Medway Council
Medway Aimsun Model

Model Validation Report

4 September 2017
Version 1.0
Issue

Fore

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1 Introduction

1.1 Background

In coming years, it is expected that there will be increasing amounts of traffic moving around Medway's highway network, principally generated by the new housing and employment growth that is expected to be delivered during that period. Government population projections indicate that Medway's population is set to grow by nearly 50,000 by 2037, creating a demand for up to 30,000 additional homes and 17,000 new jobs in the area.

Increasing amounts of traffic will have implications for how well the highway network operates. There are already a number of 'congestion hotspots', which are already at, or close to, capacity and increasing traffic will clearly exacerbate these capacity issues further. To ensure that the network continues to operate effectively, Medway Council must plan and deliver highway upgrades to increase capacity and thereby accommodate the expected increase in traffic occurring in line with national levels and due to local development.

Conversely the Council must ensure that growth is strategically directed towards appropriate locations, taking advantage of existing infrastructure capacity where possible, and delivering new infrastructure where necessary.

To allow effective infrastructure planning to take place, the Council must have a robust understanding of how the highway network operates now, and how it is likely to operate in the future.

1.2 Existing Models

In 2010 the Council prepared a strategic, Medway-wide model. This principally supported the Medway Core Strategy (which has subsequently been withdrawn), allowing the Council to understand and assess the impacts of strategic scale developments such as Lodge Hill and thereby aid the long-term planning of the network. However, this strategic model is now out-of-date. The Council has subsequently relied upon smaller scale models, which are focused on an individual junction or a series of junctions. Whilst these small-scale models assist in understanding traffic impacts locally, they cannot forecast the wider strategic and cumulative impacts of traffic growth.

1.3 Commission

Fore Consulting Limited (Fore) has therefore been appointed by Medway Council to develop a new highway model for the local authority area. The model will use Aimsun software so that both the wide-area strategic and detailed local impacts of growth and highway improvements can be properly assessed through a combination of macroscopic and microscopic modelling.

1.4 Report Purpose

The purpose of this report is to set out the development, calibration and validation of the Medway Aimsun Model.

2 Proposed Uses of the Model and Key Model Design Considerations

2.1 Proposed Uses of the Model

The Medway Aimsun Model will be used for the following purposes:

- The assessment of the performance of the local and strategic highway networks in and around Medway with current and future traffic demands to identify existing, and possible future, congestion hotspots;
- The assessment of strategic development options for the Medway Local Plan including the identification and appraisal of possible mitigation strategies;
- The development and assessment of future highway network improvements in Medway;
- The assessment of the impacts of specific development sites and to identify and test possible mitigation measures;
- Operational modelling of the highway network and testing of traffic management and control strategies;
- Detailed emissions and air quality modelling within Medway, particularly within the Air Quality Management Areas within Medway.

2.2 Key Model Design Considerations

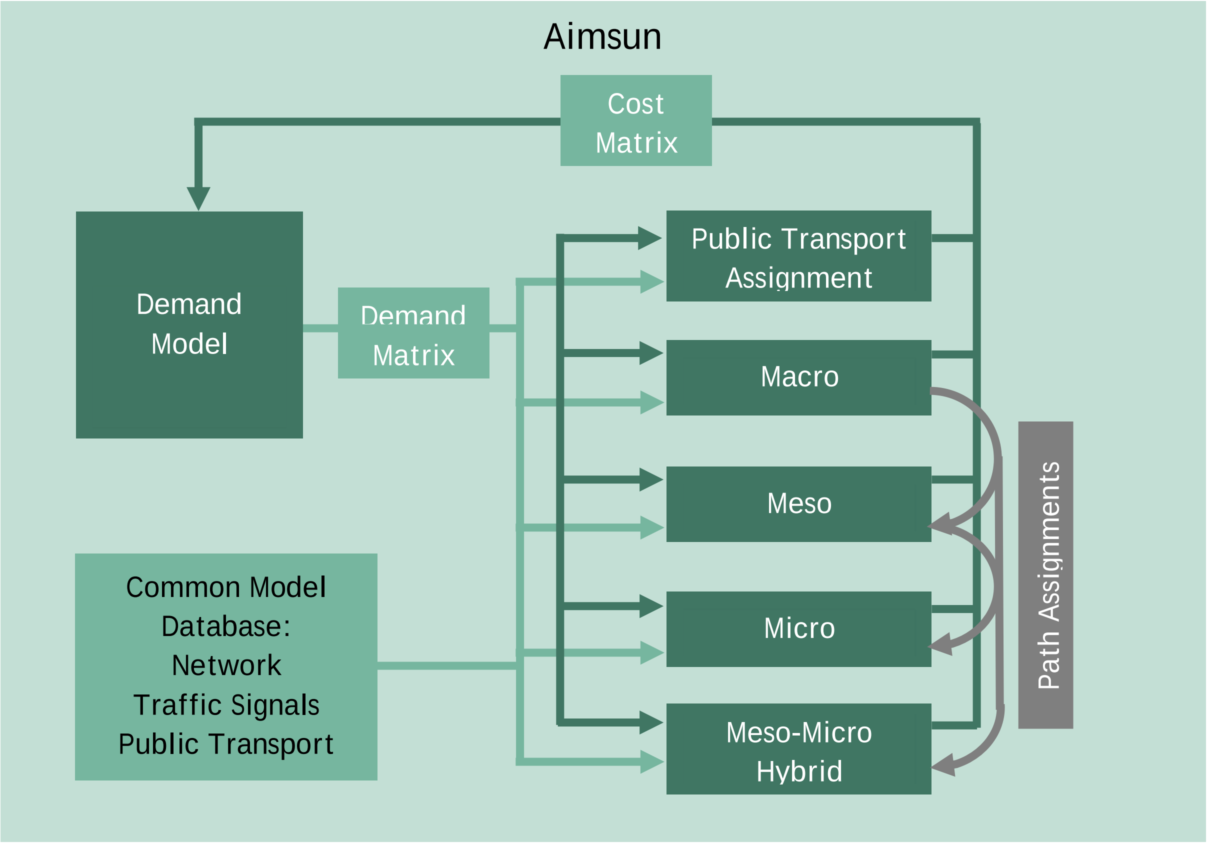
2.2.1 Introduction

Microsimulation has been identified as being essential to underpin virtually all of Medway’s modelling requirements. This is because microsimulation will be required to capture the detailed local effects of schemes and to accurately ascertain scheme benefits. Microsimulation is also the only option for many schemes that involve detailed traffic signal modelling, traffic management, emissions and pedestrians, as these can only be accurately modelled at a microscopic level.

A key issue with the microsimulation modelling is the interface with wide-area highway assignment models, which often provide cordoned demand for microsimulation models. Wide area models are essential to enable the strategic effects of transport schemes to be assessed based on the findings of detailed modelling at a local level. An example of this is determining the reassignment of traffic to a corridor following the introduction of a highway scheme that improves journey times.

To resolve this issue, a new transport model is being built for Medway using the Aimsun platform. Diagram 1, below, shows the indicative model structure. All modelling processes are handled internally within the Aimsun platform and within a single model file with a common model database that includes the network, traffic signals, demand and public transport information. This will allow the network to the modelled at macro, meso, micro and hybrid levels with interaction and feedback between the different model levels.

Diagram 1: Indicative Model Structure



The highway and public transport networks, traffic signals and other features coded as part of the full model will be available for use in the macro, meso, micro and hybrid models without any need for recoding. Additionally, any changes made to the model at the more detailed modelling levels will also be available to the macro and meso models (since they share the same model database). This allows incremental development of the model and also ensures that the correct scale of modelling can be used for each project.

This single network/database approach provides significant benefits for option testing. By sharing this information, changes that are made to demands, networks, public transport and traffic signals are available at all levels of modelling: macro, meso, micro, hybrid and public transport assignment. This means that options will only need to be coded once to be assessed at local and strategic levels, saving significant time and cost.

2.2.2 Medway Aimsun Model

The model has initially been developed, calibrated and validated the model at both macroscopic and microscopic levels. It does not yet therefore include mesoscopic or meso-micro hybrid modelling, nor does it include demand or public transport models. However, these could be added through further development of the model.

3 Key Features of the Model

3.1 Model Type

As set out above, the model has been developed in Aimsun and comprises both macroscopic and microscopic elements.

3.2 Study area

The model study area is shown on Figure 1 and is made up of the following components:

- An area of detailed modelling comprising the whole of the Medway local authority area and also extended southwards to incorporate Junctions 4 to 6 of the M20, as the Medway Local Plan is likely to have a material impact at these locations. In this area, junctions are modelled in detail in the macroscopic model and the whole are is also modelled microscopically (microsimulation).

- A buffer area surrounding the area of detailed modelling, that provides route choice into the area of detailed modelling.

- An external area that covers the rest of the country.

3.3 Zoning System

3.3.1 Zone Structure

The zone structure for the model has been based on ONS Geographies, which allows aggregation / disaggregation to other ONS geographies and NTEM zones as well as being able to easily use census-based demographic data within the model.

As the model will be run at both macroscopic and microscopic levels, it is necessary to have a relatively fine grain zoning system commensurate with the level of detail present within the microsimulation modelling. In the area of detailed modelling, the zoning system for the model has been based on Census Output Areas (OAs). Because OAs cover areas of broadly equal residential population, this results is some fairly large zones within Chatham Town Centre and Medway City Estate. As such, the zoning is these areas has been further disaggregated using Workplace zones, which are areas with broadly equal workplace populations but have boundaries that are consistent with OAs. Zones within the town centres have further granularity achieved by identifying individual car parks. Conversley, some aggregation of OAs has been undertaken in suburban and rural areas, where a less detailed network structure is required.

Immediately adjacent to the main study area are a series of buffer zones that are typically at Middle Layer Super Output Area (MSOA) level. Outside of the buffer area, zones are aggregated further and include full UK coverage, typically at a regional level.

The zone structure is presented in Figure 2 to Figure 4 and contains 909 zones.

3.3.2 Zone Nomenclature

The zones have been aggregated into nine sectors. Zones were initially assigned four digit external IDs, and these zones have standard ONS geographies (i.e. OA, LSOA, MSOA, Local Authority District or Region). The first digit represents the sector number and the following three digits represent the zones within that sector (e.g. Zone 1106 is Zone 106 in Sector 1).

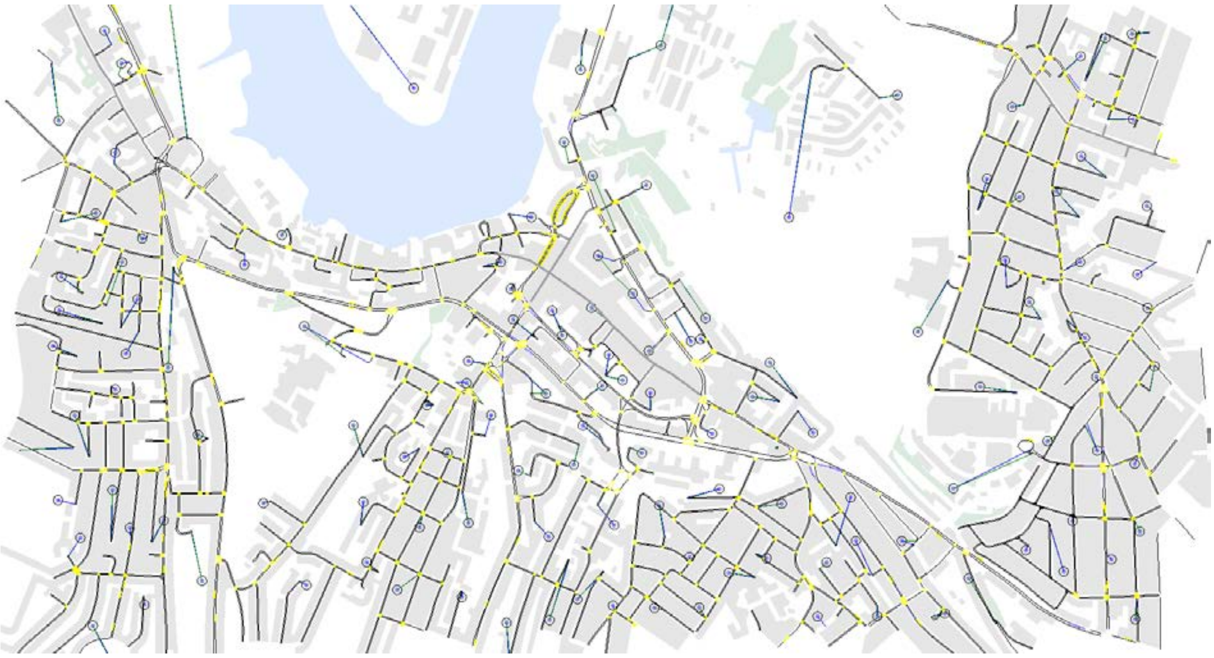
Where zones have been further disaggregated into car parks, a fifth digit has been added, to denote the car park (e.g. Zone 11062 is the car park 2 in zone 1106). Finally, where zones have been split into Workplace Zones, these are denoted by fifth and sixth digits (e.g. Zone 110602, is Workplace Zone 02 in zone 1106).

3.4 Network Structure

3.4.1 Area of Detailed Modelling

Within the area of detailed modelling, all roads but the most minor residential roads have been included within the model and the network has been coded to a high degree of detail suitable for microsimulation. The network was automatically generated from OpenStreetMap, which brought in an initial road hierarchy and also assigned road names to each section. The network was then checked and refined using a combination of Ordnance Survey MasterMap, aerial photography and site visits. Information on the level of detail that has been included is set out in Section 5 and is illustrated in Screenshot 1, below.

Screenshot 1: Model Coding Detail



3.4.2 Buffer Area

Within the buffer area, the model comprises a more simplified representation of the highway network including key roads that ensure that traffic is loaded from the buffer zones into the area of detailed modelling in a realistic way.

3.4.3 External Area

Within the rest of the UK, the network is represented within the centroid connectors, with functions used to represent the journey time between the zone and point of loading in the model.

3.5 Centroid Connectors

Centroid connectors are used to load trips from zones onto the network. These have been connected using actual access points where possible (e.g. car park accesses). In other locations, these have been attached directly to nodes, as this enables trips to choose their route via any direction from the node.

Functions have been used to represent the typical travel time between the zone centroid (located at the zone centre of gravity) and the network and vice versa. In many cases, this travel time will be very small, if not negligible. However, it is important to include the additional travel time for trips with origins or destinations outside the buffer area in order for these to be properly represented within the model statistics.

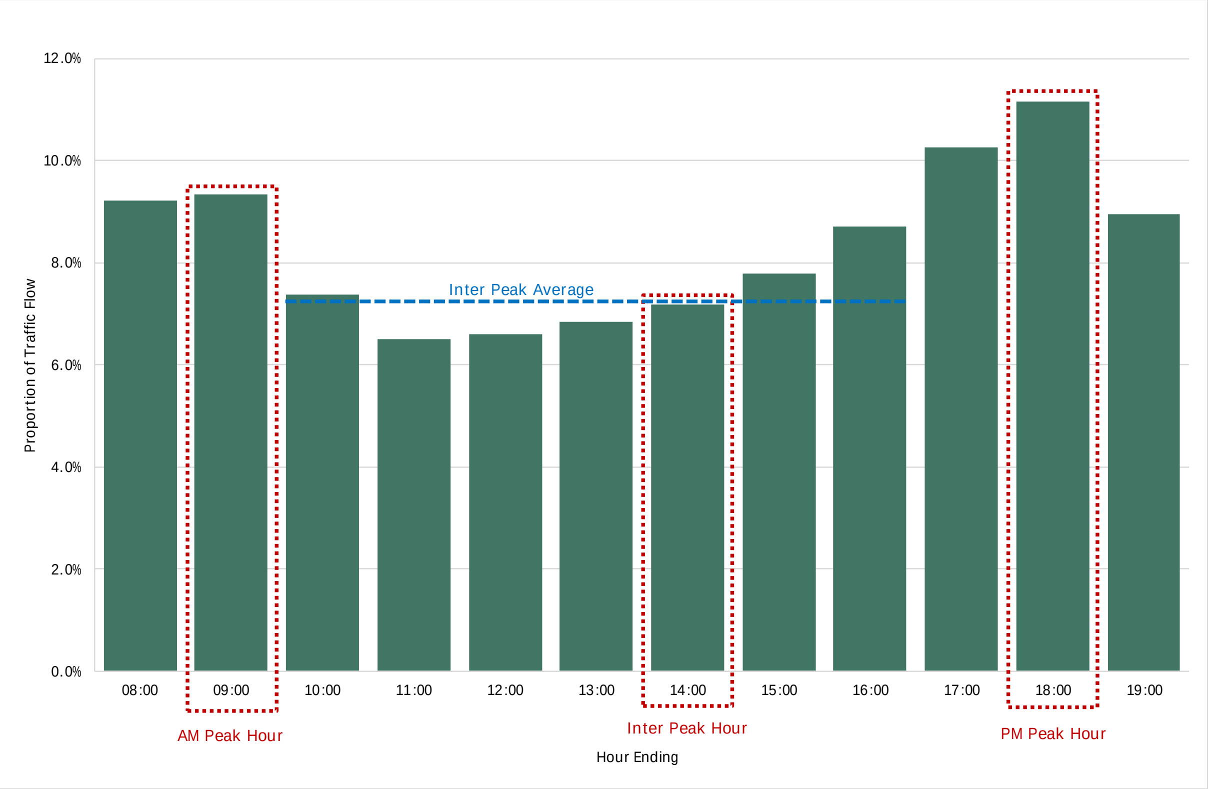
3.6 Time Periods

Traffic count data collated and collected for the development of the model has been analysed to determine the AM and PM peak hours. This is shown in Graph 1 which confirms the following time periods:

- AM Peak Hour (08:00 to 09:00)
- PM Peak Hour (17:00 to 18:00)

An interpeak hour has also been modelled. For strategic modelling, this is usually taken as an average hour between 10:00 and 16:00. However, it makes very little sense to model an “average” hour in microsimulation. Therefore, the interpeak hour modelled is 13:00 to 14:00, as this represents the hour that most closely represents an average hour between 10:00 and 16:00.

Graph 1: Modelled Time Periods



3.7 User Classes

The following user classes are included in the model:

- Car (Home Base Work (HBW)) (1)
- LGV (HBW) (2)
- Car (Non-Home Based Work (NHBW)) (3)
- LGV (NHBW) (4)
- HGV (NHBW) (5)
- Car (Home Base Other + Non-Home Based Other (HBO+NHBO)) (6)
- LGV (HBO+NHBO) (7)

In addition, all public transport services will be explicitly coded into the model using timetable data.

In the macroscopic model, these user classes are created from combining three vehicle types (Car, LGV, HGV) with three trip purposes (HBW, NHBW and HBO+NHBO). This enables multi-class matrix adjustment to be undertaken, where trip purpose split in the traffic survey data is unknown (e.g. all car vehicle type matrices can be calibrated to a count of cars).

However, Aimsun microscopic does not allow the use of matrices with different trip purposes. Therefore, seven new vehicle types have been created reflecting each user class as follows:

- Micro_1_Car - HBW Car (1)
- Micro_2_LGV - HBW LGV (2)
- Micro_3_Car - NHBW Car (3)
- Micro_4_LGV - NHBW LGV (4)
- Micro_5_HGV - NHBW HGV (5)
- Micro_6_Car - HBO + NHBO Car (6)
- Micro_7_LGV - HBO + NHBO LGV (7)

A Python script is then used to convert the macroscopic matrices into matrices with unique vehicle types that can be used in the microscopic simulations.

3.8 Assignment Methodology

3.8.1 Macroscopic Model

Traffic has been assigned in the macroscopic model using user equilibrium. Whilst a number of assignment algorithms are available in Aimsun, experience has shown that where junction delay functions are used (see Capacity Restraint Mechanisms, below), it is necessary to use the Method of Successive Averages (MSA) in order to achieve convergence and this approach has been adopted for this model.

3.8.2 Microscopic Model

A proportion of paths from the macroscopic model will be used by vehicles in the microscopic model. These user equilibrium paths can be thought of as representing the routes that drivers habitually follow day after day based on their historic knowledge of the highway network. Followingt best practice from other Aimsun models, the following proportions have been assigned to follow user equilibrium paths:

- Car - 85%
- LGV - 90%
- HGV 95%

The remaining vehicles are set to follow dynamically chosen paths based costs experienced by vehicles currently travelling through the network. Drivers choose these paths before they depart on their journey however some of these may alter their paths within their journey. These dynamic paths represent those drivers that have additional knowledge of current network conditions obtained, for example, from satellite navigation systems and radio traffic alerts.

3.9 Generalised Cost

The generalised cost equation used in the Medway Aimsun Model takes the following form:

$$cost = travel\ time$$

$$+\frac{vehicle\ operating\ cost\ per\ km\ \times distance}{value\ of\ time}$$

$$+\frac{first\ user\ defined\ cost}{value\ of\ time}$$

$$+\frac{second\ user\ defined\ cost\ \times distance}{value\ of\ time}$$

The generalised cost is expressed in units of time (seconds in the Medway Aimsun Model) to removes the difficulty of changes in costs over time, due to inflation and other changes, which may change from year to year.

Travel Time

Travel time is calculated using the volume delay, turn penalty and junction delay functions (see below) and represents the time taken to travel along a section, to make a turn and any delay associated with passing through a junction.

Vehicle Operating Cost

The vehicle operating cost has two components: fuel costs and non-fuel costs and are calculated in accordance with the guidance set out in WebTAG unit A1.3.

Fuel costs, L, are calculated using the following formula:

$$L = \frac{a}{v} + b + (c \times v) + (d \times v^2)$$

where L is the cost expressed in pence per kilometre,

v is the average speed in km/h,

a, b, c and d are parameters defined for each vehicle category.

The values for the parameters are taken from Table A1.3.12 of the WebTAG Data Book (November 2016) for the 2016 base year and are summarised in Table 1 below.

Table 1: Vehicle Operating Cost Parameters

Vehicle Type	Parameter			
	A	b	c	d
Average Car	61.475	4.215	-0.028	0.0003
Average LGV	110.255	2.608	-0.017	0.0006
Average OGV1	165.225	29.783	-0.451	0.0039
Average OGV2	263.691	55.000	-0.787	0.0059
Average HGV	230.114	46.401	-0.672	0.0052

Note: Average HGV is calculated as a weighted average of OGV1 and OGV2 using the surveyed proportions of 34.1% and 65.9%, respectively, derived from ATC survey information across Medway.

Non-fuel operating costs are calculated using the following formula:

$$C = \mathrm{a1} + \frac{b1}{v}$$

where C is the cost in pence per kilometre,

v is the average speed in km/h,

a1 is a parameter for distance related costs for each vehicle category, b1 is a parameter for the vehicle capital saving defined for each vehicle category.

The values for parameters a1 and b1 are taken from Table A 1.3.15 of the WebTAG shown in Table 2.

Table 2: Vehicle Operating Cost Parameters

Vehicle Type	Parameter	
	a1	b1
Average Car	3.972	16.394
Average LGV	7.213	41.458
Average OGV1	6.714	263.817
Average OGV2	13.061	508.525
Average HGV	10.897	425.080

Note: Average HGV is calculated as a weighted average of OGV1 and OGV2 using the surveyed proportions of 34.1% and 65.9%, respectively, derived from ATC survey information across Medway.

The values of time used in the model have been taken from the WebTAG Databook and are set out below.

User Class	Value of Time (£ / h)		
	AM Peak Hour (08:00 to 09:00)	Interpeak Hour (13:00 to 14:00)	PM Peak Hour (17:00 to 18:00)
Car (HBW) (1)	12.15	12.35	12.19
LGV (HBW) (2)	9.62	9.62	9.62
Car (NHBW) (3)	21.56	22.09	21.87
LGV (NHBW) (4)	15.76	15.76	15.76
HGV (NHBW) (5)	15.47	15.47	15.47
Car (HBO+NHBO) (6)	8.38	8.93	8.78
LGV (HBO+NHBO) (7)	9.62	9.62	9.62

First and Second User Defined Costs

The first user defined cost is effectively a fixed monetary cost of travelling along a link and could be used to model a toll road, for example. However, this is not currently used in the model.

The second user defined cost can be used to represent additional perceived costs incurred travelling along a link or turn as a function of distance travelled. It can be used to represent other costs that are explicitly taken into account in the cost function or cruise speeds, such as the deterrence effect of a narrow carriageway or cobbled street.

3.10 Capacity Restraint Mechanisms

3.10.1 Macroscopic Model

In the macroscopic model, travel time and delay are determined by the use of the following functions:

- Volume Delay Function (VDF) - these calculate the cost of travelling along a section and is set to represent the free-flow cost using the generalised cost equation set out above.
- Turn Penalty Function (TPF) - these calculate the cost of traversing a turn and is set to represent the free-flow cost using the generalised cost equation set out above.
- Junction Delay Function (JDF) - these calculate the additional cost of completing a turn at junctions and take into account the volume of traffic sharing an approach or undertaking conflicting turns. These are used to model the additional delay incurred at traffic signal controlled junctions, pedestrian crossings, give-ways, roundabouts and merges.

The above functions use information taken from the detailed microscopic coding of the highway network. For example, VDFs and TPFs use the coded lengths of links and turns. JDFs use the coded signal timings, give-way parameters and geometry to determine the available capacity and delay. In this way, the macro model is consistent with the micro model coding and provides appropriate capacity constraint within the macroscopic assignment. Furthermore, the detailed nature of the microscopic coding means that mid-block delays caused by pedestrian crossings and minor road right turns and other minor junctions will be explicitly taken into account in the macro assignment. The delay functions used in the model are discussed further in section 8.5.

3.10.2 Microscopic Model

Within the microsimulations, capacity constraint, queuing and blocking back is fully taken into account by virtue of the nature of the simulation.

3.11 Public Transport

3.11.1 Bus Stops and Interchanges

Bus stops have been coded in the model using the NaPTAN data. This provides information on the locations, names and types of stops. The bus stops in the model were generated from the NaPTAN data using a Python script and then their locations were reviewed manually to ensure that there were correctly located and were of the correct type (i.e. on-carriageway stop, bus bay or bus terminus). In transport interchanges, such as the Chatham Waterfront Bus Station or the Railway Street mini-interchange, the bus stops have been coded as bus terminals to prevent buses waiting or laying over blocking other buses and grid-locking the network.

3.11.2 Bus Routes and Schedules

Kent County Council have provided data for all buses operating within Medway in ATCO-CIF format. This data provides routing and timetables information for every bus and has been read into the model using a Python script.

3.12 Relationships with Demand Models and Public Transport Assignment Models

3.12.1 Demand Model

At this initial stage, a dedicated demand model has not been developed due to cost and time constraints. However, a variable demand model could be included should this become necessary in the future.

3.12.2 Public Transport Assignment Model

At this initial stage, a dedicated public transport assignment model due to cost and time constraints. However, given that the whole bus network, including full scheduling information, has been coded as part of the development of the highway model, this will enable the future development of a full public transport assignment model.

4 Calibration and Validation Data

4.1 Existing Traffic Count Data

4.1.1 Permanent Traffic Count Data

Medway Council operate a small network of 19 permanent traffic counters, the locations of which are shown on Figure 5Error! Reference source not found.. The permanent traffic counters provide volumetric data at 5 minute intervals.

4.1.2 Automatic Traffic Counts (ATCs)

Medway Council have provided data from 105 temporary ATCs that have been undertaken in the years 2014, 2015 and 2016. This data typically comprises 7-day counts (although a few cover longer periods) in hourly intervals. The count data is also classified. In addition, data from six ATCs undertaken in November 2016 have been provided by the developer of the proposed Lodge Hill development. The locations of the existing ATC data are shown on Figure 6.

4.1.3 Manual Classified Turning Counts (MCTCs)

Data from 44 Manual Classified Turning Counts (MCTCs) undertaken in the years 2014, 2015 and 2016 has been provided by Medway Council. These counts typically cover AM, interpeak and PM peak periods in 15 minute intervals. In addition, data from 12 MCTCs undertaken on 22 November 2016 have been provided by the developer of the proposed Lodge Hill development. The locations of the MCTCs are shown on Figure 7.

4.1.4 Highways England TRIS Database

Highways England’s TRIS Database holds traffic count data for the M2, M20 mainlines and a number of the slip and connector roads. This data is collected from permanent count sites and is typically classified and available in 15 minute intervals. Figure 8 identifies the locations of 150 such sites within the model study area.

4.1.5 All Traffic Count Data

Figure 9 maps the locations of all existing traffic count data. This shows comprehensive coverage within Chatham Town Centre and along the M2 and M20. However, there is a lack of data for many key links and junctions and therefore additional traffic count data collection was required.

4.2 Additional Traffic Count Data Collection

4.2.1 Introduction

A comprehensive programme of ATCs and MCTCs has been developed with the following objectives:

- To directly observe all traffic movements entering the leaving the detailed modelled area via the perimeter cordon defined on Figure 15. This will ensure that the number of vehicle trips entering and leaving the area of detailed modelling (ultimately microsimulation) is accurate.

- To directly observe all traffic movement entering and leaving the Chatham town centre cordon, which is a principal origin and destination of trips.

- To observe traffic crossing the screenlines identified on Figure 15 and Figure 17. The River Medway, M2 and North-South screenlines are “watertight” and will capture all crossing traffic. The A2 screenlines are designed to capture major traffic movements across the screenline, as the minor movements are too numerous to survey cost-effectively. These screenlines enable key north-south and east-west movements to be calibrated and validated within the study area.

- To capture detailed turning count data for all key junctions that currently experience congestion, or are likely to experience congestion in the future. This ensures that delays at these junctions are accurately modelled which will be critical for the detailed microsimulation modelling of the study area.

- To provide sufficient data to create robust calibration and independent validation datasets.

In addition, to ensure that survey costs are reasonable, the survey locations that would require significant traffic management measures such as road closures have been avoided.

4.2.2 ATC/RADAR Surveys

Having regard to the above objectives, Figure 11 shows the locations of additional ATC data collection. In total, 52 additional sites have been identified. In one further location, a RADAR survey has been proposed due to the high speed nature of the road

The ATC/RADAR surveys have been undertaken to the following specification:

Date: 24 September 2016 to 7 October 2016

Period:	14 days
Classifications:	Fully classified
Interval:	15 minutes
Direction:	Bi-directional

4.2.3 MCTC Surveys

Having regard to the above objectives, Figure 12 shows the proposed locations of additional MCTC collection. In total, 72 additional sites have been identified

The MCTCs have been undertaken to the following specification:

Type:	Full turning movement traffic count to be undertaken by video
Date:	Tuesday 27 September 2016
Times:	0700 to 1900
Classifications:	Fully classified to include cycles, motorbikes, cars, LGVs, OGV1, OGV2 and PSV as a minimum.
Interval:	15 minutes

4.2.4 Full Dataset

The existing and additional data are shown on Figure 13, and show that in combination they will cover the cordons and screenlines identified as well as all key junctions.

4.3 Traffic Counts for Calibration and Validation

The traffic count data set out above has been arranged into independent calibration (for use in matrix adjustment) and validation (for use in trip matrix and route choice validation) datasets, as shown in Moreover, the data in each dataset has also been used to define a number of independent calibration and validation screenlines and cordons. The calibration and validation datasets and associated screenlines and cordons are shown on Figure 14 to Figure 17.

To ensure that sufficient data is included in the datasets, Aimsun's "*Detector Location Tool*" has been used to determine the percentage of O-D pairs that are intercepted by the calibration and validation datasets. The following methodology has been adopted, in accordance with advice set out in the Aimsun User's Manual:

- Detectors were created on each section corresponding the counts in the calibration and validation datasets;
- A demand of one trip per O-D pair was created for that network comprising the area of detailed modelling;
- The demand was assigned to the network using a macroscopic assignment;
- The detection location tool was run separately for the detectors corresponding to the calibration and validation datasets.

The process was repeated to seek to maximise the number of O-D pairs intercepted by the calibration dataset to ensure that the matrix adjustment process does not alter trips that are not observed. At the same time, the number of O-D pairs intercepted by the validation dataset was also sought to be maximised, whilst maintaining spatial independence with the calibration dataset.

The process resulted in 94.8% of O-D pairs being intercepted by the calibration dataset, ensuring that the majority of trips in the matrix adjustment process are adjusted to observed data. Similarly, 60.6% of O-D pairs are intercepted by validation dataset, providing a reasonable level of validation of the trip matrices.

4.4 Journey Time Data

TrafficMaster data for the year 2015/16 has been provided by Medway Council. Journey times within the model have been validated using historic journey time data obtained from this dataset, from which average school-day weekday journey times have been extracted.

4.5 Data Processing

All traffic count data has been processed into a suitable format such that it could be imported into the Aimsun model as “real datasets”. This is necessary for the matrix adjustment process and allows model calibration and validation to be undertaken quickly and easily. In total, the calibration dataset comprises data for 2,252 sections and turns and the validation dataset comprises data for 317 sections and turns.

5 Network Development

5.1 Introduction

The Medway Aimsun Model will be run at both at macroscopic and microscopic level of detail using the same network coding. It is therefore necessary to code the network at a level of detail suitable for microsimulation.

5.2 Network Data, Coding and Checking

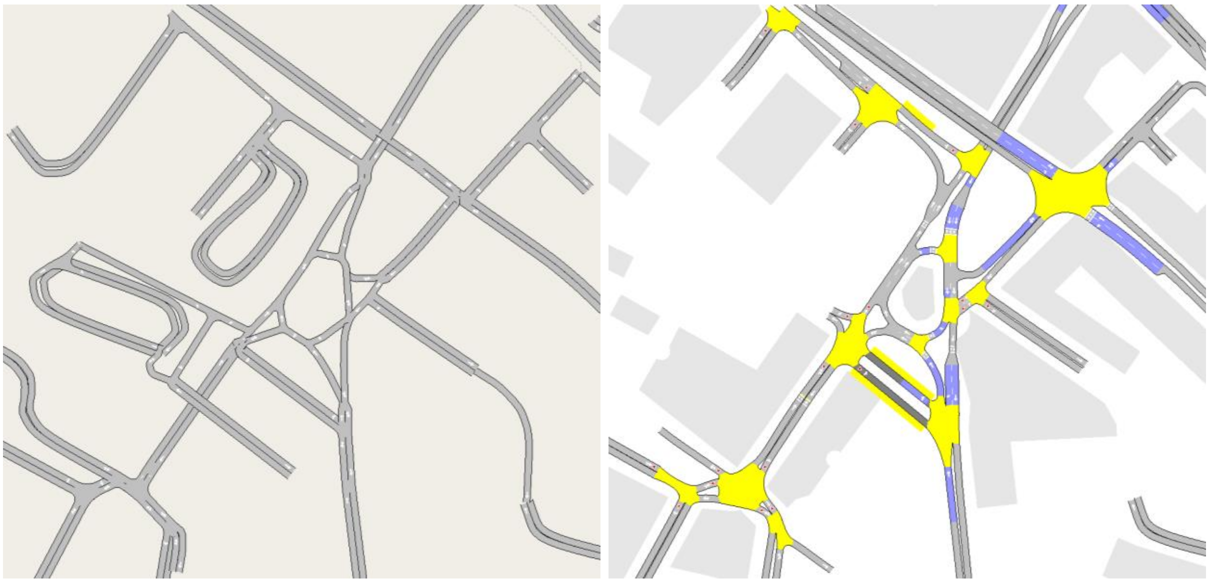
5.2.1 Network Data

The network has been automatically generated from Open Street Map using Aimsun's Open Street Map importer. This ensures that the network is correctly georeferenced and also brings in a basic network hierarchy and other information such as road names. The network was then checked and refined using a combination of Ordnance Survey digital mapping, aerial photography and site visits. The level of detail coded includes:

- Detailed representation of geometry including lanes, lane widths, flares, stop lines, gradients, bus stops.
- Detailed representation of junctions including form of control (e.g. stop, give-way, traffic signals) and prohibited movements.
- Detailed representation of traffic signals at all signal controlled junctions and pedestrian crossing. Traffic signals have been coded using controller configuration information with phasing, staging , intergreens and phase delays reflecting those on street. Green times and offsets are based on signal plans, where junctions run fixed time. Where there are demand dependant stages or actuated control, these are replicated in the microscopic model whereas the macroscopic model uses fixed time approximations.
- Detailed representation bus public transport infrastructure including all bus stops, bus lanes and bus gates.

An example of the network prior to, and after, refinement is shown in Screenshot 2.

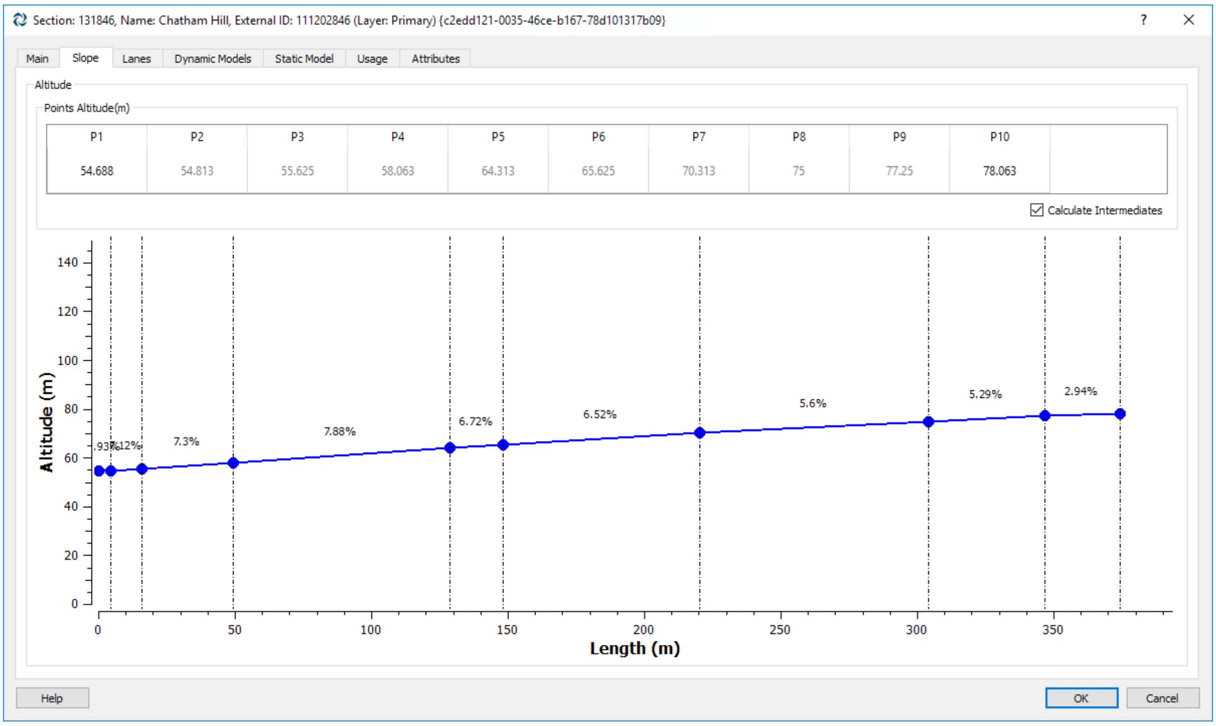
Screenshot 2: Network Prior to (left), and after (right) refinement



5.2.2 Elevation Data

Elevation data has been taken from a digital terrain model produced from the Environment Agency's LIDAR (LIght Detection And Ranging) data. This provides the height of the surface at a 2m spatial resolution. The coordinates of each section vertex was outputted from the model and cross referenced with the digital terrain model to determine the elevation of that point. The data was then imported back into Aimsun and applied to the network to provide detailed information on elevation and hence gradients. An example of this data applied to the model is shown in Screenshot 3. Where bridges and other structures are present on the highway, the elevation data has been checked to ensure that it correctly represents the structure and does not lead to unrealistic gradients.

Screenshot 3: Elevation data applied to a section on Chatham Hill



Section: 131846, Name: Chatham Hill, External ID: 111202846 (Layer: Primary) {c2edd121-0035-46ce-b167-78d101317b09}

Altitude

Points Altitude(m)

P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
54.688	54.813	55.625	58.063	64.313	65.625	70.313	75	77.25	78.063

☑ Calculate Intermediates

5.3 Road Types (Road Hierarchy)

As set out above, the network was initially generated from OpenStreetMap (OSM), which brought in an initial road hierarchy based on the following OSM classifications:

- OSM 1 - Motorway
- OSM 2 - Trunk
- OSM 3 - Primary
- OSM 4 - Secondary
- OSM 5 - Tertiary
- OSM 6 - Residential
- OSM 7 - Unclassified

Since COBA speed-flow curves are used within the model (see section 8.5), it was also necessary to allocate one of the following COBA road types to the sections in the model:

- COBA 1 - Rural All Purpose Single Carriageway

- COBA 2 - Rural All Purpose 2 Lane Dual Carriageway
- COBA 3 - Rural All Purpose 3+ Lane Dual Carriageway
- COBA 4 - Motorway, 2 Lanes
- COBA 5 - Motorway, 3 Lanes
- COBA 6 - Motorway, 4+ Lanes
- COBA 7 - Urban, Non-Central
- COBA 8 - Urban, Central
- COBA 9 - Small Town

In order to preserve both the OSM and COBA road type hierarchies, a number of road types were created in the Aimsun model that reflected both descriptions. These have been numbered with the first number representing the OSM classification and the second number representing the COBA road type and are as follows:

- 1.4 | OSM Motorway | COBA 4 (Motorway, 2 Lanes)
- 1.5 | OSM Motorway | COBA 5 (Motorway, 3 Lanes)
- 1.6 | OSM Motorway | COBA 6 (Motorway, 4+ Lanes)
- 2.1 | OSM Trunk | COBA 1 (Rural AP Single)
- 2.3 | OSM Trunk | COBA 3 (Rural AP 3+ Lane Dual)
- 2.10 | OSM Trunk | COBA 10 (Suburban Single)
- 2.11 | OSM Trunk | COBA 10 (Suburban Dual)
- 2.2 | OSM Trunk | COBA 2 (Rural AP 2 Lane Dual)
- 2.2 | OSM Trunk | COBA 2 (Rural AP 2 Lane Dual) - Tiger Tail
- 2.9 | OSM Trunk | COBA 9 (Small Town)
- 3.1 | OSM Primary | COBA 1 (Rural AP Single)

- 3.10 | OSM Primary (Internal) | COBA 10 (Suburban Single)
- 3.10 | OSM Primary | COBA 10 (Suburban Single)
- 3.11 | OSM Primary | COBA 11 (Suburban Dual)
- 3.2 | OSM Primary | COBA 2 (Rural AP 2 Lane Dual)
- 3.3 | OSM Primary | COBA 3 (Rural AP 3+ Lane Dual)
- 3.9 | OSM Primary | COBA 9 (Small Town)
- 4.1 | OSM Secondary | COBA 1 (Rural AP Single)
- 4.10 | OSM Secondary (Internal) | COBA 10 (Suburban Single)
- 4.10 | OSM Secondary | COBA 10 (Suburban Single)
- 4.11 | OSM Secondary | COBA 11 (Suburban Dual)
- 4.2 | OSM Secondary | COBA 2 (Rural AP 2 Lane Dual)
- 4.7 | OSM Secondary | COBA 7 (Urban, Non-Central)
- 4.9 | OSM Secondary | COBA 9 (Small Town)
- 5.1 | OSM Tertiary | COBA 1 (Rural AP Single)
- 5.1 | OSM Tertiary | COBA 9 (Small Town)
- 5.10 | OSM Tertiary | COBA 10 (Suburban Single)
- 5.7 | OSM Tertiary (Internal) | COBA 7 (Urban, Non-Central)
- 5.7 | OSM Tertiary | COBA 7 (Urban, Non-Central)
- 6.7 | OSM Residential | COBA 7 (Urban, Non-Central)
- 6.9 | OSM Residential | COBA 9 (Small Town)
- 7.1 | OSM Unclassified | COBA 1 (Rural AP Single)
- 7.7 | OSM Unclassified | COBA 7 (Urban, Non-Central)

- 7.8 | OSM Unclassified | COBA 8 (Urban, Central)
- 7.9 | OSM Unclassified | COBA 9 (Small Town)

These road types have been applied to each section in the model, as appropriate, and this is shown on Figure 18.

6 Trip Matrix Development (Macro)

6.1.1 Travel Demand Data

Origin-destination matrices for the model have been developed using mobile network data provided by CitiLogik using data from the Vodafone network. Appendix A presents a detailed overview of the methodology used to create matrices from mobile network data.

6.1.2 Verification Checks

The mobile data matrices have been subject to a number of verification checks, and these are set out in detail in Appendix B. The following verification checks have been undertaken:

- Average 24hr Working Day Total Travel Flow.
- 'All Purpose' Symmetry.
- Symmetry Test for All Home Based 'from home' and 'to home' trips;
- Symmetry Test for Home-Base Work (HBW) Trips;
- Trip rates;
- Correlation between All-Purpose Trips and Population;
- Correlation between Home-Based Trips and Population;
- Correlation between Home-Based Work Trips and Population;
- Correlation between Home-Based Other Trips and Population;
- Symmetry Test for Non Home-Based Trips;
- HBW Outbound Versus Inbound by Time of Day; and
- All Purpose Trips by Time of Day.

The overall conclusions from these verification tests are as follows:

- The overall mode split between slow and motorised trips tallies reasonably well with NTS results. In addition, the number of rail trips identified is in accordance with what might be expected.

- The overall working day all-purpose trip rate per Medway resident is identified at 2.57, which is in line with the statistics established by NTS (around 2.5 for an average day). The trip rate falls to around 1.61 for home-based trips (all modes) which again lies within the expected range.

- The all-purpose trip ends symmetry confirms that the overall distribution of trips is well balanced, since the overwhelming majority of such trips start and finish in the same zones.

- The purpose allocation between HB and NHB is acceptable. There is a slight shortfall in HBW trips, as a certain proportion of these are likely to be included within the HBO category. This may be explained by a lack of ‘inferred’ Work location references assigned to travelling workers with Vodafone mobile phones. Not having a regular work destination makes it impossible to qualify associated with it travel as HBW journeys. Nevertheless, the identified HBW trips show a satisfactory symmetry.

- A good symmetry is also observed for NHB trips and HBO trips.

- Trip directionality is good for both HBW and HBO trips and confidence in identifying these is high.

6.2 Matrix Refinement

6.2.1 Zone Splitting and Infilling

The mobile network data matrices are provided with disaggregation down to LSOA level and are split into motorised trips, rail trips and slow modes (e.g. walk trips). For the purposes of developing a highway assignment model, it is necessary to only use the mobile network data matrices for motorised trips disaggregated by trip purpose. Given that the verification checks confirmed that the mode split of motorised modes is reasonable, no further adjustments to the data is this regard were considered necessary.

The mobile network data matrices are only disaggregated to LSOA level, whereas the model zones are disaggregated down to OA level, with further disaggregation to work place zones and individual car parks. There is therefore a need to further disaggregate the mobile network data matrices. Furthermore, trips by bus need to be removed from the motorised trips and the remaining motorised trips need to be separated into car, LGV and HGV trips. A methodology has been adopted to generate the vehicle trip matrices, based wholly on observed data (mobile network data, Census origin-destination data, Census mode share data, traffic count data and car park capacity data). The methodology is summarised as follows:

- Corrections are applied to the mobile network data to account for the shortfall in HBW trips. These corrections move trips from the HBO + NHBO matrices to the HBW matrices such that the overall level of HBW trips is in-line with the proportions set out in the WebTAG Databook.

- A zone equivalence table has been produced that sets out the spatial relationship between OAs, MSOAs, mobile network data zones and the model zones. This table is used throughout the process to convert between the different zone structures that are used in the different datasets.

- Census origin-destination data is available at OA level for all trips and provides commuting trip patterns. There is a reasonable degree of correlation between home-based work trips in the mobile data matrices and census origin-destination data. This data is therefore considered a reasonable proxy to use for the purposes of zone splitting and matrix infilling.

- However, the census data only covers commuting (i.e HBW) trips and is representative of the travel to work trips that would occur in the AM peak period. Other trip types (NHBW and HOB + NHBO) are therefore estimated by applying the trip type proportions determined from the mobile network data to the census OA data. This is done at origin-destination level to ensure that the trip purpose patterns observed in the mobile network data matrices are replicated in the Census origin-destination matrices at output area level.

- Matrices are estimated for the PM peak period by inverting the Census origin-destination matrix (to reflect work-to-home trip patterns for commuting trips) before applying the same process. Similarly, inter-peak trips are based on an average of the AM and PM Census data matrices.

- The Census origin-destination data, which reflects all travel to work trips in a day, is then factored down to the relevant hourly period by applying the ratio of hourly to daily trips in the mobile network data.

- The mobile network data is disaggregated the OA zones on an O-D pair basis using the following assumptions:

    - Where the mobile network data zone origin-destination pair is non-zero, the mobile network data is split using the proportions in the relevant census origin-destination.

    - Where the mobile network data zone origin-destination pair is non-zero, but there are no census origin-destination pairs at OA level, the mobile network data is split evenly across OAs.

  - Where the mobile network data zone origin-destination pair is zero, but Census data is non-zero, the Census data is used to in-fill the matrix.
  - Where both mobile network data and Census data is zero, it is assumed that there are no trips for that particular O-D pair.

  The methodology therefore disaggregates the mobile network data and in-fills missing data, particularly short trips.

- The resulting matrices are aggregated to the model zone structure.
- The matrices at this stage represent people trips by motorised modes and will include car passengers as well as passenger trips by public transport. In order to derive the vehicle trip matrices, the number of car and bus passengers are estimated using mode share data from 2011 Census and deducted from the total. This Census data is available at MSOA level. It is therefore disaggregated to the model zone structure and applied on a cell-by-cell basis.
- The matrices therefore represent vehicle trips and will be disaggregated by time period and trip purpose.
- The next stage is to estimate the vehicle type (i.e. car, LGV or HGV) so that matrices for each user class can be determined. This is achieved by using traffic count data to determine as a proxy for the vehicle type percentages for the origin and destination zones, and using these to split the matrices by vehicle type on a cell-by-cell basis.
- This provides matrices for each user class. The final stage is, where necessary, to further split trips in each zone into individual car parks, which is done pro-rata to the capacity of the car parks.

6.3 Matrix Adjustment

6.3.1 Reasons for Matrix Adjustment

Whilst the broad O-D patterns in the prior matrices are correct, errors could come from a number of sources including:

- Errors in allocating mobile device locations to a particular zone. This is quite common when using mobile network data, particularly for small zones and near zone boundaries. This is because radiofrequency boundaries are not exact and can fluctuate on a day-to-day basis as the result of weather conditions. The consequence of this are trips allocated to one zone should actually be allocated to a neighbouring zone.

- There is a minimum reporting requirement in the mobile network data of 15 trips to protect privacy. For small trip numbers, this can result in distortions of the matrices.

- In the Census origin-destination data at OA level, trips between particular O-D pairs are small and are set to a minimum of three trips to protect privacy.

- The Census origin-destination data is based on a single day, albeit very large, sample and errors may occur due to day-to-day variations in trip patterns.

- The Census data dates from 2011 and will therefore be dated in some areas, particularly where new developments have been constructed.

- The conversion of motorised all person trip matrices to vehicle trip matrices uses Census data at MSOA level and may not therefore reflect the true levels of bus and car passengers at higher levels of granularity.

- The Census data used for this purpose also dates from 2011 and may not reflect current bus services or patronage.

In the absence of further data to address the possible sources of error set out above, the matrices have been improved significantly by the use of matrix adjustment. The purpose of matrix adjustment is to seek to correct such errors in the prior matrices by making small adjustments so that, when assigned to the network, they better replicate observed traffic count data, whilst maintaining the patterns in the prior matrices. This exercise was undertaken using Aimsun’s in-built matrix adjustment algorithms and the observed turn and link counts in the calibration dataset.

6.3.2 Matrix Adjustment Constraints

If unconstrained, the matrix adjustment algorithms can significantly distort the prior matrices. To prevent this, the following approaches were adopted:

- Centroid reliability vectors were used to assign a reliability of 1.0 to the origin and destination totals in the prior matrices and to use these totals as calibration data. Since the traffic data has also been assigned a reliability of 1.0, the matrix adjustment algorithm seeks to retain the origin and destination totals giving these the same weight as the survey data.

- A matrix elasticity has been applied to the individual cell values. This uses the prior matrix as calibration data and penalises cell values as they are adjusted further from their original values. The level of elasticity used was 0.01 for all matrices, which is highly inelastic and helps to better preserve the patterns in the prior matrix.

6.3.3 Matrix Adjustment Process

Matrix adjustment is an iterative process that that has to be undertaken concurrently with network and route choice calibration, as all these elements of the model are interdependable. The final calibrated matrices therefore represent the culmination of many iterations of this process.

The initial matrix adjustment iterations were undertaken with convergence to a relative gap of 1.0%, to assist with the efficient calibration of the model. In the final iteration, a relative gap of 0.1% was used, consistent with the convergence requirements of the model.

6.3.4 Monitoring the Effects of Matrix Adjustment

The level of distortion in the adjusted matrices relative to the prior matrices has been monitored during the matrix adjustment process by undertaking regression analysis between the prior and adjusted cell values and zone totals. This is summarised in Table 3.

Table 3: Matrix Distortion

Measure	Slope	Intercept	R^2
AM Peak Hour (08:00 to 09:00)			
Matrix zonal cell values	1.009	0.777	0.941
Matrix zonal trip ends	1.049	0.052	0.960
Inter Peak Hour (13:00 to 14:00)			
Matrix zonal cell values	0.950	0.012	0.920
Matrix zonal trip ends	0.997	0.012	0.945
PM Peak Hour (08:00 to 09:00)			
Matrix zonal cell values	0.966	0.024	0.914
Matrix zonal trip ends	0.922	-0.18	0.968

WebTAG sets out the standards for the above criteria and these are summarised in Table 4, below.

Table 4: Matrix Adjustment Significance Criteria

Measure	Significance Criteria
Matrix zonal cell values	Slope with 0.98 and 1.02 Intercept near zero R^2 in excess of 0.95
Matrix zonal trip ends	Slope within 0.99 and 1.01 Intercept near zero R^2 in excess of 0.98

Comparing the values in Table 3 with the significance criteria in Table 4, it can be seen that intercepts are generally close to zero. However, the slope and R^2 values show that both zonal cell values and trip ends have generally been adjusted by a greater amount than is normally permitted by the guidance.

It should be noted that the criteria set out in WebTAG applies to traditional strategic models. The structure of the Medway Aimsun model is such that it will be used for both macroscopic and microscopic modelling. As such, a great deal of traffic data for both links and turns has been included in the matrix adjustment process. This is necessary, as if the model poorly replicates traffic flows (at both section and turn levels), this will manifest in the microsimulations as significant network issues that do not exist in practice. Indeed, experience has shown that when cordoned matrices are taken from strategic models where the matrices do meet the guidance for matrix adjustment set out in WebTAG, the resulting matrices perform poorly in microsimulation, and further matrix adjustment is generally required, with matrix distortion generally exceeding the WebTAG significance criteria.

Given the need for the model to reproduce traffic flows accurately and turn and section levels for use in the microsimulation, it is considered that the level of distortion in the adjusted matrices relative to the prior matrices is considered to acceptable.

7 Trip Matrix Development (Micro)

7.1 Creation of the Microscopic Matrices

The trip matrices for the microscopic model are developed directly from the macroscopic trip matrices by creating cordoned matrices for the microsimulation area. The methodology is as follows:

- Aimsun microscopic does not allow the use of matrices with different trip purposes but requires each matrix to be assigned to a different vehicle type. The macro matrices created through the matrix estimation process (where user classes are a combination of vehicle types and trip purposes) are converted into matrices for each of the micro vehicle types defined in Section 3.7.

- The macroscopic assignment is re-run, assigning the vehicle type, rather than the trip purpose, matrices.

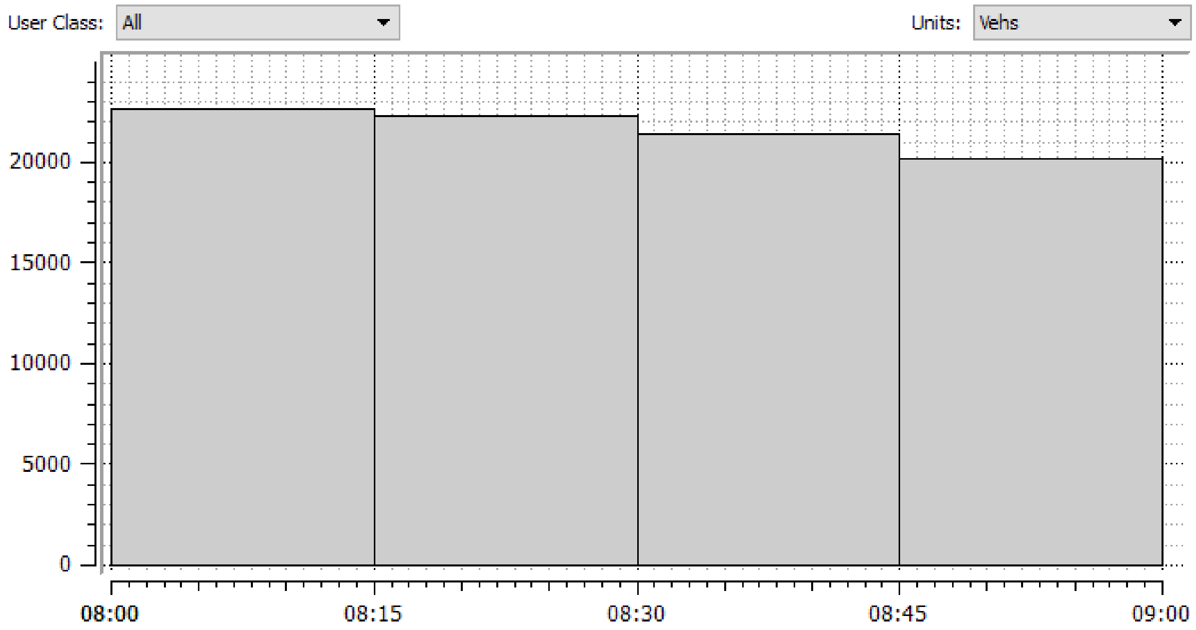
- A sub-network is defined for the microscopic modelling area and a static traversal is undertaken to generate the matrices for the subnetwork.

- These matrices are then placed into a traffic demand. A profile is applied that has been derived from the traffic survey data to better reflect the build-up and decay of queues during the modelled period. The profiles used are set out in Table 5 and are shown graphically in Screenshot 4 and Screenshot 5.

Table 5: Micro Matrix Profiles

Period	Percentage of Demand in each Interval (%)			
	1st 15 Minute Period	2nd 15 Minute Period	3rd 15 Minute Period	4th 15 Minute Period
AM Peak Hour (0800 to 0900)	26.2	25.8	24.7	23.3
Inter Peak (1300 to 1400)	25.0	25.0	25.0	25.0
PM Peak Hour (1700 to 1800)	25.2	25.5	24.9	24.3

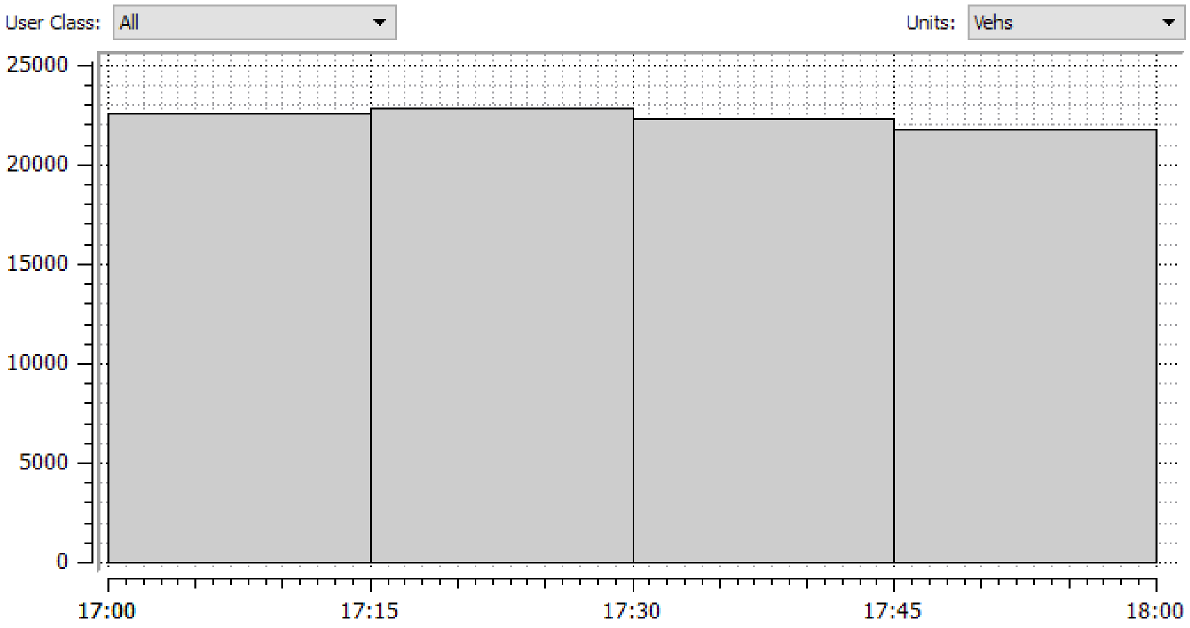
Screenshot 4: AM Peak Traffic Demand Profile



User Class: All

Units: Vehs

Screenshot 5: PM Peak Traffic Demand Profile



User Class: All

Units: Vehs

8 Model Calibration

8.1 Introduction

Model calibration is the process of adjusting the parameters of the model to ensure that simulated traffic flows, routes and travel behaviour correspond with observed behaviour. A number of features within the Aimsun models were calibrated to ensure the best representation of the network and driver behaviour.

The calibration parameters in the model include:

- Route Choice Model.
- Macroscopic model calibration parameters including:
  - Cost Functions;
  - Site Specific Capacity Corrections;
  - Cruise Speeds.
- Microscopic model calibration parameters including:
  - Cost Functions;
  - Section characteristics;
  - Turning characteristics;
  - Vehicle characteristics;
  - Simulation step and reaction time;
  - Behavioural Models.

The calibration of the model is discussed in detail in the following sections.

8.2 Route Choice Model

8.2.1 Introduction

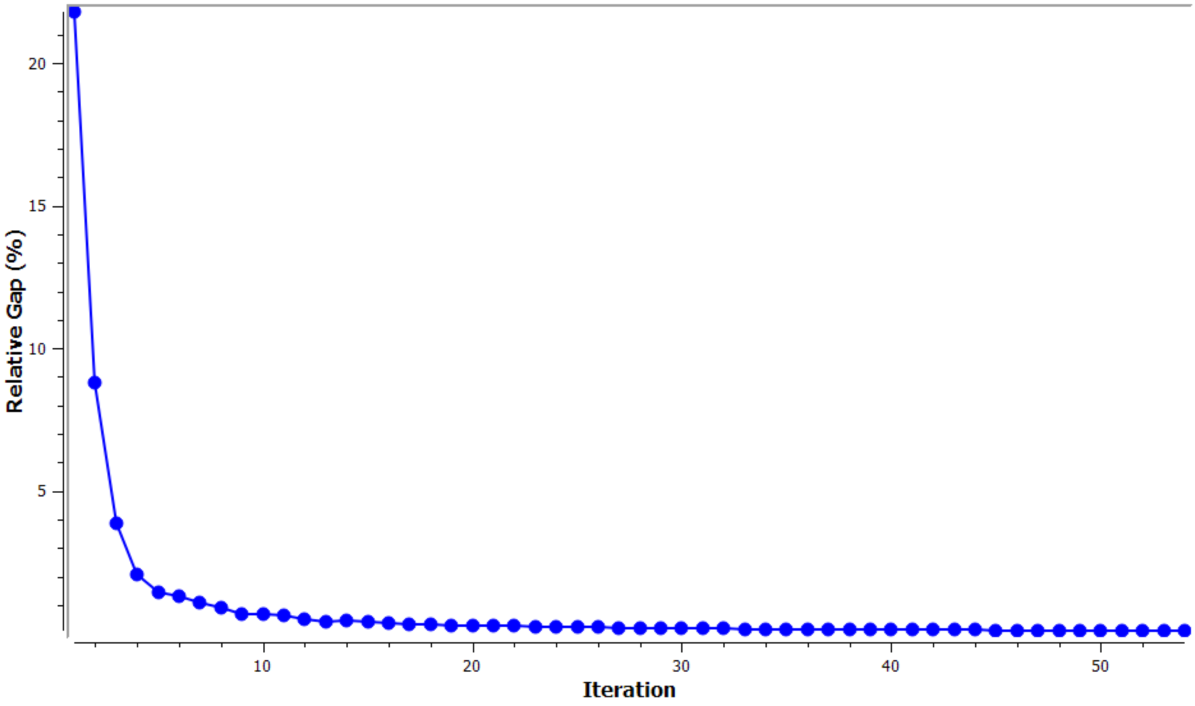
As set out in Section 3.8 above, a user equilibrium assignment is used in the macroscopic model. A proportion of paths from the macroscopic model will be used by vehicles in the microscopic model. These user equilibrium paths can be thought of as representing the routes that drivers habitually follow day after day based on their historic knowledge of the highway network. The remaining vehicles are set to follow dynamically chosen paths based costs experienced by vehicles currently travelling through the network. Drivers choose these paths before they depart on their journey however some of these may alter their paths within their journey. These dynamic paths represent those drivers that have additional knowledge of current network conditions obtained, for example, from satellite navigation systems and radio traffic alerts.

8.2.2 User Equilibrium (Macro)

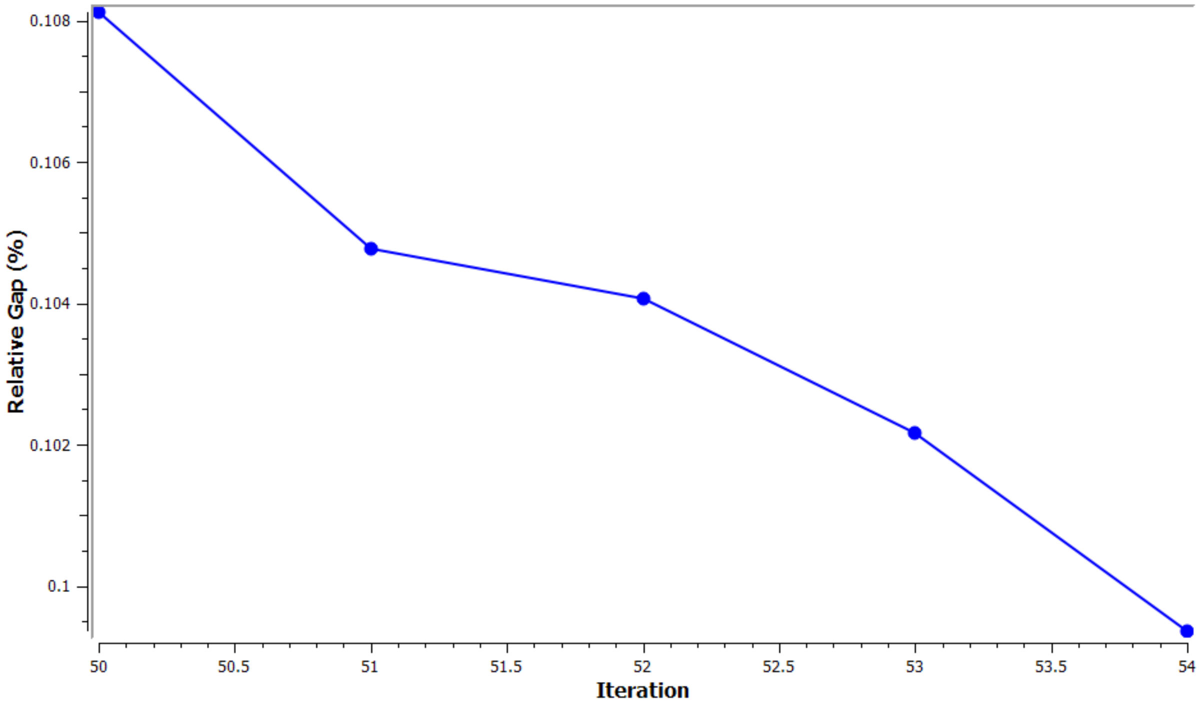
User equilibrium is achieved in the macroscopic model by an iterative process using the Method of Successive Averages (MSA). With each iteration, the solution should converge towards an equilibrium solution. The measure used to define how close the modelled traffic flows are to a user equilibrium is the relative gap, which is the ratio of the total excess cost with respect to the total minimum cost if all trips had used the shortest paths.

The convergence in the base year macroscopic model is shown in Screenshot 6 to Screenshot 11, which present graphs showing the relative gap achieved at every iteration as well as the last five iterations in detail. The graphs confirm that a relative gap of 0.1% is achieved in each period modelled and that the models are stable as they converge towards equilibrium with no significant oscillations in the relative gap values.

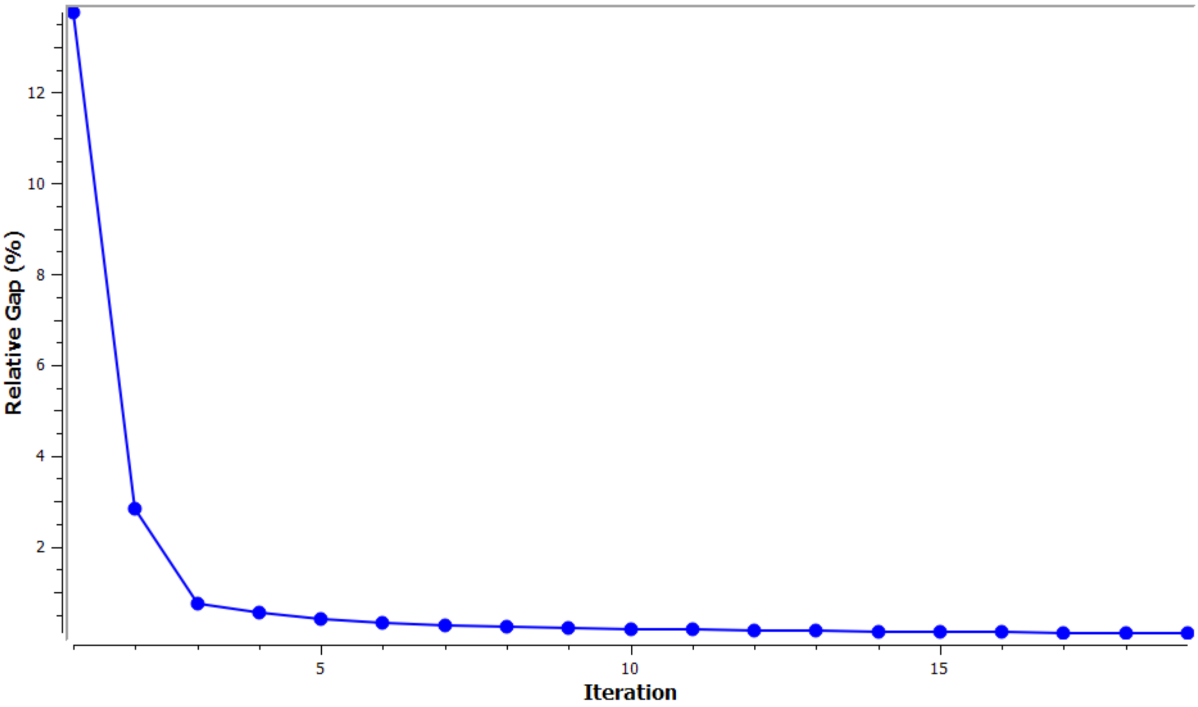
Screenshot 6: Macroscopic Model Convergence - AM Peak Hour



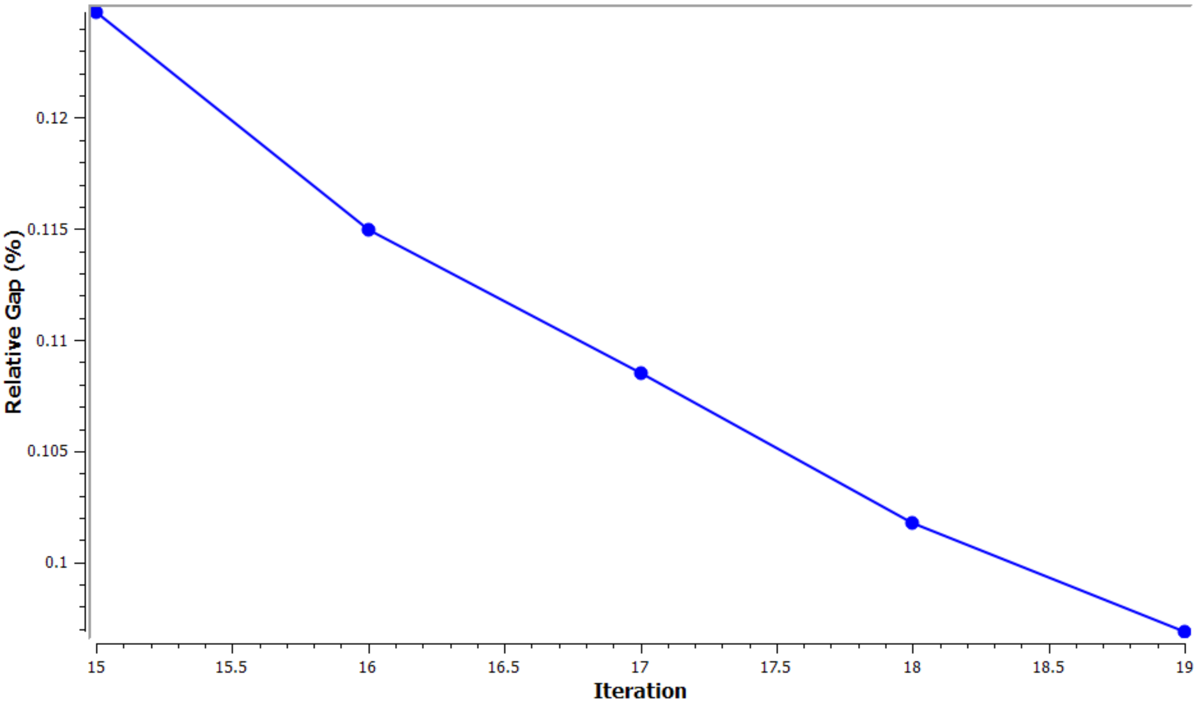
Screenshot 7: Macroscopic Model Convergence (Last Five Iterations) - AM Peak Hour



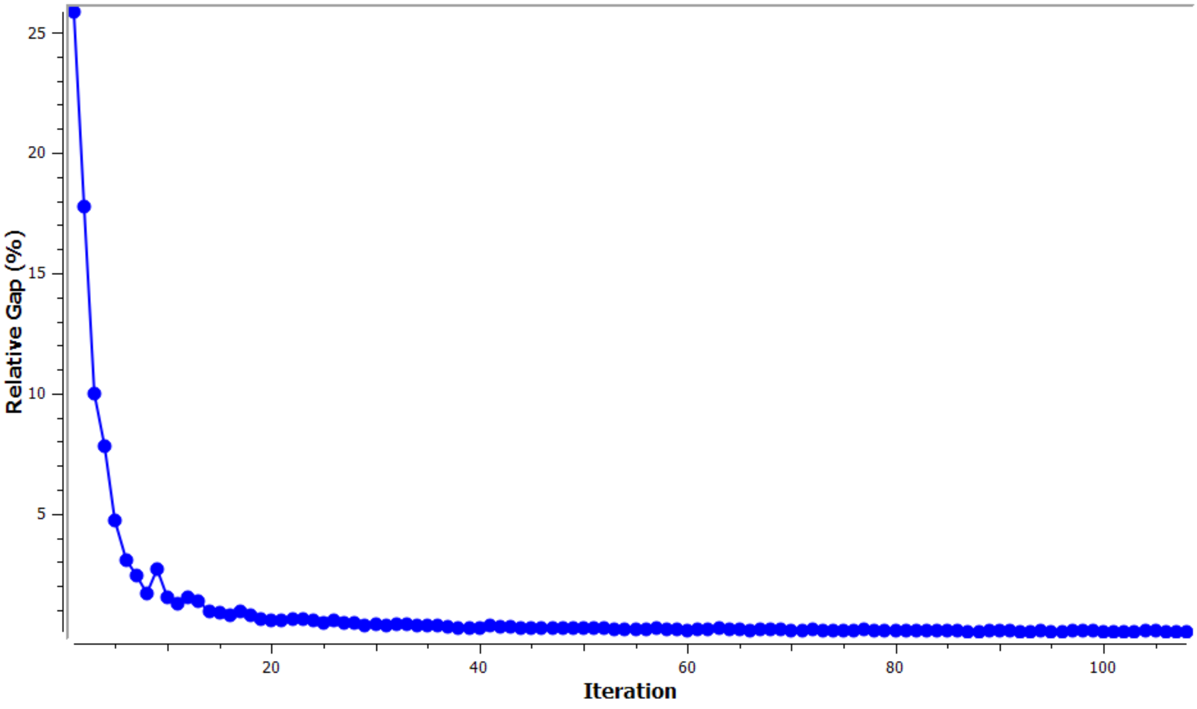
Screenshot 8: Macroscopic Model Convergence - Inter Peak Hour



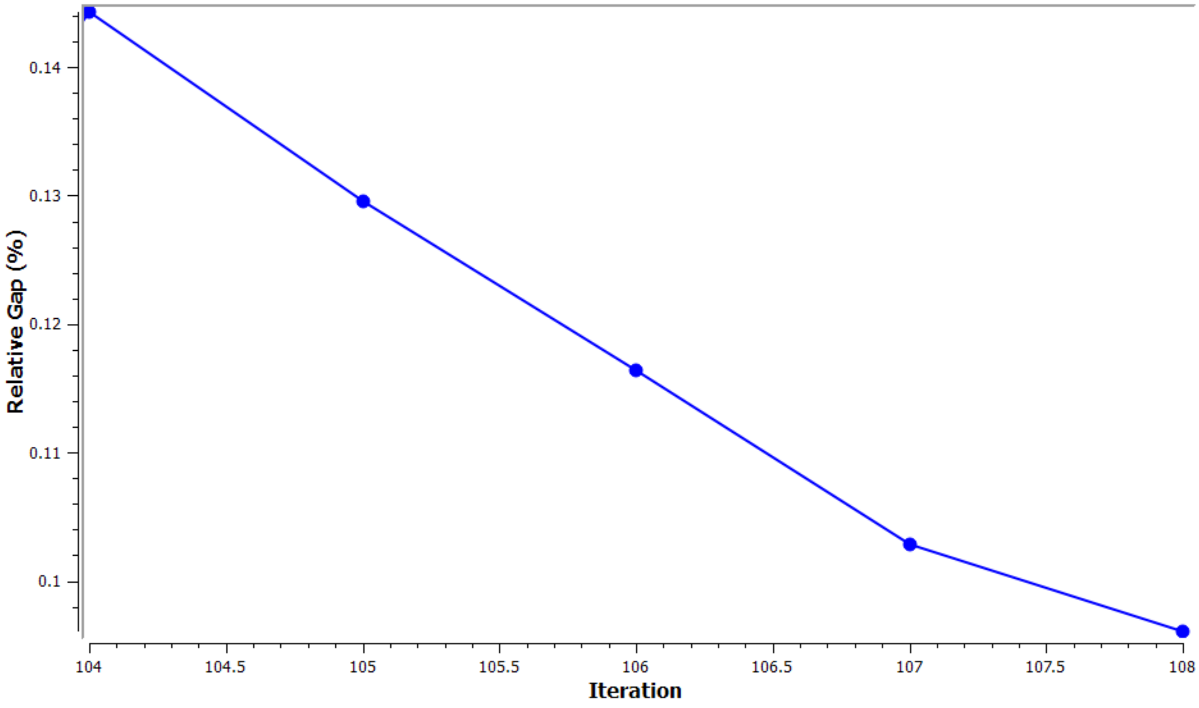
Screenshot 9: Macroscopic Model Convergence (Last Five Iterations) - Inter Peak Hour



Screenshot 10: Macroscopic Model Convergence – PM Peak Hour



Screenshot 11: Macroscopic Model Convergence(Last Five Iterations) - PM Peak Hour



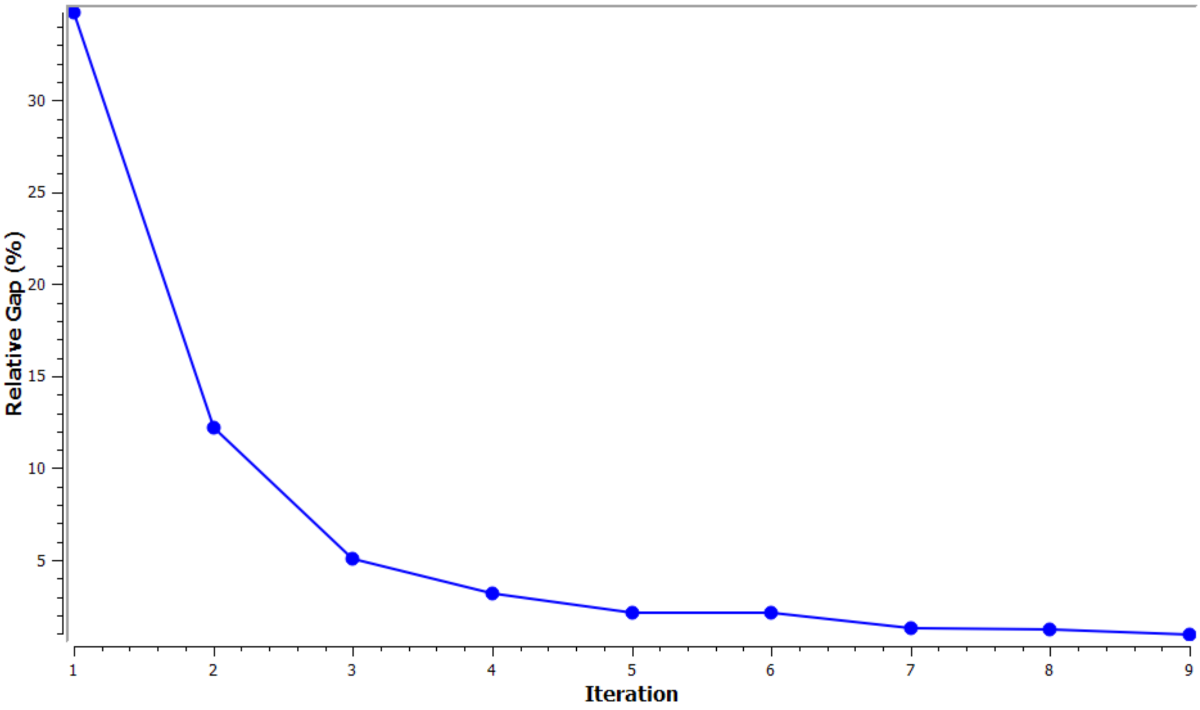
8.2.3 User Equilibrium (Micro)

It was found that a relative gap of 0.1% produces a large number of paths with very low numbers of vehicles assigned. This results in very large path files (.apa files) that significantly increase the time it takes for a microscopic simulation to be initialised.

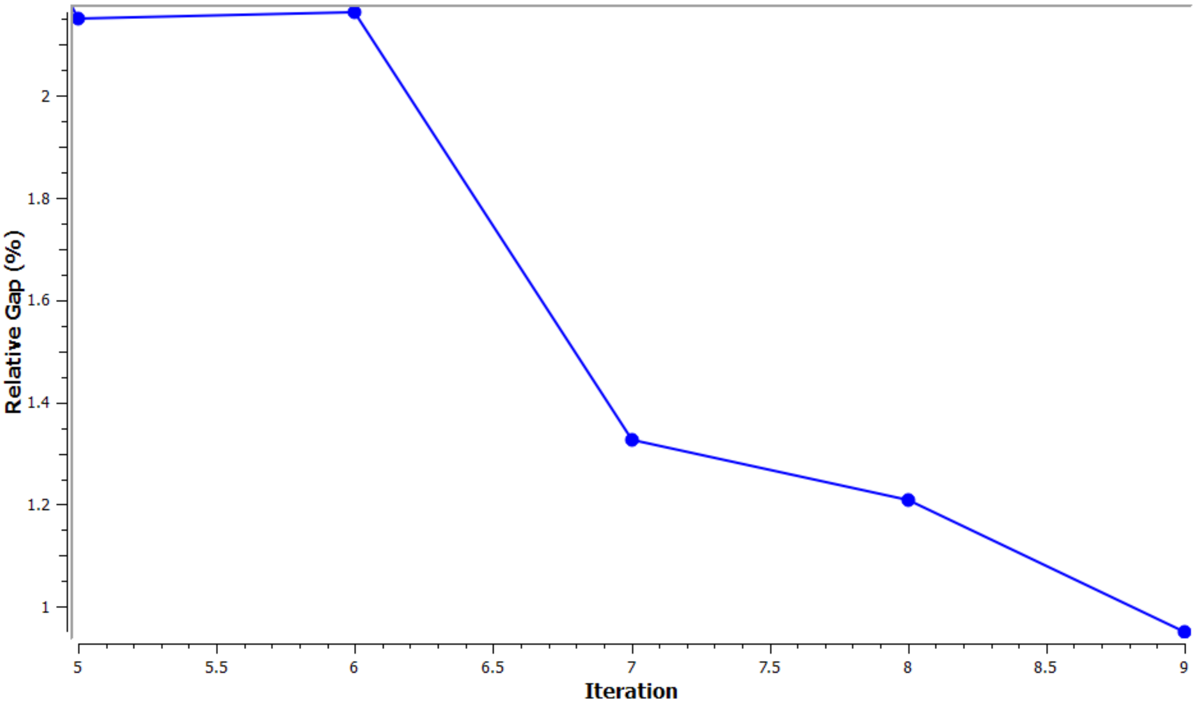
The stopping criteria for convergence for macroscopic user equilibrium paths that are subsequently used in the microscopic model was therefore changed to relative gap of 1.0%. Whilst this is higher than the recommendations set out in WebTAG, it has to be considered in the context that microsimulation is a stochastic processs. Up to 15% of vehicles in the microscopic model follow stochastically chosen dynamic paths, which may differ from the user equilibrium paths. Furthermore, many paths that that are assigned very small (fractional) numbers of trips will be ignored, as there is only a very small probability that the single vehicle will be generated to follow those paths. The effects of this stochasticity is greater than any errors that would occur by not reaching perfect equilibrium and, as such, any further convergence beyond a relative gap of 0.1% represents spurious levels of accuracy. It is considered that the stopping criteria adopted achieves the necessary model accuracy and stability whilst minimising model run times. Furthermore, it is considered that the accuracy in modelling congestion and delay gained through using microsimulation would more than offset any accuracy achieved through a higher degree of convergence. Notwithstanding the above, macroscopic paths derived using a relative gap of 0.1% could be used in the microsimulations, if desired.

The convergence in the base year macroscopic model used to generate paths for use in the microscopic model is shown in Screenshot 12 to Screenshot 16, which present graphs showing the relative gap achieved at every iteration as well as the last five iterations in detail. The graphs confirm that a relative gap of 1.0% is achieved in each period modelled and that the models are stable as they converge towards equilibrium with no significant oscillations in the relative gap values.

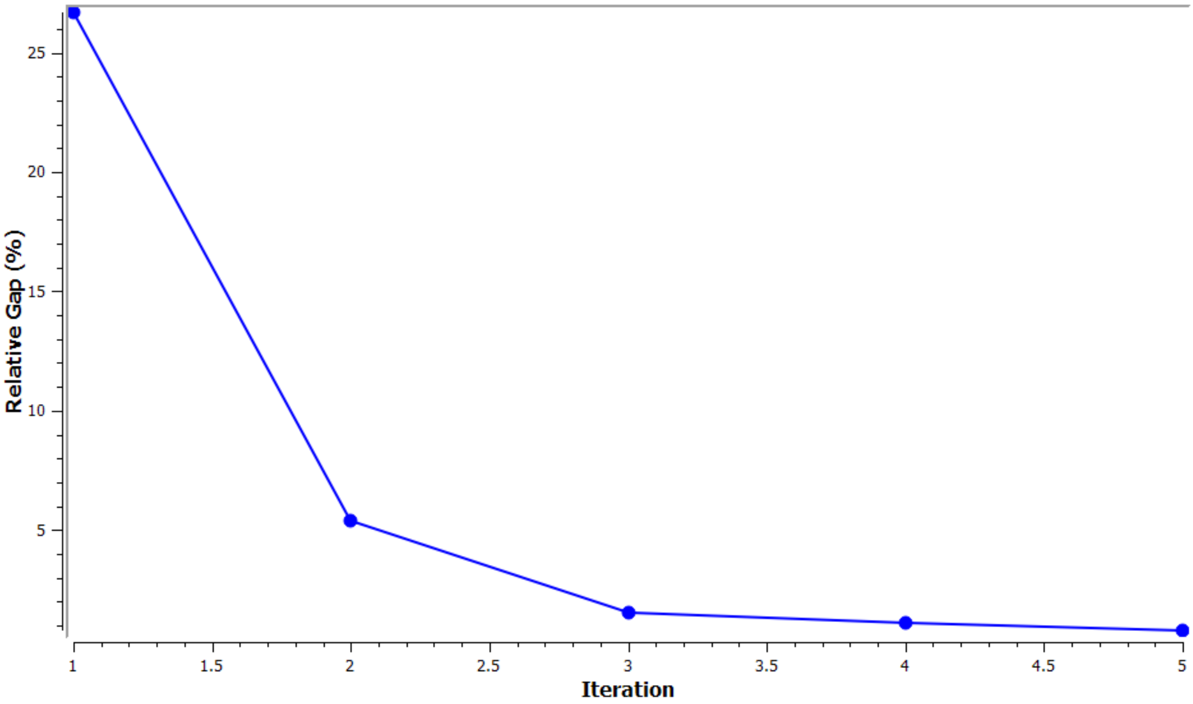
Screenshot 12: Macroscopic Model Convergence (For use in Micro) - AM Peak Hour



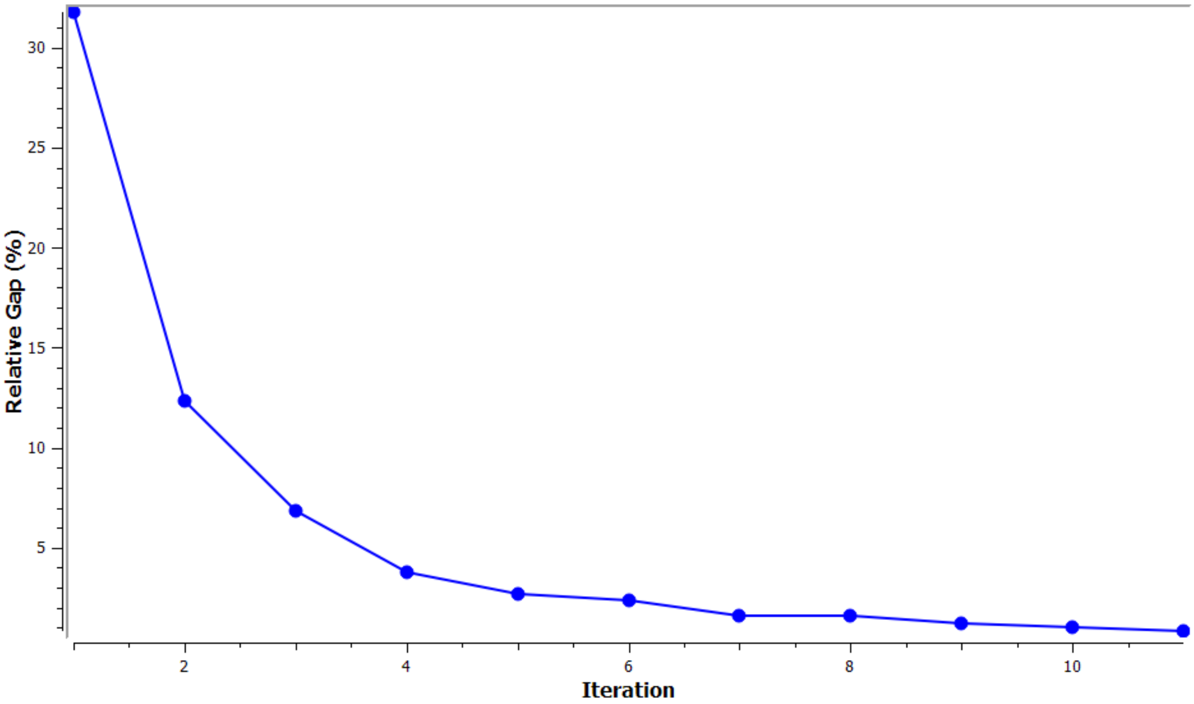
Screenshot 13: Macroscopic Model Convergence (For use in Micro) (Last Five Iterations) - AM Peak Hour



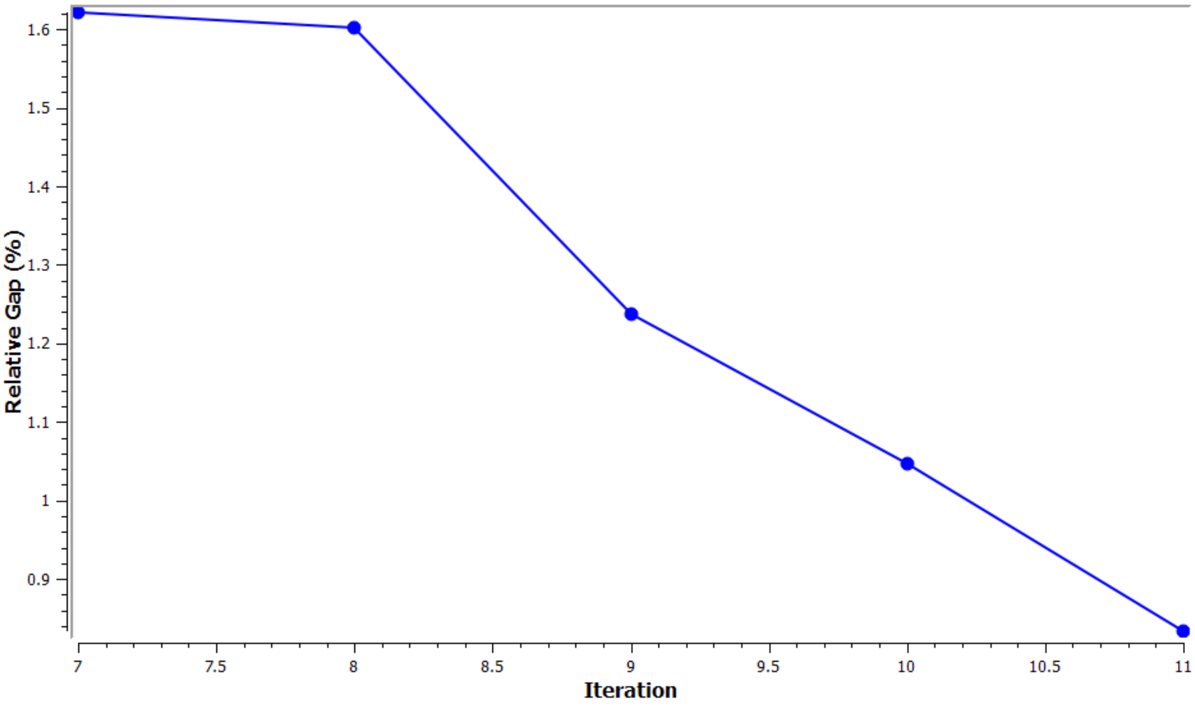
Screenshot 14: Macroscopic Model Convergence (For use in Micro) - Inter Peak Hour



Screenshot 15: Macroscopic Model Convergence (For use in Micro) – PM Peak Hour



Screenshot 16: Macroscopic Model Convergence (For use in Micro) (Last Five Iterations) - PM Peak Hour



8.3.1 Dynamic Traffic Assignment (Micro)

As set out in above, stochastic dynamic traffic assignment (DTA) has been used to determine the paths that the non-user equilibrium vehicles will take between a given origin and destination from a set of alternative routes. In a stochastic model, the probability of a vehicle taking a particular route depends on the cost of that route relative to the costs of the alternative route(s). The costs are determined by the cost function and the probabilities are determined by the route choice model. The route choice model defines the drivers' decision of which path to take from a set of alternatives, connecting one origin to one destination, depending on the cost calculation by the cost function. The 'standard' route choice models within Aimsun include:

- Fixed (time);
- Binomial;
- Proportional;
- Logit;
- C-Logit.

The fixed model is not appropriate to use, as it will not allow vehicles to respond to congestion as it determines fixed routes at the start of simulation using travel time in free-flow conditions (or the travel time during the warm-up period). The Binomial model has not been used as it does not consider the travel costs in the decision process. The proportional model has also not been used, as it is not particularly sensitive to small changes in travel costs.

The remaining models are therefore the Logit and the C-Logit model. In these models, the probability of a given path is expressed as a function of the difference between the costs of that path and all other alternative paths. In the C-Logit model, a commonality factor is introduced which controls the degree to which overlapping routes between a given OD pair are used in large networks where many alternative paths between origins and destinations exist.

In calibrating the model, there are a number of parameters that need calibrating in the C-Logit model as follows:

- Cycle time: this is the length of the period after which the route choice paths and probabilities are recalculated;

- Number of intervals: this is the number of preceding cycles that are used to calculate the route choice paths in the next route choice cycle;
- Initial K-SPs: the number of route choice paths used at the beginning of the simulation;
- Maximum number of routes: the maximum number of routes for each O-D pair to which vehicles are assigned;
- Scale factor, θ: this influences the standard error of the distribution of expected travel times and effectively determines the weight given to differences in costs between routes. For a small value of the scale factor (θ<1), there is a large variability about the true route costs and hence a trend towards using many routes whereas for large value of the scale factor (θ > 1) there is a small variability about the true route costs and route choice is concentrated in very few routes;
- Commonality factor: this is directly proportional to the degree of overlap of a given path with other alternative paths and is scaled by the parameters β and γ. The β parameter scales the commonality factor such that as β gets larger, the overlapping factor has greater importance with respect to utility (or cost). The γ parameter has a smaller influence than β and has the opposite effect.
- Attractiveness weight: this is the weighting afforded to the capacity when the route costs are calculated by the cost function;
- User defined cost weight: this is the weighting afforded to the user defined costs when the route costs are calculated by the cost function.

The final calibrated values for the route choice model are shown in Table 6.

Table 6: DTA Model Calibrated Values

Logit Model Parameter	Final Calibrated Values
Cycle time	00:15:00
Initial K-SPs	3
Maximum Number of Paths	3
Scale Factor, θ	1
Beta Factor, β	0.15
Gamma Factor, γ	1
Attractiveness Weight	1
User-Defined Cost Weight	1

8.5 Macroscopic Model Calibration

8.5.1 Cost Functions

The Aimsun macroscopic model uses the same network as the microscopic model and assigns traffic onto the network using a user equilibrium. In user equilibrium, the journey costs on all the routes actually used are equal, and less than those which would be experienced by a single vehicle on any unused route.

In Aimsun, the costs are calculated using the following functions:

- Volume Delay Function (VDF): this provides the cost of travelling along a section having regard to the volume of traffic assigned to the section.
- Turn Penalty Function (TPF): this provides the cost of travelling along a particular turn.
- Junction Delay Function (JDF): this provides the cost of travelling along a particular turn having regard to the volume of traffic undertaking this turn and, where, relevant, the volume of traffic that opposes the turn.

In the Medway Aimsun Model, a range of different functions are used, as these are discussed in the following sections.

8.5.2 Buffer Area

In the buffer area, costs are determined using VDFs. No TPFs or JDFs are used in this area. The speed-flow relationships used are those set out in Appendix D of TAG Unit M3.1. The parameters for these functions are generated from network coding using a Python script, where possible. These are then stored as section attributes and used within the VDFs. For example, average carriageway width is taken from the coded section width, bendiness is calculated from the coded section geometry and hilliness from the coded gradients. In this way, any new network coding, or changes to network coding, can easily be applied to the VDF parameters. The VDF functions used in the model are as follows:

- FORE_MACRO_VDF_ COBA_1_Rural_Single_Carriageway
- FORE_MACRO_VDF_ COBA_2_Rural_All_Purpose_Dual_2_Lane_Carriagway
- FORE_MACRO_VDF_ COBA_3_Rural_All_Purpose_Dual_3+_Lane_Carriagway
- FORE_MACRO_VDF_ COBA_4_Motorway_Dual_2_Lanes

- FORE_MACRO_VDF_ COBA_5_Motorway_Dual_3_Lanes
- FORE_MACRO_VDF_ COBA_6_Motorway_Dual_4+_Lanes
- FORE_MACRO_VDF_ COBA_7_Urban_Non-Central
- FORE_MACRO_VDF_ COBA_8_Urban_Central
- FORE_MACRO_VDF_ COBA_9_Small_Town
- FORE_MACRO_VDF_ COBA_10_Suburban_Single_Carriageway
- FORE_MACRO_VDF_ COBA_11_Suburban_Dual_Carriageway

8.5.3 Area of Detailed Modelling

In the area of detailed modelling, a fixed speed VDF (FORE_MACRO_VDF_ Fixed_Speed) is used for sections, with travel time being calculated from the section length and cruise speed. The overall cost of traversing the section calculated using the generalised cost function set out in section 3.9.

Delays on turns are calculated using a combination of TPFs and JDFs, with the latter providing the detailed junction modelling.

The turn penalty function (FORE_MACRO_TPF_Detailed) calculates the time taken to traverse a turn using the length of the coded turn and the turn speed that is automatically calculated by Aimsun. In addition, the delay incurred in decelerating from the preceding section speed to the turn speed and then accelerating from the turn speed to the following section speed is also calculated and taken into account.

Junction Delay Functions

The JDF is allocated depending on the junction type coding in the microscopic model. The following lists the JDFs are used in the model together with a simple description of the calculation used:

- FORE_MACRO_JDF_1_Minor_Road_Give_Way: This function is used to calculate the delay incurred at turns that give-way to a major road flow. The capacity of the give-way is calculated as a function of the conflicting flow using a simplified PICADY capacity relationship. The slope and intercept are calculated from a combination of the coded geometry (e.g. left turn, right turn, minor road width and major road width) and the calibrated microscopic parameter “visibility along main stream”. Delay is then calculated from the calculate ratio of flow to capacity (RFC).

- FORE_MACRO_JDF_2_Major_Road_RT_Give_Way: This function is used for major road right turning movements at priority junctions and is calculated in a similar way to the minor road give-way, but using the major road capacity relationship from PICADY.

- FORE_MACRO_JDF_3_Roundabout: This function is used to calculate the delay incurred on the approach to a roundabout. Capacity is calculated as a function of the circulating flow based on the capacity relationship used in ARCADY. The geometric parameters (entry width, approach road half-width, flare length, turning radius and inscribed circular diameter) are all calculated from the coded network geometry using a Python script. The resulting RFC is then used to calculate the delay.

- FORE_MACRO_JDF_4_Signalled: This function is used to calculate the delay on signalised turns and calculates the degree of saturation (DoS) using Webster and Cobbe formulae. Saturation flow is calculated from the coded network geometry (lane width, nearside / offside lane, turning radius and gradient) using the RR67 formula. Traffic signal timings are taken from the timings coded in the microscopic signal plans. Delay is calculated using Webster's delay formula.

- FORE_MACRO_JDF_5_Signalled_Give_Way: This function is used to calculate the delay on signalised turns that are opposed for all or part of the cycle, for example, a right turn within a signal-controlled junction. The DoS and delay is calculated separately for the opposed and unopposed parts of the cycle and then combined to give the overall delay.

Site Specific Capacity Corrections

As set out above, the capacity of each turn in the macro model is calculated from the microscopic coding and parameters. Whilst this provides reasonable values of capacity in most cases, in some cases, it is necessary to apply a further adjustment to correct the macro capacity to account for site-specific factors that are not captured by junction capacity models or within the microscopic network coding or parameters. This is applied on a turn-by-turn basis as a factor that is applied in the JDFs to the calculated capacity value.

Trip Purpose or Vehicle Type Functions

Two sets of functions are included in the model and are used depending on whether trip purposes are represented by user-classes (e.g. for a multi-class macroscopic assignment or adjustment) or whether they are represented by vehicle type (e.g. for generating paths for use in a microscopic simulation), as explained in section 3.7. The former functions have “MACRO” in their name whereas the latter have “MICRO” in the their name. The relevant functions are applied to the network in the experiment pre-run scripts.

8.5.4 Cruise Speeds

Within the area of detailed modelling, travel times along links in the macro model are calculated using a fixed cruise speed. Delays incurred at junctions and mid-block pedestrian crossings are calculated explicitly using JDFs, as described above. However, delays incurred due to other factors such as on-street parking and direct frontage access are not explicitly taken into account and these therefore need to be reflected in the cruise speeds. Cruise speeds have been determined by road type, having regard to the road speed limit, and those used in the model are summarised in Appendix C.

The exception to the above is for the M2, M20 and A249, which are modelled using speed-flow curves.

8.5.5 Calibrated Traffic Flows

Criteria for Calibration

Modelled traffic flows have been compared to observed traffic flows to assist in the calibration of the model. This calibration has been undertaken using the following measures:

- The absolute and percentage differences between modelled and observed flows;

- The GEH statistic, which is a form of the Chi-squared statistic that incorporates both relative and absolute errors, and is defined as follows:

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

Where M is the modelled flow

C is the observed flow

The calibration criteria and acceptability guidelines that have been adopted for both link and turning movement flows are as follows:

Criteria	Description	Acceptability Guideline
1	Individual flows within 100 veh/h of counts for flows less than 700 veh/h	> 85% of cases
	Individual flows within 15% of counts for flows from 700 to 2,700 veh/h	
	Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h	
2	GEH < 5 for individual flows	

In accordance with the guidance set out in the TAG Unit, any links or turning movements that meet either of the criteria are considered to be acceptable.

Calibration Results

The results from the calibration exercise are presented in Appendix D and are summarised in Table 7.

Table 7: Traffic Flow Calibration Summary – Macroscopic Model

Criteria	Description	Percentage Meeting Criteria	
		Sections	Turns
AM Peak Hour			
1	Individual flows within 100 veh/h of counts for flows less than 700 veh/h	93.5%	94.4%
	Individual flows within 15% of counts for flows from 700 to 2,700 veh/h	94.2%	95.9%
	Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h	100.0%	100.0%
2	GEH < 5 for individual flows	89.5%	87.6%
Percentage meeting either criteria 1 or 2		94.9%	95.2%
Inter Peak Hour			
1	Individual flows within 100 veh/h of counts for flows less than 700 veh/h	95.7%	96.1%
	Individual flows within 15% of counts for flows from 700 to 2,700 veh/h	96.8%	98.8%
	Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h	100.0%	-
2	GEH < 5 for individual flows	92.5%	91.2%
Percentage meeting either criteria 1 or 2		96.9%	96.6%
PM Peak Hour			
1	Individual flows within 100 veh/h of counts for flows less than 700 veh/h	91.5%	93.0%
	Individual flows within 15% of counts for flows from 700 to 2,700 veh/h	92.4%	95.0%
	Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h	100.0%	100.0%
2	GEH < 5 for individual flows	86.5%	85.9%
Percentage meeting either criteria 1 or 2		93.8%	94.7%

The above table shows that the macroscopic model accurately reproduces the observed traffic flows in the calibration dataset on both sections and turns, with a very high proportion (at least 93.8%) of calibration sections turns meeting either the GEH or absolute and relative difference criteria.

Regression Analysis

The calibrated modelled and observed section and turn flows have also been compared using regression analysis. The criteria and acceptability guidelines that has been adopted are as follows:

Criteria	Acceptability Guideline
Slope	Between 0.9 and 1.1
Correlation coefficient, R	Greater than 0.95

The findings of the regression analysis are presented in Appendix E and summarised in Table 8 below. The table confirms that model reproduces traffic flows on sections and turns with a high degree of accuracy, with the regression parameters being well within the acceptability guidelines.

Table 8: Traffic Flow Regression Summary - Calibration Dataset - Macroscopic Model

Description	Percentage Meeting Criteria	
	Sections	Turns
AM Peak Hour (08:00 to 09:00)		
Slope	0.994	1.003
Correlation coefficient, R	0.995	0.992
Inter Peak Hour (13:00 to 14:00)		
Slope	0.988	1.011
Correlation coefficient, R	0.994	0.991
PM Peak Hour (17:00 to 18:00)		
Slope	0.997	0.998
Correlation coefficient, R	0.994	0.992

8.6 Microscopic Model Calibration

8.6.1 Section Characteristics

There are a number of section characteristics that can be calibrated in the Aimsun model as follows:

- Section Maximum Speed: This gives the maximum speed that vehicles travel on the section, although the maximum speed for each vehicle will vary (higher or lower) depending on speed limit acceptance characteristic of the drivers. The section maximum speed in the model has generally been set to be equal to the signed speed limit.

- Visibility to Give Way: This is distance from the end of the link where vehicles begin to apply the gap acceptance model and is used to calibrate the capacity of priority junctions. In Aimsun 8, adjustments to visibility are undertaken at the turn level. In several locations the model has been altered to give visibility distances which accurately reflect reality.

- Visibility along Main Stream: This is the distance along the major road within which vehicles travelling on the main road are taken into account in the gap acceptance model.

- Yellow Box Speed: The yellow box speed prohibits a vehicle from entering the junction area (which is designated as a yellow box) should the preceding vehicle leaving be travelling at a speed lower than the specified value. This facility can be used to model yellow boxes that are marked on-street. However, it is also used to simulate the effect of slow moving traffic on the main road allowing traffic to emerge from minor side roads, to avoid gridlock which often occurs in many microsimulation models, and to adjust the relative capacity of approaches. The yellow box speed can also be set by turning movement. The yellow box speed has been set to zero for many of the turns to and from minor road arms at priority junctions, whilst the major road yellow box speeds have been maintained at the default values. This has the effect of major road traffic creating gaps and showing courtesy to minor road traffic in congested situations.

- Stop lines: Stop lines are placed on turns to identify the location on the turn at which vehicles stop at a junction (rather than at the end of a section). These have been used extensively in the model to ensure that vehicles wait in the correct position, particularly at roundabouts and priority junctions. Stop lines can also be expanded to show the area on a turn where vehicles do not apply yellow box rules. These have also been used throughout the model to ensure that vehicles use the appropriate road space when queueing.

- Lane Changing Cooperation: This parameter considers the percentage of upstream vehicles that try to create a gap for a vehicle that tries to change lanes. The default value of 80% has generally been assumed in the model.

8.6.2 Turning Characteristics

- Turning Speed: This is the maximum speed a vehicle will travel when making the turn, although the speed will vary (higher or lower) depending on speed limit acceptance characteristic of the drivers. A vehicle driving through a section will start to decelerate while approaching the turn in order to reach its turning speed at the end of the section. The turning speed is maintained during the turn and, when entering the next section, the vehicle will start to accelerate again according to its desired speed for this section. The turning speeds in the model have been automatically calculated by Aimsun based on the geometry of the turn. The “check and fix experiment” option notes that some of the automatically calculated speeds are potentially low and these have been reviewed to ensure they are appropriate.

- Look Ahead Distance Zones 1 and 2: The lane changing model considers three zones labelled Zone 1, 2 and 3. In Zone 1, lane-changing decisions are mainly governed by the traffic conditions of the lanes involved and the next desired turning movement is not taken into account. In Zone 2, it is the desired turning movement that affects the lane-changing decision. Vehicles not driving in the correct lane for the next turn tend to move towards the correct lane. Vehicles looking for a gap may try to adapt to it, but do not affect the behaviour of vehicles in the adjacent lanes. In Zone 3, vehicles are forced to reach the correct lane, reducing speed if necessary, and even coming to a complete stop in order to make the lane change possible. Also, vehicles in the adjacent lane can modify their behaviour in order to provide a gap big enough for the vehicle to change lanes. The “Distance Zone 1” and “Distance Zone 2” parameters determine the locations of Zones 1, 2 and 3 and therefore affect how the lane changing model is applied in different parts of the network. These parameters were reviewed in order to obtain realistic lane-changing behaviour, lane usage and queuing in the model.

8.6.3 Vehicle Characteristics

There are several vehicle characteristics specified in the model. The mean, standard deviation, maximum and minimum values, as well as types and limits of distribution are carefully defined. The characteristics can be broadly split into two categories: vehicle properties and driver characteristics. Vehicle properties include size, maximum speed and maximum acceleration and driver characteristics include speed acceptance, minimum distance between vehicles and maximum give way time. The values used in the model have been based on the default Aimsun values for “Car”, “Van”, “Truck” and “Bus” for cars, LGVs, HGVs and buses, respectively.

8.6.4 Simulation Step and Reaction Time

The reaction time is a global parameter which defines the time it takes a driver to react to changes in speed of the preceding vehicle. The parameter can be either fixed (for all vehicle types) or variable (a discrete probability function is defined for each vehicle type). The parameter was sensitivity tested in the calibration process. The reaction time at stop (which determines how quickly a vehicle reacts from a complete stop) and reaction time at traffic light (which determines how quickly the vehicle at the head of the queue at a traffic signal reacts to the changing signals) are also global parameters which can be varied. The parameters set for each time period in the model are shown in Table 9. The reaction time at stop and reaction time at traffic light have been set at default values. The reaction time has been set at 0.6s in order that the LEGION for Aimsun plug-in can be used, if necessary, in the future.

Table 9: Simulation Step and Reaction Time

Parameter	Calibrated Value (s)
Simulation Step / Reaction Time	0.6
Reaction Time at Stop	1.20
Reaction Time at Traffic Light	1.60

8.6.5 Behavioural Models

Car Following and Lane Change Models

Both car following and lane changing models have global parameters for which it is possible to alter the default settings. The 2-lane car following model with default parameters was used in the model.

The lane changing model is a decision process and the factors of the model include percentage overtake (percentage of the desired speed of a vehicle below which the vehicle may decide to overtake), percentage recover (percentage of the desired speed of a vehicle above which a vehicle may decide to get back into the slower lane) and distance zone variability (the percentage variability in the look ahead distances described in section 4.3). In the model, none of the values were changed from these default settings, which are shown in Table 10.

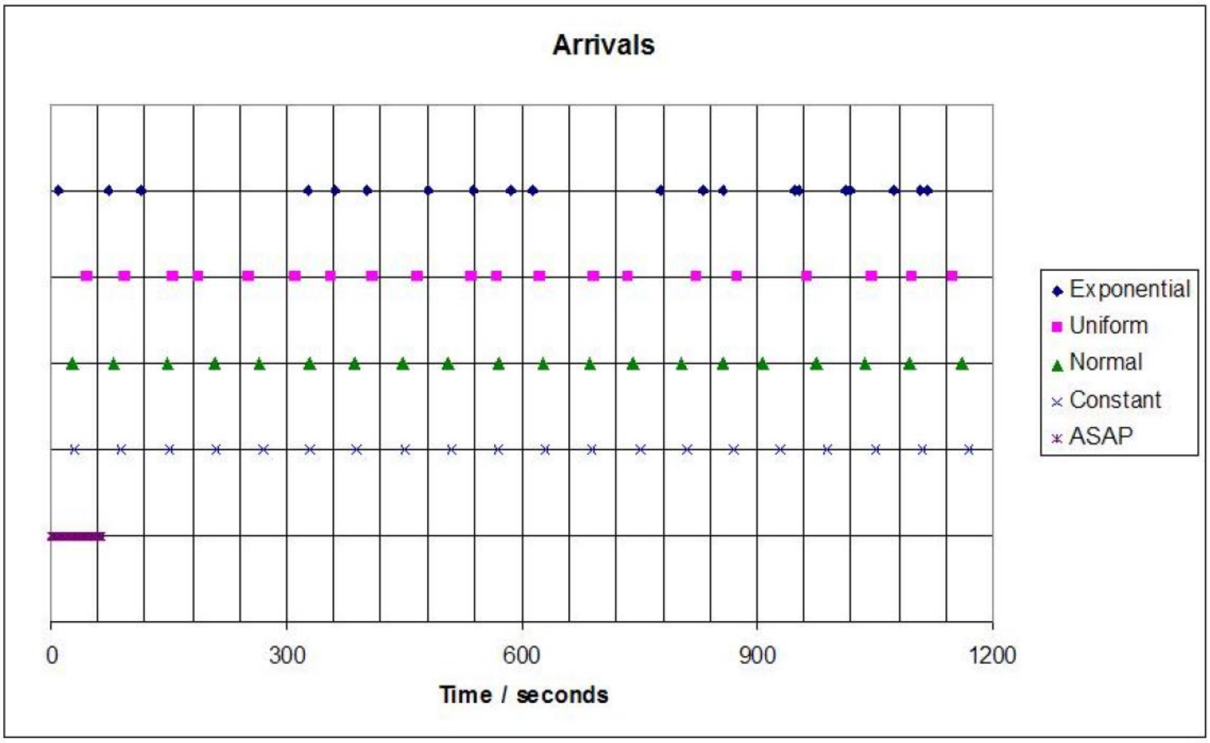
Table 10: Car Following and Lane Changing Model Parameters

Parameter	Value
Percentage Overtake	90%
Percentage Recover	95%
Distance Zone Variability	40%

8.6.6 Trip Generation

When loading a traffic demand into the simulation model a number of different models can be used to determine the headway between two consecutive vehicle arrivals. Five types of traffic generation are available in Aimsun: exponential uniform, normal, constant and ASAP. Diagram 2 illustrates the trip generation profile for each type of distribution. Clearly, the ASAP distribution is not appropriate for this model and was therefore discounted. Sensitivity testing of the other distributions was undertaken to determine which best reflected reality. The constant and normal distributions do not result in any significant variation in headway. However, it was found that the exponential distribution gave the most realistic results, as it provides some variation in headway on entry arms of the model. This distribution has therefore been used in the model.

Diagram 2: Trip Generation



8.6.7 Calibrated Traffic Flows

Criteria for Calibration

Modelled traffic flows have been compared to observed traffic flows to assist in the calibration of the microscopic model. This calibration has been undertaken using the measures set out in section 8.5.5, above.

Calibration Results

The results from the calibration exercise for the microscopic model are presented in Appendix F and are summarised in Table 7.

Table 11: Traffic Flow Calibration Summary – Microscopic Model

Criteria	Description	Percentage Meeting Criteria	
		Sections	Turns
AM Peak Hour			
1	Individual flows within 100 veh/h of counts for flows less than 700 veh/h	91.7%	93.4%
	Individual flows within 15% of counts for flows from 700 to 2,700 veh/h	92.0%	93.4%
	Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h	88.9%	100.0%
2	GEH < 5 for individual flows	87.6%	86.3%
Percentage meeting either criteria 1 or 2		93.2%	94.4%
Inter Peak Hour			
1	Individual flows within 100 veh/h of counts for flows less than 700 veh/h	96.7%	97.5%
	Individual flows within 15% of counts for flows from 700 to 2,700 veh/h	95.6%	97.6%
	Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h	100.0%	-
2	GEH < 5 for individual flows	92.4%	92.1%
Percentage meeting either criteria 1 or 2		97.0%	97.5%
PM Peak Hour			
1	Individual flows within 100 veh/h of counts for flows less than 700 veh/h	90.1%	91.6%
	Individual flows within 15% of counts for flows from 700 to 2,700 veh/h	90.2%	93.7%
	Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h	88.5%	100.0%
2	GEH < 5 for individual flows	83.5%	84.3%
Percentage meeting either criteria 1 or 2		91.1%	92.6%

The above table shows that the microscopic model accurately reproduces the observed traffic flows in the calibration dataset on both sections and turns, with a very high proportion (at least 89.9%) of calibration sections turns meeting either the GEH or absolute and relative difference criteria.

Regression Analysis

The calibrated modelled and observed section and turn flows have also been compared using regression analysis. The criteria and acceptability guidelines that has been adopted are as follows:

Criteria	Acceptability Guideline
Slope	Between 0.9 and 1.1
Correlation coefficient, R	Greater than 0.95

The findings of the regression analysis are presented in Appendix G and summarised in Table 12 below. The table confirms that model reproduces traffic flows on sections and turns with a high degree of accuracy, with the regression parameters being well within the acceptability guidelines.

Table 12: Traffic Flow Regression Summary - Calibration Dataset - Microscopic Model

Description	Percentage Meeting Criteria	
	Sections	Turns
AM Peak Hour (08:00 to 09:00)		
Slope	0.976	0.986
Correlation coefficient, R	0.993	0.990
Inter Peak Hour (13:00 to 14:00)		
Slope	0.978	1.003
Correlation coefficient, R	0.992	0.991
PM Peak Hour (17:00 to 18:00)		
Slope	0.986	0.993
Correlation coefficient, R	0.992	0.990

8.7 Iteration between Macro and Micro Models

Since the macroscopic and microscopic models share the same network, changes made to the microscopic model may affect the calibration of the macroscopic model, which may then affect route choice in the microscopic model. The calibration of the macroscopic and microscopic models therefore was undertaken iteratively and the calibration results presented are the culmination of this process.

9 Model Validation

9.1 Route Choice Validation

Routing in both the macroscopic and microscopic models has been validated by examining the modelled routes between selected origins and destinations. The routes have been chosen so that they:

- Are between important centres of population and employment;
- Have a significant number of trips;
- Are of signification length;
- Pass through areas of interest;
- Include both directions of travel;
- Link different compass areas (e.g. north to south, east to west, etc.);
- Coincide with journey time routes.

In accordance with guidance set out in WebTAG, the number of O-D pairs that should be investigated is given by the following formula:

$$\text{Number of OD pairs} = (\text{number of zones})^{0.25} \text{ x number of user classes}$$

Evaluating this for the Medway Aimsun model gives 38 OD pairs.

Appendix H shows example path trees from the AM peak hour macroscopic model for 40 OD pairs. The path trees show model produces realistic routing, with the majority of vehicles taking strategic and main road routes. There is also evidence of the model generating equilibrium paths that use more minor roads in response to congestion, for example, along the A2. Inspection of the percentage of vehicles assigned to such paths indicate that these paths are used by only a small proportion of the vehicles, as would be expected.

9.2 Trip Matrix Validation

Trip matrix validation has been undertaken by comparing modelled and observed traffic flows across the screenlines and cordons identified in Section 5, above, having regard to the acceptability guidelines set out below.

Criteria	Acceptability Guideline
Differences between modelled and observed flows should be less than 5% of the observed flows	All or nearly all screenlines

The results are set out in Table 13, which presents relative difference between modelled and observed flows across both the calibration and validation cordons and screenlines. The table shows that a number of calibration screenlines / cordons are modelled with differences slightly more than 5%. However, the table also presents the GEH statistic for the screenlines / cordons. For screenlines / cordons that exceed a 5% difference, it can be seen that these are generally modelled with low GEH statistics of less than 4. Further investigation shows that these screenlines have relatively low total flows, meaning that small discrepancies between modelled and observed flows manifest as larger percentage increases, but are considered to be acceptable when the GEH statistic is considered. The exception to this is for the Fully Modelled Area Cordon (Outbound), however, this is modelled within 5.1% of the observed cordon flow and therefore is considered to be acceptable.

Table 13: Trip Matrix Calibration / Validation

Screenline	Relative Difference (%)			GEH Statistic		
	AM	IP	PM	AM	IP	PM
Calibration						
M2 Screenline (Northbound)	4.22	3.63	0.36	3.12	2.20	0.31
M2 Screenline (Southbound)	-0.99	6.73	4.44	0.82	3.93	3.36
North-South Screenline (Eastbound)	-0.17	1.11	3.85	0.13	0.77	3.44
North-South Screenline (Westbound)	4.91	1.79	2.23	4.11	1.22	1.75
Hoo Peninsula Screenline (Eastbound)	1.98	0.66	0.15	0.74	0.21	0.06
Hoo Peninsula Screenline (Westbound)	1.28	10.84	-0.55	0.60	3.24	0.20
Fully modelled area cordon (Inbound)	1.51	0.11	0.76	2.28	0.14	1.31
Fully modelled area cordon (Outbound)	1.76	3.69	5.10	2.97	4.93	8.63
Chatham Cordon (Inbound)	-1.94	5.46	2.27	1.29	3.14	1.44
Chatham Cordon (Outbound)	0.71	1.84	0.65	0.46	1.16	0.46
Validation						
River Screenline (Eastbound)	1.52	0.59	-1.80	1.24	0.42	1.67
River Screenline (Westbound)	2.04	1.94	0.79	1.75	1.37	0.69
A2 Western Screenline (Northbound)	11.11	-2.24	11.17	3.44	0.77	3.89
A2 Western Screenline (Southbound)	9.22	13.46	6.34	2.43	3.80	1.72
A2 Central Screenline (Northbound)	-4.85	-6.80	-4.02	2.14	2.42	1.54
A2 Central Screenline (Southbound)	0.98	-1.72	2.22	0.38	0.63	0.97
A2 Eastern Screenline (Northbound)	-0.10	-4.73	2.53	0.09	4.27	2.44
A2 Eastern Screenline (Southbound)	-1.92	3.54	-5.68	1.16	1.83	3.64

9.3 Assignment Validation

9.3.1 Introduction

Validation of the traffic assignment has been undertaken by considering the following:

- Comparisons of observed and modelled traffic flows on sections and turns;
- Comparisons of observed and modelled journey times.

9.3.2 Traffic Flow Validation

Modelled traffic flows have been validated against observed traffic flows in the validation dataset using the criteria set out in section 8.5.5, above.

The results from the validation exercise are presented in Appendices I and J and are summarised in Table 14 and Table 15 for the macroscopic and microscopic models, respectively.

The table confirms that at least 91.5% and 86.5% of the validation sections and turns meet the validation criteria in the macroscopic and microscopic models, respectively. This indicates that both models reproduce traffic flows to an acceptable degree of accuracy, validating both the user equilibrium and dynamic traffic assignment.

Table 14: Traffic Flow Validation Summary – Macroscopic Model

Criteria	Description	Percentage Meeting Criteria	
		Sections	Turns
AM Peak Hour			
1	Individual flows within 100 veh/h of counts for flows less than 700 veh/h	92.9%	94.8%
	Individual flows within 15% of counts for flows from 700 to 2,700 veh/h	93.5%	95.5%
	Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h	100.0%	-
2	GEH < 5 for individual flows	89.4%	80.9%
Percentage meeting either criteria 1 or 2		94.4%	95.5%
Inter Peak Hour			
1	Individual flows within 100 veh/h of counts for flows less than 700 veh/h	95.9%	99.3%
	Individual flows within 15% of counts for flows from 700 to 2,700 veh/h	92.1%	100.0%
	Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h	100.0%	-
2	GEH < 5 for individual flows	90.6%	82.8%
Percentage meeting either criteria 1 or 2		97.5%	99.4%
PM Peak Hour			
1	Individual flows within 100 veh/h of counts for flows less than 700 veh/h	85.6%	92.8%
	Individual flows within 15% of counts for flows from 700 to 2,700 veh/h	91.5%	94.7%
	Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h	100.0%	-
2	GEH < 5 for individual flows	84.4%	81.5%
Percentage meeting either criteria 1 or 2		90.0%	93.0%

Table 15: Traffic Flow Validation Summary – Microscopic Model

Criteria	Description	Percentage Meeting Criteria	
		Sections	Turns
AM Peak Hour			
1	Individual flows within 100 veh/h of counts for flows less than 700 veh/h	83.7%	78.8%
	Individual flows within 15% of counts for flows from 700 to 2,700 veh/h	92.0%	96.0%
	Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h	89.7%	90.5%
2	GEH < 5 for individual flows	100.0%	-
Percentage meeting either criteria 1 or 2		92.2%	96.6%
Inter Peak Hour			
1	Individual flows within 100 veh/h of counts for flows less than 700 veh/h	83.7%	81.5%
	Individual flows within 15% of counts for flows from 700 to 2,700 veh/h	94.3%	100.0%
	Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h	94.3%	100.0%
2	GEH < 5 for individual flows	100.0%	-
Percentage meeting either criteria 1 or 2		95.0%	100.0%
PM Peak Hour			
1	Individual flows within 100 veh/h of counts for flows less than 700 veh/h	77.3%	79.5%
	Individual flows within 15% of counts for flows from 700 to 2,700 veh/h	81.8%	93.0%
	Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h	90.0%	100.0%
2	GEH < 5 for individual flows	100.0%	-
Percentage meeting either criteria 1 or 2		86.5%	93.8%

9.3.3 Regression Analysis

Modelled and observed section and turn flows have also been validated using regression analysis. The validation criteria and acceptability guidelines that has been adopted are as follows:

Criteria	Acceptability Guideline
Slope	Between 0.9 and 1.1
Correlation coefficient, R	Greater than 0.95

The findings of the regression analysis are set out in Appendices K and L and summarised in Table 16 and Table 17 below for the microscopic and macroscopic models, respectively. The tables confirm that model reproduces traffic flows on sections and turns with a high degree of accuracy, with the regression parameters being well within the acceptability guidelines.

Table 16: Traffic Flow Regression Summary – Macroscopic Model

Description	Percentage Meeting Criteria	
	Sections	Turns
AM Peak Hour (08:00 to 09:00)		
Slope	1.001	0.990
Correlation coefficient, R	0.996	0.994
Inter Peak Hour (13:00 to 14:00)		
Slope	0.988	0.992
Correlation coefficient, R	0.994	0.992
PM Peak Hour (17:00 to 18:00)		
Slope	0.980	1.004
Correlation coefficient, R	0.994	0.993

Table 17: Traffic Flow Regression Summary – Microscopic Model

Description	Percentage Meeting Criteria	
	Sections	Turns
AM Peak Hour (08:00 to 09:00)		
Slope	0.990	0.966
Correlation coefficient, R	0.994	0.992
Inter Peak Hour (13:00 to 14:00)		
Slope	0.988	0.989
Correlation coefficient, R	0.990	0.993
PM Peak Hour (17:00 to 18:00)		
Slope	0.961	0.985
Correlation coefficient, R	0.993	0.992

9.3.4 Journey Time Validation

TrafficMaster data for the year 2015/16 has been provided by Medway Council from which average school-day weekday journey times have been extracted. Journey times are validated by considering the percentage difference between modelled and observed journey times, subject to an absolute maximum difference. The validation criteria and acceptability guidelines that have been adopted are as follows:

Criteria	Acceptability Guideline
Modelled times along routes should be within 15% of surveyed times (or 1 minute, if higher than 15%)	> 85% of routes

The journey time validation is presented separately for each modelled period.

Sixteen journey time routes have been defined that cover the main routes and congested junctions, as shown on Figure 19. The results of the journey time validation are presented in Table 18 to Table 20 for the macroscopic model and Table 21 to Table 23 for the microscopic model.

Graphs of modelled and observed journey time plotted against distance for each of the routes are presented in Appendix M and N for the macroscopic and microscopic models, respectively. These confirm that, in general, the modelled delays are occurring in the correct location and are of the correct magnitude.

Table 18: Journey Time Validation Summary – Macroscopic Model – AM Peak Hour

Route	Length (km)	Observed (s)	Modelled (s)	Relative Diff (s)	Absolute Diff (%)	Validates ?
Route 1A: A231 / A230 Southbound (Dark Blue)	6.26	744	846	101	13.63%	Yes
Route 1B: A231 / A230 Northbound (Dark Blue)	6.24	905	941	36	3.95%	Yes
Route 2A: M2 Eastbound (Light Blue)	20.78	712	783	71	10.01%	Yes
Route 2A: M2 Westbound (Light Blue)	20.89	784	828	44	5.65%	Yes
Route 3A: A228 Hoo Peninsula Eastbound (Yellow)	16.24	993	1008	15	1.48%	Yes
Route 3B: A228 Hoo Peninsula Westbound (Yellow)	16.20	1020	1016	-4	-0.39%	Yes
Route 4A: A228 A2 to M20 Southbound (Orange)	10.30	700	804	104	14.79%	Yes
Route 4B: A228 M20 to A2 Northbound (Orange)	10.27	698	679	-19	-2.70%	Yes
Route 5A: A228 (A289 to M20) Southbound (Red)	15.44	1436	1352	-84	-5.82%	Yes
Route 5B: A228 (M20 to A229) Northbound (Red)	13.69	1242	1203	-38	-3.07%	Yes
Route 6A: A289 and A278 Eastbound (Green)	18.48	1238	1350	112	9.05%	Yes
Route 6B: A289 and A278 Westbound (Green)	18.29	1215	1149	-66	-5.41%	Yes
Route 7A: A2 Eastbound (Purple)	18.45	2451	2441	-9	-0.39%	Yes
Route 7B: A2 Westbound (Purple)	18.57	2708	2542	-165	-6.10%	Yes
Route 8A: M20 Eastbound (Dark Green)	12.15	399	456	57	14.35%	Yes
Route 8B: M20 Westbound (Dark Green)	10.78	546	450	-95	-17.47%	No
Percentage of Routes meeting Validation Criteria:						93.8%

Table 19: Journey Time Validation Summary – Macroscopic Model – Inter Peak Hour

Route	Length (km)	Observed (s)	Modelled (s)	Relative Diff (s)	Absolute Diff (%)	Validates ?
Route 1A: A231 / A230 Southbound (Dark Blue)	6.26	696	778	82	11.80%	Yes
Route 1B: A231 / A230 Northbound (Dark Blue)	6.24	709	800	91	12.89%	Yes
Route 2A: M2 Eastbound (Light Blue)	20.78	681	781	99	14.57%	Yes
Route 2A: M2 Westbound (Light Blue)	20.89	688	774	86	12.46%	Yes
Route 3A: A228 Hoo Peninsula Eastbound (Orange)	16.24	964	1007	43	4.51%	Yes
Route 3B: A228 Hoo Peninsula Westbound (Orange)	16.20	962	1010	48	4.95%	Yes
Route 4A: A228 A2 to M20 Southbound (Peach)	10.30	614	734	121	19.69%	No
Route 4B: A228 M20 to A2 Northbound (Peach)	10.27	580	675	95	16.43%	No
Route 5A: A228 (A289 to M20) Southbound	15.44	1231	1220	-11	-0.91%	Yes
Route 5B: A228 (M20 to A229) Northbound	13.69	1155	1093	-62	-5.39%	Yes
Route 6A: A289 and A278 Eastbound	18.48	1096	1179	83	7.58%	Yes
Route 6B: A289 and A278 Westbound	18.29	1068	1092	24	2.27%	Yes
Route 7A: A2 Eastbound	18.45	2193	2300	107	4.88%	Yes
Route 7B: A2 Westbound	18.57	2269	2238	-31	-1.35%	Yes
Route 8A: M20 Eastbound	12.15	405	447	43	10.54%	Yes
Route 8B: M20 Westbound	10.78	396	386	-10	-2.46%	Yes
Percentage of Routes meeting Validation Criteria:						87.5%

Table 20: Journey Time Validation Summary – Macroscopic Model – PM Peak Hour

Route	Length (km)	Observed (s)	Modelled (s)	Relative Diff (s)	Absolute Diff (%)	Validates ?
Route 1A: A231 / A230 Southbound (Dark Blue)	6.26	891	877	-14	-1.59%	Yes
Route 1B: A231 / A230 Northbound (Dark Blue)	6.24	793	816	22	2.82%	Yes
Route 2A: M2 Eastbound (Light Blue)	20.78	845	896	51	6.05%	Yes
Route 2A: M2 Westbound (Light Blue)	20.89	692	782	91	13.10%	Yes
Route 3A: A228 Hoo Peninsula Eastbound (Orange)	16.24	938	1011	73	7.81%	Yes
Route 3B: A228 Hoo Peninsula Westbound (Orange)	16.20	935	1012	77	8.22%	Yes
Route 4A: A228 A2 to M20 Southbound (Peach)	10.30	784	783	-1	-0.13%	Yes
Route 4B: A228 M20 to A2 Northbound (Peach)	10.27	694	702	8	1.16%	Yes
Route 5A: A228 (A289 to M20) Southbound	15.44	1407	1328	-79	-5.63%	Yes
Route 5B: A228 (M20 to A229) Northbound	13.69	1499	1510	11	0.76%	Yes
Route 6A: A289 and A278 Eastbound	18.48	1455	1499	44	3.04%	Yes
Route 6B: A289 and A278 Westbound	18.29	1102	1216	114	10.36%	Yes
Route 7A: A2 Eastbound	18.45	2768	2535	-233	-8.43%	Yes
Route 7B: A2 Westbound	18.57	2549	2522	-26	-1.03%	Yes
Route 8A: M20 Eastbound	12.15	549	607	59	10.69%	Yes
Route 8B: M20 Westbound	10.78	396	396	0	0.05%	Yes
Percentage of Routes meeting Validation Criteria:						100.0%

Table 21: Journey Time Validation Summary – Microscopic Model – AM Peak Hour

Route	Length (km)	Observed (s)	Modelled (s)	Relative Diff (s)	Absolute Diff (%)	Validates ?
Route 1A: A231 / A230 Southbound (Dark Blue)	6.26	744	846	102	13.68%	Yes
Route 1B: A231 / A230 Northbound (Dark Blue)	6.24	905	968	63	7.00%	Yes
Route 2A: M2 Eastbound (Light Blue)	20.78	712	753	42	5.86%	Yes
Route 2A: M2 Westbound (Light Blue)	20.89	784	769	-14	-1.85%	Yes
Route 3A: A228 Hoo Peninsula Eastbound (Yellow)	16.24	993	960	-33	-3.37%	Yes
Route 3B: A228 Hoo Peninsula Westbound (Yellow)	16.20	1020	1002	-17	-1.69%	Yes
Route 4A: A228 A2 to M20 Southbound (Orange)	10.30	700	789	89	12.68%	Yes
Route 4B: A228 M20 to A2 Northbound (Orange)	10.27	698	697	-2	-0.24%	Yes
Route 5A: A228 (A289 to M20) Southbound (Red)	15.44	1436	1357	-79	-5.48%	Yes
Route 5B: A228 (M20 to A229) Northbound (Red)	13.69	1242	1287	45	3.64%	Yes
Route 6A: A289 and A278 Eastbound (Green)	18.48	1238	1557	319	25.75%	No
Route 6B: A289 and A278 Westbound (Green)	18.29	1215	1165	-50	-4.08%	Yes
Route 7A: A2 Eastbound (Purple)	18.45	2451	2758	307	12.52%	Yes
Route 7B: A2 Westbound (Purple)	18.57	2708	2895	188	6.93%	Yes
Route 8A: M20 Eastbound (Dark Green)	12.15	399	438	39	9.82%	Yes
Route 8B: M20 Westbound (Dark Green)	10.78	515	399	-116	-22.54%	No
Percentage of Routes meeting Validation Criteria:						87.5%

Table 22: Journey Time Validation Summary – Microscopic Model – Inter Peak Hour

Route	Length (km)	Observed (s)	Modelled (s)	Relative Diff (s)	Absolute Diff (%)	Validates ?
Route 1A: A231 / A230 Southbound (Dark Blue)	6.26	696	778	82	11.78%	Yes
Route 1B: A231 / A230 Northbound (Dark Blue)	6.24	709	829	121	17.06%	No
Route 2A: M2 Eastbound (Light Blue)	20.78	681	753	72	10.57%	Yes
Route 2A: M2 Westbound (Light Blue)	20.89	688	757	69	9.98%	Yes
Route 3A: A228 Hoo Peninsula Eastbound (Orange)	16.24	964	955	-9	-0.90%	Yes
Route 3B: A228 Hoo Peninsula Westbound (Orange)	16.20	962	941	-21	-2.20%	Yes
Route 4A: A228 A2 to M20 Southbound (Peach)	10.30	614	730	116	18.96%	No
Route 4B: A228 M20 to A2 Northbound (Peach)	10.27	580	664	84	14.42%	Yes
Route 5A: A228 (A289 to M20) Southbound	15.44	1231	1172	-59	-4.80%	Yes
Route 5B: A228 (M20 to A229) Northbound	13.69	1155	1017	-139	-12.02%	Yes
Route 6A: A289 and A278 Eastbound	18.48	1096	1111	15	1.36%	Yes
Route 6B: A289 and A278 Westbound	18.29	1068	1046	-22	-2.04%	Yes
Route 7A: A2 Eastbound	18.45	2193	2375	182	8.30%	Yes
Route 7B: A2 Westbound	18.57	2269	2396	127	5.60%	Yes
Route 8A: M20 Eastbound	12.15	405	438	34	8.33%	Yes
Route 8B: M20 Westbound	10.78	368	383	15	4.14%	Yes
Percentage of Routes meeting Validation Criteria:						87.5%

Table 23: Journey Time Validation Summary – Microscopic Model – PM Peak Hour

Route	Length (km)	Observed (s)	Modelled (s)	Relative Diff (s)	Absolute Diff (%)	Validates ?
Route 1A: A231 / A230 Southbound (Dark Blue)	6.26	891	892	1	0.12%	Yes
Route 1B: A231 / A230 Northbound (Dark Blue)	6.24	793	969	176	22.18%	No
Route 2A: M2 Eastbound (Light Blue)	20.78	845	762	-83	-9.78%	Yes
Route 2A: M2 Westbound (Light Blue)	20.89	692	750	59	8.48%	Yes
Route 3A: A228 Hoo Peninsula Eastbound (Orange)	16.24	938	956	19	1.98%	Yes
Route 3B: A228 Hoo Peninsula Westbound (Orange)	16.20	935	969	33	3.58%	Yes
Route 4A: A228 A2 to M20 Southbound (Peach)	10.30	784	873	90	11.43%	Yes
Route 4B: A228 M20 to A2 Northbound (Peach)	10.27	694	784	91	13.08%	Yes
Route 5A: A228 (A289 to M20) Southbound	15.44	1407	1599	192	13.62%	Yes
Route 5B: A228 (M20 to A229) Northbound	13.69	1499	1343	-155	-10.37%	Yes
Route 6A: A289 and A278 Eastbound	18.48	1455	1451	-4	-0.25%	Yes
Route 6B: A289 and A278 Westbound	18.29	1102	1172	71	6.41%	Yes
Route 7A: A2 Eastbound	18.45	2768	2612	-156	-5.65%	Yes
Route 7B: A2 Westbound	18.57	2549	2774	226	8.86%	Yes
Route 8A: M20 Eastbound	12.15	549	450	-98	-17.92%	No
Route 8B: M20 Westbound	10.78	368	383	15	4.20%	Yes
Percentage of Routes meeting Validation Criteria:						87.5%

10 Summary of Model Development, Standards Proposed and Fitness for Purpose

10.1 Summary of Model Development

The Medway Aimsun model covers the whole of the Medway local authority area as well as junctions 4 to 6 of the M20 in detail and also includes a wider buffer area to enable route choice on entry to the detailed modelled area to be considered. The model has been developed, calibrated and validated at both macroscopic level and microscopic levels, which will enable both the wide area strategic, and detailed local, impacts of proposals anywhere within Medway to be considered.

The model covers the AM (08:00 to 09:00) and PM (17:00 to 18:00) peak hours and also a representative inter-peak hour (13:00 to 14:00). The highway demand matrices have been developed from mobile network data with granularity improved using Census origin-destination data. Matrix adjustment has been subsequently been undertaken to modify the matrices to better match observed data. The matrices are therefore fully based on observed data with no trip synthesis.

A comprehensive dataset of existing and new traffic counts and journey time data has been used in model calibration and validation

The model will also be capable in the future of being further developed to include demand modelling and public transport assignment.

10.2 Summary of Standards Achieved

The model has been calibrated and validated in accordance with the guidelines set out in WebTAG Unit 3.1 and as set out in this report. In particular:

- The level of distortion resulting from matrix adjustment is greater than the guidelines set out in the WebTAG unit. However, the matrices are to be used for microsimulation, and the level of distortion is in line with what is normally required to calibrate such models at a turn flow level.

- Trip matrices have been validated at a screenline / cordon level and are considered to be of an acceptable quality.

- Traffic flows at both section and turn levels are modelled to an appropriate degree of accuracy compared to both the calibration and validation datasets.

- Journey times along key routes are modelled with an appropriate degree of accuracy.

- Where user equilibrium assignment is used (i.e. within the macroscopic model), the model meets the convergence criteria and standards set out in the WebTAG unit.

10.3 Assessment of Fitness for Purpose

The Medway Aimsun Model has been demonstrated to be fit for the purposes set out in section 2.1 by virtue of the validation standards achieved and subject to the following limitations:

- The model only includes highway elements. As such, transport schemes that are likely to result in a significant shift in mode share (for example, the introduction of a new public transport routes or a new mode) will not be accurately appraised in the model. However, the model could be used to understand the impact of such schemes on the highway network through sensitivity testing.

- The model is a fixed demand model. As such, the effects of induced demand as a result of schemes that reduce congestion will not be taken into account.

- The microsimualtion model has been calibrated and validated at a wide-area level and, as such, may not fully reflect all driver behaviour and interactions at a very local level. Further calibration and validation of the microsimulation model may be required when assessing schemes in some areas, particularly on parts of the network that have not been subject to detailed traffic flow and journey time validation.