Operational Modelling Guidelines

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Contents

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Where the guidelines refer to Main Roads or a specific Directorate and further clarification on which branch or team is needed, or for any other enquiries, suggestions and feedback, please contact: omv@mainroads.wa.gov.au

Recommendation and Approval

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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.

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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Foreword

Main Roads is responsible for managing and operating the strategic road network within Western Australia. As part of this responsibility, Main Roads uses a range of operationally focussed traffic modelling tools to assess road network performance, optimise the road assets, develop operational strategies and plan for future development of the network in close collaboration with our Portfolio Partners and other stakeholders.

The capacity for the road network to cope with the ever-increasing demands of our State's growing population and mobility needs is a challenge. Main Roads considers it essential that impacts on the network are adequately assessed in order to *Keep WA Moving*. In this respect, accurate traffic modelling plays an increasingly vital role in the way we undertake our work in order to effectively operate the network.

I am very proud of the collaborative effort between the Transport Portfolio and industry in Western Australia in producing these Operational Modelling Guidelines. They will provide invaluable support to traffic modelling practitioners in achieving Main Roads' aspiration to provide world class outcomes for our customers through a safe, reliable and sustainable road-based transport system.

Approved by

Peter Woronzow, Managing Director of Main Roads

Acknowledgements

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The development of the *Operational Modelling Guidelines* was undertaken by the Network Performance Branch of Network Operations directorate at Main Roads Western Australia (WA):

- Hannah Saunders
- Rafael Carvajal
- Hector Lee
- TK Kim
- Miaad Khayatian
- Kevin Guo

A number of stakeholders were consulted in the development of this document, including:

Main Roads Western Australia internal stakeholders

- Network Operations
- Planning and Technical Services
- Infrastructure Delivery

Other Government stakeholders

- Department of Transport, WA
- Public Transport Authority, WA

Main Roads also acknowledges input from private organisations (including the software vendors) in the development of this document:

- PTV Group
- Aimsun
- JCT Consultancy
- Sidra Solutions

With the knowledge and expertise from stakeholders and private organisations, Western Australian specific parameters were sourced to provide better traffic modelling. Furthermore the modelling approach outlined in these guidelines were chosen, with consultation from the software vendors, in order to get best analysis of the data.

Definitions

Definitions of a number of terms used throughout this document are outlined below:

Term	Description
Aimsun	traffic modelling software developed by Aimsun (formerly TSS)
CCGs	common control groups
DoS	degree of saturation
DoT	Department of Transport, Western Australia
JCT	JCT Consultancy Ltd, developer of LinSig
JDF	junction delay function
LinSig	traffic modelling software developed by JCT
LoS	level of service
Main Roads	Main Roads Western Australia
MF	maximum flow
MMQ	mean max queue
NetPReS	Main Roads Network Performance Reporting System
NPD	Network Planning and Development, Main Roads
OD	origin–destination
OMV	Operational Modelling and Visualisation team, Main Roads
PCE	passenger car equivalent
PCU	passenger car unit
PRC	practical reserve capacity
PTA	Public Transport Authority, Western Australia
RIMS	Road Information Mapping System, Main Roads
RO&DS	Recognising Opportunities & Developing Solutions, Main Roads
ROM24	24-hr Regional Operations Model is Main Roads' strategic transport model
RR67	Research Report 67, publication by TRL describing a methodology for the prediction of saturation flow
SCATS	Sydney Coordinated Adaptive Traffic System
SCATSIM	Interface software to simulate SCATS
SIDRA	traffic modelling software developed by Sidra Solutions
STREAMS	Main Roads ITS control system
TCS	traffic control signal
TPF	turning penalty function
TRANSYT	traffic modelling software developed by TRL
TRL	Transport Research Laboratory (TRL Ltd), developer of TRANSYT
TWSC	two-way stop control
UGT	underutilised green time
VAP	vehicle actuated programming
VDF	volume delay function
VDS	vehicle detection station
Vissim	traffic modelling software developed by PTV
WA	Western Australia

1 Introduction

The Main Roads' *Operational Modelling Guidelines* has been developed by Network Operations directorate, with contributions from the Transport Portfolio, other directorates and external industry experts.

The objective of the guidelines is to ensure consistency in traffic modelling practice and to promote the production of accurate modelling outputs that will result in high-quality project design and assessment that transitions into operations.

The development of this document was influenced by a number of sources including:

- *Traffic Modelling Guidelines (Version 1.0)* - Roads and Maritime Services NSW
- *Traffic Modelling Guidelines (Version 3)* - Transport for London (TfL)
- *Model Audit Process (Version 3.5)* - Transport for London
- *Economic Evaluation Manual (Volume 1)* - New Zealand Transport Agency
- *LinSig User Guide* - JCT Consultancy
- *SIDRA Intersection 9 User Guide* - SIDRA Solutions
- *Vissim User Guide* - Planung Transport Verkehr (PTV)
- *Aimsun User Guide* - Transport Simulation Systems (TSS)

1.1 Document Structure

This document is designed to give a common structure for modelling submissions using Main Roads' currently supported traffic model software. It also provides guidance on the use of these software packages. The structure of this document is as follows:

- Section 1: Background and purpose
- Section 2: Traffic Operational Modelling Overview
- Section 3: LinSig Guidelines
- Section 4: SIDRA Guidelines
- Section 5: Vissim Guidelines
- Section 6: Aimsun Guidelines

This document focuses on:

- SIDRA and LinSig for isolated intersection analysis
- SIDRA and LinSig for deterministic network modelling
- Aimsun and Vissim for microsimulation modelling (isolated intersection or network modelling).

Additional documentation has been provided in the following appendices:

- Appendix A: Signal Data Information for Modelling
- Appendix B: Saturation Flow Information
- Appendix C: Future Traffic Demand calculations for Operational Modelling

It is intended that this document will be periodically reviewed and updated as required to ensure its currency, usefulness and relevance for practitioners and to incorporate innovative thinking and advancements in traffic and transport modelling.

It is essential for all users to review and familiarise themselves with Sections 1 and 2 of this guideline as these are applicable for all operational modelling projects.

1.2 Background

Western Australia has one of the world's most expansive road networks. Main Roads is responsible for the planning, delivery and management of a safe and efficient State Road Network. It does this by:

- Building the State's major government road infrastructure projects.
- Providing infrastructure and operations that improve road efficiency and result in improvements in traffic and freight service levels.
- Maintaining the State's major government roads, bridges, verges and reserves.
- Using technology to optimise the real-time management of the network and providing traveller information.
- Improving community amenity by developing roadside stopping places, incorporating public art into infrastructure and understanding the needs of all transport users.

- Providing world class outcomes for our customers through a safe, reliable and sustainable transport system.

Main Roads is also responsible for managing the operation and maintenance of all traffic signals within Western Australia. As part of this responsibility, Main Roads uses a range of analytical tools to assess road network performance and the impact of any road based transport schemes.

1.3 Purpose

The purpose of this document is to ensure consistency in traffic modelling practice and to promote the production of accurate modelling outputs that will result in high-quality project design and assessment that easily transitions into operations.

A number of Main Roads' policies and guidelines detail the need for traffic modelling assessment or define traffic modelling requirements, such as, *Vehicular Signals Policy* and *Traffic Signals Approval Policy* (refer to Main Roads website for copies of these policies).

The requirement for traffic modelling is also outlined by The Western Australian Planning Commission's *Transport Impact Assessment Guidelines* (August 2016) and in the *Transport Modelling Guidelines for Development in Activity Centres* produced by Department of Transports (DoT).

The Operational Modelling Guidelines provides guidance on how to build high quality operational traffic models. These guidelines may be also used for planning projects, development applications, traffic impact assessments, infrastructure upgrades, and traffic signal designs.

The modelling software sections of this guideline provides guidance for the modelling practitioner on what should be considered when building a traffic model using Main Roads supported software (LinSig, SIDRA, Vissim or Aimsun). These guidelines are designed to ensure consistency in the quality of all models received and assessed by Main Roads, so that a good baseline can be provided for assessment.

These software-specific guidelines require the reader to have an in-depth understanding of traffic engineering and modelling principles.

Whilst traffic modelling is recommended for scheme assessment it should be emphasised that the purpose of the model is for informed decision making and should not be used to predict the outcome of a scheme.

2 Traffic Operational Modelling Overview

This section provides key information for anyone undertaking traffic modelling that will be submitted to Main Roads. All modellers are encouraged to familiarise themselves with this section to ensure that the considerations outlined will be met in any existing situation or proposed model for any scheme that requires regulatory approval.

2.1 Purpose

This overview has been designed to provide guidance without being prescriptive or limiting the modeller in the development of their traffic model. The content has been designed to make the model scope and build requirements as transparent as possible for all parties without inhibiting the practitioner in the technical construction of the model. The subsequent modelling software guidelines describe current best-practice modelling techniques that should be applied to traffic modelling projects in Western Australia, however there is opportunity for flexibility and innovation as defined in Main Roads' guiding principles.

These guidelines are specifically for operational modelling in Western Australia and align with Main Roads' Guiding Principles and Values. At the discretion of Main Roads and where appropriate an alternative methodology could also be acceptable.

This guideline may be read in conjunction with the Main Roads' *Auditing Process for Operational Modelling* which describes the audit process of traffic models for Main Roads.

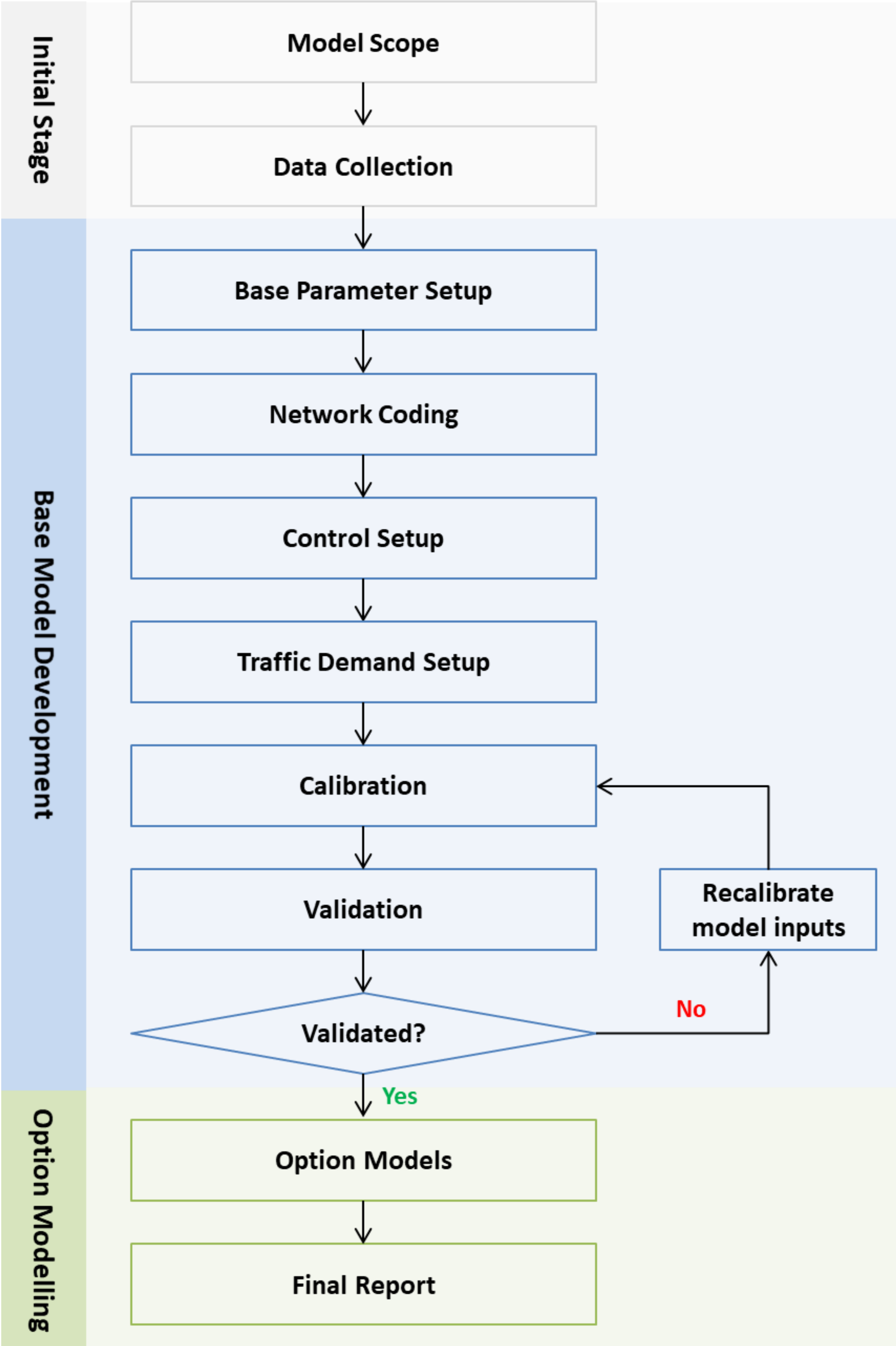
2.2 Operational Model

Operational models are normally developed for network performance assessment or for Traffic Signal Approval schemes, having scenarios with a maximum 10 year horizon (from 'opening'). The difference between an operational model, compared with a planning model for example, may be the level of detail, including calibration and validation requirements, as an operational model is expected to be used for detailed assessment. While a planning model may not need this detail at the planning stage, but may later be used for operational assessment, it is recommended at the scope meeting to determine appropriate model type to be developed.

2.3 Modelling Process

An overview of the modelling process is illustrated in Figure 2-1.

Figure 2-1: Overview of modelling process



The initial stages of the modelling process are important to confirm modelling requirements; it is recommended that a scope meeting is arranged with Main Roads. Examples of what can be discussed at the scope meeting can include but is not limited to:

- Modelling Purpose
- Available traffic models
- Study Area Selection.
- Data Collection and Analysis:
    - Modelling Periods.
    - Traffic, Signal and Onsite Data collection.
    - Analysis methodology.
    - Calibration and Validation methodology.
    - Gradient, Heavy Vehicle considerations and likely parameter adjustments.

Further detail and purpose of the scope meeting is described in more detail in the Main Roads Auditing Process for Operational Modelling.

2.4 Appropriate Use of Traffic Modelling and Model Expertise

As traffic modelling can be expensive, it is important to determine whether or not it needs to be undertaken in the first place. Preliminary analysis using first principles, simple analytical methods or site visits may be sufficient to confirm whether traffic modelling is required.

If traffic modelling is required, the next step is to determine the most appropriate level of modelling. Both the appropriate level of modelling and use of the right software are critical to the success of a modelling project, otherwise poor project outcomes, as well as significant cost and delays, may result. Section 2.5 details the modelling software supported by Main Roads and its appropriate use.

Once the appropriate level of modelling and software type has been agreed, the level of detail and the accuracy of a model must be considered. The detail required will depend on the model's intended purpose and the project's objectives will directly influence the type and extent of the modelling required.

The quality of the modelling inputs will be reflected in the quality of the outputs. Main Roads' *Operational Modelling Guidelines* (hereafter referred to as *Operational Modelling Guidelines*) provide modellers guidance of input data required to develop an accurate model.

Throughout a project, a model may pass through a number of development phases and at each stage the required level of detail and modelling accuracy may increase. Common stages of development may include, but are not limited to:

- assessment stage,
- business case for funding,
- option testing,
- developing the preferred option, and
- project scheme approval[1].

To avoid inaccurate traffic modelling, the person(s) involved in developing traffic models must have the following:

- In-depth knowledge of traffic engineering and modelling,
- Considerable modelling experience using the relevant software,
- Considerable experience in on-site data collection for traffic control parameters including saturation flows, queues, degree of saturation, lane utilisation identification, exit blocking and wasted green measurement, and
- An excellent understanding of traffic signal control principles, design and operational requirements (for new traffic signals or traffic signal modification).

[1] Not all projects will be developed to the point where approval is sought.

2.5 Main Roads Supported Traffic Modelling Software

Specific modelling software is supported by Main Roads to ensure internal reviews can be carried out with confidence. To guide the modeller, Main Roads has developed documentation outlining its preferred approach to model development, standard model parameters, model considerations and calibration and validation requirements.

Examples of supported software and its typical uses are detailed in Table 2-1.

It is noted that each software package may have certain modelling limitations. Main Roads has therefore recommended the most appropriate use in the table below.

Table 2-1: Main Roads supported traffic modelling software

Software	Use
LinSig	For existing or proposed signalised intersections or networks: • traffic signal design • traffic signal modification • traffic signal timing improvement.
SIDRA	To analyse feasible intersection types such as: • roundabouts • priority controlled • traffic signals.
Vissim / Aimsun	Where modelling in LinSig or SIDRA is too simplistic: • demand dependant phase sequence e.g. bus priority • mix of different intersection control types • heavy vehicle impacts • uneven lane utilisation • weaving/merging behaviours • exit blocking • critical links operate near or above capacity • ramp and roundabout metering To analyse significant infrastructure upgrades When the project requires significant stakeholder and public consultation where visualisation would be useful / necessary

LinSig and SIDRA (analytical models) will always model more simplistically compared to Vissim and Aimsun (simulation models). Main Roads is aware of these limitations; it is encouraged at the scope meeting with Main Roads that the consultant confirms appropriate use of software for the project.

It should also be noted that LinSig or Sidra may be used for signal timing inputs into simulation models, similarly Vissim or Aimsun may be used as traffic flow input into analytical models. The level of model detail for these models should be discussed at the scope meeting.

2.6 Use of Main Roads' Traffic Models

If available, third parties may request the use of existing traffic models (LinSig, Vissim or Aimsun) from Main Roads as a way to reduce model development time and costs.

The Operational Modelling and Visualisation (OMV) team is developing a traffic model library where all traffic models used by Main Roads and / or is part of the review process are stored in one central location and if appropriate can be provided to external parties for further update, which may reduce model development time and build costs.

It is important to note that if available, the provided model is only a starting point for model development process. Therefore, the model parameters and input data from the supplied model should not be relied upon and Main Roads expects the data to be updated to reflect the requirements specified for the project.

When using the traffic models available from Main Roads, the applicant should be aware of the following terms and conditions:

1. The traffic models should not be used for any purpose other than the stated purpose for which it was requested from Main Roads.
2. It is the responsibility of the modeller to verify parameters and ensure accuracy of the model.
3. The traffic models should be used by an experienced/qualified modeller, who would refer to *Operational Modelling Guidelines* when developing, updating and verifying calibration and validation of the supplied traffic model to suit the project.

The Traffic Model Request form is available for download on the Main Roads website and can be emailed to the OMV Team[2] at omv@mainroads.wa.gov.au.

2.7 Desktop Network Familiarisation

Before commencing any modelling work, the modeller should familiarise themselves with the area to be modelled. Examples of ways for the modeller to gain an initial understanding of the area prior to undertaking a site visit (Refer to Section 2.10.2) include:

- Meet with the Project Manager to have a full understanding of the project and any relevant background information
- Inspecting aerial photography and mapping
- Examining local land use data
- Collating and inspecting available traffic data to ensure adequate data is collected and it is reliable and consistent
- Collating recent or planned network or traffic control changes
- Identifying surrounding network restrictions, construction activities and way-finding signage

[2] ROM24 Traffic Model data for future traffic flow calculations can only be requested for Main Roads projects or through Local Government and cannot be obtained by the OMV team. Refer Section 2.10.8.2.1.

2.7.1 Main Roads' Traffic Data

A selection of traffic data is available from the Main Roads website.

Available data may include:

- Traffic count data for the Perth Metropolitan area:
  - SCATS detector traffic volume data and metro count data available from *trafficmap*.
  - Custom date SCATS detector traffic volume data requested via Enquiry Form selecting SCATS – Traffic Volumes and Signal Data from the *What does this relate to* drop down menu).
- Traffic control signal information:
  - SCATS signal data available from *trafficmap*.
  - Custom date SCATS signal data requested via Enquiry Form selecting SCATS – Traffic Volumes and Signal Data from the *What does this relate to* drop down menu. Further information on Traffic Signal Data is discussed in Appendix A.
- Crash Analysis Reporting System (CARS) data.
- Road Information Mapping System (RIMS) – provides information on the road hierarchy (local or state road) and posted speed limits.
- Restricted Access Vehicle (RAV) mapping system – provides information on heavy vehicle routes (Note: if a route runs through the site being modelled it is important that heavy vehicles are modelled as they will have an impact on intersection performance).

2.8 Study Area Selection

The modelling study area should be determined taking into account considerations including, but not limited to:

- proximity of neighbouring intersections,
- impact of vehicle platooning on intersection performance,
- traffic congestion and queueing in and around the site,
- existence of merging / weaving sections,
- impact of acceleration profiles (e.g. heavy vehicles) on intersection performance, and
- road gradient on all intersection approaches.

It is recommended that the study team consult with Main Roads' Network Operations directorate to define, and / or confirm the appropriate study area prior to undertaking modelling assessments.

2.9 Modelling Periods

The time periods to be modelled should be determined by reviewing the traffic volume profile in the core of the study area, and are typically weekday AM and PM peaks, however, off-peak or weekend may be required to be modelled depending on the scope of modelling and nature of the study area (e.g. shopping centre, airport or construction sites). These periods should be agreed with Main Roads' Network Operations directorate prior to commencing modelling.

2.10 Data Collection and Analysis

To develop a traffic model to the standards required by Main Roads, the modeller must conduct site visits for each time period being modelled in order to:

- Familiarise themselves with general traffic conditions and the surrounding environment.
- Confirm the accuracy of supplied drawings.
- Understand how the intersection/network operates in terms of traffic behaviour, capacity and safety.
- Collect accurate data for developing the calibrated model and validating the base model.

While some of the data required in the development of the traffic model can be collected by third-party survey companies, there is certain data which should only be collected by an experienced modeller to ensure accurate data collection. In addition, all third-party survey data should be checked thoroughly by an experienced modeller with local area knowledge to ensure that it is fit for purpose.

2.10.1 Data Accuracy

Collection of high-quality, accurate traffic data, network characteristics and site observations is extremely important for the development of any traffic model. A significant amount of data collection will be required to produce well-calibrated and validated models.

Modellers should be satisfied with the accuracy of all data used for modelling purposes and ensure that it is included in the modelling report.

All traffic volume data should be checked thoroughly by someone with local area knowledge to ensure validity as there is significant potential for error when collating large volumes of traffic data. The raw data collected should be provided as part of the model submission.

Ideally, all data collected, all observations made and all measurements taken should be on the same day. As this may not be possible, particularly across networks where all data collection and measurements need to be undertaken across multiple sites in one peak hour, it is recommended that surveys be designed to capture as much information as possible by video so that observations and measurements can be made off-site without time restrictions.

2.10.2 Site Observations

Site visits should be carried out during traffic count surveys to collect relevant calibration and validation data and ensure site conditions remain typical. These visits are important as travel time, degree of saturation and queue length surveys should ideally be conducted while traffic counts are taking place. Multiple factors, such as traffic management, may have an impact on survey results and it is important that these, in addition to the usual weather and incident reports provided by survey companies, are identified.

A range of data can be collected and recorded while on-site. To assist in the calibration and validation of the traffic models, it is important that site data, SCATS traffic data and signal data is requested for the same day that the traffic surveys are undertaken.

2.10.2.1 Typical Traffic Conditions

When collecting traffic data, it is important that the data collected represents typical conditions and that the network is operating normally. It is necessary to avoid collecting traffic data at particular times of the year, on particular days or when incidents, works or bad weather could have an impact on traffic demand, traffic patterns or driver behaviour. When possible, data collection should be avoided during:

- Mondays and Fridays,
- school or university holidays,
- public holidays,
- roadwork or temporary road closures,
- bad weather,
- events (for example, demonstrations or festivals),
- traffic incidents, and
- faulty operation of traffic signals.

When organising traffic surveys, the modeller or their representative should contact Main Roads' Network Operations directorate to ensure that normal traffic conditions are expected during data collection periods. As unplanned incidents may occur, a contingency plan to collect data at a later date should be made.

Incidents, traffic signal faults, roads works and events affecting road networks are published externally in real time during incident operations in Main Roads' Travel Map to inform and assist road users with planning their journeys. These incidents are also logged by Main Roads' Incident Information Management System (WebEOC).

Data should be collected for all critical time periods to be assessed. The time periods to be assessed should be defined in the project brief and at least three hours of data should be collected for each peak period (AM or PM) to ensure that both the peak period and the shoulder of each peak is also captured. SCATS traffic data may be used to identify the peak hour(s), which may assist the modeller in specifying the period when the traffic survey should be undertaken.

2.10.2.2 Stop Line and Non-Blocking Storage

Storage in front of the stop line is an important input for traffic models, particularly for filter movements and also where left-turning traffic is required to give-way to pedestrian movements. The practical storage in front of the stop line, and non-blocking storage at mixed lanes, should be observed and recorded as part of the site visits. In SIDRA, storage does not need to be observed, instead free queues are observed to confirm the number of vehicles in a lane that may then block traffic movement.

2.10.2.3 Lane Utilisation

In some circumstances, lane usage may be incorrectly assigned in the traffic model compared to what is observed on-site. This may occur for reasons including:

- when a short turning lane blocks the through traffic lane,
- exit blocking,
- on street parking,
- on street bus stops,
- bus lanes, and
- drivers familiarity with the local network.

The modeller should observe the actual lane utilisation when on-site, so that the model can be calibrated appropriately.

2.10.2.4 Exit Blocking / Underutilised Green Time

When on site, it is important to check whether the study area is being affected by exit blocking which typically results in the green time allocated to some movements not being utilised effectively at traffic signals.

Exit blocking refers to traffic at the stop line that has a green signal but cannot cross and exit the intersection or when full saturation flow is impeded. An example of exit blocking downstream could be traffic congestion at the next intersection downstream causing long queues to extend back to the study intersection. If exit blocking is observed, it is important to note what causes the blocking and how much traffic is being blocked (the surveyed traffic crossing the stop line may differ to actual demand at the intersection and should therefore be included in the model to make sure the validation of the model is correct).

Underutilised green time (UGT) refers to the amount of green time in a signal cycle that traffic is unable to discharge across the stop line at saturation flow rate despite the presence of full demand. UGT is measured in seconds and is calculated when measuring the degree of saturation.

There are two types of UGT:

1. ‘Wasted green’ is when traffic wants to cross the stop line but cannot proceed due to downstream blocking.
2. ‘Sub-saturation flow’ is when traffic crosses the stop line at flows lower than the saturation flow, meaning the full capacity of approach lanes is not being used. This can be caused by a number of factors including signal offsets, driver behaviour or downstream blocking.

The appropriate modelling parameters should be modified as part of the calibration process to take into account the observed UGT.

2.10.2.5 Degree of Saturation

Degree of saturation (DoS) is generally used to validate LinSig and SIDRA traffic models.

Ideally, a DoS survey should be undertaken on all critical approaches for each modelled period, concurrent with all other traffic surveys. In order to achieve a sample that is representative across a modelled period, sample data should be evenly spread across the whole period to be modelled.

2.10.3 Saturation Flow

Saturation flow is defined as the maximum flow that can be discharged from a traffic lane when there is a continuous green indication and a continuous queue on the approach. It is an expression of the maximum capacity of a lane and can be influenced by a number of factors, including road geometry, topography, visibility and vehicle classifications e.g. heavy vehicles.

Saturation flow is a key parameter in traffic modelling and the accuracy of lane saturation flow has significant impacts on model output. Where possible, Main Roads requires that saturation flows of the critical lane(s) of each approach are measured on-site.

Refer to the Saturation Flow Information document (Appendix B of this guideline) for guidance on how to measure saturation flows. It is available to download from the Main Roads website.

2.10.4 Cruise Time

For network models, cruise time is an important input to determine the current performance of existing offsets and optimum offsets. Cruise time refers to the typical un-delayed time taken for a vehicle in the middle of a platoon to travel between stop lines (assuming that no delay is encountered as a result of traffic signals).

As it may be difficult to obtain accurate free-flow cruise times in congested conditions, cruise time should be measured on-site, from stop line to stop line, ideally outside of the peak period.

If it is not possible to measure the cruise time from stop line to stop line, another method is to measure a free-flowing section of the link/route and then extrapolate for the whole link/route distance, based on the relative lengths of the free-flowing and congested sections.

If there is reasonable justification for not measuring cruise times on-site, the posted speed limit may be used instead. This option should be considered as a last resort, as each site can be affected by external factors associated with the study area and the use of the posted speed limit might unrealistically improve or reduce corridor performance.

2.10.5 Travel Time[3]

A common technique used to assess the accuracy of a microsimulation model is to compare surveyed and modelled travel times along key routes in the study area. This is an important comparison since travel times can affect driver route choice and have a significant impact on traffic volumes, contributing to delays and congestion. All travel times should be collected under ‘normal’ network conditions, free from incidents and events. Traffic surveys should also be undertaken on a neutral day (Refer to Section 2.10.2.1) in order to capture typical traffic behaviour and levels of congestion.

When collecting travel time data, it will be necessary to disaggregate the route into smaller predefined sections so that the location of key delays within the overall travel time can be easily identified. These sections may be defined as being the distance between intersection stop lines in an urban area. Travel time surveys should be undertaken on this basis, unless alternative approaches are discussed and agreed with Main Roads.

If private transport travel time measurements are required for microsimulation validation, these should be performed using the ‘floating car’ technique. The ‘floating car’ technique involves one or more survey cars driving along prescribed routes within the study area and recording travel times for the predefined sections. The survey car(s) should attempt to balance the number of vehicles overtaking with those being overtaken, while remaining within the speed limit. Where stop lines are used to define the sections of a route, travel time measurements should begin and end immediately after crossing the stop lines. These segmented travel times provide valuable information with respect to signal coordination and queue delay, which may be useful during later model development.

[3] Some content in Section 2.10.5 has been adapted from the Roads & Maritime Services’ *Traffic Modelling Guidelines* and reproduced with permission.

Make sure that a sufficient number of travel time samples have been undertaken during the data collection stage of the study. This will provide an accurate understanding of:

- average travel time for each route
- variability in travel time for each route.

It is recommended that at least six observations are needed in order to derive a statistically reliable estimate of average travel time. Collecting multiple travel time observations also allows analysis of travel time variability (range, maximum, minimum and standard deviation). This information is useful to compare against model outputs during base model validation.

Main Roads supports and encourages use of new and innovative technologies for collection of travel time data, including the use of GPS or other similar data sources.

In addition, Main Roads may have travel time data for specific routes and may be able to provide access to this information. If so, this data should be disaggregated into sections. The use of sections allows a cumulative graph of travel time along the route to be developed. This type of graph can provide an accurate analysis that demonstrates how the model is performing in each key section, rather than simply providing a total travel time.

2.10.6 Queue Length

Queue length data can be collected on-site and compared against modelled outputs to provide an indication of how accurately the model replicates congestion on approaches to key intersections in the model.

Although queue lengths are generally used to validate traffic models, the issues with both queue calculation within traffic models and accurate on-site measurement have been well documented. Despite these limitations, queue length data does provide a measure of intersection performance and un-serviced demand.

If queue lengths are to be collected as part of traffic surveys for use in model validation, the following should be considered:

- Queue lengths should be measured at the start of green period. A minimum of 10 samples should be collected across the peak hour. They should be collected on the same day as the traffic survey.
- Accurately identifying the length of the queue can be problematic as it can be difficult to determine whether a vehicle is queued or not, and queue lengths are likely to be subject to significant variation across a data collection period.
- Queue lengths become highly variable on approaches that are operating at or close to capacity; under these conditions it can be challenging to provide an accurate prediction of queuing traffic when using intersection software such as LinSig and SIDRA.

The level of accuracy in queue measurement surveys can often be lower than for other surveys as the definition of a queue can be ambiguous as well as difficult to identify.

Furthermore, counting or calculating queue lengths is a subjective exercise since queued vehicles will often still be moving slowly and it will not always be clear what criteria should be used to constitute a queue. Also, since data is likely to be collected by a number of surveyors, it is unlikely that consistent and accurate reporting will be possible across the study area.

2.10.7 Existing Traffic Counts

Traffic surveys can be performed on-site by manual counters, using fixed location video cameras. Wherever possible, traffic counts should be recorded on the same day at all modelled intersection and for all modelled periods. In some cases it may be acceptable to use flow-factoring techniques, based on flows recorded during another representative peak, but approval should be sought from Main Roads before applying this technique.

Main Roads should be contacted before commencing road traffic counts in order to establish current best-practice for data collection and to ensure data formatting complies with Main Roads' requirements. For certain projects 24-hour turning count traffic surveys are required however where the project is a short term low cost improvement usually for local road suburbia areas, 24-hour surveys may not be needed. Traffic survey requirements can be confirmed at the scope meeting, when commencing the modelling process.

2.10.7.1 Time Period and Duration

The time and duration of the peak period to be modelled will be determined from the survey count data. This should represent the time within the survey period during which the largest total volume of traffic was observed. Although a modelled peak period is typically one hour, longer peaks may be appropriate where necessary.

To help minimise survey costs, historical traffic data can be used to identify the likely period when the peak hour will occur. Historical data can also be used to determine seasonal traffic fluctuations, variations in traffic demand during school holidays or public holidays and actual travel demand on an average weekday.

Types of historical data that can be used include:

- Classified turning traffic count surveys.
- SCATS traffic data (this can be requested from Main Roads using the SCATS request form if this is not available on *trafficmap*).
- Metropolitan traffic count data (available through the Main Roads' reporting centre).

2.10.7.2 Un-met Traffic Demand

Un-met traffic demand is generally the remaining queue of vehicles which could not pass the stop line at the end of the study period. When traffic signal green time is short or exit blocking exists, a traffic count at the stop line may not represent the actual demand for the movement. In these situations, the traffic demand should be captured from the upstream links or estimated from the residual queues.

2.10.7.3 Site Survey Classification

Site Survey Classified turning counts should be obtained at each intersection, with light vehicles and heavy vehicles being surveyed at a minimum. It is recommended that Austroads' vehicle classification system is applied as shown in Table 2-1Table 2-2. Pedestrian counts should also be carried out if required. Traffic survey requirements should be agreed with Main Roads' Network Operations directorate prior to any data collection being carried out.

Table 2-2: Austroads Vehicle Classification

Austroads Class	Vehicle Type
1	Short Vehicle
2	Short Vehicle Towing
3	Two axle truck
4	Three axle truck
5	Four axle truck
6	Three axle articulated
7	Four axle articulated
8	Five axle articulated
9	Six axle articulated
10	B-double
11	Double road train
12	Triple road train

2.10.7.4 Vehicle Detection Stations

Main Roads has a system of Vehicle Detector Stations (VDS) collecting real time freeway traffic data. The data is used for traffic management functions (detecting incidents, traffic flow information) and is archived in STREAMS and NetPReS for planning and historical analysis.

Detector stations are typically "in-pavement" sensors configured to measure and collect volume, occupancy and speed on a lane-by-lane basis.

Advantages of VDS are:

- high sampling rate (clocse to 100 per cent),
- high temporal resolution (up to one minute), and
- measures speed, occupancy and volume.

VDS sensors are spot measurements and may not accurately reflect upstream or downstream conditions in stop/start traffic.

VDS data can be provided to Main Roads or external consultants engaged by Main Roads on request.

2.10.7.5 Network Traffic Surveys

For networks with complex route choices, an Origin–Destination (OD) survey may be more appropriate. The chosen approach will depend on the road network being modelled and the type of software being used.

Using an OD survey improves data accuracy and reduces the time required to analyse traffic surveys taken at individual intersections. As OD surveys are expensive, an alternative option is to carry out a desktop analysis of individual surveys and create a traffic flow network for each period being modelled. When using this technique, the following should be considered:

- Check to see whether traffic leaving one intersection arrives at neighbouring intersections. If there is a discrepancy of more than five per cent between intersections, the modeller should augment the classified counts with short site surveys to determine if there are other major sinks and sources of traffic (for example, side roads, car park entries and exits) that were not captured in the original survey. If sinks or sources are found, 15 minute spot counts should be conducted in order to estimate hourly flow rates.
- Analysis of traffic flows across the network as a whole may identify a particular count site as being in error (for example, if flows at neighbouring survey sites are inexact by a similar value). Where a manual counting error appears to have been made, the higher flow count from adjacent survey sites should be used, as it is more common for errors to be the result of under-counting than over-counting. This also represents the worst case scenario as far as the network is concerned, as the highest observed flow will be modelled.
- ROM24's base year model data may be used as a form of calibration if a desktop study was carried out to determine the OD movements of the intersections combined as a network. If ROM24 data is available, a sub-area matrix from the model may be extracted for the study area.

2.10.7.6 Heavy Vehicles

When undertaking traffic counts, light and heavy vehicles must be considered (Refer to Section 2.10.7.3). A detailed breakdown of heavy vehicle may be required where heavy vehicles are found to have a significant impact on intersection/network performance, such as:

- restricted access vehicles (RAV) routes,
- around construction sites,
- freight routes, and
- commercial areas.

Confirm Main Roads' requirements on heavy vehicles data collection prior to any surveys being carried out. It may be necessary to categorise the vehicles using the Austroads and/or restricted access vehicle (RAV) classification system.

In Western Australia, heavy vehicles tend to be larger than the default vehicles used in some traffic model software. As such, it is important to confirm whether the heavy vehicles that pass through the study area are modelled correctly. Depending on the model software, the following may need to be considered:

- gap acceptance(s),
- loaded mass (kg) and engine power (kw),
- deceleration and acceleration,
- speed acceptance, and
- clearance (m).

2.10.8 Future Traffic: Growth Factor Techniques

There are various methods that can be used to forecast traffic flows for input into traffic models. At Main Roads the following methods are generally considered:

- historical growth
- strategic model growth.

2.10.8.1 Historical Growth

The historical growth method uses historical data to confirm what the annual traffic growth has been in the area. Historical traffic data tends to be used to identify the growth using Metropolitan traffic count data, SCATS traffic flows or turning count survey data. This provides a basis for understanding changes in traffic growth patterns.

Where strategic model data is not available or deemed unsuitable, analysis of historical traffic growth data is often used to carry out short to medium term modelling.

2.10.8.2 Strategic Model Growth

Calculating traffic growth using a strategic model may provide a more accurate analysis of the likely future traffic flows within the study area. Generally, strategic models take into account future land use, road upgrades and public transport schemes along with other factors that influence trip generation and trip distribution which are not be represented in historical data.

Main Roads' strategic models such as ROM24 can be used for calculating traffic growth. DoT's Strategic Transport Evaluation Model (STEM) is another model that may be used for growth rate estimation. Access to either strategic model is restricted to use in government-related projects, with the exception of projects where there is likely to be significant impacts on local or state roads.

Furthermore, Strategic Models cover large areas and whilst it includes the major road sections, not all minor roads are coded into the model. This results in more traffic on links than expected therefore turning volumes at intersections, particularly for the peak period, should not be relied upon. It is important with outputs from Strategic models that some adjustment is applied to the data; this is discussed further in Appendix C, however confirmation on the agreed process is also discussed during the scope meeting.

2.10.8.2.1 ROM24

ROM24 (24-hour Regional Operations Model) is Main Roads' strategic transport model. It covers the entire Perth Metropolitan region from Yanchep to Mandurah and used to model travel demand patterns based on different land use, transport and pricing scenarios.

Based on land use data provided by the Road Planning Branch, ROM24 currently has separate models for 2016, 2021, 2026, 2031, 2036, and 2041 which are regularly updated.

ROM24 provides forecast traffic volumes for each peak of an average weekday, as well as for the full 24-hour period. As data is generally considered to be most accurate when taken over the full 24-hour period, daily forecast traffic volumes are used in most situations. In some situations the use of peak period forecasts (for example, 7am-9am or 6am-9am and 4pm-6pm or 4pm-7pm) may be more appropriate.

A wide range of data outputs can be generated from ROM24 including:

- Zone boundaries map to show how land is divided, and what land use is assumed for each zone. Zone boundaries can be requested with centroid connectors so that the modeller may understand how traffic is loaded onto the road network.
- Link volume plots − provides modelled forecast traffic volumes for each direction on each road link for a selected model area.
- Turning volumes diagrams (24-hour only) − provides intersection turning movement volumes at any intersection represented in the modelled network.
- Select link plots − plots the distribution of total traffic flows across the network using a specific selected link. This can be used to determine traffic distribution and re-routing.
- Sub-area matrices – provides a matrix of traffic flows within a specifically requested sub-area of the overall model. Sub-area matrices are useful in the determination of trip distribution in the specified sub-area model network and can be used to calculate the overall modelled growth rate for the selected sub-area.

When ROM24 data outputs have been provided by Main Roads, it is the responsibility of the modeller to calibrate the ROM24 data before future traffic flows are determined.

ROM24 outputs can only be requested for Main Roads' projects or via Local Government. ROM24 requests can be submitted to TMS@mainroads.wa.gov.au, Asset & Geospatial Information Branch, Planning and Technical Services Directorate.

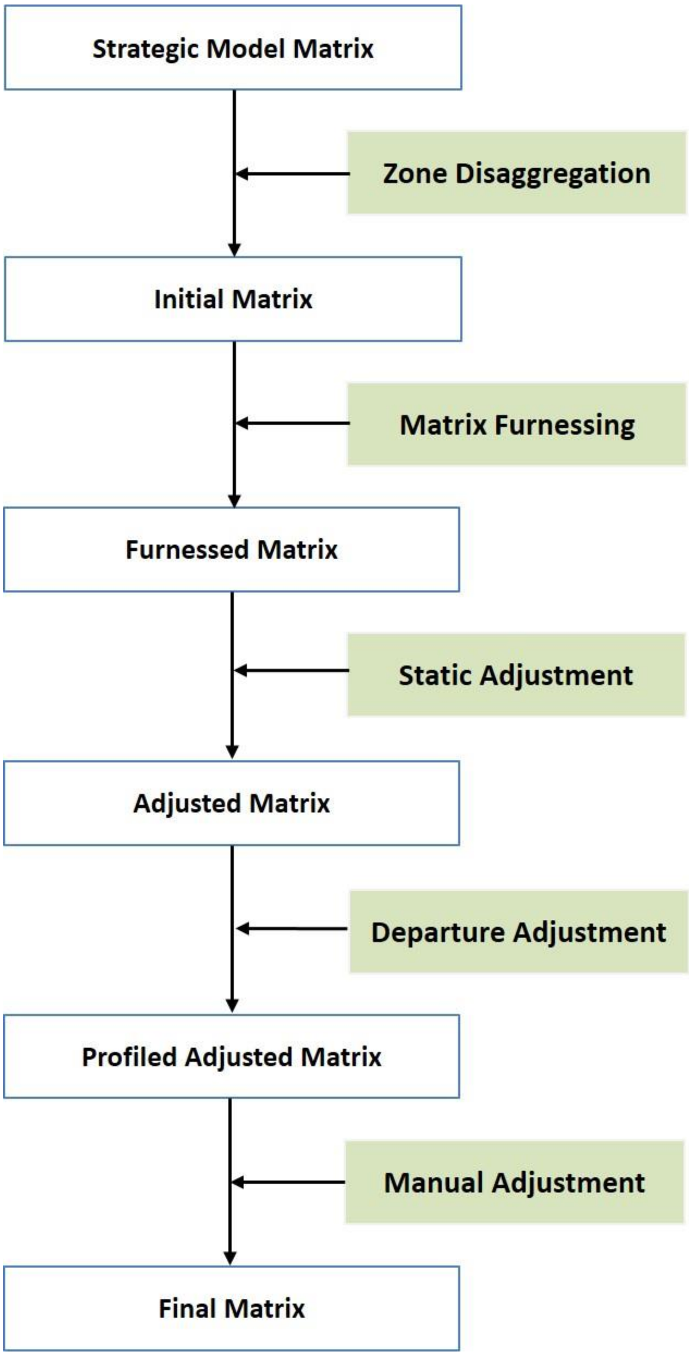
Main Roads' *Future Traffic Demand calculations for Operational Modelling* (Appendix C of this guideline) includes guidance on how ROM24 data can be used to calculate and determine future traffic flows for the traffic model. In addition to future traffic flow data, the outputs can provide a better understanding of existing traffic behaviour and trip distribution.

The intention of the Appendix C is to provide guidance in future traffic flow calculations for projects submitted directly to Main Roads' Network Operations Directorate (e.g. council submitted projects for traffic signal approval). Future traffic flow methodology and approval within Main Roads depends on the project; as there are several methods for calculating future traffic flows, it is important that the most appropriate method is discussed and agreed upon at the scope meeting.

2.10.9 Traffic Demand Estimation from Strategic Model

If traffic demand is based on the strategic model, it is recommended that the demand matrix is developed from cordoned strategic demand data. Figure 2-2 below outlines the process for estimating traffic demand:

Figure 2-2: Demand estimation methodology



2.10.9.1 Trip Balancing

As part of the development of the model, surveyed count data, SCATS counts data and other count data should be analysed to develop an indication of volumes at locations throughout the network. As the count data is usually collected from different sources and at different times, there may be discrepancies between the upstream and downstream flows on some road sections. The counts should be carefully balanced to minimise these differences without excessively distorting the collected data.

2.10.9.2 Matrix Furnessing

The prior matrices should be adjusted to reflect the collected survey data using the Furness method. The Furness method of matrix updating is an iterative process 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 OD pairs should be fixed to known survey values or established during the calibration process.

2.10.9.3 Static Adjustment

Static adjustment is a procedure that should be used to calibrate an OD matrix, from a prior matrix, using available section/detector traffic counts or turn traffic counts. The solution algorithm is based on a bi-level model solved heuristically by a gradient algorithm, and includes an assignment during each iteration.

In order to achieve a consistent route choice outcome, it is important that the modeller uses the same settings for static OD adjustment as for the static assignment.

Matrix elasticity is a value between ‘0’ and ‘1’ which indicates the elasticity of the adjusted matrix in regard to the original matrix. A ‘0’ value means that no variation is allowed and ‘1’ value means no variation is penalised. A value of ‘0.5’ adds the objective of keeping the original total demand value per cell per user class to the algorithm with the same weight of the objective for matching detection. The recommended value should be between ‘0.5’ and ‘1’.

Maximum deviation permitted should be set up for matrix adjustment. Tests should be carried out to compare different scenarios using different *maximum deviation permitted* values. The scenario which achieves the best GEH results (refer Section 2.12.2.2) without significant change to the general composition of the prior matrix should be applied.

Reliability can be set up to apply different weights to different data locations. If no *reliability* values are set, they are taken as ‘1’ by default and the adjusted weight values become the final reliability. Generally, different reliability values should be used for data sets from different sources.

2.10.9.4 Departure Adjustment

Departure adjustment is a procedure that should be used to create a profiled demand from a static demand. To obtain profiled demand, the original static demand should be distributed through smaller time intervals (for example, every 15 minutes) over a simulation period. The objective is to reproduce the observed traffic counts specified in the real data set per interval while keeping as close as possible to the original number of OD trips for the period.

As with static OD adjustment, the recommended value for matrix elasticity should be between ‘0.5’ and ‘1’.

The maximum deviation permitted should be the same as the value used in the static OD adjustment. Tests should be undertaken to compare different scenarios using different demand bounds. The scenario which achieves good GEH results (refer Section 2.12.2.2) without significant change to the composition of the prior matrix should be applied.

2.10.9.5 Manual Adjustment

As the last step to match the observed turn counts with the modelled turn counts, the modeller may need to make manual adjustments to the model. Any adjustments must be recorded in the modelling report.

2.10.10 Public Transport

The level of Public Transport (PT) detail required within a traffic model will depend on the objectives of the project and the impact that PT may have on the overall operation of the network.

Although the development and calibration of PT elements within a model varies on a case by case basis, for the majority of arterial roads under congested conditions there would be a requirement to model bus operations.

PT modelling may be required where there are:

- Buses stopping at on-street stops.
- Buses merging with general traffic from indented bus stops.
- Bus lanes for full or part links.
- PT phases in signal operation altering available green time for general traffic movements.

> When the intended purpose of the modelling is to test PT schemes, a higher level of detail will be required for coding, calibration and validation of PT parameters.

2.10.10.1 Coding in the Traffic Model

PT vehicles are generally defined as an independent vehicle type within the model, but are assigned separately as a PT line with headway/frequency. The coding of PT demand and routes depends on the software being used.

2.10.10.2 Public Transport Demand

PT services should be coded in the model based on timetable data sourced from the relevant Public Transport Authority (PTA).

In some areas, non-scheduled bus services may occur (for example, school buses, dead running). To identify these services, existing PT vehicle movements in the timetables should be removed from the turning count survey. For future traffic model scenarios it is recommended that PTA is contacted to confirm any intention of increasing the existing bus frequency or if there are proposed new routes/rerouting within the study area. As part of the submission of the traffic model, Main Roads may require confirmation that PTA was consulted.

2.10.10.3 Public Transport Behaviour

The modeller should confirm whether the PT behaviour evident in the area is likely to have a significant impact on the network and code this information in the traffic model accordingly.

Site visits may assist in identifying the impacts of PT operations and may provide insight into driver behaviour.

An example of the type of observation which can made on-site is the means by which public transport vehicles leave and re-join the main flow of traffic. Where there are indented stops, the interaction of the PT vehicle with traffic in the main flow can have implications on travel times for the public transport service itself and also general traffic.

PT behaviour and any subsequent adjustment to the local capacity can then be calibrated within the model to ensure consistency with the on-site observations.

2.10.10.4 Dwell Time

Dwell times at bus stops should be coded for PT services using available datasets. Where the dwell time is likely to have a significant impact on road capacity and congestion, dwell time surveys should be undertaken to establish a distribution that can be applied within the model. Where detailed modelling is required, the number of passengers should be counted and the boarding and alighting rates should be measured.

2.10.10.5 Traffic Signals with Public Transport Priority

Other issues that may require attention in the modelling include PT priority at traffic signals and signalised level crossings. The operation of signals at level crossings may be linked to adjacent signalised sites and this should be investigated prior to coding. For complex situations, microsimulation models should be developed using vehicle actuated signals.

2.10.11 Pedestrians

Pedestrian facilities are provided to assist pedestrians in safely crossing the carriageway. Pedestrian crossings can be standalone or incorporated within intersections. Details of the various types of pedestrian crossings and facilities available in Western Australia are available in Main Roads' *Guidelines for Pedestrian Crossing Facilities at Traffic Signals*.

The guideline outlines good practice for the design and construction of pedestrian facilities and focus on mid-block crossings and pedestrian crossings at signalised intersections, which are the most common pedestrian crossing types included in traffic modelling.

2.10.11.1 Modelling Pedestrian Crossings

The needs of all road users, including pedestrians, should be addressed when considering design options at signalised intersections.

Detailed pedestrian modelling may be required for pedestrian-related projects or where the interaction of pedestrian and traffic movements is to be assessed. In such cases, more detailed pedestrian information must be collected.

Main Roads must be consulted to confirm if pedestrian modelling is required. Any justification for the exclusion of pedestrians from modelling must be documented in the modelling report.

Modellers should have an understanding of the volume and location of demand for pedestrian movements around the study area, and how pedestrian interactions with traffic may cause an impact to the traffic operation. This information is useful for accurate modelling and can be obtained from on-site observations and from pedestrian surveys (usually taken as part of the traffic survey). Pedestrian desire lines, which identify major pedestrian movements, should also be recorded. This data is useful in the design of intersection layouts and signal timing plans, and should be used to ensure that proposed facilities will be effectively used by pedestrians.

Modelling software packages provide a variety of ways to account for pedestrian activity and the modeller should choose the most accurate and relevant method for the project[4].

2.10.11.1.1 Pedestrians at Zebra Crossings

As heavily used zebra crossings can cause delays to traffic and restrict the capacity of the local road network, it is important to code zebra crossings and calibrate the associated level of disruption (distribution of times that vehicles are stopped) to replicate observed conditions.

The modeller should assess locations where zebra crossings are likely to have a significant impact on vehicle travel times or where they are likely to discourage drivers from using a route (either due to the delay or the perceived delay that they cause). The level of delay observed on-site should be replicated in the modelling by coding a set of dummy signals or explicitly coding pedestrian movements across the zebra crossing (subject to the software being used providing such capability).

2.10.11.1.2 Pedestrians at Mid-Block Signal Crossings

In addition to the delaying of traffic during the pedestrian ‘invitation-to-cross’ period and clearance time at mid-block signalised crossings, the platooning of vehicles on the network are also impacted. Signal coordination with nearby intersections and potential queuing to the upstream intersection due to the midblock crossing should be considered as part of the modelling assessment.

2.10.11.1.3 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 a number of reasons why this may occur, including:

- An exclusive pedestrian phase is activated, increasing delay for traffic waiting at the stop line and possibly reducing the green time available in subsequent phases.
- Pedestrians crossing during a traffic phase (with or without full pedestrian protection) have priority over turning traffic and reduce the capacity of the traffic movements by blocking the exit for a proportion of the allocated green time.
- Phase durations are extended beyond the time needed for the traffic demand when pedestrian signal groups are activated, due to the long clearance times needed for the pedestrian signal groups.

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[4] The modelling scenarios have been adapted from the Roads & Maritime Services’ *Traffic Modelling Guidelines* and reproduced with permission.

The modeller should assess the impact of pedestrians on traffic movements during site visits in order to develop an understanding of locations that are subject to significant capacity constraints. Where the pedestrian impact on traffic is significant, this should be simulated in the model to improve calibration and provide a more realistic outcome.

2.10.11.1.4 Existing Pedestrian Signal Timings

Existing pedestrian signal timings (invitation to cross, delays and clearance, demand frequency) under SCATS control can be obtained from Main Roads' *trafficmap* or requested from Main Roads using the SCATS request form for historical data for a specific date. This data can provide an indication of the number of times that pedestrian phases are activated during signal operation, allowing the coding of vehicle actuated signals to simulate the call of pedestrian phases on an appropriate basis for any given time period. While this provides useful information on the activation frequency of the phase, it will not provide an indication of the actual volume of pedestrians and the disruption caused for left or right turning vehicles.

2.10.11.1.5 Proposed Modifications to Pedestrian Signal Timings

When upgrading signalised intersections or proposing new sites, Main Roads' *Guidelines for Pedestrian Crossing Facilities at Traffic Signals* must be referred to for best practice guidance on the provision of pedestrian crossing facilities and the appropriate Timed Control type for safe and efficient operation.

> Changes to intersection layout and traffic lane widths would have an impact on the pedestrian crossing length which affects the pedestrian signal timings. Modellers must review and update the pedestrian walk time (green figure) and clearance times in the proposed models, refer to Appendix A for information.

When developing proposed models, various pedestrian crossing activation frequency scenarios may need to be modelled for scheme assessments; Main Roads should be consulted to agree on the activation frequencies to be modelled.

Modelling pedestrians can be challenging (correctly modelling pedestrian demand, zebra crossings and shared space) and achieving successful outcomes depends on the capabilities of the modelling software.

2.10.12 Signal Data

As it is important that base traffic models are built to represent the current arrangement of the intersection(s), signal phasing and signal group labelling should be consistent with that employed on-site. In addition, pedestrian walk and clearance times, as well as minimum green, late start, early cut-off, all red and yellow times, should also be identical to those currently employed.

To ensure consistency in the traffic models developed, it is recommended that SCATS signal data is used when modelling any signalised intersection. This data can be requested from the Main Roads website using the SCATS request form if not available from *trafficmap*.

2.10.12.1 SCATS Timings

To assist with the development of traffic models, Main Roads currently provides access to a wealth of SCATS data. Available information includes, but is not limited to:

Pavement and Signage Drawing (Light Maintenance drawings, LMB[5]) to identify:

- lane configuration
- permitted movements

Traffic Signal Arrangement Drawing (LMA[6]) to identify:

- signal group numbers
- phasing arrangement
- detector locations and numbers (for interpreting SCATS traffic volumes)
- signal lantern configurations per signal group
- filtered movements

Signal Data spreadsheet which contains following tabs:

1. **Site tab** to identify:
    - TCS number(s)
    - SCATS region(s)
2. **Timings tab** to identify:
    - phase late start
    - phase minimum green
    - phase early cut-off green
    - phase yellow
    - phase all-red
    - phase maximum green
    - pedestrian delay times
    - pedestrian walk time
    - pedestrian clearance 1 and clearance 2 times
    - pedestrian protection time

[5] LMB plans are signs and lines drawings showing the built geometry, carriageway widths and lane utilisation.
[6] LMA plans are traffic signal drawing plans that show the location of existing signal heads, SCATS detector loops and existing signal phases.

3. **Link and Offset Plans** tab to identify:
   - subsystem
   - coordinated phases plans
   - link plans
   - upper/lower cycle lengths
4. **SCATS Phase History** tab to identify:
   - operated phase lengths
   - operated cycle lengths
   - operated phase sequences
   - traffic phase demand frequency

Detector Volume Data spreadsheet also contains SCATS traffic volume data.

Phase Sequence Chart which generally contains late start, delays, pedestrian protection and special facilities.

Strategic Monitor (system data) to identify selected link plans by SCATS.

SCATS Event History data to identify alternative phase and pedestrian demand frequency.

Traffic flow data (lane by lane)[7].

SCATS should not be used as the primary source of traffic counts. The disadvantage of SCATS data is that sometimes not all traffic is captured and there may be instances when the detectors are not working or may not be available for some turning movements (for example, at left-turn slips at a signalised intersection). Furthermore, SCATS detectors cannot determine turning proportions when the approach lane is shared by two movements (for example, left turn and ahead).

2.10.12.2 Phasing and Sequences

For new signalised intersections or when upgrade to an existing signalised intersection(s) is proposed, the existing phasing should be reviewed and alternative phasing and phase sequences may be proposed, taking into consideration road user safety and intersection / network performance. To ensure that the proposed phasing and phase sequences will be acceptable to Main Roads, refer to Appendix A which details the standard phasing and phase sequences that can be used as a starting point.

[7] Where there is a detector at the lane approach SCATS traffic count data can be collected. This data can be used to identify peak hour traffic demand and the appropriate time periods for the traffic model. Subject to Main Roads' agreement, SCATS traffic data may also be used in the absence of traffic turning count survey data.

2.10.12.3 Demand Dependency

Demand dependency relates to the calling of a signal phase (for pedestrian or traffic) only if it is demanded. For pedestrians, this is when the pushbutton is pressed while for traffic this is when the presence of a vehicle is detected on one or more of the detector loops located at an intersection. If a signal phase is demand dependent, it is important to know how often the phase is called so that the green time allocated to those movements in the appropriate signal phase is realistically modelled as part of the calibration process.

Demand dependency can be determined using history file viewer which can be requested from Main Roads.

2.10.12.4 Fixed Time/VA/SCATSIM[8]

It is recommended that fixed time signals are used to model the average SCATS timings for the peak period, if any SIDRA or LinSig traffic model is to be reviewed by Main Roads.

Signalised intersections can be modelled in microsimulation software using a number of different techniques. Main Roads may recommend a technique to apply for signal control within the project brief. If the brief does not provide signal control guidance, the modeller should apply the technique that is most appropriate for each site by taking into account the significance of each site to both the study area and to the operation of the network. The preferred technique for each location should be agreed with Main Roads prior to the development of a traffic model.

Three techniques are commonly used when coding signalised intersections in microsimulation models:

1. fixed time signals
2. vehicle actuated signal coding
3. SCATS operation through the SCATSIM interface.

2.10.12.4.1 Fixed Time Signal Timings

Average signal timings can be derived from SCATS data provided by Main Roads, site visits or a combination of both. In locations where signal timings show significant variability over the modelled period, it may be necessary to operate a number of fixed-time plans throughout the modelled period (subject to the software offering this functionality).

2.10.12.4.2 Vehicle Actuated Signal Timings

In more complex situations, signals may be coded using vehicle actuated signals. These signals operate under a dynamic plan responding to calls from detectors or other controller logic to provide variable green times, phase calls and cycle times. Vehicle actuated signals provides an excellent representation of intersections that respond to demand from detector loops in the road or for intersections that include public transport priority phases, pedestrian crossing phases or similar. Vehicle actuation can also be used to simulate ramp-metering operations, part-time signals and other logic-controlled situations.

[8] The timing information has been adapted from the Roads & Maritime Services' *Traffic Modelling Guidelines* and reproduced with permission.

2.10.12.4.3 SCATS Signal Timings

In some cases it may be necessary to simulate the SCATS system of signal control within the model. To do this will require the use of the SCATSIM interface and it will be necessary to obtain data from Main Roads on the current operational set-up. The use of SCATSIM is not required for all projects and will only be requested when it is considered to be critical to the study. As this method of signal control requires significant Main Roads resources, the agreement of NO should be sought prior to specifying that SCATSIM will be used.

2.11 Intergreen Calculations

In existing traffic models, intergreen calculations are based on the SCATS signal timings. If modifications are proposed at the existing signalised intersection, the modeller should confirm whether the intergreens would need to be amended to accommodate the proposed modifications (for example, an additional lane may increase both pedestrian and vehicle intergreens).

For intersections where traffic signals are proposed, for intergreen calculations refer to Appendix A

2.12 Calibration and Validation

This section provides detail on calibration and validation considerations, so that site characteristics and behaviour are accurately replicated in traffic models.

The modelling report must include separate sections for documenting the calibration and validation process. The modeller must detail which datasets have been used for each process. It is important to note that validation data must be independent and cannot have been used during calibration.

2.12.1 Model Calibration[9]

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. Calibration can generally be split into three core areas:

1. Network verification – refinement of network inputs.
2. Demand calibration – refinement of trip volumes, patterns and driving behaviour.
3. Route choice calibration – refinement of parameters that influence a driver's route decisions.

Each of these core areas should be investigated and addressed as a part of the overall model calibration.

These core areas are described in more detail in the sections below. While the focus is on microsimulation models, the information is also applicable to deterministic models (such as SIDRA and LinSig).

The calibration of a parameter in one area of the model may have subsequent and unexpected impacts in other areas of the model. It is important to develop a calibration strategy and to approach each step in a logical and disciplined manner. Generally, it is advisable to adjust one single parameter at a time so that the impacts of the change can be isolated and understood when the simulation is run. Adjustments should be logical, reasonable and appropriate for purpose.

It is unlikely that a single iteration of calibration addressing each of the core areas will achieve a sufficiently accurate model in the first attempt. There may be circumstances where the input or parameters used to calibrate the model need to be recalibrated so that the model outputs match site observations. A number of iterations are usually required before the base model is refined to a level of detail that is fit for purpose and will provide reliable forecasts going forward.

[9] Model calibration information has been adapted from the Roads & Maritime Services' *Traffic Modelling Guidelines* and reproduced with permission

2.12.1.1 Basic Network Coding

The initial network coding phase is an important stage in the overall development of the model. The creation of a basic network that is of a consistent and accurate standard can significantly reduce the duration of the subsequent model calibration process. Each area of the network should be verified over the course of the calibration process to ensure that it is accurately representing the observed capacity and driver behaviour for that location.

As it is likely that many links and intersections will exhibit similar characteristics, the initial development of a consistent approach to coding provides a stable platform from which to undertake subsequent calibration adjustments.

Each software package represents road networks in a slightly different manner. Some packages use a link and node structure while others use a link and connector structure. Regardless of the technique employed, there are a number of key parameters that must be coded when developing a basic network:

- number of lanes
- lane widths
- lane closures or restrictions
- elevation or gradient
- basic geometry (based on an accurately scaled background)

In all cases, links and intersections must be coded to represent their on-site operation. Aerial photography and survey information may not adequately reflect localised vehicle behaviour or may simply be out of date. Modellers should include any changes made to the model during the calibration process as a result of field observations in the modelling report.

2.12.1.2 Vehicle Speeds

Posted speed limits should be assessed for the full extent of the study area and coded during the base model build. The posted speed limit can be sourced from Main Roads' RIMS. This data will provide a starting point from which any further localised adjustments can be made as required. The method by which the posted speed limits are applied also varies between software with some applying speed distributions to entire links and others using explicit locations to inform drivers of speed changes.

Each software package provides default speed distribution categories that can be used during the initial stages of modelling. As in some cases the distributions may not be appropriate for the localised area, it may be necessary to make adjustments. In some studies (particularly those assessing freeway operations) it is possible to acquire point-speed data from detector loops or other sources. The analysis of this data for periods of low traffic flow can provide an indication of appropriate speed distribution for vehicles under free-flow conditions. This speed data can replace the default software values that represent desired speeds and is a useful calibration tool to ensure that localised driver behaviour is more accurately simulated within the model.

In areas of the network that experience congested conditions, it is inappropriate to adjust speed distributions in the model to match observed values as the observed values are a consequence of the congestion. Observed values can be used as a validation parameter of model outputs but not as a calibration parameter of model input.

For locations where speed data is not available, it may still be acceptable to adjust speed distributions from the default values. In select cases, it may be necessary to adjust the speed distribution on isolated links as a result of activities that cannot otherwise be accurately represented within the model. Examples of this might include side friction from pedestrian activity, narrow lanes, parking activity or visibility issues. The manual adjustment of speeds on individual links should be a last resort and only used if other network coding cannot adequately simulate the actual cause of the issue. If the modeller decides to apply speed distributions on isolated links, these need to be recorded and justified (supply supporting evidence) in the modelling report. Reducing speed distributions on isolated links in order to match modelled travel times with observed datasets is not acceptable. Modellers should use other methods to replicate the desired speed.

2.12.1.3 Priority Intersections

Due to their prevalence across the entire road network, priority intersections often account for a large proportion of all the intersections to be coded in a microsimulation model. They form an important constraint on network capacity in many study areas and can cause significant delays and re-routing in some models. Correctly modelling the parameters associated with priority intersections is an important part of the wider calibration process.

Gap acceptance is one of the critical parameters affecting the capacity of approaches to priority-controlled intersections. Many software packages provide default gap acceptance values and care should be taken to ensure that these values are appropriate for each modelled conflict location. It is not acceptable to assume that the default parameters are suitable at all locations throughout the network without assessing the intersection performance and calibrating values where necessary (for roundabout modelling, refer to Section 2.13).

There are many factors that influence the value of gap acceptance and these should be assessed and taken into account on an individual location basis (where a particular model allows). Key factors that might affect gap acceptance include:

- visibility
- geometry
- vehicle type
- level of congestion

In locations where visibility is poor or the angle of approach or exit is acute, an increased gap acceptance may be required. In some urban areas where congestion is severe and drivers are prepared to take more risks (or are more familiar with the local network), the gap acceptance may be reduced.

There may also be a need to specify different gap acceptance values for various user classes within the model. Heavy vehicles often require larger gaps than light vehicles to join fast-moving streams of traffic from side roads or to make right-turns across oncoming traffic. If the modelled network has a significant volume of heavy vehicles, it may be necessary to explicitly code different gap acceptance values for each vehicle type (where possible).

2.12.1.4 Blocking

In dense urban networks it is possible for intersections to become blocked by queuing vehicles. As blocking can decrease the capacity of some movements at priority intersections and roundabouts, it is an important calibration tool in defining the capacity and efficiency of the local road network.

The nature of blocking behaviour should be observed on-site and replicated in the model. Most software packages offer a direct or indirect method of achieving different levels of blocking – either through specific blocking parameters or via the use of a number of other network coding tools that can be applied through workarounds.

The location of blocking behaviour and the method by which it has been simulated should be described in the modelling report as often cooperation between drivers allows for minor road turns to take precedence over slow-moving major movements.

2.12.1.5 Turning Lanes

Turning lanes allow traffic wanting to make a turning movement to queue without blocking traffic on other movements. They can play an important role in local road capacity as congestion can quickly develop when a turning lane becomes full and begins to block other movements on the same approach. It is important to ensure that turning lanes are defined correctly in terms of length, entry location and upstream driver awareness.

The correct calibration of turning lanes in the base model also has implications for any future year scenarios to be assessed. This is important as many intersections in the network may operate at or below capacity in the base year but subsequently operate over capacity in future year scenarios.

Correct calibration of turning lane parameters in the base year may ensure that the behaviour of vehicles within future year models is realistic and that the model will be able to provide an accurate assessment of intersection performance.

If a carriageway is wide enough to accommodate passing vehicles but only line marked as a single lane, it is reasonable for the model to be coded using two lanes to allow for passing traffic. The modeller must ensure that the passing lane is available and not blocked by parking, bus stops or local driver behaviour.

2.12.1.6 Signalised Intersections

Signalised intersections have a significant impact on the capacity of modelled traffic networks as they are the focus of high-volume conflicting traffic movements that are only allocated a portion of available green time to undertake their manoeuvres. The adjustment of signal timings, and associated parameters that affect stop line saturation flow, directly control the throughput of each approach in the model and often dictate capacity.

For fixed signal timings, during the calibration stage signal timings should be verified against SCATS data and observations made on-site to ensure that they provide an accurate representation of typical operation. To account for variability across the peak period, limited adjustment from the observed hourly average can be made. Signal offsets must also be included in the coding of fixed time signals.

For vehicle actuation signal timings, signal timing settings, detector locations and control logic should be sourced from Main Roads for each site to allow an accurate simulation of the on-site control to be developed. Signal offsets must also be included in the coding of vehicle actuated signals.

As both SCATS and vehicle actuation timings are dynamic by nature, it is useful to compare the modelled operation of the simulated intersections against real-world data. This comparison can help ensure that the model is adequately replicating the on-street intersection control over the modelled time period.

Since most microsimulation model applications are for congested urban areas with many signalised intersections, the accurate calibration of parameters is often critical in the development of a robust base model.

The development of an accurate simulation of on-street signal operation has benefits beyond the calibration stage of the modelling. One of the key benefits of microsimulation over other modelling techniques is the ability to simulate signalised intersections operating as part of an integrated wider adaptive control network or as vehicle actuated. To realise these benefits during the scenario testing stage, it is important that base models are developed to a sufficiently high level of accuracy.

In order to accurately code a signalised intersection, the light maintenance (LM) plans and the relevant SCATS signal data for the modelled time periods should be obtained from Main Roads (using the SCATS request form if not available from *trafficmap*). The intersection coding should reflect the detail in the layout plan and should be confirmed during a site visit. The length of turning lanes should be assessed from plans or from scaled aerial photography and accurately coded into the model to reflect actual vehicle behaviour during the most congested periods.

If a turning movement has a dedicated lane, it is acceptable for this to be coded as a separate link to improve lane discipline on approach to the intersection. Care should be taken to ensure that the entry point to the turning lane is accurately positioned, as observed vehicle behaviour may not correspond with lane markings on the ground.

2.12.1.7 Saturation Flow at Signalised Stop Lines

Saturation flow is used in LinSig and SIDRA for calibration and is used in Vissim and Aimsun for validation. The saturation flow modelled at signalised stop lines has a significant impact on the throughput of any approach. There are a number of factors which may affect the stop line saturation flow on-site and these must be replicated as closely as possible in the model. These factors include:

- geometry
- gradient
- visibility
- gap acceptance for turning traffic

- lane width
- downstream blocking

The method by which these factors can be controlled depends on the software package used. Most packages allow for the use of gradient on individual links and this should be coded as appropriate for each approach.

While some packages automatically assess the geometry of any turning movement and reduce vehicle speeds accordingly, others require a reduction in speed to be applied manually. Care should be taken to ensure that the geometry for each movement is taken into account. It may be necessary to undertake a basic site survey of saturation flow in order to assess the calibration of key approaches.

Visibility and lane width also have an impact on the saturation flow and should be assessed on-site. Some packages allow for a visibility parameter to be coded directly into the model, but if this feature is not available visibility issues should be accounted for using other parameters (for example, adjustments to approach speed or gap acceptance).

Lane widths generally have no impact on modelled saturation flow in microsimulation models and the implications of a reduced lane width should be taken into account using other available parameters (if appropriate).

2.12.1.8 Lane Utilisation

Lane utilisation can significantly impact on network capacity and network operation in a congested study area and should be calibrated against observed site conditions. It is recommended that modellers with significant local knowledge undertake this process.

A number of different parameters can affect lane utilisation and these should be checked and adjusted as appropriate throughout the network. Modellers should undertake site visits during peak time periods in order to observe lane discipline and utilisation at all major intersections and other areas of significant congestion. This should enable driving behaviour that is consistent with observations made on-site to be developed within the model.

A key parameter affecting lane utilisation is the upstream distance at which a driver will become aware that they are required to change lane for a downstream turn movement. Lane utilisation can be influenced by a number of factors including:

- Drivers who are unfamiliar with the local network may react to signposting or lane markings that indicate the correct lane a short distance in advance of necessary turn manoeuvre.
- Drivers who are more familiar with the network may make the necessary lane choice earlier in order to make changing lanes easier (sometimes this can be multiple intersections in advance of the turn manoeuvre).

Each software package will provide a method of informing drivers of an upcoming lane change through the use of an upstream awareness distance value. As distance values will vary significantly between approaches and turn movements, they should be adjusted throughout the model. A useful technique is to initially code these distances to reflect the on-street signage and lane marking strategy and subsequently adjust any that require further calibration due to other factors such as driver familiarity.

In order to improve lane discipline, it may be necessary to split approaches into separate links. While this technique is acceptable to Main Roads when used for this purpose, if it is applied too far in advance of the stop line then insufficient weaving distance or insufficient friction due to lane changes may result.

Observations of lane utilisation for different vehicle types should be undertaken (if possible), as some sites demonstrate clear segregation for various reasons (for example, some lanes may be more attractive to heavy vehicles or buses due to lane width or turning geometry). In addition, dedicated lanes (such as bus lanes) may operate at certain times of day.

On links that feed traffic from zones into the model it is important to ensure that the links are sufficiently long to allow vehicles to make lane changing manoeuvres prior to the first turn movement. This is particularly important for freeway links where unrealistic congestion can occur if the fully signposted distance (as a minimum) is not modelled.

2.12.1.9 Public Transport

When calibrating PT in the traffic model, the modeller should take into consideration the factors outlined in Section 2.10.10. The source of PT data, together with the dwell times assumed in the modelling, should be documented in the modelling report.

2.12.1.10 Demand Calibration

Demand refers to the trips that drivers want to make from any given origin to any given destination within the modelled study area (including unmet demand, refer to 2.10.7.1). The demand must be calibrated to ensure that the vehicle movements within the model are an accurate representation of the observed vehicle movements that exist on-site.

The demand calibration process comprises adjustments to the definition of different vehicle types, the development of trip volumes for each OD pair and the profiling of the demand over the total modelled time period.

All software packages covered in this document (with the exception of LinSig) enable travel demand to be segmented for a range of vehicle types. The differing characteristics of each vehicle type can affect both route choice through the network and also the localised network capacity. This is due to parameters such as acceleration rates, gap acceptance and vehicle length differing greatly between vehicle types. It is important to ensure that accurate trip demand is defined for each of the vehicle types to be modelled and that these demands are later calibrated to an acceptable level.

The calibration of link flows and turning movements ensures that the model demand is accurate over each hourly period. As microsimulation models assess the performance of the network at every time step, it is also necessary to ensure that the model adequately represents the peak travel demand within each hour. This is often referred to as profiling of demand. The profiling of demand at major entry points into the model can have a significant impact on the development of congestion and queue lengths throughout the network. In some locations such as those near schools or areas where shift work is prevalent there may be a short and defined peak when queues at nearby intersections quickly develop at a specific time of day and then dissipate quickly as demand drops. Areas where traffic is fed by more mixed-use zoning may have a flatter profile, with queue lengths sustained over the entire time period.

An assessment of the study area should be made to understand the likely implications of the local demand profile. This assessment should include analysis of count data throughout the network and site observations from key locations. It is recommended that survey data disaggregated into 15 minute intervals is sourced as this provides a good level of detail for the development of a profile.

Profiles should be developed for as many zones as possible and for each vehicle type (*where possible*). While a single adjusted profile over the entire study area may be acceptable, models should not be developed with a flat profile without justification being provided.

2.12.1.11 Route Choices

Modellers should check all the key route choices before calibrating the traffic volumes in the model. The adjustment of key parameters regarding cost is generally required in order to reduce the number of unreasonable route choices modelled. The main purpose of checking the key routes is to guarantee that vehicles have been discouraged from using any unreasoned routes through the network.

If changes to default cost values have been made, modellers should document the changes, including the location and justification, in the modelling report.

2.12.1.12 Behavioural Parameters

There is a wide range of behavioural parameters that may affect the calibration of a microsimulation model. Each software package will use some or all of these parameters to simulate driver behaviour. As each package uses the parameters differently, it is not possible to specify the appropriate values for each.

> Modellers should check the suitability of default values in the modelling software. Any necessary modifications to these values should be documented in the modelling report.

Some packages allow the user to adjust high-level parameters which influence or determine lower-level parameters (for example, aggressiveness or awareness). Modellers should ensure that they are familiar with the effects of the high-level parameters before making adjustments as the use of these parameters may have unintended impacts throughout the network.

2.12.1.13 Calibration Guidelines for Main Roads Supported Software

For guidance on calibration requirements, appropriate criteria to use and the behavioural parameters that can be adjusted to calibrate the traffic model using the different modelling software refer to:

- LinSig – Section 3
- SIDRA – Section 4
- Vissim – Section 5
- Aimsun – Section 6

Assessment of key intersections against the provided guidelines is a useful indication of the level of calibration required for each approach at any given location. The accurate modelling of signal timings and control at an intersection will provide a robust base from which to calibrate and subsequently validate a model. It is recommended that modellers review the operation of the modelling area at an early stage during model calibration.

2.12.2 Model Validation

Model validation describes the independent verification process that a model has been calibrated to a sufficient extent to represent on-street conditions accurately.

Modellers compare model outputs with the observed and surveyed site data and this must be data that has not been used during the calibration process.

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 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.

Adjustments made to parameters during the model development process should be documented in the modelling report to provide a record of the changes. In addition to this record, Main Roads requires a statistical comparison of model performance with on-street observations. This produces a measureable record of the level to which the model has been calibrated and subsequently validated.

The modelling report should include separate sections for the reporting of calibration and validation and the modeller should state which of the observed datasets have been used for each process.

A comparison of each of the observed datasets against modelled outputs should then be presented in either the calibration or validation sections of the report. The software specific guidelines in sections 3 to 6 provide the criteria to confirm if a model represents on-site conditions.

There will be occasions where models may not meet the model validation criteria but are still considered fit for purpose. Likewise, some models may meet the criteria but require further attention in areas of critical significance to the study. The extent, structure and objectives of every modelling exercise are different and these will influence the level of importance placed on achieving each of the targets.

The decision to accept or reject a model lies with Main Roads and modellers should explain any limitations in the modelling that might prevent the model from achieving the guideline calibration and validation criteria.

2.12.2.1 Model Categories for Validation

Main Roads defines the following three model categories for the model validation:

- Model Category 1
  - Single intersection or short corridor model (up to four full movement intersections).
  - Models in this category are built and used to assess the performance of intersections or corridors under different design layouts or traffic conditions.
- Model Category 2
  - Small area network or long corridor model with limited route choices.

  - Models in this category are developed to assess the performance of networks or corridors under different traffic management schemes.
- Model Category 3:
  - Large area networks including multiple long corridors with various routes between origin and destination zones, and use dynamic traffic assignment.
  - Models in this category are generally used in transport network planning, assessment of traffic management and road schemes.

Model category should be agreed with Main Roads prior to the start of the modelling.

In accordance with model categories, various model outputs are required when validating the base model. The model outputs required for individual model category are stipulated in Table 2-3.

Table 2-3: Model validation requirements based on model category

Output	Category 1 (LinSig & SIDRA)	Category 1 (Vissim & Aimsun)	Category 2 (Vissim & Aimsun)	Category 3 (Vissim & Aimsun)
Queue length	✓	✓	✓	✓
Degree of Saturation	✓	✗	✗	✗
Saturation flow	✗	✓	✗	✗
Traffic turning movement and directional link volume	✗	✓	✓	✓
Travel Time	✗	✓	✓	✓
Signal timings	✗	✓	✓	✓
Vehicle speed map	✗	✗	✓	✓

2.12.2.2 Validation Statistics

Useful measures of "goodness-of-fit" generally used to compare model flows against observed counts are GEH and R-square (R^2).

The GEH (invented by Geoffrey E. Havers) statistic is a formula used to compare two set of traffic volumes.

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

M is the modelled flow and C is the observed flow.

Plots of observed against modelled hourly flows are required to be reported for all observations.

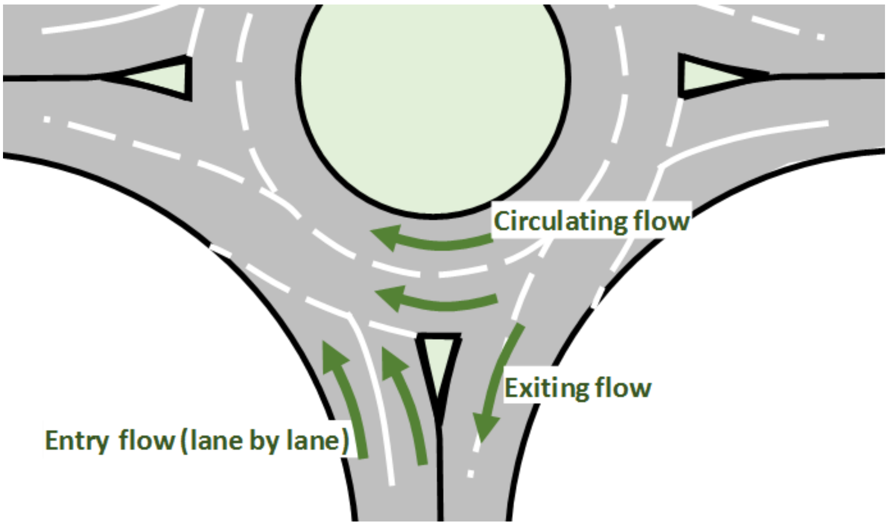
The R-Square (R^2) is a statistical measure of the correlation between the entire count data set and the predicted model volumes. Unlike the GEH statistic (which applies to individual flows and screenlines), the R-Square (R^2) applies to the entire comparison data set and is expressed as a single value.

2.13 Operational Modelling of Roundabouts

When modelling roundabouts in microsimulation it may be necessary to adjust the default gap acceptance parameters (critical gap and follow-up headway) in line with the roundabout geometry in order to calibrate or validate the model. Modellers using Vissim and Aimsun must adjust approach and departure speed to simulate site behaviour.

Australian and New Zealand practice for determining the capacity of roundabouts is based on headway acceptance theory. Traffic entering the roundabout gives way to, and accepts opportunities (gaps) in the circulating traffic stream, as depicted in Figure 2-3.

Figure 2-3: Major and minor flows at a roundabout



In order to calculate the critical gap and follow-up headway modellers need to measure the roundabout geometry and traffic flow through the roundabout. The modeller may use researched values (Troutbeck 1989) from roundabout surveys, which have determined a correlation between geometry and traffic flow, to calculate the gap acceptance parameters.

Gap acceptance parameters are affected by the geometry of the entry. Geometrics which offer an easier entry path give lower gap acceptance values. These parameters are also a function of the circulating flow. At higher circulating flows, the circulating speeds are lower and drivers are more willing to accept smaller gaps. Also at higher circulating flows, more circulating drivers slow and allow entering drivers to move in front of them. This leads to priority sharing or even a reversal of priority.

2.13.1 Estimating the Critical Gap Parameters

2.13.1.1 Single lane entry

Table 2-4 lists the dominant stream follow-up headway (t_{fd}). If there is one circulating lane, these values are used for the entry stream. If there are two or more circulating lanes, then the values in Table 2-4 should be increased by 0.39 (Refer to Table 2-5).

The ratio of the critical acceptance gap to the follow-up headway (t_{ad}/t_{fd}) is given in Table 2-7. The critical acceptance gap is the product of the appropriate values from Table 2-4 and Table 2-7.

2.13.1.2 Multi-lane approaches

To estimate the entry lane flows at approaches with two or more lanes, it can be assumed that drivers wishing to turn right will use the right hand entry lanes and the drivers turning left will use the left hand lanes. However in some situations lanes may be marked with signs or pavement arrows to restrict them to particular traffic movements and the lane arrangement so marked would be used in the analysis. The through traffic then needs to be proportioned to the appropriate lanes to finalise the lane entry flows.

While the above provides the most accurate assessment, it is pointed out that estimates of approach capacity are not significantly affected by the distribution of traffic in the lanes.

The entry lane with the greatest flow at an approach is termed the `dominant' lane and the traffic in this lane is termed the dominant stream. Other lanes contain subdominant streams.

The critical gap parameters for an approach with two or more entry lanes are estimated using Table 2-4, Table 2-5, Table 2-6 and Table 2-7.

Table 2-4 gives values for the follow-up headway for the dominant stream. These values are adjusted if the number of entry lanes differs from the number of circulating lanes.

Table 2-4: Dominant Movement Follow-up Headways (t_{fd}) (Initial values in seconds)

Inscribed Diameter (m)	Circulating Flow (veh/h)					
	0	500	1000	1500	2000	2500
20	2.99	2.79	2.60	2.40	2.20	2.00
25	2.91	2.71	2.51	2.31	2.12	1.92
30	2.83	2.63	2.43	2.24	2.04	1.84
35	2.75	2.55	2.36	2.16	1.96	1.77
40	2.68	2.48	2.29	2.09	1.89	1.70
45	2.61	2.42	2.22	2.02	1.83	1.63
50	2.55	2.36	2.16	1.96	1.76	1.57
55	2.49	2.30	2.10	1.90	1.71	1.51
60	2.44	2.25	2.05	1.85	1.65	1.46
65	2.39	2.20	2.00	1.80	1.61	1.41
70	2.35	2.15	1.96	1.76	1.56	1.36
75	2.31	2.11	1.92	1.72	1.52	1.33
80	2.27	2.08	1.88	1.68	1.49	1.29

Source: Troutbeck 1989

The adjustment values are given Table 2-5.

Table 2-5: Adjustment Times for the Dominant Movement Follow-up Headway

Number of circulating lanes	Number of entry lanes		
	1	2	3
1	0.00	-0.39	
2	0.39	0.00	-0.39
3		0.39	0.00

Source: Troutbeck 1989

Table 2-6 gives the values of the sub-dominant stream follow-up headway (t_{fs}) as a function of the dominant stream follow-up headway (t_{fd}) and the ratio of dominant stream entry flow to the sub-dominant stream entry flow.

Table 2-6: Sub-dominant Movement Follow-up Headway (t_{fs})

Dominant stream follow-up headway (t_{fd}) (s)	Ratio of flows (Dominant flow/Sub-dominant flow)				
	1.0	1.5	2.0	2.5	3.0
1.5	2.05	1.99	1.94	1.89	1.84
1.6	2.10	2.07	2.05	2.02	1.99
1.7	2.15	2.15	2.15	2.15	2.15
1.8	2.20	2.23	2.25	2.28	2.30
1.9	2.25	2.30	2.35	2.40	2.46
2.0	2.30	2.38	2.46	2.53	2.61
2.1	2.35	2.46	2.56	2.66	2.76
2.2	2.41	2.53	2.66	2.79	2.92
2.3	2.46	2.61	2.76	2.92	3.07
2.4	2.51	2.69	2.87	3.05	3.23
2.5	2.56	2.76	2.97	3.17	3.38
2.6	2.61	2.84	3.07	3.30	3.53
2.7	2.70	2.92	3.17	3.43	3.69
2.8	2.80	3.00	3.28	3.56	3.84
2.9	2.90	3.07	3.38	3.69	4.00
3.0	3.00	3.15	3.48	3.82	4.15

Source: Troutbeck 1989

The critical acceptance gap values for each lane are given by the product of the follow-up headway (from Table 2-4 and Table 2-6) and the ratios in Table 2-7. As stated above, critical acceptance gap values need to be calculated separately for each entry lane.

Table 2-7: Ratio of the Critical Acceptance Gap to the Follow-up Headway (t_{ad}/t_{fd})

Circulating flow (veh/h)	Number of circulating lanes / Average lane width (m)					
	One			More than one		
	3	4	5	3	4	5
0	2.32	1.98	1.64	2.04	1.70	1.36
200	2.26	1.92	1.58	1.98	1.64	1.30
400	2.19	1.85	1.52	1.90	1.58	1.24
600	2.13	1.79	1.45	1.85	1.51	1.18
800	2.07	1.73	1.39	1.79	1.45	1.11
1000	2.01	1.67	1.33	1.73	1.39	1.10
1200	1.94	1.60	1.26	1.67	1.33	1.10
1400	1.88	1.54	1.20	1.60	1.26	1.10
1600	1.82	1.48	1.14	1.54	1.20	1.10
1800				1.48	1.14	1.10
2000				1.41	1.10	1.10
2200				1.35	1.10	1.10
2400				1.29	1.10	1.10
2600				1.23	1.10	1.10

Source: Troutbeck 1989

Refer to 2.13.2 for a worked example of these calculations.

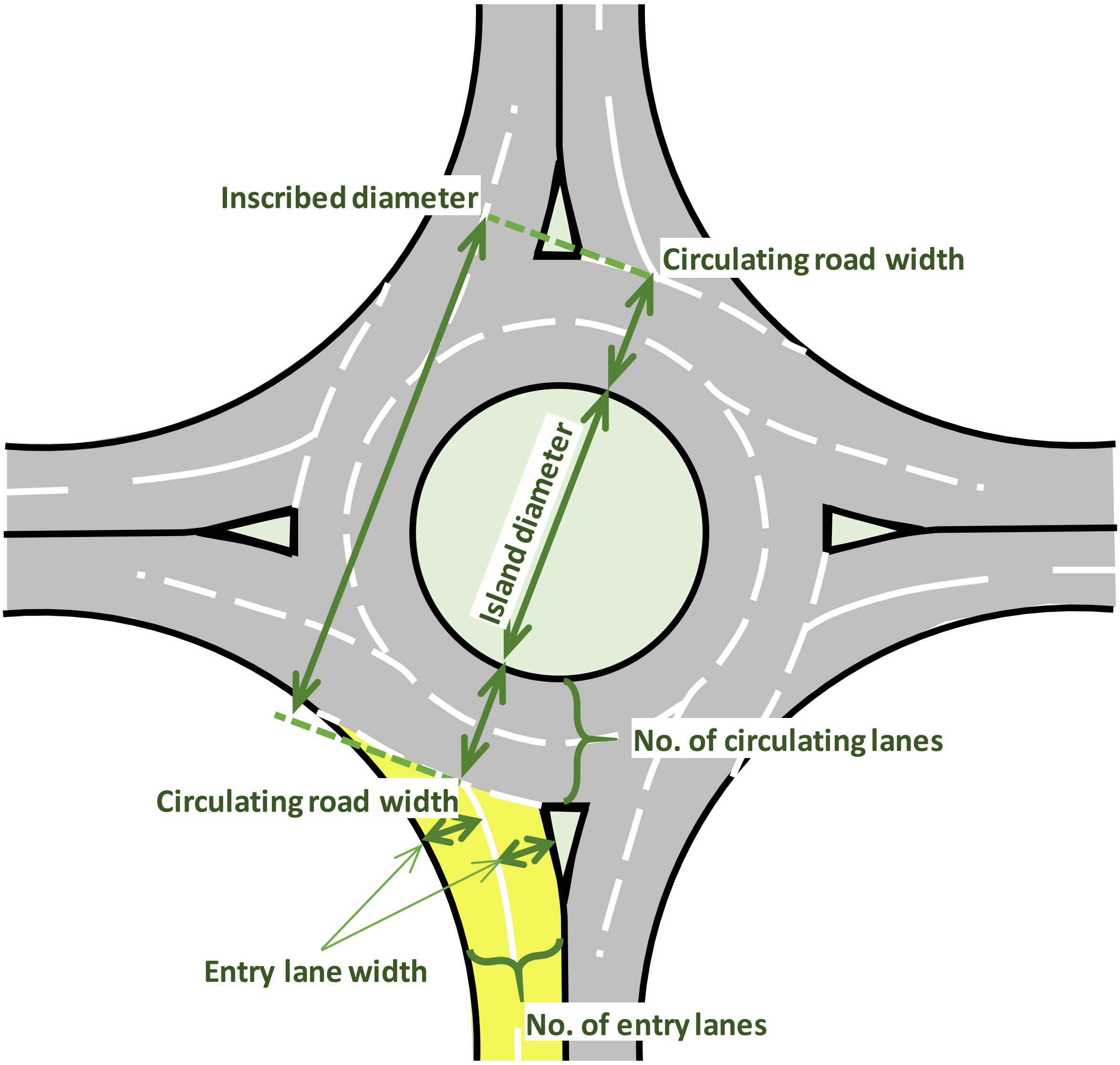
2.13.2 Worked Example - Record the Geometric Properties

The following geometric values are required to calculate the gap acceptance parameters of the roundabout:

- inscribed diameter
- circulating lane(s) width
- entry lane(s) width

Figure 2-4 illustrates the dimensions of a typical roundabout design.

Figure 2-4: Roundabout Geometry



The worked example describes how to calculate gap acceptance using the tables that summarise typical Australian values as researched by Troutbeck (1989).

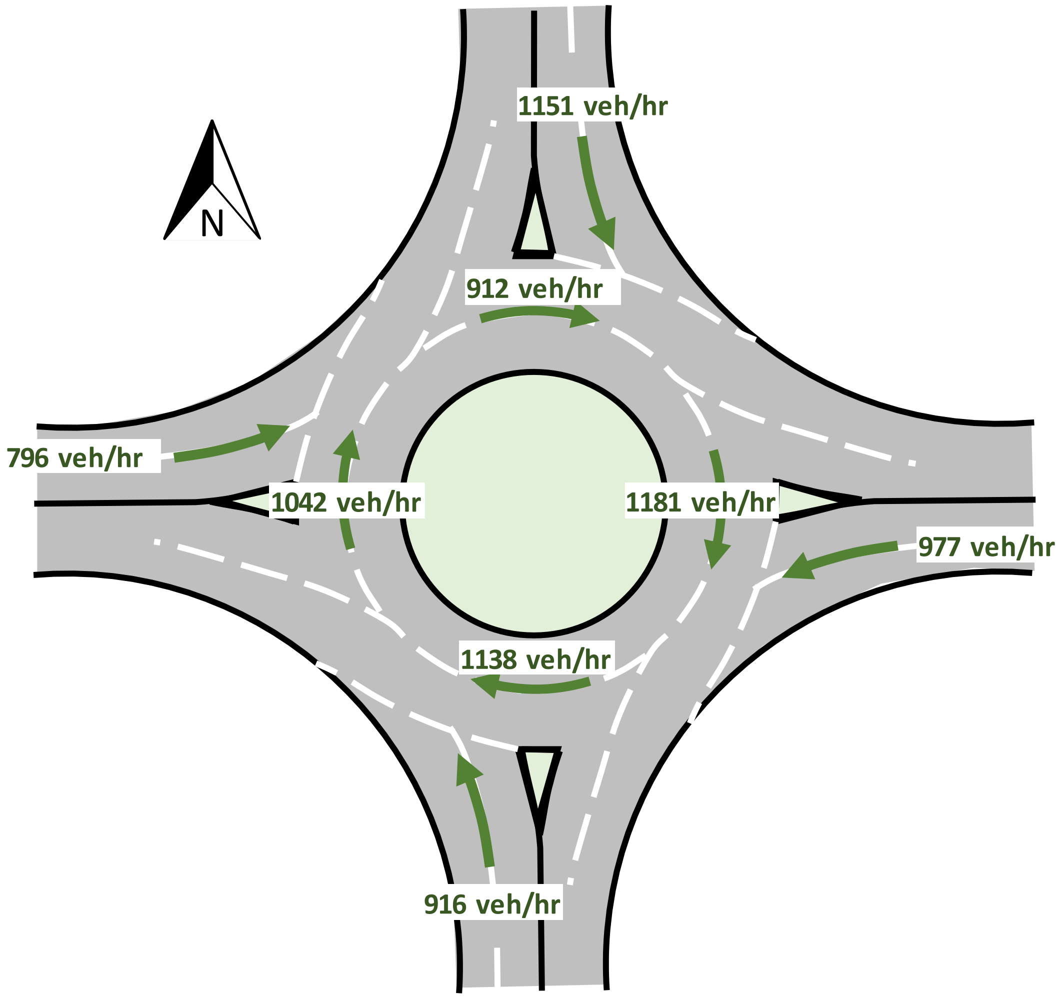
Table 2-8 shows the geometric properties of the roundabout for the worked example.

Table 2-8: Geometric properties of the roundabout

Geometric property	Measurement
Inscribed diameter	50 metres
Average entry lane width	4 metres
Number of entry lanes	2
Number of circulating lanes	2

The traffic flows for the worked example are shown in Figure 2-5.

Figure 2-5 Traffic flow for the roundabout



The traffic volumes used in this example are based on the turning movements as described in Table 2-9.

Table 2-9: Roundabout entry lane turning movements

Movement	Approach Leg			
	North	East	South	West
Left	132	76	86	63
Through	782	689	651	571
Right	237	212	179	162
Total	1151	977	916	796

Only the analysis of the north leg will be described here. The same analysis will be required for each subsequent leg of the roundabout. It is assumed that the left lane will carry the traffic turning left and half the through traffic. Using the figures in the above table for the north entry, the left traffic lane is assumed to be 132 + 782/2 or 523 vehicles per hour. Similarly, the right lane is assumed to be 237 + 782/2 or 628 vehicles per hour. At this approach the right hand lane has the greater flow and will be the dominant movement. The left hand lane will be the sub-dominant movement.

2.13.3 Worked Example - Estimating the Gap Acceptance Parameters

The critical gap parameters are evaluated for each entry lane. The dominant movement follow-up time can be interpolated from Table 2-10. For a circulating flow of 912 vehicles per hour and an inscribed diameter of 50 metres, the dominant movement follow-up time is **2.20** seconds.

Table 2-10: Dominant movement follow-up headways (excerpt)

Inscribed Diameter (m)	Circulating Flow (veh/h)					
	0	500	1000	1500	2000	2500
20	2.99	2.79	2.60	2.40	2.20	2.00
25	2.91	2.71	2.51	2.31	2.12	1.92
30	2.83	2.63	2.43	2.24	2.04	1.84
35	2.75	2.55	2.36	2.16	1.96	1.77
40	2.68	2.48	2.29	2.09	1.89	1.70
45	2.61	2.42	2.22	2.02	1.83	1.63
50	2.55	2.36	2.16	1.96	1.76	1.57

Source: Troutbeck 1989

Table 2-11 is used to adjust the dominant movement follow-up headway when the number of entry lanes does not equal the number of circulating lanes. As the number of entry lanes is equal to the number of circulating lanes there is no need to use Table 2-11.

Table 2-11: Adjustment times for the dominant movement follow-up headway

Number of circulating lanes	Number of entry lanes		
	1	2	3
1	0.00	-0.39	
2	0.39	0.00	-0.39
3		0.39	0.00

Source: Troutbeck 1989

Table 2-12 gives the sub-dominant movement follow-up time. The ratio of the dominant entry lane flow to the sub-dominant entry is equal to 628/523 or **1.20**. Using this value (1.20) and the dominant movement follow-up time (2.20), the sub-dominant movement follow-up time is **2.46** seconds.

Table 2-12: Sub-dominant movement follow-up headway (excerpt)

Dominant stream follow-up headway (t_{fd}) (s)	Ratio of flows (Dominant flow/Sub-dominant flow)				
	1.0	1.5	2.0	2.5	3.0
1.5	2.05	1.99	1.94	1.89	1.84
1.6	2.10	2.07	2.05	2.02	1.99
1.7	2.15	2.15	2.15	2.15	2.15
1.8	2.20	2.23	2.25	2.28	2.30
1.9	2.25	2.30	2.35	2.40	2.46
2.0	2.30	2.38	2.46	2.53	2.61
2.1	2.35	2.46	2.56	2.66	2.76
2.2	2.41	2.53	2.66	2.79	2.92

Source: Troutbeck 1989

The critical acceptance gaps for both entry movements are evaluated from the ratio of the critical gap to the follow-up time.

Table 2-13 indicates that this ratio is 1.42. The critical acceptance gap for the dominant movement is therefore 1.42 x 2.20 = **3.1** seconds. The sub-dominant movement critical acceptance gap is therefore 1.42 x 2.46 = **3.5** seconds. The gap acceptance values for the sub-dominant movement are always greater than that of the dominant movement.

Table 2-13: Ratio of the critical gap to the follow-up headway (excerpt)

Circulating flow (veh/h)	Number of circulating lanes / Average lane width (m)					
	One			More than one		
	3	4	5	3	4	5
0	2.32	1.98	1.64	2.04	1.70	1.36
200	2.26	1.92	1.58	1.98	1.64	1.30
400	2.19	1.85	1.52	1.90	1.58	1.24
600	2.13	1.79	1.45	1.85	1.51	1.18
800	2.07	1.73	1.39	1.79	1.45	1.11
1000	2.01	1.67	1.33	1.73	1.39	1.10

Source: Troutbeck 1989

Values of the ratio may be interpolated for intermediate widths of entry lane. For single lane circulating carriageways, if the critical gap calculated from Table 2-10 and Table 2-13 is less than 2.1s, use 2.1s. For multi-lane circulating carriageways, the minimum value of critical gap should be 1.5s.

2.13.4 Roundabout Size

Larger roundabouts enable better geometry to be designed. In general, roundabouts in high speed areas need to be larger to enable better entry and approach. The design of these roundabouts is more critical than that for those in low speed areas. A guide for choosing the minimum central radius for a circular roundabout can be found in Austroads' Guide to Road Design Part 4b: Roundabouts.

3 LinSig Guidelines

3.1 Introduction

JCT Consultancy's LinSig software is a design and assessment tool for signalised intersections and small networks. Used extensively in the United Kingdom and worldwide for over 30 years, LinSig has been adopted by numerous road agencies as the preferred tool for the assessment of existing and new traffic signal sites.

This section is designed to complement JCT's *LinSig 3.2 User Guide SCATS Version*. It provides detail on key parameters to be adopted when modelling intersections in Western Australia.

Modellers should refer to sections 1 and 2 for an overview of traffic modelling.

3.1.1 Appropriate Use of LinSig

As an intersection modelling tool, LinSig is used primarily to assess isolated signals or small networks, including signalised roundabouts, and can optimise traffic signal timings for a single intersection or groups of signals. While it is also capable of modelling priority movements within signalised intersections or priority intersections, its use to model isolated priority intersections or conventional roundabouts is not recommended.

LinSig can be used as a design tool to identify new intersection capacity requirements or assess the benefit of intersection improvements and refine options. LinSig should be considered for the following types of project:

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

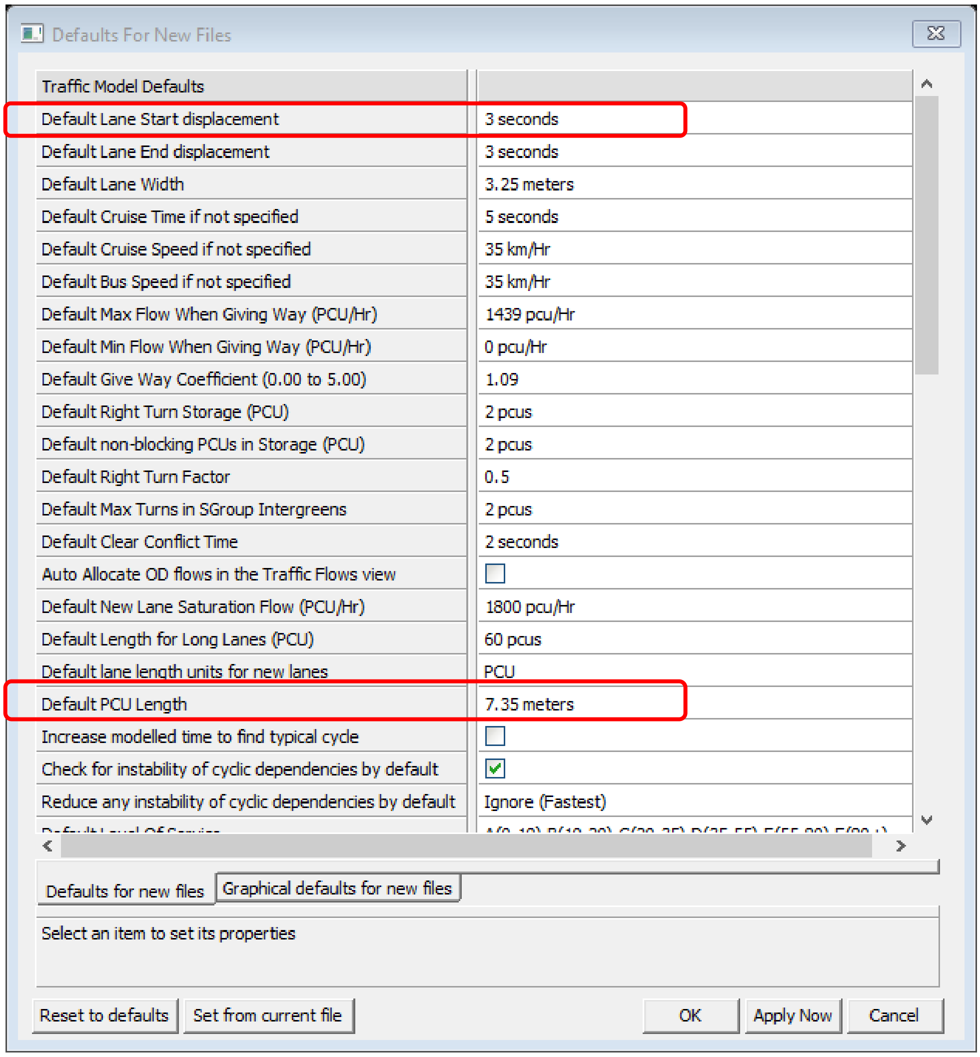
3.1.2 Software Version

This guideline is for Version 3.2 of the LinSig software package. While the *Operational Modelling Guidelines* will need to be updated for future versions of the software, the general principles outlined will continue to apply.

3.2 Program Settings

Modellers should change the default lane start displacement time and the default PCU length when developing LinSig models for the Western Australian road network, as shown in Figure 3-1.

Figure 3-1: Defaults for new files window



3.2.1 Default Lane Start Displacement

The *Default Lane Start Displacement* value should be changed from 2 seconds (software default) to 3 seconds (Western Australian driving behaviour) [10].

- For a new LinSig model, this should be changed in the *Defaults for New Files* window, as shown in Figure 3-1.
- For an established model, the lane start displacement time should be checked in *Model Audit View – Lane Data* and updated for each lane under the *Advanced* tab of the *Edit Lane* window, shown in Figure 3-21*.*

[10] Akcelik, Besley and Roper (1999) ARRB Research Report ARR340 Fundamental relationships for traffic flows at signalised intersections

3.2.2 Default PCU Length

The *Default PCU Length* should be changed from 5.75 metres (software default) to 7.35 metres (Western Australian environment) [11].

- For a new LinSig model, this should be changed in the *Defaults for New Files* window, as shown in Figure 3-1.
- For an established model, the PCU Length should be checked and updated in the *Network Settings* window.

3.2.3 Use SCATS Based Terminology

Use SCATS-based terminology should be selected in the *Program Settings* window to model SCATS signal set up at the start of the modelling process.

3.2.4 Use Separate Capacities for Long and Short Lanes

Use separate capacities for long and short lanes should be selected in *Network Settings* window to ensure the long and short lanes are analysed separately.

3.3 Network Inputs

This section details the LinSig input requirements for developing the network.

3.3.1 Network Information

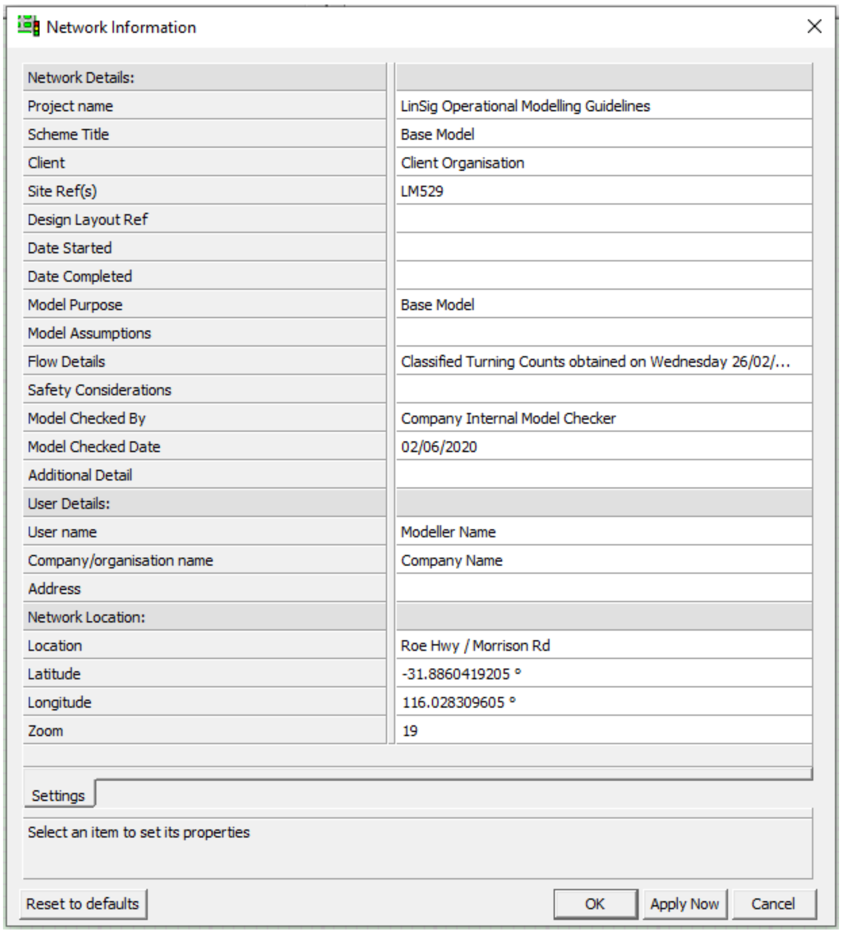
Information on the modelling project should be populated in the *Network Information* window, an example is shown in Figure 3-2. As a minimum, the following should be completed and updated for each stage of the project:

- *Project Name* – the overall project title, for example: Blackspot Programme
- *User Name* – name of the modeller
- *Company/organisation name* – company undertaking the work, and
- *Location* – location(s) of the study area being modelled.

The provision of latitude and longitude is optional for easy referencing of the site in Google Maps direct from LinSig. The coordinates can be obtained from Main Roads' *trafficmap* or other mapping services.

[11] Main Roads OMV Team (2018), Passenger Car Unit Length Desktop Research D18#213020

Figure 3-2: Network information window



Network Information

Network Details:	
Project name	LinSig Operational Modelling Guidelines
Scheme Title	Base Model
Client	Client Organisation
Site Ref(s)	LM529
Design Layout Ref	
Date Started	
Date Completed	
Model Purpose	Base Model
Model Assumptions	
Flow Details	Classified Turning Counts obtained on Wednesday 26/02/...
Safety Considerations	
Model Checked By	Company Internal Model Checker
Model Checked Date	02/06/2020
Additional Detail	
User Details:	
User name	Modeller Name
Company/organisation name	Company Name
Address	
Network Location:	
Location	Roe Hwy / Morrison Rd
Latitude	-31.8860419205 °
Longitude	116.028309605 °
Zoom	19

Settings

Select an item to set its properties

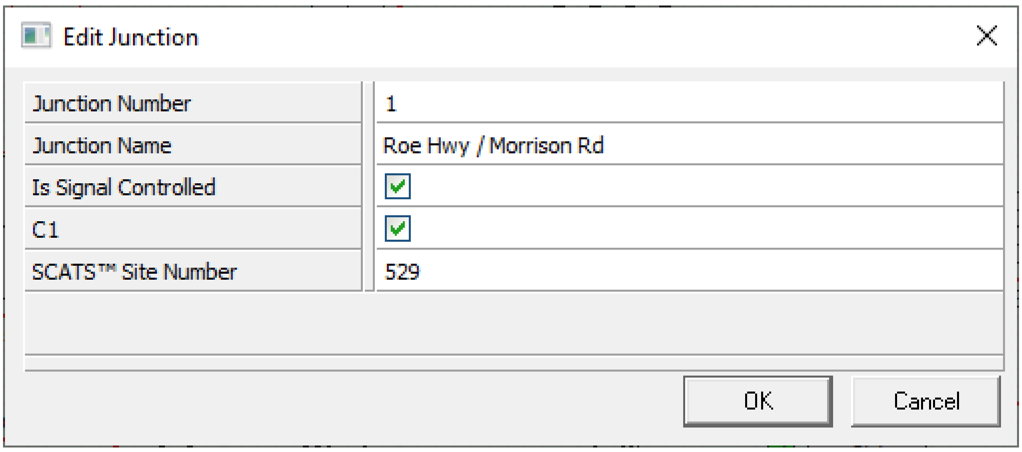
Reset to defaults | OK | Apply Now | Cancel

3.3.2 Junction Details and Network Information

Edit Junction details, as shown in Figure 3-3 should be updated to include the following:

- *Junction Name* – the name of the intersecting roads
- *Is Signal Controlled* – selected if the intersection is signal controlled
- *C1* etc – selected for the appropriate signal controller(s), and
- *SCATS Site Number* – the SCATS LM number for the site.

Figure 3-3: Edit Junction window



Edit Junction

Junction Number	1
Junction Name	Roe Hwy / Morrison Rd
Is Signal Controlled	☑
C1	☑
SCATS™ Site Number	529

OK | Cancel

3.3.2.1 Model Extent

In terms of the extent of small networks, it is not possible to put an upper limit on the number of controllers or length of corridor to be assessed. Modellers need to consider the specific nature of each corridor in the project that needs to be modelled. For example, LinSig may be appropriate over a significant length of corridor with several intersections if the carriageway pattern is reasonably uniform and it is subject to controlled access and limited side friction. The SCATS settings should be reviewed to decide if neighbour intersections are linked and if the neighbour intersections are required to be modelled. The modelling extent should be decided and agreed with Main Roads at the start of each modelling project.

3.3.3 Notes

The use of the *Add Note* function in *Network Layout View* is strongly recommended for providing a list of high level assumptions that are unique to the particular model, some examples are shown in the figures in Section 3.3.6.

While the detailed assumptions and the reasoning should still be provided in the modelling report, the high level list displayed in the *Network Layout View* would provide a snapshot of the assumptions when other modellers view the LinSig model.

3.3.4 Arms

The arm layout should replicate the site layout, that is, the northern arm should be located on the northern side of the intersection.

For consistency, arms should be added to the model using the following convention:

1. Arm 1 should correspond with the approach containing SCATS loop number 1.
2. Subsequent entry arms should then be added in the same order as the SCATS loop numbers, usually in the anti-clockwise direction.
3. Exit arms should then be added starting at the **opposite direction**[12] of entry arm 1 and added anti-clockwise.

Arms should be named using the following convention:

- Road Name
- Direction, and
- Exit, if appropriate.

  For example *Roe Hwy NB* or *Morrison Rd WB exit*

While using different arm numbering and naming systems would not affect the modelling results, Main Roads recommends the same system is used for consistency of the modelling in Western Australia.

[12] if the *Edit Junction's Turning Counts* function is used to enter the turning movements, the origins and destinations are listed in the same order for ease of processing.

For the intersection shown in Figure 3-4, an example of the arm, lane and zone layout is shown in Figure 3-5.

Figure 3-4: SCATS arms and loop numbers example for an isolated intersection

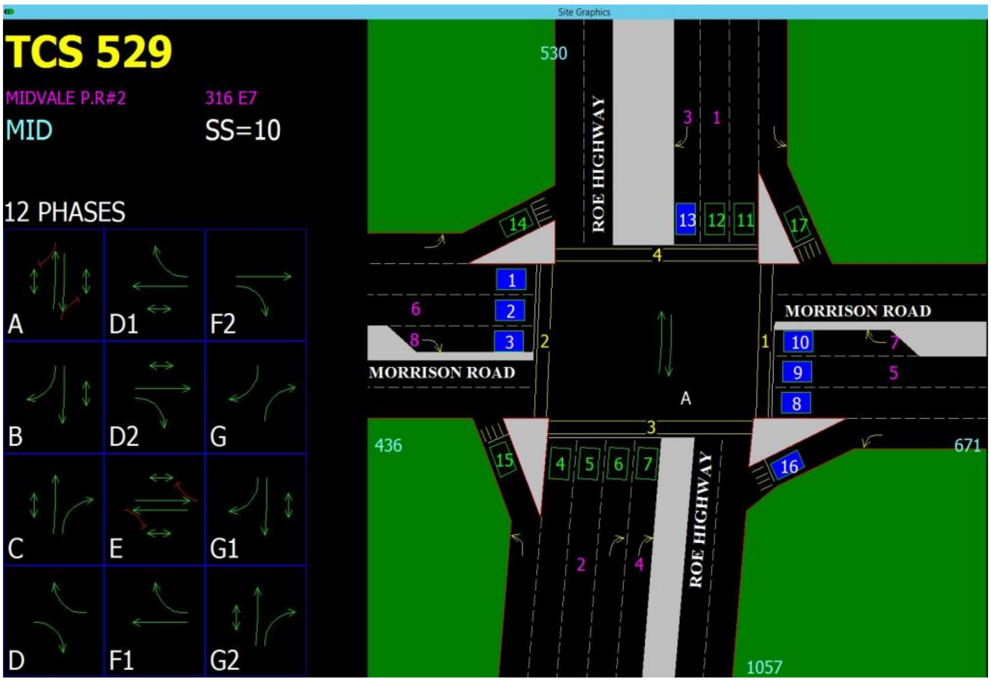
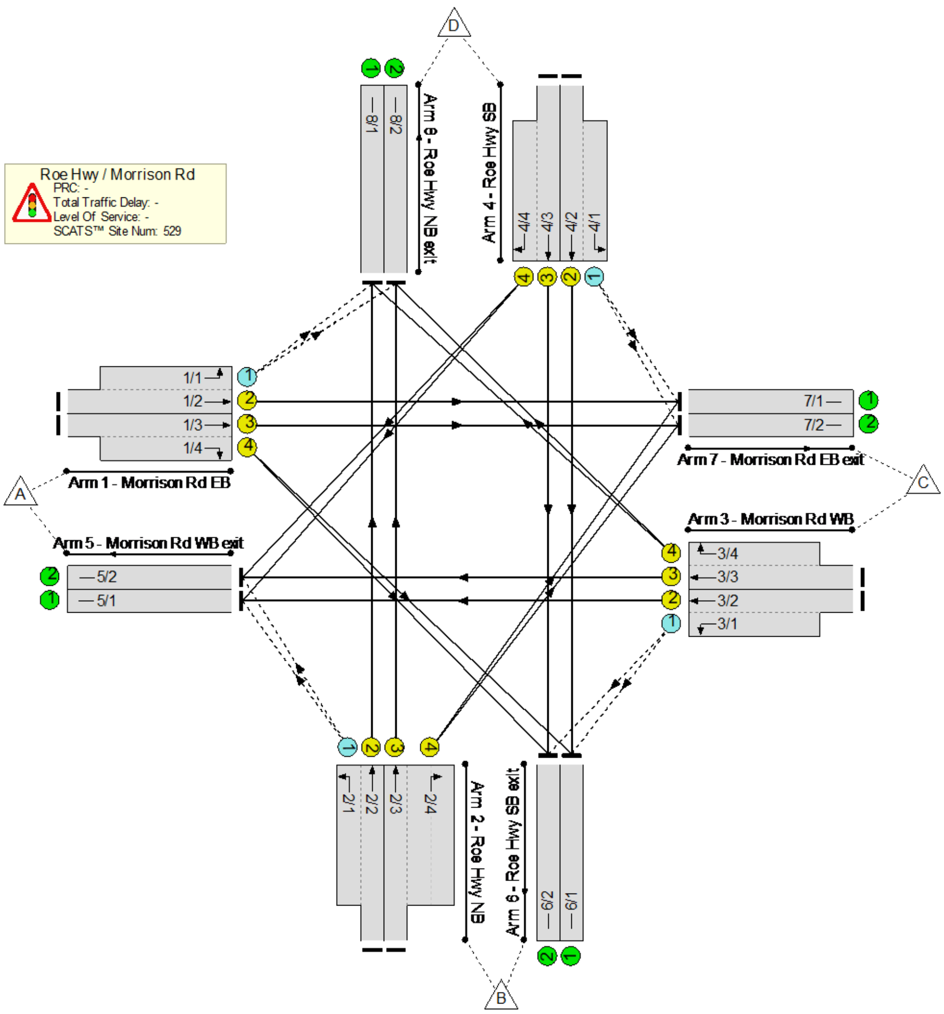


Figure 3-5: Arm set up, naming and numbering example for an isolated intersection



3.3.5 Network Modelling

In the LinSig section of the document, 'network modelling' is defined as multiple intersections modelled in the same LinSig file.

3.3.5.1 Interchange

When modelling an interchange, it is possible to assign all lanes to the same *Junction* and there is no need to model separate exit and entry arms. If the interchange is operated under two separate signal controllers, both controllers can be assigned under the same *Junction*.

For the interchange shown in Figure 3-6, an example of the arm, lane and zone layout is shown in Figure 3-7.

Figure 3-6: SCATS arms and loop numbers example for an interchange

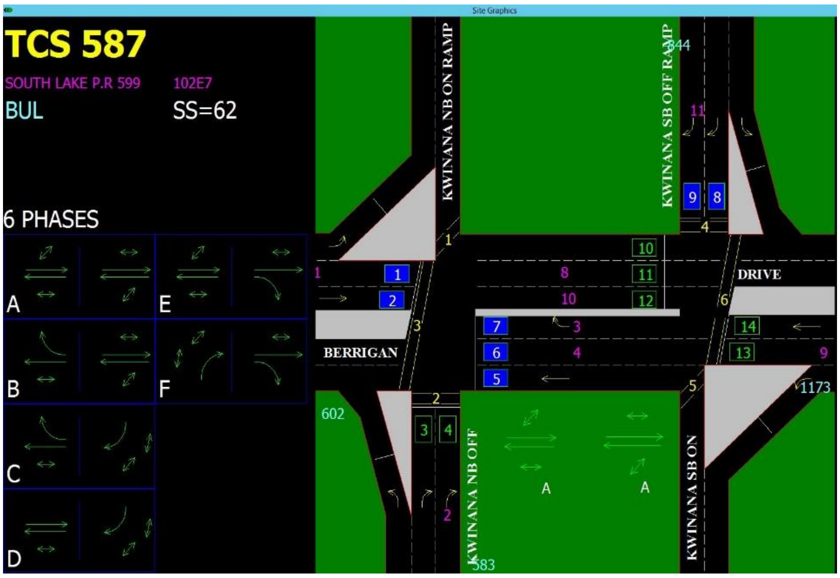
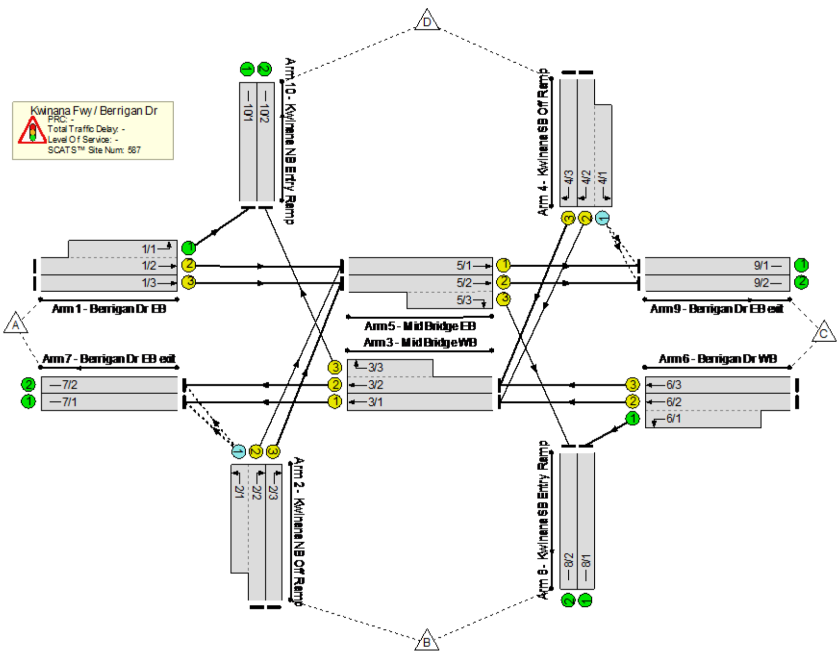


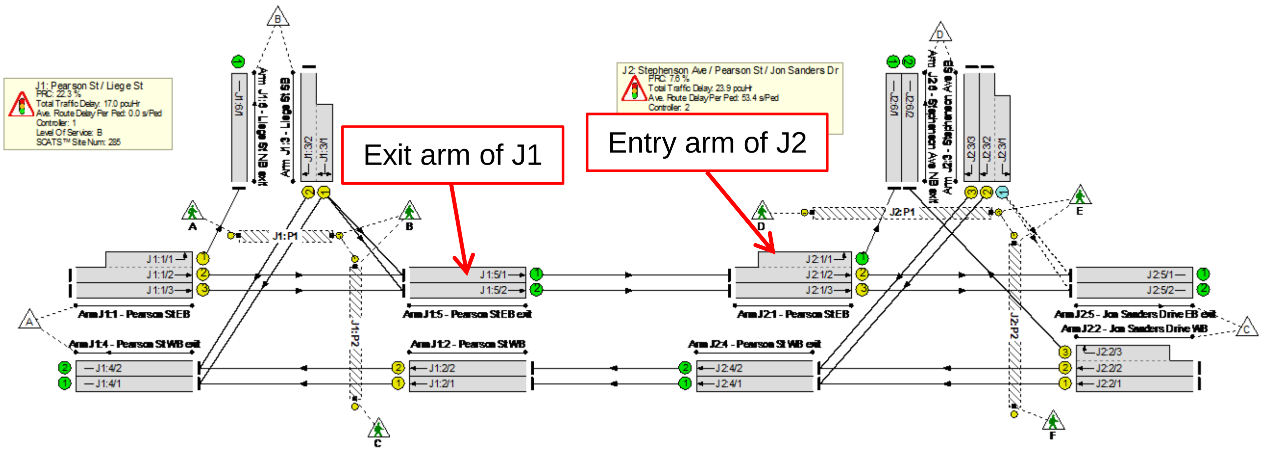
Figure 3-7: Arm set up, naming and numbering example for an interchange



3.3.5.2 Multiple Intersections

When modelling multiple intersections in a network model, it is recommended that each intersection contains separate exit arms and entry arms, as shown in Figure 3-8. The network layout missing an exit arm of the upstream intersection in is not recommended.

Figure 3-8: Lane structure for network modelling of multiple intersections



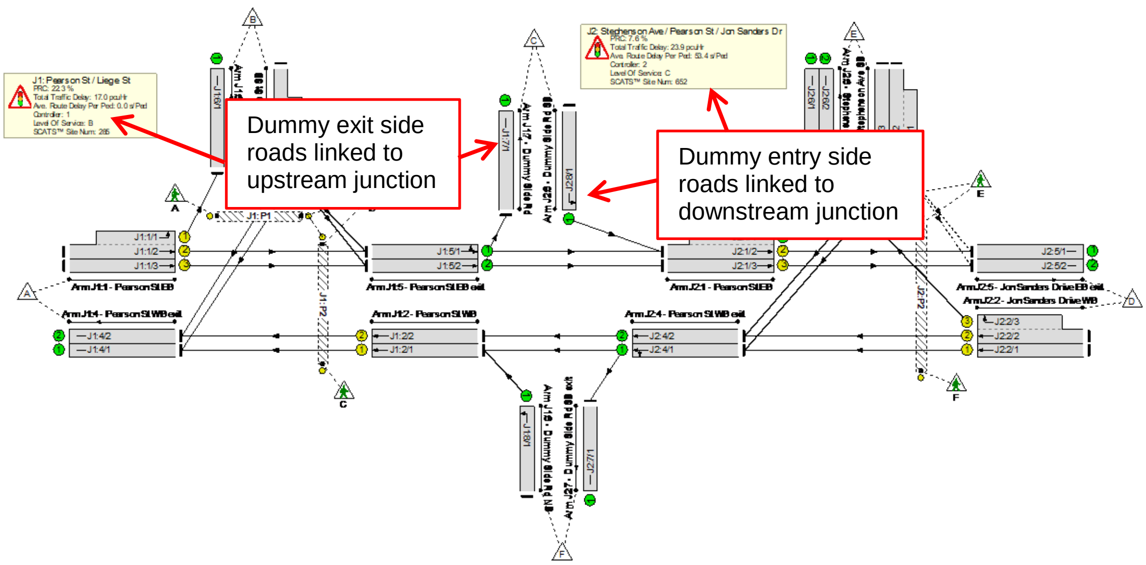
3.3.5.3 Side Roads

If dummy side roads are required solely for balancing traffic flow, there is no need to create a separate *Junction* to avoid creating excessive number of *Junctions* and *Arms* in the model:

- the exit side roads are grouped as part of the upstream *Junction,* and
- the entry side roads are grouped as part of the downstream *Junction*.

Give-way parameters are not required for the dummy side roads. An example is shown in Figure 3-9.

Figure 3-9: Lane structure for network modelling with dummy side roads



While LinSig does not require the dummy side roads to be included for modelling sources and sinks traffic zones, Main Roads' preference is to model the dummy side roads in the network because modellers have more control over the matrix estimation. This is because they can enter the turning volume at the dummy sites prior the matrix estimation process (refer to Section 3.4.4.1); moreover, the turning volume at the side roads can be displayed in *Network Layout View* for ease of checking.

It should be noted that if the priority controlled side roads are required for scheme analysis, then the side road intersection should be treated as a separate *Junction* as discussed in Section 3.3.5.2, with the appropriate give-way parameters coded.

3.3.6 Long and Short Lanes

It is important for the modeller to appreciate that the arm/lane structure should be designed to best model the issues that will have the greatest effect on capacity. The modeller should design the lane structure to provide the best model rather than simply entering lanes to replicate what is physically on the street. This may mean that the arm/lane structure in LinSig may not be exactly as they occur on the street.

Modellers need to decide the modelled lane structure on a case-by-case basis depending on the site layout, signal set up, traffic volume, lane usage and the nature of the scheme being analysed.

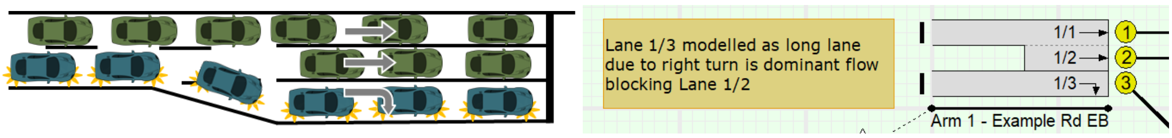
A better model may be produced by varying the lane structure to reflect how traffic actually queues and uses the lanes.

When developing the base model, modellers should already consider how the proposed scheme is likely to be modelled in order to provide a like-for-like calculation when comparing the base and option modelling results. For example, if the existing layout consists of one lane with a short lane, and the proposed scheme is to analyse impact when another short lane is added, modellers may consider modelling the base layout with two long lanes and the apparent impact of the proposed short lane can be shown in the proposed model.

3.3.6.1 Dominant Demand Pocket

For example, where a dominant flow movement blocks back from a short lane and in effect forms its own long lane, it may be better to restructure the LinSig lanes to reflect this, as shown in Figure 3-10. The physical lane length for the modelled short lane may need to be shortened based on how the right-turn queue blocks the through lane. Refer to Section for 3.3.7.3 for general guidelines on short lane lengths.

Figure 3-10: LinSig lane structure for modelling dominant flow blocks from a short lane

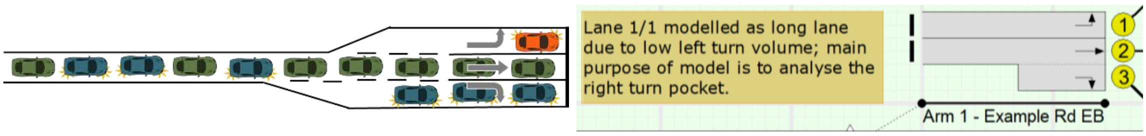


3.3.6.2 Multiple Pocket Lanes

The current version of LinSig has a limitation that only one short lane can be attached to each long lane, which can be problematic to the typical road layout seen in Western Australia. Where complex flaring occurs, it is still often possible to model this in LinSig by making assumptions to ensure the most critical capacity issues are measured accurately while lesser issues are modelled with compromises (and insignificant issues are not modelled).

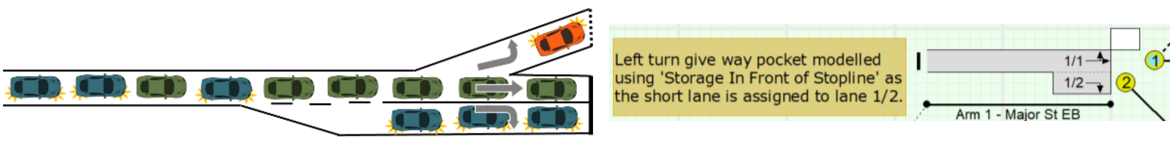
In the example shown in Figure 3-11, the left-turn volume is low, the through traffic queue blocks the right-turn traffic from access the pocket; it is more important to analyse usage of the right-turn pocket than the left-turn pocket as the left-turn is relatively less significant. In this case, the right-turn lane is modelled as a short lane in LinSig to analyse the interactions between the through and right-turn traffic, otherwise if the right-turn lane is modelled as a long lane, LinSig overestimates the capacity for the right turn traffic.

Figure 3-11: Example LinSig lane structure for modelling more than one pocket lanes based on traffic demand and lane usage



In the example shown in Figure 3-12, the left-turn short lane is a give-way slip, modellers can utilise the *Storage in front of stop line* and *Non-blocking storage* functions in the give-way setup to model the layout. Note that the give-way parameter values may need to be calibrated. Refer to Section 3.6 for general guidelines on give-way inputs.

Figure 3-12: Example LinSig lane structure for modelling more than one pocket lanes with a left turn slip lane

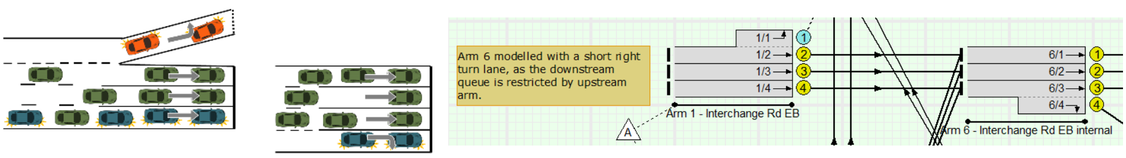


Refer to Section 3.3.10.2 for modelling double pocket lanes.

3.3.6.3 Interchange

In the interchange example shown in Figure 3-13, the queue for the downstream arm (Arm 6) is restricted by the upstream approach arm (Arm 1). One of the lanes from the internal arm (Arm 6) should be modelled as a short lane to replicate the restricted capacity. Modelling the internal arm with four full lanes would overestimate the capacity. This should be decided on a case-by-case basis depending on the signal set up and queuing behaviour.

Figure 3-13: Example LinSig lane structure for modelling restricted internal arm at an interchange



3.3.7 Lane Lengths

3.3.7.1 Long Lanes (Entry and Exit Lanes)

For an isolated intersection model, the length of long lanes can be left as software default (60 PCUs = 441.0m).

3.3.7.2 Long Lanes (Internal Lanes)

Entering correct lane lengths for internal lanes is critical when cruise speed is applied in the connectors, as LinSig uses lane lengths and cruise speed to calculate the platooning cruise time in a network.

The total lane lengths of the internal long lanes should be measured between the upstream and the downstream stop lines, typically based on the through movement between the two intersections. The combined distance of the internal lanes should be added up to be the same as the total physical distance between the two stop lines on-site.

An example of the distance measurement is shown in Figure 3-14 where:

- The upstream exit lane length is typically the distance from the upstream intersection stop line to the exit of the intersection (roughly to the stop line of the opposite lane).
- The downstream entry lane length is measured from the exit of the upstream intersection to the downstream intersection stop line.

Figure 3-14: Recommended lane length measurements for internal long lanes

Source: SkyView

While the lane lengths for internal lanes would not affect the modelling results if cruise time, instead of cruise speed, is applied in the connectors, Main Roads strongly recommends the lane lengths still be entered in the LinSig model in all situations for consistency. Refer to Section 3.3.12.3 for information on cruise time / speed.

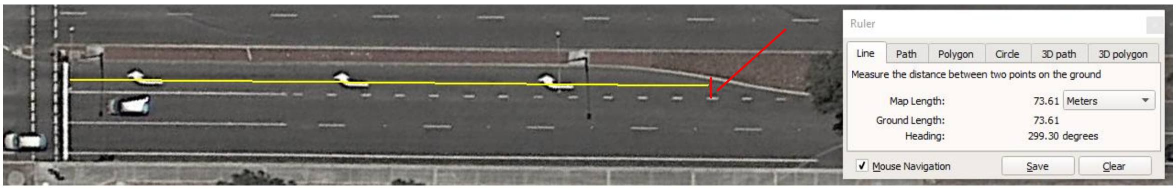
3.3.7.3 Short Lanes

The *Physical Lane Length* of a short lane should be determined by examining where the queueing traffic on the short lane would block the adjacent long lane.

3.3.7.3.1 Pocket Lanes

The length of the short lanes can be estimated from mapping services by measuring the distance between the stop line and where the traffic of the short lane would meet the main traffic lane. Typically this would be where the lane width is approximately two metres at the taper section, as shown in Figure 3-15. The physical lane lengths should be entered directly into LinSig in metres or PCUs (based on 1PCU = 7.35m).

Figure 3-15: Short lane length measurement example



3.3.7.3.2 Free Flow Lanes

If the short lane is a free flowing lane, i.e. does not have a give-way or stop line, then the distance of the free flow short lane should be determined by measuring the distance from the stop line of the *adjacent lane* to where the traffic of the long lane would block the short lane, as shown in Figure 3-16.

Figure 3-16: Free flow short lane length measurement example

It is recommended that screenshots of the measurements taken with AutoCAD or mapping services, such as the examples shown in Figure 3-15 and Figure 3-16, are included in the modelling submission package to demonstrate how the lane lengths were determined for ease of auditing.

3.3.7.4 Custom Occupancy

There is an option to adjust the occupancy of the short lanes in *Custom Occupancy*. This function should not be used unless justifiable.

3.3.8 Entry Lane Cruise Time

Main Roads recommends the cruise time / speed values of the entry lanes to be left blank as software default, unless considered to be necessary.

Note that cruise times are required for the connectors to internal lanes, see Section 3.3.12.3.2.

3.3.9 Saturation Flow

Main Roads' order of preference for determining the saturation flow (refer to Section 2.10.3) is to:

1. Measure on-site where possible for the critical lane(s) of each approach.
2. Use RR67 geometric calculations, with a local factor applied based on lanes that can be measured on-site.
3. Use RR67 geometric calculations, with a local factor applied based on lanes that can be measured on-site at a neighbouring intersection with a similar geometric layout.
4. Use RR67 geometric calculations without adjustments.

Information on the measurement requirements and the understanding of the RR67 geometric calculations can be found in Appendix B. This section examines the application of saturation flow specifically for LinSig modelling.

3.3.9.1 Directly Entered Lane Saturation Flow

Where possible, saturation flow should be measured on-site for the critical lane(s) of each approach. These values should be entered on a lane-by-lane basis using the *Directly Entered Lane Saturation Flow* input.

All flow groups should have the same directly entered lane saturation flow value and therefore the *Default* box for all flow groups should be checked for all flow groups. However, if the saturation flow values are found to be significantly different between flow groups, this should be stated in the modelling report.

When factored geometric calculated lane saturation flow is used in the LinSig modelling, the modeller needs to undertake the calculations in the spreadsheet and enter the calculated values using the *Directly Entered Lane Saturation Flow* option.

3.3.9.2 Geometric Calculated Lane Saturation Flow

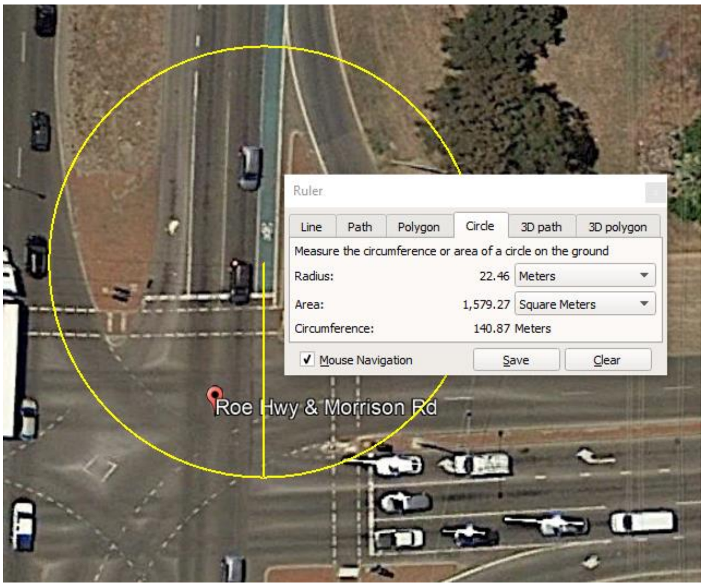
Where measurement of saturation flow is not possible for base cases or for proposed intersections, *Geometric Calculated Lane Saturation Flow* input can be used. The calculations are based on the RR67 geometric calculation and requires the following inputs:

- **Lane width** – measured on-site or scaled from LM plan or appropriate aerial photographs or design drawings.
- **Radius** – measured from LM plan or appropriate aerial photographs or design drawings based on the centre-line of the turning vehicle movement. For through movement, the radius should be left as *Inf.*
- **Gradient (%)** – for uphill, measured from Google Earth or mapping services or noted from design drawings. For flat or downhill, the gradient should be left as 0.

- **Treat as nearside lane** – identification of nearside or offside lane. Modellers should refer to Section 3.3.9.2.1 for guidance.
- **Turning proportions** – for a lane with mixed movements, LinSig calculates the proportion of vehicles making each movement based on the assigned traffic. This is not a direct input in LinSig as the software calculates the turning proportions based on the assigned traffic on movement.

The modeller should supply evidence of the geometric measurement (such as marked-up plans or aerial maps indicating measurements indicating the curvature used for determining the radii, as shown in Figure 3-17) in the modelling report for ease of auditing.

Figure 3-17: RR67 geometric measurement mark-up example



Modellers should consider if the geometric calculated saturation flow values are representative of the driving behaviour at the modelled intersection, by comparing the calculated saturation flow with the site measured values. A local factor may need to be applied to the intersection. Refer to Section 3.3.9.4.

3.3.9.2.1 RR67 Nearside and Offside Lanes

When using RR67 estimates for lane saturation flow, a lane needs to be identified as nearside or offside. The interpretation of the nearside/offside setting in RR67 is vague. A nearside lane is loosely defined as the first lane from the kerb in which a particular traffic movement appears. Figure 3-18 shows some examples of lane compositions to aid in identification of nearside lanes.

Figure 3-18: Nearside lane identification

If the selection of nearside or offside leads to significantly different engineering consequences in the modelling, then measured or locally-derived saturation flow values should be used to improve the accuracy of the modelling.

All decisions should be made on a case-by-case basis depending on the site layout and the lane usage.

3.3.9.3 Unconstrained (Infinite Saturation Flow)

For exit lanes, the saturation flow should be set to *Unconstrained*, unless there is a good modelling reason not to do so. Setting an inappropriate saturation flow at an exit lane can cause undesirable side-effects, such as sliver queues which would not occur in practice.

When a free flow exit lane has a short lane attached to it, for example to model mid-block turning pockets, LinSig requires a saturation flow value for the long lane and *Unconstrained* cannot be applied. In those situations, a nominal high value, such as 2400 PCU/hr, should be applied to the long lane. If an unrealistically high Mean Maximum Queue is calculated by LinSig as a result, queue graphs should be examined to determine the cause of the queue and further calibration is required.

3.3.9.4 Factored RR67 Saturation Flow Using Site-Measured Saturation Flow

The saturation flow values measured on-site should be compared with the RR67 geometric calculation. If the average of the site values are found to be more than five per cent different from the RR67 geometric calculation, the modeller should consider applying a local site factor to the RR67 calculated lanes. For consistency, the same factor should also be applied in the option models. Failure to apply a site factor may result in inaccurate assessment of the option model outputs.

If it is not possible to measure saturation flow on-site to obtain a local factor, site measured saturation from a nearby intersection with similar geometry, traffic compositions and driving behaviour can be used to determine the local factor.

LinSig has a built-in geometrically-calculated lane saturation flow function based on the RR67 formula. If a local factor is required, the modeller would need to calculate the RR67 and the factored saturation flow in a separate spreadsheet. The RR67 research paper and the formula can be obtained from the TRL website (https://trl.co.uk/reports/RR67).

In the example shown in Table 3-1, the site measured saturation flow is found to be on average 93.0% of the RR67 equivalent values, therefore the local factor of 93% should be applied for the remaining traffic lanes with saturation flow estimated using RR67.

Table 3-1: Saturation flow comparison

Lane	Site measured saturation flow	RR67 calculated saturation flow	Site measured : RR67 ratio (local factor)	Saturation flow used in LinSig modelling	Saturation Flow Method
1/1	-	1809	-	1682	Factored RR67
1/2	-	1925	-	1789	Factored RR67
1/3	1889	2065	91.5%	1889	Site measurement
2/1	1816	1955	92.9%	1816	Site measurement
2/2	-	1865	-	1734	Factored RR67
3/1	1999	2115	94.5%	1999	Site measurement
3/2	-	2036	-	1893	Factored RR67
		Average	93.0%		

3.3.9.5 Saturation Flow at Interchanges

If two signal intersections are closely spaced with limited lane changing opportunities, the discharge rate of the upstream stop line may be dependent on the downstream stop line discharge rate.

The saturation flow for the upstream stop line may need to be adjusted to replicate the on-site behaviour, for example matching the same value as the downstream stop line, or if geometric calculation is used, the lane should be identified as nearside as shown in the bottom right example in Figure 3-18.

3.3.10 Multi-Lanes

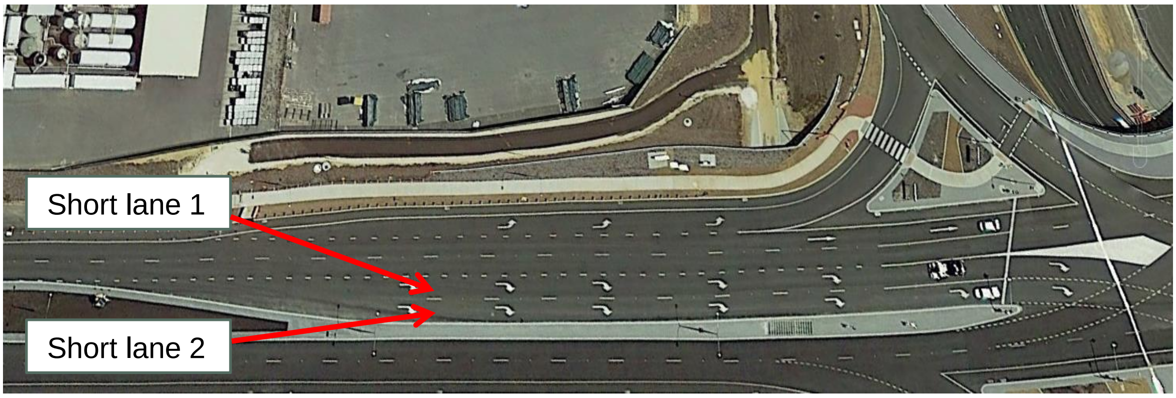
3.3.10.1 Multiple Long Lanes

Multiple-lanes for long lane should be avoided where possible. If this is used, the physical lane length should be the average of all lanes, and the saturation flow value applied to the multi-lane represents the combined saturation flow of all lanes.

3.3.10.2 Multiple Short Lanes

LinSig has a shortcoming when reflecting certain road geometry common in Western Australia, where multiple short lanes are adjacent to one another, such as the layout shown in Figure 3-19 in which two lanes then flared to five lanes, including a double pocket for the right-turn movement.

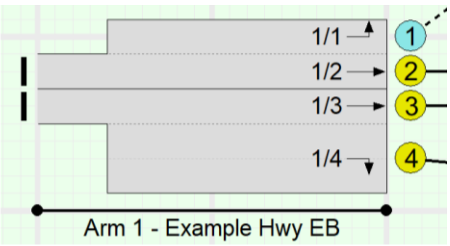
Figure 3-19: Typical double short lane layout

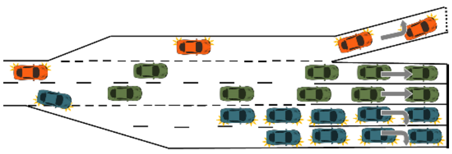


Source: SkyView

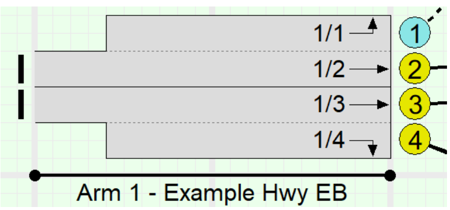
There are a number of methods that can be adopted to deal with this issue. The modeller should identify the most appropriate approach and document the assumptions and reasoning behind the choice of lane representation; this should be chosen on a case-by-case basis. Common techniques to deal with this situation are shown in Figure 3-20.

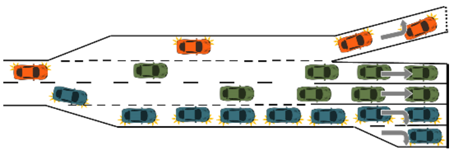
Figure 3-20: Common techniques to model double pocket layout in LinSig

<table>
<tr>
<td>



</td>
<td>
Multi-lane Representation
This is the preferred method if there equal use of both short lanes.

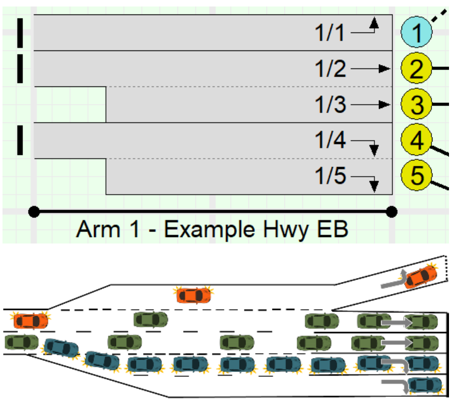
All lanes in a multi-lane have the same green time.
Physical lane length in LinSig is the average of the two short lanes.
Saturation flow is the combined value of the two short lanes.
This method is not suitable if the physical lane length and/or lane usage of both short lanes are not equal.

</td>
</tr>
<tr>
<td>



</td>
<td>
Combine Multiple Short Lanes as a Single Short Lane
This method is applicable if the physical lane length of one of the short lanes is significantly short (i.e. only 1-2 PCU).

Physical lane length in LinSig is the combined value of the two short lanes.
For saturation flow, refer to Section 3.3.10.2.1 for the formula.

</td>
</tr>
</table>

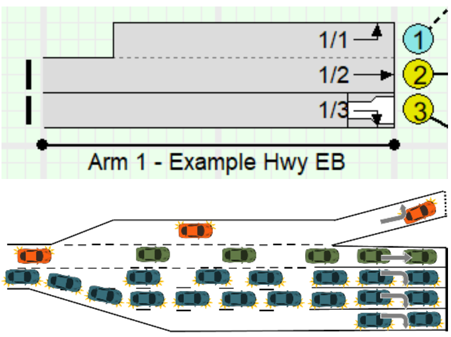


Modelled One Short Lane as a Long Lane

This method is applicable if it is more important to analyse the unequal lane utilisation of the double pocket over a relatively insignificant movement.

In this example, despite the available physical space on-site, right-turn traffic does not use both lanes fully due to downstream layout.

- The lane with the insignificant movement is treated as a long lane in LinSig (e.g. left lane in this example).
- Flow on the non-utilised lane (e.g. right lane of double pocket) is locked to represent the usage.
- Alternatively a *delay based cruise time weighting* can be added to the non-utilised connector.
- Modellers should always check and verify the queue results to ensure the modelled queue does not exceed the physical pocket lane. If exceeded, alternative modelling methods would need to be considered.



Enable Flared Saturation Flows

This method assumes the long lane and the associated short lanes are assigned for the same traffic movement and operated under the same signal group. It cannot be used if the long and short lanes are assigned for different traffic movements.

- Select *Enable Flared Saturation Flows* in *Multi-Lane* and add the number of flares associated with this long lane.
- Adjust the saturation for each flare lane.
- Enter the expected usage of each flare lane for each scenario. Note that this is based on the actual usage per cycle and not the physical flare length. The usage can be estimated from the queue surveys data.

3.3.10.2.1 Saturation Flow for Multiple Short Lanes

For a multi-short lane configuration, if the lane lengths are relatively long and both lanes have equal usage, then it is acceptable to combine the saturation flow of individual lanes in the LinSig modelling.

However, if the usage of both lanes is significantly different, then the total effective saturation flow for both short lanes needs to be calculated using the following formula[13]:

- When $L_1 > L_2$ and $Q_2 < g$, effective saturation flow = $\frac{[S_1(g-Q_2)+Q_2(S_1+S_2)]}{g}$
- When $Q_2 > g$, effective saturation flow = $S_1 + S_2$

Refer to Figure 3-19 for an illustration of short lane 1 and short lane 2 configuration.

[13] Formula sourced from Traffic Modelling Guidelines Version 1 Roads & Martitime Services page 167.

- L_1 = effective length of short lane 1 (PCU)
- L_2 = effective length of short lane 2 (PCU)
- S_1 = saturation flow of short lane 1 (PCU/hr)
- S_2 = saturation flow of short lane 2 (PCU/hr)
- g = green time (seconds)
- h_2 = headway for shortest lane = $3600 \div S_2$
- Q_2 = queue clearance time for shortest lane = $L_2 \times h_2$

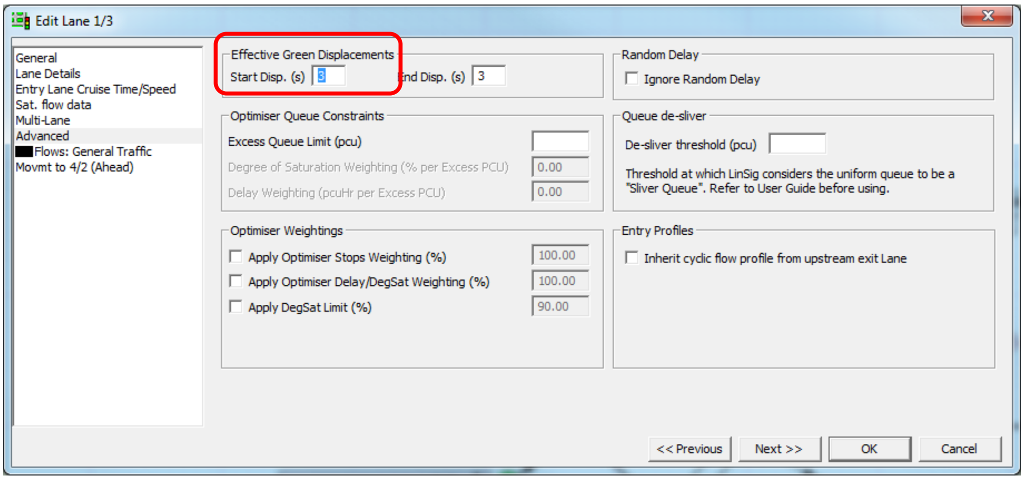
While this formula can be used to calculate the effective saturation flow of situations with different lane lengths in a multi-lane, it should be used to produce an estimate rather than be re-calculated repeatedly for minor green time changes.

3.3.11 Advanced Settings in Lanes

The *Advanced* tab can be found in the *Edit Lane* window, an example is shown in Figure 3-21. With exception of the effective green start displacement, all other parameters should be left as software default unless justifiable:

- *Effective green start displacement* – should be changed from two seconds to three seconds (refer to Section 3.2.1).
- Effective end green start displacement – as default three seconds.
- *Optimiser Queue Constraints* – refer to Section 3.5.12.4.1 if this is required for the signal optimisation model.
- *Optimiser Weightings* – refer to Sections 3.5.12.4.2 and 3.5.12.4.3 if changes are required for the signal optimisation model.
- *Random Delay – Ignore Random Delay* should be left unchecked.
- *Queue De-sliver* – refer to Section 3.9.4 if this is required.
- *Entry Profiles – Inherit cycle flow profile from upstream exit lane* should be left unchecked. This function is only applicable if separate OD matrices are used for each individual intersection, but as Main Road recommends a single OD matrix is formatted for the entire network, this function is not required. Refer to *LinSig3 User Guide* for information.

Figure 3-21: Edit Lane window, Advanced tab



3.3.12 Lane Connectors and Cruise Time

Lane connectors should be added to represent the allowed movements from each lane. Note that the input parameters are applied across all scenarios.

3.3.12.1 Turning Connectors

For turning movements, it is generally recommended to add connectors to all lanes of the downstream arm, but this depends on the intersection layout, driving behaviour and on-site lane usage.

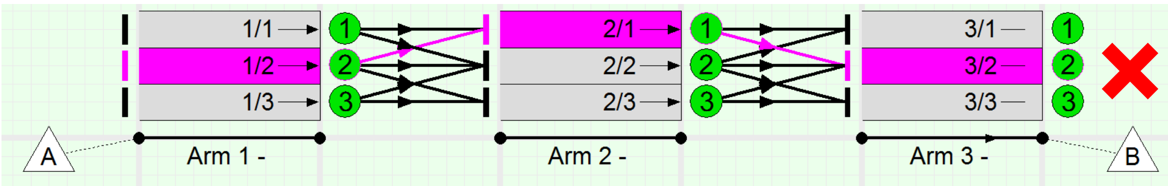
3.3.12.2 Weaving Connectors

Within an intersection, weaving connectors should be not be used as traffic should not change lanes within the intersection.

For a network model, weaving connectors should only be used if there are legitimate lane changes between intersections.

Criss-cross connectors and excessive number of weaving connectors, as shown in Figure 3-22, should be avoided. Providing an excessive number of weaving opportunities could cause LinSig to evaluate all the possible scenarios and increase the run times, particularly when the number of intersections is increased.

Figure 3-22: Unrealistic criss-cross connectors and weaving routes should be removed



Modellers should review the connector structure in the first instance and consider deleting any unnecessary connectors. In addition, modellers should review if the traffic assigned by LinSig on the weaving connectors reflects realistic on-street conditions, refer to Section 3.4.6 for further information.

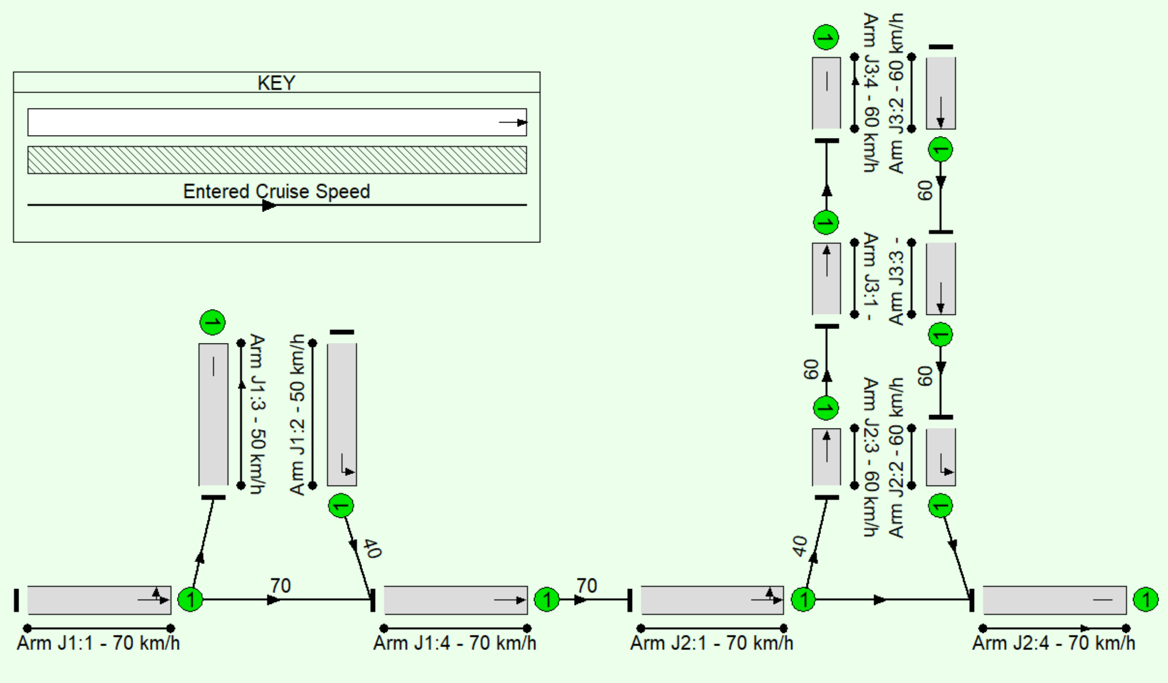
3.3.12.3 Cruise Times / Speed

Cruise time is the un-delayed travel time between two points in the study network. It is a critical input for signal coordination with incorrect cruise time resulting in a badly coordinated network.

Modellers can enter either cruise time or cruise speed to the relevant connector. The use of cruise speed is acceptable for ease of model inputs. If cruise speed is used, the downstream physical lane length should be correct as LinSig calculates the modelled cruise time based on lane length and cruise speed inputs by the modeller.

Modellers should note that the cruise time / speed at the connectors represent the time / speed travelling into the next connector. The example in Figure 3-23 displays the cruise speed at the connectors, where the major road has a posted speed limit of 70km/h and minor roads with 50km/h to 60km/h as shown in Figure 3-23.

Figure 3-23: Modelled cruise speed (shown on connectors) to major and minor roads



3.3.12.3.1 Connectors to Exit Lane

In general, cruise time / speed on connectors to exit lanes can be left blank, however, it would not affect the model outcome if values have been entered.

It should be noted that if a cruise time / speed value is added to an exit lane connector, the neighbouring connector making the same movement should have the same value, otherwise it affects the delay-based traffic flow distributions assigned by LinSig.

3.3.12.3.2 Connector to Internal Lanes

When networks are being modelled, cruise time / speed is required to be added to the connectors for the internal lanes.

If cruise times cannot be measured on-site, it may be acceptable to apply a cruise speed. The cruise speed is typically the same as the posted speed limit for long distances between intersections. However note that cruise speeds often are less than the posted speed limit as some vehicles will travel at less than the speed limit and geometry. Turning and closely spaced intersections may also limit cruise speeds.

If cruise speed is used in the LinSig, the modeller should ensure that all of the internal lane lengths (Refer to Section 3.3.7.2) are modelled correctly, as LinSig calculates the cruise times based on the inputs for cruise speed and lane lengths. Modellers can use the multi-select function (Ctrl + left click mouse to draw a box) to edit multiple connectors with the same parameter (such as cruise speed) at the same time.

Modellers should check the resultant total cruise time between two signal intersections in the LinSig model is representative to the free flowing cruise time between the two stop lines in site conditions.

3.3.12.3.3 Turning Connectors to Internal Lanes

For turning connectors, it is recommended that the input cruise time is increased or the input cruise speed is reduced to replicate the effect of traffic travelling at a lower speed when turning. This should be decided on a case-by-case basis depending on the size of the intersection and the on street operations.

3.3.12.4 Custom Lane Length

While *Custom Lane Length* can be added to specific connectors to calculate the cruise time using a different lane length, this function should only be used if the resultant cruise time is significantly different. For turning connectors, reducing the cruise speed or increasing the cruise time inputs should be considered first before adjusting the custom lane length.

3.3.12.5 Cruise Time Weighting

Delay based assignment cruise time weighting should only be applied if the LinSig assigned traffic volume is not considered to be realistic for weaving routes or exit restrictions. Alternative calibration methods should be explored first before adjusting the cruise time weighting. The weighting is added to the relevant connector to reduce the amount of traffic assigned by LinSig to a specific connector such as for weaving routes or exit merging. A value of 5 to 10 seconds should be used as a starting point.

3.3.12.6 Buses

If bus flows (refer to Section 3.4.1.1) have been modelled in the network model, mean bus stopped time and bus speed may be added to the connectors, only if necessary.

If the bus speed cells in the connectors are left blank, LinSig calculates the bus speed based on the speed shown in the *Network Settings* window.

Main Roads recommends the *Mean Bus Stopped Time* to be left blank in the connectors, as it may complicate the bus flow assignment unless further bus set-up has been made. If the presence of a bus stop reduces the capacity of the general traffic lanes, negative bonus green times should be used instead to replicate the effect.

3.3.12.7 Platoon Dispersion

The setting should be left as software default, with *Use Platoon Dispersion* selected, and *Platoon Dispersion Coefficient* of 35 applied. Justifications should be provided in the modelling report if these have been changed.

3.3.12.8 Overrides

The *Overrides* tab should be left blank as software default. Justifications should be provided in the modelling report if this has been changed.

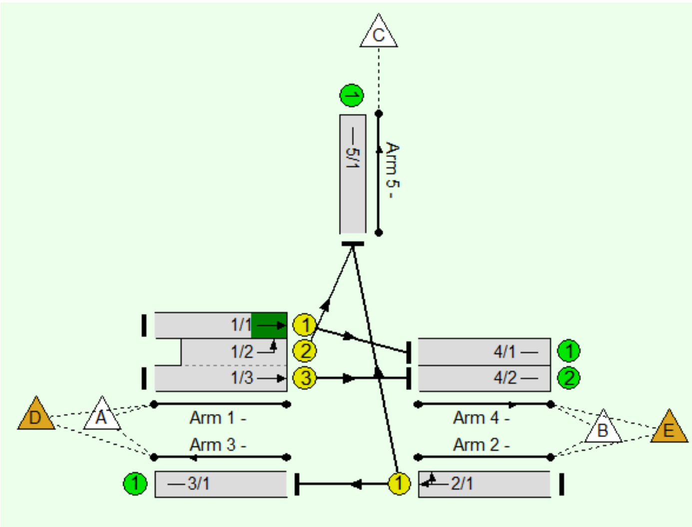
3.3.13 Bus Lanes

For projects that include bus facilities (such as bus lanes or bus only signals) or where efficient public transport operation is a consideration, buses should be modelled separately from general traffic so that the public transport benefits can be evaluated.

Refer to Section 3.4.1.1 and Section 3.4.6.1 for information on modelling bus zones and bus routes.

As general traffic is only permitted to use the last 100m section of the bus lane to make a left-turn, modellers should not assign the turning traffic directly to the bus lane as it would overestimate the capacity for the turning traffic. A potential modelling method to overcome this is shown in Figure 3-24.

Figure 3-24: Recommended method to model turning general traffic using a bus lane



This is the preferred method to model a bus lane with left-turning general traffic, as it can replicate the capacity at the bus lane. In this example, lanes 1/1 and 4/1 are bus lanes.

- A short lane is added (1/2), attached to the offside general lane (1/3), to replicate that general traffic is able to use the end of the nearside bus lane to turn left.
- The length of the short lane (1/2) depends on where the left-turning general traffic can enter the bus lane (for example, 100m).
- In *Route List View*, general traffic from Zones A to B is 'disallowed' to travel on the bus lane (from lanes 1/1 to 4/1).
- In *Route List View*, bus traffic from Zones D to E is 'disallowed' to travel on the general traffic lane (from lanes 1/3 to 4/2).
- In *Lane Timings View*, negative bonus greens is added at the start of lane 1/1 to replicate buses cannot pass the stop line at the start of the phase due to the presence of the left-turning general traffic. Typically two-second negative bonus green is applied for each PCU of turning traffic in a cycle.

As LinSig has a limitation of not able to model two short lanes attached to a long lane, alternative modelling methods may need to be considered if another short lane needs to be included in the assessment. The modelling method should be decided on a case-by-case basis depending on the site layout and queuing behaviour. Modellers can discuss the assumptions with Main Roads when developing the models.

3.3.14 Pedestrian Links

The need to model pedestrian links, connectors, zones and volumes will depend on the project, to be discussed with Main Roads. Generally, these should be included when pedestrian delay results are required such as staged crossings or schemes involving pedestrian facilities upgrades. These should be included in all stages of the modelling for comparisons to be made between the base and proposed models.

When modelling pedestrian links, the following should be considered:

- *Pedestrian Link Number* – if possible, this should correspond to the pedestrian crossing numbers used in the signal settings.
- *Controlling SGroup* – the corresponding signal group should be selected.
- *Crossing Time* – refer to the estimated based on the crossing distance divided by typical walking speed of 1.2 m/s.
- *Crossing Type* – leave as unspecified.

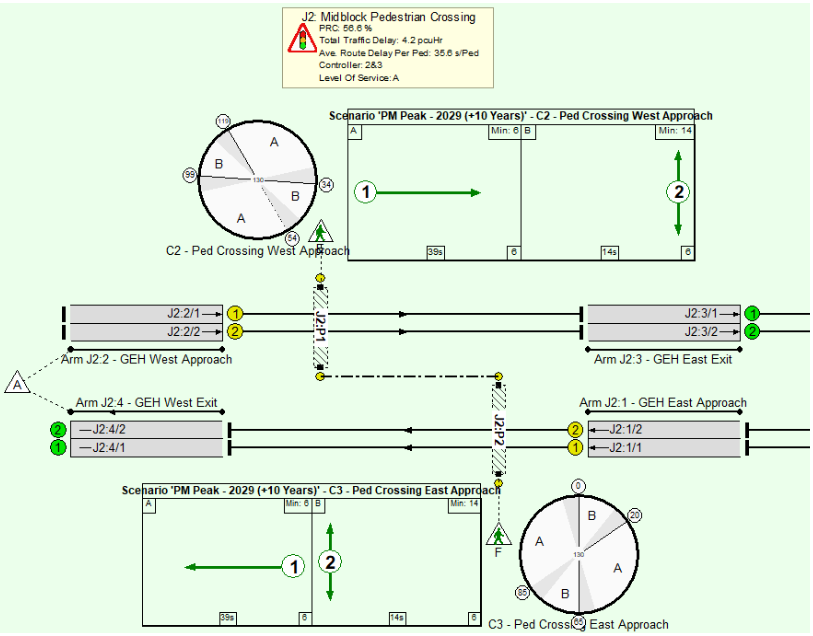
In addition, if pedestrian connectors are used, *Mean Walk Time Between Crossings* should also be entered based on the estimated crossing distance and walking speed of 1.2m/s.

Note that pedestrian signal groups should be included in the LinSig model regardless of what pedestrian links are modelled, refer to Section 3.5.3.2.

3.3.14.1 Two-Staged Crossing

If a mid-block two-stage crossing is required, Main Roads' preferred modelling method is shown in Figure 3-25. Separate signal controllers are set up at each staged crossing, but both controllers are assigned under the same *Junction*. If the crossings are coordinated with a neighbouring signal intersection, the cycle time should be the same in the model to examine the traffic platooning. It may be necessary to set up the crossing controllers with double cycling depending on the scheme requirements.

Figure 3-25: Common LinSig setup to model mid-block two-staged crossings



3.4 Traffic Flows Inputs

This section details the LinSig input requirements for traffic flows.

3.4.1 Traffic Zones

Traffic zones are required for the network with *Zone A* corresponding to the approach containing SCATS loop number 1. Subsequent zones should then be added in the same order as the arm numbers, usually in the anti-clockwise direction, as shown in Figure 3-5.

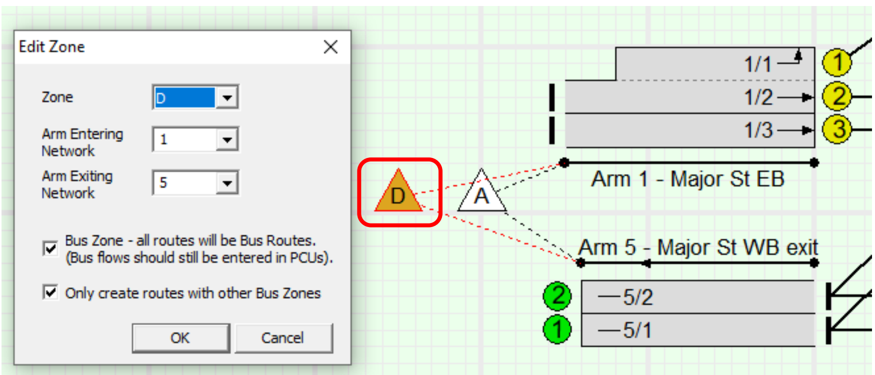
For a network model, it is recommended a similar convention is used with *Zone A* assigned to the western or northern intersection of the whole network, and subsequent zones are added to the remaining entry lanes of the intersections, usually in the anti-clockwise direction. Subsequent zones are then added to the next intersection of the network. An example is shown in Figure 3-8 and Figure 3-9 in Section 3.3.5.

3.4.1.1 Bus Zones

For models with bus lanes or special bus facilities, the bus traffic should be modelled separately from general traffic with separate bus zones, an example is shown in Figure 3-26.

Even if the bus facilities are not present in the existing situation but need to be analysed in the options modelling, bus traffic and bus zones should still be modelled in the base model for a ‘like for like’ comparison of the bus traffic related results, such as delay time.

Figure 3-26: Example of a Bus Zone



If the bus flow is required to be modelled to travel on a particular lane, modellers need to set up the bus routes as discussed in Section 3.4.6.1.

3.4.2 PCU Conversion

Traffic is composed of various types of vehicles, the range and relative composition of which can vary from location to location. LinSig uses a common unit to represent general traffic, known as the Passenger Car Unit (PCU). Common vehicle types are assigned a conversion factor so that an equivalent PCU value can be generated from classified vehicle data collected as described in Table 3-2.

Base case traffic data should be determined from classified turning count surveys as they provide greater accuracy than SCATS counts and allow the conversion of vehicles into Passenger Car Units (PCUs). Modellers need to calculate the number of PCUs for each traffic movement in each peak.

Table 3-2: PCU conversion factors

Austroads' vehicle class	PCU
1	1.0
2-5	2.0
6-9	3.0
10-11	4.0
12	5.0

Vehicle type	PCU
Pedal cycle	0.2
Motorcycle	0.4
Rigid buses	2.0
Articulated buses	3.0

3.4.3 Traffic Flows Group

In the *Traffic Flows View* window, the modeller should provide suitable description names and enter the start and end times to distinguish between different flow groups. For existing traffic flows, the date of the existing traffic count should be included in the description names for the base traffic flow groups for ease the checking. Exemplar traffic flow group names are, *AM Base 01-07-2020* or *AM 2031*.

Modellers are advised to disable the *Auto Assign* function in *Traffic Flows View*. This is to avoid LinSig reassigning the traffic flows automatically every time an adjustment is made in the LinSig model as this causes needless delays, particularly when working on a large file, with multiple intersections or routes with the same origin and destination.

3.4.3.1 Formula Flow Group

Modellers can use the *Flow Group Formula* function in the *Edit Flow Group* window to calculate new flow groups to reduce the chance of introducing errors when entering the flow values individually for each flow group. For example, if the modeller wants to add a 2 per cent growth to the base traffic group *F1*, modellers can create a new flow group and enter *F1*1.02* in the *Formula* box.

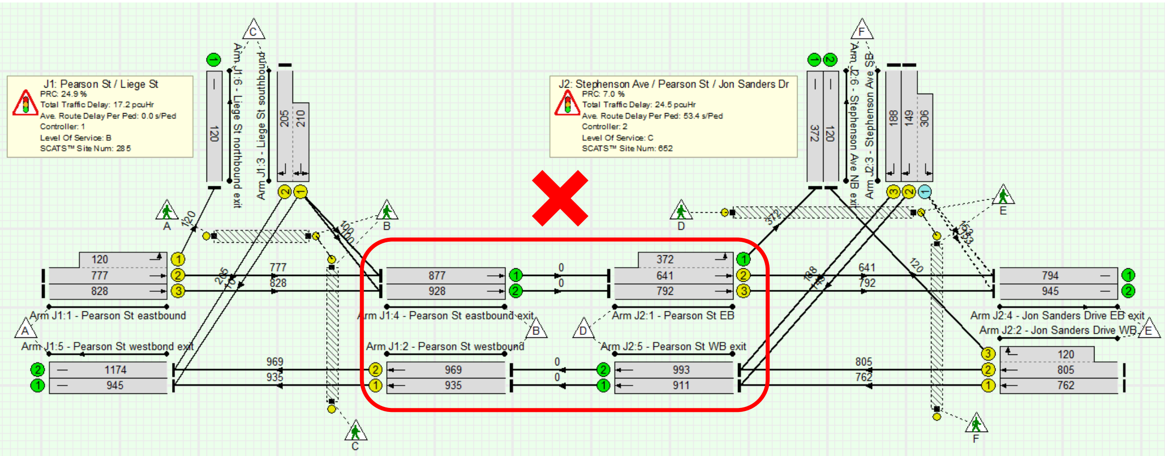
3.4.3.2 Component Flow Group

Modellers can also select the *Component Flow Group* option if the flow group is only used as part of a formula, and not intended to be a standalone flow group to be assigned to the model. For example, the traffic solely generated from a new development can be set as a component flow group, as it would not be assigned in the model without the existing background traffic.

3.4.4 Origin Destination Matrix

Main Roads' preference is to formulate a single OD matrix for the entire modelled network. When working in a multiple intersection model, modellers should not set up a separate OD matrix for each intersection, as LinSig assigns the lane traffic flow based on the delay at individual intersections and does not take into consideration the delay across the network, which results in flow discrepancies between intersections as shown in Figure 3-27.

Figure 3-27: Separate OD set up resulting in inaccurate lane traffic flow allocation across network should not be used

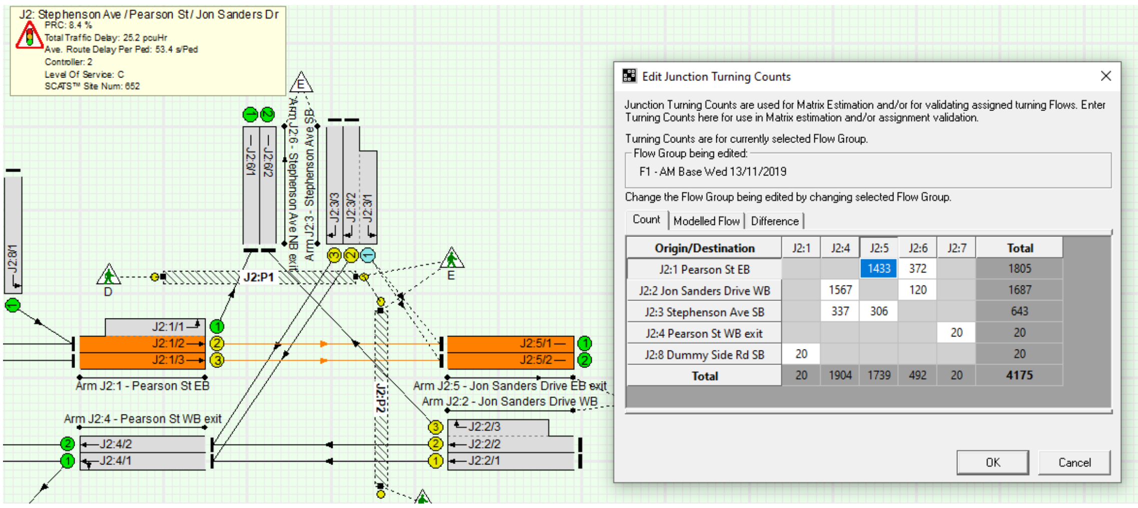


3.4.4.1 Matrix Estimation Tool

Where possible, the OD matrices for a multiple intersection model should be estimated based on the OD proportions obtained from site survey or strategic model outputs, as it provides the movement proportions between each origin and destination pair as per site conditions.

However, if only the intersection turning counts are available, LinSig's built-in matrix estimation tool can be used to estimate a matrix for the network. Modellers can enter the turning count volume in the *Edit Junctions Turning Counts* window for each intersection (see Figure 3-28) and/or in the *Matrix Estimation View* window. Modellers can then use the *Estimate Traffic Flow Matrix from Turning Counts* function to estimate the OD matrix. The process needs to be repeated for each flow group.

Figure 3-28: Example of Edit Junction Turning Counts window



Modellers should check if the matrix flows derived by LinSig are reasonable, particularly between two adjacent side roads in which the traffic is likely to travel via local roads outside of the modelled area rather than travel via the network within the study area.

Modellers should check the OD matrices derived by LinSig:

- In the *Matrix Estimation View* window, GEH should be less than **2.0** for all movements. The GEH requirement is stricter than large scale microsimulation or strategic models because LinSig focuses on local level assessments with fewer numbers of intersections, the modelled volume should be close to the site survey.
- In the *Traffic Flows View* window, check the derived volume for individual OD pairs are reasonable, particularly between two adjacent side roads. If required, modellers can 'lock' the volume of a particular OD pair by manually enter the value in *Traffic Flows View* and apply the *Lock this Value for Matrix Estimation* function before using LinSig's built-in tool to re-estimate the matrix.

When large discrepancies exist between intersections, and these are explained by real sources or sinks of traffic, internal zones and dummy side road arms can be used to represent these sources and sinks (Refer to Section 3.3.5.3). These should only be used where the sources and sinks are significant, as adding numerous internal zones for minor discrepancies may unnecessarily complicate the model.

3.4.4.2 Bus Flows

If bus zones have been used in the model, the bus volume should not be included in the *Junction Turning Counts* for Matrix Estimation.

When reviewing the comparison outputs (such as % difference or GEH) in *Matrix Estimation View*, modellers should ensure the *Bus Routes* flows icon is deselected, otherwise LinSig would include the bus volume in the Modelled Flow when calculating the comparison outputs.

3.4.5 Traffic Flow Assignment Options

Following the development of the OD matrix, the traffic should then be assigned in the model network.

3.4.5.1 Delay Based Assignment

The most common and preferred method is to assign traffic using *Delay Based Assignment*. This method assigns traffic to the routes so that the journey time between the routes with the same origin and destination zones are as equal as possible. Modellers should review the assigned traffic, refer to Section 3.4.6 for information.

3.4.5.2 Customised Delay Based Assignment

The use of the *Customised Delay Based Assignment* method is not recommended. Justifications should be provided if this method is chosen.

3.4.5.3 Entry Lane Balancing

The *Entry Lane Balancing* method assumes the traffic is evenly distributed across the available lanes regardless of the lane delay, therefore, this method is not recommended for modelling analysis.

However, modellers may sometimes find that the *Delay Based Assignment* values do not provide a logical flow distribution, as LinSig re-distributes the traffic based on the volume previously assigned to the network. Occasionally, the *Entry Lane Balancing* method may be used to 'reset' the flow assignment across all lanes before using *Delay Based Assignment* again. The final flow iteration should be based on *Delay Based Assignment* method.

3.4.5.4 Traffic Zones to Assign

It is recommended that the *Assign all Traffic Zones* option is selected to ensure traffic from all zones are assigned in the model. Justifications should be provided if particular zones have been de-selected.

3.4.6 Review of the Assigned Traffic

Following the traffic assignment, modellers should check the *Error View.* If the 'Desired Flows do not match the Actual Route Flows' warning message is received, this should be addressed as modeller's input OD volume has not been fully assigned to the network.

> The modeller should always check that the lane distributions assigned by LinSig are similar to observed site lane distributions, as on-street signing, parking, downstream network layout, perceived delay, perceived safety and other sometimes irrational factors may affect driver route choice.

Although the use of SCATS detector volume data is not recommended as direct inputs to develop base models, comparisons can be made to traffic volumes on a lane-by-lane basis to ensure the proportions closely reflect actual lane-use.

A range of methods can be used to influence the assigned traffic volume:

- Review and remove any unnecessary connectors in the first instance (refer to Section 3.3.12.2)
- Apply a *Delay-Based Assignment Cruise Time Weighting* to the connectors to reduce the amount of traffic being assigned to the route (refer to Section 3.3.12.5)
- 'Lock' the traffic flows for a particular route in the *Route List View* window. However, the modeller should not 'lock' all the routes as it removes the purpose of the delay based assignment, or
- 'Disallow' the unrealistic routes by using the *Edit Permitted Routes* function in the *Route List View* window. It should be noted that the *Disallowed* route is applied to all scenarios in the LinSig model.

3.4.6.1 Bus Traffic

Bus movements between the bus zones should be checked in the *Route List View* window. In the *Edit Permitted Routes* window, modellers can change the permitted setting from software default to *Disallow* to prevent general traffic from using the bus lane. Similarly, the function can be used to prevent buses from using the general traffic lanes, if necessary.

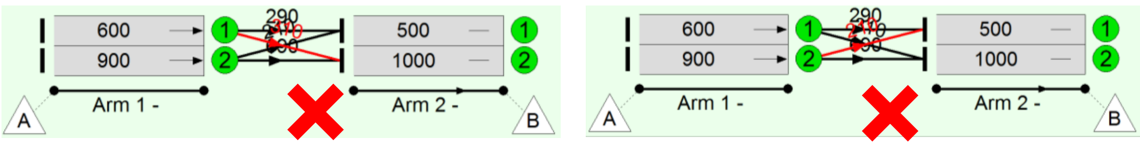
The *Disallow* setting is applied to all scenarios in the model, therefore if the bus lane is peak dependent then this function is not suitable and modellers may instead 'lock' the un-permitted route flows to be zero.

3.4.6.2 Weaving Traffic

As discussed in Section 3.3.12.2, modellers should review the use of any weave connectors to ensure that traffic can be distributed across downstream lanes. The use of weave connectors should be based on observed weaving or lane-changing. In order to maintain only realistic traffic routes in a network and increase the speed of traffic assignment calculations, care should be taken to minimise the number of weave connectors in the network.

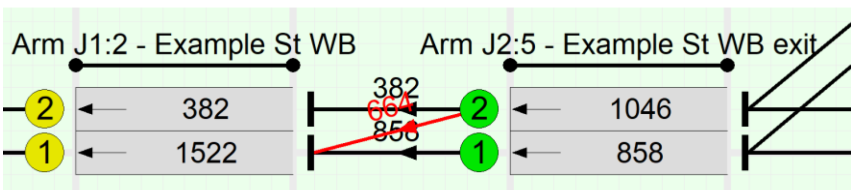
Modellers should review the LinSig assigned flow on each lane and determine if weaving connectors are necessary, as criss-cross connectors are likely to result in unrealistic lane changes of the assigned flow. For example, Figure 3-29 shows that 310 PCU travel from lane 1 to lane 2, and at the same time 210 PCU travel from lane 2 to lane 1; where in reality only 100 PCU may travel from lane 1 to lane 2 and no traffic changing from lane 2 to lane 1.

Figure 3-29: Excessive weaving traffic crossing over should be removed



In addition, modellers should review and address any unrealistically high volume of lane change traffic. In the example shown in Figure 3-30, modeller should exercise engineering judgement to examine if it is realistic for 664 PCU to change from lane 2 to lane 1 where there is already a high volume of 858 PCU travelling on lane 1.

Figure 3-30: Unrealistically high lane change volume should be reviewed



3.4.6.3 Traffic Assignment in an Option Model

When working on a future year or an option model, engineering judgement is required when deciding the traffic volume to be locked, as the traffic distributions on lanes may not be the same as the current conditions if the lane layout, traffic volume and signal timings have been changed.

3.4.7 Lane-Based Flow Entry Method

Lane-Based Flow Entry method is when modellers manually assign the traffic volume on each lane and connector. Note that this is different from the *Entry Lane Balancing Assignment* discussed in Section 3.4.5.3.

For base models, using the *Lane-Based Flow Entry* method is acceptable, but not recommended. Although this method can model the lane flows as per current site conditions, it takes longer to update the flows for each scenario and it may not be a fair comparison to the future year flow models. If the *Lane-based Flow Entry* method is chosen, justification should be made in the modelling report.

Modellers should ensure that there are no discrepancies between lanes and connectors; *Flow Consistency Mode* can be used to display flow discrepancies.

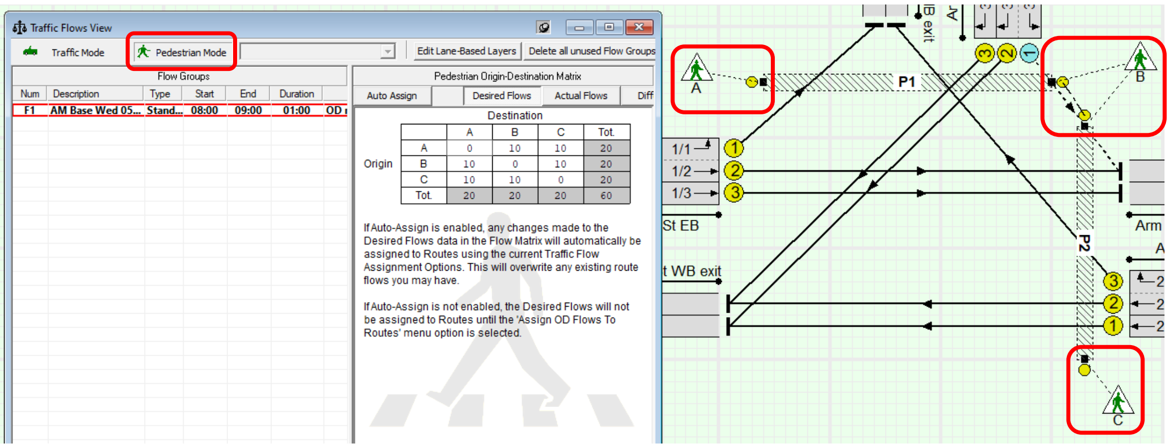
For future year flow and option models, only the *Delay Based Assignment* method should be used, as this method takes into consideration the capacity based on the new layout and timings when assigning traffic to the network.

It is acceptable, but not recommended, to combine *Lane-based Flow Entry* and *Delay-based Assignment* methods for future year traffic analysis. If the base traffic flow is assigned manually using the *Lane-based Flow Entry* method, the modeller can use *Delay-Based Assignment* to assign only the additional traffic to the network.

3.4.8 Pedestrian Flows

If pedestrian links have been modelled (refer to Section 3.3.14), pedestrian volumes can be entered by setting up pedestrian zones and origin destination matrices as shown in Figure 3-31. Otherwise, a nominal pedestrian volume (e.g. 10) can be entered to generate the pedestrian delay results.

Figure 3-31: Example of Pedestrian Matrix and Pedestrian Zones



The pedestrian volumes in the LinSig model is used for generating pedestrian related results, such as delay times. The pedestrian volume entered does not influence the signal optimisation outcome and it does not affect the demand dependent frequencies or the further delay to turning traffic during parallel walks. The effect should be taken into account using bonus green time or other calibration methods discussed in Section 3.5.15 and Section 3.9.

3.5 Traffic Signals Inputs

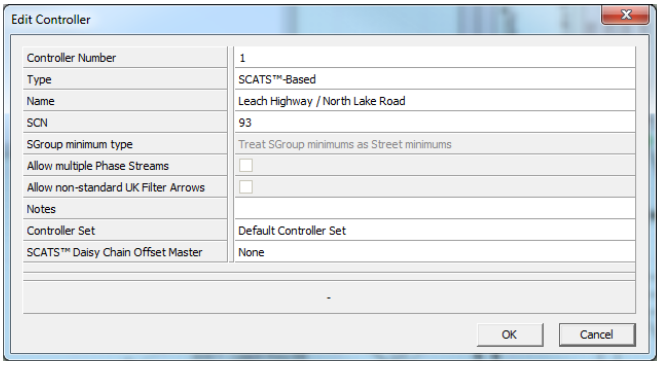
This section details the LinSig input requirements for traffic signals.

3.5.1 Controller Details

A separate controller should be added for each signalised intersection based on the site SCATS set-up. The controller details should include the following, as shown in Figure 3-32:

- *Type* – SCATS Based should be selected.
- *Name* – location of the intersection.
- *SCN* – LM/site number.
- *Notes* – added if required.
- *Controller Set* – select the appropriate controller set, usually *Default Controller Set*. Refer to Section 3.5.2 if different controller sets are available.
- *SCATS Daisy Chain Offset Master* – leave *None* as software default.

Figure 3-32: Edit Controller window



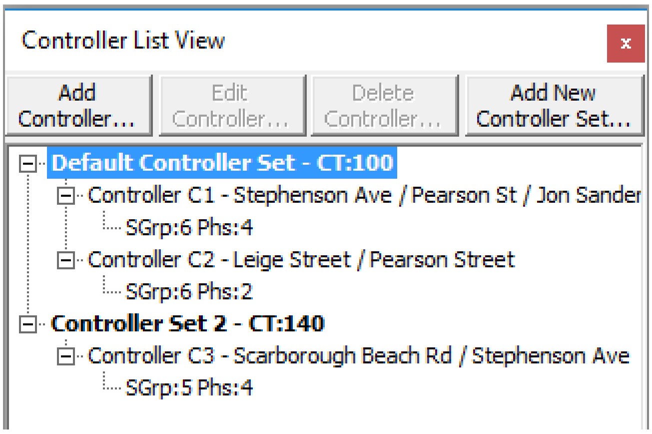
3.5.2 Controller Set

In general, all controllers with the common cycle time should be grouped under the same controller set; this reduces the amount of user inputs required to edit the cycle times.

Separate controller sets should only be set up if the modelled intersections are operated with different cycle times.

If an intersection has been imported from another LinSig model, *Controller Sets* should be reviewed and the imported controllers should be grouped under the same controller set with the common cycle time. An example is shown in Figure 3-33.

Figure 3-33: Controller List View window

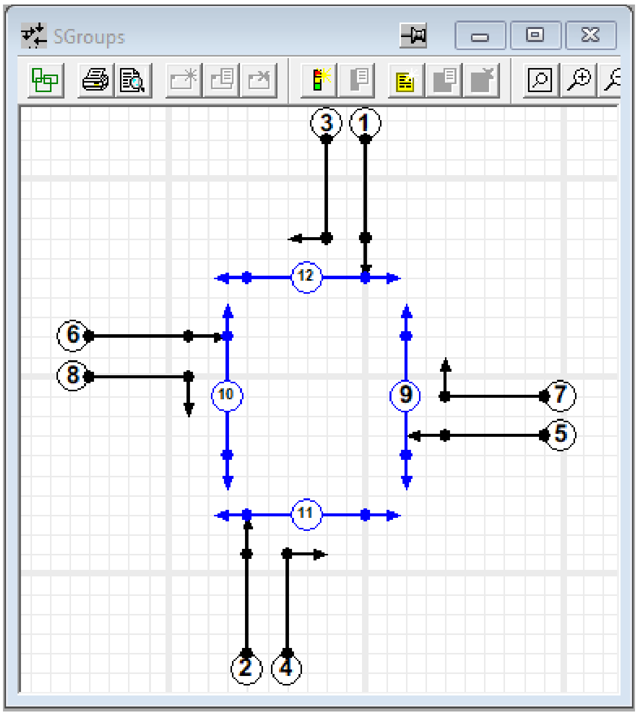


3.5.3 Signal Groups (SGroups)

SGroups should be added and numbered in a manner that is consistent with the signal groups for existing intersections and the proposed design drawings. Pedestrian *SGroups* should be numbered after all traffic *SGroups* have been determined and should be numbered in the order of crossing numbers; this arrangement is usually set up in the *Traffic Signal Arrangement (LMA) Drawings* which can be obtained from Main Roads' *trafficmap*.

Generally, only *Traffic* and *Pedestrian* SGroup types should be used. An example of a *SGroup* layout (based on the intersection shown in Figure 3-4) is shown in Figure 3-34.

Figure 3-34: SGroups window – SGroup numbering



Non UK arrow should be avoided; arrow signal groups should be modelled using the *Traffic* SGroup type. When *Non UK arrow* is assigned to a lane, LinSig considers all traffic in the lane can proceed if either the full or arrow SGroup is at green, which is different from the signal operations in Western Australia. Refer to Figure 3-41 for an example on how using *Non UK arrow* has led to incorrect green time being modelled.

3.5.3.1 Traffic Signal Groups

As the *Minimum Green* is entered in the *Phase* details (refer to Section 3.5.5), it does not generally need to be entered again for each signal group in the *Edit SGroup* window.

However, if late start is applied to the phase set up (refer to Section 3.5.6.2) or pedestrian protection time is applied to a traffic signal group (refer to Section 3.5.3.3), modellers should consider adding the minimum green in the *Edit SGroup* window to prevent the traffic signal group from running less than its intended minimum green, as the late start or pedestrian protection time takes away some green time from the traffic signal group.

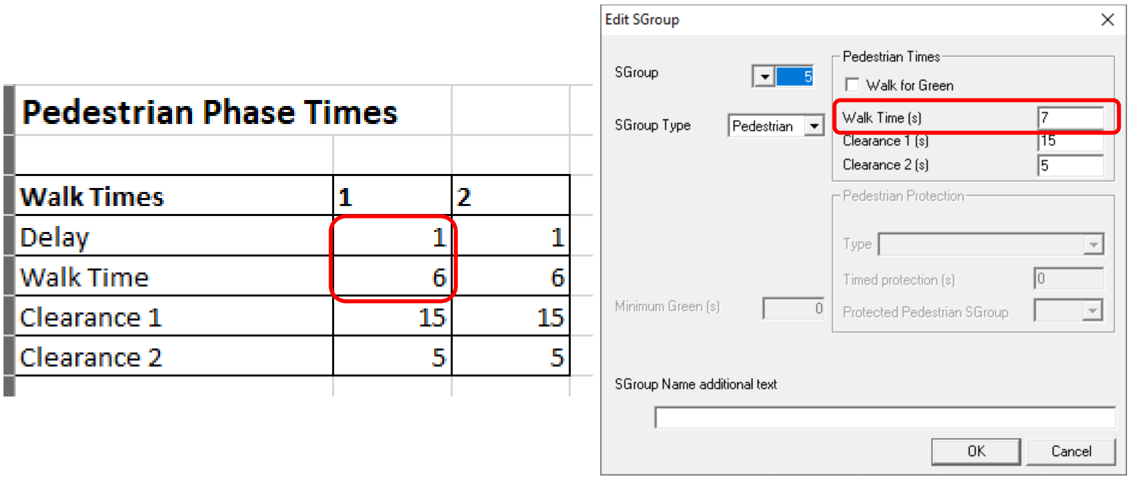
3.5.3.2 Pedestrian Signal Groups

For all sites where signalised pedestrian crossings are present or proposed, pedestrian SGroups should be added to the model regardless of the type of scheme to be tested.

For pedestrian SGroups, the pedestrian walk time (invitation to cross), clearance 1 and 2 should match the controller/SCATS system for an existing model.

If there is a *Delay* time in the pedestrian signal group in the controller/SCATS system, it should be added to the *Walk Time* in LinSig, as shown in Figure 3-35.

Figure 3-35: Pedestrian Delay and Walk Time combined in Edit SGroup window

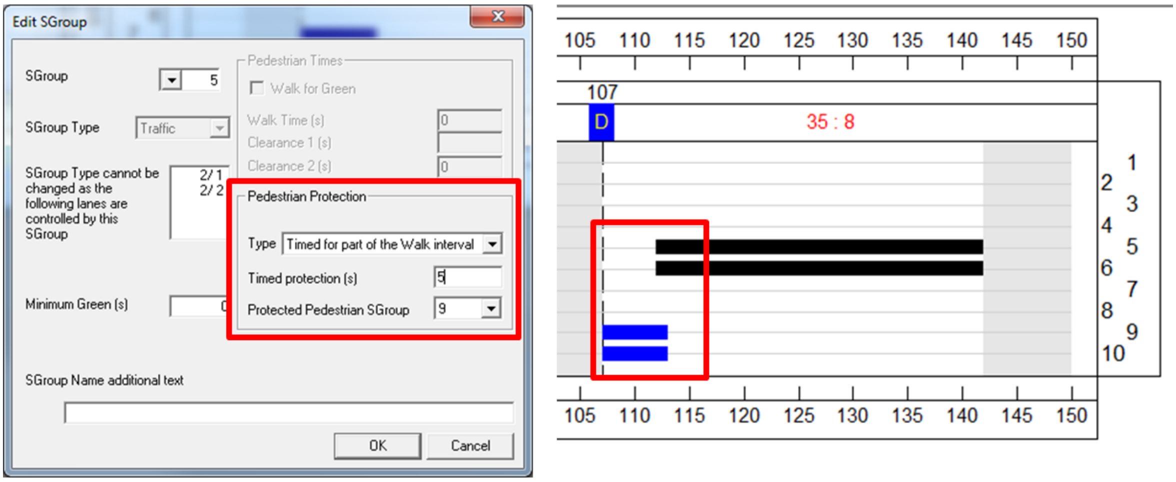


Walk for green should not be selected for LinSig modelling, as it is not possible to enter the Clearance 1 time when this function is selected in LinSig, which is different from the signal operations in Western Australia.

3.5.3.3 Pedestrian Protection

If pedestrian protection has been set up on-site, it should be modelled in the relevant traffic SGroup based on the controller/SCATS system in the *Edit SGroup* window. An example is shown in Figure 3-36.

Figure 3-36: Edit SGroup window (left) and Signal Timing View (right) for pedestrian protection



There are different Pedestrian Protection types in LinSig:

- *Timed for part of the Walk intervals* should be used for modelling parallel walks. Modellers need to determine the timed protection period based on the protection type.
- *Duration of Walk intervals* or *Timed for Walk interval and part of the Clearance* should not be used as these settings are not reflective to the pedestrian protection set up in Western Australia.
- *Full protection during Walk and Clearance intervals* can be used for modelling fully controlled crossings.

Late start in *Phases* (refer to Section 3.5.6.2) should not be used for modelling pedestrian protections, as the signal parameter inputs should match the settings in SCATS.

Modellers should refer to relevant signal documents on Main Roads' *trafficmap* for the existing pedestrian protection set up and the timed protection period, and refer to the relevant guidelines[14] for determining suitable set up for the proposed design.

3.5.4 SGroup Conflict Matrix

The SGroup conflict matrix can be populated if desired but is not essential. This prevents modellers from accidently activating conflicted signal groups in *Phase View* (refer to Section 3.5.6).

Note that while a filter SGroup can be considered as conflicted with the opposing traffic SGroup, this should not be selected in LinSig's conflict matrix, as both signal group / movements would still receive green in the same phase in LinSig.

[14] Main Roads (2020), Guidelines for Pedestrian Crossing Facilities at Traffic Signals D19#532308

3.5.5 Modelling Shared Lanes Operated with Different Signal Groups

While LinSig can model multiple traffic movements using the same lane, it has a limitation of not being able to model two SGroups operated for different movements using the same traffic lane, which can be problematic for some of Western Australian's signal set ups.

3.5.5.1 Modelling Left-turn Arrow for a Mixed Lane

Figure 3-37 illustrates that due to the presence of the parallel walk with time red arrow control, the left-turn traffic cannot proceed at the start of the phase until the red arrow is dropped, blocking the through traffic on the kerbside lane.

Figure 3-37: Parallel walk with timed red arrow example

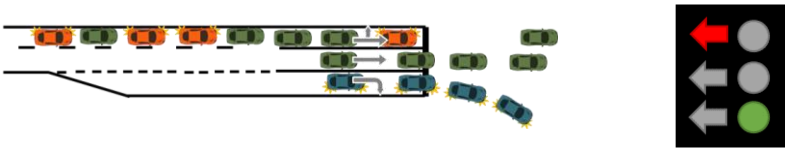
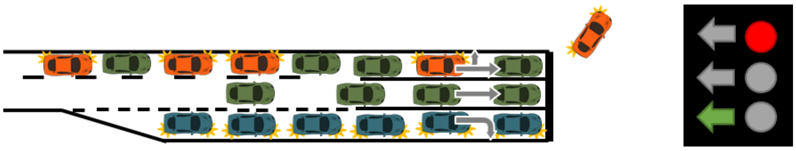


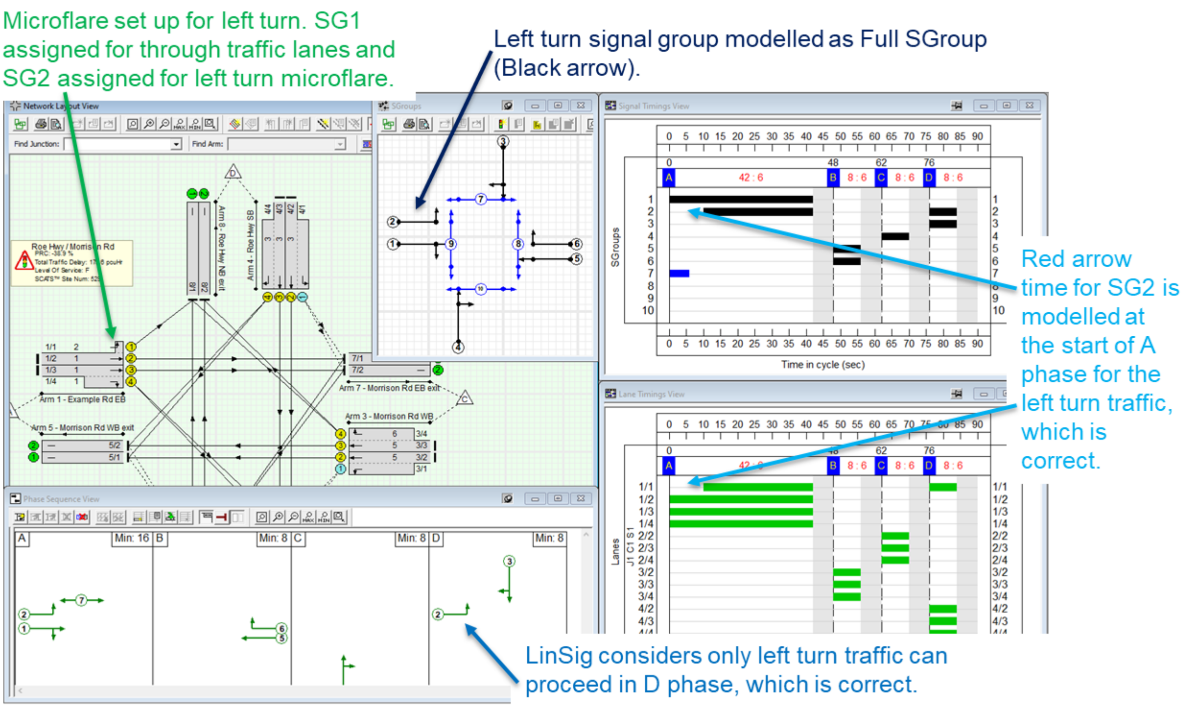
Figure 3-38 illustrates only the left-turn traffic can proceed at the bonus left-turn (aggro arrow) phase, the through traffic on the kerbside lane would block the left-turn traffic queuing behind.

Figure 3-38: Aggro Arrow example



Given that the two movements operate under separate SGroups, they should be modelled as two separate lanes in order to assign each lane (movement) to its relevant SGroup, as outlined in Figure 3-39.

Figure 3-39: Modelling method for mixed signal lanes



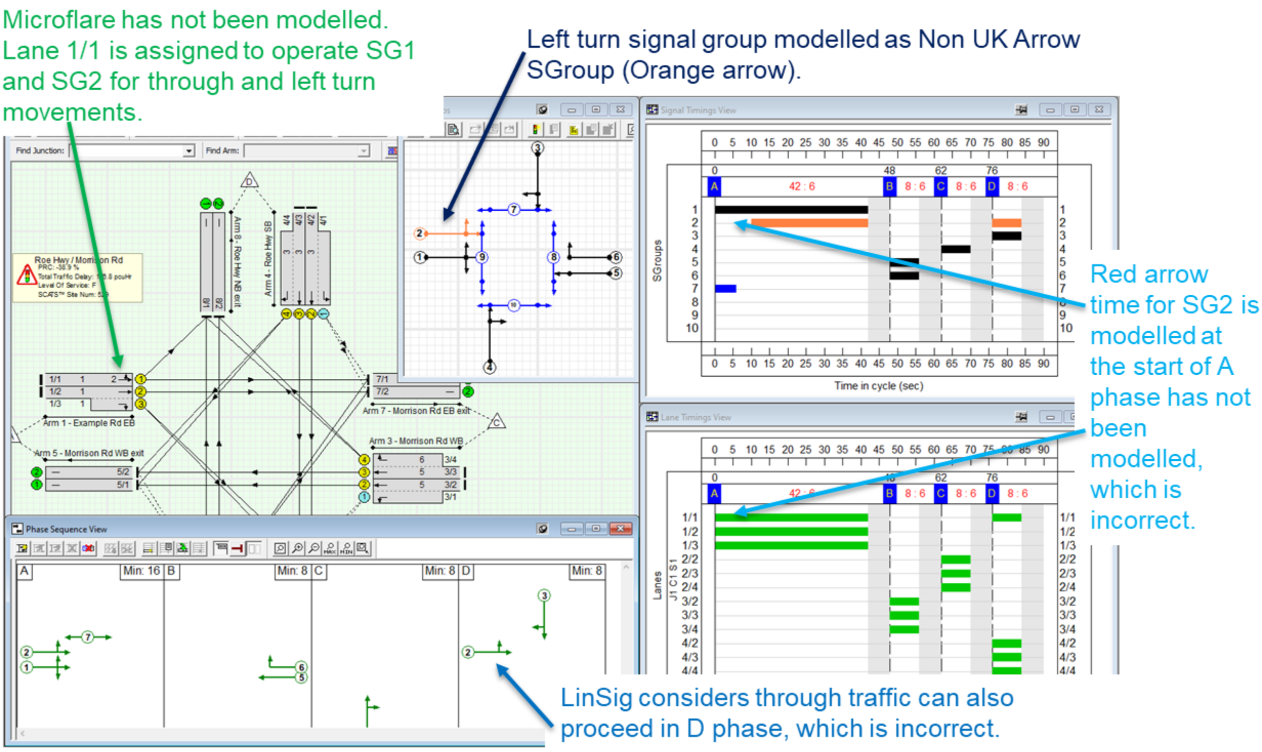
One of the lanes should be modelled as a long lane (lane 1/2) and the other as a short lane with a 0.5 PCU micro short lane (lane 1/1). The micro short lane should be given to the least dominant movement with the lowest flow. The saturation flow for both the long lane (lane 1/2) and the micro short lane (lane 1/1) should be the same. This method ensures that any blocking of through movements by turning movements in shared lanes is accounted for by LinSig.

In instances where the shared movements occur in a short lane, the modeller should determine the most appropriate way to model this situation by considering the carriageway pattern, driver behaviour and the purpose of the modelling analysis. It may be necessary to convert the pocket short lane into a long lane in LinSig to model the micro short lane. The decision should be made on a case-by-case basis and justification for this approach should be detailed in the modelling report.

3.5.5.1.1 Incorrect Use of Non UK Arrow for Left Turn

Non UK Arrows SGroup type should not be used for this situation. Figure 3-40 demonstrates how *Non UK Arrow* and not setting up a micro flare would lead to incorrect modelling.

Figure 3-40: Incorrect modelling method for mixed signal lanes



3.5.5.2 Modelling Filtered Right Turn

When modelling a filtered right-turn with its own arrow signal group, modellers should ensure the following are included:

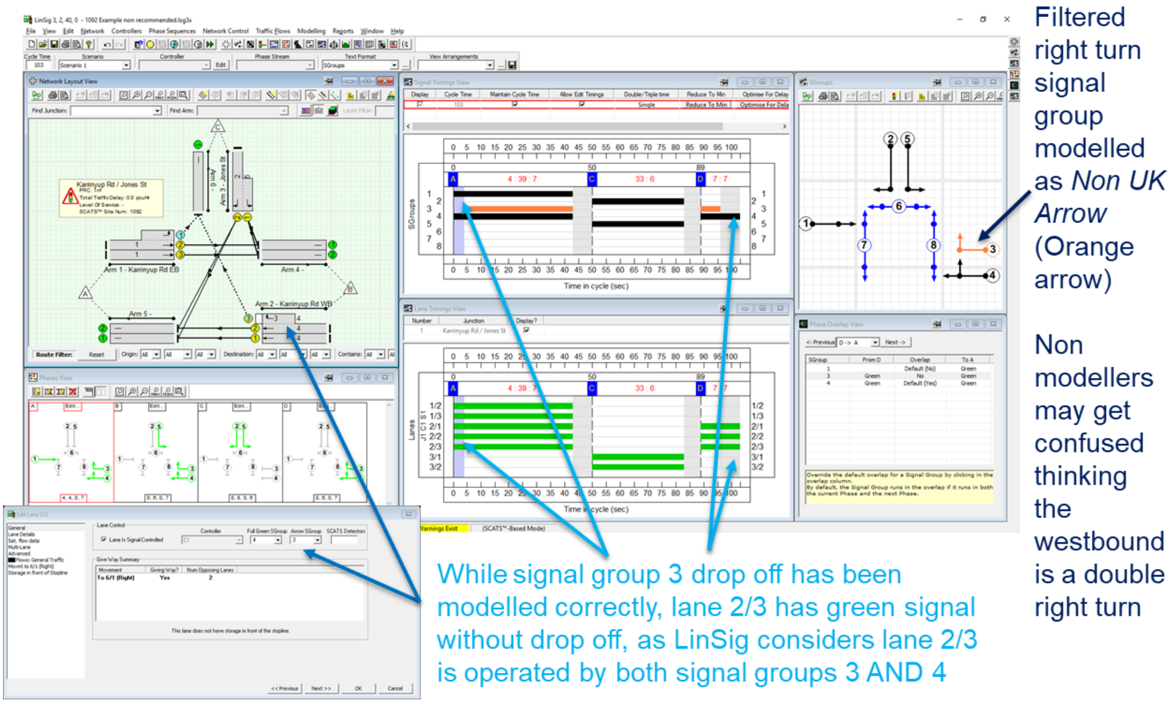
- *Traffic* SGroup is used for the right-turning signal group, *Non UK Arrow* should not be used. Refer to Figure 3-41.
- Activate the right-turning signal group in both the unopposed right-turn phase and the filtered right-turn phase. Refer to Section 3.5.6.1.

- Intergreen drop off (phase overlap) is set up for the phase transition from the unopposed right-turn phase to the filtered right-turn phase. Refer to Section 3.5.10.
- Late start for the right-turn signal group at the start of the filtered phase. Refer to Section 3.5.6.2.
- Pedestrian protection for the right-turn signal group for the conflicting pedestrian crossing, if applicable. Refer to Section 3.5.3.3.
- Right-turning give-way parameters and the appropriate storage in front of stop line and non-blocking storage values be applied to the right-turn filtered lane. Refer to Section 3.6.
- If the traffic lane is shared for through and right-turn movements, a microflare should be set up, similar to the method discussed in Section 3.5.5.1. Note that the physical lane length of the microflare would need to be reduced to the minimum 0.1 PCU as the *non-blocking storage* parameter already considers the blockage between the through and right-turn movements.
- Demand dependency adjustments made, if applicable. Refer to Section 3.5.15.
- The network set up shown in Figure 3-12 cannot be used for filtered right-turn because unlike a left-turn give-way slip lane, the right-turn is controlled by traffic signals.

3.5.5.2.1 Incorrect Use of Non UK Arrow

Non UK Arrow SGroup type should not be used for modelling in Western Australia. When applying the *Non UK Arrow* SGroup to a traffic lane, LinSig assumes the lane receives green time in both the Full Green SGroup and Arrow SGroup, and does not take into account the intergreen drop off and late start, as demonstrated in Figure 3-41.

Figure 3-41: Incorrect modelling method for filtered right turn using Non UK Arrow



3.5.6 Signal Phases

Signal phases should be coded in accordance with the site LM plan/SCATS information. All phases and alternate phases should be coded, even if they are not used in the signal phasing sequence. This allows for option testing of different phase sequences to be undertaken quickly, as only the *Network Control Plans* need to be changed.

The phasing timings (late starts, minimum greens, early cut-off greens and yellow + all red) should be directly input from controller/SCATS information.

If the SCATS system shows the combined yellow + all red value is a fraction (for example, 0.5), the modeller should always round up the value for the inputs.

For option models, the phasing timings should be reviewed and updated based on the proposed change to the intersection or phase configuration. Refer to Appendix A for guidance on determining the timings.

3.5.6.1 Arrow Signal Groups Activation

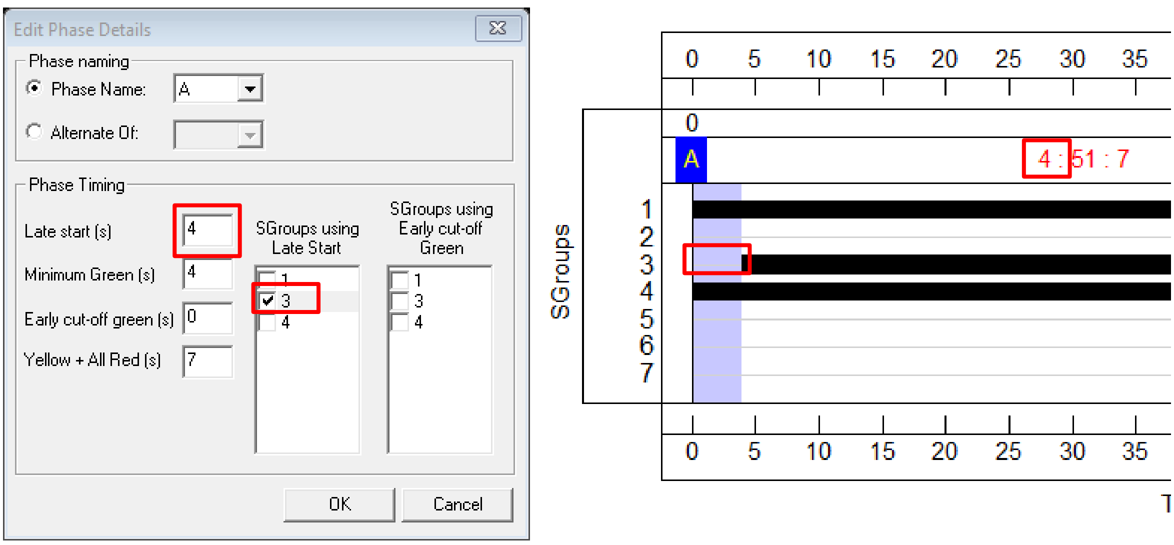
Note that some of the signal documents only show when the SGroup is 'green' or 'not green' in a phase and may not provide information when the SGroup is 'blank' (i.e. the turning traffic can still proceed but subject to give-way to oncoming traffic or pedestrians). It may be necessary to observe the signal pattern on-site to identify the SGroup operations in each phase.

When an arrow SGroup is shown as 'blank' on-site in certain phases, e.g. in a filtered phase or after the timed red arrow pedestrian protection, modellers should activate the SGroup in the relevant phases in LinSig, otherwise it would under estimate the capacity of the lanes.

3.5.6.2 Late Start

If there is a late start value in the phase, the modeller should select the relevant SGroup that starts later than the other SGroups in the *Edit Phase Details* window for each phase as shown in Figure 3-42. It may be necessary to obtain the *Phase Sequence Chart* document or observe the signal pattern on-site to identify the SGroup association.

Figure 3-42: Edit Phase Details window (left) and Signal Timing View (right) for late start

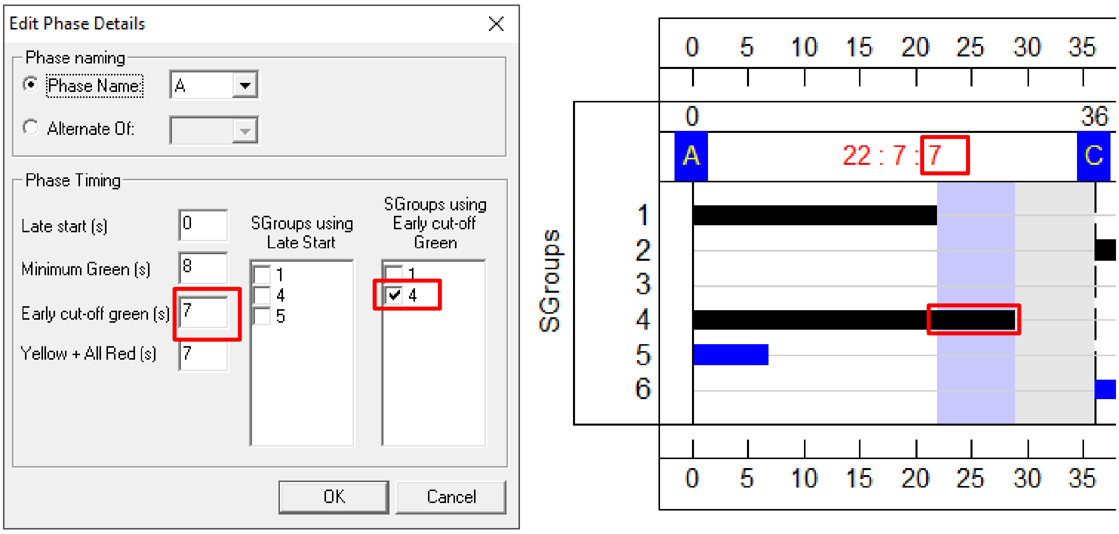


Pedestrian protections should not be modelled using the late start function in signal phases, as the signal parameter inputs should match the settings in SCATS (refer to Section 3.5.3.3). Refer to Appendix A for applications of late start in phases.

3.5.6.3 Early Cut Off

If there is an early cut off value in the phase, the modeller should select the relevant SGroup in the *Edit Phase Details* window that uses the extra green time, i.e. green time extended to be longer than the other SGroup, as shown in Figure 3-43. It may be necessary to observe the signal pattern on-site to identify the SGroup association.

Figure 3-43: Edit Phase Details window (left) and Signal Timing View (right) for early cut off



When early cut off has been set up for the Advance Warning Flashing Signals, the relevant SGroup should be selected in the *Edit Phase Details* window to ensure the minimum phase time is replicated correctly in the modelling. Refer to Appendix A for applications of early cut off in phases.

3.5.6.4 Signal Head Start

Bus head start or cycle lantern head start should be modelled based on the SCATS/controller set up. If this has been set up with late start applied to the other traffic SGroups, then this should be modelled as a late start (refer to Section 3.5.6.2). It may be necessary to observe the signal pattern on-site to identify the head start arrangement.

3.5.7 Signal Phasing Sequence

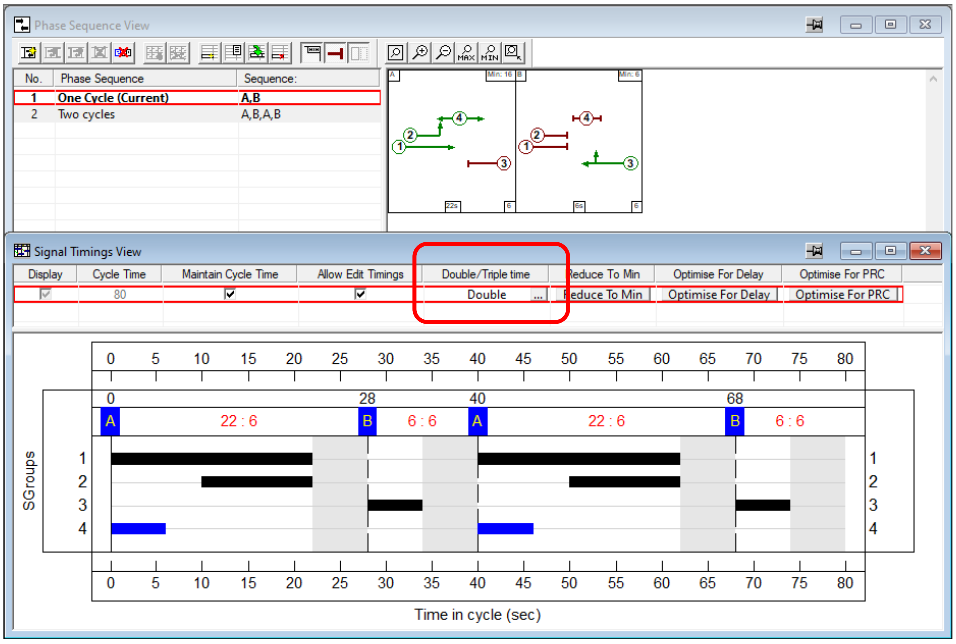
Phase sequences to be used in base models should be determined from SCATS history files and entered in *Phase Sequence View*. If the phase sequence is the same for each peak, then the same phase sequence can be used for modelling both scenarios, rather than setting up separate phase sequences for each peak with identical phases. However if the phase sequences are different between each peak and in the option models, then separate phase sequences will be required to be produced.

Occasionally, the phase sequence may need to be rearranged to model fixed offset relationships, refer to Section 3.5.14 for further information.

3.5.8 Double Cycle

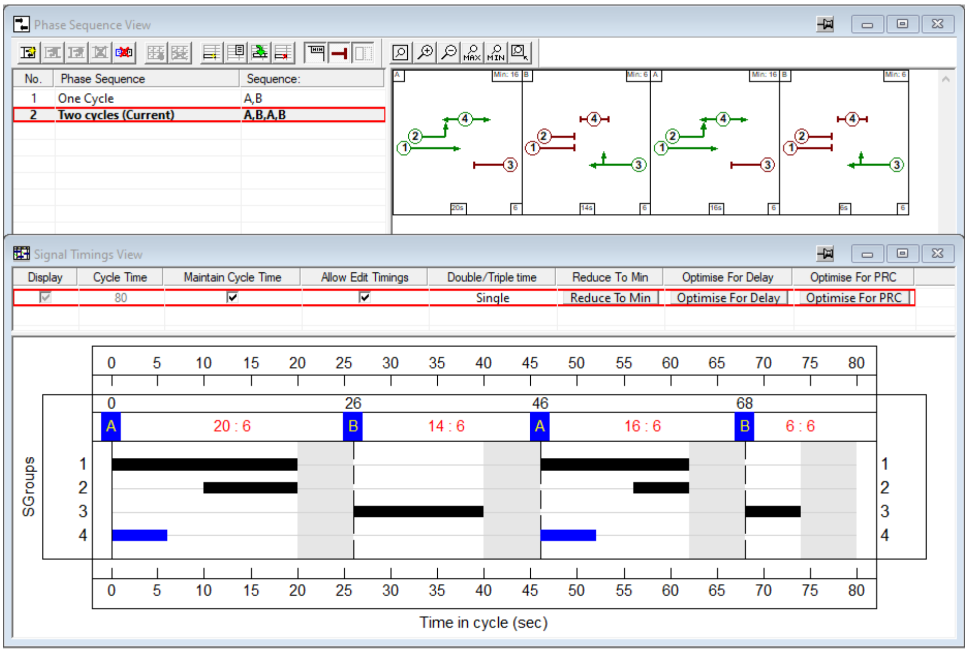
If the phase sequence is operated twice within one cycle period with identical phase lengths for each half of the cycle, the modeller should select *Double* under the *Double/Triple time* on *Signal Timings View* for the double cycle set up, as shown in Figure 3-44.

Figure 3-44: Double Option selected in Signal Timings View for equal phase lengths



If the phase lengths are required to be different for each half of the cycle, modellers need to create a new phase sequence repeating the phase orders and select *Single* under the *Double/Triple time* on *Signal Timings View* as shown in Figure 3-45. Note that this method is likely to increase the signal optimisation run time as the number of phases increases and therefore is not recommended.

Figure 3-45: Repeated Phase Sequence for modelling Double Cycle with unequal phase lengths



3.5.9 Network Control Plans

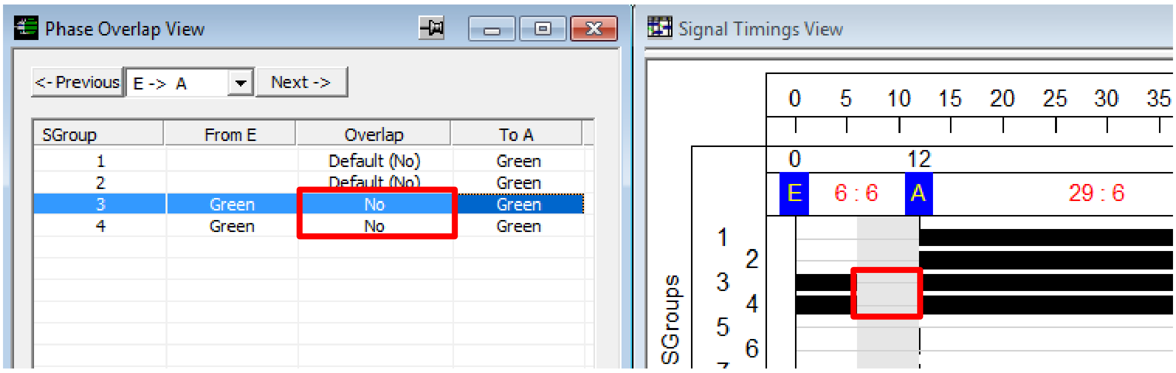
Network control plans should be developed for each combination of signal phase sequencing. If the phase sequence is the same for each peak, then the same network control plan can be used for different scenarios, rather than setting up separate network control plans with identical information. However if the phase sequences are different between each peak and in the option models, then separate network control plans will be required to be produced.

3.5.10 Phase Clearance Overlaps

Intergreen shut down of signal groups (i.e. the signal group operates in continuous phases but returns to yellow and all red during the intergreen period) should be modelled correctly as it would result in inaccurate capacity assessment. Modellers should check the relevant phase transitions in *Phase Overlap View* and if applicable change the overlap setting from *Default (Yes)* to *No*, as shown in Figure 3-46, to model the intergreen shut down.

It may be necessary to observe the signal pattern on-site to identify the signal drop off in each phase transition.

Figure 3-46: Phase Overlap View window (left) and Signal Timings View window (right) for intergreen shut down



3.5.11 Phase Lengths and Cycle Times

For base LinSig models, phase lengths, signal group green times and cycle times should be based on the weighted average phase length of the study period. These phase times should be taken from SCATS history files and replicated in LinSig. Refer to Appendix A on analysing the phase length data.

It is acknowledged that due to demand dependency, it is not always possible to model the weighted average phase time LinSig. Refer to Section 3.5.15 for guidance.

3.5.11.1 Cycle Time in a Network Model

In a network model, if the signal intersections are set up to be coordinated on site, the cycle time for the intersections should ideally be the same.

If different cycle times are used, LinSig would not be able to consider the upstream platooning and assume a flat arrival rate in the calculations; this affects the modelling results such as mean maximum queue and delay time (refer to Section 3.11 for definitions).

When working in a base model, if the coordinated signal intersections found to have different cycle times in the SCATS historical phase length calculation, modellers should review the data and make reasonable assumptions to adjust the calculation methods.

For example, cycle time differences of the two intersections is a couple of seconds, the cycle time for one of the intersections can be rounded to match the linked site and the phase lengths can be adjusted by one to two seconds accordingly.

If the difference of the cycle times is found to be significant, modellers should review the raw data and examine the times of individual cycles to determine a 'typical' cycle time, rather than an average cycle time.

The adjustment of the cycle time in a base model should be decided on a case-by-case basis depending on the signal setup. Main Roads' *trafficmap* provides information on the on-street signal coordination setup in the offset data. Modellers should contact Main Roads to clarify the intended coordination and discuss suitable modelling methods.

3.5.12 Phase Length Optimisation

Signal timing optimisation is a key feature of LinSig and can be used to optimise phase splits on the basis of either delay or practical reserve capacity (PRC). Delay-based optimisation minimises overall network delay based on the traffic volume, while optimising for PRC maximises network capacity (and minimise DoS), potentially increasing reliability and network resilience.

When optimising signal timings, modellers should use *Optimising for PRC* as a starting point because DoS is the main assessment criteria for LinSig modelling in Main Roads.

There may be instances where optimising for delay is more appropriate and in these cases the justification for using this approach should be included in the modelling report.

If the signal optimiser function in the *Scenario View Window* is selected, LinSig optimises the phase lengths and offsets for all intersections in the network. Whereas, if the signal optimiser function is selected in the *Signal Timings View* of a particular signal controller, LinSig optimises the phase lengths for that site only.

These functions optimise the phase lengths and splits only, whilst keeping the cycle time constant. Refer to Section 3.5.13 for cycle time optimisation.

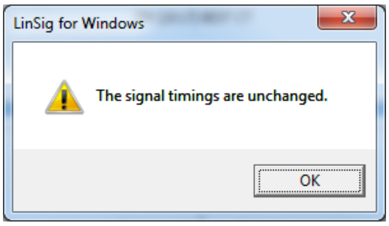
Regardless of the optimisation strategy, when optimising signal timings with LinSig, the software default *Optimisers Settings* should not be modified. This includes the *Stops Valuation for Delay* be set to software default 6.59 seconds per stop/pcu, and *Optimiser Bus Delay Weight* be set to software default 1000 per cent.

The *Advanced* settings in Lanes can be used to influence the signal optimiser in favour of particular lanes, as discussed in Section 3.3.11.

3.5.12.1 Iterations between Optimised Signal Timings and Traffic Assignment

Following signal optimisation (refer to sections 3.5.12 and 3.5.13), the modeller should re-assign the OD traffic using delay-based assignment (refer to Section 3.4.4). To ensure that the traffic flow assignment and the signal timings are optimal for the study area, the modeller should repeat the signal optimisation and traffic assignment processes until the 'Signal timings are unchanged' message appears, as shown in Figure 3-47.

Figure 3-47: Signal timings are unchanged window



3.5.12.2 Review of the Optimised Timings

When optimising signal timings with LinSig it is important to critically assess the resulting green times from the optimisation to ensure that the results make good engineering sense, as well as good mathematical sense. There can be factors which affect the choice of signal times which cannot easily be taken into account by a mathematical optimiser.

Following the LinSig signal optimisation, modellers should review the optimised timings and adjust the phase splits manually to meet the scheme requirements, if necessary.

Note that the traffic flows should then be reassigned in LinSig to re-distribute the traffic based on the adjusted signal timings.

3.5.12.3 Signal Optimisation Strategy in a Network Model

When working in a network model, a variety of signal optimisation strategies can be employed to achieve results including:

- Optimise the green splits and offsets of all intersections in the network using the optimiser function in *Scenario View*. In this method, LinSig optimises the signal timings to provide the optimal results for the entire network rather than the individual intersections.
- Optimise only the intersection of interest using the optimiser button in *Signal Timings View*, and keep the remaining signal intersection timings unchanged. LinSig optimises the signal timings of the study intersection based on the arrival platoons of the other intersections in the network. Offsets optimisation may be required. This method can be used if the neighbouring intersection layouts and signal timings are intended to be unchanged in the option modelling.
- Optimise the green splits of the intersections individually in *Signal Timings View* for each controller, then optimise the signal offsets of the network in *Scenario View*.

While the first method is generally used, the optimisation strategy should be decided on a case-by-case basis depending on the purpose of the analysis and the objectives of the scheme. This should be discussed with Main Roads for each modelling project.

3.5.12.4 Influencing the Optimiser

The type of optimisation used is likely to be influenced by the operational objectives of the network or corridor (for example, to reduce delay, to maximise capacity or to maintain reliability). There may be instances where a particular movement or objective is being assessed which can be influenced by settings within the LinSig optimiser. The network or operational objectives can be influenced by parameters discussed in the following sub sections, which can be entered in the *Advanced* tab of the *Edit Lane* window.

Applying these optimiser parameters requires an advanced understanding of modelling and an experienced modeller. It may be more appropriate to adjust the signal timings manually to achieve the specific objectives rather than applying the optimiser parameters.

When using any of the parameters, careful consideration needs to be given to achieving the required outcome without unduly penalising other movements or side roads. Any use of these factors needs to be justified on the basis of network or operational objectives and detailed in the modelling report.

In a base model when signal optimisation is not required, modellers do not need to enter values for the optimiser inputs.

3.5.12.4.1 Optimiser Queue Constraints

The *Optimise Queue Constraints* set up can be used to influence the signal timings to prevent the queues from exceeding the available storage space. This may be applied to the internal lanes in a network model, or to the pocket lanes that are modelled as long lanes due to LinSig software limitation.

- The *Excess Queue Limit* is normally set to three-quarters of the queuing space on the lane, i.e. if the physical length is 8 PCU, then 6 PCU is used in the model.
- *Degree of Saturation Weighting* or *Delay Weighting* of low values (for example, 1 or 2) are recommended as the starting point to examine the impact; this can be increased as part of model calibration.

3.5.12.4.2 Optimiser Stops, Delay or DoS Weightings

The *Apply Optimiser Stops Weighting (%)* option can be used to increase the cost associated with vehicle stops and provides additional green time on particular lanes to provide a more favourable offset to reduce the number of stops.

Similarly, the *Apply Optimiser Delay/DegSat Weighting (%)* option can be used to influence the cost associated with either delay or DoS results and adjusts additional green time accordingly.

- 100 per cent is the default ‘do nothing’ value.
- A value higher than 100 per cent suggests the lane is more important, e.g. 200 per cent implies the lane is twice as important.
- A value less than 100 per cent implies the lane is less critical.

3.5.12.4.3 Degree of Saturation Limit

The *Apply DegSat Limit (%)* option is used to influence the LinSig optimiser to ensure the DoS does not exceed this value (where possible) when undertaking signal optimisation.

This function is particularly useful if the scheme has a specific upper limit DoS on certain lanes, for example if the DoS of the major road cannot be greater than 80 per cent in an option model.

3.5.13 Cycle Time Optimisation

If cycle time optimisation is required in the modelling scope, the *Cycle Time Optimisation* function should be used to determine the most appropriate cycle time for the entire study area.

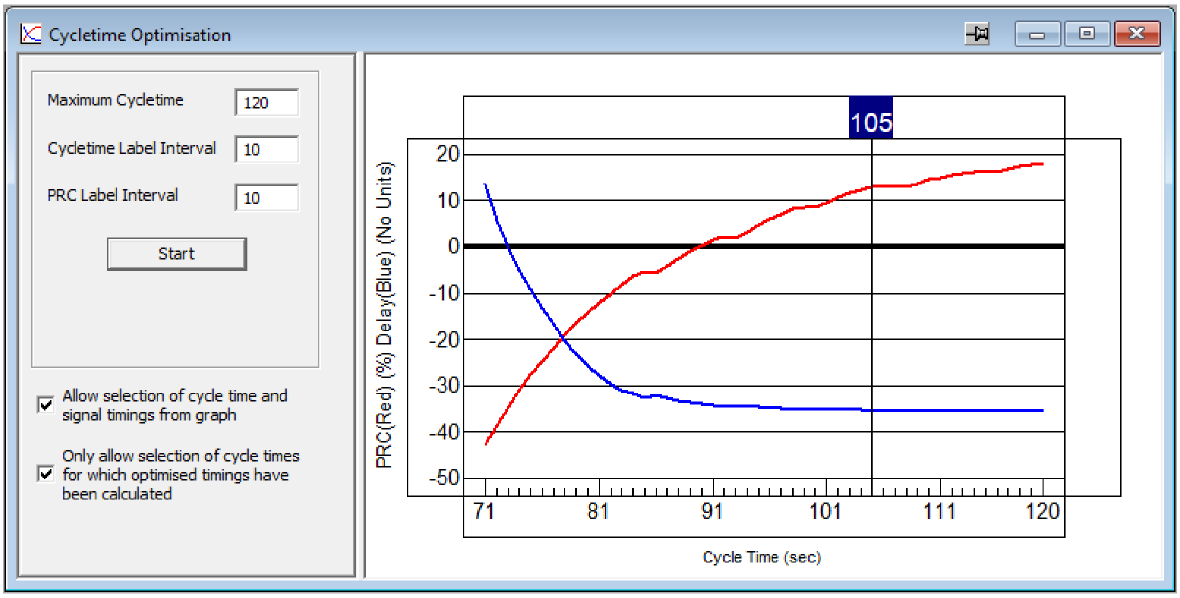
The cycle time optimisation graph, as shown in Figure 3-48, displays the vehicle delay and PRC results for a range of cycle times. Note that the blue value at the top of the graph (cycle time slider) shows the initial cycle time, not an optimised cycle time.

The modeller should move the cycle time slider manually to the desired cycle time that meets the scheme criteria and the DoS and delay performance requirements, as discussed in Section 3.5.13.1.

Once the desired cycle time is chosen, the modeller should then repeat the iteration of signal phase splits, offsets optimisation and traffic re-assignment until the model is optimised, as discussed in Section 3.5.12.1.

Screenshots of the cycle time optimisation graph should be included in the modelling report to justify the proposed cycle time.

Figure 3-48: Cycle time optimisation



3.5.13.1 Desired Cycle Time Selection

A desired cycle time may not necessarily provide the best results, but rather should be a minimum cycle time that achieves the accepted performance requirements.

For example, if the performance requirement is to achieve Degree of Saturation (DoS) of 80 per cent, i.e. Practical Reserve Capacity (PRC) of 12.5 per cent (refer to Section 3.11.2 for definitions), Figure 3-48 shows while 120 second cycle time provides the best overall results, 105 second cycle time is sufficient for meeting the performance requirements. The lower cycle time should be chosen to avoid unnecessary delay time for traffic and pedestrians.

Depending on the scheme requirements, the cycle time selection can be based on fixed intervals (for example every five seconds), and not all possible cycle times need to be analysed. This should be decided on a case-by-case basis depending on the nature of the analysis and the modelling results.

3.5.14 Offsets

When modelling multiple intersections in a network model, it is important to understand how SCATS operates to achieve coordination between two or more adjacent intersections, this is particularly important for interchanges. Refer to Appendix A for information on determining the offset setup and on-site timings.

For a base model, if there is a fixed time offset relationship between two close-by controllers, the modeller should replicate the offsets as per the site conditions. It is recommended that the reference phase of the master site starts at zero and the other intersections are manually shifted based on the offset setting in SCATS.

It is recommended to lock the offset setup in the base LinSig model if the relationship is to be maintained in the option model, this can be done by either:

- right click in the *Signal Timings View* window or in the *Timing Dial* and select *Lock Offset of first Phase in Sequence*, and a blue line appears at the locked phase offset time, as shown in Figure 3-49, or
- Set up a new *Offset Optimiser Group* in the *Optimiser Settings* window, as shown in Figure 3-50.

Figure 3-49: Signal Timings View window with a locked offset

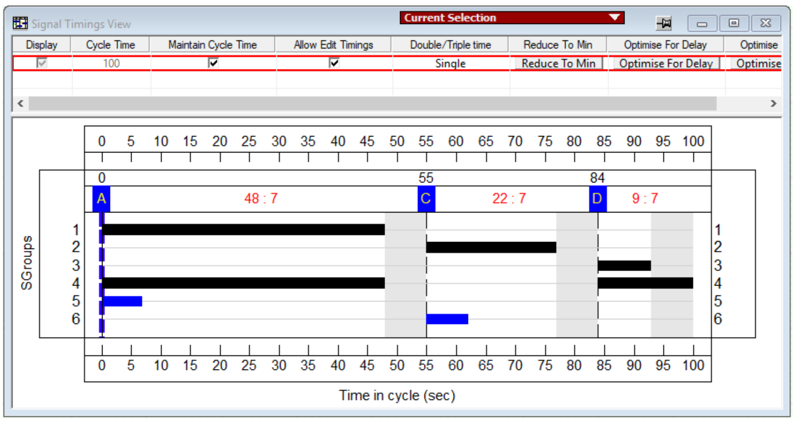
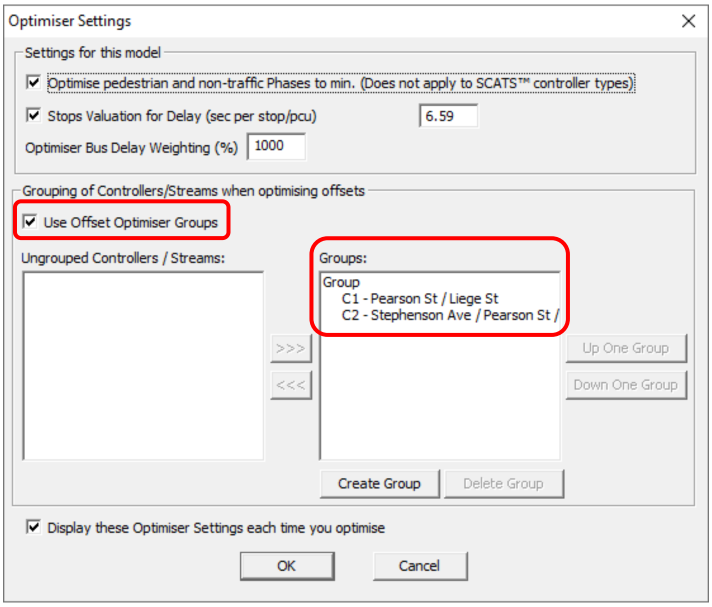


Figure 3-50: Grouping of Controllers in Optimiser Settings window



While both methods achieve the same outcome, Main Roads' preference is the former method to lock the offset phase, as the offset setup is visually clear in the signal windows in LinSig for easy reference.

When undertaking phase length or cycle time optimisation, the modeller should always review the resultant offsets following the optimisation process to ensure the desired offsets have not been altered.

In either methods, if the reference phase in SCATS setup is not the start of A phase, it is necessary to rearrange the phase ordering in the *Phase Sequence View* so that the first phase of the sequence is the reference phase, i.e. if the start of B phase is the reference phase, phase sequence of B,C,A should be used instead of A,B,C.

3.5.15 Demand Dependency

LinSig models a single ‘average’ cycle in peak hour. However in reality the pedestrian and traffic demand may be different in each cycle, operating with different signal phase sequence and length in each cycle.

When using history files, the number of occurrences of particular phases can be seen from the outputs. For phases that are demanded very infrequently, this may mean that the average phase time falls below the minimum being used in the model.

Some of the situations where demand dependency adjustments are required include:

- infrequent phases (refer to Section 3.5.15.2)
- where pedestrian demand affects the minimum phase lengths
- where pedestrian demand affects the pedestrian protection delay to traffic (refer to Section 3.5.15.3), and
- alternative phases e.g. diamond movements (refer to 3.5.15.4).

Some of the criteria for determining a suitable adjustment method include:

- nature of the infrequent phase and signal group
- demand frequency in the existing situation
- demand frequency to be modelled and analysed as set out in the modelling scope
- signal set up, and
- scheme assessment and options to be analysed.

As each modelling project and the intersection setup are different, there is not a definitive method on making demand dependency adjustments for each case.

While the guidelines discuss the common methods and Main Roads’ preference, the modeller should make the engineering judgement on the most appropriate demand dependency adjustment method for each project, discuss the assumptions with Main Roads and document the assumptions in the modelling report.

Mixing different methods within a modelling project is not recommended. The selection of the modelling method should also consider how the intersections will be modelled and optimised for the options and future year scenarios. The chosen method should be applied in all scenarios and all stages of modelling for consistency.

It is recommended that modellers use the *Add Notes* function in LinSig’s *Network Layout View* stating the demand dependency frequencies and the high level modelling method to make it clear for other modellers to understand the assumptions made when viewing the LinSig models.

For the demand dependency modelling methodology when signal optimisation is required, refer to Section 3.5.16

3.5.15.1 Demand Dependency Methods

This section provides the general methodology for each demand dependency adjustment method and discusses Main Roads' preference. The application of these methods is provided in subsequent sub-sections.

3.5.15.1.1 Bonus Green Time Method

Main Roads' preferred method for modelling demand dependency is the use of bonus green time in *Lane Timings View*. The general modelling method is:

1. Calculates the total green time for each signal group in the modelled hour.
2. Divides the total green time in step 1 by the number of cycles in the hour.
3. Calculates the bonus green time for each signal group, which is the average green time in step 2 subtracts the modelled green time in *Signal Timings View*.
4. Apply the signal group bonus green time to the relevant lanes in *Lanes Timings View*.

This method has the flexibility of applying different demand dependency frequencies in each scenario. The bonus green times need to be estimated for each peak and applied to each scenario individually reflecting the different frequencies in each peak.

When undertaking signal optimisation, it may be necessary to remove the bonus green time prior the optimisation process, but this depends on the purpose of applying bonus green time.

3.5.15.1.2 Dummy Phases Method

This method is to add alternative dummy phases in the phase sequence replicating when the demand dependent signal group is not activated.

The general modelling method is:

1. Set up an alternative dummy phase in *Phase View*, with the same phase letter and signal timings as the original phase.
2. Activate the same signal groups as the original phase, with exception of the demand dependent signal groups which should be deactivated.
3. Model the dummy phase, replacing the original phase, in the *Phase Sequence*.

Main Roads recommends not to modify the original phases as they may be needed for other assessments. The original signal setup should match the SCATS setup, therefore dummy phases are modelled for ease of checking and to avoid confusion.

This method may need to be combined with adding bonus green times and / or setting up multiple cycle sequences depending on the situation.

3.5.15.1.3 Multiple Sequences Method

This method is used to create a new phase sequence that consist of multiple cycles replicating the demand frequency of a particular phase. The general modelling method is:

1. Create a new dummy phase as discussed in Section 3.5.15.1.2, if needed.
2. Double or triple the cycle time, depending on the frequency being modelled.
3. Create a new *phase sequence* that consists of the multiple cycles replicating the frequency of the dummy phase.
4. Adjust the phase lengths in *Signal Timings View* or in *Timing Dials*.
5. Double or triple the cycle time of the coordinated controllers, if modelling in a network (refer to Section 3.5.11.1). Select the *Double* or *Triple* set up in *Signal Timings View* of the neighbouring sites to avoid creating a multiple cycle sequence as discussed in Section 3.5.8.

This method can be used if the phase sequence is simple and the frequency is straight forward such as one-in-two or one-in-three cycles, and is not be suitable for complex demand percentage.

However, this method is not preferred as it significantly increases the signal optimisation and run-time, particularly when the phase sequence is complex or working in a large network. As a result manual adjustments to the phase time may be required following the signal optimisation.

3.5.15.1.4 Adjust signal setup

This method is used to adjust the signal input parameters proportionally based on the demand frequencies. The general modelling method is:

1. Estimate the weighted average signal timings based on the demand frequencies.
2. Create a new dummy phase as discussed in Section 3.5.15.1.2, if needed.
3. Reduce the signal timing inputs in the dummy phase based on the weighted average, such as:
   - pedestrian protection period in traffic signal groups
   - walk time, clearance 1 and clearance 2 time in pedestrian signal groups, and
   - late start, minimum green, early cut-off green, yellow & all red times in phases.
4. Model the phase sequence and phase lengths based on the average timings.

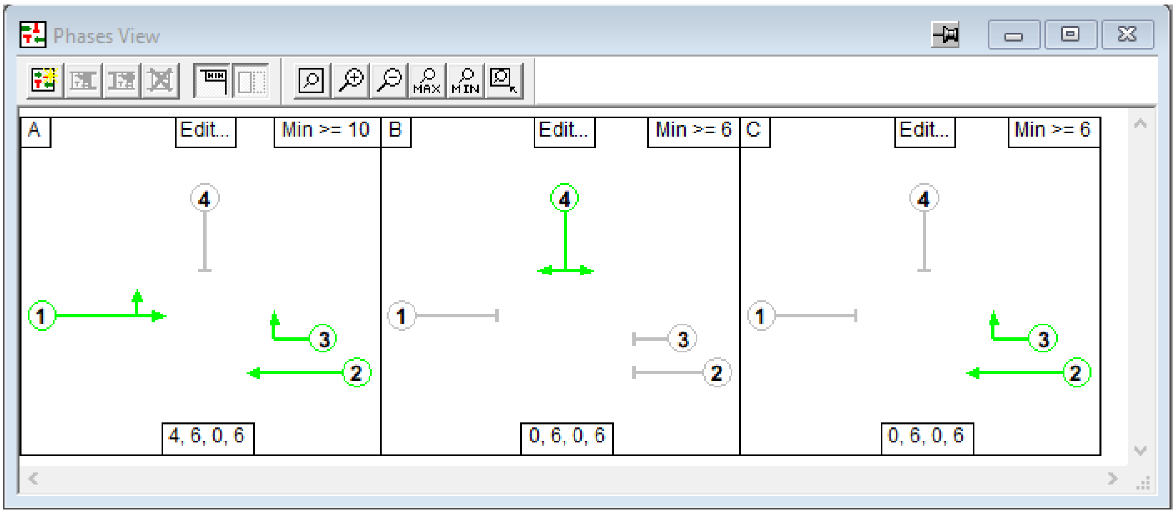
While this method is quick to model, it is not recommended by Main Roads. Signal inputs should match the SCATS set up to avoid confusion. Moreover, the reduced timings are applied to all scenarios in the LinSig files and not specific to each scenario. This becomes problematic when using the model file for analysing other scenarios.

This method is not generally recommended as the adjusted phase timings are applicable to all scenarios in the model and therefore, affect the timings for the other peaks. This method also does not provide an assessment for option modelling.

3.5.15.2 Demand Dependency Example: Infrequent Phases

In the example shown in Figure 3-51, C phase is a demand dependent phase, this phase is skipped in some cycles when there is no demand.

Figure 3-51: Leading right turn example



The SCATS history file can be used to determine the demand frequencies and to calculate the weighted average phase lengths and cycle time, as shown in Table 3-3 using the following formulae:

- Total phase time is the sum of all phase lengths in an hour. Refer to Appendix A for further information.
- Average phase time = total phase time in an hour ÷ number of occurrences.
- Weighted average phase time = Total phase time in an hour ÷ number of cycles.
- Minimum phase time is the minimum time when the phase is activated in a cycle.

In this example, the weighted average phase time for C phase is shorter than minimum phase time.

Table 3-3: Infrequent phase calculations

Phase	Demand Frequencies = Number of Occurrences / Number of Cycles	Total Phase Time (seconds)	Actual Average Phase Time (seconds)	Weighted Average Phase Time (seconds)
A	100% = 36 / 36	2223	62	62
B	100% = 36 / 36	1113	31	31
C	61% = 22 / 36	264	12	7
Total		3600	105	100

The cycle time of 100 seconds, not 105 seconds, should be modelled replicating the correct number of cycles in an hour (36 cycles).

3.5.15.2.1 Bonus Green Time Method

In *Phase Sequence*, the sequence that occurred most of the time should be modelled. In this example, *A,B,C*.

In *Signal Timings View*, the estimated phase time if C phase is demanded in modelled, as shown in Figure 3-52. In this example:

- The demand dependent phase (C phase) runs to its minimum phase length.
- The stretch phase (A phase) length is reduced accordingly.
- The unaffected phase (B phase) length remains the same as the average phase length calculated in Table 3-3.

Figure 3-52: Assumed phase lengths if the infrequent phase is demanded in a cycle

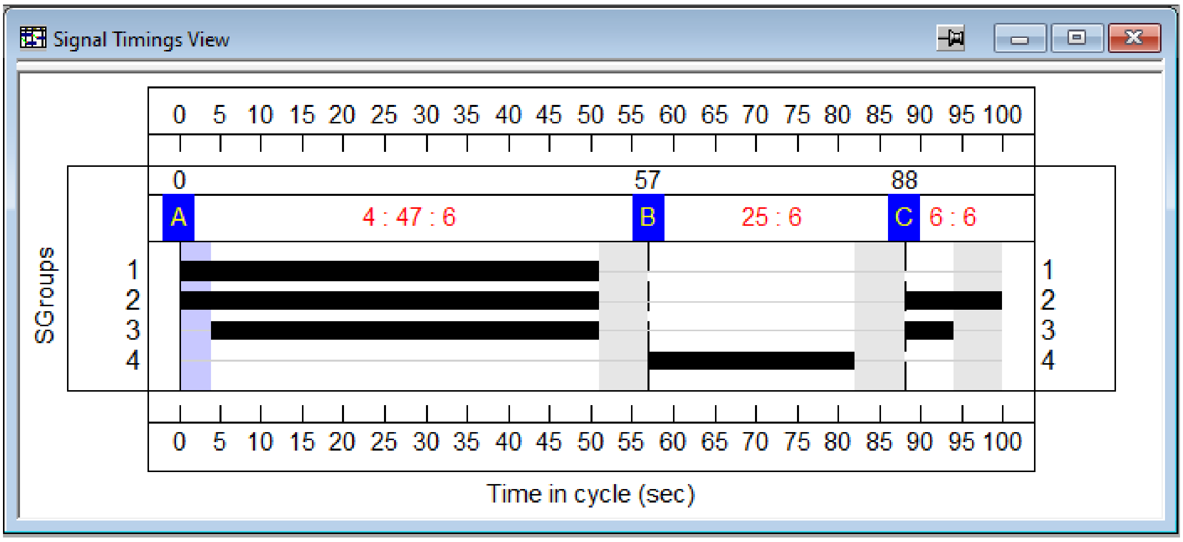
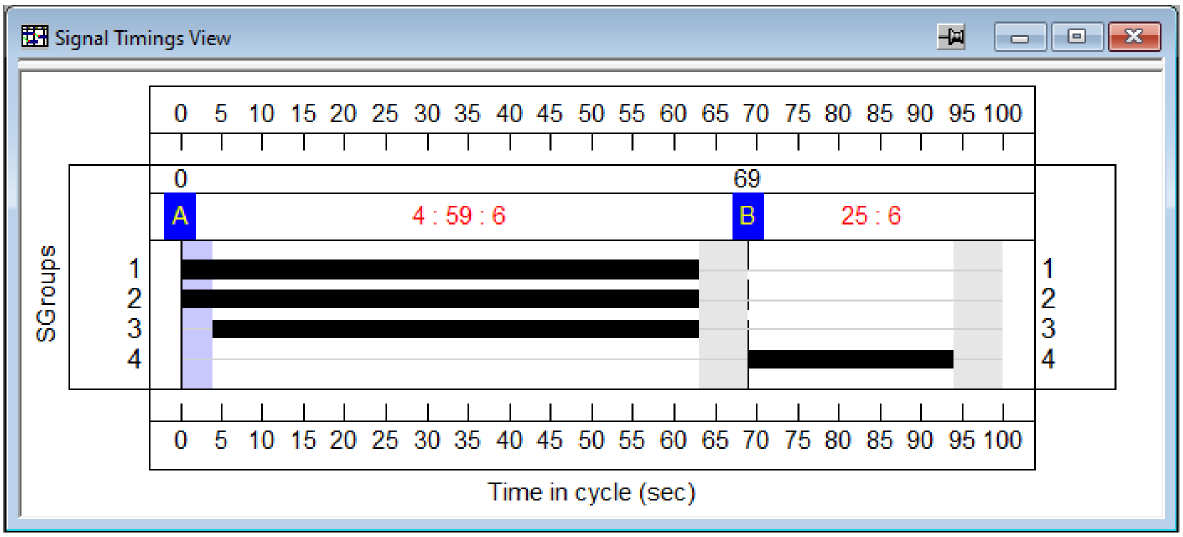


Figure 3-53 shows an estimated phase split if C phase is not demanded in a cycle. This figure is for demonstration only and does not need to be modelled in LinSig. In this example:

- The unaffected phase (B phase) length remains the same as the average phase length calculated in Table 3-3.
- The remaining time is assigned to the stretch phase (A phase).

Figure 3-53: Assumed phase lengths if the infrequent phase is not demanded in a cycle



The green time for each signal group can then be calculated as summarised in Table 3-4:

- Weighted average green is calculated based on the % activation
- Bonus green time = weighted average green − modelled green (Figure 3-52)

It is important to separate SG3 to opposed and unopposed periods as it affects the capacity calculations during the give-way period.

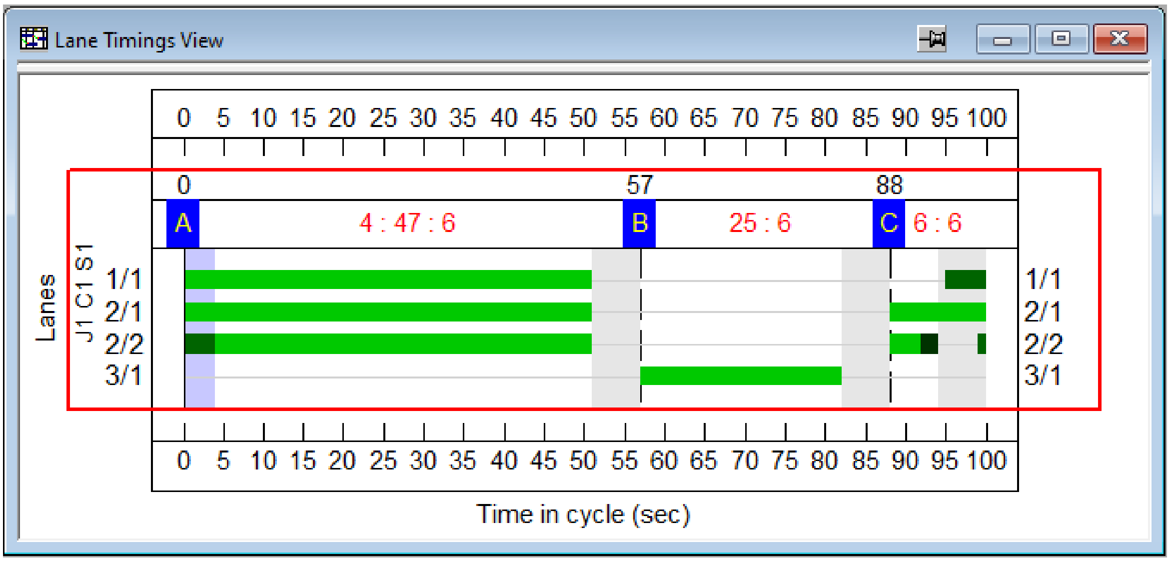
Table 3-4: Weighted average signal group green time calculations

Phase Sequence	% activation	SG1 Green Time	SG2 Green Time	SG3 Opposed Green Time	SG3 Unopposed Green Time	SG4 Green Time
A,B,C (Figure 3-52)	61%	51	63	47	6	25
A,B (Figure 3-53)	39%	63	63	59	0	25
Weighted Average Green Time		55.68	63	51.68	3.66	25
Bonus Green Time		+4.68	0	+4.68	-2.34	0

The green time calculation spreadsheet should be included in the modelling submission for ease of reference.

In *Lane Timings View*, the bonus green times are added to the relevant traffic lanes as demonstrated in Figure 3-54.

Figure 3-54: Lane Timings View with bonus green time to replicate infrequent phase



While this method can also be applied by reducing the B phase time instead of A phase time in *Signal Timings View*, modellers should ensure the SG3 times are calculated separately for the opposed and unopposed periods, as it affects the capacity calculations for the filtered right-turn movement.

3.5.15.2.2 Multiple Sequences Method

In *Phase Sequence*, a new sequence with repeated phases is set up based on the demand frequency e.g. if the infrequent phase is activated approximately two out of three times, the sequence is *A,B,C, A,B,C, A,B*.

In *Signal Timings View*, multiply the cycle time accordingly and manually adjust the phase lengths.

See Section 3.5.15.1.3 for general discussion about using this method.

3.5.15.2.3 Signal Set Up Adjustment Method

In *Phase View*, create a new dummy phase duplicating the same phase activations as the phase of interest (C phase).

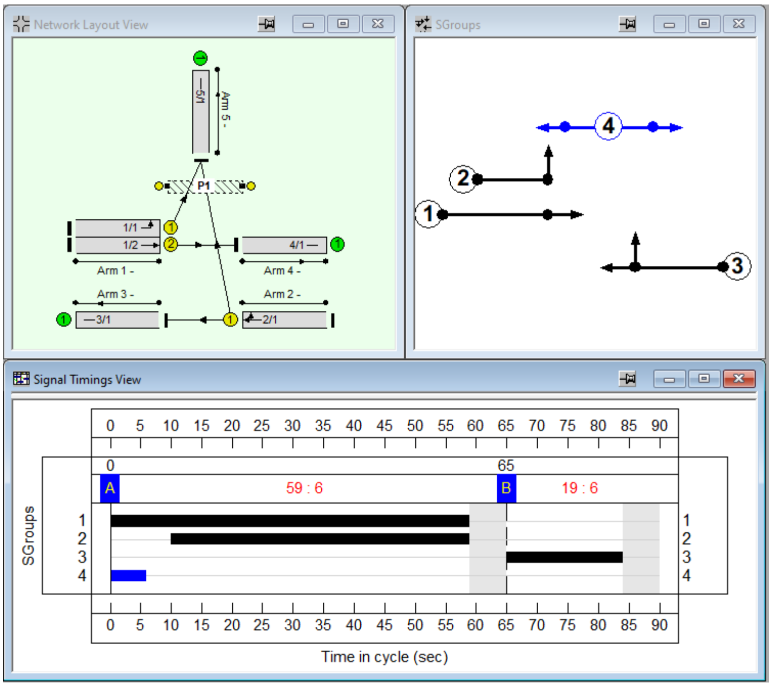
In *Phase View* of C phase, reduce the *late start*, *minimum green, early cut off* and *yellow and all red* periods based on the activation frequency. For example if the phase is activated 61% of the time, the *minimum green* should be adjusted from the original 6 seconds to 4 seconds (61% x 6s = 3.66).

This method assumes the activation frequency in all scenarios is the same in all scenarios. Refer to Section 3.5.15.1.4 for general discussion regarding this method.

3.5.15.3 Demand Dependency Example: Pedestrian Protection

In this example, the timed red arrow pedestrian protection period is 10 seconds, as shown in Figure 3-55. If the pedestrian crossing is not activated in a particular cycle, the left-turn signal group would begin at the start of the phase. Note that in this example, the modelled phase length is affected by the crossing activation.

Figure 3-55: Pedestrian protection example

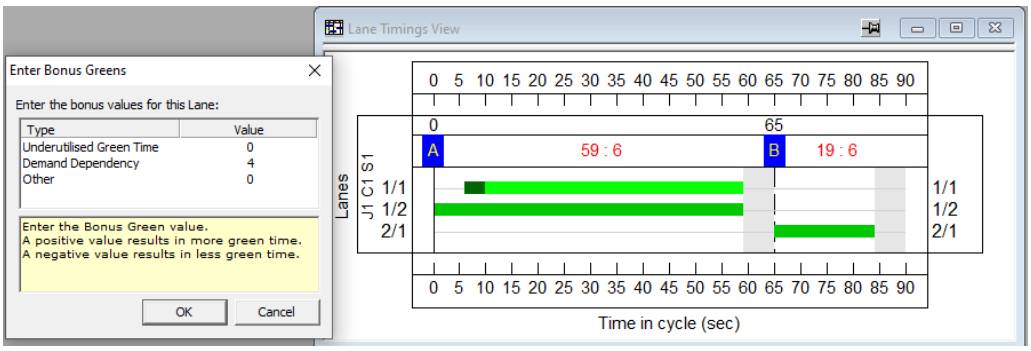


3.5.15.3.1 Bonus Green Time Method

This is Main Roads' preferred method as it provides flexibility on modelling a different demand frequency in each scenario without adjusting the standard signal setup.

In *Lane Timings View*, a positive bonus green is applied to the relevant traffic lanes to replicate the average protection time in an hour. For example, if the crossing is activated 60% of the time (i.e. not activated 40% of the time), a positive bonus green time of 4 seconds (40% x 10s) is applied to Lane 1/1 to compensate for cycles when the green time begins at the start of the phase, as shown in Figure 3-56.

Figure 3-56: Bonus green time for pedestrian protection demand dependency adjustment



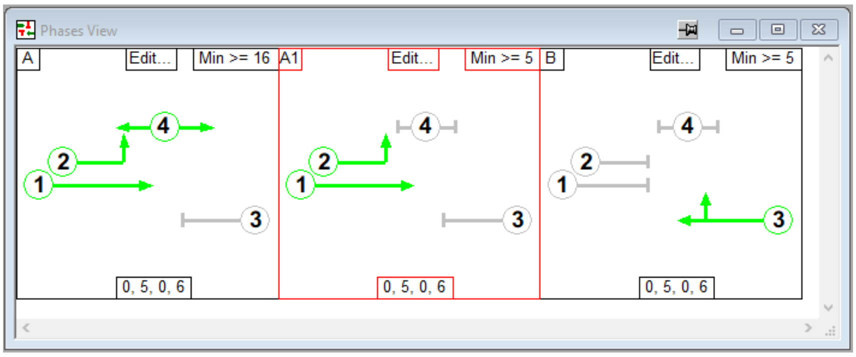
Different bonus green values can be applied to different peak scenarios depending on the demand frequency.

3.5.15.3.2 Dummy Phase Method

This method can be used if crossing activation frequency is assumed to be low (almost 0 per cent).

In *Phases View*, an alternative dummy phase to A phase is set up without the activation of the pedestrian signal group, as shown in Figure 3-57.

Figure 3-57: Alternative dummy phase without the pedestrian activation



In *Phase Sequence*, the dummy phase A1 is used instead of A, i.e. *A1,B*.

As SG2 green time begins at the start of the phase, it would overestimate capacity if the pedestrian crossings are still occasionally activated. In *Lane Timings View*, a negative bonus green time may need to be applied to the relevant traffic lanes to replicate the average protection period in an hour. For example, if the pedestrian crossing is activated 20% of the time, a negative bonus green time of 2 seconds (20% x 10 seconds protection period) is required.

3.5.15.3.3 Multiple Sequences Method

In *Phase View*, dummy phase A1 is set up, as shown in Figure 3-57.

In *Phase Sequence*, a new sequence with repeated phases is set up based on the demand frequency, e.g. if the crossing is activated two out of three times, the sequence is *A,B, A,B, A1,B*.

In *Signal Timings View*, multiply the cycle time accordingly and manually adjust the phase lengths.

See Section 3.5.15.1.3 for general discussion for using this method.

3.5.15.3.4 Signal Set up Adjustment Method

In *Edit SGroup* window, reduce the *Timed Protection Period* based on the crossing activation frequency. For example if the pedestrian crossing is activated 40% of the time, then 4 seconds (40% x 10 seconds) is applied.

This method assumes the activation frequency in the same in all scenarios. Refer to Section 3.5.15.1.4 for general discussions about using this method.

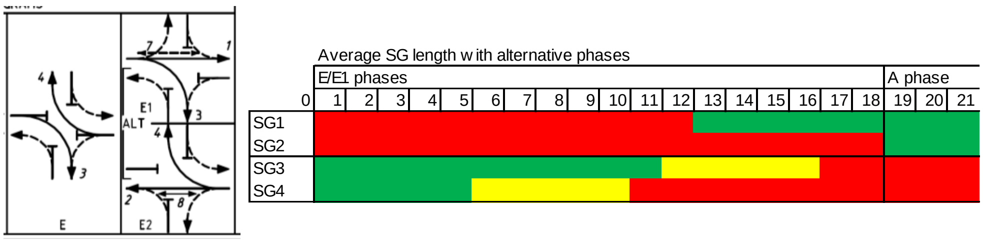
3.5.15.4 Demand Dependency Example: Alternative Phases

Alternative phases is common in Western Australian signal setup. The frequency and the duration of the alternative phases can be estimated based on the traffic demand of each right-turn or determined from the signal group outputs such as *SCATS Event History File*.

In this example:

- The total duration of E phase (whether E or E1 or E2) is 18 seconds.
- The westbound right-turn demand is less than the eastbound right-turn demand, therefore in some cycles, E1-phase is activated with SG4 terminates earlier and SG1 commences sooner.
- On average, the green time for SG4 is five seconds, which is shorter than the minimum green time set out in E phase.

Figure 3-58: Alternative phase example and average signal group green time



Note that for a leading right-turn with filtered right-turn situation, the average calculation should also take into account the lost green time due to signal drop off and late start of the right-turn arrow. The intergreen time between SG1 and SG4 should be maintained.

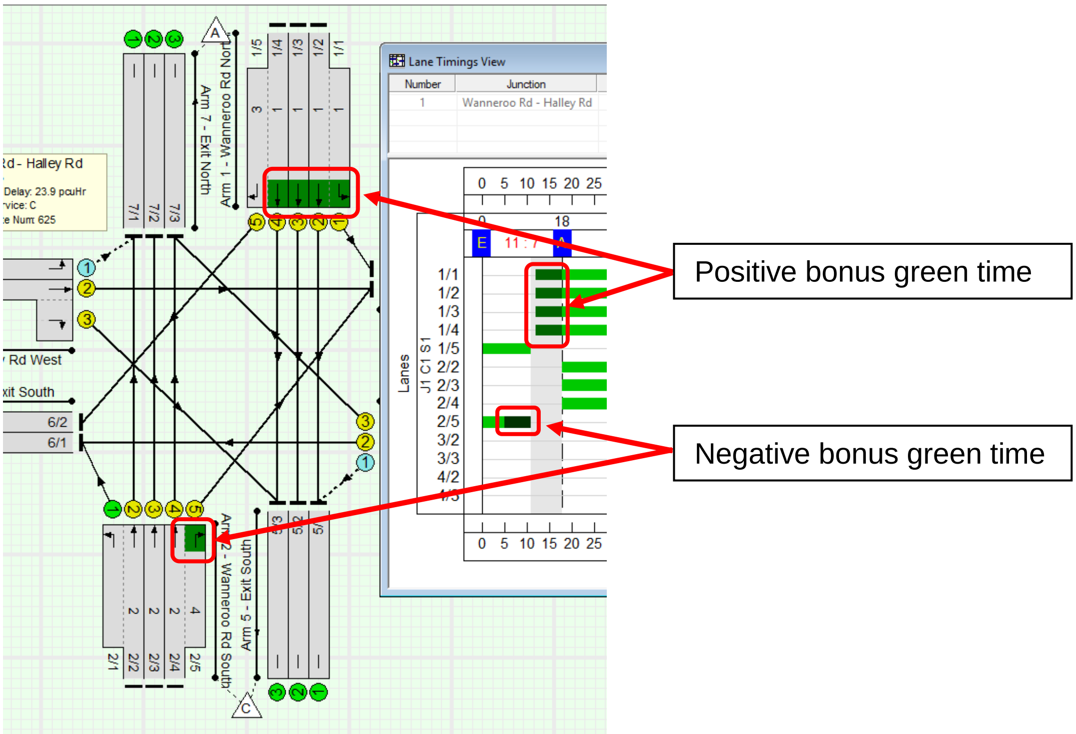
3.5.15.4.1 Bonus Green Method

Main Roads' preferred method is to examine the green time for each signal group and calculate the weighted average and apply bonus green time to the relevant lanes as shown in Figure 3-59:

In *Lane Timings View*, negative bonus green time is applied to the traffic lanes that get less green time due to the early termination.

Similarly, positive bonus green time is applied to the traffic lanes that get extra green time due to operating the alternative phase.

Figure 3-59: Positive and negative bonus green time added in Lane Timings View



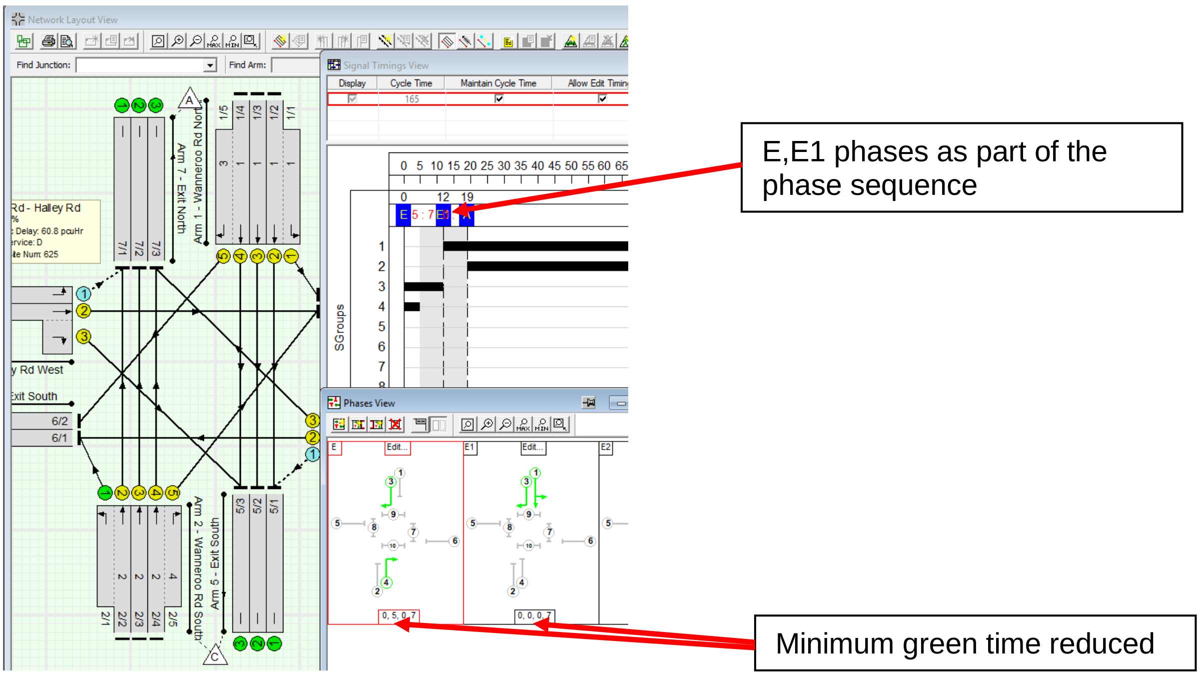
3.5.15.4.2 Alternative Phases in Phase Sequence

In *Phase Sequence View*, a separate phase sequence is set up to include E and E1 phases.

In *Signal Timings View*, the phase lengths are manually adjusted to replicate the average signal group green time.

Note that it may be necessary to reduce the *minimum green time* of the alternate phase in *Phase View* as shown in Figure 3-60, which may cause confusion when reviewing the model.

Figure 3-60: Alternative Phases added in Phase Sequence



3.5.16 Demand Dependency for Proposed Modelling

Depending on the project requirements, demand dependency should be taken into consideration when optimising the signal timings for the option models. While it is usually acceptable to consider the demand dependency frequency for the option model when it remains unchanged from the existing situation, many factors in the future scenarios, such as land use, pedestrian demand or cycle time, could also affect the demand frequency.

The following method can be used to consider the potential demand frequency, this is particularly useful for a diamond signal arrangement when alternative phases may run:

1. For the alternative phases, reduce the restrictions of minimum green from the existing timing to one second.
2. Optimise the signal timings for PRC and note the resultant phase lengths.
3. Re-enter the minimum green as per the site condition.
4. Apply the bonus green time to replicate the traffic lane green time as per point two above.

3.6 Give-Way Inputs

While the main function of LinSig is to analyse the impact of signalised intersections, it can also analyse give-way movements and priority controlled intersections based on user inputs. This section details the LinSig input requirements for give-way situations.

3.6.1 Give-Way Parameters at a Signalised Intersection

The most common give-way parameters at a signalised intersection are shown in Table 3-5 based on the intersection set up as shown in Figure 3-61. Refer to Section 3.6.3 for comments on modifying give-way parameters.

Figure 3-61: Example of give-way modelling at a signal intersection

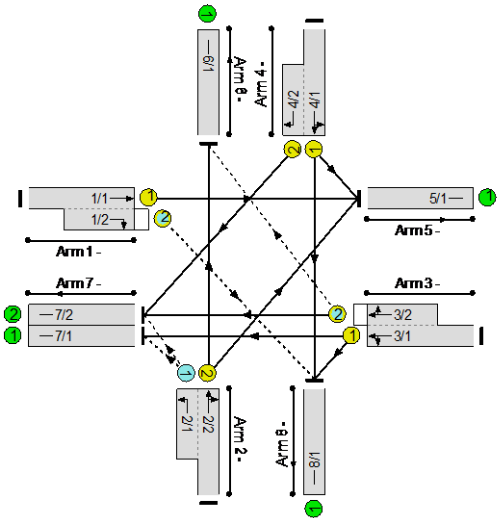


Table 3-5: Give-way parameters at a signal intersection

Give-way movements at signals	Signal right-turn opposed movement			Left-turn give-way slip			
Opposed lane	1/2		3/2	2/1			
Movement to lane	8/1		6/1	7/1	7/2		
Maximum flow while giving way (pcu/Hr)	1,439		1,439	715	715		
Minimum flow while giving way (pcu/Hr)	0		0	0	0		
Flow when opposing traffic is stopped	Use lane saturation flow value			Use maximum flow while giving way value			
Opposing lanes	3/1	3/2	1/1	3/1	3/1	3/2	4/2
Coefficient	1.09	1.09	1.09	0.22	0.22	0.22	0.22
Opposing movement	All opposing	Ahead only	All opposing	Ahead only	Ahead only	All opposing	All opposing

Source: JCT Consultancy, with added information by Main Roads

3.6.2 Give-way Parameters at a Priority Controlled Intersection

Modellers can add priority controlled intersections as part of a network model if required.

Modelling a priority controlled intersection in a network model, in the *Edit Junction* window, the *Is Signal Controlled* option should be deselected. The most common give-way parameters at a priority controlled intersection are shown in Table 3-6 based on the intersection set up as shown in Figure 3-62. Refer to Section 3.6.3 for comments on modifying give-way parameters.

Figure 3-62: Example of give-way modelling at a priority controlled intersection

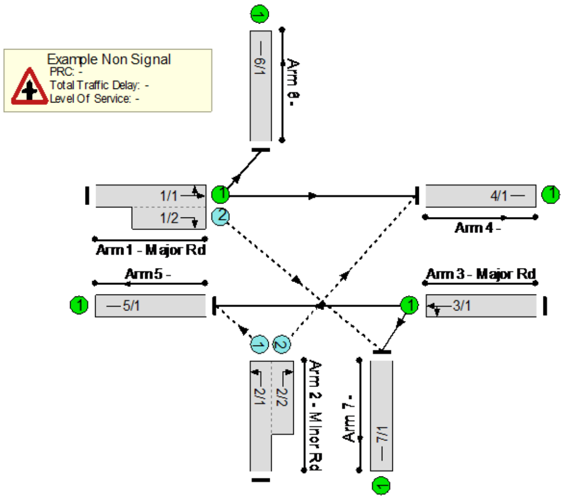


Table 3-6: Give-way parameters at a priority controlled intersection

Give-way movements at a priority controlled intersection	Minor Road Left Turn Give-way	Minor Road Right Turn Give-way			Major Road Right Turn Give-way
Opposed lane	2/1	2/2			1/2
Movement to lane	5/1	4/1			3/1
Maximum flow while giving way (pcu/Hr)	715	600			850
Minimum flow while giving way (pcu/Hr)	0	0			0
Flow when opposing traffic is stopped	Use maximum flow while giving way value				
Opposing lanes	3/1	3/1	1/1	1/2	3/1
Coefficient	0.22	0.22	0.19	0.19	0.35
Opposing movement	Ahead only	Ahead only	Ahead only	All opposing	All opposing

Source: JCT Consultancy, with added information by Main Roads

3.6.3 Modifications to the Give-way Parameters

The link and connector structure set up in sections 3.6.1 and 3.6.2 are based on generic intersections. For some turning movements onto multiple exit lanes, such as the left-turn slip lane (lane 2/1) in Figure 3-61 that has two connectors to both exit lanes on arm 7, the turning movement behaviour may be site specific and should be observed on-site.

It should be noted that the give-way values in Table 3-5 and Table 3-6 are derived from UK research and in some instances may not provide an accurate representation of existing performance. If these values are to be adjusted (for example, for the left-turn give-way slip, the maximum flow while giving way can be increased up to 1000 pcu/hr, or the minimum flow while giving-way can be increased up to 100 pcu/hr). The modelling report should include justification and evidence from site observations to support the changes.

3.6.4 Clear Conflict

The clear conflict time is the time between a vehicle crossing the opposing lane’s stop line and the time it ceases to oppose traffic on the give-way lane. The value should be reviewed and observed on-site for each opposing movement, or estimated by measuring the distance from the opposing stop line to the conflict point and divided by the travelling speed. The clear conflict time needs to be entered under each *Opposing Lane* in the *Movement to* tab of the *Edit Lane* window.

3.6.5 Storage in Front of Stop Line

For signal controlled mixed through and filtered right-turn lanes, modellers need to identify the number of right turning vehicles that would wait to filter in front of the stop line.

The *Right-turn Storage in Front Of Stopline* and *Max Right-turns In Intergreen* values should be updated based on site observations, driving behaviour and local driving rules. The software default values of two PCU should not be used unless justified with site evidence.

Right-turn Move Up time and *Right-turn Factor* should be left as software default. If the values are updated, justifications should be provided in the modelling report.

3.6.6 Non-Blocking Storage

For mixed through and turning lanes, modellers need to identify if the opposed turning traffic blocks the non-opposed through traffic.

The *Total number of PCUs on a give-way movement that can store without blocking the non-giving way movement* value should be updated based on site observations, driving behaviour and local driving rules. The software default value of two PCU should be used unless justified with site evidence.

Note that if the microflare method (refer to 3.5.5) is used to model the filtered right-turn signal group in a shared lane, the physical lane length of the microflare should be reduced to 0.1 PCU, as the *Non-Blocking Storage* would also take into consideration the right-turn traffic blocking the through traffic.

3.6.7 Zebra crossings

LinSig is not able to model the impact of traffic giving way to pedestrians at zebra crossings. However, if it has been observed that zebra crossings at left-turn slip lanes have caused an impact to traffic, modellers can consider reducing the *Maximum Flow while Giving Way* value. The assumption should be noted in the modelling report.

3.7 Scenarios

Multiple scenarios can be set up in a LinSig file. Each scenario is a combination of different traffic flow groups and different network control plans with different signal timings. A separate LinSig model is required if a scenario consists of any lane layout changes.

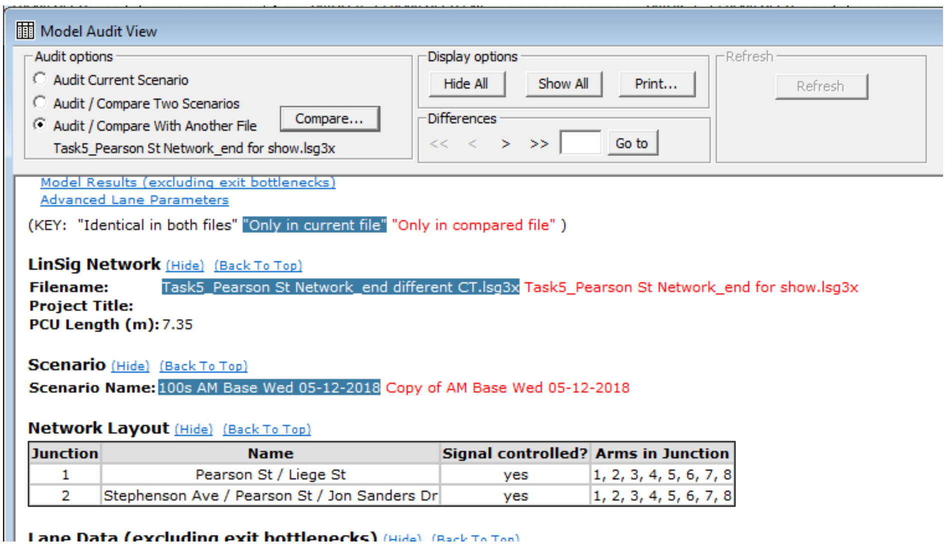
As the *Scenario* tab in the toolbar can only display the start of the scenario names, the names should be clear, with critical information placed at the start to make it easy to distinguish each scenario in the same model. For example, *AM 2020 Base*, *PM 2020 Base Optimised*, *AM 2025 Option Optimised* are acceptable.

In the *Scenarios View* window, under the *Automatically recalculate results for* drop down menus, modellers are advised to select the *Current Scenario* option, rather than the *All Scenarios* option. This is to avoid LinSig processing the results automatically every time an adjustment is made in the LinSig model as this can cause needless delays, this is particularly important when working on a large file, with multiple intersections or multiple scenarios.

3.8 Model Audit View

The *Model Audit View* window can be used for listing all model inputs and critical modelling results to ease the audit process. In addition, it can provide a comparison between scenarios or LinSig files, which is particularly useful when comparing a base model with an option model, as LinSig highlights and displays the differences between two scenarios or two LinSig files, which can save significant time when reviewing models and also reduce errors.

Figure 3-63: Model Audit View window



3.9 Base Model Calibration

Base model calibration employs verifiable observed data into a model to replicate on-street conditions. All input data used for calibration should be auditable and collected as described in Section 2.

It may be necessary to adjust some parameters based on the time period being modelled. As such, calibrated base models are likely to differ slightly between modelled periods.

3.9.1 Bonus Greens Calibration

In the *Lane Timings View* window, bonus greens can be used to replicate the traffic behaviour described below:

- **Underutilised green time (UGT)** – entered as a negative value to replicate slow movement or exit blocking during the green time (refer to Section 3.9.2).
- **UGT** – entered as a negative value for the turning traffic giving-way to pedestrians (refer to Section 3.9.3).
- **Demand dependency** – entered as negative or positive values to replicate an 'average' cycle (refer to Section 3.5.15).
- **Other** – entered as a negative value on a bus lane if the general traffic is permitted to use the bus lane and results in delaying the bus traffic (refer to Section 3.3.13).
- **Other** – entered as a negative value if the presence of the bus stop operation reduces the capacity of the general traffic lane.
- **Other** – entered for other situations, for example as a positive value if traffic is constantly observed to cross the stop line during the non-green time.

Justifications should be made in the modelling report if bonus green times (whether positive or negative) are added to the LinSig models.

3.9.2 Exit Blocking and Underutilised Green Time

Underutilised green time (UGT) in LinSig modelling refers to when there is a green signal on the street and there is still traffic demand but the traffic is not able to travel at the saturation flow rate. In this context, UGT does not refer to when there is a green signal on the street but there is no traffic demand to utilise the green time.

These situations are generally the result of downstream blocking, such as traffic giving way to pedestrians at parallel or partially protected crossings. These can also occur as a result of driver behaviour, public transport operations, pedestrian movements on side streets or poor signal coordination.

LinSig has limitations when it comes to modelling the effects of downstream blocking. In a network model, even if LinSig predicts a queue at the downstream signal stop line, it would not recognise if the queue would block back onto the upstream signal stop line.

UGT can be observed and measured on-site, or estimated from video surveys in some circumstances, by timing the length of time when traffic cannot proceed on a green signal. UGT is entered as negative bonus greens on a lane-by-lane basis in *Lane Timings View*.

As changes in demand or capacity may result in an increase or decrease in UGT, care should be taken to not replicate the impact of UGT in project cases or future case models. If UGT in future cases is to be reduced or increased, the justification for this should be provided in the modelling report.

3.9.3 Traffic Giving Way to Pedestrians

With the exception of the exclusive pedestrian phase and full red arrow-protected crossings, each pedestrian protection crossing type can potentially increase delays to turning traffic at the start of green as there is a requirement for vehicles to give-way to pedestrians still on the crossing. This is further delay to the turning traffic, in addition to the pedestrian protection time discussed in Section 3.5.3.3.

For base models, it is important that the additional delay per cycle at the start of green is observed for turning traffic, particularly for areas with high pedestrian activities. This additional average delay should then be added as negative bonus greens in the *Lane Timings View* window for the lanes delayed for each scenario. Site observations should also identify any non-blocking storage in front of the stop line, this should also be included in base models.

In the example shown in Figure 3-64, pedestrian link P4 already has five seconds parallel protection from lane 2/1 and lane 2/2 based on the signal set up (refer to Section 3.5.3.3 for modelling pedestrian protection). If the site observations indicate that for this scenario, the left-turning traffic on lane 2/1 is delayed by a further three seconds (the total delay is eight seconds) as the traffic gives-way to the pedestrians who are still crossing, a negative bonus green of three seconds should be entered in the *Lane Timings View* window to replicate the additional delay, as shown in Figure 3-65.

Figure 3-64: Pedestrian example

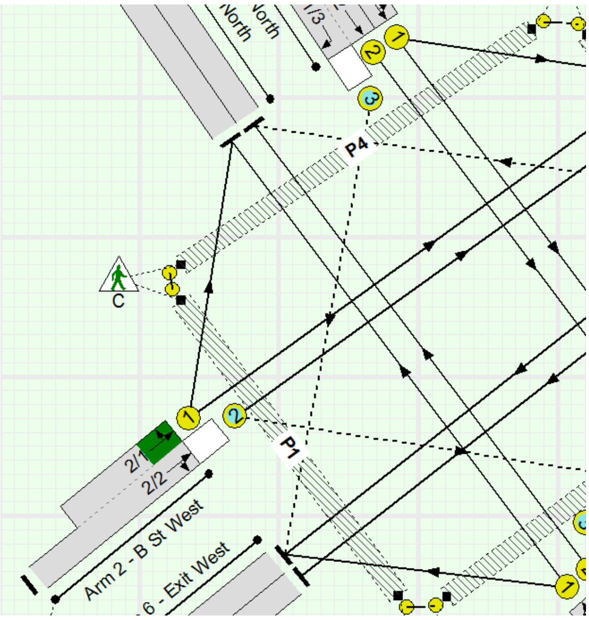
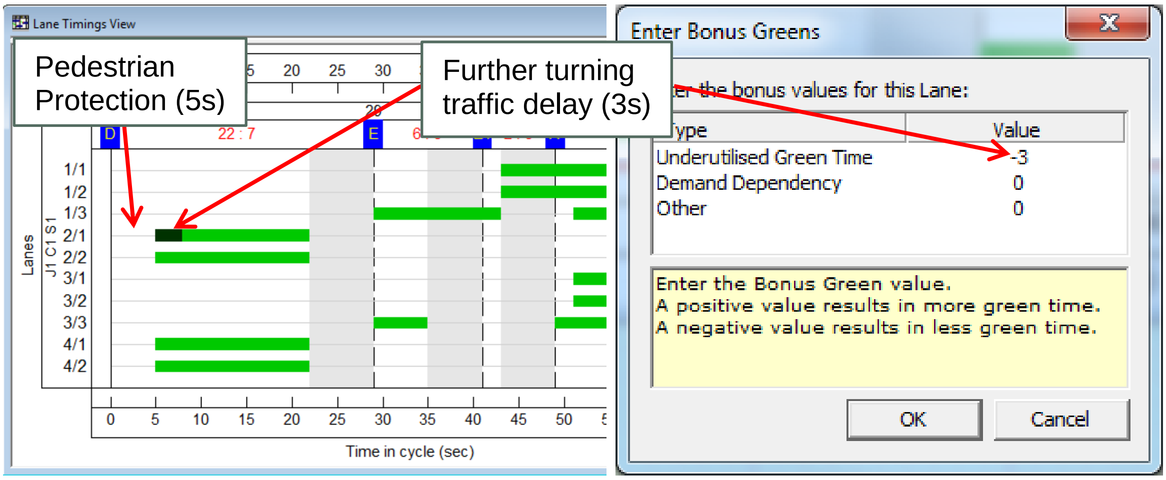


Figure 3-65: Lane Timings View window (left) and Enter Bonus Greens window (right) example



For option models, some assumptions may need to be made based on the number of expected pedestrian movements and assumed delay in order to estimate any potential turning traffic delay.

3.9.4 Queue De-sliver

Sliver queues occur when LinSig predicts a high queue length but a low number of vehicles in that queue. These occur when the arrival rate of traffic exceeds the maximum discharge rate of a lane. Common causes of this include:

- two lane connectors are attached to a single lane
- merges downstream of intersections, and
- lower saturation flow at the downstream section.

Modellers should examine queue graphs in the first instant to determine the potential cause of the sliver queues. Occasionally the sliver queues may be reflective to the actual on-site conditions.

Where two closely-spaced stop lines exist and the downstream one has a lower saturation flow, sliver queues will often form. In practice, the closeness of the stop lines would mean that the upstream saturation flow would be limited to a similar value to the downstream saturation flow. In this case it is often preferable to eliminate the sliver queue by reducing the upstream saturation flow to a similar value to the downstream value. Modellers may do this intuitively, rather than using the de-sliver parameter.

If sliver queues still occur, a de-sliver threshold can be applied in the *Advanced* tab of the lane setting. To identify the number of vehicles in a queue of excessive length that would represent a sliver queue, a lower value should be investigated first and then gradually increased up to one PCU; the value should not be greater than one PCU. This method should not be used as a means of calibrating / validating queue lengths.

3.10 Base Model Validation

Validating the LinSig base model ensures that the models developed accurately reflect the performance of the network or intersection being modelled. Validated models can then form the basis of any future models and should provide a reliable measure of future performance following upgrades or changes to the network/intersection.

Validation requirements should be agreed with Main Roads prior to undertaking any data collection or modelling. The validation comparisons should include:

- degree of saturation, and
- queue length at the start of green period.

3.10.1 Degree of Saturation

Degree of saturation (DoS) is a LinSig output that represents the ratio of flow to capacity. As it is recognised as the most reliable indication of model validity, it is the primary validation method.

For a base model, if the traffic data is collected using stop line turning counts and the signal timings are extracted from the SCATS system, the DoS should not exceed 100 per cent.

In addition, modellers should review the magnitude of the modelled DoS is reflective to on-site conditions.

Main Roads may request on-site recording the DoS at critical intersections to be compared with the modelled DoS results for validation purposes.

3.10.2 Queue Lengths

Queue lengths should be used for validation. The modeller should ensure that the queue at the start of the green period on each lane is captured, rather than recording the maximum back of the queue.

Multiple queue cycles should be recorded from site visits or videos, spread over each peak period, to form an average queue representation of the traffic conditions evident over each peak period. As a minimum, the queue of each lane on the critical approaches should be recorded on-site and compared to the LinSig outputs.

The average site queue at the end of the red period / the start of the green period should be compared to the *Back of Uniform Queue at End of Red* output in the *Network Results* window. The values should be similar with the same magnitude between the site measured queue and the LinSig output queues.

In addition, modellers should review if the modelled queues can fit into the physical operating space, particularly at the internal links of interchanges and closely spaced intersections.

3.11 Model Outputs

Modellers are required to report model assessment results to Main Roads for review when the base model is validated and again when proposed option models are completed. This section outlines model outputs when undertaking scheme assessments in LinSig.

Modellers should refer to the *Traffic Modelling Instruction Forms* (or model scoping documents) and *Traffic Signal Approval Policy* for the model assessment and outputs requirements for each project.

3.11.1 Error Messages

If the model contains error messages, notifications are shown on the error bar at the bottom of the LinSig window. Typical error messages include:

- **Critical error messages (shown in red)** – should be resolved before the model is submitted, as LinSig is not able to calculate outputs when there are critical errors.
- **Warning messages (shown in yellow)** – should be investigated and resolved, as while LinSig can generate outputs, the results may not be accurate due to incorrect inputs. In some situations, some warning messages may be acceptable due to certain modelling assumptions, these should be justified in the modelling report.

  The warning message 'Desired Flows do not match the Actual Route Flows' cannot be accepted and should be addressed prior submission.
- **Information messages (shown in green)** – should be investigated and resolved, where possible.

In the *Error View* window, while it is possible to 'hide' warning and information messages this function should not be used. It is better to show the error messages for transparency, as some of the messages may be acceptable due to modelling assumptions. If this has been applied the modeller should provide the justification in the comment section.

3.11.2 Degree of Saturation

Degree of saturation (DoS) is defined as the ratio of demand flow to the maximum flow which can be passed through the intersection from a particular lane. It is used as the primary performance indicator for determining the suitability of proposals for Main Roads projects. Refer to Section 3.10.1 for DoS validation in a base model.

For scheme assessments, the highest DoS results of each arm should be reported for the study intersections. Modellers should ensure the DoS results satisfy the performance requirements set out in Main Roads' *Traffic Signal Approval Policy* or in the modelling scope.

3.11.2.1 Practical Reserve Capacity

Practical Reserve Capacity (PRC) is the amount by which traffic at an intersection can increase before any link becomes a practical operating level of 90%. It is calculated based on the highest degree of saturation in the intersection using the following formulae:

PRC = $\frac{90\% - \text{Highest DoS}}{\text{Highest DoS}}$ (if highest DoS <90%)

PRC = $\frac{90\% - \text{Highest DoS}}{90\%}$ (if highest DoS ≥90%)

For example, if the highest DoS in the network is 80.0%, the PRC is 12.5%.

PRC is a function of cycle time and therefore the cycle time should be referenced.

The PRC result displayed in the network results is calculated based on the highest DoS of the whole network. This value is used when LinSig undertakes signal optimisation for PRC, refer to sections 3.5.12 and 3.5.13 on signal optimisation for further information.

3.11.3 Mean Maximum Queue

Modellers should review the Mean Maximum Queue (MMQ) outputs from LinSig and consider if the modelled queues are realistic and whether it can fit into the physical operating space. If the modelled MMQ exceeds the physical lane length, LinSig highlights the MMQ value in red.

For *Traffic Signal Approval*, the highest MMQ output of each intersection is usually required. The results should be converted to meters assuming 1 PCU = 7.35 m.

Depending on the scheme requirements, the highest MMQ of each lane may need to be reported for assessments.

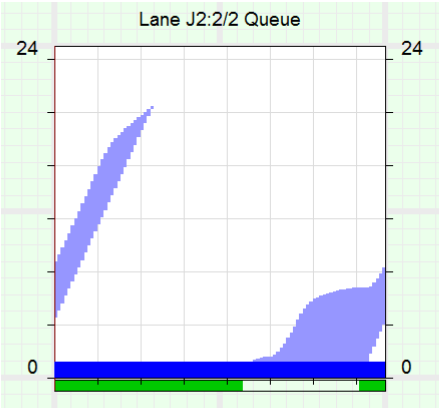
Occasionally sliver queues may appear at mid-block lanes causing unrealistic MMQ numerical outputs when the traffic should be free flowing. Queue graphs can be used to examine the formation of the queues, refer to Section 3.11.3.1.

3.11.3.1 Queue Graphs

Queue graphs can be used to examine how the queue is formed throughout the cycle, taking account of the traffic arrival and departure at each lane. The graphs are useful when examining the cause of unrealistic MMQ numerical outputs and deciding if further calibration is required.

Modellers can also add the random and oversaturated component in the queue graphs, if required, for the analysis. An example of the queue graph is shown in Figure 3-66. Refer to JCT's *LinSig 3.2 User Guide* for further information.

Figure 3-66: Queue graph



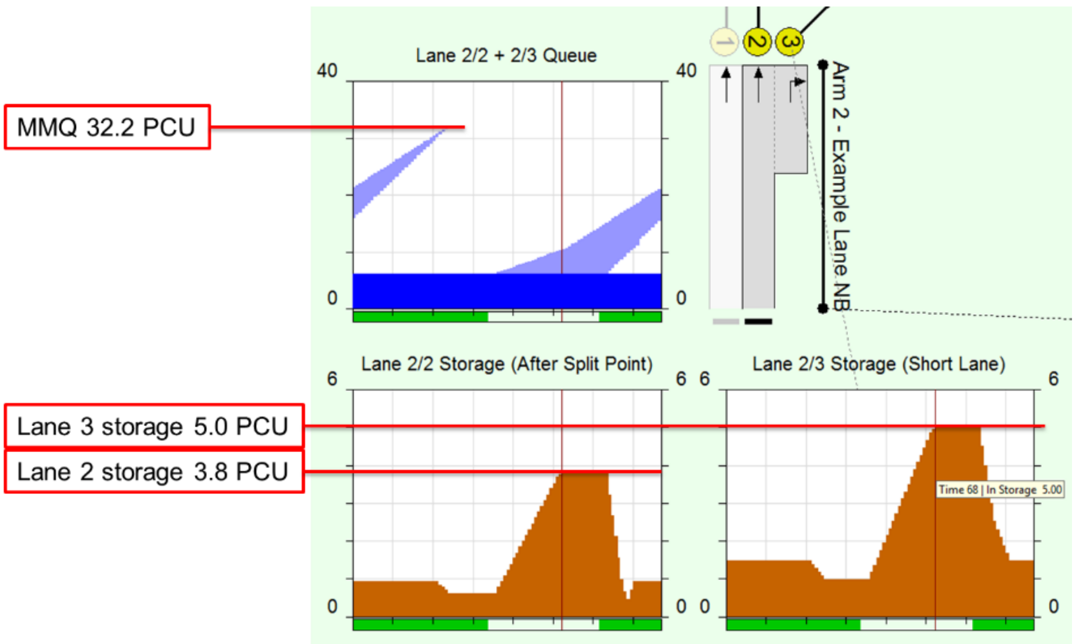
3.11.3.2 Short Lane Queues

It should be noted that the MMQ reported for a long / short lane pair is the longest extent of the queue in either of the two lanes. If a scheme requires examining the potential queue blocking between the long and short lanes, storage graphs can be used to aid the assessments.

In the example of the storage graphs shown in Figure 3-67:

- Lane 2/3 is a short lane with a physical lane length of 5 PCU.
- The storage graph (brown graph) for lane 2/3 suggests that the short lane is full at time 68 in the cycle. This is where the graph becomes flat with 5 PCU, the physical length of the short lane.
- Through traffic can no longer join the queue on the long lane 2/2 after time 68, due to the queue on the short lane. Based on the storage graph for lane 2/2, the queue is 3.8 PCU.
- LinSig reports the MMQ for the lane group rather than individual long/short lanes; in this example the MMQ for the lane group 2/2+2/3 is 32.2 PCU, as shown in the queue graph (blue graph).

Figure 3-67: Example storage graph



3.11.4 Delay and Level of Service

Level of Service (LoS) is the secondary performance indicator for determining suitability of proposals. LoS is determined based on the average delay per PCU.

For scheme assessments, modellers should ensure the average delay and the LoS results satisfy the performance requirements set out in *Traffic Signal Approval Policy* or the modelling scope. LoS results are usually required for each intersection.

3.11.4.1 Average Delay per PCU

While LinSig provides the Average Delay per PCU output for each lane, scheme assessments usually required the average delay results for each intersection rather than for each lane.

3.11.4.1.1 Average Delay for each intersection

LinSig does not currently report delay per intersection as this delay is co-dependent on the interaction between the junctions, i.e. traffic starvation from one intersection to another could affect this result. Modellers need to calculate the weighted average delay based on the demand and delay of all lanes in the intersection. An example of the calculation is provided in Table 3-7.

Table 3-7: Example of Average Delay per PCU calculation for an intersection

Lane	Demand Flow (pcu)	Av. Delay Per PCU (s/pcu)	Total Delay = Demand Flow x Av Delay per PCU (s)
1/2+1/1	999	33.6	33566.4
1/3	806	41.2	33207.2
2/1	1329	45.2	60070.8
2/2	478	47.0	22466.0
3/2+3/1	495	39.8	19701.0
Total	4107		169011.4

Average delay per PCU at intersection = Total Delay at Intersection ÷ Total Demand

= 169011.4 ÷ 4107 = **41.15 seconds**

3.11.4.1.2 Average Delay for each interchange or network

If the Average Delay per PCU result is required for an interchange or for the entire network, modellers need to calculate the average delay based on each **origin-destination movement/route**.

The lane-based method in Section 3.11.4.1.1 is not suitable for interchanges or networks, because it does not consider the route platoon delay time and it also double counts the traffic demand using the internal lanes.

The traffic demand for each OD route can be obtained from *Traffic Flows View* or *Show Route List View* or *Traffic Route Flows* outputs.

The average delay for each OD route can be obtained from *Travel Time / Delay Matrices* view, *Show Route List View* or *Traffic Route Delay Times* outputs.

An example of the calculation is provided in Table 3-8.

Table 3-8: Example of Average Delay per PCU calculation for a network

Demand Flow	A	B	C	D	E	F	Total
A	0	120	19	1242	344	0	
B	215	0	1	174	26	0	
C	0	0	0	18	2	0	
D	1549	0	0	0	120	18	
E	335	0	0	306	0	2	
F	20	0	0	0	0	0	
Total							4511

Av Delay per PCU	A	B	C	D	E	F
A	0	8.9	16	36.7	25.9	0
B	42.8	0	43.3	86.2	52.2	0
C	0	0	0	27.9	9.5	0
D	23.8	0	0	0	48.9	15.6
E	65.5	0	0	21.9	0	42.5
F	13.3	0	0	0	0	0

Total Delay	A	B	C	D	E	F	Total
A	0	1068	304	45581.4	8909.6	0	
B	9202	0	43.3	14998.8	1357.2	0	
C	0	0	0	502.2	19	0	
D	36866.2	0	0	0	5868	280.8	
E	21942.5	0	0	6701.4	0	85	
F	266	0	0	0	0	0	
Total							153995

Average delay per PCU at network = Total Delay at network ÷ Total Demand

= 153995.4 ÷ 4511 = **34.14 seconds**

3.11.4.2 Level of Service

The Level of Service (LoS) displayed in the network results is based on the *Average Delay per PCU*, using the criteria as set out in Austroads[15].

3.11.4.3 Total Delay

The delay time displayed in the network results is the total delay time for all PCUs in the whole network. This value is used in LinSig when undertaking signal optimisation for delay. The unit is pcu-Hr. Refer to sections 3.5.12 and 3.5.13 on signal optimisation for further discussion.

[15] Austroads Guide to Traffic Management Part 3 Traffic Studies and Analysis (AGTM03-17) Table 6.7

3.11.4.4 Journey Time

While the journey time results between traffic zones can be extracted as one of the model outputs, Main Roads does not recommend using the journey time outputs.

Journey time is calculated by combining cruise time and delay time; as the cruise time is an input parameter entered by the modeller, rather than an output calculated by the software, the resultant journey time could have been incorrectly manipulated by entering a different cruise time value. Delay time results should be used for scheme analysis.

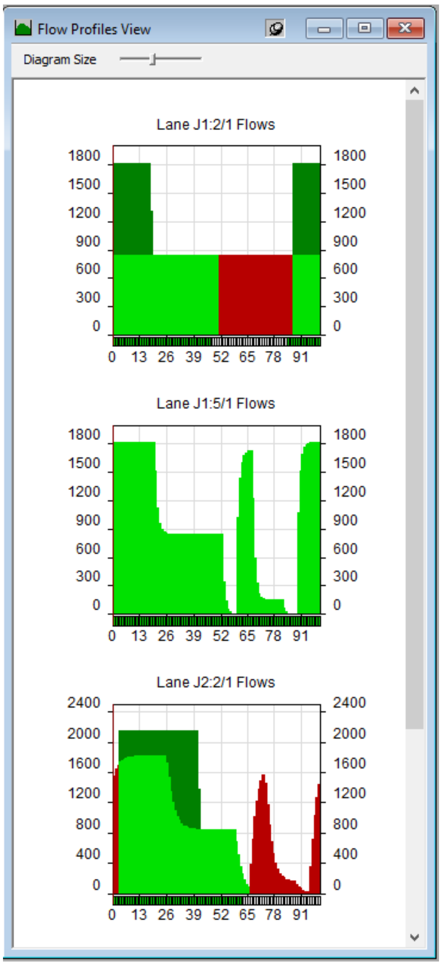
3.11.5 Pedestrian Delay

Pedestrian delay time between pedestrian zones can be obtained from *Pedestrian Route List View*. This information is useful when analysing the overall pedestrian delay time of crossing multiple pedestrian links, such as staged crossings.

3.11.6 Cyclic Flow Profile Graphs

Cyclic flow profile graphs are useful for examining the modelled traffic platoons between intersections in a network model and the arrival patterns throughout the cycle period. These can either be presented in *Network Layout View* or in *Flow Profiles View*, an example of the latter is shown in Figure 3-68. Refer to JCT's *LinSig 3.2 User Guide* for further information.

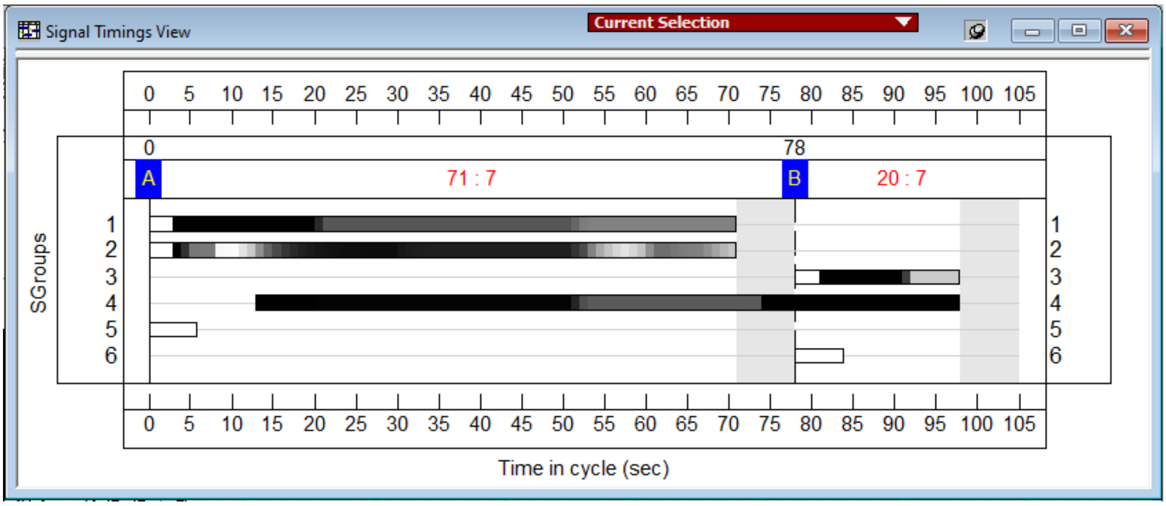
Figure 3-68: Cyclic Flow Profile graphs in Flow Profiles View



3.11.7 Outflow diagrams

The *Show Out Flow* function in *Signal Timings View* is useful to examine how well each signal group is utilised by the traffic demand as indicated by the grey scaled shadings. An example is shown in Figure 3-69. Refer to JCT's *LinSig 3.2 User Guide* for further information.

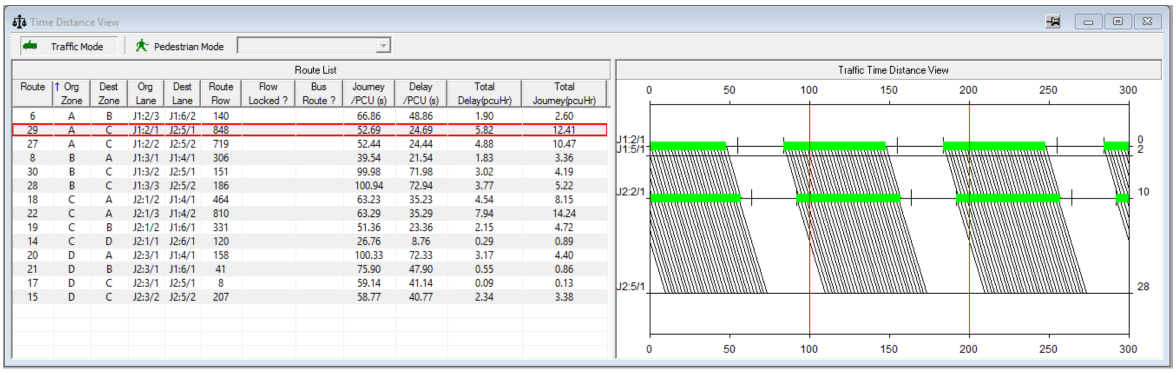
Figure 3-69: Signal Timings View with Out Flow



3.11.8 Time Distance View

Time Distance View can be used to examine the signal offsets and traffic green waves along a route. Modellers can use this view to adjust the green time and offsets manually, if required. An example of the time distance view is shown in Figure 3-70. Refer to *JCT's LinSig 3.2 User Guide* for further information.

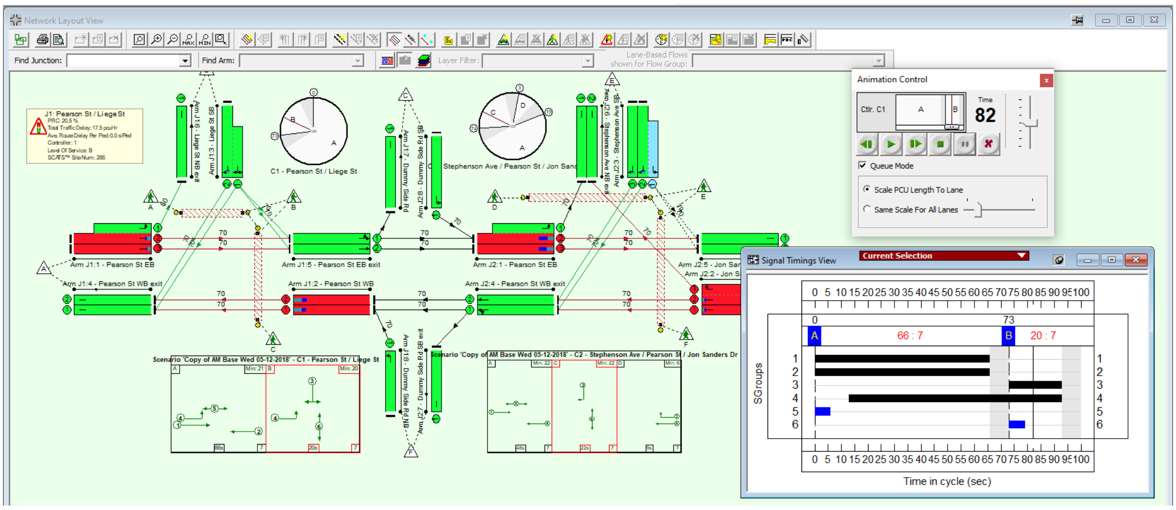
Figure 3-70: Time Distance View window



3.11.9 Animation Mode

Animation mode can be used to demonstrate the signal green and red time and coordination in a network visually in a cycle, as shown in Figure 3-71. *Queue mode* can be selected to demonstrate how the queue is built up in each cycle. Refer to *JCT's LinSig 3.2 User Guide* for further information.

Figure 3-71: Animation Mode



4 SIDRA Guidelines

4.1 Introduction

SIDRA SOLUTIONS' SIDRA INTERSECTION (SIDRA) software is used to aid the design and evaluation of individual intersections and networks. This section is designed to complement the *SIDRA Intersection 9 User Guide*. It provides detail on key parameters to be adopted when modelling intersections in Western Australia.

Modellers should refer to sections 1 and 2 for the overview of traffic modelling.

4.1.1 Appropriate Use of SIDRA

SIDRA can be used to model isolated intersections or networks where there are signalised and non-signalised (priority controlled or roundabout) intersections.

4.1.2 Software Version

This guideline is written for version 9 of SIDRA. While the *Operational Modelling Guidelines* will need to be updated for future versions of the software, the general principles outlined will continue to apply.

4.1.3 Manage Software Setup Group

In the *Manage tab*, the *standard left* option should be selected as the current setup, or a user-defined setup based on *standard left* should be used.

4.2 Site Input

This section discusses the input dialogs for Sites in SIDRA.

Key points for file setup are:

- This guide will help to clarify which values can be left as the default values and which should be modified to reflect site conditions.
- Ensure that either stop (two-way) or give-way/yield (two-way) is selected to match the sign control which is to be modelled.

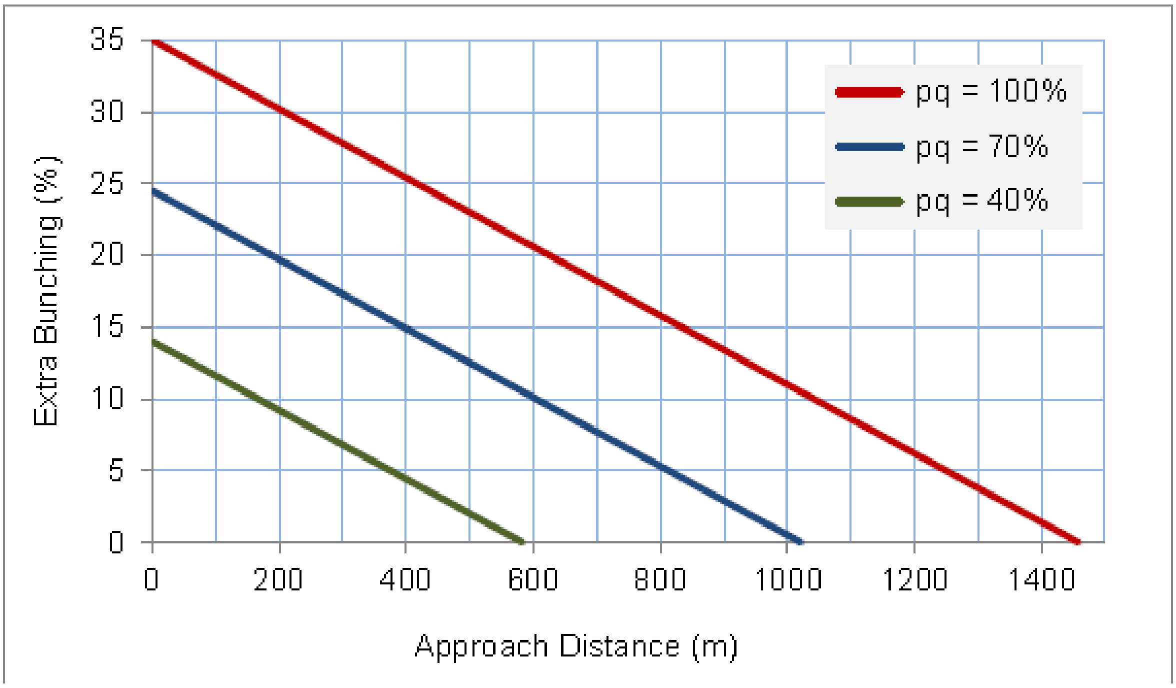
4.2.1 Intersection

When using the *Intersection* tab, the following should be noted:

- Rotate site layout to provide the north direction to the top.
- *Site Name* generally includes the intersecting road names, peak period (AM or PM) and year of modelling.
- For *Site ID*, the TCS (traffic control system) reference supplied by Main Roads should be used (if it is an existing signalised intersection).

- For internal arms within a network, *Approach Distance* should be measured from the last conflict point of all exit movements at the upstream site to the stop line of the current site. The default value of *Approach Distance* (500 meters) can be used for external arms.
- *Exit Distance* should be left as *Program* if it is the same as A*pproach Distance*.
- *Extra Bunching* allows for the effect of upstream signals on gap acceptance to be modelled and should be specified as a percentage based on *Approach Distance* and *Proportion Queued* at upstream signals (this is of most relevance to roundabouts and two-way sign-controlled intersections and opposed turns at signalised intersections). When *Extra Bunching (Site Analysis)* is set to *Program*, with site analysis, the *Extra Bunching* value will be zero. Figure 4-1 shows *Extra Bunching* value specification as function of approach distance and proportion queued. This can be used to define extra bunching value in the model. For example, Table 4-1 shows *extra bunching* values for *proportion queued* of 70%. The amount of platooning should be documented in the modelling report.

Figure 4-1: Extra bunching specification as function of approach distance and proportion queued (pq)



Source: SIDRA User Guide

Table 4-1: Extra Bunching Values for PQ=70%

Distance to upstream Signals (m)	<100	100-200	200-400	400-600	600-800	>800
Extra Bunching (%)	25	20	15	10	5	0

Source: SIDRA Intersection User Guide

- *Extra Bunching (Network Analysis)* should be *Program* for internal approaches within network, otherwise justification should be provided in the modelling report.
- *Area Type Factor* for signals allows calibration of the saturation flow. This value should be left at the default value of 1.0 if no calibration of saturation flow is required. Justification of other values other than 1.0 should be provided in the modelling report.

- For sign-controlled intersections, the type of *Approach control* should be specified here as per existing site configuration or proposed scheme.

4.2.2 Movement Definitions

The *Movement Definitions* dialog contains *Movement Classes* and *Origin-Destination (OD) Movements* tabs.

4.2.2.1 Movement Classes

The default movement classes are for light and heavy vehicles. The standard light and heavy vehicle movement classes used in SIDRA are based on seven light vehicle classifications and six heavy vehicle classifications. Refer to *SIDRA Intersection User Guide* for more information about default vehicle compositions and other parameters.

In certain situations there may be a need to consider the additional standard movement classes, which are additional to the predefined movement classes in SIDRA (Buses, Bicycles, Large Trucks and Light Rail / Trams). It is possible to define up to six further user classes using the standard base model data and then altered in *Parameter Settings* and *Vehicle Movement data* dialogs.

Main Roads recommends defining five separate movement classes for modelling heavy vehicles in SIDRA where there are significant numbers of Austroads' vehicle classes 3 to 12. The classifications are:

- rigid trucks (Austroads class 3 to 5)
- semi-trailers (Austroads class 6 to 9)
- B-doubles (Austroads class 10)
- double road trains (Austroads class 11), and
- triple road train (Austroads class 12).

The recommended *mass*, *maximum power*, *length* and *PCE* (passenger car equivalent) value for the individual movement classes are specified in Table 4-2. These should be defined in the *Model Parameters* and *Fuel & Emissions* tabs of the *Parameter Settings* dialog and *Calibration* tab in *Vehicle Movement Data* dialog, as shown in Figure 4-2.

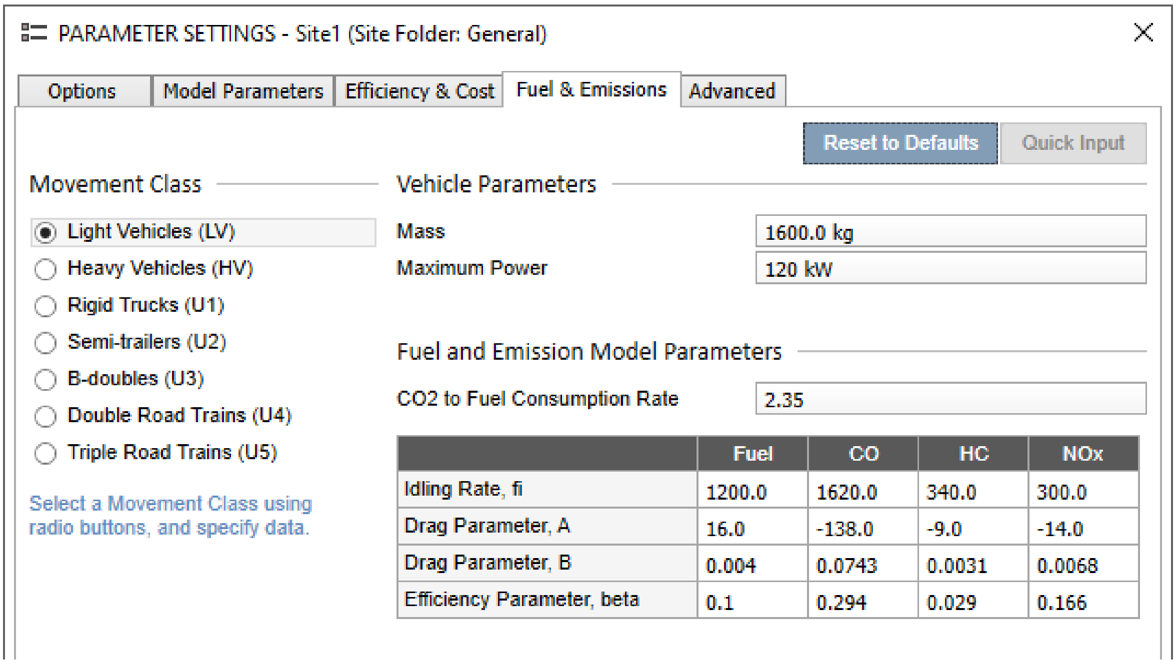
Table 4-2: Recommended Movement Classes by Main Roads

Austroads Vehicle Class	Vehicle Mass (kg)[16]	Power (kw)[16]	Length (m)[16]	PCE (pcu/veh)[17]
1	1600	120	4.85	1
2, 3, 4, and 5	35500	160	12.5	2
6, 7, 8 and 9	64000	350	20	3
10	92500	410	30	4
11	134500	522	42	4
12	200000	522	60	5

[16] Based on the larger vehicle combinations approved by Main Roads.
[17] Austroads Guide to Traffic Management Part 3: Traffic Studies and Analysis

Source: Main Roads

Figure 4-2: Fuel & Emissions tab



4.2.2.2 Origin Destination Movements

The *Origin-Destination Movements* tab allows the designation of the movements that are permitted at the intersection. Where there is a restricted movement on an approach (such as a right-turn ban), the *Movement Exists* box should be unchecked. U-turn movements that exist should be checked and assigned to appropriate lanes in the Lane Geometry dialog. U-turns before the intersection can be excluded from signal analysis.

4.2.3 Lane Geometry

This section discusses lane geometry parameters in SIDRA.

4.2.3.1 Lane Configuration

The *Lane Configuration* should be specified, with consideration given to:

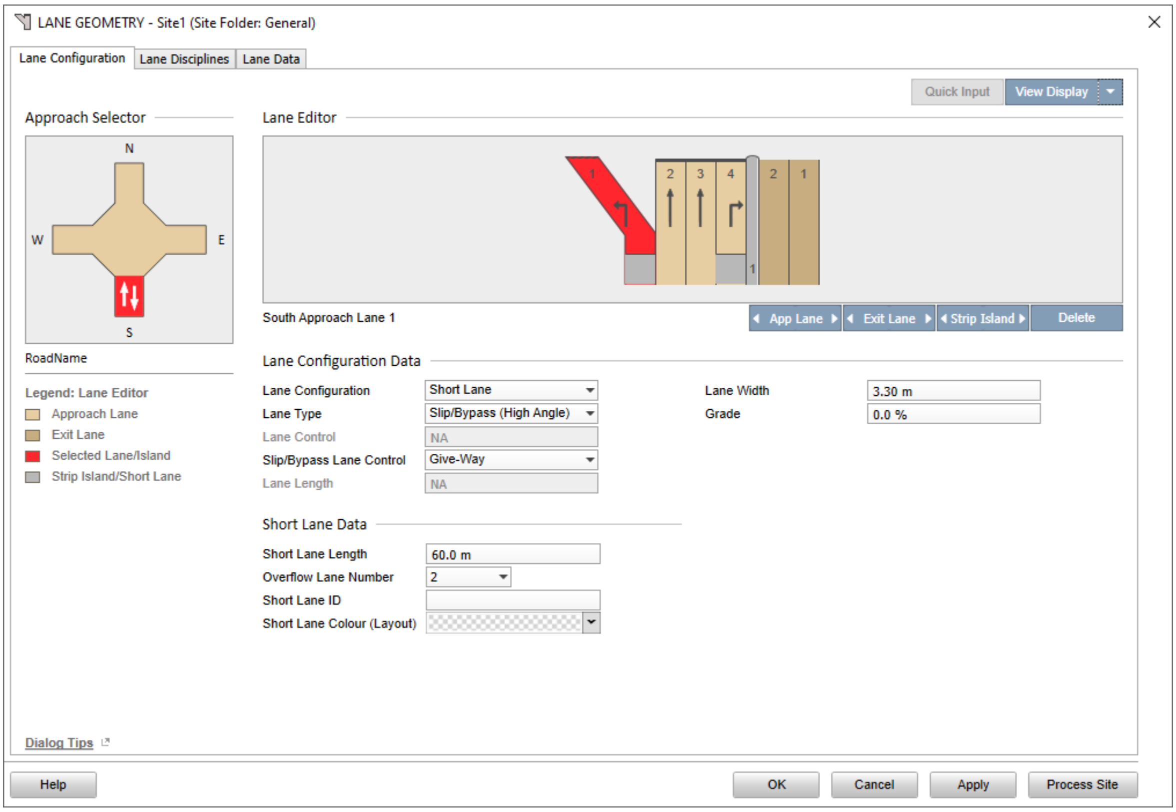
- *Lane Editor* – the number of approach and exit lanes on each approach (including medians or strip islands).
- *Lane Configuration* – the *short lane with parking* and *two-segment lane* options must be considered when appropriate, with the *two-segment lane* option typically used to model the beginning or termination of a bus lane adjacent to the intersection.
- *Lane Type* – comprising *normal* lanes and *slip/bypass* lanes, with *low angle* typically used for free-flow slip lanes that continuously adjoin an added lane on the exit approach and *high angle* typically used for left-turn give-way lanes.
- Lane Control (normal or slip/bypass) – signals, continuous, give-way / yield or stop.
- Detailed measurement of *Lane Width*, *Lane Length*, *Grade* and *Strip Island Configuration Data* including:

- For short lanes, the lane length should be taken from the stop line to where the traffic of the pocket lane would meet the main traffic lane (typically it would be where the lane width is 2.0 m at the taper section) and in the situations where vehicles can fit into the queue past the marked end of the lane, the extra storage area should be considered.
- For approach short lanes, the lane in which the queue overflow will spill into should be specified (*Overflow Lane Number*).
- For exit short lanes, the lane to which the short lane flow moves should be specified (*Merge Lane Number*). Merge type should be also specified in *Lane Data* tab (Refer to Section 4.2.3.3).
- For two-segment lanes, ensure that the *Segment Length* and *Overflow Lane Number* of both segments are specified.
- The gradient should be included unless the intersection is noticeably flat (zero for level road).
- The gradient should be in the direction of travel (positive values for uphill grade and negative values for downhill grade).

- *Lane ID* can provide a two-letter reference inserted onto the particular lane where required to highlight lane function or use (such as for bus lanes or transit lanes).
- *Lane Colour* can be used to highlight lanes which are restricted to certain vehicles (bus lanes or cycle lanes), or can be used to highlight another issue.
- For left-in / left-out movements, strip islands should be connected to the relevant approach.

The *Lane Configuration* tab is shown in Figure 4-3.

Figure 4-3: Lane configuration tab

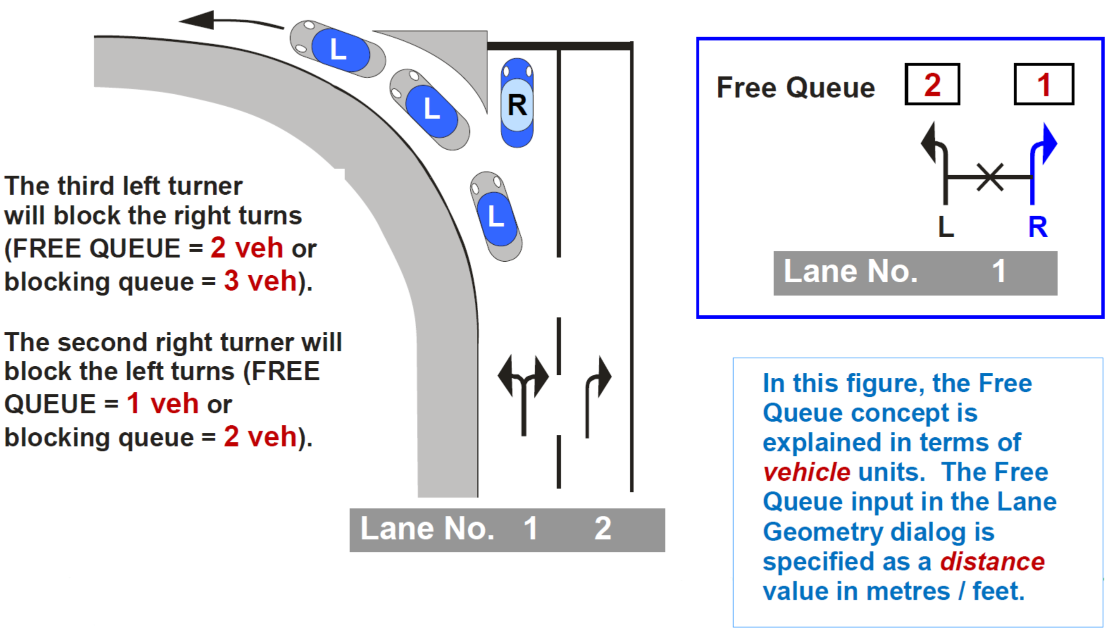


4.2.3.2 Lane Disciplines

Lane Discipline should be specified, with consideration given to:

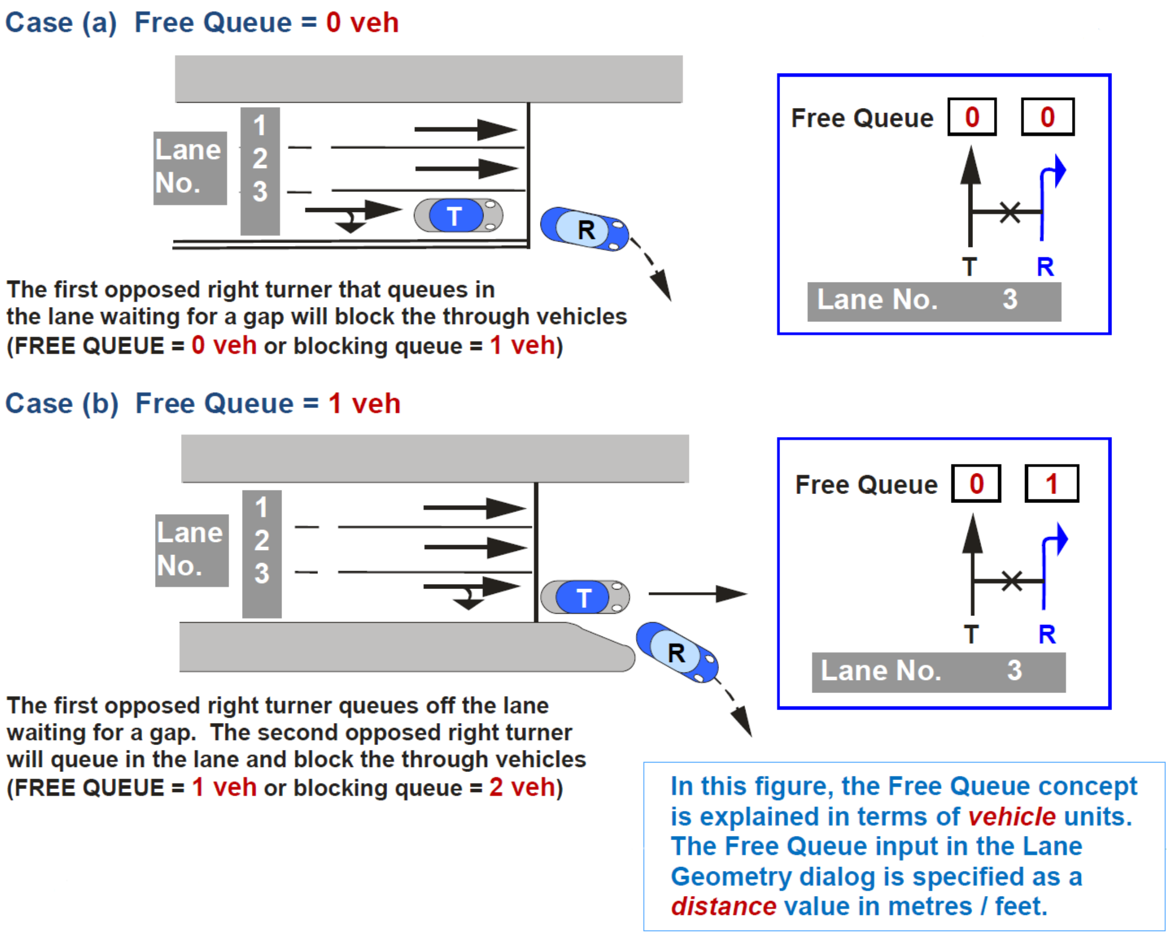
- By default, all movement classes are allowed on each approach lane / movement. Should certain movements or lanes be restricted to specific vehicle classes, the appropriate box is to be unchecked. For two-segment lanes, ensure that the correct lane disciplines are specified for both the downstream and upstream segments.
- *Free Queue Distance* can be used for shared lanes in signalised at-grade intersections and single-point interchanges. It defines the length that the vehicles performing a movement can queue away from the lane without blocking other movements sharing that lane. It is specified as a distance value in metres. Figure 4-4 illustrates the use of the *Free Queue Distance* parameter for a shared slip lane, while Figure 4-5 illustrates the use of the parameter for opposing turns in a shared lane.

Figure 4-4: Free Queue parameters for a shared slip lane



Source: SIDRA User Guide

Figure 4-5: Free Queue parameters for opposed right-turn and through traffic in a shared lane



Source: SIDRA User Guide

4.2.3.3 Lane Data

Lane Data should be specified, with consideration given to:

- *Basic Saturation Flow* (starting value for saturation flow estimation) should be calibrated based on the measured saturation flow (refer to Section 4.4.1.1). Details of saturation flow measurement are provided in Appendix B.

Measured saturation flows should not be used in place of *Basic Saturation Flow*. However, if this is required, the *Apply Saturation Flow Estimation* checkbox should be deselected and justifications should be provided in the modelling report.

  - Higher or lower values of saturation could be defined in situations where traffic conditions are poorer or better than average, using on-site observations and with adequate justification provided in the modelling report.

- *Lane Utilisation Ratio* is used to determine the reduced flow rate of an underutilised lane relative to the critical lane of the approach, using a specified percentage value (range one to 100 per cent).

  - If the Lane Utilisation Ratio is set to the default *Program* option, a lane utilisation ratio of 100 per cent (that is, full lane utilisation) is applied, subject to various cases of program-determined lane underutilisation.

   - A user-defined input for the *Lane Utilisation Ratio* can only be provided as part of the model calibration process, subject to appropriate intersection data being collected, observed or provided, with adequate justification provided in the modelling report.

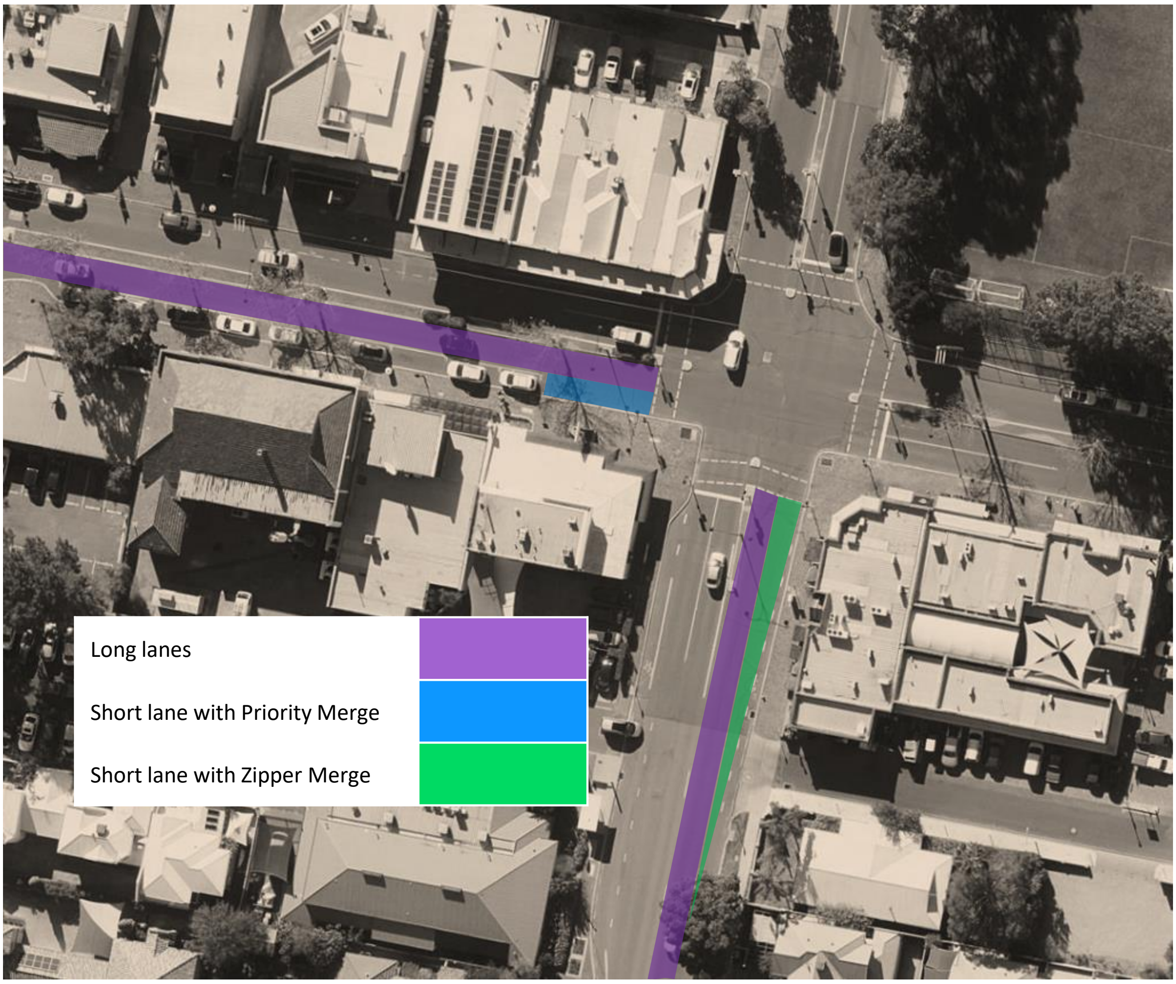
- *Short Lane Capacity (Calibration Options)* should be set to the default *Program* option otherwise, justifications should be provided in the modelling report.
- *Saturation Speed* is set to the *Program* option by default or set to *input* to use an observed value from a car crossing the stop line after accelerating from a queued position at the signals, where its position was about the sixth car, or further back, in the queue (Refer to the *SIDRA Intersection User Guide*).
- *Capacity Adjustment* is a general parameter which can be used to specify capacity gain / loss with respect to the value calculated by the program. It is not recommended to use this parameter in lieu of saturation flow adjustment as it is best if the network model determines capacity adjustment due to lane blockage (*Lane Blockage Factor* values can be specified to override program-determined values).
- To include exit merge delay in the analysis, *Apply Merge Analysis* should be checked for downstream short lane. Merge type should be selected based on site lane configurations and driving behaviours.
- If default *Critical Gap* and *Follow-up Headway* parameters for priority merge and zipper merge shown in Table 4-3 are modified, justifications should be provided in the modelling report. Figure 4-6 shows examples of merge types at a signalised intersection.

Table 4-3: Gap Acceptance and Follow-up headway for Merging

Parameter	Priority Merge	Zipper Merge
Critical Gap	3.0 sec	2.5 sec
Follow-up Headway	2.0 sec	2.0 sec

Source: SIDRA User Guide

Figure 4-6: Merge Type Examples



- If the *Minimum Departure (vehicles per minute)* value for Merge Analysis needs to be increased, justifications should be provided.
- *Buses Stopping* allows specification of the number of buses per hour that stop within approximately 80 metres upstream or downstream of a signalised intersection and have an impact on the saturation flow (default setting being zero buses).
- *Parking Manoeuvres* allows specification of the number of parking manoeuvres per hour which occur within approximately 80 metres upstream or downstream of a signalised intersection and have an impact on the saturation flow (default setting being zero parking manoeuvres).
- Data on *Buses Stopping* and *Parking Manoeuvres* should be collected and included in the model where this data is expected to have a significant impact on the performance of the intersection. A summary of the collected data should be included in the modelling report.

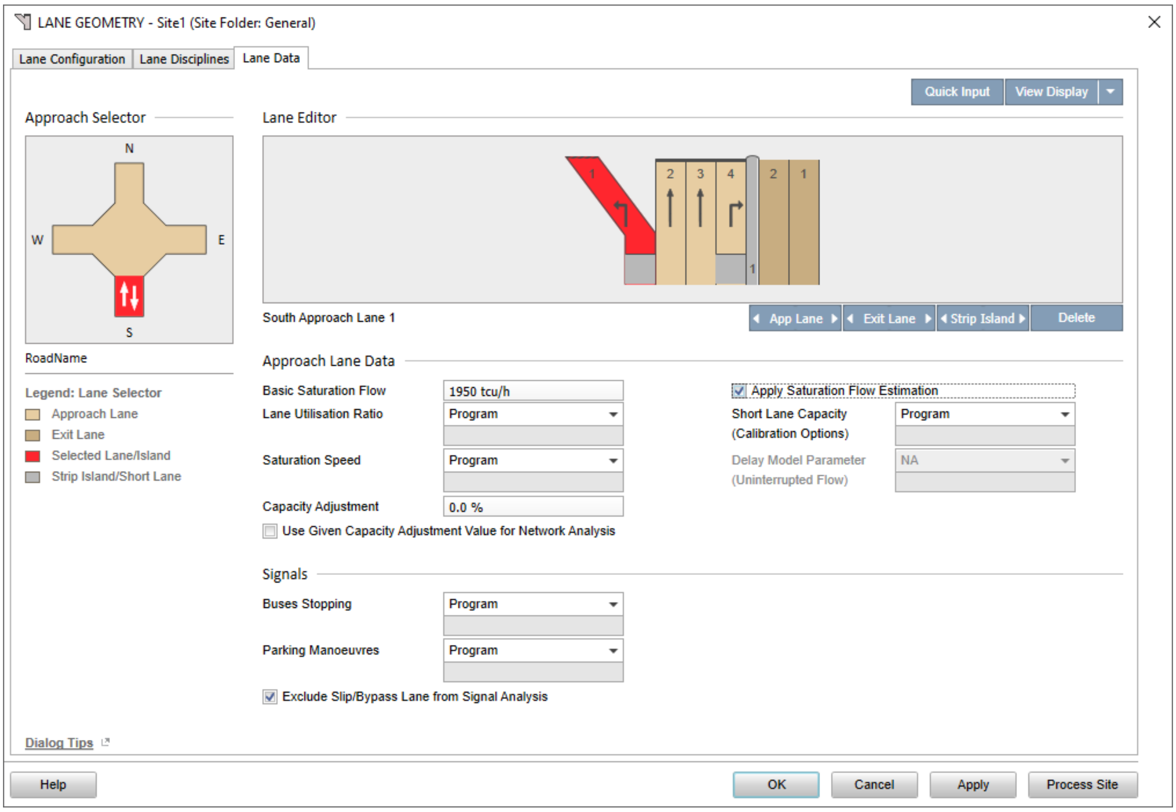
The standard SIDRA values for saturation flows are based on research by Andrew Cuddon (1994) and are shown in Table 4-4. More recent research (Akçelik, Besley and Roper 1999 and Akçelik and Besley 2002) has identified that values of 2100 and 1900 tcu/h may be appropriate for environmental classes 1 and 2 respectively.

Table 4-4: Basic Saturation Flows in through car units per hour

Environment class (area type)	Definition	Basic saturation flow, S_0 (tcu/h)	
		Standard left, standard right, New Zealand, New South Wales software setups	US HCM (customary and metric) software setups
1 (ideal)	Near ideal conditions for free movement of vehicles on both approach and exit sides indicated by good intersection geometry, long distances to upstream and downstream intersections, good visibility, small numbers of pedestrians, and little interference due to loading and unloading of goods vehicles, buses or parking turnover.	1950	1900
2 (average to poor)	Average to poor conditions indicated by adequate to poor intersection geometry, usually closely-spaced intersection environment, possibly poor visibility, moderate-to-large numbers of pedestrians, and interference from standing vehicles, loading and unloading of goods vehicles, buses, parking turnover, and vehicles entering and leaving premises.	1800	1750

The *Lane Data* tab is shown in Figure 4-7.

Figure 4-7: Lane Data tab



4.2.4 Lane Movements

The *Lane Movements* dialog allows the nature of vehicle movements on the departure side of a modelled intersection to be specified in terms of flow proportions and blockage calibration.

In the *Flow Proportions* tab, the percentage split of each approach lane's flow on the corresponding exit can be specified. By default, a 100 per cent value is applied to the closest and the most direct exit lane and whether these values need to be amended depends on the operation of the network. An example of a flow proportion adjustment is provided in Section 4.5.2.1

Blockage Calibration applies to the probability of blockage by exit queues and this value would generally be set to the default value of 1.0.

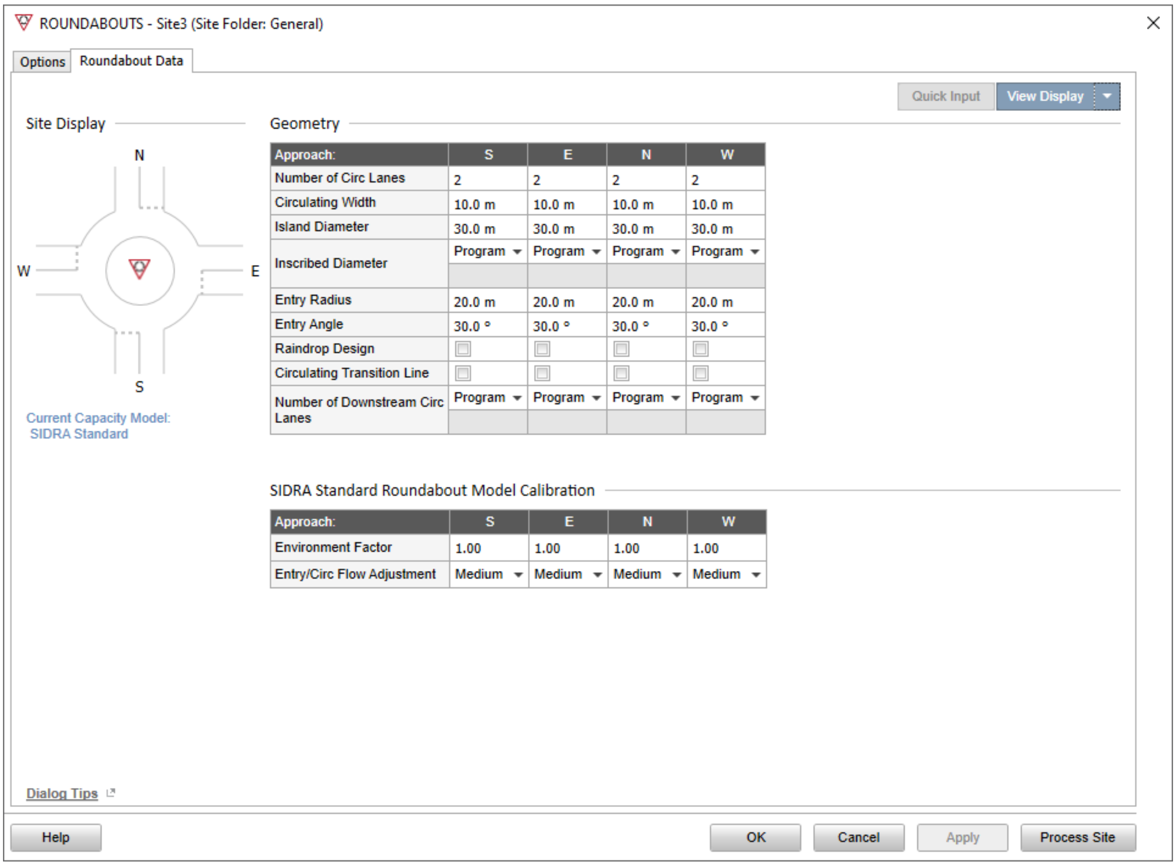
Any adjustment of *Lane Movement Flow Proportions* and *Lane Blockage Calibration Factor* should be justified in the modelling report.

4.2.5 Roundabouts

In the *Options* tab, the default settings (the *SIDRA standard* capacity model and *SIDRA roundabout level of service* method options selected and no other box checked) should be used in most cases. Main Roads will advise if any other *roundabout model options* need to be considered.

For the *Roundabout Data* tab (Figure 4-8), the various parameters of the roundabout's geometry should be carefully specified, including *Number of Circulating Lanes*, *Circulating Width*, *Island Diameter*, *Inscribed Diameter*, *Entry Radius* and *Entry Angle* for each arm. This data is critical to the calculation of approach capacity.

Figure 4-8: Lane Data tab



More details of roundabout model calibration are provided in Section 4.4.1.2.

4.2.5.1 Metered Roundabouts

Signal settings for signalised roundabouts should be defined in the *Roundabout Metering* tab.

For a metered approach:

- The *Stop Line Setback Distance* should be defined based on the existing or proposed layout.
- *Start Loss* should be three seconds.
- *End Gain* should be three seconds.

For controlling approach, *Queue Detector Setback Distance* should be defined based on the existing or proposed layout.

Roundabout metering signals are based on a simple two-phase system (Blank Phase and Red Phase). The Cycle Time Option for an existing site can be set to User-Given Cycle Time, which should be set to sum of average length of Blank Time (or Red Time), Yellow Time and All-Red Time for the subject phase. Yellow time is a nominal setting for the red phase as it will be displayed as a red interval.

For proposed modifications or new intersections, Yellow Time, All-Red Time and should be specified in accordance with Main Roads' standards (Refer to Appendix A). Minimum Phase Time for Blank Phase / Red Phase should be greater than sum of Yellow Time and All-Red Time. User-Given Cycle Time should not be less than sum of Minimum Blank Phase Time and Red Phase Time.

Where there is a need to identify the cycle time, Practical Cycle Time should be used, with the Maximum Cycle Time and Cycle Rounding set to meet Main Roads' requirements.

4.2.6 Pedestrians

The key information to specify in the *Pedestrian Movements* tab is the pedestrian crossing type (*none*, *full crossing* or *staged crossing*, *signalised slip / bypass lane crossing, unsignalised (zebra) slip/bypass lane crossing* or *diagonal crossing*) and the pedestrian volumes. For the other parameters, where default settings need to be adjusted, supporting information should be provided in the modelling report.

In the *Pedestrian Movement Data* tab, if the *Program* value is selected for the *Crossing Distance* shown in Figure 4-9, SIDRA calculates this based on the lane geometry coded in the *Lane Configuration* tab. Where the *Crossing Distance* is known to be wider (such as with the presence of kerb alignment or cycle lanes or parking lanes that are not included in the model), a user input value can be specified. The *Crossing Distance* and *Walking Speed* are used to calculate Pedestrian *Minimum Green* time for pedestrians crossing which can significantly influence the calculated phase times depending on the cycle time option selected. Therefore, *Walking Speed* of 1.2m/s value should be applied here in accordance with Main Roads' standards for pedestrian timing calculation (Refer to Appendix A). *Conflict Zone Length* for zebra crossing should be set as *Program.* Otherwise, justification should be provided in the modelling report.

For signalised intersections, *Pedestrian Timing Data* must also be adjusted based on Main Roads' requirements, refer to Appendix A:

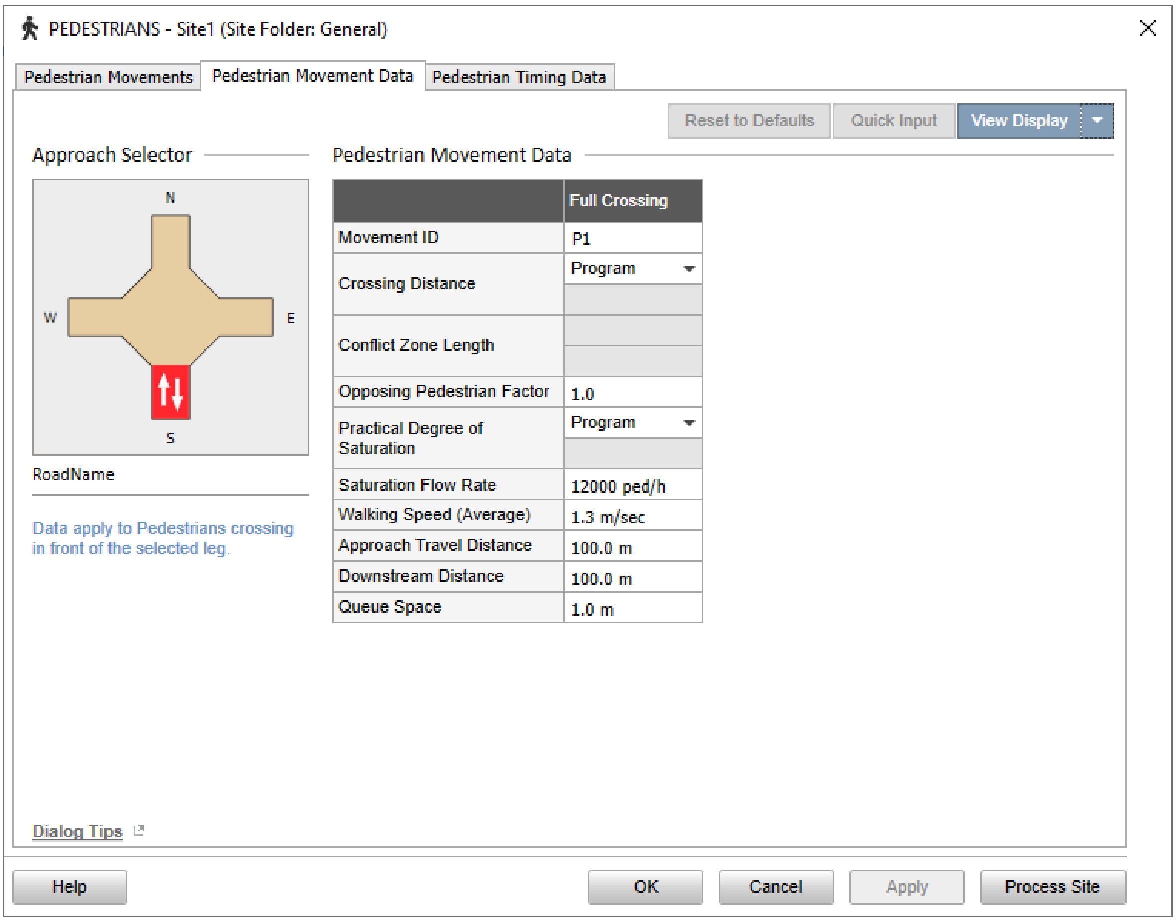
- *Walk Time Extension* should only be ticked if the pedestrian green figure is expected to run for the entire duration of the phase, and not just the minimum green time at the start of the phase (refer to Walk for Green in Appendix A).
- *Crossing Speed* should be keep as the default value of 1.2m/s.
- *Minimum Walk Time* should be set equal to the sum of SCATS walk time and delay. Pedestrian *Start Loss* should be increased for the pedestrian delay calculation.
- *Minimum Clearance Time* should be equal to total clearance time (sum of SCATS clearance time 1 and clearance time 2) for the pedestrian crossing.
- *Clearance 1 Time* should be set equal to SCATS clearance 1 (*Input*).
- *Clearance 2 Time* should be set equal to SCATS clearance 2 (*Input*).
- SCATS pedestrian delay should be added to Start Loss for the pedestrian delay calculation.

- Other parameters should be left as default.

Pedestrian Analysis output report provides details of pedestrian timing calculations.

For a new signalised intersection or an existing intersection with geometry modifications, the clearance timing calculations should be provided in the modelling report.

Figure 4-9: Pedestrian Movement Data tab



4.2.7 Volumes

The default volume data settings are:

- Unit Time for Volumes (in the Vehicle Volumes tab) – 60 minutes
- Peak Flow Period (in the Vehicle Volumes tab) – 30 minutes, and
- Peak Flow Factor (in the Volume Factors tab) – 95%.

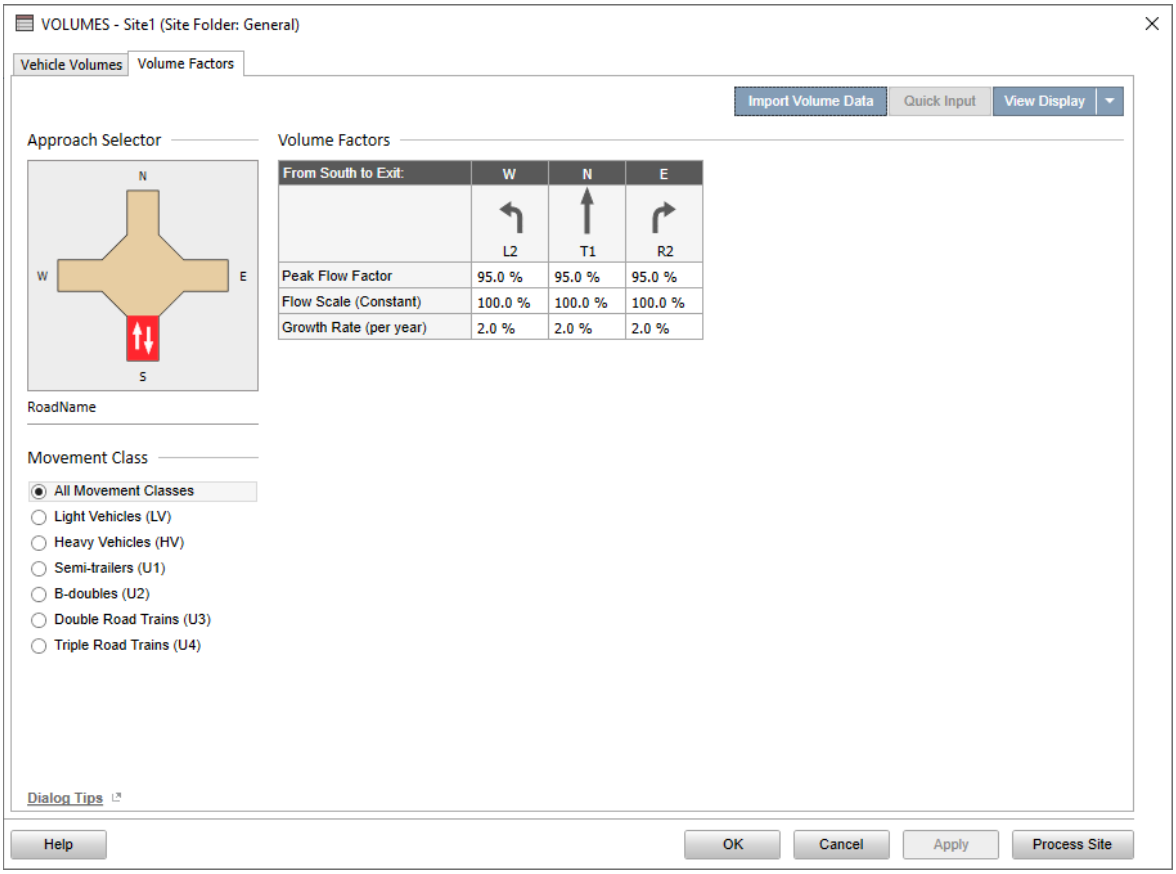
When the site is located close to area with specific land use such as schools, peak flow period / factor can be changed to better represent the peak profile. If changes to these parameters are required, supporting traffic data should be provided in the modelling report.

The *Volume Data Method* provides three different methods for specifying the volume data, with a specific method chosen depending on the format of the volume data source.

The use of the *separate* or *Total & Veh* volume data options are recommended when movement classes such as buses and bicycles need to be modelled.

In the *Volume Factors* tab, shown in Figure 4-10, the *Flow Scale* and *Growth Rate* inputs should be used for assessing variances in traffic volume. If the *Flow Scale* parameter is used for calibration purposes, justification should be provided in the modelling report (refer to Section 4.4.1.3). The *Growth Rate* parameter should be used in conjunction with the *Demand & Sensitivity* dialog. Refer to *SIDRA Intersection User Guide* for more information.

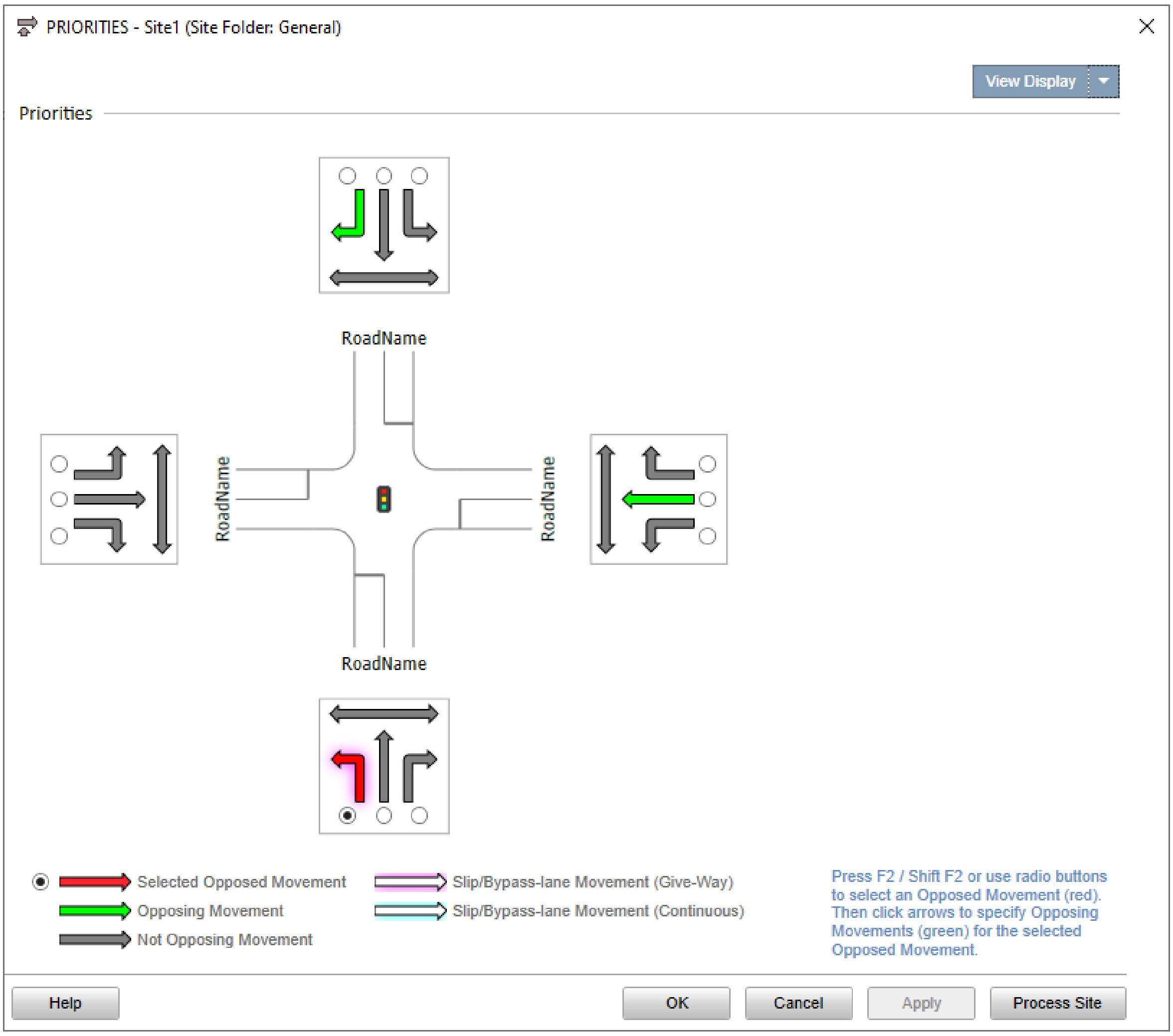
Figure 4-10: Volume Factors tab



4.2.8 Priorities

The *Priorities* dialog is only used for signal and two-way sign control (TWSC) intersections and allows the specification of which movements are opposing and not opposing a movement of interest. While specification of the opposing movements is set automatically based on the intersection geometry and control conditions specified, it is recommended that these are carefully checked and modified (where required) to reflect actual site conditions. An example of the *Priorities* dialog is shown in Figure 4-11, where the opposed left-turn movement using a sign-controlled slip / bypass lane on the southern approach gives-way to the through movement from the east and the right-turn movement from the north.

Figure 4-11: Priorities dialog



If pedestrian protection time is to be modelled, the pedestrian movement should be specified as an opposing movement for the opposed left turn. This is not defined by default in SIDRA and it enables the Opposing Ped (Signals) box in the Gap Acceptance dialog, Gap Acceptance Data tab (refer to Section 4.2.9).

A staged crossing at a TWSC intersection (modelled as a two-site network) is detailed in Section 4.3.

4.2.9 Gap Acceptance

The *Gap Acceptance* dialog is used for specifying gap acceptance data relevant to opposed movements at signals and, in particular, TWSC intersections and roundabouts. Default values provided by SIDRA are based on the coded geometry and movements, and may be adjusted based on site observations; however, it is not recommended to adjust *Critical Gap* and *Follow-up Headway* for roundabouts. Refer to *SIDRA Intersection User Guide* for more information. Follow-up headway is generally 60 per cent of the critical gap. As sign-controlled intersections are particularly sensitive to gap acceptance parameters, caution should be used when modifying these parameters.

Table 4-5 provided by *SIDRA Intersection User Guide* can be used as a guideline for critical gap acceptance and follow-up headway parameter values adjustment.

Table 4-5: Austroads and SIDRA Standard Model Gap Acceptance Parameters

Type of movement	Austroads Road Design Guide Part 4A (AGRD04A-10)		SIDRA Standard Model Defaults and reasonable range for user specification	
	Critical Gap (Sec)	Follow-up Headway (sec)	Critical Gap (Sec)	Follow-up Headway (sec)
Left Turn [18]	5	2 - 3	(3 – 6)	(2.0 – 3.5)
1-lane opposing			4.5	2.5
2-lane (or more) opposing			5.0	3.0
Through movement crossing one-way road				
2-lane one-way	4	2	4.5 (4 – 5)	2.5 (2 – 3)
3-lane one-way	6	3	5.5 (5 – 6)	3.0 (2.5 – 3.5)
4-lane one-way	8	4	6.0 (5 – 8)	3.5 (3 – 4)
Through movement crossing two-way road				
2-lane two-way	5	3	5.0 (4.5 – 5.5)	3.0 (2.5 – 3.5)
4-lane two-way	8	5	6.5 (5 – 8)	3.5 (3 – 5)
6-lane two-way	8	5	7.5 (7 – 8)	4.5 (4 – 5)
Right Turn from Major Road [19]				
Across 1 lane	4	2	4.0 (3.5 – 4.5)	2.0 (2 – 3)
Across 2 lane	5	3	4.5 (4 – 5)	2.5 (2 – 3)
Across 3 lane	6	4	5.5 (5 – 6)	3.5 (3 – 4)
Right Turn from Minor Road [20]				
One-way	3	3	Use Left turn values above	
2-lane two-way	5	3	5.5 (5 – 6)	3.5 (3 – 4)
4-lane two-way	8	5	7.0 (6 – 8)	4.0 (3 – 5)
6-lane two-way	8	5	8.0 (7 – 9)	5.0 (4 – 6)
Merge from acceleration lane	3	2	3.0 (2.5 – 3.5)	2.0 (1.5 – 2.5)

Notes below are not included in the *Austroads Guide*:
[18] This is considered to apply to left-turn movement from minor road, as well as slip-lane left-turn movement from minor road.
[19] This case is relevant to two-way major road conditions with one direction of major road opposing (1-lane, 2-lane or 3-lane)
[20] The conditions specified (one-way, 2-lane two-way, 4-lane two-way, 6-lane two-way) are relevant to the opposing movement lanes on the major road

To allow for a user defined pedestrian protection time for an opposing pedestrian crossing, Opposing Peds (Signals) for the left turn movement should be input option for extra loss (Inp (StL)). The Input Start Loss will only apply if the Pedestrian movement starts in the same phase.

Opposing Peds (Signals) is not enabled by default for signalised left turn movements. For more information refer to Section 4.2.8.

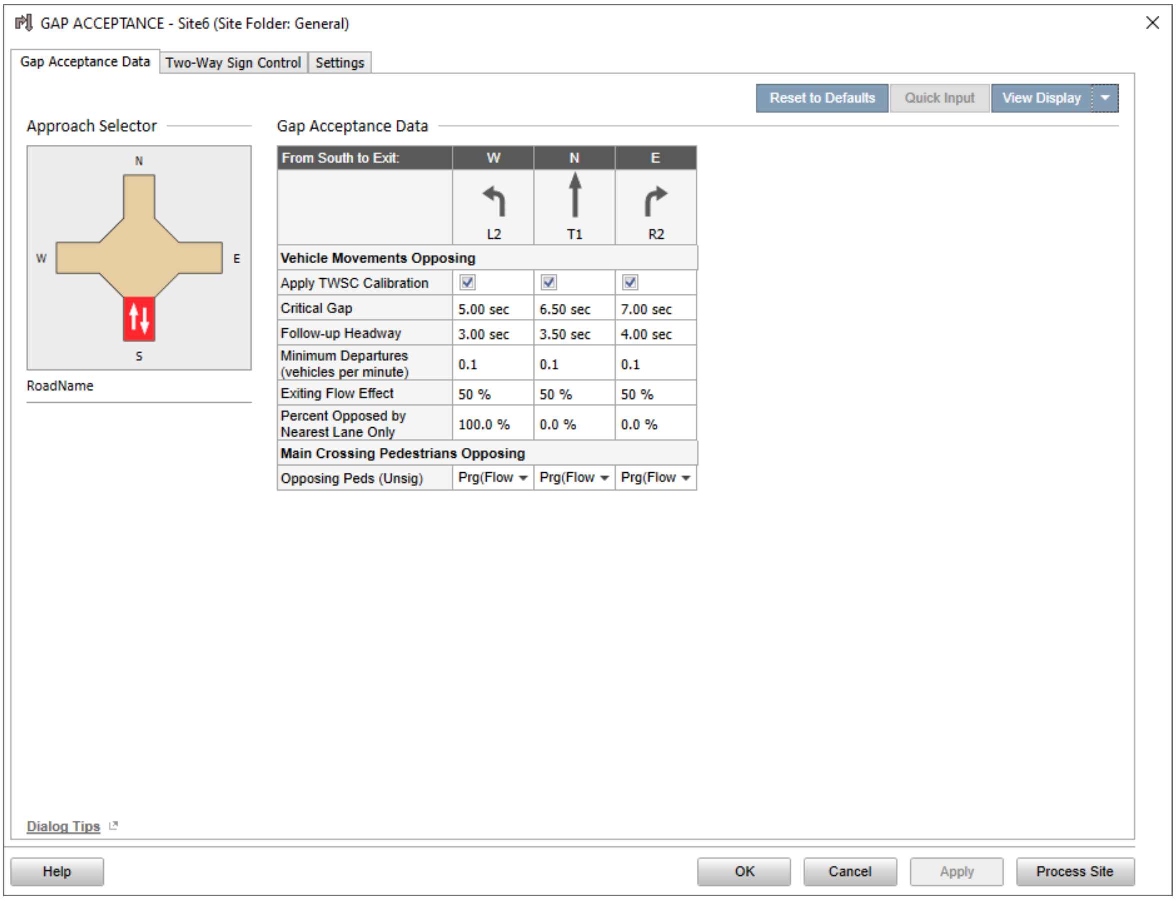
Critical Gap and *Follow-up Headway* should be *Program* for vehicles at zebra crossings. Otherwise, justification should be provided in the modelling report.

If the *Minimum Departure (vehicles per minute)* value needs to be increased, justifications should be provided.

Percent Opposed by Nearest Lane Only for sign control left-turn movements should be set to zero per cent as a starting point, however, it can be increased based on site observations. Any value other than zero should be mentioned in the modelling report.

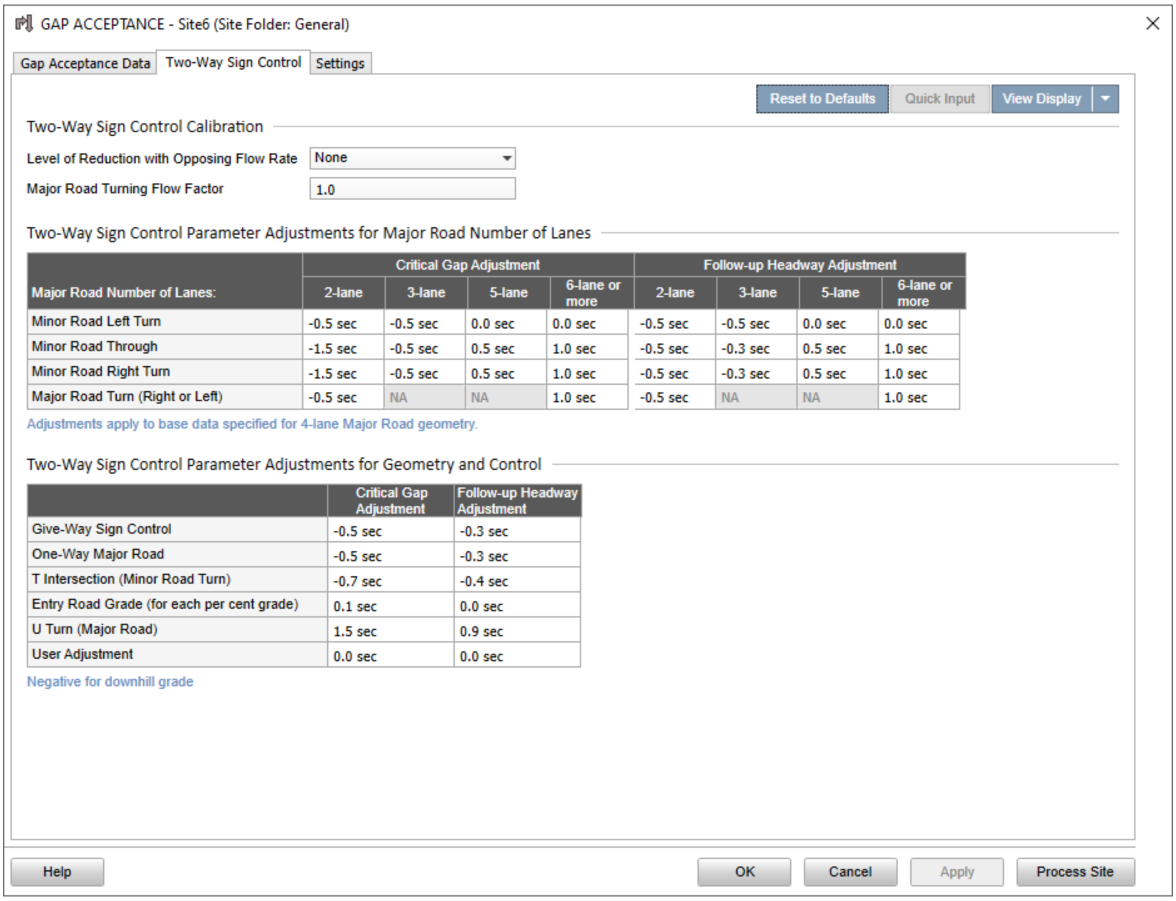
The TWSC calibration should initially be undertaken using the Low / Medium / High options for the *Level of Reduction with Opposing Flow Rate* field in the *Two-Way Sign Control* tab. This decreases the critical gap and follow-up headway of minor (opposed) movements with increasing opposing flow rates. Alternatively, the *Apply TWSC Calibration* option in the *Gap Acceptance Data* tab may be unchecked with specific values being input (although these will not be sensitive to changes in geometry).The *Gap Acceptance Data* tab default for a signed-control intersection is shown in Figure 4-12.

Figure 4-12: TWSC Gap Acceptance Data tab



The *Two-Way Sign Control* tab defaults for a two-way sign control site are shown in Figure 4-13. The *Major Road Turning Flow Factor* should be left at 1.0.

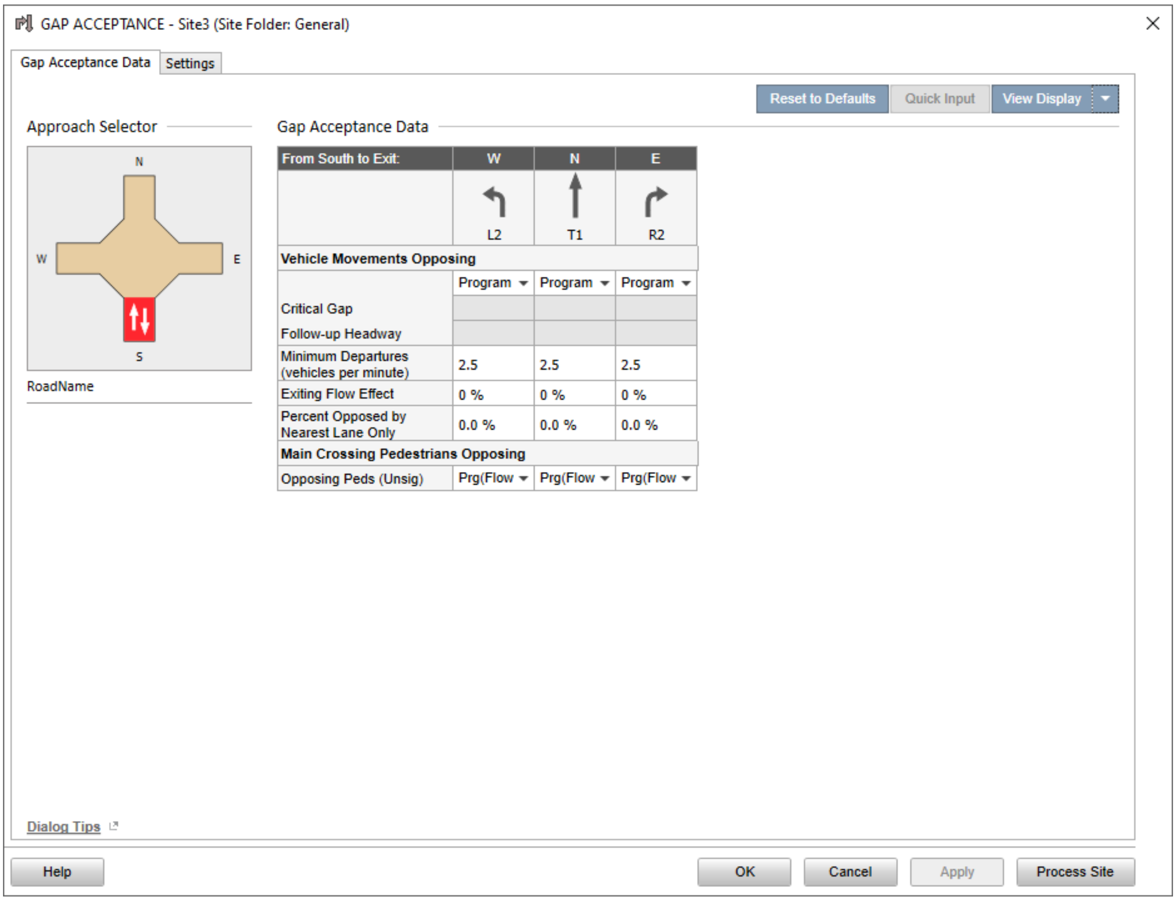
Figure 4-13: Two-way signal control calibration tab



The *Gap Acceptance* tab defaults for a roundabout site are shown in Figure 4-14

Critical Gap and *Follow-up Headway* for roundabouts should be *Program* to allow model adjustment for geometry and flow conditions. Input value should be justified in the modelling report.

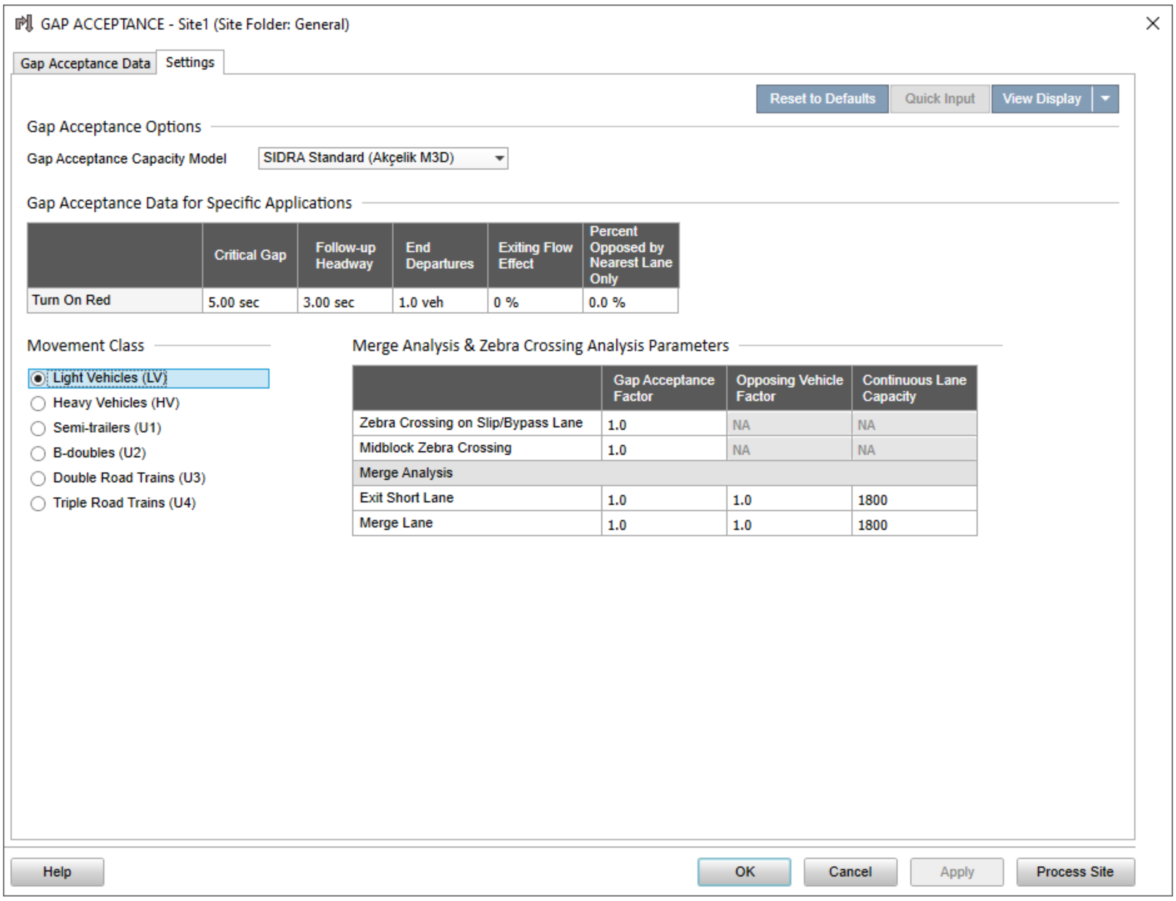
Figure 4-14: Roundabout Gap Acceptance Data tab



The *Settings* tab is shown in Figure 4-15. The default *SIDRA Standard (Akçelik M3D)* capacity model based on bunched exponential headway distribution of opposing traffic headways should be used.

For recommended *Gap Acceptance Factor* and *Opposing Vehicle Factor* for merge analysis and zebra crossing analysis for movement classes (discussed in Section 4.2.2.1) refer to Figure 4-6 in Section 4.2.10.2.

Figure 4-15: Settings tab



4.2.10 Vehicle Movement Data

This section discusses vehicle movement data in SIDRA.

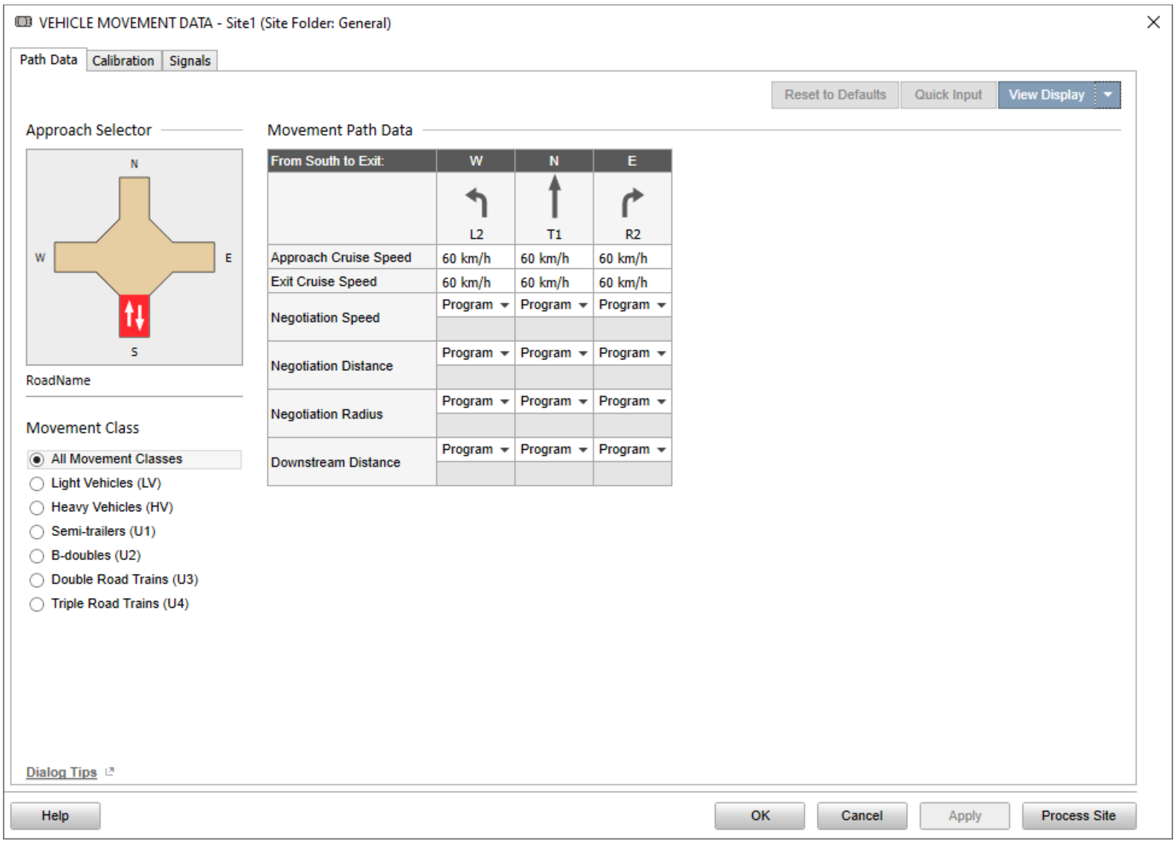
4.2.10.1 Path Data

Modifications to the *Path Data* tab defaults, as shown in Figure 4-16, should take into consideration:

- All the parameters listed can be specified for each movement, either by movement class or collectively for all movement classes. While these parameters do not affect capacity, they affect geometric delay, cost, fuel consumption and emissions.
- *Approach Cruise Speed* and *Exit Cruise Speed* should be updated to the posted speed limits, if required.

- The *Negotiation Speed, Negotiation Distance* and *Negotiation Radius* default values (as calculated by the program based on specified geometric data) may need to be overridden to reflect situations like roundabouts with deflected (reverse-curved) approaches and sign-controlled intersections where two-staged crossings can be performed (refer to Section 4.3).
- All user-given values overriding the default and program-calculated values should be detailed and justified in the modelling report.

Figure 4-16: Path Data tab



4.2.10.2 Calibration

In the *Calibration* tab the *Vehicle Length* for all movement classes should be modified based on Table 4-2. To calculate *Queue Space,* Main Roads recommends to add 2.5 metres to the vehicle length of each movement class.

Table 4-6 shows the recommended *Gap Acceptance Factor* and *Opposing Vehicle Factor* for movement classes discussed in Section 4.2.2.1.

Table 4-6: Gap Acceptance & Opposing Vehicle Factors

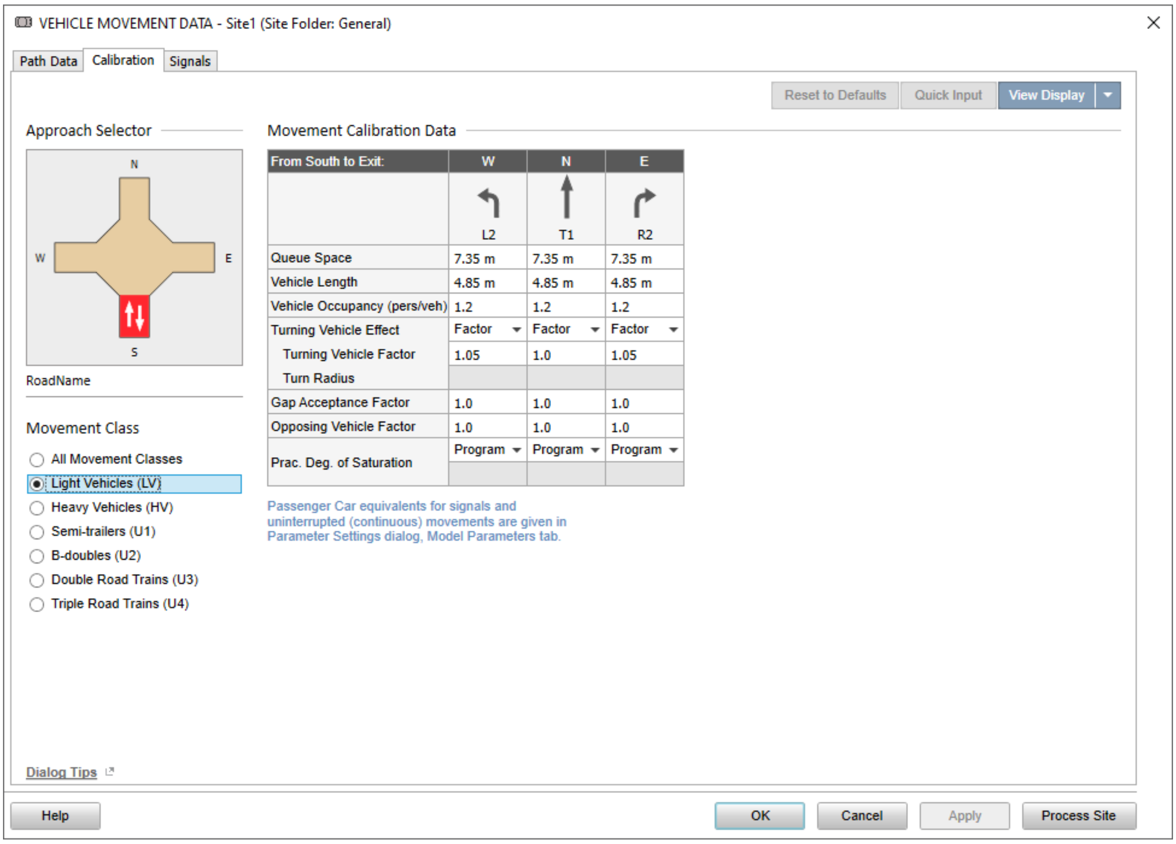
Austroads Class	Gap Acceptance Factor	Opposing Vehicle Factor
1	1	1
2	1.5	1.5
3-5	1.5	1.5
6-9	2	2

Austroads Class	Gap Acceptance Factor	Opposing Vehicle Factor
10	2.5	2.5
11	2.5	2.5
12	2.5 - 4.5[21]	2.5 - 4.5[21]

Source: Main Roads

The *Calibration* tab is shown in Figure 4-17: Calibration tab.

Figure 4-17: Calibration tab



[21] **Note:** applied value in the model should be agreed with Main Roads.

4.2.10.3 Signals

In the *Signals* tab, the key parameters which should be checked and modified include:

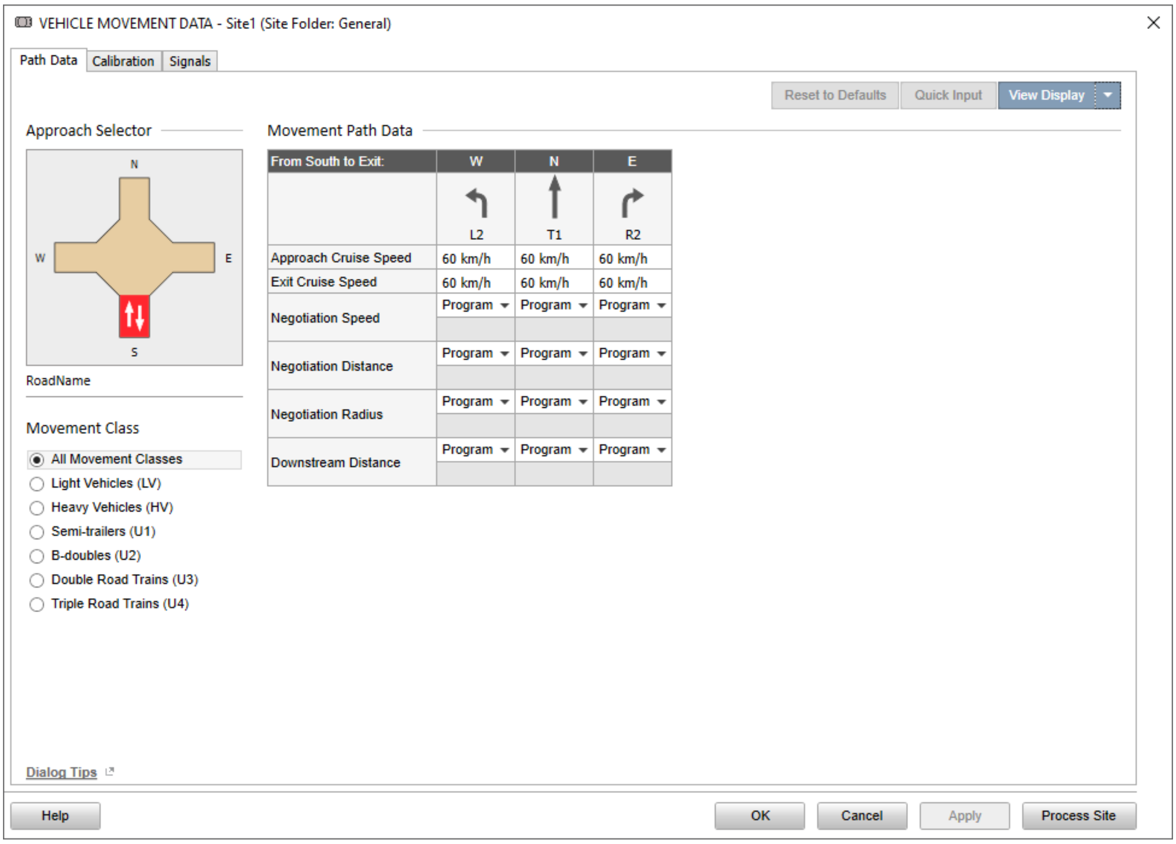
- *Signal Coordination* should normally be set to *Program* to use platoon patterns based on signal offsets in network modelling. If *arrival type* or *arrivals during green* options are applied, it should be justified in the modelling report.
- *Start Loss* – three seconds
- *End Gain* – three seconds
- *Minimum Green* – the minimum green of the phase in which the movement operates. This can be set to *Program*, however modellers should check the calculated phase time for 100 per cent frequency is not longer than the minimum phase in SCATS. If the define minimum green or the calculated phase times are shorter than SCATS minimum green, justification should be provided in the modelling report (e.g. low frequency phase).
- *Phase Actuation* should be set to *none* in most cases.
- *Early Cut-Off* and *Late Start* – the early cut-off and late start of the phase in which the movement operates.

Late start for a filtering right-turn which comes after the leading right-turn movement in the sequence should be defined using *Red Arrow Drop Off* parameter under *Movement Data* tab, *Phasing & Timing* Dialog (refer to Section 4.2.11).

Pedestrian protection time should be defined as extra loss for opposed left turn movement rather than late start time (refer to Section 4.2.9).

The rest of the parameters, as shown in Figure 4-18, should generally be left as default. If any modifications are made, these should be justified in the modelling report.

Figure 4-18: Signals tab



4.2.11 Phasing and Timing

The *Phasing & Timing* dialog contains key information on the configuration of the traffic signals and the timings to be adopted. The *Sequences* tab allows definition of the signal analysis method, which should be set to EQUISAT (*Fixed-Time / SCATS)* for intersections running under SCATS-coordinated or master-isolated control. The *Actuated* analysis method should be used for intersections operating under a traditional actuated control method.

A new sequence can be added or cloned using existing sequences in the list. The *Sequence Name* can be used to specify descriptions of the sequence, such as client supplied data or sequence testing. New user-defined sequences can be modified in the *Sequence Editor* tab. For the base model, phase sequence should be defined based on SCATS history data (Refer to Appendix A).

The *Sequence Editor* tab allows the definition of phases, their sequence as well as the OD movements by movement class and pedestrian movements that run in each phase.

The *Phase and Sequence Data* tab allows specification of:

- *Variable Phases* – are not compulsory and can be skipped depending on the demand pattern.
- *Reference Phase* (compulsory) – this refers to reference and coordinated phases used for signal coordination purposes (Refer to Appendix A).

- *Phase Times* –if the user-given phase times is selected under the *Timing Options* tab, phase times should be defined here. For average phase time calculations, refer to Appendix A.
- *Phase Frequency* – if the user-given phase times is selected under the *Timing Options* tab, *phase frequency* allows the specification of the percentage of signal cycles when the phase is called, with the default being that the phase is called each cycle. User-given phase frequencies should be justified in the modelling report.
- *Yellow Time* and *All-Red Times:*
  - For existing signals, refer to Appendix A. If only one yellow time or all-red time has a decimal value, it should be rounded up. However, if both have decimal values, one should be rounded up and the other should be rounded down. This ensures that the total intergreen time remains equal to the intergreen time in SCATS.
  - For proposed modifications or new intersections, intergreens should be specified in accordance with Main Roads' standards (Refer to Appendix A). Calculations should be provided in the modelling report.

Dummy Movement Data may be needed in certain advanced instances, such as where there is no unique movement in the phase.

Detection data is typically left at the default values.

For a new signal or modifications to an existing signal time setting refer to Appendix A.

Timing Options tab will generally be set to *User-Given Cycle Time*, reflecting the current cycle time which is in operation or proposed. The *Timing Options* tab can also be set to *User-Given Phase Time*, reflecting the observed average signal time for the base model. Where there is a need to identify the cycle time for a new coordinated network, in the *Network Timing Options Data* tab the *Practical Cycle Time* check box should be used, with the *Maximum Cycle Time* and *Cycle Rounding* should meet Main Roads' requirements.

The *green split priority* method should be used to allocate longer green times to a movement's assigned high priority for green splits while keeping other movements at their target degree of saturation (DoS). Using this feature is not recommended, otherwise justification should be provided in the modelling report.

The *Movement Data* tab allows for specification of *undetected* movements, allowing slip / bypass lanes to be excluded from signal timing analysis. While this can be used where slip / bypass lanes do not cross over the stop line detectors, it should not be used where the turning vehicles using slip / bypass lanes cross over advanced detector loops, or with controllers using fixed-time signal plans where the plans are designed to accommodate all turning vehicles.

The *Phase Transition* box should be checked only in some cases when it is not obvious to the program that the movement is stopped at the end of the phase before being started again in the next phase (e.g. left turns with green arrow control). If the movement status changes between opposed and unopposed, the green periods will be set automatically and the *Phase Transition* specification is not required. Modellers should review the phases before specifying the *Phase Transition* parameter. Unnecessarily application of *Phase Transition* may produce errors during SIDRA processing.

In order to define the late start for a filtering right-turn phase which comes after a leading right-turn phase, *Red-Arrow Drop Off* box should be checked.

4.2.12 Site Demand and Sensitivity

The *Site Demand & Sensitivity* dialog should be used to assess the forecast operation of the intersection based on certain growth scenarios. Options are provided to test the analysis objective, for both *Design Life* and *Flow Scale*, and the method of presenting results (*Sensitivity*).

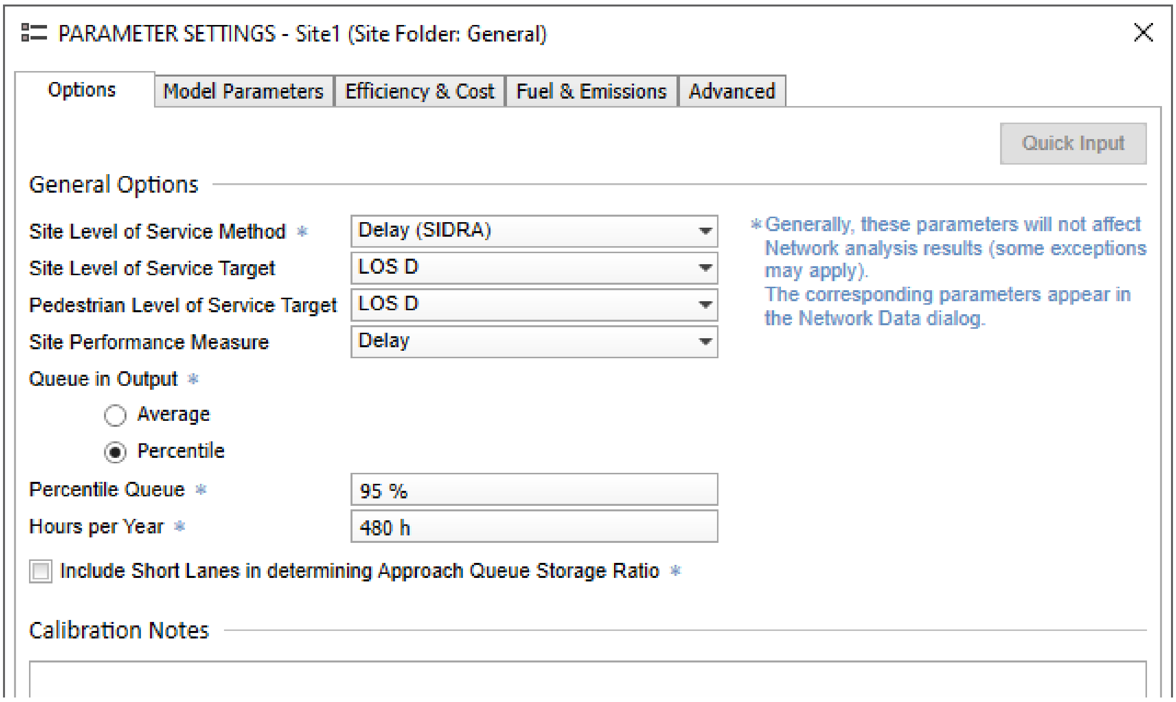
4.2.13 Parameter Settings

The *Parameter Settings* dialog applies to the intersection as a whole and contains important parameters that can significantly affect the results of the modelling.

The key parameters to be considered with respect to the *Options* tab, as shown in Figure 4-19: Options tab, are:

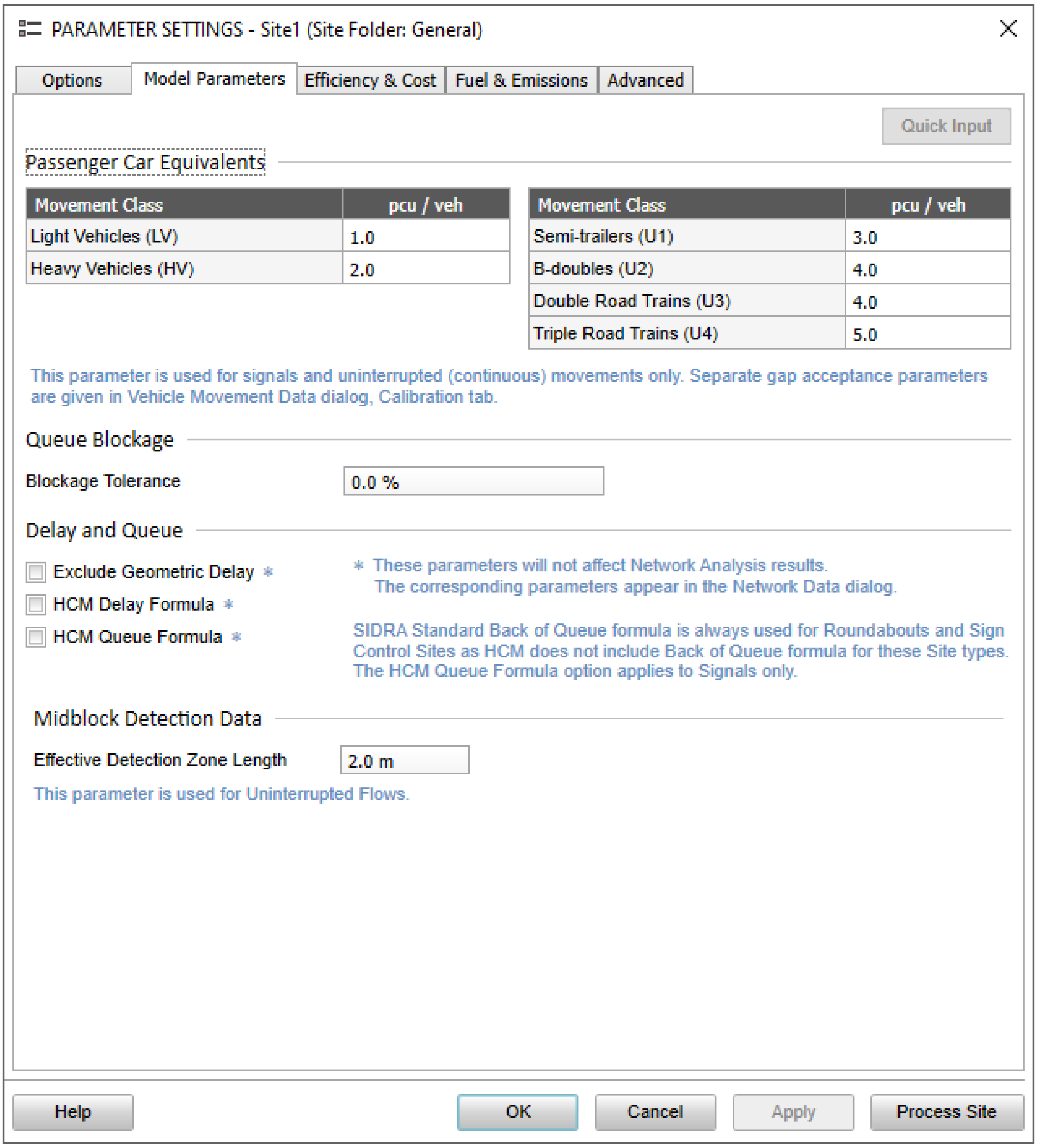
- *Site Level of Service Method* – should be set to *Delay (SIDRA)*.
- *Site Level of Service Target* – should be set to *LoS D*.
- *Queue in Output* – may be selected based on the format of data collected on site for calibration purposes. Depending on the scheme, the modeller may be required to report either 95th percentile back of queue or average back of queue.
- All other values – should be set to SIDRA defaults and if any modifications are made, these should be justified in the modelling report.

Figure 4-19: Options tab



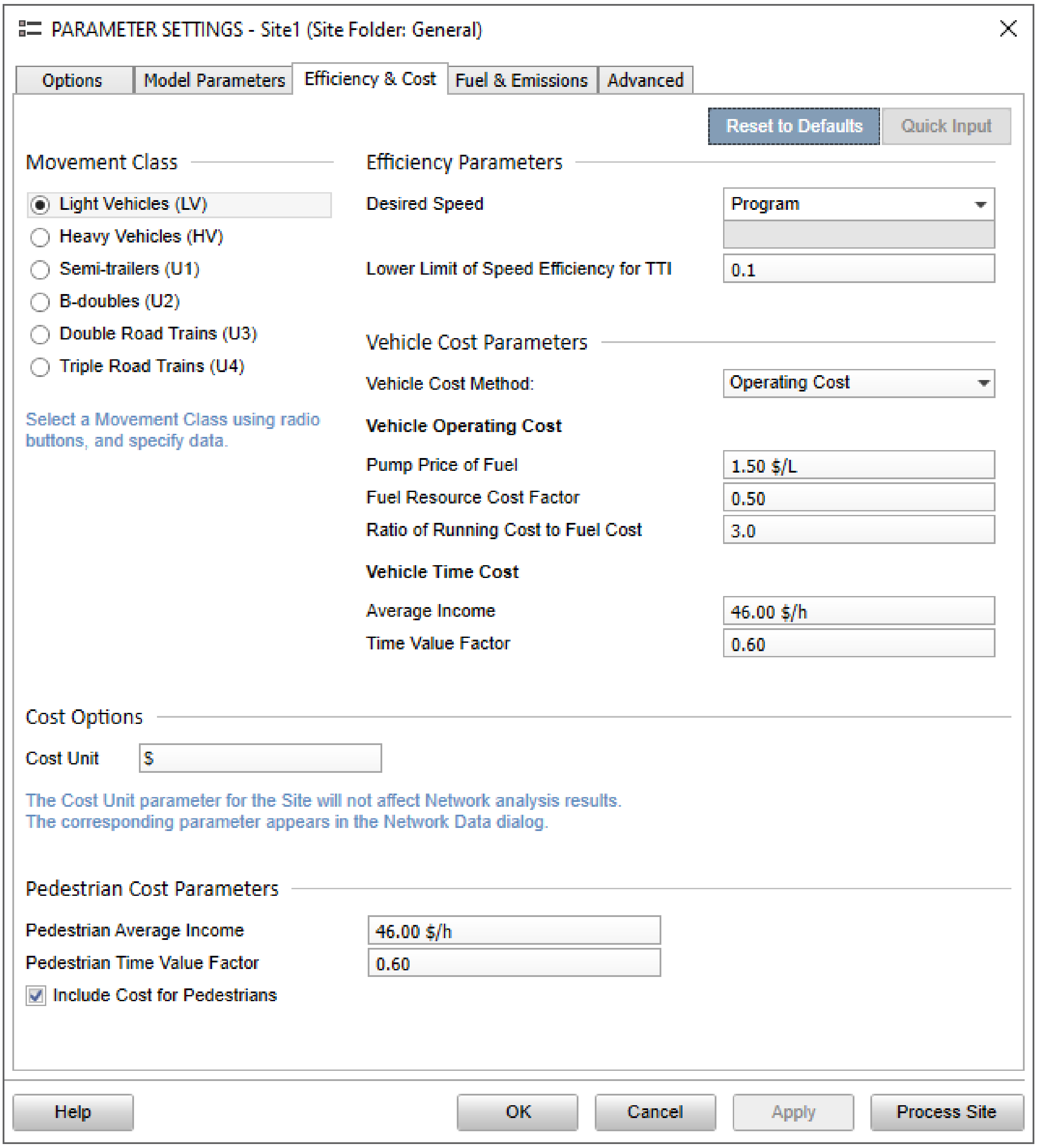
The values in the *Model Parameters* tab, shown in Figure 4-20, should generally be set to the SIDRA defaults. However, as explained in Section 4.2.2.1, *passenger car equivalent* (PCE) parameters should be defined by modellers (refer to Table 4-2) to more accurately reflect the vehicle composition. All user-defined PCE values used and any modifications to the default values for the other parameters should be detailed in the modelling report.

Figure 4-20: Model Parameters tab



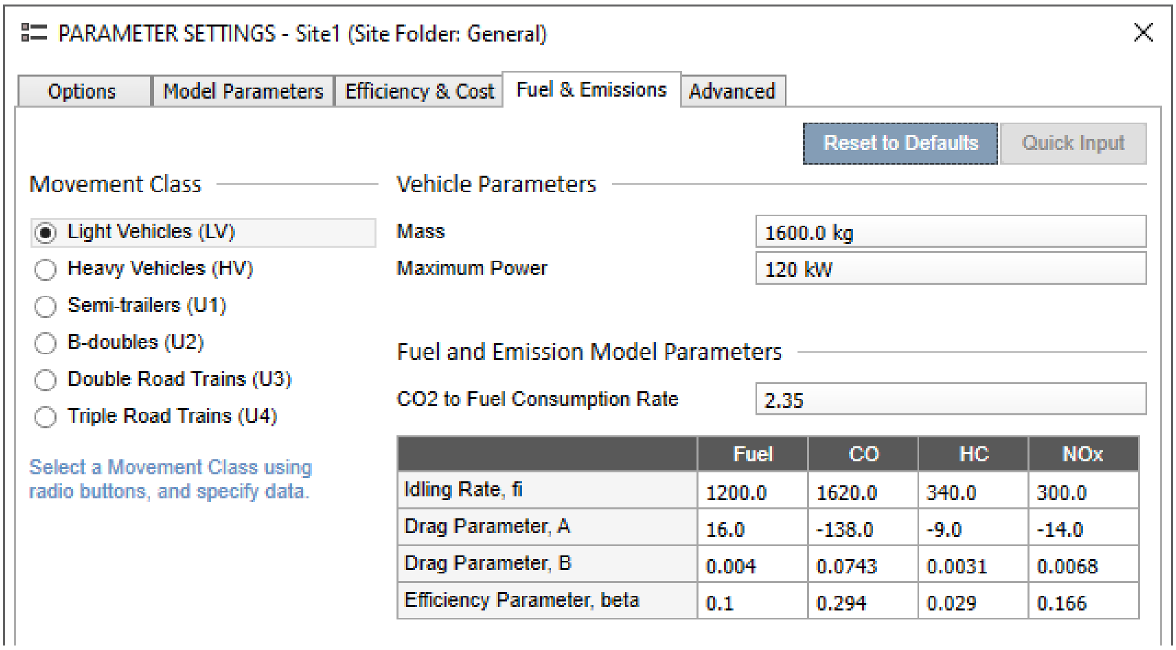
The SIDRA default values should generally be used for all parameters in the *Efficiency & Cost* tab, shown in Figure 4-21. Any modifications should be justified and detailed in the modelling report.

Figure 4-21: Efficiency & Cost tab



The SIDRA default values should generally be used for all parameters in the *Fuel & Emissions* tab, shown in Figure 4-22. Recommended values for vehicle parameters, *Mass* and *Maximum Power* for movement classes are included in Table 4-2. Any modifications should be justified and detailed in the modelling report.

Figure 4-22: Fuel & Emissions tab

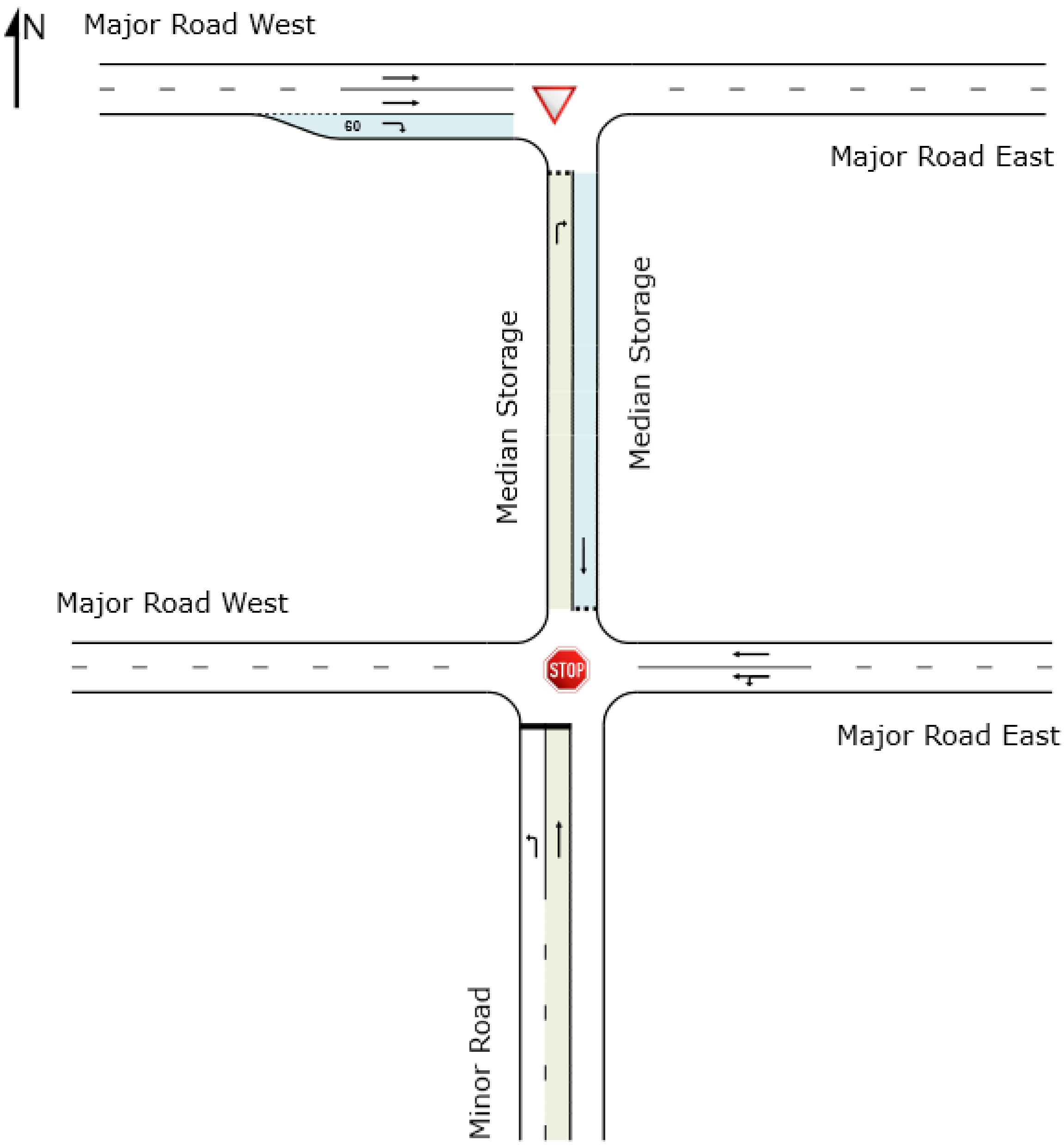


Generally, default values should be used for platoon dispersion and downstream short lane model parameters in the *Advanced* tab. Any modifications should be justified and detailed in the modelling report.

4.3 Staged Crossing at Two-way Sign Control

To model staged crossings at two-way sign control (TWSC) intersections where the major road has sufficient median width to store at least one vehicle, it is recommended that the intersection is modelled as a network consisting of two separate sites (e.g. Figure 4-23). The two sites are created to model the two stages of crossing that a vehicle from the minor road effectively completes when either driving through/across the major road or turning right onto the major road.

Figure 4-23: Example of a network for staged crossing



Network templates are available in SIDRA for three types of stage crossing at a T-intersection (Type A, B and C) and a staged crossing at a four-way intersection.

Stage 1 and 2 for three type for of T-intersection stage crossing templates are explained in the Table 4-7.

Table 4-7: T-intersection stage crossing templates

T- Intersection Stage Crossing Type	Stage 1 (crossing the major road to the median storage)	Stage 2 (turning from the median storage)
A	Opposed by westbound major road traffic	Opposed by southbound and eastbound major road traffic
B	Opposed by Westbound major road traffic and the west-to-south traffic which is represented southbound through traffic on the median storage	Opposed by the eastbound major road traffic
C (seagull)	Opposed by Westbound major road traffic and the west-to-south traffic which is represented southbound through traffic on the median storage	Merging

Source: SIDRA Intersection User Guide

The provided templates can be used as a starting point for modelling staged crossing in SIDRA; however, modelling parameters may need to be calibrated. Refer to SIDRA INTERSECTION User Guide for more details on modelling staged crossing sites.

Following modelling results for stage crossing movements should be based on overall conditions for two sites:

- Degree of Saturation: maximum of degree of saturation for two stages (Site Reports);
- Overall average delay: sum of average delay for two stages (Site Reports);
- Level of Service: based on the overall average delay for two stages.

4.4 Site Output

There are key site output parameters which should be considered when assessing calibration of existing models and also assessing forecast operation of proposed models.

4.4.1 Calibration Overview

The capacity and performance characteristics (for example, delay, queue length, stops) of a traffic facility are influenced by both the intersection geometry and the driver behaviour. While all input parameters related to intersection geometry and driver behaviour are important for calibrating SIDRA models, those parameters which reflect the general road and driver characteristics of the local areas, as well as the conditions of the intersection, are the most important.

The key elements of base model calibration are shown in Table 4-8, with the second column highlighting key model parameters that need to be calibrated and the third column highlighting the key parameters recommended for modification.

Table 4-8: Key elements of model calibration

Site type	Key parameters used in the capacity model	Recommended key calibration parameter	Input dialogue
Signals	Saturation Flow Rate	Area Type Factor	Intersection (per approach)
		Basic Saturation Flow	Lane Geometry dialogue – Lane Data tab (per lane)
Roundabouts	Follow-up Headway and Critical Gap	Environment Factor	Roundabouts (per approach)
Two-way sign control	Follow-up Headway and Critical Gap`	Basic Follow-up Headway and Critical Gap	Gap Acceptance (per movement)

Source: SIDRA Intersection User Guide

Table 4-9 shows other general parameters which may be used for model calibration.

Table 4-9: Other general parameters of model calibration

Parameter	Input dialogue	Input tab
Lane utilisation Ratio	Lane Geometry	Lane Data
Short Lane Capacity (Calibration Options)	Lane Geometry	Lane Data
Lane Movement Flow Proportion	Lane Movements	Flow Proportions
Lane Blockage Calibration Factor	Lane Movements	Blockage Calibration
Entry/Circulating Flow Adjustment	Roundabouts	Roundabout Data
Flow Scale (Constant)	Volume	Volume Factors
Percent Opposed by Nearest Lane Only	Gap Acceptance	Gap Acceptance Data
Apply TSWC Calibration	Gap Acceptance	Gap Acceptance Data
Level of Reduction with Opposing Flow Rate	Gap Acceptance	Two-Way Sign Control
Major Road Turning Flow Factor	Gap Acceptance	Two-Way Sign Control

Model calibration assumptions should be recorded in the modelling report.

4.4.1.1 Saturation Flow Calibration

To calibrate saturation flows (when saturation flow estimation is applicable), the following method is recommended:

- Undertake on-site measurements of saturation flow (vehicle / h) in accordance with standard methodologies defined in Appendix B.

- Compare the measured saturation flow with the lane saturation flow estimated by SIDRA, provided in the *lane flow* and *capacity information* table in the *detailed output report* (not the basic saturation flow).
- Calculate a calibration factor, by dividing the observed saturation flow by the saturation flow estimated by SIDRA.
- Adjust the basic saturation flow, by multiplying the calibration factor with the previous basic saturation flow, and enter the new value in the *Lane Data* tab in the *Lane Geometry* window.
- Repeat steps above as required.

4.4.1.2 Roundabout Calibration

The *Environment Factor* and the *Entry / Circulating Flow Adjustment* allow calibration of the model to be undertaken.

The default *Entry / Circulating Flow Adjustment* is *Medium*, with *High* providing higher capacity and *Low* providing lower capacity.

The *Environment Factor* parameter can be used to adjust the *Critical Gap* and *Follow-up Headway* values generally, while the *Entry / Circulating Flow Adjustment* parameter is more relevant to roundabouts where unbalanced flow patterns cause queuing conditions that indicate a need for model calibration. These calibration factors should only be changed as part of the model calibration process with all adjustments to be adequately justified in the modelling report.

4.4.1.3 Traffic Demand Calibration

Calculated queue length can differ significantly from the observed queue length because of the following reasons:

- Observed flows from the stop / give-way line may not represent the actual demand for that approach at oversaturated intersection (e.g. due to exit blocking). For this situation, demand for the approach can be scaled using *Flow Scale* in the *Volumes* dialog. The scaling factor can be estimated by observing upstream traffic flows.
- Default peak hour factor may need to be modified based on observed traffic demand profile during the queue data collection period.

Traffic demand calibration assumptions should be provided in the modelling report.

4.4.2 Validation

The validation criteria for the base model in SIDRA are described in this section.

4.4.2.1 Queue Length

For validation purposes, back of queue data collected on site should be utilised to review consistency with *Back of Queue* estimates given by SIDRA (*average back of queue)*. Back of queue is ‘the maximum backward extent of the queue relative to the stop line or give way line during a signal cycle or gap acceptance cycle. The last queued vehicle that joins the back of queue is the last vehicle that departs at the end of the saturated part of green interval of the available gap interval’.

For signalised intersections, the observed queue length at the start of green should be utilised for validation of the model. Queue length at the start of green per lane can be found in SIDRA's *Detailed Output*.

Depending on the scheme, the modeller may require to report either 95^{th} percentile back of queue or average back of queue.

4.4.2.2 Degree of Saturation

For validation purposes, the base model, which was developed based on recorded SCATS signal timing data and stop line turning counts for the same day, should have less than or equal to 100 per cent degree of saturation for all of the movements.

4.5 Network Modelling

Network modelling in SIDRA involves the modelling of the individual sites that constitute the network.

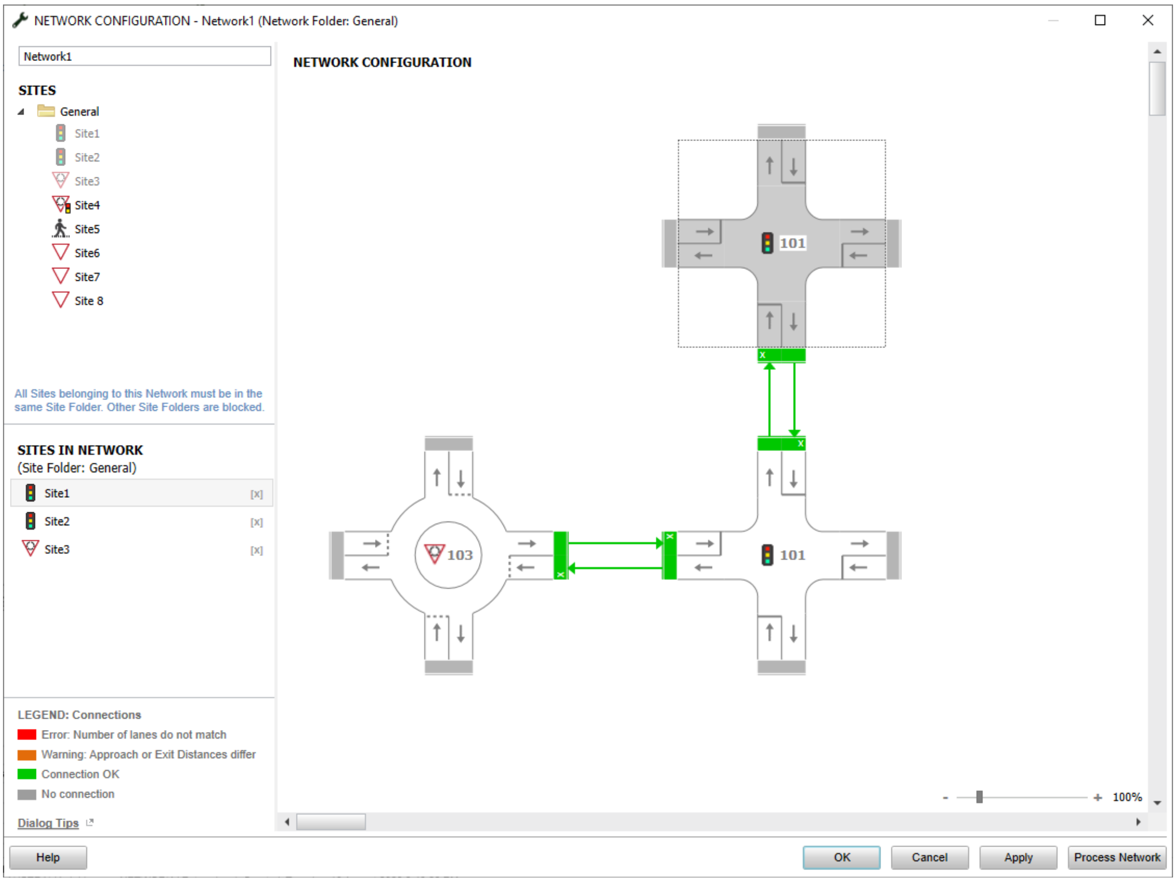
4.5.1 Network Input

The network input dialogs are described in the following sections.

4.5.1.1 Network Configuration

A new network can be created or the existing network can be edited in the *Network Configuration* dialog shown in Figure 4-24.

Figure 4-24: Network Configuration dialog



The left-hand side bar presents the individual sites modelled. The network can be created using sites within the same folder. Therefore, each folder should only contain sites which belong to one particular network (i.e. one folder in *Site* tab per network).

Before completing the network layout specification in the *Network Configuration* dialog, the modeller should ensure there is no network connection with error or warning (all the connectors should be green, indicating a valid connection which means the geometry of the upstream exit lanes matches the geometry of the downstream approach lanes).

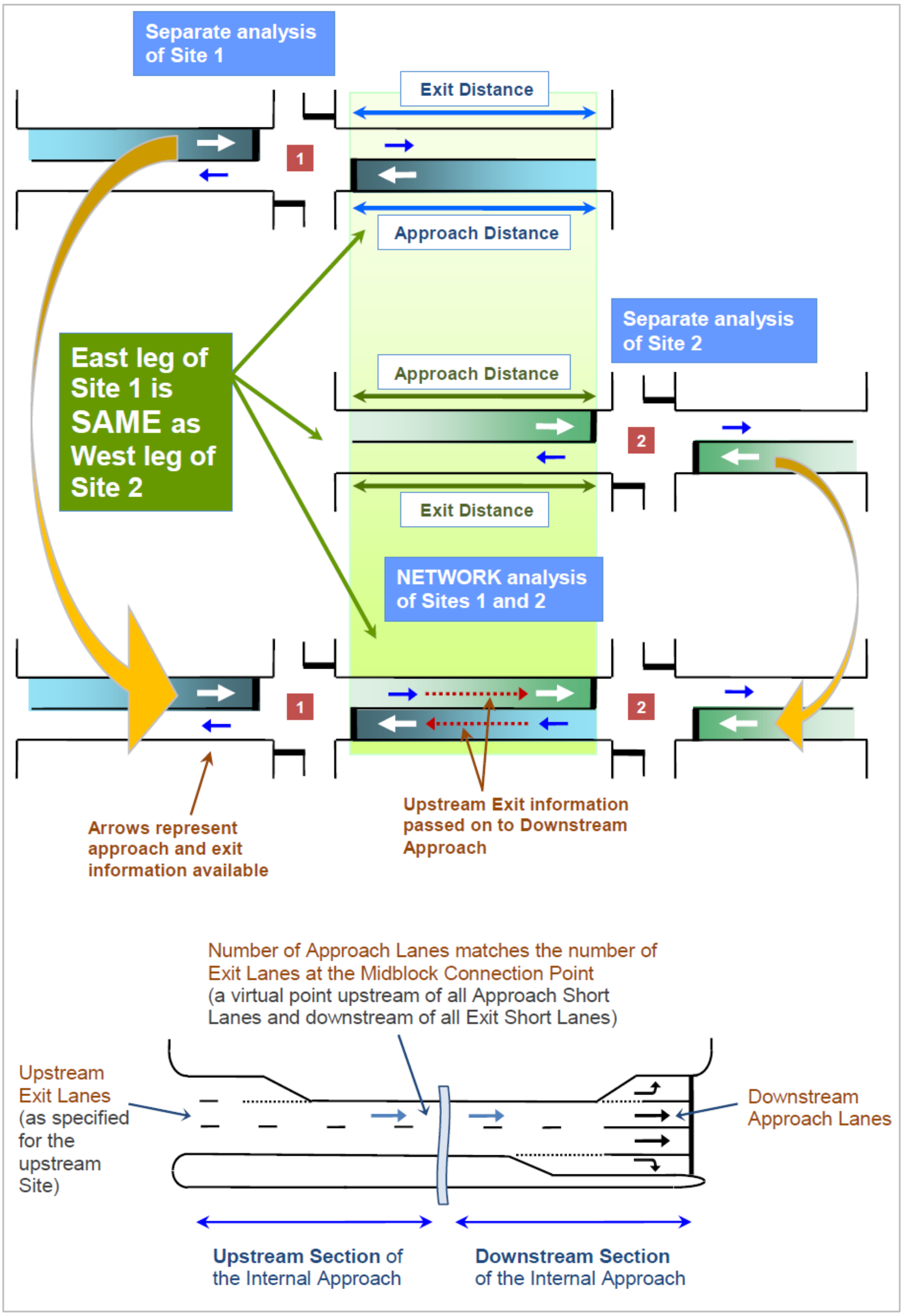
To avoid any error or warning when creating connection(s) between two sites, modellers should check the:

- number of lanes between the two sites

- movement classes, and
- approach and exit distance values for the common internal leg.

Connection between two sites is a virtual connection. This means the mid-block leg between two connected sites is essentially the same road and the lane–based flow rates and platoon patterns of upstream lanes are transferred to the downstream lanes at the virtual connection every second of simulation. Figure 4-25 demonstrates the connectivity between two intersections.

Figure 4-25: Concept of Network Connection

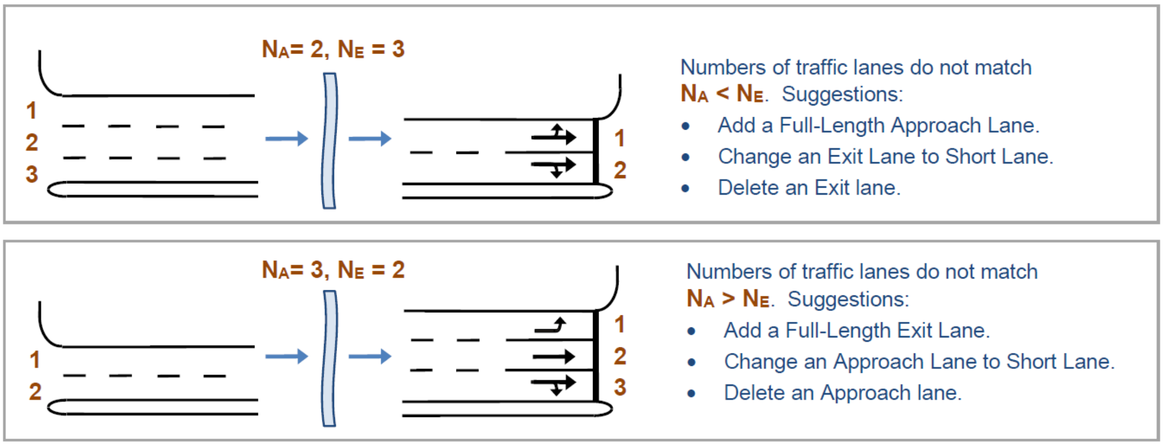


Source: SIDRA Intersection User Guide

4.5.1.1.1 Number of Lanes between the Two Sites

To connect the legs of two or more sites, the number of exit traffic lanes in the upstream site should match the number of approach traffic lanes in the downstream site. Conflict in the number of lanes is recognised by red connection lines in the *Network Configuration* dialog. Examples of when the number of lanes between two sites does not match are shown in Figure 4-26.

Figure 4-26: Examples when the number of traffic lanes for network connection do not match ($N_A \neq N_E$)



Source: SIDRA Intersection User Guide

The modeller should also update the configuration in the *Site Lane Geometry* dialog, for more details refer to Section 4.2.3.

4.5.1.1.2 Movement Classes

Total discontinuity of a movement class at a mid-block connection will have an effect on inflow / outflow when:

- A movement class exists at the upstream section but does not exist in any lane in the downstream section – the movement class should be treated as an outflow (will leave the network mid-block).
- A movement class does not exist in any lane at the upstream section but exists in the downstream section – the movement class should be treated as an inflow (enters the network mid-block).

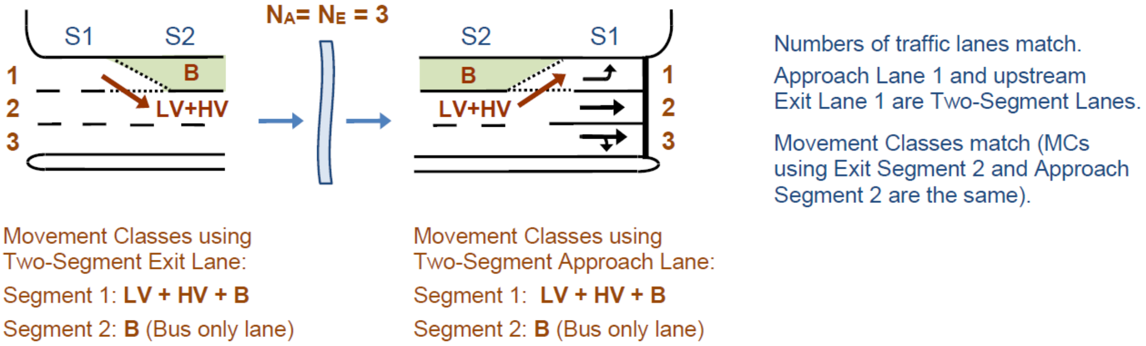
In those cases, there will be a warning message displayed and justifications should be provided in the modelling report.

Discontinuities in a movement class allocated to different lanes at the upstream and downstream locations will have lane change implications. There will not be any warning messages displayed in this case.

Midblock inflows/outflows and lane changes should be reviewed by the modeller and any unrealistic inconsistencies should be justified in the modelling report.

An example of matching movement classes in two-segment lanes is shown in Figure 4-27.

Figure 4-27: Two-segment lane examples with matching movement classes



Source: SIDRA Intersection User Guide

Corrections made to movement classes should be specified in the *Site Lane Geometry* dialog (refer to Section 4.2.3).

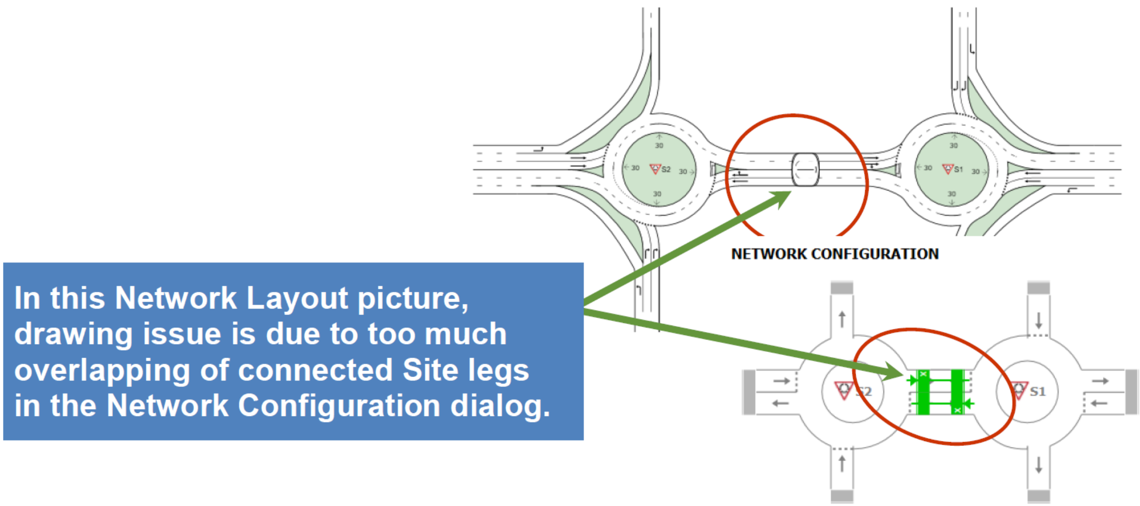
4.5.1.1.3 Approach and Exit Distances

For an internal approach in a network in SIDRA, approach distance should be measured from the stop line to the upstream intersection. The exit distances in the upstream site should match the approach distances in the downstream site. Conflict in the length of approach and exit lanes is recognised by dark orange connection lines in the *Network Configuration* dialog. This can be corrected in the *Site Intersection* dialog (refer to Section 4.2.1).

After completing work in the *Network Configuration* window, modellers should check the network configuration in the *Network Layout* to ensure that the connections between intersections are appropriately made and the network is correctly presented.

Although all the connections are green, the picture layout may still have some drawing issues. Figure 4-28 shows common drawing issues in the *Network Layout*.

Figure 4-28: Network Layout Display – Example of drawing issue



Source: SIDRA Intersection User Guide

While a layout picture problem does not necessarily mean the model will not work, it is recommended that road levels are defined as per site configuration and layout display issues are avoided where possible, for example by leaving enough space between site legs to enable the green connection to be visible.

Modellers should rotate the network to ensure that the network has the right geographic orientation, with north to the top. It should be noted that individual site rotation is not allowed for a site which is included in a network.

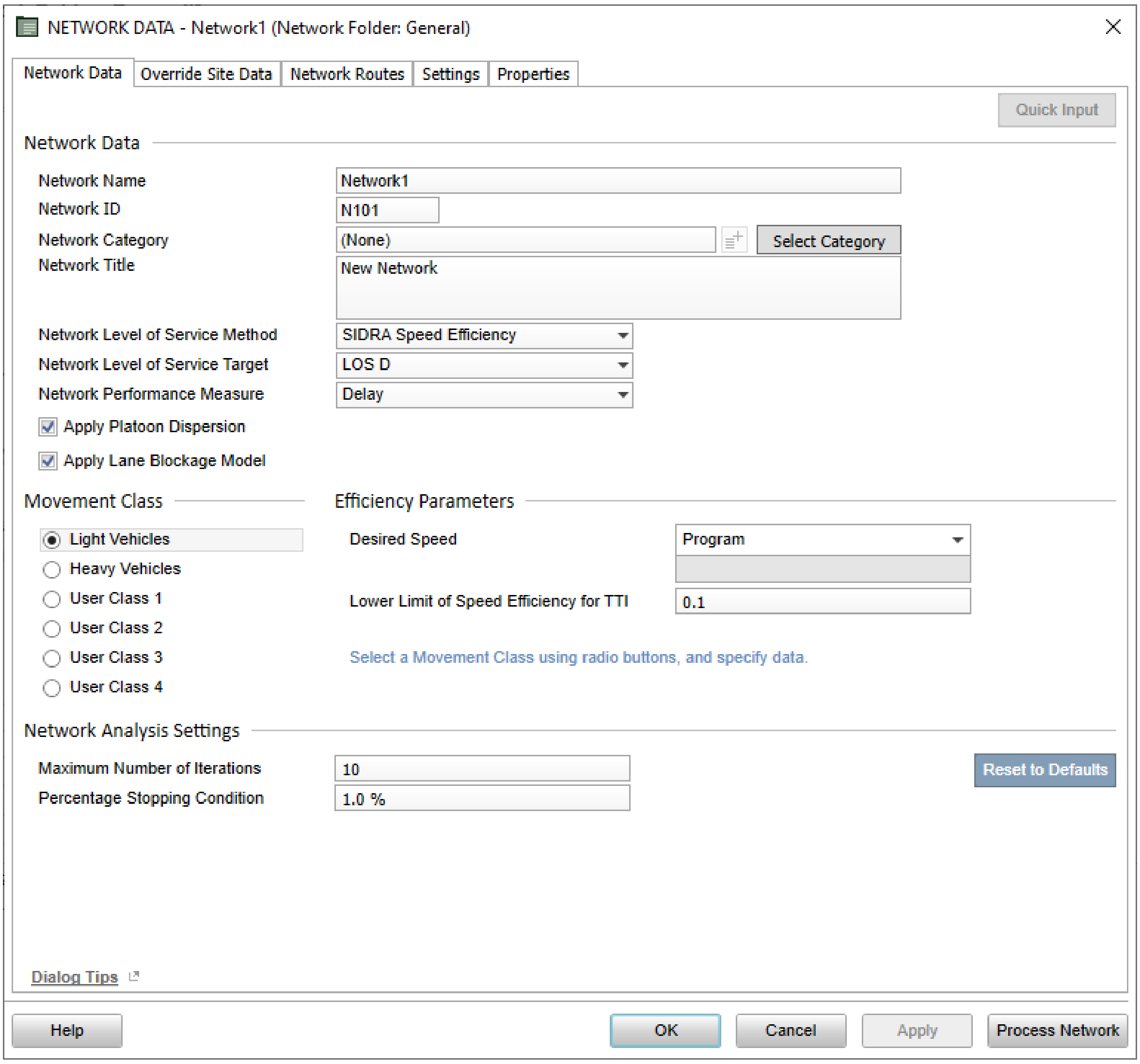
4.5.1.2 Network Data

When defining the network data, the modeller should refer to the following for key data:

- *Network Name* – generally includes the road names or location of the network, peak period (AM or PM) and year of modelling.
- *Network ID* – when there is one controller for the whole network the Main Roads TCS reference can be used.
- *Network Level of Service Method* – the *SIDRA Speed Efficiency* method should be used to determine the results in the *Network Summary* report.
- *Network Level of Service Target* – should be set to *LoS D.*
- *Performance Measure* – should be set to the default (*Delay*).
- *Apply Platoon Dispersion check* box – to be unchecked if the distance between network sites is short and there is zero offset for individual sites.
- *Apply Lane Blockage Model* box – should be checked.
- *Desired Speed* – should be set as *Program* if posted speed limits in the network vary significantly, or set using the majority posted speed limit in the network.
- *Lower Limit of Speed Efficiency for TTI* – should be set at the default value (0.1).
- *Maximum Number of Iterations* – should be set at default (10) or higher value (up to 30) for the output calculation process.
- *Percentage Stopping Condition* – should be set at default (1.0%) or lower value (down to 0.1%) for the output calculation process.

Figure 4-29 shows the *Network Data* dialog in SIDRA.

Figure 4-29: Network Data dialog



Network parameters that override site data are in *Override Site Data* tab.

- Peak Flow Period here only overrides the site data for uniform use in network analysis for performance calculations (delay, queue length, stop rate, etc.). If any changes to *Peak Flow Period* are required, supporting traffic data should be provided in the modelling report.
- *Site Level of Service* – should be set to the default value (*Delay (SIDRA)*) to ensure the levels of service for the individual sites in the network are determined based on the same method.
- *Queue in Output* – may be selected based on the format of the data collected on site for calibration purposes. Depending on the scheme, the modeller may require to report either 95th percentile back of the queue or average back of the queue.
- *Hours per Year* – should be set at default (480 hours for peak hour models).
- *Cost Unit* – should be set at default (dollar ($)).
- *Exclude Geometric Delay* box should be unchecked.
- If *Include Short Lanes in determining Approach Queue Storage Ratio* checkbox is checked (will overwrite the setting for the sites in the network), adequate justification should be included in the modelling report.

4.5.1.3 Common Control Groups (CCGs)

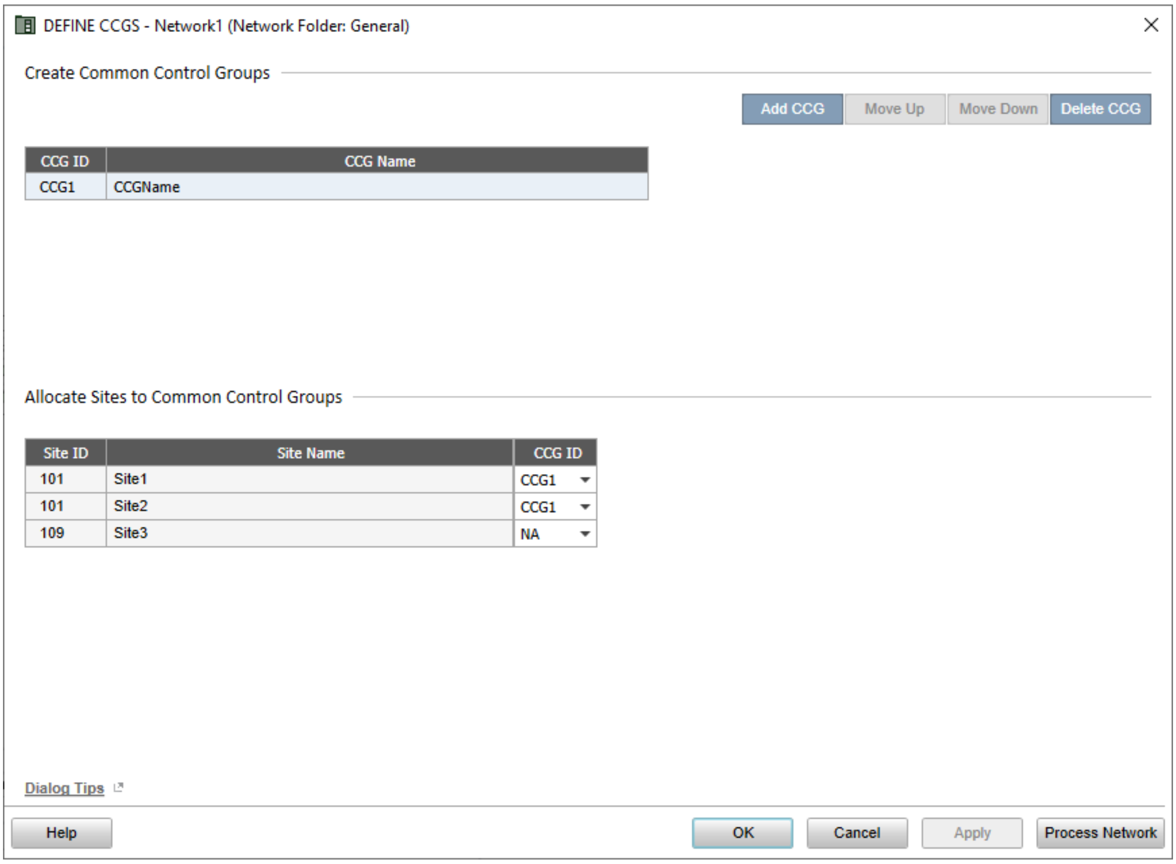
This section provides information on common control group settings in SIDRA.

4.5.1.3.1 Define CCGs Dialog

Common control groups (CCGs) are defined in the *Define CCGs* Dialog, as shown in Figure 4-30. The modeller should note:

- For *CCG ID* – the Main Roads TCS reference should be used.
- CCGs – sites should be allocated to their corresponding CCGs.
- The *CCG ID* for other intersections in the network – should be set as *NA*.

Figure 4-30: Define CCGs Dialog



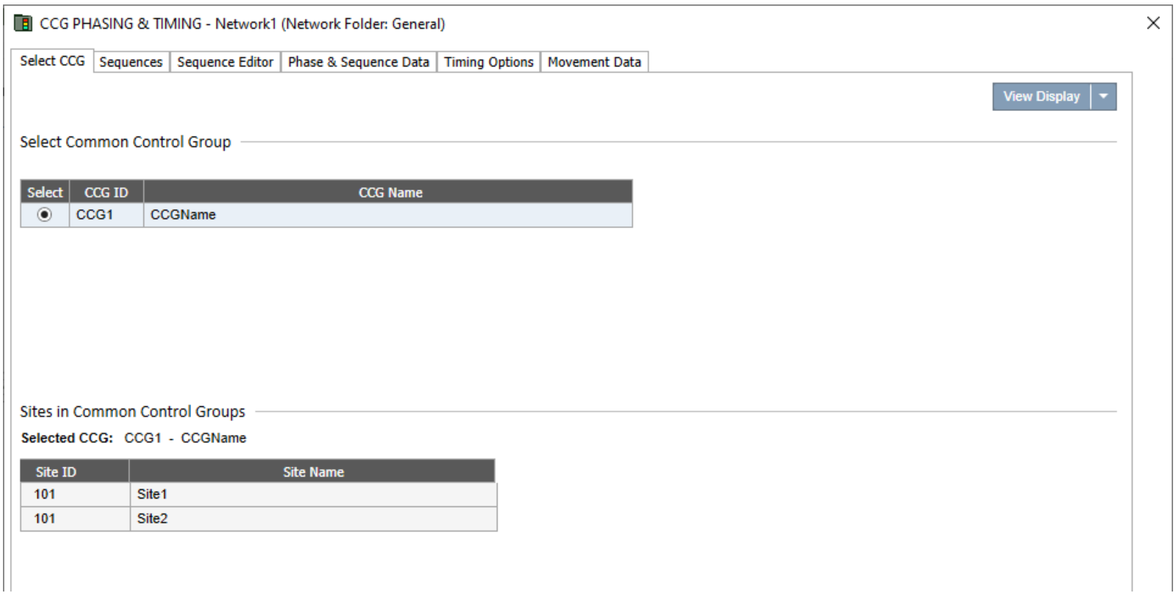
4.5.1.3.2 CCG Phasing & Timing Dialog

The *CCG Phasing & Timing* dialog (shown in Figure 4-31) should be added in the *Network Input* section, if at least one CCG is defined.

Phasing, sequence and timings of the CCG settings have similar principles as the isolated intersections. Modellers should ensure that the intended CCG is selected when there is more than one.

For parameter settings for *Sequences*, *Sequence Editor, Phase & Sequence Data, Timing Options* and *Movement Data* tabs, refer to Section 4.2.11.

Figure 4-31: CCG Phasing & Timing dialog

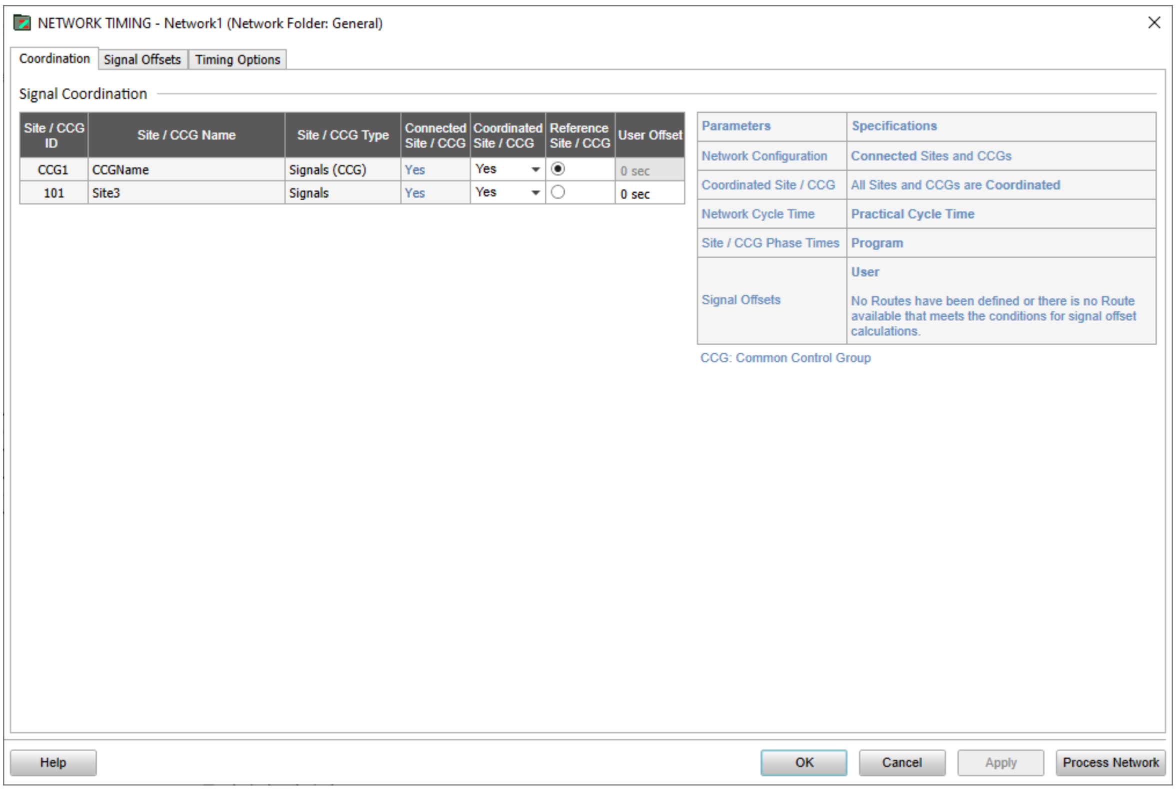


4.5.1.4 Network Timing

The lane-based second-by-second platoon model is used to calculate signal coordination effects in the internal approach movements in a network. The relevant parameters should be set in the *Network Timing* dialog.

If there are signalised sites and CCGS in the network, they should be listed in a table in the *Network Timing Data* tab, as shown in Figure 4-32.

Figure 4-32: Network Timing Data tab



For traffic signal coordination, the modeller should ensure the relevant network connections are set up for the sites and CCGs (*Connected Site/CCG* must be *yes*):

- *Coordinated Site / CCG* should be set as *Yes*, if the internal approach movements for that site in the network should be treated as a part of the coordinated movement (applicable for networks with more than one signalised site or CCG).
- The *Signal Coordination* parameter (in the *Signals* tab in the *Vehicle Movement Data* dialog) should be set as *Program* and if either the *Arv Type* or *%Green* option is used it should be justified in the modelling report.

For the existing coordinated sites/CCGs:

- One of the coordinated sites in the network must be set as the reference site, and for the existing network the reference site must be based on SCATS (refer to Appendix A).
- For all coordinated sites/CCGs, the relevant *Reference Phase* must be selected (in the *Phase & Sequence Data* tab in the *Phasing & Timing* dialog for sites, and in the *Phase & Sequence Data* tab in the *Common Control Groups* dialog for CCGs). The reference phase must be based on SCATS (refer to Appendix A).
- Offset time should be input into *User Offset* in the *Network Timing Data* based on SCATS offset settings (refer to Appendix A), and *User* option should be selected in the *Signal Offset* tab.
- All of the routes in the *Signal Offset* tab should be deselected.
- For the base model, in the *Network Timing Data* tab*, Cycle Times* and *Phase Times* should generally be set to *User-given Cycle Time*, reflecting the current cycle time in operation or that proposed (refer to Appendix A*)*.

For the new coordinated sites/CCGs or proposed offsets:

- *Program* should be selected for *Signal Offsets.*
- At least one route should be defined (refer to *SIDRA Intersection User Guide*) and the relevant route(s) for offset calculations should be selected in *Signal Offset* tab. It is recommended that the route which includes the reference site / CCG with the most critical movements should be selected.
- *Signal Offset Method* (for *Program* signal offsets only) should be set at the default value (*start of green (leading)*).
- *Movement Class* should be set to the majority vehicle class observed on the route.
- *Signal Offset Definition* should be set to *Green Start Offsets*.
- Where there is a need to identify the cycle time for a new coordinated network, in the *Timing Options* tab the *Practical Cycle Time* check box should be used, and the *Maximum Cycle Time* and *Cycle Rounding* should meet Main Roads' requirements.

Practical Cycle Time, Optimum Cycle Time or *User-given Cycle Time* will be applied to signalised sites / CCGs without relevant connection into the coordinated network if the *Coordinated Site* is set to *Yes*.

The signal coordination between two signalised sites / CCGs will be disabled, if those are connected via at least one of the following site types:

- Minor road of a TWSC site.
- A signal site where the coordinated is set to *No.*
- A roundabout site.
- An all-way stop control (AWSC) site.

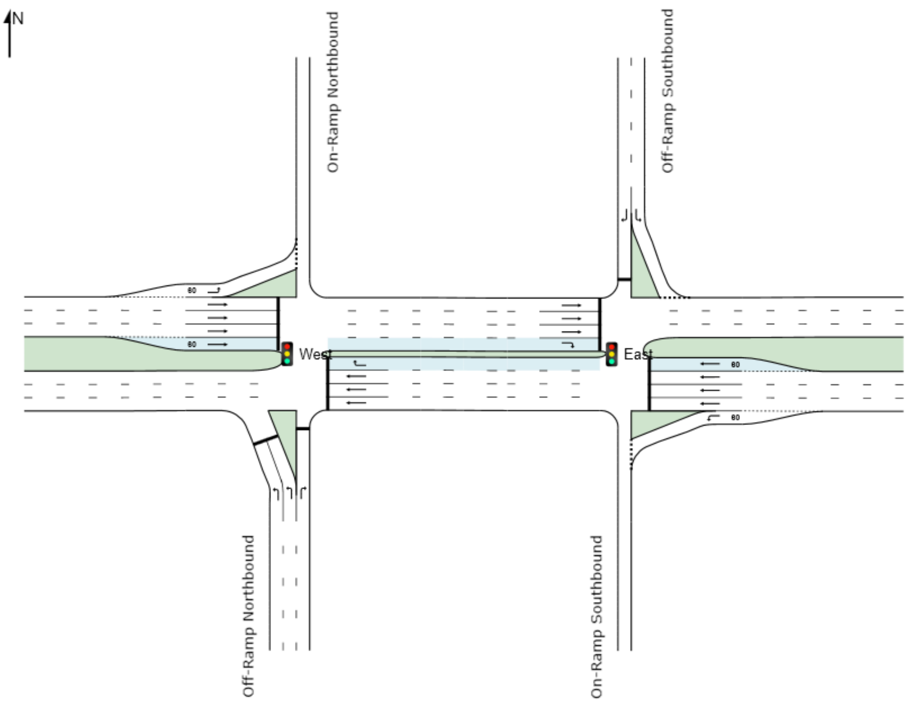
The *Signal offsets* tab is shown in Figure 4-33.

Figure 4-33: Signal Offsets tab

4.5.2 Case Study

Figure 4-34 shows a signalised interchange network which incorporates two signalised sites (west and east).

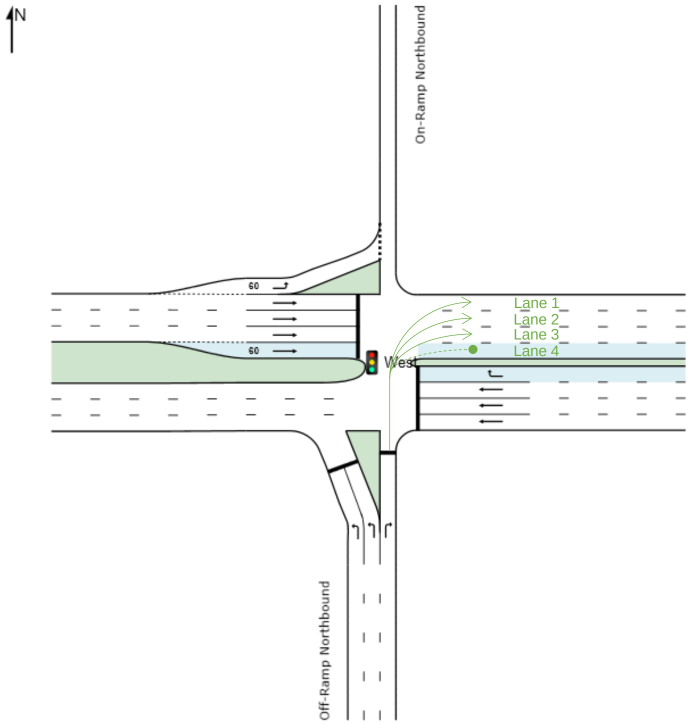
Figure 4-34: Signalised Interchange Network



4.5.2.1 Flow Distribution

By default, SIDRA allocates 100 per cent of the flows turning right from the freeway off-ramp west to lane four of the exit to eastbound mid-block. In practice, almost 100 per cent of the traffic flows turn-right into lanes one, two and three, as shown in Figure 4-35.

Figure 4-35: West site

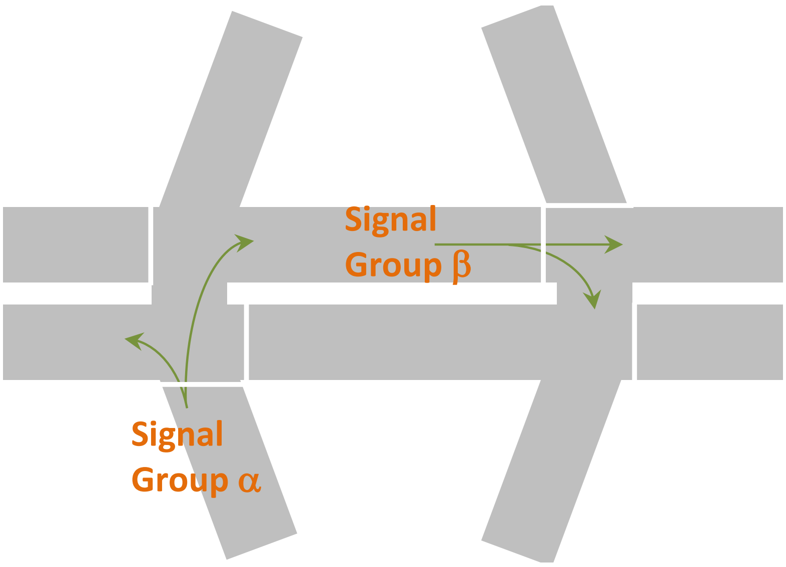


To address this issue, the *Lane Movement Flow Proportions* should be modified for the site (in the *Flow Proportions* tab in the *Lane Movements* dialog). In this example, these changes should also be applied to the freeway off-ramp east.

4.5.2.2 Early Cut-Off or Late Start

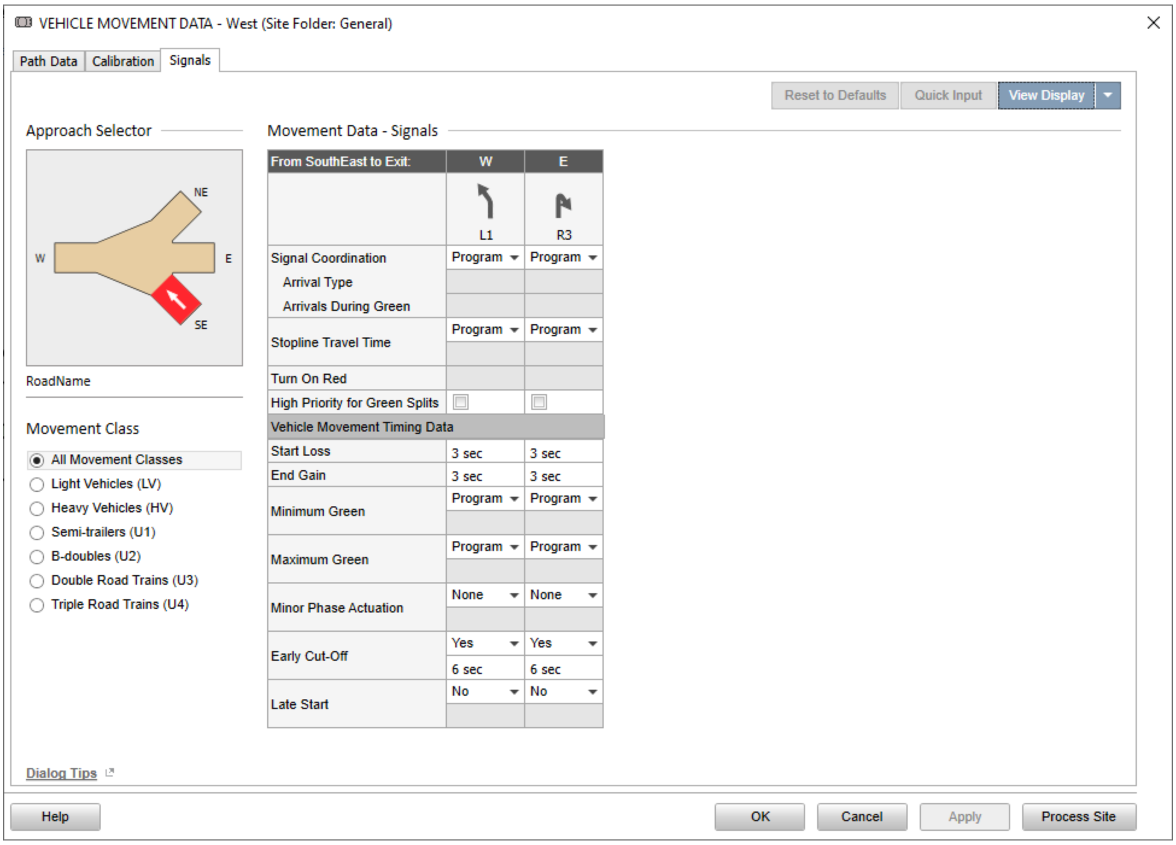
Figure 4-36 shows 'A' phase of the signalised interchange. Signal Group α and Signal Group β are run during 'A' phase.

Figure 4-36: 'A' phase with early cut-off



In this example, Signal Group α has an early cut-off of six seconds. Early cut-off and late starts for the relevant site should be defined in the *Signals* tab in the *Vehicle Movement Data* dialog. In this case, the west site should be updated, as shown in Figure 4-37.

Figure 4-37: Early cut-off example

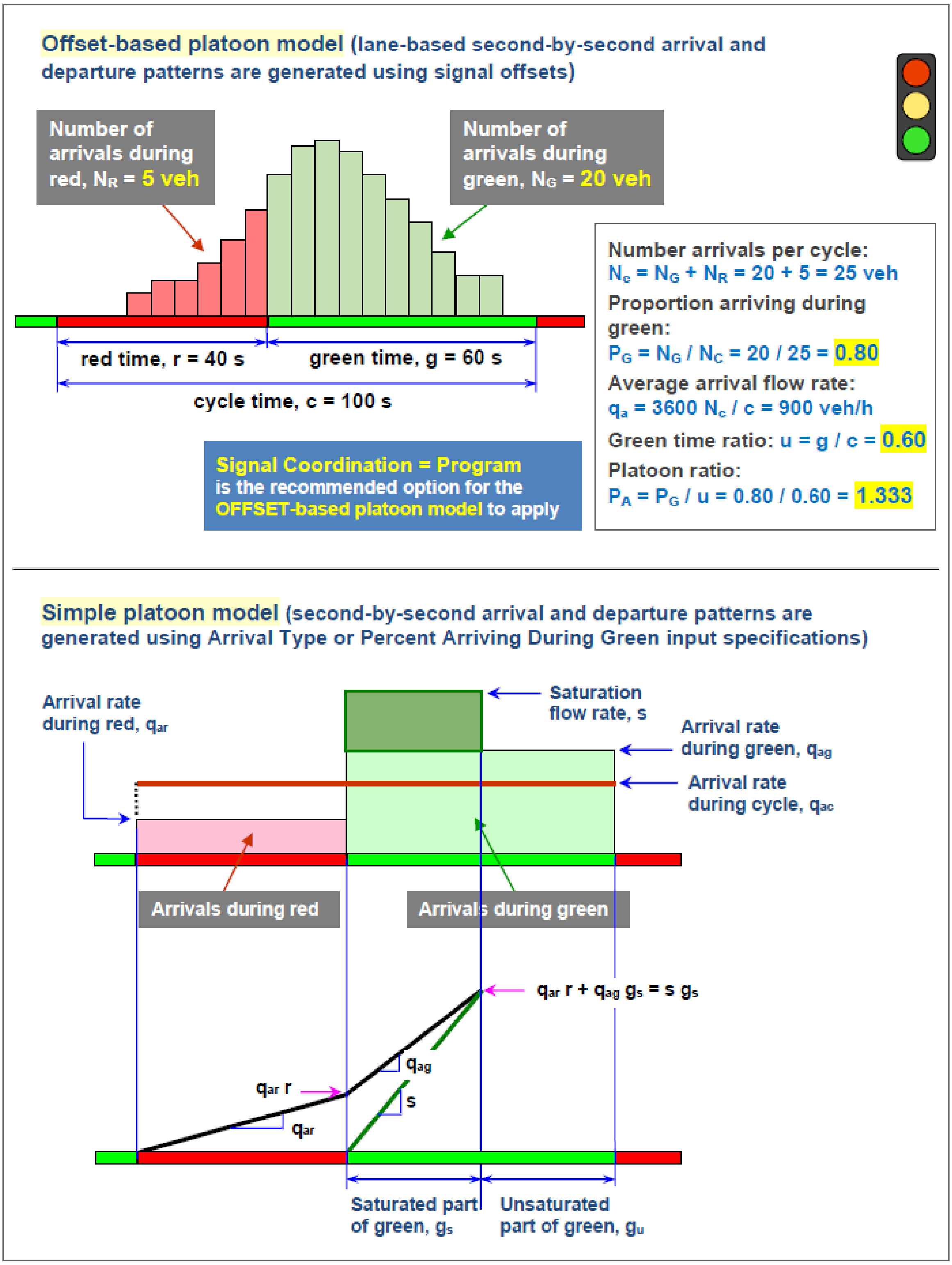


4.5.3 Network Outputs

Main Roads recommends that the following outputs are reported:

- Network Level of Service (LoS).
- Capacity adjustment (*Cap Adj %*) and blockage probability (*Prob. Block %*) – should be checked if the capacity adjustment (reduction) was applied on any downstream lane in the network due to upstream lane blockage.
- Degree of Saturation (*DoS*) – lane DoS should be checked for all lanes.
- Lane utilisation ratio (*Lane Util %*) – should be checked and reported if it is less than 100 per cent.
- Mid-block inflow and outflow rates (*Net Inflow/Outflow*) – should be checked and reported if it is not zero. Network flows can be displayed as an image in the modelling report.
- Mid-block lane change rates – should be checked and reported if the value is high.
- Arrival flow rates (*Arrival Flows*) – should be checked and reported if the capacity constraint at oversaturated upstream lanes causes a reduction in the arrival flow values.
- Platoon ratio ($\frac{\%\ Arrival\ During\ Green}{Green\ Time\ Ratio}$) – a platoon ratio greater than 1 is desirable (refer to Figure 4-38).

Figure 4-38: Platoon models for signal coordination effects on arrival flow pattern



Source: SIDRA Intersection User Guide

5 Vissim Guidelines

5.1 Introduction

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

The software uses a behaviour-based stochastic modelling approach to simulate vehicle-to-vehicle and control device interactions. It has the ability to provide visual outputs to demonstrate the modelled condition in a simulation and graphical format.

This section is designed to complement the *PTV Vissim User Manual*. It provides detail on key parameters to be adopted when undertaking Vissim mesoscopic, microscopic and hybrid simulation modelling in Western Australia.

Modellers should refer to sections 1and 2 for the overview of traffic modelling.

5.1.1 Appropriate Use of Vissim

Vissim can assess the performance of any transport networks, however, it is typically data and labour intensive to achieve accurate modelling of the complex and adaptive operations, compared to micro-analytical software such as LinSig and SIDRA. It is therefore recommended to use Vissim when evaluating the performance of detailed operations that exhibit:

- Network-wide traffic capacity implications when part of the network becomes over-saturated.
- Closely spaced intersections or interchanges.
- Advanced traffic management schemes (for example priority signals, congestion management).
- Complex intersection or interchange layouts.
- Complex or dynamic (non-cyclic or demand-based) signal operations.
- Feasibility studies for high occupancy vehicle and high occupancy toll lanes.
- Impact analysis of infrastructure design such as highway corridor improvement.
- Impact of heavy vehicles to network capacity.
- Evaluation of variable speed policies and other intelligent transportation systems.
- A high level of pedestrian interaction.

5.1.2 Software Version

This guideline is based on version 20 of Vissim. While the *Operational Modelling Guidelines* will need to be updated for future versions of the software, the general principles outlined will continue to apply.

5.2 Model Base Data

The base data for simulation models should be defined prior to building the models. The defined base data includes network settings, model input time periods, various vehicle types, vehicle classes and driving behaviours.

5.2.1 Network Settings

Network settings are the general base data for the entire network. This section outlines the recommended network settings for the Western Australian transport network in Vissim.

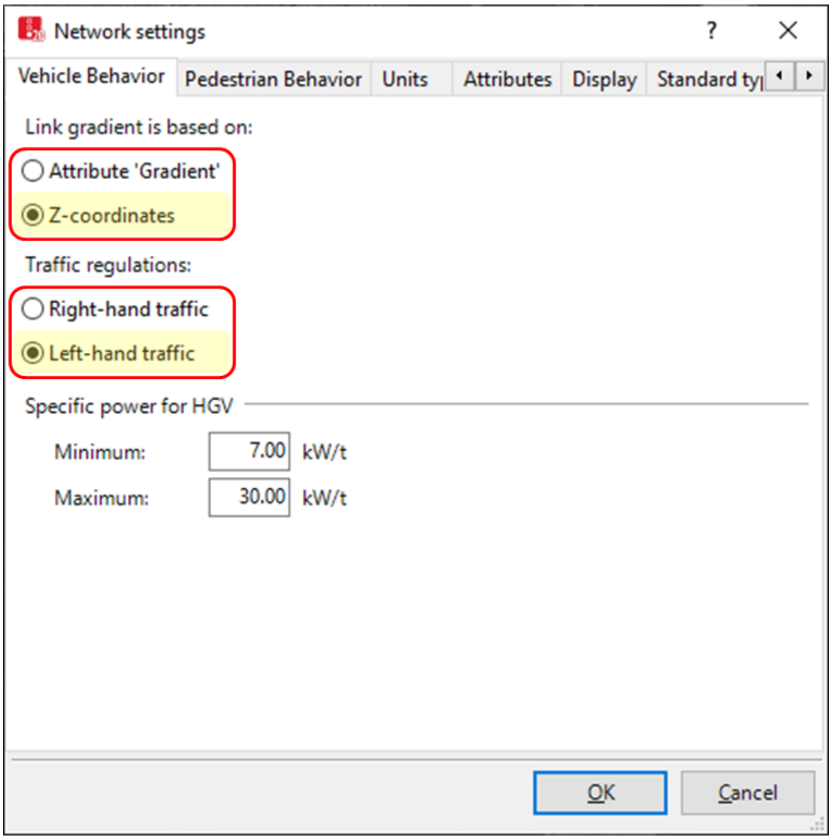
5.2.1.1 Vehicle Behaviour

Left-hand traffic should be adopted for *Traffic regulations*.

If the model includes network components where link gradients will play an important part (for example the impacts of heavy vehicle performance), these should be included in the *Vehicle Behaviour* tab in the *Network Settings* window (as shown in Figure 5-1). The modeller can either use the gradient attribute as a direct input or use Z-coordinates with the model calculating the gradient based on link lengths:

- Gradient attribute – is recommended where the number of locations is minimal and gradients/elevations are unlikely to change across models.
- Z-coordinate approach – is more appropriate for use across a larger network or for networks with significant elevation changes.

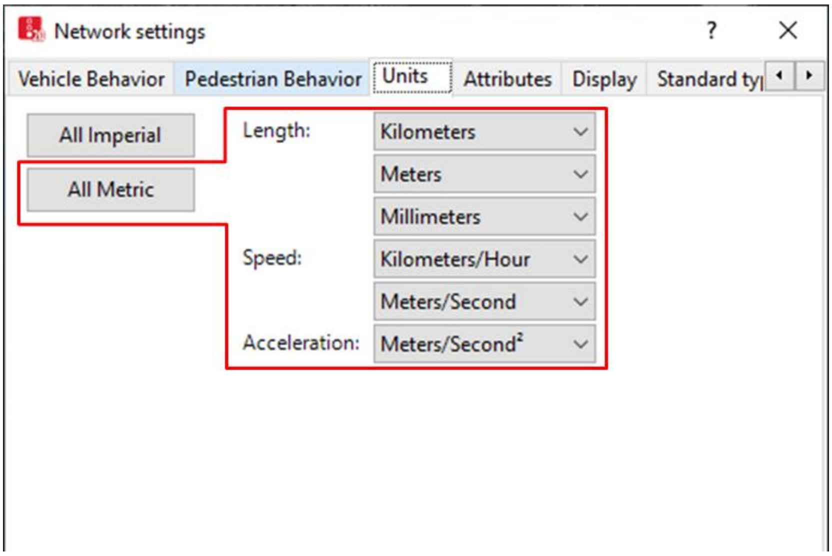
Figure 5-1: Recommended vehicle behaviours



5.2.1.2 Units

In the *Units* tab (as shown in Figure 5-2), the metric system should be adopted.

Figure 5-2: Recommended units



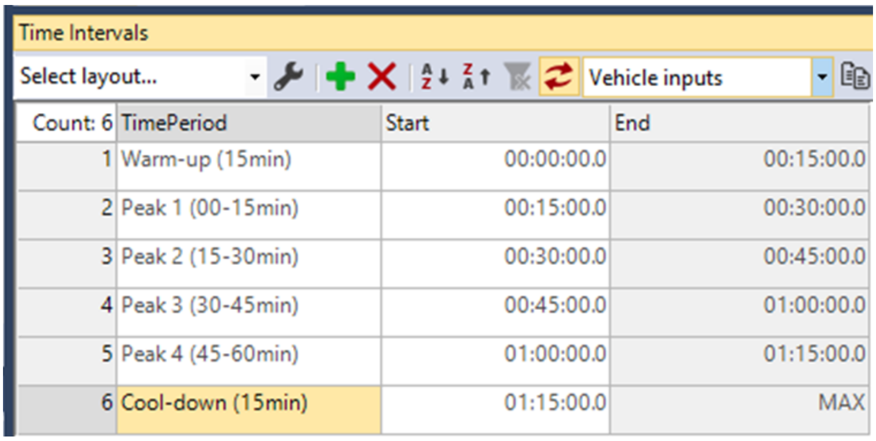
5.2.2 Time Period Settings

The modelling should not only include the simulation assessment period, but also the warm-up and cool-down periods. The warm-up period is the time allowed for the traffic demands and queues to reflect a realistic level of congestion as observed on-site at the beginning of the analysis period. The cool-down period is the time that allows vehicles to complete their trips and replicate the congestion observed at end of the analysis period.

The duration of the warm-up and cool-down periods should be sufficient for the traffic volumes and queues in the network to reflect the traffic conditions observed on-site. Depending on the model network size, a minimum of two times of the longest travel time or 15 minutes (whichever is greater) should be defined for each of the warm-up and cool-down periods. The duration for the warm-up and cool-down periods should be agreed with Main Roads.

Figure 5-3 demonstrates time intervals defined for a static assignment model for a one hour assessment period, and 15 minute warm-up and cool-down periods.

Figure 5-3: Vehicle input time intervals



Count: 6	TimePeriod	Start	End
1	Warm-up (15min)	00:00:00.0	00:15:00.0
2	Peak 1 (00-15min)	00:15:00.0	00:30:00.0
3	Peak 2 (15-30min)	00:30:00.0	00:45:00.0
4	Peak 3 (30-45min)	00:45:00.0	01:00:00.0
5	Peak 4 (45-60min)	01:00:00.0	01:15:00.0
6	Cool-down (15min)	01:15:00.0	MAX

5.2.3 Vehicle Types

Traffic surveys should contain information on the vehicle compositions to be modelled.

Vehicles in Western Australia can be classified using the *Austroads Vehicle Classification System*. The model should include vehicle types which are critical to the performance of the network or are a primary component of the project's objectives. Figure 5-1 shows the breakdown of the recommended minimum vehicle types to be defined in the model.

Table 5-1: Recommended vehicle types

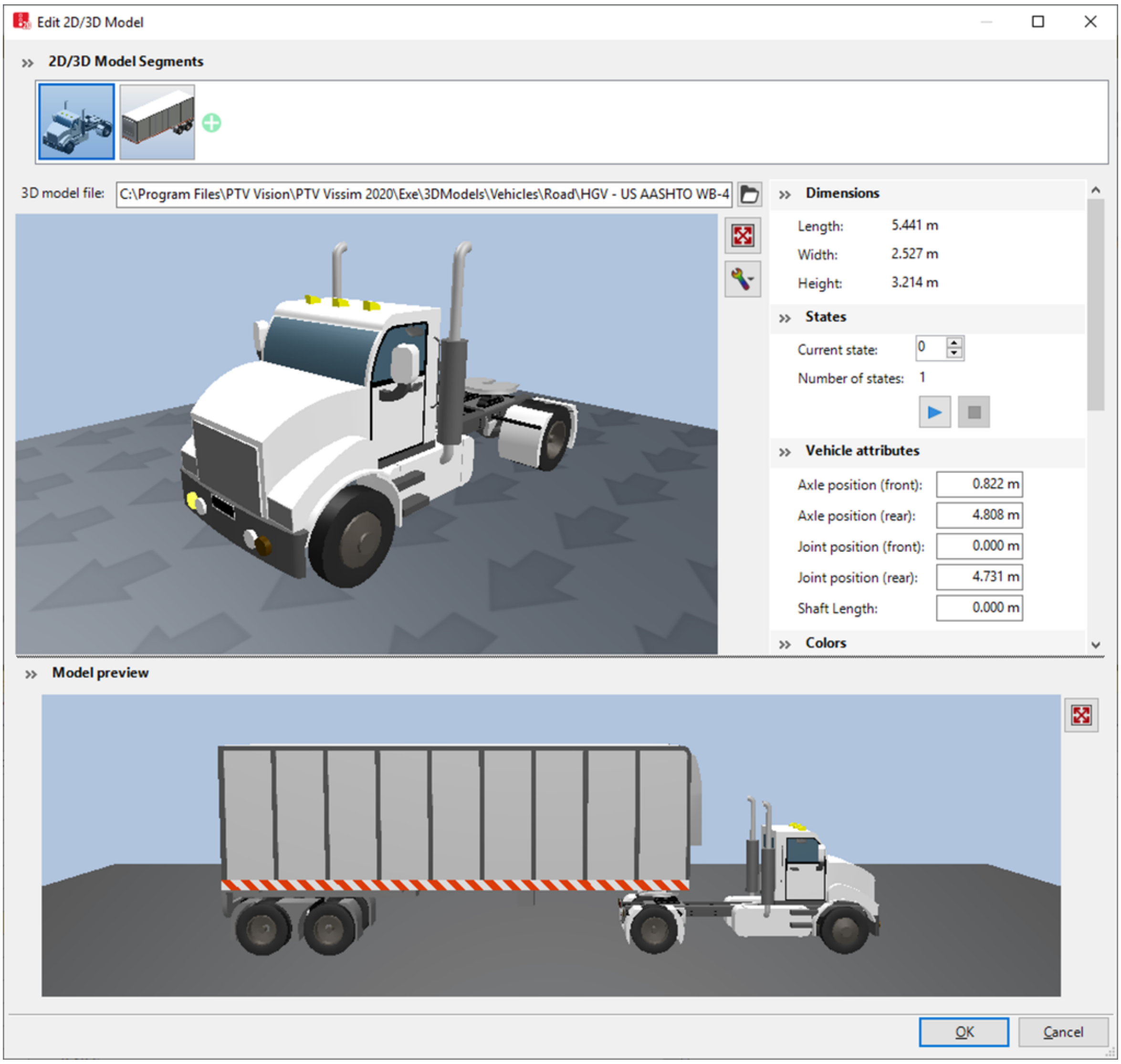
Vehicle type	Axles	Axle groups	Length
1 Short		1 or 2	Short (up to 5.5 m)
2 Short-towing	3, 4 or 5	3	Medium (5.5 m to 14.5 m)
3 Two axle truck	2	2	
4 Three axle truck	3	2	
5 Four axle truck	> 3	2	
6 Three axle articulated	3	3	Long (11.5 m to 19.0 m)
7 Four axle articulated	4	> 2	
8 Five axle articulated	5	> 2	
9 Six axle articulated	6≥	> 2	
10 B-double	6>	4	Medium combination (17.5 m to 36.5 m)
11 Double road train	6>	5 or 6	
12 Triple road train	6>	> 6	Large combination (over 33.0 m)

For projects that include the evaluation of public transport facilities, schemes or operation efficiencies, the Vissim default vehicle types for public transport can be used.

5.2.3.1 2D/3D Model

For all vehicle types, 2D and 3D models should be defined based on the vehicle model profiles and connected with the corresponding 2D and 3D model distributions and vehicle types. An example of 2D and 3D models and model distributions defined in a Vissim model is shown in Figure 5-4.

Figure 5-4: 2D and 3D models defined in Vissim



5.2.3.2 Acceleration and Deceleration Attributes

In the base model build, the default desired and maximum deceleration attributes can be adopted as a starting point for the vehicle types. For the desired heavy vehicle acceleration the values in Figure 5-2 should be adopted. The desired acceleration values were estimated by the Main Roads' Operational Modelling and Visualisation team, based on

- acceleration rates and power usages from Typical maximum acceleration rates for tractor-semitrailer combination trucks documented in the ITE traffic engineering handbook (Pline ,1999), and
- power and mass ranges stipulated in Heavy Vehicle Dynamics and Microsimulation Modelling (by Graham Jacoby, MRWA).

Table 5-2: Desired acceleration attributes for heavy vehicle types

Vehicle Type	X (km/h)	0	32	40	48	56	64	72	80	88	96	120
3	yMin(m/s^2)	0.664	0.664	0.597	0.530	0.419	0.309	0.278	0.247	0.172	0.098	0.000
	Y(m/s^2)	1.053	1.053	1.041	1.029	0.809	0.588	0.556	0.524	0.283	0.043	0.000
	yMax(m/s^2)	1.930	1.930	1.930	1.930	1.587	1.243	1.112	0.980	0.506	0.031	0.000
4	yMin(m/s2)	0.552	0.552	0.470	0.387	0.308	0.230	0.199	0.167	0.140	0.113	0.000
	Y(m/s2)	0.761	0.761	0.708	0.655	0.517	0.379	0.347	0.316	0.200	0.084	0.000
	yMax(m/s2)	1.004	1.004	0.986	0.967	0.760	0.553	0.521	0.489	0.269	0.050	0.000
5	yMin(m/s2)	0.482	0.482	0.390	0.298	0.240	0.181	0.148	0.115	0.114	0.112	0.000
	Y(m/s2)	0.618	0.618	0.544	0.471	0.374	0.277	0.245	0.214	0.159	0.104	0.000
	yMax(m/s2)	0.761	0.761	0.708	0.655	0.517	0.379	0.347	0.316	0.200	0.084	0.000
6	yMin(m/s2)	0.599	0.599	0.523	0.446	0.355	0.263	0.232	0.200	0.154	0.107	0.000
	Y(m/s2)	0.761	0.761	0.708	0.655	0.517	0.379	0.347	0.316	0.200	0.084	0.000
	yMax(m/s2)	1.819	1.819	1.819	1.819	1.489	1.160	1.042	0.925	0.478	0.031	0.000
7	yMin(m/s2)	0.499	0.499	0.409	0.318	0.255	0.191	0.16	0.129	0.125	0.121	0.000
	Y(m/s2)	0.761	0.761	0.708	0.655	0.517	0.379	0.347	0.316	0.200	0.084	0.000
	yMax(m/s2)	1.819	1.819	1.819	1.819	1.489	1.160	1.042	0.925	0.478	0.031	0.000
8	yMin(m/s2)	0.491	0.491	0.399	0.308	0.247	0.186	0.154	0.123	0.123	0.122	0.000
	Y(m/s2)	0.664	0.664	0.597	0.530	0.419	0.309	0.278	0.247	0.172	0.098	0.000
	yMax(m/s2)	0.831	0.831	0.787	0.744	0.586	0.429	0.397	0.365	0.220	0.074	0.000
9	yMin(m/s2)	0.501	0.501	0.411	0.321	0.257	0.193	0.162	0.130	0.126	0.121	0.000
	Y(m/s2)	0.649	0.649	0.580	0.510	0.405	0.299	0.267	0.236	0.168	0.100	0.000
	yMax(m/s2)	0.883	0.883	0.847	0.811	0.638	0.466	0.434	0.403	0.235	0.067	0.000
10	yMin(m/s2)	0.409	0.409	0.317	0.225	0.191	0.157	0.100	0.043	0.017	0.000	0.000
	Y(m/s2)	0.518	0.518	0.430	0.342	0.274	0.205	0.174	0.143	0.130	0.118	0.000
	yMax(m/s2)	0.717	0.717	0.657	0.598	0.473	0.347	0.316	0.284	0.187	0.090	0.000
11	yMin(m/s2)	0.368	0.368	0.276	0.185	0.126	0.068	0.007	0.000	0.000	0.000	0.000
	Y(m/s2)	0.409	0.409	0.317	0.225	0.191	0.157	0.100	0.043	0.017	0.000	0.000
	yMax(m/s2)	0.622	0.622	0.549	0.476	0.378	0.279	0.248	0.217	0.160	0.104	0.000
12	yMin(m/s2)	0.346	0.346	0.254	0.162	0.082	0.002	0.000	0.000	0.000	0.000	0.000
	Y(m/s2)	0.464	0.464	0.372	0.280	0.228	0.175	0.136	0.097	0.090	0.082	0.000
	yMax(m/s2)	0.582	0.582	0.503	0.425	0.338	0.251	0.219	0.188	0.149	0.109	0.000

5.2.3.3 Power and Weight Distributions

In the base model, the default power and weight distributions can be adopted for vehicle types including cars, buses, coaches, motorcycles and bicycles. In addition, appropriate power and weight distributions should be identified and defined for the heavy vehicle types.

Figure 5-3 shows recommended power and weight distributions for heavy vehicle types that should be adopted in the base model and referenced at the calibration stage.

Table 5-3: Recommended Power and Weight Distributions for Heavy Vehicles

Name	Power distribution (kW)	Weight distribution (t)		
		Minimum	Medium	Maximum
240 hp	180	6.0	9.7	25.7
300 hp	225	7.5	12.2	32.1
400 hp	300	10.0	16.2	42.9
500 hp	375	12.5	20.3	53.6
600 hp	450	15.0	24.3	64.3

5.2.3.4 Colour Distributions

In the base model, colour distributions should be defined and adopted for the vehicle types. Different colours for each vehicle type enables modellers and model auditors to check the model's efficiently by easily identifying different vehicle type while running Vissim simulation.

Figure 5-4 demonstrates the recommended colour distributions that are categorized based on vehicle classes stipulated in Section 5.2.4. When the scope of modelling is to assess bus operations, the modellers should define a separate vehicle type and colour distribution for buses accordingly. The recommended colour for buses is green.

Table 5-4: Recommended colour distribution

Name	Colour (RGB)	Share (%)	Vehicle Type
1 Short	Aqua (0,255,255)	100%	1 Short, 2 Short-towing
2 Medium	Lime Green (182,255,0)	100%	3 Two axle truck, 4 Three axle truck, 5 Four axle truck
3 Long	Pink (255,127,237)	100%	6 Three axle articulated, 7 Four axle articulated, 8 Five axle articulated, 9 Six axle articulated
4 Medium combination	Orange (255,106,0)	100%	10 B-double, 11 Double road train
5 Large combination	Red (255,0,0)	100%	12 Triple road train
6 Bus	Green (38,127,0)	100%	30 Bus

5.2.3.5 Vehicle Type Attributes

Figure 5-5 shows an example of the recommended vehicle types and selected attributes in a Vissim model.

Figure 5-5: Recommended Attributes for Vehicle Types

Vehicle Types

Count: 18	Name	Category	Model2D3DDistr	PowerDistr	WeightDistr	DesAccelFunc	MaxAccelFunc	DesDecel...	MaxDec...	ColorDistr1
1	Short vehicle	Car	1: Short vehicle			1: Car	1: Car	1: Car	1: Car	1: Short
2	Short vehicle towing	Car	2: Short vehicle towing			1: Car	1: Car	1: Car	1: Car	1: Short
3	Two-axle truck or bus	HGV	3: Two-axle truck or bus	2: 240hp (180kW)	2: 240hp (6.0-25.7ton)	3: Two axle truck	3: Two axle truck	2: HGV	2: HGV	2: Medium
4	Three-axle truck or bus	HGV	4: Three-axle truck or bus	3: 300hp (225kW)	3: 300hp (7.5-32.1ton)	4: Three axle truck	4: Three axle truck	2: HGV	2: HGV	2: Medium
5	Four-axle truck	HGV	5: Four-axle truck	3: 300hp (225kW)	3: 300hp (7.5-32.1ton)	5: Four axle truck	5: Four axle truck	2: HGV	2: HGV	2: Medium
6	Three-axle articulated	HGV	6: Three-axle articulated	3: 300hp (225kW)	3: 300hp (7.5-32.1ton)	6: Three axle articulated	6: Three axle articulated	2: HGV	2: HGV	3: Long
7	Four-axle articulated	HGV	7: Four-axle articulated	3: 300hp (225kW)	3: 300hp (7.5-32.1ton)	7: Four axle articulated	7: Four axle articulated	2: HGV	2: HGV	3: Long
8	Five-axle articulated	HGV	8: Five-axle articulated	4: 400hp (300kW)	4: 400hp (10.0-42.9ton)	8: Five axle articulated	8: Five axle articulated	2: HGV	2: HGV	3: Long
9	Six-axle articulated	HGV	9: Six-axle articulated	4: 400hp (300kW)	4: 400hp (10.0-42.9ton)	9: Six axle articulated	9: Six axle articulated	2: HGV	2: HGV	3: Long
10	B-double	HGV	10: B-double	5: 500hp (375kW)	5: 500hp (12.5-53.6ton)	10: B-double	10: B-double	2: HGV	2: HGV	4: Medium Combination
11	Double road train	HGV	11: Double road train	5: 500hp (375kW)	5: 500hp (12.5-53.6ton)	11: Double road train	11: Double road train	2: HGV	2: HGV	4: Medium Combination
12	Triple road train	HGV	12: Triple road train	6: 600hp (455kW)	6: 600hp (15.0-64.3ton)	12: Triple road train	12: Triple road train	2: HGV	2: HGV	5: Large Combinati

5.2.4 Vehicle Classes

The defined vehicle types should be grouped into vehicle classes based on vehicle characteristics such as vehicle length and turning speed. The recommended vehicle classes for the vehicle types defined (based on the *Austroads Vehicle Classification System*) are set out in Figure 5-5. The vehicle classes are grouped together based on vehicle length.

Table 5-5: Recommended vehicle classes

Vehicle class	Vehicle types
1 Short	1 Short, 2 Short-towing
2 Medium	3 Two axle truck, 4 Three axle truck, 5 Four axle truck
3 Long	6 Three axle articulated, 7 Four axle articulated, 8 Five axle articulated, 9 Six axle articulated
4 Medium combination	10 B-double, 11 Double road train
5 Large combination	12 Triple road train

When the project area includes specific vehicle facilities (for example an exclusive bus lane, bicycle lane, pedestrian footpaths), appropriate vehicle types and classes should be defined to reflect the vehicle movements associated with user characteristics.

5.2.5 Driving Behaviours

Various link types represent the different roadway classes in Western Australia, such as urban roads, freeways and merging areas.

5.2.5.1 General

Driving behaviours should be defined for each of the link types:

- Urban – for all urban roads including collectors, distributors and arterial networks.
- Freeway – for use on motorways with no controls on lane choice.
- Merging areas – the modeller should define additional driving behaviours and link type to reflect the merging behaviour observed on-site.

Default driving behaviours should generally be adopted, with the exception of *car following model parameters,* and *waiting time before diffusion* to reflect observed driving behaviours.

Car following model parameters to be updated are*:*

- *Standstill distance* – 2.5 metres.
- *Additive part of safety distance* and *Multiplic. part of safety distance* values should be determined based on measured straight movement saturation flow at key intersection(s). Figure 5-6 demonstrates recommended values for the parameters.

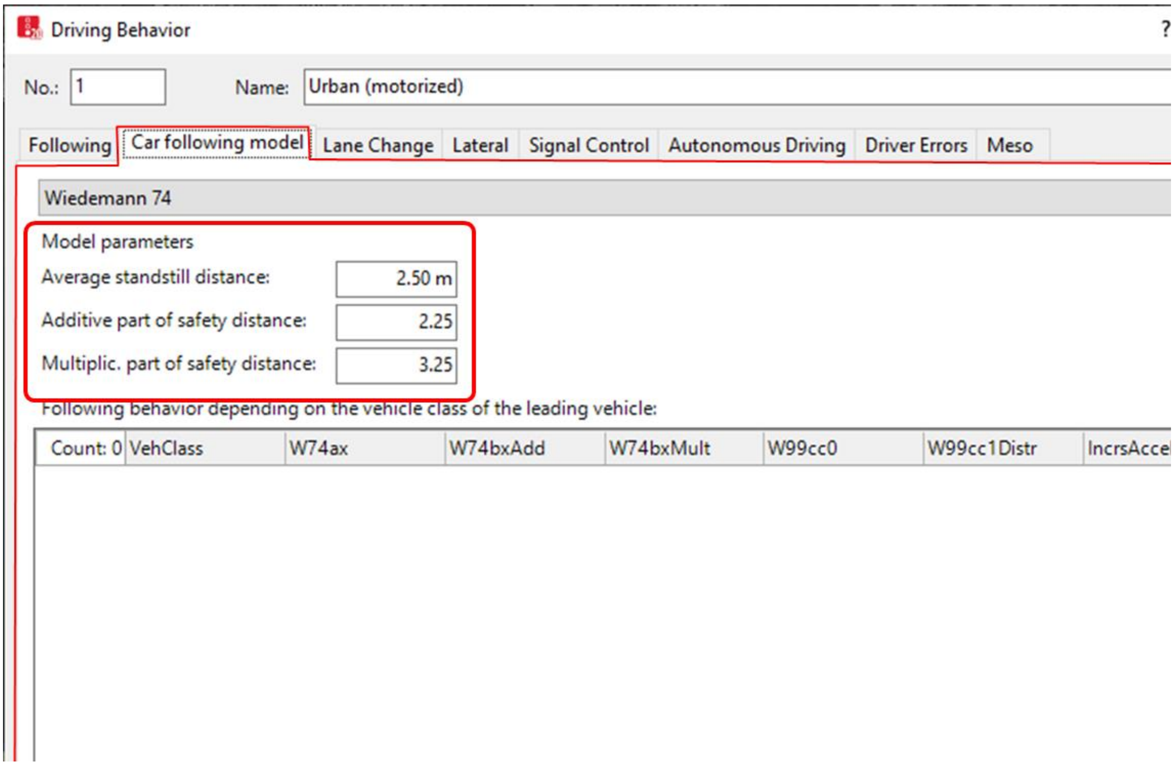
Table 5-6: Recommended car following model parameters

Average saturation flow (pcu)	Additive part of safety distance	Multiplic. part of safety distance
1,630	2.75	3.75
1,780	2.50	3.50
1,950	2.25	3.25
2,050	2.00	3.00
2,100	1.75	2.75
2,200	1.50	2.50

The recommended *car following* parameter values are based on the saturation flow chart stipulated in the *PTV Vissim 2020 User Manual*.

Figure 5-6 highlights the *car following* model parameters that should be amended for *urban (motorized) driving behaviours*.

Figure 5-6: Car following model parameters for urban driving behaviours



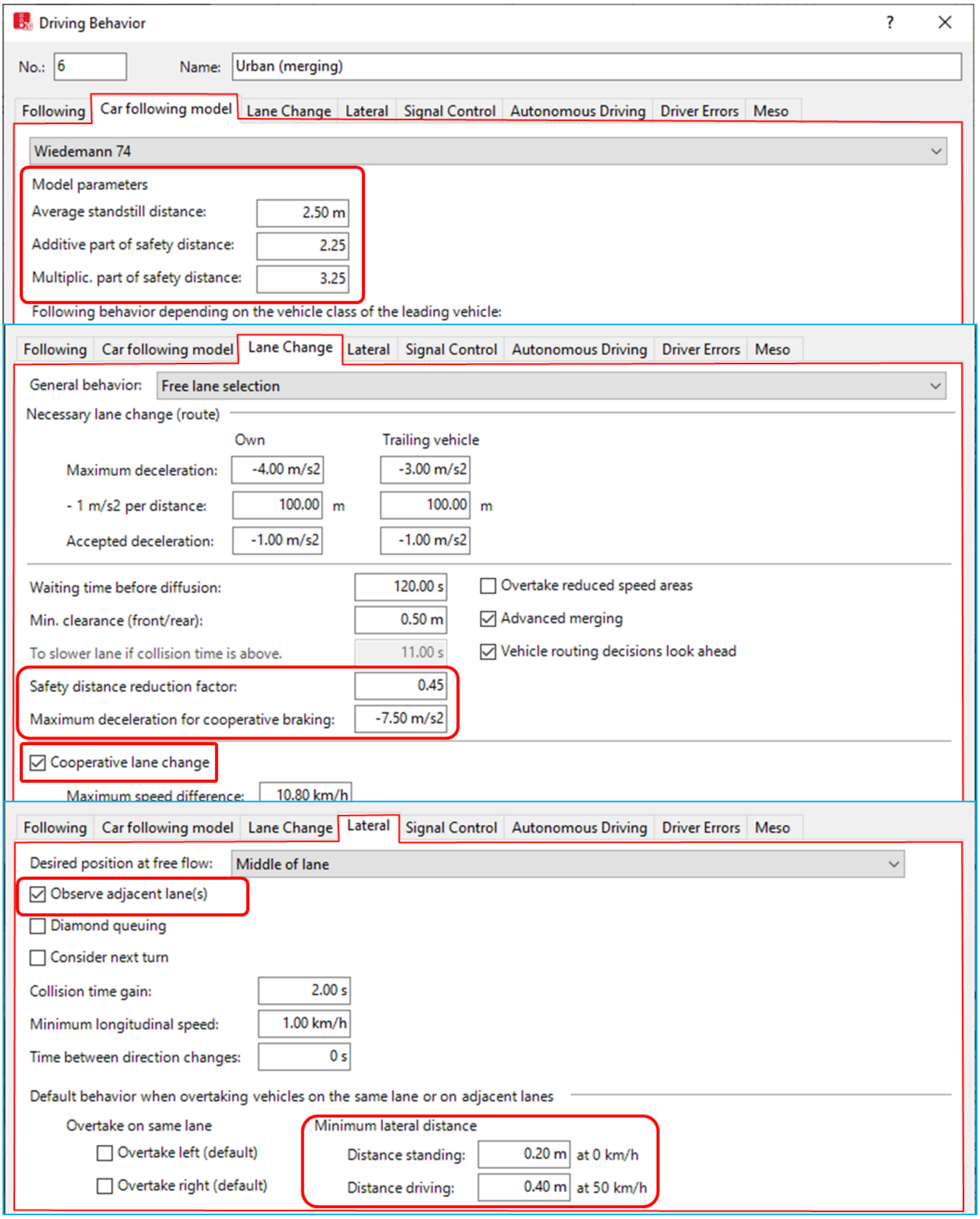
Waiting time before diffusion in the *urban driving behaviour* parameters should be increased to the maximum observed signal cycle time to avoid waiting vehicles being removed during simulation.

Driving behaviour for a merging area should be defined based on the updated *urban (motorized) car following* model parameters, with changes made to the *lane-change* and the *lateral* parameters

- *Average standstill distance* (2.5 m)
- *Updated additive part of safety distance* and *multiplic. part of safety distance*
- *Safety distance reduction factor* – 0.25 to 0.45
- *Maximum deceleration for cooperative braking* – from -5.00 m/s^2 to -9.00 m/s^2
- *Cooperative lane change* to be ticked
- *Observe adjacent lane(s)* to be ticked
- *Minimum lateral distance standing at 0 km/h* – 0.1 m to 0.4 m, and
- *Minimum lateral distance driving at 50 km/h* – 0.2 m to 1.0 m.

The factors should be determined based on driving behaviours observed on-site. Figure 5-7 highlights the *driving behaviour* parameters that should be amended for a merging area.

Figure 5-7: Driving Behaviour (merging) - Lane Change and Lateral tabs



For specific locations where the observed driving behaviours are different from the simulation, modellers can adjust the *driving behaviour* parameters to better reflect the observed behaviours. This should be documented in the modelling report.

At locations where vehicles on adjacent lanes are observed to be affected by the lateral clearance between vehicles, the modeller should apply appropriate lateral driving behaviour settings for the relevant links and connectors.

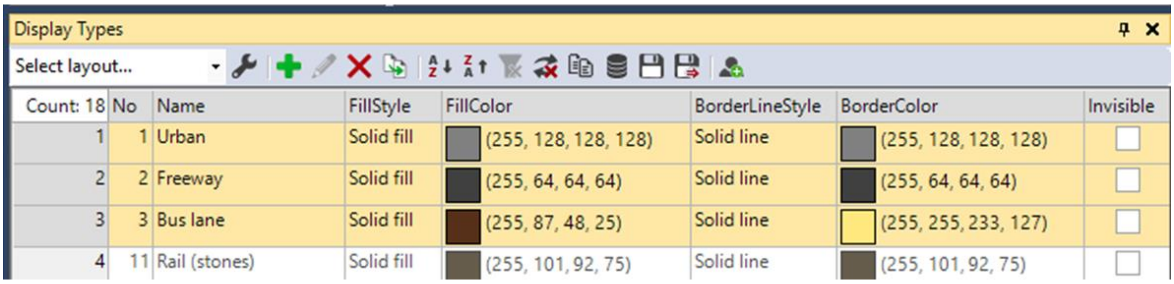
The number of driving behaviour types should be minimised, and the modeller should ensure that all similar driving behaviour types are consolidated unless they need to be modelled separately.

5.2.5.2 Display Types

Display types can be used when specifying the representation of network objects in a Vissim model. Using display types for different network object types (e.g. links with different link behaviour types), modellers and model auditors can review Vissim models efficiently by easily recognising network object types. Therefore, it is recommended that modellers define different display types and use them representing different link behaviour or lane types.

Figure 5-8 demonstrates the recommended display types for link behaviour and lane types.

Figure 5-8: Recommended display types



Display Types

Select layout...

Count: 18	No	Name	FillStyle	FillColor	BorderLineStyle	BorderColor	Invisible
1	1	Urban	Solid fill	(255, 128, 128, 128)	Solid line	(255, 128, 128, 128)	☐
2	2	Freeway	Solid fill	(255, 64, 64, 64)	Solid line	(255, 64, 64, 64)	☐
3	3	Bus lane	Solid fill	(255, 87, 48, 25)	Solid line	(255, 255, 233, 127)	☐
4	11	Rail (stones)	Solid fill	(255, 101, 92, 75)	Solid line	(255, 101, 92, 75)	☐

5.2.5.3 Desired Speed Profile

Default speed profiles (linear) should be adopted for all speed limits up to and including 60 km/h. For speed limits of 70 km/h or greater, the default values should be adjusted to align with prevailing driver behaviour.

Modellers should consult Main Roads for the speed distributions for roads with speed limits of 70km/h or greater prior to commencing modelling.

5.3 Network Data

Network data is used when building transport networks in Vissim. This section outlines recommended ways for Western Australian transport network development in Vissim.

5.3.1 Background Information

Main Roads recommends uploading background images for the network coding and verification. Modellers can also import network data from existing Visum and Vissim models.

5.3.1.1 Background Image

When developing the existing network the modeller should ensure up-to-date background aerial imagery is used. Changes to the existing network that may not be reflected in the background imagery must be incorporated into the network. Scaling of the background imagery should be undertaken using the project areas' coordinates and dimensions. It is the modeller's responsibility to ensure that the aerial imagery coordinate and proposed design coordinate systems are aligned.

5.3.1.2 Import Network Data from VISUM

Whilst a VISUM[22] network can be exported to create a Vissim network, the modeller should review and refine the network outputs and all associated network parameters and objects.

5.3.1.3 Import Network Data from Other Vissim Models

If the model is comprised of any elements from another model, all parameters should be checked to ensure there is consistency across all network objects including the base data. The details of the duplicated model components and the process should be provided in the modelling report.

5.3.2 Model Boundaries

To help confirm the model time period and boundaries, site visits should be undertaken in the relevant peak periods to confirm the geographic extent of congestion within the project area. This should be done prior to undertaking data collection exercises.

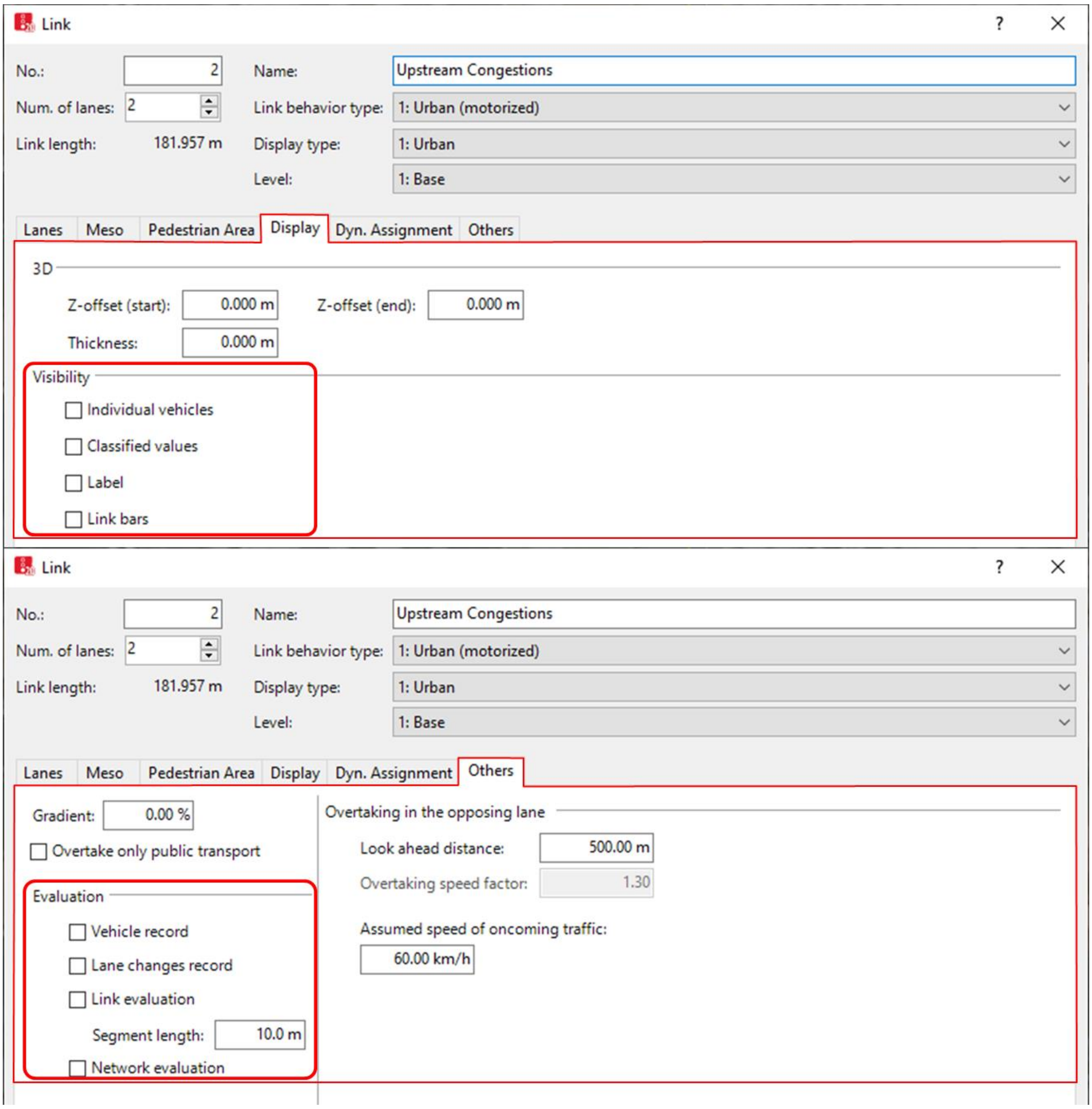
The model boundary should also consider the location of adjacent intersections surrounding key intersections. The inclusion of upstream and downstream intersections to control arrival and departure rates is often necessary.

[22] PTV VISUM software is used to model transport networks and travel demand, to analyse expected traffic flows, to plan public transport services and to develop advanced transport strategies and solutions.

5.3.2.1 Upstream Congestion

Links should be long enough so that all queuing traffic is within the model boundary. Vehicles queuing beyond the boundary may affect the number of vehicles within the model and the performance of the network modelled. As a result of certain existing traffic conditions, the back of queue may not always be contained. Where the road link extension is considered to be impractical, the modeller should report the un-captured condition as a limitation of the developed model. If the links have been extended and no longer represent the modelled network, visualisation and evaluation should be turned off in the *Link Display* and *Others* tabs respectively (as shown in Figure 5-9).

Figure 5-9: Link Display and Others tabs



5.3.2.2 Downstream Congestion

Downstream congestion such as exit blocking, which may exist beyond the boundary of the initial modelling area, and has an impact on traffic in the project area, should be included in the final modelling area to reflect the existing traffic conditions on-site. The modeller should illustrate the induced delays and congestion through the calibration and validation process.

5.3.3 Links and Connectors

Links and connectors are used for roads and paths that vehicles and pedestrians can move on. When coding links and connectors, it is recommended that:

- The number of links and connectors be minimised.
- Overlapping between links and connectors be minimised.
- Lane gains and lane drops (refer to Section 5.3.3.2) should be modelled using one connector to ensure merging and diverging movements are smoother and occur within the link. This will also minimise the number of alternative paths.

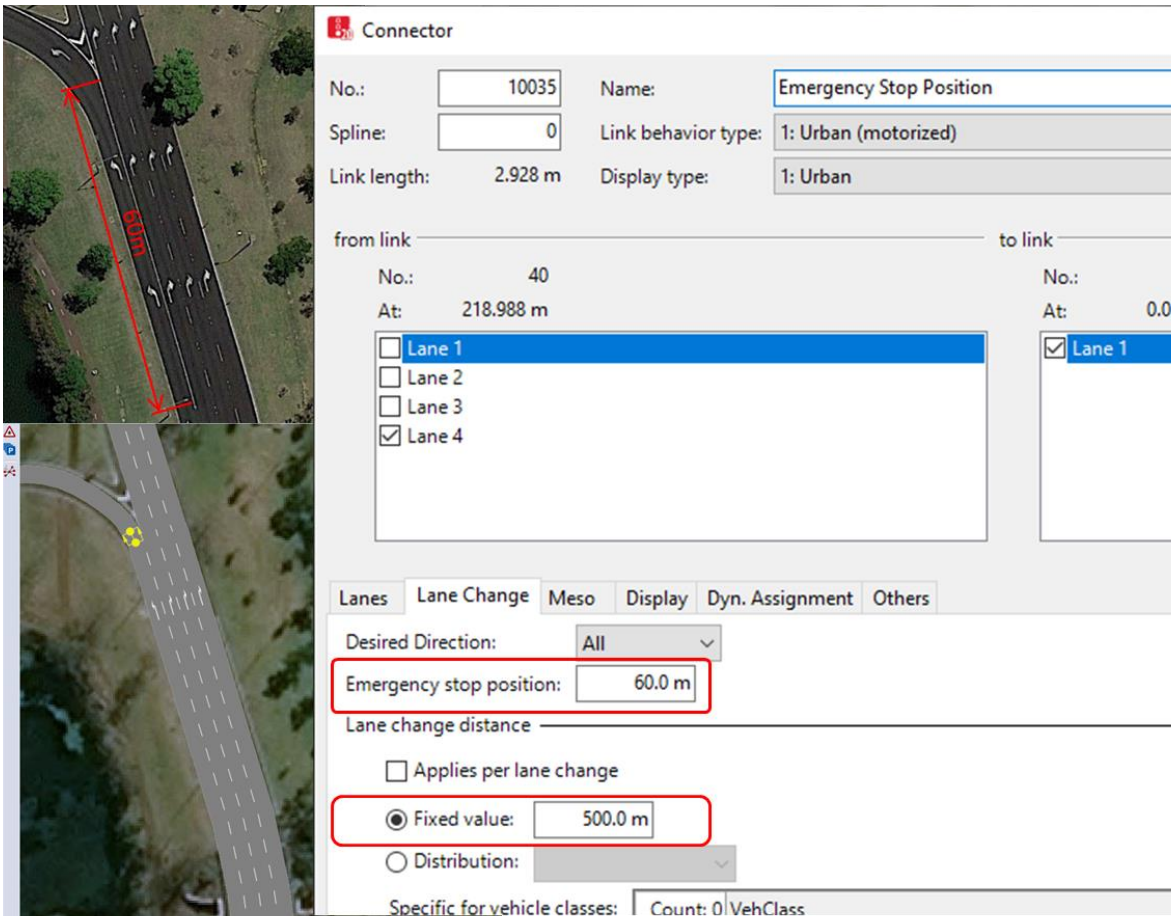
5.3.3.1 Connector Route Parameters

Connectors have attributes and options that affect vehicle behaviour in model simulation. Among the connector's attributes *emergency stop* and *lane change* parameters are used to model the lane change role of vehicles that follow their route or path.

Modellers should adjust the parameters to better reflect the driving behaviour and lane discipline observed on-site, however, 500 meters is recommended for the value of the *lane change* parameter at the diverging section, as a starting point.

Figure 5-10 shows an example of updated *emergency stop* and *lane change* parameters.

Figure 5-10: Emergency stop parameter update



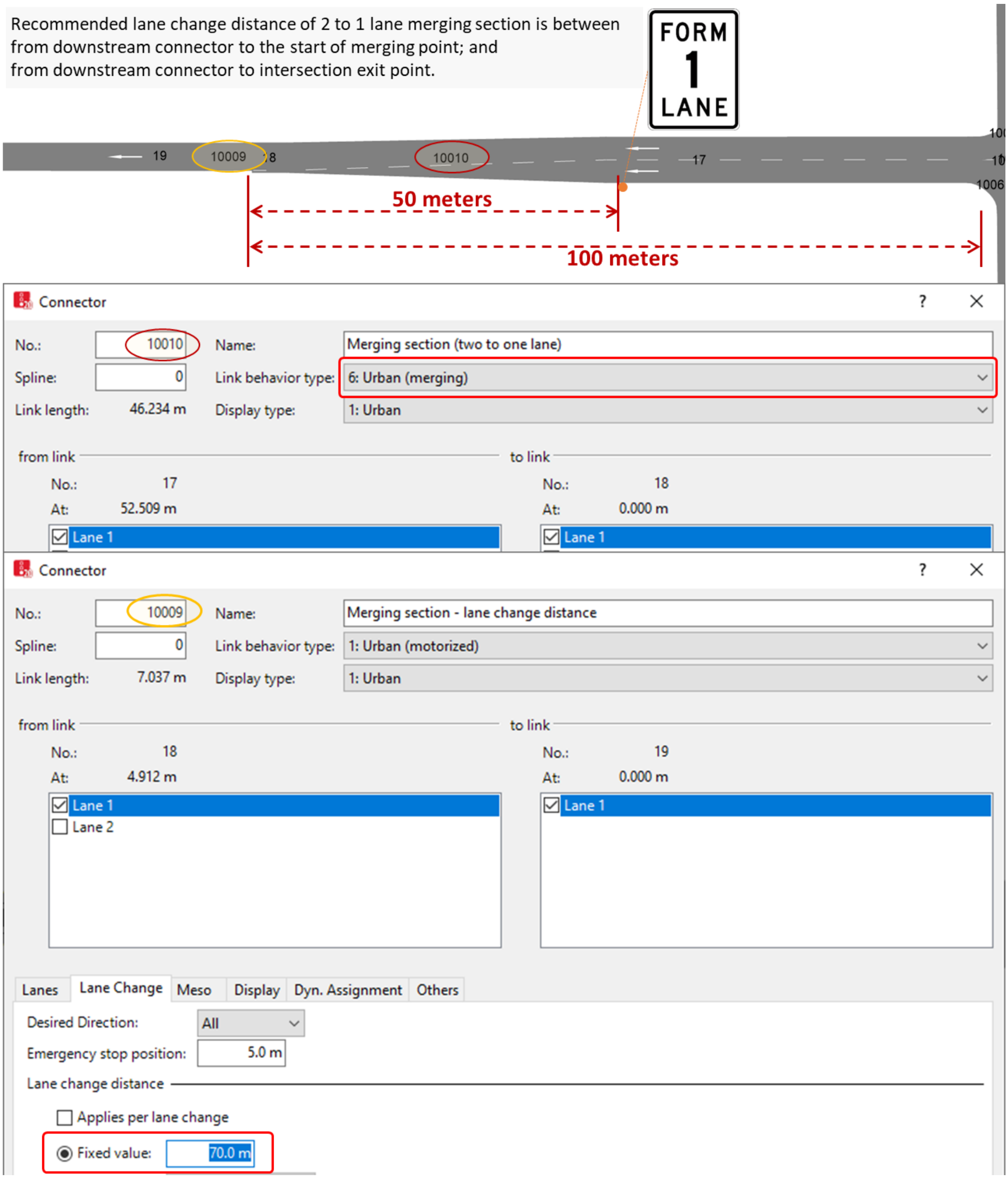
Emergency stop position of a turning lane connector should be at least the length of approach lane's solid line.

5.3.3.2 Merging Section Coding

For merging, modellers should code the sections in detail to better reflect the on-site observed behaviour, capacity and queue space.

Figure 5-11 demonstrates the *link coding*, *lane change distance* parameter, and link *behaviour type* adopted for a two-lane section merging into one lane.

Figure 5-11: Merging section – behaviour type and lane change distance



The *lane change* distance parameter of the downstream connector should be updated based on the vehicle lane change behaviour and upstream lane utilisation observed on site. The predefined behaviour type of merging (refer to Section 5.2.5.1) is selected for the merging connector.

The merging area in Figure 5-11 consists of multiple links and connectors. Table 5-7 shows the links and attributes adopted for the merging section.

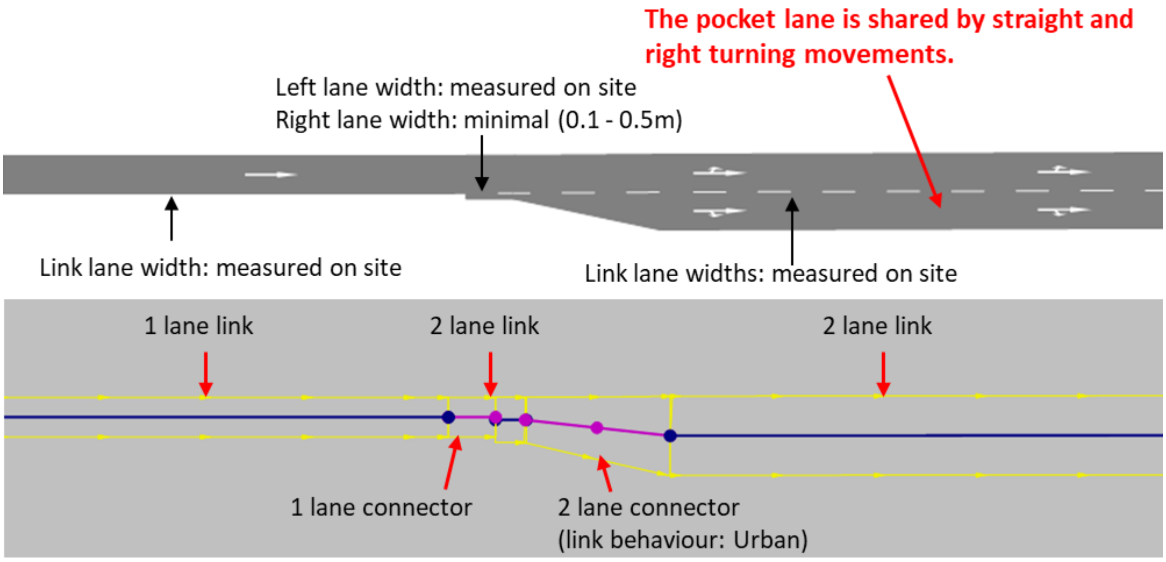
Table 5-7: Merging section links

Link number	19	10009	18	10010	17
Lane 1 width	3.5 m	3.5 m	3.5 m	3.5 m	3.5 m
Lane 2 width	-	-	0.5 m	0.5 to 3.5 m	3.5 m
Link behaviour type	1 Urban (motorized)	1 Urban (motorized)	1 Urban (motorized)	6 Urban (merging)	1 Urban (motorized)
Lane change distance	-	Merging distance	-	500 m	-

5.3.3.3 Diverging Section Coding

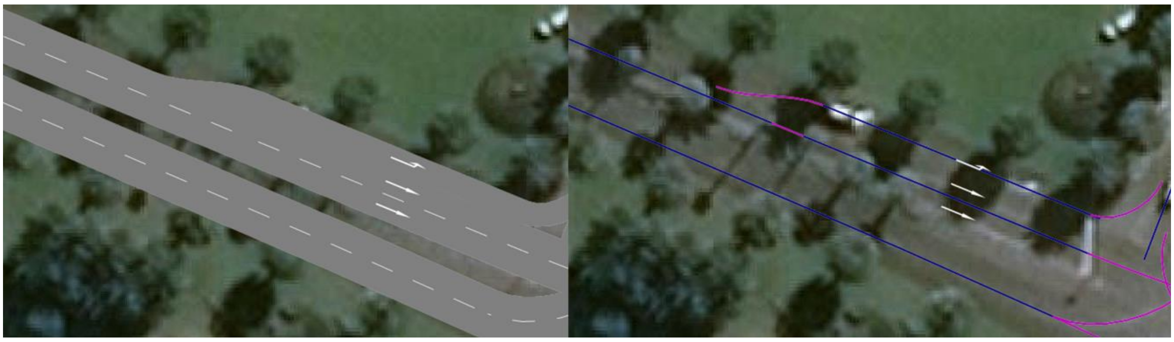
The intersection approach diverging areas should be coded in a similar manner with merging area link coding when the exit lane(s) is shared by multiple movements, and lane utilisation is critical to the approach's capacity, as shown in Figure 5-12.

Figure 5-12: Diverging section link coding for shared movements lane



When exit lanes are dedicated to a movement, separated link coding for the pocket lane is recommended as shown in Figure 5-13.

Figure 5-13: Diverging section link coding for dedicated movement lane

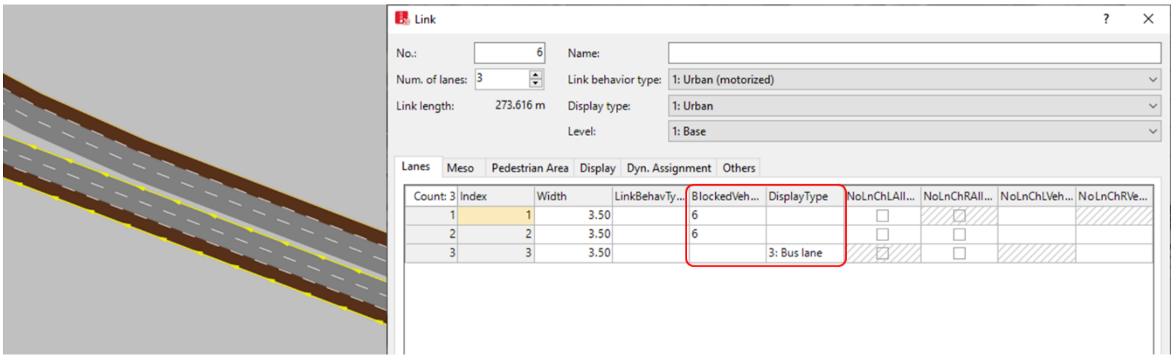


5.3.3.4 Dedicated Bus and Heavy Vehicle Lane

Where heavy vehicles are observed to only use a specific lane(s), for example corners with tight radii, lane closures should be used to ensure correct lane use.

To enable interaction between buses and general traffic, bus lanes should be coded as one lane of a link using lane closures rather than as a separate link. Bus lanes modelled using a separate link will not allow interaction between vehicles, especially at merge points or locations where general traffic must cross the bus lane to turn left (as shown in Figure 5-14).

Figure 5-14: Bus lane coding

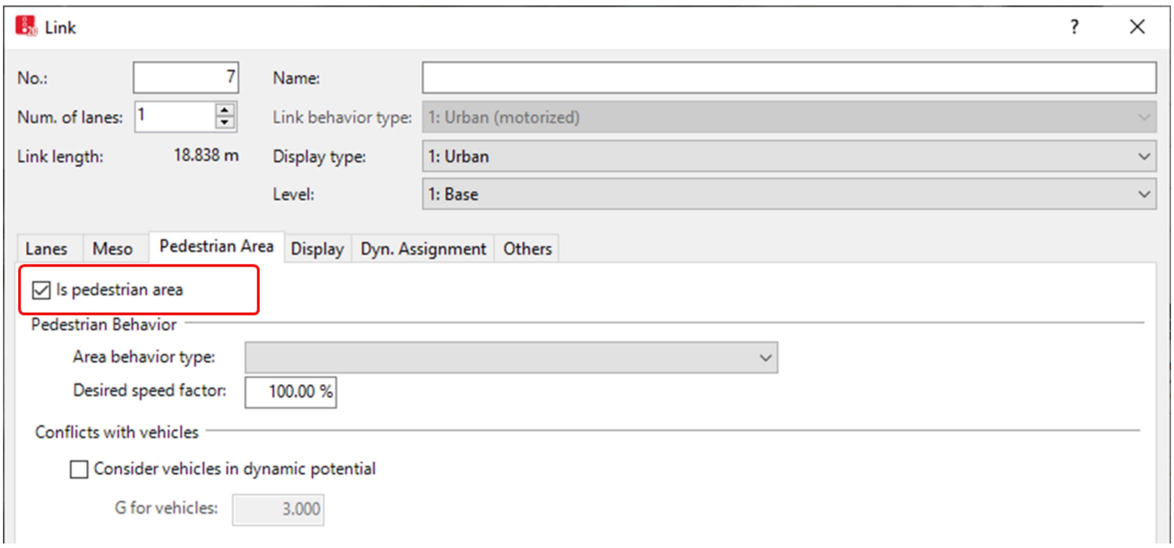


Along with the default link behaviour types, any additional link behaviour types with adjusted parameters can be defined in the model to reflect the traffic behaviours observed on-site. Additional link behaviour types and associated driving behaviour must be described and explained in the modelling report. User-defined driving behaviour links should be coded in a different display colour.

5.3.3.5 Pedestrian Crossings

Where pedestrian crossings are observed to impact the performance of the network (for example intersections in the CBD), *Use as pedestrian area* (as shown in Figure 5-15) should be selected and conflict areas between pedestrian and vehicular links should be defined to simulate the interaction between vehicle and pedestrian movements.

Figure 5-15: Link for pedestrian crossing



5.3.4 Desired Speed Decisions

Desired speed decision markers should be set where vehicles are observed to change speed. This is generally at posted speed limit sign locations. Modellers should generally follow the speed limit published in the road information mapping system available from Main Roads' website.

5.3.5 Reduced Speed Areas

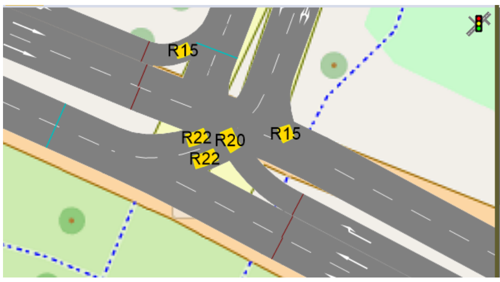
Reduced speed areas should be set at any location at which the road geometry prevents traffic from travelling at the posted speed safely (for example, tight bends, all turning movements or areas of poor visibility). In the base model build, the vehicle speed distributions for different turn types defined in Figure 5-8 can be adopted as a starting point.

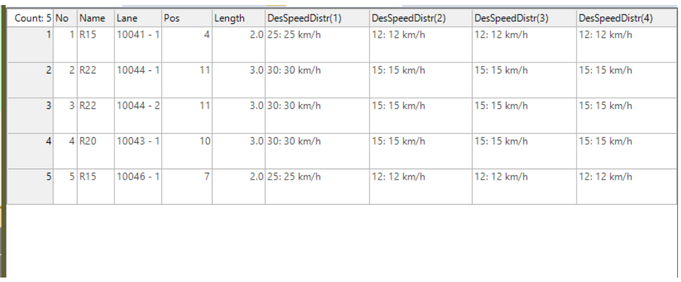
Table 5-8: Vehicle reduced speed range

Turn type / Radius (Approx.)	Typical example	Short – desired speed	HV – desired speed
Very tight turn 12.5 m	Turns entering/leaving car parks, driveways or other narrow roads/lanes	20 km/h (20-25 km/h)	5 km/h (4-6 km/h)
Tight turn 15.0 m	Most left-turn operations and small single lane roundabouts	25 km/h (25-30 km/h)	12 km/h (12-15 km/h)
Moderate turn 20.0 m	Most right-turn operations and medium-sized roundabouts	30 km/h (30-35 km/h)	15km/h (15-20 km/h)
Gentle turn 30.0 m	Large multi-lane intersections and large (multi-lane) roundabouts	40 km/h (40-45 km/h)	25km/h (25-30 km/h)

When defining reduced speed areas approximately two to five metre areas are generally recommended, considering that vehicles decelerate to match driving speed with the defined reduced speed. Figure 5-16 shows an example of reduced speed areas defined at an intersection.

Figure 5-16: Reduced speed areas coding





Count: 5	No	Name	Lane	Pos	Length	DesSpeedDistr(1)	DesSpeedDistr(2)	DesSpeedDistr(3)	DesSpeedDistr(4)
1	1	R15	10041 - 1	4	2.0	25: 25 km/h	12: 12 km/h	12: 12 km/h	12: 12 km/h
2	2	R22	10044 - 1	11	3.0	30: 30 km/h	15: 15 km/h	15: 15 km/h	15: 15 km/h
3	3	R22	10044 - 2	11	3.0	30: 30 km/h	15: 15 km/h	15: 15 km/h	15: 15 km/h
4	4	R20	10043 - 1	10	3.0	30: 30 km/h	15: 15 km/h	15: 15 km/h	15: 15 km/h
5	5	R15	10046 - 1	7	2.0	25: 25 km/h	12: 12 km/h	12: 12 km/h	12: 12 km/h

Default speed distribution profiles should be used unless the desired speed range does not match the default distribution, and site observations show that these are not valid for the specific location modelled. Any change in the default speed distributions should be justified in the modelling report.

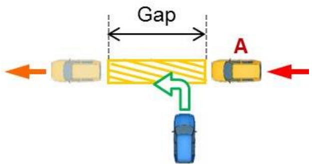
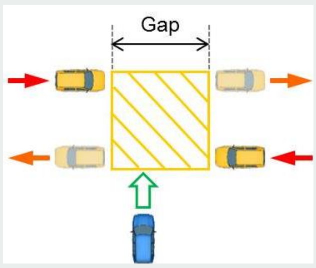
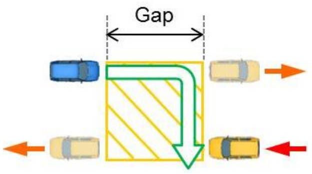
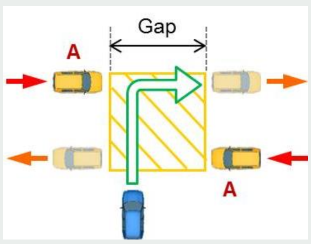
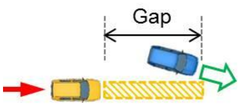
5.4 Intersection Control Data

Intersections can be categorised into two types that are priority controlled and traffic signal controlled intersections. This section discusses the recommended network objects and parameters for each intersection type in Vissim.

5.4.1 Priority Controlled Intersections

Priority controlled intersections can be managed by conflict areas or priority rules. In general, conflict areas are recommended to be used, however, for complex intersections priority rules should be used. When using conflict areas or priority rules, gap acceptance parameters in Table 5-9 should be considered as a starting point.

Table 5-9: Critical acceptance gaps and follow-up headways from Austroads

Movement	Diagram	Description	Critical acceptance gap	Follow up headway
Left-hand turn		Requiring a to slow	5 seconds	2-3 seconds
Crossing		One-way - two-lane - three-lane - four-lane Two-way - two-lane - four-lane - six-lane	 4 seconds 6 seconds 8 seconds 5 seconds 8 seconds 8 seconds	 2 seconds 3 seconds 4 seconds 3 seconds 5 seconds 5 seconds
Right-hand turn from major road		Across 1 lane Across 2 lanes Across 3 lanes	4 seconds 5 seconds 6 seconds	2 seconds 3 seconds 4 seconds
Right-hand turn from minor road		One-way Two-way - two-lane - four-lane - six-lane	3 seconds 5 seconds 8 seconds 8 seconds	3 seconds 3 seconds 5 seconds 5 seconds
Merge		Acceleration lane	3 seconds	2 seconds

These timings should be compared to the existing operation of the project location and amended accordingly. For example, the default parameters may need to be changed as a result of geometry. To accommodate variations in acceleration, different gap acceptance parameters are recommended for different vehicle types. The exact gap acceptance will need to be determined during the calibration process.

5.4.1.1 Conflict Areas

Typically, conflict areas are a more streamlined way of identifying vehicle priority between two conflicting streams. Conflict areas are the preferred approach for non-critical intersections with no obvious unusual priorities and no overlapping and contradicting priorities.

When using conflict areas, the default gap acceptance parameters such as front gap, rear gap, avoid blocking the minor flow, and avoid blocking major flow should be refined based on intersection and movement types.

- Front gap is the minimum gap time in seconds between the rear end of a vehicle in the main traffic stream and the front end of a vehicle in the minor traffic stream.
- Rear gap is the minimum gap time in seconds between the rear end of a vehicle in the minor traffic stream and the front end of a vehicle in the main traffic stream. This is the time that must be provided, after a yielding vehicle has left the conflict area and before a vehicle with the right of way enters it.
- Avoid blocking minor flow makes a vehicle with the right-of-way check the space available downstream of the conflict area, and does not drive into the conflict area when the space available downstream is less than the total of the individual vehicle length + 0.5 metres and the blocking vehicle is slower than 5m/s and slower than 75 per cent of its desired speed.
- Avoid blocking major flow makes sure a yielding vehicle does not enter or stop within the conflict area, unless it can drive through it in one go.

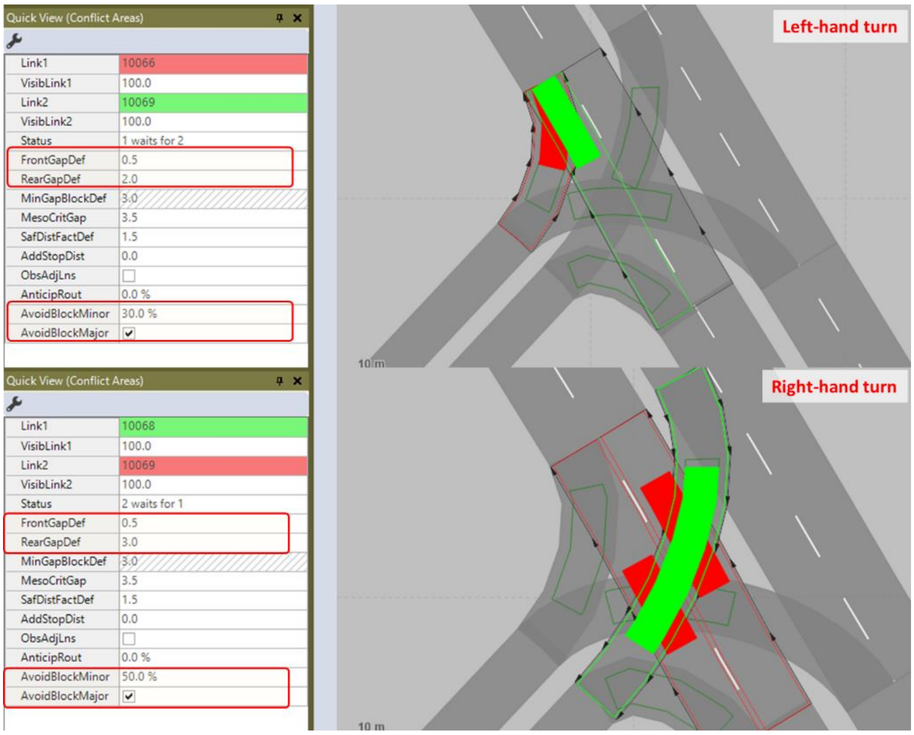
When using conflict areas, the critical gap and follow up headway gap defined in Table 5-9 should be taken into account and the recommended parameter values in Table 5-10 can be adopted as a starting point for calibration.

Table 5-10: Recommended Conflict Area Parameters

Movement	Front Gap	Rear Gap
Left-hand turn	0.5 -1.0 second	2.0 – 4.0 seconds
Crossing	0.5 -1.0 second	2.0 – 4.0 seconds
Right-hand turn from major road	0.5 -1.0 second	2.0 – 4.0 seconds
Right-hand turn from minor road	0.5 -1.0 second	2.0 – 4.0 seconds
Merge	0.5 -1.0 second	1.5 – 3.0 seconds

Figure 5-17 shows examples of left-hand and right-hand turns and updated conflict area parameters.

Figure 5-17: Conflict area and updated parameters



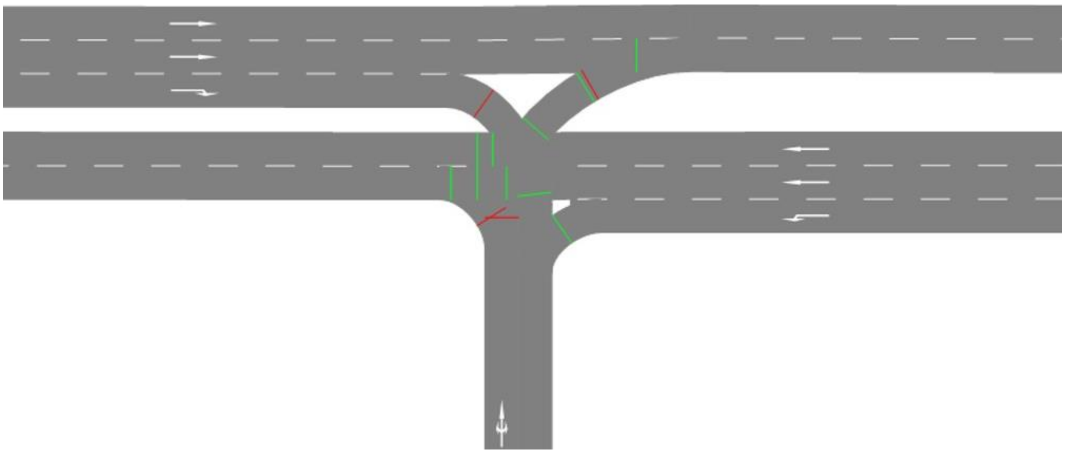
The status of conflict areas can be indicated by its colour:

- Green main flow (right of way).
- Red minor flow (yield).
- Both red for branching conflicts, so that vehicles can "see" each other. There is no right-of-way, as vehicles simply remain in their original sequence.
- Both yellow passive conflict area without right-of-way.

5.4.1.2 Priority Rules

For complex intersections, locations with a high heavy vehicle percentage and intersections which are deemed critical to the performance of the overall network, priority rules should be used, as illustrated in Figure 5-18.

Figure 5-18: Priority rules



When using priority rules, gap acceptance parameters in Table 5-9 should be adopted as a starting point.

5.4.2 Signalised Intersections

The type of signal control used for the modelling should be agreed with Main Roads. The accuracy of the signal operation will generally depend on the complexity of the project location, type of assessment and its impact on network performance. Signal offsets should be correctly modelled using the information from SCATS (where applicable).

5.4.2.1 Traffic Signal Groups

Signal groups in the model must be defined in accordance with the site LM plan and SCATS information for existing signals (refer to Appendix A). Signal group numbers in Vissim models must match the signal groups defined in SCATS.

The signal group/phase timings (minimum greens and yellow + all reds) should be directly input from controller/SCATS information and should not be changed. If the SCATS system shows a value as a fraction (for example, 0.5), the modeller should always round up the value for the inputs. For pedestrian protection, late starts and early cut-offs, it may be necessary to obtain the relevant signal documents from the Main Roads' *trafficmap* or observe on-site to identify the signal groups associated with these.

5.4.2.2 Signal Heads

Signal heads should generally be set on links or on connectors where partially controlled turns exist. To ensure that signal heads are not mismanaging traffic or being ignored, care should be taken in the setting of signal heads relative to the adjacent lanes and link/connectors.

5.4.2.3 Fixed Time Signals

Fixed time signals should generally be used where there is minimal variation of phase sequences and timing throughout the assessment period. IDM data or SCATS history files should be used to determine the average phase lengths for the intersection(s) during the modelled time periods.

Pedestrians should be modelled where there are high levels of pedestrian movements which may result in delays to the corridor due to crossing movements or signal controls. SCATS signal time settings can be used as the base data for pedestrian signals. If the pedestrian crossing is not fully protected, priority rules can be set to reflect vehicle movements during pedestrian signal clearance times.

5.4.2.4 SCATSIM

The use of SCATSIM should be considered if high level accuracy of signal operations is required or if the signal operations are of high complexity. To ensure all required SCATSIM input files are accessible and available for modelling purposes, modellers should consult Main Roads.

The use of SCATSIM may require the development of personality files (.sft) to model proposed intersections or phasing arrangement operations. Mixing SCATSIM with other forms of signal control is not generally recommended.

5.4.2.5 Vehicle Actuated Programming (VAP)

VAP signal controls should be considered to mimic the SCATS operations for complex signal operations, such as infrequent demand dependant phases that have severe impact to signal operations (e.g. bus priority, alternative and pedestrian phases). Prior to using VAP in Vissim, two files should be defined:

- Inter-stage file – a text file which details all stages, intergreens, phase delays and interstage timings, with the detailed information derived from SCATS data.
- Logic file – the actual control logic to be executed by the program file.

The recommended VAP (.vv file) structure is:

- Program initiation – initiation of the program.
- Program schedule – various phase proportions or time settings throughout the modelling period.
- Signal linking module – for signal coordination purposes.
- Recording functions – to enable the recording of the modelled phase and cycle frequency, time checks or validation process.
- Stage logic module – used for phase transition purposes and should consider gap-out, minimum green, maximum phase time and phase call / detection operations.
- Other transport priority and pedestrian operations that may apply to more than one phase should be kept separate to the stage logic module (where applicable).
- All numerical values (such as minimum green time, phase splits settings) should be stalled in the parameters section and not within the main logic module (flow chart).
- Expressions should be used where possible for the simplification of the logic code and to streamline review processes. The expressions module should contain gap-out and phase call conditions.

While direct coding of VAP may be appropriate, it is recommended modellers use VisVAP[23] to code a VAP program. The use of VisVAP should be noted in the modelling report.

5.4.2.6 Detectors

Signal detectors generally need to be set when SCATSIM or VAP is adopted for signal control in the model. Signal detectors in the model should reflect existing or design information (for example, traffic signal plans or operation sheets).

If there is no information provided to indicate the detector size and location, signal detectors for vehicle detections should be modelled 2.0m back from signal heads and 4.5m in length at intersection approaches.

5.4.3 Ramp Metering

Ramp metering is used to improve freeway efficiency by regulating flows at the on-ramps onto the freeway. There are several methods of modelling that can be used, but it will depend on the purpose of the study.

[23] VisVAP is a tool for defining the program logic of actuated signal controllers as flow charts.

5.4.3.1 Fixed-Time Metering

Fixed-time controls should generally be used unless the purpose of the model is to assess the operations of the freeway and on-ramps. This simplified method allows modellers to simulate the operations of the ramps by inputting the observed data. The required data may vary depending on the type of metering option selected in Aimsun. The fixed metering options are as follows:

- green-time metering
- green-time by lane metering
- flow metering, and
- delay metering.

The fixed-time ramp meters will have to be validated against the observed on-ramp and freeway operations, however this should be confirmed during the project scope meeting as the requirements will vary depending on the purpose of the project.

5.4.3.2 ALINEA Ramp Metering

The ALINEA algorithm is a closed-loop dynamic system that improves the efficiency of the freeway by dynamically controlling the on-ramp flows based on the mainline downstream occupancy rate. The algorithm runs in isolation and queues cannot be managed on the on-ramps.

5.4.3.3 Adaptive Ramp Metering

Adaptive Ramp Metering (ARM) is an AImsun algorithm comparable to HEuristic Ramp metering cOordination (HERO). It is an extended version of ALINEA with a feedback system that coordinates and controls local ramp meters under specific conditions. When ARM is activated, the ramp that triggered ARM will become the master ramp, while any upstream ramps will become slaves to reduce flows resulting in improved efficiency on the mainline. ARM will deactivate once the specific conditions are satisfied and the trigger conditions are as follows:

- Activation trigger:
  - the mainline occupancy is over a threshold of the target occupancy, and
  - the queue on the on-ramp (which becomes the master ramp) is over the threshold of the maximum queue length.
- Deactivation trigger:
  - the mainline occupancy drops below the threshold of the target occupancy, or
  - the queue on the master ramp is lower than the threshold of the maximum queue length.

Main Roads recommends ARM as the preferred option when the purpose of the model is to assess the operation of the freeway and fixed timing for other assessments. The preferred method should be confirmed at the scope meeting.

5.5 Traffic Data

Once a transport network is built in Vissim, modellers should define traffic data such as demands and routes in the model. This section discusses recommended traffic input types.

5.5.1 Vehicle Composition

Vehicle composition used within the model should be determined using recent classified traffic counts and aligned with specific vehicle types (refer to Section 5.2.3).

5.5.2 Public Transport Stops and Lines

Public transport operations should be modelled where they may have a significant impact on the performance of the project area, such as bus only lanes and intersections with public transport priority operations. Public transport coding should be based on information obtained from *Transperth*, including public transport routes, stop locations, timetables and dwell time.

If there is no dwell time data available, and the model does not require detailed public transport operations, the parameters shown in Table 5-11 may be used as a guide depending on the purpose of the model and the study area.

Table 5-11: Bus dwell time parameters if bus dwell time data not available

Parameter	Suggested value
Transfer Station – Mean	20 seconds
Bus Stop – Mean	10 seconds
Deviation	5 seconds

A bus dwell time of 10 seconds is sufficient in most cases, however bus dwell times may be higher within the CBD, around schools and universities and bus stations. On-site observations of dwell time should be used to help determine bus dwell time parameters

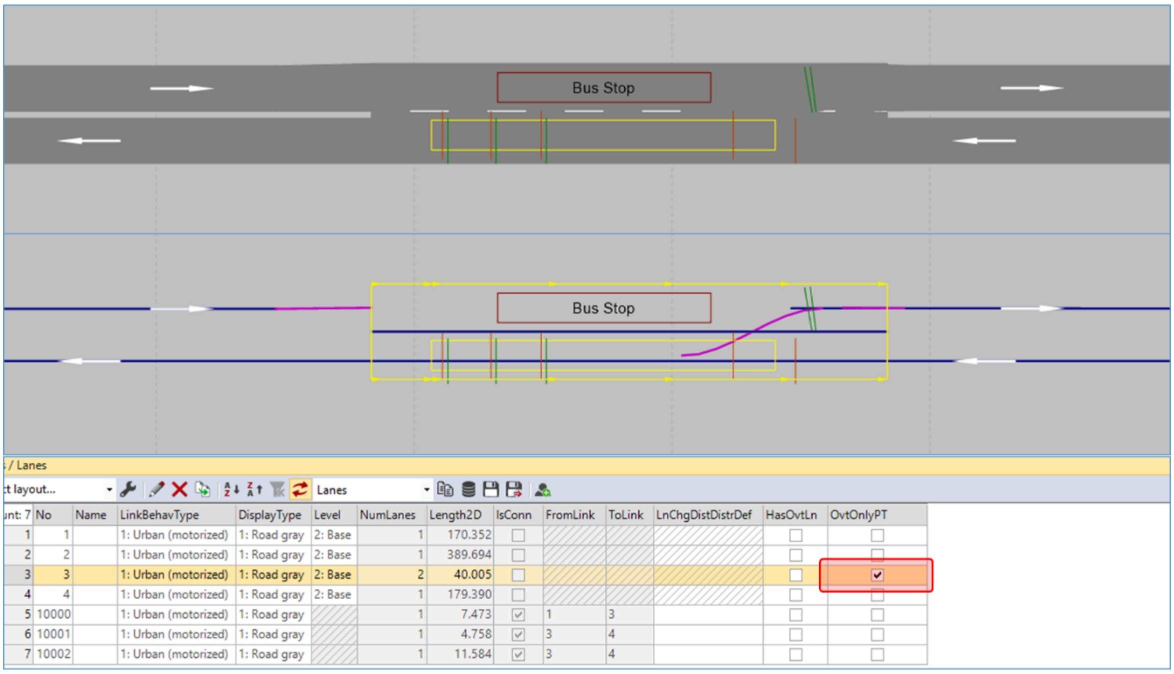
Modellers should include school buses in the public transport coding. The routes and timetables of school buses can be obtained from *Transperth's* website.

The layout of the public transport bays should reflect existing or design configurations.

When observations indicate general traffic overtakes a bus dwelling at an on-street bus stop on a single lane road and the behaviour impacts the network performance, it is recommended to model public transport overtaking lane with *Overtake Only PT* activation.

Figure 5-19: Bus overtaking lane coding with Overtake only public transport activeFigure 5-19 illustrates an example of bus overtaking lane.

Figure 5-19: Bus overtaking lane coding with Overtake only public transport active



5.5.3 Parking

Vehicle parking spaces and parking manoeuvres should be modelled where they may have a significant effect on the operation and capacity of the network within the project area. The layout and vehicle movements associated with parking should reflect the existing or design conditions. Parking delays should not be induced by setting *reduced speed areas* in the model.

5.5.4 Static Assignment

While the use of static vehicle routes is generally recommended, the model assignment method should be agreed with Main Roads.

5.5.4.1 Vehicle Inputs

Traffic demands should generally be introduced using the vehicle inputs in network objects. Modellers should define peak period demands and include warm-up and cool-down periods. Main Roads recommends that modellers use at least 15 minutes or two times of the longest travel time for warm-up and cool-down periods with a minimum of 85 per cent of peak hour volumes unless modellers have justifications to use other values.

It is recommended for model category 1 (refer to Section 2.12.2.1) that traffic count data is analysed for 15 minute intervals and vehicle inputs are set for peak periods to enable a model to replicate observed on-site traffic flow accurately.

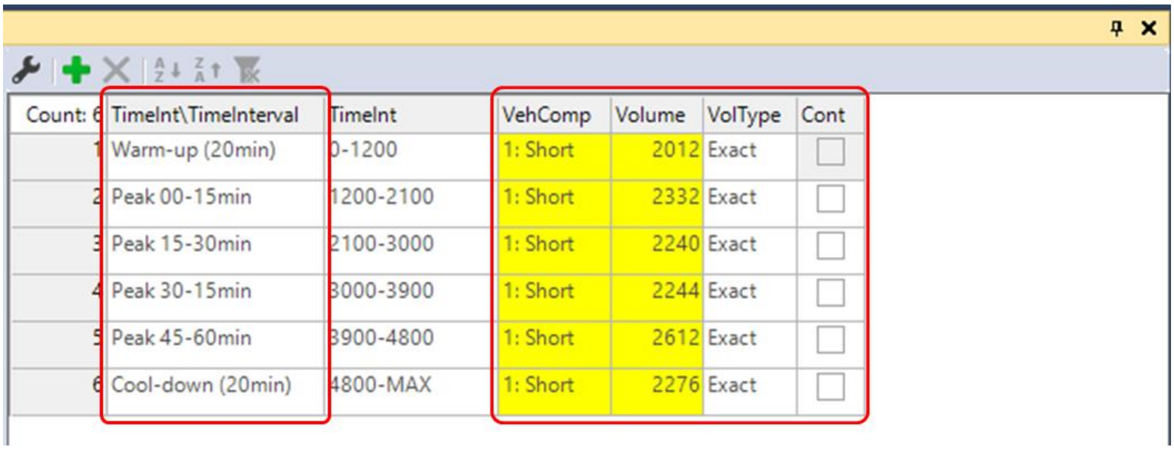
Modellers can use hourly volumes for model categories 2 and 3 and set at 15 minute intervals using *continued* attribute in *vehicle input*.

It should be noted that vehicle inputs in Vissim are expressed in hourly volumes. Therefore, the analysed 15 minute interval traffic flows must be recalculated to one-hour traffic flows (for example, an analysed 15 minute flow is 200 vehicles, then the value for the vehicle input must be 800).

Traffic volumes can be assigned a vehicle composition and either set to generate exact volumes or, if variability is required, to a stochastic loading. However, it is recommended that modellers use exact volumes to minimise the discrepancies of model outputs between simulation runs with different seed numbers.

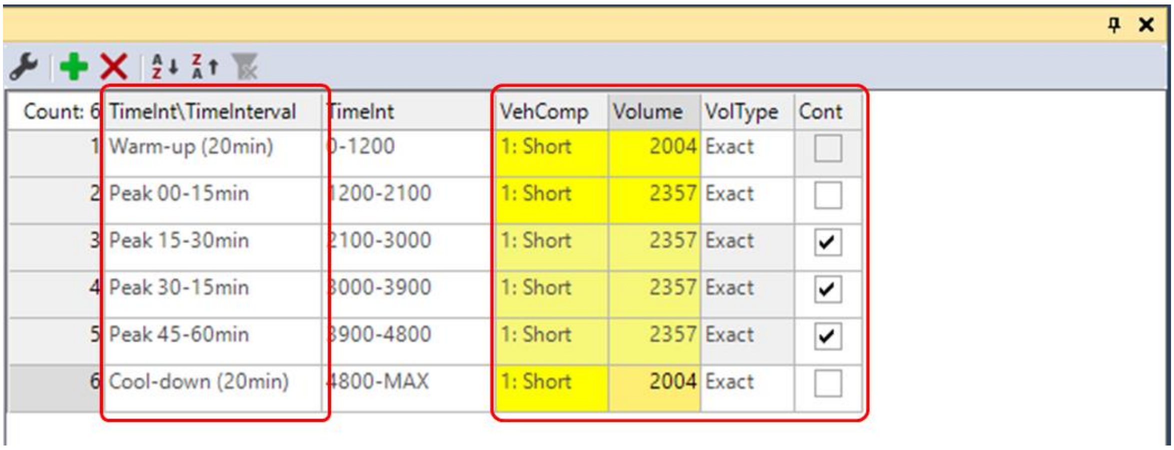
Figure 5-20 shows an example of vehicle input defined for model category 1 while Figure 5-21 illustrates an example of vehicle input defined for model category 2 or 3.

Figure 5-20: Example of vehicle input defined for model category 1



Count: 6	TimeInt\TimeInterval	TimeInt	VehComp	Volume	VolType	Cont
1	Warm-up (20min)	0-1200	1: Short	2012	Exact	☐
2	Peak 00-15min	1200-2100	1: Short	2332	Exact	☐
3	Peak 15-30min	2100-3000	1: Short	2240	Exact	☐
4	Peak 30-15min	3000-3900	1: Short	2244	Exact	☐
5	Peak 45-60min	3900-4800	1: Short	2612	Exact	☐
6	Cool-down (20min)	4800-MAX	1: Short	2276	Exact	☐

Figure 5-21: Example of vehicle input defined for model category 2 or 3



Count: 6	TimeInt\TimeInterval	TimeInt	VehComp	Volume	VolType	Cont
1	Warm-up (20min)	0-1200	1: Short	2004	Exact	☐
2	Peak 00-15min	1200-2100	1: Short	2357	Exact	☐
3	Peak 15-30min	2100-3000	1: Short	2357	Exact	☑
4	Peak 30-15min	3000-3900	1: Short	2357	Exact	☑
5	Peak 45-60min	3900-4800	1: Short	2357	Exact	☑
6	Cool-down (20min)	4800-MAX	1: Short	2004	Exact	☐

It is recommended for model category 1 (refer to Section 2.12.2.1) that traffic count data is analysed for 15 minute intervals and demand profiles are set for peak periods to enable a model to replicate observed on-site traffic flow accurately. Modellers can use hourly volumes for model categories 2 and 3 and set at 15 minute intervals with the observed demand profiles or a flat demand profile. The demand development methodology will require agreement with Main Roads during the scope meeting.

Where peak fluctuations due to schools and shopping centres may occur, and therefore depending on the purpose of the model, traffic data analysis for 15 minutes or 30 minutes intervals may be required for categories 2 or 3.

5.5.4.2 Vehicle Routes

Vehicle route decision markers should be set to mimic the point where motorists would likely begin to perform lane changes to reach their desired destination. To manage demands for trip purposes or vehicle types, the use of vehicle routes for individual vehicle classes is recommended.

It is generally recommended to activate *Combine static routing decisions* when static assignment is used.

Figure 5-22 shows an example of static vehicle routing decisions defined for different vehicle classes.

Figure 5-22: Example of static routing decisions

Static Vehicle Routing Decisions / Static Vehicle Routes

Select layout... Static vehicle routes

Count: 12	No	Name	Link	Pos	AllVehTypes	VehClasses	RouteChoiceMeth	CombineStaRou...
1	1	Westbound 1st section_VehClass1	4	6.542	☐	1	Static	☑
2	2	Westbound 2nd section_VehClass1	56	12.393	☐	1	Static	☑
3	3	Westbound 3rd section_VehClass1	50	12.606	☐	1	Static	☑
4	11	Westbound 1st section_VehClass2	4	6.542	☐	2	Static	☑
5	12	Westbound 2nd section_VehClass2	56	12.393	☐	2	Static	☑
6	13	Westbound 3rd section_VehClass2	50	12.606	☐	2	Static	☑
7	21	Westbound 1st section_VehClass3	4	6.542	☐	3	Static	☑
8	22	Westbound 2nd section_VehClass3	56	12.393	☐	3	Static	☑
9	23	Westbound 3rd section_VehClass3	50	12.606	☐	3	Static	☑
10	31	Westbound 1st section_VehClass4	4	6.542	☐	4	Static	☑
11	32	Westbound 2nd section_VehClass4	56	12.393	☐	4	Static	☑
12	33	Westbound 3rd section_VehClass4	50	12.606	☐	4	Static	☑

5.5.5 Dynamic Assignment

If route choice exists, vehicles can be loaded into the network by using OD matrices and dynamic assignment. Dynamic assignment provides drivers with choices on routes to a destination based on different traffic conditions. Assignment should be set according to the user-defined route selection criteria for distance and travel time.

The use of dynamic assignment should be agreed with Main Roads before modelling begins.

When dynamic assignment is used, the modeller needs to ensure that traffic flows are correctly specified in the OD matrix files and that the method used to estimate OD matrices is documented in the modelling report. The modeller must also ensure that the modelled network is stable during the assignment process to enable the model to reach a converged state.

It is up to the modeller to decide what the most appropriate method is to achieve the desired outcome and best reflect the traffic conditions observed in the network.

It is recommended that traffic is initially loaded at a reduced level of demand (typically 50 per cent) and then progressively increased.

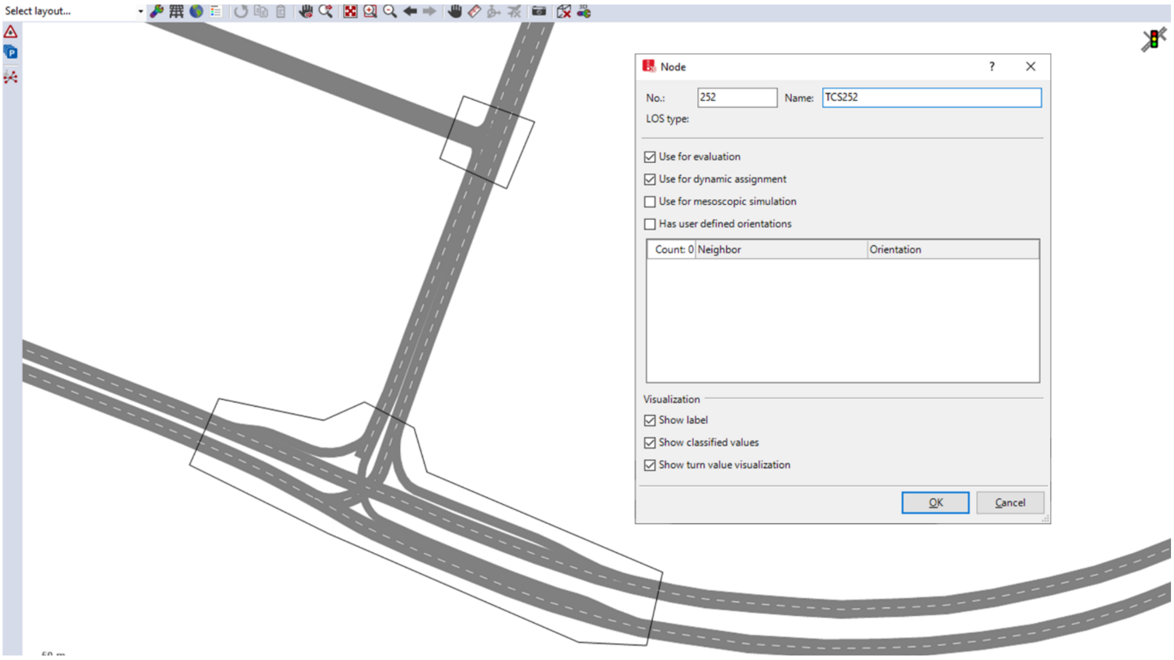
If equilibrium assignment is used in place of stochastic user equilibrium, the modelling report should contain details on why this assignment method was considered more appropriate.

5.5.5.1 Nodes

Nodes are primarily used for dynamic assignment, intersection evaluation or mesoscopic modelling purposes.

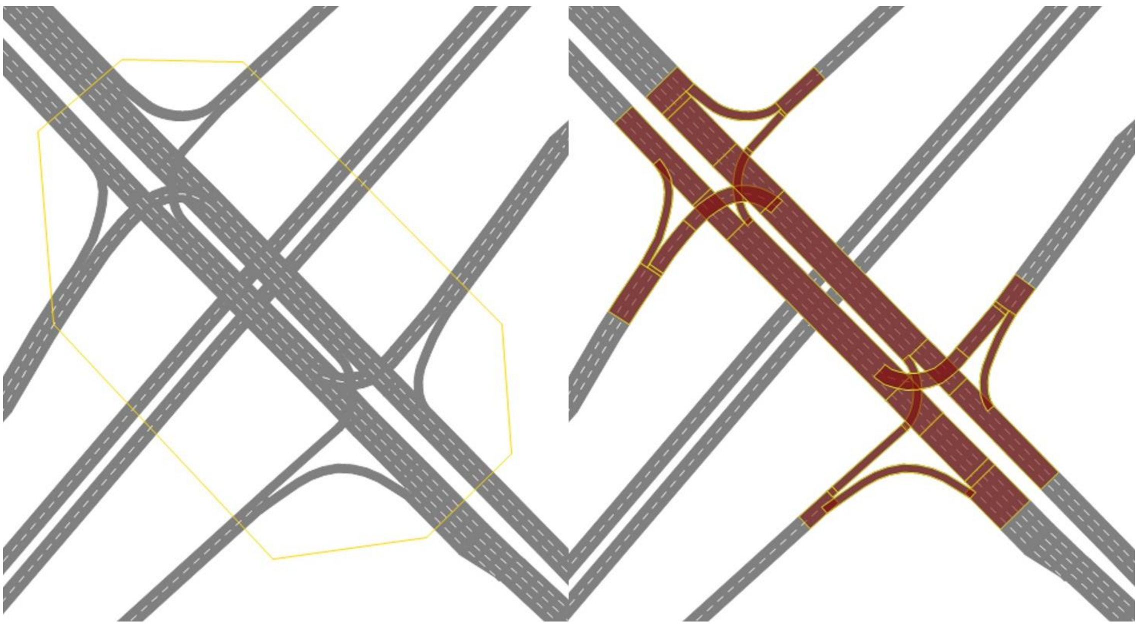
For dynamic assignment, nodes should be set at locations where a route decision needs to be made by a vehicle, as shown in Figure 5-23.

Figure 5-23: Node placement



To limit the links that the node is assigned to, the modeller may convert the node. This is particularly relevant for situations where the primary highway should be excluded from the interchange above / below the highway (for example, at multi-level single point interchanges as shown in Figure 5-24.

Figure 5-24: Example of node convert



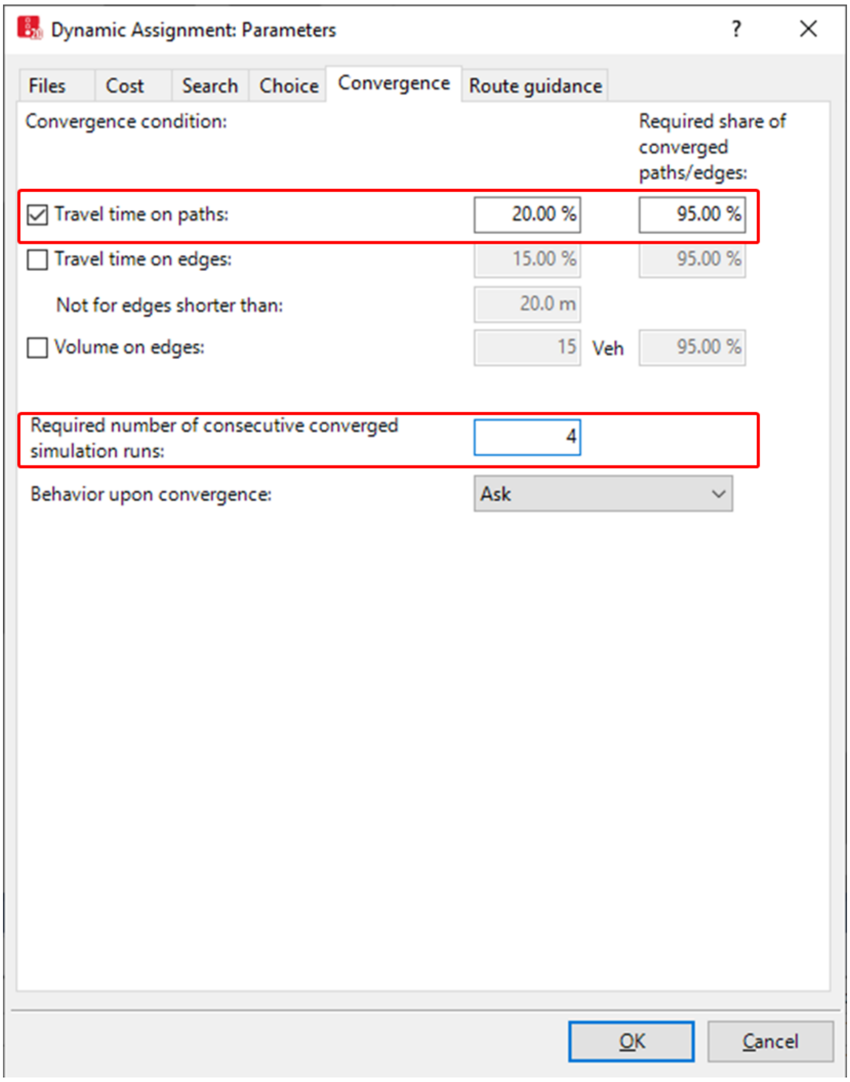
Nodes can also be used to evaluate intersection performance. Particular care should be taken with node structure if node evaluation is being used.

5.5.5.2 Convergence

Main Roads recommends modellers use the dynamic assignment convergence criteria:

- 95% of travel times on all paths and edges change by less than 20% for at least four consecutive iterations as shown in Figure 5-25.

Figure 5-25: Dynamic assignment parameters



Once convergence has been achieved, the convergence evaluation file (*.CVA), path file (*.WEG) and cost file (*.WGA) for each calibrated model should be stored for use during all subsequent modelling and provided to Main Roads as part of the base model submission.

5.6 Model Calibration and Validation

In general, calibration and validation require an iterative process of adjusting parameters and analysing model results until the model has achieved an accepted level of confidence when compared to the on-street conditions.

The calibration and validation requirements can be defined based on the importance of a specific project and its significance to the region. It is recommended that modellers discuss the requirements with Main Roads.

5.6.1 Model Calibration Requirements

Base model calibration is the process of employing verifiable observed data into a model to replicate on-street conditions. The following sub-sections discuss the recommended requirements and model input data for the base model calibration.

5.6.1.1 Data Collection

The type of data required for the modelling should be determined specifically for each project. It is the modeller's responsibility to ensure appropriate data is collected to enable the development of the model. The format of output should be specified for modelling purposes. For consistency and accuracy of the modelling, it is recommended that all data is collected on the same day. The following list of data to be collected is not exhaustive but should be considered:

- design layout information
- SCATS data
- traffic counts
- OD surveys
- public transport route and timetable information
- travel time data
- queue length
- saturation flow
- vehicle speed, and
- video footage.

5.6.1.2 Site Observations

It is important for modellers to observe the existing site conditions. Driving behaviours, network configuration, signal operations and other events which may impact on the performance should be captured and reported as part of the modelling. The operating conditions and site findings should be captured in the form of photographs and videos.

5.6.1.3 Model Input Check

Modellers should check network coding and network object's attributes to confirm that the model network replicates the existing or the proposed transport network, and that the simulation is consistent with the observed on-street vehicle behaviour. The key inputs to check include:

- number of lanes
- lane width
- lane closure
- link behaviour type
- elevation (*Z-height*)
- feasible movements
- vehicle speed (desired speed decisions and reduced speed areas)
- priority control (conflict areas and priority rules)
- signalised intersection control (signal timing plans, signal groups, signal heads)
- traffic demands (vehicle inputs or OD matrices)
- vehicle routes, and
- dynamic assignment cost parameters (cost and surcharges).

5.6.1.4 Vehicle Behaviour

As it is difficult to set up a standard for vehicle behaviour, modellers should undertake a visual check to confirm the observed on-street vehicle behaviour is consistent with that observed in the model. Vehicle behaviour such as speed / flow performances, bottlenecks, queue formation and discharging need to be carefully compared and calibrated.

A correctly coded network should reflect on-street vehicle behaviour, especially during congested peak times. Main Roads recommends modellers drive through the network and capture videos of critical locations to familiarise themselves with driving behaviour.

Modellers should include notes and changes to the network in the modelling report.

5.6.1.5 Error Files

Ideally, there should be no error messages for a calibrated and validated base model.

If error messages are generated and persistent errors (e.g. latent traffic demands and diffused vehicles) occur at certain location(s), modellers must review network coding and model parameters to ensure all model deficiencies are addressed.

5.6.2 Simulation Parameters

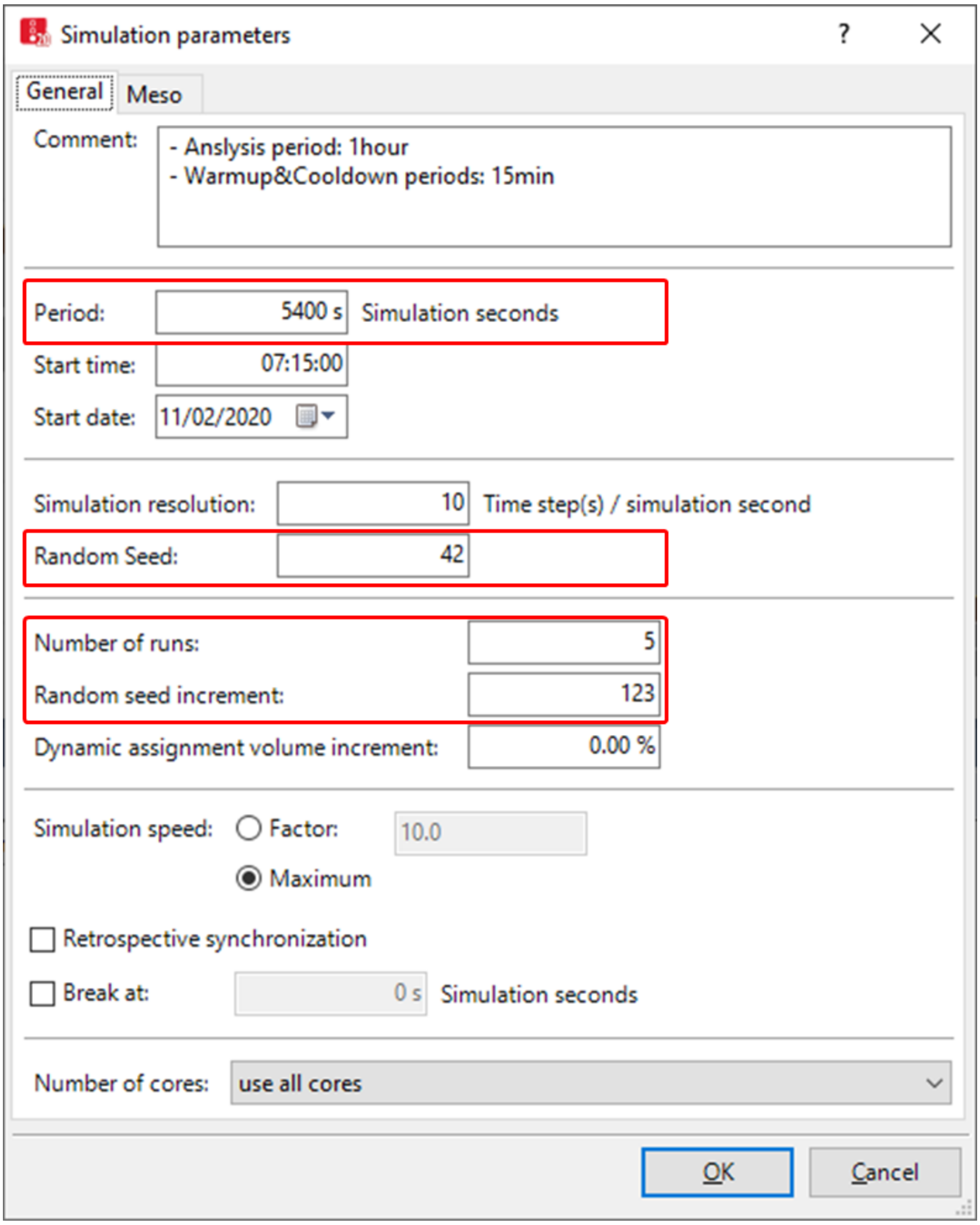
This section discusses the recommended simulation parameters.

5.6.2.1 Key Parameters

The simulation period is defined as the total simulation time which includes warm-up, cool-down and the assessment period. The simulation period and start time should be reflected in the simulation parameters prior to simulations being run.

Simulation resolution should be set to the default 10 time steps per second, as shown in Figure 5-26. This should not be changed, especially when modelling different scenarios. If time steps need to be modified for specific operational modelling purposes, consistency should be maintained across all compared scenarios.

Figure 5-26: Simulation parameters general tab



5.6.2.2 Seed Values

There is variability in traffic conditions as a result of random driver behaviour and different daily events. Vissim attempts to replicate this random variability by altering individual driver decisions based on random numbers. The set of random numbers is determined by Vissim random seed value (refer toFigure 5-24) at the start of a simulation run.

Modellers should run a minimum of five and a maximum of 10 simulations with different random seed values and present average model outputs. The modeller should list the seed numbers used in the modelling report.

For dynamic assignment models, one seed value should be used to search for paths and to achieve convergence. Once the model has met convergence criteria, the paths should be locked and the multi-runs undertaken. Model calibration and validation results should be based on the average of the seed runs and not on the single seed model used to search for the paths.

Seed values must remain consistent across all scenarios.

5.6.3 Model Validation Requirement

Main Roads defines the three model categories for model validation, based on the network size and modelling purposes (Refer to Section 2.12.2.1). The following sub-sections discuss the validation criteria for Vissim models.

5.6.3.1 Traffic Volumes

Main Roads requires hourly turning movement and directional link volumes to be validated for each major vehicle type. Table 5-12 demonstrates the model validation criteria for individual model categories.

Table 5-12: Traffic flow validation criteria

Criteria	Category 1	Category 2	Category 3
GEH < 5	95%	85%	80%
GEH < 10	100%	95%	90%
< 700 vph within 100 vph	95%	90%	85%
700 – 2,700 vph within 15%	95%	90%	85%
> 2,700 vph within 400 vph	95%	90%	85%
R squared value	>0.95	>0.95	>0.9

Even if the model outputs meet the traffic volume validation criteria for the entire network, the modeller should check and ensure that turning volumes at critical intersection(s) achieve GEH less than 5.

Where throughput between upstream and downstream intersections do not match due to survey error, the flow discrepancy should be identified and detailed in the modelling report. While it is recommended that in these circumstances the most appropriate traffic flow be used is based on engineering judgement, this will also need to be explained in the modelling report.

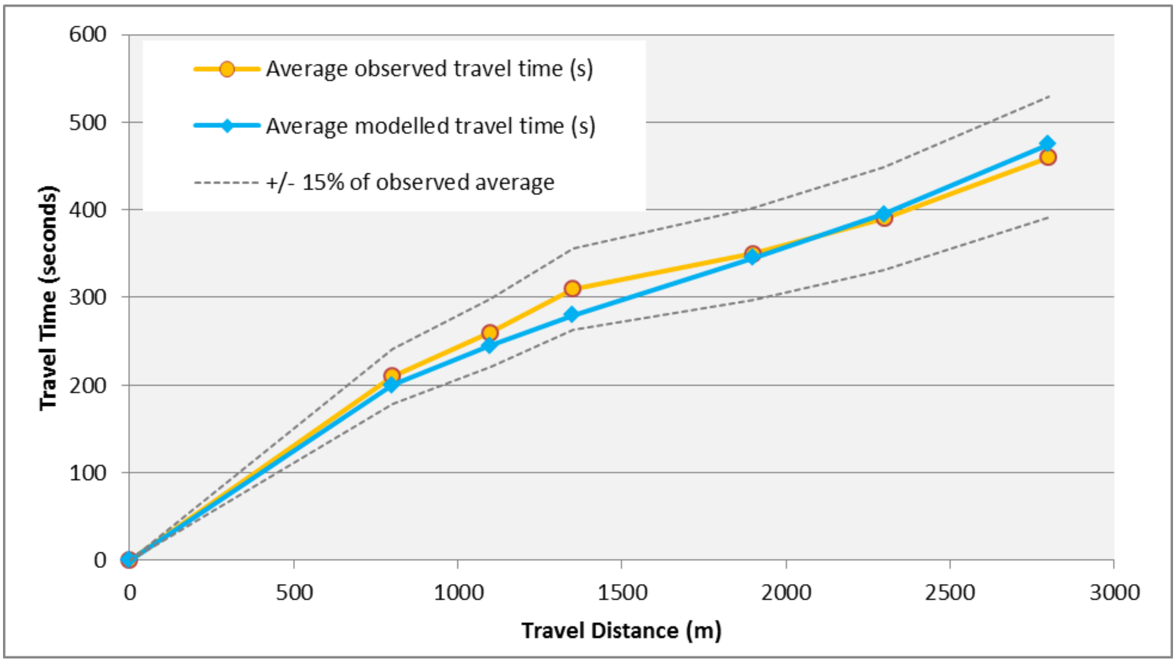
5.6.3.2 Travel Times

Travel time is a common technique used to assess the accuracy of a model by comparing surveyed and modelled travel times along key routes in the study area. It is important to ensure that a sufficient number of travel time surveys have been undertaken during the data collection stage of the project. When collecting data the route should be disaggregated into smaller sections so that the location of key delays within the overall travel time can be easily identified.

Main Roads recommends modellers measure travel times between intersection stop lines along key routes in the study area. The sections to compare should be agreed with Main Roads during the scope meeting. The extracted travel time for the model validation should be average values over several simulation runs (refer to 5.6.2.2).

The use of sections allows a cumulative graph of travel time along the route to be developed. This type of graph can provide an accurate analysis that demonstrates how the model performs in each key section, rather than simply providing a total travel time. Figure 5-27 provides an example of this type of comparison.

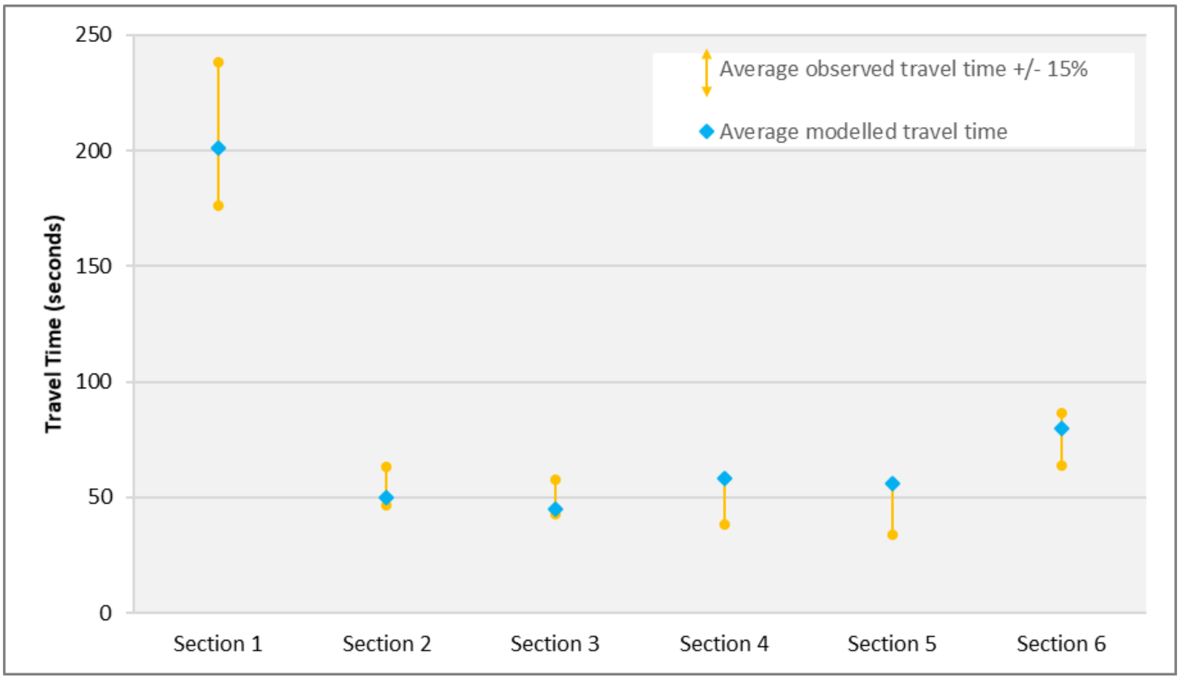
Figure 5-27: Example of cumulative travel time comparison



Modellers should not only compare cumulative travel time, but also need to analyse each section's travel time as well and identify any issue causing the travel time discrepancy.

Figure 5-28 shows an example of each section travel time comparison.

Figure 5-28: Example of each section travel time comparison



The modelled travel times should be within 15 per cent or one minute (whichever is greater) of average observed travel time. Table 5-13 demonstrates the model validation criteria for individual model categories.

Table 5-13: Travel time validation criteria

Criteria	Category 1	Category 2	Category 3
15 % or one minute of average observed travel time	100%	90%	85%

Where there are insufficient observed sample sizes to compare with the modelled average travel time, the minimum and maximum observed travel time should be shown.

5.6.3.3 Queue Length

Queue length data should be collected on-site and compared with modelled outputs to provide an indication of how accurately the model replicates congestion on approaches to key intersections in the model.

Modelled queues should correlate reasonably with on-site observations of queuing behaviour, with any significant discrepancies indicating that areas of the model may require further calibration including link driving behaviour, vehicle inputs and traffic controller updates.

It is recommended that the modelled average maximum queue length be compared to observed queue length data. The queue data should be surveyed and recorded for five minute intervals over the peak period.

5.6.3.4 Signal Timing

An evaluation of model output and surveyed data should provide confidence that signal cycles and timings are comparable in the model to the recorded average SCATS operation.

The modeller should compare selected signalised intersections in the core area of the model with the recorded average SCATS history data. The nominated intersections should be agreed with Main Roads during the scope meeting.

Table 5-14 shows the signal timing validation criteria for the intersections.

Table 5-14: Microsimulation signal timing validation criteria

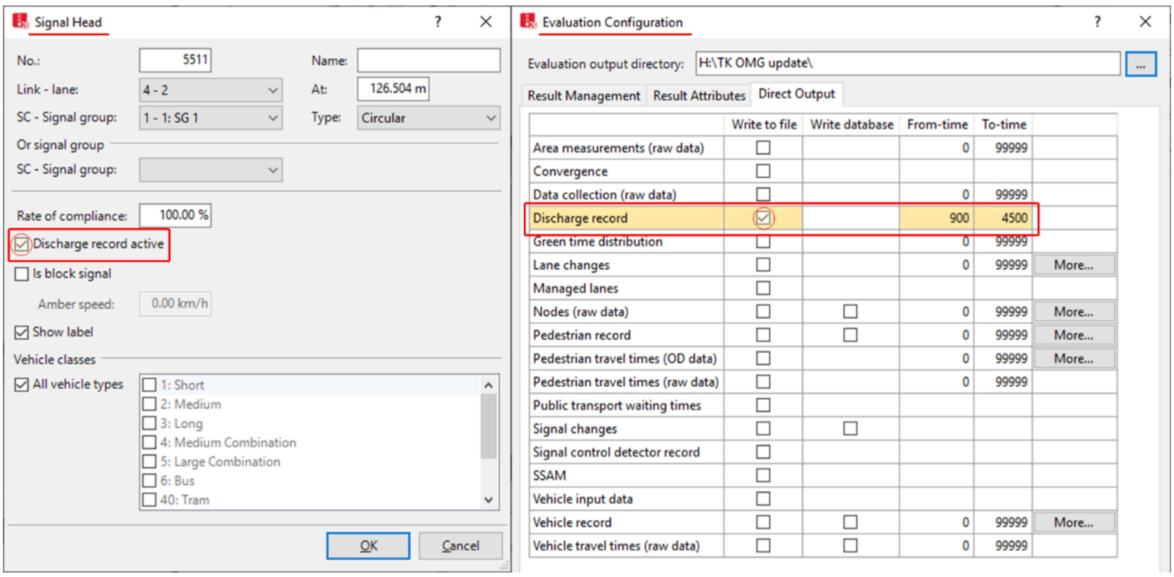
Signal operation	Criteria
Fixed time control - cycle time	Within 3 seconds or 5% (whichever is smaller) of recorded average of SCATS history data for same one hour period
Fixed time control - green time	Within 3 seconds or 10% (whichever is smaller) of recorded average phase of SCATS history data for same one hour period
Vehicle actuated control - Call frequency	Call frequency of demand-dependent phases (including pedestrian phases) to be compared with recorded average phase of SCATS history data for same one hour period

5.6.3.5 Saturation Flow

Lane saturation flow model outputs should be validated against saturation flow measured on-site for critical lanes. The critical lanes and key intersections to be compared should be agreed with Main Roads during the scope meeting.

The preferred method to extract saturation flow outputs from Vissim is using the discharge record. The modeller should select *discharge record active* in the *Signal Head* window and *discharge record* in the *Evaluation Configuration* window. Figure 5-29 shows an example of discharge record configuration selection. Once the discharge record is produced, modellers should calculate the saturation flow for the desired link according to the saturation flow measurement method outlined in Section 2.10.3.

Figure 5-29: Example of discharge record configuration



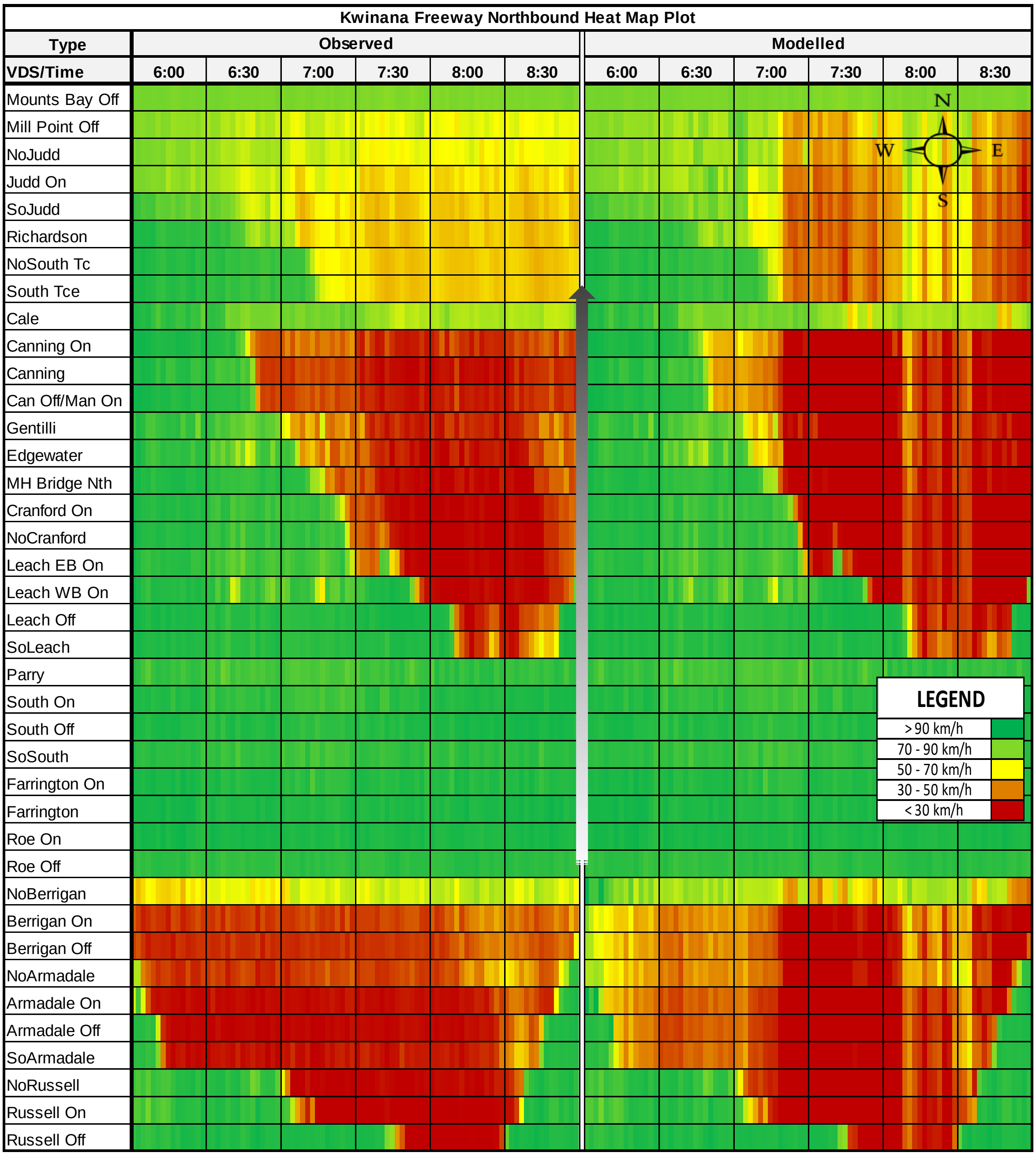
All observed and modelled saturation flow values should be tabulated and the percentage error between the two values provided in the modelling report.

Modelled saturation flow values should be within 10 per cent of observed values.

5.6.3.6 Vehicle Speed

For all freeway modelling projects, speed plots (heat maps) must be produced to compare the modelled and observed freeway segment condition. Critical bottlenecks may require lane-by-lane comparisons. Figure 5-30 provides an example of speed plots.

Figure 5-30: Example of speed plots



5.7 Scenario Management

Modellers are required to maintain consistency in network settings between scenarios (e.g. AM and PM peaks). For consistency, it is recommended that modellers use scenario management to establish scenarios using developed modifications.

The naming and descriptions of each modification should be easily comprehended by other users, and the number of modifications should be kept minimum. It is recommended that modellers create individual modification files for each peak, and geometry update scenario.

Figure 5-31: Example of modification files for peak and design scenarios

Project Structure

Basic settings | Scenarios | Modifications

Count: 10	No	LoadIndex	Name	Description	Group	E
1	1	1	Base AM Peak	Base AM - Traffic demands and signal plans		
2	2	2	Base PM Peak	Base PM - Traffic demands and signal plans		
3	3	3	Design Option A	Option A - Network updates based on Option A		
4	4	4	Design Option B	Option B - Network updates based on Option B		
5	5	5	Opening AM Peak	Opening AM - Traffic demands and signal plans		
6	6	6	Opening PM Peak	Opening PM - Traffic demands and signal plans		
7	7	7	+5 Year AM Peak	+5year Base AM - Traffic demands and signal plans		
8	8	8	+5 Year PM Peak	+5year Base PM - Traffic demands and signal plans		
9	9	9	+10 Year AM Peak	+10year Base AM - Traffic demands and signal plans		
10	10	10	+10 Year PM Peak	+10year Base PM - Traffic demands and signal plans		

The order of the scenarios should be in sequence and a consistent naming convention should be adopted to assist users in identifying the relevant scenarios more effectively. Figure 5-32 shows an example of scenario naming and descriptions.

Figure 5-32: Example of scenario naming and descriptions

Project Structure

Basic settings | Scenarios | Modifications

Count: 10	No	Name	Description	Modifications
1	1	Base AM Peak	Existing AM Peak scenario	1
2	2	Base PM Peak	Existing PM Peak scenario	2
3	3	Option A - Opening AM Peak	Option A - Opening Year AM Peak scenario	3,5
4	4	Option A - Opening PM Peak	Option A - Opening Year PM Peak scenario	3,6
5	5	Option B - Opening AM Peak	Option B - Opening Year AM Peak scenario	4,5
6	6	Option B - Opening PM Peak	Option B - Opening Year PM Peak scenario	4,6
7	7	Option A - Opening+5Year AM Peak	Option A - Opening +5Year AM Peak scenario	3,7
8	8	Option A - Opening+5Year PM Peak	Option A - Opening +5Year PM Peak scenario	3,8
9	9	Option A - Opening+10Year AM Peak	Option A - Opening +10Year AM Peak scenario	3,9
10	10	Option A - Opening+10Year PM Peak	Option A - Opening +10Year PM Peak scenario	3,10

The structure and scope of the modifications developed should be provided in the modelling report. It is important that modellers pay extra attention to the modifications that should be amended.

To prevent unnecessary changes being made to the original external files, modellers should ensure that external files (such as signal program, cost and path files) are duplicated and renamed for each scenario.

5.8 Model Output

Modellers are required to report model assessment results to Main Roads for review when the base model is validated and when proposed option models are completed. This section outlines model evaluation outputs to be reported and recommends ways to extract the data from Vissim models.

5.8.1 Model Evaluation Outputs

Main Roads will require the model evaluation results to be reported as the final model outcomes in the modelling report. The model outputs include, but are not limited to those shown in Table 5-15. The results extracted from the model should be clearly presented in tabular or graphical forms.

Table 5-15: Model evaluation outputs

Type	Model output	Evaluation method	Time period
Network-wide	Number of vehicle served Total travel distance Total travel time Average speed Total delay Average delay per vehicle Total latent traffic demand	Vehicle network performance	Total analysis period (peak)
Intersection	Turning movement volume Approach queue length Average delay for each approach and intersection LoS for each turning movement and intersection	Node Queue counter	1 hour interval analysis period
Route	Volume Average travel time Travel distance Average delay time	Vehicle travel time Delay	1 hour interval analysis period
Critical section (for example, bottle neck)	Traffic volume Density LoS Heat map Vehicle speed	Link Data collection	15 minute interval analysis period

5.8.1.1 Network-wide Performance Assessment

Network-wide model performance outputs should be presented for the scoped evaluation time period with appropriate time intervals.

Table 5-16 shows an example of network-wide performance outputs for two peak period scenarios.

Table 5-16: Example of network performance outputs

Scenario	Base AM	Base PM
Time Interval	07:45 – 08:45	16:30 – 17:30
Vehicles arrived (veh)	15,969	22260
Total travel distance (km)	51,906	72,223
Total travel time (hh:mm)	1217:39	1567:34
Total delay (hh:mm)	501:30	567:14
Average vehicle speed (km/h)	42.6	46.1
Average delay (s)	101	86
Demand latent (veh)	0	1

5.8.1.2 Intersection Assessment

Intersection performance outputs should be generated for the analysis of the existing condition or proposed traffic management scheme. The intersection performance outputs should include directional traffic volume, vehicle delay, level of service and queue length. Table 5-16 demonstrates an example of a signalised intersection performance based on the node evaluation outputs.

Table 5-17: Example of intersection performance outputs

Movement	Volume (veh)	Delay (s)	LOS	Queue (m)
Westbound Right-turn	3	127.1	F	130.9
Westbound Thru	991	20.1	C	130.9
Westbound Left -turn	191	2.12	A	35.5
Eastbound Right -turn	19	96.4	F	317.1
Eastbound Thru	1,759	27.2	C	317.1
Eastbound Left -turn	12	22.6	C	283.1
Northbound Right -turn	650	82.6	F	169.2
Northbound Thru	23	103.2	F	169.2
Northbound Left -turn	2	2.7	A	0.0
Southbound Right -turn	49	83.5	F	35.4
Southbound Thru	39	90.4	F	35.4
Southbound Left -turn	69	9.8	A	25.7
Intersection	**3,807**	**35.44**	**D**	**317.1**

5.8.1.3 Route Assessment

Critical route assessment should be presented for travel time, volumes and delays, to confirm that the developed model reflect existing traffic condition within the study area, and to compare traffic management schemes.

5.8.1.4 Critical Section Assessment

Detailed performance assessment should be carried out for critical sections of the study area such as bottle necks and freeway on and off-ramps.

Link evaluation enables detailed analysis of the link performance including vehicle volume, speed and density.

6 Aimsun Guidelines

6.1 Introduction

Aimsun is an integrated transport modelling software package that allows integration between various tiers of the model, 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 is designed to complement *Aimsun User Manual*. It provides detail on key parameters to be adopted when undertaking Aimsun mesoscopic, microscopic and hybrid simulation modelling in Western Australia.

Modellers should refer to Sections 1 and 2 of this document for traffic modelling guidelines.

6.1.1 Appropriate Use of Aimsun

Aimsun allows users to carry out traffic operation assessments for projects of most scales and complexity. However, it is typically data and labour intensive to achieve accurate modelling of complex and adaptive operations, compared to micro-analytical software such as LinSig and SIDRA. It is therefore recommended to use Aimsun when evaluating the performance of detailed operations that exhibit:

- Network-wide traffic capacity implications when part of the network becomes over-saturated.
- Closely spaced intersections or interchanges.
- Advanced traffic management schemes (for example priority signals, congestion management).
- Complex intersection or interchange layouts.
- Complex or dynamic (non-cyclic or demand-based) signal operations.
- Feasibility studies for high occupancy vehicle and high occupancy toll lanes.
- Impact analysis of infrastructure design such as highway corridor improvement.
- Impact of heavy vehicles to network capacity.
- Travel demand management strategies.
- Variable speed policies and other intelligent transportation systems.

6.1.2 Software Version

This guideline is based on Aimsun 20. While the Operational Modelling Guidelines will need to be updated for future versions of the software, the general principles outlined will continue to apply.

6.2 Model Set-up

Main Roads recommends the use of *OpenStreetMap* option to set-up a new Aimsun model and reference to recent aerial images to confirm network layout.

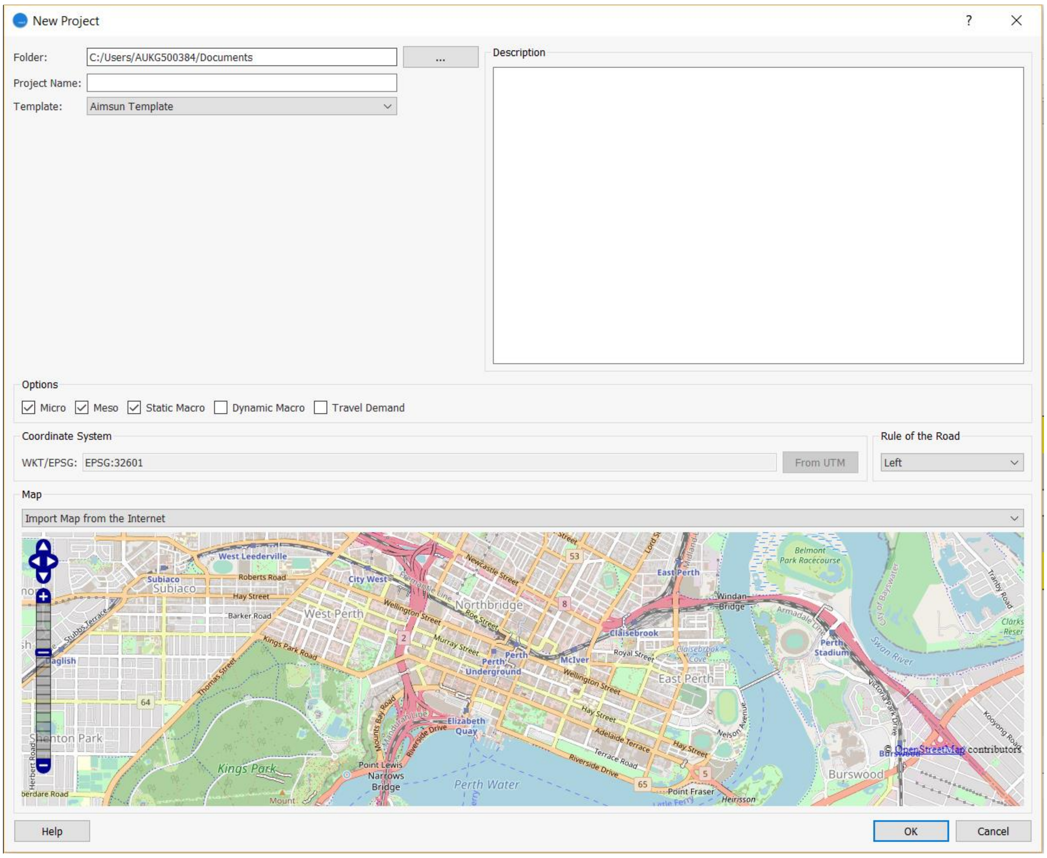
6.2.1 OpenStreetMap

OpenStreetMap is a free open format, crowd-sourced mapping resource available from www.OpenStreetMap.org. Aimsun provides the option to automatically create an initial network by importing *OpenStreetMap* data from the internet.

The automatically generated network needs to be refined in order to fit the purposes of the project.

Figure 6-1 shows the interface of starting a new project from *OpenStreetMap*.

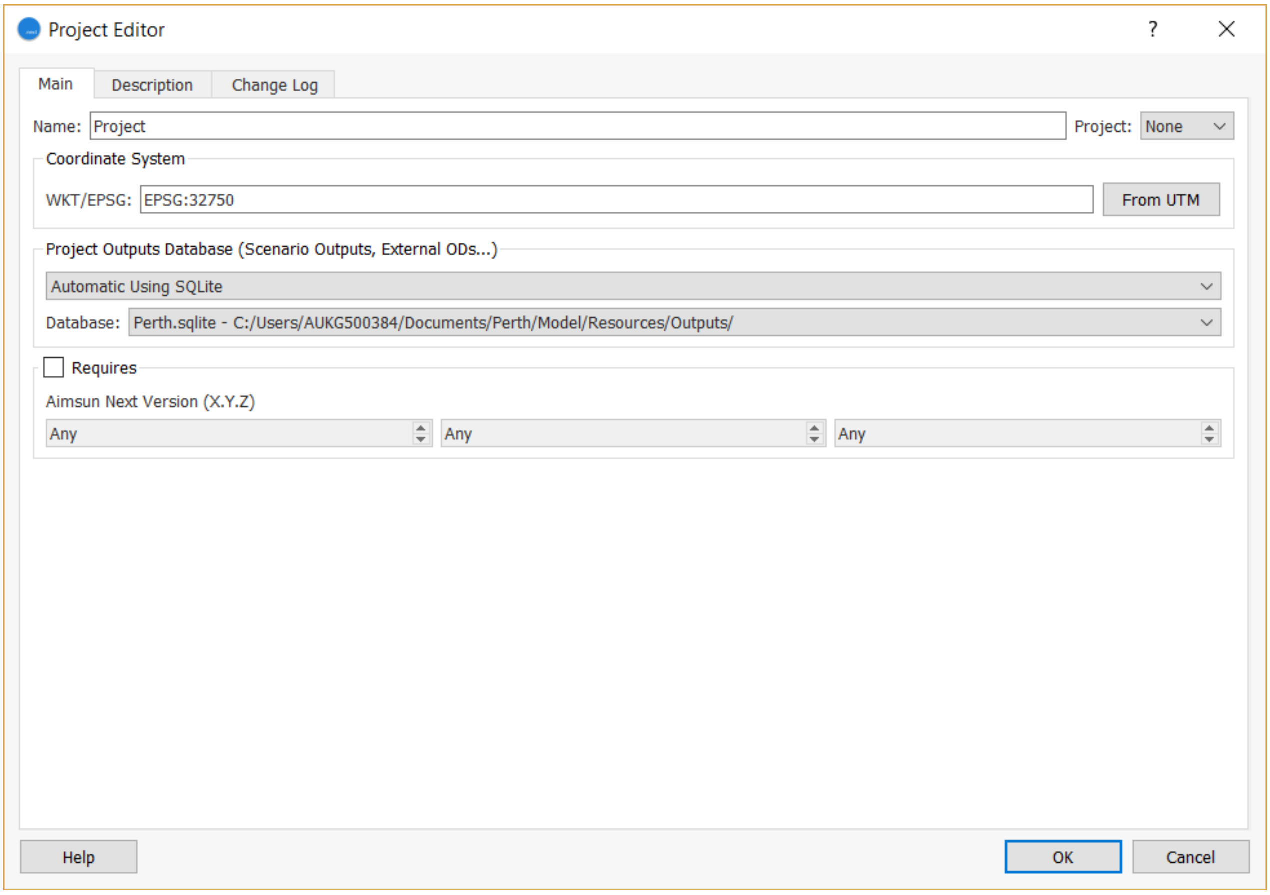
Figure 6-1: OpenStreetMap – new project options



6.2.2 Coordinate system

The initial network import from *OpenStreetMap* will incorporate the coordinate system in Aimsun. However, this may not be appropriate for some projects, and therefore the modeller needs to ensure that Aimsun is set-up in the correct coordinate system. Figure 6-2 shows the coordinate system under *Project Editor*.

Figure 6-2: Recommended general settings



The coordinate system varies depending on the longitude and latitude, the following 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; and
- EPSG:32752 – Area of use: Between 126°E and 132°E.

Projects within the Perth Metropolitan area would likely use the EPSG:32750 coordinate system.

6.2.3 Aerial Images

Geo-referenced aerial images may provide the base for the network coding. The background image should be imported in a separate layer. It is necessary to check the aerial image coordination system to ensure they are the same as the Aimsun model network, as stipulated in Section 6.2.2. To align the network geometry with the imported aerial images, manual network refinement is usually needed after the import has been undertaken.

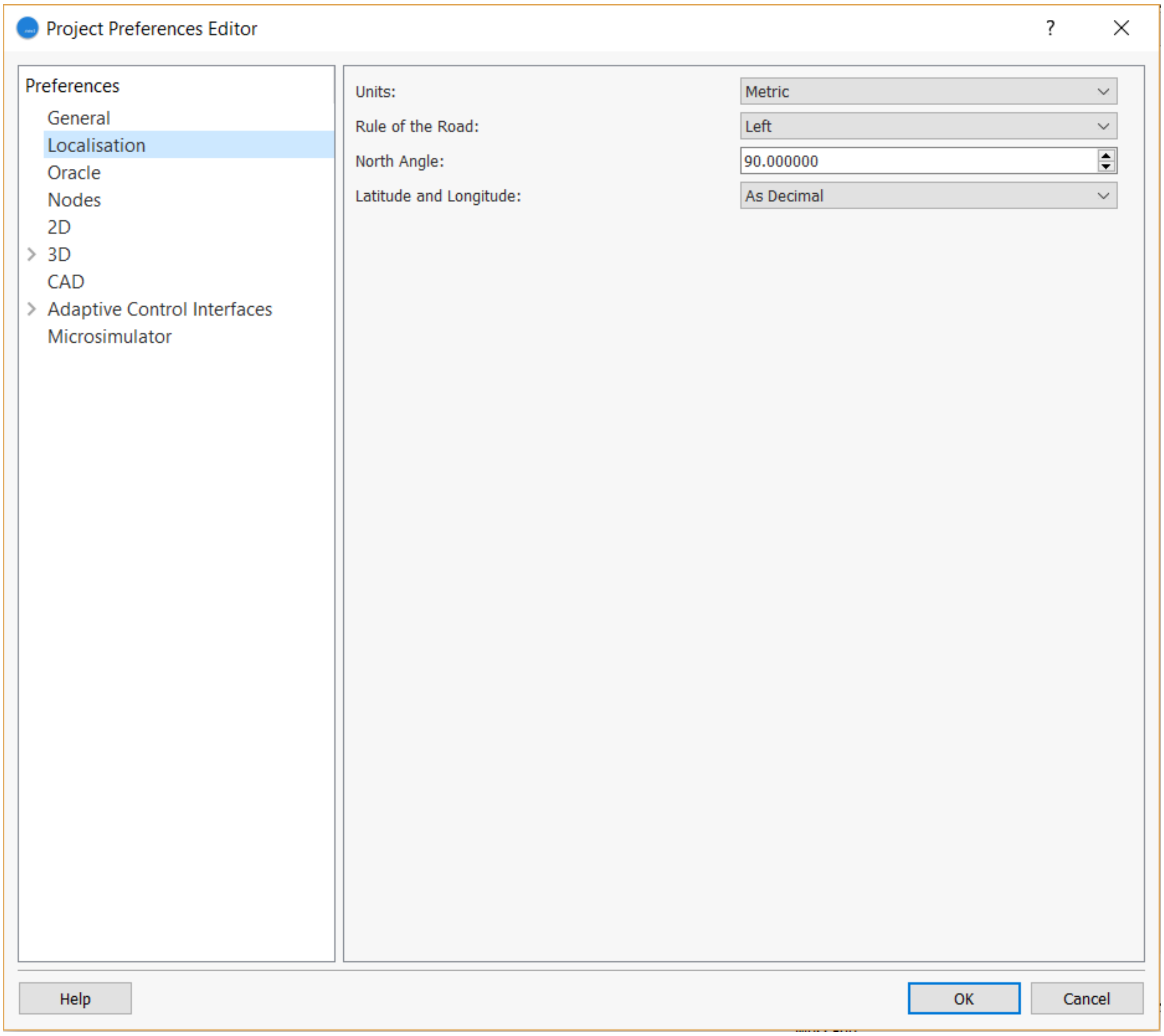
6.2.4 Model General Settings

Modellers should ensure that the correct settings for Western Australia are applied. These settings are the general base data for the entire network:

- *Units* – metric, and
- *Rules of the road* – left-hand drive.

The general settings can be checked through *Localisation* in *Project Preference Editor* dialog. Figure 6-3 shows an example of the general settings defined for an Aimsun model.

Figure 6-3: Recommended general settings



6.3 Network Coding

After the initial set-up, modellers should ensure that model details including network geometry, traffic controllers and traffic management strategies correspond to the existing road network conditions.

6.3.1 General Settings

The following elements need to be included in the network coding:

- Network geometry – layout and geometry configurations including road sections, nodes, turns, section and turn parameters.
- Zone system – centroids and how centroids are connected to the network for the matrices including centroids, centroid ID and centroid parameters.
- Traffic signals – traffic signals and signal settings including the signal type, cycle time, offset, yellow time, red percentage, signal groups, signal timing, interphase time, and signal phases.
- Public transport – including public transport vehicles, stops, routes and timetables.
- Traffic management plans – any traffric operations to modify the network conditions to affect driver behaviour or to simulate events on the network including speed changes and incidents.

The following features need be checked and considered for inclusion in the network coding:

- Turn restrictions – turn bans for all vehicles or different vehicle types including allowed lanes to turn into and the restriction time.
- Speed limits – the maximum posted speed including permanent and variable limits for sections and turns.
- On-street parking – road sections where on-street parking is allowed including parking areas and time allowed.
- Heavy vehicle restrictions – including designated areas and restriction times.
- Bus only lanes – road lanes where only buses are allowed to travel at certain times.
- School zones – road sections near schools which have reduced speed limits during school hours.

6.3.2 Network Geometry

As outlined in Section 6.2, a new modelling project can be set-up through different sources. After initial set-up, network refinement will be needed to ensure that the model network geometry, including sections, nodes and turns, reflects the existing road network.

Modellers should use latest geo-referenced aerial images as the base (refer to Section 6.2.2).

6.3.3 Section Parameters

This section provides information on section parameters to be used in Aimsun models.

6.3.3.1 Road Type

Road types allow the classification of sections and the fast editing of a set of sections using the road type editor. The modeller should identify and assign the appropriate road types and apply reasonable section parameters to the road network as a starting point.

6.3.3.2 Capacity and Attractiveness

Capacity defines the maximum number of vehicles that can get through the section. Section capacity is a key factor in determining route choices in static assignment.

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 OD pair.

While it is recommended that modellers use the default method where capacity is equal to attractiveness, in some cases the modeller may need to calibrate the section attractiveness based on locally observed behaviour that could not be justified by other parameters. Modellers must document any changes in the modelling report.

6.3.3.3 Speed Limit

The section speed limit should follow the speed limit published in Main Roads' road information mapping system available from the website. Manual checks based on site observations are required to ensure that the posted speed limits are correct.

6.3.3.4 Section Slope

Main Roads may request slopes to be modelled in Aimsun to replicate driver behaviour due to steep vertical road grades in the existing or proposed network. Road grade information can be obtained from the following sources:

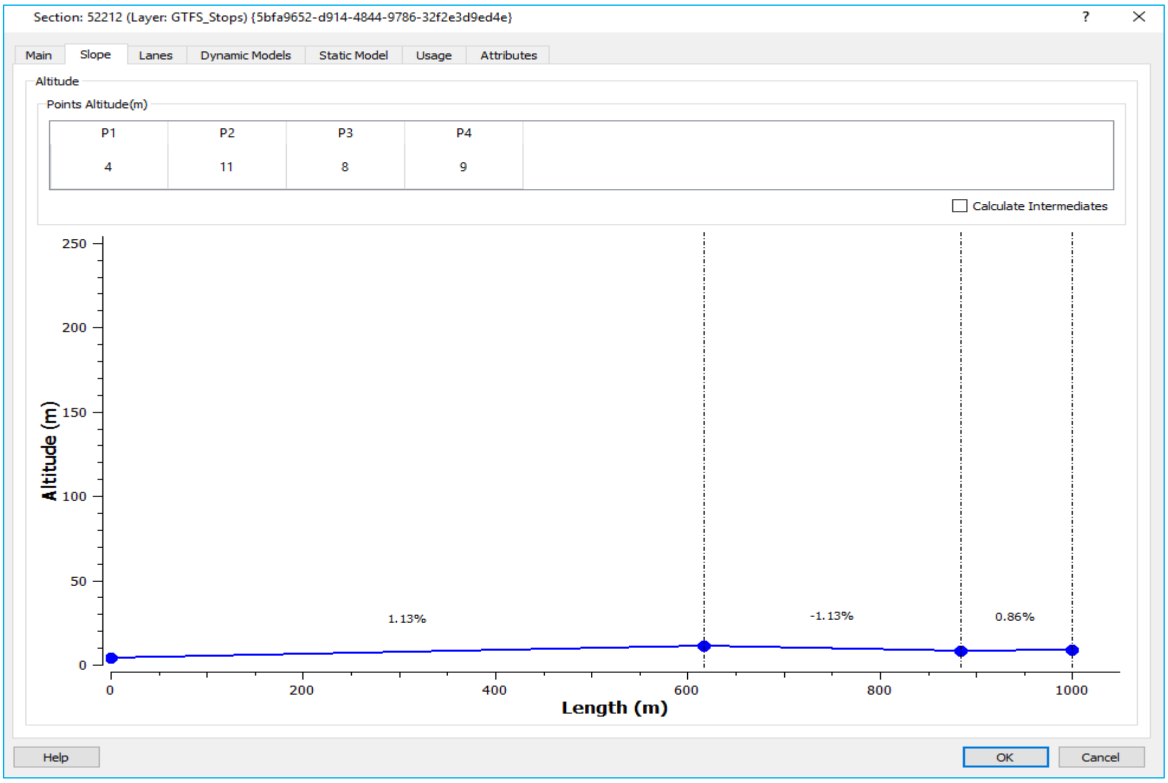
- surveyor data
- design drawings (as constructed or proposed)
- GIS database, and
- Google Earth or Google Maps.

Once the data has been obtained, the modeller may elect to analyse the data and average the measured vertical road grades to simplify the coding procedure. As shown in Figure 6-4, Google Earth provides elevation data in meters, which can be simplified and averaged over three segments to be coded into Aimsun.

Figure 6-4: Example of vertical road grades from Google Earth

The section slope editor under *Points Attitude (m)* in the *Slopes* tab can be modified by numerically setting the altitude of a section based on the number of vertices within the section. As shown below in Figure 6-5, the obtained slope data from Figure 6-4 can be coded into Aimsun to replicate the road grades.

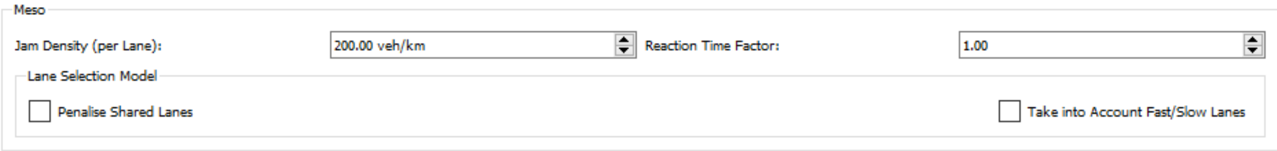
Figure 6-5: Example of Aimsun section slopes



6.3.3.5 Meso Parameters

Jam Density and *Reaction Time Factor* are two major section parameters for mesoscopic simulation. *Penalise Shared Lanes* and *Penalise Slow Lanes* options can be selected to influence lane utilisation, as shown in Figure 6-6.

Figure 6-6: Default section meso parameters

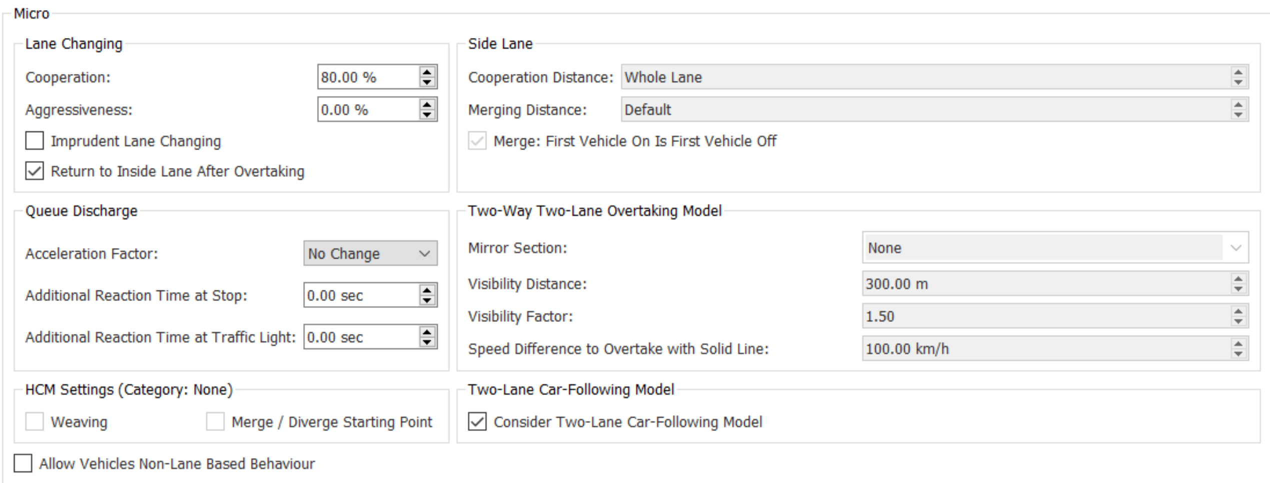


The default value for reaction time factor is 1.00 and the default value for jam density (per lane) is 200 veh/km for Aimsun 8.2 and later. As the gap between vehicles tends to be smaller when a network is congested, the reaction time factor can be slightly reduced. Modellers may also consider marginally adjusting the jam density factor based on the level of congestion. All changes to these parameters should be documented in the modelling report.

6.3.3.6 Micro Parameters

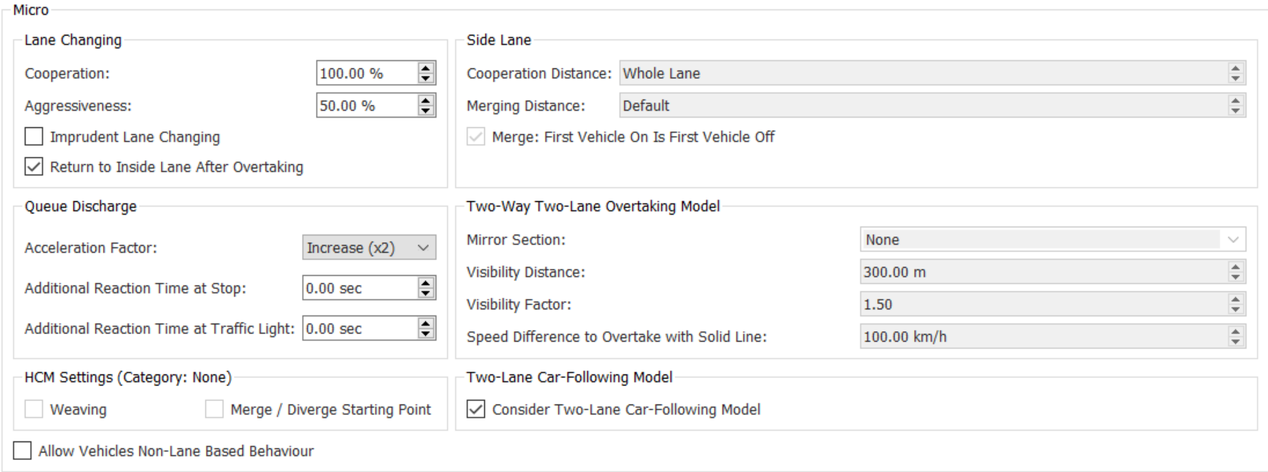
Figure 6-7 describes the default values for typical section micro parameters.

Figure 6-7: Typical section micro parameters



Main Roads recommends the use of default settings for merge sections. If simulations do not reflect street observations, modellers can adjust lane changing and side-lane parameters. Figure 6-8 illustrates suggested values as a starting point to increase the aggressiveness and cooperativeness of vehicles within the section. These parameters should be calibrated based on the observed merging conditions. Changes to these parameters must be documented in the modelling report.

Figure 6-8: Merge section micro parameters



The *Queue Discharge* parameters should only be changed when the changing of other parameters cannot replicate the observed driver behaviours at an intersection. Changes to these parameters must be documented in the modelling report.

6.3.4 Node Parameters

This section provides information on node parameters to be used in Aimsun models.

6.3.4.1 Turn Speed

The turning speed should generally be lower than the approach speed for turning movements.

Aimsun automatically calculates turning speed based on the angle of the movement. In general, Main Roads recommends that modellers check the automatically calculated speed for all turn movements to ensure that turning speeds are reasonable. This is particularly important when the operation of the intersection is being assessed. Turning speeds for various radii are shown in Table 6-1 and modellers are required to exercise their judgement to estimate the appropriateness of the turning speeds.

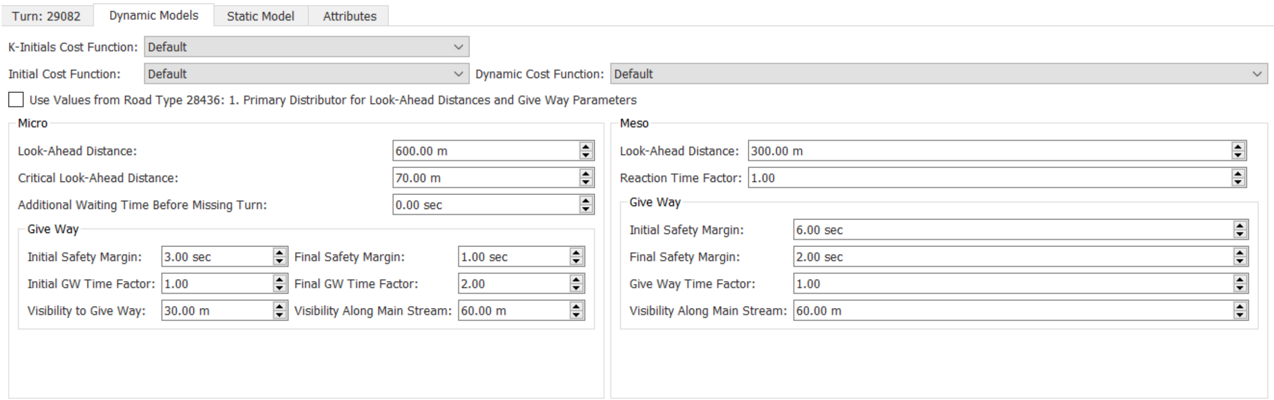
Table 6-1: Recommended Aimsun Turning Speeds

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

6.3.4.2 Turn Dynamic Model Parameters

Figure 6-9 shows the default dynamic model parameters at a priority intersection for a turn and it may differ depending on the assigned road type.

Figure 6-9: Default turn dynamic model parameters



The look-ahead distance and give-way parameters can be adjusted based on the different circumstances. For example, for a freeway off-ramp or a right-turn movement, the look-ahead distance can be increased to the same distance as the advanced warning sign. Figure 6-10 and Figure 6-11 show examples of turn parameters for a freeway ramp and a right-turn movement. Values should be adjusted based on site conditions and must be documented in the modelling report.

Figure 6-10: Example of turn dynamic model parameters for an exit freeway ramp

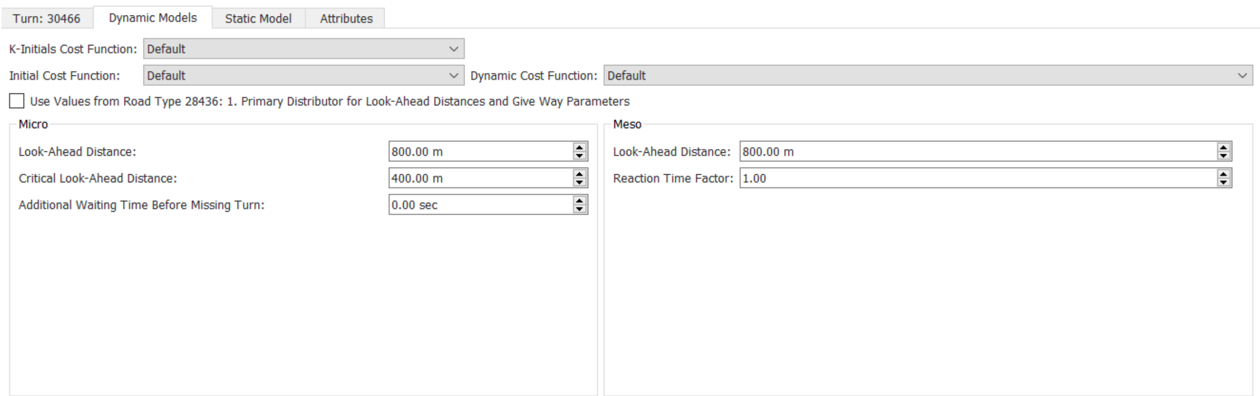
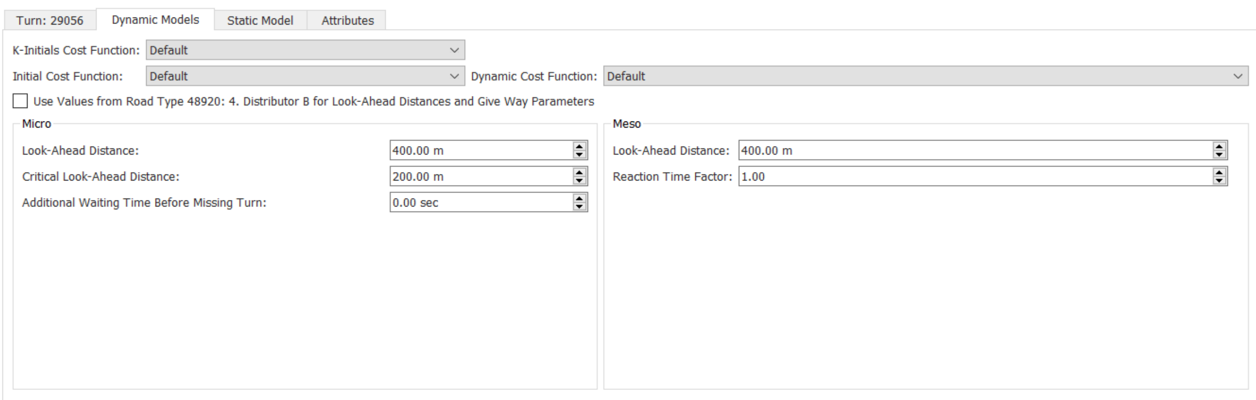


Figure 6-11: Example of turn dynamic model parameters for a right-turn movement



6.3.4.3 Turn Static Model Parameters

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

Figure 6-12 shows the default static model parameters from Aimsun for signalised and priority intersections. The key parameters involved in this interface include the TPF for signalised intersections and JDF for priority intersections. All the functions need to be consistently defined within the model.

Figure 6-12: Turn static model parameters

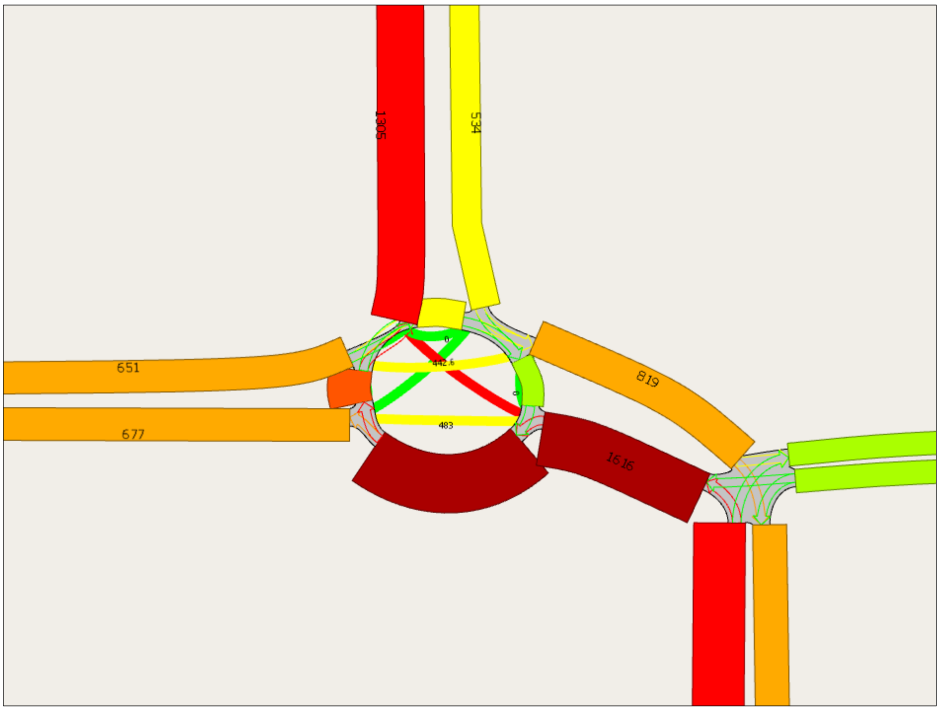
6.3.4.4 Yellow Box

The default yellow box speed is 10km/h. This parameter can be changed during the calibration process to replicate specific behaviour (for example, courtesy give-ways).

6.3.4.5 Supernode

Aimsun 8.3 introduced supernodes as an extended functionality of a node that is commonly applied to roundabouts to import real data and generate outputs. Figure 6-13 illustrates how a supernode can be applied at a roundabout.

Figure 6-13: Supernode at a roundabout – Assigned Volumes



6.3.5 Zone System

This section provides information on setting up zone systems to be used in Aimsun models.

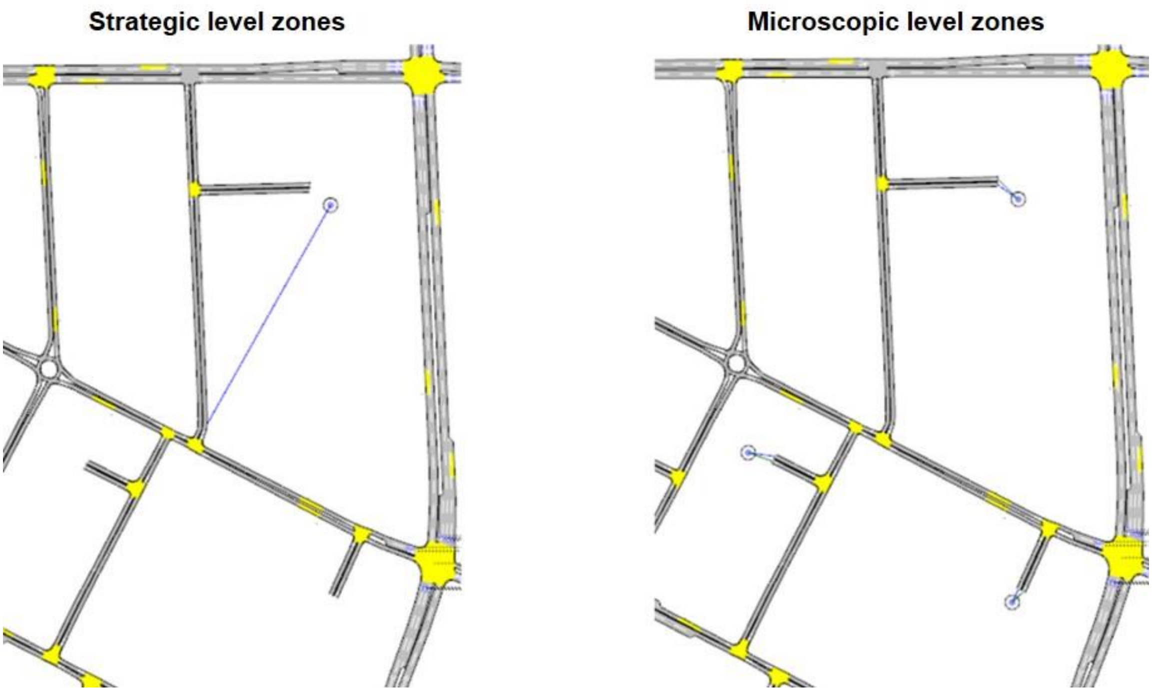
When coding a new model based on OpenStreetMap or aerial images, modellers must create centroids at each entry and exit section for the study area.

When coding a new model based on a strategic model, model zones or centroids are generally already established, however, they may not be sufficiently disaggregated for mesoscopic or microscopic modelling. Zonal disaggregation and aggregation are needed to provide a detailed representation of trip loading points. The strategic model zone boundaries should be provided to assist modellers with the disaggregation of zones.

As the strategic model zones are directly connected into strategic level nodes, the strategic connector configurations are likely to generate unrealistic delays or congestion in the network at the mesoscopic or microscopic level. The zone connections should be modified to model more realistic trip generation and attraction locations, such as local streets, parking entrances and exits, taxi ranks or other access points.

Figure 6-14 shows an example of strategic level zones that have been disaggregated and edited to microscopic Aimsun zones. All assumptions related to the aggregation or disaggregation of zones should be stated in the modelling report.

Figure 6-14: Example of converting strategic level zones to microscopic Aimsun zones



6.3.6 Signal Control Types

Aimsun allows users to simulate signal operations using different signal control types, including:

- Fixed-time signal control with fixed offsets between intersections.
- Vehicle actuated signal operation with fixed offsets between intersections.
- A *SCATSIM* interface plug-in.

6.3.6.1 Fixed-Time Signals

Fixed time signals should generally be used where there is minimal variation of phase sequences and timing throughout the assessment period.

Fixed-time control also allows modellers to easily simulate the signal offset. In order to model the signal offset correctly, it is recommended that site set-up be coordinated with the same cycle time value or a multiple of each other. The offset value can be determined by analysing SCATS outputs (Refer to Appendix A).

6.3.6.2 Vehicle Actuated Signals

Vehicle actuated signals are used to replicate SCATS signal operations, boom gates, public transport priority or variable phase sequences.

The set-up and operation of vehicle actuated signals should follow the SCATS set-up and operations.

6.3.6.3 SCATSIM

The coding of signalised intersections as *SCATSIM*-controlled allows realistic replication of the network conditions and is an efficient way for information transfer.

To guarantee correct connection between Aimsun and SCATS, it is essential that the SCATS objects such as signals and detectors correspond with the Aimsun objects. The following rules should be followed:

- **SCATS intersections** – each SCATS intersection should be represented in Aimsun as one SCATS type controller, setting the SCATS intersection ID in the *Intersection ID* tab. One SCATS intersection can be represented by one or more Aimsun intersections. All intersections that represent one SCATS intersection should be represented using connections between its SCATS controller and the associated Aimsun intersections.
- **SCATS *SGroups*** – the model must contain the same *SGroup* definition as SCATS with the same association of turns.
- **SCATS detector** – SCATS has two types of detectors:
  - physical detectors which measure *count* and *occupancy*
    - » each SCATS detector should be modelled as one corresponding Aimsun detector and must have *count* and *occupancy* as measuring capabilities
  - logical detectors (beacons) identify public transport vehicles and are associated with one physical detector and a set of public transport lines
    - » if this detector represents one physical detector associated with one logical detector then the Aimsun detector must have at least *equipped vehicle* as a measuring capability. All public transport lines associated with logical detectors should be modelled as public transport lines with 100 per cent of *equipped vehicle* in the public transport vehicle types
  - Note that detector length is strongly related to the measured occupancy and the Aimsun detector length should be set to match the expected SCATS occupancies.
- **Control plan** – for each intersection controlled by SCATS it is necessary to set the control type as *external* and define a pre-timed or fixed control plan with the definition of all phases with their durations.

The Aimsun-SCATS ITS interface can be used to support the coding of the SCATS intersection geometry, *SGroups*, detectors, controllers, historical signal timings and detector counts.

It is the responsibility of the modeller to ensure that all required SCATS system files are available for the modelling exercise (the SCATS files can usually be obtained from Main Roads). The SCATS required system files include:

- central manager database (*.mdb*)
- region system files for each region
  - sys.lx
  - sys.tc
  - sys.ram
- *WinTraff* file (*.sft*) for each intersection
  - *SimHub* or equivalent connection software.

It is recommended that the modeller follows the set-up specifications of *SCATSIM*.

Fixed time signals should generally be used where there is minimal variation of phase sequences and timing throughout the assessment period.

6.3.7 Ramp Metering

The purpose of ramp metering operations is to improve freeway efficiency by regulating flows on the on-ramps to the freeway. There are several methods of modelling for the metering of the ramps but it will depend on the purpose of the study.

6.3.7.1 Fixed-Time Metering

Fixed-time control is a simplified method to simulate the operations of the ramps by inputting the observed ramp metering data. The input data required will vary depending on the type of metering option selected in Aimsun. The fixed metering options are:

- green-time metering
- green-time by lane metering
- flow metering, and
- delay metering.

The fixed-time ramp meters will have to be validated against the observed on-ramp and freeway operations. This will be confirmed during the project scope meeting as the requirements will vary depending on the purpose of the project.

6.3.7.2 ALINEA Ramp Metering

The ALINEA algorithm is a closed-loop dynamic system that improves the efficiency of the freeway by dynamically controlling the on-ramp flows based on the mainline downstream occupancy rate. The algorithm only runs in isolation and queues cannot be managed on the on-ramps.

6.3.7.3 Adaptive Ramp Metering

Adaptive Ramp Metering (ARM) is an Aimsun algorithm comparable to (HEuristic Ramp metering coOrdination) HERO. It is an extended version of ALINEA with a feedback system that coordinates and controls local ramp meters under specific conditions. When ARM is activated, the ramp that triggered ARM will become the master ramp of any upstream ramps which will become slaves to reduce flows to improve efficiency on the mainline. ARM will deactivate once the specific conditions are satisfied. The trigger conditions are:

- Activation trigger
  - the mainline occupancy is over a threshold of the target occupancy, and
  - the queue on the on-ramp (which becomes the master ramp) is over a threshold of the maximum queue length.
- Deactivation trigger
  - the mainline occupancy drops below the threshold of the target occupancy, or
  - the queue on the master ramp is lower than the threshold of the maximum queue length.

6.3.7.4 STREAMS Plug-in

Aimsun 20 introduced an interface to connect Aimsun with the ITS platform STREAMS by Transmax. It allows the most realistic replication of the ramp metering condition, however, there is a trade-off as it can only be simulated in real-time. Therefore this method will not provide results as efficiently as the other methods referenced.

ARM is recommended when the focus of the model is to assess the operation of the freeway and fixed timing is appropriate for all other modelling assessments.

6.3.8 Pedestrians

As stated in Section 2.10.11, pedestrian facilities are provided to assist pedestrians in safely crossing the carriageway. Pedestrian crossings can be standalone or incorporated within intersections. To ensure a level of realism in the microsimulation models, pedestrians should be accounted for where it causes additional delays to the road network. These additional delays can be at signalised intersections, uncontrolled intersections and mid-block sections. There are several methods to capture the pedestrian and vehicle interaction on the carriageways, with the level of realism varying based on the purpose of the project.

In most cases, individual pedestrians are not required to be modelled in Aimsun, however, the impacts of pedestrians at intersections or mid-block sections need to be captured in the model. At signalised intersections, it is recommended that delayed starts based on observations or surveys are applied at specific signal groups to replicate vehicle delay due to vehicles yielding to pedestrians. At mid-block sections, it is recommended to code in dummy signals or traffic management plans to capture pedestrian related delays based on observations or surveys. All assumptions are to be stipulated in the modelling report.

If detailed pedestrian and vehicle interaction is required, the modeller may elect to use the Legion for Aimsun plug or the built-in pedestrian simulator introduced in Aimsun 20 that is capable of replicating pedestrians on sidewalks, between pedestrians and traffic at crosswalks, as well as boarding and alighting movements at public transport stops.

Main Roads recommends that delayed starts based on observations or surveys are applied at specific signal groups to replicate vehicle delay due to vehicles yielding to pedestrians.

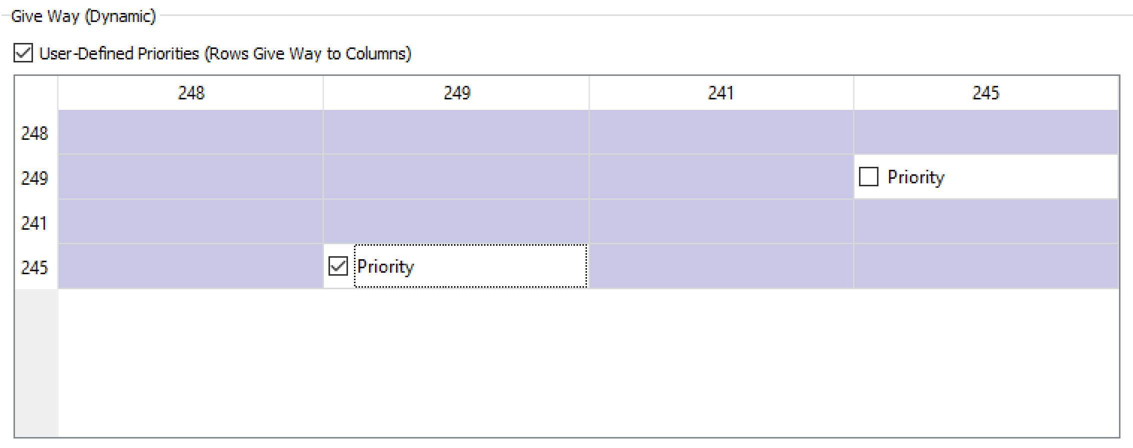
6.3.9 Priority Rules

There are two priority types: give-way and stop. Priorities for the movements need to be set up correctly. It is essential for modellers to use the correct control type, that is, the give-way warning for give-way-controlled intersections and the stop warning for stop sign-controlled intersections.

Give-way priority rules must also be coded for any filter right-turn movements at a signalised intersection.

Checks are needed at priority intersections to ensure that opposing movements are correctly represented, for example, the right-turn movements in and out of side roads correctly interact. This can be completed on the *Give Way* tab in the *Node* window as shown in Figure 6-15.

Figure 6-15: Example of Applying Dynamic Give Way Priorities



6.3.10 Public Transport

Public transport coding should be based on the information obtained from *Transperth*, including public transport routes, stop locations, timetables and dwell time. If there is no dwell time data available, and the model does not require detailed public transport operations, the parameters shown in Table 6-2 may be used depending on the purpose of the model and the study area.

Table 6-2: Bus dwell time parameters

Parameter	Suggested value
Mean	10 - 20 seconds
Deviation	5 seconds
Offset(s)	0 seconds

Alternatively, for bus priority projects, the modeller is required to obtain additional bus data from the Public Transport Authority (PTA) to accurately replicate bus operation. This data may include:

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

Modellers should include school buses in the public transport coding. The routes and timetables of school buses can be obtained from the *Transperth* website. All bus-only lanes should be included in the model. This can be done by applying the public transport only lane type.

A bus dwell time of 10 seconds is sufficient in most cases, however, bus dwell times may be higher within the CBD, around schools and universities and bus stations. On-site observations of dwell time should be used to help determine bus dwell time parameters

6.3.11 Parking

Off-street parking should be modelled as zones if they are considered to have a significant impact on traffic flow. Part-time on-street parking and clearways can be modelled as lane closures using a traffic management plan.

6.3.12 Traffic Management

A traffic management strategy consists of a number of policies which are applied to a traffic network to replicate existing conditions or to test specific traffic management measures, that is, to manage traffic around roadworks or incidents.

Possible traffic management actions under each policy are presented in Table 6-3.

Table 6-3: Traffic management actions and examples

Traffic management actions	Application
Lane closure	On-street parking and clearways
Turn closure	Time-dependent turn bans
Turn cooperation model activation	Turn priority change
Speed change	School zones, VMS
Forced turn	A certain percentage of vehicles need to turn at a certain location
Force en route assignment	A certain percentage of vehicles need to use alternative routes
Destination change	When the destination zone is required to change (this should be done carefully as it is essentially a change to the matrix)

Park and ride	Similar to destination change but relating to public transport
Section incident	Blocks lane(s) to replicate an incident
Periodic section incident	A time-based section incident
Deactivation of a reserved lane	Makes reserved lane accessible to all vehicle types
Control plan change	Changes the current plan to alternative signal control plans, similar to a SCATS action being implemented
Section behavioural parameters change	Mesoscopic reaction time change

6.3.13 Attribute Override

Aimsun holds a base network that can be modified without having to create a new model, reducing the errors inherent in creating variants of the network.

The aim of the *attribute override* object is to allow the modification of attributes without having to replicate networks for each configuration such as section distance zones, capacities, section *VDF*s and turn penalties.

6.3.14 Scripts

Python scripting is ideal for writing small utilities to automate some operations that would usually be done manually with the graphical user interface (GUI). Typical tasks that might be performed with scripting are:

- modifying the model or a group of objects
- importing or exporting data
- performing calculations with the model's data
- modifying the meta data model, and
- introducing new attributes.

6.3.15 Subpaths

A subpath is a set of consecutive sections that can have any length and can be located anywhere in the model. Subpaths have two main uses:

- To gather subpath statistics, for example travel time, flow, counts, and delays.
- To be used in traffic management actions as part of a vehicle's route.

6.3.16 Subnetworks

A subnetwork is a subarea of the global network that can be analysed independently. Subnetworks are used for detailed analysis of an area within a wider network. Typical applications of subnetworks include:

- Analysis of a subarea within the wider strategic network. Generally, the strategic model information should be stored in the main model and subnetworks should be created for each project.
- Analysis of a subarea within an existing simulation model.

Once a subnetwork is defined, a traversal demand should be generated based on the assignment results from the main model. To generate the traffic demand in a subnetwork, a static or dynamic traversal may be used. A traversal requires input from a previously-run static experiment or dynamic simulation replication of the wider project network to provide the demand data for the subnetwork demand.

6.3.17 Geometry Configuration

Geometry configuration is an alternative network geometry of a traffic network. For example, it can be used to code an intersection upgrade, including new links to the intersection (sections and nodes) and smaller modifications to the intersection (for example, an additional turn lane). It allows modellers to simulate different scenarios with different combinations of possible network changes.

Geometry configuration is implemented as a list of objects that exist only (*existent only here*) and a list of objects that do not exist (*non-existent here*) in a specific scenario when the configuration is selected. Objects that are not selected in any geometry configuration are common to all scenarios.

Main Roads recommends that modellers use a single geometry configuration for each distinct project, as this allows maximum flexibility for the assessment of individual projects as well as the aggregated impacts of each project. The same geometry configurations should be used consistently in each related level of modelling in order to ensure consistent outcomes.

As geometry configurations will affect the network in terms of link connectivity, checks and changes will be needed for the following aspects:

- public transport lines
- subpaths
- traffic management plans
- network attribute overrides
- section and turn parameters, and
- traffic signal plans.

6.3.18 Revisions

A revision is a traffic network modification which only stores those elements that have been changed. Revisions are useful for projects that start from an initial situation and want to study changes or events without creating new scenarios, geometry changes or demands in the base model file. Revisions are also useful when several modellers are working on different parts of the network and their changes need to be combined into one model revision.

A revised network contains objects which overwrite those in the base model network file with only those modified objects. The base network must be present when loading a revised network and if it cannot be found, Aimsun will request its location. As the objects in the revised network overwrite the base network objects, any subsequent changes to the base network for those objects will not be included in the revised network.

As it only contains the revision modifications, it needs the base network to load the whole network. It is possible to transform a revision into a full network by consolidating the base and the revision information in the same file. This can be done from the *Project/Consolidate Revision* window where:

- ***Consolidate in base*** – copies the revisions into the base which in turn will affect any other revisions based on this base model. This also updates object IDs in the base revision.
- ***Consolidate in revision*** – copies the base into the revised model and makes the base and revision into two independent documents.

6.4 Demand Set-up

Once transport and network parameters are coded in a model, modellers should define traffic demand data to be assigned in the network. This section discusses the information for demand data set-up in Aimsun.

6.4.1 Centroid Configuration

A *Centroid Configuration* holds a set of centroids, OD matrices and routes related to those centroids. A network may have multiple *centroid configurations*; these are used to hold:

- OD matrices for the whole network
- OD matrices for sub areas, and
- variations of demand due to future infrastructures.

More than one configuration can exist in the same network but only one can be active for editing, or in use in a simulation at the same time. Only centroids from the active configuration will be drawn.

6.4.1.1 OD Matrices

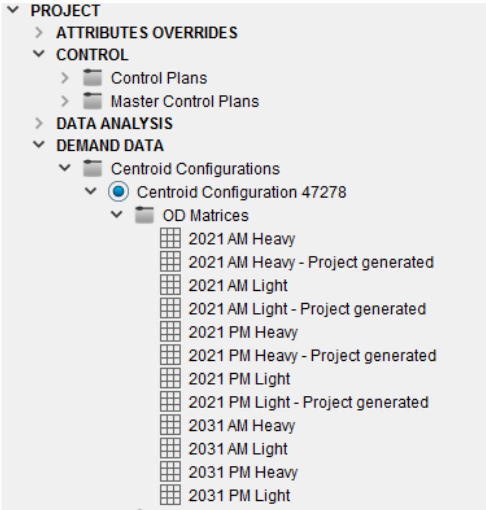
The traffic conditions to be simulated can be defined by a set of OD matrices.

An OD matrix contains all the trips that will be generated in a network for a particular vehicle type and trip purpose in a defined time period. Each cell of an OD matrix contains the number of vehicles going from origin to destination zones. An OD matrix is linked to *Centroid Configuration*.

Main Roads recommends that every new OD matrix is named accordingly using year, peak time and any specific use.

Figure 6-16 shows an example of OD matrices naming convention.

Figure 6-16: Example of OD Matrices naming convention



6.4.2 Path Assignment

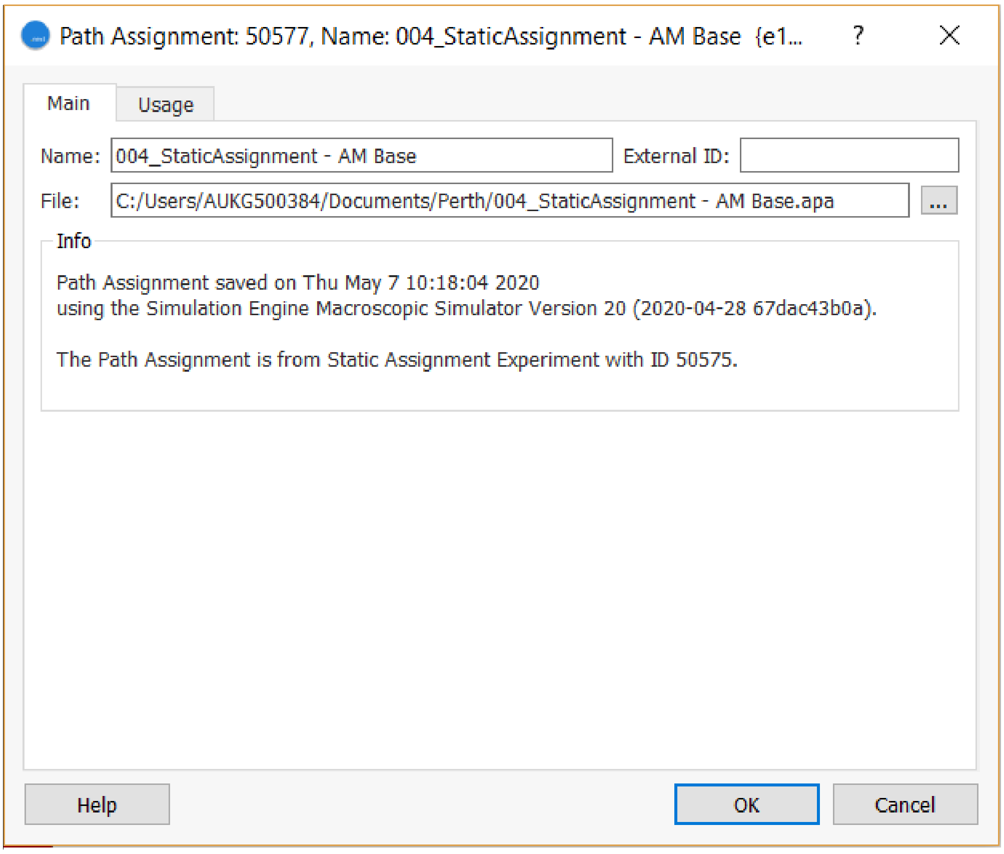
A path assignment contains the information generated in a traffic assignment (either dynamic or static). It is stored as a binary file with an Aimsun specific format (.apa).

The information in a path assignment can be explored as an output of static and dynamic assignments.

A *Path Assignment* object in Aimsun contains information about the data file location and the objects that are using it (scenarios can use it as input, experiments or replications can produce an .apa file as an output).

Figure 6-17 shows an example of a *Path Assignment* object window.

Figure 6-17: Example of Path Assignment details



Main Roads recommends that the modeller names *Path Assignments* according to the scenario and assignment type to avoid confusion.

6.4.3 Traffic Demand

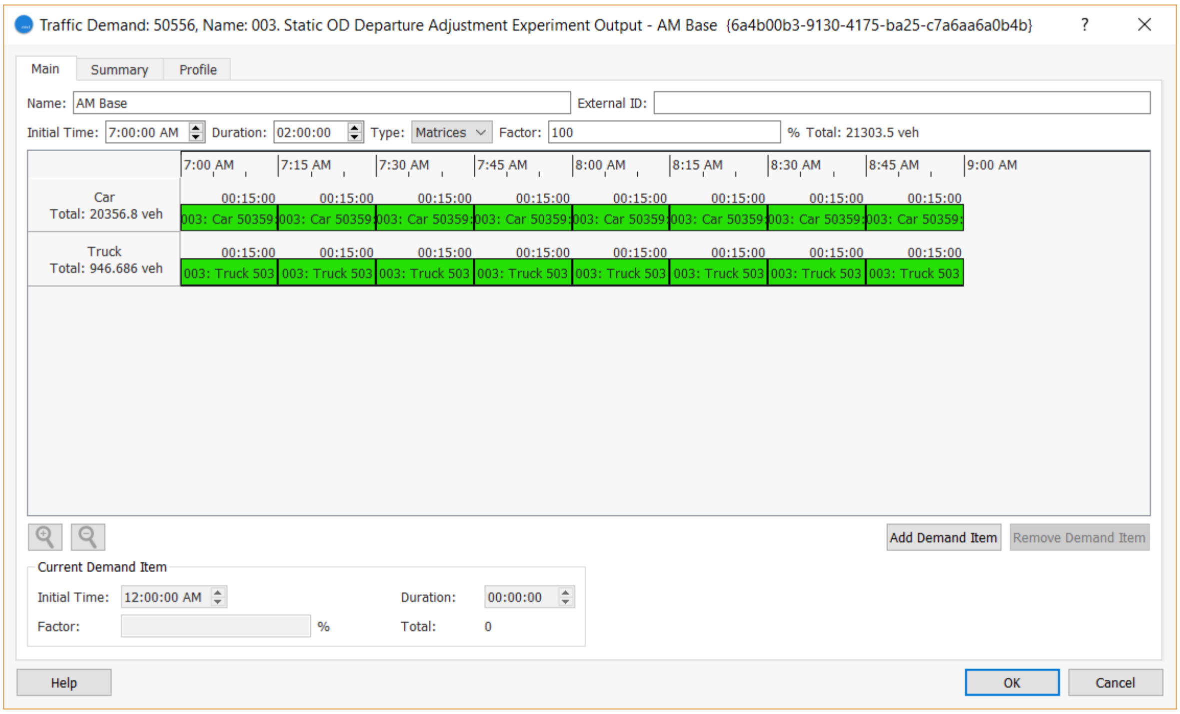
A *Traffic Demand* is a collection of OD Matrices, which can be placed as a single object in different scenarios. A *Traffic Demand* object is intended to simplify the process of managing demand states and facilitate allocating them consistently across scenarios.

In Aimsun, OD matrices are created for a single vehicle type and trip purpose (in the case of OD matrices, that is, for a single user class) in a single time period. Several OD matrices will be grouped into a *Traffic Demand* which contains traffic data for several vehicle types (or several user classes) and time intervals and are used as an input for one or more Aimsun scenarios.

There is also a global factor that can be used for scaling all the OD matrices included in a traffic demand. Modellers can set a percentage to scale all the trips in the OD matrix for future year or other scenario assessments.

Figure 6-18 shows an example of how to set-up a *Traffic Demand* in Aimsun.

Figure 6-18: Example of Traffic Demand editor



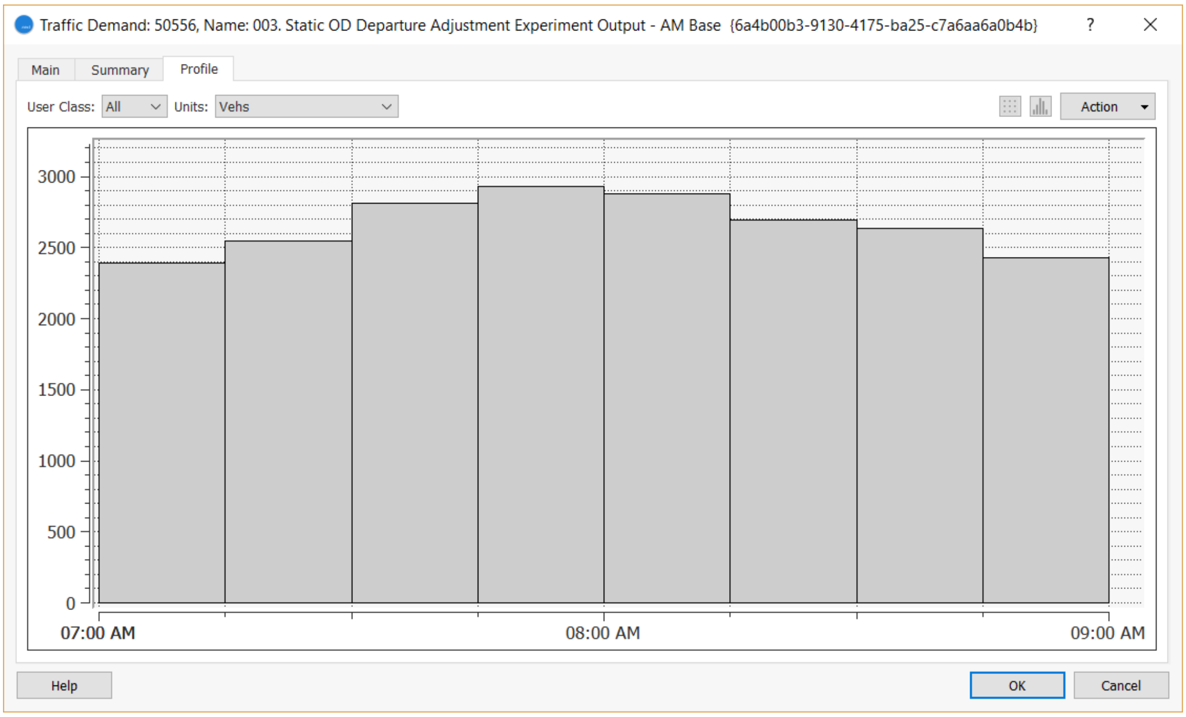
The *Profile* folder shows the demand profile, that is, a diagram showing the percentage of trips of each of the matrices in the demand, for each user class.

It is recommended for model category 1 (Refer to Section 2.12.2.1) that traffic count data is analysed for 15 minute intervals and demand profiles are set accordingly for peak periods to enable a model to more accurately replicate on-site observed traffic flow.

A flat demand profile or hourly volumes with set intervals is appropriate for model categories 2 and 3. However, peak fluctuations due to schools and shopping centres may occur and therefore, depending on the purpose of the model, traffic data analysis for 15 minute or 30 minute intervals may be required for categories 2 or 3. The demand development methodology will require agreement with Main Roads during the scope meeting.

Figure 6-19 shows an example of a *Traffic Demand* profile used in Aimsun.

Figure 6-19: Example of Traffic Demand profile



The modelling should not only include the simulation assessment period, but also the warm-up and cool-down periods. The warm-up period is the time that allows the traffic demands and queues to get into a realistic level of congestion observed on-site at the beginning of the analysis period. The cool-down period is the time that loads vehicles to complete their trips and to replicate the congestion observed at end of the analysis period.

The duration of the warm-up and cool-down periods should be sufficient to reflect traffic volume and queue conditions in the network observed on-site. Depending on the model network size, a minimum of two times of the longest travel time or 15 minutes, whichever is greater should be defined for each of the warm-up and cool-down periods. The duration for the warm-up and cool-down periods should be agreed with Main Roads.

6.4.4 Real Data Sets

Aimsun can read external detection data as a time series that can be used to calibrate and validate a model, to adjust an OD matrix or to display the current traffic data on the network. The time value in the real data set *.txt* file should be the end time, while the time value in real data simple file reader editor should be the initial time.

Figure 6-20 shows an example of real data simple file reader editor settings and Figure 6-21 shows an example of a real data set *.txt* file.

Figure 6-20: Real data simple file reader editor settings

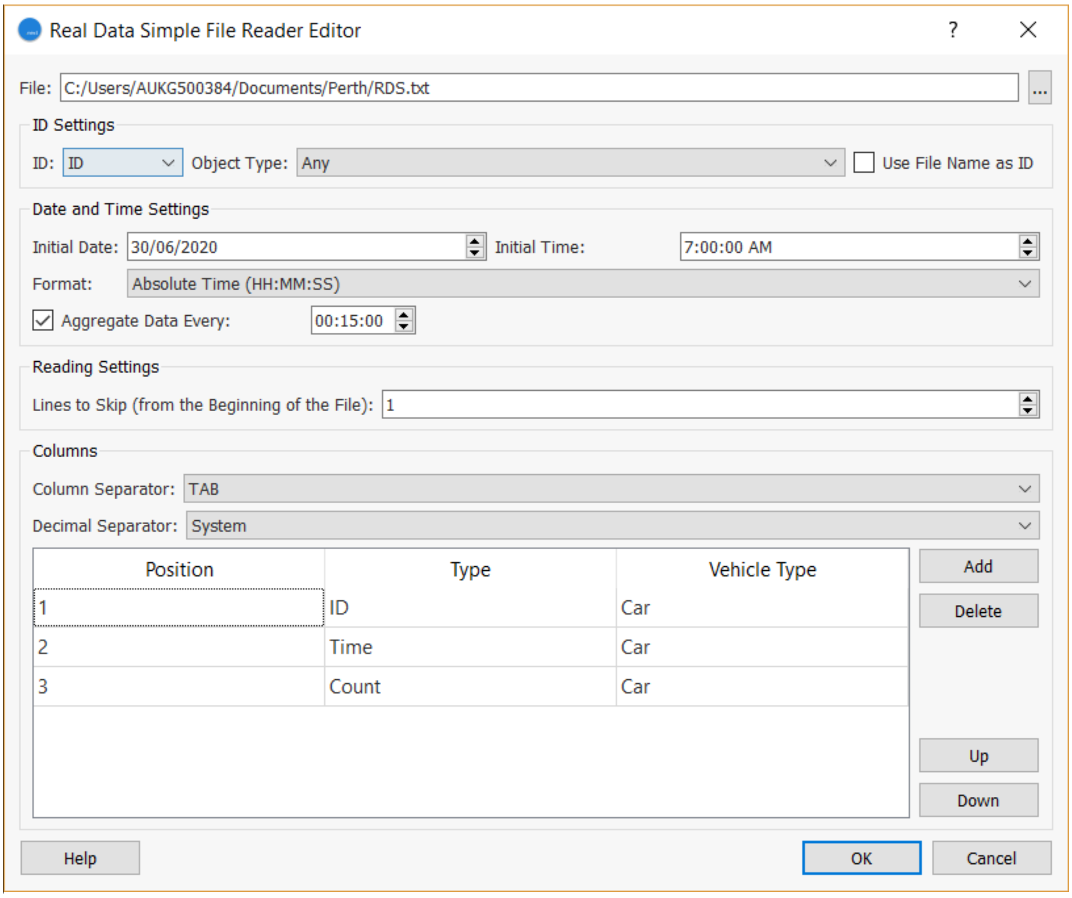
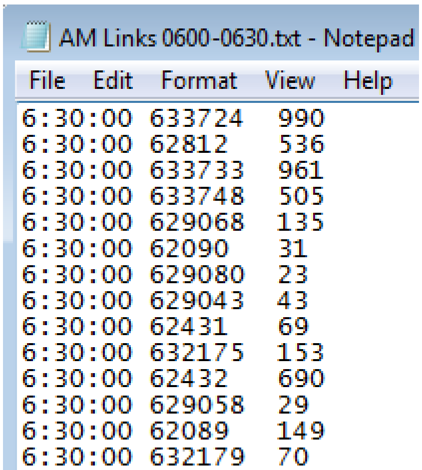


Figure 6-21: Real data set file



6.4.5 Vehicle Settings

The vehicle settings have been developed for on-site conditions in Western Australia, as well as with reference to other states' guidelines[24]. The recommended vehicle parameter ranges are shown in Table 6-4 to Table 6-10. The modeller may elect to use alternative parameters but is required to provide justification in the modelling report.

[24] Department of Planning, Transport and Infrastructure's (South Australia) *Aimsun Traffic Simulation Model Development Manual*, and Department of Transport and Main Roads' (Queensland) *Aimsun Template.*
[24] Only applicable in Aimsun 8.2 and later.

Table 6-4: Car parameters

Parameter	Mean	Deviation	Minimum	Maximum
Length (m)	4.0 - 4.6	0.45 - 0.5	3 - 3.35	5 - 5.35
Width (m)	1.75 - 2.00	0 - 0.25	1.75 - 2.00	1.75 - 2.00
Max. desired speed (km/h)	110	5.5 - 10.0	80 - 99	120
Speed acceptance	0.96 - 1.05	0.05 - 0.09	0.75 - 0.95	1.12 - 1.16
Clearance (m)	1.85 - 3.00	0.25 - 0.80	0.50 - 2.50	3.20 - 3.50
Max. give-way time (seconds)	15- 30	3-5	5 - 24	30 - 36
Guidance acceptance (%)	100	0	100	100
Max. acceleration (m/s^2)	2.70 - 2.80	0.20 - 0.56	1.68 - 2.20	3.50 - 3.92
Normal deceleration (m/s^2)	3.5 - 4.0	0.2 - 0.4	3.0 - 3.2	4.0 - 4.8
Max. deceleration (m/s^2)	6.0 - 6.5	0.50 - 0.65	5.0 - 5.2	7.0 - 7.8
Sensitivity factor	1	0	1	1
Gap (s)	1.1	0.2	0.5	2.0
Headway aggressiveness[24]	0	0	-1.0	1.0
Margin for overtaking manoeuvre (s)	5	3	1	10

Table 6-5: Bus parameters

Parameter	Mean	Deviation	Minimum	Maximum
Length (m)	12.0 - 15.5	2.0	9.0 - 12.5	15.0 - 19.0
Width (m)	2.3 - 2.4	0.0 - 0.5	1.9 - 2.4	2.4 - 3.0
Max. desired speed (km/h)	90	5 - 10	80	100 - 120
Speed acceptance	0.93 - 1.00	0.10	0.69 - 0.9	1.09 - 1.10
Clearance (m)	1.5 -3.0	0.15 - 0.50	1.0 - 2.7	2.5 - 3.5
Max. give-way time (s)	15 - 50	5 - 20	5 - 30	30 - 80
Guidance acceptance (%)	100	0	10 0	100
Max. acceleration (m/s^2)	0.9 - 1.0	0.2 - 0.3	0.8	1.6 - 1.8
Normal deceleration (m/s^2)	2.0 - 3.0	0.3 - 2.0	1.5 - 2.0	3.5 - 4.8
Max. deceleration (m/s^2)	5.0	0.5 - 2.0	4.0 - 4.5	6.0 - 7.8
Sensitivity factor	1	0	1	1
Gap (s)	1.1	0.2	0.5	2.0
Headway aggressiveness	0	0	-1.0	1.0
Margin for overtaking manoeuvre (s)	5	3	1	10

Table 6-6: Truck parameters (Short-towing, two-axle, three-axle, four-axle truck)

Parameter	Mean	Deviation	Minimum	Maximum
Length (m)	8.65 - 12.00	1.0 - 1.9	5.5 - 10.0	11.65 - 14.5
Width (m)	2.4 - 2.5	0.0	2.4 - 2.5	2.4 - 2.5
Max. desired speed (km/h)	100 - 110	5.0 - 5.5	80 - 99	110 - 121
Speed acceptance	0.94 - 1.00	0.05 - 0.10	0.69 - 0.90	1.09 - 1.10
Clearance (m)	2.0 - 3.0	0.15 - 1.30	0.50 - 2.70	3.30 - 3.80
Max. give-way time (s)	15 - 30	3 - 5	5 - 24	30 - 36
Guidance acceptance (%)	100	0	100	100
Max. acceleration (m/s^2)	1.50 - 1.60	0.15 - 0.80	0.80 - 1.20	1.80 - 2.40
Normal deceleration (m/s^2)	2.2 - 3.0	0.22 - 0.30	1.76 - 2.00	2.64 - 3.50
Max. deceleration (m/s^2)	3.00 - 5.00	0.06 - 0.50	2.88 - 4.00	3.12 - 6.00
Sensitivity factor	1	0	1	1
Gap (s)	1.3	0.2	0.5	2.5
Headway aggressiveness	0	0	-1.0	1.0
Margin for overtaking manoeuvre (s)	5	3	1	10

Table 6-7: Semi-trailer parameters (Three-axle, four-axle, five-axle, six-axle articulated)

Parameter	Mean	Deviation	Minimum	Maximum
Length (m)	17.0 - 19.0	0.0 - 2.0	11.5 - 19.0	19.0 - 19.1
Width (m)	2.4 - 2.5	0.0	2.4 - 2.5	2.4 - 2.5
Max. desired speed (km/h)	100 - 110	5.0 - 5.5	80 - 99	110 - 121
Speed acceptance	0.94 - 1.00	0.05 - 0.10	0.69 - 0.90	1.09 - 1.10
Clearance (m)	2.0 - 4.0	0.25 - 1.30	0.5 - 3.0	3.8 - 5.0
Max. give-way time (s)	15 - 30	3 - 5	5 - 24	30 - 36
Guidance acceptance (%)	100	0	100	100
Max. acceleration (m/s^2)	1.00	0.05 - 0.50	0.50 - 0.90	1.10 - 1.50
Normal deceleration (m/s^2)	2.0 - 3.0	0.2 - 0.3	1.6 - 2.0	2.4 - 3.5
Max. deceleration (m/s^2)	2.90 - 5.00	0.09 - 0.50	2.73 - 4.00	3.07 - 6.00
Sensitivity factor	1	0	1	1
Gap (s)	1.3	0.2	0.5	2.5
Headway aggressiveness	0	0	-1.0	1.0
Margin for overtaking manoeuvre (s)	5	3	1	10

Table 6-8: B-double parameters (B-double, double road train)

Parameter	Mean	Deviation	Minimum	Maximum
Length (m)	25.0 - 25.5	0	17.5	25.0 - 36.5
Width (m)	2.5	0	2.4 - 2.5	2.4 - 2.5
Max. desired speed (km/h)	100 - 110	10 - 11	80 - 88	110 - 132
Speed acceptance	0.94 - 1.00	0.02 - 0.10	0.69 - 0.90	1.04 - 1.09
Clearance (m)	2.0 - 4.0	0.2 - 1.3	0.5 - 3.6	3.8 - 4.4
Max. give-way time (s)	15 - 60	5-6	5 - 48	30 - 72
Guidance acceptance (%)	100	0	100	100
Max. acceleration (m/s^2)	0.80	0.04 - 0.60	0.50 - 0.72	0.88 - 2.40
Normal deceleration (m/s^2)	2.0 - 3.0	0.2 - 0.3	1.6 - 2.0	2.4 - 3.5
Max. deceleration (m/s^2)	2.75 - 5.00	0.08 - 0.50	2.59 - 4.00	2.92 - 6.00
Sensitivity factor	1	0	1	1
Gap (s)	1.3	0.2	0.5	2.5
Headway aggressiveness	0	0	-1.0	1.0
Margin for overtaking manoeuvre (s)	5	3	1	10

Table 6-9: B-triple parameters (Triple road train)

Parameter	Mean	Deviation	Minimum	Maximum
Length (m)	36.5	0	36.5	36.5
Width (m)	3.0	0.20	2.50	3.50
Max. desired speed (km/h)	100	10	90	110
Speed acceptance	0.94 - 1.00	0.02 - 0.10	0.69 - 0.90	1.04 - 1.09
Clearance (m)	2.0 - 4.0	0.2 - 1.3	0.5 - 3.6	3.8 - 4.4
Max. give-way time (s)	35.0	10.0	20.0	60.0
Guidance acceptance (%)	100	0.00	100	100
Max. acceleration (m/s^2)	0.60	0.25	0.40	0.80
Normal deceleration (m/s^2)	2.00	0.50	2.00	4.00
Max. deceleration (m/s^2)	3.50	0.30	3.20	3.80
Sensitivity factor	1.00	0	1.00	1.00
Gap (s)	0.00	0.00	0.00	0.00
Headway aggressiveness	0	0	-1.0	1.0
Margin for overtaking manoeuvre (s)	5	3	1	10

Table 6-10: Pedestrian parameters

Parameter	Mean	Deviation	Minimum	Maximum
Length (m)	0.30 - 0.34	0	0.30 - 0.34	0.30 - 0.34
Width (m)	0.45 - 0.50	0.02	0.47	0.53
Max. desired speed (km/h)	3.60 - 4.86	0.918 - 2.00	2.34 - 2.50	5.40 - 7.38
Speed acceptance	1.00	0.50	0.25	1.50
Clearance (m)	0.20	0.15	0.05	0.35
Max. give-way time (s)	20	5	10	30
Guidance acceptance (%)	100	0	100	100
Max. acceleration (m/s2)	0.5	0.2	0.2	0.7
Normal acceleration (m/s2)	1.2	0.2	0.2	1.6
Max. deceleration (m/s2)	1.5	0.2	1.0	2.0
Sensitivity factor	1	0	1	1
Gap (s)	1.3	0.2	0.5	2.5
Headway aggressiveness	0	0	-1.0	1.0
Margin for overtaking manoeuvre (s)	5	3	1	10

6.5 Scenario Set-up

Once the model network and demand data are set up, modellers should determine the traffic assignment method. This section discusses different traffic assignment types and the recommended method for the Western Australian road network.

6.5.1 Static

Static traffic assignment is generally used in macroscopic modelling to estimate the routes between origin and destination zones and link traffic volumes on a network. The path assignment (refer to Section 6.4.2) as an output of static assignments can be used as an initial path data for dynamic assignments in large mesoscopic and microscopic models.

There are five different static assignment methods available:

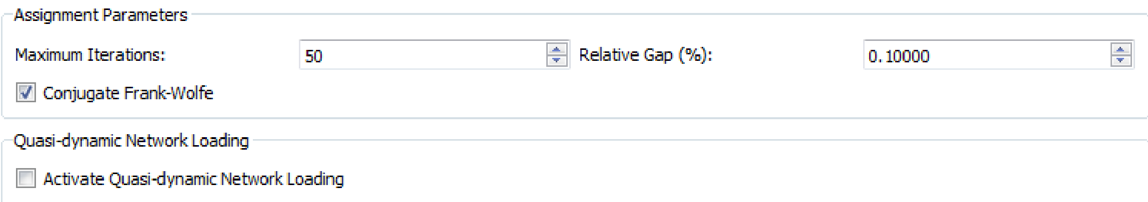
- all or nothing assignment
- incremental assignment
- MSA assignment
- Frank-Wolfe method for equilibrium traffic assignment, and
- stochastic assignment.

It is recommended that modellers use the assignment type which corresponds with that used in the strategic model. Frank-Wolfe assignment used in ROM24 should be applied to a model developed from ROM24.

Before undertaking a static traffic assignment, the modeller should set or check all the input data needed, including road type, section capacity, speed limit, school zones, cost functions and the parameters they depend on.

Figure 6-22 shows the recommended parameters setting for Frank-Wolfe assignment for the models developed from ROM24. These settings should be adjusted based on the needs of the specific project.

Figure 6-22: Recommended parameters for Frank-Wolfe assignment



There are three types of functions which model the macroscopic costs on the network:

- **Volume delay functions (VDF)** – model the generalised cost of the sections and centroid connections.
- **Turn penalty functions (TPF)** – model the primary generalised cost of crossing a turn.
- **Junction delay functions (JDF)** – model the delay caused in a turn due to conflicting turn volumes, the own turn volume or the origin's section volume.

6.5.2 Dynamic User Equilibrium

A dynamic scenario of mesoscopic, microscopic and hybrid models can assign traffic using either dynamic user equilibrium or stochastic route choice.

As a foundation point, Table 6-11 outlines the parameters for setting up a dynamic user equilibrium assignment. However, adjustments of these parameters may be needed for different models as they could impact driver behaviour. Modellers must document the parameter values in the modelling report.

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 6-11: Recommended dynamic user equilibrium assignment parameter setting

Type	Parameter	Suggested value
Stopping criteria	Max. iterations	50
	Relative gap	0.5 - 5
Lane changing	Look-ahead distance variability	40% - 100%
Micro parameters	Two-lane car following model	Follow
	Number of vehicles	4
	Max. speed difference	30 - 50 km/h
	Max. distance	100 m
	Max. speed difference on ramp	50 - 70 km/h
	Speed difference setting	Relative
	Queue entry speed	1 m/s
	Queue exit speed	4 m/s
Simulation step	Simulation step	0.45 s
Micro reaction time (car)	Reaction time	0.90 s
	Reaction time at stop	1.20 s
	Reaction time at traffic light	1.35 s
Micro reaction time (truck and bus)	Reaction time	1.35 s
	Reaction time at stop	1.30 s
	Reaction time at traffic light	1.70 s
Meso reaction time (car)	Reaction time	1.35 s
	Reaction time at traffic light	1.60 s
Meso reaction time (truck and bus)	Reaction time	1.35 s
	Reaction time at traffic light	1.70 s
Arrival type	Global arrivals	Exponential

Type	Parameter	Suggested value
Dynamic assignment	Feedback cycle	Dependent on model size, should be less than the average model travel time
	Number of intervals	1-3
	User-defined cost weight	Dependent on model route choice calibration, can be of a value of up to 5 or more
	Attractiveness weight	Dependent on model route choice calibration, can be of a value of up to 10
	Assignment model	Gradient
	Path cost	Experienced
	Max. paths from path assignment results	3
	Max. paths per interval	3
	Initial K-SP trees	1

6.5.3 Stochastic Route Choice

As a foundation point, Table 6-12 outlines the parameters for setting up a stochastic route choice assignment. However, similar to the dynamic user equilibrium assignment, adjustments of these parameters may be needed for different models as they could impact driver behaviour. Modellers should document the parameter values in the modelling report.

If the model has limited route choice, it is recommended that modellers use fixed travel time under free-flow conditions in the model (in the *Dynamic Traffic Assignment* window).

Table 6-12: Recommended stochastic assignment parameter settings

Type	Parameter	Suggested value
Lane changing	Look-ahead distance variability	40%-100%
Micro parameters	Two-lane car following model	Follow
	Number of vehicles	4
	Max. speed difference	30 - 50 km/h
	Max. distance	100 m
	Max. speed difference on ramp	50 - 70 km/h
	Speed difference setting	Relative
	Queue entry speed	1 m/s
	Queue exit speed	4 m/s
Meso reaction time (car)	Reaction time	1.35 s
	Reaction time at traffic light	1.6 s

Type	Parameter	Suggested value
Meso reaction time (truck and bus)	Reaction time	1.35 s
	Reaction time at traffic light	1.7 s
Simulation step	Simulation step	0.45 s
Micro reaction time (car)	Reaction time	0.90 s
	Reaction time at stop	1.20 s
	Reaction time at traffic light	1.35 s
Micro reaction time (truck and bus)	Reaction time	1.35 s
	Reaction time at stop	1.30 s
	Reaction time at traffic light	1.70 s
Arrival type	Global arrivals	Exponential
Dynamic assignment	Feedback cycle	Should be less than the average network travel time
	Number of intervals	1-3
	User-defined cost weight	Dependent on model route choice calibration, can be of a value of up to 5 or more
	Attractiveness weight	Dependent on model route choice calibration, can be of a value of up to 10
	Stochastic route choice model	C-Logit
	En route	Yes
	En route after virtual queue	No
	Max. paths from path assignment results	3
	Max. paths per interval	3
	Do not consider paths with a percentage below	1 (can be adjusted)
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
En route percentage	Following OD routes	Depends on the project
	Following path assignment result	Depends on the project, at least 50%
	Following route choice models	100% but can be adjusted

6.5.4 Seed Number

There is variability in traffic conditions as a result of random driver behaviour and different daily events. Aimsun attempts to replicate this random variability by altering individual driver decisions based on random seed numbers.

For a dynamic user equilibrium scenario, it is important to ensure the random seed number is the same as the mesoscopic, microscopic or hybrid scenario which created the assigned paths.

For stochastic route choice replications, modellers must run a minimum of five and a maximum of 10 replications with different random seed values and present average model outputs. The modeller should list the used seed numbers in the modelling report.

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

Seed values must remain consistent across all scenarios.

6.6 Model Calibration and Validation

General calibration and validation requires an iterative process of adjusting parameters and analysing model results until the model has achieved an accepted level of confidence when compared to the on-street conditions.

The calibration and validation requirements can be defined based on the importance of a specific project and its significance to the region. It is recommended that modellers discuss the requirements with Main Roads.

6.6.1 Model Calibration Requirement

Base model calibration is the process of employing verifiable observed data into a model to replicate on-street conditions. The following sub-sections discuss the recommended requirements and model input data for the model calibration.

6.6.1.1 Data Collection

For model consistency and accuracy, it is recommended that all data is collected on the same day. The following list of data, although not exhaustive, should be collected.

- design layout information
- SCATS data
- traffic counts
- OD surveys
- public transport route and timetable information
- travel time data
- queue length
- saturation flow

- vehicle speed, and
- video footage.

6.6.1.2 Site Observations

It is important for modellers to observe the existing site conditions. Driving behaviours, network configuration, signal operations and other events which may impact on performance should be captured and reported as part of the modelling. The operating conditions and site findings should be captured in the form of photographs and videos.

6.6.1.3 Model Input Check

Modellers should check network coding and network objects' attributes to confirm that the model replicates the existing or the proposed transport network, and that the simulation is consistent with the observed on-street vehicle behaviour.

The key input to be checked includes:

- number of lanes
- lane width
- lane closure
- section parameters (type)
- Z-height
- feasible movements
- vehicle speed
- priority intersection controllers
- signal control
- traffic demands (OD matrices)
- vehicle routes, and
- dynamic assignment parameters.

6.6.1.4 Vehicle Behaviour

As it is difficult to set up a standard for vehicle behaviour, modellers should undertake a visual check to confirm that the observed on-street vehicle behaviour is consistent with that observed in the model. Vehicle behaviour such as speed/flow performances, bottlenecks, queue formation and discharging need to be carefully compared and calibrated.

> A correctly coded network should reflect on-street vehicle behaviour, especially during congested peak times. Main Roads recommends modellers drive through the network and capture videos of critical locations to familiarise themselves with driving behaviours.

Modellers should include notes and changes to the network in the modelling report.

6.6.1.5 Error Files

Ideally, there should be no error messages for a calibrated and validated model.

If error messages are generated and consistent errors occur at certain location(s), modellers must review network coding and model parameters to ensure all deficiencies are addressed or reported.

6.6.2 Model Validation Requirement

Main Roads defines the three model categories for model validation, based on the network size and modelling purposes. Refer to Section 2.12.2.1 for the model category definitions and validation requirements. The following sub-sections discuss the validation criteria for Aimsun models.

6.6.2.1 Traffic Volumes

Main Roads requires hourly turning movements and directional link volumes to be validated for each major vehicle type. Table 6-13 below demonstrates the model validation criteria for individual model categories.

Table 6-13: Traffic flow validation criteria

Criteria	Category 1	Category 2	Category 3
GEH < 5	95%	85%	80%
GEH < 10	100%	95%	90%
< 700 vph within 100 vph	95%	90%	85%
700 – 2,700 vph within 15%	95%	90%	85%
> 2,700 vph within 400 vph	95%	90%	85%
R squared value	>0.95	>0.95	>0.9

Plots of observed against modelled hourly flows are required to be reported for all observations.

Where throughput between upstream and downstream intersections does not match potentially due to survey error, the flow discrepancy should be identified and detailed in the modelling report. While it is recommended that in these circumstances the most appropriate traffic flow be used based on engineering judgement, this also needs to be explained in the modelling report.

Aimsun compares the modelled result with the real data set in the *Validation* tab. Modellers can check three different available comparisons: by means of a graph, a regression chart or a table.

Under the same *Validation* tab, there is an option to calculate the GEH/Theil statistic for a specific replication and the function will automatically generate a view mode that displays the results in the user interface, as shown in Figure 6-23. Results should be tabulated and included in the modelling report.

Figure 6-23: GEH/Theil statistic view

6.6.2.2 Travel Times

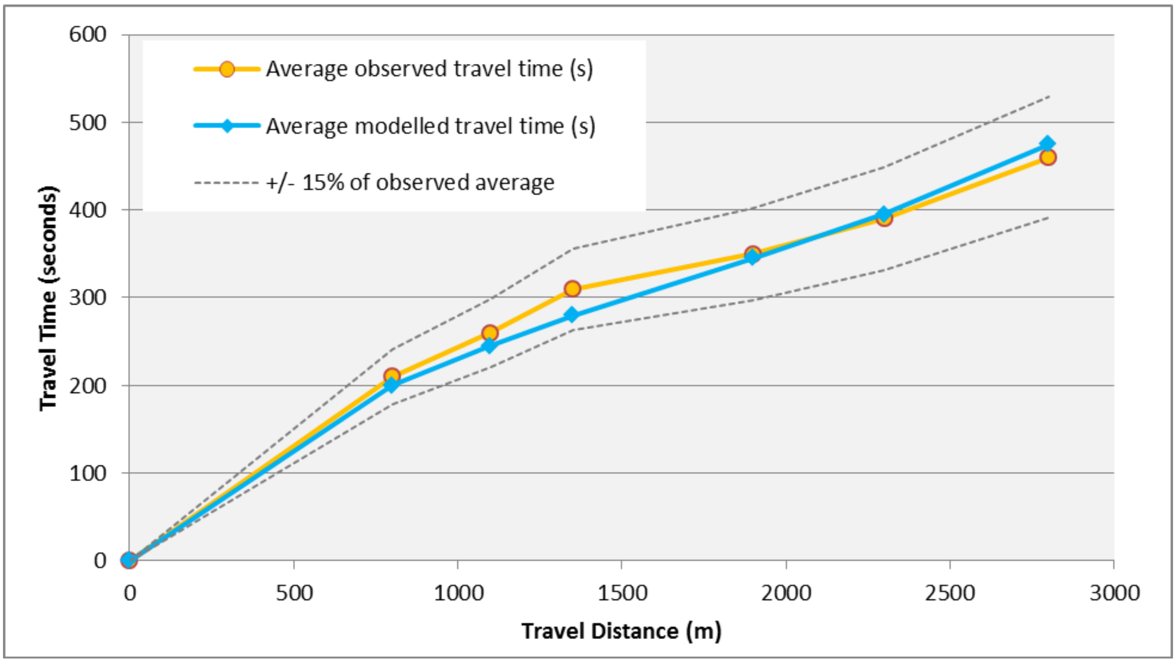
As discussed in Section 2.10.5 travel time is a common technique used to assess the accuracy of a microsimulation model and compare surveyed and modelled travel times along key routes in the study area. Travel times can affect driver route choice through the model and have a significant impact on traffic volumes and the development of delays and congestion.

To collect travel times it is important to create smaller sections called *Subpaths*. A subpath is a set of consecutive sections that can be any length and located anywhere in the model.

Main Roads recommend that modellers measure travel times between intersection stop lines along key routes in the study area. The sections to compare should be agreed with Main Roads during the scope meeting. The extracted travel time for the model validation should be average values over five replications.

The use of sections allows a cumulative graph of travel time along the route to be developed. This type of graph can provide an accurate analysis that demonstrates how the model performs in each key section, rather than simply providing a total travel time. Figure 6-24 illustrates the graphed cumulative travel time comparison between observed and modelled.

Figure 6-24: Example of travel time comparison



The modelled travel times should be within 15 per cent or one minute (whichever is greater) of average observed travel time. Table 6-14 shows travel time validation criteria for individual model categories.

Table 6-14: Microsimulation travel time validation criteria

Criteria			
	Category 1	Category 2	Category 3
15 % or one minute of average observed travel time	100%	90%	85%

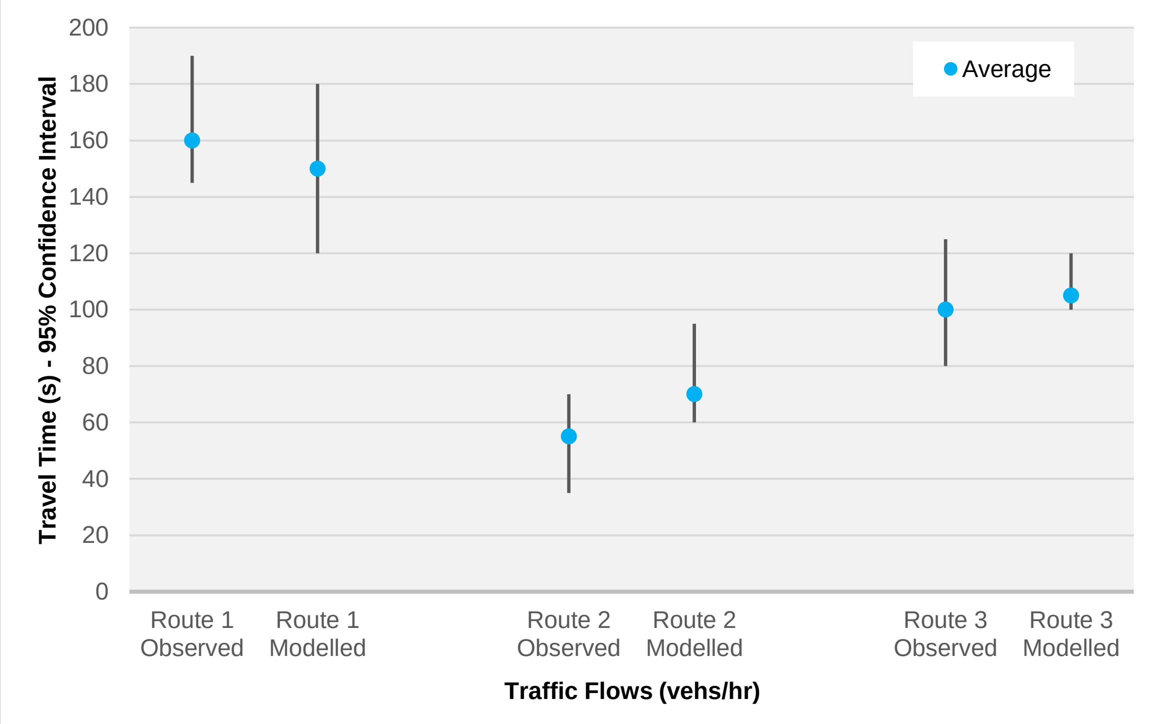
6.6.2.2.1 Travel Time Variability

While the cumulative graph of travel times by section provides a good assessment of average travel times for each route, it is also important to ensure that the model accurately represents the variability of the travel times noted during the surveys.

In order to provide a comparison of observed and modelled variability, a graph plotting the average travel time and a 95 per cent confidence interval for both the observed and modelled datasets can be used. This graph will demonstrate the level of variability within each dataset and provide a clear indication of how closely the model reflects the observed values.

An example graph showing this data for a number of travel time routes is shown in Figure 6-25. It should be noted that the purpose of the graph is not to achieve a numerical target for model calibration/validation, but to provide a visual indication of how accurately the model is performing in respect to observed and modelled travel time variability.

Figure 6-25: Travel time variability

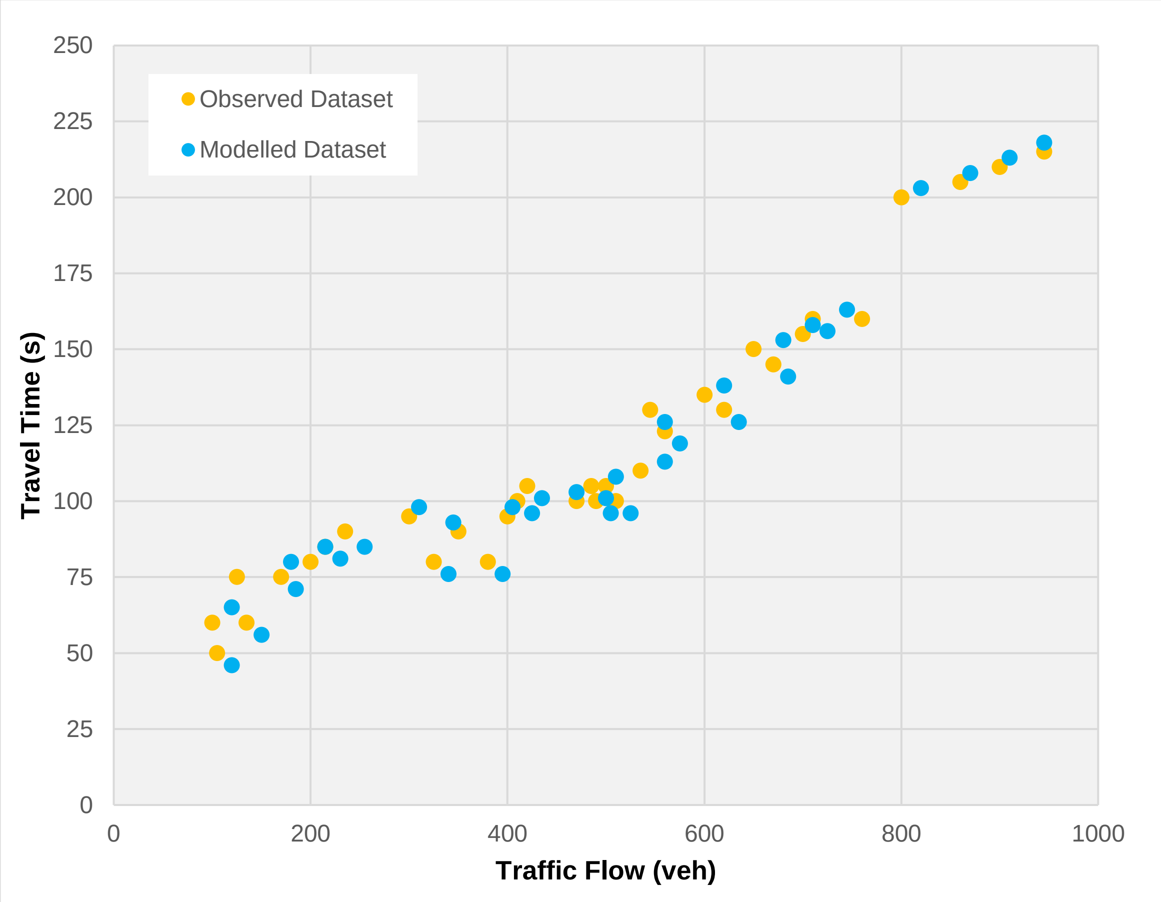


Main Roads may request that a more detailed assessment be made of any isolated sections of the travel time routes that are of critical significance to the study area. This assessment will require an analysis of the relationship between travel time and traffic volume for both the observed and modelled datasets for that section.

A useful way to confirm the validity of the traffic model is to perform a sense check between the observed and the modelled travel time data. This can be shown as a scatter graph that depicts travel time data collected at any time of day and under any flow conditions. Data points in the scatter graph should correspond to section traffic volume on the X-axis and section travel time on the Y-axis.

The graph in Figure 6-26 shows the relationship between traffic flow and travel time. This data may be useful as it provides an indication of how closely the model replicates the operation of the links and intersections at different levels of congestion, rather than simply the average peak hour observation.

Figure 6-26: Traffic flow rates vs. travel time



6.6.2.3 Queue Length

Measuring queue lengths on the road is a difficult process and differs to the way Aimsun measures queue lengths on sections.

While Main Roads does not consider queue lengths as a robust indicator to validate a model, queues should appear in the model at the locations where they are observed during site visits and travel time surveys. The model queuing behaviour should be consistent with site observations.

6.6.2.4 Signal Timing

An evaluation of model output and surveyed data should provide confidence that signal cycles and timings are comparable in the model to the recorded average SCATS operation.

Modellers should compare selected signalised intersections in the core area of the model with the recorded average SCATS history data. The intersections to compare should be agreed with Main Roads during the scope meeting.

Table 6-15 shows the signal timing validation criteria for the intersections.

Table 6-15: Microsimulation signal timing validation criteria

Signal operation	Criteria
Fixed time control - cycle time	Within 5% of recorded average of SCATS history data for same one hour period
Fixed time control - green time	Within 10% of recorded average phase of SCATS history data for same one hour period
Vehicle actuated control - Call frequency	Call frequency of demand-dependent phases (including pedestrian phases) to be compared with recorded average phase of SCATS history data for same one hour period

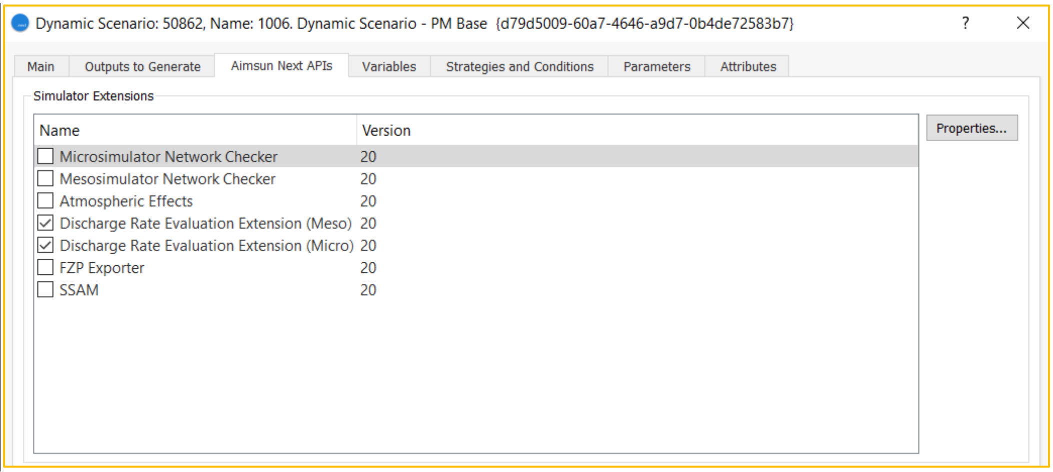
Source: RMS 2013, Traffic Modelling Guidelines

6.6.2.5 Saturation Flows

Saturation flows are measured by exporting link headway files, which contain the headways of vehicles as they cross a stop line at the intersection. These should be processed to calculate the saturation flow at each signalised stop line.

The file is generated using the discharge rate evaluation extension API module. This is selected in the scenario editor section in the '*Aimsun API*' tab. There are two extensions: one that works in mesoscopic simulation and another one that works in microsimulation. If the model uses hybrid simulation, then both extensions must be selected.

Figure 6-27: Aimsun API Discharge Rate Evaluation Extension



The modeller should ensure that saturation flows are measured on-site for all key sections where queues are observed and that these are used to validate the saturation flows derived from the model. The intersections to compare should be agreed with Main Roads during the scope meeting. All observed and modelled saturation flow values should be tabulated and the percentage error between the two values provided in the modelling report.

Table 6-16 shows saturation flow validation criteria.

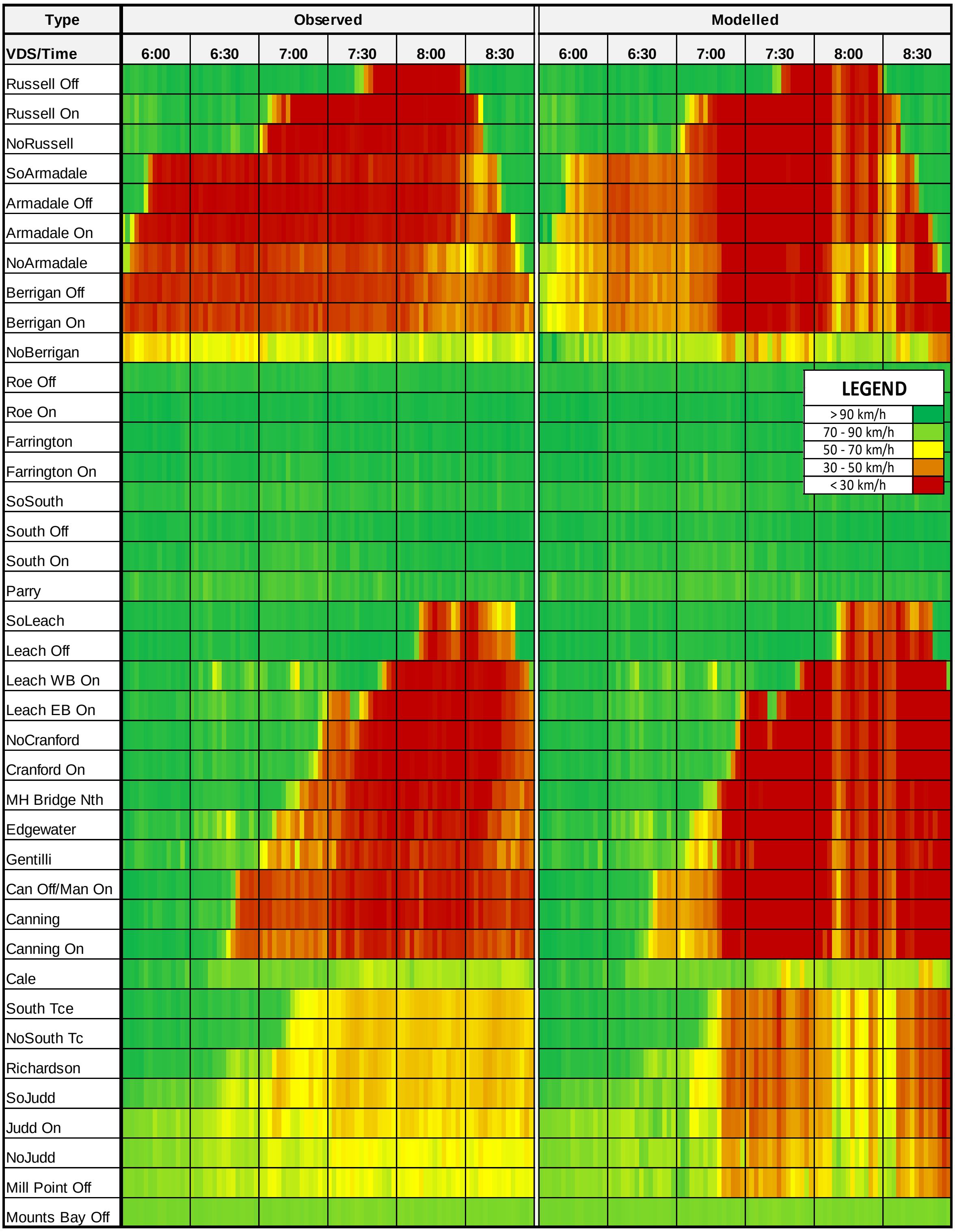
Table 6-16: Microsimulation saturation flow validation criteria

Saturation flow	Criteria
Modelled saturation flows against observed values	Within 10%

6.6.2.6 Vehicle Speed

For all freeway modelling projects, speed plots (heat maps) should be produced to compare the modelled and observed freeway segment condition. Critical bottlenecks may require lane-by-lane comparisons. Figure 6-28 provides an example of speed plots.

Figure 6-28: Example of speed plots



6.7 Model Outputs

Modellers are required to report assessment results to Main Roads for review when the base model is validated and again when proposed option models are completed. This section outlines model evaluation outputs to be reported and recommended ways to review the model outputs in Aimsun.

6.7.1 Model Evaluation Outputs

Main Roads requires the model evaluation results to be presented in the modelling report. The model outputs include, but are not limited to, those shown in Table 6-17. The results extracted from the model should be clearly presented in tabular or graphical forms.

Table 6-17: Model evaluation outputs

Type	Model output	Evaluation method	Time period
Network-wide	Number of vehicle Total travel distance Total travel time Average speed Total delay Average delay per vehicle	Replication Output (Summary, Time Series – Variables) SQLite	Total analysis period (peak)
Intersection	Turning movement volume LoS for each turning movement and intersection Approach queue length Average delay for each approach and intersection	Node (Time Series – Variables) Section (Time Series – Variables) SQLite	15 minute interval analysis period
Critical corridor (for example, bottle neck)	Traffic volume Density LoS Heat map	Subpaths (Time Series – Variables) Section (Time Series – Variables) SQLite	15 minute interval analysis period
Route	Volume Average travel time Travel distance Average delay time	Subpaths (Time Series – Variables) SQLite	Total analysis period (peak)

6.7.2 Outputs Set-up

Model outputs can be obtained from view mode, table view and the output database. View mode allows modellers to view the map-based outputs such as section delays, section density and section flows. Figure 6-29 shows an example of 2D view mode.

Figure 6-29: 2D view mode

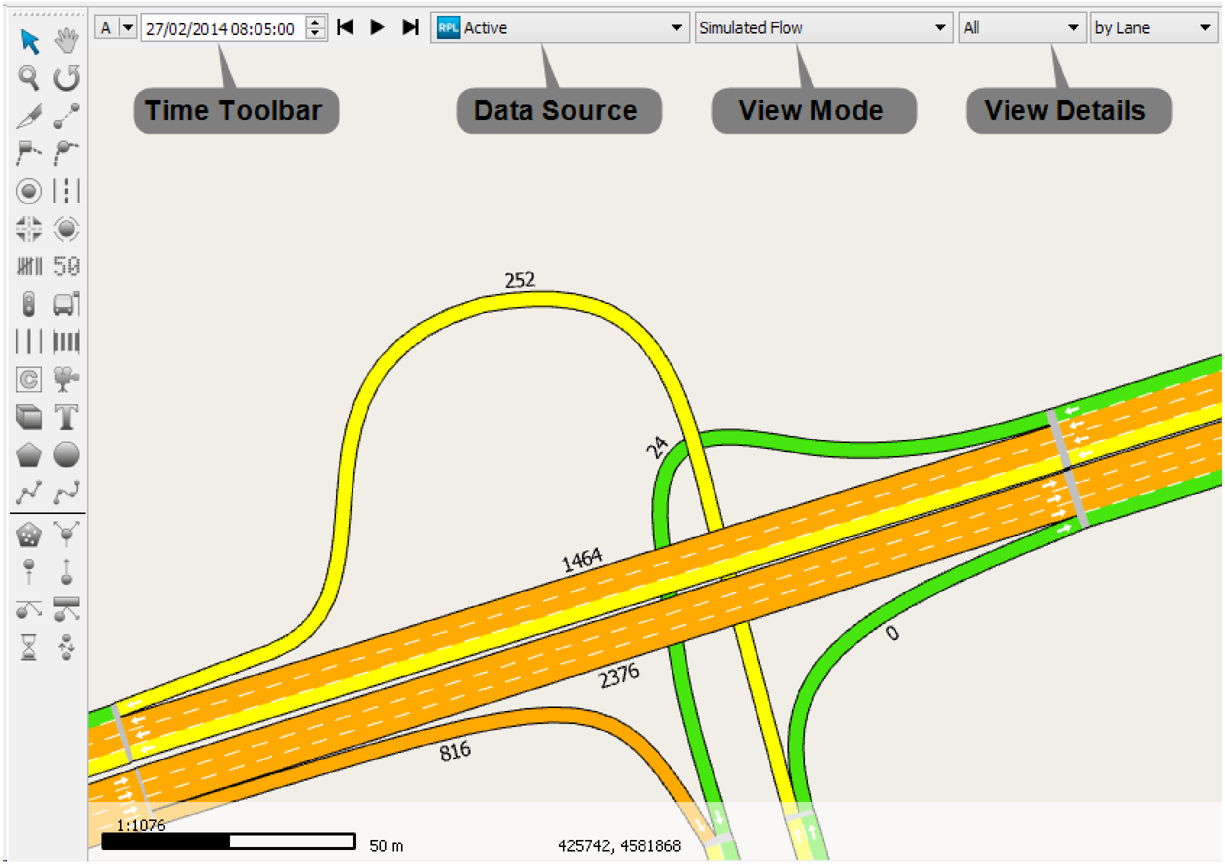
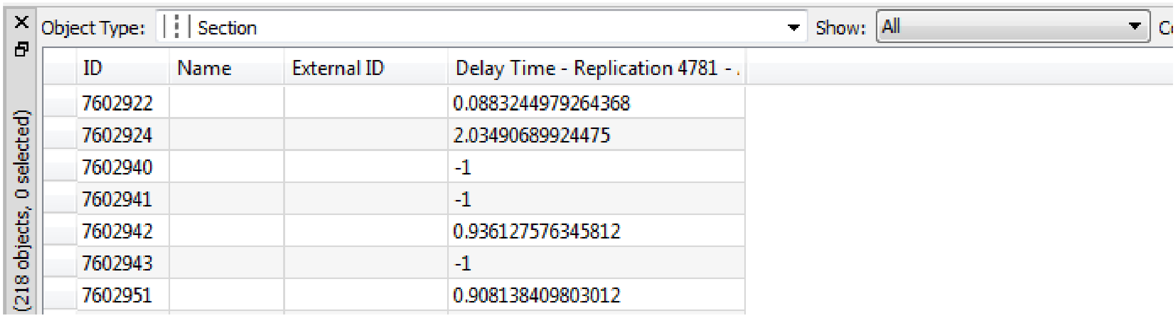


Table view enables modellers to view the outputs in a table format. There are options to select specific object type, filter the objects based on their attributes and to display a subset of all attributes. Figure 6-30 illustrates a table view of modelled outputs.

Figure 6-30: Table view



Object Type: Section Show: All

(218 objects, 0 selected)

ID	Name	External ID	Delay Time - Replication 4781 - .
7602922			0.0883244979264368
7602924			2.03490689924475
7602940			-1
7602941			-1
7602942			0.936127576345812
7602943			-1
7602951			0.908138409803012

The simulation outputs (statistics and detection) can be stored in either an automatic or a custom database. The database can be defined in the *Project Properties* window or may be defined separately for each scenario in the *Scenario Editor* window.

The databases supported are:

- Windows 32-bit – Access 32-bit, SQLite, ODBC and Postgres 9.
- Windows 64-bit – Access 64-bit, SQLite and ODBC.
- Linux – SQLite, MySQL, ODBC and Postgres 9.
- Mac OS X – SQLite, MySQL, ODBC and Postgres 9.

Modellers can select the statistics they want to store in the database. The typical statistics required for almost all projects include sections, section lanes, nodes and turns, subpaths and public transport. Other statistics can be selected based on the needs of the project.

For a detailed explanation of the output database terms, modellers should refer to the Output Database Definition section in the Aimsun User Manual.

6.7.3 View Modes and View Styles

A view mode is a combination of several view styles that are applied at the same time. To modify how the network objects are displayed using static or dynamic information, a view mode is applied to a 2D view.

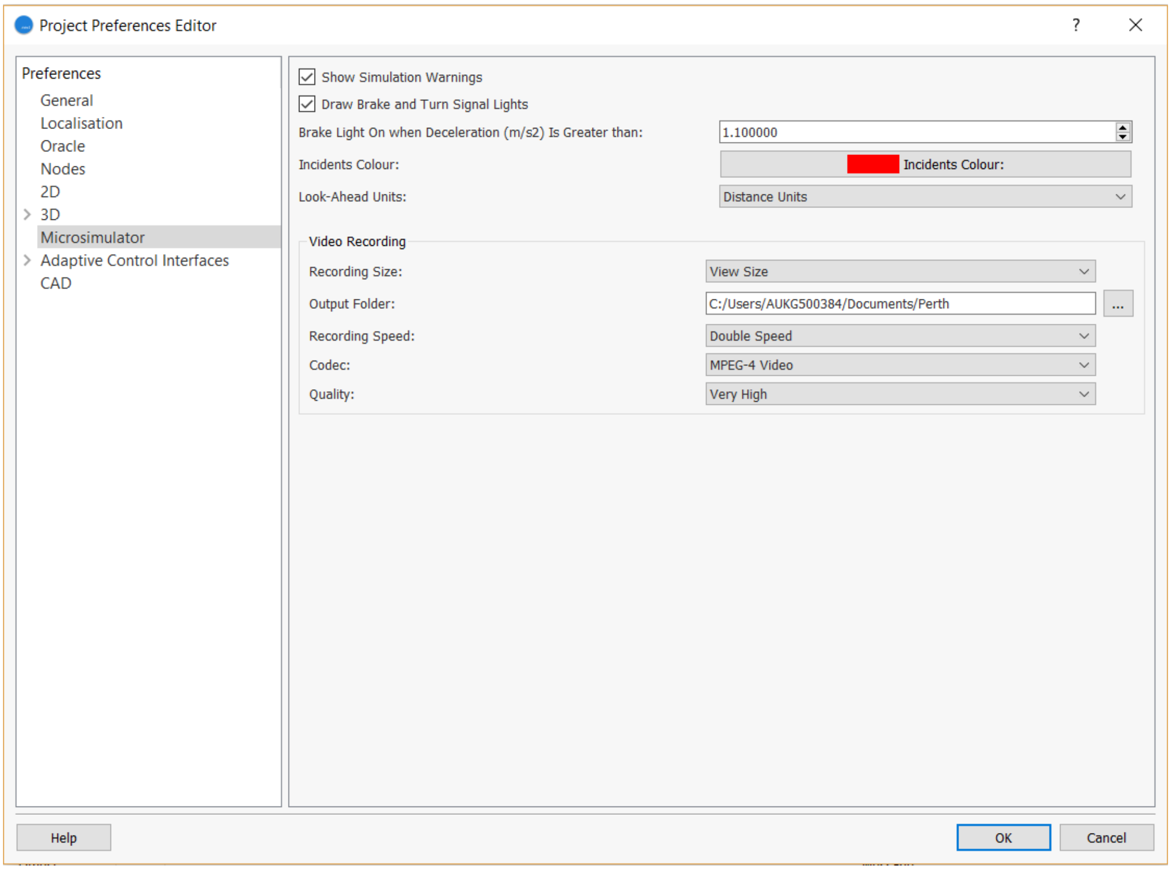
To assist the modeller in interpreting the behaviour in the model, a view mode will often have several view styles attached to it which change the display of objects. View styles may be applied at different levels of zoom, for example a view mode may display a section-related measure by lane at close zoom levels but as a section aggregate at higher zoom levels. Styles may be complementary, using different objects displaying, for example, lost vehicles and nodes where vehicles get lost.

View styles may use dynamic data where the display will be updated as the simulation runs to show different network behaviour, or they may be static and used to find network coding anomalies (for example, displaying section types in different colours to assist the modeller in spotting any discontinuity in road type).

6.7.4 Presentation

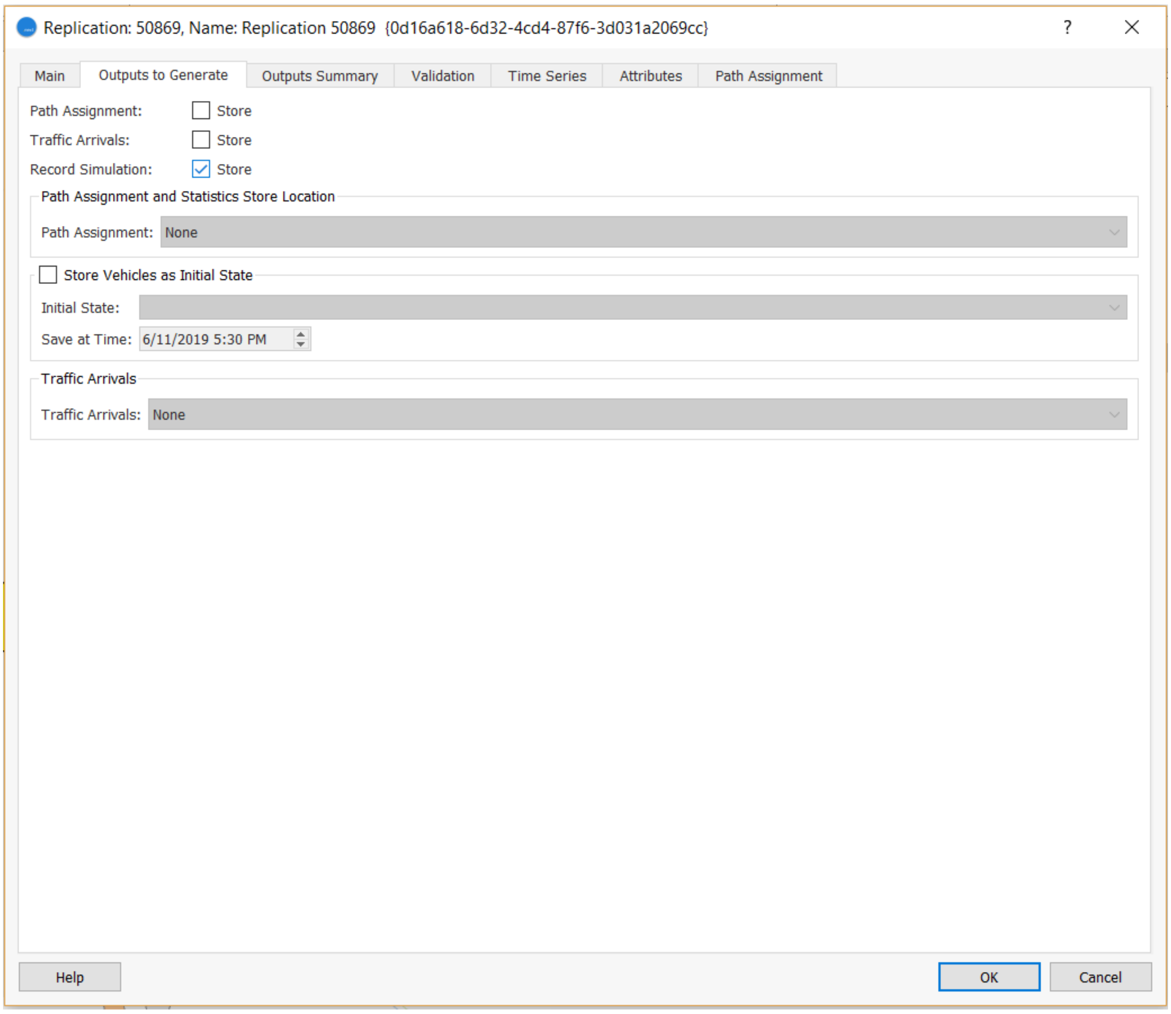
Aimsun allows modellers to record the simulation as video outputs. The video quality, recording speed, recording size and output folder can be adjusted in the *Microsimulator* section in the *Project Preference Editor* window, as shown in Figure 6-31.

Figure 6-31: Video recording



Aimsun also allows modellers to save pre-recorded simulation runs for each replication and as shown in Figure 6-32, it can be activated in Replication *Properties* under *Outputs to Generate*. The files are saved in *.arf* format and can be viewed within Aimsun or Aimsun viewer.

Figure 6-32: Pre-recorded videos



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Appendices

- Appendix A: Signal Data Information for Modelling
- Appendix B: Saturation Flow Information
- Appendix C: Future Traffic Demand calculations for Operational Modelling