Appendix 3

City of Braford Metropolitan District Council
A650 Hard Ings Road

Model Validation Report

18 March 2015
Version 0.1

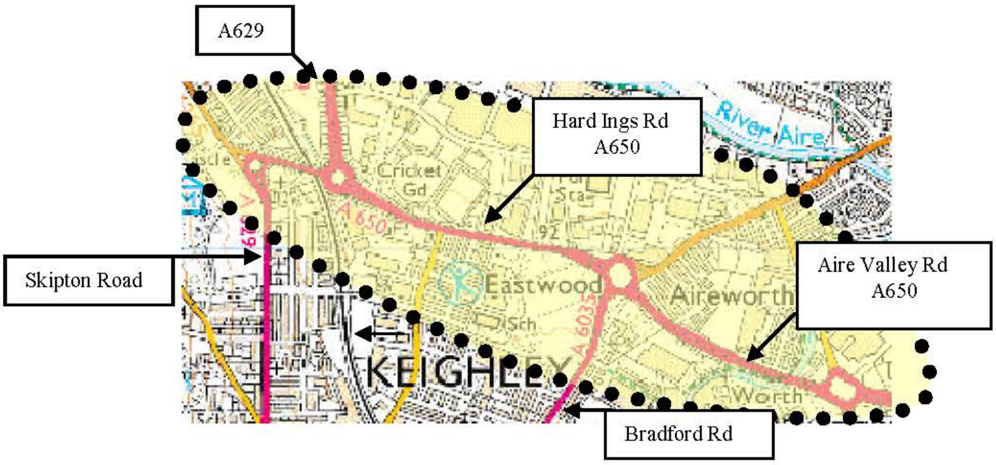
Contents

1 Introduction:

1.1 Commission

In September 2014, the Transport Planning Section of the City of Bradford Metropolitan District Council (CBMDC) embarked on the preparation of a micro-simulation traffic model for A650 Hard Ings Road to investigate various transport management proposals for Hard Ings Road improvements.
The traffic study area of Hard Ings Road which could be covered in an Aimsun model is shown in the following location map.

Location Map:



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;
- 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.
- Chapter 7 provides results from various proposed options which were tested

2 Model Development

2.1 Purpose of the Model

The purpose of model is to assess various possible improvement proposals to the A650 Hard Ings Road

2.2 Aimsun Version

The model has been developed in Aimsun version number 8.0.5 (R29862)

2.3 Modelled Year & Time Periods

The model has been developed to replicate typical conditions in the year 2014 during the following time periods:

During Weekday:

- AM peak period: 0730 to 0930
- PM peak period: 1630 to 1830

Saturday:

- IP period: 1200 to 1400

These periods were chosen to best represent peak traffic flows on the highway network during a school term time weekday and on Saturday. 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 Good Vehicles (LGVs) & Heavy Goods Vehicles
- Buses (all public service buses)

2.5 Network Development

The network has been developed to show the extent of queuing on Hard Ings Road, Bradford Road, Airevalley Road and A629. The extent of the model is shown in Figure-1. Figure-2 and Figure-3 shows the network coding of two junctions within the modelled area.

FIGURE-1 Extent of the Modelled Area:

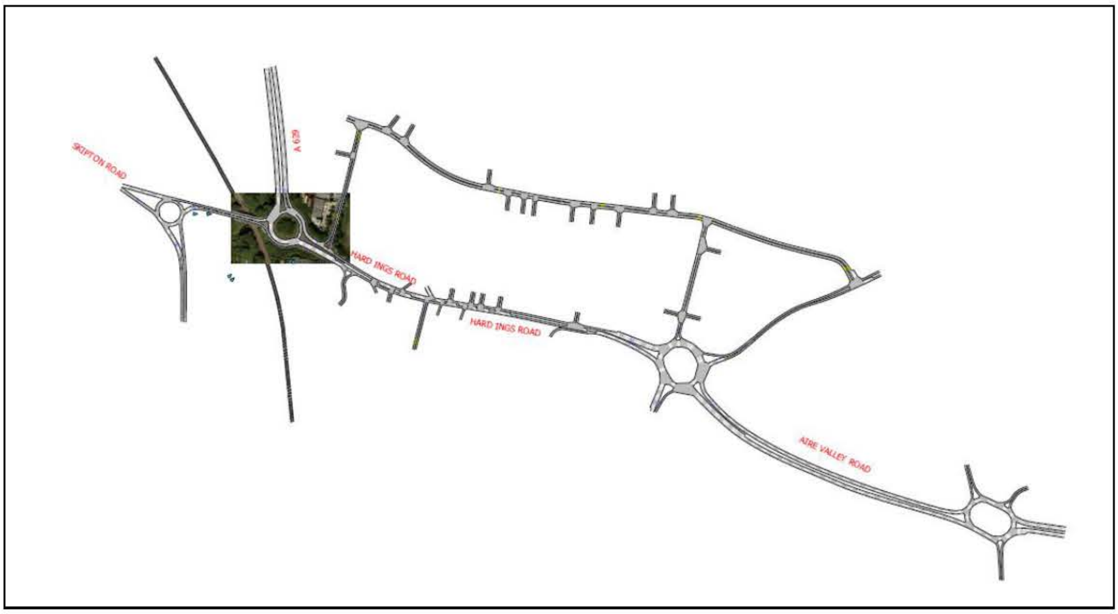


FIGURE-2 Bradford Road Signalised Roundabout:

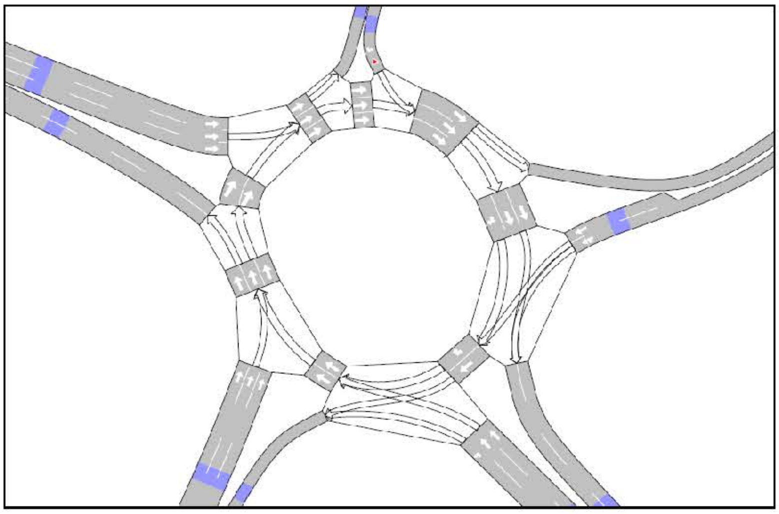
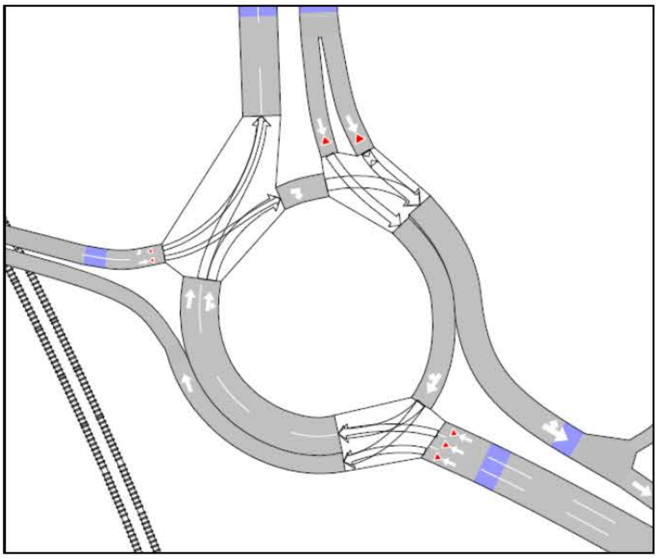


FIGURE-3 Beechcliffe Roundabout:



2.6 Traffic Signal Coding

The Council's Urban Traffic Control (UTC) Unit provided the traffic signal data which were input into the Aimsun model.

2.7 Public Transport

There is only one public transport bus route on Hard Ings Road.

727 Cullingworth – Keighley Bus Station

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.

2.8 Traffic Demand

2.8.1 Traffic Survey Data

Traffic count data for turns and sections have been collected by CBMDC 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:

Location	Source	Year
Beechcliffe Roundabout	CBMDC	2014
All side roads along Hard Ings Road	CBMDC	2014
Bradford Road Roundabout	CBMDC	2012

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 4 and Figure 5.

FIGURE-4: AM Peak (07:30-09:30)

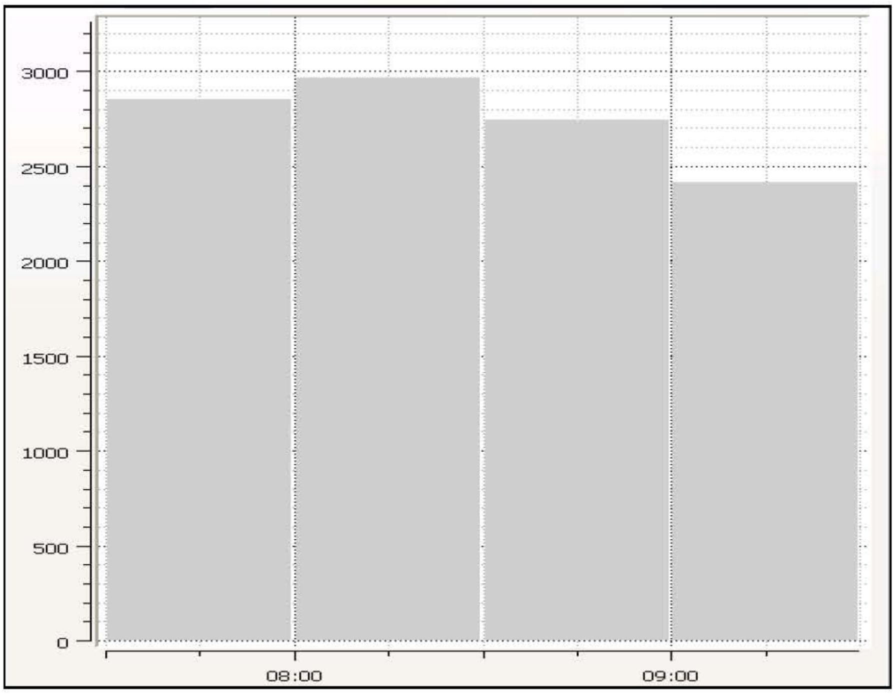
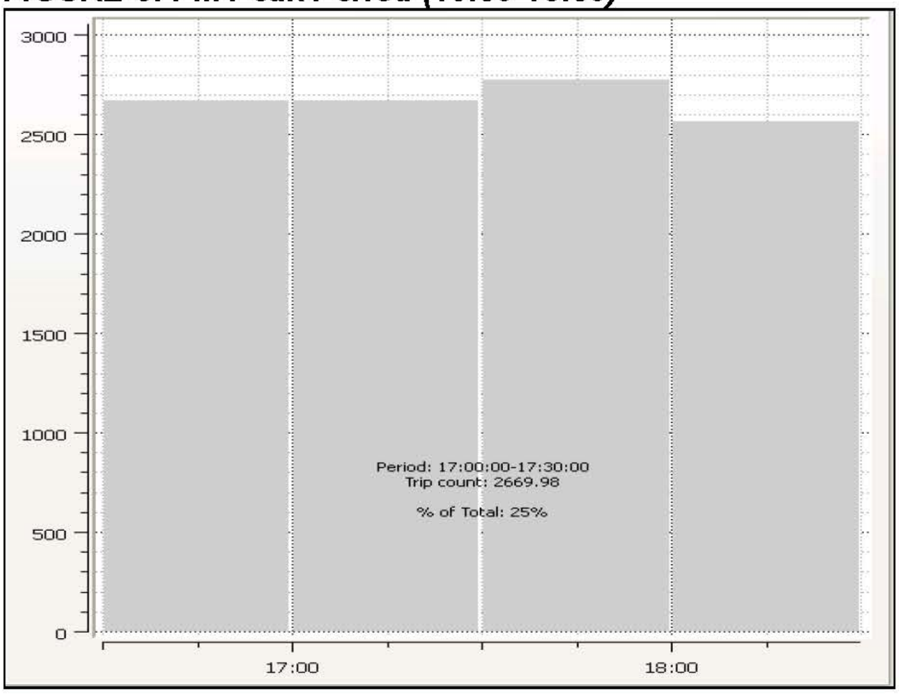


FIGURE-5: PM Peak Period (16:30-18:30)



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 Characteristrics

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 taken as the same as default values in Aimsun.

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. In the model, none of the values were changed from the default settings, which are shown in Table 3.

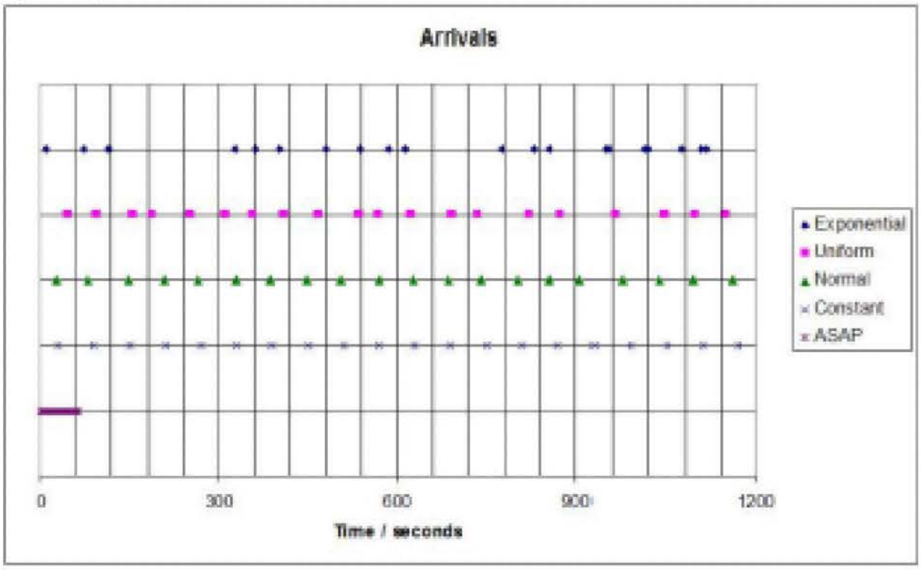
Table-3

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-6 Trip Generation:



4.7 Route Choice Model

The "fixed 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 A629 taking a left turn into A650 Hard Ings Road. Due to a high level of congestion at the junction some vehicles use the outer lane, travel around the roundabout, to continue towards Hard Ings Road. Based on analysis of the traffic survey data the spilt is as follows:

Turn	AM	PM
Tradition left turn (near side lane)	88%	72%
Roundabout loop movement (outer lane)	12%	28%

"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. The 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	PM Peak
Average of 7	% of calibration sections with GHE <5	100%	96%

The results of the traffic flow calibration exercise are summarised in Table 4. Additionally, the results are shown in Table-5. Figure 7 and Figure 8 illustrate the graphical representation of GEH for AM and PM peak hours respectively.

Table-5:

Link	Actual Count	Modelled	Diff	GEH	Actual Count	Modelled	Diff	GEH
Bradford Road OB	1070	1156	86	2	1329	1343	14	0
Bradford Road IB	1303	1434	131	3	1296	1347	51	1
Aire Valley Road IB	1801	2095	294	5	1897	1954	57	1
Aire Valley Road OB	1907	2019	112	2	1951	1935	-16	0
Bradford Road IB	1063	1204	141	3	934	958	24	1
Alston Road IB	125	195	70	4	125	283	158	8
Alston Road OB	143	157	14	1	115	71	-44	3
Royd Way OB	467	375	-92	3	466	454	-12	0
Hard Ing Road EB	3160	2860	-300	4	2918	2760	-158	2
Hard Ings Road WB	2850	2878	28	0	3054	2961	-93	1
A629 IB	2908	2604	-304	4	2423	2293	-130	2
A629 OB	2865	2842	-23	0	2508	2446	-62	1
Hard Ings Road EB	1802	1817	15	0	1528	1485	-43	1
Hard Ings Road WB	1535	1606	71	1	1579	1532	-47	1
Hard Ings Road EB	1802	1814	12	0	1528	1493	-35	1
Hard Ings Road WB	1535	1607	72	1	1579	1530	-49	1
Skipton Road IB	1113	1106	-7	0	975	924	-51	1
Skipton Road OB	1331	1354	23	0	1499	1523	24	0
Skipton Road IB	2090	2084	-6	0	1815	1835	20	0
Skipton Road OB	1605	1635	30	1	1342	1263	-79	2
Lawkholme Lane IB	246	248	2	0	400	408	8	0
Lawkholme Lane OB	365	310	-55	2	434	392	-42	1
Mean	1504	1518	14	2	1441	1418	-23	1

Figure:7 (AM Peak)

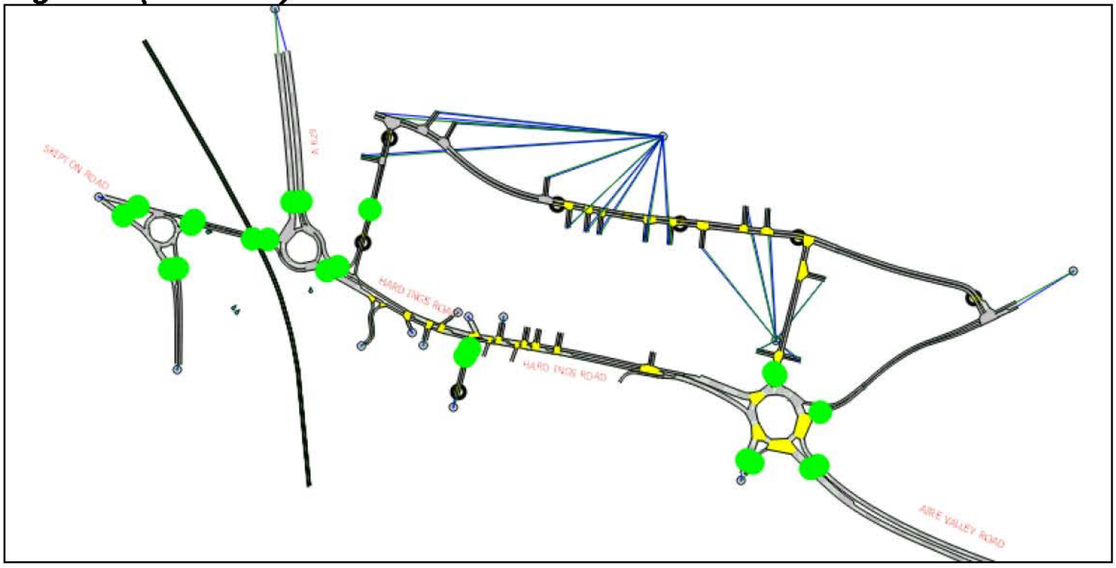
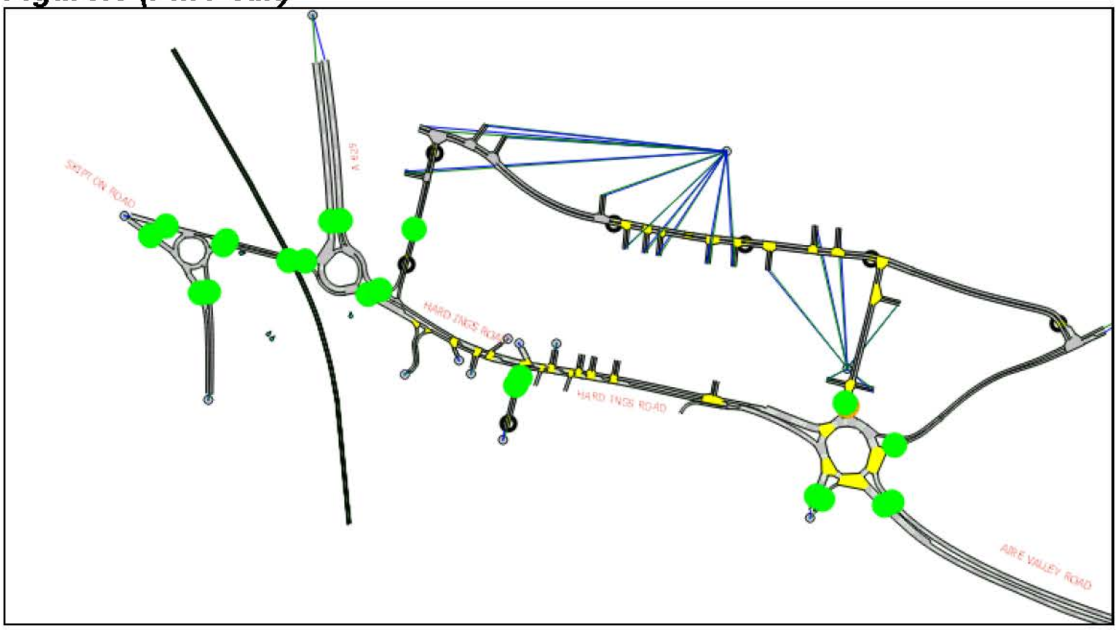


Figure:8 (PM Peak)



4.9 Regression Analysis

As well as considering the GEH statistic, the 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 the DMRB advises that the correlation coefficient should be greater than 0.95.
Figure 9 and Figure 10 illustrate the regression lines in AM and PM peak hours and Table 6 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 6: Aimsun Model Traffic Flow Calibration Correction Coefficients:

Parameter	AM Peak	PM Peak
Correlation Coefficient, R	97	99

Figure-9:

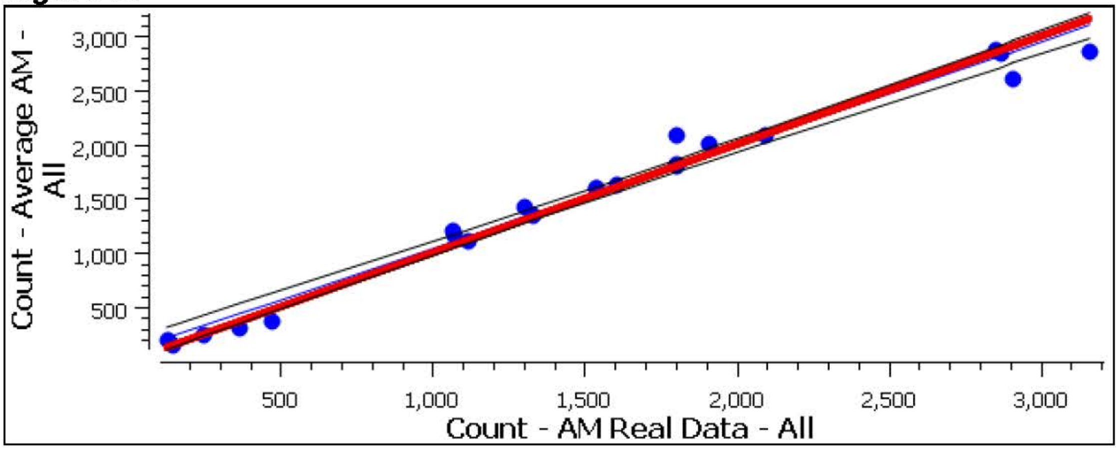
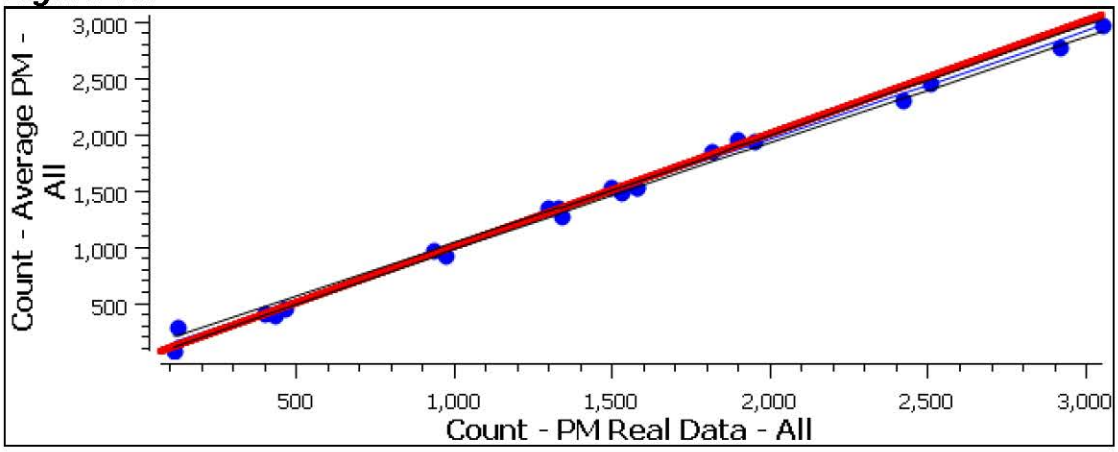


Figure-10:



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 was extracted from internet for subpaths long A650 Airevalley Road and A650 Hard Ings Road in eastbound and westbound directions. The data covers the hours 0730 to 0930 and 1630 to 1830 which is an average of data collected between September 2013 and August 2014 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 7 and Table 8 for the AM and PM peak periods, respectively.

Table-7: AM Peak Journey Time Validation

Journey Time Route	Direction	Observed Time	Modelled Time	Differenec	Validates (<60s difference)
Airevalley Road A650	Westbound	71	84	13	Y
	Eastbound	38	32	-6	Y
Hard Ings Road (E) A650	Westbound	75	65	-10	Y
	Eastbound	85	80	-5	Y
Hard Ings Road (W) A650	Westbound	19	16	-3	Y
	Eastbound	41	58	17	Y

Table-8: PM Peak Journey Time Validation

Airevalley Road A650	Westbound	124	163	39	Y
	Eastbound	39	32	-7	Y
Hard Ings Road (E) A650	Westbound	116	67	-49	Y
	Eastbound	86	78	-8	Y
Hard Ings Road (W) A650	Westbound	21	15	-6	Y
	Eastbound	56	97	41	Y

6 Summary and Conclusion

6.1 Introduction

This document comprises of the processes of Model Verification, Calibration Validation Report.

6.2 Model Description

The purpose of the model is to assess possible improvements to the A650 Hard Ings Road. The model has been developed to be representative of typical conditions in the year 2014 during the following time periods:

During Weekday:

- AM peak period: 0730 to 0930
- PM peak period: 1630 to 1830

Saturday:

- Peak period: 1200 to 1400

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 Hard Ings Road Improvements.

7 Results of Tested Options

Modelling Results
Year 2014

AM Peak (07:30-09:30) ***Year 2014***

Options	Delay (sec/km)	Travel Time (h)	Total Flow (v/h)	Total Distance (km)	MQL (v)	Speed (km/h)	Vehicles Out side	Vehicles Waiting to enter
Base (Do-Nothing)	76	434	5653	11617	75	32	11307	345
Dual Carriageway (L3A)	58	364	5788	12155	48	33	11575	1
One-way System (Royd Ings Way)	54	374	5787	13370	50	33	11016	1
Composite Part Dual (L5)	47	359	5806	11872	50	36	11613	1

PM Peak (16:30-18:30) ***Year 2014***

Options	Delay (sec/km)	Travel Time (h)	Total Flow (v/h)	Total Distance (km)	MQL (v)	Speed (km/h)	Vehicles Out side	Vehicles Waiting to enter
Base (Do-Nothing)	105	477	5484	10629	104	29	10967	255
Dual Carriageway (L3A)	57	362	5649	11610	52	31	11298	0
One-way System (Royd Ings Way)	56	379	5625	12642	52	32	11250	1
Composite Part Dual (L5)	46	336	5658	11112	48	35	11317	1

Saturday (12:00-14:00) ***Year 2014***

Options	Delay (sec/km)	Travel Time (h)	Total Flow (v/h)	Total Distance (km)	MQL (v)	Speed (km/h)	Vehicles Out side	Vehicles Waiting to enter
Base (Do-Nothing)	137	572	5845	10999	148	28	11691	781
Dual Carriageway (L3A)	Not tested							
One-way System (Royd Ings Way)	Not tested							
Composite Part Dual (L5)	55	365	6260	11538	55	34	12520	66

Modelling Results
Year 2017

AM Peak (07:30-09:30) — ***Year 2017***

Options	Delay (sec/km)	Travel Time (h)	Total Flow (v/h)	Total Distance (km)	MQL (v)	Speed (km/h)	Vehicles Out side	Vehicles Waiting to enter
Base (Do-Nothing)	100	516	5868	11997	105	29	11736	442
Dual Carriageway (L3A)	78	471	6054	12717	78	31	12108	59
One-way System (Royd Ings Way)	76	462	6062	15890	77	31	12124	20
Composite Part Dual (L5)	70	428	6064	12351	74	34	12129	2

PM Peak (16:30-18:30) — ***Year 2017***

Options	Delay (sec/km)	Travel Time (h)	Total Flow (v/h)	Total Distance (km)	MQL (v)	Speed (km/h)	Vehicles Out side	Vehicles Waiting to enter
Base (Do-Nothing)	140	557	5576	10856	136	26	11151	570
Dual Carriageway (L3A)	61	411	5884	12028	60	33	11767	3
One-way System (Royd Ings Way)	62	430	5878	13163	56	33	11172	20
Composite Part Dual (L5)	50	362	5896	11593	55	34	11792	2

Saturday (12:00-14:00) — ***Year 2017***

Options	Delay (sec/km)	Travel Time (h)	Total Flow (v/h)	Total Distance (km)	MQL (v)	Speed (km/h)	Vehicles Out side	Vehicles Waiting to enter
Base (Do-Nothing)	177	698	5955	11209	207	24	11910	1027
Dual Carriageway (L3A)	Not tested							
One-way System (Royd Ings Way)	Not tested							
Composite Part Dual (L5)	58	387	6503	11973	61	34	13005	137

Modelling Results
Year 2026

AM Peak (07:30-09:30) ***Year 2026***

Options	Delay (sec/km)	Travel Time (h)	Total Flow (v/h)	Total Distance (km)	MQL (v)	Speed (km/h)	Vehicles	
							Out side	Waiting to enter
Base (Do-Nothing)	186	813	6114	12524	235	22	12227	1029
Dual Carriageway (L3A)	Not tested							
One-way System (Royd Ings Way)	Not tested							
Composite Part Dual (L5)	93	574	6648	13634	119	30	13297	95

PM Peak (16:30-18:30) ***Year 2026***

Options	Delay (sec/km)	Travel Time (h)	Total Flow (v/h)	Total Distance (km)	MQL (v)	Speed (km/h)	Vehicles	
							Out side	Waiting to enter
Base (Do-Nothing)	214	830	5783	11258	268	21	11565	1278
Dual Carriageway (L3A)	Not tested							
One-way System (Royd Ings Way)	Not tested							
Composite Part Dual (L5)	75	511	6458	12679	116	30	12916	25

Saturday (12:00-14:00) ***Year 2026***

Options	Delay (sec/km)	Travel Time (h)	Total Flow (v/h)	Total Distance (km)	MQL (v)	Speed (km/h)	Vehicles	
							Out side	Waiting to enter
Base (Do-Nothing)	265	830	5349	10055	368	19	10698	3608
Dual Carriageway (L3A)	Not tested							
One-way System (Royd Ings Way)	Not tested							
Composite Part Dual (L5)	68	456	7046	13040	79	32	13377	476

Modelling Results (Sensitivity Test)

Year 2026

AM Peak (07:30-09:30) ***Low (7.5%)***

Options	Delay (sec/km)	Travel Time (h)	Total Flow (v/h)	Total Distance (km)	MQL (v)	Speed (km/h)	Vehicles	
							Out side	Waiting to enter
Base (Do-Nothing)	117	557	5922	12116	119	28	11844	521
Composite Part Dual (L5)	75	451	6162	12579	81	33	12324	12

PM Peak (16:30-18:30) ***Low (7.5%)***

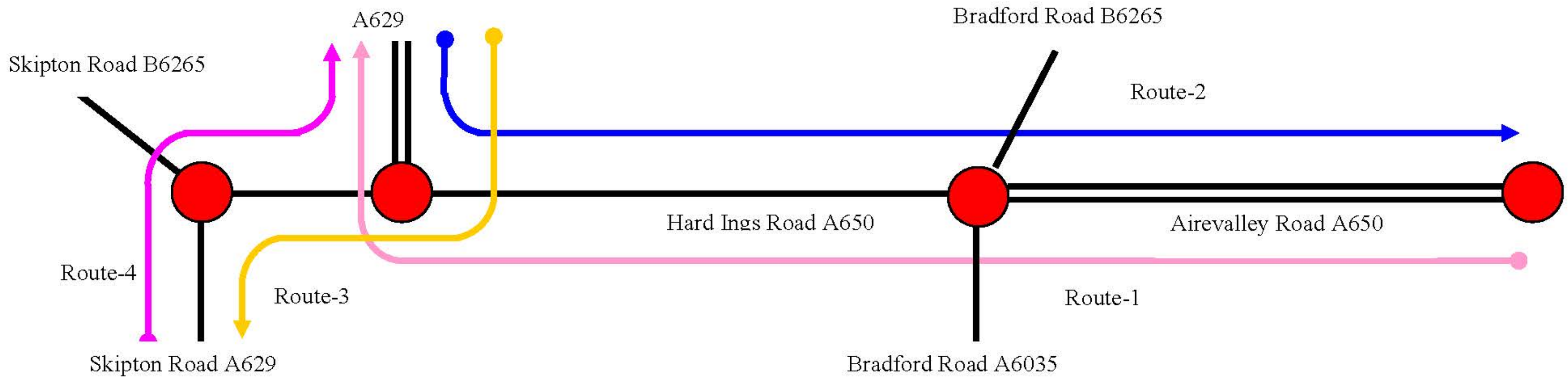
Options	Delay (sec/km)	Travel Time (h)	Total Flow (v/h)	Total Distance (km)	MQL (v)	Speed (km/h)	Vehicles	
							Out side	Waiting to enter
Base (Do-Nothing)	150	594	5641	10975	151	25	11281	651
Composite Part Dual (L5)	50	368	6007	11809	55	34	12013	9

AM Peak (07:30-09:30) ***High (7.5%)***

Options	Delay (sec/km)	Travel Time (h)	Total Flow (v/h)	Total Distance (km)	MQL (v)	Speed (km/h)	Vehicles	
							Out side	Waiting to enter
Base (Do-Nothing)	227	975	6236	12744	304	19	12471	1672
Composite Part Dual (L5)	128	794	7049	14339	198	26	14098	219

PM Peak (16:30-18:30) ***High (7.5%)***

Options	Delay (sec/km)	Travel Time (h)	Total Flow (v/h)	Total Distance (km)	MQL (v)	Speed (km/h)	Vehicles	
							Out side	Waiting to enter
Base (Do-Nothing)	261	985	5917	11510	332	18	11834	2042
Composite Part Dual (L5)	114	723	6840	13323	211	27	13680	184



Link	Length (m)	DN 2017		DS 2017		Difference (sec)	(sec)	%	%
		AM	PM	AM	PM	AM	PM	AM	PM
Route-1	1600	234	302	151	166	-83	-136	-35%	-45%
Route-2	1600	299	349	173	169	-126	-180	-42%	-52%
Route-3	700	74	121	67	62	-6	-58	-9%	-48%
Route-4	700	85	165	65	67	-21	-99	-24%	-60%
		DN 2026		DS 2026					
Route-1	1600	485	587	186	336	-299	-250	-62%	-43%
Route-2	1600	315	359	249	183	-66	-175	-21%	-49%
Route-3	700	114	212	70	64	-44	-149	-39%	-70%
Route-4	700	132	203	70	69	-62	-133	-47%	-66%

Note:

DN : Do Nothing Scenario (without any scheme)
DS : Do Something Scenario (with proposed scheme)