CALIBRATION OF NETSIM TO NEW ZEALAND CONDITIONS

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Transit New Zealand Research Report No. 9

ISBN 0-478-04144-6
ISSN 1170-9405

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Dunn, R. C. M., Tan, H. H. 1992. Calibration of NETSIM to New Zealand conditions. *Transit New Zealand Research Report No. 9. 27pp.*

Keywords: calibration, computer simulation, NETSIM, parameter sensitivity, traffic modelling, urban networks, validation

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ABSTRACT

NETSIM, a very detailed computer model for traffic simulation developed in the United States, is validated and calibrated for use in urban street networks in New Zealand conditions. It is particularly valuable for dense and complex networks where other methods are seldom appropriate.

The development, logic and structure of NETSIM is documented. Each submodel is examined, and its associated requirements for sensitivity, validation and calibration, as well as its embedded parameters are identified.

Although more field calibrations and analyses of other than the four submodels considered for this report are required, most of the submodels tested were found to be valid. It is concluded that NETSIM can be usefully applied with its embedded parameters to New Zealand conditions.

Recommendations for further research and development of NETSIM for use by local authority practitioners and consultants are supplied.

1. INTRODUCTION

1.1 Background

This report is a summary of the work undertaken and more fully described in "Simulation of Traffic Flow on Dense Urban Street Networks : A Study of the Calibration Requirements of the FHWA-NETSIM Model for New Zealand Conditions", by H. H. Tan as a thesis submitted in partial fulfilment of the requirements for the degree of Master of Engineering, University of Auckland, under the supervision of R. C. M. Dunn. The non-University assessor for the thesis (Tan 1989) was R. O'N. Hill, Auckland.

NETSIM, which is a computer-simulation model developed for the FHWA (USA), was one of the models chosen for further investigation in Research Project AD/50, "Urban Road Traffic Models for Economic Appraisal" (Fisk and Dunn 1986). It was subsequently recommended for development and adoption for simulating vehicle movements at intersections or on small networks (Fisk and Dunn 1992). This project, TM/21, has been undertaken as part of and in conjunction with Project AD/50.

The authors acknowledge the support of the Traffic Committee Transit New Zealand for a Study Award and other financial assistance for the project.

1.2 Research Objectives

The specific objectives of Project TM/21 were to:

1. Document the subroutines, the submodels and the systematic structure, and include the input parameter requirements of NETSIM.

2. Assess the validation and calibration work needed to ensure that the submodels in NETSIM reflect actual driver behaviour in the New Zealand environment.

3. Carry out data collection for the validation and calibration of selected submodels in NETSIM.

2. DESCRIPTION OF NETSIM

2.1 Purpose of NETSIM Model

NETSIM, a microscopic and stochastic simulation model of urban traffic, is designed primarily as a powerful tool to assist the traffic engineer in analysing street network systems. It is particularly well suited for analyses of dense and complex networks with interrelated traffic operations. However, it is a large complicated package comprising over 45,000 lines of FORTRAN code and 300 subroutines.

As discussed in Tan (1989), considerable caution is required when using NETSIM to analyse traffic on short street sections or at intersections.

2.2 Different Versions of NETSIM

Two different versions of NETSIM were obtained for this study:

1. TRAF NETSIM: the version of NETSIM which was incorporated into TRAF-integrated simulation package. It was considerably enhanced during its transformation into TRAF. This version was made operational on a mainframe computer (IBM 4341).

2. PC NETSIM: a microcomputer version of NETSIM identified as Release II, dated May 1986. It was developed from mainframe NETSIM, which was an earlier version than TRAF NETSIM, for PC use. Thus, it does not have the enhancements found in TRAF NETSIM. This version was made operational on an IBM-compatible PC.

It should be noted that more recent versions of TRAF-NETSIM have been specifically designed to operate on personal computers. These more recent versions have been further enhanced. Refer to Section 7.3 for more information.

2.3 Features of NETSIM

The major features of NETSIM model are shown in Figure 1. It can be seen that NETSIM simulates traffic networks in considerable detail, including many traffic control features.

The modular form of NETSIM allows for the flexibility to evaluate a wide range of urban network configurations. By choosing the various control devices, such as channelisation, signal timing and co-ordination, the traffic engineer can properly model and analyse the effects of a strategy on the operation of the network.

2.4 Model Operation

Figure 2 shows the logical flow of the model operation. TRAF NETSIM program is made up of three modules, each controlled by its executive module:

1. Preprocessor, PN, is controlled by "PX",
2. Simulator, SN, is controlled by "SX",
3. Output Processor, ON, is controlled by "OX".

The three executive modules are, in turn, managed by the main executive routine, "XX".

The program starts with the "Flag" set for executing the input preprocessor. This input preprocessor contains a set of thorough diagnostic tests which check the validity of each data item of the input stream. Details of the diagnostic checks are discussed in Section 3.7 of Tan (1989).

When fatal errors are detected, the program will not allow simulation to be carried out, i.e. the program will abort at the end of preprocessor execution. This feature is useful and important as it prevents wasted computer time.

When the preprocessor diagnostic gives an all-clear flag signifying no fatal errors, the execution will proceed to the simulation stage, unless the user specifically requests a "diagnostic-only" run. An outline of the simulation process is discussed in Section 2.5.

Type of simulation	Microscopic, stochastic simulation of individual vehicle movements through a dense urban network and stochastic simulation of driver behaviour
Control features	Simulation of a full range of control devices including: • "Stop" and "Yield" signs • Fixed-time signal • Vehicle-actuated signal • Turn channelisation
Disturbance	Simulation of intra-link temporary disturbance, such as: • Short-term event (loading, unloading, etc.) • Long-term event (blockages, breakdowns, etc.) • Road-side parking
Traffic flow behaviour	Detailed treatment of the following: • Car-following • Queueing formation and discharge • Intra-link frictions and lane-changing behaviour in queues • Pedestrian-vehicular conflicts
Transit vehicles	Comprehensive treatment of buses
Link geometry	Detailed approach geometry at node

Figure 1. Major features of NETSIM model.

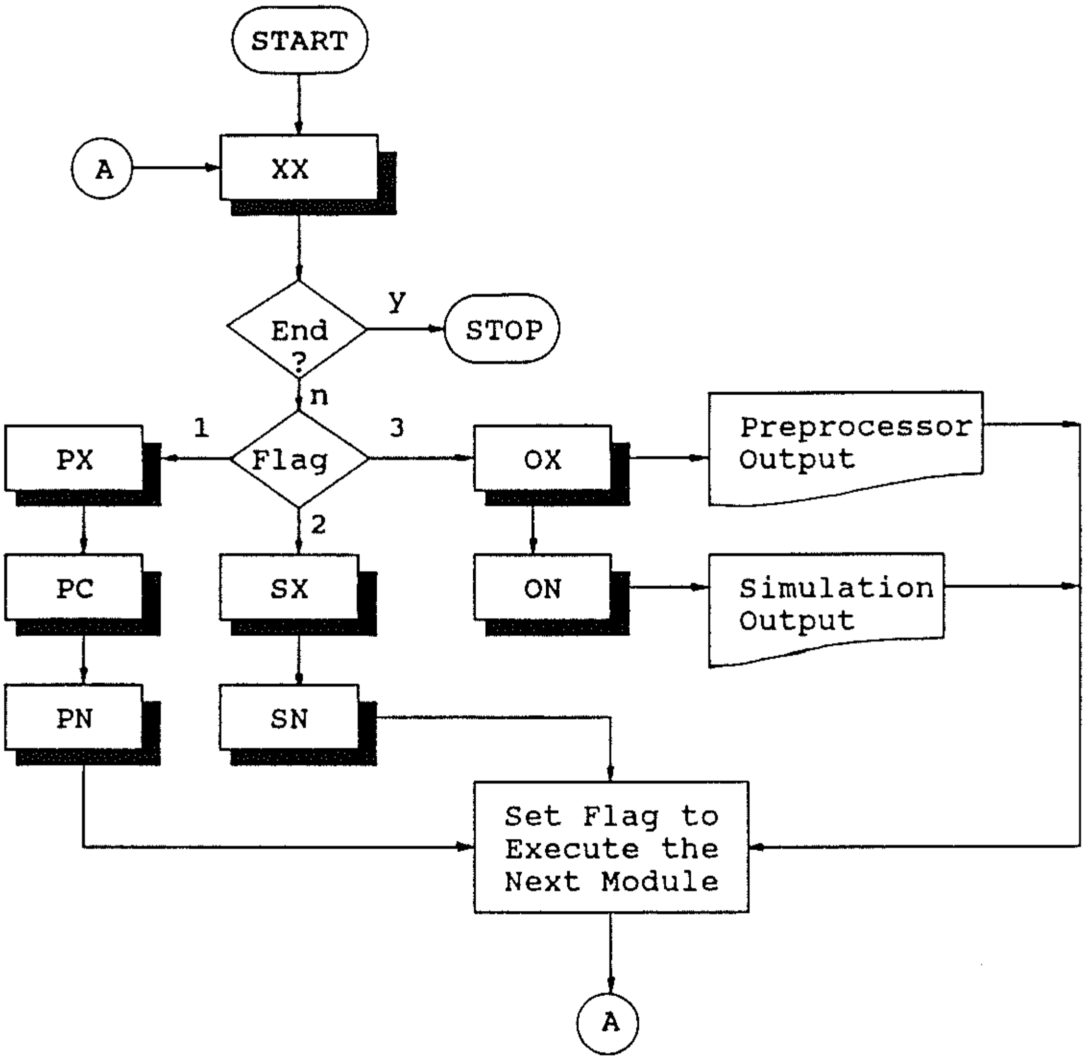

Figure 2. Logical flow of program execution.

2.5 Traffic Flow Simulation in NETSIM

As a microscopic model, NETSIM simulates individual vehicles moving through the network system. A network is represented by a set of unidirectional "links" and "nodes". The links of the network represent the streets, the nodes represent the intersections.

Each vehicle in the network is treated as a separate entity. It is distinguished as one of four categories: private cars, car pools, trucks and buses. In all, 16 types of vehicles may be specified, based on their operating and performance characteristics. The type and category, together with the associated performance characteristics, are assigned to each vehicle stochastically as it enters the network. Vehicles enter the network in a series of "entry" links or from "source" nodes located within the network. They are discharged through a set of peripheral "exit" links or "sink" nodes located within the network. "Source/sink" nodes may include traffic generators, such as minor streets and parking lots.

Figure 3 shows an example of link-node diagram representing a section of Auckland Central Business District network.

As the vehicle enters the network, it is randomly assigned various characteristics, according to a set of distributions. These characteristics include vehicle category and type, and driver type (in a scale of 10, from passive to aggressive character). Associated with each driver type are some operational criteria. These include:

- Desired free-flow speed;
- Acceptable gaps for various manoeuvres;
- Lost time at intersection discharges and discharge headways;
- Intended turning movement at downstream node.

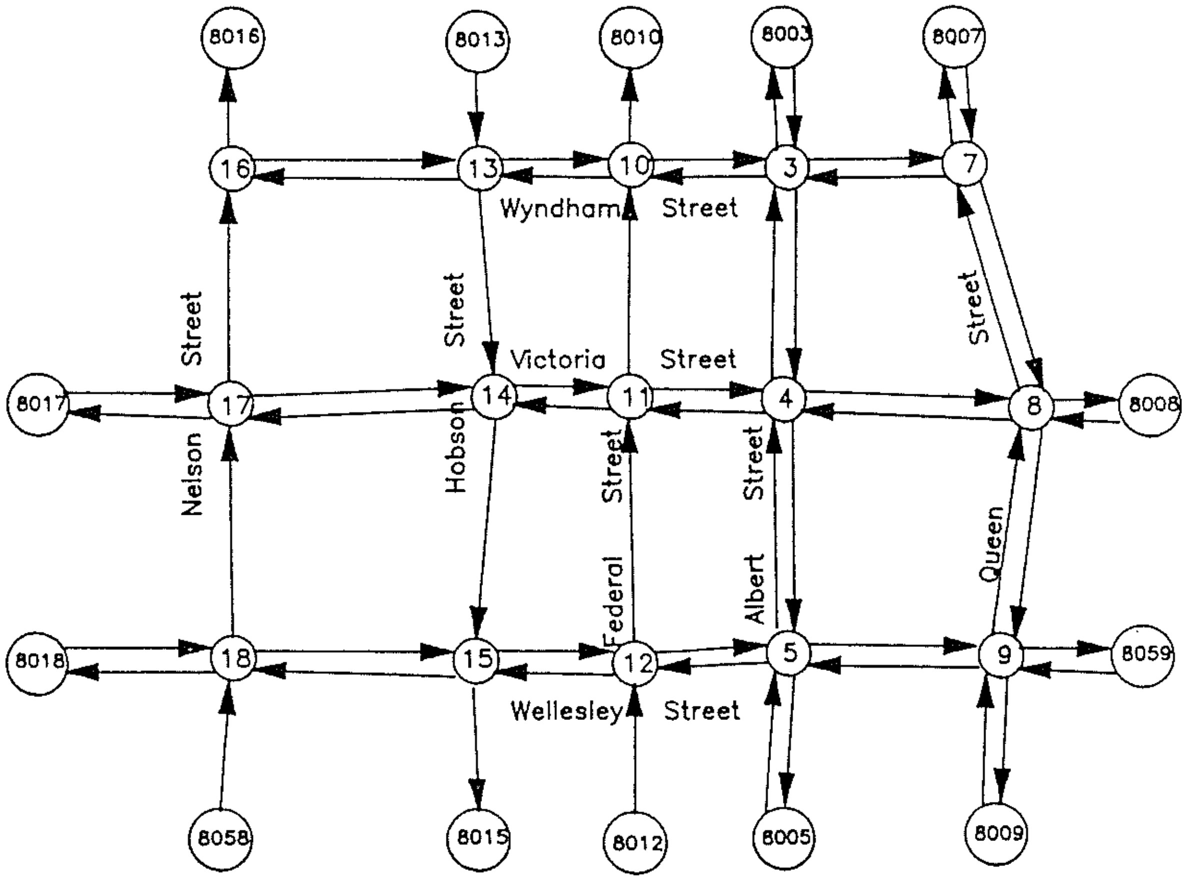

Figure 3. Link-Node diagram of a section of Auckland Business District. Numbers in circles are node numbers, arrows indicate the direction of traffic flow on the link.

Nodes are operated according to the type of traffic control specified. The "yield" rule and gap acceptance behaviour are modelled. Signalised controls such as fixed-time signals and vehicle-actuated signals are also modelled. Turning movements at intersections are randomly assigned according to the input proportion of the turn movements.

Operating as a one-second interval-scanning model, each vehicle in the network is processed once every second, as it moves through the system, with its time-space trajectory being recorded at 0.1 second resolution. Recent versions use 1 second resolution to reduce computing time. The internal simulation of vehicle motion is complex and is governed by a series of car-following, queue discharge, and lane-changing algorithms, in response to traffic control devices.

The time-step record of each vehicle's performance, as it moves through the network, is updated in a detailed "vehicle array" and a "link array". The vehicle array contains recorded data, such as cumulative time, distance, delay and number of stops, in addition to its present position and its projected action at the next node. The link array contains link statistics similar to the vehicle array, but also includes the cumulative number of vehicles and the turning movements processed, as well as the link occupancy and the queue lengths.

One of the most important features of NETSIM is its ability to simulate changing conditions over time. For instance, the volume on entry links and the operational time-setting of signalised intersections can be varied for different times.

The simulation of changing operational conditions is achieved by partitioning the duration of the simulation into suitable sub-intervals called "Time Periods". Up to 19 Time Periods may be specified in the program.

The overall operation of the simulation model is summarised in the five steps listed below. The sequence of the steps is iterated for each successive one-second time-step throughout the simulated sub-intervals. At the end of the first sub-interval, any necessary updates on operational changes specified in the input stream are made and the process is repeated for the subsequent sub-intervals.

1. Any new vehicles emitted onto the network via entry links in accordance with the specified flow rates for each entry link or for any internal source nodes are processed.

2. All vehicles on the network will be processed, on a lane basis, from the stop line to upstream of the link, including vehicles in the queue.

3. The status of all traffic signals in the network is updated.

4. The set of standard vehicle and link statistics contained within the vehicle-array and link-array are accumulated and a series of diagnostic checks performed.

5. If a statistical output is called for, the necessary results are printed.

2.6 Input requirement for NETSIM

The input data required for NETSIM is considerable but can be broken down into two groups "location-specific" and "network-wide". The former pertains only to a specific link or node but the latter to all links or nodes throughout the network.

Input data can then be classified either as "exogenous input", which are read in by the programmer, or as "endogenous (embedded) input", which has been pre-coded directly into the simulation model. Figure 4 shows the input data required for NETSIM.

	Location-Specific	Network-Wide
EXOGENOUS	• Intra-link free-flow speed* • Intersection discharge rate* • Input flow rates • Frequency of rare events • Intersection turning movements • Bus system data • Pedestrian flow* • Lane channelisation • Signal timing • Detector location and type	
ENDOGENOUS	• Distribution of queue-discharge headway* • Distribution of bus-dwell times*	• Traffic composition* • Amber phase behaviour* • Parameters in car-following model# • Parameters in lane-switching model# • Parameters in intersection movement# • Distribution of free-flow speed* • Turning speeds* • Gap acceptance distribution* • Distribution of pedestrian-vehicle delay

* These input data have default values built in, which may be used directly without specific input for them.

Default values built into the program code which cannot be altered by input stream. Alteration, if desired, must be done by altering the source codes.

Figure 4. Data input required by NETSIM.

2.7 Output from NETSIM

A summary of important statistics or Measures of Effectiveness, both link by link and network-wide, is reported at the end of each sub-interval. Links are identified as node pairs and with names if they are specified in the input stream. The main Measures of Effectiveness, together with their appropriate definitions, are shown in Figure 5.

Measure of Effectiveness	Definition
Total vehicle-km	Total vehicle kilometres of travel, by link, for the simulation interval
Vehicle trips	Number of vehicles travelling along each link during the simulation interval
Average speed (km/hr)	Average vehicular speed, by link, for the simulation interval
Total delay (vehicle-minute)	Total vehicle delay accumulated for the link for the simulated period selected. It includes both moving delay and stopped delay
Delay per vehicle (sec/veh)	Average delay experienced by each vehicle traversing the link
Delay per vehicle-km (sec/km)	Average delay time per vehicle-kilometre, by link, for the simulation interval
Percentage of vehicles stopped	The percentage of vehicles which experienced a complete stop while traversing the network. Also the percentage of vehicles which stop at least once when passing through a specific link during the simulation interval

Figure 5. Main measures of effectiveness of NETSIM.

As well, NETSIM outputs many other useful statistics, which may supplement the main Measures of Effectiveness listed in Figure 5. These include:

- Total moving time along a link,
- Total travel time for a link,
- Ratio of moving time to total travel time,
- Average travel time per vehicle,
- Average link occupancy,
- Average saturation percentage,
- Number of phase failures (i.e. failure to discharge in one phase).

Details of the summary reports generated by NETSIM are discussed in Section 3.10 of Tan (1989).

In recent versions of NETSIM, two additional link-specific measures of effectiveness: "average queue by lane" and "maximum queue by lane" which are estimated over the simulation interval, have been introduced.

3. EXECUTION OF NETSIM

3.1 Introduction

Despite the considerable initial difficulty, NETSIM was made operational on the University's IBM 4341 mainframe computer and on an AT personal computer.

The procedures for executing NETSIM on both mainframe and personal computers are discussed in Tan (1989), Chapter 4. Several executive programs have been written to enhance the execution of a NETSIM simulation.

As noted in Section 2.2, most of these difficulties would not be expected to occur now with the more recent versions of TRAF-NETSIM as they have been specifically designed to operate on personal computers.

3.2 An Illustrative Application

The application of NETSIM to evaluate various signal-cycle timing and pedestrian-crossing strategies is illustrated by a hypothetical case study depicting a downtown network in Auckland Central Business District. Details are described in Chapter 4 of Tan (1989). This example case study showed that the current version of NETSIM can be usefully applied, with its embedded parameters, to small networks which is a typical application in New Zealand.

3.3 Computer Time Requirements

The computer time requirements to execute typical networks were investigated and further details are given in Tan (1989), Section 4.9. As expected, the factors that significantly affected computer time requirements were:

- Duration of simulation run,
- Volume of traffic simulated,
- Size of network,
- Type of intersection control.

3.4 Driving Rules and Units of Measure

Because NETSIM originated in the United States, it assumes that vehicles are "driving on the right". This difference has been examined and it does not pose problems in using the model. A special "Driving on the Left" input coding guide has been developed, details of which are in Tan (1989), Chapter 4 and Appendix C, as it was concluded that a modified version of NETSIM operating according to New Zealand's "driving on the left" rule is desirable for general use.

NETSIM uses Imperial units in all its computation. Although metric units may be specified, they are all converted to Imperial units for processing. The processed results are then converted back to metric units for presentation in the output. The conversions between Imperial and SI units are transparent to the user, and should therefore not be a problem. In fact, its versatility to present results in both units is considered an asset.

4. SUBMODELS OF NETSIM

4.1 An Outline of Main Submodels in NETSIM

The main submodels in NETSIM are listed in Figure 6. Each of these submodels and their components are discussed in Chapter 5 of Tan (1989). Below is an outline of the more important aspects of these submodels:

- The stochastic variation in the submodels are introduced by generation of pseudo-random numbers using the multiplicative linear congruential method. This method of generating random numbers has an established usage and has a large cycle or period before the number repeats itself.

- Up to 16 types of vehicle may be specified over four fleet categories: private car, truck, bus, car pool. Each type of vehicle has an operational characteristics as defined by a linear approximation of acceleration versus speed.

- Drivers are ranked in ten types of character: from passive (type 1) to aggressive (type 10). Each vehicle is randomly assigned one type of driver.

- Pedestrians are not explicitly modelled. However, the interference of platoons of pedestrians crossing an intersection is represented.

- Vehicles are emitted onto the network at uniform intervals, in accordance with the arrival volume specified by the user.

- Gap-acceptance behaviour at priority intersections is represented by a cumulative distribution of varying gap sizes, with less aggressive drivers accepting a larger gap.

- Both "stop" and "yield" sign traffic controls are modelled. The gap acceptance for the "yield" sign is assumed to be 1.5 seconds shorter than the corresponding gap if the vehicle stops at the intersection.

- The microscopic nature of NETSIM allows the signalised intersection to be modelled explicitly. The following types of movement may be specified for each approach to the intersection at each signal interval:

Main Submodel	Components
Representation of Network Traffic System	• Street networks • Vehicles • Drivers • Pedestrians • Environments
Representation of Stochastic Process	• Generation of randomness by multiplicative linear congruential method
Representation of Queue Discharge Process	• Priority intersection models: — Stop and Yield signs — Gap-acceptance distribution • Signalised intersection models: — Signal phasing — Response to onset of amber signal — Queue-discharge headway distribution — Lost time distribution
Pedestrian Influence	• Pedestrian-vehicle interaction at intersection
Car Following	• Speed-space profile of free-flow vehicle • Acceleration and deceleration characteristics • Choice of desired free-flow speed and its distribution
Intralink Disturbances	• Effect of short-term events (<60 sec) • Effect of long-term events (>60 sec) • Effect of kerb-side parking • Effect of blockages
Transit Vehicles	• Bus path, bus route, bus station • Distribution of bus-dwell time at station • Bus-only lane
Fuel Consumption and Emission	• Fuel consumption tables • Fuel emission tables: — Hydrocarbon — Nitrogen oxide — Carbon monoxide

Figure 6. Main submodels and their components in NETSIM.

  - Amber
  - Green
  - Red
  - Red with green left arrow
  - Red with green right arrow
  - Red with green diagonal arrow
  - Green through — no turn allowed
  - Red with left and right arrows
  - Green through and right — no left turn

- Each individual vehicle approaching or queueing at an intersection proceeds through the intersection according to the signal phasing. The following are modelled explicitly and are discussed in detail in Sections 5.9 and 5.10 of Tan (1989):

  1. Response to onset of amber signal
  2. Start-up lost time
  3. Queue-discharge headway
  4. Spillback at intersection
  5. Right-turn jumper
  6. Right-turn lagger

- The speed profile of a free-flowing vehicle (leading vehicle) is described by a speed profile, depicted in Figure 7. Details are in Section 5.12.2 in Tan (1989).

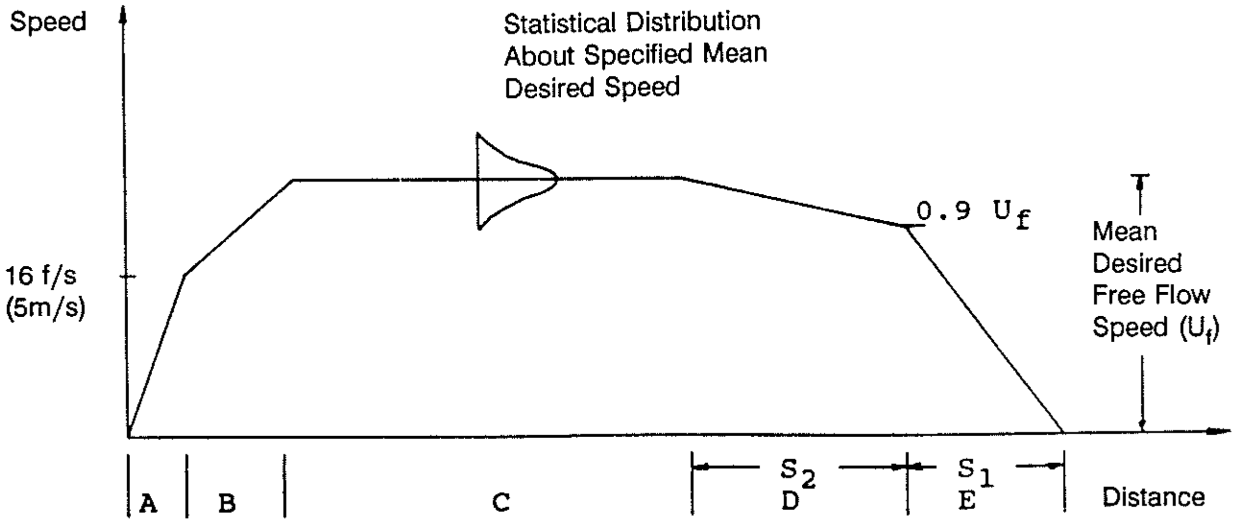

Figure 7. Speed profile of lead vehicle.
(f/s feet/second; m/s metre/second; S = distance; A-E = sections of road)

- Each driver will choose to travel at a desired free speed (if unimpeded by others) according to an observed free-speed distribution. However, the driver may not be able to attain the desired speed because of interaction or friction with other vehicles on the link. These interactions, including slow lead vehicle, parking, blockages, bus stops, etc., are explicitly modelled.

- A detailed algorithm is used for the intra-link car-following process. This is described in detail in Sections 5.11 and 5.12 of Tan (1989).

- Buses are treated separately with their specific service routes, bus stations, and mean dwell times.

- Fuel consumption and vehicle emissions are also modelled by cross-referencing consumption and emission tables embedded in NETSIM. However, it is believed that these tables, being standards for United States vehicles, will not be appropriate for New Zealand vehicles.

4.2 Validation and Calibration

Below is an outline of the validation and calibration requirements of the NETSIM submodels if they are to reflect New Zealand driver behaviour.

Notation: * submodels that have been calibrated or validated in this study (Tan 1989)

** submodels that have parameters embedded in the source code, and hence cannot be calibrated without modifying the source code.

The following submodels and/or embedded parameters will require rigorous validation or remodelling:

- Vehicle fleet components
- Speed profile of leading vehicle**
- Acceleration and deceleration characteristics
- Turn speed*
- Fuel consumption and emission
- Vehicle generation**
- Car following

The following submodels, believed to be valid for New Zealand conditions, will require calibration of their embedded parameters to obtain representative values:

- Gap-acceptance distribution*
- Stop and yield sign gap**
- Response to onset of amber signal*
- Queue-discharge headway
- Lost time at intersection

- Pedestrian-vehicle interaction
- Desired free-flow speed distribution*
- Spillback at intersection
- Right-turn jump probability
- Right-turn lagger probability

The following submodels or embedded parameters in NETSIM are determined as being location-specific. The values may vary from city to city and therefore they are not meaningful to calibrate. Hence it is suggested that users of NETSIM should calibrate these parameters to suit the local environment and its characteristics:

- Short-term event distribution
- Long-term event distribution
- Blockages
- Kerbside parking mean manoeuvre time
- Bus-dwell time
- Bus station type

The following submodels should be considered for incorporation in NETSIM as they would have useful applications:

- Roundabouts
- Random vehicle-generation model

5. SENSITIVITY ANALYSIS OF EMBEDDED PARAMETERS

5.1 Parameters Investigated

The effects of variations in selected NETSIM embedded parameters on the final simulated results were investigated to determine the sensitivity of the program. As explained in Section 6.1 of Tan (1989), the following parameters were investigated:

- Free-flow speed distribution
- Amber-response distribution
- Turning speed
- Pedestrian-vehicle interaction
- Gap-acceptance distribution

5.2 Effects of Free-Flow Speed Distribution

To check this effect, simulated vehicles traversed a long street with no parking activity, no bus stops or other disturbances. In essence, the only delay incurred on this straight continuous street was caused by free-flow interactions, namely faster vehicles catching up to slower vehicles.

It was found that the average network delay was very sensitive to varying the mean and the variance of the desired free-flow speed distribution. It was also observed that both a lower mean and higher variance of the free-flow speed distribution significantly increased delay on the network.

5.3 Effects of Amber-Response Distribution

Drivers' responses to the onset of amber signal are represented by a distribution of acceptable deceleration. The effect of varying the specification of this acceptable deceleration distribution was studied by simulating vehicles traversing a signalised intersection. Three variations of acceptable deceleration were used:

- The default values,
- About 50% higher than the default values,
- A distribution with a lower variance than the default value.

Simulation runs indicated that the effect of varying the acceptable deceleration for the default values was insignificant.

5.4 Effects of Turning Speed

The effect of changing the allowable turning speed on the simulation results was investigated by simulating vehicles turning freely (unimpeded) through a T-intersection. Both left and right turns were studied using different turning speeds.

The simulation results were sensitive to the influence of the turning speeds specified for both left and right turns. Slower turning speeds resulted in significantly higher delays.

5.5 Effects of Pedestrian-Vehicle Interaction

Pedestrians cause delays to turning vehicles at an intersection with parallel pedestrian crossings. These delays, stochastically assigned, are embedded in NETSIM and their effects on the results of simulation were investigated. Two distributions, one with 50% more delay than the other, were specified.

It was concluded that the average delay incurred in the network was sensitive to the variation in the specified pedestrian interactions.

5.6 Effects of Gap-Acceptance Distribution

Near-side and far-side gap acceptances at a minor stream of a T intersection were studied. The left-turning vehicles accept a near-side gap, while the right-turning vehicles take a far-side gap. Since the far-side gap acceptance in NETSIM is based on the near-side gap-acceptance distribution, only the latter distribution needed to be varied to study the effect on both left- and right-turning vehicles.

Three varying distributions were specified, first the default distribution, a second distribution with lower gap acceptances and a third with higher gap acceptances. It was observed that delays to both left- and right-turning vehicles were not sensitive to the variation in gap-acceptance distribution.

6. FIELD CALIBRATION OF NETSIM SUBMODELS

6.1 Field Calibration of Turning Speed Submodel

To validate the deterministic, radius-independent, turning speed submodel used in NETSIM, the turning speeds at an urban intersection in Auckland, at Karangahape Road and Pitt Street, were recorded on two occasions.

Turning speed was found to be dependent on the radius of curvature of the turning movement, though the relationship was not rigorously determined because of the limited data.

The conclusion was that NETSIM's default turning speed of 14 km/hr for the "left" turn and 24 km/hr for the "right" turn is not applicable to New Zealand. NETSIM's deterministic turning speed model, therefore, needs to be reviewed.

The recommendation is for a turning speed model based on the radius of curvature to be employed for New Zealand street networks. As the recorded turning speeds showed some variations, the possible need for using a distribution of turning speeds, as compared to single mean speeds, should also be investigated.

6.2 Field Calibration of Free-Flow Speed Distribution Submodel

In this study, radar equipment was used to collect desired free flow speeds of vehicles on five streets in Auckland, each with different side frictions.

The speed distributions of all five streets were found to have the same shape. This indicated that the free-flow speed distribution patterns (in Auckland streets) may be represented by a single distribution function.

This observed distribution was also found to be similar to the distribution embedded in NETSIM's default parameters for the desired free-flow distribution. Therefore, based on the limited data collected, NETSIM's free-flow speed distribution submodel is concluded to be valid for New Zealand conditions and driver behaviour.

6.3 Field Calibration of Amber-Response Distribution Submodel

A major intersection in Auckland central, the Fanshawe Street-Nelson Street intersection, was chosen for validating the amber-response distribution submodel embedded in NETSIM. Data were collected on two occasions using time-lapse photography.

The acceptable deceleration distributions obtained for the two occasions were marginally different. When compared with NETSIM's embedded distribution, it was found that the local drivers stopped less readily.

NETSIM's amber-response distribution submodel will not apply to New Zealand driver behaviour and therefore, the amber-response distribution needs to be calibrated for New Zealand.

6.4 Field Calibration of Gap-Acceptance Distribution Submodel

The data collected by Rosser and Milne (1981) were used to calibrate the gap-acceptance distribution submodel embedded in NETSIM. Three turning movements were observed:

1. Minor street left-turn movements,
2. Minor street right-turn movements,
3. Major street right-turn movements.

The percentage of gap acceptance for each turn movement was plotted against gap size. NETSIM's embedded default distribution for each of the turn movements was also plotted for comparison.

The comparison showed that the observed gap-acceptance distribution and NETSIM's gap-acceptance distribution were both very close except for major street right-turn movements. In this case, New Zealand drivers were observed to accept relatively smaller gaps than United States drivers.

Therefore, based on the limited data available, the conclusion is that the gap-acceptance submodel embedded in NETSIM is applicable to New Zealand except for the major street right-turn waiting for gaps in oncoming traffic.

7. SUMMARY

7.1 Conclusions

NETSIM is a very detailed simulation model, particularly useful for dense street networks and/or where traffic conditions are strongly interrelated. The package has undergone extensive validation in USA.

TRAF NETSIM and PC NETSIM have been made operational for mainframe (IBM 4341) and AT personal computers respectively. The procedures for execution have been streamlined and documented (Tan 1989).

This study has also documented the development, logic and structure of NETSIM. In particular, each submodel has been examined and its associated requirements and embedded parameters have been identified. It has shown too that, with extended effort, it can be usefully applied with its embedded parameters to New Zealand. A typical case of a small network application which illustrates the use of NETSIM is outlined in Section 2.

Most of the NETSIM models were found to be valid for New Zealand traffic conditions and the submodels which require further validation and calibration are listed in Section 4.2.

Ideally, each NETSIM submodel should be calibrated to New Zealand conditions but, because of time and resource constraints, it was possible to undertake calibration of only four submodels and their parameters. The results are outlined in Sections 5 and 6.

7.2 Recommendations

Some further research and development of NETSIM are required if the package is to be useful to practitioners. The package would have most use to those in large local authorities and to consultants.

The following recommendations are not in priority order but are probably in order of increasing effort and resources needed for their execution and incorporation in the program:

1. A "drive on the left" version be developed.

2. A turning speed model be developed, probably based on turning radii.

3. Two submodels require further investigation as they have a considerable effect on the results of a NETSIM simulation:

    (i) speed profile (free speed, acceleration and deceleration characteristics);
    (ii) car-following.

4. A random arrival model be incorporated (as a substitute for the constant headway arrival model).

5. The modelling be extended to incorporate the inclusion of roundabouts.

6. Fuel consumption and emission tables embedded in NETSIM require complete replacement with New Zealand data.

7.3 Recent Enhancements to TRAF-NETSIM

As noted in Sections 2.2 and 3.1, more recent versions of TRAF-NETSIM are now available than the TRAF NETSIM and PC NETSIM versions which were used on this study. These more recent versions have been specifically designed to operate on personal computers and have been further enhanced.

At the time of writing (April, 1992), the current TRAF-NETSIM package was version 3.0. This package includes:

- NEDIT, a menu-driven input preprocessor including an "On-screen" network editor.
- TSIS, which provides an environment for running TRAF-NETSIM and will eventually incorporate other simulation and optimisation models.
- GTRAF, an **optional** graphics package to provide colour displays of input and output data, including details of the intersection geometrics, highlights of problem areas and an animation of the simulated traffic flow on the network.

The FHWA (USA) plans to release another enhanced version of TRAF-NETSIM later in 1992. This version will be released with CORFLO (corridor simulation) and FREFLO (freeway simulation). All three simulations will be accessible under the TSIS program. NEDIT is to be replaced by a new editor called TRAF-EDIT and a new graphics program will permit viewing CORPLO and FREFLO data.

8. REFERENCES

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