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WESTERN AUSTRALIA

Mesoscopic and Hybrid Modelling Guidelines

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Owner	Johann Brits, Manager Network Performance
Custodian	Rafael Carvajal, A/Operational Modelling & Visualisation Manager
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Recommendation and Approval

Document Recommended by:	**Name**	Mehdi Langroudi
	Position	Director of Congestion and Movement Strategy
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Document Approved by:	**Name**	Tony Earl
	Position	Executive Director Network Operations
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Disclaimer

This document is specific to Western Australia. It is intended to be a guide for modelling practitioners and managers undertaking work for Main Roads WA.

The guidelines provided in this document are accurate and relevant at the time of production.

This document only outlines the minimum requirements for model development, calibration and validation. Some models may require more rigorous standards. It is the user's responsibility to ensure that the models they develop are fit for their intended purposes.

The application of the guidelines in this document does not guarantee that the traffic modelling thereby developed will be fit-for-purpose, nor does it guarantee approval or support by Main Roads. The guidelines may not be appropriate in all circumstances.

The information provided in this document is a guide only and is not considered a statutory requirement.

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    - SMEC
    - PTV Group
    - Aimsun

DEFINITIONS

The definitions of commonly used terms throughout this document are outlined below:

- ***Assignment*** – the resulting path a vehicle takes through a network, calculated during the modelling process.
- ***Assignment methodology*** – the method adopted for determining the path a vehicle takes through a network.
- ***Base model*** – a model calibrated and validated to observed traffic data.
- ***Calibration*** – a process of modifying model parameter values until model outputs replicate observed data to within a specified tolerance level. Any adjustments to the model intended to reduce the differences between the modelled and observed data should be regarded as calibration.
- ***Convergence*** – stabilisation of a model between iterations where the value of a defined convergence metric (relative gap or percentage change in link flows) is below a threshold limit. It is an indication that equilibrium conditions are achieved where the assignment pattern yields the optimal (or near optimal) state.
- ***Cool-down period*** – an additional period allocated after the model analysis period to enable an assessment of the decay in traffic.
- ***Do-minimum scenario*** – like the "do-nothing" scenario but where demand and network changes due to committed projects, or projects likely to be committed, are also included.
- ***Do-nothing scenario*** – a scenario where only traffic growth is considered, while any network changes are not considered.
- ***DoT*** – Department of Transport, Western Australia.
- ***Dynamic Traffic Assignment (DTA)*** – the modelling of time-dependent vehicle movements throughout a network. The DTA must include a model of how travel time varies over time due to changing demands.
- ***Geographic Information System (GIS)*** – a database that can also be presented spatially.
- ***Global Positioning System (GPS)*** – a navigation and tracking system using satellites.
- ***Granularity*** – the level of detail provided in a data set.
- ***Gravity model*** – a computational process for estimating a demand matrix, based on known attraction and generation values.
- ***Hybrid modelling*** – a mesoscopic model with critical areas within the model analysed using more detailed microsimulation.
- ***Latent demand*** – (or unreleased demand) in traffic modelling refers to the excess traffic demand that cannot be serviced by the network due to congestion.
- ***Legacy model*** – a model provided rather than built for a task.
- ***Level of service*** – a qualitative measure for ranking operating conditions or service quality, based on service measures such as speed, travel time, delay, density, freedom to manoeuvre, interruptions, comfort and convenience.
- ***Localised area*** – a smaller urban study area with limited route choice. The applications will be comparable to the *Urban Area* but with the expectations that it can provide higher resolution outputs for a more detailed assessment of the network.
- ***Macroscopic modelling*** – aggregates individual vehicle behaviour into analytic flow equations, i.e. the number of vehicles per hour that pass a certain point without considering the constituent parts (the vehicles).
- ***Main Roads*** – Main Roads Western Australia.
- ***Matrix estimation*** – adjustment of a demand matrix to match observed values.

- ***Matrix furnessing*** – a mathematical process used to assign values between each origin–destination pair to match the recorded total flows in and out of each zone to a given margin of error.
- ***Measurement error*** – an error occurring during the measurement of a variable.
- ***Mesoscopic modelling*** – uses the fundamental concept of dynamic traffic assignment as a means of introducing time-dependent movement of vehicles throughout a network. Depending on the form of mesoscopic modelling adopted, demand is most commonly treated as individual vehicles or may be treated as aggregated trips, but with disaggregation of time and/or space. It can essentially describe traffic entities in a high level of detail, but their behaviour and interactions at a lower level.
- ***Microsimulation/microscopic modelling*** – captures the behaviour of individual vehicles in great detail based on the car-following theory that includes interaction among vehicles, lane changing, response to incidents, and behaviour at merging points.
- ***Mode choice*** – the choice of how to undertake travel (e.g. private vehicle or public transport).
- ***Mode split*** – splits the estimated trips from each origin and destination zone into the various modes (e.g. driving, walking, cycling, train and bus).
- ***Model analysis period*** – the time period that traffic performance is to be analysed over.
- ***Model seed*** – a number utilised in the random number generator of a model package to stochastically vary model outputs. This is also referred to as a random seed.
- ***Model hierarchy*** – (or model type) is the type of analysis that a model performs, i.e. macroscopic, mesoscopic, hybrid or microscopic.
- ***Network data sets*** – data used to inform network qualities, such as road geometry, prevailing speed and other infrastructure.
- ***Option model*** – a scenario of estimated future demand and/or network modifications that have not been designed and have relatively unknown driver behaviour.
- ***Overarching model*** – a model that covers the same geographic extents as the model being developed, used to obtain a sub-matrix/cordon for demand development purposes.
- ***Peak contraction*** – is the inverse of peak spreading and it is defined as the contraction of the peak period due to significant capacity and travel time improvements in the network.
- ***Peak spreading*** – is when the demand exceeds the capacity of the network for a sustained period resulting in the spreading of the peak period into the shoulder peaks.
- ***Pocket/microsimulation pocket*** – the area of a hybrid model that is analysed using a microsimulation methodology.
- ***PTA*** – Public Transport Authority, Western Australia.
- ***Regional area*** – relates to a region of considerable extent in order to assess the movement of people from one area to another.
- ***Resolution*** – the smallest time interval measurable by the model.
- ***ROM24*** – 24-hour Regional Operations Model is Main Roads' strategic transport model.
- ***SCATS*** – Sydney Coordinated Adaptive Traffic System.
- ***Static assignment*** – an assignment that does not change variables over the model temporal period.
- ***STEM*** – Department of Transports' Strategic Transport Evaluation Model.
- ***Strategic modelling*** – a broad term for macrosimulation, macroscopic and macroanalytical modelling. See *macroscopic modelling* for the definition.
- ***Stochastic*** – in terms of traffic modelling, a stochastic model has a degree of randomness such that there is a slight difference in results each time the model runs with a new seed value.
- ***Sub-regional area*** – a complex study area with several high-order parallel roads to allow the diversion of traffic from the congested roads. It may also entail a combination of urban areas with highways or arterial roads through the network.

- ***Temporal period*** – a defined time period.
- ***Traffic demand*** – derived demand where individuals traverse a road network to access specific land uses and services. In a modelling context, it is the traffic that is generated and distributed by the model throughout the network. This demand may or may not complete the desired trip depending on congestion and simulation time period.
- ***Traffic zones*** – aggregated spatial data in modelling to simplify travel demand in the network.
- ***Trip assignment*** – estimates the traffic flows and route choices on the network.
- ***Trip distribution*** – estimates the number of trips that travel between each zone.
- ***Trip generation*** – estimates the number of trips that are generated and attracted to each zone for a defined purpose.
- ***Urban area*** – an area that encompass city centres or local government areas with a reasonable quantity of meaningful route choices. A mesoscopic model of such scale can be developed for traffic studies including road network planning, land-use planning, traffic management assessments or development applications.
- ***Validation*** – the process of determining to what extent the model's underlying fundamental rules and relationships are able to adequately capture the observed behaviour reflected in field surveys.
- ***Vehicle class*** – the categorisation of a set of vehicles based on a common attribute.
- ***Volume delay functions*** – a calculated relationship between traffic volume and delay.
- ***Warm-up period*** – an additional period allocated prior to the model analysis period to enable the model to be pre-populated with traffic.

1 INTRODUCTION

There are several traffic modelling tools available to assist decision-makers in reaching informed conclusions through all stages of a project. These different types of models are all within the modelling hierarchy and include macroscopic or strategic models, mesoscopic models, microscopic models and analytical intersection models.

These modelling tools can and should be used for specific purposes, based on the required tasks which include but are not limited to:

- business case evaluation;
- network planning;
- multi-criteria assessment;
- operational assessment; and
- design.

Mesoscopic models serve as the middle ground between macroscopic and microscopic models to inform planning decisions of typically sub-regional study areas. Macroscopic models may not provide sufficient network detail, while microscopic models of such scope require time, resources, budgets and efforts potentially exceeding those allocated for the project. Mesoscopic models bridge this gap.

Main Roads' *Operational Modelling Guidelines* was developed by the Network Operations Directorate in 2018 in order to standardise and improve the consistency of microsimulation and analytical models in Western Australia. The inputs and assumptions to develop mesoscopic models may not align with the *Operational Modelling Guidelines*, as mesoscopic models are generally used for planning-related projects to provide higher-level assessments.

As with the *Operational Modelling Guidelines*, a standardised approach should be taken when using mesoscopic and hybrid modelling in order to enable a transparent modelling process. The *Mesoscopic and Hybrid Modelling Guidelines* provide guidance on the development of fit-for-purpose mesoscopic and hybrid models with the aim of improving the consistency of such model development in Western Australia.

1.1 Document Structure

This document is designed to provide a consistent structure for the preparation of mesoscopic and hybrid models. It also provides guidance on the use of software packages to create the models. The structure of this document is as follows:

- Section 1: Introduction
- Section 2: Modelling Overview
- Section 3: Project Investigation and Scoping
- Section 4: Data Collection and Analysis
- Section 5: Base Model Development
- Section 6: Option Model Development
- Section 7: Recommended Software Settings
- Section 8: References

This document will be periodically reviewed and updated as required in order to ensure its currency, usefulness and relevance for practitioners and to incorporate innovative thinking and advancements in traffic modelling.

1.2 Purpose of the Guidelines

The purpose of this document is to standardise mesoscopic and hybrid modelling practices used by Main Roads in order to enable a transparent modelling process to be carried out while also improving the robustness of the model outputs.

This document is intended to be a guide for modelling practitioners and project managers undertaking work for Main Roads. As such, the purpose of the guidelines is twofold:

1. Provide project managers with detailed information on the benefits of mesoscopic or hybrid modelling, how it could be appropriate for their project and the Main Roads procedure to execute the works.
2. Provide traffic modelling practitioners with technical guidance on the assumptions, inputs and outputs required to develop a robust model for their project.

The *Mesoscopic and Hybrid Modelling Guidelines* provide technical and procedural guidance for the development of mesoscopic and hybrid traffic models for Main Roads. Where Main Roads have no direct involvement in the project, the technical component of the guidelines should still be adhered to as it sets best-practice for mesoscopic and hybrid modelling.

1.3 Limitations

The subject matter within this document, and its scope, is restricted to mesoscopic and hybrid models. The scope of this document broadly covers traffic assignment modelling that (in a methodology sense) falls between strategic modelling and microscopic modelling. Any mention of other types of traffic modelling within this document is only for context.

2 MODELLING OVERVIEW

This section describes the various modelling types, the features of mesoscopic modelling and its existing application in Western Australia. Key information is provided for project managers and traffic modelling practitioners on the fundamentals of traffic modelling, as this document has been developed based on these modelling principles.

2.1 Modelling Hierarchy

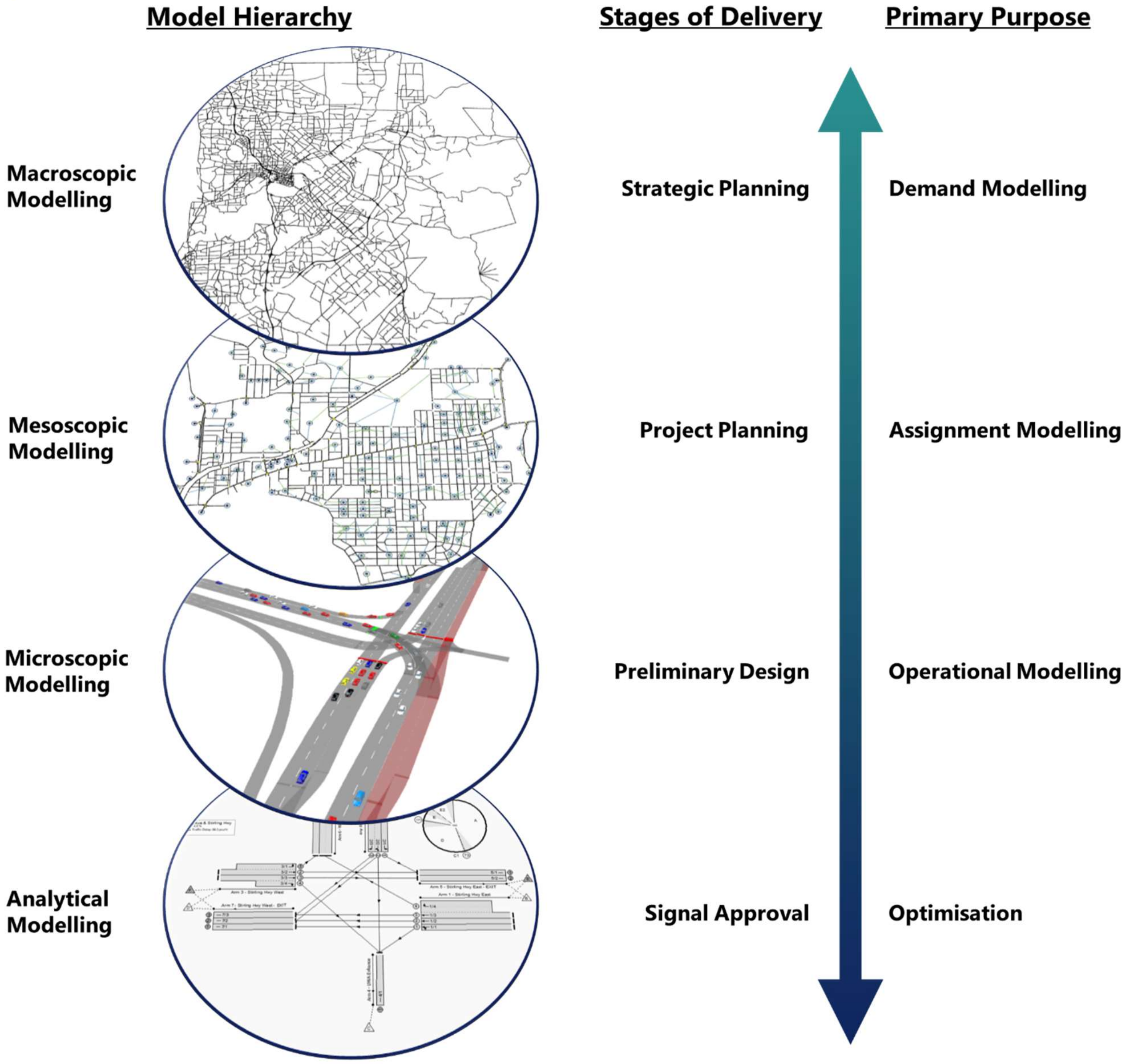
The traffic modelling hierarchy, as shown in Figure 2-1, consists of four types of modelling approach and a model is typically referred to as one of the following:

1. macroscopic/strategic model;
2. mesoscopic model;
3. microscopic model/microsimulation; or
4. analytical model.

At the top of the hierarchy is macroscopic modelling, whereby the model area covers a larger area, the coverage of model time is larger (up to 24 hours) and the model inputs and outputs are generally less detailed. Moving down the hierarchy from macroscopic modelling down to analytical modelling, where the modelling tiers progressively cover smaller areas, the modelled time period decreases to peak hours, and the level of detail for the inputs and outputs progressively increases. It should be noted that the stages of delivery between the model tiers may overlap (e.g. macroscopic modelling can be used in strategic planning and project planning) but the figure demonstrates the primary function and purpose.

The different modelling types are used at different stages of transport projects, as each offers succinct and sometimes unique strengths while also being compromised by similarly distinctive weaknesses.

Figure 2-1: Model hierarchy and purpose



2.1.1 Macroscopic/Strategic Model

Macroscopic modelling, also known as travel demand modelling or strategic modelling, is typically large in scale and covers a regional area. It is a mathematical model that uses the steady-state relationship between density, flow and speed of a traffic stream. It is primarily used to estimate future conditions to assess different demographic growth and traffic distribution, major transport infrastructure changes and travel demand management scenarios.

Macroscopic models commonly have the following features:

- The road network is modelled at an aggregate level of detail. While the network typically consists of road segments, turn lane lengths and intersection controls are not modelled in detail.
- Traffic demands are usually defined in “person trips” and are derived from demographic census data or household travel surveys. Traffic generation and mode choice outputs are used.
- The traffic flows are typically represented over hours or days.
- Assigned traffic flows can exceed road capacity, as the demand is required to travel through the network from origin to destination in the modelled time period.

- Vehicle impacts on the road capacity are calculated (such as the steady-state relationship between density, flow and speed of a traffic stream), but not the impact they have on each other.
- Traffic assignment in a strategic model typically does not change over the model temporal period.
- The model considers congestion based on an empirical function that relates traffic volume to delay. Within the most common equilibrium-based traffic assignment method, vehicles are distributed between routes so that on all routes used between an origin and destination, travel times are equal, and no driver can improve their travel time by choosing an alternative route.

2.1.2 Mesoscopic Model

Mesoscopic models are underpinned by the fundamental concept of dynamic traffic assignment as a means of simulating time-dependent movements of vehicles throughout a network. It is commonly referred to as the middle ground between macroscopic models and the more detailed microscopic models. The precise definition of mesoscopic modelling has changed over time, but it is a tool to bridge the gap between the aggregated traffic flow approach of a macroscopic model and the detailed vehicle interactions approach of a microscopic model.

Mesoscopic models can take different forms and there are two categories from a functional perspective:

1. analytically-based mesoscopic models – are more comparable to macroscopic models and can provide separate delay metrics at nodes and links to better replicate congestion; and
2. simulation-based mesoscopic models – are more comparable to microscopic models as it captures traffic entities with simplified car behavioural algorithms.

Simulation-based mesoscopic models are established from a discrete-event simulation approach, where the simulation time changes as events occur (Aimsun Next, 2020). Traffic entities are also simplified in mesoscopic simulation-based models and the simplification may include the following characteristics:

- car-following behaviour;
- vehicle merging and weaving behaviour;
- vehicle gap acceptance;
- driver reaction time; and
- no consideration of acceleration and deceleration.

Mesoscopic models can also be characterised as an aggregated approach to microscopic models in order to capture the temporal trajectory of traffic entities through the network at specified time intervals. Depending on the software package, the traffic entities in mesoscopic models conform to one of the following approaches:

- grouped as packets of vehicles; or
- replicated as simplified individual vehicles.

In summary, mesoscopic modelling allows traffic entities to be replicated in a high level of detail but their behaviour and interactions are captured at a lower level than in microsimulation models. A detailed discussion of the strengths and weaknesses of mesoscopic modelling is provided in Section 2.4.

2.1.3 Microscopic Model

Microsimulation modelling simulates the movement of individual traffic entities (e.g. vehicles, cyclists, pedestrians) travelling within a road network through accurate replication of driver behaviour and tracked as low as 0.1 second resolution. The variations in driver behaviour and vehicle characteristics are incorporated in microsimulation in order to provide detailed outputs and visualisations. Microsimulation models normally have the following key features:

- can be applied across all spatial scales but the size of a model is normally restricted by the amount of data required to generate an accurate simulation, so it typically covers a smaller area in comparison to macroscopic models and mesoscopic models;
- consists of detailed road segments and intersections;
- simulates the individual movement of traffic across multiple time steps within a second;
- simulates individual traffic entities within the model and how they interact with each other in detail;
- traffic entities typically use simplified route choice, such as shortest path (in terms of travel time) from an origin to a destination or static route assignment; and
- can consider dynamic equilibrium to determine route choice, which means that congestion effects can be simulated directly, instead of being an input to the model, at a similar or even finer level compared to the requirement of a mesoscopic model.

These key features make microsimulation models highly realistic and a preferred tool to assess the operational performance of relatively small networks. Microsimulation modelling for larger sub-regional networks would require higher computational effort, time, costs and resources compared to a corresponding mesoscopic model.

2.1.4 Analytical Model

Analytical modelling focuses predominantly on the performance of individual intersections to allow option testing of modifications to the geometric layout and signal staging design to be carried out. Primarily used for detailed assessment, design and signal optimisation of isolated intersections or small corridor networks.

Analytical modelling can be considered for the following types of project:

- intersection design;
- corridor assessment;
- signal optimisation and coordination;
- bus priority design;
- cycling or pedestrian performance assessment;
- new development transport assessments;
- traffic management plan development; and
- cost–benefit analysis.

Further detail on analytical modelling can be found in Section 3 and Section 4 of Main Roads' *Operational Modelling Guidelines*.

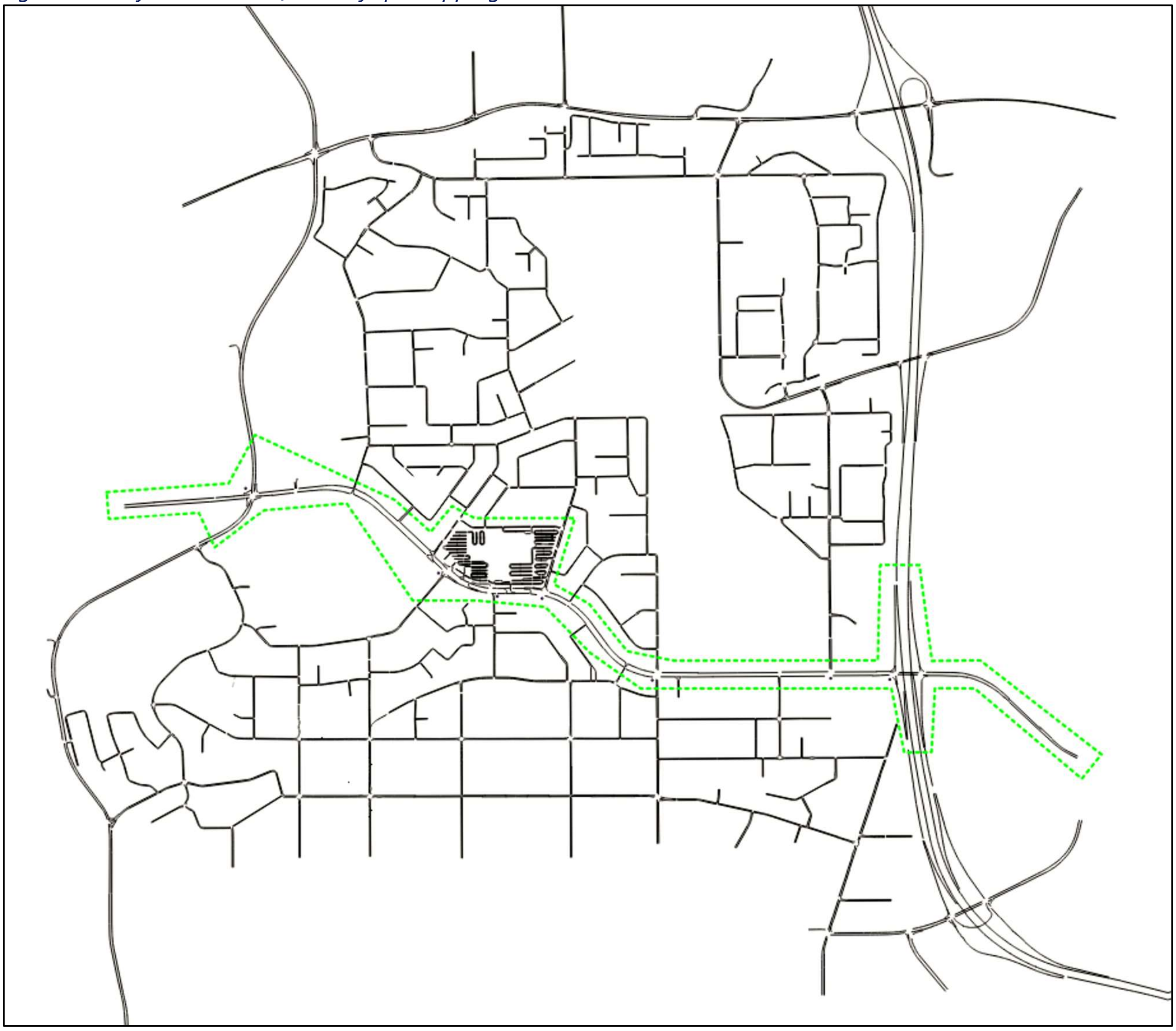
2.2 Hybrid Model

Hybrid (or multi-resolution) models are defined as multiple model types concurrently running in a single network. This document denotes mesoscopic models with microscopic pockets as hybrid models. Although macroscopic models with mesoscopic or microscopic pockets are also considered hybrid models, it is not commonly adopted in Western Australia.

Hybrid models can be suitable when a large network needs to be assessed at a higher level, but a smaller sub-area needs to be analysed in finer detail to assess operational performance. For example, hybrid models can be useful when a large study area includes a freeway that will require detailed modelling to replicate complex interactions, such as queue propagation at the weave or merge locations.

Figure 2-2 illustrates a hybrid model, where the green line boundary represents the microscopic pocket and peripherals modelled with the mesoscopic algorithm.

Figure 2-2: Hybrid model of Karrinyup Shopping Centre – model extents

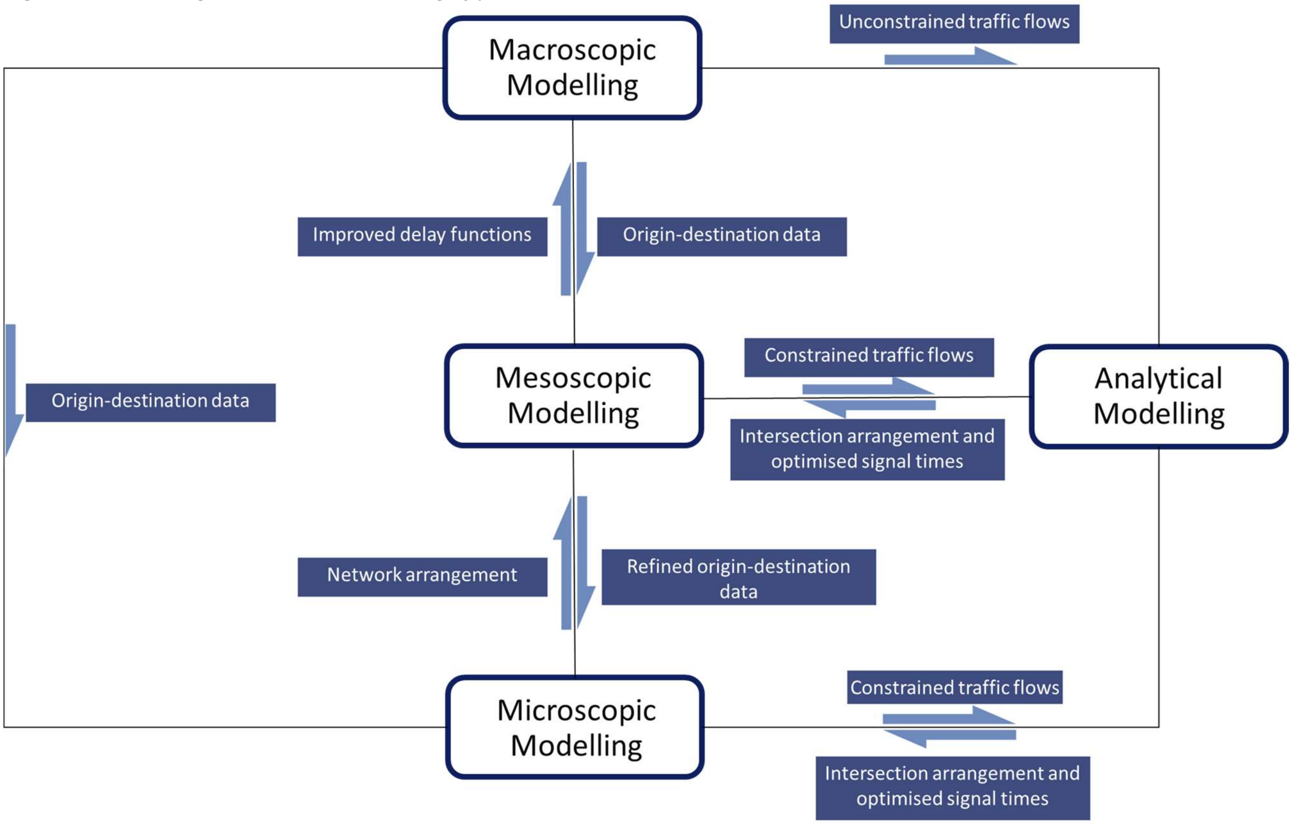


2.3 Model Linkage

The various modelling types described in Section 2.1 can be used to support the decision-making process at different stages of a project. While it is unlikely a single-tiered approach can provide all the answers, the outputs of a particular model type can be used as valuable inputs into subsequent more detailed modelling.

As shown in Figure 2-3, the temporal origin–destination matrix outputs extracted from the four-step macroscopic model are fundamental inputs into mesoscopic or microsimulation models. Similarly, mesoscopic outputs based on a constrained network can provide more refined route choice inputs for microsimulation models or turning volume inputs for analytical modelling. While the figure demonstrates that mesoscopic models can be avoided entirely, the macroscopic modelling outputs may not always be appropriate for use in microscopic or analytical modelling.

Figure 2-3: Linkage between modelling types



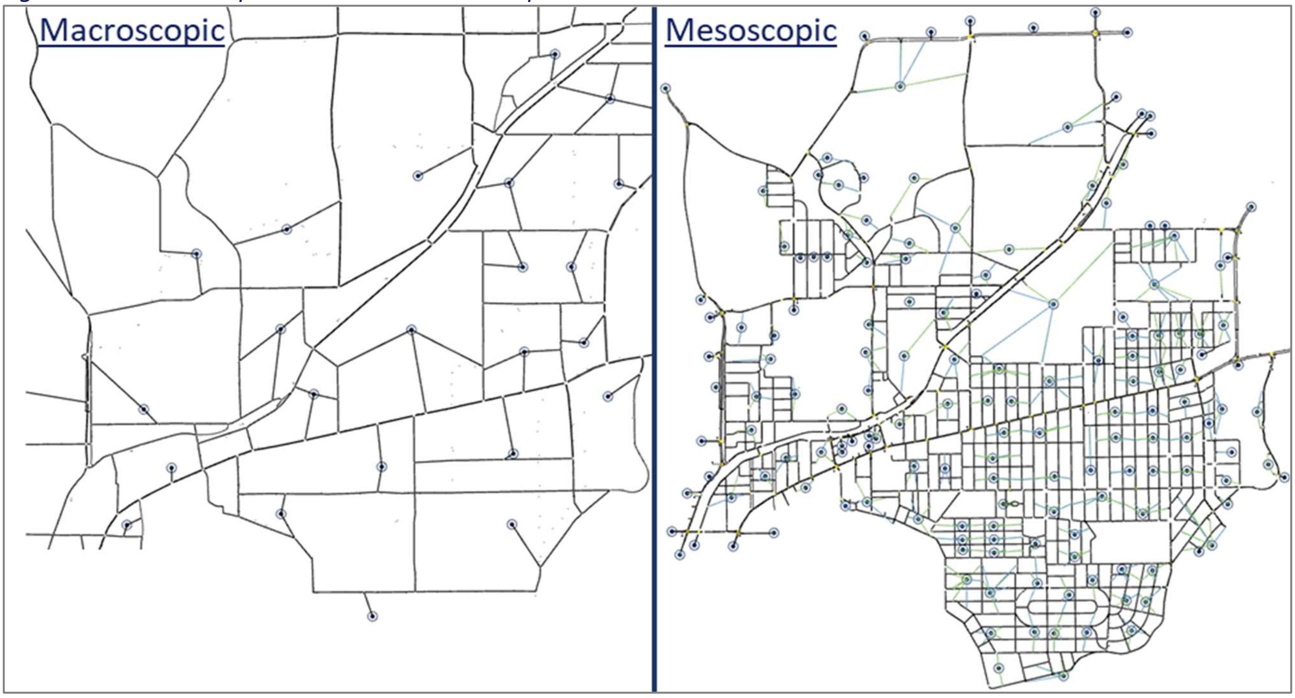
2.4 Strengths and Weaknesses of Mesoscopic Modelling

This section describes the strengths and weaknesses of mesoscopic modelling compared to macroscopic or microscopic modelling.

2.4.1 Detailed Network and Zone System

Mesoscopic models typically have a more detailed network representation and zone structure than macroscopic models of a similar size, with an example illustrated in Figure 2-4. This is because the aim of the macroscopic model is to estimate regional travel patterns from each zone. As a result, the outputs (i.e. turning volumes, link volumes) from macroscopic models may not be as representative when compared to the corresponding mesoscopic models due to the coarser road network.

Figure 2-4: Macroscopic network and mesoscopic network



2.4.2 Route Choice Calculation

Mesoscopic models are primarily used as a vehicle-based assignment to capture time-dependent traffic conditions that cannot be analytically derived from macroscopic modelling or efficiently derived from microscopic modelling. A more realistic representation of the traffic conditions from mesoscopic models can provide a better estimation of queue propagation and dissipation, allowing the model to calculate the optimal route choices for each origin–destination pair.

Mesoscopic models can produce a more robust route choice with a dynamic response to road congestion than a corresponding macroscopic model and produce results in a shorter time frame than a microscopic model.

2.4.3 Model Congestion

The relationship between traffic delay and volumes with physical network constraints are demonstrated in Figure 2-5. The figure shows that in a constrained network, such as a mesoscopic or microscopic model, traffic delay increases with traffic volume until it reaches network “capacity” and a breakdown occurs, thereafter delays will continue to increase without increasing volume. Whereas, under the same conditions, macroscopic models can typically allow the assigned volumes to increase indefinitely and exceed road or intersection capacity, as shown in the dotted red line of Figure 2-5.

Figure 2-5: Traffic volumes in macroscopic model unconstrained by capacity (source: INRO)

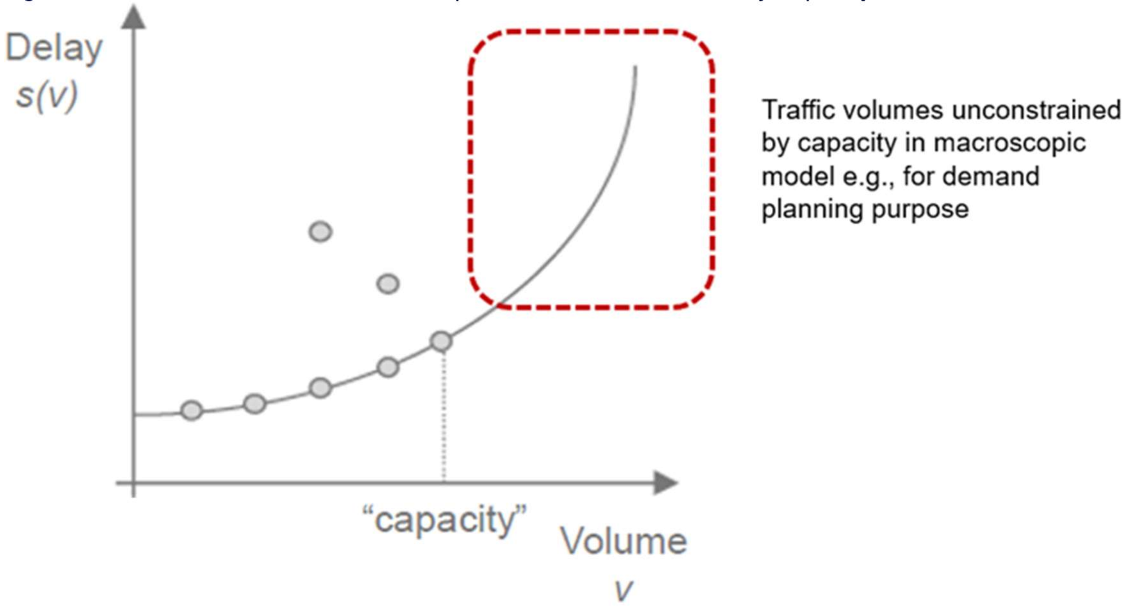
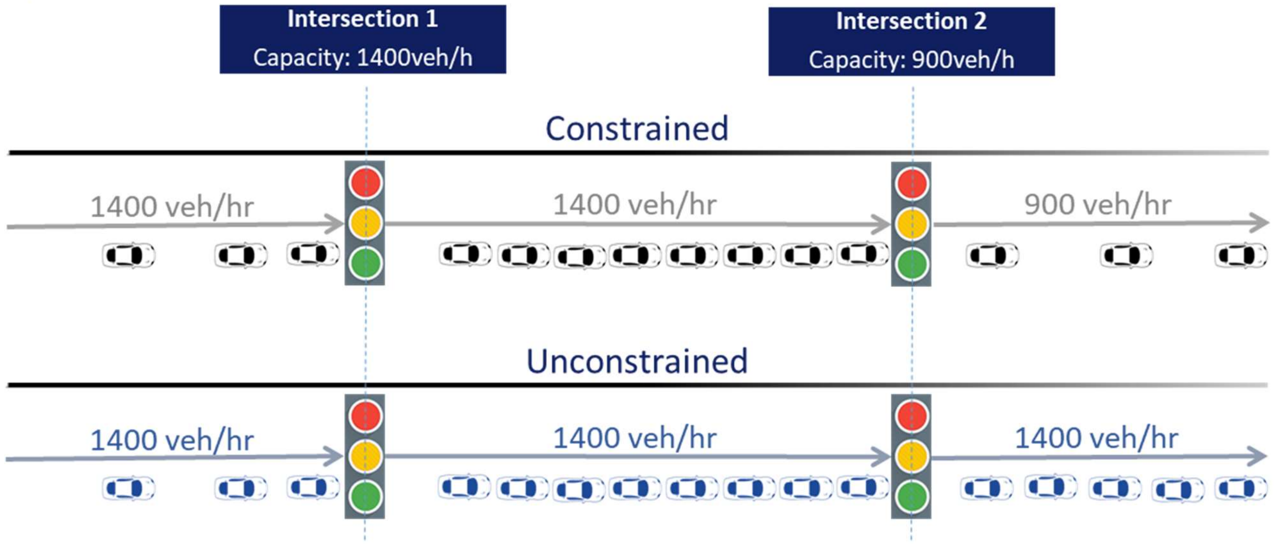


Figure 2-6 further demonstrates the difference between an unconstrained macroscopic model and a constrained mesoscopic or microscopic model. In the figure, Intersection 2 has a throughput capacity of 900 vehicles per hour (veh/h) but an unconstrained model will disregard the physical constraints of the intersection and will typically overestimate the traffic throughputs in the network. In comparison to a constrained model, the 900 veh/h capacity at Intersection 2 will result in queueing due to 1400 veh/h arriving from Intersection 1.

Figure 2-6: Unconstrained and constrained models



2.4.4 Model Resolution

Model resolution can be defined as the smallest time interval measurable by the model. A higher resolution model can provide more detailed outputs, for example, the outputs can be generated every five minutes for each vehicle type. Higher resolution outputs will also require higher resolution inputs and additional effort to extract and analyse the data.

The input and output resolutions for a mesoscopic model are generally lower than a corresponding microscopic model as it does not consider detailed individual vehicle behaviour. As a result of such limitations in mesoscopic modelling, more detailed modelling may subsequently be required.

2.4.5 Summary

The integration of mesoscopic models can address the limitations of other model types. It is commonly used as an assignment model for city centres or local government areas with a reasonable quantity of meaningful route choices as it offers the following benefits:

- gives better representation of congestion in comparison to a strategic model, which is essential in determining route choice for large networks;
- generates a more refined zone structure and road network in comparison to a strategic model;
- captures time-dependent interactions between the demand and supply of the network;
- identifies network constraint locations and describes the queue propagation and dissipation;
- offers guidance on project staging requirements at a wider network level;
- provides more realistic constrained traffic flows for analytical modelling; and
- delivers improved computational results and model stability in comparison to a microsimulation model of a similar size.

Although there are clear benefits associated with the use of mesoscopic modelling, it does have limitations due to the simplified features (as outlined in Section 2.1.2). Limitations include:

- lower resolution outputs compared to microscopic modelling;
- simplified driver behaviour may not sufficiently replicate complex driver behaviour such as weaving and merging in comparison to microscopic modelling; and
- requires higher computational requirements and more effort to develop compared to a macroscopic model of a similar size.

2.5 Mesoscopic Modelling Application

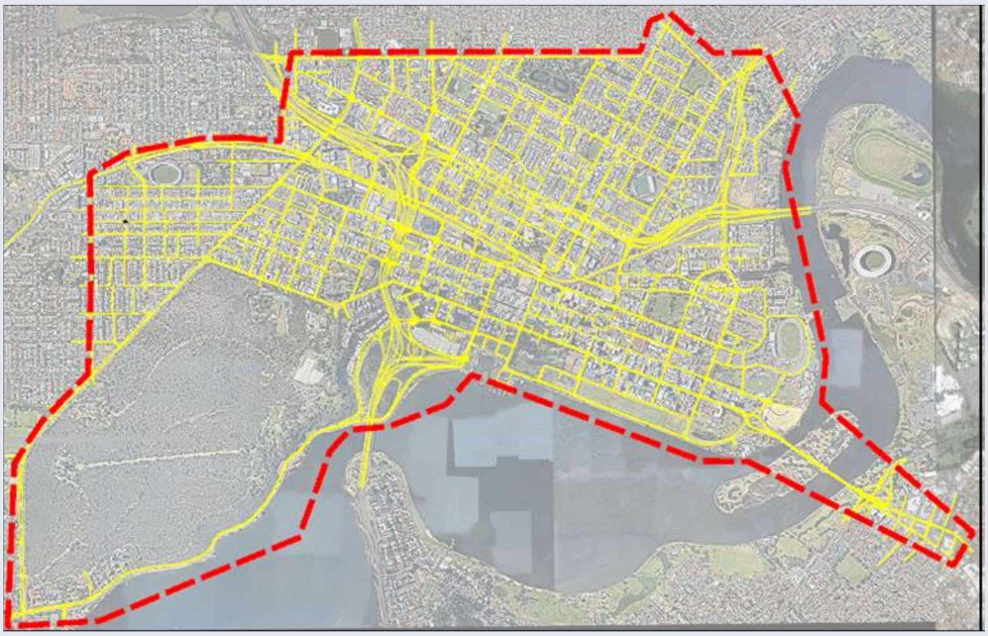
2.5.1 Project Application

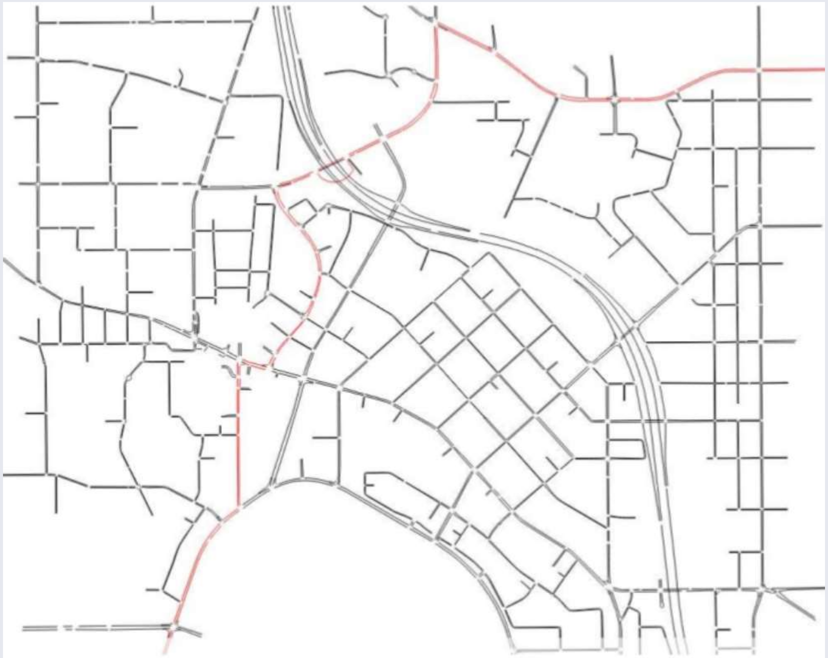
The application of mesoscopic and hybrid models can be suitable for several project types and purposes including but not limited to:

- developing major activity centres;
- determining land intensification or significant land-use changes;
- assessing large-scale infrastructure schemes that may influence travel behaviour; and
- identifying potential congestion locations in a large network and assessing mitigation measures.

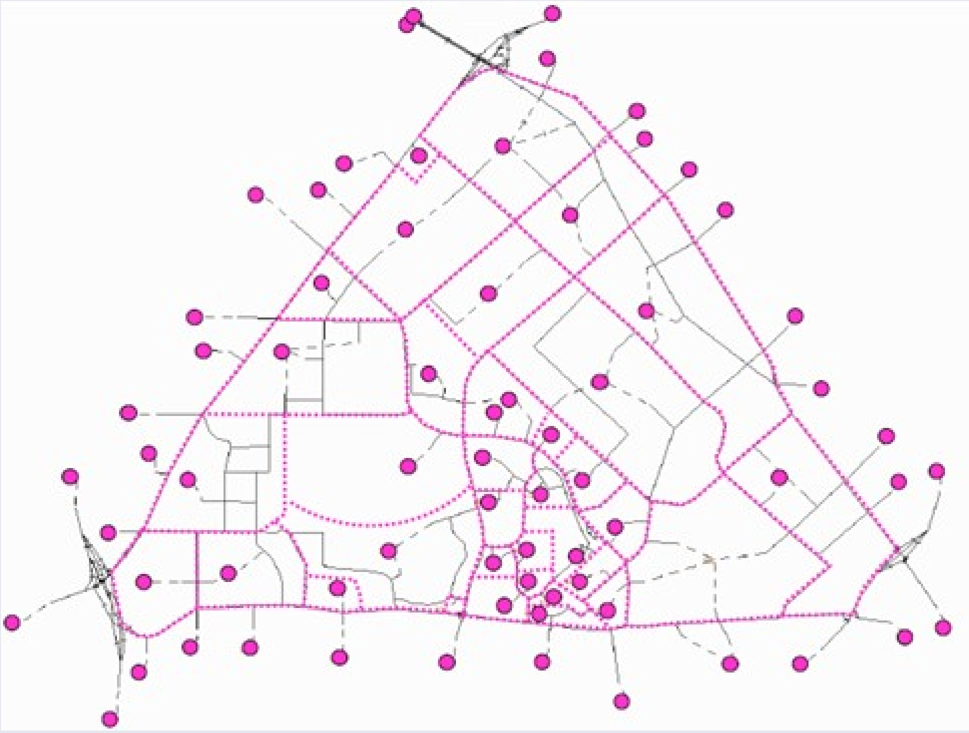
It should be noted that macroscopic modelling will still be required, as significant land-use or infrastructure changes would likely change the mode choice and trip distribution.

The following summaries demonstrate where mesoscopic and hybrid models have been applied in Western Australia.

Model Type	Simulation-based mesoscopic model
Study Extents	
Area Size	20 km^2
Software	Aimsun
Model Objectives	• Primary objective: Evaluate potential infrastructure projects • Secondary objectives: Assess future land-use and infrastructure schemes
Model Periods	3-hour AM and PM peak period
Model Category	Category 3 (refer to Section 3.5.3)
Study Area and Model Features	• Fixed-time signals • Significant route choices • Complex driver behaviour on the freeway • Considerable pedestrian and cyclist movement • Public transport • Volume delay functions from STEM
Model Outputs	• Intersection delay and level of service • Travel time • Density plots

Model Type	Simulation-based mesoscopic model
Study Extents	
Area Size	20 km^2
Software	Aimsun
Model Objectives	• Primary objective: Strategic assessment of road network operations • Secondary objective: Assess future transport infrastructure schemes
Model Periods	3-hour AM and PM peak period
Model Category	Category 2 (refer to Section 3.5.3)
Study Area and Model Features	• Fixed-time and actuated signals • Significant route choices • Complex driver behaviour on the freeway • Considerable pedestrian movement • Public transport • Heterogeneous land-use
Model Outputs	• Intersection delay and level of service • Future year volumes for subsequent analytical modelling • Sub-area matrices for subsequent microscopic modelling • Passenger car and bus travel time • Volume plots, delay plots, select link plots and density plots
Subsequent Modelling	• Hybrid modelling with microsimulation pockets • Microsimulation modelling • SIDRA modelling • LinSig modelling

Model Type	Analytically-based mesoscopic model
Study Extents	
Area Size	25 km^2
Software	Visum
Model Objectives	• Strategic assessment of road network operations • Area-wide traffic impact assessment • Bridge gap between ROM24 and microsimulation modelling
Model Periods	1-hour AM, PM and Saturday peak periods
Model Category	Category 2 (refer to Section 3.5.3)
Study Area and Model Features	• Traffic signals • Complex driver behaviour on the highway • Considerable pedestrian movement • Public transport • Heterogeneous land-use
Model Outputs	• Intersection delay and level of service • Travel time • Sub-area matrices for subsequent microscopic modelling • Geometry option analysis • Network connectivity analysis • Volume plots, delay plots, select link plots and density plots • Route choice assessment
Subsequent Modelling	• Microsimulation modelling • Analytical modelling

Model Type	Analytically-based mesoscopic model
Study Extents	
Area Size	25 km^2
Software	SATURN
Model Objectives	Transport strategy to support the structure plan
Model Periods	1-hour AM and PM peak period
Model Category	Category 2 (refer to Section 3.5.3)
Study Area and Model Features	• Fixed-time signals • Complex driver behaviour on the freeway • Considerable pedestrian movement • Public transport • University trips
Model Outputs	• Intersection delay and level of service • Travel time
Subsequent Modelling	• Microsimulation modelling

2.5.2 Modelling Software

Specific modelling software is supported by Main Roads to ensure internal reviews can be carried out with confidence. To guide the modeller, the preferred approach to model development, model parameters, model considerations and calibration and validation requirements are outlined in this document. Main Roads' supported software for mesoscopic and hybrid modelling are:

- Aimsun Next
- PTV Visum
- PTV Vissim

While alternative software packages can also be adopted, this document does not provide any detailed guidance on their use. Alternative software packages include but are not limited to:

- Cube Avenue
- Dynameq
- SATURN

3 PROJECT INVESTIGATION AND SCOPING

This section provides guidance on the project investigation and scoping stage. It is a good reference for project managers executing a mesoscopic or hybrid modelling project for Main Roads. A well-developed scope will ensure that the model will be developed to the correct specifications and achieve the project objectives.

3.1 Project Investigation

It is recommended that an introduction to the project is created at the beginning of the scoping stage in order to provide background information on the problem that needs to be solved. The information in the introduction will form the foundation for identifying the problem definition and the model purpose that need to be clearly stated in the *Project Brief*. At a minimum, the following need to be considered to describe the project background:

- project context describing the current conditions including:
  - location of the study area;
  - road hierarchy and characteristics of key roads;
  - land-use (i.e. residential, commercial, shopping centre);
  - existing network congestion locations;
- previous studies (if any);
- problem definition;
- key stakeholders (i.e. Transport portfolio, local government);
- proposed schemes and the possible impacts on the surrounding network;
- other proposed schemes in the surrounding road network;
- land-use changes and the possible impacts on the surrounding network; and
- key limitations and the proposed measures to mitigate the limitations (if any).

3.2 Problem Definition and Model Purpose

The *problem definition* underpins all decision-making in relation to traffic model development. There must be a clear understanding of the problem so that direction on the required inputs, modelling methodology and required outputs are provided in order to ultimately inform the model selection.

The *model purpose* is then developed based on the clear problem definition. It forms a key selection criterion for what type of traffic model to use, according to the features of each model type under the hierarchy (refer Section 2.1). To a lesser extent, it will help determine whether a mesoscopic model should be used for the project, based on the model's strengths (refer Section 2.4).

3.3 Study Area Selection

The project scope should ensure that the study area is suitable to address the model purpose, account for the impacts of the proposed infrastructure changes and consider concerns from the key stakeholders. In addition, major or congested intersections should also be considered within the study area boundary, even if they may not be directly impacted by the proposed upgrades. This information should be used to assess how to best manage the congestion immediately upstream or downstream of the project.

3.3.1 Mesoscopic and Hybrid Modelling Area

As it is primarily used as an assignment model, the study area of a mesoscopic or hybrid model should include alternative route choices. For example, a mesoscopic assessment at an intersection level or a condensed segment of a road corridor will unlikely be more cost-effective or produce meaningful results compared to a microscopic model at this scale.

3.3.2 Core Study Area

Mesoscopic and hybrid models can also vary in scale and complexity. The larger and more complex models generally lose some form of precision due to several factors such as the assignment method, the assumptions or the calibration and validation of the model.

To improve the robustness of the model, core areas within the study extent should be defined, based on the model purpose in order to designate parts of the network that are of critical significance to the study. The core areas will be subjected to higher levels of scrutiny so that the areas are better replicated to the existing conditions. This may include a more stringent network coding requirement or calibration and validation criteria. Alternatively, the core areas can include microsimulation pockets (creating a hybrid model) to capture detailed vehicle behaviours.

Core areas should be defined within the study extent to ensure that models are fit-for-purpose. The proposed core areas should be stipulated in the *Project Brief* and *Methodology Report* before the traffic survey and model development are undertaken.

3.4 Peak Period Identification

It is recommended that the indicative peak periods are identified so that the modelled peak hours can be stipulated in the *Project Brief*. The peak hour(s) should be identified using the analysis of historical traffic counts or SCATS detector data in order to assist with the specification of the survey time and model period requirements. The data should be surveyed for all required time periods and should include the shoulder period in each peak.

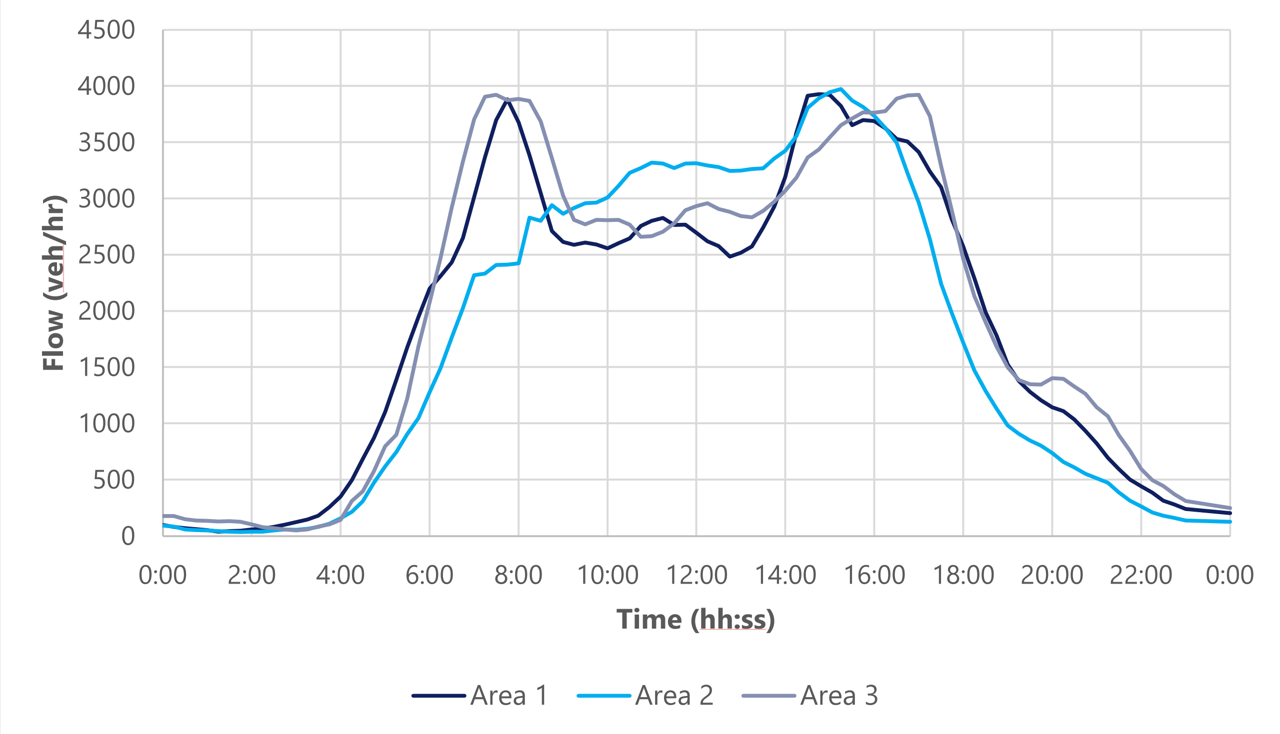
Figure 3-1 illustrates volume profiles and the variance at three different study areas. It highlights the importance of using localised traffic data to identify the peak periods, as these may vary significantly depending on the characteristics of the area.

The types of historical data that can be used to determine the peak period include:

- classified turning traffic counts;
- mid-block traffic counts (e.g. automatic traffic counts); and
- detector data (e.g. SCATS detector data or freeway vehicle detector stations).

It is recommended that the project manager identify the indicative peak periods so that the required peak hour(s) to be modelled can be stipulated in the *Project Brief*.

Figure 3-1: Traffic profile for different study areas



3.5 Model Selection

As outlined in Section 2.1, there are several model types and each has its advantages when it comes to being used for different purposes. The most appropriate model type must be identified during the project scoping stage in order to achieve the model purpose. The selection of a mesoscopic or hybrid model depends on several factors, most importantly:

- problem definition or model purpose;
- model scale;
- model outputs;
- costs and budget constraints;
- time available to conduct the study; and
- resources available to undertake the study.

3.5.1 Model Selection Matrix

A model selection matrix is shown in Table 3-1 and it summarises four factors that should be considered in order to ensure that mesoscopic or hybrid modelling is appropriate for the model purpose. While the modelling output requirements is a key factor, not all model types can provide specific modelling outputs of equal resolution or accuracy. Section 6.6 further details typical modelling outputs that can be used in the decision-making process.

Table 3-1: Model selection matrix

Properties		Macroscopic	Mesoscopic	Hybrid	Microscopic
Model Purpose					
Primary Purpose		Demand	Assignment	Assignment & Operational	Operational
Stages of Delivery		Strategic & Network Planning	Project Planning	Planning & Inform Design	Inform Design
Typical Model Periods		All-day	1-3 Hours	1-3 Hours	1-2 Hours
Model Outputs (Realism of Results)					
Intersection Delay		Not Recommended	Permitted	Recommended	Recommended
Intersection Queue		Not Recommended	Permitted	Recommended	Recommended
Corridor Travel Time		Permitted	Recommended	Recommended	Recommended
Weaving and Merging		Not Recommended	Permitted	Recommended	Recommended
Speed Heat Maps		Not Recommended	Permitted	Recommended	Recommended
Assess by Vehicle Type		Permitted	Recommended	Recommended	Recommended
Network Statistics		Permitted	Recommended	Recommended	Recommended
Network Plots by Link		Permitted	Recommended	Recommended	Recommended
Network Plots by Lane		Not Recommended	Recommended	Recommended	Recommended
Visual Animation		Not Recommended	Not Recommended	Recommended	Recommended
Capacity Constrained Vehicle Demand		Not Considered	Considered	Considered	Considered
Model Features (Relative Comparison)					
Run Time Per Zone		Fast	Moderate	Slow	Slow
Stability		High	Moderate	Low	Low
Resolution		Low	Moderate	Moderate	High
Signal Operation Detail		Low	Moderate	High	High
Public Transport Operation		Low	Moderate	Moderate	High
Model Scale and Study Area Characteristics					
Network Scale and Type	**Regional**	Recommended	Permitted	Not Recommended	Not Recommended
	Freeway	Permitted	Permitted	Recommended	Recommended
	Activity centre	Permitted	Recommended	Recommended	Permitted
	Small Network*	Not Recommended	Permitted	Permitted	Recommended
	Corridor	Not Recommended	Permitted	Permitted	Recommended
	Isolated Intersection	Not Recommended	Not Recommended	Not Recommended	Recommended
Zones	**< 50 Zones**	Not Recommended	Permitted	Permitted	Recommended
	50-250 Zones	Permitted	Recommended	Recommended	Permitted
	> 250 Zones	Recommended	Permitted	Permitted	Not Recommended
Possible Route Choice Options	**Limited**	Not Recommended	Recommended	Recommended	Recommended
	Moderate	Permitted	Recommended	Permitted	Permitted
	Significant	Recommended	Recommended	Permitted	Not Recommended

* Less than 50 intersections

3.5.2 Model Cost and Timeframes

The required timeframes and costs to develop a mesoscopic or hybrid model are typically higher in comparison to a microsimulation model due to the network area and the data required to develop the model. While this may influence the model selection, model choice should ultimately be determined by the factors outlined in Section 3.5.1.

Model timeframes and costs can vary considerably due to various factors including but not limited to:

- network size and complexity;
- assessment period;
- data availability and quality;
- resourcing (i.e. data collection sub-contractor, strategic modeller, auditor or consultant); and
- number of intersections and signalised intersections.

High-level guidance on mesoscopic and hybrid model development timeframe requirements is shown in Table 3-2. The table is based on the modelling categories described in Section 3.5.3, whereby mesoscopic and hybrid models are generally Category 2 or Category 3. The timeframes are broken down into two different stages:

- base model stage; and
- option model stage.

The base model stage includes the preparation of the methodology report, data collection and analysis, base model calibration and validation reporting. The option model stage includes the delivery and approval of the future year growth numbers, model assessment and reporting.

These timeframes also assume appropriate input data is made available for each stage of the traffic modelling works.

The indicative timeframes are provided for project managers as high-level guidance on the time required to develop a mesoscopic or hybrid model. The timeframes exclude two audits organised by Main Roads, totalling approximately four weeks, during each stage and future year growth approval.

Table 3-2: Indicative timeframes for mesoscopic or hybrid models

Model Stage	Category 1	Category 2	Category 3
Base Model	6-12 Weeks	8-16 Weeks	16-24 Weeks
Option Model	4-6 Weeks	6-10 Weeks	6-12 Weeks

3.5.3 Model Categories

Once the mesoscopic or hybrid model has been identified as the most appropriate model type for the project, it can be categorised for model calibration and validation purposes. Main Roads has defined the following three model categories for model calibration and validation purposes based on the scale and characteristics of the study area:

- **Model Category 1 – Localised Area**
  Localised area models are smaller urban area models with limited route choice. A model of such scale can be developed for traffic studies including traffic management assessments or development applications. The expectations with a Category 1 model are that it can provide high resolution outputs for a more detailed network assessment.
- **Model Category 2 – Urban Area**
  Urban area models can encompass city centres or local government areas with a reasonable quantity of meaningful route choices. A model of such scale can be developed for traffic studies including road network planning, land-use planning, traffic management assessments or development applications.
- **Model Category 3 – Sub-Regional Area**
  Sub-regional models can cover a large study area or complex network with many high-order parallel roads to allow the diversion of traffic from the congested roads. It may also entail a combination of urban areas with highways or arterial roads through the network. A model of such scale will be primarily used for assignment purposes and to assess network impacts.

The model categories should be stipulated in the *Project Brief* and *Methodology Report*. A number of past mesoscopic and hybrid project applications and the respective model categories are shown in Section 2.5. It should be noted that a mesoscopic model is more commonly used for sub-regional areas and urban areas, while a microscopic model is usually preferred for a detailed operational network assessment for a localised area.

The modelled categories are generalised and may not exactly describe the coverage of a specific study area. As such, the model category should be agreed with Main Roads prior to starting the mesoscopic or hybrid modelling work.

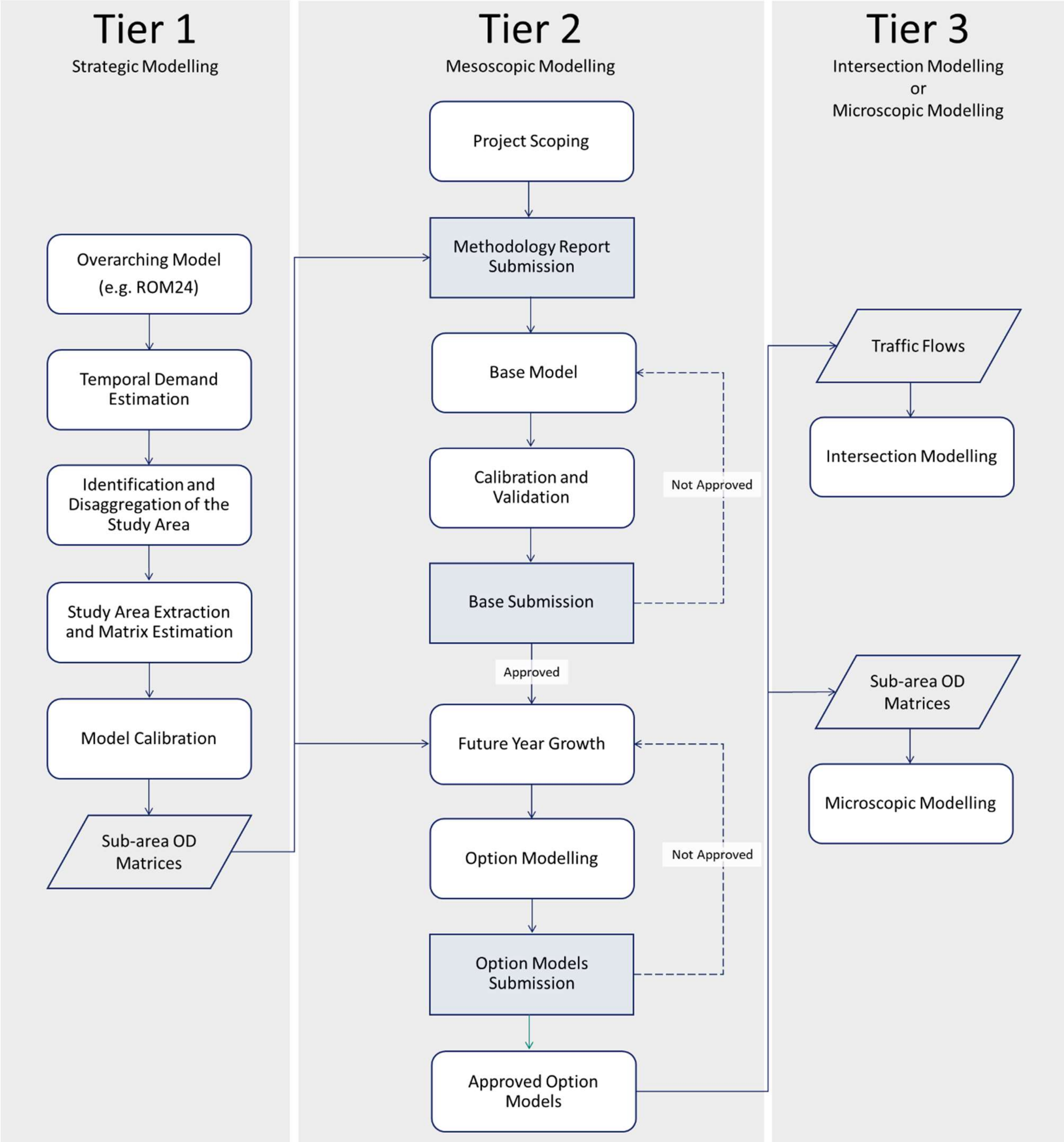
3.6 Modelling Methodology

In general, Main Roads recommends an integrated three-tiered approach for mesoscopic or hybrid models to assist with the planning stage through to the design stage.

Figure 3-2 demonstrates a high-level three-tiered approach based on using outputs from a macroscopic model. The steps highlighted in blue are the deliverables or hold points for mesoscopic model development. Further detail on the process are outlined in Section 5 for base model development and Section 6 for option model development.

Tier 1 is governed by Main Roads' *Dynamic Matrix Estimation Guidelines* and Tier 3 is governed by Main Roads' *Operational Modelling Guidelines*. In Tier 3, analytical modelling is recommended to assess intersections of interest due to the relative ease to produce the outputs. Main Roads' *Traffic Signals Approval Policy* should be referred to for further information on the preferred analytical modelling software.

Figure 3-2: Three-tiered modelling approach



It should be noted that mesoscopic models are sensitive to signal timings and, as such, there may be an iterative loop between analytical modelling and mesoscopic modelling. In addition, the three-tied approach may not be appropriate for all purposes, as Tier 3 modelling (intersection or microscopic modelling) may not be required if the project is specifically planning-related and/or detailed outputs are not required.

Main Roads' modelling methodology approval is a requirement for all Main Roads' mesoscopic or hybrid modelling projects.

3.7 Roles and Responsibilities

Where Main Roads is the client commissioning the development of the traffic model or is a key stakeholder, an example of the roles and responsibilities is summarised in Table 3-4. These demonstrate the required deliverables for each role and the order in which they are to be carried out. It is recommended that the project manager include a similar roles and responsibilities table in the *Project Brief* which identifies key stakeholders for the project.

The roles can typically be divided into three key parties:

1. Client – commissions the development of the traffic model.
2. Main Roads – which should be included if the work is to be presented to Main Roads for approval, either directly or indirectly. Table 3-3 identifies the stakeholders from Main Roads who are to be included at a minimum.
3. Other stakeholders – those not directly involved but can provide input into the project (e.g. local government).

Table 3-3: Minimum stakeholders from Main Roads

Main Roads Directorate	Main Roads Branch	Purpose
Planning and Technical Services	Transport Modelling	• Strategic Modeller
Planning and Technical Services	Network Planning and Development or Urban Road Planning	• Project Scoping Advisor • Future Traffic Growth Approver
Network Operations	Operational Modelling and Visualisation	• Project Scoping Advisor • Mesoscopic/Hybrid Modelling Advisor • Model Auditor

Each task has an approver (A) and at least one stakeholder responsible for the delivery of the task (R). The other responsibilities are optional and the stakeholder can be consulted to provide valuable input (C) or representatives may provide input but must be informed of the outcome (I).

Further guidance on the tasks from Table 3-4 are outlined in Section 3.8.

Table 3-4: Example of roles and responsibilities

Roles		Project Brief	Strategic Modelling	Methodology Report Submission	Methodology Report Approval	Base Model Submission	Base Model Audit and Approval	Future Traffic Growth Submission	Future Traffic Growth Approval	Option Model Submission	Option Model Audit and Approval
Client Representation	Project Manager – Client	A	I	A	I	A	I	A	I	A	I
	Modeller – Consultant		I	R	I	R	I	R	I	R	I
Main Roads Representation	Transport Modelling Representative	C	R, A		C						
	Network Planning and Development Representative	R	C		R		C		A		C
	Urban Road Planning Representative	R	C		R		C		R		C
	Operational Modelling and Visualisation Representative	R	I	I	R, A	I	A	I	C		R, A
	Network Performance Representative	C			C		C				C
	Traffic Management Services Representative	C			C		C				C
	Road Traffic Engineering Representative	C			C		C				C
Other Representation	Other Stakeholders	I	I	I	I				I		I

R – Representative(s) who are responsible for delivering the task.
A – A representative who reviews and approves the task.
C – Representative(s) who are consulted to provide valuable input in the delivery of the task.
I – Representative(s) who can provide input and must be informed of the outcome.

3.8 Tasks and Deliverables

This section describes the minimum tasks and deliverables required for mesoscopic and hybrid models.

3.8.1 Project Brief

The project manager is responsible for the delivery of the *Project Brief*. The purpose of the brief is to provide guidance on the model and requirements so that modellers have a clear understanding of the problem definition and project purpose. A concise brief will enable modellers to accurately scope and price the modelling works for the project manager.

The common technical contents required in a *Project Brief* are:

- background information including:
  - location of the study area;
  - road hierarchy and characteristics of key roads;
  - land-use (i.e. residential, commercial, shopping centre);
  - existing network congestion locations;
  - proposed schemes and the possible impacts on the surrounding network;
  - other proposed schemes in the surrounding road network;
  - land-use changes and the possible impacts on the surrounding network;
- previous studies (if any);
- problem definition and specific model purpose;
- scope of works – outlining project requirements such as:
  - proposed study area;
  - model periods;
  - data collection (including available data);
  - calibration and validation requirements;
  - future years;
  - proposed schemes;
  - output requirements;
- limitations (if any);
- model review process;
- project program;
- milestones and hold points;
- project deliverables; and
- roles and responsibilities.

3.8.2 Strategic Model Preparation

It is recommended that the origin–destination (O–D) data is obtained from a government agency strategic transport model such as Main Roads' ROM24 or the Department of Transport's STEM. The O–D data forms the basis of traffic models, as it provides information on travel patterns and behaviours through the network over a specific time period.

The project manager is responsible for requesting the data and the Transport Modelling Branch within Main Roads' Planning and Technical Services Directorate is responsible for the delivery and approval of this task. An overarching strategic model may not always be readily available and Section 4.1.5 describes the alternative options.

3.8.3 Methodology Report

The *Methodology Report* must document the proposed approach the modeller will take for the project. The report must be approved prior to modelling commencing in order to ensure that Main Roads and the modeller are in agreement with the inputs, assumptions, approach and outputs. At a minimum, the report should contain the following information:

- project investigation;
- problem definition and model purpose;
- study area;
- data collection and analysis methodology;
- model assumptions and limitations;
- model development methodology (e.g. integrated three-tiered approach, fixed-signal timing);
- calibration and validation criteria;
- option modelling scenarios and subsequent modelling;
- traffic growth estimation method; and
- model output requirements.

3.8.4 Base Model

The following section details the process and requirements for base model development. It also outlines Main Roads' submission requirements.

3.8.4.1 Base Model Development and Submission

The development of the base model is essential in order to ensure that the model is representative of the existing conditions and is appropriate to achieve the model purpose, as the option models will be developed from the base model. Further information on the base model development process and the calibration and validation criteria are outlined in Section 5.

Once the base model has been completed in accordance with the *Methodology Report*, the modeller must submit the base model and any relevant documents to Main Roads' auditor. A *Model Audit Checklist* must be included in the submission. The checklist ensures that the modeller has considered the key parameters and provided the relevant documents in the development of the traffic model. It also formalises the process for internal and external review.

The checklist provides an audit trail for each of Main Roads' supported modelling software packages (detailed in Section 2.5.2). The *Model Audit Checklist* is available for download from the Main Roads website. If a software alternative to Aimsun Next, Visum or Vissim is used, the modeller must demonstrate that similar checks have been conducted.

3.8.4.2 Base Calibration and Validation Report

The *Base Calibration and Validation Report* must include information on the approach adopted by the modeller and the calibration and validation results, as these may be different to the proposed approach stipulated in the *Methodology Report*. At a minimum, the report should contain the following information:

- project investigation and study area selection;
- model purpose and objectives;
- data collection and analysis methodology;

- model development;
- demand development;
- calibration and validation results;
- model performance results and analysis; and
- conclusion.

3.8.4.3 Base Model Audit

Main Roads' Operational Modelling and Visualisation Branch representative will be the auditor and, in consultation with other key stakeholders shown in Table 3-4, will be responsible for the model audit. The audit may prompt an iterative update by the modeller based on the comments provided by the auditor. Updates will be required until the model has met the specified criteria. The modeller must re-issue the finalised version of the model and report for Main Roads' approval.

3.8.5 Future Year Growth Memorandum

The future traffic growth methodology must be included in the *Methodology Report* for Main Roads' approval. Further guidance on traffic growth estimation methods is outlined in Section 6.3.

The calculated growth rates should be summarised in the *Future Year Growth Memorandum*. In order to assess the option models, Main Roads must first approve the future year volumes. At a minimum, the memorandum should contain the following information:

- traffic growth methodology;
- macroscopic model outputs (e.g. link volume plots, O–D matrices, V/C plots);
- growth factors per zone comparison between the macroscopic and mesoscopic model;
- overall growth (total growth or growth per annum);
- development traffic generation growth (based on available development plan or traffic generation guidelines); and
- preliminary mesoscopic/hybrid modelling outputs (e.g. latent demand, volume plots, density plots or delay plots) to demonstrate the demands are appropriate and that no further adjustments are required (overestimation of demand often occurs by using strategic model outputs).

If excessive latent demand is anticipated in the network, the modeller must discuss the outcomes with Main Roads' Network Planning and Development Branch representative or Urban Road Planning Branch representative and identify methods to mitigate the latent demand. The approval of the future year demands may be an iterative process between the modeller and Main Roads' Network Planning and Development or Urban Road Planning Branch representatives. Updates will be required until the demands are suitable for the project purpose.

3.8.6 Option Model

The following section details the process and requirements for option model development. It also outlines Main Roads' submission requirements.

3.8.6.1 Option Model Development and Submission

The approved base model will form the basis of the option models. The model parameters, such as driver behavioural factors and user-defined costs, should remain consistent across the base model and future scenarios in order to inform a like-to-like assessment of the impact of future schemes. Further information on option model development is outlined in Section 6.

Once the option models have been completed, the modeller must submit the option models and any relevant documents to Main Roads' auditor. The *Model Audit Checklist* used in the base model submission includes a separate section for the option models and it should be updated accordingly.

3.8.6.2 Option Modelling Report

The *Option Modelling Report* must include information on the approach adopted by the modeller. It should also include the option modelling results in accordance with the *Project Brief* or *Methodology Report*. At a minimum, the report should contain the following information:

- project background;
- model purpose and objectives;
- proposed options to be assessed;
- proposed future year horizons and growth rates;
- modelled results and interpretations; and
- conclusion.

3.8.6.3 Option Model Audit

Main Roads' Operational Modelling and Visualisation Branch representative will be the auditor and, in consultation with other key stakeholders shown in Table 3-4, will be responsible for the model audit. The audit may be an iterative process between the modeller and the auditor. Updates will be required until the model has met the specified criteria. The modeller must re-issue the finalised version of the model and report to Main Roads for approval.

Main Roads' approval of the option model does not represent approval of any regulatory control, but the approval can allow the option model outputs to be used as part of the regulatory control assessment. Further detail on the regulatory control procedure can be found in Main Roads' *Traffic Signals Approval Policy*.

4 DATA COLLECTION AND ANALYSIS

This section provides guidance on data collection and analysis requirements in order to assist project managers and modelling practitioners develop mesoscopic or hybrid models for Main Roads.

4.1 Data Collection

The development of traffic models depends on the quality and consistency of the traffic data used. A robust data collection and analysis methodology to identify the survey requirements are needed in order to ensure that a model that is fit-for-purpose can be developed. The data collection scope should be informed by:

- model purpose;
- model scale;
- available historical data;
- data collection and analysis cost;
- data type for model calibration and validation;
- model output requirements;
- understanding of the general traffic conditions and the surrounding environment; and
- extent of future option scenarios.

The data collection and analysis methodology need to be adequate in order to develop a model and address the model purpose. The project manager may choose to collect the data during the planning stage and use the results to inform the *Project Brief*. The methodology must be stipulated in the *Methodology Report* and approved by Main Roads.

4.1.1 Traffic Data Requirements and Granularity

The traffic data collection requirements will be specific to the model type. Table 4-1 summarises the required data and recommended data granularity based on the model type. The table shows that hybrid modelling will require more extensive data for the microscopic pocket, while the mesoscopic area within the hybrid model will be the same as a standard mesoscopic model.

Table 4-1: Data collection requirements

Data Type	Recommended Granularity		Mesoscopic	Hybrid (Microscopic)
	Time Interval	Vehicle Classification		
Classified Intersection Counts	15 min	Yes	✓	✓
Classified Mid-Block Counts	15 min	Yes	✓	✓
SCATS Detector Data	15 min	No	✓	✓
Freeway VDS	15 min	No	✓	✓
Travel Time	15 min or By Section	Permitted	✓	✓
Queue Length	5 min	Permitted	✓[1]	✓
Origin–Destination Survey	15-30 min	Permitted	✓	✓
SCATS Signal Data	Per Cycle	No	✓	✓
Ramp Metering	Per Cycle	No	✓	✓
Public Transport	Timetable	No	✓	✓
Level Crossing	Per Cycle	No	✓	✓
Pedestrians	15 min	No	✓[2]	✓
Cyclists	15 min	No	×[3]	×[3]
Saturation Flow	Per Cycle	No	×	✓[4]

[1] Queue observations are required at a minimum
[2] Pedestrian-related delays need to be observed at a minimum
[3] Delays due to cyclists need to be observed at a minimum
[4] Only required for signal optimisation projects

4.1.2 Traffic Survey Preparation

The data collected must represent typical network traffic conditions. Where possible, data collection should be avoided during:

- Mondays and Fridays;
- school or university holidays;
- public holidays;
- roadwork or temporary road closures;
- bad weather;
- events (unless the purpose is to assess event traffic);
- traffic incidents; and
- faulty operation of traffic signals.

4.1.3 Site Observations

Site visits should be carried out by the modeller, preferably on the same day the traffic data is being collected, in order to gain an appreciation of the actual traffic conditions and to supplement the traffic survey. The information gathered on-site may include:

- driver behaviour;
- route choice (e.g. rat-running);
- lane utilisation;
- traffic incidents or events (if any);
- traffic management plans (if any);
- queue length;
- pedestrians and cyclists (e.g. delay, behaviour, routing etc.);
- heavy vehicle behaviour;
- bus operations; and
- kerbside activities and restrictions.

While site visits are essential, it can be difficult to capture the full extent of the study area during peak hours. It is recommended that modellers refer to local knowledge or online tools in order to identify the areas of concern so that conditions can be validated during the site visit.

4.1.4 Traffic Counts

4.1.4.1 Classified Traffic Count Surveys

Classified traffic surveys are commonly performed on-site using manual counters, automatic tube counters (ATCs) or classified turning counts captured by video cameras. It is recommended that Austroads' vehicle classification system is applied, as per the recommendation in Table 4-2.

Pedestrian counts should also be carried out (if required) within the core areas. Further detail is outlined in Section 4.1.11.

4.1.4.2 Freeway Vehicle Detection Stations

Main Roads has a system of vehicle detector stations (VDS) which collect real-time freeway traffic data. Detector stations are typically "in-pavement" sensors configured to measure and collect volume, occupancy and speed data on a lane-by-lane basis. The VDS do not capture vehicle classification.

As there is a relatively low cost involved in obtaining the data, traffic counts from the VDS can be collected over several days or weeks. The data can be used to determine seasonal traffic fluctuations, variations in traffic demand during school holidays or public holidays, and travel demand on an average weekday.

4.1.4.3 SCATS Detector Volume

SCATS signalised intersections use embedded detector loops that allow intersections to operate based on demand. The detector loops count the number of vehicles that pass through each detector on an allocated lane. Like VDS data, traffic counts from SCATS detectors can be collected over several days or weeks (on account of the relatively low cost) and can be used to determine seasonal traffic fluctuations.

The detector data does not capture vehicle classification or determine turning proportions when the approach lane is shared by two movements. As such, SCATS detector data should not be used as the primary source of traffic count but may be considered in the study area peripherals to supplement the classified traffic count surveys in the core area.

4.1.4.4 Historical Traffic Counts

Historical data that is no more than three years old can be used in the model peripheries to help minimise survey costs, but the modeller must demonstrate that the traffic behaviour in the study area has not significantly altered due to recent changes in the traffic network.

It should be noted that the use of historical data may increase the resource requirements during the data analysis stage. The use of historical data may also result in an overrepresentation of assumptions that could potentially compromise the ability of the model to achieve the project objectives. As such, the use of historical traffic count data should be minimised and only used at the model peripheries.

The types of historical data that can be used include:

- Main Roads' *trafficmap* website;
- SCATS traffic data (this can be requested from Main Roads using the SCATS request form if this is not available on the *trafficmap* website); and
- metropolitan traffic count data (available through the Main Roads reporting centre).

4.1.4.5 Heavy Vehicles

When undertaking traffic counts, light and heavy vehicles must be considered. For the purpose of traffic modelling, Main Roads recommends heavy vehicles be classified into three groups, as shown in Table 4-2. Further count breakdowns may be required where there are higher demands from Austroads Class 10, 11 or 12 heavy vehicles that are known to significantly impact network performance. In order to assess the significance of heavy vehicles in the study area, and to what extent they should be reviewed in more detail, the following should be considered:

- restricted access vehicles (RAV) routes, freight routes and routes within/around freight terminal precincts;
- routes around construction sites and commercial or industrial areas;
- the operation of freeways, tunnels and access ramps;
- study areas where a high percentage of heavy vehicles (e.g. over 10 per cent) are observed in classified traffic count data; and
- any other projects where heavy vehicle movements are considered an important component of traffic performance (e.g. study area with steep grades).

Table 4-2: Grouped heavy vehicle classification

Groups	Detail of Groups	Austroads Class
1	Rigid Heavy Vehicle	2-5
2	Articulated Heavy Vehicle	6-12
3	Public Transport Buses	-

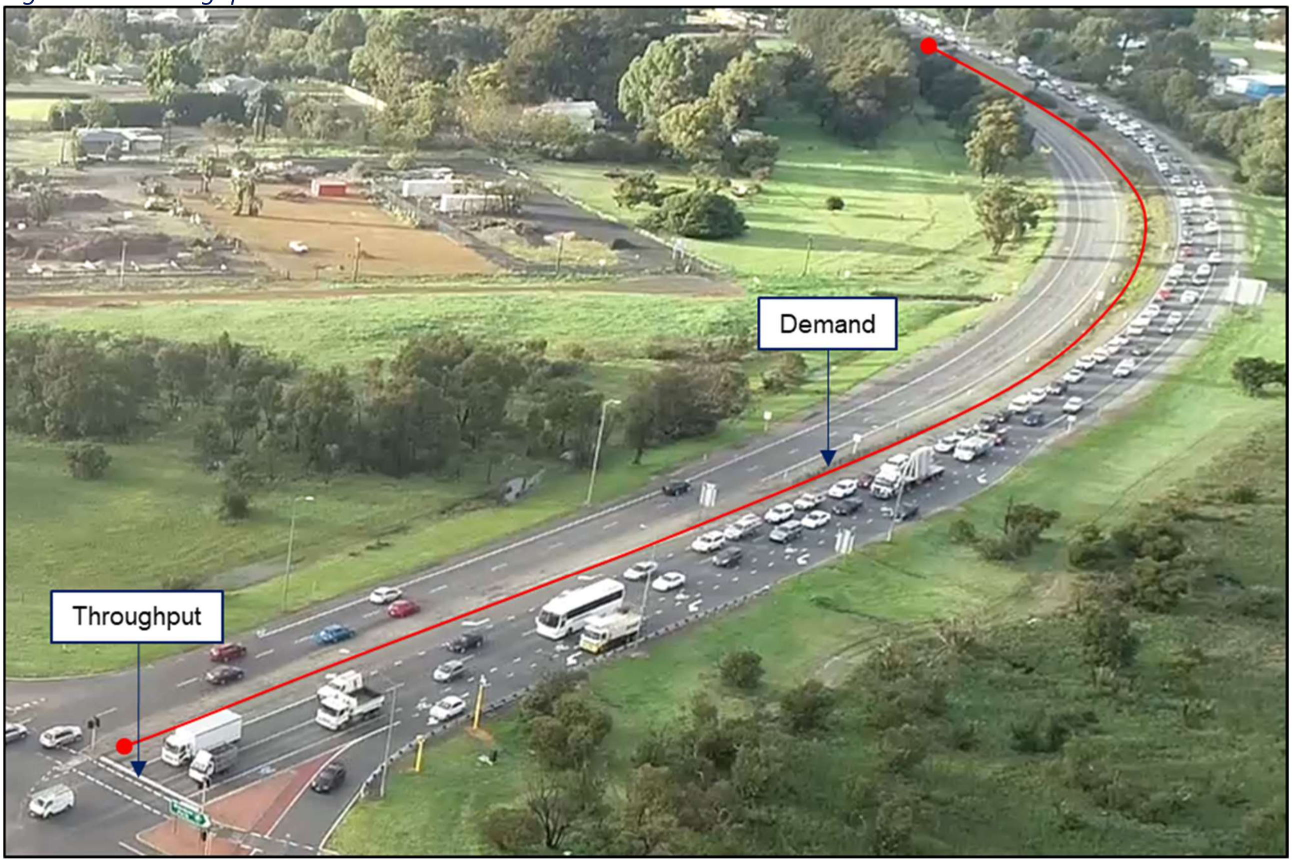
Based on the Austroads and/or restricted access vehicle (RAV) classification systems, detailed heavy vehicle counts may be required for the model. However, certain survey methods will not have that level of granularity due to collection limitations.

4.1.4.6 Limitations

Traffic counts based on throughput, as outlined in Section 4.1.4, are often measured at stop lines and these counts are used as an input into demand-based simulation models. The limitation of throughput volume is that it does not capture the remaining queue of vehicles that could not pass the stop line. This is defined as un-met traffic demand and it occurs when demand exceeds capacity. In these situations, traffic demand should be captured from the upstream links (e.g. by ATC) or estimated from the observed queues or travel time.

Figure 4-1 demonstrates a long queue where the throughput volumes are captured at the stop line. It does not consider the full demand that is waiting to cross the stop line. Other locations where the throughput volumes may be reduced include merging and weaving areas.

Figure 4-1: Throughput and demand



4.1.5 Origin–Destination

Origin–destination (O–D) data forms the basis of mesoscopic and hybrid models, as it provides information on travel patterns and behaviours through the network over a specific time period. The O–D data should be obtained using surveys or based on an overarching strategic model. The overarching models are generally Main Roads' ROM24 or the Department of Transport's STEM.

It is recommended that the O–D data is obtained from an overarching strategic model. The strategic modelling O–D data can be supplemented with O–D survey data to gain a more robust modelling outcome.

4.1.5.1 Strategic Model

For O–D information relating to Perth's metropolitan area, overarching strategic models are normally used. This allows a direct link between strategic model outputs and simulation models, ensuring that O–D travel patterns are reflected in the base and future simulation models. To improve integration between the strategic models and project-specific mesoscopic models, these key steps should be followed:

- estimate temporal traffic demand;
- identify and disaggregate the study area;
- extract the study area from the regional model as a sub-area;
- estimate and adjust the matrix of the study area; and
- extract the project-specific sub-area model from the study area with outputs including:
  - sub-area model zone structure and zone boundaries;
  - sub-area existing and future year O–D matrices; and
  - network plots (e.g. v/c plots, link volume plots, and select link plots).

4.1.5.2 Origin–Destination Survey

O–D data can also be collected by conducting surveys using various technologies, each with advantages and disadvantages. The different options for undertaking O–D surveys are summarised in Table 4-3. Regardless of how the O–D data is obtained, it will need to undergo adjustment. Further details are outlined in Section 5.7.3.

Table 4-3: Alternative O–D survey methods and typical characteristics (source: Austroads, 2017)

	Household Survey	Roadside Interview	ANPR[1]	Bluetooth	Mobile Phone	GPS
Sample Size	1-3%	10-25%	90-100%	10-30%	20-50%	5-15%
Time Coverage	1-3 Average Days	1 Average Day	1 or More Days	1 or More Weeks	Any Time Period, Any Day	Any Time Period, Any Day
Vehicle Classification	Yes	Yes	Yes	Difficult	Difficult	Yes
Cost	Very High	High	Medium	Medium	Medium	Low

[1] Automatic number plate recognition

4.1.5.3 Legacy Model

The O–D data can also be extracted from a calibrated and validated legacy mesoscopic model. The legacy model must cover the full extents of the study area in order to allow the modeller to create sub-area matrices based on the cordoned area. The benefits of using O–D data from a legacy model, as opposed to from a strategic model, include:

- provides a more finer zone structure;
- provides a more detailed road network; and
- require less effort to calibrate and validate the model.

As using legacy models poses a risk that the road network and land-use information may be outdated, the modeller must review and verify the model to ensure that the legacy model is suitable for the project purpose.

4.1.6 Travel Time

A common technique used to validate mesoscopic and hybrid models is to compare surveyed and modelled travel times along key routes in the study area. This is an important comparison since travel times can influence driver route choice and have a significant impact on traffic volumes, contributing to traffic delays and congestion.

The travel time data should be collected on the same day as other traffic data. When collecting travel time data, it is necessary to disaggregate the route into smaller predefined sections so that the location of vehicles encountering delays within the overall travel time route can be easily identified. The use of sections allows a cumulative graph of travel time along the route to be developed and analysed.

Subject to the granularity of the data, the travel time measurements should begin and end immediately after crossing the stop lines for each section. Segmented travel times provide valuable information with respect to signal coordination and queue delay, which may be useful during model development.

The “floating car” method used to collect travel time data involves one or more survey cars driving along prescribed routes within the study area and recording travel times for the predefined sections. Alternatively, Main Roads may have travel time data for specific routes and may be able to provide access to this information.

It is recommended that at least six observations are recorded for each route within each peak period, so that a statistically reliable estimate of average travel time can be derived. Collecting multiple travel time observations also enables travel time variability (range, maximum, minimum and standard deviation) to be analysed.

4.1.7 Queue Length

Queue length data can be collected on-site and compared against modelled outputs. This provides an indication of how accurately the model replicates congestion on approaches to key locations in the study area. The analysis of queue lengths can be subjective, due to the difficulties in defining a queue when there are slow-moving vehicles. This generally makes the level of accuracy in queue length surveys lower than other measurements. Despite the limitations, queue length data does provide a measure of intersection performance and un-serviced demand.

Queue length data, measured at the start of the green period, should be collected on the same day as the traffic survey. Queue length surveys for microsimulation pockets of hybrid models should include a minimum of 10 samples taken across the peak hour. Queue lengths for mesoscopic models require less granularity and average queue length data should be collected at a minimum of 30 to 60-minute intervals.

Main Roads recommends queue length data is collected on the day of the traffic surveys in order to help replicate the level of congestion within the network. Queue length surveys with a minimum of 10 samples across the peak hour are recommended for microsimulation pockets of hybrid models. The average queue length, in 30 to 60-minute intervals, should be collected for mesoscopic models.

4.1.8 Public Transport

The impact of public transport on the operation of a transport network can be significant and needs to be incorporated into mesoscopic and hybrid traffic models. The granularity of the public transport data required to develop the model will depend on the model purpose and the impact that public transport may have on the overall operation of the network.

4.1.8.1 Public Transport Buses

Aerial photography images should be used to assist with the network coding of public transport infrastructure, such as bus priority lanes. Transperth's bus timetable information provides bus routes, bus frequency and stop locations. If bus operations are critical to the network, the Public Transport Authority (PTA) should be able to provide additional bus data including:

- bus travel time;
- dwell time;
- boarding and alighting patronage data; and
- on-board patronage data.

The modeller should be aware that bus travel time information is often based on GPS trackers located on each bus. If the buses are queued at the bus stop after the boarding or alighting of patrons, additional stopping time due to downstream delays may be incorrectly recorded as bus dwell time data. Similarly, as there are some timed stops, if the buses are ahead of schedule they dwell longer and this time may be incorrectly recorded as bus dwell time.

4.1.8.2 Level Crossings

Level crossings are found at railway lines intersecting with a general traffic road. There are four levels of at-grade controls used to operate level crossings in Western Australia:

1. give-way signs;
2. stop signs;
3. flashing lights; and
4. boom gate barriers.

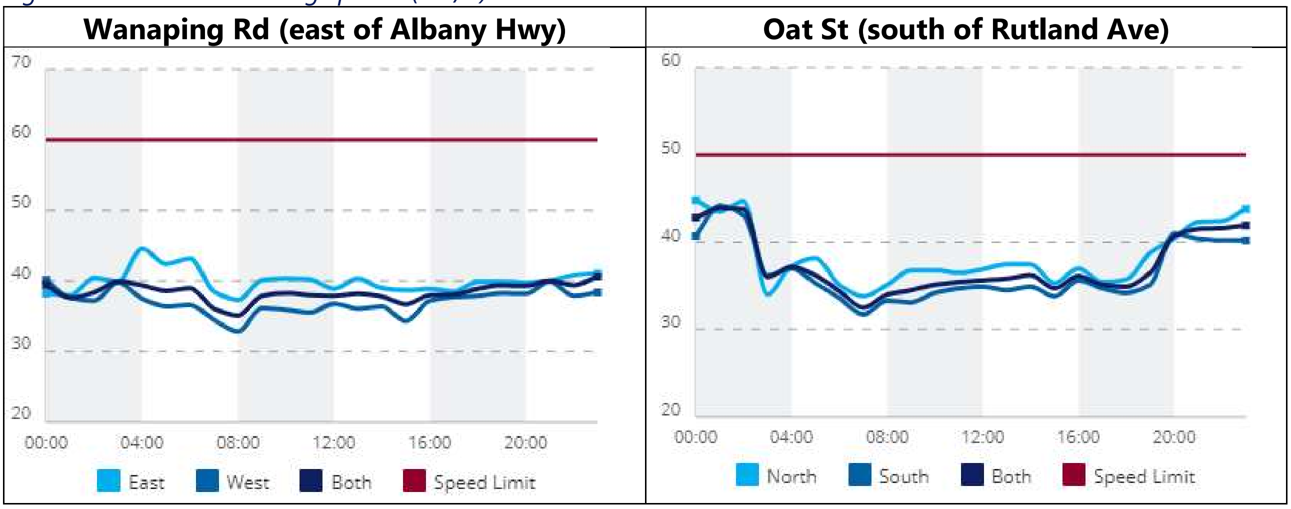
Within the Perth metropolitan area, the majority of rail level crossings use boom gate barriers. When the adjacent upstream or downstream intersection is signalised, the gates may be operated with

SCATS. The incorporation of level crossings in a simulation model will require additional data to be collected in order to appropriately replicate behaviours at the crossing. It is recommended that the following data sources and types of data are used:

- site observations (i.e. queue lengths, driver behaviour);
- PTA data (i.e. train frequency, dwell time, boom gate downtime); and
- SCATS data (i.e. SCATS history, phase diagrams).

Driver behaviour around level crossings can vary from site to site. Figure 4-2 illustrates the posted and observed speeds through two level crossings within the Perth metropolitan area. It shows that the median crossing speed can be significantly lower than the posted speed limit and this should be accounted for in the model.

Figure 4-2: Median crossing speeds (km/h)



4.1.9 SCATS Signals

The base model should be developed to represent the current intersection arrangement. Signal phasing and signal group labelling in the model should be consistent with that employed on-site, so it is recommended that SCATS signal data is used when modelling any signalised intersection. SCATS data can be requested from the Main Roads website using the *SCATS request form* or by using Main Roads' *trafficmap*. Available SCATS information includes:

- pavement and signage drawings (light maintenance drawings, LMB[1]);
- traffic signal arrangement drawings (LMA[2]);
- link and offset plans;
- SCATS phase history;
- phase sequence charts;
- strategic monitor; and
- SCATS event history data.

The SCATS signal data should be analysed and replicated in mesoscopic or hybrid models using the three techniques for coding signalised intersections in models:

[1] LMB plans are sign and line drawings showing the built geometry, carriageway widths and lane utilisation.

[2] LMA plans are traffic signal drawing plans that show the location of existing signal heads, SCATS detector loops and existing signal phases.

1. fixed-time signals;
2. vehicle actuated signal coding; and
3. SCATS operation with SCATSIM.

Main Roads may recommend a technique to apply for signal control based on the *Project Brief* but, if not, the technique must be stipulated in the *Methodology Report*.

The SCATS signal data required will depend on the method being used to replicate signal operations in the model. The preferred method should be agreed with Main Roads and stipulated in the Methodology *Report*.

4.1.10 Ramp Metering

Ramp metering operations are used to improve freeway efficiency by regulating flows on the freeway on-ramps. Like SCATS signal operations, the ramping meter operations developed in the base model should represent the current arrangements. Where applicable, Main Roads may be able to provide ramp metering data including:

- ramp metering rates;
- cycle times;
- yellow and red times;
- isolated ramp settings (i.e. gain factor (K_r), mainline target occupancy, minimum and maximum flow rate); and
- coordinated ramp settings (i.e. mainline occupancy threshold, ramp queue thresholds and number of slaves).

Depending on the purpose of the study, a number of ramp metering modelling methods can be used including:

- fixed-timed metering;
- dynamic isolated ramp metering; and
- dynamic coordinated ramp metering.

Further information on ramp metering is outlined in Section 5.4.4. Main Roads may recommend a methodology to replicate the ramp metering operations in the *Project Brief* but, if not, the methodology must be stipulated in the *Methodology Report*.

The ramp metering data required will depend on the method being used to replicate the ramp metering operations. Fixed-timed metering is the most appropriate method for mesoscopic models where the objectives are not related to the freeway or ramp operations.

4.1.11 Pedestrians

Pedestrian facilities are provided to assist pedestrians to safely cross carriageways. Pedestrian crossings can be standalone or incorporated within intersections and include:

- zebra crossings;
- school crossings;
- mid-block signal crossings; and
- signalised intersections.

An initial assessment of pedestrian activity in the study area should be conducted before any survey works are undertaken. This assessment will help the modeller to understand pedestrian movement volumes around the study area, and how pedestrian interactions with traffic may impact traffic operations. Pedestrian count surveys may be required within the core area to accurately replicate pedestrian-related impacts on the network.

In most cases, pedestrians are not explicitly modelled in mesoscopic or hybrid models but pedestrian impacts on the road network must be considered, particularly at crossings where give-way manoeuvres to accommodate high pedestrian volumes are observed.

4.2 Data Analysis

As traffic patterns can change in a relatively short period of time, particularly within urban networks, it is essential to check that survey data being used for modelling is current. Since traffic counts can be collected from different sources, and at different times, there may be discrepancies, for example, between the upstream and downstream flows at mid-block locations. The cause of discrepancies should be carefully investigated by the modeller in order to determine appropriate action, such as:

- the flow discrepancies are the result of un-met demands, as outlined in Section 4.1.4.6 and it is reasonable to use the flows without adjustments.
- manually adjusting flows in order to minimise the upstream and downstream flow discrepancies stemming from traffic counts being collected on different dates or from different sources; or
- including additional traffic zones in order to minimise flow discrepancies.

4.2.1 Data Analysis Time Interval

Once the data has been collected and reviewed, it is commonly averaged into 60-minute intervals so that the data can be used as an input for the modelling assessment. Table 4-4 illustrates the recommended time intervals to be inputted into the model.

Table 4-4: Recommended data analysis time interval for model input

Data Type	Recommended Time Intervals for Model Input
Classified Intersection Counts	15-60 min
Classified Mid-Block Counts	15-60 min
SCATS Detector Data	15-60 min
Freeway VDS	15-60 min
Travel Time	15-60 min
Queue Length	15-60 min
Origin–Destination	15-60 min
SCATS Signal Data	30-60 min
Ramp Metering	30-60 min
Public Transport	60 min
Level Crossing	60 min
Pedestrians	60 min
Cyclists	60 min

4.2.2 Risks and Limitations

The aggregation of the collected data so that it is suitable for the model can sometimes conceal information such as variations or outliers. The modeller must carefully analyse the data in smaller time intervals (i.e. 15 minutes) or use statistical distribution to assess the variations through the peak period as the congestion propagates and dissipates. If the data was aggregated without exploration at a more granular level, the model may not be able to replicate the actual traffic conditions required for model calibration and validation.

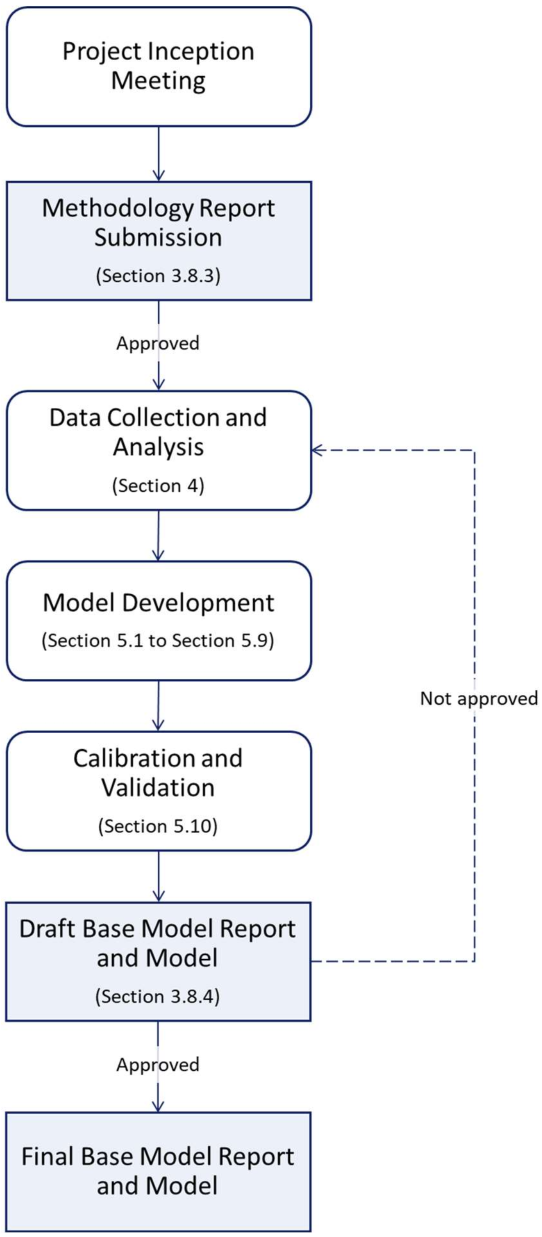
It is recommended that modellers analyse the data in smaller time intervals in order to assess variations through the peak period, before averaging the dataset to develop the model.

5 BASE MODEL DEVELOPMENT

This section describes the best practices to assist modellers in developing a base year mesoscopic or hybrid model for Main Roads. Although a recommended method has been provided at the end of each sub-section, the modeller must determine the most appropriate method based on the model purpose and stipulate it in the *Methodology Report*. The chosen methodology must be approved by Main Roads.

Figure 5-1 illustrates Main Roads' base model development procedure. The boxes highlighted in blue denotes the deliverables or hold points.

Figure 5-1: Base model development process



Main Roads' approval of the base model means that it can be used for the defined model purpose.

5.1 Model Set-up

The model set-up for mesoscopic and hybrid models should be defined prior to building the models. Depending on the selected software, the basic set-up settings may include network settings, behaviour, and background aerial information.

5.1.1 Network Settings

The modeller must ensure that the correct network settings for Australia are applied. Depending on the selected software, basic settings that can be applied to the entire road network may be included. Common network settings for the modelling software should be set for:

- units – metric; and
- rules of the road – drive on the left.

5.1.2 Coordinate System

The modeller must ensure that the model is set-up using the correct coordinate system. The coordinate system varies depending on the longitude and latitude of the study area. These systems would apply to projects in Western Australia:

- EPSG:32749 – area of use: between 108°E and 114°E;
- EPSG:32750 – area of use: between 114°E and 120°E;
- EPSG:32751 – area of use: between 120°E and 126°E; or
- EPSG:32752 – area of use: between 126°E and 132°E.

Projects within the Perth metropolitan area would use the EPSG:32750 (or equivalent) coordinate system.

5.1.3 Background Aerial Images

The network must be developed using current background aerial images. Software packages may have default aerial images and the modeller must ensure that the aerials used reflect the existing network, as the images may be outdated. It is recommended that the modeller imports updated geo-referenced aerial images into the model.

5.2 Traffic Assignment Selection

Mesoscopic models are underpinned by the fundamental concept of dynamic traffic assignment as a means of introducing time-dependent movement of vehicles throughout a network. The selection of the traffic assignment method will form the basis of the model development procedure.

Traffic assignment allows traffic demand to be incorporated into the capacity of the road network. Assignment methods may differ between software packages and the modeller must select the most appropriate method or process for the study. There are two assignment types that are based on generalised costs and can be broadly categorised as:

1. static traffic assignment; and
2. dynamic traffic assignment.

Further information related to traffic assignment for Aimsun Next, Visum and Vissim is detailed in Section 7.

5.2.1 Generalised Cost

It is generally assumed that drivers choose the route that yields the least travel time or the lowest generalised cost. All route choice traffic assignments are based on a generalised cost equation by summing the monetary and non-monetary costs of a trip and estimating the driver's route choice in the model. A simplified version of generalised cost equation is:

$$Generalised\ Cost = (\alpha \times travel\ time) + (\beta \times distance) + (\gamma \times user\ defined\ cost)$$

Where α, β and γ are user defined factors.

The costs are calculated for each O–D pair and used to assign traffic from the most attractive route to the least attractive route. Two key assumptions are applied to enable the traffic assignment process:

1. how the choice behaviour route is modelled; and
2. how the traffic flow and conditions are represented.

5.2.2 Equilibrium Assignment

The concept of equilibrium assignment can be described as an iterative approach that aims to achieve equal perceived travel time (generalised cost) across all the routes used within the O–D pair and time intervals. The travel times of each route from the previous iteration are used as cost inputs for the following iteration until equilibrium is achieved. The iterative nature of equilibrium improves the robustness of models as it reduces reliance on single-seed simulation runs.

The equilibrium approach is generally more appropriate for planning assessments, while the non-equilibrium approach is more appropriate for unplanned event assessments. Both static traffic assignment and dynamic traffic assignment can use the equilibrium approach and the differences are outlined in Section 5.2.3 and Section 5.2.4, respectively.

5.2.3 Static Traffic Assignment (STA)

STA is predominantly used in macroscopic models, expressing steady-state travel time as a function of volume. It uses a combination of volume delay functions (VDFs) and turn penalty functions (TPFs) through the links and turns, respectively, to calculate the generalised cost of the paths. As the functions approximate network delays without the simulation of individual vehicles, STA offers the benefit of computational efficiency.

STA does not consider the physical constraints in a network in the context of reducing demand, which allows the assigned volumes to exceed the physical capacity. The downside of this is that it may not correlate with congestion metrics such as speed, density or queue. As such, modellers must be careful when comparing the STA volumes against site-measured stop line flows.

TPFs are applied at signalised intersections, roundabouts and priority junctions to replicate intersection delays. The application of TPFs may be of greater importance than VDFs because intersections are generally the bottlenecks in an urban road network. TPF is not only a function of flow through the turning movement but may also be a function of conflicting movement flows.

The default volume delay functions and turn penalty functions will differ between each software package. It is recommended that static assignment parameters are applied logically and consistently throughout the modelled study area as a starting point.

5.2.4 Dynamic Traffic Assignment (DTA)

DTA is a modelling approach that captures temporal components related to varying network conditions and varying travel demand requirements. In comparison to STA, DTA explicitly accounts for variations over time and can capture the gradual spread of congestion in the network. This transient state assignment can be classified into two categories:

1. analytical assignment; or
2. simulation-based assignment.

5.2.4.1 Analytical Dynamic Traffic Assignment

Analytical DTA applies time-varying network conditions from the aggregation of a static model to assign traffic through the network. It can constrain flow to capacity and simulate the queue propagation at bottleneck locations. In comparison to simulation-based assignment, analytical DTA will generally have faster model run times and require less effort to develop. Such simplification may not reproduce the same level of congestion propagation as the simulation-based assignment.

5.2.4.2 Simulation-Based Dynamic Traffic Assignment

Simulation-based DTA captures more realistic vehicle behaviours and complex traffic conditions by simulating individual vehicle movements. As these interactions cannot be analytically derived, simulation-based DTA used in microscopic, mesoscopic and hybrid assignment can provide a better estimation of traffic congestion, particularly in respect to propagation through the road network over time.

In general, the benefits of simulation-based DTA include:

- ability to capture time-dependent interactions between the demand and supply of the network;
- enables identification of network constraint locations and describes the queue propagation and dissipation; and
- allows intersection operations and intelligent transport system (ITS) strategies to be simulated.

Dynamic equilibrium in simulation-based assignment is commonly adopted for each time interval, as opposed to establishing equilibrium for the entire analysis period (static equilibrium). The goal is to find an equilibrium based on pre-specified convergence criteria so that the equilibrium can be obtained within a reasonable timeframe.

The increase in model complexity will also demand higher computational time, data requirements and sometimes may result in poorer convergence. As such, a hybrid equilibrium assignment, with a large microsimulation pocket (e.g. encompassing more than 15 per cent of the network) and complex route choices is generally not recommended. Similarly, there may be risks associated with the hybrid equilibrium assignment, as the network representation between two model types have different path calculation methods which may skew the results.

The selection of the assignment methodology should be based on the model purpose. Where possible, Main Roads encourages the use of simulation-based equilibrium assignment where route choice is the focal point of the model purpose. Analytical assignment can be considered for sub-regional models.

5.3 Road Links and Sections

A traffic model network generally consists of a combination of road links, connector nodes and intersection nodes. Road links form the basis of the traffic modelling network, which is commonly developed in conjunction with other network elements, such as zones and intersections to form a complete road network.

5.3.1 Link Types

All modelled links should be assigned with a road link type, as shown in Table 5-1. The link type parameters and attributes will differ between software packages and the modeller must identify and assign the appropriate link types and apply reasonable parameters to the road network.

Table 5-1: Link types

Link Type	Application
1	Managed Freeways
2	Freeway
3	Ramps
4	Expressways
5	Divided Arterials
6	Undivided Arterials
7	Residential

Main Roads recommends link attributes be applied consistently, depending on road type.

5.3.2 Link Capacity

Road capacity is defined as the maximum number of vehicles that can travel through a given point during a specified time period under prevailing roadway, traffic and control conditions. The capacity of the road can be a factor in determining route choices in traffic modelling. Depending on the software package, link capacity may be used as an indication of "attractiveness", which is used in the generalised path cost calculation to reflect driver likelihood of using higher ranked roads.

It is recommended that modellers use the link capacity parameters shown in Table 5-2. During the calibration and validation process, adjustments to the capacity may be required and it is recommended that the link type capacities are collectively adjusted. The modeller may also need to adjust specific link capacities based on locally observed behaviour that could not be justified by available model parameters. These changes must be documented in the *Base Calibration and Validation Report*.

Table 5-2: Link capacity per lane

Link Type	Description	Typical Speed Limit (km/h)	Hourly Link Capacity (veh/lane)
1	Managed Freeways	100	1870
2	Freeway	100	1700
3	Ramps	80	1500
4	Expressways	80	1500
5	Divided Arterials	70	1400
6	Undivided Arterials	60	1200
7	Residential	50	600

5.3.3 Speed Limit

Speed decision points must be set where vehicles are required to change speed on the road. This is generally at posted speed limit sign locations. Modellers should adopt the speed limit published in the road information mapping system available from the Main Roads website or recorded during the site visit.

5.3.4 Lane Restrictions

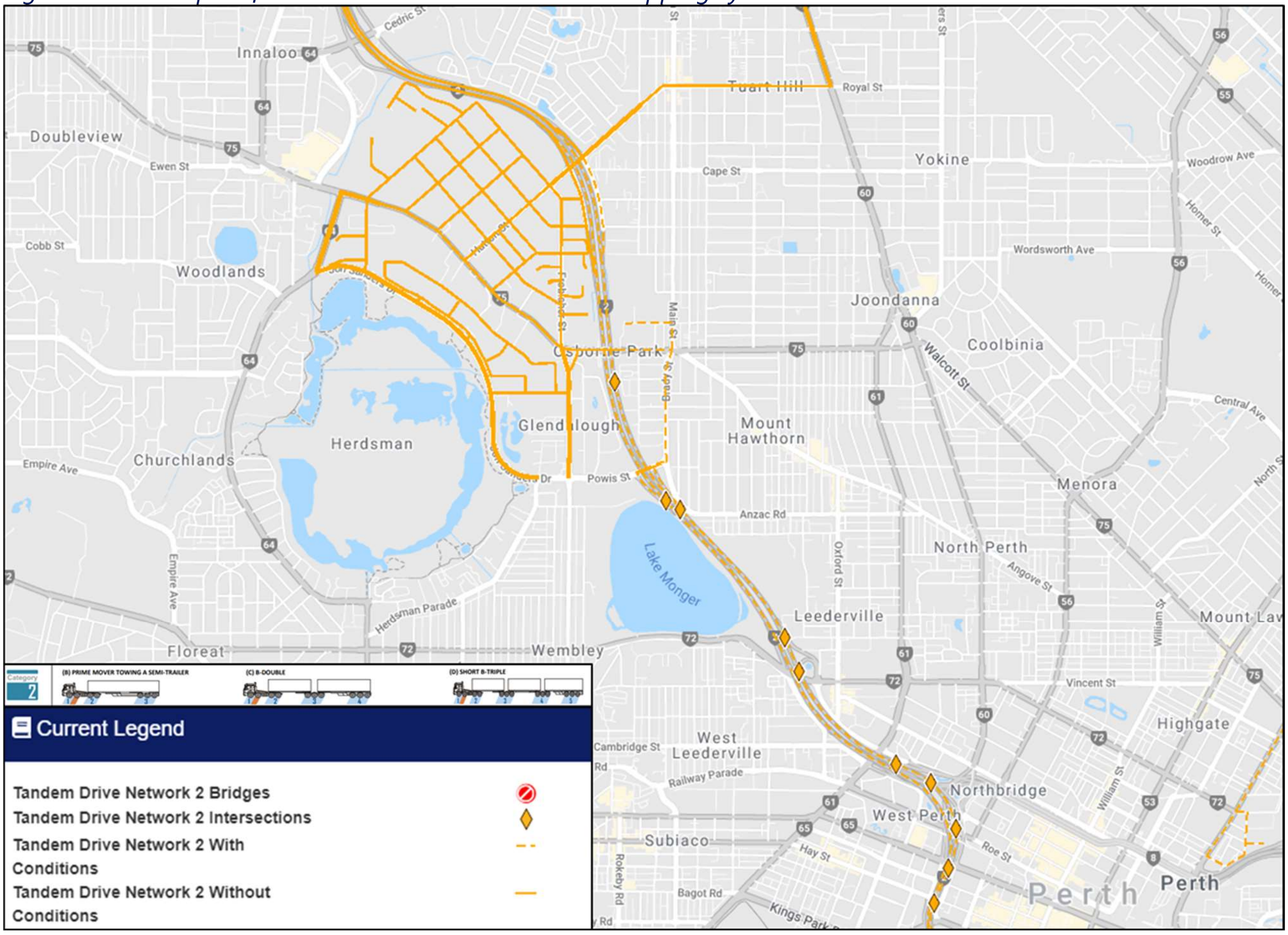
Lane restrictions may include reserved lanes for public transport and lanes which restrict heavy vehicles. In addition, on-street parking will reduce the capacity of the link and needs to be considered. Some lane restrictions are time dependent and should be considered under Traffic Management, which is discussed in Section 5.8.

5.3.4.1 Heavy Vehicle Access and Restrictions

Main Roads is responsible for administering road access for restricted access vehicles (RAVs) in Western Australia. The heavy vehicle restrictions are based on the various types of RAVs and their differing performance characteristics, road space requirements and impacts on road infrastructure.

The modelled extents can cover a large and complex network that may comprise of various land-uses. The network may be subject to large/heavy vehicle restrictions which prohibit such vehicles from accessing local roads to reach a destination. The modeller should refer to Main Roads' heavy vehicle services (HVS) online mapping services to identify approved heavy vehicle routes and restrictions. An example screenshot from the HVS website is shown in Figure 5-2, and this information should be applied to the modelled network in respect to heavy vehicle routes.

Figure 5-2: Example of the Main Roads RAV network mapping system



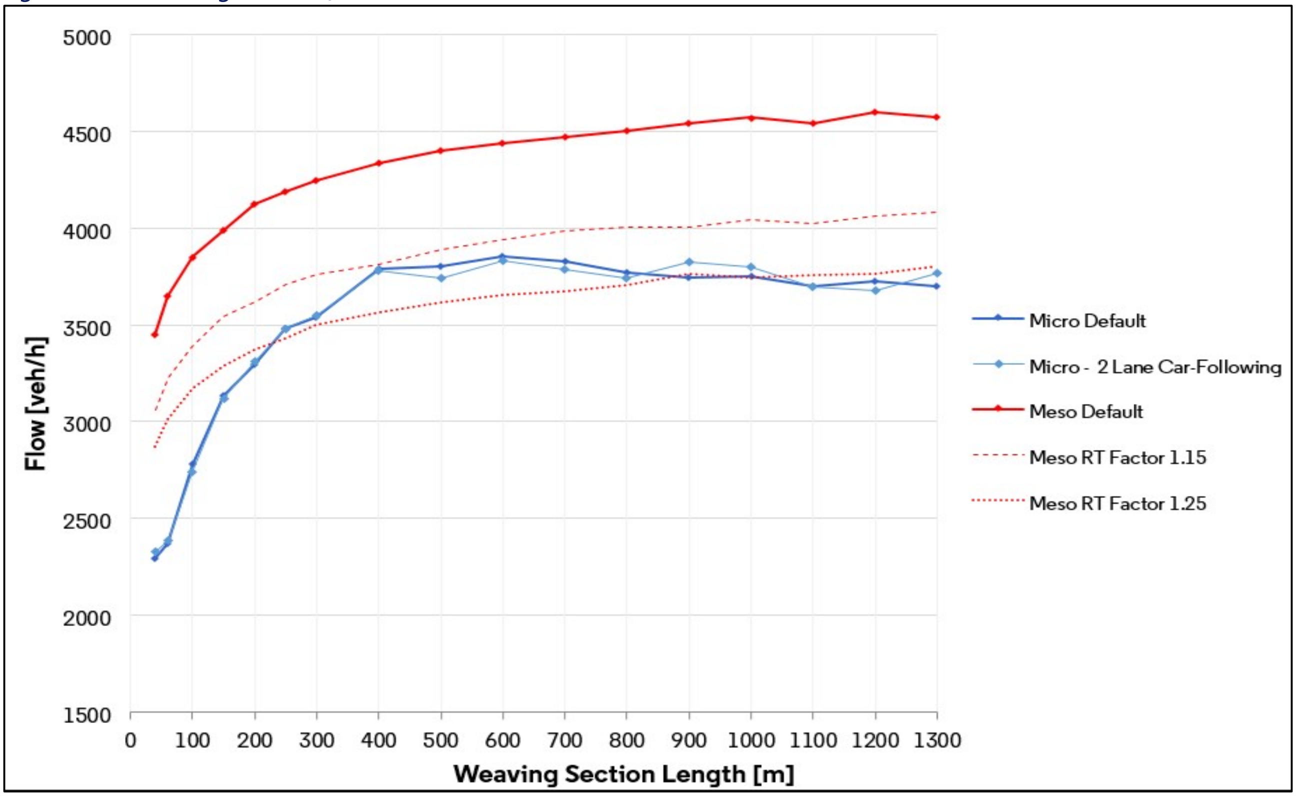
5.3.5 Merging and Weaving

Road links with merging or weaving sections will result in capacity drops. These impacts may not be well replicated as the default settings in mesoscopic models use a simplified car-following algorithm. Depending on the software being used, it is recommended that modellers review the relevant factors that replicate observed queues and delays.

Figure 5-3 illustrates an example of traffic flow throughput against the weaving section length with varying reaction time factors in an Aimsun Next mesoscopic model. In comparison to a corresponding microscopic model, the default mesoscopic reaction time does not demonstrate an equivalent reduction in capacity and subsequent reduction in traffic flow. Adjustments to the reaction time in a mesoscopic model should be made to reflect site-specific conditions in order to achieve model validation. This could lead to an over-fitted model as changes to every merge and weave location for each peak period may be required.

The level of detail to simulate the merging and weaving behaviour will depend on the model purpose and the impact of driver behaviour on network operation. If replication of the merging and weaving is essential, Main Roads recommends a hybrid model, with microsimulation pockets to cover the areas that require the simulation of such driver behaviour, be used.

Figure 5-3: Weaving section flows (source: L. Oriol, 2018)



5.3.6 Road Grades

Steep vertical grades can affect vehicle performance on a corridor and the impacts should be accounted for by adjusting the local link parameters in the model. Main Roads may request slopes to be modelled in hybrid models, particularly on existing or future road networks with heavy freight movements and steep vertical grades.

5.4 Intersection Controls and Nodes

Intersection control nodes and connector nodes form the basis of the modelling network and, in conjunction with road links, are developed to form a complete road network. The coding of intersection junctions may include the node control type, turn speed, pocket lanes, signal timing, gap acceptance and turn restrictions.

5.4.1 Intersection Turning Speeds

The turning speed for all turn movements (e.g. at signalised intersections, priority intersections and roundabouts) be reviewed in order to ensure that turning speeds are reasonable. While this is particularly important when the operation of the intersection is being assessed, it can also influence the capacity of the intersection and route choice. The recommended turning speeds, based on the identified turning radius, are shown in Table 5-3. The modeller is required to exercise their judgement and select the appropriate turning speeds.

Table 5-3: Recommended turning speeds

Turn Type	Radius (Approx.)	Typical Example	Desired Speed
Very Tight Turn	12.5m	Turns Entering/Leaving Car Parks, Driveways or Other Narrow Roads/Lanes	10-20km/h
Tight Turn	15.0m	Most Left-Turn Operations and Small Single-Lane Roundabouts	15-25km/h
Moderate Turn	20.0m	Most Right-Turn Operations and Medium-Sized Roundabouts	20-30km/h
Gentle Turn	30.0m	Large Multi-Lane Intersections and Large (Multi-Lane) Roundabouts	30-40km/h

5.4.2 Traffic Signal Intersections

Traffic signal operations can be simulated in mesoscopic and hybrid modelling using different signal control types, as outlined in the following sub-sections. The level of detail required to model the traffic signals will depend on the model purpose, the characteristics of the site and the variation in the phase times throughout the assessment period. The preferred method should be agreed with Main Roads before the development of a traffic model. Section 5.10.7 details the calibration requirements of signal timings. Further guidance on the coding of the signal times can be found in Appendix A of Main Roads' *Operational Modelling Guidelines*.

5.4.2.1 Fixed-Time Signals

Fixed-time signal control is commonly adopted in mesoscopic and hybrid models in Western Australia. It is generally the most cost-effective method to code signal operations and can be used when there is minimal variation in phase sequences and timing throughout the assessment period. As signal timing can vary throughout the modelled period, the replication of fixed-time signals requires SCATS signal data to be averaged over a specific period no greater than one-hour.

It is recommended that modellers include signal offsets and alternative phases for fixed-time signals. The coordinated sites should be set-up with the same cycle time value or a multiple of each other in order to model the signal offset correctly. *SCATS Events Files* may be used to estimate the alternative phases, which can also be estimated based on the turning volumes and site observations.

5.4.2.2 Vehicle Actuated Signals

In contrast to fixed-time signal control, vehicle actuated signals adapt to traffic arriving at the intersection. The adaptive approach is recommended when there is significant variation in phase time or phase sequence throughout the assessment period. For example, intersections with complex signal phasings (e.g. diamond or double diamond), level crossings or bus priority operations. The adaptive approach is also recommended when there may be a significant change in traffic flows within the assessment period (e.g. events or incidents), in which actuated signals can appropriately respond.

The set-up and operation of vehicle actuated signals should follow SCATS operations so that alternative phasing is considered based on the actuation algorithm. The replication of the actuated signal operations should include signal offsets and alternative phases at a maximum of one-hour intervals.

It should be noted that since the signals are more dynamic, the modelled phase times might differ from the observed average times. As such, the modelled signals must be validated against the observed times. The criteria for this are detailed in Section 5.10.

When considering the merits of fixed-time or actuated signal adoption, fixed-time signals are simple to implement in the base case but additional modelling effort may be required in the option models in order to ensure the traffic signals are appropriate for the future traffic conditions. Actuated signal adoption may require more detailed coding effort in the base case but can be more effective in adapting to future traffic conditions, so the adoption of actuated signals may be less resource intensive and also provide more realistic outputs. These factors must be taken into consideration in order to appropriately resource and manage a modelling project, especially projects which involve numerous signalised intersections.

5.4.2.3 SCATSIM Interface

SCATSIM is an interface that allows the traffic modelling software to communicate with the SCATS system. Depending on the software package, it can be implemented in mesoscopic and hybrid modelling. The use of SCATSIM, subject to model purpose, is recommended for hybrid models where the operation of the signals are a concern.

The coding of signalised intersections as SCATSIM-controlled allows realistic replication of the network conditions and is an efficient way to transfer information. The implementation of the SCATSIM interface to develop the model requires the modelled signal timings to be validated against the average observed time over a specific time period.

Fixed-time or vehicle actuated signal operations with offsets, in accordance with SCATS are recommended for mesoscopic and hybrid models. A combination of signal control types can also be considered in a model.

5.4.2.4 Additional Storage Capacity

Many intersections within Western Australia may have additional storage capacity. For example, drivers will queue within an intersection in order to find an acceptable gap to turn right at signalised intersections with filtered right-turn phases. The vehicles that are queued within the intersection would discharge during the interphase time and therefore increases the capacity of the intersection.

By default, mesoscopic models do not replicate this behaviour and the intersection will be modelled with a reduced capacity. Depending on the software package, there are various methods which can be used to replicate the increase in capacity at the intersection due to the additional storage capacity including:

- adding internal links within the node;
- calibrating mesoscopic gap acceptance parameters;
- adjusting the signal phase times; or
- adjusting the location of the stop line for filtered right-turn (only applicable in microsimulation).

5.4.3 Priority Intersections and Roundabouts

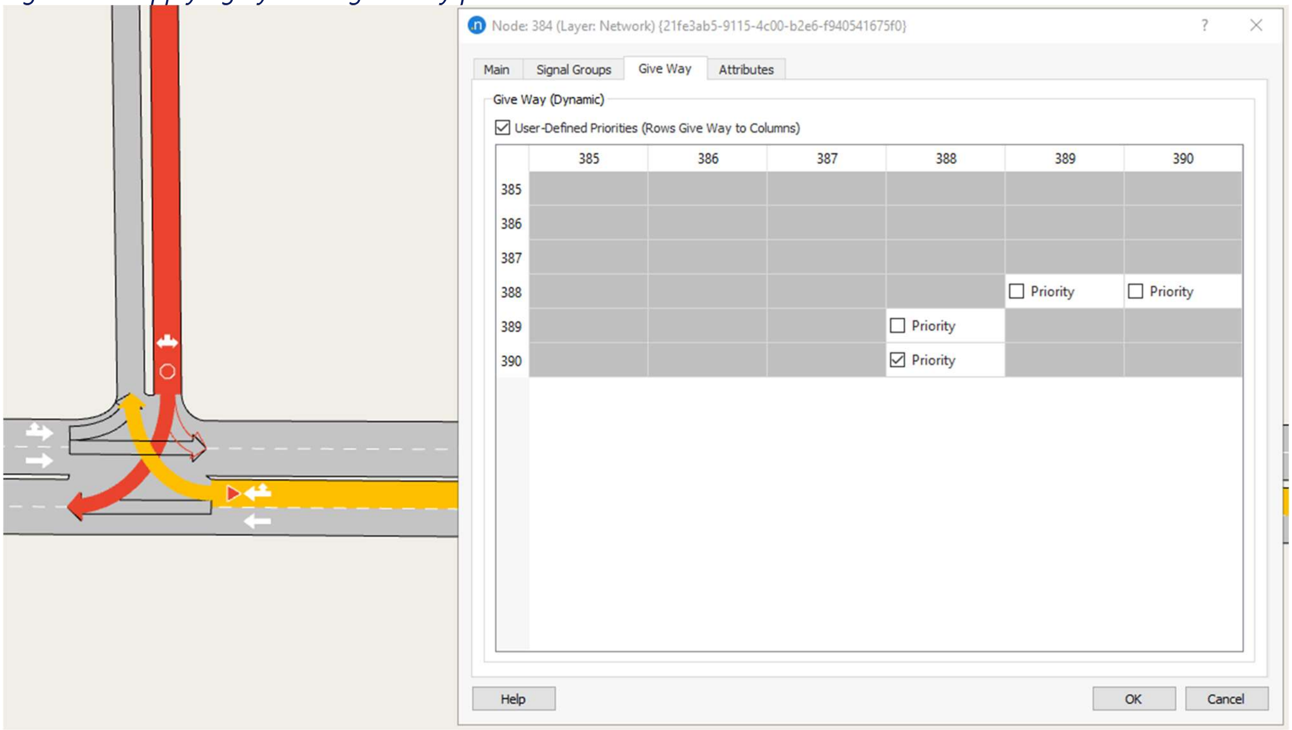
5.4.3.1 Priority Rules

There are two priority intersection types: give-way controlled and stop controlled. The priorities of the movements need to be correctly set up. Unless observed otherwise, it is essential for modellers use the correct control type:

- give-way warning for give-way controlled intersections; and
- stop warning for stop controlled intersections.

Depending on the selected software, the priority rules may have to be defined once the control type has been defined. For example, as shown in Figure 5-4, Aimsun Next can automatically assign the relative priority between turns with a give-way or stop sign, depending on the road rules. User-defined priority rules should be assigned at priority intersections to ensure that vehicles are yielding appropriately at the intersections.

Figure 5-4: Applying dynamic give-way priorities in Aimsun Next



5.4.3.2 Driver Behaviour at Priority Intersections

In mesoscopic simulation models, all priority intersections may produce similar yielding behaviour in front of the stop line.

Depending on the software package, the default mesoscopic parameters may not correlate with the actual behaviours (or those replicated in microsimulation) in terms of site characteristics, vehicle acceleration and deceleration, or sight distance. As such, calibration of the turn parameters may be required to simulate the observed behaviour, which may include the adjustment of reaction time, gap acceptance or turning speed.

Figure 5-5 illustrates the capacity reduction from minor roads based on conflicting movements in Aimsun Next and Figure 5-6 illustrates how a critical gap can alter the turning capacity in Visum.

Figure 5-5: Minor road capacity and conflicted flows with default parameters (source: L. Oriol, 2018)

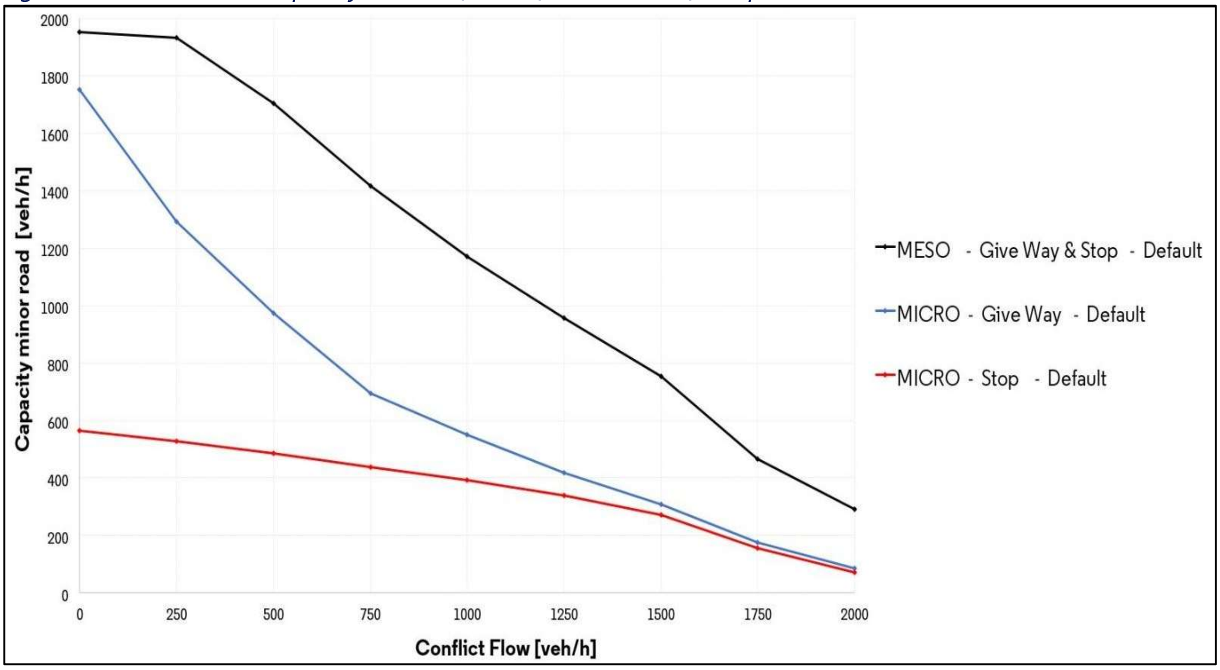
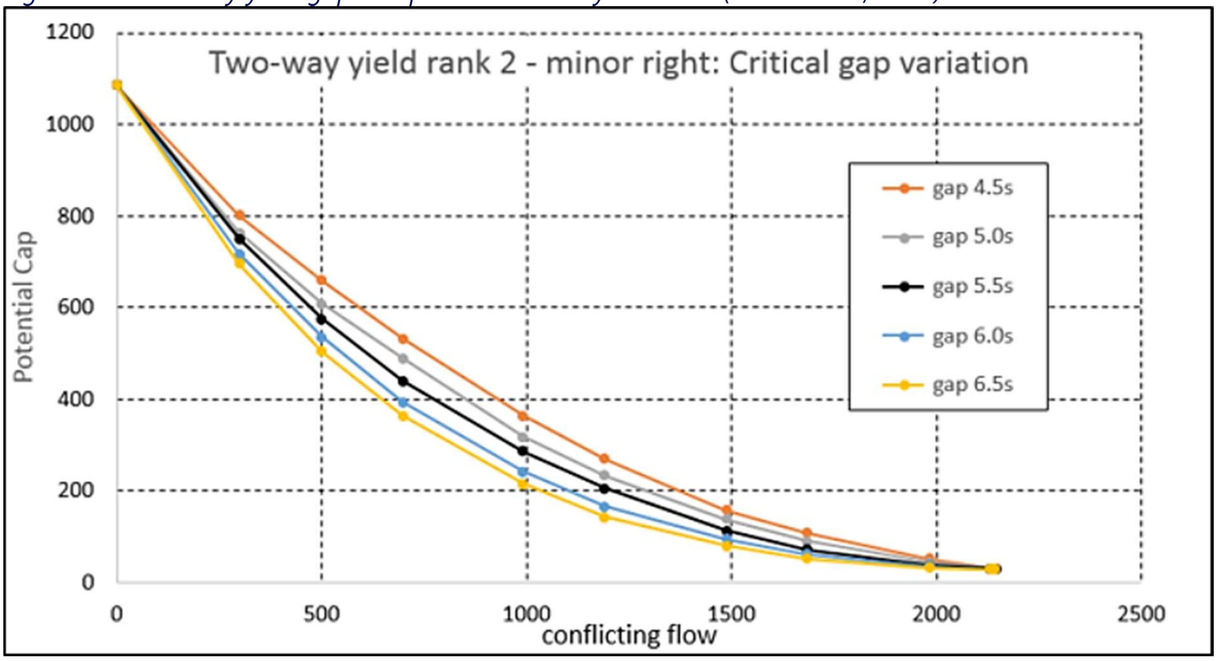


Figure 5-6: Two-way yield gap acceptance sensitivity in Visum (source: PTV, 2020)



The number of conflicting movements can also affect the capacity from the priority approach and the modeller needs to ensure that the conflicting movements are clearly defined. This also includes the consideration of staged right-turn movements.

5.4.4 Ramp Metering

Ramp metering operations improve freeway efficiency by regulating flows onto the freeway on-ramps. Depending on the purpose of the study, there are several methods of modelling ramp metering.

5.4.4.1 Fixed-Time Metering

Fixed-time metering control is a simplified method which simulates the operation of the ramps using observed ramp metering data. As timings may vary considerably throughout the modelled period, the replication of fixed-times requires ramp metering times to be averaged over a specific period no greater than one-hour.

Generally, the modelled ramp metering times must be validated against the observed on-ramp and freeway operations. Main Roads will confirm if this is required, based on the purpose of the project.

5.4.4.2 Isolated Ramp Metering

Isolated ramp metering independently controls the entry ramp based on the performance of the freeway. Asservissement Linéaire d'Entrée Autoroutière (ALINEA) is widely adopted to simulate a closed-loop system in order to improve the efficiency of the freeway. It does this by controlling the on-ramp flows, based on the desired mainline downstream occupancy rate. The risk of using the closed-loop system is that queues cannot be managed on the adjacent on-ramps to minimise delays to the network and a gridlock may be created. The ramp metering flow rate for time interval $(t,(t-1))$ is based on the following formula:

Equation 1 ALINEA formula (source: Papageorgiou et al., 1997)

$$q(t) = q(t-1) + K_r\left(\rho_{target} - \rho_{out}(t-1)\right)$$

Where:

q is the metering ramp flow rate
K_r is the regulator parameter
ρ_{target} is the target occupancy rate on the mainline
ρ_{out} is the measured occupancy rate on the mainline

5.4.4.3 Coordinated Ramp Metering

Heuristic ramp-metering coordination (HERO) is widely adopted to coordinate ramp meters. The HERO algorithm is an extended version of ALINEA, with feedback systems that coordinate and control local ramp meters under specific conditions. The ramps operate under ALINEA conditions until a ramp begins to fail under specified criteria, which activates HERO. The failing ramp becomes the master ramp to adjacent upstream ramps that operate as slaves by using storage capacities in order to reduce the flows along the mainline. The reduction in flows on the mainline continue until the master ramp traffic conditions have been met and HERO is deactivated.

Certain software packages provide an interface to connect with Transmax's STREAMS ITS platform. This provides the most realistic replication of the ramp metering conditions but, as it can only be simulated in real-time, this method will not provide results as efficiently as the other methods outlined in this section.

Fixed-time ramp metering is appropriate for mesoscopic models in order to replicate delays on the on-ramps. Isolated or coordinated ramp metering may be used in hybrid models with microscopic pockets that capture the on-ramps.

5.4.5 Level Crossings

As outlined in Section 4.1.8.2, the majority of rail level crossings within the Perth metropolitan area use boom gate barriers, which may operate with SCATS when the adjacent upstream or downstream intersection is signalised. If the barriers operate with SCATS signals, the level crossing can be replicated in a similar manner to traffic signals, as outlined in Section 5.4.2, but the level of detail will depend on the crossing type and model purpose.

At all level crossing controls except boom gate barriers, gap acceptance parameters may differ from standard traffic intersections and the modeller may consider adjustments of the parameters in order to validate the model.

5.4.6 Other Considerations

5.4.6.1 Stop Line Flows

The simplified car-following algorithm used in mesoscopic models may result in an overestimation of intersection capacity. Where required, the modeller should adjust the global or local parameters in order to offset the overestimation. The parameters that can be adjusted may vary between software packages but it may include reaction time, gap acceptance factor, jam density and the standstill distance. Within the microscopic core area of a hybrid model, the calibration of saturation flows may be required in order to ensure that the traffic throughput is realistically captured in the model.

5.4.6.2 Lane Utilisation

Lane utilisation can significantly impact network capacity and network operation in a congested study area and should be calibrated against observed site conditions. A key parameter affecting lane utilisation is the upstream distance at which a driver will need to be in the correct lane to make the turn.

5.4.6.3 Additional Delays

The modeller should take into consideration intersections with high pedestrian or cyclist movements. This is discussed in detail under Active Transport in Section 5.6.

5.5 Public Transport

The impact of public transport services on the performance of a transport network may be significant and it is therefore necessary to include them in any traffic model. This is particularly relevant for models that are used for strategic appraisals, such as a mesoscopic model or hybrid models. The inclusion of public transport services in the model depends on:

- the level of detail of the traffic model;
- the level to which public transport services affect the network performance; and
- the model purpose.

In general, public transport services should be coded as a public transport line based on the information obtained from Transperth, including routes, stop locations and timetables. Alternatively, public transport services can be incorporated into the model as a separate heavy vehicle demand matrix.

Aerial photography and site observations should be used to define public transport infrastructure, such as bus lanes or bus stops. Bus dwell times also need to be included in the model and the bus dwell time assumptions shown in Table 5-4 may be used as a starting point, depending on the purpose of the model and the study area.

Table 5-4: Bus dwell time assumption

Parameter	Suggested Starting Values
Mean	10-20 seconds
Deviation	5 seconds

In most cases, a bus dwell time of 10 seconds is sufficient, however, dwell times may be higher within the CBD and other locations such as schools, high-density dwellings, universities and bus stations where there are more passengers. On-site observations of dwell time should be used to help refine the dwell time assumptions.

5.6 Active Transport

Active transport activity and pedestrians are generally not modelled in detail within mesoscopic models. Given the desire to appropriately account for multiple modal transport systems in traffic models at the strategic planning stage, there have been efforts to incorporate active transport and pedestrians within mesoscopic models, underpinned by the improvement in such capabilities in some modelling packages.

There are several methods to capture active transport and it is subject to the model purpose and the impacts to the road network.

5.6.1 Pedestrians

Pedestrian facilities are provided to assist pedestrians in safely crossing the carriageway and pedestrian crossings can be standalone or incorporated within intersections. To ensure a level of realism in mesoscopic models, pedestrians should be accounted for if it causes additional delays to the vehicle movements. These additional delays from pedestrians can be at signalised intersections, priority intersections and mid-block crossings.

While modelling of individual pedestrians is generally not required in mesoscopic models, the impact of pedestrians on the road network performance should be captured in the model.

5.6.1.1 Pedestrians at Signalised Intersections

Signalised intersections are one of the key locations where pedestrians and vehicles interact. Pedestrian use of these facilities can have significant impacts on network capacity, affecting left, right and (in the case of shared lanes) through movements on some approaches. There are several reasons why this may occur, including:

- pedestrians crossing during a traffic phase (with or without full pedestrian protection) have priority over left or right turning traffic and reduce the capacity of those movements by blocking the exit for a portion of the allocated green time (this is particularly significant for left-turning traffic);
- a dedicated pedestrian phase is provided in the signal plan (e.g. CBD or level crossing); or

- traffic phase durations are altered when pedestrian phases are activated due to the need for longer clearance times.

The impact of pedestrian crossings should be analysed with SCATS signal data, except at locations without full pedestrian protection, as this data does not take into consideration the additional delays due to vehicles yielding to pedestrians. In this case, the pedestrian call frequency, pedestrian flow and crossing time should be reviewed in order to estimate the impact on yielding vehicles. Alternatively, local knowledge or site visit observations could be used, with all assumptions stipulated in the *Base Calibration and Validation Report*. Appendix A of Main Roads' *Operational Modelling Guidelines* can be referred to for further guidance on pedestrian impacts at signalised intersections.

5.6.1.2 Pedestrians at Mid-Block Signal Crossings

Pedestrian movements at a mid-block signalised crossing may significantly affect road network operations. The modeller should analyse SCATS signal data in order to estimate pedestrian operations during the peak period. Once that has been determined, traffic signals or other means to periodically stop vehicles should be used to simulate pedestrian-related delays.

5.6.1.3 Pedestrians at Zebra Crossings

The modeller should assess locations where zebra or school crossings are likely to have a significant impact on vehicle delay or where they are likely to discourage drivers from using a route. The level of delay observed on-site should be replicated in the modelling by coding a set of dummy signals or traffic management plans.

5.6.1.4 Detailed Pedestrian Crossing Operation

A hybrid model should be considered if the pedestrian and vehicle interaction is complex and requires detailed modelling. Subject to software capabilities, the microsimulation pocket may have a built-in pedestrian simulator to explicitly code pedestrian movements on sidewalks, pedestrian crossings, and boarding and alighting movements at public transport stops.

5.6.2 Cyclists

Cyclists can be an important consideration in the traffic model, as vehicle behaviour may be impacted. The level of impact will vary depending on how the different modes interact on the road network. In general, cyclists do not need to be explicitly replicated in the mesoscopic or hybrid model, but the impacts should be considered if they are significant.

5.7 Demand Development

The development of the traffic demands for mesoscopic and hybrid models are comparable to microscopic models and include the following four steps:

1. Determine the model period (temporal coverage).
2. Determine the vehicle types.
3. Develop the travel zoning structure.
4. Estimate the traffic demand/matrix.

5.7.1 Model Period

The defined model periods need to be sufficient to address the model purpose. This is particularly important for highly congested study areas where the modeller should also consider the likely future traffic conditions, such as peak spreading.

The time periods need to cover the full extent of the peak hour(s) as the analysis period, as well as the warm-up and cool-down periods. The warm-up period is the time that it takes for the traffic demands and queues to reach a realistic level of congestion in order to reflect conditions observed on-site before the analysis period. The cool-down period is included to replicate the traffic state following the analysis period in order to demonstrate that the traffic can appropriately discharge from the road network following of the analysis period.

The duration and intensity of the warm-up and cool-down periods should be sufficient to reflect the observed traffic conditions so that the traffic volumes and queues in the network can be accurately modelled. The model period duration must be stipulated in the *Methodology Report* to be agreed by Main Roads.

It is recommended that the warm-up and cool-down periods are based on the longest travel time route within the model or 30-minutes (whichever is greater). The warm-up period should align with the observed demand profile.

5.7.2 Vehicle Types

In Western Australia, vehicle classifications are defined using the Austroads Vehicle Classification System. The model must include vehicle classes that are critical to the performance of the network or appropriate to achieve the model purpose. Vehicle classification should be aggregated to streamline the modelling process and the recommended vehicle types are shown in Table 5-5. Disaggregation of heavy vehicle groups should be considered if it suits the model purpose, particularly where heavy vehicles:

- must be included in order to achieve the model purpose;
- demands are high (greater than 10 per cent); or
- have significant impact on the network operation.

Table 5-5: Vehicle type consideration

Groups	Details of Group(s)	Austroads Class	Modelling Application
1	Light Vehicle	1	Minimum requirement
2	Rigid Vehicle Articulated Vehicle	2-5 6-12	Recommended requirement
3	Public Transport Buses	-	Normally required with fixed routes and dwell times Refer to Section 3.5.7
4	Cyclists	-	Required if impact on road is evident Refer to Section 3.5.8
5	Pedestrian	-	Required if impact on road is evident Refer to Section 3.5.8

Main Roads recommends grouping the vehicle classifications in order to simplify the modelling process and minimise modelling errors. The vehicle type parameters for Aimsun Next and Vissim are to be based on Main Roads' *Operational Modelling Guidelines*.

5.7.3 Demand Development Methodology

5.7.3.1 Initial Matrix (Prior Matrix or Seed Matrix)

As stated in Section 3.6, Main Roads recommends an integrated three-tiered modelling approach is taken by using sub-area O–D matrices extracted from the overarching strategic model (Tier 1) and using these as the initial matrices for mesoscopic or hybrid model development (Tier 2). If an overarching strategic model is not available, O–D surveys can be used to develop the initial matrices. The overall adjustment process will follow a similar process regardless of the source of the initial matrices.

5.7.3.2 Zone Disaggregation

The zonal structure derived from strategic models are coarse in nature and will likely require disaggregation into smaller zones in order to enable a detailed coverage of demand loading points across the network. Depending on the model purpose, there are two approaches to disaggregate zone that can be used:

1. zones can be disaggregated within ROM24 as part of the Tier 1 procedure outlined in Section 3.6; or
2. coarse zone structure can be extracted from ROM24 and the modeller is responsible for the disaggregation procedure.

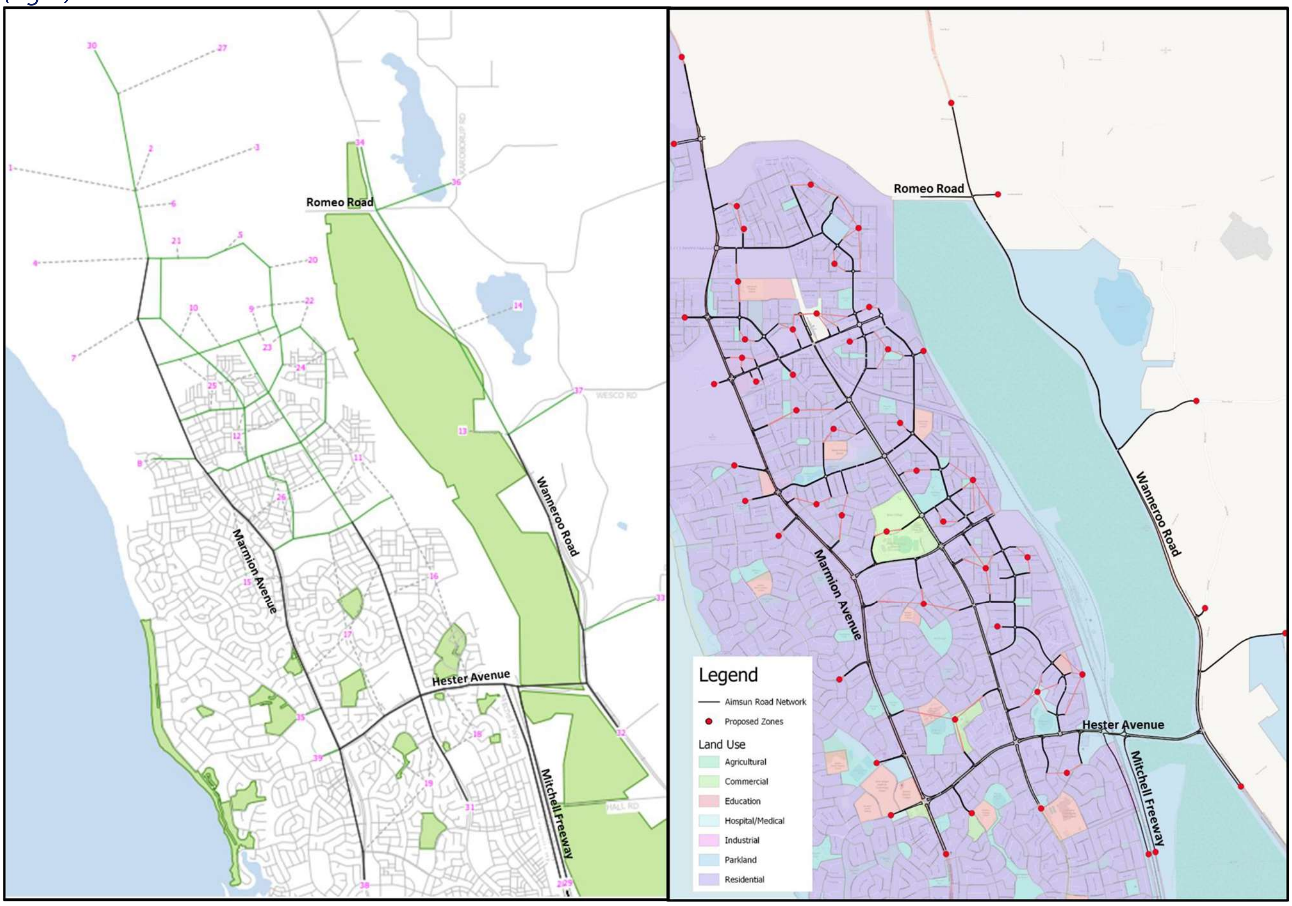
Where the modeller is responsible for the disaggregation procedure, care must be taken to maintain the linkage between the strategic and mesoscopic model. The disaggregation procedure should closely reflect the strategic zonal structure by considering:

- model purpose, which may include finer disaggregation around the core area;

- appropriate vehicle loading locations (e.g. local streets, park accesses, taxi ranks or other access points), following the review of existing connectors applied in the strategic model and avoiding linking connectors directly at intersections;
- study area boundaries and the available access points for external trips;
- surrounding road network and level of existing connectivity required to access the various local areas;
- number and locations of existing connectors applied in the strategic model;
- statistical boundaries from the Australian Bureau of Statistics (ABS) or Australian Statistical Geography Standard (ASGS);
- broader land-use categories such as residential, employment, shopping, recreational facilities and education (i.e. homogenous land-use and special generators);
- total generated and attracted trips per zone from the strategic model; and
- land reservation for future development is reflected in the model based on the available information.

Figure 5-7 illustrates the ROM24 zone structure (at left) and the application of land-use information and the considerations for disaggregating the zones (at right). Land-use mesh block data (obtained from the Australian Bureau of Statistics) can be used to broadly identify land-uses such as residential, commercial etc.

Figure 5-7: Zonal disaggregation with land-use information – ROM24 zones (left) and disaggregated zones (right)



5.7.3.3 Matrix Adjustment

The adjustment of the initial traffic demand matrices obtained from the strategic model may need to undergo several iterative steps in order to align the traffic demands to the existing traffic conditions. The modeller must detail the matrix adjustment methodology in the *Base Calibration and Validation Report*.

5.7.3.3.1 Matrix Furness Method

The initial matrices may need to be adjusted using the furness method in order to reflect the collected survey data. The furness method of matrix adjustment is an iterative process used to derive matrices that result in the best match to trip end count data. Trip end totals for each zone should be formed from external link survey data, internal link survey data and other filler zones with the values based on surveys, surrounding land-use or the number of individual households. Within this, individual O–D pairs should be fixed to known survey values or established during the calibration process.

5.7.3.3.2 O–D Matrix Adjustment with Software Packages

Most software packages have a built-in matrix adjustment tool that uses available traffic count data, commonly from mid-blocks, turns, detectors or screenlines. The adjustment tool may be based on STA or DTA, and the model should be reviewed in order to minimise errors during the matrix adjustment process. Before commencing the matrix adjustment process, route choice between O–D pairs also need to be reviewed in order to ensure that the calculated paths are reasonable.

The adjustment tool may also provide settings to guide and limit the adjustment of the matrix, which is recommended so that the travel patterns from the initial matrices are upheld. Depending on the software package, the matrix adjustment tool may include the following parameters:

- *Maximum number of iterations* to run the built-in adjustment algorithm to match the observed traffic count data.
- *Matrix elasticity* is a value that indicates the elasticity of the adjusted matrix in respect to the original matrix.
- *Maximum correction* per O–D pair should be set-up for matrix adjustment. Tests should be carried out to compare different scenarios using different maximum correction permitted values. The scenario which achieves the required calibration results without significant change to the general composition of the initial matrix should be applied.
- *Estimated number of total trips,* if known, can assist the adjustment process by ensuring that the adjusted total trips are comparable to the initial total trips.

5.7.3.3.3 Manual O–D Matrix Adjustments

The modeller may need to make manual refinements to the demand matrices when the other options have been exhausted in order to finalise the demand estimation process. The modeller must document significant changes to the demand matrix made through the manual adjustment process in the *Base Calibration and Validation Report*.

5.7.3.4 Heavy Vehicle Demand Matrices

While heavy vehicles account for a small percentage of the total traffic, they can significantly affect the performance of a road network due to less favourable behaviours such as acceleration and deceleration profiles, speed acceptance, gap acceptance, clearance and maximum speed. The modelled extents can cover a large and complex network that may consist of various land-uses. This may result in a significant number of heavy vehicles needing to travel from concentrated industrial areas and only being able to travel via specific sections of the road network. To ensure that all vehicles types are considered, the modeller should analyse traffic data for each vehicle type (as outlined in Section 5.7.2) and consider the heavy vehicle groups that need to be reflected in the model.

There are several methods to estimate the heavy vehicle demand matrices in the modelled network. A common approach is to split the demand into appropriate vehicle groups (as outlined in Section 5.7.2) after the matrix adjustment process has been undertaken, since the process is commonly based on total trips. Alternatively, light commercial vehicle (LCV) and heavy commercial vehicle (HCV) matrices can be obtained from the strategic model and used as the initial matrices for when adjusting the matrices for each vehicle group.

Estimation of heavy vehicle demand matrices should consider:

- flows through the network and around trip end zones;
- demand profile;
- land-use; and
- initial HCV seed matrix from the strategic model.

The adopted method will depend on the model purpose and the availability of commercial vehicle matrices. The methodology must be detailed in the *Methodology Report* and *Base Calibration and Validation Report*.

5.7.3.5 Demand Profile

The level of granularity in the modelled demand profile will depend on the model purpose and the surrounding land-use. Adjusted hourly demand matrices profiled into 15-minute intervals for each vehicle group are commonly adopted for mesoscopic and hybrid models. Although there are benefits in reducing the hourly demand profile for higher resolution outputs, it may not provide noticeable value for the analysis.

5.7.3.6 Post-Adjustment Matrix Check

The modeller should review the post-adjusted O–D demand in order to ensure that the adjustment process did not distort the initial matrices to achieve the key calibration and validation criteria. The adjustment process outlined in this section may:

- disproportionally increase/decrease the total trip length distribution (e.g. disproportionally large number of shorter trips, compared to the corresponding distribution from an overarching strategic model);
- produce unrealistic trip ends at certain zones (e.g. disproportionally lower traffic from an established residential area in peak hour); or
- produce unrealistic travel patterns, trip generation or attraction numbers based on the existing land-use information (e.g. disproportionally high traffic movements between two employment zones in peak hour).

The criteria to check the robustness of the post-adjustment matrix is outlined in Section 5.10.3.

5.8 Traffic Management

Traffic management strategies can be applied in mesoscopic or hybrid models in order to replicate existing conditions or to assess specific traffic management measures. Common application of traffic management strategies include the examples shown in Table 5-6.

Table 5-6: Traffic management actions and examples

Traffic Management Actions	Example Application
Lane Closure	On-street parking and clearways
Turn Closure	Time-dependent right turn bans
Turn Cooperation Model Activation	Turn priority change
Speed Change	School zones, variable speed limit signs
Incident	Blocks lane(s) to replicate traffic delays caused by an incident on the road
Periodic Section Incident	A time-based section incident
Deactivation of a Reserved Lane	Makes reserved lane accessible to all vehicle types (e.g. parking restriction changes at certain point of the simulation)

5.9 Scenario Set-Up

5.9.1 Scenario Management

It is recommended that modellers maintain consistency in global network settings between scenarios (e.g. AM and PM peaks). The order, naming and descriptions of each scenario should be in sequence and easily understood by other users.

5.9.2 Seed Number

There is variability in traffic conditions as a result of random driver behaviour and different daily events. Simulation-based models attempt to replicate this random variability by altering individual driver decisions based on random seed numbers. This results in greater instability than in analytical models, even though the modelled inputs remain consistent. The variability may be the result of different network loading timing, public transport schedules or dwell times, traffic management or vehicle behaviour from different seed numbers.

The stability of a model improves with the implementation of an equilibrium assignment because of the iterative process to calculate the minimum experienced travel time for every time departure and O–D pair to reach a user-defined equilibrium. It is recommended that a minimum of five random seed numbers are used in order to demonstrate the stability of the model. Further guidance on analysing the network statistics is outlined in Section 5.10.9. The number of random seeds may need to be increased if the model demonstrates high variability.

The modelled results should be extracted from either an average of five seed runs or a single seed run representative of the median results (e.g. the seed with the median vehicle hours travelled statistics). It should be noted that the median seed needs to be determined for each scenario. All calibration and validation outputs must be drawn from a consistent approach.

Main Roads recommends using the average of the five seeds with different random seed numbers to present the modelled outputs. The modeller must choose the random seed numbers, which must remain consistent across all scenarios, and list the numbers in the *Base Calibration and Validation Report*.

5.9.3 Assignment Convergence

Dynamic equilibrium assignment is an iterative process used to calculate the minimum travel time for every time departure and O–D pair to reach a user-defined equilibrium. The equilibrium convergence is based on pre-specified criteria in order to allow the model to reach equilibrium within a reasonable timeframe. The equilibrium algorithm varies in each software package or assignment type. The recommended convergence criteria for Main Roads' supported software packages are outlined in Section 7.

The following parameters are the common convergence settings:

- *Maximum iterations* is the maximum number of iterations before the assignment stops, regardless of reaching the other stopping criteria.
- *Relative Gap* (%) is based on travel time and expressed as a percentage. This metric compares the current travel time against the shortest times for each O–D pair and departure times. The relative gap will approach zero when all routes achieve travel times closest to the shortest times.

5.10 Model Calibration and Validation

Model calibration and validation is an iterative procedure to refine the model and analyse the modelled outputs until the model has achieved an acceptable level of confidence in comparison to the existing traffic conditions. This section describes the calibration and validation requirements of mesoscopic and hybrid modelling for varying purposes and scales.

Model calibration describes a wide range of adjustments that can be made to model coding, parameters and demand in order to assist in the development of an accurate representation of on-street conditions. Model validation describes the independent verification process that confirms that a model has been calibrated to a sufficient extent to accurately represent on-street conditions.

If the validation process indicates that the model is not yet at a sufficient level of accuracy, the specific areas of concern should be identified and analysed. The model returns to the calibration stage so that the relevant parameters can be adjusted in order to address the issues. The calibration and validation processes are part of an iterative cycle that continues until the validation can confirm that the model has reached an acceptable level of accuracy.

A comparison of each of the hourly-observed datasets against hourly-modelled outputs should then be presented in the calibration and validation section of the *Base Calibration and Validation Report*. Further information on reporting requirements is outlined in Section 3.8.4.2.

Model calibration and validation is an iterative procedure to provide an acceptable level of confidence in a model in comparison to the on-street conditions fitting the project purpose. The *Base Calibration and Validation Report* must include a section for the model calibration and validation outcomes.

5.10.1 Verification

Verification is a process within the calibration and validation stage whereby the model undergoes internal peer review in order to ensure that the model has been developed without critical errors. Errors in the modelled network can affect the calibration and validation process as modellers are able to adjust model parameters to replicate on-site conditions.

5.10.2 Route Choice Review

The main purpose of route choice calibration is to ensure that the modelled route choices are logical and will not contribute to the overestimation or underestimation of road congestion within the modelled network. A review of the route choice should be undertaken during the calibration stage and route choice-related parameters may need to be adjusted in order to minimise unrealistic route choices in the network. A series of route choice techniques are available, including but not limited to:

- comparing the paths between major O–D pairs at different time intervals of the model period and reviewing whether they are reasonable choices;
- ensuring the vehicles do not favour long-distance routes, even though there may be travel time savings when compared to a much shorter but congested route (i.e. the weighting of the "travel distance" in the generalised cost for the route choice selection should be reviewed);
- ensuring that the localised traffic management in the model does not result in unrealistic route choice (e.g. school speed zones will unlikely to deter the school trips using alternative routes); and
- investigating the route choice within the core areas as part of the overall model calibration.

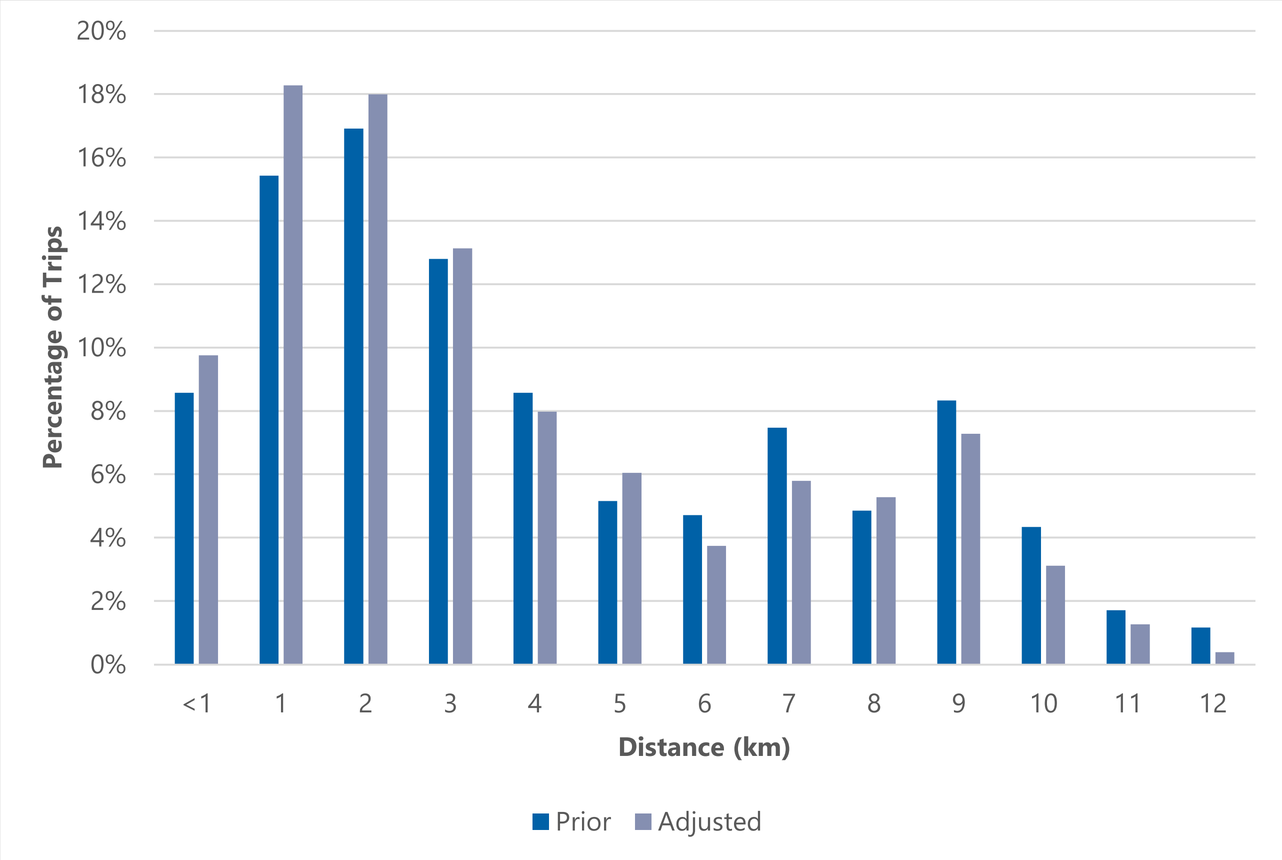
5.10.3 Demand Matrix Comparison

As outlined in Section 5.7.3.6, it is recommended that a review of the post-adjusted O–D demand matrices is carried out once the adjustment process has been completed, in order to ensure that the adjustment process has not significantly altered the prior matrices to achieve the model calibration and validation criteria. The modeller should conduct logic checks on the prior matrices against adjusted matrices by comparing trip length distribution and total trip end volumes.

5.10.3.1 Trip Length Distribution

A comparison of the trip length distribution will confirm that the O–D adjustment process has not favoured shorter trips or significantly changed the travel patterns. Figure 5-8 shows how trip length distribution can be analysed.

Figure 5-8: Example of trip length distribution comparison

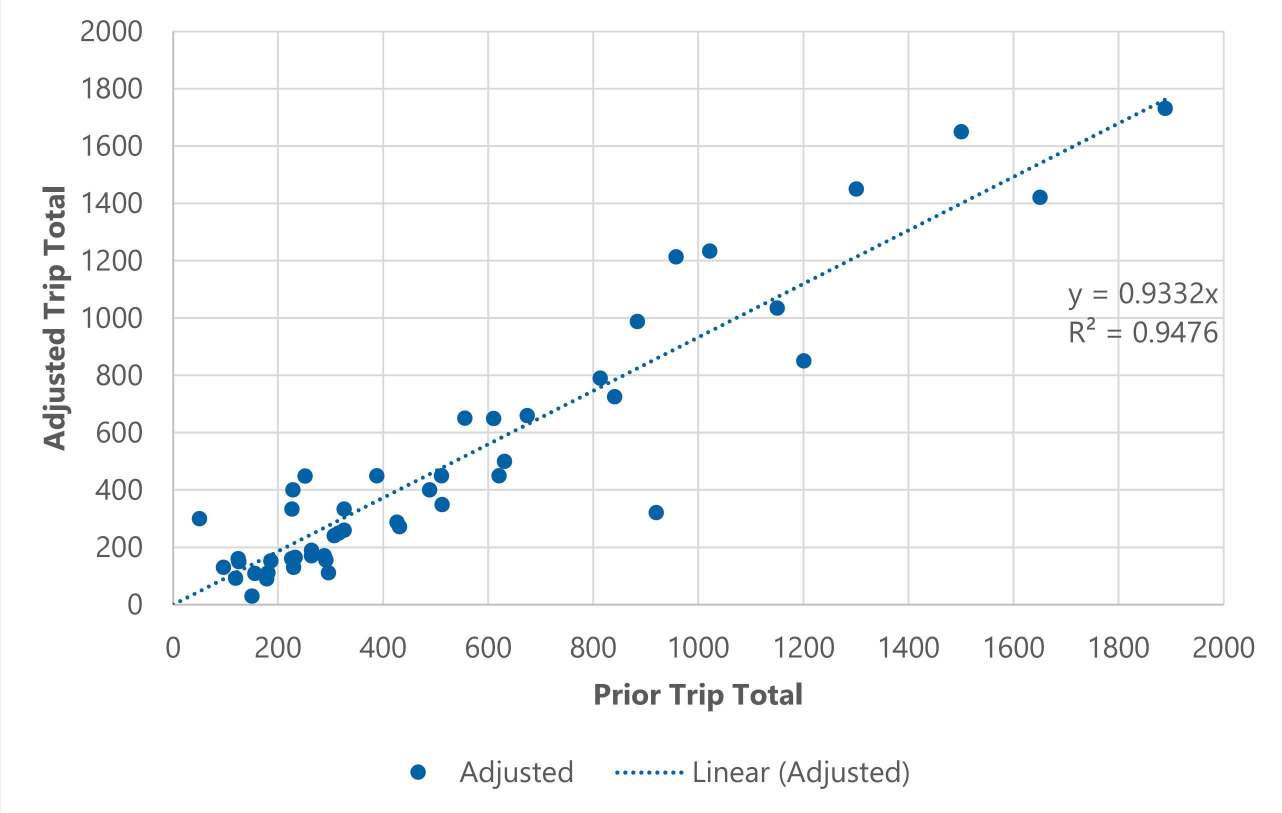


The trip length distribution graph should illustrate comparable trip lengths between the prior and post-adjusted demand matrices. Any trip changes greater than five per cent from the prior matrix should be justified in the *Base Calibration and Validation Report*.

5.10.3.2 Matrix Trip End Volumes

It is recommended that a comparison of the O–D trip end volumes between the prior and post-adjusted matrices is carried out in order to review the differences. A perfect correlation between the prior and post adjusted matrices may be difficult to obtain, as the prior matrices are commonly based on the coarse strategic model zone structure. Justification of any significant trip changes must be stipulated in the *Base Calibration and Validation Report*. Figure 5-9 provides an example of the trip end total analysis.

Figure 5-9: Example of origin trip total comparison



The trip end total comparison should achieve a coefficient of determination (R^2) of 0.85 or higher and a slope of linear relationship between 0.95 and 1.05. Any significant trip changes must be stipulated in the *Base Calibration and Validation Report* so that any changes can be accounted for in the future year demand estimation process.

5.10.4 Traffic Volumes

The comparison of observed and modelled traffic volume is commonly undertaken as part of the model calibration process. Depending on the model purpose, volume comparison by each vehicle type may be required using the criteria guidance detailed in this section.

As outlined in Section 3.3.2, the model can be divided into the core and peripheral areas, with the core being the focal point of the study. As the core area is subject to more stringent criteria and it must be separately analysed and reported.

The comparison of volume can be achieved individually and at screenline levels. A model screenline is defined as an imaginary line in the network that intersects one or more road links. The screenline analysis compares the summed observed and modelled flows at a directional or bidirectional level. Main Roads recommends the use of directional link screenlines on larger sub-regional models across key travel directions through the study area.

5.10.4.1 Individual Traffic Volume Comparison

The GEH statistic is a formula based on the chi-squared statistical measure used to determine how well a modelled dataset fits an observed dataset. The GEH statistic is more tolerant of errors associated with low values, making it more applicable to datasets with a large range of values, such as those traffic flows on arterial roads in a sub-regional or urban area mesoscopic model. The following formula is used to calculate GEH based on hourly volumes:

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

Where:

M is the modelled volume

O is the observed volume

The GEH criteria for individual turn and link volumes (the total network and core area) and screenlines across the three model categories is shown in Table 5-7. The criteria under *total network area* is the default criteria. Additional and more stringent GEH criteria are required when a core area has been defined based on the model purpose. Directional link count screenline criteria are only applicable to larger Category 3 models.

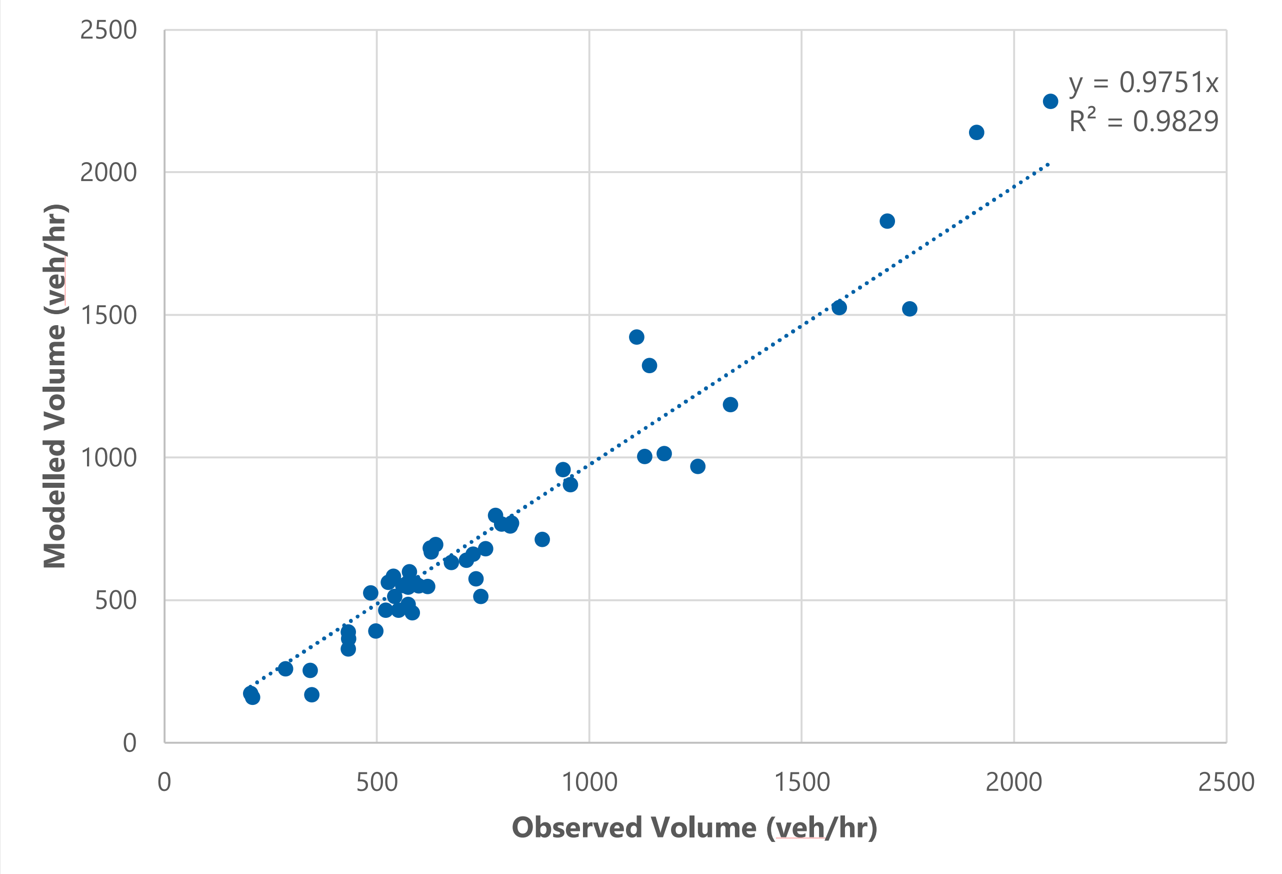
Table 5-7: GEH and banded volumes criteria

Comparison	Category 1	Category 2	Category 3
Individual Link and Turn Volume (% of Counts) – Total Network Area			
GEH <5	> 85%	> 82.5%	> 80%
GEH <10	> 95%	> 92.5%	> 90%
<700vph within 100vph	> 90%	> 85%	> 80%
700vph-2,700vph within 15%	> 90%	> 85%	> 80%
>2,700vph within 400vph	> 90%	> 85%	> 80%
Individual Link and Turn Volume (% of Counts) – Core Area			
GEH <5	> 90%	> 87.5%	> 85%
GEH <10	> 97.5%	> 97.5%	> 95%
Directional Link Count Across Screenlines (% of Screenlines)			
GEH <5	-	-	> 80%
GEH <10	-	-	> 90%

The individual hourly traffic volume comparison should also be plotted in order to determine the strength of the relationship between the observed and modelled datasets. As illustrated in Figure 5-10, the individually observed and modelled hourly volumes must be shown on a scatter plot and the following statistical measures must be included in the plot:

- observed data on the x-axis and modelled data on the y-axis;
- coefficient of determination (R^2); and
- slope from the linear line of best-fit, where y-intercepts with zero.

Figure 5-10: Example of scatter plot



The outcomes of the scatter plot analysis must meet the criteria for the three model categories shown in Table 5-8.

Table 5-8: XY scatter plot criteria

Comparison	Category 1	Category 2	Category 3
Coefficient of Determination (R^2)	> 0.95	> 0.925	> 0.90
Slope	0.95-1.05	0.925-1.075	0.90-1.10

5.10.4.2 Total Traffic Volume Comparison

The root mean square error (RMSE) provides an indication of the level of prediction error in a model. RMSE aggregates the magnitude of errors and is expressed as a single value in order to demonstrate the concentration of data around the line of best-fit. The percentage RMSE formula is defined as:

$$\% \, RMSE = \frac{\sqrt{\frac{\sum(O-M)^2}{c-1}}}{\frac{\sum O}{c}} \times 100$$

Where:

O is the observed flow in vehicles per hour
M is the modelled flow in vehicles per hour
c is the number of count locations in the set

The RMSE criteria for the three model categories are shown in Table 5-9.

Table 5-9: RMSE criteria

Comparison	Category 1	Category 2	Category 3
RMSE Criteria	< 15%	< 20%	< 25%

5.10.5 Travel Time

The comparison of observed and modelled travel time will indicate how accurately the model replicates congestion along key routes in the study area. The travel time criteria require the modelled times to be within 15 per cent or one minute (whichever is greater) of the averaged observed travel time. Table 5-10 shows travel time validation criteria for the model categories.

Although the validation criteria focus on the complete travel route, the modeller should also analyse the travel time of each segment in order to resolve any travel time discrepancies in the model.

Table 5-10: Travel time criteria

Criteria	Category 1	Category 2	Category 3
15% or 1 Minute of Average Observed Travel Time (whichever is greater)	> 90%	> 85%	> 80%

Figure 5-11 illustrates the graphed cumulative travel time comparison between observed and modelled outputs with the 15 per cent tolerance limit. The use of predetermined segments allows a cumulative graph of travel time along the route to be developed. The cumulative travel time graph slope between segments indicates the level of congestion along the route and the slope should be comparable between the observed and modelled outputs. As shown in Figure 5-12, the travel time validation results for all routes can be summarised as a graph.

Figure 5-11: Example of cumulative travel time comparison graph

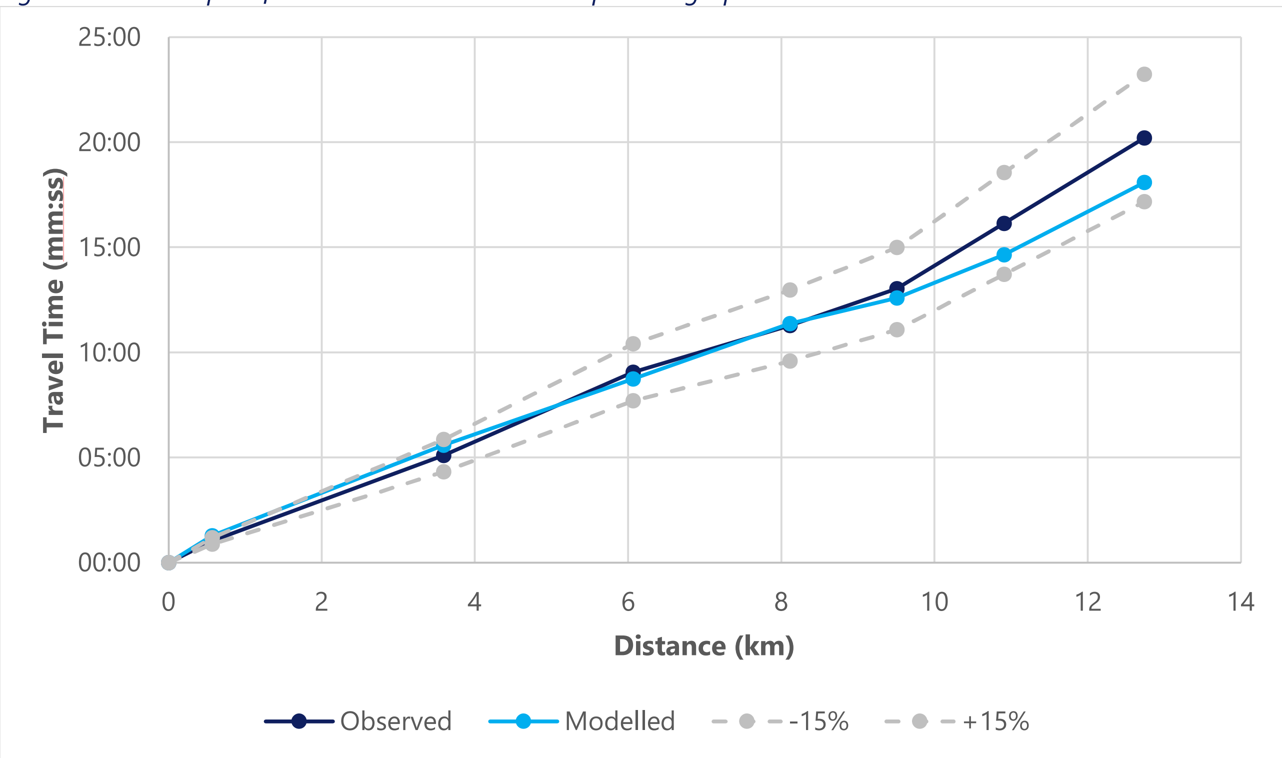


Figure 5-12: Example of cumulative travel time summary table

Time period		7-8 AM					8-9 AM				
Routes	Direction	Survey	Model	Diff	Diff %	Criteria	Survey	Model	Diff	Diff %	Criteria
		MM:SS	MM:SS	Seconds			MM:SS	MM:SS	Seconds		
A: 1->2	Northbound	01:23	01:25	-2	2%	TRUE	01:23	01:25	-2	1%	TRUE
B: 2->3	Southbound	00:41	00:37	4	-9%	TRUE	00:37	00:38	-1	3%	TRUE
C: 4->5	Northbound	01:28	01:29	-1	2%	TRUE	01:29	01:28	1	-1%	TRUE
D: 5->6	Southbound	00:40	00:41	-1	3%	TRUE	00:42	00:40	2	-4%	TRUE
Total				4					4		
Meet criteria				0					0		
% meet criteria				0%					0%		

*The difference is less than 15% of the observed results or one minute, whichever is greater

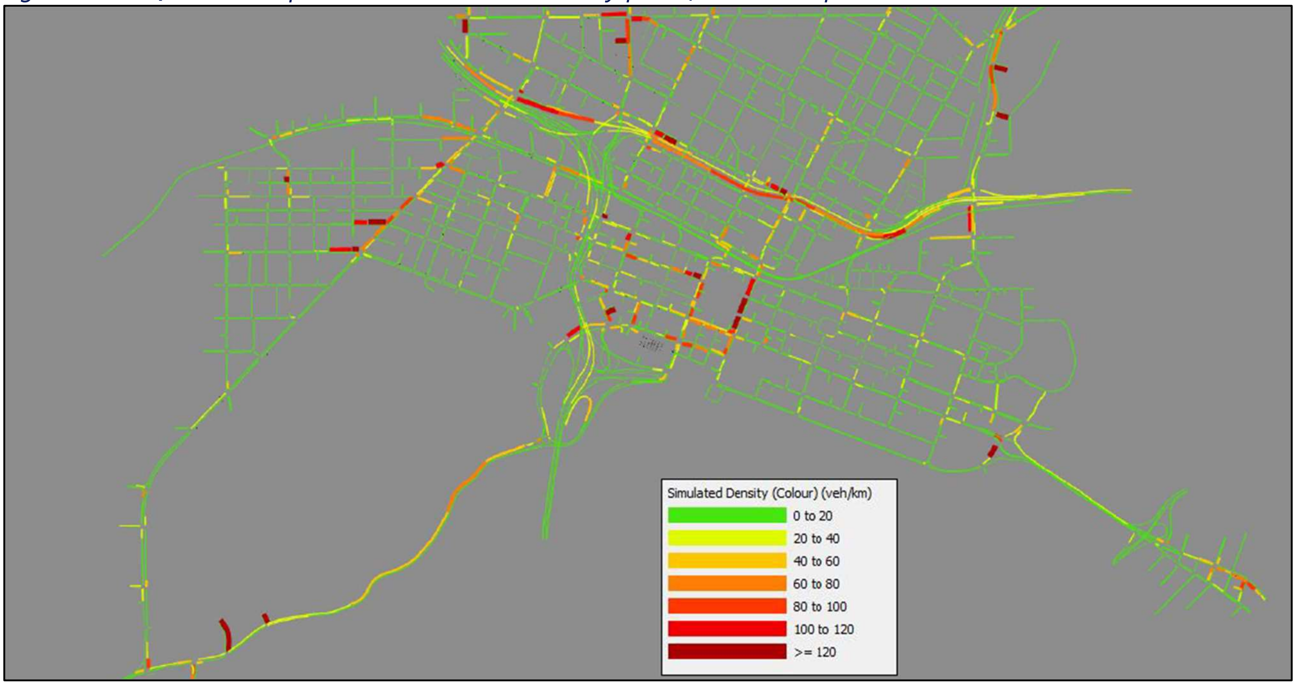
5.10.6 Queue Length

Queue length data is to be collected on-site and compared with modelled queues in order to indicate how accurately the model replicates congestion on approaches to key intersections in the study area. Depending on the model type, the validation of the queues should be achieved qualitatively or quantitatively.

In a hybrid model, queue length validation within the microsimulation pocket should be quantitatively validated between the observed and modelled queues. In a mesoscopic model, queue length validation should be qualitatively assessed and supplemented with images of the existing traffic conditions. This qualitative assessment should be achieved by comparing the existing traffic conditions to modelled link density plots or speed plots. Density plots demonstrate the number of vehicles occupying a unit length of roadway (e.g. veh/km) and speed plots demonstrate the simulated vehicle speed.

Figure 5-13 illustrates a density plot of a modelled network where modellers should provide commentary on the level of congestion in comparison to the observed traffic conditions.

Figure 5-13: Qualitative queue validation with density plots for mesoscopic models



The modelled queue lengths should correlate with the on-site queue lengths. A qualitative assessment of the queues is sufficient for mesoscopic models, while a quantitative assessment is more appropriate for the microsimulation pockets of hybrid models.

5.10.7 Signal Timing

The modelled signal timings are to be based on the recorded average SCATS operation data. The modeller is required to review the timings in order to ensure that it is comparable to the observed timings and to provide confidence in the modelled outputs. If actuated signals or SCATSIM is adopted in the model, signal timing validation needs to be shown in the *Base Calibration and Validation Report* to illustrate conformance with the signal timing criteria.

The modelled signals should conform to the signal timing criteria shown in Table 5-11.

Table 5-11: Signal timing criteria

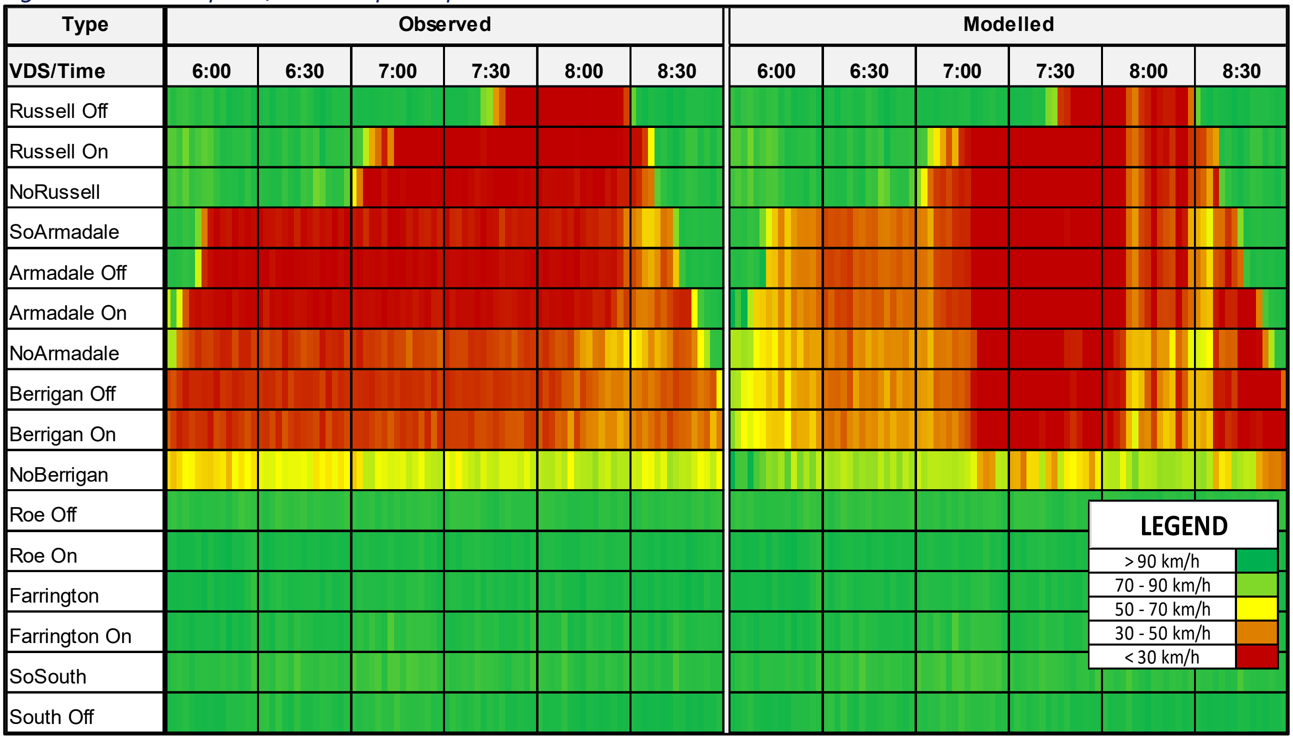
Signal Operation	Criteria
Cycle Time	Within 5 seconds of recorded average of SCATS history data for the same 1-hour period
Green Time	Within 3 seconds of recorded average phase of SCATS history data for the same 1-hour period

5.10.8 Heat Maps

Speed validation is commonly adopted for freeway models in order to compare speeds across certain points of the freeway mainline throughout each peak period. Heat maps are typically used to visualise speed, and can illustrate the location, start time, duration and end time of the flow breakdown, based on freeway mainline speeds.

Figure 5-14 provides an example of a heat map comparison of the observed and modelled speed. The modelled speed plot needs to demonstrate a breakdown comparable to that observed on the mainline in terms of both space and time. It should be noted that travel time validation should take precedence over heat map validation, as heat map validation does not have objective criteria.

Figure 5-14: Example of heat map comparison



5.10.9 Origin and Destination

A comparison of observed and modelled O–D data should establish how accurate the model replicates the observed distribution. The comparison should be undertaken when the distribution is known to have a significant impact on the network, such as weaving areas on a freeway.

Figure 5-15 illustrates a comparison of the observed and modelled O–D data. The GEH statistics of the observed and modelled O–D data can also be calculated and outlined in the *Base Calibration and Validation Report*.

Figure 5-15: Example of origin–destination comparison

ORIGIN	DESTINATION			
	Observed		Modelled	
	Riverside Dr	Mounts Bay Rd	Riverside Dr	Mounts Bay Rd
Charles St	209	168	222	155
GFF Off-Ramp	186	225	206	213
Elder St	39	9	9	23
Murray St	65	11	60	10
Market St	17	15	15	13
Freeway South	247	196	305	179

5.10.10 Model Stability

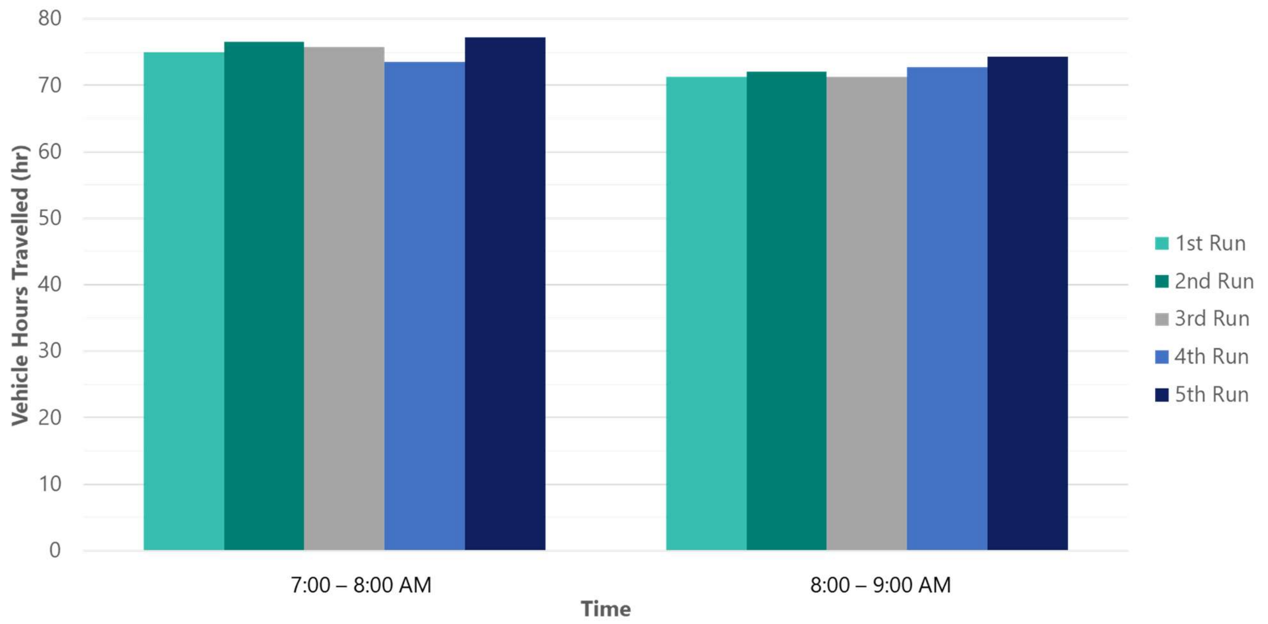
As outlined in Section 5.9.2, there is variability in traffic conditions as a result of driver behaviour and simulation-based models attempt to replicate this random variability by altering individual driver decisions based on random seed numbers. Main Roads recommends multi-simulation runs with different seed numbers in order to evaluate the stability of simulation-based models.

As shown in Figure 5-16, model stability between seed numbers can be assessed with vehicle hours travelled (VHT) network statistics over five seed runs. Other metrics such as average network speed or delay can also be used to assess the stability of the model between seeds.

Where a high level of model variability is observed in the stability assessment, the modeller should provide commentary in the *Base Calibration and Validation Report*. It should be noted that high variability between seed numbers is highly probable when the network is saturated.

The model stability assessment of the base model must be stipulated in the *Base Calibration and Validation Report*.

Figure 5-16: Vehicle hours travelled (VHT) model stability assessment



5.10.11 Latent Demand

Latent demand (or unreleased demand) in traffic modelling refers to the excess traffic demand that cannot be serviced by the network. From a modelling perspective, it is the demand that is unable to enter the network due to congestion. These demands (vehicles) that are not released into the network during the evaluation simulation period may result in an underestimation of network congestion. The network must be evaluated in respect of any unreleased demand in order to ensure scenarios can be comparably assessed.

The base mesoscopic or hybrid model should have minimal (e.g. less than one per cent) unreleased demand in the network. This can be achieved using the following steps:

1. Review the constraints causing the queues to propagate to the model peripherals, and ensure it is correlated with the existing traffic conditions.
2. Revise the demands at model peripherals based on observed queues and then extend the model scope to allow the majority of, if not all, the traffic volumes to load into the network during the evaluation period.
3. Discuss with Main Roads and agree on the extent of the model area that was expanded due to the latent demand.

5.10.12 Sensitivity Analysis

A well calibrated and validated base model that replicates the existing travel behaviours does not guarantee that the model is appropriate to respond to the proposed schemes. It is recommended that a sensitivity analysis to stress test the base model is carried out in order to assess the validity of the modelling parameters that influences the dynamic capabilities of the model.

A sensitivity analysis with an additional 10-30 per cent demand is recommended to review the assignment in a more congested network. Alternatively, the sensitivity test can include removing and/or adding significant transport infrastructure and reviewing the assignment predictions. This sensitivity test can also be useful to identify coding errors in the model.

6 OPTION MODEL DEVELOPMENT

Option models are developed where a project requires the assessment of the potential road network changes in the respective planning horizons. This can vary widely although essentially involves:

- updating the base model to reflect a defined set of proposed or anticipated changes; and
- comparing the project scenario model against the base model in order to determine the impacts of the scenario.

The development of the option models should commence after the base model has been approved by Main Roads, as approval confirms that the base model is suitable for future options assessment. This section describes the recommended procedures for mesoscopic and hybrid modelling options development.

6.1 Scenario Nomenclature

While the number of options and future year scenarios must be defined in the *Project Brief* and *Methodology Report*, changes to the scope of option scenarios may be developed as the project progresses. For example, changes to the scope may be a result of a more refined understanding of the future traffic conditions during the option testing stage, or stem from additional requests from relevant stakeholders.

Table 6-1 describes the option modelling scenario nomenclature that can be considered based on the planning horizons agreed in the *Methodology Report*.

Table 6-1: Option modelling scenario nomenclature

Nomenclature	Description
Base	Existing transport network and existing traffic demands.
Do-Nothing	Existing transport network and future traffic demand for the planning horizon.
Do-Minimum	Like Do-Nothing, it also includes committed projects that will be implemented regardless of the projects/schemes to be assessed as part of the project.
Do-Something	Built up from Do-Minimum, it also includes the proposed options to be explicitly assessed as per the project objective of developing the mesoscopic or hybrid traffic model. It also includes the additional traffic growth as a result of the proposed options (e.g. induced traffic, improved network connectivity).
Do-Something With Mitigation (Optional)	This is potentially required as the project progresses. It is built up from the Do-Something scenario and will include additional mitigations/schemes to be assessed as per the evolving objective and scope throughout the project. It may also include the additional work for the proposed project or schemes to enable the relevant road network to meet the operational criteria (e.g. level of service) with the future traffic growth.

6.2 Option Modelling Procedure

The calibrated and validated base model will form the basis for the option models. The model parameters, such as driver behaviours and user-defined costs, should remain consistent across the base model and future scenarios in order to inform a like-for-like assessment of future schemes. The justification of changes to these factors must be discussed with Main Roads and documented in the *Option Modelling Report*.

Figure 6-1 illustrates a typical option model development process, where the boxes highlighted in blue are the deliverables or hold points. The process may vary and must be clearly stated in the *Methodology Report*.

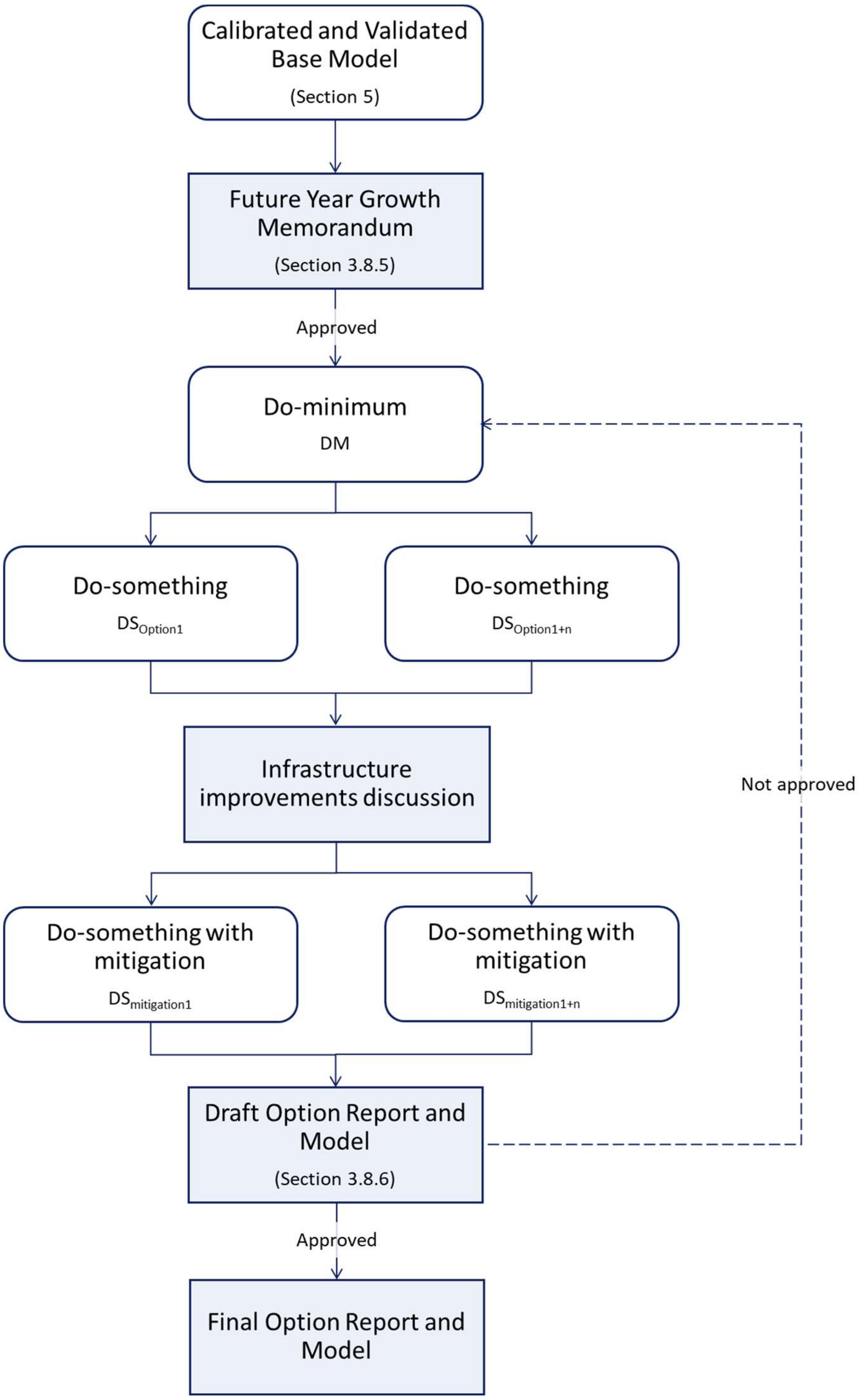
The option model development process typically includes:

- base model;
- future year growth memorandum;
- “do-nothing” and/or “do-minimum” scenario for benchmarking purposes;
- “do-something” scenario in order to assess the proposed changes;
- meeting with key stakeholders to propose and agree on mitigative measures identified in the “do-something” scenario; and
- “do-something with mitigation” scenario in order to assess the proposed changes.

Future year growth approval may be an iterative process with Main Roads until the demands are suitable for the project purpose. An iterative process is required as the application of the agreed growth method stipulated in the *Methodology Report* may result in latent demand. In this case, it is recommended to discuss the outcome with Main Roads to determine a method to address this.

It is recommended that the modeller includes preliminary mesoscopic modelling outputs for the proposed options in the *Future Year Growth Memorandum* for Main Roads’ approval. The preliminary outputs can demonstrate that no further adjustments are required.

Figure 6-1: Option modelling process example



Main Roads' approval of the option model means that the model has been developed, assessed and determined appropriate to address the model purpose.

6.3 Future Year Demand Estimation Methodology

Main Roads' recommended growth demand estimation methodology involves exploitation of the strategic modelling O–D matrices in order to develop the future year demands. The recommended pivot-point growth method can be applied with all-day or peak period strategic O–D matrices.

6.3.1 Pivot-Point Method

The pivot-point method relies on the mesoscopic model as the baseline and uses the future peak period traffic demands in the overarching strategic model to inform relevant growth on baseline demands.

While the pivot-point method predominately applies additive growth at individual O–D pairs, other approaches may be more appropriate under specific conditions, as outlined in Table 6-2. The growth method pivots off the calibrated mesoscopic base matrices, ensuring that traffic growth derived from the overarching strategic model is captured in the corresponding mesoscopic future year traffic demands.

Where all-day strategic O–D matrices have been provided (in lieu of peak period matrices), the following steps must be undertaken prior to applying the pivot-point method:

1. Calculate the peak flow factors for the respective peak hours based on observed counts at a zonal level.
2. Apply and furness the all-day $Strategic_{Base}$ matrices and existing peak flow factors to obtain the peak hour $Strategic_{Base}$ matrices.
3. Apply and furness the all-day $Strategic_{Future}$ matrices and existing peak flow factors to obtain the peak hour $Strategic_{Future}$ matrices.
4. Apply the peak hour $Strategic_{Base}$ matrices and $Strategic_{Future}$ matrices in accordance with Table 6-2.

Table 6-2: Pivot-point growth method

No.	Method	Formula	Description of Approach
1	Additive Growth (Default)	$Meso_{Future} = (Strategic_{Future} - Strategic_{Base}) + Meso_{Base}$	By default, adopt absolute growth under the following conditions: • $(Strategic_{Future} - Strategic_{Base}) + Meso_{Base} > 0$ • If 'negative' growth is derived from this method, careful checking is required to discern whether it is realistic; manual adjustment may be required to use 'zero' growth or a 'minimum' growth instead for a conservative approach accounting for the unknown. *This approach is recommended when applying the future traffic from new land-use/development with known scale (e.g. the master plan of a new precinct is known to provide 500 new jobs in the next 10 years).*
2	Relative Growth (Alternative)	$Meso_{Future} = (Strategic_{Future} / Strategic_{Base}) \times Meso_{Base}$	This relative growth method should be adopted under the following conditions: • $(Strategic_{Future} - Strategic_{Base}) + Meso_{Base} < 0$ • $Strategic_{Base} > 0$ • This approach is used in situations when there is a large reduction in demand and the mesoscopic base volumes are lower than the strategic volumes. *This approach is recommended when the future traffic from the new land-use/development has a known scale relevant to the existing land-use of the same zone e.g. the future land-use strategy of a town centre plans to increase the population by 20%. This is also preferred in situations where the overarching strategic model is known to overestimate the growth of a certain area relevant to its traffic study.*
3	Strategic Future (New Strategic Zones)	$Meso_{Future} = Strategic_{Future}$	This approach should be adopted when there are new strategic zones, where: • $Strategic_{Base} = 0$, $Meso_{Base} = 0$ and $Strategic_{Future} > 0$ *Generally applied where more confidence is given to the strategic model (e.g. the strategic model has recently been updated with the future land-use assumptions within the area).*
4	No/Minimum Growth (Special Case)	$Meso_{Future} = Meso_{Base}$	This special case method should be adopted under the following conditions: • $Meso_{Base} > 0$, $Strategic_{Base} = 0$ and $Strategic_{Future} = 0$ • $Meso_{Base} = 0$, $Strategic_{Base} > 0$ and $Strategic_{Future} > 0$ *This method can also be applied where it is known that the future growth in the strategic model is attributed to land-use changes/new developments which have already occurred and are captured in mesoscopic baseline demands.*

6.3.2 Alternative Method

When an overarching strategic model is not available, Main Roads recommends a combination of historical growth factors and trip generation rates of known developments are used to calculate the future year growth rates. Once the growth rates have been calculated, assumptions related to mode share are required. The assumptions for this alternative approach must be stipulated in the *Future Year Growth Memorandum* for Main Roads' approval.

Subject to the availability of an overarching strategic model, Main Roads recommends the pivot-point method. This method relies on the mesoscopic model as the baseline and uses the future traffic demands in the overarching strategic model to inform relevant growth on baseline demands.

6.3.3 Latent Demand

Latent demand needs to be carefully considered in option modelling, as the mesoscopic or hybrid model can demonstrate excessive demands that can be misrepresented and result in incorrect recommendations.

The adoption of the pivot-point method based on the strategic model outputs may overestimate demand as the strategic model does not consider physical constraints on the network, resulting in unrealistic volumes travelling through the network. The overestimation of demand will ultimately result in latent demand at the model peripherals, as downstream congestion inside the boundary leads to vehicles waiting outside the defined boundary of the mesoscopic or hybrid model.

If the excess demands result in unrealistic or unmeasurable outputs, there are a number of potential methods which can be used to reduce the demands waiting to enter the network. The mesoscopic or hybrid model should have minimal unreleased demand in the network. This can be achieved using following steps:

1. Review the constraints causing the queues to propagate to the model peripherals, and ensure it is correlated with the estimated growth rates.
2. If applicable, review and optimise the traffic signal timings at model peripherals with latent demand to reduce the level of congestion.
3. If latent demand still exists, the future year growth rates should be discussed with Main Roads. Main Roads may recommend further demand adjustments, as described in Section 6.3.3.1 to Section 6.3.3.3 in order of preference.

It is recommended that modellers analyse areas that are demonstrating latent demand and discuss the issues with Main Roads before undertaking any further demand adjustments.

6.3.3.1 Out-of-Model Results Adjustment

Some software may not incorporate latent demand into the modelled output statistics. The modelled results must be adjusted when latent demand exists in order to normalise the outputs and ensure valid like-for-like comparability is achieved. When latent demand exists in the option models, the normalisation of the commonly used outputs are as follows:

- *Total vehicle travel distance (VKT)* = Average travel distance (of vehicles completed the journey) × (number of vehicles that have completed the journey + total vehicles in the network + number of latent vehicles)
- *Total vehicle travel time (VHT)* = Average travel time (of vehicles completed the journey) × (number of vehicles that have completed the journey + total vehicles in the network + number of latent vehicles)
- *Total vehicle number of stops (stops)* = Average number of stops (of vehicles completed the journey) × (number of vehicles that have completed the journey + total vehicles in the network + number of latent vehicles)

The out-of-model results adjustment process apportions the modelled average trip time to the total vehicle demand (i.e. completed, incomplete and latent). This is a conservative adjustment method because if the additional traffic had been able to enter the network, the average travel times across all vehicles would have increased due to volume/capacity effects.

6.3.3.2 Peak Spreading

The concept of peak spreading can be defined as where demand exceeds the capacity of the network for a sustained period and results in the peak period spreading into the shoulder peaks. Peak spreading can be applied to future year option models when the peak period is heavily congested.

There are three methods which can be used to apply peak spreading:

1. iterative manual estimation of time slice ratio to flatten the peak traffic profile;
2. time departure choice adjustments from the overarching strategic model; or
3. dynamic time departure adjustment that simulates drivers changing departure times in order to achieve the same arrival time.

6.3.3.3 Demand Capping

Demand capping is an artificial method used to reduce future traffic demands. It should only be used in selective areas with extreme demands and the modeller must provide evidence to support the demand capping justification and assumptions. This section describes demand capping methods in different circumstances.

6.3.3.3.1 Demand Capping at External Zones

As shown in Table 6-3, Austroads' *Guide to Traffic Management Part 3: Transport Study and Analysis Methods* sets out typical mid-block capacities for various types of urban roads based on upstream constraints. The mid-block capacities can be considered as an option to cap demand at external zones, as intersections immediately outside the model boundary may reduce traffic flows arriving into the model.

Table 6-3: Typical mid-block capacities with interrupted flow per lane (source: Austroads, 2020)

Type of Lane	One-Way Mid-Block Capacity (pc/h)
Median or Inner Lane	
Divided Road	1000
Undivided Road	900
Middle Lane (of a 3-Lane Carriageway)	
Divided Road	900
Undivided Road	1000
Kerb Lane	
Adjacent to Parking Lane	900
Occasional Parked Vehicles	600
Clearway Conditions	900

The mid-block capacity volumes may increase to 1200-1400 pc/h/ln on any approach road when the following conditions exist or can be implemented (Austroads, 2020):

- adequate flaring at major upstream intersections;
- uninterrupted flow from a wider carriageway upstream of an intersection approach and flowing at capacity;
- control or absence of crossing or entering traffic at minor intersections by major road priority controls;
- control or absence of parking;
- high-volume flows of traffic from upstream intersections during more than one phase of a signal cycle; or
- good coordination of traffic signals along the route.

6.3.3.3.2 Demand Capping at Internal Zones

The internal zones can undergo demand scaling so that the O–D or destination trip end total equals a specific known value. For example, the demand from an internal zone should not exceed a known value from a master planned development. This approach is only recommended if certain traffic zones are known to have a capped scale of land-use (e.g. no more than 1000 dwellings are planned).

6.4 Route Choice

It is recommended that modellers check all the key route choices during the option model development stage. Route choice related parameters in the calibrated and validated base model should be retained or consistently updated with justifications. It is recommended that spot checks on paths between major O–D pairs at different time intervals of the model period are performed.

6.5 Verification

Network verification is a process in the option modelling stage to verify the model to minimise errors, and it is recommended to be carried out by an internal peer reviewer. Errors in the modelled network can affect the modelled results but the removal of all errors may not be possible due to the scale of the network. Notable areas where errors may occur in the option modelling stage may include:

- future traffic demand estimation;
- incorrect coding of the proposed schemes;
- adjustments of appropriate parameters for the new links (e.g. capacity, lane change distance);
- route choice;
- poorly optimised signal timing; and
- fake gridlock (more common in microsimulation or hybrid modelling).

6.6 Model Outputs

This section demonstrates typical outputs that can be generated from mesoscopic or hybrid models in order to help achieve the project objectives. As previously shown in Table 3-1, not all model types can provide equal resolution or accuracy and the appropriate model must be selected.

6.6.1 Intersection Assessment

Intersection level of service (LOS) is a function of the average vehicle delay at the intersection and it is commonly used to assess the performance of intersections. The resolution of the output will depend on the model purpose, but it can be assessed by movement, approach or at an intersection level per hour. Table 6-4 provides an example of intersection performance outputs based on flow, LOS and queue length. These outputs can also be depicted spatially in the model.

Table 6-4: Example of detailed intersection outputs

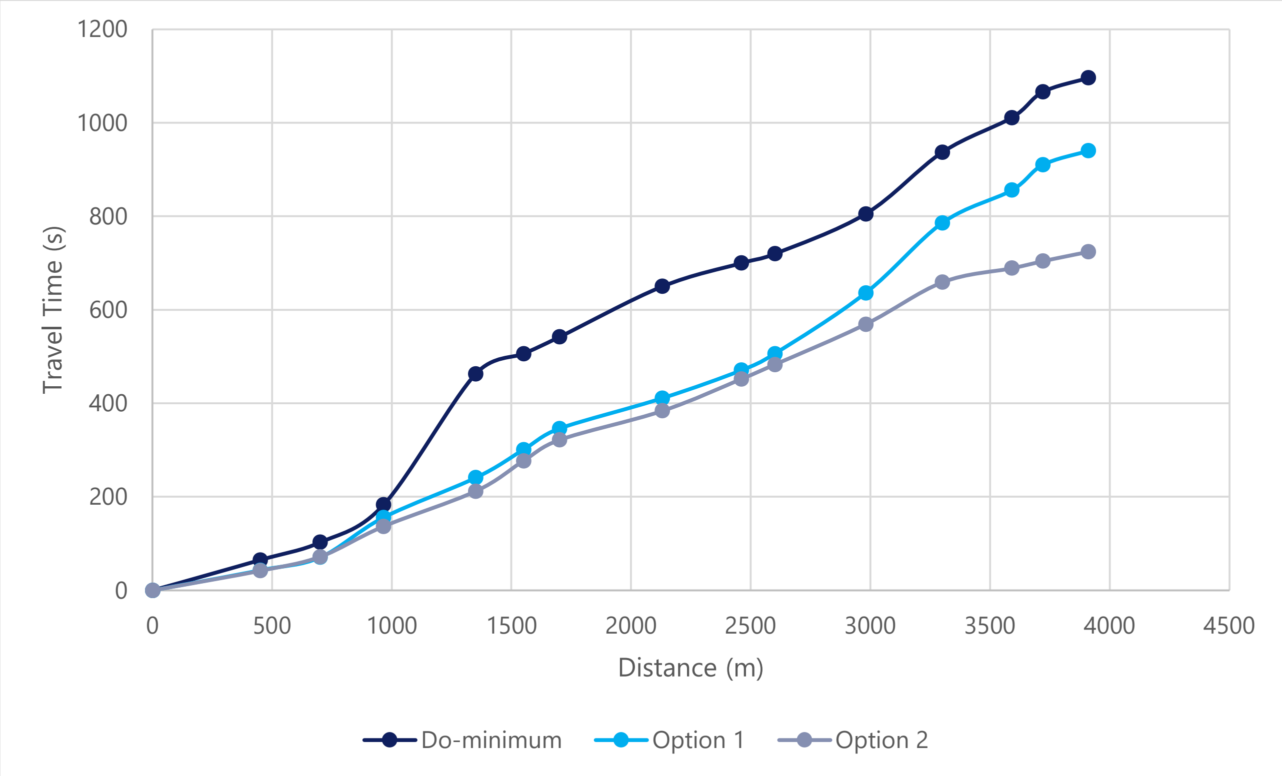
Turn Movement	Flows (veh/hr)	Average Delay (s)	Level of Service	Queue (m)
East Approach: Mill Point Road				
Left	23	55	D	108
Through	346	47	D	118
Approach	**369**	**49**	**D**	**118**
South Approach: Douglas Avenue				
Left	135	48	D	136
Right	30	47	D	102
Approach	**165**	**48**	**D**	**136**
West Approach: Mill Point Road				
Through	552	47	D	85
Right	26	68	E	110
Approach	**578**	**63**	**C**	**110**
Intersection	**1112**	**52**	**D**	**136**

6.6.2 Corridor Assessment

6.6.2.1 Travel Time

A corridor assessment can be undertaken using travel time outputs that are segmented at user-specified locations. As shown in Figure 6-2, the travel time of each option can be graphically represented, with the travel time on the y-axis and distance on the x-axis. If required, the travel time can be assessed by vehicle type, most commonly public transport in order to assess bus operations.

Figure 6-2: Example of hourly travel time comparison

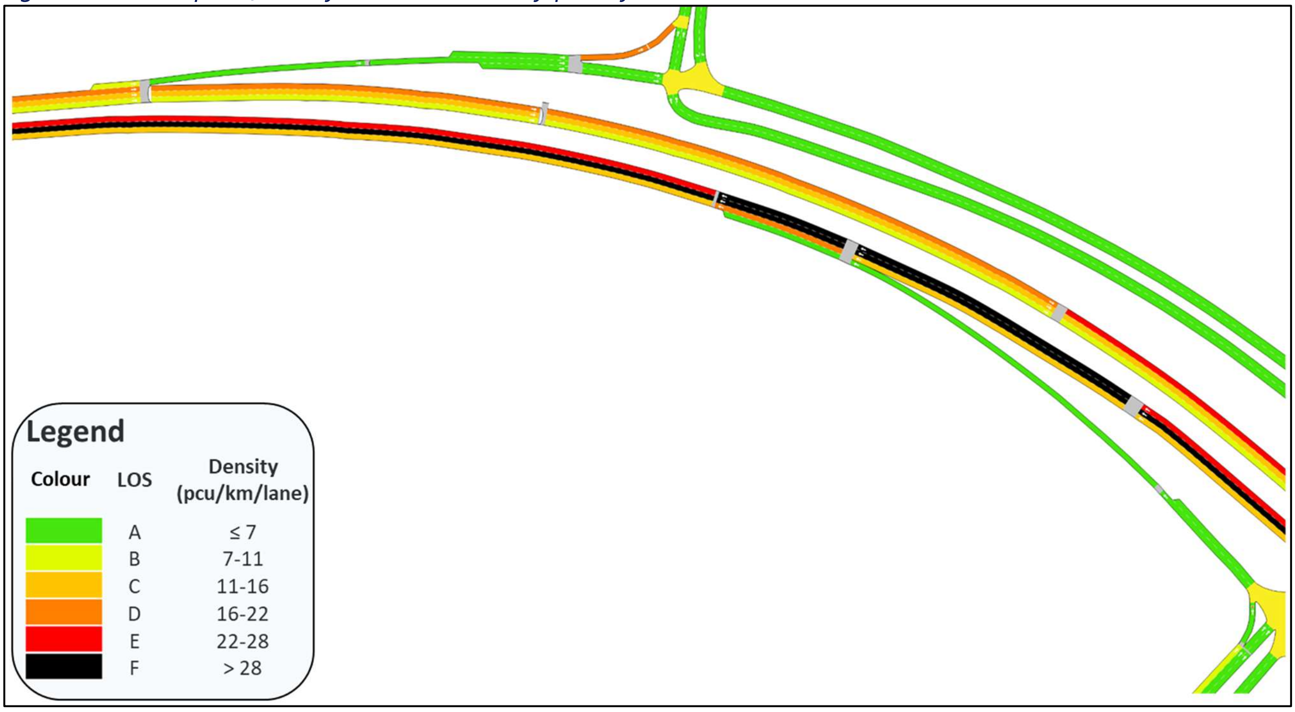


A steeper travel time slope demonstrates a higher level of congestion on the corridor. Alternatively, the travel time of the full traversal can be used for comparison in higher-level assessments. As travel time does not show the level of congestion on side roads, this assessment should be supplemented with intersection assessment.

6.6.2.2 Freeway Density

A freeway corridor can be evaluated as a function of density in passenger car per kilometre per lane units to reflect the level of freedom to travel at the desired speed on the freeway. Figure 6-3 illustrates a lane-based density plot on a freeway.

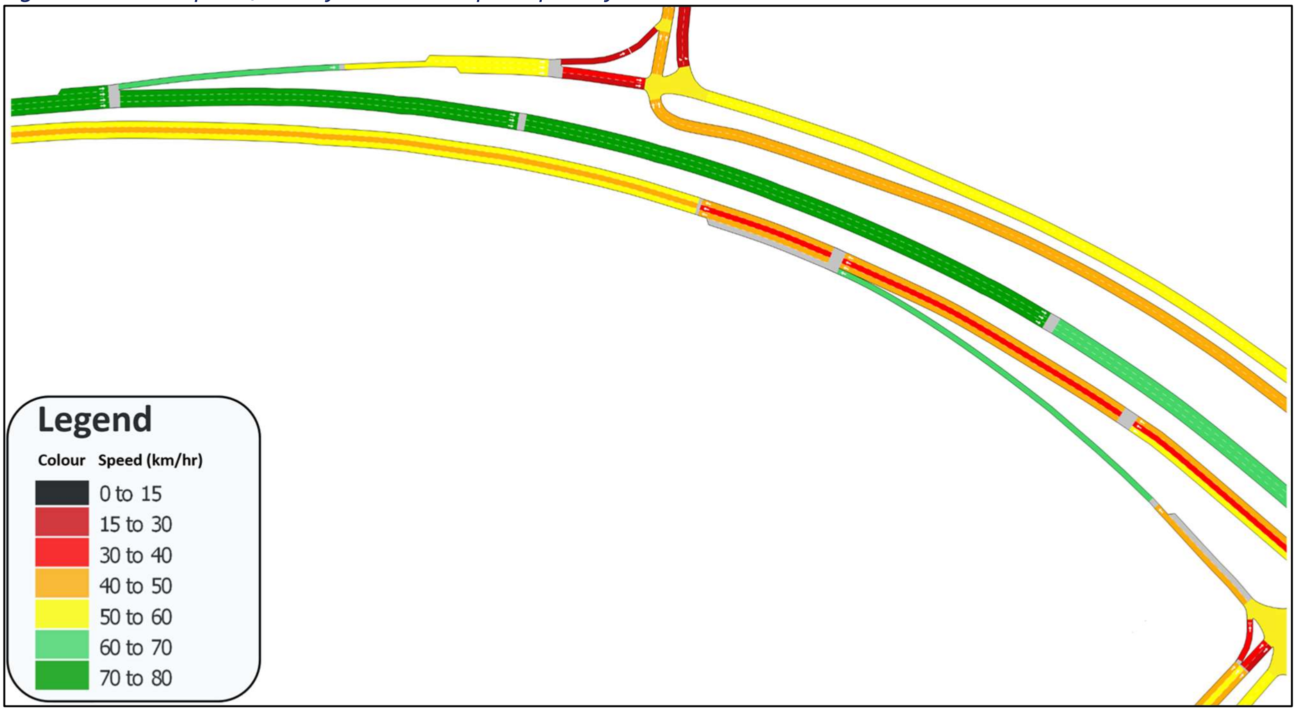
Figure 6-3: Example of hourly simulated density plot by lane



6.6.2.3 Freeway Speed

A freeway corridor can also be evaluated based on the simulated speed or represented as a percentage of the posted speed limit. Figure 6-4 illustrates a lane-based simulated speed plot on a freeway.

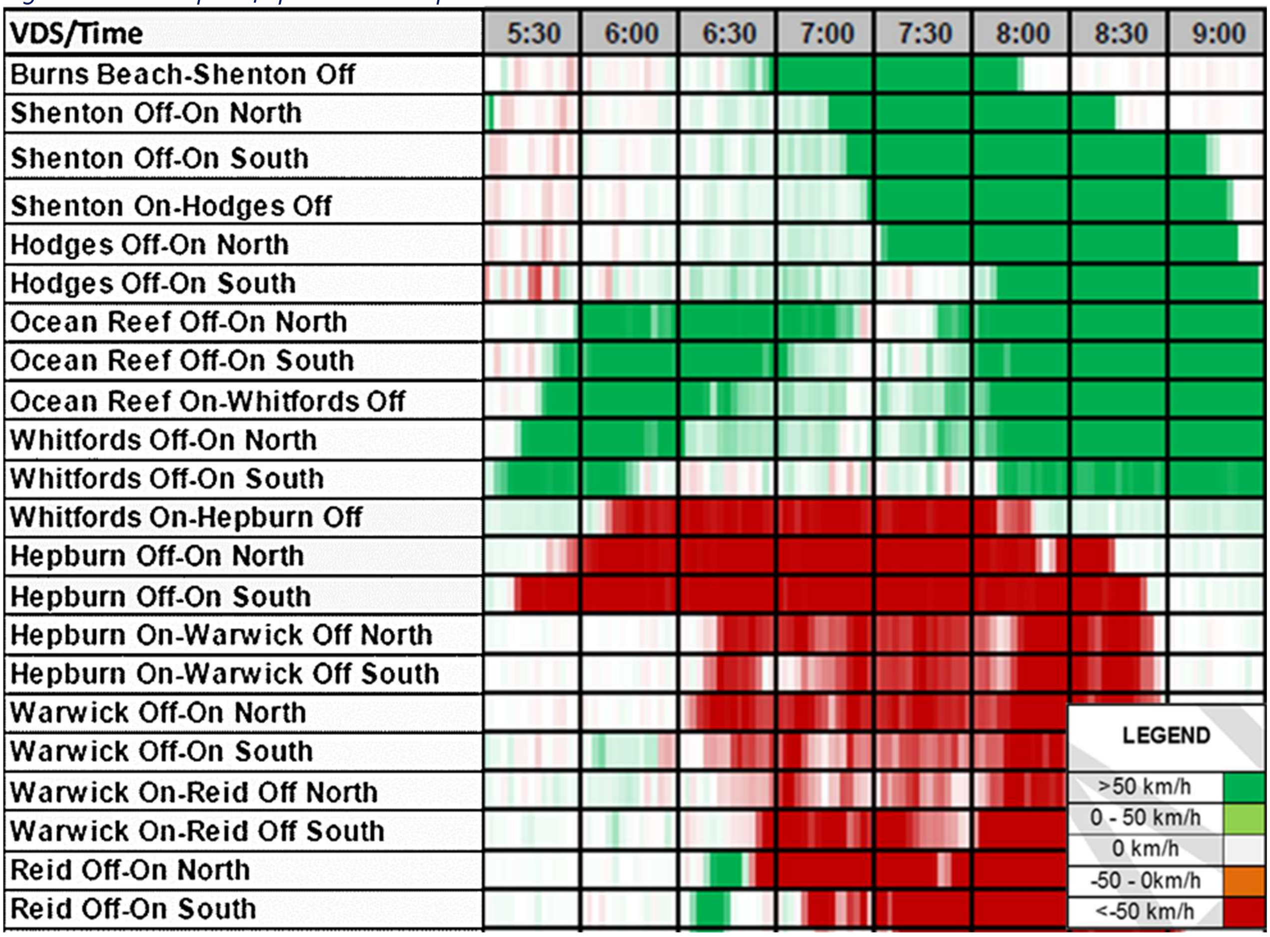
Figure 6-4: Example of hourly simulated speed plot by lane



6.6.2.4 Freeway Speed Heat Maps

A heat map can be used to illustrate the location, start time, duration and end time of bottlenecks based on freeway mainline speeds. Figure 6-5 provides an example of a heat map that compares speed differences with the "do-minimum" option in order to identify potential flow breakdown locations in the proposed option. The assessment of heat maps can also be expressed as a percentage of the posted speed limit.

Figure 6-5: Example of speed heat map



6.6.3 Network Wide Performance Assessment

6.6.3.1 Network Statistics

Network performance statistics are used to evaluate the aggregated model statistics at a network level. The statistics are used for comparative options assessment and also commonly used in economic benefit–cost ratio (BCR) assessments.

Network performance statistics should be presented for the agreed evaluation time period with appropriate time intervals. Table 6-5 provides an example of network performance statistics.

Table 6-5: Example of network performance statistics

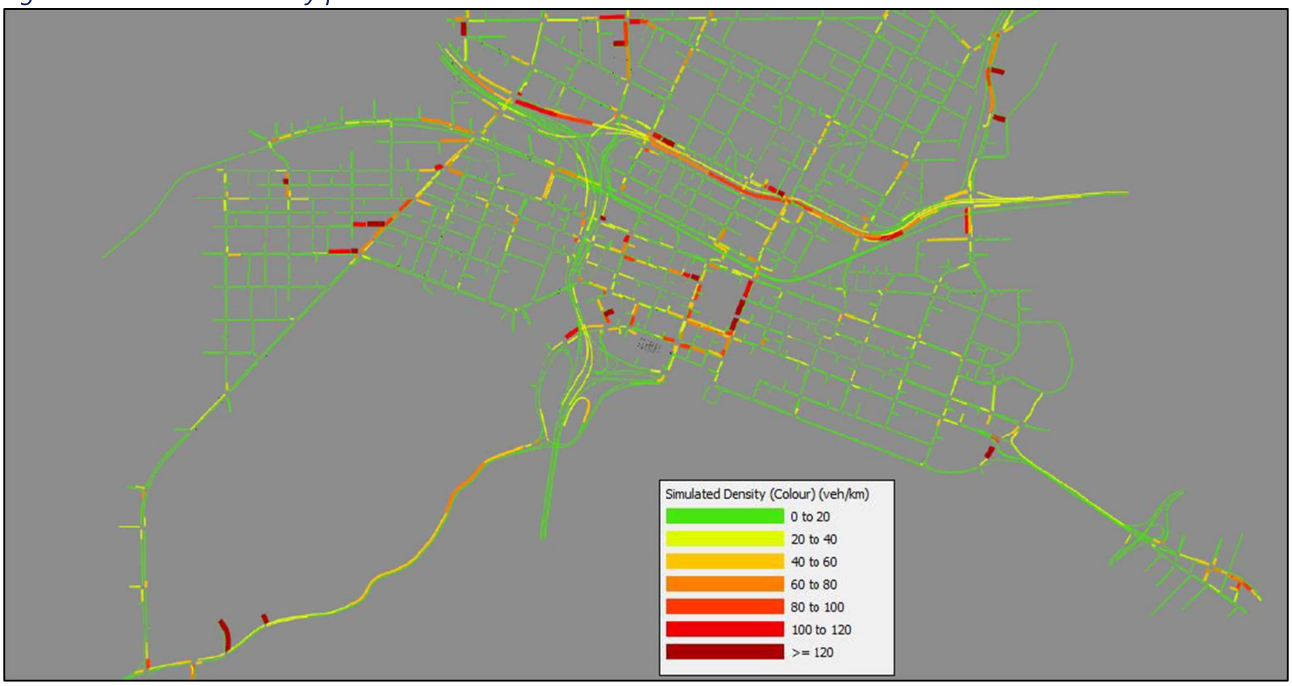
Scenario	Do-Minimum	Option 1	Option 2
Time Interval	07:00-09:00	07:00-09:00	07:00-09:00
Vehicles Arrived Into Network (veh)	41,994	42,580	42,588
Total Network Travel Distance (km)	78,279	82,568	82,657
Total Network Travel Time (hh:mm)	2017:39	2067:34	2069:05
Total Network Delay (hh:mm)	1796:41	1561:26	1537:64
Average Vehicle Speed (km/h)	40.6	43.1	43.1
Average Vehicle Delay (s)	154	132	130
Latent Demand (veh)	576	5	3
CO_2 Emissions (tonnes)	40.66	38.12	37.98
NO_x Emissions (kg)	124.92	108.45	106.78

6.6.3.2 Network Plots

Network plots can be extracted in order to visually evaluate the entire modelled network performance. As shown in Figure 6-6, network-wide density plots can be extracted to identify network constraints within the model. Other network plots that are commonly extracted include:

- *flows* (veh/h) which evaluate the simulated flows in the network;
- *delays* (s) which evaluate the simulated vehicle delays in the network; and
- *speed* (km/h) which evaluates the simulated vehicle speeds in the network.

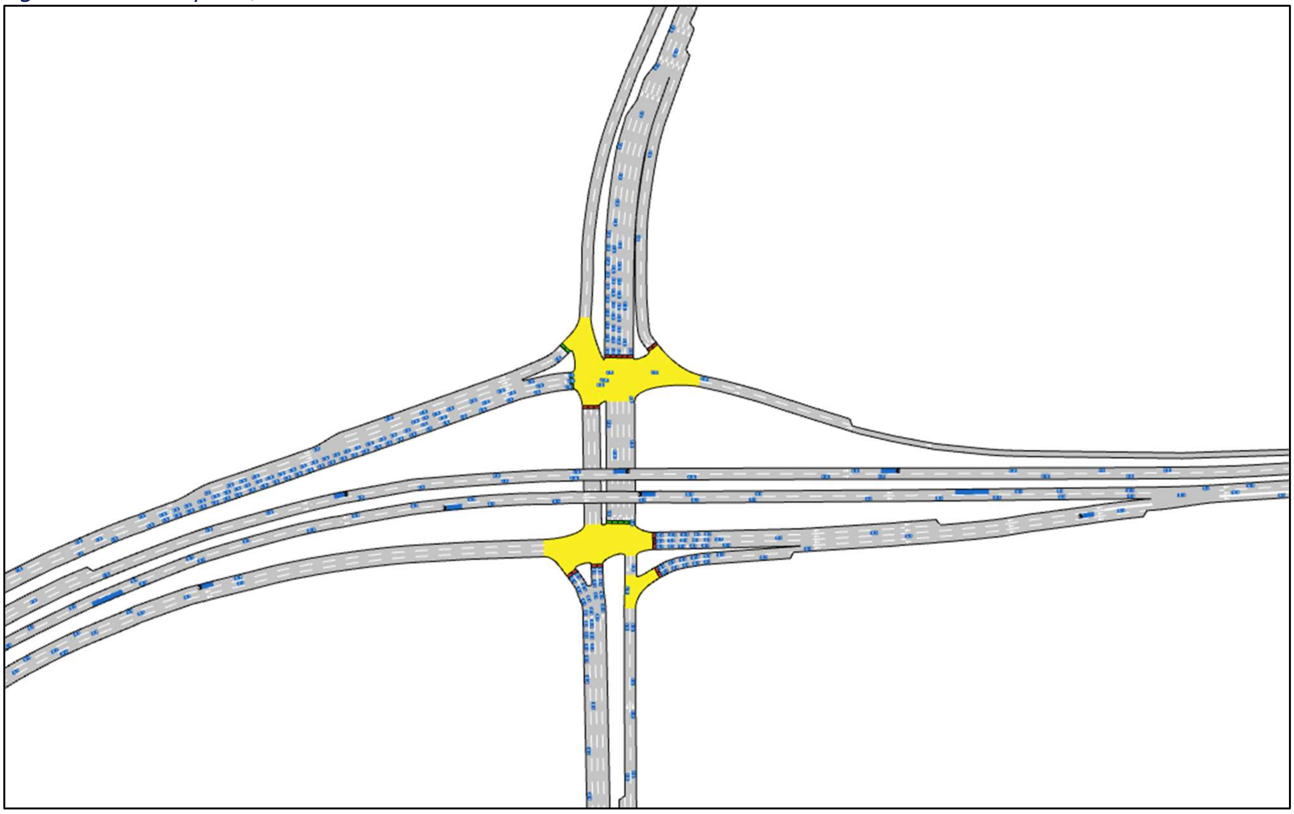
Figure 6-6: Network density plot



6.6.4 Visual Animation

Visualisation of the model can demonstrate vehicle behaviours or other operations of the network that may be difficult to describe through statistical outputs. As shown in Figure 6-7, visualisation outputs in hybrid models can demonstrate vehicle behaviour within the microsimulation pocket in order to supplement other performance metrics. Depending on the software package, it may be possible to obtain mesoscopic video outputs but the outputs are generally limited due to the simplified algorithm used.

Figure 6-7: Example of microsimulation visual animation



7 RECOMMENDED SOFTWARE SETTINGS

This section provides detail on the model development process and the key parameters to be applied within the mesoscopic modelling software packages commonly used in Western Australia, namely:

- Aimsun Next;
- Visum; and
- Vissim.

7.1 Aimsun Next

Aimsun Next is an integrated transport modelling software package that allows integration between various types of model. It provides high-speed simulations and combines travel demand modelling and static assignment with mesoscopic, microscopic and hybrid simulation within a single software application.

This section describes key parameters within Aimsun Next and provides recommendations to be used as a starting point in the model development. Modellers should read these sub-sections in conjunction with Section 5 and Section 6. Section 6 of Main Roads' *Operational Modelling Guidelines* can also be referred to, as some parameters from microscopic modelling can also be used for mesoscopic modelling.

7.1.1 Traffic Assignment

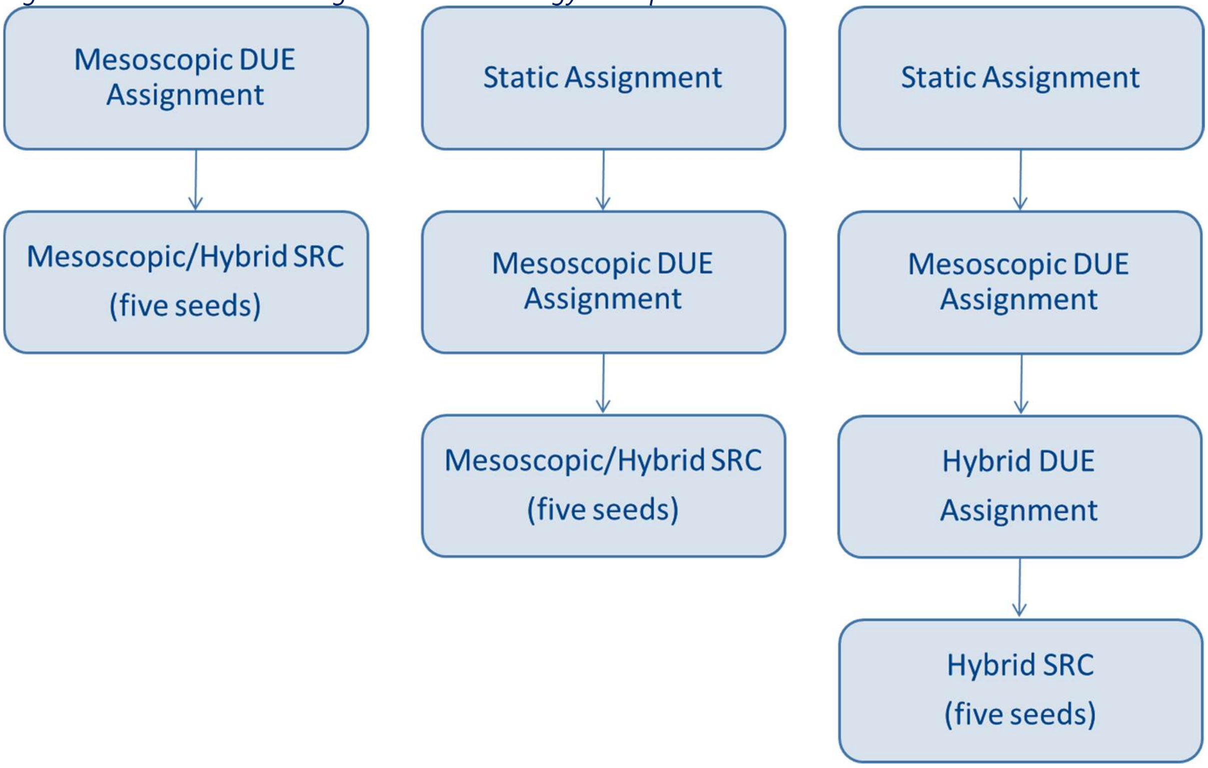
The selection of the traffic assignment will form the basis of the model development procedure and the modeller must select the most appropriate assignment method for the study. There are two broadly categorised assignments in Aimsun Next that can be used in numerous ways and these are outlined in the following sub-sections.

7.1.1.1 Assignment Methodology

As Aimsun Next has multi-resolution features, the assignment process can consist of a combination of assignment types to identify the optimal routes for each time slice and vehicle type. Figure 7-1 provides examples of the assignment methodologies that are commonly adopted in Aimsun Next for mesoscopic or hybrid modelling.

For reasons outlined in Section 5.2, as a minimum, Main Roads recommends the incorporation of a single seed mesoscopic DUE assignment in all mesoscopic and hybrid models. This should be followed by stochastic route choice (SRC) replications with five different seed values in order to replicate the variabilities of traffic conditions.

Figure 7-1: Aimsun Next assignment methodology examples



While the selection of the assignment methodology should be based on the model purpose, Main Roads recommends the use of mesoscopic DUE assignment for all mesoscopic and hybrid models, followed by five seed SRC assignment.

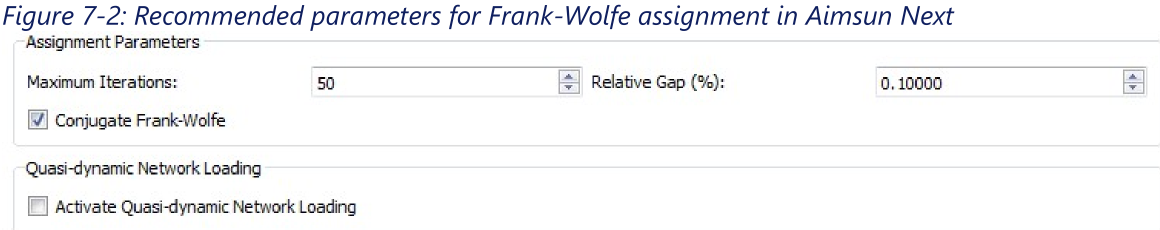
7.1.1.2 Static Assignment Parameters

Static traffic assignment is generally used in macroscopic modelling to estimate the routes between O–D zones and to assign traffic volumes on a network. Individual vehicles are not considered in this assignment, as flows are assigned to the network using a deterministic algorithm. As such, the static path assignment output is commonly used as initial path data for dynamic assignments.

It is recommended that modellers use the assignment type which corresponds with that used in the strategic model. Frank-Wolfe assignment is used in ROM24 and should be applied to a model developed from ROM24. Method of successive averages (MSA) and incremental assignments may also be considered when *junction delay functions* are introduced into the model.

Figure 7-2 shows the recommended parameters setting for Frank-Wolfe assignment to be used for models developed from ROM24. These settings should be adjusted to meet the needs of the specific project.

Figure 7-2: Recommended parameters for Frank-Wolfe assignment in Aimsun Next



7.1.1.3 Dynamic Assignment Parameters

Mesoscopic, microscopic and hybrid assignments can be made using either dynamic user equilibrium or stochastic route choice. Both these are simulation-based assignments that simulate individual vehicles through the network, but each uses differing vehicle behavioural models.

7.1.1.3.1 DUE Convergence Criteria

Model convergence is essential in order to achieve a stable model and the criteria to be met will depend on the model size and complexity. The recommended DUE convergence stopping criteria for Aimsun Next will depend on the model category, as described in Section 3.5.3. Table 7-1 can be used as a starting point for the convergence requirements. The model convergence should be reviewed in order to ensure that it improves steadily through each iteration, as a sign that the convergence metrics (e.g. relative gap, link flows and travel time) have improved.

Table 7-1: DUE convergence guidance

Parameters	Category 1	Category 2	Category 3
Maximum Iterations	50-100	50-100	50-100
Relative Gap (%)	2%	3%	4%

7.1.1.3.2 Dynamic Experiment Settings

As a starting point, Table 7-2, Table 7-3 and Table 7-4 outline the behaviour, reaction time and dynamic traffic assignment settings for the dynamic experiment. Adjustments to these parameters may be needed for different models, as it could impact driver behaviour (e.g. car-following parameters or reaction time).

It is recommended that a single seed value be used to run the dynamic user equilibrium experiment in order to obtain the path assignment to be used in the stochastic route choice replications.

Table 7-2: Behaviour settings in Aimsun Next

Type	Parameter	Suggested value
Mesoscopic Settings		
Car-Following	TWOPAS Slope Model	Enabled, if slope needs to be considered in greater detail
Lane-Changing	Look-Ahead Distance Variability	40%-100%
Microscopic Settings for Hybrid Modelling		
Car-Following	Two-Lane Car-Following Model	Enabled
	Number of Vehicles	4
	Maximum Speed Difference	30-50km/h
	Maximum Distance	100m
	Maximum Speed Difference on Ramp	50-70km/h
	Speed Difference Setting	Relative
	Queue Entry Speed	1 m/s
	Queue Exit Speed	4 m/s
Lane-Changing	Non-Lane Based Behaviour	Disabled

Table 7-3: Reaction time and arrival settings in Aimsun Next

Type	Parameter	Suggested Value
Arrivals	Global Arrivals	Exponential
Mesoscopic Settings		
Fixed (Same For All Vehicle Types)	Reaction Time	1.20-1.35 s
	Reaction Time At Traffic Light	1.60 s
Microscopic Settings for Hybrid Modelling		
Simulation Step	Simulation Step	0.45-0.90 s
Micro Reaction Time (Car)	Reaction Time	0.8-0.90 s
	Reaction Time At Stop	1.20 s
	Reaction Time At Traffic Light	1.35-1.60 s
Micro Reaction time (Truck and Bus)	Reaction Time	0.8-1.35 s
	Reaction Time At Stop	1.20-1.30 s
	Reaction Time At Traffic Light	1.60-1.70 s

Table 7-4: Dynamic traffic assignment settings in Aimsun Next

Type	Parameter	Suggested value
Dynamic User Equilibrium (DUE)		
Costs	Interval	Dependent on model size, should be less than the average model travel time
	Number of Intervals	1-3
	Attractiveness Weight	Dependent on model route choice calibration, can be of a value of up to 5 or more
	User-Defined Cost Weight	Dependent on model route choice calibration, can be of a value of up to 10[1]
	Path Cost	Experienced
Dynamic User Equilibrium	Model	Gradient-Based
Stopping Criteria	Maximum Iterations	Refer to Table 7-1
	Relative Gap	Refer to Table 7-1
Path Calculation	Calculate Additional Paths	Yes
Stochastic Route Choice		
Costs	Interval	Dependent on model size, should be less than the average model travel time
	Number of Intervals	1-3
	Attractiveness Weight	Dependent on model route choice calibration, can be of a value of up to 5 or more
	User-Defined Cost Weight	Dependent on model route choice calibration, can be of a value of up to 10[1]
Stochastic Route Choice	Model	C-Logit
	En-Route Path Update	Disabled
	Path Update After Virtual Queue	Disabled
Path Calculation	Initial K-SP	1
C-Logit Parameters	Scale	<1: trend towards utilising many alternative routes or >1: alternative choices are concentrated in very few routes
	Beta	0.15
	Gamma	1

[1] If the user-defined cost represents a toll, the user-defined cost weight should be the reciprocal of the value of time (in monetary units per second).

7.1.2 Calibration Parameters

There are several localised model parameters that can be adjusted in order to calibrate and validate the model. The following sections outline recommended parameters that can be considered at a section and node level.

7.1.2.1 Section Parameters

The following parameters are commonly adjusted at road sections to calibrate the model:

- *capacity* and *attractiveness*;
- *jam density*;
- *reaction time factor*; and
- *user-defined costs*.

7.1.2.1.1 Capacity and Attractiveness

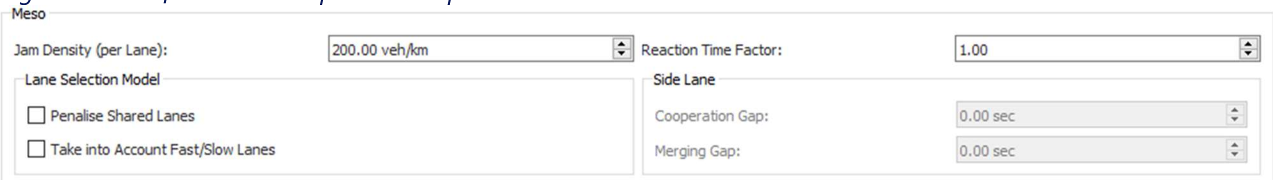
As there is no absolute *capacity* in mesoscopic or microscopic simulation. By default, section *capacity* is used as an indication of the *attractiveness* of a section. The higher the *attractiveness* (capacity) of a section, the higher traffic volume it attracts. *Attractiveness* is one of the main components in determining the dynamic generalised cost of an O–D pair if it has been considered in the dynamic assignment settings illustrated in Table 7-4.

As a starting point, Main Roads recommends using the section *capacity* parameters shown in Table 5-2 but adjustments may be required based on locally observed behaviours that could not be justified by other parameters. These changes must be documented in the *Base Calibration and Validation Report*.

7.1.2.1.2 Jam Density

Jam density is the maximum density that a lane in a section can reach. The queue on a lane is considered to be full when the lane reaches the prescribed *jam density* and, at that point, no further vehicles can enter the section. Figure 7-3 illustrates the mesoscopic dynamic parameters where *jam density* and *reaction time factor* are two major parameters that can be considered. *Penalise shared lanes* and *take into account fast/slow lanes* options can be selected to influence lane utilisation.

Figure 7-3: Default mesoscopic section parameters in Aimsun Next



The default value for *jam density* (per lane) is 200 veh/km but this physical capacity is considered high for Western Australian networks.

While *jam density* of 140 veh/km is recommended as a starting point for the entire modelled network, it can be adjusted to between 110 veh/km and 170 veh/km during the calibration stage based on observed behaviours. Any adjustments outside the recommended values must be documented in the *Base Calibration and Validation Report*.

7.1.2.1.3 Section Reaction Time Factor

The section *reaction time factor* is a localised parameter that multiplies the global vehicle reaction time. Figure 7-3 illustrates the default *reaction time factor* where adjustments can be considered under the following conditions:

- sections with a sharp bend to left or to right;
- sections with a high slope;
- weaving and merging zones to substitute lane-changing cooperation and aggressiveness parameters; or
- other situations liable to be influenced by the vehicle reaction time.

It is recommended that the default *reaction time factor* of one is used as a starting point. Changes can be considered during the calibration stage based on observed behaviours and must be documented in the *Base Calibration and Validation Report*.

7.1.2.1.4 User-Defined Cost

The *user-defined cost* allows modellers to define an additive component of the generalised cost that is not related to travel time at each link. *User-defined cost* is commonly used to express tolls at a static or dynamic level. It is recommended that modellers apply *user-defined cost* once other methods to calibrate the model have been exhausted.

7.1.2.2 Node Parameters

The following parameters are commonly adjusted at nodes and turns to calibrate the model:

- give-way factors;
- static turn penalty function (if static assignment has been adopted); and
- dynamic cost function.

It should be noted that the dynamic cost function is not a turn penalty but is applied from the entrance of the section before the turn to the exit of the turn.

7.1.2.2.1 Gap Acceptance Factors

The gap acceptance model is used to model give-way behaviours by taking into account the estimated collision point, the estimated time at which the vehicle with priority and the vehicle that has to yield reaches the collision point, and the safety gap. The mesoscopic gap acceptance model is a simplification of the microsimulation model.

The parameters that control the gap acceptance model are set globally in the road type editor or individually in the node editor. Although the defaults supplied by the road type may be overwritten, Main Roads recommends using the default gap acceptance factors as a starting point. Adjustments can be considered during calibration based on observed behaviours and must documented in the *Base Calibration and Validation Report*.

7.1.2.2.2 Turn Penalty Functions

Turn penalty functions can be applied at a static or dynamic level, and the recommended process is outlined in the following sections.

7.1.2.2.2.1 Static Penalty Functions

Turn penalty function (TPF) and *junction delay function* (JDF) for signalised and priority intersections was introduced in Aimsun 8.2. The signalised TPF introduced the ability to access control plan information so that signalised intersections can be considered in the static link cost calculation. Similarly, JDF applies to priority turning movements in order to calculate static turn capacity based on conflicting movements.

Figure 7-4 shows the default static model parameters for signalised and priority intersections. It is recommended that modellers apply turn penalty functions logically and consistently throughout the modelled study area. It should be noted that, by default, geometric conflicts between turns are automatically calculated and are used in the JDF cost calculations, but it is possible to manually specify the conflicts.

Figure 7-4: Static turn penalty functions

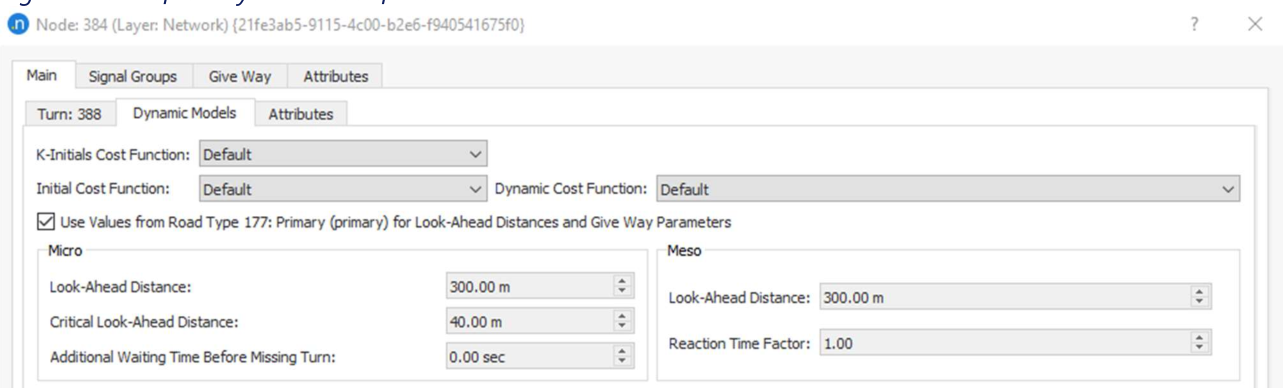
7.1.2.2.2.2 Dynamic Cost Functions

The default *dynamic cost function* is based on three components used to evaluate the generalised costs:

1. travel time;
2. attractiveness; and
3. user-defined cost.

Main Roads recommends using the default *dynamic cost functions* shown in Figure 7-5, whereby adjustments to the *attractiveness* or *user-defined costs* can be made to calibrate and validate the model.

Figure 7-5: Default dynamic cost function



It is recommended that turn penalty functions are applied logically and consistently throughout the modelled study area. *User-defined costs* may be applied thereafter to calibrate and validate the model.

7.2 Visum

Visum is a macroscopic and mesoscopic simulation software package. It is recommended for use as a mesoscopic modelling tool as it is able to perform dynamic assignment and to assess the performance of a larger transport network with precision in respect to demand, congestion and route choice. It can be used as a stepping-stone from a macroscopic to a microscopic simulation model.

This section describes key parameters within Visum and provides recommendations for their use in mesoscopic model development. Modellers should read these sub-sections in conjunction with Section 5 and Section 6.

7.2.1 Transport Systems/Modes/Demand Segment settings

Prior to the network build and travel demand set-up, modellers must set-up the *transport systems*, *modes*, and *demand segments*, which are linked to network objects and used as base segments for demands.

Main Roads recommends defining the *transport systems*, *modes* and, *demand segments* by vehicle type – car (C), medium (M), heavy (H), medium combination (MC) or large combination (LC) – and adopting the transport system parameters outlined in Table 7-5 as a starting point, depending on traffic assignment type.

Table 7-5: Recommended transport systems, modes, and demand segments

Transport System	Car	Medium	Heavy	Medium Combination	Large Combination
Type	PrT	PrT	PrT	PrT	PrT
PCU	1	2	3	4	5
SBA Reaction Time	1.35 s	1.35 s	1.35 s	1.35 s	1.35 s
SBA Effective Vehicle Length	7.3m	14.6m	21.9m	29.2m	36.5m
SBA Maximum Wait Time	120 s	120 s	120 s	120 s	120 s

SBA parameters are required for simulation-based assignment (SBA), while passenger car unit (PCU) values are required for other assignment methods.

7.2.2 Assignment Type

There are various traffic assignment methods embedded in Visum which can be broadly categorised into two types:

1. static assignment; and
2. dynamic assignment.

Taking into account the network sizes and purposes of mesoscopic models for Main Roads' projects, the following assignment methods are recommended:

- static assignment for assignment using intersection capacity analysis (ICA); or
- dynamic assignment for SBA.

The traffic assignment type selection should be based on the purpose of the project, as outlined in Table 7-6.

Table 7-6: Assignment types

Project Purpose/Network Size	Assignment with ICA	SBA
Simulation of green field area with land use and infrastructure upgrade in future years where route choice estimation is required for future years	Recommended	Permitted
Simulation of heavily congested network where oversaturation is present over a large part of the network for several hours	Recommended	Recommended
Simulation of networks with transient congestion effects, leading to route choice during assignment period	Permitted	Recommended
Simulation of network in presence of dynamic management and/or time varying access policies such as signal timing plans, lane usage permission	Permitted	Recommended
Simulation of incident effects and incident management	Not recommended	Recommended

Modellers must consider the purpose of the project when selecting assignment type. The assignment type must be documented in the *Methodology Report*.

7.2.3 Assignment Procedure Settings

This section outlines the recommended settings for procedure sequence and parameters for the assignment methods.

All calculation processes and their detail settings are set-up in the procedure sequence. Modellers are required to keep all used procedures in the *procedure sequence* and deactivate unused procedure in the final process.

7.2.3.1 Assignment with ICA Settings

The following sections outline the recommended parameters for assignment using ICA.

7.2.3.1.1 Input

When assignment using ICA is adopted, it is recommended that modellers consider the input parameters detailed in Table 7-7.

Table 7-7 Recommended blocking back model attributes

Attribute	Recommended Value
Saturation Flow Rate of Turns	1800 (Default)
Number of Lanes at Shared Lane	Share of Capacity for Each Turn
Minimum Capacity of Turns	10 * 1.0 (Default)
Use Link Capacity for Blocking-Back Model	X
Link Capacity Model	Capacity PrT
Number of Shares for the Flow Distribution	20 (Default)
Average Space Required Per Car Unit	7.30m

7.2.3.1.2 Assignment Convergence Criteria

In accordance with the model categories, it is recommended that modellers use WebTAG-compliant convergence criteria and adopt the termination conditions and attributes outlined in Table 7-8.

Table 7-8: Assignment with ICA convergence guidance

Parameters	Category 1	Category 2	Category 3
Maximum Iterations	50	50	50-100
Maximum Gap	0.001	0.001	0.001
Link Volume Less Than	1	1	1
- Share of Links (%):	95	95	95
Link Impedance Less Than	1	1	1
- Share of Links (%):	95	95	95
Turn Volume Less Than	1	1	1
- Share of Turns (%):	95	95	95
Turn Impedance Less Than	1	1	1
- Share of Turns (%):	95	95	95
Ignore Links and Turns with a Volume Less Than	5	5	5
Consider Only Active Links and Turns	X	X	X
Number of Iterations Taken into Account for Convergence	3	3	3

7.2.3.2 Simulation-Based Assignments Settings

The following sections outline the recommended settings for convergence criteria and assignment time periods using the SBA method.

7.2.3.2.1 Assignment Convergence Criteria

For the SBA convergence condition, the termination conditions and attributes outlined in Table 7-9 can be adopted, based on model categories.

Table 7-9: SBA convergence guidance

Parameters	Category 1	Category 2	Category 3
Maximum Iterations	50	50	50-100
Relative Gap (%)	0.5%-2%	2%-4%	4%-6%
Maximum Number of Additional Iterations	5	5-10	10
Use Gridlock Avoidance	X	X	X

7.2.3.2.2 Assignment Time Period

Modellers should consider demand time series and model categories when defining parameters for assignment time period:

- assignment time period (from and to) should be defined based on demand data (demand time series); and
- extension time interval should take into consideration the network size and congestion, as convergence is only considered achieved in SBA if all vehicles leave the network in the last iteration (generally more than one hour is recommended for this value).

For time intervals used to balance and analyse time, the modeller can adopt the time ranges outlined in Table 7-10.

Table 7-10: Attributes for SBA assignment time period

Parameters	Category 1	Category 2	Category 3
Time Interval Duration for Balancing	5-15 min	10-20 min	15-30 min
Time Interval Duration for Analysis	5-10 min	5-15 min	10-20 min

7.2.4 Calibration Attributes

In general, calibration and validation require an iterative process of adjusting parameters and analysing model results. Adjustments are required until there is an acceptable level of confidence that the model reflects the on-street conditions. This section outlines the model attributes that could be considered for the model calibration.

7.2.4.1 Impedance Function

Using the default setting is recommended but modellers can consider updating the impedance calculation equation by adding other attribute such as *length* and *AddValues*.

7.2.4.2 Node Impedance Calculation

When assignment using ICA is adopted and model outputs show congested intersections are still more attractive than other intersections, the modeller can update the *maximum tCur* for different control types (e.g. from 10 min to 10 hr).

7.2.4.3 SBA-Related Attributes

When SBA is adopted and model estimated SBA capacity is not realistic, the modeller can consider updating the following SBA parameters to make the model better reflect observed traffic conditions:

- *SBA reaction time factor* – depending on site conditions, a value between 0.5 and 4.0 can be adopted.
- *SBA effective vehicle length factor* – depending on site conditions, a value between 0.5 and 1.5 can be adopted.
- *SBA critical gap/follow-up gap* – the gap times of turns/legs can be updated to replicate existing site conditions.
- *SBA merge weight* – for congested merging sections, an appropriate merge weight with the control type "unknown" can be applied to lane turns, taking into account the probability equation for a vehicle selection from a lane turn (*lt1*) below:

$$prob = \frac{SBA\ Merge\ Weight_{lt1}}{(SBA\ Merge\ Weight_{lt}\ +\ SBA\ Merge\ Weight_{lt2})}$$

7.3 Vissim

Vissim is a mesoscopic and microscopic multi-modal traffic flow simulation software package that is generally used as a tool to simulate real-world transport systems. It enables modellers to model and assess the performance of a wide range of transport modes including pedestrians, cyclists, freight, and public transport by simulating individual vehicles.

This section describes the key parameters within Vissim and provides recommendations for their use in mesoscopic and hybrid simulation model development.

7.3.1 Base Data Settings

The base data should be defined prior to building the models. The base data should include network settings, various vehicle types, vehicle classes and driving behaviours.

7.3.1.1 Vehicle Types and Classes

Vehicle types and *vehicle classes* are primary components of the model objectives. For accurate traffic assessment, modellers should define appropriate vehicle types and classes. Where required, the vehicle types and classes outlined in Table 7-11 can be used.

Table 7-11: Recommended vehicle types and classes

Vehicle Types	Vehicle Classes (Length)
1 Short	1 Short (up to 5.5m)
2 Short-Towing	2 Medium (5.5m-14.5m)
3 Two-Axle Truck	
4 Three-Axle Truck	
5 Four-Axle Truck	
6 Three-Axle Articulated	3 Long (11.5m-19.0m)
7 Four-Axle Articulated	
8 Five-Axle Articulated	
9 Six-Axle Articulated	
10 B-Double	4 Medium Combination (17.5m-36.5m)
11 Double Road Train	
12 Triple Road Train	5 Large Combination (over 33.0m)

7.3.1.2 Driving Behaviours/Link Behaviours

Link behaviour type can represent the different roadway classes in Western Australia. A *link behaviour type* is defined by a *driving behaviour type* with appropriate behaviour parameters. When defining *driving behaviour types* in mesoscopic models it is recommended that modellers adopt the values outlined in Table 7-12.

Table 7-12: Recommended meso parameters for driving behaviour

Meso Parameters	Reaction Time
Reaction Time	1.35 s
Stand-Still Distance	2.5m
Maximum Waiting Time	120 s

7.3.2 Assignment Settings

For mesoscopic simulation modelling, modellers should set-up appropriate mesoscopic assignment parameters. This section outlines the settings that should be considered.

7.3.2.1 File Settings

O–D matrices should be established for different vehicle compositions and time intervals. Modellers should ensure that simulation duration within the simulation parameters is consistent with the duration of the defined O–D matrices.

The definition for the *evaluation interval for cost calculation* and *routes search* should be based on the model network size and congestion level. As a starting point, modellers can consider adopting the time ranges outlined in Table 7-13.

Table 7-13: Recommended evaluation time for Vissim meso model

Category 1	Category 2	Category 3
10-15 min	15-20 min	20-30 min

7.3.2.2 Cost, Path Search and Choice

For *cost* and *path search and selection*, modellers can adopt the default settings as a starting point.

7.3.2.3 Convergence Condition

Convergence stopping criteria vary depending on the model category. Table 7-14 outlines the convergence requirements for different model categories, as described in Section 3.5.3. Once convergence has been achieved, the path file (*.WEG) and cost file (*.BEW) should be stored for use during all subsequent modelling and provided to Main Roads as part of the base model submission.

Table 7-14: Mesoscopic assignment convergence guidance

Parameters	Category 1	Category 2	Category 3
Travel Time on Path (%)	15 %	15 %	15 %
Required Share of Converged Paths/Edges (%)	90 %	85 %	80%
Required Number of Consecutive Converged Runs	4	4	4
Maximum Number of Iterations	50-100	50-100	50-100

7.3.3 Calibration Attributes

In general, calibration and validation require an iterative process of adjusting parameters and analysing model results. Adjustments are required until there is an acceptable level of confidence that the model reflects the on-street conditions. Model attributes that could be considered during the model calibration include:

- *Meso penalty* of nodes
- *Meso speed model* and *meso follow-up gap* of links
- *Meso critical gap* and *meso follow-up gap* of conflict areas

The values outlined in Table 7-15 can be adopted the critical and follow-up gaps for different movements.

Table 7-15: Recommended gaps for meso turns

Movement	Critical Gap (s)	Follow-Up Gap (s)
Left-Hand Turn	5.5	3.3
Straight Minor-to-Minor	5.5	3.3
Right-Hand Turn from Major Road	3.5	2.2
Right-Hand Turn from Minor Road	6.5	3.5
Channelised Left-Hand Turn	5.5	3.3
Entry into Roundabout	3.5	3.2

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