Lincolnshire County Council

GREATER LINCOLN TRANSPORT MODEL

Local Model Validation Report

LMVR001
APRIL 2024

CONFIDENTIAL

Lincolnshire County Council

GREATER LINCOLN TRANSPORT MODEL UPDATE

Local Model Validation Report

TYPE OF DOCUMENT (VERSION) CONFIDENTIAL

PROJECT NO. 70100445

OUR REF. NO. LMVR001

DATE: APRIL 2024

Lincolnshire County Council

GREATER LINCOLN TRANSPORT MODEL UPDATE

Local Model Validation Report

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QUALITY CONTROL

Issue/revision	First issue	Final Issue
Remarks	First Draft	Final
Date	December 2023	April 2024
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Project number	70100445	70100445
Report number	LMVR001	LMVR001
File reference		

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1 INTRODUCTION

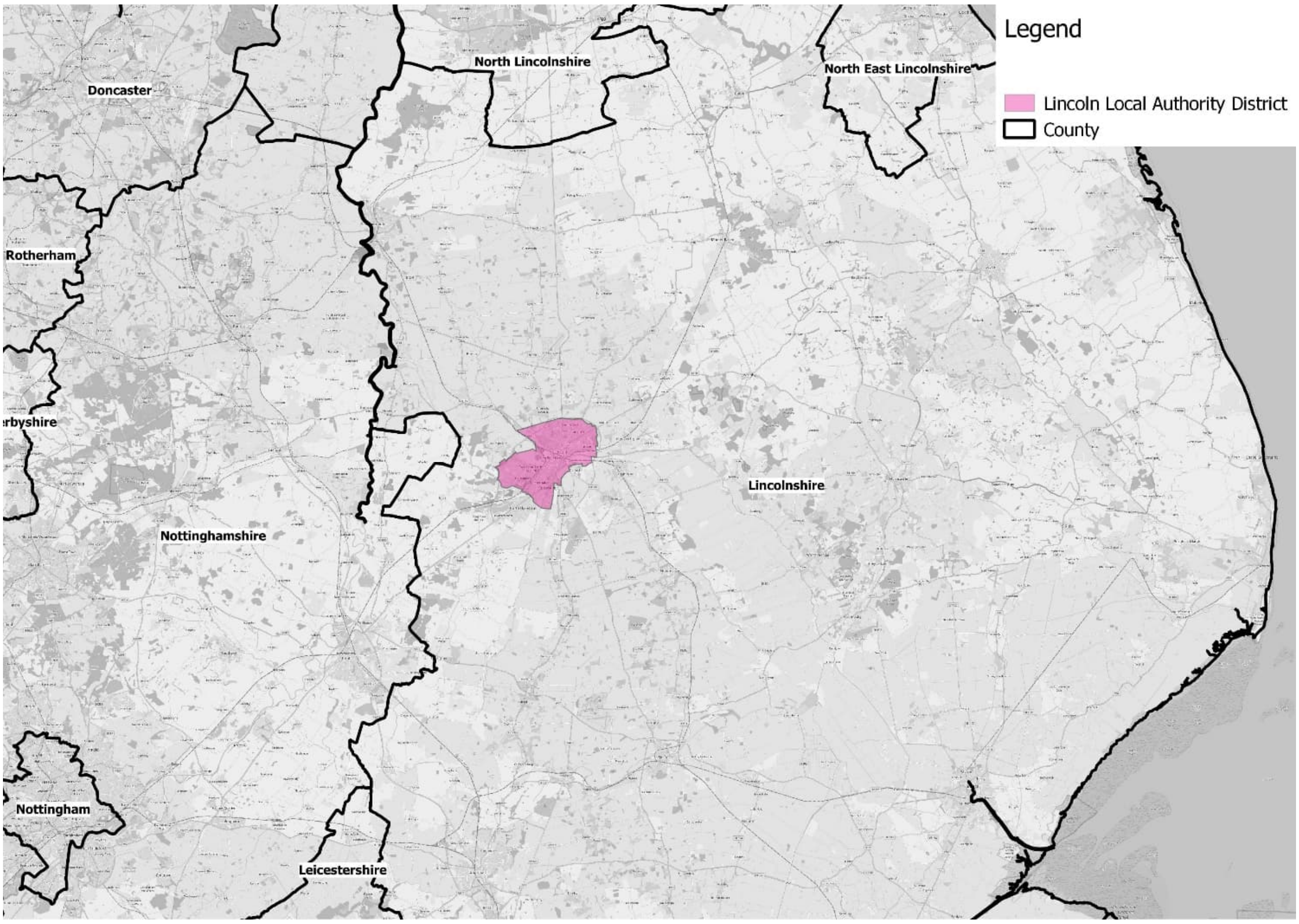
1.1 BACKGROUND

1.1.1. WSP has been commissioned by Lincolnshire County Council (LCC) to develop an updated multi-modal model of the Greater Lincoln area referred to as the Greater Lincoln Transport Model 2 (GLTM2) for assessing the impact of future developments and highway schemes. The Model Specification Report (May 2023) set out the agreed methodology for the model build.

1.1.2. Located in the West of Lincolnshire, Lincoln is a city situated within the district of Lincoln adjacent to the A1. Lincoln represents the centre of a dynamic urban region with approximately 100,000 people residing within the city proper. This increases to a population in excess of 130,000 when extended to the continuous urban area of Lincoln, including North Hykeham and Waddington, both nominally within North Kesteven district.

1.1.3. The location of Lincoln relative to the surrounding areas is shown in Figure 1-1.

Figure 1-1 Location of Greater Lincoln



1.2 Greater Lincoln Transport Model Background

1.2.1. The previous Greater Lincoln Traffic Model (GLTM), owned by Lincolnshire County Council (LCC), was developed in 2017/2018. The model base year is 2016, which was underpinned by an extensive traffic and travel survey data collection across the study area during the base year period including traffic counts, public transport passenger counts, highway link journey times and mobile network data to derive multi-modal travel demands. It includes a SATURN highway assignment model, Cube Voyager public transport model and a Cube Voyager variable demand model, to enable transport forecasting and assessment for various types of proposed schemes and interventions within the model study area.

1.2.2. The previous GLTM model coverage is illustrated in Figure 1-2.

1.2.3. An earlier Greater Lincoln Traffic Model had been used to support traffic forecasting and economic appraisal of the Lincoln Eastern Bypass, which had its final funding bid confirmed by the DfT in 2016. However, a scoping exercise had determined that an updated transport model would be required to support future funding bids for projects in the Greater Lincoln area, including the North Hykeham Relief Road (NHRR) Outline Business Case (OBC), which was planned to be brought forward for development once the Lincoln eastern Bypass (LEB) was under construction (which began in 2017).

1.2.4. The previous GLTM was developed based on that scoping exercise, with a base year and data collection representing travel demands and conditions prior to the LEB opening, to enable progression of the NHRR OBC and other projects.

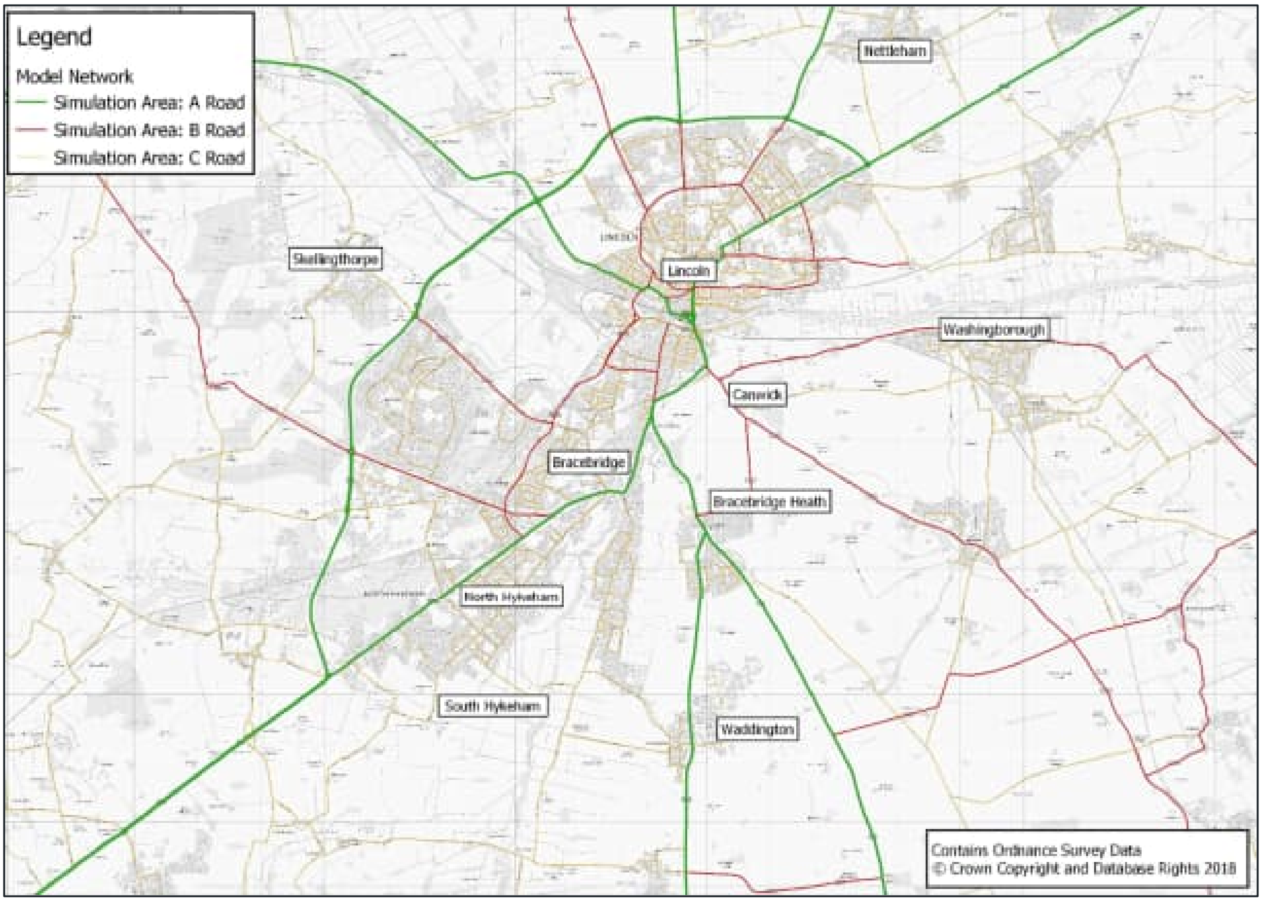
1.2.5. However, the LEB is a major scheme that provides a bypass to the east of the Greater Lincoln urban area, that will have impacted on travel choices and network conditions across a wide region of the Greater Lincoln area.

1.2.6. This means that in the context of updating the GLTM base modelling to the present year, most of the previous survey data, including travel demands, are considered in need of a refresh both in terms of the age of the data (over six years old) and possible changes to travel behaviours associated with LEB and other infrastructure projects which have been delivered in the meantime.

1.2.7. Beyond this local context, there are also potential impacts of travel behaviour changes associated with COVID-19.

1.2.8. Therefore, a more thoroughly updated GLTM2 will be helpful to facilitate the analysis of the Full Business Case (FBC) for the NHRR being developed by Lincolnshire County Council and its partners.

Figure 1-2 – Previous GLTM Network Coverage: Greater Lincoln Urban Area



1.3 ACCOUNTING FOR COVID-19 IN TRANSPORT MODELLING

The Department for Transport released advance notice of changes to its Transport Modelling and Appraisal Guidance (TAG) (19th April 2023), which recommended how to account for COVID-19 impacts on the pattern and volume of travel when dealing with forecasting and uncertainty. This change was adopted on the 31st of May 2023 at TAG Unit M4 'Forecasting and Uncertainty', Appendix B 'Adapting the Core Scenario to Large Scale Changes'. TAG suggested that the guidance be applied in a proportionate manner to all models with a base year before 2023.

TAG suggested three scenarios for accounting for COVID-19 impacts based on the status of the model:

1. Create a forecast to the present day by applying adjustments to include a COVID-19 impact, based on observed data. This forecast can be used as a "new base year" as a substitute basis for scheme forecast;
2. Apply adjustments to a forecast year model to produce a new scheme opening year forecast, or the first required forecast year, which include a COVID-19 impact to that point. This will be the new pivot off which further forecast years are based; or
3. Apply the adjustment globally to model results as a post-model adjustment.

1.3.1. A technical note was subsequently prepared by WSP which established that the three COVID-19 scenarios suggested by TAG are not applicable to the creation of the GLTM2 but that the following alternatives should instead be considered:

1. Option 1: Continue to develop the GLTM2 to an October 2022 base;
2. Option 2: Adjust existing, non-2023 data to create a 2023 base for the GLTM2; or
3. Option 3: Acquire additional data to create a 2023 base for the GLTM2.

1.3.2. The strengths and limitations of each of the above options for the GLTM2 were presented in the note. Although Option 3 was agreed with LCC to develop the GLTM2 model.

1.3.3. The assessment of the three options are presented in 'TN01 GLTM2 Base Year and TAG Covid Guidance Note_v2.3' (July 2023).

1.4 GLTM2 TRAFFIC MODELLING

1.4.1. The GLTM2 has been developed using the SATURN software package, in accordance with the Department for Transport's (DfT) Transport Analysis Guidance (TAG), with particular reference to Unit M3.1 Highway Assignment Modelling. The development of the GLTM2 is described in the following chapters.

1.4.2. The GLTM2 will provide a robust tool for analysis and appraisal towards a number of objectives:

- **Strategic Business Case Evaluation**
  - A core intention of the model is to support the FBC for the NHRR and a Public Inquiry evidence base.
- **Development Management**
  - A model of Greater Lincoln can be used to forecast and assess the impact of developments within the study area. The model will need to be capable of representing transport solutions to meet the needs of cars, goods vehicles, and public transport users. Specific functionalities would include estimating trip generation of new developments, informing junction analysis and design, assisting in the determination of developer contributions that emerge from the LTS and traffic management advice.
- **High Level Policy Evaluation**
  - Policy considerations in the case of Greater Lincoln would typically involve the evaluation and appraisal of measures to change travel behaviour which are within the control of local authorities (both the County Council and City of Lincoln, and to a lesser extent North Kesteven District Council and West Lindsey District Council), consistent with changes to the Central Lincolnshire Local Plan and the current Local Transport Plan (LTPV,2022).
- **Tactical measures (traffic management and localised responses)**
  - In its role as the local Highway Authority, LCC will be required to address traffic impacts of day-to-day network management issues. These include issues as diverse as air pollution mitigation, carbon emissions, planned and unplanned maintenance, gritting routes, event management, signage strategies and a range of measures where existing and projected network volumes differ.

1.5 PURPOSE OF THIS REPORT

1.5.1. This Local Model Validation Report (LMVR) describes the work carried out in the development and validation of the highway traffic model for Greater Lincoln. It summarises the various data sources used for the model development, as well as explains the methods used for the development of the highway network and demand matrices. It presents the results of the model calibration and validation with reference to Department of Transport's (DfT) TAG guidelines. This report demonstrates that the model produced is an accurate representation of existing traffic conditions both in and around Greater Lincoln. This makes the model suitable to support the evaluation of potential highway network interventions and land use changes in line with LCC overall objectives.

1.6 STRUCTURE OF REPORT

1.6.1. Following this introduction, the structure of the LMVR includes:

- **Chapter 2** – Model Specification
- **Chapter 3** – Summary of Data Collection
- **Chapter 4** – Highway Network Development
- **Chapter 5** – Highway Matrix Development
- **Chapter 6** – Assignment Process
- **Chapter 7** – Model Calibration
- **Chapter 8** – Highway Model Validation
- **Chapter 9** – Summary and Conclusions

2 MODEL SPECIFICATION

2.1 INTRODUCTION

2.1.1. This chapter provides an overview of the scope and specification of the traffic model including matrix development, the highway network and the model coverage.

2.1.2. A *Model Specification Report (May 2023)* [1] was written at the outset of this study which contains further details on the model specifications. In summary, the model will be used to achieve the following high-level objectives:

- Supporting the development of a Full Business Case of the North Hykeham Relief Road;
- supporting the work of LCC in managing the existing transport network; and
- supporting the work of LCC in developing the future transport network consistent with its Transport Strategy aspirations.

2.1.3. In order to support the objectives, a highway model was developed using various data sources to meet DfT's Transport Analysis Guidance (TAG) criteria and to produce plausible routeing, traffic flows and journey times.

2.2 MODEL SOFTWARE PLATFORM

2.2.1. The highway model was developed using the SATURN software package version 11.5.05N.

2.3 BASE AND FUTURE FORECAST YEARS

2.3.1. The model was developed to represent a base year of 2023.

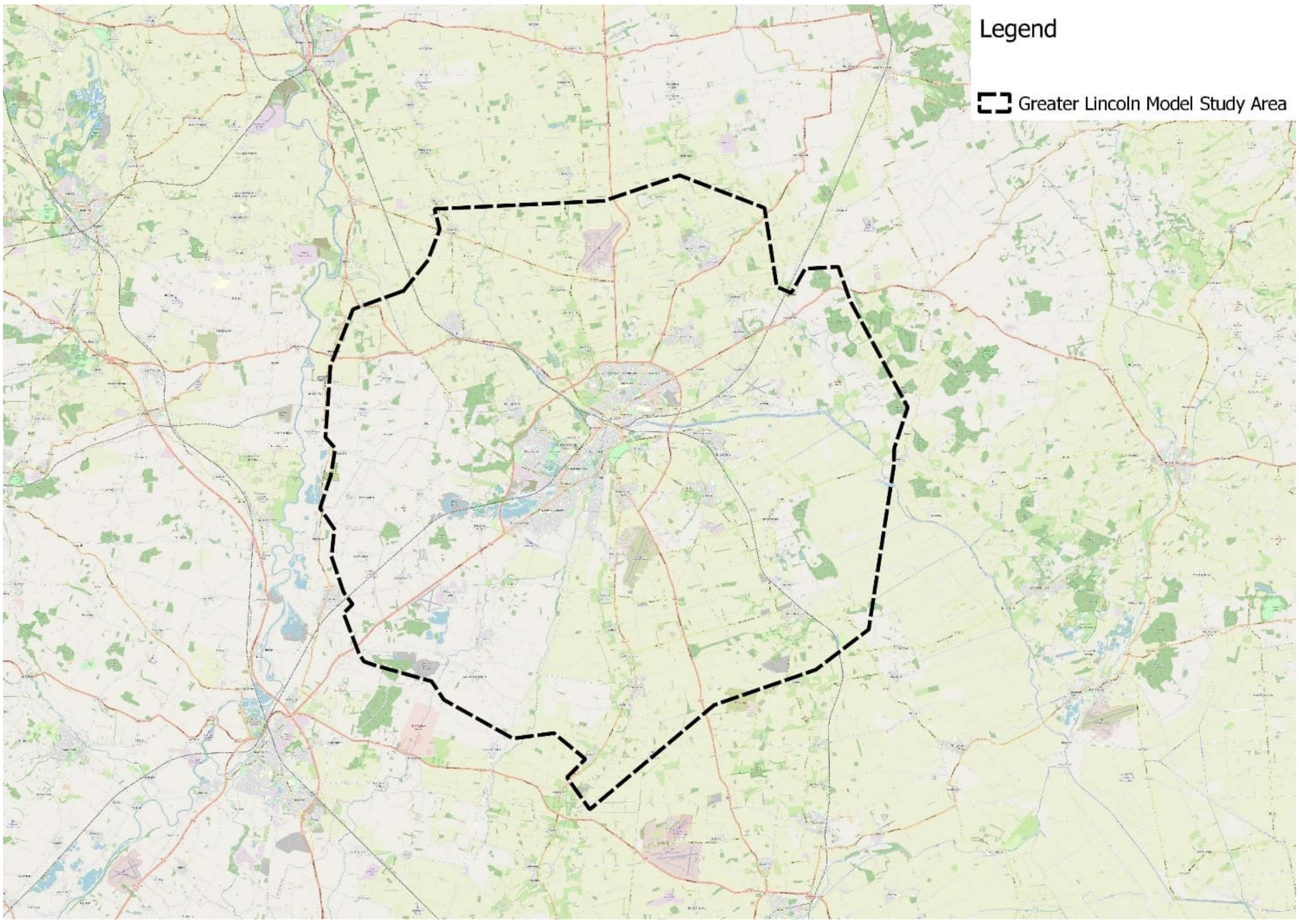
2.3.2. Future forecast years will be developed for 2028, 2038 and 2043.

2.4 STUDY AREA

2.4.1. Figure 2-1 represents the extent of the study area. It includes the Greater Lincoln area, which consists of Lincoln and North Hykeham and major employment sites in the area. The fully modelled area is defined by a cordon around the existing orbital bypass (A46 and A15)

[1] GLTM2 MSR FINAL.pdf

Figure 2-1 Greater Lincoln Transport Model2 Study Area



2.5 MODELLED TIME PERIODS

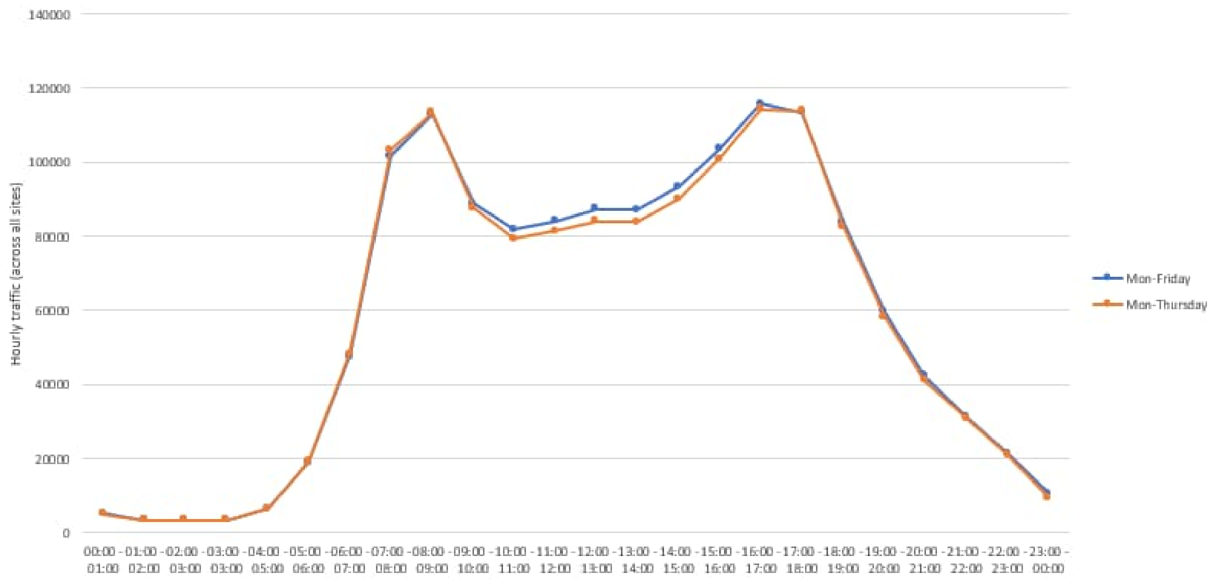
2.5.1. The model reflects the typical traffic conditions during the morning peak, average inter-peak and evening peak hours.

2.5.2. The peak hours with respect to both the weekday AM and PM peak periods were established with reference to traffic flow profiles.

2.5.3. The data were recorded across a two-week duration. Data were then reviewed, and, in line with TAG unit M1-2 recommendations, data outside of two standard deviations from the mean were removed. A new mean was then calculated to exclude those outliers which could represent atypical traffic.

2.5.4. Figure 2-4 presents the daily traffic profile comparison between the average of Monday to Friday during a neutral month. For a neutral weekday, it is evident that the AM peak hour is between 08:00-09:00. The PM did not show a clear single hour peak. The PM peak is therefore taken as an average of 16:00 to 18:00.

Figure 2-2 ATC Monday-Friday daily flow by hour



2.6 VEHICLE CLASSES AND TRIP PURPOSES

2.6.1. As stated in Section 2.6 of TAG 3.1, operating costs vary by vehicle types and values of time vary by the purpose of the trip being made. Therefore, separate matrices were developed for various combinations of vehicle type and trip purpose. This recognises the different characteristics of trips and facilitates distinction in some of the modelling processes.

2.6.2. There are five user classes in the model, including:

- UC1 – Car Business users (journeys undertaken on behalf of an employer);
- UC2 – Car Commuters (journeys between home and work and vice versa);
- UC3 – Car Other (such as leisure or education);
- UC4 – Light Goods Vehicles (LGVs); and
- UC5 – Heavy Goods Vehicles (HGVs).

2.7 MODEL ZONING SYSTEM

2.7.1. The Greater Lincoln zoning system was based on common census Lower / Middle Layer Super Output Area (LSOA / MSOA) boundary layer with additional detail within the City. The spatial granularity reflects the magnitude of population within the local area, with similar population per zone. This forms a key principle of zoning whereby travel demands to and from the study area determine a greater need for granularity.

2.7.2. Within Greater Lincoln itself, it was necessary to have a zoning system that was finer than LSOA. This was due to the concentration of buildings, along with the layout of the highway network.

2.7.3. Further details on the model zoning system are presented in Section 4.9.

2.8 HIGHWAY NETWORK

2.8.1. In accordance with TAG Unit M3.1 section 2.4, the proposed network for the transport model has been developed as a three-level structure with a high level of detail within the study area and with the level of detail inversely proportional to the distance away from the study area. The traffic model network is therefore divided into the three levels of simulation, buffer and external areas.

2.8.2. The area of detailed modelling is defined by where the level of impact from potential schemes is anticipated to be the greatest. Therefore, the detail within the network and the demand matrices is at its greatest in these areas.

2.8.3. The buffer area (i.e. immediately outside the study area) is where the level of detail is lower and determined by speed flow curves only.

2.8.4. The external area is where the level of network detail is at its lowest with no capacity restraint and fixed speeds utilised.

2.8.5. Full details of the network, its development and checking are provided in Chapter 4.

2.9 MATRIX DEVELOPMENT

2.9.1. The base matrix was developed using the following sources of data:

- National Travel Survey (NTS) data;
- Mobile Phone Network Data (MND) converted into Origin-Destination (MND); and
- Census population, (economically active population and workplace population)

2.9.2. The MND was obtained from Telefonica who supply and process mobile phone data from O2.

2.9.3. The sources of data used and the procedures adopted to develop the base trip matrices are described in Chapter 5.

2.10 MODEL CALIBRATION AND VALIDATION

2.10.1. Calibration of the base year (2023) traffic model was based upon an iterative process of refining network characteristics, including link and junction capacities, in line with the observed journey time and traffic flow data.

2.10.2. The calibration process involved checking the network to verify that the network structure was accurate and that the characteristics of the network were suitably represented in the model. Range and logic checks were undertaken including routeing checks.

2.10.3. Matrix estimation was used to refine the matrices developed from the survey data to more closely match observed traffic flow data. This is further explained in Chapter 6.

2.10.4. Assignment validation was then undertaken by comparing modelled traffic flows and journey times with observed data with reference to the DfT TAG validation criteria.

2.10.5. Details of model calibration are provided in Chapter 7, with link flow, screenline and journey time validation statistics presented in Chapter 8.

3 SUMMARY OF DATA COLLECTION

3.1 INTRODUCTION

3.1.1. As stated in TAG Unit M1.1, *'data collection is necessary in order to inform the parameters that represent the model responses (calibration) and to provide a source of information against which the model can be compared to assure its quality (validation).'*

3.1.2. Various data was collected in order to develop the Greater Lincoln SATURN Model in line with guidance contained in TAG Unit M1.2: Data Sources and Surveys. Data was collected for the following model development tasks:

- Highway network development;
- Demand matrix development; and
- Model Calibration and Validation.

3.2 SOURCES OF TRAFFIC COUNT DATA

3.2.1. Traffic survey data were commissioned to provide:

- Automatic Traffic Counts (ATC),
- Manual Classified Junction Counts (MCJC), and
- Bus passenger counts (for the Public Transport model)

3.2.2. WSP contacted six survey companies and reviewed bids from five (all on WSP's approved supplier framework). Nationwide Data Collection was selected as the Data Survey Provider.

3.2.3. The ATC surveys were collected in April 2023. There were delays and resurveys to allow for the omission of data affected by roadworks, school holidays, equipment faults and vandalism.

3.2.4. The MCJC surveys were undertaken for a twelve-hour period (7:00-19:00) on Tuesday 25th April 2023 which was a school-term time weekday that was also not affected by industrial action.

3.2.5. Other sources of traffic count data were WebTRIS, Lincs Laboratory (for the Lincoln Eastern Bypass Monitoring data) and the DfT Count Database.

WebTRIS

3.2.6. Permanent traffic counts are collected by National Highways along their Strategic Road Network which in the context of the GLTM2 includes the A1 and A46. A total of 34 WebTRIS counts from the A1 and the A46 have been selected with data collected in June 2023.

DfT Count Database

3.2.7. The one-day MCLC (manual classified link counts) available in the DfT Count Database were reviewed and it was found that the extensive new data collection provided sufficient coverage of the same or similar locations. However, the DfT Count Database was used to provide classified vehicle type data for applying to the WebTRIS counts on the A1 in the buffer zone.

Automatic Number Plate Recognition

3.2.8. A group of Automatic Number Plate Recognition (ANPR) surveys were undertaken on Tuesday 25th April 2023. The focus of these surveys were trips made on the A46 approaching/leaving Lincoln. Other crucial interception points were also targeted along the orbital route including those passing around Lincoln which directly and indirectly benefit from the NHRR scheme.

3.3 OTHER DATA SOURCES

3.3.1. In addition to the historical data, other traffic data was obtained from several other sources. This data and its application for the model development is described as follows:

- **Mobile Network Data (MND)** – WSP obtained data from O2 (Including Tesco and GiffGaff) on behalf of Lincolnshire County Council (LCC). The sample collected covered the subset of the population who use O2 devices. The Origin and Destination (OD) data, derived from the mobile phone data, was used to produce base year matrices for inclusion in the STM. Data was collected from period between October to the end of to November 2022.
- **Inrix (Journey Times)** –The Journey Time (JT) data for the GLTM was obtained by LCC from Inrix. It is sourced via Global Positioning System (GPS) data gathered from devices and trackers fitted to a variety of fleet vehicles (Cars, LGVs and HGVs) and buses. JT data was used for defining network cruise speeds, identifying junction delays and for model validation. The journey time routes, journey times and route distances used for the model validation are presented in Chapter 8. June 2023 journey time data was chosen to accurately reflect levels of congestion within Greater Lincoln during the journey time validation process.
- **National Travel Survey Data (NTS)** – The National Travel Survey (NTS) contains travel diary information for journeys made from a sample of UK households and provides a rich data source that allows the trip making characteristics across the country to be understood. NTS data were sourced from 2002-2021 for East of England and East Midlands to broadly reflect local travel characteristics. The data were used at various points in the demand matrix development including; verification of MND, trip generalised costs distributions for calibration of synthetic matrices, and trip return time factors for synthetic matrices to convert producer/attractor to origin-destination.
- **Census Data** – Datasets from the UK Census 2011 were used to assist the matrix development. 2021 census data was not available at the onset of model development.
- **Signal Data** – A total of 110 signal specifications were provided by Lincolnshire County Council. The specifications for the signal timings were used for the coding of these junctions in the base model.
- **Integrated Transport Network (ITN)** – the ITN is a digital representation of the UK road network. It was used to help develop the highway network and is supplied by the DfT.
- **Public Transport Data –** bus service route and frequency information for inclusion of the Lincoln Transport Model was sourced from the online journey planner https://www.cartogold.co.uk/lincs. Rail service frequencies were obtained from manually searching online timetable information directly from the operator and National Rail Journey Planner.

3.3.2. Full details of the traffic data collected for the creation of the GLTM2 are included in the Traffic Data Collection Report (October 2023).

3.4 DATA CHECKING

3.4.1. Before count and journey time data was used in the matrix build and calibration/validation, work was undertaken to check the validity of the data. Checks on the count data included:

- Checks of daily and hourly flow profiles. Large variations in day-to-day flows could be indicative of a technical problem with the count or an issue with the local network (such as roadworks or an accident) which has affected the count for one day or more;
- Resolution of conflicting count data on adjacent links - particularly important when running matrix estimation;
- Mapping of observed traffic flows – displaying traffic volume as bandwidth provides a quick visual check of any very large or small flows; and
- Sense checks based on local knowledge.

3.4.2. The result of the data collection review left count sites to be used in the matrix build and calibration/validation processing. The locations of the count sites are shown in Figure 3-2.

Figure 3-1 Final Count Sites - Wider Area

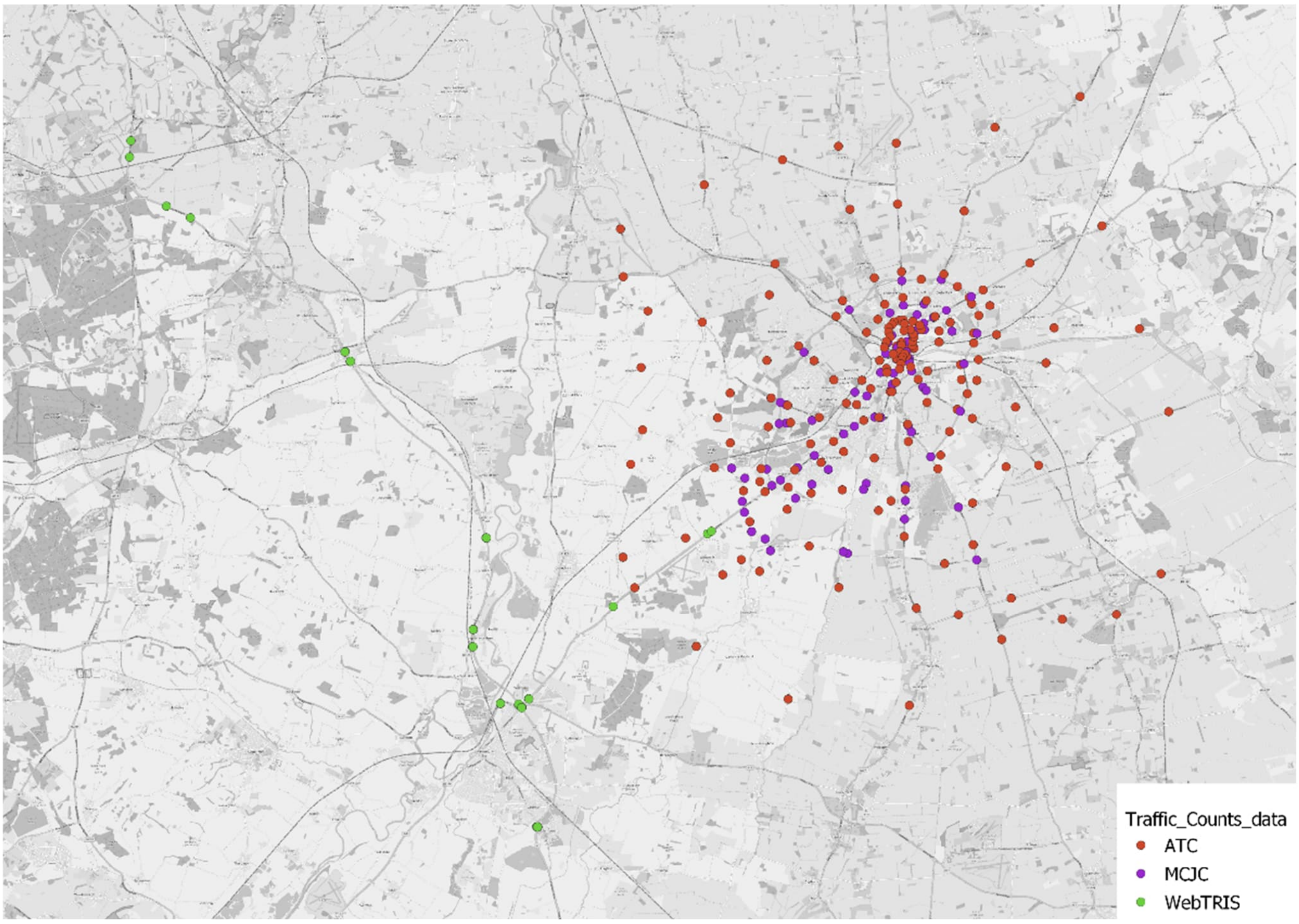


Figure 3-2 - Final Count Sites – Lincoln City Centre

3.5 DATA COLLECTION AND COVID-19 IMPACT

3.5.1. The Model Specification Report for the GLTM2 was written in May 2023. This specification set out that the base year of the model was intended to be October 2022. This was based on the latest available journey time data from the Department for Transport being from the final quarter of 2022. That same month (31st May 2023), the Department adopted its updated guidance to TAG Unit M4 'Forecasting and Uncertainty' around the treatment of COVID-19 impacts in Transport Modelling. TAG was updated to suggest that the guidance be applied in a proportionate manner to all models with a base year before 2023.

3.5.2. It was decided to change the base year of the GLTM2 to June 2023. This would be achieved by undertaking the following:

- Collect June 2023 observed travel time data (supplied by INRIX);
- Adjust the observed flow data (collected in April 2023); and
- Review and adjust the mobile network data (from October 2022).

3.5.3. The reviews and adjustments were undertaken to create a GLTM2 base year of June 2023. Further details of the data can be found in the Traffic Data Collection Report.

4 HIGHWAY NETWORK DEVELOPMENT

4.1 INTRODUCTION

4.1.1. The network is a representation of the highway transportation system within the study area. The network comprises a system of nodes connected by links. The nodes generally represent junctions and the links represent stretches of highway between the nodes.

4.2 HIGHWAY NETWORK DEFINITION

4.2.1. The ITN network provided the starting point for developing the 2023 base model highway network. The ITN was used as a starting point as it represented the most up to date highway network available.

4.2.2. In accordance with TAG Unit M3.1 section 2.4, the Greater Lincoln highway network has been developed as a three-tier structure with levels of detail reducing away from the centre of the study area. The area of detailed 'simulation' modelling covers the Lincoln and the Greater Lincoln area (i.e. the study area).

4.2.3. Within the simulation area all junctions have been coded in detail and link speed flow curves have been applied so that the existing traffic capacity can be simulated explicitly and the impact of traffic on queues and delays are accurately represented within the model.

4.2.4. The buffer area extends as far as:

- Gainsborough to the north west;
- Market Rasen to the north east;
- Newark to the south west; and
- Horncastle to the east.

4.2.5. The remainder of the 'external' area includes a relatively sparse network and includes the key motorway and trunk road network across the rest of the UK, and has been coded with fixed speeds only, as local interventions are not expected to have an impact in this area.

4.2.6. The extent of the highway network is shown in Figure 4-1.

Figure 4-1 Network Coverage – Wider Area

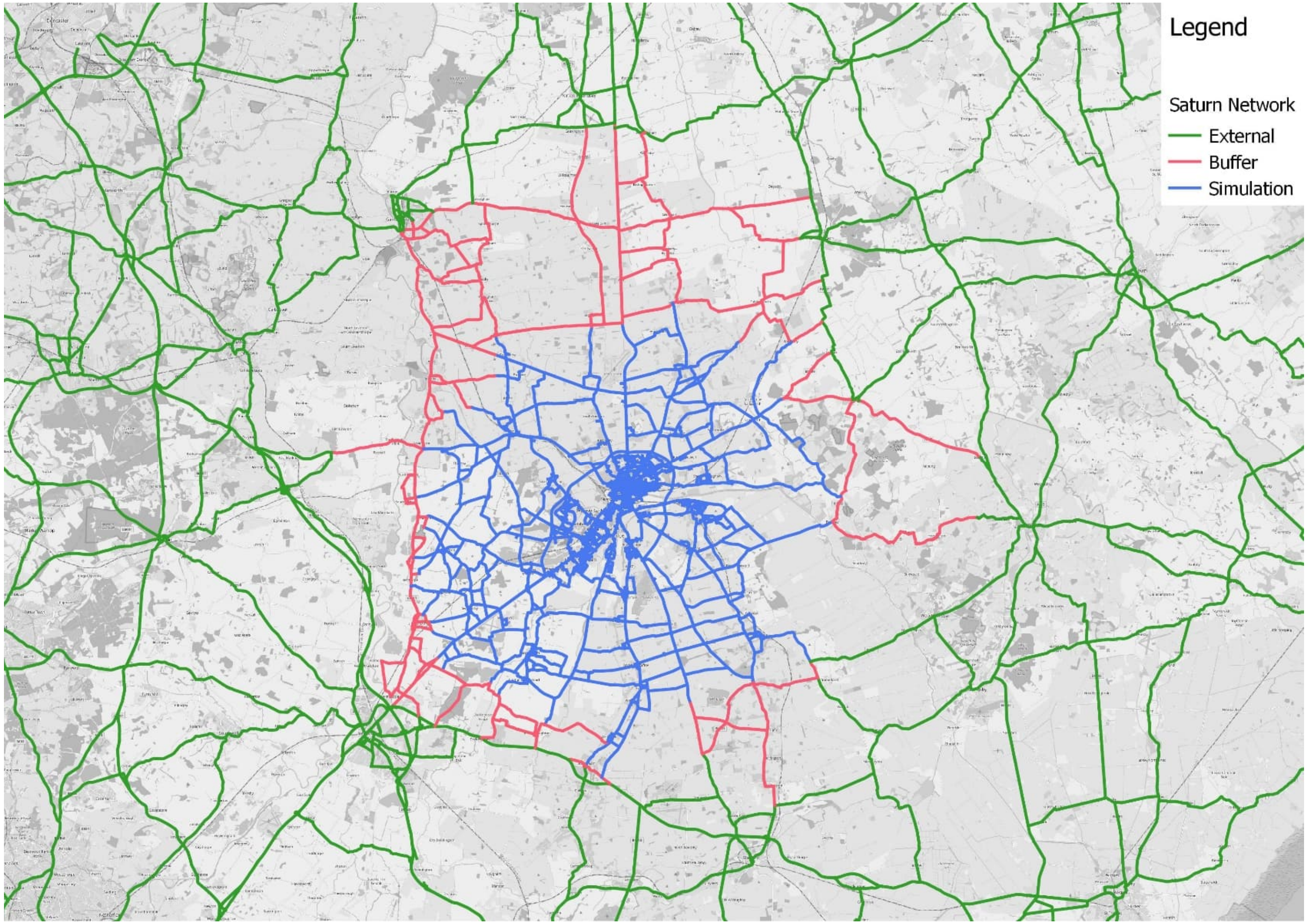
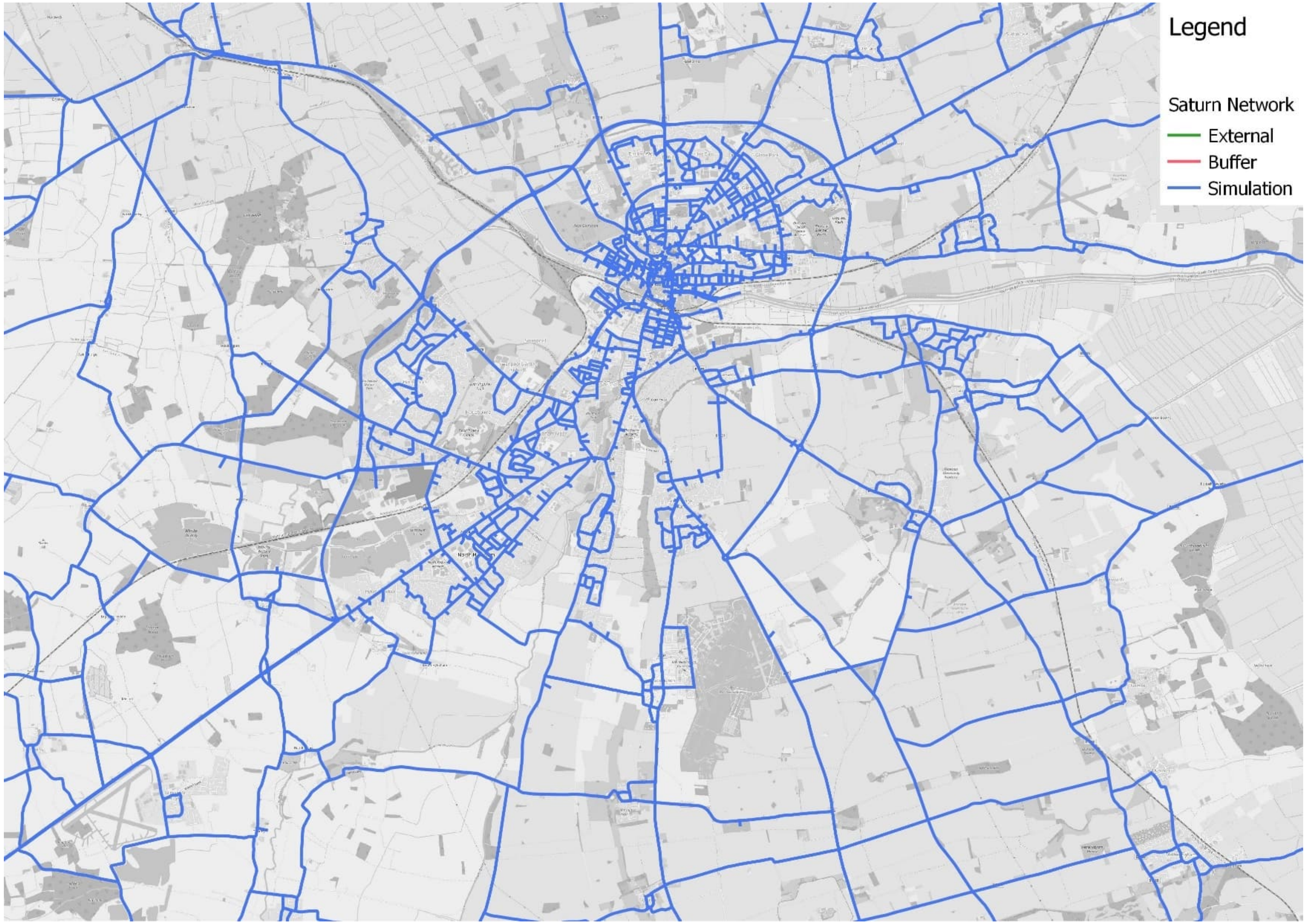


Figure 4-2 Network Coverage - Lincoln City Centre



4.3 LINK CODING

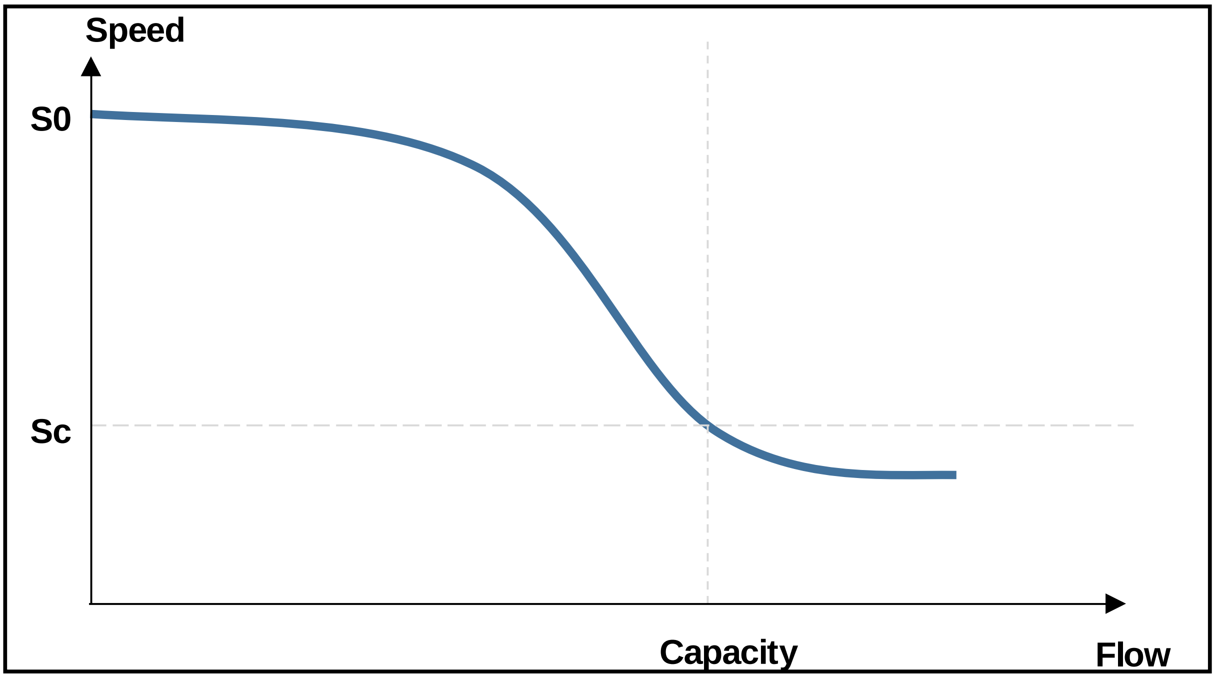
4.3.1. The starting point for the development of the network was the ITN layer which provided details of the network coverage, road hierarchy / class and carriageway type. In addition, online satellite imagery and street view imagery were used to derive information on the link speed limits, number of lanes, lane markings, flare lengths and links with height/weight restrictions.

4.3.2. The link information specified above (as well as other factors) is then used by SATURN to determine the link capacity.

4.4 SPEED-FLOW CURVES

4.4.1. Based on the information above, a set of appropriate speed-flow curves was adopted to reflect a relationship between traffic volume and travel speed on a link. A generic form of a speed-flow curve is illustrated in Figure 4-3 as follows.

Figure 4-3 Example of Speed-Flow Curve



4.4.2. For each speed-flow curve, capacity, free-flow speed (S0), speed at capacity (Sc) and the rate of speed decline relative to flow increase was determined by various factors including the road class, road type, number of lanes and consideration of street characteristics including on-street parking or traffic management which may prohibit the free flow of traffic.

4.4.3. Speed-flow curves for the Greater Lincoln Transport Model were derived from the speed/flow relationships used in the DfT’s link-based Cost Benefit Analysis (COBA) software and used for links within the buffer area and on longer links (above 40m) within the simulation area where volume delay is likely to be of importance to the traffic routeing. Links within the ‘external’ area were not assigned speed-flow curves and instead assigned a fixed speed.

4.4.4. The list of all the speed-flow curves adopted for the Greater Lincoln Transport Model are provided in Appendix A.

4.5 FIXED SPEEDS

4.5.1. Fixed speeds for Lincolnshire were sourced from DfT Congestion Statistics. Fixed speed data were sourced from Trafficmaster Journey time data from the National Highways Regional Transport Models v2 (RTM2s). These RTM2s were used to derive the fixed speeds for outside of Lincolnshire.

4.5.2. Fixed Speed coding in the highway network simulation area and external area follows the established approaches used in the previous GLTM.

4.5.3. The RTM2s were developed across England and are split into 5 separate models – North, Trans Pennine South, Midlands, South West and South East. They were calibrated and validated to average hours across neutral days in 2019.

4.5.4. Within the Urban areas, links with a length of less than 40m generally have travel speeds determined by the simulated delays at junctions and so these are coded with a fixed speed value.

4.6 JUNCTION MODELLING

4.6.1. Junctions play a key role within the simulation area as they affect route choice particularly with respect to turning delays. Within the simulation area, the junctions were modelled in detail to represent the effects of traffic flows on delays and queues. Each junction was coded by using detailed information which included:

- Junction type (signalised, priority, roundabout);
- Number of arms and lanes (including flares);
- Permitted turns;
- Turning capacities based on geometric parameters;
- Traffic signal details (stage/phase arrangements and timings); and
- Vehicle circulating capacity and travel time (for roundabouts).

4.6.2. Data for junction layouts was obtained from satellite imagery.

4.6.3. 1,409 priority junctions are coded into the simulation network. This includes 17 roundabouts in Greater Lincoln, which are coded as a series of exploded priority junctions. There are 16 standard roundabouts.

4.6.4. Within the simulation area there are 100 signalised junctions coded in detail. Details of the signalised junction timings were provided by Lincolnshire County Council, including detailing staging, green/red/inter-green times and turning allocations. Signals timings were obtained by modelled time period.

4.6.5. Pedestrian crossings within Greater Lincoln have been coded as signalised junctions. The red time of these signalised junctions represents the assumed time the signals are on for pedestrians (estimated based on proximity to retail and other services), plus inter-green time.

4.6.6. Railway level crossings within Greater Lincoln have been coded as signalised junctions. The red time of these signalised junctions represents the assumed time the signals are on for trains passing through (estimated based on rail timetables), plus inter-green time.

4.6.7. Figure 4-4 and Figure 4-5 show the modelled junction locations and junction types.

Figure 4-4 Modelled Junctions - Wider Area

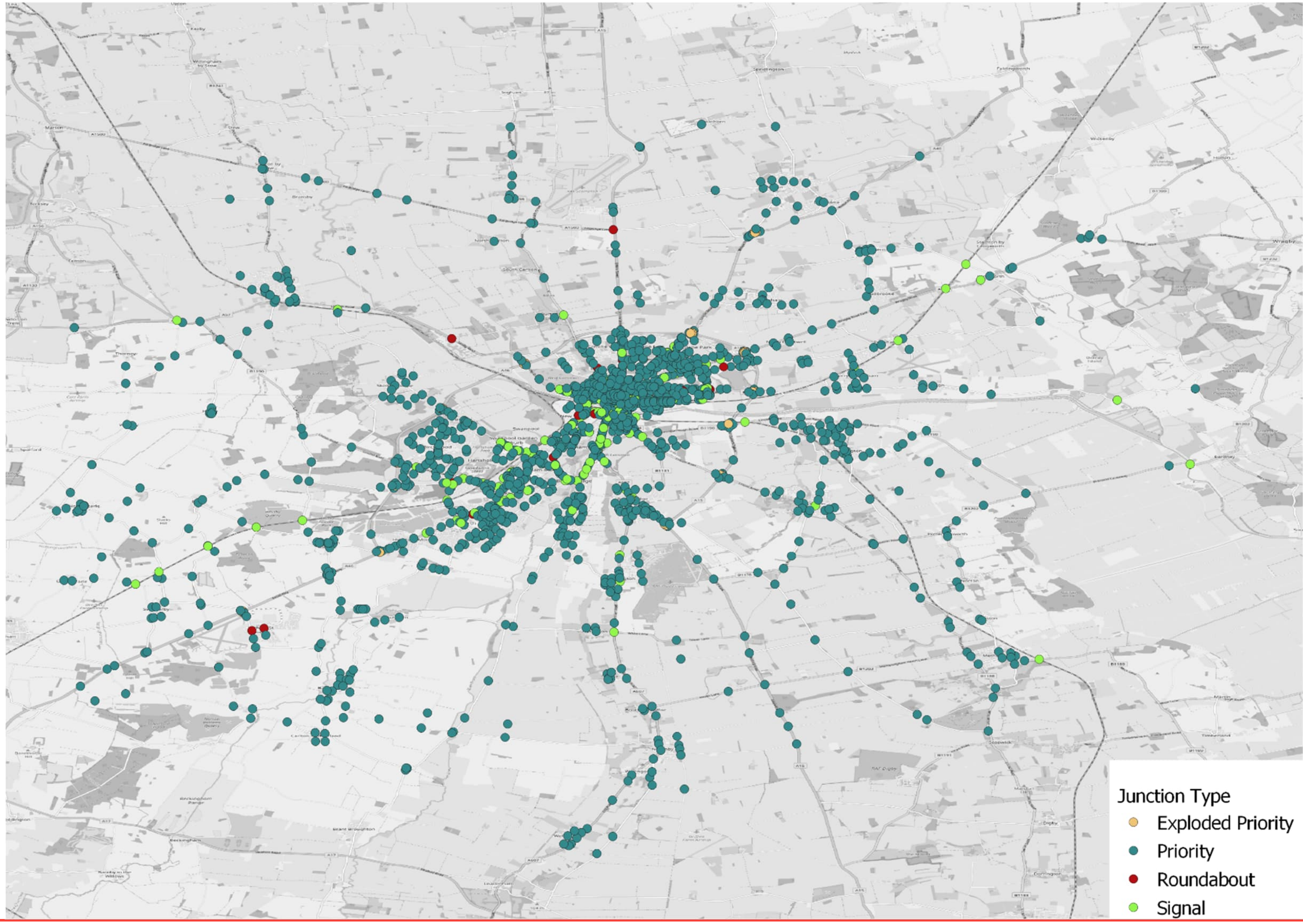
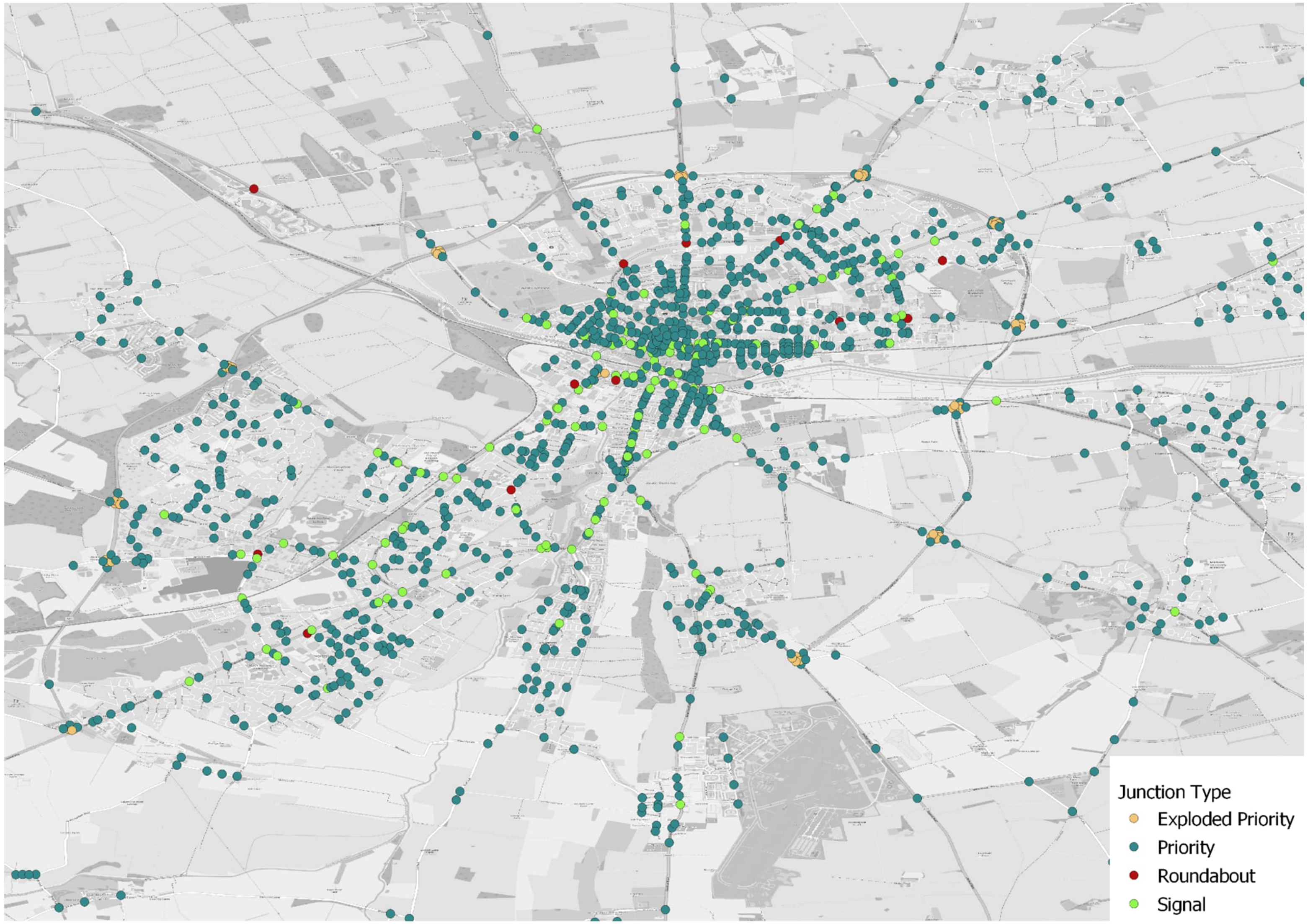


Figure 4-5 Modelled Junctions –Lincoln City



4.7 BUS ROUTES

4.7.1. Bus flows typically have a higher frequency during the peak periods and therefore their impact on general traffic flow will be greater.

4.7.2. Bus route information for Greater Lincoln and the surrounding areas was obtained through timetables from a number of local journey planning websites:

- The bus data was primarily obtained from BODS https://lincolnbus.co.uk/journey-tools/timetables
- Key services were checked against the data from https://lincolnbus.co.uk/journey-tools/timetables
- School services were omitted based on the information from https://lincolnbus.co.uk/school-bus-services-lincoln

A total of 81 bus services were coded in the GLTM2 across the three time periods and are summarised in Table 4-1 and shown graphically in Figure 4-6 and Figure 4-7 as follows. Separate variants such as a school service which is available to the public have been coded as separate routes in the model.

Table 4-1 AM Journey Time Validation

Bus Service	Route	Operator	AM Peak Hour	Inter Peak Hour	PM Peak Hour
1	Grantham - Lincoln	Stagecoach	4	4	3
1	Lincoln - Grantham	Stagecoach	4	6	1.33
1	Lincoln - Welbourn	Stagecoach	0	0.17	0
1	Lincoln - Wellingore	Stagecoach	3	4	1.33
1	Skegness - Chapel	Stagecoach	4	12	12
1	Welbourn - Lincoln	Stagecoach	0.33	0.17	0
1	Wellingore Church - Lincoln	Stagecoach	1.33	4	1.33
2	Branston - Lincoln	Stagecoach	12	12	12
2	Lincoln - Branston	Stagecoach	12	12	12
3	Fiskerton - Lincoln	Stagecoach	12	12	12
3	Lincoln - Fiskerton	Stagecoach	6	6	12
6	Lincoln - Lincoln	Stagecoach	4	12	6

9	Lincoln - Lincoln	Stagecoach	4	12	12
12	Dunholme - Lincoln	Stagecoach	0	0	0.33
12	Lincoln - Welton	Stagecoach	12	12	12
12	Lincoln - William Farr Sch	Stagecoach	0.33	0	0
12	Welton - Lincoln	Stagecoach	12	12	12
13	Lincoln - Waddington	Stagecoach	0	0	12
16	Lincoln Bus Station - Pennells	Stagecoach	0	0	12
19	Lincoln - Skellingthorpe	Stagecoach	3	4	4
19	Skellingthorpe - Lincoln	Stagecoach	4	3	3
28	Blidworth - Mansfield	Stagecoach	0.33	0	0
28	Newark - Mansfield	Stagecoach	0.33	0.67	1.33
29	Newark - Mansfield	Stagecoach	0.33	0.67	0
30	Horncastle - Lincoln	Stagecoach	0.67	0	1.33
30	Lincoln - Horncastle	Stagecoach	0	0.33	0.67
31	Lincoln - Sleaford	Stagecoach	1.33	1.33	1.33
31	Sleaford - Lincoln	Stagecoach	1.33	1.33	1.33
50	Grimsby - Saltfleet	Stagecoach	0	0.17	0.33
50	Saltfleet - Grimsby	Stagecoach	0.33	0.33	0.67
51	Grimsby - Louth	Stagecoach	4	4	4
51	Louth - Grimsby	Stagecoach	4	4	6
53	Grimsby - Market Rasen	Stagecoach	1	1.58	1.11
53	Lincoln - Market Rasen	Stagecoach	1.33	4	3

53	Market Rasen - Grimsby	Stagecoach	3.33	1.33	3
53	Market Rasen - Lincoln	Stagecoach	3	3	3
56	Horncastle - Lincoln	Stagecoach	6	6	4
56	Horncastle - Skegness	Stagecoach	4	6	6
56	Lincoln - Horncastle	Stagecoach	4	6	4
56	Lincoln - Wragby	Stagecoach	0.33	0	0
56	Skegness - Horncastle	Stagecoach	1.71	6	6
56	Skegness - Spilsby	Stagecoach	0.33	0	0
56	Spilsby - Skegness	Stagecoach	0.33	0	0
56	Wragby - Lincoln	Stagecoach	0.33	0	0
57	Boston - Skegness	Stagecoach	2	3	1
57	Skegness - Boston	Stagecoach	1	0.50	2
59	Mablethorpe - Skegness	Stagecoach	3	6	4
59	Skegness - Mablethorpe	Stagecoach	2	4	3
96	Chapel - Spilsby	Stagecoach	0.33	0	0
96	Splisby - Skegness	Stagecoach	0	0.17	0
97	Gainsborough - Retford	Stagecoach	2	1.50	0
97	Misterton - Gainsborough	Stagecoach	0.33	0	0
97	Retford - Gainsborough	Stagecoach	0.67	0.67	0
98	Doncaster - Gringley	Stagecoach	0	0	0.33
98	Gainsborough - Doncaster	Stagecoach	1.33	0.67	0
103	Hemswell - Scunthopre	Stagecoach	0.33	0	0

103	Kirton - Lincoln	Stagecoach	1.33	1	0.33
103	Lincoln - Kirton	Stagecoach	1	1.50	2
558	Cherry Willingham - Wragby	Stagecoach	0	0.17	0
558	Wragby - Cherry Willingham	Stagecoach	0.33	0	0
609	Newark - Tuxford	Stagecoach	0.33	0	0
28B	Mansfield - Bilsthorpe	Stagecoach	0	0.17	0
28B	Mansfield - Eakring	Stagecoach	1.33	4	1.33
31X	Lincoln - Sleaford	Stagecoach	0.67	0.33	0.67
31X	Sleaford - Lincoln	Stagecoach	0.67	0	0.67
51B	Louth - Grimsby	Stagecoach	0	0	0.33
53A	Grimsby - Market Rasen	Stagecoach	0	0.17	0
53A	Lincoln - Market Rasen	Stagecoach	0.33	0	0
53A	Market Rasen - Lincoln	Stagecoach	0	0.17	0
53B	Market Rasen - Grimsby	Stagecoach	0	0.17	0
B3	Lincoln - Newark	Stagecoach	0	0.33	0
B3	Newark - Lincoln	Stagecoach	0	0	0.33
G	Great Gonerby - Grantham	Stagecoach	0.33	0	0
G	Grantham - Great Gonerby	Stagecoach	0	0.17	0
M1	Moy Park - North Hykeham	Stagecoach	0	0	0.67
M2	Monks Road - Moy Park	Stagecoach	0	0.33	1.33
M2	Moy Park - Monks Road	Stagecoach	0	0.17	0
M3	Boston - Moy Park	Stagecoach	0	0	1

SLE9	Spar Shop - Robins Crescent	Sleafordian coaches	0.33	0	0.33

Figure 4-6 Modelled Bus Routes – Lincoln Wider Area

Figure 4-7 Modelled Bus Routes – Lincoln Study Area

Figure 4-8 Modelled Bus Routes – Lincoln City Centre

4.8 ZONE SYSTEM

4.8.1. A detailed zones system was developed for Greater Lincoln. Zones were made progressively larger further away from Greater Lincoln. Zones within Lincoln are created to reflect likely land use (such as Lincoln railway station) and transport network accessibility. The granularity of zones within Greater Lincoln allows for precise network loading.

4.8.2. Zones immediately outside of Greater Lincoln were set up to nest within census Middle Super Output Area level.

4.8.3. In total there are 805 zones in the model. 713 of these are within the Study Area. There are 24 empty zones retained with no trips, ready for implementation in the forecast models.

4.9 CENTROID ZONE CONNECTORS

4.9.1. The loading of traffic onto the network from zones was achieved through the use of centroid connectors at appropriate locations. In line with TAG Unit M3.1 guidance, the number of centroid connectors were kept to a minimum (which also helps to avoid/reduce highway model assignment convergence issues).

4.9.2. Zone connectors should represent 'real' junctions within the highway network. The loading points and types of connectors were determined specifically for each zone within the simulation and buffer areas. For the external zones (outside the study area) the loading points were attached to the appropriate locations at the edge of the network.

4.9.3. For the buffer and external network, the appropriate length of the connector in each case was based on the distance to the mid-point of the zone. A speed limit of 40kph was then assigned to the zone connectors.

4.9.4. Speed-flow curves were not assigned to the zone connectors as this is not required in SATURN.

Figure 4-8 Zoning System - Wider Area

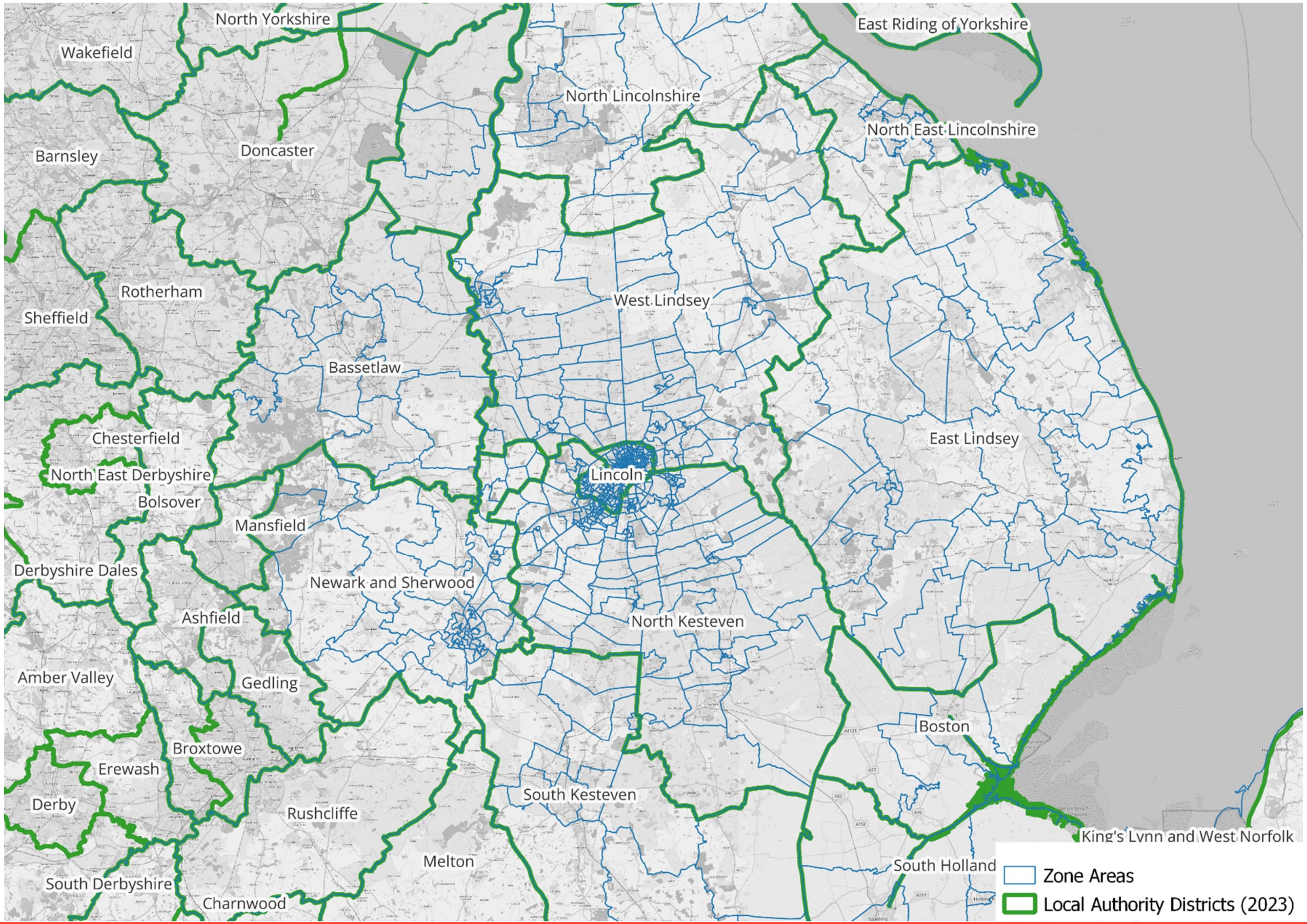
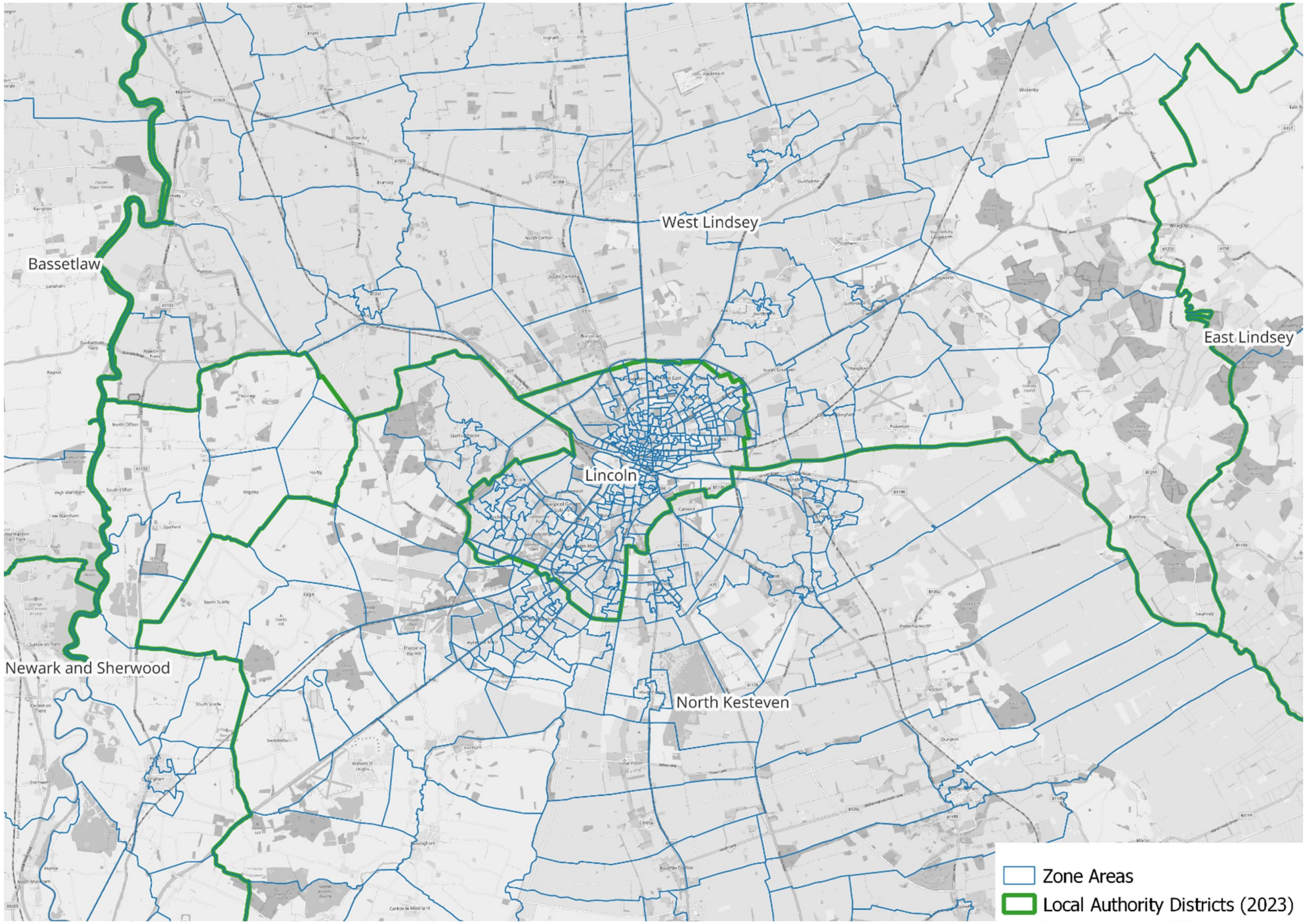


Figure 4-9 Zoning System – Greater Lincoln Area



4.10 NETWORK CHECKS

4.10.1. In line with TAG unit M3.1, checks were undertaken systematically to ensure that no problems arose once the model network was coded. The main checks included:

- **Check 1** – SATURN Compilation Check: ensures that all the errors and warnings produced by SATNET have been reviewed and addressed as appropriate.
- **Check 2** – Inspection of Key Junctions: ensures that all the key junctions within Greater Lincoln and areas of interest are coded and coded correctly.
- **Check 3** – Range/ Logic Checks: the modelled networks were imported into GIS (and using satellite imagery) to check that the characteristics of the coded network (junction type, number of arms and lanes, lane usage) and the properties assigned to the network (road class, speeds, speed-flow curves) were coded correctly. The coded link speeds are presented in Figure 7-2.
- **Check 4** – Link Consistency Checks: ensures that link type, distance, speed limit, etc. are consistent between directions and up/downstream.
- **Check 5** – Network Routeing Checks: ensures that the network shows plausible routeing. In line with TAG guidance, O-D route options were tested and checked against local knowledge, common sense and routes suggested by Google Maps. The comparisons (for all user classes) are presented in **Appendix B** and show a very close match between the routes chosen in the model and those suggested by Google Maps, across all modelled time periods.
- **Check 6** – Flat Matrix Assignment Test: ensures that model assignment with a flat matrix produces plausible routeing, and to investigate whether locations with excessively high delays are because of significant flows or due to coding error.

4.10.2. During the network-building process all warnings and errors generated by the SATNET program were reviewed and addressed as appropriate. In addition, the model network was imported into GIS and a series of further logic checks were undertaken. These included:

- Physical characteristics of the coded network (i.e., junction type, number of arms and lanes, lane usage).
- Properties assigned to the network (i.e., distances, speed limits, speed-flow curves, HGV restrictions).
- Anomalies with traffic signal data; and
- Loadings points of zones.

4.10.3. The following serious warnings were yielded. Where no change was considered necessary, spot checks were carried out.

Table 4-2 Serious Warning Checks

Warning Message	Number of cases	Changes needed?
2+ give-way turns in a single lane: Major arm priority jcn.	803	N
A priority marker G looks suspiciously like a merge! (M)	19	Y
A simulation zone is connected to a bus-only link - no exits	1	N

A single lane arm at signals which includes an X-marked turn	22	N
A turn is coded as an X turn but is not the last	5	N
A zone coded under 33333 would be better coded under 22222	274	N
An X marker has no opposing major flows	2	Y
An X-turn at a priority junction has no major turns opposing	2	Y
An X-turn at signals is only in unopposed stages - no TAX	3	N
Buffer zones to stub links: different directionalities;5.5.4	2	N
Bus route with U-turns at non-simulation nodes	14	Y
Calculated speed outside the expected min/max range	19	N
Flare length exceeds link distance and/or 100 metres	1	Y
Give-ways have both shared and unshared lanes	40	N
LCY for a node differs from its neighbours	88	N
Link exists but only in the opposite direction	1	Y
Mixture of late cut-offs and opposed stages for sig. X-turns	1	N
More than one give-way turn sharing a single lane; Priority	116	N
Multiple turns sharing multiple lanes: leads to weaving	3	N
No opposing turns found for a turn with a Priority Marker	6	Y
Possible opportunity for a Clear Exit Priority Modifier?	36	N
Priority marker X has appeared for 2 or more turns on 1 link	1	Y
Rather high or low speed relative to KPHMIN / KPHMAX	2	N
Rather long intergreen time for a stage (> 20 seconds)	17	Y
Redundant intergreen stage time - all turns continuous green	21	Y
Saturation flows differ widely between roundabout arms	1	N
Simulation link distances and/or times differ in reverse	1	Y
Strange stage sequencing for an X-turn at signals	10	N
The mid-link capacity is either >> or << stop-line sat flow	133	N
Total stage plus intergreen times not equal input cycle time	1	Y
Total upstream sat flow inconsistent with lanes downstream	5	Y

Turn coded F - Filter at signals - included in stage defs	3	Y
Turn saturation flows per lane differ widely. See 6.4.6.3	890	N
Two priority turns share the same exit; should one give way?	4	N
Very short red phase	12	N
Very short red phase - less than 1 time unit in duration	8	N
X-Turn shares lanes with a turn which could use inside lanes	3	N

4.10.4. An examination of the network and zone boundaries confirmed that each zone centroid had been loaded within its geographical boundary. Zone connectors in some instances however were found to span either side of a link with an observed count. This is considered not ideal as the model is able to use the choice of which centroid connectors to use as part of the matrix estimation process. Instead, these were updated either by adding a spigot to load into a fixed location, or by creating an additional node such that the centroid connectors do not span the link with the observed count.

4.10.5. The coded link lengths were also checked against the ITN 'real-world' network.

4.10.6. Note additional local network refinements were made during the calibration process (see section 8.2).

5 HIGHWAY MATRIX DEVELOPMENT

5.1 OVERVIEW

5.1.1. This chapter describes procedures used to develop the base year trip matrices for the SATURN traffic model utilising the data sets that were described in Chapter 3.

5.1.2. The development of the trip matrices from the various data sources is described, including how the data sets were utilised for various sectors of the matrices and combined to form the 'prior' matrices.

5.2 DATA FOR MATRIX DEVELOPMENT

5.2.1. The highway matrices consist primarily of Mobile Network Data (MND), which represents a series of anonymised origin destination movements from O2/Telefonica mobile handsets.

5.2.2. Additionally, synthetic matrices are developed to supplement the Mobile Network Data matrices, based on:

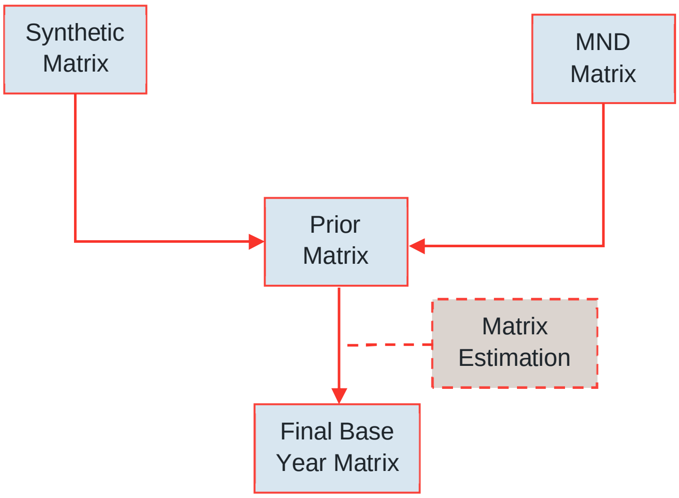
- National Trip End Data (NTEM)
- Census population / workplace population data, and
- National Travel Survey data

5.2.3. The synthetic matrices are used to infill missing movements in Mobile Network Data.

5.3 OVERVIEW OF MATRIX DEVELOPMENT PROCESS

5.3.1. The matrix development process involved 5 main stages and is visualised in Figure 5-1 as follows:

Figure 5-1 Base Matrix Development Process



5.3.2. The methodology adopted for each Stage is detailed in the following sections.

5.4 STAGE 1: CREATION OF SYNTHETIC CAR TRIP MATRICES

5.4.1. Initial verification of the MND against NTS trip length data indicated that there was under reporting of short distance trips (as demonstrated in the plots in Appendix C of the Traffic Data Collection Report[2]). The synthetic matrices were developed in order to infill short distance trips and to provide additional trip purpose segmentation.

5.4.2. The first stage in the matrix development process involved the development of synthetic trip matrices, primarily to infill the short distance car trips within the study area.

5.4.3. The synthetic matrices were developed using a gravity model which involved the following steps:

Step 1: Preparing Inputs

5.4.4. The following inputs were prepared for the synthetic matrix build:

- **NTEM 8.0 Trip Ends:** Production-Attraction Trip Ends were extracted from the National Trip End Model for an average weekday by time period (AM Peak Period, Inter-peak Period, PM Peak Period and Off-Peak Period), purpose (Car Commuting, Car Business, Car Other) and trip type (home based or non-home based);
- **Distance Matrix:** A distance skim was produced from SATURN using an assignment of a flat matrix; and
- **Observed Trip-Length Distribution (TLD):** Each TLD was generated by time period and purpose but also by area type. The TLDs were derived from NTS data from Lincolnshire and Other counties that displayed similar travel statistics.
- **Area Type Classification**: The 2011 Rural-Urban Classification (RUC2011), available from the Office for National Statistics (ONS), was used to apply area type classification to the model zones. The RUC2011 was viewed at the appropriate geography level (output area (OA) lower layer super output area (LSOA)/ middle layer super output area (MSOA)) for each internal model zone and the appropriate classification was set manually. This classification enabled the appropriate trip-length distribution to be applied to each model zone during the gravity model process.
- **Experian MOSAIC data –** a postcode-based mid-year 2021 population dataset which allows for easy aggregation of the statistics to the model zone system which was used to derive population splitting factors.
- **School Data –** Government - published dataset detailing school locations and enrolment size used to derive splitting factors for trip productions relating to education.

Step 2: Calculation of splitting factors for modelled zones

5.4.5. NTEM outputs are provided at the Middle Super Output Area (MSOA) level. This is the most detailed spatial level available.

[2] GLTM2 TDCR v1igt.pdf

5.4.6. For the GLTM2, zones in and around the town are more disaggregate than MSOAs. The NTEM outputs therefore needed to be split into the model zones using sensible markers for trip activity at the production and attraction ends.

5.4.7. For trip productions, Experian MOSAIC mid-year 2021 population statistics were used to split zones within the same MSOA.

5.4.8. For trip attractions, a combination of Census workplace population data by Industry (WP605EW) bound to workplace zones and Census Workplace Population (WP101EW) bound to output areas were combined to provide estimates of attractions per model zone (acting as a proxy for relative trip attractions between zones in the same MSOA)

5.4.9. Splitting factors for trip attractions relating to primary and secondary phase education were derived using government-published schools data including their geolocation and their number of pupils.

5.4.10. Splitting factors for Higher Education (i.e. University) trip attractions were derived using information about universities located within the study area obtained from the websites of those universities.

Step 3: Gravity model

5.4.11. The distribution of the origin productions to destination zones was undertaken using a form of a gravity model that has been undertaken at PA level. A gravity model calculates a theoretical matrix of movements where trips are proportionally less likely to occur as cost between zones increases. It can be carried out as long as there are estimates of trip end totals and a measure of cost representation between model zones.

5.4.12. A bespoke application was used to define and run an iterative search on the parameters for a log-normal deterrence function to optimise the outturn trip length distribution based on the zonal trip ends and pairwise generalised costs that has the closest fit to the observed trip length distribution. The closeness of fit is measured through the R squared metric, represented by:

$$R^2 = 1 - \frac{SS_{res}}{SS_{tot}}$$

Where:

- SS_{res} is the residual sum of squares;
- SS_{tot} is the total sum of squares.

5.4.13. In a trip distribution context, the attractiveness between two zones is proportional to the product of the productions from the origin zone and the attractions to the destination zone.

5.4.14. The log-normal distribution was used to determine the attractiveness from zone i to zone j (F_{ij}) by purpose. The log-normal function with some fitted purpose-specific parameters, μ and σ is described as follows:

$$F_{ij} = \frac{1}{c_{ij}\sigma\sqrt{2\pi}} \exp\left(-\frac{(ln\, c_{ij} - \mu)^2}{2\sigma^2}\right), \qquad c_{ij} > 0$$

…where c_{ij} is the generalised cost of travel from zone i to zone j.

5.4.15. Define:

- P_i as the number of productions for zone i;

- A_j as the number of attractions for zone j.

The number of trips from zone i to zone j in the gravity model is given by:

$$T_{ij} = P_i \frac{A_j F_{ij}}{\sum_k A_k F_{ik}}$$

5.4.16. The calibrated parameters and the resultant R-squared values, which evaluates the fit of the estimated TLD to the observed TLD, are shown in Table 5-1.

Table 5-1 Parameters and R-squared Values - External

Purpose	μ	σ	R^2	alpha	beta
HB Business AM	3.704	1.806	0.728		
HB Business IP	3.682	1.770	0.731		
HB Business OP	3.629	1.617	0.736		
HB Business PM	3.679	1.778	0.732		
HB Work AM	0.855	5.00	0.146		
HB Work IP	0.829	5.00	0.154		
HB Work OP	1.102	5.00	0.141		
HB Work PM	0.656	5.00	0.172		
HB Education AM			0.947	1.668	-0.108
HB Education IP			0.959	2.257	-0.342
HB Education OP			0.965	3.197	-0.407
HB Education PM			0.961	2.495	-0.375
HB Other AM	0.031	3.853	0.901		
HB Other IP	0.004	3.358	0.897		
HB Other OP	0.054	3.629	0.903		
HB Other PM	0.015	3.423	0.902		
NHB Business AM	3.303	4.413	0.683		
NHB Business IP	3.394	3.225	0.690		
NHB Business OP	3.344	2.135	0.699		
NHB Business PM	3.378	2.556	0.694		
NHB Other AM	4.799	5.000	0.031		
NHB Other IP	0.005	5.000	0.594		
NHB Other OP	0.292	4.988	0.606		
NHB Other PM	0.002	4.999	0.596		

NHB Education AM			0.319	-1.567	0.020
NHB Education IP	5.648	4.998	0.271		
NHB Education OP	5.998	4.796	0.258		
NHB Education PM	5.301	4.979	0.276		

Table 5-2 Parameters and R-squared Values – Rural

Purpose	μ	σ	R^2	alpha	beta
HB Business AM	0.145	1.399	0.991		
HB Business IP	0.163	1.400	0.990		
HB Business OP	0.125	1.401	0.991		
HB Business PM	0.218	1.371	0.991		
HB Work AM	1.779	0.772	0.979		
HB Work IP	1.800	0.749	0.979		
HB Work OP	1.828	0.727	0.975		
HB Work PM	1.851	0.694	0.973		
HB Education AM			0.997	1.523	-0.796
HB Education IP			0.987	-0.223	-0.423
HB Education OP			0.991	0.155	-0.587
HB Education PM			0.989	-0.069	-0.520
HB Other AM	1.409	0.737	0.997		
HB Other IP	1.380	0.764	0.996		
HB Other OP	1.475	0.701	0.998		
HB Other PM	1.449	0.725	0.997		
NHB Business AM	1.594	0.828	0.997		
NHB Business IP	1.585	0.831	0.997		
NHB Business OP	1.592	0.807	0.997		
NHB Business PM	1.599	0.808	0.997		

NHB Other AM	1.501	0.771	0.993		
NHB Other IP	1.505	0.787	0.994		
NHB Other OP	1.574	0.747	0.994		
NHB Other PM	1.535	0.769	0.994		
NHB Education AM			0.988	-0.637	-0.193
NHB Education IP	0.412	1.071	0.985		
NHB Education OP	0.357	1.073	0.982		
NHB Education PM	0.261	1.116	0.983		

Table 5-3 Parameters and R-squared Values - Urban

Purpose	μ	σ	R^2	alpha	beta
HB Business AM	1.552	1.047	0.992		
HB Business IP	1.544	1.050	0.992		
HB Business OP	1.557	1.040	0.992		
HB Business PM	1.534	1.035	0.991		
HB Work AM	1.738	0.740	0.995		
HB Work IP	1.715	0.732	0.995		
HB Work OP	1.697	0.718	0.996		
HB Work PM	1.666	0.700	0.998		
HB Education AM			0.999	0.558	-0.967
HB Education IP			0.991	-0.120	0.482
HB Education OP			0.995	0.432	-0.598
HB Education PM			0.999	0.248	-0.512
HB Other AM	1.362	0.925	0.999		
HB Other IP	1.327	0.922	0.999		
HB Other OP	1.188	0.849	0.999		
HB Other PM	1.247	0.879	0.999		

NHB Business AM	1.746	0.918	0.990		
NHB Business IP	1.762	0.920	0.990		
NHB Business OP	1.709	0.903	0.990		
NHB Business PM	1.711	0.904	0.990		
NHB Other AM	0.002	1.324	0.989		
NHB Other IP	0.001	1.409	0.981		
NHB Other OP	0.001	1.305	0.967		
NHB Other PM	0.001	1.377	0.977		
NHB Education AM			0.997	0.010	-0.243
NHB Education IP	0.915	0.996	0.915		
NHB Education OP	1.068	0.945	0.995		
NHB Education PM	1.081	1.027	0.996		

5.4.17. Although Non-Home based gravity models were run with separately sourced trip ends by time period, the low samples of NTS data meant data were combined to produce all-day observed trip length distributions for Non-Home based business and for Non-Home based other.

5.4.18. The graphs shown in Figure 5-2 to Figure 5-7 show the comparison between the estimated TLDs and the respective observed TLDs for AM Home Based Employers business and AM Home Based Work (for (external, rural and urban). Remaining TLD plots for other purposes are included in appendices.

Figure 5-2 TLD - HB – Business – External – AM

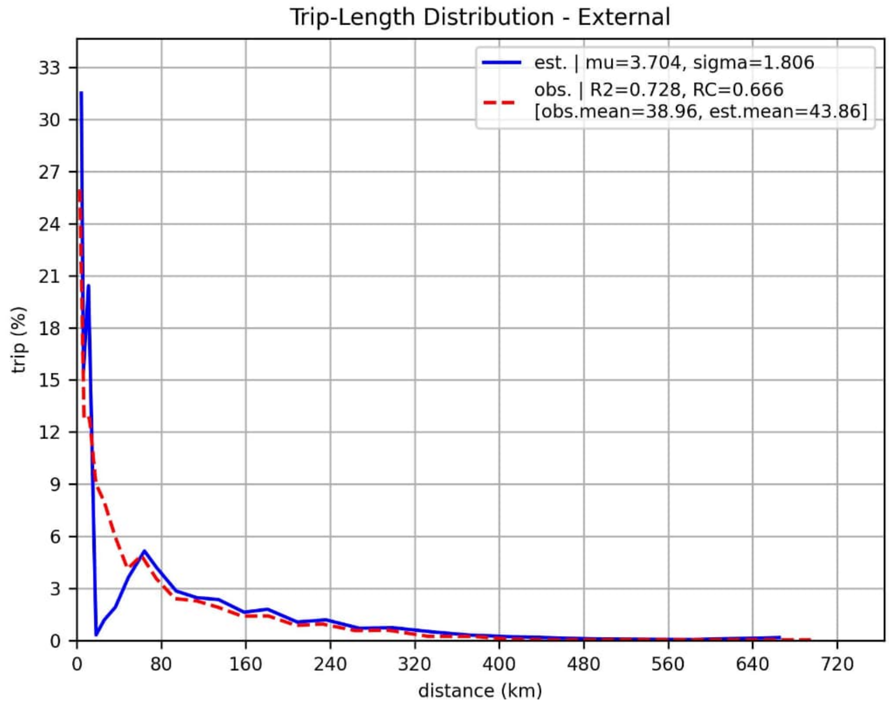


Figure 5-3 TLD - HB – Business – Rural – AM

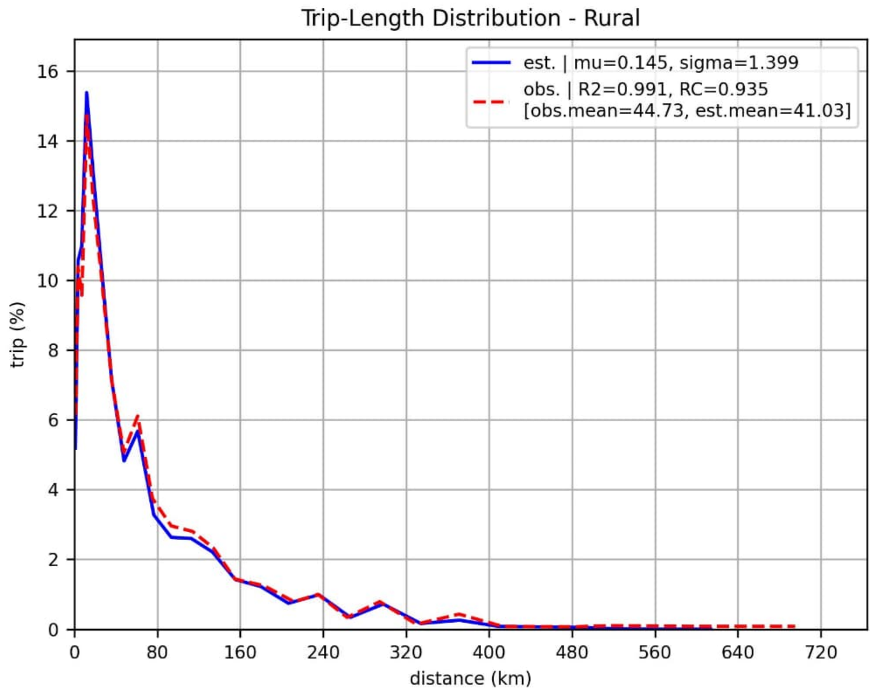


Figure 5-4 TLD - HB – Business – Urban – AM

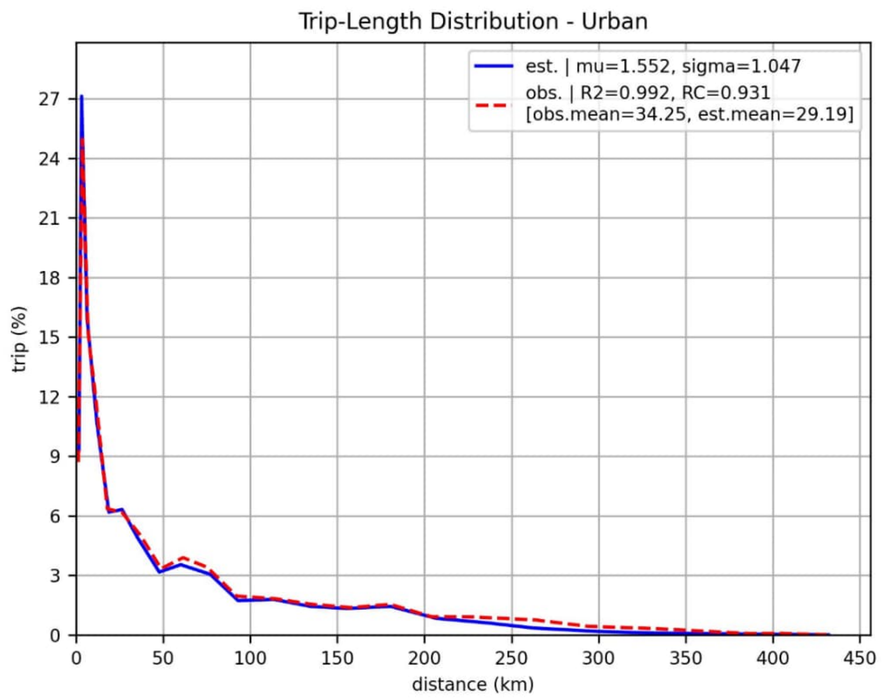


Figure 5-5 TLD - HB – Work – External – AM

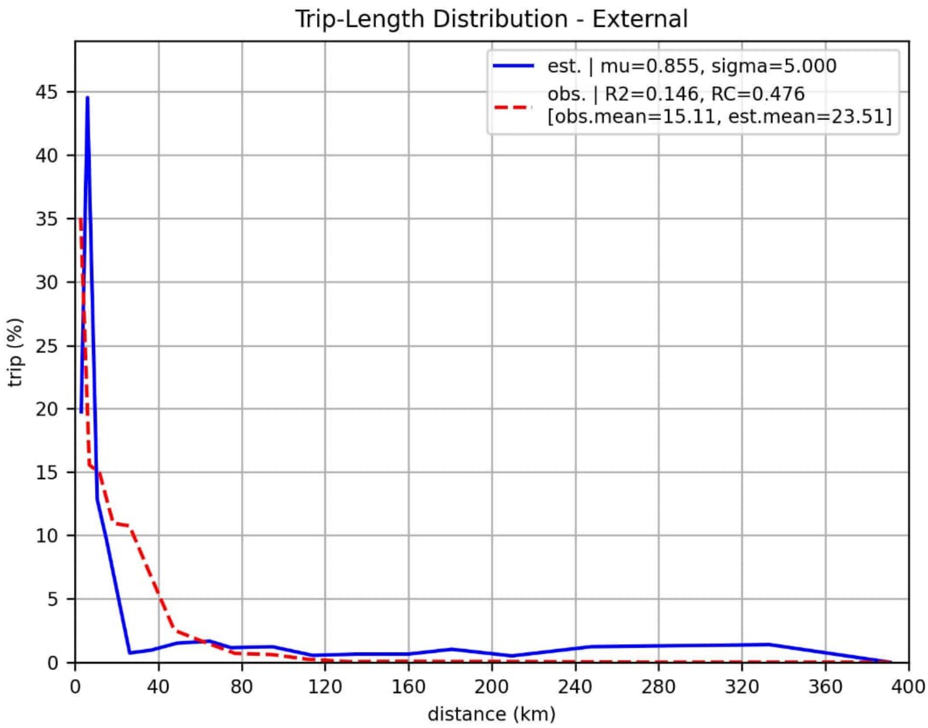


Figure 5-6 TLD - HB – Work – Rural – AM

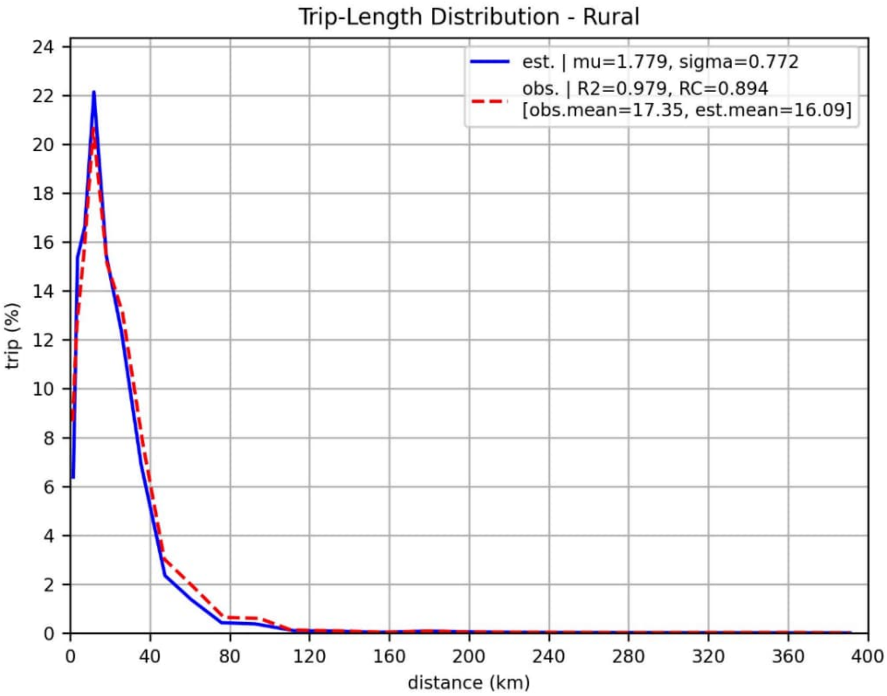
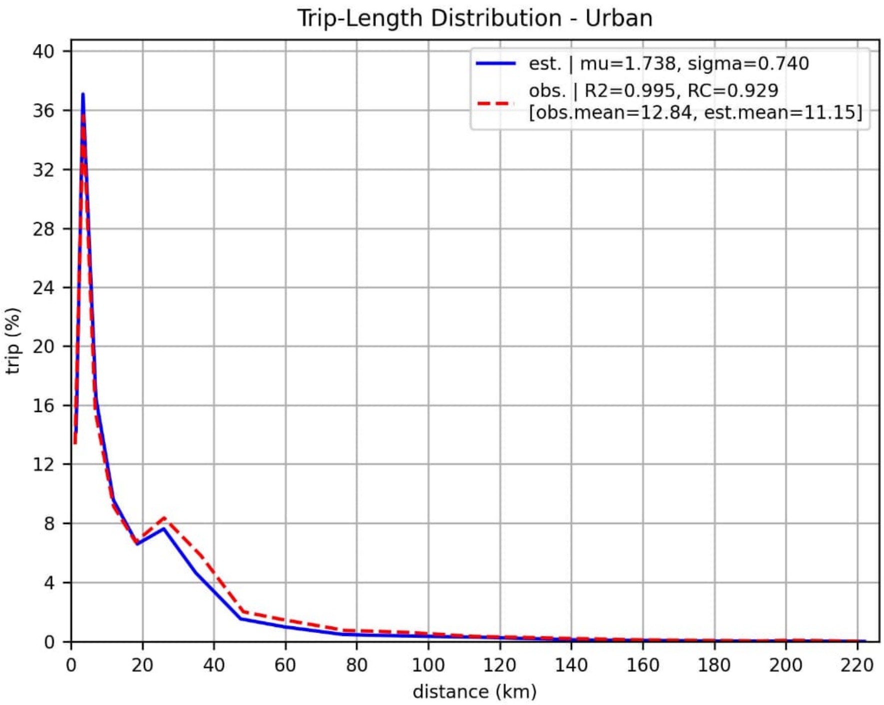


Figure 5-7 TLD - HB – Work – Urban – AM



5.4.19. Table 5-4 summarises the PA demand by time period and purpose, for trips from, to and within the Study Area.

Table 5-4 Summary of PA trips by time period and purpose

Based	Purpose	AM Period	Inter Peak Period	PM Period
Home Based	Business - from home	2,589	1,296	363
	Business - return home	223	1,901	1,926
	Commuting - from home	20,618	3,934	1,748
	Commuting - return home	1,276	7,163	18,024
	Other - from home	22,925	38,895	13,837
	Other - return home	5,336	42,102	19,792
Non-Home Based	Business	1,291	4,249	1,339
	Other	4,840	16,053	5,929

Step 4: Conversion to OD

5.4.20. The synthetic demand matrices were produced in the PA form, by individual time period. To convert to OD format, it is required that information of outbound and return proportions, by each individual time period, be derived so that OD demand can be calculated using the following equation:

$$OD_{ij}^{t} = PA_{ij}^{out/t} + \sum_{k} PA_{ji}^{out/k\,\&\,ret/t}$$

…where: OD_{ij}^{t}= the number of OD trips between zone i and zone j in time period t;

$PA_{ij}^{out/t}$ = the number of outbound PA trips from zone i to zone j departing in time period t;

$PA_{ji}^{out/k\,\&\,ret/t}$ = the number of outbound PA trips from zone j to zone i that depart in any time period but return to zone i in time period t.

5.4.21. For this purpose, matrices of trip-return proportions per each outbound trip by time period were derived from 19 years' worth of NTS data for East of England and East Midlands (2002-2021). These proportions are tabulated in

5.4.22. Table 5-5 to 5-7. 19 years' worth of data was used to provide a reliable sample size.

Table 5-5 Synthetic Matrix – Trip Return Proportions – Urban

Business		RETURN				
		AM	IP	PM	OP	Total
OUTBOUND	AM	0.072	0.413	0.480	0.035	1.00000
	IP	0.009	0.041	0.321	0.162	1.00000
	PM	0.053	0.041	0.354	0.553	1.00000
	OP	0.095	0.391	0.280	0.234	1.00000
Commute		RETURN				
		AM	IP	PM	OP	Total
OUTBOUND	AM	0.051	0.215	0.674	0.060	1.00000
	IP	0.003	0.282	0.337	0.378	1.00000
	PM	0.050	0.015	0.420	0.515	1.00000
	OP	0.058	0.338	0.402	0.202	1.00000
Education		RETURN				
		AM	IP	PM	OP	Total
OUTBOUND	AM	0.232	0.540	0.198	0.029	1.00000
	IP	0.000	0.842	0.147	0.012	1.00000
	PM	0.000	0.000	0.734	0.266	1.00000
	OP	0.000	0.297	0.147	0.577	1.00000
Other		RETURN				
		AM	IP	PM	OP	Total
OUTBOUND	AM	0.194	0.607	0.169	0.030	1.00000
	IP	0.001	0.719	0.244	0.036	1.00000
	PM	0.004	0.010	0.426	0.560	1.00000
	OP	0.035	0.031	0.40	0.894	1.00000

Note: Totals may not sum exactly due to rounding.

Table 5-6 Synthetic Matrix – Trip Return Proportions – Rural

Business		RETURN				
		AM	IP	PM	OP	Total
OUTBOUND	AM	0.036	0.408	0.505	0.051	1.00000
	IP	0.011	0.550	0.341	0.098	1.00000
	PM	0.000	0.025	0.265	0.710	1.00000
	OP	0.118	0.339	0.353	0.189	1.00000
Commute		**RETURN**				
		AM	IP	PM	OP	Total
OUTBOUND	AM	0.027	0.219	0.688	0.066	1.00000
	IP	0.006	0.298	0.399	0.297	1.00000
	PM	0.055	0.062	0.352	0.531	1.00000
	OP	0.052	0.312	0.479	0.157	1.00000
Education		**RETURN**				
		AM	IP	PM	OP	Total
OUTBOUND	AM	0.250	0.514	0.211	0.025	1.00000
	IP	0.000	0.820	0.166	0.014	1.00000
	PM	0.000	0.019	0.821	0.160	1.00000
	OP	0.102	0.000	0.200	0.698	1.00000
Other		**RETURN**				
		AM	IP	PM	OP	Total
OUTBOUND	AM	0.200	0.615	0.159	0.027	1.00000
	IP	0.001	0.731	0.231	0.036	1.00000
	PM	0.005	0.010	0.465	0.519	1.00000
	OP	0.042	0.037	0.024	0.897	1.00000

Note: Totals may not sum exactly due to rounding.

Table 5-7 Synthetic Matrix – Trip Return Proportions – External

Business		RETURN				
		AM	IP	PM	OP	Total
OUTBOUND	AM	0.053	0.410	0.493	0.043	1.00000
	IP	0.010	0.530	0.332	0.128	1.00000
	PM	0.031	0.034	0.318	0.617	1.00000
	OP	0.106	0.366	0.316	0.212	1.00000
Commute		**RETURN**				
		AM	IP	PM	OP	Total
OUTBOUND	AM	0.039	0.217	0.681	0.063	1.00000
	IP	0.004	0.289	0.364	0.343	1.00000
	PM	0.052	0.031	0.396	0.520	1.00000
	OP	0.056	0.328	0.433	0.184	1.00000
Education		**RETURN**				
		AM	IP	PM	OP	Total
OUTBOUND	AM	0.241	0.528	0.204	0.027	1.00000
	IP	0.000	0.832	0.156	0.013	1.00000
	PM	0.000	0.013	0.794	0.193	1.00000
	OP	0.057	0.129	0.177	0.637	1.00000
Other		**RETURN**				
		AM	IP	PM	OP	Total
OUTBOUND	AM	0.197	0.612	0.163	0.028	1.00000
	IP	0.001	0.725	0.238	0.036	1.00000
	PM	0.005	0.010	0.444	0.541	1.00000
	OP	0.038	0.034	0.033	0.895	1.00000

Note: Totals may not sum exactly due to rounding.

5.4.23. The above trip return proportions were applied to the home-based PA demand matrices to produce return trips that travel out in a period and return in the remaining periods.

5.4.24. The return trips were then transposed, and the above equation was used to create the OD matrices by time periods and journey purposes.

5.4.25. The synthetic demand matrices were produced at person-trips level, therefore there was a further step required to convert them to vehicle trips, for purpose of highway assignment. Also, they were produced as period matrices which were required to be converted to hourly matrices. These two conversions were performed using the respective tables as follows.

Table 5-8 Hour-to-Period Factors

Time Period	Hour-to-Period Factors
AM (08:00-09:00)	2.69
IP (average hr)	6
PM (17:00-18:00)	2.73

Source: The peak period factors were derived from collected ATC data.

Table 5-9 Vehicle Occupancies by Purpose and Time Period

Car Purpose	AM	IP	PM
Business	1.20	1.19	1.17
Commuting	1.17	1.15	1.16
Other	1.68	1.65	1.71

Source: TAG data book (May 2023)

5.4.26. The non-home-based trips were also converted into peak hour matrices of vehicle trips.

5.5 STAGE 2: DEVELOPMENT OF TRIP MATRICES FROM MND DATA

5.5.1. The Mobile Network Data are collected across Autumn 2022 (1st October to 27th November, omitting the school half-term holiday), covering a total of 35 weekdays. Data are collected for:

- Road non-HGV (includes car, LGV and bus),
- HGV,
- Rail, and
- Active (not processed)

5.5.2. The MND study area includes Lincolnshire and expands to the west and south to cover parts of Bassetlaw, Newark and Sherwood and Peterborough. Trips to, from or within these internal zones are recorded within the dataset. External to external trips (such as London to Leeds) are only included if they pass through this internal study area.

5.5.3. Data are recorded at census levels of LSOA or MSOA within the study area, and aggregations of MSOA, district and Government Region outside of this. In total there are 290 Mobile Network Zones, of which 162 are internal to the study area. The MND contain trips between the study area and Northern Ireland. The Northern Ireland zone is immediately subsumed within zone 270 (North West) at the start of the process to retain these trips, on the basis of ferry sailings between Great Britain and Northern Ireland.

MND Verification

5.5.4. After receiving Mobile Network Data, the first step was to process a series of verification tests to ensure suitability of the dataset. The findings of the MND verification are presented as an appendix to the Traffic Data Collection Report[3].

5.5.5. The following conclusions were laid out in the verification report:

- Demand segmentations were found to be in line with comparator datasets, although Education trips were inferred to be contained within Work trips;
- Trip end comparisons against NTEM 8.0 show reasonably strong correlation at MSOA and district level; and
- Deficiency of short distance coverage was found. Parameters for blending with synthetic matrices (to infill short distance trips) may vary across Lincolnshire due to variations in market share and mast coverage.

5.5.6. The following steps were undertaken to process the raw data into matrices for the GLTM2.

[3] GLTM2 TDCR v1igt.pdf

Step 1: LGV and Bus Removal

5.5.7. MND road data include car, LGV, and bus. MND are also provided as a separate source for HGV.

5.5.8. The ANPR data have been processed to produce car, LGV, HGV and bus volumes at a sector level. The sectors include an internal cordon as one sector, and 4 separate sectors for external trips. LGV and bus proportions from ANPR sector to sector movements are cascaded down to the MND zones.

5.5.9. ANPR records vehicle trips whilst MND are collected as person trips. An occupancy factor is therefore required to adjust the car proportions of ANPR data to estimate ANPR person trip proportions. The occupancy factor was created as a weighted average of DfT databook v1.21 occupancy values based on proportions of synthetic matrix trips by purpose (business, commute, other). The following steps were carried out:

- Calculate weighted average occupancy (1.65);
- Divide car ANPR proportions by weighted average occupancy to produce ANPR car person trip proportions estimates; and
- Re-scale LGV and bus based on implied non-car ANPR person trip proportions (note an occupancy of one is assumed for HGV).

5.5.10. For internal-to-internal trips within Lincoln that occur wholly within the ANPR cordon, there is no ANPR data available. The proportion of Goods Vehicle trips required to be removed was therefore calculated from the Manual Classified Count data collected within Lincoln as part of the data collection exercise. Equivalently the car proportions were divided by the weighted occupancy of 1.65 to yield an estimate of car, LGV and HGV person trip proportions.

5.5.11. The above process yields a set of LGV and HGV proportions by model zone and time period. Finally, the proportions were assigned an appropriate MND trip purpose to be removed from.

5.5.12. The DfT's TAG databook states there is an 88/12 split between business and non-business trips for Light Goods Vehicles. This is used as a proxy for non-home/home based trip splits. The GV proportions were removed by purpose as:

- LGV: 6% Home Based Non-work outbound, 6% Home Based Non-work inbound, 88% Non-Home Based non-work; and
- HGV: 100% Non-Home Based Non-work.

(*Note this does not mean 100% of Non Home Based Non-work trips are HGV, rather that 100% of HGV trips are considered Non Home Based Non-work).*

Step 2: Zone Split

5.5.13. MND was processed by Telefonica to standardised census areas such as Middle Super Output Area (MSOA). The MND received for the GLTM2 consists of a series of LSOAs, aggregations of LSOAs and MSOAs within Lincolnshire, and aggregations outside of Lincolnshire.

5.5.14. The model zones within the GLTM2 study area are more detailed than the census LSOA layers as the zones are sensitive to particular land use and route choice within Lincoln.

5.5.15. After full splits by mode (into car, bus, LGV, HGV and rail), the MND was split further down to model zone using synthetic matrices. The synthetic matrices for Home Based were developed originally at Production/Attraction level, with National Travel Survey data used to provide an estimate of time of day of return trips to generate Origin Destination time period matrices by direction. Non Home

Based trips were developed by time period at Origin/Destination level. The MND were split down to model zone equivalently at Origin/Destination level by direction and time period, separately for car, bus and rail.

5.5.16. For external zones such as the South East, in some cases the model zones are more aggregate than MND zones – the MND was therefore aggregated to model zones in these areas with no split required.

Step 3: MND and Synthetic Blend

5.5.17. MND is recognised as having limitations in detecting short trips. Synthetic matrices however are not limited by capacity to model trips by distance, although such trips are theoretically derived rather than observed.

5.5.18. A blended matrix was built that incorporates the strengths of both MND and synthetic elements.

5.5.19. MND matrices were developed and compared against synthetic matrices and National Travel Survey (NTS) trip length distribution. NTS data was compiled for trips to and from Lincolnshire for urban and rural areas respectively. There is confidence in the trip length distribution of the synthetic matrices as these have been calibrated against NTS trip lengths.

5.5.20. The matrix blend is based on three categories:

- Short trips (entirely synthetic),
- Middle distance trips (MND trips scaled up to match synthetic trip totals), and
- Long trips (entirely MND)

5.5.21. The distance thresholds are calculated in the following way:

Short/Middle distance cut-off:

5.5.22. MND trip lengths are compared to NTS at distance band intervals, initially for 2km and following up in bands of 4km. The distance band with the highest proportion of trips in both synthetic and NTS is 2 to 6km. Since this peak is not present in MND, there is not enough confidence in the MND under 6km. Therefore, those trips under 6km are taken as entirely synthetic. (Plots are presented in Appendix C in the Traffic Data Collection Report with and without the distance cut-offs).

Middle distance trips:

5.5.23. The trips in the middle band are believed to be correctly identified in the MND but under-represented due to bias in the data towards longer distance capture. For these trips, the distribution is retained from the MND but scaled to match synthetic totals at Local Authority District level.

Middle / long distance cut-off: Coincidence ratio

5.5.24. The coincidence ratio was calculated between MND and NTS. This calculation takes the min and max value (of either MND or NTS) at each distance band, summing the total minimums by the total maximums. The calculation tends towards 1, with the higher the score, the better the value (the closer matched the datasets are to each other).

5.5.25. With trips under 6km excluded from MND, the coincidence ratio is calculated at various thresholds of trip exclusion. The chosen lower and upper distance cut-offs by trip purpose are as follows:

Table 5-2 Distance cut-offs for MND/synthetic blend

Purpose	Lower	Upper
Urban Home Based Work	6	14
Urban Home Based Other	6	14
Urban Non-Home Based	6	14
Rural Home Based Work	6	14
Rural Home Based Other	6	18
Rural Non Home Based	6	18

Step 4: Purpose Segmentation

5.5.26. MND was collected at the following trip purposes:

- Home Based Work From Home;
- Home Based Work To Home;
- Home Based Non-Work From Home;
- Home Based Non-Work To Home;
- Non-Home Based Work; and
- Non-Home Based Non Work.

5.5.27. Verification of the MND (against National Travel Survey) suggests Education trips may be grouped together with work. The MND are split into the following purposes using the synthetic matrices, by time period, as shown in table 5-3.

Table 5-3 MND to Model Purpose Disaggregation Purpose

MND Purpose	Model Purpose
Home Based Work From Home	Home Based Work From Home
	Home Based Education From Home
Home Based Work To Home	Home Based Work To Home
	Home Based Education To Home
Home Based Non Work From Home	Home Based Business From Home
	Home Based Other From Home
Home Based Non Work To Home	Home Based Business To Home
	Home Based Other To Home
Non Home Based (Work and Non-Work)	Non Home Based Business
	Non Home Based Education
	Non Home Based Other

Car Matrix Totals

5.5.28. Table 5-4 shows the trip totals yielded from the prior matrix (in persons at whole time period level) by trip purpose, for trips to and from the Study Area.

Table 5-4 Car Prior Matrix Totals (person, whole time period by OD Direction)

Trip Purpose	AM	IP	PM
Business From Home	6,044	3,170	1,863
Business To Home	1,535	4,092	3,543
Work From Home	42,405	14,111	3,765
Work To Home	2,669	18,516	42,291
Other From Home	26,738	67,806	27,286
Other To Home	10,345	74,992	35,421
Education From Home	19,974	11,452	717
Education To Home	1,761	8,068	5,544
Non Home Based Business	3,450	3,895	2,642
Non Home Based Other	16,495	18,870	20,109

5.6 STAGE 3: DEVELOPMENT OF LGV MATRICES

5.6.1. Although ANPR provides an estimate of LGV to be removed (to leave remnant car and bus), there remains a bias in resulting remnant LGV trips in under-detection of short trips. Inrix Origin Destination data was sourced to provide LGV matrices used in the model.

5.6.2. The data consist of Inrix trips made throughout June 2023 for a defined catchment area around Lincoln. (More information on the Inrix data specification can be found in the Traffic Data Collection Report[4]).

5.6.3. The data are broken down by vehicle weight classification. The class "Medium Duty Trucks / Vans: ranges from 14,001-26,000 lb." was taken as a proxy for LGV and constitutes approximately 90% of the sample.

5.6.4. The data consists of the Inrix sample of vehicles. In order to expand the sample in the model, the 'trajectories' data (confirming each MasterMap link traversed by each trip) were summed at model links in a cordon around Lincoln. The following steps were taken:

1. Trips data for weight class 2, weekday by time period, were assigned to model zone based on start and end coordinates;

2. Separately, the Inrix 'trajectories' data were processed to reveal the number of times a vehicle traversed each cordon link;

3. Observed ATC/MCJC trip volumes for LGV were multiplied by peak hour factors to aggregate to whole time period (AM: 2.69, IP:6, PM: 2.733);

4. Trajectories data and observed ATC/MCJC data were aggregated to sector level and direction; and

5. Expansion factors were calculated by comparing the trajectories link data to observed ATC/MCJC data at each sector, by time period and direction.

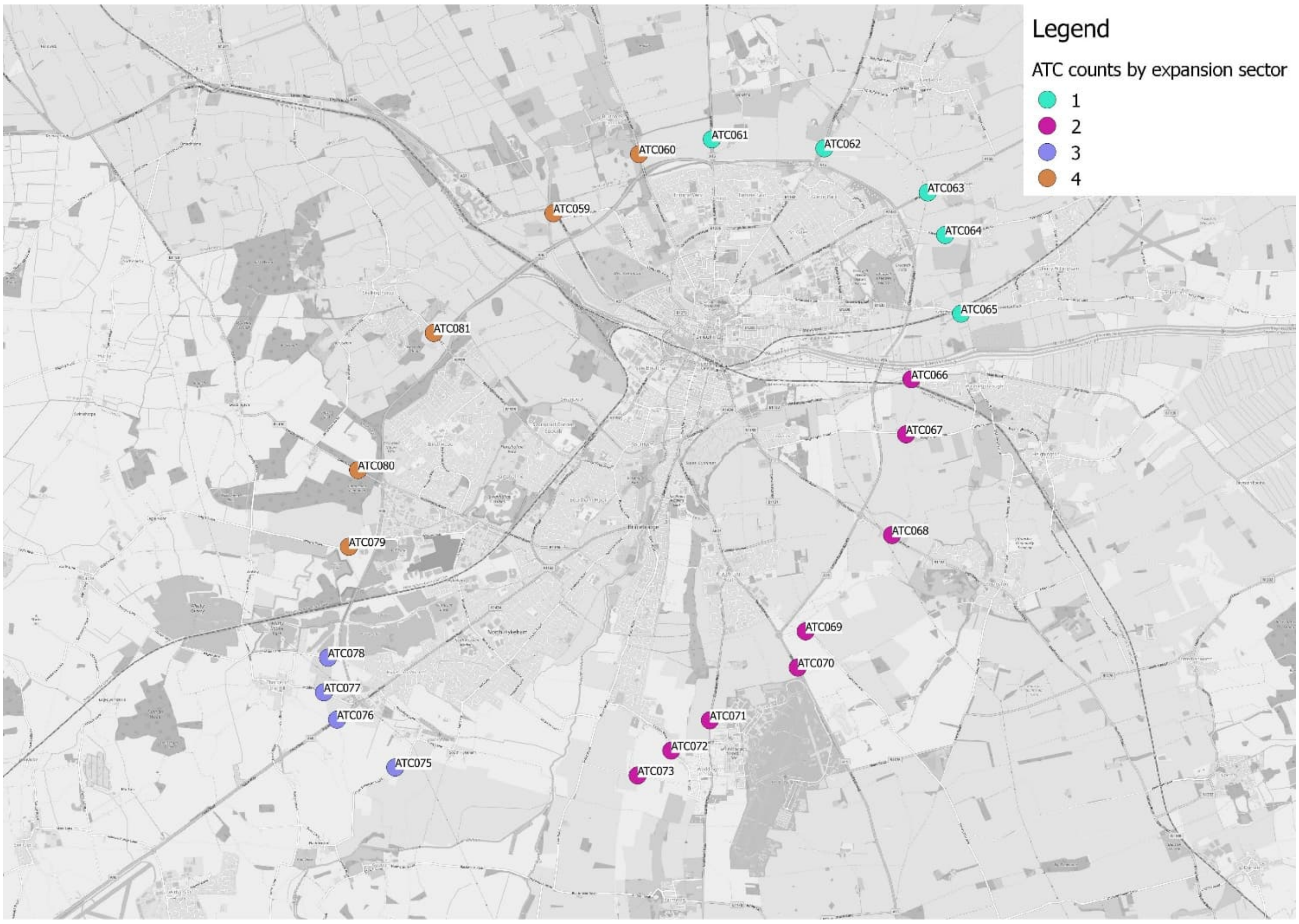
5.6.5. For trips within the Lincoln cordon an average expansion factor was calculated based on the overall cordon data.

5.6.6. The Inrix data was captured at vehicle level (rather than persons) and so an occupancy factor of 1 was applied when the matrices (containing car trips in persons at that stage) were converted into vehicles.

5.6.7. The cordon counts form the following sectors as illustrated in Figure 5-8.

[4] GLTM2 TDCR v1igt.pdf

Figure 5-8 - Expansion sectors formed from ATCs



5.6.8. The following expansion factors have been applied. It is noted that expansion factors are higher in the PM peak period, reflecting a lower sample of Inrix vehicles in that time period. However, impacts of matrix estimation (section 7.4) show similar patterns between AM and PM suggesting the PM is a suitable sample matrix.

Table 5-5 LGV expansion factors by time period

Origin Sector	Destination Sector	AM	IP	PM
1	1	7.1	6.7	24.9
1	2	8.3	7.9	28.9
1	3	7.0	7.3	24.8
1	4	8.6	7.7	24.8
1	5	7.2	6.5	22.1
2	1	9.2	7.3	31.0
2	2	10.4	8.5	35.0
2	3	9.1	8.0	30.8
2	4	10.7	8.3	30.9
2	5	11.4	7.9	34.3
3	1	10.7	9.4	39.4
3	2	12.0	10.6	43.5
3	3	10.7	10.0	39.3
3	4	12.3	10.4	39.3
3	5	14.5	11.9	51.2

4	1	8.0	8.3	33.7
4	2	9.2	9.5	37.8
4	3	7.9	9.0	33.6
4	4	9.5	9.3	33.6
4	5	9.0	9.9	39.7
5	1	6.9	6.8	27.7
5	2	9.4	9.2	35.8
5	3	6.9	8.0	27.4
5	4	10.0	8.8	27.5
5	5	8.4	7.9	29.5

5.7 STAGE 4: CONVERSION TO SATURN USER CLASS FORMAT

5.7.1. After blending car MND with synthetic matrices (stage 2) and updating LGV matrices (stage 3), the matrices were retained at whole time period level, separately by home basis. Trips were aggregated into the following SATURN user classes.

Table 5-6 MND Trip Purpose Allocation to SATURN User Class

MND purpose	User Class
From Home Business	Business
To Home Business	
Non-Home Based Business	
From Home Work	Commute
To Home Work	
From Home Other	Other
From Home Education	
To Home Other	
To Home Education	
Non-Home Based Other	
Non-Home Based Education	
LGV	LGV
HGV	HGV

5.7.2. Trips were then converted from whole period to peak hour based on the peak hour factors calculated from the collected ATC data (Inter-peak is utilised as inter-peak). Note the PM is taken as an average of 16:00 to 18:00.

Table 5-7 Peak Hour Factors

AM	PM
2.69	2.733

5.7.3. Car trips were converted from person to vehicle based on standard TAG databook v1.21 occupancy factors. Note that LGV matrices (stage 3) were calculated in vehicles so an occupancy factor of 1 was applied at this stage. HGV is assumed an occupancy of 1.

Table 5-8 Vehicle Occupancy Factors

User Class	AM	IP	PM
Business	1.20	1.19	1.17
Commute	1.17	1.15	1.16
Other	1.68	1.65	1.71
HGV	1	1	1

5.7.4. The following trip totals in vehicles from, to and within the Study Area are shown in table 5-11.

Table 5-9 Summary of Peak Hour Prior Matrices by User Class and Time Period (vehicles)

User Class	AM	IP	PM
Business	3,430	1,557	2,524
Commute	14,308	4,711	14,472
Other	16,713	18,316	19,080
LGV	7,442	5,048	6,140
HGV	4,393	3,753	2,857
Total	**46,286**	**33,385**	**45,073**

5.8 STAGE 5: ASSESSMENT OF 'PRIOR' TRIP MATRICES

Before undertaking matrix estimation the prior matrices were assigned to the network as a check on their performance. Tables 5-10 to 5-12 show the comparisons between the modelled flows across calibration screenlines (note Figure 7-3 in section 7.3 illustrates the location of the calibration screenlines). Modelled flows for car are typically slightly higher than observed.

Table 5-10 Comparison of AM Prior Matrix Against Screenline/Cordon Counts

Screenline		AM Peak											
		Car				LGV				HGV			
ID	Name	Observed	Modelled	Difference	GEH	Observed	Modelled	Difference	GEH	Observed	Modelled	Difference	GEH
3	Outer East Screenline Inbound	705	814	15%	4.0	146	145	0%	0.1	50	49	-3%	0.2
4	Outer East Screenline Outbound	371	470	27%	4.9	236	202	-14%	2.3	84	69	-18%	1.7
9	LEB Screenline Inbound	2,599	2,863	10%	5.1	332	348	5%	0.8	105	91	-14%	1.5
10	LEB Screenline Outbound	1,223	1,344	10%	3.4	298	370	24%	3.9	158	139	-12%	1.5
11	LSB Screenline Inbound	2,133	2,195	3%	1.3	401	431	8%	1.5	233	194	-17%	2.7
12	LSB Screenline Outbound	1,661	1,900	14%	5.7	449	457	2%	0.4	281	255	-9%	1.6
13	LWB Screenline Inbound	839	969	15%	4.3	132	144	10%	1.1	70	78	11%	0.9
14	LWB Screenline Outbound	646	681	5%	1.4	188	155	-18%	2.5	74	62	-16%	1.4
15	LNB Screenline Inbound	2,326	2,386	3%	1.2	384	425	11%	2.0	249	217	-13%	2.1
16	LNB Screenline Outbound	1,567	1,582	1%	0.4	331	401	21%	3.7	205	175	-15%	2.2
21	Inner SouthEast Screenline Inbound	2,044	2,066	1%	0.5	193	257	34%	4.3	43	40	-8%	0.5
22	Inner SouthEast Screenline Outbound	820	983	20%	5.4	151	244	62%	6.7	70	70	0%	0.0
23	Inner SouthWest Screenline Inbound	1,926	2,109	10%	4.1	237	276	17%	2.4	50	59	19%	1.3
24	Inner SouthWest Screenline Outbound	1,398	1,500	7%	2.7	247	268	9%	1.3	59	70	18%	1.3
31	Inner EastWest 1 Screenline Inbound	1,105	1,467	33%	10.1	180	224	25%	3.1	44	52	19%	1.2
32	Inner EastWest1 Screenline Outbound	1,140	1,228	8%	2.6	106	156	46%	4.3	36	43	19%	1.1
33	Railway Screenline Inbound	2,118	2,127	0%	0.2	281	239	-15%	2.6	63	73	17%	1.3
34	Railway Screenline Outbound	1,849	2,093	13%	5.5	220	247	12%	1.8	76	89	18%	1.5

Table 5-11 Comparison of IP Prior Matrix Against Screenline/Cordon Counts

Screenline		IP											
		Car				LGV				HGV			
ID	Name	Observed	Modelled	Difference	GEH	Observed	Modelled	Difference	GEH	Observed	Modelled	Difference	GEH
3	Outer East Screenline Inbound	505	591	17%	3.7	128	122	-5%	0.5	54	43	-20%	1.5
4	Outer East Screenline Outbound	528	574	9%	1.9	105	97	-8%	0.8	60	53	-11%	0.9
9	LEB Screenline Inbound	1,420	1,521	7%	2.6	249	254	2%	0.3	116	117	1%	0.1
10	LEB Screenline Outbound	1,537	1,609	5%	1.8	236	238	1%	0.1	105	108	3%	0.3
11	LSB Screenline Inbound	1,387	1,479	7%	2.4	341	373	9%	1.7	307	262	-15%	2.7
12	LSB Screenline Outbound	1,409	1,518	8%	2.9	330	367	11%	2.0	272	255	-7%	1.1
13	LWB Screenline Inbound	593	614	4%	0.9	103	110	7%	0.7	48	68	40%	2.5
14	LWB Screenline Outbound	664	691	4%	1.0	115	116	1%	0.1	51	60	18%	1.2
15	LNB Screenline Inbound	1,491	1,543	4%	1.3	272	306	12%	2.0	224	211	-6%	0.9
16	LNB Screenline Outbound	1,427	1,503	5%	2.0	265	302	14%	2.3	256	219	-15%	2.4
21	Inner SouthEast Screenline Inbound	976	1,093	12%	3.6	141	186	31%	3.5	63	55	-13%	1.0
22	Inner SouthEast Screenline Outbound	1,028	1,134	10%	3.2	141	197	39%	4.3	48	49	2%	0.2
23	Inner SouthWest Screenline Inbound	1,489	1,513	2%	0.6	200	213	6%	0.9	57	66	16%	1.1
24	Inner SouthWest Screenline Outbound	1,612	1,664	3%	1.3	216	227	5%	0.7	68	67	0%	0.0
31	Inner EastWest 1 Screenline Inbound	865	1,111	28%	7.8	143	159	12%	1.3	31	45	47%	2.3
32	Inner EastWest1 Screenline Outbound	863	967	12%	3.5	128	142	11%	1.2	29	45	58%	2.7
33	Railway Screenline Inbound	1,505	1,516	1%	0.3	202	194	-4%	0.5	67	89	33%	2.5
34	Railway Screenline Outbound	1,631	1,726	6%	2.3	237	247	4%	0.6	64	83	30%	2.2

Table 5-12 Comparison of PM Prior Matrix Against Screenline/Cordon Counts

Screenline		PM Peak											
		Car				LGV				HGV			
ID	Name	Observed	Modelled	Difference	GEH	Observed	Modelled	Difference	GEH	Observed	Modelled	Difference	GEH
3	Outer East Screenline Inbound	574	695	21%	4.8	164	151	-8%	1.0	36	33	-8%	0.5
4	Outer East Screenline Outbound	720	803	12%	3.0	170	142	-16%	2.2	41	36	-13%	0.8
9	LEB Screenline Inbound	1,591	1,646	4%	1.4	315	336	7%	1.2	73	71	-3%	0.2
10	LEB Screenline Outbound	2,475	2,638	7%	3.2	323	321	-1%	0.1	65	57	-12%	1.0
11	LSB Screenline Inbound	2,195	2,262	3%	1.4	467	475	2%	0.4	153	125	-18%	2.4
12	LSB Screenline Outbound	2,007	2,260	13%	5.5	298	392	32%	5.1	157	131	-17%	2.2
13	LWB Screenline Inbound	696	800	15%	3.8	124	128	3%	0.4	27	28	3%	0.2
14	LWB Screenline Outbound	943	1,013	7%	2.2	146	130	-11%	1.4	30	32	5%	0.3
15	LNB Screenline Inbound	1,991	2,035	2%	1.0	410	425	4%	0.8	155	132	-15%	1.9
16	LNB Screenline Outbound	2,464	2,361	-4%	2.1	377	397	5%	1.0	122	101	-17%	1.9
21	Inner SouthEast Screenline Inbound	1,061	1,162	10%	3.0	132	245	86%	8.2	24	27	9%	0.4
22	Inner SouthEast Screenline Outbound	1,715	1,829	7%	2.7	160	250	56%	6.3	18	21	15%	0.6
23	Inner SouthWest Screenline Inbound	1,670	1,645	-1%	0.6	191	193	1%	0.1	19	23	25%	1.0
24	Inner SouthWest Screenline Outbound	2,201	2,215	1%	0.3	253	319	26%	3.9	20	34	66%	2.6
31	Inner EastWest 1 Screenline Inbound	1,148	1,467	28%	8.8	128	112	-12%	1.5	17	24	44%	1.6
32	Inner EastWest1 Screenline Outbound	1,220	1,460	20%	6.6	135	148	10%	1.1	23	25	8%	0.4
33	Railway Screenline Inbound	1,891	1,939	3%	1.1	197	196	-1%	0.1	26	41	58%	2.6
34	Railway Screenline Outbound	2,240	2,255	1%	0.3	243	252	4%	0.6	24	38	57%	2.5

5.9 PRIOR MATRIX CALIBRATION

5.9.1. The derived 'prior' matrices were assigned to the networks and reviewed at a link and screenline level to determine performance against the model validation criteria (a relaxed threshold of 10%, as opposed to 5%, was used for the screenline performance at this stage). The high-level statistics for link flow performance and screenline performance for all links and screenlines are reported in Table 5-13 and Table 5-14.

Table 5-13 Link Flow Performance Summary – Prior Matrices (All Vehicles)

Performance Measure	AM Peak	Inter Peak	PM Peak
Calibration links:			
Pass TAG Flow Criteria	74%	79%	76%
Pass TAG GEH Criteria	70%	76%	71%
Validation links:			
Pass TAG Flow Criteria	83%	86%	84%
Pass TAG GEH Criteria	78%	83%	80%

Table 5-14 Screenline Performance Summary – Prior Matrices (All Vehicles)

Performance Measure	AM Peak	Inter Peak	PM Peak
All screenlines:			
Screenlines and Cordons within 10% of observed flows	74%	87%	79%
Screenlines and Cordons within GEH < 4 of observed flows	74%	89%	82%
Calibration screenlines:			
Screenlines and Cordons within 10% of observed flows	56%	75%	63%
Screenlines and Cordons within GEH < 4 of observed flows	50%	75%	69%
Validation screenlines:			
Screenlines and Cordons within 10% of observed flows	86%	95%	91%
Screenlines and Cordons within GEH < 4 of observed flows	91%	100%	91%

5.10 STAGE 6: REFINING OF TRIP MATRICES USING MATRIX ESTIMATION

5.10.1. This stage of the matrix development process is detailed in Chapter 7.

6 ASSIGNMENT PROCESS

6.1 OVERVIEW

6.1.1. The GLTM2 has been constructed in the SATURN modelling suite using an assignment process based upon Wardrop's Equilibrium Theory. The theory states that traffic arranges itself on a network so that the costs of travel on a route between an origin and a destination is equal to, or less than, all other potential but unused routes. This applies to all trips in the network such that the lowest overall or aggregate cost within the network extents can be achieved.

6.1.2. The 2023 base year model has been developed using SATURN version 11.5.05N. The modelling suite covers all aspects of transport modelling from initial network and matrix construction through to detailed assignment and is further described in the remainder of this chapter.

6.2 GENERALISED COST, VALUES OF TIME AND VEHICLE OPERATING COSTS

6.2.1. The highway assignment model has two parameters that are defined for each user class to calculate generalised cost. These combine journey times, journey distances and any tolls included in the model into a standard unit of generalised time based upon these two parameters.

6.2.2. The two parameters are the pence per minute (ppm) and the pence per kilometre (ppk) associated with each user class and are calculated using the following formula:

$$GeneraliseD Costs_{minutes} = JourneyTime_{minutes} + \left(\frac{ppk}{ppm}\right) * JourneyDistance_{km} + \left(\frac{1}{ppm}\right) * Toll_{pence}$$

6.2.3. For each of the five user classes detailed in Section 2.4, a generalised cost formulation is required to produce a standardised journey time cost for any trip in the network based on distance and time coefficients.

6.2.4. Within the GLTM2 the cost of a trip through the network is calculated as a combination of two elements:

- The cost of the road user's time (value of time); and
- The operating cost of the vehicle (vehicle operating cost)

6.2.5. The values of the PPM and PPK parameters within the assignment are based on the TAG databook v1.21 released by the DfT in May 2023. The PPK values were derived based on an average network speed of 37kph.

6.2.6. As per WebTAG guidance M3.1, section 2.8.8 states that the Value of Time for HGVs provided within the TAG Databook does not take into account the influence of owners on the routeing of HGVs. WebTAG suggests that the HGV Values of Time should be around twice that which is stated within the TAG Databook.

6.2.7. Information obtained from the "Advice on Modelling of Congestion Charging or Tolling Options for Multimodal Studies", ITEA division January 2002, which is based on the report "The Value of Time on UK roads – 1996" produced by Accent Marketing and Hague Consulting Group, shows that an average factor of 2.3 should be applied to the TAG Databook's HGV Values of Time to reflect the operational practises of freight operators. Since no further analysis has been conducted, the above factor was used for the purpose of the calculation of the PPM values for HGVs.

6.2.8. TAG requires that if the higher value of time for HGVs is used (which is the case of the GLTM2 it has been) then a sensitivity test showing the impact of using these values of time is undertaken. To that end SATURN assignments with and without the adjustment factor applied have been run and Figure 6-1 and Figure 6-2 show the HGV flow difference between the with and without adjustment factor assignments in both the AM Peak and PM Peak periods (the calculation being without adjustment factor – with adjustment factor). They show that without the adjustment factor HGVs would be less inclined to use the SRN/MRN (which allow for faster speeds but are longer distances) and more inclined to drive through the city centre of Lincoln (which is the short distance but have slower speeds). This is unrealistic based on the observed data and therefore justifies use of the adjustment factor.

Figure 6-1 - HGV Flow Difference - AM Peak

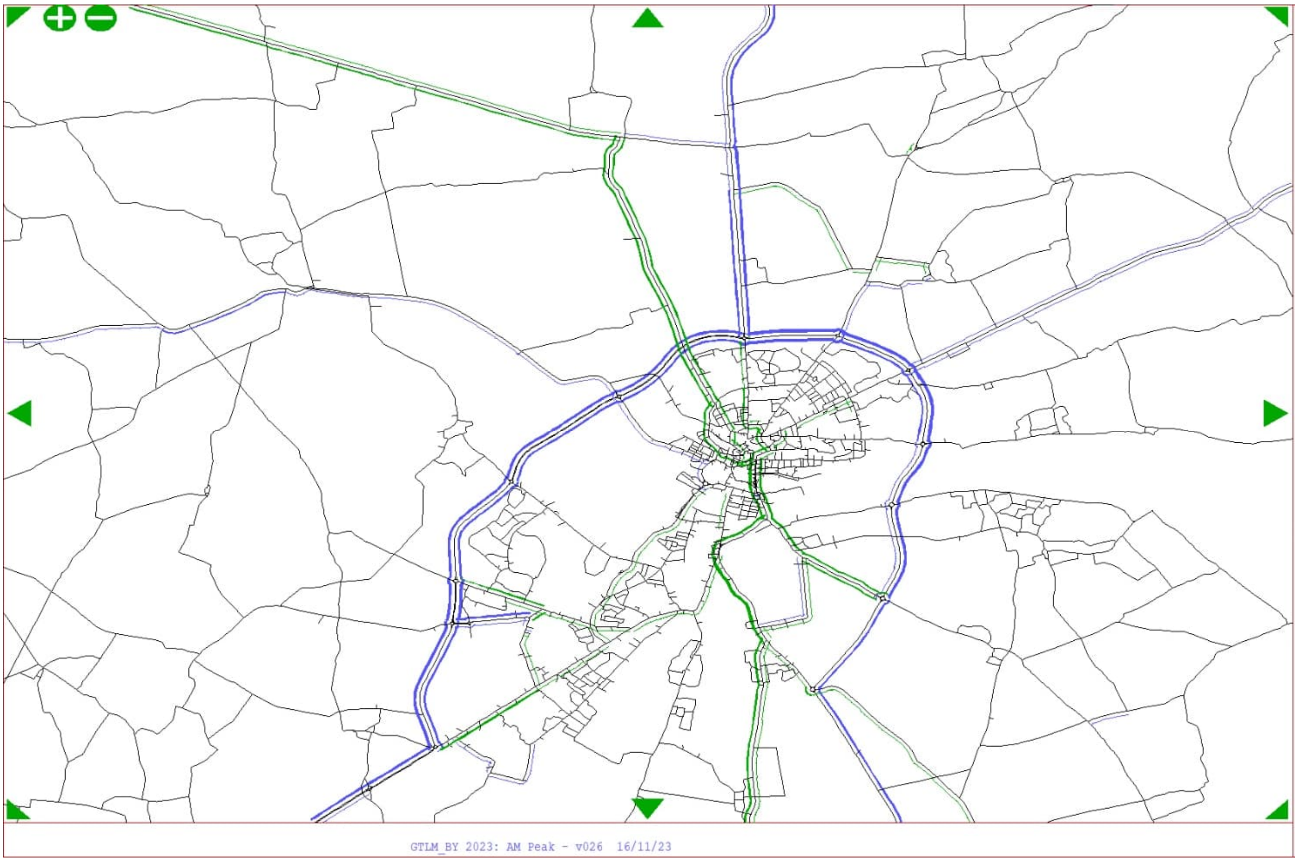
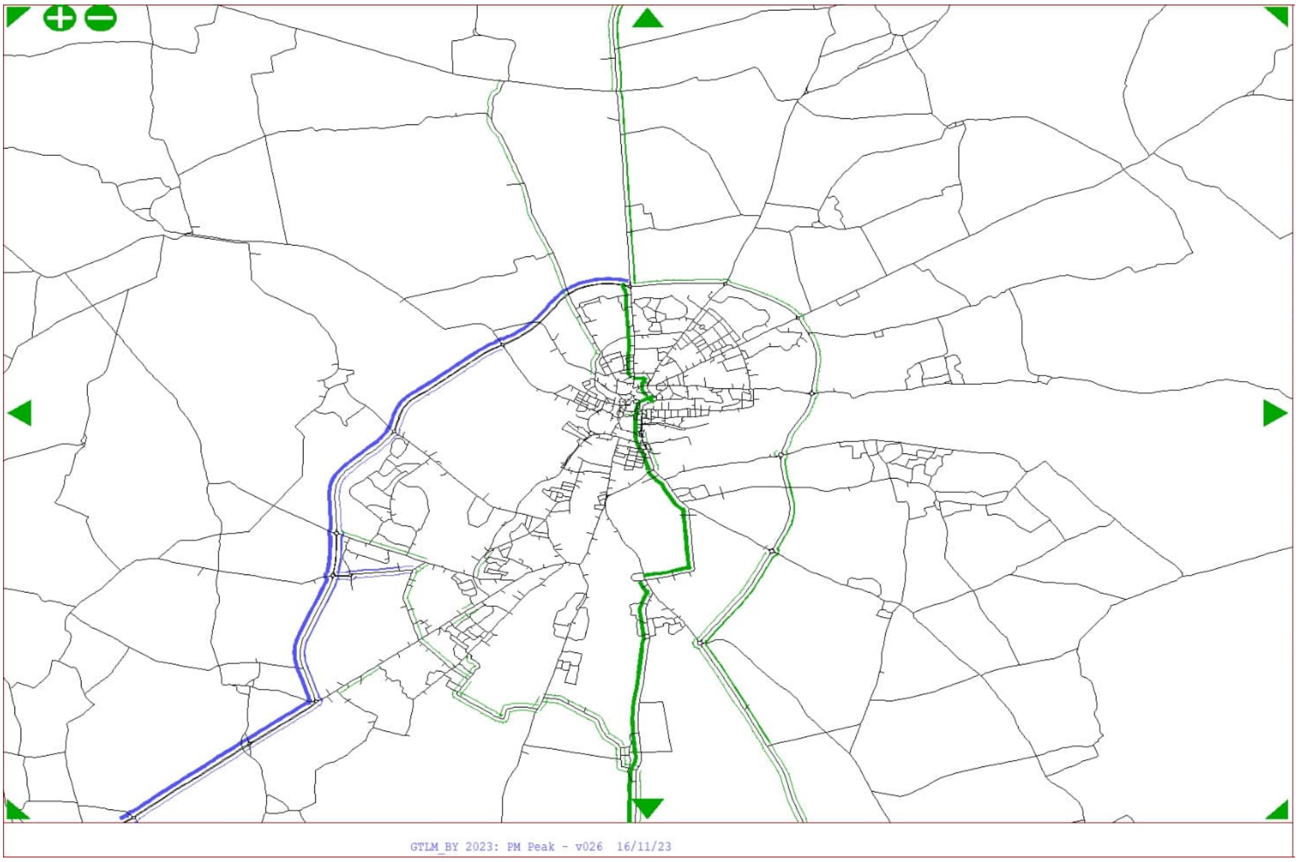


Figure 6-2 - HGV Flow Difference - PM Peak



6.2.9. Table 6-1 displays the generalised costs (per PCU) that were used in the base year model.

Table 6-1 Base Year PPM & PPK Values

Journey Purpose	PPM			PPK		
	AM	IP	PM	AM	IP	PM
Car – Business	30.75	31.51	31.19	14.49	14.38	14.49
Car - Commute	20.62	20.96	20.69	8.23	8.17	8.23
Car - Other	14.23	15.15	14.90	8.23	8.17	8.23
LGV	22.28	22.28	22.28	15.45	15.37	15.45
HGV	51.04	51.04	51.04	44.10	43.71	44.10

6.3 CONVERGENCE CRITERIA

6.3.1. Model convergence criteria has been set out as required in TAG Unit M3.1 Section 2.

6.3.2. Model convergence guidance, outlined in the TAG guidance, seeks to ascertain the stability of the assignment. This means that as SATURN loops between assignment and simulation, gradually getting closer to convergence, the assignment of trips to links between loops becomes more consistent and less likely to be reassigned. Ultimately a model is considered to be converged when it reaches a point in the assignment process where it obeys Wardrop's First Principle of Traffic Equilibrium – that the generalised costs for any chosen route is equal or less than the generalised costs on alternative routes.

6.3.3. The first measure relates to how close the model is to a particular converged situation, which varies depending on the preferences of the user in the Parameters section of the SATURN input data file. This is discussed in Section 0. Gap (denoted 'σ') is calculated as follows:

$$\sigma = \frac{\sum T_{pij}(C_{pij} - C^*_{ij})}{\sum T_{ij} C^*_{ij}}$$

Where:

Tpij is the flow on route p from origin *i* to destination *j*

Tij is the total travel from *i* to *j*

Cpij is the (congested) cost of travel from *i* to *j* on path *p*

Cij is the minimum cost of travel from *i* to *j*

6.3.4. The gap value 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 origin-destination pair and multiplied by the number of trips between those pairs. This is divided by the minimum cost summed over each route by each origin-destination pair, also multiplied by the number of trips between those pairs. 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 6-2.

Table 6-2 TAG 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%

6.3.5. The second measure relates to the stability indicator. TAG Unit M3.1 provides the convergence criteria that transport models should aim to achieve in order to provide stable, consistent and robust results.

6.3.6. The GLTM2's base year performance against both proximity and stability measures is reported in Table 8-1.

6.4 SUMMARY OF ASSIGNMENT PARAMETERS USED BY SATURN

6.4.1. The Parameters section of a SATURN data input file contains user definable attributes for options within the model. Several of these relates specifically to model convergence. Table 6-3 highlights the parameters that have been modified within the assignment.

Table 6-3 SATURN Assignment Parameter Modified Attributes

Parameter	Function	Default Value	Amended Value
MASL	Maximum number of assignment-simulation loops	15	100
KONSTP	Control of Stopping Criteria: based on selection	0 (ISTOP)	5
ISTOP	Used in convergence of assignment/simulation loops	95% (TAG criteria 98%)	99%
NOMADS	Number of multiple user classes to be assigned separately	1	5
CLICKS	Sets the maximum speed limit by user class	Optional parameter	96
STPGAP	Critical gap value (%) used to terminate assignment-simulation loops when KONSTP = 1 or 5	1% (TAG criteria 0.1%)	0.01%
PCNEAR	Percentage change in flows judged to be "near" in successive assignments	1	1
NISTOP	The number of successive loops which must satisfy the "ISTOP" criteria in the test for convergence of the assignment/simulation loops.	4	4

6.4.2. By setting the parameter KONSTP to '5' SATURN seeks to terminate the assignment only when proximity (STPGAP) and stability (RSTOP/PCNEAR/NISTOP) measures are both satisfied. It is clear from the table above that the criteria coded into SATURN are either consistent with, or more onerous than the requirements laid out in TAG Unit M3.1. All other parameters within the assignment process are as defaults within the SATURN 'SATALL' model assignment programme.

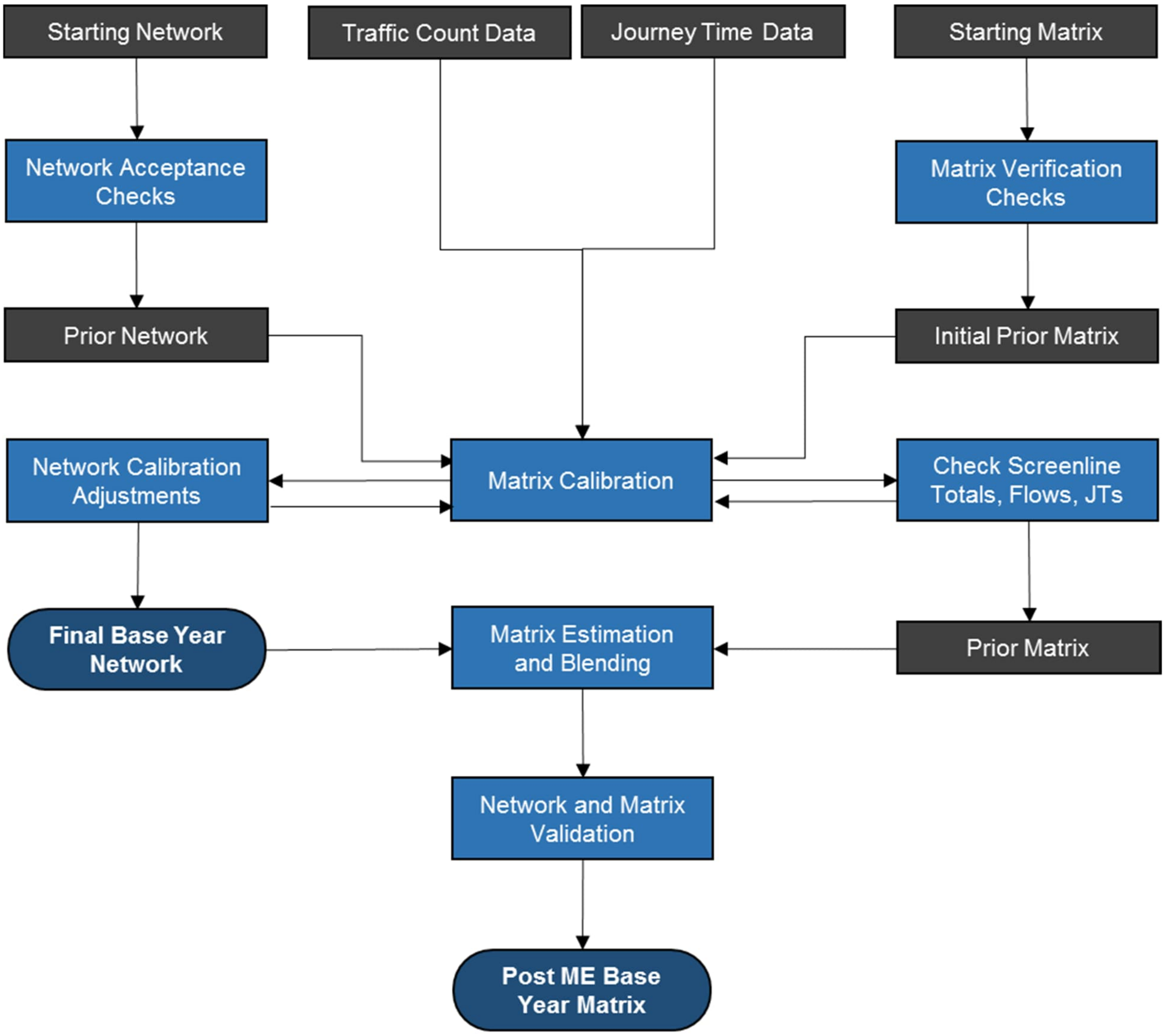
7 MODEL CALIBRATION

7.1 OVERVIEW

7.1.1. This chapter outlines the calibration process undertaken for the GLTM2 base year (2023) traffic model based on best practice from TAG. Calibration of the base traffic model was based upon an iterative process of refining the model network and trip matrices so that the modelled traffic flows, speeds, junction delays and routeings through the network provide a reliable match to observed data.

7.1.2. A summary of the calibration and validation process is illustrated in Figure 7-1.

Figure 7-1 Process for Calibration and Validation



7.2 NETWORK CALIBRATION – LOCAL ADJUSTMENTS

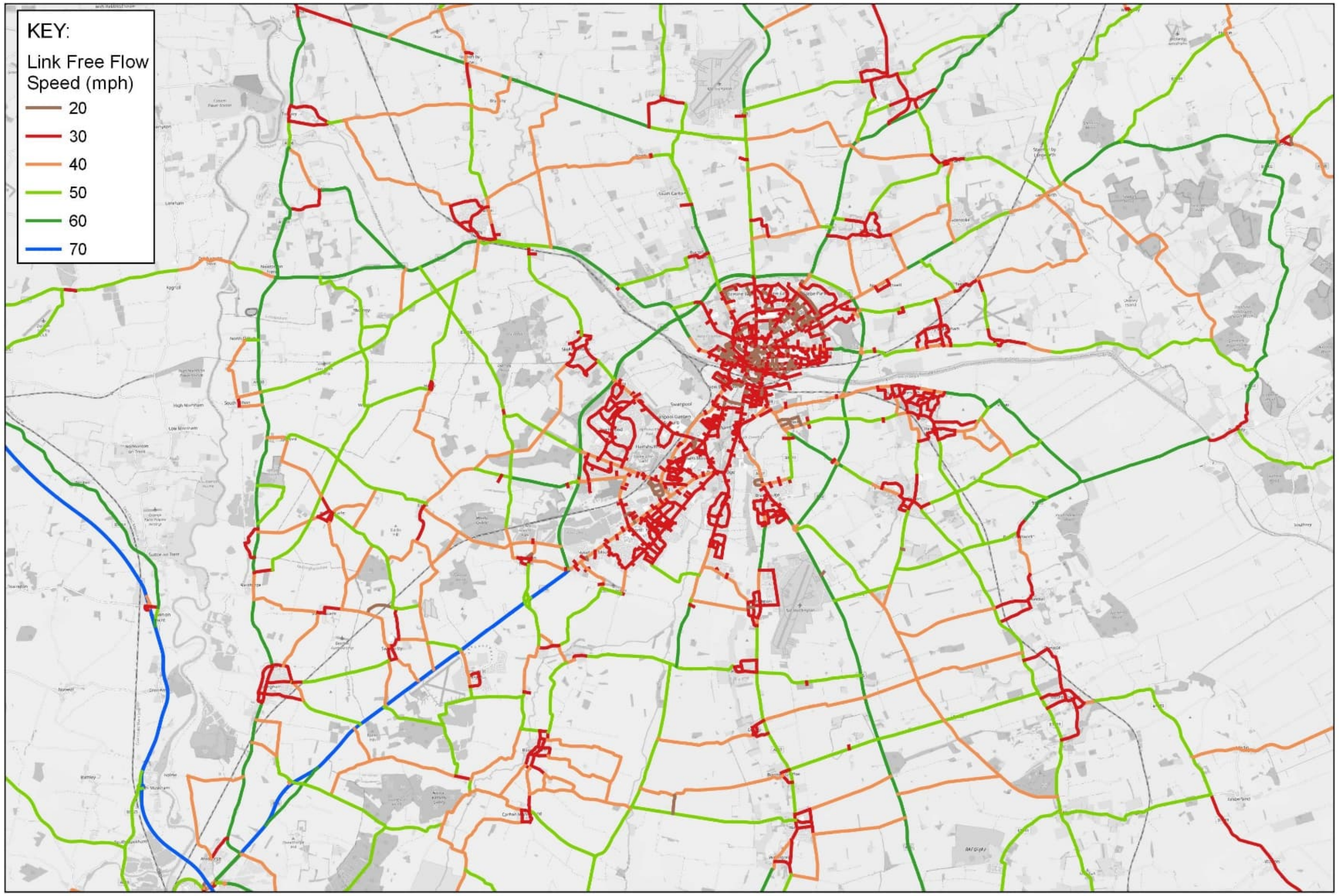
7.2.1. Continual debugging and adjustments of SATURN networks was undertaken using assignments based on current network and preliminary matrices. Checks included:

- Free flow speed versus Inrix speeds;
- Capacities versus observed counts; and
- Modelled delays versus observed delays.

7.2.2. Signal timings were reviewed as part of the network debugging. Initial coding of signals with pedestrian crossing phases assumed the full contingent of pedestrian crossing time within each traffic cycle. Assumptions as to likely frequency of pedestrian crossing activations were considered in some instances, resulting in reduced inter-green and cycle times.

7.2.3. Link free flow speeds are presented in Figure 7-2.

Figure 7-2 Modelled Link Free Flow Speeds



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7.3 MATRIX CALIBRATION (MATRIX ESTIMATION)

7.3.1. Matrix Estimation forms part of the calibration process and is designed to modify the origin-destination volumes by reference to the observed traffic counts. Trips from the prior matrices were adjusted based on the observed link counts to produce an estimated set of 'post-ME' matrices, to improve the fit between modelled flows and observed counts.

7.3.2. The SATURN modules SATME2 and SATPIJA were used for matrix estimation. The matrix estimation process used an iterative approach to generate a matrix with improved calibration and validation in the model. Six iterations were used, whereby the PIJA factors were taken from the previous iteration but the original prior matrix was always used for the demand adjustment.

7.3.3. Matrix estimation was carried out on individual vehicle types that comprised of Cars (UC1, UC2, UC3), light goods vehicles (UC4) and heavy goods vehicles (UC5) matrices in accordance with TAG Unit 3.1.

7.3.4. The observed counts were split between the calibration (matrix estimation) and validation process. From the 765 links with count information, 508 were used for calibration and 257 were held back for validation.

7.3.5. In accordance with guidance set out in Section 8.3.5 of TAG Unit M3, some count sites were grouped to screenlines and cordons which are described further in Section 7.8. The location of the calibration and validation count sites are presented in Figure 7-3 and Figure 7-4 respectively.

7.3.6. Although SATURN version 11.6.3 was available, it was not considered suitable for use in matrix estimation. A test of ME in 11.6.3 was conducted, in which extreme changes were concentrated in only a handful of OD pairs rather than more even changes across the matrix. After consultation with the software provider Atkins, this phenomenon was noted as a theoretical possibility stemming from the philosophy of this SATURN version (which attempted to improve processing time and efficiency by effectively trimming PIJA pairs between zones). It was therefore decided to use the latest stable SATURN version for matrix estimation which is 11.5.05N.

7.3.7. A summary of the steps in ME process was as follows and shown graphically in Figure 7-5:

- **Step 1** – Assign the prior matrices to the network.
- **Step 2** – Extract origin destination path files.
- **Step 3** – Estimate the prior matrices against the observed traffic counts using SATME2.
- **Step 4** – Reassign the estimated matrix.
- **Step 5** – Check for convergence. If converged: stop and if convergence is not achieved, steps 2 to 4 were repeated.

Figure 7-3 Calibration / Validation Sites – Full view

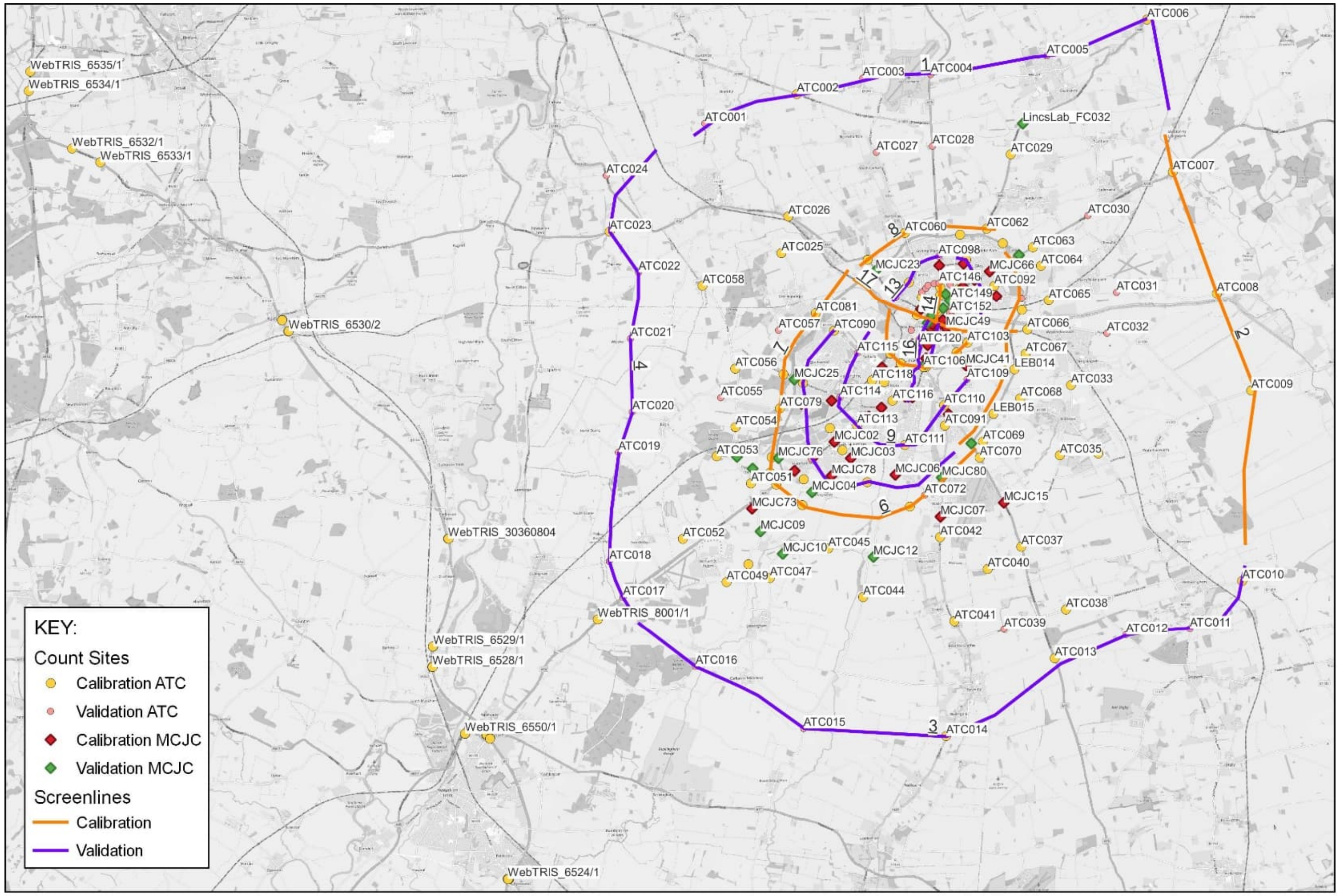

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Figure 7-4 Calibration / Validation Sites – Lincoln City

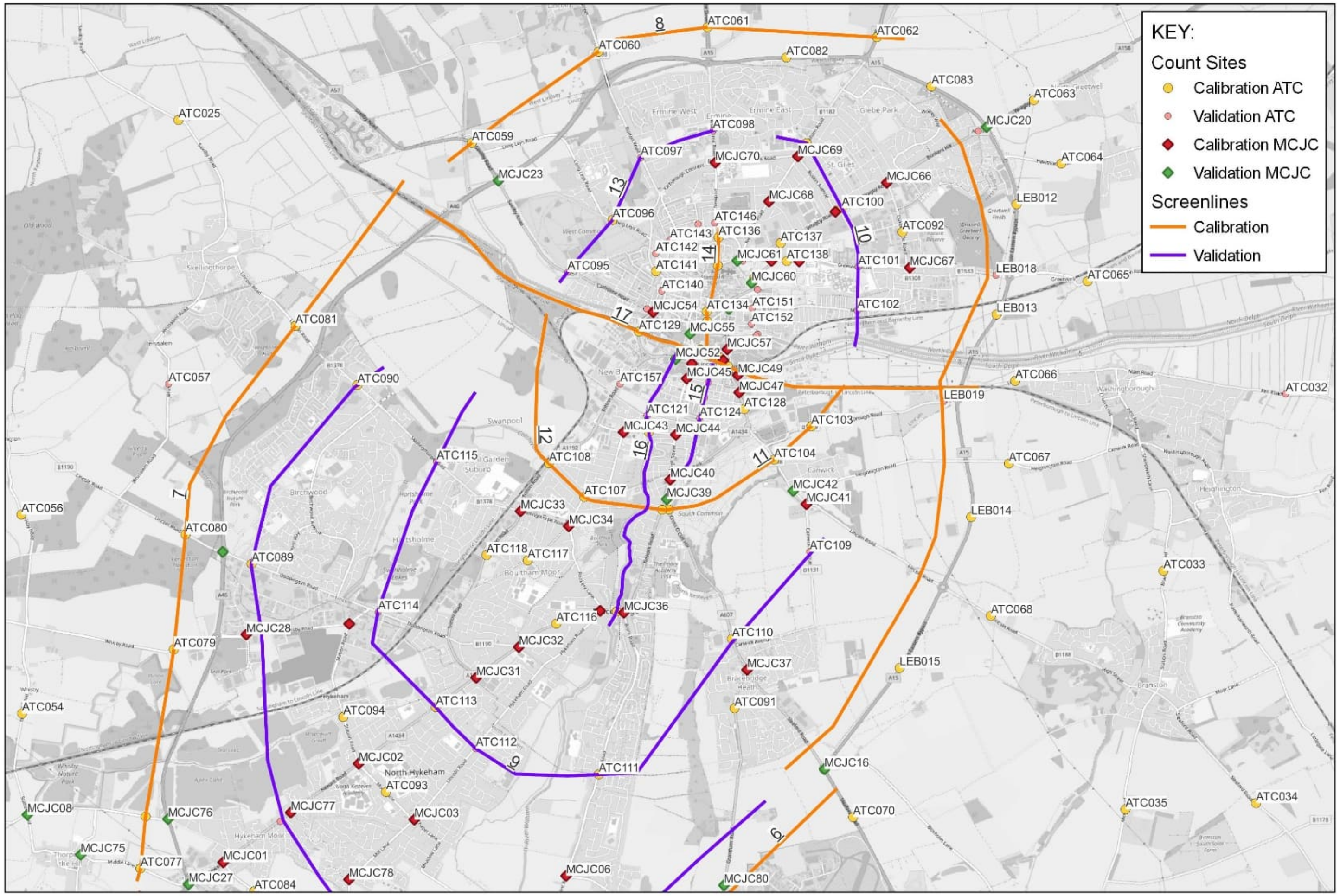

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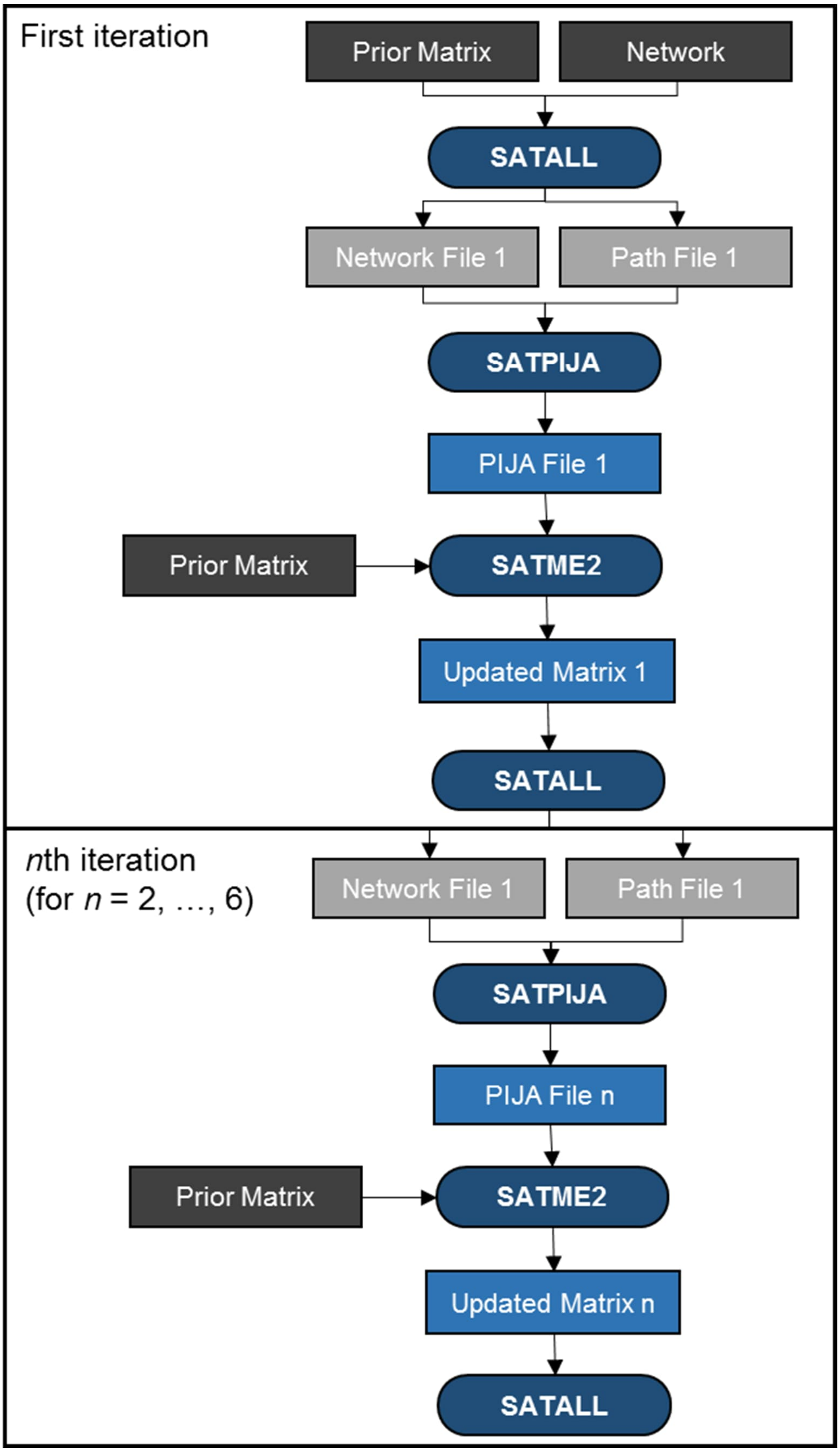
Figure 7-5 Methodology for Matrix Estimation



7.3.8. There are several parameters within SATURN that permit the user to control the extent of change that will be caused by the matrix estimation. For the GLTM2, the process adopted the values which have been used successfully on previous studies by the modelling team including ones which utilised mobile phone data and similar matrix development techniques. The key principle adopted for matrix estimation was that it should not excessively distort the prior demand but allow sufficient scope to reasonably improve the calibration and validation. The parameters used are listed in Table 7-1.

Table 7-1 SATURN Constraints for Matrix Estimation

Parameter	Description	Value Used
XAMAX	The maximum balancing factor to be applied to avoid large changes to the prior matrix. (The minimum balancing factor is taken as the inverse)	Car: 2 LGV: 5 HGV: 5
EPSILN	The convergence criteria for the difference between individual observed counts and their respective model flow.	0.001
ITERMX	The maximum number of iterations that will be run to achieve convergence.	299

7.4 TESTS OF VALIDITY OF MATRIX ESTIMATION CHANGES

7.4.1. TAG guidance on the application of matrix estimation, set out in Section 8.3 of TAG Unit M3.1, advises that the changes brought about by matrix estimation should not be significant. The changes between the prior and post-ME trip matrices were assessed using the significance criteria set out in TAG, reproduced in Table 7-2 as follows.

Table 7-2 TAG Criteria for Matrix Estimation

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 zonal 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%

IMPACTS OF ME – ZONAL CELL VALUES

7.4.2. The zonal cell value regression statistics (prior and post-matrix estimation), are summarised in Table 7-3. for all three time-periods. All criteria are met for car. For LGV ad HGV, the R squared criteria is not met due to outlier zones. However, the slope and intercept criteria are met indicating modest overall changes to trip volumes.

Table 7-3 Impacts of ME – Zonal Cell Value Regression Statistics

Period	User Class	Aspect	Measure	Require	Value	Pass?
AM	Business	Zonal Cells	R^2	>0.95	0.99	✓
			Slope	0.98 - 1.02	1	✓
			Intercept	Near zero	-0.0001	✓
	Commute	Zonal Cells	R^2	>0.95	1	✓
			Slope	0.98 - 1.02	1	✓
			Intercept	Near zero	-0.0009	✓
	Other	Zonal Cells	R^2	>0.95	1	✓
			Slope	0.98 - 1.02	1	✓
			Intercept	Near zero	0.001	✓
	LGV	Zonal Cells	R^2	>0.95	0.85	×
			Slope	0.98 - 1.02	0.99	✓
			Intercept	Near zero	0.0008	✓
	HGV	Zonal Cells	R^2	>0.95	0.93	×
			Slope	0.98 - 1.02	1	✓
			Intercept	Near zero	0.0004	✓
IP	Business	Zonal Cells	R^2	>0.95	0.99	✓
			Slope	0.98 - 1.02	1	✓
			Intercept	Near zero	0.00003	✓
	Commute	Zonal Cells	R^2	>0.95	1	✓
			Slope	0.98 - 1.02	1	✓
			Intercept	Near zero	-0.0003	✓
	Other		R^2	>0.95	1	✓

Period	User Class	Aspect	Measure	Require	Value	Pass?
IP contd.		Zonal Cells	Slope	0.98 - 1.02	1	✓
			Intercept	Near zero	0.0009	✓
	LGV	Zonal Cells	R^2	>0.95	0.91	×
			Slope	0.98 - 1.02	0.98	✓
			Intercept	Near zero	0.0005	✓
	HGV	Zonal Cells	R^2	>0.95	0.9	×
			Slope	0.98 - 1.02	1.01	✓
			Intercept	Near zero	0	✓
PM	Business	Zonal Cells	R^2	>0.95	0.99	✓
			Slope	0.98 - 1.02	1	✓
			Intercept	Near zero	0.00003	✓
	Commute	Zonal Cells	R^2	>0.95	1	✓
			Slope	0.98 - 1.02	1	✓
			Intercept	Near zero	0.0004	✓
	Other	Zonal Cells	R^2	>0.95	1	✓
			Slope	0.98 - 1.02	1	✓
			Intercept	Near zero	0.0019	✓
	LGV	Zonal Cells	R^2	>0.95	0.76	×
			Slope	0.98 - 1.02	0.94	×
			Intercept	Near zero	0.013	✓
	HGV	Zonal Cells	R^2	>0.95	0.87	×
			Slope	0.98 - 1.02	1.02	✓
			Intercept	Near zero	0.0001	✓

IMPACTS OF ME – ZONAL TRIP ENDS

7.4.3. Analysis of the change in matrix zonal trip ends against the TAG stability criteria is presented in Table 7-4 to Table 7-6. They show that the TAG criteria are met for the majority of indicators for car.

Table 7-4 Impacts of ME Zonal Trip End Regression Statistics – AM Peak

User Class	Aspect	Measure	Require	Value	Pass?
Business	Origins	R^2	>0.98	0.99	✓
		Slope	0.99 - 1.01	0.99	✓
		Intercept	Near zero	0.03	✓
	Destinations	R^2	>0.98	0.99	✓
		Slope	0.99 - 1.01	0.99	✓
		Intercept	Near zero	0.04	✓
Commute	Origins	R^2	>0.98	1	✓
		Slope	0.99 - 1.01	1	✓
		Intercept	Near zero	-0.43	✓
	Destinations	R^2	>0.98	1	✓
		Slope	0.99 - 1.01	0.99	✓
		Intercept	Near zero	-0.14	✓
Other	Origins	R^2	>0.98	1	✓
		Slope	0.99 - 1.01	1	✓
		Intercept	Near zero	0.63	✓
	Destinations	R^2	>0.98	1	✓
		Slope	0.99 - 1.01	1	✓
		Intercept	Near zero	0.81	✓
LGV	Origins	R^2	>0.98	0.98	✓
		Slope	0.99 - 1.01	0.93	×
		Intercept	Near zero	0.6	✓
	Destinations	R^2	>0.98	0.91	×

User Class	Aspect	Measure	Require	Value	Pass?
		Slope	0.99 - 1.01	0.94	×
		Intercept	Near zero	1.1	×
HGV	Origins	R^2	>0.98	0.94	×
		Slope	0.99 - 1.01	1.04	×
		Intercept	Near zero	0.04	✓
	Destinations	R^2	>0.98	0.94	×
		Slope	0.99 - 1.01	1	✓
		Intercept	Near zero	0.21	✓

Table 7-5 Impacts of ME – Zonal Trip End Regression Statistics – Inter Peak

User Class	Aspect	Measure	Require	Value	Pass?
Business	Origins	R^2	>0.98	0.99	✓
		Slope	0.99 - 1.01	1	✓
		Intercept	Near zero	0.003	✓
	Destinations	R^2	>0.98	0.99	✓
		Slope	0.99 - 1.01	0.99	✓
		Intercept	Near zero	0.05	✓
Commute	Origins	R^2	>0.98	0.99	✓
		Slope	0.99 - 1.01	0.99	✓
		Intercept	Near zero	-0.09	✓
	Destinations	R^2	>0.98	1	✓
		Slope	0.99 - 1.01	0.99	✓
		Intercept	Near zero	-0.08	✓
Other	Origins	R^2	>0.98	1	✓
		Slope	0.99 - 1.01	1	✓
		Intercept	Near zero	0.55	✓

User Class	Aspect	Measure	Require	Value	Pass?
	Destinations	R^2	>0.98	1	✓
		Slope	0.99 - 1.01	1	✓
		Intercept	Near zero	0.72	✓
LGV	Origins	R^2	>0.98	0.95	×
		Slope	0.99 - 1.01	0.92	×
		Intercept	Near zero	0.72	✓
	Destinations	R^2	>0.98	0.95	×
		Slope	0.99 - 1.01	0.94	×
		Intercept	Near zero	0.63	✓
HGV	Origins	R^2	>0.98	0.9	×
		Slope	0.99 - 1.01	0.99	✓
		Intercept	Near zero	0.06	✓
	Destinations	R^2	>0.98	0.91	×
		Slope	0.99 - 1.01	0.99	✓
		Intercept	Near zero	0.06	✓

Table 7-6 Impacts of ME – Zonal Trip End Regression Statistics – PM Peak

User Class	Aspect	Measure	Require	Value	Pass?
Business	Origins	R^2	>0.98	0.99	✓
		Slope	0.99 - 1.01	0.99	✓
		Intercept	Near zero	0.02	✓
	Destinations	R^2	>0.98	0.99	✓
		Slope	0.99 - 1.01	0.98	✓
		Intercept	Near zero	0.09	✓
Commute	Origins	R^2	>0.98	1	✓
		Slope	0.99 - 1.01	1	✓

User Class	Aspect	Measure	Require	Value	Pass?
		Intercept	Near zero	-0.12	✓
	Destinations	R^2	>0.98	1	✓
		Slope	0.99 - 1.01	1	✓
		Intercept	Near zero	-0.09	✓
Other	Origins	R^2	>0.98	1	✓
		Slope	0.99 - 1.01	1	✓
		Intercept	Near zero	1.01	×
	Destinations	R^2	>0.98	1	✓
		Slope	0.99 - 1.01	1	✓
		Intercept	Near zero	1.2	×
LGV	Origins	R^2	>0.98	0.9	×
		Slope	0.99 - 1.01	0.97	×
		Intercept	Near zero	0.47	✓
	Destinations	R^2	>0.98	0.9	×
		Slope	0.99 - 1.01	0.91	×
		Intercept	Near zero	1	×
HGV	Origins	R^2	>0.98	0.91	×
		Slope	0.99 - 1.01	1.07	×
		Intercept	Near zero	-0.06	✓
	Destinations	R^2	>0.98	0.88	×
		Slope	0.99 - 1.01	1	✓
		Intercept	Near zero	0.14	✓

IMPACTS OF ME – TRIP LENGTH DISTRIBUTION

7.4.4. Figure 7-6 to Figure 7-8 show the final comparison between the prior and post trip length distributions for all vehicles for each modelled time period. (Graphs for each user class are provided in the appendices).

7.4.5. Table 7-7 shows the results by changes to average trip length. For car, changes to mean trip length and standard deviation are within 5% for each time period and trip purpose.

Figure 7-6 Prior and Post-ME Trip Length Distribution – AM Peak

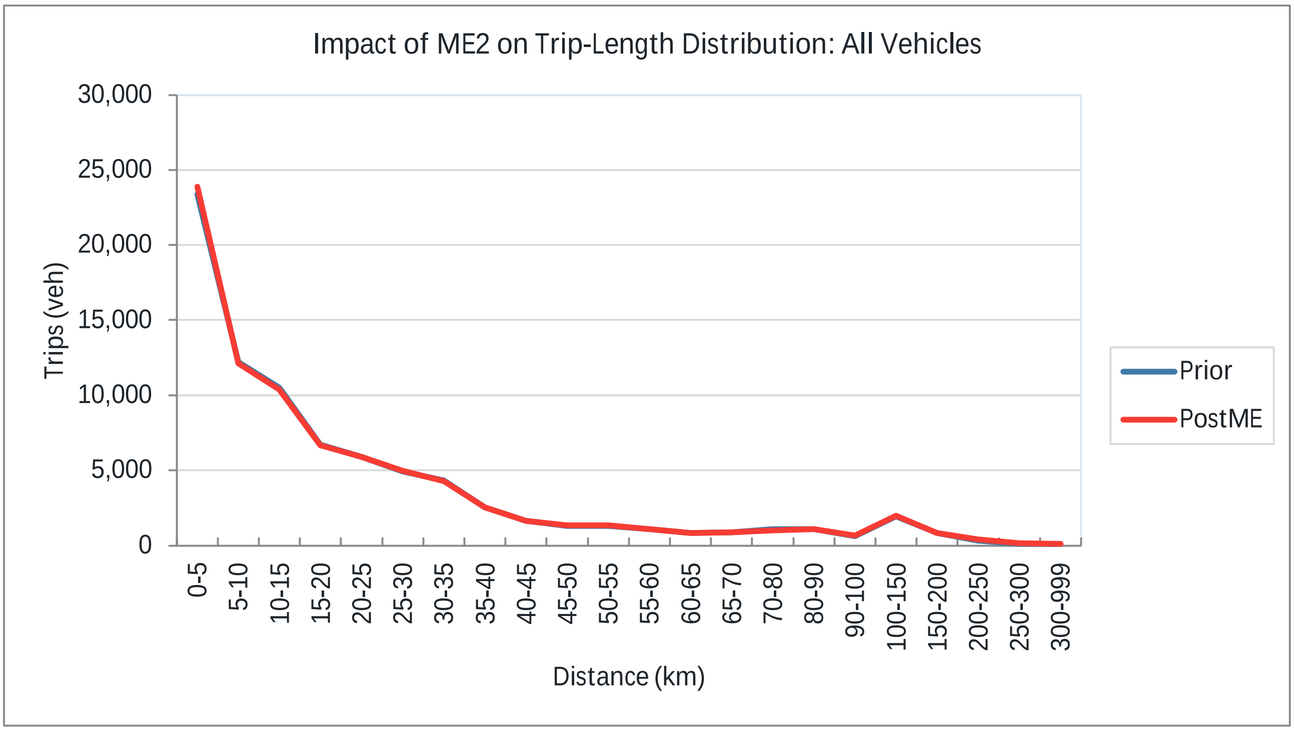


Figure 7-7 Prior and Post-ME Trip Length Distribution – Inter Peak

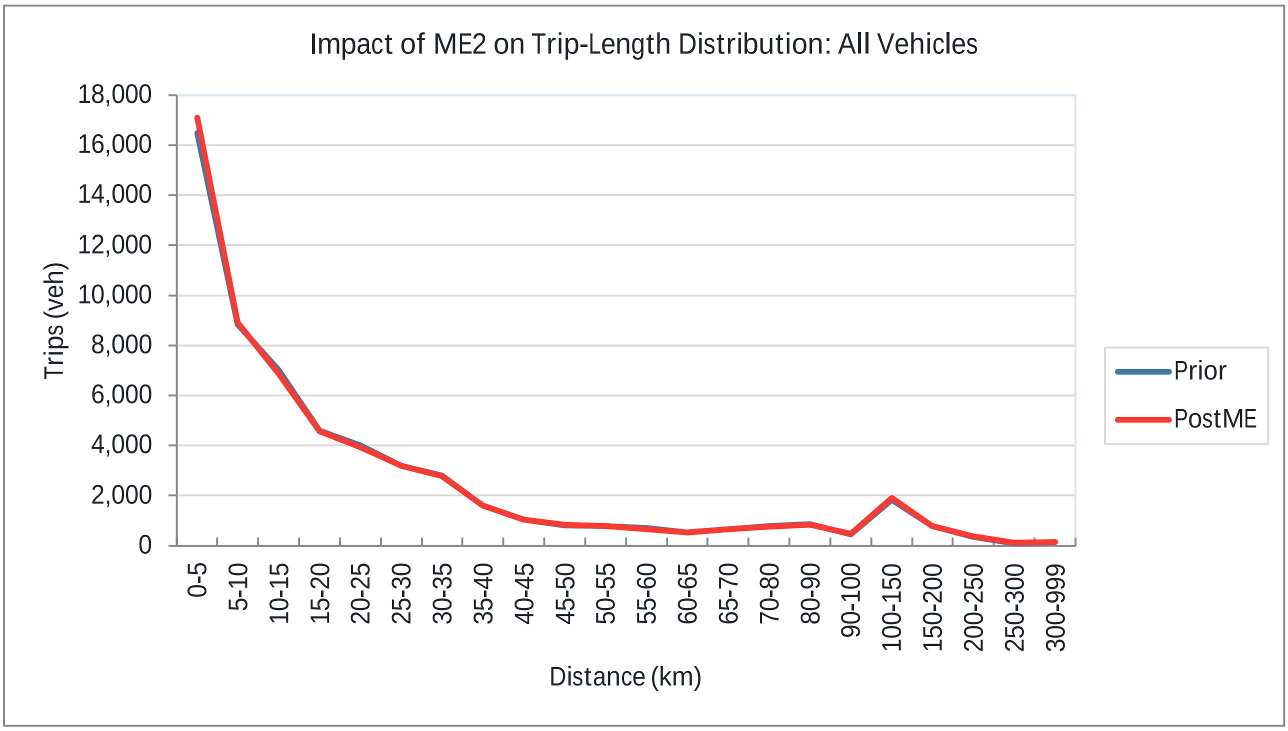


Figure 7-8 Prior and Post-ME Trip Length Distribution – PM Peak

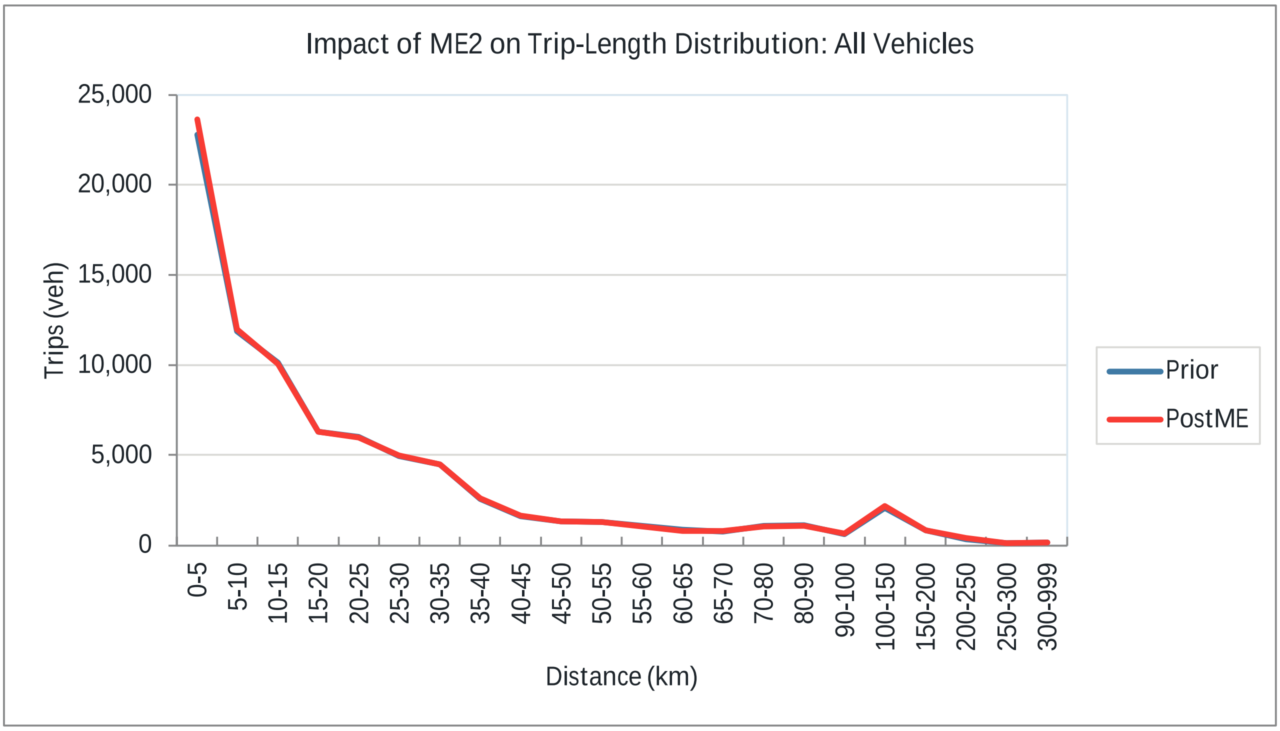


Table 7-7 TAG Tests for Changes in Trip Length Distribution

User Class	Measure	AM Peak		Inter-Peak		PM Peak	
		Mean	St. Dev	Mean	St. Dev	Mean	St. Dev
Business	Prior ME	48.39	53.28	53.83	60.39	50.25	57.06
	Post ME	48.40	53.85	54.50	61.72	49.92	57.31
	Difference	0.0%	1.1%	1.2%	2.2%	-0.7%	0.4%
	Pass?	✓	✓	✓	✓	✓	✓
Commute	Prior ME	15.57	20.30	17.89	25.87	17.79	23.37
	Post ME	15.48	20.26	17.73	26.14	17.70	23.50
	Difference	-0.6%	-0.2%	-0.9%	1.1%	-0.5%	0.6%
	Pass?	✓	✓	✓	✓	✓	✓
Other	Prior ME	14.63	27.10	17.41	32.64	16.32	30.60
	Post ME	14.57	27.33	17.41	33.20	16.13	30.61
	Difference	-0.4%	0.9%	0.0%	1.7%	-1.2%	0.0%
	Pass?	✓	✓	✓	✓	✓	✓
LGV	Prior ME	22.12	36.28	23.73	39.49	25.35	40.82
	Post ME	23.26	39.18	24.09	40.97	26.91	44.52
	Difference	5.2%	8.0%	1.5%	3.8%	6.1%	9.1%
	Pass?	×	×	✓	✓	×	×
HGV	Prior ME	45.74	64.36	54.83	68.69	47.59	74.36
	Post ME	48.88	65.99	56.33	69.01	52.87	74.82
	Difference	6.9%	2.5%	2.7%	0.5%	11.1%	0.6%
	Pass?	×	✓	✓	✓	×	✓

IMPACTS OF ME – SECTOR TO SECTOR MOVEMENTS

7.4.6. The change in prior and post-ME trip matrices in relation to sector-to-sector movements was also analysed. A 7-sector system was developed covering the whole of Great Britain and corresponding to the Greater Lincoln model zoning system. The first sector forms a cordon around Lincoln, with 4 sectors immediately outside of this, split based on key route corridors. The sectors defined are listed as follows and shown in Figure 7-9. (Screelines 5 to 8 are shown in the plot to illustrate the boundary of sector 1).

- **Sector 1** – Lincoln cordon;
- **Sector 2** – Rest of Lincolnshire NE (A46);
- **Sector 3** – Rest of Lincolnshire SE (A15);
- **Sector 4** – External Near SW (A46);
- **Sector 5** – External Near NW (A57);
- **Sector 6** – Rest of East Midlands + South Yorkshire; and
- **Sector 7** – Remaining External areas

7.4.7. The results for the sector-to-sector analysis for all vehicles are summarised in Table 7-8 to Table 7-16 as follows. The tables list prior totals, post-ME totals, percentage difference and GEH difference. It shows that changes brought about by matrix estimation are typically within the 5% TAG threshold for all time periods. Changes within Lincoln (sector 1) are typically also less than 5%. As there are low trip volumes for some sector movements, GEH of changes is also presented, with the majority of sector movements within a GEH of 4.

7.4.8. For sector changes for each vehicle type, not all sectors are within the 5% threshold. However, this is impacted by small absolute numbers for many of the sector-to-sector movements and the GEH equivalent is typically within 4. Car changes overall, within sector 1 (Lincoln) and the totals to and from sector 1, are within 5% for each time period.

7.4.9. A breakdown of the various matrix estimation validity tests (by vehicle class) is presented in Appendix C.

Figure 7-9 Matrix Estimation Sectors

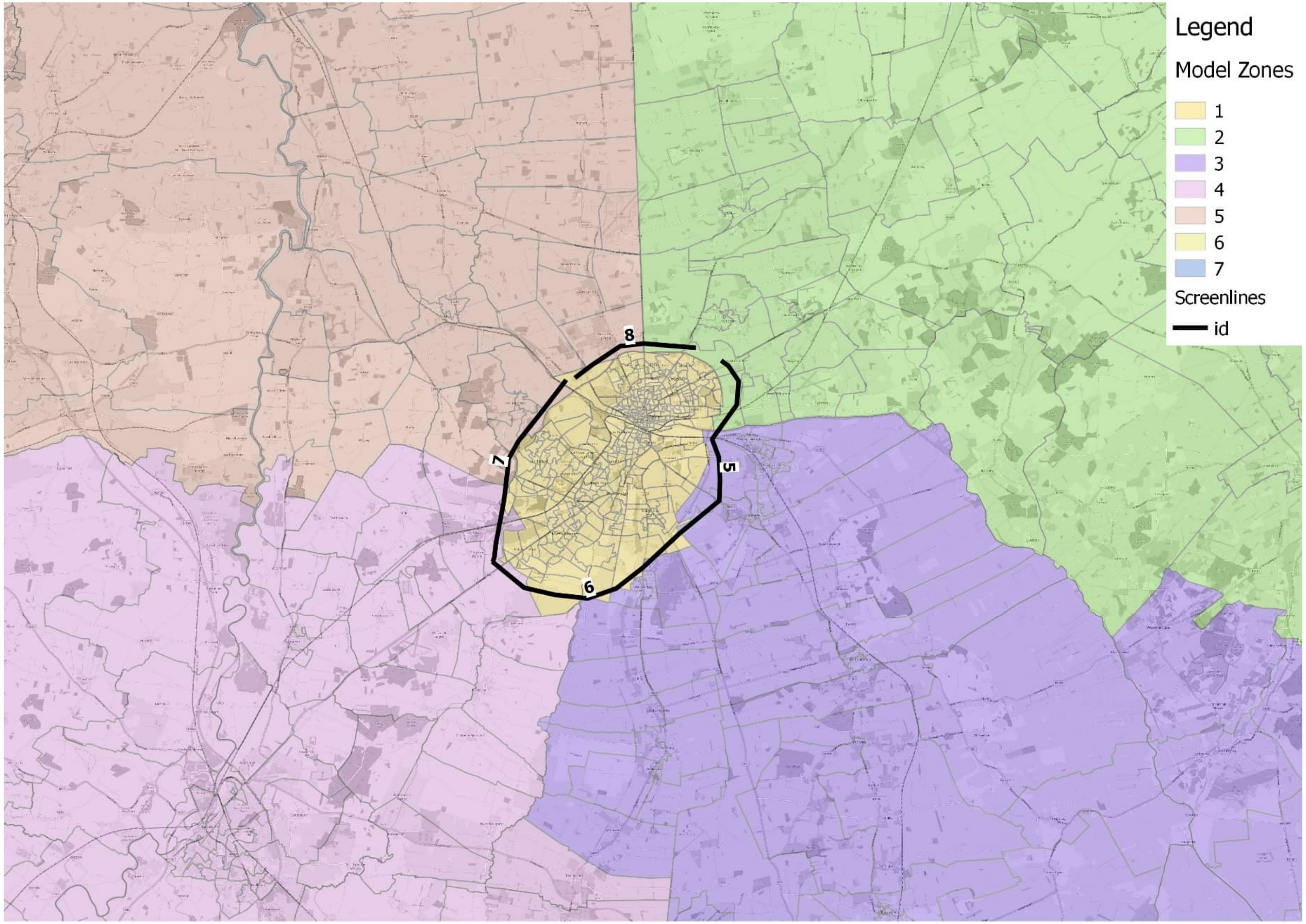


Table 7-8 Sector to Sector Comparison – AM Peak Cars

Prior Matrix Totals

OD	1	2	3	4	5	6	7	Total
1	15,047	1,077	1,232	877	767	446	150	**19,595**
2	2,120	7,431	1,467	98	322	1,466	112	**13,016**
3	2,156	1,280	25,538	708	170	931	3,297	**34,080**
4	1,113	74	920	9,347	762	1,794	390	**14,400**
5	1,356	319	219	793	-	-	-	**2,686**
6	461	996	1,029	1,677	-	-	-	**4,163**
7	103	59	1,832	237	-	-	-	**2,230**
Total	**22,356**	**11,236**	**32,237**	**13,736**	**2,020**	**4,637**	**3,948**	**90,170**

Post ME Matrix totals

OD	1	2	3	4	5	6	7	Total
1	15,125	1,070	1,159	875	706	474	152	**19,561**
2	1,952	7,416	1,429	70	347	1,459	106	**12,777**
3	2,235	1,266	25,657	692	125	911	3,291	**34,176**
4	1,161	68	918	9,592	718	1,846	448	**14,750**
5	1,324	313	133	736	-	-	-	**2,506**
6	473	988	974	1,704	-	-	-	**4,139**
7	106	56	1,818	269	-	-	-	**2,248**
Total	**22,375**	**11,175**	**32,088**	**13,938**	**1,896**	**4,690**	**3,997**	**90,158**

Absolute Dif

OD	1	2	3	4	5	6	7	Total
1	78	-7	-72	-3	-61	28	3	**-34**
2	-169	-16	-38	-28	25	-8	-6	**-239**
3	79	-14	119	-16	-45	-20	-6	**97**
4	48	-6	-2	245	-44	52	58	**350**
5	-33	-6	-86	-57	0	0	0	**-181**
6	12	-8	-55	28	0	0	0	**-23**
7	3	-3	-14	32	0	0	0	**18**
Total	**19**	**-60**	**-149**	**202**	**-125**	**53**	**49**	**-12**

% Dif

OD	1	2	3	4	5	6	7	Total
1	0.5%	-0.7%	-5.9%	-0.3%	-7.9%	6.3%	1.7%	**-0.2%**
2	-8.0%	-0.2%	-2.6%	-28.3%	7.9%	-0.5%	-5.5%	**-1.8%**
3	3.7%	-1.1%	0.5%	-2.3%	-26.3%	-2.2%	-0.2%	**0.3%**
4	4.3%	-8.5%	-0.2%	2.6%	-5.8%	2.9%	15.0%	**2.4%**
5	-2.4%	-1.9%	-39.1%	-7.1%				**-6.7%**
6	2.7%	-0.8%	-5.4%	1.7%				**-0.6%**
7	2.8%	-4.6%	-0.8%	13.4%				**0.8%**
Total	**0.1%**	**-0.5%**	**-0.5%**	**1.5%**	**-6.2%**	**1.1%**	**1.2%**	**0.0%**

GEH dif

OD	1	2	3	4	5	6	7	Total
1	0.6	0.2	2.1	0.1	2.2	1.3	0.2	**0.2**
2	3.7	0.2	1.0	3.0	1.4	0.2	0.6	**2.1**
3	1.7	0.4	0.7	0.6	3.7	0.7	0.1	**0.5**
4	1.4	0.8	0.1	2.5	1.6	1.2	2.9	**2.9**
5	0.9	0.3	6.4	2.0				**3.5**
6	0.6	0.3	1.7	0.7				**0.4**
7	0.3	0.4	0.3	2.0				**0.4**
Total	**0.1**	**0.6**	**0.8**	**1.7**	**2.8**	**0.8**	**0.8**	**0.0**

Table 7-9 Sector to Sector Comparison – AM Peak LGV

Prior Matrix Totals								
OD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	3,444	203	274	188	187	136	10	**4,442**
2	190	438	117	33	44	34	5	**860**
3	234	118	713	149	61	77	16	**1,368**
4	217	31	139	538	68	129	43	**1,164**
5	196	55	57	73	-	-	-	**381**
6	106	52	110	158	-	-	-	**425**
7	12	4	24	59	-	-	-	**99**
Total	**4,400**	**901**	**1,433**	**1,198**	**359**	**375**	**74**	**8,739**
Post ME Matrix totals								
OD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	3,581	201	257	195	179	154	13	**4,581**
2	204	445	101	29	35	32	4	**850**
3	240	119	729	191	50	94	22	**1,446**
4	238	25	128	558	64	158	60	**1,232**
5	196	44	36	72	-	-	-	**348**
6	119	45	118	193	-	-	-	**473**
7	14	4	30	59	-	-	-	**106**
Total	**4,590**	**882**	**1,399**	**1,296**	**329**	**439**	**100**	**9,035**
Absolute Dif								
OD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	137	-3	-16	6	-7	18	3	**139**
2	13	7	-16	-4	-8	-2	0	**-10**
3	6	0	16	42	-11	18	6	**77**
4	20	-6	-11	21	-3	30	17	**68**
5	-1	-12	-20	-1	0	0	0	**-33**
6	13	-7	8	35	0	0	0	**48**
7	2	0	6	0	0	0	0	**7**
Total	**190**	**-19**	**-33**	**98**	**-29**	**64**	**26**	**297**
% Dif								
OD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	4.0%	-1.2%	-6.0%	3.4%	-3.9%	13.2%	30.1%	**3.1%**
2	6.9%	1.7%	-13.7%	-12.3%	-18.6%	-4.7%	-8.4%	**-1.1%**
3	2.4%	0.4%	2.3%	28.2%	-17.4%	23.2%	36.0%	**5.7%**
4	9.4%	-17.9%	-7.8%	3.8%	-4.9%	23.2%	40.2%	**5.9%**
5	-0.4%	-21.0%	-35.6%	-1.2%				**-8.7%**
6	12.1%	-13.5%	7.1%	21.9%				**11.4%**
7	16.0%	-2.4%	23.7%	-0.8%				**7.1%**
Total	**4.3%**	**-2.1%**	**-2.3%**	**8.2%**	**-8.2%**	**17.1%**	**34.7%**	**3.4%**
GEH dif								
OD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	2.3	0.2	1.0	0.5	0.5	1.5	0.9	**2.1**
2	0.9	0.3	1.5	0.7	1.3	0.3	0.2	**0.3**
3	0.4	0.0	0.6	3.2	1.4	1.9	1.3	**2.1**
4	1.3	1.0	0.9	0.9	0.4	2.5	2.4	**2.0**
5	0.1	1.6	2.9	0.1				**1.7**
6	1.2	1.0	0.7	2.6				**2.3**
7	0.5	0.0	1.1	0.1				**0.7**
Total	**2.8**	**0.6**	**0.9**	**2.8**	**1.6**	**3.2**	**2.8**	**3.1**

Table 7-10 Sector to Sector Comparison – AM Peak HGV

Prior Matrix Totals

OD	1	2	3	4	5	6	7	Total
1	596	79	99	44	35	64	23	**940**
2	39	224	27	13	20	51	14	**389**
3	74	26	560	33	16	67	110	**886**
4	42	23	37	317	18	178	78	**694**
5	65	14	49	27	-	-	-	**155**
6	43	44	140	183	-	-	-	**410**
7	16	17	68	99	-	-	-	**201**
Total	**875**	**427**	**981**	**715**	**90**	**361**	**225**	**3,675**

Post ME Matrix totals

OD	1	2	3	4	5	6	7	Total
1	562	69	82	52	35	66	28	**894**
2	36	220	27	16	22	56	12	**388**
3	67	25	580	42	16	67	90	**887**
4	50	43	43	346	29	214	76	**802**
5	66	18	46	29	-	-	-	**159**
6	45	44	184	220	-	-	-	**492**
7	15	24	69	132	-	-	-	**239**
Total	**841**	**442**	**1,030**	**836**	**103**	**403**	**206**	**3,860**

Absolute Dif

OD	1	2	3	4	5	6	7	Total
1	-34	-10	-18	8	1	2	5	**-46**
2	-3	-4	0	3	2	4	-2	**0**
3	-7	-1	20	9	0	0	-21	**0**
4	8	20	6	29	11	35	-1	**107**
5	0	4	-3	2	0	0	0	**4**
6	2	0	44	36	0	0	0	**82**
7	-1	6	0	33	0	0	0	**38**
Total	**-34**	**15**	**49**	**121**	**13**	**42**	**-19**	**185**

% Dif

OD	1	2	3	4	5	6	7	Total
1	-5.6%	-13.1%	-17.8%	19.1%	1.7%	3.3%	20.6%	**-4.9%**
2	-6.8%	-1.7%	-1.8%	19.3%	8.8%	8.6%	-14.5%	**-0.1%**
3	-9.5%	-4.9%	3.6%	28.7%	-2.1%	0.0%	-18.8%	**0.0%**
4	18.2%	83.8%	16.0%	9.1%	57.1%	19.9%	-1.6%	**15.4%**
5	0.7%	30.8%	-6.3%	7.4%				**2.4%**
6	5.2%	-0.9%	31.4%	19.9%				**20.0%**
7	-8.3%	37.0%	0.1%	33.7%				**19.2%**
Total	**-3.9%**	**3.4%**	**5.0%**	**16.9%**	**14.0%**	**11.6%**	**-8.6%**	**5.0%**

GEH dif

OD	1	2	3	4	5	6	7	Total
1	1.4	1.2	1.9	1.2	0.1	0.3	0.9	**1.5**
2	0.4	0.3	0.1	0.7	0.4	0.6	0.6	**0.0**
3	0.8	0.2	0.8	1.5	0.1	0.0	2.1	**0.0**
4	1.1	3.4	0.9	1.6	2.2	2.5	0.1	**3.9**
5	0.1	1.1	0.4	0.4				**0.3**
6	0.3	0.1	3.5	2.6				**3.9**
7	0.3	1.4	0.0	3.1				**2.6**
Total	**1.2**	**0.7**	**1.5**	**4.3**	**1.3**	**2.1**	**1.3**	**3.0**

Table 7-11 Sector to Sector Comparison – Inter Peak Cars

Prior Matrix Totals								
OD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	11,650	1,144	1,047	689	850	378	117	**15,875**
2	1,178	5,142	989	49	171	845	78	**8,452**
3	1,070	930	16,937	486	124	719	1,573	**21,838**
4	653	55	517	6,228	540	1,213	246	**9,452**
5	788	166	99	499	-	-	-	**1,551**
6	325	913	759	1,081	-	-	-	**3,078**
7	106	100	1,489	237	-	-	-	**1,932**
Total	**15,769**	**8,450**	**21,837**	**9,269**	**1,685**	**3,154**	**2,015**	**62,178**
Post ME Matrix totals								
OD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	11,968	1,122	1,097	626	812	395	117	**16,137**
2	1,147	5,107	961	40	180	851	77	**8,362**
3	1,032	902	17,030	488	96	746	1,580	**21,874**
4	639	40	498	6,373	469	1,270	285	**9,575**
5	797	165	58	435	-	-	-	**1,454**
6	350	893	739	1,131	-	-	-	**3,113**
7	116	92	1,481	275	-	-	-	**1,964**
Total	**16,047**	**8,321**	**21,864**	**9,367**	**1,557**	**3,262**	**2,059**	**62,478**
Absolute Dif								
OD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	318	-22	50	-63	-38	17	0	**261**
2	-31	-36	-28	-9	10	6	-2	**-90**
3	-38	-27	93	2	-28	28	8	**36**
4	-14	-15	-19	145	-70	57	38	**122**
5	9	-1	-41	-64	0	0	0	**-98**
6	25	-20	-20	50	0	0	0	**35**
7	10	-8	-8	38	0	0	0	**32**
Total	**278**	**-129**	**27**	**98**	**-127**	**108**	**44**	**299**
% Dif								
OD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	2.7%	-1.9%	4.7%	-9.2%	-4.5%	4.5%	0.0%	**1.6%**
2	-2.7%	-0.7%	-2.8%	-18.0%	5.6%	0.7%	-2.2%	**-1.1%**
3	-3.6%	-3.0%	0.5%	0.5%	-22.7%	3.8%	0.5%	**0.2%**
4	-2.2%	-27.1%	-3.7%	2.3%	-13.0%	4.7%	15.6%	**1.3%**
5	1.1%	-0.6%	-41.7%	-12.8%				**-6.3%**
6	7.7%	-2.2%	-2.6%	4.6%				**1.1%**
7	9.3%	-8.5%	-0.5%	15.9%				**1.6%**
Total	**1.8%**	**-1.5%**	**0.1%**	**1.1%**	**-7.6%**	**3.4%**	**2.2%**	**0.5%**
GEH dif								
OD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	2.9	0.6	1.5	2.5	1.3	0.9	0.0	**2.1**
2	0.9	0.5	0.9	1.3	0.7	0.2	0.2	**1.0**
3	1.2	0.9	0.7	0.1	2.7	1.0	0.2	**0.2**
4	0.6	2.2	0.8	1.8	3.1	1.6	2.4	**1.3**
5	0.3	0.1	4.7	3.0				**2.5**
6	1.4	0.7	0.7	1.5				**0.6**
7	0.9	0.9	0.2	2.4				**0.7**
Total	**2.2**	**1.4**	**0.2**	**1.0**	**3.2**	**1.9**	**1.0**	**1.2**

Table 7-12 Sector to Sector Comparison – Inter Peak LGV

Prior Matrix Totals								
OD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	2,343	121	176	149	143	100	18	**3,049**
2	141	284	71	17	45	39	3	**600**
3	196	65	388	111	33	71	14	**878**
4	164	20	78	383	54	86	31	**816**
5	154	37	22	51	-	-	-	**264**
6	72	31	66	116	-	-	-	**284**
7	12	3	14	76	-	-	-	**104**
Total	**3,081**	**561**	**815**	**902**	**274**	**296**	**66**	**5,995**

Post ME Matrix totals								
OD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	2,418	131	170	164	122	107	24	**3,135**
2	169	283	60	14	41	40	4	**611**
3	182	58	403	120	21	66	13	**862**
4	165	21	80	400	54	107	31	**858**
5	144	36	19	51	-	-	-	**251**
6	70	31	64	130	-	-	-	**295**
7	11	3	14	85	-	-	-	**112**
Total	**3,160**	**562**	**810**	**964**	**237**	**319**	**71**	**6,124**

Absolute Dif								
OD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	75	9	-6	15	-21	7	7	**85**
2	29	-2	-11	-2	-4	1	0	**10**
3	-14	-7	15	9	-12	-5	-2	**-15**
4	1	2	2	18	0	21	0	**43**
5	-10	-1	-3	0	0	0	0	**-14**
6	-1	0	-1	14	0	0	0	**11**
7	-1	0	0	9	0	0	0	**8**
Total	**79**	**2**	**-5**	**62**	**-37**	**23**	**5**	**129**

% Dif								
OD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	3.2%	7.7%	-3.5%	9.9%	-14.8%	6.7%	37.1%	**2.8%**
2	20.4%	-0.7%	-16.1%	-13.4%	-8.7%	2.1%	14.2%	**1.7%**
3	-7.1%	-10.1%	4.0%	8.1%	-37.1%	-7.5%	-11.0%	**-1.7%**
4	0.6%	7.9%	2.4%	4.6%	-0.6%	24.1%	0.1%	**5.2%**
5	-6.3%	-3.8%	-11.8%	0.3%				**-5.1%**
6	-2.1%	1.2%	-2.2%	11.8%				**3.9%**
7	-5.9%	7.7%	-1.6%	11.9%				**8.0%**
Total	**2.6%**	**0.3%**	**-0.6%**	**6.9%**	**-13.6%**	**7.8%**	**8.3%**	**2.2%**

GEH dif								
OD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	1.5	0.8	0.5	1.2	1.8	0.7	1.4	**1.5**
2	2.3	0.1	1.4	0.6	0.6	0.1	0.3	**0.4**
3	1.0	0.8	0.8	0.8	2.3	0.6	0.4	**0.5**
4	0.1	0.3	0.2	0.9	0.0	2.1	0.0	**1.5**
5	0.8	0.2	0.6	0.0				**0.8**
6	0.2	0.1	0.2	1.2				**0.7**
7	0.2	0.1	0.1	1.0				**0.8**
Total	**1.4**	**0.1**	**0.2**	**2.0**	**2.3**	**1.3**	**0.7**	**1.7**

Table 7-13 Sector to Sector Comparison – Inter Peak HGV

Prior Matrix Totals								
OD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	512	60	73	54	45	63	24	**831**
2	78	115	19	8	10	44	16	**289**
3	73	23	303	27	21	68	85	**601**
4	26	6	21	248	26	240	79	**645**
5	50	7	17	24	-	-	-	**98**
6	71	40	63	195	-	-	-	**369**
7	36	18	75	115	-	-	-	**245**
Total	**847**	**270**	**571**	**670**	**102**	**416**	**203**	**3,078**

Post ME Matrix totals								
OD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	474	58	60	77	44	48	19	**779**
2	62	110	18	10	12	42	17	**271**
3	61	26	314	30	17	61	81	**590**
4	33	10	20	253	32	275	68	**691**
5	54	9	25	35	-	-	-	**122**
6	59	40	63	237	-	-	-	**399**
7	42	17	73	121	-	-	-	**253**
Total	**784**	**271**	**573**	**762**	**105**	**426**	**186**	**3,107**

Absolute Dif								
OD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	-38	-3	-13	24	-1	-15	-5	**-52**
2	-16	-5	-1	2	2	-2	1	**-18**
3	-13	3	11	3	-4	-7	-3	**-11**
4	8	4	-1	5	6	35	-10	**46**
5	4	2	7	11	0	0	0	**24**
6	-12	0	0	42	0	0	0	**31**
7	6	-1	-2	6	0	0	0	**8**
Total	**-63**	**1**	**2**	**92**	**3**	**10**	**-18**	**29**

% Dif								
OD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	-7.5%	-4.6%	-17.6%	43.8%	-2.1%	-24.2%	-21.6%	**-6.2%**
2	-20.8%	-4.0%	-5.1%	27.6%	25.1%	-4.3%	8.3%	**-6.1%**
3	-17.2%	13.9%	3.5%	10.2%	-19.8%	-10.9%	-4.0%	**-1.9%**
4	29.7%	69.6%	-5.0%	2.0%	22.1%	14.6%	-13.3%	**7.2%**
5	7.0%	30.9%	42.6%	45.0%				**24.2%**
6	-17.4%	0.1%	0.7%	21.8%				**8.3%**
7	15.3%	-6.1%	-2.3%	4.8%				**3.4%**
Total	**-7.4%**	**0.5%**	**0.3%**	**13.8%**	**3.0%**	**2.5%**	**-8.7%**	**0.9%**

GEH dif								
OD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	1.7	0.4	1.6	2.9	0.1	2.1	1.1	**1.8**
2	1.9	0.4	0.2	0.7	0.7	0.3	0.3	**1.1**
3	1.5	0.6	0.6	0.5	1.0	0.9	0.4	**0.5**
4	1.4	1.5	0.2	0.3	1.1	2.2	1.2	**1.8**
5	0.5	0.7	1.6	2.0				**2.3**
6	1.5	0.0	0.1	2.9				**1.6**
7	0.9	0.3	0.2	0.5				**0.5**
Total	**2.2**	**0.1**	**0.1**	**3.4**	**0.3**	**0.5**	**1.3**	**0.5**

Table 7-14 Sector to Sector Comparison – PM Peak Cars

Prior Matrix Totals								
OD	1	2	3	4	5	6	7	Total
1	16,247	2,008	1,810	1,040	1,277	591	120	**23,093**
2	1,339	6,873	1,292	80	263	1,018	54	**10,920**
3	1,526	1,246	24,913	830	219	936	2,159	**31,829**
4	1,047	103	809	9,412	821	1,693	226	**14,111**
5	983	273	184	814	-	-	-	**2,253**
6	579	1,543	1,028	1,749	-	-	-	**4,899**
7	184	118	3,324	438	-	-	-	**4,064**
Total	**21,905**	**12,165**	**33,361**	**14,362**	**2,580**	**4,237**	**2,559**	**91,169**
Post ME Matrix totals								
OD	1	2	3	4	5	6	7	Total
1	16,746	1,876	1,964	942	1,384	609	124	**23,644**
2	1,280	6,835	1,286	60	277	1,002	49	**10,789**
3	1,535	1,235	25,051	805	167	913	2,150	**31,856**
4	1,061	72	776	9,729	789	1,772	274	**14,471**
5	964	263	118	726	-	-	-	**2,070**
6	625	1,501	970	1,796	-	-	-	**4,892**
7	203	101	3,308	501	-	-	-	**4,113**
Total	**22,414**	**11,882**	**33,472**	**14,559**	**2,617**	**4,296**	**2,597**	**91,837**
Absolute Dif								
OD	1	2	3	4	5	6	7	Total
1	499	-132	153	-98	107	18	4	**551**
2	-59	-39	-7	-20	15	-16	-5	**-130**
3	9	-11	137	-25	-52	-22	-9	**27**
4	14	-32	-33	316	-32	79	48	**360**
5	-19	-10	-66	-88	0	0	0	**-183**
6	46	-42	-58	48	0	0	0	**-6**
7	19	-17	-17	63	0	0	0	**49**
Total	**508**	**-283**	**110**	**197**	**38**	**59**	**38**	**668**
% Dif								
OD	1	2	3	4	5	6	7	Total
1	3.1%	-6.6%	8.5%	-9.4%	8.4%	3.0%	3.5%	**2.4%**
2	-4.4%	-0.6%	-0.5%	-24.5%	5.6%	-1.5%	-9.0%	**-1.2%**
3	0.6%	-0.9%	0.6%	-3.0%	-23.7%	-2.4%	-0.4%	**0.1%**
4	1.3%	-30.8%	-4.1%	3.4%	-3.9%	4.7%	21.1%	**2.6%**
5	-1.9%	-3.7%	-35.7%	-10.9%				**-8.1%**
6	8.0%	-2.7%	-5.7%	2.7%				**-0.1%**
7	10.5%	-14.0%	-0.5%	14.4%				**1.2%**
Total	**2.3%**	**-2.3%**	**0.3%**	**1.4%**	**1.5%**	**1.4%**	**1.5%**	**0.7%**
GEH dif								
OD	1	2	3	4	5	6	7	Total
1	3.9	3.0	3.5	3.1	2.9	0.7	0.4	**3.6**
2	1.6	0.5	0.2	2.3	0.9	0.5	0.7	**1.2**
3	0.2	0.3	0.9	0.9	3.7	0.7	0.2	**0.2**
4	0.4	3.4	1.2	3.2	1.1	1.9	3.0	**3.0**
5	0.6	0.6	5.3	3.2				**3.9**
6	1.9	1.1	1.8	1.1				**0.1**
7	1.4	1.6	0.3	2.9				**0.8**
Total	**3.4**	**2.6**	**0.6**	**1.6**	**0.7**	**0.9**	**0.8**	**2.2**

Table 7-15 Sector to Sector Comparison – PM Peak LGV

Prior Matrix Totals								
OD	1	2	3	4	5	6	7	Total
1	2,375	210	231	154	148	102	21	**3,240**
2	162	358	101	25	33	38	1	**719**
3	340	99	510	147	24	89	13	**1,221**
4	189	27	96	416	67	66	99	**958**
5	178	26	50	70	-	-	-	**323**
6	156	20	68	109	-	-	-	**352**
7	20	1	9	91	-	-	-	**122**
Total	**3,419**	**741**	**1,065**	**1,011**	**271**	**295**	**134**	**6,936**
Post ME Matrix totals								
OD	1	2	3	4	5	6	7	Total
1	2,435	213	211	150	149	113	25	**3,297**
2	187	341	115	19	41	36	2	**740**
3	304	110	523	142	22	75	14	**1,190**
4	187	30	87	444	82	89	119	**1,038**
5	182	23	61	58	-	-	-	**324**
6	165	17	69	114	-	-	-	**366**
7	33	1	12	102	-	-	-	**147**
Total	**3,493**	**734**	**1,078**	**1,030**	**294**	**313**	**160**	**7,101**
Absolute Dif								
OD	1	2	3	4	5	6	7	Total
1	60	3	-20	-3	1	11	4	**56**
2	25	-17	14	-6	8	-3	0	**21**
3	-36	10	13	-5	-1	-14	2	**-32**
4	-2	3	-8	29	15	24	20	**79**
5	5	-3	11	-11	0	0	0	**1**
6	10	-3	1	6	0	0	0	**14**
7	12	0	3	11	0	0	0	**26**
Total	**74**	**-7**	**13**	**19**	**23**	**18**	**26**	**166**
% Dif								
OD	1	2	3	4	5	6	7	Total
1	2.5%	1.4%	-8.5%	-2.1%	0.7%	10.9%	18.9%	**1.7%**
2	15.2%	-4.7%	13.5%	-24.7%	24.9%	-7.3%	32.9%	**2.9%**
3	-10.6%	10.4%	2.6%	-3.6%	-5.7%	-15.9%	11.8%	**-2.6%**
4	-1.1%	11.1%	-8.8%	6.9%	22.3%	35.9%	20.1%	**8.3%**
5	2.6%	-12.9%	21.4%	-16.1%				**0.2%**
6	6.3%	-13.0%	1.4%	5.2%				**3.9%**
7	60.5%	-12.0%	33.9%	11.6%				**21.3%**
Total	**2.2%**	**-0.9%**	**1.3%**	**1.9%**	**8.4%**	**6.0%**	**19.2%**	**2.4%**
GEH dif								
OD	1	2	3	4	5	6	7	Total
1	1.2	0.2	1.3	0.3	0.1	1.1	0.8	**1.0**
2	1.9	0.9	1.3	1.3	1.3	0.5	0.3	**0.8**
3	2.0	1.0	0.6	0.4	0.3	1.6	0.4	**0.9**
4	0.1	0.6	0.9	1.4	1.7	2.7	1.9	**2.5**
5	0.3	0.7	1.4	1.4				**0.0**
6	0.8	0.6	0.1	0.5				**0.7**
7	2.4	0.1	0.9	1.1				**2.2**
Total	**1.3**	**0.2**	**0.4**	**0.6**	**1.4**	**1.0**	**2.1**	**2.0**

Table 7-16 Sector to Sector Comparison – PM Peak HGV

Prior Matrix Totals								
OD	1	2	3	4	5	6	7	Total
1	362	38	53	27	22	24	20	**546**
2	67	187	14	6	8	15	8	**304**
3	65	24	417	7	4	22	30	**569**
4	22	2	8	300	35	90	37	**495**
5	10	11	6	11	-	-	-	**39**
6	19	23	45	216	-	-	-	**302**
7	30	12	44	182	-	-	-	**268**
Total	**575**	**297**	**587**	**748**	**70**	**152**	**94**	**2,524**
Post ME Matrix totals								
OD	1	2	3	4	5	6	7	Total
1	327	30	43	30	19	34	22	**504**
2	73	187	14	6	11	13	14	**317**
3	57	23	427	7	5	22	29	**569**
4	22	1	11	303	38	158	42	**575**
5	8	14	4	14	-	-	-	**39**
6	23	26	37	255	-	-	-	**341**
7	30	22	41	202	-	-	-	**295**
Total	**538**	**303**	**576**	**817**	**73**	**227**	**107**	**2,640**
Absolute Dif								
OD	1	2	3	4	5	6	7	Total
1	-35	-8	-11	3	-4	10	2	**-43**
2	6	0	0	0	3	-1	6	**13**
3	-9	0	10	0	0	-1	-1	**0**
4	-1	-1	3	4	3	68	5	**81**
5	-3	3	-2	3	0	0	0	**1**
6	4	4	-8	39	0	0	0	**39**
7	0	9	-3	21	0	0	0	**27**
Total	**-37**	**6**	**-11**	**69**	**3**	**75**	**12**	**117**
% Dif								
OD	1	2	3	4	5	6	7	Total
1	-9.6%	-22.0%	-20.3%	10.8%	-15.7%	41.3%	11.3%	**-7.8%**
2	9.6%	-0.2%	-0.2%	-4.1%	34.1%	-10.0%	77.2%	**4.3%**
3	-13.0%	-0.8%	2.4%	0.1%	11.4%	-4.2%	-3.7%	**-0.1%**
4	-2.7%	-60.3%	37.8%	1.2%	7.8%	74.7%	14.1%	**16.3%**
5	-27.0%	25.1%	-33.0%	25.5%				**2.0%**
6	22.3%	15.8%	-18.4%	18.1%				**12.8%**
7	-1.4%	76.7%	-6.2%	11.3%				**10.0%**
Total	**-6.4%**	**1.9%**	**-1.8%**	**9.2%**	**3.7%**	**49.5%**	**13.0%**	**4.6%**
GEH dif								
OD	1	2	3	4	5	6	7	Total
1	1.9	1.4	1.6	0.5	0.8	1.8	0.5	**1.9**
2	0.8	0.0	0.0	0.1	0.9	0.4	1.8	**0.7**
3	1.1	0.0	0.5	0.0	0.2	0.2	0.2	**0.0**
4	0.1	0.9	1.0	0.2	0.5	6.1	0.8	**3.5**
5	0.9	0.8	0.9	0.8				**0.1**
6	0.9	0.7	1.3	2.5				**2.2**
7	0.1	2.3	0.4	1.5				**1.6**
Total	**1.6**	**0.3**	**0.4**	**2.5**	**0.3**	**5.5**	**1.2**	**2.3**

7.4.10. It is noted that LGV and HGV changes in ME (for average trip length, sector movements and trip end changes) are typically larger than for car. The ability to construct a blended matrix of both MND and synthetic for car allows for more finesse in the prior matrix development leading to less of an impact from ME. For LGV and HGV, the R squared for trip end changes (prior vs post) is reduced by a few outlier zones, but the intercept is typically close to 1. Sector changes exceed 5% in more examples than for car, but the GEH equivalent is typically less than 4. Overall, there is confidence that the model has not required too large an impact on the prior matrix from matrix estimation.

7.5 LINK FLOW CALIBRATION

7.5.1. Observed link count data was available for 765 links across Lincoln and surrounding areas. From these, 508 were used as part of calibration, with 257 retained for validation.

7.5.2. The TAG acceptability guidelines for individual links is detailed in Table 7-17.

Table 7-17 TAG Link Flow Validation Criteria

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

7.5.3. Table 7-18 as follows presents results of link flow calibration. TAG targets for link calibration are met. A breakdown of the calibration by individual link and by time period is presented in Appendix D.

Table 7-18 Link Flow Calibration Summary

Measure	AM	IP	PM
Pass Flow	100% (508 of 508)	100% (508 of 508)	99% (502 of 508)
Pass GEH	97% (493 of 508)	99% (505 of 508)	98% (498 of 508)

7.6 SCREENLINE CALIBRATION

7.6.1. The model contained eight calibration screenlines. The calibration screenlines have been shown earlier in Figure 7-3 in section 7.3.

7.6.2. The TAG guidance for screenlines, reproduced in Table 7-19 as follows, advises that modelled flow should be within 5% of the observed counts for “all or nearly all” screenlines.

Table 7-19 TAG Screenline Validation Criteria

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

7.6.3. Table 7-20 provides a summary of the screenline calibration results. The GEH statistic (< 4 for screenlines) has also been reported to demonstrate the robustness of the model. The GEH statistic is designed to provide a weighting in accordance to scale of traffic flow and is calculated as follows;

$$GEH = \sqrt{\frac{(V_A - V_O)^2}{(V_A + V_O)/2}}$$

where V_O = observed traffic flow and V_A = assigned traffic flow.

7.6.4. For all vehicles, each calibration screenline is within target for flow (<5% difference to observed) and GEH criteria (<4) except for one in AM.

Table 7-20 Screenline Calibration Summary

	Calibration Screenlines		
	AM	IP	PM
Within 5%	100% (16 of 16)	100% (16 of 16)	100% (16 of 16)
GEH < 4	100% (16 of 16)	100% (16 of 16)	100% (16 of 16)

7.6.5. The calibration results for the individual screenlines are presented in Table 7-21 to Table 7-23. A breakdown of the calibration by individual links on each screenline and by time period are presented in Appendix D.

Table 7-21 Screenline Calibration (veh/h): AM Peak

Screenline	Description	Direction	Observed	Modelled	Mod - Obs	% Diff	GEH	Pass - Flow	Pass - GEH
2	Outer East Screenline	Inbound	687	687	0	0%	0.0	Yes	Yes
	Outer East Screenline	Outbound	693	692	-1	0%	0.0	Yes	Yes
5	LEB Screenline	Inbound	1,785	1,784	-1	0%	0.0	Yes	Yes
	LEB Screenline	Outbound	1,879	1,877	-2	0%	0.0	Yes	Yes
6	LSB Screenline	Inbound	2,035	2,062	27	1%	0.6	Yes	Yes
	LSB Screenline	Outbound	2,012	2,008	-4	0%	0.1	Yes	Yes
7	LWB Screenline	Inbound	744	745	1	0%	0.0	Yes	Yes
	LWB Screenline	Outbound	830	829	-1	0%	0.0	Yes	Yes
8	LNB Screenline	Inbound	1,987	1,987	0	0%	0.0	Yes	Yes
	LNB Screenline	Outbound	1,948	1,947	-1	0%	0.0	Yes	Yes
11	Inner SouthEast Screenline	Inbound	1,180	1,181	1	0%	0.0	Yes	Yes
	Inner SouthEast Screenline	Outbound	1,217	1,209	-8	-1%	0.2	Yes	Yes
12	Inner SouthWest Screenline	Inbound	1,747	1,747	0	0%	0.0	Yes	Yes
	Inner SouthWest Screenline	Outbound	1,896	1,897	1	0%	0.0	Yes	Yes
16	Inner EastWest 1 Screenline	Inbound	1,039	1,041	2	0%	0.1	Yes	Yes
	Inner EastWest1 Screenline	Outbound	1,019	1,017	-2	0%	0.1	Yes	Yes
17	Railway Screenline	Inbound	1,774	1,775	1	0%	0.0	Yes	Yes
	Railway Screenline	Outbound	1,933	1,950	17	1%	0.4	Yes	Yes

Table 7-22 Screenline Calibration (veh/h): Inter Peak

Screenline	Description	Direction	Observed	Modelled	Mod - Obs	% Diff	GEH	Pass - Flow	Pass - GEH
2	Outer East Screenline	Inbound	687	687	0	0%	0.0	Yes	Yes
	Outer East Screenline	Outbound	693	692	-1	0%	0.0	Yes	Yes
5	LEB Screenline	Inbound	1,785	1,784	-1	0%	0.0	Yes	Yes
	LEB Screenline	Outbound	1,879	1,877	-2	0%	0.0	Yes	Yes
6	LSB Screenline	Inbound	2,035	2,064	29	1%	0.6	Yes	Yes
	LSB Screenline	Outbound	2,012	2,009	-3	0%	0.1	Yes	Yes
7	LWB Screenline	Inbound	744	745	0	0%	0.0	Yes	Yes
	LWB Screenline	Outbound	830	829	0	0%	0.0	Yes	Yes
8	LNB Screenline	Inbound	1,987	1,987	0	0%	0.0	Yes	Yes
	LNB Screenline	Outbound	1,948	1,948	0	0%	0.0	Yes	Yes
11	Inner SouthEast Screenline	Inbound	1,180	1,181	1	0%	0.0	Yes	Yes
	Inner SouthEast Screenline	Outbound	1,217	1,209	-8	-1%	0.2	Yes	Yes
12	Inner SouthWest Screenline	Inbound	1,747	1,746	-1	0%	0.0	Yes	Yes
	Inner SouthWest Screenline	Outbound	1,896	1,896	1	0%	0.0	Yes	Yes
16	Inner EastWest 1 Screenline	Inbound	1,039	1,041	2	0%	0.1	Yes	Yes
	Inner EastWest1 Screenline	Outbound	1,019	1,017	-3	0%	0.1	Yes	Yes
17	Railway Screenline	Inbound	1,774	1,775	2	0%	0.0	Yes	Yes
	Railway Screenline	Outbound	1,933	1,949	17	1%	0.4	Yes	Yes

Table 7-23 Screenline Calibration (veh/h): PM Peak

Screenline	Description	Direction	Observed	Modelled	Mod - Obs	% Diff	GEH	Pass - Flow	Pass - GEH
2	Outer East Screenline	Inbound	773	772	-1	0%	0.0	Yes	Yes
	Outer East Screenline	Outbound	931	934	3	0%	0.1	Yes	Yes
5	LEB Screenline	Inbound	1,979	1,979	0	0%	0.0	Yes	Yes
	LEB Screenline	Outbound	2,862	2,864	2	0%	0.0	Yes	Yes
6	LSB Screenline	Inbound	2,815	2,855	40	1%	0.8	Yes	Yes
	LSB Screenline	Outbound	2,462	2,453	-9	0%	0.2	Yes	Yes
7	LWB Screenline	Inbound	847	847	0	0%	0.0	Yes	Yes
	LWB Screenline	Outbound	1119	1122	3	0%	0.1	Yes	Yes
8	LNB Screenline	Inbound	2,555	2,554	-1	0%	0.0	Yes	Yes
	LNB Screenline	Outbound	2,963	2,958	-5	0%	0.1	Yes	Yes
11	Inner SouthEast Screenline	Inbound	1,217	1,224	7	1%	0.2	Yes	Yes
	Inner SouthEast Screenline	Outbound	1,893	1,930	37	2%	0.9	Yes	Yes
12	Inner SouthWest Screenline	Inbound	1,879	1,873	-6	0%	0.1	Yes	Yes
	Inner SouthWest Screenline	Outbound	2,475	2,483	8	0%	0.2	Yes	Yes
16	Inner EastWest 1 Screenline	Inbound	1,294	1,311	17	1%	0.5	Yes	Yes
	Inner EastWest1 Screenline	Outbound	1,378	1,389	11	1%	0.3	Yes	Yes
17	Railway Screenline	Inbound	2,114	2,093	-21	-1%	0.5	Yes	Yes
	Railway Screenline	Outbound	2,507	2,520	13	0%	0.2	Yes	Yes

8 HIGHWAY MODEL VALIDATION

8.1 INTRODUCTION

8.1.1. Validation of the GLTM2 was based upon a comparison of observed against modelled traffic flow and journey time data. The data used to validate the model was independent from data used to calibrate the model.

8.2 CONVERGENCE

8.2.1. Convergence results are summarised in Table 8-1 with details for the last four iteration loops provided. It shows that the model has achieved a high level of convergence, and the model meets all the TAG convergence criteria (shown earlier in Table 6-2). They are stable for at least four consecutive assignment simulation loops and the delta and %gap values comfortably exceed the targets specified in the TAG of 0.1%. Similarly, the percentage flow difference achieved is higher than the 98% required by guidance.

Table 8-1 Convergence Summary

Time Period	Loop	Proximity indicator: Delta (δ) / (Gap (%)	Stability Indicator: % Flow	Stability Indicator: % GAP
AM	24	0.001	99.7	0.00016
	25	0.001	99.8	0.00017
	26	0.001	99.7	0.0001
	27	0.002	99.6	0.00008
IP	10	0.001	99.6	0.0006
	11	0.001	99.6	0.0003
	12	0.001	99.7	0.00002
	13	0.001	99.8	0.00002
PM	13	0.004	99.6	0.00014
	14	0.004	99.7	0.00022
	15	0.004	99.8	0.00013
	16	0.003	100	0.00011

8.2.2. A ‘stress test’ of all three time periods was undertaken using the GONZO parameter within SATURN. GONZO applies a user defined factor that is applied uniformly across the matrix and then assigned to the network. This allows a user to have a representation of future traffic growth in the network and see how the assignment performs.

8.2.3. A GONZO factor of 1.18 was applied in the assignment. This represents a projected 18% growth in traffic between 2023 (the base year) and 2043 (the final forecast year) in the East Midlands region according to the National Road Transport Projections (NRTP22).

8.2.4. The AM Peak, IP and PM Peak GONZO models converge in 38, 21 and 46 loops respectively. The GONZO tests indicate a robustness of the model to be able to accommodate higher demand as anticipated in forecast scenarios.

8.2.5. The model convergence summary for the GONZO test is presented in table 8-2.

Table 8-2 Convergence Summary for GONZO 18% Test

Time Period	Loop	Proximity indicator: Delta (δ) / (Gap (%)	Stability Indicator: % Flow	Stability Indicator: % GAP
AM	35	0.0003	99.8	0.00024
	36	0.0003	99.7	0.00042
	37	0.0002	99.5	0.00024
	38	0.0002	99.7	0.00019
IP	18	0.0000	99.7	0.00005
	19	0.0000	99.7	0.00011
	20	0.0001	99.6	0.00003
	21	0.0000	99.6	0.00004
PM	43	0.0006	99.8	0.00049
	44	0.0005	99.8	0.00052
	45	0.0005	99.7	0.00050
	46	0.0004	99.7	0.00046

8.3 LINK FLOW VALIDATION

8.3.1. As described in Section 7.5, observed link count data was available for 765 links across Lincoln and the surrounding area. From these, 257 were excluded from model calibration and instead retained for evaluating model validation.

8.3.2. Table 9-2 as follows presents the link flow validation results for all validation links. This exceeds the Flow and GEH TAG link criteria in each time period.

Table 8-3 Link Flow Validation Summary (All Vehicles)

Measure	AM	IP	PM
Pass Flow	94% (241 of 257)	97% (249 of 257)	94% (241 of 257)
Pass GEH	88% (227 of 257)	93% (239 of 257)	89% (230 of 257)

8.3.3. A breakdown of the model validation by individual link (and by time period and vehicle class) is presented in Appendix E.

8.4 SCREENLINE VALIDATION

8.4.1. For validation of the trip matrix, TAG advises that comparisons of observed counts and modelled flows should be undertaken at a screenline level.

8.4.2. The validation screenlines are illustrated in Figure 8-1. Table 8-3 provides a summary of the results whilst the results are presented in detail in Table 8-4 to Table 8-6. A breakdown of the validation by individual links on each screenline and by time period is presented in Appendix E.

8.4.3. One of the original screenlines defined in the Model Specification Report (screenline 20) comprised a series of counts undertaken during 2021 for the purposes of the Lincoln Easter Bypass monitoring. These counts had been scaled up to be representative estimates of 2023 traffic. Once this was completed these uplifted 2021 counts demonstrated inconsistency with surrounding counts and screenlines from the commissioned 2023 traffic surveys. As the counts were undertaken during 2021 during the disruption to traffic volumes brought about due to restrictions related to Covid-19, a decision was taken to remove this screenline from the analysis and reporting totals due to lower confidence in the data – hence a total of 22 validation screenline results (11 screenlines by 2 directions) in Table 8-4.

8.4.4. The screenline validation results show that the criteria of GEH < 4 is met for all screenlines in all time periods. Validation flow criteria (within 5%) is achieved in 95% of validation screenlines in each time period for car, and at least 95% in each time period for all vehicles.

Table 8-4 Overall Screenline Validation Summary (All Vehicles)

	Validation screenlines		
	AM	IP	PM
Within 5%	100% (22 of 22)	95% (21 of 22)	100% (22 of 22)
GEH < 4	100% (22 of 22)	100% (22 of 22)	100% (22 of 22)

Figure 8-1 Validation Screenlines

Table 8-5 Screenline Validation (veh/h): AM Peak

Screenline	Description	Direction	Observed	Modelled	Mod - Obs	% Diff	GEH	Pass - Flow	Pass - GEH
1	Outer North Screenline	Inbound	1,977	2,027	50	2%	1.1	Yes	Yes
	Outer North Screenline	Outbound	1,506	1,494	-12	-1%	0.3	Yes	Yes
3	OuterSouth Screenline	Inbound	1,587	1,558	-29	-2%	0.7	Yes	Yes
	Outer South Screenline	Outbound	1,526	1,477	-49	-3%	1.3	Yes	Yes
4	Outer West Screenline	Inbound	2,308	2,295	-13	-1%	0.3	Yes	Yes
	Outer West Screenline	Outbound	2,038	2,085	47	2%	1.0	Yes	Yes
9	Suburban South Screenline	Inbound	3,067	3,164	97	3%	1.7	Yes	Yes
	Suburban South Screenline	Outbound	2,892	2,862	-30	-1%	0.6	Yes	Yes
10	Inner NorthEast Screenline	Inbound	2,174	2,169	-5	0%	0.1	Yes	Yes
	Inner NorthEast Screenline	Outbound	1,586	1,521	-65	-4%	1.7	Yes	Yes
13	Inner NorthWest Screenline	Inbound	2,329	2,269	-60	-3%	1.2	Yes	Yes
	Inner SouthWest Screenline	Outbound	1,509	1,529	20	1%	0.5	Yes	Yes
14	Inner EastWest 3 Screenline	Inbound	1,779	1,837	58	3%	1.4	Yes	Yes
	Inner EastWest 3 Screenline	Outbound	2,116	2,038	-78	-4%	1.7	Yes	Yes
15	Inner EastWest 2 Screenline	Inbound	1,377	1,354	-23	-2%	0.6	Yes	Yes
	Inner EastWest 2 Screenine	Outbound	1,631	1,598	-33	-2%	0.8	Yes	Yes
18	Inner Southern Screenline	Inbound	6,252	6,302	50	1%	0.6	Yes	Yes
	Inner Southern Screenline	Outbound	4,640	4,593	-47	-1%	0.7	Yes	Yes
19	South of Greater Lincoln	Inbound	2,460	2,416	-44	-2%	0.9	Yes	Yes
	South of Greater Lincoln	Outbound	2,341	2,352	11	0%	0.2	Yes	Yes

Table 8-6 Screenline Validation (veh/h): Inter Peak

Screenline	Description	Direction	Observed	Modelled	Mod - Obs	% Diff	GEH	Pass - Flow	Pass - GEH
1	Outer North Screenline	Inbound	1,249	1,265	16	1%	0.4	Yes	Yes
	Outer North Screenline	Outbound	1,350	1,345	-5	0%	0.1	Yes	Yes
3	OuterSouth Screenline	Inbound	1,114	1,107	-7	-1%	0.2	Yes	Yes
	Outer South Screenline	Outbound	1,023	1,040	17	2%	0.5	Yes	Yes
4	Outer West Screenline	Inbound	1,813	1,756	-57	-3%	1.4	Yes	Yes
	Outer West Screenline	Outbound	1,820	1,813	-7	0%	0.2	Yes	Yes
9	Suburban South Screenline	Inbound	2,533	2,500	-33	-1%	0.6	Yes	Yes
	Suburban South Screenline	Outbound	2,602	2,542	-60	-2%	1.2	Yes	Yes
10	Inner NorthEast Screenline	Inbound	1,533	1,447	-86	-6%	2.2	No	Yes
	Inner NorthEast Screenline	Outbound	1,580	1,515	-65	-4%	1.7	Yes	Yes
13	Inner NorthWest Screenline	Inbound	1,452	1,408	-44	-3%	1.2	Yes	Yes
	Inner SouthWest Screenline	Outbound	1,449	1,424	-25	-2%	0.7	Yes	Yes
14	Inner EastWest 3 Screenline	Inbound	1,725	1,756	31	2%	0.8	Yes	Yes
	Inner EastWest 3 Screenline	Outbound	1,721	1,637	-86	-5%	2.1	Yes	Yes
15	Inner EastWest 2 Screenline	Inbound	1,194	1,194	0	0%	0.0	Yes	Yes
	Inner EastWest 2 Screenine	Outbound	1,355	1,343	-12	-1%	0.3	Yes	Yes
18	Inner Southern Screenline	Inbound	4,598	4,527	-71	-2%	1.1	Yes	Yes
	Inner Southern Screenline	Outbound	4,490	4,316	-174	-4%	2.6	Yes	Yes
19	South of Greater Lincoln	Inbound	1,965	1,892	-73	-4%	1.7	Yes	Yes
	South of Greater Lincoln	Outbound	1,948	1,870	-78	-4%	1.8	Yes	Yes

Table 8-7 Screenline Validation (veh/h): PM Peak

Screenline	Description	Direction	Observed	Modelled	Mod - Obs	% Diff	GEH	Pass - Flow	Pass - GEH
1	Outer North Screenline	Inbound	1,608	1,581	-27	-2%	0.7	Yes	Yes
	Outer North Screenline	Outbound	1,895	1,980	85	5%	1.9	Yes	Yes
3	OuterSouth Screenline	Inbound	1,745	1,808	63	4%	1.5	Yes	Yes
	Outer South Screenline	Outbound	1,534	1,575	41	3%	1.0	Yes	Yes
4	Outer West Screenline	Inbound	2,526	2,450	-75	-3%	1.5	Yes	Yes
	Outer West Screenline	Outbound	2,264	2,252	-12	-1%	0.3	Yes	Yes
9	Suburban South Screenline	Inbound	2,953	2,841	-113	-4%	2.1	Yes	Yes
	Suburban South Screenline	Outbound	3,227	3,334	107	3%	1.9	Yes	Yes
10	Inner NorthEast Screenline	Inbound	1,835	1,872	37	2%	0.9	Yes	Yes
	Inner NorthEast Screenline	Outbound	2,068	2,047	-21	-1%	0.5	Yes	Yes
13	Inner NorthWest Screenline	Inbound	1,860	1,884	24	1%	0.6	Yes	Yes
	Inner SouthWest Screenline	Outbound	2,136	2,188	52	2%	1.1	Yes	Yes
14	Inner EastWest 3 Screenline	Inbound	1,996	2,040	44	2%	1.0	Yes	Yes
	Inner EastWest 3 Screenline	Outbound	1,873	1,889	16	1%	0.4	Yes	Yes
15	Inner EastWest 2 Screenline	Inbound	1,301	1,310	9	1%	0.3	Yes	Yes
	Inner EastWest 2 Screenine	Outbound	1,553	1,497	-56	-4%	1.4	Yes	Yes
18	Inner Southern Screenline	Inbound	5,213	5,352	139	3%	1.9	Yes	Yes
	Inner Southern Screenline	Outbound	5,651	5,754	103	2%	1.4	Yes	Yes
19	South of Greater Lincoln	Inbound	2,614	2,572	-42	-2%	0.8	Yes	Yes
	South of Greater Lincoln	Outbound	2,400	2,433	33	1%	0.7	Yes	Yes

8.5 JOURNEY TIME VALIDATION

8.5.1. Journey time routes were defined to validate modelled travel times, in line with guidance contained in TAG Unit M1.2. The validation was assessed using the TAG validation criteria as set out in section 3.2.10 of TAG Unit M3.1 and replicated in Table 8-8.

Table 8-8 TAG Journey Time Validation Criteria

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

8.5.2. A total of 41 routes (82 by direction) were defined across the Study Area. The journey time routes are shown in Figure 8-2 and Figure 8-3.

8.5.3. Observed journey time data were sourced from Inrix data for June 2023.

8.5.4. Table 8-9 shows the percentage of routes that achieve TAG criteria of modelled times within 1 minute of 15% of observed journey times. Each time period indicates a high level of validation compared against TAG criteria, with at least 96% within 15% or 1 minute. For AM, two routes are marginally outside the criteria, being 15% slower than observed.

Table 8-9 Journey Time Validation Summary

Criteria	All Routes		
	AM	IP	PM
Within 15% (or 1 minute)	96% (79 of 82)	100% (82 of 82)	99% (81 of 82)

8.5.5. The detailed results of the validation of the modelled journey times for each individual route are presented in Appendix F.

Figure 8-2 Validation Journey Time Routes – Wider View

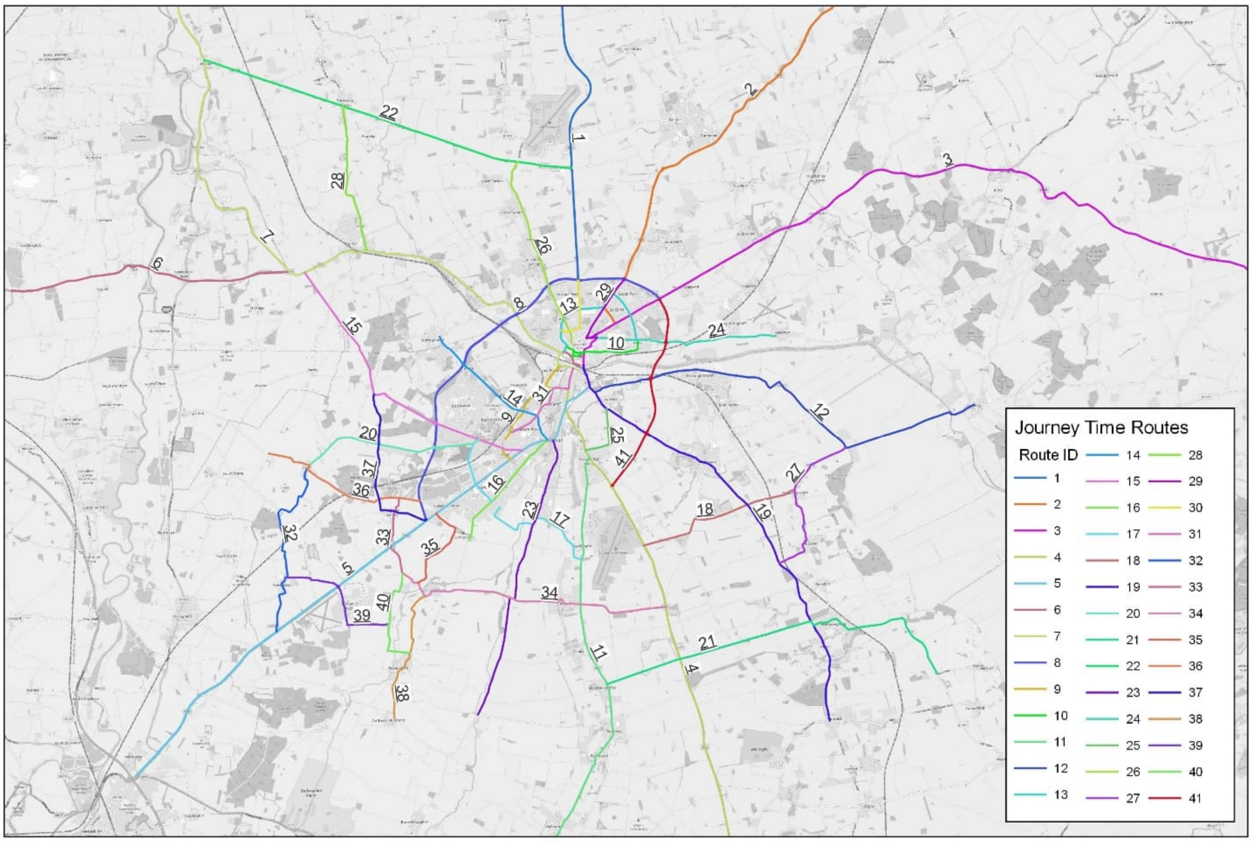


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Figure 8-3 - Validation Journey Time Routes in City Centre (Inset of Figure 8-2 Above)

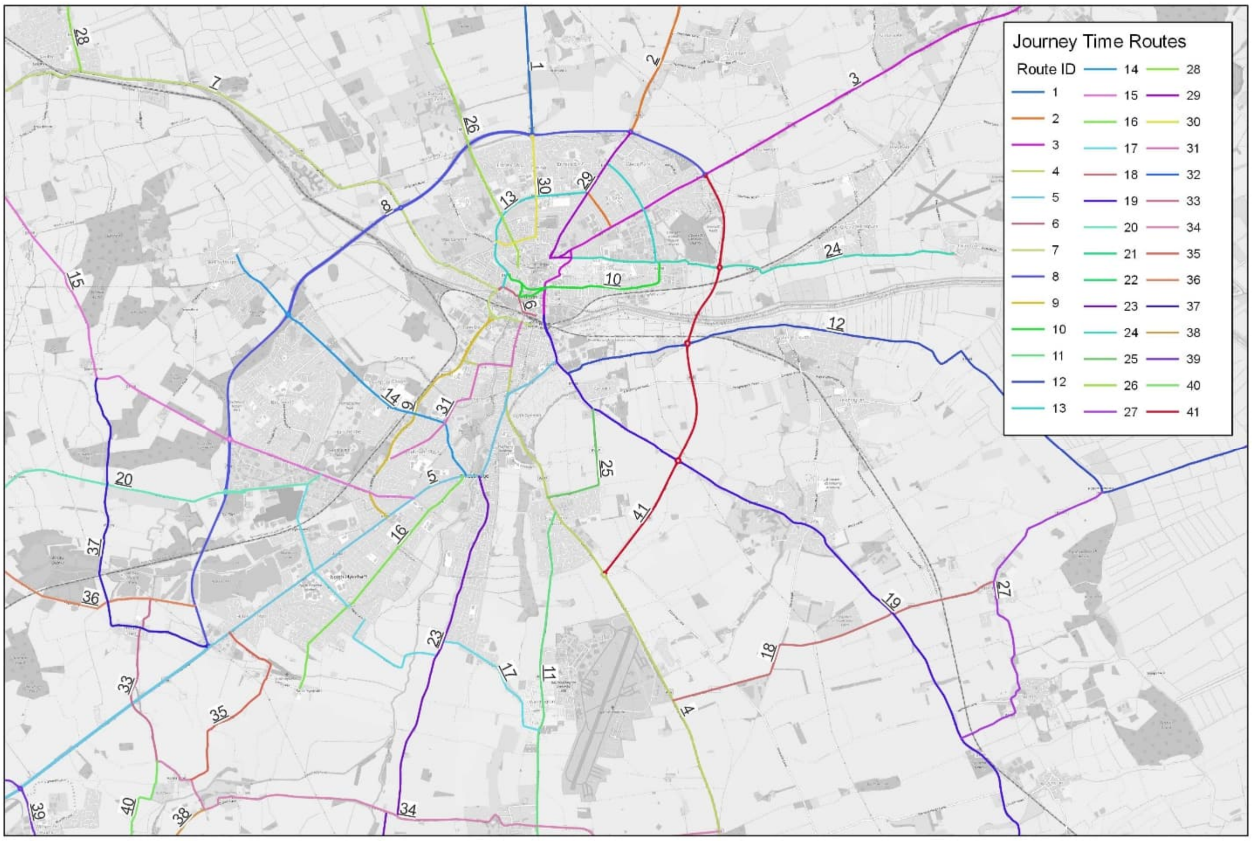

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Table 8-10 AM Journey Time Validation

ID	Name	Distance (km)	Obs. Time	Mod. Time	Diff	%	Pass
1_NB	Pelham Bridge to A631 North of Lincoln	20.8	1364	1398	34	2%	Yes
1_SB	A631 North of Lincoln to Pelham Bridge	20.8	1361	1474	113	8%	Yes
2_NB	Pelham Bridge to A46 Middle Rasen	23.9	1675	1430	-245	-15%	Yes
2_SB	A46 Middle Rasen to Pelham Bridge	23.9	1604	1540	-64	-4%	Yes
3_EB	Pelham Bridge to A158 Horncastle	33.6	2120	2009	-111	-5%	Yes
3_WB	A158 Horncastle to Pelham Bridge	33.6	2206	2069	-136	-6%	Yes
4_NB	A1192 Tritton Rd to A15 Sleaford	25.6	1545	1712	167	11%	Yes
4_SB	A15 Sleaford to A1192 Tritton Rd	25.6	1528	1636	108	7%	Yes
5_NB	A46 Newark to Pelham Bridge	23.2	1584	1587	3	0%	Yes
5_SB	Pelham Bridge to A46 Newark	23.1	1602	1651	48	3%	Yes
6_EB	A57 Darlton to Lincoln Central Station	23.1	1535	1600	65	4%	Yes
6_WB	Lincoln Central Station to A57 Darlton	23.1	1451	1488	37	3%	Yes
7_NB	A57 Lincoln TC to A156 Gainsborough	30.2	1825	1895	70	4%	Yes
7_SB	A156 Gainsborough to A57 Lincoln TC	30.1	1933	2034	101	5%	Yes
8_NB	A46 Hykeham Roundabout to A15/A158	14.9	747	861	114	15%	No
8_SB	A15/A158 to A46 Hykeham Roundabout	14.9	881	908	27	3%	Yes
9_NB	A1434/A1192 North Hykeham to A1192/A57 New Boultham	4.3	549	605	56	10%	Yes
9_SB	A1192/A57 New Boutlham to A1434/A1192 North Hykeham	4.3	530	491	-39	-7%	Yes
10_EB	B1273/B1398 Lincoln to B1308/B1533 Lincoln	3.3	446	499	53	12%	Yes
10_WB	B1308/B1533 Lincoln to B1273/B1398 Lincoln	3.1	420	481	61	14%	Yes
11_NB	A607 Leadenham to A607 Bracebridge	17.2	1052	1089	37	3%	Yes
11_SB	A607 Bracebridge to A607 Leadenham	17.2	1109	1053	-56	-5%	Yes
12_EB	B1190 Canwick to B1202/B1190 Bardney	15.6	1005	945	-59	-6%	Yes
12_WB	B1202/B1190 Bardney to B1190 Canwick	15.6	1016	987	-29	-3%	Yes
13_EB	B1273 Lincoln to Outercircle/Greetwell Rd	5.4	671	752	81	12%	Yes

13_WB	Outercircle/Greetwell Rd to B1273 Lincoln	5.4	665	782	117	18%	No
14_EB	Skellingthorpe to Bracebridge	5.7	773	677	-96	-12%	Yes
14_WB	Bracebridge to Skellingthorpe	5.7	671	653	-18	-3%	Yes
15_EB	A57/B1190 Broadholme to B1190/A1434 North Hykeham	11.1	851	799	-53	-6%	Yes
15_WB	B1190/A1434 North Hykeham to A57/B1190 Broadholme	11.1	839	831	-7	-1%	Yes
16_NB	South Hykeham to Bracebridge	4.7	447	505	58	13%	Yes
16_SB	Bracebridge to South Hykeham	4.7	453	454	2	0%	Yes
17_EB	Whisby Rd/Station Rd to Waddington	7.6	748	776	28	4%	Yes
17_WB	Waddington to Whisby Rd/Station Rd	7.6	761	754	-6	-1%	Yes
18_EB	A15 Waddington to Potterhanworth	6.1	289	327	38	13%	Yes
18_WB	Potterhanworth to A15 Waddington	6.1	347	338	-9	-3%	Yes
19_NB	Scopwick to Melville Street, Lincoln	17.0	1046	1208	162	15%	No
19_SB	Melville Street, Lincoln to Scopwick	17.0	1070	1043	-27	-3%	Yes
20_EB	Eagle to Doddington Rd	6.7	453	441	-12	-3%	Yes
20_WB	Doddington Rd to Eagle	6.7	402	425	22	5%	Yes
21_EB	Boothby Graffoe to B1191 Martin	13.9	799	815	16	2%	Yes
21_WB	B1191 Martin to Boothby Graffoe	13.9	769	814	45	6%	Yes
22_EB	Marton to A15/Horncastle Ln	14.0	702	712	10	1%	Yes
22_WB	A15/Horncastle Ln to Marton	14.0	689	688	-2	0%	Yes
23_NB	Church Ln/Broughton Ln to Bracebridge	10.7	680	718	38	6%	Yes
23_SB	Bracebridge to Church Ln/Broughton Ln	10.7	647	691	44	7%	Yes
24_EB	Wragby Rd/Greetwell Rd to Fiskerton	6.7	463	452	-11	-2%	Yes
24_WB	Fiskerton to Wragby Rd/Greetwell Rd	6.7	551	592	41	7%	Yes
25_NB	Bracebridge Heath to Canwick (B1131)	2.2	153	168	15	10%	Yes
25_SB	B1131 Canwick to Bracebridge Heath	2.2	129	157	28	22%	Yes
26_NB	Drury Lane, Lincoln to A1500 Till Bridge Lane	7.1	474	488	14	3%	Yes
26_SB	A1500 Till Bridge Lane to Drury Lane, Lincoln	7.1	476	533	57	12%	Yes

27_NB	Potterhanworth Booths to B1188 Nocton	6.0	469	403	-65	-14%	Yes
27_SB	B1188 Nocton to Potterhanworth Booths	6.0	448	404	-44	-10%	Yes
28_NB	Sturton by Stow to Saxilby	5.5	376	363	-13	-3%	Yes
28_SB	Saxilby to Sturton by Stow	5.5	375	376	1	0%	Yes
29_NB	Wragby Rd/Greetwell Rd to Nettleham Roundabout	2.9	327	343	16	5%	Yes
29_SB	Nettleham Roundabout to Wragby Rd/Greetwell Rd	2.9	349	392	44	12%	Yes
30_NB	Whitton Park to Riseholme Roundabout (along Rasen Rd and B1226)	2.5	291	282	-9	-3%	Yes
30_SB	Riseholme Roundabout to Whitton Park (along B1226 and Rasen Rd)	2.4	266	312	46	17%	Yes
31_NB	Tritton Rd/Moorland Ave to A57/High Street	3.7	495	523	28	6%	Yes
31_SB	A57/High Street to Tritton Rd/Moorland Ave	3.7	528	476	-52	-10%	Yes
32_NB	A46/Newark Rd to Eagle	7.4	573	564	-9	-2%	Yes
32_SB	Eagle to A46/Newark Rd	7.4	643	648	5	1%	Yes
33_NB	Haddington to Whisby Nature Park	3.0	233	211	-22	-9%	Yes
33_SB	Whisby Nature Park to Haddington	3.0	191	214	23	12%	Yes
34_EB	Haddington to Harmston	10.6	614	681	67	11%	Yes
34_WB	Harmston to Haddington	10.6	687	676	-12	-2%	Yes
35_NB	Haddington to Hykeham Moor	3.5	237	254	17	7%	Yes
35_SB	Hykeham Moor to Haddington	3.5	248	234	-15	-6%	Yes
36_EB	Eagle Road, Eagle to A46	6.3	420	478	59	14%	Yes
36_WB	A46 to Eagle Road, Eagle	6.3	417	425	7	2%	Yes
37_NB	Doddington to Hykeham Roundabout	6.1	395	391	-4	-1%	Yes
37_SB	Hykeham Roundabout to Doddington	6.1	417	440	23	5%	Yes
38_NB	Carlton le Moorland to Aubourn	5.0	330	366	36	11%	Yes
38_SB	Aubourn to Carlton le Moorland	5.0	393	367	-25	-6%	Yes
39_NB	Thurlby to Swinderby	4.9	309	331	22	7%	Yes
39_SB	Swinderby to Thurlby	4.9	354	335	-18	-5%	Yes
40_NB	Bassingham to Haddington	3.9	288	249	-39	-14%	Yes

40_SB	Haddington to Bassingham	3.9	239	249	10	4%	Yes
41_NB	Sleaford Road Roundabout to A158/A15	7.5	433	401	-33	-8%	Yes
41_SB	A158/A15 to Sleaford Road Roundabout	7.5	412	409	-3	-1%	Yes

Table 8-11 IP Journey Time Validation

ID	Name	Distance (km)	Obs. Time	Mod. Time	Diff	%	Pass
1_NB	Pelham Bridge to A631 North of Lincoln	20.8	1342	1409	67	5%	Yes
1_SB	A631 North of Lincoln to Pelham Bridge	20.8	1320	1367	47	4%	Yes
2_NB	Pelham Bridge to A46 Middle Rasen	23.9	1621	1403	-219	-13%	Yes
2_SB	A46 Middle Rasen to Pelham Bridge	23.9	1497	1423	-74	-5%	Yes
3_EB	Pelham Bridge to A158 Horncastle	33.6	2087	2025	-62	-3%	Yes
3_WB	A158 Horncastle to Pelham Bridge	33.6	2145	2008	-137	-6%	Yes
4_NB	A1192 Tritton Rd to A15 Sleaford	25.6	1517	1597	80	5%	Yes
4_SB	A15 Sleaford to A1192 Tritton Rd	25.6	1607	1556	-50	-3%	Yes
5_NB	A46 Newark to Pelham Bridge	23.2	1609	1496	-113	-7%	Yes
5_SB	Pelham Bridge to A46 Newark	23.1	1552	1533	-19	-1%	Yes
6_EB	A57 Darlton to Lincoln Central Station	23.1	1498	1438	-60	-4%	Yes
6_WB	Lincoln Central Station to A57 Darlton	23.1	1444	1485	40	3%	Yes
7_NB	A57 Lincoln TC to A156 Gainsborough	30.2	1834	1839	5	0%	Yes
7_SB	A156 Gainsborough to A57 Lincoln TC	30.1	1849	1856	7	0%	Yes
8_NB	A46 Hykeham Roundabout to A15/A158	14.9	783	763	-21	-3%	Yes
8_SB	A15/A158 to A46 Hykeham Roundabout	14.9	860	780	-80	-9%	Yes
9_NB	A1434/A1192 North Hykeham to A1192/A57 New Boultham	4.3	567	578	11	2%	Yes
9_SB	A1192/A57 New Boutlham to A1434/A1192 North Hykeham	4.3	509	545	36	7%	Yes
10_EB	B1273/B1398 Lincoln to B1308/B1533 Lincoln	3.3	471	466	-5	-1%	Yes
10_WB	B1308/B1533 Lincoln to B1273/B1398 Lincoln	3.1	402	422	20	5%	Yes

11_NB	A607 Leadenham to A607 Bracebridge	17.2	1058	1038	-20	-2%	Yes
11_SB	A607 Bracebridge to A607 Leadenham	17.2	1063	1028	-35	-3%	Yes
12_EB	B1190 Canwick to B1202/B1190 Bardney	15.6	943	937	-6	-1%	Yes
12_WB	B1202/B1190 Bardney to B1190 Canwick	15.6	1007	964	-43	-4%	Yes
13_EB	B1273 Lincoln to Outercircle/Greetwell Rd	5.4	667	703	36	5%	Yes
13_WB	Outercircle/Greetwell Rd to B1273 Lincoln	5.4	670	699	29	4%	Yes
14_EB	Skellingthorpe to Bracebridge	5.7	614	644	30	5%	Yes
14_WB	Bracebridge to Skellingthorpe	5.7	609	619	10	2%	Yes
15_EB	A57/B1190 Broadholme to B1190/A1434 North Hykeham	11.1	837	761	-76	-9%	Yes
15_WB	B1190/A1434 North Hykeham to A57/B1190 Broadholme	11.1	725	788	63	9%	Yes
16_NB	South Hykeham to Bracebridge	4.7	450	473	23	5%	Yes
16_SB	Bracebridge to South Hykeham	4.7	418	433	15	4%	Yes
17_EB	Whisby Rd/Station Rd to Waddington	7.6	758	691	-66	-9%	Yes
17_WB	Waddington to Whisby Rd/Station Rd	7.6	720	690	-31	-4%	Yes
18_EB	A15 Waddington to Potterhanworth	6.1	306	323	17	6%	Yes
18_WB	Potterhanworth to A15 Waddington	6.1	337	325	-12	-3%	Yes
19_NB	Scopwick to Melville Street, Lincoln	17.0	1020	1038	19	2%	Yes
19_SB	Melville Street, Lincoln to Scopwick	17.0	1053	1033	-20	-2%	Yes
20_EB	Eagle to Doddington Rd	6.7	384	415	31	8%	Yes
20_WB	Doddington Rd to Eagle	6.7	402	409	7	2%	Yes
21_EB	Boothby Graffoe to B1191 Martin	13.9	736	794	58	8%	Yes
21_WB	B1191 Martin to Boothby Graffoe	13.9	758	795	37	5%	Yes
22_EB	Marton to A15/Horncastle Ln	14.0	674	695	22	3%	Yes
22_WB	A15/Horncastle Ln to Marton	14.0	680	682	1	0%	Yes
23_NB	Church Ln/Broughton Ln to Bracebridge	10.7	681	681	0	0%	Yes
23_SB	Bracebridge to Church Ln/Broughton Ln	10.7	679	672	-7	-1%	Yes
24_EB	Wragby Rd/Greetwell Rd to Fiskerton	6.7	476	453	-23	-5%	Yes

24_WB	Fiskerton to Wragby Rd/Greetwell Rd	6.7	506	491	-15	-3%	Yes
25_NB	Bracebridge Heath to Canwick (B1131)	2.2	133	134	1	1%	Yes
25_SB	B1131 Canwick to Bracebridge Heath	2.2	133	153	20	15%	Yes
26_NB	Drury Lane, Lincoln to A1500 Till Bridge Lane	7.1	483	484	1	0%	Yes
26_SB	A1500 Till Bridge Lane to Drury Lane, Lincoln	7.1	492	479	-13	-3%	Yes
27_NB	Potterhanworth Booths to B1188 Nocton	6.0	450	401	-49	-11%	Yes
27_SB	B1188 Nocton to Potterhanworth Booths	6.0	440	402	-38	-9%	Yes
28_NB	Sturton by Stow to Saxilby	5.5	328	357	29	9%	Yes
28_SB	Saxilby to Sturton by Stow	5.5	350	358	8	2%	Yes
29_NB	Wragby Rd/Greetwell Rd to Nettleham Roundabout	2.9	354	343	-11	-3%	Yes
29_SB	Nettleham Roundabout to Wragby Rd/Greetwell Rd	2.9	327	354	27	8%	Yes
30_NB	Whitton Park to Riseholme Roundabout (along Rasen Rd and B1226)	2.5	305	279	-26	-9%	Yes
30_SB	Riseholme Roundabout to Whitton Park (along B1226 and Rasen Rd)	2.4	256	282	26	10%	Yes
31_NB	Tritton Rd/Moorland Ave to A57/High Street	3.7	525	479	-46	-9%	Yes
31_SB	A57/High Street to Tritton Rd/Moorland Ave	3.7	461	464	3	1%	Yes
32_NB	A46/Newark Rd to Eagle	7.4	540	563	23	4%	Yes
32_SB	Eagle to A46/Newark Rd	7.4	605	619	14	2%	Yes
33_NB	Haddington to Whisby Nature Park	3.0	237	204	-33	-14%	Yes
33_SB	Whisby Nature Park to Haddington	3.0	210	207	-3	-1%	Yes
34_EB	Haddington to Harmston	10.6	679	648	-31	-5%	Yes
34_WB	Harmston to Haddington	10.6	644	642	-2	0%	Yes
35_NB	Haddington to Hykeham Moor	3.5	228	234	6	2%	Yes
35_SB	Hykeham Moor to Haddington	3.5	228	229	1	0%	Yes
36_EB	Eagle Road, Eagle to A46	6.3	473	439	-34	-7%	Yes
36_WB	A46 to Eagle Road, Eagle	6.3	440	424	-17	-4%	Yes
37_NB	Doddington to Hykeham Roundabout	6.1	396	385	-11	-3%	Yes
37_SB	Hykeham Roundabout to Doddington	6.1	408	406	-3	-1%	Yes

38_NB	Carlton le Moorland to Aubourn	5.0	359	362	3	1%	Yes
38_SB	Aubourn to Carlton le Moorland	5.0	371	366	-5	-1%	Yes
39_NB	Thurlby to Swinderby	4.9	292	322	29	10%	Yes
39_SB	Swinderby to Thurlby	4.9	317	327	10	3%	Yes
40_NB	Bassingham to Haddington	3.9	268	246	-21	-8%	Yes
40_SB	Haddington to Bassingham	3.9	264	247	-16	-6%	Yes
41_NB	Sleaford Road Roundabout to A158/A15	7.5	425	363	-62	-14%	Yes
41_SB	A158/A15 to Sleaford Road Roundabout	7.5	415	366	-50	-12%	Yes

Table 8-12 PM Journey Time Validation

ID	Name	Distance (km)	Obs. Time	Mod. Time	Diff	%	Pass
1_NB	Pelham Bridge to A631 North of Lincoln	20.8	1340	1466	126	9%	Yes
1_SB	A631 North of Lincoln to Pelham Bridge	20.8	1446	1434	-12	-1%	Yes
2_NB	Pelham Bridge to A46 Middle Rasen	23.9	1543	1464	-78	-5%	Yes
2_SB	A46 Middle Rasen to Pelham Bridge	23.9	1572	1477	-95	-6%	Yes
3_EB	Pelham Bridge to A158 Horncastle	33.6	2169	2093	-76	-4%	Yes
3_WB	A158 Horncastle to Pelham Bridge	33.6	2238	2050	-188	-8%	Yes
4_NB	A1192 Tritton Rd to A15 Sleaford	25.6	1516	1681	165	11%	Yes
4_SB	A15 Sleaford to A1192 Tritton Rd	25.6	1617	1676	58	4%	Yes
5_NB	A46 Newark to Pelham Bridge	23.2	1584	1582	-2	0%	Yes
5_SB	Pelham Bridge to A46 Newark	23.1	1515	1625	111	7%	Yes
6_EB	A57 Darlton to Lincoln Central Station	23.1	1512	1510	-2	0%	Yes
6_WB	Lincoln Central Station to A57 Darlton	23.1	1537	1634	97	6%	Yes
7_NB	A57 Lincoln TC to A156 Gainsborough	30.2	1877	2083	207	11%	Yes
7_SB	A156 Gainsborough to A57 Lincoln TC	30.1	1895	1920	25	1%	Yes
8_NB	A46 Hykeham Roundabout to A15/A158	14.9	805	793	-11	-1%	Yes
8_SB	A15/A158 to A46 Hykeham Roundabout	14.9	842	822	-20	-2%	Yes

9_NB	A1434/A1192 North Hykeham to A1192/A57 New Boultham	4.3	547	540	-7	-1%	Yes
9_SB	A1192/A57 New Boutlham to A1434/A1192 North Hykeham	4.3	474	541	68	14%	Yes
10_EB	B1273/B1398 Lincoln to B1308/B1533 Lincoln	3.3	491	516	24	5%	Yes
10_WB	B1308/B1533 Lincoln to B1273/B1398 Lincoln	3.1	475	473	-2	0%	Yes
11_NB	A607 Leadenham to A607 Bracebridge	17.2	1055	1069	14	1%	Yes
11_SB	A607 Bracebridge to A607 Leadenham	17.2	1044	1063	19	2%	Yes
12_EB	B1190 Canwick to B1202/B1190 Bardney	15.6	904	954	51	6%	Yes
12_WB	B1202/B1190 Bardney to B1190 Canwick	15.6	981	973	-7	-1%	Yes
13_EB	B1273 Lincoln to Outercircle/Greetwell Rd	5.4	722	774	52	7%	Yes
13_WB	Outercircle/Greetwell Rd to B1273 Lincoln	5.4	774	775	2	0%	Yes
14_EB	Skellingthorpe to Bracebridge	5.7	788	704	-85	-11%	Yes
14_WB	Bracebridge to Skellingthorpe	5.7	692	676	-16	-2%	Yes
15_EB	A57/B1190 Broadholme to B1190/A1434 North Hykeham	11.1	908	779	-129	-14%	Yes
15_WB	B1190/A1434 North Hykeham to A57/B1190 Broadholme	11.1	735	810	75	10%	Yes
16_NB	South Hykeham to Bracebridge	4.7	429	504	75	17%	No
16_SB	Bracebridge to South Hykeham	4.7	409	455	46	11%	Yes
17_EB	Whisby Rd/Station Rd to Waddington	7.6	814	777	-36	-4%	Yes
17_WB	Waddington to Whisby Rd/Station Rd	7.6	728	769	40	6%	Yes
18_EB	A15 Waddington to Potterhanworth	6.1	299	329	30	10%	Yes
18_WB	Potterhanworth to A15 Waddington	6.1	332	332	0	0%	Yes
19_NB	Scopwick to Melville Street, Lincoln	17.0	998	1078	79	8%	Yes
19_SB	Melville Street, Lincoln to Scopwick	17.0	1093	1137	44	4%	Yes
20_EB	Eagle to Doddington Rd	6.7	396	438	43	11%	Yes
20_WB	Doddington Rd to Eagle	6.7	415	420	4	1%	Yes
21_EB	Boothby Graffoe to B1191 Martin	13.9	754	826	73	10%	Yes
21_WB	B1191 Martin to Boothby Graffoe	13.9	805	832	27	3%	Yes

22_EB	Marton to A15/Horncastle Ln	14.0	616	700	83	14%	Yes
22_WB	A15/Horncastle Ln to Marton	14.0	658	694	36	6%	Yes
23_NB	Church Ln/Broughton Ln to Bracebridge	10.7	695	718	23	3%	Yes
23_SB	Bracebridge to Church Ln/Broughton Ln	10.7	748	698	-51	-7%	Yes
24_EB	Wragby Rd/Greetwell Rd to Fiskerton	6.7	465	495	31	7%	Yes
24_WB	Fiskerton to Wragby Rd/Greetwell Rd	6.7	498	510	12	2%	Yes
25_NB	Bracebridge Heath to Canwick (B1131)	2.2	132	138	6	5%	Yes
25_SB	B1131 Canwick to Bracebridge Heath	2.2	135	168	32	24%	Yes
26_NB	Drury Lane, Lincoln to A1500 Till Bridge Lane	7.1	461	516	55	12%	Yes
26_SB	A1500 Till Bridge Lane to Drury Lane, Lincoln	7.1	451	487	36	8%	Yes
27_NB	Potterhanworth Booths to B1188 Nocton	6.0	400	402	2	1%	Yes
27_SB	B1188 Nocton to Potterhanworth Booths	6.0	459	406	-53	-12%	Yes
28_NB	Sturton by Stow to Saxilby	5.5	328	374	46	14%	Yes
28_SB	Saxilby to Sturton by Stow	5.5	350	361	11	3%	Yes
29_NB	Wragby Rd/Greetwell Rd to Nettleham Roundabout	2.9	341	369	28	8%	Yes
29_SB	Nettleham Roundabout to Wragby Rd/Greetwell Rd	2.9	348	369	21	6%	Yes
30_NB	Whitton Park to Riseholme Roundabout (along Rasen Rd and B1226)	2.5	295	311	16	6%	Yes
30_SB	Riseholme Roundabout to Whitton Park (along B1226 and Rasen Rd)	2.4	306	297	-10	-3%	Yes
31_NB	Tritton Rd/Moorland Ave to A57/High Street	3.7	469	485	15	3%	Yes
31_SB	A57/High Street to Tritton Rd/Moorland Ave	3.7	466	517	52	11%	Yes
32_NB	A46/Newark Rd to Eagle	7.4	554	566	12	2%	Yes
32_SB	Eagle to A46/Newark Rd	7.4	613	703	89	15%	Yes
33_NB	Haddington to Whisby Nature Park	3.0	228	209	-19	-8%	Yes
33_SB	Whisby Nature Park to Haddington	3.0	215	225	10	4%	Yes
34_EB	Haddington to Harmston	10.6	664	691	27	4%	Yes
34_WB	Harmston to Haddington	10.6	605	673	69	11%	Yes
35_NB	Haddington to Hykeham Moor	3.5	221	236	15	7%	Yes

35_SB	Hykeham Moor to Haddington	3.5	216	239	23	11%	Yes
36_EB	Eagle Road, Eagle to A46	6.3	433	440	7	2%	Yes
36_WB	A46 to Eagle Road, Eagle	6.3	401	429	27	7%	Yes
37_NB	Doddington to Hykeham Roundabout	6.1	377	393	16	4%	Yes
37_SB	Hykeham Roundabout to Doddington	6.1	413	425	12	3%	Yes
38_NB	Carlton le Moorland to Aubourn	5.0	346	363	18	5%	Yes
38_SB	Aubourn to Carlton le Moorland	5.0	356	367	10	3%	Yes
39_NB	Thurlby to Swinderby	4.9	324	330	6	2%	Yes
39_SB	Swinderby to Thurlby	4.9	334	334	0	0%	Yes
40_NB	Bassingham to Haddington	3.9	246	248	2	1%	Yes
40_SB	Haddington to Bassingham	3.9	249	251	2	1%	Yes
41_NB	Sleaford Road Roundabout to A158/A15	7.5	399	384	-15	-4%	Yes
41_SB	A158/A15 to Sleaford Road Roundabout	7.5	401	394	-7	-2%	Yes

9 HIGHWAY MODEL VALIDATION FOR THE NORTH HYKEHAM RELIEF ROAD

9.1 INTRODUCTION

9.1.1. The main purpose of the development of the GLTM2 is to support in the creation of the Full Business Case for the North Hykeham Relief Road. With that purpose in mind it is worth discussing the validation of the GLTM2 on the area impacted by the NHRR.

9.2 POTENTIAL IMPACT AREA OF THE NHRR

9.2.1. The previous GLTM was used to support the Outline Business Case of the NHRR. As such there is a SATURN model version of the NHRR that can be used to understand the scale of the highway impacts.

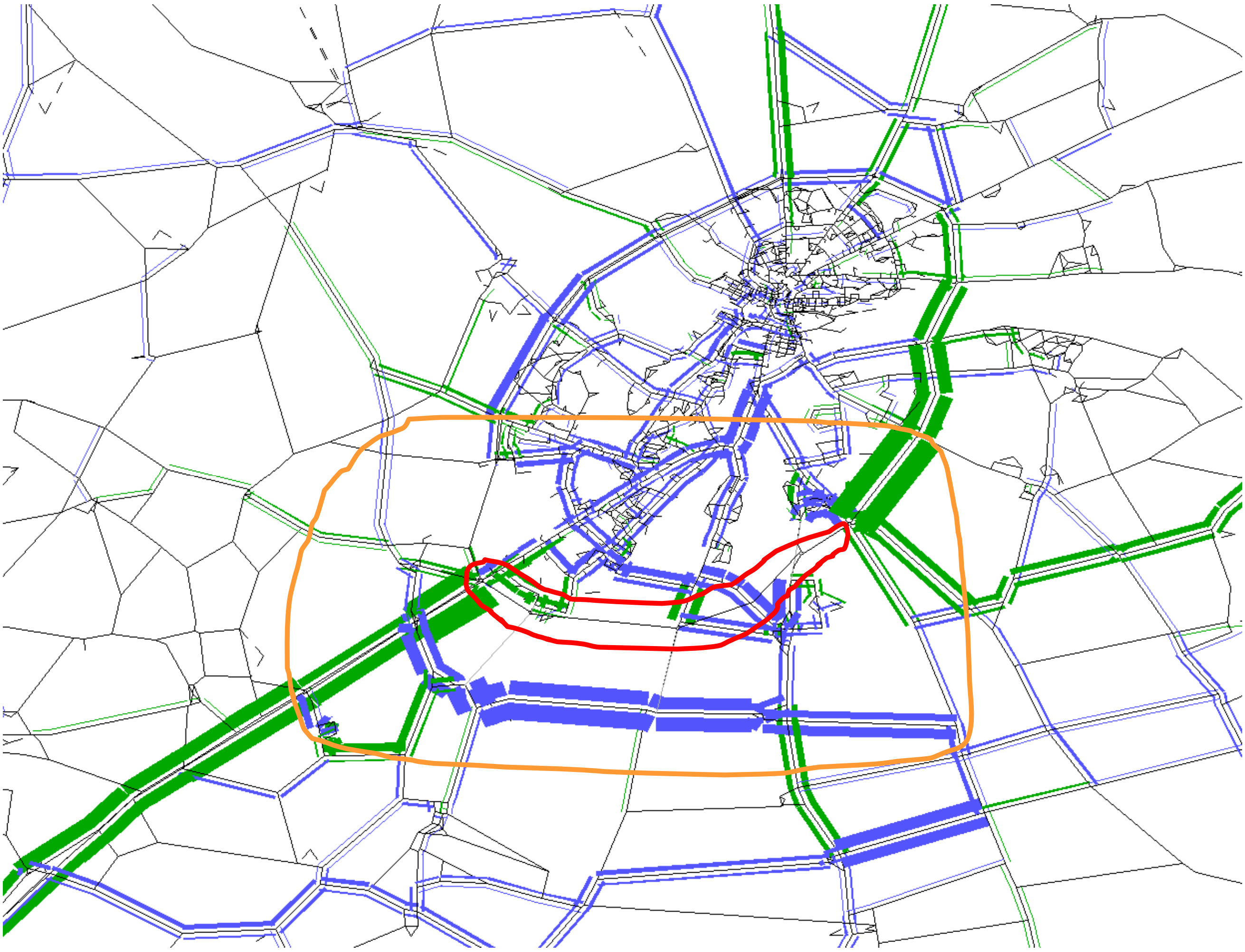
9.2.2. A flow difference plot between the Do Something (with NHRR) against the Do Minimum (no NHRR) is illustrated in Figure 9-1.

9.2.3. This shows that the NHRR:

- Increases traffic volumes on the A46 between Lincoln and Newark;
- Increases traffic volumes on the Lincoln Eastern Bypass;
- Reduces traffic volumes on the A1434 inside the ring road;
- Reduces traffic volumes around the North Hykeham area such as along Meadow Lane; and
- Reduces traffic volumes along the Blackmoor Road corridor.

9.2.4. The NHRR is circled in red in Figure 9-1. Based on the impacts described the impact area of the NHRR has been defined by the area circled in orange.

Figure 9-1 - Flow Difference Plot of Do Something against Do Minimum (previous GLTM)



9.2.5. Based on the defined impact area there are:

- 251 Link Counts split between:
  - 175 Calibration counts; and
  - 76 independent Validation counts.
- Five Screenlines:
  - 5 – LEB Screenline
  - 6 – LSB Screenline
  - 7 – LWB Screenline
  - 9 – Suburban South; and
  - 19 – South of Lincs.
- 23 Journey Time Routes:
  - 4 – A1192 Tritton Rd to A15 Sleaford;
  - 5 – A46 Newark to Pelham Bridge;
  - 8 – A46 Hykeham Roundabout to A15/A158;

- 9 – A1434/A1192 North Hykeham to A1192/A57 New Boultham;
- 11 – A607 Leadenham to A607 Bracebridge;
- 14 – Skellingthorpe to Bracebridge;
- 15 – A57/B1190 Broadholme to B1190/A1434 North Hykeham;
- 16 – South Hykeham to Bracebridge;
- 17 – Whisby Rd/Station Rd to Waddington;
- 18 – A15 Waddington to Potterhanworth;
- 20 – Eagle to Doddington Rd;
- 23 – Church Ln/Broughton Ln to Bracebridge;
- 25 – Bracebridge Heath to Canwick (B1131);
- 31 – Tritton Rd/Moorland Ave to A57/High Street;
- 33 – Haddington to Whisby Nature Park;
- 34 – Harmston to Haddington;
- 35 – Haddington to Hykeham Moor;
- 36 – Eagle Road, Eagle to A46;
- 37 – Doddington to Hykeham Roundabout;
- 38 – Carlton le Moorland to Aubourn;
- 39 – Thurlby to Swinderby;
- 40 – Bassingham to Haddington; and
- 41 – Sleaford Road Roundabout to A158/A15.

9.3 LINK FLOW CALIBRATION AND VALIDATION PERFORMANCE IN THE NHRR IMPACT AREA

9.3.1. Table 9-1 as follows presents results of link flow calibration. TAG targets for link calibration are met. A breakdown of the calibration by individual link and by time period is presented in Appendix D.

Table 9-1 Link Flow Calibration Summary

Measure	AM	IP	PM
Pass Flow	100% (175 of 175)	100% (175 of 175)	99% (173 of 175)
Pass GEH	96% (168 of 175)	99% (174 of 175)	97% (170 of 175)

9.3.2. Table 9-2 as follows presents the link flow validation results for all validation links. This exceeds the Flow and GEH TAG link criteria in each time period.

Table 9-2 Link Flow Validation Summary (All Vehicles)

Measure	AM	IP	PM
Pass Flow	95% (72 of 76)	96% (73 of 76)	92% (70 of 76)
Pass GEH	91% (69 of 76)	91% (69 of 76)	91% (69 of 76)

9.4 SCREENLINE CALIBRATION AND VALIDATION PERFORMANCE IN THE NHRR IMPACT AREA

9.4.1. For all vehicles, each calibration screenline is within target for flow (<5% difference to observed) and GEH criteria (<4) within the NHRR Impact Area.

Table 9-3 Screenline Calibration Summary

	Calibration Screenlines		
	AM	IP	PM
Within 5%	100% (4 of 4)	100% (4 of 4)	100% (4 of 4)
GEH < 4	100% (4 of 4)	100% (4 of 4)	100% (4 of 4)

9.4.2. The screenline validation results show that the criteria of GEH < 4 is met for all screenlines in all time periods. Validation flow criteria (within 5%) is achieved for all validation screenlines in each time period for all vehicles.

Table 9-4 Overall Screenline Validation Summary (All Vehicles)

	Validation screenlines		
	AM	IP	PM
Within 5%	100% (6 of 6)	100% (6 of 6)	100% (6 of 6)
GEH < 4	100% (6 of 6)	100% (6 of 6)	100% (6 of 6)

9.5 JOURNEY TIME VALIDATION PERFORMANCE IN THE NHRR IMPACT AREA

9.5.1. Table 8-9 shows the percentage of routes that achieve TAG criteria of modelled times within 1 minute of 15% of observed journey times. Each time period indicates a high level of validation compared against TAG criteria, with at least 98% within 15% or 1 minute. For AM, one route is marginally outside the criteria, being 15% slower than observed. In the PM, one route is 17% slower than observed.

Table 9-5 Journey Time Validation Summary

Criteria	All Routes		
	AM	IP	PM
Within 15% (or 1 minute)	98% (45 of 46)	100% (46 of 46)	98% (45 of 46)

9.6 SUMMARY

9.6.1. This subset of the overall GLTM2 highway base model results show that the GLTM2 performs well against the TAG criterion in the NHRR Impact Area.

10 SUMMARY AND CONCLUSIONS

10.1 SUMMARY

10.1.1. This report has described how the traffic model for Greater Lincoln has been developed and validated to a base year of 2023. The model was developed in SATURN software backed by a comprehensive data collection programme.

10.1.2. The model demand development process incorporated MND data, together with a synthetic matrix methodology. The observed prior matrix was derived from Mobile Network Data for all modes within the mobile phone data study area. The data was processed by Telefonica through cell tracking of O2 mobile devices and developed into travel demand matrices using tested processes and algorithms. The data was verified by Telefonica and subsequently by WSP.

10.1.3. A synthetic matrix, developed by a gravity model, was used to infill trips within Greater Lincoln which were not fully represented within the mobile phone data. Matrix estimation was then carried out to produce the final demands.

10.1.4. The assignment model was calibrated and validated. The purpose of the validation is to assess the accuracy of the traffic model against independent data and to demonstrate its suitability as a forecasting and appraisal tool.

10.1.5. The validation process involved comparisons of observed and modelled flows over a number of screenlines and major road links together with a comparison of modelled and observed journey times. The comparisons were assessed using the DfT TAG criteria that provides acceptability guidelines for the validation of link flows, screenline totals and journey times.

10.1.6. The model validation screenlines achieve a pass within 5% in nearly all cases (at least 95% for all vehicles and cars in each time period). GEH criteria is met for all screenlines.

10.1.7. The results of the link flow validation presented in this report demonstrate that the model meets the TAG link flow and GEH criteria at the individual sites. In the AM peak 88% of the links achieve a GEH lower than five, 93% in the interpeak and 89% in the PM peak.

10.1.8. Journey time route validation exceeds TAG criteria, being within 15% or 1 minute for 96% of routes in AM, 100% in IP, and 99% in PM.

10.1.9. These results demonstrate that the model provides an accurate and realistic representation of travel times in the three modelled time periods.

10.2 CONCLUSIONS

10.2.1. The results of the model calibration and validation process demonstrates that the base year traffic model provides a good representation of the current traffic demands and conditions in the study area. This makes the model suitable for evaluating the impacts of the North Hykeham Relief Road as part of a Full Business Case as well as other potential highway network intervention or land use changes within Lincoln.

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