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Traffic Modeling To Evaluate Potential Benefits Of Advanced Traffic Management And In-vehicle Information Systems In A Freeway/Arterial Corridor

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Traffic Modeling to Evaluate Potential Benefits of Advanced Traffic Management and In-Vehicle Information Systems in a Freeway/Arterial Corridor

Yonnel Gardes
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EXECUTIVE SUMMARY

1. Background

A preliminary evaluation of in-vehicle information systems (IVIS) potential benefits was conducted by a research team at ITS in 1988. The real life Santa Monica freeway corridor in Los Angeles, California, was simulated using the FREQ8 freeway simulation model and the TRANSYT-7F arterial simulation model. Continuing along the same line but with more traffic scenarios, the 1988/1989 project showed that potential benefits of IVIS could be significant under incident conditions or under heavy freeway demand. The report for this phase contained recommendations for future research in which the need for more realistic simulation of interactions between freeway and parallel arterials was emphasized.

2. Objectives

The current study includes a literature review of existing traffic simulation models potentially suited for evaluating advanced traffic control strategies and in-vehicle information systems within an integrated freeway/arterial corridor.

An assessment of model suitability is carried out in order to answer the fundamental question: can any existing model be potentially suited? If yes, what are the specific modifications that are needed to be included in a reasonable level of effort. If no, what are the specifications required for developing a new model?

3. Approach

The approach consists of the following major steps:

- A. Literature review and identification of candidate models
- B. Preliminary screening of candidate models
- C. In-depth evaluation of short list of models
- D. Conclusions and recommendations

4 Results

The extensive literature review resulted in the identification of twenty-four simulation models potentially suited for purposes of this study. The screening process resulted in the selection of five of these models for further evaluation. Finally, on the basis of the evaluation process, three models appear to be very promising and are recommended for further analysis and application. These models are CONTRAM, SATURN and INTEGRATION.

5. Future plans

A research proposal for 1990/1991 has been submitted to the PATH program. The proposed work plan would be closely coordinated with the current project. It would include the following tasks:

1. Acquire the three models selected in the current study
2. Perform test runs on a sample network
3. Select the most promising model
4. Identify what specific modifications can be considered within the time frame of the project
5. Develop, incorporate and test these specified modifications
6. Design an experiment to apply this model to a real-life freeway corridor, like the SMART corridor

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

1.1.1 PATH Research Project on In-Vehicle Information Systems

A preliminary evaluation of In-Vehicle Information Systems (IVIS) has been conducted by a research team at the University of California at Berkeley. The report for the first phase, entitled "Potential Benefits of In-Vehicle Information Systems in a Real Life Freeway Corridor under Recurring and Incident-Induced Congestion" [1] was submitted to the PATH program in July 1988. The principal outputs of this study were the development of a simulation test-bed for the Santa Monica freeway (SMART) corridor and the estimation of the travel time savings to potential IVIS users under non-incident and incident situations. The real life SMART corridor in Los Angeles was simulated using the FREQ freeway simulation model and the TRANSYT arterial simulation model.

Continuing along the same line, the 1988/1989 research focused on traffic demand and incident sensitivity analysis of potential benefits of IVIS. The report for this phase, entitled "Potential Benefits of In-Vehicle Information Systems (IVIS): Demand and Incident Sensitivity Analysis" [2] was submitted to the PATH program in May 1989. The sensitivity analysis was performed by designing an experiment for studying the effects of variations in traffic demand levels, variations in incident severity, and variations in incident location. The main conclusions were the following:

1. Potential benefits are insignificant under non-incident average traffic demand situation.
2. Potential benefits for long distance freeway to freeway travelers can be significant under non-incident conditions but high level of traffic demand.

3. Potential benefits for long distance freeway to freeway travelers can be significant under incident conditions.
4. Under both incident conditions and high level of demand, travel potential benefits were large.

The working paper [2] contained recommendations for future research. In particular, the need for more realistic modelling of interactions between freeway and parallel surface streets was identified: this is the starting point of the current study.

1.1.2 Potential of integrated freeway/arterial corridor

The integration is defined as the joint control of different traffic subsystems [3]. For the purposes of this study, the integration of freeways and arterials is emphasized. Members of a workshop [4] identified the following potential benefits of freeway/arterial integration:

1. Quality of driver information during incidents should accelerate public acceptance.
2. Freeway control systems will have better demand information from street systems and vice versa.
3. Greater efficiency in queue control and on- and off-ramps.
4. Street control will have earlier warning of effects of freeway incidents
5. Freeway control systems may be able to help minimize the effects of freeway incidents.
6. Joint use of communication and control equipment.

Appendix A shows an illustration of the cost-effectiveness evaluation of integrated control, as presented by the workshop

members [4].

Members of the workshop also noted that too often, urban control systems not only operate essentially independent of one another, but often they even operate at cross purposes. This is evident particularly under severe congestion, when there is no integrated overall control strategy that attempts to simultaneously optimize the performance of traffic flow on both the arterials and freeways.

Although the potential benefits of integration were identified, Van Aerde and Yagar [5] noted in 1988 that a detailed review of research and development on "integration" indicated that the development of models and strategies for global optimum control of integrated systems has been almost ignored by the traffic engineering community.

1.2 STATEMENT OF WORK

The objectives of this research are the following:

1. Review of the state of the art in traffic models for use in evaluating:

- advanced traffic control strategies
- in-vehicle information systems potential benefits

within an integrated freeway/arterial corridor.

2. Based on this review, preliminary assessment as to whether existing models are adequate, if they could be made adequate (implying further development and modification), or if totally new models need to be developed.(1)

(1) The current interest for this question is emphasized by the Federal Highway Administration Request for Proposal issued on the 5/16/90, whose objectives are closely related to purposes of the present study (See Appendix B).

1.3 STUDY APPROACH

The approach consists of the following major steps:

1. Identification of candidate models
2. Preliminary screening of the list of candidate models
3. In-depth evaluation of short-list of models
4. Conclusions and recommendations

1.4 PAPER OVERVIEW

Chapter 2 of this working paper presents the literature review of candidate models and the initial screening process by which the number of candidate models is reduced from twenty-four to five models.

Chapter 3 presents an in-depth evaluation of the short list of models and a comparative assessment of model suitability with regard to purposes of this study.

Chapter 4 gives conclusions of the research and recommendations for future directions.

CHAPTER 2

**REVIEW AND INITIAL SCREENING
OF CANDIDATE MODELS**

2.1 INTRODUCTION

This chapter presents an initial review of a number of different types of corridor-related models, a tabular summary of the various preliminary model characteristics, and the short-list of those models which are selected for further evaluation.

A number of researchers have attempted to enumerate the various types and versions of models that have been developed for the purpose of evaluating freeways and freeway corridors. Examples of these have been published by Ross and Gibson [6], May [7,8], Skabardonis [9], Van Aerde and Yagar [10], Sullivan and Wong [11].

The ideal model for purposes of this study should be capable of modelling traffic performance and traffic assignment within an integrated network of freeways and parallel arterials. This model should consider the effects of variable traffic demands, the presence of different fixed-time and real-time traffic signal and ramp metering controls, the occurrence of incidents and the dynamic reassignment between freeways and arterials. Moreover it is essential that the model be able to deal with dynamic queuing conditions.

The early reviews and an initial literature study suggested that such a perfect model does not exist. Therefore, the present review of corridor-related models includes models that do not at present completely model freeways, traffic-signalized arterials, queuing, and traffic assignment.

Specifically, Table 2.1 presents models or model types that are considered in this review, and their primary application.

NO	PAGE	MODEL	PRIMARY APPLICATION
1 2 3 4 5 6 7	9 9 9 9 10 10 10	CARS EMME MICROTRIPS MINUTP MULATM TMODEL TRANPLAN	TRANSPORTATION PLANNING
8 9 10 11 12 13	11 11 11 12 12 13	FREESIM FREQ INTRAS KRONOS MACK-FREFLO-FRECON ROADRUNNER	FREEWAY OPERATION
14 15 16 17 18	13 15 15 16 17	CONTRAM JAM MICRO-ASSIGNMENT SATURN TRAFFICQ	SIGNALIZED NETWORKS OPERATION
19 20 21 22 23 24	17 18 18 19 19 20	CORQ1C CORQ-CORCON DYNEV INTEGRATION SCOT TRAFLO	CORRIDOR OPERATION

TABLE 2.1: LIST OF REVIEWED MODELS

2.2 SUMMARY DESCRIPTION OF INDIVIDUAL MODELS

Each model considered in this review is briefly described in the following paragraphs.

2.2.1 CARS

This model was developed for metropolitan traffic and land development impact modelling with a relatively small network capacity [12]. CARS offers very limited information on operating conditions on freeway links.

2.2.2 EMME2

EMME2 was developed for urban transportation planning studies with emphasis on urban streets and transit network modelling [13]. Its highway trip assignment method is limited to equilibrium assignment.

2.2.3 MICROTRIPS

This program is another comprehensive computer software system designed for transportation planning [14]. Capacity restraint trip assignment can be applied to network modelling, but equilibrium assignment is not available. MICROTRIPS does not have the capability to analyze the surface street system in a detailed manner in the current version.

2.2.4 MINUTP

MINUTP was developed for the purpose of comprehensive urban transportation planning. It is capable of performing both highway and transit network modelling for transportation studies [15]-MINUTP has the ability to perform equilibrium traffic assignment, but the network performance parameters are confined to the major highway and arterial network only, since the model does not have

the capability to deal with the surface street network in detail.

In its current form, MINUTP does not have the capability to analyze explicit queue lengths on network links, or to perform multiple time period assignment.

2.2.5 MULATM

MULATM is a traffic planning software best described as a traffic database with modelling capability [16]. The spectrum of applications ranges from the use of the package as an inventory of the traffic network, through incremental analysis of the effects of local street traffic control devices, simulation of network-wide travel conditions and traffic impact analysis to the estimation of environmental impacts.

2.2.6 TMODEL

This model is designed for urban transportation planning applications. It has the capability for highway network modelling and surface arterial network modelling, but the program capacity is relatively small and can not accommodate large networks [17]. All-or-nothing assignment is available, but the program does not have the capability to perform equilibrium assignment. Network link queue length analysis is not available.

2.2.7 TRANPLAN

TRANPLAN is an urban transportation planning program with very large capacity to handle both highway traffic network modelling and transit network modelling [18]. Like MINUTP, it does not have the capability to perform detailed surface street traffic network modelling. TRANPLAN's equilibrium trip assignment is identical to the method employed in MINUTP. Again, link queuing analysis is not available.

2.2.8 FREESIM

FREESIM is a microscopic freeway simulation model particularly designed for evaluation of the effects of freeway lane closures [19]. A number of papers describing the development and application of the FREESIM model have been prepared by the authors [8], but there is no evidence that the model has been applied by others.

2.2.9 FREQ

Since 1968, a series of freeway models belonging to the FREQ Family have been developed at the University of California [20,21,22,23]. These models are macroscopic and are intended to evaluate a directional freeway and its ramps, based on ramp origin-destination information. Some diversion to parallel alternatives is considered for vehicles queued on-ramps, but this treatment is not directly applicable to the other route assignment situations.

The major input to most FREQ models *is* a set of ramp counts for each time slice (typically about 15 minutes). These tables would correspond to volumes or percentages of various vehicle-occupancy classes. The model can calculate the effect of weaving on capacity, and speed-flow relationships can be selected or specified by the user. The output consists of freeway performance tables, containing travel time, speed, ramp delays and queues, fuel consumption and emission.

There have been a number of reported applications of the FREQ models [7,8]. Most of these applications include the investigation of various ramp metering, priority-entry, and priority-lane strategies on freeway flows and queues.

2.2.10 INTRAS

The INTRAS model [24,25] is a stochastic, microscopic model especially developed for studying freeway incidents. INTRAS is a microscopic time-stepping simulation designed to realistically

represent traffic and traffic control in a freeway and surrounding surface street environment.

The program is quite large and complex in order to model all vehicle movements in the corridor. A few control strategies are incorporated into the model.

In 1982, Bullen reported the development of a FOMIS model based on the INTRAS model [26]. The intend was to streamline the simulation process by restricting it to the freeway only, eliminating the link structure and reducing vehicle processing to a single scan. The model is said to be primarily intended as a supplemental tool to current macroanalysis methods.

2.2.11 KRONOS

KRONOS is a dynamic freeway simulation program including flow models that describe complex phenomena such as lane changing, merging, and weaving [27].

Input to the program is conventional traffic parameters, freeway and ramp characteristics, demands, and origin-destination information. Output includes dynamic description of speed, flow, and density, both numerical and graphic; estimation of the most common measures of effectiveness; and graphic representation of flow conditions and congestion levels.

The KRONOS model has been applied to a section of the Ottawa Queensway freeway.

2.2.12 MACK-FREFLO-FRECON

The MACK model and its later versions are deterministic, macroscopic models that basically consist of a set of conservation equations and corresponding set of speed-density equations. The MACK I and MACK II models were developed for evaluation of ramp control under incident and recurring congestion conditions [28,29].

The FREFLO model [30] was a successor to the MACK II model. It was designed to provide a basic model, perform input data diagnostics, represent incidents, model on-ramps, represent two traffic-responsive metering schemes, provide standard measures of travel and travel time, include fuel consumption, and include fuel emissions. However, it cannot model parallel routes.

FRECON [31] is a dynamic, macroscopic freeways simulation model developed from FREFLO model. The original version simulates freeway performance and generates point detector information for calibration and validation. The model can interact with control programs in order to evaluate pretimed, local traffic-responsive, and segmentwide control strategies.

FRECON II [32] contains enhancements to simulate alternative routes (surface streets), as in a corridor. It can simulate a freeway with mixed modes of ramp metering, and the driver's spatial diversion due to ramp metering. The model was applied to the Santa Monica Freeway.

2.2.13 ROADRUNNER

The ROADRUNNER freeway model [33] intends to be used to characterize global system performance. This is a macroscopic model dealing with average quantities of flow, density, and speed. The ROADRUNNER model is an attempt to join the use of the numerical integration approaches of the MACK model with the hydrodynamic theory of the FREQ model.

2.2.14 CONTRAM

CONTRAM [34,35] is a traffic assignment model primarily developed for use in the design of traffic management schemes in urban areas. It is a capacity restrained model which takes account of the interactive effects of traffic between intersections over a network and the variation through time of traffic conditions. In particular, it models the build up and decay of congestion.

Traffic demands are expressed as O-D rates for each given time interval. These O-Ds are converted into an equivalent number of vehicle packages, which are assigned to the network at a uniform rate for each time interval. Each such packet is indivisible and travels along its path to its destination. For each link along its path, flows and travel times are updated, whereas for each vehicle packet a record is kept of the links used and the arrival time at that link. With the latter information, each vehicle packet can be conveniently removed from the network during any subsequent iterations and a detailed queue diagram can be constructed for each link. A traffic assignment equilibrium is achieved through iterations in which each vehicle packet in turn is removed from the network and reassigned to its new minimum path.

The total link travel times are calculated on the basis of any oversaturation delay due to extended queuing, the duration of the red indication at traffic signals, and any random delay effects due to randomness in either arrival or departure rates. As traffic volume estimates become available from an initial assignment, delay functions for traffic signals can be updated to reflect optimized signal splits or cycle lengths.

The recent developments in CONTRAM 5 [36] include speed/flow relationship for links, minimum perceived cost assignment, a more detailed modelling of the effect of linked signals, an improved fuel consumption model, estimation of geometric delay at junctions, variable and automatic packet sizing, variable saturation flows and capacities for individual time intervals.

CONTRAM's main weakness for purposes of this study is its lack of routines for modelling freeway ramps and freeway merging and weaving sections. Other concerns are the extensive memory and execution time requirements.

2.2.15 JAM

JAM [37] is a computer model developed for traffic assignment to urban networks in which intersection delays plays a significant role in determining driver's route choice. JAM can be used in most urban traffic studies, whether addressed to the design and evaluation of traffic management schemes, intersection improvements or new highway construction, or to assessment of the effects of major new developments.

Within the assignment process, trips are loaded onto the network incrementally within a single run of the program. In each increment a fraction of the matrix is assigned to a new set of path trees based upon the delays at each intersection node and link speeds calculated from a normalization of the previous loading.

Link speed changes are operated in a conventional way through user-defined speed/flow curves, but are not normally called in to operations on links forming the approach to a delay-producing junction, in order to avoid double-counting of delays.

The intersection types that may be coded include signals (fixed-time and vehicle actuated), roundabouts, priority intersections and highway merges.

Over thirty JAM studies [37] are currently being undertaken in areas that range from freestanding towns to inner-city boroughs.

2.2.16 MICRO-ASSIGNMENT

MICRO-ASSIGNMENT is a microscopic adaptation of traditional transport planning assignment techniques. Traffic is assigned in a conventional fashion, but the network is coded in considerably more detail, so that individual movements or lanes can be considered [38,39].

Two types of delay are considered: zero-volume delay and congestion delay. Assignment is based on an iterative multipath procedure that deals in time periods from 6 min to 24 hr. The technique assigns time-slice O-D patterns to the links in the network so that arrival rates and updated delays can be derived. Although the higher delays associated with oversaturation are considered in the assignment, queuing conditions are not modeled explicitly,.

MICRC-ASSIGNMENT's weaknesses for purposes of this study are its lack of routines for modelling freeway ramps and freeway weaving and merging sections, and the lack of explicit queuing conditions analysis.

2.2.17 SATURN

SATURN [40,41,42] is a traffic assignment model based on a detailed simulation of intersection delays and an assignment that employs a more general travel time relationship that is derived from the detailed simulation. SATURN performs assignment in a network of signalized and unsignalized intersections.

Intersection delays are determined primarily by using cyclical profiles. Consequently the effects on delay of coordination of signal timings and platoon progression can be accounted for. On the basis of delay estimates at free-flow conditions, at the conditions modeled using the cyclic profiles, and at capacity, an aggregate power curve is fitted to represent delays at any approach volume. This power function is further supplemented with a queuing relationship for oversaturated conditions.

Traffic flows on each network link are estimated by using a combination of all-or-nothing assignments. These new estimates of link flow are then reevaluated with the cyclic profile approach until equilibrium is reached between the evaluation and the assignment.

SATURN's main weaknesses with regard to purposes of this study are its lack of freeway modelling routines and its lack of explicit queuing based assignment.

2.2.18 TRAFFICQ

TRAFFICQ is a simulation model of pedestrian delay, vehicle queuing, and platooning behavior [43]. It takes into account dynamic and stochastic variations, varying roadwidths, and movements temporarily blocked by other vehicles. Each vehicle or pedestrian is modeled as an individual entity, and the output gives distributions of queue lengths, travel times, and pedestrian delay.

This simulation technique is aimed at relatively small-scale systems. Routes taken by vehicles are prespecified by the user, and no internal assignment technique is present. The microscopic simulation allows modeling of temporary blockages and queue spill-backs.

Routes taken by vehicles are prespecified by the user: there is no assignment technique.

2.2.19 CORQLC

CORQLC [44] is an urban freeway corridor control model which combines two simulation models (FREQ3 and TRANSYT) with a decision model.

This model first uses a traffic assignment technique to distribute the entire O-D demand to each subnetwork. Subsequently, the two simulation models estimate the expected performance measures for each link that are aggregated over all links and subnetworks to produce an overall network performance summary. Unfortunately there is no effective feedback loop from the detailed evaluation back to the initial traffic assignment.

2.2.20 CORO-CORCON

CORQ [45] is a dynamic assignment technique for allocating time-varying O-D demands to a time-dependent traffic network. The technique models the impact of queuing and ramp metering on traffic assignment within a freeway-arterial corridor. CORCON [46] is a modification of the original CORQ program but contains essentially the same core model logic.

CORQ considers time-slice O-D movements for a freeway-arterial corridor and assigns these in accordance with separate minimum-path and equilibrium consideration for each time slice. Traffic flows that are unable to reach their destination within the given time period because of capacity restraints are queued and carried over for reassignment to the network during the subsequent time slice.

The model considers primarily a directional freeway, its ramps, major cross streets, and any competing alternative surface streets.

2.2.21 DYNEV

DYNEV was developed to estimate evacuation travel times in Emergency Planning Zones as part of the larger software system developed for the Emergency Exercise Simulation Facility [47].

DYNEV is essentially an iterative procedure starting with an data input routine and followed by an assignment procedure and the I-DYNEV traffic simulation model. The simulation model computes network performance measures based on the traffic volumes and turning movements generated within the assignment.

The assignment model uses a modified TRAFFIC algorithm [48]. The traffic simulation model is an adaptation of TRAFLO Level II in which the traffic stream is described in terms of a set of link-specific statistical flow histograms.

2.2.22 INTEGRATION

INTEGRATION [49] was developed specifically to evaluate and optimize the operation of integrated freeway/traffic signal networks during periods of recurring and non-recurring congestion.

The approach considers the behavior of traffic flows in terms of individual vehicles that have self-assignment capabilities. This capability serves as a traffic assignment function and 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.

The INTEGRATION model has been applied to the Burlington Skyway Corridor, near Hamilton, Ontario, Canada.

2.2.23 SCOT

SCOT [50,51] is the synthesis of two previous models: UTCS-1 (Urban Traffic Control System) and DAFT (Dynamic Analysis of Freeway Traffic).

UTCS-1 [52] is a microscopic simulation of urban traffic, in which each vehicle is treated as an individual entity as it traverses its path through a network of urban streets. Routing is performed on the basis of specification of turning movements.

DAFT [53] is a macroscopic simulation model of freeways, ramps, and arterials. Vehicle are grouped into platoons and lose their individual identities.

For each entry link at the periphery of the study network, traffic volumes are specified according to their destination node. The model distributes the resulting platoons of vehicles over the network according to minimum-cost paths, which are calculated frequently on the basis of current conditions.

The SCOT model is no longer supported. The same authors have subsequently developed DYNEV (2.2.21) and TRAFLO (2.2.24), which are said to be improvements over SCOT.

2.2.24 TRAFLO

TRAFLO [54] is a system of four traffic simulation models and one assignment model. The assignment model calculates the flows on each link, which are subsequently evaluated by using one or more of the simulation models.

Traffic assignment is performed with the TRAFFIC model [48] which assigns a specified trip table to a network that is compatible with the four simulation models. One or more of the simulation models are then used to describe traffic operations in each subnetwork.

The following four component submodels are included in the TRAF software system [55]:

- \ Urban Level I Model (NETFLO I) is a microscopic simulation model
- . Urban Level II Model (NETFLO II) is supposed to be an extension and refinement of TRANSYT
- . Urban Level III Model (NETFLO III) is used for the network's major arterials
- . The Freeway Model (FREFLO) is a refinement and extension of MACK.

The TRAFFIC assignment model used within TRAFLO is a good assignment model for planning applications. But its inability to deal with queuing, non-steady-state traffic conditions, and dynamic assignment is detrimental for purposes of this study.

2.3 MAJOR EMPHASIS IN THE SCREENING

Through the initial screening process, three major features are given special consideration due to their importance for evaluating corridor-related models capabilities. The first is the operating environment, the second is the approach to traffic assignment, and the third is the model ability to deal with oversaturated conditions.

2.3.1 Operating Environment

Control models for traffic signal networks and for freeways were historically developed independently.

Signalized network models were primarily developed to select efficient cycle and phase lengths, and to optimize signal offsets within a coordinated network. Some signalized network models combine a detailed operational evaluation of traffic signal timings with a planning-oriented traffic assignment technique.

Freeway models usually represent traffic on a freeway and its ramps as a aggregate steady-state fluid flow: some of these models consider merging and weaving sections, and/or have the capacity to optimize ramp metering rates at a series of freeway ramps.

Freeway-arterial corridor models are those that explicitly consider traffic flows in a network consisting of a freeway and any major parallel arterials. Some of these models (called composite models) are derived by simply linking a freeway model and a signalized network model. Other corridor models were developed to directly represent integrated networks, without artificial division into subnetworks.

2.3.2 Traffic Assignment

The need for a true traffic assignment technique is identified as a major requirement for freeway-arterial corridor traffic models. The ideal traffic assignment technique should consider within an integrated network, the effects of variable traffic demands, the presence of different fixed and real-time traffic signal and ramp metering controls, the occurrence of incidents and the dynamic re-assignment between freeways and arterials.

Simple diversion is not a true assignment technique and is considered inadequate when several alternatives exist within a network.

2.3.3 Oversaturated Conditions

The interactions between freeways and parallel arterials are expected to increase with the level of congestion within the system. Moreover most freeway-arterial control strategies are designed to help alleviate congestion. Therefore, it is essential that the model be able to handle oversaturated conditions, by accurately representing delays due to queues in a dynamic analysis framework.

2.4 TABULATION OF MODEL CHARACTERISTICS

The characteristics of each described model related to the three above mentioned features are summarized in Table 2.2.

MODEL	OPERATING ENVIRONMENT			TRAFFIC ASSIGNMENT	QUEUING CONDITIONS
	Freeway	Corridor	Arterial		
1) CARS	x	P	P	x	
2) EMME2	x			x	
3) MICROTIPS	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) FREP	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

TABLE 2.2: TABULATION OF MODEL CHARACTERISTICS

2.5 SELECTION OF MODELS FOR FURTHER EVALUATION

Traffic assignment and queuing capabilities are considered as essential desired features. Due to the difficulty for incorporating these capabilities to existing models, it is decided to eliminate all the models that do not truly present these two features.

The limitations of these models in regard to the purpose of this study is not to detract from their usefulness in other applications.

Only five models appear to be able to simultaneously perform assignment and deal with queuing. These models are retained for further analysis:

- CORQ
- INTEGRATION
- CONTRAM
- SATURN
- JAM

CONTRAM, SATURN and JAM are primarily traffic signal-oriented assignment models. These models do not currently contain any freeway logic, but have an important capability of modelling traffic assignment in a network that includes traffic signals. Freeway routines will be required if any of these models is selected for purposes of this study.

CORQ and INTEGRATION are typically freeway-arterial corridor models capable of considering queuing and reassignment.

CHAPTER 3

**IN-DEPTH EVALUATION OF SHORT LIST
OF MODELS**

3.1 SCOPE OF DETAILED EVALUATION

The first phase of this project (described in Chapter 2) resulted in the selection of five existing operational models for further evaluation. These models - CONTRAM, SATURN, JAM, CORQ, AND INTEGRATION - were selected because they exhibited characteristics which most closely meet the requirements of this study.

Although the CORQ model was retained in the initial screening process, it has been ruled out in the in-depth evaluation. This program is proprietary, and can not be acquired, as it was developed privately, without funding by any U.S. agencies ⁽¹⁾.

The information available about the JAM model is not complete enough to allow performing an in-depth evaluation of this program. Therefore, the present version of the report does not include the JAM model evaluation.

Three models are considered in the present detailed evaluation process (CONTRAM, SATURN and INTEGRATION). The purpose of the model evaluation described in this chapter is to decide the relative merits of each model with regard to the specific requirements of this project, and not to determine whether a model is good or bad.

The evaluation process is composed of two phases:

- (a) evaluation of models' performance based on selected criteria
- (b) highlights of models' major strengths and weaknesses.

The first section of this chapter presents the criteria used in the in-depth model evaluation. The second section gives tabular summaries of the models' characteristics. The third section proposes a rating system and evaluates model performance. The fourth section highlights major strengths and weaknesses of the models. The last section discusses the suitability of the evaluated models with regard to the purposes of this study and presents the conclusions of the evaluation process.

(1) Based on personal conversation with Sam Yagar, author of the CORQ model.

3.2 MODEL EVALUATION FACTORS

The model evaluation factors used to assess model suitability for the purposes of this study fall into fourteen (14) model elements (from A to N) and fifty-seven (57) criteria.

These evaluation criteria represent either a requirement or a model descriptive feature. The importance of each criterion and their importance relative to each other are taken into account by considering three categories of criteria (III, II, I). Table 3.1 shows how the criteria importance is evaluated.

CRITERIA CATEGORY	DESCRIPTION
III	Necessary requirement Very important feature
II	Desirable requirement Important feature
I	Less important requirement/feature

TABLE 3.1: CRITERIA IMPORTANCE CATEGORIES

Table 3.2 presents the list of the selected criteria used in the in-depth evaluation process and their importance relative to the three categories described above.

CRITERIA DEFINITION	IMPORTANCE
A. FREEWAY REPRESENTATION	
Unidirectional/bidirectional links	I
Merging sections analysis	I
Weaving sections analysis	I
Ramp metering rate simulation	II
Ramp capacity	II
Dynamic capacity representation	III
B. ARTERIAL REPRESENTATION	
Unidirectional/bidirectional link	I
Traffic signal: cycle length, phasing, and green split	III
Signal coordination	II
Yield intersection simulation	I
Uncontrolled intersection simulation	I
Separate turning movements	II
Platoon progression	II
Fixed time control simulation	II
Actuated control simulation	II
Dynamic capacity representation	II
C. TRAFFIC FLOW REPRESENTATION	
Macroscopic representation	II
Mesoscopic representation	II
Microscopic representation	II
Classes of vehicles	II
D. QUEUE AND DELAY MODELLING	
Dynamic growth and decay of queues	III
Queue spillback	II
E. ASSIGNMENT	
Equilibrium traffic assignment	III
Increment assignment	II
Direct account of queue size and delay in the assignment	II
En-route reassignment	III
Ability to represent varying levels of information (dynamic minimum path trees + static path trees)	II
F. OPTIMIZATION ROUTINES	
Freeway ramps isolated control	II
Freeway ramps coordinated control	II
Traffic signals isolated control	II
Traffic signals coordinated control	II

TABLE 3.2: CRITERIA DEFINITION AND IMPORTANCE

CRITERIA DEFINITION	IMPORTANCE
G. INPUT DATA REQUIREMENTS	
Node coordinates.....	I
Links.....	I
Different levels of detail in coding the network.....	I
Initial traffic signal timings.....	I
Traffic signal constraints.....	I
User specified time slice for traffic demand.....	III
Sequence of varying time slices.....	I
Linkage with a synthetic O/D generation technique.....	III
Incident description file.....	I
H. OUTPUTS	
Real-time graphical output.....	I
Flows, queues, travel time, speed by individual link.....	II
Number of stops.....	I
Fuel consumption.....	I
Motorist diversion information.....	II
Interface with actual control/information system.....	II
I. PROGRAM SOURCE CODE	
Language.....	II
Suitability for modification.....	II
J. IMPLEMENTATION	
Mainframe.....	II
Microcomputer.....	II
K. PROGRAM EFFICIENCY AND LIMITATIONS	
Network size limitations.....	III
Execution time (typical run with a medium sized network of 100 nodes and 200 links).....	III
L. USER DOCUMENTATION	
Model's theory.....	II
Software installation.....	II
Interpretation of results.....	II
M. DISTRIBUTION AND SUPPORT	
Purchase cost (for research purposes).....	II
Support and maintenance costs.....	II
Availability of source code.....	II
N. EXPERIENCE AND VALIDATION	
Reported applications.....	II
Use by public agencies, consultants, and universities.....	II

TABLE 3.2 (cont'd): CRITERIA DEFINITION AND IMPORTANCE

3.3 TABULATION OF MODEL CHARACTERISTICS

This section presents tabular summaries (Table 3.3) of the model characteristics with regard to each criterion listed above.

The information used to carry out this evaluation was gathered from reports and articles on the models, and from letters and telephone conversations with model authors and users.

CRI TERIA	CONTRAM	SATURN	INTE GRATION
A. FREEWAY REPRESENTATION			
Unidirectional/bidirect. links	Unidirect	Unidirect	Unidirect
Merging sections analysis	No	No	Yes
Weaving sections analysis	No	No	Yes
Ramp metering rate simulation	No	No	Yes
Ramp capacity	No	No	Yes
Dynamic capacity represent.	Yes	No	Yes
B. ARTERIAL REPRESENTATION			
Unidirectional/bidirect. links	Unidirect	Unidirect	Unidirect
Traffic signal: cycle length phasing, and split	All	All	All
Signal coordination	Yes	Yes	Yes
Yield intersection simulation	Yes	Yes	Yes
Uncontrolled intersection	Yes	Yes	Yes
Separate turning movements	Yes	Yes	Yes
Platoon progression	No	Yes	No
Fixed time control simulation	Yes	Yes	Yes
Actuated control simulation	Approx	No	Yes
Dynamic capacity represent.	Yes	No	Yes
C. TRAFFIC FLOW REPRESENTATION			
Macroscopic representation	No	No	No
Microscopic representation	No	No	Yes
Mesoscopic representation	Packets	Cyclic Flow Prof	No
Classes of vehicles	3	2	Many
D. QUEUE AND DELAY MODELLING			
Dynamic growth and decay of queues	Within time slice	Within time slice	Continuous, No TS
Queue spillback	Yes	No	Yes
E. ASSIGNMENT			
Equilibrium assignment	Yes	Yes	Yes
Increment assignment	O/D veh. packets	Total TS OD demand	Ind. veh.
Direct account of queue and delay in the assignment	Yes	No	Yes
En-route reassignment	Yes	Not clear	Yes
Ability to represent varying levels of information	Not clear	Not clear	Yes
F. OPTIMIZATION ROUTINES			
Freeway ramps			
isolated control	No	No	Yes
coordinated control	No	No	Yes
Traffic signals			
isolated control	Yes	Yes	Yes
coordinated control	Yes	Yes	Yes
G. INPUT DATA REQUIREMENTS			
Node coordinates	Yes	Yes	Yes
Links	Yes	Yes	Yes
Different levels in coding	No	Yes	No
Initial signal timings	Yes	Yes	Yes
Traffic signal constraints	Yes	Yes	Yes
User specified time slice	Typ. 15'	15 or 30'	Typ. 15'
Sequence of varying TS	Possible	Possible	Not clear
Synthetic O/D generation	COMEST	ME2	SODGE
Incident description file	No	No	Yes

CRI TERIA	CONTRAM	SATURN	INTE GRATION
H. OUTPUTS			
Real time graphical output	No	No	Yes
Flows, queues, travel time, speed by individual link	Yes	Yes	Yes
Number of stops	Yes	Yes	Yes
Fuel consumption	Yes	Yes	Yes
Motorist diversion information	Not clear	Not clear	Yes
Interface with actual control/information systems	No	No	Under develop. (P-ROUTE:)
I. PROGRAM SOURCE CODE			
Language	FORTRAN	FORTRAN	C-LANG. or Compiled BASIC
Suitability for modification	Possible	Possible	Possible
J. IMPLEMENTATION			
Mainframe	Yes	Yes	Yes
Microcomputer	Yes	Yes	Yes
K. PROGRAM EFFICIENCY AND LIMITATIONS			
Network size limitations	Up to 500 links	Up to 150 nodes	Up to 300 links
Execution time	15-60 min	15-45 min	?
L. USER DOCUMENTATION			
Model's theory	Yes	Yes	Yes
Software installation	Yes	Yes	?
Interpretation of results	Yes	Yes	?
M. DISTRIBUTION			
Purchase cost	\$ 262.50	0	0
Support and maintenance	?	?	?
Availability of source code	?	?	?
N. FIELD APPLICATIONS			
Reported applications	London Bahrain Edmonton	Harrogate Liverpool	Burlington on Skyway
Use by public agencies, consultants and universities	Extensive	Extensive	No

TABLE 3.3: TABULATION OF MODEL CHARACTERISTICS

3.4 SCORING

3.4.1 Rating system

For each criterion the model performance is evaluated by using the following rating system:

PERFORMANCE	POINTS
Excellent	3
Good	2
Fair	1
Poor	0

TABLE 3.4: RATING SYSTEM

A weighting **system** is adopted in order to reflect the relative importance of the criteria. This weighting system is based on the classification presented in Table 3.1:

- Criteria III are affected a coefficient 3
- Criteria II are affected a coefficient 2
- Criteria I are affected a coefficient 1

3.4.2 Scoring results and comments

The evaluation points summary is given in Table 3.5. Model performance relative to each criterion is evaluated by using the four-point scale, as indicated above. It is not always easy to assess the model performance because of the differences in the information available on the different models. Another limitation of the method is that for some criteria, the four-point scale is not very suitable. However, the presented results give a good idea of the general global performance of the three models.

The scoring results presented in Table 3.5 indicates that the three models are approximately equal overall. INTEGRATION (265 points) has the highest score, followed by CONTRAM (243) and SATURN (236). Considering the subjective nature of the scoring system, it has been decided to complete the analysis with a summary of the models' major strengths and weaknesses.

		C. ONTRAM	SATURN	INTEGRA
A.	FREEWAY REPRESENTATION			
	Uni directional/bi directional links.....	I	2	2
	Merging sections analysis.....	I	0	2
	Weaving sections analysis.....	I	1	2
	Ramp metering rate simulation.....	II	1	3
	Ramp capacity.....	II	1	3
	Dynamic capacity representation.....	III	2	2
B.	ARTERIAL REPRESENTATION			
	Uni directional/bi directional link.....	I	2	2
	Traffic signal: cycle length, phasing, and green split.....	III	2	2
	Signal coordination.....	II	2	2
	Yield intersection simulation.....	I	2	2
	Uncontrolled intersection simulation.....	I	2	2
	Separate turning movements.....	II	2	2
	Platoon progression.....	II	1	0
	Fixed time control simulation.....	II	1	0
	Actuated control simulation.....	II	1	0
	Dynamic capacity representation.....	II	2	2
C.	TRAFFIC FLOW REPRESENTATION			
	Macroscopic.....	II	0	0
	Mesoscopic.....	II	0	0
	Microscopic.....	II	0	0
	Classes of vehicles.....	II	2	3
D.	QUEUE AND DELAY MODELLING			
	Dynamic growth and decay of queues.....	III	3	3
	Queue spillback.....	II	3	3
E.	ASSIGNMENT			
	Equilibrium traffic assignment.....	III	3	3
	Increment assignment.....	II	3	3
	Direct account of queue size and delay in the assignment.....	II	1	1
	En-route reassignment.....	III	1	2
	Ability to represent varying levels of information.....	II	1	2
F.	OPTIMIZATION ROUTINES			
	Freeway ramps isolated control.....	II	1	3
	Freeway ramps coordinated control.....	II	1	3
	Traffic signals isolated control.....	II	3	3
	Traffic signals coordinated control.....	II	3	3
G.	INPUT DATA REQUIREMENTS			
	Node coordinates.....	I	3	3
	Links.....	I	3	3
	Different levels of detail in coding the network.....	I	3	3
	Initial signal timings.....	I	3	3
	Traffic signal constraints.....	I	3	3
	User specified time slice for traffic demand.....	III	3	3
	Sequence of different time slices.....	I	3	3
	Synthetic O/D generation technique.....	III	1	3
	Incident description file.....	I	1	3
H.	OUTPUTS			
	Real-time graphical output.....	I	0	3
	Flows, queues, travel time, speed by individual link.....	II	3	3
	Number of stops.....	I	3	3
	Fuel consumption.....	I	1	2
	Motorist diversion information.....	II	1	2
	Interface with actual control/information system.....	II	0	2
I.	PROGRAM SOURCE CODE			
	Language.....	II	3	3
	Suitability for modification.....	II	3	3
J.	IMPLEMENTATION			
	Mainframe.....	II	3	3
	Microcomputer.....	II	3	3
K.	PROGRAM EFFICIENCY AND LIMITATIONS			
	Network size limitations.....	III	2	1
	Execution time.....	III	2	1
L.	USER DOCUMENTATION			
	Model's theory.....	II	3	2
	Software installation.....	II	3	2
	Interpretation of results.....	II	3	2
M.	DISTRIBUTION AND SUPPORT			
	Purchase cost (for research purposes).....	II	1	3
	Support and maintenance costs.....	II	2	2
N.	EXPERIENCE AND VALIDATION			
	Reported applications.....	II	3	1
	Use by public agencies, consultants, and universities.....	II	3	0
TOTAL			243	236
				265

TABLE 3.5: SCORING RESULTS

3.5 MODELS' MAJOR STRENGTHS AND WEAKNESSES

This section highlights models major strengths and weaknesses.

3.5.1 CONTRAM

CONTRAM's major strengths and weaknesses with regard to purposes of this study are summarized in Table 3.6.

CONTRAM's main promise for purposes of this study derives from its superior dynamic traffic assignment technique. This technique assigns packets (which are the unit of traffic movement in CONTRAM) to their minimum journey time routes through the network by an iterative procedure (see Appendix C.2). The recalculations 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. In this respect CONTRAM is believed to be superior to traditional models in its ability to assess current traffic conditions along routes as each packet moves through the network.

CONTRAM permits each vehicle packet in turn to be a marginal user who decides on his path seeing a fully loaded network rather than a network that has only been loaded to the extent of the previous increments.

CONTRAM's main weakness with regard to purposes of this study is its lack of routines for freeway ramps and freeway merging and weaving sections. There is no major obstacle in the model's structure to prevent such an addition, but there is no evidence that model authors have planned to incorporate freeway routines in a future version of the model. Another concern is the extensive computational requirements due to the need to explicitly store all vehicle packet routes. Finally, unlike SATURN, CONTRAM does not explicitly consider platoon progression along signalized arterials.

STRENGTHS	WEAKNESSES
<ul style="list-style-type: none"> - Sophisticated queuing-based assignment technique - Flexibility of the assignment /evaluation/queuing technique - Detailed modelling of traffic signals with coordination and optimization capabilities - Synthetic O/D generation technique: COMEST - Availability (mainframe + microcomputer) - Support (TRRL + MVA Systematica)- - Extensive number of applications 	<ul style="list-style-type: none"> - Lack of routines to model freeway ramps and freeway merging and weaving sections - Associates all delay with intersections - Extensive use of memory and computer time - No platoon progression consideration

TABLE 3.6: CONTRAM - STRENGTHS AND WEAKNESSES SUMMARY

Appendix C presents additional information about CONTRAM.

Recent contacts with Peter Gower (Transport and Road Research Laboratory) provided following additional points:

.CONTRAM 5 allows user's specification of speed/flow relationship adapted to freeway links, but there is no representation of merging and weaving freeway sections.

.There is no theoretical network size limitation. The program can easily handle 300 or 400 links.

.CONTRAM 5 is currently being applied on a motorway network near Paris, France within the European DRIVE program.

3.5.2 SATURN

SATURN's major strengths and weaknesses are summarized in Table 3.7

The main strength of SATURN is its ability to perform assignment in a network consisting of traffic signals while giving considerations to the platooning structure of vehicle arrivals and the phasing of the signals.

SATURN's main weaknesses with regard to purposes of this study are its lack of freeway modelling routines and its lack of queuing based assignment. Although SATURN adopts an iterative procedure to correct and update the network parameters for the assignment, it would appear that queuing should be directly accounted for in the assignment. Another concern is SATURN's approach assuming cyclic flow profiles (turning movements at each intersection are modelled using cyclical flow profiles, much like TRANSYT). This representation would appear to be only suited for signalized arterials, and therefore limits SATURN's applicability for freeway corridor analysis without major modifications.

STRENGTHS	WEAKNESSES
<ul style="list-style-type: none"> - Traffic signals modelling with coordination and optimization capabilities - Synthetic O/D generation technique: M2 - Platooning structure of vehicles arrivals at signalized intersections - Networks may be coded at two levels of detail (inner and buffer networks) - Extensive use by government and private organizations 	<ul style="list-style-type: none"> - Lack of routines to model freeway sections and freeway ramps - Associates all delay with intersections - Too signal-oriented to allow the incorporation of freeway without major changes to the assignment and/or queuing analysis - Queuing is not directly accounted for in the assignment - Difficulties in, reassignment of queues in subsequent time slices - Uses all-or-nothing assignments

TABLE 3.7: SATURN - STRENGTHS AND WEAKNESSES SUMMARY

Appendix D presents additional information about SATURN.

Recent contacts with Dirck Van Vliet (Institute for Transport Studies at Leeds) confirmed that the SATURN8 version of the program, which is on the point of release, will contain a number of options orientated towards the modelling of vehicle route guidance systems.

3.5.3 INTEGRATION

INTEGRATION's major strengths and weaknesses are illustrated in Table 3.8.

Developed specifically to perform traffic assignment in an integrated freeway/surface street environment, the INTEGRATION model appears to meet most of the major requirements identified in this study. INTEGRATION, as a microscopic simulation model considers the behavior of traffic flow in terms of individual vehicles that have self-assignment capabilities. The model is not based on a time-slice approach; rather it assigns individual vehicles sequentially to a network that is already loaded with any previous departures that have not reached their destination. The turning movements of each vehicle at each node and instant are dictated by the minimum-path tree table existing at that instant and are recalculated every 6 seconds.

The main weakness of INTEGRATION is that this model is still at an early stage of development. Potential difficulties may appear when applying the model to a real-life situation because of the originality and complexity of INTEGRATION's approach. At present, only one application of the model has been reported. Another concern is that the microscopic simulation requires extensive memory and computer time, and may result in serious network size limitations that could be critical for purposes of this study.

STRENGTHS	WEAKNESSES
<ul style="list-style-type: none"> - Specifically developed to perform traffic assignment in an integrated freeway/arterial corridor - No use of the time slice approach: dynamic traffic demand patterns and a wide variety of variable controls can be simulated - Explicit account of queue size and delay through the assignment - Microscopic simulation: individual veh. self assignment capabilities - Updated minimum path-tree table every six seconds - Routing of traffic can represent the behavior of drivers with varying knowledge of traffic conditions - Synthetic O/D generation technique: SODGE - Interface with a prototype route guidance system: Q-ROUTE 	<ul style="list-style-type: none"> - Only in a developing stage. Requires significant amount of further development - Potential difficulties due to the originality and the complexity of the approach - Lack of user-oriented documentation - Only one reported real-world application - Computational requirements (memory + time) of a microscopic approach

TABLE 3.8: INTEGRATION - STRENGTHS AND WEAKNESSES SUMMARY

Appendix E presents additional information about INTEGRATION.

3.6 SELECTION OF MODELS FOR FURTHER DEVELOPMENT

On the basis of the evaluation process (rating system and strengths/weaknesses tables) it appears that INTEGRATION is the most promising model with regard to purposes of this study mainly because it was originally designed to perform traffic assignment in typical freeway/arterial corridors. Although still at an early stage of development, results so far have been promising. It is not yet clear that this approach will be suitable for large networks.

CONTRAM and SATURN appear to present close characteristics. However, CONTRAM might be more promising than SATURN. Although SATURN 8 (on the point of release) will be modified to deal with the modelling of vehicle route guidance, two of SATURN's approach identified main weaknesses appear to be particularly critical with regard to purposes of this study: namely, the lack of truly queuing-based assignment and a too signal-oriented structure.

Although neither model includes freeway sections and ramps analysis, the flexibility of CONTRAM's structure could make it more suitable than SATURN to incorporate freeways without major fundamental changes. Moreover the CONTRAM 5 version already provides user's specification of speed/flow relationship adapted to freeway links.

The three programs SATURN, CONTRAM and INTEGRATION are recommended for further analysis, development and application. It is recommended that the models be acquired and applied to a test network. Such a study should identify what specific modifications the models need and what potential applications can be envisaged.

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

4.1 GENERAL SUMMARY OF CHAPTERS 2 AND 3

The literature review of existing traffic simulation models potentially suited for evaluating advanced traffic control strategies and in-vehicle information systems within an integrated freeway/arterial corridor identified twenty-four candidate models.

The screening process described in Chapter 2 resulted in the selection of five of these models that appeared to be able to simultaneously perform assignment and deal with oversaturated conditions.

Chapter 3 presented a more detailed evaluation of selected model capabilities. The evaluation process concluded that three models are very promising for purposes of this study, and are recommended for further analysis and application. Specifically, these three models are CONTRAM, SATURN, and INTEGRATION.

4.2 RECOMMENDATIONS

The three models, CONTRAM, SATURN, and INTEGRATION are recommended for further development because these models appear best suited for purposes of this study. It is recommended that the programs be acquired and studied in greater detail.

A theoretical study should focus on the following critical points:

1. Traffic Assignment Technique

- . Queuing
- . Dynamic reassignment

2. Program Efficiency and Limitations

- \ Maximum size of network
- . Execution time
- . Memory requirement

3. Program Source Code

- \ Access to source code
- . Suitability for modifications

4. Input Data Requirement

- . Linkage with a synthetic O/D generation technique

In parallel to the theoretical study, the models should be applied to a sample freeway/arterial corridor, in order to provide a more accurate overall appraisal. Test runs should permit to identify what specific modifications the models need and provide an estimation of the feasibility to incorporate these modifications. In particular, the model capabilities for modelling freeway sections and ramps would be given particular attention.

These test runs on a sample network could be the first phase in an incremental development and testing of models, initially aimed at a finite-sized network and a well-defined situation.

4.3 FUTURE RESEARCH DIRECTION

Based on the conclusions and recommendations presented in the present study, a proposed one-year work plan has been submitted to the PATH program in May 1990. A copy of the proposal is provided in Appendix F. The new project would include the following tasks:

1. Acquire the three selected models: CONTRAM, SATURN, and INTEGRATION
2. Perform test runs on a sample freeway/arterial corridor
3. Identify what specific modifications the models require and the associated level of effort
4. Select the most promising model for purposes of the study
5. Identify the most important modifications that can be considered within the time frame of the project
6. Develop, incorporate, and test these specified modifications
7. Design and conduct an experiment to apply the model to a real-life freeway/arterial corridor, like the SMART corridor in Los Angeles. The experiment would consist of testing different management strategies (freeway control, arterial control, in-vehicle information systems) under incident and no-incident conditions, by giving particular attention to interactions between control strategies and route diversion.

REFERENCES

1. H. Al-Deek, M. Martello, A. May and W. Sanders. Potential Benefits of In-Vehicle Information Systems in a Real Life Freeway Corridor under Recurring and Incident Induced Congestion. PATH Research Report UCB-ITS-PRR-88-2, 1988.
2. H. Al-Deek and A. May. Potential Benefits of In-Vehicle Information Systems (IVIS): Demand and Incident Sensitivity Analysis. PATH Research Report UCB-ITS-PRR-89-1, 1989.
3. S. Yagar. Integrated Networks, Traffic Monitoring and Control Systems. Proc. Eng. Found. Conf., Henniker, New Hampshire, 1983.
4. A. May. Integrated Control of Interacting Traffic Systems (workshop report). Proc. Eng. Found. Conf., Henniker, New Hampshire, 1983.
5. M. Van Aerde and S. Yagar. Dynamic Integrated Freeway/Traffic Signal Networks: Problems and Proposed Solutions. Transpn. Res. -A, Vol. 22A, No. 6, pp. 435-443, 1988.
6. P. Ross and D. Gibson. Review of Road Traffic Network Simulation Models. Transportation Research Record 644, TRB, 1977.
7. A. May. Models for Freeway Corridor Analysis. TRB Special Report 194, 1981.
8. A. May. Freeway Simulation Models - Revisited. TRB Freeway Operations Committee Meeting, 1987.
9. A. Skabardonis. Computer Programs for Traffic Operations. ITS, University of California, Berkeley, 1984.
10. M. Van Aerde and S. Yagar. Review of Freeway Corridor Traffic Models. Ontario Ministry of Transportation and Communications, Ontario, Canada, 1987.
11. E. Sullivan and S. Wong. Development of a Dynamic Equilibrium Assignment Procedure for Network-Level Analysis of New Technology. PATH Research Report. ITS, University of California, Berkeley, 1989.
12. Roger Creighton Associates, Inc. CARS. Delmar, NY.
13. A. Babin, M. Florian, L. James-Lefebvre, H. Spiess. EMME/ - An Interactive Graphic Method for Road and Transit Planning. University of Montreal, 1982.

14. MVA Systematica. MICROTRIPS Users Manual. London, 1987.
15. COMSIS Corporation. MINUTP Technical User Manual. 1987
16. M.A.P. Taylor. A Spectrum of Applications of MULATM in Local Area Traffic Management. Monash University, Clayton, Australia, 1989.
17. Professional Solutions, Inc. TMODEL2. Vashon, WA.
18. DKS Associates. TRANPLAN Users Manual. 1985
19. N. Roupail. A Model of Traffic Flow at Freeway Construction Lane Closures. Ohio State University, 1982.
20. A. May. Traffic Management Research at the University of California. Schriftenreihe des Instituts für Verkehrswesen des Universität Karlsruhe, 1984.
21. M. Cilliers, R. Cooper and A. May. FREQGPL - A Freeway Priority Lane Simulation Model. ITS, University of California, Berkeley, 1978.
22. D. Roden, W. Okitsu, A. May. FREQ7PE - A Freeway Corridor Simulation Model. ITS, University of California, Berkeley, 1980.
23. T. Imada and A. May. FREQ8PL - A Freeway Priority Lane Simulation Model. ITS, University of California, Berkeley, 1985.
24. D. Wicks. INTRAS - A Microscopic Corridor Simulation Model. Overview of Simulation in Highway Transportation, Vol 1, pp. 95-107, 1977.
25. D. Wicks and E. Lieberman. Development and Testing of INTRAS, A Microscopic Freeway Simulation Model. Vol 1, Program Design, Parameter Calibration, and Freeway Dynamics Component Development, FHWA, 1980.
26. A. Bullen. Development of Compact Microsimulation for Analyzing Freeway Operations and Design. In Transportation Research Record 841, TRB, 1982.
27. P. Michalopoulos. A Dynamic Freeway Simulation Program for Personal Computers. Transportation Research Record 971, TRB, 1984.
28. H. Payne. Models of Freeway Traffic Control. Simulation Councils Proceedings, Vol.1, No.1, 1971.
29. H. Payne. MACK: A Macroscopic Simulation Model of Freeway Traffic (Version II). ORICON, La Jolla, Calif., 1977.

30. H. Payne. FREFLO: A Macroscopic Simulation Model of Freeway Traffic. Transportation Research Record 722, TRB, 1979.
31. P. Babcock. Freeway Simulation and Control. ITS, University of California, Berkeley, 1982.
32. J. Campbell. FRECON2 User's Guide. ITS, University of California, Berkeley, 1984.
33. E. Hauer. The ROADRUNNER Freeway Model. Toronto, 1978.
34. D. Leonard and al.. CONTRAM: A Traffic Assignment Model for Predicting Flows and Queues During Peak Periods. TRRL Report LR841, 1978.
35. D. Leonard and P. Gower. User Guide to CONTRAM Version 4. TRRL, SR735, 1982.
36. D. Leonard, P. Gower and N. Taylor. CONTRAM: Structure of the Model. TRRL Research Report 178, 1989.
37. N. Bishton and D. Miller. The use of JAM assignment model for urban scheme design and evaluation. In Traffic Engineering & Control, Vol.31, No-1, January 1990.
38. G. Brown and R. Scott. Micro-Assignment: A New Tool for Small Area Planning. In Highway Research Record 322, 1970.
39. D. Chenu. San Jose Central Business District Project: Validation of Micro-Assignment and Evaluation of Two Loading Procedures. CALTRANS, 1977.
40. D. Van Vliet and al.. SATURN - A Simulation-Assignment Model for the Evaluation of Traffic Management Schemes. In Traffic Engineering and Control, Vol.21, No.4, 1980.
41. D. Van Vliet. SATURN: A Modern Assignment Model. In Traffic Engineering and Control, Vol.23, No.12, 1982.
42. D. Van Vliet and M. Hall. SATURN 7.1 - A User's Manual - Universal Version, 1987.
43. D. Logie. TRAFFICQ: A Comprehensive Model for Traffic Management Schemes. In Traffic Engineering and Control, Nov.1979.
44. M. Orthlieb and A. May. Freeway Corridor Control Strategies. Institute of Transportation and Traffic Engineering, University of California, Berkeley, 1975.
45. S. Yagar. CORQ - A Model for Predicting Flows and Queues in a Road Corridor. In Transportation Research Record 533, TRB, 1975.

46. B. Allen and S. Easa. Analysis of Urban Freeway Corridors. Ontario, Canada, 1977.
47. KLD Associates. Application of the I-Dynev System to Compute Estimates of Evacuation Travel Time at Nuclear Power Stations: Four Demonstration Case Studies. 1984.
48. S. Nguyen and L. James. TRAFFIC: An Equilibrium Traffic Assignment Program. University of Montreal, 1975.
49. M. Van Aerde and S. Yagar. Dynamic Integrated Freeway/Traffic Signal Networks: A Routing-Based Modelling Approach. In Transportation Research, Vol. 22A, No.6, 1988.
50. E. Lieberman. Simulation of Corridor Traffic - The SCOT Model. In Highway Research Record 409, 1972.
51. FHWA. SCOT Model - User's Manual and Program Documentation - Working Document. 1975.
52. E. Lieberman and al.. Network Flow Simulation for Urban Traffic Control System. KLD Associates. 1971.
53. E. Lieberman. Dynamic Analysis of Freeway Corridor Traffic. Joint Transportation Engineering Conference, Chicago, 1970.
54. E. Lieberman and B. Andrews. TRAFLO: A New Tool to Evaluate Transportation System Management Strategies. Transportation Research Record 772, TRB, 1980.
55. FHWA. Integrated Traffic Simulation Model - Phase 1. 1980.

APPENDICES

Appendix A: COST-EFFECTIVENESS EVALUATION OF INTEGRATED CONTROL

Appendix B: TRAFFIC MODELING TO SUPPORT ADVANCED DRIVER
INFORMATION SYSTEMS - FHWA REQUEST FOR PROPOSAL -
STATEMENT OF WORK

Appendix C: CONTRAM

- C.1 Approach Overview
- C.2 Assignment Procedure
- C.3 Facilities in CONTRAM 5
- C.4 List of References

Appendix D: SATURN

- D.1 Approach Overview
- D.2 List of References

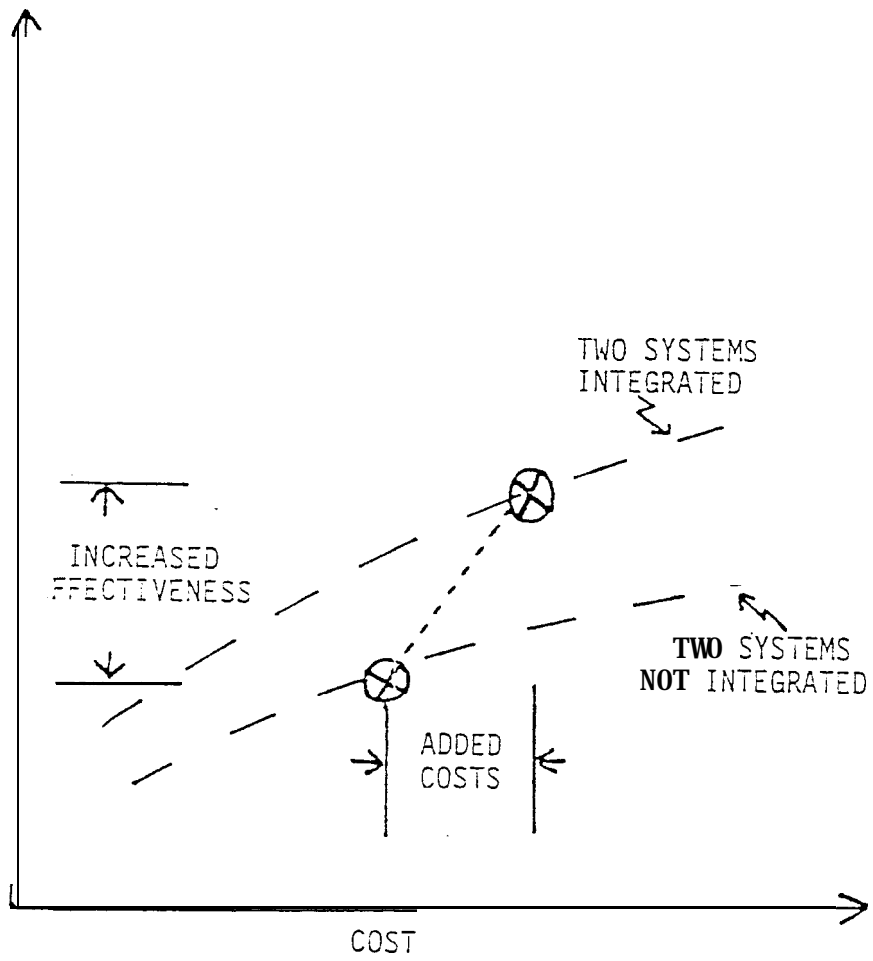
Appendix E: INTEGRATION

- E.1 Approach Overview
- E.2 List of References

Appendix F: PROPOSED FUTURE WORK PLAN SUBMITTED TO THE PATH PROGRAM

A

COST-EFFECTIVENESS EVALUATION OF INTEGRATED CONTROL



Source: Reference [4]

OBJECTIVES

The objectives of this project are to:

- 1 Design real-time dynamic traffic assignment models and traffic simulation models which satisfy all of the technical and operational requirements for an integrated Advanced Traffic Management Systems - Advanced Driver Information Systems (ATMS-ADIS) system.
- 2 Determine the hardware and software requirements, in terms of functionality and processing speed, to ensure the real-time implementation of an integrated ATMS-ADIS system.

SCOPE OF WORK

This study involves two separate but interrelated parts as follows:

- I. Review of the state-of-the-art in traffic assignment with particular emphasis on dynamic traffic assignment algorithms developed for use in incident management and advanced driver information systems. Based on this review, a selection or if needed a design of a new dynamic traffic assignment model shall be performed to be used in developing real-time diversion strategies for urban networks during recurring and non-recurring congestion and which is applicable to route guidance systems. Additionally, there shall be a review of the state-of-the-art in traffic simulation. Based on this review, a selection or if needed a design shall be made of a new real-time simulation model/s suitable for use in an ATMS environment in which real-time control is provided on a network-wide basis (i.e., for both freeways and surface streets). A determination shall be made of the need for an off-line traffic assignment model (which may not necessarily be the dynamic assignment model) to initially load the simulated network with vehicle route guidance systems. If an off-line traffic assignment model is deemed appropriate, a determination shall be made as to whether a new one needs to be developed or if a suitable one is already available. The real-time integration of the dynamic traffic assignment model and the simulation model/s shall be a basic requirement of this study.
2. Review of the state-of-the-art in software design and computer hardware to determine what would be the optimal environment where the dynamic traffic assignment model and the traffic simulation model/s shall reside.

The scope of this study does not include the actual development of the dynamic assignment model or the traffic simulation model/s. It only encompasses the design thereof to the extent of developing flow diagrams, HIPO charts, and pseudo code.

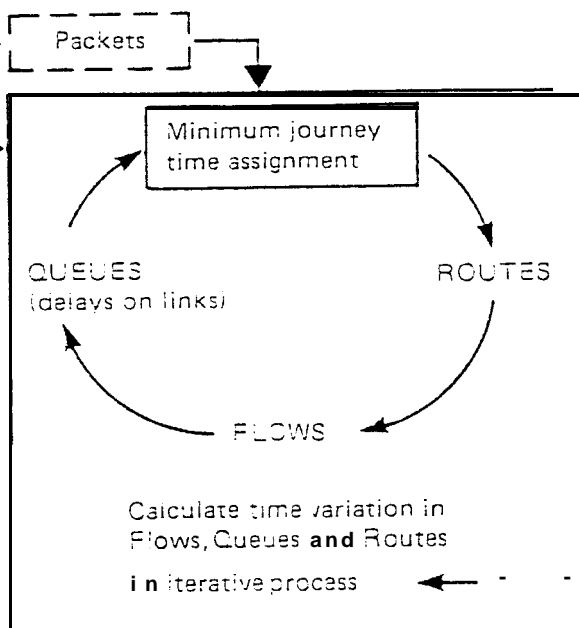
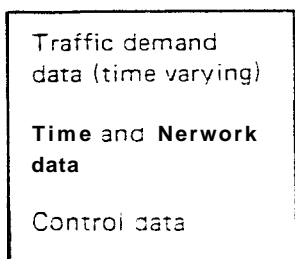
TECHNICAL NOTE: Throughout this Statement of Work, the words Model's is used in reference to assignment and simulation of traffic. Given the objectives and functional specifications, the study needs to determine if these needs can be satisfied with a single model or a variety of integrated models.

All software to be designed as part of this study shall have user-friendly features such as, but not limited to, menus, on-line help and graphics. The resulting products shall be amenable for use by transportation professionals who are not computer users.

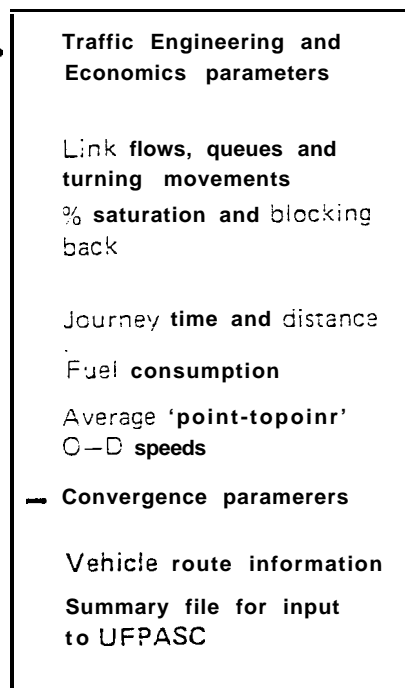
Reference: This Request for Proposal was issued by the US Federal Highway Administration on the 5-16-90, under the Solicitation No. DTFH61-90-R-00074.

C.1 CONTRAM - APPROACH OVERVIEW

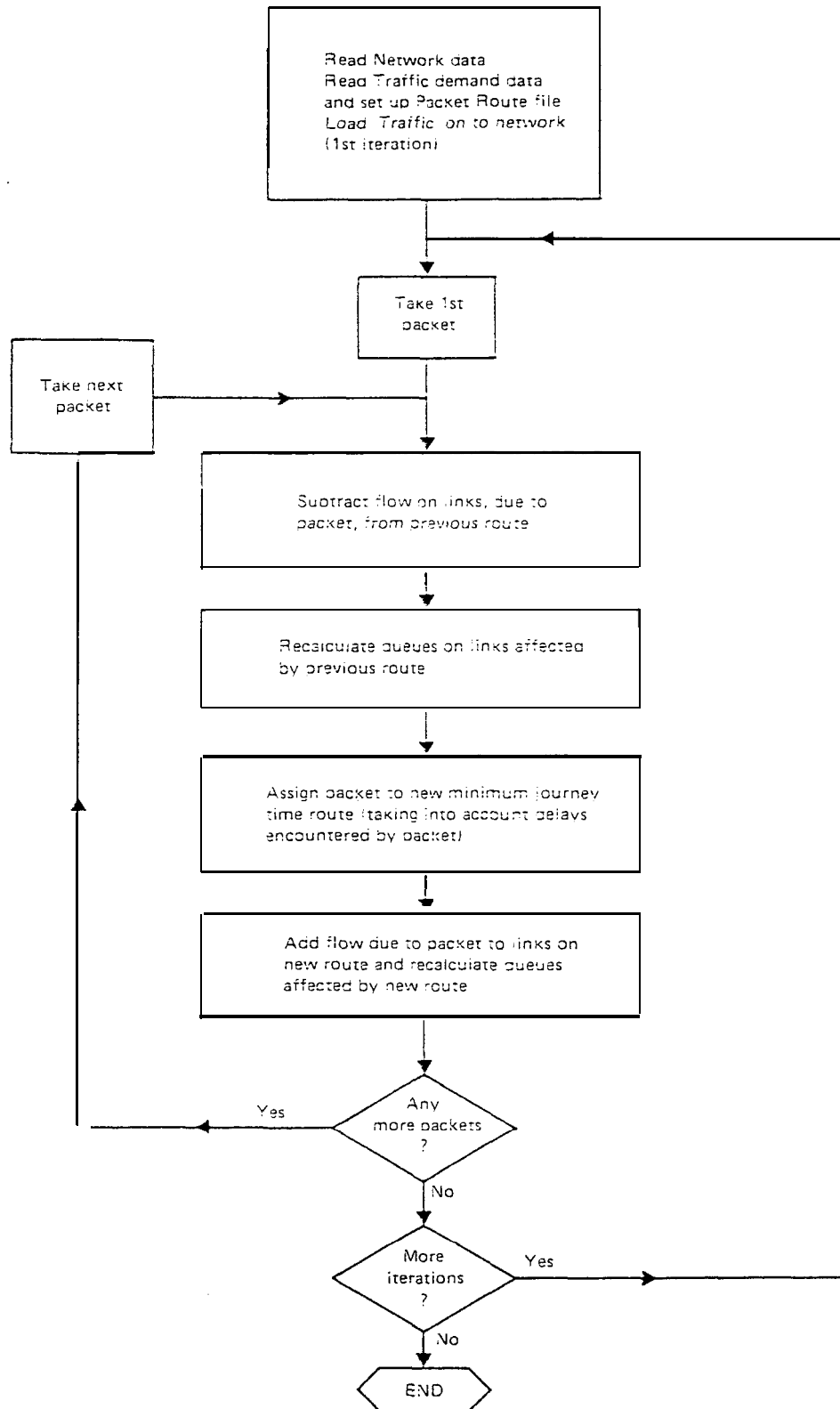
INPUTS



OUTPUTS



C-2 CONTRAM - ASSIGNMENT PROCEDURE



C.3 CONTRAM - FACILITIES IN CONTRAM 5

Models all types of road and junction
Time variation - build up and decay of congestion
Generalised cost or minimum journey time assignment
Blocking back
3 Vehicle classes - cars, buses and lorries
Fixed routes - eg buses - no preloading
Signal plan options - Fixed cycle/Fixed splits, Fixed cycle/Optimal -splits,
Optimised cycle/Optimised splits
Linked signals, signal staging
Banned traffic movements - without recoding (eg pedestrianisation)
Turning movements
Fuel consumption (new modelling)
Measure of 'fairness'
Route information
Convergence indicators
Accepts previous data sets
Change of mind cards and data card exclusion
Improved modelling for give way links
Variable and automatic packet sizing
Speed/Flow (COBA compatible) - buffer network
Geometric delay
Automatic configuration of computer store for large or small networks
Journeys can extend beyond final time interval
Extended title cards
Saturation flows - specified for individual time intervals
Capacities - specified for individual time intervals

C.4 CONTRAM - LIST OF REFERENCES

1. D.R. Leonard and P. Gower
User Guide to CONTRAM 4
TRRL Report SR735, 68 pages, 1982.
2. M. Talbot and M. Murray Clark
The use of CONTRAM in London
Traffic Engineering & Control, Dec. 1982
3. R.D. Coombe, T.J. Annesley and R.P. Goodwin
The use of CONTRAM in Bahrain
Traffic Engineering & Control, March 1983
4. B. Stephenson and Stan Teply
The Verification of CONTRAM in Edmonton
Traffic Engineering & Control, Vol.25, July/August 1984.
5. N.B. Taylor
Speeding up quickest-route assignments in CONTRAM with an
heuristic algorithm
Traffic Engineering & Control, February 1989.
6. D.R. Leonard, P. Gower and N.B. Taylor
CONTRAM: Structure of the Model
TRRL Research Report 178, 24 pages, 1989.
7. N.B. Taylor, M.J. Maher, W.J. Tootill
CONTRAM Userguides - TRRL Application Guide AG13
1989
8. N.B. Taylor
CONTRAM 5: an enhanced traffic assignment model
TRRL Research Report 249, 21 pages, 1990.

D.1 SATURN - APPROACH OVERVIEW

	NETWORK DATA (Card Image file)	TRIP MATRIX (MT file)
I	I	I
I	V	I
I	*****	I
I	*	I
I	NETWORK BUILD	I
I	(SATNET)	I
I	*	I
I	*****	I
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I	I	I
I	NETWORK UNFS (MT)	I
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I	*	I
I	SIMULATION	I
I	(SATSIM)	I
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I	*****	I
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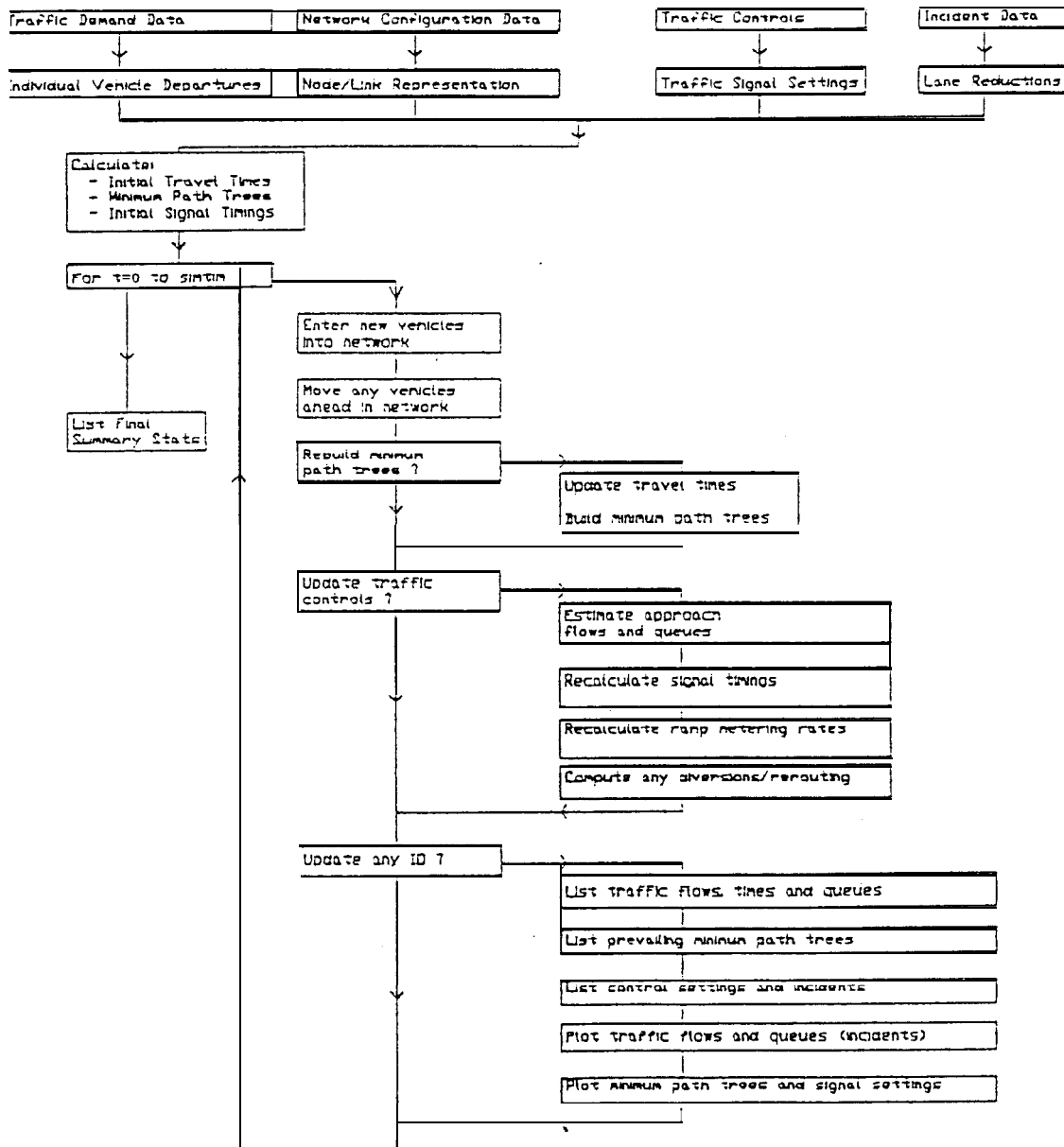
D.2 SATURN - LIST OF REFERENCES

1. M.D. Hall, D. Van Vliet and L.G. Willumsen
SATURN - A Simulation-Assignment Model for the Evaluation
of Traffic Management Schemes
Traffic Engineering & Control, Vol.21, 9 pages, April 1980
2. L.J.A. Ferreira, M.D. Hall and D. Van Vliet
Applications of SATURN to the analysis of traffic management
schemes
PTRC Summer Annual Meeting, July 1982
3. D. Van Vliet
SATURN - A Modern Assignment Model
Traffic Engineering & Control, Vol.23, 4 pages, December 1982
4. A. Choraffa and L.J.A. Ferreira
Using SATURN to Assess the Impact of Traffic Management
Measures in Liverpool
Traffic Engineering & Control, Vol.24, 9 pages, January 1983
5. M.L. James and M.W. Davies
SATURN Traffic Management Model Evaluation
17 pages
11th Australian Transport Research Forum, Darwin, May 1986
6. D. Van Vliet and M. Hall
SATURN 7.1 - A User's Manual - Universal Version
1987.
7. Dirck Van Vliet, Jeremy Randle, and Barry Weston
A validation of the SATURN and ME2 models using before and
after survey data from Manchester
Traffic Engineering & Control, 3 pages, December 1988
8. D. Van Vliet
Fundamental Requirements of full-scale dynamic route
guidance - Recent developments to SATURN
6 pages, 1990.

E.1 INTEGRATION - APPROACH OVERVIEW

Dynamic integrated freeway/traffic signal networks

453



1. M. Van Aerde and S. Yagar
Dynamic Integrated Freeway/Traffic Signal Networks: A
Routing-Based Modelling Approach
Transp Res., Vol.22A, 9 pages, 1988.
2. M. Van Aerde and Y. Blum
Electronic Route Guidance in Congested Networks
ITE Journal, 5 pages, August 1988.
3. M. Van Aerde, J. Voss, A. Ugge and E.R. Case
Managing Traffic Congestion in Combined Freeway and Traffic
Signal Networks
ITE Journal, 7 pages, February 1989
4. M. Van Aerde, J. Voss and Y. Blum
Modelling the Burlington Skyway FTMS during recurring and
non-recurring Traffic Congestion
Traffic Engineering & Control, Vol.30, 13 pages, May 1989.

**PROGRAM ON ADVANCED TECHNOLOGY
FOR THE HIGHWAY**

Potential Benefits of
In-Vehicle Navigation Systems

Adolf D. May
Yonnel Gardes

PROPOSAL

Institute of Transportation Studies
University of California at Berkeley

May 1990

1.0 Introduction

Recently, the California Department of Transportation (Caltrans) and the Institute of Transportation Studies at the University of California at Berkeley (ITS) worked together on a number of projects related to urban and freeway control, and in-vehicle information systems (IVIS) within the Program on Advanced Technology for the Highway (PATH).

One of these projects focusses on quantitative assessment of IVIS in a real-world freeway corridor using simulation. This study is of particular interest for other PATH projects such as the SMART Corridor Statewide Study and PATHFINDER Evaluation.

2.0 Progress to-date

A preliminary evaluation of IVIS has been conducted by a research team at ITS and a final report for the first phase has been submitted to the PATH program in July 1988. The principle end-products of this study were the development of a simulation test-bed for the SMART corridor and the estimation of the travel time savings to potential IVIS users under both recurring and non-recurring congestion.

Continuing along the same line but with more traffic scenarios, the 1988/1989 project showed that potential benefits of IVIS could be significant under incident conditions or under heavy freeway demand. The working paper contained recommendations for future research. In particular, the need for more realistic evaluation of potential benefits of IVIS was identified.

The research team participated in the organization of a one-day seminar held on October 1989 to present Caltrans sponsored traffic management and IVIS related activities. A document summarizing the presentations made at the seminar has been prepared.

The 1989/1990 research project focusses on the modelling approaches for evaluating advanced traffic control strategies and IVIS within an integrated network of traffic signals and freeways. Efforts include a review and preliminary assessment of candidate freeway/arterial models, an in-depth evaluation of the most

promising models, the selection of two models potentially suited for specified purposes. The final report for this phase is expected to be completed by June 1990.

3.0 1990/1991 Proposed Work Plan

The new project would be closely coordinated with the 1989/1990 project. It is likely that the report recommends to use one of the following models: CONTRAM, SATURN, CORQ and INTEGRATION.

Based on the assumption that two of these programs could be acquired, the initial work would be to become very familiar with these models. In particular, an accurate overall appraisal of the models could be provided by test runs on a sample network. This should identify what model is the most promising for our purposes, and what modifications this model requires. The specified modifications would then be developed, incorporated and tested.

The model could then be applied to a real-life freeway corridor simulation, like the SMART Corridor. An updated data base would need to be prepared. This work would be done in coordination with the SMART Corridor-staff and PATHFINDER team.

The experiment would consist of testing different management strategies (freeway control, arterial control, in-vehicle information systems) under incident and no incident conditions. The interactions between route diversion and control strategies would be given a particular attention.

4.0 Schedule of Deliverables

It is anticipated that the project would commence in July 1990 and be completed by the end of June 1991. A verbal report progress would be prepared by December 1990 and the final report would be completed by June 1991.

The results of the application to the SMART Corridor could be helpful with regard to the PATHFINDER project. Estimates of potential benefits of IVIS would be improved. Finally, the operating model that we would use in this experiment could be applied in the future to a wide variety of simulation studies.