03	2.44
3102s	.03	.22	.32	.18	.13	.15	.07	.03	.00	1.13
3103s	.44	.83	1.05	.91	1.02	.76	.54	.46	.00	6.01
3107s	.39	1.09	1.83	6.34	4.74	.91	.51	.39	.00	16.20
3110s	.04	.12	.06	.07	.06	.06	.05	.04	.00	.50
3201s	.07	.70	.78	.69	.76	.58	.31	.16	.01	4.07
32033	.00	.00	.00	.04	.06	.01	.01	.00	.00	.12
3204s	.45	1.51	2.28	1.42	1.64	1.20	.70	.48	.04	9.73
32053	.20	.36	.48	.68	.54	.31	.26	.24	.00	3.06
3303s	.01	.02	.03	.22	.08	.02	.03	.01	.00	.43
3305s	.03	.34	2.34	8.00	3.57	.40	.06	.03	.00	14.77
3306s	.07	2.11	2.96	5.23	4.35	1.73	.34	.10	.00	16.88
3307s	.05	.13	.42	.75	.38	.13	.06	.05	.00	1.96
33088	.02	.03	.03	.04	.03	.02	.02	.02	.00	.20
3501s	.01	.06	.04	.06	.06	.03	.01	.01	.00	.28
3502s	.00	.00	.06	.15	.34	.00	.00	.00	.00	.55
3505s	.11	.67	1.09	2.20	1.39	.62	.22	.12	.00	6.43
3506s	.05	.06	.23	.36	.29	.11	.09	.05	.00	1.24
3507s	.16	.40	1.11	2.25	2.18	.45	.22	.17	.00	6.94
3508s	.00	.00	.00	.54	.01	.00	.00	.00	.00	.55
3601s	.00	.07	.13	.14	.14	.04	.00	.00	.00	.53
36025	.25	1.12	.98	.97	.35	.38	.38	.27	.00	4.70

3603S	.04	.41	.53	.75	.56	.23	.06	.04	.00	2.61
3607s	.19	.60	1.96	5.10	2.58	.53	.36	.19	.00	11.49
3610s	.29	1.16	.60	1.77	1.61	.60	.40	.29	.00	6.72
3701s	.10	.28	.31	.38	.22	.13	.14	.10	.00	1.66
3703s	.10	.37	.77	1.16	.85	.28	.22	.10	.00	3.86
3704s	.04	1.37	5.20	6.39	5.00	.97	.16	.04	.00	19.17
3705s	.24	.68	.72	.58	.71	.56	.35	.27	.02	4.12
3709S	.91	7.76	11.29	10.62	2.30	4.12	1.25	.88	.00	39.14
3803s	.16	.40	.77	.89	.78	.36	.25	.20	.01	3.82
3804s	.00	.01	.08	.41	.09	.00	.00	.00	.00	.60
3805S	.12	1.27	4.58	18.97	3.78	1.13	.30	.13	.00	30.26
3806S	1.72	1.85	2.00	4.74	4.02	1.65	1.65	1.93	.00	19.56
3807s	.04	.13	.40	.61	.55	.25	.05	.04	.00	2.09
3808s	.03	.04	.06	.19	.28	.03	.05	.03	.00	.71
4101s	.24	.99	1.34	1.50	1.29	.87	.44	.33	.02	7.02
4102s	.00	.00	.07	.23	.92	.06	.00	.00	.00	1.29
4105s	.10	.58	1.40	3.79	1.73	.44	.23	.10	.00	8.35
4106S	.72	.35	.97	2.18	2.87	1.25	.59	.65	.01	9.59
4107s	.25	.68	3.40	10.49	16.21	2.54	.35	.25	.00	34.17
4108S	.00	.00	.14	4.77	1.63	.03	.00	.00	.00	6.57
4201s	.11	.25	.30	.79	1.30	.32	.13	.12	.00	3.33
42033	.34	.75	1.27	1.43	1.85	1.05	.45	.34	.00	7.48
4205s	.06	.65	.69	.57	.73	.40	.24	.07	.00	3.40
4207s	.39	1.42	2.79	5.43	3.93	1.63	.65	.48	.03	16.75
4303s	.01	.03	.13	.16	.13	.07	.02	.01	.00	.57
4305S	.15	.30	.18	.05	.13	.21	.17	.15	.00	1.34
4403S	.14	.36	.64	.56	.58	.43	.22	.14	.00	3.06
4404s	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
4405S	.01	.13	1.09	1.56	1.20	.09	.02	.01	.00	4.12
4406S	.00	.00	.05	4.08	5.18	.00	.00	.00	.00	9.32
4407s	.05	.16	.60	.93	.95	.31	.07	.06	.00	3.13
4408s	.00	.00	.09	.25	.23	.04	.00	.00	.00	.60
4601S	1.44	8.27	11.13	16.41	4.67	5.24	2.30	1.91	.09	51.47
4603S	.10	.75	1.55	2.69	1.11	.38	.20	.12	.00	6.89
4605S	.06	.00	.00	.00	.06	.00	.04	.04	.00	.20
4606S	.00	.00	.00	.05	.04	.00	.00	.00	.00	.09
4607S	.51	1.35	2.45	3.12	3.74	1.43	.65	.51	.00	13.76
4701s	.10	.72	1.49	3.08	2.12	.91	.19	.11	.00	8.72
4702S	.05	.19	1.23	2.44	2.91	1.87	.32	.05	.00	9.06
4707s	.95	3.13	4.86	5.93	7.60	5.57	1.35	1.15	.07	30.61
4801S	.21	1.08	2.64	5.84	3.09	1.53	.58	.24	.00	15.22
4803s	.12	.76	1.39	.79	1.05	.82	.17	.12	.00	5.20
48048	1.33	11.52	18.00	21.87	8.50	8.13	4.58	1.39	.00	75.31
4805s	.44	.23	.69	1.24	.83	.36	.34	.41	.00	4.54
4807s	.00	.19	.42	2.25	3.03	.69	.00	.00	.00	6.57
4808s	.61	2.73	2.52	2.40	3.49	2.44	1.50	.85	.06	16.62
4809s	.62	7.62	10.98	13.38	4.68	1.82	.92	.60	.00	40.62
4903s	.03	.06	.15	.10	.06	.05	.04	.03	.00	.53
4904s	.00	.15	1.31	1.69	1.41	.02	.01	.00	.00	4.60
4905s	.20	.75	1.88	3.47	1.85	.55	.31	.21	.00	9.20
4907s	.06	.26	1.23	2.22	1.85	.93	.09	.07	.00	6.70
4908s	.00	.02	.02	.08	.12	.04	.00	.00	.00	.28
4910s	.36	2.01	4.84	1.87	2.71	4.21	.77	.49	.03	17.31
5201s	.72	2.04	2.90	2.31	2.41	2.97	1.43	.93	.08	15.78
5202s	.22	.80	9.07	12.33	33.74	3.45	1.23	.22	.00	61.06
5205S	.11	.35	.60	.66	.55	.40	.15	.11	.00	2.93
5303s	.01	.04	.05	.07	.05	.03	.02	.01	.00	.28
5304S	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
5305s	.09	.40	2.17	12.71	2.45	.21	.20	.09	.00	18.33
5307S	.75	2.12	5.30	16.71	40.89	25.15	1.47	.88	.05	93.33

53083	.05	.16	.21	.24	.18	.20	.08	.07	.01	1.20
5311s	.02	.06	.08	.08	.06	.05	.03	.02	.00	.40
7605s	.50	1.17	2.11	2.71	1.56	.95	.67	.60	.02	10.29
7606s	.02	.06	.14	.19	.10	.06	.02	.02	.oo	.60
7607s	.11	.38	.75	.95	1.05	.38	.14	.11	.oo	3.88
76129	.08	.22	.50	1.09	1.15	.59	.12	.09	.oo	3.84
7801s	.05	.17	.34	.45	.52	.22	.07	.05	.oo	1.87
7803s	.12	.22	.28	.20	.18	.20	.15	.08	.oo	1.43
8001s	.05	.13	.25	.42	.38	.17	.07	.05	.00	1.51
80035	.08	.17	.21	.15	.13	.15	.11	.09	.00	1.09
OTOTALS	33.82	140.33	543.26	1181.42	1144.84	465.16	65.44	37.44	1.15	3612.86

LINK-BY,-LINK ALL-TIME-SLICES - AVERAGE SPEED OF A CAR (KM/H) RUN ON 11/6/91

SMART CORRIDOR BASE RUN NETWORK and TIME DATA (6/11/91)
SMART CORRIDOR BASE DEMAND
SMART CORRIDOR CONTROL DATA

ITERATION NUMBER 3

TIME SLICES :

600 630 700 730 800 830 900 930 1000 1300

LINK NO.& TYPE	1	2	3	4	5	6	7	8	9	OVERALL AVERAGE SPEED
7U	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	.O	87.7
8u	86.1	86.1	81.7	51.4	28.9	86.1	86.1	86.1	.O	60.1
9U	87.8	87.8	68.9	33.3	52.9	86.4	87.8	87.8	.O	60.8
10U	91.2	91.2	74.7	53.2	71.8	74.4	91.2	91.2	.O	73.9
11U	86.6	86.6	72.5	48.5	60.3	75.1	86.6	86.6	.0	68.9
12U	88.8	88.8	70.4	47.4	56.4	71.3	88.8	88.8	88.8	67.4
13u	86.7	86.7	42.2	25.4	26.5	59.9	86.7	86.7	86.7	43.3
14U	94.1	94.1	65.3	29.0	24.2	94.1	94.1	94.1	94.1	49.0
15u	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8
16U	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4
17U	86.3	86.3	86.3	86.3	86.3	86.3	86.3	86.3	86.3	86.3
18U	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0
19U	86.0	86.0	86.0	86.0	86.0	86.0	86.0	86.0	86.0	86.0
2ou	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8
21u	88.6	88.6	42.9	83.4	82.8	86.6	88.6	88.6	88.6	73.1
22u	87.3	87.3	87.3	78.3	73.5	74.2	87.3	87.3	87.3	81.5
23U	86.1	86.1	86.1	65.1	65.2	78.3	86.1	86.1	86.1	77.2
24U	86.6	86.6	86.1	67.1	57.3	71.5	86.6	86.6	86.6	75.0
25U	91.5	91.5	83.8	49.4	48.4	71.4	91.5	91.5	91.5	68.7
26U	86.9	86.9	73.0	47.8	48.5	70.8	86.9	86.9	86.9	65.7
27U	95.9	95.9	79.1	62.4	41.5	66.4	86.7	95.9	95.9	68.2
28U	89.4	89.4	38.0	20.3	19.8	22.6	76.3	89.4	89.4	31.8
29U	95.8	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9
3ou	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0
31u	89.7	89.7	89.7	89.7	89.7	89.7	89.7	89.7	89.7	89.7
32U	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.8	95.9	95.8
5ou	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	.O	87.8
51u	87.1	87.1	87.1	87.1	87.1	87.1	87.1	87.1	.O	87.1
52U	88.6	88.6	88.6	88.6	88.6	88.6	88.6	88.6	.O	88.6
53u	86.1	86.1	86.1	86.1	86.1	86.1	86.1	86.1	86.1	86.1
54u	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8
55u	88.8	88.8	88.8	88.8	88.8	88.8	88.8	88.8	88.8	88.8
56U	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0
57U	87.8	87.8	87.1	80.5	79.4	87.8	87.8	87.8	87.8	84.8
58U	94.1	94.1	39.2	26.1	79.0	94.1	94.1	94.1	94.1	52.5
59U	86.3	86.3	86.1	83.4	84.1	86.3	86.3	86.3	86.3	85.3

60U	94.1	94.1	44.4	25.4	85.1	94.1	94.1	94.1	94.1	54.6
61U	86.9	86.9	72.9	66.1	67.7	86.9	86.9	86.9	86.9	76.4
62U	87.5	87.5	86.4	67.1	62.9	78.5	87.5	87.5	87.5	77.3
63U	87.3	87.3	78.3	56.0	60.7	71.4	87.3	87.3	87.3	72.3
64U	88.1	88.1	41.5	28.1	37.0	62.4	88.1	88.1	88.1	48.3
65U	89.1	89.1	89.1	89.1	52.7	85.2	89.1	89.1	89.1	80.5
66u	90.9	90.9	90.9	90.9	30.7	76.0	90.9	90.9	90.9	69.6
67U	89.4	89.4	89.4	60.5	49.8	76.7	89.4	89.4	89.4	73.7
68U	87.5	87.5	85.3	58.4	35.7	49.4	87.5	87.5	87.5	61.9
69U	87.0	87.0	79.7	51.7	43.2	82.8	87.0	87.0	87.0	67.4
7ou	87.8	87.8	76.4	43.2	35.0	47.5	73.2	87.8	87.8	55.8
71U	87.2	87.2	37.9	21.3	18.8	20.6	71.1	87.2	87.2	30.9
72U	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0
80U	86.9	86.9	86.9	86.9	86.9	86.9	86.9	86.9	.0	86.9
81U	86.9	86.9	86.9	86.9	86.9	86.9	86.9	86.9	.0	86.9
82U	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	.0	90.0
83U	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	.0	90.0
84U	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	.0	90.0
85U	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0
86U	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0
87U	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	.0	90.0
120s	51.4	51.4	51.4	51.4	51.4	51.4	51.4	51.4	.0	51.4
121s	50.0	50.0	32.7	11.1	9.1	31.7	50.0	50.0	.0	21.9
122s	50.0	50.0	45.9	18.5	16.4	29.4	50.0	50.0	.0	25.5
123S	51.4	51.4	51.4	39.9	30.2	45.7	51.4	51.4	.0	43.2
124S	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
125S	51.4	51.4	51.4	51.4	51.4	51.4	51.4	51.4	51.4	51.4
126S	.0	51.4	51.4	51.4	51.4	.0	.0	.0	.0	51.4
127S	51.4	51.4	51.4	47.2	39.2	48.1	51.4	51.4	.0	48.4
128S	51.4	51.4	44.5	21.6	17.6	51.4	51.4	51.4	.0	29.3
150s	51.4	51.4	51.4	51.4	51.4	51.4	51.4	51.4	.0	51.4
151s	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	.0	50.0
152S	- 50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	.0	50.0
153s	51.4	51.4	51.4	49.1	50.2	51.4	51.4	51.4	.0	50.8
154s	50.0	50.0	50.0	26.9	33.3	50.0	50.0	50.0	.0	39.9
155s	51.4	51.4	30.0	26.6	26.3	33.7	51.4	51.4	.0	32.9
156S	51.4	51.4	51.4	17.0	12.6	15.9	51.4	51.4	.0	17.7
157s	50.4	50.4	20.0	6.7	4.3	7.6	32.5	50.4	.0	9.7
158S	51.4	51.4	51.4	51.4	51.4	51.4	51.4	51.4	.0	51.4
202s	43.3	43.3	43.3	41.2	41.2	43.2	43.3	43.3	.0	41.7
205S	49.8	49.8	49.2	49.2	49.8	49.8	49.8	49.8	49.8	49.6
206S	.0	53.0	52.9	49.9	50.9	.0	.0	.0	.0	51.3
209S	43.3	43.3	43.3	43.3	43.3	43.3	43.3	43.3	.0	43.3
211s	49.8	49.2	48.7	47.2	47.3	49.3	49.8	49.8	.0	48.1
301s	46.2	46.2	46.2	46.2	46.2	46.2	46.2	46.2	.0	46.2
303s	48.4	48.4	48.4	48.4	48.4	48.4	48.4	48.4	.0	48.4
304s	48.4	47.0	47.0	44.9	44.7	48.1	48.4	48.4	.0	46.2
309S	46.2	46.2	46.2	46.2	46.2	46.2	46.2	46.2	46.2	46.2
703s	42.9	42.9	42.9	42.9	42.9	42.9	42.9	42.9	.0	42.9
704s	.0	.0	57.3	55.2	47.7	.0	.0	.0	.0	50.4
705s	45.7	45.0	44.0	39.2	41.4	45.0	45.7	45.7	46.4	42.5
901s	34.7	33.2	33.2	33.2	34.7	33.2	34.7	34.7	34.7	33.8
902S	34.7	34.7	33.2	31.7	34.7	34.7	34.7	34.7	.0	32.8
905s	46.1	46.1	46.2	45.3	45.3	46.1	46.1	46.1	.0	45.7
906S	46.1	43.8	40.7	32.3	24.9	40.5	45.3	46.1	.0	33.0
907s	49.7	49.7	49.7	49.7	49.7	49.7	49.7	49.7	.0	49.7
908S	49.7	49.1	49.1	45.5	43.3	48.3	49.7	49.7	.0	46.0
909s	33.2	31.8	31.7	31.8	33.2	33.1	33.2	33.2	34.7	32.5
1001s	33.8	32.1	32.0	33.0	33.8	32.7	33.8	33.8	33.8	32.9
1002s	19.6	15.5	14.5	14.1	14.6	15.7	19.0	19.6	.0	15.6

2502s	50.9	50.9	48.9	39.6	43.7	50.9	50.9	50.9	.0	42.2
25058	43.9	42.6	41.4	39.2	39.4	42.6	43.3	43.9	.0	40.9
2506s	43.9	42.0	41.4	39.7	39.3	42.0	43.2	43.9	.0	40.8
2507S	43.4	43.4	43.0	42.4	42.7	43.4	43.4	43.4	.0	42.8
2508S	.0	.0	42.9	42.1	.0	.0	.0	.0	.0	42.5
2601s	38.9	38.9	37.9	37.9	37.9	38.9	38.9	38.9	.0	38.3
2602s	32.0	27.2	27.1	25.7	29.9	30.0	31.3	32.0	.0	28.5
26035	46.1	45.4	44.7	44.7	45.4	45.4	45.4	46.1	.0	45.2
2607S	31.3	30.5	29.2	25.3	29.4	30.9	31.3	31.3	.0	28.2
2610s	44.7	39.1	39.6	40.1	40.6	42.2	43.8	44.7	.0	41.0
2701s	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	.0	48.5
2703s	37.9	36.9	36.2	34.4	36.0	36.9	37.9	37.9	.0	35.7
27043	34.3	30.6	29.9	32.0	33.1	32.3	33.5	34.3	.0	31.9
2705S	29.0	28.3	27.6	27.3	26.3	28.3	29.0	29.0	.0	27.7
2709s	48.5	47.2	43.8	43.5	42.1	46.8	47.5	48.5	.0	44.5
2803s	50.4	50.4	49.9	50.0	49.9	50.4	50.4	50.4	.0	50.2
2804s	.0	50.4	48.2	43.6	47.4	49.4	.0	.0	.0	46.1
2805s	47.3	47.4	45.9	43.6	43.8	47.3	47.3	47.3	.0	44.6
2806S	.0	46.9	34.2	32.5	25.4	46.7	49.8	.0	.0	31.5
28075	47.3	47.3	47.3	47.3	47.3	47.3	47.3	47.3	.0	47.3
2808S	47.3	46.6	45.8	45.8	46.6	46.6	47.3	47.3	.0	46.5
2810s	42.7	42.7	42.4	37.4	41.5	42.7	42.7	42.7	.0	39.3
3001s	51.0	50.3	49.1	48.7	48.8	50.3	50.3	51.0	51.0	49.5
3005s	46.8	45.8	44.0	41.3	42.0	45.7	46.3	46.8	.0	43.5
3006S	45.8	41.8	36.0	23.3	21.1	37.0	44.4	45.8	.0	29.3
3007s	43.9	43.3	40.5	33.2	37.7	44.0	43.9	43.9	.0	37.5
3011s	43.6	34.4	17.9	13.9	18.5	37.9	41.2	43.6	.0	23.7
3101s	35.3	34.3	33.8	33.8	33.8	34.8	34.8	34.8	34.8	34.2
3102s	30.0	28.8	27.7	29.2	29.2	29.2	30.0	30.0	.0	28.8
3103s	46.7	46.1	45.6	46.0	45.7	46.1	46.7	46.7	46.7	46.1
3107s	27.0	24.7	22.0	13.3	14.4	25.4	27.0	27.0	.0	17.9
3110s	47.2	46.7	47.2	47.2	47.2	47.2	47.2	47.2	.0	47.1
3201s	49.2	48.0	47.8	48.0	48.0	48.1	48.5	48.6	48.8	48.1
3203S	36.0	36.0	36.0	36.0	36.0	36.0	36.0	36.0	.0	36.0
32043	31.8	25.0	20.7	25.0	24.9	26.4	30.2	31.8	36.0	25.6
32053	30.9	30.9	29.8	29.8	29.2	30.9	30.9	30.9	.0	30.2
3303s	50.6	50.8	50.8	50.6	50.6	50.6	50.6	50.6	.0	50.7
3305s	49.8	49.4	46.6	36.6	44.7	49.3	49.8	49.8	.0	42.8
3306S	48.6	38.4	34.4	26.3	28.5	39.2	47.1	49.0	.0	33.8
3307s	45.8	45.8	45.3	44.5	45.6	45.9	45.8	45.8	.0	45.2
3308S	45.8	45.8	45.8	45.8	45.8	45.8	45.8	45.8	.0	45.8
3501s	52.1	52.1	52.1	52.1	52.1	52.1	52.1	52.1	.0	52.1
3502s	.0	.0	51.3	49.4	47.0	.0	.0	.0	.0	48.5
3505s	49.5	49.1	48.7	48.0	48.7	49.1	49.5	49.5	.0	48.6
3506S	48.6	48.2	46.0	43.9	44.7	47.4	47.8	48.6	.0	46.0
3507s	47.6	47.8	46.7	45.8	45.5	47.6	47.6	47.6	.0	46.3
3508s	.0	.0	.0	39.3	39.2	.0	.0	.0	.0	39.3
3601S	39.3	39.3	38.1	38.4	38.1	39.3	39.3	39.3	.0	38.5
3602S	29.5	22.7	23.0	23.0	28.5	28.2	28.2	29.5	.0	25.2
36036	50.8	50.4	50.5	50.0	50.2	50.4	50.8	50.8	.0	50.3
3607S	30.9	30.0	27.5	19.6	25.4	30.0	30.1	30.9	.0	24.5
3610S	49.6	46.7	48.1	44.5	44.3	48.1	49.2	49.6	.0	46.7
3701s	48.3	48.3	48.3	47.5	48.3	48.3	48.3	48.3	.0	48.1
3703s	41.8	40.5	40.2	39.3	39.3	40.5	41.8	41.8	.0	40.0
3704s	27.6	16.0	6.7	5.0	6.0	16.4	27.6	27.6	.0	7.8
3705s	30.0	28.4	28.4	28.5	28.4	29.2	29.2	30.0	30.9	28.8
3709s	43.3	23.1	18.0	17.7	36.4	30.6	41.6	43.3	48.3	26.3
38033	50.0	50.0	49.1	49.1	49.1	50.0	50.0	50.0	50.0	49.5
3804s	.0	50.0	47.3	41.6	46.7	.0	.0	.0	.0	44.0
3805s	48.8	47.1	41.5	24.5	40.9	47.2	48.4	48.8	.0	36.1

3806s	32.2	30.0	31.1	20.4	22.9	29.3	32.9	29.6	.0	27.4
3807s	49.0	49.0	48.5	48.2	48.1	48.5	49.0	49.0	.0	48.4
3808S	49.0	48.5	48.6	47.4	46.2	48.5	48.5	49.0	.0	47.5
4101s	51.1	50.7	50.3	50.2	50.3	50.7	51.1	51.1	51.1	50.5
4102s	.0	.0	44.2	42.5	31.5	44.7	.0	.0	.0	36.7
4105s	47.5	47.0	45.6	40.9	45.1	47.0	47.5	47.5	.0	44.2
4106s	35.7	40.3	33.4	25.9	17.1	29.4	36.7	37.4	49.0	29.5
4107s	47.4	46.5	41.8	30.0	24.3	37.7	46.9	47.4	.0	32.8
4108S	.0	.0	45.9	22.0	34.9	39.6	.0	.0	.0	27.9
4201S	43.7	43.7	43.9	42.5	35.0	38.3	43.7	43.7	.0	40.4
4203s	49.9	50.0	49.5	49.2	48.8	48.9	49.9	49.9	.0	49.3
4205S	34.8	32.7	32.5	32.7	32.7	33.7	35.0	35.5	.0	33.1
4207s	40.0	36.8	32.7	25.9	30.2	36.5	39.2	39.1	40.9	32.2
4303s	53.5	53.5	51.9	51.9	51.9	52.5	53.5	53.5	.0	52.3
4305s	26.3	25.7	26.3	27.0	25.7	26.3	26.3	26.3	.0	26.2
4403s	27.0	27.0	25.3	26.3	25.2	27.0	27.0	27.0	.0	26.2
4404s	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
4405s	50.6	50.6	49.5	48.7	49.5	50.7	50.6	50.6	.0	49.3
44068	.0	.0	49.9	26.7	23.3	.0	.0	.0	.0	25.7
4407s	49.7	49.8	49.2	48.6	48.4	49.3	49.7	49.7	.0	48.9
44088	.0	49.7	49.9	47.9	48.0	49.3	.0	.0	.0	48.4
4601s	30.7	15.6	12.9	9.6	21.2	20.1	28.0	29.0	36.0	16.7
4603s	30.4	27.4	23.2	20.6	25.4	28.8	28.8	30.4	.0	23.9
4605s	27.2	.0	.0	.0	27.2	.0	27.2	27.2	.0	27.2
46068	.0	.0	.0	25.5	26.3	.0	.0	.0	.0	25.9
4607S	41.9	41.2	39.8	38.3	37.0	40.8	41.9	41.9	.0	39.4
4701s	28.0	24.3	21.8	17.4	21.0	24.1	26.5	28.0	.0	21.0
4702s	25.2	20.5	8.8	5.4	4.7	6.8	19.4	25.2	.0	7.4
4707s	20.3	15.6	11.6	9.1	6.4	8.5	18.8	19.5	22.6	11.0
4801s	28.4	25.6	20.2	12.3	15.3	20.4	27.2	28.4	.0	17.8
4803s	21.9	20.2	18.4	19.6	19.5	20.1	23.2	21.9	.0	19.7
4804s	14.0	3.3	1.7	1.6	3.4	4.3	5.6	13.6	.0	3.2
4805S	31.8	32.7	31.6	30.2	31.1	31.8	32.4	31.8	.0	31.3
4807s	.0	27.8	27.3	16.9	16.0	23.6	.0	.0	.0	18.5
4808S	24.0	13.3	15.0	14.1	11.9	14.4	18.0	21.9	28.4	15.1
4809s	23.2	5.9	4.0	3.5	6.8	15.8	20.7	23.2	.0	6.5
4903s	38.3	38.8	38.5	38.3	38.3	38.3	38.3	38.3	38.3	38.4
4904s	38.3	29.1	14.2	10.7	13.8	30.7	38.3	38.3	.0	13.9
4905s	39.4	38.4	34.5	29.8	34.4	38.4	39.4	39.4	.0	34.2
4907s	50.6	50.6	49.3	48.0	48.4	49.7	50.6	50.6	.0	48.9
4908s	50.6	50.6	50.6	50.3	49.9	50.6	50.6	50.6	.0	50.2
4910s	33.3	21.2	12.6	21.0	18.3	14.2	28.6	32.0	37.9	18.4
5201s	26.1	23.7	21.8	22.9	22.9	21.6	24.5	25.2	27.0	23.1
5202s	25.2	20.7	4.6	4.1	1.6	8.6	16.9	25.2	.0	4.0
5205s	38.3	37.5	36.7	36.7	36.7	37.5	38.3	38.3	.0	37.1
5303s	30.2	30.2	30.2	30.2	30.2	30.2	30.2	30.2	.0	30.2
5304s	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
5305s	37.1	36.0	30.2	12.5	23.1	36.0	36.0	37.1	.0	19.3
5307s	37.5	35.8	29.0	13.6	6.4	8.8	36.6	37.5	39.4	13.8
5308s	38.4	37.9	37.6	37.6	37.5	37.7	38.4	38.4	39.4	37.8
5311s	37.1	36.0	36.0	36.0	36.0	36.0	37.1	37.1	.0	36.2
7605s	48.4	47.6	46.0	45.3	46.8	47.5	48.3	48.3	49.1	46.8
7606s	49.2	48.3	46.7	46.0	47.5	48.3	49.2	49.2	.0	47.3
7607s	51.2	50.7	50.7	50.1	50.1	50.6	51.2	51.2	.0	50.5
7612s	50.6	50.1	49.0	46.8	46.1	48.5	50.6	50.6	.0	48.0
7801s	38.8	34.9	34.9	32.7	32.2	34.9	38.8	38.8	.0	34.1
7803s	41.8	41.8	41.8	41.8	41.8	41.8	41.8	45.3	.0	42.1
8001s	48.8	48.8	48.8	46.9	46.7	48.8	48.8	48.8	.0	47.8
8003s	38.9	38.9	38.8	38.8	38.8	38.8	38.8	38.8	38.8	38.8
OOVERALL	75.4	72.6	58.8	45.0	43.8	56.4	74.4	75.9	83.6	56.1