City of Bradford Metropolitan District Council
A658 Harrogate Road / A657 New Line Aimsun Model

Model Validation Report

11 June 2014
Version 0.1
Draft

Contents

1 Introduction

1.1 Commission

City of Bradford Metropolitan District Council (CBMDC) commenced work on an initial Aimsun microsimulation model for the A658 Harrogate Road / A657 New Line junction. Fore Consulting Limited (Fore) has been commissioned by CBMDC to complete, calibrate and validate the model. This document comprises the Model Validation Report.

1.2 Report Structure

This report is structured as follows:

- Chapter 2 describes the development of the model, including the coding of the network, traffic signals and public transport and the estimation of traffic demand matrices;
- Chapter 3 sets out the model verification process that was undertaken;
- Chapter 4 discusses the model calibration;
- Chapter 5 presents the validation of the model against journey times;
- Chapter 6 provides a summary and conclusions to the report.

2 Model Development

2.1 Purpose of the Model

It is understood that the purpose of the model is to assess possible improvements to the A658 Harrogate Road / A657 New Line junction.

2.2 Aimsun Version

The model has been developed in Aimsun version number 8.0.4 (R29148 x64).

2.3 Modelled Year and Time Periods

The model has been developed to replicate typical conditions in the year 2013 during the following time periods:

- AM peak period: 0700 to 0900
- PM peak period: 1600 to 1800

These periods were chosen to best represent peak traffic flows on the highway network during a school term time weekday. A fifteen minute warm-up period has been used to generate the initial state of traffic in the model.

2.4 Vehicle Types

The model considers the following vehicle types:

- Light vehicles – comprising cars and light vans with a gross vehicle weight of less than 3.5t;
- Light goods vehicles (LGVs)
- Heavy goods vehicles (HGVs) – comprising vehicles (except buses) with a gross vehicle weight greater than 3.5t;
- Buses – comprising all public service buses.

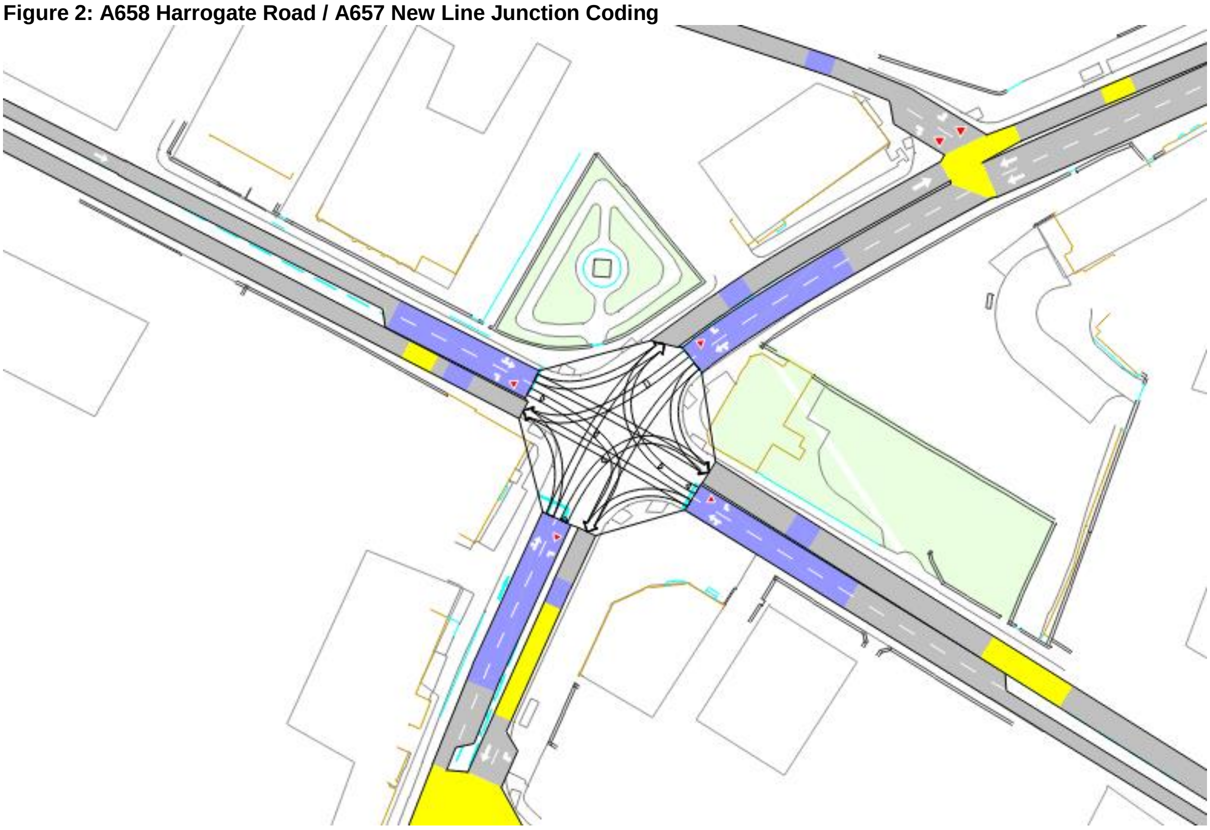
2.5 Network Development

The network has been developed to show the extent of queuing from the A658 Harrogate Road/A657 New Line junction. Key elements of the local highway infrastructure have been modelled to accurately represent behaviour of traffic in close proximity to the junction.

The extent of the model is shown in Figure 1. Figure 2 shows the network coding of the junction.

Figure 1: Extent of the Harrogate Road/New Line Aimsun Model

Figure 2: A658 Harrogate Road / A657 New Line Junction Coding



The network coding has been fully reviewed using Ordnance Survey mapping, aerial photography and site visits to ensure that it accurately reflects the highway network in year 2014.

2.6 Traffic Signal Coding

The A658 Harrogate Road/A657 New Line junction operates using MOVA (Microprocessor Optimised Vehicle Actuation). To reflect the effects of MOVA , the traffic signal timings within Aimsun are modelled as actuated signals and have been optimised for the modelled traffic flows.

The A658 Harrogate Road/Tenterfileds junction has been modelled using fixed signal timings supplied by CBMDC.

2.7 Public Transport

All bus stops within the modelled area have been coded into the model using various sources including OS digital mapping, site observations and aerial photography.

Bus routes have been coded into the model based on timetable and routeing information provided on the West Yorkshire Metro website. Services only running outside the peak hours used in the model have been omitted. The bus routes included in the model are as follows:

- 62 - Leeds, Pudsey, Greengates & Shipley
- 670 and 671 – Bradford & Leeds
- 747 – Bardford & Leeds Bradford Airport
- 947 – Bradford & Yeadon
- 760 – Keighley, Shipley & Leeds

Dwell times for buses at each bus stop have been coded with a mean of 20 seconds and standard deviation of 20 seconds. This results in a variation in bus stop dwell times, with some buses stopping for short periods (for example for passengers to alight) and some buses stopping for longer periods (for example for passengers to board).

2.8 Traffic Demand

2.8.1 Traffic Survey data

Traffic count data for turns and sections have been supplied by BMDC for calibrating the model. Section counts have been calculated from the turn counts. The turn counts were observed at the locations listed in Table 1.

Table 1: Traffic Survey Locations

Location	Source	Year
A657 Leeds Road / Albion Road West	CBMDC	2011
A657 Leeds Road / Albion Road East	CBMDC	2011
A658 Harrogate Road/A657 New Line	CBMDC	2014
A658 Harrogate Road/Tenterfields	CBMDC	2011

Due to the economic recession, it is considered that traffic levels have remained broadly static between 2011 and 2014 and as a result of this, all traffic data has been taken as being representative of 2014 traffic levels. These assumptions are consistent with those used in other Aimsun model validation reports, such as the "*Thornbury Aimsun Model Validation Report*" dated August 2013 and the "*Canal Road Aimsun Model Validation Report*" dated 11 December 2013.

2.8.2 Matrix Estimation

The traffic demand matrices have been estimated from the traffic survey data in 30 minute intervals for Cars, LGVs and HGVs. The use of 30 minute time-sliced matrices allows a realistic traffic profile to be created within the model that reflects both changes in traffic levels and traffic patterns over the modelled periods. The resulting traffic demand profiles for the 2014 base year are shown in Figure 3 and Figure 4.

Figure 3: AM Peak Period Traffic Demand Profile (All Vehicles)

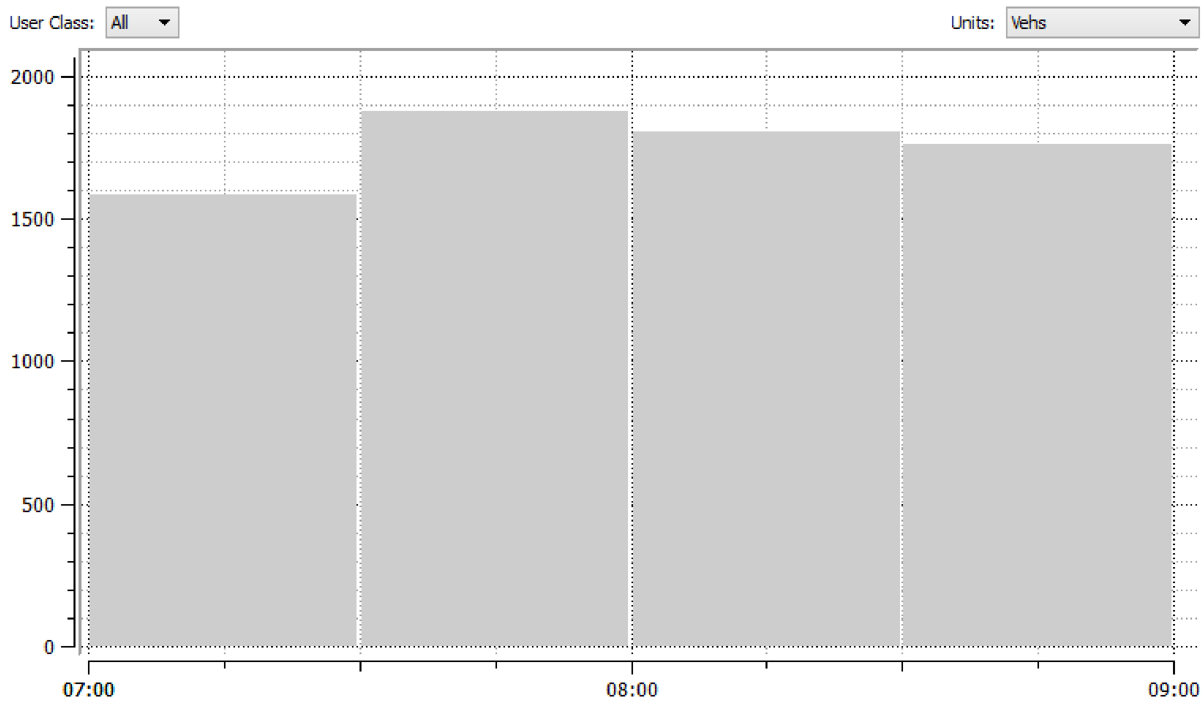
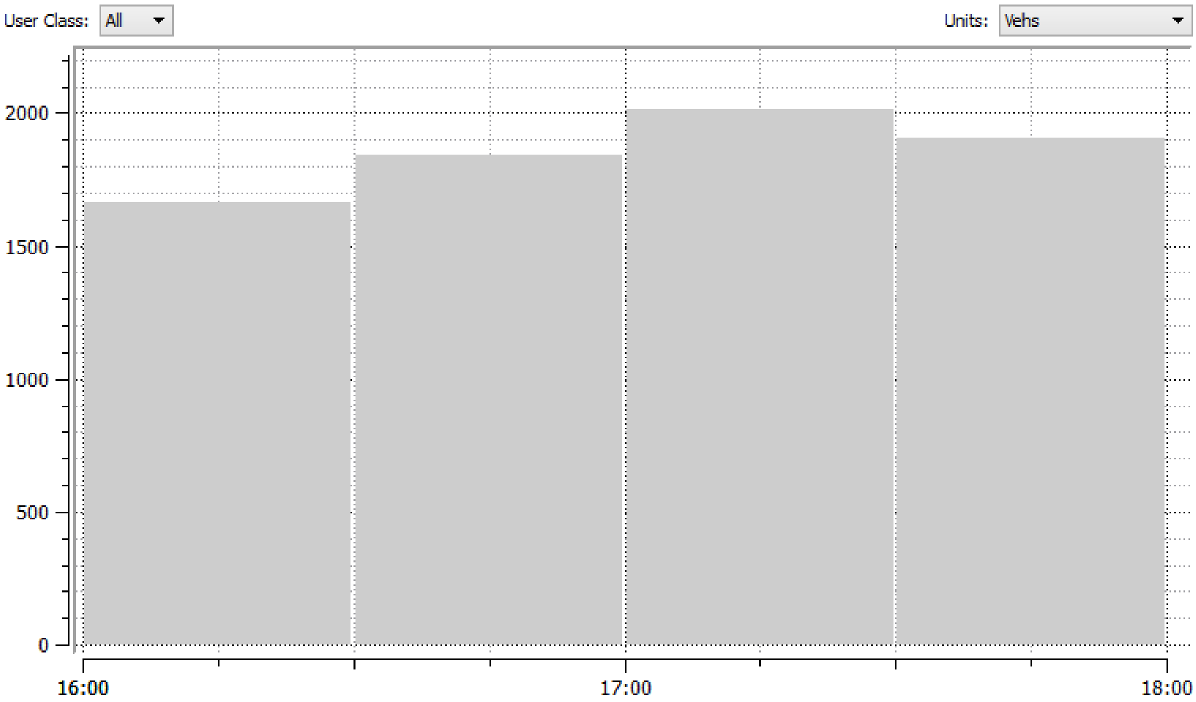


Figure 4: PM Peak Period Traffic Demand Profile (All Vehicles)



3 Model Verification

3.1 Introduction

Model verification is the process of ensuring the model is correctly specified and operates as expected. The inputs to the model have all been checked to ensure that geometry, stop-line location, number of lanes, bus stop locations, etc. have been coded as accurately as possible.

The “Check and Fix Network” feature in Aimsun has been used to identify any errors in the model coding and all warnings have been investigated and addressed, as necessary.

The models have been run as “animated simulations” and observed carefully to check that they are working correctly, with any errors being corrected. Traffic signal coding has been reviewed and the resulting operation has been compared to the operation on-site.

4 Model Calibration

4.1 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;
- Link characteristics;
- Vehicle characteristics;
- Simulation step and reaction time;
- Behavioural Models.

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

4.2 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 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. This has been set by road type and is based on default values.

- **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 and is based on default values.

- **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 some 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.

- **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 50% has been assumed for in the model.

4.3 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 were initially based on the default Aimsun values for “Car”, “Van”, “Truck” and “Bus” for cars, LGVs, HGVs and buses, respectively. However, experience has shown that the default maximum acceleration parameter for cars is very high. This has therefore been reduced by 10% to better reflect observed behaviour.

Car following model parameters for the drivers have been refined from the default values. In the deceleration component of the car-following model, the follower makes an estimation of the deceleration of the leader using the sensitivity factor. This factor has been set as 1.2 for car users to better represent a driver’s response to deceleration of the vehicle in front. The minimum headway parameter ensures a minimum headway between the leader and the follower, and this has been adjusted to 2.2s for all vehicles to properly represent the gaps between moving vehicles.

4.4 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 default parameter values have been used and are shown in Table 2.

Table 2: Simulation Step and Reaction Time

Parameter	AM Peak	PM Peak
Simulation Step / Reaction Time	0.8	0.8
Reaction Time at Stop	1.20	1.20
Reaction Time at Traffic Light	1.60	1.60

4.5 Behavioural Models

4.5.1 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 parameters 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 3.

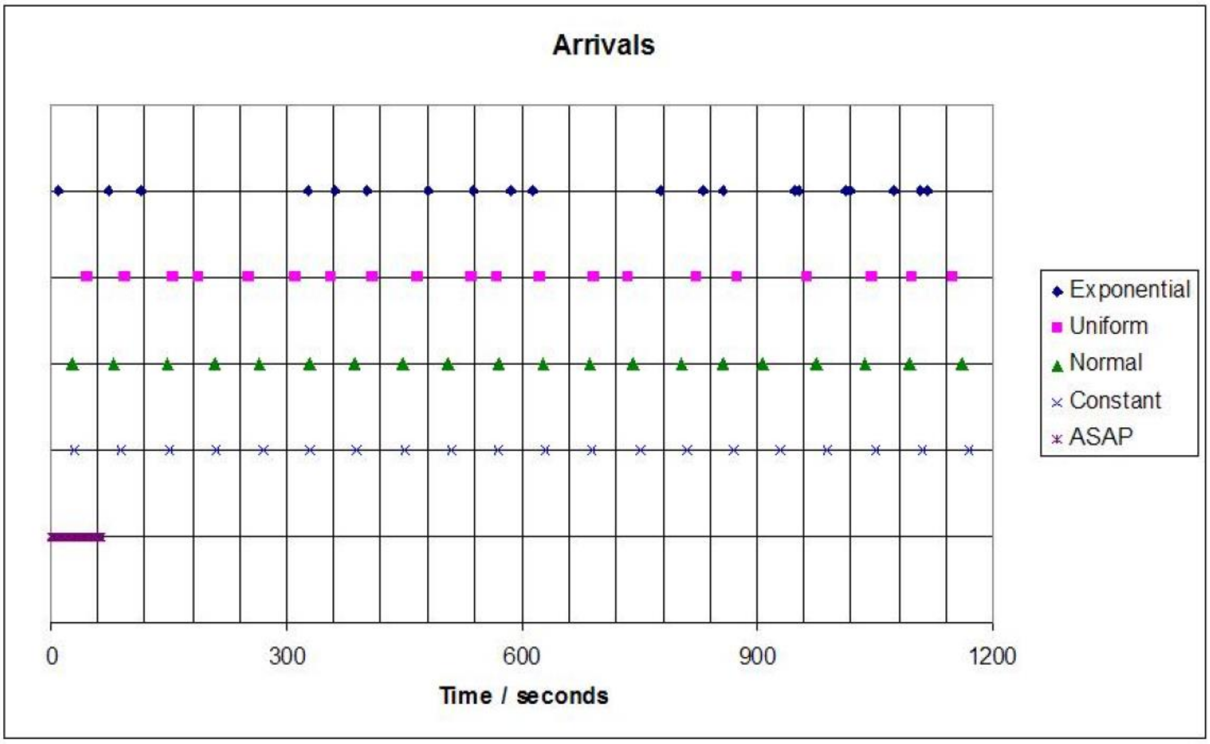
Table 3: Car Following and Lane Changing Model Parameters

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

4.6 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. Figure 5 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. Through sensitivity testing it was found that the exponential distribution gave more realistic results than the uniform distribution, resulting in faithful replication of the inputted traffic demand. This distribution has therefore been used in the model.

Figure 5: Trip Generation



4.7 Route Choice Model

The "fixed using travel time in free flow conditions" model has been used as there is no significant route choice in the model. There is only one case of route choice for vehicles travelling from the A657 Leeds Road to the A658 Harrogate Road, which can route either through the A658 Harrogate / A657 New Line junction or via Stockhill Road. Based on analysis of the traffic survey data, it was found that these trips are distributed with approximately 25% travelling through the junction and 75% of trips using Stockhill Road. "O-D Routes" have therefore been used in the model to reflect this split for the relevant O-D pairs.

4.8 Calibrated Traffic Flows

4.8.1 Criteria for Calibration

Modelled traffic flows have been compared to observed traffic flows to assist in the calibration of the demand matrices and route choice models.

The GEH statistic is a widely used goodness of fit test to compare two sets of traffic data. DMRB requires 85% of links to have a GEH statistic of less than 5.0.

Green represents a GEH statistic of less than 5, orange represents a GEH statistic between 5 and 10 and red represents a GEH statistic greater than 10. The analysis shows that the traffic flows on the calibration links in the model are represented to an excellent level of accuracy, with nearly 100% of calibration sections and turns having a GEH statistics of less than 5 in the microsimulations.

Table 4: Summary of Traffic Flow Calibration

Scenario	Criteria	AM Peak Period	PM Peak Period
Micro (average of 9)	% of calibration sections with GEH < 5	100%	100%
	% of calibration turns with GEH < 5	97%	100%

The results of the traffic flow calibration exercise are summarised in Table 4. Additionally, the results are shown spatially in, Figure 6,

Figure 7, Figure 8 and Figure 9.

Figure 6: AM Section Calibration

Figure 7: AM Turn Calibration

Figure 8: PM Section Calibration

Figure 9: PM Turn Calibration

4.9 Regression Analysis

As well as considering the GEH statistic, DMRB also recommends the use of regression analysis to compare how well the observed and modelled data are correlated. The regression analysis calculates the correlation coefficient (R), which can be used to measure the goodness of model fit. A correlation coefficient of 1.0 would denote a perfect fit and DMRB advises that the correlation coefficient should be greater than 0.95.

Figure 10 and Figure 11 illustrate the regression lines in AM and PM peak hours and Table 10 summarises the values of the correlation coefficient, R. The table shows that the validation links in all three periods have a correlation coefficient that exceeds the DMRB guidance for validation.

Table 5: Aimsun Model Traffic Flow Calibration Correlation Coefficients

Parameter	AM Peak Period	PM Peak Period
Correlation Coefficient, R	0.981	0.988

Note: All values rounded to 3 decimal places

Figure 10: Calibration Regression Analysis – AM Peak Period – Average of 9 Microscopic Experiments

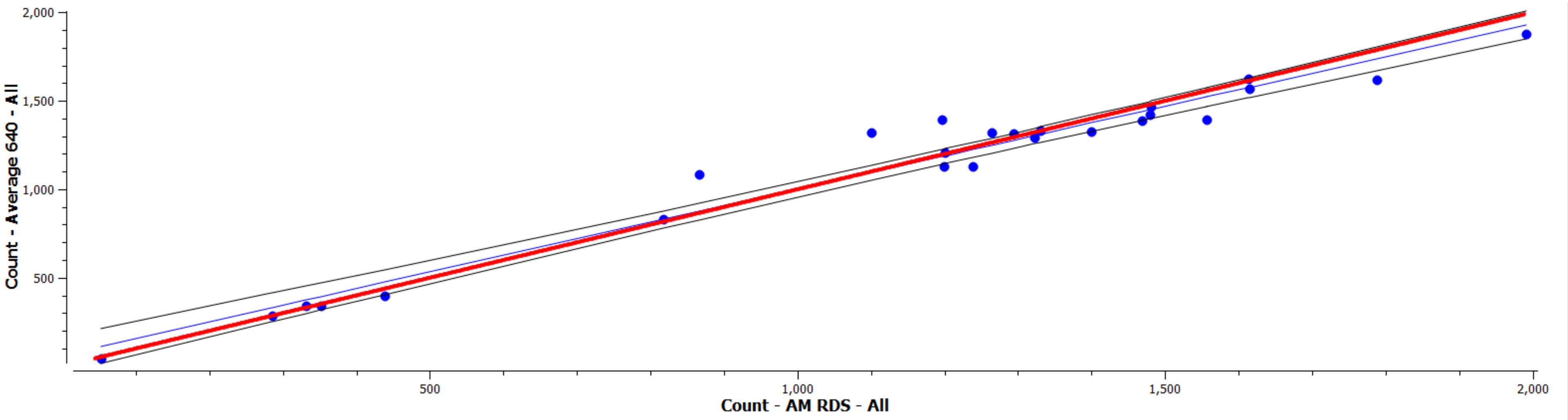
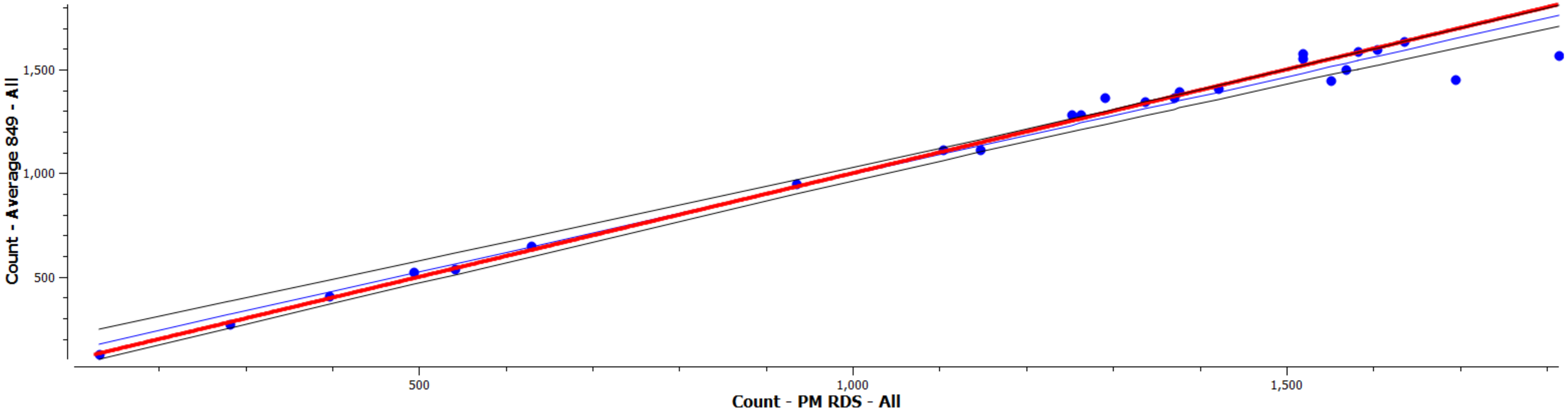


Figure 11: Calibration Regression Analysis – PM Peak Period – Average of 9 Microscopic Experiments



5 Model Validation

5.1 Introduction

The validation process determines whether the simulated model is an accurate representation of the observed situation by comparing modelled output data with observed data. The validation results are an average of nine model runs for each modelled period, as each model replication is unique.

Journey time data were used to validate the model.

5.2 Journey Time Validation from CJAMS data

CJAMS journey time data has been provided by CBMDC for subpaths eastbound, westbound, northbound and southbound through the junction. The data covers the hours 0700 to 0900 and 1600 to 1800 and is an average of data collected between September 2012 and August 2013 on weekdays during school term time.

TAG Unit M3.1 section 3.2.10 states that journey times across 85% of routes should be modelled within 15% of the observed journey times (or within one minute of the observed journey time if 15% of the observed journey time is less than one minute).

5.3 Journey Time Validation

Journey times have been extracted from the model, and can be compared to the observed journey times in Table 6 and Table 7 for the AM and PM peak periods, respectively.

Table 6: AM Peak Journey Time Validation

Journey Time Route	Direction	Observed Time	Modelled Time	Difference	Validates (<60s difference)
Harrogate Road	Northbound	161	154	-7	Y
	Southbound	356	335	-21	Y
New Line	Eastbound	239	288	49	Y
	Westbound	300	281	-18	Y

Table 7: PM Peak Journey Time Validation

Journey Time Route	Direction	Observed Time	Modelled Time	Difference	Validates (<60s difference)
Harrogate Road	Northbound	204	202	-3	Y
	Southbound	284	305	21	Y
New Line	Eastbound	232	287	55	Y
	Westbound	412	365	-46	Y

The tables show the times along routes in the model meet the validation criteria in every case.

6 Summary and Conclusion

6.1 Introduction

CBMDC commenced work on an initial Aimsun microsimulation model for the A658 Harrogate Road / A657 New Line junction. Fore has been commissioned by CBMDC to complete, calibrate and validate the model. This document comprises the Model Validation Report.

6.2 Model Description

The purpose of the model is to assess possible improvements to the A658 Harrogate Road / A657 New Line junction. The model has been developed to be representative of typical conditions in the year 2014 during the following time periods:

- AM peak period: 0700 to 0900
- PM peak period: 1600 to 1800

6.3 Calibration and Validation

The model has been fully calibrated and validated and accurately reflects observed traffic flows and journey times. The model also produces queues that are broadly consistent with observed queue lengths.

6.4 Conclusion

It is therefore concluded that the model is a suitable tool for assessing the impact of proposed junction improvements.

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