INTERIM ADVICE NOTE (IAN 36/01)

THE USE AND APPLICATION OF MICRO-SIMULATION TRAFFIC MODELS

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Foreword

Why Choose Traffic Micro-Simulation?

The perception of many people who have seen the visual outputs from traffic micro-simulation models is that they are a valuable tool, they could be the next generation of traffic models, and could provide the medium by which lay and technical people can discuss the respective merits of transport proposals on equal terms. Micro-simulation models are closer than conventional (macro) modelling in representing transport networks and their operation and the behaviour of travellers and vehicles. They broaden the range of applications that can be modelled, and visually they are extremely useful.

Several factors combine to extend considerably the use being made of traffic micro-simulation models. Besides their ability to visually represent transport networks and their operation in considerable detail, improved models and faster computers are becoming available, there are rising levels of network congestion, there is a search for more multi-modal and more integrated and better use of the networks, and there are increasing needs for and availability of network informatics and control technologies. On the cautionary side though it is important to recognise that extra modelling problems and costs can be present compared with more conventional modelling approaches - these drawbacks as well as the potential benefits should be understood before a decision to develop a micro-simulation model is taken.

This Interim Advice Note provides some general advice on issues to be considered before deciding on a modelling approach, and on the types of application for which micro-simulation modelling may be most appropriate. It also refers to some of the main software packages that are currently available, and offers interim advice concerning some of the modelling, design, calibration and validation issues that need to be considered.

Some matters to consider at the outset include:

What are the purposes and functions of the proposed model?
Would a conventional model meet the requirements sufficiently well?
Is micro-simulation the only available or suitable methodology for this application?
How is the model to be funded and managed and further developed and used?
What is the simplest and cheapest way that the results and usage needed can be obtained?
What is the nature and quality of model needed? The model needs to be 'fit for purpose'.

Model calibration, validation, testing and forecasting procedures, documentation and reporting should follow existing good practice, as described in DMRB (ref 1) for example, but be carefully tailored to meet the particular requirements.

Micro-simulation modelling of operating transport networks is a relatively new and developing field. This advice is based on current experience and knowledge, but it is recognised that new developments may require changes to the advice in the future.

1 Background

1.1 *Introduction*

1.1.1 Traffic modelling plays an important part in the assessment of a range of traffic schemes, whether these are new road schemes, junction improvements, changes to traffic signal timings or the impact of transport telematics. Models can be used to demonstrate the effectiveness of schemes and other operational measures against a range of objectives. Where alternatives are being considered, information can be presented to allow the selection of the most appropriate option.

1.1.2 There is a wide range of alternative approaches now available based on micro- or macro- simulation methods. Micro-simulation (also termed microscopic) models differ significantly from traditional transport models (termed macroscopic) in terms of their methodology and supporting algorithms. Traditional models could be regarded as traffic engineering design tools (such as ARCADY, PICADY, TRANSYT), or transport planning tools (such as CONTRAM, SATURN, TRIPS and EMME/2).

1.1.3 Traditional models provide an aggregated representation of demand, typically expressed in terms of total flows per hour (although the CONTRAM model deals with packets of vehicles entering the network and expressed as a flow rate per hour). In such models, all vehicles of a particular group obey the same rules of behaviour.

1.1.4 By contrast, micro-simulation models have the ability to model each individual vehicle within a network. In theory, such models provide a better, and 'purer', representation of actual driver behaviour and network performance. They are the only modelling tools available with the capability to examine certain complex traffic problems (e.g. complex junctions, shockwaves, effects of incidents). In addition, there is the appeal to users of the powerful graphics offered by most software packages that show individual vehicles traversing across networks that include a variety of road categories and junction types.

1.1.5 There are a number of key issues involved in the use of any transport model. The Design Manual for Roads and Bridges Volume 12 and 12a (reference 1) sets out advice on the traffic appraisal of road schemes. This includes the definition of the study area, survey methods and data analysis, model development, forecasting and appraisal. Specific advice is given for traffic appraisal in urban areas (see for example reference 1), which includes guidelines on calibration and validation criteria.

1.1.6 With the potential for increased use of micro-simulation models, there is a need for advice on their development and application. Key issues to be addressed include how well and under what conditions or restraints micro-simulation models work. The calibration, validation and subsequent performance of any model are fundamental and, sometimes, contentious issues. This Advice Note assists project managers and their consultants to deal with these issues.

1.2 ***The Design Manual for Roads and Bridges- Advice on Traffic Modelling***

1.2.1 In defining the use of any traffic model, the user is referred to the Design Manual For Roads and Bridges vol. 12.2.1 para 1.2.6. This comments that:

' One of the key requirements of scheme appraisal is that it should provide a robust and consistent basis for decision making There is no case for a more elaborate analysis which reduces consistency with only marginal benefits in terms of robustness. An analysis that reduces robustness with only marginal benefits in terms of consistency is not recommended. For this reason the quality of an appraisal should not be judged by the size of its traffic model, nor by its apparent sophistication, but by the speed and efficiency with which it can provide the information needed to make and justify decisions '

Importantly, the DMRB goes on to state

'The use of more sophisticated methods can only be justified if they provide a significant reduction in the risk of the wrong decisions being made.

1.2.2 In the present context, this implies that micro-simulation modelling is likely to be more costly than a conventional modelling approach and therefore should be selected only where the circumstances of the case warrant this. What these circumstances might be is explored below.

1.2.3 The DMRB Volumes 12 and 12a have been devised for the traffic appraisal of schemes on the trunk road network. A separate section is included featuring advice on appraisal in urban areas. These volumes provide a consistent approach to traffic and economic appraisal. They give advice on appraisal methods covering a wide variety of schemes, from new infrastructure to traffic management.

1.2.4 The DMRB notes that the decision as to which traffic appraisal method is used is left to the local teams in the Highways Agency in England and their specialists in other overseeing organisations. There are three requirements which are mandatory for traffic appraisal on trunk roads:

- Preparation of a study database;
- Production of a local model validation report; and
- Production of a forecasting report.

1.2.5 These criteria apply in the use of many macroscopic models. Similar processes should be adopted for micro-simulation models in order to achieve consistent approaches. However, the use of micro-simulation models provides a different range and extent of issues to be addressed during model development.

1.3 ***Application of This Interim Advice Note***

1.3.1 It is noted that the pace of development of micro-simulation programs is currently very rapid. As such it would be impossible for re-issues of the Advice Note to keep pace with new software release versions and their features. This Note seeks to provide interim advice in the context of those features that are available at the time of writing. The user should check with the software suppliers on the detailed facilities that are available. General references are made here to such facilities.

2 Choosing a Micro-Simulation Approach

2.1 *Introduction and Summary*

This chapter provides background to the types of scenario or problem where a micro-simulation modelling approach can prove useful. Some basic issues to be considered in choosing a micro simulation model are:

(a) Modelling alternatives include both macro-scopic and micro-scopic models. Macro-models provide a 'simplified' representation of reality, with input assumptions required on aspects such as saturation flow. All vehicles are assumed to behave in the same manner. By contrast, micro-simulation models represent individual vehicles and detailed networks, and provide a powerful tool for assessing network conditions in complex or congested traffic systems where variability in driver behaviour is important.

(b) The micro simulation approach can provide a more realistic detailed approach since individual vehicles are modelled. A micro-simulation model is able to use geometric and traffic management information and driver behaviour to replicate actual traffic conditions. Saturation flows are an output of the model. Micro-simulation models can also visually display on a screen the changing traffic conditions during a modelled time period.

(c) There are many micro-simulation packages on the market. These vary between those which can represent exclusively motorways, urban areas, or both. The user should identify the nature of the study and establish the type of package best able to carry out the required assessment. There is a wide range of scenarios for which micro-simulation models can be used.

2.2 *Preliminary Matters for Consideration*

2.2.1 The first issue to address in the development of any model is to define the modelling requirements, problems and options under study. A check list of potential issues to consider are:

- **Would a traditional (non-micro-simulation) model meet the requirements?** - are there particular issues that a traditional model cannot address?
- **Is this an urban trunk road, rural trunk road or motorway situation?**- this can be an important influence on the type of approach and software package adopted- for example, some packages are better able to represent motorway merging and weaving than others;
- **What types of network improvement schemes are being considered?**- this also can be an important influence on the type of approach and software package being adopted- for example, some

packages are better able to represent adaptive traffic signal control methods or public transport options;

- **What is the range of alternative options or strategies**?- is the assessment simply looking at one type of solution or are wider alternative approaches being considered, for example different junction control methods (e.g. signal, roundabout or other traffic management measures);
- **Over what area will the scheme have an impact? -** will the scheme that is being considered have an effect over a wider area? In this case a modelling package that allows for route choice assignment should be considered- the model may need to cover an area sufficiently broad to cover the main re-routing effects;
- **How detailed will the model need to be?** - how many junctions, links and traffic zones are required? This is important for specifying the software package and computing facilities;
- **How many schemes or options are being considered?** - this can be important for assessing how many computer runs are required and how long they will take;
- **What time periods are being considered? -** for what period of time do the peak traffic conditions exist - within an hour, across the peak hour or over a peak period (such as in a major conurbation);
- **Are there specific vehicle type issues to be addressed?** - for example, does the assessment need to examine the impact on public transport, high occupancy vehicles or heavy goods vehicles or vehicles that have route advice;
- **What sources of data will be used?** - data will be needed for setting up the model and for calibration and validation purposes;
- **What is the level of detail of available or required data? -** for example, traffic flow by hour or for smaller time periods such as 1 minute or 15-minute time slices, or individual records (such as for speed information);
- **What are the likely data requirements?** - having established what is available, what other data is needed to build/validate the model;
- **What is the timetable and budget available for model development and scheme appraisal? -** this will determine what can be achieved within the time available;
- **Does the operation of the scheme need to be presented visually to the decision makers or the public?**

2.3 *Defining the Modelling Objectives*

2.3.1 In relation to dealing with whether a micro-simulation approach is appropriate, the choice of approach and type of computer software should reflect the output requirements of the study. In particular, the key issues to be addressed are:

- **How does the modelling inter-act with the design process? -** will the development of the scheme design need to respond to the results of the modelling, (for example, if a model demonstrates particular queueing problems at a new junction, will the designer need to consider these);

- **Are economic assessments needed? -** does the assessment need to produce evidence of travel time savings for different time periods throughout the week or year, for example;
- **Are safety assessments needed?** - does the assessment need to estimate the relative safety merits of a scheme or option;
- **Are environmental assessments needed? -** does the assessment have to estimate the impact on air quality, noise levels and other attributes;

2.3.2 The modelling may need to address some or all of the over-arching objectives as defined in Applying the Multi-modal New Approach to Appraisal to Highway Schemes ('The Bridging Document')[2] or the GOMMMS manual[3] (Advice on the Methodology for Multi Modal Studies). CHE Memo 100/01 refers.

- Environmental;
- Safety;
- Accessibility;
- Economy; and
- Integration

2.4 *The Choice Between Macro and Micro- Simulation Methodologies*

2.4.1 There are three standard traffic modelling approaches that can generally be adopted within the capabilities of PC-based computers. Firstly, there are traditional traffic engineering design tools (such as ARCADY, PICADY, TRANSYT). Secondly, there are transport planning tools (such as CONTRAM, SATURN, TRIPS and EMME/2). Both of these traditional approaches treat vehicles as an aggregate demand where all vehicles exhibit similar behavioural characteristics. In some computer packages the demand is aggregated to the full time period being modelled (such as the peak hour), in others, (CONTRAM) the demand is broken down into packets of vehicles with each packet able to select different routes through the network.

2.4.2 Thirdly, there are micro-simulation models which differ from the conventional models in that they purport to represent the individual behaviour of each vehicle. However, these models can vary significantly in their ability to reflect different driving situations (e.g. urban or motorway). Some are based on O/D demand matrices which allow route choice; others, for example, use fixed traffic flow data and turning proportions in their assessment.

2.4.3 Table 2.1 provides a summary comparison between alternative macro-simulation and micro-simulation methods. Consideration of these three approaches is given in more detail. It should be made clear, that these approaches deal with traffic assignment issues. Any other issues related to trip generation, distribution or mode split need to be dealt with by an external model.

2.4.4 The first group consists of traffic engineering tools designed for the assessment of particular junction types, such as roundabouts (ARCADY), priority junctions

(PICADY) and traffic signals (TRANSYT, OSCADY, LINSIG). Typically they model an individual junction, although TRANSYT can model combinations of signal controlled junctions. These programs have been extensively used over the last 20 years to assist with junction design and scheme appraisal.

2.4.5 They represent traffic demands at an aggregate level and do not allow for re-assignment. Input traffic flows are fixed by turning proportions over a modelled period, which can be broken down into time slices. As such, vehicles are assumed to behave in a consistent manner. These programs are more limited in their graphic outputs although Windows based versions are beginning to appear. These packages contain assumptions and simplifications in order to represent 'real' scenarios. As congestion increases, and driver behaviour responds to this, there is concern as to the ability of these programs to represent congested scenarios. In this case, the assumption over consistent driver behaviour weakens.

2.4.6 The second group consists of traffic and transport planning tools that are assignment models such as SATURN, CONTRAM, TRIPS, EMME/2. They vary in their ability to model junction delays but each is capable of route choice based on time, distance or user defined costs, often in conjunction with other travel demand or network supply or public transport features. As such these packages allow the user to identify the wider area effects of traffic schemes. The packages have been extensively used over the last 20-30 years and can be used on a PC.

Issue	Traffic Engineering Design Tools	Transport Planning tools	Micro-simulation
Potential use	Single isolated junctions (roundabout, traffic signal, priority) or combinations of signal junctions	Single isolated junctions to area wide models	Single isolated junctions to area wide models
Example Packages	ARCADY, PICADY, OSCADY, LINSIG, TRANSYT	SATURN, EMME/2, CONTRAM, TRIPS	PARAMICS, VISSIM, AIMSUN2, HUTSIM, DRACULA
Current use	Extensive use	Extensive use, guidelines for validation	Increasing use
Demand	Aggregated demand in flow profiles based on time slices or hour	Aggregated demand in flow profiles based on time slices or hour	Individual vehicles aggregated in flow profiles by time slice
Network	Requires link length, saturation flow, numbers of lanes and average speed	Requires link length, saturation flow, numbers of lanes and average speed	Uses geometric information to deduce congestion /saturation flows
Size of network	Single junctions or groups of traffic signal junctions (TRANSYT)	Small networks to large strategic networks	Typically small to medium sized networks
Driver behaviour	All vehicles have the same behaviour	All vehicles have the same behaviour	Individual vehicles have different behaviour
Assignment	Fixed demand	Can assign on the basis of time and/or distance	Can be fixed or assigned on basis of time and/or distance
Visualisation	None	None	Yes
Outputs	Limited graphical output	Outputs for flows, travel times	Outputs for flows, travel times

Table 2.1 - A Comparison of Macro and Micro Simulation Methods

2.4.7 Models have been developed covering a range of study areas from small junctions, town centres, urban areas, up to regional models. Typically they model a peak hour and represent a 'simplified' version of reality. Vehicles can chose alternative routes but demand is assigned in an aggregate fashion, and as such the models assume a consistency in driver behaviour. These packages do not provide visualisation but a range of tabular and graphical outputs showing flows, delays, queues, routes, and bus routes. As with the traffic engineering tools, these packages contain assumptions and simplifications to represent the 'real' world.

2.4.8 The third group of models comes under the label of micro-simulation, which has seen an increase in use in recent years. This is due to increased computer power, the availability of improved models, the rise in congestion levels, the search for better and more integrated use of the network, and the availability of information and control technologies. These types of program provide a much more localised and detailed representation of traffic behaviour since each vehicle is released separately on a randomised basis and can behave in an individual fashion.

2.4.9 Typically, the use of micro-simulation models has ranged from individual junctions or link sections through to medium sized towns, although one application was developed for the whole of the Scottish Trunk Road Network. There are a number of packages available, some of which model motorway systems only, others which can model urban and motorway systems. One advantage of micro-simulation models is the graphical presentation since the user can see 2- or 3-dimensional representations of the network in operation.

2.4.10 A key feature in the use of micro-simulation models lies in their level of dis-aggregation. This allows a much more rigorous treatment of the complexity of traffic behaviour. Modelling is undertaken at an individual driver/vehicle level, such that each makes its own driving decisions on speed, lane changing and route choice, for example. This can be far more akin to the 'real world'. In most cases the inputs to a micro-simulation model are the number of vehicles per time slice, the geometric data representing the road network, and the behaviour of drivers. Saturation flows are an output of the model rather than a fixed input as in macro-models. The resulting congestion within the model arises from the travel demands, traffic mix, highway geometric layout and junction characteristics. By contrast, macro models typically need assumptions on the saturation flows for a given link or junction which the user must derive.

2.4.11 Even within micro-simulation models, there are differences of approach. Some packages can be viewed as animated deterministic systems since the package is using routes/flows determined outside the system. In these cases, the paths across the network are determined by another package, or by the user (such as from turning counts). Other packages are 'pure' micro-simulation systems since all the decisions made by vehicles are totally internal to the system.

2.4.12 Given advances in computer power, there is likely to be far greater use of micro-simulation models for assessing traffic congestion problems. A range of network sizes have already been modelled using these approaches.

2.5 *What do Micro-simulation Programs Offer?*

2.5.1 The main characteristics of micro-simulation packages are (though not all packages offer all these characteristics):

- The programs can be used to model individual vehicles at a very local and detailed manner.
- Some computer packages are specifically designed to model motorway scenarios, such as weaving and merging sections, and the flow breakdown which occurs at high traffic flow.
- Other packages can be used to assess traffic conditions in urban areas; some cover both motorway and urban scenarios.
- Many of the computer packages offer a high degree of visualisation such that the user can view traffic conditions as if watching from a helicopter or mounted camera.
- They provide a powerful tool to demonstrate to designers and decision makers, the forecast operation of a particular traffic scheme.

- Visualisation can be in 2 or 3 dimensions with vehicles moving across the screen.
- They can represent changing traffic conditions across the modelled time period in short time increments.
- They employ car following models where each vehicle moves up to its desired speed unless held up by a slower vehicle. When held up, vehicles may change lanes to move faster across the network.
- Different vehicle types can be modelled.
- The computer packages vary in their treatment of driver behaviour. Vehicles move according to driver behaviour characteristics such as awareness and aggressiveness, or based on a desired speed distribution.
- Public transport services in relation to the highway network can be modelled.
- Some computer packages allow the user to investigate the interaction between trams and private vehicles.
- Delays caused by parked vehicles, roadworks, toll plazas and buses stopped at bus stops can be modelled.
- Micro-simulation methods can represent innovative solutions such as an ITS (Intelligent Transport System).
- They have the potential to provide more detailed inputs into air quality models.
- Different computer packages vary in their treatment of route choice.

2.5.2 However, care is needed in relation to the following issues:

- The user needs to understand in detail the operation and the limits of the package being used.
- Depending on the scale and nature of the model being developed, there is likely to be a need for more detailed calibration or validation data than is traditionally collected in traffic studies;
- The user will need to check modelled operation and performance of all aspects of the model carefully during a simulation and be satisfied regarding accuracy and realism. This may require review of the way individual aspects of driver behaviour are represented, including consideration of the suitability and robustness of the default values set for parameters within the program;
- The programs contain a number of variables which can be adjusted (for example, driver awareness and aggressiveness, gap acceptance). The user should only change parameters from their pre-set default values with respect to driver behaviour where there is local evidence to justify this;
- The simulation programs currently deal specifically with modelling traffic conditions and not with other modelling features such as mode split or distribution.

2.6 ***The Choice between Micro-Simulation Packages***

2.6.1 A number of reviews have been undertaken of the available simulation models that are currently (1999/2000) being used in the UK:

1) Work carried out by the Institute for Transport Studies, University of Leeds as part of the European Union's SMARTEST project[5]. Information for this project is available on the World Wide Web at ITS's site.

2) The Scottish Executive carried out a comparison between the PARAMICS and VISSIM programs[6].

3) Work undertaken on behalf of the Highways Agency in 1999/2000, partly in support of this Advice Note, and partly by TRL in considering software for the analysis of Designated Lanes [4]. The development of micro-simulation packages is rapid and the HA intends to monitor this development.

2.6.2 This section provides a broad overview of the main differences in approach at the time of writing, although the reader should bear in mind the advances currently being made. The HA review focussed on the following commercially available packages:

- AIMSUN2 - developed in Spain to simulate urban and interurban traffic networks containing a wide range of advanced transport telematics systems. The program is part of the GETRAM (Generic Environment for Traffic Analysis and Modelling) package;
- HUTSIM was especially developed for traffic signal simulation by the Helsinki University of Technology (HUT);
- PARAMICS has been used in a wide variety of applications in the UK in both urban and motorway scenarios;
- SISTM, developed by the Transport Research Laboratory (TRL) on behalf of the Highways Agency to study and evaluate methods to reduce motorway congestion; and
- VISSIM models transit and traffic flow in urban areas as well as on inter-urban motorways;

2.6.3 In addition, the HA Review included:

- DRACULA- which has just been released and which has direct links to SATURN;
- MITSIM- developed by the Massachusetts Institute of Technology (MIT);
- FLOWSIM- being developed by the Transport Research Group at Southampton University; and
- CORSIM (FREESIM AND NETSIM) developed by the Federal Highways Agency in the USA;

2.6.4 Four of these packages have been developed in the UK: PARAMICS, DRACULA, SISTM and FLOWSIM. SISTM and FLOWSIM are packages which can only represent motorways. FLOWSIM can handle only link modelling, while SISTM can model links and the merge/diverge sections whilst other junctions are not modelled. The other packages can be used for urban and motorway scenarios.

2.6.5 Each of the packages is available from its developer. The programs are continually being improved and updated.

2.6.6 Four of the packages allow the network to be built graphically against an image such as a map, scale drawing or aerial photograph. These include AIMSUN2, HUTSIM, PARAMICS and VISSIM. All the packages display the simulation in a 2-dimensional form, although the quality of the graphics varies between the packages. The PARAMICS and VISSIM packages allow the user to represent their scenarios in 3-dimensions, and from different perspectives.

2.6.7 Packages vary in their treatment of route choice. In some packages the program uses input turning flows or proportions for the assignment. AIMSUN2, PARAMICS and the new version of VISSIM allow the user to apply an O/D matrix and let the assignment proceed on the basis of travel costs. In the case of SISTM and smaller networks generally, there is no route choice as there are no alternative routes allowed.

2.6.8 Packages vary in the scale of network that they can accommodate. The user should check that a package is suitable for the scale of application being considered. This should cover the number of junctions, number of vehicles, geographical area, and model run conditions. The user should be aware of these before starting the development of a model otherwise there may be a need for late changes in software/hardware at a cost to the project.

2.6.9 Tables 2.2 and 2.3 compare the types of application that can be modelled by the packages. These tables broadly show the capabilities of the models with respect to each attribute. It is noted that some packages will handle particular features better than others. These features are being updated regularly. As such, the user should familiarise themselves with the capabilities of the packages before selecting one for a task.

2.6.10 For motorways, table 2.2 shows that each of the models can handle weaving (or lane changing). Only FLOWSIM cannot handle merges as it does not model junctions. AIMSUN2, PARAMICS, SISTM and VISSIM model the widest choice of motorway applications. All packages allow overtaking on dual carriageway roads. However, few packages can handle the issue of overtaking on single carriageway roads.

2.6.11 The applications that can be modelled for urban areas are illustrated in table 2.3. Between the various packages there are differences in the treatment of public transport. In some, buses are assigned as an O/D pair and not to a fixed route.

hjMost packages allocate buses to particular routes, timetables, set departure times and allow dwell times at stops which can be related to passenger boarding flows.

2.6.12 The packages vary in their ability to model traffic signals. Some of the packages have had historical links with traffic signal control packages and are more able to replicate adaptive and co-ordinated signals. These use detectors to identify the presence of vehicles to allow traffic signals to change. Others tend to rely more on fixed time plans as would a conventional SATURN model.

2.6.13 Each of the models provides a range of outputs. Typically, each of the programs provides data on flows at 'detector' locations. Thus they are able to replicate an automatic traffic count locations. The programs also provide information on vehicle speeds and travel times by class (either individual vehicles, link based, or for O/D pairs). PARAMICS also allows the user to assess 'events', which can include aspects such as vehicles lane changing and vehicle conflicts. Add-on modules have been added for a number of packages to assess fuel consumption and vehicle emissions.

2.6.14 Some packages allow route advice to be modelled. This can be 'static' advice in which pre determined paths are adopted by vehicles travelling through the network. Some packages allow 'variable' advice in which the vehicle can adjust its route in mid-journey. Thus if an incident is modelled, a vehicle on its journey whose path is affected by the journey can change route for the remainder of the journey based on knowledge of the network conditions. In the static case, the alternative routes are preset and once followed cannot be deviated from.

Table 2.2 Potential Motorway Applications

	AIMSUN2	HUTSIM	PARAMICS	SISTM	VISSIM	DRACULA	FLOWSIM	MITSIM	CORSIM
Motorways									
Motorway weaving	✓	✓	✓	✓	✓	✓	✓	✓	✓
Motorway merges	✓	✓	✓	✓	✓	✓		✓	✓
Ramp metering	✓	✓	✓	✓	✓			✓	✓
Dynamic speed controls			✓	✓	✓				
Motorway junctions	✓		✓		✓	✓		✓	
Incidents	✓	✓	✓	✓	✓	✓	✓	✓	
Variable message signs	✓	✓	✓	✓	✓	✓	✓	✓	
Static route advice	✓	✓	✓	✓	✓			✓	
Variable route advice	✓		✓					✓	
Toll Plazas	✓	✓	✓		✓			✓	
Vehicle detectors	✓		✓	✓	✓		✓	✓	
Priority Lanes- Buses	✓		✓	✓	✓	✓	✓		
Priority Lanes- HOV	✓		✓	✓	✓	✓	✓		
Crawler lanes	✓		✓	✓	✓	✓	✓		
Roadworks	✓		✓	✓	✓	✓	✓		
Tolls	✓		✓		✓	✓			

Table 2.3: Potential Urban Applications

	AIMSUN2	HUTSIM	PARAMICS	SISTM	VISSIM	DRACULA	FLOWSIM	MITSIM	CORSIM
Traffic signals									
Fixed time plans	✓	✓	✓		✓	✓		✓	✓
Co-ordinated traffic signals- Fixed UTC	✓	✓	✓		✓	✓		✓	✓
Adaptive traffic signals – vehicle actuated	✓	✓	✓		✓	✓		✓	
Priority to public transport	✓		✓		✓	✓			
Pedestrian phases	✓	✓	✓		✓	✓			✓
Pedestrian signals	✓	✓	✓		✓	✓			✓
Pedestrian flow			✓		✓				
Cyclists									
Cycle lanes		✓							
Roundabouts	✓	✓	✓		✓	✓			
Mini roundabouts	✓		✓		✓				
Priority Junctions	✓	✓	✓		✓	✓		✓	✓
Non-standard junction layouts	✓	✓	✓		✓	✓		✓	✓
Signalised roundabouts	✓	✓	✓		✓	✓		✓	✓
Traffic calming		✓	✓		✓			✓	
Public Transport									
Bus Routes	✓	✓	✓		✓	✓			✓
Bus frequencies & schedules			✓		✓	✓			
Bus bays			✓		✓				
Bus lanes	✓		✓	✓	✓	✓			
Bus pre-signals	✓	✓	✓		✓	✓			
Light Rail	✓		✓		✓				
Incidents	✓	✓	✓	✓	✓	✓		✓	✓
Roadworks			✓	✓				✓	✓
Signing			✓		✓			✓	
Parked vehicles			✓		✓			✓	
Overtaking on Single Carriageway Roads			✓						
Congestion charging	✓		✓		✓				

2.7 ***Defining the Modelling Brief***

2.7.1 If a micro-simulation model is selected for a project, there is a need for a clearly defined modelling brief to be issued. The design of the modelling brief can either be for internal use within the Highways Agency or for external consultants to undertake the work on behalf of the Highways Agency. The modelling brief should address:

- The key objectives of the modelling –
  - whether it is for design purposes requiring interface between the designer and modeller;
  - whether it is for operational/economic assessment;
  - whether it is to be used for presentation purposes at exhibition/ public meetings/ liaison with council officers/councillors
- The study area, network and network features to be modelled;
- Vehicle types to be modelled separately
- The time periods to be modelled
- The available data- whether is it observed or synthesised;
- The need for new data;
- Validation requirements;
- Forecasting tests – source of assumptions;
- The types of presentation and reporting required.

2.8 ***Practical Illustrations***

2.8.1 This section provides some illustrations of the use of micro-simulation modelling for trunk road planning.

- **Single motorway link**- can be modelled to demonstrate the lane changing behaviour on a motorway. The model could be used to demonstrate the impact of banning certain types of vehicle from specific lanes (such as trucks and coaches). Models can be developed to show the impact of a climbing lane or a bus/taxi lane to demonstrate driver behaviour at the merge point, or the operations of a planned roadworks site. These are scenarios that conventional models generally cannot assess in sufficient detail.
- **Grade separated junction**- design options for a large grade separated junction could be tested in micro-simulation. A particular example may be the introduction of traffic signals on the roundabout. The model would provide a basis for examining different lane configurations, traffic signal timings and their impact on vehicle movements/queuing around the junction and back on to the approach roads and motorway slip roads. Micro-simulation models can assess these issues in a far more disaggregate manner than conventional models.

- **Motorway merge/diverge scenarios –** micro-simulation provides the ability to model the merge/diverge areas on a motorway. The model can be used to assess different types of merge configuration and their impact on traffic. This is particularly useful when examining the safety impacts of a scheme. Models may be able to demonstrate the shockwave that occurs on the main carriageway where queues develop upstream of the merge. These are scenarios that conventional models cannot realistically assess.

- **Junction types-** micro-simulation allows the user to examine the impact on vehicle behaviour for a range of junction types (priority, traffic signal, and roundabout). The approach is particularly useful to help assess the impact of innovative junction designs (such as are found in the Highways Agency Toolkit[7]). Micro-simulation models can represent these alternatives in a far more disaggregate manner than conventional models.

- **Network wide modelling-** there is an increased use of micro simulation models to assess the wider network impacts of traffic management schemes. The micro-model is able to represent small networks consisting of 2 or 3 junctions as well as area wide models (such as a motorway corridor or town). These models can assess the impact of schemes in a more disaggregate manner. However, for very large strategic models, the conventional approach is still relevant and cost-effective.

- **Intelligent Transport Systems-** the influence of transport telematics is an area where micro-simulation methods have a major advantage over conventional models. These models can be used for example, to demonstrate how vehicles/drivers respond to changes in speed limits (such as through MIDAS) ramp metering and VMS messages. Within the travel matrix, those vehicles with route advice systems can be modelled and in some packages these can change routes in response to incidents.

- **LRT systems-** micro-simulation models have been used to assess the interaction of LRT services with other traffic. For example, at traffic signal junctions where the LRT service may have priority over other traffic movements. Again, this is an area which conventional models treat in a more aggregate manner.

3 Developing the Model

3.1 Introduction

3.1.1 This chapter provides background to the development of a micro-simulation model. This includes the types of data required to develop the model, the calibration and validation of the model and its use for forecasting.

3.2 Data Requirements

3.2.1 All traffic models have significant data requirements. In the case of micro-simulation models, there is potentially a greater amount of data needed to understand and replicate existing travel behaviour. The exact form and type of data needed is dependent on the type of package being used, the scale of the model being developed and the time periods under consideration. Data collection is expensive, and the quality of the model is heavily dependent on the quality and type of data collected. Micro-simulation models can be more data hungry than their macro-scopic counterparts as they have additional capabilities.

3.2.2 Data is required for two main purposes, to construct and calibrate the model, and to validate it., that is, to show that it represents observed behaviour and network operation satisfactorily.

3.2.3 Table 3.1 provides an example of the types of datasets that are needed to construct the model, and their potential sources. Exact data requirements are dependent on the package being used. There are broadly two types of data;

- **Static data** - the physical and technical characteristics of the network (the supply side). This includes accurate and detailed information on the network being used; for example, the number of lanes, their width and usage, the location of junctions, their mechanism of control, the location and geometry of bus stops and the operation of public transport services;

- **Dynamic data** - the trip or traffic demands to use the network. In a micro-simulation model these can be represented as turning volumes or as an origin-destination matrix, often by vehicle type. Other dynamic data include traffic signal timings that may respond to changes in travel demands.

Static Data

3.2.4 Much of the static (supply) data which can be used to generate the network (in terms of links and connectors) can be derived from:

- **Paper based maps of junctions and highway network-** from which the user has to transcribe the appropriate data to the computer package. For a package such as SISTM that does not possess a graphical editor, this is the most appropriate form of data entry;
- **Network data from other models-** AIMSUN2, DRACULA and PARAMICS for example, allow the user to directly convert data from other network packages into the micro-simulation models;
- **Digitised maps (such as AutoCAD drawings**)- VISSIM, PARAMICS, and AIMSUN2 for example, provide a graphical network editor, which allows the user to 'draw' the network interactively on screen. This is the most efficient method of deriving the initial network.

3.2.5 These data can be used to define network characteristics such as junction geometry, link lengths, lane widths, stopline locations, and bus stop locations. In some packages, the user will be required to define priority rules (these identify the stream of vehicles an individual vehicle considers when assessing the available gap before making a move). This will require an understanding of traffic behaviour at the location being modelled. Bus schedule information can be incorporated into some of the packages.

Dynamic Data

3.2.6 The dynamic data includes aspects such as travel demands, traffic signal timings and bus dwell times at stops. Depending on the package being used, demand matrices can typically be input:

- by vehicle type;
- by time period;
- by O/D pair or by turning movement proportion; and
- by volume.

3.2.7 The source data for demand matrices can be:

- from simple traffic counts such as manual classified counts or automatic traffic counts - the former allows a detailed breakdown by vehicle type to be specified; the latter can provide very detailed volumetric or flow or speed data over long periods (hourly or minute by minute), permitting trends or peaks to be identified;
- from traffic count data which allow matrices to be developed, such as from vehicle registration plate surveys or roadside interview surveys; and
- from matrices developed from existing macro models such as CONTRAM, SATURN and EMME2 - these provide a period based matrix, which can be converted to the micro-simulation model format; where the micro-simulation model covers a small part of the larger macro model area, some form of cordon matrix will need to be defined.

3.2.8 The user will need to define the time periods being represented in the model and the vehicle classes being represented. Typically SATURN or EMME/2 matrices will be based upon an average peak hour, and a time profile distribution will need to be applied to these matrices in order to produce 5 or 15 minute time slice data. CONTRAM matrices may already be developed in 15-minute time slices. Where real arrival profile data is available from automatic traffic counters in short time increments, this should be used. Such data will provide a robust input time profile for the micro-simulation model.

3.2.9 An important decision will be whether an individual hour or day, an average hour or day, a typical or actual peak period (or a 50th or 30th highest hour) is to be represented. The various priorities for use of the model as a design tool, a forecasting tool, or as a means for preparing a scheme appraisal will be relevant considerations here.

3.2.10 In addition to the above data, there are attributes that are included in the micro-simulation program as default values. These may include distributions for:

- Vehicle length;
- Desired vehicle speed;
- Vehicle acceleration and deceleration; and
- Driver awareness and aggressiveness.

Type	Inputs	Notes	Source
Static Data	Link data	Provide the network on which the microscopic vehicles travel and are built up graphically from digitised maps/plans	Digitised maps/junction arrangement plans Can also be derived from a macro-model such as EMME/2 or SATURN
	Link connectors	'on the ground' lane usage and lane markings, important criteria which should be reflected in the model	Digitised maps/junction arrangement plans Can also be derived from some macro-models
	Priority Rules	Minimum gap times and minimum headways	Digitised maps/junction arrangement plans, observations of reality and simulation
	Bus routes	Fixed bus routes defined as a series of links, connectors and bus stops	Bus schedules
	Bus frequencies	Timetable arrival times with facility to model unreliable arrival rates	Bus schedules
	Signal stoplines	Input graphically from digitised plans, each lane has its own stop line allowing for signal phases to be modelled explicitly	Digitised maps/junction arrangement plans
	LRT/bus stop locations	Input graphically from digitised plans (on-street or lay-by)	Digitised maps/junction arrangement plans
	Bus stop lengths	Input graphically from digitised plans, dictate whether 1 or more buses can stop at bus stop at any one time	Digitised maps/junction arrangement plans, observations
Dynamic data	Turning movements	Expressed as turning proportions or OD matrix	Registration plate data/trip matrix Can be derived from macro-models
	Traffic volumes	Expressed as rate for each time slice (service vehicles loaded to timetables)	Classified counts/ Registration plate data/trip matrix
	Signal timings	Taken from traditional signal timings optimisation programs and red end, green end and amber period defined	UTC outputs/TRANSYT/observations
	Traffic composition	Car, hgv, psv, lrt proportions can be defined, also pedestrians and cyclists can be defined	Surveys
	LRT/bus dwell times	Average dwell time and standard deviation defined for each bus stop	Surveys
	Pedestrian crossing flows	Can be included in the model	Surveys

Table 3.1: Example Datasets needed for developing a Micro-simulation model

3.3 ***Calibration and Validation***

Introduction

3.3.1 Calibration and validation are the processes of developing and then assessing the suitability of the model. In developing a traffic model, the Design Manual for Roads and Bridges volumes 12 and 12a provides advice on conventional model calibration and validation. Most of that advice is relevant in a micro-simulation modelling context. The overall aim of the process is to demonstrate that a model is suitable for use. The DMRB notes that '*Each stage of base year model development should* *be validated against independent data, so that any weaknesses in the model can be properly understood and remedial action taken'.* This philosophy should be adopted for micro-simulation models. The key requirement is that the model is shown to be robust for the applications being tested, and that users and decision-makers agree that the model is sufficiently reliable.

3.3.2 Model calibration is a process of tuning and refining the input data and parameters within the model in order to agree with real observed data, and thus provide a tool which is reliable for forecasting. Model validation is a process of comparing the results of the model with independent observed data.

3.3.3 The two processes are interlinked. In developing any model, it is necessary to carry out both a calibration and validation process. But given the range of micro-simulation software packages, and the variety of potential modelling scenarios and modelling applications, no single or precise advice is appropriate for all cases.

3.3.4 It is important to distinguish for example between cases where careful calibration and validation is essential to derive robust results, and cases where less robust and more illustrative or indicative results are sufficient. Recommended model development principles of model calibration and validation are 'horses for courses', and 'fit for purpose' . The approach to be adopted should be agreed at the outset.of the model development process between the client and the model developer.

3.3.5 The above relates to the general approach to calibration and validation. The types of parameter that are examined in a micro-simulation model are different to those used in macro-models. Parameters within a micro-simulation model tend to be more detailed than those of macro-models. In particular, the user can target the calibration at those factors which influence vehicle and driver behaviour, as well as network characteristics.

3.3.6 The resources devoted to model development, and the areas or aspects of the model to be given priority in terms of calibration detail and validation accuracy, depend on the ultimate uses for the model. For example, in a motorway link context, lane changing behaviour and individual lane speeds might be particularly important, whereas these may be less important where the focus is on the urban network.

3.3.7 It is the discretion of the model developer how the model is demonstrated as robust and suited for its purpose. The model developer should seek to validate defined model outputs to local and agreed criteria, chosen in relation to the intended model functions. Potentially, given the scope of these models, a greater amount of data will be required to validate a micro-simulation model.

Of particular importance will be the nature and degree of variation in flows and times and queues which is introduced into the simulation by the randomisation process and the choice of pseudo-random number. An early decision will be needed on what time period the model is intended to represent, for example one individual named day, or a typical or average weekday in November, since this will determine the data inputs required and the format of the validation. How realistic is the modelled variation in relation to observed daily, hourly or minute-by-minute variation?

Calibration

3.3.8 The SMARTEST report[8] provides examples of the calibration of micro-simulation models. These relate to examples using the AIMSUN2 and DRACULA models. The outline of an approach recommended by SMARTEST includes:

- an initial simulation run based on the initial network and matrix;
- identification of potential errors such as abnormal queues, blocked vehicles (in some packages it is possible for vehicles to reach a point on the network and get 'stuck' and cannot force their way into the main traffic stream), u-turns, unrealistic route choices;
- comparison of simulated flows with observations;
- re-coding the network based on errors discovered;
- examination of route choice parameters and appropriate adjustments;
- re-running the simulation;
- examination of flows and speeds at detectors;
- sensitivity analysis on key parameters;
- further refinements.

3.3.9 The calibration (and validation) should concentrate on those issues that affect the model's objectives. Specific features may be more or less important in particular projects (for example; lane changing, merge behaviour, lane speed variability, visibility, driver reaction points to ITS information, or overtaking). In undertaking the calibration and validation, it is further recommended that:

- the model should be initially set up using the default parameters and the results from these runs should be reported;
- sensitivity analyses should be undertaken to assess the impact of changing key parameters and using non-default parameters in certain instances;
- analyses should be undertaken to assess modelled variation in important model variables and model outputs, in relation to desired accuracy in representing observed variation, and the stability and robustness of model results;
- the user should assess the impact of different seed values on queuing variability, particularly at key junctions, and the number of alternative runs needed and the presentation in terms of the modelled variation should be assessed.

3.3.10 Sensitivity analyses are important in order to obtain a better understanding of which factors have the greatest importance to the quality of the model in relation to its intended use. The sensitivity analysis can reveal whether improvements in the calibration can or need to be obtained by amending the default values. Where the defaults do not perform well, sensitivity analysis will provide a guide as to which factors are locally important. A range of values could be used as part of the calibration process.

3.3.11 An important modelling decision may be needed concerning which aspects of the modelled situation are subject to variation and by how much. Many of these may be covered by default distributions or profiles, but the user should be aware what these are and how they affect the model performance and whether they are appropriate to the required model, the required analysis, and the format for model testing. The most significant model input is demand, or traffic flow, actual or constrained or unconstrained, represented as trip matrices, and/or traffic flow. The user should be conscious of how demand is represented and varied, and whether the variation represented is around an actual, typical or average situation. The user should also be aware of whether it reasonably represents daily, seasonal or peak conditions. The required number of repeat runs with different seed values, if any, can then be decided.

3.3.12 Different input parameters affect the modelling of the various highway features found on a network. Information should be sought by the user concerning which of the influential parameters can be varied legitimately, how much variation is realistic, what is the evidence base, and what is appropriate in the study context. Examples of the input parameters that most affect the calibration of different highway features are shown in Table 3.2.

Highway Feature	Example Input Parameters that most affect Calibration
Roundabouts	Entry speed Circulating Speed Gap Acceptance
Signal Junctions	Signal timings (are they consistent with the flows adopted in the model?) Geometric speed restrictions Gradients Vehicle acceleration profiles
Priority Junctions	Gap Acceptance (where there is a breakdown in main road flow what are the forcing characteristics?)
Links	Vehicle Speed Distribution on links (especially external links) Arrival Profile Routing Decision points Lane Usage

Table 3.2: Example Input Parameters which influence Calibration

3.3.13 In order to calibrate the model, traffic data and local knowledge of traffic behaviour is needed. A basic issue is for the base year version of the model to represent the correct flows which can pass through links and junctions given different traffic demands. These in turn influence the amount of congestion, and delay times. Choices will be necessary about which data will be used for calibration and which for validation, and whether certain available data items will not be used for calibration.

3.3.14 Model calibration, model validation, and even model scheme testing or forecasting may in some cases be an iterative process, for example when it is necessary to explore the model testing requirements before all implications for the nature of the calibration are clear. Once the model calibration is finalised, it is important to document (in the MVR Report, see below) the initial and final model structure and input data, including the model parameters, default values, default distributions, and any changes made.

3.3.15 One area where the user should give careful consideration is the treatment of route choice, particularly when using a 'dynamic assignment option'. Packages vary in their treatment of route choice with some only using input turning flows or proportions for the assignment while others allow an O/D matrix to be assigned on the basis of some form of travel costs. The user should carefully check the paths that a model is assigning vehicles to a network to ensure that spurious routes are minimised.

<u>Validation Indicators</u>

3.3.16 The following are some of the basic validation checks on the network which should be undertaken:

- check lane widths: if using information from a digitised map;
- check permitted turns can be made;
- check priority rules, give ways and stops at junctions are being obeyed;
- check vehicles do not collide with each other because of poorly defined priority rules;
- ensure yellow boxes (used in some packages to prevent junctions being locked) are used as appropriate to ensure junctions are kept clear of queuing;
- check reserved lanes are being used correctly, for example buses using bus lanes;
- check for unexpected queues or blocked vehicles;
- check signal timings and phases are correct;
- check the behaviour of vehicles on red-and-amber and amber phases of signal settings;
- check driver behaviour at merges and diverges;
- check the behaviour of buses waiting at bus stops; and
- check error messages supplied by the package in carrying out the run.

3.3.17 The validation of model output or simulated network performance should be related to the type of application the model is being put to, the package being used and its available outputs, the scale of the model and the data available. However, the type of issues to be assessed might include:

- traffic flows - probably by vehicle type and time period at various locations, and profile;
- saturation flows - (defined as maximum flow rate that can be sustained by traffic from a queue on an approach- depends on geometry, proportion of turning traffic, radius of turn and gradient.
- journey times and speeds for private and commercial vehicles (at appropriate level of aggregation or detail);
- journey times and speeds for buses including dwell times at bus stops;
- delays at junctions;
- location of queues;
- queuing times;
- routes being used (if route choice assignment being undertaken) and
- lane selection and changing – if deemed to be appropriate such as in some motorway case studies.

3.3.18 The user should be aware that the validation of a micro-simulation model can be a challenging task. Model outputs vary according to the random number seed used within the model. This variation can range from slight to extremely extensive depending mainly on model complexity and the degree of traffic congestion. The representation and interpretation of this variation can significantly affect overall results, and the scheme assessment and scheme performance interpretations and judgements made on the basis of model outputs. It is important to agree the meaning of the variation, in relation to the model inputs and depending on its magnitude and the intended uses for the model; also how it is to be presented or reported, and how it is to be controlled in presenting the relative performance of alternative scenarios.

3.3.19 The validation data may be collected by a range of survey methods which are outlined in the DMRB and include counts, journey time surveys, queue length observations and video surveys. The observed measurement of queues is always subject to some judgement on the part of the enumerator. The validation of queues should focus on the key junctions within the modelled area. Initially the visualisation should be used to assess whether queues are forming in the correct locations in the study area. However, the user should be aware of the different queuing results that may be obtained from different initial seed values. Care should be taken in the assessment of queues, particularly if the user is using one assignment as the basis for assessing impacts.

3.3.20 Lane changing (frequency, location) may be the most challenging to validate against observed data. If validation is required, observations will be needed from video surveys, which may be limited in their coverage. Such surveys should be set up to view key sections, such as of a motorway from an overbridge. The observations would seek to record the number of lane changes within a specified time period.

Validation Criteria

3.3.21 In carrying out the validation, consideration should be given to:

- the day and time period being considered- for example, is the model being used to replicate average day conditions or one particular day (if so which one), or used to examine the variability of flows between different days;
- the types of parameter being looked at, such as flows, queues, saturation flows, delays, merge behaviour or lane changing;
- issues of route choice may need to be considered over larger networks; and
- the effect of incidents or local network conditions.

3.3.22 The user should define model validation criteria which are relevant to the modelling scenario being undertaken. DMRB (12.2.1 Chapter 4) gives basic validation criteria and statistical performance indicators for traditional macro-simulation models, for assessing and comparing modelled output values with observed data, and these can be applied initially in a micro-simulation context, or as background targets. But a common reason for developing a micro-simulation model in the first place is to provide a more accurateor more responsive model than can be developed using more traditional modelling methods. Where this is the case, the validation criteria should therefore reflect this, both in terms of the particular outputs (for example delays, queues, speeds, manouvres on certain key links, possibly by vehicle type), their definition (for example delay/vehicle and queue length per 5 minutes through the period 8-9am at a particular intersection or junction approach), and the precision of their specifi.cation.

3.3.23 A **Model Calibration and Validation Report (MVR)** should be produced. This should describe:

- the model purpose and outline design of the model, including dates;
- the sources of data used to develop the model;
- the surveys and survey data collected;
- the network development and traffic management assumed;
- the matrix development and other traffic data represented;
- results from initial runs using the default parameters, and from sensitivity tests exploring the significance of individual modelling assumptions;
- justification for significant default assumptions (e.g. parameters or distributions) and for any changes made to these;
- visual and logic and other checks made to confirm model validity;
- the model calibration process, and changes made to improve the model to its final form;
- recommendations related to the randomisation and modelling of variation, in relation to validation, forecasting and scheme assessment;

- validation tables showing results by time period for traffic flow, speeds, delays, travel times and queue comparisons, at least, together with any additional or more refined validation needed to establish model robustness in relation to the intended specific role of the model.

3.3.24 Following current practices as outlined in the DMRB, the above report (MVR) should normally (but see below) be presented to the client for acceptance or otherwise, before the model is applied for real to scheme or policy testing work. See also DMRB vol 12.1.1 Chapter 11.

3.4 ***Forecasting and Option Testing Procedures***

3.4.1 Once the base case model has been developed and accepted, and the MVR approved, the model is available for scheme testing. The 'with scheme' or future year networks can be developed from scheme drawings as with the base case. The development of the forecasts should generally and where appropriate follow the best modelling practice advice and procedures for traditional models set out in the DMRB vol. 12.1.1 Chapters 12-15 and also vol 12a relating to forecasting. Much of this is relevant in a micro-simulation modelling context. However, as with the base year calibration and validation work, the nature of some micro-simulation modelling applications means that alternative methods need to be employed. This should all be explained and justified within the Model Forecasting Report or Report of Model Tests:

3.4.2 A **Model Forecasting Report (MFR)** or **Report of Model Tests** should be produced which describes:

- The development of the model forecasts or model test situation from the base year or base situation;
- Any changes in modelling assumptions from the base year;
- The representation of variation, and any other features of the model which significantly affect interpretation of the results
- the development of the model tests
- model results in appropriate summary or sufficiently detailed or graphic form;
- scheme or scenario effects or impacts or assessments in appropriate detail.

It is important that the robustness of the modelling work is presented so that appropriate conclusions can be drawn concerning the degree of reliability which can be placed on the forecasts and scenario or scheme assessments.

3.4.3 There may be inter-dependence between the model testing work and the model calibration and validation work, for example when the significance of particular features of the base model do not become apparent until the future testing work is in progress. This would require a return to the model calibration and validation phase. There may then be a case for combining the MVR and MFR into a single document. But the principle of client acceptance of the separate stages of the modelling work, MVR and MFR should nevertheless be retained as far as possible.

Substantial testing work should not normally be commenced until the MVR validation report is accepted.

3.4.4 Outputs from the modelling assessment may be used within the frameworks of the standard DMRB, GOMMMS and NATA appraisal methodologies. These are based on five over-arching objectives, relating to Environment, Safety, Economy, Accessibility and Integration.

3.4.5 Given that micro-simulation models represent each vehicle on the network separately, there are a variety of indicators for which these models provide relevant estimates, for example:.

Environment (*relevant estimates can be derived using procedures contained within DMRB volume 11)

- Air quality- PM10, Hydrocarbon, CO and NO2 changes- models are able to reflect the individual driving characteristics of vehicles such as speed, queueing, braking
- Change in global emissions of CO2 in tonnes;
- Visual intrusion- the visualisation may be able to give a subjective impression of congestion;
- Fear and intimidation-can be related to traffic flow data and vehicle speed;
- Severance- based on traffic flow and speed, and delays to pedestrians crossing roads.
- Noise- typically based on 18-hour flows; micro-simulation outputs limited to a peak period simulation will only be partially useful

Safety (* estimates can be derived using standard procedures)

- Estimated number of accidents;
- Estimated number of casualties;
- Degrees of hazard / risk related to manoeuvres, vehicle braking, events etc;
- Size, location, time of queued vehicles;
- Vehicle speeds and speed variability by vehicle type.

Economy (*can be derived using procedures from DMRB volume 12-14)

- Changes in travel times and travel distances across the network; micro – simulation models can provide global statistics on travel times;
- Changes in travel distance across the network
- Delays to vehicles- queue locations can be identified
- Journey time reliability and network stress;

Accessibility / Integration

- Public transport and slow mode flows and delays and vehicle interactions;
- Interchange design and operation;
- Operation of dual operation (light rail, bus, rail systems)

- New development and park-and-ride access arrangements.

3.5 ***Use for Demonstration Purposes***

3.5.1 The micro-model can be used for a number of demonstration purposes:

- during the scheme design phase - for the designer to see how a scheme will perform and then revise the design as appropriate;
- during scheme decision making – to demonstrate to decision makers the operation and impact of a scheme
- during public consultation – to demonstrate to the public consultees the operation and impacts of a scheme.

3.5.2 In using a model during consultation, the following issues need to be considered:

- will the model be run in its entirety;
- will the model be shown in 2-dimensions or 3-dimensions
- will a video be produced to show example snapshots of a scheme;
- which snapshots are used - at grade or overhead views;
- will an average model run (which is representative of the range of iterations that have been undertaken) or the results from one particular run be used.

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