

Guidelines for the Use of | **Microsimulation Software** |

July 2007

**This document has been prepared for the Highways Agency
by FaberMaunsell**

Prepared by:
Brian Vaughan

Approved by:
Andy McGregor

Guidelines for Microsimulation Modelling

Rev No	Comments	Date
1		

Dunedin House, 25 Ravelston Terrace, Edinburgh, EH4 3TP
Telephone: 0131 311 4000 Fax: 0131 311 4090 Website: <http://www.fabermaunsell.com>

Job No:- 40451TEDT

Date Created July 2007

This contains confidential and commercially sensitive information, which shall not be disclosed to third parties.

document3



Table of Contents

1	Introduction	3
2	Modelling Approach: The use of Micro-simulation on the Highways Agency's Network	5
2.1	Introduction	5
2.2	Preliminary Matters for Consideration	6
2.3	What has micro-simulation to offer in modelling the network?	6
2.4	Application of Micro-simulation to the HA's network.....	6
2.5	Would a traditional model meet the requirements?	6
2.6	Study Area Coverage	7
2.7	Output Requirements of the Study	8
2.8	Micro-simulation Software Selection.....	8
2.9	Technical Capabilities	8
2.10	Input/Output/Interfaces	9
2.11	User Training/Support.....	9
2.12	Ongoing Software Enhancements	9
2.13	Management of a Micro-simulation Study	9
3	Data Requirements, Resources and Collection	13
3.1	Data Collection/Preparation	13
3.2	Data Requirements	13
3.3	Geometric Data	14
3.4	Control Data	14
3.5	Demand Data	14
3.6	Count Locations and Duration	15
3.7	Estimating Origin-Destination (OD) Trip Tables	15
3.8	Vehicle Characteristics	16
3.9	Vehicle Mix.....	16
3.10	Calibration Data	16
3.11	Validation Data.....	17
3.12	Site Survey.....	17
3.13	Travel Time Data	17
3.14	Highways Agency's Journey Time Information.....	17
3.15	Capacity and Saturation Flow Data	18
3.16	Delay and Queue Data	18
3.17	Data Preparation/Quality Assurance	18
3.18	Reconciliation of Traffic Counts	19
4	Data / Model Checking	21
4.1	Error Checking	21
4.2	Review Software Errors	21
4.3	Review Input	21
4.4	Review Animation	22
4.5	Error in Analyst Expectations.....	23
4.6	Analyst Data Coding Errors	23
4.7	Residual Errors	24
4.8	Key Decision Point.....	24
4.9	Example Problem: Error Checking	24
4.10	Software	24
4.11	Review of Input Data and Parameters.....	24
4.12	Review Animation	25
4.13	Key Decision Point.....	25
5	Model Calibration	27
5.1	Overview	27

5.2	Micro-simulation Calibration Parameters.....	27
5.3	Parameter Calibration Data Sources.....	30
5.4	Indicative Parameter Values and Distributions.....	31
5.5	Random Seed Guidance	37
6	Model Validation.....	40
6.1	Overview	40
7	Forecasting Procedures	43
7.1	Introduction	43
7.2	Adjustment of Driver Behaviour : Base to Future	43
7.3	Forecasting Reporting	44
8	Economic Assessment Using Micro-simulation.....	46
8.1	Introduction	46
8.2	Model convergence and Stability.....	46
Table 1 - Milestones and Deliverables for a Micro-simulation Study.....		10
Table 2 - Indicative Parameter Values - The Evidence Base.....		32

1 Introduction

- 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. There is a wide range of alternative modelling approaches now available based on macro- or micro-simulation methods. Micro-simulation (also termed microscopic) models differ significantly from traditional transport models (termed macroscopic) in terms of their methodology and supporting algorithms.
- 1.2** Traditional models could be regarded as traffic engineering design tools (such as ARCADY, PICADY and TRANSYT), or transport planning tools (such as CONTRAM, SATURN, TRIPS, EMME/2 and VISUM). Macro-models provide a 'simplified' representation of reality, with input assumptions required on critical aspects such as saturation flow, capacity and speed / flow relationships. All vehicles are assumed to behave in the same manner and provide an aggregated representation of demand, typically expressed in terms of total flows per hour.
- 1.3** By contrast, micro-simulation models have the ability to model each individual vehicle within a network. In theory, such models should provide a better representation of actual driver behaviour and network performance, particularly when networks are approaching capacity and vehicle interactions become far more important in determining the outturn operational performance. They are the only modelling tools available with the capacity to examine certain complex traffic problems (e.g. complex junctions, shockwaves, effects of incidents, interaction with pedestrian traffic etc.). In addition, there is the appeal to users of the powerful graphics offered by most micro-simulation packages. Whilst this can provide decision makers and consultee's graphical representation of the performance of a scheme it should never be the only reason for using micro-simulation.
- 1.4** With the increasing application of micro-simulation models, there is a need for advice on their development and application, particularly in the context of their application to the motorway and trunk road network. Key issues to be addressed include how well and under what conditions or constraints micro-simulation work and offer the greatest benefits. The calibration, validation and subsequent performance of any model are fundamental and, sometimes, contentious issues. The range of variables that are taken into account in micro-simulation models, compared to the very limited ranges included in traditional models, have lead to questions as to the validity of the results obtained and the degree to which confidence can be placed on the modelling.
- 1.5** The aim of these guidelines is to provide advice on the development, application and reporting of micro-simulation models. The objective is to bring clarity to the main issues and to provide clear, and unambiguous, guidelines on the parameters that are considered most crucial in determining how well the model reflects reality, and which in effect dictate the outturn capacity and operational performance of the model. The advice is supplemental to the guidance given in DMRB and WebTAG particularly in regard to validation and calibration of the model.

Modelling Approach

2 Modelling Approach: The use of Micro-simulation on the Highways Agency's Network

2.1 Introduction

2.1.1 This chapter provides guidance on where a micro-simulation modelling approach should be used on the Highways Agency's network. Micro-simulation models represent individual vehicles and detailed networks, and provide a potentially powerful tool for assessing network conditions in complex or congested traffic systems where variability in driver behaviour is an important contributory factor to network performance. It is also important, however, to recognise that care is needed when deciding upon the use of micro-simulation as the higher degree of complexity inherent with this type of modelling can result in a level of modelling and resource which is disproportionate to the problem being addressed or the decision that needs to be made.

2.1.2 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 decision being made.'

2.1.3 From previous experience on motorways and trunk roads, the development, calibration, validation and application of micro-simulation models can require a significantly greater amount of resources and time to achieve consistent and robust results when compared to more traditional models. Consequently, prior to the use of micro-simulation for scheme evaluation on the HA network there needs to be an assessment into whether micro-simulation provides the most appropriate and cost effective method of assessing the proposal under consideration. It is very important to draw a distinction between the application of micro-simulation in urban areas and on the HA's network. In an urban area where the traffic interactions are more numerous and controlled through the use of signals and roundabouts, with clear short sections between junctions and limited opportunities for lane changing then, micro-simulation model development costs can be much closer to those for traditional models. In a motorway applications on the HA network, where the interaction between vehicles has a much greater impact on outturn operational performance and the range of parameters that combine to produce the model performance can be significantly greater than those for traditional traffic engineering and macro-models, then the micro-simulation model development costs can be several times greater than those of a more traditional application.

2.1.4 These guidelines explore under what circumstances micro-simulation should be considered as an alternative to traditional techniques and also how micro- and macro-simulation models can be integrated to maximise the benefits that each has to offer in terms of consistency, robustness and ease of development and application. It has to be borne in mind that it is often not a case of either/or but of a structured integration of both approaches to achieve the desired outcomes.

2.1.5 There are several well established micro-simulation model packages currently in use in the UK and these vary between those that 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.

2.2 Preliminary Matters for Consideration

2.2.1 It is important to ensure, prior to embarking on the use of micro-simulation on the Highways Agency's network that it is the correct tool to use. In order to do this the model user should have considered/be aware of the following:

- What micro-simulation has to offer as regards modelling the Highways Agency's network
- How should the modelling be applied to the HA network
- The management of the modelling.

2.3 What has micro-simulation to offer in modelling the network?

2.3.1 It is important to first consider what micro-simulation offers in relation to traditional modelling approaches and to identify areas where micro-simulation has current weaknesses compared to traditional modelling tools.

2.3.2 Micro-simulation modelling is best suited to the modelling of situations where networks are operating close to capacity and there are many interactions between individual elements of the network and driver behaviour. In such situations traditional models and empirical approaches have limitations. Where it is necessary to make best use of an existing motorway by better managing traffic e.g. by the use of access control or active traffic management then micro-simulation can offer advantages.

2.3.3 It is extremely important to recognise that micro-simulation does not provide a magic 'black box' that is capable of deriving network performance measures without the need for user specified capacity and saturation flows. The capacity and saturation flows output from a micro-simulation model are every bit as dependent on model inputs as those in traditional models, they are just different inputs and ones that most modellers take as the default values in the calibrated car following and lane changing models. Indeed the issue of saturation flows is a very good example of how traditional methods and micro-methods are equally dependent on user inputs. Empirical evidence clearly shows that the saturation flow of a narrow 3.0m lane is significantly different to a wide 4.5m lane, generally assumed to be related to side friction issues and staggered queuing potential. Micro-simulation models generally take no account of lane width on driver behaviour and hence produce the same saturation flow whatever the lane width, and in order to reflect differing saturation flows the model user has to adjust driver characteristics on individual links. Hence, the user 'fixes' the saturation flows in much the same way as occurs in a macro-model.

2.3.4 The outputs obtained from a micro-simulation model are equally dependent on key parameter values input to the model, in much the same way as are the outputs from a macro-model, and the importance of these parameters and their calibration forms an important element of later sections of this guidance. In deciding what role micro-simulation can play and when it provides added benefits over traditional methods that justify the generally higher level of resource associated with micro-simulation modelling it is critical to identify the 'real' differences that such models provide.

2.4 Application of Micro-simulation to the HA's network

2.4.1 The first stage in determining whether micro-simulation is a possible modelling approach is to define the modelling requirements, problems and options likely to be studied. The following issues need to be considered in that decision process:

2.5 Would a traditional model meet the requirements?

2.5.1 As indicated para 2.1.3 micro-simulation modelling can be more complex and resource intensive than traditional modelling. Therefore prior to embarking on micro-simulation modelling it needs to be made clear, as part of a scoping report on the modelling options, why this approach has been undertaken. This will include a statement on the reasons why traditional modelling was considered to be inappropriate.

2.6 Study Area Coverage

- 2.6.1 In order to fully exploit the benefits that micro-simulation can offer for the assessment of congested networks it is essential that considerable attention to detail is given to the modelling procedures. Micro-simulation, by its very name and nature, is about modelling behaviour and interactions between drivers/vehicles and network elements at a very detailed level. To achieve the required degree of model calibration/validation, and hence confidence in the model outputs, considerable effort may have to be put in to the model development process. The level of this effort is such that the current move towards building larger micro-simulation models to cover long lengths of the motorway network, as a replacement for more traditional macro models, is not seen as the best use of micro-simulation on the HA network. Whilst micro-simulation has been used as a transport modelling tool within urban areas it is considered that micro-simulation is best used to assess operational performance of a project for the Agency's network. Therefore the geographical scope of the modelling should be based on the operational characteristics of the junction or length of road under consideration (extent of blocking back etc). However it is envisaged that micro-simulation modelling should only extend one junction or max 2km for motorways beyond the boundary of the improvement being evaluated. This applies whether micro-simulation is being used on its own or in conjunction with a higher tier model. Any extension to this coverage will require a special case to be made to the Agency. The modeller should be wary of a perceived need to continually extend the micro-simulation model to cover all the peripheral impacts of the problem being modelled. These extensions have the potential to result in a large scale model which is not fit for purpose.
- 2.6.2 It is considered that micro-simulation should be used in conjunction with higher tier macro-models, but mainly as an operational assessment tool to provide traffic data to the higher tier model. There have been attempts to directly link micro-simulation with macro-models in order to pass data directly between them in an iterative process to reach convergence. However due to the different methodologies (e.g. assignment procedures) used in the deriving the model outputs this has been of limited success and has proved to be time consuming and costly. In view of this, it is not recommended that convergence between micro and macro models should be attempted.
- 2.6.3 In the context of motorway and trunk road modelling, micro-simulation models do provide a mechanism to undertake analyses that cannot be realistically addressed using traditional packages. Typical examples of the types of situations where micro-simulation offers particular benefits are:
- **Signalised Gyratory** – micro-simulation can overcome problems associated with the vertical queuing problems inherent in TRANSYT however many packages need to interface to TRANSYT in order to derive co-ordinated signal times and offsets;
 - **Ramp Metering** – micro-simulation models can examine alternative control algorithms (e.g. ALINEA), model the interactions of the merging and mainline traffic, and undertake queue management analyses;
 - **HOV Lanes** – micro-simulation enables the interaction between HOV lanes and general traffic lanes to be modelled in terms of lane selection, merge and diverge effects at start and end points of HOV lanes or where vehicles need to join or leave motorway; and
 - **Overtaking and Platooning** – micro-simulation enables the interaction between HGVs and other vehicles to be modelled on sections of the network where overtaking opportunities are relatively few and far between and platooning occurs.
- 2.6.4 Micro-simulation provides a tool that can potentially better model interactions between closely spaced junctions on the motorway network and the effects of flow breakdown on network performance. It is particularly suited to the development, testing and evaluation of intelligent transport systems and active traffic management measures. The examples in section 2.6.3 are typical of such measures

2.7 Output Requirements of the Study

- 2.7.1 A further key factor to be taken into account in the selection of the modelling approach is that it should reflect the output requirements of the study. In particular;
- how is the modelling expected to interact with the design process?
 - are economic assessments required?
 - what level of assessment is required? and
 - how detailed are the environmental assessments requirements?

2.8 Micro-simulation Software Selection

- 2.8.1 Traditional models tend to produce single number answers based on convergent iterative assignment procedures embodied within single model runs. Some micro-simulation packages do not incorporate any measure of convergence, instead the model must be run enough times with different random seed values to produce a statistically sound conclusion in which there can be confidence in the model's validation. This may be a concern when economic evaluation is to be undertaken with a micro-simulation model. Where the potential for a converged assignment does exist the level of convergence achieved must be reported on in the Calibration/Validation report. Where different Random Seeds are used, the degree of confidence of the model outputs must be included in the Calibration/Validation report
- 2.8.2 The selection of the appropriate software is a key part of the study scope and is tied into the selection of the analytical approach. Prior to any work being undertaken it must be clear that the proposed software can perform all of the tasks required of it during the course of the modelling, eg are the effects of gradients reflected in vehicle performance? If adjacent junctions are an issue, does the software model junctions?

2.9 Technical Capabilities

- 2.9.1 The technical capabilities of the software are related to its ability to accurately forecast the traffic performance of the alternatives being considered in the analysis. The model developer must first consider whether the software can meet basic criteria i.e.:
- Is it capable of handling the situation being evaluated in the study?
 - If the impact of junctions is important to the network, can they be modelled? and
 - Are the technical analytical procedures that are incorporated into the software sensitive to the variables of concern in the study?
- 2.9.2 The following is a general list of technical capabilities to be considered in the selection of software:
- Maximum problem size (the software or available licence may be limited by maximum number of vehicles that may be present on the network at any one time or the maximum number of signal controllers that can be in a single network).
 - Vehicle movement logic (lane changing, car following, etc.) that reflects the state of the art.
 - Sensitivity to specific features of the alternatives being analyzed (such as HGVs on gradients, effects of horizontal curvature on speeds, or advanced traffic management techniques).
 - Model parameters available for model calibration.
 - Variety and extent of prior successful applications of the software program (should be considered by the model developer).

2.10 Input/Output/Interfaces

- 2.10.1 Input/output, and the ability of the software to interface with other software that will be used in the study (such as traffic forecasting models) are other key considerations. The model developer should review the ability of the software to produce reports on the measures of effectiveness needed for the study. The ability to customize output reports can also be very useful to the analyst. It is essential that the manager or analyst understands the evaluation output data as defined by the software. This is because a given output measurement eg delay or queues, may be calculated or defined differently by the software in comparison to how it is defined or calculated by the appropriate section of the DMRB.

2.11 User Training/Support

- 2.11.1 User training and support requirements are another key consideration. What kind of training and support is available? Are there other users in the area that can provide informal advice?

2.12 Ongoing Software Enhancements

- 2.12.1 Finally, the commitment of the software developer to ongoing enhancements ensures that the software user's investment in staff training and model development for a particular software tool will continue to pay off over the long term. Unsupported software can become unusable if improvements are made to operating systems and hardware.

2.13 Management of a Micro-simulation Study

- 2.13.1 Much of the management of a micro-simulation study is the same as managing any other highway design project:
- establish clear objectives,
 - define a solid scope of work and schedule,
 - monitor milestones, and
 - review deliverables.

2.13.2

The key milestones and deliverables for a micro-simulation study are shown in Table 1:

Table 1 - Milestones and Deliverables for a Micro-simulation Study

Milestone	Deliverable	Contents
1. Scope Project	1. Study scope and schedule 2. Proposed data collection plan 3. Proposed calibration plan 4. coding quality assurance plan	Identifies study objectives, modelling approach (including reasons why traditional modelling was not considered appropriate) geographic and temporal scope, costs, timescales, alternatives, data collection plan, coding error checking procedures
2. Data Collection	1. Data collection results report	Specifies what data are available, what is needed and survey requirements. Identifies data collection procedures, quality assurance and provides a summary of results.
3. Model Development	1. 50% coded model	Software input files including network description, input traffic data, matrix creation, and junction control and routing through the network.
4. Checking	1. Fully coded model	Software input files including checks on driver behaviour, signal and junction operation, lane operation, public transport and vehicle speeds
5. Calibration	1. Calibrated model	Calibration procedures, note of adjusted parameters and reasoning, achievement of calibration/validation targets
6. Validation	1. Model Validation Report	Report summarising validation data selection, comparison of observed/modelled data, ensuring of correct speed/flow relationship and DMRB criteria acceptability.
7. Option Testing / Final Report	1. Final Report	Description of options, analysis and results including use of future matrices, base model future runs, modification of network to reflect proposals, use of base calibration/validation in design. Summary tables and graphics highlighting key results
	2. Technical documentation	Compilation of prior reports documenting model development, calibration/validation and software input files.

- 2.13.3 Two problems are often encountered when managing micro-simulation models developed by others:
- a. Insufficient managerial expertise for verifying the technical application of the model.
 - b. Insufficient data/documentation for calibrating the model.
- 2.13.4 The study manager may, in certain circumstances, choose to appoint a third party to audit the model. This may be a single person or a technical advisory group. Use of such a group may support a project of regional importance and detail, or address stakeholder interests regarding the acceptance of new technology. The members of the group may be drawn from experts at other public agencies, consultants, or from a nearby university.
- 2.13.5 The experts must have had prior experience in developing simulation models with the specific software being used for the particular model.
- 2.13.6 All interested parties must have access to the input files and the software for the micro-simulation model. It must be noted that as there are numerous parameters involved in the development and calibration of a simulation model it is impossible to assess the technical validity of a model based solely on its printed output and visual animation of the results. The manager must have access to the model input files so that he or she can assess the veracity of the model by reviewing the parameter values that go into the model and looking at its output. Finally, good documentation of the model calibration process and the rationale for parameter adjustments is required so that the technical validity of the calibrated model can be assessed. A standardized format for the calibration report can expedite the review process and advice on this is given in Chapter 5.

Data Requirements, Resources and Collection

3 Data Requirements, Resources and Collection

3.1 Data Collection/Preparation

- 3.1.1 This chapter provides guidance on the identification, collection, and preparation of the data sets needed to develop a micro-simulation model for a specific project analysis, and the data needed to evaluate the calibration and validation of the model to real-world conditions present in the project analysis study area. Some Guidance Notes have been produced previously and this document seeks to acknowledge and add to the previous documents such as:

Design Manual for Roads and Bridges Ch. 12

IAN 36 – The Use and application of Micro-simulation Traffic Models.

- 3.1.2 These sources should be consulted regarding appropriate data collection methods (they are not all-inclusive on the subject of data collection). The discussion in this chapter focuses on data requirements, potential data sources, and the proper preparation of data for use in micro-simulation analysis. If the amount of available data does not adequately support the project objectives and scope identified in Section 1, then the scope of the model/study should be curtailed accordingly.

3.2 Data Requirements

- 3.2.1 The precise input data required by a micro-simulation model will vary by software and the specific modelling application as defined by the study objectives and scope. Most micro-simulation analytical studies will require the following basic types of input data.

Road geometry (lengths, lanes – as used and marked, curvature, gradients).

Traffic controls (signal timing, signs, pedestrian crossings – locations/usage).

Demands (entry volumes, turning volumes, O-D table, traffic composition).

Public transport details (services, frequencies, stop locations, dwell times)

On-street parking (where? for how long?)

Calibration data (traffic counts and performance data such as speed/journey time, queues).

- 3.2.2 In addition to the above input data, micro-simulation models may also require data on vehicle and driver characteristics (vehicle length, maximum acceleration rate, driver aggressiveness, etc.). However, as these data can be difficult to measure in the field, it is often supplied within the software in the form of various default values. It should be noted that many of the 'defaults' are not necessarily calibrated values appropriate to all networks and will invariably require to be modified for calibration purposes. Typical examples of this are:

VISSIM	Lane Change (default - 200m)
Paramics	Visibility (default - 0m)
AIMSUN	Distance Zone 1 (default - 15s)

- 3.2.3 Each micro-simulation model will also require various control parameters that specify how the model conducts the simulation. The user guide for the specific simulation software should be consulted for a complete list of input requirements. The discussion below describes only the most basic data requirements shared by the majority of micro-simulation model software.

3.3 Geometric Data

3.3.1 The basic geometric data required by most models consist of some or all of the following:

- the number of lanes, lane width; lane usage
- link length;
- 'flare' length;
- free-flow speed distribution;
- gradients;
- horizontal curvature likely to affect vehicle speed

While the more obvious data are identified above, this is not an exhaustive list and there may be other factors specific to the study area in question. The exact definition of the above data varies with the model software and therefore reference to the software manual should be made to ascertain detailed descriptions of the data. These data can usually be obtained from construction drawings, field surveys, geographical information system (GIS) files, or aerial photographs using Light Detection and Ranging (LIDAR).

3.3.2 A site visit to observe the network in question must be undertaken to gain an appreciation of the situation on the ground and an understanding of the operation of the section of highway under consideration before any work commences on network development.

3.4 Control Data

3.4.1 Control data consist of the locations of traffic control devices and signal-timing settings. These data can best be obtained from the files of the highway authorities operating the traffic controls or from field inspection. Generally, the existing signal time data are best obtained from on-site observations as the original 'design' timings may well have altered over time. A probable consequence of failing to use the actual on-site data would be that calibration of the Base model is likely to be problematic.

3.4.2 Where traffic signal timings are dependant on the traffic demand (VA control) it will be necessary to utilise signal control logic facilities which have now been incorporated in to most micro-simulation software. Details of the minimum/maximum green times and signal plan logic will need to be obtained from the local agency responsible for the signals. Where UTC fixed time plan systems are in place it should be possible for the signal timing data to be readily downloaded for the peak period in question.

3.4.3 In situations where pedestrian crossings are sited close to junctions and hence possibly impact on the flow through the junction, data relating to the operation of the crossing must also be obtained from survey for inclusion in the model.

3.4.4 There may also be a requirement to incorporate toll operations in certain schemes. If so, data relating to the dwell time of vehicles using the booths and lane usage must be collected as these will be critical to the successful development of the micro-simulation model.

3.5 Demand Data

3.5.1 In the most simplistic case, the basic travel demand data required for most models consist of entry volumes (traffic entering the study area) and turning movements at intersections within the study area. The vehicle composition (mix of cars, LGVs, HGV's etc) of the basic demand data must also be derived and included (see below).

3.5.2 While the HA does not consider that large scale micro-simulation modelling is the best use of micro-simulation on its network it is recognised that, in some circumstances and with some of the available software it may be necessary to allow models to determine multiple routes (eg 2 – 3 alternatives through junctions) between origins and destinations (OD's). In addition, some software may require one or more vehicular OD tables. These may also be disaggregated by vehicle types and more refined time periods (e.g. 10min / 15min) which then enable matrix profiling. Procedures exist in many demand modelling software and some micro-simulation software for estimating OD tables from traffic counts.

3.5.3 Whichever option is selected it will always be necessary to allow for a 'build-up' period at the start of the model run. This must be included to ensure that the model network is suitably populated, in terms of traffic, queues, vehicle speeds, etc., at the beginning of the critical model period. The length of the 'build-up' period will depend on the size of the network but will typically be twice as long as the free-flow journey time over the longest length of the network.

3.6 Count Locations and Duration

3.6.1 Traffic counts (manual or automatic) should be conducted at key locations within the micro-simulation model study area for the duration of the proposed simulation analytical period. This period will include for the 'build up' as indicated in paragraph 3.5.3. The counts should ideally be aggregated to no longer than 15min. time periods; however, alternative aggregations can be used if dictated by circumstances. In cases where the proposed model covers a long length of highway, consideration will have to be given to the 'peak' period as the network peak may differ from specific movement/junction peaks. This is likely to be of particular concern on motorways.

3.6.2 If congestion is present at a count location (or upstream of it), care should be taken to ensure that the count measures demand and not capacity ie in these circumstances it is not appropriate to only undertake stopline counts (although they would provide important turning proportion data) but upstream demand flow counts must also be carried out. The count period should ideally start before the onset of congestion and end after the dissipation of all congestion to ensure that all queued demand is eventually included in the count.

3.6.3 Similarly, while automatic traffic count data is extremely useful, it is a 'spot' measurement and may not accurately reflect the actual demand on a link. In addition, speeds obtained from sources such as MIDAS only provide 'observed' speeds as opposed to 'desired' speeds ie the speed at which the driver wishes to travel at if not constrained by other vehicles, incidents etc. Calibrating a congested model to MIDAS data alone is unlikely to produce a model which adequately reflects reality.

3.6.4 Preferably, counts should be conducted simultaneously if resources permit so that all count information is consistent with a single simulation period. Often, resources do not permit this, so the analyst must establish one or more control stations where a continuous count is maintained over the length of the data collection period. The analyst may then use the control station counts to adjust the data collected over several days into a single consistent set of counts representative of a single typical day within the study area.

3.7 Estimating Origin-Destination (OD) Trip Tables

3.7.1 For some simulation software, the counts must be converted into an estimate of existing OD trip patterns while other software can work with either turning-movement counts or an OD table. Whenever possible, OD data should be taken from calibrated and validated strategic models which encompass the area in question, however it must be emphasised that, due to the different assignment procedures used in the strategic and micro-simulation modelling packages, some subsequent modification of the matrices should be anticipated. Where it is desirable to model route choice shifts within the micro-simulation model eg signalised gyratory, then limited dynamic assignment, with routes determined by the model, with full OD matrices can be used. Alternatively, static assignments with paths and flows defined by the modeller can be used.

3.7.2 Local planning travel demand models can provide basic OD data; however, these data sets are generally limited and the zone system is likely to be too coarse for micro-simulation. In addition, as previously mentioned, it must be remembered that the assignment procedures in the strategic planning model and the micro-simulation model are very different, even when compatible modelling suites are used eg VISUM/VISSIM. Consequently, demand data from a

strategic planning model may not always be fully assigned in a microscopic model network. Therefore, the analyst will usually need to estimate the microscopic model OD table from the strategic OD data in combination with other data sources, such as traffic counts. This process will probably require consideration of OD pattern changes resulting from recent additional developments and the time of day, especially for simulations that cover an extended period of time throughout the day.

- 3.7.3 A license plate matching survey is possibly the most accurate method for measuring existing OD data particularly for a model of a section of motorway with relatively few junctions. The analyst establishes checkpoints within and on the periphery of the study area and notes the license plate numbers of all vehicles passing by each checkpoint. A matching program is then used to determine how many vehicles travelled between each pair of checkpoints. However, license plate surveys can be quite expensive. For this reason, the estimation of the OD table from traffic counts is often selected.

3.8 Vehicle Characteristics

- 3.8.1 The vehicle characteristics typically include vehicle mix, vehicle dimensions, and vehicle performance characteristics (maximum acceleration, etc.). With the exception of vehicle mix, obtaining localised observed data for these characteristics is not likely to be cost effective or necessary. In these cases it is considered more appropriate to adopt the default data which has generally been developed from long term studies or industry supplied information. Where the default information has not been used for these parameters, details must be provided as to why this is the case.

3.9 Vehicle Mix

- 3.9.1 The vehicle mix is defined by the analyst, often in terms of the percentage of total vehicles generated in the OD process. Typical vehicle types in the vehicle mix might be passenger cars, light goods vehicle, rigid HGVs, articulated HGVs and buses. Default percentages are usually included in most software programs; however, the vehicle mix is highly localized and national default values will rarely be valid for specific locations. For example, the percentage of HGVs in the vehicle mix can vary from a low of 2 percent on urban streets during rush hour to highs of around 40 percent of daily weekday traffic on busy motorways.
- 3.9.2 It is recommended that the analyst obtain one or more vehicle classification studies for the study area for the time period being analyzed. It may be possible to obtain vehicle classification data from HGV weigh stations which are sited at various locations around the country.
- 3.9.3 A useful source of data relating to vehicle mix and speeds is the Annual Transport Statistics produced by the Department for Transport. Typically, Transport Statistics Great Britain 2005 data can be accessed via the internet at:

http://www.dft.gov.uk/stellent/groups/dft_transstats/documents/page/dft_transstats_041496.pdf

These data will be updated annually.

3.10 Calibration Data

- 3.10.1 Calibration data consist of measures of capacity, traffic counts, and measures of system performance such as travel times, speeds, delays, and queues. Capacities can be gathered independently of the traffic counts (except during incidents, adverse weather or poor lighting conditions); however, travel times, speeds, delays, and queue lengths must be gathered simultaneously with the traffic counts to be useful in calibrating the model. It is not reasonable to expect the simulation model to reproduce observed speeds, delays, and queues if the model is using traffic counts of demand for a different day or time period than when the system performance data were gathered.
- 3.10.2 If there are one or more continuous counting stations in the study area, it may be possible to adjust the count data to match the conditions present when the calibration data were collected;

however, this introduces the potential for additional error in the calibration data and weakens the strength of the conclusions that can be drawn from the model calibration task.

- 3.10.3 Finally, as indicated earlier, the analyst should verify that the documented signal-timing plans coincide with those operating in the field. This will confirm any modifications resulting from a signal retiming program.

3.11 Validation Data

- 3.11.1 Validation data consists of measures of traffic flow, journey times, speeds which are independent of the calibration/model building process and is used for the validation of the model. It is important as part of the data collection process that sufficient count locations are identified for use in validating the model.

3.12 Site Survey

- 3.12.1 It is extremely important for the modeller to observe existing operations on site during the time period being simulated. A simple visual inspection can identify vehicle behaviour which can not be observed from counts and floating car runs. Photographs and video images will prove to be invaluable sources of data; however, they may not focus on the upstream conditions causing the observed behaviour, which is why a site survey during peak conditions is always important. A site visit is essential for aiding the modeller in identifying potential errors in data collection.
- 3.12.2 Modelling should not be carried out by staff who have not visited the location in question and hence have little or no first hand experience of the network operation.

3.13 Travel Time Data

- 3.13.1 When calibrating and validating the traffic model it is essential that not only do the traffic flows match observed data but also that travel times over sections of the network match observed data. Where journey times are reduced due to congestion this must be reflected in the traffic model and not be through the use of reduced vehicle speeds. Details of the requirements and survey methodology can be obtained from the following DMRB documents:

DMRB Vol. 12 Section 2 Part 1 Traffic Appraisal in Urban Areas (Chapter 3)

DMRB Vol. 13 Part 5 The COBA Manual (Chapters 10 & 11)

- 3.13.2 However, it is important to note the number of runs/journeys whether by floating car, video survey or registration survey that may be required to statistically satisfy confidence level criteria as this would have serious survey cost implications. Guidance should be sought from the overseeing department on possible relaxations to the confidence level limits if there are serious time/cost implications in achieving the DMRB requirements. The number of vehicle runs required to establish a mean travel time within a 95-percent confidence level depends on the variability of the travel times measured in the field. Free-flow conditions may require as few as three runs to establish a reliable mean travel time. Congested conditions may require 10 or more runs.
- 3.13.3 Guidance on the minimum number of runs/journeys needed to determine the mean travel time is given in DMRB Volume 13 Part 5 Chapter 11.

3.14 Highways Agency's Journey Time Information.

- 3.14.1 A further source of journey time for the Highways Agency's network is the Agency's Journey Time Database (JTDB) which, together with the traffic flow information held in TRADS, forms the Highways Agency's Traffic Information System (HATRIS). The journey database currently stores speed data from four sources: Trafficmaster, MIDAS, ITIS and National Traffic Control Centre Cameras. The data have been collected since September 2004. The database contains average speeds and total flow for each 15 minute period throughout the year for each junction to junction link on the Highways Agency's core network. The junction to junction links being for the motorways as junction to junction and for the All Purpose network A road to A road junction. Examination of the data has shown that the derived speeds provide a 'reasonable reflection' of

the observed junction to junction speeds. It is considered that this, together with floating car data for example, would be appropriate for calibration/validation purposes.

3.15 Capacity and Saturation Flow Data

3.15.1 Capacity and saturation flow data are particularly valuable calibration data since they determine when the system goes from un-congested to congested conditions:

- Capacity can be measured in the field on any link of the motorway immediately downstream of a queue of vehicles. The queue should ideally last for a full hour; however, reasonable estimates of capacity can be obtained if the queue lasts only 0.5hr. The analyst would simply count the vehicles passing a point on the downstream segment for 1hr (or for a lesser time period if the queue does not persist for a full hour) to obtain the link capacity.
- Saturation flow rate at traffic signals is defined as “the equivalent hourly rate at which previously queued vehicles can traverse an intersection approach under prevailing conditions, assuming that the green signal is available at all times and no lost times are experienced, in vehicles per hour or vehicles per hour per lane”. The saturation flow rate should be measured at all signalized intersections that are operating at or more than 90 percent of their existing capacity. At these locations, the estimation of saturation flow and, therefore, capacity will critically affect the predicted operation of the signal. Thus, it is cost-effective to accurately measure the saturation flow and, therefore, capacity at these intersections.

3.16 Delay and Queue Data

3.16.1 Delay can be computed from floating car runs or from delay studies at individual junctions. Floating car runs can provide satisfactory estimates of delay along the motorway mainline; however, they are usually too expensive to make all of the necessary additional runs to measure all of the slip road delays. Floating cars are somewhat biased estimators of junction delay on roads since they reflect only those vehicles travelling a particular path through the network. For an arterial route with coordinated signal timing, the floating cars running the length of the arterial will measure delay only for the through movement with favourable progression. Other vehicles on the arterial will experience much greater delays. Clearly, this problem may be overcome by running the floating cars on different paths; however, this has obvious cost implications which may be prohibitive.

3.16.2 Comprehensive measures of junction delay can be obtained from surveys of stopped delay on the approaches to an intersection. The number of stopped cars on an approach is counted at regular intervals, such as every 30s. The number of stopped cars multiplied by the counting interval (30s) gives the total stopped delay. Dividing the total stopped delay by the total number of vehicles that crossed the stop line (a separate count) during the survey period gives the mean stopped delay per vehicle.

3.16.3 Queue length data, as is the case with delays, can vary appreciably from day to day, and so data should be collected over several days. The queue length at each junction approach lane should generally be recorded at regular (5 minute) intervals during each of the peak periods. However at signalised junctions both the maximum and minimum queue lengths in each signal cycle should be recorded. Video surveys of the junctions should help in the collection of this data.

3.17 Data Preparation/Quality Assurance

3.17.1 Data preparation consists of review, error checking, and the sifting of the data collected in the field to remove extraneous values and develop meaningful profiles. This section focuses on review and error checking of the data. The following checks of the data should be made during the data preparation step:

- Geometric and control data should be reviewed for apparent infringements of design standards and/or traffic engineering practices. Sudden breaks in geometric continuity (such as a short section of a two-lane carriageway sandwiched in between long stretches of a four-lane carriageway) may also be worth checking with people who are knowledgeable about local conditions. Breaks in continuity and infringements of design standards may be indicative of data collection errors.
- Internal consistency of counts should be reviewed. Upstream counts should be compared to downstream counts. Unexplained large variations in the counts should be reconciled.
- Floating car run results should be reviewed for realistic link speeds.
- Counts of capacity and saturation flow should be compared to the DMRB estimates for these values. Large differences between field measurements and the DMRB warrant double-checking the field measurements and the DMRB computations.

3.18 Reconciliation of Traffic Counts

- 3.18.1 Inevitably, there will be traffic counts at two or more nearby adjacent locations that do not match. This may be a result of counting errors, counting on different days (counts typically vary by 10 percent or more on a daily basis), major traffic sources (or sinks) between the two locations, or queuing between the two locations. In the case of a motorway, a discrepancy between the total traffic entering the motorway and the total exiting it may be caused by storage or discharge of some of the vehicles in growing or shrinking queues on the motorway.
- 3.18.2 The analyst must review the counts and determine (based on local knowledge and field observations) the probable cause(s) of the discrepancies. Counting errors and counts made on different days are treated differently than counting differences caused by mid-link sources/sinks or mid-link queuing.
- 3.18.3 Discrepancies in the counts resulting from counting errors or counts made on different days must be reconciled before proceeding to the model development task. Clearly, inconsistent counts make error checking and model calibration much more difficult. Differing counts for the same location should be normalized or statistically combined assuming that they are reasonable. This is especially true for entry volumes into the model network. Intersection turning volumes should be expressed as percentages based on an average of the counts observed for that location. This will greatly assist with calibrating the model later.
- 3.18.4 Differences in counts caused by mid-link sources (such as a car park) need not be reconciled; however, they must be dealt with by coding mid-link sources and sinks in the simulation model during the model development task.
- 3.18.5 Differences in entering and exiting counts that are caused by queuing in between the two count locations suggest that the analyst should extend the count period to ensure that all demand is included in both counts.

4 Data / Model Checking

4.1 Error Checking

4.1.1 The error correction step is essential in developing a working model so that the calibration process does not result in parameters that are modified simply to compensate for overlooked coding errors. The succeeding steps of the calibration process rely on the elimination of all major errors in demand and network coding before calibration. Error checking involves various reviews of the coded network, coded demands, and default parameters. Error checking proceeds in three basic stages:

- Software error checking,
- Input coding error checking, and
- Animation review to spot less obvious input errors.

4.2 Review Software Errors

4.2.1 The analyst should review the software and user group Web sites to ensure that he or she is aware of the latest known “bugs” and user workarounds for the software. The analyst should ensure that he or she is using the latest version and “patch” of the software.

4.3 Review Input

4.3.1 A checklist for verifying the accuracy of the coded input data is provided below:

1. Basic Information
 - a. Model duration includes for ‘build-up’ period.
 - b. Check that network has been scaled accurately.
2. Link and node network:
 - a. Check basic network connectivity (are all connections present? Do the vehicles operate correctly at the connections? Observing controlling features e.g. traffic signals.)
 - b. Check link geometry (lengths, widths, number of lanes, free-flow speed, gradients etc.)
 - c. Check junction controls (control type, control data).
 - d. Check for prohibited turns, lane closures, and lane restrictions at the junction and on the links.
 - e. Routing decision points enclosed in Nodes where software requires.
 - f. Ensure that network elements are effective for the whole model period.
3. Demand:
 - a. Check vehicle mix proportions at each entry node/gate/zone.
 - b. Check identified sources and sinks (zones) for traffic.

- c. Verify zone volumes against traffic counts.
 - d. Check vehicle occupancy distribution (if modelling HOV's).
 - e. Check turning count percentages (if appropriate).
 - f. Check O-Ds of trips on the network.
- 4. Traveller behaviour and vehicle characteristics:
 - a. Ensure appropriate driving rules apply i.e. left-hand driving
 - b. Check and revise, as necessary, the default vehicle types and dimensions.
 - c. Check and revise the default vehicle performance specifications.
- 5. Software assistance:
 - a. **Always** review error messages produced by the software as they help identify problem areas.

4.3.2 The following techniques may be useful to increase the efficiency and effectiveness of the error-checking process:

- Overlay the coded network on aerial photographs of the study area to quickly verify the accuracy of the network geometry.
- If working with software that supports three-dimensional modelling, turn on the node numbers and look for superimposed numbers. They are an indication of unintentionally superimposed links and nodes. Two or more nodes placed in the same location will look like a single node in a three-dimensional model when viewed in two dimensions. The links may connect to one of the nodes, but not to the other.
- For a large network, a report summarizing the link attributes should be created so that their values can be easily reviewed.
- Use colour codes to identify links by the specific attribute being checked (e.g., links might be colour-coded by free-flow speed range). Out-of-range attributes can be identified quickly if given a particular colour. Breaks in continuity can also be spotted quickly (e.g., a series of 56-km/h (35-mph) links with one link coded as 40 km/h (25 mph)).
- Some software also allow colour coded display of links with gradients or lane closures

4.4 Review Animation

4.4.1 Animation output enables the analyst to see the vehicle behaviour that is being modelled and assess the reasonableness of the micro-simulation model itself. Running the simulation model and reviewing the animation, even with artificial demands, can be useful to identify input coding errors.

4.4.2 A two-stage process can be followed in reviewing the animation output:

- 1 Run the animation at an extremely low demand level (so low that there is no congestion). The analyst should then trace single vehicles through the network and see if they unexpectedly slow down. If so, these will usually be locations of minor network coding errors that disturb the movement of vehicles over the link or through a node. This test should be repeated for several different O-D zone pairs.
- 2 Once the extremely low demand level tests have been completed, run the simulation at 50 percent of the demand level. At this level, demand is usually not yet high enough to cause congestion. If congestion appears, it may be the result of some more subtle coding errors that affect the distribution of vehicles across lanes or their headways. Check entry and exit link flows to verify that all demand is being correctly loaded and moved through the network. The animation should be observed in close detail at key congestion points to determine if the animated

vehicle behaviour is realistic. If the observed vehicle behaviour appears to be unrealistic, the analyst should explore the following potential causes of the unrealistic animation in the order shown below:

4.5 Error in Analyst Expectations

4.5.1 The analyst should first verify, through reference to on-site observations, the correct vehicle behaviour for the location and time period being simulated before deciding that the animation is showing unrealistic vehicle behaviour. Many times, analyst expectations of realistic vehicle behaviour are not matched by actual behaviour in the field. On-site observations may also reveal the causes of vehicle behaviour that are not apparent when coding the network from plans and aerial photographs. These causes need to be coded into the model if the model is expected to produce realistic behaviour.

4.5.2 Analysts should **not** expect classic macroscopic traffic-flow concepts to apply at the microscopic individual-vehicle level. Macroscopic flow concepts (e.g. no variance in mean speed at low flow rates) do not apply to the behaviour of an individual vehicle over the length of the highway. An individual vehicle's speed may vary over the length of the highway and between vehicles, even at low flow rates. Macroscopic flow theory refers to the average speed of all vehicles being relatively constant at low flow rates, not individual vehicles.

4.6 Analyst Data Coding Errors

4.6.1 The analyst should check for data coding errors that may be causing the simulation model to represent travel behaviour incorrectly. Subtle data coding errors are the most frequent cause of unrealistic vehicle behaviour in commercial micro-simulation models that have already been subjected to extensive validation. These errors include apparently correctly coded input that is incorrect because of how the model software uses it to determine vehicle behaviour.

4.6.2 For example, it could be that the warning sign for an upcoming off-ramp is posted in the real world 0.40 km (0.25 mi) before the off-ramp; however, because the model uses warning signs to identify where people start positioning themselves for the exit ramps, the analyst may have to code the warning sign at a different location (the location where field observations indicate that the majority of the drivers start positioning themselves for the off-ramp).

4.6.3 A comparison of model animation to field design and operations cannot be overemphasized. Some of the things to look for include:

- Overlooked data values that need refinement.
- Unusual vehicle operations.
- Previously unidentified points of major ingress or egress (these might be modelled as an intersecting street).
- Operations that the model cannot explicitly replicate (certain operations in certain tools/models).
- Unusual parking configurations.
- Average travel speeds that exceed posted or legal speeds (use the observed average speed in the calibration process).
- Turn bays that cannot be fully utilized because of being blocked by through traffic.
- In general, localized problems that can result in a system wide impact.

4.7 Residual Errors

- 4.7.1 If the analyst has field-verified his or her expectations of traffic performance and has exhausted all possible input errors, and the simulation still does not perform to the analyst's satisfaction, there are still a few possibilities. For example, the desired performance may be beyond the capabilities of the software, or there may be a software error.
- 4.7.2 Software limitations can be identified through careful review of the software documentation. If software limitations are a problem, then the analyst may have to work around the limitations by modifying the model to produce the desired performance. If the limits are too great, the analyst might seek an alternative software program without the limitations. Some packages allow advanced analysts to write their own software interface with the micro-simulation software (typically via an "application program interface" (API) or COM interface) to overcome the limitations and produce the desired performance. Any changes made to the software should be detailed in the Local Model Validation Report.
- 4.7.3 Software errors can be tested by coding simple test problems (such as a single link or intersection) where the result (such as capacity or mean speed) can be computed manually and compared to the model. In some cases it may be that the software errors can only be resolved by working with the software developer.

4.8 Key Decision Point

- 4.8.1 The completion of error checking is a key decision point. The next task — model calibration and validation — can be very time-consuming. Before embarking upon this task, the analyst should confirm that error checking has been completed, specifically:
- All input data are correct.
 - Values of all initial parameters and default parameters are reasonable.
 - Animated results look fine based on on-site observations or judgement.
- Once the error checking has been completed, the analyst has a working model (though it is still not calibrated).

4.9 Example Problem: Error Checking

- 4.9.1 An example of the approach to error checking and its reporting is shown below.

4.10 Software

- 4.10.1 The latest version of the software was used. Review of the model documentation and other material in the software and user groups' Web sites indicated that there were no known problems or bugs related to the software and how it is applied to the network under study and the scenarios to be simulated.

4.11 Review of Input Data and Parameters

- 4.11.1 The coded input data were verified using the input files, the input data portion of the output files, static displays and animation. The basic network connectivity was checked, including its consistency with coded geometry and turning restrictions. All identified errors were corrected. For example, a link with exclusive left- and right-turn lanes (no through traffic) was coded as feeding a downstream through link.
- 4.11.2 Static network displays were used extensively to verify the number of lanes, lane use, lane alignment (i.e., lane number that feeds the downstream through link), and the location of lane drops. At this step, the consistency of link attributes was checked. For example, has a suitable speed distribution been adopted for the motorway links?
- 4.11.3 Next, the traffic demand data were checked. Input volumes at the network entrances were specified in four time slices. The input values were checked against the collected data.
- 4.11.4 Special attention should be given to the traffic patterns at ramp terminals to avoid unrealistic movements. The software provisions (and options) were exercised to force the model not to assign movements to travel paths that were not feasible.

- 4.11.5 The vehicle characteristics and performance data were reviewed.
- 4.11.6 The model displays and animation were used to verify the input data and operation of the traffic signals. For fixed-time signals, the phasing and signal settings were checked (see Figure 4.1). For actuated signals, initial simulations were performed with reduced, but balanced, volumes to ensure that all phases were activated by the traffic demand. This was done because often the inappropriate settings of the phase flags cause signals to malfunction within the simulation and produce unreasonable results. This step also involves checking the location of the detectors and their association with the signal phases.

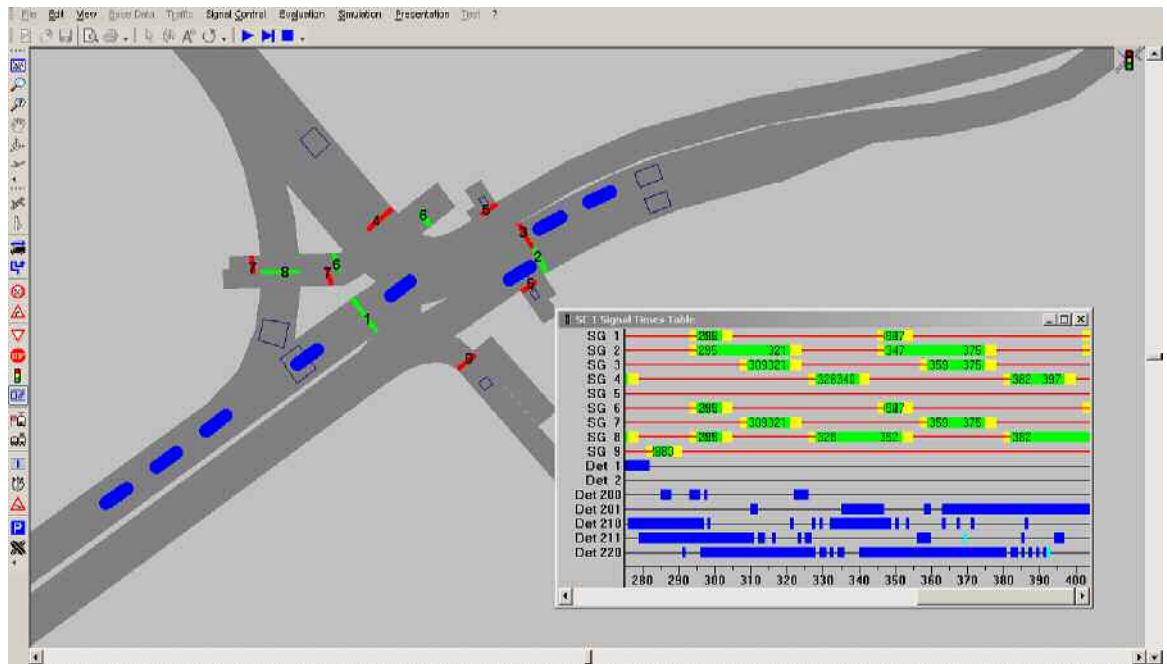


Figure 4.1 – Traffic Signal Timing Review (VISSIM)

- 4.12 Review Animation**
- 4.12.1 Following the checking of the input data, the model was run using very low demand volumes to verify that all of the vehicles travel the network without slowdowns. This step uncovered minor errors in the links alignments that needed to be adjusted.
- 4.12.2 Next, the traffic demands were specified to about 50 percent of the actual volumes and the simulation model was rerun. Animation was used to verify that all demands were properly loaded in the network links and the traffic signals were properly operating. The link and system performance measures (travel time, delay) were also checked for reasonableness (i.e., they should reflect free-flow conditions).
- 4.12.3 Careful checking of the animation revealed subtle coding problems. For example, the coded distance of a warning sign (for exiting vehicles) or the distance from the start of the link to the lane drop affects the proper simulation of driver behaviour. These problems were corrected.
- 4.13 Key Decision Point**
- 4.13.1 The model, as revised throughout the error-checking process, was run with all the input data (actual demands) and the default model parameters. The output and animation were also reviewed and discussed with other agency staff familiar with the study area. The conclusion was that the model was working properly.

5 Model Calibration

5.1 Overview

5.1.1. Before discussing in detail the recommended approach to the calibration and validation of micro-simulation models it is pertinent to state what exactly comprises ‘calibration’ and ‘validation’.

- Model calibration is the 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; and
- Model validation is a process of comparing the results of the model with independent observed data.

5.1.2 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 traditional model calibration and validation. Most of that advice is relevant in a micro-simulation modelling context and should be applied in the calibration and validation of the model. The overall aim of the process is to demonstrate that a model is suitable for use.

DMRB Volume 12 states that

“Calibration is the process of adjusting the parameters used in the various mathematical relationships within the model to reflect the data as well as is necessary to satisfy the model objectives”

and 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’.

5.1.3 The philosophy set down in the above statements should also 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. It is essential that the calibration and validation of the model are considered in an integrated manner and that both are consistent with the aims set out above. For example, a model may well appear to validate acceptably in terms of base year flows and speeds but unless this is as a result of a proper calibration process where the parameters used are specifically tested and then selected to produce the expected behaviour, then in forecasting mode the model may prove unreliable as the base behavioural relationships have not been adequately identified.

5.2 Micro-simulation Calibration Parameters

5.2.1 The types of parameter that are used in a micro-simulation model, and available for modification in the calibration process, 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 that influence vehicle and driver behaviour, as well as network characteristics.

5.2.2 The provision of advice on the calibration of micro-simulation models is further complicated by the differences that exist in the various micro-simulation software platforms with respect to how certain parameters are defined and then influence the model outputs. In this Guidance we do not intend to address individual software platforms but to provide generic guidance on the key

principles that should be followed to ensure that models are established in a structured manner and that the main parameters adopted have a sound basis.

- 5.2.3 The resources devoted to model calibration, 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 of the model. For example, in the context of motorway assessments, lane changing behaviour and individual lane speeds might be particularly important, whereas these will be less important where the focus is on the urban network.
- 5.2.4 Research that has been undertaken in the preparation of this guidance has revealed that in many cases the default values contained in many micro-simulation packages fall in to two quite separate categories. These are:
- Values that have been derived as part of the calibration of the underlying simulation models and hence for which there has to be a robust reason for making adjustments to these parameters; and
 - Values which are not necessarily sensible default values but merely a value to ensure that the model will run.
- 5.2.5 In the latter case it is imperative that the model developer reviews the values contained in the default fields in the context of the situation that they are modelling and adjusts the parameters to appropriate values. The onus is very much on the model developer to provide the evidence for the adoption of parameter values in their work and to fully report this in the Model Calibration/Validation Report. **A key directive that arises out of this guidance, and is discussed in greater detail later is that the model developer cannot adopt the 'default' values in the existing micro-simulation software packages without critical review and adjustment.** This review and adjustment has then to be reported so that it is clear to the Agency and other users what the basis for the model is.
- 5.2.6 It should be noted that the main emphasis of this guidance is on the modelling of motorway and trunk roads but many of the principles equally apply to urban areas.
- 5.2.7 During the preparation of this guidance, detailed consultation has been undertaken with the main micro-simulation software developers to identify the critical parameters that influence how the packages will model motorways and trunk roads, and to ascertain how sensitive to these parameters the model outputs are likely to be. This has been substantiated by technical research on the parameter sensitivities which will enable the Agency to make informed judgements on the acceptability of models that are presented to them in support of scheme assessment and appraisal.
- 5.2.8 In view of the different terminology that is adopted in the different software platforms it is difficult to provide a common set of parameter definitions. It is necessary to adopt a descriptive set of definitions which can be used by the model developer to identify within the particular package that they are using the most appropriate parameters. The following describe those elements of micro-simulation modelling that are considered to be the most sensitive and important in determining how a model determines network capacity, and driver utilisation of that capacity.
- **Headway** - The mean headway (distance in metres) between vehicles at differing traffic speeds
 - **Gap** - The minimum gap (usually time in seconds) between vehicles that will be accepted for lane changing, merging and give way situations
 - **Distribution of headway and gap acceptance** – can be used to reflect differing levels of driver behaviour which is commonly referred to as awareness and aggressiveness and is often manifested in closer driving at speed and acceptance of smaller gaps.
 - **Vehicle dynamics** - acceleration and deceleration profiles and the impact of gradients on vehicle performance
 - **Reaction Time** – driver response time to decision making when confronted with changing vehicle behaviour.

- ***Desired Speed Distribution*** – the speed distribution from which the model ‘driver’ will sample on entry to the model. In an urban area with the speed limit at 30mph the desired speed distribution is effectively flat at 30mph. However, on motorways and trunk roads the desired speeds of drivers plays an important role in determining the stability of the traffic flow.
- ***Driver awareness of vehicles around and ahead of them*** – relates to the number of vehicles that it is assumed that a driver observes ahead in making his decisions on lane changing etc.
- ***Influence of signing on the approach to a diverge on the motorway on lane selection*** – modelling of how vehicles move across, and when to make the move in order to leave the motorway or dual multilane carriageway, can have significant impacts on congestion levels at high diverge slip roads.
- ***Co-operative merging*** – treatment of merging traffic and the co-operative behaviour of the main line traffic also has a fundamental effect on a models capability to reflect the true capacity of a merge lane, and more importantly the impact of the merging traffic on the motorway flow stability.
- ***Implied capacity at roundabouts and signal stop lines*** – ability of model to replicate observed entry capacities at roundabouts based on geometric characteristics and level of circulating traffic, and the models representation of saturation flow.
- ***Speed Acceptance*** - Determines whether the driver will adhere to speed limits
- ***Min Distance between Vehicles at standstill*** - This parameter will only slightly affect capacity on motorways but will be important for queue lengths. However, at signal stop lines smaller minimum distances will result in increased saturation flows.

5.2.9

There are many other parameters that play a role in the development of a micro-simulation model but the above list represents those factors that are considered to be of greatest influence in respect of how well a micro-simulation model will replicate observed motorway and trunk road behaviour. The above parameters effectively describe driver characteristics such as:

- how fast do they want to travel
- how quickly are they prepared to accelerate/decelerate
- what is their propensity to change lane
- how well informed are they in relation to lane positioning for forward manoeuvres such as diverging; and
- how do they respond to traffic entering the motorway stream.

5.2.10

Each of the above parameters is represented in one form or another in each of the leading micro-simulation packages. It is important that any models developed address the calibration of those parameters which represent the above in such a way that confidence can be engendered in the modelling process and the Agency can clearly see that the developed models, and parameter values, are reasonable and will lead to robust model estimations of operating conditions.

5.2.11

Clearly there is a significant amount of variability between drivers with each having their own set of characteristics, i.e. no two drivers are the same, and in order to produce this variability within a micro-simulation model distributions are specified for many parameters and a random seed used to sample from the specified distribution. The effect of the random seed is such that it is necessary to carry out several runs of any micro-simulation model in order to achieve an acceptable level of stability in the model results, particularly where the model outputs are to be used in economic appraisal. The number of separate runs required to achieve acceptable

levels of stability is dictated by a number of factors including the size of the model network, the extent of congestion in the modelled area, and the nature of the model area.

- 5.2.12 The following sections provide guidance on potential sources of information that could be used to assist in calibrating the main parameters identified above, and in setting down typical distributions and profiles that would be expected and against which modellers can benchmark their calibration data set.

5.3 Parameter Calibration Data Sources

- 5.3.1 The performance of a micro-simulation model in terms of the representation of the outturn capacity achievable on the motorway and trunk road network is fundamentally determined by the values adopted for the parameters listed in Section 5.2.8. Consequently, the calibration process should focus on the derivation of appropriate local parameter values, where suitable data sources exist or it is practical to collect new data as described in chapter two; the adoption of any 'true' defaults that exist in the individual software packages; or the use of average parameter values derived from general data on motorway and trunk road driver characteristics.

- 5.3.2 An important data source that can be used to inform the local parameter calibration on the motorway network is the MIDAS data which is obtainable for individual vehicles passing calibrated loops on the motorway and yields data on headway, speed and vehicle volume by lane and time period.

This data can be analysed to produce local parameter estimates for:

- **Mean headway** of vehicles at differing speeds which can then be used to adjust, if necessary, the parameters in the micro-simulation package to better reflect observed values;
- **Desired speed distribution** of vehicles in free flow conditions can be determined from the MIDAS data by selecting time periods where the motorway flow is such that it is not impinging on a drivers personal desired speed of travel. This would enable local conditions to be reflected and provide a much stronger basis for the model calibration than accepting default values, or standard implied normal distributions.; and
- **The distribution of headway** values at differing speeds can also be determined from the MIDAS data and where allowed for in particular micro-simulation packages adjustments can then be made to the variance in the headway values.

- 5.3.1 It is considered essential that where MIDAS data is available for the section of motorway or trunk road that is being modelled then it should be used to provide local calibration of the above core parameters.

- 5.3.2 Where practical the operation of the most complex sections of the motorway, or trunk road, under investigation should be observed using video cameras. The use of judiciously placed cameras can provide the basis for local calibration of many of the parameters identified in Section 5.2 including:

- The **distribution of gaps** (as defined in the modelling package) that are accepted for merge, lane change, and give way situations;
- The **minimum distance (in metres) between vehicles** at standstill can be obtained in congested conditions;
- An indication of the points at which traffic begins to move towards the inside lanes on the **approaches to diverges**; and
- The **co-operative merging behaviour** observed at different merge layouts – this may involve adjustments to a number of parameters including speed, headway(m) or time gap (secs.) or all as well as use of lane closures.

(Note: It is necessary to make specific requests to obtain the data at the detailed level identified above)

- 5.3.3 It is acknowledged that it may not be practical or cost effective to undertake video surveys in all cases. However, it is strongly recommended that in order to make informed, and acceptable, changes to key parameters, documentary evidence is produced that local parameter values do indeed differ from those that would be generally expected based on national data sources.
- 5.3.4 It is not acceptable that the calibration process involves arbitrary changes in key parameters simply to make the model outputs in terms of implied capacity, and modelled speeds fit observed validation data. The Local Model Validation Report will have to document the parameter values used for each of the parameters listed in Table 2, provide the source of the parameter data values, and produce distribution plots of the values that can be compared with the expected profiles provided in this guidance document.
- 5.3.5 The Agency will require the model developer to clearly demonstrate how a model has been calibrated to local conditions and that will involve the detailed description of the methods used to derive the main parameter values and to provide an evidence based listing of the parameters.

5.4 Indicative Parameter Values and Distributions

- 5.4.1 The software consultation exercise and technical research undertaken in preparation of these guidelines has revealed that in certain cases the 'defaults' contained, or implied, in some of the micro-simulation software packages for the main parameters are not consistent with research evidence, or are arbitrary default values that should be adjusted by the model user. It is not the purpose of this guidance to identify the specific instances where this occurs, as software developments could rapidly render the guidance redundant, but to provide where available, indicative parameter value ranges that the model developer can use to compare their own calibration values to. In this way the model developer is made aware of the Agency's expectations of the range and type of parameter values that would be used in micro-simulation models and for which it will be a requirement for reporting on in the calibration/validation report.
- 5.4.2 It should be emphasised that the values presented in the following paragraphs are not intended to be taken as hard and fast rules that the model developer should adopt but as an indication of the type of parameter values that would be expected for the model developer to benchmark their adopted values against. In this way it will be possible to minimise the situations where models have been developed using software package 'defaults' that in reality have no evidence base, or are in contradiction to the general evidence base.
- 5.4.3 Table 2 provides a summary of the main parameters that may be encountered in micro-simulation modelling along with indications of the expected value ranges. Typical distributions are provided where it is practical to provide quantitative evidence, and a qualitative statement of the issues that must be addressed by the model developer where quantitative evidence is difficult to define. The parameters listed will not necessarily all be found in every modelling software package therefore modellers should only report on those which are pertinent to the package which is being used. The information is based on the research carried out in the development of this guidance.

Table 2 - Indicative Parameter Values - The Evidence Base

Parameter	Indicative Range and Distribution	Comments
<i>Headway</i>	Figure 5.1 provides an indicative mean headway distance at varying speeds. It would be expected that the adopted mean headways would be in the order of +/- 10% of these values. The graph is based on a core time headway of 1 second.	The methods used to determine the mean headway between vehicles at different speeds varies between the software packages that are currently available. In one package it is simply expressed as a time in seconds, whilst in another it is calculated as a safe distance based on speed.
<i>Gap</i>	Merge / Lane change Give Way : 1.5 to 3.5 seconds Roundabout : 1.0 to 4.0 seconds	Motorway merges should be modelled as a lane change rather than a give way. Give way value to vary by movement type and number lanes opposing Roundabout value is lane specific and also needs to reflect vehicle type.
<i>Vehicle dynamics</i>	Figures 5.2 and 5.3 for light vehicle acceleration and deceleration rates by current speed. Figures 5.4 and 5.5 for HGV vehicle acceleration and deceleration rates by current speed.	These are critical for the correct estimation of the impact of gradients on the attainable speed by different vehicles when combined with the power functions contained in models
<i>Reaction Time</i>	0.9 seconds with a maximum range of 0.8 seconds to 1.0 second.	Is used in some packages as a direct input to the model and has a significant influence on model performance. In other packages it is not explicitly defined in this manner.
<i>Desired Speed Distribution</i>	Figure 5.6 for 70mph rural motorways, and Figure 5.7 for 50mph controlled motorway sections.	These are very much indicative speed distributions but do show the type of profile that would be expected and in the case where the modelled profile is significantly different the model developer should provide evidence for the adopted distribution
<i>Driver awareness of vehicles around and ahead of them</i>	2 appears a sensible compromise. Can be increased up to 5 with minor effects but should not be set to unity.	Some packages allow the number of vehicles observed by a driver to be varied. This is to reflect how far ahead drivers observe in order to make decisions about braking and lane changing depending on traffic conditions.
<i>Influence of signing on the approach to a diverge on the motorway on lane selection</i>	Some packages enable the probability of lane changing to make a diverge to be spaced out along a stretch of the motorway and this is the recommended approach. In cases where a fixed distance has to be provided the guidance is that it should be in the range 200m to 500m in general, but subject to observation of the visualisation	This is an important element of micro-simulation network coding as it can have a highly significant effect on the network performance. Setting signposting / lane changing distances too far back results in long queues in the inside lane, whilst setting it too close results in excessive late weaving as vehicles leave it too late to merge safely and hence result in disruption. Ideally the signposting should reflect reality with a proportional amount of the traffic responding to signposting at different distances. It is essential to observe the outturn operation of the model to ensure that appropriate weaving behaviour is taking place.
<i>Co-operative merging</i>	No specific values as it is a behavioural action dependent on	It is essential that any simulation model properly allows for the co-operative merging behaviour

	many variables.	exhibited by main line motorway drivers moving over to allow slip road traffic to merge, or if not able to move over to moderate their speed to allow traffic to merge. This is a very important element of modelling motorway behaviour and all models should state how this has been accommodated in the model. It is incumbent on the model developer to state how this behaviour has been modelled and it is not acceptable to simply state that the default procedures in the package have been adopted without stating what these are.
Implied capacity at roundabouts and signal stop lines	<p>Roundabouts – based on geometric values and can be empirically defined using ARCADY formulae</p> <p>Traffic signals – 1800 to 2200 pcu's dependent on lane width.</p>	Micro-simulation models do not have input values for capacity and saturation flow as the outturn values are determined from the interaction of a range of other input variables. It is, however, essential that the model developer provides output data that shows the effective outturn capacity and saturation flow for key points and hence demonstrates that reasonable values are obtained. As the outturn capacity is significantly affected by changes in headway and reaction time, for example, the impact of any such changes must be reported by providing the capacity and saturation output flows.
Min Distance between Vehicles at standstill	<p>Between vehicles 1.5m.</p> <p>Range 1.0m to 2.0m but this in itself will change saturation throughput and the impact should be checked in model outputs.</p>	This parameter can have a significant impact on the length of queues in the model and hence on outturn saturation flow levels and the extent of blocking back through junctions and merge / diverge areas.

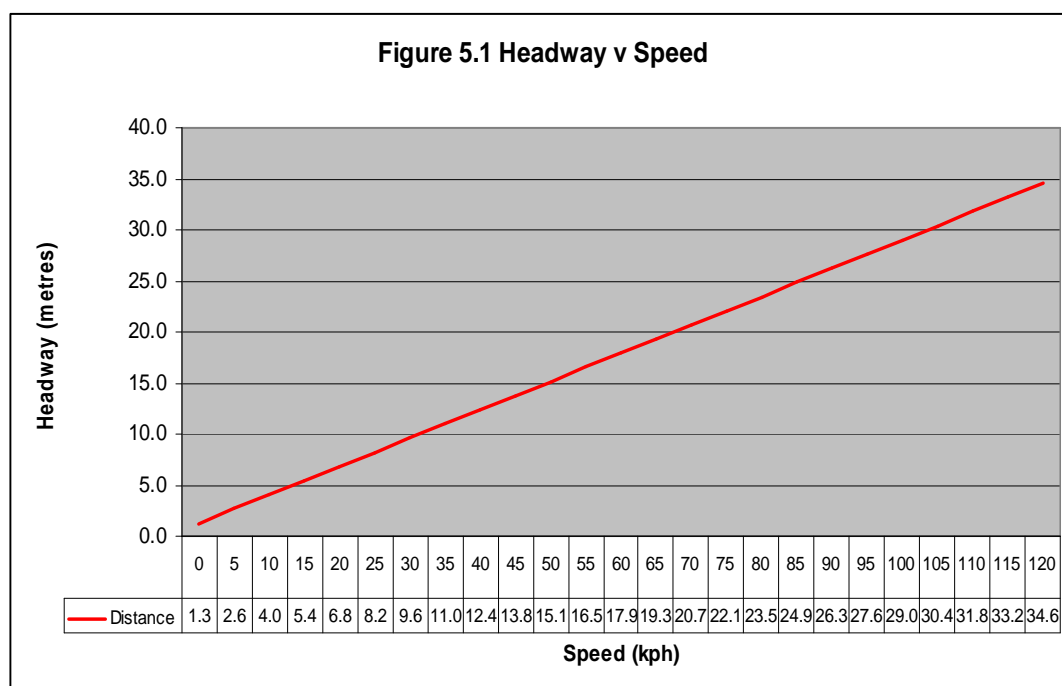


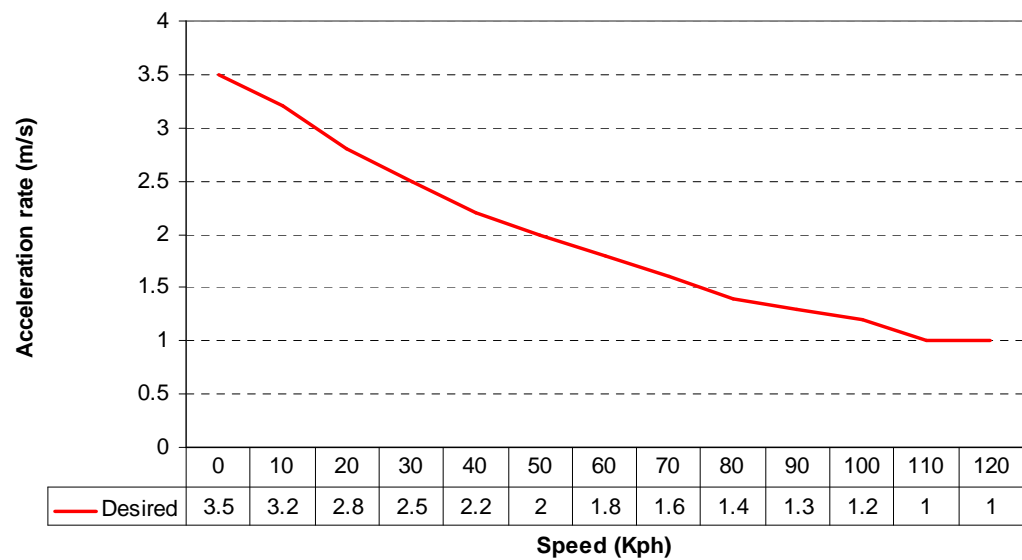
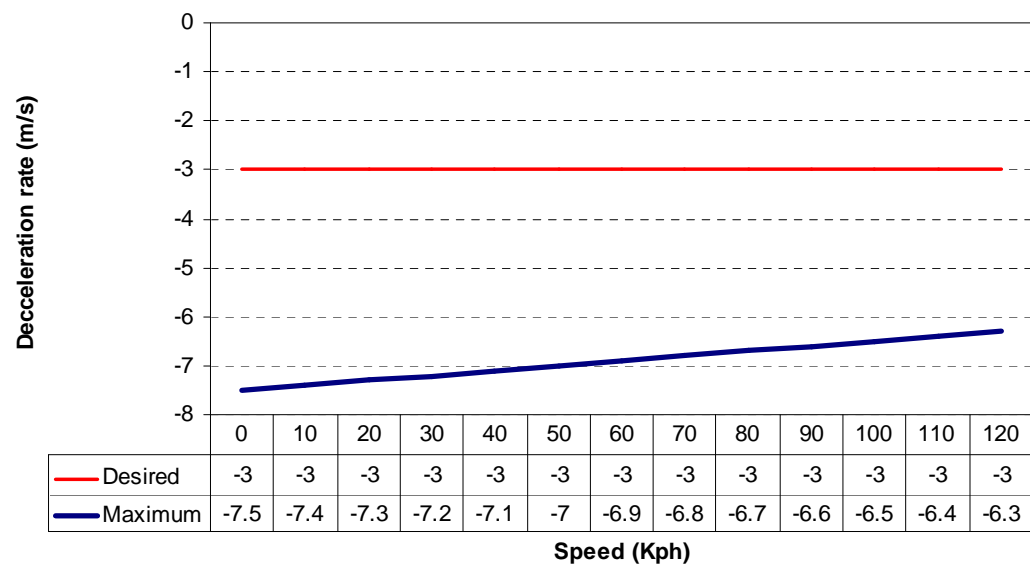
Figure 5.2 Acceleration Rate Cars**Figure 5.3 Deceleration Rate Cars**

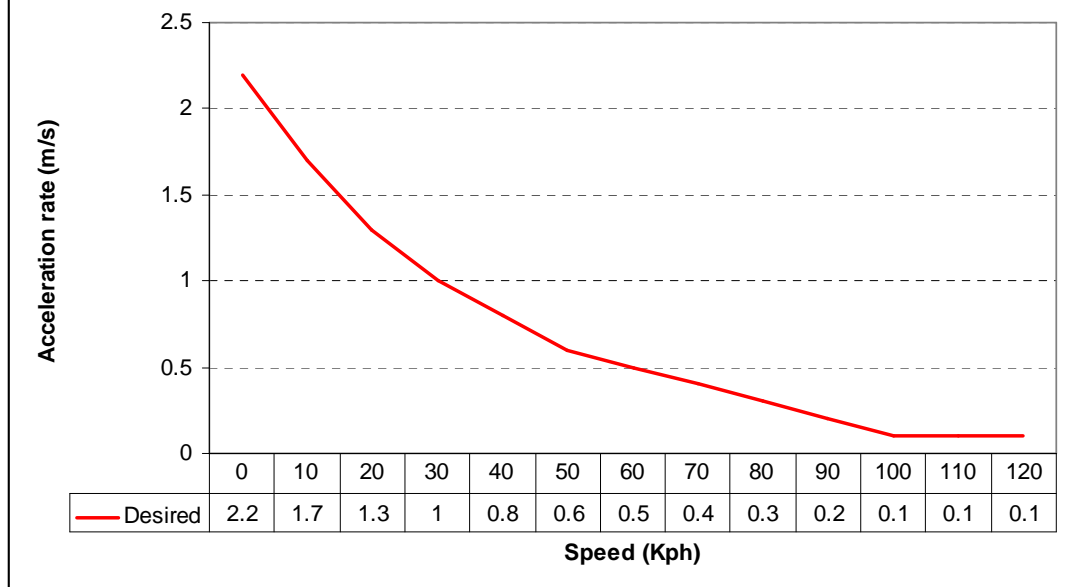
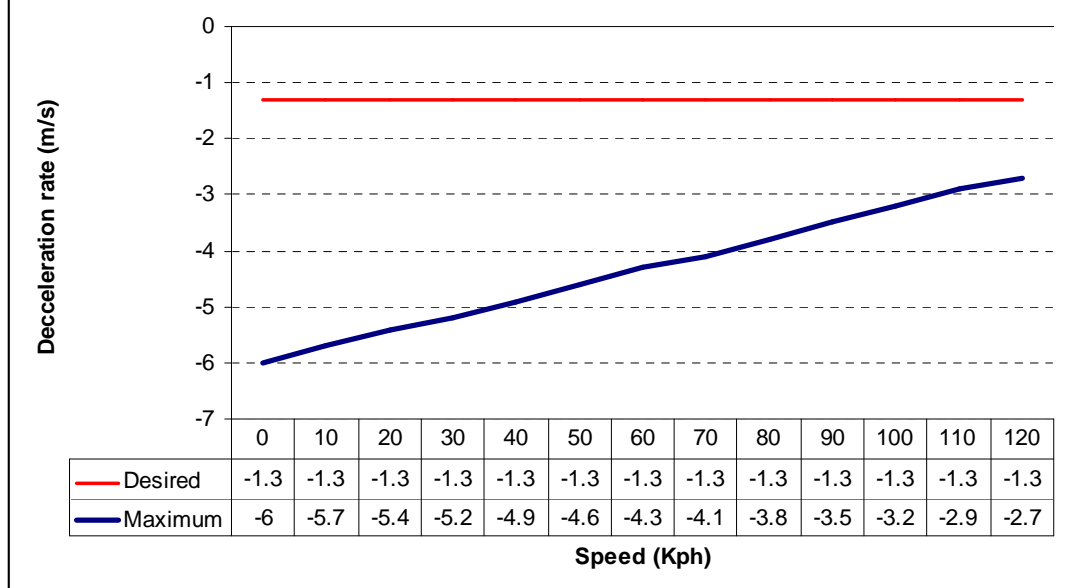
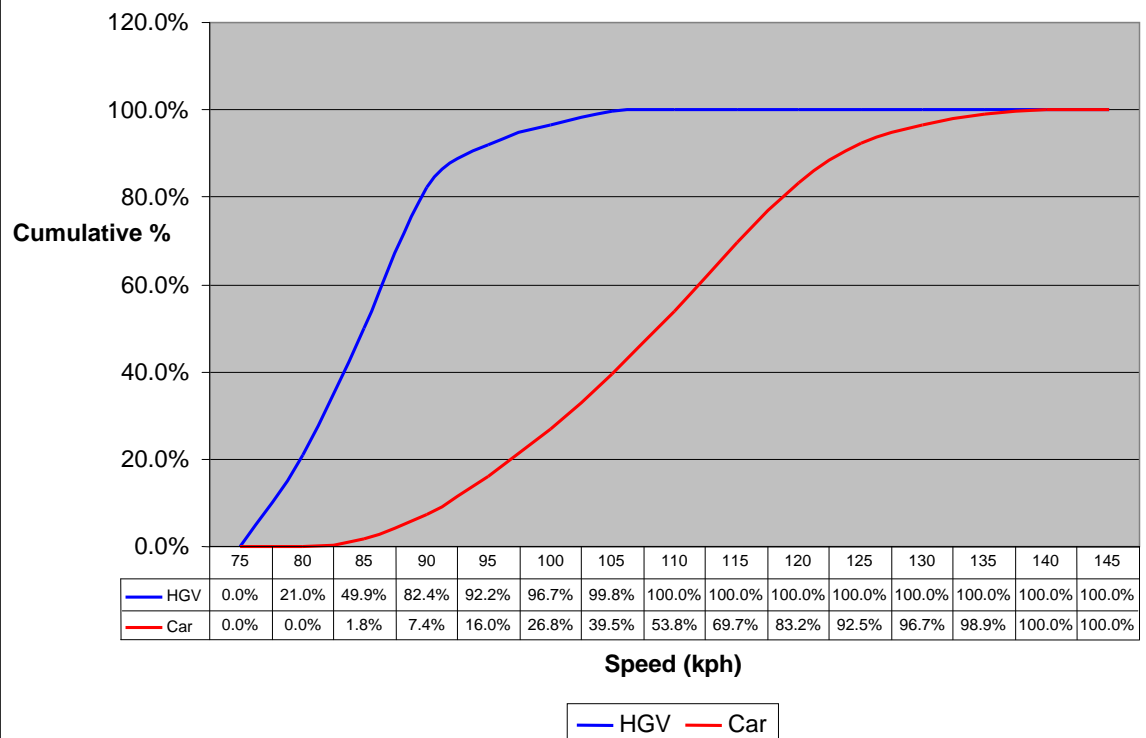
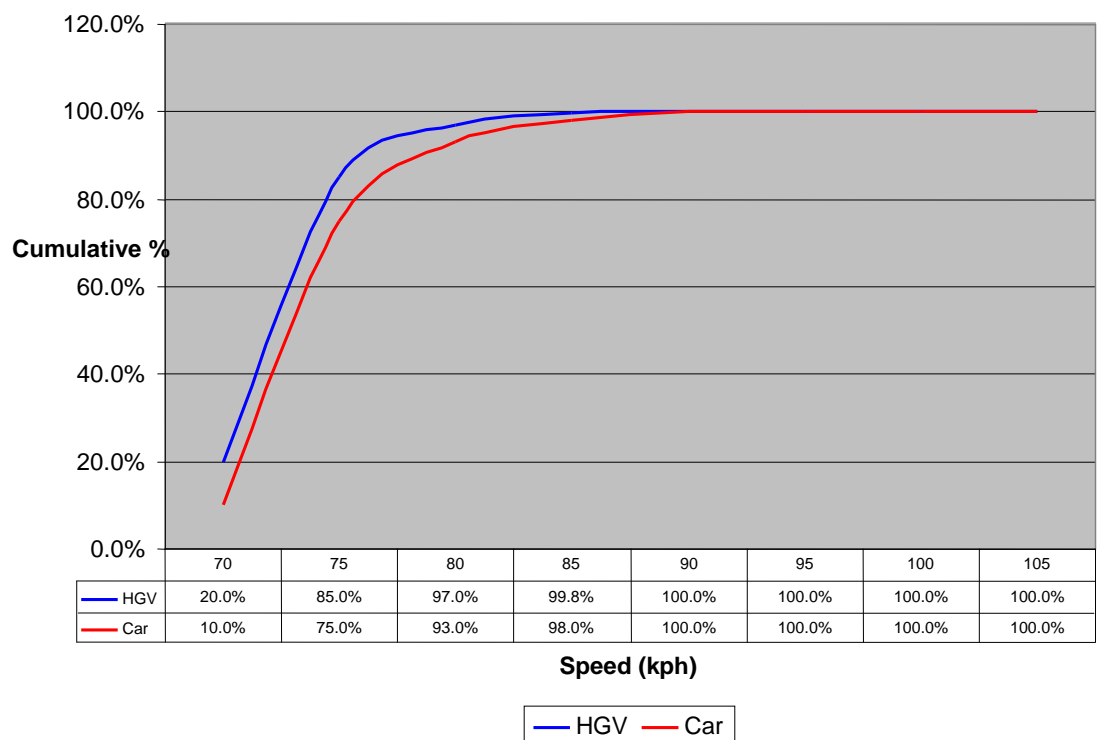
Figure 5.4 Acceleration Rate HGVs**Figure 5.5 Deceleration Rate HGVs**

Figure 5.6 Desired Speed Distributions : 70mph Motorway**Figure 5.7 Desired Speed Distributions : 50mph Motorway**

- 5.4.4 Table 2 and the associated figures provide general guidance on the type of parameter values that would be expected in micro-simulation models. It is provided as a benchmark and check list for the model developer to use so that they can sense check the actual parameters that they are using. It is not the intention of this guidance to be prescriptive on the actual values used, that is for the model developer to determine from their own evidence base, but it is the intention to clearly define the parameters that the model developer will be expected to report on and where these differ significantly from the indicative values the model developer will need to provide evidence for the parameter values adopted. It also makes it clear what the Agency will be looking for in terms of micro-simulation models so that model developers are fully aware of the information that will be required by the Agency so that they can make informed judgements as to the acceptability, or 'fitness for purpose', of motorway and trunk road models used for scheme assessment and appraisal.
- 5.4.5 It is a requirement of the model calibration and validation report for micro-simulation models that a table similar to Table 2 is produced which documents the parameter values used in the model and the source and reasons for the adoption of the specific parameter values.
- 5.4.6 The Agency has undertaken a range of technical research in preparing this guidance which has explored the primary parameters that effectively define and calibrate model performance, and the sensitivity of micro-simulation model outputs to changes in these primary parameters. This technical research has highlighted the sensitivity of certain parameter values and the significant impact that can be achieved by relatively minor changes. By setting out the requirements for calibration reporting as above it is intended that the Agency will be able to better understand why models produce the results that they do, and to make decisions on whether this is appropriate given the model developers evidence base.

5.5 Random Seed Guidance

- 5.5.1 The stochastic nature of micro-simulation models means that simply by changing the random seed number, that influences the sampling of values from specified distributions, you will get differing results from your models. This is generally taken to be acceptable within the context of micro-simulation as a reflection of the variability that exists in actual traffic behaviour from one day to the next. Technical work on a number of networks and software packages has shown that:
- Generally the variation in traffic flows resulting from several random seed runs is low and of the order of standard deviations of less than 1.5% of the average flow;
- The variation in journey times produced by the models is much greater and is very dependent on the level of congestion in the modelled network; and
 - In order to obtain robust results from micro-simulation models, particularly where congestion levels are high, it is essential to undertake several random seed runs and derive the average values for each of the desired outputs.
- 5.5.2 Experience has shown that in large scale motorway models the simulation time can often be measured in hours to achieve the desired degree of confidence in the model outputs, in view of the number of vehicles being simulated at any one time. Consequently this can impose a significant overhead on model run times. In view of this the following approach with regard to random seeds can be adopted where there are significant number of vehicles being simulated or where run times are excessively long:
- Early in the model development process the models should be run with several random seeds, say 10, to establish in the base case the degree of variation that is likely to occur in the model outputs;
 - From the set of random seeds select one that reflects the average network performance and then use this as a suitable indicator of the models performance for the remaining work towards model calibration/validation and for visualisation of the model;
 - At varying intervals test the model with several random seeds to check that the working value being used is still representative of the model performance;

- On completion of model calibration and validation the figures reported in the LMVR must be derived from an appropriate number of random seed runs;
- For future year networks and alternative network strategies a similar procedure can be adopted to provide suitable working values of the random seed; and
- If the models are to be used to provide inputs to an economic assessment then each of the do-minimum and do-something networks for each forecast year must all be run with sufficient random seeds to meet the specified degrees of confidence. This is essential to ensure that the economic benefits are a direct function of the physical changes made to the network and not noise in the results created by variation due to the random seed.

5.5.3

The above process will enable work to be progressed in an efficient manner yet ensure that the final outputs from the models at key points in the reporting and assessment stages are robust and appropriate for the purpose of making investment decisions. This implicitly means that the number of random seeds will not necessarily be the same for each model run but is determined by the need to achieve an acceptable level of confidence in the model outputs. This is critical if the models are to be used for economic assessment.

6 Model Validation

6.1 Overview

- 6.1.1 The preparation of a Local Model Validation Report (LMVR) is mandatory for trunk road schemes (DMRB Vol 12 Section 2). 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. These requirements are detailed in DMRB (12.2.1 Appendix B).
- 6.1.2 A common reason for developing a micro-simulation model in the first place is to provide a more accurate or 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, manoeuvres 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 specification.
- 6.1.3 The validation of model output or simulated network performance should be related to the type of application the model is being put to, the scale of the model and the data available. However, the issues to be assessed include:
- traffic flows - probably by vehicle type and time period at various locations, and profile over the simulated period;
 - saturation flows – advisable to check the outturn saturation flow;
 - journey times and speeds for private and commercial vehicles (at appropriate level of aggregation or detail);
 - 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.
- 6.1.4 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 seed number 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.
- 6.1.5 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.

- 6.1.6 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.
- 6.1.7 An essential feature of the LMVR will be a table similar to Table 2 which describes the values adopted for each of the main model parameters and the reason for their adoption.
- 6.1.8 Following current practices as outlined in the DMRB, the above report (LMVR) should 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.
- 6.1.9 Where a dynamic assignment procedure is used to develop cost and path files, the modeller must set out the process used to develop the paths/costs in order that the process can be repeated by a third party to produce the same assignment.

Forecasting Procedures

7 Forecasting Procedures

7.1 Introduction

7.1.1 There are four distinct issues with respect to the derivation of forecasting procedures for application in micro-simulation models. These are:

- The development of growth factors to apply to base year demands to produce future demand profiles;
- The identification of the reference networks for the future years in terms of infrastructure and management;
- The effects of variable demand; and
- The driver behaviour parameters to be adopted in future year, and alternative scenario models.

As indicated in paragraph 2.6.2 it is considered that, for the HA network, the best use that can be made of micro-simulation is to model the operational performance of a proposal and not for modelling the strategic impact of proposals. The first three of the above issues will either be covered by the higher tier model or by adoption of the forecasting methodology contained in TEMPPO and are no different from the forecasting procedures required for traditional modelling tools. In this respect, the guidance provided in relevant DfT WebTAG units should be followed for the derivation of future year travel demands. The fourth issue is dealt with in detail below.

7.2 Adjustment of Driver Behaviour : Base to Future

7.3.1 The issue of adjustment of driver behaviour, or other key model parameters between the base year calibration and validation is, however, an area of concern to the Agency. As micro-simulation models have many parameters that can be adjusted to achieve a calibrated and validated model in congested network conditions there is a tendency amongst modellers to 'tweak' the parameter values to meet observed conditions on site. A typical example of this in micro-simulation modelling is the increasing of the parameters that determine driver aggressiveness and their propensity to accept smaller gaps in highly congested conditions.

7.3.2 As stated in chapter five any such changes in the base year calibration have to be fully documented and a suitable evidence base provided for the adoption of the parameter values. It is also essential that any such localised adjustments are actually made on a link basis rather than by adjustments to the global parameters. This would reflect the fact that there are locations in congested networks where more risks are taken and smaller gaps accepted by using increased acceleration. Provided that there is supporting evidence such adjustments to reflect existing conditions are supportable.

7.3.3 The issue that has to be addressed in developing forecast networks and models is whether the base year calibrated parameters readily translate to improved networks or whether changes are required to reflect different operating conditions. The presumption is that the parameters derived for the base year will be taken forward into forecasting unless it can be shown that exceptional conditions genuinely arise which require amendment to the base year parameters. The following key principles should be adopted if future year parameters are to be reviewed:

- That global adjustments to driver behaviour and model parameters to match modelled with observed throughput at specific locations is not supportable;
- That any changes to reflect localised issues of congestion, and its impact on driver aggressiveness, should be link specific adjustments in the base year and should be reviewed in future years if significant capacity improvements have been implemented; and

- That any changes between the base year calibrated network and the future year network need to be fully justified with the evidence for the change recorded in the forecasting report.

The critical issue is that global behavioural parameters should not be adjusted to reflect localised capacity representation problems. The process for adjusting the model parameters to better fit observed data should be undertaken in a similar manner to that which occurs in ARCADY/PICADY where observed data can be used to adjust the central estimate of capacity to fit each approach capacity.

7.3 Forecasting Reporting

- 7.3.1 Finally if changes are made between the base and future years these must be fully documented in the forecasting report and sensitivity analyses undertaken with the base year calibrated values in place. This will enable an assessment of the sensitivity of the model outputs to changes in behavioural coding to be determined.

Economic Assessment Using Micro-simulation

8 Economic Assessment Using Micro-simulation

8.1 Introduction

- 8.1.1 Many of the currently available micro-simulation packages can produce output matrices of traffic demand, journey distance, journey time, and toll cost and as such can, in principle, be used as a basis for providing inputs to economic assessments of highway schemes, using TUBA for example. The critical factor is the achievement of an acceptable degree of convergence/confidence and stability in the micro-simulation model process.

8.2 Model convergence and Stability

- 8.2.1 The stochastic nature of micro-simulation with the reliance on random seeds to abstract driver behaviour from pre-specified distributions means that the results from two consecutive model runs with different seeds can display considerable variability in congested conditions. Earlier in this guidance the need to undertake a number of model runs with different random seeds has been identified as critical to establishing that the model outputs are robust and stable and not just the result of random seed effects. This is also of paramount importance in deriving the demand, cost and distance matrices to be used for economic assessment.
- 8.2.2 The use of random seeds in conjunction with the dynamic assignment routines in many micro-simulation packages does not guarantee a unique solution in the way that an equilibrium assignment algorithm will in macro assignment models.
- 8.2.3 Therefore, if the outputs from the micro-simulation model are to be used in economic assessments a detailed report must be produced on the degree of convergence/confidence in the model process covering travel demands on links and travel times by matrix cell. It is essential that detailed statistics are provided, otherwise given the inherent variability in the outputs from micro-simulation models there would be limited confidence that the results produced were a direct result of the network intervention or of residual instability in the model process.
- 8.2.4 As indicated in Chapter 5 when microsimulation is to be used in an economic assessment of the project under consideration then each of the do-minimum and do-something networks for each forecast year must all be run with sufficient random seeds to achieve a satisfactory degree of confidence. A variation of $\pm 5\%$ in modelled journey times at the 95% confidence level is expected for economic evaluation. This is essential to ensure that the economic benefits are a direct function of the physical changes made to the network and not noise in the results created by variation due to the random seed. Any reduction in these confidence levels must be agreed with the Agency. The calculation of the number of random seeds required to achieve the level of confidence is the same as that used to determine the number journey time runs needed to for given accuracy levels given in DMRB Vol 13 Section 1 Part 5 Chapter 11.
- 8.2.5 As is the case with validation and forecasting an economic assessment report will be required. The report should document the economic assessment carried out including the assessment software used eg TUBA and the random seed analysis carried out.