Lincolnshire County Council

GREATER LINCOLN TRANSPORT MODEL 2023 UPDATE (GLTM2)

Model Specification Report

MSR
MAY 2023

CONFIDENTIAL

Lincolnshire County Council

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Lincolnshire County Council

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1 INTRODUCTION

1.1 GREATER LINCOLN TRANSPORT MODEL BACKGROUND

1.1.1 The current 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.

1.1.2 The current GLTM structure and model coverage are illustrated in Figures 1-1, 1-2 and 1-3, reproduced from the GLTM reporting.

1.1.3 A previous 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).

1.1.4 The current 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.

1.1.5 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.

1.1.6 The NHRR OBC was approved in 2019 and received a £110m funding allocation from DfT in 2020. The scheme will complete a ring road around the Greater Lincoln urban area connecting the existing western bypass (A46) and the LEB which opened to traffic in 2020. In the NHRR OBC modelling, the impacts of LEB were forecast using the GLTM as a committed scheme in the 'Do Minimum' traffic forecasting, which was necessary to proceed with the NHRR OBC programme (prior to a time when post-opening data from LEB may have been collected). Since that approval of the model by DfT, both midlands Connect and national Highways have used and approved the model, most recently in the provision of updated forecast to reflect the emerging changes to the Central Lincolnshire Local Plan (CLLP), in 2022/23.

1.1.7 However, this means that in the context of updating the GLTM base modelling to the present year, most of the current survey data, including travel demands, may be 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.

1.1.8 Beyond this local context, there are also potential impacts of travel behaviour changes associated with Covid-19 to be accounted for with new survey data in a present year validation. Covid recovery data across the city has already been collected to provide the evidence to support the one-year monitoring and evaluation of LEB, including at the A46 'Pennells' roundabout, and these data will be used where appropriate.

1.1.9 A more thoroughly updated GLTM is therefore helpful to facilitate the analysis of new projects (the Full Business Case (FBC) for the NHRR being developed by Lincolnshire County Council and its partners.

Figure 1-1 – Current GLTM Structure

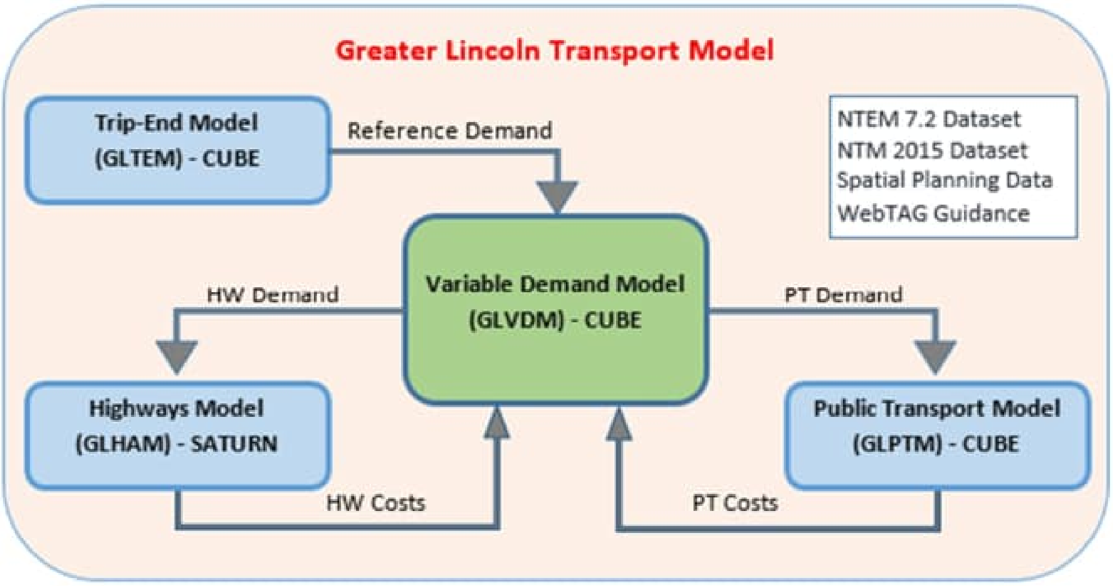


Figure 1-2 – Current GLTM Network Coverage: Greater Lincoln Urban Area

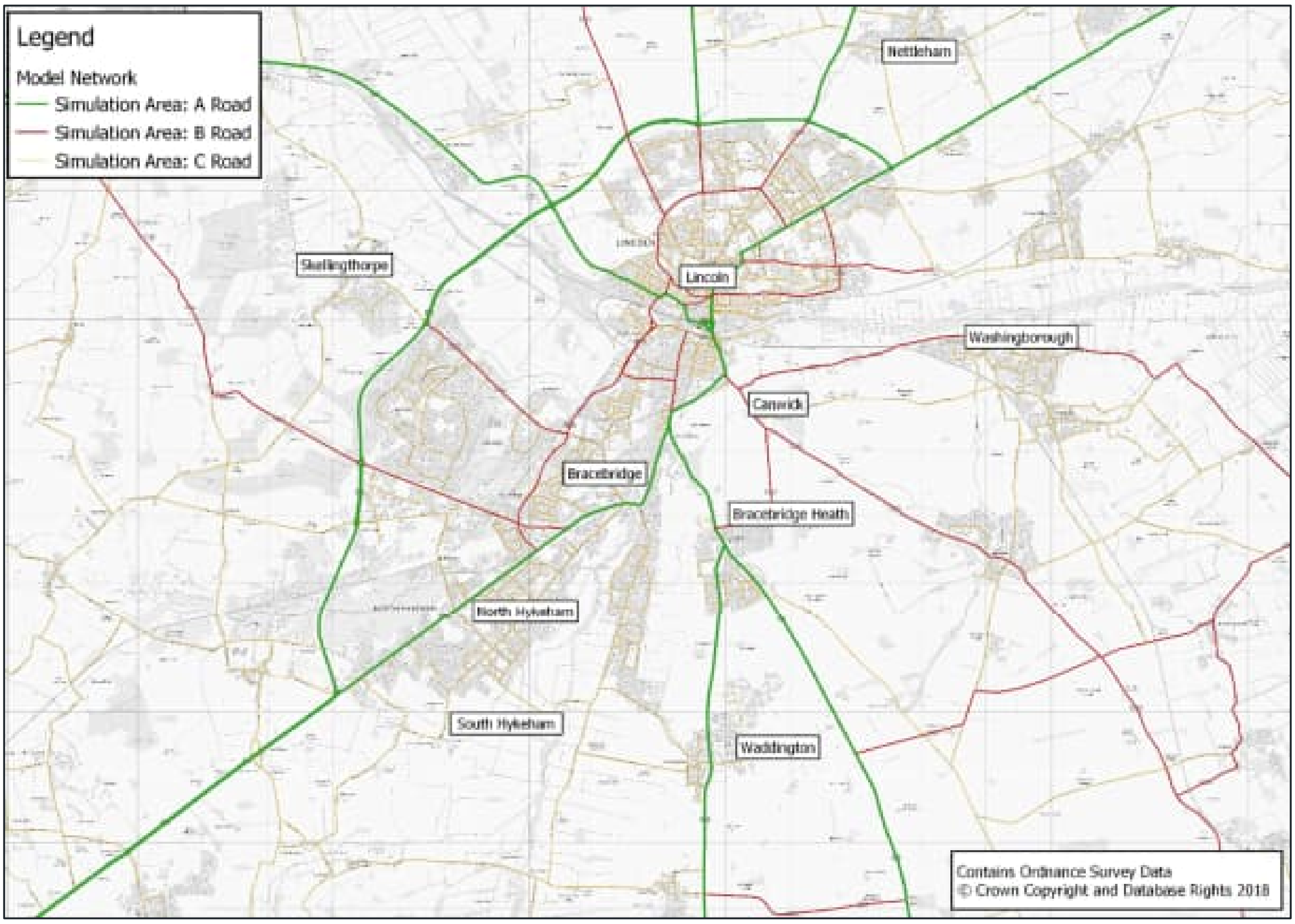
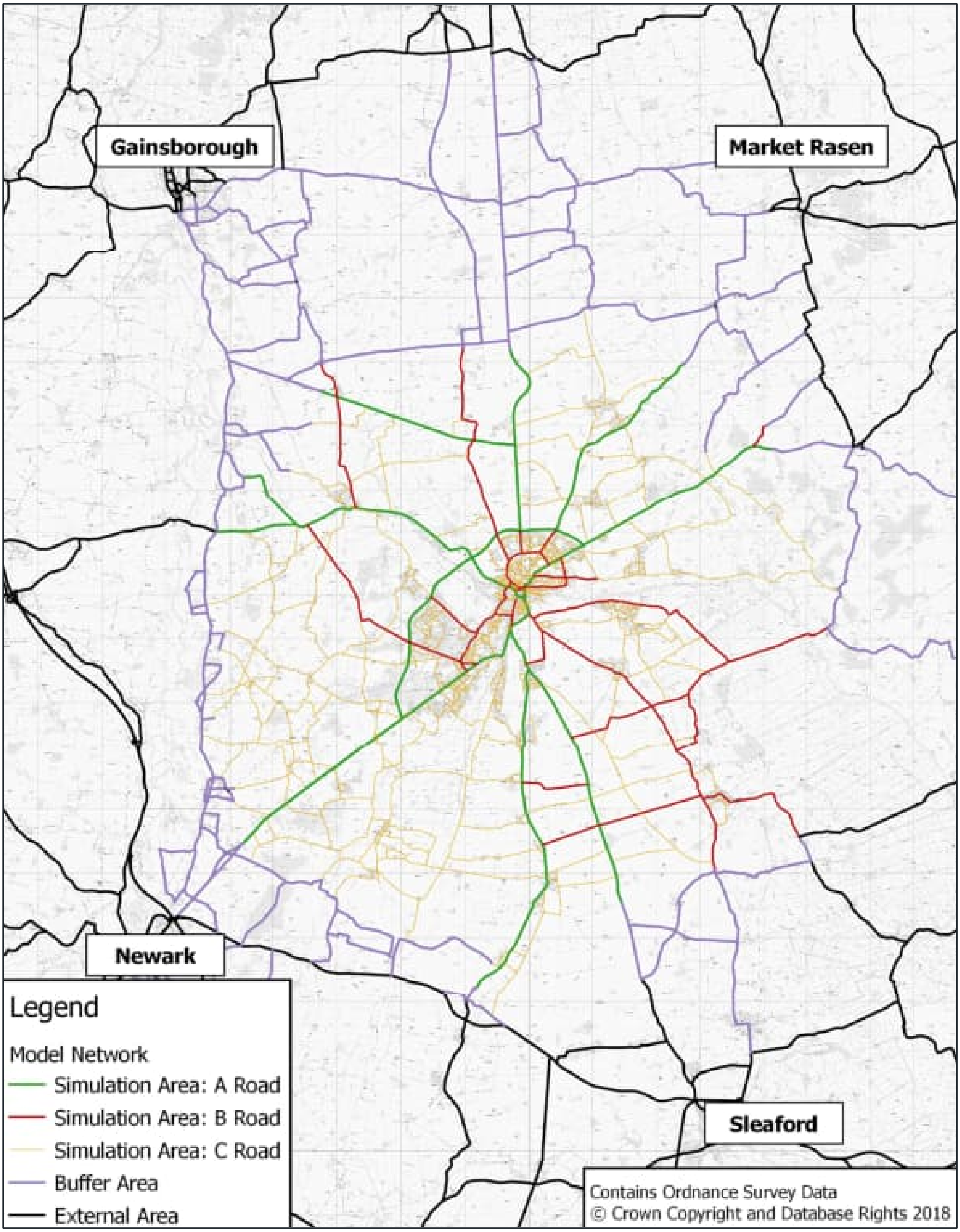


Figure 1-3 – Current GLTM Network Coverage: Wider Area



1.2 PURPOSE OF THIS REPORT

1.2.1 Based on the commonly understood position that an updated GLTM is required, including data collection to support rebasing the model to a present year taking account of recent demand responses including post-LEB opening changes and post Covid-19 travel patterns, LCC has commissioned WSP to the delivery of an updated GLTM.

1.2.2 This report provides the specification against which new model is to be developed.

1.2.3 The content of this report includes:

- Model scope and extent;
- Model data specification;
- Network and zoning specification;
- Travel demand processing;
- Highway assignment model standards;
- Public transport assignment model standards;
- Variable demand modelling; and
- Forecast modelling.

1.2.4 The starting point for this document was the “Transport Model Scoping” technical note (September 2022) which presented the outcome of the scoping study into updating the GLTM.

1.2.5 This MSR may evolve throughout the stages of the model development process and is a live document which can be updated further during the remaining stages of the project.

2 MODEL SCOPE AND EXTENT

2.1 MODEL OBJECTIVES

2.1.1 The current GLTM has provided the analytical basis for undertaking transport forecasting across a range of local studies including the NHRR OBC, updating the Lincoln Transport Strategy, development testing and network operational (traffic management) projects. Traffic forecast model outputs have also been used to undertake economic and environmental appraisal in the relevant cases.

2.1.2 These applications align with the range of objectives for which the current GLTM was specified, that were aligned to those in the Lincoln Transport Strategy (LTS), including:

- Supporting growth and the local economy;
- Improving access to employment, training and key services;
- Providing and maintaining an inclusive and reliable transport network; and
- Contributing to a healthier community and addressing the environmental impact of travel.

2.1.3 In line with the need and requirements described above, WSP propose to update the current GLTM, which will include updating the model base year to take account of recent changes and impacts on the local transport network related to major transport projects such as LEB which have since opened and observed traffic volumes post-COVID 19.

2.1.4 This will ensure that the updated GLTM – herein referred to as the **GLTM version 2** (abbreviated as **GLTM2**) – is upgraded to a robust specification such that the model will continue fulfil its objectives and facilitate the analysis of new projects being developed by Lincolnshire County Council and its partners including the NHRR FBC.

2.2 MODEL USES

2.2.1 A list of potential uses of the GLTM are:

- **Model Use A: Core Requirement - Strategic Business Case Evaluation**
  - A core intention of the model is to support the FBC for the NHRR and a Public Inquiry evidence base.
- **Model Use B: Core Requirement - 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.

- **Model Use C: 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).
- **Model Use D: 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.

2.3 MODEL SCOPE

2.3.1 This model specification proposes to update the current GLTM, based on the existing model structure and functionality as a starting point, but with upgrades and enhancements applied were relevant to ensure that the **GLTM2** will continue to provide a robust and proportionate tool for satisfying the required needs and objectives as set out above, and in line with TAG guidance.

2.3.2 The current GLTM has four primary components, which were illustrated above in Figure 1-1.

- **Greater Lincoln Highway Assignment Model (GLHAM):** A highway assignment model developed within SATURN (Simulation and Assignment of Traffic in Urban Road Networks) to determine journeys travelling on the highway network including traffic flows, speed, delays, route choice and journey costs.
  - It is proposed that the GLHAM will be upgraded to the latest version of SATURN and the model will be updated to reflect the new GLTM base year, including collecting new observed data, updating the network coding and parameters, and deriving new travel demand matrices. Further details are provided in Chapters 4,5 and 6.
- **Greater Lincoln Public Transport Model (GLTPM):** A public transport assignment model developed within Cube Voyager to reflect journeys travelling on public transport routes, including route choice, service patronage and travel costs.
  - It is proposed that the GLPTM will be upgraded to the latest version of Cube Voyager and the model will be updated to reflect the new GLTM base year, including collecting new observed data, updating the network coding and parameters, and deriving new travel demand matrices. Further details are provided in Chapters 4,5 and 6.
- **Greater Lincoln Variable Demand Model (GLVDM):** A variable demand model (VDM) developed within Cube Voyager to predict the future demand for private vehicle travel through consideration of cost change impacts on distribution and mode split. GLVDM facilitates mode choice between private highway and public transport assignments.

- It is proposed that the existing structure of the GLVDM, including demand choices and segmentation, will be retained, but the process will be translated into using WSP's latest Python-based variable demand model template which offers enhanced flexibility for demand segmentation and run times. The model parameters and calibration will need to be updated to reflect the latest travel costs received from the updated GLHAM and updated GLPTM. Further details are provided in Chapter 7.

- **Greater Lincoln Trip End Model (GLTEM):** A bespoke model developed within Cube Voyager to develop forecast year reference case travel demand matrices, including development trip distribution using a gravity model calibrated with local parameters.

  - It is proposed that the existing functionality of the GLTEM, including background growth and the gravity model development trip distribution, will be retained, but the process will be translated into using WSP's latest Python-based external forecast model (EFM) model template which offers enhanced flexibility for demand segmentation and run times. The GLTEM would be renamed to the GLEFM to reflect this. The input data sources would be updated to the use their latest versions, and the gravity model parameters will need to be updated to reflect updates in the local trip distribution received from the updated GLHAM and updated GLPTM. Further details are provided in Chapter 8.

2.3.3 The current GLTM has two additional sub-components, which are linked to the GLVDM.

- **Greater Lincoln Park & Ride Model (GLPRM):** A post-VDM process, which can be activated once a converged solution of the GLVDM supply/demand loop has been achieved, to predict the future demand for proposed park & ride sites through consideration of cost change impacts between 'car only' and 'car with park & ride' route options.
- **Greater Lincoln Parking Allocation Model (GLPAM):** A post-VDM process, which can be activated once a converged solution of the GLVDM supply/demand loop has been achieved, to predict the future impacts for proposed city centre car parking policies through consideration of cost change impacts for car park capacity, parking charges, and localised highway network conditions.

2.3.4 The model structure and inputs for the GLPRM and GLPAM are intrinsically linked to the GLVDM, and so they would require upgrading in parallel with the GLVDM to maintain functionality. They are also dependent on additional data collection, processing, and model calibration. However, the parking models are not activated or required for the NHRR modelling.

2.3.5 For that reason, WSP propose not to include the GLPRM or the GLPAM in the **GLTM2** given they are outside the immediate modelling requirements. But this doesn't exclude the opportunity that either or both components could be redeveloped at a future time if a need or application may arise.

2.4 MODEL STUDY AREA

2.4.1 The current GLTM model study area was illustrated above in Figures 1-2 and 1-3.

2.4.2 It is proposed that the extent of the study area for the **GLTM2** will remain the same, but there will be local refinements and enhancements of the model coverage within this area. This will include expanding the coverage of observed data for model calibration and validation and increasing the level of detail for network and zoning detail around schemes and developments which have been delivered since the current model base year in 2016.

2.4.3 Detailed consideration of these aspects for data coverage, network and zoning is set out in the relevant chapters later in the report.

2.5 MODELLED TIME PERIODS

2.5.1 The time periods modelled in the current GLTM are defined in Table 2-1.

2.5.2 The peak hours for **GLTM2** will be verified based on analysis of recent traffic survey data, to ensure the definitions are still relevant for the new model base year.

2.5.3 The recent scoping exercise for this project has also noted that there are expansion proposals for RAF Waddington which is a large site immediately adjacent to the NHRR scheme. It is possible that the site could be found to have a different peak hour compared to that which may be established for the wider network. However, if this was the case, it would also be pertinent to review if the actual impact from the site is proportionate to require a separate modelled time period within the strategic model context.

2.5.4 This current proposal is based on three modelled time periods, however, if there was a need for another time period this could be discussed and agreed with LCC as a change event.

Table 2-1 – Modelled Time Period Definitions

Period	GLHAM	GLPTM
AM Period	Peak hour (08:00-09:00)	Average hour (07:00-10:00)
Inter Peak	Average hour (10:00-16:00)	Average hour (10:00-16:00)
PM Period	Peak hour (17:00-18:00)	Average hour (16:00-19:00)

2.6 MODELLED USER CLASSES

2.6.1 The time user classes modelled in the current GLTM are defined in Table 2-2.

2.6.2 It is proposed that same user class definitions will be modelled in **GLTM2** since they remain relevant but proportionate for the proposed model uses set out above.

Table 2-2 – Modelled User Class Definitions

User Class	GLHAM	GLPTM
1	Car Employer's Business	PT Employer's Business
2	Car Commute	PT Commute
3	Car Other	PT Other
4	Light Goods Vehicles	NA
5	Heavy Goods Vehicles	NA

2.7 MODEL OUTPUTS

2.7.1 Users of the **GLTM2** will continue to be able to obtain the following information:

- Vehicular traffic data:
  - AM peak, inter peak and PM peak traffic flows;
  - Actual flows, demand flows, queued flows; and
  - Flows by user class (car employer's business, car commuting, car other, Light Goods Vehicles (LGVs), Heavy Goods Vehicles (HGVs)).
- Public transport data:
  - AM peak, inter peak and PM peak traffic flows passenger flows;
  - Boardings, alightings and vehicle level of service by route;
  - Overall public transport boardings and number of interchanges between modes; and
  - Revenue by route and mode.
- Mode share data:
  - Motorised versus public transport.
- Detailed data analysis (for both highways and public transport):
  - Turn volumes and delays;
  - Selected link analyses;
  - Traversal matrices (routing through complex junctions);
  - Daily vehicle volumes and composition for environmental and economic analysis; and
  - Network level of service analysis.
- Demand data:
  - Pre and post VDM by period; and
  - Sectored summary demands by area.
- Skim data:
  - Travel times and distances by highway mode; and
  - Walk, wait, in-vehicle times, transfer times, fare cost by public transport mode.

2.7.2 This is not an exhaustive list, but it is focussed on the most anticipated information required from a transport model, including applications of the current GLTM.

2.8 SOFTWARE CHOICE

2.8.1 As per Section 2.3, the current GLHAM is developed in SATURN software. SATURN is a suite of flexible network analysis programs developed at the Institute for Transport Studies, University of Leeds and distributed and updated by Atkins (now owned by SNC-Lavalin) since 1982. It is commonly operated as a combined traffic simulation and assignment model for the analysis of road investment schemes ranging from traffic management schemes over relatively localised networks.

2.8.2 In combination with speed flow or fixed speed networks it can extend its capability to regional or national modelling, and as such it was the ideal tool for the needs of the current GLTM, and it is compatible with the requirements set out in TAG.

2.8.3 It is proposed to retain SATURN for the updated GLHAM, but that the model will be upgraded to use the latest version of SATURN, which is important so that new functionality within SATURN and its compatibility with other software and hardware is embedded into the model update.

2.8.4 As per Section 2.3, the current GLPTM is developed in Cube Voyager software. It is part of the overall Cube family of software products that can form a complete travel forecasting system, including multi-modal network assignment, bespoke demand processing, and model run scenario management. Other software and scripting languages, including SATURN software applications and bespoke scripts such as Python, can also be integrated into Cube and so it provides the ideal software choice for hosting the overall GLTM model system, and this is critical for facilitating the transfer of data between the different model components.

2.8.5 It is proposed to Cube Voyager for the updated GLPTM and to host the overall GLTM, but that the modelling will be upgraded to use the latest version of Cube.

2.8.6 As per Section 2.3, it is proposed that the GLVDM and GLEFM (formerly GLTEM) will be translated into using WSP's latest Python-based VDM and EFM templates respectively which offer enhanced flexibility for demand segmentation and run times. These applications would be embedded into and activated from within the GLTM Cube catalogue.

2.8.7 The proposed Python-based VDM template is tried-and-tested across several model development projects, and it will ensure that travel demand is balanced with network supply in a manner which is consistent with TAG recommendations.

2.8.8 The remainder of this report will cover the development of the data collection requirements, and the highway model, public transport model, demand model and forecast model specifications.

3 MODEL DATA SPECIFICATION

3.1 INTRODUCTION

3.1.1 This chapter outlines the data specification required in the development of the **GLTM2**.

3.1.2 As described in Chapter 1, in the context of updating the GLTM base modelling to the present year, most of the survey data from the 2016 base model development, including travel demands, may be considered unreliable given changes to travel behaviours associated with LEB and other infrastructure projects which have been delivered in the meantime, combined with impacts on travel volumes following the Covid-19 pandemic.

3.1.3 Both aspects in combinations with the underlying age of the data (over six years old) means that a substantial new survey data collection process will be needed to deliver the requirements of this model specification.

3.1.4 Data will be required for the following model development tasks:

- Highway network development;
- Public transport network development;
- Highway and public transport demand matrix development;
- Highway model calibration and validation; and
- Public transport model calibration and validation.

3.1.5 The chapter has been prepared in line with guidance contained TAG Unit M1.2.

3.2 MODEL BASE YEAR

3.2.1 As described above, it is intended that the **GLTM2** base year will reflect traffic conditions post-opening of LEB and other infrastructure projects which have been delivered since the 2016 model development, combined with impacts on travel volumes following the Covid-19 pandemic.

3.2.2 This will necessitate the collection of travel demand data and journey time data plus the commission of new traffic surveys, which are proposed for Spring 2023. However, based on the current project delivery timescale through 2023, it is likely that the available travel demand and journey time data will be for 2022.

3.2.3 On this basis, it is proposed that **2022 will be the model base year** for **GLTM2**.

3.2.4 Data to be used in the model which was surveyed in other years will be normalised to 2022. Normalisation factors to 2022 will be derived using the best available data, ideally to be based on analysis of data from permanent traffic counts within the model study area, if available.

3.3 MODEL BASE MONTH

3.3.1 Further to the base year, a base month will be established. It is desirable for models to have an average neutral month and average neutral weekday. This will be in line with guidance set out in TAG Unit M1.2 which recommends the following 'neutral' months:

- late March and April – excluding the weeks before and after Easter;
- May - excluding the Thursday before and all of the week of each Bank Holiday;
- June;
- September – excluding school holidays or return to school weeks;
- all of October – excluding school holidays; and
- all of November – provided adequate lighting is available.

3.3.2 It is proposed that the model base month can be determined once the data collection has been completed, so that the survey months of the various survey data sources can be considered, but the choice will be in line with the recommendations above.

3.3.3 Data to be used in the model which was surveyed in other months will be normalised to the model base month. Normalisation factors to the base month (when it has been determined) will be derived using the best available data, ideally to be based on analysis of data from permanent traffic counts within the model study area, if available.

3.4 NETWORK DATA

Existing Data

3.4.1 The current GLTM provides a good starting point for the network data requirements.

3.4.2 The highway network links were developed from the Integrated Transport Network, and are coded with the following information:

- Road class (Motorways, Trunk roads, A road, B road and C/unclassified roads);
- Road type (single or dual carriageway);
- Speed limit;
- Number of lanes; and
- Any other restrictions on the roads (e.g., heigh, weight restriction etc).

3.4.3 Highway links are also coded with speed/flow curve relationships and/or fixed speed data, subject to their classification in the network hierarchy. Bus priority measures and lanes are also included, where relevant.

3.4.4 The highway model junctions in the simulation area were coded with the following information:

- Junction type (priority, roundabout and signalised);
- Saturation flows for all movements;
- Configuration and geometry including number of approach arms, width of approach arms, plus flare lengths and lane discipline including permitted and banned turns; and
- Additional parameters relevant to specific junction types such as gap acceptance values and signal data.

3.4.5 The existing highway network coding is representative of the network conditions in November 2016, and it is proposed that it will be used as the basis for developing the updated GLTM networks. Additionally, the current forecast networks include coding for schemes which have now been constructed – including LEB – which will be copied into the new base year coding were applicable.

3.4.6 The coded traffic signal and level crossing timings were derived from traffic signal specifications and observed level crossing barrier downtime data provided by LCC.

3.4.7 The current GLTM public transport network also includes rail links and walk links. The rail network coding is likewise representative of the infrastructure in 2016. Walk links are primarily included within Lincoln city centre to enable access to and between public transport stops via pedestrian only routes.

New Data Collection

3.4.8 A gap analysis will be undertaken to identify and confirm network changes associated with schemes, developments, and roadworks (if relevant) that need to be added or updated in the network coding to account for changes between the 2016 networks and the updated model base year. This will apply for all link types, including highway, rail, and walk.

3.4.9 Updated traffic signal specifications and observed level crossing barrier downtime data will be requested, were available, from LCC, in addition to the traffic specifications for any new signalised junctions, if relevant. Traffic signal timing updates could be related to schemes, and the barrier downtime will be influenced by changes in the frequency of rail services.

3.5 PUBLIC TRANSPORT SERVICE DATA

Existing Data

3.5.1 The current GLTM represents bus and rail services operating within the model study area for 2016 including:

- Service name;
- Service operator;
- Frequency per modelled hour;
- Stop locations; and
- Service run time – for model validation (bus) or for service coding (rail).

3.5.2 However, it is noted that there will have been several updates to this data, including a reorganisation of some bus services following the opening of the Lincoln Transport Hub, and there have been several updates to the National Rail timetable in the meantime.

3.5.3 The current GLTM also represents bus and rail fare structures which were derived based on analysis of fares for various routes at the time.

New Data Collection

3.5.4 Bus Open Data Service (BODS) is a service hosted via the DfT webpages which provides access to free open data for bus timetables. WSP have previous and on-going experience through several projects using tools in Python and R to convert bus service data in BODS (or Traveline) into a format that can be used for the purposes of public transport model development.

3.5.5 National Rail timetables will be used to compile an up-to-date database of rail services, including stop locations, frequencies and run times, for the model study area.

3.5.6 As a minimum, the current modelled bus and rail fares would need to be uplifted to account for real fare increases between 2016 and the updated model base year. However, a new analysis of fares may be required if there have been structural changes to the fare system that could impact on the assumptions embedded within the previous analysis.

3.6 TRAFFIC COUNT DATA

Existing Data

3.6.1 The current GLHAM was developed following an extensive traffic survey data collection process, including:

- Ninety-nine new automatic traffic count (ATC) surveys;
- Forty-four new manually classified junction count (MCJC) surveys;
- Three additional manually classified link counts (MCLCs) surveys undertaken and incorporated into the GLTM in 2017 to support the NHRR OBC modelling;
- WebTRIS (formerly TRADs) for permanent ATCs on the Strategic Road Network (SRN) including the A46;
- Lincs Laboratory permanent ATC surveys;
- Existing traffic survey data collected from other LCC projects; and
- The DfT Traffic Count Database, consisting of MCLCs on various links.

3.6.2 However, utilising existing data in a model update requires it to be normalised to the new model base period. Factors may be applied to account for general background changes in traffic growth, but this approach will not reflect changes that will occur due to demand responses and route choice in response to major transport interventions such as the LEB. Therefore, as per the project background from Chapter 1, most of this data may be considered unreliable to use for this model update.

3.6.3 Monitoring data that has been collected from the Lincoln Eastern Bypass Monitoring and Evaluation project (undertaken in 2021) will be reviewed for suitability and incorporated if appropriate. Additionally, recent data collected for other local studies, such as Transport Assessments, which is made available to this project will be reviewed for its suitability and incorporated into the modelling if appropriate.

3.6.4 Any existing data that is of suitable quality will be adjusted so that it reflects the **GLTM2** base month and year as appropriate, based on factors to be derived from continuous observed data sets, such as data from permanent ATCs.

New Data Collection

3.6.5 For the permanent ATC locations, the most relevant recent data available, in relation to corresponding with model base period and/or an alternative neutral month, will be collected.

3.6.6 A large new traffic survey commission is being undertaken. All the ATC and MCJC locations that were undertaken in the 2016 and 2017 supplementary data collection will be surveyed. Additionally, this survey will include other locations that utilising existing data in the previous model development, and infilling other locations that may benefit from observed data in the model update, particularly around the NHRR scheme.

3.6.7 The locations of 156 new ATC surveys are illustrated in Figures 3-1, 3-2 and 3-3. These surveys will be undertaken for a two-week period primarily between 17th April 2023 to 30th April 2023 inclusive, to cover a school-term period which is in between bank holidays. Data collection may be extended into May (excluding bank holidays) if required due to loss of data such as equipment faults or damage.

3.6.8 The locations of 80 new MCJC surveys are illustrated in Figures 3-4 and 3-5. These surveys will be undertaken for a twelve-hour period (07:00-19:00) currently planned for Tuesday 25th April 2023, which is a school-term time weekday that will also not be affected by industrial action.

3.6.9 The locations of 11 new ANPR surveys are illustrated in Figure 3-6. These surveys will be undertaken for 1-day which is currently planned to run concurrently with the MCJCs.

3.6.10 Full reporting of the new survey data collection will be provided in the Traffic Data Collection Report (TDCR).

Figure 3-1 – ATC New Survey Locations: Wider area

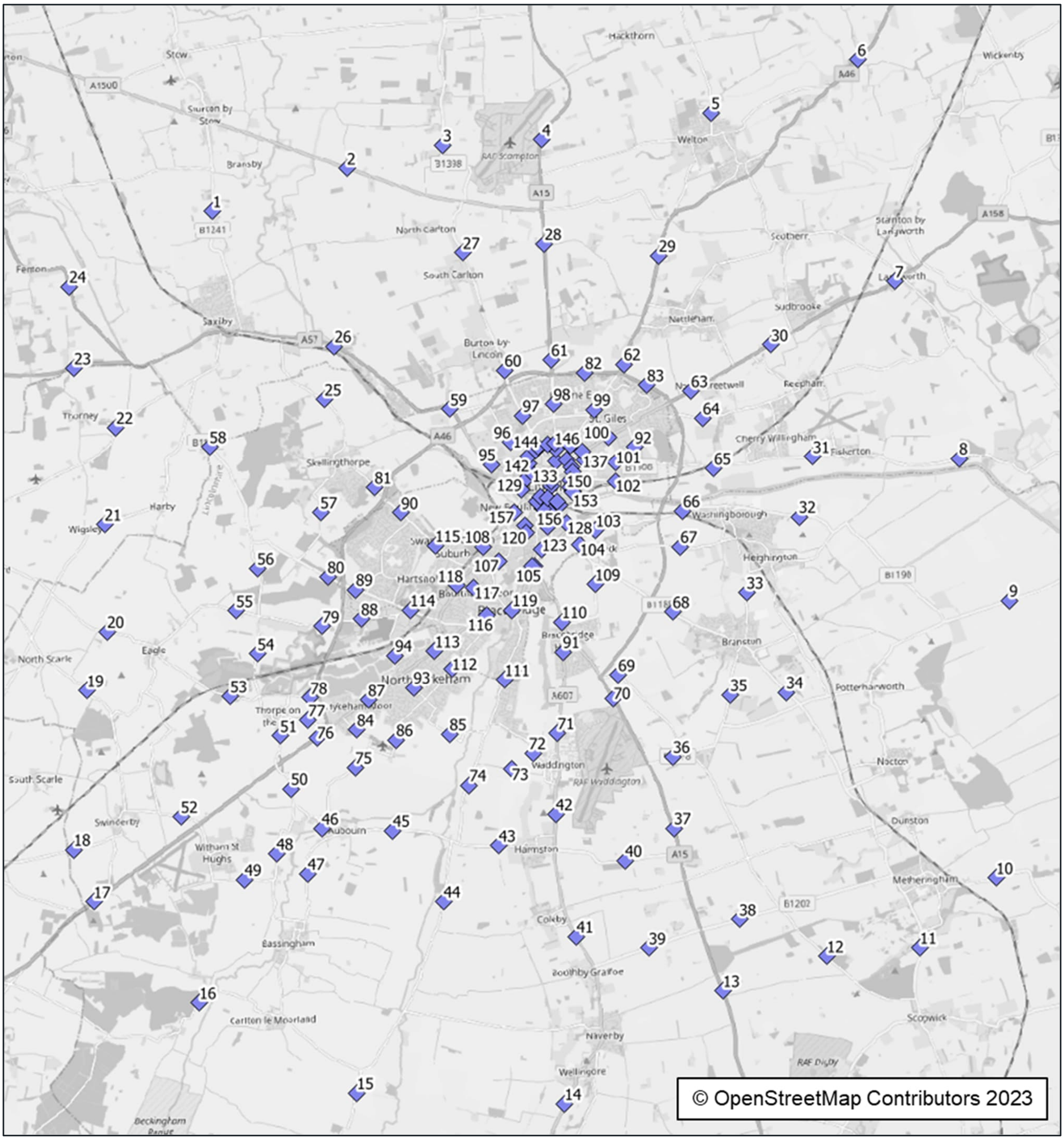


Figure 3-2 – ATC New Survey Locations: Greater Lincoln urban area

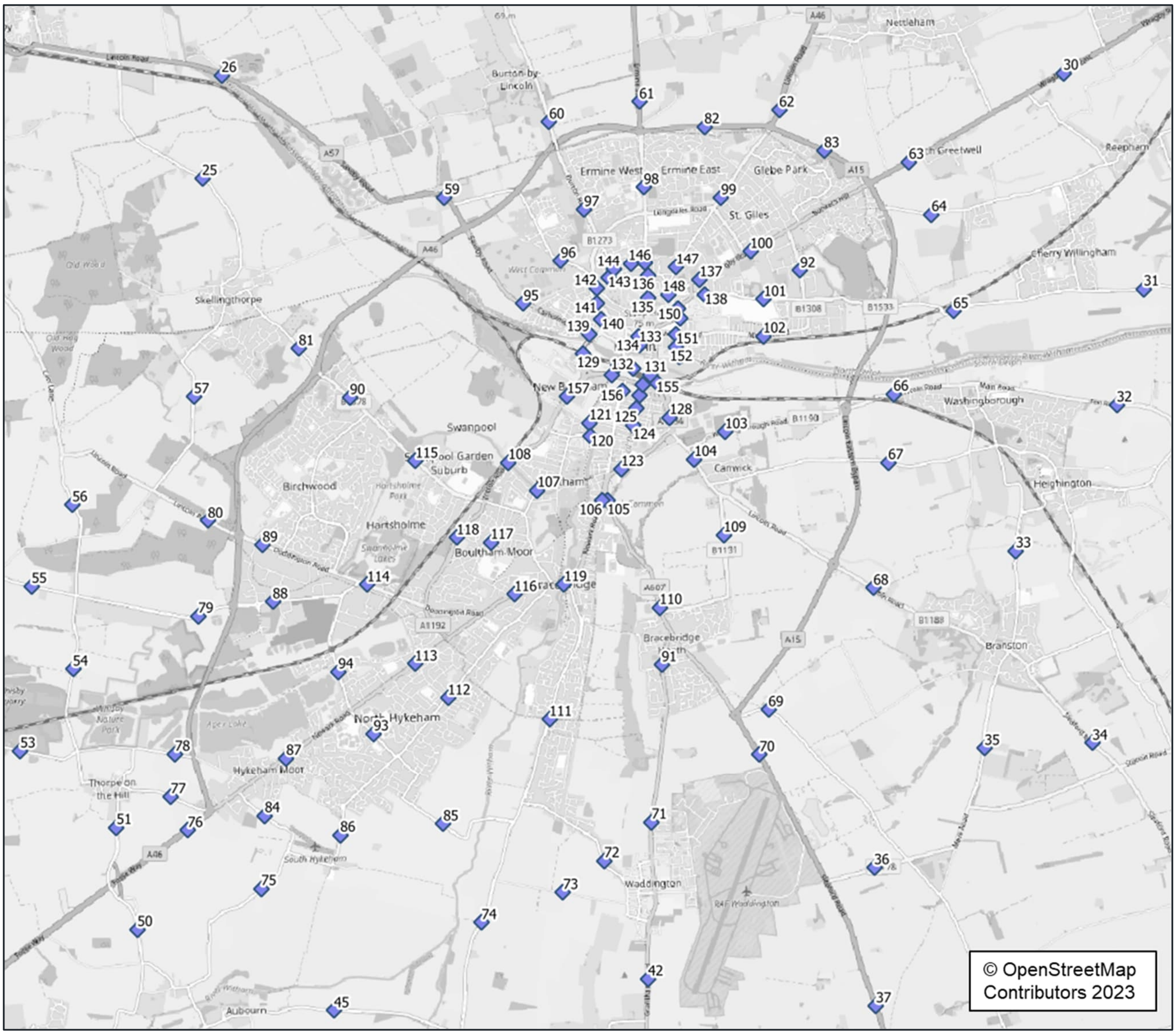


Figure 3-3 – ATC New Survey Locations: Lincoln city centre

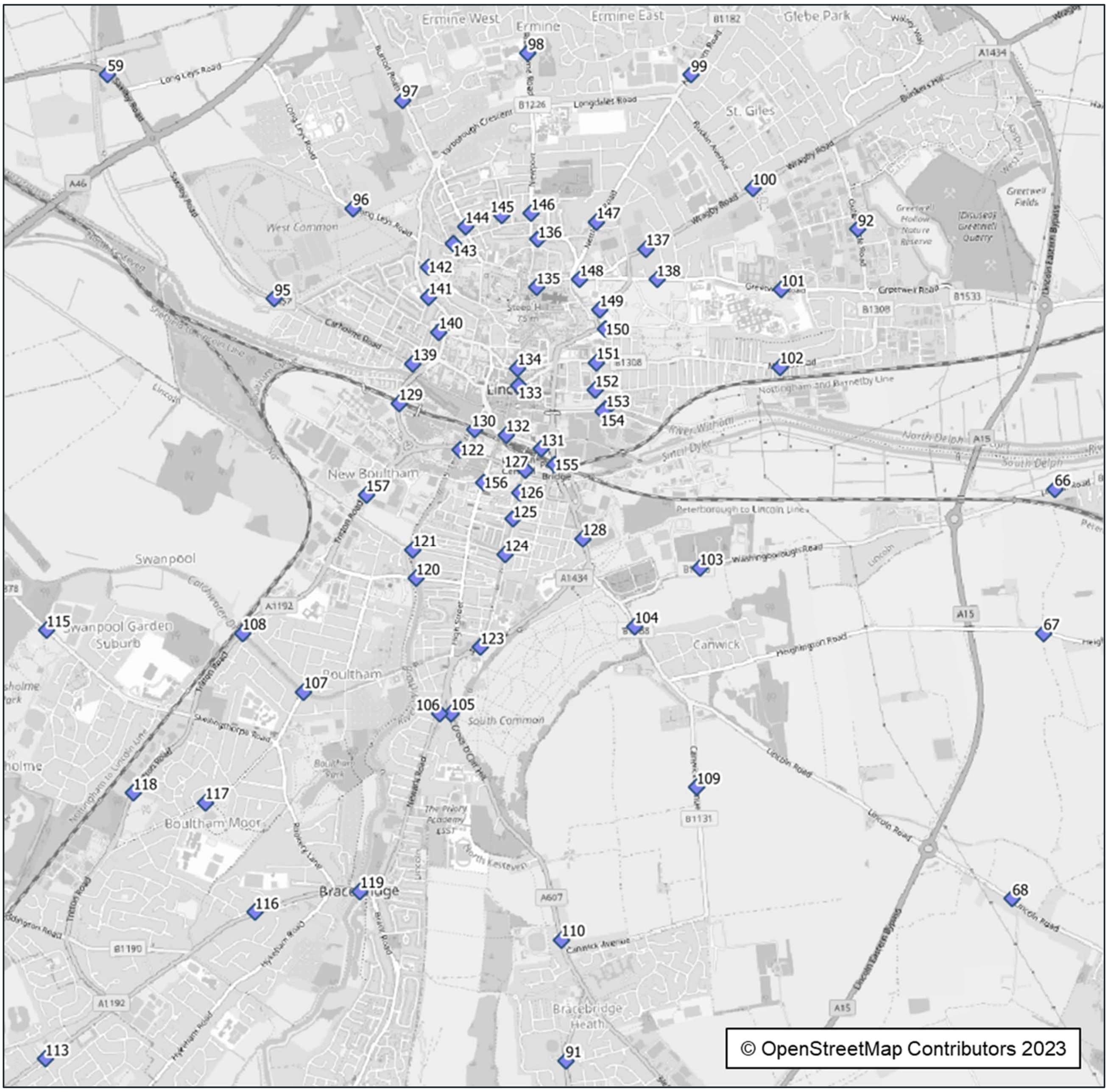


Figure 3-4 – MCJC New Survey Locations: Wider area

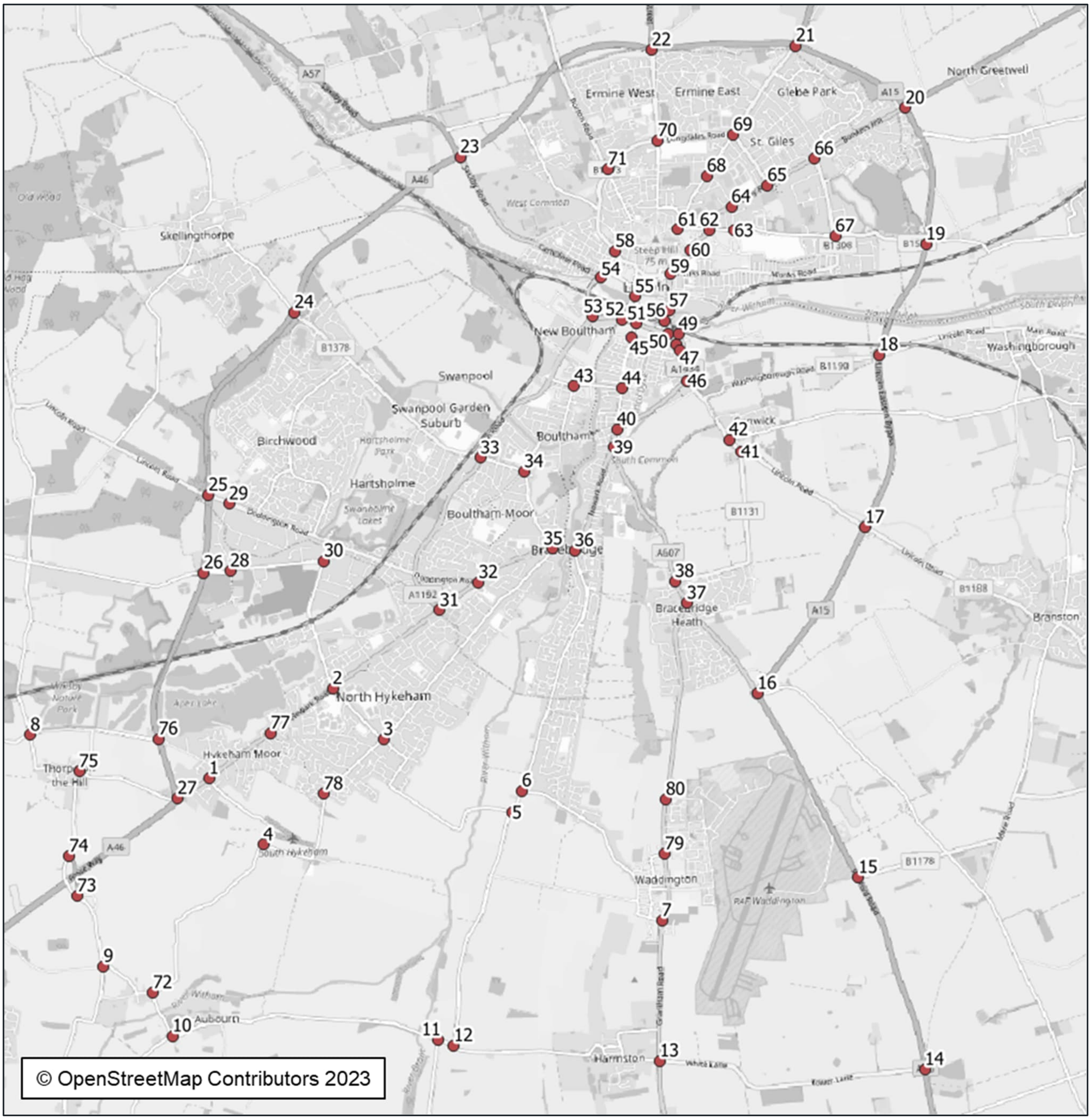


Figure 3-5 – MCJC New Survey Locations: Lincoln city centre area

Figure 3-6 – ANPR New Survey Locations

Proposed Highway Model Screenline Definitions

3.6.11 Given the scope of the data available and planned data collection, the proposed **GLTM2** highway model screenlines are indicated in Figure 3-7. Screenlines are typically defined to:

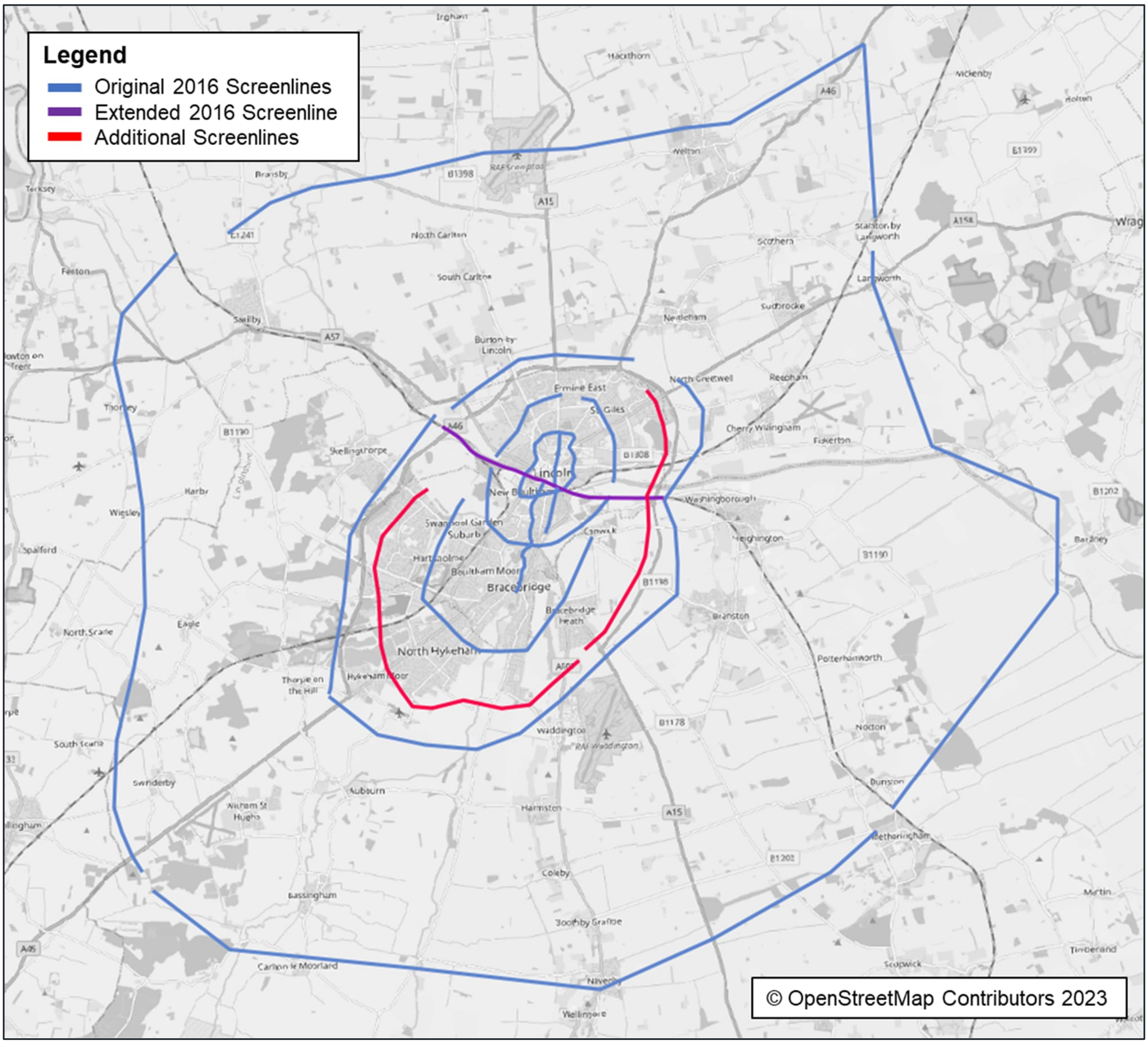
- Separate traffic flows between distinct areas;
- Enable a control mechanism for matrix development; and =
- Provide independent model validation data against which model performance can be measured.

3.6.12 The proposed screenlines include:

- All the current GLTM screenlines, with the 'railway screenline' extended across to include LEB;
- A new screenline parallel to LEB, capturing east-west movements to/from Lincoln city centre; and
- A new screenline in the south and west of Lincoln, providing additional coverage in that area to support the primary application of the model for the NHRR.

3.6.13 The screenline locations detail will be confirmed during the model development, following the data collection process.

Figure 3-7 – Existing and Proposed Highway Model Screenlines



3.7 PUBLIC TRANSPORT PASSENGER COUNT DATA

Existing Data

3.7.1 The current GLPTM was developed following an extensive survey data collection process, including:

- Eleven bi-directional bus passenger count surveys (BPCs);
- Passenger boardings data by route for Stagecoach services via LCC;
- Existing manual passenger count surveys at Lincoln rail station; and
- Open-source rail station annual passenger estimates from the Office for Rail and Road (ORR).

3.7.2 The Transport Hub was under-construction during the 2016 base model period. Monitoring data for the Transport Hub will be reviewed for suitability and incorporated if appropriate.

3.7.3 Any existing data that is of suitable quality will be adjusted so that it reflects the **GLTM2** base month and year as appropriate, based on factors to be derived from continuous observed data sets, such as trends in public transport patronage from the DfT Bus Statistics and the ongoing ORR station patronage estimates for rail.

New Data Collection

3.7.4 All the BPC locations that were undertaken in the 2016 data collection will be surveyed and an additional two bi-directional locations that will infill locations that can benefit from observed data in the model update, linked to changes in bus routes and frequencies and/or and the model development focus around the NHRR scheme. The locations are illustrated in Figure 3-8.

3.7.5 Rail passenger count (RPC) surveys will be undertaken at Lincoln rail station and Hykeham rail station. The locations are illustrated in Figure 3-9.

3.7.6 These BPC and RPC surveys will be undertaken for a twelve-hour period (07:00-19:00) currently planned for Tuesday 25th April 2023, which is a school-term time weekday that will also not be affected by industrial action.

3.7.7 The availability of updated ticket sales data from local bus operators that can be available for this study will be investigated during the model development process.

3.7.8 Full reporting of the new survey data collection will be provided in the Traffic Data Collection Report (TDCR).

Figure 3-8 – BPC New Survey Locations

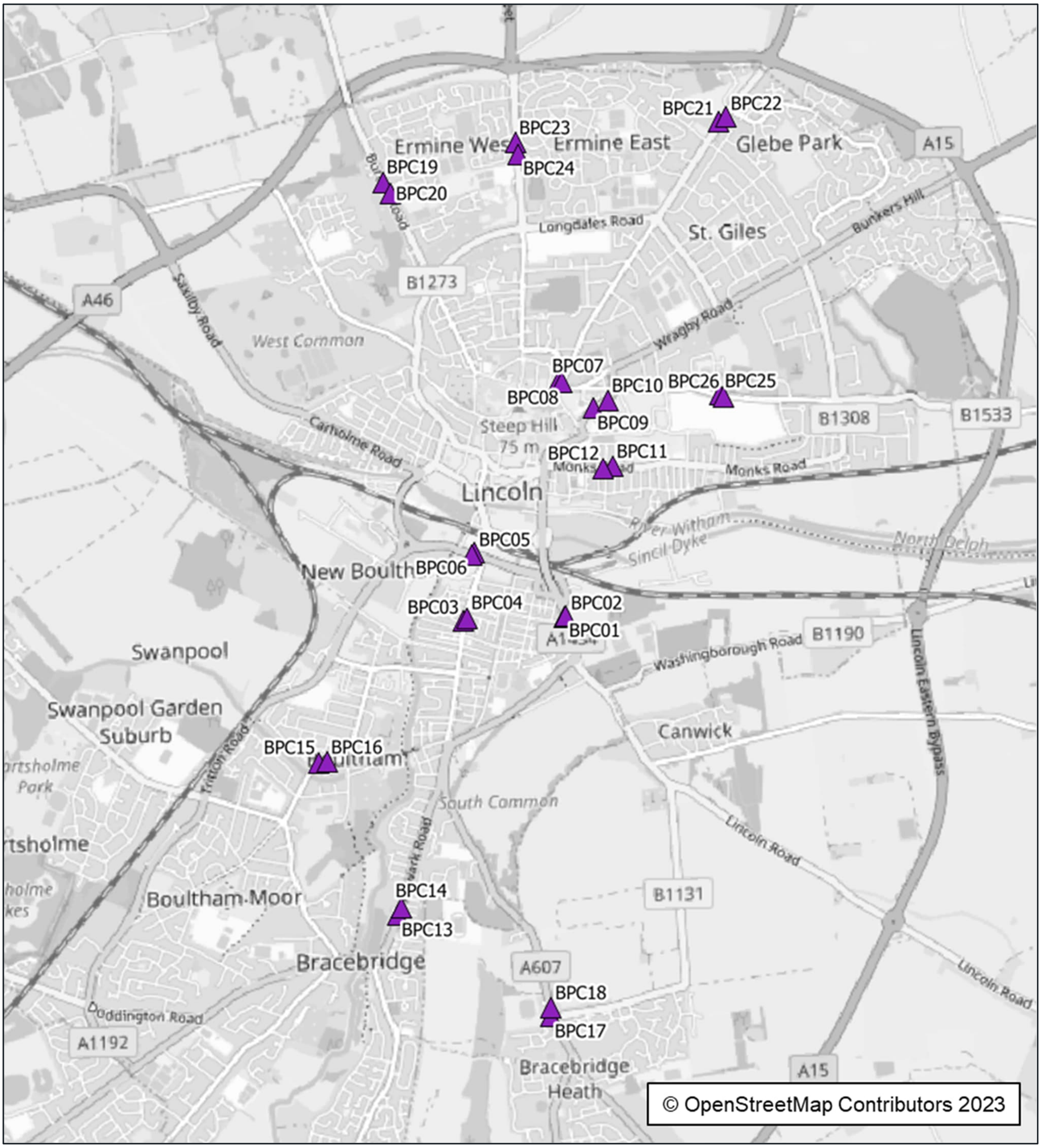
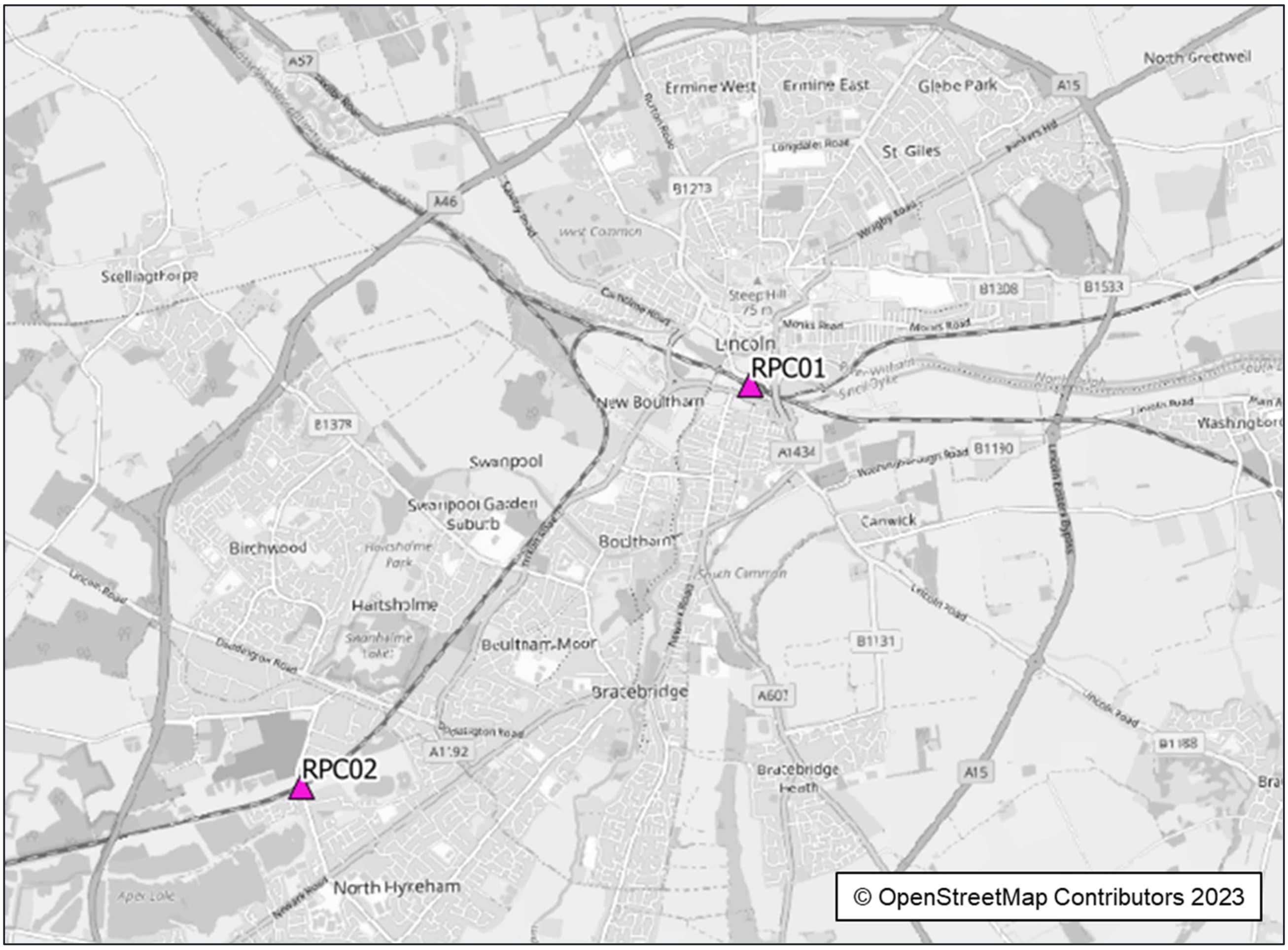


Figure 3-9 – RPC New Survey Locations



Proposed Public Transport Screenline Definitions

3.7.9 Given the scope of the data available and planned data collection, the proposed **GLTM2** public transport model screenlines are indicated in Figure 3-10.

3.7.10 The proposed public transport model screenlines include:

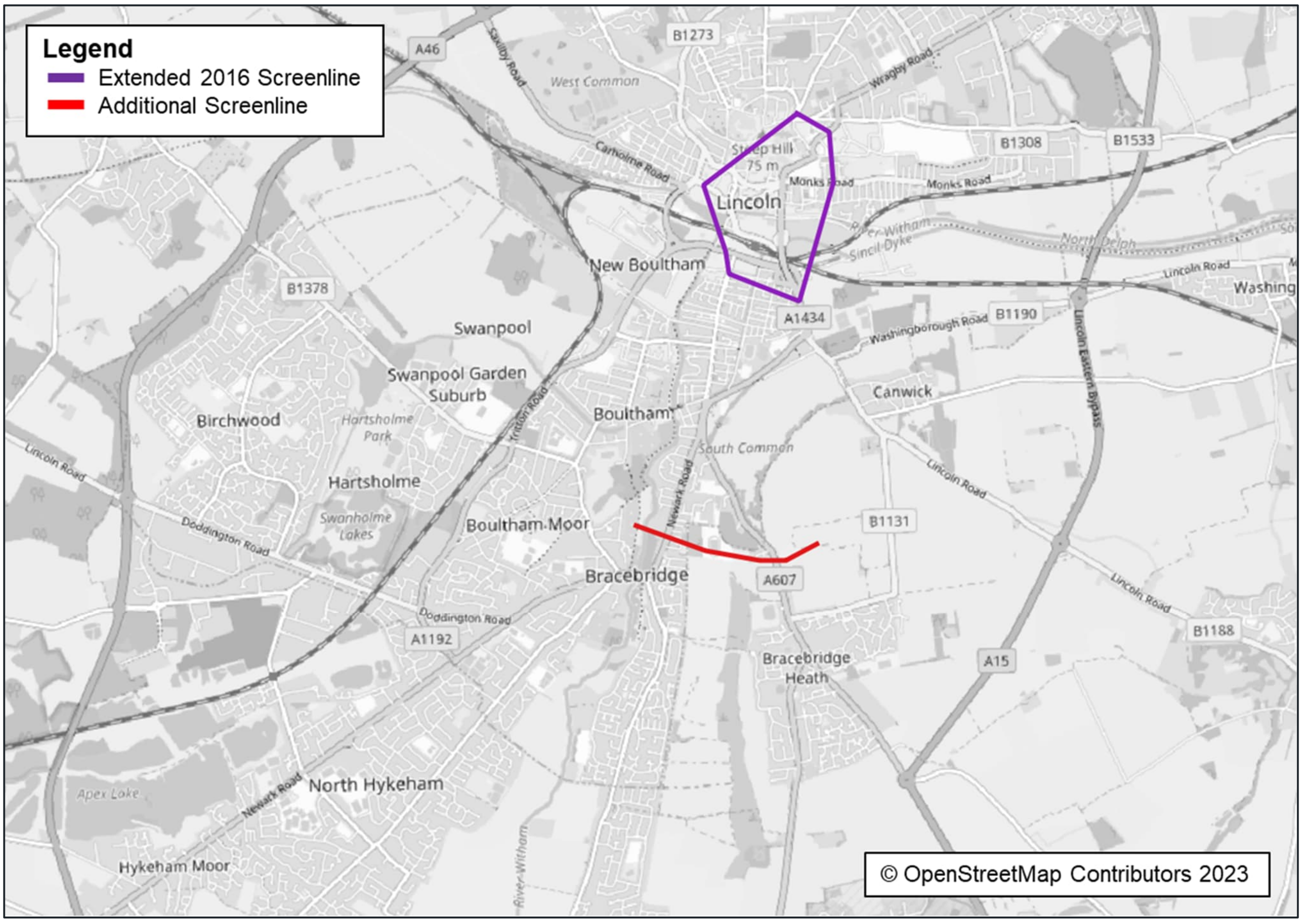
- An extension of the existing bus passenger cordon within Lincoln city centre; and
- A new bus 'mini-screenline' in the south Lincoln, covering the A1434 and the A607 which intercepts the locations for bus services coming to and from the Hykeham area.

3.7.11 It is noted that the 'mini-screenline' does not meet the recommended threshold for number of links in a screenline. However, this is due to the number of links with bus services in the area, and so it is proposed to include this 'mini-screenline' to enhance the data coverage within the vicinity of the NHRR scheme. This limitation will be noted in the reporting, and the data for these locations will also be presented as standalone counts.

3.7.12 There are several other BPC survey locations which are proposed to be applied only as standalone counts.

3.7.13 The rail passenger data will provide boardings and alightings at stations, but not on-board volumes that would be required to support forming link-based screenlines. Therefore, the rail data will be presented as standalone counts.

Figure 3-10 – Existing and Proposed Public Transport Model Screenlines



3.8 JOURNEY TIME DATA

Existing Data

3.8.1 Trafficmaster journey time data was provided by LCC to use in the development of the current GLTM. It was processed to provide independent observed data to use for the validation of modelled travel times along thirty-six journey time routes in the model.

3.8.2 However, utilising the existing journey time data will have similar issues to using traffic survey data, in respect of changes in travel times on links across the network in response to changes in traffic volumes due to major transport interventions such as the LEB. Therefore, as per the project background from Chapter 1, the existing journey time data may be considered unreliable to use for this model update.

New Data Collection

3.8.3 It is proposed to request new journey time data from DfT, which is now supplied by Inrix, for a time covering neutral months in 2022. The exact specification will have to be determined when the request is made, since there can be a time lag before the data becomes available.

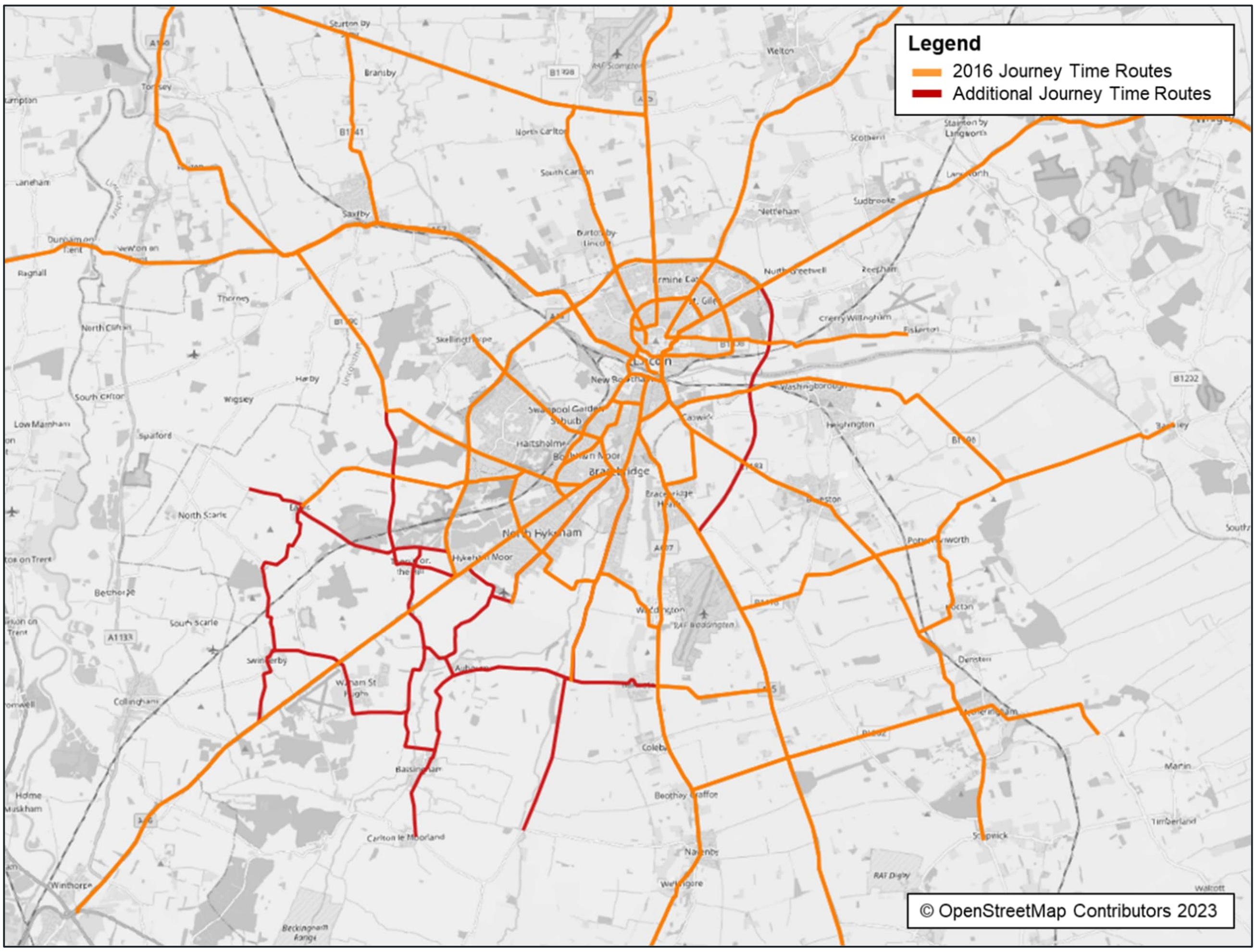
3.8.4 It is proposed that the data will be used to form an updated set of forty-six journey time routes, which is an increase on the current GLTM model coverage. The routes are illustrated in Figure 3-11.

3.8.5 The additional routes include LEB, plus several rural routes around the NHRR and A46 Pennell's Roundabout. Some of these additional routes were included in the 'NHRR LMVR Addendum' which was provided as a supporting document to the OBC, alongside the original GLTM LMVR.

3.8.6 These additional; routes will be developed in line with guidance, including the recommendations that they should be neither excessively long (greater than 15 km) nor excessively short (less than 3 km).

3.8.7 The exact number of routes and their coverage will be confirmed as part of the model development, following the data collection.

Figure 3-11 – Existing and Proposed Journey Time Routes



3.9 TRAVEL DEMAND DATA

Existing Data

3.9.1 A Mobile Network Data (MND) survey was commissioned to provide the primary travel demand data source used in the development of the current GLTM. The data was provided by Citi Logik using events from Vodafone mobile devices and was specified to provide full representation of trips to, from, within and passing through Lincolnshire.

3.9.2 The reasons and advantages of using MND over traditional data sources such as Roadside Interview Surveys (RSIs) were detailed in that previous model specification.

3.9.3 It is proposed that MND will also be used as the primary travel demand data source in the development of the **GLTM2**. However, for the reasons described in Chapter 1, the existing MND data set may be considered unreliable to use for this model update given the changes to travel distribution and travel patterns associated with the delivery of major schemes such as LEB, and the impacts of the COVID-19 pandemic.

New Data Collection

3.9.4 A new commission is being undertaken to collect MND data covering Lincolnshire, for a time covering neutral months in 2022. This will exclude school holidays, bank holidays, and take account of key term dates at the University of Lincoln. The exact survey dates are being determined in collaboration with the chosen data provider, to take account of these and any other issues raised such as network specific outages or issues.

3.9.5 Chapter 5 provides further details around the MND specification and processing. Full reporting of the MND data collection be provided in the Traffic Data Collection Report (TDCR).

3.9.6 As part of the traffic survey specification, it was also scoped to undertake a group of Automatic Number Plate Recognition (ANPR) surveys as per Section 3.6. This includes the A46 approaching Lincoln (south of Pennell's Roundabout) and other key strategic intercept points from the orbital route.

3.9.7 The purpose of this data would be to verify the distribution of external trips passing around Lincoln which directly (using the NHRR) and indirectly (traffic relief on the A46) benefit from the NHRR scheme. The details around the choice of ANPR data for this purpose is provided in Appendix A.

3.9.8 The proposed approaches to processing travel demand data are discussed in Chapter 5.

3.10 PARKING DATA

3.10.1 Based WSP's proposal in Section 2.3 that the parking sub-models will not be redeveloped at this stage, it would follow that there would be no direct need at this time to collect additional data specifically for the parking model purposes.

3.11 OTHER DATA SOURCES

3.11.1 Several other available data sources will be used to support various tasks or other ad-hoc requirements in the model development process. This will include the following data sources.

3.11.2 National Trip End Model (NTEM) data will be used at various stages in the matrix development process, including verification of the MND and trip end data for the synthetic matrix development. This may be accessed via TEMPro and/or CTripEnd software packages released by the DfT.

3.11.3 National Travel Survey (NTS) data will also be used at various stages in the matrix development process, including verification of the MND, trip length distribution data for the synthetic matrix development and travel pattern data for demand model such as tour proportions.

3.11.4 Socio-demographic datasets such as the Census, MOSAIC or others produced by the ONS can support tasks related to land uses including disaggregation to model zones in the matrix development process.

3.11.5 A large amount of open-source GIS data, including background mapping and census data boundaries, will be used for analysis and reporting throughout the model development.

3.11.6 The TAG DataBook published by the DfT will provide economic parameters required for the model development, including values of time, vehicle operating costs, GDP deflator and other inflation indices.

3.12 FORECAST DATA

3.12.1 Additional data will be required for the forecast modelling in the later stages of the model development, including:

- National Trip End Model (NTEM) data will need to be extracted for the “Core” scenario and the DfT Common Analytical Scenarios to derive the forecast growth for car and public transport trip ends.
- Road Traffic Projections (RTP) data will need to be extracted for the “Core” scenario and the DfT Common Analytical Scenarios to derive the forecast growth for goods vehicles trip ends.
- Information on local developments and transport schemes sourced from LCC to prepare an Uncertainty Log, and subsequently future year development trip ends and scheme coding.
- The DfT TAG Databook to derive future year economic parameters including values of time, vehicle operating costs, GDP deflator and other inflation indices.

3.13 DATA CHECKING AND NORMALISATION

3.13.1 Before traffic survey and journey time data is used in calibration and validation work will be undertaken to check the validity of data.

3.13.2 This will include the following checks on count data:

- 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; and
  - This will also inform the AM and PM peak periods that will be used in the modelling.
- Where counts appear on consecutive links;
  - This will be 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.
- Sense checks based on local knowledge.

3.13.3 The completed traffic count database will include data survey types. ATCs are likely have been undertaken for at least a two-week period and can provide greater confidence in overall flow volumes, whereas MCJCs are likely to only cover a single day but can be more reliable for vehicle classifications and provide additional detail around turning proportions.

3.13.4 A process will be undertaken to reconcile data from the ATCs and MCCs, to make use of the data from both sources in the most appropriate way for the model development, based on their respective strengths and weakness. This may include validating MCJC volumes using an adjacent ATC or classifying ATC volumes using the vehicle split from a relevant MCJC.

3.13.5 For the journey time data, checks will be made on:

- Sample size of Trafficmaster records;
- Review of outliers within the sample;
- Calculation of average speed – are average speeds within the speed limit; and
- Sense checks based on local knowledge.

3.13.6 For data sources which were surveyed in a different base month and/or year to the **GLTM2** base model period, following factors will need to be generated to 'convert' the survey data to the modelled month and year, referred to as 'normalisation'. This includes:

- Annual factors to convert counts undertaken other years to the **GLTM2** base year; and
- Month to month factors to convert counts undertaken in other months to the designated **GLTM2** base month.

3.13.7 A 'global' factor will be calculated using trends across sites, such an approach is expected to be sufficiently robust for a medium sized city such as Lincoln, subject to exclusion of outlier events. Factors will be derived using data available from continuous observed data sets, such as permanent ATCs for highway data. Factors to convert modelled flows to Annual Average Daily Traffic (AADT), Annual Average Weekday Traffic (AAWT) and Heavy Vehicles (HV) will also be provided.

4 NETWORK AND ZONING SPECIFICATION

4.1 INTRODUCTION

4.1.1 The highway assignment model requires a representation of the highway transport network using a series of nodes and links, where links represent sections of the roads and nodes typically represent junctions within the networks.

4.1.2 The public transport assignment model also requires a representation of the local multi-modal network service provision, where additional links will represent sections of the rail track and pedestrian routes, and nodes can also represent transit stops within the network.

4.1.3 Trip making is aggregated for spatial areas into zones, which typically have a common area type or land use and would join the modelled networks at the same or a similar point. The level of detail in the zone system is commensurate to the level of the detail in the network coverage and its location within the modelled area.

4.2 ZONING SYSTEM

4.2.1 It is proposed to use the current GLTM base year zoning system as a starting point for **GLTM2** with the possibility of local refinements and enhancements. This would include changes to take account of since 2016 and to focus on the area around the NHRR scheme given the primary intended application of the new model. The existing zone system is illustrated in Figure 4-1 and Figure 4-2.

4.2.2 The current GLTM was specified and then applied to support the NHRR scheme at OBC stage and so this approach ensures continuity with some enhancement of that original specification into the **GLTM2** for supporting the NHRR scheme at FBC stage.

4.2.3 Following this approach, updates to the zoning coverage will therefore primarily focus on a gap analysis between changes to the network, land uses and developments since 2016. This will also include checks to ensure aspects of the starting point are still relevant.

4.2.4 The current GLTM zoning system is based on the LSOA/ MSOA (Lower/ Middle Layer Super Output Area) boundary layer which was the level of spatial granularity that travel demand data was provided. This is also expected to be the case for the new travel demand data collection (see Section 3.9).

4.2.5 The zoning system is entirely consistent between the highway and public transport assignment models which enables a simple and direct transfer of cost and trip data between outputs from the two models within the demand model calculations.

Figure 4-1 – Existing Zoning System (Lincoln city centre)

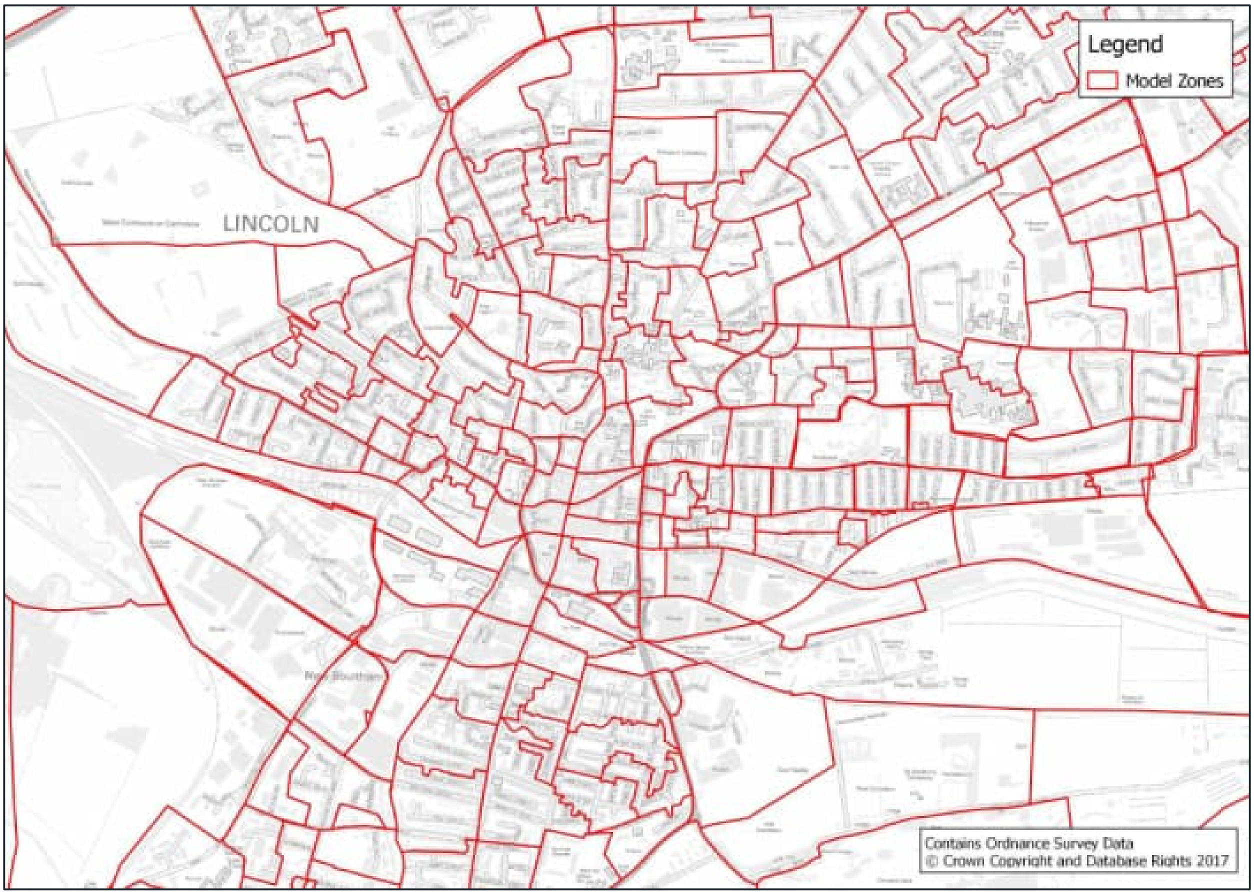
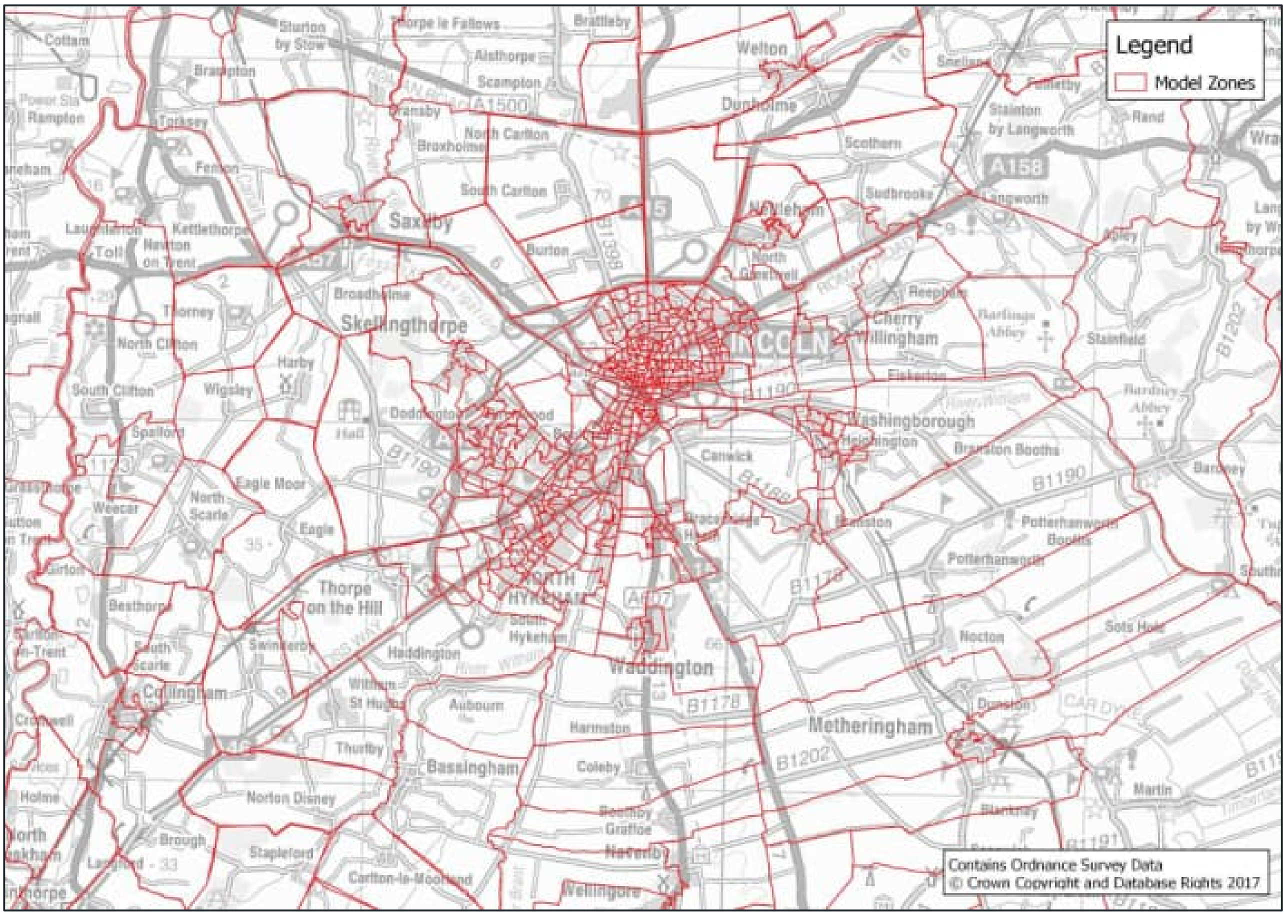


Figure 4-2 – Existing Zoning System (Simulation area)



4.3 NETWORK STRUCTURE

4.3.1 TAG Unit M3.1 advises that the geographic coverage of the model needs to:

- Allow for the strategic re-routeing impacts of interventions;
- Ensure that areas outside the main area of interest, which are potential alternative destinations, are properly represented; and
- Ensure that the full lengths of trips are represented for the purpose of deriving costs.

4.3.2 Further to this, the guidance recommends that the model is broken down into two areas.

- The fully modelled area (FMA) over which interventions are expected to impact. In this area full trip movements will be included, and the network will be simulated.
- The external area over which interventions are not expected to have an impact. In this area, only partial representation of trips and a sparse network with speed/flow relationships is required.

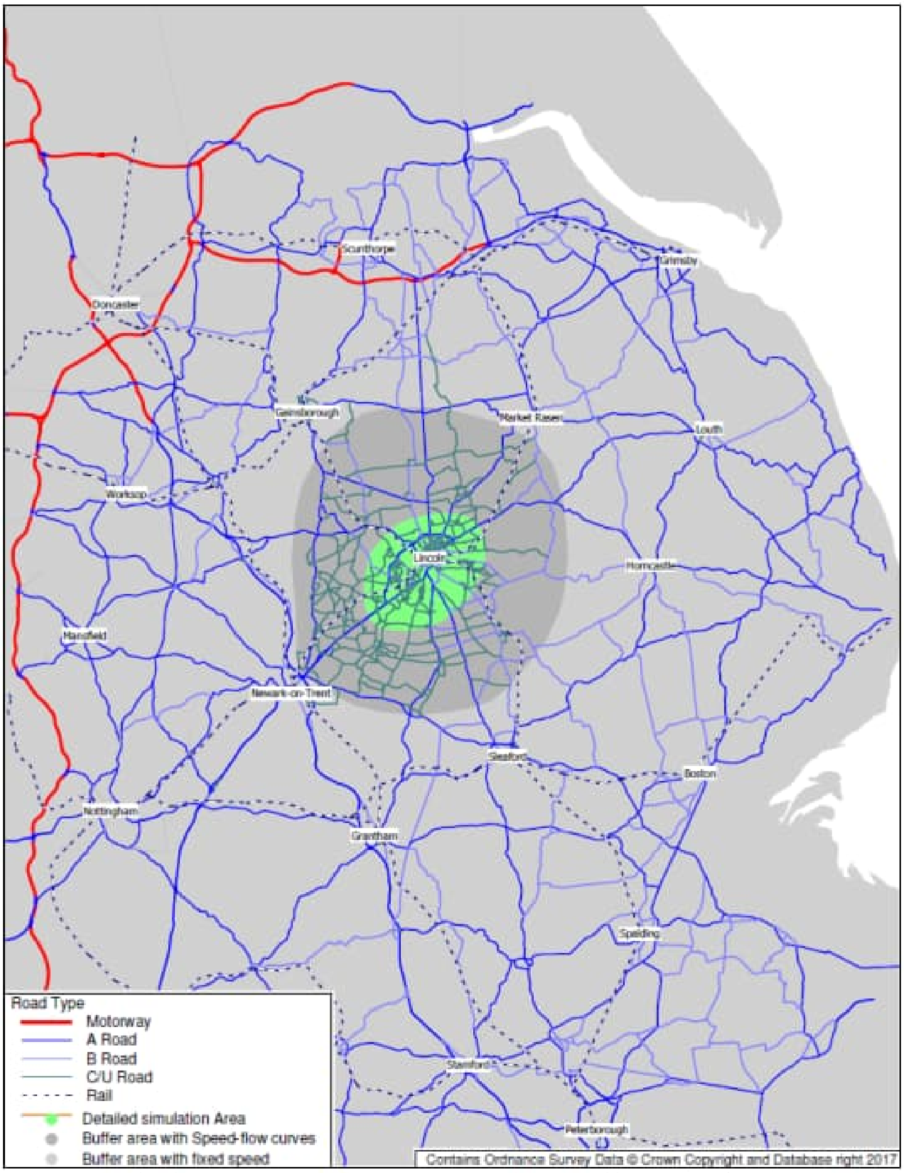
4.3.3 The current GLTM model coverage is illustrated in Figure 4-3. This applies a three-tier hierarchical structure in line with the guidance above.

- Area 1 (illustrated in green) – model study area referred to in TAG as the "fully modelled area (FMA)" defined by a cordon around the existing orbital bypass (A46 and A15) consisting of Lincoln and North Hykeham. Within this area full simulation with detailed junction coding and link speed flow curves has been applied to accurately represent travel costs.

- Area 2 (illustrated in dark grey) – model external area adjacent to the FMA defined by a cordon roughly bounded by Newark, Gainsborough, Market Rasen and Sleaford. Within this area less detailed coding has been adopted where travel costs have been represented through speed flow curves.
- Area 3 (illustrated in light grey) – remainder of the model external area including more detailed network coverage in the rest of Lincolnshire plus Humberside and Nottinghamshire. This area serves as a means of connectivity for traffic from external regions to the study area and fixed speed coding is adopted.

4.3.4 It is proposed that the model coverage for the **GLTM2** will remain the same as the current GLTM, but there may be local refinements and enhancements likely to be focussed around the NHRR scheme. The current GLTM was specified and then applied to support the NHRR scheme at OBC stage and so this approach ensures continuity with some enhancement of that original specification into the **GLTM2** for supporting the NHRR scheme at FBC stage.

Figure 4-3 – Existing Network Structure



4.4 NETWORK COVERAGE

4.4.1 It is proposed to use the current GLTM base year networks as a starting point for **GLTM2** with the possibility of local refinements and enhancements. This would include changes to take account of since 2016 and to focus on the area around the NHRR scheme given the primary intended application of the new model.

4.4.2 The current GLTM was specified and then applied to support the NHRR scheme at OBC stage and so this approach ensures continuity with some enhancement of that original specification into the **GLTM2** for supporting the NHRR scheme at FBC stage.

4.4.3 Following this approach, the updated network coverage will therefore primarily focus on a gap analysis between the current road network and the 2016 model network. The gap analysis will determine if and where updates will be made, principally to bring them up to date for the new **GLTM2** base year based on changes in land use plus completed schemes and developments since 2016. This will also include checks to ensure aspects of the starting point are still relevant.

4.4.4 The latest version of the ITN network can support with providing a spatial dataset to undertake the network comparison. However, several of the major network updates are already known, including:

- Lincoln Transport Hub – completed in February 2018.
- A46 Riseholme roundabout improvements – completed in November 2020.
- Lincoln Eastern Bypass – completed in December 2020.
- A46 Dunholme/Welton roundabout – completed in June 2021.

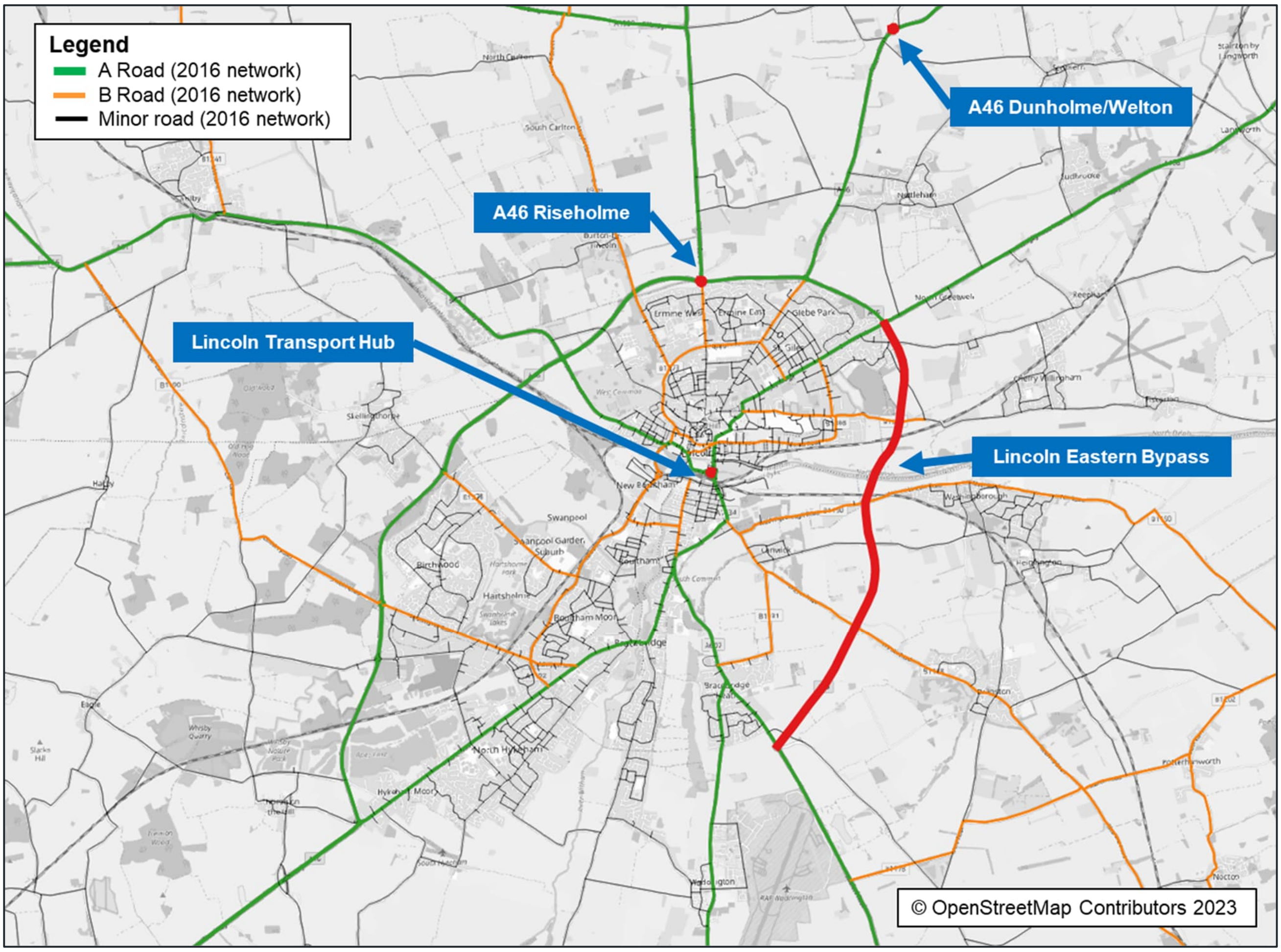
4.4.5 These schemes have also been modelled in the 'forecast' networks using the current GLTM which will provide a basis for adding the coding for these schemes into the new base year networks.

4.4.6 Network coding that represented roadwork conditions in the 2016 base year model will also be updated to reflect the present-day network, which is also linked to a couple of the schemes in the list above that were under construction at the time. The roadwork schemes coded in the current model are documented in the previous LMVR for reference and are primarily within Lincoln city centre around the East-West Link Road, Lincoln Transport Hub (with the temporary bus station at Tentercroft Street), High Street and Brayford Wharf East.

4.4.7 The list above may not yet be extensive, and a detailed review will be undertaken during the model development. We will consult with LCC to verify the completeness of the list once completed. This could include if there are any Covid-19 related Traffic Regulation Orders (TROs) that were still in effect in 2022.

4.4.8 Although this planned approach updates the existing network coding, a complete network acceptance checking process across all aspects of the network development will still be undertaken in full following the recommendations in TAG Unit M3.1.

Figure 4-4 – Existing Network Coverage and Completed Major Schemes



4.5 LINK CODING

4.5.1 Link coding will follow the established approaches used in the current GLTM.

4.5.2 Highway links are coded by direction and the following characteristics are included:

- Link length;
- Road class;
- Road type (single or dual carriageway);
- Speed limit;
- Number of lanes; and
- Any other restrictions on the roads (e.g., bus only, height/weight restrictions etc.)

4.5.3 The public transport network is built using the highway network plus the addition of rail and walk links, which are also coded by direction and include the following characteristics:

- Link length;
- Link type (road, rail, walk); and
- Link travel speed.

4.5.4 The travel speed for road links in the public transport is transferred from the highway network for road links to ensure commonality between both models. Travel speeds for rail links are based on the track speed limits. An average walking speed is assumed for walk links.

4.6 JUNCTION CODING

4.6.1 Junction coding in the highway network simulation area (see Figure 4-3) will follow the established approaches used in the current GLTM.

4.6.2 The characteristics represented include:

- Junction type (priority, roundabout, signalised);
- Configuration and geometry including number of approach arms, width of approach arms plus flare lengths and lane discipline including permitted and banned turns;
- Saturation flows for all movements; and
- Additional parameters relevant to specific junction types such as gap acceptance values and signal data.

4.6.3 As part of the validation and calibration of key junctions, junction coding will be checked and refined to ensure that the model represents the "logic" level of route choice as well as satisfactory traffic flow and journey time validation.

4.7 TRAFFIC SIGNAL CODING

4.7.1 Traffic signal coding in the highway network simulation area (see Figure 4-3), including level crossings, will follow the established approaches used in the current GLTM.

4.7.2 The coded traffic signal and level crossing timings in the current GLTM were derived from traffic signal specifications and observed level crossing barrier downtime data provided by LCC.

4.7.3 As per Section 3.2, it is proposed to request the latest versions of the traffic signal specifications so that any changes and updates can be incorporated into the new **GLTM2** base year networks.

4.8 ZONE CONNECTORS

4.8.1 Trips from and to zones in the highway model are loaded at one or more points on the network from a zone centroid (centre of gravity of the zone) using specialised links known as centroid connectors. Ideally a simulation area zone should have only one connector, but this may be exceeded in outer areas.

4.8.2 The equivalent access and egress from a zone centroid to the transit network and stop opportunities is achieved in the public transport model using non-transit links (NTLs).

4.8.3 It is proposed to use the current GLTM zoning system as a starting point with some refinements. As such, where zones are unchanged spot checks will be undertaken but it is generally proposed to not change the zone centroid or its connector. Zone connectors for new zones will be coded in line with the existing standards for GLTM.

4.9 PUBLIC TRANSPORT SERVICES

4.9.1 A representation of the base year bus service routes and frequencies are required for both the highway and public transport assignment models.

4.9.2 Bus services are coded into the highway network as ‘fixed flows’ which contribute to the overall traffic volumes and the outcomes for travel times and delays in the network. This is particularly relevant within Lincoln city centre where many routes converge at the Transport Hub.

4.9.3 The bus service coding in the public transport model includes additional data such as stop locations, dwell times and service fares.

4.9.4 A consistent database of bus routes will be used between the highway and public transport models to ensure commonality within the overall modelling system.

4.9.5 It was proposed in Section 3.5 that new data will be collected via BODS to develop the database of bus services, given the number of changes that have been made since 2016 including a large reorganisation of bus services related to the opening of the Transport Hub.

4.9.6 Rail services are also required for the public transport model. It was proposed in Section 3.5 that National Rail timetables will be used to compile an up-to-date database of rail services given there have been multiple versions of the timetable since 2016.

4.10 LINKS: SPEED/FLOW RELATIONSHIPS

4.10.1 Speed/flow relationship coding in the highway network simulation area and adjacent external areas (see Figure 4-3) will follow the established approaches used in the current GLTM.

4.10.2 Speed-flow curves that are based on adjusted DfT COBA speed/flow relationships are adopted. Differential speeds are implemented for HGVs where the speed definitions exceed 60mph.

4.10.3 Within the simulation area, links are applied appropriate speed-flow curves to ensure that delays and speed on the network will be represented for calibration/validation purposes and for the forecasting stage, where the impact of increased demand on travel speed is appropriately modelled. This approach is also applied to all the links within the “Tier 2” part of external area described in Figure 4-3.

4.10.4 The exception to this for the simulation area are links within urban areas where the length is less than 100m as travel speeds are largely determined by delays at junctions, so these links have a fixed speed.

4.10.5 It is proposed that the speed-flow curves used by the 2016 version of the GLTM are retained and updated where appropriate. Spot checking and cross referencing with the latest journey time data (see Section 3.8) will ensure that these speed-flow curves remain relevant.

4.11 FIXED SPEEDS

4.11.1 Fixed speed coding in the highway network simulation area and external area (see Figure 4-3) will follow the established approaches used in the current GLTM.

4.11.2 Within the urban areas, links with a length of less than 100m generally have travel speeds determined by the simulated delays at junctions and so these are coded with a fixed speed value.

4.11.3 Fixed speeds are also applied to links in the “Tier 3” part of external area described in Figure 4-3.

4.11.4 All fixed speed values will be updated using the latest journey time data (see Section 3.8) so that the reflect the latest network conditions in the new model base year. The values will be derived by time period so that they reflect the different levels of congestion across the day.

4.12 GENERALISED COST FORMULATION AND PARAMETER VALUES

4.12.1 Generalised costs determine travel choice between alternative modes, time, destination, and routes, based on a combination of travel time, operating costs and charges in a unit of generalised time for the purpose of the demand modelling.

Highway Model

4.12.2 Traffic routeing is implemented in SATURN through a function of generalised cost. This normalises time, distance, and monetary charges into a standard unit.

4.12.3 The function is defined as

$$GC = T + \frac{(D \times VOC) + M}{VOT}$$

where:

- GC is the generalised cost in minutes;
- T is the travel time in units of minutes (including delays and time penalties);
- D is the travel distance in kilometres;
- M includes monetary charges in pence (e.g. tolls, users charges, parking costs);
- VOT is the value of time in pence per minute (PPM); and
- VOC is the vehicle operating costs in pence per kilometre (PPK).

4.12.4 Updated values for the PPM and PPK parameters will be derived from the latest TAG Databook (currently v1.20.2 January 2023) for the base year and similarly for each future year scenario.

4.12.5 The current GLTM has three tolls coded which are all located in the external network:

- Humber Bridge;
- Dunham Bridge; and
- M6 Toll.

4.12.6 The representation of these toll charges will be reviewed and updated in the new **GLTM2** networks to reflect any changes to the charges levied since 2016.

Public Transport Model

4.12.7 Model assignment of trips to the GLTM public transport network is undertaken using a 'frequency cost' approach which considers the fare of frequency of services to determine the optimum paths for travellers. Bus and rail demand are combined and assigned to the public transport network as a single trip matrix, thus facilitating sub-mode choice through the assignment and for competing bus and rail services.

4.12.8 The generalised cost formulation applied in GLPTM is described as follows.

$$GCost_{PT} = F_{Walk} * A + F_{wait} * W + F_{IVT} * IVT + \frac{Fare}{VoT} + F_{Int} * Int + Penalty$$

where:

- GC is the generalised cost in minutes;
- A is the total walk access/egress time in minutes;
- F_{Walk} is the weight factor for walk time;
- W is the total wait time during transfer in minutes;
- F_{wait} is weight factor for waiting and transfer time;
- IVT is the in-vehicle time in minutes;
- F_{IVT} is the weight applied for in-vehicle time in minutes;
- $Penalty$ is a transfer penalty in minutes;
- VoT is the value of time in pence per minute (PPM);
- Int is an interchange penalty in minutes; and
- F_{Int} is the weight factor applied for interchange time.

4.12.9 Updated values for the PPM parameters will also be derived from the latest TAG Databook (currently v1.20.2 January 2023) for the base year and similarly for each future year scenario.

4.12.10 Values for weight factors and penalties will be taken from the existing GLPTM as a starting point and reviewed against the latest guidance, and during the model calibration and validation.

4.12.11 Fares will be updated to at least take account of uplifts due to inflation since 2016, but also other changes that may be found to be relevant from a review.

5 TRAVEL DEMAND PROCESSING

5.1 INTRODUCTION

5.1.1 Acquiring high-quality origin-destination (OD) information for traffic in a geographic area is both time consuming and expensive. Methods generally present only a snapshot of the traffic situation at a certain point in time.

5.1.2 When the current GLTM was scoped in 2016, an exercise was completed to review the merits of using different travel demand data sources. Roadside Interview Surveys (RSIs) were a conventional data source but costly to set up and implement, and they only intercept a snapshot of travel movements for a single day at the surveyed locations. RSI locations were typically designed to form a cordon which would have required many sites to cover the Lincoln and North Hykeham urban area within the orbital route.

5.1.3 However, Mobile Network Data (MND) survey had emerged as a newer data source that could be used for travel demand processing. Instead of monitoring the flow of vehicles in a transportation network, approaches had been developed where the flow of mobile phones in a cell-phone network is measured and correlated to traffic flow. It could be surveyed over a longer period and capture all movements across the network including external trips passing through the study area, but it also had limitations such as full detection of short distance trips.

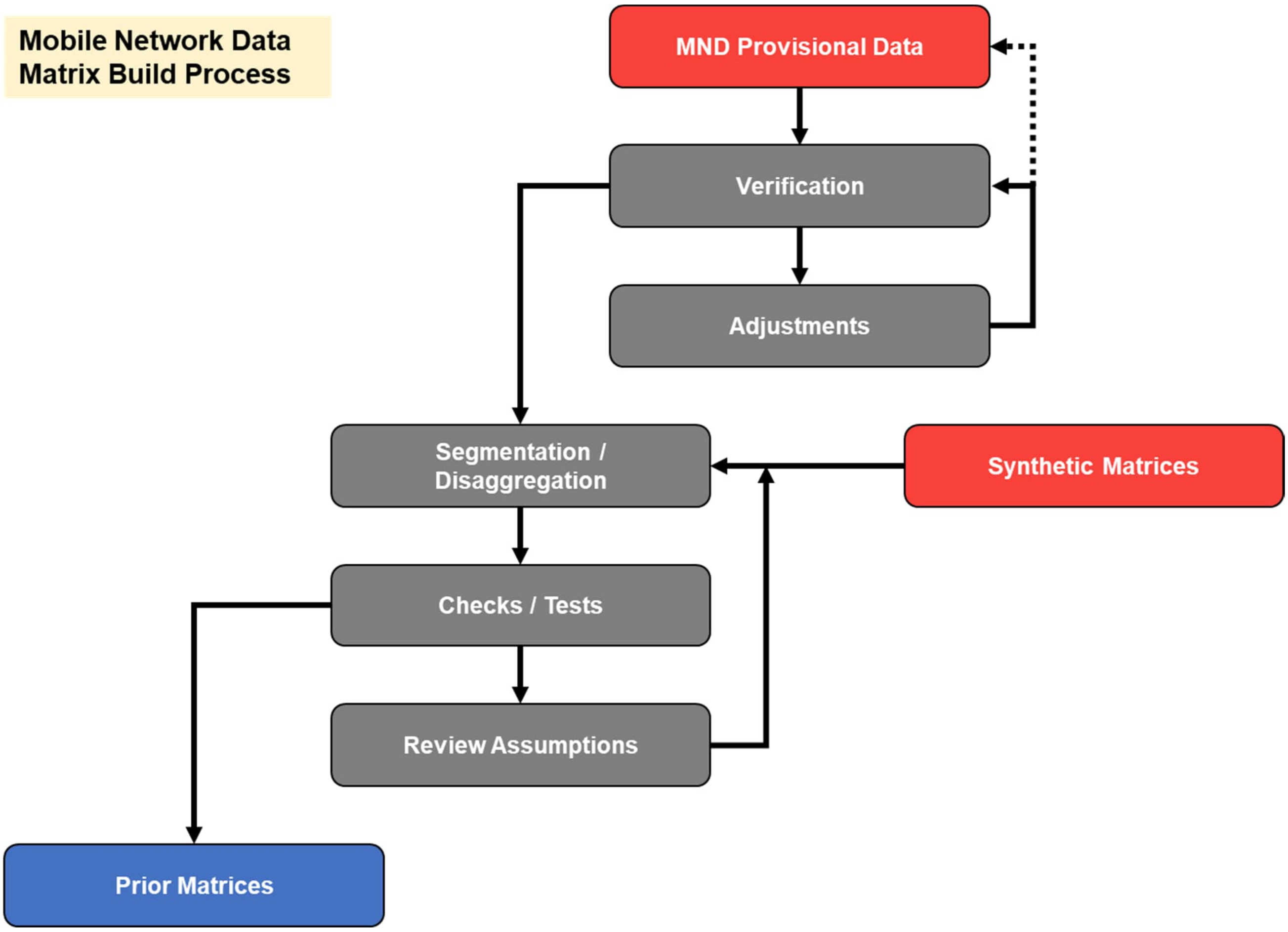
5.1.4 Taking all of this into account, MND data was commissioned to provide the primary travel demand data source used in the development of the current GLTM. The data was provided by Citi Logik using events from Vodafone mobile devices and was specified to provide full representation of trips to, from, within and passing through Lincolnshire.

5.1.5 It is proposed that MND will be used as the primary travel demand data source in the development of the **GLTM2**, but a new survey is required the reasons described in Section 3.9.

5.1.6 This chapter sets out how the MND will be processed into a form suitable for the assignment and demand models, in accordance with the principles set out in TAG Unit M2.2.

5.1.7 The general principals of the MND matrix development process are summarised by Figure 5-1.

5.1.8 **Figure 5-1 – MND Matrix Build Process**



5.2 MOBILE NETWORK DATA COLLECTION

5.2.1 Mobile phone positioning data are sporadically acquired by cellular carriers because of user-initiated events. Recorded events typically include calls, Internet use (e.g., email or web browsing), short message service (SMS) activity, or handovers/handoffs (which are triggered when transferring between wireless cells).

5.2.2 The data are anonymously collected through cellular networks by signals sent from phones to base stations, each of which corresponds to a geographical cell – the standard unit of aggregation for a cellular network – allowing for the identification of a phone within that cell. Positional accuracy is low because the level of precision depends on cell size, but rough vehicle trajectories can be approximated, allowing for the estimation of travel time, speed, and trip origin-destination (OD) matrices.

5.2.3 It is possible to better estimate position within a cell based on signal strength or through triangulation, though these techniques require the use of SMS data or Internet protocol traffic. Such techniques become increasingly important in rural areas where cells are larger, resulting in uncertainty errors as high as several hundred metres.

5.2.4 Mobile phone positioning data sets typically include the time each event occurred, the coordinates of the corresponding transmitter location and cell dwell time (CDT), which refers to the duration a phone is associated with each cell. CDT can be a useful measure of traffic congestion and can also be used to distinguish home and work locations for trip purpose imputation.

5.2.5 Event data translates through to a travel trajectory as indicated in Figure 5-1. The general principles of MND analysis are indicated in Figure 5-2.

5.2.6 The principles of the process require fusion of information on both geospatial positioning and likely inference on mode and purpose. Mode can be separated based on speed and trajectory (resulting in clustering of public transport, removal of air trips based on airport to airport, snapping to rail lines etc). Purposes rely on habitual dwell times for overnight, assumed as home, and work (assumed as significant daytime duration). These are simplifications which are often sufficient to infer strategic movements, with some further post-processing review and adjustment.

Figure 5-2 – Movement tracking by MND

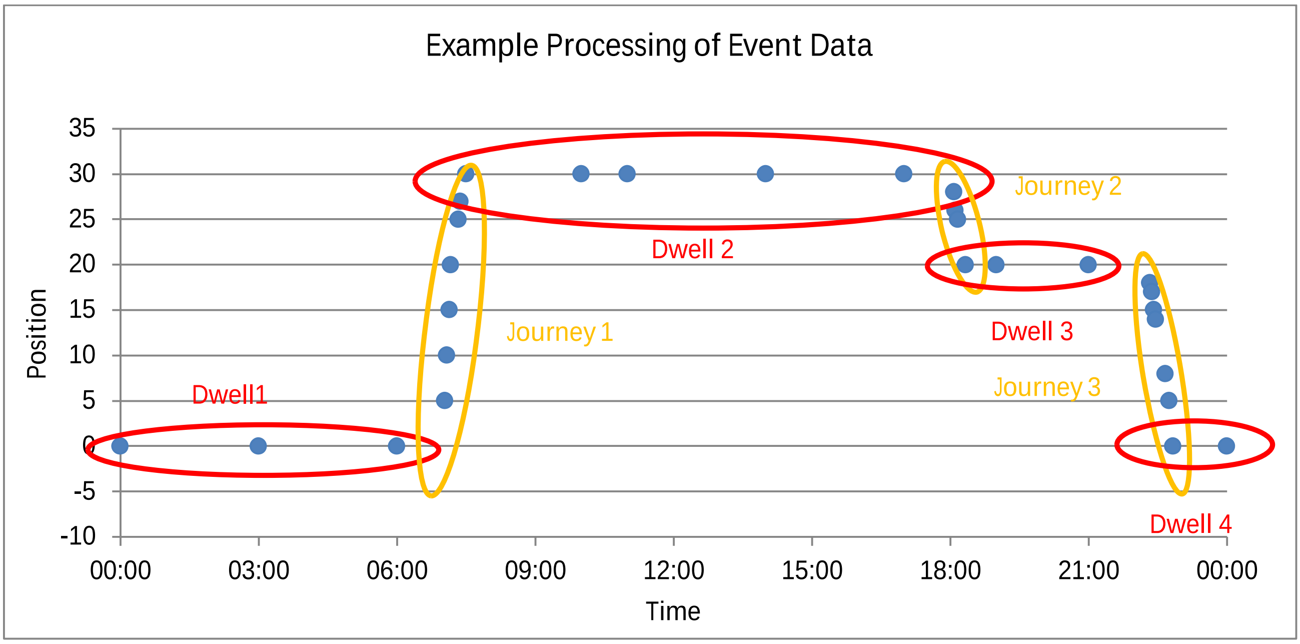
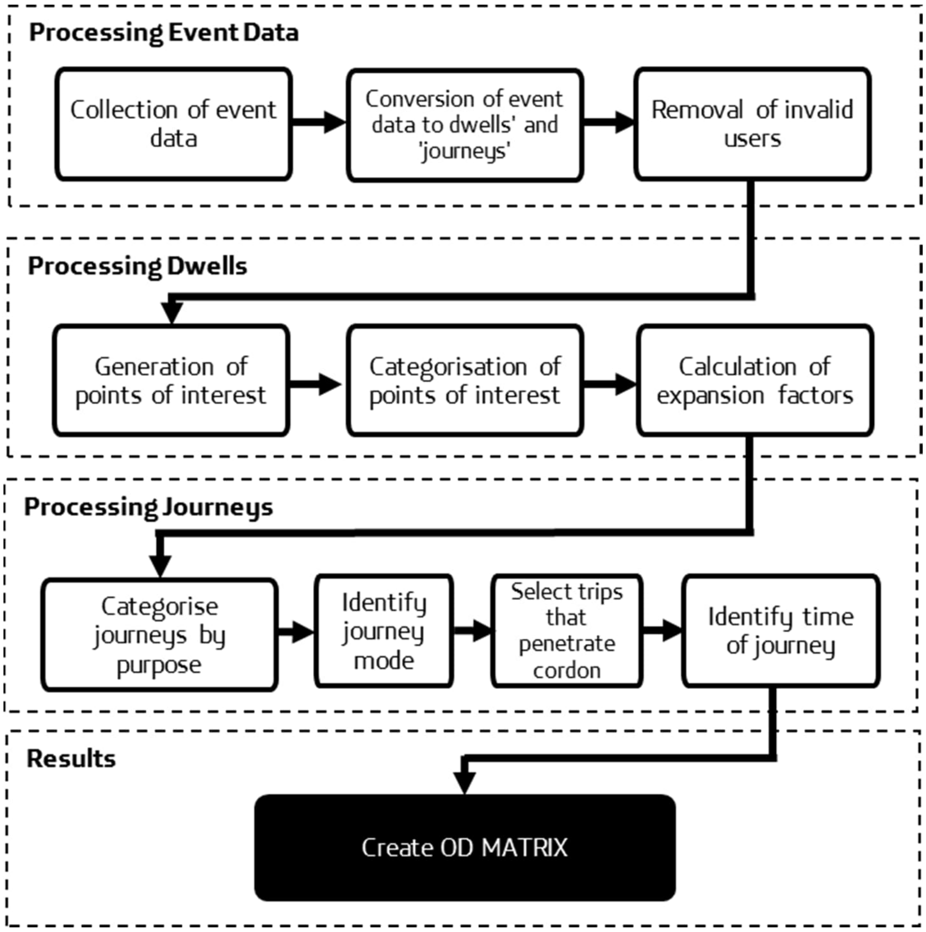


Figure 5-3 – General Principles of MND Analysis



5.3 MOBILE NETWORK DATA LIMITATIONS

5.3.1 There are known limitations of MND will be relevant to the **GLTM2** dataset.

- Flow volumes below a minimum threshold will be anonymised to respect privacy laws. The threshold and approach to how anonymised values are treated varies between suppliers.
- Mobile phone data may not pick up all short distance trips, which don't trigger handover events between cells. This is subject to cell size which are typically smaller in urban areas but may increase to several kilometres in rural areas.
- Some devices are excluded from the data analysis, including devices registered to children, Pay-As-You-Go and certain corporate users.
- General biases in MND may exist towards more active, higher income users, or underrepresentation of older retirees.
- Specific biases may exist for the mobile network used by the chosen data supplier, such as a greater prominence in a specific the target audience, e.g., business accounts or leisure and recreational promotions.

5.3.2 The primary usage of MND will be to represent medium and longer distance trips to, from and passing through the study area, including external to external trips. These trips are particularly important for the NHRR scheme assessment given that they may directly (reroute onto NHRR) or indirectly (traffic relief on A46 orbital route) benefit from the scheme which will form an important component of the travel user benefits.

5.4 MOBILE NETWORK DATA SPECIFICATION

5.4.1 It was proposed in Section 3.9 that a new MND survey commission will be undertaken. A Mobile Network Data Specification has been prepared which will be used to begin this process. Based on the responses, WSP will propose a data supplier for this commission which will be agreed with LCC.

5.4.2 That document sets out the required specification for the data, plus other considerations which the supplier may consider. The requirements ensure parity with the level of detail and segmentation in the previous 2016 dataset, whilst the considerations can enable any innovations in the processing since then to be reviewed for this new dataset.

5.4.3 The 2016 MND zone system is illustrated in Figure 5-1, and the segmentation is summarised in Table 5-1.

Figure 5-4 – Lincolnshire 2016 MND Zone System

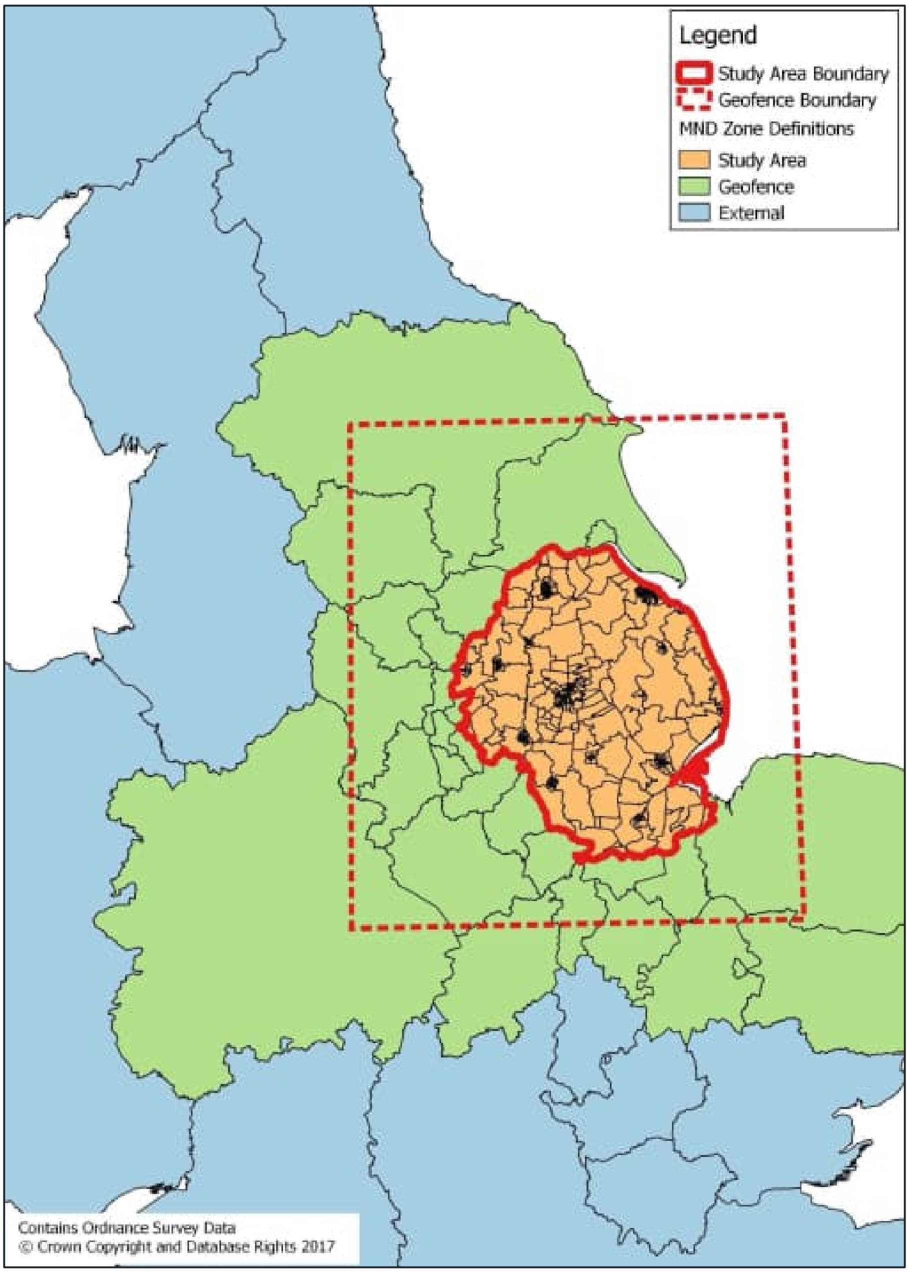


Table 5-1 – Lincolnshire 2016 MND Segmentation

Mode	Period	Day	Purpose	Direction
Rail	AM Period	Weekday	HBW	From Home
Motorised	Inter Peak	Saturday	HBO	To Home
Static*	PM Period	Sunday	NHBW	Non Home
Slow	Off Peak		NHBO	
			Unknown	

** Static referred to events where a device remained within the proximity of the same cell – based on the verification tests these were discarded as "trips", but it is possible that this may have included some short distance intra-cell trips*

5.5 MOBILE NETWORK DATA VERIFICATION

5.5.1 The MND will be subject to a two-stage verification process.

5.5.2 The Mobile Network Data Specification requires the data supplier to verify the validity of the data needs to be demonstrated by reporting several high-level checks in respect of district or more detailed level analysis covering:

- Time period splits;
- Trip purpose proportion splits;
- From home and return to home symmetry;
- Implicit trip rates based on expansion targets;
- Trip time and distance distribution splits; and
- Rail mode share.

5.5.3 WSP will then undertake a longer list of more detailed verification tests on the MND in line with the requirements of Table 2 in TAG Unit M2.2. The outcomes of these tests will be reviewed to determine the dataset is suitable for the next stage processing into assignment matrices.

5.6 MOBILE NETWORK DATA MATRIX PROCESSING

5.6.1 Following the verification tests, the MND will be processed into assignment matrices. This will include the following stages, which take account of the limitations noted in Section 5.3 and the variable specification noted in Section 5.4:

- Resolving the impacts of anonymised cell values;
- Disaggregation of the MND specified modes into the modelled modes;
- Disaggregation of the MND specific journey purposes into the modelled user classes;
- Disaggregation of the MND zones into the assignment model zone system;
- Conversion to modelled hours;
- Conversion to PCU trips (for highway modes); and
- Merging with synthetic matrices for short distance trips not fully detected in the MND.

5.7 SYNTHETIC MATRIX

5.7.1 It was noted above that MND is known to be limited in its capacity to reliably detect short distance movements, and so it is unlikely to reliably provide short distance movements within urban areas such as Lincoln city centre. Furthermore, the MSOA/LSOA data capture is likely to not be sufficiently detailed to match model assignment zones within the city centre of Lincoln.

5.7.2 Therefore, there is a need for an alternative travel demand data to merge or infill these short distance movements. However, RSIs also do not generally capture intra-urban trips that are within internal to the survey cordon and so this would have the same limitation for a different reason.

5.7.3 Synthetic matrices for car and public transport trips can be developed to overcome this limitation. The approach is predicated on the following principles:

- Calculating PA trip ends for the model zones using NTEM or CTripEnd with the required demand segmentations (mode – car or public transport, user class, home based/non home based and time period);
- Extracting observed trip length distributions from NTS data for the local area for each of the required demand segmentations;
- Extracting a model zone cost matrix;
- Creating a PA synthetic matrix for each demand segmentations by using a gravity model to distribute the PA trip ends such that the estimated trip length distribution closely matches the observed trip length distribution, using a 3-dimensional achieved (balancing row totals with the input productions, balancing column totals with the input attractions, and closely fitting the estimated distribution with the observed distribution);
- Converting the output PA matrices to OD using tour proportions derived from NTS; and
- Converting the matrices to PCUs (for car user classes).

5.8 FREIGHT MATRICES

5.8.1 The MND segmentation steps described above will provide travel demand for LGVs and HGVs, but it would therefore have the same expected limitation for representing short distance trips.

5.8.2 It is not proposed to develop synthetic matrices for goods vehicles, since the trip end data sources listed above do not cover these modes and the sample rates in NTS are generally low.

5.8.3 This aspect is likely to be more pertinent for LGVs which may have more shorter distance inter-urban trips, whereas HGVs are more likely to have longer trips which should be captured in the MND. But it is also noted that the medium and longer distance trips that are likely to have greater confidence in the MND are also likely to be those that are most relevant to the NHRR scheme assessment in the context of that model application.

5.8.4 The potential scale of the issue with short distance freight trips will be reviewed during the verification process to establish the needs for trip infill with additional freight data sources and/or processing.

5.9 PRIOR MATRICES

5.9.1 The prior matrices will represent a combination of the processed MND for medium and longer distance trips, with shorter distance trips merged or infilled from the synthetic matrices.

5.9.2 It is possible that the 'short distance' trips may be a represented by a single threshold or applied through multiple bands with a phased change in the proportion of synthetic trips. This will be determined by the data outcomes, including the verification tests in Section 5.4 and the prior matrix performance against screenline and cordon totals.

5.9.3 The prior matrix performance will also serve as a key indicator for the wider MND processing, and whether earlier assumptions may need to be revisited or refined. The modelled prior matrix screenline and cordon totals will need to be sufficiently close to the observed data such that the impacts of matrix estimation, as described in the following chapter, are supported by the guidance around levels of change suggested in TAG Unit M3.1.

6 HIGHWAY ASSIGNMENT MODEL STANDARDS

6.1 INTRODUCTION

6.1.1 The updated GLHAM will be developed in accordance with the guidance set out in TAG Unit M3.1 to ensure that the base year model achieves expected standards and is suitable for the specified modelling and appraisal applications of the model in future.

6.1.2 This section describes the methodologies and standards which will be adopted for GLHAM including those reproduced from TAG M3.1 relating to comparisons in three key areas including:

- Assigned flows and observed counts across screenlines and cordons as a check on the quality of the trip matrices;
- Assigned flows and observed counts on individual links and turning movements at junctions as check on the quality of the network and the assignment; and
- Modelled journey times and observed journey times along routes as a check on the quality of the assignment.

6.2 ASSIGNMENT METHODOLOGY

6.2.1 Assignment models split trips according to the routes they take through the network, and then calculate the costs of travelling via each route. The assignment procedure adopted for the highway model is based on an equilibrium assignment with multiple demand segments for three modelled time periods.

6.2.2 Assignment will need to be conducted based on detailed supply modelling using SATURN. The general principles of this involve:

- Free flow and congested link travel times;
- Junction control delay and over capacity delay;
- Reduced capacities resultant from excess flow;
- Traffic blocking back;
- Assignment algorithm to maximise convergence; and
- Reassignment according to 'Wardop's User Equilibrium'.

6.2.3 Wardop's Equilibrium seeks to minimise travel costs for each vehicle type in the network, based on the following propositions:

"Traffic arranges itself on congested network such that the cost of travel on all routes used between each origin-destination pair is equal to the minimum cost of travel and used routes have equal or greater costs".

6.3 CONVERGENCE CRITERIA AND STANDARDS

6.3.1 A highway assignment model is deemed converged if no significant change in travel costs across all the routes between successive iterations. TAG M3.1 recommends number of criteria to be applied for all the model assignments to achieve a final solution (i.e., route choice, flows and delays produced from the model are deemed stable).

6.3.2 TAG recommends that the model should continue until, for at least 98% of cases the percentage of link flow or cost differences change by no more than 1% on four successive iterations.

6.3.3 This corresponds to setting the following SATURN parameters:

```
RSTOP: 98%      PCNEAR: 1%      NISTOP: 4
```

6.3.4 That is, the assignment should continue until at least **RSTOP** of links have a flow or cost change of at most **PCNEAR** percent for **NISTOP** successive iterations.

6.3.5 Within SATURN, the percentage flows report how stable the assignment is. The proximity between the assignment and simulation loop is given by %GAP in the reporting tables, i.e., how close the assignment is to Wardop's equilibrium.

Table 6-1 – Convergence Criteria

Criteria	Base Model Acceptance Values
Delta and %GAP	Less than 0.1%
Percentage of links with flow change (P) < 1%	Four consecutive iterations > 98%
Percentage of links with cost change (P2) < 1%	Four consecutive iterations > 98%
Percentage change in total user costs (V)	Four consecutive iterations > 0.1%

6.4 DATA VERIFICATION STANDARDS

6.4.1 Various traffic and travel survey data will be obtained from various sources for use within the model build including newly commissioned surveys and other existing data sources within the area of interest.

6.4.2 The data collection and verification process will follow followed the guidance set out in TAG Unit M2.1 documented in Chapter 3 of this specification and will be reported in the Traffic Data Collection Report (TDCR).

6.5 NETWORK CALIBRATION STANDARDS

6.5.1 A set of network verification tests will be undertaken prior to the commencement of the calibration/validation.

- **Test 1 – Completeness Check:** ensures that the network produced is complete according to this MSR.
- **Test 2 – SATURN Compilation Check:** ensures that all the errors/warnings produced by SATNET have been reviewed and checked.
- **Test 3 – Inspection of Key Junctions:** ensures that all the key junctions within Lincoln and areas of interest in network are coded correctly.
- **Test 4 – Network Routeing:** ensures that routeing on the network appear realistic.
- **Test 5 – Link Consistency Tests:** ensures that link type, distance, speed limit, etc. are consistent between directions and up/downstream.
- **Test 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.

6.5.2 For test four, the following equation taken from TAG Unit M3.1 defines the number of OD pairs that should be examined:

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

6.5.3 These checks are designed to provide reassurance that:

- The network building is complete to the agreed specification;
- The network and inputs have been appropriately checked, the SATURN warnings have been reviewed and formal testing has been carried out against a list of potential errors; and
- The network coding is satisfactory, as far as can be determined, before commencement of the calibration/validation stage.

6.5.4 The network will be validated against the journey time criteria set out in Table 6-4 and the link flow criteria set out in Table 6-5.

6.6 MATRIX CALIBRATION STANDARDS

6.6.1 The developed trip matrices will be assigned for each modelled period and the modelled flows compared at a full screenline level against the observed counts. A matrix estimation (ME) process will be undertaken to refine the trip matrices by vehicle type.

6.6.2 The changes brought about by ME will be reported against the significance checks as set out in TAG Unit M3.1, reproduced in Table 6-2. Any exceedance of these criteria will be examined and assessed for their importance to the accuracy around the simulation area.

Table 6-2 – Significance of Matrix Estimation Criteria

Measure	Significance Criteria
Matrix zonal cell values	Slope within 0.98 and 1.02; intercept near zero; R^2> 0.95
Matrix zonal trip ends	Slope within 0.99 and 1.01; intercept near zero; R^2> 0.98
Trip length distributions	Means within 5%; standard deviations within 5%
Sector to sector level matrices	Differences within 5%

6.7 VALIDATION CRITERIA AND ACCEPTABILITY GUIDELINES

6.7.1 The model will be validated against the guidelines set out in TAG Unit M3.1. This states that comparisons should be carried out in three areas:

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

Trip Matrix Validation Criteria

6.7.2 The trip matrices will be validated against the criteria set out in Table 6-3 that is reproduced from TAG Unit M3.1.

6.7.3 Presentation of the outputs will be based around the TAG reporting guidelines as follows:

- Screenlines should be made up of 5 links or more;
- The comparisons for screenlines containing high flow routes such as motorways should be presented both including and excluding such routes; and
- The comparisons should be presented by vehicle type, by modelled time period and separately for screenlines used as constraints in the ME process and screenlines used for independent validation.

Table 6-3 – Trip Matrix Validation Criteria

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

Journey Time Validation Criteria

6.7.4 Journey time routes will be validated against the criteria set out in Table 6-4 that is reproduced from TAG Unit M3.1.

6.7.5 Presentation of the output will be based on the TAG reporting guidelines as follows:

- Comparisons should be presented separately where distinct speed/flow relationships and/or link speeds have been used for light and other vehicles; otherwise they should be presented together; and
- Comparisons should be presented separately by modelled period and by user class if a sufficient sample to a level of accuracy has been obtained for each to allow a meaningful validation.

Table 6-4 – Journey Time Routes Validation Criteria

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

Link Flow Validation Criteria

6.7.6 The measures used for link flow validation will be:

- The absolute and percentage differences between modelled flows and counts; and
- The GEH statistic which is a hybrid of the Chi-squared statistic to incorporate both relative and absolute errors. It is defined by

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

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

6.7.7 Both measures are considered broadly consistent and meeting either is considered satisfactory by TAG Unit M3.1. The following, taken from TAG, should be noted:

- The above criteria should be applied to both link flow and turning movements however it is accepted that it may be more difficult to achieve for the latter;
- The comparisons should be presented separately for each modelled time period and separately for cars and all vehicles but not for goods vehicles unless sufficiently accurately link counts have been obtained; and
- It is recommended that comparisons against both measures are reported.

6.7.8 The acceptability criteria are given in Table 6-5 reproduced from TAG Unit M3.1.

Table 6-5 – Link Flow and Turning Movement Validation Criteria

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

7 PUBLIC TRANSPORT ASSIGNMENT MODEL STANDARDS

7.1 INTRODUCTION

7.1.1 The updated GLPTM will be developed in accordance with the guidance set out in TAG Unit M3.1 to ensure that the base year model achieves expected standards and is suitable for the specified modelling and appraisal applications of the model in future.

7.1.2 This section describes the methodologies and standards which will be adopted for GLPTM including those reproduced from TAG M3.2 relating to comparisons in three key areas including:

- Validation of the trip matrix;
- Network and service validation; and
- Assignment validation.

7.2 ASSIGNMENT METHODOLOGY

7.2.1 The following assignment methodology will be implement based on the guidance set out in TAG Unit M3.2.

7.2.2 The assignment method undertaken is ‘frequency cost’ based (as opposed to schedule based) which considers both the fare and frequency of services to determine the optimum paths for travellers. This provides a more stable assignment than ‘frequency’ on its own and reflects some prior knowledge of travel choices, which is common in a smaller assignment network.

7.2.3 Bus and rail demand have been combined and assigned to the public transport network as a single trip matrix. That is, the public transport assignment determines the sub-mode choice where rail and bus services are competing. As the model has limited competition between bus and rail and there is no significant investment proposed for either model then this aspect is likely to have a limited impact in practical terms.

7.3 TRIP MATRIX VALIDATION

7.3.1 The criteria defined in TAG M3.2 states that across complete screenlines and cordons, “the differences between assigned and counted flows should, in 95% of the cases, be less than 15%”.

7.3.2 Within the current GLPTM, this reporting included “stop groups” which were commensurate definitions given the number of data points in this study area context.

7.4 NETWORK AND SERVICE VALIDATION

7.4.1 The criteria defined in TAG M3.2 states that validation of the network and services should involve:

- Checks on the accuracy of the coded network geometry; and
- Comparing modelled flows of public transport vehicle roadside counts respectively.

7.4.2 As per Section 4.3, the bus network will be developed based on the highway network to assure consistency between the models. The geometry of the highway network will have been checked as part of the GLHAM development and is recorded within the respective LMVR.

7.4.3 The rail network will be developed based on GIS data for the national rail network and station locations (such as from Ordnance Survey’s Meridian 2 open-source dataset) to ensure accurate representation of the geometry.

7.4.4 As per Section 4.9, the travel time coded for the rail services will be derived from the timetables hence there will be equivalency across all services.

7.4.5 The observed and modelled travel times for bus services will be compared to ensure that modelled times are sufficiently close to the observed across all routes.

7.5 ASSIGNMENT VALIDATION

7.5.1 Validation of the assignment should involve comparing modelled and observed passengers from the following perspectives as per TAG Unit M3.2:

- Flows across screen lines and cordons, usually by public transport mode and sometimes at the level of individual bus or train services; and
- Boardings and alighting in urban centres.

7.5.2 On individual links of the network, modelled flows should be within 25% of counts, except where observed flows are particularly low (less than 150). Wherever possible a check should be made between the annual patronage derived from the model and annual patronage derived by the operator from revenue records.

8 VARIABLE DEMAND MODELLING

8.1 INTRODUCTION

8.1.1 It is stated in TAG Unit M2.1 that *"any change to transport conditions will, in principal, cause a change in the demand for travel." Further, "it is of key importance … to establish a realistic scenario in the absence of and with the inclusion of the proposed scheme or strategy. For schemes that may affect traveller behaviour such as choice of mode, realistic levels of demand across the modes needs to be established".*

8.1.2 The current GLVDM has been developed to reflect mode and distribution responses to changing travel conditions. The inclusion of these travel choice responses is considered important for producing realistic future forecasts for "with scheme" and "without scheme" which reflect differential impacts of congestion, fuel costs and network availability.

8.1.3 TAG Unit M2.1 advises variable demand modelling will be required if one, or more, of the following criteria are satisfied:

- The model is being used to appraise a scheme with capital cost greater than £5 million;
- There is significant congestion on the network in forecast years (10 to 15 years post opening year for the scheme) without the scheme; or
- The scheme would be expected to have an appreciable impact on travel choice (e.g., mode choice or distribution) in the corridor containing the scheme.

8.1.4 Given the primary intended application for the **GLTM2** is supporting the NHRR scheme at FBC stage, the first condition is more than satisfied whilst the second and third would also appear to be highly relevant.

8.1.5 It is advised in TAG Unit M2.1 that it is sufficient to assume demand for freight is fixed, but susceptible to re-routeing at the assignment stage.

8.2 AREA OF INFLUENCE

8.2.1 The area of influence for the current GLVDM is illustrated in Figure 8-1. It is defined to be:

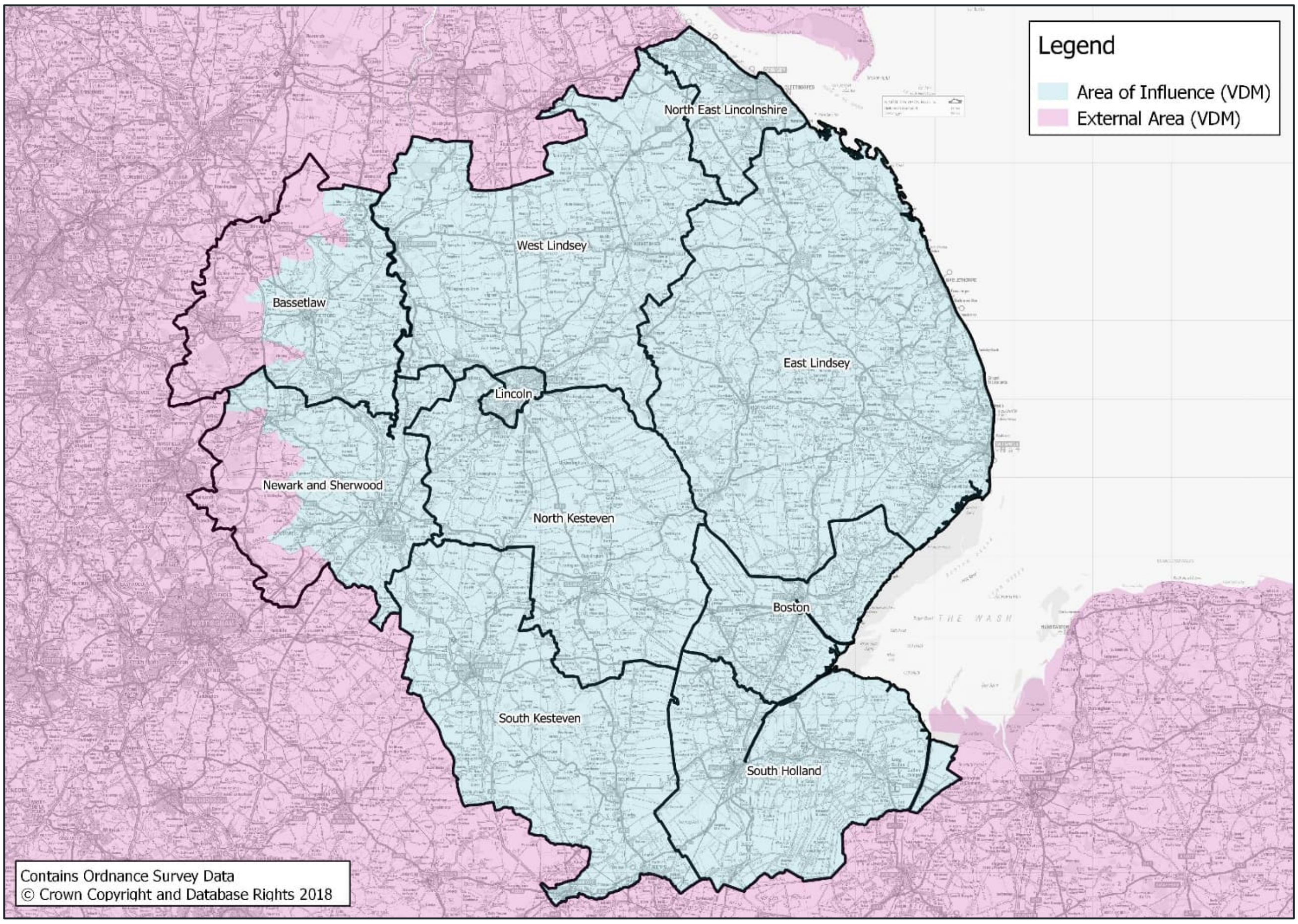
- Lincolnshire county comprising seven districts – Lincoln, North Kesteven, West Lindsey, South Kesteven, East Lindsey, Boston and South Holland;
- North East Lincolnshire district in Humberside; and
- The eastern areas of Bassetlaw and Newark and Sherwood districts in Nottinghamshire.

8.2.2 This area was determined by the geographical influence from testing the NHRR, specifically the areas over which traffic flows change on the existing SATURN highway network when the bypass scheme is introduced.

8.2.3 This includes areas of detailed representation of highway network, public transport service provision, zone density and validation in the highway and public transport models. Beyond this area network coverage and zone representation are at an increasingly aggregate level.

8.2.4 On that basis, his area of influence will be taken as the starting point for the updated GLVDM, and it is likely to remain the same, subject to the updated model calibration and review outcomes.

Figure 8-1 – VDM Area of Influence



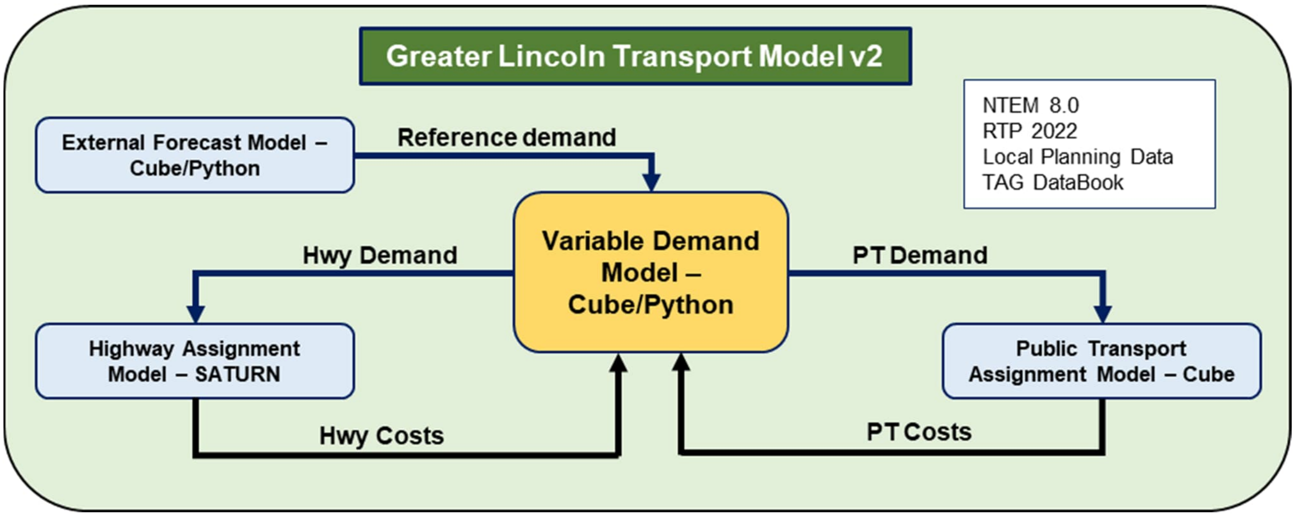
8.3 STRUCTURE OVERVIEW

8.3.1 As per Section 2.8, it is proposed that the GLVDM will be translated into using WSP's latest Python-based VDM template which offers enhanced flexibility for demand segmentation and run times. These applications would be embedded into and activated from within the GLTM Cube catalogue.

8.3.2 The proposed Python-based VDM template is tried-and-tested across several model development projects, and it will ensure that travel demand is balanced with network supply in a manner which is consistent with TAG recommendations.

8.3.3 This proposed updated structure for the GLTM is summarised in Figure 8-2.

Figure 8-2 – GLTM Structure Overview



8.4 FORM OF MODELS

8.4.1 TAG M2.1 describes several model forms that can be employed as follows:

- Absolute models, which produces a direct estimate of the number of trips in each demand category;
- Absolute models applied incrementally, which use changes in absolute model estimates to apply to a base matrix; and
- Pivot-point models, which use cost changes to estimate changes in the number of trips from a base matrix.

8.4.2 The updated GLVDM will continue to employ a pivot-point model which uses incremental cost changes to derive changes in demand from a reference trip matrix.

8.4.3 The change in generalised costs is produced by calculating the difference between the 'pivot-point cost' (validated base year models) and 'reference costs' (assignment of the matrix to be adjusted). The costs are composite (i.e., inclusive of all perceived elements) and are calculated for each level of the choice hierarchy to reflect the choice(s) made at each of the lower level(s) in the hierarchy.

8.5 HIERARCHY OF CHOICE RESPONSES

8.5.1 TAG M2.1 describes the main choice response mechanisms and their hierarchical orders that may be considered in variable demand models as below:

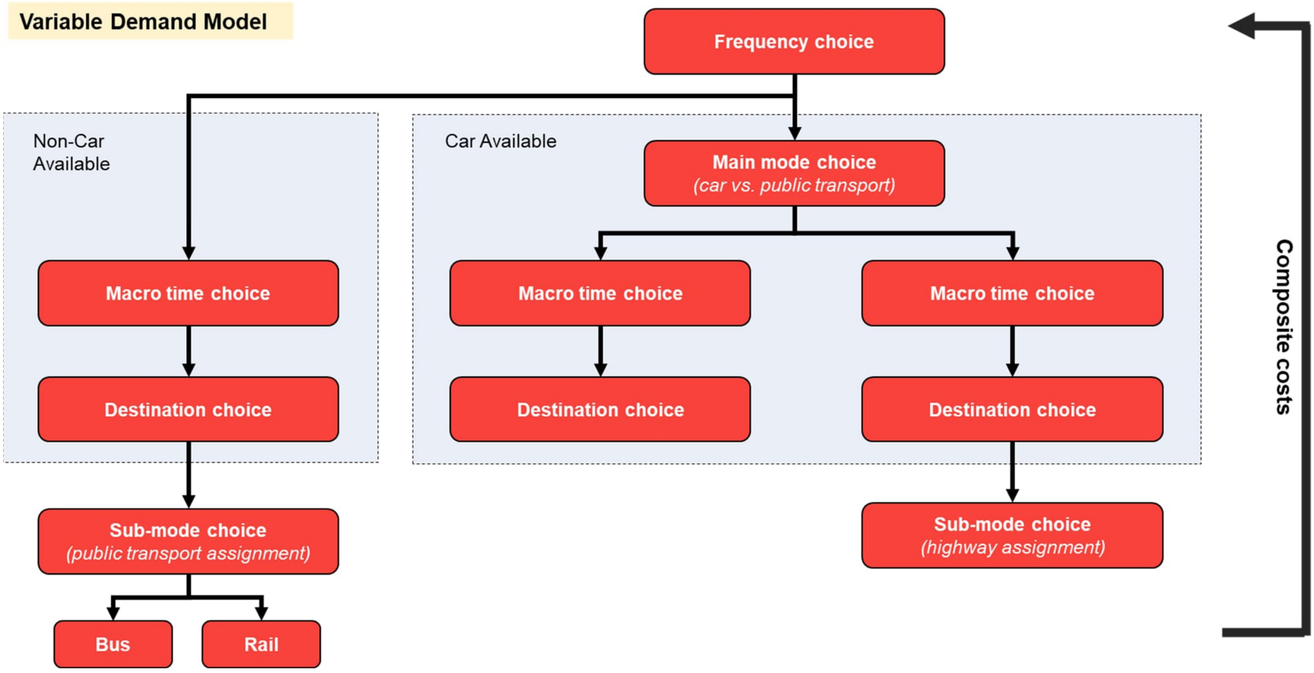
- Trip frequency;
- Mode choice;
- Time of day choice (macro and/or micro time period choice);
- Destination choice (trip distribution); and
- Route choice (assignments).

8.5.2 A choice mechanism placed higher in the hierarchy should reflect the composite costs of choices lower in the hierarchy.

8.5.3 Demand models adopt a looping procedure to achieve stability. During each cycle, the composite costs must be calculated for each level in the hierarchy, since each level requires combinations of cost in relation to choices made lower in the hierarchy. In the hierarchy, the composite cost calculation weights costs by demand choice parameters used. Choice calculations are then made down the hierarchy and subsequently the whole cycle is recalculated until an acceptable degree of convergence is achieved. A typical choice hierarchy with associated cost transfers is illustrated in Figure 8-3.

8.5.4 In the subsequent sections the individual choice mechanisms are considered in turn and their relevance to the Greater Lincoln area are reviewed.

Figure 8-3 – Typical Choice Hierarchy with Associated Cost Transfers



Frequency Choice

8.5.5 Trip frequency can be thought of in several ways, firstly as modelling the potential mode diversion from active modes – typically walking and cycling – into and out of motorised modes. Secondly frequency is a way of quantifying changes in discretionary trip purposes where behaviour is more contingent on cost of travel. All other things being equal frequency responses result in a variable sized travel market and lead to higher demand elasticities for any given cost change.

8.5.6 In the current GLVDM, an acceptable level of calibration for the base year was achieved during the realism testing without a frequency choice response being utilised. Subject to the outcome from the realism test on the updated **GLTM2** model, it is proposed that frequency choice can remain an optional, but excluded, element of the GLVDM choice responses.

Mode Choice (and Car Availability)

8.5.7 TAG M2.1 states that it is desirable to include some representation of mode choice in VDM; however, the level of detail depends upon the importance attached to it, based on the travel market and the study in question. It could be acceptable to include alternative modes merely as a set of fixed costs, but conversely, it may be necessary to model mode choice alternatives in detail, for example, the effect of changing highway conditions on bus travel times.

8.5.8 There are two types of mode choice that can be represented within a VDM:

- **Main mode choice** – representing fundamental choices, for example, between car (private) and public transport and/or active modes (walk/cycle); and
- **Sub-mode choice** – representing choice within the specific nest, for example, between bus and rail within public transport, or between car and P&R within highway.

8.5.9 The GLTM model suite has active highway and public transport assignment models from which modelled costs are imported into the current GLVDM and used to facilitate mode shift in the forecast years for testing both highway and/or public transport interventions in the model area. This approach will continue to be used with the updated model components in **GLTM2**.

8.5.10 Sub-mode choice of bus or rail is implemented at the assignment stage of GLPTM (see Section 7.2). The approach for optional parking components is considered below in Section 8.10.

8.5.11 The current GLVDM does not explicitly model active modes (walk and cycle) as a demand segment, and this is not proposed for the updated GLVDM at this stage given the primary application will be the NHRR FBC where they are likely to be a marginal impact on the scheme forecasting. However, there is the option for this approach for active modes to be considered as a new functionality that could be developed as a change event to this specification at a future time if a modelling need arises.

8.5.12 In general, mode shift would be restricted to trip makers from the 'car available' market. However, in the current version of GLVDM, this additional segmentation was not applied due to the high proportion of car mode share and car ownership in the model study area.

8.5.13 The data upon which the previous decision was based around not applying car availability are presented in Table 8-1, alongside the updated values using NTEM v8 with the proposed new model base year. It is noted that both sets are values are very similar, however, it is proposed to upgrade the functionality of the new GLVDM to include car availability segmentation in the new model. This can provide an enhancement to the level of detail within highway scheme forecasting such as the NHRR model application.

Table 8-1 – Car Ownership

Area	NTEM v7.2; 2016		NTEM v8.0; 2022	
	Car Available	NCA	Car Available	NCA
Great Britain	75.0%	25.0%	74.7%	25.3%
East Midlands	78.9%	21.1%	78.6%	21.4%
Lincolnshire	82.3%	17.7%	82.1%	17.9%

Table 8-2 – Person Trip Mode Share

Area	NTEM v7.2; 2016		NTEM v8.0; 2022	
	Car	Bus and Rail	Car	Bus and Rail
Great Britain	84.3%	15.7%	84.7%	15.3%
East Midlands	89.3%	10.8%	89.5%	10.5%
Lincolnshire	91.3%	8.6%	91.4%	8.6%

Time of Day Choice

8.5.14 There are two different aspects of time of day choice:

- **Macro time choice** – represents the choice between broad modelled time periods, for example, between AM period and inter peak period; and
- **Micro time choice** – represents choices within a modelled period, for example, early or late arrival during the AM peak hour (i.e., peak spreading) to avoid congestion.

8.5.15 Macro time choice is often relevant for longer journeys where active modes is not a variable choice and for journeys on networks which are significantly over capacity for extended periods.

8.5.16 It is proposed to employ macro time choice in the updated GLVDM, using a logit choice model in a similar way to the choice response mechanisms for other stages of the demand modelling, i.e., as cost differentials between time periods are evident in the base year models. These are anticipated to develop further in the forecast years since the growth in travel demand is not expected to be uniform across all hours of the whole day.

8.5.17 Micro time choice was excluded in the current GLVDM. There is currently limited evidence on modelling micro time choice without sufficient local data to calibrate and so this choice will also be excluded from the choice set within the updated GLVDM.

Destination Choice

8.5.18 Destination or distribution choice involves the transfer of trips between different destination zones because of changes to travel costs and consequently it can have a substantial impact on the composition and volume of traffic using a particular scheme. This can be applied in terms of zonal production and attraction or for origin and destination trip totals.

8.5.19 It is modelled to reflect the long-term impact of cost change and is considered critical to the function of most variable demand model systems.

8.5.20 According to TAG M2.1, it is common to use:

- **Doubly constrained** models for estimating commuting and education trips where their origins and destinations are well defined by planning data; and
- **Singly constrained** (origin constraint) models for business and other purposes where the total number of trips generated in each zone is known, but not necessarily the trip attractions.

8.5.21 These conventions are adopted in the current GLVDM and this will also be the case in the updated GLVDM. Mode specific highway and public transport destination choice responses were included, and continuing this approach is also proposed for the updated GLVDM.

Route Choice (Assignment)

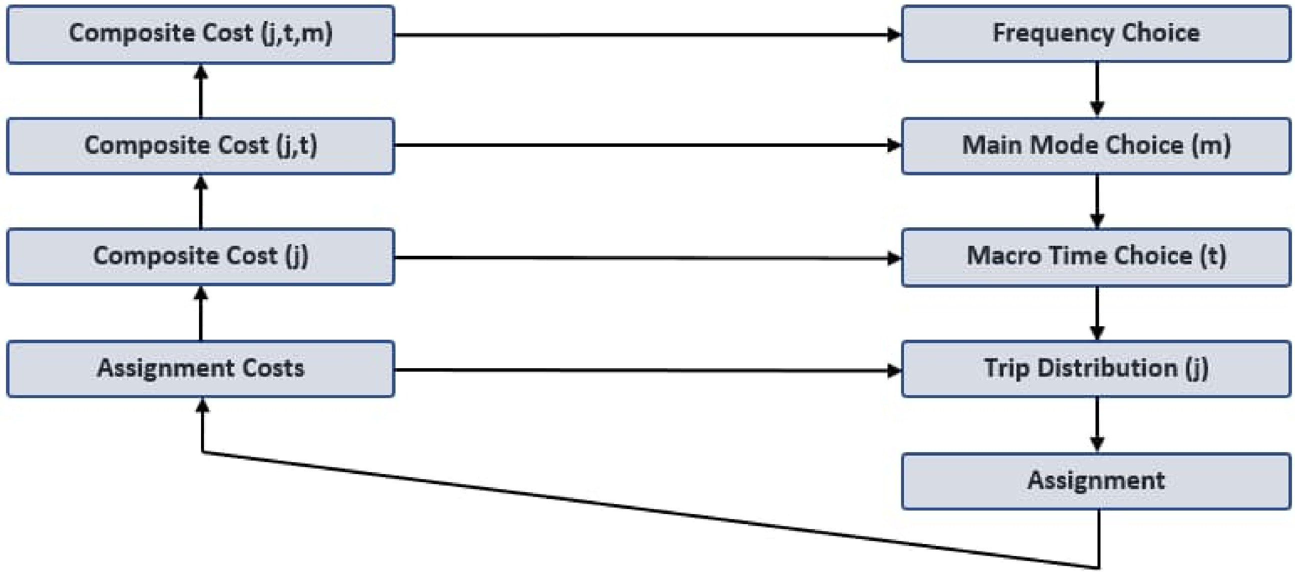
8.5.22 Variable demand models include an assignment stage to provide travel cost information for other responses. The assignment must be adequately converged to ensure stability of costs for predictable and appropriate outcomes.

8.5.23 In the current and proposed model set up, this is undertaken in SATURN (through GLHAM) for highway trips and in CUBE (through GLPTM) for public transport trips.

Summary of GLVDM Hierarchy and Application of Choice Responses

8.5.24 Based on text above, the order of the updated GLVDM hierarchy of choice responses is summarised in Figure 8-4.

Figure 8-4 – GLVDM Choice Responses Hierarchical Order



8.6 IMPLEMENTATION METHODS

8.6.1 The proposed implementation methods in the updated GLVDM are generally based on those which were implemented in the current GLVDM specification.

Modelled Periods

8.6.2 The GLHAM and GLPTM assignment models will reflect the typical traffic conditions on an average weekday (Monday to Friday) for a neutral month (to be confirmed during the model development), during the morning, inter-peak and evening peak hours.

8.6.3 The GLVDM will be a 24-hour weekday demand model that represents four time periods:

- AM period (07:00-10:00),
- Inter-Peak period (10:00-16:00),
- PM period (16:00-19:00); and
- Off-peak period (19:00-07:00 of the following day).

8.6.4 To ensure a linkage between the demand model and the supply assignment models, the demand estimated from each period will be converted between peak/average hour and peak period using factors from the respective data collection.

8.6.5 Off-peak demand will be derived from the 12-hour weekday demand for the purpose of the demand model only and is not used in the assignment models.

Demand Segmentation

8.6.6 The correspondence between assignment user classes and GLVDM demand segments is provided in Table 8-3. The overall GLVDM segmentation is provided in Table 8-4.

8.6.7 Education trips are not explicitly identified as a separate segment in the current GLVDM, and it is not proposed to include that in the updated GLVDM at this stage. The primary reason for including this may be around the growth around the University of Lincoln, however, these trips are likely to be within the city centre, so this is not likely to be pertinent detail for the NHRR scheme forecasting. However, there is the option for this approach with further detailed modelling of education trips to be considered as a new functionality that could be developed as a change event to this specification at a future time if a modelling need arises.

8.6.8 Demand segments from GLVDM will be converted from PA format to OD format by period and subsequently aggregated to respective highway and public transport assignment user classes prior to their respective assignments being carried out.

8.6.9 As mentioned in above, freight demand (LGV and HGV) will not be subject to the VDM; however, it will be susceptible to route choice modelling within highway assignments.

Table 8-3 – User Classes to Demand Segments

Highway Assignment User Classes	Public Transport Assignment User Classes	Demand Model Journey Purposes
Car Business	Public Transport Business	HB Business (24Hr PA)
		NHB Business (Period OD)
Car Commuting	Public Transport Commuting	HB Commuting (24Hr PA)
Car Other	Public Transport Other	HB Other (24Hr PA)
		NHB Other (Period OD)
LGV	NA	LGV (assignment only)
HGV	NA	HGV (assignment only)

Table 8-4 – Variable Demand Model Segmentation

Segment	Purpose	PA/OD	Direction	Car Available	Highway	PT
1	HBW	PA	From Home	CA	✓	✓
2	HBW	PA	To Home	CA	✓	✓
3	HBW	PA	From Home	NCA		✓
4	HBW	PA	To Home	NCA		✓
5	HBEB	PA	From Home	CA	✓	✓
6	HBEB	PA	To Home	CA	✓	✓
7	HBEB	PA	From Home	NCA		✓
8	HBEB	PA	To Home	NCA		✓
9	NHBEB	OD	OD	CA	✓	✓
10	NHBEB	OD	OD	NCA		✓
11	HBO	PA	From Home	CA	✓	✓
12	HBO	PA	To Home	CA	✓	✓
13	HBO	PA	From Home	NCA		✓
14	HBO	PA	To Home	NCA		✓
15	NHBO	OD	OD	CA	✓	✓
16	NHBO	OD	OD	NCA		✓
17	LGV	OD	OD	NA	✓ (Fixed)	NA
18	HGV	OD	OD	NA	✓ (Fixed)	NA

Generalised Cost

8.6.10 Generalised costs determine travel choice between alternative modes, time, destination and routes, based on a combination of travel time, operating costs and charges in a unit of generalised time for the purpose of the demand modelling.

8.6.11 The highway and public transport model generalised cost formulations were described in Section 4.12.

Model Formulation

8.6.12 Following the recommendation in TAG M2.1, the GLVDM will continue to adopt an incremental logit model form, pivoting off the base year models, in which the choice between travel alternatives (frequency, mode, time period and destination choices) depends upon an exponential function of the generalised cost, or disutility.

8.6.13 The logit-based formulation implemented within the GLVDM is described below for each of the four demand modelling stages, with three distinct applications:

- **Incremental P/A model** – to be applied for HB trips;
- **Incremental O/D model** – to be applied for NHB trips; and
- **Fixed demand** – to be applied for car trips external to the study area and for freight demand (LGV and HGV).

8.6.14 The demand model will be implemented in terms of utilities and composite utilities that are consistent with the TAG hierarchical logit formulation in which:

- Travel costs or utilities are obtained from the lowest levels of the hierarchy and composite costs or utilities are calculated as the costs move up to the next level of the hierarchy; and
- Demand is subsequently calculated from the top to the bottom level of the hierarchy to represent change in demand in response to cost change.

8.6.15 At the bottom of the hierarchy, the lambda parameters are used for the destination choice and thetas as scaling parameters for appropriately weighting time, mode and frequency choices. The mechanism of modelling choice response from destination choice to frequency choice is provided in the steps below.

Demand Model Structure

8.6.16 The GLVDM will have a hierarchical logit choice structure as shown previously in Figure 8-4.

8.6.17 An overview of the demand model stages functional forms (i.e., PA/OD) and time periods that will be adopted are listed in a hierarchical order in Table 8-5. Stages 1-4 will be undertaken entirely within the demand model, whilst stage 5 will be provided through the highway assignment model.

8.6.18 The demand model will operate at 24-hour level until the macro time of day choice (Stage 3) is undertaken, where 24-hour demand is then disaggregated to time period level to allow for the macro time choice mechanism to be implemented.

8.6.19 For the destination choice (Stage 4), the demand model will consider all four time periods (AM, inter peak, PM and off-peak periods) for all person types in parallel. The resulting PA matrices by individual time periods from Stage 4 will be converted to peak hour OD matrices prior to the respective highway and public transport assignments being undertaken.

Table 8-5 – GLVDM Choice Responses Hierarchical Order

Stage	Choice Responses	Period	Form
1	Frequency Choice **(not invoked)**	24-hour	PA Trip-Ends
2	Main Mode Choice	24-hour	PA Trip-Ends
3	Macro Time Choice	Translate 24-hour to AM, Inter-Peak, PM and Off-Peak periods	PA Trip-Ends by time periods
4	Destination Choice	By individual AM, Inter-Peak, PM and Off-Peak periods	Translate PA trip-Ends to PA matrices by time periods
5	Assignment	AM, inter peak and PM peak hour	Peak Hour OD matrices

8.7 SUPPLY-DEMAND CONVERGENCE

8.7.1 The GLVDM will employ an iterative method to achieve convergence between the assignment models and the bespoke demand model.

8.7.2 Convergence will be achieved by passing costs from the assignment models to the demand model and subsequently passing trips from the demand model back to the assignment models, where the process will terminate once the convergence criterion has been met.

8.7.3 The recommended criterion specified by TAG M2.1, for measuring convergence between the demand and supply models, is the demand/supply %Gap over all segments, defined by the formula below:

$$Convergence\ Gap = \frac{\sum_{ijmpct} C(X_{ijmpct}) * ABS(D(C(X_{ijmpct})) - X_{ijmpct})}{\sum_{ijmpct} C(X_{ijmpct}) * X_{ijmpct}} * 100$$

where:

- X_{ijmpct} is the current demand matrix;
- $C(X_{ijmpct})$ is the generalised cost matrix obtained by assigning the matrix X_{ijmpct};
- $D(C(X_{ijmpct}))$ is the demand matrix output by the demand model, using costs $C(X_{ijmpct})$ as input; and
- $ijmpct$ represents origin i, destination j, mode m, purpose p, person type c and time period t.

8.7.4 It is important to achieve a high level of supply-demand convergence to provide assurance that the model results are as free from error and 'noise' as possible. For this reason, TAG M2.1 recommends that a %Gap of less than 0.1% should be achieved and remedial steps should be taken to improve the convergence if the convergence Gap is over 0.2%.

8.7.5 To aid searching for a convergence solution, a number of methods can be used to achieve a stable converged solution between the demand and supply responses:

- **Conventional method** – the demand output from the demand model for the current iteration is used directly as the input demand in the next iteration. This method can reach a lower gap value very quickly; however, it can lead to a non-converged solution if the networks are congested;
- **Method of successive average (MSA)** – a 'slow but true' traditional method with a lengthy duration to a convergence solution; and
- **Fixed step length** – this is normally the optimum of the three methods for a quicker convergence solution. However, with a congested network this method may take longer or not converge if the step length is not appropriately selected.

8.7.6 For the updated GLVDM a 'variable step length' method will be adopted as illustrated by the equation below:

$$X^N = X^{N-1} + \alpha * \left(D\left(C(X^{N-1})\right) - X^{N-1}\right)$$

where:

- X^N is the demand matrix to be used to the next demand model loop;
- X^{N-1} is the current demand matrix from the demand model;
- $D\left(C(X^{N-1})\right)$ is the new demand matrix output by the demand model, using the costs $C(X^{N-1})$ produced from the assignment of the matrix X^{N-1} as the input; and

- α is the variable step length to be applied, being set to 1.0, 0.9, 0.8, etc. for VDM loop 1, 2, 3, etc. respectively and set to 0.5 from loop 6 onward, if required (devised from number of trial test runs while searching for the optimal convergence solutions from number of previous experiences).

8.7.7 The variable step length will allow faster yet more stable results when searching for the convergence solutions compared to the abovementioned methods.

8.8 BASE YEAR REALISM TESTS

8.8.1 The acceptability of a VDM is determined by its demand elasticities, which are derived through applying a small global change to costs within the model and calculating the proportionate change in demand. This is the basis for the realism testing.

8.8.2 The elasticity calculation recommended by TAG Unit M2 is defined by the formula

$$e = \frac{\log(T^1) - \log(T^0)}{\log(C^1) - \log(C^0)}$$

where the superscripts 0 and 1 correspond to the values of demand (T) and cost (C) before and after the change in cost respectively.

Fuel Cost Elasticity

8.8.3 The car fuel cost elasticity required by TAG M2.1 is the percentage change in car vehicle kilometres with respect to a percentage change in fuel cost. The elasticity will be calculated for a 20% fuel cost increase.

8.8.4 TAG states that the average fuel cost elasticity across all purposes should lie within the range -0.25 to -0.35 with the elasticity near to -0.1 for business trips, near to -0.4 for other trips and near to the average for commuting trips. These values will be targeted in the model.

Journey Time Elasticity

8.8.5 The car journey time elasticity required by TAG M2 is the change in car trips with respect to a change in journey time. This has been undertaken with a 20% increase in car travel time, applied using a single run of the demand model in line with TAG since the target elasticities in this instance were derived from stated preference data. Responses no greater than -2 will be targeted.

PT Fare Elasticity

8.8.6 The PT generalised costs within the model will be developed inclusive of access time, wait time, travel time and fares. The fare element of this will be incremented to test mode choice sensitivity. An PT fare elasticity response of -0.2 to -0.9 will be targeted.

Lambda Sensitivity

8.8.7 Sensitivity tests will also be carried out with +/-50% of the calibrated lambda values to ensure the model still behaves realistically with changes in the model response parameters.

8.9 SENSITIVITY PARAMETERS FOR REALISM TESTS

8.9.1 TAG M2.1 provides illustrative values which can be used to assist in delivering the realism tests.

8.9.2 For the current GLVDM, the realism tests were carried out with 20% change in fuel cost price, public transport fare and car journey time and found that the models behaved realistically in accordance with TAG guidance.

8.9.3 The current GLVDM parameters will therefore provide a good starting point that can be refined as required during the model calibration, subject to outcomes once the updated demand and cost outputs are utilised from the updated assignment models.

8.10 PARKING MODELS

8.10.1 The current GLVDM has two additional sub-components that were developed to facilitate the modelling of parking strategy and interventions in future local studies.

8.10.2 These two parking models were developed to operate outside of the GLVDM loop and are only invoked when a converged solution has been achieved.

8.10.3 It is noted that the parking models were not activated for the NHRR OBC forecasting, and it is not expected that they would be required for the NHRR FBC forecasting.

8.10.4 For this reason, WSP proposed in Section 2.3 that the parking models would not be redeveloped at this stage, on the basis the immediate modelling needs for the NHRR FBC and this project requirements, but this does not exclude the opportunity that they could be redeveloped at a future stage if a specific modelling need arises.

9 FORECAST MODELLING

9.1 INTRODUCTION

9.1.1 Forecasting the usage and performance of transport networks is a critical requirement of a transport model.

- Support for Strategic Business Cases; and
- Support local development planning.

9.1.2 The first element of forecast capability requires support of continued LCC funding bids for major scheme bids including the NHRR at FBC stage. The remainder of this chapter describes the various requirements of the forecasting and appraisal process for such involvements. These include the prediction of the future year travel demands and the assumptions relating to changes in the future year highway network.

9.1.3 The second element relies on a close level of detail across the study area, adherence to appropriate calibration targets and an effective assignment response. Whilst trip rates associated with the developments may be evaluated externally the model will provide a comprehensive platform to evaluate the transport outcomes of developments. A range of model metrics already outlined earlier in this report can be used to evaluate outcomes.

9.1.4 The forecasting model will be developed in accordance with guidance provided by the DfT in the TAG series of documents, primarily TAG Unit M4.

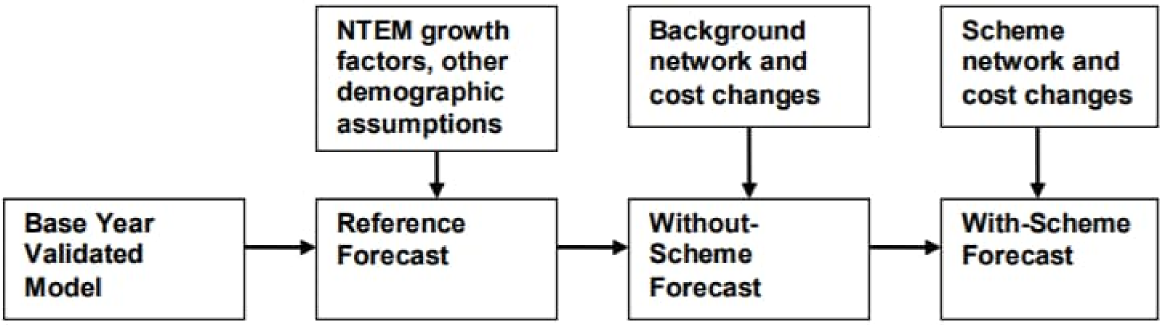
9.2 APPROACH TO FORECASTING

9.2.1 The current and proposed future approach to forecasting using the **GLTM2** is broadly summarised in Figure 9-1, reproduced from TAG Unit M4.

9.2.2 The starting point is the validated base year model which was specified throughout the earlier chapters.

- **Reference case** forecasts incorporate changes in travel demand incurred through demographic changes but not changes related to travel costs (including congestion and fares) or other parameters (e.g., value of time).
- **Without-scheme forecasts** incorporate background network changes (i.e., committed schemes) and changes to travel costs.
- **With-scheme forecasts** incorporate network changes and changes to travel costs associated with the scheme being tested.

Figure 9-1 – Approach to Forecasting



9.3 TRAVEL DEMAND UNCERTAINTY

9.3.1 Sources of uncertainty need to be considered at both national and local level.

- National uncertainty refers to national projections such as demographic changes, GDP growth and fuel price trends. This forms part of the background growth and is reflected in the data obtained from national models such as National Trip End Model (NTEM) and Road Traffic Projections (RTP).
- Local uncertainty considers whether developments or other planned transport schemes will go ahead in the vicinity of the scheme. This information is documented in the Uncertainty Log.

National Uncertainty

9.3.2 The latest National Trip End Model (NTEM) datasets will be extracted for the "Core" scenario and each of the DfT Common Analytical Scenarios which have alternative NTEM datasets to derive the forecast growth for car and public transport trip ends. Version 8 is the most recent release at the time of writing.

9.3.3 As per Section 9.9 below, it is only proposed to develop a "Core" scenario test within this commission. However, including the NTEM data inputs for all the CAS scenarios will future-proof the **GLTM2** forecast model for the potential downstream forecasting scenario requirements at the NHRR FBC stage. The distinct CAS scenario datasets that will be set up as inputs for the model system are:

- Core;
- High economy;
- Low economy;
- Regional;
- Technology; and
- Behavioural.

9.3.4 The "Decarbonisation" CAS has alternative appraisal parameters but uses the Core scenario NTEM data.

9.3.5 Road Traffic Projections (RTP) data will also need to be extracted for the "Core" scenario and each of the DfT Common Analytical Scenarios (as per the list for NTEM above) to derive the forecast growth for goods vehicles trip ends. The 2022 dataset is the most recent release at the time of writing.

Uncertainty Log

9.3.6 There is an existing Uncertainty Log for the current GLTM, and this will be updated to take account of the latest information regarding the status of various schemes and developments in the model study area.

9.3.7 The primary sources of local uncertainty include the Lincoln Transport Strategy (LTS) 2020-2036 and the Central Lincolnshire Local Plan (CLLP) which previously adopted in 2017 and reviewed in 2019.

9.3.8 Local data is supplemented by national uncertainty associated with schemes proposed by National Highways (mostly likely to related to the A46 for the study area) and Network Rail.

9.3.9 All developments and schemes are allocated to one of the following four categories according to its likelihood of happening:

- Near Certain;
- More Than Likely;
- Reasonably Foreseeable, and;
- Hypothetical.

9.4 FORECAST YEARS

9.4.1 It is proposed that three forecast years will be developed within this commission.

9.4.2 Given the primary intended use of the model, the choices of forecast years are expected to correspond to the latest assumed opening year of NHRR, the design year of NHRR (+15 years from the opening year) and an intermediate year (possibly +10 years from the opening year).

9.4.3 Based on this, the **forecast years may be 2028, 2038 and 2043**, although this specification will be discussed and agreed with LCC at the relevant time in this project programme.

9.4.4 This does not preclude other forecast years may be required and developed on other project applications using this updated **GLTM2**, subject to agreement of scope with LCC.

9.5 FUTURE YEAR TRAVEL DEMAND SCENARIOS

9.5.1 Future year travel demands for the modelled forecast years consider the existing base year traffic demand together with the effects of traffic growth, including additional traffic due to new developments.

9.5.2 Projected traffic growth is largely driven by an increasing population, changes to vehicle operating costs and increasing car ownership, linked to greater affluence. Wealth enhances economic activity and can underpin new household formation. Travel demand forecasting is required to assess network performance given these circumstances.

9.5.3 TAG M4 describes the **Core scenario** as representing the best basis for decision-making given current evidence. It should be based on more certain, unbiased assumptions although this necessitates consideration of some sources of uncertainty. This is the central scenario for reporting scheme appraisal outcomes in business cases.

9.5.4 The Core scenario reference demand will be developed using the latest sources of national forecast data including background growth changes from NTEM v8, Road Traffic Projections (RTP) 2022 for goods vehicles and local uncertainty represented by developments classified as 'Near certain' or 'More than likely'.

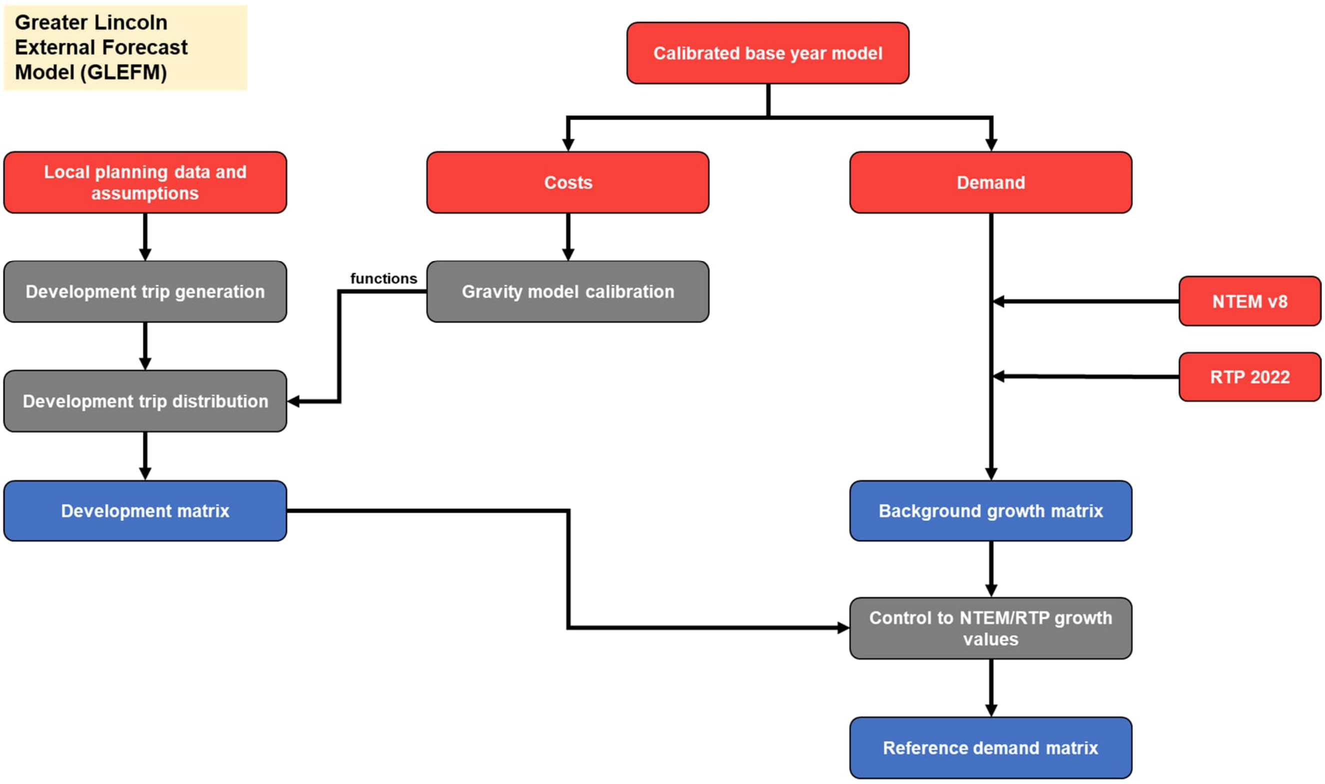
9.5.5 It is proposed that the Core scenario reference case demand (see Figure 9-1) will be developed using an updated GLEFM (see Section 2.8). The GLEFM will be a Python-based tool which takes the sources of local and national uncertainty described above to develop future year reference demand matrices. This includes control to NTEM as required to follow TAG M4 guidance.

9.5.6 The existing approaches for development trip generation and distribution are proposed to be retained in the updated **GLTM2**.

- Development trip generation will be undertaken externally to the GLEFM in a spreadsheet, using a database of trip rates derived from TRICS. These could be overridden with trip ends from another source (such as a Transport Assessment) for specific developments if preferred.
- Development trip distribution will be undertaken using a gravity model, with the functions and parameters updated to reflect the updated observed base year trip length distribution.

9.5.7 The GLEFM will also be set up to include the NTEM and RTP datasets associated with the DfT Common Analytical Scenarios, in preparation for its intended application on the NHRR FBC scheme forecasting.

Figure 9-2 – GLEFM Structure



9.6 FUTURE YEAR SUPPLY

9.6.1 The future year "without-scheme" networks will consist of the following updates appended to the base year network files:

- Updates to fixed speeds to account for expected higher levels of congestion in the future years, sourced from the RTP 2022;
- Updates to the PPM and PPK parameters for the future year highway assignments;
- Updates to the PPM parameters for the future year public transport assignments;
- Assumed real changes to public transport fares for the future year public transport assignments;
- Scheme coding in the highway and public transport networks based on the data in the uncertainty log assumptions; and
- Coding new development site accesses, in parallel with the development assumptions.

9.6.2 Given the primary intended use of the model, the future year "with-scheme" networks will consist of the "without-scheme" networks plus the NHRR scheme, using the latest coding assumptions to be confirmed with LCC.

9.7 ECONOMIC ASSESSMENT

9.7.1 The model must be able to provide for cost-benefit assessment, to estimate the value for money provided by major schemes including the NHRR FBC.

9.7.2 This type of economic assessment will typically utilise TUBA (Transport User Benefit Analysis), a computer program developed for the Department for Transport (DfT) to undertake the appraisal of highway schemes and multi-modal transport studies.

9.7.3 To operate effectively with TUBA requires:

- Appropriate network definition and zonal detail
- Close calibration
- Stable model results and
- Appropriate forecast mechanisms.

9.7.4 This model specification is intended to fulfil these requirements

9.7.5 This commission does not cover the development of an economic evaluation module, although the **GLTM2** as specified in this document will provide highway and public transport assignment model files – including assigned networks, demand matrices and cost files – which will provide the necessary data for a downstream user to set up and implement the appraisal assessments for the NHRR FBC.

9.7.6 The potential appraisal requirements for NHRR FBC may include the following aspects, the requirements for which would be developed in more detail in an updated Appraisal Specification Report (ASR) for the FBC stage.

- Level 1 benefits:
  - Transport user benefits – calculated in TUBA using modelled demand and cost skims;
  - Accident benefits – calculated in COBA-LT using modelled flows;
  - Greenhouse gases – calculated using model flows; and
  - Environmental assessment – calculated using model flows.

- Level 2 benefits:
  - Reliability benefits – calculated using model travel demand and cost skims;
  - Wider impact been – calculated in WITA using modelled demand and cost skims; and
  - Distributional impacts – calculated using various modelled outputs.
- Level 3 benefits:
  - Wider impacts with change in land-use – calculated for dependent development including the transport network impacts using modelled outputs.

9.8 ENVIRONMENTAL APPLICATION

9.8.1 The model may be required to provide inputs to environmental assessments, namely air quality and noise. These elements can be covered by virtue of the modelled traffic mix, flow, speed, and daily traffic profile data.

9.9 EXAMPLE TEST

9.9.1 As referenced earlier in this chapter, the forecast model will be developed to cover up to three forecast years and will be run to produce the Core scenario with a Do Minimum ("without-scheme") forecast and a Do Something ("with-NHRR") forecast.

9.9.2 This can form the basis for further testing on behalf of LCC, including the forecasting for the NHRR FBC as required.

9.9.3 As per Section 9.5, the inputs will be developed for the other DfT CAS to future-proof the model set up for the likely downstream requirements, but the CAS will not be run at this stage. The requirements for scenario testing with the CAS would need to be confirmed in an updated ASR for the NHRR FBC.

Appendix A

ANPR DATA FOR MND VERIFICATION

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