50-443/444-OL
11/5/87
A-15

REPRESENTATIVE RESULTS

The TRAFLO Level II model was validated on a network in downtown Washington, D.C., that consisted of 96 links and 51 nodes and represented a wide range of geometrics. Validation runs were made for morning peak and off-peak periods, and a wide range of turn movements and traffic volumes was reflected. Each run was executed for 32 min as a sequence of eight 4-min time periods. Sperry Systems Management validated the model, reporting results on a link-by-link basis for each of the eight time periods (1). The field measurement of networkwide average speed over the 32-min morning peak period was 9.71 miles/h compared with a model estimate of 10.29 miles/h. For the off-peak period, the model estimated an 8.79-mile/h average speed, which compared very favorably with an observed speed of 8.73 miles/h.

PROGRAM EFFICIENCY

The Level II model was executed on a CDC 7600 computer at the Brookhaven National Laboratory in Upton, New York. Computer time for the model depends strongly on the size of the network. Runs of the validation network of 96 links indicate a ratio of simulated time to computer time of approximately 160:1 and a cost of less than $8 for a 32-min simulation and "fill" time of 6 min. The computer memory requirement is reasonable. For IBM computers, less than 250 K bytes are required; on CDC machines, less than 40 K words are needed.

ACKNOWLEDGMENT

The development of a model such as that described in this paper represents the contributions of many people. In particular, we want to acknowledge the contributions of Guido Radelat and George Tiller of the Traffic Systems Division of the Federal Highway Administration, Barbara Andrews and Manfredo Davila of KLD Associates, Inc., William McShane of the Polytechnic Institute of New York, and Fred Wagner of Wagner/McGee Associates. This work was performed under a contract with the U.S. Department of Transportation.

REFERENCES

1. E.B. Lieberman and others. Macroscopic Simulation for Urban Traffic Management: The TRAFLO Model. Federal Highway Administration, U.S. Department of Transportation, Vols. 1-7, 1980.
2. D.I. Robertson. 'TRANSYT': A Traffic Network Study Tool. Transport and Road Research Laboratory, Crowthorne, Berkshire, England, Rept. LR 253, 1969.

Publication of this paper sponsored by Committee on Traffic Flow Theory and Characteristics.

DOCKETED
USNRC
'88 FEB -2 A9:27
OFFICE OF SECRETARY
DOCKETING & SERVICE
BRANCH

TRAFLO: A New Tool to Evaluate Transportation System Management Strategies

E. B. LIEBERMAN AND B. J. ANDREWS

The TRAFLO model, which combines the attributes of traffic simulation with traffic assignment, is described. TRAFLO was developed as a tool for use in transportation planning and traffic engineering to test transportation management strategies. It is a software system, programmed in FORTRAN that consists of five component models that interface with one another to form an integrated system. Four of the models simulate traffic operations, and the fifth is an equilibrium traffic assignment model. The operating characteristics of the component simulation models are described. These models are capable of simulating traffic on one or more of the following networks: freeways, corridors that include the freeway/ramp/service road complex, urban and suburban arterials, and grid networks representing the central business districts of urban centers. Also described is the traffic assignment component, which can be used in conjunction with the simulation components to determine the response of a traffic system to a transportation management strategy.

In recent years, events have shifted attention to the need for providing safe, efficient, and economical movement of people and goods on existing highway facilities. Furthermore, there is a growing awareness that factors such as air and noise pollution and the conservation of energy must be weighted heavily in any decision process involving the nation's transportation system.

These considerations have led to the emergence of transportation management as the basis for improving the mobility of people and goods. The application of the transportation management process requires the ability to quantitatively assess alternative transportation management strategies to identify those that best satisfy the stated objectives.

The scope of the process involves both the transportation planning and traffic engineering disciplines. The involvement of these two disciplines reflects the intrinsic dependence of behavioral responses (trip generation, distribution, and assignment and modal choice) on the performance of the transportation system as expressed in terms of travel time, cost, and accessibility.

It is clear that the need to develop effective transportation management strategies implies a requirement to develop analytic tools for that purpose. Furthermore, these tools must be sufficiently broad in scope to meet the objectives of the transportation management process for both disciplines identified above.

One tool that is particularly effective for evaluating transportation management strategies applied to a dynamic environment is traffic simulation. Simulation models provide the means for evaluating a wide spectrum of traffic management schemes within the framework of a controlled

Applic Exh 15

experiment. This simulation approach is far more appealing and practical than a strictly empirical approach, for the following reasons:

1. It is much less costly.
2. Results are obtained in a fraction of the time required for field experimentation.
3. The data generated by simulation include measures of effectiveness that cannot, in a practical sense, be obtained empirically.
4. Disruption of traffic operations, which often accompanies field experimentation, is completely avoided.
5. Many transportation management strategies involve significant physical changes that are not acceptable for experimental purposes.

Most projects undertaken by transportation planners address a time period that lies in the future and thus require estimates of transportation demand. Based on these estimates, trip tables that delineate traffic demands between origin and destination zones within a region are developed. It is then necessary to identify a transportation management strategy that will satisfy the mobility, environmental and economic objectives perceived for that future time period. To do this, a traffic assignment model must be applied to estimate the distribution of traffic demand over a regional network, consistent with the projected trip tables.

An assumption implied in every traffic assignment model is that the traffic environment is steady state. That is, it is assumed that the specified trip tables reflect constant traffic volumes on each network link and that any dynamic effects do not influence the assignment process. Furthermore, all estimates of flow impedances included in the assignment models are also based on the assumption of steady-state conditions, and it is assumed that dynamic interactions between traffic on adjoining network links may be disregarded. The efficacy of the results provided by a traffic assignment model depends on the degree of validity of these underlying assumptions and on the accuracy of the estimates of traffic impedance. Finally, the transportation planner has no means for verifying the estimates of travel time on each network link that are provided by the traffic assignment model.

Simulation models, on the other hand, are specifically designed to describe the dynamic effects of traffic flow. Factors that impede traffic are explicitly represented at a high degree of detail. Consequently, simulation tools can provide a detailed description of the dynamic performance of traffic over a network.

The availability of an analytic tool that combines the attributes of traffic simulation with those of traffic assignment will greatly expand the opportunity for the development of new and innovative transportation management concepts and designs. Transportation planners and engineers will no longer be restricted by the lack of a mechanism for fully testing these designs prior to field demonstration.

Such a tool is of value to both transportation planners and traffic engineers. It gives the planner the opportunity to examine the net result of a design based on transportation system management (TSM) principles. These results are expressed as measures of effectiveness (MOEs), which describe traffic operations on each network link. With this detailed information, the planner can reexamine the estimates of travel time and accessibility that were involved earlier in the transportation management process (e.g., when preparing the trip generation data).

This tool provides the traffic engineer with the information needed to explore candidate operational solutions to resolve bottleneck conditions, expedite mass transit operations, or satisfy other TSM objectives. He or she can apply the simulation model repeatedly as an integral part of an iterative design procedure.

Of course, any design improvement implemented by the traffic engineer can "feed back" and influence the results obtained from the planning process. It is this interdependence, noted earlier, that requires a strong interaction between the two disciplines. The TRAFLO model, which is designed to provide the capability described above, can act as a primary mechanism for encouraging this strong interaction and providing the information needed for designing effective transportation management strategies.

The TRAFLO model was conceived as the tool to fill this role by the Traffic Systems Division of the Federal Highway Administration (FHWA), in consultation with that agency's Planning Division and with personnel of the Urban Mass Transportation Administration (UMTA). This paper describes several innovative concepts and design features incorporated in the model, which has been implemented as a computer program.

GENERAL MODEL DESCRIPTION

TRAFLO is a valuable tool in the transportation management process. Its design includes features that permit the analyst to conduct a wide variety of studies on large roadway networks of general configuration. These networks may contain components such as freeways, corridors that include the freeway/ramp/service-road complex, urban and suburban arterials, and grid networks representing the central business district (CBD) of urban centers. The analyst has complete flexibility to configure the network according to his or her needs. The network may consist of any one or more of the components mentioned above.

Since the TRAFLO model is actually a system composed of well-defined component models, the analyst can also select those component models that are most responsive to his or her needs. This flexibility enables the user to apply TRAFLO in the most cost-effective manner.

The simulation models that constitute the TRAFLO program describe traffic flow macroscopically. Past experience with other models has demonstrated that it would be possible to retain sufficient accuracy for evaluating transportation management strategies if the less detailed macroscopic representation were used. It has also been concluded that TRAFLO should provide a hierarchy of macroscopic detail for simulating traffic on urban streets. That is, the user can select among three levels of simulation detail: The more detail, the greater is the accuracy obtained and the higher is the associated computing cost. This hierarchy would permit the user to decide on the optimal trade-off between the accuracy required and the computer resources at his or her disposal. Regardless of this selection process, TRAFLO is far more economical in every respect than any of the existing microscopic models.

The selection of an existing traffic assignment model for inclusion in TRAFLO was based on the idea that the most satisfactory traffic assignment models, from a mathematical viewpoint, are those that use Wardrop's principles of equilibrium (1). These models apply optimization theory to calculate the assignment of traffic over a network, taking into consideration all link impedances. As expected, these models are computationally more complex, although computational costs are reasonable. The accurate estimation of link impedances is necessary if the potential of these models is to be fully realized.

Since the TRAFLO software is designed to be machine independent, it was necessary to select a model already coded in FORTRAN. Fortunately, such a model does exist (2) and, in fact, has been carefully validated (3). This model is similar to the equilibrium traffic assignment model currently embedded in the UROADS module of the Urban Transportation Planning System (UTPS) package developed by UMTA.

MAJOR PROGRAM FEATURES

The TRAFLO program is actually a software system that consists of five functionally independent models. The logical structure of TRAFLO is designed to permit these independent models to interface with one another so as to form a coherent, integrated system. Four of the models simulate traffic operations over a specified network of roadways; the fifth model is an equilibrium traffic assignment model.

Representing the Traffic Environment

In order to use any of the simulation models in the TRAFLO program, the user must specify the following features of the physical traffic environment:

1. The topology of the roadway system;
2. The geometrics of each roadway component;
3. The channelization of traffic on each roadway component;
4. Motorist behavior, which, in aggregate, determines the operational performance of vehicles in the system;
5. Circulation pattern of traffic on the roadway system;
6. Traffic control devices and their operational characteristics;
7. Volumes of traffic entering and leaving the roadway system;
8. Traffic composition; and
9. The configuration of the mass transit system, i.e., bus routes, bus stations, and frequency of service.

In using the traffic assignment model, the user must also specify the trip table that defines the volume of traffic traveling from each origin to each associated destination.

To provide an efficient framework for defining these specifications, the physical environment is represented as a network. The unidirectional links of the network generally represent roadway components--either urban streets or freeway segments. The nodes of the network generally represent urban intersections or points along the freeway where a geometric property changes (e.g., a lane drop or a change in grade).

Figure 1 shows an example of a network representation. The freeway is defined by the sequence of links (1, 2), (2, 3),...,(5, 6). Links (8000, 1) and (6, 8001) are entry and exit links, respectively. An arterial extends from node 7 to node 15 and is partially subsumed within a grid network.

Each of the four simulation models in TRAFLO describes traffic operations in a subnetwork. That is, the user may partition the analysis network into subnetworks if he or she wishes to apply more than one simulation model concurrently [if the network consists of a freeway and urban streets, it must be partitioned (at least) into freeway and urban subnetworks, each of which may consist of several noncontiguous sections]. The user must also specify "interface nodes" at the juncture of the various subnetworks.

Urban Level I Model

The Urban Level I model is the most detailed of the macroscopic simulation models. Since it treats each vehicle in the traffic stream as a separate, identifiable entity, the representation of traffic can be considered microscopic. The treatment of the traffic stream, however, which is intermittent, or event based, can be considered macroscopic.

By treating each vehicle in the traffic stream individually, it is possible to explicitly distinguish between different types of vehicles (automobiles, trucks, and buses) and to treat each type according to its respective operating characteristics. Hence, the interaction of these vehicle types and the impact of lane channelization of bus-only or truck-only streets, and other detailed traffic management strategies, can be studied in adequate detail. Furthermore, much of the stochastic nature of the traffic-flow process can be explicitly represented.

Each vehicle is processed (i.e., moved) as infrequently as possible. This frequency depends on the conditions encountered by the vehicle immediately downstream. The less impedance a vehicle encounters, in the form of queues and no-go signal indications, the fewer processing steps are required to move a vehicle a given distance.

Associated with each vehicle is an "activation time" (AT), which is expressed in terms of the simulation clock time. When the simulation clock time equals the vehicle's AT, the vehicle will be processed (i.e., moved). The vehicle is generally moved to a point downstream--either on its current link or onto a receiving link--and its new location, speed, and AT are calculated. This vehicle then remains "dormant" until the simulation clock time advances to this new AT, whereupon the vehicle is again processed. [In contrast, a microscopic model such as NETSIM (4) moves all vehicles every time step and generates detailed trajectories.]

When a vehicle is processed, the determination of its new location, speed, and AT (i.e., its status) depends on conditions downstream of its starting point. A small number of scenarios (or "cases") have been identified that, in aggregate, span the entire spectrum of possible conditions. For each such case, explicit analytic expressions have been derived to compute the vehicle's new status. Spillback conditions that arise from inadequate capacity on one or more network links are also properly accounted for.

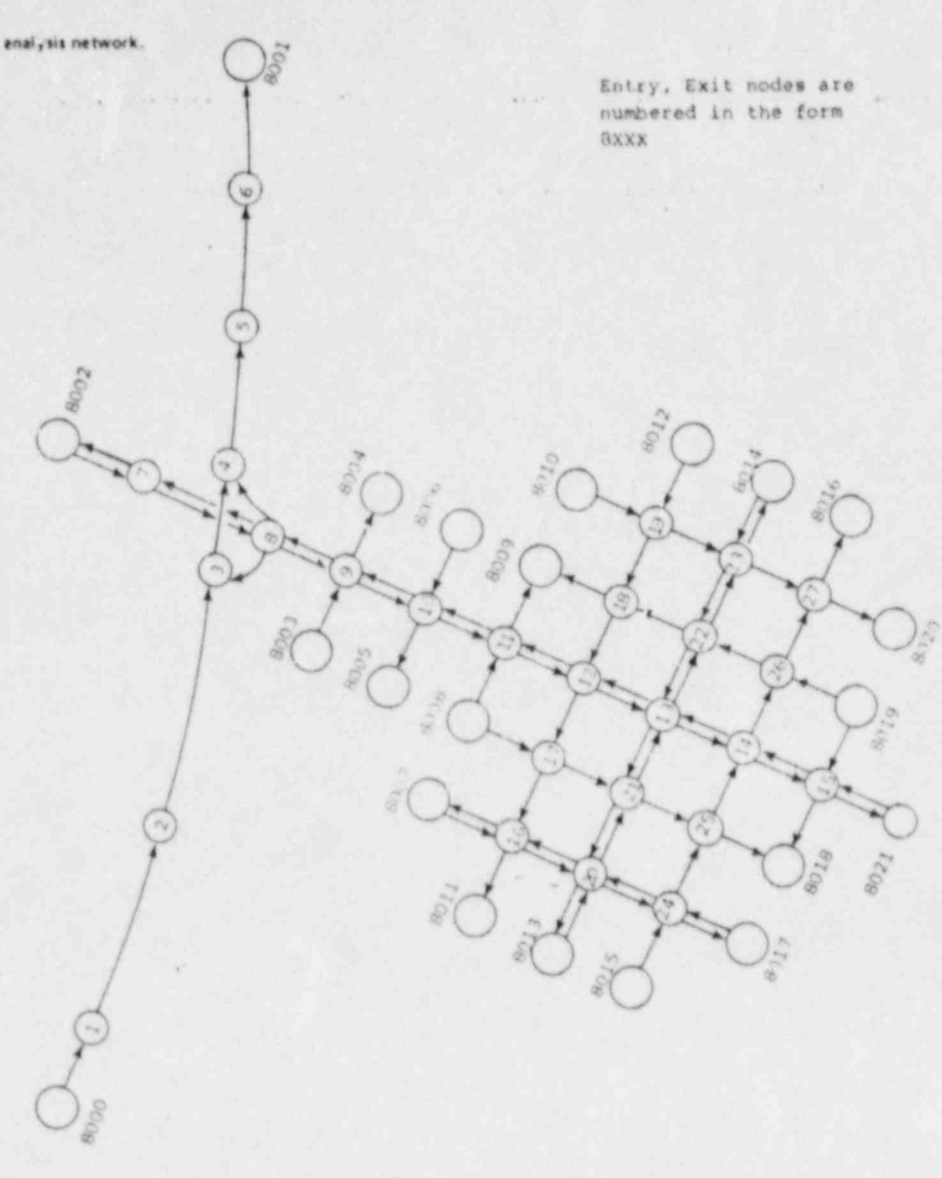
Urban Level II Model

The Urban Level II model is an extension and refinement of the flow model used in the TRANSYT signal optimization program (5). This flow model in the Level II simulation represents the traffic stream in the form of movement-specific statistical histograms. Figure 2 shows this histogram representation, which preserves the platoon structure of the traffic stream.

The Level II logic constructs a total of five such histograms for each (turn) movement on each network link:

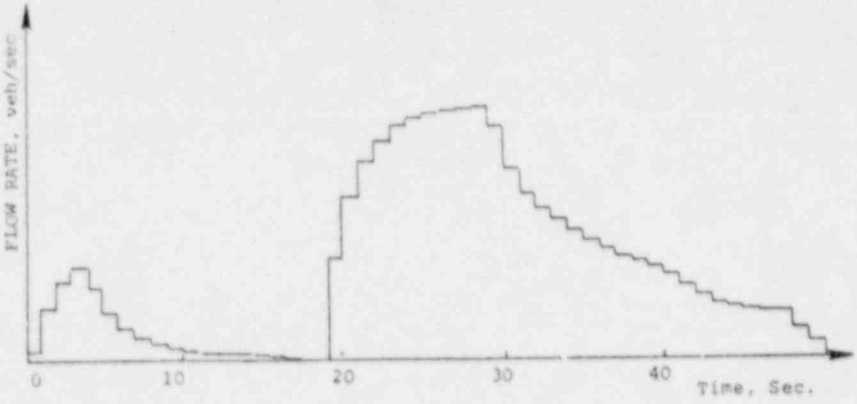
1. The ENTRY histogram describes the platoon flow at the upstream end of the subject link. This histogram is simply an aggregation of the appropriate OUT turn-movement-specific histograms of all feeder links.

Figure 1. Representative analysis network.



Entry, Exit nodes are
numbered in the form
8XXX

Figure 2. Statistical representation of traffic-stream platoon structure.



2. The IN histograms describe the platoon flow pattern arriving at the stop line. These dispersed histograms are turn-movement-specific and are obtained by disaggregating the ENTRY histogram to reflect the specified turn percentages for the subject link and then dispersing each histogram separately. This histogram representation, of course, describes the end result of the physical dispersion of platoons as they travel along the subject link to the stop line.

3. The SERVICE histograms describe the service volumes for each turn movement. These service volumes reflect the type of control device on this approach; if it is a signal, the histogram reflects the specified movement-specific signal phasing. A separate model was developed to estimate service

volumes for each turn movement, given that the control is "go".

4. The QUEUE histograms describe the time-varying ebb and growth of the queue formation at the stop line. These histograms are derived from the interaction of the respective IN histograms with the SERVICE histograms.

5. The OUT histograms describe the pattern of traffic discharging from the subject link. Each of the IN histograms is transformed into an OUT histogram by the control applied to the subject link. Each of these OUT histograms is added into the (aggregate) ENTRY histogram of its receiving link.

Note that this approach provides the Level II model with the ability to identify the characteristics of each turn-movement-specific component of the traffic stream. Each component is serviced at a different saturation flow rate, as it is in the real world. Furthermore, the Level II logic is able to recognize when one component of the traffic flow is encountering saturation conditions even if the others are not.

Algorithms provide estimates of delay and stops, reflecting the interaction of the IN histograms with the SERVICE histograms. Level II logic also provides for representing bus traffic as separate entities (although at a lower level of detail than Level I) and for properly treating spillback conditions.

Urban Level III Model

Level III logic is designed for major arterials that act as collectors, distributors, circulators, or connectors. As a collector, an arterial would serve to feed traffic from, say, an outlying region (or suburb) to a region of higher traffic density. As a distributor, the arterial would serve a reverse role, servicing a high demand level at one end and distributing this traffic to cross streets throughout its length. An arterial that serves primarily to provide access to adjoining traffic generators can be called a circulator. Finally, a connector arterial links two high-density areas, each of which would be modeled in greater detail (at Level I or Level II).

A user may determine that, although an arterial plays an important functional role, as described above, a detailed anlysis of its traffic operations lies outside his or her realm of interest. For example, a planner may wish to determine travel time along the arterial from various points to a particular location (e.g., a shopping center or a rail station). A traffic engineer may wish to determine whether congested conditions will occur as part of a quick precursor study to find out whether a more detailed analysis is necessary.

To satisfy such needs it is not necessary to explicitly simulate traffic elements either as individual vehicles or as platoons. It is sufficient to calculate the MOEs associated with a traffic environment that is described in relatively gross, aggregate terms.

Many investigators have developed explicit analytic expressions that relate delay to traffic volume, control settings, and saturation flow rate by using various techniques and asserting a variety of assumptions. One formulation that is widely accepted is that developed by Webster (6). The Level III simulation model uses an extension of Webster's formula to calculate vehicle delay.

Although the Level III model is far less detailed than Level II, it is still necessary to properly represent the "time lags" in the system; that is, all the link-segment-specific values of volume are time dependent.

In addition, it is necessary to recognize that the delay experienced by vehicles at intersections is a function of the turn-movement percentages, the presence or absence of oncoming traffic opposing left turners, and the channelization of lanes on the link.

Freeway Model

FREFLO, the freeway traffic simulation model included in TRAFLO, is an extension and refinement of the MACK model developed at the University of Southern California (7). This macroscopic simulation model represents traffic in terms of aggregate measures associated with sections of freeway generally less than 1 mile (1.6 km) in length. The aggregate measures used are flow rate, density, and space mean speed within the section. The formulation is based on a fluid-flow analogy to traffic operations.

The earliest modeling work (7) used a conservation equation and an equilibrium speed-density relation. In FREFLO, the equilibrium speed-density relation is incorporated into a dynamic speed equation. Another extension allows vehicles to be distinguished by type in three categories: (a) automobiles and trucks, (b) buses, and (c) carpools.

Most of the capabilities of FREFLO are shown in Figure 3. For each freeway section, there is a variable for entry flow rate, exit flow rate, density, and space mean speed. These variables are distinguished by vehicle type according to the three categories given above.

Vehicles enter the freeway subnetwork either at the upstream end of a freeway segment or by way of on ramps. In the on-ramp case, it should be noted that FREFLO represents only the movement on the freeway main line so that vehicles are introduced at the ramp gore and immediately merged. Vehicles exit the freeway subnetwork at the downstream end of a freeway segment or by way of off ramps. In the off-ramp case, FREFLO represents movement only up to the off-ramp gore so that movement down the ramp is represented within the adjoining subnetwork.

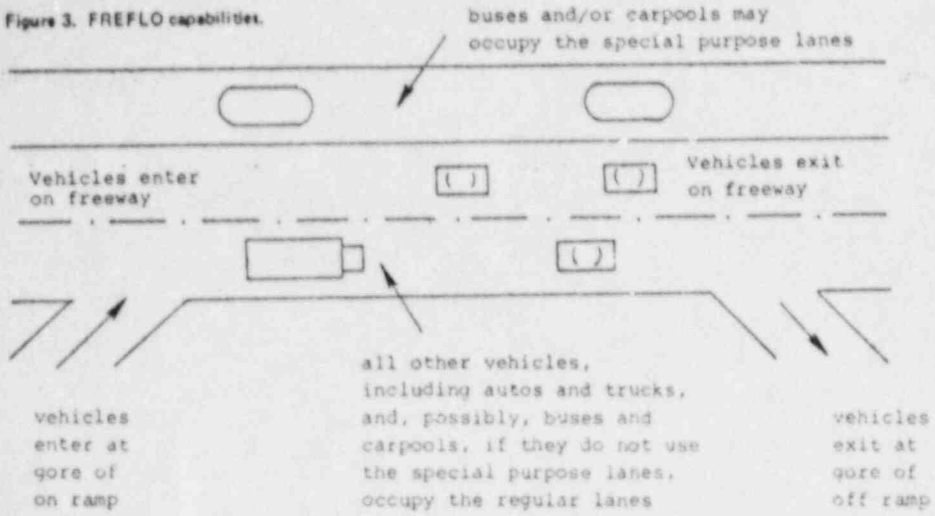
Traffic is associated with two types of lanes: (a) special-purpose lanes that can be designated to allow use by buses and/or carpools only and (b) regular lanes that can accommodate all other traffic and all vehicle types, including buses and carpools. Traffic is not associated with a particular lane but is considered to be uniformly distributed over the special-purpose and regular lanes, separately. The number of lanes of each type is arbitrary.

The network that can be represented is quite general. Disjoint segments or more general disjoint pieces are accommodated. Freeway-to-freeway connectors that involve merge and diverge points, as well as several connected freeways, can be accommodated. FREFLO provides for the representation of an incident on the freeway by allowing for the specification of a reduced number of available lanes and a constraint on the flow rate past the incident site.

Traffic Assignment Model

The equilibrium traffic assignment model embedded in TRAFLO interfaces with the simulation models. That is, the traffic assignment model in TRAFLO accepts a specified trip table (matrix of origin-destination demand volumes) and assigns these trips over the specified network. The assigned traffic volumes are then transformed into link-specific turn percentages, as required by the simulation models.

Figure 3. FREFLO capabilities.



The software then executes the simulation model(s) requested by the user to generate statistical measures that quantify the performance of traffic operations over the analysis network. This entire process is automatic, requiring no manual intervention beyond the initial preparation of the input data.

It is the inclusion of a traffic assignment model that makes TRAFLO a tool for the transportation planner as well as the traffic engineer. TRAFLO provides the planner with a description of the dynamic response of a transportation system to an applied transportation management strategy for the specified current, or projected, travel demand pattern (trip table). The information provided by TRAFLO offers far more detail and accuracy than are currently available to the planner.

The TRAFFIC model (2) uses the U.S. Bureau of Public Roads formulation to relate link travel time to volume. It then calculates the link-specific volumes that minimize an objective function representing Wardrop's first principle (i.e., user optimization). These data are subsequently transformed into link-specific turn percentages, as required by the simulation models, and the simulation is then implemented.

OPERATING CHARACTERISTICS

The TRAFLO software was developed by rigorously applying structured design and programming methodologies to reduce subsequent maintenance costs and to provide an efficient FORTRAN code.

The computing time for the Level I model depends almost linearly on the number of vehicles that occupy the analysis network. The relevant statistic for this model is expressed in terms of the ratio of the number of vehicle seconds of travel time to computer time. Based on results obtained on the CDC 7600 computer, Level I provides a ratio of 20 000:1. For the validation network of 95 links, and an average content of 375 vehicles, the total execution time for a simulation of 32 min plus 5 min of fill time was 26 s, which corresponds to a cost of less than $15.

The computing times consumed by the Level II and Level III models, as well as the FREFLO model, depend strongly on the size of the network rather than on the traffic volume. For a network of approximately 95 links, the ratio of simulated time to computing time for the Level II model is 160:1 on the CDC 7600 computer. For the validation case noted above, the Level II program consumed 10 s of computer time at a cost of $5. The computing cost for the Level III and FREFLO models is insignificant (on the order of less than 5 s) regardless of network size or volume.

Table 1. TRAFLO card types.

Set	Group	Card Type
Network independent	Run specification	00-05
Subnetwork specific	Urban link characteristics	11
	Freeway link characteristics	15
	Turning movements	21
	Freeway turning movements	26
	Freeway incident specifications	27
	Link specifications: Level III	30-31
	Freeway parameters	34
	Fixed-time signal control	35-36
	Actuated signal control	39-41
	Traffic volume	50-52
	Subnetwork delimiter	170
Global network	Traffic assignment	175-177
	Bus transit	185-189
	Time period delimiter	210

INPUT REQUIREMENTS

The input stream for TRAFLO is partitioned into sets of cards. Each set consists of one or more card groups, and each group contains one or more card types (see Table 1). Only those card types that are required for a particular application need be specified.

Although a substantial data base is required to adequately define the traffic environment under study, care has been taken to minimize user effort. For example, default values are available wherever possible, and all input data items are integers. Exhaustive diagnostic tests protect the user against improper inputs to the extent possible. The user also has the option to review his or her specified inputs prior to the execution phase of TRAFLO to further reduce the prospects of incorrect results.

VALIDATION

All three urban simulation models (Level I, Level II, and Level III) have been carefully validated by comparing model results with field data on a statistical basis. Details are provided elsewhere (8).

CURRENT STATUS OF TRAFLO

The TRAFLO program is now complete and is currently undergoing in-house testing by FHWA personnel. More detailed descriptions of TRAFLO appear elsewhere (8).

ACKNOWLEDGMENT

The development of a model such as that described in this paper is the result of the contributions of many people. In particular, we want to acknowledge Guido Radelat and George Tiller of the Traffic Systems Division of FHWA; Mark Yedlin and Manfredo Davila of KLD Associates, Inc.; William McShane of the Polytechnic Institute of New York; and Fred Wagner of Wagner/McGee Associates.

This work was performed under a U.S. Department of Transportation contract. A portion of the first part of the paper was extracted from the Request for Proposal statement of work.

REFERENCES

1. J.G. Wardrop. Some Theoretical Aspects of Road Traffic Research. Proc., Institute of Civil Engineers, Part 2, Vol. 1, 1952, pp. 325-378.
2. S. Nguyen. An Algorithm for the Traffic Assignment Problem. Transportation Science, Vol. 8, No. 3, Aug. 1974.
3. M. Florian and S. Nguyen. Recent Experience with Equilibrium Methods for the Study of a Congested Urban Area. Proc., International Symposium on Traffic Equilibrium Methods, Univ. of Montreal, Nov. 1974.
4. Network Flow Simulation for Urban Traffic Control System: Phase II (NETSIM). Peat, Marwick, Mitchell, and Co., Washington, DC; and KLD Associates, Inc., Huntington Station, NY, 1973. NTIS: PB 230 760-4.
5. D.I. Robertson. TRANSYT: A Traffic Network Study Tool. Transport and Road Research Laboratory, Crowthorne, Berkshire, England, Rept. LR 253, 1969.
6. F.V. Webster and B.M. Cobbe. Traffic Signals. Her Majesty's Stationery Office, London, Road Research Tech. Paper 56, 1966.
7. H.J. Payne, W.A. Thompson, and L. Isaksen. Design of a Traffic-Responsive Control System for a Los Angeles Freeway. Trans., Institute of Electrical and Electronics Engineers, Systems Science Cybernetics, Vol. SSC-3, May 1973, pp. 213-224.
8. E.B. Lieberman and others. Macroscopic Simulation for Urban Traffic Management: The TRAFLO Model. Federal Highway Administration, U.S. Department of Transportation, Vols. 1-7, 1980.

Publication of this paper sponsored by Committee on Traffic Flow Theory and Characteristics.

Abridgment

Hybrid Macroscopic-Microscopic Traffic Simulation Model

M. C. DAVILA AND E. B. LIEBERMAN

The Level I model, a component of the TRAFLO macroscopic traffic simulation program designed to evaluate transportation system management strategies, is described. The Level I model is designed to explicitly treat traffic control devices, include all channelization options, and describe traffic operations at grade intersections in considerable detail. Other features include actuated signal logic, right turn on red, pedestrian interference, and source-sink flow. Automobiles, buses, carpools, and trucks are explicitly treated as individual entities. The simulation processing uses "event-based" logic, which moves these vehicles intermittently, as required, rather than at every time step (interval scanning). Thus, this model is hybrid in the sense that the entities are microscopic but the processing is macroscopic in treatment. An overview of the Level I model logic is presented, the input requirements and measures of effectiveness provided by the model are indicated, and program efficiency and validation results are discussed.

This paper briefly describes the Level I model, a component of the TRAFLO macroscopic traffic simulation program (1), which has been designed to evaluate transportation system management (TSM) strategies. Level I is the most detailed simulation model within TRAFLO. It provides a microscopic description of the traffic stream and a macroscopic description of each vehicle movement. This approach is designed to provide a reasonably high resolution of detail as well as economy of operation.

Ideas embedded in several existing traffic simulation models have been selected, synthesized, refined, and expanded to form the Level I logic. These include the System Development Corporation macroscopic model (2), the TRANS model (3), the NETSIM (formerly UTCS-1) model (4), and the SCOT-Q model (which is not documented). The basic concept of processing each vehicle only when it is time to do so is called (in GPSS terminology) "event-based transactions". The intrinsic benefit of this concept is that it greatly reduces computing time, particularly when each event is widely spaced in time.

A careful analysis of these existing models revealed that it would be feasible and desirable to use an event-based approach in processing all vehicles; that is, even when a vehicle is in queue state, it could be "jumped" to the stop line and yet the mechanism of the queue discharge expansion wave could be preserved. By treating each vehicle in the traffic stream individually, the model is able to