Lincoln Eastern Bypass

Local Model Validation Report
(Revised August 2012)

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1 Introduction

1.1 Background

In 2011, Mouchel was commissioned under the Lincolnshire County Council Technical Services Partnership (LCC) to undertake traffic forecasting and scheme appraisal work in support of the Best and Final Bid (BaFB) Business Case for the Lincoln Eastern Bypass. This followed earlier studies prepared by another consultancy to support the original Major Scheme Business Case (MSBC) submission for the scheme in 2009. The scheme was successful in obtaining Programme Entry status in 2011.

1.2 Model Review & Re-calibration

Following the BaFB submission to the DfT in September 2011, the opportunity was taken to enhance and update certain aspects of the traffic model in order to provide a more robust platform for the detailed highway design stages and for subsequent updating of the business case.

These enhancements considered two aspects of the model: the highway network model and the travel demand matrices:

- Issues relating to the network model included the assignment parameters and settings, detailed junction definition and coding and use of the blocking back function.
- The issues with the demand matrices are slightly more fundamental and are concerned largely with the age of the data used to construct the observed elements of the base year matrices, the method of data collection and gaps in the survey cordon.

Improvements to the highway network model were undertaken in 2012 and concerned the enhancement of the network coding and subsequent recalibration of the model, using the original demand data collected in 2006.

In the longer term Mouchel has advised LCC that it is desirable to collect new, up-to-date travel demand data. Due to time constraints associated with major road works on the A46 and the need to collect data during neutral months, the collection of new travel data has been deferred until 2013.

In the mean time, the recalibrated base model will be used as a basis for forecasting and to inform the detailed design process. It should be considered very much as an interim model which will be further improved with the 2013 travel data to ensure compliance with DfT guidance.

1.3 Purpose of this Report

This Local Model Validation Report (LMVR) describes the development of the Greater Lincoln Transport Model and its validation against observed traffic data for 2006, based on criteria set out by the Department for Transport (DfT) in Transport

Appraisal Guidance (TAG) unit 3.19 on Highway Assignment Modelling. It is to be read in conjunction with the GLTM Traffic Survey Report (July 2011), which describes the observed traffic datasets that have been used to build the model.

This report seeks to demonstrate that the model provides an accurate representation of highway travel patterns in the Greater Lincoln area. This document explains the improvements that have been made to the model and also describes the criteria that were adopted during model re-calibration.

1.4 Structure of this Report

This report is structured as follows:

- **Section 2 – Model Overview:** provides a brief summary of the main features of the highway model and also how it has been developed.
- **Section 3 – Traffic Data:** describes the traffic datasets that have been used to develop the model. Further detail on these is provided in the Traffic Survey Report.
- **Section 4 – Network Development:** describes the extent of the highway network included in the model and how it has been developed.
- **Section 5 – Matrix Development:** describes how the trip matrices, which represent travel patterns in the Greater Lincoln area, have been developed. A separate report, GLTM Matrix Build Report, provides fuller details of this process. As part of the recalibration work, factors were applied to certain elements of the BaFB prior matrices to enhance the modelling work and create a more realistic model.
- **Section 6 – Model Calibration:** describes the improvements that were made to the model during the recalibration. It also details the processes that have been undertaken to adjust the transport model so that it reflects travel patterns and conditions in the Greater Lincoln area.
- **Section 7 – Model Validation:** summarises the work undertaken to demonstrate that the model provides an accurate representation of travel patterns in the Greater Lincoln area, including details of comparisons made with independent datasets and its accordance with TAG Unit 3.19 criteria.

2 Model Overview

2.1 Introduction

This section of the report provides a brief overview of the Greater Lincoln Transport Model (GLTM), developed to support the design and evaluation of the Lincoln Eastern Bypass.

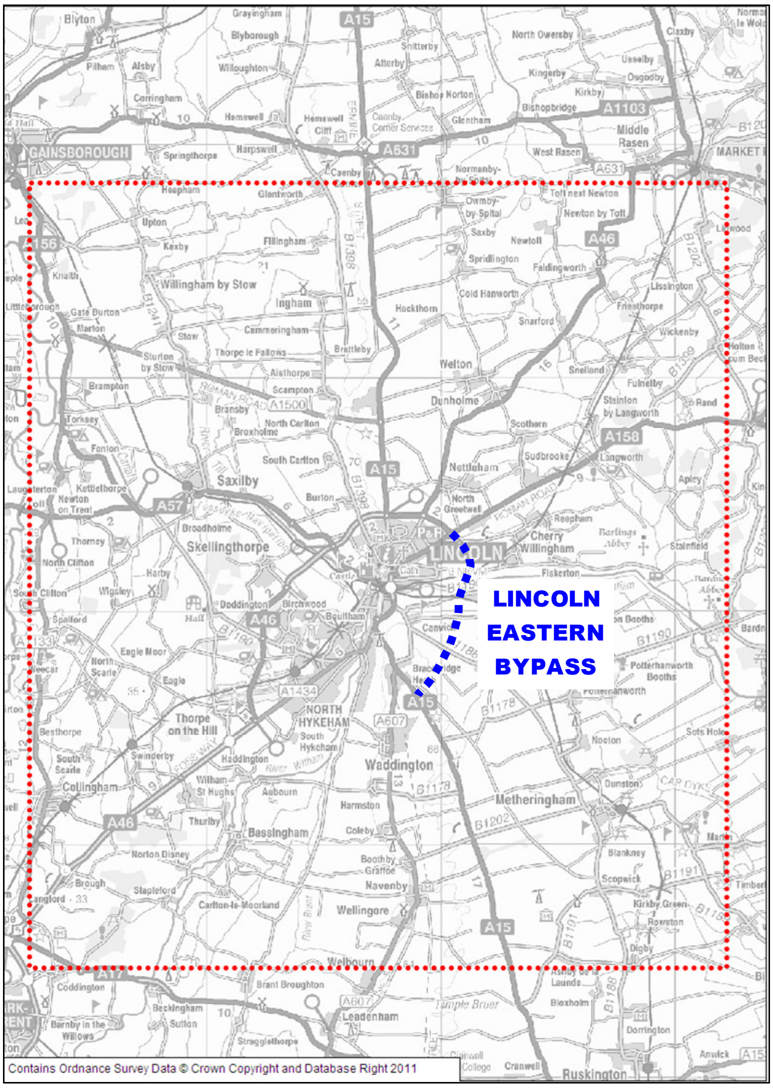
2.2 Modelling Software

The Greater Lincoln Transport Model was developed using PTV VISUM software V12.01-09.

2.3 Study Area

The model covers the urban area of Lincoln and surrounding countryside and broadly aligns with the Lincoln Planning Area (LPA), as shown in Table 2.1**Error! Reference source not found.**.

Figure 2-1 – Study Area



2.4 Zoning System

A zoning system has been developed which covers the whole of the UK. The study area is defined by the Lincoln Planning Area (LPA) and zones within this area are generally much smaller than those outside the LPA. Zones within the study area are known as internal zones and zones covering areas outside the LPA are known as external zones. The zoning system designed for the Greater Lincoln Transport model comprises 174 zones, of which 139 are internal zones and 35 are external zones.

2.5 Modelled Time Periods

Three time periods have been modelled in order to represent the different travel patterns that exist during a typical weekday:

- AM Peak hour (08:00 – 09:00);
- PM Peak hour (17:00 – 18:00);
- Average Inter Peak hour (10:00 – 16:00).

The above AM and PM Peak hours were identified through the analysis of Automatic Traffic Count (ATC) data described in the Traffic Survey Report.

2.6 Vehicle Classes

Three vehicle classes have been modelled; Cars, Light Goods Vehicles (LGVs) and Other Goods Vehicles (OGVs).

2.7 Modelled Highway Network

The study area, known as the simulation area includes junction coding to a high level of detail whilst the network outside the simulation area, known as the buffer network, is less detailed in terms of junction coding and only included links that carry strategic trips.

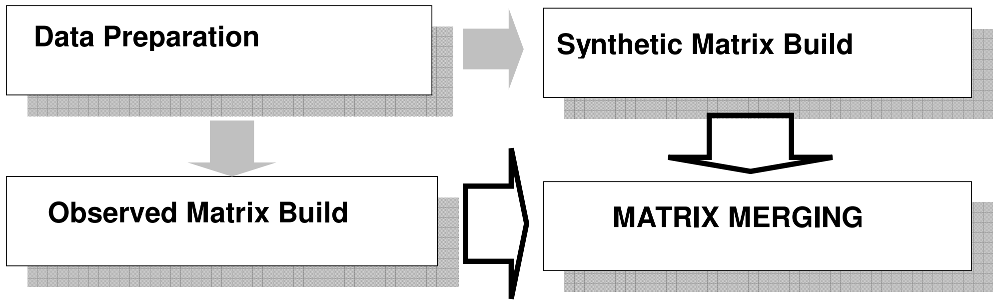
The simulation network includes all ‘A’ and ‘B’ class roads and most minor roads. Within Lincoln, residential roads that act as distributor routes or rat-runs have also been included in the model. The network has been coded in detail to reproduce the effects of traffic queues and delays on vehicle routing patterns.

The buffer area comprises a coarse network of links have been defined to include all major ‘A’ roads; from the A1 in the west to the A153 in the east, and from the M180 in the north to the A52 south. This ensures that all long distance traffic is properly routed into and around the Lincoln area.

2.8 Matrix Development

The process of demand modelling was essentially the same as in the earlier version of the model, albeit based on a comprehensive review of available data sources and their application. Construction of the base year matrices is therefore as illustrated below.

Following analysis of available survey data and other data sources, the principle task included construction of the observed trip matrices, largely from the Lincoln cordon survey, and development of complementary, synthetic matrices to represent the unobserved demand components. The observed and synthetic matrices were merged to form the final base year model demand matrices.



2.9 Model Calibration

The calibration of the Base Year (2006) traffic models was undertaken using an approach where the network was adjusted to ensure that the model realistically replicated routeing and vehicle speeds through the study area. Matrix estimation was then incorporated in the model calibration process in order to improve overall model validation.

2.10 Model Validation

Network validation was undertaken to establish that the network structure was accurate and that characteristics of the network are suitably represented in the model. A number of range and logic checks were undertaken, including routeing checks. Assignment validation was then undertaken for traffic flows (links and turns) and journey times. In all cases, the model compared extremely well with the observed situation, and met the TAG Unit 3.19 validation criteria.

3 Traffic Data

3.1 Introduction

This section provides a summary of the observed data that has been used to develop the model and the analysis that has been undertaken. Fuller details of the traffic data are provided in the Traffic Survey Report (Mouchel, July 2011).

3.2 Overview of Data

This subsection provides a brief overview of the observed traffic data used to build the Greater Lincoln Transport Model. Further detail on this data is provided in Chapter 2 of the Traffic Survey Report.

3.2.1 Postcard Interview Surveys

Postcard Interview Surveys were carried out at 18 locations for a 12 hour period, between 7:00 and 19:00, on one weekday between Monday 2nd October 2006 and Wednesday 29th October 2006. At each site, postcards were distributed to drivers travelling in the inbound direction, with the exception of sites 13 and 14 in the city centre where postcards were distributed to drivers travelling in both directions.

The locations of the interview sites are shown in Figure 3-1. In this plot, Interview sites 1-12 have been used to form a cordon around Lincoln. However, the cordon was not watertight and a number of links cross the cordon but were not included in the interview survey. The analysis of these non-interview sites is described in Chapter 5 of this report. Concurrent 12 hour Manual Classified Link Counts and 2-week, 24 hour ATC Counts were undertaken at each of these sites, with the exception of site 6 where no ATC count is available.

Postcard questionnaires contain the following information:

- Where/ when the postcard is received
- Vehicle occupancy
- Vehicle type
- Purpose of travel
- Origin and destination of the trip
- Household Income

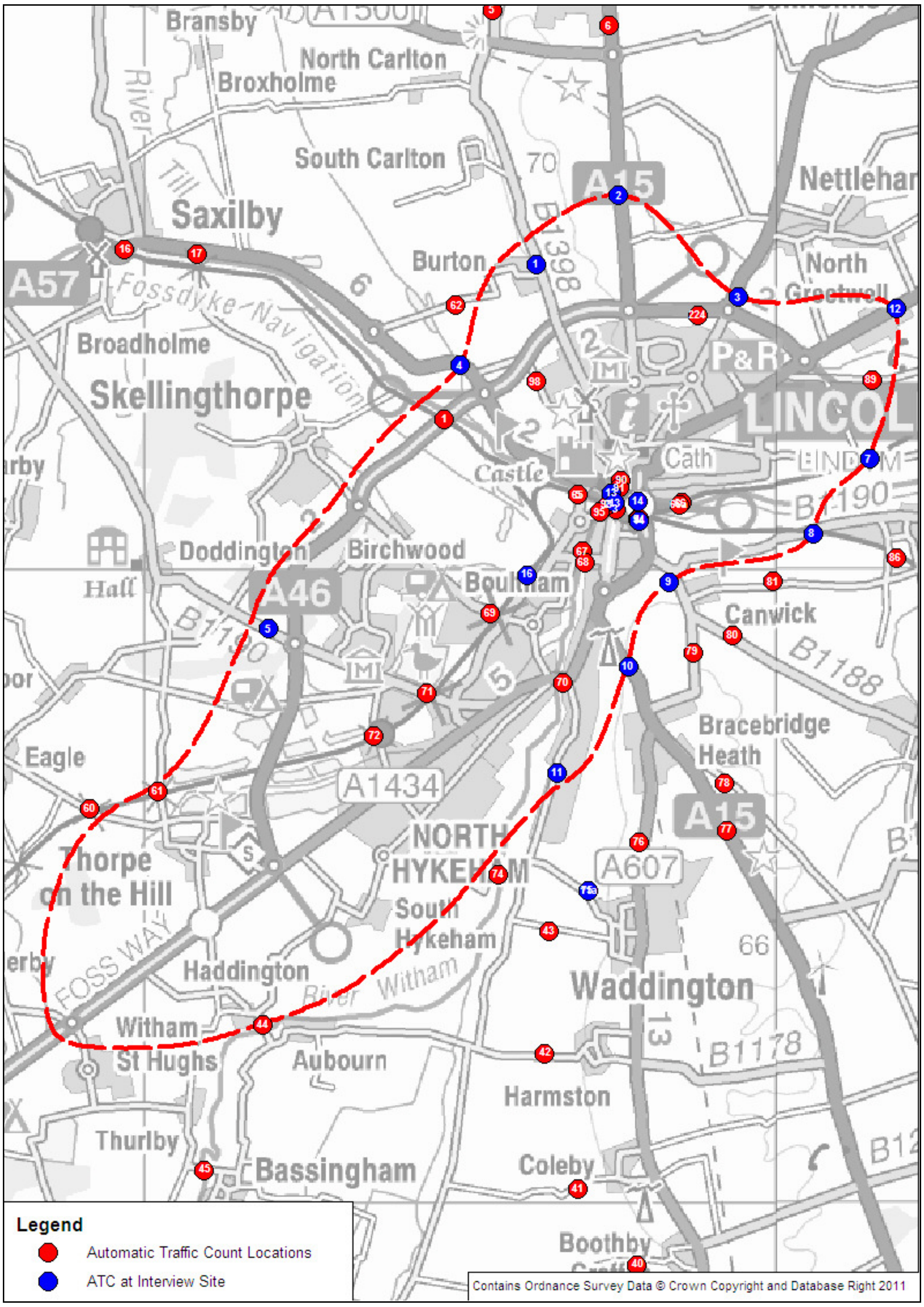
Figure 3-1 – Postcard Interview Sites

3.2.2 *Automatic Traffic Count Surveys*

Automatic Traffic Count (ATC) surveys were undertaken in September and October 2006 at 93 locations in the Greater Lincoln area, 17 of which were at Postcard

Interview sites. Each survey collected 24 hour data in both directions and lasted for a period of 14 days. The locations of the ATC surveys in the immediate vicinity of Lincoln are shown in Figure ***3-2***. This data has been supplemented by an additional 6 ATC sites in the centre of Lincoln, provided by LCC, carried out between 07:00 and 19:00 on one weekday in October/November 2006.

Figure 3-2 – Automatic Traffic Count Surveys

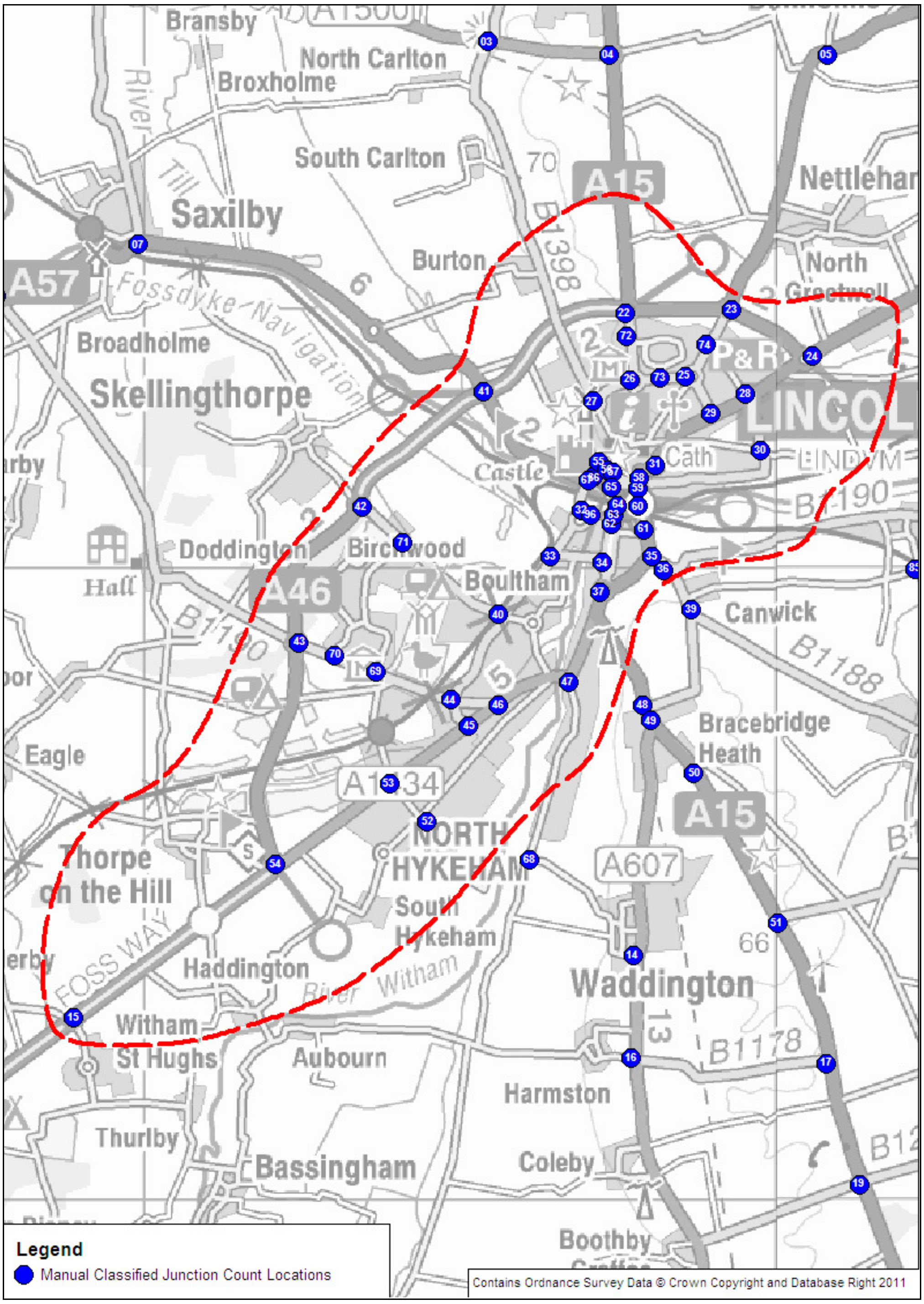


3.2.3 *Manual Classified Junction Count Surveys*

Manual Classified Junction Count (MCJC) surveys were undertaken at 76 junctions within the Greater Lincoln area. Each survey was undertaken on one day in

September, October or November 2006, between 07:00-19:00. The locations of those surveys in the immediate vicinity of Lincoln are shown in Figure 3-3. This data has been supplemented by 13 MCJC surveys carried out in 2006, 2008 and 2011, which have been provided by LCC.

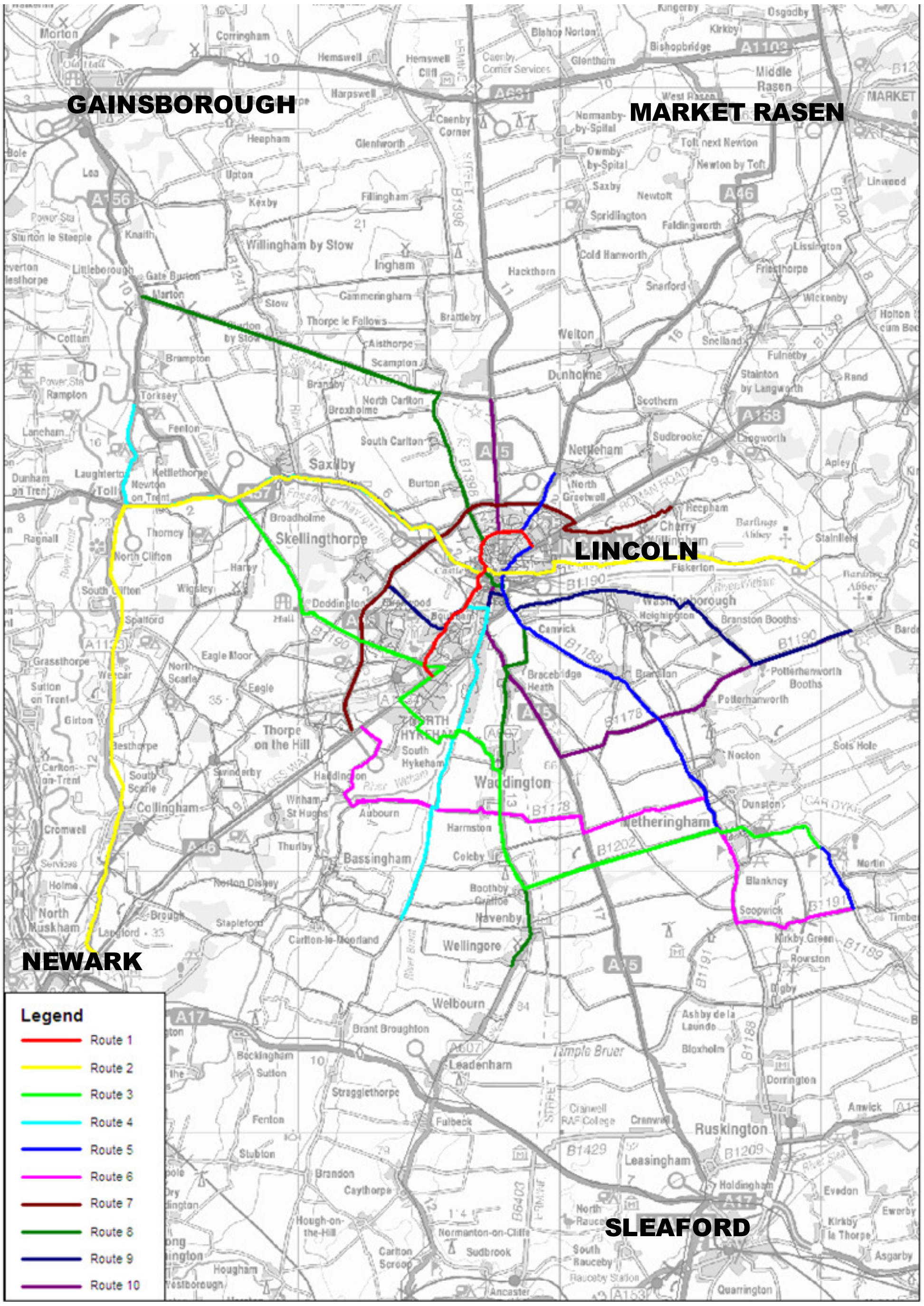
Figure 3-3 – Manual Classified Junction Count Surveys



3.2.4 *Journey Time Surveys*

Trafficmaster journey time data for the year September 2009 to August 2010 was obtained and analysed to extract average journey times in both directions for ten routes described below in Figure 3.4. Travel time data obtained from journey time surveys undertaken in 2006 were available from the original model commission, however, this data was analysed and it was found that the timings on some routes suggested unrealistic speeds, particularly through the city centre. On this basis, it was decided to instead use Trafficmaster data as this data is gathered from a larger and hence more reliable set of observations.

Figure 3-4 – Journey Time Routes



3.3 Overview of Data Analysis

This subsection provides an overview of the processing and analysis of the observed traffic data. More detail on this is provided in Chapter 3 of the Traffic Survey Report.

The processing and analysis carried out is summarised as follows:

- All traffic count data has been standardised into three classifications; Cars, LGVs and OGVs (aggregated to Light Vehicles and Total Vehicles), and each link and turning count has then been allocated to an Anode, Bnode and (where appropriate) Cnode to enable comparison with the model.

- All traffic count data has also been normalised, using a set of Day, Month and Year factors derived from TRADS data, to an "average weekday" in an "average month" in 2006.

- The accuracy of ATC data has been analysed in accordance with TAG UNIT 3.19 12.2.1 and found to have an acceptable level of accuracy. (Further details of this analysis are provided in the Traffic Survey Report).

- ATC average weekday profiles have also been created, which confirm that the AM and PM Peak hours are 8:00-9:00 and 17:00-18:00 respectively.

- Analysis has also been undertaken to produce plots that illustrate traffic flows across screenlines and at junctions.

- The validity of Journey Time data has been checked and average travel times for each route in each direction have been calculated.

3.4 Rationalisation of Traffic Count Data

In order to produce a set of traffic counts that could be used in the model building process, analysis of the count database was undertaken to identify and resolve inconsistencies between multiple traffic counts carried out at similar locations.

The locations of each count were overlaid on the coded model network and a map base and the data compared at common sites. In total, 83 instances were identified where alternative sources of count data were available. In many cases, flow estimates vary from one source to another, so an exercise was then undertaken to analyse the differences in flows and to determine how best to resolve these anomalies.

Adjustments included using average traffic flows across the common sites, using total traffic flows from one survey and classification/ turning proportions from another or selecting one survey over another because of its higher level of reliability. These actions were guided by the following general principles (in order of importance):

- Total traffic flows from ATC sites are more reliable than total traffic flows from MCC sites as they are an average over 8 days as opposed to 1 day.

- Vehicle type proportions from MCC sites are more reliable than those from ATC sites due to the limitations of pneumatic tubes.
- Counts from neutral months in 2006 are considered to be more reliable than counts from other months due to the need to apply larger normalisation factors in the latter cases.

In some instances, up to three data sources are available, for example three turning count surveys at junctions connected by two links. These added an additional layer of complexity to the calculation. In such situations, the reliability of the alternative data sources was afforded the highest rating.

Of the 83 instances of alternative counts data, 19 (~20%) where found to have differences in flow with GEH values greater than 5. However most of these 19 instances involved comparisons between single day surveys and it is therefore considered that, with daily fluctuations and potential survey errors, a degree of inconsistency is to be expected.

A list of the sites with alternative data sources is attached at Appendix A together with descriptions of how each has been resolved.

3.5 Calibration and Validation Counts

Table 3.1 below provides a summary of the allocation of the traffic count datasets to either model calibration or validation. Detailed tables are presented in Appendix B.

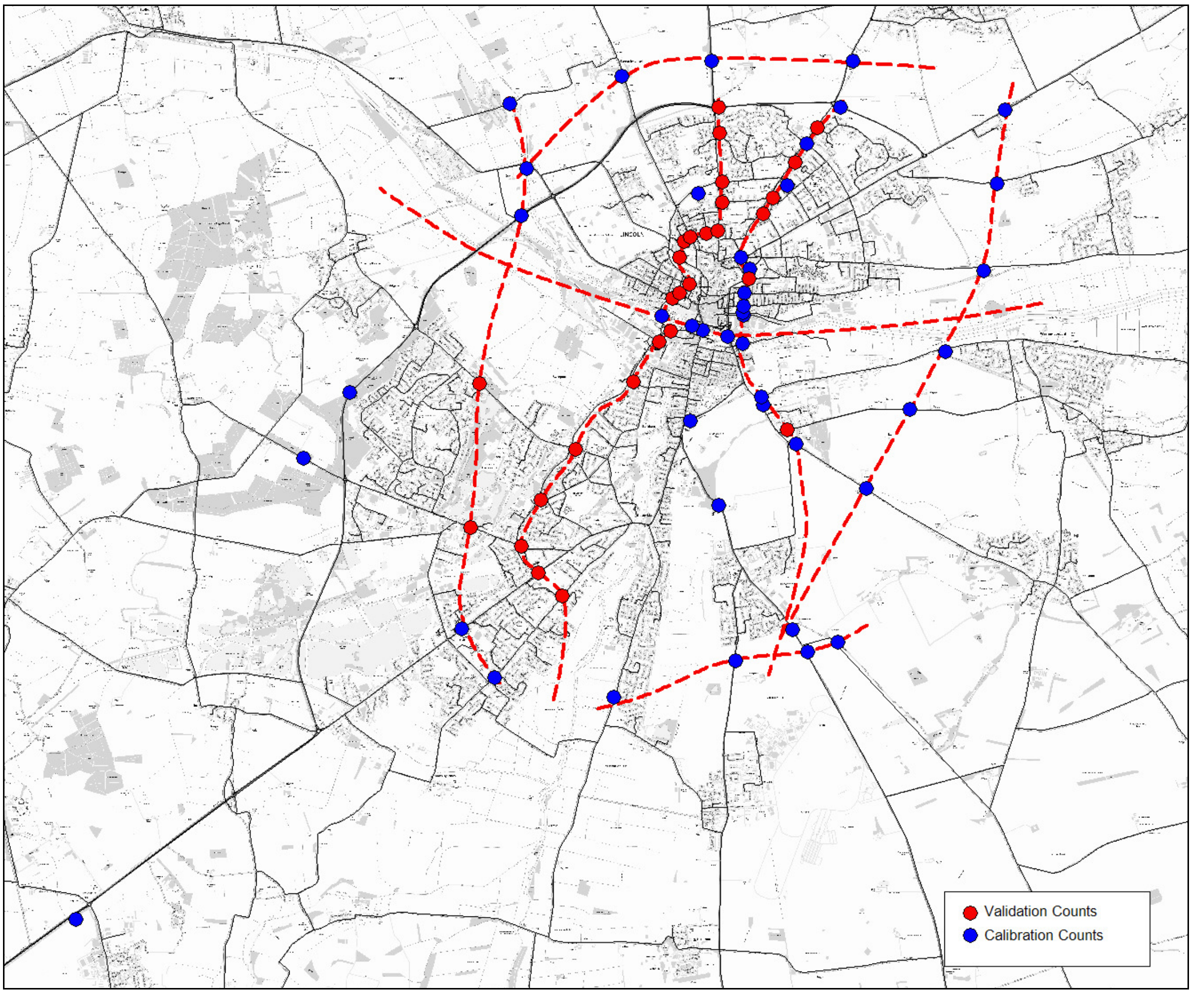
Figure 3.5 and Figure 3.6 show the locations of the calibration and validation counts respectively. A small number of turning counts have been used in both calibration and validation, with individual movements split between the two.

It should be noted that during recalibration of the model, comparisons of observed / modelled flows were focussed mainly on screenline totals and so not all count data was used during recalibration / validation. Further details are provided in Chapters 6 and 7.

Table 3-1 – Calibration and Validation Counts

Type	Count Type	Number
Calibration Counts	Link count	77 **(66%)**
(Validation Counts)	Link count	39 **(34%)**
All Counts	**Total Counts**	**116**

Figure 3-5 –Location of Calibration and Validation Counts and Screenlines



4 Network Development

4.1 Introduction

The road network represents the supply side of the modelling process, i.e. what the transport system offers to satisfy the movement needs of trip makers in the study area. The network is a system of nodes, representing junctions, which are connected by a number of links, which represent homogeneous stretches of road between junctions.

This section of the report describes the steps that have been taken to develop the highway network for the Greater Lincoln Transport Model.

4.2 Highway Network Definition

The modelled network provides an accurate representation of the existing highway network in Lincoln and its surrounding area.

Inside the study area it includes all ‘A’ and ‘B’ class roads and most of the minor roads within Lincoln. Residential roads that act as distributor routes have also been included. All junctions within the study area have been coded in detail in order to reproduce the effects of traffic queues and delays on vehicle routing patterns.

Outside the study area, a coarse network of buffer links has been defined to include all major ‘A’ roads; from the A1 in the west to the A153 in the east, and from the M180 in the north to the A52 in the south. This ensures that all long distance traffic is properly routed into and around the Lincoln area. The coverage of the Highway Network is shown in Figure 4.1 below.

4.3 Network Inventory

The network was developed using a combination of aerial photographs and site surveys. Junction layouts, number of lanes and turn priority markers were coded using aerial photographs.

As part of the model review/ update in 2012, all links included in the networks were reviewed and street level imagery used to determine whether each link is likely to carry traffic volumes significant enough to be included in the traffic model. This resulted in changes to the configuration of the network, particularly in rural areas where certain narrow lanes that were previously included in the network were removed. Conversely, certain links deemed likely to carry high volumes of traffic were added to the network.

4.4 Node / Link Coding and Speed Flow Curves

All nodes were geo-coded using 1:10K raster maps. All link lengths for the model were checked from OS mapping with scale of 1:10,000. Roads are modelled as links in VISUM and links were assigned correct distances. A suitable speed-flow curve was also assigned for each link based on road type, number of lanes, speed limits, etc.

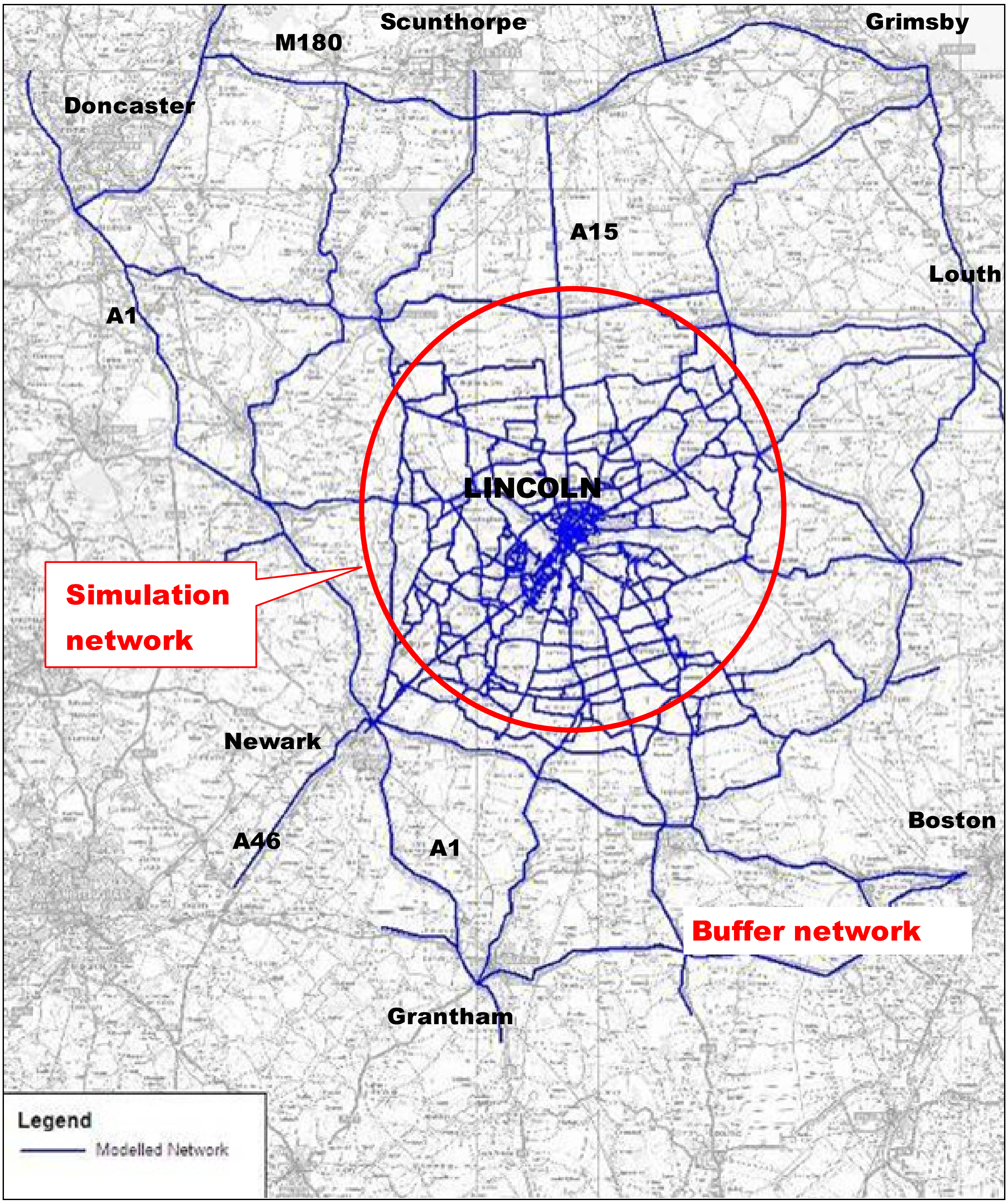
Information about all roads within the study area was gathered from the network inventory. This information included; type of road (urban, suburban, or rural, etc.), road classification (single, dual carriageway), speed limits and number of lanes of all the roads within the study area. The information was used to allocate the appropriate speed-flow curves to all the modelled links. A list of the speed-flow curves used for GLTM is presented in Appendix C.

The network coverage includes all the main roads to and from Lincoln. The wider network extends from Louth in the east to Retford in the west and from Boston and Grantham in the south to Grimsby and Doncaster in the north.

Major routes into Lincoln city centre include the A1434 Newark Rd and A15 Sleaford Rd to the south of Lincoln; A15 Riseholme Rd and A46 Lincoln Rd to the north; A57 Saxilby Rd to the west; and A158 Wragby Rd to the north east.

The network contains two main parts: simulation network in which junction/delay is modelled in detail and buffer network in which links are modelled only. Simulation network and buffer network are marked in Figure 4-1.

Figure 4-1 – Highway Network Coverage



4.5 Junction Modelling

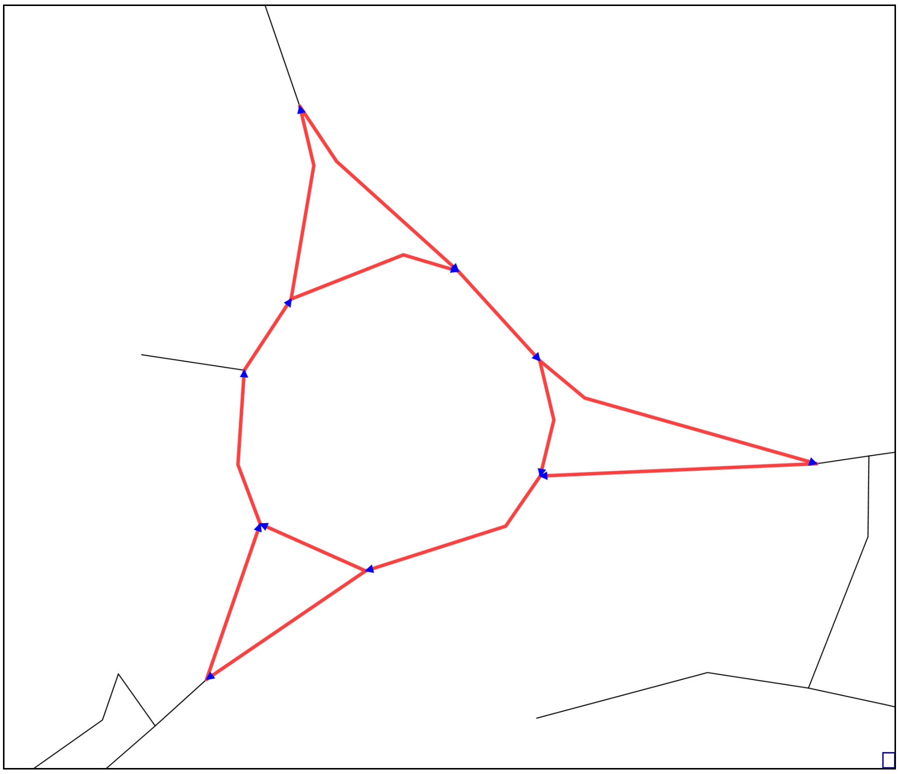
In order to represent the effects of traffic delays and queues at junctions, junctions have been modelled in detail to take into account traffic flows and conflicting movements. Each junction has been coded using detailed information from the highway network, which includes:

- **Priority Junction Modelling:** Priority junctions were modelled using the node impedance function (ICA function) within the study area network. Within the VISUM software, there are several methods of modelling junction performance but the ICA method involves calculation of junction capacity to the highest level of detail (i.e. it includes consideration of opposing turns).

- **Network Checking:** “Network Check“ function within the VISUM suite was used to ensure that junctions were correctly coded for the ICA function to work correctly. Junction geometries were adjusted during the calibration/validation process taking into account attributes such as lane widths, number of lanes and lane marking of the junction.

- **Roundabout Modelling:** All roundabouts within the study area were modelled in detail. Capacities of roundabouts were calculated on the basis of the geometry of the roundabouts using the ICA junction modelling function. Large roundabouts and gyratory were coded using the composite nodes. The “Main Nodes” function within VISUM was applied to large roundabouts so that their capacities were calculated as if they were a single junction. An example of a roundabout modelled using composite nodes is shown in Figure 4.2.

Figure 4-2 Example of a modelled roundabout junction



4.6 Signalised Junction Modelling

All signalised junctions inside the study area have been modelled in detail. Signal specifications, which contained details of phase, stages and inter-green timings, have been provided by Lincolnshire County Council and converted into the format required by VISUM for the three model time periods (AM, Inter Peak and PM).

In VISUM signal timings are entered using a number Signal Groups, which are created to represent the individual movements that occur at a junction. The starting and ending green time for each signal group must then be specified along with a total cycle time and offset should it be required. An example signalised junction is shown in Figure 4-3.

The locations of signalised junctions in Lincoln are shown in Figure 4-4.

Outside the city centre all signalised junction are much further apart and so have been assumed to operate independently. Initial starting and ending green times and a cycle time have therefore been calculated for each junction under the assumption that phases run to their maximum allowed green times in the AM and PM Peak hours and to their average green times in the Inter Peak.

Figure 4-3 – An example of signalised junction coded in VISUM

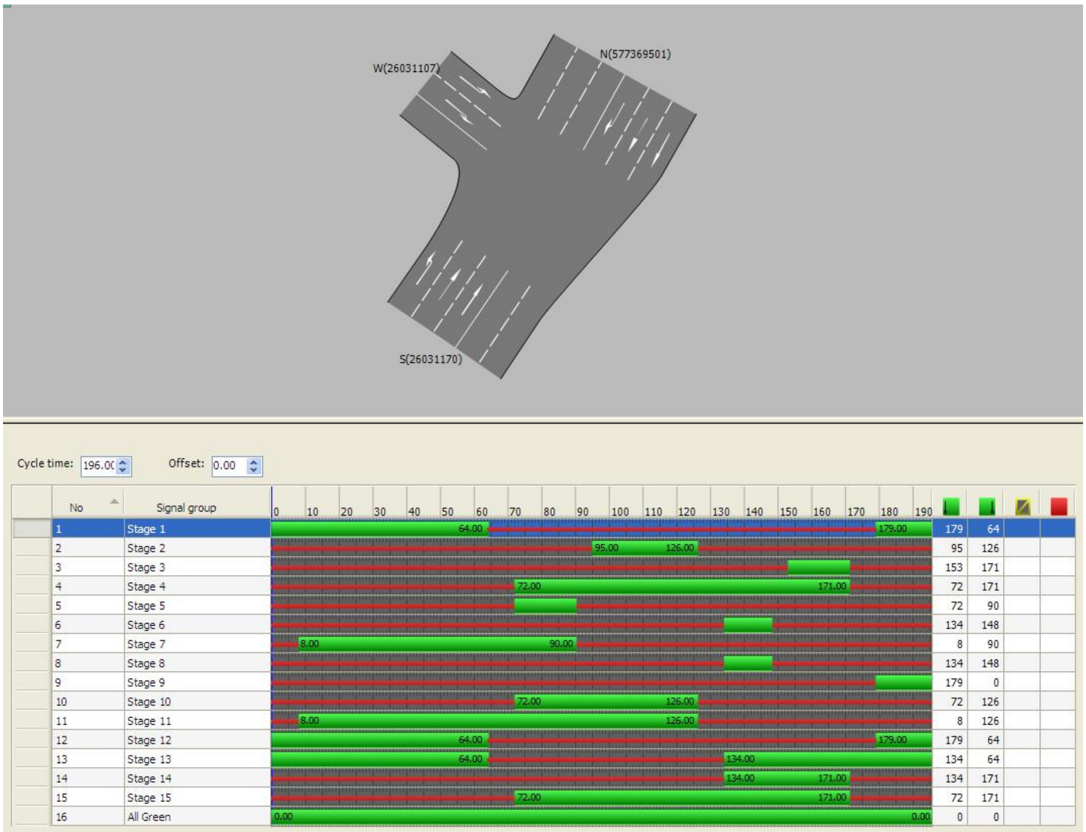


Figure 4-4 – Signalised junction Locations in Lincoln

4.7 Enabling of Blocking Back Function

In the previous version of the calibrated base model, the blocking back function was not activated. Blocking back models the effect that queues from a congested junctions have on traffic flows at junctions upstream of the congested junction. When blocking back is activated, queues are prevalent in the network and it is possible to compare the modelled queue patterns against the local knowledge as an independent realism check. Blocking back has now been activated and the model displays queues along congested roads.

In the recalibrated model, blocking back has been calculated taking into account two limiting capacities:

- Link capacity
- Turn capacity (final capacity from junction modelling)

The average space required per car unit is set at 7m.

4.8 Zone (Centroid) Connectors

The loading of traffic onto the network from zones is achieved through centroid connectors at appropriate locations.

The loading points and types were reviewed carefully for each zone. The distance for the connector was calculated from plans/maps. The appropriate speed was then assigned based on the network characteristics of the zone.

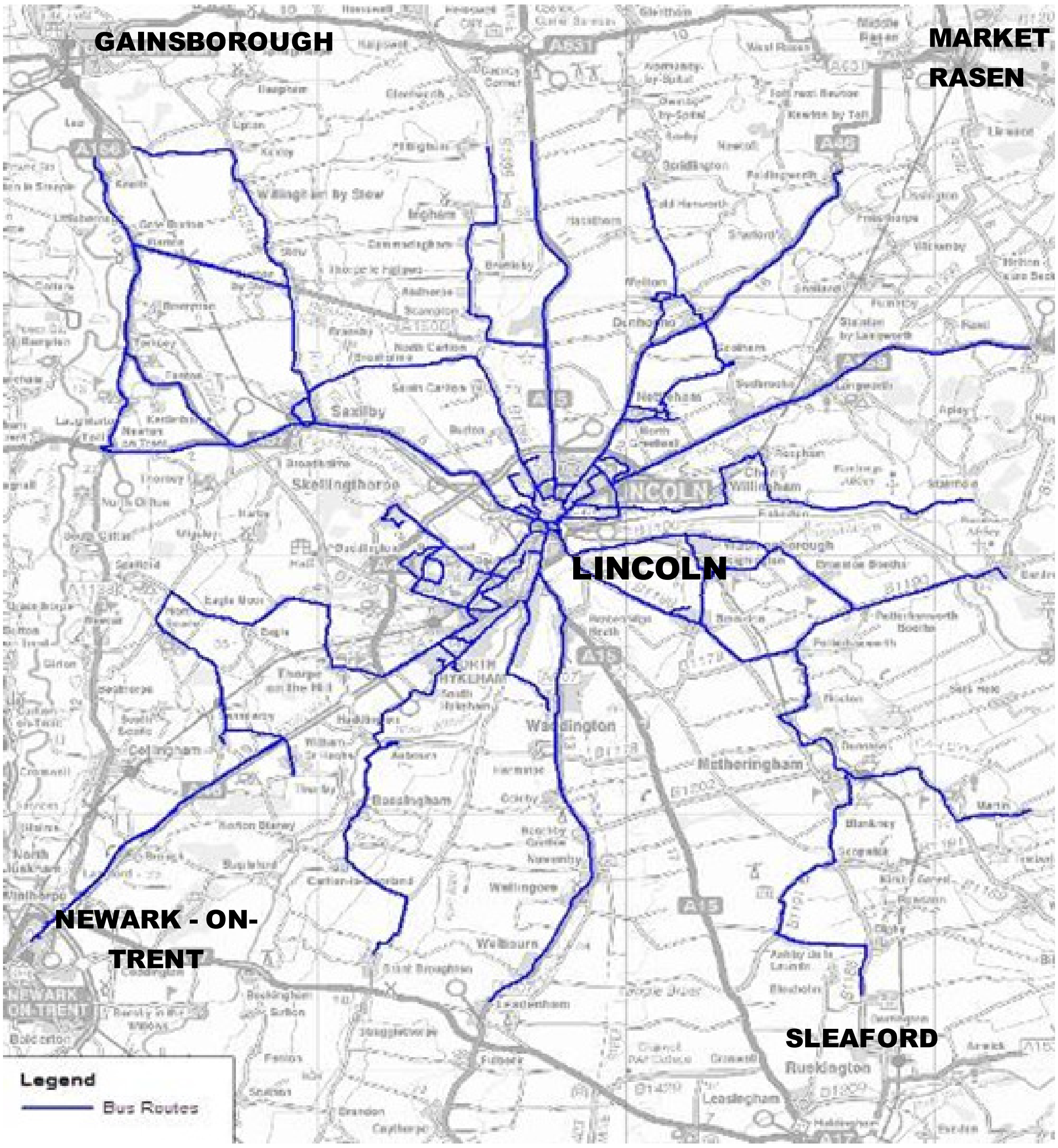
For external zones (outside the simulation area), loading points were attached to the appropriate locations at the edge of the buffer network. The distance and speed for these connectors have been estimated using GIS. Fuller details of the zoning system are provided in Appendix D.

4.9 Bus Routes

Public bus services have been represented in the model so that the effect of buses on link and junction capacities can be taken into account. Bus routes and frequencies for each time period (AM, IP, PM) have been coded into the network using data from the Public Transport Information Section of the Lincolnshire County Council website. Buses were assigned as a fixed preload prior to the assignment of other vehicle matrices.

Figure 4-5 shows the coverage of bus routes. Detailed bus routes are shown in Appendix E.

Figure 4-5 – Bus Routes Coverage



4.10 Inclusion of Effects of Level Crossings

A rail line runs through of the centre of Lincoln, which dissects several links in the network at level crossings but the previous version of the base model did not include the effect that the level crossings have on the network capacity. During the recalibration, level crossings have been coded at the following seven links in the network:

- B1378 Skellingthorpe Road
- B1190 Doddington Road
- Station Rd, Hykeham
- Thorpe Road
- Thorpe Lane
- Swinderby Road
- A1133 High St

The level crossings were coded into the network as signalised junctions with two stages; all green to represent the crossing being open and all red to represent the crossings being closed to traffic. Junctions representing level crossings were given consistent signal timings to simulate the effects of the rail line. Signal timings were adjusted so that modelled traffic flows reflected observed traffic flows along links with level crossings.

4.11 Network Checks

The previous model included a large number of unnecessary nodes, arising from the use of NAVTEQ tiles to build the original Jacobs model. The number of nodes was reduced from 4,160 to 1,498 and the number of links reduced from 6,298 to 3,788. Reducing the number of links and nodes results in a tidier network, makes the network easier to edit and reduces the model assignment time.

In coding the network, a number of checks were carried out on the network in order to demonstrate its robustness in replicating the highway network. These checks included:

- Checking the routes through the network, produced by a standard path building algorithm by assigning a unity matrix;
- Checking the physical characteristics of the coded network (junction type, number of arms and lanes, lane usage);
- Checking of properties assigned to the network (distances, speeds, saturation flow for each turning movement, speed flow curves);
- Checking the loading points of every zone;
- Checking zone to zone distances;
- Checking that bus routes/ bus frequencies are coded properly;
- Comparing the observed and modelled distances of the journey time routes (see Appendix H);
- Range of network routeing forests (see Appendix J)

5 Matrix Development

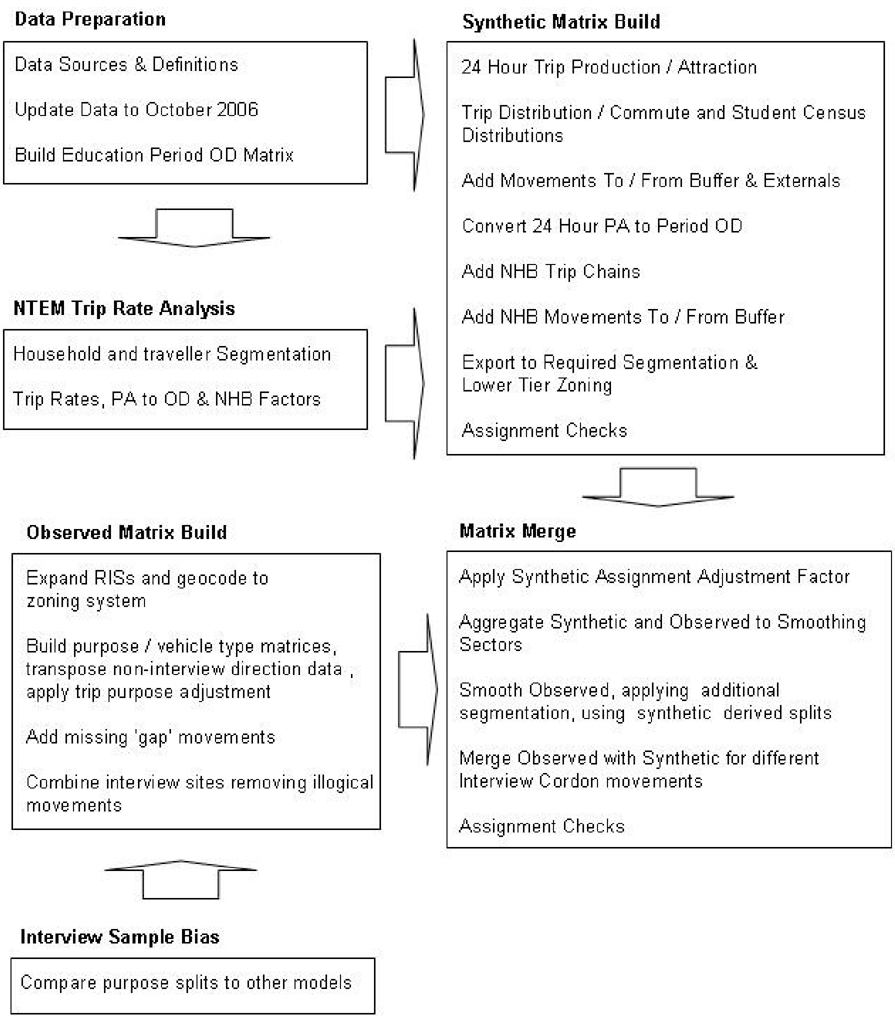
5.1 Introduction

The process of rebuilding the Base Year matrices is illustrated in Figure 5-1 and included the following principal stages:

- Data preparation and analysis
- Synthetic matrix build
- Observed matrix build; and
- Matrix merging.

This chapter discusses the matrix building steps briefly. Greater details of the matrix building process are provided in the GLTM Matrix Build Report, June 2011.

Figure 5-1 - Matrix Build Process



5.2 Data Preparation and Analysis

The synthetic build used established procedures and datasets. Key to this process was the preparation of data to represent GLTM zoning. This included considering a number of key boundaries. For the synthetic matrices the Internal area used the Lincoln Policy Area (LPA) and included 139 zones. Within the Internal area detailed land use data was prepared. This area represented an area where productions and attractions were assumed largely self-contained with regards to general daily trip making and included ODs that may be significantly affected by the proposed Lincoln Eastern Bypass (LEB). The Internal area also contained the main highway network detail.

Within the Internal area the Interview Cordon represents the cordon around the Lincoln conurbation defined by the location of interview surveys. This is an important boundary for the merging of observed and synthetic matrices.

The Internal area was surrounded by a number of Buffer zones that had finite boundaries and contained areas that are expected to be influenced by the introduction of LEB. This Buffer area included only strategic highway network. Around the Buffer network are a number of External zones that represent the rest of the UK. These zones only connect to the strategic highway network and have no network of their own. They represent assumed strategic highway movement catchments, for example the A1 South to North.

The previous work included the data collection of all required interview records, traffic counts and journey time data. Interview records were subject to a rigorous checking and cleaning process. Also, all traffic counts were normalised to a neutral 2006 average weekday, checked for outliers where multiple observations were available, and checked for consistency with adjacent counts.

As well as 2001 Census data and data from the National Trip End Model (NTEM), reported through TEMPRO, new datasets used in the matrix build, including:

- Census Area Statistics (CAS) household and population data;
- NTEM 6.2 trip rates;
- Pupil Level Annual Student Census (PLASC), college and university student data including home postcode and mode of travel;
- total employment and retail employment Annual Business Inquiry (ABI) data; and
- DfT freight annual tonnage data.

The majority of the effort in data cleaning has been associated with the interview data. This included the following tasks:

- interview data coded using Land Use Segmentation indexing;

- sample manual checks on interview records;
- missing postcodes derived from address or location details where possible;
- range checks on answer indexing;
- interview records converted to database format;
- trip origins and destinations converted from postcodes to OSGRs and plotted in MapInfo with illogical points checked and corrected or removed as required; and
- manual classified counts compared to ATCs and converted to database format.

All traffic count data has been normalised to a neutral 2006 month, assumed as November 2006 where necessary, and reformatted into a Microsoft (MS) Excel spreadsheet that contains the cordon / screenline / key junction reference, the Highway Assignment Model (HAM) node numbers, a location description and the Travel Segmentation model hour based vehicle flows. For ATC data the counts were reformatted to allow them to be imported into a MS Access database and averaged as necessary.

5.3 Observed Matrix Build

In order to model the trip patterns of vehicles entering the Lincoln Planning Area (LPA), postcard interview surveys were undertaken at several of the main routes into the study area, forming the basis of the interview cordon. This section describes the analysis that was involved in developing observed matrices from the postcard interview data. The cordon also includes minor road links for which postcard interviews were not conducted and their analysis is also described in this section.

The sites that formed the interview cordon are shown below in Figure 5-2 below.

Figure 5-2 – Postcard Interview Locations

5.3.1 Postcard Interview Data – Cleaning Process

The postcard interview data consisted of respondent's answers to the interview questions plus Ordinance Survey Grid References (OSGR) for the trip origin and destination locations. The OSGR data was used to append a set of zone numbers and analysis cordons to each postcard record. The initial stage in the interview analysis was to process and clean the interview and count data. This process began by importing the postcard interview data supplied by LCC to MS Access.

The initial process of cleaning the data involved removing any records that had blank origin or destination data. Any records where the origin and destination postcodes were identical were also discarded. Records with an illogical purpose were also discarded, e.g. where origin purpose and destination purpose were both stated as home.

Records with a vehicle type listed as pedal cycle or motorcycle were not to be included in the highway assignment model and so were discarded. Any records with a missing interview time or with an illogical journey direction (e.g. a home based trip with vehicle type equal to OGV) were also discarded.

Crow fly distances were calculated between origin point to destination point (O-D) and also between origin point to interview site point to destination point (O-I-D). It was considered that where the O-I-D distance was greater than three times the O-D distance, then this signified some illogical routing and records were discarded.

Zones within the GLTM have been aggregated to create analysis cordons. Analysis cordons 1 to 15 represent zones in the LPA, whilst analysis cordons 16 to 20 largely represent zones in the rest of Lincolnshire and analysis cordon 21 represents the rest of the UK. Any illogical cordon-to-cordon movements were identified and those records were removed from the data set. Table 5-1 shows the number of interview records discarded during each stage of the cleaning process.

Table 5-1 – Breakdown of Records Lost through Cleaning Process

Initial Interview Records	**9,055**
Interviews discarded due to missing origin details	278
Interviews discarded due to missing destination details	385
Interviews discarded due to identical origin and destination details	289
Interviews discarded due to error in purpose	25
Interviews discarded due to error in vehicle type	23
Interviews discarded due to error in time element	8
Interviews discarded due to error in distance factor	3
Interviews discarded due to record having distance factor >3	103
Interviews discarded due to Illogical movement relative to interview direction	718
Total Percentage of Interview Data Discarded	**20.2%**
Interview Records After Cleaning Process	**7,223**

5.3.2 *Expansion and Transposition of Postcard Interviews*

At each of the postcard interview sites, ATC data and MCLC data was collected in both directions. For each site, the ATC data consisted of at least two weeks of data, whilst for the MCLC data usually a single classified 12-hour count was available. All the counts were normalised to a neutral 2006 count, based on day and month.

The counts that were used in the expansion process adopted the vehicle proportions observed through MCLC data but the counts were ultimately controlled to the normalised ATC counts. In order to avoid using count data from faulty ATC equipment, any ATC counts that were more than two standard deviations from the mean were identified and excluded when calculating averages.

Due to a low rate of postcard return across all vehicle types, expansion of the postcode records was undertaken for the period from 0700 to 1000 hours for the AM peak, and from 1600 to 1900 hours for the PM peak.

Low return rates for LGVs and HGVs were especially prevalent at interview sites 6, 9 and 12 and so records from the full 12-hour interview period were used in the AM and PM peaks. All interview direction purpose splits were controlled back to the hour-specific purpose split.

Postcard interviews were distributed in the inbound (to the city centre) direction at the Lincoln cordon. To expand interview records to counts in the outbound direction, interview records were transposed by swapping origin and destination zones and adjusting time periods. Records collected in the AM period were assigned to the PM period for the non-interview direction and vice versa. Records collected in the inter-peak only had their origin and destination zones swapped.

The transposed interview data was adjusted so that the specific hour purpose splits were correct according to the interview direction splits. Table 5-2 presents a comparison between the observed purpose split across the cordon and the adjusted transposed purpose split.

Note - In the table below, HB stands for Home Based refers to a trip where either the origin or destination is residential in purpose. Any trip with an origin or destination which is not residential in purpose is termed Non Home Base (NHB).

Table 5-2 – Cordon Wide Purpose Split (Interview/Non-Interview Direction)

Modelled Hour	Purpose	Purpose Split Interview Direction	Purpose Split Non-Interview Direction
		AM Peak Period	
1	HB Commute	0.495	0.471
2	HB Education	0.032	0.037
3	HB Shopping	0.094	0.090
4	HB Other	0.054	0.057
5	HB Emp Bus	0.058	0.063
6	NHB Emp Bus	0.055	0.051

Modelled Hour	Purpose	Purpose Split Interview Direction	Purpose Split Non-Interview Direction
7	NHB Other	0.071	0.072
8	LGV	0.103	0.110
9	OGV	0.034	0.044
	AM Peak Period Total	**1.000**	**1.000**
Inter Peak Period			
1	HB Commute	0.106	0.108
2	HB Education	0.011	0.011
3	HB Shopping	0.230	0.227
4	HB Other	0.146	0.146
5	HB Emp Bus	0.056	0.057
6	NHB Emp Bus	0.091	0.091
7	NHB Other	0.121	0.121
8	LGV	0.144	0.144
9	OGV	0.091	0.092
	Inter-Peak Period Total	**1.000**	**1.000**
PM Peak Period			
1	HB Commute	0.362	0.361
2	HB Education	0.012	0.008
3	HB Shopping	0.058	0.062
4	HB Other	0.166	0.189
5	HB Emp Bus	0.094	0.086
6	NHB Emp Bus	0.023	0.022
7	NHB Other	0.112	0.109
8	LGV	0.128	0.124
9	OGV	0.040	0.034
	PM Peak Period Total	**1.000**	**1.000**

Table 5-3 below summarises the average expansion factors that were derived during each model period.

Table 5-3 – Average Expansion Factors derived for Interview Data

Time Period	Vehicle Type	Expansion Factor	
		Interview Direction	Non Interview Direction
AM Peak	Car	3.4	3.0
	LGV	7.0	9.4
	OGV	9.2	9.6
Inter Peak	Car	1.3	1.4
	LGV	6.2	6.5
	OGV	6.5	6.8
PM Peak	Car	3.8	3.4

	LGV	8.3	7.3
	OGV	7.8	5.7

5.3.3 *Non-Interview Sites*

The Lincoln cordon is made up of a total of 25 links, 12 of which were included in the postcard interview survey and the remainder were non-interview sites. Traffic count data was available for 9 of these non-interview sites and further 4 minor roads were judged to carry insignificant levels of flow and were not therefore included in the original survey coverage. Vehicles on the non-interviewed links represent a relatively small proportion of trips crossing the cordon, as shown in Table 5-4 below.

Table 5-4 – Summary of Count Data on Interview Cordon

Site Type	AM Peak hour		Average Inter Peak hour		PM Peak hour	
	Flow	%	Flow	%	Flow	%
Interview Site	13,211	82%	9,858	86%	13,996	82%
Non-Interview Site	2,986	18%	1,570	14%	2,981	18%
Total	16,197		11,428		16,977	

For each non-interview site with count data available, trips were in-filled by creating all-vehicle select link analysis (SLA) matrices at each link and in both directions using the previous incarnation of the base model. These have then been cleaned in a similar fashion to the postcard interview data to discard any illogical movements. The matrices were then segmented by purpose by applying the observed cordon-wide purpose splits from the observed records. Segmented matrices were then controlled to the normalised count data and person trips were calculated by applying the average vehicle occupancy for each purpose.

Count data was unavailable for four of the sites shown as gaps in Figure 5-2. However, Lincolnshire CC confirmed the flows on these links were considered to be low (in the region of 600 vehicles per week) and so omitting them from the matrix building process would have an insignificant effect on trip patterns crossing the cordon.

5.3.4 *Merging of Expanded Postcard Records and SLA Matrices*

A factor was applied to each record that removed the potential for double counting. If a trip is fully observed and only crosses the cordon once, it maintains a factor of 1.0. Any trips that are partially observed or are likely to cross the cordon twice or three times were assigned a factor of 0.5 or 0.333 respectively. The analysis cordons and road layouts were used to assign factors to each analysis cordon to analysis cordon movement.

Once the postcards interview records and SLA matrices had been expanded they were merged to create one matrix of cordon crossing movements for each of the three modelled hour periods; 0800 to 0900, 1000 to 1600 average hour and 1700 to 1800. Table 5-5 shows the person trip and vehicle trip totals by modelled hour and direction.

Table 5-5 – Merged Vehicle & Person Trip Totals

Direction	Time Period	Vehicle Trips	Person Trips
Interview Direction	AM	7,321	9,355
	IP	4,226	6,299
	PM	4,593	6,298
Non-interview Direction	AM	4,118	5,709
	IP	4,334	6,438
	PM	7,080	9,608

5.3.5 Assignment Check of Observed Matrices

In order to check the accuracy of the observed matrices described in the sections above, these matrices were assigned to the highway model network. With only partially observed study area matrices, the network will be relatively uncongested and speeds unrealistically high. However, the assignment does provide an initial indication of how well the observed trips assign to the links on which they were recorded.

The results of these assignments are summarised in Tables 5-6 and 5-7 which compare modelled and observed flows in each modelled period and for inbound and outbound cordon flows. These show that the modelled flow crossing the cordon is lower than that observed. This is to be expected as some of the assigned traffic will not cross the cordon but seek alternative routes when the network is not fully unloaded.

Table 5-6 - Assignment Check of Observed Matrices (Inbound direction)

Site Number	AM				IP				PM			
	Observed counts (veh)	Modelled counts (veh)	Diff	% Difference	Observed counts (veh)	Modelled counts (veh)	Diff	% Difference	Observed counts (veh)	Modelled counts (veh)	Diff	% Difference
RSI01	641	249	-392	-61.2	186	111	-75	-40.3	276	171	-105	-38.0
RSI02	758	626	-132	-17.4	392	188	-204	-52.0	502	302	-200	-39.8
RSI03	1036	1559	523	50.5	549	947	398	72.5	563	992	429	76.2
ATC62	110	39	-71	-64.5	41	6	-35	-85.4	110	10	-100	-90.9
NA	41	41	0	0.0	1	1	0	0.0	1	0	-1	-100.0
RSI07	561	484	-77	-13.7	169	280	111	65.7	120	172	52	43.3
RSI08	441	363	-78	-17.7	224	196	-28	-12.5	290	186	-104	-35.9
RSI09	1117	999	-118	-10.6	608	630	22	3.6	579	673	94	16.2
RSI10	454	756	302	66.5	432	445	13	3.0	446	612	166	37.2
RSI11	415	409	-6	-1.4	306	187	-119	-38.9	400	217	-183	-45.8
RSI11a	328	136	-192	-58.5	206	88	-118	-57.3	379	180	-199	-52.5
RSI12	607	583	-24	-4.0	513	211	-302	-58.9	511	291	-220	-43.1
near 12	491	91	-400	-81.5	490	37	-453	-92.4	54	54	0	0.0
ATC74	438	327	-111	-25.3	202	212	10	5.0	343	251	-92	-26.8
ATC44	413	382	-31	-7.5	128	160	32	25.0	216	241	25	11.6
ATC45	71	86	15	21.1	34	69	35	102.9	48	94	46	95.8
NA	1	0	-1	-100.0	1	0	-1	-100.0	1	0	-1	-100.0
RSI04	642	739	97	15.1	487	357	-130	-26.7	556	508	-48	-8.6
RSI05	326	395	69	21.2	192	255	63	32.8	261	354	93	35.6
RSI06	1290	811	-479	-37.1	815	557	-258	-31.7	1244	889	-355	-28.5
TC15	101	0	-101	-100.0	77	33	-44	-57.1	104	0	-104	-100.0
ATC60	37	35	-2	-5.4	32	31	-1	-3.1	42	43	1	2.4
ATC61	106	49	-57	-53.8	50	10	-40	-80.0	96	18	-78	-81.3
L115	154	22	-132	-85.7	1	3	2	200.0	91	16	-75	-82.4
TC42	422	420	-2	-0.5	214	253	39	18.2	274	260	-14	-5.1
	11001	**9601**	**-1400**	**-12.7**	**6350**	**5267**	**-1083**	**-17.1**	**7507**	**6534**	**-973**	**-13.0**

Table 5-7 Assignment Check of Observed Matrices (Outbound direction)

Site Number	AM				IP				PM			
	Observed counts (veh)	Modelled counts (veh)	Diff	% Difference	Observed counts (veh)	Modelled counts (veh)	Diff	% Difference	Observed counts (veh)	Modelled counts (veh)	Diff	% Difference
RSI01	166	98	-68	-41.0	180	112	-68	-37.8	573	268	-305	-53.2
RSI02	436	228	-208	-47.7	412	181	-231	-56.1	436	228	-208	-47.7
RSI03	652	959	307	47.1	525	929	404	77.0	652	959	307	47.1
ATC62	1036	1559	523	50.5	549	947	398	72.5	1036	1559	523	50.5
NA	1	0	-1	-100.0	1	1	0	0.0	1	0	-1	-100.0
RSI07	122	177	55	45.1	188	268	80	42.6	122	177	55	45.1
RSI08	123	185	62	50.4	166	198	32	19.3	123	185	62	50.4
RSI09	572	642	70	12.2	719	646	-73	-10.2	572	642	70	12.2
RSI10	310	427	117	37.7	404	499	95	23.5	310	427	117	37.7
RSI11	268	115	-153	-57.1	303	150	-153	-50.5	268	115	-153	-57.1
RSI11a	374	137	-237	-63.4	214	108	-106	-49.5	374	137	-237	-63.4
RSI12	471	223	-248	-52.7	530	224	-306	-57.7	471	223	-248	-52.7
near 12	247	55	-192	-77.7	576	53	-523	-90.8	247	55	-192	-77.7
ATC74	271	179	-92	-33.9	213	173	-40	-18.8	271	179	-92	-33.9
ATC44	196	242	46	23.5	123	141	18	14.6	196	242	46	23.5
ATC45	33	93	60	181.8	44	53	9	20.5	33	93	60	181.8
NA	1	0	-1	-100.0	1	0	-1	-100.0	1	0	-1	-100.0
RSI04	340	429	89	26.2	499	381	-118	-23.6	340	429	89	26.2
RSI05	228	382	154	67.5	210	245	35	16.7	228	382	154	67.5
RSI06	1235	800	-435	-35.2	849	583	-266	-31.3	1235	800	-435	-35.2
TC15	115	122	7	6.1	65	70	5	7.7	115	122	7	6.1
ATC60	46	45	-1	-2.2	30	29	-1	-3.3	46	45	-1	-2.2
ATC61	121	81	-40	-33.1	50	38	-12	-24.0	121	81	-40	-33.1
L115	68	5	-63	-92.6	1	0	-1	-100.0	68	5	-63	-92.6
TC42	212	199	-13	-6.1	229	251	22	9.6	212	199	-13	-6.1
	7644	**7382**	**-262**	**-3.4**	**7081**	**6280**	**-801**	**-11.3**	**8051**	**7552**	**-499**	**-6.2**

5.3.6 Interview Sample Bias

The potential for response bias was considered with the self-completion postcard interviews. Whilst there was concern over the personal details given by a number of respondents, the primary concern was the validity of the trip purpose descriptions.

Any bias with the interview returns could have the effect of misrepresenting business travel (EB) in particular as the type of person making such trips is less likely to have time available to return a completed questionnaire.

The interview questionnaires did not include data describing the respondent which might have been used to allow re-weighting the sample to the true make-up of the resident population. Hence the main focus on checking response bias was in checking the trip purpose splits. The trip purpose splits reported in the observed matrices are shown below in Table 5-9.

5.3.7 Bias checks

The interview purpose splits provided have been checked against a number of different data sources as discussed below.

The first check was made against the National Trip End Model (NTEM) 6.2, as reported through TEMPRO and 2006 average weekday productions by purpose for the Lincoln urban area. Table 5-9 shows the comparison of the NTEM data against the observed matrix totals from the Lincoln surveys.

Table 5-8 – Matrix Comparisons

Purpose	GLTM Trips	GLTM Splits	Shrews-bury	Shrews-bury %	Heysham	Heysham %	NTEM Productions	NTEM Splits
HB Commute	34,525	28.2%	12,216	24.2%	33,829	24.6%	24,927	17.9%
HB Employers Business	7,258	5.9%	7,115	14.1%	10,989	8.0%	3,836	2.8%
HB Other	52,667	43.1%	19,929	39.5%	62,981	45.8%	88,007	63.4%
NHB Employers Business	8,105	6.6%	6,073	12.0%	11,194	8.1%	4,208	3.0%
NHB Other	19,737	16.1%	5,130	10.2%	18,561	13.5%	17,907	12.9%
All Purpose Total	**122,292**	**100.0%**	**50,462**	**100.0%**	**137,553**	**100.0%**	**138,885**	**100.0%**
Commute + EB Total	49,888	40.8%	25,404	50.3%	56,012	40.7%	32,971	23.7%
All Other Total	79,662	59.2%	32,174	49.7%	92,531	59.3%	109,750	76.3%

It appears that the GLTM Commute and EB purpose proportions are overstated when compared to NTEM. The purpose HB Other also seems underrepresented compared to NTEM. This is believed to be a direct result of comparing the GLTM interview cordon data with NTEM productions, which are representative of the entire urban area - the interview cordon can be expect to include significantly longer distance commuting and EB and fewer local trips, for example education and shopping.

It was therefore decided to compare the interview cordon observed matrices with data from other projects where these involved face-to-face roadside interviews. The second check available was therefore against a study in Lancaster, as shown in Table 5-9.

This table shows a closer match to the interview data but the model has the Irish Sea to the West and is effectively a 'cul-de-sac' for trips.

The third check available was from a study in Shrewsbury that used roadside interviews. Shrewsbury is a free standing town of a similar size and nature to Lincoln. This again shows a much closer comparison to the GLTM purpose splits but surprisingly higher EB proportions. This may mean that the returns in Lincoln were low for this journey purpose but ultimately this is likely to 'undervalue' the scheme as this purposes tends to represents above average benefits.

When the observed total Commute and EB are compared to similar models with RIS observed matrices, the splits are similar to the GLTM splits. It has therefore been concluded that GLTM interviews do not show any bias in terms of interview purpose.

Table 5-9 – Observed Matrix Totals

Time Period	Journey Purpose	Person Matrix Total	% Split	Vehicle Matrix Total	% Split
AM	HB Commute	6,419	50.3%	5,719	50.3%
	HB Education	707	5.5%	414	5.5%
	HB Employers Business	679	5.3%	635	5.3%
	HB Other	2,721	21.3%	1,709	21.3%
	NHB Employers Business	728	5.7%	627	5.7%
	NHB Other	1,510	11.8%	835	11.8%
	Total	**12,763**	**100.0%**	**9,939**	**100.0%**
IP	HB Commute	1,038	10.9%	953	10.9%
	HB Education	137	1.4%	97	1.4%
	HB Employers Business	494	5.2%	444	5.2%
	HB Other	5,236	55.1%	3,283	55.1%
	NHB Employers Business	909	9.6%	802	9.6%
	NHB Other	1,685	17.7%	1,067	17.7%
	Total	**9,499**	**100.0%**	**6,646**	**100.0%**
PM	HB Commute	4,900	36.7%	4,381	36.7%
	HB Education	203	1.5%	134	1.5%
	HB Employers Business	1,040	7.8%	955	7.8%

	HB Other	4,540	34.0%	2,782	34.0%
	NHB Employers Business	332	2.5%	278	2.5%
	NHB Other	2,342	17.5%	1,350	17.5%
	Total	**13,357**	**100.0%**	**9,880**	**100.0%**
12 Hour	HB Commute	34,525	28.2%	30,965	28.2%
	HB Education	3,098	2.5%	1,952	2.5%
	HB Employers Business	7,258	5.9%	6,640	5.9%
	HB Other	49,569	40.5%	30,923	40.5%
	NHB Employers Business	8,105	6.6%	7,076	6.6%
	NHB Other	19,737	16.1%	11,864	16.1%
	Total	**122,292**	**100.0%**	**89,421**	**100.0%**
12 Hour	Commute	34,525	28.2%	30,965	28.2%
	Education	3,098	2.5%	1,952	2.5%
	Employers Business	15,363	12.6%	13,716	12.6%
	Other	69,306	56.7%	42,787	56.7%
	Total	**122,292**	**100.0%**	**89,421**	**100.0%**

5.4 Synthetic Matrix Build

Synthetic matrices are required in order to represent the full extent of the Internal area and for external trips with a potential to cross this area. The synthetic matrices are required for unobserved movements and to provide additional segmentation and spatial 'smoothing' not available from travel interview data.

The synthetic data is also likely to be the only source of information for bus, walk and cycle trips.

The trip production and attraction information required for the synthetic matrix build can only realistically be prepared for the Internal area, which in itself is a significant task. Therefore the main scope for the synthetic matrix build is the Internal area alone, and zones within this area are referred to as Internal zones.

5.4.1 Scope

If the large External zones were included in the attraction data, then the trip distributions using the 'gravity models' would be skewed towards these large zones. This is because the distribution function used is doubly constraint to ensure that the distribution replicates input production and attraction totals. It is therefore important that the productions and attractions are specified in a consistent manner for different geographical areas. For example if an attraction in Newark within the External area was fully specified, but the production excluded, the distribution model would have to satisfy the attraction from other productions, thus skewing the distribution to Newark, which had no production specified.

However, it is important that all relevant External to External movements that have the potential to cross the Internal area are also synthesised. Therefore, Commute and Employer's Business (EB) trip productions have been derived for England and Wales and then distributed directly from Journey to Work (J2W) census data, with External catchments being defined as passing through or not passing through the Internal area. This also includes trips using the strategic highway network around the Internal area, for example the A1, to ensure that there are realistic levels of traffic on these roads. This therefore provides an estimate of External to External strategic movements for the Commute and EB purposes. Other External area trip purposes are synthesised from the J2W data, as discussed below.

The synthetic matrix process operates at the twenty four hour level and full Land Use Segmentation for trip Production / Attraction (PA) analysis, and then the Land Use Segmentation aggregated by household composition and car ownership for the trip distribution analysis. Both these processes use a PA format. The later stages of the process convert from twenty four hour PA to period Origin / Destination (OD) formats and finally the Travel Segmentation. The synthetic process works independently for the following modes of travel:

- Car;
- Bus;
- Rail;
- Walk/Cycle;
- LGV; and
- OGV.

It also works independently of journey purpose for the following:

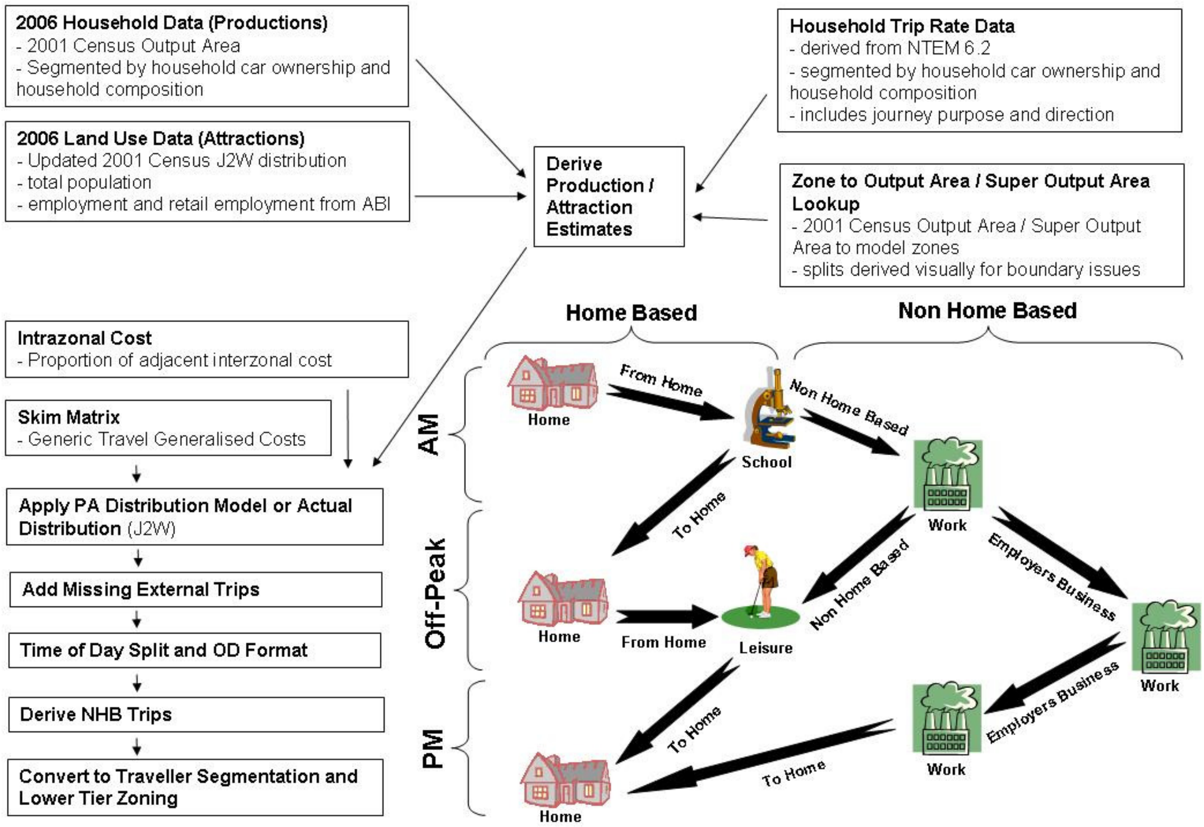
- Home Based (HB) Commute;
- HB Education;
- HB Shopping;
- HB Other;
- HB Employers Business (EB);
- Non Home Based (NHB) EB; and
- NHB Other.

Whilst intrazonal movements are developed from the distribution process none are assigned within the assignment models and no cost information is Available from the assignment models. However, intrazonal movements are required for the Demand Model and for forecasting. Intrazonal costs are therefore synthesised using proportions from adjacent interzonal movements.

5.4.2 *Method Overview*

The synthetic matrix build is focused on HB trip production / attraction and then trip distribution, all of which is undertaken separately by mode. Figure 5-3 provides an overview of the synthetic matrix build process, and includes an example 'graphic' of typical daily trips represented.

Figure 5-3 – Synthetic Matrix Build



The overview shows the HB production analysis is based on the product of households and trip rates. The trip attractions are controlled by the totals implied by the trip productions and use a variety of data sources to indicate the attraction of zones for different journey purposes. Retail employment Annual Business Inquiry (ABI) data are used for Shopping attractions, and Other is based on total populations. No HB attractions are required for Commute and EB as the J2W distributions are used directly. Also, no attractions are required for Education as the distributions are taken directly from school PLASC, and college and university student data.

Figure 5-3 then shows the process post production / attraction calculations as consisting of the derivation of interzonal and intrazonal travel costs for input to the trip distribution process.

The output from the distribution process is twenty four hour PA matrices. These then have missing trips associated with External movements added in based on scaling and re-weighting the distribution of Commute trips. These include relevant External to External trips, and Internal to External and External to Internal movements. The

PA matrices are then rescaled so that the attractions associated with each Internal zones are as originally calculated. This is followed by a similar process with the Internal productions, thus leaving the matrices with the correct Internal productions and small, but acceptable, discrepancies with the Internal attractions.

These PA matrices are then converted to an OD time period format. The time periods used at this stage represent 3 hour morning and evening periods, a 6 hour inter-peak period and a 12 hour off-peak / overnight period.

The process then derives estimates of NHB movements from the product of the destination totals of HB trips and NHB trip rates, derived from travel diary analysis.

No reliable method was available for constructing LGV and OGV freight movements. Therefore the LGV and OGV freight matrices are simply built from the total employment as a production and attraction, and then Furnessed with a unitary matrix. In addition the OGV matrices are then attracted to district level and controlled to the DfT trip movements, derived from annual tonnages. It should be noted that freight movements are longer distance movements and are expected to be mostly observed following Phase C when RIS data is combined with the synthetic matrices.

Initial assignments of the synthetic matrices are used for checking and to prepare a global factor Car, LGV and OGV matrix adjustment factor derived from the total of observed counts / modelled flows for these three vehicle types. These factors are applied directly to the LGV and OGV synthetic matrices to produce the final version. However, Car Adjustment is applied to the trip rates and the synthetic matrices rebuilt. This is necessary as the trip rates can be expected to require a certain amount of local adjustment and they could be useful for future forecasts, although not used in the LEB model application. This factoring is important as when merging the synthetic matrices with the observed RIS matrices the synthetic needs to have reasonably similar volumes to the observed, which is controlled to counts at each interview site. A summary of the trip totals for the synthetic HAM matrices is shown in Table 5-10.

Table 5-10 – Synthetic Matrix Trip Totals by Vehicle Type

Flow Group	Time Period		
	AM	IP	PM
Commute	99,901	14,077	66,286
Other	58,941	68,679	62,779
EB	19,435	8,651	13,344
GV	4,421	2,537	3,116
OGV	2,464	1,812	1,304

5.5 Observed and Synthetic Matrix Merge

The two different private vehicle matrix builds of synthetic and observed needed to be merged together. This not only allows missing observed movements to be added but also allows the observed matrices to be 'smoothed', additional segmentation to be added and improves the connection of observed matrices to land use data. The final matrices are held at the entire Lower Tier zoning system, and provide the level of detail necessary for Variable Demand Modelling (VDM). Public transport, Walk and Cycle matrices only exist as synthetic.

5.5.1 Smoothing and Additional Segmentation

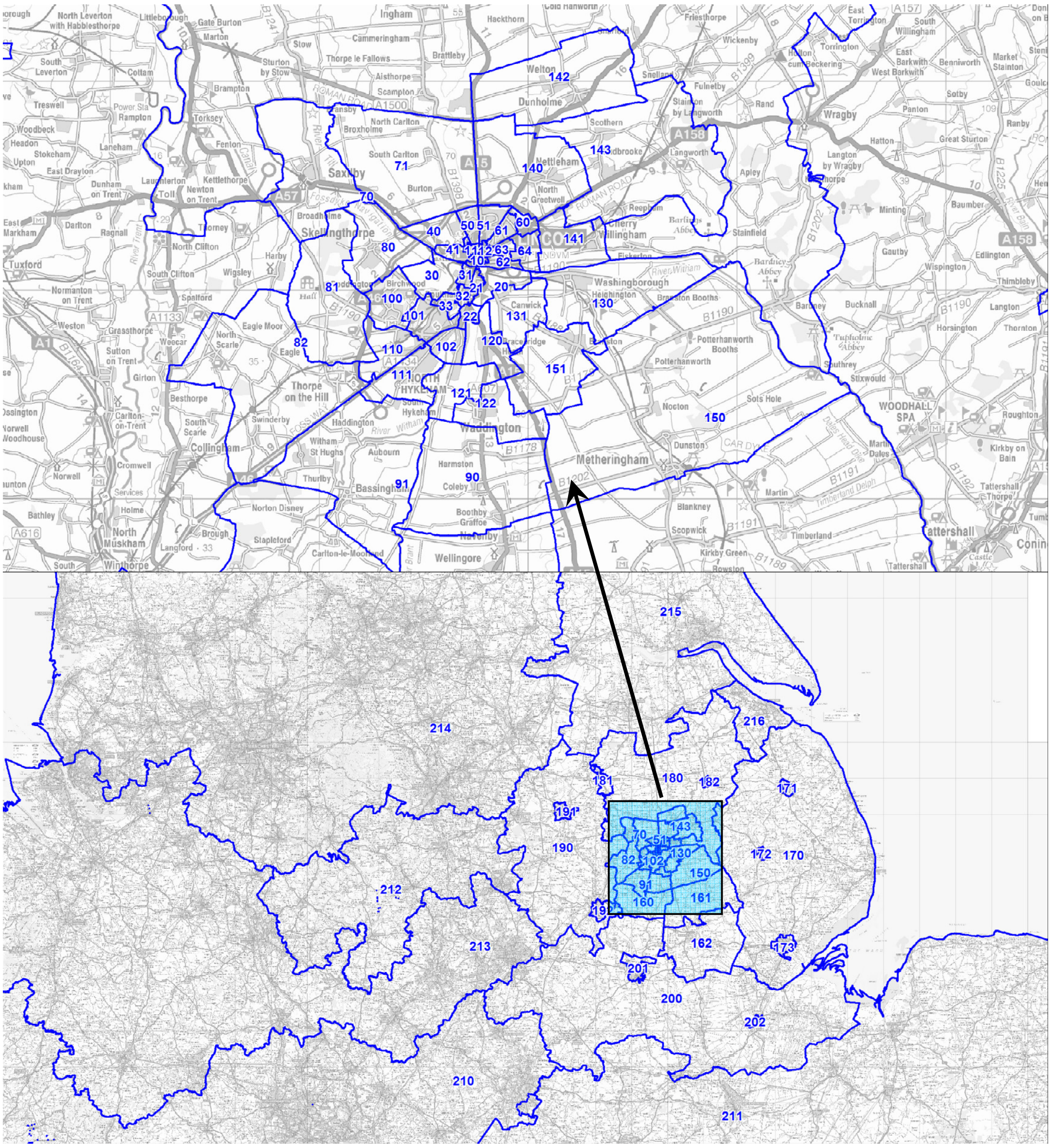
Smoothing was only applied to the Car matrices as the synthetic freight was not considered sufficiently reliable plus segmentation of freight matrices is not necessary.

The process to smooth and further segment the observed matrix required a set of smoothing sectors to be prepared. A key point of smoothing the observed matrices is to remove any sampling issues that may exist in the interview data. It is likely that respondents will correctly state the broad area to which they have travelled from and are travelling to. Therefore the smoothing sectors split the analysis cordons into conurbation areas, built by aggregating Lower Tier zones.

Another important function of the smoothing is to ensure a better connection with land use data. One issue can be where interview postcode coordinate accuracy could allocate an origin or destination to the wrong zone. This is likely to be more prevalent with specific locations for example schools or shopping areas. By arranging the smoothing sectors to wholly encompass such areas the smoothing process better realigns the trips to the underlying land uses. The additional segmentation of Household Income and Car Availability has also been added by smoothing sector.

Figure 5-4 shows the smoothing sectors and there index, which is built from the constituent analysis cordon * 10. The smoothing sectors are smaller within the interview cordon and adjacent to it as that represents a concentration of observed movements. Further from the interview cordon the observations are more parse and therefore the smoothing sectors become larger. As the GLTM zones are relatively large outside of the LPA area the smoothing sectors are mostly a copy of the Lower Tier zones.

Figure 5-4 – Smoothing Sectors



The vast majority of the 31,705 observed car vehicle trips were smoothed at the first attempt using smoothing sector to smoothing sector synthetic data. This process aggregated to the observed matrices at the trip level by smoothing sector origin and smoothing sector destination. To achieve this the synthetic matrices were aggregated to the same level and a set of splitting factors were then derived to disaggregate the observed sector movements to Lower Tier origin and destination, and Household Income and Car Availability.

From this initial process 28,800 observed vehicle trips were smoothed. To cater for the unsmoothed trips splitting factors were derived for all synthetic trips associated with each origin sector and associated with each destination sector. The unsmoothed observed sector to sector movements were then smoothed by applying these splitting factors to the observed origin and the observed destination. This increase the total smoothed trips to 30,356 vehicles.

After this second process there were still observed vehicle trips that had not been smoothed. These were added by smoothing using the synthetic aggregated to the Report Cordons (see model specification for details). Household Income and Car Availability splitting factors were derived from cordon to cordon synthetic movements and applied to the missing observed movements. This increase the total adjusted trips to 31,607 vehicles.

Dealing with the final missing observed trips involved again retaining the original observed origin and destination and applying global Household Income and Car Availability splits. This increase the total adjusted trips to the complete 31,697 vehicles.

A small number of additional illogical movements were also removed from the smoothed observed matrices but these only reduced the total trips to 31,705 vehicles.

The smoothing process adds substantially more segmentation. The original 11,458 observed records were increased to 113,211 records with the inclusion of select link matrices for interview cordon gaps. When smoothed this increases to 984,571 records which include the additional Household Income and Car Availability segmentation. This level of segmentation is important to allow VDM. When the matrices are converted to a format for use in the HAM most of the detailed segmentation is aggregated and the HAM matrices contain more feasible numbers for use in the assignment process

5.5.2 *Merging process*

The smoothing process disaggregates the observed matrices to the same level of segmentation available in the synthetic matrices. The two sets of data can therefore be combined directly. However, the substantial buffer model network that surrounds the interview cordon means that many interview cordon movements will be partial.

To assist in understanding partial interview cordon movements ODs were categorised using the interview cordon, and local routing knowledge and judgement, into the following movement indices:

1. Fully Observed Interviews;
2. Internal To Interview Cordon;
3. External To Interview Cordon;
4. Irrelevant;
5. Partially Observed Interviews - Short Distance;
6. Partially Observed Interviews - Medium Distance; and

7. Partially Observed Interviews - Long Distance.

Movements categorised as 1 included trips with an origin or destination within the interview cordon. These observed trips were combined directly with synthetic movements wholly within the interview cordon (category 2).

Movements categorised as 3 were not expected to travel through the interview cordon and therefore have been added directly. Also, the volume correction added to improve the synthetic flow to count comparison was removed if the trip was without an origin or destination within the LPA, as discussed previously.

Movements categorised as 4 were removed from the matrices.

Movements categorised as 5, 6 and 7 were dealt with in two stages: firstly for the movements with an observed record; and secondly for potentially unobserved movements. The definition of movements categorised as 5, 6 and 7 had been prepared through local routing knowledge. As such it was possible that some of the OD pairs may have been miscoded and may not have potential to travel through the interview cordon. Furthermore, an assumed proportion of an OD movement that had been observed travelling through the interview cordon was used to calibrate the merged matrices. This proportion was specified for three different OD distance categories of:

1. Short (< 31 km) = 100%;
2. Medium (< 51 km) = 70%; and
3. Long (< 110 km) = 10%.

These proportions assume that the further away from the interview cordon the more likely that OD movements will route around the cordon, thus a lower proportion can be expected to pass through the cordon.

The first stage in dealing with these partial cordon movements was to merge all observed movements categorised as 5, 6 and 7, and divide them by the percentages listed above. However, this clearly is not applicable for movements that have not been sampled. Therefore, for any missing analysis cordon aggregated movements categorised as 5, 6 and 7 the synthetic OD movement was used, with the volume correction removed if without an origin or destination within the LPA, as discussed previously.

Table 5-11 below shows a breakdown of the trips as they were merged for the different types of movements. The fully observed totals only include trips with an origin or destination within the interview cordon and as such they don’t match the smoothed observed trip totals. These trips do account for some 85% of observed car movements, with the remaining 15% representing through trips some of which are assumed to be partial. These 15% are factored by around 1.89 to account for the missing trips that are expected to divert around the interview cordon.

Table 5-11 – Merging of Different Types of Movements

Merged Data	AM Peak Hour			IP Peak Hour			PM Peak Hour			Total
	Car	LGV	OGV	Car	LGV	OGV	Car	LGV	OGV	
1: Fully Observed Car	10,511	0	0	6,567	0	0	9,963	0	0	27,041
Plus 1: Fully Observed Freight	10,511	1,162	313	6,567	1,166	589	9,963	1,511	355	32,137
Plus 2: Internal Synthetic Car	22,837	1,162	313	12,852	1,166	589	19,313	1,511	355	60,099
Plus 2: Internal Synthetic Freight	22,837	4,227	2,021	12,852	2,924	1,845	19,313	3,672	1,259	70,950
Plus 3: External Synthetic Car	144,751	4,227	2,021	85,863	2,924	1,845	150,769	3,672	1,259	397,331
Plus 3: External Synthetic Freight	144,751	18,148	5,177	85,863	14,536	8,350	150,769	15,775	3,489	446,858
Plus 5/6/7. Partially Observed Car	146,924	18,148	5,177	87,364	14,536	8,350	153,391	15,775	3,489	453,154
Plus 5/6/7. Partially Observed Freight	146,924	18,419	5,390	87,364	14,750	8,512	153,391	16,211	3,700	454,661
Plus 5/6/7. Partially Observed Synthetic Car	147,262	18,419	5,390	87,472	14,750	8,512	153,627	16,211	3,700	455,343
Plus 5/6/7. Partially Observed Synthetic Freight	147,262	18,448	5,396	87,472	14,775	8,526	153,627	16,236	3,705	455,447
Final Merged	**147,262**	**18,448**	**5,396**	**87,472**	**14,775**	**8,526**	**153,627**	**16,236**	**3,705**	**455,447**

5.6 Model Recalibration

Following the BaFB submission in 2011, the VISUM model was reviewed as it became apparent that a number of enhancements were required for the model in order to make the model more robust. Activation of the blocking back function revealed a high level of queuing on links that connected external zones which was deemed to be unrealistic. This was apparent in all three modelled time periods and so factors were applied that reduced the volume of trips between zones outside the Lincoln Planning Area (LPA). These factors were applied at a sector level, using the ten reporting sectors previously described in this chapter. Zones outside of the LPA are contained in sectors numbered 5 to 10 inclusive.

In additional to this some factors were applied to trips with origins and/or destinations within the LPA. During the calibration process modelled flow volumes were compared against observed flow volumes at screenline levels and factors were manually applied to sector to sector movements in order to reduce the trip adjustment that was required in the matrix estimation process. The factors that were applied are shown in Tables 5.12 to 5.14. The overall matrix sizes of the prior matrices for the BaFB model and the prior matrices that were produced by applying the factors are shown in Table 5.15.

Table 5-12 – Manual Factors Applied to BaFB Prior Matrices – AM Peak

Origin Sector	Destination Sector									
	1	2	3	4	5	6	7	8	9	10
1	0.85	-	-	-	-	-	-	-	1.8	1.2
2	1	-	-	-	-	-	-	-	1.8	1.2
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	0.1	0.1	0.1	0.1	0.1	0.1
6	-	-	-	-	0.1	0.1	0.1	0.1	0.1	0.1
7	-	-	-	-	0.1	0.1	0.1	0.1	0.1	0.1
8	-	-	-	-	0.1	0.1	0.1	0.1	0.1	0.1
9	1.4	1.4	-	-	0.1	1	0.1	0.1	0.1	0.1
10	0.9	0.9	-	-	0.4	0.4	0.4	0.4	0.4	0.4

Table 5-13 – Manual Factors Applied to BaFB Prior Matrices - Interpeak

Origin Sector	Destination Sector									
	1	2	3	4	5	6	7	8	9	10
1	-	-	-	-	-	-	-	-	-	-
2	0.8	-	-	-	-	-	-	-	-	-
3	0.8	-	-	-	-	-	-	-	-	-
4	0.8	-	-	-	-	-	-	-	-	-
5	0.8	-	-	-	0.4	0.4	0.4	0.4	0.4	0.4
6	0.8	-	-	-	0.4	0.4	0.4	0.4	0.4	0.4
7	0.8	-	-	-	0.4	0.4	0.4	0.4	0.4	0.4
8	0.8	-	-	-	0.4	0.4	0.4	0.4	0.4	0.4
9	0.8	-	-	-	0.4	0.4	0.4	0.4	0.4	0.4
10	0.8	-	-	-	0.4	0.4	0.4	0.4	0.4	0.2

Table 5-14 – Manual Factors Applied to BaFB Prior Matrices – PM Peak

Origin Sector	Destination Sector									
	1	2	3	4	5	6	7	8	9	10
1	0.85	1	-	-	-	-	-	-	1.4	0.9
2	-	-	-	-	-	-	-	-	1.4	0.9
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	0.1	0.1	0.1	0.1	0.1	0.4
6	-	-	-	-	0.1	0.1	0.1	0.1	1	0.4
7	-	-	-	-	0.1	0.1	0.1	0.1	0.1	0.4
8	-	-	-	-	0.1	0.1	0.1	0.1	0.1	0.4
9	1.8	1.8	-	-	0.1	0.1	0.1	0.1	0.1	0.4
10	1.2	1.2	-	-	0.1	0.1	0.1	0.1	0.1	0.4

Table 5-15 – Prior Matrix Totals – BaFB Totals against Factored

Time Period	Trip Purpose		Prior Matrices (veh)	
			BaFB	Factored
AM	1	Commute	80,937	26,970
	2	Other	49,859	16,915
	3	Work	16,465	5,605
	4	LGV	18,448	8,180
	5	OGV	5,396	2,951
		Total	**171,106**	**60,622**
IP	1	Commute	12,863	6,127
	2	Other	65,579	31,153
	3	Work	9,030	4,570
	4	LGV	14,775	6,736
	5	OGV	8,526	4,018
		Total	**110,773**	**52,603**
PM	1	Commute	69,637	21,260
	2	Other	68,738	21,186
	3	Work	15,252	5,214
	4	LGV	16,236	7,351
	5	OGV	3,705	2,010
		Total	**173,568**	**57,023**

6 Model Calibration

6.1 Introduction

The plan to enhance the model involved improvements to the network in the short term but in the longer term, building a new set of demand matrices using a more recent set of interview data. The recalibration work carried out so far has reflects the first stage of these upgrades and has involved implementing changes to the assignment procedure as well as carrying out a review and altering various aspects of network coding.

The model had been recalibrated using the improved network but using prior matrices derived from those produced in 2011 for the BaFB. The changes made to the prior matrices from the BaFB are detailed in the previous chapter.

The recalibrated base model is very much an interim model and will form the basis of a set of forecast models that will support a planning application for LEB. It will also be used to inform the highway design team of likely flows along various sections of the LEB.

During the recalibration work, greater emphasis has been placed on screenline flow totals rather than on individual roads. In addition to this, journey time validation, routing checks and congestion plots have been produced to ensure that the model is representative of the existing network conditions.

6.2 Calibration Process

The calibration of the model was undertaken whereby the network was adjusted to ensure that the model realistically replicated routeing and vehicle speeds within the study area. Matrix estimation was incorporated in the model calibration process in order to obtain matrices based on the routeing patterns to which the network was calibrated.

The calibration process involved a number of tasks, as follows:

- Checks on the basic structure of the network, including link lengths, junction configuration and banned turns;
- Checks on speed-flow curves to ensure that they reflect the existing situation;
- Checks to ensure that link speeds and journey times are reasonable;
- Checks to ensure that vehicle routeings are realistic and appropriate; and
- Use of matrix estimation procedures to adjust and ‘fit’ the prior trip matrices to observed traffic flows.

Any observed traffic flows used in the calibration process, for matrix estimation, cannot be considered as independent for validation purposes. Under these circumstances, TAG Unit 3.19 advises that some count data should be retained and used only at the validation stage. Therefore, a number of traffic counts from different parts of the network were retained as independent counts and were not used in the matrix estimation.

Successful calibration entails matching the observed traffic counts (used in matrix estimation) with modelled flows. The matching is monitored using statistical procedures as recommended in TAG Unit 3.19. The recommended statistic is the GEH statistic, a form of chi-squared statistic, and is defined as:

$$GEH = \sqrt{\frac{(M - C)^2}{0.5(C + M)}}$$

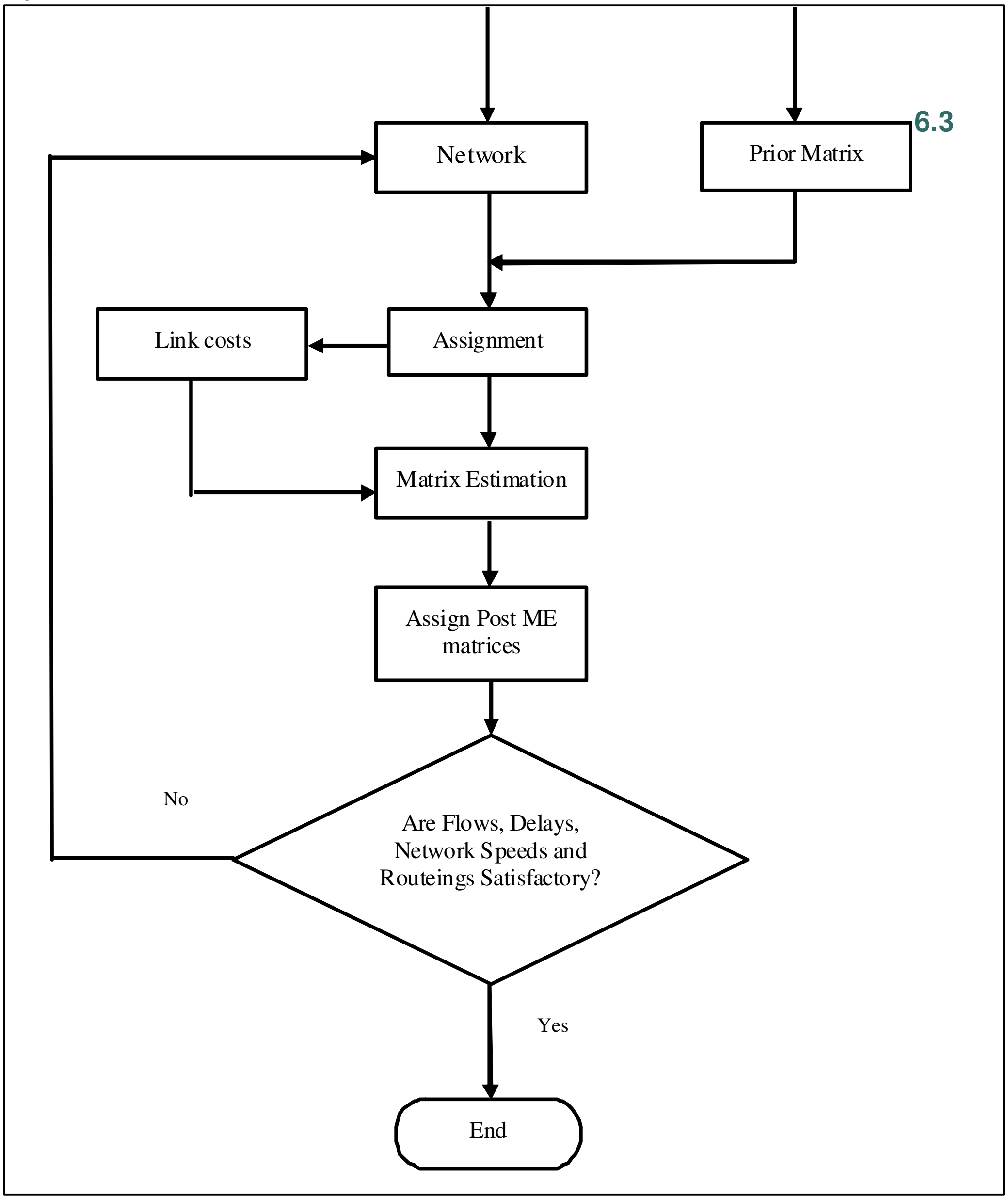
Where: M = modelled flow; and

C = observed flow (count)

Based on TAG Unit 3.19 guidance, a GEH value of less than 5, which indicates a satisfactory fit between modelled flows and independent observed data, (whatever the level of flow) should be achieved on 85% of individual links. For screenlines, or other combinations of links, a GEH value of less than 4 is required in all, or nearly all, cases. The acceptability guidelines set out for validation in TAG Unit 3.19 were adopted as criteria against which to gauge the results of the model calibration process.

Figure 6-1 provides a schematic representation of the main steps involved in the model calibration process. It can be seen that it is an iterative process where network and junction properties are adjusted until a point is reached where network speeds, flows, delays and routeings are deemed to be representative of the observed conditions.

Figure 6-1 – Model Calibration Process



6.3 Acceptability Guidelines

The acceptability guidelines set out for validation in TAG Unit 3.19 Section 3.2.8 were adopted as criteria against which to gauge the results of the model calibration process. These are shown in Table 6-1.

Table 6-1 – TAG Unit 3.19 Acceptability Guidelines for Assignment Validation

Criteria and Measure	Acceptability Guidelines	
1. Assigned Model Hourly Flows compared with Observed Flows		
i. Observed Flows < 700 vph	Modelled flow within ± 100	> 85% of links
ii. Observed Flows between 700 – 2,700 vph	Modelled flow within ± 15%	> 85% of links
iii. Observed Flows > 2,700 vph	Modelled flow within ± 400	> 85% of links
iv. Screenline Flow Totals (normally > 5 links)	Modelled flow within ± 5%	All (or nearly all) screenlines
2. GEH Statistic		
i. Individual Flows	GEH < 5	> 85% of links

Note - Guidelines for model calibration/validation stated in TAG Unit 3.19 do not suggest using the GEH criteria along screenline totals, which is a departure from the superseded DMRB (Design Manual for Roads & Bridges) guidance. GEH statistics along screenlines have been included in this report and have been used as an additional check during the model calibration/validation.

6.4 Assignment Parameters

Assignment of the O/D matrices to the Lincoln road network was undertaken using the Equilibrium_Lohse iterative assignment procedure in VISUM. Equilibrium_Lohse1 combines elements of both standard Equilibrium (Wardrop) and 'all-or-nothing' assignment methodologies. The procedure models the 'learning process' of users on the network over a number of iterations, where information gained on the previous trip is used for the next route search.

For each O/D pair, the least impeded route is initially calculated via the Intersection Capacity Analysis (ICA) module and traffic assigned to it in an all-or-nothing approach. Impedance is then recalculated and factored into the cost of the route for the next iteration which subsequently loads a proportion of traffic onto the next least impeded route. With successive iterations the most cost-effective route per O/D pair is optimised. The process ends when the shift of vehicles between routes is minimal.

6.5 Generalised Cost Parameters

The cost of travel is expressed in terms of generalised cost minutes, which can be related to the value of time and out of pocket costs. A multiple user class assignment method was used that allows Cars, LGV's and HGV's to be assigned simultaneously to the same network but using different generalised cost functions.

The components of the generalised cost function used in the traffic model were based on the Transport Economics Note (TEN 2007) with assumptions provided from WebTAG 3.5.6 (2007). WebTAG calculates the costs of travel based on the assumptions of the value of money which a traveller is willing to pay to compensate for the time spent driving on the road.

For modelling purposes, generalised costs were calculated based on the assumptions of average travel speed on the road, vehicle fuel consumption, values of time, and average vehicle occupancies of each trip purpose. Non-fuel vehicle operating costs, such as maintenance or insurance etc., were not taken into account as drivers generally only perceive the fuel and time elements of their journey in making route choices.

The average travel speed on the network was obtained from the observed journey time surveys which were carried out in the study area in 2006. The average travel speeds derived from these surveys were 52.6kph in the AM Peak, 56kph in the Inter Peak, and 52.1kph in the PM Peak.

Based on the above and the WebTAG guidance, values of pence per kilometre (PPK) and pence per minute (PPM) for three vehicle classes (Car, LGV, HGV) by purpose type (Work, Commute, Other) were calculated for all three time periods. Monetary time (PPM) and distance (PPK) costs were then converted into generalised costs and used in VISUM. They are shown in Table 6-2.

Table 6-2 – Generalised Cost Parameters

User Class	Time Period	Monetary Values		Generalised Cost	
		Time (pence per minute)	Distance (pence per kilometre)	Time	Distance
Car Commute	AM Peak	11.56	6.03	1.00	0.52
	Inter Peak	11.56	6.03	1.00	0.52
	PM Peak	11.56	6.03	1.00	0.52
Car Other	AM Peak	15.76	6.03	1.00	0.38
	Inter Peak	15.76	6.03	1.00	0.38
	PM Peak	15.76	6.03	1.00	0.38
Car Employed Business	AM Peak	51.08	12.21	1.00	0.24
	Inter Peak	51.08	12.21	1.00	0.24
	PM Peak	51.08	12.21	1.00	0.24
LGV	AM Peak	21.20	13.25	1.00	0.62
	Inter Peak	21.20	13.25	1.00	0.62
	PM Peak	21.20	13.25	1.00	0.62
HGV	AM Peak	17.22	38.68	1.00	2.25
	Inter Peak	17.22	38.68	1.00	2.25
	PM Peak	17.22	38.68	1.00	2.25

6.6 Matrix Estimation

The matrix estimation (ME) process was an integral part of the development of the base year model matrices and designed to provide greater local detail to the local traffic model and enhance the precision of the matrices.

The matrix estimation process employed within the calibration was designed to adjust the travel pattern to the observed traffic counts. This process adjusted trips using available observed traffic counts to give the best-fit matrix. This process is dependent on several factors including the quality of the prior matrix, traffic routeing and the order and consistency of the observed traffic counts. Thus it is essential that the process is monitored closely to ensure the following:

- The trip matrix is converging to a stable solution;
- Travel patterns at a sector level are reasonable;
- Trip length distributions are reasonable.

The matrix estimation was undertaken within VISUM, using the TFlowFuzzy element of the suite. Trips were adjusted in the matrix to produce estimated matrices consistent with the observed traffic counts.

The equation used in the matrix estimation procedure may be written as:

$$T_{ij} = t_{ij} \prod_a X_a^{Pija}$$

where:

T_{ij} is the output post matrix of OD ‘ij-pairs’;

t_{ij} is the input prior matrix of OD ‘ij-pairs’;

$\prod_a$ is the product over all counted links a;

X_a is the balancing factor associated with counted link a;

^{Pija} is the fraction of trips from i to j using link a.

The process starts with the assignment of the prior trip matrices. Trip movements using the target links (for which counts are available – see Figure 3.5) are then identified and factored to match the target flows, as closely as possible given that several movements may go through any one site and individual movements may go through several sites. The resultant post-ME2 matrices may then be reassigned to start a subsequent iteration of the matrix estimation process, to further fine tune the prior trip matrices. There are no specific convergence criteria for matrix estimation, but the aim of the procedure is to improve the goodness of fit between modelled flows and counts.

For the Lincoln Eastern bypass Traffic Model, the procedure achieved a satisfactory level of fit between modelled and observed flows in 4 to 6 iterations.

Comparisons between traffic counts and modelled flows used in the matrix estimation process were undertaken during each iteration of the process. The calibration procedure was monitored by reviewing the changes to the trip matrices resulting from matrix estimation and the comparison of observed traffic counts and modelled traffic flows.

The changes in travel patterns were also monitored at a sector level during the calibration process

6.7 Effects of Matrix Estimation on Prior Matrices

The effects of matrix estimation (ME) on the trip matrices were monitored by comparing movement totals at sector level. The study area was compressed into 10 sectors as shown in Figure 6-2, defined as follows:

Internal sector (Main Lincoln, inside RSI cordon),

LPA sectors (sector 2, 3 and 4, surrounding RSI cordon)

External sectors (5, 6, 7, 8, 9 and 10).

In total, the all-vehicle trip matrices changed in size between the prior and post-estimation stages as follows:

- AM Peak hour: -1%;
- Inter Peak hour: +6%;
- PM Peak hour: -12%.

These changes are shown at individual sector level and by time period in Table 6-3 to Table 6-5. At a sector to sector level, absolute differences between prior and post matrices are small across all time periods. This indicates that the matrix estimation process has not significantly affected the prior matrices and the post ME matrices will maintain a strong correlation to land use.

Key changes at a more aggregate level are summarised in Tables 6-6 to 6-8.The important movements are between sector 1 and LPA sectors 2-4. Matrix estimation changed these movements by less than 4% in the AM peak, by less than 30% in the interpeak and less that 16% in the PM peak.

Figure 6-2 – Sector Map

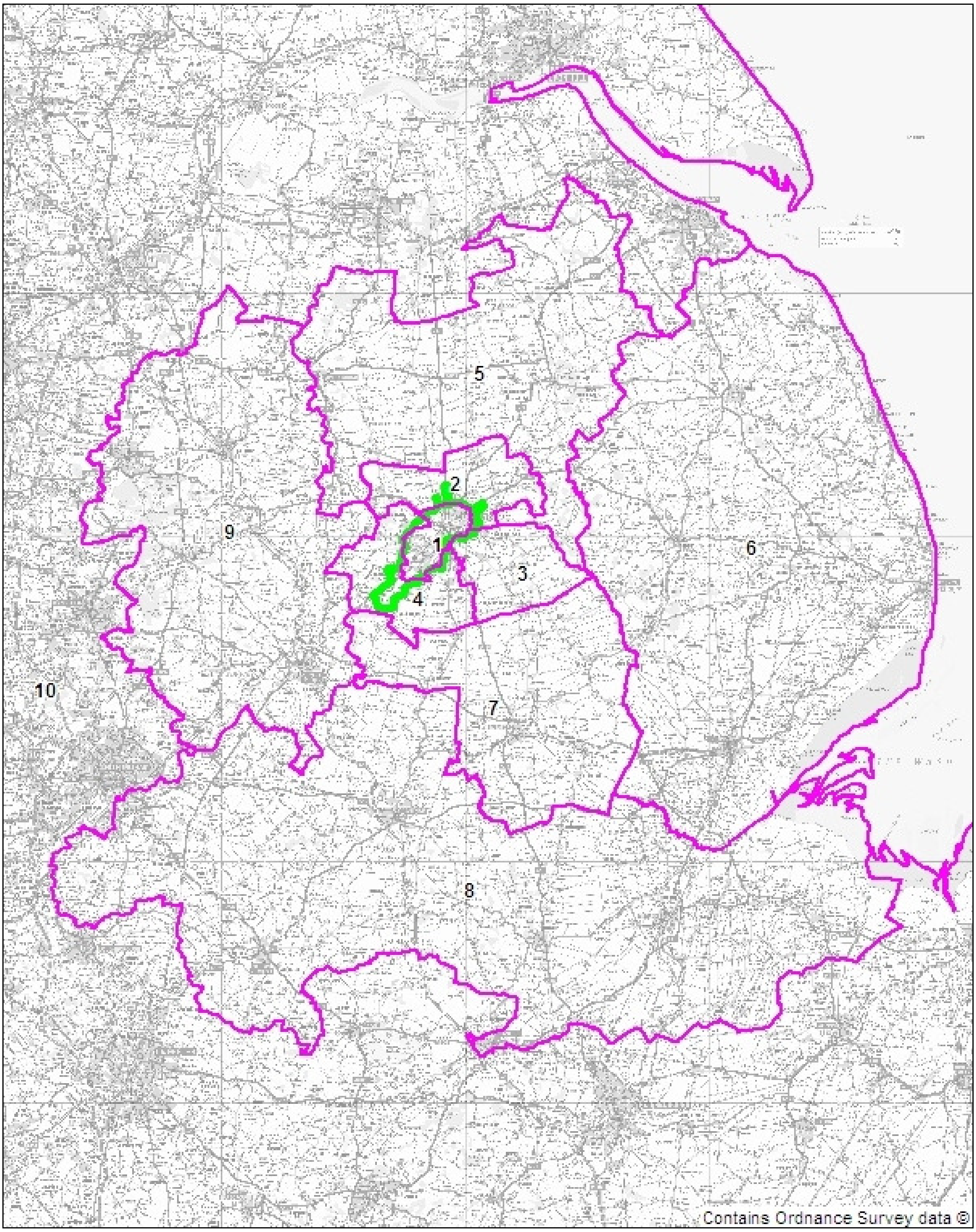


Table 6-3 – Effects of Matrix Estimation on Prior Matrix – AM Peak (updated)

Origin Sector	Matrix	Destination Sector										
		1	2	3	4	5	6	7	8	9	10	Total
1	Prior	9,580	524	332	2,256	461	265	198	152	591	613	14,972
	Post	9,378	648	301	2,263	317	254	148	122	498	490	14,418
	%Diff	-2%	24%	-9%	0%	-31%	-4%	-25%	-20%	-16%	-20%	-4%
2	Prior	1,506	1,491	41	187	405	99	41	41	122	586	4,518
	Post	1,580	1,503	22	194	414	96	32	23	118	550	4,531
	%Diff	5%	1%	-47%	4%	2%	-3%	-22%	-43%	-3%	-6%	0%
3	Prior	776	21	1,002	254	29	83	262	53	99	147	2,726
	Post	797	22	1,004	433	17	83	262	54	63	110	2,843
	%Diff	3%	3%	0%	70%	-41%	0%	0%	0%	-36%	-26%	4%
4	Prior	2,736	135	138	2,596	171	81	365	182	256	236	6,895
	Post	2,639	146	152	2,728	135	91	385	192	225	181	6,874
	%Diff	-4%	9%	10%	5%	-21%	13%	5%	6%	-12%	-23%	0%
5	Prior	1,049	476	31	175	472	26	2	6	2	96	2,334
	Post	893	483	17	141	472	26	1	4	1	94	2,133
	%Diff	-15%	1%	-44%	-20%	0%	-3%	-31%	-33%	-9%	-1%	-9%
6	Prior	405	101	37	101	26	2,256	32	104	3	181	3,246
	Post	382	101	37	106	26	2,256	32	104	3	181	3,228
	%Diff	-6%	1%	0%	5%	-1%	0%	0%	0%	0%	0%	-1%
7	Prior	358	31	134	361	3	48	450	68	21	18	1,492
	Post	329	46	135	386	1	48	450	68	20	17	1,501
	%Diff	-8%	50%	0%	7%	-44%	0%	0%	0%	-6%	-4%	1%
8	Prior	304	39	17	208	1	63	45	3,230	61	549	4,519
	Post	292	32	17	252	1	63	45	3,230	61	548	4,542
	%Diff	-4%	-18%	0%	21%	-56%	0%	0%	0%	0%	0%	1%
9	Prior	611	83	28	307	1	61	13	77	1,581	283	3,044
	Post	691	76	28	317	1	64	12	77	1,581	283	3,130
	%Diff	13%	-9%	0%	3%	0%	5%	-3%	0%	0%	0%	3%
10	Prior	567	143	7	197	242	361	59	1,478	931	9,940	13,925
	Post	588	104	7	200	237	358	57	1,472	931	9,909	13,863
	%Diff	4%	-27%	-8%	1%	-2%	-1%	-3%	0%	0%	0%	0%
Total	Prior	17,890	3,043	1,767	6,643	1,810	3,343	1,466	5,392	3,668	12,649	57,671
	Post	17,570	3,161	1,720	7,019	1,621	3,339	1,423	5,347	3,501	12,363	57,064
	%Diff	-2%	4%	-3%	6%	-10%	0%	-3%	-1%	-5%	-2%	-1%

Notes:

(i) Trips are in vehicles
(ii) Sectors are shown in Figure 6.3, and defined below

- Sector 1 - Interview Cordon (including all Lincoln District and part North Kesteven District)
- Sector 2 – Lincoln Planning Area North (within West Lindsey District)
- Sector 3 – Lincoln Planning Area South East (within North Kesteven District)
- Sector 4 – Lincoln Planning Area South West (within North Kesteven District)
- Sector 5 – West Lindsey District
- Sector 6 – East Lindsey and Boston Districts
- Sector 7 – North Kesteven District
- Sector 8 – Rushcliffe, Melton, South Kesteven and South Holland Districts
- Sector 9 – Bassetlaw and Newark & Sherwood Districts
- Sector 10 – Rest of England, Wales and Scotland

Table 6-4 – Effects of Matrix Estimation on Prior Matrix – Inter Peak (updated)

Origin Sector	Matrix	Destination Sector										
		1	2	3	4	5	6	7	8	9	10	Total
	Prior	5,982	680	408	1,300	402	274	256	140	198	388	10,029
	Post	7,046	826	372	1,596	391	296	201	107	222	393	11,450
1	***%Diff***	18%	22%	-9%	23%	-3%	8%	-22%	-23%	12%	1%	14%
	Prior	541	705	17	106	232	28	33	20	20	188	1,891
	Post	750	714	18	131	228	30	30	21	23	187	2,132
2	***%Diff***	39%	1%	3%	24%	-2%	4%	-9%	6%	14%	-1%	13%
	Prior	322	17	415	103	14	17	90	13	7	117	1,116
	Post	353	12	417	164	7	16	90	13	10	86	1,168
3	***%Diff***	10%	-29%	0%	59%	-49%	-1%	0%	0%	36%	-27%	5%
	Prior	1,099	101	103	1,358	130	54	179	113	148	230	3,516
	Post	1,425	123	130	1,613	113	63	187	145	171	255	4,225
4	***%Diff***	30%	22%	26%	19%	-13%	16%	4%	28%	15%	11%	20%
	Prior	317	204	15	81	1,155	33	7	17	8	182	2,019
	Post	373	201	9	67	1,155	31	4	14	6	174	2,035
5	***%Diff***	18%	-1%	-35%	-17%	0%	-5%	-39%	-20%	-31%	-4%	1%
	Prior	211	23	17	60	32	5,164	48	129	15	330	6,029
	Post	268	23	17	74	30	5,164	48	129	19	327	6,099
6	***%Diff***	27%	-3%	0%	24%	-4%	0%	0%	0%	24%	-1%	1%
	Prior	193	31	90	139	7	49	1,109	77	60	48	1,803
	Post	231	23	90	152	4	49	1,108	77	59	45	1,837
7	***%Diff***	20%	-27%	0%	9%	-48%	0%	0%	0%	-2%	-6%	2%
	Prior	99	20	14	86	6	127	71	7,782	99	1,342	9,645
	Post	108	18	14	106	3	127	71	7,782	99	1,336	9,664
8	***%Diff***	9%	-7%	1%	23%	-57%	0%	0%	0%	0%	0%	0%
	Prior	144	19	6	194	8	14	40	105	4,316	761	5,605
	Post	188	22	8	239	6	15	40	105	4,316	760	5,699
9	***%Diff***	30%	19%	35%	24%	-28%	11%	1%	0%	0%	0%	2%
	Prior	300	181	114	227	157	295	48	1,278	741	3,592	6,933
	Post	369	207	94	270	154	292	46	1,273	741	3,573	7,018
10	***%Diff***	23%	14%	-17%	19%	-3%	-1%	-4%	0%	0%	-1%	1%
Total	Prior	9,206	1,981	1,200	3,654	2,144	6,055	1,882	9,674	5,614	7,177	48,585
	Post	11,110	2,170	1,169	4,412	2,091	6,084	1,826	9,665	5,664	7,137	51,327
	%Diff	21%	10%	-3%	21%	-2%	0%	-3%	0%	1%	-1%	6%

Notes: ***(i) Trips are in vehicles***

(ii) Sectors are shown in Figure 6.4, and defined below

- Sector 1 - Interview Cordon (including all Lincoln District and part North Kesteven District)
- Sector 2 – Lincoln Planning Area North (within West Lindsey District)
- Sector 3 – Lincoln Planning Area South East (within North Kesteven District)
- Sector 4 – Lincoln Planning Area South West (within North Kesteven District)
- Sector 5 – West Lindsey District
- Sector 6 – East Lindsey and Boston Districts
- Sector 7 – North Kesteven District
- Sector 8 – Rushcliffe, Melton, South Kesteven and South Holland Districts
- Sector 9 – Bassetlaw and Newark & Sherwood Districts
- Sector 10 – Rest of England, Wales and Scotland

Table 6-5 – Effects of Matrix Estimation on Prior Matrix – PM Peak (updated)

Origin Sector	Matrix	Destination Sector										
		1	2	3	4	5	6	7	8	9	10	Total
	Prior	7,215	1,416	670	2,360	872	368	409	261	490	502	14,562
	Post	6,117	1,440	624	2,128	630	298	350	167	524	434	12,712
1	*%Diff*	-15%	2%	-7%	-10%	-28%	-19%	-14%	-36%	7%	-14%	-13%
	Prior	587	873	51	151	263	71	47	48	51	233	2,374
	Post	446	866	59	145	256	64	20	25	53	205	2,139
2	*%Diff*	-24%	-1%	17%	-4%	-3%	-9%	-57%	-47%	4%	-12%	-10%
	Prior	425	60	546	142	35	27	104	16	25	6	1,385
	Post	342	23	547	220	11	25	100	12	23	0	1,303
3	*%Diff*	-20%	-61%	0%	55%	-69%	-7%	-4%	-20%	-7%	-100%	-6%
	Prior	1,821	238	219	1,907	238	80	359	176	211	183	5,432
	Post	1,622	187	278	1,921	159	82	314	186	203	123	5,074
4	*%Diff*	-11%	-21%	27%	1%	-33%	2%	-13%	6%	-4%	-33%	-7%
	Prior	507	282	33	109	454	22	3	7	1	258	1,677
	Post	378	256	24	76	447	21	1	5	1	217	1,424
5	*%Diff*	-25%	-9%	-28%	-31%	-2%	-7%	-68%	-37%	-21%	-16%	-15%
	Prior	287	58	53	89	20	2,165	42	63	73	432	3,282
	Post	290	54	52	107	19	2,113	41	56	59	314	3,104
6	*%Diff*	1%	-7%	-3%	20%	-7%	-2%	-2%	-11%	-20%	-27%	-5%
	Prior	289	72	191	213	1	31	427	39	18	67	1,348
	Post	235	41	187	198	1	29	424	37	16	43	1,211
7	*%Diff*	-19%	-43%	-2%	-7%	-38%	-4%	-1%	-5%	-10%	-36%	-10%
	Prior	158	44	38	186	4	90	58	3,258	69	1,840	5,746
	Post	108	32	35	170	2	83	55	3,141	63	1,407	5,096
8	*%Diff*	-31%	-26%	-9%	-9%	-59%	-8%	-4%	-4%	-9%	-24%	-11%
	Prior	575	116	68	198	2	4	21	62	1,965	1,152	4,162
	Post	549	83	65	178	2	2	20	55	1,926	875	3,755
9	*%Diff*	-5%	-28%	-4%	-10%	-20%	-50%	-6%	-10%	-2%	-24%	-10%
	Prior	606	699	268	303	97	177	20	626	329	11,918	15,043
	Post	512	603	219	187	86	148	14	516	261	9,920	12,464
10	*%Diff*	-16%	-14%	-18%	-38%	-12%	-16%	-32%	-17%	-21%	-17%	-17%
	Prior	12,472	3,859	2,136	5,657	1,988	3,034	1,488	4,555	3,232	16,590	55,012
Total	Post	10,598	3,585	2,089	5,329	1,611	2,864	1,338	4,201	3,129	13,538	48,282
	%Diff	-15%	-7%	-2%	-6%	-19%	-6%	-10%	-8%	-3%	-18%	-12%

Notes: (i) Trips are in vehicles

(ii) Sectors are shown in Figure 6.5, and defined below

- Sector 1 - Interview Cordon (including all Lincoln District and part North Kesteven District)
- Sector 2 – Lincoln Planning Area North (within West Lindsey District)
- Sector 3 – Lincoln Planning Area South East (within North Kesteven District)
- Sector 4 – Lincoln Planning Area South West (within North Kesteven District)
- Sector 5 – West Lindsey District
- Sector 6 – East Lindsey and Boston Districts
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- Sector 8 – Rushcliffe, Melton, South Kesteven and South Holland Districts
- Sector 9 – Bassetlaw and Newark & Sherwood Districts
- Sector 10 – Rest of England, Wales and Scotland

Table 6-6 – Aggregated Sector movements changes AM Peak

Origin Sector	Matrix	Destination Sectors			
		1	2 to 4	5 to 10	Total
1	Prior	9,580	3,112	2,281	14,972
	Post	9,378	3,212	1,829	14,418
	%Diff	**-2%**	**3%**	**-20%**	**-4%**
2 to 4	Prior	5,017	5,864	3,258	14,140
	Post	5,016	6,202	3,030	14,249
	%Diff	***0%***	***6%***	***-7%***	***1%***
5 to 10	Prior	3,293	2,477	22,790	28,559
	Post	3,176	2,485	22,736	28,397
	%Diff	**-4%**	**0%**	**0%**	**-1%**
Total	Prior	17,890	11,453	28,328	57,671
	Post	17,570	11,899	27,595	57,064
	%Diff	***-2%***	***4%***	***-3%***	***-1%***

Table 6-7 – Aggregated Sector movements changes inter peak

Origin Sector	Matrix	Destination Sectors			
		1	2 to 4	5 to 10	Total
1	Prior	5,982	2,388	1,658	10,029
	Post	7,046	2,795	1,610	11,450
	%Diff	***18%***	***17%***	***-3%***	***14%***
2 to 4	Prior	1,961	2,926	1,635	6,523
	Post	2,528	3,320	1,676	7,525
	%Diff	***29%***	***13%***	***2%***	***15%***
5 to 10	Prior	1,263	1,520	29,251	32,034
	Post	1,536	1,636	29,181	32,353
	%Diff	***22%***	***8%***	***0%***	***1%***
Total	Prior	9,206	6,834	32,545	48,585
	Post	11,110	7,751	32,467	51,327
	%Diff	***21%***	***13%***	***0%***	***6%***

Table 6-8 – Aggregated Sector movements changes PM Peak

Origin Sector	Matrix	Destination Sectors			
		1	2 to 4	5 to 10	Total
1	Prior	7,215	4,445	2,901	14,562
	Post	6,117	4,192	2,403	12,712
	%Diff	***-15%***	***-6%***	***-17%***	***-13%***
2 to 4	Prior	2,833	4,186	2,172	9,191
	Post	2,410	4,247	1,860	8,516
	%Diff	***-15%***	***1%***	***-14%***	***-7%***
5 to 10	Prior	2,423	3,021	25,815	31,259
	Post	2,071	2,565	22,418	27,054
	%Diff	***-15%***	***-15%***	***-13%***	***-13%***
Total	Prior	12,472	11,652	30,888	55,012
	Post	10,598	11,003	26,681	48,282
	%Diff	***-15%***	***-6%***	***-14%***	***-12%***

6.8 Effects of Matrix Estimation on Trip Ends

Comparisons of prior and post matrix estimation matrices in terms of origin and destination trip ends totals are presented in Figure 6-3 to Figure 6-14. It can be seen that, in most cases, differences in trip-end totals between prior and post matrices are small.

Figure 6-3 – Effects of ME on Origin Trip Ends - AM Peak (Zones In Sector 1)

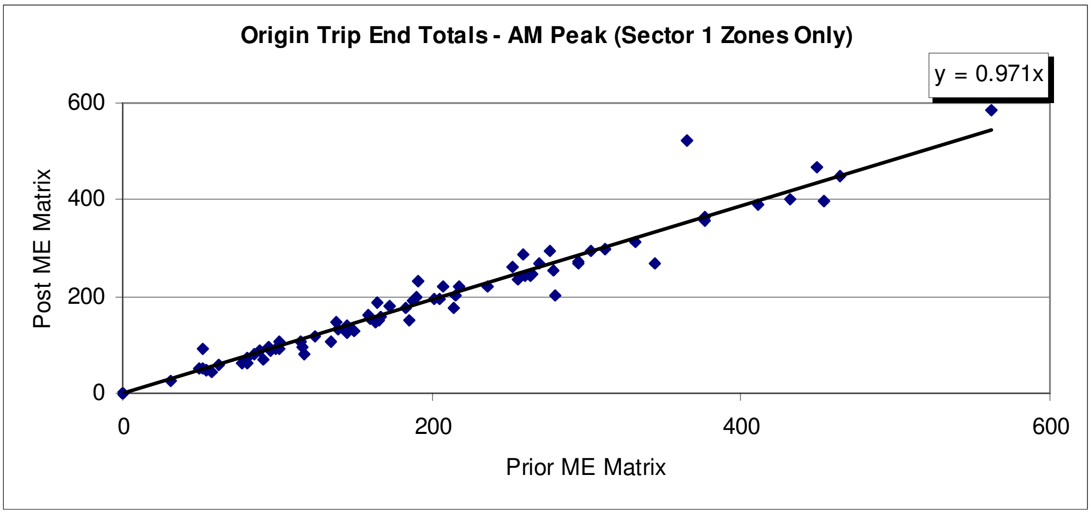


Figure 6-4 – Effects of ME on Dest. Trip Ends - AM Peak (Zones In Sector 1)

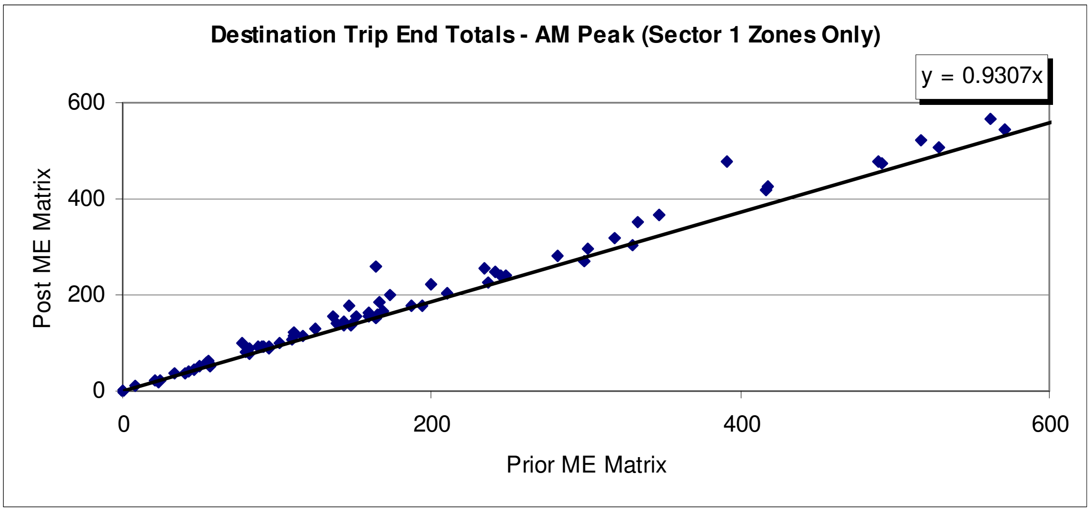


Figure 6-5 – Effects of ME on Origin Trip Ends - AM Peak (Zones In Sectors 2 to 10)

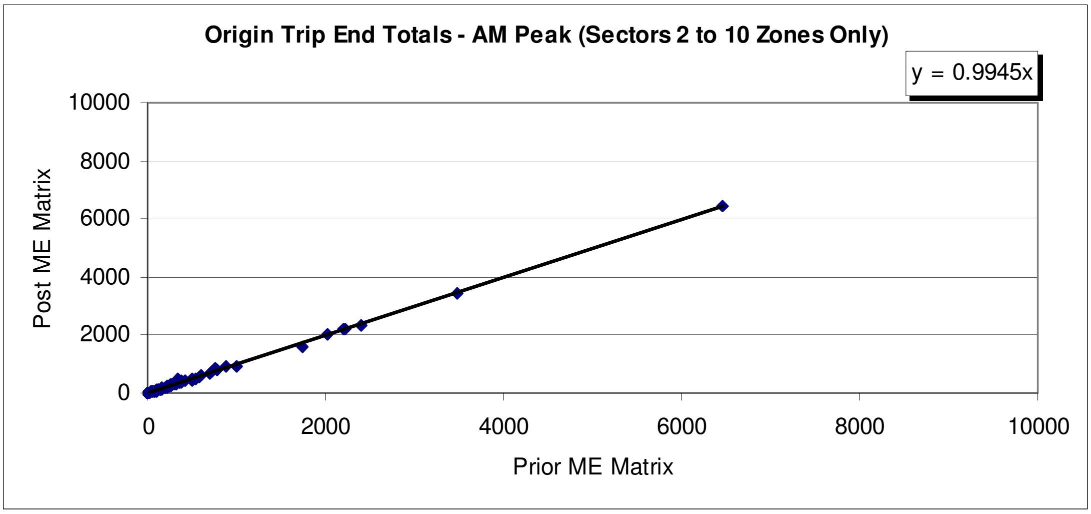


Figure 6-6 – Effects of ME on Destination Trip Ends - AM Peak (Zones In Sectors 2 to 10)

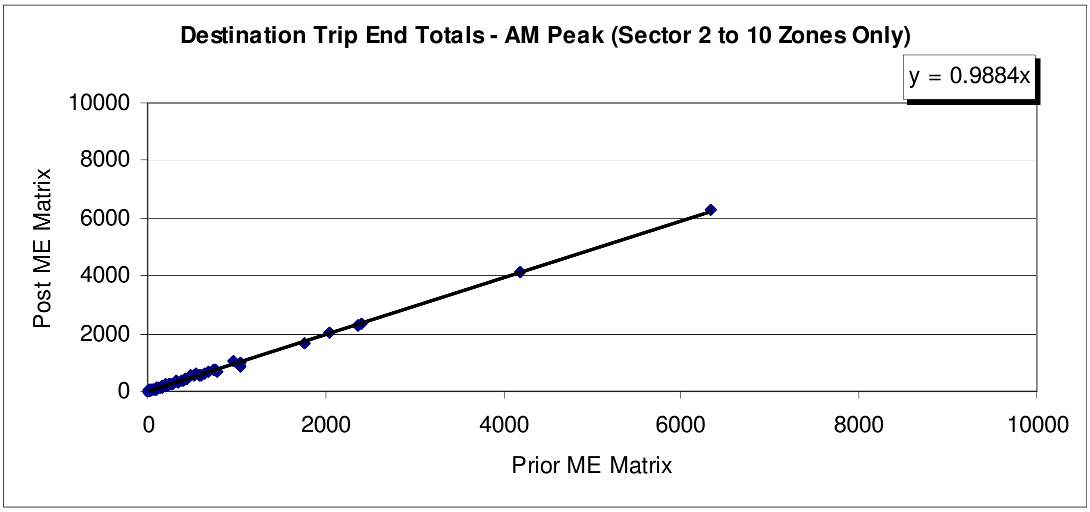


Figure 6-7 – Effects of ME on Origin Trip Ends - Interpeak (Zones In Sector 1)

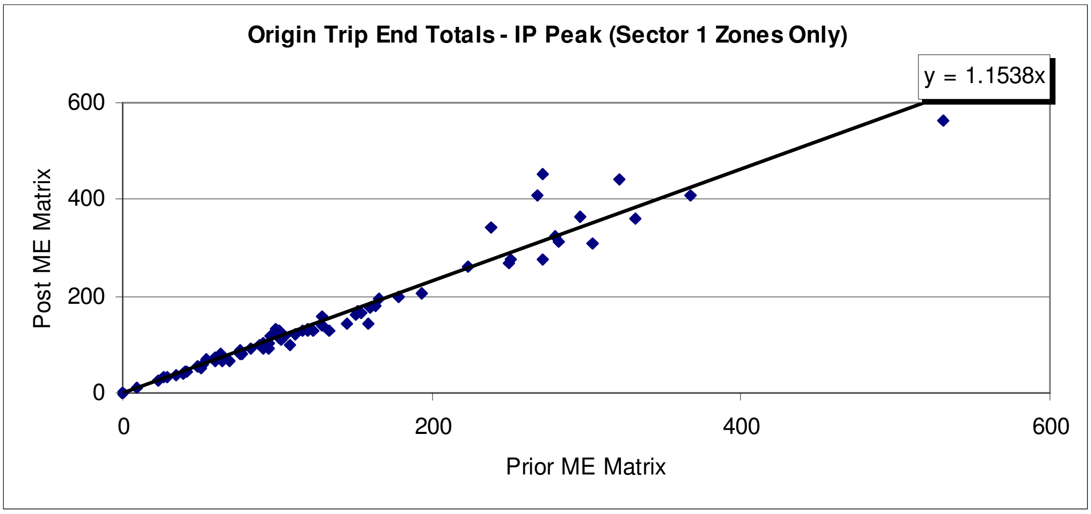


Figure 6-8 – Effects of ME on Destination Trip Ends - Interpeak (Zones In Sector 1)

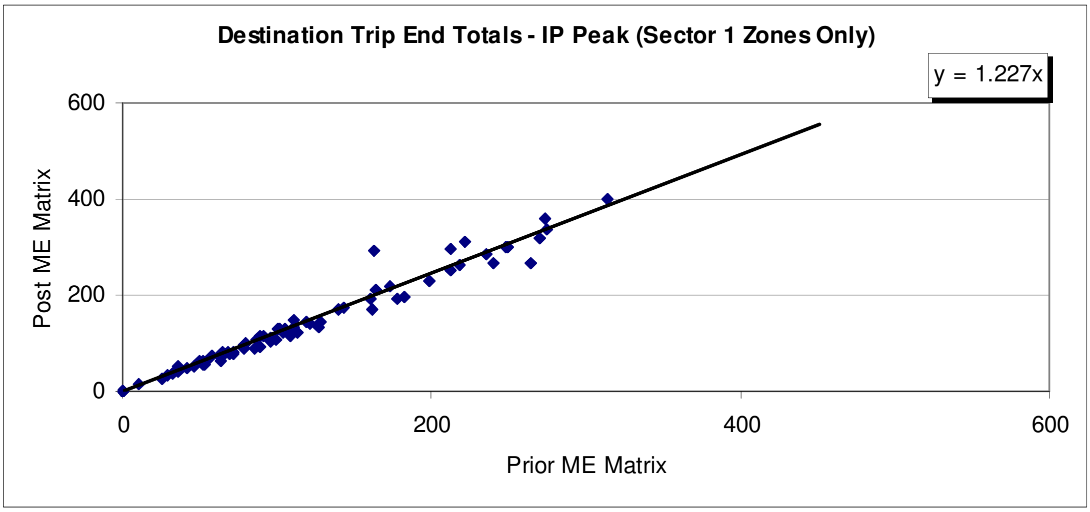


Figure 6-9 – Effects of ME on Origin Trip Ends - Interpeak (Zones In Sectors 2 to 10)

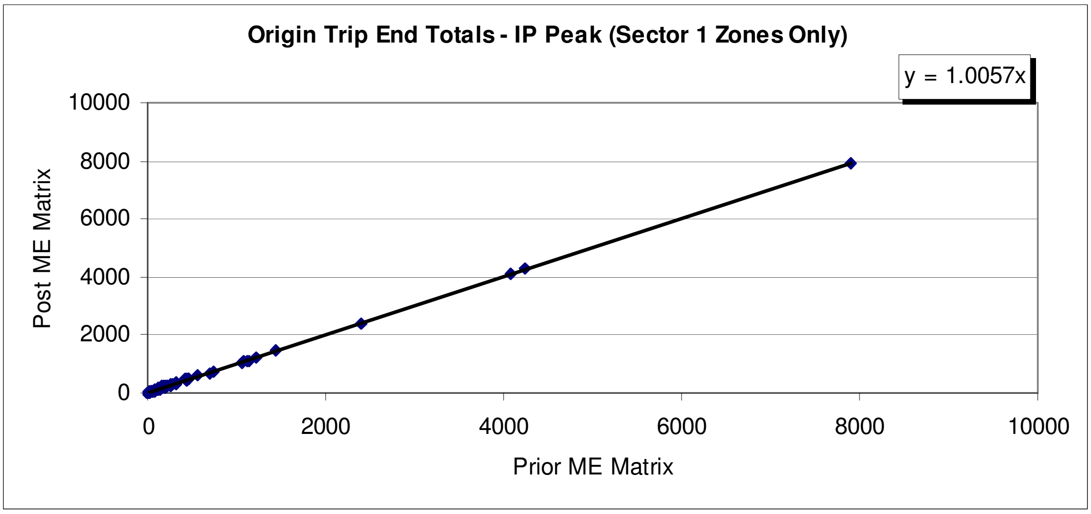


Figure 6-10 – Effects of ME on Destination Trip Ends - Interpeak (Zones In Sectors 2 to 10)

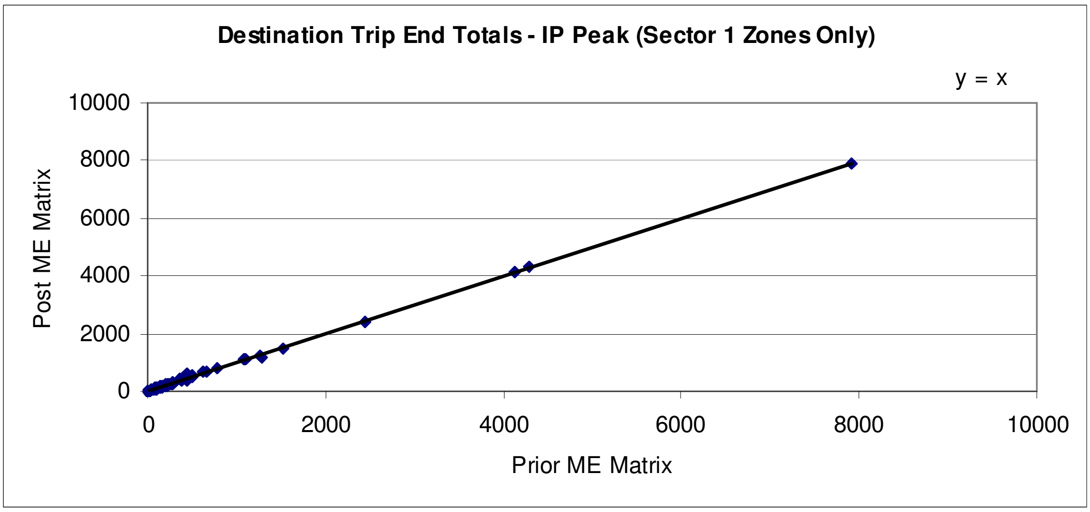


Figure 6-11 – Effects of ME on Origin Trip Ends - PM (Zones In Sector 1)

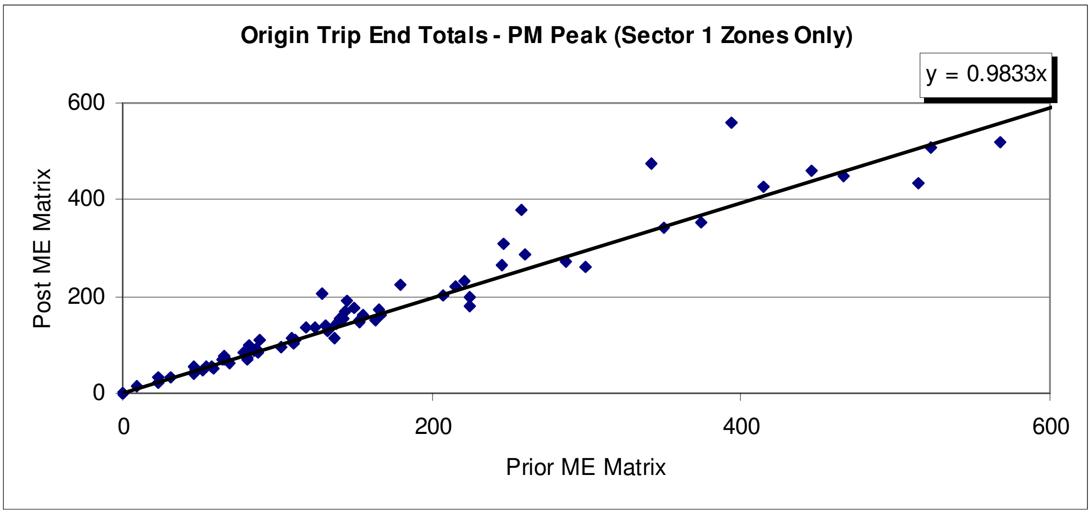


Figure 6-12 – Effects of ME on Destination Trip Ends - PM (Zones In Sector 1)

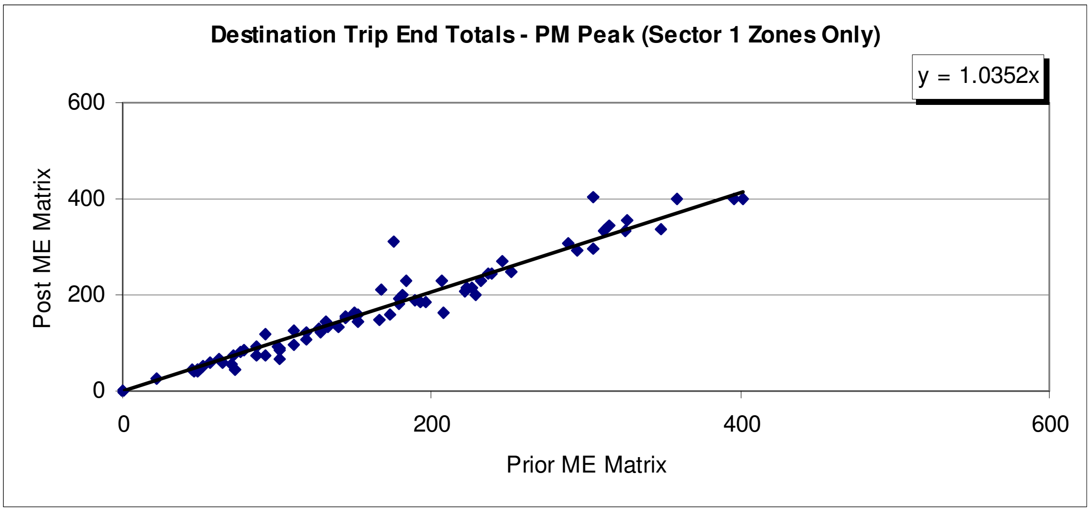


Figure 6-13 – Effects of ME on Origin Trip Ends - PM (Zones In Sectors 2 to 10)

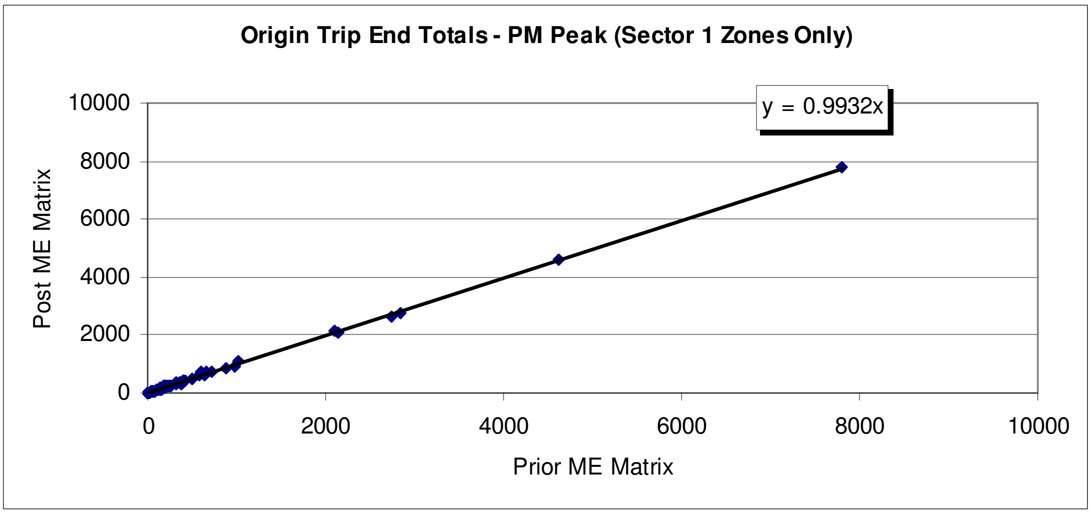
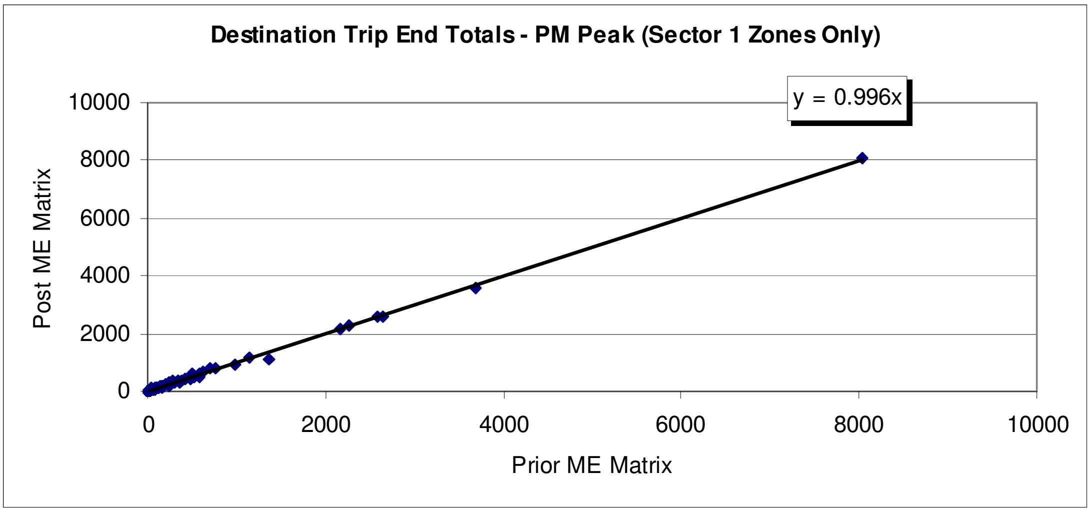


Figure 6-14 – Effects of ME on Destination Trip Ends - PM (Zones In Sectors 2 to 10)



6.9 Trip Length Distribution

Comparisons of the prior and post matrix trip length distributions have been undertaken for the AM, PM and Inter Peak models.

Figures 6-15 to 6-17 present the trip length distributions for the prior and post matrix estimation trip matrices as altered by the matrix estimation process. It can be seen that matrix estimation has the biggest effect on short distance trips, whilst longer distance trips remained relatively unchanged.

Figure 6-15 – Trip Length Distribution – AM Peak

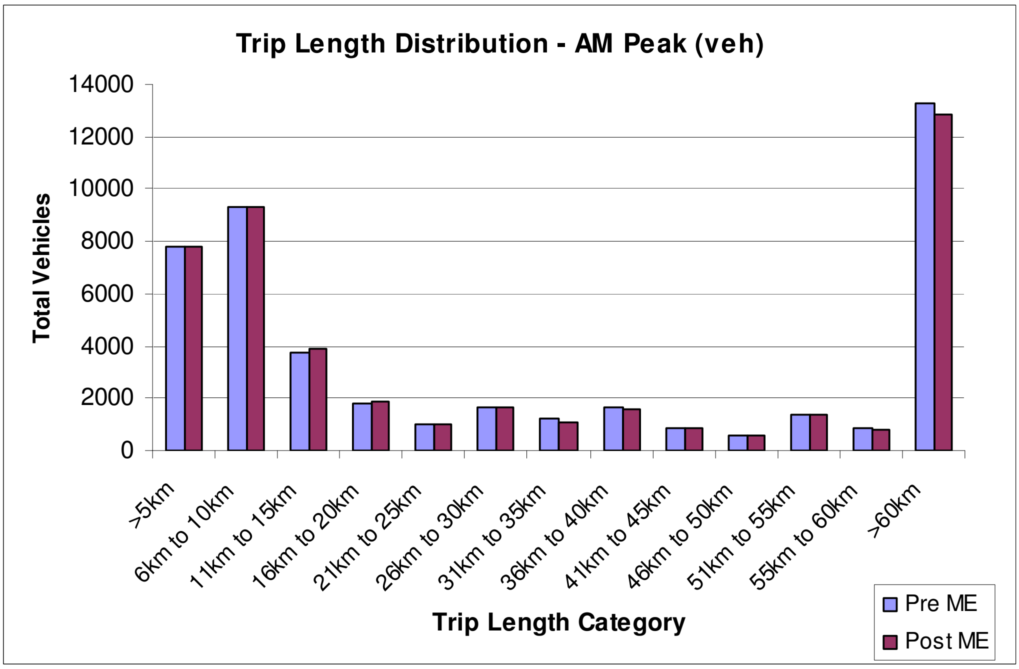


Figure 6-16 – Trip Length Distribution – Inter Peak

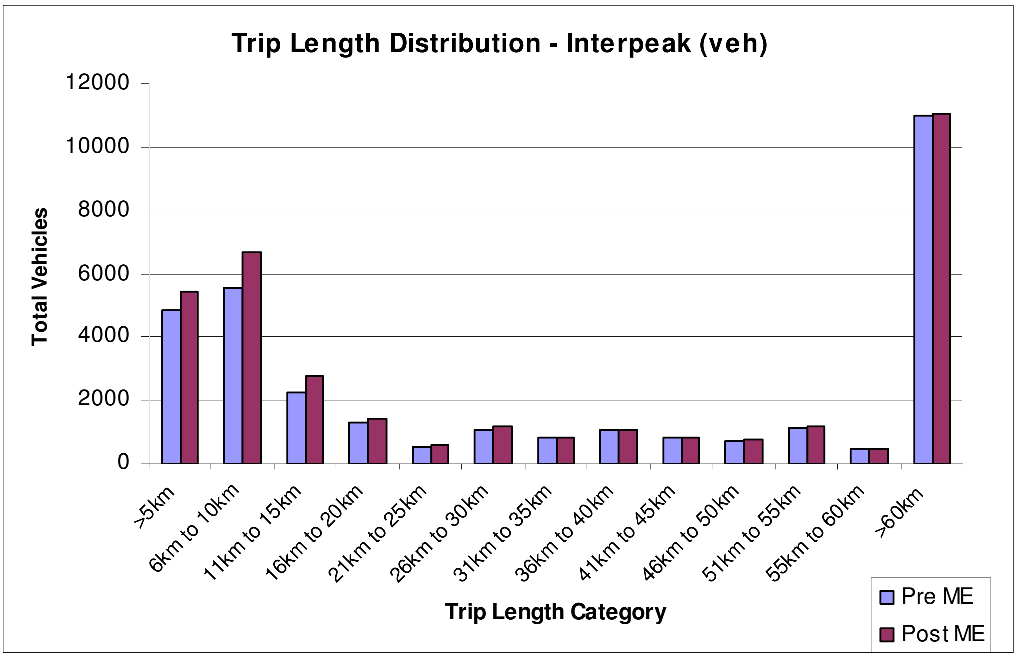
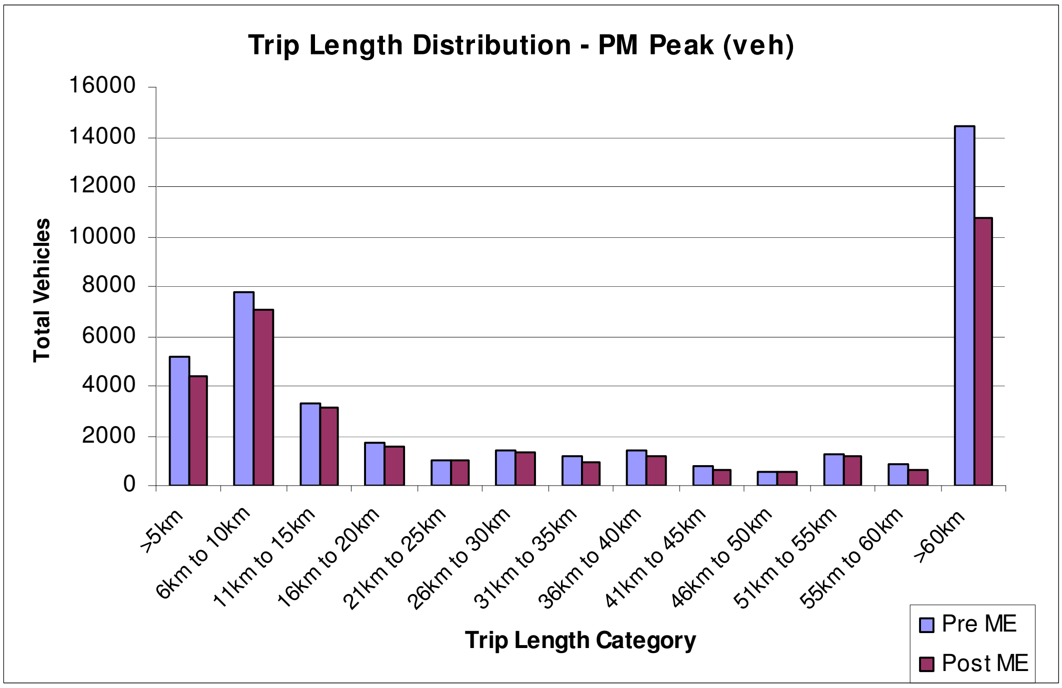


Figure 6-17 – Trip Length Distribution – PM Peak



6.10 Model Convergence

Convergence is the measure used to determine model stability during the assignment process (see Section 5.2). A suitably converged model can be expected to produce consistent outputs with minimal model noise. A total of 50 iterations were run to gain a statistically significant sample of convergence data.

The following convergence criteria are recommended in TAG Unit 3.19:

- Duality Gap less than 1% - this expresses the difference between the current estimates of the costs associated with trips through the modelled network against the theoretical costs if all traffic were to use the minimum cost route associated with their journey. It measures how far modelled flows differ from the desired equilibrium.

- Average absolute difference less than 1 – this is the number of routes that deviate from each other based on the impedances of the assignment.

- Relative average absolute difference less than 5% - this is the percentage of routes that deviate from each other based on the impedances of the assignment.

Figure 6-18 to Figure 6-20 below show the graphs of Duality Gap against the number of iterations in each time-period. Where no join between points can be observed, it indicates that the duality gap fell to a figure close enough to 0 to be rounded down to 0, and therefore does not register on a logarithmic chart.

Figure 6-18 – Model Convergence – AM Peak

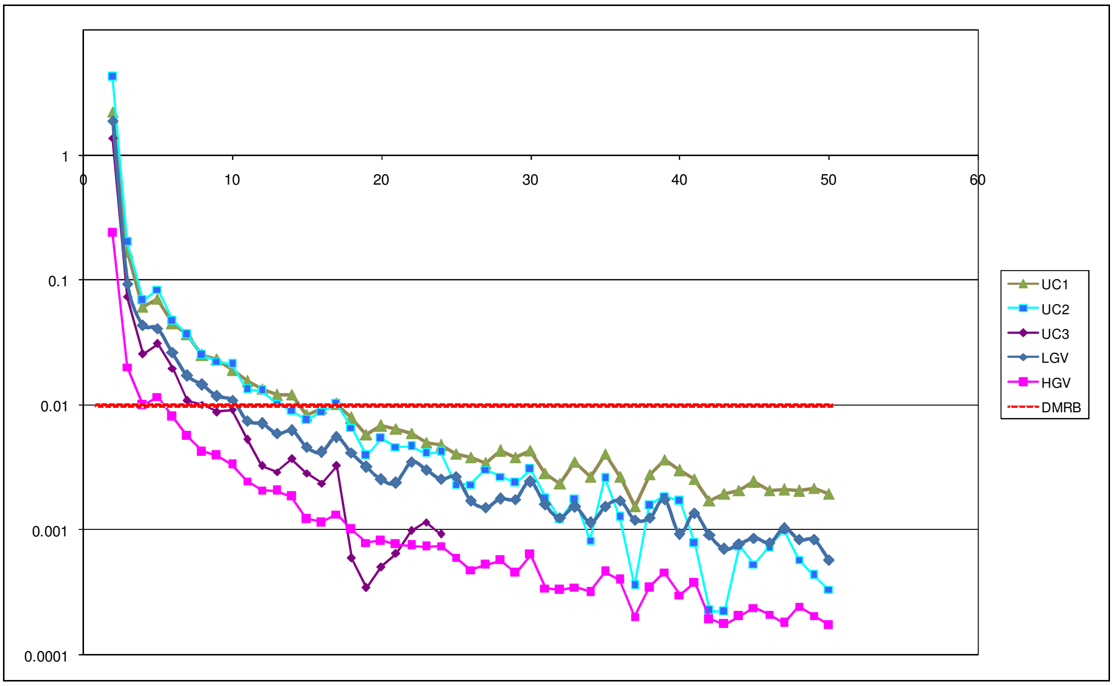


Figure 6-19 – Model Convergence – Inter Peak

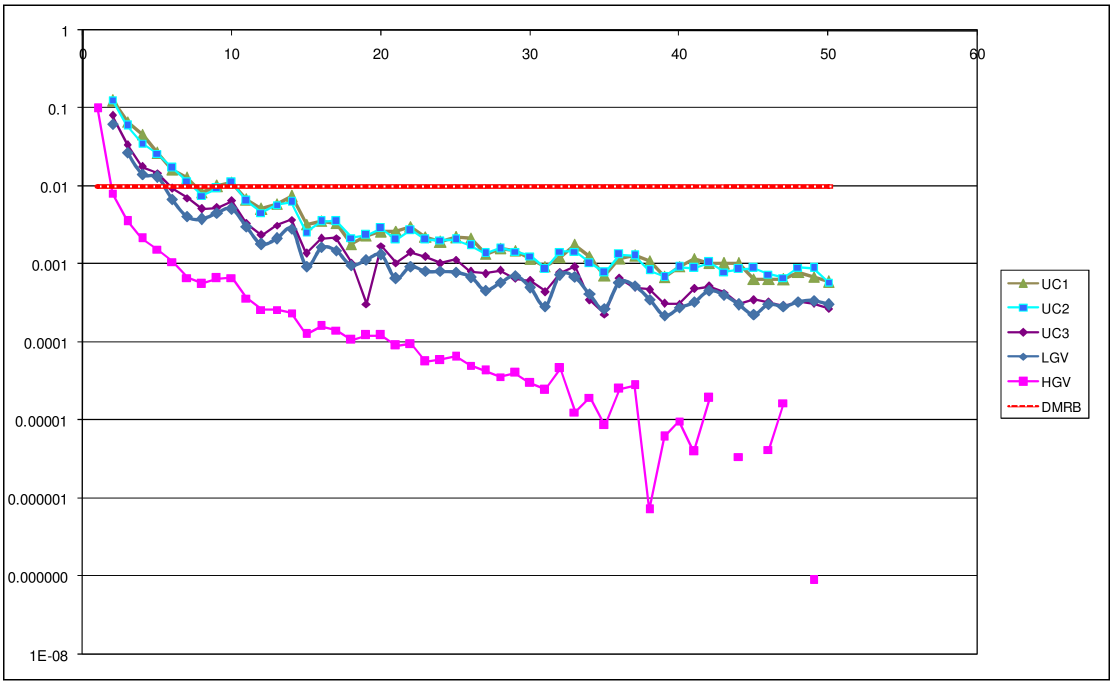
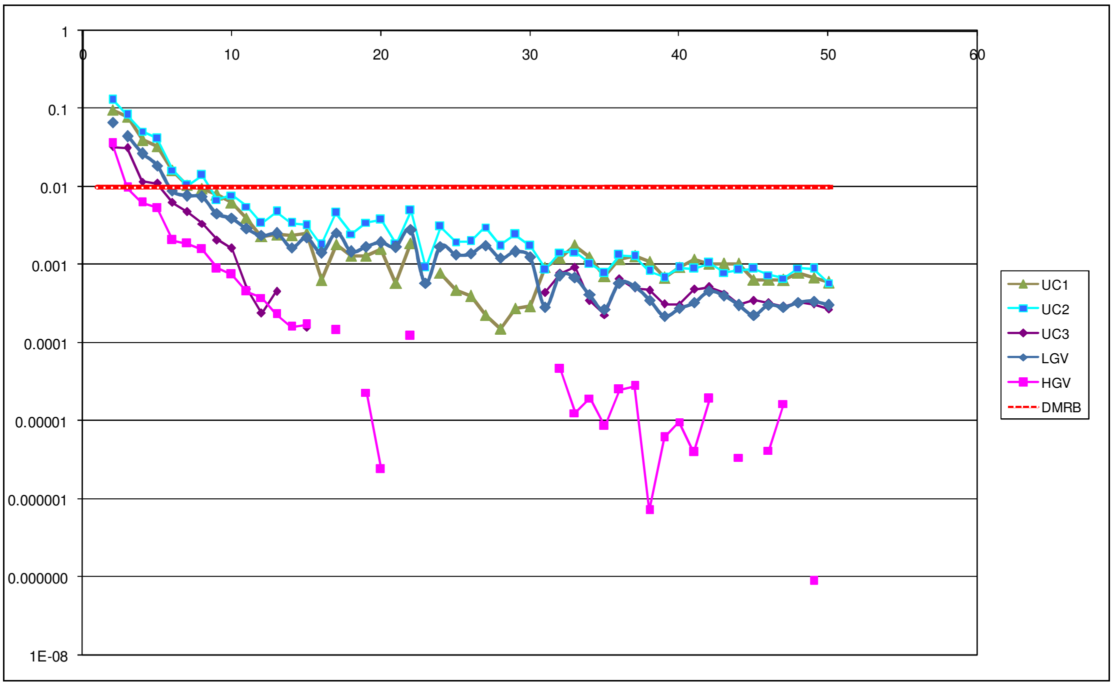


Figure 6-20 – Model Convergence – PM Peak



It can be seen from the figures above that all three models for each time period reached convergence within 50 assignment iterations. Along with satisfactory results from modelled link flow against observed counts, a high degree of confidence was established with the calibrated models.

Where no join between points can be observed, it indicates that the duality gap fell to a figure close enough to 0 to be rounded down to 0, and therefore does not register on a logarithmic chart.

6.11 Calibration Results

The calibration at the postcard sites are summarized in Tables 6-6, 6-7 and 6-8 below. These results indicate a fair correlation between observed and modelled flows with many postcard screenlines meeting DfT (validation) criteria in respect of percentage flow differences.

Table 6-9 - Calibration at Postcard sites AM Peak

Site Number	Road section	Observed counts (pcu)	Modelled counts (pcu)	Abs Diff	% Diff	GEH	Validated (Flow)	Validated (GEH)
Inbound Movements								
01	B1398 Middle St	642	580	62	-64%	2.5	✓	✓
02	A15 North of Lincs	774	797	23	3%	0.8	✓	✓
03	A57 West of Linc	1042	1019	22	-2%	0.7	✓	✓
04	A46 North of Lincs	652	809	157	24%	5.8	×	×
05	B1190 Lincoln Rd	329	434	105	32%	5.4	×	×
06	A46 SW of Lincs	1322	1171	151	-11%	4.3	✓	✓
07	B1308 Greetwell Rd	563	437	126	-22%	5.6	×	×
08	B1190 Washingb. Rd	443	504	61	14%	2.8	✓	✓
09	B1188 Canwick Rd	1122	1157	36	3%	1.1	✓	✓
10	A15 Cross O Cliff	458	409	49	-11%	2.4	✓	✓
11	Brant Rd	418	511	93	22%	4.3	✓	✓
11a	Station Rd	329	285	44	-13%	2.5	✓	✓
12	A158 Ragby Rd East	612	789	177	29%	6.7	×	×
	Total	**8,705**	**8,902**	**197**	**2%**	**2.1**	2.5	✓
						Total Passed Guidance	**69%**	**69%**
Outbound Movements								
01	B1398 Middle St	166	98	69	-41%	6.0	✓	×
02	A15 North of Lincs	447	447	0	0%	0.0	✓	✓
03	A57 West of Linc	661	450	211	-32%	8.9	×	×
04	A46 North of Lincs	346	356	10	3%	0.5	✓	✓
05	B1190 Lincoln Rd	230	185	45	-20%	3.1	✓	✓
06	A46 SW of Lincs	1267	1021	246	-19%	7.3	×	×
07	B1308 Greetwell Rd	123	112	11	-9%	1.0	✓	✓
08	B1190 Washingb. Rd	124	119	5	-4%	0.4	✓	✓
09	B1188 Canwick Rd	577	640	63	11%	2.6	✓	✓
10	A15 Cross O Cliff	314	352	37	12%	2.0	✓	✓
11	Brant Rd	271	348	77	28%	4.3	✓	✓
11a	Station Rd	376	408	32	8%	1.6	✓	✓
12	A158 Ragby Rd East	481	475	6	-1%	0.3	✓	✓
	Total	**5,384**	**5,010**	**374**	**-7%**	**5.2**	**✓**	**✓**
						Total Passed Guidance	**85%**	**77%**

Table 6-10 - Calibration at Postcard sites Interpeak

Site Number	Road section	Observed counts (pcu)	Modelled counts (pcu)	Abs Diff	% Diff	GEH	Validated (Flow)	Validated (GEH)
Inbound Movements								
01	B1398 Middle St	196	130	66	-0.34	5.2	✓	×
02	A15 North of Lincs	413	534	121	0.29	5.6	×	×
03	A57 West of Linc	578	582	4	0.01	0.2	✓	✓
04	A46 North of Lincs	513	545	32	6%	1.4	✓	✓
05	B1190 Lincoln Rd	202	219	17	8%	1.2	✓	✓
06*	A46 SW of Lincs	822	822	0	0%	0.0	✓	✓
07	B1308 Greetwell Rd	199	169	30	-15%	2.2	✓	✓
08*	B1190 Washingb. Rd	223	223	0	0%	0.0	✓	✓
09	B1188 Canwick Rd	641	678	38	6%	1.5	✓	✓
10	A15 Cross O Cliff	455	415	41	-9%	1.9	✓	✓
11	Brant Rd	322	320	2	-1%	0.1	✓	✓
11a	Station Rd	217	209	8	-4%	0.6	✓	✓
12	A158 Ragby Rd East	540	577	37	7%	1.5	✓	✓
	Total	5,322	5,423	100	0.02	1.4	✓	✓
						Total Passed Guidance	**92%**	**85%**
Outbound Movements								
01	B1398 Middle St	190	164	26	-14%	2.0	✓	✓
02	A15 North of Lincs	434	537	103	24%	4.7	×	✓
03	A57 West of Linc	553	452	101	-18%	4.5	×	✓
04	A46 North of Lincs	526	567	42	8%	1.8	✓	✓
05	B1190 Lincoln Rd	221	235	14	6%	0.9	✓	✓
06	A46 SW of Lincs	894	864	30	-3%	1.0	✓	✓
07	B1308 Greetwell Rd	211	169	42	-20%	3.1	✓	✓
08*	B1190 Washingb. Rd	163	163	0	0%	0.0	✓	✓
09	B1188 Canwick Rd	758	767	9	1%	0.3	✓	✓
10	A15 Cross O Cliff	426	461	35	8%	1.7	✓	✓
11	Brant Rd	319	408	88	28%	4.6	✓	✓
11a	Station Rd	225	241	15	7%	1.0	✓	✓
12	A158 Ragby Rd East	558	615	57	10%	2.3	✓	✓
	Total	5,478	5,643	164	0.03	2.2	✓	✓
						Total Passed Guidance	**88%**	**92%**

Note - * Denotes that count data was unavailable at these sites and so the observed count is set to equal the modelled count.

Table 6-11 - Calibration at Postcard sites PM peak

Site Number	Road section	Observed counts (pcu)	Modelled counts (pcu)	Abs Diff	% Diff	GEH	Validated (Flow)	Validated (GEH)
Inbound Movements								
01	B1398 Middle St	293	228	65	-0.22	4.0	✓	✓
02	A15 North of Lincs	533	620	87	0.16	3.6	✓	✓
03	A57 West of Linc	597	644	46	0.08	1.9	✓	✓
04	A46 North of Lincs	590	685	95	0.16	3.8	✓	✓
05	B1190 Lincoln Rd	277	379	102	0.37	5.6	×	×
06*	A46 SW of Lincs	1261	1261	0	0.00	0.0	✓	✓
07	B1308 Greetwell Rd	127	97	30	-0.24	2.8	✓	✓
08*	B1190 Washingb. Rd	272	272	0	0.00	0.0	✓	✓
09	B1188 Canwick Rd	614	632	17	0.03	0.7	✓	✓
10	A15 Cross O Cliff	473	491	18	0.04	0.8	✓	✓
11	Brant Rd	424	351	74	-0.17	3.7	✓	✓
11a	Station Rd	402	327	75	-0.19	3.9	✓	✓
12	A158 Ragby Rd East	542	575	33	0.06	1.4	✓	✓
	Total	6,407	6,562	155	2%	1.9	✓	✓
						Total Passed Guidance	**92%**	**92%**
Outbound Movements								
01	B1398 Middle St	608	566	42	-0.07	1.7	✓	✓
02	A15 North of Lincs	688	660	28	-0.04	1.1	✓	✓
03	A57 West of Linc	1025	750	275	-0.27	9.2	×	×
04	A46 North of Lincs	749	541	208	-0.28	8.2	×	×
05	B1190 Lincoln Rd	292	230	62	-0.21	3.8	✓	✓
06	A46 SW of Lincs	1165	945	220	-0.19	6.8	×	×
07	B1308 Greetwell Rd	506	372	134	-0.27	6.4	×	×
08*	B1190 Washingb. Rd	295	295	0	0.00	0.0	✓	✓
09	B1188 Canwick Rd	1354	1080	274	-0.20	7.9	×	×
10	A15 Cross O Cliff	740	828	89	0.12	3.2	✓	✓
11	Brant Rd	538	649	111	0.21	4.6	×	✓
11a	Station Rd	236	259	23	0.10	1.5	✓	✓
12	A158 Ragby Rd East	776	683	93	-0.12	3.4	✓	✓
	Total	8,971	7,858	111	-12%	12.	×	×
						Total Passed Guidance	**73%**	**77%**

Note - * Denotes that count data was unavailable at these sites and so the observed count is set to equal the modelled count.

7 Model Validation

7.1 Introduction

Model Validation is undertaken to check that a transport model accurately represents the transport network that it has been based upon. The main aims of this process, as stated in TAG Unit 3.19 - Highway Assignment Modelling, are:

- To demonstrate that the model accurately reproduces an existing and independently observed situation
- To summarise the accuracy of the base from which future forecasts are to be prepared.

7.2 Screenline Flow Validation

Seven screenlines (as shown in Figure 7-1) controlling major movements in the study area have been devised from observed data. Due to an overall lack of count data, some counts have been included in more than one screenline. This has resulted in screenlines containing a combination of both calibration and validation counts. Comparisons of modelled and observed flows were undertaken for these screenlines (by direction) as shown below in Tables 7-1 to 7-4.

Note - Guidelines for model calibration/validation stated in TAG Unit 3.19 do not suggest using the GEH criteria along screenline totals, which is a departure from the superseded DMRB (Design Manual for Roads & Bridges) guidance. GEH statistics along screenlines have been included in this report and have been used as an additional check during the model calibration/validation.

Table 7-1 – Screenlines Summary

Pass/Fail	AM		Inter Peak		PM	
	Flow	GEH	Flow	GEH	Flow	GEH
Screenline 1 - NB	✓	✓	✓	✓	✓	×
Screenline 1 - SB	✓	✓	✓	✓	✓	✓
Screenline 2 - EB	✓	×	✓	✓	✓	×
Screenline 2 - WB	✓	×	✓	✓	✓	✓
Screenline 3 - NB	✓	✓	✓	✓	✓	✓
Screenline 3 - SB	✓	✓	✓	✓	✓	✓
Screenline 4 - EB	×	×	✓	✓	✓	✓
Screenline 4 - WB	✓	×	✓	✓	×	×
Screenline 5 - NB	✓	✓	×	×	✓	✓
Screenline 5 - SB	✓	×	×	×	✓	✓
Screenline 6 - EB	✓	✓	✓	×	×	×
Screenline 6 - WB	✓	✓	✓	✓	✓	✓
Screenline 7 - EB	✓	✓	✓	✓	×	×

Pass/Fail	AM		Inter Peak		PM	
	Flow	GEH	Flow	GEH	Flow	GEH
Screenline 7 - WB	✓	✓	✓	✓	×	×
Total Passing Criteria	**13 / 14**	**9 / 14**	**12 / 14**	**11 / 14**	**10 / 14**	**8 / 14**
% Passing Criteria	**93%**	**64%**	**86%**	**79%**	**71%**	**57%**

Figure 7-1 - Calibration & Validation Screenlines

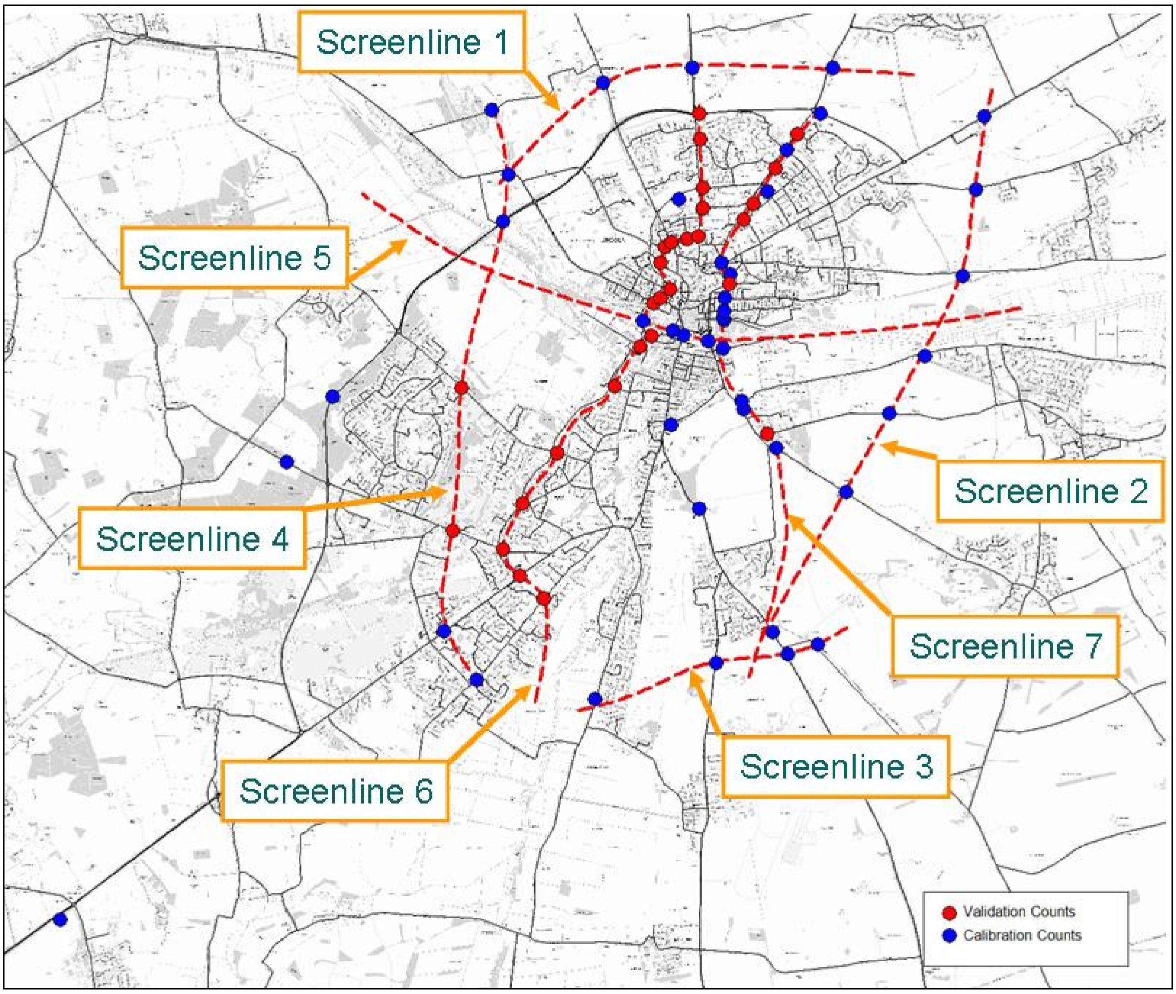


Table 7-2 –Screenline Summary – AM Peak

Screenline	Direction	Observed (pcu)	Modelled (pcu)	Abs Diff (pcu)	% Diff	Average GEH	Pass TAG Flow	Pass DMRB GEH
Screenline1	NB	1,767	1,638	129	-0.07	3.1	✓	✓
	SB	3,356	3,321	35	-0.01	0.6	✓	✓
Screenline2	EB	1,895	1,714	181	-0.10	4.2	✓	×
	WB	3,723	3,451	272	-0.07	4.5	✓	×
Screenline3	NB	1,371	1,362	9	-0.01	0.2	✓	✓
	SB	1,538	1,470	68	-0.04	1.8	✓	✓
Screenline4	EB	4,837	4,098	739	-0.15	11.1	×	×
	WB	3,237	2,869	368	-0.11	6.7	✓	×
Screenline5	NB	5,272	5,522	251	0.05	3.4	✓	✓
	SB	4,212	4,588	376	0.09	5.7	✓	×
Screenline6	EB	7,205	7,257	52	0.01	0.6	✓	✓
	WB	6,053	6,255	202	0.03	2.6	✓	✓
Screenline7	EB	5,555	5,464	91	-0.02	1.2	✓	✓
	WB	6,127	6,329	202	0.03	2.6	✓	✓
Number of Screenlines passing Criteria							**13/14**	**9/14**
Percentage of Screenlines passing Criteria							**93%**	**64%**

Table 7-3 –Screenline Summary – Inter Peak

Screenline	Direction	Observed (pcu)	Modelled (pcu)	Abs Diff (pcu)	% Diff	Average GEH	Pass TAG Flow	Pass DMRB GEH
Screenline 1	NB	1,814	1,849	35	0.02	0.8	✓	✓
	SB	1,840	1,818	21	-0.01	0.5	✓	✓
Screenline 2	EB	1,929	1,965	36	0.02	0.8	✓	✓
	WB	1,843	1,895	52	0.03	1.2	✓	✓
Screenline 3	NB	855	881	25	0.03	0.9	✓	✓
	SB	1,021	1,048	27	0.03	0.8	✓	✓
Screenline 4	EB	3,512	3,545	33	0.01	0.6	✓	✓
	WB	3,617	3,617	0	0.00	0.0	✓	✓
Screenline 5	NB	3,510	4,015	505	0.14	8.2	×	×
	SB	3,904	4,520	615	0.16	9.5	×	×
Screenline 6	EB	5,594	5,272	322	-0.06	4.4	✓	×
	WB	5,472	5,371	101	-0.02	1.4	✓	✓
Screenline 7	EB	4,803	4,721	82	-0.02	1.2	✓	✓
	WB	5,318	5,123	196	-0.04	2.7	✓	✓
Number of Screenlines passing Criteria							**12/14**	**11/14**
Percentage of Screenlines passing Criteria							**86%**	**79%**

Table 7-4 –Screenline Summary – PM Peak

Screenline	Direction	Observed (pcu)	Modelled (pcu)	Abs Diff (pcu)	% Diff	Average GEH	Pass TAG Flow	Pass DMRB GEH
Screenline 1	NB	3,264	2,878	386	-0.12	7.0	✓	×
	SB	2,302	2,219	83	-0.04	1.7	✓	✓
Screenline 2	EB	3,385	3,029	356	-0.11	6.3	✓	×
	WB	1,875	1,938	63	0.03	1.4	✓	✓
Screenline 3	NB	1,396	1,376	20	-0.01	0.5	✓	✓
	SB	1,492	1,383	109	-0.07	2.9	✓	✓
Screenline 4	EB	4,687	4,524	163	-0.03	2.4	✓	✓
	WB	4,963	4,250	713	-0.14	10.5	×	×
Screenline 5	NB	4,358	4,238	120	-0.03	1.8	✓	✓
	SB	5,269	5,387	119	0.02	1.6	✓	✓
Screenline 6	EB	6,843	6,098	745	-0.11	9.3	×	×
	WB	6,474	6,319	155	-0.02	1.9	✓	✓
Screenline 7	EB	6,275	5,531	743	-0.12	9.7	×	×
	WB	6,299	5,687	612	-0.10	7.9	×	×
Number of Screenlines passing Criteria							**10/14**	**8/14**
Percentage of Screenlines passing Criteria							**71%**	**57%**

7.3 Journey Time Validation

It is important that journey times are properly validated to ensure that speeds on links and delays at junctions are accurately represented by the model. This will give confidence in the model's ability to correctly forecast the likely impacts of changing traffic demand and network improvements.

The journey time validation is based on comparisons of observed and modelled journey times along 10 (bi-directional) routes (shown below).

Figure 7-2 – Journey Time Routes

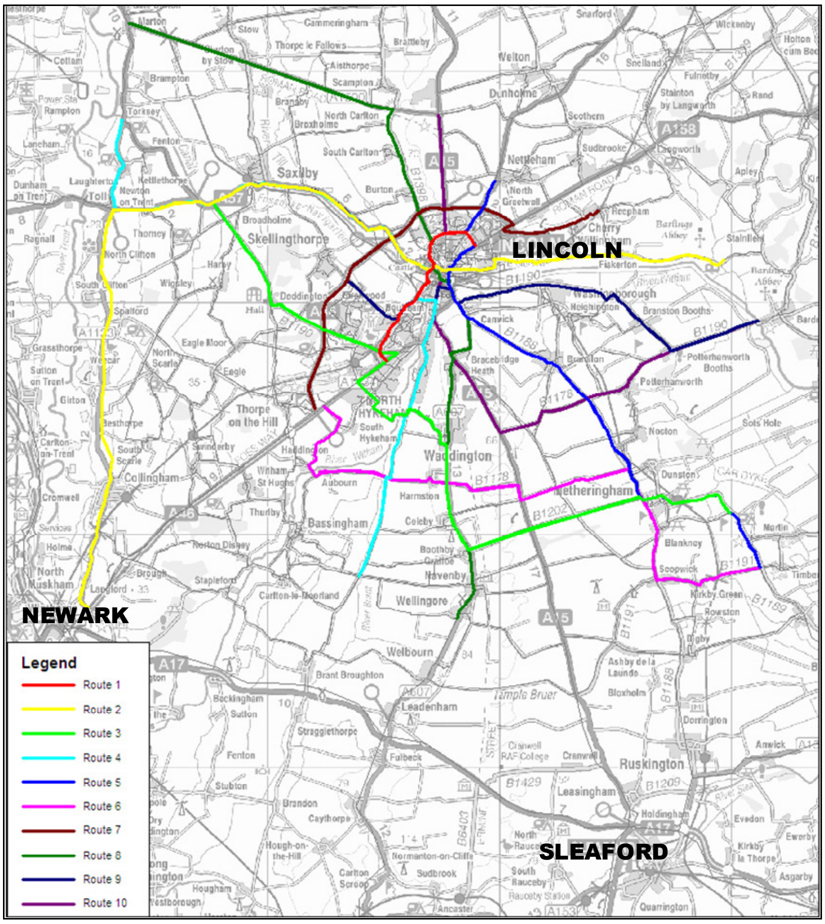


Table 7-5 provides a summary of the journey time validation results for the three modelled time periods. It shows that, for all three time periods, the difference between modelled and observed journey times is within 15% or 1 minute for 18 out of 20 routes (90%) for AM Peak, 18 out of 20 routes (90%) for the Inter-Peak and 18 out of 20 routes (90%) for the PM Peak. All periods therefore meet the TAG Unit 3.19 journey time validation criteria (as described in Table 6-1).

Detailed journey time validation results for all routes are presented in Appendix I, which includes tables and figures showing comparisons of observed and modelled journey times over the length of each route.

Table 7-5 – Journey Time Validation Summary – All Periods

Route	Description	Pass Criteria		
		AM	IP	PM
Route 1	B1182 Ruskin Ave/A15 Wragby Rd and A1434 Newark Rd/B1003 Tritton Rd	✓	✓	✓
		✓	✓	✓
Route 2	Ferry Rd/Short Ferry Rd and A1133/A46	✓	✓	✓
		✓	✓	✓
Route 3	B1189 Moor Ln and A57 Gainsborough Rd/B1190 Tom Otters Ln	×	✓	×
		✓	✓	✓
Route 4	Hopyard Ln/Navenby Ln and A1133 Newark Rd/A156	✓	✓	✓
		✓	✓	✓
Route 5	B1189/B1191 Main St/Station Rd and A46 Lincoln Rd/Washdyke Ln	✓	✓	✓
		✓	✓	✓
Route 6	B1191 Main St/B1189/Station Rd and A1434 Newark Rd/Boundary Ln	✓	✓	✓
		✓	✓	✓
Route 7	A46/A1434 Newark Rd and Moor Ln/Fiskerton Rd	✓	×	✓
		×	×	×
Route 8	A607 Cliff Rd/Skinnand Ln and A1500 Stow Park Rd/High St	✓	✓	✓
		✓	✓	✓
Route 9	B1190 Branston Causway at river and B1378 Skellingthorpe Rd/Lincoln Rd	✓	✓	✓
		✓	✓	✓
Route 10	B1190 Branston Causeway at river and A1500 Horncastle Ln/A15	✓	✓	✓
		✓	✓	✓
Number of routes passing criteria		**18 / 20**	**18 / 20**	**18 / 20**
Percentage of routes passing criteria		**90%**	**90%**	**90%**

7.4 Checking of Routing & Congestion

Further checks were undertaken on all major routes in the network to ensure that the routes used between origin and destination pairs were realistic. Example of these checks can be seen in Appendix J.

To ensure that the congestion patterns in the models resembled the observed queuing patterns across Lincoln, several employees from Lincolnshire County Council were interviewed and asked to contribute to a congestion map of Lincoln. Figures 7.3 and 7.4 show the observed congestion maps for the AM and PM peaks that were derived from discussions with Lincolnshire County Council employees.

The observed queuing patterns are based on peoples' perceptions of queues, rather than precise measurements, therefore the observed diagram includes areas with slow moving traffic as well as standing traffic. With this in mind, the diagrams show that the modelled queuing pattern is similar to the observed queue patterns with both diagrams showing queues on the main strategic routes through Lincoln.

Figure 7-3 – Queue Patterns – AM Peak

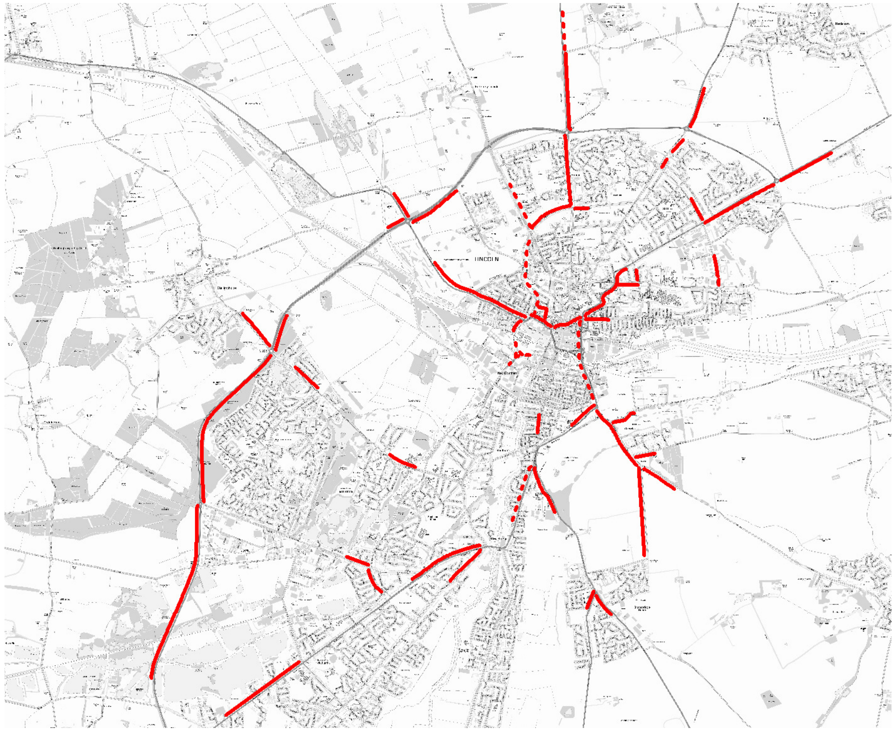
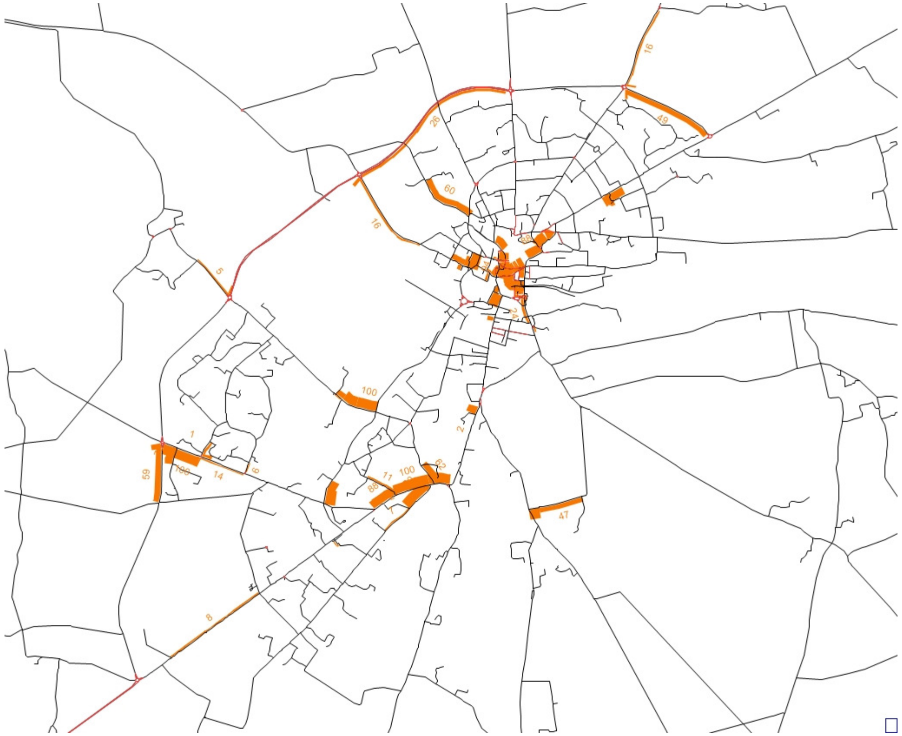
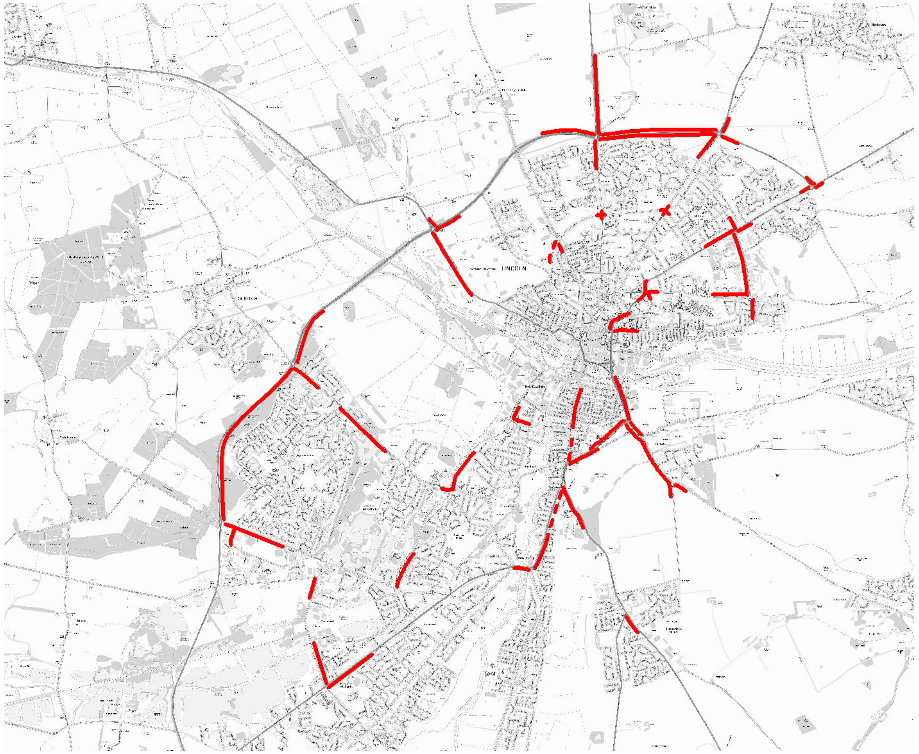
	
Local Knowledge	**Modelled Relative Queues**

Figure 7-4 – Queue Patterns – PM Peak

	
Local Knowledge	**Modelled Relative Queues**

7.5 Network Flow Summaries

Summary plots of network flows for the validated Base Year traffic model are shown, for each time period, in Figures 7-6 to 7-7 below.

Figure 7-5 - Flow Diagram AM Peak (Hourly PCUs)

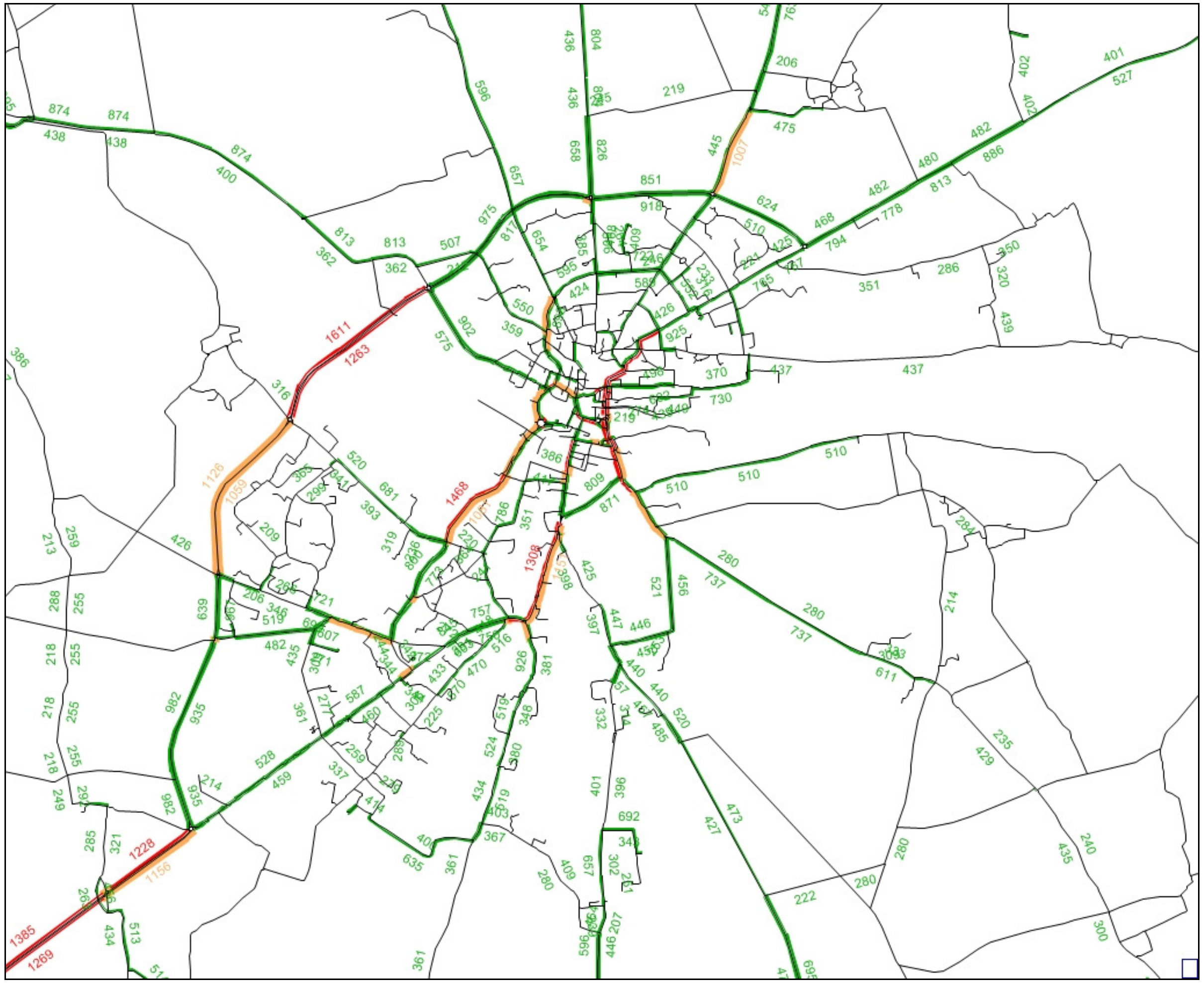


Figure 7-6 - Flow Diagram AM Peak (Hourly PCUs)

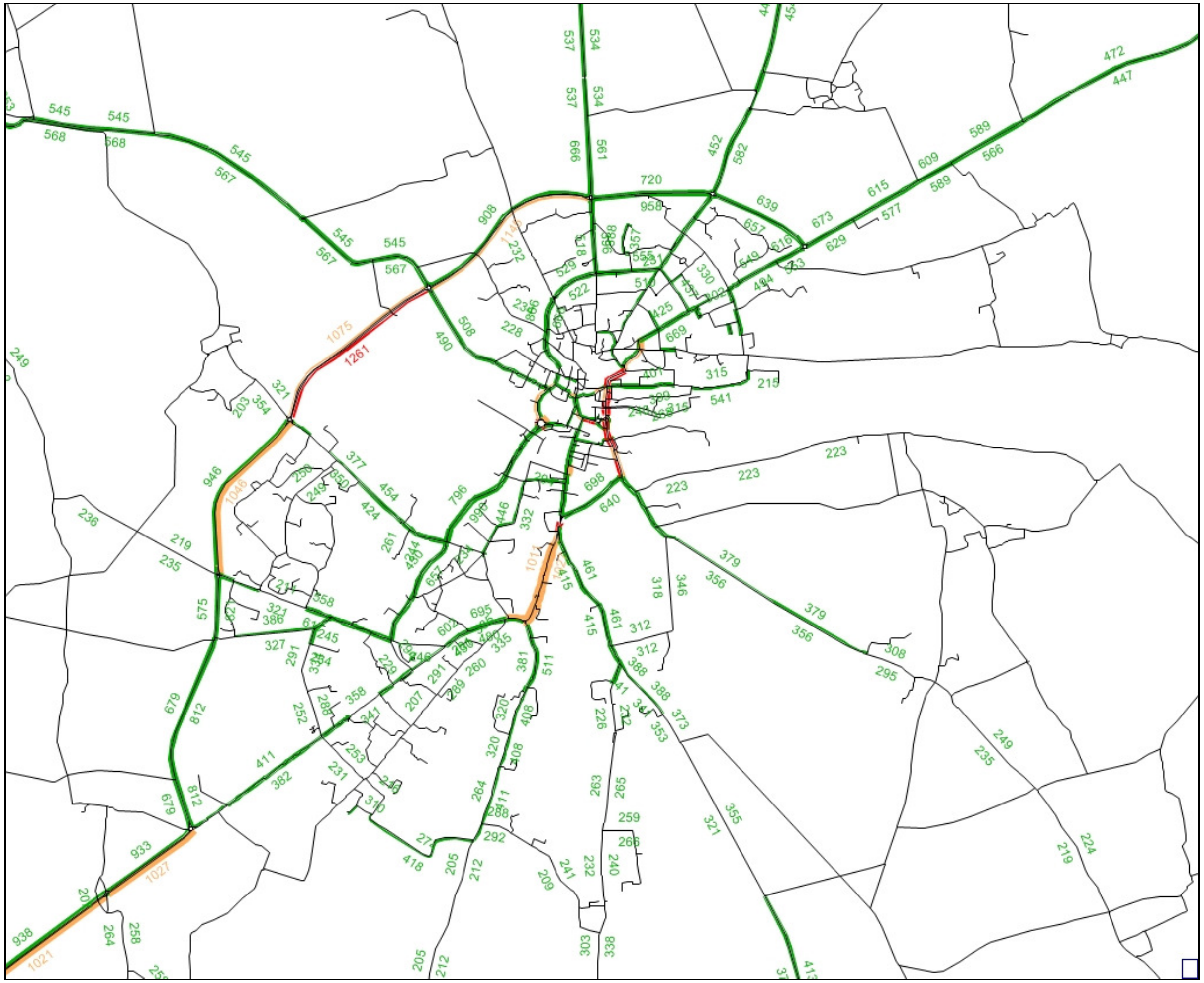
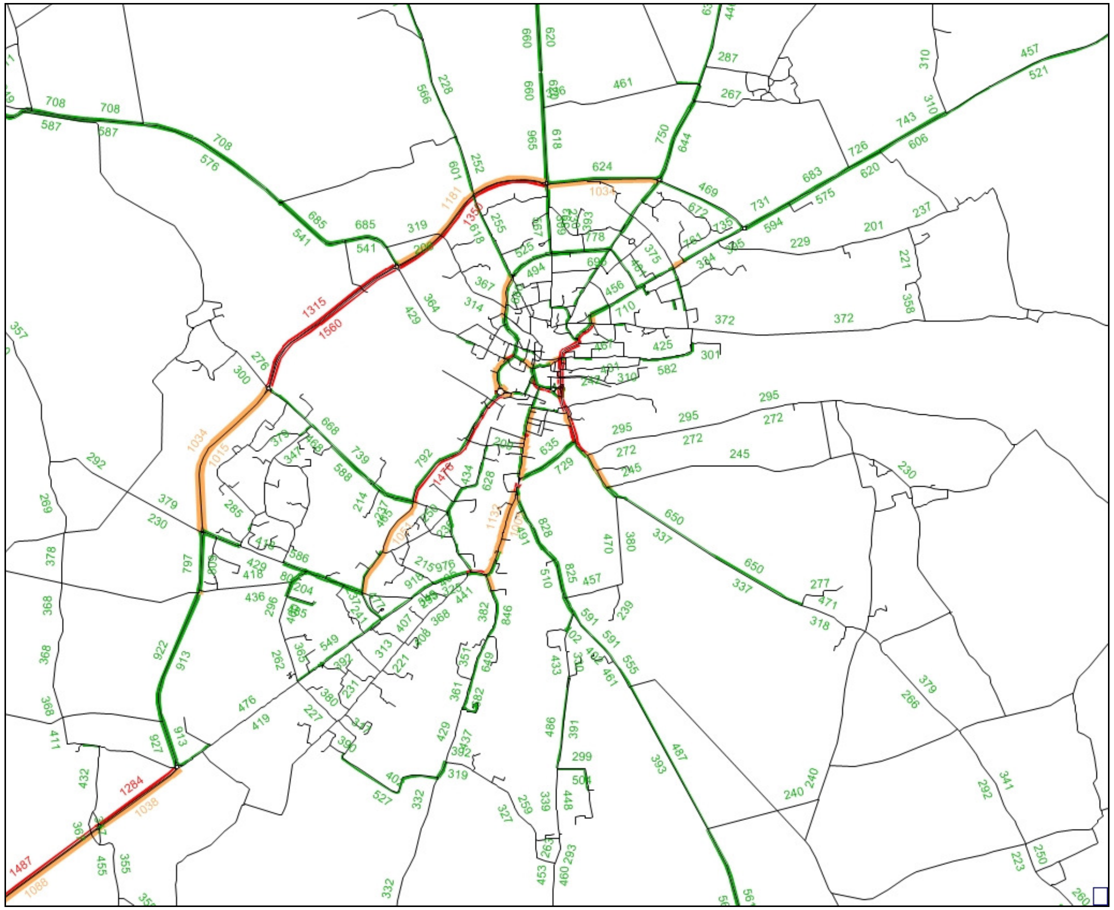


Figure 7-7 - Flow diagram PM



8 Summary and Conclusions

8.1 Summary and Conclusions

The “Greater Lincoln Transport Model" (GLTM) was developed to support, amongst other things, the Major Scheme Business Case (MSBC) funding bid for the Lincoln Eastern Bypass. The original model was used in 2011 to provide an updated funding application for this scheme.

This Local Model Validation Report (LMVR) describes the subsequent updating of the modelled networks and trip matrices and the revalidation of the Base Year model in 2012.

8.2 Model overview

The model reconstruction retained the original structure, in particular the approach to demand forecasting, but involved a thorough review and reworking of the available traffic data. Hence the principle stages reported here include network validation, matrix development (combining observed and synthetic elements), model calibration and model validation.

The model itself represents typical weekday (Tuesday-Thursday) conditions in October and November 2006. Separate models were developed for the AM Peak hour (08:00-09:00), PM peak hour (17:00-18:00) and an average inter-peak hour (10:00-16:00). The model has used data primarily from a comprehensive set of highway traffic surveys undertaken during the last quarter of 2006.

The model covers the urban area of Lincoln City and surrounding countryside, and broadly aligns with the Lincoln Planning Area (LPA). The highway network model was capacity restrained, incorporating junction delay simulation within the Lincoln urban area.

The travel demands were derived from trips observed at a cordon around Lincoln combined with synthetic estimates of internal and wholly external trips. Checks included the assignment of the observed matrix cells and comparison with traffic flow data at the study area cordon. Subsequently, the observed and synthetic matrices were merged prior to the calibration of the overall demand matrices using matrix estimation techniques.

8.3 Traffic Data

The available traffic data used in the model was thoroughly checking, including the postcard returns from roadside surveys at the study area cordon.

The database of traffic counts was also reviewed and conflicting or inconsistent counts removed. The count data was also allocated to either the model calibration or validation stages.

Whilst the original 2006 journey time data was largely retained, the relatively low sample size was enhanced using observations from the Trafficmaster database.

8.4 Network Development

A comprehensive review of the highway network model was undertaken as part of the updating process and corrections or adjustments made for application of the model to the Lincoln Eastern Bypass assessment.

External 'buffer' network links were either extended or added to the model and the detailed coding of simulation nodes revised within the detailed study area. The latter included the derivation of signal timings to represent the SCOOT control system in Lincoln city centre. Bus services were also updated and coded into the highway model.

Network validation checks included link attributes, junction type coding, link distances and assignment routing checks.

8.5 Matrix Development

The matrix development process retained the original study methodology in combining observed and synthetic matrix elements, although all steps in this process were updated and data sources revisited.

The observed matrix elements were derived from the roadside surveys undertaken at the study area cordon. Where (the less busy) roads crossing the cordon were not included in the original survey, estimated movement patterns were derived from analyses using the existing model.

Possible bias in the self-completion interview survey, in particular journey purpose descriptions, was tested against comparable databases from other studies. This did not reveal any significant bias judged to have affected the quality of the data.

The synthetic matrix process included the derivation of internal and external trips, for all vehicle purposes including freight transport. In merging the observed and synthetic matrices, smoothing was undertaken to reduce the effects of variable sample sizes within the model data.

8.6 Model Calibration

Model calibration involved the iterative adjustment of the network models, including junction and speed/ flow coding, and matrix estimation to derive model outputs which were measured against count and journey time data, adopting TAG 3.19 validation guidelines. Assignment parameters were derived from guidance in the Transport Economics Note (TEN 2007) and WebTAG 3.5.6.

The effects of matrix estimation were monitored at sector level to gauge the extent of adjustment within the model. This was judged to be acceptable within the various sectors, including those where observed data was incorporated within the model.

Other aspects of the performance of the model were also monitored and reported here; including origin/ destination trip ends, trip length distribution and model convergence.

Observed and modelled flow comparisons were also carried out over a number of sites, including the study area cordon and other ATC sites, as summarised below in Table 8-1.

8.7 Model Validation

The process of model validation again followed the guidance given in TAG Unit 3.19 in terms of comparisons between observed and modelled traffic flows and journey times.

Data was formed for a series of 7 two-way screenlines at which observed and modelled traffic flows were compared. In most cases, these comparisons met or exceeded the TAG Unit 3.19 guidelines for flow statistics, as shown in Table 8-1.

Table 8-1 - Summary of Screenlines

Pass/Fail	AM		Inter Peak		PM	
	Flow	GEH	Flow	GEH	Flow	GEH
Screenline 1 - NB	✓	✓	✓	✓	✓	×
Screenline 1 - SB	✓	✓	✓	✓	✓	✓
Screenline 2 - EB	✓	×	✓	✓	✓	×
Screenline 2 - WB	✓	×	✓	✓	✓	✓
Screenline 3 - NB	✓	✓	✓	✓	✓	✓
Screenline 3 - SB	✓	✓	✓	✓	✓	✓
Screenline 4 - EB	×	×	✓	✓	✓	✓
Screenline 4 - WB	✓	×	✓	✓	×	×
Screenline 5 - NB	✓	✓	×	×	✓	✓
Screenline 5 - SB	✓	×	×	×	✓	✓
Screenline 6 - EB	✓	✓	✓	×	×	×
Screenline 6 - WB	✓	✓	✓	✓	✓	✓
Screenline 7 - EB	✓	✓	✓	✓	×	×
Screenline 7 - WB	✓	✓	✓	✓	×	×
Total Passing Criteria	**13 / 14**	**9 / 14**	**12 / 14**	**11 / 14**	**10 / 14**	**8 / 14**
% Passing Criteria	**93%**	**64%**	**86%**	**79%**	**71%**	**57%**

Journey time validation showed that, for each of the three time periods, the difference between modelled and observed journey times was within 15% or 1 minute, if higher, for all routes, and therefore 90% or more of routes pass the journey time validation criteria defined in TAG Unit 3.19 Table 3. A summary of the journey time validation is provided in Table 8.2 below.

Table 8-2 - Summary of Journey Time Validation

Time Period	% of Routes Passing TAG Validation Criteria
AM Peak	90%
Inter Peak	90%
PM Peak	90%

In all cases, the model compares very well with the observed situation, and largely meets TAG validation criteria. On this basis, it has been demonstrated that the base year traffic model, for each of the three modelled time periods, provides an accurate representation of the current traffic demands in the wider Lincoln area.

Given that the model update reported here is intended as an interim improvement, prior to further traffic surveys in 2013, the model is judged to be sufficiently robust for the current planning and design studies of the Lincoln Eastern Bypass.

We have used our reasonable endeavours to provide information that is correct and accurate and have discussed above the reasonable conclusions that can be reached on the basis of the information available. Having issued the range of conclusions it is for the client to decide how to proceed with this project

9 Appendices