

TECHNICAL NOTE

MANSFIELD LOCAL PLAN

LOCAL MODEL VALIDATION REPORT

IDENTIFICATION TABLE

Client/Project owner	Mansfield District Council
Project	Mansfield Local Plan
Title of Document	Local Model Validation Report
Type of Document	Technical Note
Date	12/09/2024
Reference number	108308
Number of pages	53

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1. INTRODUCTION

1.1 Report Background

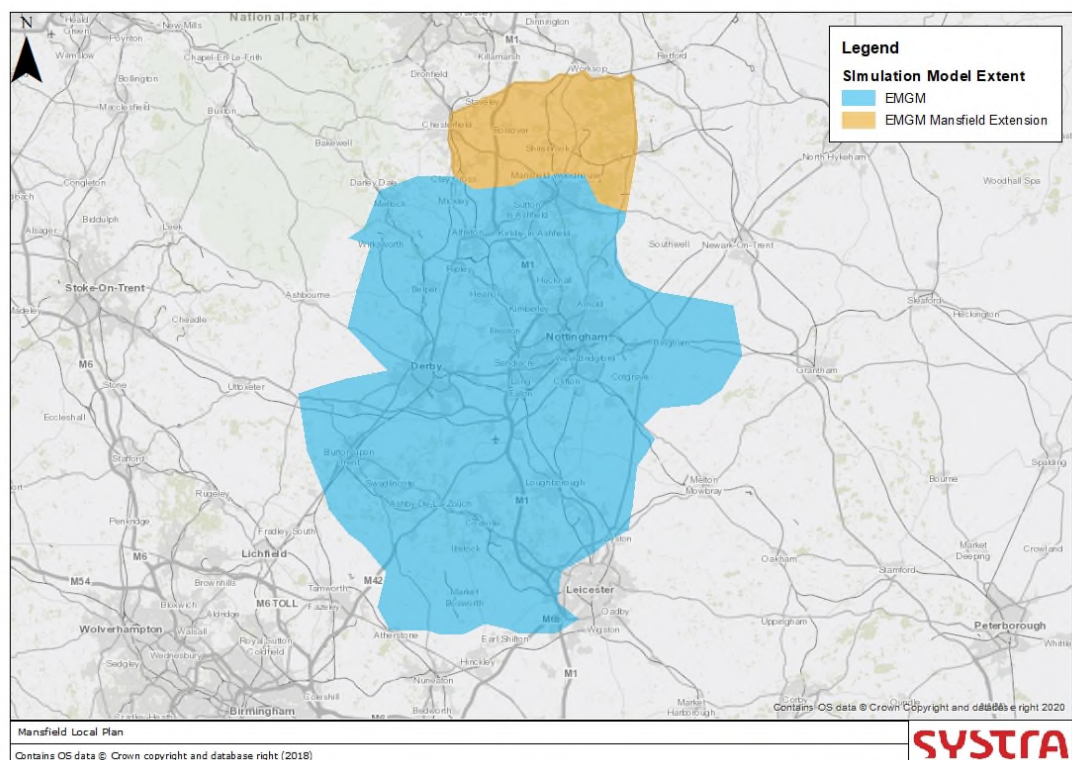
- 1.1.1 SYSTRA has been commissioned by Mansfield District Council to enhance the East Midlands Gateway Model to assess the implications of their Local Plan strategy. The model (highway and public transport) will be utilised to assess the impacts of a series of sustainable travel and public transport schemes, including rail schemes and the proposed Local Plan developments and associated mitigation packages on the local transport networks.
- 1.1.2 The East Midlands Gateway Model (EMGM) is a multimodal transport model built following the guidance in TAG. The model was fully calibrated and validated in line with TAG guidance in 2018 and has a base year of 2016. It has since been used for a variety of studies, including local plans, development assessments, DfT compliant business cases and regional growth strategies.
- 1.1.3 For the purpose of the Mansfield Local Plan, the EMGM has been expanded to provide suitable model coverage of the entire Mansfield Area of Influence (AOI), which is shown in Figure 1.
- 1.1.4 This extension required a revalidation of the EMGM to ensure it is ‘fit for purpose’ for use in the Local Plan, and to ensure the improvements to the model have not detrimentally affected the performance of the rest of the model.
- 1.1.5 The purpose of this note is to outline the methodology and results of the local calibration and validation of the EMGM in the Mansfield AOI. It is intended to serve as an addendum to, and should be read alongside, the full East Midlands Gateway LMVRs, which have previously been issued to all local authorities including Nottingham and Derby City Councils, and National Highways. These documents, along with the VDM Report are provided in Appendix A.

2. OVERVIEW OF THE GATEWAY MODEL

2.1 Model Extent

- 2.1.1 The geographical extent of the EMGM model is shown in Figure 1. The existing EMGM simulation extent is shown in blue whilst the area covered by the extension is shown in orange.
- 2.1.2 The model includes detailed simulation coding for the authorities of Mansfield, Nottingham City, Ashfield, Broxtowe, Erewash, Gedling, Rushcliffe, Derby City, Amber Valley, South Derbyshire, Charnwood, and North-West Leicestershire. Areas outside of this simulation area are modelled as a buffer network, this includes Leicester City and areas to the south of the A46 and Chesterfield to the north.

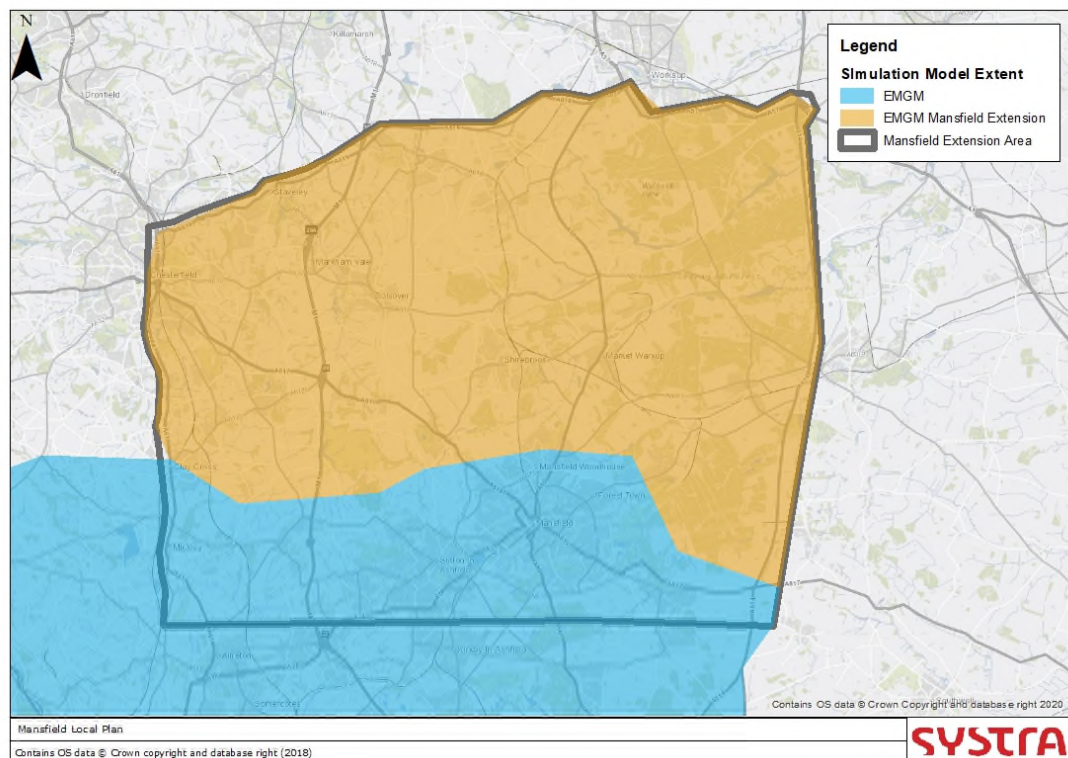
Figure 1. Model Extent



2.2 The Mansfield Extension Area

- 2.2.1 The Mansfield Extension Area refers to the portion of the model where the detailed simulation network has been either expanded or revised as part of this study. The extended simulation area is broadly constrained by the A614 to the East, the A619 to the North and the A61 to the West. This boundary was agreed in consultation with the client team.
- 2.2.2 Chesterfield is partially represented within the simulation coding. This includes the A67/A61 to the West and the A619 to the north. This network definition allows for representative access onto the local strategic road network (SRN) and for suitable definition of key PT routes.
- 2.2.3 The same level of coverage is applied to Worksop in the north. The simulation coding extends to include the A57 but does not include the town itself. This again provides suitable coverage to accurately represent loading onto the SRN alongside access for PT services.
- 2.2.4 The existing simulation network within the Mansfield Extension Area has been reviewed and upgraded to a higher definition of network and zonal detail. Simulation areas south of the of the Mansfield Extension Area already maintain suitable definition and have remined unaltered.
- 2.2.5 The Mansfield Extension Area as depicted in Figure 2 forms the basis of our revalidation area and is referred to as the Mansfield AOI.

Figure 2. Model Extent



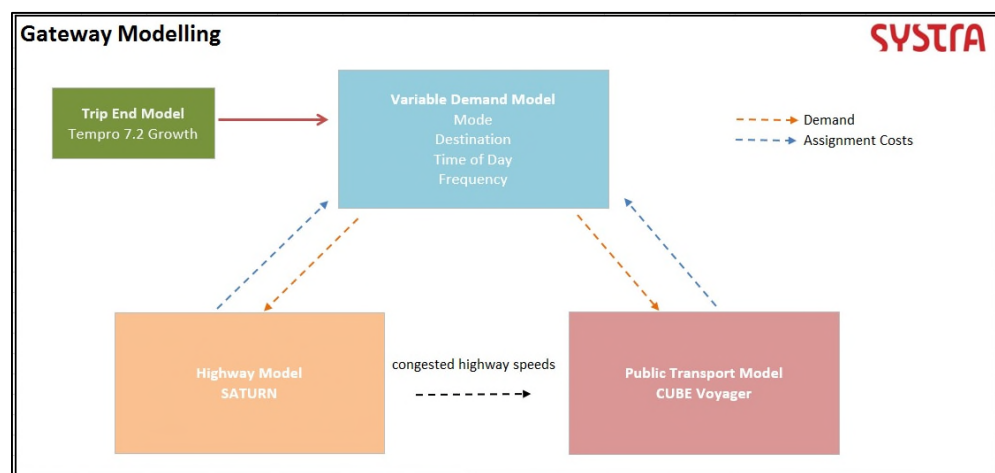
2.3 Structure of the Gateway Model

2.3.1 The EMGM is a multimodal transport model built following the guidance in TAG Unit M2. The EMGM has all the expected TAG responses (time of day, main mode, destination, frequency, route/sub mode) arranged in the standard hierarchy order.

2.3.2 An overview of the structure of the model is shown in Figure 3. The modelling suite is comprised of the following elements:

- SATURN Highway Model.
- CUBE Voyager Public Transport Model.
- Cube Variable Demand Model including destination, mode choice, trip frequency and time of day responses; and,
- TRICs based Trip End Model.

Figure 3. EMGM Overview



2.4 Assignment Model User Classes

2.4.1 Current TAG guidance in Unit 3.1 requires that transport models should be disaggregated by journey purpose to reflect individual user group behaviour where feasible. For the EMGM, the model has been developed in such a way as to allow it to be run with or without Clean Air Zone (CAZ) functionality. The advantage of this approach is that there may be circumstances where CAZ modelling is not required and the ability to 'switch off' the functionality will result in substantial model run time benefits.

2.4.2 With CAZ functionality switched off the model possess seven user classes (UC1 – UC7) where private car is comprised of four purpose constituents and LGV, HGV and Taxi account for the remaining three user classes.

2.4.3 The calibration and validation process have been undertaken on the 7-user class model. The car user class includes private cars and taxis.

- Car - Commuting (No Workplace Parking Levy)
- Car - Commuting (Workplace Parking Levy)
- Car - Employer's Business
- Car – Other

- LGV
- HGV (OGV1 and OGV2)

2.5 Assignment Model Time Periods

2.5.1 The following time periods are represented in the highway and public transport models:

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

2.6 Saturn Version

2.6.1 The highway model uses SATURN version 11.6.03A. The revalidated base year model has the following network dimensions:

- 1,126 zones.
- 9,937 nodes.
- 23,000 Links.



3. MANSFIELD NETWORK DEVELOPMENT

3.1 Overview

- 3.1.1 The EMGM highway network was initially created using information from the Greater Nottingham Transport Model, Greater Derby Transport Model, Derby Area Transport Model and the Leicester and Leicestershire Integrated Transport Model.
- 3.1.2 Details on the network build for the full EMGM can be found in chapter two of the full East Midlands Gateway Highway Local Model Validation Report. The expansion of the model into Mansfield has adopted the same assumptions in terms of network characteristics (e.g. speeds, SFCs, junction coding).
- 3.1.3 For the purposes of Mansfield expansion, the network build occurred in several steps:
- A review of existing EMGM network including definition of expansion area.
 - Network expansion to cover the Mansfield AOI.
 - Addition of new zones and zone connectors.
 - Application of network speeds and speed flow curves in line with existing EMGM assumptions.
 - Review of banned links and turns, including HGV restrictions in rural areas; and
 - Final network checks and comprehensive coding review of entire network.

3.2 Network Definition

- 3.2.1 The area around Mansfield has been significantly expanded upon to cover the Mansfield AOI. This extension is broadly defined by the A614 to the East, the A619 to the North and the A61 to the West.
- 3.2.2 Network definition within this area has been improved significantly to cover all A and B roads and any minor routes that are capable of carrying through traffic movements. The revised network extent detailed in Figure 4.
- 3.2.3 The full extent of the expanded EMGM network is depicted in Figure 5. Network within the simulation boundary is fully modelled whilst the external network comprises of buffer coding.



Figure 4. Mansfield Network Extent

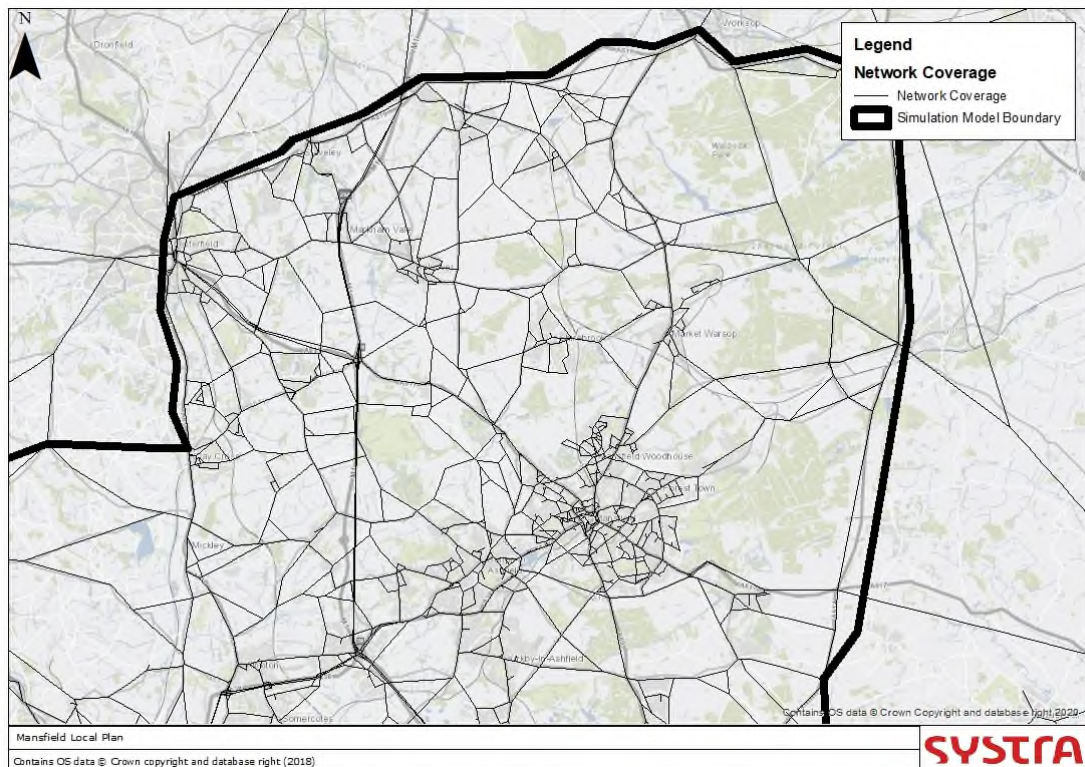
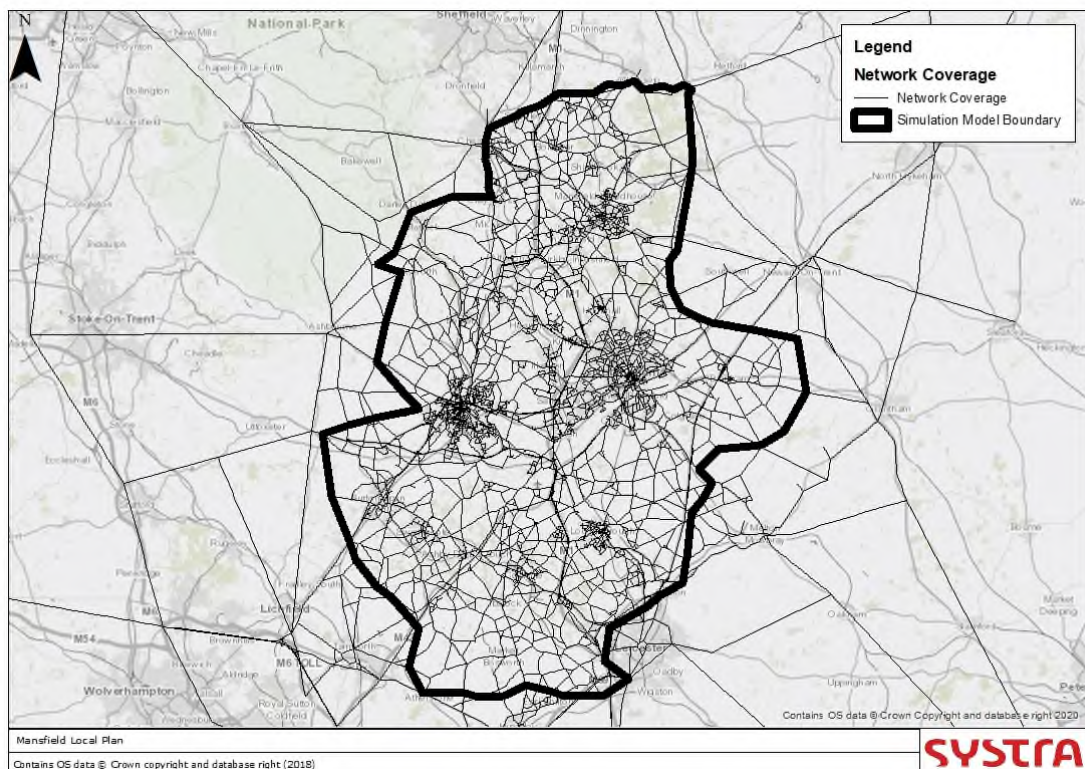


Figure 5. Full Model Extent



3.3 Network Coding

3.3.1 The standardised approach to network coding is documented in the EMGM coding manual provided in as an appendix to the full East Midlands Gateway Highway LMVR (provided as Appendix A of this document). This covers the following topics:

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

3.4 Network Speeds

3.4.1 Network link speeds were derived from survey data commissioned for the full EMGM highway validation exercise. An average speed was calculated across all authorities for each road type and speeds were updated globally within each peak hour network.

3.4.2 During the calibration process, and with knowledge of road conditions across the modelled area, network speeds were adjusted on a global level to bring the modelled speeds more in line with observed journey time information (network speeds on all journey time routes were consistently too fast). A global reduction in network speeds was applied rather than speed flow curves as speed-flow curves should not be used to represent 'junction' delay, and therefore should only be used on longer grade separated links (eg M1 Motorway). Table 1 summarises the network speeds used within the original and expanded 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

3.5 Signal Timings

3.5.1 No signal time data was available for the Mansfield model expansion area. Many of the signals are controlled by SCOOT or MOVA systems. As a result, signals within this area have had timings derived from a network wide signal optimisation exercise. These derived signal timings are hard coded and combined with those timings used in the existing calibrated and validated EMGM base year model.

3.6 Review of Banned Links and Turns

- 3.6.1 Banned turn and link information was reviewed visually and updated where necessary. Particular attention was made to HGV bans in Nottinghamshire as many rural routes are unsuitable for HGV vehicles.
- 3.6.2 The model cannot restrict HGV access on all rural routes as it need to provide local access to towns and villages, however, by using a combination of link speeds and HGV bans longer distance HGV trips primarily route via either the strategic road network or suitable trunk roads.

3.7 Network Checks

Queues

- 3.7.1 A critical part of the network build was to ensure that the delays simulated within the model had a close correlation with reality in order to replicate the highway conditions and provide robust base year model.
- 3.7.2 SYSTRA have a good knowledge of the roads and junctions within the Mansfield AOI and used this knowledge along with Google traffic information to conduct logic checks to ensure that queues are represented in the correct places.

Routing

- 3.7.3 Modelled routes were checked using Select link Analysis and Tree Analysis to ensure integrity. These checks show that the model assigns traffic along logical and expected routes in order for traffic to reach its destination. Appendix B presents a set of modelled routes between a representative sample of origin and destination pairs.

Strategic Road Network Checks

- 3.7.4 Within the Mansfield AOI, the expanded network was subject to extensive checks to ensure that distances, speeds, lanes, and lane allocation were correct. These checks included a comparison against mapping tools to check for consistency in both speed, distance, and capacity. Junction layouts and operations have also been checked against Google Maps.

SATNET Errors and Warnings

- 3.7.5 The SATURN network-building program SATNET produces error and warning messages that were dealt with individually. All fatal and semi-fatal errors introduced into the model were corrected, and warning messages were inspected, and faults corrected where necessary. Not all warnings have been rectified as some relate to legitimate coding decisions made within the model build and calibration and validation process.
- 3.7.6 A number of zone loading checks were also performed to ensure that zones loaded onto the correct parts of the network and all trips associated with the zone were able to get onto the highway network.



4. MATRIX DEVELOPMENT

4.1 Overview

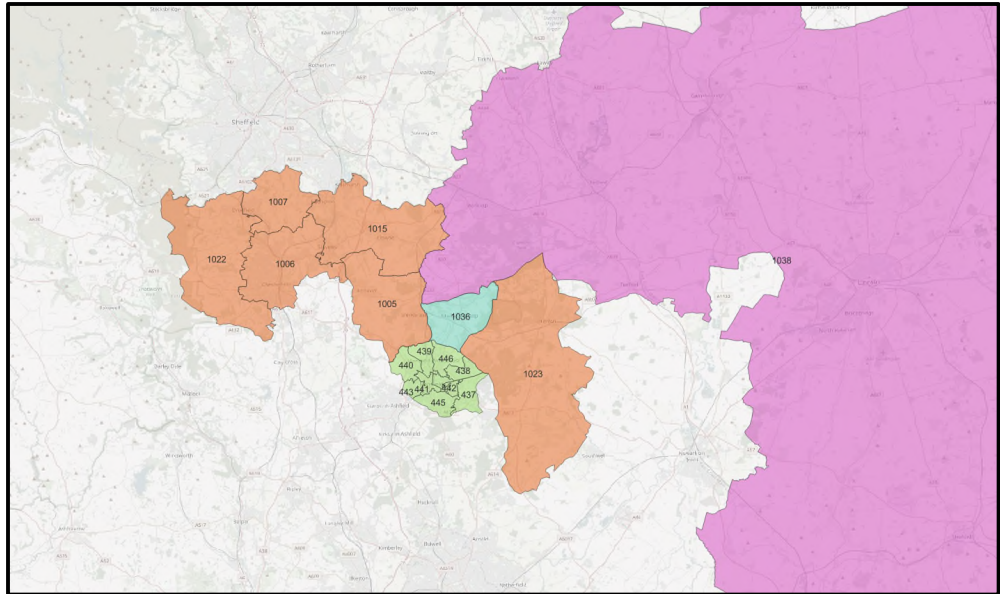
- 4.1.1 The existing assignment matrices for both highway and public transport were updated to reflect the extended model area with extra detail added in Mansfield District.
- 4.1.2 The refined matrices are based on the original EMGM matrices, created as part of the model build in 2018.
- 4.1.3 The alterations made as part of the Mansfield AOI expansion are as follows:
- Enhanced zoning definition in and around Mansfield.
 - Switching of some zones from “external” to “internal” and therefore becoming subject to demand model responses.
 - Checks to resultant matrices to ensure overall demand has not changed significantly.

4.2 Zone Enhancements

- 4.2.1 The adjustments to the base year zoning can be grouped as follows and shown graphically in Figure 6:
- Disaggregation of Internal Zones (Green) – this applies to the internal part of Mansfield District.
 - Conversion of External Zones to Internal (Orange) – this applies to the areas where we do not need greater zonal detail but do require these to be modelled as internal zones to be subject to demand responses.
 - Conversion of External Zones to Internal and Disaggregation (Turquoise) – this applies to the external part of Mansfield District.
 - Splitting of External Zones into multiple zones (Purple) – The “Lincolnshire” zone contains the area of Worksop which will be represented by a single internal zone.



Figure 6. Mansfield Network Zones



Disaggregation of Zones

- 4.2.2 Model zones which were disaggregated based on Output Areas and Lower Super Output Areas (LSOAs) in the urban areas and MSOAs in rural areas. Outside of the model boundary zones are amalgamations of MSOAs or regions.
- 4.2.3 To ensure consistency with the remaining EMGM, codepoint (postcode) data from the original East Midlands Gateway Study was used to calculate splitting factors where zones needed to be disaggregated. The process adopted is as follows:
- Used GIS to determine how many postcodes were within each new zone.
 - Used the postcodes to find the “centre of mass” of each zone (each post code has the same weight).
 - For the original (parent) zone and the new (child) zone, determined the splitting factors.
 - Applied these splitting factors to the Assignment Matrices and the Input Trip Ends of the base year model.

Conversion of External to Internal Demand

- 4.2.4 The disaggregation of zones resulted in the following districts becoming entirely internal to the model:
- North-East Derbyshire District.
 - Chesterfield District.
 - Bolsover District.
- 4.2.5 Newark and Sherwood District remained partially internal and partially external.
- 4.2.6 In total, the model expansion has added 76 new base year zones to the model, resulting in a total of 1,126 zones within the full EMGM. Figures 7 and 8 illustrate the new zone boundaries for the local and full model areas.

Figure 7. Mansfield Network Zones

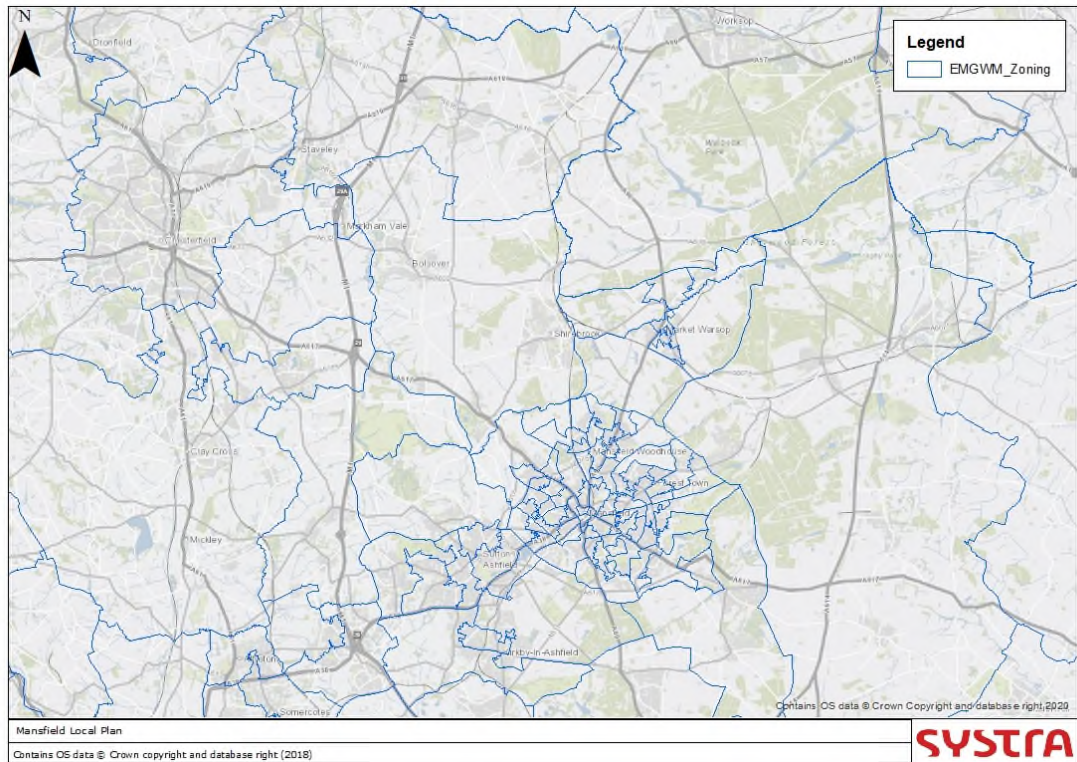
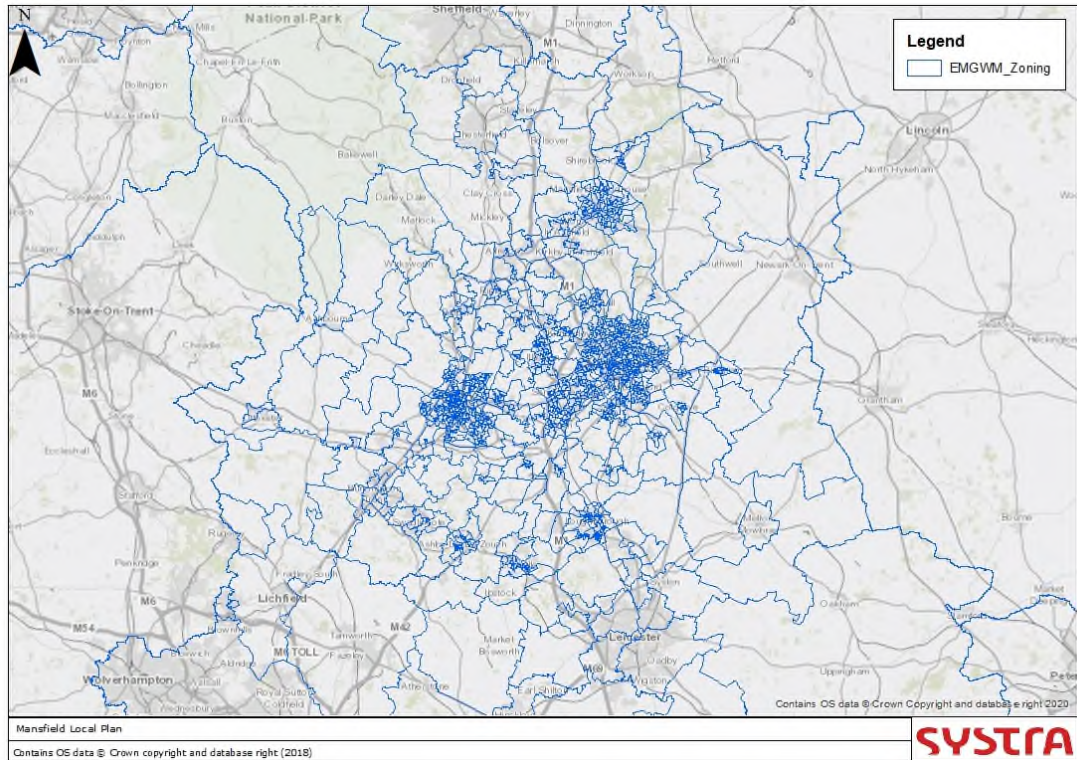


Figure 8. EMGM Network Zones



5. COUNT DATA

5.1 Traffic Count Data

- 5.1.1 The EMGM Data Specification Report details the data used in the full EMGM highway (and public transport) model validation. This data was retained for the use in the Mansfield expansion and supplemented with additional data in the Mansfield AOI.
- 5.1.2 Data used in the EMGM originates from the following sources:
- Derby and Nottingham City Councils.
 - Derbyshire, Nottinghamshire, and Leicestershire County Councils.
 - HE TRADS system.
 - AECOM Capita Ineco JV (data collected on behalf of HS2 Ltd).
 - AECOM (data collected on behalf of Highways England).
- 5.1.3 Extra survey data for the Mansfield area has been sourced from the Drakewell online resource held by Nottinghamshire County Council.
- 5.1.4 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).
- 5.1.5 All count data used within the model calibration and validation has been taken from a neutral week in a neutral month. At sites where data for more than one day was available average traffic flows between Tuesday and Thursday have been used.
- 5.1.6 All counts were factored to the 2016 base year using an average factor from all authorities within the model boundary within TEMPRO 8. The factors applied to the counts are shown in Table 2 below.

Table 2. TEMPRO Factors

YEAR	MORNING PEAK	INTER PEAK	EVENING PEAK
2015	1.005367	1.007308	1.006371
2016	1	1	1
2017	0.993734	0.992918	0.99357
2018	0.987536	0.98586	0.98723
2019	0.981433	0.978814	0.980942

- 5.1.7 Surveys were selected from between 2015 and 2019 and factored to the 2016 base year using the factors in Table 2.

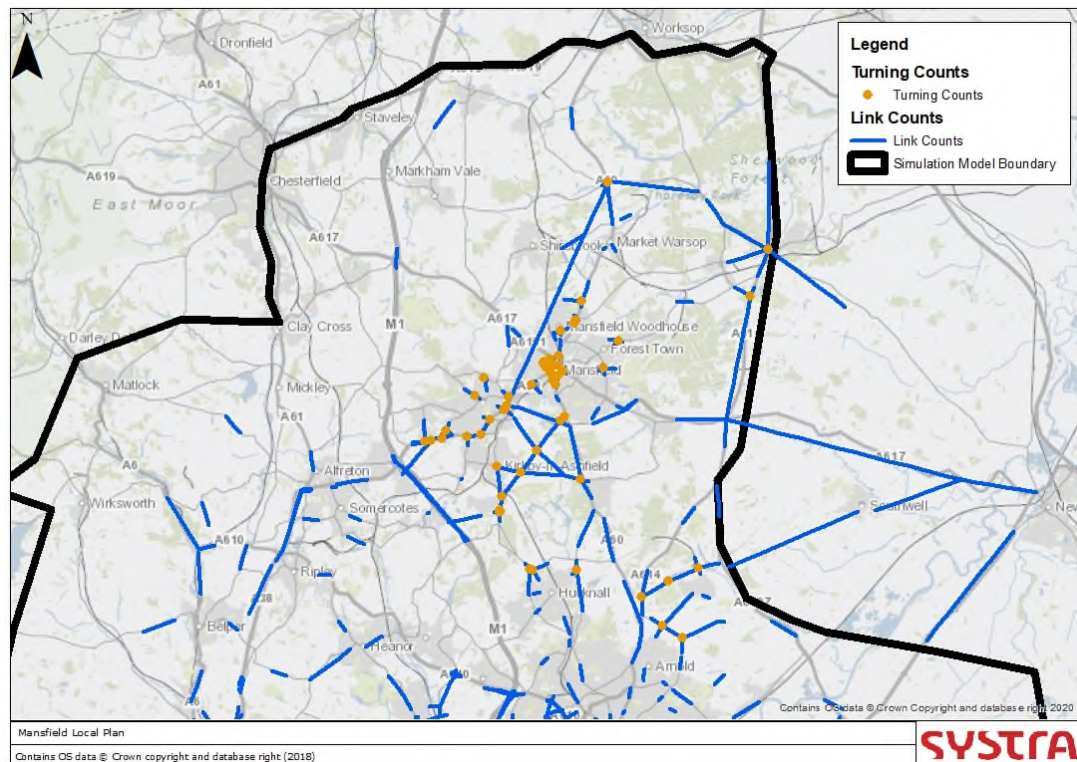


5.2 Count Cleaning and Checking

- 5.2.1 All counts 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.
- 5.2.2 Where counts were situated in locations that are in proximity to zone loading points, careful consideration was paid as to whether it was appropriate to use this data.
- 5.2.3 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. The links were updated or removed if issues were identified.
- 5.2.4 A total of 584 new individual counts were included for the AM peak, with 571 individual counts in the IP and 521 in the PM peak. These new counts were integrated into the existing EMGM count database.
- 5.2.5 Figure 9 shows the location of counts within the Mansfield AOI.



Figure 9. Count Locations – Mansfield



- 5.2.6 There is a high a density of counts within Mansfield centre and on strategic routes into and out of Mansfield, including along the A38 corridor and the A60 corridor.
- 5.2.7 Coverage of the North-West and South-East quarters of Mansfield is more sparse, due to the unavailability of suitable counts within these areas. Count coverage to the north of Mansfield in also sparse, however due to the decreased zone definition in this area, coupled with the likely extents of AOI's resulting from the Mansfield Local plan, this coverage is deemed suitable to account for key routes into and out of Mansfield.

5.3 Calibration and Validation Assignment

- 5.3.1 Counts have been assigned as either calibration or validation. Turning counts have predominantly been used in validation whilst link counts have predominantly been used in calibration.
- 5.3.2 Table 3 shows how the available count data for Mansfield was split between calibration and validation.

Table 3. Split between Calibration and Validation in the Mansfield Area

TIME PERIOD	TOTAL COUNTS	CALIBRATION	VALIDATION
AM	584	352	232
		60%	40%
IP	571	345	226
		60%	40%
PM	521	312	209
		60%	40%

5.3.3 Table 4 shows how the count data is split between calibration and validation, across the entire EMGM Model.

Table 4. Split between Calibration and Validation across the EMGM

TIME PERIOD	TOTAL COUNTS	CALIBRATION	VALIDATION
AM	2,497	1,459	1,038
		58%	42%
IP	1,608	1008	600
		63%	37%
PM	2,484	1,498	986
		60%	40%

5.4 Count Locations

5.4.1 Figures 10 and 11 show the locations of calibration and validation counts.

Figure 10. Count Locations – Mansfield

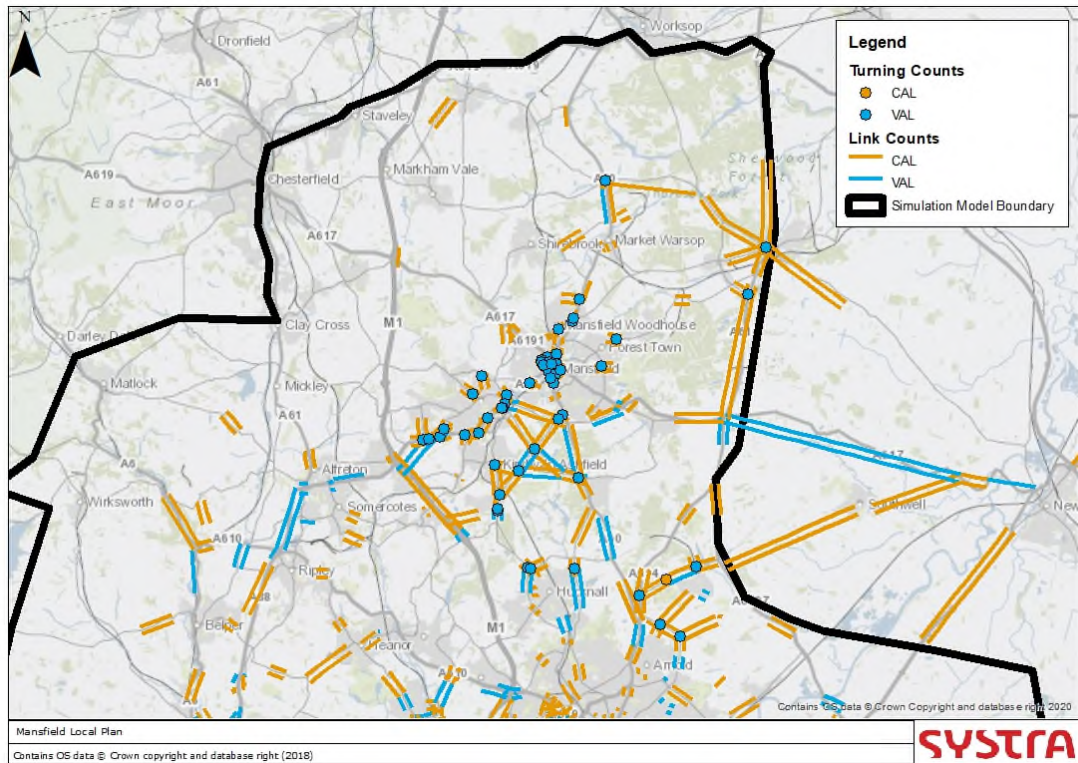
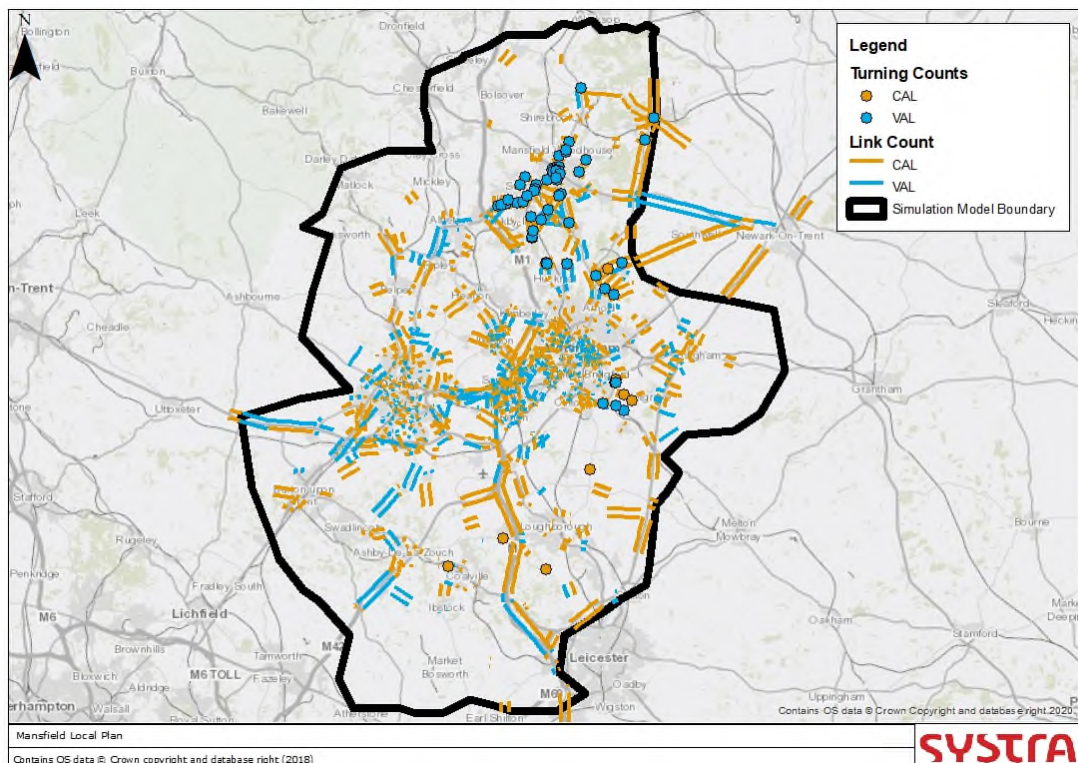


Figure 11. Count Locations - EMGM



6. HIGHWAY MATRIX ESTIMATION METHODOLOGY

6.1 Overview

- 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.
- 6.1.2 Matrix estimation was run for 7 loops, focussing on each vehicle type in turn (HGV, LGV and Car).
- 6.1.3 A series of constraints were applied to matrix estimation using the XAMAX function to minimise the ability of the program to make significant changes to demand to meet individual counts. The XAMAX setting was set to 5 for the Mansfield District area and adjacent zones, and 2 for the rest of the model to avoid significant, and potentially erroneous, demand changes in areas away from the Mansfield AOI.
- 6.1.4 ME was run through multiple iterations, with successive reviews made of the network and matrix undertaken until calibration and validation targets were met.

6.2 Changes to Matrix Totals

- 6.2.1 Tables 5, 6 and 7 provide the full highway matrix totals for pre and post matrix estimation for the morning peak, inter peak and evening peak. The overall trip levels have changed by 4.2% in the morning peak, by 4.8% in the inter peak and by 4.9% in the evening peak. These changes are inside the 5% recommendation set in the TAG guidance.
- 6.2.2 HGVs and LGVs experience notable increases in the AM and PM peaks of around 8%. This is likely due to the increased count definition in the Mansfield AOI which allows for a better fit between modelled and observed data compared to the original EMGM where the count data was relatively limited.



Table 5. Impact on Morning Peak matrix totals (vehicles)

	BEFORE MATRIX ESTIMATION	AFTER MATRIX ESTIMATION	PERCENTAGE DIFFERENCE
Cars	258,822	267,435	3.3%
LGV	31,765	34,070	7.3%
OGV	30,531	33,073	8.3%
Total	321,119	334,579	4.2%

Table 6. Impact on Inter Peak matrix totals (vehicles)

	BEFORE MATRIX ESTIMATION	AFTER MATRIX ESTIMATION	PERCENTAGE DIFFERENCE
Cars	190,735	199,481	4.6%
LGV	27,838	29,114	4.6%
OGV	28,847	30,795	6.8%
Total	247,421	259,390	4.8%

Table 7. Impact on Evening Peak matrix totals (vehicles)

	BEFORE MATRIX ESTIMATION	AFTER MATRIX ESTIMATION	PERCENTAGE DIFFERENCE
Cars	279,507	289,961	3.7%
LGV	25,426	26,986	6.1%
OGV	18,845	20,066	6.5%
Total	323,780	337,013	4.1%

6.3 Change In 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 12, 13 and 14 graphically represent this data for each peak, focussing on a total trip end basis (all user classes combined).
- 6.3.2 Table 8 conveys the correlation between prior and post matrix estimation trip ends at Origin and Destination levels. The correlation coefficient R^2 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^2 and a slope of between 0.99 and 1.01 with a value of 1.00 for each being a perfect fit. Where trip numbers are large it may be difficult to obtain a perfect slope and values of R^2 . A linear model with the following formula has been used:

$$\text{Post ME2 Trips} = a * \text{prior}$$

Table 8. Correlation between trip end totals between before and after matrix estimation

	ORIGIN TRIP ENDS		DESTINATION TRIP ENDS	
	R^2	slope	R^2	Slope
Morning Peak	0.995	1.025	0.995	1.017
Inter Peak	0.994	1.030	0.995	1.023
Evening Peak	0.994	1.028	0.994	1.017

6.3.4 The correlation is reasonable between the trip ends before and after matrix estimation. For each peak, the R^2 value, an indicator of goodness of fit between the two datasets, is greater than 0.98. The slope is marginally outside of guidance; however, it is considered reasonable given the size of the model and the use of the MRTM matrix which was developed to model inter-city movements on the strategic road network rather than urban movements.

Figure 12. Morning Peak Trip End Comparison

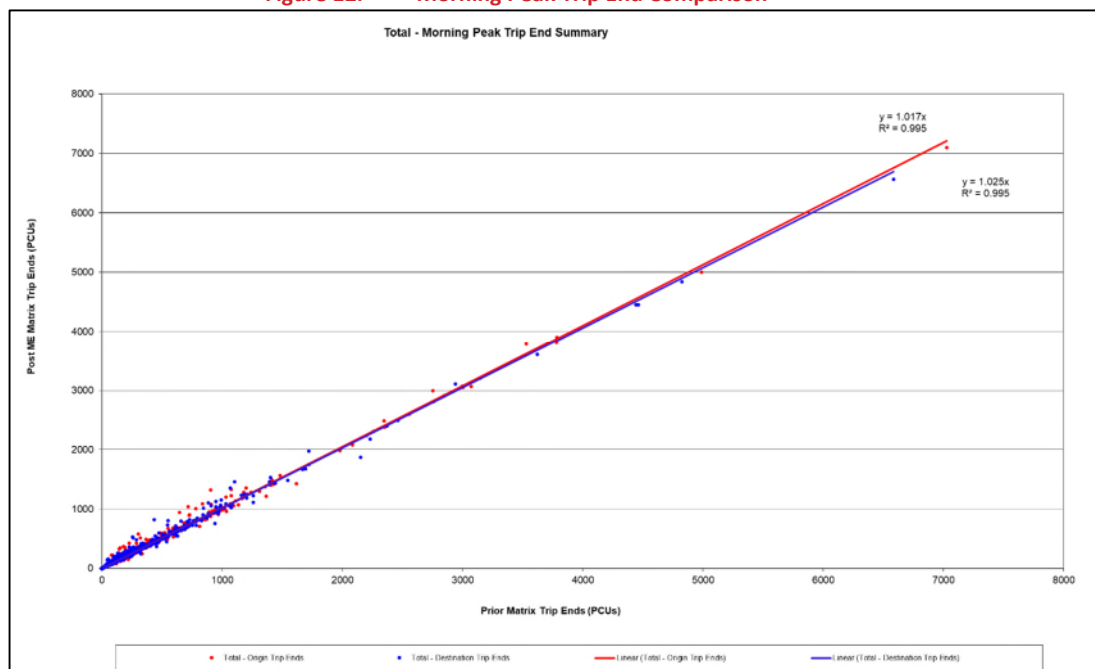


Figure 13. Inter Peak Trip End Comparison

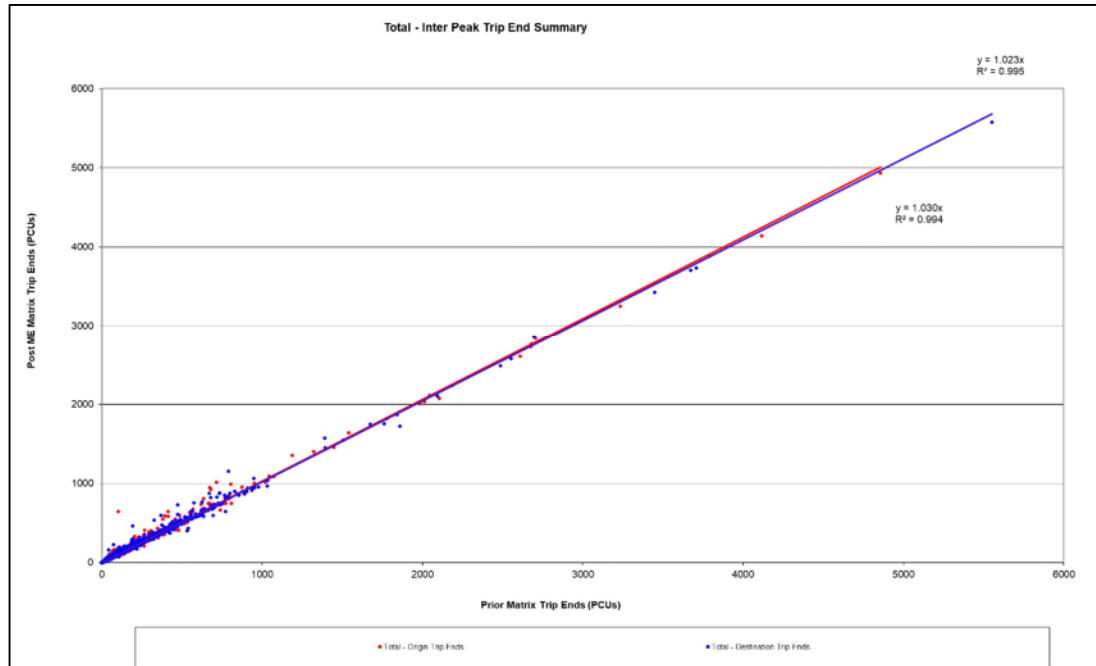
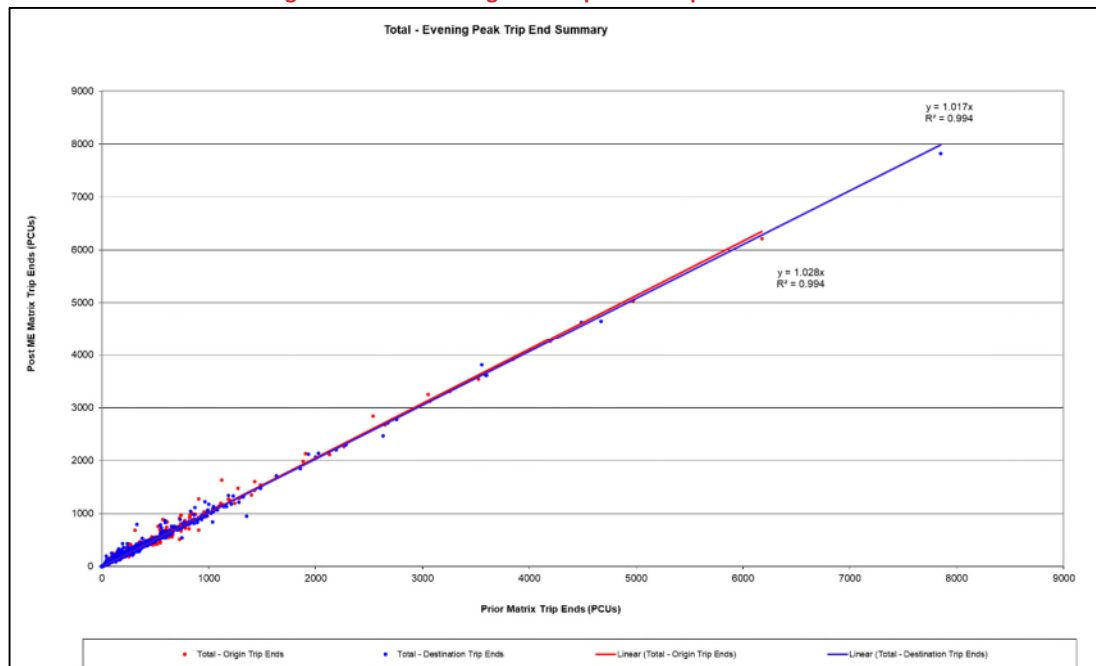


Figure 14. Evening Peak Trip End Comparison



6.5 Changes to Trip Length Distributions

- 6.5.1 The distributions of trip lengths within the model are shown in Figures 15, 16 and 17 for all vehicles combined by period. The blue bars represent trips for the prior matrix, whilst the purple bars represent the post matrix estimation trips.

Figure 15. Morning Peak Trip Length Distributions

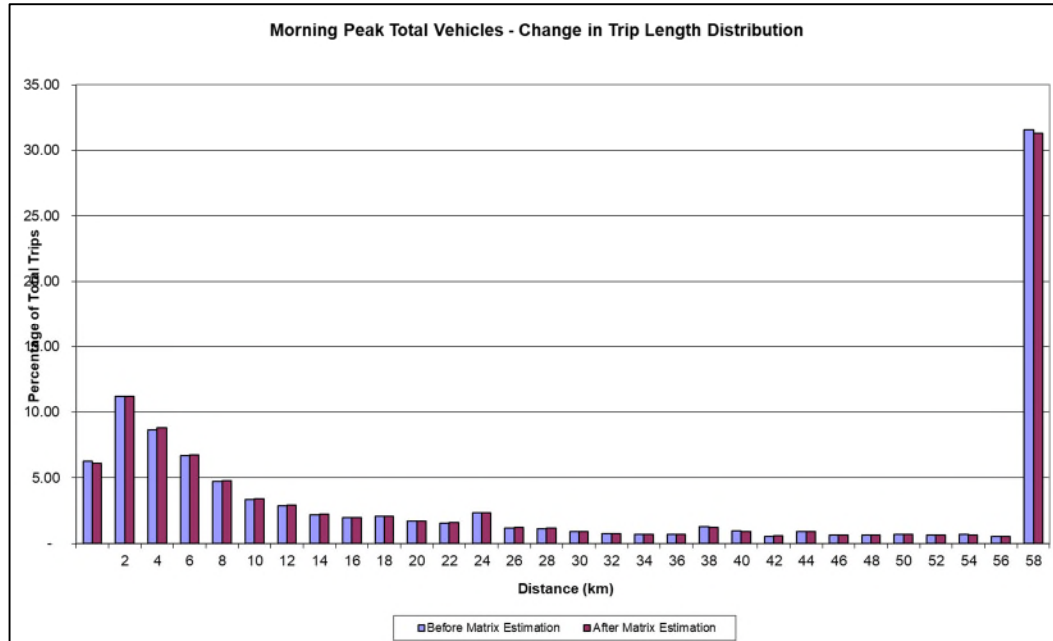


Figure 16. Inter Peak Trip Length Distributions

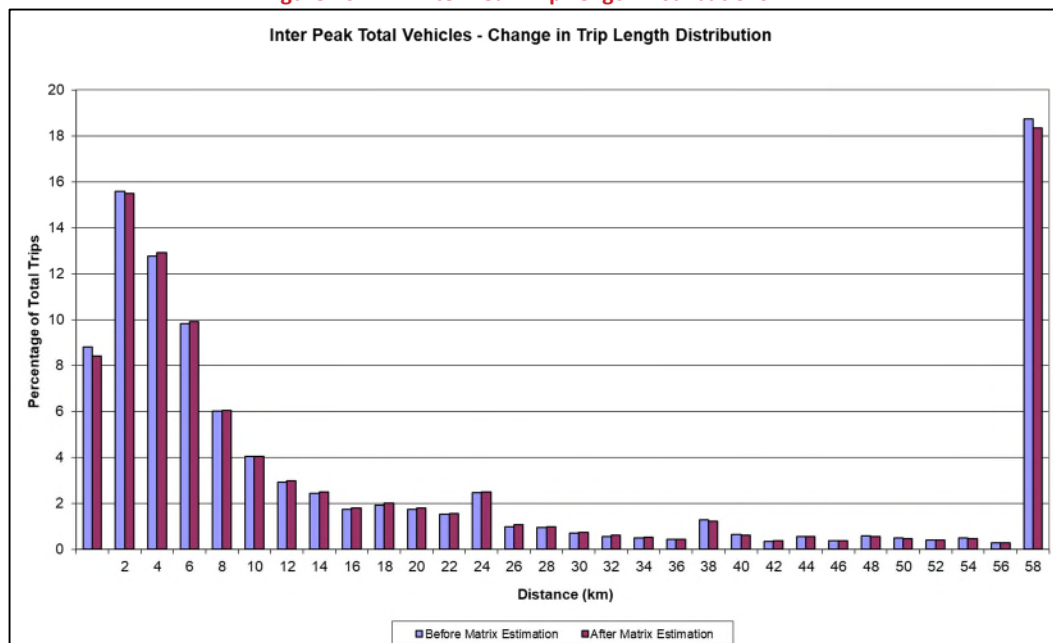
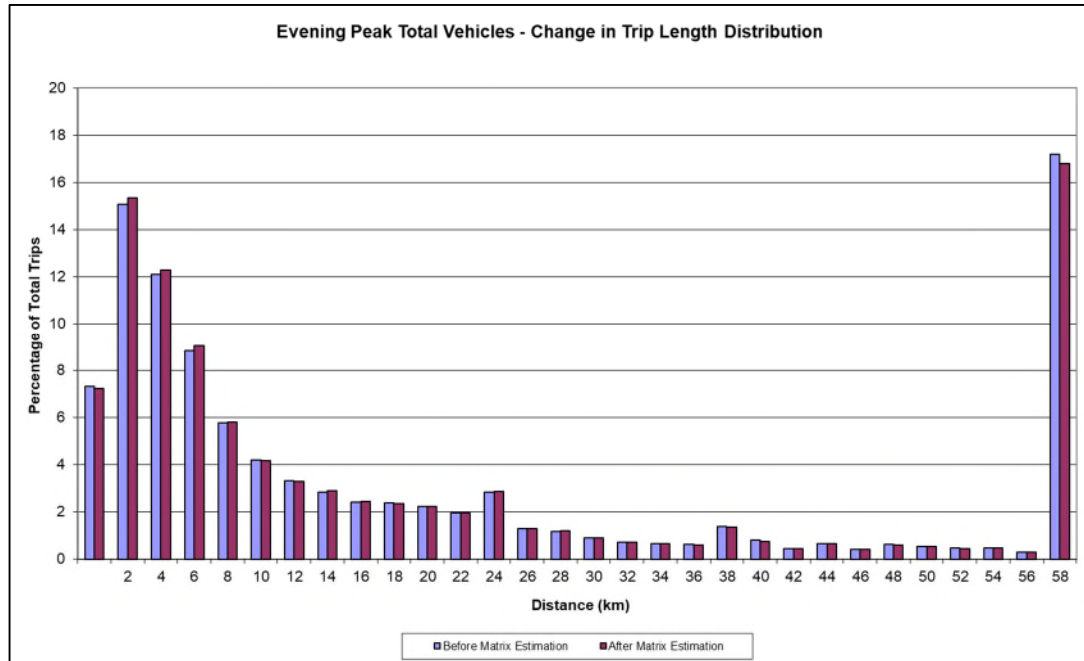


Figure 17. Evening Peak Trip Length Distributions



- 6.5.2 Table 9 shows the change in mean car trip lengths for the prior and post matrix estimation matrices for the morning evening and inter peaks, respectively. This includes all trips within the network, including exogenous trips that travel through the study area.
- 6.5.3 These show that matrix estimation changes the mean car trip lengths by 0.96% in the morning peak, 0.52% in the inter peak, and 1.31% in the evening peak. TAG advises that changes to mean trip length by matrix estimation should be no more than 5%.

Table 9. Average Car Trip Lengths

	BEFORE ME	AFTER ME	% DIFFERENCE
Morning	20.9	20.7	0.96%
Inter	20.4	20.3	0.52%
Evening	20.7	20.4	1.31%

- 6.5.4 Overall, the average trip length has changed by only a small amount in all time periods which 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 0.1%.
- % 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.
- % 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 four consecutive iterations.

7.1.2 Table 10 provides the convergence statistics for the revalidated model. The model is considered stable, with the change in flows between the final four loops being limited, and Delta and %GAP values within acceptable values.

Table 10. Network Convergence Statistics

CRITERION	TARGET	AM PEAK - REVALIDATED	PM PEAK - REVALIDATED
Delta	< 0.1%	0.0355	0.0264
%GAP	< 0.1%	0.035	0.017
Number of Loops	150	55	46
% of links with < 1% flow change on final iteration	98%	98.0	98.2
Final iteration one		98.0	98.2
Final iteration two		98.1	98.1
Final iteration three		98.1	98.3

8. FLOW VALIDATION

8.1 Guidelines

8.1.1 TAG Unit M3.1 Table 2 sets out validation guidelines for comparing modelled and observed traffic flows based on the level of flow in vehicles per hour (vph). These are:

- **For observed flows less than 700 vph**, at least 85% of model flows should be within 100 vph of observations.
- **For observed flows of between 700 and 2,700 vph**, at least 85% of model flows should be within 15% of observations.
- **For observed flows greater than 2,700 vph**, at least 85% of model flows should be within 400 vph of observations.

8.1.2 These guidelines are referred to as the TAG flow criteria in the text, and as ‘% Flow Criteria’ in the tables.

8.1.3 In addition to the flow criteria described above, TAG also refers to the GEH statistic, where.

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

and M is the modelled flow and C is the counted (observed) flow.

8.1.4 The GEH statistic is a form of Chi squared statistic, incorporating both relative and absolute errors. TAG recommends that greater than 85% of counted links should have a GEH value of less than 5.0.

8.1.5 TAG advice on counts meeting flow criteria and GEH criteria is as follows that:

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

8.1.6 The guidance also requires that for any cordons and screen lines, that the difference between the modelled flows and counts should be less than 5% of the counts in nearly all cases.



8.3 Performance of the AOI

- 8.3.1 Table 11 presents the calibration and validation statistics for the Mansfield AOI prior to the running of matrix estimation. The statistics are based on the GEH, DMRB, and the combined criteria.
- 8.3.2 The poor level of validation demonstrates that the use of matrix estimation is justified, with low validation results across all three peaks.
- 8.3.3 Table 12 presents the final calibration and validation statistics in the AOI after matrix estimation has been run. The statistics are based on the GEH, DMRB and the combined criteria.
- 8.3.4 Full count data is provided in Appendix C.

Table 11. Calibration and Validation Statistics Prior to Matrix Estimation

	CALIBRATION				VALIDATION			
	Counts	GEH < 5	DMRB	GEH < 5 or DMRB	Counts	GEH < 5	DMRB	GEH < 5 or DMRB
Morning Peak								
Cars	353	36%	44%	47%	231	48%	62%	61%
LGV	353	36%	97%	97%	231	48%	100%	88%
HGV	353	36%	97%	97%	231	48%	99%	99%
Total	353	36%	41%	42%	231	48%	60%	62%
Inter Peak								
Cars	344	36%	52%	53%	209	44%	67%	64%
LGV	344	36%	100%	100%	209	44%	109%	100%
HGV	344	36%	99%	99%	228	40%	99%	99%
Total	344	36%	47%	48%	228	40%	56%	57%
Evening Peak								
Cars	312	42%	49%	50%	209	44%	56%	55%
LGV	312	42%	100%	100%	209	44%	100%	100%
HGV	312	42%	99%	99%	209	44%	100%	100%
Total	312	42%	45%	46%	209	44%	54%	54%

Table 12. Calibration and Validation Statistics After Matrix Estimation

	CALIBRATION				VALIDATION			
	Counts	GEH < 5	DMRB	GEH < 5 or DMRB	Counts	GEH < 5	DMRB	GEH < 5 or DMRB
Morning Peak								
Cars	352	90%	91%	92%	232	81%	88%	83%
LGV	352	90%	97%	97%	232	81%	99%	88%
HGV	352	90%	98%	99%	232	81%	100%	100%
Total	352	90%	86%	89%	232	81%	87%	88%
Inter Peak								
Cars	345	84%	92%	92%	207	82%	98%	90%
LGV	345	84%	100%	100%	207	82%	93%	100%
HGV	345	84%	99%	99%	226	75%	100%	100%
Total	345	84%	88%	90%	226	75%	84%	84%
Evening Peak								
Cars	312	91%	91%	94%	209	78%	86%	85%
LGV	312	91%	99%	99%	209	78%	100%	85%
HGV	312	91%	99%	99%	209	78%	100%	100%
Total	312	91%	86%	89%	209	78%	84%	86%

8.3.5 Figures 18 to 20 show the distribution and performance of counts across the Mansfield area in the AM, IP and PM Peaks. Where counts have not met TAG guidance, the flow is shown as high (red) or low (blue).

Figure 18. Morning Peak Mansfield Count Performance

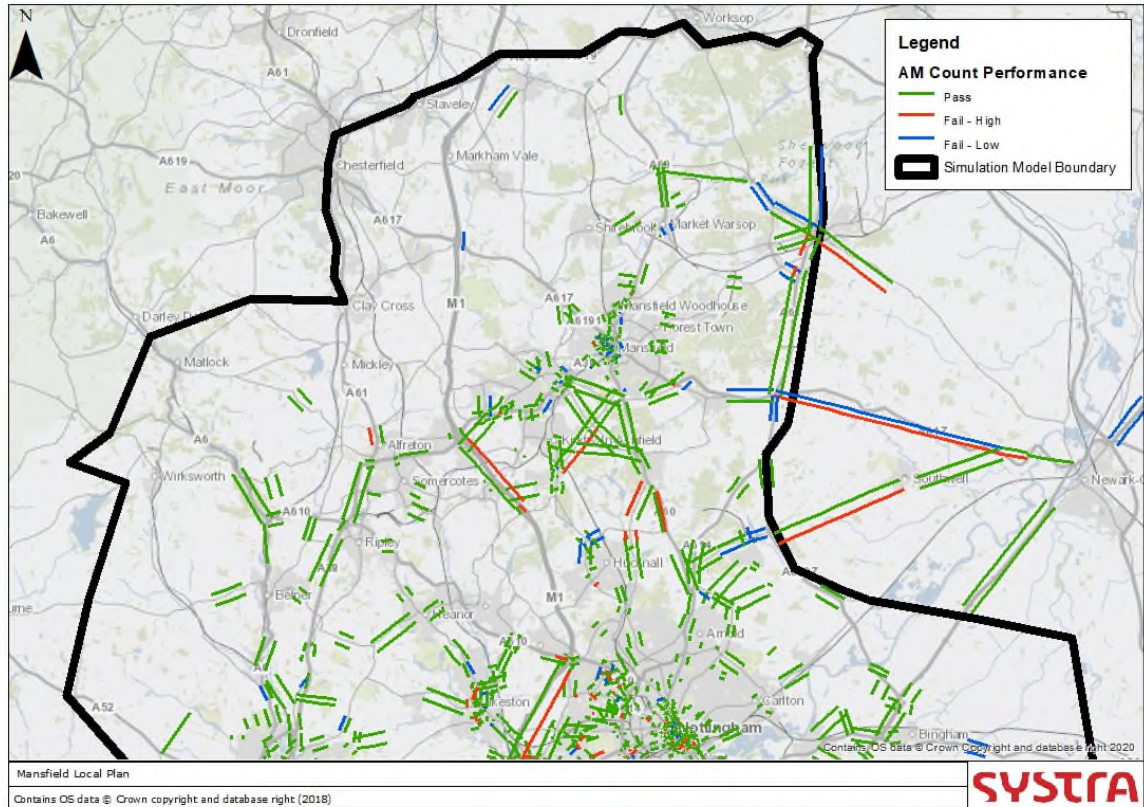


Figure 19. Inter Peak Mansfield Count Performance

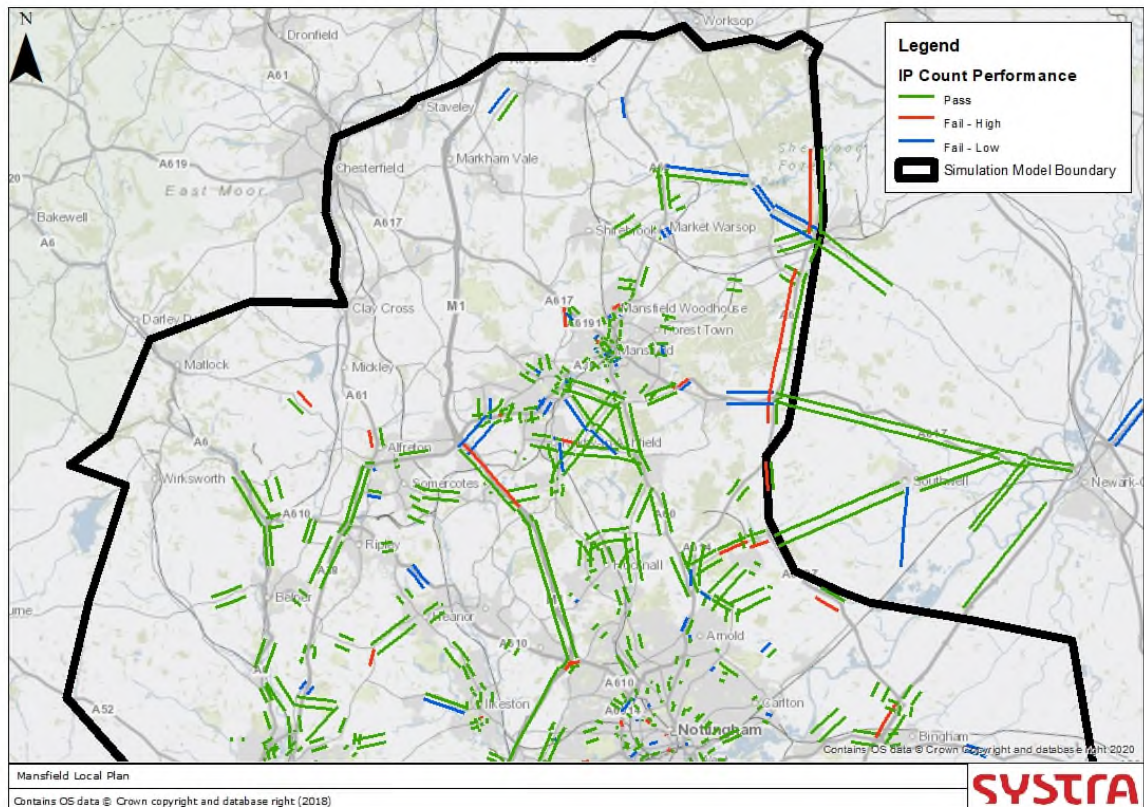
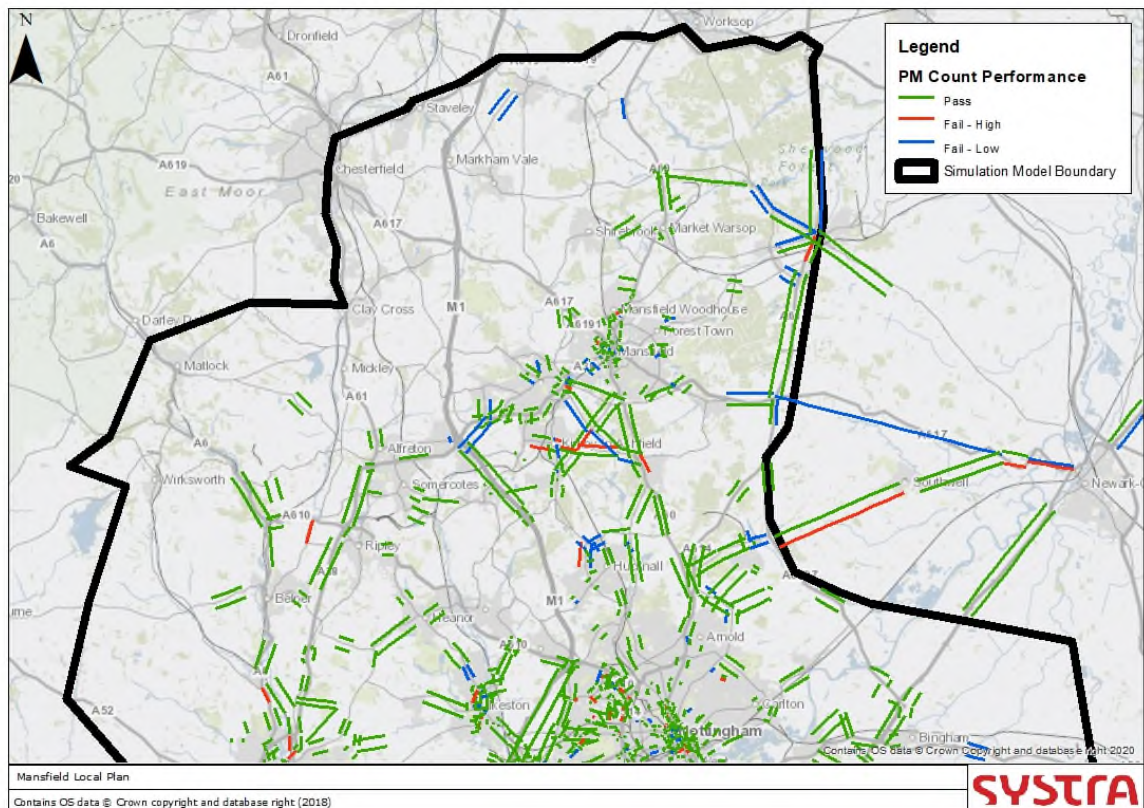


Figure 20. Evening Peak Mansfield Count Performance



8.4 Mansfield AOI Summary

- 8.4.1 An excellent level of validation has been achieved in both peak hours with values exceeding the recommended 85% target specified by TAG. This 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. The validation of LGVs and HGVs is also particularly strong, far exceeding the 85% TAG target.

8.5 Performance of the Full Model

- 8.5.1 Table 13 presents the final calibration and validation statistics across the full model after matrix estimation has been run. The statistics are based on the GEH, DMRB and the combined criteria. Figures 21 to 23 show the distribution and performance of counts across the full model area in the AM IP and PM Peaks.
- 8.5.2 An excellent level of validation has been achieved in both peak hours. Whilst the peaks are narrowly 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. The validation of LGVs and HGVs is particularly strong, far exceeding the 85% TAG target.



Table 13. Calibration and Validation Statistics in Full Model After Matrix Estimation

	CALIBRATION				VALIDATION			
	Counts	GEH < 5	DMRB	GEH < 5 or DMRB	Counts	GEH < 5	DMRB	GEH < 5 or DMRB
Morning Peak								
Cars	1214	90%	93%	94%	994	78%	85%	87%
LGV	1214	88%	97%	97%	994	82%	95%	95%
HGV	1459	87%	98%	99%	1038	85%	98%	98%
Total	1459	87%	89%	91%	1038	76%	83%	84%
Inter Peak								
Cars	783	88%	92%	93%	560	71%	81%	83%
LGV	783	87%	98%	99%	560	81%	96%	96%
HGV	1008	86%	97%	97%	600	81%	95%	95%
Total	1008	83%	89%	90%	600	70%	79%	80%
Evening Peak								
Cars	1183	91%	93%	94%	794	74%	82%	84%
LGV	1183	92%	99%	99%	794	85%	98%	98%
HGV	1498	93%	99%	99%	986	91%	98%	99%
Total	1498	88%	90%	92%	986	74%	80%	83%

Figure 21. EMGM Count Performance AM Full Model

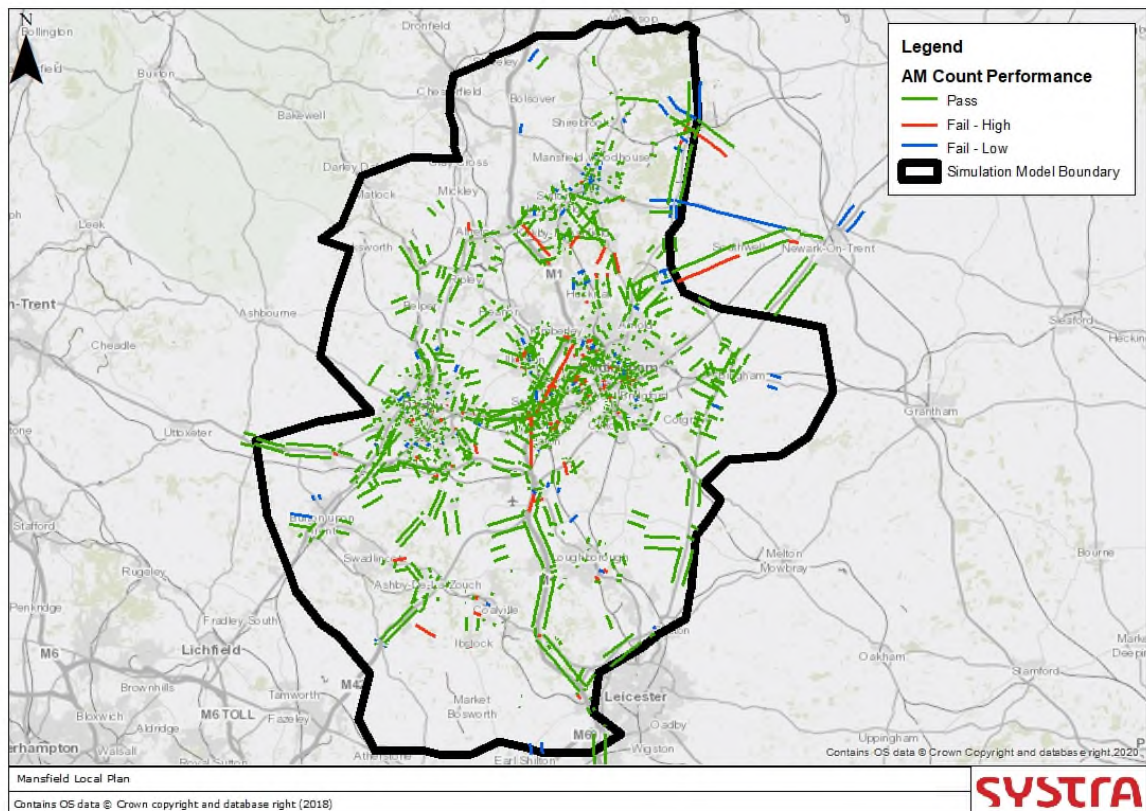


Figure 22. EMGM Count Performance IP Full Model

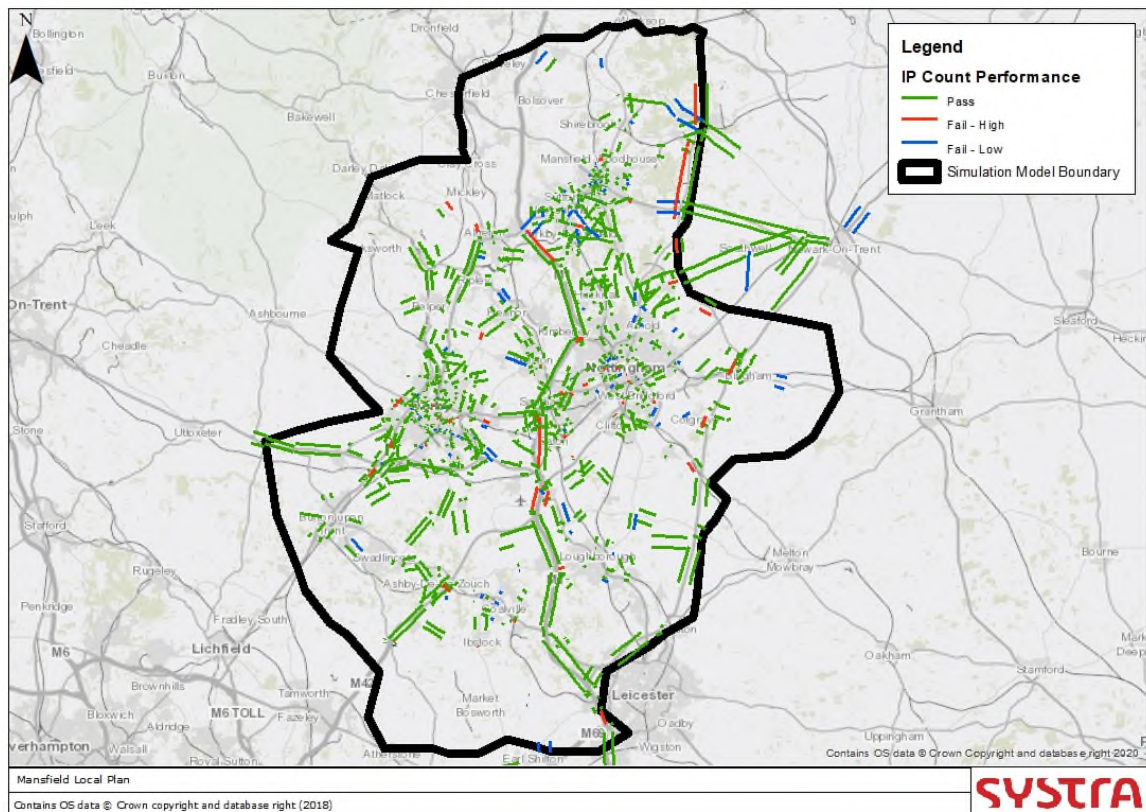
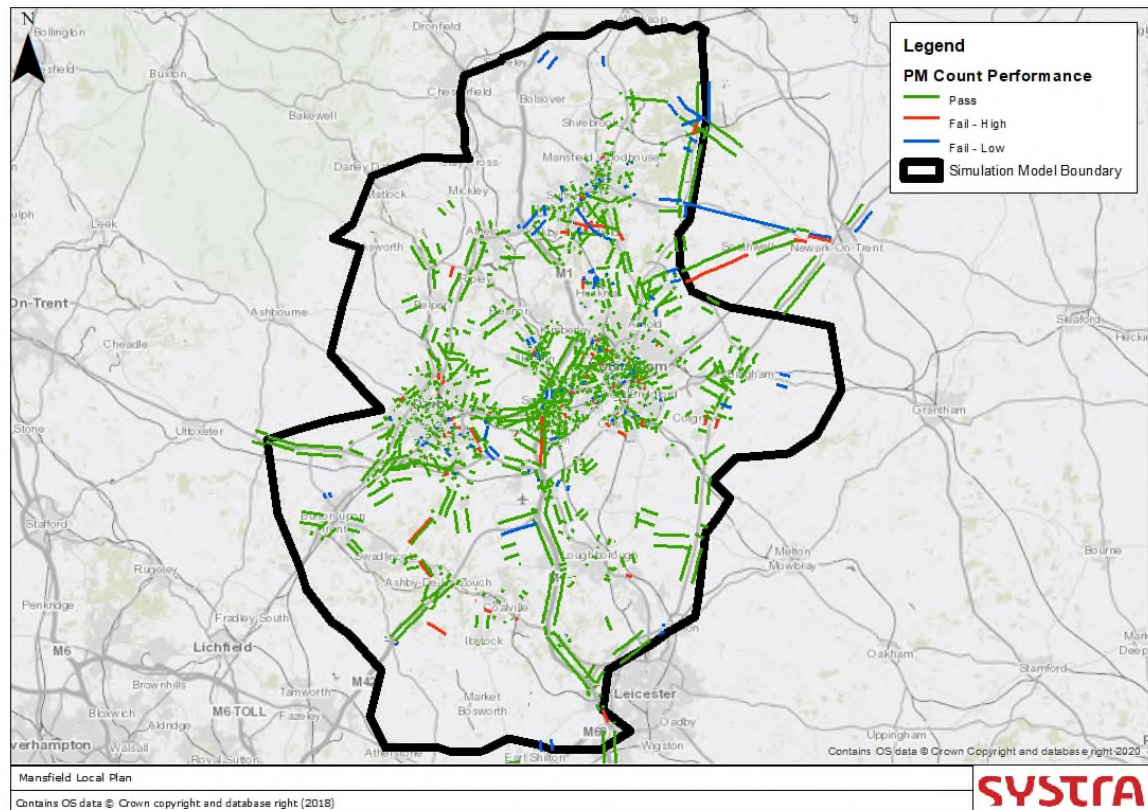


Figure 23. EMGM Count Performance PM Full Model



9. JOURNEY TIME VALIDATION

9.1 Introduction

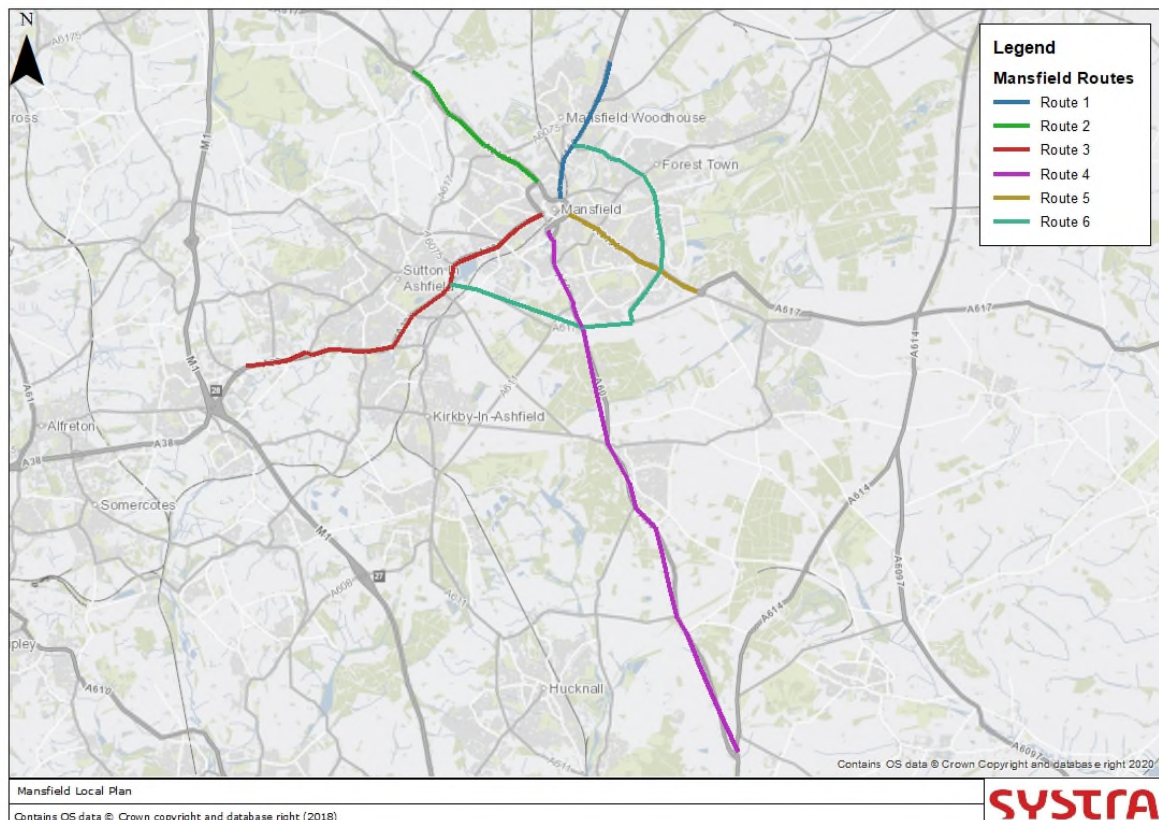
- 9.1.1 To support the validation of the Mansfield AOI data, observed journey time data for 6 routes was obtained to ensure the model was producing representative journey times on key routes into and out of the Mansfield AOI.

9.2 Route Locations

- 9.2.1 Morning Peak (08:00 – 09:00) and Evening Peak (17:00 – 18:00) observed journey times from Traffic Master GPS 2019 data was provided by Nottinghamshire County Council for a total of six routes shown in Figure 24. These routes cover:

- Route 1 – A60
- Route 2 – A6191
- Route 3 – A38
- Route 4 – A60
- Route 5 – A6191
- Route 6 – A6117/A617

Figure 24. Mansfield Route Locations



9.3 Journey Time Validation Guidelines

- 9.3.1 The TAG requirement (as set out in TAG Unit M3.1 Table 3) for journey time validation is that modelled times along the route should be within 15% of the observed time on more than 85% of routes.



- 9.3.2 The modelled times represent the time taken to travel between the start and end of the routes and have been calculated using the Saturn 'Joy Ride' facility.

9.4 Journey Time Validation

- 9.4.1 Tables 14 and 15 detail the journey time validation for each route in Mansfield. Additional information regarding journey time performance can be found in Appendix D.
- 9.4.2 In the morning peak 9 out of 12 (or 75%) of the journey time routes are within +/- 15% of the observed data which is narrowly outside the TAG guidance. In the evening peak, 11 out of 12 (or 92%) of routes are within +/- 15% of the observed data. This level of validation exceeds TAG guidance.



Table 14. Mansfield Routes AM Journey Validation

ROUTE	DIRECTION	OBSERVED	MODELLED	% CHANGE	TAG
Route 1	Outbound	425	500	18%	SLOW
	Inbound	678	532	-22%	FAST
Route 2	Outbound	566	602	6%	PASS
	Inbound	609	564	-7%	PASS
Route 3	Outbound	953	987	4%	PASS
	Inbound	1,063	1,050	-1%	PASS
Route 4	Outbound	1,244	1,199	-4%	PASS
	Inbound	1,308	1,208	-8%	PASS
Route 5	Outbound	439	549	25%	SLOW
	Inbound	537	553	3%	PASS
Route 6	Outbound	1,071	1,118	4%	PASS
	Inbound	1,036	1,088	5%	PASS

Table 15. Mansfield Routes PM Journey Validation

ROUTE	DIRECTION	OBSERVED	MODELLED	% CHANGE	TAG
Route 1	Outbound	587	519	-12%	PASS
	Inbound	577	521	-9%	PASS
Route 2	Outbound	616	580	-6%	PASS
	Inbound	540	565	5%	PASS
Route 3	Outbound	1,039	1,027	-1%	PASS
	Inbound	1,161	1,142	-2%	PASS
Route 4	Outbound	1,280	1,242	-3%	PASS
	Inbound	1,356	1,239	-6%	PASS
Route 5	Outbound	453	510	13%	SLOW
	Inbound	531	548	3%	PASS
Route 6	Outbound	1,053	1,074	2%	PASS
	Inbound	1,176	1,100	-6%	PASS

10. PUBLIC TRANSPORT MODEL

10.1 Public Transport Network Development

Review of Public Transport Services

- 10.1.1 In order to extend the model further north to encompass Mansfield, more services and routes have been added between Mansfield, Chesterfield and Worksop.
- 10.1.2 The bus and NET services were thoroughly reviewed against timetables provided on the websites listed below. All bus services were reviewed and amendments made if required:
- Nottingham City Transport: <http://www.nctx.co.uk/>;
 - Travel Line: <https://www.traveline.info/>;
 - Derbyshire Bus Information: <http://www.derbybus.info/maps/>;
 - Derby Connected: <http://www.derbyconnected.com/getting-around-derby/buses/>
 - Bus Times.org: <https://bustimes.org/>
 - Geopunk; <https://www.geopunk.co.uk/>
 - Various bus operator sites.
- 10.1.3 All regular bus services were included in the model with all the major local bus operators represented, school buses and coaches were excluded. Figure 25 illustrates the spatial distribution of bus routes across the network. Figure 26 illustrates the NET services within Nottingham City. Higher frequency bus and NET routes are shown by a darker colour.



Figure 25. Bus Routes

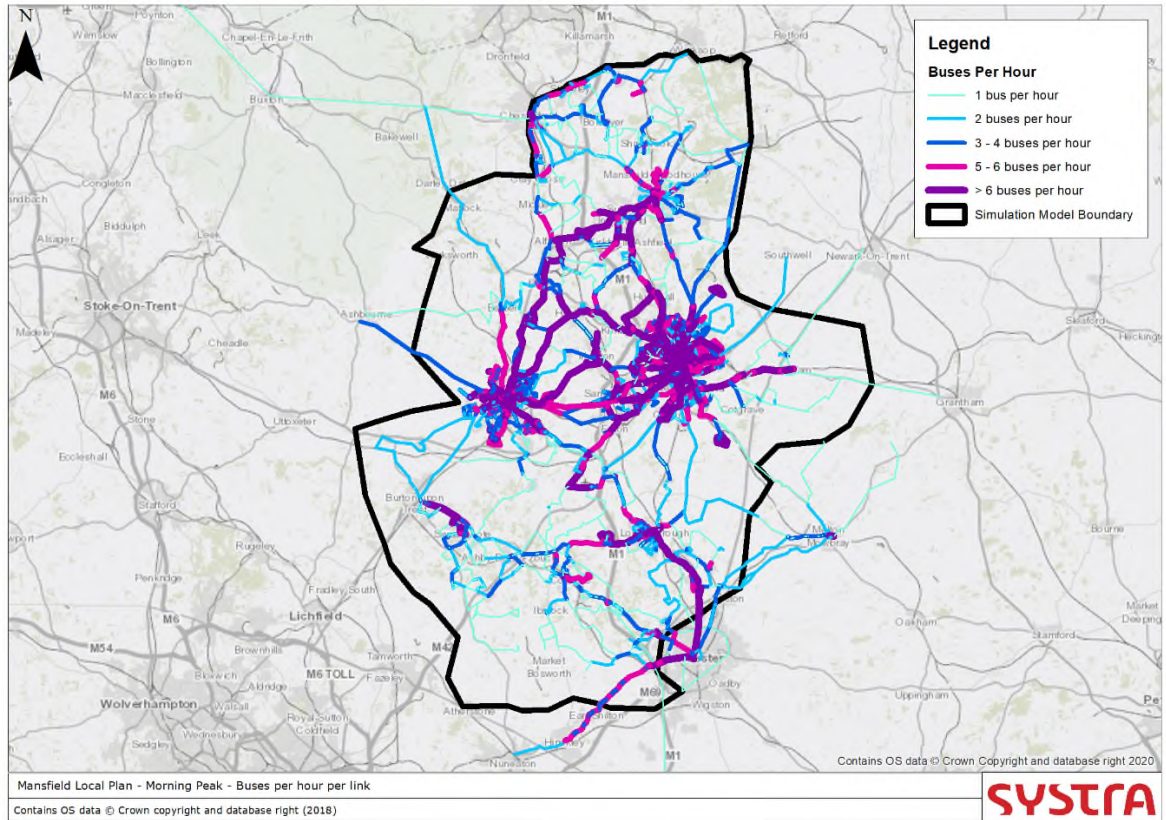
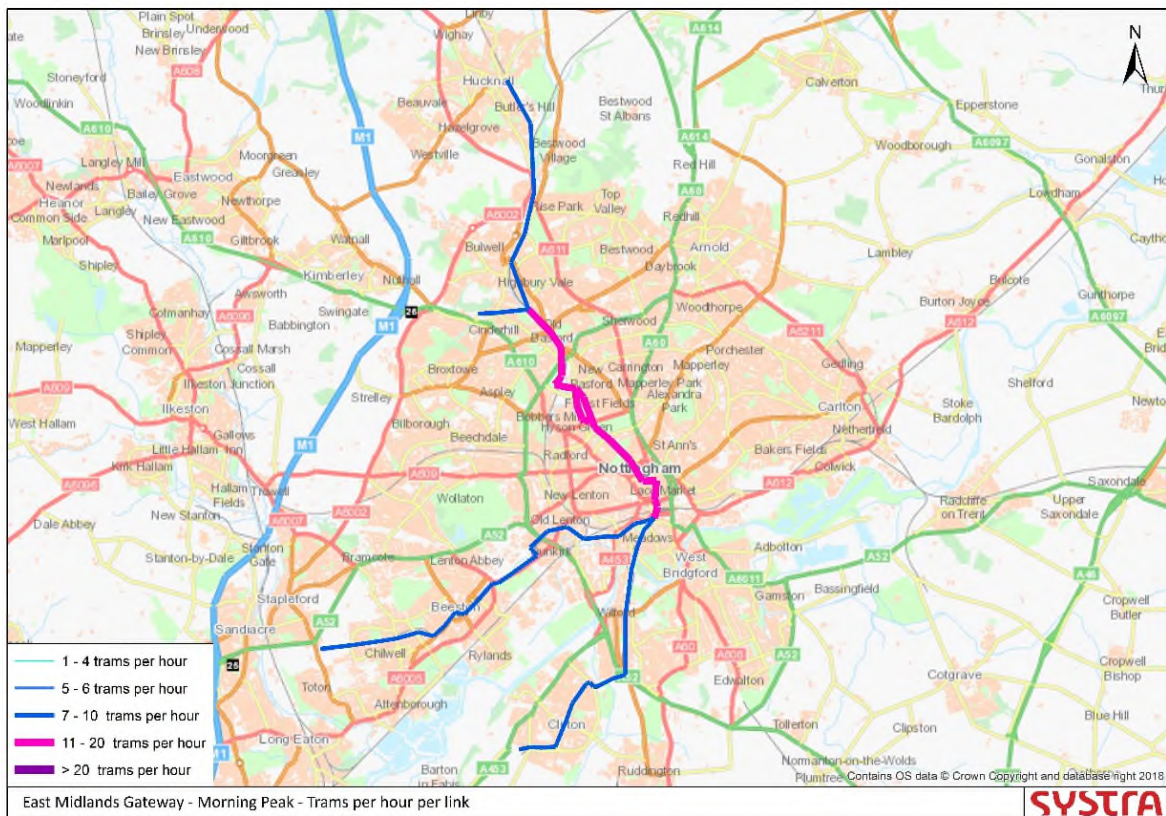
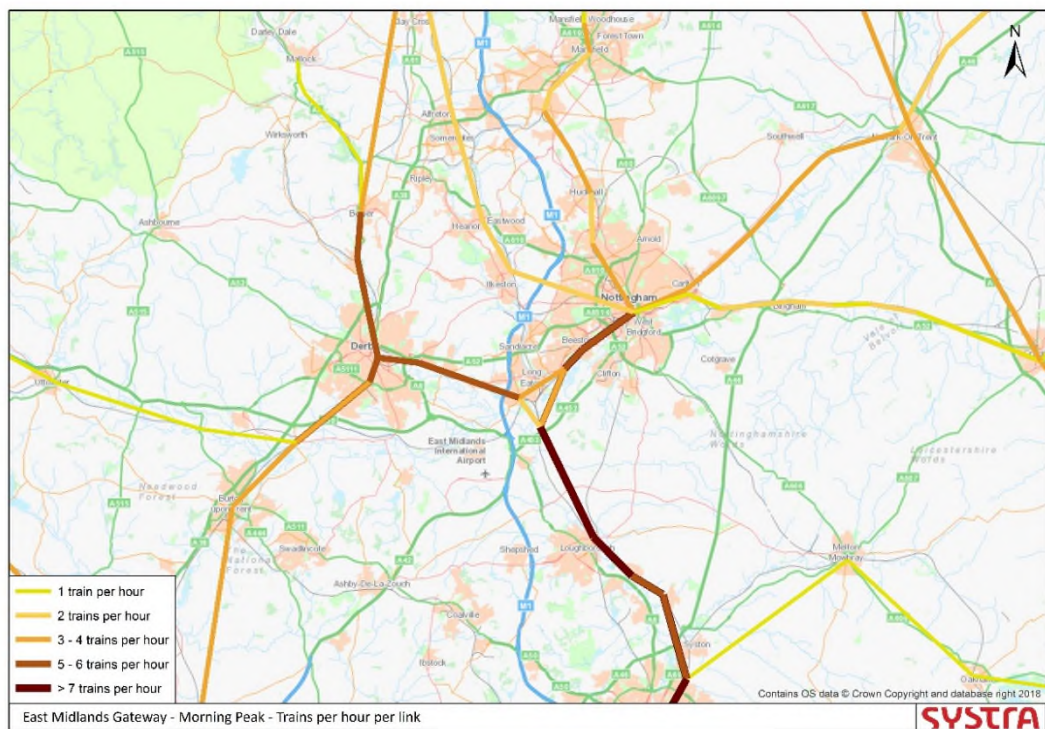


Figure 26. Net Services



- 10.1.4 Rail services were taken from the Planet Midlands (PfM) Base Model (version 7.1) and converted from Emme format to CUBE Voyager. This approach was agreed with HS2 to ensure consistency of rail services between the two models. Both models have a 2016 base year and therefore services are comparable.
- 10.1.5 As the Planet Midland model represents a three hour AM peak, model services were reviewed against actual/public timetables for key stations around the network, particularly Leicester, Derby, Nottingham and Mansfield Town & Woodhouse. This information was used to derive typical AM, IP and PM peak hour services.
- 10.1.6 Figure 27 shows the distribution and frequency of AM peak hour rail services in the model.

Figure 27. Rail Services



Fares

- 10.1.7 The fare structure within the Mansfield AOI is consistent with the rest of the EMGM.
- 10.1.8 Fare levels are based on single ticket journeys, however, a global factor for each ticket type was applied to take account of season ticket, smart card and multi ticket usage.
- 10.1.9 The fare tables used within the model are shown in Table 16 for the peak hours and Table 1717 for off peak.

Table 16. Peak Hour Fares (£)

	TRENT BARTON /STAGECOACH	NCT BUS /HULLEYS /VECTARE	BUS P&R	NET	RAIL
Fare Type	Distance	Distance	Flat	Flat	Distance
Board Fare	1.61	1.61	1.03	1.58	2.20
Distance Band*					
0 (0)	0	-	-	-	0
5 (8)	0.44	1.25	-	-	0
10 (30)	1.32	-	-	-	5.10
20 (80)	2.49	1.83	-	-	18.65
99 (320)	5.50	2.70	-	-	93.65

* () indicates rail distance bands

Table 17. Off Peak Hour Fares (£)

	TRENT BARTON /STAGECOACH	NCT BUS /HULLEYS /VECTARE	BUS P&R	NET	RAIL
Fare Type	Distance	Distance	Flat	Flat	Distance
Board Fare	1.61	1.61	1.03	1.58	2.20
Distance Band*					
0 (0)	0	-	-	-	0
5 (8)	0.44	1.25	-	-	0
10 (32)	1.32	-	-	-	3.65
20 (160)	2.49	1.83	-	-	23.65
99 (320)	5.50	2.70	-	-	58.65

* () indicates rail distance bands



10.2 Available Data

- 10.2.1 Requests were made to the bus operators for passenger counts and journey times via Nottinghamshire County Council, however, no information was made available.

10.3 Model Checks

Journey Time Validation

- 10.3.1 Modelled journey times for five key bus routes around Mansfield were compared against timetabled information. All five routes were within 15% of observed times and therefore meet TAG guidance. Figures 28 –30 provide journey time graphs for each peak and route.

Figure 28. Mansfield Journey Time Comparison – AM Peak

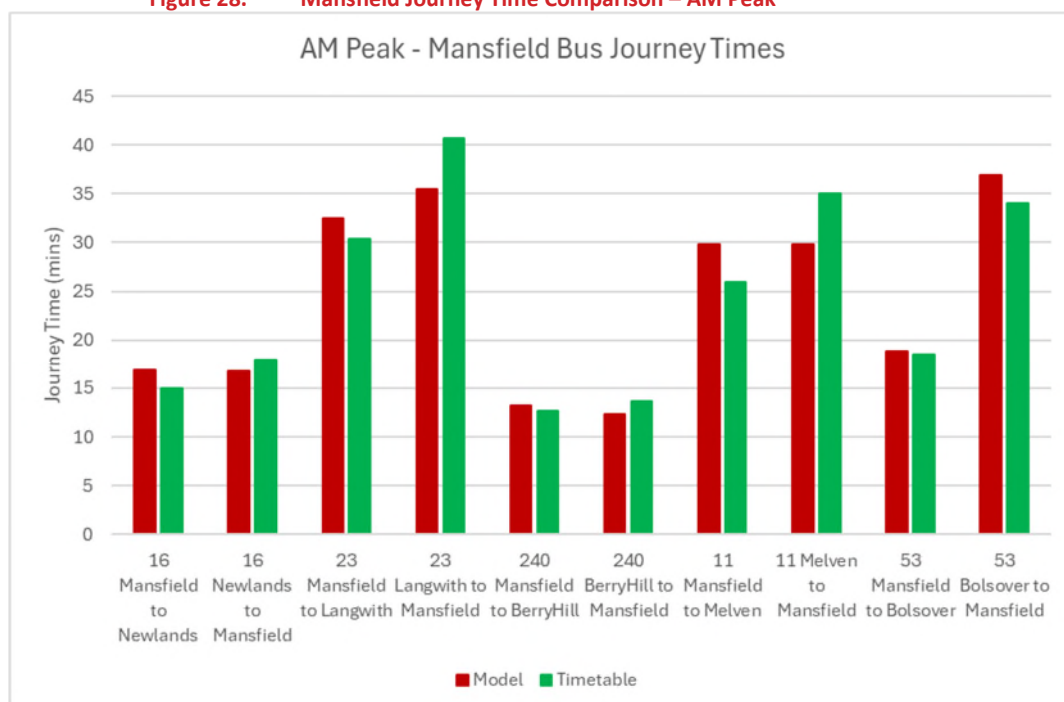


Figure 29. Mansfield Journey Time Comparison – IP Peak

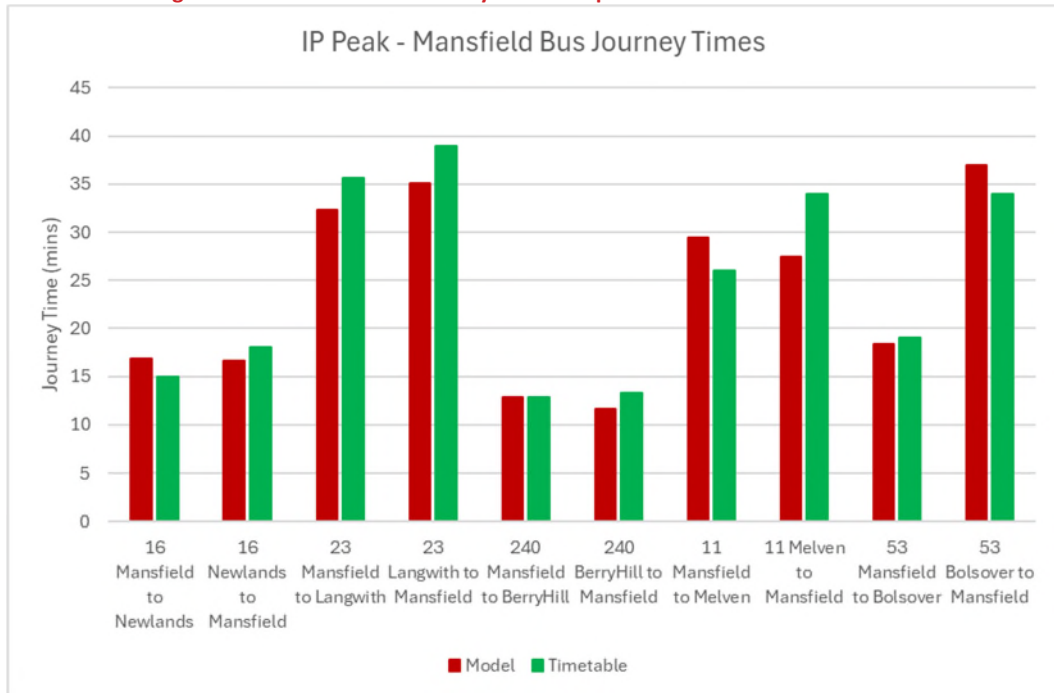
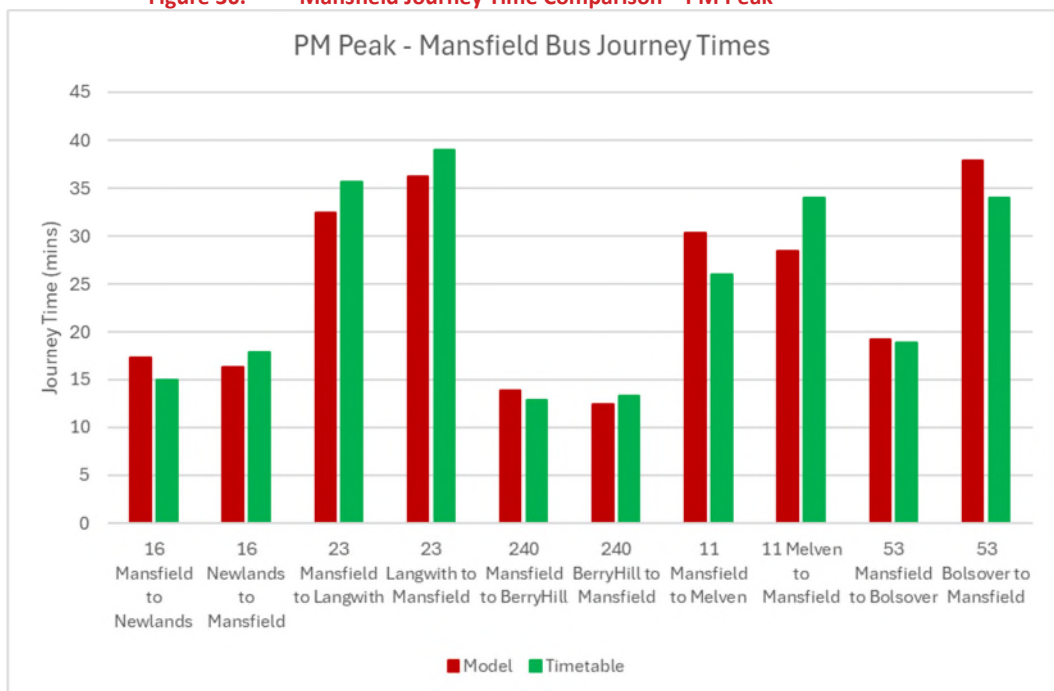


Figure 30. Mansfield Journey Time Comparison – PM Peak



11. VARIABLE DEMAND MODEL

11.1 Overview

- 11.1.1 The expansion of the model to include the Mansfield AOI has been undertaken. This chapter outlines the adjustments made to the Variable Demand Model and subsequent checks to ensure that the model is robust tool for forecasting.

11.2 Disaggregation of Trip Ends

- 11.2.1 The basic input data required by the demand model for the base year and any future years are total numbers of trip productions and trip attractions to and from each model zone.
- 11.2.2 These productions and attractions are totals for the 12-hour period covering the AM, Inter-peak and PM periods between 0700 and 1900, and as raw inputs they are not segmented by mode.
- 11.2.3 The trip production totals are segmented by journey purpose and, within each of these, by car availability category. The trip attractions for each journey purpose are not segmented in this way but expressed simply as totals to each zone.
- 11.2.4 Trip Ends were disaggregated using the same codepoint approach as the assignment matrices.

Conversion of External to Internal Demand

- 11.2.5 Internal and external zones are treated differently by the demand model, with the demand response models only being applied to the Internal zones shown shaded in the table below:



Table 18. Trip matrix movements processed by Demand Model

		Attraction Zone	
		Internal	External
Production Zone	Internal		
	External		

- 11.2.6 In the original EMGM, Mansfield District was comprised of a mix of internal and external zones. As part of the expansion all zones within the Mansfield AOI were made internal with the same level of detail as the remainder of the EMGM internal simulation areas.

11.3 Demand Model Parameters

- 11.3.1 The parameters applied by the demand model were expanded to cover the new zones with information applied from the parent zones in areas of disaggregation and expansion.

- 11.3.2 The Splitting Factors which convert from all-day Production-Attraction demand to assignment hour Origin-Destination demand were updated based on information from the parent zones in the areas of disaggregation and expansion. These include:

- OD to PA factors.
- Day to Period factors.
- Period to Hour Factors.
- Occupancy factors.

- 11.3.3 The Incremental Adjustment Factors (IAFs) were also recalculated as part of the model update.

11.4 Realism Testing

- 11.4.1 Once a variable demand model has been changed, it is essential to ensure that it behaves 'realistically'. Realism testing was undertaken in accordance with TAG (Transport Analysis Guidance) M2 section 6.4. by changing the various components of travel costs and times and checking that the overall demand response accords with general experience.

- 11.4.2 Three tests were carried out in the base year using different “Do Something” scenarios. The tests involved calculating the elasticities of car fuel cost, car journey time, and public transport (PT) fares, and ensuring they fell within TAG defined ranges.



Fuel Test

- 11.4.3 Changes in fuel price are imposed on the model by changing two sets of inputs: data in the SATURN assignment model's network data file, and data used in calculating generalised costs for use by the choice models.
- 11.4.4 The PPK (pence per kilometre) values for each purpose/user class were adjusted to the values presented in Table 19.

Table 19. PPK values used in Base and Fuel Realism Test

PURPOSE	BASE	10% FUEL INCREASE	% CHANGE
Employer's Business	13.90	14.43	4%
Commute	10.23	10.87	6%
Other	10.23	10.87	6%

- 11.4.5 Section 6.4 of TAG Unit M2-1 indicated that plausible targets for car fuel cost elasticities for those trips that are subject to the processes of the demand model are:
- An overall average value within the range -0.25 to -0.35;
 - For employer's business trips, a value of around -0.1;
 - For discretionary (i.e. Other) trips, a value of around -0.4; and
 - For commuting trips, a value around the average, i.e. approximately -0.3.
- 11.4.6 It is also suggested in TAG Unit M2-1 paragraph 6.4.22 that elasticities will be more plausible if those for the peaks are weaker (that is, less negative) than those in the inter-peak when all purposes are considered together (i.e. the Total).
- 11.4.7 The results for each time period and journey purpose, for trips excluding external to external movement, are shown in Table 20 below. All elasticities are within TAG guidance.



Table 20. Fuel Price Realism Test Results

PURPOSE	AM	IP	PM	12HR
Home Based Work	-0.19	-0.20	-0.21	-0.20
Home Based Employers Business	-0.11	-0.10	-0.12	-0.11
Home Based Other	-0.44	-0.38	-0.43	-0.41
Non-Home Based Employers Business	-0.19	-0.18	-0.21	-0.19
Non-Home Based Other	-0.23	-0.19	-0.22	-0.21
Total	-0.26	-0.27	-0.27	-0.26

Fares Test

- 11.4.8 Sensitivity to public transport fares was tested by increasing all values in the Voyager Public Transport assignment model's fare tables by 10% and running the model to convergence.
- 11.4.9 Guidance in TAG Unit M2-1, paragraph 6.4.26, states that the elasticity of public transport trips in response to changes in fares should lie in the range -0.2 to -0.9. Values close to -0.2 are regarded as unlikely, suggesting that values closer to the higher end of the range are more plausible.
- 11.4.10 Elasticities are calculated using the same formula as in the fuel price sensitivity test. The results for each time period and journey purpose, for trips excluding external to external movement, are shown in Table 21 below. All elasticities are within TAG guidance.

Table 21. PT Fare Realism Test Results

PURPOSE	AM	IP	PM	12HR
Home Based Work	-0.48	-0.47	-0.47	-0.47
Home Based Employers Business	-0.64	-0.62	-0.65	-0.64
Home Based Other	-0.34	-0.44	-0.56	-0.44
Non-Home Based Employers Business	-0.89	-0.76	-0.88	-0.83
Non-Home Based Other	-0.65	-0.64	-0.65	-0.65
Total	-0.41	-0.48	-0.54	-0.48

Journey Time Test

- 11.4.11 Sensitivity to car journey time was tested by increasing the total generalised costs for car trips within the demand model by 10% and running the demand model to convergence.



- 11.4.12 Guidance in TAG Unit M2, paragraph 6.4.42 states that the elasticity of car trips in response to changes in journey time should not be stronger than -0.75.
- 11.4.13 The results are displayed in the tables below. Comparing the values given in Table 22 and Table 23 with the target values identified in paragraph 11.4.12, it is seen that all values are within the required range.

Table 22. Highway Journey Time Realism Test Results (Converged, Vehicles)

PURPOSE	AM	IP	PM	12HR
Home Based Work	-0.08	-0.12	-0.16	-0.12
Home Based Employers Business	-0.15	-0.07	-0.14	-0.12
Home Based Other	-0.11	-0.06	-0.12	-0.09
Non-Home Based Employers Business	-0.31	-0.25	-0.38	-0.28
Non-Home Based Other	-0.12	-0.04	-0.12	-0.07
Total	-0.10	-0.07	-0.14	-0.10

Table 23. Highway Journey Time Realism Test Results (Converged, Vehicle Kilometres)

PURPOSE	AM	IP	PM	12HR
Home Based Work	-0.91	-0.98	-1.01	-0.96
Home Based Employers Business	-0.88	-0.84	-0.92	-0.88
Home Based Other	-1.76	-1.59	-1.74	-1.66
Non-Home Based Employers Business	-1.58	-1.56	-1.81	-1.61
Non-Home Based Other	-1.13	-0.96	-1.12	-1.03
Total	-1.17	-1.28	-1.26	-1.24

- 11.4.14 In conclusion, there are no abnormal behaviours that would give reason to question the realism of the updated model, as all values for each realism test fall within TAG's requirements.



12. SUMMARY AND CONCLUSIONS

12.1 Overview

- 12.1.1 A local revalidation has been conducted on EMGM, a large strategic model, to better assess the Mansfield Local Plan. This revalidation process includes the expansion of the model north to adequately cover the Mansfield AOI.
- 12.1.2 The network coding in the Mansfield area was expanded, reviewed, and validated. Matrix estimation was then carried out to calibrate the highway model. Validation has been assessed on traffic count data from the existing EMGM count database further supplemented with counts within the Mansfield AOI.
- 12.1.3 An excellent level of highway validation has been achieved in both peak hours with values exceeding the recommended 85% target specified by TAG. This 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. The validation of LGVs and HGVs is also particularly strong, far exceeding the 85% TAG target.
- 12.1.4 The public transport model has also been enhanced to include more services and routes within Mansfield and between Mansfield, Chesterfield and Worksop. A check of modelled journey times against timetabled information has been carried out for key routes within the Mansfield area. This demonstrates a close correlation between modelled and timetabled journey times, with all routes being within +/- 15% of the timetabled times. Further checks were not possible due to lack of available data.
- 12.1.5 The Variable Demand Model has been updated to represent changes to the model zoning system and highway/public transport networks and appropriate realism testing has been carried out in line with TAG to ensure that the model sensitivity is within TAG guidelines.
- 12.1.6 The expanded EMGM is considered fit for purpose for the assessment of the Mansfield Local Plan.



APPROVAL

Version	Name		Position	Date	Modifications
1	Author	Ben Lander	Senior Consultant	24/07/2024	V1
	Checked by	Rhian Collier	Associate Director	24/07/2024	
	Approved by	Duncan Irons	Director	24/07/2024	
2	Author	Ben Lander	Senior Consultant	12/09/2024	V2 addressing NCC comments
	Checked by	Rhian Collier	Associate Director	12/09/2024	
	Approved by	Duncan Irons	Director	12/09/2024	

