Available Computer Models for Traffic Operations Analysis

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The purpose of this report is to make the user aware of the availability of computer models for analyzing traffic operations problems. It will show their use in both proposing solutions and analyzing problems in detail. The use of these models is one of the newest areas of traffic engineering. Practicing traffic engineers may only be slightly aware that these tools are available to assist in reducing the considerable amount of time spent in developing and evaluating alternative improvements to traffic systems. Traffic signal systems in particular could take advantage of the currently available models.

The outline of what is available in this report is based on previous work done in developing the outline and intended contents for a handbook on computer models for traffic operations analysis, an FHWA project.

In order to put what is available in perspective, it will be necessary to also portray what and how FHWA is making computer models available. Present and future work in the implementation process will be described. (Work in progress and needed future work are described in separate reports by Radelat and Ross in these proceedings.)

WHAT IS AVAILABLE?

In the review of models for the handbook, a total of 104 distinct computer models were located that could be applied to traffic engineering problems. The technical appendix gives a one-page summary of "all significant models".

Types of Models

The major goal in describing what is available in computer models for traffic operations analysis is to describe the models in terms of typical problems that need to be analyzed. After looking at various methods of problem classification (such as signal phasing, ramp metering, lane operations, etc.), it was felt that the simplest classification would be by the geometrics that the model analyzes.

Intersection Models

There are more than 250 million signalized intersections in the United States. Most drivers regard these as a major problem on their way to their destination. Inefficient operation of an intersection can lead to excessive fuel consumption.

Manual design procedures for intersection signal timing does not permit comprehensive evaluation due to the trial-and-error nature of the process. As a result, many phasing patterns cannot be considered and the traffic engineer must use his or her experience in deciding which patterns and traffic conditions to analyze in detail.

Many solutions to intersection problems require geometric changes. Adding lanes or widening them can be very expensive and the traffic engineer will need an extremely strong case before funds will be allocated.

Considerable effort was expended in trying to develop models that would provide accurate and quantifiable estimates for assessing proposed improvements at intersections. A total of 26 models were identified that could be used to optimize and analyze traffic at intersections. Table 1 summarizes the models reviewed for possible inclusion in the handbook. Most of these were found to be inappropriate. They were old and had not been maintained. Thus they became outdated. Two of the models are relatively new and potentially useful. These are the SOAP and the TEXAS models.

SOAP (see Figure 1) was developed for FHWA and the Florida Department of Transportation by the University of Florida. It provides a tool for examining and evaluating a wide range of intersection signal design alternatives. It is an optimization, not a simulation, model. Solutions are found for cycle length, phasing, and left-turn analysis. It also has a theoretical capability for analyzing coordination effects; however, other models are more appropriate for this purpose. (See a more detailed description of this model in a paper by Courage and Wallace in this report.)

TEXAS (see Figure 2), the Traffic Experimental and Analytical Simulations model, was developed by the University of Texas for the Texas State Department of Highways and Public Transportation. TEXAS allows the user to evaluate the effects of roadway changes, driver and vehicle characteristic changes, intersection control, lane control, and signal-timing plan effects on single intersection operations. It is perhaps the most microscopic traffic simulation program in existence. It does have some problems in being brought up on new computer systems and is recommended only for those cases where its supermicroscopicity is needed.

Both SOAP and TEXAS are maintained by public agencies. Future enhancements of both models are expected.

Arterial Models

Many arterial highways are now congested. This severely restricts the flow of traffic to and from work and major shopping areas. In this era, new highway construction is coming to an end due to environmental, right-of-way, and construction cost problems. Engineers have a wide range of improvements that can be applied to reduce congestion. Usually, the first to be looked at are traffic control techniques such as improved coordination and parking restriction. These are the lowest-cost measures. Minor geometric improvements such as adding turn lanes and bus pullouts are the next level of improvements to be considered. Arterial computer control systems can now be implemented economically. Table 2 summarizes the models reviewed for possible inclusion in the handbook.

A variety of arterial signal coordination programs has been developed. The most widely used of these are PASSER II, PASSER III, SIGPROG, SIGART, and the LITTLE/MORGAN model. Of these, PASSER II and PASSER III are the best maintained. Of the remaining models, the SUB model provides a unique capability for simulating urban buses. It is hoped that SUB's capabilities will be integrated into the TRAF model.

PASSER II (see Figure 3) was developed to determine optimum progression along arterials while considering phasing sequences. The model developer combined Little's optimized unequal bandwidth equations with methods for handling multiphase signals. Inputs include turning movements, saturation capacity flow rates, minimum green times, distances be-

Table 1. Summary of models reviewed for FHWA handbook project.

Number	Name	Date	Application	Modeling Approach	Program Language	Computer
1-1	TEXAS	1978	Traffic Performance	Mic., Stoc., TS, Sim.	Fortran IV	CDC 6600 IBM 370
1-2	SOAP	1977	Signal Timing (Cycle, splits & phasing)	Mac., Det., TS, Opt.	Fortran IV	IBM 360/ 370
1-3	SPLIT	1976	Signal Timing (Splits only)	Mac., Det., TS, Opt.	Fortran	IBM 360
1-4	CYCLE	1976	Signal Timing (Cycle only)	Mac., Det., TS, Opt.	Fortran	IBM 360
1-5	HARPST	1975	Pedestrian Effects	Mac., Det., TS, Sim.	GPSS	IBM
1-6	SIGCAP	1975	Signal Timing (Splits only)	Mac., Det., TS, Opt.	Fortran	
1-7	UTCS-1S	1973	Traffic Performance	Mic., Stoc., TS, Sim.	Fortran IV	IBM 360
1-8	BLY	1973	Bus Priority Lanes	Mic., Sim.	Fortran	Unknown
1-9	SIGSET	1971	Signal Timing (Cycle & Splits)	Mac., Det., TS, Opt.	Fortran	IBM 360
1-10	BRADFORD	1968	Gap Acceptance	Mic., Stoc., TS, Opt.	ALGOL	ICL 1909
1-11	TEC	1968	Traffic Performance	Sim.	GPSS	IBM 7094 IBM 360
1-12	JONES	1968	Left Turn Storage	Mic., Stoc., TS, Sim.	Fortran	IBM 1130
1-13	DARE	1966	Advisory Speed Signals	Sim.	GPSS	IBM 360
1-14	WRIGHT	1967	Stop Control Delays	Mic., Stoc., TS, Sim.	ALGOL (Ext.)	Unknown
1-15	BOTTGER	1965	Four Way Stop	Mic., TS, Sim.	Unknown	Unknown
1-16	MILLER	1965	Effect of Turns	Mic., Stoc., Sim.	Unknown	Unknown
1-17	NCHRP	1964	Traffic Performance	Mic., Stoc., TS, Sim.	Fortran II, FAP	IBM 1094
1-18	AUSTRAL-IAN	1964	Capacity and Controls	Mic., Stoc., TS, Sim.	Fortran	IBM 7090
1-19	BLEYL	1964	Traffic Performance	Mic., Stoc., TS, Sim.	Fortran II	IBM 7094
1-20	EVANS	1963	Queueing at Stop Signs	Mic., Stoc., TS, Sim.		IBM 7090
1-21	AITKEN	1963	Queueing at "Tee" Junction	Sim.	Unknown	Ferranti Sirius
1-22	KELL	1962	Vehicular Delay	Mic., Stoc., TS, Sim.	FAP	IBM 701& 7094
1-23	LEWIS	1962	Traffic Control	Mic., Stoc., TS, Sim.	Fortran II/FAP	IBM 7094
1-24	NPL	1962	Traffic Performance	Mac, Det., Sim.	Unknown	Ferranti Pegasus
1-25	CHEUNG	?	Delay	Mac., Det., TS, Sim.	Fortran	ICL 1907
1-26	GOODE	1956	Delay	Mic., Det., TS, Sim.	Unknown	MIDAC IBM 704

Abbreviations: Mic. - Microscopic; Det. - Deterministic; TS - Time Scan; Sim. - Simulation; Mac. - Macroscopic; Stoc. - Stochastic; ES - Event Scan; Opt. - Optimization

Figure 1. Intersection model: SOAP.

MODEL: SOAP

DEVELOPED BY: K.G. Courage and M.R. Landmann, University of Florida Transportation Research Center

MAINTAINED BY: Florida Department of Transportation

PURPOSE: Optimal signalization of isolated intersections.

MODELING APPROACH: Macroscopic, deterministic, time-scan, optimization.

DEGREE OF DOCUMENTATION:
- Model Development - Yes
- Program Description - Yes
- User Manual - Yes

GENERAL DESCRIPTION:

SOAP is a design and analysis tool which enables the user to design the signalization for any two to four legged intersection. Either fixed or actuated control and multiple phasing may be specified. Multiple runs may be included in one job to obtain comparisons of alternative design configurations. SOAP uses a search and find optimization procedure to find the optimum cycle length, splits and dial assignments. Measures of effectiveness are delays, stops, excess fuel consumption due to stops and delay, degree of saturation and left-turn conflicts. SOAP may be used to analyze existing or pre-determined timing. Inputs consist of a wide variety of options and control parameters. Volumes, headways, capacities and special parameters are input. The latter permits SOAP to consider coordination of the signal with an adjacent intersection and the effect of platoon arrivals.

NUMBER: 1-2

YEAR: Original: 1977

PROGRAM LANGUAGE: FORTRAN IV

PROGRAM STRUCTURE: Structured

MACHINE: IBM

CORE REQUIREMENTS: 176 K

EFFICIENCY: High

DEGREE OF VALIDATION: Extensive field testing

REFERENCES:

* (1) Courage, K.G. and M.R. Landmann, "Signal Operations Analysis Package," five documents "Volume 1 - Computational Methodology," "Volume 2 - Users Manual," Volume 3 - Programmer's Manual," and "Volume 4 - Portable Calculator Routines," University of Florida, Transportation Research Center, FHWA Implementation Package 79-9, July, 1979.

Figure 2. Intersection model: TEXAS.

MODEL: TEXAS

DEVELOPED BY: T.W. Rioux and C.E. Lee, Center for Highway Research, University of Texas at Austin

MAINTAINED BY: Texas Departemnt of Highways and Public Transportation

PURPOSE: Evaluation of traffic performance

MODELING APPROACH: Microscopic, stochastic, time scan, simulation.

DEGREE OF DOCUMENTATION:
- Model Development - Yes
- Program Description - Yes
- User Manual - Yes

GENERAL DESCRIPTION:

The TEXAS package is designed to perform detailed evaluations of traffic performance at isolated intersections. The geometry processor, GEOPRO, translates the user input data into the required geometry information. These geometry input data are straightforward and comprehensive. The driver-vehicle processor, DVPRO, randomly generates the individual driver-vehicle units based on a variety of user data and program default values. The particular driver characteristics and the vehicle generation are treated stochastically. The simulation processor, SIMPRO, microscopically processes each driver-vehicle unit through the intersection in a fixed, discrete-time increment, and accumulates data on the vehicle performance and traffic interaction. This model is useful in developing and evaluating alternative geometric or control improvements and appears to be an efficient, well-developed tool.

NUMBER: I-1

YEAR: Original: 1977

PROGRAM LANGUAGE: FORTRAN IV

PROGRAM STRUCTURE: Structured

MACHINE: CDC 6600 & IBM 370

CORE REQUIREMENTS: Est. 205K

EFFICIENCY: 1:48 to 1:8

DEGREE OF VALIDATION: Computational & Field

REFERENCES:

*(1) T.W. Rioux and C.E. Lee, "TEXAS - Microscopic Traffic Simulation Package for Isolated Intersections", presented at the 56th annual meeting of the Transportation Research Board, Washington, D.C., 1977.

*(2) C.E. Lee, et al., "The TEXAS Model for Intersection Traffic - Development", Research Report No. 184-1, Center for Highway Research, University of Texas, Austin.

*(3) C.E. Lee, et al., "The TEXAS Model for Intersection Traffic - Programmer's Guide", Research Report No. 184-2, Center for Highway Research, University of Texas, Austin.

*(4) C.E. Lee, et al., "The TEXAS Model for Intersection Traffic - User's Guide", Research Report No. 184-3, Center for Highway Research, University of Texas, Austin, July, 1977, 82 kpp.

*(5) C.E. Lee, et al., "The TEXAS Model for Intersection Traffic - Analysis of Signal Warrants and Intersection Capacity", Research Report No. 184-4, Center for Highway Research, University of Texas, Austin.

Table 2. Summary of arterial models.

Number	Name	Date	Application	Modeling Approach	Program Language	Computer
A-1	SIMTOL	1976	Grades & Trucks	Mic., Stoc., TS, Sim.	Fortran IV	CDC 6400
A-2	NC STOP 1	1975	Signal Progression	Mac., Det., TS, Opt.	Fortran IV	Unknown
A-3	PASSER III	1974/1976	Signal Timing Diamond Ramps	Mac., Det., TS, Opt.	ANSI/ Fortran IV	IBM 360/370
A-4	PASSER II	1974/1978	Signal Progression	Mac., Det., TS, Opt.	Fortran IV	IBM 360/370
A-5	SUB	1973	Urban Bus Operations	Mic., Stoc., ES, Sim. (for buses) Mac., Stoc., TS, Sim. (for others)	Fortran IV	IBM 360/370
A-6	NCSU	1973	Passing Sight Distance Requirements	Mac., Det., TS, Opt.	Fortran IV	Unknown
A-7	YU	1973	Parking Effects on Capacity	Mic., Det., Sim.	Unknown	Unknown
A-8	VECELLIO	1973	Platoon Dispersion	Mac., Det., Sim.	GPSS	IBM 360/165
A-9	TSUMB	1971	Intersection Operations	Mic., Stoc., Sim.	Machine Code	Elliott 920 NB
A-10	MRI	1970	Traffic Flow in Mtns.	Mic., Stoc., TS, Opt.	Fortran IV /Assembly	CDC 6900
A-11	MACCLEN-AHAN	1969	Vehicle Lengths	Mic., Det., TS, Sim.	Fortran IV	Unknown
A-12	DELAY/ DIFFERENCE	1969	Signal Progression	Mac., Det., TS, Sim.	Fortran IV	IBM 7094
A-13	SIGPROG	1967	Signal Progression	Mac., Det., TS, Opt.	Fortran	IBM 360
A-14	FIRL	1967	Passing Maneuvers	Mic., Det., TS, Sim.	Fortran IV	Unknown
A-15	WARNSHIUS	1967	Traffic Flow - Rural Roads	Mic., Det., TS, Sim.	Fortran IV	IBM 7094
A-16	CRAFT/ SMITH	1967	Traffic Flow	Sim.	Unknown	Unknown
A-17	SIGART	1967	Signal Progression	Mac., Det., TS, Opt.	Fortran IV	IBM 360/510
A-18	NEWARK	1965	Car Following Mon.	Mic., Stoc., Sim.	Unknown	Unknown
A-19	LITTLE	1965	Signal Progression	Mac., Det., TS, Opt.	Fortran IV	IBM 7094 & 1620
A-20	YARDENI	1964	Signal Progression	Mac., Det., TS, Opt.	Fortran IV	IBM 7090 & 7040
A-21	FISHER	1964	Lateral Restrictions	Mic., Stoc., TS, Sim.	Unknown	IBM 650
A-22	PRETTY	1964	Traffic Flow Signalized Arterial	Sim.	Unknown	Unknown
A-23	ARNOLD/ RESZ	1964	Traffic Flow on Two-Lane Roads	Sim.	Unknown	Unknown
A-24	MANCHESTER	1963	Traffic Performance	Mac, Stoc., TS, Sim.	Atlas Autocode	Atlas ICT
A-25	RHREE	1963	Traffic Control Pol.	Mac., Det., TS, Sim.	Unknown	Unknown
A-26	NBS	1961	Traffic Flow	Mac., Sim.	Assembly	IBM 704

Figure 3. Arterial model: PASSER II.

MODEL: PASSER II

DEVELOPED BY: C.J.MESSER, et al
Texas Transportation Institute

MAINTAINED BY: Texas Department of Highways and Public Transportation

PURPOSE: Maximization of Bandwidth along signalized arterial

MODELING APPROACH: Macroscopic, deterministic, time scan, optimization.

DEGREE OF DOCUMENTATION:
Model Development - Unknown
Program Description - Yes
User Manual - Yes

GENERAL DESCRIPTION:

This model, Progression Analysis and Signal System Evaluation Routine, was developed to analyze individual signalized intersection operations or to determine optimum progression along an arterial street considering varied multi-phase sequences. The model developer's have combined Brook's interference algorithm with Little's optimized unequal bandwidth equations and expanded them to include multi-phase signal operation. Basic inputs include turning movements, saturation capacity flow rates and minimum green times for each movment that must be provided for at each intersection. For progression analysis distance between intersections, average link speed, queue clearance intervals and permissable phasing sequences are provided. Standard outputs include an echo copy, progression values (optimum cycle length, and bandwidth in seconds) and average speed in both directions as well as two measures of effectiveness, bandwidth efficiency and percent of minimum arterial green time included in the band. Also included is signal timing information on phase sequence, offset and v/c ratios. As an option a printer or digital plotted time space diagram can be provided.

NUMBER: A-4

YEAR: Original: 1974
Revised: 1978

PROGRAM LANGUAGE: FORTRAN IV

PROGRAM STRUCTURE: Single Routine, 1600 Statements

MACHINE: IBM 360/370

CORE REQUIREMENTS: Unknown

EFFICIENCY: High

DEGREE OF VALIDATION: Computational and Field Verification

REFERENCES:

*(1) Messer, C.J., et al, "A Variable-Sequence Multiphase Progression Optimization Program," TRB, Highway Research Record 445, 1973, pp. 24-33.

*(2) Messer, C.J., Haenel, H.E. and Koeppo, E.A., "A Report on the User's Manual for Progressive Analysis and Signal System Evaluation Routine - PASSER II," Texas Trans. Institute, Research Report 165-14, August, 1974 (NTIS-PB-241-582)

*(3) Messer, C.J. and Fambro, D.C., "A Guide for Designing and Operating Signalized Intersections in Texas," Texas Transportation Institute Research Report 203-1, August, 1974.

tween intersections, average link speeds, queue clearance intervals, and permissible phasing sequences. Outputs include an echo of input, progression values, signal timing, and information on phase sequence, offset, and V/C ratios. A printer plot of a time spacing diagram is optional. PASSER II-80 has just been released by Texas and will be included in the handbook if time permits. PASSER-80 is an example of graceful model improvement. It uses input formats almost identical to PASSER II but has improved processing algorithms and measures of effectiveness. PASSER II is written in FORTRAN IV and was developed on IBM computers.

PASSER III (see Figure 4) provides optimal offset relationships for diamond interchanges. The objective is to minimize total delay for the interchange for a given cycle length and phasing pattern. Four phasing patterns are permitted, including all combinations of leading and lagging greens plus the four-phase, two-overlap sequence. Inputs to the model include an interchange description, phasing pattern, cycle length, overlaps, movement volumes, and capacities. A progressive mode is available that determines the optimal cycle length and progressive phasing for progression along frontage roads for a series of diamond interchanges. Time space diagrams are available as an output for this use of the model. PASSER III was written in FORTRAN 66 and requires approximately 168k-bytes of memory. The Texas transportation department has extensively field tested the model.

The SUB model is a special-purpose program for simulating bus operations on arterials. It provides a number of performance measures. Vehicular traffic is treated macroscopically, while buses are treated microscopically. Twenty arterial blocks may be modeled with either protected or unprotected bus stops. The detailed logic for bus stop operation requires input of bus descriptions, discharge headways, passenger service time, traffic volumes, bus routes, link, and signal data. Outputs include arrival and departure time for each bus, passenger statistics, and travel speeds. SUB was written in 1973 in FORTRAN 66 and requires approximately 90k of memory. Many of SUB's capabilities will be placed into the TRAF model currently under development by FHWA.

In addition to the arterial models selected for inclusion in the handbook, there is another model of interest. It is the MRI Mountainous Terrain Model (see Figure 5). It provides for simulation of directional flow on a four-lane, divided roadway up to 131 000 ft in length with intermittent hill-climbing lanes. Speed and acceleration characteristics are controlled by grade and horizontal curvature. Driver-vehicle characteristics and maximum speed on downgrades can be specified. The model has been extensively validated and appears to be realistic. The MRI Mountainous Terrain Model is written primarily in FORTRAN 66 but does have some CDC assembly code. It requires only 32k of memory.

Network Models

In most urban areas, there are one or more central business districts (CBDs) that have extremely dense road networks. These areas have been undergoing a resurgence of construction and development as rising fuel costs have reestablished their value. During the next decade, this growth may be expected to tax the transportation system. The modernization of the infrastructure of the CBD area has not extended to the physical street systems. In some areas it has been accompanied by the establishment of computerized UTCS systems. In most areas, however, traffic slows to around 20 mph when it enters the downtown area.

Efforts to improve traffic flow, such as signal interconnection, parking prohibition, one-way streets, reversible lane operations, and other changes, frequently meet with opposition from local businesses. Improvements also meet opposition from residents on the fringes of the central areas who want to restrict the flow of traffic.

Developments in computer technology provide the traffic engineer with a rather inexpensive method of developing and evaluating different techniques of improving traffic flow and persuading council, business, and residents of the potential benefits. Table 3 summarizes the models that were considered for possible inclusion in the handbook.

NETSIM and TRANSYT are the two most widely used network models, each in its own category. TRANSYT has several variations. TRANSYT-6 served as the basis for the TRANSYT-6N and TRANSYT-6C models (see Figure 6). The TRANSYT-7 model reduced input requirements from TRANSYT-6 and speeded up the optimization. An anglicized version of TRANSYT, called TRANSYT-7F, has a preprocessor to provide simplified input and a postprocessor to provide a time-space diagram and improved output. The TRANSYT traffic model also provided the basis for much of the SIGOP III traffic model. SIGOP III provides a form of in-

Figure 4. Arterial model: PASSER III.

MODEL: PASSER III

NUMBER: A-3

DEVELOPED BY: C.J. Messer and D.B. Fambro, Texas Transportation Institute

YEAR: Original: 1974; Revised: 1976

MAINTAINED BY: Texas Department of Highways and Public Transportation

PROGRAM LANGUAGE: ANSI FORTRAN

PROGRAM STRUCTURE: Modular

PURPOSE: Optimizes signalization of diamond interchanges both isolated or along frontage road systems.

MODELING APPROACH: Macroscopic, deterministic, time-scan, optimization.

CORE REQUIREMENTS: 168 K

EFFICIENCY: High

DEGREE OF DOCUMENTATION:
- Model Development - No
- Program Description - Yes
- User Manual - Yes

DEGREE OF VALIDATION: Extensive field testing in Texas

GENERAL DESCRIPTION:

PASSER III is a design tool which enables engineers to determine the optimal offset between the two signals of a diamond interchange which minimizes total interchange delay for a given cycle length and phasing pattern. Four phasing patterns are permitted including all combinations of "leading" and "lagging" greens, plus the so-called "4-phase with overlap" pattern. Inputs to this isolated mode include interchange descriptions, desired phasing pattern(s), cycle length, overlap, queue capacities, movement volumes, and capacities (expressed as equivalent number of lanes and minimum greens). The progressive mode determines the optimal cycle length and priority phasing for progression on a system of interconnected interchanges with continuous frontage roads. The above data (or constants for patterns) plus progression speeds are input (cycle length may vary over a range). Outputs are optimal designs, measures of effectiveness and time-space diagrams.

REFERENCES:

*(1) Fambro, D.B., et.al., "A Report on the User's Manual for Diamond Interchange Signalization - PASSER III," Texas Transportation Institute Research Report No. 178-1, August, 1976.

*(2) Messer, D.J., D.B. Fambro and J.M. Turner, "Analysis of Diamond Interchange Operation and Development of a Frontage Road Level of Service Evaluation Program - PASSER III - Final Report," Texas Transportation Institute Research Report No. 178-2F, August, 1976.

Figure 5. Arterial model: MRI Mountainous Terrain.

MODEL: MRI Mountainous Terrain

NUMBER: A-10

DEVELOPED BY: Midwest Research Institute

YEAR: Original: 1970; Revised: Unknown

PROGRAM LANGUAGE: FORTRAN IV/ASSEMBLY

MAINTAINED BY: Unknown

PROGRAM STRUCTURE: Modular

PURPOSE: Evaluation of traffic characteristics of roadways in mountainous areas.

MACHINE: CDC 6400

MODELING APPROACH: Microscopic, stochastic, simulation.

CORE REQUIREMENTS: 32K

DEGREE OF DOCUMENTATION:
- Model Development - Yes
- Program Description - Yes
- User Manual - Yes

EFFICIENCY: 20:1 to 10:1

DEGREE OF VALIDATION: Field Verification

GENERAL DESCRIPTION:

The geometric configuration of this model allows simulation of directional flow on a four-lane, divided roadway up to 131,000 feet long with intermittent hill-climbing lanes. The simulation dynamics are parallel to those in the MRI Freeway model, except that desired speeds and acceleration characteristics are controlled by grades and horizontal curvature. Different driver/vehicle characteristics are also defined and maximum speeds for downgrades can be specified. Extensive validation has been performed and realistic results have been reported.

REFERENCES:

*(1) A.D. St. John, D.R. Kobett, Sommerville, and W.D. Colanz, "Traffic Simulation for the Design of Uniform Service Roads in Mountanous Terrain", 4 Volumes, Final Report, Midwest Research Institute, Contract No. CPR-11-6093 for FHWA, 1970.

Table 3. Summary of arterial network models.

Number	Name	Date	Application	Modeling Approach	Program Language	Computer
N-1	SIGOP II	1979	Opt. Signal Timing	Mac., Det., TS, Opt.	Fortran	CDC 660 IBM 360/370
N-2	TRANSYT7	1978	Opt. Signal Timing	Mac., Det., TS, Opt.	Fortran IV	ICL 4-70 IBM 360/370
N-3	NETSIM	1977	Evalute Signal Control Systems	Mic., Stoc, TS, Sim.	Fortran IV	IBM 360/370 CDC 6600
N-4	TRANSYT6C	1977	Opt. Signal Timing	Mac., Det., TS, Opt.	Fortran	CDC 6600 IBM 360/370
N-5	TRASOM	1976	Opt. Signal Timing	Mac., Det., TS, Opt.	Fortran IV	Unknown
N-6	MITROP	1974	Opt. Signal Timing	Mac., Det., TS, Opt.	MPSX/MIP	IBM 370/165
N-7	SIGOP I	1974	Opt. Signal Timing	Mac., Det., TS, Opt.	Fortran IV	IBM 370/165
N-8	ROONEY	1974	Eva. Vehicle Perform.	Mic., Sim.	Unknown	Unknown
N-9	ERIKSEN	1973	Eva. Bus Movement	Mic., Stoc., ES, Sim.	Unknown	Unknown
N-10	SIGNET	1972	Eva. Signal Timing	Mic., Stoc., TS, Opt.	Fortran IV	CDC 6500
N-11	UTS-1	1971	Evaluate Traffic Flow	Mis., Stoc., TS, Sim.	Unknown	Unknown
N-12	BIRMING-HAM	1970	Evaluate Signal Timing	Mic., Det., TS, Sim.	Egtran 3	Atlas ICL
N-13	DYNET	1969	Evaluate Traffic Flow	Mic., Stoc., TS, Sim.	Fortran	Unknown
N-14	SAKAI/ NAGAO	1969	Evaluate Traffic Flow	Mac. Stoc., TS, Sim.	Unknown	Unknown
N-15	SCHALK-WIJK	1968	Evaluate Traffic Flow	Mac., Sim.	SimScript	CDC
N-16	BRITISH COMBIN.	1967	Opt. Signal Timing	Mac., Det., TS, Opt.	Fortran IV	IBM 360/50
N-17	MIT	1966	Eval. Signal Timing	Mac., Sim.	Unknown	Unknown
N-18	VETRAS	1966	Evaluate Traffic Flow	Mic., Stoc., TS, Sim.	GPSS	IBM 360
N-19	TRRL	1965	Eval. Signal Timing	Mac., Stoc., TS, Sim.	Unknown	Ferranti Pegasus
N-20	UTS	1964	Evaluate Traffic Flow	Mic., Stoc., TS, Sim.	GPSS/FAP	IBM 7090
N-21	SIGRID	1964	Opt. Signal Timing	Mac., Det., TS, Opt.	Fortran	Unknown
N-22	TRANS	1963	Evaluate Signal Timing	Mac., Stoc., TS, Sim.	SAP/FAP	IBM 709
N-23	LONGLEY	1954	Evaluate Traffic Flow	Mic., Det., TS, Sim.	Fortran	Elliott 4100
N-24	TRAUTMAN	UNK	Evaluate Traffic Flow	Mac., Stoc., TS, Sim.	Unknown	SWAC

Figure 6. Arterial network model: TRANSYT 6C.

MODEL: TRANSYT 6C

DEVELOPED BY: P.P. Jovanis, and A.D. May, et.al. (6C) University of California, Berkeley

MAINTAINED BY: University of California Berkeley

PURPOSE: Extends TRANSYT6 to include environmental and mode shift impacts.

MODELING APPROACH: Macroscopic, deterministic, time-scan, optimization

DEGREE OF DOCUMENTATION:

- Model Development - Yes
- Program Description - Yes
- User Manual - Yes

GENERAL DESCRIPTION:

This version extends TRANSYT 6 to add environmental impacts and demand responses. The network traffic flow is simulated to estimate fuel consumption and exhaust emissions for each link. Outputs of this simulation give the fuel and emissions data plus traffic performance measures. Plots of these may be obtained. The demand responses predict the effects of special and model shifts. In addition to the previous outputs, this submodel outputs the various demand shifts. All normal TRANSYT 6 inputs are required (as applicable). This version also requires data on the roadway and traffic composition (for fuel consumption) and parameters for the demand response.

NUMBER: N-4

YEAR: Original: 1967; Revised: 1977

PROGRAM LANGUAGE: ANSI FORTRAN

PROGRAM STRUCTURE: Structured

MACHINE: CDC, IBM

CORE REQUIREMENTS: 320 K (IBM)

EFFICIENCY: Low

DEGREE OF VALIDATION: Field tested in California

REFERENCES:

(1) Jovanis, P.P., A.D. May and W. Yip, "Further Analysis and Evaluation of Selected Impacts of Traffic Management Strategies on Surface Streets," ITS, University of California, Berkeley, October, 1977.

(2) Jovanis, P.P. and A.D. May, "TRANSYT 6C Model Workshop, Student Workbook," ITS, University of California, Berkeley, (undated).

put that is very similar to the type of traffic data traffic engineers typically collect whereas data required for TRANSYT are somewhat different. SIGOP III provides for a comprehensive evaluation, including cycle lengths, with measures of effectiveness for both individual links (one direction of each block) and the network as a whole. Neither SIGOP III nor TRANSYT-7F are available to the public; both are undergoing comprehensive field trials and final development. Both models represent the latest state of the art and should provide the traffic engineer with useful tools.

NETSIM (see Figure 7) is the most widely used network simulation model. It is a microscopic, stochastic model based on the UTCS-1 model that in turn was based on the DYNET model and the TRANS model. It treats individual vehicles rather than platoons and is the main reason this conference is being held. Plans for improvements and refinements to this model as part of the TRAF family are described later in this paper as well as in other papers in this conference (see, for example, the paper by Lieberman in this proceedings).

NETSIM, TRANSYT, and SIGOP III are all written in standard FORTRAN 66. Due to their wide use, they are perhaps the most portable of the models for traffic operations analysis. The data required for input are similar. The SIGOP III input data set is a proper subset of the NETSIM data set although it is formatted slightly differently. On one occasion, we were able to code an arterial network in NETSIM directly from the SIGOP III input data. These three

Figure 7. Arterial network model: NETSIM.

MODEL: NETSIM

DEVELOPED BY: E.B Lieberman & W. Rosenfield, KLD Associates, Inc., and J.J Bruggeman and R.D. Worral, Peat, Marwick, Mitchell & Co.

MAINTAINED BY: FHWA

PURPOSE: Evaluation of alternative urban arterial network control strategies, with particular emphasis on sophisticated signal control systems.

MODELING APPROACH: Microscopic, stochastic, time scan, simulation.

DEGREE OF DOCUMENTATION:

Model Development -	Yes
Program Description -	Yes
User Manual -	Yes

GENERAL DESCRIPTION:

The NETSIM model is a microscopic, stochastic network simulation model extensive of the UTCS-1 model which incorporated and expanded on the TRANS and DYNET models. It treats the street network as a series of interconnected links and nodes, along which vehicles are processed in a time-scan format subject to the imposition of traffic control systems. This refined model can treat most major forms of urban traffic controls and was primarily designed as a tool for testing alternative control strategies under conditions of heavy demand. It is particularly applicable to evaluation of dynamically controlled signal systems which use real-time traffic surveillance information. A wide variety of simpler problems can also be addressed. In addition to the normal data on vehicle performance (speed, delay, vehicle-miles, etc.) output data incudes estimates of fuel consumption and vehicle emissions.

NUMBER: N-3

YEAR: Original: 1971; Revised: 1977

PROGRAM LANGUAGE: FORTRAN IV

PROGRAM STRUCTURE: Modular, consisting of a (1) pre-processor, (2) simulator, (3) fuel consumption and emissions and (4) post-processor.

MACHINE: IBM 370, CDC 6600 and UNIVAC

CORE REQUIREMENTS: 256 K

EFFICIENCY: Approx. 1:2 (IBM 360/370) 1:5 (CDC 6600)

DEGREE OF VALIDATION: The model has been subjected to an extensive program of field testing and validation.

REFERENCES:

*(1) E. Lieberman and W. Rosenfield, "Network Flow Simulation for Urban Traffic Control System - Phae II", Extension of NETSIM Simulation Model (formerly UTCS-1) to Incorporated Vehicle Fuel Consumption and Emissions", Vols. 1-5, KLD Associates, Inc., 1977, 53 pages.

*(2) E. B. Lieberman and R.D. Worrall, "Network Flow Simulation for Urban Traffic Control System - Phase II, Vols. 1-5, Peat, Marwick, Mitchel and Co., and KLD Associates, Inc., 1973-74.

*(3) E.B. Lieberman et al., "Logical Design and Demonstration of UTCS-1 Network Simulation Model:, HRR 409, Transportation Research Board, Washington, D.C., 1972, pp. 45-56.

*(4) J.J Bruggeman, E.B. Lieberman and R.D. Worrall, "Network Flow Simulation for Urban Traffic Control System", Peat, Marwick, and Co., 1971.

models are also among the most extensively validated. TRANSYT and SIGOP are based on field studies of platoon dispersion by Denis Robertson in Great Britain. The NETSIM model was validated through film-recorded data of a traffic network in Washington, D.C., and to a lesser extent by traffic studies by various users.

FHWA is making available the computer models selected for inclusion in the handbook. The tape library will include the source listing for each model and the sample problems used in the handbook. These problems will be useful in testing compatibility with the user's computer.

Freeway Models

Strong emphasis has been placed on increasing the capacity, safety, and efficiency of the nation's freeways in recent years due to the unavailability of new construction funds. These limited-access highways were built generally during the last 25 years to serve existing and future traffic for years to come. However, due to the attractiveness of these facilities, design volumes were often exceeded within several years.

Today, the nation's freeways operate during portions of the day with stop-and-go traffic and low speeds, much as the arterials they were designed to relieve. This congestion is due to demand in excess of capacity and frequently to traffic accidents and incidents. Because most of the congested freeways are within the urbanized areas, the typical solutions of adding lanes are not feasible, due to right-of-way and construction costs. Land use and environmental impacts also restrict new construction. The more economical solutions to these problems have concentrated on providing higher vehicle occupancy, controlling the rate of access to the freeway, relieving bottlenecks caused by weaving and inadequate merging lanes, and detection of incidents to permit improved response through traffic control measures.

In the last decade, a considerable number of computer models have been developed to aid the transportation engineer and planner in evaluating alternative traffic control strategies for these facilities. Table 4 summarizes the freeway models reviewed for the handbook.

The most common method of encouraging higher vehicle occupancy has been through the designation of a priority lane reserved exclusively for high-occupancy vehicles. The earliest reliable model, which has been used extensively in the past to evaluate the effectiveness of this technique, is the PRIFRE model. PRIFRE is an acronym for FREeway PRIority lane model (see Figure 8). PRIFRE can be used to evaluate existing conditions without priority-lane treatments and various types of priority treatments.

Another method of improving the level of service of freeways is the use of ramp metering to either control the flow of entering vehicles or provide priority treatment for high-occupancy vehicles. The FREQ3CP model (see Figure 9) has been used extensively to evaluate alternative priority entry control strategies for freeways. This model can be used to determine the entry control strategy such as metering rates and priority cut-off levels that maximize the objective function (passenger or miles of travel).

Both of these models are included in the FHWA Transportation Planning Back Pack library. They have proved to be a valuable tool in evaluating freeway operations. They were developed by Adolph D. May and his associates at the Institute of Transportation Studies (ITS) at Berkeley. In recent years May and his associates have extended FREQ3CP to include fuel consumption, vehicle emissions, and demand-response impacts (see Figure 10). They have integrated the extended model with PRIFRE to provide a more comprehensive model, FREQ6PL (see Figure 11). However, these models are still being modified to reflect operational characteristics of the motor vehicle fleet (e.g., more strictly regulated fuel and emissions control) and other enhancements that promote a more comprehensive approach to freeway operations such as the effect of ramp control on parallel arterial streets. The handbook includes the more widely used versions, PRIFRE and FREQ3CP.

Corridor Models

During the last decade, transportation engineers

Table 4. Summary of freeway models.

Number	Name	Date	Application	Modeling Approach	Program Language	Computer
F-1	FREQ6PL	1976	Evaluate HOV Lanes	Mac., Det., TS, Opt.	ANSI Fortran	CDC/IBM
F-2	FREQ4CP	1976	Develop Optimal Ramp Metering	Mac., Det., TS, Opt.	ANSI Fortran	CDC/IBM
F-3	FREQ3CP	1975	Develop Optimal Rampa Metering	Mac., Det., TS, Opt.	Fortran IV	IBM 360 CDC 6900
F-4	TRAFFIC	1975	Evaluate Incident Detection Strategies	Mic., Stoc., TS, Sim.	Fortran IV	CDC 6400
F-5	MACK	1974	Evalate Traffic Flow	Mac., Det., TS, Sim.	Fortran	CDC 6400
F-6	PRIFRE	1973	Evaluate HOV Lanes	Mac., Det., TS, Sim.	Fortran IV	CDC 6400 IBM 360
F-7	RAMPCON	1973	Develop Opt. Metering Rates	Mac., Det., TS, Sim.	Fortran	Unknown
F-8	SDC	1972	Evaluate Traffic Flow	Mic., Stoc., TS, Sim.	Fortran IV	IBM 360/67 UNIVAC 1108
F-9	GEORGIA	1971	Eva. Affects of Trucks	Mic., Stoc., TS, Sim.	Fortran IV /Assembly	IBM 360/30 & 50
F-10	CONNECTI-CUT	1970	Evalaute Traffic Flow	Mic., Stoc., TS, Sim.	Fortran IV	UNIVAC 1106
F-11	MIKHALKIN	1970	Eva. Sensor Locations	Mic., Stoc., TS, Sim.	Fortran IV	IBM 360
F-12	SINHA	1969	Evaluate Traffic Flow	Mic., Stoc., TS, Sim.	Fortran IV /Assembly	IBM 360/65
F-13	NORTH-WESTERN	1969	Evaluate Lane Changing	Mic., Stoc., TS, Sim.	Fortran IV /SPURT	CDC 6400
F-14	TTI - MERGING	1969	Evaluate Ramp Controls	Mic., Stoc., TS, Sim.	Fortran IV	IBM 7094
F-15	MRI	1968	Evaluate Traffic Flow	Mic., Stoc., TS, Sim.	Fortran IV /Assembly	IBM 360/50
F-16	MIESSE	1966	Evaluate Ramp Closures	Mic., Stoc., TS, Sim.	Unknown	Unknown
F-17	ARIZONA	1964	Evalaute Ramp Design	Mic., Stoc., TS, Sim.	Fortran & Autocoder	IBM 7072 or 1401
F-18	GERLOUGH	1965	Evaluate Traffic Flow	Mic., Stoc., TS, Sim.	Unknown	SWAC

Figure 8. Freeway model: PRIFRE.

MODEL: PRIFRE

DEVELOPED BY: R.D. Minister, P.E. Lew, K. Ovaici, and A.D. May
ITTE, University of California, Berkely

MAINTAINED BY: FHWA

PURPOSE: Evaluation of HOV lanes on freeway.

MODELING APPROACH: Macroscopic, deterministic, time scan, simulation.

DEGREE OF DOCUMENTATION:
Model Development - Yes
Program Description - Yes
User Manual - Yes

GENERAL DESCRIPTION:

The PRIFRE model was developed to simulate the operation of a directional freeway section with a concurrent-flow priority lane for high-occupancy vehicles. Its structure and modeling approach is based on two earlier models, FREEQ and EXBUS. The simulation approach employed is macroscopic and deterministic, in which vehicular flow is modeled as a compressible fluid and queueing is idealized. In operation, PRIFRE calculates the total travel time expended under normal freeway operations and total travel time expended under any number of different priority operation strategies, and compares the two. Any travel time difference (savings or losses) is noted in the final output. Similarly, PRIFRE also calculates total vehicle miles accumulated under normal and priority operations, and compares the two. A variety of occupancy shifts, number of priority lanes, model splits, and growth periods can be input to the program and results are calculated and compared. With manual interfacing, PRIFRE can also be used to evaluate wrong-way reversible lanes, separate bus roadways, freeway design improvement strategies, and ramp cotnrol schemes affording priority entry to high-occupancy vehicles.

NUMBER: F-6

YEAR: Original: 1973
Revised:

PROGRAM LANGUAGE: FORTRAN IV

PROGRAM STRUCTURE: Modular

MACHINE: CDC 6400 & IBM 360

CORE REQUIREMENTS: 80 K (Est.)

EFFICIENCY: Unknown

DEGREE OF VALIDATION: Computational & Field

REFERENCES:

*(1) R.D. Minister, L.P. Lew, K. Ovaici and A.D. May, "A Computer Simulation Model for Evaluating Priority Operations on Freeways", ITTE, University of California, Berkley, 1973, 315 pages.

*(2) R.D. Minister, L.P. Lew, K. Ovaici and A.D. May, "A Computer Simulation Model for Evaluating Priority Operationson Freeways", HR 461, Transportation Research Board, Washington, D.C., 19873, pp. 35-44.

Figure 9. Freeway model: FREQ3CP.

MODEL: FREQ3CP

DEVELOPED BY: K. Ovaici, A.D. May, R.F. Teal and J.K. Ray University of California

MAINTAINED BY: University of California

PURPOSE: Design and operational evaluation of freeway entry control systems, with or without HOV priority treatment.

MODELING APPROACH: Macroscopic, deterministic, time scan, optimization.

DEGREE OF DOCUMENTATION:

- Model Development - Yes
- Program Description - Yes
- User Manual - Yes

GENERAL DESCRIPTION:

The FREQ3CP model was developed to evaluate alternative priority entry control strategies for freeways and to select the best strategy for a given system. The model consists of a simulation submodel, FREQ3, and an optimization submodel, PREFO. The simulation submodel is a macroscopic, deterministic model that predicts traffic performance as a function of freeway design and demand O-D patterns. The optimization submodel has a linear programming formulation designed to determine the entry control strategy (metering rates and priority cut-off level) that maximizes an objective function such as passenger input or miles of travel. The optimization process is constrained such that no freeway congestion will occur and the selected metering rates will be within reasonable limits.

NUMBER: F-3

YEAR: Original: 1975

PROGRAM LANGUAGE: FORTRAN IV

PROGRAM STRUCTURE: Modular

MACHINE: CDC 6400 and IBM 360

CORE REQUIREMENTS: 150 K (Est.)

EFFICIENCY: Unknown

DEGREE OF VALIDATION: Limited

REFERENCES:

*(1) K. Ovaici, A.D. May, R.F. Teal and J.K. Ray, "Simulation of Freeway Priority Strategies (FREQ3CP)", ITTE, University of California, Berkeley, Contract DOT-GH-11-8083 for FHWA, 1975, 471 pages.

*(2) K. Ovaici, A.D. May, R.F. Teal and J.K. Ray, "Developing Freeway Priority Entry Control Strategies", TRR 533, Transportation Research Board, Washington, D.C., 1975, pp. 122-137.

Figure 10. Freeway model: FREQ4CP.

MODEL: FREQ4CP

DEVELOPED BY: A.S.Kruger, A.D. May & others Univiversity of California Berkley

MAINTAINED BY: University of California Berkley

PURPOSE: Develop optimal ramp metering strategy for a freeway.

MODELING APPROACH: Macroscopic, deterministic, time-scan, optimization

DEGREE OF DOCUMENTATION:

- Model Development - Yes
- Program Description - Yes
- User Manual - Yes

GENERAL DESCRIPTION:

This version in the FREQ-series extends FREQ-3CP to include fuel consumption, vehicle emissions and demand response impacts. During the simulation the model estimates the amount of fuel consumed in the study area and the amounts of effluents of HC, CO and NO_x. The demand response sub-model estimates the shift of vehicles in space due to metering and estimates the change in model choice based on travel time savings and an input elasticity after optimization. In addition to the FREQ3CP inputs, data on the geometrics and vehicle mix are reuqired. Extended output include measures of effectiveness and plots of the added functions.

NUMBER: F-2

YEAR: Original: 1972 Revised: 1976

PROGRAM LANGUAGE: ANSI FORTRAN

PROGRAM STRUCTURE: Structured

MACHINE: CDC, IBM

CORE REQUIREMENTS: 280 K

EFFICIENCY: Medium

DEGREE OF VALIDATION: Field tested at a number of locations

REFERENCES:

(1) Kruger, A.J. and A.D. May, "The Analysis and Evaluation of Selected Impacts of Traffic Management Strategies on Freeways," ITS, University of California, Berkaly, October, 1976.

*(2) Feldman, M., R. Cooper and A.D. May, "Development of Priority Strategies on Freeways (FREQ4CP) - Student Workbook," ITS, University of California, Berkely, March, 1977.

have realized that the problems on arterials, central urban grids, and freeways interweave. As a result, they have begun to look to solutions that considered the entire system of arterials, freeways, and feeder streets comprising transportation corridors. These efforts have focused not only on increasing freeway capacities and vehicle occupancies but also on fuller use of the existing capacity available on parallel facilities, as well as efforts to minimize the travel time and delay for the system as a whole. Efforts toward accomplishing this purpose have included the same elements of treatment that were covered in the arterial, grid, and freeway model analysis: preferential treatment for high-occupancy vehicles, priority entry, and improved signal timing. In addition, such elements as traffic diversion to parallel facilities and systemwide surveillance have been studied.

Most of the computer models available for developing and evaluating transportation corridor strategies are recent and are still in the process of development, testing, and refinement. Table 5 summarizes those corridor models identified and reviewed for the handbook project.

While not a single model, the TRAF family of simulation models will be capable of transportation corridor analysis when completed. In addition, two models of the TRAF family, FREFLO (freeway flow) and

Figure 11. Freeway model: FREQ6CP.

MODEL: FREQ6PL

DEVELOPED BY: T. CilIirs, A.D. May, et. al. University of California Berkeley

MAINTAINED BY: University of California Berkeley

PURPOSE: Evaluate priority lanes on freeways.

MODELING APPROACH: Macroscopic, deterministic, time-scan, optimization.

DEGREE OF DOCUMENTATION:
- Model Development - Yes
- Program Description - Yes
- User Manual - Yes

GENERAL DESCRIPTION:

This model combines the functions of PRIFRE and FREQ5CP. It is used to evaluate priority lanes for buses and car pools on a directional freeway with or without entry ramp control. The model estimates traffic impacts, fuel consumption, exhaust emissions and facility costs. Special and model shifts are included similar to FREQ6PE.

NUMBER: F-1

YEAR: Original: 1972; Revised: 1978

PROGRAM LANGUAGE: ANSI FORTRAN

PROGRAM STRUCTURE: Structured

MACHINE: CDC, IBM

CORE REQUIREMENTS: 165 K

EFFICIENCY: Low

DEGREE OF VALIDATION: Field tested in California

REFERENCES:

(1) Cilliers, T., A.D. May and R. Cooper, "FREQ6PL - A Freeway Priority Lane Simulation Model," California Department of Transportation, Final Report and Volume II, September, 1978.

Table 5. Summary of transportation corridor models.

Number	Name	Date	Application	Modeling Approach	Program Language	Computer
T-1	FREQ6PE	1978	Develop Optimal Metering Strategy and Corridor Analysis	Mac., Det., TS, Opt.	ANSI Fortran	CDC/IBM
T-2	INTRAS	1977	Eva. Freeway Incidents On Corridor Operations	Mic., Stoc., TS, Sim.	Fortran IV	IBM 370 CDC 7600
T-3	CORQIC	1975	Develop Optimal Controls for Corridor Operations	Mac., Det., TS, Opt.	Fortran IV	CDC 6400
T-4	CORQ	1974	Eva. Traffic Control Strategies within Corridor	Mic., Det., TS, Sim.	Fortran IV	Unknown
T-5	VPT	1974	Evaluation of Traffic Flow in Freeway Network	Mic., Stoc., TS, Sim.	Fortran IV /COMPASS	CDC 7600
T-6	LIEW	1974	Evaluate Optimal Ramp Control Strategies	Mac., Stoc., TS, Sim.	Unknown	Unknown
T-7	STAR	1974	Evaluate Surveillance and Control Strategies for Route Diversions	Mac., Det., TS, Sim.	Unknown	Unknown
T-8	SCCT	1975	Evaluate Traffic Control Strategies within Corridor	Mic., Stoc., TS, Sim.	Fortran IV	CDC 660 IBM 370 UNIVAC
T-9	FRICP	1972	Develop Optimal Interchange Configuration	Mac., Det., TS, Opt.	Fortran IV /Assembly	IBM 360
T-10	DAFT	1970	Evaluate Traffic Control Strategies within Corridor	Mac., Stoc., TS, Sim.	Unknown	Unknown
T-11	SDC	1966	Evaluation of Alternative Diamond Interchange Configurations	Mac., Stoc., TS, Sim.	Unknown	Unknown
T-12	TRANSIM	1966	Evaluation of Traffic Performance in System	Mic./Mac., Stoc./Det. TS, Sim.	Fortran IV	IBM 7090, 7094, 1401

NETFLO (street NETwork FLOw) have been developed as the TRAFLO (TRAffic FLOw) model, which macroscopically simulates large transportation areas. Testing of this model is under way.

A number of corridor models were developed at the University of California at Berkeley. Models such as PRIFRE, FREQ, CORQUIC, and TRANSYT6C were specifically developed to examine transportation system management type improvements. (See the paper by May in this proceedings.)

Due to the relatively new status of the transportation corridor models and the limited space available in the handbook, it was decided not to include corridor models. Instead, potential users are referred to the University of California or to FHWA's Office of Research and Development.

WHAT FHWA IS MAKING AVAILABLE

FHWA is sponsoring and making available a variety of models. The Arterial Analysis Package (AAP) family of models includes SOAP, PASSER II, PASSER III, and TRANSYT. The AAP is currently under development for the Traffic Systems Division of the Office of Research and Development and will be made available when successfully completed.

The TRAF family of models is still under development. However, the NETSIM program is available from FHWA. TRAFLO is available for testing and experimental use, but only under tightly restricted conditions, and is not yet operational.

The TRANSYT-7F and SIGOP III programs are undergoing extended pilot-city testing and will not be made available until after completion of the testing. They are included in the handbook with the expectation that they will be available for use by the time the handbook is printed and distributed.

The FREQ family of models is technically in the public domain. However, the University of California charges a nominal fee for copying, which includes limited consultation on setup and use of the models. Since FHWA does not have the staff or expertise to do this for cities and states, it is recommended that copies be obtained from the University of California.

PROBLEM TO BE ADDRESSED

Considering all these seemingly wonderful traffic simulation and optimization models and the long lists of users that FHWA, ITS, and the British Transportation and Road Research Laboratory can point to, the question is, Why aren't computer models being used more widely in traffic engineering practice? This was the basic problem considered by FHWA as it was planning its implementation support efforts.

The objectives of this implementation effort were quite simple: to improve safety, reduce delay and fuel consumption, reduce air pollution, and generally make traffic flow better. However, to accomplish these goals, real-world changes in the behavior of traffic engineers were needed. To get traffic engineers to use traffic simulation and optimization models, they would have to be made both easy and less expensive to use. The models would also have to be reliable and valid. Of course, the results produced by the models would have to be useful to the engineer in achieving traffic improvements.

The approach taken to establish the credibility of the models and their validity was through demonstration and testing. Making the models easier to use was the goal of the training course and the implementation support effort. Information dissemination was planned to get the results of these efforts to engineers in order to convince them to use the models. These efforts were quite successful. As a result, many engineers are now using the NETSIM model but many problems and limitations were identified. FHWA research and development now has several short-term activities planned to make NETSIM easier and cheaper to use and several long-term concepts under discussion to address the input/output problem.

DEMONSTRATION AND TESTING

FHWA contracted with the states of Utah and California to conduct real-world uses of the UTCS-1 model (the predecessor to NETSIM). These field uses identified limitations in the model that require several minor changes and one major change. The use of annotated coding forms was invented to overcome limitations in input of data. Several of the most successful applications of the model involved identifying do-nothing alternatives as the most reasonable alternatives. These efforts proved that the concept of applying traffic models to real-world traffic engineering problems could prove quite fruitful. A variety of desired enhancements was identified by Utah, California, and Michigan engineers that are part of the current FHWA recoding of NETSIM.

IMPLEMENTATION SUPPORT

A major problem found in the demonstration and testing and subsequent distribution of UTCS-1 and NETSIM codes to various users was the need for assistance to users in setup and use of the model. As a result, severe demands are made on the time of several engineers who are supposed to be conducting research activities. The FHWA Office of Traffic Operations, which is normally responsible for such activities, will not be able to conduct them until its TRANSYT-7F project is completed. Therefore, a contract effort for what might be typified as debugging, problem-solving, and program maintenance has been conceived. This effort will last from one to three years and will assist users in bringing up NETSIM on their computers, understanding its data requirements, and answering the inevitable questions that arise.

SHORT-TERM PLANS

For the next year, FHWA will be concentrating on providing basic user support through the support contract. We will also be arranging for the state of Michigan to make its forms display input program available for wider use by converting it to FORTRAN 77 and transporting it to one or more new types of computers. IBM, CDC, and UNIVAC computers are the primary candidates. Next year a test and demonstration effort of the TRAFLO program will begin. This program consists of a macroscopic version of NETSIM and a macroscopic freeway model. Before this effort begins, it is hoped that Michigan will be able to test the prototype version of the program.

FUTURE PLANS AND CONCEPTS

For the long term, FHWA plans to get involved in graphics. There is now some movement toward standards in the graphics area. The Association for Computing Machinery and the IEEE have supported a core-graphics standard and the U.S. Army Corps of Engineers has created a public-domain portable graphics software package.

Interactive input in a truly intelligent sense will require the creation of a very sophisticated input processor. FHWA hopes that the experienced gained with the Michigan forms display processor and the RPI graphics input system will provide the foundation for any easy-to-use input system. Such a system will allow the integration of simulation and optimization models.

This integration will also provide an excellent training tool. It could revolutionize the process of educating traffic engineers by providing hands-on experience. How this should be done may be the topic of some future conference.

ACKNOWLEDGMENT

Alexander Byrne of Diaz, Seckinger, and Associates compiled the tables and figures used in this paper as part of a project to develop a Handbook of Computer Models for Traffic Operations Analysis. Paul Ross of FHWA's Traffic Systems Division participated in the design of the handbook study and assisted in the identification of many of the models reviewed in it. The WYLBUR editing system of the National Institutes of Health was used in the preparation of the text.