Central Lancashire Highway Transport Model Update

Base Year 2019 Recalibration Report

02 | 3

04 February 2021

Lancashire County Council

B2327FTB

Central Lancashire Highway Transport Model Update

Project No: B2327FTB
Document Title: Base Year 2019 Recalibration Report
Document No.: 02
Revision: 3
Document Status: <DocSuitability>
Date: 04 February 2021
Client Name: Lancashire County Council
Client No: B2327FTB
Project Manager: Sergey Makov
Author: Juan Pablo Fonseca Zamora
File Name: CLHTM_Present_Year_Validation_rev3.docx

Jacobs Consultancy Ltd.

1 City Walk,
Leeds
LS11 9DX
UK

www.jacobs.com

Document history and status

Revision	Date	Description	Author	Checked	Reviewed	Approved
0	04/08/20	Draft Version for LCC review	Juan Fonseca, Matthew Jessop	Sabin Karimbil	Sergey Makov	Sergey Makov
1	25/09/20	Draft for DfT review	Juan Fonseca, Matthew Jessop	Sabin Karimbil	Sergey Makov	Sergey Makov
2	16/11/20	Updated to address DfT comments	Sabin Karimbil Matthew Jessop	Stuart Rees	Sergey Makov	Sergey Makov
3	04/02/2021	Report updated to address further comments from DfT received on 21.01.22 and include updated cal/val resuls following correction of minor network coding error in central Preston	Sabin Karimbil	Juan Fonseca	Sergey Makov	Sergey Makov

Revision	Date	Description	Author	Checked	Reviewed	Approved

Contents

Figures

Tables

1. Introduction

1.1 Background and Scope

During 2015-2016, Jacobs built a TAG compliant RSI based highway traffic model in SATURN to support Central Lancashire's ambitious programme of economic growth and associated infrastructure improvements set out in the Preston City Deal and Central Lancashire Highways & Transport Masterplan. The City Deal area and key transport interventions are shown in Figure 1-1.

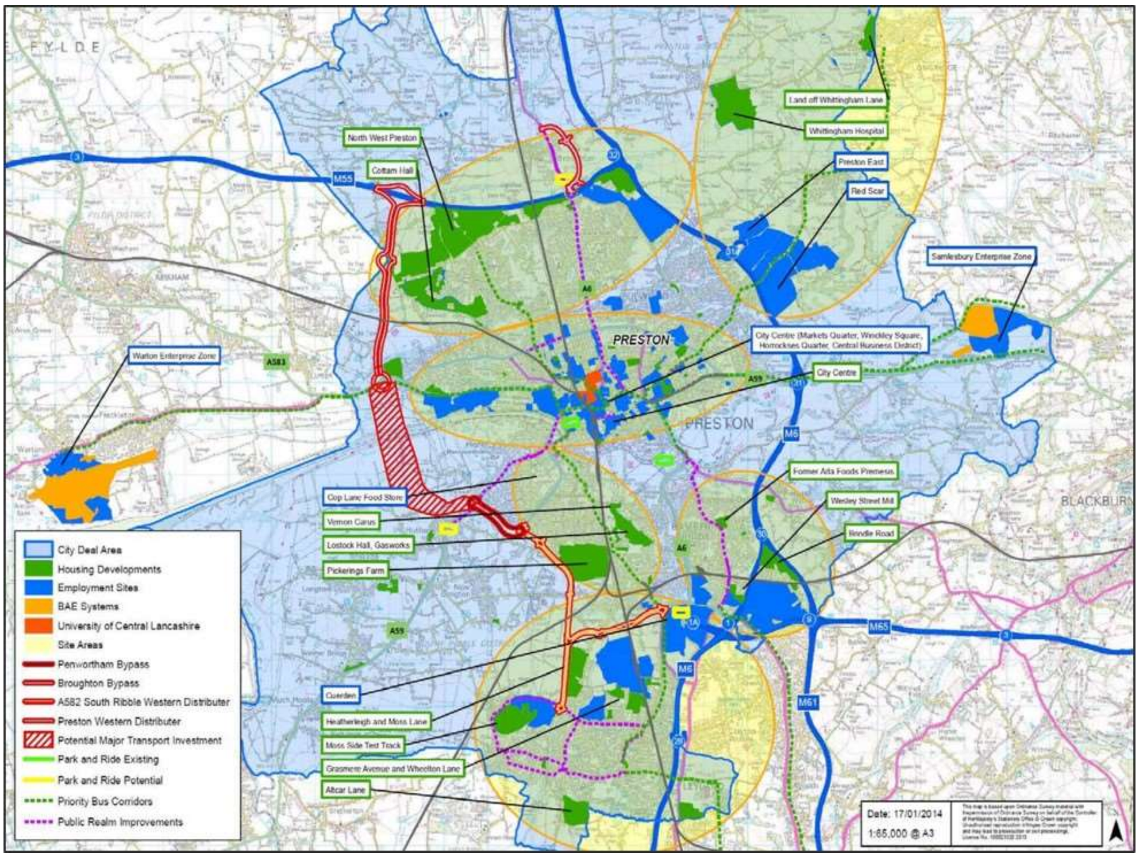


Figure 1-1: Preston City Deal Area and Transport Infrastructure Schemes

Since then the traffic model, hereinafter referred to as Central Lancashire Highway Transport Model (CLHTM), has been used to support:

- planning applications for three Preston City Deal schemes (Preston Western Distributor (PWD), Penwortham Bypass and A582 South Ribble Western Distributor),
- the PWD Business Case,
- Wyre District Local Planning,
- the A582 South Ribble Wester Distributor SOBC;
- Preston Transforming Cities Fund SOBC;
- multiple local schemes and bus gate schemes in Preston.

The CLHTM was originally calibrated and validated to Autumn 2013 data using 2015 TAG parameters (values of time and vehicle operating costs). In 2018, the model was re-calibrated to 2018 TAG for the purpose of the PWD FBC; nonetheless, the Base Year remained 2013 in the absence of more recent traffic data.

In line with TAG requirements and the feedback received form DfT on the TCF Appraisal Specification Report (July 2019); the CLHTM was due for an update, since the age of the data used to build the model was reaching six years. For this purpose, a data collection exercise has been undertaken to update and re-calibrate the model to Autumn 2019 traffic counts and journey times. The detailed specification and methodology steps were agreed with DfT by means of producing and obtaining approval on the Model Base Year Revalidation Methodology Technical Note (Jacobs, December 2019) in advance of the actual calibration work. The note is provided in Appendix A.

Subsequently, DfT requested that as part of the CLHTM model update the Variable Demand Model (VDM) should be upgraded to the TAG recommended Production/Attraction (P/A) format, rather than the Origin/Destination (O/D) used in the previous version of the CLHTM.

The methodology for the P/A based VDM was set out in the CLHTM P/A Based VDM Technical Note (Jacobs, March 2020) included as Appendix B to this document and accompanied by the results of the Modal Shift Significance Test signed off by DfT in September 2020.

Future applications of the updated model will be informed by LCC transport strategy; however, it is anticipated that the model, as a minimum, will be used to support the following schemes:

- the A582 Dualling OBC and FBC
- TCF Ringway Transformation;
- Cottam Parkway Station Planning Application.

It was critical that the traffic surveys for 2019 re-base were undertaken prior to the starting of the PWD construction works in November 2019; the temporary traffic management arrangement would have had a significant impact on routing of the traffic which would complicate the model calibration in the first place and would create issues during the forecasting.

On the other hand, Penwortham Bypass was still under construction at the time of data collection and therefore it is not included in the 2019 base year network.

1.2 Purpose of the Report

This report details the data, processes, methodologies and results of the model recalibration to 2019 Base Year. The updated model scope and setup are largely consistent with the previous PWD FBC version of the model that passed Department for Transport (DfT) assurance in 2019. All changes from the PWD FBC model are stipulated in the subsequent sections of this report. The PWD FBC Local Model Validation Report - LMVR (Jacobs, April 2019) is available upon request.

The main objective of this report is to demonstrate that the procedures adopted in updating the model are consistent with best practice and advice given by the DfT as per TAG guidance and that the model is suitable for its intended purpose.

1.3 Report Structure

Chapter 2 *- Details the uses of the model and key design considerations*

Chapter 3 *- Identifies the standards to which the model was built*

Chapter 4 *- Details the data used for model calibration and validation*

Chapter 5 *- Describes the model network refinement methodology*

Chapter 6 *- Describes the processes used in developing highway assignment trip matrices*

Chapter 7 *– Details prior matrices calibration and validation*

Chapter 8 *- Details the network calibration and validation*

Chapter 9 - *Describes the route choice calibration and validation*

Chapter 10 - *Provides information on the calibration and validation of the trip matrices*

Chapter 11 - *Details the calibration and validation of the assignment*

Chapter 12 - *Details the development and validation of Variable Demand Model*

Chapter 13 *– Provides a summary of the model and its fitness for purpose*

2. Model Description and Specification

2.1 Modelled Area

The geographical scope and the network of the updated CLHTM model are generally consistent with the previous version of the model.

The primary use of the updated model will be the appraisal of the A582 dualling scheme along with planning and supporting assessment of other future transport schemes in and around Preston. Therefore, the geographical scope of the model network and specifically the detailed/simulation area should cover areas of impacts of those schemes.

The A582 scheme is expected to improve travel times along the A582/B5254 corridor between M6/M65 and Preston City and accommodate future traffic growth associated with the Cuerden Strategic Site and at Pickering Farm residential development. In addition, it will have some wider area impacts and, particularly, reducing inappropriate use of the M6 between J27 and J32 by local traffic. Moreover, based on the feedback there are two motorway junctions that are of particular concern for Highways England where impacts of the scheme are anticipated (M65 J1 and M6 J29).

Figure 2-1 shows the extent of the fully modelled area along with the location of A582 scheme highlighted in red (the rest of Great Britain is classed as the external area).

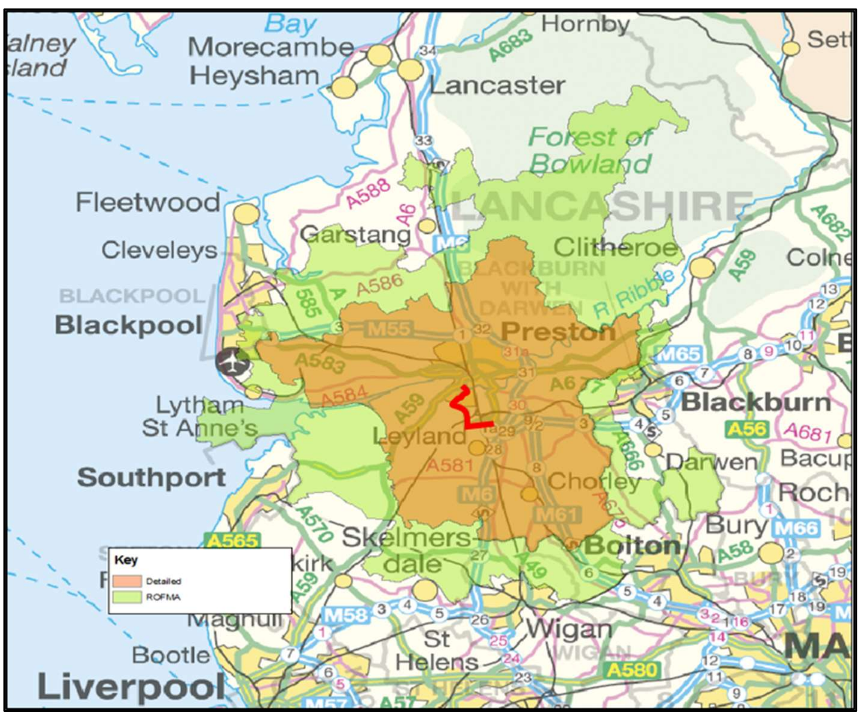


Figure 2-1: CLHTM Fully Modelled Area

Consistent with the previous version of the model, the modelled area makes use of a three-stage structure with levels of detail of network coding reducing away from the centre of the study area. The breakdown of the modelled area is outlined below:

- Fully modelled area:
  - Area of detailed modelling (Detailed) – highest detail

- Rest of fully modelled area (ROFMA) – reduced network coverage but variable travel times enabled

- External Area – lowest network coverage and fixed speeds used

The fully modelled area in the updated model was extended further east to include Samlesbury and south near Tarleton to account for any future aspirational interventions in these areas. In addition, screenlines near these areas have also been defined to ensure more accurate demand is modelled. Figure 2-2 shows the simulation and buffer network coded in the model.

Figure 2-2: CLHTM Modelled Network

Outside of the detailed modelled area, typically Motorways, A and B Roads have been modelled, to reflect the more spatially aggregate nature of the zoning system. As this area is some way from the study area, it is only necessary to have enough detail to ensure that trips from these areas enter the study area at the appropriate locations.

Figure 2-3 shows the entire CLHTM model network, covering trip distances and costs across the whole Britain, including the external modelled area.

Figure 2-3: Full Network

2.2 Zoning System and Centroid Connectors

The original model zone system built from Census Output Areas (COA) has been preserved in the updated model and comprises a total of 579 zones (including 17 spare zones).

Within the detailed model study area (illustrated in Figure 2-4) the zones were comprised of COAs or aggregations thereof. In some instances, zones were based on a disaggregation of COAs in order to isolate individual pockets of land (for example, to separate large industrial land uses from residential uses). The area approximately covered by the Preston City Council boundary was zoned in this way.

Areas further away from the study area, where less spatial detail was required were based on MSOA or district boundaries. In the area immediately surrounding the study area these were mostly comprised of single MSOA. Beyond that point, in the external area of the model, several district zones were aggregated to comprise the modelled zone.

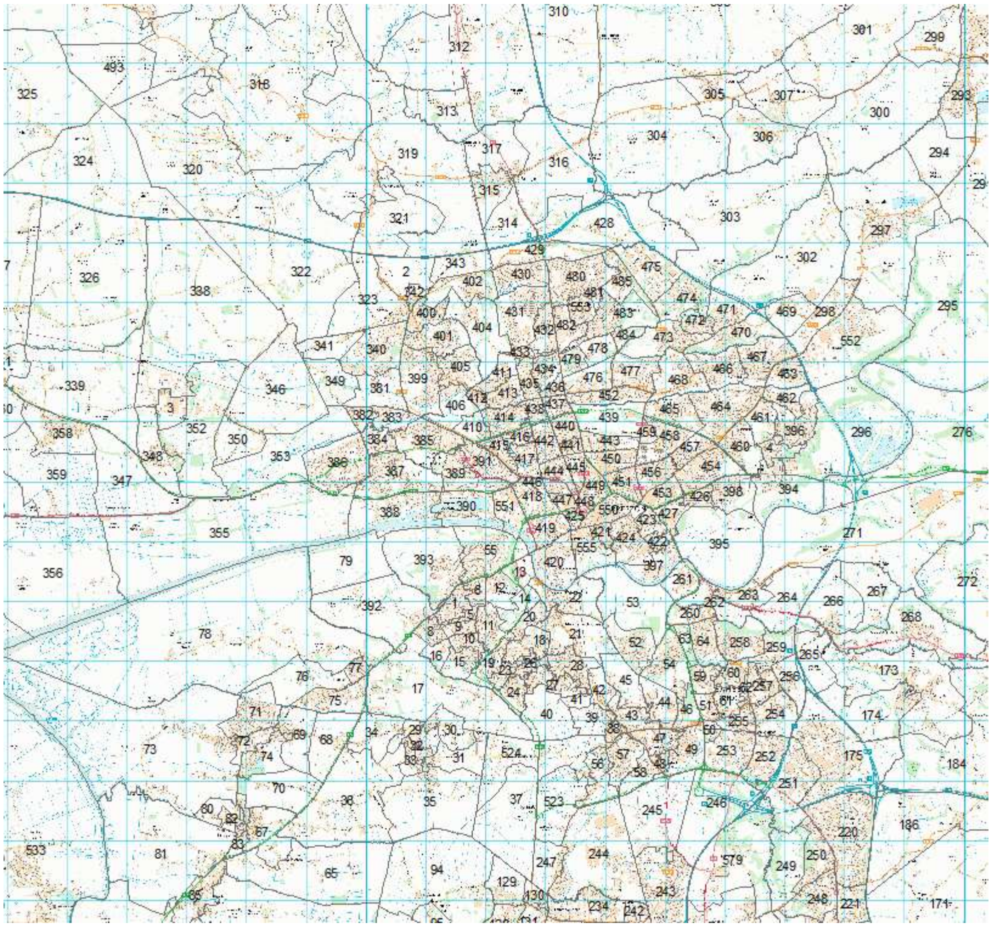


Figure 2-4: Zone system surrounding Preston

A small number of changes to the zoning system was required in the centre of Preston as part of the model update. They aimed to improve accuracy of demand loading onto the network and either consisted in splitting a zone or adding additional zone connectors.

2.3 Zone Sectoring

For ease of analysis and understanding of the trip making patterns, the zoning system is grouped together into sectors. As with the zoning system itself, the sectors are more refined within the detailed modelled area, becoming coarser further out from the detailed area. The 34 sectors were created taking into account the model screenlines and sector-to-sector movements to, from and withing the A582 scheme impact area.

This sector system is shown in Figure 2-5 and Figure 2-6. Table 2-1 includes further description for the sectors.

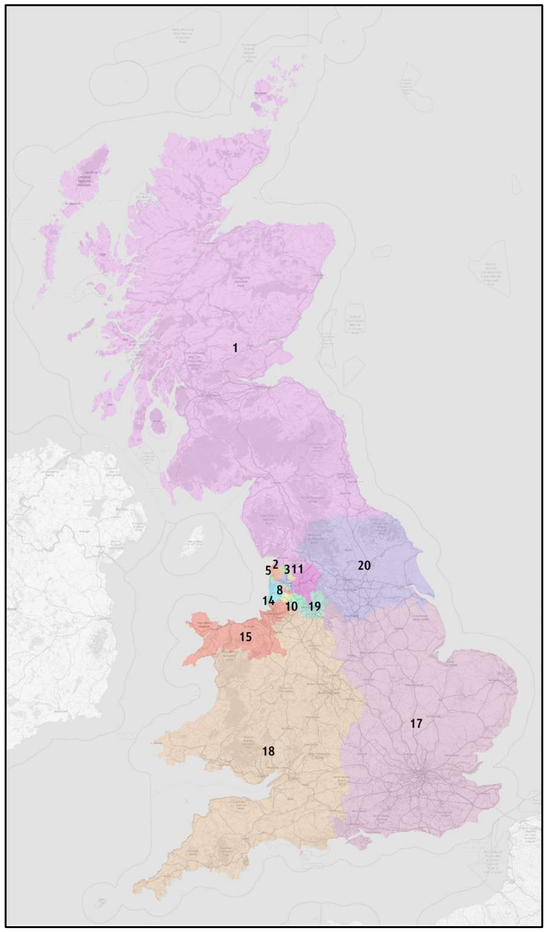


Figure 2-5: CLHTM Sectors

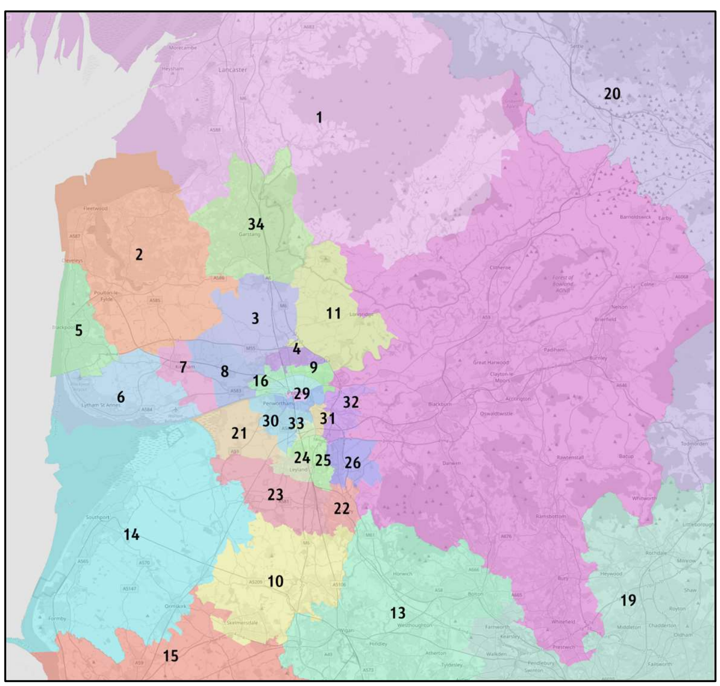


Figure 2-6: CLHTM Sectors - Zoomed In

Table 2-1: Sector Description

Sector	Sector Name
1	North of Model
2	North West of Model - Poulton, Fleetwood etc
3	North Outer Screenline
4	North Preston
5	Blackpool
6	West of Model
7	Western Outer Screenline
8	North West Preston
9	Inner North Preston - North East
10	South of Model - Skelmersdale etc
11	North East Outer Screenline
12	East of Model - Blackburn etc
13	South East of Model - Wigan, Bolton etc
14	South West of Model
15	Northern Wales & Merseyside
16	Inner North Preston - North West
17	London, South East, East England & East Midlands
18	South West, West Midlands & Wales
19	Manchester
20	Yorkshire
21	Hutton
22	Chorley
23	South Outer Screenline
24	Leyland
25	East of Leyland
26	South East Preston
27	Inner South Preston
28	Preston City Centre
29	Inner North Preston - North
30	Penwortham and Lostock Hall
31	Bamber Bridge
32	Outer Eastern Screenline
33	Tardy Gate
34	Garstang

2.4 Key Model Components

2.4.1 Modelled hours

The three modelled hours[1] used in the previous model update (am peak hour, pm peak hour and average interpeak hour) were reconfirmed using the traffic counts collected for the project. More detail on the analysis of peak flows can be found in TDCR Section 5.1 (Jacobs, February 2020).

The modelled hours in the model are therefore:

- AM peak hour (8-9am)

[1] The three modelled hours discussed in this section are relevant to the assignment model only. Modelled time periods represented in Variable Demand Model are discussed in Chapter 12.

- PM peak hour (5-6pm)
- Average hour in the interpeak (10am-4pm)

The peak hour to peak period factors were derived using 2019 ATC data at the RSI locations. Traffic counts at RSI screenline were used as they best represent the traffic flows for the study area. Average of two-week ATC bi-directional traffic flows were summed for each of the peak periods and was divided by the total flows for the identified peak hour to estimate the factor.

The relationship between peak hour and peak period derived from analysis of observed daily traffic flow profiles in the modelled area are as follows:

- AM Peak Period: 07:00-10:00
  - AM Peak Hour to AM Peak Period Factor = 2.668
- Interpeak Period: 10:00-16:00
  - IP Average Hour to IP Period Factor = 6
- PM Peak Period: 16:00-19:00
  - PM Peak Hour to AM Peak Period Factor = 2.776

2.4.2 User classes

Following the approach adopted in the original model, the updated CLHTM model segregates trips by vehicle type and trip purpose. Different levels of segregation are used at different points of the model building process, as summarised in Table 2-3.

Table 2-2: Purpose/User Class/Vehicle Class Correspondence

<table>
<tr><th>Trip Purpose ID</th><th>Purpose</th><th>User Class (UC)</th><th>Vehicle Class (VC)</th><th>PCU Factor</th></tr>
<tr><td>1</td><td>Home Based Work (HBW)</td><td>UC1</td><td rowspan="7">VC1</td><td rowspan="7">1.0</td></tr>
<tr><td>2</td><td>Home Based Employer's Business (HBEB)</td><td rowspan="2">UC2</td></tr>
<tr><td>3</td><td>Non-Home Based Employer's Business (NHBEB)</td></tr>
<tr><td>4</td><td>Home Based Education (HBED)</td><td rowspan="4">UC3</td></tr>
<tr><td>5</td><td>Home Based Shopping (HBS)</td></tr>
<tr><td>6</td><td>Home Based Other (HBO)</td></tr>
<tr><td>7</td><td>Non-Home Based Other (NHBO)</td></tr>
<tr><td>8</td><td>LGV</td><td>UC4</td><td>VC2</td><td>1.0</td></tr>
<tr><td>9</td><td>HGV</td><td>UC5</td><td>VC3</td><td>2.0</td></tr>
</table>

These trip purpose and user class splits are consistent with the guidance contained in TAG Unit M3.1 and allow differing vehicle operating costs and values of time to be applied.

2.4.3 Software package

The previous version of the model was developed using SATURN V11.3.12W and the updated model uses the latest release of SATURN at the time of model calibration - version 11.4.07H (August 2018). The PWD FBC variable demand model was undertaken using DIADEM 5.0 software and the updated model uses DIADEM 7.

2.4.4 Base Year

The updated model has been developed with a base year of 2019 with all observed data based on data collection undertaken in November 2019, which as per TAG Unit M1.2 represents neutral month.

2.4.5 Summary of Key Model Components

Table 2-3 provides the summary of key model components used in the updated 2019 CLHTM.

Table 2-3: Summary of the key model components

Characteristic	Model Approach
Model Type	Highway Assignment Model
Software package	SATURN (latest version at time of model build, currently 11.4.07H)
Base Year	2019
Time Periods	AM peak hour (0800-0900) Interpeak (average hour 1000-1600) PM peak hour (1700-1800)
User Classes	5 user classes: Car – Commute Car – Business Car – Other LGV HGV
Zone System	579 zones (including 17 spare zones)
Assignment methodology	SATURN assignment – Wardrop Equilibrium
Capacity restraint mechanism	Capacity Index functions on links Defined capacity at junctions Fixed speed buffer networks
Variable Demand Model	P-A based VDM using DIADEM 7

2.5 Generalised Cost Formulations and Parameter Values

Within the SATURN assignment two parameters are defined for each user class to calculate generalised cost: value of time; and vehicle operating cost. Journey times, distances and any tolls included in the model are then combined into a standard unit of generalised time based on these two parameters.

The values of time (VOT) used in the present year model were taken from the latest available TAG data book (May 2019, v1.12) at the time of model development. The values are provided in Table 2-4.

Calculations were undertaken using perceived values of time and distance (i.e. with VAT for non-business and without VAT for business trips), and as per guidance and processes advised by both TAG and Highways England TPG, using Highways England's VOT/VOC calculation worksheet.

When calculating the Vehicle operating cost (VOC), the average speeds for each user class and each time period were taken from the previously validated CLHTM model (see Table 2-5.)

In line with TAG unit M3.1, the HGV VOT were doubled to better take into account the driver's and employer's VOT.

Table 2-4: Generalised Cost Parameters

Vehicle type	Trip Purpose	Time Period	Value of Time / PPM (p/min)	Vehicle operating cost / PPK (p/km)
Car	Commute	AM	20.79	5.75
	Business		31.02	12.08
	Other		14.35	5.75
LGV	Business		21.92	13.84
HGV	Business		44.51	35.69
Car	Commute	IP	21.14	5.67
	Business		31.78	11.89
	Other		15.29	5.67
LGV	Business		21.92	13.76
HGV	Business		44.51	35.69
Car	Commute	PM	20.87	5.81
	Business		31.46	12.22
	Other		15.03	5.81
LGV	Business		21.92	13.91
HGV	Business		44.51	35.69

Table 2-5: Average Speeds

User Class	Time Period	Average Speed (km/hr)
Car	AM	57
LGV		57
HGV		78
Car	IP	60
LGV		60
HGV		78
Car	PM	55
LGV		55
HGV		78

2.6 Capacity Restraint Mechanisms

2.6.1 Links

Capacity restraint on links was modelled through the use of speed flow curves.

The general rule of whether to use a fixed cruise speed on a given link or a speed-flow curve relates to whether the majority of the delay on the link is likely to be as a result of junction delays or weight of traffic on the link. Where the majority of delay is related to the junction, a fixed cruise speed has been coded. Whereas when the delay is likely to be caused by the weight of traffic a speed-flow relationship has been coded.

In general, this rule results in fixed cruise speeds being coded within urban areas, and speed-flow relationships being coded on longer rural links.

HGV speeds were capped for each capacity index to ensure that HGVs travel at reduced speeds compared to other vehicles on the road network in rural areas, where speeds between vehicle types would be expected to vary more significantly.

2.6.2 Junctions

All junctions within the study area were fully coded in line with the Central Lancashire Model Coding Manual, developed from a range of model development experience in similar areas and for Highways England modelling.

Elements of coding included the junction type, number of lanes, permitted movements and geometric measurement of each junction, to calculate typical capacities and likely ranges of capacity, and thereby turning delays once assigned.

Motorway Network merges were effectively coded using Q nodes that were located 300m downstream from the merging node. A full description of Q nodes can be found in the SATURN User Manual, and also defined in the CLHTM Jacobs Coding Manual.

3. Model Standards

3.1 Introduction

The criteria used for calibration and validation of the model, and convergence standards applied to check the stability and reliability of the assignment results were consistent with the PWD FBC version of the model signed off by DfT and are based on the measures set out in TAG Unit M3.1.

3.2 Validation Criteria and Acceptability Guidelines

The validation of the highway assignment has been quantified using the following measures taken from TAG unit M3.1 paragraph 3.2.3:

- Assigned flows and counts totalled for each screenline or cordon, as a check on the quality of the trip matrices;
- Assigned flows and counts on individual links as a check on the quality of the assignment; and
- Modelled and observed journey times along routes, as a check on the quality of the network and the assignment.

3.2.1 Screenlines

Base matrix validation is defined as the differences between modelled and observed flows along screenlines within the model, the criteria to meet is set out in Table 3-1.

Table 3-1: Screenline Flow Validation Criterion

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

TAG specifies the following, within unit M3.1 paragraph 3.2.6:

- Screenlines should normally consist of five or more links;
- The comparison of modelled and observed flows for screenlines containing high flow routes (such as motorways) should be presented both with and without such routes;
- The comparison should be presented separately for:
    - roadside interview screenlines;
    - other screenlines used as constraints in matrix estimation; and
    - screenlines used as independent validation.
- The comparison should be presented by vehicle type.

It should be noted here that given a relatively small focus area, it was not always possible to draw up screenlines consisting of more than five links. This is also in part due to the rural nature of some areas outside Preston and a limited route choice, whilst also making best use of the data that are available.

The GEH value (see definition below) has also been used to assess screenline performance. This is deemed prudent where percentage differences on short or low-flow screenlines, particularly for LGV and HGV, is above 5%.

3.2.2 Link based calibration and validation

In addition to validation of total screenline flows, TAG Unit M3.1 also contains guidelines on the validation criteria for individual links or turning movements.

These criteria are detailed in Table 3-2 presented below and include reference to the GEH statistic measuring the difference between modelled and observed flows. The GEH statistic is of the form:

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

where M is the modelled flow and C is the observed count.

Table 3-2: Link Flow and Turning Movement Validation Criteria

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

According to the TAG guidance unit M3.1 paragraph 3.2.9, the above comparison of modelled and observed flows should be presented for total vehicle flows and for car flows, but not for LGV and HGV flows due to there being insufficient accuracy in the individual link counts for these vehicle types. In addition, the above information should be presented by time period and applied to link flows.

Data collection sites used in the validation of the base year, as well as those sites used in the development of the base year model are presented within Chapter 4.

3.3 Journey Times

TAG also specifies acceptability guidelines for the validation of journey times. The acceptability criterion for journey time validation is given in Table 3-3.

Table 3-3: Journey Time Validation Criterion

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

3.4 Impact of Matrix Estimation

Independent validation as specified above quantifies the ability of the model to replicate base year travel conditions within the model area. To ensure these conditions have a sound basis TAG provides guidance as to the acceptable changes to the highway 'prior' matrices that should result from the application of matrix estimation. These have been reproduced in Table 3-4.

Table 3-4: Significance of Matrix Estimation Changes

Measure	Significance Criteria
Matrix zonal cell values	Slope within 0.98 and 1.02 Intercept near zero R^2 in excess of 0.95
Matrix zone trip ends	Slope within 0.99 and 1.01 Intercept near zero R^2 in excess of 0.98
Trip length distributions	Means within 5% Standard deviations within 5%
Sector to sector level matrices	Differences within 5%

TAG Unit M3.1 paragraph 8.3.15 states that all exceedances of the above should be noted and assessed as to their importance to assess the scheme.

3.5 Convergence Criteria and Standards

In order for the outcomes of the modelling to be reliable, the stability of the modelled flows needed to be confirmed. This ensures that when modelling the scheme, any flow changes which occur do so directly as a result of the scheme, rather than as a result of random flow changes due to poor convergence. In addition, the model should converge to a point in which routes obey Wardrop's First Principle of Traffic Equilibrium which unit M3.1 paragraph 2.7.3 defines as:

"Traffic arranges itself on networks such that the cost of travel on all routes used between each OD pair is equal to the minimum cost of travel and all unused routes have equal or greater cost."

This relates to how close the model is to a particular converged solution, which varies depending on the preferences of the user or software package being used. In SATURN this equates to how close the model is to Wardrop's Principle of Equilibrium and is measured using the Gap function.

The gap value therefore represents the excess cost incurred by failing to travel on the route with the lowest generalised cost and is expressed relative to that minimum route cost. The excess cost is summed over each route between each O/D pair and multiplied by the number of trips between each O/D pair. This is divided by the minimum cost summed over each route between each O/D pair, also multiplied by the number of trips between each O/D pair.

For the model to be considered sufficiently well converged, the gap value must be less than 0.1%.

TAG describes other measures for assessing the model convergence, as detailed in Table 3-5; in terms of both stability and proximity measures.

Table 3-5: WebTAG Convergence Measures

Measure of Convergence	Base Model Acceptable Values
Delta and %Gap	Less than 0.1% or at least with convergence fully documented and all other criteria met
Percentage of links with flow change < 1%	Four consecutive iterations greater than 98%
Percentage of links with cost change < 1%	Four consecutive iterations greater than 98%

Measure of Convergence	Base Model Acceptable Values
Percentage change in total user costs	Four consecutive iterations less than 0.1%

The convergence statistics provided in the LPN output file enable the ability to both check and ensure the model converges within the TAG guidance provided above for the base year.

4. Calibration and Validation Data

4.1 Introduction

The survey data used to re-calibrate the model to the 2019 base and the results of data cleaning and checking are detailed in the Traffic Data Collection Report (TDCR) submitted in February 2020 and approved by DfT in April 2020. This chapter provides a summary of the data collection and how it was used in the model update.

The 2019 observed traffic data consisted of:

- Traffic Count Data for Matrix Estimation / Calibration
- Traffic Count Data for Validation
- Journey Time Data for Validation

22 bi-directional screenlines were constructed using the traffic count information to capture the total flow of vehicles within and around the study area (Figure 4-1). Out of these screenlines, 14 were used for calibrating the transport model, one RSI screenline was used to develop and check the observed matrices, while the remaining seven screenlines were applied for validation purposes. These are discussed further in following sections.

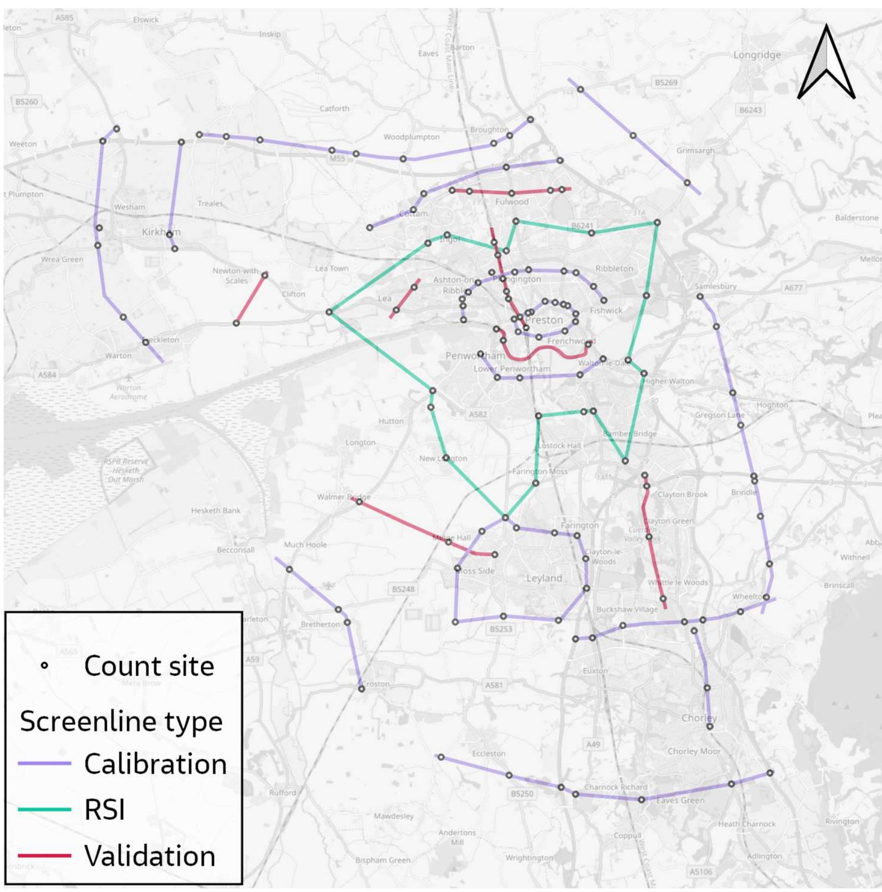


Figure 4-1: Model Screenlines

Table 4-1 summarises the number of survey sites by type. Full details of the data sources and dates of collection is documented in the TDCR.

Table 4-1: Number of survey sites

Count type	Number of sites
Calibration	85
RSI	19
Validation	24
Individual Counts	52

In addition, historic 2016 turning movement and link counts provided by LCC were used as a benchmark with the aim of assuring the right levels of traffic and distribution in the area around M65(J1) and M6(J29). This additional verification of the model performance at the two strategic road network (SRN) junctions was agreed with Highways England as part of the A582 Strategic Outline Business Case assurance.

Moreover, recent MCTC and ATC data collected by LCC at various locations and for various projects between 2016 and 2019 has been obtained. This data was used to verify some of the 2019 counts where the model was struggling to reflect the observed data. Furthermore, although this model specification does not require validation against turning counts MCTC data was used as a supplementary data for the route choice calibration.

4.2 Traffic Counts for Calibration

Based on the lessons learnt during calibration of the PWD FBC model, adjustments were made to some of the screenlines to facilitate the model calibration process. The screenlines have been designed to include all sections of motorway that pass through each of the screenlines.

Figure 4-2 illustrates the calibration counts and screenlines for the modelled area.

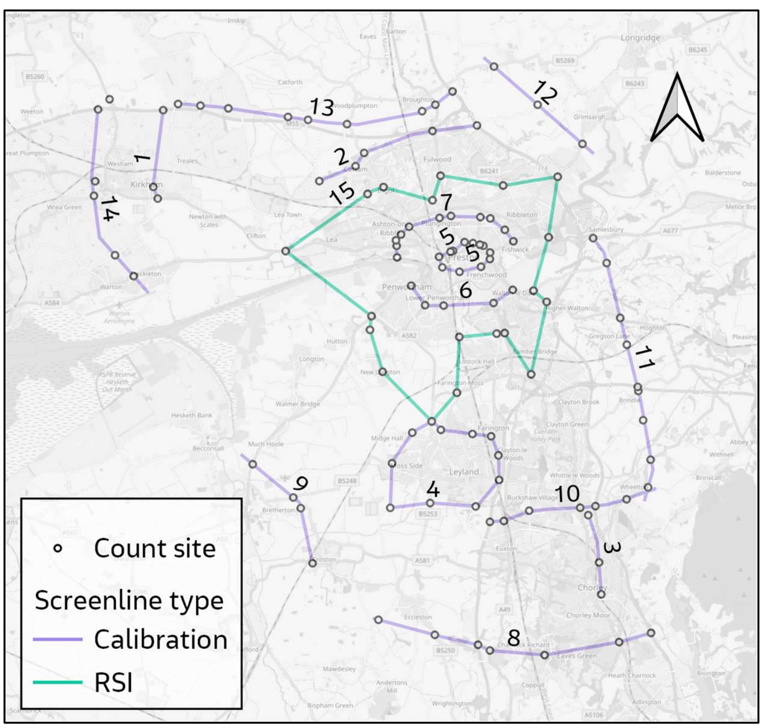


Figure 4-2: Calibration Counts and Screenline

Traffic counts undertaken at RSI cordon (screenline 15) capturing trips to and from Preston were used to derive the expansion factors required for normalising the RSI survey data to the 2019 base and to control prior and final matrices to the observed demand within the core modelled area.

Calibration screenlines 8, 9, 11, 12, 13 and 14 were categorised as outer cordon screenlines and were designed to capture trips outside the RSI cordon.

Given the proximity of the Leyland area to the A582 and M6, the calibration screenline 4 around Leyland was defined to ensure that traffic loadings from this area on A582 and M6 are at the right level especially focussing on Flensburg Way, Wigan Road and Stanified Ln that would have immediate impacts due to A582 scheme.

A tight city centre cordon (screenline 5) and screenlines 6 and 7 were established to confirm the model demand in the city centre is quantified and distributed at the right level. This was particularly important as the internal demand within the RIS cordon is purely synthetic.

Calibration screenline 6 south of River Ribble was particularly important in the context of the A582 scheme as it captured traffic demand along the corridor that the A582 dualling aims to improve.

4.3 Traffic Counts for Validation

The validation screenlines were established independent from screenlines that were used for calibration or roadside interview sites. The validation counts are located on key radial and arterial routes within the study area including Preston City Centre.

Figure 4-3 shows the validation counts and screenlines for the modelled area.

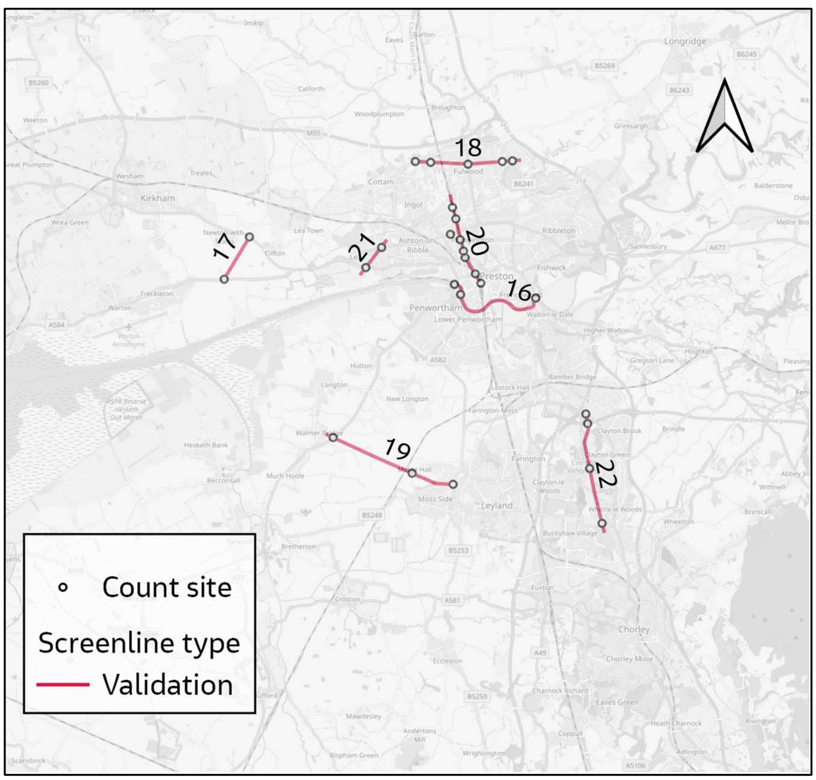


Figure 4-3: Validation Counts and Screenline

Two short validation screenlines 17 and 21 are included to confirm the trips from West of Preston that are important in the context of the future PWD scheme.

Screenline 16 consisting of three bridges across the River Ribble is key to validate the traffic demand between Preston City and South Ribble.

4.4 SRN Junctions

One of the objectives for this model update is to ensure that the model calibration and validation is strongest around the A582 study area. Although a light-touch re-validation was undertaken for this purpose in the A582 SOBC stage, as per Highway England's advice further improvements to the model specifically for M65 J1 and M6 J29 were undertaken to ensure that a satisfactory operation of the junctions is achieved for the purpose of A582 OBC.

During calibration a special attention was given to links and junctions shown in Figure 4-4. Turning movement counts for M6 J29 and M65 J1 were obtained from LCC. The turning movement counts were undertaken in June 2016 for 1 weekday (Wednesday) for AM and PM peak period. This traffic data was used to confirm if the model flows are within reasonable limits.

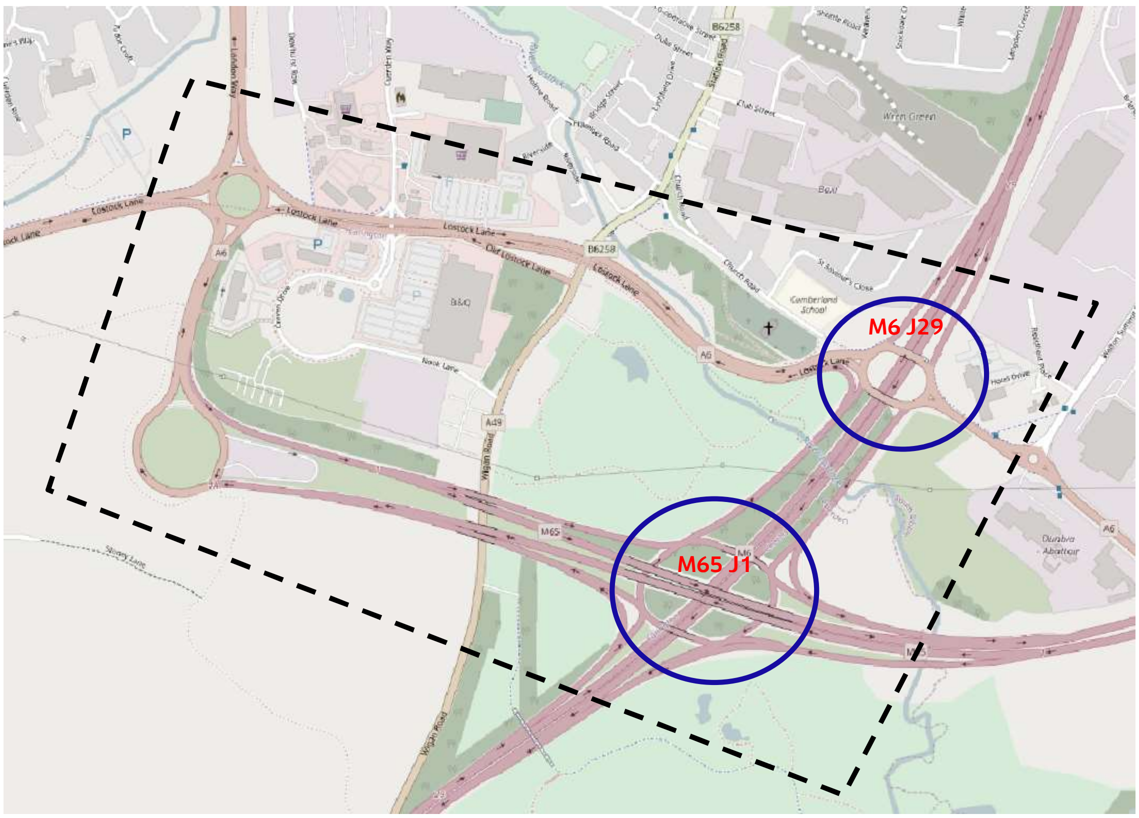


Figure 4-4: SRN Mini Network and Junctions

4.5 Journey Time Surveys

Journey time data was used to check how well the model was performing in terms of replicating observed travel times. The 14 journey time routes used for the PWD FBC model were developed to be comprehensive covering both the local road network and SRN and took into account the analysis of traffic delays and congestion using TrafficMaster data.

These routes have been reviewed to check if any modifications were required as part of the model update. The routes were found to be fit for the journey time validation purpose as it covered a wide range of road types within the fully modelled area. The identified routes also included the A582 and parallel B5254 road sections and therefore no additional routes were required.

Figure 4-5 illustrates the journey time routes used for the journey time validation.

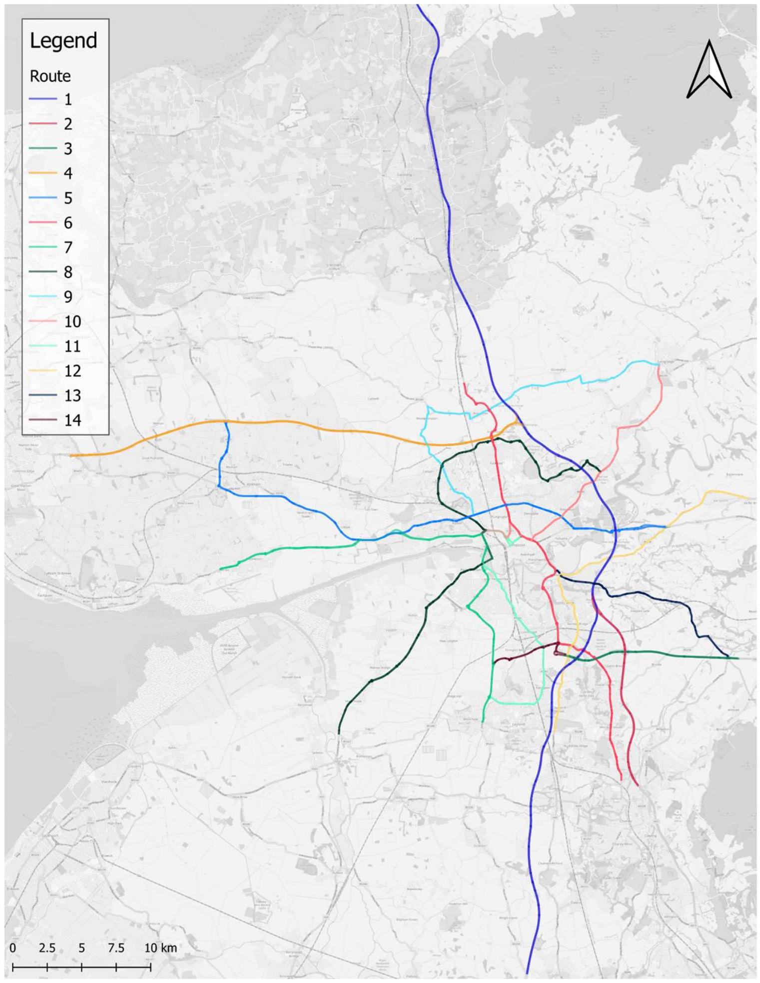


Figure 4-5: Journey Time Routes

Route 2 near Broughton area was amended slightly to include Broughton By-Pass which was completed in 2017.

As per TAG 3.1 guidelines, the journey time routes ideally should not be excessively long (greater than 15 km) and nor excessively short (3 km). There are a few routes that are greater than the threshold of 15 km, however, these routes were split into smaller segments and journey times were checked for each of the segments to ensure there were no huge variances that could distort the overall route times.

2019 journey times were obtained from the TrafficMaster dataset and was processed for the selected routes (both directions). The data processing methodology is consistent with the original CLHTM model process. Data period selection was consistent with TAG requirements, only neutral months and dates were used. Data quality assurance was undertaken to ensure no major outliers were included. These are detailed in the TDCR.

Robustness of the observed journey time surveys was analysed by using mean and median by checking the variation around the mean. The variation for most of the routes were found to be low, which confirmed a relatively stable set of observed times. However, a few routes had higher variation, and these were mainly the routes with signalised junctions where varying signal phase between the different observation runs could affect the variance.

For consistency weighted average of the vehicle types captured by TrafficMaster were used to provide the average journey time for each of the identified journey time routes. However, as part of investigating any variation between modelled and observed travel times the comparison against median value was also undertaken.

5. Network Updates

5.1 Introduction

The starting point for the 2019 network was the PWD FBC 2013 Base Year model network.

A thorough review of the previous network was undertaken to ensure its robustness. Banned turning movements, one-way street information, speed restrictions, number of lanes, link lengths and road types were checked and adjusted where required to create an accurate base network model.

HGV restrictions were also reviewed and updated where required.

Care was taken over recently introduced schemes, particularly road improvements where the scheme on the ground was different to available aerial photography. These were checked with LCC with a focus on the networks in and around future schemes.

A detailed list of network checks that were undertaken is provided in Appendix C.

The following sections provide detail on capacity restraint mechanisms used in the model.

5.2 Link speeds and speed-flow curves

For the links imported into the model the parameters governing speeds, capacities and the relationship between speed and traffic flow were derived from Part 5 of the COBA manual. The link characteristics described in the manual were translated into parameters appropriate for use in the SATURN model.

A total of 77 different link types were drawn up based on COBA with the coding manual, to accommodate all different combinations of urban/suburban/rural, levels of development, road widths, number of lanes, and vehicle restrictions.

For each link type, the relationship between vehicle flow and average speed, also known as a speed-flow curve was defined.

$$t_{cur} = \begin{cases} t_0\left(1 + a \cdot \left(\frac{q}{q_{max} \cdot c}\right)^{b}\right), & \frac{q}{q_{max} \cdot c} \leq 1 \\ t_0\left(1 + a \cdot \left(\frac{q}{q_{max} \cdot c}\right)^{b'}\right), & \frac{q}{q_{max} \cdot c} > 1 \end{cases}$$

Where: t_{cur} is the calculated link travel time, t_0 is the link travel time at free flow conditions, q is the flow on the link, q_{max} is the link capacity, and a, b, b', and c are parameters specific to each link type.

From the formulae, it clear that there is a different relationship for links that are over capacity, to those which are under capacity. However, it must be noted that the propensity for this to occur is reduced as the model makes use of flow metering. This meets the guidance in TAG unit M3.1 appendix D.

The full list of link types, along with free flow speed, capacity, and parameters for the volume-delay function is given in Appendix K.

For HGV's, the speed capacity index function is adjusted such that HGVs have reduced maximum speed for each link type.

The HGV speeds for all link types can also be seen in Appendix K.

For all links it is important to note the cruise speeds are specified in line with TAG Unit M-3 in the coding manual; rather than speed limits.

5.3 Junctions and Delays

All junctions within the study area are fully coded in accordance with the Jacobs Coding Manual documentation (Appendix K), and a specific spreadsheet set up for SATURN coding was used, so that all junctions are coded in a consistent manner, removing common errors and issues at the same time - as well as ensuring consistency of approach. The Coding Manual details how the turn saturation flows are calculated and applied for each junction included within the SATURN simulation network.

As with the link data, all the parameters of simulation junction and turn data have been coded, for each of the following aspects:

- Node, or junction, type and associated parameters;
- Individual turning saturation flows including lane allocations;
- Turn priority markers such as give-way, opposed turn and merging traffic; and
- Signal timing data

These attributes were coded using Google Earth, Google StreetView and local knowledge.

The coding of priority junctions has used the direct application of SATURN give-way and opposed traffic turn priority markers to represent the individual movements at a junction. Opposed and unopposed movements at signalised junctions were also deliberately specified.

Figure 5-1 shows the location of various junctions that are coded in the simulation area.

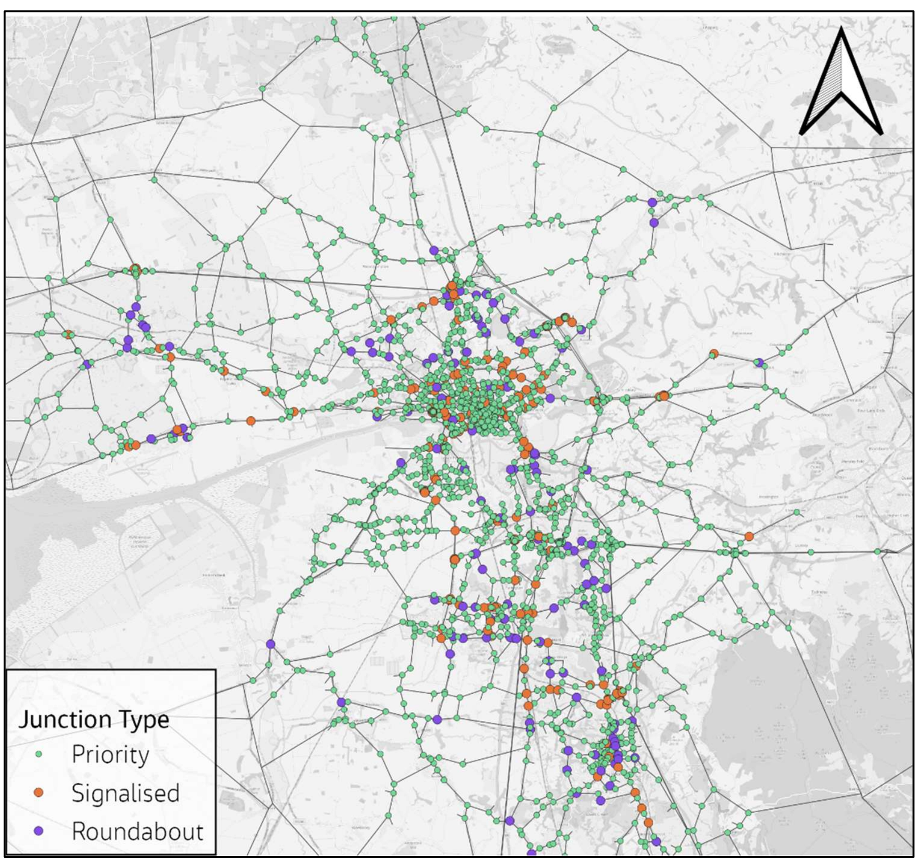


Figure 5-1: Model Junction Types

5.4 Recent Schemes

All scheme completed between 2013 (PWD BC Model Base Year) and 2019 have been identified in cooperation with LCC and coded into the updated model. A list of schemes is provided below, and the affected model network is highlighted in Figure 5-2.

- M6/M55 - M6 J32 and M55 Jn1 junction improvements
- A6 Broughton Bypass and new D'Urton Lane Junction
- Lightfoot lane – Eastway junction improvements, signalisation
- New Hall Lane Local Centre
- Golden Way dualling
- A582 junction improvements
- Bamber Bridge Local Centre - Brownedge Lane/ Collins Road junction improvements
- Preston City Centre bus gate schemes and Fishergate scheme
- Tabley Lane Junction signalisation

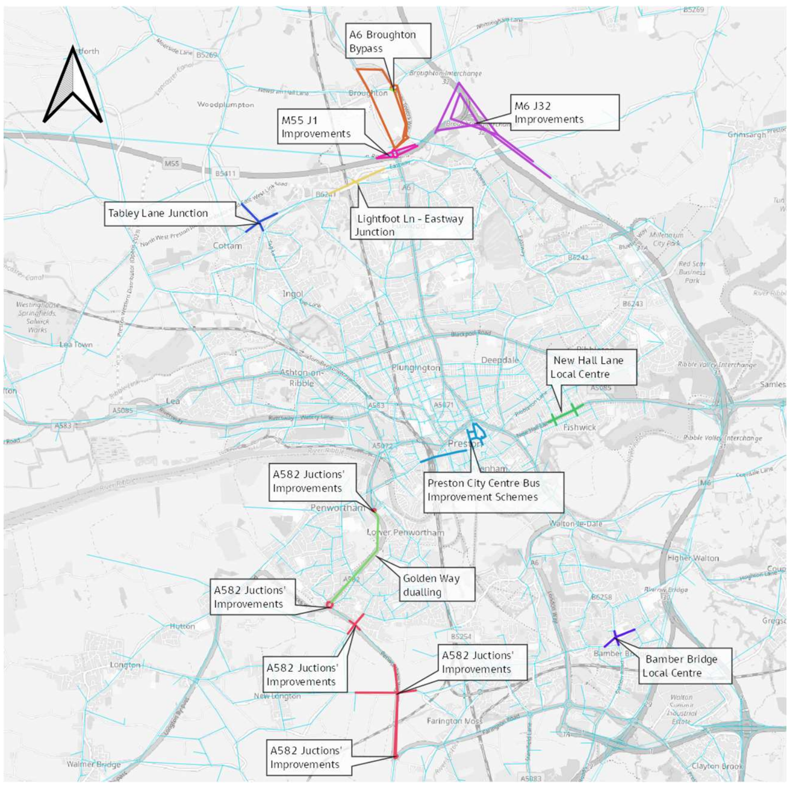


Figure 5-2: Links and nodes affected by transport schemes completed between 2013 and 2019

In addition to the above listed improvements, there were instances where other network modifications had to be done to represent the network at the time of model development. This was important as these changes would have direct impact on the traffic count data collected and some of the initially proposed count sites had to be modified to account these.

The examples include closure of D'Urton Lane due to construction of the D'Urton Link Road and speed reductions on Liverpool Road due to construction of the Penwrotham Bypass.

5.5 Signal Timings

PWD FBC model included the signal staging and timing data for majority of the signalised junctions. 2019 Signal timings for new signalised junctions and refurbished junctions were obtained from LCC and updated in the model. Care was taken to minimise the use of signal optimisation making as much use as possible of actual signal data where available. A few junctions that did not have appropriate data were developed according to typical LCC timings.

The extent of alterations to the observed signal times were based on professional judgement and based on the comparison of the modelled traffic and journey during the network calibration process.

Where possible signal times coded in the base year model will be kept consistent in the future Do Minimum and Do Something network for testing A582 scheme to ensure that the scheme impacts are not masked by any other non-scheme related network differences.

5.6 Restrictions for Goods Vehicle

Majority of HGV bans and penalties have been taken from the PWD model. Height and weight restrictions were confirmed using the Lancashire mapping website (MARIO[2]). Identified modifications were updated in the SATURN model accordingly for the affected vehicle classes.

5.7 Network Speed

The 2018 accident data (STATS 19) was used as a reference to confirm that the model free-flow speeds are generally consistent with the speed limits across the network. Google Street view images were also used to confirm and define variable speed limits along the same road. Figure 5-3 shows the STATS 19 speed limit data within the study area.

[2] http://mario.lancashire.gov.uk/agsmario/default.aspx

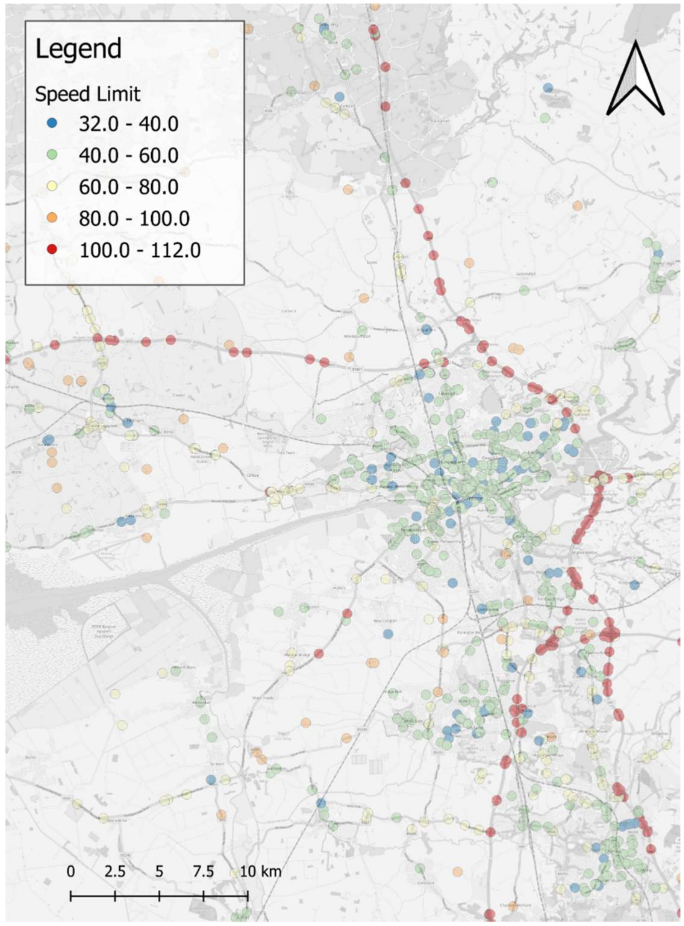


Figure 5-3: STATS19 - Speed Limit data [km/h] (2018) in the study area

5.8 Bus Route Data

The public transport passengers are not explicitly modelled in SATURN. However, as buses play an important part in ensuring correct delay calculations at junctions, they are coded in the network as fixed routes with a set frequency for AM, IP and PM. Hourly frequencies and routes of the bus services were extracted from the Traveline National Dataset (TNDS) and the national dataset of public transport access points (NaPTAN).

Figure 5-4 illustrates the routes that were included in the coding of the bus network.

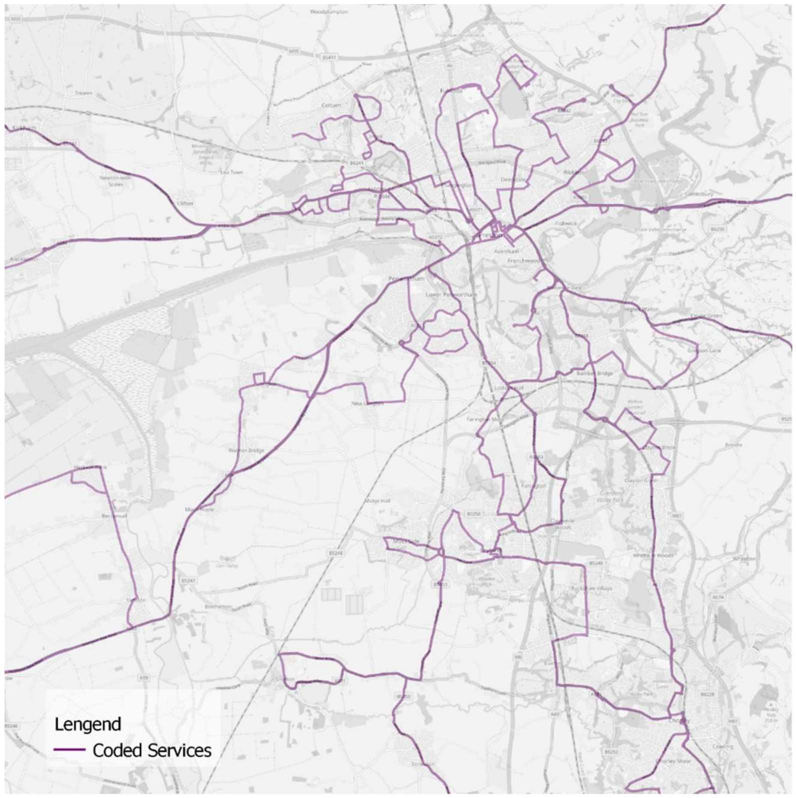


Figure 5-4: Bus routes represented in the model network

5.9 Network Parameters

All SATURN global network parameters including locally calibrated ones (e.g. minimum gap accepted by a vehicle which gives way at the junction: GAP, GAPM, GAPR) were retained from the PWD FBC model.

6. Highway Assignment Matrix Development

6.1 Introduction

The purpose of this chapter is to explain the stages of developing and adjusting the traffic demand for assignment to the model network described above and calibrating the model to the observed counts and journey times.

It should be noted that the VDM methodology was agreed with Dft after the calibration of the assignment model in O/D, and the P/A based demand model has been retrofitted at the request of DfT to ensure a more robust appraisal of the A582 scheme. The VDM set up, which also required a more disaggregated segmentation, is discussed in detail in Chapter 12.

For the purpose of the assignment model the highway matrices were built for three vehicle categories: Car, LGV and HGV. Car matrices were further split based on user class into Commute, Business and Other, in line with TAG unit M-3 requirements.

The impact of different vehicle categories on the assignment process is weighted by representing the trips as passenger car units (PCU's), as detailed in Table 2-2.

Three time periods have been modelled to ensure that the model represents the typical range of traffic movements undertaken on the network and traffic conditions.

The time periods are weekday and relate to the following periods:

- *AM Peak Hour (08:00-09:00);*
- *Inter-Peak Hour (Average 10:00-16:00); and*
- *PM Peak Hour (17:00-18:00).*

In summary the highway matrix development is split into several stages, at each stage the matrix is enhanced to provide a more robust estimate of travel demand in the study area.

6.2 Car Demand Methodology Overview

The 2019 matrix development methodology generally follows the same approach as adopted in the previous versions of the model: it uses the RSI and demographic data to produce the initial prior matrices which are then subjected to a series of adjustments through controlled sector factoring and matrix estimation.

TAG Unit M2-2 appendix B sets out an approach to the development of prior matrices based upon synthetic matrices, using trip end estimations from local demographic information.

These are then adjusted and modified to fit observed trip patterns taken from the survey data and constrained to trip end estimates.

Figure 6-1 summarises the matrix development process and comprises of following main stages:

- Synthetic Trip Ends: Trip ends are derived for each modelled zone utilising TEMPRO 7.2 in P/A format and disaggregated to model zones using the PWD FBC model synthetic demand proportions;
- Synthetic Trip Distribution: The distribution was undertaken using a gravity model to create synthetic P/A matrices;
- Observed Matrix Development: The observed matrices were developed using 2014 roadside interview data expanded to 2019 traffic counts. For the purpose of merging with Synthetics RSI Trips were converted to P/A format using Home end of the journey information in the RSI data;
- Merging observed and synthetic: The statistical merging of locally surveyed travel demand patterns using roadside interviews and synthetic trips;

- Sector factoring and Prior Matrix Validation: Controlled prior matrix adjustments at a sector level to ensure a close match with observed screenline flows. The success of this stage determined the extent of matrix estimation required;
- Matrix Estimation: Where prior matrix does not match observed flows, matrix estimation is used to further refine the matrices and improve the model fit at the individual link level to obtain final matrices.

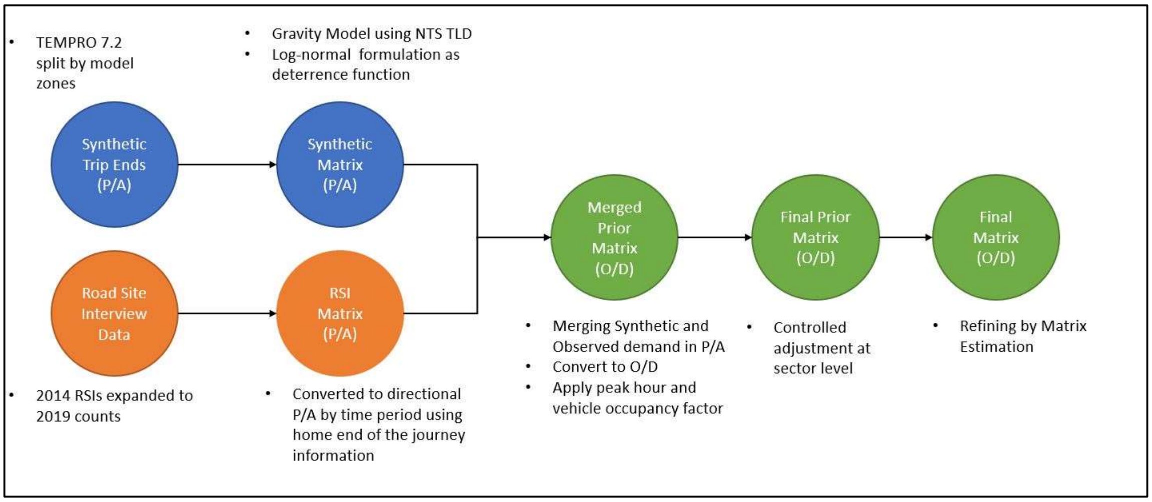


Figure 6-1: Matrix Development Process

6.3 Synthetic Matrix Development

6.3.1 PWD Model Synthetic Demand and Rationale for Update

Synthetic trip ends in the original CLHTM and PWD FBC version of the model were estimated using a combination of 2011 Census, NATCOP, NTEM 6.2 and Blue Sheep employment database. The details can be found in the PWD FBC LMVR (April 2019). Given the release of NTEM7.2 and in line with DfT feedback it was prudent to update the synthetic trips to this latest version of NTEM.

6.3.2 Trip Ends

NTEM 7.2 trips in P/A were extracted at Middle Layer Super Output Area (MSOA) level and were aggregated and disaggregated where necessary to match the CLHTM model zones. The disaggregation was done using the proportions derived from the PWD FBC model synthetic trip ends, which were originally based on population and job numbers from Census 2011.

Synthetic trips were segregated by trip purpose, and at the production end were further split by time of day and car availability.

6.3.3 Trip Distribution

The trips were distributed using a gravity model, the general formulation of which is given below:

$$T_{ij} = k_{ij} P_i A_j f(U_{ij})$$

Where, for each *ij* pair, *T* is the number of trips between production *i* and attraction *j*, P_i is the total number of trip productions for zone *i*, A_j is the total number of attractions for zone *j* and *f(U)* is a function of the utility between *i* and *j* (see below). *k* is a scaling factor determined such that the row and column totals of the resulting trip matrix matches the total productions (*P*) and attractions (*A*) for each zone.

For the CLHTM model, the synthetic trip ends were distributed using a gravity model, called JDIST developed by Jacobs. The gravity formulation was determined by a log-normal function, and the utility was distance between zone pairs. The function is shown below:

$$f(U_{ij}) = \frac{1}{\sigma U_{ij}\sqrt{2\pi}} e^{-(lnU_{ij}-\mu)^2/2\sigma^2}$$

Where σ and μ are calibration parameters to be modified to National Travel Survey (NTS) standard deviation and mean for each purpose and mode in order to produce the desired trip length distribution. Log Normal deterrence function provides a good fit with NTS trip length distribution, particularly with short distance trips.

The gravity model was calibrated to reproduce average trip lengths by journey purpose from the NTS (2017/2018). These are reproduced in Table 6-1.

Table 6-1: Mean Trip Length by Journey Purpose

Trip purpose	**Mean trip length (km)**
Home Based Work	16.05
Home Based Employer's Business	33.14
Home Based Education	6.65
Home Based Other	17.76
Home Based Shopping	9.67
Non Home Based Employer's business	16.05
Non Home Based Other	17.76

The gravity model was applied to 24-hour production and attraction trip ends by trip purpose to produce an all-day production-attraction (PA) matrix for an average weekday. The used costs were taken from the previously validated model. Time of day factors from NTEM were used to split the 24-hour matrix into PA matrices by time period.

6.3.4 Synthetic Matrix Validation

The synthetic matrices were validated by comparing their trip length distributions against NTS Data. Synthetic matrix trip purpose split was also compared with TEMPRO for each time period to confirm there were no distortions after the trip distribution was undertaken. The validation results are discussed in the following sections.

a) Trip Length Distributions

Comparisons of the synthetic trip length distribution to the NTS data is presented in the figures below for Internal to Internal and Internal to External trips. Graphs for all day comparisons of the Internal to Internal Only, External to Internal and all trips are available upon request. Table 6-2 summarises the comparison based on the coincidence ratio for each trip purpose. The internal (I) and external (E) areas refer to inside RSI cordon and outside areas, respectively.

Table 6-2: All Day Trip Length Distribution Coincidence Ratios (1 indicates a perfect fit)

Purpose	Coincidence Ratio			
	I-I trips	I-I and I-E trip	I-I, I-E and E-I trips	All trips
HB Work	0.7049	0.9968	0.8101	0.1124
HB Employers Business	0.5475	0.9564	0.7866	0.1731
HB Education	0.8182	0.9782	0.8979	0.0563
HB Shopping	0.7989	0.9900	0.8532	0.0721
HB Other	0.7158	0.9834	0.8847	0.0927
NHB Employers Business	0.5389	0.9694	0.7927	0.1653
NHB Other	0.7230	0.9745	0.8565	0.0934

The trip length distributions were compared using CR, which is used to compare two distributions by measuring the percent of area that "coincides" for the two curves. It is calculated by dividing the sum of the lower value of the two distributions at each distance band by the sum of the higher value of the two distributions at each distance band. In other words, the coincidence ratio shows the alignment of two datasets (in terms of area shared).

As the NTS data is given for all trips regardless of time period, the synthetic and observed data included in the graphs below are for all time periods combined. Note that the graph shows, for each type of data, the relative proportion of the total trips at each distance band rather than the absolute totals.

Comparisons for each period are provided in Appendix D.

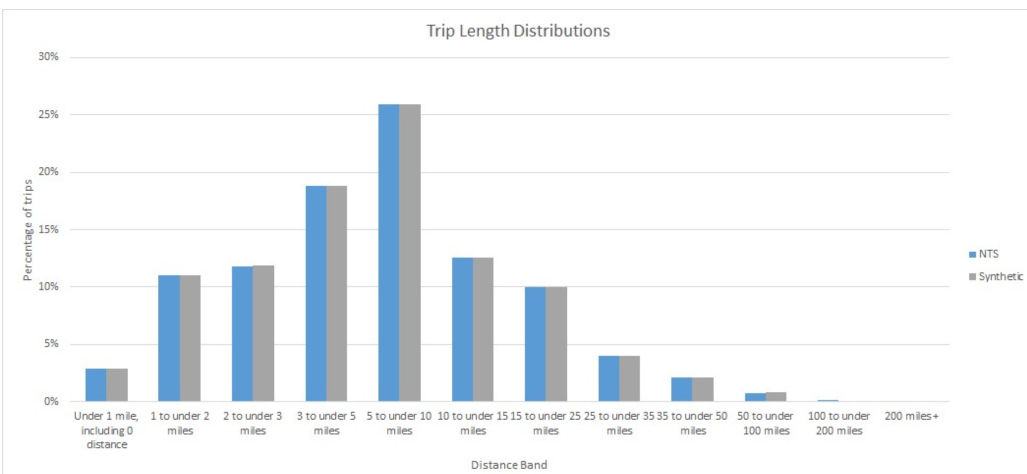


Figure 6-2: Home Based Work – Trip length distribution comparison

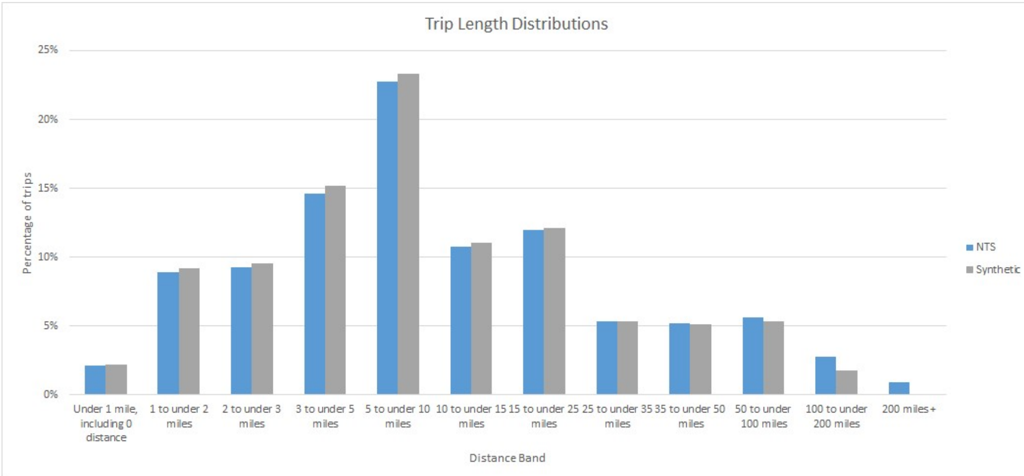


Figure 6-3: Home Based Employers Business – Trip length distribution comparison

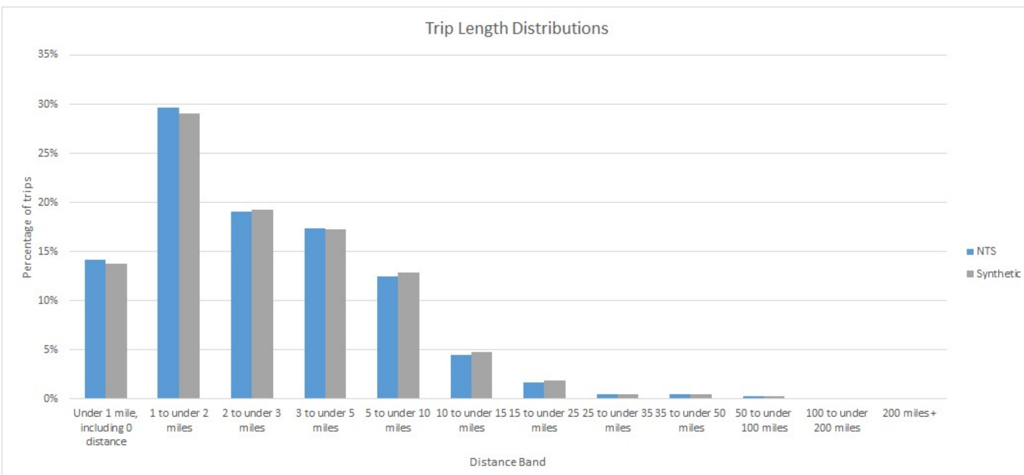


Figure 6-4: Home Based Education – Trip length distribution comparison

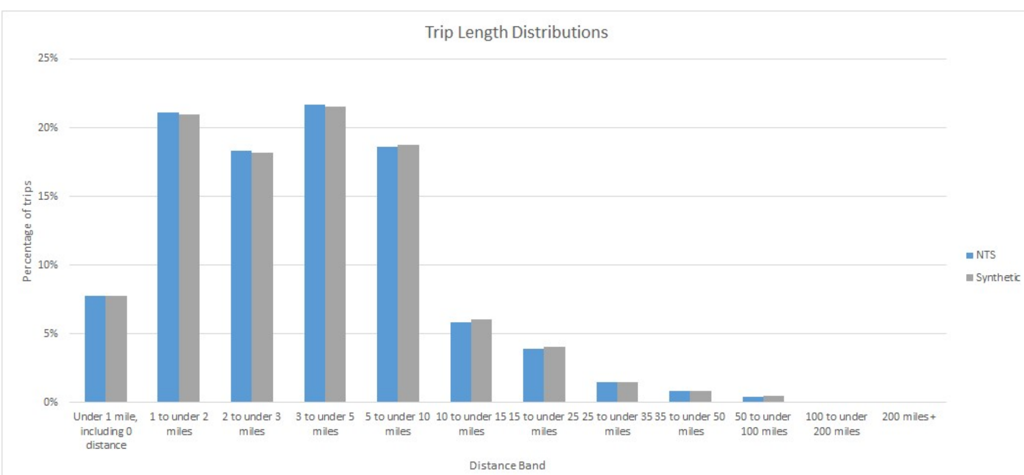


Figure 6-5: Home Based Shopping – Trip Length Distribution Comparison

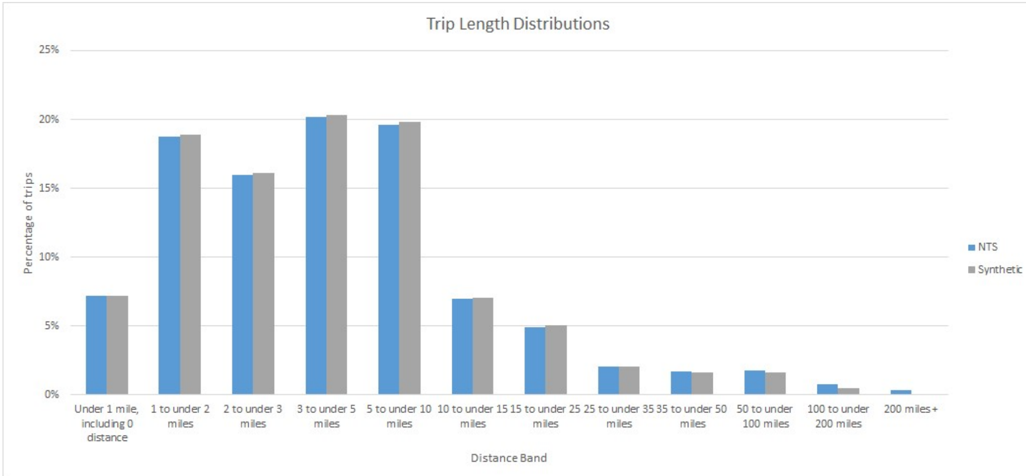


Figure 6-6: Home Based Other – Trip Length Distribution Comparison

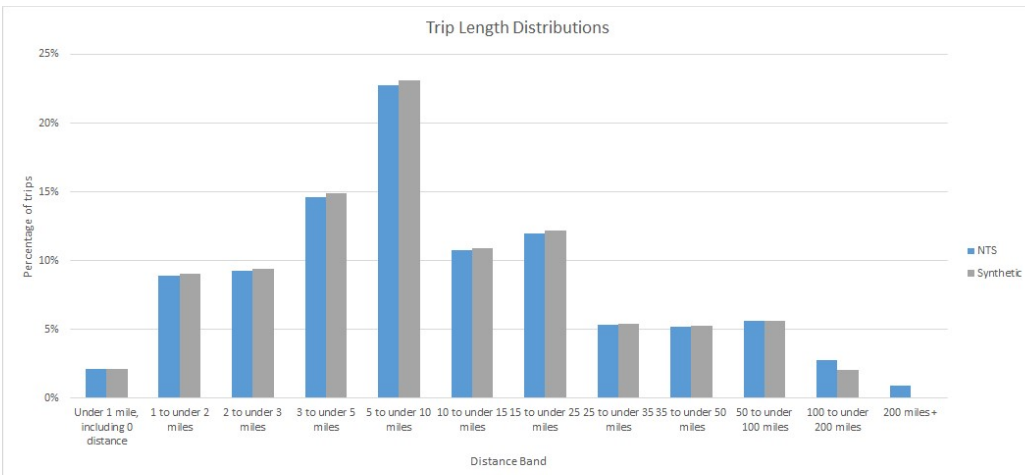


Figure 6-7: Non-Home Based Employers Business – Trip Length Distribution Comparison

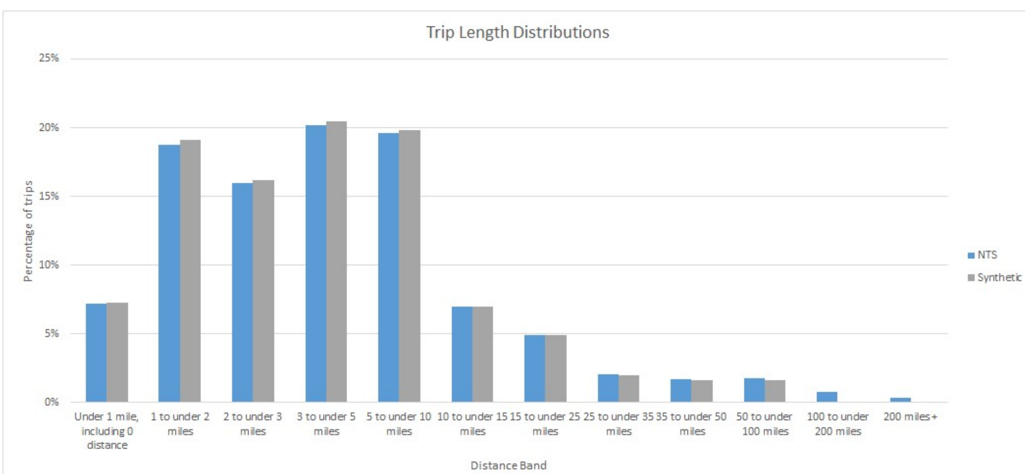


Figure 6-8: Non-Home Based Other – Trip Length Distribution Comparison

Trip length distribution figures and Table 6-2 show a good fit when Internal to Internal and Internal to External are considered as this provides the greatest range of trips covering all distance bands.

For shorter range trips (Internal to Internal), the fit is not as good due to the lack of long-distance trips that are included within the NTS data.

Similarly, the fit is poor for External to External trips as the proportions are heavily skewed towards longer distance bands due to the size of external zones that accounts for huge intrazonal trips and interzonal trips for the external zones.

b) Trip Purpose Splits

To investigate that the synthetic matrix has an appropriate split across all 7 purposes a comparison has been made against TEMPRO data for each time period. The percentage split by user class from the synthetic matrix is compared to TEMPRO for each of the following areas, in the AM, IP and PM Periods:

- Great Britain,
- North West England,
- Lancashire,
- RSI Cordon (i.e. the zones inside RSI cordon).

The comparisons at the RSI cordon level are shown in the figures below, comparisons of other periods and geographies are provided in Appendix E and summary of the Coincidence Ratios for each comparison is shown in Table 6-3.

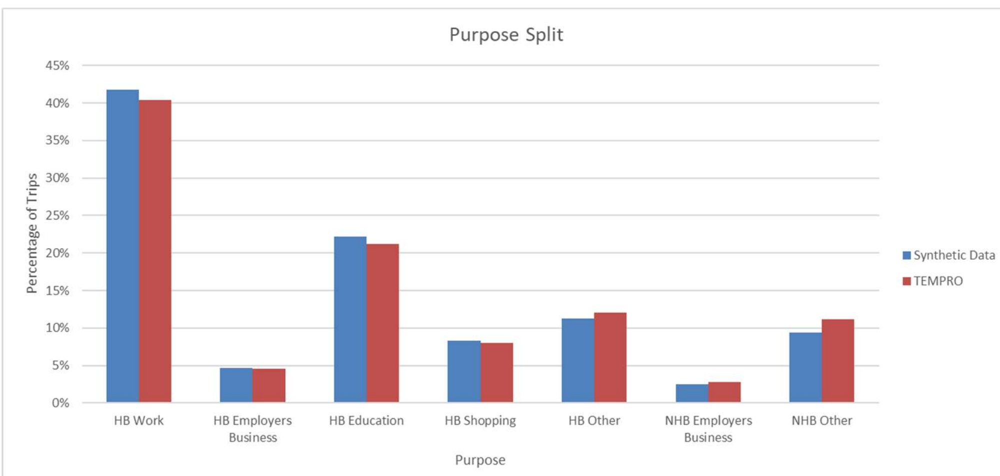


Figure 6-9: AM Peak comparison to TEMPRO purpose splits – RSI Cordon Level

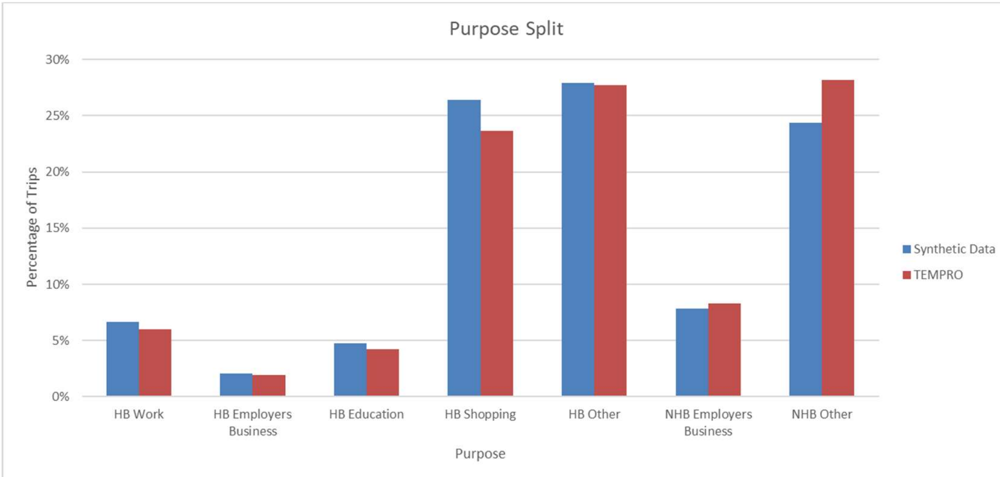


Figure 6-10: IP Peak comparison to TEMPRO purpose splits – RSI Cordon Level

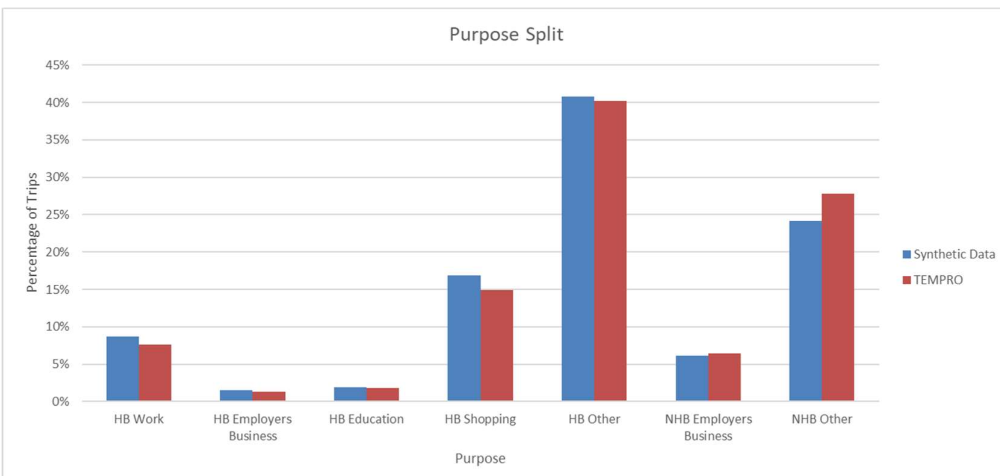


Figure 6-11: PM Peak comparison to TEMPRO purpose splits – RSI Cordon Level

TEMPRO Area	Coincidence Ratio		
	AM	IP	PM
Great Britain	1	1	1
North West England	1	1	1
Lancashire	0.989	0.994	0.993
RSI internal	0.944	0.918	0.925

Table 6-3 Purpose Split Coincidence Ratio

From the coincidence ratios shown above it can be seen that the synthetic matrix shows an excellent fit with TEMPRO for purpose splits at all geographies. The fit is strongest at the largest levels of geography as trip ends are split by purpose at a national level while at the RSI internal level the TEMPRO zones do not exactly match the model zones.

c) Time of Day Split

To check that the synthetic matrix has been split into time periods correctly the total number of trips in the synthetic matrix has been compared to TEMPRO totals at the same four geographies as for the trip purpose split as shown in the figures below.

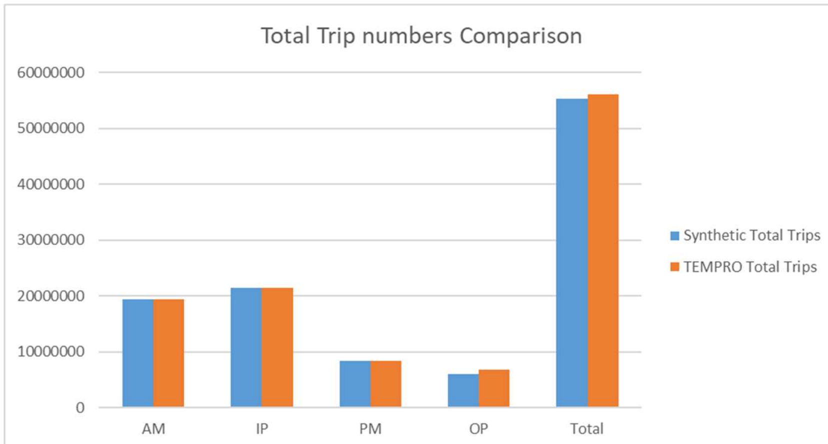


Figure 6-12: Comparison of total trips at a national level (GB)

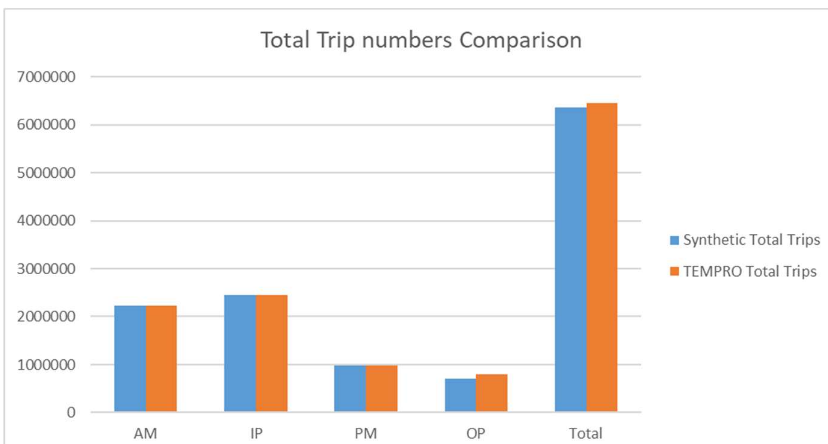


Figure 6-13: Comparison of total trips at a regional level (NW)

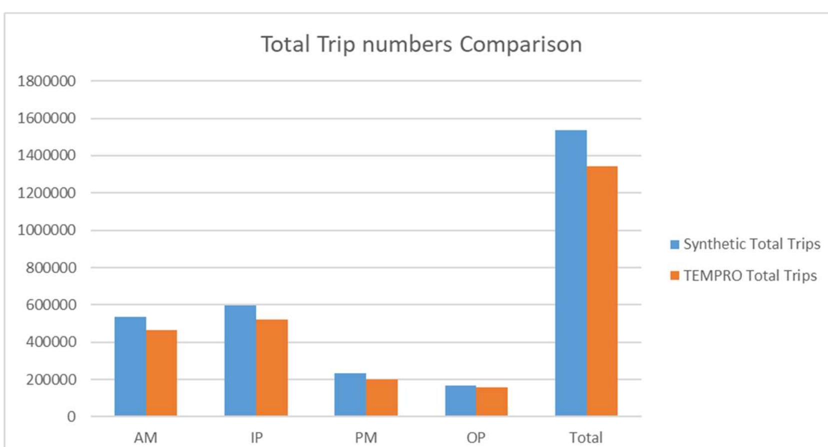


Figure 6-14: Comparison of total trips at a county level (Lancashire)

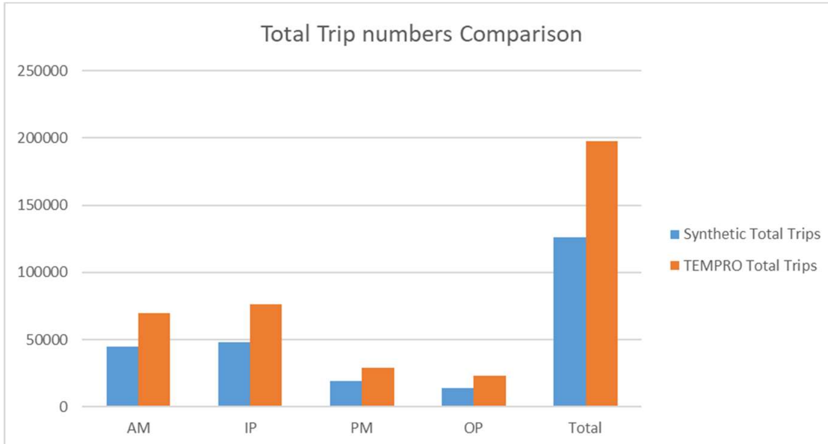


Figure 6-15: Comparison of total trips at a local level (RSI internal)

This shows that at a national, regional and county level the synthetic matrix has a very strong fit with TEMPRO. At a more local level there is a discrepancy as modelled zones do not equate to the TEMPRO zones in the area, however, if a comparison of the percentage split of the total trips by time period is reviewed (as shown in Figure 6-16) a very strong fit is seen.

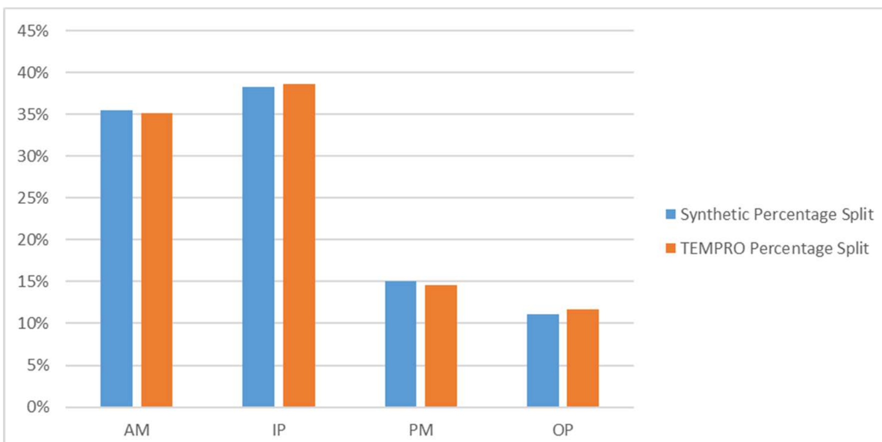


Figure 6-16: Percentage Split of total trips by period (local level)

6.4 Synthetic Matrices – Goods Vehicles

The method used to generate trip ends for cars could not be applied to produce trip ends for LGVs and HGVs. This is because it relies on use of NTEM data, which is concerned only with private, rather than freight or business trips. Therefore, an alternative methodology was employed.

In the original CLHTM model HGV matrices were built from the 2006 Base Year Freight Matrix (BYFM), which were uplifted to 2013 using growth factors from the DfT Road Traffic Forecasts 2015 and disaggregated from local authority districts into model zones using employment data weighted by goods vehicle trips rates per job type.

The methodology for developing LGV matrices used OGV trip rates extracted from TRICS as a proxy for HGV trips. LGV trip ends were calculated by applying a factor to the HGV trip ends. The factor itself was derived from count data and represented the relative proportion of LGVs compared to HGVs.

In order to have consistency in building GV matrices and in accordance with Highways England's comments on the previous model, in the updated model GV matrices were built from the TransPennine South Regional Transport Model (TPSRTM) base year (2015) prior matrices.

TPSRTM LGV and HGV matrices were originally created from Trafficmaster Origin Destination data and 2006 Base Year Freight Matrix (BYFM), respectively. The TPSRTM LGV matrices were then uplifted to 2015 using the traffic count at various locations and the HGV demand was uplifted using the factors from the DfT's Continuing Survey of Road Goods Transport.

To account for the difference in the zoning systems, where the CLHTM model zones were smaller, the TPSRTM demand was disaggregated using the proportions calculated from CLHTM 2013 GV trips per zone. In the buffer areas, however, the TPSRTM zones were smaller, and therefore, they were aggregated into CLHTM zone.

The growth factor was calculated from DfT's Road Traffic Statistics (RTS) using counts for a number of sites at motorways and major roads to scale up the trips from 2015 to 2018. Since RTS data was available only up to 2018, a second growth factor was calculated from Road Traffic Forecast 2018 (RTF18) to uplift trips from 2018 to 2019. The RTF18 factor was calculated from Table 1 for North West all roads.

Table 6-4 summarises the estimated growth factors for HGV and LGV.

Table 6-4 Estimated GV Growth Factors

GV Category	RTS (2015 to 2018)	RTF (2018 to 2019)	Final Factor
LGV	1.080	1.018	1.100
HGV	0.976	0.998	0.975

Since the RTM matrices are based on average hour matrix, the variation between the peak hour and average hour was investigated using the current traffic counts and necessary factors were applied to convert matrices into peak hour.

The final derived matrices served as Initial Prior GV Matrices for the model calibration exercise.

6.5 Observed Trip Matrices

It has been agreed with DfT that the 2014 RSI data would remain the basis for the Observed Matrices given that transport schemes and changes in land use between 2014 and 2019 have not had a significant impact on distribution patterns in the fully modelled area. The 25 RSI survey locations and resulting cordon are shown in Figure 6-17.

Figure 6-17: RSI 2013 - Survey Locations

The RSI data have the advantage of having undergone extensive checks during the PWD FBC model update. RSI observations were checked for logical OD movements and the sample trip length distribution and purpose splits compared to NTS and NTEM. These are detailed in the PWD FBC LMVR report in Section 7.4.2.

The RSI sample rates remained strong following updating traffic counts to 2019 observed data. Table 6-5 provides a summary of the sample rate for each of the sites.

Table 6-5: RSI Survey Sample Rate

Site	No. surveys	Total Traffic Flow		2019 Car Sample %
		2014	2019	
1NBD	1,187	5,273	5,745	22%
1SBD	1,010	5,394	4,976	21%
2EBD	1,298	11,653	12,353	11%
2WBD	1,235	11,837	14,847	9%
3NBD	1,232	8,691	8,163	16%
3SBD	1,213	8,734	7,474	17%
4NBD	847	4532	5,730	15%
4SBD	885	4147	5,035	18%
5NBD	1,054	8,741	9,530	11%
7SBD	1,185	7,349	6,490	19%
9SBD	1,077	7,286	8,714	13%

10SBD	888	5713	6,651	14%
11WBD	1,224	2,728	3,771	33%
13NBD	1,131	6,852	8,509	15%
28EBD	597	1843	2,430	25%
28WBD	565	1833	2,299	25%
29EBD	975	2956	4,228	25%
29WBD	930	3832	4,718	21%
30SBD	957	4886	6,281	16%
31WBD	1,090	10,790	10,560	10%
32NBD	975	6273	6,510	16%
33EBD	1,398	10,788	11,166	13%
33WBD	1,143	8,742	11,833	11%
34NBD	1,228	11,109	12,971	10%
35WBD	1,045	2,254	2,788	38%
Average	**1,054**	**6,537**	**7,288**	**18%**

2019 Traffic count surveys undertaken at the RSI sites were used to estimate the expansion factors. Expansion factor for each time interval is calculated by dividing the total traffic volume by the number of survey records.

Table 6-6 provides the peak hour expansion factors derived from RSI interviews and normalised ATC flow for each of the time periods. The vehicular split from the Manual Classified Counts (MCC) were applied to the average of two-week ATC data to calculate the normalised flow.

Table 6-6: Peak Hour Expansion Factors Car

Site	Direction	AM	IP	PM
1	Northbound	1.38	7.15	3.10
1	Southbound	3.68	7.55	2.97
2	Eastbound	5.03	9.11	4.23
2	Westbound	5.46	10.51	4.42
3	Northbound	2.72	7.01	2.47
3	Southbound	2.99	7.68	2.26
4	Northbound	3.73	10.77	5.00
4	Southbound	3.89	8.20	3.14
5	Northbound	6.42	10.10	3.98
5	Southbound	5.50	13.77	4.11
7	Northbound	5.07	11.12	2.20
7	Southbound	5.75	9.77	3.31
9	Northbound	6.23	10.62	2.52
9	Southbound	3.05	9.49	4.92
10	Northbound	13.21	14.44	2.51
10	Southbound	5.57	12.16	5.14
11	Eastbound	4.27	4.79	1.41
11	Westbound	3.30	3.17	1.33
13	Northbound	2.59	9.59	3.08
13	Southbound	5.08	12.26	1.58

Site	Direction	AM	IP	PM
28	Eastbound	3.97	6.65	2.98
28	Westbound	2.70	5.82	3.07
29	Eastbound	3.14	5.79	2.75
29	Westbound	4.64	11.90	4.81
30	Northbound	11.93	14.27	2.66
30	Southbound	2.78	10.98	5.91
31	Eastbound	6.25	13.56	3.54
31	Westbound	4.19	10.88	4.14
32	Northbound	5.52	11.19	4.68
32	Southbound	8.07	12.05	3.07
33	Eastbound	1.96	9.30	3.62
33	Westbound	3.57	11.52	6.14
34	Northbound	3.96	11.63	4.71
34	Southbound	7.98	15.07	3.87
35	Eastbound	4.27	3.79	1.82
35	Westbound	2.42	2.50	2.24

With higher expansion factors there is a greater risk of introducing bias into the survey, whereby the few trips that were observed are over represented at the expense of those which were not. This is undesirable as it is more likely to lead to trip matrices that are unrepresentative of trip movements.

The RSI matrices were built using the same methodology as adopted in the PWD FBC model. Following completion of all the processing steps, each surveyed record had an origin zone, destination zone, trip purpose, vehicle type, time period and revised expansion factor.

Using this information, a trip matrix was constructed for each site, time period, trip purpose and vehicle type (car). Each cell in the trip matrices was populated with the number of records for the corresponding origin and destination zone multiplied by the expansion factor.

Merging the individual RSI site matrices into the combined observed matrix was undertaken in the same way as the PWD FBC model. The index of dispersion (based on the Erica software principles) was applied such that expanded site wise matrices were merged at cordon level using a variance merging technique. This was applied on a cell by cell basis at purpose/mode and time period level. Further information on the processing of the observed data and the various checks that were undertaken is documented in PWD FBC LMVR (Section 7.4).

Using the home end of the journey information from the RSI survey the observed trips have been converted to P/A for the purpose of merging with synthetic demand.

6.6 Merging Data from Surveys and Trip Synthesis

The synthetic and the observed demand matrices were merged based on the general principle that where the RSI surveys intercepted a trip between a given origin and destination pair, the merged matrix should be based on observed data. For an origin-destination pair that were not intercepted by the RSI surveys, the merged matrix should be based on the synthetic trips.

The merge process was carried out in PA format (for each trip purpose) and at lumpy sector level in order to smooth out the observed demand across model zones. Because the RSI surveys only intercepted a sample of all trips, the resulting observed trip matrix is ‘lumpy’. Rather than having a small number of trips for all the origin-destination pairs that travelled through the survey site, the matrix has a large number of trips for the (relatively) small number of origin-destination pairs that were actually surveyed. This apparent bias in the observed matrix needed to be removed before the data could be merged with the synthetic trip matrices.

The principle behind the 'smoothing' process was to take the large trip volumes from the small number of observed origin destination pairs, and portion them out to other origin-destination pairs representing a similar movement, which did not have any observed trips. In such a way, there would be more cells in the matrix containing trips, with no single cell containing inordinately more trips than any other.

Therefore, every model zone was grouped with 3 or 4 neighbouring zones based on their geographical location to form 'lumpy sectors'. The (factored) observed trips were then summed into the lumpy sector matrix. Before distributing the trips among zones in a lumpy sector, the (unfactored) number of interviews were deducted from the total trips and were allocated to the zone which had the survey data. The remaining trips were then proportioned out amongst all zones in that sector using their proportions in the total sector synthetic trips. This approach was adopted to ensure that the observed trip pattern, in terms of number of interviews, would be preserved.

The resulting PA matrices were converted into origin-destination (OD) matrices using adjusted 'phi factors'. The phi factors determine for each outbound trip (i.e. from the production end to the attraction end) by time period and trip purpose, what the likely time period and trip purpose of the return trip will be.

For example, the morning period, home based work trip purpose PA matrix will contain a number of trips between a production (home) and attraction (work). The PA matrix effectively provides the OD matrix for the outbound (from home) trip. The PA matrix also contains details of the return trip (back home from work) and the phi factors specify in what time period the trip will return, and what the trip purpose would be. Given that the phi factors account for return trips with a different purpose than the outbound trip when for example the individual stopped at the shops on the way home from work (the return trip purpose would therefore by home based shopping), the phi factors have been adjusted to ensure the total number of outbound trips matched the total number of return trips for each journey purpose. For example, if there was 5% returning in PM with a different trip purpose, and 10% with the original purpose, they were added together to make it 15% returning as the original purpose.

The resulting factors are shown in Table 6-7.

Table 6-7: Adjusted Phi Factors

HB Work		**Return Trip Time Period**			
		AM	**IP**	**PM**	**OP**
Outbound Trip Time Period	AM	4%	20%	67%	8%
	IP	0%	27%	49%	24%
	PM	3%	2%	47%	49%
	OP	13%	34%	25%	28%
HB Employer Business		**Return Trip Time Period**			
		AM	**IP**	**PM**	**OP**
Outbound Trip Time Period	AM	6%	27%	54%	12%
	IP	0%	44%	45%	12%
	PM	0%	0%	42%	58%
	OP	8%	6%	9%	77%
HB Education		**Return Trip Time Period**			
		AM	**IP**	**PM**	**OP**
	AM	21%	56%	22%	0%

Outbound Trip Time Period	IP	0%	85%	15%	0%
	PM	0%	2%	64%	34%
	OP	2%	7%	7%	83%
HB Shopping		**Return Trip Time Period**			
		AM	**IP**	**PM**	**OP**
Outbound Trip Time Period	AM	34%	61%	5%	0%
	IP	0%	83%	17%	0%
	PM	0%	0%	79%	21%
	OP	1%	0%	0%	99%
HB Other		**Return Trip Time Period**			
		AM	**IP**	**PM**	**OP**
Outbound Trip Time Period	AM	31%	44%	20%	5%
	IP	0%	56%	36%	8%
	PM	0%	7%	54%	39%
	OP	3%	4%	3%	90%

For each time period, the matrices by trip purpose were aggregated to the user classes in the model. A vehicle occupancy factor was then used to convert the matrices from person trips to vehicle trips, and a further factor applied to convert from the time period to the modelled hour.

The matrices were assigned on CLHTM highway network and the modelled flows were compared with the traffic count data at screenline level. The comparisons were made against counts that formed the RSI screenline and those used for the purpose of calibration and validation. It was observed that for all time periods the RSI screenline performed well as expected since the RSI matrices were developed using the 2019 expansion factors. RSI screenline results for all three peaks are summarised in Table 6-8.

Table 6-8: After the merge RSI Screenline Performance

Time Period	SL ID	Direction	Observed Flow	Model Flow	Actual Diff	Percentage Diff
AM	15	Inbound	14,627	15,370	- 743	-5%
	15	Outbound	11,668	11,617	51	0%
IP	15	Inbound	10,029	9,830	199	2%
	15	Outbound	10,280	10,400	- 120	-1%
PM	15	Inbound	13,476	13,192	284	2%
	15	Outbound	13,985	14,029	- 44	0%

6.7 Land Use Change since 2014

Land use changes due to housing and employment sites completed since 2014 were reviewed to understand whether they needed to be explicitly modelled as part of the model update.

It was noted that vast majority of the new developments have been an extension to the existing residential or employment areas that fall within the same model zones. Given that the base year prior demand matrices are developed using 2019 Tempro and RSI data re-expanded to 2019 counts, these new development trips are already accounted and do not require explicit modelling to avoid double counting.

There were a small number of greenfield sites, however, which would not be present in the 2019 prior matrices. Trips generated by these developments were estimated using TRICS trip rates applied to quantum of each development (i.e. number of houses/ jobs depending on a land use). These developments however only accounted for under 250 trips in each modelled hour and it was considered disproportionate to model them explicitly as part of the 2019 model update.

6.8 Sector Factoring and Final Prior Demand Matrices

The merged synthetic and observed matrices were assigned to the network and went through several iterations of controlled modification in order to improve the screenline and individual link results at an aggregated level to minimise the changes made by Matrix Estimation (ME) for final calibration.

The modifications tool the form of sector factoring, applying an increase or decrease to sector-sector movements depending on the modelled level of traffic compared to observed at count sites on links that form the routes between the sectors. The same 34 sector system as shown in Figure 2-5 was used during this process.

This process was repeated until the comparisons between observed and modelled flows at screenline level were considered acceptable to move on to the next stage.

The overall change at matrix level (by purpose) and trip length distribution were closely monitored to ensure that modifications did not significantly distort the matrices. As shown in Table 6-9, except for a few cases, the change at matrix level was less than 5% for most of the cases in all time periods. This is specifically noticed in IP, and this can be attributed to the fact that the IP demand is estimated by taking an average of the IP period unlike AM and PM peaks where a peak hour factor was used to determine the peak hour matrices.

The trip length distributions are compared using a Coincidence Ratio (CR) and Regression Analysis (specifically R-Squared). CR is used to compare two distributions by measuring the percent of area that “coincides” for the two curves. It is calculated by dividing the sum of the lower value of the two distributions at each distance band by the sum of the higher value of the two distributions at each distance band.

As presented in Table 6-9, both CR and R-squared are close to 1 at all time periods across all trip purposes, indicating that there is no significant difference in the pre and post sector factoring distributions. Trip length distribution histograms and regression analysis plots are available upon request.

Table 6-9: Prior Matrix Sector Factoring Changes

Period	Purpose	Primary Prior Trips	Final Prior Trips	Difference	TLD (CR)	TLD R^2
AM	Commute	152,660	158,360	3.73%	0.97	1.00
	Business	24,767	26,316	6.25%	0.95	1.00
	Other	168,130	172,669	2.70%	0.98	1.00
IP	Commute	33,627	35,597	5.86%	0.96	1.00
	Business	20,070	21,376	6.51%	0.92	1.00
	Other	184,998	192,984	4.32%	0.97	1.00
PM	Commute	131,757	136,870	3.88%	0.97	1.00
	Business	24,857	26,535	6.75%	0.95	1.00
	Other	178,293	184,438	3.45%	0.98	1.00

7. Prior Matrices Calibration and Validation

7.1 Introduction

This section provides the result of assigning the final prior matrices to the SATURN network and comparing it against the calibration and validation screenlines before running ME. Network and logic checks were undertaken prior to the sector factoring process to ensure that the matrix adjustments were not made to mask problems within the network.

7.2 Prior Matrices Calibration and Validation Results

The map of screenlines is shown in Figure 7-1.

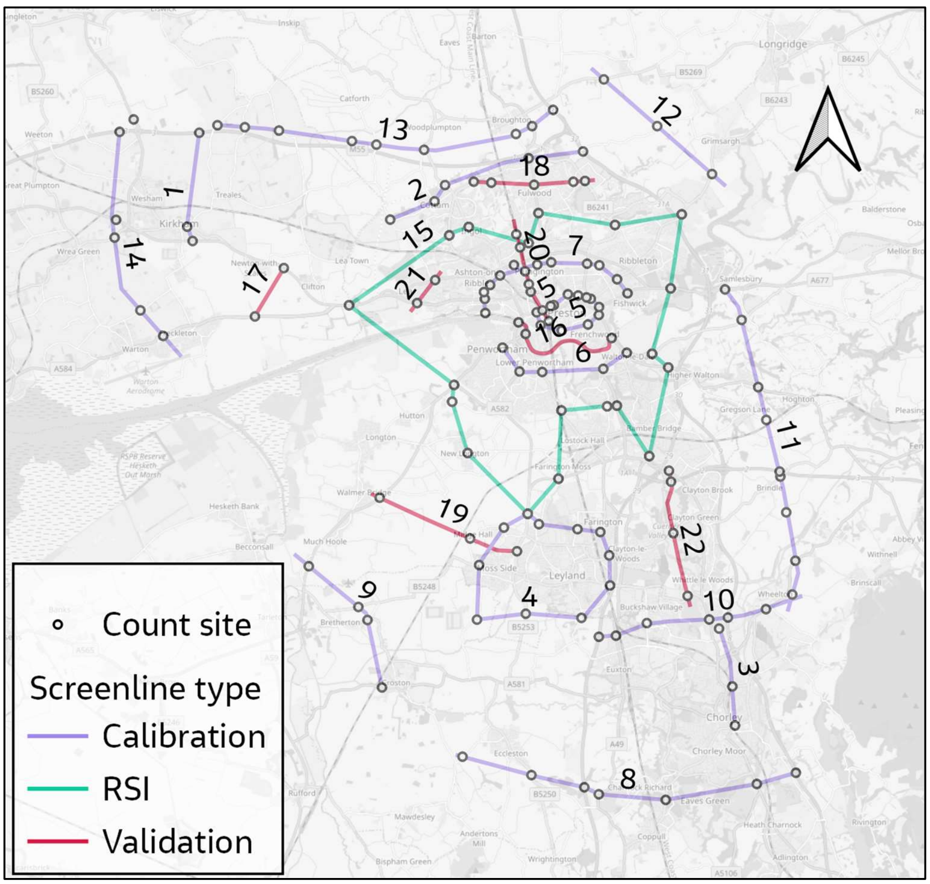


Figure 7-1: Map of Screenlines

Table 7-1 , Table 7-2 and Table 7-3 show the calibration screenline comparisons for the AM, IP and PM time periods, respectively.

The majority of screen lines in all the three peaks are within 10% of the total observed screenline counts except for screenline 2 and 13. It is acknowledged that these screenlines do not perform as well as other screenlines prior to ME. This is related to a major congestion problem on one of the links belonging to both screenlines and is further discussed in Section 11.4.

All the RSI screenline total counts, highlighted in the tables, are within 5% for all three time periods.

Table 7-1: Prior Calibration Screenlines AM

Screenline Number	Inbound/ Outbound	Observed Flow	Modelled Flow	% of Links Compliant	Actual Difference	% Difference
SL_1	Inbound	3944	3743	100%	201	5%
SL_2	Inbound	1499	1797	25%	-298	20%
SL_3	Inbound	1240	1261	100%	-21	2%
SL_4	Inbound	5302	5496	100%	-194	4%
SL_5	Inbound	5493	5950	63%	-457	8%
SL_6	Inbound	5759	5936	40%	-177	3%
SL_7	Inbound	5055	5559	80%	-504	10%
SL_8	Inbound	9487	9863	100%	-376	4%
SL_9	Inbound	1642	1657	75%	-15	1%
SL_10	Inbound	9826	9846	33%	-20	0%
SL_11	Inbound	6425	6243	78%	182	3%
SL_12	Inbound	1225	1247	67%	-22	2%
SL_13	Inbound	935	748	71%	187	20%
SL_14	Inbound	4820	4825	100%	-5	0%
SL_15	Inbound	14627	15371	58%	-744	5%
SL_1	Outbound	3965	3782	100%	183	5%
SL_2	Outbound	1786	1769	50%	17	1%
SL_3	Outbound	1178	1223	33%	-45	4%
SL_4	Outbound	5616	5761	80%	-145	3%
SL_5	Outbound	3879	3977	89%	-98	3%
SL_6	Outbound	2773	2955	40%	-182	7%
SL_7	Outbound	3609	3782	70%	-173	5%
SL_8	Outbound	9016	9777	83%	-761	8%
SL_9	Outbound	1237	1316	100%	-79	6%
SL_10	Outbound	9475	9705	67%	-230	2%
SL_11	Outbound	6309	6280	89%	29	0%
SL_12	Outbound	1176	1163	33%	13	1%
SL_13	Outbound	800	593	86%	207	26%
SL_14	Outbound	5102	4973	33%	129	3%
SL_15	Outbound	11668	12212	79%	-544	5%

Table 7-2: Prior Calibration Screenlines IP

Screenline Number	Inbound/ Outbound	Observed Flow	Modelled Flow	% of Links Compliant	Actual Difference	% Difference
SL_1	Inbound	2855	2792	67%	63	2%
SL_2	Inbound	1347	1418	75%	-71	5%
SL_3	Inbound	869	841	67%	28	3%
SL_4	Inbound	3979	4134	80%	-155	4%
SL_5	Inbound	4017	4050	88%	-33	1%
SL_6	Inbound	3328	3473	100%	-145	4%
SL_7	Inbound	3487	3739	70%	-252	7%
SL_8	Inbound	7519	7808	83%	-289	4%
SL_9	Inbound	968	978	100%	-10	1%
SL_10	Inbound	7606	7724	83%	-118	2%
SL_11	Inbound	4103	4043	89%	60	1%
SL_12	Inbound	810	793	67%	17	2%
SL_13	Inbound	366	462	86%	-96	26%
SL_14	Inbound	3434	3389	100%	45	1%
SL_15	Inbound	10029	10580	79%	-551	5%
SL_1	Outbound	2903	2730	100%	173	6%
SL_2	Outbound	1239	1206	100%	33	3%
SL_3	Outbound	975	941	33%	34	4%
SL_4	Outbound	4088	4269	80%	-181	4%
SL_5	Outbound	4423	4866	89%	443	10%
SL_6	Outbound	3634	3677	40%	-43	1%
SL_7	Outbound	3566	3724	60%	-158	4%
SL_8	Outbound	7919	8136	83%	-217	3%
SL_9	Outbound	1060	1092	75%	-32	3%
SL_10	Outbound	8076	8208	67%	-132	2%
SL_11	Outbound	4076	4007	89%	69	2%
SL_12	Outbound	915	867	33%	48	5%
SL_13	Outbound	446	393	100%	53	12%
SL_14	Outbound	3473	3409	67%	64	2%
SL_15	Outbound	10280	10440	84%	-160	2%

Table 7-3: Prior Calibration Screenlines PM

Screenline Number	Inbound/ Outbound	Observed Flow	Modelled Flow	% of Links Compliant	Actual Difference	% Difference
SL_1	Inbound	3888	3753	67%	135	3%
SL_2	Inbound	1758	1934	50%	-176	10%
SL_3	Inbound	1157	1120	33%	37	3%
SL_4	Inbound	5680	5836	70%	-156	3%
SL_5	Inbound	4237	4422	38%	-185	4%
SL_6	Inbound	3731	3862	80%	-131	4%
SL_7	Inbound	3834	4227	70%	-393	10%
SL_8	Inbound	9672	10293	83%	-621	6%
SL_9	Inbound	1161	1200	100%	-39	3%
SL_10	Inbound	9588	9724	67%	-136	1%
SL_11	Inbound	6639	6552	78%	87	1%
SL_12	Inbound	939	987	33%	-48	5%
SL_13	Inbound	583	722	86%	-139	24%
SL_14	Inbound	4783	4845	67%	-62	1%
SL_15	Inbound	13476	13862	79%	-386	3%
SL_1	Outbound	4168	4042	100%	126	3%
SL_2	Outbound	1784	1790	75%	-6	0%
SL_3	Outbound	1395	1365	33%	30	2%
SL_4	Outbound	5304	5343	40%	-39	1%
SL_5	Outbound	5763	6184	67%	-421	7%
SL_6	Outbound	5507	5416	40%	91	2%
SL_7	Outbound	4945	5027	70%	-82	2%
SL_8	Outbound	10466	11133	83%	-667	6%
SL_9	Outbound	1604	1647	100%	-43	3%
SL_10	Outbound	11032	11260	67%	-228	2%
SL_11	Outbound	6422	6372	78%	50	1%
SL_12	Outbound	1290	1286	33%	4	0%
SL_13	Outbound	732	712	100%	20	3%
SL_14	Outbound	5076	5025	83%	51	1%
SL_15	Outbound	13985	14277	89%	-292	2%

Table 7-4 to Table 7-6 shows the validation screenline comparisons. It can be seen the total counts across all the screenlines in all three time periods majority are within 10% of the observed total screenline count.

Table 7-4: Prior Validation Screenline Performance AM

Screenline Number	Inbound/ Outbound	Observed Flow	Modelled Flow	% of Links Compliant	Actual Difference	% Difference
SL_16	Inbound	4647	5083	67%	-436	9%
SL_17	Inbound	1599	1641	50%	-42	3%
SL_18	Inbound	7564	8074	60%	-510	7%
SL_19	Inbound	2021	2012	67%	9	0%
SL_20	Inbound	3088	3145	80%	-57	2%
SL_21	Inbound	1957	1992	100%	-35	2%
SL_22	Inbound	4502	4167	75%	335	7%
SL_16	Outbound	2819	3027	67%	-208	7%
SL_17	Outbound	1571	1606	100%	-35	2%
SL_18	Outbound	7616	7683	60%	-67	1%
SL_19	Outbound	1327	1486	100%	-159	12%
SL_20	Outbound	2451	2907	80%	-456	19%
SL_21	Outbound	1510	1563	100%	-53	4%
SL_22	Outbound	4322	3554	75%	768	18%

Table 7-5: Prior Validation Screenline Performance IP

Screenline Number	Inbound/ Outbound	Observed Flow	Modelled Flow	% of Links Compliant	Actual Difference	% Difference
SL_16	Inbound	3116	3329	100%	-213	7%
SL_17	Inbound	998	997	100%	1	0%
SL_18	Inbound	6749	7280	40%	-531	8%
SL_19	Inbound	1119	1156	100%	-37	3%
SL_20	Inbound	1923	2117	80%	-194	10%
SL_21	Inbound	1350	1324	100%	26	2%
SL_22	Inbound	3089	3029	100%	60	2%
SL_16	Outbound	2668	2858	67%	-190	7%
SL_17	Outbound	962	937	100%	25	3%
SL_18	Outbound	6555	6802	80%	-247	4%
SL_19	Outbound	1264	1284	100%	-20	2%
SL_20	Outbound	2436	2540	80%	-104	4%
SL_21	Outbound	1159	1176	100%	-17	1%
SL_22	Outbound	3068	2570	50%	498	16%

Table 7-6: Prior Validation Screenline Performance PM

Screenline Number	Inbound/ Outbound	Observed Flow	Modelled Flow	% of Links Compliant	Actual Difference	% Difference
SL_16	Inbound	3573	3850	100%	-277	8%
SL_17	Inbound	1417	1472	100%	-55	4%
SL_18	Inbound	8256	8682	40%	-426	5%
SL_19	Inbound	1369	1397	100%	-28	2%
SL_20	Inbound	2271	2432	60%	-161	7%
SL_21	Inbound	1501	1540	100%	-39	3%
SL_22	Inbound	4519	4240	75%	279	6%
SL_16	Outbound	3864	3963	100%	-99	3%
SL_17	Outbound	1543	1457	100%	86	6%
SL_18	Outbound	7953	8386	60%	-433	5%
SL_19	Outbound	2030	2070	100%	-40	2%
SL_20	Outbound	3061	3341	40%	-280	9%
SL_21	Outbound	1807	1774	100%	33	2%
SL_22	Outbound	4640	4142	60%	498	11%

8. Network Calibration and Validation

8.1 Introduction

This chapter details the checks undertaken on the network coding to ensure the model reflects realistic road conditions.

TAG Unit M3-1 specifies that calibration should not start unless the network has passed a series of basic checks. Although initial network coding checks were undertaken to eliminate any apparent errors, the main objective of network calibration at this stage was to identify and eliminate the common sources of error such that the calibration and validation process is largely confined to monitoring network performance and fine-tuning it to match observed conditions.

The prior trip matrix was assigned to the network for all time periods and routing, travel times and turn movement delays were assessed.

8.2 Network Checking and Calibration

A comprehensive review of the base year network was undertaken to ensure that coding of junctions and links, both in simulation and buffer areas, are correct and consistent with the new 2019 base year situation across the whole study area.

Initial network checks included but were not limited to: junction types and configuration, assigned speed flow curves, link distances, and error/warning messages.

The standard network check offered by the modelling packages consisted in checking network connectivity and identifying and correcting any illogical coding of junctions (SEMI-FATAL errors).

SATURN produces warning messages if the coded link length is significantly different from the crow–fly distance, and these warnings were checked and verified.

Additional checking focussed on the coded attributes of the links, including link speeds, number of lanes and capacity, as detailed below.

Free flow link speeds are a function of the link type and the speeds in the model were checked by plotting in GIS and colouring links according to speed, in set bands as shown below. This plot is shown below in Figure 8-1 for the detailed study area.

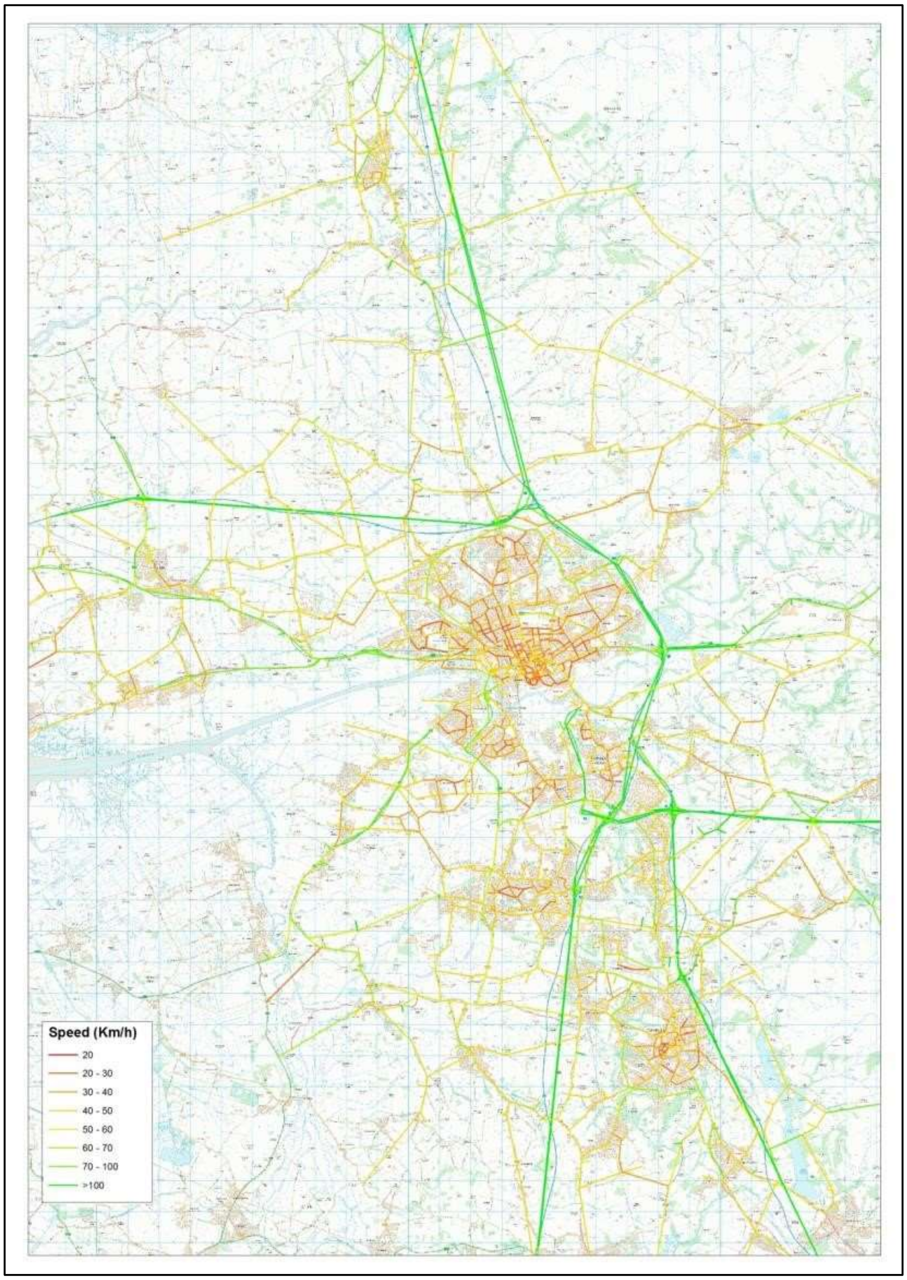


Figure 8-1: Model Link Speeds

The plot confirmed that the coded free flow speeds were logical, with urban areas such as Preston, Broughton, Leyland, Chorley having free flow speeds of around 30-50kph on residential streets, and 50-60kph on main through roads.

In rural areas the free flow speed is generally between 70kph and 100kph; unless where speed limits prevent. Finally, it's notable that the free flow speed on the M6, M55 and surrounding motorways were in excess of 100kph, as would be expected for motorway links.

The coded number of lanes was checked in a similar manner, with the plot of this shown in Figure 8-2 below.

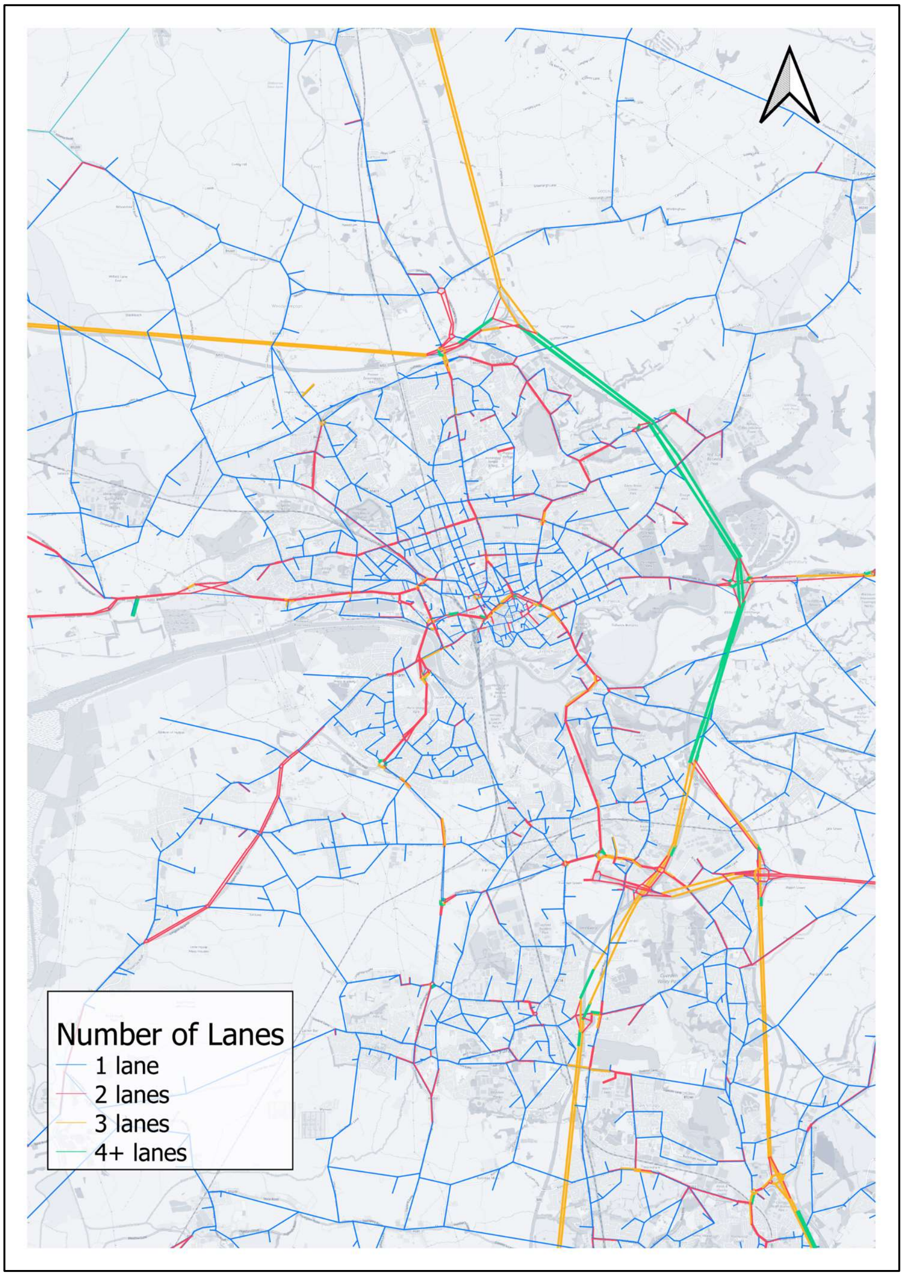


Figure 8-2: Number of Lanes

In line with TAG guidance, other network checks included checking appropriate junction types, turn restrictions, and appropriate link saturation flows.

Finally, it should be noted that checks were made to ensure that there was consistency of coding across all time periods, with only signal timings differing across the periods. A detailed list of network checks that were undertaken is provided in Appendix C.

To aid checks on the network, 'stress testing' was undertaken, in which the base year matrices were factored up and assigned to the network, to see where the increased demand leads to excessive delays. This more easily identified junctions which required investigation.

Major delays at junctions were examined and where possible compared to the journey time data. One junction that required modification was the new Broughton Roundabout, signalised roundabout junction with M55 and Garstang Road. The initial coding was giving low delay compared to the observed travel time which indicated major congestion and excessive queueing at one of the approaches. Signal timings and turn capacity were adjusted to better match the traffic situation and observed delays.

Speeds along roadway segments where ongoing construction were noted, such as Liverpool Road and D'Urton Road were reviewed and adjusted to reflect actual traffic conditions.

A detailed network review was undertaken along the sections of Penwortham Way, Flensburgh way and A582 sections to ensure the coding was correct and matched the field conditions.

Link travel times were examined compared to the observed journey time data. In general, the model travel times were found to be faster than the observed travel times. Link speeds and type were rechecked for those routes where model journey times were found to be faster than the observed. In city centre, speeds were reviewed to represent delays caused by on-street parking or by-roads.

To prevent illogical traffic on minor side roads within the network on links that in reality would be unattractive due to reduced capacity due to on street parking and delays caused by both, parking cars and pedestrians crossing the street, adjustments to free flow link speeds and capacity were required in some cases.

9. Route Choice Calibration and Validation

9.1 Introduction

This chapter assesses the performance of the highway model in terms of route choice between zones in different parts of Central Lancashire.

In relation to the A582 scheme, emphasis was placed in this chapter on movements across and through Preston to demonstrate the plausibility of routing in the model.

9.2 Routing Through the Modelled Network

The model was further checked by examining shortest paths and minimum generalised cost routes through the network. These checks were done at an early stage of the model development, prior to matrix estimation to ensure suitability, and again towards the end of the model development process, with final versions of the trip matrices.

Major urban areas covered by the network were identified, and routes between them checked against local knowledge, common sense, and also routes suggested by Google Maps based on historic travel times and routing information. The urban areas identified are listed below:

- Garstang
- Preston
- Leyland
- Blackpool
- Chorley
- Woodplumpton
- Broughton
- Blackburn
- Tarleton
- Samlesbury
- Warton

In accordance to TAG unit M3.1 guidance, the number of routes that should be checked is defined by:

$$Number\ of\ OD\ Pairs = (Number\ of\ Zones)^{0.25} * (Number\ of\ User\ Classes)$$

$$Number\ of\ OD\ Pairs = 579^{0.25} * 5$$

$$Number\ of\ OD\ Pairs = 24.52$$

On that basis, with 579 zones, and 5 user classes, 24 routes should be checked. To ensure a robust network, an additional 2 routes were identified, making it 26 checked routes in total. Those routes selected were developed with LCC and Highways England, and the routes selected by combinations of the urban areas listed above all meet the criteria for routes which advise that they should:

- Relate to significant number of trips
- Are of significant length
- Pass through areas of interest
- Include both directions of travel
- Link different compass areas
- Coincide with journey time routes as appropriate

An example of the route checked in the model is illustrated in Figure 9-1 and Figure 9-2 with the modelled routes shown in red. In the AM scenario the model predicts that the A6 is the most attractive route for vehicles travelling from Leyland to Preston (Bus station zone was chosen as a representative location) with a small proportion of trips rat-running via parallel residential streets. In the PM scenario due excessive congestion at some of the junctions particularly on Preston Ringway difference in cost of travelling via the A582 and via the A6 is reduced and consequently the model predicts that some trips will switch to the A582 route. This routing is consistent with the local knowledge and Google Journey Planner.

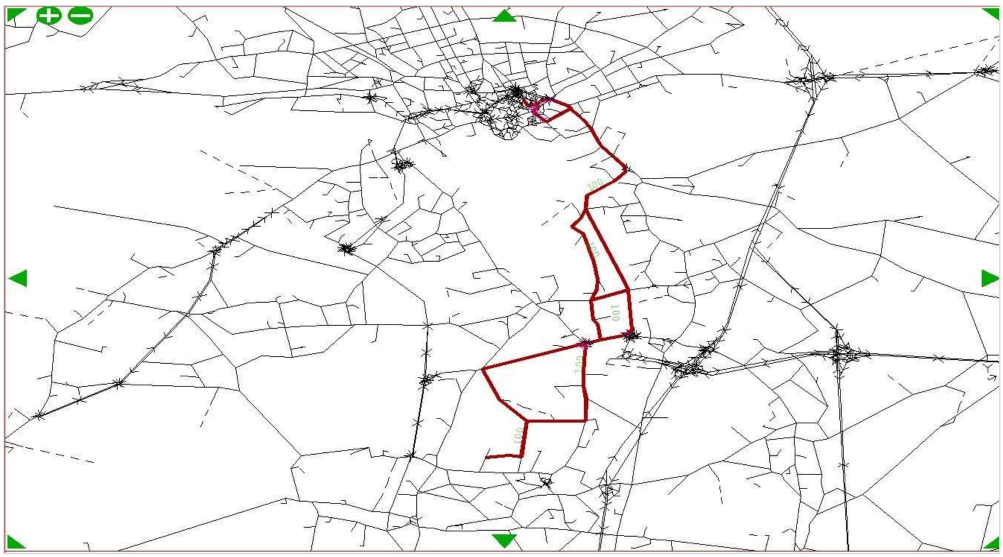


Figure 9-1: Leyland to Preston (AM)

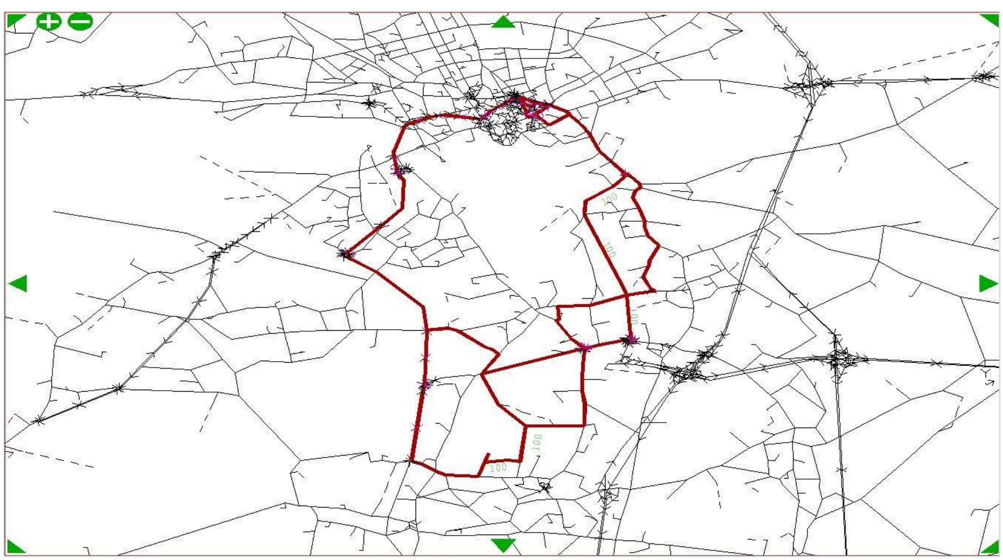


Figure 9-2: Preston to Lyeland (PM)

The checks on the routes were undertaken using engineering judgement, Google Journey Planner and confirmed against local knowledge of the area. Where the route used in the model was contrary to expectations, the modelled network was adjusted to correct the routing.

In most cases the routes were found to be logical, few minor changes such as free flow speed correction and HGV route restrictions were sufficient to correct the routing.

To meet with the TAG criteria, the routes that were checked are detailed in Appendix F.

It should be noted that both Car Commute and HGV routings were checked for logical movements. Any required adjustments were applied to all trip purposes.

10. Matrix Calibration/Validation

10.1 Matrix estimation

Following the prior matrix assignment and refining of the modelled network, the trip matrices underwent a process of 'matrix estimation' whereby trip matrices are adjusted such that the resulting assigned flows matches are able to match count data better; in a controlled as possible process.

The following parameters were used for matrix estimation:

- XAMAX – 4.0
- Number of iterations – 9

It is important when running a matrix estimation process that the original 'prior' (to estimation) trip matrices are not distorted in such a way that the underlying trip patterns are altered.

To ensure that there was minimum distortion, short screenlines (Combined constraints) were applied. Counts used as constraints in matrix estimation were derived from count data, and applied at the Car, LGV and HGV level.

In addition to the short screenline approach, a frozen cell matrix was also setup to ensure that fully observed car trips were not altered in the process, and the car trips developed through trip synthesis were primarily impacted.

All HGV and LGV trip movements were left unfrozen due to the synthetic nature of demand.

To test whether this altering process has occurred, and resulted in minimum distortion to the trip matrices, the guidelines set out within TAG unit M3-1 were applied to the prior - and post-ME matrices, as detailed below:

Table 10-1: Significance of Matrix Estimation Changes

Measure	**Significance Criteria**
Matrix zonal cell values	Slope within 0.98 and 1.02 Intercept near zero R^2 in excess of 0.95
Matrix zone trip ends	Slope within 0.99 and 1.01 Intercept near zero R^2 in excess of 0.98
Trip length distributions	Means within 5% Standard deviations within 5%
Sector to sector level matrices	Differences within 5%

The significance of matrix estimation for each measure listed in the above table is described in the following section.

10.1.1 Matrix Cell Value Changes

Table 10-2 below shows for each time period and vehicle type (cars and HGVs), the cell values of the prior matrix plotted against the values in the same cell of the post matrix. The graphs are provided in Appendix G.

The guidance states that the trend line must have a gradient between 0.98 and 1.02, an intercept close to zero, and an R^2 value exceeding 0.95. It also suggests that the criteria should be met by car and total vehicle. In this study, the criteria have been separately applied to cars and HGVs to ensure that prior matrices are not significantly distorted by ME. These conditions are met for car and HGV matrices and it can be seen that the fit exceeds guidance by a greater margin in all time periods, which is one of the model's strengths.

Table 10-2: Summary of Matrix Cell Value Changes

Measurement		Requirement	AM		IP		PM	
			Value	Pass/Fail	Value	Pass/Fail	Value	Pass/Fail
Total Matrix - Car	Slope	Within 0.98 and 1.02	1.000	Pass	1.001	Pass	1.000	Pass
	Intercept	Near 0	0.005	Pass	0.008	Pass	0.001	Pass
	R-Sq	> 0.95	1.000	Pass	1.001	Pass	1.000	Pass
Trips Less than 500 - Car	Slope	Within 0.98 and 1.02	0.993	Pass	1.012	Pass	0.997	Pass
	Intercept	Near 0	0.007	Pass	0.001	Pass	0.002	Pass
	R-Sq	> 0.95	0.982	Pass	0.993	Pass	0.994	Pass
Total Matrix - HGV	Slope	Within 0.98 and 1.02	1.000	Pass	1.000	Pass	1.000	Pass
	Intercept	Near 0	0.001	Pass	0.002	Pass	-0.004	Pass
	R-Sq	> 0.95	1.000	Pass	1.000	Pass	1.000	Pass
Trips Less than 500 - HGV	Slope	Within 0.98 and 1.02	0.998	Pass	1.000	Pass	0.997	Pass
	Intercept	Near 0	0.001	Pass	0.002	Pass	-0.004	Pass
	R-Sq	> 0.95	0.999	Pass	1.000	Pass	0.999	Pass

10.1.2 Matrix Trip End Changes

The check on how much matrix trip ends have been affected by matrix estimation is a similar one to the check on individual cell values in that the prior and post trip ends must be plotted on a graph and a trend line added. The graphs showing these are provided in Appendix G.

A trend line, with equation and R^2 value has also been plotted. The results are provided for both the full matrix and also just for trips less than 500; the latter test ensures that cells with a large number of trips do not mask changes occurring to row and column totals with lower values.

The guidance on these trend lines is the following:

- Slope to be within 0.99 and 1.01
- Intercept near zero
- R Squared in excess of 0.98

As shown Table 10-3 and Table 10-4, in majority of cases the effect of ME on trip end values fall within the guidelines prescribed by TAG for all vehicle classes. And where it is observed not passing, the values fall slightly below the TAG criteria.

Only trip end intercepts (judged to have failed if less than -3 or greater than +3) have been considered to be not meeting the criteria.

Table 10-3: Matrix Row Total Changes - Trend Line Statistics

Measurement		Requirement	AM		IP		PM	
			Value	Pass/Fail	Value	Pass/Fail	Value	Pass/Fail
Row Total - Total Car	Slope	Within 0.99 and 1.01	1.00	Pass	1.00	Pass	1.00	Pass
	Intercept	Near 0	2.51	Pass	3.44	Fail	0.11	Pass
	R-Sq	> 0.98	1.00	Pass	1.00	Pass	1.00	Pass
Row Total - Car Trips Less than 500	Slope	Within 0.99 and 1.01	0.99	Pass	1.00	Pass	0.99	Pass
	Intercept	Near 0	3.96	Fail	2.56	Pass	2.31	Pass
	R-Sq	> 0.98	0.97	Fail	0.98	Pass	0.97	Fail
Row Total - Total HGV	Slope	Within 0.99 and 1.01	1.00	Pass	1.00	Pass	1.00	Pass
	Intercept	Near 0	0.63	Pass	0.69	Pass	-1.28	Pass
	R-Sq	> 0.98	1.00	Pass	1.00	Pass	1.00	Pass
Row Total - HGV Trips Less than 500	Slope	Within 0.99 and 1.01	1.00	Pass	1.01	Pass	0.94	Fail
	Intercept	Near 0	0.65	Pass	0.20	Pass	0.36	Pass
	R-Sq	> 0.98	0.98	Pass	0.99	Pass	0.96	Fail

Table 10-4: Matrix Column Total Changes - Trend Line Statistics

Measurement		Requirement	AM		IP		PM	
			Value	Pass/Fail	Value	Pass/Fail	Value	Pass/Fail
Column Total - Total Car	Slope	Within 0.99 and 1.01	1.00	Pass	1.00	Pass	1.00	Pass
	Intercept	Near 0	2.75	Pass	2.05	Pass	-0.03	Pass
	R-Sq	> 0.98	1.00	Pass	1.00	Pass	1.00	Pass
Column Total - Car Trips Less than 500	Slope	Within 0.99 and 1.01	0.99	Pass	0.99	Pass	0.99	Pass
	Intercept	Near 0	4.25	Fail	4.78	Fail	2.23	Pass
	R-Sq	> 0.98	0.97	Fail	0.97	Fail	0.97	Fail
Column Total - Total HGV	Slope	Within 0.99 and 1.01	1.00	Pass	1.00	Pass	1.00	Pass
	Intercept	Near 0	0.69	Pass	0.91	Pass	-1.29	Pass
	R-Sq	> 0.98	1.00	Pass	1.00	Pass	1.00	Pass
Column Total - HGV Trips Less than 500	Slope	Within 0.99 and 1.01	1.01	Pass	1.01	Pass	0.99	Pass
	Intercept	Near 0	0.23	Pass	0.36	Pass	-0.29	Pass
	R-Sq	> 0.98	0.99	Pass	0.99	Pass	0.98	Pass

10.1.3 Trip length distributions

For trip length distributions, it is stipulated in TAG that both the mean and standard deviation of the post matrix trip lengths should not differ by more than 5% from those of the prior matrices.

Whilst the change in average and standard deviation tip lengths for non E-E trips is negligible and well within guidelines, a more detailed assessment has been undertaken to derive the means and standard deviations broken down by internal and external movements as summarised in Table 10-5 and Table 10-6 for cars and HGVs respectively. All variations except for I-I for AM peak are in line with 5% tolerance required by the TAG.

Table 10-5: ME Trip Length Distribution Changes – Cars

Measurement			Requirement	AM		IP		PM	
				Value	Pass/Fail	Value	Pass/Fail	Value	Pass/Fail
Mean Trip Length	Internal - Internal	Prior	Within 5%	6.7	Fail	6.1	Pass	6.6	Pass
	Internal - Internal	Post		6.3		5.8		6.2	
	Internal - Internal	Diff		-6.08%		-4.85%		-5.00%	
	Internal - External	Prior	Within 5%	29.7	Pass	32.1	Pass	28.9	Pass
	Internal - External	Post		29.1		31.5		28.2	
	Internal - External	Diff		-1.99%		-1.76%		-2.32%	
	External - Internal	Prior	Within 5%	28.0	Pass	32.6	Pass	30.9	Pass
	External - Internal	Post		27.6		31.2		30.7	
	External - Internal	Diff		-1.53%		-4.35%		-0.69%	
	External - External	Prior	Within 5%	18.8	Pass	19.0	Pass	20.6	Pass
	External - External	Post		18.8		19.0		20.6	
	External - External	Diff		-0.01%		-0.42%		0.22%	
	Total	Prior	Within 5%	18.3	Pass	18.5	Pass	19.7	Pass
	Total	Post		18.1		18.3		19.6	
	Total	Diff		-0.85%		-1.35%		-0.46%	
Trip Length Standard Deviation	Internal - Internal	Prior	Within 5%	8.9	Fail	8.1	Fail	8.7	Fail
	Internal - Internal	Post		8.2		7.5		8.1	
	Internal - Internal	Diff		-7.63%		-7.33%		-6.82%	
	Internal - External	Prior	Within 5%	45.2	Pass	50.8	Pass	42.8	Pass
	Internal - External	Post		44.0		50.0		41.6	
	Internal - External	Diff		-2.54%		-1.64%		-2.79%	
	External - Internal	Prior	Within 5%	40.3	Pass	51.3	Pass	47.9	Pass
	External - Internal	Post		40.0		48.9		47.1	
	External - Internal	Diff		-0.59%		-4.71%		-1.62%	
	External - External	Prior	Within 5%	44.1	Pass	47.6	Pass	47.1	Pass
	External - External	Post		44.0		47.4		47.1	
	External - External	Diff		-0.19%		-0.45%		0.05%	
	Total	Prior	Within 5%	41.5	Pass	45.0	Pass	44.0	Pass
	Total	Post		41.3		44.5		43.9	
	Total	Diff		-0.59%		-0.95%		-0.29%	

Table 10-6: ME Trip Length Distribution Changes – HGV

Measurement			Requirement	AM		IP		PM	
				Value	Pass/Fail	Value	Pass/Fail	Value	Pass/Fail
Mean Trip Length	Internal - Internal	Prior	Within 5%	8.1	Fail	7.6	Fail	6.1	Fail
	Internal - Internal	Post		9.1		8.5		6.9	
	Internal - Internal	Diff		12.41%		11.77%		14.42%	
	Internal - External	Prior	Within 5%	76.0	Pass	79.3	Fail	64.5	Pass
	Internal - External	Post		75.2		73.0		67.9	
	Internal - External	Diff		-1.08%		-7.99%		5.00%	
	External - Internal	Prior	Within 5%	71.4	Pass	90.8	Fail	75.3	Pass
	External - Internal	Post		69.4		82.0		76.0	
	External - Internal	Diff		-2.83%		-9.77%		0.82%	
	External - External	Prior	Within 5%	18.8	Pass	19.0	Pass	20.6	Pass
	External - External	Post		18.8		19.0		20.6	
	External - External	Diff		-0.01%		-0.42%		0.22%	
	Total	Prior	Within 5%	32.3	Pass	30.8	Pass	33.5	Pass
	Total	Post		32.2		30.9		32.7	
	Total	Diff		-0.34%		0.28%		-2.48%	
Trip Length Standard Deviation	Internal - Internal	Prior	Within 5%	9.8	Fail	9.2	Fail	8.5	Fail
	Internal - Internal	Post		10.9		10.1		9.5	
	Internal - Internal	Diff		11.02%		10.02%		11.20%	
	Internal - External	Prior	Within 5%	104.7	Pass	113.6	Fail	96.7	Pass
	Internal - External	Post		102.8		104.0		100.3	
	Internal - External	Diff		-1.84%		-8.44%		3.81%	
	External - Internal	Prior	Within 5%	102.3	Pass	126.8	Fail	106.5	Pass
	External - Internal	Post		99.6		115.9		108.5	
	External - Internal	Diff		-2.64%		-8.62%		1.86%	
	External - External	Prior	Within 5%	77.4	Pass	75.7	Pass	80.7	Pass
	External - External	Post		77.0		75.9		78.9	
	External - External	Diff		-0.47%		0.28%		-2.20%	
	Total	Prior	Within 5%	77.5	Pass	75.9	Pass	80.8	Pass
	Total	Post		77.1		76.1		79.0	
	Total	Diff		-0.47%		0.21%		-2.22%	

Figure 10-1 to Figure 10-6 compare the trip length distributions in distance bands for prior and post matrices for all time periods for both cars and HGVs. As these figures show the matrix estimation process has generally not increased the number of trips within all distance bands except in PM HGV, where an increase is observed for the distance band 30-40 Km, suggesting some long-distance trips have increased due to matrix estimation process.

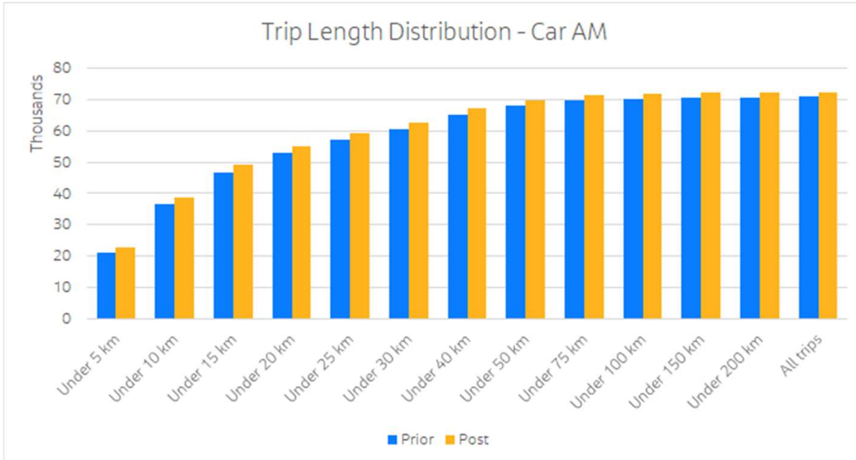


Figure 10-1: AM Car Trip Legth Distribution Comparison

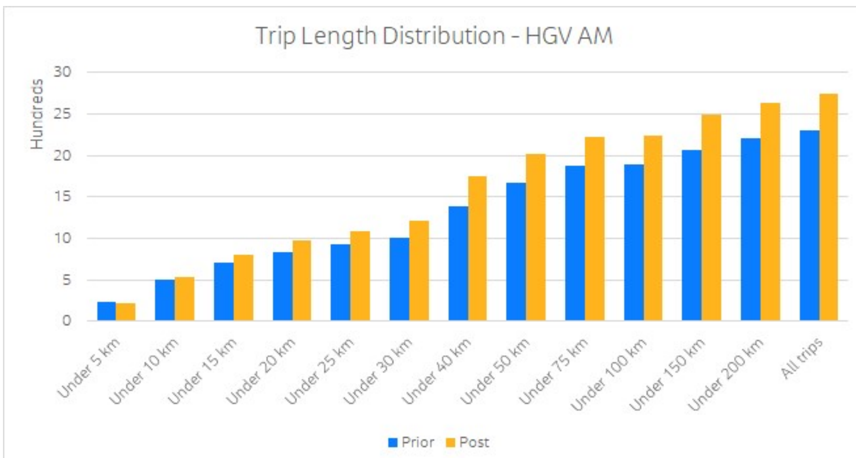


Figure 10-2: AM HGV Trip Legth Distribution Comparison

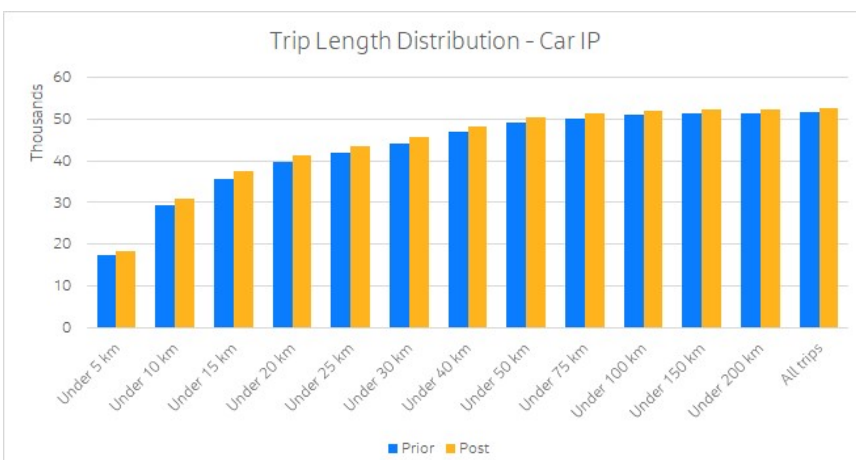


Figure 10-3: IP Car Trip Legth Distribution Comparison

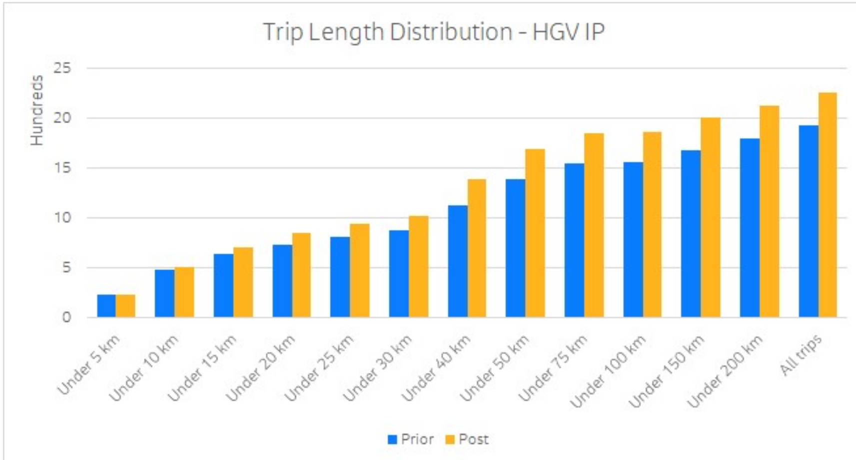


Figure 10-4: IP HGV Trip Legth Distribution Comparison

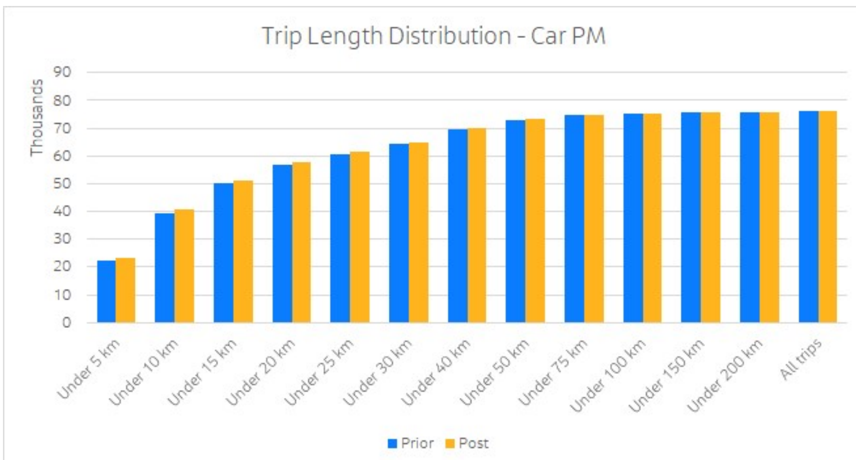


Figure 10-5: PM Car Trip Legth Distribution Comparison

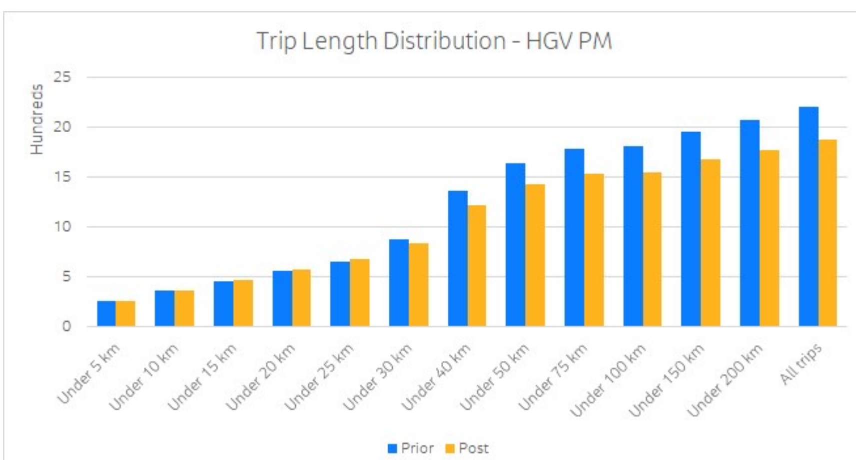


Figure 10-6: PM HGV Trip Legth Distribution Comparison

10.1.4 Sector to Sector movements

Finally, the guidelines require a check on the matrix cells on a sector basis.

The guidelines state that trips should not change by more than 5% prior and post Matrix Estimation.

It should be noted that a proportion of trip movements were frozen during ME to account for trips that were fully observed in the RSI matrix. As a result, some sector-to-sector movements change relatively little, compared to sector to sector movements with a low proportion of observed zone to zone movements.

Table 10-7, Table 10-10 and Table 10-13 show the total trip differences between the prior and post Matrix Estimation for all time periods. The highlighted cells show sector trip movements that increase by more than 50. It is assumed that a change of less than 50 vehicles can be considered as minor given the size of the sectors. A high percentage change for the sector-to-sector movements of less than 50 is acceptable as the overall number of trips is low.

Table 10-8, Table 10-11 and Table 10-14 show the percentage differences between the prior and post Matrix Estimation for sector movements for each time period. For the purpose of the report, the table shows only the cell values that change by more than 50 vehicles and the percent difference is above 5% as a result of Matrix Estimation. These values are highlighted to help distinguish a pattern in all three time periods.

It can be seen that there are few sector-to-sector movements that change by more than 5%, and as expected the majority of changes that have been factored are synthetic trip movements.

The tables also show that generally the sector to sector movements with the greatest differences between pre-matrix estimation and post matrix estimation contain few zone-to-zone movements that have been observed, and therefore are frozen during the matrix estimation process.

In order to further investigate the significance of these changes, the GEH values were calculated and presented in Table 10-9, Table 10-12 and Table 10-15. There are very few sector pairs with GEH above 5 and although it is acknowledged that ME resulted in some noticeable changes at sector level the overall scale of variation from the prior is relatively minor and considered satisfactory.

The highest GEH in AM peak is observed for the following sector pairs:

- Sector 4-4: GEH 8 - Sector 4 is in north Preston area (far from the A582 scheme) and the high difference can be attributed to the fact that these are short trips that will not be captured in the RSI surveys and therefore are derived from synthetic matrix. Given the synthetic matrices use national average trip length distributions, ME process can have more significant impact on such OD pairs to match local distribution.
- Sector 9-4: GEH 10 - Sector 9 represents the inner north Preston (north east) and lies adjacent to Sector 4 (North Preston area). The reason for the high differences is the same as above, given that the short trips are not captured in the RSI surveys, they are primarily synthetic. It should be also noted that sector 4 is a large sector consisting of 26 zones and hence the magnitude of the difference. Both sectors are far from the scheme.
- Sector 11-28: GEH 9 - Sector 11 represents the zones in the north east outer screenline, the zones in this sector are partly outside the simulation area and consists of 22 large zones. Sector 28 represents the Preston City Centre. The difference is because the trips are not fully observed in the RSI surveys and partly uses synthetic matrices to infill those gaps.

The highest GEH in IP peak is observed for the following sector pairs:

- Sector 5-6: GEH 15 – Sector 5 and 6 represents north and south Blackpool area. Given these 2 sectors are in the periphery of the simulation area and outside the RSI screenline, the trips are purely synthetic and ME was required to refine travel demand between two sectors. Both sectors are far away from the scheme.
- Sector 11-28: GEH 11 - Sector 11 represents the zones in the north east outer screenline, the zones in this sector are partly outside the simulation area and consists of 22 zones. Sector 28 represents the

Preston City Centre. The difference is because the trips are not fully observed in the RSI surveys and partly uses synthetic matrices to infill those gaps.

- Sector 24-33: GEH 8 – Sector 24 represents Leyland and sector 33 represents Tardy Gate. Sector 24 includes 22 zones and the overall increase in trips is only 86.

The highest GEH in PM peak is observed for following sector:

- Sector 7-5: GEH 7 – Sector 7 represents the zones in the western outer screenline, and Sector 5 represents Blackpool North. Both sectors lie outside the RSI screenline cordon and the trips are purely synthetic and therefore ME process has made changes to the OD trips.
- Sector 24-33: GEH 8 – Sector 24 represents Leyland and sector 33 represents Tardy Gate. Sector 24 includes 22 zones and the overall increase in trips is only 93.

Most of the sector pairs which show high differences after the ME process are either outside the RSI cordon area or are far from the scheme area.

The changes brought by ME were necessary for improving the overall model performance and therefore is deemed to be acceptable considering the synthetic nature of some demand.

The sector to sector movement changes for HGVs are shown in Appendix G. The percentage difference tables only show trip movements that differ by 5% or more, and where the number of HGVs has increased by more than 50 vehicles. It should be noted that there are large percentage changes, but in terms of the total HGV trip numbers, the number of trip changes and GEH values are relatively small in most cases.

Based on the above results, the comparison of the prior and post ME matrices did not show significant distortions and therefore is considered acceptable.

Table 10-7: Sector to Sector Changes - Cars AM Trips

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1	0	0	5	-3	4	53	-1	11	-5	-8	9	-36	3	-9	-14	3	0	-22	11	0	-10	-17	-14	-9	-2	10	-8	-23	-2	-12	1	16	-1	0
2	0	0	6	15	0	-4	-63	17	9	-1	9	7	6	4	-2	18	2	-4	21	4	2	-1	0	-2	0	2	20	-17	12	7	6	7	5	0
3	1	2	12	0	4	7	-10	9	-8	-1	-20	-28	-3	7	-5	39	0	-10	-1	-1	1	-3	-2	-2	-2	1	21	-9	25	15	-3	1	-2	0
4	-12	52	15	258	47	20	-18	55	-13	-4	-26	-105	-15	-10	-10	115	-1	-20	-3	0	-7	-34	-6	-11	6	6	33	-87	-3	-7	2	2	6	2
5	1	0	6	-1	0	0	7	15	-12	-1	2	-6	-3	2	-5	14	0	-6	2	1	4	-2	-1	-1	1	-2	11	0	-7	5	0	2	0	0
6	51	1	30	3	0	-2	-127	8	1	-1	-8	-32	-1	1	-4	-7	0	-6	4	1	3	-6	0	-8	0	3	8	-93	-44	4	-1	2	-1	16
7	5	-3	4	-1	-88	-113	-18	10	-10	0	-12	-31	-3	0	-2	-2	0	-12	-16	-3	0	-13	1	-1	0	0	4	-51	-23	-1	-1	-1	-2	2
8	4	38	15	15	40	-10	2	-3	-5	1	1	2	0	-2	0	-9	0	-3	4	0	0	0	0	0	1	0	7	-23	-13	28	0	0	0	3
9	-4	6	3	206	-4	-1	-3	2	1	0	-42	-13	-1	-1	-3	0	9	-3	17	1	-2	0	-1	-4	0	0	12	33	76	-8	7	27	0	1
10	-15	1	0	-1	-1	-8	-1	-1	-5	4	-1	12	8	4	-1	-7	0	-1	3	0	9	30	33	-24	2	5	-2	0	-5	-5	10	15	9	0
11	-4	3	-2	56	1	-3	-5	2	40	-1	-2	-12	1	-4	-4	14	0	-8	7	0	-2	-2	-3	-3	-3	4	25	114	63	-4	2	6	0	0
12	71	30	9	36	14	-29	-18	-4	-52	-31	31	21	0	-6	-30	-16	-1	-65	15	0	-35	0	-61	-47	22	76	63	14	-75	-14	152	98	20	11
13	-14	12	1	8	1	-19	-12	-1	-9	-12	5	0	0	1	0	-8	0	0	0	-1	-7	-79	73	-58	-12	0	-4	-7	-38	-5	24	38	4	2
14	-18	2	1	-27	-8	-17	-11	-3	-5	6	-8	-30	3	1	0	-6	0	0	1	-1	53	30	31	-29	-1	-7	-6	-5	5	19	2	15	2	0
15	-11	0	0	0	-1	-6	-4	-2	-2	0	-2	-21	0	0	0	-1	0	0	0	0	4	-1	4	-10	-3	-3	-1	2	-1	2	7	9	2	1
16	-5	51	8	105	3	-14	5	-12	-41	3	-14	-11	-2	1	-1	3	0	-1	-2	0	8	-14	14	4	29	-1	70	-76	-61	64	-4	-2	3	2
17	-4	0	0	1	0	0	0	0	-1	0	0	-1	0	0	0	0	0	0	0	0	0	0	1	-1	-1	0	4	0	0	0	3	0	0	0
18	-13	-1	0	0	-1	-16	-4	-2	-1	0	-3	-36	0	0	0	-2	0	0	0	0	2	-3	8	-16	-5	-6	0	-5	-2	0	14	13	3	2
19	12	9	9	24	5	-20	-11	-1	-19	-8	41	11	0	1	0	-8	0	0	0	0	-4	31	18	-2	9	29	-4	-19	-57	-4	19	19	2	13
20	0	1	0	1	0	0	0	2	-1	0	0	0	0	-1	0	0	0	0	0	0	-2	0	-1	0	0	0	10	1	0	-1	5	0	0	0
21	-11	-2	-4	-23	-10	-15	-15	0	-5	-4	-4	8	-2	-18	-4	-9	-1	-6	1	1	1	-9	-10	17	9	3	-6	-10	-20	-41	3	7	29	-2
22	-7	1	0	-3	-1	-24	-3	-5	-7	-27	-1	146	8	14	-10	-10	0	-24	34	1	-19	-8	8	-16	26	47	-4	-5	-30	-33	3	1	-5	0
23	-7	0	0	-5	-2	-3	-1	-2	-4	39	-3	16	66	22	7	-21	1	20	36	-1	-8	10	25	-9	42	19	0	-23	1	3	30	32	7	0
24	-7	1	-1	-2	-2	12	-2	-3	-5	-11	-6	-29	-19	5	-19	2	2	-44	43	0	-18	39	17	32	97	-13	-12	-10	-21	-38	19	22	82	0
25	9	3	1	-2	5	-11	-11	-1	-7	-10	-3	35	-13	-1	-13	-6	0	-28	9	1	-20	30	-3	10	8	31	-2	-16	-16	-23	23	41	0	1
26	16	7	6	19	2	-13	-2	-3	-8	1	22	61	-6	2	-1	-3	0	-4	12	1	-6	40	14	27	39	3	0	0	-8	-1	68	27	9	2
27	-4	1	0	-17	-5	-17	-6	-1	-1	0	-19	8	-11	-8	-4	-6	-1	-6	3	-1	-5	-10	-5	2	5	2	2	-5	-25	-20	1	1	-4	-1
28	-2	-36	-2	46	-28	-9	-10	-5	12	2	-29	0	0	-3	0	64	0	0	1	0	2	0	-3	-3	1	5	23	14	61	8	21	19	11	-12
29	-2	12	-7	8	5	8	14	0	28	-1	-6	-31	-13	-9	-5	10	-1	-2	-16	3	0	-6	-3	-10	0	8	50	-77	33	3	2	2	-5	-1
30	-3	-3	2	13	2	-22	-17	8	10	-5	1	-3	-16	-10	-13	8	-1	-3	-9	0	14	-27	-18	-47	32	0	34	17	102	157	5	9	20	1
31	-2	4	0	4	-1	-14	-16	-4	-7	-1	-12	56	5	-11	-2	-14	0	-4	0	4	-12	-8	-17	-11	1	11	-4	-27	-53	-5	48	31	0	2
32	-7	2	0	-4	0	-7	-7	-3	-1	4	-4	-42	16	1	6	-15	0	6	25	0	-9	9	-3	-8	11	6	34	-3	-34	-1	84	13	-2	1
33	-3	0	0	-1	0	-7	-7	-1	0	-2	-1	-9	-7	-6	-5	-10	0	-6	-5	0	3	-5	-26	59	11	6	6	-5	30	65	5	10	2	1
34	0	0	1	-4	1	-12	-4	2	-5	-1	0	-15	-3	-3	-5	2	-1	-10	-7	0	-1	-2	-1	-1	-2	0	4	-4	-2	-1	-2	1	-1	0

Table 10-8: Sector to Sector % Changes - Cars AM Trips

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1	--	--	--	--	--	24%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	-18%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4	--	60%	--	28%	--	--	--	61%	--	--	--	-35%	--	--	--	24%	--	--	--	--	--	--	--	--	--	--	--	-40%	--	--	--	--	--	--
5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6	46%	--	--	--	--	--	-21%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-34%	--	--	--	--	--	--
7	--	--	--	--	-16%	-18%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-17%	--	--	--	--	--	--
8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9	--	--	--	62%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	19%	--	--	--	--	--
10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
11	--	--	--	107%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	121%	46%	--	--	--	--	--
12	20%	--	--	--	--	--	--	--	-36%	--	--	--	--	--	--	--	--	-8%	--	--	--	--	-34%	--	--	43%	29%	--	-17%	--	66%	35%	--	--
13	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-12%	34%	-30%	--	--	--	--	--	--	--	--	--	--
14	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	33%	--	--	--	--	--	--	--	--	--	--	--	--	--
15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
16	--	97%	--	19%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	71%	-44%	-10%	71%	--	--	--	--
17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
18	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
19	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-29%	--	--	--	--	--
20	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
21	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
22	--	--	--	--	--	--	--	--	--	--	--	30%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
23	--	--	--	--	--	--	--	--	--	--	--	--	32%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
24	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	42%	--	--	--	--	--	--	--	92%	--
25	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
26	--	--	--	--	--	--	--	--	--	--	--	16%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	63%	--	--	--
27	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
28	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	40%	--	--	--	--	--	--	--	--	--	--	--	--	18%	--	--	--	--	--
29	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-13%	--	--	--	--	--	--
30	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	24%	29%	--	--	--	--
31	--	--	--	--	--	--	--	--	--	--	--	21%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-42%	--	--	--	--	--
32	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	47%	--	--	--
33	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	48%	--	--	--	--	--	31%	--	--	--	--
34	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 10-9: Sector to Sector GEH Values- Cars AM Trips

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4	--	--	--	8	--	--	--	--	--	--	--	7	--	--	--		--	--	--	--	--	--	--	--	--	--	--	7	--	--	--	--	--	--
5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6	--	--	--	--	--	--
7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9	--	--	--	10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
11	--	--	--	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9	--	--	--
13	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
14	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
16	--	6	--		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6	7	--	6	--	--	--	--
17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
18	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
19	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
20	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
21	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
22	--	--	--	--	--	--	--	--	--	--	--	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
23	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
24	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6	--	--	--	--	--	--	--	7	--
25	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
26	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6	--	--	--
27	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
28	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
29	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
30	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6	--	--	--	--
31	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
32	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6	--	--	--
33	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--		--	--	--	--
34	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 10-10: Sector to Sector Changes - Cars IP Trips

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1	0	0	1	-2	0	15	-2	0	-10	-13	2	-10	17	-31	-17	-4	0	-25	14	0	-12	-20	-22	-15	-4	25	-9	-13	-15	-5	3	13	-7	0
2	0	0	2	16	201	0	-7	8	-2	-1	4	-3	1	-2	-5	10	1	-8	16	3	-3	-2	-4	-5	-1	1	-4	-17	1	-5	-1	3	-1	0
3	1	2	8	35	2	7	4	3	-2	-1	-12	-13	-2	0	-4	-1	0	-7	4	0	-1	-2	-2	-3	-3	2	-6	-10	-13	-1	0	-1	3	0
4	-5	45	9	85	14	19	-4	26	41	-4	-21	-56	-11	-7	-7	-5	-2	-12	5	1	-6	-16	-5	-14	-9	7	-30	-43	-12	20	-1	3	-1	1
5	1	-131	3	9	0	487	-2	4	-7	-3	4	-7	-5	-8	-7	9	-1	-10	5	2	-2	-2	-4	-6	-1	0	-8	-16	-10	-7	0	0	-2	0
6	39	4	26	6	98	-1	-24	5	-1	-4	4	-27	-9	-6	-8	11	-1	-11	3	2	-3	-10	-5	-11	-2	4	-8	-20	16	-8	-2	-1	-2	31
7	7	28	6	-1	-94	-56	17	13	-4	-2	-2	-13	-7	-2	-4	4	-1	-4	-12	0	-1	-2	-1	-3	-2	0	-4	-16	14	-4	-2	-3	-2	3
8	3	26	3	1	-3	6	34	-1	-11	0	-3	-9	-2	1	-1	-15	0	-1	-4	0	1	-2	-1	-3	-1	-1	0	-9	0	3	0	-1	0	0
9	-2	25	8	-4	1	5	-4	-12	6	-1	12	-9	-2	-6	0	-52	10	-1	5	10	-1	-8	-4	-7	-1	19	-14	22	57	0	1	6	-3	2
10	-9	0	0	-5	-4	-3	-1	-1	-2	4	0	-12	-14	4	0	0	0	0	-6	0	6	-4	45	-6	6	2	-4	-4	-1	0	0	7	-2	1
11	1	5	-3	-4	0	-2	-3	4	17	0	27	-6	7	-3	0	2	1	1	23	0	-2	-1	-3	-3	0	9	0	118	30	-1	3	3	-1	0
12	12	6	0	-37	-10	-41	-15	-6	-8	-19	-2	36	183	-12	6	-6	0	12	4	0	-7	0	-29	-42	-16	90	-17	9	14	-9	42	46	-10	6
13	21	12	2	-9	-7	-18	-6	-2	-3	-16	8	112	0	1	0	-3	0	0	0	1	-1	-92	75	-13	25	0	-20	-7	-4	-5	-1	26	-3	3
14	-18	4	-2	2	-6	0	3	0	-3	0	1	-14	0	0	0	4	0	0	1	-1	12	5	2	-7	-1	-1	-4	-4	2	7	-7	9	-1	0
15	-7	1	1	-7	-5	-9	-6	-1	-1	0	4	-11	0	0	0	-2	0	0	0	0	2	-5	9	-5	4	1	-4	-2	-2	-1	0	8	-1	4
16	-3	12	6	51	-2	1	4	-10	-45	-1	2	-9	0	14	-1	-3	0	-1	31	4	4	-2	-3	-10	4	0	5	-55	-40	39	-2	4	-1	4
17	-1	2	1	-1	0	-4	-1	-1	0	0	1	0	0	0	0	0	0	0	0	0	-1	0	1	1	0	0	-1	0	0	0	0	1	0	1
18	-10	0	1	-13	-4	-13	-6	-1	-1	0	7	-22	0	0	0	-1	0	0	0	0	1	-10	20	-11	6	1	-3	-3	-2	-1	-1	13	-2	7
19	16	21	14	3	0	-3	-16	-6	-2	-7	31	2	0	1	0	-5	0	0	0	0	-6	19	13	25	8	17	-26	-10	13	-8	0	17	-3	23
20	0	2	0	0	0	0	0	0	1	0	0	0	1	-1	0	-1	0	0	0	0	-2	0	-2	-1	0	0	-4	-1	1	0	2	0	0	0
21	1	1	0	-6	-3	-1	1	0	0	6	2	5	-2	2	0	1	0	-1	-1	0	0	-3	6	14	4	5	2	-5	-3	7	11	9	8	0
22	-8	0	0	-12	-2	-7	-4	-4	-5	-19	1	28	-116	15	-9	-2	0	-18	5	0	-3	36	14	-30	10	-43	-16	-12	-8	-21	-8	8	-8	1
23	-19	-4	-1	-9	-6	-2	1	0	-7	36	-4	-29	56	20	8	0	1	14	24	-1	11	10	24	-3	8	-4	-13	-5	-7	6	6	6	-1	0
24	-16	-4	-1	-14	-10	-6	-2	-1	-9	-8	-4	-35	-15	-2	-10	-1	0	-21	19	-1	28	24	31	15	28	-6	-6	-6	-11	-8	5	12	86	0
25	-2	0	0	-6	-2	-1	-3	0	-4	-2	0	26	7	-7	-6	3	0	-11	9	0	7	44	8	39	8	35	10	3	11	32	25	56	16	0
26	9	2	2	-5	-3	-4	-8	-2	0	3	7	45	-27	-1	-1	0	0	-1	1	0	1	1	24	11	31	-1	-2	11	5	-1	49	30	3	1
27	-13	4	-1	26	-5	1	1	2	13	-2	5	29	-7	-4	2	12	0	0	-2	-1	5	-7	-19	-12	0	2	-5	2	34	5	9	17	-2	-1
28	-13	-44	-6	-56	-40	-14	5	8	43	-1	4	7	-4	-9	0	-72	0	0	-4	-1	-8	-5	-15	0	2	4	-41	-21	8	-18	13	23	-2	-7
29	-10	4	-7	-34	-17	0	-2	-4	39	-3	0	-7	-7	-5	-1	-24	2	0	8	0	1	-7	-2	-4	2	3	-25	-77	92	54	3	14	18	-2
30	0	3	-2	3	-4	0	1	1	-7	1	10	8	-3	23	0	17	0	-1	3	0	29	-16	-11	-9	13	8	-3	-12	28	89	9	10	8	0
31	-1	4	0	-11	-2	-2	-2	0	-1	2	-1	50	0	-12	3	-13	1	1	4	1	6	-10	4	-3	7	33	-8	-2	4	25	52	35	0	1
32	-4	1	0	-11	-2	-3	-4	0	-5	4	0	28	10	2	5	1	0	9	6	0	7	-6	-4	-7	34	25	-3	0	2	15	30	14	0	0
33	-3	-1	1	-3	-2	2	-2	2	0	0	-1	1	0	5	0	4	0	0	-1	0	12	-2	-9	66	12	6	8	1	15	30	5	7	1	1
34	0	0	0	16	0	4	0	5	7	0	0	-1	0	-2	-1	-1	0	-2	12	0	-1	-1	-1	-1	0	1	-3	-6	-9	0	0	1	0	0

Table 10-11: Sector to Sector % Changes – Car IP Trips

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1	--	--	--	--	--	--	--	--	--	--	--	--	--	-24%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2	--	--	--	--	22%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3	--	--	--	26%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4	--	66%	--	15%	--	--	--	--	12%	--	--	-43%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-38%	--	--	--	--	--	--
5	--	-14%	--	--	--	59%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6	48%	--	--	--	12%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	94%
7	--	--	--	--	-30%	-14%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
8	--	--	--	--	--	--	48%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-22%	--	--	--	--	--	--	--	--	--	--	--	--	22%	--	--	--	--	--
10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	36%	--	--	--	--	--	--	--	--	--	--	--
11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	193%	--	--	--	--	--	--
12	--	--	--	-35%	--	-43%	--	--	--	--	--	--	13%	--	--	--	--	--	--	--	--	--	--	-35%	--	64%	--	--	--	--	59%	39%	--	--
13	--	--	--	--	--	--	--	--	--	--	--	8%	--	--	--	--	--	--	--	--	--	-16%	46%	--	--	--	--	--	--	--	--	--	--	--
14	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
16	--	--	--	13%	--	--	--	--	-30%	--	--	--	--	--	--	--	--	--	31%	--	--	--	--	--	--	--	--	-39%	-8%	38%	--	--	--	--
17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
18	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
19	--	--	--	--	--	--	--	--	--	--	62%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
20	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
21	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
22	--	--	--	--	--	--	--	--	--	--	--	--	-21%	--	--	--	--	--	--	--	--	--	--	-18%	--	-12%	--	--	--	--	--	--	--	--
23	--	--	--	--	--	--	--	--	--	36%	--	--	41%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
24	--	--	--	--	--	--	--	--	--	--	--	-35%	--	--	--	--	--	--	--	--	--	--	14%	--	--	--	--	--	--	--	--	--	114%	--
25	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	40%	--	22%	--	29%	--	--	--	57%	--	85%	--	--
26	--	--	--	--	--	--	--	--	--	--	--	30%	--	--	--	--	--	--	--	--	--	--	--	--	20%	--	--	--	--	--	67%	34%	--	--
27	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16%	--	--	--	--	--
28	--	-39%	--	-22%	-67%	--	--	--	23%	--	--	--	--	--	--	-25%	--	--	--	--	--	--	--	--	--	--	-33%	--	--	--	--	--	--	--
29	--	--	--	-9%	--	--	--	--	14%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-15%	13%	29%	--	--	--	--
30	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	35%	--	--	--	--
31	--	--	--	--	--	--	--	--	--	--	--	72%	--	--	--	--	--	--	--	--	--	--	--	--	--	68%	--	--	--	--	33%	40%	--	--
32	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	45%	--	--	--	--	--	32%	--	--	--
33	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	84%	--	--	--	--	--	41%	--	--	--	--
34	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 10-12: Sector to Sector GEH Values- Cars IP Trips

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2	--	--	--	--	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4	--	--	--	--	--	--	--	--	--	--	--	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5	--	--	--	--	--	15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6	--	--	--	--	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7	--	--	--	--	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
8	--	--	--	--	--		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	11	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7	--	--	--	--	--	--	--	--
13	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
14	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
18	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
19	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
20	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
21	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
22	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
23	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
24	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8	--
25	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6	--	--
26	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
27	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
28	--	--	--	--	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
29	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
30	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
31	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
32	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
33	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6	--	--	--	--	--	--	--	--	--	--
34	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 10-13: Sector to Sector Changes - Cars PM Trips

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1	0	0	2	11	1	31	6	4	12	-17	-1	-7	8	-13	-7	12	-2	-10	15	0	-14	-6	-26	-7	26	11	-19	-19	-43	-22	8	18	3	0
2	0	0	3	8	0	-5	-3	-7	10	0	-3	5	13	-2	2	6	2	2	17	6	-2	1	-2	-4	5	4	-1	-2	6	-4	5	12	1	0
3	4	2	9	-30	0	-2	-1	10	-3	-1	-17	-14	-1	-3	-2	-38	0	-4	3	0	-3	-1	-4	-1	2	2	-15	-17	-36	-1	-1	0	-1	0
4	-7	12	9	52	-5	-18	-6	12	117	-8	-42	-91	-12	-46	-7	-107	0	-12	5	0	-27	-14	-22	-13	4	11	-2	-18	-76	-46	16	25	-6	0
5	3	0	7	10	0	0	39	4	4	-1	2	6	10	-5	1	3	1	1	13	4	-2	0	-3	-4	17	3	-5	-15	6	-7	1	4	1	1
6	44	-14	34	-54	0	-3	-91	-6	-5	-7	-12	-69	-18	-5	-4	0	-1	-9	-21	4	-3	-21	-10	-20	2	0	-7	-6	44	-24	-6	-2	-3	4
7	-7	-63	4	-51	-126	-111	-1	45	0	-2	-6	-34	-14	2	-6	8	-1	-5	-13	-1	0	-4	-4	-5	-1	-2	-5	32	20	-3	-3	-3	0	-3
8	6	42	16	98	30	-21	17	-2	-14	-1	2	-8	3	-1	0	-14	0	-1	-1	9	-1	-2	-1	-5	1	1	-2	-3	4	2	-1	-1	-1	5
9	8	15	3	0	-1	-3	0	-13	4	-1	-2	-2	1	-8	0	-78	4	-1	56	2	-3	1	-8	-9	2	4	-17	-2	62	-33	5	11	-1	6
10	-10	-1	0	-5	-4	-5	-3	-1	-2	5	0	-13	4	11	0	1	0	-1	2	0	2	9	63	-20	3	4	-3	0	1	-5	1	4	-2	1
11	22	13	0	36	3	6	3	7	28	1	31	24	25	-1	3	-2	1	6	27	0	3	4	-4	-2	12	11	-19	78	-21	0	14	14	1	0
12	43	40	15	14	0	-17	-21	1	-9	-96	7	-122	0	-32	-32	-24	-1	-56	7	0	6	-110	-85	-52	63	72	-55	-10	-49	21	82	46	5	16
13	6	10	4	-8	-9	-9	-5	-3	-3	-29	10	0	0	3	0	-7	0	0	0	-1	-5	-81	108	-49	28	26	-33	10	-15	-22	17	13	-1	7
14	-12	-6	5	-6	-1	2	9	-2	1	6	-7	-14	2	3	0	-1	0	0	0	-2	7	22	25	5	6	-1	3	4	-1	4	3	4	2	-3
15	-9	-1	3	-7	-7	-8	-1	-1	-1	0	5	-29	0	0	0	-3	0	0	0	0	2	-3	10	-18	-1	1	-3	-1	-1	0	4	3	0	6
16	-6	6	13	20	-8	-20	-13	-24	-18	-1	-12	-12	-4	-3	0	-1	0	0	43	0	-2	0	-6	-9	4	0	-10	-18	11	10	7	22	-3	1
17	-1	2	1	-2	-1	-1	-1	0	-2	0	0	-1	0	0	0	-2	0	0	0	0	-1	0	1	0	0	0	0	0	12	-2	1	0	0	2
18	-14	-3	4	-13	-8	-10	-15	-2	-2	0	10	-60	0	0	0	-3	0	0	0	0	1	-7	29	-41	-3	1	-6	0	-3	-5	2	8	-1	13
19	16	28	23	4	-1	-3	-16	-5	-10	-21	34	-4	0	1	0	-6	0	0	0	0	-8	18	28	24	21	39	-34	-5	-11	-11	7	21	-3	32
20	0	5	0	1	1	2	-1	0	2	-1	0	0	3	-2	0	-2	0	0	0	0	0	-1	-2	0	1	1	-4	0	2	1	11	0	0	0
21	-15	-4	-1	-7	1	-3	-1	-2	0	-1	0	27	-6	9	-1	0	-1	-5	2	2	2	1	-2	-27	-8	8	-10	1	3	-46	-10	0	-8	-1
22	-8	-1	0	-11	-2	-8	-8	0	-5	-85	1	55	22	27	-16	-13	0	-30	56	0	-10	33	17	-16	34	-30	-48	-13	-10	-40	-24	-3	-15	1
23	-17	-2	-1	-5	-6	0	2	0	-3	29	-4	-51	48	34	1	-1	1	5	28	0	1	10	17	-22	13	-5	-3	6	-5	-18	6	3	-4	-1
24	-15	-4	-3	-15	-5	-20	-4	-2	-7	-22	-6	-44	-58	-10	-18	2	4	-32	31	2	25	45	6	20	55	7	-1	1	-6	-38	36	19	93	0
25	-5	0	1	-3	-3	-5	0	1	-4	-18	1	1	-18	-1	-13	15	-1	-24	2	1	0	79	12	116	15	25	-17	0	3	10	14	40	-12	1
26	13	4	4	6	-1	3	-2	2	0	-2	11	76	-19	10	-1	-4	0	-2	7	2	6	43	53	5	52	0	2	36	10	-1	19	9	1	2
27	-15	20	1	-8	23	4	11	-2	-9	-1	-6	34	-7	9	-2	31	1	-1	-6	1	3	-1	-10	-6	28	4	-6	41	9	13	14	41	1	-4
28	-6	-18	3	-35	-32	-11	16	4	102	-2	19	39	-7	-10	-3	-89	1	-2	-9	0	1	-5	3	-11	14	-1	-49	-19	75	4	31	32	-1	-5
29	-14	-11	-8	-148	-34	-35	-42	-67	46	-5	-11	-72	-15	1	-4	-33	1	-3	9	-1	-1	-3	-1	-4	20	0	-28	-31	66	143	6	17	2	-2
30	-7	2	1	-18	36	8	6	-1	-4	10	3	21	2	43	-1	18	1	-10	-3	2	30	-12	14	-46	19	6	5	47	21	63	-11	-2	-3	-3
31	-5	-4	0	-38	-10	-6	-1	0	-10	-5	-4	68	-5	-10	0	-39	-1	0	0	2	-3	-5	7	-6	25	25	-7	10	1	9	94	63	1	1
32	-12	-2	0	-28	-4	-8	-6	-2	-10	-2	-7	102	25	-3	1	-17	-1	3	31	0	-2	-7	-20	-20	34	5	-26	-4	0	9	18	8	-2	1
33	2	-1	2	-1	-2	14	-4	5	-1	4	3	18	5	5	1	2	0	2	1	0	2	1	8	125	42	5	-3	11	1	42	-4	4	1	2
34	0	0	1	-4	0	2	0	-1	-16	-1	0	-2	-1	-2	-2	-4	0	-3	3	0	-1	-1	-1	-1	1	1	-8	-12	-18	-10	-1	3	0	0

Table 10-14: Sector to Sector % Changes - Cars PM Trips

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1	--	--	--	--	--	29%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-38%	--	--	--	--	--
2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3	--	--	--	-13%	--	--	--	--	--	--	--	--	--	--	--	-25%	--	--	--	--	--	--	--	--	--	--	--	--	-40%	--	--	--	--	--
4	--	--	--	5%	--	--	--	--	25%	--	-23%	-30%	--	-52%	--	-12%	--	--	--	--	--	--	--	--	--	--	--	--	-15%	-22%	--	--	--	--
5	--	--	--	--	--	--	12%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6	24%	--	42%	-25%	--	--	-19%	--	--	--	--	-39%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	34%	--	--	--	--	--
7	--	-17%	--	-45%	-30%	-19%	--	52%	--	--	--	-51%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	90%	--	--	--	--	--	--
8	--	67%	--	48%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-26%	--	--	46%	--	--	--	--	--	--	--	--	--	23%	-57%	--	--	--	--
10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	31%	--	--	--	--	--	--	--	--	--	--	--
11	--	--	--	34%	--	--	--	--	--	--	7%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	55%	--	--	--	--	--	--
12	14%	35%	--	--	--	--	--	--	--	-27%	--	--	--	-18%	-10%	--	--	-10%	--	--	--	-13%	-30%	-40%	24%	26%	-24%	--	-20%	--	44%	17%	--	--
13	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-12%	36%	-26%	--	--	-25%	--	--	--	--	--	--	--
14	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	68%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
18	--	--	--	--	--	--	--	--	--	--	--	-11%	--	--	--	--	--	--	--	--	--	--	--	-51%	--	--	--	--	--	--	--	--	--	--
19	--	--	--	--	--	--	--	--	--	--	48%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	34%	-36%	--	--	--	--	--	--	83%
20	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
21	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-18%	--	--	--	--
22	--	--	--	--	--	--	--	--	--	-24%	--	10%	--	--	--	--	--	-36%	22%	--	--	--	--	--	16%	-7%	-46%	--	--	-48%	--	--	--	--
23	--	--	--	--	--	--	--	--	--	--	--	-38%	22%	23%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
24	--	--	--	--	--	--	--	--	--	--	--	-37%	-31%	--	--	--	--	-60%	60%	--	--	30%	--	--	34%	--	--	--	--	-24%	45%	--	99%	--
25	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	39%	--	38%	--	--	--	--	--	--	--	43%	--	--
26	--	--	--	--	--	--	--	--	--	--	--	20%	--	--	--	--	--	--	--	--	--	11%	30%	--	31%	--	--	73%	--	--	--	--	--	--
27	--	--	--	--	--	--	--	--	--	--	--	15%	--	--	--	32%	--	--	--	--	--	--	--	--	--	--	--	35%	--	--	--	50%	--	--
28	--	--	--	-12%	-44%	--	--	--	48%	--	--	21%	--	--	--	-25%	--	--	--	--	--	--	--	--	--	--	-31%	--	8%	--	35%	55%	--	--
29	--	--	--	-22%	-29%	-16%	-26%	-35%	8%	--	--	-23%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-5%	6%	31%	--	--	--	--
30	--	--	--	--	85%	--	--	--	--	--	--	--	--	31%	--	--	--	--	--	--	--	--	--	-34%	--	--	--	43%	--	19%	--	--	--	--
31	--	--	--	-37%	--	--	--	--	--	--	--	27%	--	--	--	-63%	--	--	--	--	--	--	--	--	--	--	--	--	--	--	33%	43%	--	--
32	--	--	--	--	--	--	--	--	--	--	--	18%	--	--	--	--	--	--	30%	--	--	--	--	--	37%	--	--	--	--	--	--	--	--	--
33	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	103%	87%	--	--	--	--	26%	--	--	--	--
34	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 10-15: Sector to Sector GEH Values- Cars PM Trips

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4	--	--	--	--	--	--	--	--	--	--	--	6	--	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6	--	--	--	--	--	--	--	--	--	--	--	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7	--	--	--	--	7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
8	--	--	--	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
13	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6	--	--	--	--	--	--	--	--	--	--	--
14	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
18	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
19	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
20	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
21	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
22	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
23	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
24	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8	--
25	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6	--	--	--	--	--	--	--	--	--	--
26	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
27	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
28	--	--	--	--	--	--	--	--	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
29	--	--	--	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6	--	--	--	--
30	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
31	--	--	--		--	--	--	--	--	--	--	--	--	--	--	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
32	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
33	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9	--	--	--	--	--	--	--	--	--	--
34	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

11. Assignment, Calibration and Validation

11.1 Introduction

This chapter details the calibration and validation results within the Central Lancashire Highways Transport Model, in relation to the required model standards, as outlined in Section 3.

11.2 Model Convergence

Model assignment of trips to the highway network remained consistent with the original model and was undertaken based on a 'Wardrop User Equilibrium', which seeks to minimise travel costs on all routes for traffic flows in the network through an iterative process. Convergence of the model was monitored as a measurement of the stability of the traffic model, i.e. traffic flows remain stable between successive iterations, and the proximity of the model, i.e. reflecting how close the current flow and cost pattern is to the assignment objective (Wardrop equilibrium), providing a robust platform for further modelling and confidence for the user.

A converged model is therefore stable and produces results that are consistent and robust.

Convergence results as set out in TAG M3.1 are shown in Table 11-1.

Table 11-1: Model Convergence Results

Time Period	Assignment Simulation Loop	Loop	Proximity Indicators		Stability Indicators		
			% Delta	% Gap	% Flow	% Delays	RAAD
AM	44	41	0.0011	0.0009	98.7	99.6	0.03
		42	0.0010	0.0013	98.4	99.6	0.03
		43	0.0008	0.0008	98.7	99.7	0.03
		44	0.0006	0.0021	99.0	99.7	0.02
IP	17	14	0.0003	0.0004	98.2	99.9	0.04
		15	0.0002	0.0003	98.7	99.9	0.03
		16	0.0001	0.0002	98.6	99.9	0.03
		17	0.0002	0.0002	98.4	99.9	0.03
PM	23	20	0.0019	0.0017	98.5	99.5	0.04
		21	0.0018	0.0018	98.4	99.6	0.04
		22	0.0014	0.0016	98.2	99.5	0.05
		23	0.0009	0.0020	98.6	99.6	0.04
% Delta: Less than 0.1% or at least stable with convergence fully documented and all other criteria met							
%Gap: Less than 0.1% or at least stable with convergence fully documented and all other criteria met							
% Flow: Link Flows Differing by < 1% Between Assignment & Simulation							
% Delays: Turn Delays Differing by < 1% Between Assignment & Simulation							
RAAD: % Relative Average Absolute Difference in Link Flows							

The results show that the model achieves a high level of convergence, in line with TAG Unit M3.1, Table 4. Results are robust, consistent and stable for at least four consecutive assignment/simulation loops and all proximity and stability indicators comfortably exceed the targets specified in TAG. As a result, the model can be said to be suitably converged locally at every location and outstandingly convergence when considering global model characteristics. It can be noted that AM has more assignment loops than other peaks due to higher congestion.

11.3 Count Calibration

The locations of counts used for calibration (i.e. those counts used as part of the creation of the trip matrices and/or the matrix estimation) are shown in Figure 11-1.

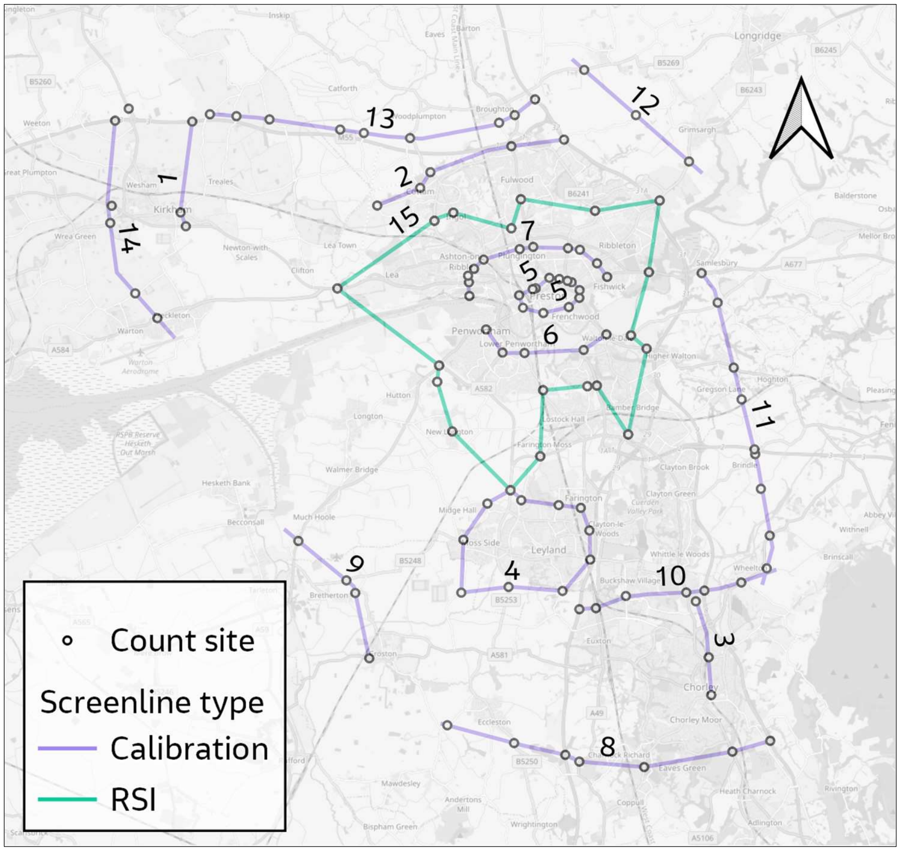


Figure 11-1: Location of Calibration Counts

The performance of the model in terms of comparisons with count data are measured in two ways. The first of these is the GEH statistic, as defined below:

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

Where: *M* is the modelled flow on a link, and *O* is the observed.

The second is made by reference to the following table, extracted from TAG Unit M 3-1:

Table 11-2: Link Flow Validation Criterion

Size of observed flow	Criteria for valid modelled flow
< 700 vehicles/hour	Modelled flow within 100 vehicles/hour of observed flow
700-2,700 vehicles/hour	Modelled flow within 15% of observed flow
> 2,700 vehicles/hour	Modelled flow within 400 vehicles/hour of observed

TAG advises that in ordinary circumstances the practitioner should aim to reach a state where 85% of modelled links have a GEH of less than 5 or satisfy the criterion in link flow.

There were 310 calibration counts used in the base year model. The comparison of modelled flows against these counts is summarised in Table 11-3, Table 11-4 and Table 11-5, for all time periods.

Table 11-3: - Calibration Count Summary – AM Peak Hour

TAG Guideline Values	All Vehicles				Cars			
	Total Count	Compliant	Result	Not compliant	Total Count	Compliant	Result	Not compliant
Individual flows within 100 vph for <700 vph	193	90%	Pass	20	220	92%	Pass	17
Individual flows within 15% for 700-2,700 vph	96	92%	Pass	8	84	92%	Pass	7
Individual flows within 400 vph for >2,700 vph	21	100%	Pass	0	6	100%	Pass	0
Total of above								
GEH: Individual flows GEH <5	310	90%	Pass	31	310	91%	Pass	29
Links meeting either TAG criteria	**310**	**93%**	Pass	**23**	**310**	**93%**	Pass	**21**

Table 11-4: Calibration Count Summary – IP Average Peak Hour

TAG Guideline Values	All Vehicles				Cars			
	Total Count	Compliant	Result	Not compliant	Total Count	Compliant	Result	Not compliant
Individual flows within 100 vph for <700 vph	237	98%	Pass	4	262	98%	Pass	4
Individual flows within 15% for 700-2,700 vph	62	97%	Pass	2	44	98%	Pass	1
Individual flows within 400 vph for >2,700 vph	11	100%	Pass	0	4	100%	Pass	0
Total of above								
GEH: Individual flows GEH <5	310	96%	Pass	13	310	96%	Pass	12
Links meeting either TAG criteria	**310**	**98%**	Pass	**6**	**310**	**98%**	Pass	**5**

Table 11-5: Calibration Count Summary – PM Peak Hour

TAG Guideline Values	All Vehicles				Cars			
	Total Count	Compliant	Result	Not compliant	Total Count	Compliant	Result	Not compliant
Individual flows within 100 vph for <700 vph	197	91%	Pass	17	210	93%	Pass	15
Individual flows within 15% for 700-2,700 vph	90	93%	Pass	6	85	93%	Pass	6
Individual flows within 400 vph for >2,700 vph	23	100%	Pass	0	15	100%	Pass	0
Total of above								
GEH: Individual flows GEH <5	310	93%	Pass	22	310	94%	Pass	18
Links meeting either TAG criteria	**310**	**94%**	Pass	**19**	**310**	**95%**	Pass	**16**

In line with guidance, the statistics are shown for all vehicles combined and for cars separately.

The table demonstrates that 85% of sites meet link flow criteria and GEH criteria for both car and total vehicles for all time periods.

The results are encouraging as it gives confidence that modelled flows are representative of real-life traffic flows.

A full breakdown of the comparison at the individual count level is included in Appendix H.

A summary of the Strategic Road Network statistics is shown in Table 11-6. All links meet the requirements across all time periods for both all vehicles and cars.

Table 11-6: Strategic Road Network Calibration Count Summary

Time Period	All Vehicles			Cars		
	Flow Difference (%Pass)	GEH (%Pass)	Passes at least 1 criterion	Flow Difference (%Pass)	GEH (%Pass)	Passes at least 1 criterion
AM	97%	97%	97%	100%	100%	100%
IP	100%	100%	100%	100%	100%	100%
PM	100%	97%	100%	100%	100%	100%

11.4 Calibration Screenlines

As indicated above, many of the counts are arranged along screenlines. TAG has a separate criterion for total screenline flows, which is that total modelled flows on all links crossing a screenline should be within 5% of the observed totals. Since percentage difference is not always the best measure, particularly for low flows, a relaxed criterion based on GEH criterion has also been used for assessing screenline performance. It is assumed that a GEH of less than 4 is considered as a pass.

The performance of the models along the calibration screenlines are summarised in the tables below.

Table 11-7: AM Calibration Screenlines – All Vehicles

Screenline	Direction	Observed Flow	Modelled Flow	Actual Difference	% Difference	Pass/ Fail	GEH	Pass/ Fail
SL_1	Inbound	3,944	3,921	23	1%	Pass	0.4	Pass
SL_2	Inbound	1,499	1,662	- 163	11%	Fail	4.0	Pass
SL_3	Inbound	1,240	1,269	- 29	2%	Pass	0.8	Pass
SL_4	Inbound	5,302	5,282	20	0%	Pass	0.3	Pass
SL_5	Inbound	5,493	5,309	184	3%	Pass	2.5	Pass
SL_6	Inbound	5,759	5,573	186	3%	Pass	2.5	Pass
SL_7	Inbound	5,055	5,223	- 168	3%	Pass	2.3	Pass
SL_8	Inbound	9,487	9,592	- 105	1%	Pass	1.1	Pass
SL_9	Inbound	1,642	1,655	- 13	1%	Pass	0.3	Pass
SL_10	Inbound	9,826	9,615	211	2%	Pass	2.1	Pass
SL_11	Inbound	6,425	6,571	- 146	2%	Pass	1.8	Pass
SL_12	Inbound	1,225	1,219	6	0%	Pass	0.2	Pass
SL_13	Inbound	935	805	130	14%	Fail	4.4	Fail
SL_14	Inbound	4,820	4,814	6	0%	Pass	0.1	Pass
SL_15	Inbound	14,627	14,661	- 34	0%	Pass	0.3	Pass
SL_1	Outbound	3,965	3,929	36	1%	Pass	0.6	Pass
SL_2	Outbound	1,786	1,702	84	5%	Pass	2.0	Pass
SL_3	Outbound	1,178	1,336	- 158	13%	Fail	4.5	Fail
SL_4	Outbound	5,616	5,795	- 179	3%	Pass	2.4	Pass
SL_5	Outbound	3,879	3,720	159	4%	Pass	2.6	Pass
SL_6	Outbound	2,773	2,875	- 102	4%	Pass	1.9	Pass
SL_7	Outbound	3,609	3,641	- 32	1%	Pass	0.5	Pass
SL_8	Outbound	9,016	9,109	- 93	1%	Pass	1.0	Pass
SL_9	Outbound	1,237	1,284	- 47	4%	Pass	1.3	Pass
SL_10	Outbound	9,475	9,001	474	5%	Pass	4.9	Fail
SL_11	Outbound	6,309	6,294	15	0%	Pass	0.2	Pass
SL_12	Outbound	1,176	1,232	- 56	5%	Pass	1.6	Pass
SL_13	Outbound	800	694	106	13%	Fail	3.9	Pass
SL_14	Outbound	5,102	5,038	64	1%	Pass	0.9	Pass
SL_15	Outbound	11,668	11,715	- 47	0%	Pass	0.4	Pass
Total Passing						**87%**		**90%**

Table 11-8: IP Calibration Screenlines – All Vehicles

Screenline	Direction	Observed Flow	Modelled Flow	Actual Difference	% Difference	Pass/ Fail	GEH	Pass/ Fail
SL_1	Inbound	2,855	2,841	14	0%	Pass	0.3	Pass
SL_2	Inbound	1,347	1,292	56	4%	Pass	1.5	Pass
SL_3	Inbound	869	846	23	3%	Pass	0.8	Pass
SL_4	Inbound	3,979	3,851	128	3%	Pass	2.0	Pass
SL_5	Inbound	4,017	3,986	32	1%	Pass	0.5	Pass
SL_6	Inbound	3,328	3,297	31	1%	Pass	0.5	Pass
SL_7	Inbound	3,487	3,396	91	3%	Pass	1.6	Pass
SL_8	Inbound	7,519	7,486	33	0%	Pass	0.4	Pass
SL_9	Inbound	968	990	- 22	2%	Pass	0.7	Pass
SL_10	Inbound	7,606	7,317	289	4%	Pass	3.4	Pass
SL_11	Inbound	4,103	4,005	98	2%	Pass	1.5	Pass
SL_12	Inbound	810	775	35	4%	Pass	1.2	Pass
SL_13	Inbound	366	433	- 67	18%	Fail	3.4	Pass
SL_14	Inbound	3,434	3,376	58	2%	Pass	1.0	Pass
SL_15	Inbound	10,029	10,258	- 229	2%	Pass	2.3	Pass
SL_1	Outbound	2,903	2,868	35	1%	Pass	0.7	Pass
SL_2	Outbound	1,239	1,127	112	9%	Fail	3.3	Pass
SL_3	Outbound	975	1,103	- 128	13%	Fail	4.0	Pass
SL_4	Outbound	4,088	4,053	35	1%	Pass	0.5	Pass
SL_5	Outbound	4,423	4,392	31	1%	Pass	0.5	Pass
SL_6	Outbound	3,634	3,582	52	1%	Pass	0.9	Pass
SL_7	Outbound	3,566	3,420	146	4%	Pass	2.5	Pass
SL_8	Outbound	7,919	7,879	40	1%	Pass	0.4	Pass
SL_9	Outbound	1,060	1,066	- 6	1%	Pass	0.2	Pass
SL_10	Outbound	8,076	7,965	111	1%	Pass	1.2	Pass
SL_11	Outbound	4,076	3,858	218	5%	Pass	3.5	Pass
SL_12	Outbound	915	958	- 43	5%	Pass	1.4	Pass
SL_13	Outbound	446	395	51	12%	Fail	2.5	Pass
SL_14	Outbound	3,473	3,387	86	2%	Pass	1.5	Pass
SL_15	Outbound	10,280	10,293	- 13	0%	Pass	0.1	Pass
Total Passing						**87%**		**100%**

Table 11-9: PM Calibration Screenlines – All Vehicles

Screenline	Direction	Observed Flow	Modelled Flow	Actual Difference	% Difference	Pass/ Fail	GEH	Pass/ Fail
SL_1	Inbound	3,888	3,816	72	2%	Pass	1.2	Pass
SL_2	Inbound	1,758	1,668	90	5%	Pass	2.2	Pass
SL_3	Inbound	1,157	1,100	57	5%	Pass	1.7	Pass
SL_4	Inbound	5,680	5,568	112	2%	Pass	1.5	Pass
SL_5	Inbound	4,237	4,129	108	3%	Pass	1.7	Pass
SL_6	Inbound	3,731	3,690	41	1%	Pass	0.7	Pass
SL_7	Inbound	3,834	3,805	29	1%	Pass	0.5	Pass
SL_8	Inbound	9,672	9,905	- 233	2%	Pass	2.4	Pass
SL_9	Inbound	1,161	1,171	- 10	1%	Pass	0.3	Pass
SL_10	Inbound	9,588	9,197	391	4%	Pass	4.0	Pass
SL_11	Inbound	6,639	6,369	270	4%	Pass	3.3	Pass
SL_12	Inbound	939	901	38	4%	Pass	1.2	Pass
SL_13	Inbound	583	707	- 124	21%	Fail	4.9	Fail
SL_14	Inbound	4,783	4,746	37	1%	Pass	0.5	Pass
SL_15	Inbound	13,476	13,073	403	3%	Pass	3.5	Pass
SL_1	Outbound	4,168	4,068	100	2%	Pass	1.6	Pass
SL_2	Outbound	1,784	1,676	108	6%	Fail	2.6	Pass
SL_3	Outbound	1,395	1,465	- 70	5%	Pass	1.9	Pass
SL_4	Outbound	5,304	5,284	20	0%	Pass	0.3	Pass
SL_5	Outbound	5,763	5,819	- 56	1%	Pass	0.7	Pass
SL_6	Outbound	5,507	5,284	223	4%	Pass	3.0	Pass
SL_7	Outbound	4,945	4,721	224	5%	Pass	3	Pass
SL_8	Outbound	10,466	10,539	- 73	1%	Pass	0.7	Pass
SL_9	Outbound	1,604	1,614	- 10	1%	Pass	0.3	Pass
SL_10	Outbound	11,032	10,805	227	2%	Pass	2.2	Pass
SL_11	Outbound	6,422	6,407	15	0%	Pass	0.2	Pass
SL_12	Outbound	1,290	1,329	- 39	3%	Pass	1.1	Pass
SL_13	Outbound	732	749	- 17	2%	Pass	0.6	Pass
SL_14	Outbound	5,076	4,865	211	4%	Pass	3.0	Pass
SL_15	Outbound	13,985	13,793	192	1%	Pass	1.6	Pass
Total Passing						**93%**		**97%**

A total of 24 calibration screenlines and 2 observed screenlines were used. The tables above show that the vast majority of calibration screenlines meet the 5% difference criterion in all peaks.

The list of screenlines failing to meet the criteria are summarised below:

AM:

- Screenline 2 is 11% or 163 vehicles too high in inbound direction but passes the GEH 4 criterion
- Screenline 13 is more than 130 vehicles too low in both inbound and outbound direction
- Screenline 3 is 13% or 158 vehicles too high in outbound direction

IP:

- Screenline 2 is 9% or 112 vehicles too low in outbound direction but passes GEH 4 criterion
- Screenline 13 is failing in inbound and outbound directions but passes GEH 4 criterion
- Screenline 3 is 13% or 128 vehicles too high in outbound direction but passes GEH 4 criterion

PM:

- Screenline 2 is 6% or 108 vehicles too low in outbound direction but passes GEH 4 criterion
- Screenline 13 is 21% or 123 vehicles too high in inbound direction

It should be noted that all failing screenlines are far away from the A582 impact area and most of them pass the GEH 4 criterion or stop slightly short of passing it. However, it was prudent to investigate the reasons for these failures and the analysis is provided below.

The poor model performance at screenline 2 especially in AM and PM is primarily due to traffic congestion along Garstang Road in the north Preston area. During peak hours this corridor is recording abnormally low observed flows at the majority of traffic survey locations on that road and not only at screenline 2.

Low traffic flows for the Garstang Road count location ATC-76 (included in screenline 2) were due to severe delays, which limited the amount of traffic able to pass through the count site. This is primarily because of the traffic spill back from the M55 Junction 1 and from the signalised junction on Garstang Road with Lightfoot Lane.

Figure 11-2 shows the dip in count traffic flow for AM peak in southbound direction.

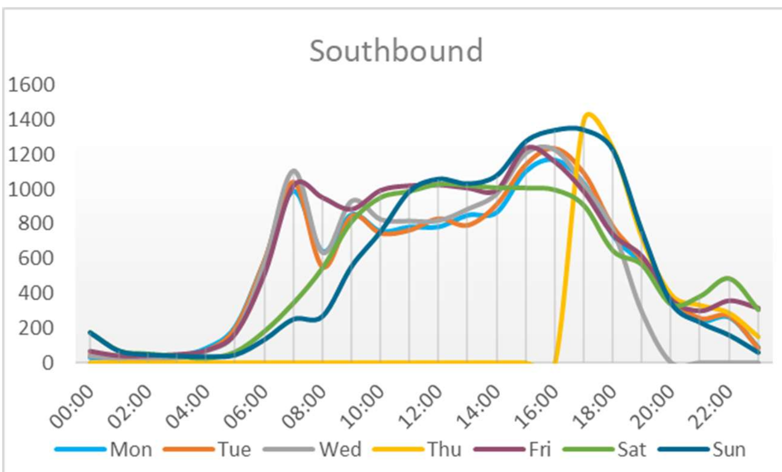


Figure 11-2: ATC 76 Traffic Profile SB

The speed profiles were also investigated and sudden reduction in speed was observed especially for AM peak hour. Figure 11-3 and Figure 11-4 shows the percentage of vehicles for ATC-76 in NB and SB direction for each of the below mentioned category. The posted speed limit for Garstang Road is 30mph.

PSL	Posted Speed Limit
ACPO	Association of Chief Police Officers (Used to display the speed limit the police will generally enforce, 110% of PSL +2mph)
DFT	Department for Transport (Used to display a speed statistic used by the government looking at vehicles travelling over 15mph above the PSL)

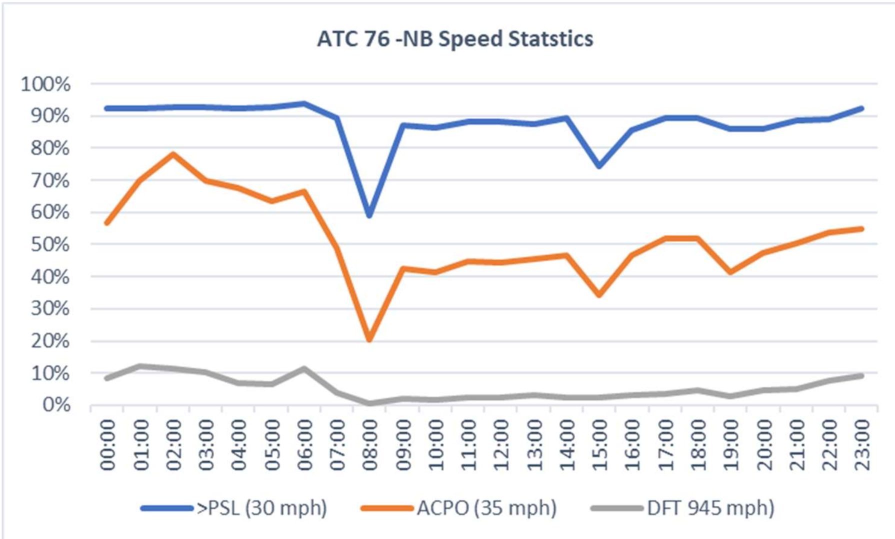


Figure 11-3: ATC 76 - Speed Stastics -NB

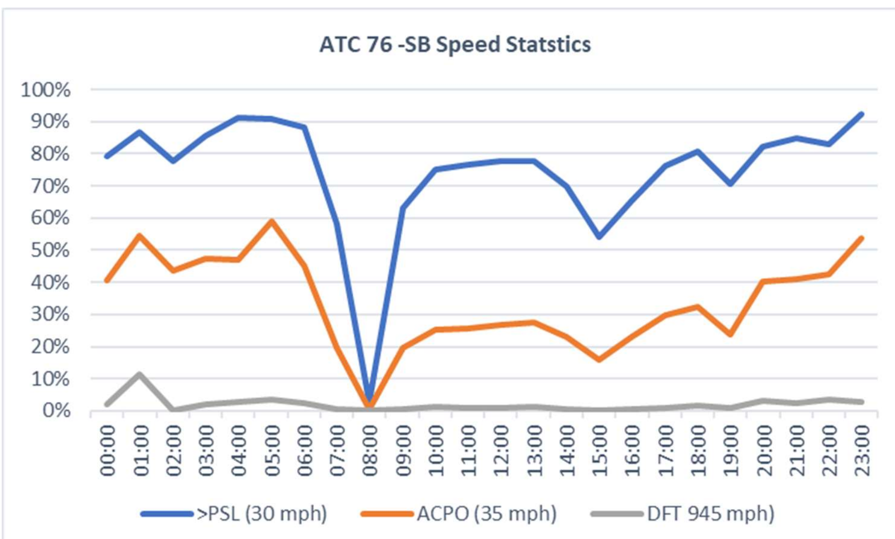


Figure 11-4: ATC 76 - Speed Stastics -SB

While this confirms that in peak hour the traffic recorded in the congested section is low even when the demand is high, strategic models developed in SATURN are unable to replicate such delays, and such delays can be reproduced only in microsimulation models. The delays at junctions and links were reviewed to confirm if the network coding were correct.

Considering the facts mentioned above, the decision was made to maintain the integrity of the matrices rather than further adjust them to bring the links in line with the guidance. Reducing the traffic demand to match traffic counts would result in overall less delay for the corridor, which would affect the travel time validation. This is primarily because of SATURN's inability to model very congested situations like this.

Screenline 13 mainly consists of low trafficked rural roads and while all individual counts are passing the criteria the screenline fails because of the cumulative differences at each individual link.

Screenline 3 was investigated for the failure and all links except one link along Moss Lane (eastbound) is passing. The traffic flow difference for this link in AM peak is around 170 and 140 in IP. Although the traffic counts did not show any major anomalies, observed traffic flow seems to be quite low considering that it gives direct connection to A674. It should be noted that although the flows at this screenlines do not pass the percentage criterion, they are generally close to passing particularly with respect to GEH values, and therefore are still considered to be acceptable.

Calibration screenlines results for each vehicle type are provided in Appendix H.

The calibration results are summarised in Table 11-10. The table shows the percentage of screenlines meeting the 5% flow difference and relaxed GEH of 4 criteria for all vehicle types, as outlined in TAG unit M3.1.

In relation to LGV and HGV, as expected the overall performance when evaluated against 5% difference the percentage of screenlines passing the criteria is below the threshold. This is because total flows are low and so even a low difference between modelled and observed flows results in a high percentage difference. On the other hand, when the modelled and observed flows are compared using the GEH statistics, the results show that all screenlines pass the requirement.

Table 11-10: Summary Results of Calibration Cordons and Screenlines

	Time Period	5% Difference	Relaxed GEH <4
All Vehicles	AM	87%	90%
	IP	87%	100%
	PM	93%	97%
Car	**Time Period**	**5% Difference**	**Relaxed GEH <4**
	AM	87%	87%
	IP	87%	100%
	PM	87%	97%
LGV	**Time Period**	**5% Difference**	**Relaxed GEH <4**
	AM	60%	97%
	IP	77%	97%
	PM	60%	87%
HGV	**Time Period**	**5% Difference**	**Relaxed GEH <4**
	AM	30%	97%
	IP	43%	93%
	PM	23%	97%

11.5 Count Validation

Count validation relies on making similar comparisons to the ones made for the count calibration, but against independent counts, i.e. those not used in the model building process up to this point, in either the matrix building or the matrix estimation.

The locations of these counts are show in Figure 11-5.

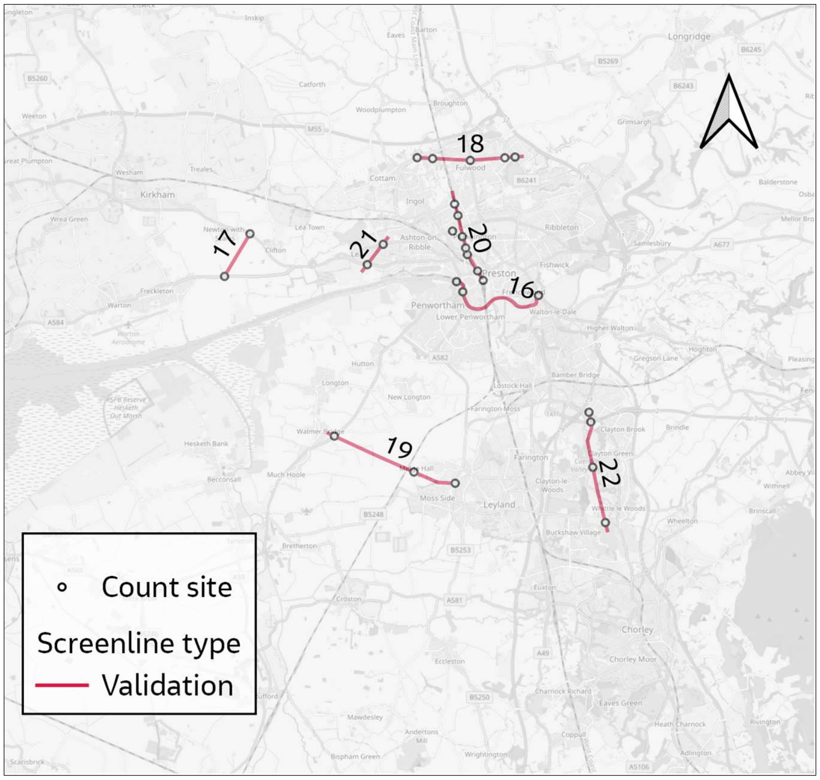


Figure 11-5: Locations of Validation Counts Location and Respective Screenlines

Table 11-11 to Table 11-5 below provide a summary of the detailed results. Full validation results are contained in Appendix H.

Table 11-11: Validation Count Summary – AM Peak Hour

TAG Guideline Values	All Vehicles				Cars			
	Total Count	Compliant	Result	Not compliant	Total Count	Compliant	Result	Not compliant
Individual flows within 100 vph for <700 vph	25	96%	Pass	1	31	90%	Pass	3
Individual flows within 15% for 700-2,700 vph	20	90%	Pass	2	15	87%	Pass	2
Individual flows within 400 vph for >2,700 vph	3	100%	Pass	0	2	100%	Pass	0
Total of above								
GEH: Individual flows GEH <5	48	94%	Pass	3	48	96%	Pass	2
Links meeting either TAG criteria	**48**	**94%**	**Pass**	**3**	**48**	**96%**	**Pass**	**2**

Table 11-12: Validation Count Summary – IP Average Peak Hour

TAG Guideline Values	All Vehicles				Cars			
	Total Count	Compliant	Result	Not compliant	Total Count	Compliant	Result	Not compliant
Individual flows within 100 vph for <700 vph	36	94%	Pass	2	40	95%	Pass	2
Individual flows within 15% for 700-2,700 vph	10	100%	Pass	0	6	100%	Pass	0
Individual flows within 400 vph for >2,700 vph	2	100%	Pass	0	2	100%	Pass	0
Total of above								
GEH: Individual flows GEH <5	48	96%	Pass	2	48	98%	Pass	1
Links meeting either TAG criteria	**48**	**96%**	Pass	**2**	**48**	**98%**	Pass	**1**

Table 11-13: Validation Count Summary – PM Peak Hour

TAG Guideline Values	All Vehicles				Cars			
	Total Count	Compliant	Result	Not compliant	Total Count	Compliant	Result	Not compliant
Individual flows within 100 vph for <700 vph	26	92%	Pass	2	30	93%	Pass	2
Individual flows within 15% for 700-2,700 vph	18	95%	Pass	1	16	94%	Pass	1
Individual flows within 400 vph for >2,700 vph	4	100%	Pass	0	2	100%	Pass	0
Total of above								
GEH: Individual flows GEH <5	48	94%	Pass	3	48	94%	Pass	3
Links meeting either TAG criteria	**48**	**94%**	Pass	**3**	**48**	**94%**	Pass	**3**

The above results show that the traffic model fully meet 85% criteria for all link flows for all time periods. It should be also noted that count sites close to the proposed A582 scheme also validate well.

A summary of the Strategic Road Network statistics for validation counts is shown in Table 11-14 . All links meet the requirements across all time periods for both all vehicles and cars.

Table 11-14: Strategic Road Network Validation Count Summary

Time Period	All Vehicles			Cars		
	Flow Difference (%Pass)	GEH (%Pass)	Passes at least 1 criterion	Flow Difference (%Pass)	GEH (%Pass)	Passes at least 1 criterion
AM	100%	100%	100%	100%	100%	100%
IP	100%	100%	100%	100%	100%	100%
PM	100%	100%	100%	100%	100%	100%

11.6 Validation Screenlines

Similar to the calibration counts, the validation counts are also arranged along screenlines. The performance of the models along the validation screenlines are provided in the tables below.

Table 11-15: AM Validation Screenlines – All Vehicles

Screenline	Direction	Observed Flow	Modelled Flow	Actual Difference	% Difference	Pass/ Fail	GEH	Pass/ Fail
SL_16	Inbound	4647	4596	51	1%	Pass	0.7	Pass
SL_17	Inbound	1599	1624	-25	2%	Pass	0.6	Pass
SL_18	Inbound	7564	7476	88	1%	Pass	1.0	Pass
SL_19	Inbound	2021	2016	5	0%	Pass	0.1	Pass
SL_20	Inbound	3088	2930	158	5%	Pass	2.9	Pass
SL_21	Inbound	1957	2042	-85	4%	Pass	1.9	Pass
SL_22	Inbound	4502	4397	105	2%	Pass	1.6	Pass
SL_16	Outbound	2819	2923	-104	4%	Pass	1.9	Pass
SL_17	Outbound	1571	1579	-8	1%	Pass	0.2	Pass
SL_18	Outbound	7616	7563	53	1%	Pass	0.6	Pass
SL_19	Outbound	1327	1337	-10	1%	Pass	0.3	Pass
SL_20	Outbound	2451	2765	-314	13%	Fail	6.1	Fail
SL_21	Outbound	1510	1517	-7	0%	Pass	0.2	Pass
SL_22	Outbound	4322	3839	113	3%	Fail	1.8	Fail
Total Passing						**93%**		**93%**

Table 11-16: IP Validation Screenlines – All Vehicles

Screenline	Direction	Observed Flow	Modelled Flow	Actual Difference	% Difference	Pass/ Fail	GEH	Pass/ Fail
SL_16	Inbound	3116	3045	71	2%	Pass	1.3	Pass
SL_17	Inbound	998	987	11	1%	Pass	0.4	Pass
SL_18	Inbound	6749	6704	45	1%	Pass	0.6	Pass
SL_19	Inbound	1119	1113	6	1%	Pass	0.2	Pass
SL_20	Inbound	1923	1920	3	0%	Pass	0.1	Pass
SL_21	Inbound	1350	1275	75	6%	Fail	2.1	Pass
SL_22	Inbound	3089	3061	28	1%	Pass	0.5	Pass
SL_16	Outbound	2668	2757	-89	3%	Pass	1.7	Pass
SL_17	Outbound	962	963	-1	0%	Pass	0.0	Pass
SL_18	Outbound	6555	6440	115	2%	Pass	1.4	Pass
SL_19	Outbound	1264	1261	3	0%	Pass	0.1	Pass
SL_20	Outbound	2436	2142	294	12%	Fail	6.1	Fail
SL_21	Outbound	1159	1166	-7	1%	Pass	0.2	Pass
SL_22	Outbound	3068	2896	-5	0%	Pass	0.1	Pass
Total Passing						**86%**		**93%**

Table 11-17: PM Validation Screenlines – All Vehicles

Screenline	Direction	Observed Flow	Modelled Flow	Actual Difference	% Difference	Pass/ Fail	GEH	Pass/ Fail
SL_16	Inbound	3573	3718	-145	4%	Pass	2.4	Pass
SL_17	Inbound	1417	1414	3	0%	Pass	0.1	Pass
SL_18	Inbound	8256	8189	67	1%	Pass	0.7	Pass
SL_19	Inbound	1369	1369	0	0%	Pass	0.0	Pass
SL_20	Inbound	2271	2273	-2	0%	Pass	0.0	Pass
SL_21	Inbound	1501	1498	3	0%	Pass	0.1	Pass
SL_22	Inbound	4519	4436	83	2%	Pass	1.2	Pass
SL_16	Outbound	3864	3825	39	1%	Pass	0.6	Pass
SL_17	Outbound	1543	1575	-32	2%	Pass	0.8	Pass
SL_18	Outbound	7953	8037	-84	1%	Pass	0.9	Pass
SL_19	Outbound	2030	2048	-18	1%	Pass	0.4	Pass
SL_20	Outbound	3061	2874	187	6%	Fail	3.4	Pass
SL_21	Outbound	1807	1854	-47	3%	Pass	1.1	Pass
SL_22	Outbound	4640	3802	391	9%	Fail	6.2	Fail
Total Passing						**86%**		**93%**

The performance of the model along the validation screenlines shows for all time periods, screenlines totals passes the flow difference and GEH criteria. It should also be noted that the remaining screenlines which do not satisfy the thresholds are all fairly close to meeting the standards.

The performance of LGVs and HGVs along validation screenlines are below the threshold with respect to flow difference requirements, which can be explained by the low volume of these vehicle types across screenlines. However, evaluating these against the GEH value shows a significant improvement in the number of screenlines passing.

Validation screenlines results for each vehicle type are provided in Appendix H.

Similar to the overall calibration screenline traffic totals, overall traffic levels throughout all the validation screenlines represent a very close fit.

Table 11-18: Summary Results of Validation Screenlines

	Time Period	5% Difference	Relaxed GEH <4
All Vehicles	AM	93%	93%
	IP	86%	93%
	PM	86%	93%
Car	**Time Period**	**5% Difference**	**Relaxed GEH <4**
	AM	86%	93%
	IP	93%	93%
	PM	86%	93%
LGV	**Time Period**	**5% Difference**	**Relaxed GEH <4**
	AM	64%	93%
	IP	64%	93%
	PM	57%	93%
HGV	**Time Period**	**5% Difference**	**Relaxed GEH <4**
	AM	14%	93%
	IP	21%	93%
	PM	57%	100%

11.7 A582 Screenline Summary

Calibration and validation screenline near the A582 scheme are reported separately in this section to demonstrate that whilst there are some model failures across the whole modelled area the model performance in the A582 area of impact is strong and fit for purpose. Modelled traffic flows in the A582 corridor and relevant sections is provided in Appendix L.

The screenlines considered for the A582 scheme are shown in Figure 11-6, with the scheme itself shown in red.

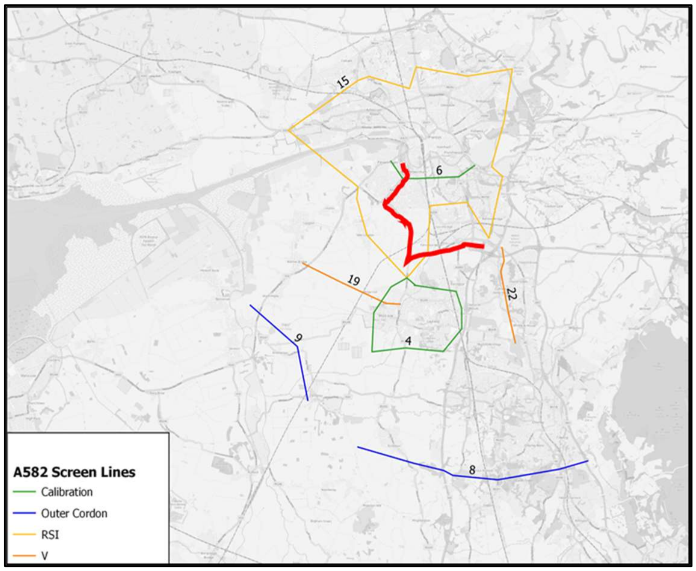


Figure 11-6: A582 Screenlines

The performance of the models along the calibration and validation screenlines are summarised in the tables below.

Table 11-19: A582 Calibration Screenline Summary – AM Peak Hour

Screenline	Direction	Observed Flow	Modelled Flow	Actual Difference	% Difference	Pass/ Fail	GEH	Pass/ Fail
SL_4	Inbound	5,302	5,282	20	0%	Pass	0.3	Pass
SL_6	Inbound	5,759	5,573	186	3%	Pass	2.5	Pass
SL_8	Inbound	9,487	9,592	- 105	1%	Pass	1.1	Pass
SL_9	Inbound	1,642	1,655	- 13	1%	Pass	0.3	Pass
SL_15	Inbound	14,627	14,661	- 34	0%	Pass	0.3	Pass
SL_4	Outbound	5,616	5,795	- 179	3%	Pass	2.4	Pass
SL_6	Outbound	2,773	2,875	- 102	4%	Pass	1.9	Pass
SL_8	Outbound	9,016	9,109	- 93	1%	Pass	1.0	Pass
SL_9	Outbound	1,237	1,284	- 47	4%	Pass	1.3	Pass
SL_15	Outbound	11,668	11,715	- 47	0%	Pass	0.4	Pass

Table 11-20: A582 Calibration Screenline Summary – IP Peak Hour

Screenline	Direction	Observed Flow	Modelled Flow	Actual Difference	% Difference	Pass/ Fail	GEH	Pass/ Fail
SL_4	Inbound	3,979	3,851	128	3%	Pass	2.0	Pass
SL_6	Inbound	3,328	3,297	31	1%	Pass	0.5	Pass
SL_8	Inbound	7,519	7,486	33	0%	Pass	0.4	Pass
SL_9	Inbound	968	990	- 22	2%	Pass	0.7	Pass
SL_15	Inbound	10,029	10,258	- 229	2%	Pass	2.3	Pass
SL_4	Outbound	4,088	4,053	35	1%	Pass	0.5	Pass
SL_6	Outbound	3,634	3,582	52	1%	Pass	0.9	Pass
SL_8	Outbound	7,919	7,879	40	1%	Pass	0.4	Pass
SL_9	Outbound	1,060	1,066	- 6	1%	Pass	0.2	Pass
SL_15	Outbound	10,280	10,293	- 13	0%	Pass	0.1	Pass

Table 11-21: A582 Calibration Screenline Summary – PM Peak Hour

Screenline	Direction	Observed Flow	Modelled Flow	Actual Difference	% Difference	Pass/ Fail	GEH	Pass/ Fail
SL_4	Inbound	5,680	5,568	112	2%	Pass	1.5	Pass
SL_6	Inbound	3,731	3,690	41	1%	Pass	0.7	Pass
SL_8	Inbound	9,672	9,905	- 233	2%	Pass	2.4	Pass
SL_9	Inbound	1,161	1,171	- 10	1%	Pass	0.3	Pass
SL_15	Inbound	13,476	13,073	403	3%	Pass	3.5	Pass
SL_4	Outbound	5,304	5,284	20	0%	Pass	0.3	Pass
SL_6	Outbound	5,507	5,284	223	4%	Pass	3.0	Pass
SL_8	Outbound	10,466	10,539	- 73	1%	Pass	0.7	Pass
SL_9	Outbound	1,604	1,614	- 10	1%	Pass	0.3	Pass
SL_15	Outbound	13,985	13,793	192	1%	Pass	1.6	Pass

Table 11-22: A582 Validation Screenline Summary – AM Peak Hour

Screenline	Direction	Observed Flow	Modelled Flow	Actual Difference	% Difference	Pass/ Fail	GEH	Pass/ Fail
SL_19	Inbound	2021	2016	5	0%	Pass	0.1	Pass
SL_22	Inbound	4502	4397	105	2%	Pass	1.6	Pass
SL_19	Outbound	1327	1337	-10	1%	Pass	0.3	Pass
SL_22	Outbound	3952	3839	113	3%	Pass	1.8	Pass

Table 11-23: A582 Validation Screenline Summary – IP Peak Hour

Screenline	Direction	Observed Flow	Modelled Flow	Actual Difference	% Difference	Pass/ Fail	GEH	Pass/ Fail
SL_19	Inbound	1119	1113	6	1%	Pass	0.2	Pass
SL_22	Inbound	3089	3061	28	1%	Pass	0.5	Pass
SL_19	Outbound	1264	1261	3	0%	Pass	0.1	Pass
SL_22	Outbound	2891	2896	-5	0%	Pass	0.1	Pass

Table 11-24: A582 Validation Screenline Summary – PM Peak Hour

Screenline	Direction	Observed Flow	Modelled Flow	Actual Difference	% Difference	Pass/ Fail	GEH	Pass/ Fail
SL_19	Inbound	1369	1369	0	0%	Pass	0.0	Pass
SL_22	Inbound	4519	4436	83	2%	Pass	1.2	Pass
SL_19	Outbound	2030	2048	-18	1%	Pass	0.4	Pass
SL_22	Outbound	4193	3802	391	9%	Fail	6.2	Fail

The performance of the model for the calibration screenlines in A582 scheme area show that across all time periods, pass the flow difference and GEH criteria.

With an exception of screenline 22 in PM peak, all validation screenlines pass the TAG criterion. Screenline 22 fails primarily because of failing link along Sheep Hill Brow in eastbound direction, which is far from the scheme area and therefore overall model performance in the scheme area represent a very close fit.

Individual count calibration and validation results are summarized in tables below. Again, the results indicate a satisfactory level of performance for both validation and calibration counts.

Table 11-25: A582 Calibration Count Summary – AM Peak Hour

TAG Guideline Values	All Vehicles				Cars			
	Total Count	Compliant	Result	Not compliant	Total Count	Compliant	Result	Not compliant
Individual flows within 100 vph for <700 vph	58	95%	Pass	3	64	95%	Pass	3
Individual flows within 15% for 700-2,700 vph	32	97%	Pass	1	29	97%	Pass	1
Individual flows within 400 vph for >2,700 vph	3	100%	Pass	0	0	-	Pass	0
Total of above								
GEH: Individual flows GEH <5	93	95%	Pass	5	93	95%	Pass	5
Links meeting either TAG criteria	**93**	**96%**	Pass	**4**	**93**	**96%**	Pass	**4**

Table 11-26: A582 Calibration Count Summary – IP Peak Hour

TAG Guideline Values	All Vehicles				Cars			
	Total Count	Compliant	Result	Not compliant	Total Count	Compliant	Result	Not compliant
Individual flows within 100 vph for <700 vph	70	97%	Pass	2	84	99%	Pass	1
Individual flows within 15% for 700-2,700 vph	22	100%	Pass	0	9	100%	Pass	0
Individual flows within 400 vph for >2,700 vph	1	100%	Pass	0	0	-	Pass	0
Total of above								
GEH: Individual flows GEH <5	93	98%	Pass	2	93	99%	Pass	1
Links meeting either TAG criteria	**93**	**98%**	Pass	**2**	**93**	**99%**	Pass	**1**

Table 11-27: A582 Calibration Count Summary – PM Peak Hour

TAG Guideline Values	All Vehicles				Cars			
	Total Count	Compliant	Result	Not compliant	Total Count	Compliant	Result	Not compliant
Individual flows within 100 vph for <700 vph	58	95%	Pass	3	60	95%	Pass	3
Individual flows within 15% for 700-2,700 vph	32	91%	Pass	3	30	93%	Pass	2
Individual flows within 400 vph for >2,700 vph	3	100%	Pass	0	3	100%	Pass	0
Total of above								
GEH: Individual flows GEH <5	93	96%	Pass	4	93	96%	Pass	4
Links meeting either TAG criteria	**93**	**96%**	Pass	**4**	**93**	**96%**	Pass	**4**

Table 11-28: A582 Validation Count Summary – AM Peak Hour

TAG Guideline Values	All Vehicles				Cars			
	Total Count	Compliant	Result	Not compliant	Total Count	Compliant	Result	Not compliant
Individual flows within 100 vph for <700 vph	6	100%	Pass	0	6	100%	Pass	0
Individual flows within 15% for 700-2,700 vph	5	80%	Fail	1	6	83%	Fail	1
Individual flows within 400 vph for >2,700 vph	1	100%	Pass	0	0	-	-	0
Total of above								
GEH: Individual flows GEH <5	**12**	**92%**	Pass	**1**	**12**	**100%**	Pass	**0**
Links meeting either TAG criteria	**12**	**92%**	Pass	**1**	**12**	**100%**	Pass	**0**

Table 11-29: A582 Validation Count Summary – IP Peak Hour

TAG Guideline Values	All Vehicles				Cars			
	Total Count	Compliant	Result	Not compliant	Total Count	Compliant	Result	Not compliant
Individual flows within 100 vph for <700 vph	6	100%	Pass	0	8	100%	Pass	0
Individual flows within 15% for 700-2,700 vph	6	100%	Pass	0	4	100%	Pass	0
Individual flows within 400 vph for >2,700 vph	0	-	Pass	0	0	-	Pass	0
Total of above								
GEH: Individual flows GEH <5	**12**	**100%**	Pass	**0**	**12**	**100%**	Pass	**0**
Links meeting either TAG criteria	**12**	**100%**	Pass	**0**	**12**	**100%**	Pass	**0**

Table 11-30: A582 Validation Count Summary – PM Peak Hour

TAG Guideline Values	All Vehicles				Cars			
	Total Count	Compliant	Result	Not compliant	Total Count	Compliant	Result	Not compliant
Individual flows within 100 vph for <700 vph	5	100%	Pass	0	6	100%	Pass	0
Individual flows within 15% for 700-2,700 vph	6	83%	Fail	1	6	83%	Fail	1
Individual flows within 400 vph for >2,700 vph	1	100%	Pass	0	0	-	-	0
Total of above	12	92%		1	12	92%		1
GEH: Individual flows GEH <5	12	92%	Pass	1	12	92%	Pass	1
Links meeting either TAG criteria	**12**	**92%**	Pass	**1**	**12**	**92%**	Pass	**1**

11.8 M65 J1 and M6 J29 Turning Flow Analysis

It is acknowledged that the A582 SRWD and the future developments unlocked by the scheme are likely to have an impact on the SRN. More specifically based on the communication with Highways England as one of the stakeholders for the scheme they are particularly concerned about the scheme impacts on the M65 J1 and M6 J29. To ensure the model is sufficiently robust to support the analysis of scheme impacts on those junctions it was agreed that as part of model calibration the junction turning flows will be benchmarked against the best available observed.

Link level traffic counts were available from the traffic surveys undertaken for the project (2019) and turning movement counts were provided by LCC for year 2016. It should be noted that turning counts were only available for one day. More details on the turning count data is available in TDCR.

Figure 11-7 through Figure 11-10 show the comparison of turning movement counts for AM and PM peaks. Due to some inconsistencies between 2016 turning counts and 2019 link counts it was not possible to achieve a close match for all movements. It should be noted that the model specification did not include calibration to turning movements. However, it can be seen from the figures that in the majority of cases modelled turning flow distribution is comparable to the observed proportions.

Figure 11-7: AM - Turning counts comparison A6/M6 Roundabout

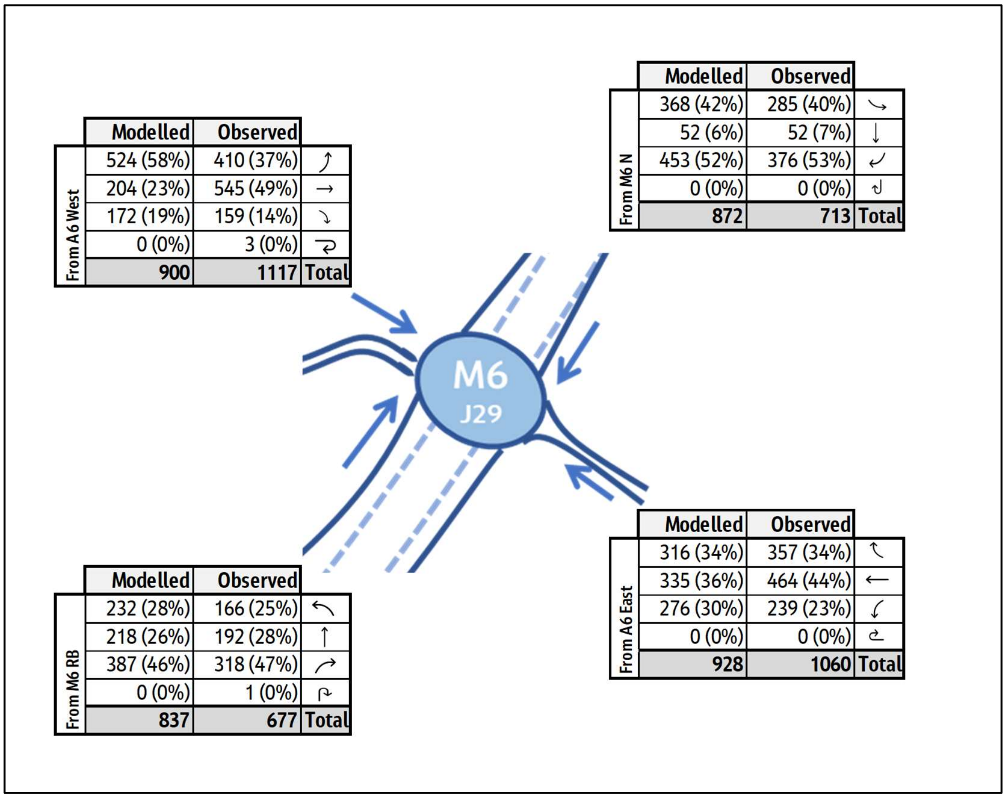


Figure 11-8: AM - Turning counts comparison M6/M65 Roundabout

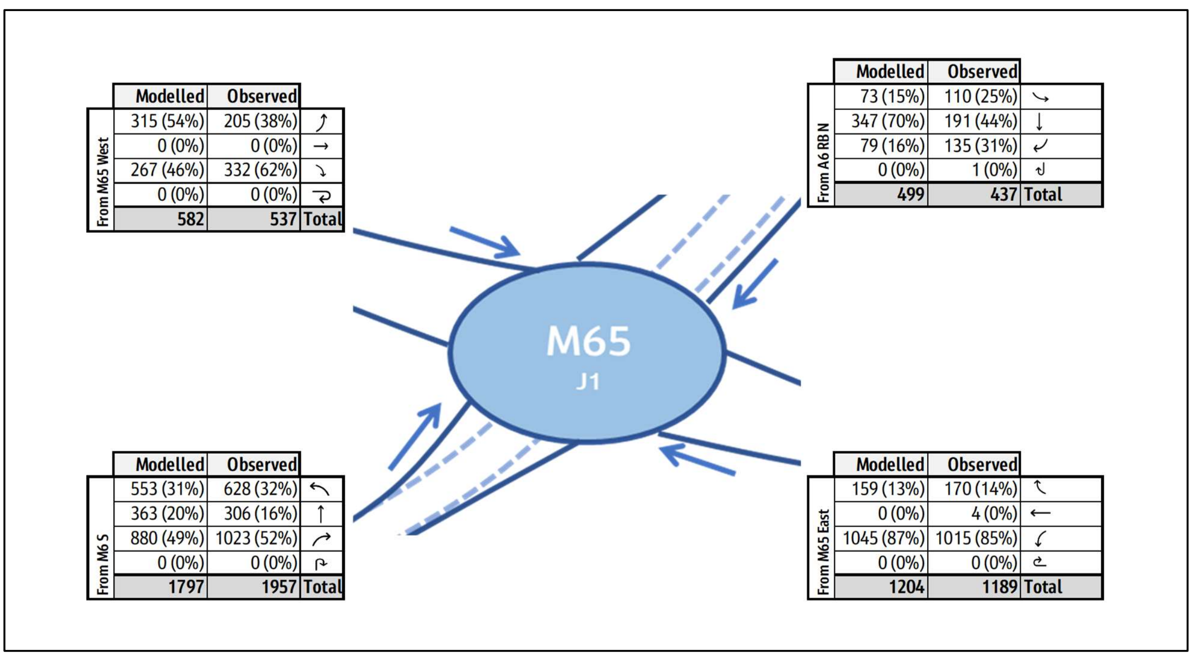


Figure 11-9: PM - Turning counts comparison A6/M6 Roundabout

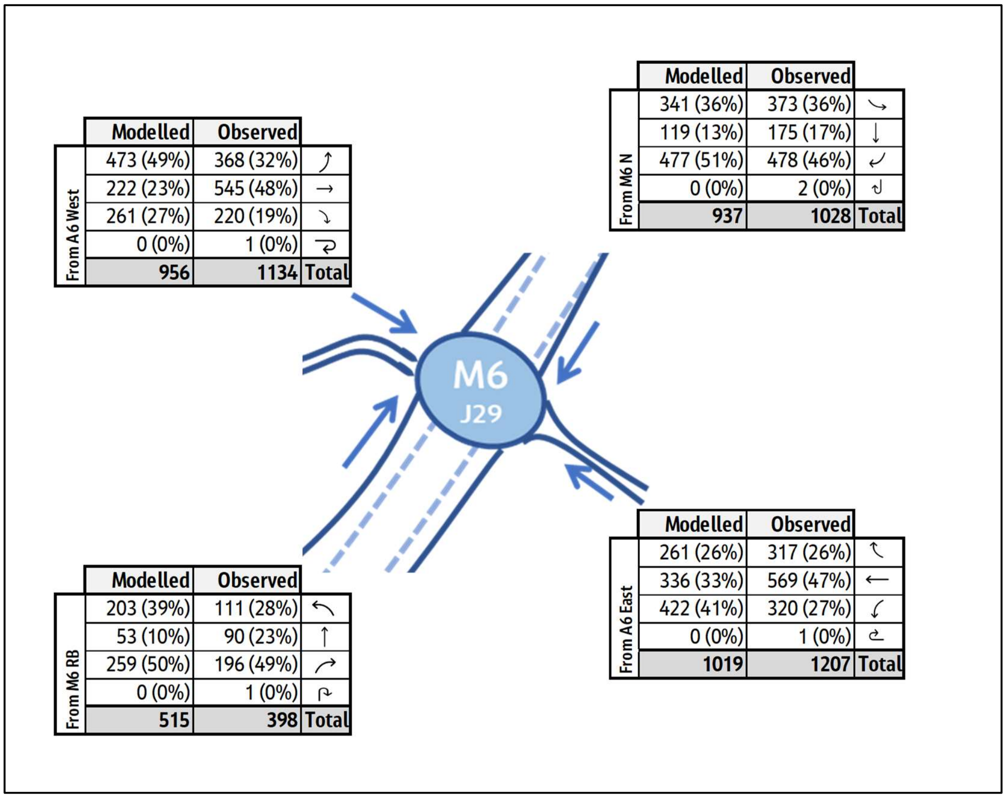
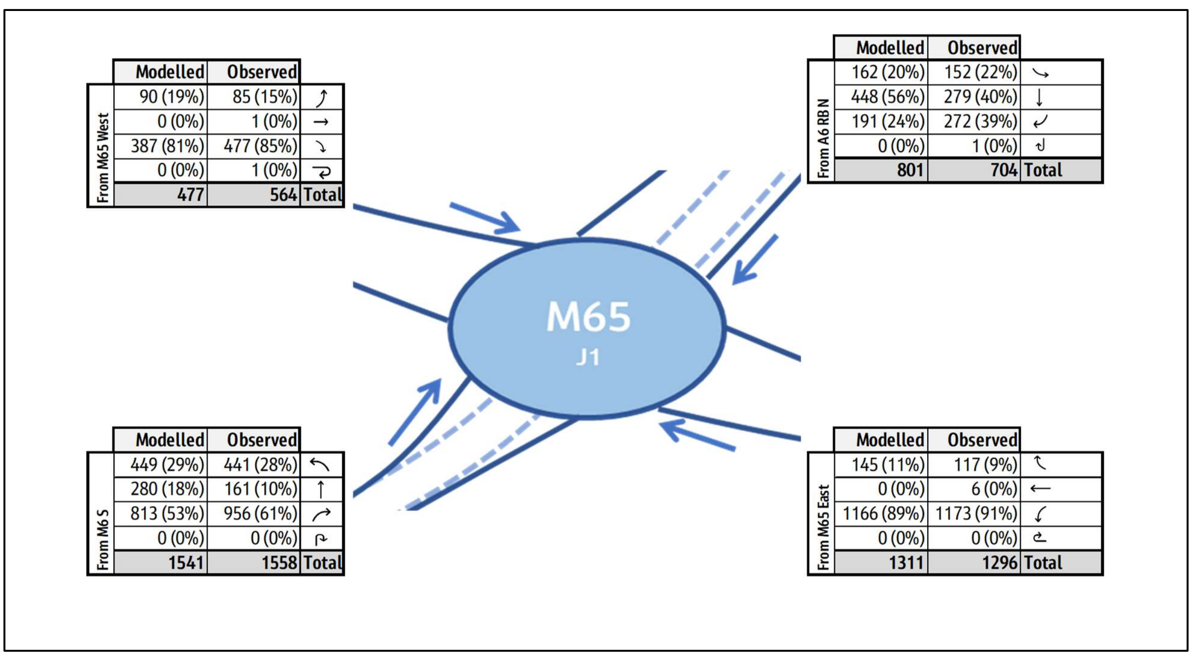


Figure 11-10: PM - Turning counts comparison M6/M65 Roundabout



11.9 Journey Time Validation

Journey times within the model were checked by comparison of the modelled journey times against the observed times along the routes identified in Section 4.5.

TrafficMaster data was used to calculate observed journey times. The weighted average of the vehicle types captured by TrafficMaster were used to provide the average journey time for each of the identified journey time routes.

These averaged journey times were then compared with the averaged PCU journey times within the SATURN models.

TAG requires that for the total route length, the modelled journey time from start to finish is within 15% (or 1 minute) of the observed time, and this must be the case for 85% of all the routes. However, that simple comparison ignores the fact that modelled and observed journey times could deviate significantly from each other along specific sections of a route, and the overall time still be within the specified acceptance criteria.

To ensure rigour in the modelled delays and journey times, the modelled times have been compared to the observed times not just for the total time along the routes, but also along the sections within each route. To that end, distance versus time graphs for the modelled and observed times are provided in Appendix I.

Figure 11-11 shows the journey time routes and Table 11-31 to Table 11-33 summarises the performance of the model in terms of the TAG criteria for each modelled time period.

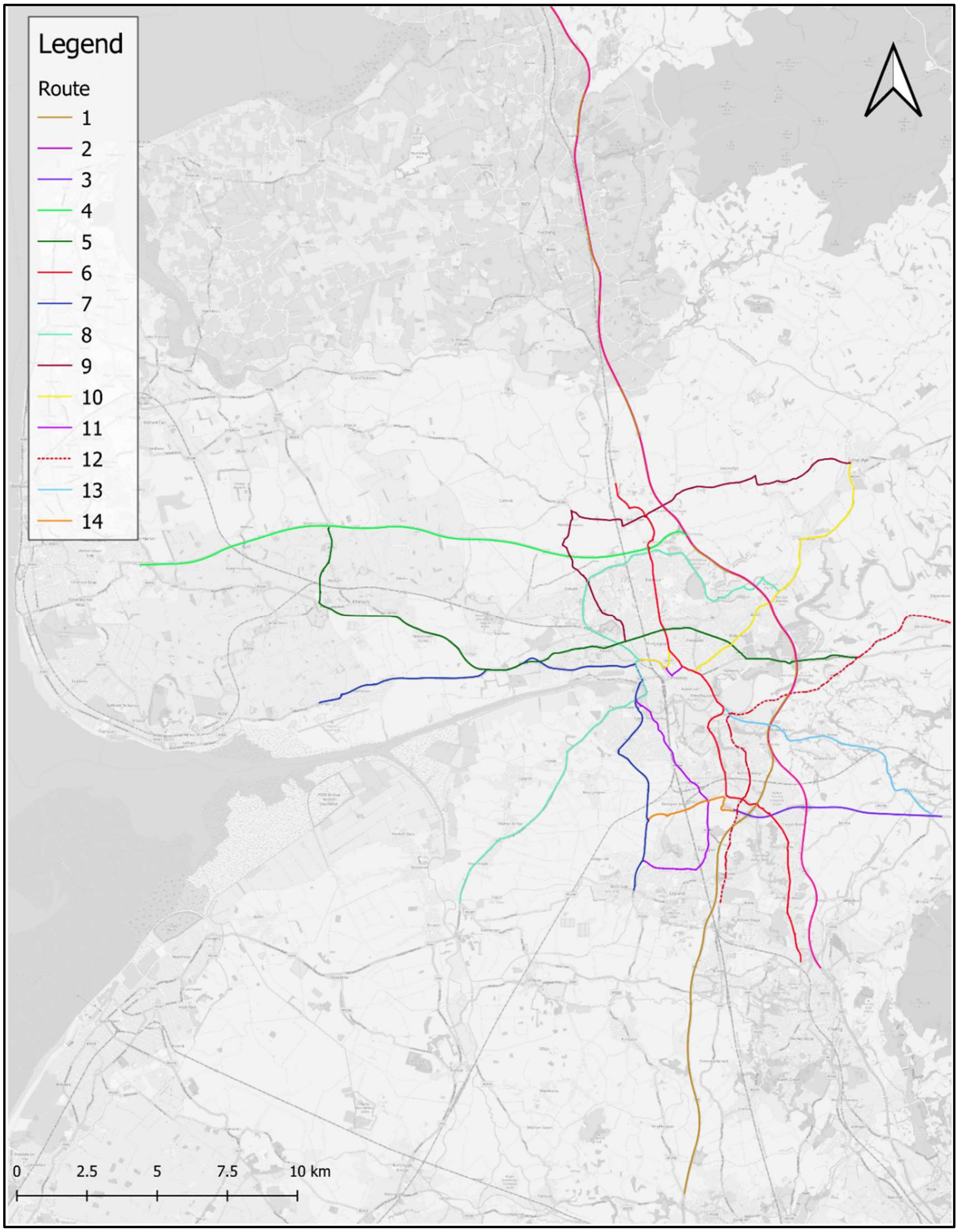


Figure 11-11: Journey Time Validation Routes

Table 11-31: Comparison of Modelled Journey Time against the Observed, AM Peak

Route	Dir	Total Observed (s)	Total Modelled (s)	Diff (s)	Rel. Diff	Result
1	1A	2591	2238	353	14%	Pass
	1B	2702	2332	370	14%	Pass
2	2A	2669	2127	542	20%	Fail
	2B	2781	2324	457	16%	Fail
3	3A	1544	1755	211	14%	Pass
	3B	1717	1754	37	2%	Pass
4	4A	2602	2315	287	11%	Pass
	4B	2677	2372	305	11%	Pass
5	5A	1613	1389	224	14%	Pass
	5B	1526	1341	185	12%	Pass
6	6A	1810	1725	85	5%	Pass
	6B	1864	2035	171	9%	Pass
7	7A	2042	2003	39	2%	Pass
	7B	1934	1972	38	2%	Pass
8	8A	1579	1508	71	4%	Pass
	8B	1570	1516	54	3%	Pass
9	9A	661	613	48	7%	Pass
	9B	837	636	201	24%	Fail
10	10A	357	382	25	7%	Pass
	10B	417	402	15	4%	Pass
M1	M1A	1705	1729	24	1%	Pass
	M1B	1558	1674	116	7%	Pass
M2	M2A	293	288	5	2%	Pass
	M2B	352	339	13	4%	Pass
M3	M3A	364	286	78	21%	Fail
	M3B	301	309	8	3%	Pass
M4	M4A	679	655	24	4%	Pass
	M4B	652	660	8	1%	Pass
Total TAG Compliant						**86%**

Table 11-32: Comparison of Modelled Journey Time against the Observed, IP

Route	Dir	Total Observed (s)	Total Modelled (s)	Diff (s)	Rel. Diff	Result
1	1A	2,194	2,091	103	5%	Pass
	1B	2,232	2,173	59	3%	Pass
2	2A	2,207	2,046	161	7%	Pass
	2B	2,178	2,208	30	1%	Pass
3	3A	1,574	1,701	127	8%	Pass
	3B	1,489	1,549	60	4%	Pass
4	4A	2,041	2,099	58	3%	Pass
	4B	2,226	2,260	34	2%	Pass
5	5A	1,481	1,362	119	8%	Pass
	5B	1,468	1,308	160	11%	Pass
6	6A	1,657	1,695	38	2%	Pass
	6B	1,705	1,968	263	15%	Pass
7	7A	1,862	1,839	23	1%	Pass
	7B	1,902	2,023	121	6%	Pass
8	8A	1,421	1,472	51	4%	Pass
	8B	1,446	1,451	5	0%	Pass
9	9A	654	601	53	8%	Pass
	9B	675	587	88	13%	Pass
10	10A	323	342	19	6%	Pass
	10B	346	372	26	7%	Pass
M1	M1A	1,555	1,625	70	4%	Pass
	M1B	1,585	1,671	86	5%	Pass
M2	M2A	296	283	13	4%	Pass
	M2B	298	313	15	5%	Pass
M3	M3A	268	258	10	4%	Pass
	M3B	262	262	0	0%	Pass
M4	M4A	641	639	2	0%	Pass
	M4B	661	649	12	2%	Pass
Total TAG Compliant						**100%**

Table 11-33: Comparison of Modelled Journey Time against the Observed, PM Peak

Route	Dir	Total Observed (s)	Total Modelled (s)	Diff (s)	Rel. Diff	Result
1	1A	2,531	2,178	353	14%	Pass
	1B	2,664	2,287	377	14%	Pass
2	2A	2,658	2,171	487	18%	Fail
	2B	2,514	2,384	130	5%	Pass
3	3A	2,007	1,801	206	10%	Pass
	3B	1,671	1,740	69	4%	Pass
4	4A	2,293	2,292	1	0%	Pass
	4B	3,184	2,397	787	25%	Fail
5	5A	1,527	1,373	154	10%	Pass
	5B	1,536	1,344	192	12%	Pass
6	6A	1,964	1,797	167	9%	Pass
	6B	2,235	2,074	161	7%	Pass
7	7A	2,397	2,017	380	16%	Fail
	7B	2,482	2,231	251	10%	Pass
8	8A	1,508	1,459	49	3%	Pass
	8B	1,703	1,471	232	14%	Pass
9	9A	664	649	15	2%	Pass
	9B	642	608	34	5%	Pass
10	10A	542	482	60	11%	Pass
	10B	407	451	44	11%	Pass
M1	M1A	1,520	1,660	140	9%	Pass
	M1B	1,634	1,780	146	9%	Pass
M2	M2A	292	299	7	2%	Pass
	M2B	297	334	37	13%	Pass
M3	M3A	298	300	2	1%	Pass
	M3B	288	290	2	1%	Pass
M4	M4A	637	656	19	3%	Pass
	M4B	664	660	4	1%	Pass
Total TAG Compliant						**89%**

The above results show that the traffic model validates well against journey times, exceeding the TAG criteria, with more than 85% of journey time routes within the required criteria.

It can be noted that 86% of journey time routes pass in the AM time period, 100% of journey times pass in the IP time period, and 89% of journey time routes pass in the PM time period.

The failing Route 2A in AM peak generally fits well with the observed time and only the section along the Garstang Road fails to match the observed. This is because of multiple signalised junctions along this corridor which have major delays during morning and evening peak. Network checks were undertaken to ensure the delays were realistic, however it is the inability of the Saturn software to accurately replicate delays caused by traffic spillback that affected the results of journey time validation for this route.

M3A also fails in AM peak, however the section that fails is in the buffer area network and the section along M6 and M65 matches the observed times.

In PM peak, for the failing route 4B, most of the sections along this route pass the TAG criteria individually except the section along Eastway Road in southbound direction.

To further ensure that the journey times are not totally off from the observed, comparison of modelled journey time was done with observed using the median times rather than mean. This was done to remove any major outliers and it was noted that all failing routes passed with this method. However, for consistency, average observed times were used for the reporting purpose.

It should be noted that routes passing through the scheme area are well within the limits.

It is also notable that the differences in times are not consistently positive or negative, suggesting there is no underlying bias of high or low journey times in the model.

11.10 Calibrated and Validation Results – Conclusion

The model calibration and validation process were undertaken successfully and shows the model provides a satisfactory representation of the existing traffic conditions within the modelled area across all three peaks.

The calibration, and validation checks have shown that generally outputs from the model accord well with expectations and fall within expected limits. They show that the model network structure and overall coverage is appropriate. It shows that predicted link speeds and delays accord well with the observed data.

The model has been calibrated and validated using the measures and criteria recommended in TAG M3.1.

In all peaks at least 26 out of 30 (87%) of calibration screenline and 12 out of 14 (86%) validation screenline are within 5% of the observed totals. And 27 out of 30 (90%) of calibration screenline and 13 out of 14 (93%) validation screenline have a GEH value under 4.

Meeting TAG criteria on screenline flow is more difficult due to the low number of sites in some of the screenlines and the relatively low total observed flows across the screenlines. The GEH comparison is included to show that the fit across screenlines while not TAG compliant is still relatively close.

The link flow calibration and validation process for all time periods are at sufficient standard to provide confidence the model is replicating existing traffic conditions. In all peaks link calibration meets TAG requirements.

Similar to calibration results, validation screenlines and link counts passes the TAG criterion for all model peaks.

Overall, the analysis shows that the model exceeds the TAG acceptability guidelines for Strategic Road Network performance, screenline performance, calibration traffic flows, and journey time validation requirements in each time period, which gives more confidence in the model's abilities to represent actual traffic conditions.

When considering the area in vicinity of the proposed A582 scheme, the results exceed the requirement of 85% on the passing links. The majority of sites that do not validate to individual GEH/DMRB criteria are unlikely to be affected as a result of the scheme being implemented.

The model has also been shown to be stable by exceeding acceptable levels of convergence.

On this basis, the highway assignment model, as discussed in the chapters above, is considered to be a robust platform upon which to develop the variable demand model component of CLHTM. The development of the VDM is discussed in the next chapter.

12. Variable Demand

12.1 Background

Following discussions with the DfT in early 2020, it was agreed that it would be a risk for the A582 scheme to pursue DfT Approval without Variable Demand Modelling (VDM) undertaken in Production/Attraction (P/A) format as recommended in TAG.

Subsequently a P/A based VDM has been developed, in accordance with the scope and specifications outlined in a technical note produced by Jacobs (Appendix B) and taking into account the results of the modal shift significance test issued to DfT in April 2020 and signed off in September 2020. It should be noted that the scope of the updated VDM and modelled responses were based on anticipated impacts of the A582 scheme. Should the updated CLHTM model be used for assessing other interventions the VDM approach will need to be reviewed and adjusted accordingly.

The CLHTM highway assignment model revalidation approach focused on making improvements to the O/D assignment matrices without reconciliation with the source 24 P/A demand matrices. Subsequently when the P/A approach was agreed a process was developed to feedback the change in the highway model calibration made to the O/D matrices in each time period were fed back to the 24 P/A matrices.

12.2 Demand Model Overview

TAG states that "any change to transport conditions will, in principle, cause a change in demand. The purpose of variable demand modelling is to predict and quantify these changes.

DIADEM (Dynamic Integrated Assignment and Demand Modelling) is a computer software package that was developed to assess variable demand for traffic models. DIADEM is used to model variable demand responses. TAG Unit M2-1 (Variable Demand Modelling) states that "The DIADEM framework controls iteration within assignment and between demand and assignment, to ensure that the calculations reach an acceptable equilibrium".

The demand model has been implemented using DIADEM 7.0 software. The demand model has been calibrated in accordance with the methodology laid out in TAG Unit M2. This process has involved adjusting the model parameters, in accordance with the values outlined in TAG Unit M2 until plausible results were produced from the realism testing. This section sets out the results obtained using the typical lambda values from TAG Unit M2 and those obtained when adjusting model parameters.

12.3 Variable Demand Model Structure

VDM is run as an incremental 24-hour Production/Attraction (P/A) based model. The spatial coverage of VDM is the same as the highway model and they use the same zone system and generalised cost parameters.

The Variable Demand Model is an incremental hierarchical choice model in line TAG M2 specification and calculates the changes of travellers liable to make travel choice based on change in travel costs. The choice mechanisms will be:

- *The destination of any given trip.*
- *The generation or loss of trips due to changes in highway accessibility.*

Mode choice is not required at this stage as it has been shown that the change in highway costs is unlikely to cause significant modal shift.

12.3.1 Time Period Choice

Time of day choice is not included in VDM as there is not a strong cost differential between time periods caused by the scheme.

Analysis of traffic flows on the scheme A582 corridor (Table 12-1) shows that flows, although high are below the maximum capacity. Indicating there are no peak- specific congestion effects the scheme will relieve.

Table 12-1: Modelled AADT and max hourly flows against typical link Capacity and Congestion Reference Flows on key routes in South Ribble at locations

Id	Location	DMRB Road Standard	Modelled AADT (2-way, vehicles)	Congestion Reference Flows	Max. Hourly Flow (1-way, vehicles)	Max. Practical Capacity
1	A582 Farrington Rd	Rural S2	16,329	22,000	1,018	1,380
2	A582 Flensburg Way	Rural S2	14,004	22,000	847	1,380
3	A582 Penwortham Way South	Rural S2	18,872	22,000	1,142	1,380
4	A582 Penwortham Way North	Rural S2	15,625	22,000	804	1,380
5	A582 Golden Way	Rural D2AP	17,973	22,000	1,247	1,380
6	A59 Liverpool Rd	UAP4 S2	16,655	18,000	1,020	1,140
7	A6 London Way	Rural D2AP	26,449	68,000	1,521	4,200
8	B5254 Leyland Rd	UAP4 S2	12,849	18,000	860	1,140

Analysis of journeys along the scheme A582 corridor has shown that the road standard along the A582 corridor is variable, with dual carriageway sections between the M65 and Stanifield Lane and on Golden Way interrupted by a long single carriageway section from Stanifield Lane to Broad Oak Roundabout.

The single carriageway sections have been investigated further to identify the cause of these low speeds. The single carriageway sections of the A582 have speed limits of 60mph or 50mph north of Chain House Lane. However, on all these sections the average inter-peak and off-peak speeds recorded were only 45mph. Major junctions on this section of the A582 are separated by distances of between 0.5 to 1.0 miles. Neither junction frequency nor geometry is the cause of these slow speeds.

Despite these sections being mostly straight and free of junctions, the road standard is too poor for vehicles to reach comfortably the 60mph speed limit, instead only reaching speeds of 45mph between junctions.

Therefore, it was concluded, improvements in journey time were likely to be similar across the day due to scheme primarily improving the road standard from a single carriageway to a dual carriageway, and not reduction in peak hour congestion in the peak hour or the peak periods, negating the need for macro and micro choice modelling.

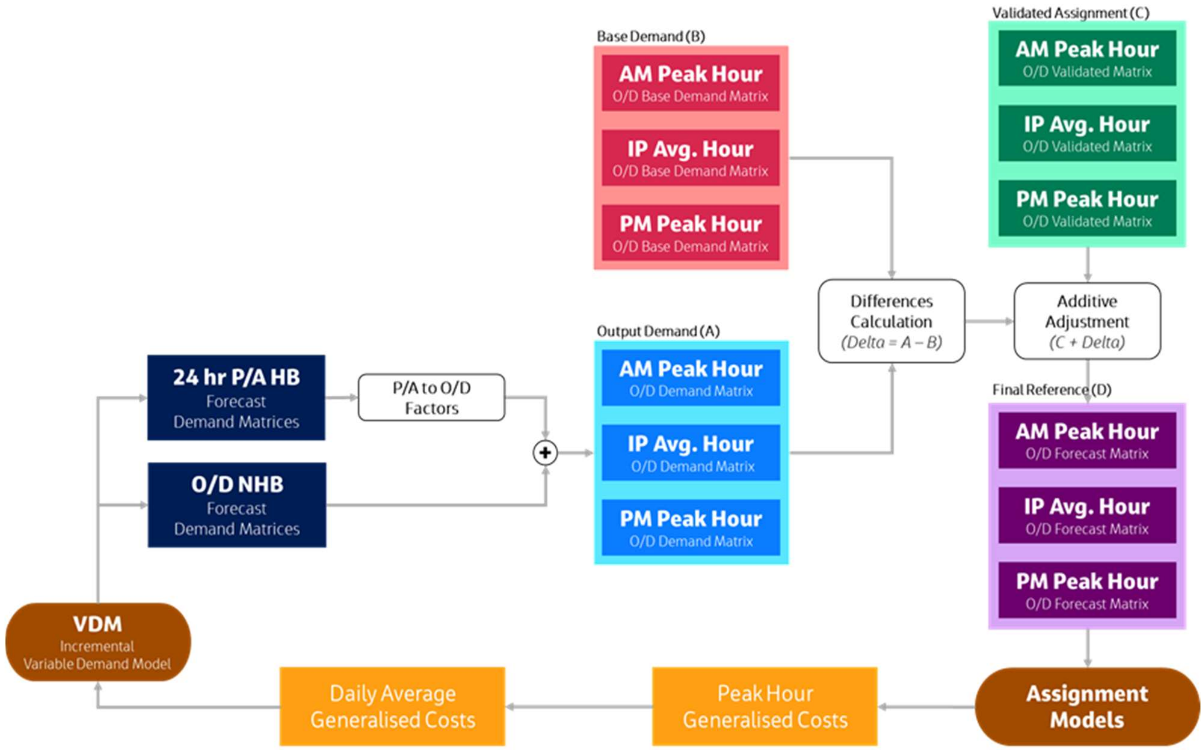
12.3.2 Model Interactions

The VDM predicts 24hr P/A person car demand based on change in travel costs from the base year assignment taken from the highway assignment model. The 24hr P/A demand is converted to Origin/Destination (O/D) demand by time period (peak period) using Time of Day factors. These factors define the proportion of from-home and return- home trips by time period. Finally, demand is converted to peak hour vehicle demand for assignment on the highway network using the peak hour and vehicle occupancies factors.

These factors have been calibrated in the process to reconcile the changes in highway model calibration O/D matrices to the 24hr P/A matrices (described in section 12.6). The factor produces O/D matrices consistent with the validated O/D matrices at the sector level. There remain small differences at the zonal level between the base year VDM O/D matrices and the validated O/D matrices. Therefore, when forecasting, the differences between base year and forecast O/D matrices are added to the validated O/D matrices.

Costs from the highway assignment are converted to the 24hr average costs by DIADEM using the time of day factors as described above. All changes in travel costs are made relative to the Base Year model and the travel demand is adjusted accordingly. Cost damping is applied for longer distance trips which are less sensitive to small changes in cost (as described in sections 12.9 & 12.10). The VDM is calibrated in accordance with the guidelines in TAG unit M2.1 Section 5.6.14 (as described in section 12.7).

Figure 12-1 below shows the relationship between the VDM and the highway assignment models.



- P/A to O/D Factors: Tour Factors, Vehicle occupancy and Peak hour factors applied to the HB Purposes.
- (A): DIADEM Output demand in O/D format. It is the result of the addition of Home-based and non-home based demand.
- (B): Base Year Demand in OD format. Used to calculate the demand differences with the DIADEM output.
- (C): Validaded Matrix. Demand matrix of the validated assignment.
- (D): Final Forecast Reference matrix. The result of adding the differences (Delta) to the validated matrix.

Figure 12-1: Relationship between Demand Model and Assignment Model

The traffic model has been developed for three time periods;

- Weekday AM peak hour = 08:00 – 09:00.
- Weekday Inter-peak (IP) hour = average hour between 10:00 & 16:00.
- Weekday PM peak hour = 17:00 – 18:00.

This is in line with the guidance, which states that actual peak hour models are to be preferred in most circumstances.

12.4 Variable Demand Model Area

The VDM has been divided into two areas: the "internal" area and the "external" area. The internal area is the area where the scheme could have an impact on trip movements (shaded blue in Figure 12-2). The external area is the non-shaded area in Figure 12-2 and corresponds to the external network in the highway model.

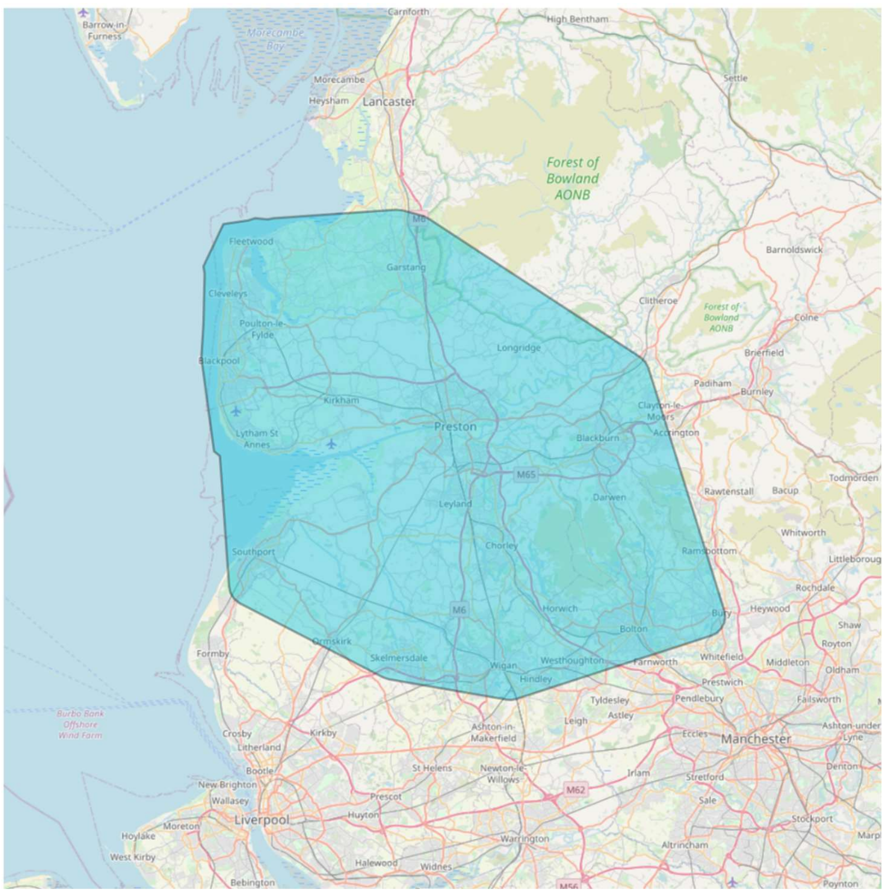
In VDM all calculations apply to the following movements:

- Internal to internal.
- Internal to external.
- External to internal.

The following movements are treated as fixed, and are excluded from the demand model calculations:

- External to external trips.

Figure 12-2: Internal VDM Area



12.5 Demand Model User Classes

Demand segmentation is outlined below. The choice model operates using three segments defined by journey purpose (commute, business, other). The underlying reason for this, as discussed in TAG Unit M2 is that the sensitivity of the model is likely to be different for different trip purposes.

The choice model uses P/A matrices for the home-based purposes and O/D matrices for the non-home-based purposes. Separate generalised cost parameters have been used for each of the user classes to reflect differences in behaviour and maintain consistency with the assignment process.

Table 12-2 - Demand Model Purposes

<table>
<tr><th>ID</th><th>Demand Model Purpose</th><th>Demand Model Type</th><th>User Classes</th><th>Vehicle Class</th></tr>
<tr><td>1</td><td>Home-Bases Work</td><td>PA Doubly Constrained</td><td>UC1</td><td rowspan="5">VC1</td></tr>
<tr><td>2</td><td>Home-Based Employers Business</td><td>PA Singly (production) Constrained</td><td>UC2</td></tr>
<tr><td>3</td><td>Non-Home-Based Employers Business</td><td>OD Singly (origin) Constrained</td><td rowspan="3">UC3</td></tr>
<tr><td>4</td><td>Home-Based Other</td><td>PA Singly (production) Constrained</td></tr>
<tr><td>5</td><td>Non-Home-Based Other</td><td>OD Singly (origin) Constrained</td></tr>
<tr><td>6</td><td>Light Goods Vehicles</td><td>Fixed</td><td>UC4</td><td>VC2</td></tr>
<tr><td>7</td><td>Heavy Good Vehicles</td><td>Fixed</td><td>UC5</td><td>VC3</td></tr>
</table>

Currently, the guidance recommends that LGV and HGV vehicle types are treated as fixed. Hence, variable demand modelling is only applied to car user classes.

12.6 24h P/A Matrix Development

The CHLTM VDM predicts 24hr P/A person car demand. To convert from 24hr P/A demand to O/D demand, factors are applied to determine the proportion of from-home and return-home trips in each time period. A final step converts the demand to peak hour vehicle demand for assignment on to the highway network, by the application of peak hour and vehicle occupancy factors.

Following the completion of the 2019 CHLTM highway model validation, it was agreed that a 24 P/A approach to VDM should be implemented. The highway model validation focused on making improvements to the O/D assignment matrices (prior matrices), without reconciliation with the source 24 P/A demand matrices.

Therefore, to feedback the changes made to the demand in the highway model calibration back to the 24hr P/A demand the conversions set out in this section were employed. This was done to improve the consistency of travel patterns between the 24hr P/A demand, which is used as the pivot point in the variable demand model, and the final calibrated O/D time period matrices and to minimise deltas that would be applied during the assignment.

12.6.1 Method

Synthetic 24 P/A matrices car person matrices have been derived and combined with observed Road Side Interview (RSI) data, using the method described in Chapter 6. The P/A 24hr matrices were converted to O/D peak period person matrices using the following factors:

- Home-based outbound trips split into peak periods (AM, IP, PM & OP) using factors from NTEM 7.2 at MSOA level.
- Non-home-based trips split into peak periods (AM, IP, PM & OP) using factors from NTEM 7.2 at MSOA level.
- Home-based return trips split into peak periods (AM, IP, PM & OP) using GB factors from NTEM 7.2

- Peak period to peak hour factors derived from local area count data.
- Vehicle occupancy factors derived from the local area RSI's.

The resultant O/D vehicle peak hour matrices for each time period (AM, IP, PM) and journey purpose (commute, business, other) were used as a basis of the highway model calibration and validation, as described in Chapter 6

The changes made to the O/D vehicle peak hour matrices in the highway model calibration were fed back into the 24hr P/A matrices using the methodology shown in Figure 12-3.

In Step 1 the original prior O/D vehicle matrices were compared with the validated O/D vehicle matrices at the sector level using the same sector system described in Section 2.3and the %age difference between the resultant and validated matrices for each time period were calculated.

In Step 2 the peak hour factors were adjusted by a maximum of +/-10% (OD factors (1)) to reconcile the differences from the validated matrices.

In Step 3 the remaining differences (OD factors (2)) were applied to the peak period person matrices. As the OD matrices did not distinguish between outbound, return and non-home based trips, the same adjustments were applied to these components of the peak period matrices. The matrices from each time period were combined to create adjusted 24 P/A outbound, return & non home based matrices. After applying the appropriate transposition to the return matrices, the adjusted outbound and return matrices were compared. Where the combined adjustment from each time period in the outbound and return matrices was different an average value was calculated.

In Step 4 the proportion of outbound, return & non home based trips in each time period (AM, IP, PM and unadjusted OP) was then recalculated at the sector level. Where the proportion of trips in each time period was more than 10% different than the original factors, the number of trips was constrained so that the revised proportions were within 10% of the original proportion. Following this adjustment, where the revised sum of proportions (AM + IP + PM + OP) did not add up to 100% the OP proportion was adjusted by a maximum of +/-10% so that the sum of the proportions in each time period was 100%. A final adjustment was made to normalise all the proportions if they still did not add up to 100%.

Following application of the revised time of day factors, where differences remained from the validated OD matrices (calculated in Step 5), additional adjustments were made to the peak period to peak hour factors, in Step 6 and then, if necessary, to the vehicle occupancy factors in Step 7. Adjustments were made at the sector level and limited to a maximum of +/-10%.

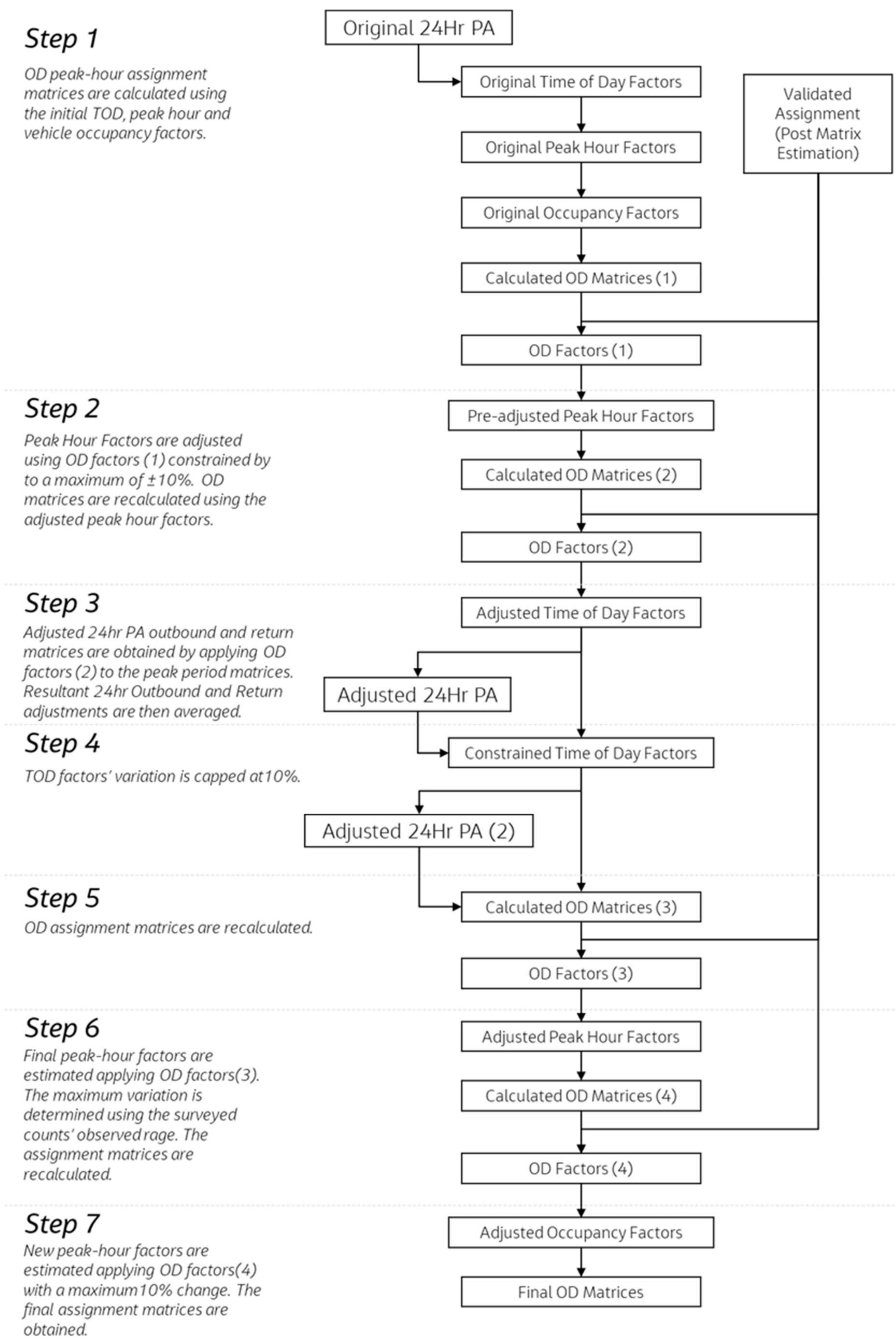


Figure 12-3: P/A Matrix Adjustment Methodology

12.6.2 Validation of the Adjusted 24hr P/A matrix

The following section presents a comparison of the originally derived 24hr P/A matrices, and the adjusted 24 P/A matrices.

Trip Length Distribution

The following figures present the trip length distribution for the original and adjusted P/A matrices, in comparison with NTS. It can be seen generally the adjusted matrices have an improved fit overall. In particular, the short distance 1-3 mile band, which in the prior matrices had a 5% shortfall of trip compared to NTS. This difference has generally been negated in the adjusted matrices. Other longer distance bands, which were generally overestimated by 2-3%, now have a much closer fit to NTS. Only the 5-10 miles band has a significantly poorer fit compared to the prior matrix of 4% for commute trips.

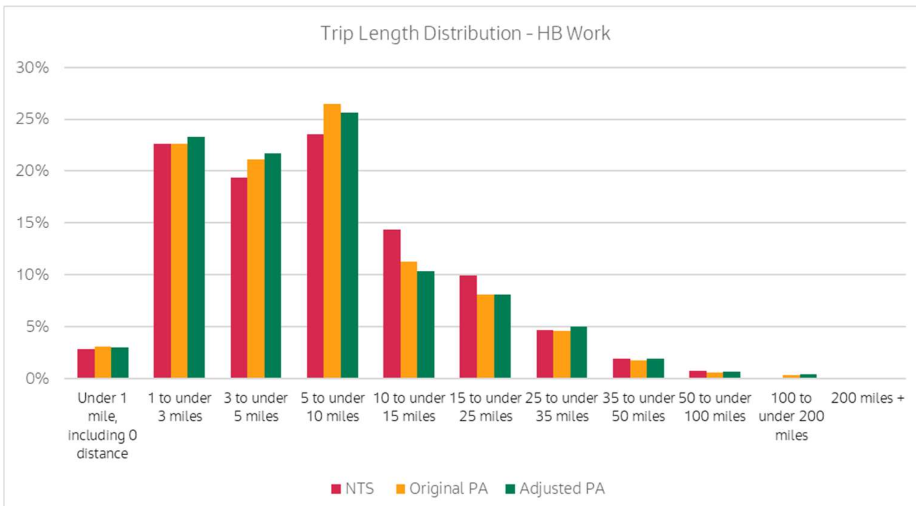


Figure 12-4: Trip Length Distribution - Commute

Figure 12-5: Trip Length Distribution – Employers Business

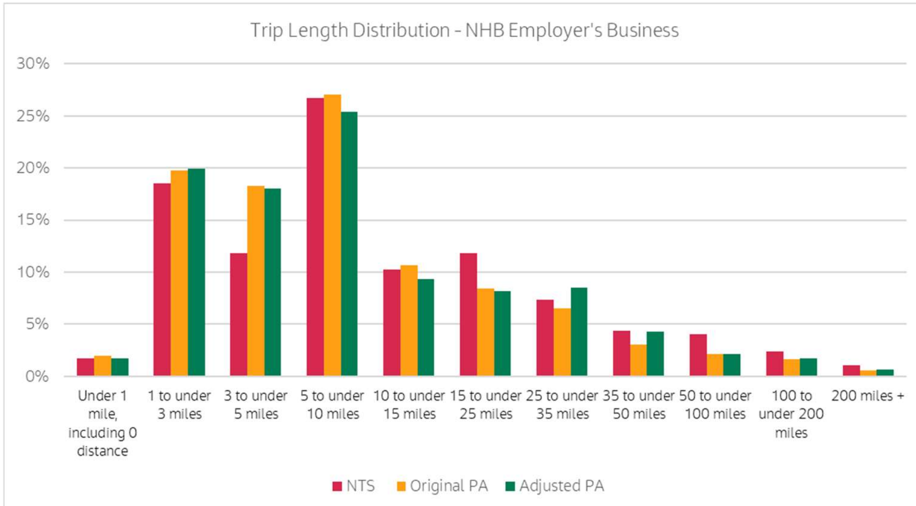


Figure 12-6: Trip Length Distribution – Non-Home-Based Employers Business

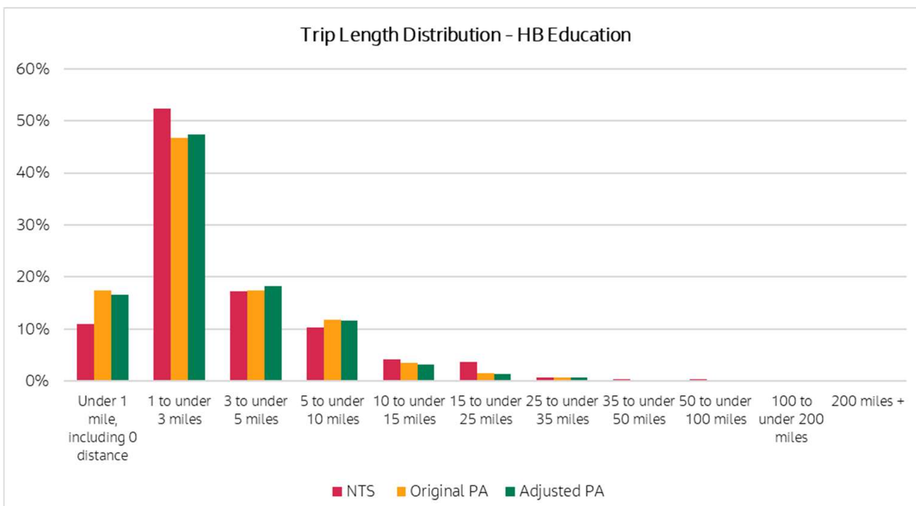


Figure 12-7: Trip Length Distribution – Education

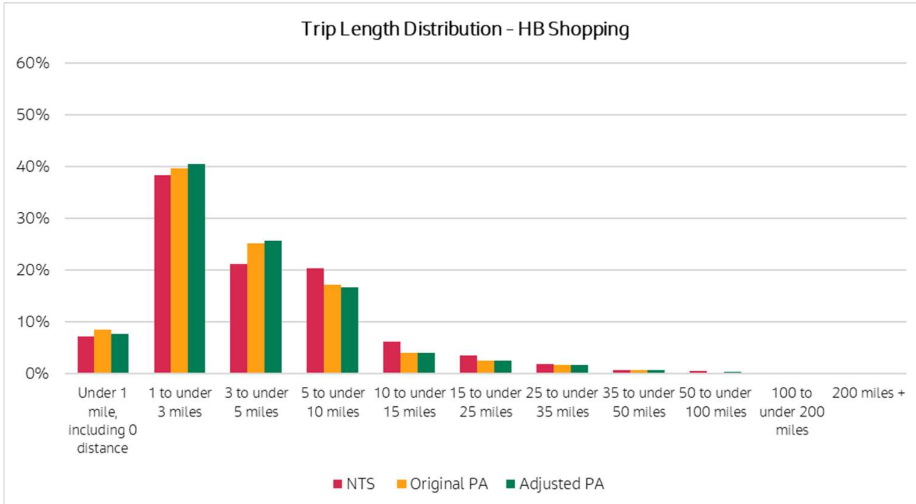


Figure 12-8: Trip Length Distribution – Home-Based Shopping

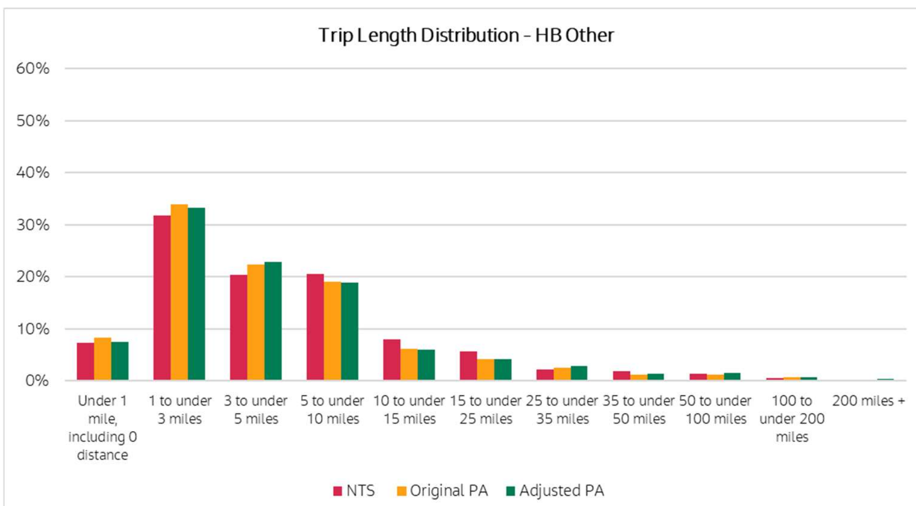


Figure 12-9: Trip Length Distribution – Home-Based Other

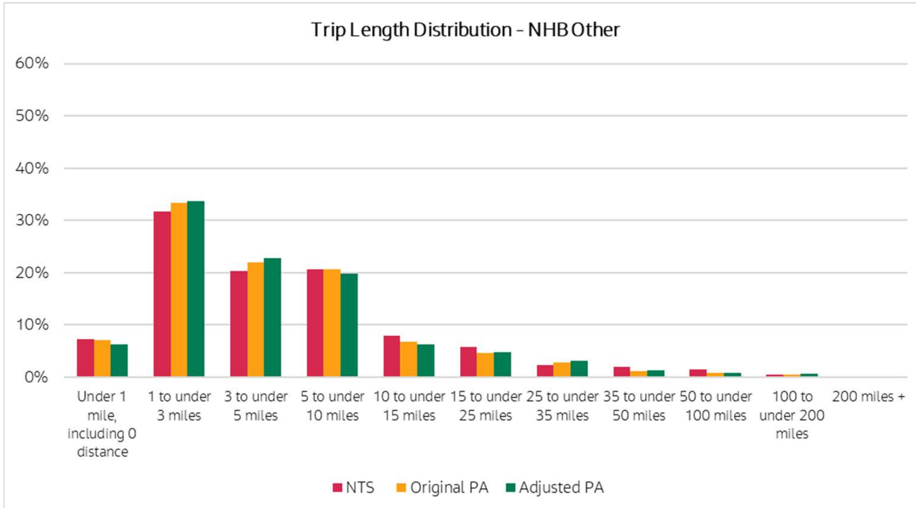


Figure 12-10: Trip Length Distribution – Non-Home-Based Other

Time of Day Trips

Figure 12-11 shows generally the number of trips in the adjusted matrices in Lancashire, which covers the core study area, in each time period has similar fit to TEMPRO totals with some small changes in the proportion of trip in each time period.

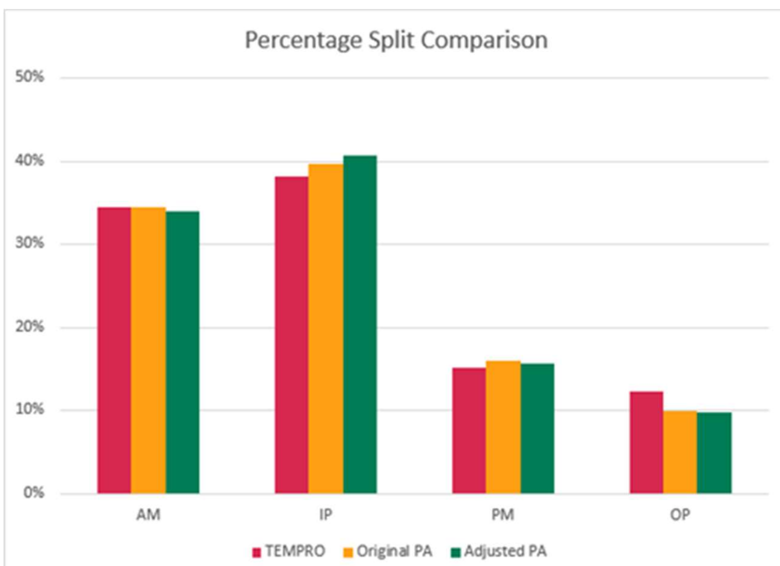


Figure 12-11: Person Trips per Peak Period – From Lancashire

12.6.3 Matrix Checks

Adjusted matrix validation included a regression analysis of the unadjusted O/D matrices versus the validation O/D matrices and also regression analysis following the update to the matrices after the adjustment to the 24P/A matrices. The regression was carried out at the zonal level, and for each time period and assignment user class. (Graphs comparing the O/D matrix cell values before and after the matrix adjustments are provided in Appendix J).

The table below summarises the R squared values from the regression analysis for the original prior matrices and the adjusted matrices. The adjusted matrices show an improvement fit to validated matrices over the prior matrices for all time period and purposes.

Table 12-3 – Regression analysis of O/D matrix Adjustment

User Class	Prior			Adjusted		
	AM	IP	PM	AM	IP	PM
Commute	0.996	0.997	0.996	0.999	0.999	0.999
Business	0.991	0.992	0.994	0.999	0.998	0.998
Other	0.999	0.991	0.999	0.999	1.000	1.000

While small differences remain due to zonal adjustments made by matrix estimation it is clear that when the revised time of day, peak hour and vehicle occupancy factors are applied to the revised 24hr matrices they produce assignment O/D matrices that are a much closer fit the validated O/D assignment matrix. Therefore, improving their suitability for use in variable demand modelling.

The prior and adjusted vehicle occupancy factors is summarised in Table 12-5.

Table 12-4 – Vehicle Occupancy Factor Adjustment

User Class	Prior			Adjusted		
	AM	IP	PM	AM	IP	PM
Commute	1.144	1.126	1.129	1.161	1.121	1.158
Business	1.241	1.178	1.181	1.256	1.180	1.208
Other	1.747	1.749	1.753	1.764	1.754	1.790

12.7 VDM Calibration – Realism Testing

The VDM guidance prescribes that where variable demand is assessed, realism tests should be carried out on the base year model to ensure that the it behaves realistically to changes in travel costs and time, and the overall model response conforms to general guidelines.

The DIADEM model is an iterative process which starts with a set of base demand car matrices and costs. Through the process the highway demand matrices and travel costs are allowed to change at each iteration until convergence is reached.

When used in forecasting mode the future year demands are calculated using the calibrated base year costs and demands as a pivot point.

DIADEM requires that model parameters are defined for each of the selected responses. For logit- based models the spread (dispersion) parameter Lambdas (λ) must be defined for the choice at the bottom of the hierarchy and for choices above the bottom the scaling parameter Thetas (θ) is required.

12.8 Fuel Cost Elasticities – Guidelines

In terms of the realism testing of the VDM, TAG Unit M2 advises that for fuel cost elasticities a number of studies have shown elasticity of car use with respect to fuel cost of about -0.3, therefore TAG states:

- The annual average fuel cost elasticity should lie within the range -0.25 to -0.35 overall, across all purposes; and

- The annual average fuel cost elasticity should lie on the "right side" of -0.3,
- Pattern of all-purpose elasticities should show peak period elasticities which are lower than inter peak which are lower than off peak.

Guidance around the expected variation of fuel cost elasticities by journey purpose is provided below:

- Values for business travel expected to be near to -0.1;
- Values for commuting and education expected to be somewhere near the average between -0.1 and -0.4.
- Values for discretionary travel expected near to -0.4.

Since the guidance was published revised Values of Time (VoT) have been released. For commute VoT has increased by 47% (values £6.81 to £10.01). This means that any monetary cost change (e.g. that in a fuel cost realism test) when converted to equivalent generalised time (minutes) would reduce to 68% (i.e. 1.0/1.47) of its previous values.

For employer's business trips the car driver VoT has approximately halved (based on short or mid distance band being used), and the generalised time equivalent of a monetary cost change would be approximately 100% larger as a result. For other journey purposes, VoT was reduced by 25%, so generalised time equivalent of a fixed monetary cost change increase by 33% on switching to new Databook values.

In the realism tests, these proportionate changes in the proportion of time and monetary cost (converted to time units with the use of revised values of time) within the generalised cost formulation, feed directly into elasticity calculations, and corresponding changes in elasticities by journey purposes should be expected. Thus, the outturn employer's business fuel cost elasticity should be expected to change from approximately -0.1 to -0.2. The commute elasticity would be in the range of -0.15 to -0.20 instead of -0.25. Trip for other journey purposes would have an elasticity in the range of -0.50 to -0.55 instead of -0.4. Although the elasticities for individual purposes change, the overall elasticity should continue to have values similar to those in WebTAG and lie in the -0.25 to -0.35 range.

Calculations are matrix based, and network based using car vehicle kilometre changes calculated from car trip matrices and skimmed distance matrices. Calculations are based on demand segments and model areas with variable demand, i.e. excludes 'external to external' trips, intrazonal demand and freight.

TAG Unit M2 also provides the recommended range for parameter values; these are shown in Table 12-5.

Table 12-5 - WebTAG Unit M2 Lambda Targets

Purpose	WebTAG Targets		
	Minimum	Median	Maximum
HB Commute	0.049	0.065	0.081
HB Employer Business	0.050	0.067	0.084
HB Other	0.068	0.09	0.113
NHB Employer Business	0.061	0.077	0.101
NHB Other	0.058	0.081	0.096

Combined with the TAG Unit M2 requirement the distribution parameters should ideally lie within 25% of the median Lambda values.

Additionally, TAG Unit M2 paragraph 6.4.14 expects that:

- *the annual average fuel cost elasticity should lie on the right side of -0.3, taking account of the levels of income and average trip lengths prevailing in the modelled area.*

The characteristics of the study area were compared against the national characteristics in order to determine which side of -0.3 the annual average fuel cost elasticity should lie. The result of this comparison is presented in Table 12-6

Conditions for elasticity weaker than -0.30	Condition met?
Trip lengths shorter than average	North West (NTS 2013/14) = 6.5miles England (NTS 2013/14) = 7.1miles **Yes** - Shorter than NTS for majority of trips (across all purposes)
Car mode share higher than average	North West (Census 2011) = 63% England (Census 2011) = 58% **Yes** - Higher than national
EB proportion higher than average	North West (TEMPRO 7.2) = 7% GB (TEMPRO 7.2) = 8% **No** - Lower than national
Higher income levels	North West (ONS 2013) = £15,791 England (ONS 2013) = £18,020 **No** - Lower than national

Table 12-6: Fuel Cost Elasticity - right side test

Given that half of the conditions are met, it is reasonable to conclude that elasticity should lie between -0.30 and -0.35, as the income is lower than the national average.

12.9 Process for Realism Testing

The realism testing approach uses a two-staged calibration method:

- *Changing model generalised cost coefficients (the distance coefficient) in the validated base model to reflect a 20% fuel increase. This has a different impact for different trip purposes. (WebTAG Unit M2 recommends a 10%-20% fuel increase). The 20% increase has been used to reduce the impact that model noise has on the calculations; and*

- *Modifying the model parameters to achieve the overall target fuel cost elasticity in the range -0.30 to -0.35. The individual purposes are calibrated to different values as suggested in WebTAG Unit M2.*

WebTAG does not provide indicative values for frequency response parameters, a value of 0.08 (theta) has been used, which is based on the value used in other transport studies in this area.

Stage 1 - Calculating generalised cost parameters to reflect fuel cost increase

A new SATURN Vehicle Operating Cost parameter PPK (Pence per Kilometre) has been calculated from the validated model PPK for each user class.

Table 12-7 shows the PPK values used in the validated base assignment model and the PPK values that reflect a 20% fuel cost increase. As part of the realism tests, the fuel cost element of the model generalised cost coefficient (the distance coefficient) was increased by 20%. The 20% increase was used to reduce the impact that model noise has on the calculations.

Table 12-7 - Fuel elasticities Generalised Cost co-efficient

Vehicle Type	Trip Purpose	Time Period	Validated Base Year	20% Fuel Cost Increase
Car	Commute	AM	5.75	6.90
	Business		12.07	13.03
	Other		5.75	6.90
	Commute	IP	5.67	6.80
	Business		11.89	12.83
	Other		5.67	6.80
	Commute	PM	5.81	6.97
	Business		12.12	13.08
	Other		5.81	6.97

Stage 2 - Calculating Model Parameters

The second stage of the calibration process is to calculate the demand model parameters required to achieve the overall target fuel cost elasticity of in the range -0.30 to -0.35. The median values of Lambdas (λ) and Thetas (θ) parameters given as in the latest TAG Unit M2 guidance are used as the starting point and then these are systematically modified until a satisfactory elasticity for the base year is achieved. The model is run after each adjustment and the elasticity calculated using the arc-elasticity formulation, which for a 20% fuel increase, is given by:

$$Fuel\ Cost\ Elasticity = \frac{In\left(\frac{Veh\_km^1}{Veh\_km^0}\right)}{In(1.20)}$$

Where the superscript 0 indicates the value from the base year model and 1 indicates the results from the model run with the increased distance coefficient. Similarly, the car journey time elasticity is calculated based on the equation below:

$$Car\ Journey\ Time\ Elasticity = Elasticity^{Fuel\ Cost}\frac{aT}{bK}$$

Where a is the cost per hour, b is cost per km, K is vehicle kilometres and T is total vehicle hours.

Cost Damping

To further improve and adjust the outturn realism test results to ensure that the change in travel costs and time are realistic, cost damping has been utilised.

There is evidence that long distance trips are less sensitive to changes in costs than short distance trips and TAG Unit M2 recommends that cost damping functions are included in the variable demand process. The idea behind cost damping is to adjust the costs for longer trips so that their sensitivity to individual cost components (such as fuel cost or travel time) is reduced.

TAG Unit M2 provides the following advice on cost damping:

Para 3.3.2 states *"not all models will need to use cost damping but, if it is employed, then functions of one of the forms specified below should generally be used. The choice of the following cost damping mechanisms is a matter for the analyst. If analysts wish to use other forms of cost damping, they should consult the Department before doing so."*

Additionally, para 3.3.3 states *"It is not necessary for analysts to conduct tests using each of the forms specified below and to prove that one is better than the others. This is because the form of cost damping and the cost damping parameter values will interact with other aspects of the model, such as the demand model parameter values and values of time. While the cost damping parameter values, demand model parameter values and values of time should all be kept within certain limits specified below and in Section 6, it is the performance of the combination of all these aspects of the model in yielding satisfactory realism test results that is important."*

The use of cost damping was deemed necessary as initial realism tests using median value parameters and varying them within the permitted 25% ranges did not give acceptable elasticities, with long distance trips being over sensitive for some purposes. The results for the initial testing without and then with cost damping are shown in Table 12-10 in the following section 12.10. This rationale for calibration of the VDM parameters and application of cost damping is further discussed in the following section.

DIADEM offers a range of different methods of applying cost damping. The approach used for this study is the first option, damping by a Function of Distance.

The damped cost is given by the formula:

$$G' = (d/k)^{-\alpha}.(t + c/VOT),$$

Where:

t = time (minutes)

c = cost (pence)

VOT = value of time (pence per minute)

d' = trip length; and

α and k = parameters that need to be calibrated.

TAG acknowledges that whilst there is no firm guidance provided on setting the parameters for cost damping, TAG Unit M2, paragraph 3.3.10 provides the following commonly used parameters which were adopted.

Table 12-8 - Cost Damping WebTAG Unit M2 Parameters

Parameter	Description	Commonly used value
α	must be positive and less than 1 and should be determined by experimentation in the course of adjusting a model so that it meets the requirements of realism tests	0.5
k	must also be positive and in the same units as d'	30 km
d'	calculated by skimming distances	30 km

12.10 Realism Testing Results

This section presents outturn results from the following analysis:

- *Car fuel cost elasticities.*
- *Network based elasticities.*
- *Journey time elasticities.*
- *DIADEM Convergence.*

12.10.1 Car fuel cost elasticities

Calibration of the destination model parameters was conducted in line with guidance from TAG Unit M2 para 6.6.5 using median values taken from Table 5.1 of the same document. A sequence of model runs was conducted, as described below, in order to achieve calibration.

Run 1 used the median parameter settings from TAG Unit M2 Table 5.1. The results indicate that in all time periods for employer business and other purposes the response is very sensitive and too strong; while, commute elasticity is not sensitive at around -0.15.

Run 2 increases the distribution parameters by 25% above median. The elasticities weakened but remained too sensitive for business and other purpose.

Run 3 decreases the distribution parameters by 25% below median. The elasticities strengthened, and increased commute sensitivity to -0.2.

As a next step Run 1,2 3 were repeated (runs 1D, 2D, 3D) with distance-based cost damping introduced based on the commonly used values quoted in WebTAG Unit M2 paragraph 3.3.10, namely k and d' set to 30km and alpha to 0.5. This again reduced and weakened the sensitivity for all time periods. However, the responses for other remained too sensitive, and too weak for commute. Business responses were at acceptable levels in run 2D (+25% distribution parameters).

In Run 4D, the distribution parameter was increased by 25% for business and other and reduced by 25% commute from median values, whilst retaining the same cost damping parameters as before.

These sequences of runs gave reductions from the initial over-sensitive responses for business and other and under sensitivity for commute. In the next steps, described below, the cost damping was strengthened for other to bring overall model sensitivity between -0.3 and -0.35, based on WebTAG Unit M2 paragraph 3.3.4 which recognises the following;

"It may also be necessary to vary cost damping parameters by trip purpose. However, these variations by mode and purpose should be avoided unless it is essential to achieve acceptable model performance".

In the Run 5D cost damping was removed for commute, to bring that purpose up to an acceptable sensitivity of -0.2. In Run 6D and 7D adjustments were made to the cost damping parameters for the other purpose to further reduce its sensitivity. First, in Run 6D increase the k and d' were reduced to 20km based upon the shorter mean trip length for 'other' purpose trips. Finally, in Run 7D the alpha was increased from 0.5 to 0.6 to further strengthen the cost damping response. The input parameters and the results of the sequence of runs are presented in Table 12-9 and Table 12-10 respectively.

The outturn fuel cost elasticities from the realism testing of the final run are presented in Table 12-11.

Table 12-9 - Car fuel cost elasticities – Parameters

Run ID	Distribution Parameter Trip (Lambda)					Cost Damping			Frequency
	HBW	HBEB	NHB EB	HB Other	NHB Other	HBW	EB	Other	Other
01	-0.065	-0.067	-0.081	-0.090	-0.077	-	-	-	0.80
02	-0.049	-0.050	-0.061	-0.068	-0.058	-	-	-	0.80
03	-0.081	-0.084	-0.101	-0.113	-0.096	-	-	-	0.80
01_D	-0.065	-0.067	-0.081	-0.090	-0.077	d'=k=30000; α = 0.5			0.80
02_D	-0.049	-0.050	-0.061	-0.068	-0.058	d'=k=30000; α = 0.5			0.80
03_D	-0.081	-0.084	-0.101	-0.113	-0.096	d'=k=30000; α = 0.5			0.80
04_D	-0.081	-0.050	-0.061	-0.068	-0.058	d'=k=30000; α = 0.5			0.80
05_D	-0.081	-0.050	-0.061	-0.068	-0.058	-	d'=k=30000; α = 0.5		0.80
06_D	-0.081	-0.050	-0.061	-0.068	-0.058	-	d'=k=30000; α = 0.5	d'=k=20000; α = 0.5	0.80
07_D	-0.081	-0.050	-0.061	-0.068	-0.058	-	d'=k=30000; α = 0.5	d'=k=20000; α = 0.5	0.80
08_D	-0.081	-0.050	-0.061	-0.068	-0.058	-	d'=k=30000; α = 0.5	d'=k=20000; α = 0.5	0.80

Table 12-10 - Car fuel cost elasticities - Results

Run ID	AM				IP				PM			
	Comm	EB	Other	Overall	Comm	EB	Other	Overall	Comm	EB	Other	Overall
Target Elasticity	Approx. -0.17	Approx. -0.2	Approx. -0.53	-0.25 to -0.35	Approx. -0.17	Approx. -0.2	Approx. -0.53	-0.25 to	Approx. -0.17	Approx. -0.2	Approx. -0.53	-0.25 to -0.35
01	-0.14	-0.56	-1.14	-0.56	-0.16	-0.70	-1.12	-1.00	-0.16	-0.40	-1.02	-0.78
02	-0.11	-0.44	-0.93	-0.45	-0.13	-0.55	-0.91	-0.82	-0.12	-0.31	-0.83	-0.64
03	-0.17	-0.68	-1.33	-0.65	-0.20	-0.85	-1.30	-1.17	-0.19	-0.47	-1.18	-0.90
01_D	-0.12	-0.24	-0.72	-0.35	-0.15	-0.30	-0.70	-0.60	-0.15	-0.19	-0.65	-0.48
02_D	-0.10	-0.18	-0.56	-0.27	-0.12	-0.23	-0.54	-0.46	-0.12	-0.14	-0.50	-0.37
03_D	-0.15	-0.29	-0.88	-0.43	-0.18	-0.37	-0.85	-0.72	-0.18	-0.23	-0.79	-0.58
04_D	-0.15	-0.18	-0.56	-0.30	-0.18	-0.23	-0.54	-0.47	-0.18	-0.14	-0.50	-0.39
05_D	-0.17	-0.18	-0.55	-0.31	-0.21	-0.23	-0.54	-0.47	-0.20	-0.14	-0.50	-0.40
06_D	-0.17	-0.18	-0.46	-0.28	-0.21	-0.23	-0.46	-0.41	-0.20	-0.14	-0.42	-0.35
07_D	-0.17	-0.18	-0.43	-0.27	-0.21	-0.23	-0.43	-0.38	-0.20	-0.14	-0.40	-0.33

Table 12-11 - Car fuel cost elasticities – Final Results

Time Period	Matrix Based			
	Commute	Employer Business	Other	Overall
Target	**Approx. -0.17**	**Approx. -0.2**	**Approx. -0.53**	**-0.25 to -0.35**
AM	-0.176	-0.181	-0.402	-0.257
IP	-0.208	-0.227	-0.396	-0.356
PM	-0.204	-0.143	-0.370	-0.309
Elasticity Results_12 Hour (excl. weekends)	**-0.178**	**-0.184**	**-0.432**	**-0.318**
Elasticity Results_12 Hour (incl. weekends)	**-0.195**	**-0.185**	**-0.434**	**-0.336**

The table indicates final demand model calibration results, based on the changes outlined above. The resulting elasticities (based on all non-fixed trips which are subject to variable demand) have:

- All-purpose all-day elasticities on the right side of -0.3 (result -0.336, is in range of -0.30 to -0.35);
- IP elasticity for all-purposes is higher than AM & PM.
- Business elasticity is close to -0.2 target
- Commute elasticity is in the range of -0.15 and -0.2
- Other elasticity is the most sensitive, but it was necessary to make it slightly lower than the -0.5 and -0.55 range to bring overall model elasticity between -0.3 and -0.35

12.10.2 Network based elasticities

Network based elasticities were calculated and are presented in Table 12-12 below. This indicates that the elasticities are close to the matrix-based values summarised above.

Table 12-12 – Network Based Elasticities – Results

Time Period	Network Based			
	Commute	Employer Business	Other	Overall
Target	**Approx. -0.17**	**Approx. -0.2**	**Approx. -0.53**	**-0.25 to -0.35**
AM	-0.19	-0.17	-0.31	-0.22
IP	-0.20	-0.12	-0.34	-0.26
PM	-0.20	-0.13	-0.34	-0.24
Elasticity Results_12 Hour (excl. weekends)	**-0.20**	**-0.13**	**-0.34**	**-0.25**
Elasticity Results_12 Hour (incl. weekends)	**-0.20**	**-0.13**	**-0.34**	**-0.25**

12.10.3 Journey Time Elasticity

Car journey time elasticities were calculated using the fuel cost elasticities and cost damping, using the equation below:

$$E^{time} = E^{fuel} \frac{p^{time}}{p^{fuel}}$$

Where p^{time} is cost of travel as a proportion of generalised cost; and

p^{fuel} is the cost of fuel as a proportion of total generalised cost.

Furthermore, if the total vehicle kilometres (K) and total vehicle hours (T) are known then the following relationship can be derived:

$$\frac{p^{time}}{p^{fuel}} = \frac{aT}{bK}$$

where a is the cost per hour; and b is the cost per km.

Consequently, using the above relationship, the car elasticities of vehicle kms with respect to journey time elasticities have been derived and the results are presented within Table 12-13 below.

Table 12-13 - Car Journey time elasticities - Results

Time Period	Purpose	Matrix based	Network based
AM	Commute	-0.513	-0.498
	EB	-0.346	-0.291
	Other	-0.883	-0.593
IP	Commute	-0.541	-0.516
	EB	-0.362	-0.215
	Other	-0.951	-0.656
PM	Commute	-0.513	-0.516
	EB	-0.353	-0.230
	Other	-0.950	-0.637

The above table demonstrates that the car journey time elasticities are below the TAG-recommended threshold of -2.0 and are therefore TAG compliant and acceptable to be used as part of forecasting.

12.10.4 DIADEM Convergence

Based on the lambda parameters derived in the realism tests, the forecast models have been run through DIADEM. In assessing the outputs of the model runs, the main parameter of importance is the 'relative gap', which is the measure of convergence between demand and supply. Current TAG guidance recommends a relative gap of at least 0.2%.

The DIADEM models achieved a relative gap convergence level of 0.03% in 12 iterations, which suggests the demand - supply convergence of the variable demand traffic model is acceptable.

The SATURN assignments in each time period have converged in 35, 17 & 25 iterations for the AM, IP, PM assignments respectively meeting the convergence criteria for 4 consecutive iterations. The convergence criteria were set so that over 98% (RSTOP) of link flows do not change by more than 1% (PCNEAR) for 4 (NISTOP) consecutive iterations.

It has therefore been shown that the traffic model is stable and has converged to an acceptable standard.

12.11 Conclusion

The variable demand model for the CLHTM model has been calibrated using the DIADEM software in accordance with the methodology and recommendations set out in TAG unit M2.

Realism tests have readily converged giving a relative gap of 0.03% (in line with TAG Unit M2).

The results presented in the preceding sections demonstrate that;

- *The demand model structure and response hierarchy have been set up correctly and comply with TAG Unit M2 requirements;*

- *The calculations and the methodology used for fuel cost elasticities are compliant to TAG Unit M2 guidance;*

- *The outturn elasticity results fall within the WebTAG Unit M2 expectations and requirements; and*
- *The distribution parameters that are adopted in the model are WebTAG Unit M2 compliant and within recommendations.*
- *The highway model has been validated against counts collected in 2019 representing an average weekday (Mon-Fri) in a neutral month. Realism test elasticities have been derived for the average weekday from the model and converted an average 7 day week (based on the 2019 traffic counts). These have been shown to lie within the TAG criteria. It is therefore it is expected annual average elasticity will also lie within the expected range.*

Overall, the demand model responses to change are realistic and within the requirements of TAG Unit M2. Thus, these calculated parameters will be considered suitable for variable demand modelling for future year forecasting.

13. Summary of Model Update, Standards Achieved and Fitness for Purpose

13.1 Summary of Model Update

The CLHTM model has been re-based to 2019 using a comprehensive set of newly collected traffic and journey time and following guidance laid out in TAG Units M1, M2 and M3.

The 2014 RSI data remained the key source of observed origins and destinations of trips in the study area. The data was expanded to 2019 traffic counts conducted at the same locations and merged with synthetic matrices generated from NTEM 2019 trip ends distributed to NTS TLD. The new developments completed since 2014 have been reviewed to confirm they have not had a major impact on the trip distribution in the study area.

The modelled network was updated to include transport interventions since 2014. Extensive checks on the coded network were conducted.

The modelled assignment satisfies WebTAG criteria for a well converged model.

Modelled flows and journey times compare very favourably to observed data, both for data used as part of the model building process, and independent data.

Both screenline and journey time validation in the model meets the criteria set out in guidance for the majority of the comparisons made.

Where the traffic count criteria are not met, it is important to note that all screenlines and the majority of counts that do not meet the TAG criteria are located away from the main area likely to be impacted by the A582 scheme.

The VDM has been updated to P/A format and calibrated to pass realism testing prescribed in TAG.

13.2 Summary of Standards Achieved

The standards to which the model aimed to conform are set out in Chapter 3. Table 13-1 summarises how the model performs against those standards.

Table 13-1: Model Performance Standards

Model aspect	Criterion	Acceptability Guideline	Actual model performance
Prior Matrix validation	Differences between modelled flows and counts should be less than 10% to 15% of the counts	All or nearly all screenlines	Satisfies criterion in all time periods except 2 screenlines which are affected by major congestion problems that cannot be accurately replicated in SATURN
Matrix estimation	Matrix zonal cell values	Slope within 0.98 and 1.02 Intercept near zero R^2 in excess of 0.95	Satisfies criterion in all time periods for cars and HGVs

Model aspect	Criterion	Acceptability Guideline	Actual model performance
	Matrix zone trip ends	Slope within 0.99 and 1.01 Intercept near zero R^2 in excess of 0.98	Largely satisfies criteria with a small number of failures noted
	Trip length distributions	Means within 5% Standard deviations within 5%	Largely satisfies criteria with a small number of failures noted
	Sector to sector level matrices	Differences within 5%	Fails criterion in all time periods. Few sector-sector movements are fully observed however, so this is likely to be expected. In addition, GEH values for majority of these cases are less than 5.
Assignment convergence	Delta and %GAP	Less than 0.1%	Satisfied for all time periods
Screenline calibration	Differences between modelled flows and counts should be less than 5% of the counts	All or nearly all screenlines	AM peak: criteria met for cars on 87% calibration screenlines and 93% validation screenlines; for total vehicles – on 87% calibration screenlines and 86% validation screenlines Interpeak: criteria met for cars on 87% calibration screenlines and 86% validation screenlines; for total vehicles – on 87% calibration screenlines and 93% validation screenlines PM peak: criteria met for cars on 93% calibration screenlines and 86% validation screenlines; for total vehicles – on 93% calibration screenlines and 86% validation screenlines Overall statistics are affected by congestion affected counts to the north of the model, otherwise 100% of screenlines around the scheme are within 5% difference.
Link calibration	Individual flows within 100 veh/hr of counts for flows less than 700 veh/hr	> 85% of cases	

Model aspect	Criterion	Acceptability Guideline	Actual model performance
	Individual flows within 15% of counts for flows from 700 veh/hr to 2,700 veh/hr	> 85% of cases	AM peak: criteria met for car flows on 93% of links, and for total vehicles on 93% of links Interpeak: criteria met for car flows on 98% of links and for total vehicles on 98% of links PM peak: criteria met for car flows on 95% of links and for total vehicles on 94% of links. In summary, criteria satisfied in all time periods and for the SRN separately.
	Individual flows within 400 veh/hr of counts for flows more than 2,700 veh/hr	> 85% of cases	
	GEH < 5 for individual flows	> 85% of cases	
Link validation	Same as for link calibration, but for independent counts		AM peak: criteria met for car flows on 96% on links, and total vehicles on 94% of links Interpeak: criteria met for car flows on 98% of links and total vehicles on 96% of links. PM peak: criteria met for car flows on 94% of links and for total vehicles on 94% of links.
Journey times	Modelled times along routes should be within 15% of surveyed time, or 1 minute if higher	> 85% of all routes	Criteria met for 86% of journey time routes in the AM, 100% in the IP and 89% in the PM time period.
VDM Realism Test	Overall fuel cost elasticity between -0.30 and -0.35 and car journey time		Satisfies the criteria

Table 13-1 demonstrates that the vast majority of the model standards are met.

Some of the criteria related to matrix estimation performance are not met, however, there are understood reasons why that is the case, as detailed in each of the previous sections.

It can be seen that the journey times are well within TAG criteria, which is important and demonstrates the model's ability to replicate traffic speeds and delay, and of particular importance to routing, and for future economic appraisal

13.3 Assessment of Fitness for Purpose

The model performs well against the model standards previously set out and this should serve to give confidence and provide reassurance that the model is representative of 2019 conditions.

However, it is acknowledged that simply meeting the validation criteria does not in itself qualify the model to be a suitable tool for assessing the effects of transport schemes.

In addition to the model meeting the TAG criteria, further confidence in the ability of the model to represent current traffic conditions should be sought from the modelled journey times on all parallel routes to the scheme, the excellent performance of the model to counts and journey times on the Strategic Road network, and other local roads around the study area, which demonstrate that the model reflects observed levels of congestion at all points to a high degree of accuracy.

Additionally, modelled traffic flows in the vicinity of the A582, and each of the screenlines that surround the proposed scheme provide further evidence of the model's robustness in representing current traffic conditions to a high level of accuracy.

Given that the model has been demonstrated to have been constructed in a manner consistent with guidance, has been developed in conjunction with local LCC checks and DfT advice, and is representative of traffic conditions likely to impacted by the scheme in the future, it is expected that a high degree of confidence may be placed in the model for the purposes of scheme assessment, appraisal, economic and environmental appraisal, as described in the opening sections of this report.

Appendix A. CLHTM Model Revalidation Methodology TN

Appendix B. CLHTM P/A Based VDM TN

Appendix C. Network Checklist

Appendix D. Synthetic Trip Length Distribution

AM Comparison

Appendix E. Synthetic Purpose Split

Appendix F. Route Checks

AM Routing

IP Routing

PM Routing

Appendix G. Matrix Estimation Changes Analysis

G.1 Scatter Plots

G.2 HGV Sector-to-Sector changes

Appendix H. Calibration and Validation

Appendix I. Journey Time Validation Routes

I.1 Journey Time Route Sections

I.2 AM Results

I.3 IP Results

I.4 PM Results

Appendix J. Matrix Adjustment Regression Analysis

Appendix K. CLHTM Model Coding Documentation

Appendix L. 2019 Base Year Model Traffic Flows

Appendix M. Zoning Detail near A582 Corridor

Appendix N. Sector Factors and Sector Summary (Total Change)

Appendix O. Sector to Sector Percentage Difference