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AUSTROADS RESEARCH REPORT

The use and application of microsimulation traffic models

Austroads
promoting improved road transport outcomes

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The use and application of microsimulation traffic models

Austroads
Sydney 2006

Austroads profile

Austroads is the association of Australian and New Zealand road transport and traffic authorities whose purpose is to contribute to the achievement of improved Australian and New Zealand road transport outcomes by:

- undertaking nationally strategic research on behalf of Australasian road agencies and communicating outcomes
- promoting improved practice by Australasian road agencies
- facilitating collaboration between road agencies to avoid duplication
- promoting harmonisation, consistency and uniformity in road and related operations
- providing expert advice to the Australian Transport Council (ATC) and the Standing Committee on Transport (SCOT).

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Austroads membership comprises the six state and two territory road transport and traffic authorities and the Australian Department of Transport and Regional Services in Australia, the Australian Local Government Association and Transit New Zealand. It is governed by a council consisting of the chief executive officer (or an alternative senior executive officer) of each of its eleven member organisations:

- Roads and Traffic Authority New South Wales
- Roads Corporation Victoria
- Department of Main Roads Queensland
- Main Roads Western Australia
- Department for Transport, Energy and Infrastructure South Australia
- Department of Infrastructure, Energy and Resources Tasmania
- Department of Planning and Infrastructure Northern Territory
- Department of Urban Services Australian Capital Territory
- Australian Department of Transport and Regional Services
- Australian Local Government Association
- Transit New Zealand

The success of Austroads is derived from the collaboration of member organisations and others in the road industry. It aims to be the Australasian leader in providing high quality information, advice and fostering research in the road sector.

SUMMARY

Microsimulation traffic models (MSTMs) have in recent years become accepted as useful tools amongst road and transport authorities to analyse and identify solutions for traffic and transport planning. The technique of microsimulation, or simulating the movement of individual vehicles in a traffic system, has long been used for traffic analysis. The synergy between information technologies and traffic engineering in recent years has enabled a new generation of microsimulation models now available for road and transport managers to analyse complex traffic operations. These applications are often complex, congested situations that are normally beyond the domain of analysis using conventional analytical or macroscopic modelling procedures.

Microsimulation is still an evolving science, but great progress has been made with packages now providing functions that range from visualisation and simulation to the more recent development of emulating the operation of a signal control system – by interfacing a signal system such as SCATS and STREAMS to a microsimulation software package. Visualisation with quality three-dimensional graphics is particularly useful for presenting solutions that address politically sensitive issues. It is important that the inducement and saleability of good graphics is matched with technically accurate and robust results on network performance with the use of an MSTM.

The purpose of this Austroads Project NS1016 (*Understanding how microsimulation traffic models can be used to improve the performance of the road network*) is to gain understanding of the models so that practitioners and decision makers can contextualise results from MSTMs and ascertain the validity of visual presentations. The project aims to provide guidelines on the limitations and usage of MSTMs for the operation of a road network. The guidelines have been prepared in three components: a core Guide, a set of Commentaries and a Repository of modelling reports. The core Guide identifies the roles and limitations of MSTMs and recommends the following issues as potentially appropriate for using an MSTM:

- complex traffic operation schemes, e.g. bus priority, advanced signal control, incident management, different modes of toll collection
- significant conflicts amongst different road users, e.g. pedestrians, cyclists, buses
- major road works on traffic movements, e.g. lane closures, one-way system, toll plazas
- politically sensitive projects that could benefit from visualisation
- planning and design of high-value projects with potential large savings if detailed MSTMs are prepared
- emulation of the operation of a dynamic signal control system, with a simulated network driven directly by the control system, with significant saving in signal timing preparation and optimisation
- town centre studies
- tram and light rail operations.

All modelling approaches have their own limitations. It is important for a project manager to adopt a fit-for-purpose approach in undertaking modelling studies. Microsimulation modelling aims to analyse complex traffic conditions. They require more parameters for model development and calibration, and hence more resources and higher costs than conventional modelling techniques. There may be easier ways to solve the problem and it is pertinent to consider all alternative approaches.

This report describes in detail the following key steps in the development of a microsimulation model:

- identifying study objectives and project scoping
- selecting the right software package for microsimulation
- developing a base model
- model calibration and validation
- auditing model output results.

Road and transport authorities are using a range of software packages for developing an MSTM. Some adopt one or more of the four packages: PARAMICS (Q- and S-Versions), AIMSUN NG and VISSIM. Brief descriptions of these software packages are included in Commentary A as reference information. Further, the following factors have been identified as important in the choice of a package:

- level of expertise within a project team and the road/transport agency
- level of support from the software supplier
- training required to get a base model developed
- level of transparency of the package structure and outputs so that meaningful interpretation of model results and hence decision making are possible
- experience in applying a package for different network sizes, i.e. the scale of application
- suitability of the facilities and parameters in a package to simulate the phenomenon that an agency wishes to investigate, e.g. pedestrian movements
- sensitivity of the required parameters on specific features to be analysed in proposed scenarios
- accuracy of vehicle movement logic such as gap acceptance, lane changing and car-following manoeuvres.

This project has not attempted to compare these packages. The aim of this project has been to make the best use of these packages through the core Guide, Commentaries and the Repository of modelling reports.

The calibration process is a critical step in the development of a useable MSTM and involves varying operational parameter values within acceptable or specified ranges until the modelled outputs and observed outputs agree to an acceptable level of accuracy. Various target accuracies currently adopted by road authorities together with overseas practices are reported in this report. Transport for London (2003) adopts the practice that the following model outputs should be within 5% of observed values:

- maximum flow at a stopline by vehicle types
- capacity per intersection approach
- maximum queue length per lane
- average delay per vehicle per lane including buses
- travel time for buses and general traffic.

This calibration practice is sufficiently comprehensive without requiring 100% accuracy in all aspects of model outputs, and should be considered in a microsimulation study.

Other findings from this project are as follows:

(a) Static and dynamic input data requirements for MSTMs are quite well-defined for model development. A check list of these input data types is included in this report. Similarly, output data at the link, corridor and area levels are also described.

(b) The procedures for model calibration and validation are reasonably standardised and the guidelines provided in this report, if followed, are adequate to produce useful output.

(c) The simulation of lane changing phenomena has been identified as a critical issue affecting the accuracy of model outputs. It is important therefore to ensure that model outputs such as delay and travel time at a link level be carefully audited. A useful way to achieve good correlation with observed data is to increase awareness to encourage lane changes and avoid lane blocking situations. This may involve increasing signposting distances for simulated vehicles to be more aware of hazard situations ahead and other parameters such as aggressiveness and familiarity.

(d) It is difficult to adopt a common set of operational parameter values for commonly used microsimulation packages because most calibration parameters are software specific. It is also unlikely that the same set of parameters could be used in different applications (or models) developed using a particular package. A standard set of parameters for model calibration for Australian traffic conditions is valuable and is the reason for developing a Repository of modelling cases. The Repository will take time to be populated and the principles for the choice of some parameters are compiled in Table 5.1 from the Repository and literature reviews to facilitate model development.

(e) Standard outputs from an MSTM often require post-processing to provide more appropriate performance metrics for decision making. For example, apart from a whole-of-network performance metric, outputs may have to be reported also at the spatial level of a detector, segment, stream or corridor. Another example is that the volume/capacity ratio may not be an accurate indicator of performance and other metrics such as level of service would have to be derived from model delays, travel times or speeds.

It is recommended that the Repository of modelling reports be updated at regular intervals as an on-going task beyond this project. This on-going task may include specific tests of software parameters and benchmarking against accepted analytical and macroscopic model values. The organisation of an Austroads microsimulation users group should facilitate such a task and is also recommended.

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1 INTRODUCTION

Microsimulation traffic models (MSTMs) have in recent years become accepted as useful tools amongst road and transport authorities to analyse and identify solutions for traffic and transport planning. The technique of microsimulation, or simulating the movement of individual vehicles in a traffic system, has long been used for traffic analysis. The synergy between information technologies and traffic engineering in recent years has enabled a new generation of microsimulation models now available for road and transport managers to analyse complex traffic operations.

The purpose of this Austroads Project NS1016 (*Understanding how microsimulation traffic models can be used to improve the performance of the road network*) is to gain understanding of the models so that practitioners and decision makers can contextualise results from MSTMs and ascertain the validity of visual presentations. The project aims to provide guidelines on how MSTMs can be used to improve the operation of a road network.

This report provides the guidelines in three components: a core Guide, a set of Commentaries and a Repository of modelling reports. The core Guide will be suitable for road managers to gain a broad appreciation of the usage and limitations of an MSTM, and for modellers to undertake the development of a model in a microsimulation study.

The Commentaries are to provide explanatory information on microsimulation packages available and their basic structures. A sample consultant brief to assist road and transport authorities in contracting out microsimulation studies is also included as one of the Commentaries. Some indicative values on the frequency distribution of vehicle length and vehicle-kilometre travelled (VKT) is provided in another Commentary.

The Repository aims to be a compilation of modelling reports or case studies in MSTMs amongst road authorities and research/academic studies undertaken in the local context. Each modelling report provides a brief description of a case study, parameter values employed in the study, key conclusions and any special modelling technique employed for the study. Through these modelling reports, the knowledge of using MSTMs becomes more accessible to modellers.

The contents of this report are structured as follows:

- The core Guide – this part addresses the following issues:
  - what is a microsimulation model? (Section 2.1)
  - roles of an MSTM (Section 2.2)
  - limitations of microsimulation (Section 2.3)
  - organising a microsimulation study (Sections 3.1 to 3.3)
  - calibration and validation of an MSTM (Sections 3.4 and 3.5)
  - auditing (Section 4).
- Commentaries:
  - microsimulation models available (Commentary A)
  - microsimulation fundamentals (Commentary B)
  - sample consultant brief (Commentary C)
  - distribution of vehicle lengths and VKT (Commentary D).

- Repository of modelling reports – it takes time to build up the knowledge base of using MSTMs and this project represents a start in building up the Repository. It is anticipated that the Repository will continue to grow beyond the duration of this project.

It is useful to distinguish between the terms ‘a model’ and ‘a software package’. In this report, a model represents an application of a software package to analyse a traffic situation, i.e. to undertake a microsimulation traffic study. The acquiring of a software package is only an initial step in developing a model.

Further, this report does not endorse any particular software package. Software packages are not compared in this project. It is worth emphasising that a key aim of this project is to assist modellers to make the best use of a package and overcome general issues related to microsimulation, thus ensuring consistency in the implementation of MSTMs.

2 BACKGROUND

Many studies on microsimulation modelling have been completed by road and transport authorities in recent years and the guidelines in this report make use of their current practices. References from overseas on the subject are valuable and include the following:

- SMARTEST: review of micro-simulation models (Algers et al. 1998; University of Leeds 2000).
- Improving the applicability of simulation models to UK conditions (Halcrow Group Ltd. 2002).
- The use and application of microsimulation traffic models (Halcrow Group Ltd. 2003a).
- Traffic micro-simulation modelling guidance: review of models (Halcrow Group Ltd. 2003b).
- Micro-simulation modelling guidelines for Transport for London (Transport for London 2003).
- Guidelines for applying traffic microsimulation modelling software (US Federal Highway Administration, FHWA 2004).

Textbook references are also useful on the basic principles of microsimulation models and include Drew (1968), Young (1984) and May (1990). Other sources of information are included in the list of references of this report.

2.1 What is microsimulation?

The management of a road network often requires the forecasting of the impacts of implementing various traffic management measures. The impact involves the road itself, the whole corridor and its abutting areas. These measures include, for example, signal coordination, high-occupancy vehicle (HOV) lanes, one-way systems, different types of intersection control (priority sign, signal or roundabout), signal priority, driver information systems and incident management. Apart from road vehicles, trams, light rails, pedestrians and cyclists can also be simulated.

Traffic modelling techniques can be broadly classified into the following four types:

(a) *Analytical modelling* – this technique relates directly to traffic flow theory and is often a set of equations governing driver behaviour such as gap acceptance, lane changing, car–following, or platoon dispersion. The combination of analytical models can constitute a more complex analytical model for traffic analysis. Individual sets of analytical equations can also act as sub-models in other modelling techniques. Analytical modelling is sometimes also known as microscopic modelling.

(b) *Microscopic simulation* – the movement of a vehicle in a microscopic simulation is traced through a road network over time at a small time increment of a fraction of a second. A detailed simulation of vehicle-road interaction under the influence of a control measure is therefore possible. This technique is useful for a wide range of applications but requires more computational resources. Random number generators are involved and the calibration of these models requires more effort, and it is difficult to optimise model parameters, e.g. signal settings.

(c) *Macroscopic simulation* – vehicles in a macroscopic simulation are no longer simulated individually. Vehicle movements are often simulated as packets or bunches in a network with a time step of one or several seconds. An analytical model such as the platoon dispersion model is used to govern the movement of a vehicle platoon along a road link. A macroscopic simulation is deterministic by nature and is useful for network design and optimisation.

(d) *Hybrid simulation* – this technique combines a detailed microscopic simulation of some key components of a model (e.g. intersection operations) with analytical models (e.g. speed-flow relationships for traffic assignment). This technique is sometimes known as *mesoscopic* simulation and provides more detail to what is normally an assignment-only model. It is also possible to interface a microsimulation model with a real-time signal control system such as SCATS - an area of active research and development at RTA NSW (Millar et al. 2003 and 2004).

In recent years, Intelligent Transport System (ITS) measures such as adaptive signal control algorithms, incident management strategies, active bus/tram priority and driver information systems have been introduced to freeways and arterial roads. These are complex traffic processes and traffic flow theories are often unable to accurately predict the impacts in terms of delay, queue length, travel times, fuel consumption and pollutant emissions. Computer models equipped with advanced graphical facilities have been developed in recent years to meet the needs of a road manager.

Computer software has long been developed to simulate traffic management processes amongst road authorities in Australia (e.g. Cotterill et al. 1984; Tudge 1988). Past research also includes the development of car-following and lane changing algorithms for microsimulation (Gipps 1981 and 1986), the review of eight small area traffic management models (Luk et al. 1983), and the comparison of macroscopic and microscopic simulations (Luk and Stewart 1984; Ting et al. 2004). More recent research includes the assessment and further development of car-following and lane changing algorithms (Hidas 2004 and 2005; Panwai and Dia 2004). A key finding is that microscopic simulation models require careful calibration to produce meaningful results, especially in the lane changing behaviour in congested conditions.

Amongst road authorities, the microsimulation package TRARR from ARRB has also been used for rural road operations since the early 1980s (Hoban 1986).

In recent years, MSTMs have also been classified into the following three categories:

- *Visualisation* MSTM – the microsimulation model is used for the basic function of displaying movements of vehicles and pedestrians, and how traffic management measures affect these movements, e.g. fixed-time signal control, priority intersections and roundabouts.
- *Simulation* MSTM – the model offers the extra functions of simulating the interaction of vehicle and pedestrian movements with simulated control measures such as freeway ramp metering, vehicle-actual signal control and variable message signs based on traffic flow data from simulated detectors.
- *Emulation* MSTM – this is a special form of hybrid simulation; as mentioned earlier, simulated detectors send traffic flow information to a ‘real’ signal control system that optimises signal timings and sends them back to an interface representing simulated signal controllers; Figure 2.1 illustrates the topology of an emulation MSTM for modelling adaptive signal control, where *WinTraff* is a software device emulating a bank of signal controllers.

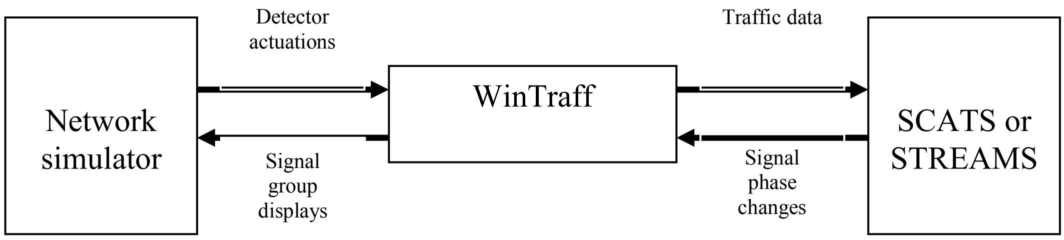

Figure 2.1: Topology of an emulation MSTM for the modelling of adaptive signal control

2.2 The role of microsimulation

Microsimulation traffic models can produce visual outputs by which lay and technical people can discuss the respective merits of traffic and transport proposals. The models can represent road and transport networks and their operation and the behaviour of vehicles and travellers in more detail, and broaden the range of applications. The visual representation of problems and solutions in a format understandable to lay people, project managers and modellers is a useful way to gain more widespread acceptance of complex strategies.

These strategies have to deal with rising levels of network congestion and search for multi-modal and integrated use of the networks. However, it is important to recognise that extra modelling effort and costs are inevitable when compared with conventional modelling approaches. These drawbacks as well as the potential benefits should be understood before a decision to develop a microsimulation model is taken.

Some pertinent questions to consider include:

- What are the purposes and functions of the proposed model?
- Would a conventional model meet the requirements sufficiently well?
- Is microsimulation the only available or suitable methodology for this application?
- How is the model to be funded, managed, further developed and used?
- What is the simplest and cheapest way to obtain the results and usage needed?
- What is the nature and quality of the model needed?

In developing any traffic model, including a microsimulation model, it is essential that the model needs to be fit for the purpose. The quality of the model is heavily dependent on the quality of the input data. Model calibration, validation, testing and forecasting procedures, documentation and reporting should follow existing best practices, such as those described in Sections 3, 4 and 5.

2.2.1 When and why microsimulation traffic models are needed

Microsimulation can potentially offer benefits over traditional traffic analysis techniques in three areas: clarity, accuracy and flexibility as follows:

Clarity – a comprehensive real-time visual display and graphical user interface illustrate traffic operations in a readily understandable manner. The animated outputs of microsimulation modelling are easy to understand and simplify checking that the network is operating as expected, and whether driver behaviour is being modelled sensibly. With microsimulation, what you see is what you get. If a microsimulation model does not look right, then it probably is not right, and vice versa (Druitt 1998).

Accuracy – by modelling individual vehicles through congested networks, the potential exists for more accurate modelling of traffic operations at complex and simple intersections or merges. Individual drivers of vehicles make their own decision on speed, lane changing and route choice, which could better represent the real world than other modelling techniques. For examples, analytical and macrosimulation models often use fixed value of saturation flows and all vehicles are assumed to behave in the same manner. In contrast, microsimulation models represent individual vehicles and detailed networks. A parameter such as the saturation flow can actually be an output of the model.

Flexibility – a greater range of problems and solutions can be assessed than with conventional methods, e.g. vehicle-activated signals, demand dependent pedestrian facilities, queue management, public transport priorities, incidents, toll booths, road works, signalised roundabouts, shock waves, incidents or flow breakdown, or slip road merges. The interaction between different vehicle types and with other modes (bus, tram and light rail) can all be represented.

The scale of application of microsimulation models depends on the size of the computer memory and on the computer power available. Models that have not been built to run simulations on large size networks but rather to achieve highly specific objectives have a small scale of application, typically less than one hundred vehicles. The scale of application varies from a typical scale of about 20 km, 50 nodes, and one thousand vehicles, to a large application of 200 nodes and many thousands of vehicles.

2.2.2 Problems and issues appropriate for microsimulation

Algers et al. (1998) reported on surveys taken of microsimulation model users (Table 2.1). The survey revealed that 84% of users use traffic simulation for the design and testing of control strategies as the most common application. The second most common application was the evaluation of large-scale schemes at 45%. Forty percent of the users employed traffic simulation for on-line traffic management or evaluation of product performance. Other areas of application were research and education. The survey also asked about the desired future use of microsimulation models and this revealed that similar percentages apply for testing of control strategies and evaluation of schemes. For on-line traffic management and evaluation of product performance, the desired future use of microsimulation rose to 32%.

The issues generally accepted as appropriate for analysis using MSTMs include the following (see, e.g. Transport for London 2003):

- complex traffic operation schemes, e.g. bus priority, advanced signal control, incident management, different modes of toll collection
- significant conflicts amongst different road users, e.g. pedestrians, cyclists, buses
- major road works on traffic movements, e.g. lane closures, one-way system, toll plazas
- politically sensitive projects that could benefit from visualisation
- planning and design of high-value projects with potential large savings if detailed MSTMs are prepared
- emulation of the operation of a dynamic signal control system, with a simulated network driven directly by the control system, with significant saving in signal timing preparation and optimisation
- town centre studies
- tram and light rail operations.

Table 2.1: Survey of usage of microsimulation model

Usage	Present use percentage	Future use percentage
Design and testing of control strategies	84%	84%
Evaluation of large-scale schemes	45%	43%
On-line traffic management	18%	32%
Evaluation of product performance	20%	32%
Other applications	29%	23%

(Source: Algers et al. 1998)

2.3 Limitations of microsimulation

Every modelling technique has its own limitations. MSTMs remain a simplification of reality. This lack of reality is the case for all modelling systems, the difference being that MSTMs simulate the detail directly, and one can argue that it could be closer to reality.

In a past comparative study of eight traffic models, Luk et al. (1983) concluded that there was no single package capable of modelling all of the control measures commonly adopted for traffic management. While the capabilities of current MSTMs and computer technology surpass those available in the past, it still holds that there is no such thing as a perfect model. It is imperative that the practitioner be cognisant that all models are built on assumptions and rules and, in the real world, there will always be exceptions.

The limitations of a traffic model, and those of an MSTM, include (Halcrow 2003a):

- the operation and limitations of a macro- or microsimulation package must be understood in detail for modelling results to be interpreted reliably
- depending on the scale and nature of the model or application being developed, there is likely to be a need for more detailed calibration or validation data than is traditionally collected in traffic studies
- the modelled operation and performance of all aspects of the model must be checked carefully during a simulation so that accuracy and realism is satisfactory. This may require a review of the way individual aspects of driver behaviour are represented, including consideration of the suitability and robustness of default parameter values
- when dealing with modelling features such as mode split or distribution, the issue of achieving a steady-state solution must be addressed.

Various modelling issues specific to microsimulation have been identified in recent years. Some of these have been resolved through the effort of road and transport authorities, software developers and others. Other specific issues that require attention include:

- overtaking to be implemented
- flexibility in specifying driver behaviour in a range of traffic conditions at a local level, e.g. in the proximity of intersections or on a link between two interchanges
- improved modelling of stop-and-go phenomena
- improved modelling of pedestrians and cyclists
- convergence in dynamic traffic assignment

- direct support for roundabouts
- wider range of pollutants resulting from vehicle emissions
- better route choice following an incident
- improved modelling of motorway merges and diverges
- improved modelling of collector and lower road classes
- the effect of reduced lane width.

With decades of experience in microsimulation at the University of California, Berkeley, May (1990) observed that some practitioners see microsimulation as the only approach to every problem. Experiences show that in some cases, the simulation model itself becomes the core focus, rather than the *use* of the simulation model to solve a problem. In other cases, the practitioner concentrates too much effort in small, less significant aspects of the model and loses sight of the model as a whole. It is worth quoting May's observations as follows:

- there may be easier ways to solve the problem; consider all possible alternative ways
- microsimulation can be time-consuming and expensive; do not underestimate time and cost
- microsimulation packages require considerable input characteristics and data, which may be difficult or impossible to obtain
- microsimulation applications or models require calibration, validation and verification or auditing which, if overlooked, could make the model useless
- development of simulation models requires knowledge in a variety of disciplines, including traffic flow theory, computer programming and operation, probability, decision-making and statistical analysis
- microsimulation is difficult unless the model developer fully understands the software platform
- the microsimulation package may be difficult for non-developers to use because of lack of documentation or unique computer facilities
- some users may apply microsimulation packages and treat them as black boxes and really do not understand what they represent
- some users may apply simulation models and not know or appreciate model limitations and assumptions.

In summary, all modelling approaches have limitations. Microsimulation modelling aims to analyse complex, congested traffic conditions and requires more parameters for model development and calibration. MSTMs have some limitations as mentioned in this section and it is important to adopt a 'horses for courses' approach in their usage. The limitations of microsimulation should not deter any road agency from using microsimulation. A modeller must be aware of these limitations, and of the ways to overcome them. Sections 3 and 4, together with the Commentaries and Repository of modelling reports, aim to provide assistance in this regard.

3 ORGANISING A MICROSIMULATION STUDY

The key steps in undertaking a microsimulation study are as follows:

- identifying study objectives and project scoping (Section 3.1)
- selecting the right software platform for microsimulation (Section 3.2)
- developing a base model (Section 3.3)
- model calibration and validation (Section 3.4)
- auditing model output results (Section 4).

The first four steps are described in this section while Section 4 addresses model auditing.

3.1 Study objectives and scoping

A microsimulation study can take up a lot of resources and it is advisable that the analyst (modeller), the project manager and decision maker have a clear understanding on what needs to be achieved. It is worth emphasising that microsimulation is more suitable for site specific or small area analysis (e.g. 5 km × 5 km) over a relatively short time period (e.g. a few hours). The advance in the processing power and memory availability in a PC has enabled the simulation of larger networks over longer time periods.

Some important questions to ask include:

- Why is the analysis needed?
- What are the characteristics of the project being analysed?
- What questions should the analysis answer?
- What are the scenarios (alternatives) to be studied?
- Who are the recipients for the results?
- Have all stakeholders involved been consulted?
- What are the performance indices required to evaluate the scenarios?
- What resources are available?
- What is the scale of the study, both in time (temporally) and in space (geographically)?

3.2 Selecting a software platform

The selection of a software platform for a particular problem depends on the nature of the problem. Road and transport authorities in Australia and New Zealand have been using four of these packages, namely, AIMSUN, PARAMICS (Q- and S- versions) and VISSIM. Commentary A provides general background information on these microsimulation packages. Each of these packages has their own strengths and weaknesses and it is beyond the scope of this report to compare these models. It is, however, important to consider both non-technical and technical factors in choosing a package.

Non-technical factors include the following:

- level of expertise within a project team and the road/transport agency
- level of support from the software supplier
- training required to get a base model developed

- level of transparency of the package structure and outputs so that meaningful interpretation of model results and hence decision making are possible.

It is rare that a single package will fit all types of simulation needs. Some technical issues relevant to the choice of a package are:

- experience in applying a package for different network sizes, i.e. the scale of application
- suitability of the facilities and parameters in a package to simulate the phenomenon that an agency wishes to investigate, e.g. pedestrian movements
- sensitivity of the required parameters on specific features to be analysed in proposed scenarios
- accuracy of vehicle movement logic such as lane changing and car-following manoeuvres.

3.3 Base model development

Like most traffic studies, a successful microsimulation study requires clear objectives and solid scope of work and schedule. Milestones need careful monitoring and deliverables should be closely reviewed. Typical key milestones and deliverables of a microsimulation study are summarised in Table 3.1 (adapted from FHWA 2004).

Table 3.1: **Milestones and deliverables for a microsimulation study**

Milestone	Deliverable	Contents
Study scope	* study scope and schedule * proposed data collection plan * proposed calibration plan * coding quality assurance plan	Study objectives, time and space domains of study, alternative data collection plan, error-checking procedures on model coding, calibration and validation plans
Data collection	* data collected * data collection report	Data collection procedures, quality assurance, summary of data collection results
Model development	* 50% coded model	Software input files
Error checking	* 100% coded model	Software input files
Calibration and validation	* calibration test report * validation test report	Calibration results, adjusted parameters and rationale, achievement of calibration and validation targets
Auditing or alternative analysis	* auditing report	Broad level checking (‘sanity check’); alternative analysis results
Final report	* final report * technical documentation or modelling report	Compiling previous reports; documentation of model development and calibration; software input files

Adapted from FHWA 2004

A typical problem of a microsimulation study is the lack of input data for establishing a base model and calibration. Sufficient resources should be allocated for this phase of work. As a guide, about 50% of the budget is for tasks leading to the coding and development of a base model, 25% for calibration and validation, and 25% for scenario analysis and documentation.

3.3.1 Input data preparation

Due to the increased complexity of MSTMs when compared to conventional model types, the requirements for input data are greater. Data is required for the purposes of constructing and calibrating the model, and then to validate it. The use of Computer Aided Design (CAD) drawing as an overlay map is an efficient tool for building a network model. Driving through a road network with a Global Positioning System (GPS)-equipped vehicle is also valuable in providing network detail. Digital aerial photographs of a road network are now readily available for network building, visualisation and checking, and are accommodated in the current generation of MSTMs.

Input data can be divided into the following two types:

- *Static data* – this data type represents the physical and technical characteristics of the network. Examples are the number of lanes, lane width and occupancy, location of intersections and their control mechanism. When bus or other transit services are modelled, the input data should include the location, geometry and operation of bus stops and terminals. This data can be derived from:
  - paper maps of intersections and the road network
  - network data imported from other models
  - digitised maps (drawings) and aerial photographs.

  These data types are then used to define network characteristics such as intersection geometry, link lengths, lane widths, stopline and bus stop locations. Priority rules may be defined.

- *Dynamic data* – this data type refers to trip or traffic demands on the network, represented by turning volumes or an origin-destination (OD) matrix and classified by vehicle types. Traffic signal timings that respond to traffic demand are also classified as dynamic data. Demand matrices by vehicle type, time period, OD pair and volume may be derived from:
  - traffic counts classified by vehicle type such as passenger cars, light goods vehicles, heavy goods vehicles, taxis or any vehicle types that are the subject of simulation
  - public transport (buses, trams, light and heavy rail) and their schedules
  - vehicle registration plate surveys or roadside interviews, enabling the generation of OD matrices
  - matrices developed from existing macro models.

In addition, the following default attributes in the microsimulation software package may need to be changed:

- vehicle length distributions (see, e.g. Commentary D)
- desired vehicle speed distributions
- vehicle acceleration and deceleration rates
- driver awareness and aggressiveness parameters, including those for car-following, gap acceptance and lane changing.

Microsimulation models can also be interfaced with other transport models for extra input data. For example, an external assignment model might be used to provide a microsimulation model with route choice data.

While microsimulation has been applied to traffic analysis for quite some time and there has been renewed interest in recent years, the standardisation of input (and output) data has not been formalised. This is due to different software platforms developed over time by different firms or individuals. Nonetheless, a body of input/output requirements is now available and these requirements are reasonably consistent across the few packages currently used by road authorities.

Signposting (or looking ahead) are associated with traffic signals, lane additions, lane drops, on-ramps or off-ramps. Signposts provide the driver with information in advance of the hazard so that they have time to react by changing lanes. For example, signposting is specified in PARAMICS in terms of two distances. The first distance is when a driver is made aware of the upcoming hazard, and the second and shorter distance is when a vehicle can react to the hazard in selecting an appropriate lane. For a high speed environment such as a freeway, longer signposting distances usually help the flow of traffic at hazard points - 1.4 km and 0.6 km were recommended in Gardes et al. (2002). Other MSTM packages have similar parameters to assist the proper simulation of lane-changing behaviour (see further discussion in Commentary B).

Table 3.2 provides these data items which make use of the materials in previous sections and the literature reviewed. The list of items is not an exhaustive list of required input and output data, but is expected to be available for input into an MSTM and most MSTMs use similar input data sets (see Section 3.3.2 on output data).

Table 3.2: Input and output data requirements

<table>
<tr><th>Category</th><th>Parameter</th><th>Comments</th></tr>
<tr><td rowspan="5">Input network coding data</td><td>Link length</td><td rowspan="2">Check the length for left and right turn bays, and gradient and width of each lane</td></tr>
<tr><td>Number of lanes</td></tr>
<tr><td>Intersection layout</td><td>Check lane configurations, markings, turn prohibitions</td></tr>
<tr><td>Signal timings</td><td>Check cycle, phase and offset times, phase sequences; for VA signal, check max and min green times, detector locations and configurations, gap and waste times</td></tr>
<tr><td>Link (cruise) speed</td><td>Measure uninterrupted average travel time; use spatial speed</td></tr>
<tr><td rowspan="2">Input demand data</td><td>OD flows</td><td>Retrieve from assignment outputs</td></tr>
<tr><td>Link flows and turning percentages</td><td>Check through and turning movements and their traffic composition</td></tr>
<tr><td rowspan="4">Input data on driver behaviour</td><td>Gap acceptance</td><td rowspan="2">Observed on-site if necessary and refer to background theory (e.g. Austroads Guide to Traffic Engineering Practice Part 1 – Traffic Theory, or see Commentary B)</td></tr>
<tr><td>Car-following</td></tr>
<tr><td>Aggressiveness</td><td rowspan="2">Fine-tune from on-site observations; high aggressiveness index aids lane changing to fast lanes and high awareness index avoids lane blocking and sudden manoeuvres near a signal stopline; also proper use of signposting</td></tr>
<tr><td>Awareness</td></tr>
</table>

3.3.2 Error checking and output data

It is important to ensure that the physical characteristics of a facility (intersection, arterial road or freeway) are accurately represented in the model network geometry. Once a network is built, it can be checked by following individual vehicles travelling through the network and looking at instantaneous vehicle positions and speeds – this visualisation facility is readily available from the current generation of MSTMs. When the geometry is not correct, vehicles may be forced to make sharp turns at the beginning and end of road links. A drop in vehicle speeds would occur due to the vehicle reacting to the geometry of the turn and reducing speed to make the turn safely. Due to vehicle braking, shock waves can also occur. This could lead to the disruption of traffic flow, and the generation of vehicles in nearby origin zones will also be affected.

In general, a microsimulation model should provide summary statistics suitable for performance analysis at the level of a link, corridor and area. It should be able to provide traffic flow characteristics at 'virtual' detector locations, simulating an automatic counting station. Most MSTMs allow the assessment of events, which include lane blockages and vehicle conflicts. Modules to assess fuel consumption and exhaust emissions are usually available.

As already mentioned, modern MSTMs can provide high quality visualisation of the output. This helps checking the operation of embedded algorithms and provides an easy-to-understand display of model applications to non-technical people.

Some typical outputs are as follows:

- Animations of the traffic network showing simulated traffic, signals, bus stations, bus routes and parking zones; general attributes for links, nodes, bus routes, bus stations, etc.
- Isolation and presentation of statistical outputs on a user-selected area or node within the simulated network. The results from an individual simulation run can be used to visualise the following range of statistics, which may be numeric or represented as charts:
  - simulated vehicle paths
  - traffic flow volumes by link and turn
  - maximum queue lengths and blocking back
  - traffic density
  - speed and delay
  - simulated journey time data
  - user-customised link data such as Level of Service (LoS).
- Environmental estimations such as fuel consumption and exhaust emissions.
- The network and simulated vehicles animated in two dimensions (plan view). Links in the network can be coloured to represent different values for a set of traffic measurements (for example, a red shading indicating heavy flows on that link).
- Results exported as a report in ASCII text format, which can in turn be imported into documents, spreadsheets or databases for further analysis. Simulation outputs may also be stored as ASCII text files or linked to a database using Open Database Connectivity (ODBC). Through ODBC, simulation results may be imported into software packages such as Excel, Access, Minitab and SPSS.

- simulation outputs processed for graphical displays, e.g. three-dimensional animation. As an illustration, the following features are provided using the 3D component of AIMSUN NG:
  - three-dimensional vehicle shapes (e.g. in 3D-studio .3DS format) assigned to each element in the simulation (vehicles, trees, buildings, bridges, etc.)
  - the user having as many views and virtual cameras as desired within the simulation area; cameras set to follow a path ('helicopter view')
  - animations saved as video files (e.g. in AVI format) and snapshots during the animation saved as picture files (e.g. in JPEG, PNG, BMP or GIF formats).

It is important also to recognise that the standard outputs from most microsimulation software packages may not provide appropriate information for road and transport managers to make decisions. The post-processing of standard outputs is often necessary. Some key examples include:

- it is necessary to analyse and report performance indices or metrics at different spatial levels of aggregation, e.g. detector, segment (or link), route (or stream) and corridor (or whole-of-network)
- there is also the need to analyse and report performance metrics in different study periods, e.g. the peak one hour, a simulation period of two to three hours a.m. or p.m., or the period when an incident occurs including the time when network returns to normal
- capacity is not an explicit output of a microsimulation model even though capacity or maximum flow is useful to check or calibrate an MSTM; the level of congestion therefore cannot be specified accurately in terms of the volume/capacity ratio or the degree of saturation
- there is therefore the need to have a range of performance metrics different from standard outputs, e.g. level of service (LoS) for a freeway, an intersection or an arterial road; LoS can be derived also from delay, density or speed values from a microsimulation model (see, e.g. Austroads (1988) Guide to Traffic Engineering Practice: Part 2).

An example of post-processing of MSTM outputs for the demonstration of using microsimulation as a training aid for incident management was reported in Luk et al. (2005) under Austroads Project NS1017 (*Improving Traffic Incident Management)*.

3.4 Calibration procedures

Calibration is the process of changing the parameter values in a model in order to achieve agreement between simulation results and observed data. It is necessary to calibrate a model if the simulation results are to be trustworthy and used to support decisions in traffic management. The importance of calibration cannot be overemphasised. FHWA (2004) reported recent tests of six different software programs for predicting freeway speeds – calibration differences of 13% in the predicted freeway speeds for existing conditions increased to differences of 68% for future conditions.

The objective of calibration is to improve the model's ability to reproduce local driver behaviour and traffic performance characteristics such as travel time, delay or queue length by varying model parameter values from the default values supplied by the software supplier. Many parameters are often involved in a microsimulation model. It is a good practice for a user to adopt a calibration strategy. Some preliminary considerations are as follows:

- accept those default parameters that can be used with confidence
- limit calibration to a workable set of parameters

- global parameters are those that affect the operation of a network model as a whole and are calibrated first
- local or site specific parameters are then calibrated, e.g. those for a road link
- a smaller time step for simulation gives more accurate results, e.g. a time step of 0.2 s allows more accurate simulation of driver reaction than a time step of 1 s, but requires more time to run a simulation; the driver reaction time is also preferably an integral multiple of the time step, e.g. reaction time = 0.8 s and time step = 0.2 s or 0.4 s
- allow the model to settle down (e.g. by filling a network with vehicles) before initiating calibration; a rule of thumb is to have a warm-up period equal to twice the travel time for a vehicle to traverse from one end of a network to the furthest destination at a free flow speed
- undertake sufficient runs using different seeds for the random number generators; five to six runs are recommended.

The following four steps are recommended as good practice for calibrating MSTMs (adapted from RTA NSW and FHWA recommended practices):

- network depiction
- calibrating capacity
- calibrating demand
- calibrating performance.

3.4.1 Network depiction

The modeller should check (and calibrate) the physical representation of the network. Examples for network calibration include answering the following questions:

- Are all specified intersections included in the model?
- Do all intersections have the right number of lanes and do they have their correct controls?
- Are all signal phasing and timings correct?
- Do all roundabouts have the correct number of entry, exit and circulating lanes?
- Do all roads have the correct number of lanes?
- Are all merges and diverges correct?
- Are all bus routes correct and bus stops in the right place?

If necessary, the modeller should recommend further data collection in order to produce an accurate model of the study area.

3.4.2 Calibrating capacity or maximum flow

This calibration step adjusts global and link-specific parameters in a simulation model to best replicate capacity values from local field measurements or acceptable historical values. This is an important step because capacity has a significant effect on predicted performance indices such as delay and queues.

The key parameters that control model capacity values are:

- mean headway (a global parameter in PARAMICS)
- driver reaction time

- critical gap for lane changing
- minimum separation under stop-go conditions
- start lags at signalised intersections
- gap acceptance for opposed turns.

It is common to use the following objective function in optimising model parameters to obtain the best match to field-observed capacity values:

$$\text{Minimise mean square error} = \frac{1}{N}\sum_{i-1}^{N}(M_i - O_i)^2$$

where M_i and O_i are the model and observed values of capacity and N is the number of observations. The model parameters must be varied within acceptable limits.

3.4.3 Calibrating demand

Traffic demand data in an MSTM is represented in one of the following two options:

- input link flows, traffic composition and turning percentages
- import an OD matrix and the microsimulation model assigns traffic to the network; the OD matrix can be specified as a time-sliced matrix to represent the variation of demand over, say, a peak period of an hour.

Experience from various modelling studies suggests that specifying an OD matrix as input rather than link flows and turning percentages is recommended because it allows vehicles to have more opportunities to plan a lane change.

Fine-tuning at the link-specific level includes adjustments to link geometry and speeds (or costs) so the target model flows can match observed flows. If the model cannot produce similar traffic levels, then there could be issues related to the modelling of lane changing (and hence lane blocking), especially at high levels of congestion, i.e. volume/capacity ratios larger than 0.80.

The current practice of RTA NSW is to calibrate demand in terms of cordon and screenline flows. Cordon and screenline flows should be compared in each direction separately and preferably in half-hour periods. The total cordon and screenline flows, with more than five counts, should be within 3% and 5% of hourly observed counts, respectively. Further, for each hour, the following tabulation should be made for each road in the cordon and in each screenline:

- percentage within 20% or 200 vehicles per hour equivalent with a target of 95%
- percentage within 10% or 100 vehicles per hour equivalent with a target of 90%
- percentage within 5% or 50 vehicles per hour equivalent with a target of 80%.

Note that the wide range of traffic volumes on individual links within a study area will usually require some re-consideration of the above thresholds, and adoption of appropriate thresholds based on relevant data.

Every attempt should be made to ensure that there is internal consistency in traffic volumes for every link and node. Unaccounted increases and decreases in volumes between nodes should be checked and mid-block source or sink may have to be introduced to achieve consistency.

3.4.4 Calibrating performance

This is the final step of model calibration. The overall traffic performance predicted by the fully functioning model is compared to the field measurements of performance indicators such as travel time, delay or queue lengths. The user or analyst refines link free-flow speeds and link capacities to better match field measurements. The changes made at this step may compromise the previous steps of calibration; these changes should be made sparingly. Nonetheless, this step is a legitimate step to ensure the overall model performance is acceptable. The iterative nature of calibration is illustrated in Figure 3.1, which summarises the various steps for calibration.

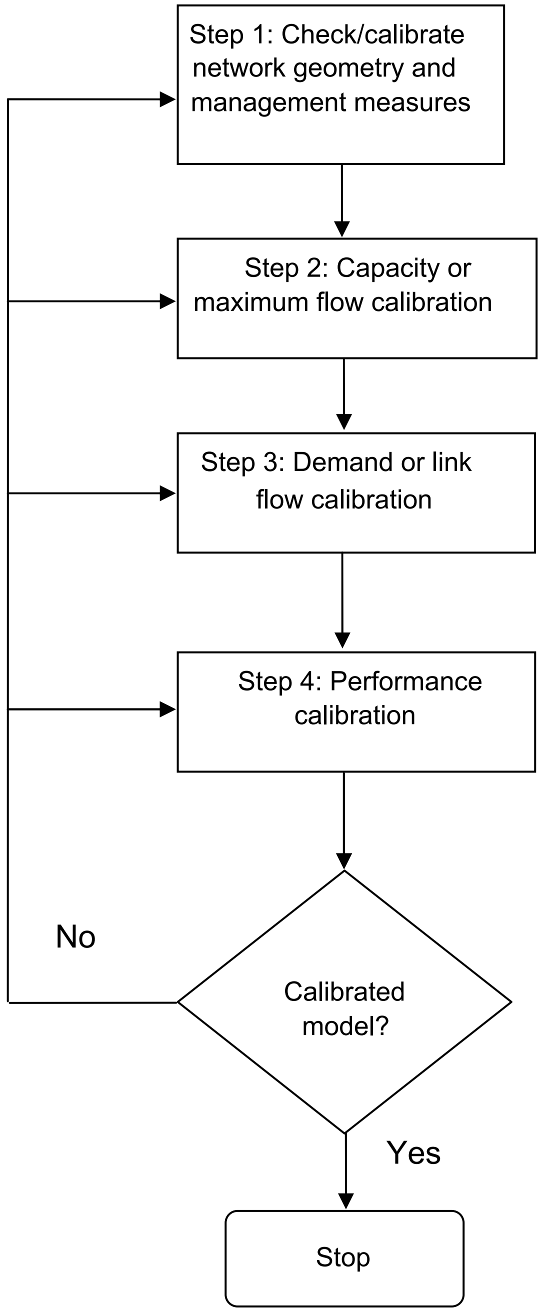

Figure 3.1: The calibration process

It is useful to have some targets to determine whether calibration has been completed. Table 3.3 summarises the values supplied by RTA NSW and those reported in FHWA (2004). Other subjective assessments should also include:

- critical intersections – compare hourly flows and queue lengths of each movement from the model with observed values; also compare intersection delays if available
- cycle lengths – compare cycle lengths if vehicle-actuated (VA) or SCATS operation are simulated
- distribution of errors - it is likely that certain areas or functions will be better calibrated than others in a complex model; it is therefore essential that confidence intervals be determined within the model and presented graphically (see also Section 3.5 on model validation)
- level of congestion – because capacity is not a well-defined metric in an MSTM, the volume/capacity ratio should be analysed in conjunction with other performance metrics to determine the true level of congestion, e.g. density, delay and speed (or travel time).

A key usage of MSTMs is to investigate an application in congested traffic conditions, which usually present challenges to modellers in getting sensible performance metrics. A model at near- or oversaturated conditions tend to become unstable, which is unavoidable. Anecdotal evidence suggests that a near- or oversaturated model may or may not be working as expected using the same set of input conditions apart from differences in random number generation. Sometimes vehicles in a software package may *jam up*, but other software may *destroy* or suppress some vehicles to get the model working.

It is therefore important to establish that a model is working properly when demand is below capacity. A very simple procedure is to reduce the OD matrix by 50% if necessary and study the operation of the model and its output statistics (see, e.g. Ting et al. 2004). A sensitivity analysis with respect to the level of demand often reveals useful insights in the application of an MSTM.

Again on the issue of near- or oversaturation, demand is usually suppressed by most microsimulation packages in order to get a model working. This suppression of demand may occur at a traffic generator (the origin), and it is important that the lost demand is recognised by the modeller who must check the relevant data in a software package, e.g. the virtual queue.

Some target values are necessary for the proper calibration of a microsimulation model. The target values for calibration in Table 3.3 are for guidance only and represent current practices of RTA NSW and those recommended in FHWA (2004). The values emphasise that there is no need to achieve 100% agreement between all model and observed outputs. Transport for London (2003) adopts a similar philosophy and the following model outputs should be within 5% of observed values:

- maximum flows at a stopline by vehicle types
- capacity per intersection approach
- maximum queue length per lane
- average delay per vehicle per lane including buses
- travel time for buses and general traffic.

Table 3.3: Model calibration criteria

Criteria and measures (model values versus observed values)	Calibration acceptance targeted	Comments / source
Cordon flow (with more than 5 counts) Screenline flow (with more than 5 counts) All link flows on cordon/screenline - within 20% or 200 veh/h within 10% or 100 veh/h within 5% or 50 veh/h	Accuracy = 3% Accuracy = 5% 95% of link flows 90% of link flows 80% of link flows	RTA NSW
Individual link flows within 100 veh/h for flow < 700 veh/h within 15% for 700 < flow <2700 veh/h within 400 veh/h for flow >2700 veh/h Sum of all link flows GEH* statistics < 5 for individual link flow GEH* statistics for sum of all link flows	 >85% of cases >85% of cases >85% of cases Accuracy = 5% >85% of cases < 4	FHWA (2004)
Travel times for selected routes Median time relative to observed Root-mean-square values (based on 5 runs)	 Within 10% 90% of all routes	RTA NSW
Model stability Total screenline variation between maximum and minimum values Tabulation of minimum and maximum flows of each road link on each cordon and each screenline according to variations of 20% (or 200 veh/h), 10% (or 100 veh/h) and 5% (or 50 veh/h)	 Within 5% To modeller's satisfaction	Five runs using different random number seeds are recommended.
Congestion pattern Inspect the dispersal of queues, the distribution of lane demand, path allocation, etc.	 To modeller's satisfaction	Lane distribution of traffic had significant effect on network delay

* GEH statistic is defined as

$$GEH = \sqrt{\frac{(M-O)^2}{(M+O)/2}}$$

where M is the model estimated volume and O is the observed volume.

3.5 Validation procedures

Validation can be defined as a comparison of model output with observed data independent from the calibration procedure. It is common to collect sufficient input data such that a portion of the input data is for calibration and the rest is for validation. The performance outputs can be travel times that are either link-specific (in seconds, minutes or hours) or flow-weighted to give a network-based index (for example, in veh-h/h). Delay or queue lengths can similarly be compared. Most network models produce both link- and network-based results for analysis.

Flow-weighted or network travel time and network speed are defined as follows:

$$\text{Network travel time} = \sum_{i=1}^{N} t_i q_i \quad \text{veh-h/h}$$

$$\text{Network speed} = \frac{\sum_{i=1}^{N} d_i q_i}{\sum_{i=1}^{N} t_i q_i} \quad \text{km/h}$$

where t_i, d_i and q_i are the travel time (h), distance (km) and flow (veh/h) on link i respectively and N is the number of links used to determine the network performance indices and for comparison.

Because of the randomness of both observed and simulated data, validation should be carried out on a statistical basis. Observed data is random due to the stochastic nature of traffic. Simulated data is random due to the many random numbers involved in simulating traffic operations. A key statistical consideration in model validation is the use of confidence limits.

Let the sample mean and standard deviation of the observed data be $\bar{x}$ and σ respectively. Assuming normality of data, the confidence limits (CL) for a sample size of n and a (1-α) probability are given by:

$$CL_{1-\alpha} = \left(\bar{x} - z_{1-\alpha/2}\frac{\sigma}{\sqrt{N}}, \ \bar{x} + z_{1-\alpha/2}\frac{\sigma}{\sqrt{N}}\right)$$

where $z_{1-\alpha/2}$ is the number of standard deviations that have 1-α/2 area on either side of the mean of a normal distribution curve. For a 95% confidence level, $\alpha = 0.05$ and $z_{0.975} = 1.96$ (the student's t-test can also be used especially for small sample sizes).

Table 3.4 illustrates how simulated results were validated using observed samples of bus travel times in a study in Leeds (Lind et al. 1999). The simulated results suggested that the average travel times on three out of four bus links in a five-stop route fell outside the confidence limits of observed values. Overall, the simulated results agreed reasonably well with observed data.

Table 3.4: Bus travel times between stops

Bus link	Mean travel time (s)	No. of samples (N)	Standard deviation (s)	Lower conf. limit (s)	Upper conf. limit (s)	Average simulated travel time (s)
Stop 1 to 2	21.88	33	4.285	20.42	23.34	24.9
Stop 2 to 3	36.31	16	5.654	33.54	39.08	38.9
Stop 3 to 4	40.87	30	15.90	35.18	46.56	34.6
Stop 4 to 5	39.92	49	12.67	36.37	43.47	44.4

Source: Lind et al. 1999

As already mentioned, in any complex model, it is likely that certain areas or functions will be better validated and calibrated than others. It is essential that confidence intervals be determined spatially (link, corridor and whole network), temporally (a.m. peak, p.m. peak etc.) and functionally (cycle time, degree of saturation, etc.) within the model. These should be presented graphically. If certain areas of the network are less accurate than others or certain time periods or certain vehicle groups exhibit less than desirable levels of calibration or validation, they should be documented within the validation report.

4 AUDITING A MICROSIMULATION MODEL

Auditing an MSTM is broadly defined as a process to verify the results from the model. It can be carried out as a peer review within a road authority or through the service of a consultant. This process can be by means of the following:

- general error checking by an independent analyst
- an independent reviewer who can provide a 'sanity check' on model outputs, especially on the warm-up period and whether the outputs have reached steady-state
- a comparative study of model outputs from several other models if time and budget are available; this could be benchmarking an MSTM with an analytical or macrosimulation model (see, e.g. Ting et al. 2004)
- more statistical analysis
- alternative analysis using different scenarios.

It is worth emphasising the principle behind an auditing process in Akcelik and Besley (2001). Analytical and macro-models are built upon basic parameters of traffic engineering and are considered useful for designs over many years. By benchmarking against MSTM output with analytical or macrosimulation output, important modelling issues can be identified – without implying that analytical and macrosimulation models have no limitations. The use of a single intersection test network to investigate the following two microsimulation issues was recommended:

- queue discharge flow rate at a signalised intersection – this allows better capacity analysis in simulation, including the dependence of capacity on demand flow rates
- lane flow distribution at intersection approaches – this relates to lane changing models embedded in microsimulation.

These tests would verify both the appropriateness of parameters used and the models employed for gap acceptance, car-following and lane changing.

A pro-forma that enables an external auditor to go through the results of a microsimulation model is shown in Table 4.1. It is an adaptation from a pro-forma supplied by RTA NSW and suitable for all microsimulation studies. It also summarises succinctly the key steps in developing, calibrating and validating a microsimulation model.

Table 4.1: Pro-forma for auditing a microsimulation model

Location / route / area	
Project description	
Purpose of modelling	
Model developed by	
Microsimulation software used	
The audit	
Auditor(s) -	
Date(s)	
Model scope description	
Geographical extent	
Years modelled	
Time periods modelled	
Time profiles in: ▪ traffic demand ▪ links ▪ junction control	(Describe time dependent aspects of the model)
Number of zones	
Number of links	
Number of nodes	
Number of junctions	
Number of traffic signals: ▪ fixed time ▪ vehicle-actuated ▪ area traffic control system	
Adequately defined in the brief?	
Work complies with the brief?	
Work adequately documented?	
Network	
Base network	Provide source and/or details
Basic geometry	
Intersection layouts	
Traffic signal controls	
Other network features, e.g. ▪ signposting ▪ ramp metering ▪ adjacent lane interaction ▪ lane restrictions	
Time dependent features	
Carparks	
Spot checks	Provide details
Network scale	
Detailed layouts	
Signal controls	
Visual check of operating model	
Future networks	Provide source and/or details

Basic geometry	
Intersection layouts	
Traffic signal controls	
Other variations from base network	
Spot checks	Provide source and/or details
Detailed layouts	
Signal controls	
Visual check of operating model	
Adequately defined in the brief?	
Work complies with the brief?	
Work adequately documented?	
Vehicle and driver data	
Data type	Provide source and/or details
Default vehicle data used	
Additional or non-standard vehicles used?	
Vehicle proportions	
Headway	
Reaction time	
Other driver parameters, e.g. ▪ familiarity ▪ aggression ▪ awareness ▪ signposting for lane changes ▪ others	
Adequately defined in the brief?	
Work complies with the brief?	
Work adequately documented?	
Base travel demand	
Source of raw data	Provide source and/or details
Automatic vehicle counts	
Manual vehicle counts	
Classified counts	
Manual turning counts	
Counts from signal control systems	
Counts from freeway management systems	
Number plate survey	
Roadside interviews	
Mail-back questionnaire	
Home interview	
Commercial vehicle survey	
Other	
Adequately defined in the brief?	
Work complies with the brief?	
Work adequately documented?	

Base trip table estimation	
Method	Provide source and/or details
Counts only	
Synthesised from counts: ▪ observed ▪ modelled ▪ other	
Details of time dependent demand profiles used	
Adequately defined in the brief?	
Work complies with the brief?	
Work adequately documented?	
Future trip table estimation	
Method	Provide source and/or details
Growth factors	
Modelled	
Other	
Adequately defined in the brief?	
Work complies with the brief?	
Work adequately documented?	
Assignment details	
Algorithm	
Cost coefficients	
Incidents	
Signposting	
Strategic routes	
Calibration	
Calibrated to	Provide calibration statistics
Trip length distribution	
Observed volumes	
Maximum flows	
Queue lengths	
Travel times	
Other (specify)	
Adequately defined in the brief?	
Work complies with the brief?	
Work adequately documented?	
Validation	
Has the calibrated model been validated against data not used for calibration?	
Validated against	Provide validation statistics
Observed volumes	
Maximum flows	
Queue lengths	
Travel times	

Other (specify)	
Adequately defined in the brief?	
Work complies with the brief?	
Work adequately documented?	
Model application	
Performance measures reported	(List measures of network performance reported)
Sufficient for proper comparison of options?	
As required by brief?	
Options tested	Reasonableness of results
Sensitivity tests	Robustness of results
Adequately defined in the brief?	
Work complies with the brief?	
Work adequately documented?	

Summary of audit recommendations

The model	
Item	Recommendations
The brief	
Item	Recommendations

5 CONCLUSIONS AND RECOMMENDATIONS

Microsimulation traffic modelling has received renewed interest amongst road and transport authorities in recent years to analyse complex, congested situations that are normally beyond the domain of analysis using conventional analytical or macroscopic modelling procedures. Microsimulation packages now provide functions that range from visualisation and simulation to the emulation of signal operation in a network – by interfacing a signal system such as SCATS and STREAMS to a microsimulation software package.

This report provides guidelines on how microsimulation models can be used to improve the performance of a road network. The guidelines have been prepared in three components: a core Guide, a set of Commentaries and a Repository of modelling reports. The core Guide identifies the roles and limitations of MSTMs and recommends the following issues as potentially appropriate for using an MSTM:

- complex traffic operation schemes, e.g. bus priority, advanced signal control, incident management, different modes of toll collection
- significant conflicts amongst different road users, e.g. pedestrians, cyclists, buses
- major road works on traffic movements, e.g. lane closures, one-way system, toll plazas
- politically sensitive projects that could benefit from visualisation
- planning and design of high-value projects with potential large savings if detailed MSTMs are prepared
- emulation of the operation of a dynamic signal control system, with a simulated network driven directly by the control system, with significant saving in signal timing preparation and optimisation
- town centre studies
- tram and light rail operations.

All modelling approaches have their own limitations. It is important for a project manager to adopt a fit-for-purpose approach in undertaking modelling studies. Microsimulation modelling aims to analyse complex traffic conditions. They require more parameters for model development and calibration, and hence more resources and higher costs than conventional modelling techniques. There may be easier ways to solve the problem and it is pertinent to consider all alternative approaches.

This report describes in detail the following key steps in the development of a microsimulation model:

- identifying study objectives and project scoping
- selecting the right software package for microsimulation
- developing a base model
- model calibration and validation
- auditing model output results.

Road and transport authorities are using a range of software packages for developing an MSTM. Some adopt one or more of the four packages: PARAMICS (Q- and S-Versions), AIMSUN NG and VISSIM. Brief descriptions of these software packages are included in Commentary A as reference information. Further, the following factors have been identified as important in the choice of a package:

- level of expertise within a project team and the road/transport agency
- level of support from the software supplier
- training required to get a base model developed
- level of transparency of the package structure and outputs so that meaningful interpretation of model results and hence decision making are possible
- experience in applying a package for different network sizes, i.e. the scale of application
- suitability of the facilities and parameters in a package to simulate the phenomenon that an agency wishes to investigate, e.g. pedestrian movements
- sensitivity of the required parameters on specific features to be analysed in proposed scenarios
- accuracy of vehicle movement logic such as gap acceptance, lane changing and car-following manoeuvres.

This project has not attempted to compare these packages. The aim of this project has been to make the best use of these packages through the core Guide, Commentaries and the Repository of modelling reports.

The calibration process is a critical step in the development of a useable MSTM and involves varying operational parameter values within acceptable or specified ranges until the modelled outputs and observed outputs agree to an acceptable level of accuracy. Microsimulation users must choose all input data with caution and should not, for example, vary significantly input demand for the sake of 'getting the model right'. Various target accuracies currently adopted by road authorities together with overseas practices are reported in this report. The practice of Transport for London (2003) is quite simple and succinct. It requires the following model outputs should be within 5% of observed values:

- maximum flow at a stopline by vehicle types
- capacity per intersection approach
- maximum queue length per lane
- average delay per vehicle per lane including buses
- travel time for buses and general traffic.

This calibration practice is sufficiently comprehensive without requiring 100% accuracy in all aspects of model outputs, and is recommended in a microsimulation study.

Other findings from this project are as follows:

(a) Static and dynamic input data requirements for MSTMs are quite well-defined for model development. A check list of these input data types is included in this report. Similarly, output data at the link, corridor and area levels are also described.

(b) The procedures for model calibration and validation are reasonably standardised and the guidelines provided in this report, if followed, are adequate to produce useful output.

(c) The simulation of lane changing phenomena has been identified as a critical issue affecting the accuracy of model outputs. It is important therefore to ensure that model outputs such as delay and travel time at a link level be carefully audited. A useful way to achieve good correlation with observed data is to increase awareness to encourage lane changes and avoid lane blocking situations. This may involve increasing signposting distances for simulated vehicles to be more aware of hazard situations ahead and other parameters such as aggressiveness and familiarity.

(d) Standard outputs from an MSTM often require post-processing to provide more appropriate performance metrics for decision making. For example, apart from a whole-of-network performance metric, outputs may have to be reported also at the spatial level of a detector, segment, stream or corridor. Another example is that the volume/capacity ratio may not be an accurate indicator of performance and other metrics such as level of service would have to be derived from model delays, travel times or speeds.

(e) In general, it is difficult to adopt a common set of operational parameter values for commonly used microsimulation packages because most calibration parameters are software specific. It is also unlikely that the same set of parameters could be used in different applications (or models) developed using a particular package.

(f) A standard set of parameters for model calibration for Australian traffic conditions is valuable and is the reason for developing a Repository of modelling cases. Commentary D provides the distribution of vehicle lengths and VKT by vehicle types and averaged over all eight capital cities, but the distribution is likely to be site-specific. The Repository will take time to be populated and the principles for the choice of some parameters are compiled in Table 5.1 from the Repository and literature reviews to facilitate model development.

Table 5.1: Principles for choosing input parameters

Parameter	Recommended principles
Reaction time	Avoid large values; consider using the minimum value allowed in a package if excessive delay occurs in the model
Lane change/selection	Signposting or looking ahead distances should be sufficiently long for simulated drivers to be more responsive to road hazards Maximum driver awareness and aggressiveness also help the model to be more responsive Headway with next vehicle in new lane should have a minimum separation before a lane change occurs
Acceleration	A minimum value should be set
Headway	Check model headways at local sites reflect on-site headways whether a global headway is adopted in a package or not
Ratio of reaction time to simulation time step	An integer larger than 1; higher accuracy can be achieved with a reaction time that is two to three times the simulation time step

See also Commentary D on the recommended distribution of vehicle lengths and VKT in urban areas

It is recommended that the Repository of modelling reports be updated at regular intervals as an on-going task beyond this project. The actual working of the Repository has not been specified in this report and the formation of an Austroads microsimulation expert group should facilitate such a task and is also recommended. The functions of such an expert group could include:

- to specify policies on the content, access and use of the Repository
- to promote consistency in the use of MSTMs amongst jurisdictions
- to promote technology transfer in the form of training workshops
- to develop specific tests on software parameters and benchmark against accepted analytical and macroscopic model values.

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COMMENTARY A MICROSIMULATION SOFTWARE PACKAGES AVAILABLE

This Commentary aims to provide a list of microsimulation software packages reported in the literature and their Internet references. The following list is not an exhaustive list of microsimulation packages available but reflects some of the recent development from various countries. In particular, the choice reflects the level of support both in development and usage. AIMSUN, PARAMICS and VISSIM are commercial products with technical support in Australia and New Zealand and other countries. They are used amongst most Austroads Member Agencies. Some information about these three models is described below.

Table A.1: List of available microsimulation software packages

Model	Internet reference	Supplier(s)
AIMSUN NG	http://www.aimsun.com	Transport Simulation Systems (TSS)
CUBE - Dynasim	http://www.citilabs.com/dynasim/	Citilabs
DRACULA	http://www.its.leeds.ac.uk/software/dracula/	University of Leeds
MITSIMLab	http://mit.edu/its/mitsimlab.html	Massachusetts Institute of Technology ITS Program
NGSIM program	http://www.ngsim.fhwa.dot.gov	Cambridge Systematics
PARAMICS (Q- and S- versions)	http://www.paramics.com	Quadstone and SIAS
TRANSIMS	http://www.transims.net	IBM (commercial version)
TSIS-CORSIM	http://www.fhwa-tsis.com	McTrans, FHWA
VISSIM	http://www.ptvag.com/traffic/vissim.htm	PTV

The information provided in this Commentary is as at November 2005 and mainly from the websites above. More up-to-date information is available from these sites. Note that PARAMICS was developed by the transport planning company SIAS Ltd. and software developers Quadstone Ltd. in a joint venture formed in 1996. This joint venture terminated in 1998 and PARAMICS is now supported by Quadstone and SIAS separately. The two companies market the PARAMICS software separately with mutual territorial agreements. Quadstone PARAMICS is used among most road authorities in Australia whereas both versions are used in New Zealand. The discussion below refers largely to the Quadstone version but the basic information applies to both PARAMICS versions.

AIMSUN (NG Version, information as at November 2005)

Introduction

AIMSUN NG (New Generation) has an integrated simulation environment combining the previous editor TEDI (Traffic network graphical EDItor), AIMSUN (the traffic simulator), AIMSUN 3D (3D visualisation), a network database, a module for storing results, and other extensions or Application Programming Interfaces (APIs). The package has an open architecture, allowing users to interface the simulator with any application of their choice. This could include, for example, a user-defined adaptive control policy, pollution emission model or vehicle generation routine. AIMSUN includes interfaces to a range of other tools including: TSS's own four-step planning package, EMME/2 planning model, TRANSYT traffic control plans optimisation model, and Geographic Information Systems (GIS).

AIMSUN runs on Windows, Linux and Solaris (Sparc) computer platforms.

Model structure and features

For traffic modelling, AIMSUN follows a microscopic simulation approach. The behaviour of every vehicle in the network is continuously modelled throughout the simulation period, using car-following, lane changing and gap acceptance driver behaviour models. AIMSUN can deal with urban networks, freeways, highways, ring roads, arterials and any combination of them. Simulation can be either based on input traffic flows and turning proportions or based on OD matrices and route selection models. In the former, vehicles are distributed stochastically around the network, whereas in the latter, vehicles are assigned to specific routes from the start of their journey to their destination.

Vehicle behaviour models are functions of several parameters that allow the modelling of different types of vehicles: cars, buses, trucks, etc. Vehicle types can be grouped into classes, and reserved lanes for given classes (e.g. bus lanes) can also be taken into account. A refined definition of parameters includes the category of local parameters to distinguish local properties from global ones. The user therefore has a better control on the models, making the calibration process easier. The user may select among different headway models for vehicle generation: constant, uniform, normal, exponential, capacity and external. The user may also define his/her own headway models. A variety of route choice models are available: fixed, binomial, multinomial logit or any other user defined model. For the shortest path calculation, a cost function library is provided, and the user is also offered the possibility of defining and using his/her own functions. Regarding public transport modelling, buses depart at line-origins according to a timetable, follow a particular bus line, and stop for a certain time at the corresponding bus stops along the line.

Different types of traffic control and management measures can be modelled: traffic signals, give-way signs and ramp metering. Signal control plans are movement based. AIMSUN can automatically deal with a set of control plans in the same simulation experiment. It can simulate many kinds of measurable data from a traffic detector: counts, occupancy, presence, speed and density. The simulated detection data can then be used to feed any external traffic control system. AIMSUN also supports the modelling of Variable Message Signs (VMS) and the influence that messages displayed on VMS have on the traffic behaviour, such as re-routing or speed control. TRANSYT-optimised control plans can be loaded into AIMSUN, which can then provide the TRANSYT measures of performance as additional output information.

Usage and interface

AIMSUN uses a graphical editor designed with the aim of making the process of network data entry as user-friendly as any of today's modern office applications using a mouse. Its main function is the construction of traffic models with which to feed traffic simulators like AIMSUN. To facilitate this task, the editor accepts as a background a graphical description of the network area, so sections and nodes can be built subsequently into the foreground.

The editor supports both urban and interurban roads, covering road elements such as side lanes, entrance and exit ramps, intersections, traffic signals and ramp metering. The geometry of the links is specified at the microscopic level, but the editor's ease of use makes it as fast as specifying one-dimensional links in some macroscopic systems and nodes can be created automatically. Building complex intersections, including the definition of turning movements, signal groups and control phases becomes a straightforward task consisting of clicking on the different intersection objects. The many parameters available for characterising the different types of objects and traffic conditions mean that the only limitation to the precision of the model is the quantity and accuracy of the data collected.

Simulation experiments are also controlled through the graphical user interface. It provides multiple views of the network and an animated representation of the vehicles in it. The user has an overview of what is happening in the network that aids performance analysis. Through the interface, the user may access any information in the model throughout the simulation including the simulated vehicles, displaying the number of vehicles present in the network, identification of lost vehicles, different animation speeds, access to particular vehicle information, and displaying of tracked vehicles and floating-car data. The user may define traffic incidents before or during the simulation run. A list of incidents may be stored for use in subsequent simulation runs. AIMSUN possesses graphical capabilities for presenting statistical outputs: the sections of the network can be coloured according to a range of colours that represents different values for a set of traffic measurements, such as flow, speed and queue length.

AIMSUN can also simulate and visualise scenarios in three dimensions. This offers a more realistic and impressive view of the network than the 2D plan view. Each view emulates a camera from which the network is seen. Figure A.1 illustrates an example of the AIMSUN interface incorporating the network editor plan view superimposed on an aerial photograph, and a 3D rendering of the same scene.

A network can be exported via an embedded interface into a ‘Shapefile,’ a standard format that can be imported by most Geographic Information Systems, including ArcInfo, ArcView and MapInfo. Simulation results that have been saved in the Microsoft Open Database Connectivity (ODBC) format can be presented graphically using the GIS interface.

AIMSUN has been used in Queensland Main Roads for a number of years and a recent development in progress is to interface signal control systems such as STREAMS and SCATS to AIMSUN.

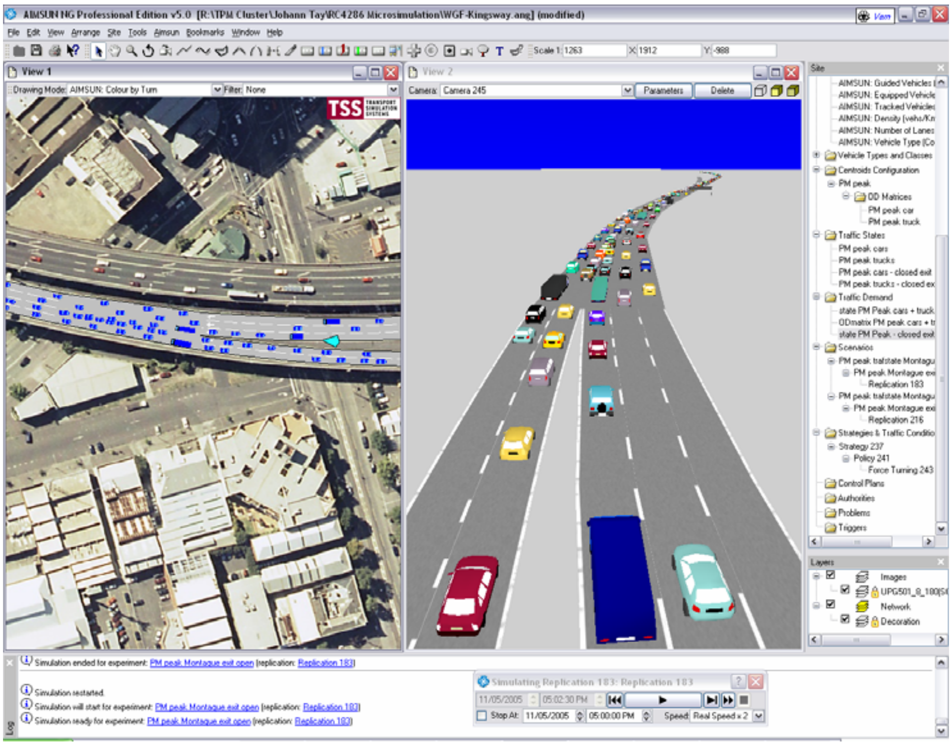

Figure A.1: AIMSUN NG displays

Quadstone PARAMICS (Q-PARAMICS Version 5, information as at November 2005))

Introduction

PARAMICS (PARAllel MICroscopic Simulation) is a suite of software tools for microscopic traffic simulation. Individual vehicles are modelled, providing detailed traffic flow, transit time and congestion information, as well as enabling the modelling of the interface between drivers and various ITS measures. The PARAMICS software is portable and scaleable, allowing a unified approach to traffic modelling across the whole spectrum of network sizes, from single junctions up to large networks.

Model structure and features

PARAMICS aims to model congested road networks and ITS infrastructures. It can currently simulate the traffic impact of signals, ramp meters, loop detectors linked to variable speed signs, VMS signing strategies, in-vehicle network state display devices, and in-vehicle messages advising of network problems and re-routing suggestions. Vehicle rerouting in the face of ITS is controlled through a user-definable behavioural rule language for flexibility and adaptability.

PARAMICS car-following and lane changing models are based on a number of other models. In most respects, it was created from scratch, with the primary objectives being to demonstrate validity from two points of view:

- using iterative simulation it should show a close correlation to an array of observed numerical data for urban and inter-urban roads in the UK (objective validation)
- using computer graphics it should show a close correlation to visual observations, both on video and 'in the mind's eye' (subjective validation).

Each Driver-Vehicle Unit (DVU) in the PARAMICS simulation has a target headway. The mean value for this headway is typically around one second, and it varies around the mean depending upon the value of certain parameters assigned to the DVU. Lane changing is done using two devices: a gap acceptance policy and a historical record of suitable gap availability.

Under congested conditions, the effective modelling of all types of intersections, such as priority junctions, signalised junctions and roundabouts and grade-separated intersections, is vital to the accuracy of a simulation model because congestion almost always starts at an intersection and then blocks back onto its inward links. PARAMICS uses located unit vectors to describe a junction. The vector is a triple (x, y, bearing) that describes both the position of a point to which a vehicle must head for any particular exit from a junction and the required angle of orientation once it gets there. PARAMICS employs an algorithm that defines a general-purpose method to steer a vehicle over a realistic path between its current position to any target position, taking angles of orientation and steering limits into account. The rate of change of bearing is regulated by both the physical attributes of the vehicle and its current speed.

Seven predefined vehicle classes exist (Car, Light Goods Vehicle, Other Goods Vehicle 1 and 2, Coach, Minibus and Bus) but the user is free to add more as required. Buses follow fixed routes and stop at bus stops.

The ability for vehicles to dynamically re-route as costs vary is a key feature of the PARAMICS software. Traditional assignment models are not used. Route choice is based on route cost tables and vehicles travel to their chosen destinations rather than follow pre-defined routes. In addition to a standard route-cost table, PARAMICS includes:

- route cost perturbation to simulate variation in driver route-cost perception
- actual route-cost feedback at a user-defined frequency to simulate route learning and the impact of in-vehicle real-time information
- dynamic route-cost re-calculation when incidents are being simulated
- alternative route-cost tables for drivers with different levels of knowledge of the network.

All of this functionality is coupled to PARAMICS' implementation of routing by destination rather than predefined routes. This enables routes to be updated dynamically in response to ITS measures or network conditions. PARAMICS also includes a route-cost calculation module for interactive cost calculations on very large networks.

The key features of PARAMICS are as follows:

- *High speed simulation* – PARAMICS has been designed to run at high-speed, enabling the real-time simulation of hundreds, thousands or millions of vehicles, with no loss of detail. However more vehicles will require more processors, and more runs require more processors. Because PARAMICS is scaleable, model development can start off small, with little risk of hitting a performance ceiling as models grow.
- *Integrated software* **–** In a single package, PARAMICS provides simulation, visualisation, interactive network creation and editing, interactive adaptive signal control, on-line simulation data and statistics gathering, vehicle following, traffic control strategy evaluation, and interactive simulation parameter tuning.
- *Interface to macroscopic data formats* – PARAMICS can load network data direct from standard node and link data sets (e.g. from SATURN or CUBE/TRIPS).
- *Interface to point-count traffic data* **–** This interface allows PARAMICS models to be constructed directly from traffic data as collected by detectors that give vehicle counts at specific destinations. The interface is used for both initial model building, and for on-line applications within traffic control centres, where real-time traffic data will be available in this form.
- *Supports large scale models* – PARAMICS is able to simulate the individual movements of 200,000 vehicles over a road network faster than real time. The only limitations are due to the memory and processor constraints of the machine that PARAMICS is run on.

Usage and interface

PARAMICS has an integrated graphical user interface for network building and visualisation of results (see Figure A.2). The top-level interface window has a standard 'look and feel' familiar to most users, utilising standard pull-down menus, mouse button combination presses and sub-windows. The visualisation system features a variety of functions to display real-time output of traffic flow, density, pollution emissions, signal phases, bus stops, vehicle routing, etc.

PARAMICS can load network data direct from standard node and link data sets and can base simulation on data from OD surveys and matrices. It allows the overlaying of AutoCAD drawings to enable engineers to use the PARAMICS interactive network editor to fine-tune junction geometry that is often coarse within macroscopic network data.

PARAMICS undergoes continuous development. Current development includes modelling of noise and exhaust pollution; multi-modal transport simulation; traffic state determination from on-line vehicle counts; and provision of predictive traffic information for in-vehicle services.

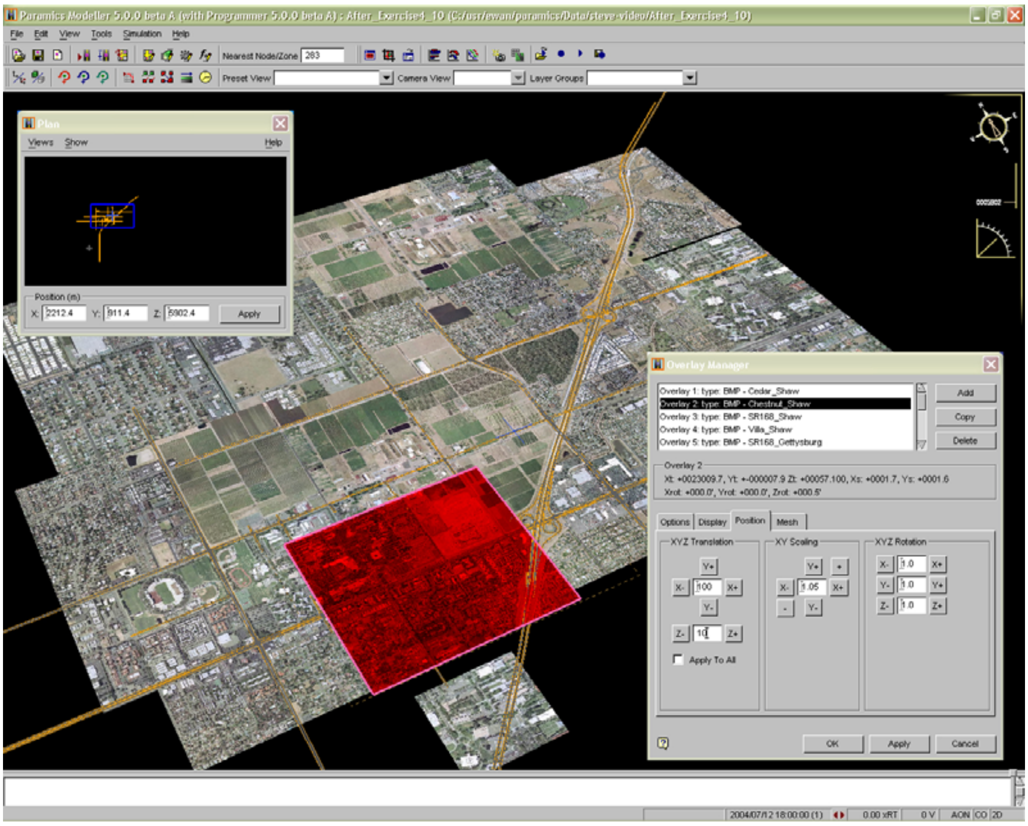

Figure A.2: Quadstone PARAMICS Modeller interface

VISSIM (Version 4, information as at November 2005)

Introduction

VISSIM (an acronym in German for Traffic in Town Simulation) models transit and traffic flow in urban areas as well as interurban motorways on a microscopic level. It is a decision support system for traffic and transport planners. Alternative scenarios of complex junctions and control strategies can be evaluated using VISSIM before implementation. Scenarios can be presented and visualised to decision makers at the technical and political level. It is the microscopic simulation component of the PTV Vision suite.

VISSIM is a tool for simulating multi-modal traffic flows including cars, trucks, buses, heavy and light rails, trams, cyclists and pedestrians. Like the other MSTM software packages, it can simulate a wide range of geometric configurations and operational/driver behaviour encountered within a transport system. It undergoes continuous development with add-ons provided by research institutions.

Model structure

VISSIM can be used to optimise vehicle-actuated signal control strategies, test various layouts and lane allocations of complex intersections, test the location of bus bays, test the feasibility of complex transit stops, test the feasibility of toll plazas, or find appropriate lane allocations of weaving sections on motorways. VISSIM can be coupled with micro-scale decentralised controllers of various signal control manufacturers to test their control strategies in detail before they are implemented.

The traffic flow model of VISSIM is a discrete, stochastic, time step based microscopic model, with Driver Vehicle Units (DVUs) as single entities. The model contains a psychophysical car-following model for longitudinal vehicle movement and a rule-based algorithm for lateral movements (lane changing). The model is based on work at the University of Karlsruhe, further calibrated and validated by PTV. Vehicles follow each other in an oscillating process. As a faster vehicle approaches a slower vehicle on a single lane, it has to decelerate. The action point of conscious reaction depends on the speed difference, distance and driver dependent behaviour. On multi-lane links, moved-up vehicles check whether they improve by changing lanes. If so, they check the possibility of finding acceptable gaps on neighbouring lanes. Car-following and lane changing together form the traffic flow model, being the kernel of VISSIM.

Default values for acceleration, maximum speed and desired speed distributions are given but can be changed by the user to reflect local traffic conditions. Various car types, truck types, trams, buses, cyclists and pedestrians can be defined. Route choice models have been incorporated.

The network size is not limited by the software but by workstation memory and processor capabilities. The usual applications run to about 4 to 30 intersections simulated in one model. Usually the networks cover an area of 1-5 km² or corridors of up to 10 km. The computation time corresponds closely with the number of vehicles in the network at the same time. About 1200 vehicles are modelled in real-time using a low-end Pentium. Improved processor power and using a multiple-processor will enable faster processing and the modelling of more vehicles.

VISSIM models intersections, motorway interchanges, transit stops, etc. in every detail (usually 10 cm accuracy). A network model overlaid on an aerial photograph is shown in Figure A.3.

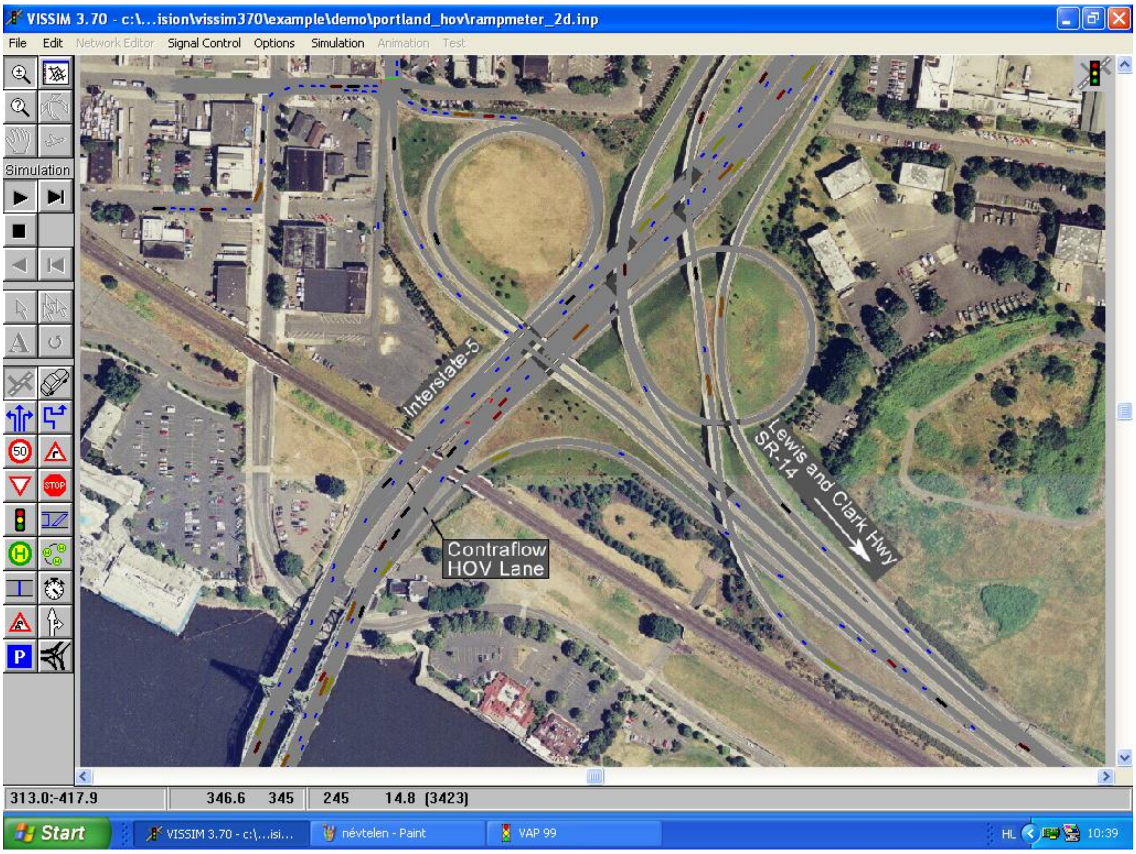

Figure A.3: A model overlaid onto an aerial photograph in VISSIM

The traffic flow model in VISSIM is the master program that sends detector values to the signal control program (slave) at time resolutions of one-tenth of a second. The signal control uses the detector values to decide on the current signal aspects. A C-like programming language (Vehicle Actuated Phasing) is included to describe local controllers and network control systems. Interfaces for SCATS and SCOOT have been developed. An open interface allows users to couple VISSIM with research type control strategies and various fuzzy logic algorithms for analysis.

Usage and interface

Data such as network definition of roads and tracks, technical vehicle and behavioural driver specifications, car volumes and paths, transit routes and schedules are entered graphically and through dialogue boxes under Windows.

Signal control depends on the strategy and controller type used. An open interface is available so that manufacturers can use their specific interface to describe the logic for area traffic control. VISSIM includes a flow charter under Windows to describe its own local controller logics.

The traffic flow model is well suited to model acceleration and speed distributions in queues and shock waves. VISSIM in the Fixed Routes option requires the users to provide the routes of cars, trucks and transit as input data. It also has an option to dynamically assign user-specified paths when specific events occur. The package can assign traffic to a network using OD matrices generated from a demand model such as VISUM and EMME/2.

VISUM and VISSIM together constitute the larger VISION suite from PTV, as shown in Figure A.4. The diagram sums up the data flow amongst various components of this larger suite, the GIS database and the signal control module.

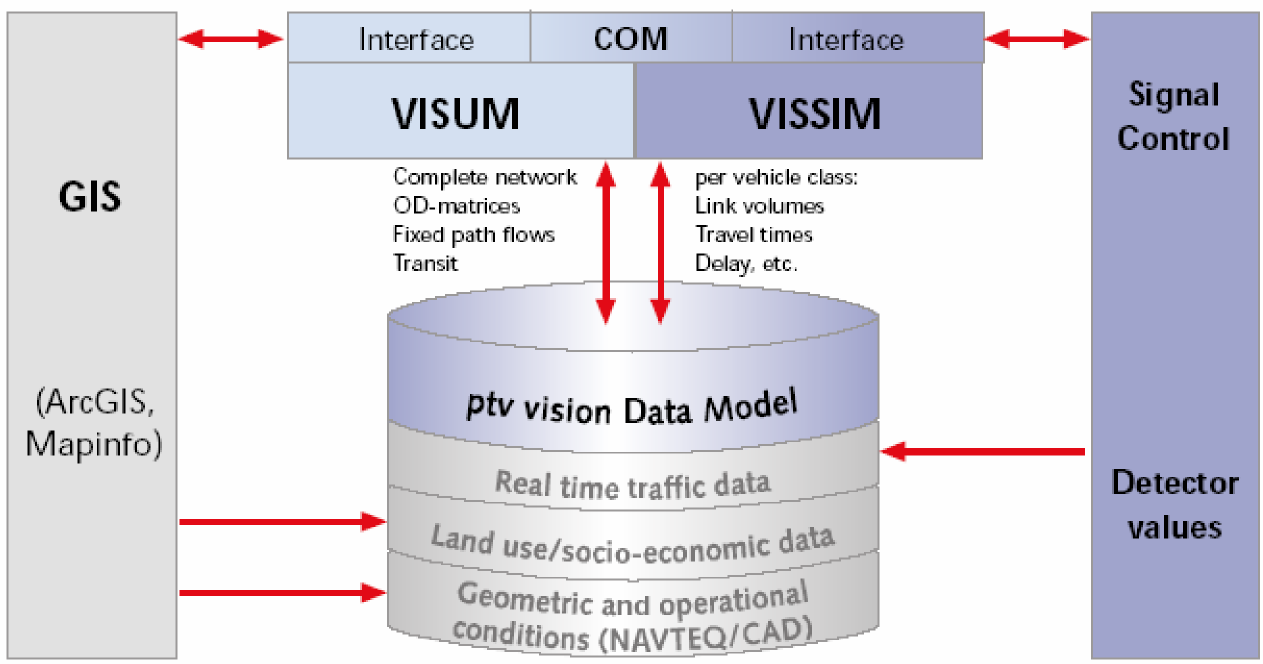

Figure A.4: PTV VISION data flow

COMMENTARY B MICROSIMULATION FUNDAMENTALS

This Commentary provides a brief description of the basic theory underpinning the structure of a typical microsimulation model. It helps project managers in understanding the key concepts in applying MSTMs. The following topics are discussed:

- randomness and generation of vehicles
- vehicle interactions: car-following and lane changing behaviour.

Randomness and generation of vehicles

Traffic models can be *deterministic* models in which driver characteristics have no variability. For example, it is assumed that all drivers have a critical gap of 5 s in which to merge into a traffic stream, or all passenger cars have a vehicle length of 5 m.

Microsimulation models are all *stochastic* models with traffic generation and driver-vehicle characteristics from statistical distributions using random numbers. For example, consider the generation of traffic with headways that follow the shifted negative exponential distribution. The probability distribution function P (h ≥ t) is given by:

$$\mathrm{P}\ (h \geq t) = e^{\frac{-(t-\alpha)}{(\bar{t}-\alpha)}}$$

where h and t are headways, $\bar{t}$ is the mean headway and α is the minimum headway (all in seconds).

Figure B.5 illustrates the cumulative headway distribution P (h ≥ t)) in log scales for the case when the mean headway is 9 s and the minimum headway is 1 s and represents traffic generated from a side-road. A random number generator is used to generate a *random decimal* or *fraction* (R) such that:

$$\mathrm{R} = e^{\frac{-(t-\alpha)}{(\bar{t}-\alpha)}}$$

For example, R is 0.60, then it can be calculated in a computer or read from Figure B.5 that a headway of 5.1 s is generated from the side-street with a vehicle waiting to enter a main road. The probability distribution functions can be measured on-site, can be of any empirical form and do not have to follow a particular mathematical function.

Other distributions are needed for gap acceptance, vehicle length distribution, acceleration and deceleration capability, speed choice and driver aggressiveness. It is also possible to randomly generate a single index for driver aggressiveness from which other related parameters are produced.

For example, a *uniform* distribution is used to represent driver aggressiveness from 1 (very aggressive) to 5 (least aggressive). The cumulative distribution is shown in Figure B.6. A random decimal of 0.25 leads to an aggressiveness index of 1.25, from which a hypothetical desired free-flow speed of 105 km/h could be possible on a motorway with a speed limit of 100 km/h. The same index can also control, say, deceleration capability. In this case, a higher deceleration capability is generated for lane changing behaviour to represent an aggressive driver.

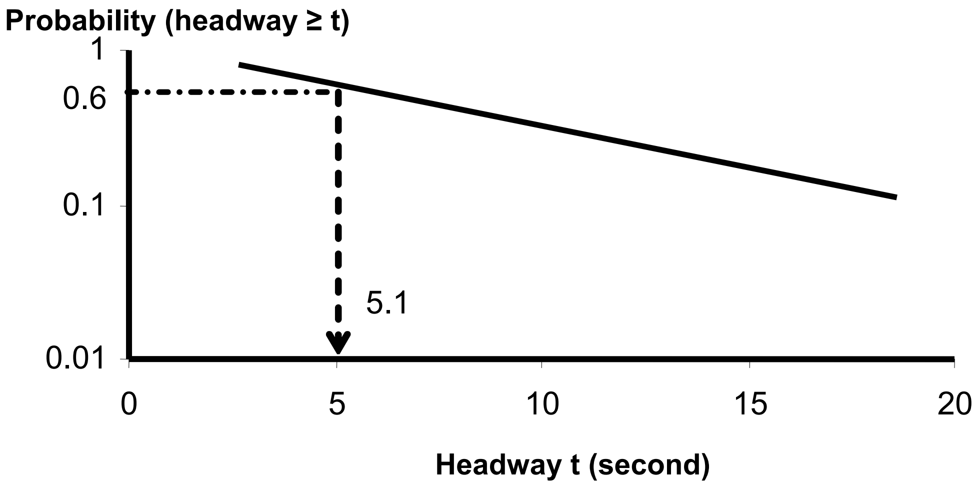

Figure B.5: Headway generation using a shifted negative exponential distribution

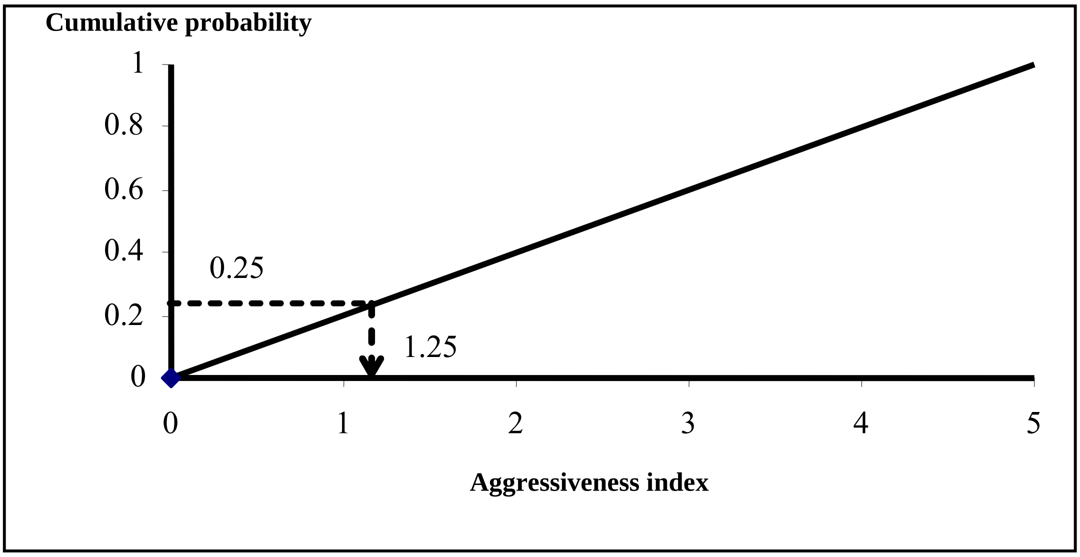

Figure B.6: Generation of aggressiveness indices using a uniform distribution

Vehicle interactions

A transport network in a microsimulation model is typically represented as a network of links and nodes. Links are one-way roadways with fixed design characteristics. Nodes represent intersections or locations when design characteristics of the link change. Centroids are also used to facilitate the input of OD matrices. Simulation packages usually have limits on the maximum numbers of nodes and links due to limitations in the memory and processing power of a PC.

Vehicles travel at their desired speeds on a transport or road link in an MSTM until they are impeded. Their desired speeds are from a *global* speed distribution for a particular vehicle class, and are further influenced by link-specific or *local* features such as horizontal and vertical alignment.

Most microsimulation packages accept input demand in the form of an OD matrix and vehicles exit a network at destination centroids. An OD-based input demand allows an individual vehicle to be tracked through its travel in a network. Some packages also allow input demand using entry link flows and turning proportions. In the turning proportion approach, the distribution of a vehicle is randomly assigned according to the turning fraction at an entry link. This turning proportion approach is not suitable for tracking the performance of individual vehicles through the network, and it is difficult to evaluate the effectiveness of, say, a driver information system on vehicles specially equipped with in-car route guidance.

In an MSTM, vehicle manoeuvres are modelled in detail using car-following, lane changing and gap acceptance models. These models are a function of several parameters that allow modelling of different types of vehicles (cars, buses, trucks, etc) and a variation of individual vehicles in each type. The use for random number generators to provide a spread of vehicle-driver behaviour has been discussed in the previous section of this Commentary.

The user can set the parameters of these behavioural models depending on the characteristics of the traffic to be reproduced. Note that the behaviour of drivers and therefore the parameters that describe them can be difficult from one application to another, e. g. the parameters in an urban area may be different from the behaviour on a rural motorway. The parameters can also vary from one country to another.

Vehicle interaction in an MSTM is an active area of development, driven mainly by the need to identify the limitations of the parameters in a microsimulation package and how to properly utilise them to reflect real world conditions (Panwai and Dia 2004; Hidas 2004 and 2005).

The basic theory underpinning car-following and lane changing behaviour in a typical microsimulation package is given in this section as background resource materials.

Car-following behaviour

Car-following theories were proposed as part of the development of traffic flow theory in the 1950s. Research laboratories around the world, especially at the US General Motor's test tracks, undertook extensive experiments to calibrate these car-flowing models. The earlier models made use of the following relationship:

$$\text{Response} = \text{sensitivity} \times \text{stimulus}$$

Hence, the first General Motor's car-following model was simply;

$$a_n(t+\tau) = \alpha_n(v_{n-1}(t) - v_n(t))$$

where a_n is the acceleration of the n^{th} vehicle (the follower vehicle) at time t

τ is the reaction time

v_{n-1} and v_n are the speeds of the $(n-1)^{th}$ or leader vehicle and the n^{th} or follower vehicle

α_n is a sensitivity parameter of the n^{th} vehicle for calibration.

Various car-following models have since been developed. Most adopt the fail-safe or collision-avoidance model with a form that specifies the safe-following distance as a function of the speeds of the follower and leader vehicles and the driver's reaction time (Panwai and Dia 2004). A popular model developed in Australia is the Gipps (1981) model. The Gipps model is often used in microscopic traffic simulation because of the realistic behaviour that the model predicts. The parameters in the model can also be easily observed and verified with field observations. The model specifies the safe speed of the follower vehicle v_n $(t+\tau)$ and can be stated as follows:

$$v_n(t+\tau) = \min\{v_n(t) + 2.5a_n\tau(1-\frac{v_n(t)}{V_n})\sqrt{0.025+\frac{v_n(t)}{V_n}},$$

$$b_n\tau + \sqrt{b_n^2\tau^2 - b_n[2(x_{n-1}(t) - s_{n-1} - x_n(t)] - v_n(t)\tau - \frac{v_{n-1}(t)^2}{\hat{b}}]}\}$$

where τ is the driver reaction time

a_n is the maximum acceleration which the driver of the n^{th} vehicle wishes to take

b_n is the most severe braking that the driver of vehicle n wishes to take (b_n is negative)

s_n is the effective size of vehicle n (physical length plus a safety margin)

V_n is the speed at which the driver of vehicle n wishes to travel

x_n (t) is the location of the front of vehicle n at time t

$\hat{b}$ is an estimate of b_{n-1}

The two expressions in the above formulation represent the constraints on the speed of vehicle n at time t+τ and it is assumed that the driver travels as fast as safety and the limitations of the vehicle permit. When the first expression is the limiting condition for a substantial proportion of the vehicles, the traffic flows freely. When the second expression is the limiting condition for most vehicles, congested flow exists with the traffic flowing as fast as the volume of the vehicles permits.

Lane changing behaviour

The modelling of lane changing behaviour is more complex than the modelling of car-following. Car-following needs to consider only the speed and location of the preceding vehicle in the same lane, and is not affected by changes in desired speed, acceleration and braking due to curves and gradients.

The decision to change lanes depends on several objectives, and at times these may conflict. For instance, a driver may be in the rightmost lane and wish to make a right turn soon, but still have to change lanes to the left to avoid, say, a vehicle breakdown. The driver, and hence the simulation package, must be able to reconcile the driver's short-term and long-term aims. Gipps (1986) summarised the factors that influence drivers to change lanes:

- whether it is physically possible and safe to change lanes
- the location of permanent obstructions
- the presence of transit or high-occupancy vehicle lanes
- the driver's intended turning movement

- the presence of heavy vehicles
- whether the traffic in the present lane and the target lane is more likely to limit the driver's speed in the short term.

Figure B.7 uses an off-ramp to illustrate how some of these factors are implemented. Three zones can be defined as follows (and relevant parameters are available for a user to specify the attributes of each zone, including their lengths):

- Zone 1: this is at the furthest distance from the next turning point (turning off from the freeway). The feasibility of the next desired turning point movement will not be taken into account in any lane changing decisions in this zone. The lane changing decision, if any, is based on traffic conditions in the zone, i.e. the possible improvement that the driver will get from changing lanes.
- Zone 2: the desired turning lane affects the lane changing decision in this zone. Vehicles not in the valid lane where the desired turning movement takes place tend to get closer to the correct side of the road from which the turn is allowed. Vehicles looking for a gap may try to adapt to it, without affecting the behaviour of vehicles in the adjacent lanes.
- Zone 3: this zone is nearest to the turning point. Vehicles are forced to reach their desired turning lanes, reducing speed if necessary and even coming to a complete stop in order to make the change possible. Vehicles in adjacent lanes also modify their behaviour to provide a gap large enough for the vehicle to succeed in changing lanes.

In the case when the stopped vehicle reaches a maximum allowable stopped time, a software package may consider it as a lost vehicle and allows it to disappear from a simulation.

As mentioned before, lane changing behaviour is critical in getting valid results from an MSTM especially in choosing the right values for signposting or indicating hazards. It is an active area of research and some of the issues concerned and relevant parameters are included in the Repository of modelling reports.

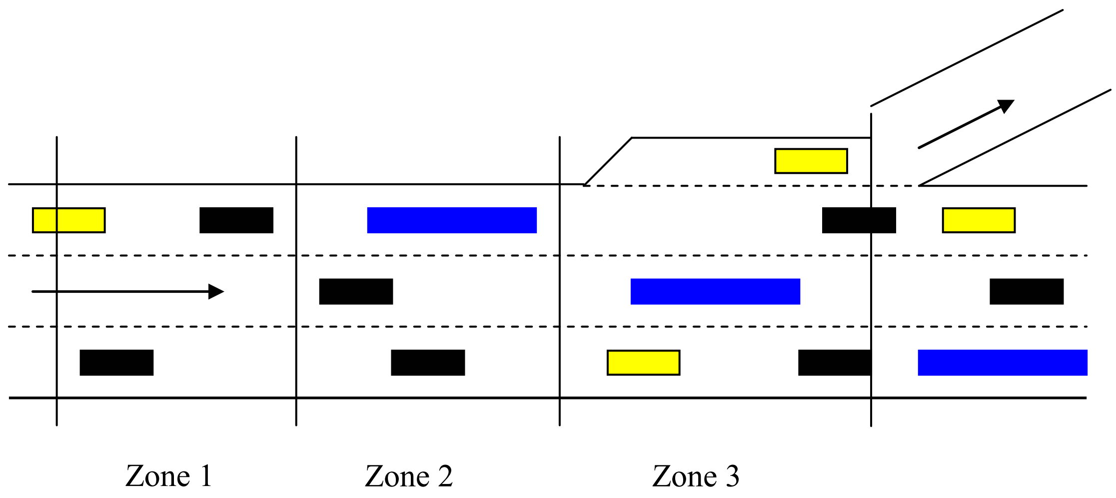

Figure B.7: Lane changing zones before an off-ramp

COMMENTARY C THE PREPARATION OF A BRIEF FOR MICROSIMULATION TRAFFIC MODELLING PROJECTS

Preamble

The purpose of this Commentary is to assist road and transport authorities in the preparation of a brief specifying the requirements of an MSTM project, either as an internally sourced study within the authority or as a contractual study out-sourced to a consultant. The materials in this Commentary make use of the Core Guide in this report, particularly those in Section 3 concerned with organising a microsimulation study. It is also assumed that this Austroads report will be available to project managers as a guide to the preparation of a project specification.

Study objectives and background:

- provide a problem statement
- state reasons why the modelling is required
- state the context of the study and background information
- provide a list of specific aims and outcomes from the study
- provide a brief description of study area.

Study scope:

- specify the parts of a network to be simulated (i.e. the spatial domain of analysis)
- specify the time periods of analysis – a.m. peak, p.m. peak, business peak, or period of incidence
- specify vehicle types, and whether public transport, pedestrians or cyclists are part of the study.

Options and scenarios:

- list the options to be analysed, and the combinations of the options
- specify performance metrics required, e.g. delay, travel time, density or speed
- mention the need for post-processing of model outputs, e.g. to determine the level of service or report results at different levels of spatial and temporal aggregation.

Traffic demand data:

- state whether an origin-destination (OD) matrix is available for the study, and whether the preparation of a demand matrix is part of the project
- determine whether a time profile of the matrix is necessary to address the project objective and what profile should be used
- if traffic flow and turning proportions at each node are used to represent traffic demand, discuss the adequacy of this approach relative to the use of an OD matrix
- if an OD matrix is available from a four-step transport planning suite, discuss the need for manual fine-tuning of the demand for the study area.

Microsimulation software platform:

- discuss what software platform will be proposed for the study (the platform need not be specified in the brief)
- discuss possible benefits and disbenefits of using microsimulation compared with more conventional modelling techniques, i.e. analytical and macro-modelling
- ascertain whether a technique simpler than microsimulation modelling is capable of addressing the study problem.

Calibration:

- specify traffic volumes on screen lines selected for flow or demand calibration
- specify the output performance metrics selected for calibration, e.g. travel times, delays, queue lengths or density on strategic links or routes, maximum flows on selected locations
- provide the list of parameters that will be used in getting the right demand and performance metrics, and the processes involved
- specify the level of accuracy proposed for calibration
- ascertain and obtain from a road/transport authority whether a list of default parameter values have already been prepared, e.g. vehicle classes and attributes (see also Commentary D).

Output and reporting:

- provide the list of outputs
- specify the methods of reporting the outputs (time series in graphical form, or tables)
- specify what level of spatial aggregation (detector, link, route, corridor or whole-of network) is required in the report
- specify what temporal presentation is required (peak hour, am. or p.m. period, duration of an incidence, etc.)
- state any other post-processing and special output requirement, e.g. video presentation.

Other considerations:

- refer to and specify policies on intellectual properties and other issues for external consultants.

COMMENTARY D DISTRIBUTION OF VEHICLE LENGTHS AND VKT

Issue:

The default vehicle lengths and their distribution from a commercially supported software package may not be sufficiently accurate to represent the local vehicle fleets in Australia and New Zealand. The model outputs may not be realistic.

Solutions:

The best way to ascertain vehicle lengths and their distributions is to monitor their values at specific sites using video cameras.

In the absence of on-site surveys, the following data from the Survey of Motor Vehicle Usage (SMVU) of the Australian Bureau of Statistics (ABS) may serve as a starting point for the model.

The ABS SMVU data provides reasonable values on VKT for different vehicle types about every three years for capital cities and other regions. The proportions of each vehicle type are recommended as a proxy indicating vehicle distributions for a particular study. Fine-tuning to suit a specific study may be necessary.

Table D.2 shows the lengths of vehicle types in the SMVU and were compiled from various sources as indicative lengths. The VKT values for capital cities for the 12 months to October 2004 are also shown in the table. Note that it is possible to get ABS to provide the above values for individual cities (Sydney, Melbourne, etc.). It is also useful to estimate the distribution by road types (motorway, arterials, collectors, local roads and CBD).

Table D.2: Distribution of vehicle lengths and VKT in urban traffic

Vehicle types	Representative lengths* (m)	2004** VKT (million)	Per cent (%)
Passenger vehicles	4	88,653	81.10
Motor cycles	2.2	618	0.57
Light commercial vehicles	4.5	14,236	13.02
Rigid trucks	7	3,679	3.37
Articulated trucks (6-axle)	19	1,059	0.97
Non-freight carrying trucks	7	110	0.10
Buses	14	963	0.88
Total	-	109,316	100.00

* indicative values from various sources

** ABS SMVU Document No. 9208.0

Repository of Modelling Reports

The modelling reports in this Repository are listed alphabetically according to the State where the application of a software package was carried out. The table below further shows what packages were used and the names of the modellers.

The Repository consists of a series of files on a file or a separate CD attached to this report.

This Repository will be populated as more modelling reports are compiled. It currently represents the reports received as at 30 November 2005.

Table 1: List of modelling reports in repository

Index	Software package	Modeller	Page no. in the Repository
NSW-1	Q-PARAMICS	Rod Tudge (RTA NSW) and consultants	50
NSW-2	VISSIM, AIMSUN and ARTEMIS	Peter Hidas, UNSW (hypothetical test sites)	51
NSW-3	ARTEMIS	Peter Hidas, UNSW (hypothetical test sites)	55
QLD-1	AIMSUN	Sakda Panwai and Hussein Dia , UQ (single lane data from a test site in Germany)	59
QLD-2	AIMSUN	David Stewart, QDMR (Pacific Motorway, Brisbane)	63
QLD-3	AIMSUN NG	David Stewart, QDMR (hypothetical test site)	67
QLD-4	AIMSUN NG	David Gyles, QDMR (Moggill Rd, Brisbane)	71
VIC-1	VISSIM	Doug Harley, VicRoads (Dandenong, Melbourne)	75
VIC-2	Q-PARAMICS	Ting et al. Monash University (Doncaster Melbourne)	79
VIC-3	AIMSUN NG	Johann Tay and James Luk, ARRB (Westgate Freeway, Melbourne)	84
WA-1	Q-PARAMICS	Maunsell (Mitchell Freeway Perth)	88

(Note: compiled as of 30 November 2005)

Austroads Project NS1016
Microsimulation Modelling Report

Index NSW-1

Model developed by	Rod Tudge (RTA NSW) and consultants
Author of report	Rod Tudge, James Luk
Date of report	1 September 2005
Study location	Various sites in Sydney
Microsimulation software used	Q-PARAMICS
Purpose of modelling and project description	This modelling report summarises the work carried out up to 2003 by RTA NSW on microsimulation traffic models (MSTMs). RTA has a long history of using and developing MSTMs, e.g. INSECTS and SCATSIM since the 1980s. Other conventional techniques cannot model the dynamic nature of a traffic system. The new generation of software also provides graphics output easily interpretable by persons who are not experts in traffic management. The reference paper (see below) outlines the reason for the choice of Q-PARAMICS, some modelling issues and the applications being pursued by RTA NSW.
General conclusions from applying the model. Please comment on: ▪ results of investigating different scenarios ▪ sensitivity tests undertaken ▪ extent of the variation from default parameters ▪ difficulties encountered and ways to overcome modelling issues ▪ comments on the general robustness of model outputs.	PARAMICS was first introduced into Australia through an application investigated by the University of SA in Adelaide in 2000. RTA has adopted the software on the ground that it has had a large user base in CALTRANS and also because of the availability of Application Programming Interface (API) to customise the software for specific applications in NSW. Some specific parameter values recommended are: ▪ passenger car length 4.45 m ▪ car weight 1.37 tonnes ▪ mean reaction time 0.5 to 1.5 s ▪ mean headway (space time) 0.5 to 1.5 s. The experience so far suggests that with low traffic flows the model results are stable and are insensitive to changes in headway and reaction times. At medium flow levels where stable results would be expected, high values of headway and reaction time produced unstable (very sensitive) results. For high flows, low values of headway produce unrealistically low vehicle speeds. With low values of reaction time, the model is insensitive to reaction time changes. More modelling reports are expected to be available for the following past and current applications: ▪ Lane Cove tunnel project ▪ Toll collection on Sydney Harbour Bridge ▪ Parramatta Bus Way ▪ Sydney CBD road network.
Reference:	Millar, G., Tudge, R. and Wilson, C. (2003). An introduction of microsimulation software in Australia. Proc. 21 ARRB Conf./11th REAAA Conf., May 18-23, 2003, Cairns, Queensland.

Austroads Project NS1016
Microsimulation Modelling Report

Index NSW-2

Model developed by	Peter Hidas, UNSW
Author of report	Johann Tay, ARRB
Date of report	18/08/2005
Study location	Melbourne
Microsimulation software used	AIMSUN (v4.1 and v4.2), VISSIM (v3.70) and ARTEMiS (v1.50)
Purpose of modelling and project description	Study to evaluate lane changing and merging behaviour in microsimulation models under congested flow conditions. Hypothetical traffic scenarios were constructed that require a large proportion of vehicles to merge or change lanes. Traffic simulators were used to model these scenarios under varying traffic flow rates and model parameter combinations.
General conclusions from applying the model. Please comment on: ▪ results of investigating different scenarios ▪ sensitivity tests undertaken ▪ extent of the variation from default parameters ▪ difficulties encountered and ways to overcome modelling issues ▪ comments on the general robustness of model outputs.	All three simulators produced a reasonably similar range of output results from the same input values. All three models have a number of parameters that can be used to calibrate the models to observed data. For each simulator, a number of weaknesses and model limitations were identified that require further investigation and development. One common weakness is the occurrence of lost vehicles, indicating failures in the model procedures. Overall, there are inconsistencies between simulation models and the results need to be treated with caution when modelling highly congested traffic scenarios. In particular: ▪ AIMSUN was found to be highly sensitive to the reaction time value. In the urban road scenario, the number of lost vehicles was consistently high, indicating a weakness in the lane changing model at lower speeds. ▪ VISSIM produced very consistent results across all scenarios. In general, it produced very few lost vehicles, but the circumstances in which the vehicles were lost are more serious than described in the user manual. ▪ ARTEMiS produced satisfactory results with its fixed 1.0 second time step. The number of lost vehicles was acceptable in most cases, but still leaves room for improvement.
Reference:	Hidas P (2004). Evaluation of lane changing and merging in microsimulation models. Forum papers 27th ATRF, Adelaide.

Please also supply background information on the model

General model scope

Location / route / area	
Years modelled	
Time periods modelled	
Time periodic variations (profiles) in: ▪ Traffic demand ▪ Links ▪ Junction control.	(Describe time dependent aspects of the model)
Number of zones	
Number of links	
Number of nodes	
Number of junctions	
Number of traffic signals: ▪ Fixed time ▪ Vehicle-actuated ▪ Area traffic control system.	

Network

Base Network	Provide source and/or details
Basic geometry	
Intersection layouts	
Traffic signal controls	
Other network features, e.g. ▪ Signposting ▪ Ramp metering ▪ Adjacent lane interaction ▪ Lane restrictions.	
Time dependent features	
Carparks	
Future networks	Provide source and/or details
Basic geometry	
Intersection layouts	
Traffic signal controls	
Other variations from base network	

Vehicle and driver data

Data type	Provide source and/or details
Default vehicle data used	
Additional or non-standard vehicles used?	
Vehicle proportions	
Headway	
Reaction time	
Driver behaviour parameters, e.g. ▪ Familiarity ▪ Aggression ▪ Awareness.	

Base travel demand

Source of raw data	Provide details
Automatic vehicle counts	
Manual vehicle counts	
Classified counts	
Manual turning counts	
Counts from signal control systems	
Counts from freeway management systems	
Number plate survey	
Roadside interviews	
Mail-back questionnaire	
Home interview	
Commercial vehicle survey	
Other sources	

Base trip table estimation

Method	Provide source and/or details
Counts only	
Synthesised from counts: ▪ Observed ▪ Modelled ▪ Other.	
Details of time dependent demand profiles used	

Future trip table estimation

Method	Details
Growth factors	
Modelled	
Other	
Adequately defined in the brief?	
Work complies with the brief?	
Work adequately documented?	

Assignment details

Algorithm	
Cost coefficients	
Incidents	
Signposting	
Strategic Routes	

Calibration

Calibrated To	This study is not aimed at calibrating the models to any real traffic scenario.
Trip length distribution	
Observed volumes	
Maximum flows	
Queue lengths	
Travel times	
Other (specify)	

Validation

Validated against	Provide validation statistics
Observed volumes	
Maximum flows	
Queue lengths	
Travel times	
Other (specify)	

Austroads Project NS1016
Microsimulation Modelling Report

Index NSW-3

Model developed by	Peter Hidas, UNSW
Author of report	Johann Tay
Date of report	19/8/2005
Study location	Melbourne
Microsimulation software used	ARTEMiS
Purpose of modelling and project description	To investigate the application of intelligent agent based techniques in a microscopic traffic simulation model in order to improve the overall efficiency and reliability of the simulation in complex traffic scenarios. Each driver-vehicle unit is modelled as an intelligent agent: a reactive, autonomous, internally motivated entity that inhabits a dynamic not fully predictable traffic environment. Project presents details of the lane changing and merging models developed using agent based concepts. Lane changing is a vital component of any traffic simulation model that involved a high level of interaction between the vehicles where the behaviour of each vehicle is influenced by the behaviour of the other. These interactions require complex behavioural decision making processes which can best be modelled by intelligent agent techniques.
General conclusions from applying the model. Please comment on: ▪ results of investigating different scenarios ▪ sensitivity tests undertaken ▪ extent of the variation from default parameters ▪ difficulties encountered and ways to overcome modelling issues ▪ comments on the general robustness of model outputs.	Based on video-recorded observations of the microscopic details of lane change manoeuvres under congested traffic conditions, a classification of the manoeuvres for free, forced, and cooperative lane changes was proposed. Then a new lane change model was developed, incorporating explicit modelling of vehicle interactions using intelligent agent concepts. The model was implemented in the ARTEMiS traffic simulator. Several hypothetical test studies were conducted to demonstrate the capabilities of the new model and the results show that the model is able to reproduce the observed behaviours of individual vehicles in terms of speed, gap acceptance and conflict resolution in all three types of lane change manoeuvres and hence it is able to simulate highly congested flow conditions in a realistic manner. The explicit modelling of forced and cooperative lane changes can eliminate the weaving and merging problems experienced in most simulation models under congested flow conditions.
Reference:	Hidas, P (2005). Modelling vehicle interactions in microscopic simulation of merging and weaving. Transportation Research 13C(1), pp. 37-62.

Please also supply background information on the model

General model scope

Location / route / area	n/a
Years modelled	
Time periods modelled	
Time periodic variations (profiles) in: ▪ Traffic demand ▪ Links ▪ Junction control.	(Describe time dependent aspects of the model)
Number of zones	
Number of links	
Number of nodes	
Number of junctions	
Number of traffic signals: ▪ Fixed time ▪ Vehicle-actuated ▪ Area traffic control system.	

Network

Base Network	Provide source and/or details
Basic geometry	
Intersection layouts	
Traffic signal controls	
Other network features, e.g. ▪ Signposting ▪ Ramp metering ▪ Adjacent lane interaction ▪ Lane restrictions.	
Time dependent features	
Carparks	
Future networks	Provide source and/or details
Basic geometry	
Intersection layouts	
Traffic signal controls	
Other variations from base network	

Vehicle and driver data

Data type	Provide source and/or details
Default vehicle data used	
Additional or non-standard vehicles used?	
Vehicle proportions	
Headway	
Reaction time	
Driver behaviour parameters, e.g. ▪ Familiarity ▪ Aggression ▪ Awareness.	

Base travel demand

Source of raw data	Provide details
Automatic vehicle counts	
Manual vehicle counts	
Classified counts	
Manual turning counts	
Counts from signal control systems	
Counts from freeway management systems	
Number plate survey	
Roadside interviews	
Mail-back questionnaire	
Home interview	
Commercial vehicle survey	
Other sources	

Base trip table estimation

Method	Provide source and/or details
Counts only	
Synthesised from counts: ▪ Observed ▪ Modelled ▪ Other.	
Details of time dependent demand profiles used	

Future trip table estimation

Method	Details
Growth factors	
Modelled	
Other	
Adequately defined in the brief?	
Work complies with the brief?	
Work adequately documented?	

Assignment details

Algorithm	
Cost coefficients	
Incidents	
Signposting	
Strategic Routes	

Calibration

Calibrated To	Provide calibration statistics
Trip length distribution	
Observed volumes	
Maximum flows	
Queue lengths	
Travel times	
Other (specify)	

Validation

Validated against	Provide validation statistics
Observed volumes	
Maximum flows	
Queue lengths	
Travel times	
Other (specify)	

Austroads Project NS1016
Microsimulation Modelling Report

Index QLD-1

Model developed by	Sakda Panwai & Hussein Dia, University of Queensland
Author of report	Johann Tay, ARRB
Date of report	15/08/05
Study location	Melbourne
Microsimulation software used	AIMSUN v4.15
Purpose of modelling and project description	Development of a car following model using reactive agent-based techniques based on an artificial neural network (ANN) approach for mapping perceptions to actions. As part of the study, the feasibility of interfacing advanced ANN models to a traffic simulator (AIMSUN v4.15) was demonstrated. A comparative evaluation of the ANN model developed in this study against established car following models (Gipps-based) was also carried out using the traffic simulator. This study does not focus on the modelling of any particular location, but on the development of an alternative car-following model, hence most of the subsequent fields of this report are not applicable.
General conclusions from applying the model. Please comment on: ▪ results of investigating different scenarios ▪ sensitivity tests undertaken ▪ extent of the variation from default parameters ▪ difficulties encountered and ways to overcome modelling issues ▪ comments on the general robustness of model outputs.	Simple back propagation neural network models performed substantially better than the Gipps-based models. However, the main limitation of the work reported in this study is the lack of large amounts of data for training and validating the ANN models. Nevertheless the performance results reported were based on a subset of 900 observations, and so demonstrate the feasibility of this approach. There is scope in future studies to collect more data and extend the evaluation framework to include car-following behaviour for critical driving situations, such as near freeway on- and off-ramps. Lane changing behaviour in each model is much more difficult to validate due to the difficulty of collecting relevant field data but with the advent of smart vehicle sensors and detection devices on the road infrastructure, such data collection efforts could be easier to complete.
Reference:	Panwai, S and Dia, H (2004) A reactive agent-based approach to modelling car following behaviour, 26th CAITR Conference, Melbourne.

Please also supply background information on the model

General model scope

Location / route / area	
Years modelled	
Time periods modelled	
Time periodic variations (profiles) in: ▪ Traffic demand ▪ Links ▪ Junction control.	(Describe time dependent aspects of the model)
Number of zones	
Number of links	
Number of nodes	
Number of junctions	
Number of traffic signals: ▪ Fixed time ▪ Vehicle-actuated ▪ Area traffic control system.	

Network

Base Network	Single lane in Stuttgart, Germany
Basic geometry	
Intersection layouts	
Traffic signal controls	
Other network features, e.g. ▪ Signposting ▪ Ramp metering ▪ Adjacent lane interaction ▪ Lane restrictions.	
Time dependent features	Afternoon peak stop-and-go traffic conditions
Carparks	
Future networks	
Basic geometry	
Intersection layouts	
Traffic signal controls	
Other variations from base network	

Vehicle and driver data

Data type	Provide source and/or details
Default vehicle data used	
Additional or non-standard vehicles used?	
Vehicle proportions	
Headway	
Reaction time	
Driver behaviour parameters, e.g. ▪ Familiarity ▪ Aggression ▪ Awareness.	

Base travel demand

Source of raw data	n/a
Automatic vehicle counts	
Manual vehicle counts	
Classified counts	
Manual turning counts	
Counts from signal control systems	
Counts from freeway management systems	
Number plate survey	
Roadside interviews	
Mail-back questionnaire	
Home interview	
Commercial vehicle survey	
Other sources	

Base trip table estimation

Method	n/a
Counts only	
Synthesised from counts: ▪ Observed ▪ Modelled ▪ Other.	
Details of time dependent demand profiles used	

Future trip table estimation

Method	n/a
Growth factors	
Modelled	
Other	
Adequately defined in the brief?	
Work complies with the brief?	
Work adequately documented?	

Assignment details

Algorithm	n/a
Cost coefficients	
Incidents	
Signposting	
Strategic Routes	

Calibration

Calibrated To	Provide calibration statistics
Trip length distribution	
Observed volumes	
Maximum flows	
Queue lengths	
Travel times	
Other (specify)	Model was calibrated to a study conducted by the Robert Bosch GmbH Research Group, as reported by Manstetten, Krautter & Schwab (1997) Traffic simulation supporting urban control system development, 4th World Congress on ITS

Validation

Validated against	Provide validation statistics
Observed volumes	
Maximum flows	
Queue lengths	
Travel times	
Other (specify)	Validation was performed using the same source as the calibration data, but using a data set that was not used in model development.

Austroads Project NS1016
Microsimulation Modelling Report

Index QLD-2

Model developed by	David Stewart, QDMR
Author of report	David Stewart, Johann Tay
Date of report	19/8/2005
Study location	Melbourne
Microsimulation software used	AIMSUN2 v4.04 and v4.13
Purpose of modelling and project description	The AIMSUN2 model was built to help develop an operational strategy for the Pacific Motorway in Brisbane. It was used to evaluate the impact of the various scenarios for the operation of a new road space (T2, T3 or General Purpose) and to investigate ramp metering and other operational strategies for the motorway.
General conclusions from applying the model. Please comment on: ▪ results of investigating different scenarios ▪ sensitivity tests undertaken ▪ extent of the variation from default parameters ▪ difficulties encountered and ways to overcome modelling issues ▪ comments on the general robustness of model outputs.	Time to breakdown is highly variable and has a major impact on the performance of the network. It is very difficult to calibrate. Reaction Time has a significant impact on the time to breakdown, but also impacts the speed flow curve and capacity of the basic freeway segment. The new model version (v4.13) may introduce problems with short merge tapers with no parallel running. The length of acceleration lane may need to be used as a calibration parameter if varying time on merge is not enough.
Reference:	Stewart, D (2003) Calibrating the Freeway Merge in AIMSUN2 for the Pacific Motorway Project QDMR Internal Report.

Please also supply background information on the model

General model scope

Location / route / area	Pacific Motorway between Brisbane River and Gateway Mwy (approx 14.5 km)
Years modelled	
Time periods modelled	6:00 am-9:00 am, but focusing calibration on 7:15 am-8:15 am as this was when travel time survey runs were undertaken
Time periodic variations (profiles) in: ▪ Traffic demand ▪ Links ▪ Junction control.	(Describe time dependent aspects of the model)
Number of zones	
Number of links	
Number of nodes	
Number of junctions	11 ramps
Number of traffic signals: ▪ Fixed time ▪ Vehicle-actuated ▪ Area traffic control system.	None (freeway)

Network

Base Network	
Basic geometry	Freeway
Intersection layouts	Ramps only
Traffic signal controls	None
Other network features, e.g. ▪ Signposting ▪ Ramp metering ▪ Adjacent lane interaction ▪ Lane restrictions.	Ramp metering reflecting the site
Time dependent features	
Carparks	
Future networks	
Basic geometry	
Intersection layouts	
Traffic signal controls	
Other variations from base network	

Vehicle and driver data

Data type	Provide source and/or details
Default vehicle data used	Mostly yes
Additional or non-standard vehicles used?	Only maximum desired speed and speed acceptance have been modified to local values based on engineering judgement
Vehicle proportions	100% cars
Headway	
Reaction time	0.75 s
Driver behaviour parameters, e.g. ▪ Familiarity ▪ Aggression ▪ Awareness.	assume defaults

Base travel demand

Source of raw data	Provide details
Automatic vehicle counts	
Manual vehicle counts	
Classified counts	
Manual turning counts	
Counts from signal control systems	
Counts from freeway management systems	
Number plate survey	
Roadside interviews	
Mail-back questionnaire	
Home interview	
Commercial vehicle survey	
Other sources	

Base trip table estimation

Method	Provide source and/or details
Counts only	
Synthesised from counts: ▪ Observed ▪ Modelled ▪ Other	
Details of time dependent demand profiles used	

Future trip table estimation

Method	Details
Growth factors	
Modelled	
Other	
Adequately defined in the brief?	
Work complies with the brief?	
Work adequately documented?	

Assignment details

Algorithm	
Cost coefficients	
Incidents	
Signposting	
Strategic Routes	

Calibration

Calibrated To	Provide calibration statistics
Trip length distribution	
Observed volumes	
Maximum flows	
Queue lengths	
Travel times	
Other (specify)	

Validation

Validated against	Provide validation statistics
Observed volumes	
Maximum flows	
Queue lengths	
Travel times	
Other (specify)	

Austroads Project NS1016
Microsimulation Modelling Report

Index QLD-3

Model developed by	David Stewart, QDMR
Author of report	David Stewart, Johann Tay
Date of report	1/9/2005
Study location	Melbourne
Microsimulation software used	AIMSUN NG 5.03
Purpose of modelling and project description	This study presents results of some experiments undertaken on the capacity of a simple merge in AIMSUN NG. It nominates time to breakdown as the most important factor when considering the performance of an oversaturated freeway network. If breakdown occurs early, queues are longer and congestion takes longer to clear, many more vehicles are delayed and network performance is reduced. Previous study has shown that with AIMSUN, the time to breakdown is very variable, even with given flow conditions.
General conclusions from applying the model. Please comment on: ▪ results of investigating different scenarios ▪ sensitivity tests undertaken ▪ extent of the variation from default parameters ▪ difficulties encountered and ways to overcome modelling issues ▪ comments on the general robustness of model outputs.	It was found experimentally that: With flows of less than 4400 vph, the two lane freeway seldom breaks down, but with flows of exactly 4400, it will always break down. If flows increase above 4400, there is little or no chance of recovery, but if flows of exactly 4400 are maintained, there is a good chance that operations will cycle between flow recovery and breakdown. The merge area has a capacity of nearly exactly 4400vph (cars only). The headway distribution of vehicles on the ramp makes a significant difference to the time to break down, but not capacity.
Reference:	Email from David Stewart (1/07/2005) The Capacity of a Merge in AIMSUN NG

Please also supply background information on the model

General model scope

Location / route / area	Virtual - Single lane merging onto two lane freeway
Years modelled	
Time periods modelled	
Time periodic variations (profiles) in: ▪ Traffic demand ▪ Links ▪ Junction control.	(Describe time dependent aspects of the model)
Number of zones	
Number of links	
Number of nodes	
Number of junctions	
Number of traffic signals: ▪ Fixed time ▪ Vehicle-actuated ▪ Area traffic control system.	

Network

Base Network	Provide source and/or details
Basic geometry	
Intersection layouts	
Traffic signal controls	
Other network features, e.g. ▪ Signposting ▪ Ramp metering ▪ Adjacent lane interaction ▪ Lane restrictions.	
Time dependent features	
Carparks	
Future networks	Provide source and/or details
Basic geometry	
Intersection layouts	
Traffic signal controls	
Other variations from base network	

Vehicle and driver data

Data type	Provide source and/or details
Default vehicle data used	AIMSUN NG v5.03 car: 2-lane car following model version 4.2 Onramp model 4.2.8 Arrival distribution: exponential
Additional or non-standard vehicles used?	No
Vehicle proportions	100%
Headway	
Reaction time	0.8 s (0.4 s simulation step)
Driver behaviour parameters, e.g. ▪ Familiarity ▪ Aggression ▪ Awareness.	

Base travel demand

Source of raw data	Provide details
Automatic vehicle counts	
Manual vehicle counts	
Classified counts	
Manual turning counts	
Counts from signal control systems	
Counts from freeway management systems	
Number plate survey	
Roadside interviews	
Mail-back questionnaire	
Home interview	
Commercial vehicle survey	
Other sources	

Base trip table estimation

Method	Provide source and/or details
Counts only	
Synthesised from counts: ▪ Observed ▪ Modelled ▪ Other.	
Details of time dependent demand profiles used	

Future trip table estimation

Method	Details
Growth factors	
Modelled	
Other	
Adequately defined in the brief?	
Work complies with the brief?	
Work adequately documented?	

Assignment details

Algorithm	
Cost coefficients	
Incidents	
Signposting	
Strategic Routes	

Calibration

Calibrated To	Provide calibration statistics
Trip length distribution	
Observed volumes	
Maximum flows	
Queue lengths	
Travel times	
Other (specify)	

Validation

Validated against	Provide validation statistics
Observed volumes	
Maximum flows	
Queue lengths	
Travel times	
Other (specify)	

Austroads Project NS1016
Microsimulation Modelling Report

Index QLD-4

Author of report	David Gyles – Network Operations and Performance, Queensland Main Roads
Date of report	28/9/2005
Study location	Moggill Road – Fig Tree Pocket Road to Sutling Street - build a microsimulation model, trial 3 options & compare delay and queues.
Microsimulation software used	AIMSUN NG
Model developed by	David Gyles
Purpose of modelling and project description	The Moggill Road network experiences the worst traffic conditions in the p.m. peak period, from 5:30 p.m. to 6:30 p.m. and the network operates at capacity. The Fig Tree Pocket Road intersection experiences approximately 300 veh/hr wanting to make the right turn with an opposed flow of approximately 2200 veh/hr westbound on Moggill Road. Field observations concur with the p.m. base model with vehicles queuing in the length of the right turn lane. Field observations showed that this queue could clear. This happens because the westbound traffic when stopped by the downstream intersection at Chapel Hill Road allows all of the right turn queue to filter into Fig Tree Pocket Road. This driver behaviour is very difficult to model as there are no rules on co-operative behaviour; only reaction time, reaction time at stop and give way time can vary in the model.
General conclusions from applying the model. Please comment on: ▪ results of investigating different scenarios ▪ sensitivity tests undertaken ▪ extent of the variation from default parameters ▪ difficulties encountered and ways to overcome modelling issues ▪ comments on the general robustness of model outputs.	By closing the right turns into and out of Sutling Street at the intersection it was assumed that the traffic would now use Fig Tree Pocket Road. From Option 1 the queues and delays at the Moggill Road right turn into Fig Tree Pocket Road has increased for the a.m. and p.m. peak conditions compared to the base case scenario. With the addition of traffic signals to the Moggill Road network at Moggill Road/Fig Tree Pocket Road intersection, the delay in the p.m. peak period for the right turn is greatly reduced. In the a.m. peak period, the delay has increased due to the modelled traffic signals running fixed time for all phases. This delay could be reduced in the field with the signal phases running releases. Queue length is reduced and controlled with the addition of the traffic signals for the a.m. and p.m. peaks. Modelling of four scenarios indicates that from a whole of network view the banning of the right turns and installation of signals has no major impact on the network operation. Difficulties encountered – initially the network was modelled in PARAMICS and a.m. conditions were modelled satisfactorily. When the p.m. OD matrix and signal times were used in the model PARAMICS had great problems in simulating the Fig Tree Pocket right turn (see above for flows). The network was then re-modelled in AIMSUN NG and the p.m. peak was able to be calibrated. This was achieved by setting the reaction time to 0.55 s and reaction time at stop to 1.0 s.
Reference	QDMR Internal Report

Please also supply background information on the model

General model scope

Location / route / area	Moggill Rd – Marshall Lane to Winton Rd
Years modelled	2005
Time periods modelled	07:00 to 08:00 and 17:30 to 18:30
Time periodic variations (profiles) in: ▪ Traffic demand ▪ Links ▪ Junction control.	No variation on flow demand
Number of zones	10
Number of links	
Number of nodes	8
Number of junctions	
Number of traffic signals: ▪ Fixed time ▪ Vehicle-actuated ▪ Area traffic control system.	5

Network

Base Network	Built up over aerial photos
Basic geometry	As per existing road layout
Intersection layouts	As per traffic signal plans supplied by Metropolitan District
Traffic signal controls	As per STREAMS
Other network features, e.g. ▪ Signposting ▪ Ramp metering ▪ Adjacent lane interaction ▪ Lane restrictions	Giveway signage on unsignalised intersections and approaches
Time dependent features	
Carparks	N/A
Future networks	Provide source and/or details
Basic geometry	
Intersection layouts	
Traffic signal controls	
Other variations from base network	

Vehicle and driver data

Data type	Provide source and/or details
Default vehicle data used	No Queensland car type used
Additional or non-standard vehicles used?	
Vehicle proportions	As per OD matrix
Headway	
Reaction time	0.55 s
Driver behaviour parameters, e.g. ▪ Familiarity ▪ Aggression ▪ Awareness.	1.0 s for reaction time at stop

Base travel demand

Source of raw data	Traffic counts provided by Metropolitan District for intersections
Automatic vehicle counts	No
Manual vehicle counts	Yes
Classified counts	No
Manual turning counts	Yes
Counts from signal control systems	Yes – where no other data was available
Counts from freeway management systems	Yes STREAMS
Number plate survey	No
Roadside interviews	No
Mail-back questionnaire	No
Home interview	No
Commercial vehicle survey	No
Other sources	No

Base trip table estimation

Method	OD matrix developed with Furness method from intersection traffic counts
Counts only	
Synthesised from counts: ▪ Observed ▪ Modelled ▪ Other	Yes
Details of time dependent demand profiles used	Peak hours used in model

Future trip table estimation

Method	Details
Growth factors	n/a
Modelled	n/a
Other	n/a
Adequately defined in the brief?	n/a
Work complies with the brief?	n/a
Work adequately documented?	n/a

Assignment details

Algorithm	Exponential
Cost coefficients	Default
Incidents	n/a
Signposting	Yes
Strategic Routes	No

Calibration

Calibrated To	Queue lengths and detector flows
Trip length distribution	n/a
Observed volumes	Yes for a.m. and p.m.peaks and at critical movements
Maximum flows	No
Queue lengths	Yes
Travel times	No
Other (specify)	

Validation

Validated against	No
Observed volumes	Provide validation statistics
Maximum flows	Yes
Queue lengths	No
Travel times	Yes
Other (specify)	No

Austroads Project NS1016
Microsimulation Modelling Report

Index VIC-1

Model developed by	Douglas V. Harley, VicRoads
Author of report	Douglas V. Harley, VicRoads
Date of report	8 September 2005
Study location	Victoria, Dandenong, South Gippsland Fwy / Pound Rd
Microsimulation software used	VISSIM
Purpose of modelling and project description	To determine mid and long term upgrade requirements for the combined intersection and interchange of the South Gippsland Highway and the South Gippsland Freeway with Pound Road.
General conclusions from applying the model. Please comment on:	
▪ results of investigating different scenarios	The modelling / analysis indicated that the existing layout was being under utilised, and that the roundabout would have to be converted to a signalised intersection in order to reduce congestion to acceptable levels. (Project not yet completed. These are only the draft / preliminary findings.)
▪ sensitivity tests undertaken	Existing traffic volumes and turning movements were counted on site, and modelled. The actual queue lengths were also recorded and compared with the modelled results.
▪ extent of the variation from default parameters	The critical gap times at the roundabout were altered so that the queue lengths on site matched the modelled queue lengths when operating under the measured volumes.
▪ difficulties encountered and ways to overcome modelling issues	Modelling of Australian roundabouts is complex. Due to the implementation of the Alberta Line Marking on roundabouts they have become more complex to model.
▪ comments on the general robustness of model outputs.	Expected to be Very Good, as the model was extensively calibrated against existing data. (This project is not yet completed. I am currently approaching the end of the calibration of the base case model.)
Reference:	VicRoads report

Please also supply background information on the model

General model scope

Location / route / area	South Gippsland Highway / South Gippsland Freeway / Pound Road.
Years modelled	2005, 2011 and 2031
Time periods modelled	a.m. and p.m. peak periods
Time periodic variations (profiles) in: ▪ Traffic demand ▪ Links ▪ Junction control.	 Yes No Yes – Roundabout metering.
Number of zones	6
Number of links	
Number of nodes	
Number of junctions	
Number of traffic signals: ▪ Fixed time ▪ Vehicle-actuated ▪ Area traffic control system.	 Nil 5 Nil

Network

Base Network	Provide source and/or details
Basic geometry	One two lane roundabout and one freeway half diamond interchange, with one structure over the freeway consisting of two lanes (one through and one right turn only) west bound and one through lane east bound.
Intersection layouts	One freeway exit ramp terminal signalised, one entry ramp terminal unsignalised.
Traffic signal controls	All Variable.
Other network features, e.g. ▪ Signposting ▪ Ramp metering ▪ Adjacent lane interaction ▪ Lane restrictions.	 Yes No Yes No
Time dependent features	None
Carparks	None
Future networks	Developed as part of the analysis
Basic geometry	Replace roundabout with signalised intersection, and duplicate structure over freeway.
Intersection layouts	One two-lane roundabout and one signalised intersection
Traffic signal controls	All intersections signalised
Other variations from base network	Nil

Vehicle and driver data

Data type	Turning movement counts for the base case, and modelled OD data for the future cases, obtained from DoI MITM.
Default vehicle data used	Yes
Additional or non-standard vehicles used?	None
Vehicle proportions	Varies
Headway	??
Reaction time	??
Driver behaviour parameters, e.g. ▪ Familiarity ▪ Aggression ▪ Awareness.	 N/A N/A N/A

Base travel demand

Source of raw data	Traffic Count provided by South East Metro. Future modelled data also provided by South East Metro, from the DoI Melbourne Integrated Transport Model
Automatic vehicle counts	No
Manual vehicle counts	No
Classified counts	No
Manual turning counts	Yes
Counts from signal control systems	No
Counts from freeway management systems	No
Number plate survey	No
Roadside interviews	No
Mail-back questionnaire	No
Home interview	No
Commercial vehicle survey	No
Other sources	Melbourne Integrated Transport Model (MITM) – a CUBE Strategic Network Modelling model.

Base trip table estimation

Method	From the turning counts and MITM model data.
Counts only	??
Synthesised from counts: ▪ Observed ▪ Modelled ▪ Other.	 Yes Yes No
Details of time dependent demand profiles used	Not Used. Only peak hours modelled.

Future trip table estimation

Method	Data obtained from MITM Cube Model.
Growth factors	N/A
Modelled	??
Other	??
Adequately defined in the brief?	Yes
Work complies with the brief?	Yes
Work adequately documented?	I believe so.

Assignment details

Algorithm	Default algorithm.
Cost coefficients	Default values.
Incidents	N/A
Signposting	Yes
Strategic Routes	Yes

Calibration

Calibrated To	Queue lengths at the roundabout in the peak hours.
Trip length distribution	N/A
Observed volumes	Used as input data.
Maximum flows	No.
Queue lengths	Yes.
Travel times	No.
Other (specify)	N/A

Validation

Validated against	Provide validation statistics
Observed volumes	Yes
Maximum flows	No
Queue lengths	Yes
Travel times	No
Other (specify)	

Austroads Project NS1016
Microsimulation Modelling Report

Index VIC-2

Model developed by	Johann Tay, James Luk
Author of report	Johann Tay, James Luk
Date of report	30/8/2005
Study location	Melbourne
Microsimulation software used	AIMSUN NG Professional 5.0.5 – August 2005 release
Purpose of modelling and project description	As part of an AUSTROADS project to investigate the use of microsimulation models as a training aid, a microsimulation model of the West Gate Freeway, South Melbourne was built and simulated using AIMSUN NG. The main routes in the model are: West Gate Freeway westbound from Domain Tunnel exit portal to Ingles St overpass West Gate Freeway westbound from base of Kings Way onramp to Ingles St overpass The project involves sensitivity analysis for the following key parameters: ▪ reaction time ▪ simulation step size ▪ signposting parameters.
General conclusions from applying the model. Please comment on: ▪ results of investigating different scenarios ▪ sensitivity tests undertaken ▪ extent of the variation from default parameters ▪ difficulties encountered and ways to overcome modelling issues ▪ comments on the general robustness of model outputs.	Reaction time has a direct influence on the efficiency of traffic flow, and hence, on network capacity. Faster reaction times in simulation resulted in improved flow across the network, reduced congestion and higher average speeds as driver vehicle units are able to interact with each other more effectively and with greater precision. A value between 0.5 s and 0.75 s is recommended for AIMSUN users. The simulation step size also can influence network flow and travel times to a significant degree. Smaller step sizes result in improved flow, reduced congestion and faster travel times. This is unexpected but it was determined that there is a mechanism whereby step size can influence the effective reaction time. Suggest using a step size equal to ½ to ¼ of reaction time (or reaction time is an integral multiple of step size between 2 and 4). Signposting or 'looking ahead' parameters also influence flow efficiencies, but their effect is not as clear cut as the previous two measures. A good balance must be found between early and late lane selection, and in most cases, this will depend on the site being modelled. It was also found that the look-ahead model is less effective when modelling complex multi-link intersections and in closely-spaced urban areas.
Reference:	Report for Austroads Project NS1017 – Improving incident management (in preparation)

Please also supply background information on the model

General model scope

Location / route / area	South Melbourne
Years modelled	2005
Time periods modelled	PM peak 3:45pm-6:30pm
Time periodic variations (profiles) in: ▪ Traffic demand ▪ Links ▪ Junction control.	Traffic demand Incidents Traffic management measures (in response to incidents)
Number of zones	8 (A subsection of a larger network of to investigate incidents)
Number of links	118 (subsection)
Number of nodes	34 (subsection)
Number of junctions	34 (subsection)
Number of traffic signals: ▪ Fixed time ▪ Vehicle-actuated ▪ Area traffic control system.	12 intersections, all fixed time (subsection)

Network

Base Network	Provide source and/or details
Basic geometry	Freeway plus surrounding arterials
Intersection layouts	Multiple, complex (basic T and cross intersections, freeway interchanges, compound intersections)
Traffic signal controls	Yes, at 12 intersections
Other network features, e.g. ▪ Signposting ▪ Ramp metering ▪ Adjacent lane interaction ▪ Lane restrictions.	VMS Lane restrictions
Time dependent features	
Carparks	None
Future networks	Provide source and/or details
Basic geometry	
Intersection layouts	
Traffic signal controls	
Other variations from base network	

Vehicle and driver data

Data type	Provide source and/or details
Default vehicle data used	Yes (car and truck types only)
Additional or non-standard vehicles used?	No
Vehicle proportions	As specified by OD matrix – varies by OD pair but overall about 7.5% trucks to 92.5% cars
Headway	
Reaction time	0.5 s
Driver behaviour parameters, e.g. ▪ Familiarity ▪ Aggression ▪ Awareness.	Two-lane car following model version 4.2 Number of vehicles = 4 Max Distance = 100m Max speed difference = 50km/h Max speed diff on ramp = 70km/h Lane changing % overtake = 90% Lane changing % recover = 95% Onramp model 4.2.8 Queuing up speed = 1m/s Queue leaving speed = 4m/s Reaction time = experimentally varied Simulation step = experimentally varied

Base travel demand

Source of raw data	Provide details
Automatic vehicle counts	
Manual vehicle counts	
Classified counts	
Manual turning counts	
Counts from signal control systems	
Counts from freeway management systems	Calibration for time-variability of traffic demand from 15 minute loop detector data at WGF-Power St entry ramp, westbound
Number plate survey	Base OD matrix from OD survey conducted by Hyder Consulting for VicRoads Metro North West Region. Surveyed on Tue 2/12/2003.
Roadside interviews	
Mail-back questionnaire	
Home interview	
Commercial vehicle survey	
Other sources	

Base trip table estimation

Method	Provide source and/or details
Counts only	
Synthesised from counts: ▪ Observed ▪ Modelled ▪ Other.	
Details of time dependent demand profiles used	

Future trip table estimation

Method	Details
Growth factors	
Modelled	
Other	
Adequately defined in the brief?	
Work complies with the brief?	
Work adequately documented?	

Assignment details

Algorithm	AIMSUN NG fixed (minimum distance) route choice model
Cost coefficients	
Incidents	
Signposting	
Strategic Routes	

Calibration

Calibrated To	Provide calibration statistics
Trip length distribution	
Observed volumes	Calibrated to West Gate Fwy westbound immediately after Power St onramp
Maximum flows	
Queue lengths	
Travel times	
Other (specify)	

Validation

Validated against	Provide validation statistics
Observed volumes	
Maximum flows	
Queue lengths	
Travel times	
Other (specify)	

Austroads Project NS1016
Microsimulation Modelling Report

Index VIC-3

Model developed by	T.K. Ting, M. Sarvi, J. Luk Monash University
Author of report	James Luk, ARRB
Date of report	12-08-2005
Study location	Melbourne
Microsimulation software used	Q-PARAMICS
Purpose of modelling and project description	The aim is to compare the performance of a microsim model with a well-established macroscopic simulation model, TRANSYT V8 from TRL. Through the comparison, it was possible to determine the parameters in PARAMICS that were sensitive for calibration and fine-tuning. The study site was Manningham Rd in Doncaster. A range of demand levels was employed, from the current demand to twice the current demand. Subjective observation of on-site traffic behaviour is the benchmark for assessing which model is closer to reality.
General conclusions from applying the model. Please comment on: ▪ results of investigating different scenarios ▪ sensitivity tests undertaken ▪ extent of the variation from default parameters ▪ difficulties encountered and ways to overcome modelling issues ▪ comments on the general robustness of model outputs.	The results from both models are equally valid for the "base case" since only small differences existed between the two models. However, the PARAMICS model was found to be sensitive to the increases in demand imposed. Extreme cases of lane blocking occurred but are not reflective of reality. This was also found when simulating the PARAMICS model with high demands for longer intervals. It was concluded from such observations that the TRANSYT model may be more reliable under higher demands (although TRANSYT cannot model queue blocking well if the link length is limited). The parameters related to lane changing in PARAMICS may need to adjust to maximise its ability to simulate on-road lane changing behaviour, e g. aggressiveness, earlier sign posting.
Reference:	Ting, T.K., Sarvi, M. and Luk, J.Y.K. (2004). Comparison between macrosimulation (TRANSYT) and microsimulation (PARAMICS). Proc. 26th Conference of the Australian Institutes of Transport Research December 8-10, 2004, Melbourne.

Please also supply background information on the model

General model scope

Location / route / area	Manningham Rd from Doncaster Rd to Bulleen Rd, Doncaster, Melbourne
Years modelled	2004
Time periods modelled	a.m. peak
Time periodic variations (profiles) in: ▪ Traffic demand ▪ Links ▪ Junction control.	no variation in the flow demand in the a.m. peka period; fixed-time control
Number of zones	14
Number of links	44
Number of nodes	8
Number of junctions	14
Number of traffic signals: ▪ Fixed time ▪ Vehicle-actuated ▪ Area traffic control system.	8 fixed-time signals

Network

Base Network	From on-site observations and measurements
Basic geometry	
Intersection layouts	
Traffic signal controls	
Other network features, e.g. ▪ Signposting ▪ Ramp metering ▪ Adjacent lane interaction ▪ Lane restrictions.	No specific sign-posting used
Time dependent features	
Carparks	
Future networks	Provide source and/or details
Basic geometry	
Intersection layouts	
Traffic signal controls	
Other variations from base network	None; extra demand on in-bound movements

Vehicle and driver data

Data type	Provide source and/or details
Default vehicle data used	Cars and buses
Additional or non-standard vehicles used?	
Vehicle proportions	Cars mainly due to small number of buses on site
Headway	Default global value of 1 s space time
Reaction time	Default value of 0.6 s
Driver behaviour parameters, e.g. ▪ Familiarity ▪ Aggression ▪ Awareness.	Also default values

Base travel demand

Source of raw data	On-site measurements
Automatic vehicle counts	None
Manual vehicle counts	Possibly manual counts plus SCATS counts
Classified counts	Bus and vehicles only
Manual turning counts	
Counts from signal control systems	Possibly
Counts from freeway management systems	None
Number plate survey	Travel times using floating-cars
Roadside interviews	
Mail-back questionnaire	
Home interview	
Commercial vehicle survey	
Other sources	

Base trip table estimation

Method	Based largely on counts for this arterial
Counts only	Yes, OK for arterial roads
Synthesised from counts: ▪ Observed ▪ Modelled ▪ Other.	
Details of time dependent demand profiles used	

Future trip table estimation

Method	Details
Growth factors	
Modelled	
Other	
Adequately defined in the brief?	
Work complies with the brief?	
Work adequately documented?	

Assignment details

Algorithm	Not investigated
Cost coefficients	
Incidents	
Signposting	
Strategic Routes	

Calibration

Calibrated To	Provide calibration statistics
Trip length distribution	
Observed volumes	
Maximum flows	
Queue lengths	
Travel times	Yes, bus and cars
Other (specify)	Headways at mid-block, modelled vs observed

Validation

Validated against	For model comparison purposes
Observed volumes	Yes
Maximum flows	Yes
Queue lengths	
Travel times	Yes
Other (specify)	

Austroads Project NS1016
Microsimulation Modelling Report

Index WA-1

Model developed by	Maunsell for Main Roads WA
Author of report	Maunsell
Date of report	February 2005
Study location	Mitchell Freeway Extension - Joondalup
Microsimulation software used	Q-PARAMICS
Purpose of modelling and project description	Model traffic impacts of the Mitchell freeway extension on the road network. The study involved developing PARAMICS models for the existing network (freeway ending at Hodges Drive), Stage 1 (freeway ending at Shenton Avenue) and Stage 2 (freeway ending at Burns Beach Road). The models were developed assuming 2006 traffic volumes for each scenario. Various traffic measures were applied to the base model to determine its impacts on the road network. Each of these scenarios was broken down further into morning and afternoon peak hours. 20 PARAMICS models were developed.
General conclusions from applying the model. Please comment on: ▪ results of investigating different scenarios ▪ sensitivity tests undertaken ▪ extent of the variation from default parameters ▪ difficulties encountered and ways to overcome modelling issues ▪ comments on the general robustness of model outputs.	Maintaining a single timeframe provided a sound measure to examine traffic impacts due to the freeway extension alone without land use or time dependent variables. The PARAMICS modeller provides a visualisation of the road network and traffic demands using graphical user interface. Geographic and travel demand data was input into the program, which then simulated lane changing, gap acceptance and car following behaviour for each vehicle. The assumptions used to input into the model were verified by onsite surveys of the road network and driver behaviour at major intersections.
Reference:	Maunsell report for Main Roads WA

Please also supply background information on the model

General model scope

Location / route / area	Area bounded by Hodges Drive, Joondalup Drive, Burns Beach Road and Marmion Avenue
Years modelled	2006
Time periods modelled	Am Peak 8.00-9.00 and PM Peak 15.00-16.00
Time periodic variations (profiles) in: ▪ Traffic demand ▪ Links ▪ Junction control.	(Describe time dependent aspects of the model)
Number of zones	61
Number of links	70
Number of nodes	63
Number of junctions	63
Number of traffic signals: ▪ Fixed time ▪ Vehicle-actuated ▪ Area traffic control system.	13

Network

Base Network	Aerial photos of the existing site conditions as an overlay and scaled auto cad drawings were used to model correct distances, angles, turning pockets, lane widths, and number. Nodes were positioned to reflect intersections and links added between nodes to build the road links. Zones in the PARAMICS model were defined as entry and exit points at the network boundaries.
Basic geometry	Mitchell freeway ends at Hodges Drive
Intersection layouts	AutoCAD and aerial photos
Traffic signal controls	Signal phasing diagrams and timing details provided by MRWA.
Other network features, e.g. ▪ Signposting ▪ Ramp metering ▪ Adjacent lane interaction ▪ Lane restrictions.	Bus stops and bus service schedules.
Time dependent features	
Carparks	
Future networks	AutoCAD drawings of the proposed Mitchell Freeway Extension
Basic geometry	AutoCAD drawings of stage 1 and stage 2 of freeway extension
Intersection layouts	Freeway Interchanges added. Prohibit right hand turns from Moore Drive to Marmion Ave. Add a dedicated right hand turn movement on Burns Beach Road into Marmion Ave.
Traffic signal controls	Signalise Connolly Drive / Shenton Avenue
Other variations from base network	Close Moore Drive between Christchurch Terrace and Blue Mountain Drive

Vehicle and driver data

Data type	Origin – destination trip matrix was established to define the vehicular flow pattern through the entire study area. Daily sub-area trip matrix from MRWA and traffic summary sheets from City of Joondalup.
Default vehicle data used	TRIPS
Additional or non-standard vehicles used?	
Vehicle proportions	Light 85% Light commercial 8% Heavy commercial 7%
Headway	
Reaction time	
Driver behaviour parameters, e.g. ▪ Familiarity ▪ Aggression ▪ Awareness.	

Base travel demand

Source of raw data	MRWA and City of Joondalup
Automatic vehicle counts	Yes
Manual vehicle counts	Yes
Classified counts	
Manual turning counts	Yes
Counts from signal control systems	
Counts from freeway management systems	
Number plate survey	Yes
Roadside interviews	Yes
Mail-back questionnaire	
Home interview	
Commercial vehicle survey	
Other sources	

Base trip table estimation

Method	Provide source and/or details
Counts only	
Synthesised from counts: ▪ Observed ▪ Modelled ▪ Other.	Modelled - aaSIDRA
Details of time dependent demand profiles used	

Future trip table estimation

Method	Details
Growth factors	
Modelled	
Other	
Adequately defined in the brief?	
Work complies with the brief?	
Work adequately documented?	

Assignment details

Algorithm	
Cost coefficients	
Incidents	
Signposting	
Strategic Routes	

Calibration

Calibrated To	Current conditions at AM and PM peak
Trip length distribution	
Observed volumes	Yes
Maximum flows	
Queue lengths	Yes
Travel times	
Other (specify)	

Validation

Validated against	Provide validation statistics
Observed volumes	
Maximum flows	
Queue lengths	
Travel times	
Other (specify)	

INFORMATION RETRIEVAL

Austroads 2006. **The use and application of microsimulation traffic models** Sydney, A4, 102pp, AP-R286/06.

Keywords:

modelling, simulation, vehicles, statistics, car-following, lane changing, calibration, software

Abstract:

Microsimulation traffic models (MSTMs) have in recent years become accepted as useful tools amongst road and transport authorities to analyse and identify solutions for traffic and transport planning. The synergy between information technologies and traffic engineering has enabled a new generation of microsimulation models now available for road and transport managers to analyse complex traffic operations. This report provides the guidelines in three components: a core Guide, a set of Commentaries and a Repository of modelling reports. The core Guide will be suitable for road managers to gain a broad appreciation of the usage and limitations of an MSTM, and for modellers to undertake the development of a model in a microsimulation study. The Commentaries are to provide explanatory information on microsimulation packages available and their basic structures. The Repository is a compilation of case studies in MSTMs amongst road authorities and research/academic studies undertaken in the local context.

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