

# TECHNICAL NOTE 01



## SOUTH DERBY GROWTH ZONE

### LUF BID LOCAL HIGHWAY MODEL VALIDATION REPORT V4.1

#### IDENTIFICATION TABLE

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# **1. INTRODUCTION**

## **1.1 Report Background**

1.1.1 Derby City Council has commissioned SYSTRA to undertake local calibration/validation of the East Midlands Gateway Transport Model (EMGM) highway model in the area surrounding a proposed new junction on the A50 and an associated link road. The purpose of this exercise is to enable a robust TUBA economics assessment to be carried out for the proposed scheme, to support the bid Derby City Council are making to fund the scheme via the Housing Infrastructure Fund.

1.1.2 This note outlines the methodology and results of the local calibration/validation. It is intended to serve as an addendum to, and should be read alongside, the East Midlands Gateway Highway LMVR (October 2018), which has previously been issued to Derby City Council.

## **1.2 Area of Influence**

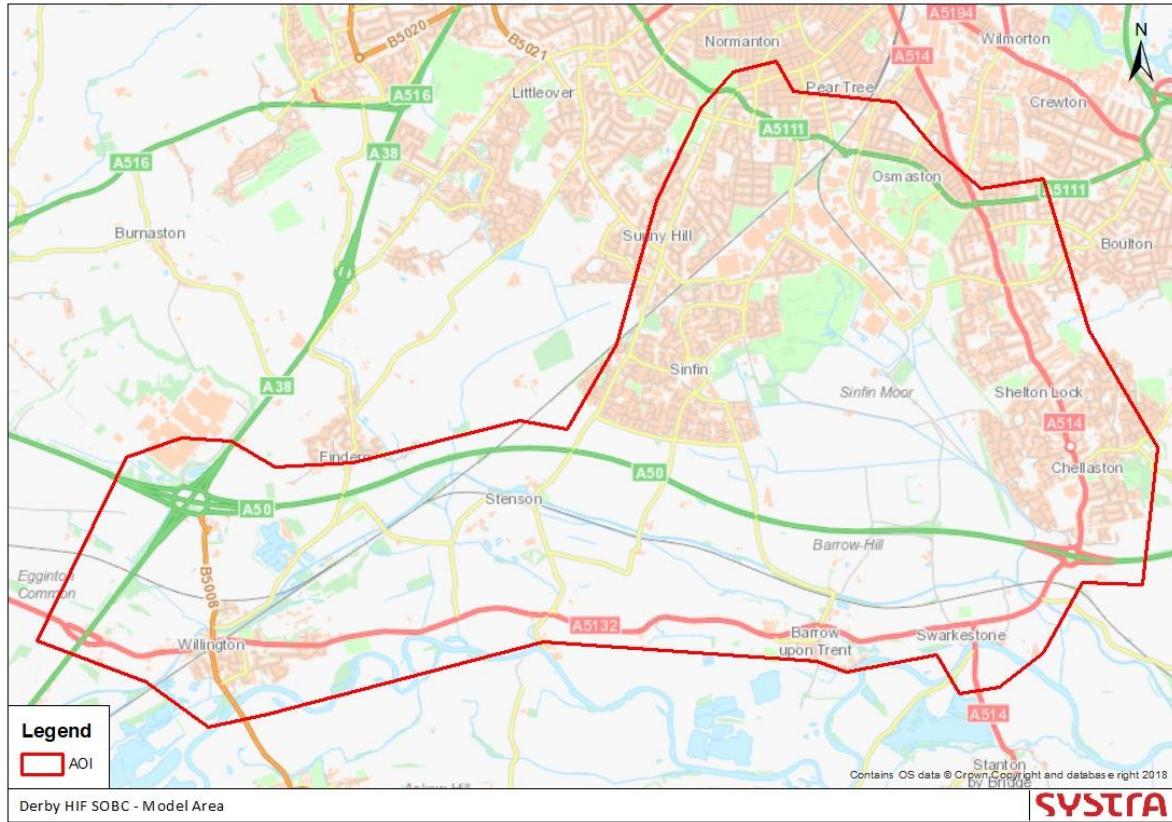
1.2.1 The proposed scheme is a new grade-separated bi-directional junction on the A50, between Toyota Island and Bonnie Prince Roundabout, and an associated link road connecting the new junction to Infinity Park Way (formerly known as the T12 scheme).

1.2.2 The junction is located to the south of Sinfin, at the location where the main carriageway currently passes via bridge over Deep Dale Lane. Deep Dale Lane will be diverted to provide local access to the new junction from the A5132.

1.2.3 Local calibration/validation has been carried out on an area identified as the Area of Influence (AOI) for the scheme. The extent of the AOI is based on the impacts of the scheme identified during previous modelling work undertaken by SYSTRA to assess South Derby Growth Zone. The extent of this area is provided in Figure 1.



Figure 1. Area of Influence



## 2. EMGM SATURN HIGHWAY MODEL

### 2.1 Model Overview

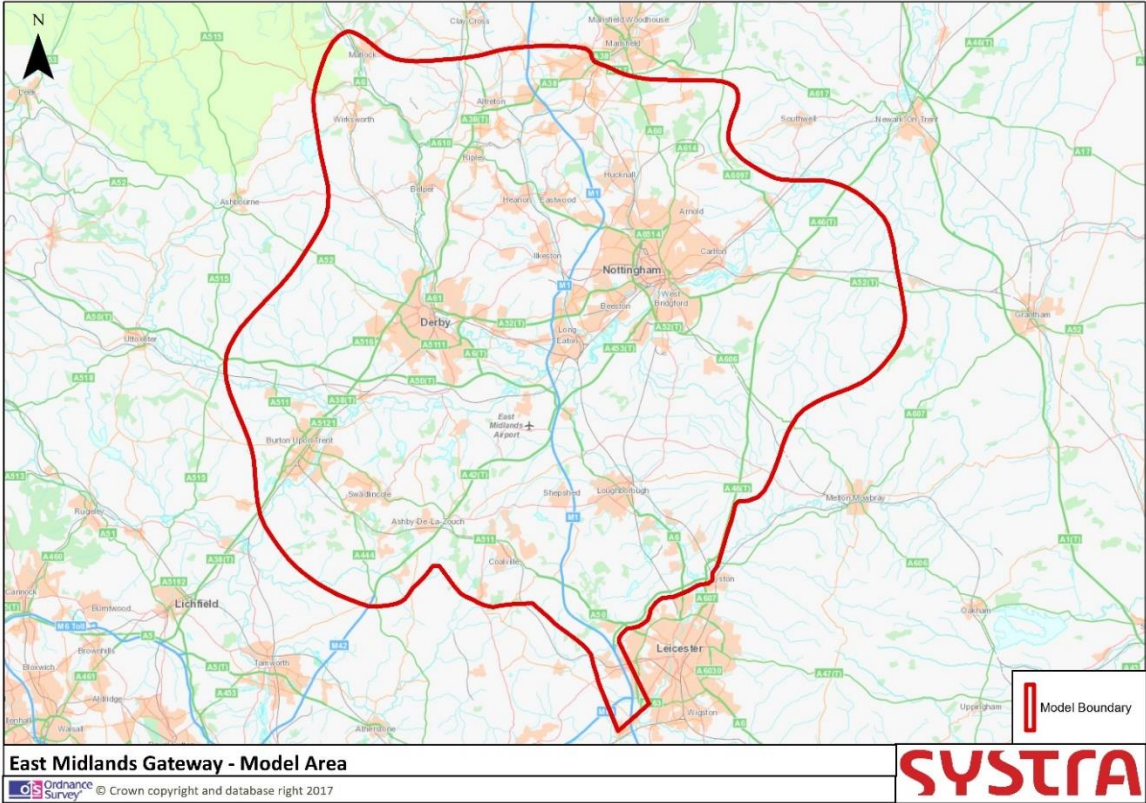
2.1.1 The East Midlands Gateway Transport Model (EMGM) was developed by SYSTRA in 2018. In Derby, the EMGM modelled network is based upon the modelled network structure in the existing Greater Derby Transport Model. The network in Derby was reviewed and enhanced in places during the EMGM development.

2.1.2 The model has been built using the SATURN suite of programs (v11.3.12W). The base year of the model is 2016.

### 2.2 Model Extent

2.2.1 The model includes the authorities of Nottingham City, Ashfield, Broxtowe, Erewash, Gedling, Rushcliffe, Derby City, Amber Valley, South Derbyshire, Charnwood and North-West Leicestershire. All strategic roads, major A, B and important minor roads are modelled in these areas. The model boundary is shown in Figure 2.

Figure 2. Model Extent



2.2.2 The zoning system for the model is shown in Figure 3 and Figure 4 below



Figure 3. Zone System SDGZ AOI

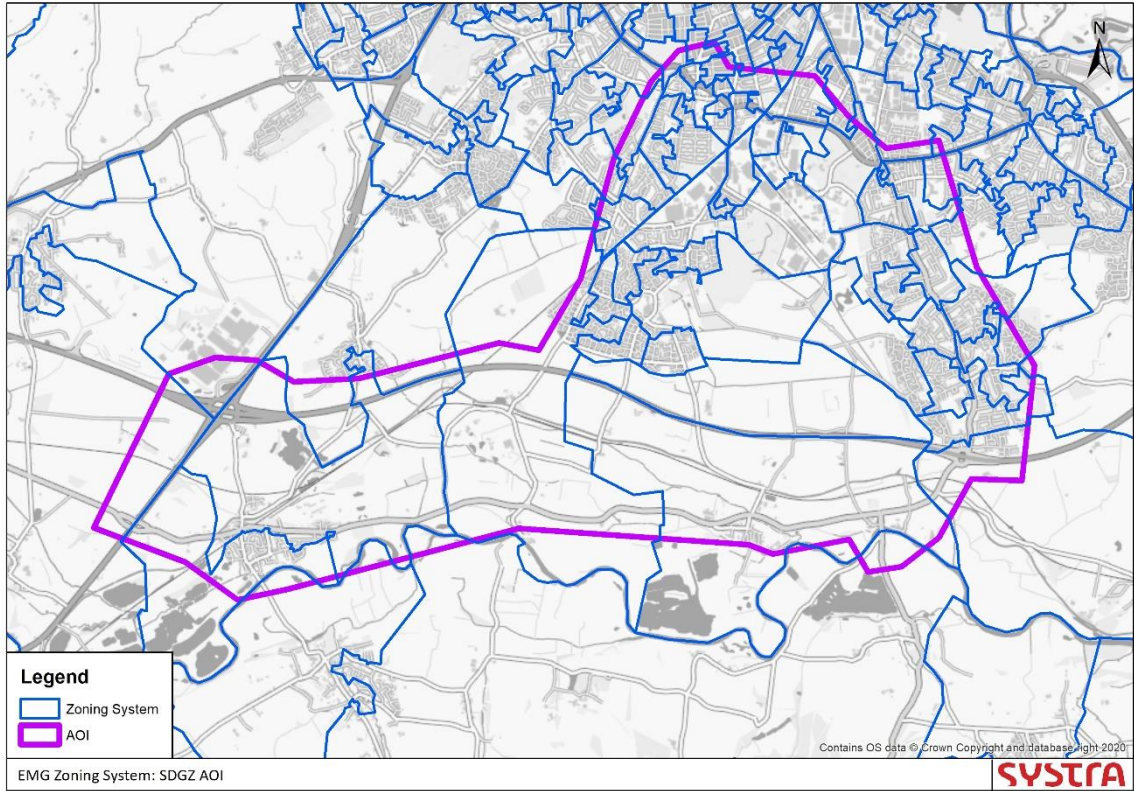
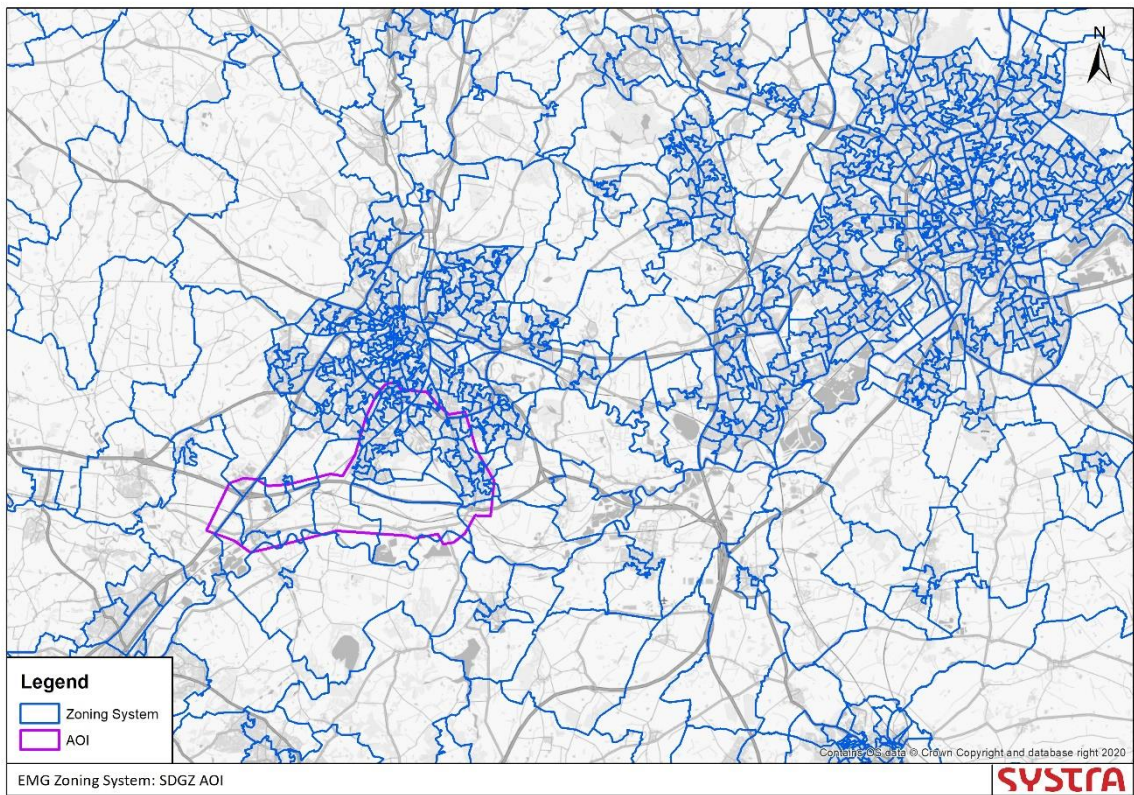


Figure 4. EMGM Zone System



## 2.3 Model Time Periods

2.3.1 The following time periods have been modelled:

- Morning Peak: 0800-0900
- Inter Peak: 1100-1400 average hour
- Evening Peak: 1700-1800

2.3.2 This note provides the results of the morning peak and evening peak validation. Local validation has also been carried interpeak, although there is significantly less count data available during this time period.

## 2.4 User Classes

2.4.1 The highway model includes the following user classes:

- Car - Commuting (No Workplace Parking Levy)
- Car - Commuting (Workplace Parking Levy)
- Car - Employer’s Business
- Car – Other
- LGV
- HGV (OGV1 and OGV2)
- Taxi

## 2.5 Network Speeds

2.5.1 During the development of the EMGM highway model, observed journey time data was used to derive maximum free flow speeds which have been applied consistently across the model. These speeds have not been altered as part of local revalidation. Table 1 summarises the network speeds used within the model.

Table 1. Network Free Flow Speeds

MPH (LIMIT)	KPH (LIMIT)	KPH ADJUSTED
20	32	25
30	48	31
40	64	42
50	80	59
60	96	67
70	112	105

## 2.6 Network Coding

2.6.1 A standardised approach to network coding has been developed and documented in a coding manual, which includes the following topics:



- Saturation Flows
- Use of Flares and Stacks
- Speeds
- Speed Flow Curves

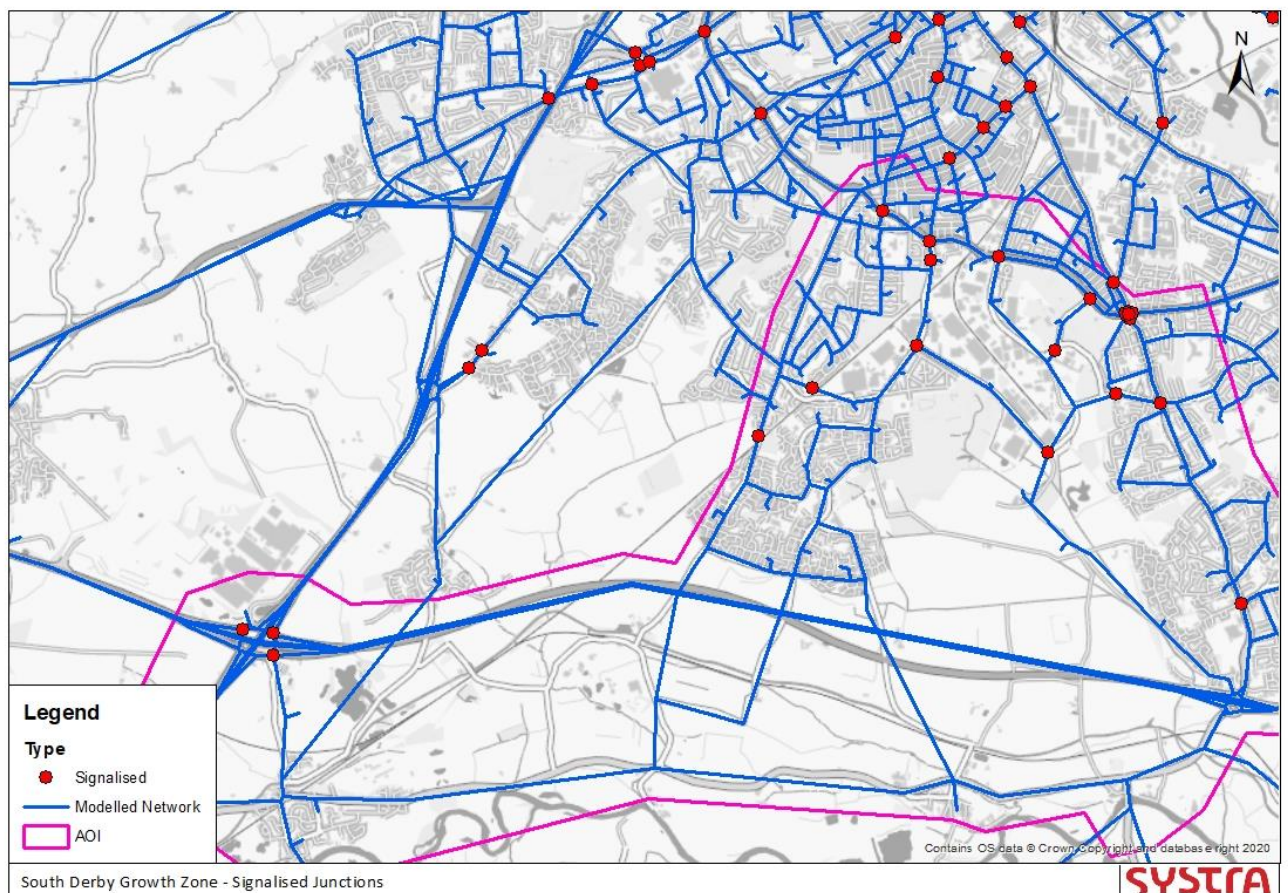
2.6.2 The coding manual is provided in Appendix A of the East Midlands Gateway Highway LMVR.

## 2.7 Traffic Signal Locations

2.7.1 Figure 5 shows the locations of signal controlled junctions in the vicinity of the SDGZ scheme. Within the base model the signal settings have been taken from local SCOOT and traffic signal data. For future year Reference Case models we utilise the SigOpt settings within Saturn to optimise the signal settings against the revised traffic flows and maximise the capacity and efficiency of these networks prior to the scheme being included.

2.7.2 There are relatively few signal controlled junctions in the vicinity of the SDGZ site and along the A50 corridor and therefore optimising the signal settings through SCOOT or MOVA beyond that already undertaken would make little difference to the operation of the local highway network.

**Figure 5. Locations of Traffic Signalised Junctions**



## **3. METHODOLOGY**

### **3.1 Introduction**

3.1.1 Calibration/validation is the process of adjusting the model to improve the fit to the observed data in two main areas:

- adjustments to the coded links and junctions in the network; and
- adjustments to the demand matrices.

### **3.2 Coding Review**

3.2.1 A detailed review of the network has been carried out to ensure the coding through the revalidation area is consistent and accurately represents the highway network in 2016. As EMGM is a strategic model, not every road within the AOI is represented in the modelled network, however the key roads which form the SRN are included, as are major A, B and important minor roads. Particular attention was paid to the following aspects of the network coding:

- Number of lanes
- Distances
- Free-flow speeds
- Speed-flow curves
- Junction type
- Saturation flows
- Location of centroid connectors
- HGV restrictions
- Signals

3.2.2 No additional signal time data has been obtained for the area of influence. Signal timings in the area of influence were reviewed during the EMGM model development and manual alterations carried out during the original calibration and validation of the model. During this local revalidation exercise signal timings, cycle times and stages have been reviewed and where necessary altered in order to provide a better representation of the 2016 network and a closer fit to local count data.

### **3.3 EMGM Traffic Count Data**

3.3.1 A large amount of count data was used for in the development of the full EMGM, some of which was part or fully processed by external companies. Upon receipt of the counts they were reviewed for quality. If there was a known problem with the collection of the count data (such as an accident or roadworks) these counts were immediately disregarded and not processed. Valid counts were then processed to select data from only neutral weekdays, relevant peak hours and vehicle type classifications. Further detail on each of these elements is provided below.

3.3.2 The majority of count data was classified by vehicle type (Car, LGV and HGV) and available for morning peak (08:00 – 09:00), inter peak (average of 11:00 – 14:00) and evening peak (17:00 – 18:00).

3.3.3 All count data used within the model calibration and validation have been taken from a neutral week in a neutral month. At sites where data for more than one day was

collected/available the model has used the average traffic flows between Tuesday and Thursday.

3.3.4 All counts were factored to a 2016 base year using an average factor from all authorities within the model boundary within TEMPRO 7.2. These factors are shown in Table 2.

3.3.5 Counts were also reviewed on ArcGIS to make sure that the observed flow on adjacent counts were similar or defensible and in cases where the counts differed they were removed from the cal/val process.

3.3.6 Counts were reviewed prior to the calibration process to identify inconsistencies between flows on adjacent counts and issues with counts being assigned to the wrong link. In the case of the latter the links were updated accordingly however where inconsistencies in flows were identified the counts were removed and not used in calibration or validation process.

### **3.4 Supplementary Survey Data for LUF Bid**

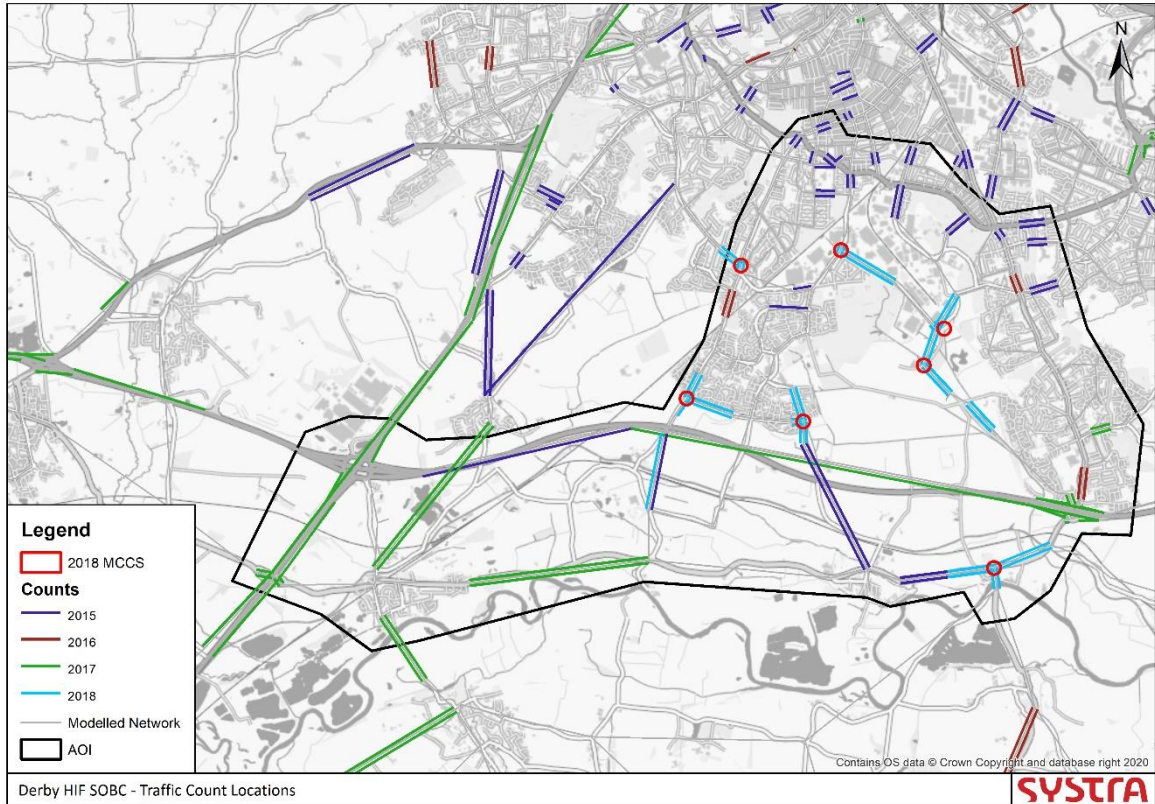
3.4.1 Traffic count data held by SYSTRA has been supplemented with additional survey data provided by Derby City Council. The new survey data consists of turning movements at 7 junctions and 2 bi-directional ATC surveys. All counts were carried out in November 2018 and data was provided for AM and PM modelled time periods. The turning movements were summed into link counts, and calibration/validation has been carried out on the link counts.

3.4.2 Counts were analysed with regards to their fit with adjacent counts, and those that were found to be unreasonably inconsistent were discarded. Following processing and evaluation of the available data, a total of 128 individual counts could be used in the morning peak and 117 counts could be used in the evening peak.

3.4.3 Figure 5 shows the locations of links within the AOI for which there is traffic count data.



**Figure 6. Count Data within the AOI**



3.4.4 The surveys provided by Derby City Council took place in November 2018. The rest of the survey data in the AOI was collected during neutral periods between 2015 and 2017.

3.4.5 All surveys were factored to the 2016 base year using the factors in Table 2. These factors were derived from TEMPRO data, following the same process as used on counts during model development, described in section 4.2.7 of the East Midlands Gateway Highway LMVR.

**Table 2. Growth Factors**

YEAR	MORNING PEAK	INTER PEAK	EVENING PEAK
2015	1.015	1.017	1.016
2016	1.000	1.000	1.000
2017	0.985	0.983	0.985
2018	0.970	0.966	0.971



# 4. CALIBRATION AND VALIDATION IN AREA OF INFLUENCE

## 4.1 General Overview

4.1.1 The DfT guidelines for the calibration/validation of highway models are based on those laid out in the Design Manual for Roads and Bridges (DMRB) Volume 12, Section 2, Part 1, Chapter 4 and TAG 3.19. In respect of the individual count comparisons presented in this section there are two separate sets of criteria against which the counts and modelled flow comparison should be measured. The two sets of criteria are:

- GEH Statistic: links should have a GEH value of less than 5;
- Vehicle Flow Comparison (DMRB):
  - where observed flow is less than 700 vehicles per hour, the modelled flow should be within 100 vehicles of the observed flow;
  - where observed flow is between 700 and 2700 vehicles per hour, the modelled flow should be within 15% of observed flow; and
  - where observed flow is greater than 2700 vehicles per hour, the modelled flow should be within 400 vehicles of the observed flow.

4.1.2 With regard to DfT guidelines on the acceptability of validation statistics, TAG Unit 3.1 section 3.2.7 discusses validation statistics for counts meeting GEH and DMRB criteria, stating that:

*“These two measures are broadly consistent and link flows that meet either criterion should be regarded as satisfactory.”*

4.1.3 All calibration and validation on the EMGM has been conducted in line with these criteria.

## 4.2 Flow Calibration/Validation in the AOI

4.2.1 Table 3 shows how the available data in the AOI was split between data used for calibration and data used for validation.

**Table 3. Split between Calibration and Validation**

TIME PERIOD	TOTAL COUNTS	CALIBRATION	VALIDATION
AM	128	71	57
		55%	45%
PM	117	70	47
		60%	40%

4.2.2 Table 6 presents the final calibration statistics in the AOI after matrix estimation has been run. The statistics are based on the GEH, DMRB, and combined criteria. Table 7 presents validation statistics for the same area.



**Table 4. Calibration Statistics after Matrix Estimation**

	COUNTS	GEH < 5	DMRB	GEH < 5 OR DMRB
<b>Morning Peak</b>				
Cars	69	87%	88%	88%
LGV	69	96%	99%	99%
HGV	71	90%	100%	100%
Total	71	86%	89%	89%
<b>Inter Peak</b>				
Cars	43	93%	100%	93%
LGV	43	95%	98%	100%
HGV	45	95%	100%	100%
Total	45	93%	100%	100%
<b>Evening Peak</b>				
Cars	68	75%	75%	78%
LGV	68	96%	99%	99%
HGV	70	94%	100%	100%
Total	70	73%	74%	77%



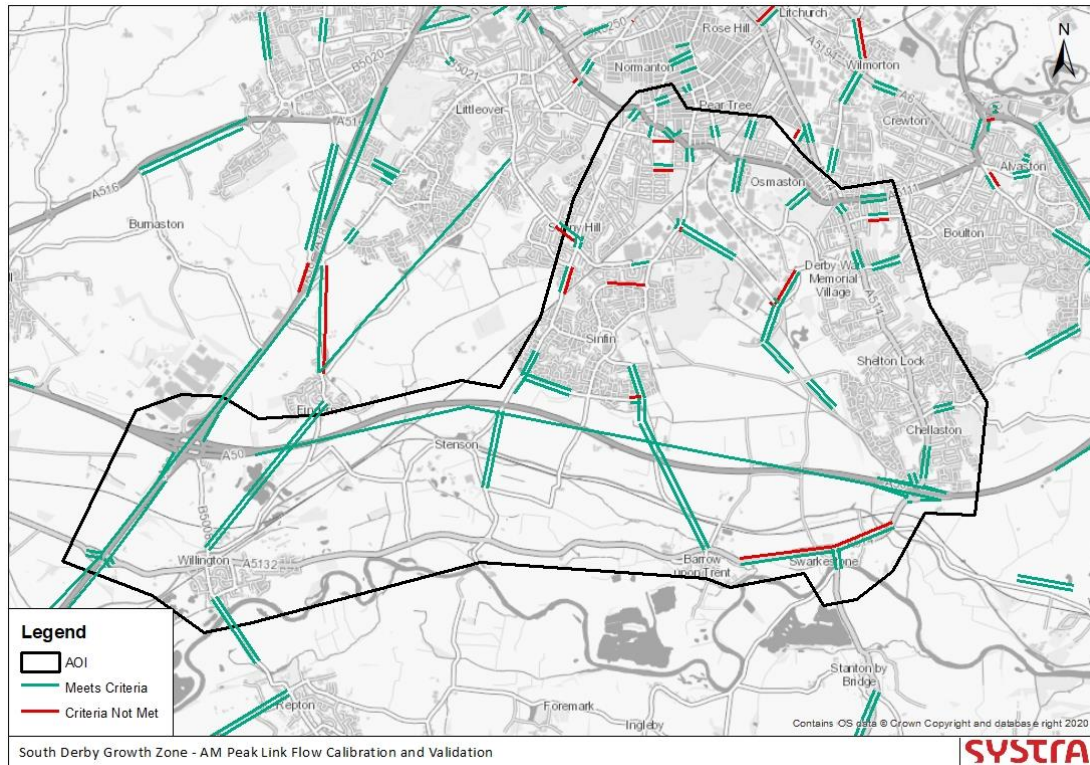
**Table 5. Validation Statistics after Matrix Estimation**

	COUNTS	GEH < 5	DMRB	GEH < 5 OR DMRB
<b>Morning Peak</b>				
Cars	49	67%	86%	86%
LGV	49	90%	94%	94%
HGV	57	84%	96%	96%
Total	57	74%	81%	86%
<b>Inter Peak</b>				
Cars	33	70%	79%	82%
LGV	33	88%	91%	91%
HGV	41	78%	98%	98%
Total	41	73%	80%	83%
<b>Evening Peak</b>				
Cars	39	72%	82%	85%
LGV	39	87%	95%	95%
HGV	47	85%	100%	100%
Total	47	66%	77%	79%

4.2.3 Figures 6,7 and 8 show the show the locations of the counts meeting calibration or validation criteria after matrix estimation has been carried out.



**Figure 7. Morning Peak Calibration and Validation after Matrix Estimation**



**Figure 8. Inter Peak Calibration and Validation after Matrix Estimation**

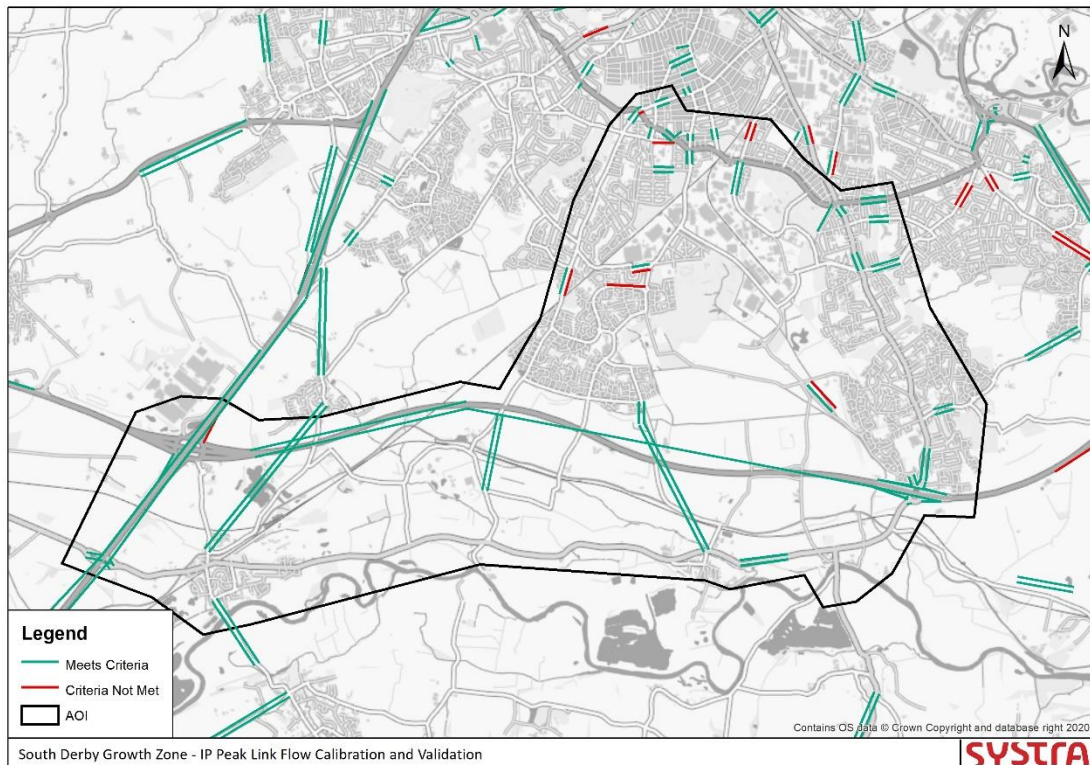
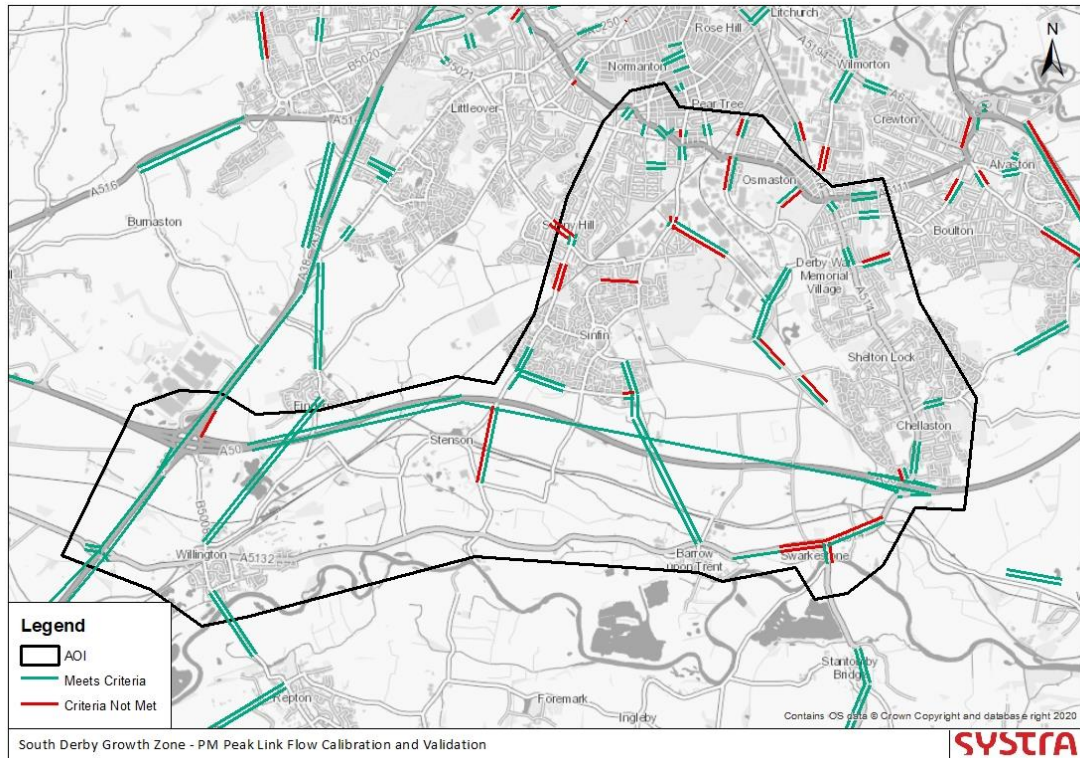


Figure 9. Evening Peak Calibration and Validation after Matrix Estimation



4.2.4 A good level of validation has been achieved in AM, IP and PM. The AM exceeds the recommended 85% target specified by TAG. The PM is marginally lower than the 85% target, however, it still demonstrates a strong level of model validation given the size of the model, the number of counts within the data set and the complexities of route choice available within the model.



## 5. CALIBRATION AND VALIDATION IN FULL MODEL

### 5.1 Link Flow Calibration and Validation

5.1.1 The link flow calibration statistics for the full model are presented in Table 8. Validation statistics for the same area are presented in Table 9.

Table 6. Link Flow Calibration – Full Modelled Area

	COUNTS	GEH < 5	DMRB	GEH < 5 OR FLOW
<b>Morning Peak</b>				
Cars	1209	88%	91%	92%
LGV	1209	93%	99%	99%
HGV	1214	94%	99%	99%
Total	1214	87%	90%	91%
<b>Inter Peak</b>				
Cars	742	88%	95%	92%
LGV	742	91%	96%	98%
HGV	747	89%	98%	98%
Total	747	87%	95%	91%
<b>Evening Peak</b>				
Cars	1208	87%	91%	91%
LGV	1208	93%	99%	99%
HGV	1213	95%	99%	99%
Total	1213	87%	90%	90%



**Table 7. Link Flow Validation – Full Modelled Area**

	COUNTS	GEH < 5	% FLOW	GEH < 5 OR FLOW
<b>Morning Peak</b>				
Cars	809	74%	82%	83%
LGV	809	88%	98%	98%
HGV	827	90%	99%	99%
Total	827	75%	81%	84%
<b>Inter Peak</b>				
Cars	408	68%	76%	78%
LGV	408	81%	95%	95%
HGV	430	81%	96%	96%
Total	430	68%	74%	76%
<b>Evening Peak</b>				
Cars	807	75%	82%	83%
LGV	807	90%	98%	98%
HGV	829	92%	100%	100%
Total	829	76%	82%	84%

5.1.2 A very good level of validation has been achieved in both peak hours. Whilst the model is marginally lower than the recommended 85% target specified by TAG it still demonstrates a strong level of model validation given the size of the model, the number of counts within the data set and the complexities of route choice available within the model.

## 5.2 Journey Time Validation

5.2.1 Journey time data for Stenson Road and Osmaston Road was provided by Derby City Council. Journey time data for the morning peak (08:00 – 09:00) and evening peak (17:00 – 18:00) was provided. The data was collected and processed by AECOM in 2015 for the purpose of the A38 model development.

5.2.2 Tables 8 and 9 summarise the journey time validation for both routes. In both peaks the modelled journey times are generally within, or are narrowly outside, +/- 15% of the observed data. The exception to this is Stenson Road in the morning peak, which includes a signal controlled single lane railway bridge crossing at its Southern end which can lead to considerable variability in journey times though this section depending on the levels of traffic and the timing of the approach to these signals which is difficult to replicate in a strategic model.

**Table 8. Journey Time Validation Morning Peak**

ROUTE	DIRECTION	OBSERVED	MODELLED	% CHANGE	TAG
Stenson Road	Inbound	854	870	2%	Y
Stenson Road	Outbound	699	906	30%	N
Osmaston Road	Inbound	1235	1137	-8%	Y
Osmaston Road	Outbound	964	1057	10%	Y

**Table 9. Journey Time Validation Evening Peak**

ROUTE	DIRECTION	OBSERVED	MODELLED	% CHANGE	TAG
Stenson Road	Inbound	952	810	-15%	Y
Stenson Road	Outbound	926	1096	18%	N
Osmaston Road	Inbound	1024	1196	12%	Y
Osmaston Road	Outbound	1074	1257	15%	Y



## 6. MATRIX ESTIMATION

### 6.1 Introduction

6.1.1 Matrix estimation is a process which alters the demand matrices in order that assigned trips from the revised matrices more closely resemble the observed data. Matrix estimation was run for 7 loops, focussing on each user class in turn.

6.1.2 Constraints have been applied to matrix estimation to minimise the ability of the program to make significant changes to demand to meet individual counts. In particular, the XAMAX setting was set to 1.5 to avoid significant, and potentially erroneous, demand changes.

6.1.3 The additional traffic counts provided for this localised revalidation within the AOI of the SDGZ scheme were added to the entire set of counts used in the creation of the full EMGM. These additional counts are only a small proportion of the total number of counts used in the development of EMGM which included around 1500 sites in each peak. Counts used in calibration in the original model were maintained in the calibration for this minor local revalidation to minimise the impact of the Matrix Estimation process outside of the AOI for the SDGZ scheme.

6.1.4 The impacts of this Matrix Estimation process are detailed in the sections below.

### 6.2 Changes to Matrix Totals

6.2.1 Tables 10 and 11 provide the highway matrix totals for pre and post Matrix Estimation for the morning peak and evening peak. The overall trip levels have changed by 1.57% in the morning peak and by 2.59% in the evening peak. These changes are well within the 'less than 5%' recommendation set in the TAG guidance.

**Table 10. Impact on Morning Peak matrix totals (vehicles)**

	BEFORE MATRIX ESTIMATION	AFTER MATRIX ESTIMATION	PERCENTAGE DIFFERENCE
Cars	245,880	249,640	1.53%
LGV	30,384	30,848	1.52%
OGV	29,628	29,991	1.22%
<b>Total</b>	<b>305,892</b>	<b>310,479</b>	<b>1.50%</b>

**Table 11. Impact on Evening Peak matrix totals (vehicles)**

	BEFORE MATRIX ESTIMATION	AFTER MATRIX ESTIMATION	PERCENTAGE DIFFERENCE
Cars	269,859	274,476	1.71%

LGV	24,771	25,044	1.10%
OGV	18,404	18,680	1.50%
<b>Total</b>	<b>313,034</b>	<b>318,199</b>	<b>1.65%</b>

### 6.3 Changes to Zonal Trip Ends

6.3.1 A regression analysis has been conducted to ascertain the degree of fit between the prior trips ends and those following the ME process. Figures 10 to 12 graphically represent this data for each peak, focussing on a total trip end basis (all user classes combined).

6.3.2 Table 12 conveys the correlation between prior and post matrix estimation trip ends at Origin and Destination levels. The correlation coefficient R<sup>2</sup> provides indication of the 'goodness of fit' whilst the slope of the best fit regression line through the origin indicates the range by which the modelled values are under or over estimated.

6.3.3 TAG Unit M3 advises that acceptable values are deemed to be above 0.98 for R<sup>2</sup> and a slope of between 0.99 and 1.01 with a value of 1.00 for each being a perfect fit.

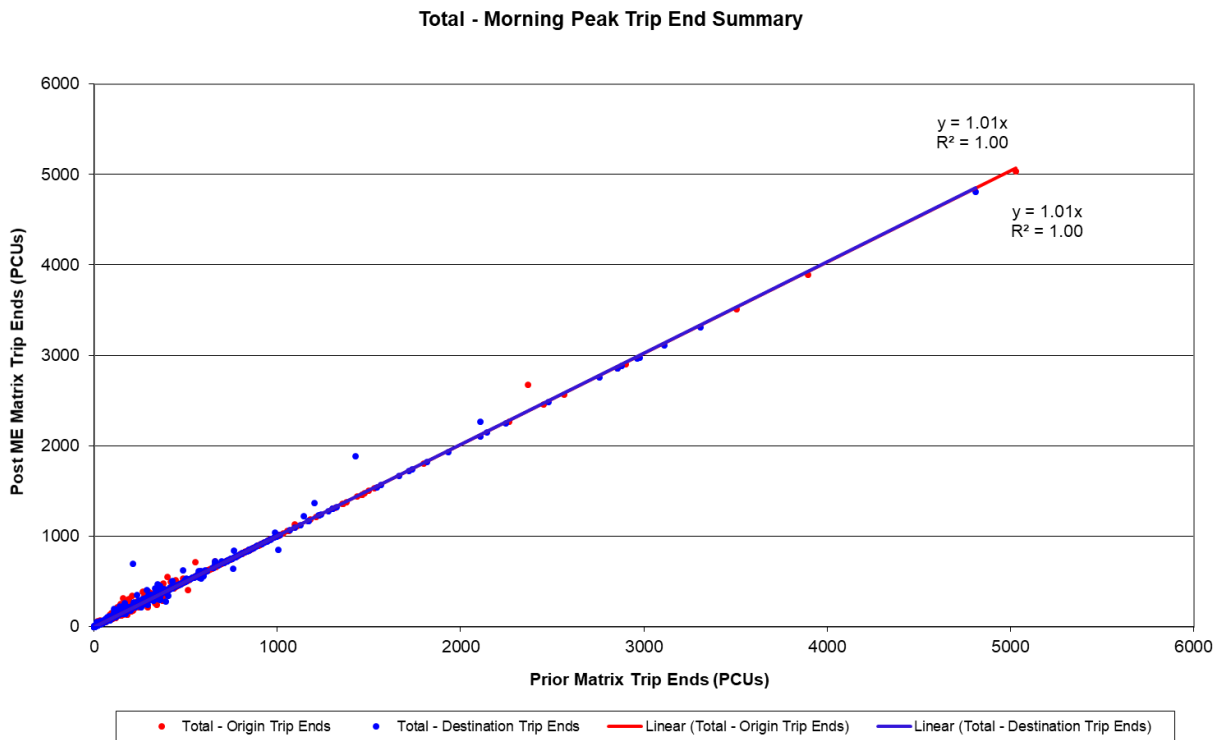
**Table 12. Correlation between trip end totals between before and after matrix estimation**

	ORIGIN TRIP ENDS		DESTINATION TRIP ENDS	
	R <sup>2</sup>	slope	R <sup>2</sup>	slope
Morning Peak	1.00	1.01	1.00	1.01
Inter Peak	1.00	1.00	1.00	1.00
Evening Peak	1.00	1.01	1.00	1.01

6.3.4 The correlation is very good between the trip ends before and after matrix estimation. For each peak the R<sup>2</sup> value, an indicator of goodness of fit between the two datasets, is greater than 0.98. The slope is also within guidance.



**Figure 10. Morning Peak Trip End Comparison**



**Figure 11. Inter Peak Trip End Comparison**

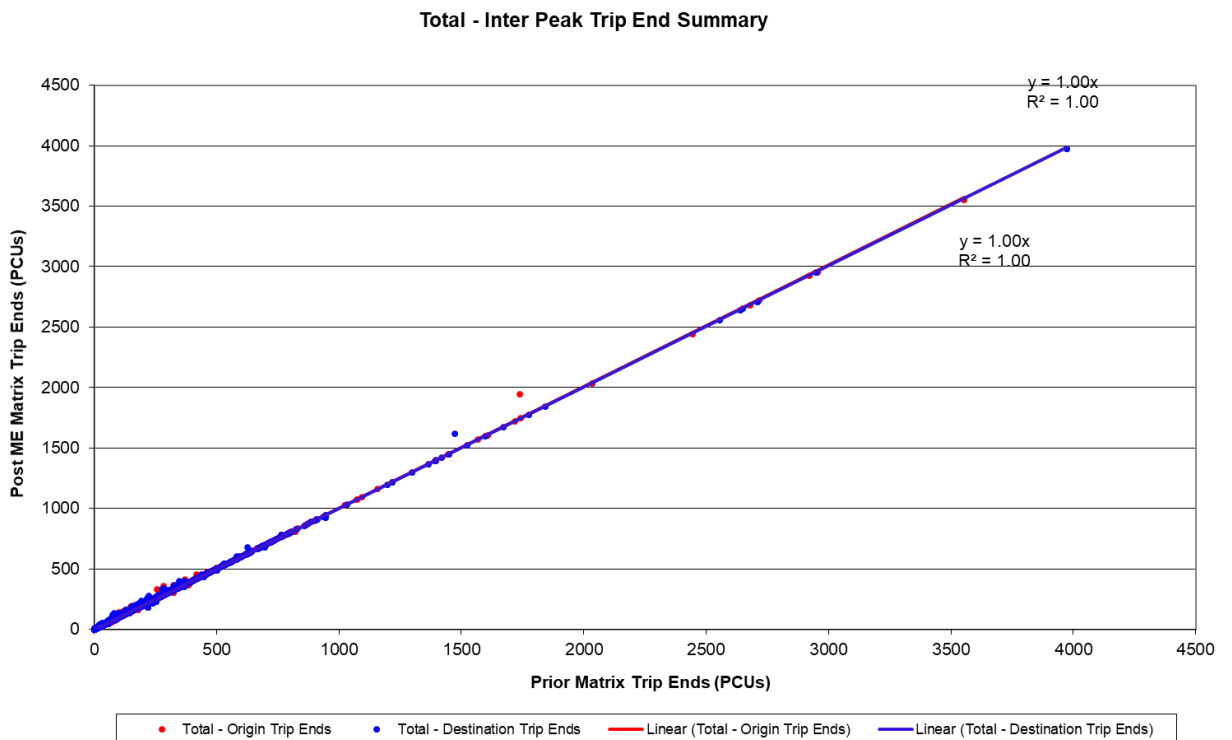
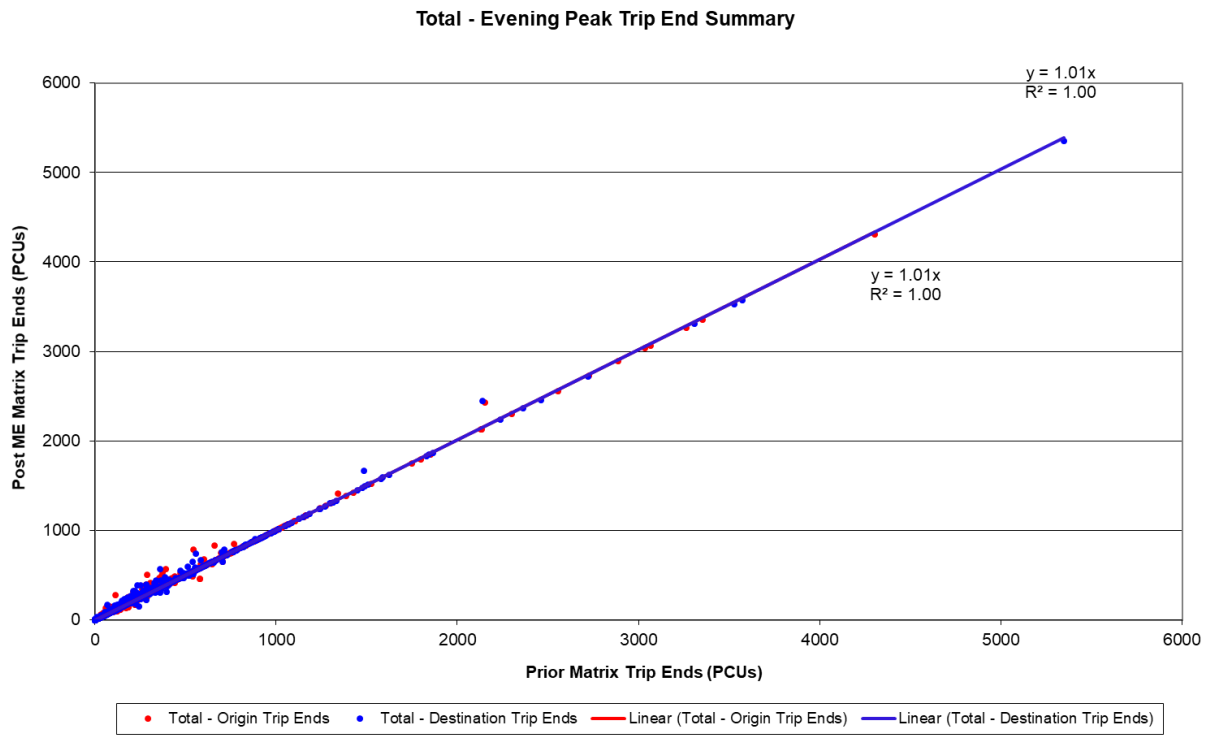


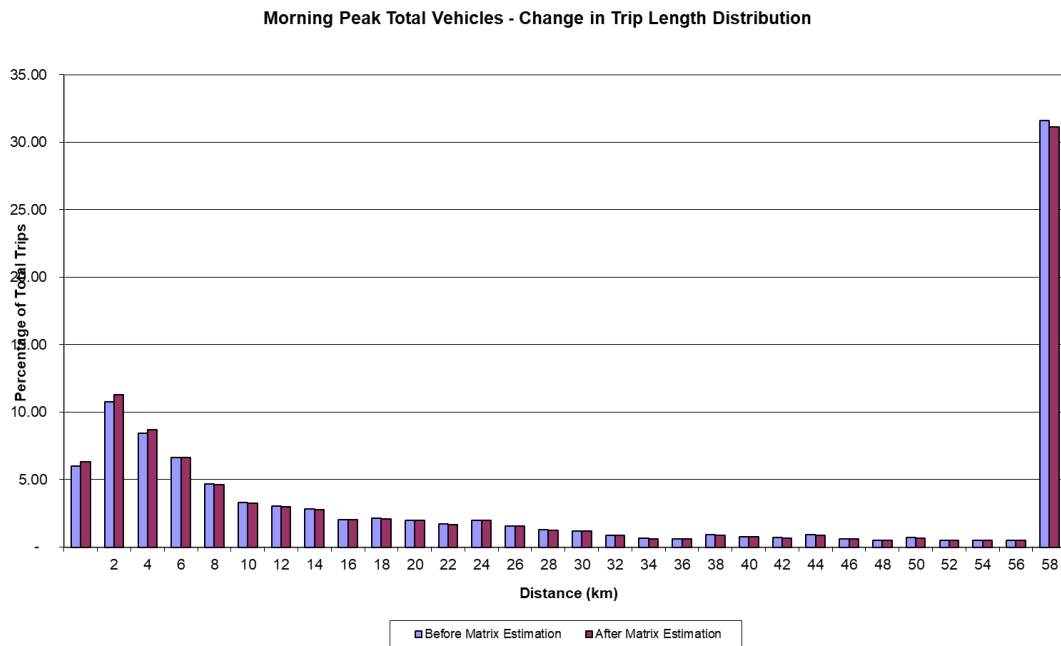
Figure 12. Evening Peak Trip End Comparison



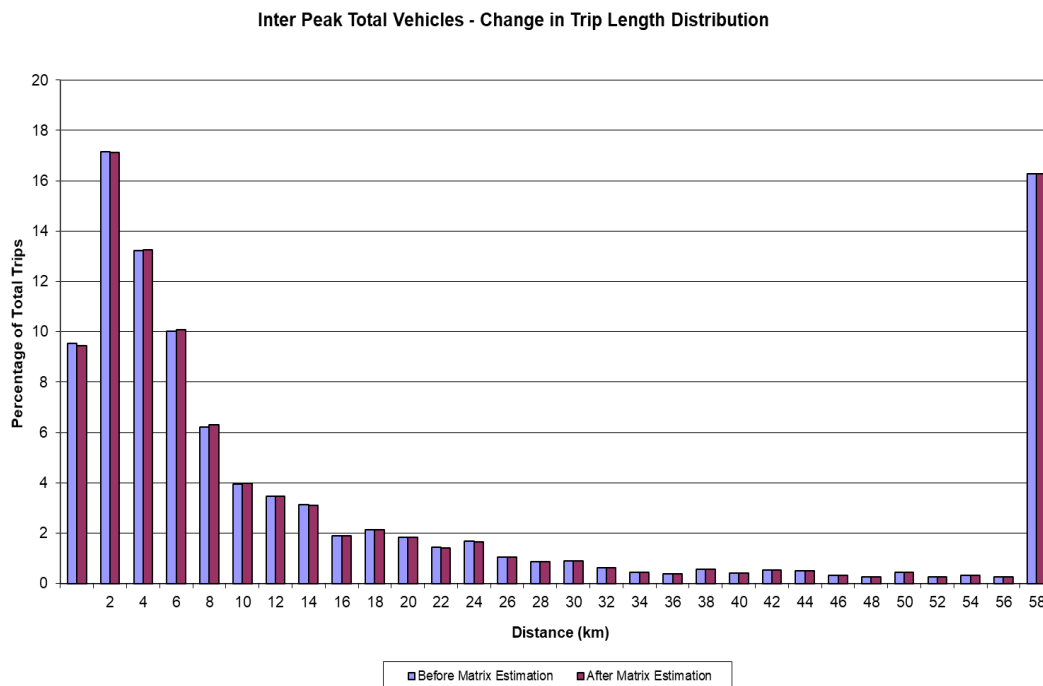
## 6.4 Changes to Trip Length Distributions

6.4.1 The distributions of trip lengths within the model are shown in Figures 13 to 15 for all vehicles combined by time period. The blue bars represent trips for the matrix before matrix estimation was applied, whilst the purple bars represent the post matrix estimation trips.

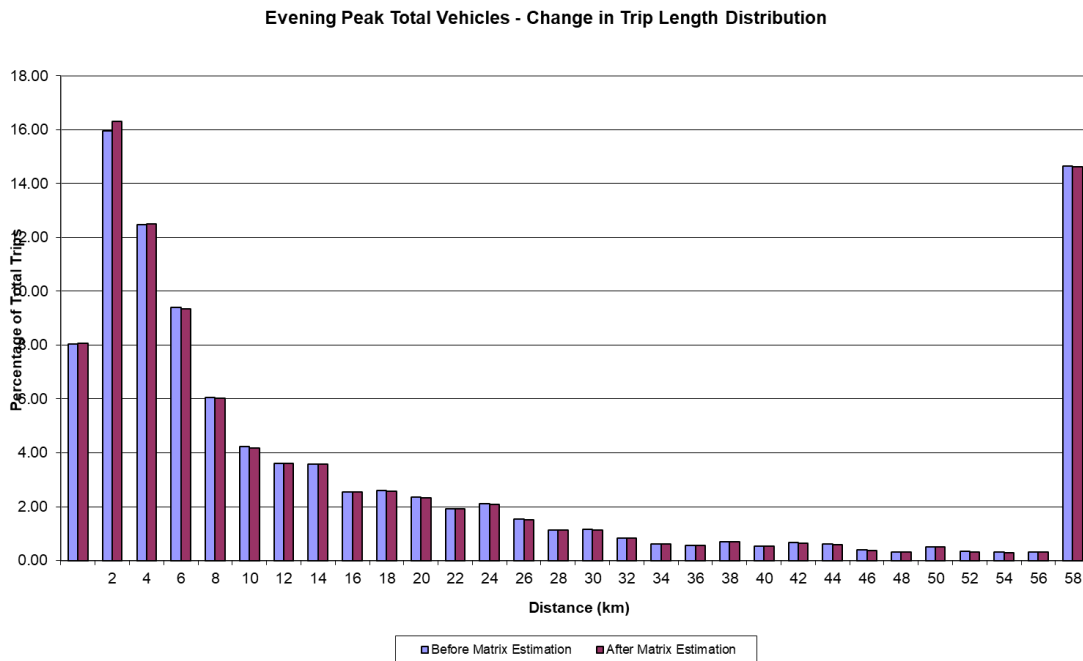
**Figure 13. Morning Peak Trip Length Distributions**



**Figure 14. Inter Peak Trip Length Distributions**



**Figure 15. Evening Peak Trip Length Distributions**



6.4.2 Table 13 shows the change in mean car trip lengths for the prior and post matrix estimation matrices for the morning and evening peaks respectively. This includes all trips within the network, including exogenous trips that travel through the study area.

6.4.3 These show that matrix estimation changes the mean car trip lengths by -0.1% in the inter peak, -0.5% in the evening peak and -0.6% in the morning peak. TAG advises that changes to mean trip length by matrix estimation should be no more than 5%.

**Table 13. Average Car Trip Lengths Before and After Matrix Estimation**

	BEFORE ME	AFTER ME	% DIFFERENCE
Morning	19.5	19.4	-0.6%
Inter	18.5	18.4	-0.1%
Evening	18.8	18.8	-0.5%

6.4.4 Overall, the average trip length has changed by a very small amount in all time periods and therefore indicates that matrix estimation has not significantly altered the trip lengths within the model.



## 7. NETWORK CONVERGENCE

### 7.1 Overview

7.1.1 TAG M3 discusses the importance of achieving highway assignment convergence. The following convergence monitoring indicators (and their acceptable values) have been specified in TAG by:

- DELTA is reported from the assignment iterations. It is the difference between the times along the actual routes and the minimum cost routes, summed across the whole network and expressed as a percentage of the minimum cost times. DELTA is expected to be below 1% shows that the model convergence is well within this target range with values less than 0.05 in all time periods;
- % GAP is a measure of the stability of the model. It is a generalisation of the Delta function to include the interaction effects within the simulation. The recommended value by TAG is less than 0.1% over four consecutive iterations;
- Epsilon is reported from the simulation iterations. It is a measure of the degree to which the area under the speed/flow curves is minimised and is expected to be below 1%; and
- % Flows is a measure of the stability of the model and shows the percentage of links where flow differs by < 1%. TAG guidance states that 98% links should not vary by more than 1% in successive iterations.

### 7.2 Base Model Convergence

7.2.1 Table 14 provides the convergence statistics for the 2016 base highway model. In all three peaks the model is well below the %GAP target of < 0.1%. With around 97% of links flows changing by less than 1%, the model just misses the % flow target of 98%, however, for a model of this scale and complexity that easily achieves the %GAP criteria this is felt to be acceptable.

Table 14. Network Convergence Statistics

CRITERION	TARGET	AM PEAK	IP PEAK	PM PEAK
Delta	< 0.1%	0.032	0.0027	0.012
%GAP	< 0.1%	0.014	0.0041	0.016
Epsilon	< 0.1%	0.0199	0.0262	0.0183
% of links with < 1% flow change on final iteration	98%	97.53	98.04	96.75
Final iteration -1		97.21	98.14	96.63
Final iteration -2		97.01	97.95	97.03
Final iteration -3		96.96	96.90	96.74

## **8. SUMMARY AND CONCLUSIONS**

- 8.1.1 Local revalidation has been carried out on EMGM, a large strategic model, in order to better assess the a proposed new junction on the A50 and an associated link road.
- 8.1.2 Validation has been assessed on 2018 traffic count data provided by Derby City Council, in addition to count data already held by SYSTRA.
- 8.1.3 The network coding in the area of influence was reviewed before matrix estimation was used to further calibrate the model. A good level of validation and calibration has been demonstrated in the area of influence.
- 8.1.4 Precautions were taken to ensure that the area outside the AOI did not change significantly. Changes in matrix totals have changed by less than 2%, well within the 5% target detailed in TAG.
- 8.1.5 As a result of the calibration/validation process, the revised model is considered 'Fit for Purpose' for use in a TUBA economics assessment of the proposed scheme.



## APPROVAL

Version	Name		Position	Date	Modifications
<b>1</b>	Author	James Homer	Assistant Consultant	08/12/2020	V1
	Checked by	Rhian Turgoose	Associate	08/12/2020	
	Approved by	Duncan Irons	Director	08/11/2020	
	Author	James Homer	Assistant Consultant	08/12/2020	Addresses DfT queries
	Checked by	Rhian Turgoose	Associate	08/12/2020	
	Approved by	Duncan Irons	Director	08/11/2020	

