Greater Lincoln Multi-Modal Model

Model Specification Report

Lincolnshire
COUNTY COUNCIL
HIGHWAYS ALLIANCE

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Lincolnshire COUNTY COUNCIL HIGHWAYS ALLIANCE

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1 Introduction

1.1 Greater Lincoln Transport Model

The current Greater Lincoln Traffic Model (GLTM), owned by Lincolnshire County Council (LCC), was first developed in 2006. Whilst some updating, refinement and revalidation has been undertaken over the subsequent years, much of the base data remains as that collected for the original 2006 model. Travel demand data exceeding six years of age is considered to be unreliable in the context of model development or application. A more thoroughly updated GL3M (to be referred to as the Greater Lincoln Multi-Modal Model) is needed to facilitate the analysis of new projects being developed by Lincolnshire County Council and its partners.

1.2 Purpose of this Report

Based on the commonly understood position the current model is life expired and a replacement is needed, Lincolnshire has commissioned Mouchel to delivery of a new model. This report provides the specification against which new model is to be developed.

The content of this report includes:

- Proposed uses of the model;
- Model data specification;
- Highway network development methods;
- Travel demand development methods;
- Calibration and validation methods;
- Public transport modelling methods;
- Variable demand model methods; and
- Forecasting methods

The starting point for this document has been the Scoping Report which presented the outcome of the scoping study into the development of the new model. This report has evolved during the early stages of the model development process and is a live document which may be updated further during the remaining stages of the project.

2 Model Scope and Extent

2.1 Model Objectives

Transport modelling is not usually an objective in itself. It is required as a tool to support the delivery of particular objectives beyond modelling. These are necessarily related to ongoing high-level LCC Local Plan objectives[1] covering:

- Supporting growth and the local economy,
- Improving access to employment, training and key services, and
- Contributing to a healthier community

At a more detailed level we suggest that the following objectives related to the "five cases" implicit in all current Government Business Case appraisal could also be applied to the development of a model itself.

- To provide a model which permits strategic evaluation of changes, in particular to:
    - support the work of Lincolnshire County Council (LCC) in managing the existing transport network; and
    - to support the work of Lincolnshire County Council in developing the future transport network.
- To provide a model which can quantify value for money. The model evaluation process should inform on the following sub-areas:
    - economic;
    - social; and,
    - environmental
- To ensure the model development process is commercially viable (procurement route)
- To ensure the model development process is financially viable (budgetary)

[1] http://uk.sitestat.com/lincolnshire/lincolnshire/s?Home.transport-and-roads.strategy-policy-and-licences.local-transport-plan.Download.102928&ns_type=pdf&ns_url=https://www.lincolnshire.gov.uk//Download/102928

- To ensure the model development process is manageable (management of risks and benefit realisation)

With these background objectives, the purposes for, and necessary content of, the model can subsequently be addressed.

2.2 Model Uses

A workshop took place between representatives of Mouchel and LCC officers on 8th June, 2016 to discuss specific schemes, policies and land use development, the assessment and appraisal of which a new model may be required in the coming years. A list of potential uses emerged from this workshop:

- Model Use A: Core Requirement - Development Management

  Lincoln is facing pressure for expansion based on the targets of the emerging local plan and speculative developer interest. Optimal traffic and transport engineering designs improve the efficiency and accessibility of new development and appropriate mitigation can be essential in securing planning approval. It is likely that the model will be used to appraise the impact of developments. The model will need to be capable of representing transport solutions to meet the needs of all cars, service vehicles, public transport, pedestrians and cyclists. Specific functionalities would include estimating trip generation of new developments, junction analysis and design, parking and pick-up/drop-off designs, internal circulation layout, signing strategies and temporary traffic management advice.

- Model Use B: Core Requirement - Strategic Business Case Evaluation

  This represents the most pressing requirement for model availability. The pressure to develop North Hykeham Relief Road (NHRR – former Lincoln Southern Bypass) is likely to increase in prominence during and following the construction of Lincoln Eastern Bypass (LEB). Indeed, the development of an Outline Business Case is likely to be one of the first applications of the model.

- Model Use C: High Level Policy Evaluation

  Policy evaluations in the case of 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). Two prominent areas of consideration include parking policies and Park & Ride (P&R), possibly separately but most likely in combination. Both policies straddle the area between assignment related issues (highway route choice) and demand related issues (impacting the propensity to travel). For this reason they would need special consideration within a model. Neither of these responses are contained within the existing GL3M model.

- Model Use D: Tactical measures (traffic management and localised responses)

  In its role as the local Highway Authority, Lincolnshire County Council will be required to address traffic impacts of day to day network management issues. These include issues as diverse as air quality impacts, 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

The model uses have been used to inform the specification, which also gives consideration to guidance and the model parameters set out below:

- WebTAG compatible:
  - Model structure;
  - Level of detail required to support evaluations anticipated;
  - Compliance to specified approach to model building; and
  - Demonstrate fitness for purpose.
- Capable of assessing appropriate demand responses including:
  - Trip frequency;
  - Trip distribution;
  - Mode choice;
  - P&R diversion; and
  - Parking supply and restraint.
- Modelled area across the Lincoln Policy Area:
  - Network detail focussed on the urbanised area;
  - Zonal detail expanded to cover those areas identified for future development.
  - Network sufficiently detailed to cover potential alternative routes in the vicinity of the proposed NHRR.
- Model Parameters

  - Time periods;
  - Segmentation and user classes;
- Detailed network representation:
  - To provide a representative distribution of traffic flows.
  - To show representative flows and delays in the base year.
  - To permit abstraction of data for subsequent micro-level capacity analysis.

Detailed consideration of these aspects is set out later in the report.

2.4 Modelled Area

TAG Unit M3.1 advises that 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.

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

- the fully modelled area over which interventions are expected to impact. In this area full trip movements will be included and the network will be simulated; and
- 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.

The extent of the fully modelled area will be informed by existing plans for interventions including the NHRR and large scale development sites (Sustainable Urban Extensions - SUEs).

The model will require the following functionality:

- Detailed representation highway network within Lincoln and North Kesteven (Lincoln Urban Area)
- Detailed modelling of route choice options in the Hykeham area.

Traffic simulation will therefore cover key junctions providing realistic capacity, queue and delay, including potential for blocking back where flows exceed storage capacity of downstream links.

2.5 Modelled Output

Users of the model will be able to obtain the following information

- Flow data
  - AM Peak, Inter Peak, PM Peak traffic flows
  - Actual flows, demand flows, queued flows
  - Flows by user class (Business, Commuting, Other, Light Goods Vehicles, Heavy Goods Vehicles
- Public Transport Data
  - Passenger flows by link by AM, Inter Peak PM modelled period
  - Boardings, alightings and vehicle level of service by route
  - Overall PT boardings and number of interchanges between modes
  - Revenue by route and mode
- P&R volumes by future year
  - Catchment areas of P&R, including choice of P&R where appropriate
  - Flow volumes by P&R
- Mode share data
  - Motorised versus slow mode trips;
  - Highway, PT mode share. Sub-mode share by rail, bus and P&R
- Detailed data analysis
  - Turn volumes and delays
  - Selected link analyses
  - Traversal matrices (routing through complex junctions)

    - Daily vehicle volumes and composition for environmental and economic analysis
    - Network level of service analysis
- Parking data
    - Parking supply and demand by time period
    - Redistribution response resultant from parking cost and capacity changes
    - Parking revenue by type of parking
    - Excess walk distance for redistributed parking
- Demand data
    - Pre and post Variable Demand by period
    - Sectored summary demands by area.
- Skim data
    - Travel times and distances by highway mode
    - Walk, wait, in-vehicle times, transfer times, fare cost by public transport mode.

This is not an exhaustive list and is focussed on the most commonly anticipated information required from a transport model.

2.6 Software Choice

SATURN (Simulation and Assignment of Traffic to Urban Road Network) was chosen as the preferred software for the highway model.

SATURN is a suite of flexible network analysis programs developed at the Institute for Transport Studies, University of Leeds and distributed by Atkins Limited 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.

In combination with speed flow or fixed speed networks it can extend its capability to regional or national modelling.

As such it is a perfect tool for the needs of the Lincoln Model. It is also compatible with the requirements set out in WebTAG[2].

CUBE Voyager will be employed for the demand model. CUBE is a family of software products that form a complete travel forecasting system providing exceptional, easy to use, capabilities for the comprehensive planning of transportation systems. Cube is comprised of Cube Base and add-on libraries of planning functions.

The demand model will ensure that travel demand is balanced with network supply in a manner which is consistent with DfT recommendation.

The remainder of this report will cover the development of the highway model and the demand model specification.

[2] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/427124/webtag-tag-unit-m3-1-highway-assignment-modelling.pdf

3 Model Data Specification

3.1 Introduction

This section outlines data required in the development of Greater Lincoln Model. An interim integrated road network has been obtained which defines a basic network structure and a provisional mobile phone origin destination (MPOD) demand dataset which can be supplied by Citilogik / Vodafone.

This supply of these data focusses on Lincoln, but is supplied to cover Lincolnshire and neighbouring counties. This chapter therefore focuses on data that is required to complete the base year model build, and calibrating and validating the model. Where available, existing data sources will be used, which should minimise the data collection required and allow the model build to progress in line with programme.

Data will be required for the following model development tasks:

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

The chapter has been prepared in line with guidance contained in *TAG Unit M1.2: Data Sources and Surveys*.

3.2 Model Time Periods

Which time periods need to be modelled is a key decision related to data collection and processing.

It is proposed that the model uses a typical morning and evening peak hour together with an average inter-peak hour. This approach is preferred because it is felt a defined peak hour best reflects the traffic conditions encountered on an urban congested network. In the less congested IP hour then an average adequately reflects the traffic flow over a longer period. The actual time periods will be defined by survey analysis and will represent a balance of different traffic profiles across the whole study area.

Further to this, a base month is to 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 break; and
- all of November – provided adequate lighting is available.

3.3 Existing data sources

3.3.1 Network database

An Integrated Transport Network (ITN) will be used to provide a buffer network for the model. An ITN will be provided in a form of:

- A node;
- B node;
- Link length; and
- Road class category.

The network coding team will need to obtain other information such as speed limits, number of lanes, road hierarchy including single/dual carriageway standards, etc. to be able to provide the following:

- Link speed/flow curve;
- Coding of the simulation network; and
- Junction coding (i.e. junction type, junction layout) to determine appropriate saturation flows.
- There is no single data source which can provide this information, although national models have made use of STATS19 accident record data to provide speed limits. Other attributes will be coded manually using information such as mapping and satellite images.

3.3.2 Traffic Signal Data

Traffic signal data will be sourced from Lincolnshire County Council. For junctions along the principal road network networks, junctions will be coded in detail against the junction layouts/signal timings. Signal timing/phasing for these areas is being sourced from Highways England. TechMACs or from Local Authorities. Low reliance will be placed on existing model information.

3.4 Traffic Count Data

The model covers a wide area including the City of Lincoln, North Kesteven and West Lindsey districts. Lincolnshire is the Highway Authority for these areas and traffic data has been made available from this source.

Where data is required, high quality data is needed. Quality is determined by age of count, duration of count and method of count. If this is not available then it will be necessary to collect additional data.

In the former cases a classified ATC undertaken for at least a two week period in a neutral month will be sought. If only manual counts have been conducted or if the automatic count took place over a shorter period than two weeks then a decision will need to be made on whether these data can be used.

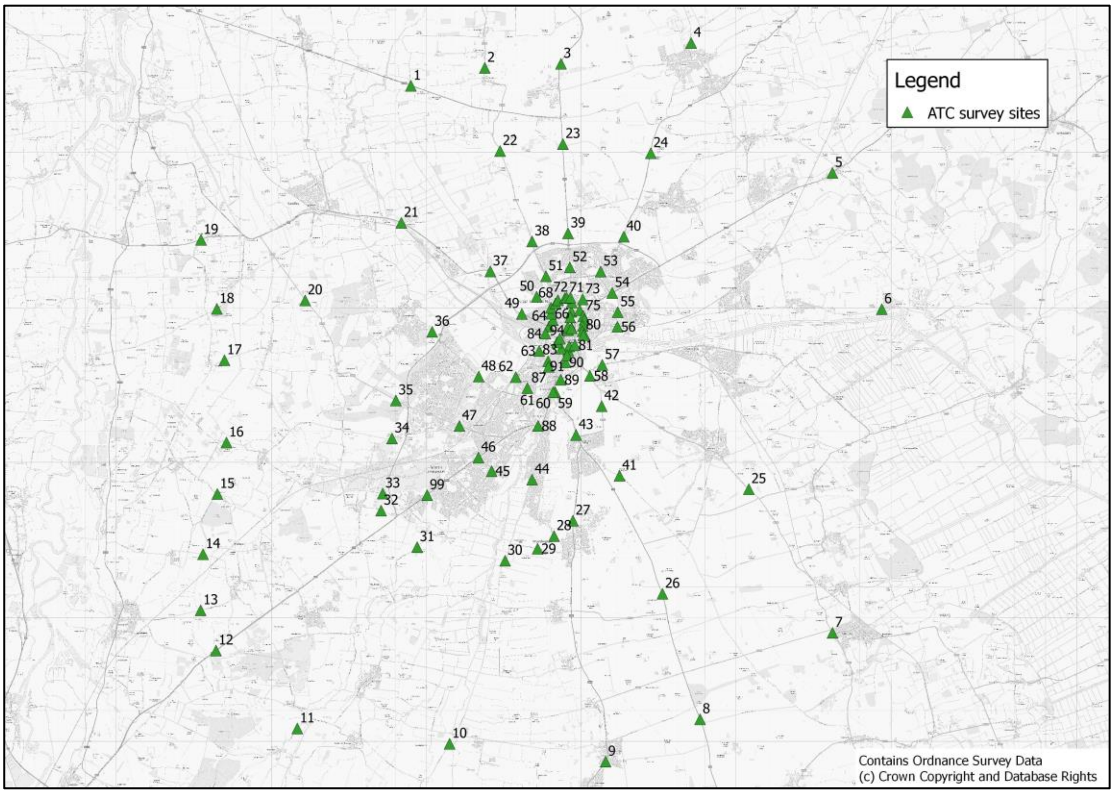
Observed count data will be collated for the areas where traffic movements need to be appropriately represented. Traffic counts are used for the following process:

- Counts used for Matrix Estimation and model calibration
- Counts used for Validation at screenline/cordons;
- Link counts used for independent validation; and/or
- Turning counts used for key junctions likely to be impacted by strategic schemes associated with the highway network.

Data which is already available and of a suitable quality has already been mapped and the most efficient method to obtain an appropriate level of count coverage from a data collection programme have been established. For the majority of locations, link data is required. Collection of these data is relatively efficient via Automatic Traffic Counter (ATC) loops. The identified count sites are included in

Figure 3-1.

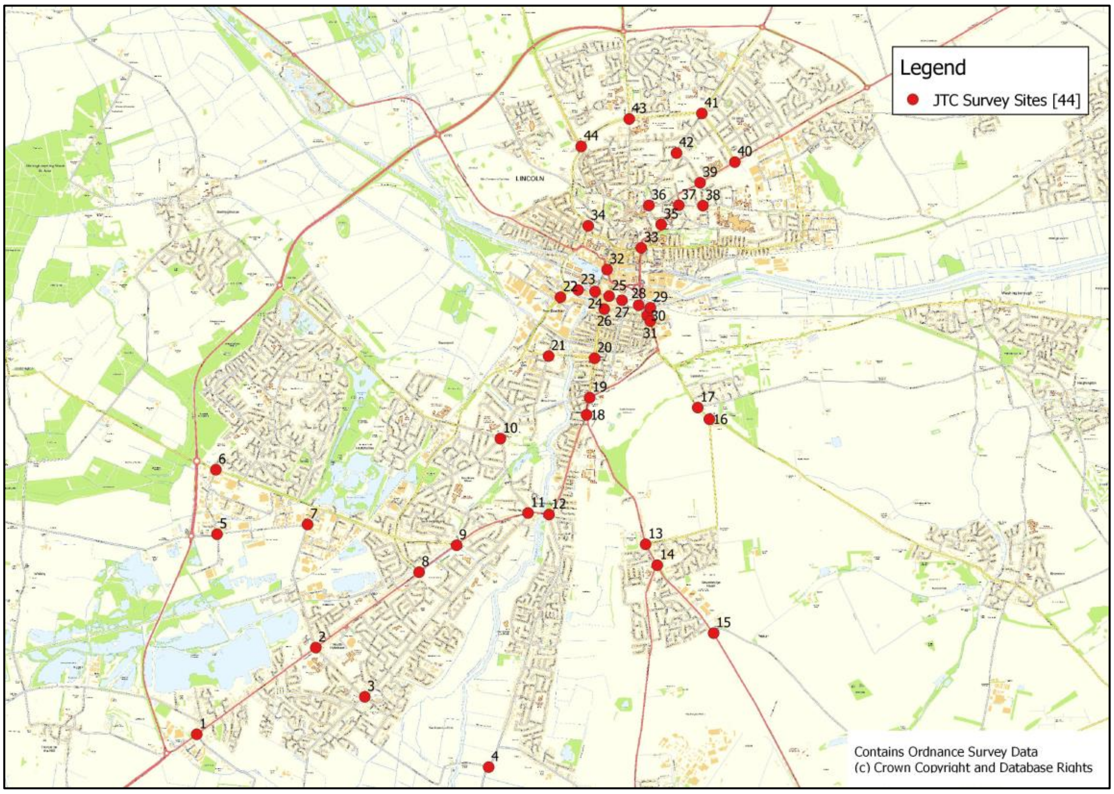
Figure 3-1 – Additional Automatic Traffic Count Locations



In addition to these data specific junctions warrant a closer level of detail including consideration of turning movements. A similar exercise identified the suitable existing data of this nature. The remaining junction turn count sites required for collection are included in

Figure 3-2.

Figure 3-2 – Additional Junction Turn Count Locations



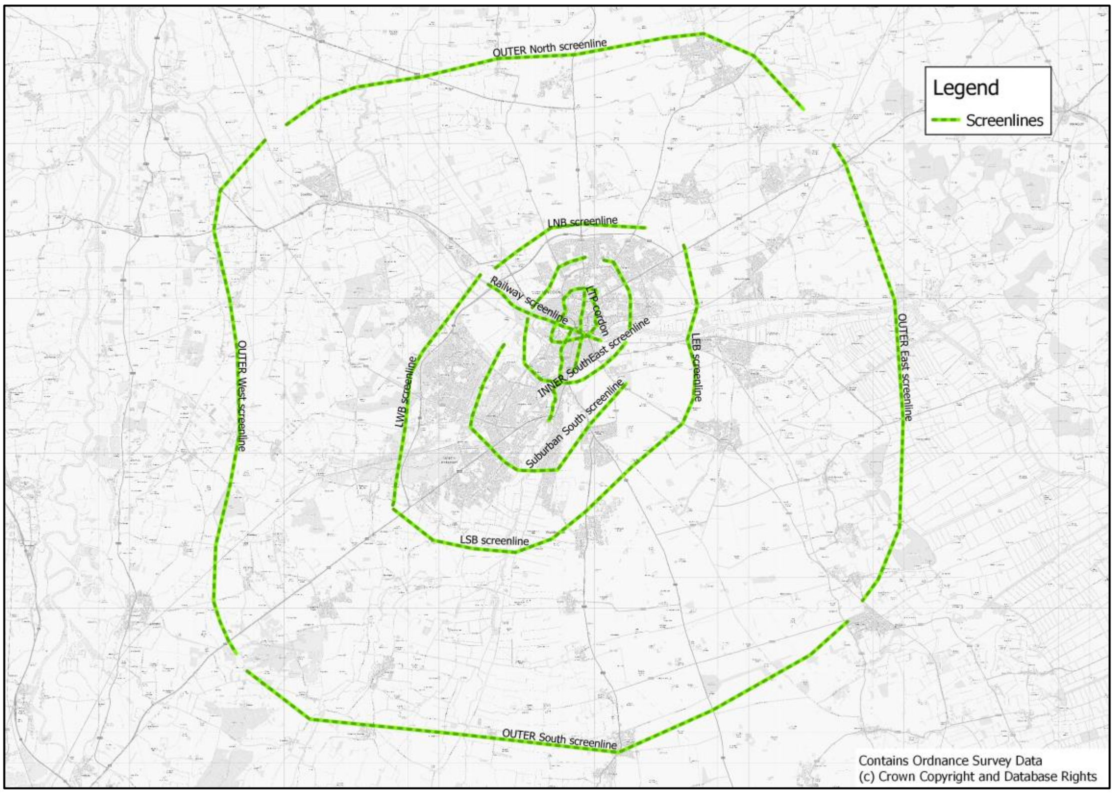
Given the scope of data availability the proposed model screenlines are indicated in Figure 3-3.

Screenlines are designed,

- to separate traffic flows between distinct areas,
- to enable a control mechanism for matrix development; and
- to provide independent model validation data against which model performance can be measured.

The wide area screenline coverage will permit the best possible highway model calibration and validation to be conducted.

Figure 3-3 – Proposed Screenline Definitions



Mindful of the multi modal nature of the model, data on Public Transport flow patterns is also required. Lincoln is predominantly a bus based public transport network with a limited rail catchment within the immediate environs of the city.

Therefore greater effort is involved in reflecting bus passenger movements.

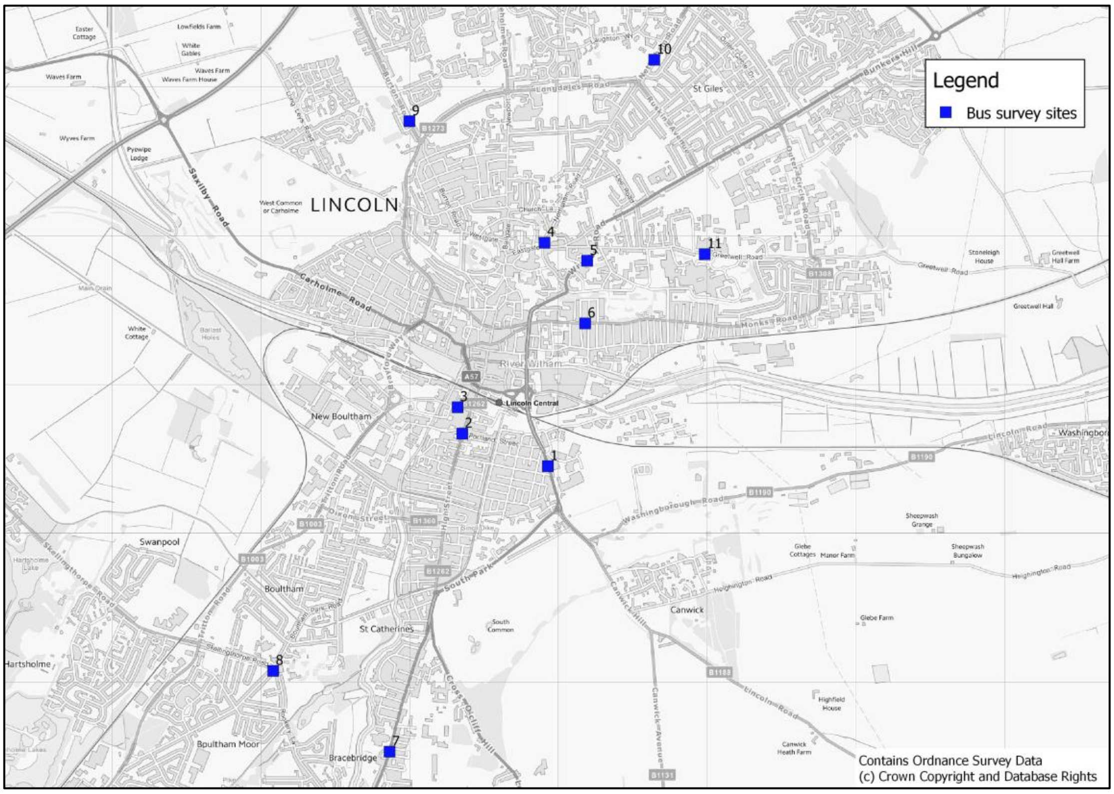
A series of bus passenger count sites has been developed on the most heavily trafficked public transport radial corridors. Roadside passenger counts, both by manual and video survey, have been conducted. Locations are indicated in

Figure 3-4.

This information will be blended with data sought from Stagecoach, the major operator, including information on bus station volumes and electronic ticket machine data.

Rail data will be sourced from peak profiling associated with station count volumes in and out of Lincoln Central. This profile will be applied to rail patronage volumes reported at stations within the modelled area.

Figure 3-4 – Bus Passenger Count Locations



3.5 Journey Time Data for Model Calibration and Validation

A full Trafficmaster dataset will be made available covering the whole of the Greater Lincoln area for the base model month. At an early stage of the model development a number of journey time routes will be defined to validate modelled journey times through the network.

These routes will be in line with guidance contained in *TAG Unit M1.2:*

- The validation routes should be neither excessively long (greater than 15 km) nor excessively short (less than 3 km).
- Routes should not take longer to travel than the modelled time periods (although, a few minutes longer is unlikely to be problematic).
- Start times should be staggered, particularly if runs are undertaken on the same day.
- For models of actual peak hours, journey time routes ought to be no longer than about 40 minutes to allow some staggering of start times.

The exact number of routes and coverage will be defined as part of the calibration although it is assumed routes will cover:

- Key arterial routes within Lincoln urban area. It will be important to accurately reflect congestion in urban areas to avoid the potential problem of 'rat-running'.
- Sections of the Strategic Road Network (Western bypass) - particularly sections known to experience congestion.
- Other key routes that future schemes may relieve (LEB, NHRR).
- It is acknowledged that journey time is an important factor on trip making in the area, perhaps more so than journey distance and therefore the model will reflect full WebTAG compliance in both flow and journey time validation.

Trafficmaster data is made up of records for individual links based on the Ordnance Survey (OS) Integrated Transport Network (ITN). This includes information on the size of the sample each journey time was calculated from and the vehicle type. An agreement will need to be reached at the programme level on what is an acceptable sample size of Trafficmaster records to give an 'average' reflection of journey time.

It has been assumed that a correspondence between OS ITN links and SATURN links will be provided as part of the conversion of the network structure from an ITN layer to a SATURN network file. This will significantly reduce the amount of manual processing required in the conversion of Trafficmaster Journey Time data to a format which is usable for the purpose of the model validation.

3.6 Other Data Sources

3.6.1 TEMPro Data

The DfT Trip End Model Presentation Program (TEMPro) will be used to define population and employment control totals at the appropriate level of aggregation, together with growth projections and trip purpose splits. The latest version TEMPRO 7.2 will be used

3.6.2 Census Data

A variety of datasets from the UK Census 2011 can be used as part of the matrix development stage of work. This may include:

- Population by Age (Table KS101);
- Household composition by car/van availability (Table KS105);
- Census Journey to Work, and;
- Employment by Industry Type (Table WP605).
- National Travel Survey

The National Travel Survey (NTS) contains travel diary information for journeys made from a sample of UK households. It provides a rich data source and allows trip making characteristics across the country to be understood. For this model, NTS will provide the following information for use as part of the matrix development work:

- Mode shares;
- Trip length distributions;
- Purpose splits, and;
- Time period splits.
- GIS Data

A large amount of GIS data is now available under the Ordnance Survey's (OS) OpenData programme. This can be used freely providing the OS copyright is acknowledged. In addition to OpenData the following OS datasets will be requested from the License holder:

- OS MasterMapTM Topography Layer;
- OS MasterMapTM ITN RRI;
- OS AddressBase Plus;
- 1:10,000 Colour Raster;
- 1:10,000 B&W Raster;
- 1:25,000 Raster;
- OS VectorMap Local Raster;
- OS VectorMap Local Vector;
- 1:50,000 Raster;

These data will be used in the network build, for reporting purposes and spatial analysis.

3.6.3 Public Transport Data

Based on the initial public transport model specification, the following key data may be required:

- Schedule information available from bus operators, national rail databases (e.g. Association of Train Operating Companies (ATOC), Common Interchange Format (CIF) or timetable data) including rolling stock information where possible (for capacity figures).

- Electronic Ticket Machine (ETM) data.

- Derived fares from ATOC data or LENNON (Latest Earnings Network Nationally Over Night) \MOIRA (Model of Inter Regional Activity) station to station data, which includes the majority of ticket types.

- Observed passenger flow data from LENNON\MOIRA station to station data and other available sources such as NRTS (National Rail Travel Survey), existing models.

The list represents the most desirable availability although the project can progress with less data.

3.6.4 *Parking Data*

Data on parking capacity, utilisation and cost will be collated for the Central areas of Lincoln for application within a Parking Model

3.7 Data Checking and Normalisation

3.7.1 *Data checking*

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

  - 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.

For 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.

- Adjusting count data – Data Consistency

It is highly likely that some count data may only be available for non-neutral months. If this is the case, the following factors will need to be generated to 'convert' available counts to the modelled month and year:

- Annual factors to convert counts undertaken in years other than 2016 to the 2016 base year; and
- Month to month factors to convert counts undertaken in non-neutral months to the designated base month.

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 such as the Lincoln Christmas Markets.

3.8 Forecast Data

Forecast model data will be required in the later stages of the model development and will include:

- Information on developments sourced from Lincolnshire and other local authorities – type, scale, floor area etc;
- Updated TEMPRO information;
- Future year model parameters including operating costs and growth in value of time; and,
- Detailed coding sufficient to represent the Do Minimum scenario within the model.

4 Network and Zoning Specification

4.1 Overview

A network for the Lincoln model is being generated to cover the requirements of the project.

4.2 Specifics

Network checking will be undertaken on the following:

- Check link lengths as provided from the ITN2SATURN process against crow-fly distance;
- Check travel distance between different origin destination (OD) pair (selective number of OD pair);
- Check speed limit on network.

In addition, to information provided from the ITN layer, the followings will need to be obtained from site visits and mapping data during the network development process:

- Road type (Single or Dual carriageway);
- Speed limit; and
- Number of lanes.

This information will allow for the process of junction coding and determination of the appropriate speed-flow curves to be applied for the network.

Junction modelling will be developed in a detailed level, which includes junction form, operation, gap acceptance criteria, and fixed time signal setting. Default values will initially be used however model calibration will refine these values to reflect those associated with local traffic characteristics.

4.3 Request Zoning System

The Lincoln request zoning system is based on the LSOA/ MSOA (Lower/ Middle Layer Super Output Area) boundary layer as this is the level of spatial granularity that will be supplied in the travel demand data to be provided. The spatial granularity reflects the magnitude of population within the local areas.

This forms a key principle of zoning whereby denser travel demands determine a greater need for granularity. The approach is generally to default to LSOA's in urban areas (Figure 4-1) and to default to MSOA's in rural areas (

Figure 4-2). The Mobile Network Operator is able to support this level of disaggregation in the analysis that they would undertake.

Figure 4-1 – LSOA Definitions - Lincolnshire

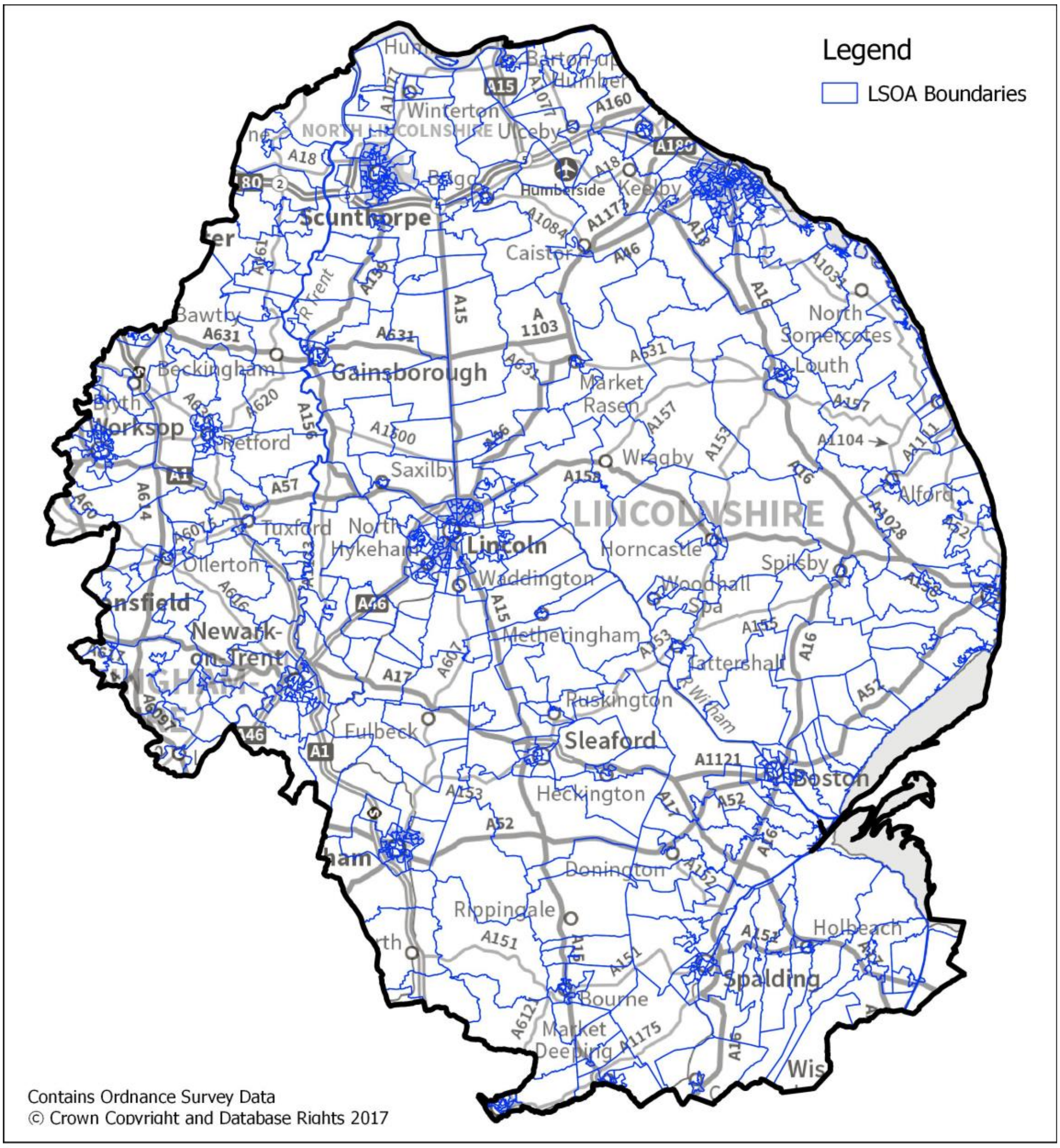
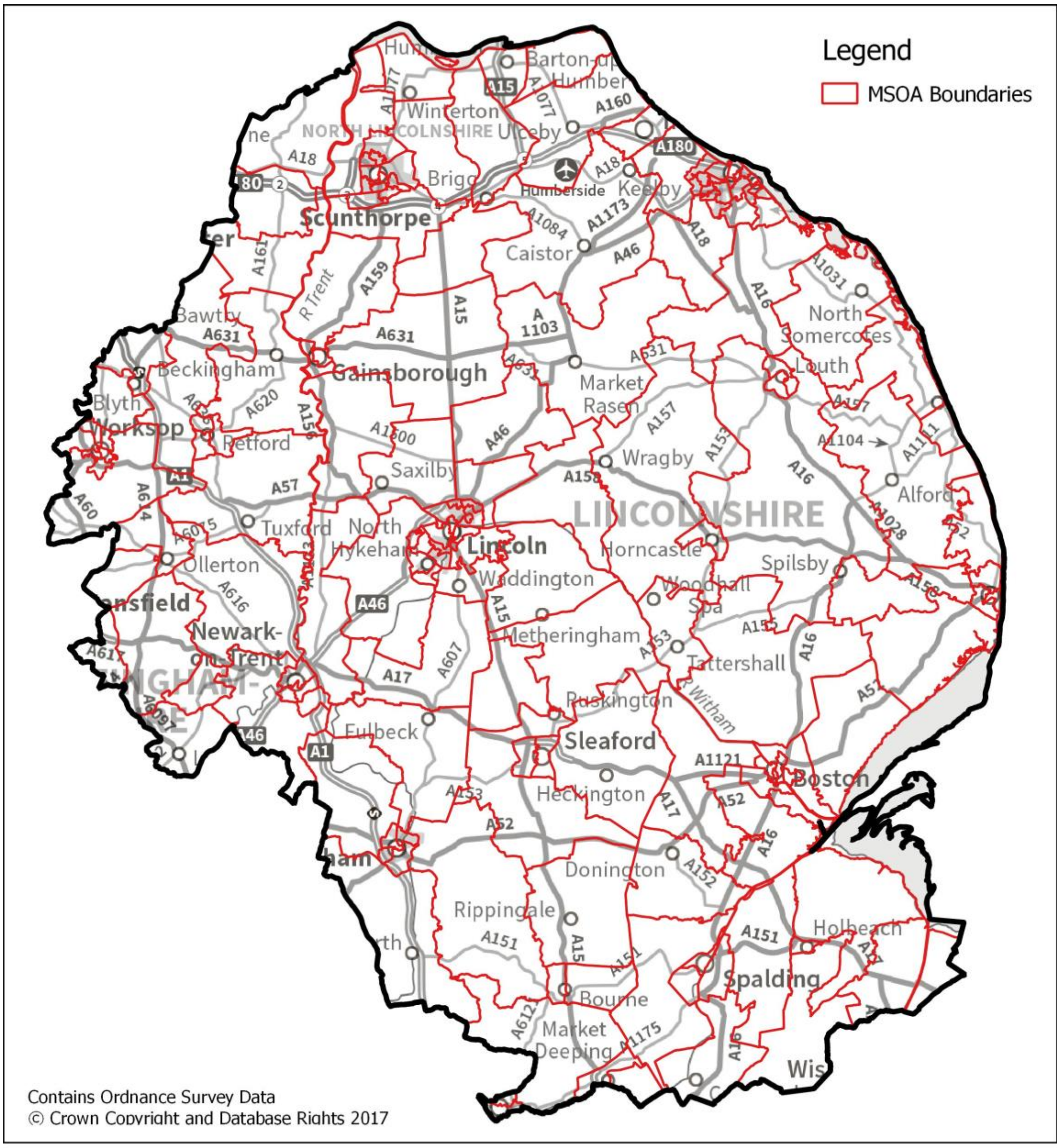


Figure 4-2 – MSOA Definitions - Lincolnshire



The zoning represents the detail of the information that is needed. Further disaggregation of these data will be undertaken to provide an assignment model zone system. This aspect is covered in a subsequent chapter.

Outside of the Full Modelled Area (FMA) the zone system will become progressively coarser with areas being represented by Local Authority, County or region boundaries.

4.4 Links

Links are coded by direction and the following characteristics are included:

- Number of lanes;

- Link capacity (Passenger Car Unit (PCU) per hour);
- Maximum free-flow speed in kilometres per hour; and
- Classes of vehicles permitted to traverse the link (e.g. Car, HGV, pedestrian, bus only)

Link capacity is assigned based on a number of factors including road class, number of lanes, type of road - single or dual carriageway, street characteristics and availability of on-street parking. These factors and the speed limit permitted on each link are then used to determine the appropriate maximum free-flow speed.

Tools available within SATURN programme, such as Tree Path Build, will be used to check the logic of the network. As links are derived from an ITN network, link length parameters will be checked against crow-fly distance as calculated by SATURN. The network may also require ‘shape’ nodes to be added to permit congruence with downstream applications such as GIS and environmental applications.

The initial network coverage is at Figures 4.3 and 4.4.

Figure 4-3 – Greater Lincoln Model – Local Area Network Coverage

Figure 4-4 – Greater Lincoln Model – Wider Area Simulation and Buffer Coverage

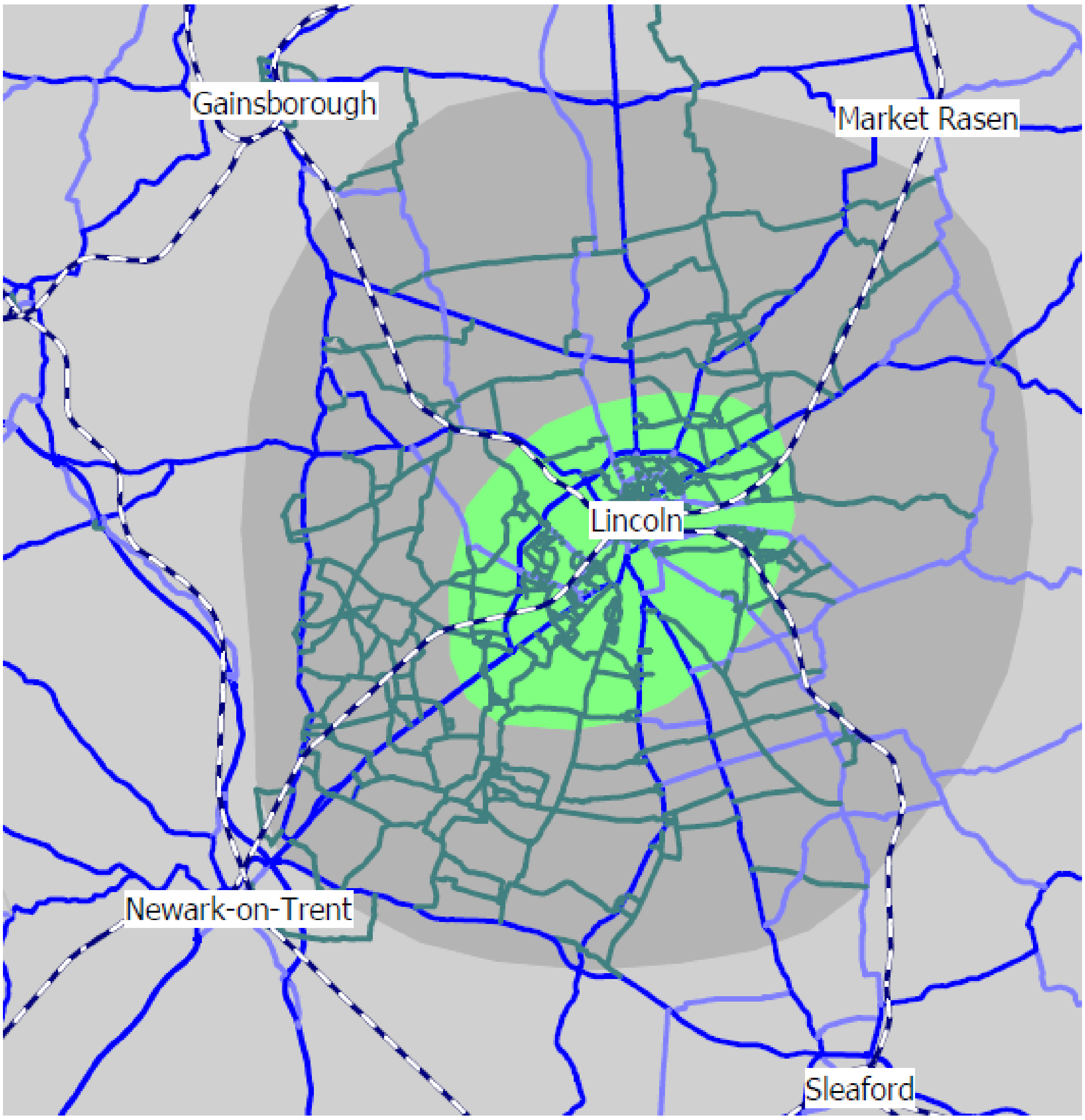
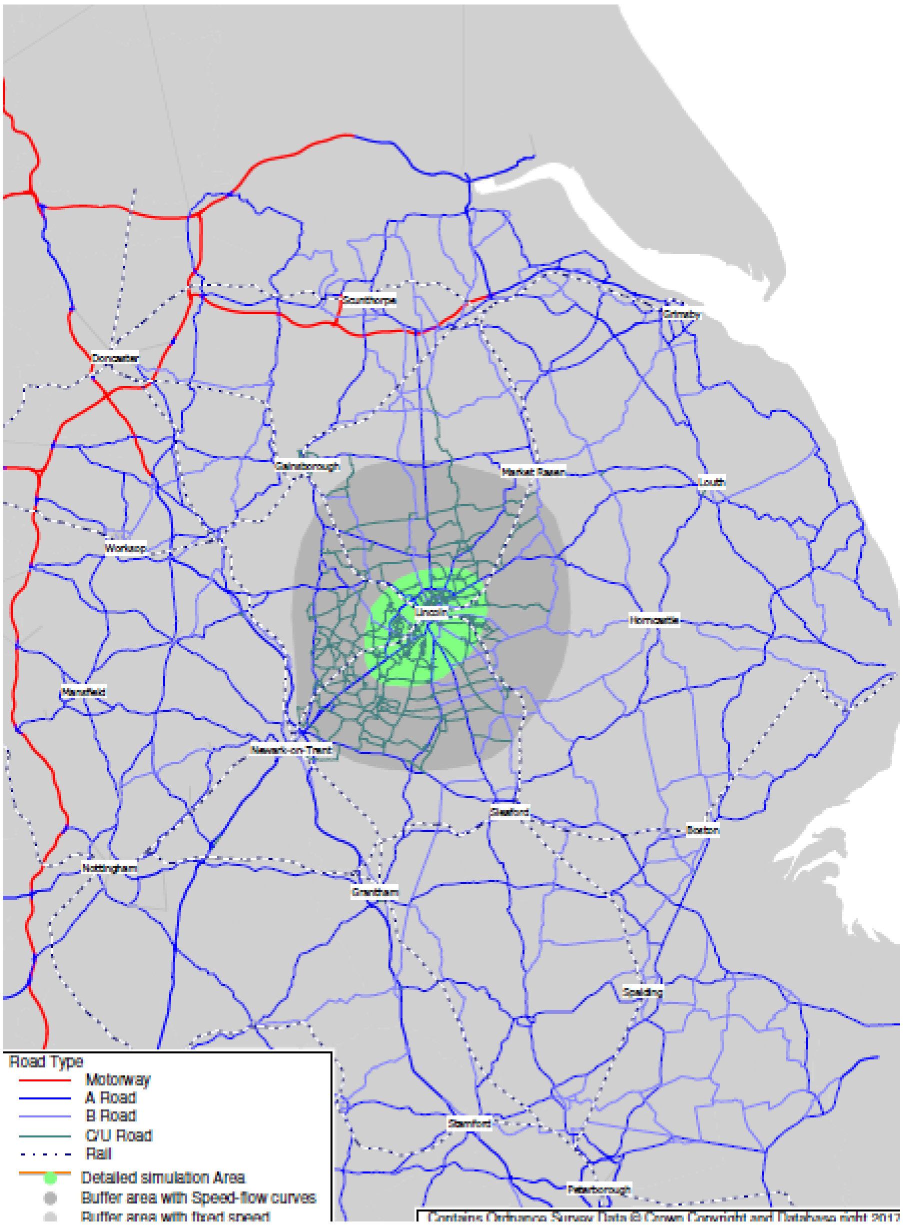
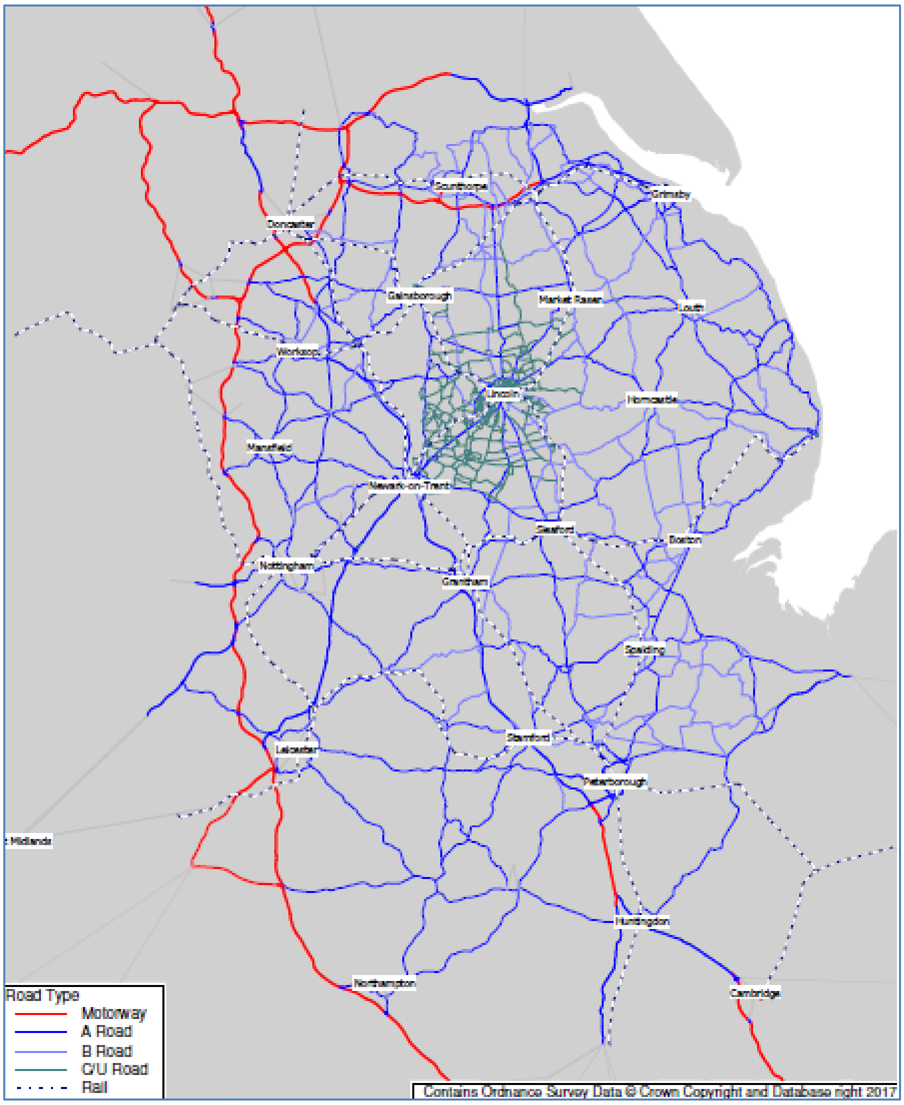


Figure 4-5 – Greater Lincoln Model – Regional Coverage





4.5 Junction Coding

Junctions are described by the following parameters:

- Junction type (traffic signal, roundabout, priority);
- Number of approach arms;
- Number and width of each approach, flare length and lane discipline;
- Permitted and prohibited turns by vehicle type; and
- Additional parameters according to junction type (e.g. saturation flows, signal timings and phasing, gap acceptance value).

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.

4.6 Signal Timings

Traffic signal timings and staging are required for coding signalised junctions. They are normally sourced on request from local authorities.

Signalised junctions include fixed time signal timings, vehicle actuated signal timings, and signal timings which are synchronised with adjacent junctions.

For vehicle actuated signal timings, average signal timing can be derived by averaging signal timings across all the cycles which fall in the modelled hour. For SCOOT or MOVA controlled signal timings, apart from deriving average signal timing across the modelled hour, off-set times are also required to reflect the synchronisation of signal timings across the SCOOT or MOVA networks. In this way the traffic impacts of a signal control policy can be included in the model and reflected at a strategic level.

Tidal flow characteristics associated with, for example, Canwick Road will also be included.

4.7 Zone Connectors

Trips from and to zones are loaded onto the network at zone centroid (centre of gravity of the zone) using specialised links known as centroid connectors.

Ideally, a zone should have only one connector. Outer areas may exceed this target. The model will therefore be examined to review whether any zone needs to be split or connectors adjusted in order to stabilise loading during assignment.

4.8 Treatment of Fixed Demand

Bus flows can contribute to significant percentage of traffic along the network and by excluding them from the model will likely underestimate delays and traffic volume on the network. Translation between the Highway and Public Transport (PT) models will be necessary. Demand responsive services (significant for rural flows to and from Lincoln) will need special consideration. Fixed routes will be included within SATURN. PT specific issues are considered later in the chapter.

4.9 Links: Speed/Flow Relationships

Speed-flow curves that are based on adjusted DfT COBA speed/flow relationships will be adopted and will be applied for all the links (Motorways, A-roads and B-roads) within the buffer area. Differential speeds will be implemented for Cars and HGV's. Within the simulation area, all the links of the local network and Strategic Road Network will also be applied appropriate speed-flow curves, this is to ensure that delays and speed on the network will be represented for calibration/validation purposes, and also for the forecasting stage, where the impact of increased demand on travel speed is appropriately modelled.

For links within urban areas where the length is less than 200m, the fixed speed and detailed junction coding will be used as for those links, and travel speeds can be determined by delays at junctions.

4.10 Fixed Speeds

Within the urban areas, links with a length of less than 200m, generally have travel speeds determined by delays at junctions. Fixed speeds will be applied throughout and detailed junction coding will be used to determine an appropriate level of delays within the network.

Fixed speeds will be derived from Trafficmaster Journey Time data separately for each modelled period.

However, it is not recommended to use fixed speed for all the links within the urban areas as this would result in a significant amount of time to derive an average cruise speed from Trafficmaster data, and also will potentially affect the travel costs of trips during calibration/validation and forecasting.

4.11 Generalised Cost Formulation and Parameter Values

Modelling of traffic re-routeing in SATURN is a function of “generalised costs”, which is a combination of time, distance and monetary charges (i.e. tolls) for each journey. The formula is as follows:

$$C = PPM \times T + PPK \times D + M$$

Where:

C – Generalised cost (pence)

T – Travel time (minutes) (including link travel time, junction delays and time penalty)

D – Travel distance (kilometres)

M – Monetary charge (pence)

PPK – Pence Per Kilometre

PPM – Pence Per Minute

Values of the PPM and PPK parameters will be derived from the latest WebTAG Databook (December, 2016) for the Base Year, 2016 and similarly for each future year scenario.

4.12 Public Transport Routes

As a variant of the highway model, a public transport model will be created. This will include representations of the following

- Bus stops;
- Rail stations;

- Bus routes;
- Rail routes;
- Walk access/egress routes; and
- Interchange links

These elements of the public transport model will be operated with a set of parameters focussed on route choice covering walk, wait, in vehicle and interchange preferences. The detail of much of this is still to be established and calibrated. However the public transport routes have been identified and are presented in the figures below.

Figure 4-6 – Greater Lincoln Model – Local Public Transport Routes

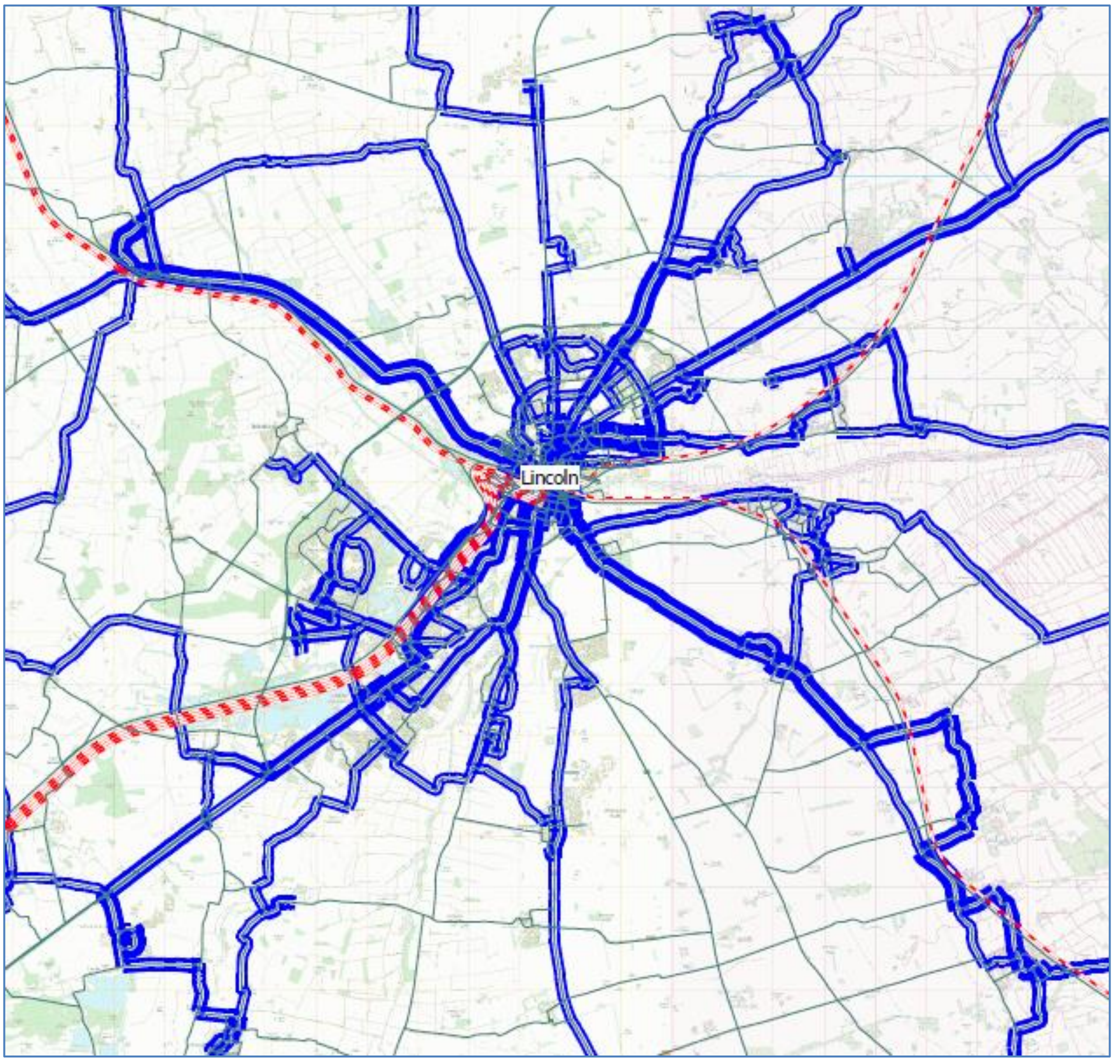
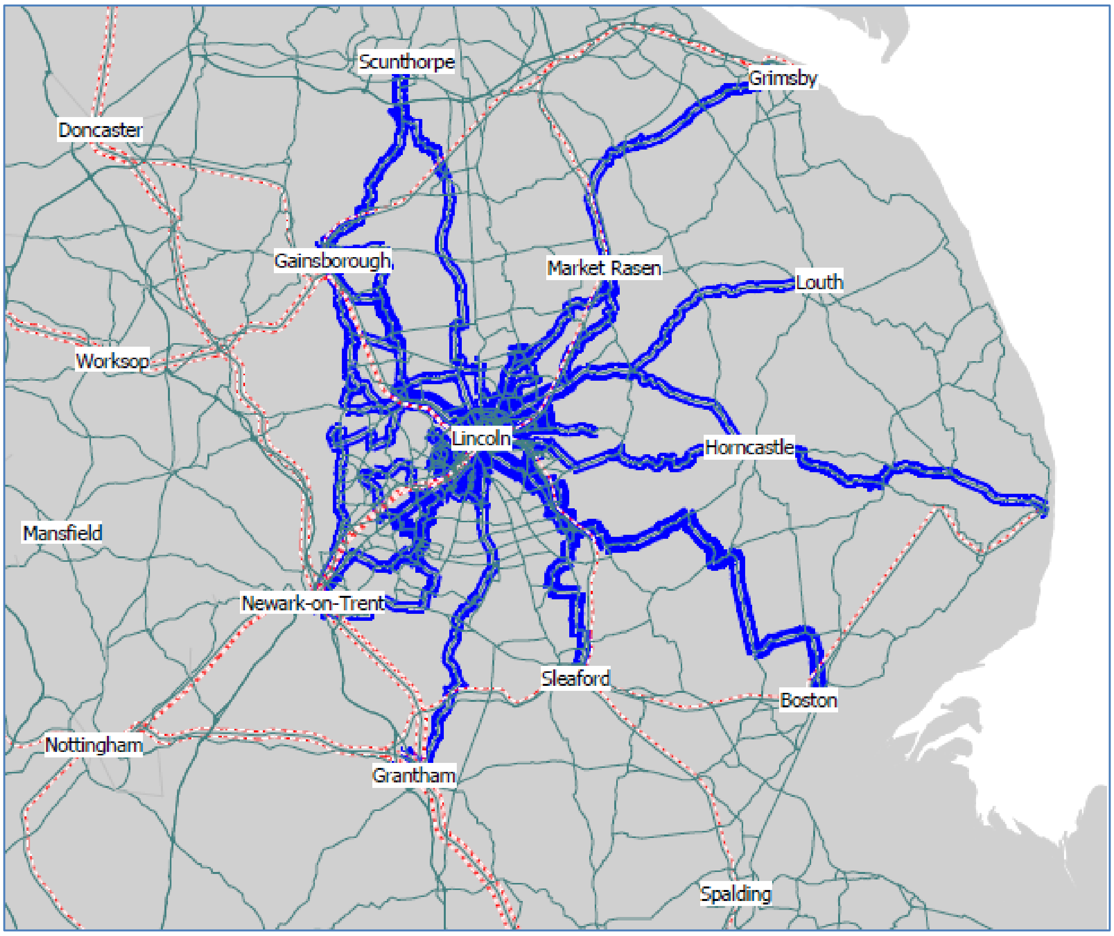


Figure 4-7 – Greater Lincoln Model – Regional Public Transport Routes



5 Travel Demand Processing

5.1 Introduction

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. In recent years transport modellers have developed an approach that makes use of the mobile phone network to generate movements (MPOD). Instead of monitoring the flow of vehicles in a transportation network, the flow of mobile phones in a cell-phone network is measured and correlated to traffic flow.

During the scoping study for the new Lincoln model this approach was agreed. This chapter sets out how mobile phone data will be processed into a form suitable for the assignment and demand models.

It is assumed that the data provided for this study will have been subjected to quality checks by the data supplier to ensure that it is fit for purpose. Additionally, in order for the model team to understand the datasets, it is expected that documentation on derivation and quality will be provided.

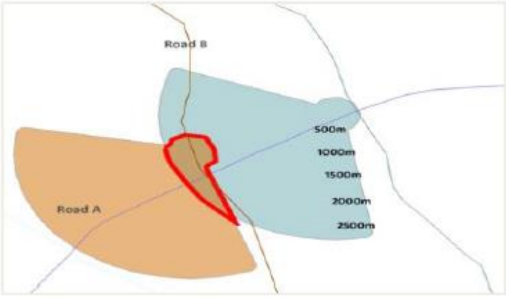
5.2 Principles of MPOD

Mobile phone positioning data are sporadically acquired by cellular carriers as a result 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). The data are anonymously collected through cellular networks by signals sent from phones to base stations, each of which corresponds to a 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. 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.

Mobile phone positioning data sets typically include the time each event occurred, the coordinates of the corresponding base tranceiver station (BTS) and cell dwell time (CDT), which refers to the duration a phone is associated with each BTS. CDT can be a useful measure of traffic congestion and can also be used to distinguish home and work locations for trip purpose imputation. Figure 5-1 demonstrates this principle.

Figure 5-1 – Examples of MPOD and Trajectory Tracking



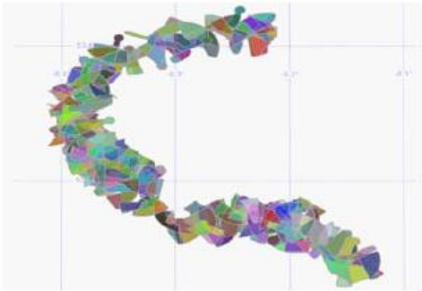


Figure 2: Simple example of footprint between two same direction cells

Figure 3: Handover footprints - Manchester Outer Ring Road (M60)

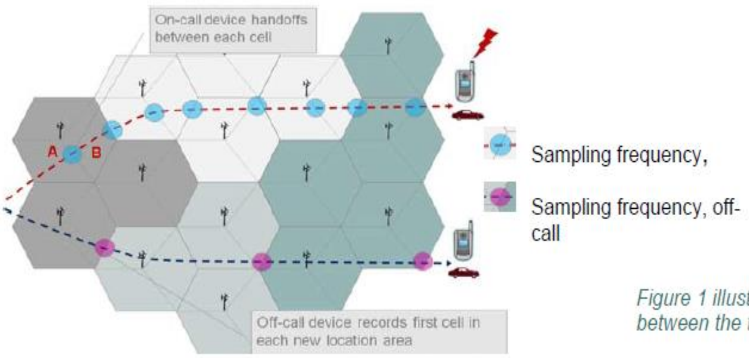
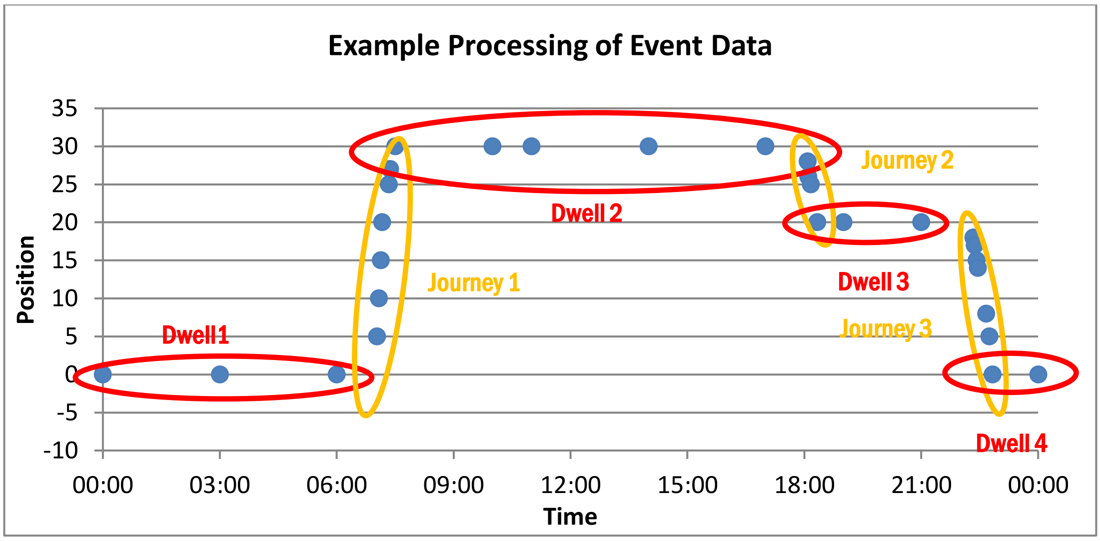


Figure 1 illustrates the differences between the two types of events:

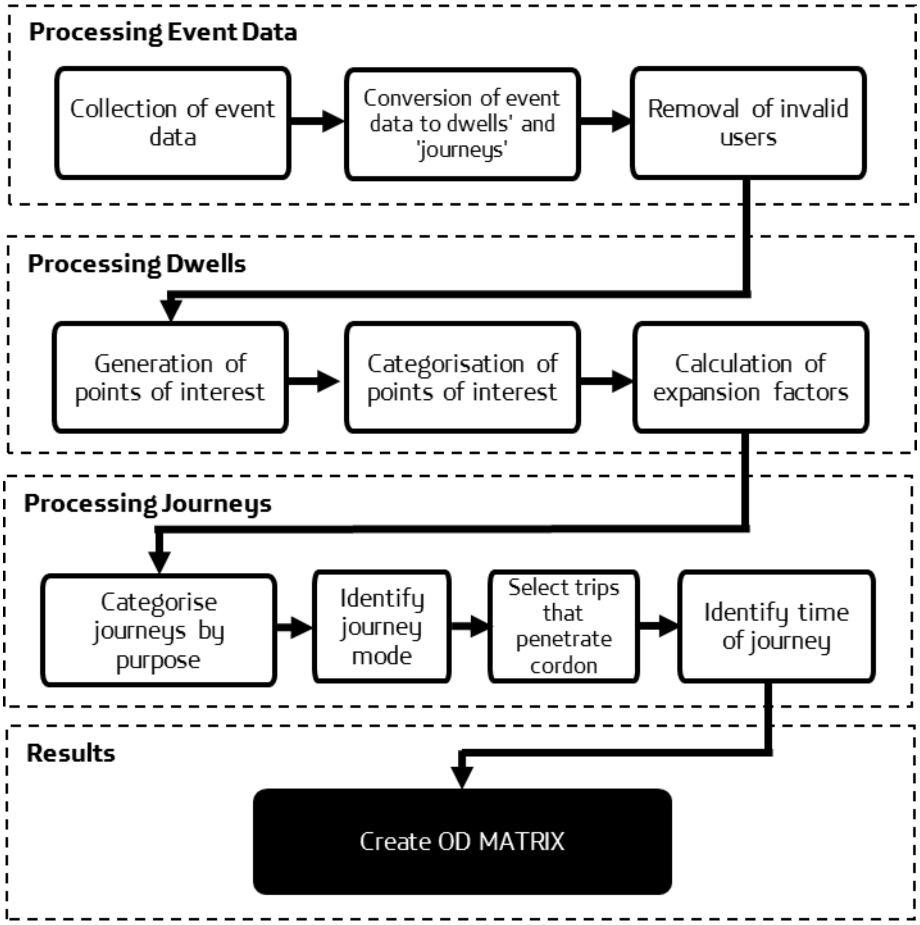
Event data translates through to a travel trajectory as indicated in Figure 5-2.

Figure 5-2 – Movement tracking by MPOD



The general principles of data analysis are indicated in Figure 5-3.

Figure 5-3 – General Principles of Data Analysis



The principles of the process require the 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. Specific segments such as education trips are difficult to establish since records of under 18's are not available. This must be infilled by other mechanisms.

5.3 Mobile Phone OD Data Sources

Several sources of this data exist for Lincolnshire. Three network providers are available, namely:

- Telefonica
- Vodafone
- EE

Nationally, each provider has roughly 30% share, with 10% to other sources.

Based on competitive tendering across companies Vodafone via Citilogik were selected as the data source. Citilogik offered a flexible approach to providing and understanding the data and were able to specify detail down to a Lower Super Output area level.

5.4 Mobile Phone OD Data Limitations

Some of the following limitations will be relevant to MPOD in Lincolnshire.

- Flow volumes below 15 events will be anonymised to respect privacy laws
- Mobile phone data may pick up all short distance trips which don't trigger handover events between cells. This is subject to cell size
- Mobile phone data miss children, Pay-As-You-Go and certain corporate users
- Biases may exist towards more active, higher income users
- Older persons are under-represented.

It is clear that MPOD data will need review, verification and potentially post processing to provide an appropriate basis for developing travel demand matrices.

In particular this will include,

- Adjustments to accurately incorporate shorter distance trips below the MPOD thresholds
- Adjustments to accurately represent mode share
- Adjustments to remove freight vehicles
- Reviews of trip rates; and
- Reviews of trip lengths.

Subject to these reviews it is expected that MPOD can form a valuable dataset for use in enhancing a strategic traffic model.

5.5 Coverage areas

MPOD data has been requested across the whole of Lincolnshire. The principles of the request were based on;

- Detailed Lower Super Output Areas (LOSA) in urban areas
- Strategic Medium Super Output Areas (MSOA) in rural areas

For areas beyond Lincolnshire the default zoning system was District or part of District notwithstanding the following variations:

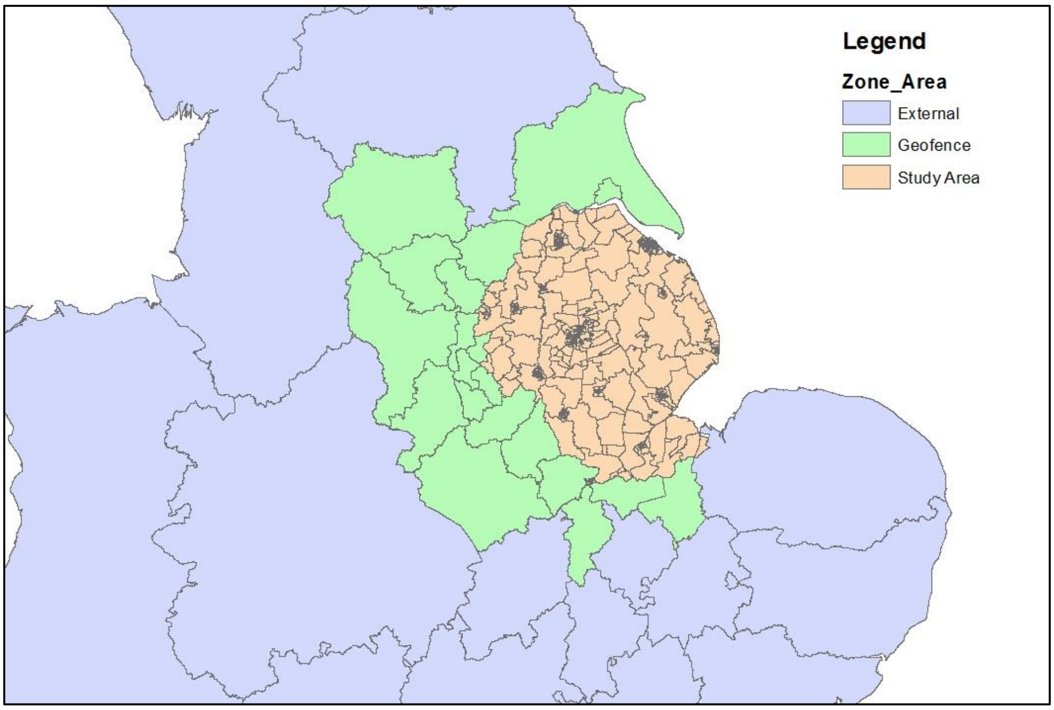
- North Lincolnshire following the principles of Lincolnshire. Detail as per the County structure

- North and East Nottinghamshire following the principles of Lincolnshire. Detail as per the County structure.

- A Geofence extending approximately 30 miles beyond the County boundary has also been supplied. Beyond this area trips are allocated to their arrival zone at the Geofence boundary. Due to the decay of trip volumes with distance this is not problematic for strategic modelling.

Figure 5-4, comprising of 487 zones, shows the data capture area.

Figure 5-4 – Request Zone System



5.6 Trip Database from Mobile Phone Origin Destinations

The Mobile Network Operator (MNO) contractor has processed a month's worth of mobile phone movements across the study into matrices suitable for transport modelling.

The data collection period for Lincolnshire ran for four weeks, starting from 03/10/2016 to 16/10/2016, 07/11/2016 to 12/11/2016, and 14/11/2016 to 20/11/2016.

This period consisted of four weeks, resulting in 20 working days (Monday – Friday) and 7 weekend days (Saturday-Sunday).

A Vodafone data outage occurred on the 13/11/2016, and therefore this day was excluded from the data collection period.

The following data classification has been provided

Table 5-1 – MPOD Data Classification

Classification				
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
Other/Slow	Off Peak		NHBO	
			Unknown	

Expansion has been made to populations aged 16 to 65 years old (working age). Exclusion of the retirement population will primarily result in reduced older persons travel movements and may impact on coastal areas of Lincolnshire more than economically dynamic areas such as the City of Lincoln. Application of data within' retirement areas' would require further post processing.

Allocation of responsibility for specific elements of detail within trip classifications are reflected in Table 5.2.

Table 5-2 – GL3M Dataset Field Derivation

Field	Citilogik	Mouchel
Origin	✓	
Destination	✓	
Start Hour	✓	
Mode 1 Highway/PT	✓	
Mode 2 Bus/Rail		✓
LGV HGV		✓
Person Trips		✓
Purpose	Partial	Full
Home-Based Flag	✓	

Datasets will require further manipulation in order to overcome the limitations they present with regard to mode, vehicle type and purpose. \it is proposed to undertake two levels of processing reflecting the increasing confidence in the datasets.

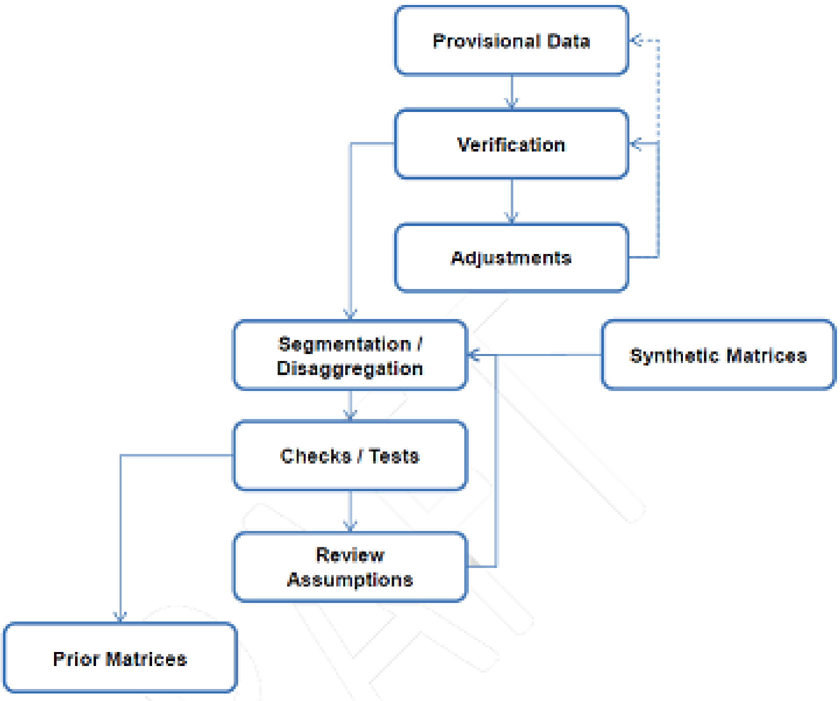
5.7 Matrix Development Principles

The matrices resulting from this process will be checked to ensure the outturn mode shares and purpose splits are in line with both local data and the National Travel Survey.

Additionally, the prior matrices will be calibrated by assigning events to a buffer network with resulting flows compared to an independent count set. Calibration levers will include the scaling of trips to reflect inaccuracies in the original expansion factors and the variation of vehicle occupancies.

The general principles of the matrix build are indicated below.

Figure 5-5 – Matrix Build Process



5.8 Data Reliability Check

Upon receipt of the datasets, and in combination with Citilogik information a series of checks on the trip movements will be undertaken and a technical note produced detailing the findings.

The initial step leading to acceptance of provisional data is verification of results. The verification process is detailed by the level of information where initial targets will be refined and subject to consideration of,

- Average 24hr Unexpanded Working Day Travel Flow;
- Device Trip Rates;
- Average 24hr Working Day Total Travel Flow;
- All Modes Symmetry:
  - Slow Modes Symmetry,
  - Motorised Symmetry,
- All Purpose' Symmetry:
  - Symmetry Test for All Home-Based 'from home' and 'to home' trips,
  - Symmetry Test for Home-Based Work (HBW) Trips,
  - Symmetry Test for Non Home-Based (NHB) Trips,
- HBW Outbound Versus Inbound by Time of Day;
- Home Based Other (HBO) Outbound Versus Inbound by Time of Day;
- All Purpose Trips by Time of Day;
- Correlation between Trips and Population:
  - Correlation between Home-Based Trips and Population,
  - Correlation between Home-Based Work Trips and Population,
  - Correlation between Home-Based Other Trips and Population.
- The symmetry of the matrices over the 24 hour period;
- Trip rates by area and purpose;
- Trip-length distributions by start sector; and
- Comparison of sector to sector movements with observed counts.

5.9 Expansion Factors

The MNO will derive expansion factors from a more detailed dataset, in which the home location of each device is identified. Therefore, the model matrix build will use the expansion factors supplied in expanding to the total catchment population.

The population targeted in the expansion is the over 16 age group total. This represents a compromise across the area. Coastal Lincolnshire contains a greater number of older persons (>65 years). Expansion to the total population may over estimate movement, particularly if older less mobile persons. Conversely Lincoln is a relatively 'young' city with a university and student population. Expansion to these groups may not make significant difference given the increased activity profile of urban dwellers.

5.10 Dataset Disaggregation

The provisional dataset will be disaggregated following the approach set out in Figure 7-2, which makes use of parallel national and local datasets to separate the components required for the modelling structure.

The disaggregation process has been developed with the model development timescales and allows for the provisional dataset to be processed quickly, enabling early checks of the networks in advance of updates to count data. The minimal number of processing stages and input datasets mean that the system will be able to be checked and updated as the performance of the matrix in the assignment matrix becomes known.

The first step in the process will be to extract road freight movements, for which the trafficmaster OD data will be used.

The next component will comprise the all other highway modes as well as slow modes and rail. The 2011 Census Journey to Work (J2W) dataset, which provides mode shares between each LSOA or MSOA, will be used to disaggregate these trips into individual modes. Although the J2W dataset does relate to commuter trips, the mode shares available from NTS do take account of the relative modal costs of each movement and can therefore be used as a proxy for the mode shares of other purposes in the model.

The following stage of the process will require splitting the trips into purposes. To do this, analysis would be undertaken on the National Travel Survey dataset to understand how trip purpose varies by time of day, mode and trip length. From this a series of purpose splitting factors will be derived for each record.

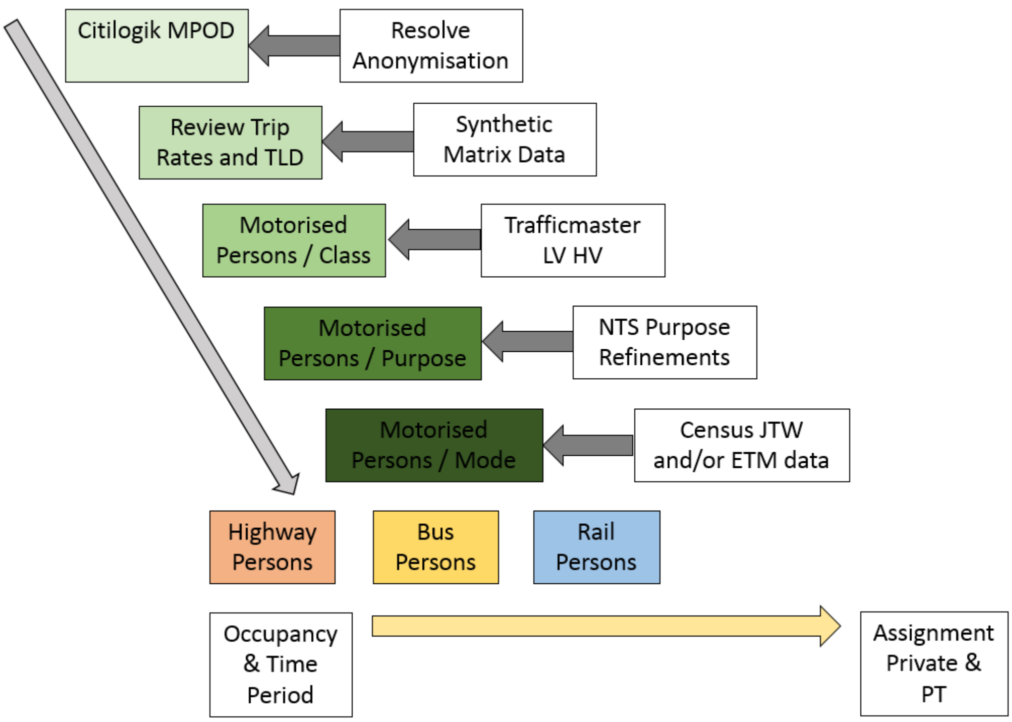
Person trips will be converted into vehicles using occupancy rates from previous studies in the region. Where required, resident and workplace population data from the 2011 census will be used to disaggregate from MSOA to assignment zones.

Table 5-3 – GL3M Dataset Process Steps

Step	Description
1.	Resolve Anonymisation by infill techniques
2.	Review Trip rates and lengths
3.	Generate Synthetic matrix to augment MPOD
4.	Derive Trafficmaster datasets of LV and HV
5.	Identify vehicle classes and refine purposes by class
6.	Separate classes by highway mode and rail modes
7.	Derive time period matrices
8.	Derive occupancy matrices and pcu matrices by vehicle (highway)
9.	Allocate pcu (highway) or person matrices (public transport) to network

A graphical understanding of this process is identified in Figure 5.6.

Figure 5-6 – Matrix Disaggregation Steps



5.11 MPOD Zonal Disaggregation

All processing thus far will have been at the requisite MPOD zone system. For both the highway and the PT assignment models and demand model, disaggregation will take place to the local model zoning system.

This is indicated below in Figures 5.8 through 5.10. In total there are 415 zones within the Simulation Area and 463 zones across the whole Study Area. The external zones are expected to contribute an additional 150 zones, giving a total of approximately 600 zones. By contrast the previous Lincoln Model contained 175 zones and therefore the level of detail will be significantly enhanced

Figure 5-7 – Lincoln Assignment Model Zones

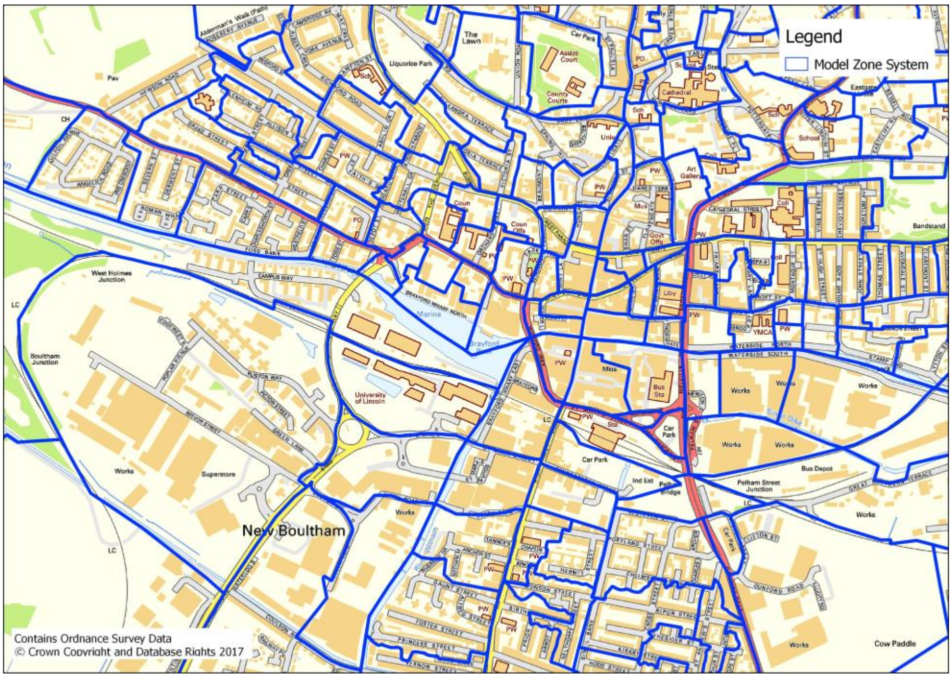


Figure 5-8 – Lincoln City Centre Zones

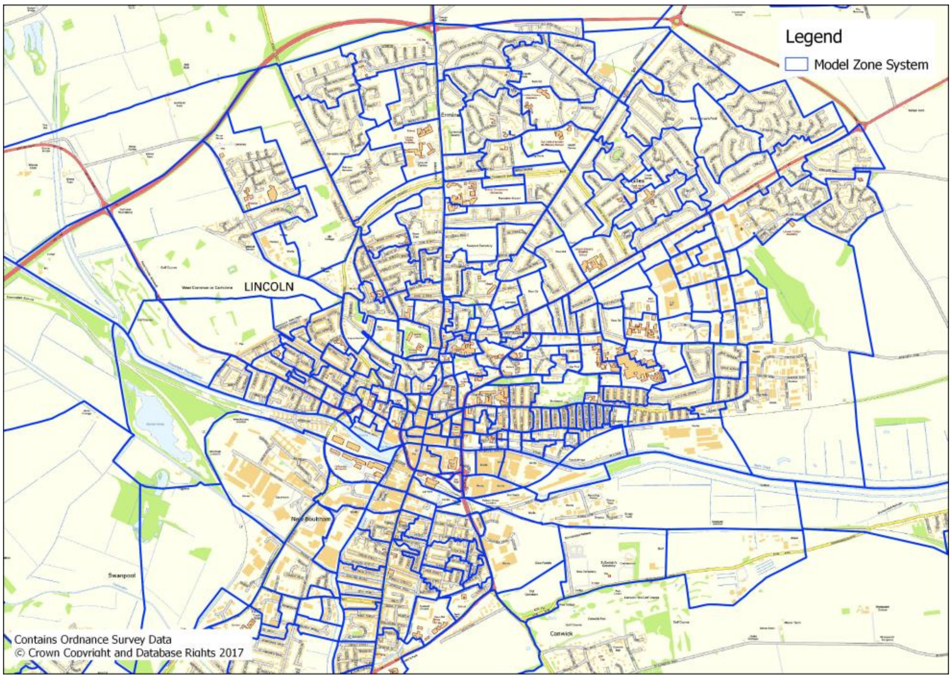
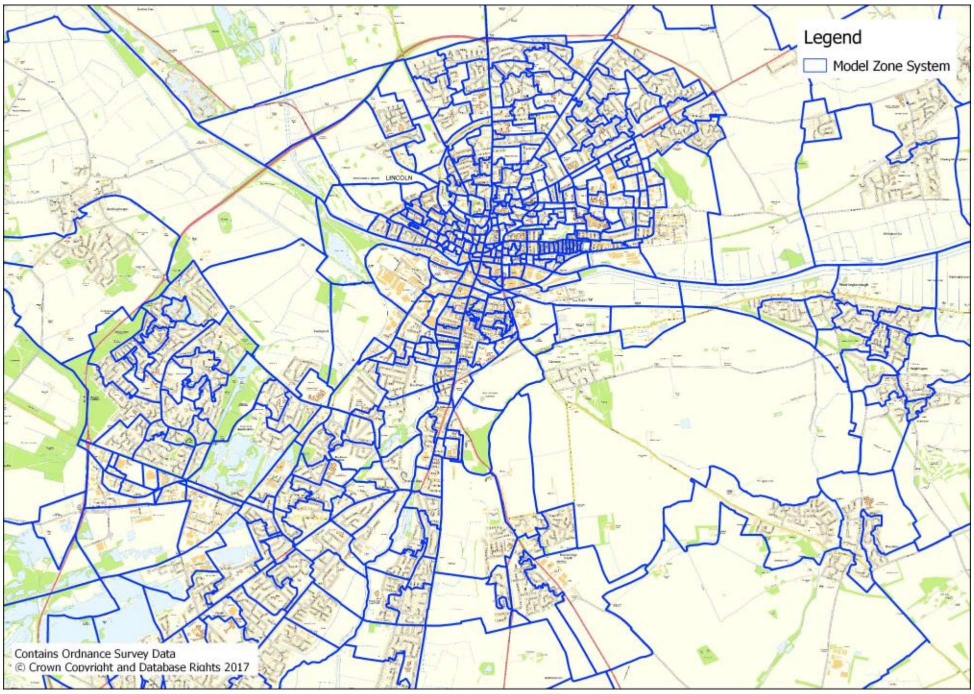


Figure 5-9 – Lincoln District Zones



5.12 Synthetic Data

Data has been received from Citilogik covering the requested zone system. Evidence from other MPOD data application projects suggests that data capture is more limited for short distance movements due to the reduced possibility of MPOD cell transfers and hence a limitation on the number of short distance trip movements which are captured.

It is therefore possible that a synthetic approach to developing matrices will be created to overcome some of these limitations. This approach is predicated on:

- Obtaining NTS data on trip length for Lincolnshire;
- Constraining trip lengths to trip ends developed through the NTEM;
- Fitting calibrating trip length relationships with respect to generalised costs derived from fixed speed networks;
- Developing synthetic demand matrices based on the above data;
- Compressing synthetic demands to an appropriate zone system which provides a sufficiently good fit for MPOD;
- Utilising the synthetic demand for any trip deficiencies in the MPOD data; and
- Consideration of application of this process to remove anonymization within the datasets.

The output of this process is expected to provide a more appropriate prior matrix rather than direct reliance on MPOD. It is also anticipated that beyond this process, calibration and validation iterations, using a maximum entropy techniques, will be required to reach the desired level of flow matching.

5.13 Risks

The suitability of the MPOD dataset is the primary risk for this stage of work. If the data reliability checks highlight significant limitations, there will be an impact on both project cost and timescales. For example a 2015 Highways England project to deliver mobile phone based demand matrices was delayed whilst data was reviewed and reinterpreted to ensure greater accuracy. Throughout the industry the lessons of early adopters have been learnt and disseminated to improve outcomes for more recent studies.

Delivery of the MPOD dataset has been on time. The content is under verification. Any adverse findings would delay the project unless a method is found to produce compliant matrices from the MPOD.

Assuming the MPOD data gives the ability to generate an appropriate assignment matrix, the calibration standards to be applied for the modelling are discussed in the next chapter.

6 Assignment Model Standards

6.1 Traffic Assignment

Assignment will need to be conducted based on detailed supply model using appropriate software. 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 Wardrop equilibrium.

Throughout the model development, a series of calibration and validation checks will be undertaken. These will consist of comparing the observed and modelled link flows. The calibration and validation link flow comparison guidelines set out in WebTAG Unit M3.1 will be used. The traffic flow data that had not been used as part of the model development (matrix estimation) is independent data and will be used as part of the validation process. The traffic flow data used as input to a matrix estimation process will be used only for calibration of the model.

6.2 Traffic Acceptability Guidelines

The acceptability guidelines outlined in WebTAG Unit M3.1 are shown in Table 6-1 and

Table 6-2. The observed flow and screenline flow criteria in the Table relate to total link flows, i.e. all vehicles, and should not be used when comparing partial link flows, e.g. heavy goods vehicles.

Table 6-1 – Link Flow and Turning Movement Validation Criterion and Acceptability Guidelines

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

Table 6-2 – Journey Time Validation Criterion and Acceptability Guidelines

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

6.3 Public Transport Assignment Model

6.3.1 PT Model Scope

It is likely that a public transport assignment model will be required given the interest in P&R trips and bus priority. The model would provide outputs covering

- Interaction with highway mode on travel speeds;
- Assignment of trips providing allocation of persons to bus, rail and mixed mode services; and
- Generalised cost skims of costs of travel for use within demand modelling

Details of the specific coding requirements, parameter derivations and assignment methods is detailed in the relevant guidance from WebTAG (Unit M3) and this will be followed.

The level of accuracy associated with PT trips is necessarily lower than that of highway demands resultant from the lower market share associated with the former.

The DfT's recommendation is that across modelled screenlines, modelled flows should, in total, "be within 15% of the observed values. On individual links in the network, modelled flows should be within 25% of the counts, except where observed hourly flows are particularly low (less than 150 passengers per hour)".

6.3.2 PT Generalised Costs

The model will operate with a frequency based assignment approach allocated according to a "Service Frequency and Cost" model. Capacity restraint is not envisaged to be required. Generalised costs, included within the network model to reflect both assignment choice costs and demand modelling costs, are as follows:

- Access time (from trip origin to PT stop);
- Egress time (from PT stop to trip destination);
- Transfer time (between PT stops);
- Origin wait time (time spent waiting for first service on path);

- Transfer wait time (time spent waiting for subsequent services);
- In vehicle time (weighting may vary by mode/vehicle type); and
- Fare; and
- Transfer penalty

Specific components of generalised cost will be weighted in accordance with behavioural perceptions and will be expected to be within typical ranges.

Cost Skim outputs, showing the relative costs between pairs of origins and destinations, will be available in weighted form for Generalised cost comparison within the VDM and in an unweighted form for economic analysis.

6.3.3 PT Data

The PT network model will be developed from the latest representation of bus and rail services within Lincoln and the surrounding area. Bus and rail modes will be modelled as an assignment choice. There are several suburban and rural stations within Greater Lincoln modelled area. The sense of multirouting choice will be controlled by the need to calibrate both bus volumes and rail station flows..

PT demand data can be obtained from several sources such as the following:

- Ticket sales data from Stagecoach services across the region. Preliminary enquiries have been made as to the availability of Electronic Ticket Machine (ETM) data;
- Rail mode share allocation derived from Mobile Phone data; and
- Synthetic data derived from NETM 7 trip ends and NTS trip length data, resultant in synthetic demand.

Survey data of flow volumes within Lincoln will be used for calibration and validation purposes. This will be based on:

- Counts at bus station and main central area stops; and
- Video surveys of a concentric cordon adjacent to the city centre and at suburban locations.

The Public Transport model will be mounted within CUBE VOYAGER software. The model will interact with the Variable Demand Model also scripted within the same software package.

7 Variable Demand Model

7.1 Introduction

WebTAG: Guidance for the Technical Project Manager emphasises the importance of a proportionate approach in relation to any modelling. That is to say that objectives should be defined first and the model specified accordingly to create a platform which is fit for purpose. It also recognises that in any modelling, there is some form of trade-off between model sophistication and constraints such as resource, computer run-times and data requirements.

Having considered the objectives set out in Section 3, the following chapter presents options for the development of the model.

7.2 Structure

It is clear from the functionality that is required, that the model needs to be a network based multimodal disaggregate model. This formulation is similar to that of the previous incarnation of the model and mirrors the requirements specified in WebTAG.

WebTAG sets out procedures to be followed in building variable demand models, and details the illustrative sensitivity parameter ranges necessary for incremental hierarchal logit forms of the models. According to WebTAG, the following demand responses will need to be considered:

- trip frequency, as walking and cycling modes are not considered as suggested by WebTAG;
- choice of mode, including car, bus, rail, P&R, and possibly park and walk; and
- destination choice, which is considered to be a more sensitive response than main mode choice and should therefore be modelled below it in the demand hierarchy.

WebTAG also gives the demand model parameter ranges against which the calibration may be checked. WebTAG strongly recommends the use of an incremental Production/Attraction (PA)-based form. The key advantage of this is that choice mechanisms underpinning these models reflect the linkage of outbound and return trips (i.e. they start and finish at the same location and use the same mode across the day).

In order to realise the practicalities of this guidance, the proposed modelling framework will encompass a traditional four stage structure, drawing upon three core models;

- trip end model;
- demand model, and;
- supply (network assignment) model.

7.3 Trip End Model

WebTAG advises that a land-use/transport interaction model should be considered where:

- the potential solutions are likely to cause significant shifts in the scale and pattern of economic activity, including jobs;
- the investigation of alternative land-use policies is a matter of key concern; or
- there is likely to be a significant interaction between transport and land-use strategies.

However, whilst land-use issues are of direct relevance for Lincoln it is believed that it will be more important to determine the implications of proposed developments on the performance of future transport networks and thus to identify infrastructure improvements and policy initiatives that would be necessary to manage the impact of this growth, rather than to predict the possible constraining and redistributive effects of the existing or improved networks on development locations.

The Lincoln model will relate zonal based land-use planning and demographic assumptions at both a base year and for each forecast year using the latest TEMPRO and land use projections. Other localised projections from, for example, the local plan model could also be employed as an alternative scenario. Together, these will forecast the number of trips, disaggregated by journey purpose and time period. Trips generated by housing zone will be forecast based on household characteristics (for example the number of employed and school-aged residents, car ownership, and household income) whereas a trip attraction module would forecast the number of trips attracted to a zone based on the number and type of employment places, school places, shopping and leisure facilities.

WebTAG guidance recommends using Production/Attraction (P/A) format matrices for demand modelling rather than Origin/Destination (O/D) matrices. This distinction is most important when forecasting travel patterns in the future due to possible non-uniform growth at either the production end or the attraction end of a trip. WebTAG states, “change in workplace distribution may well be different from those in employee’s residence. This can, in most circumstances, lead to different forecasts of trips depending on which of the two trip matrix definitions is used”.

Practically, the P/A form is the best to implement for mixed mode demand modelling; for example, there is no need to distinguish the direction of from-home trips and to-home trips in the P&R choice mechanism. The trip end model will be based on 24-hour productions and attractions.

It is proposed that the Trip productions and attractions will be controlled to values developed from the CTRIPEND programme sponsored by DfT. This is compatible with TEMPRO7.2 and will be reflective of the latest research on trip rates, showing a decline over recent years.

The demand model will be formed as an incremental hierarchical logit choice model, fully compliant to the WebTAG guidance. Modelled Time Periods

The scope of the full model framework will be a 24 hour period of an average weekday. Within the full model framework three time periods are specifically modelled, namely;

- AM peak 07:00 to 10:00, with assignment peak hour to be established;
- Inter-peak (IP) period of 10:00 to 16:00, with an assignment covering an average hour within this period;
- PM peak 16:00 to 19:00, with assignment peak hour to be established; and

Note that for the Off-Peak period (OP) of 19:00 to 07:00. It may not be explicitly necessary to model network performance

The demand model will operate as a 24 hour model, using the costs from time period models as input. This is to facilitate the use of a production-attraction modelling format. It is necessary to have an off-peak period to form a 24hr day but there is no need for an off-peak assignment model. The base off-peak demands and costs will be approximated from the base inter-peak demands and costs.

It is unlikely that Saturday or Summer variant models will be required although both aspects do impact upon the Lincoln regional road network, especially in the summer months.

7.4 Segmentation

The DfT's WebTAG Unit M2 'Variable Demand Modelling' sets out guidance for the level of segmentation needed for models to be able to robustly assess major schemes.

To ensure compliance with this latest guidance, the following personal travel demand segmentation will be used:

7.4.1 Car Availability

A review of mode share in the Lincoln region has indicated that car availability is relatively high compared to some of the more dense conurbations elsewhere in the country. This naturally impact on the mode choice. The relatively limited local bus and rail networks result in elevated car use even amongst relatively low income groups. On this basis it has been decided to exclude car availability from the demand model. The growth in car use will rely on TEMPRO outputs to derive factors for application to the base year matrices.

Within the overall vehicle travel market the trip purpose split will be as follows:

- HBW (Home Based Work);
- HBO (Home Based Other);
- NHBO (Non Home Based Other);
- HBEB (Home Based Employers business); and
- NHBEB (Non Home Based Employers business)

The differentiation is based on methods of applying the demand modelling components coupled with differential responses based on variations in value of time.

The segmentation of users in assignment models will be aggregated to those user classes with similar time values, to minimise assignment requirements.

In general, WebTAG recommends an incremental logit-based approach for each stage of multimodal demand modelling, pivoted off the base year. The development of the demand model will follow the guidance closely and illustrative sensitivity spreading parameters and tree structure parameters will be used and subsequently adjusted as suggested by the DfT. The following choice response mechanisms will be considered:

- frequency modelling;
- main mode choice modelling between car and public transport (PT);
- destination choice modelling; and
- sub-mode choice modelling between rail and bus for PT, and sub-mode choice modelling between car and P&R for highway.

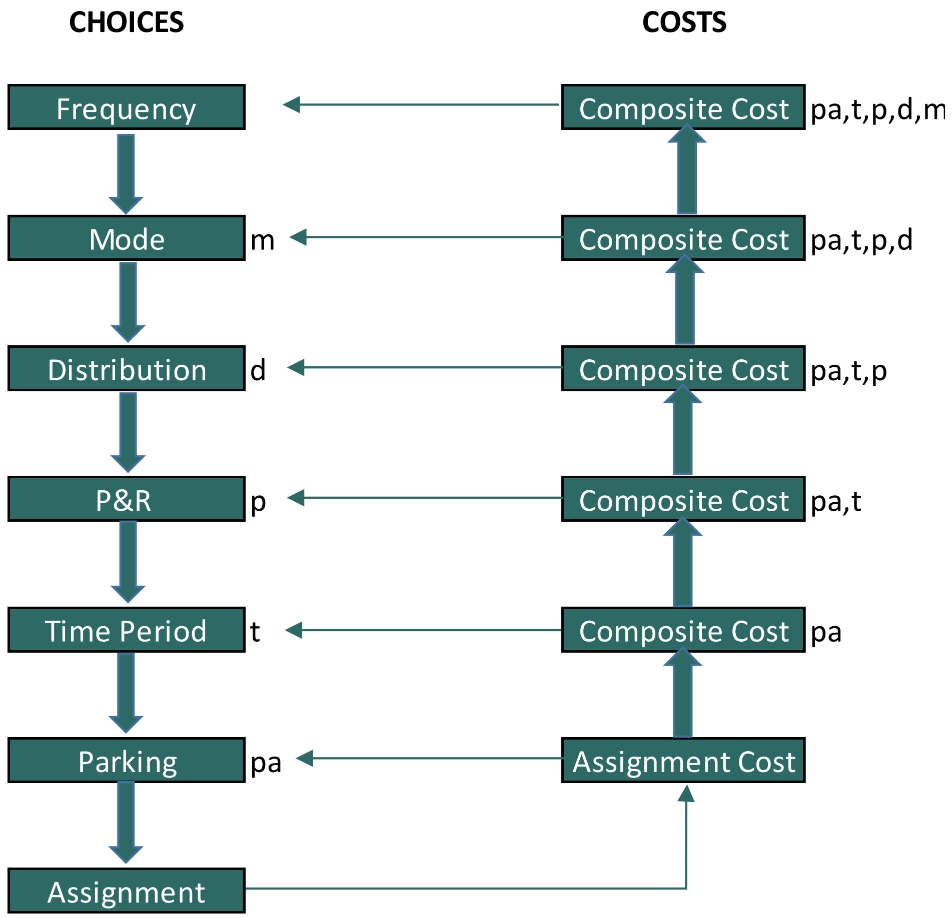
Each of the enhanced behavioural responses is discussed in the remainder of this section.

7.5 Model Responses

The following model responses should be considered within the model structure:

The proposed demand model structure is illustrated in Figure 7-1

Figure 7-1 – Demand Model Structure



7.5.1 *Trip Frequency Modelling*

WebTAG recommends that TEMPRO and other locally and/or regionally available forecasts are used in such a modelling framework. As such, trip generation models based on detailed socioeconomic variables are not considered.

Walking and cycling modes will not be modelled explicitly in the Lincoln model. Instead, the trip frequency model will be used in order to model potential mode diversion from walking/cycling to motorised modes (induced traffic) or from motorised modes to walking/cycling modes (trip suppression). This will be achieved through the application of elasticities based on research and published for application in transport models.

7.5.2 *Main Mode Choice*

The mode choice for the model will be divided into two parts: the main mode choice between car (including P&R) and public transport and, the secondary (sub mode choice) for public transport (if required) and for highway journeys (car and P&R). The main mode choice model will operate in a 24-hour modelling framework with a P/A form of matrices.

7.5.3 *Destination Choice Modelling*

Destination choice models spread the forecasts of generated trips by mode and time period over the available destinations for each time period modelled, depending on the change of generalised cost of reaching that destination over the base year, when modelled in an incremental form.

WebTAG Unit M2 recommends that the destination choice should be modelled as a singly (origin) constrained distribution for trips with HBO, NHBO, NHBEB or HBEB purposes.

In contrast, WebTAG recommends that the destination choice for HBW needs to be modelled as a doubly (i.e. origin-and-destination) constrained distribution. To meet this requirement, a rectangular ‘furnessing’ (matrix cell balancing) procedure will be developed to undertake the HBW distribution modelling.

Doubly-constrained destination modelling is much more complicated than singly-constrained destination modelling and aims to ensure that each zone attracts and generates a fixed total of trips.

The models are generally developed iteratively from a set of balance factors for each of the production/attraction trip ends. For the proposed model structure, the balancing procedure is much more complicated since the production totals produced from the mode choice stage and the time period modelling stage are subjected to change at the distribution stage.

7.5.4 *Sub-Mode Choice*

Sub-mode choice is considered to be most the sensitive, apart from the re-assignment, and is therefore placed at the bottom of the choice hierarchy.

Given a very sparse rail network in Lincoln there will be no matrix based PT sub-mode and bus/rail will be considered within the PT assignment.

Appropriate fare systems will be applied to each sub-mode.

The highway sub-mode choice is considered as follows:

- Car; and
- P&R.

Prior to implementation, local sense checks on plausibility of response will be reviewed to establish whether this step is undertaken simultaneously with main mode choice or later, as suggested.

All choice mechanisms above the sub-mode choice will be modelled incrementally as required by WebTAG.

Whilst the choice of sub-mode mechanism is not clearly specified in the guidance, incremental sub-models would be a preferred approach over the absolute models, for consistency.

The overall model stages including the assignment stage is summarised in Table 4.1 and described as:

- frequency modelling (Stages 1) is undertaken for HBO and NHBO trips only as suggested by WebTAG;
- the main mode choice (Stage 2) between car and PT operates across all trips with 'lamda (model sensitivity)' controlling the split to PT.
- the demand model operates at the 24-hour level until the time of day choice (Stage 3) is undertaken;
- for destination choice modelling (Stage 4), the demand model considers all four time periods AM peak/Inter-peak/PM peak/off-peak for all person types in parallel;
- the resulting PA matrices are converted into OD matrices after the sub mode choice based on fixed time period choice factors (Stage 5); and,
- distribution of parking within the city centre is evaluated (Stage 6) based on generalised costs and available capacity
- individual PT and highway assignments (Stage 7) are undertaken.

Table 7-1 – Model Hierarchy and Application

Stage	Model	Time Period	Purpose	Application	Form
1	Frequency Modelling	24 Hour	HBO	PA Tripends	Incremental Logit
2	Destination Choice	24 Hour	All	PA Tripends	Incremental Logit
3	Mode Choice	24 Hour	All	PA Matrices	Incremental Logit
4	P&R Sub-mode Choice	24 Hour	All	PA Matrices	Absolute Logit
5	Time Period Choice	Modelled Periods	All	OD Matrices	Fixed Factor
6	Parking Choice	Modelled Periods	Assignment User Class	OD Matrices	Absolute Logit
7	Assignment	Modelled hour	Assignment User Class	OD Matrices	Equilibrium

7.5.5 *Parameter values*

Model parameter values will be imported from the list of recommended sensitivities within WebTAG. The model will be calibrated to appropriate sensitivity responses, including impact of high and low values and outturn elasticities for fuel cost, journey time and public transport fares.

7.5.6 *Production Attraction Modelling*

The model will be based on Production Attraction (PA) modelling for the Home based modes. This allows the choices within subsequent periods to be accurately reflected within the models.

PA modelling operates by undertaking the relevant demand choices at a daily level by the aggregation of period costs into daily cost.

As the process operates as an incremental (pivot) model, the opportunity exists to develop the PA from the OD data relative to the base year models. The implicit proportions of home and return trips will be evident from the MPOD data. This together with NTS proportions of out and return totals can be used to develop a 24 hour matrix that is dependent on the verification of MPOD trip lengths and the need to infill the data. The formulation of a synthetic matrix for infill purposes may assist in this process.

With this approach, demand changes to the base P/A matrix may then be modelled incrementally.

7.6 Highway Assignment

WebTAG Unit M3.1 defines the highway Generalised Cost for private car users with elements relating to:

- fuel cost;
- in-vehicle time;
- parking costs;
- access/egress time; and
- tolls or other user charges.

The Lincoln model should follow the WebTAG formulae for the definition of generalised costs for cars, where:

Gcar, measured in units of time-minutes:

$$Gcar = Vwk*A + T + D*VOC/(occ*VOT) + PC/(occ*VOT)$$

where:

Vwk is the weight applied to walking time (assumed 0 currently);
A is the total walk time to/from the car (minutes);
T is the journey time spent in the car (minutes);
D is the motorised journey length (kilometres);

VOC is the vehicle operating cost (pence per km): including the fuel and non-fuel operating cost for work purpose but only the fuel operating cost for non-work purpose;

occ is the occupancy (i.e. the number of people in the car) whom are assumed to share the cost;

VOT is the appropriate Value of Time (pence per minute); and

PC is the parking cost and tolls (if and when incurred), in monetary units (pence).

7.7 Park & Ride

Park & Ride (P&R) represents an advance on the current model capability and will form a potential policy analysis tool, if required. P&R is a combination of car and bus modes travelling to/from the city centre from external zones. The car leg of the journey to the P&R site will be modelled within the highway assignment model and the bus leg is processed within the bus model. Both car and public transport assignments will be required. A subroutine within the demand model will be developed to transfer demand from car to P&R buses travelling to their final destination and to aggregate journey costs. The choice of travelling by P&R versus driving and parking in the City centre is dealt with within the mode choice model.

Modelling P&R as a highway sub mode raises a number of issues because it requires linking the highway and public transport elements of the model. In summary, there will be four key stages in the P&R modelling:

- derivation of P&R generalised costs;
- estimation of P&R demand in the demand model;
- site allocation of P&R demand to competing sites (if relevant); and
- assignment of highway and PT legs of P&R trips to the networks

There are two options that need to be considered for modelling P&R within the updated model:

1) develop as part of the highway model; or
2) develop as part of the public transport model;

With respect to P&R, WebTAG (Unit 5.1 para 3.2.5) states:

For models where evidence from a local estimation is not available, the positioning of P&R choice as a sub-mode of either car or public transport may be based on the following:

- *where P&R is dominated by relatively short car legs in order to gain access to a substantial public transport leg, then positioning as a sub-mode of public transport is likely to be the more appropriate; and*

- where the P&R site is located so as to attract relatively long car trips to change mode on the edge of the urban area, and where public transport mode share is low for the movements of interest, then treatment as a sub-mode of car is likely to be the more appropriate.

The assumed setup for estimating Lincoln P&R usage is therefore aligned to this guidance providing it is expected that the P&R sites will be attractive to longer distance car movements rather than shorter distance public transport trips.

The choice of alternative P&R sites is not envisaged as an immediate problem facing Lincoln. It is envisaged that the P&R programme may involve a single initial site with a defined catchment area. Subsequent sites are unlikely to impinge upon the initial catchment and would be located so as to extend rather than abstract the P&R market.

7.8 Parking Model

The model will have a dynamic parking response function, which will operate across all vehicle categories terminating in the City centre and adjacent areas. This is designed to be able to reflect parking policies and also to be able to capture full trip costs which are relevant when considering the cost of alternative trip choices such as use of P&R into the city centre.

The parking model will cover the translation from output person trips in the demand model to final vehicle trips by destination within the assignment model. Within the central area the choice of parking location will be established from a variation from the ultimate destination based on walk distance coupled with parking availability and cost. In the absence of any constraints at the earliest stage of the day then parking would be as per the intended ultimate destination. The parking capacity/cost is modelled on a zonal basis. As zones closest to the end destination become full then a longer search (drive), cost and walk time is needed to satisfy the trip.

The parking location choice model requires two logit lambda values for each time period and purpose (parking type choice followed by parking location choice). Parking type choice is mapped to trip purpose such that short and long stay conditions are satisfied. Unlike other areas of the model the two choice models will be absolute because the choice sets will vary dynamically during a model run (as car parks become full they are removed from the choice set)

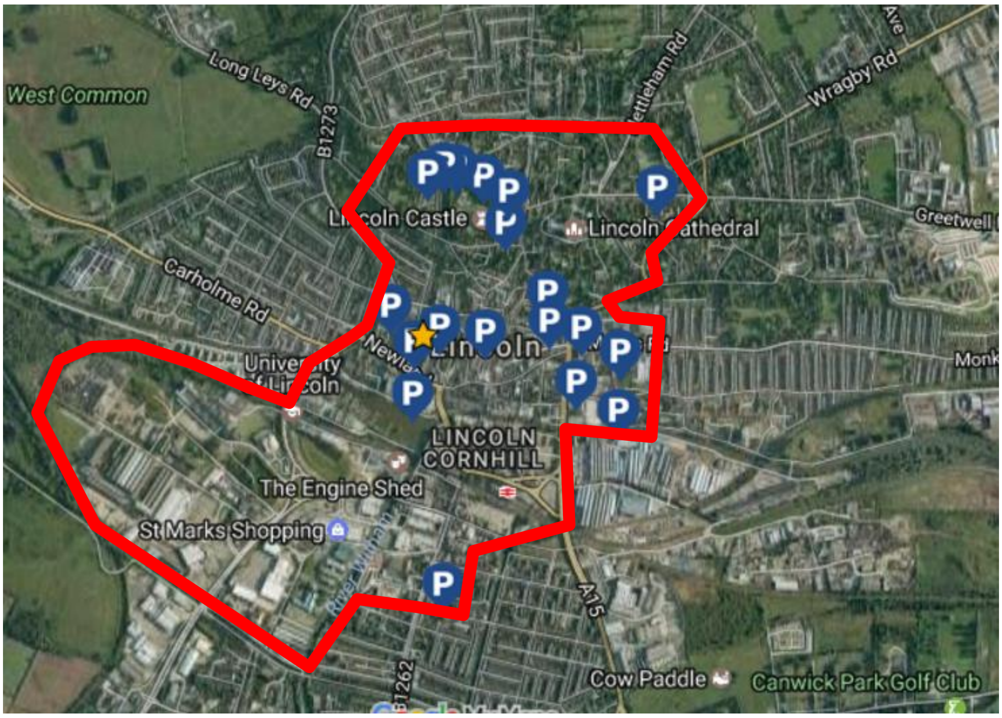
Parking choice is only applied to home based trip attractions and only at zones served by at least one parking location. Therefore no zone should be served by exactly one parking location. Wherever an option to park in another zone or in a paid car park is offered, a dummy parking location for on-street parking in the true destination zone will be coded.

Hence information will be required based on

- Parking type;
- Parking catchment (access and egress to spaces);
- Parking spaces;
- Parking purpose;
    - Commute
    - Other
    - Business
- Arrival time;
- Average duration of stay;
- Average cost of stay;
- Background parking (residents, delivery etc.); and
- Egress time

The definition of the parking zone is broadly bounded by the city centre and the uphill area coupled with an extension to the Tritton Retail Park to the south west of the City Centre. The coverage is designed to include commercial, retail leisure and tourism locations. The industrial areas to the south east of the City Centre are assumed to be self-contained in parking terms. Details are included in Figure 7.2. Extension beyond this demarcation may be considered in the event that the parking strategy needed to be applied to a wider area. However as the modelled area reduces in land use density and consequent refinement (beyond the City Centre) the ability to model parking choices is reduced by more limited detail.

Figure 7-2 – Parking Model Area



8 Forecast Model

8.1 Introduction

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

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

The first requirement 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.

The second element of a forecast capability is needed in the support of Lincolnshire County Council (LCC) funding bids for major schemes. The remainder of this chapter describes the various requirements of the forecasting and appraisal process for these requirements, including, the prediction of future year travel demands and the assumptions relating to changes in future year highway networks.

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

8.2 Future Year Travel Demand Scenarios

The principal requirement of the transport model is the provision of traffic forecasts for Do-Minimum (DM) and D0-Something (DS) situations that reflect multiple forecast years (at least opening and design years).. Future travel demands at these times will take into account existing traffic flows together with the effects of traffic growth and the additional traffic arising from new development activity.

Growth in traffic derives largely from increased incomes, reduced household sizes, and economic activity. The growth in economic activity leads to a redistribution of traffic and increased levels of goods vehicle journeys.

The new development of residential, retail and employment land-uses in the Lincoln area will also create further demand for travelling. These factors need to be taken into account in the prediction of future travel demands in the wider Lincoln area.

8.3 Future Year Highway Strategy

The future year traffic models must take into account the effects of other highway or traffic management schemes that are likely to be in place over the forecast horizon.

Information in relation to future highway/traffic management schemes will be provided by Lincolnshire County Council.

8.4 Requirements for Scheme Appraisal

The model must be able to support cost-benefit assessments and to estimate the value for money provided by major schemes. This will require TUBA (Transport User Benefit Analysis), a computer program developed for the Department for Transport (DfT) to undertake the economic appraisal of highway schemes and multi-modal transport studies.

To operate TUBA requires,

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

The model is intended to fulfil these requirements

Accident benefits resulting from the introduction of infrastructure will be based on COBALT software.

8.5 Project Specific Elements

Mouchel is contracted to deliver a Do-Minimum version at the future years. Schemes to be tested are yet to be defined. Nevertheless the process for forecasting will need to be able to:

- Growth multimodal demand using TEMPRO7.2
- Include specific development trip ends
- Distribute developments according to suitable distributions
- Produce core and alternative demand scenarios to suit forecast need.
- Apply appropriate Value of Time and Operating cost parameters to future year scenarios.
- Undertake fixed demand forecasts to gauge reference impact of schemes
- Undertake variable demand forecasts to gauge the balance of supply and demand within the multimodal network.

This functionality will be built into the model.

8.6 Update Potential

The model is constructed with a set of MPOD data which can be updated in a predominantly automated manner in the event that more recent data becomes available.

For application of the model some time beyond the original data collection (exceeding six years based on DfT guidance) a Present Year Validation may be required. This would involve forecasting from a historic base year to ensure traffic flow and travel time characteristics were comparable with data of the day.

9 Summary and Conclusion

9.1 Summary

This report has responded to the functionality requirement of a new Greater Lincoln Transport Model with a detailed specification outlined in this report.

The scope of content for an appropriate model has been assessed with particular emphasis placed on data availability, methods of development and technical delivery.

Summary of the specification is provided below

Table 9-1 – Model Functionality and Specification Response

Functionality Requirement	Specification Response
CORE Development Appraisal	• Developed from observed data • Closely calibrated to reality • Detailed representation of junctions • Incremental application to preserve positive elements of base traffic patterns • Operable as assignment only model with development trip rate applications
CORE Strategic Business Case Evaluation	• Fully WebTAG compliant for both Traffic flows and journey times • Comprehensive assessment of all modes and demand responses • Based on 2016/17 data collection • Easily updatable in the event of extended business case development
ADDITIONAL Policy Evaluation	• Contains P&R and Bus priority functionality • Contains Parking model • Can represent hard measures by coded input and soft measures by parameter sensitivity • Permits evaluation of network wide outcomes from broad range of performance statistics across all areas of transportation
ADDITIONAL Tactical Measures	• Base year available late 2017 on current programme • Close adherence to 2016 traffic patterns. • Inputs to model retained in database format for ease of update. • Available for uses beyond standard transport evaluation • MPOD data offers countywide data potential for varied uses.

Data requirements have been outlined, together with conceptual methods of data processing and development of a base year mode. The report has also covered demand model functionality and application in forecast mode.

9.2 Conclusions

A viable plan for development of an appropriate transport model has created. The model is currently under development.