- *Calibration Traffic Counts*
- *Validation Traffic Counts*

The location of the RSI traffic counts are as previously shown in Figure 5-A, and form a natural cordon screenline.

Separate to this, the location of other calibration traffic counts and screenlines developed from the data are shown in Figure 5-J.

The screenlines were developed in conjunction with LCC and Highways England, and include all sections of motorway that pass through each of the screenlines- although in terms of reporting, screenlines are reported both with and without motorway flows - as recommended in WebTAG Unit M-3.

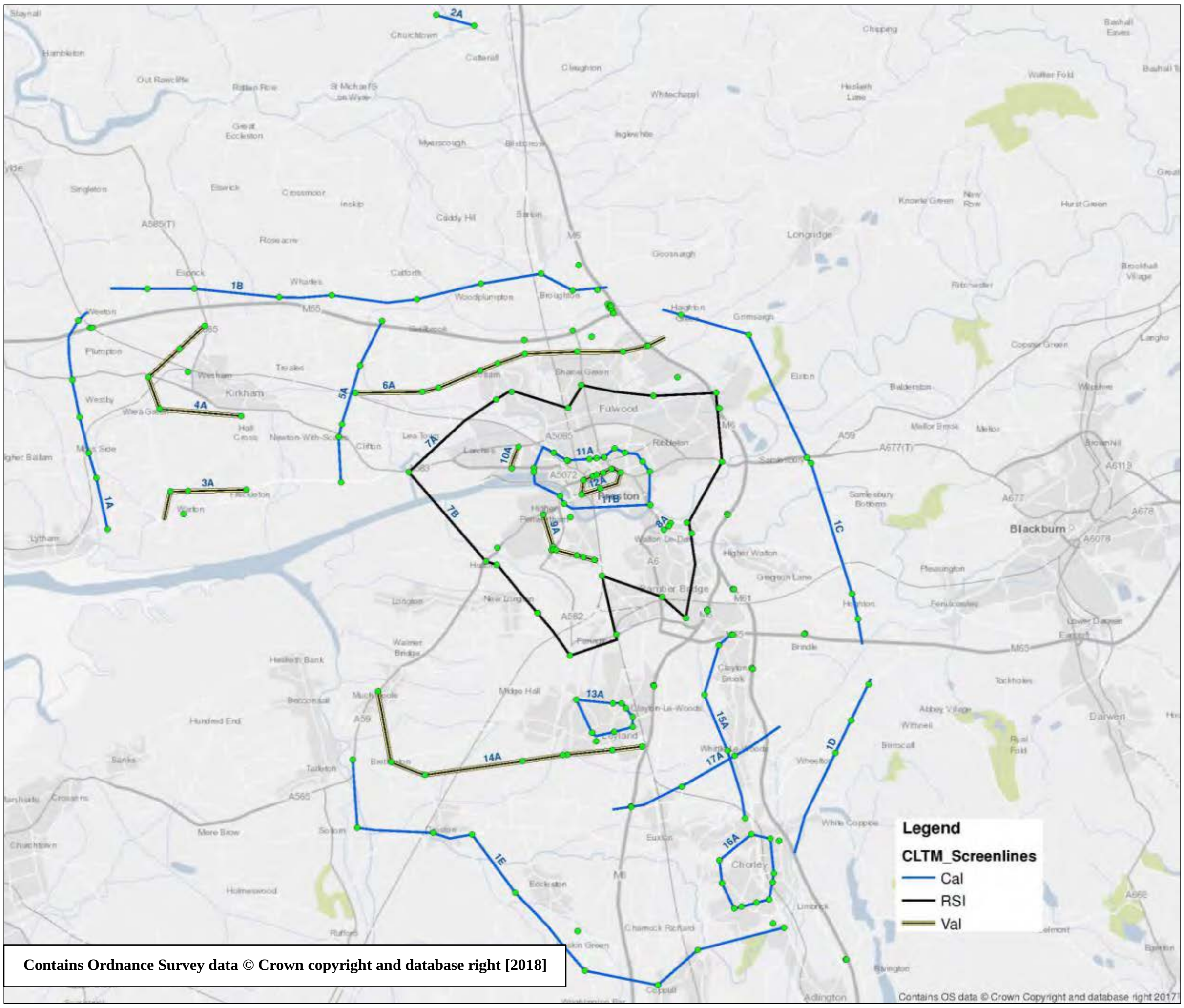

Figure 5-J – Calibration Count Locations and Screenlines

5.4 Traffic Counts for Validation

Some counts were separately held back from calibration and matrix estimation and used as independent validation counts.

There were validation counts located on both the local network, and the Highways England network, all routes affected around the PWD, and on approaches to and from Preston.

Importantly, independent screenlines were set-up around Warton, Kirkham and M55 J3, and well as across all routes impact by the Preston Western Distributor Scheme-stretching across the Northern side of Preston to ensure suitable validation of key North-South movements impacted by the scheme, and approaches to/from M55 J1.

Given data availability, a short screenline covering the A583 and A585 to the west of Preston could also be established, and which is also of importance to the PWD scheme given likely impacts on movements along these routes to the West of Preston.

A south and south-west Preston screenline was also defined, and given data availability, a very tightly defined city centre validation screenline could also be established using several one way routes; within the city centre cordon defined by calibration counts.

The locations of these are shown in Figure 5-K.

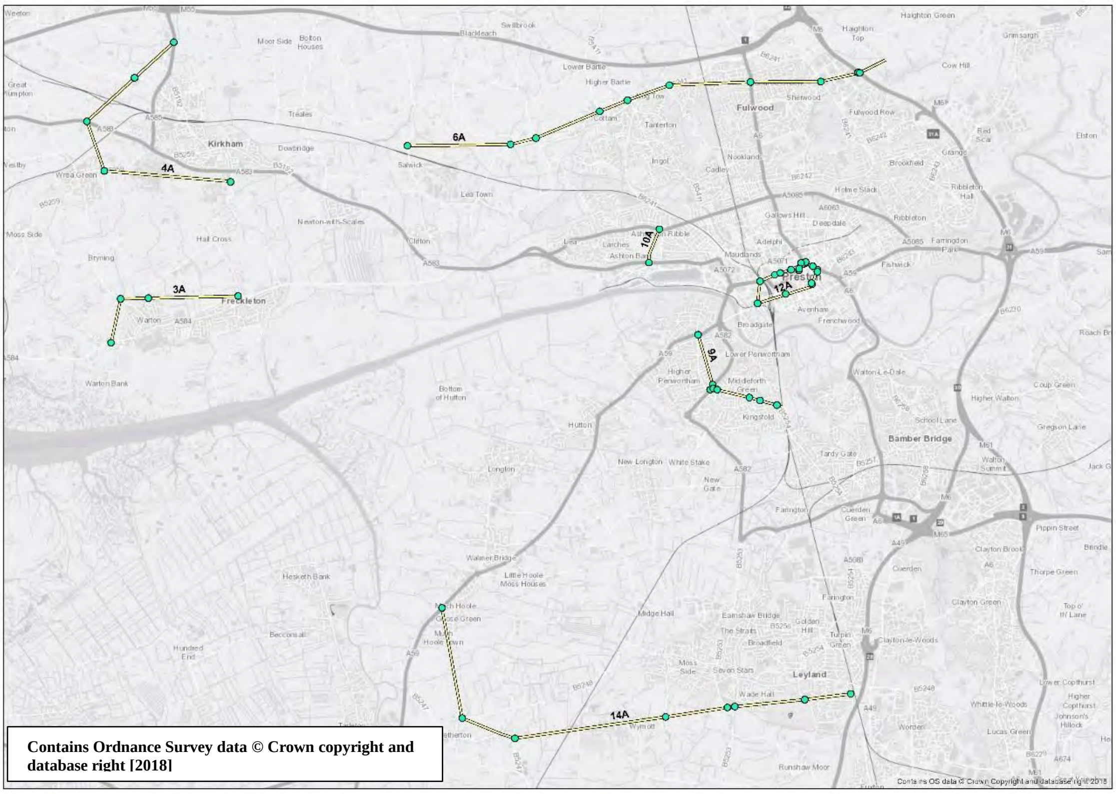

Figure 5-K – Validation Count Locations and Screenlines

5.5 Journey Time Surveys

Journey time data is used to check and compare the delays and travel times calculated by the model.

Journey time data was primarily collected from TrafficMaster for the purposes of the CLHTM model.

TrafficMaster is a dataset made available to local authorities and is based on data gathered using Satellite Navigation devices installed in cars and other vehicles. Travel times are specified for links in the Integrated Transport Network (ITN). Times along a set route are collated by aggregating the set of ITN links along the route.

During the model revalidation, the 2013 journey time data was replaced with 2014 data (March to June, excluding weekends and bank holidays), due to certain issues around missing data or low samples for a number of links in the study area. Utilising 2014 journey time data is acceptable, since there is less than one-year difference between the two datasets.

Checks have been made on the acquired dataset. Confidence intervals have been calculated on the records and where a record was outside the confidence criteria it has been removed from the calculation of the average observed journey times. Additionally, moving observer travel times were available in the Broughton area and the TrafficMaster data was benchmarked against this data.

Analysis of congestion along the key arterial routes during the morning and evening peak times has been undertaken. The results of the analysis are shown in Figure 5-L and Figure 5-M for both AM and PM peak periods respectively. It can be seen that there are multiple locations along the key arterial routes where the average traffic speed is below 20mph.

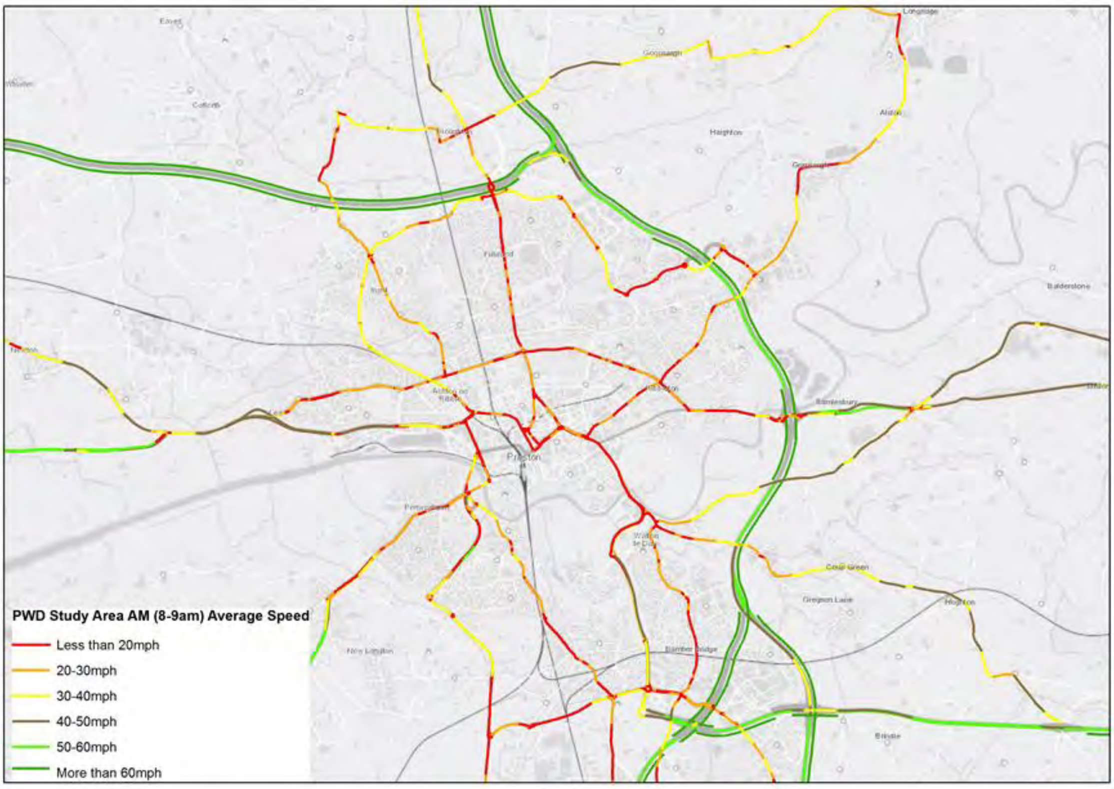

Figure 5-L – TrafficMaster Average Speeds – AM

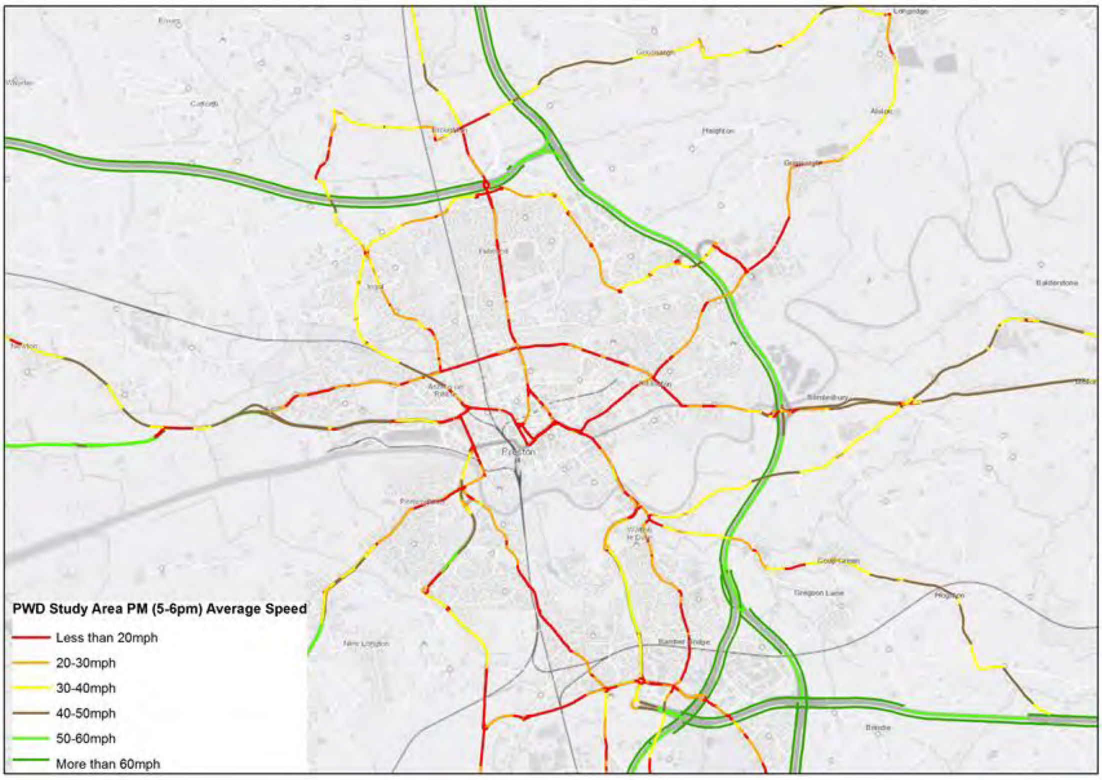

Figure 5-M – TrafficMaster Average Speeds – PM

To ensure accurate journey time representation journey time routes were specified on both the local road network and the strategic road network.

Journey Time routes for modelling were agreed in conjunction with both LCC, and Highways England TAME, and were developed to be both comprehensive, and with reference to the Central Lancashire Transport Masterplan and PWD scheme.

This was undertaken in order to ensure a robust economic appraisal and to cover any potential parallel routes in particular that traffic is most likely to divert from.

The locations of the journey time routes used for model journey time validation are shown in Figure 5-N.

This demonstrates that the routes selected cover the whole of the Strategic Road Network in the area, and all main arterial and radial routes across the simulation area.

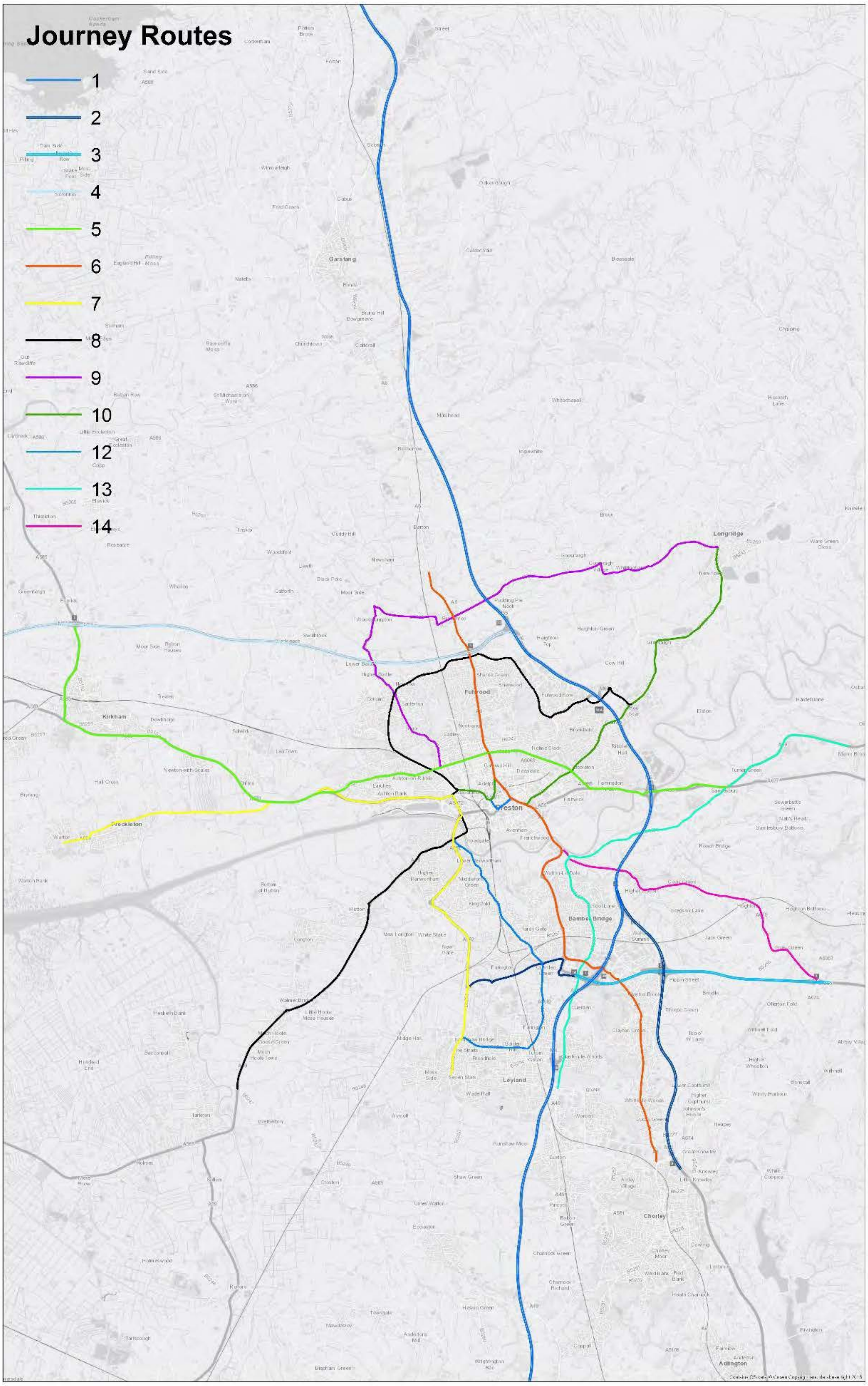

Figure 5-N - Journey Time Validation Routes

6 Network Development

6.1 Network basis

The modelled network was created using the Integrated Transport Network (ITN), an Ordnance Survey dataset representing the Great Britain transport network as a series of links and nodes. ITN contains details of the characteristics of each road, including:

- *Road type (motorway, trunk road, local route);*
- *Number of lanes and capacity;*
- *Restrictions such as one-way streets and HGV bans; and*
- *Other elements such as bus/cycle lanes.*

The network was loaded into SATURN, which converted it into a series of links and nodes appropriate for consistent coding and modelling in line with the guidance with Jacobs CLHTM Coding Manual.

All of the above characteristics of the network were also sense checked through the use of Google Earth/Street View.

To support this, a number of site visits were also undertaken by LCC for traffic signal controlled junctions in particular to ascertain signal timings for junctions where this was not freely available from the UTC system, or fixed signal plans.

6.2 Link speeds and speed-flow curves

For the links imported into the model the parameters governing speeds, capacities and the relationship between speed and traffic flow were derived from Part 5 of the COBA manual[1]. The link characteristics described in the manual were translated into parameters appropriate for use in the SATURN model.

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

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

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

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

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

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

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

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

Link lengths were automatically calculated based on the scale lengths of the polylines representing the modelled links from the ITN networks.

Link lengths were subsequently checked using comparisons with crow fly distances.

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

6.3 Junctions and Delays

All junctions within the study area were fully coded in accordance with the Jacobs Coding Manual documentation, and a specific spreadsheet set up for SATURN coding was used, so that all junctions are coded in a consistent manner, removing common errors and issues at the same time - as well as ensuring consistency of approach.

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

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

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

Care was taken over recently introduced schemes, particularly the M55 J1 improvement where the scheme on the ground was different to available aerial photography. LCC staff also undertook checks on coding; with a particular focus on the networks in and around future schemes.

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

6.4 Signal Timings

Signal staging and timings were coded using observed data provided by LCC in 2014 for the majority of signalised junctions within the model. However, due to many signalised junctions being optimised, and timings varying throughout time periods, alterations were made to timings to enable count and journey time validation where necessary. The extent of alterations to the observed signal times depended on the deviation of the modelled traffic and journey times from the observed as part of the calibration/validation process.

A small number of junctions did not have appropriate data that could be provided; these were developed according to typical LCC timings and optimised within SATURN.

Figure 6-A shows the locations of the 105 signalised junctions for which observed data was provided by LCC (including 22 MOVA operated junctions) and the 68 template coded junctions (173 signalised junctions in total).

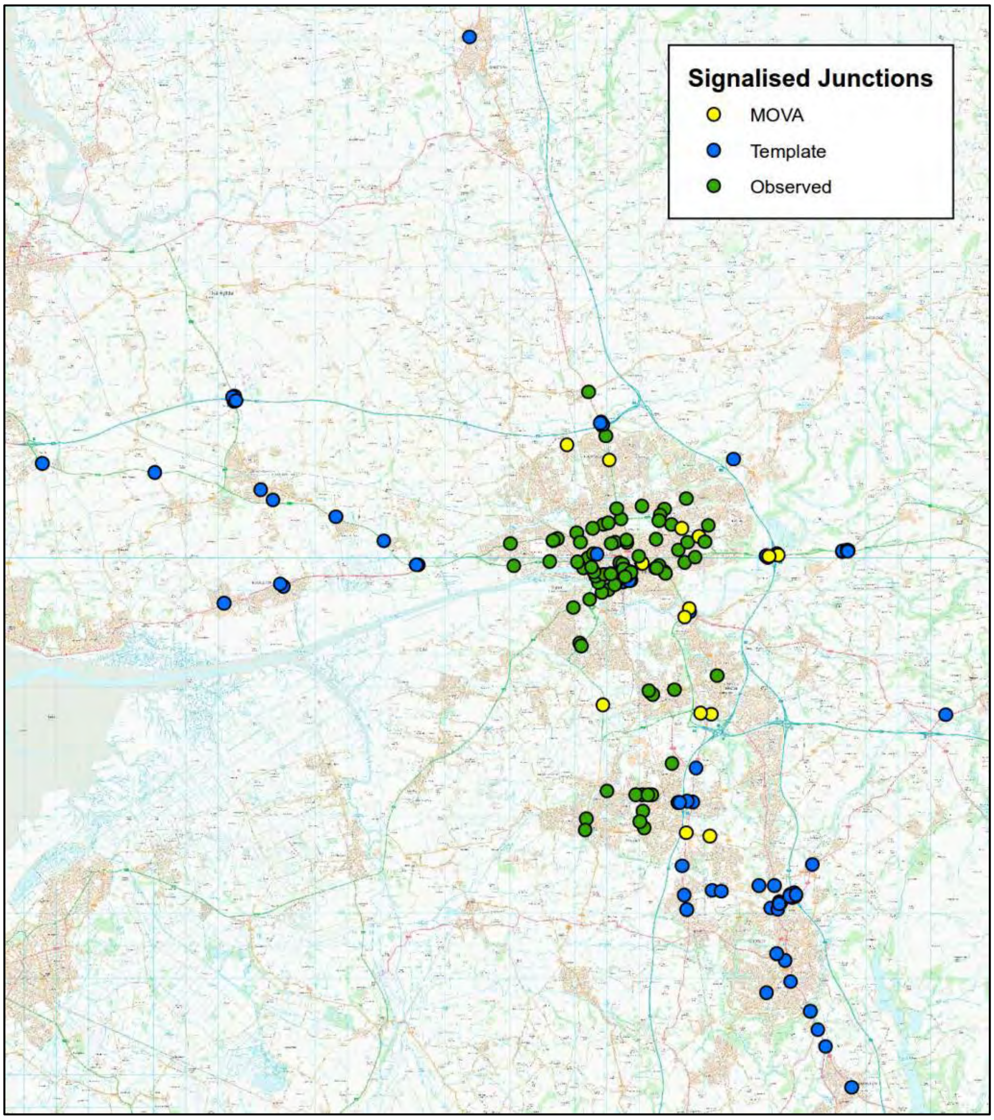

Figure 6-A - Signal Timing Data provided by LCC

6.5 Bus Route Information & Coding

Public transport passengers are not explicitly modelled in SATURN, but buses play an important part in ensuring correct delay calculations at junctions.
As a result, a full set of available bus routes and frequencies - taken from the LCC Mario database of local bus routes was extracted in GIS, and then converted into SATURN network form for coding. The bus routes included are shown in Figure 6-B.

Figure 6-B - Bus Routes

7 Trip Matrix Development

7.1 Overview

The purpose of this chapter is to explain the various stages used to develop and adjust the traffic demand for assignment to the model network described above.

The highway matrices were built for three vehicle categories: Car, LGV and HGV.

The car matrices are further split based on user class into Commute, Business and Other, in line with TAG unit M-3 requirements.

The impact of different vehicle categories on the assignment process is weighted by representing the trips as passenger car units (PCU's), as detailed in Table 4.2.

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

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

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

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

7.2 Travel Demand Data

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

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

The methodology used to build the prior matrices integrates elements of both surveyed and synthesised data in order to produce production/attraction (P/A) matrices that directly produce Origin/Destination (O/D) prior matrices for assignment and is summarised in Figure 7-A.

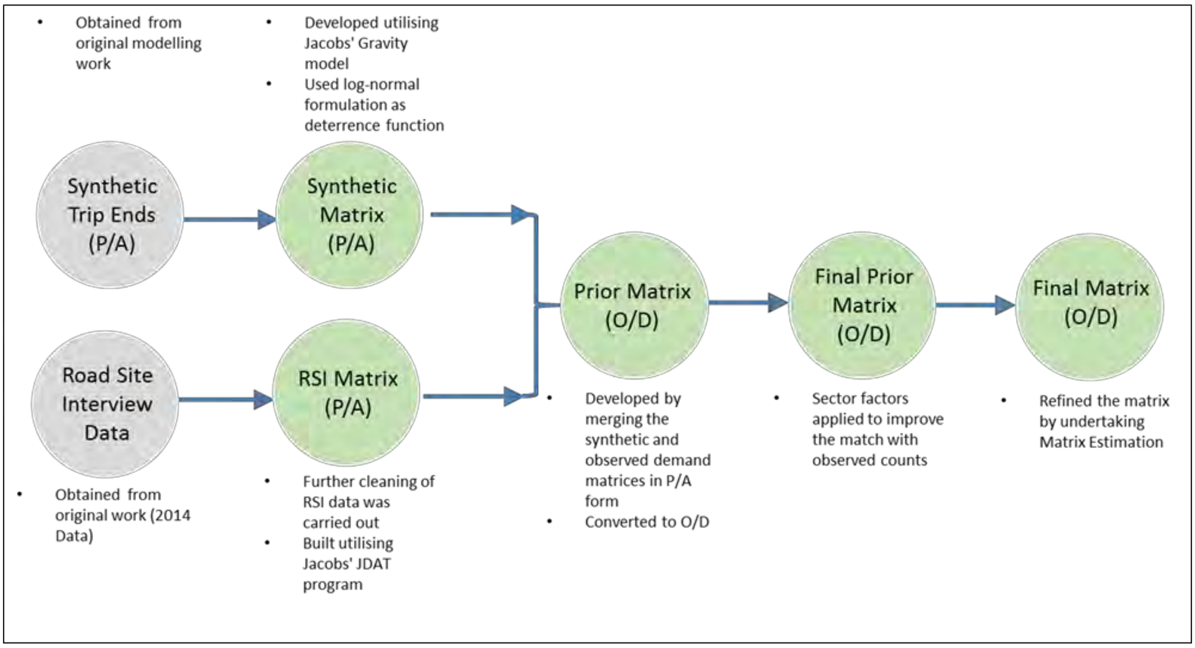

Figure 7-A - Prior Matrix Development Procedure

The matrix development thus comprises six main stages:

- *Synthetic Trip End Creation: Using a combination of the 2011 Census, NTEM and employment databases to produce population and jobs data from which trip ends are derived for each modelled zone;*
- *Synthetic Trip Distribution: The synthetic trips were distributed using a gravity model to create synthetic P/A matrices;*
- *Observed Matrix Development: Creation of an observed matrix (P/A format) using the RSI surveys collected at 26 sites around Preston;*
- *Matrix Modification: The statistical merging of locally surveyed travel demand patterns using roadside interviews and synthetic trips;*
- *Prior Matrix Validation: The comparison of the above steps in line with guidance to assess the need for Matrix Estimation; and*
- *Calibration/Matrix Estimation: Where prior matrix validation does not match observed screenline flows, adjustments (sector factoring) will need to be made. The success of this stage determines the extent of matrix estimation required.*

The final output of the process is a consistent set of P/A and O/D matrices that can be used in assignment and validation.

7.3 Synthetic Matrix Creation

A synthetic matrix is defined as a matrix that has been constructed using demographic information associated with the model area and has not been modified by traffic surveys (Roadside Interview data and traffic counts).

There are several distinct processes that have been used in creating the Base Year synthetic matrices, which are presented below in Figure 7-B.

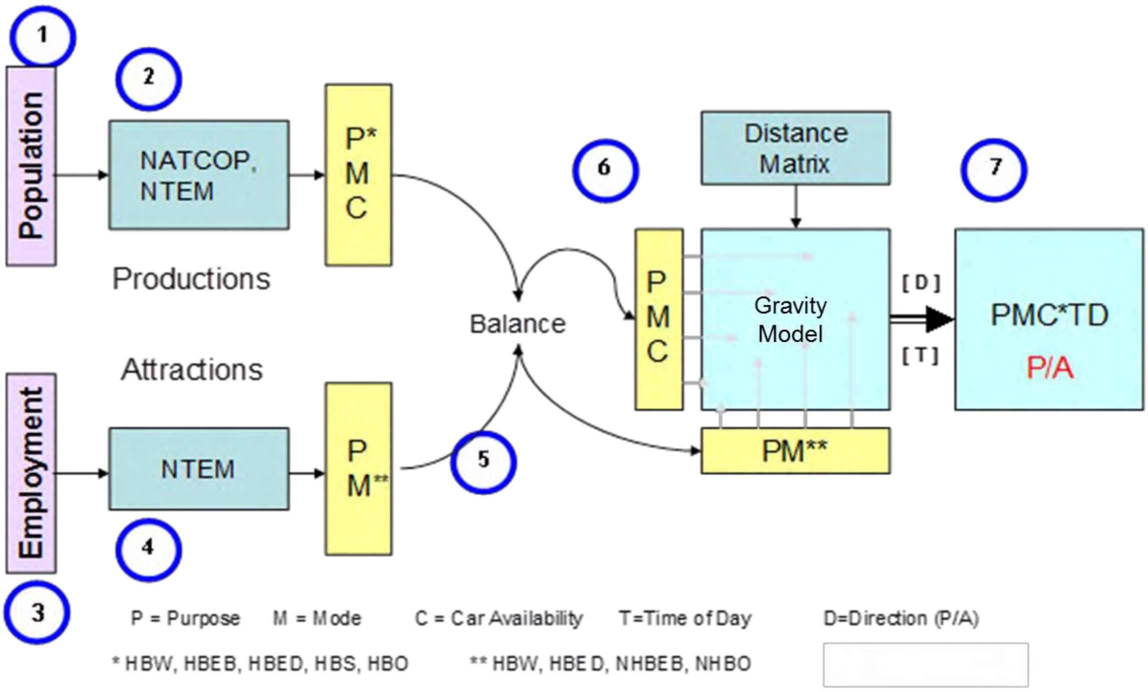

Figure 7-B - Overview of Synthetic Matrix Creation Process

The steps followed are listed below, each of them linked to the above diagram:

- *Create Population Data (1): Derive population data for all zones from 2011 Census and NTEM;*
- *Generate Productions (2): Run population estimates in each zone through NATCOP (National Car Ownership Programme) and apply NTEM trip rates to the outputs to create production trip ends by purpose, mode and car availability;*
- *Create Employment Data (3): Derive employment information from Census data and an employment data for all zones;*
- *Generate Attractions and NHB (Non-Home Based) Trips (4): Apply NTEM trip rates to employment data to create attraction trip ends by purpose and mode;*
- *Balance Productions and Attractions (5): Produce balanced trip end matrices whereby the total attractions are the same as the total productions for each purpose and mode;*
- *Distribution of Trip Ends to create Synthetic Matrices (6): Distribute the trips using a log-normal cost function based on zone-to-zone generalised cost for each zone pair and adjusted for appropriate intrazonal trip making (i.e. a log-normal gravity model);*
- *Create Synthetic Assignment Matrices (7): Factor the distributed matrices by direction and time of day using factors derived from NTEM.*

For each zone in the model, the residential and workplace population was ascertained using 2011 Census, to which trip rates were applied to estimate the total trip generation (in terms of productions and attractions) of the zone over a 24 hour period.

Prior to use in the model, the jobs and population data were adjusted, using NTEM datasets and local data for the modelled area, to grow base information from a 2011 base to a 2013 estimate (taking account of changing household sizes, an ageing population, new housing schemes within the modelled area etc).

Each aspect of this process is described in more detail below.

7.3.1 Land Uses

The method for generating trip ends for each zone required certain specific information about the population and employment within each zone. Population data was gathered using the 2011 national census, a process which was facilitated by having zone boundaries based on Census output areas. Employment data was gathered from Business directory information. These two facets of land use are described in more detail in the following sections.

(a) Population and demographics

The following aspects associated with the people living within each modelled zone were required for the purposes of generating trip ends:

Person types:

- *children (0 to 15)*
- *males in full time employment (16 to 64)*
- *males in part time employment (16 to 64)*
- *male student*
- *male not employed / students (16 to 64), unemployed, other Inactive*
- *male 65+*
- *females in full time employment*
- *females in part time employment (16 to 64)*
- *female student*
- *female not employed / students (16 to 64), unemployed, other Inactive*
- *female 65+*

Household types:

- *1 adult households with no car*
- *1 adult households with one or more cars*
- *2 adult households with no car*
- *2 adult households with one car*
- *2 adult households with two or more cars*
- *3+ adult households with no car*
- *3+ adult households with one car*
- *3+ adult households with two or more cars*

All of this required information can be ascertained from the 2011 Census Key Statistics. This information was extracted for each output area in the country, and then aggregated from output areas to modelled zones.

For zones that were generated by aggregations of district, county and regional boundaries forecasts data was taken from the National Trip End Model, which provides this information at a more aggregate level.

(b) Employment data

To generate trip ends at the attraction end, data on employment within each zone was required. This included the number of jobs in pre-specified employment categories, as listed below:

- *Primary and Secondary Education*
- *Higher Education*
- *Adult/Other Education*
- *Hotels, Campsites etc.*
- *Retail*
- *Health/Medical*
- *Services (business & other)*
- *Restaurants & Bars*
- *Recreation & Sport*
- *Agriculture & Fishing*
- *Business*

The number of jobs in each category was based on employment data provided by Blue Sheep, a B2B services company, with data purchased under licence by Jacobs. That data set is called the "Complete Business Universe" and is based on a variety of data sources including Companies House.

The data set contains details of over 4 million workplaces and provides the number of employees by business type (using the UKSIC92 standard industrial classification) and their grid reference.

7.3.2 Trip Ends

With the zonal land uses established, trip rates for each population demographic and employment category were applied to generate the total trip generation within each zone. The trips were segregated by trip purpose, and at the production end were further split by time of day and car availability.

The whole process of applying trip rates to the land use data was done using a bespoke trip end modelling tool developed by Jacobs which combines elements of CTripEnd and NATCOP, the trip end calculation and car ownership models used within the National Trip End Model (NTEM).

The resulting trip productions, when aggregated to NTEM zone boundaries, were consistent with outputs from TEMPRO using the NTEM 6.2 dataset.

7.3.3 Trip Distribution

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

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

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

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

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

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

The gravity model was calibrated to reproduce average trip lengths by journey purpose from the NTS (2013). These are reproduced in Table 7-1.

Table 7-1 - Mean Trip Length by Journey Purpose

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

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

7.3.4 Synthetic Matrix Validation

The synthetic matrices were validated in the following ways:

- *Comparing their trip length distributions against NTS Data;*
- *Comparing purpose split to TEMPRO; and,*
- *Comparing time of day totals to TEMPRO;*

The validation results of the synthetic matrices show a close fit with NTS and TEMPRO and are provided in the subsequent sections.

(a) Trip Length Distributions

Comparisons of the synthetic trip length distribution to the NTS data is presented in the figures below for Internal to Internal and Internal to External trips. Graphs for all day comparisons of the Internal to Internal Only, External to Internal and all trips are available upon request. Table 7-2 summarises the comparisons based on the coincidence ratio for each trip purpose. The internal (I) and external (E) areas refer to inside RSI cordon and outside areas, respectively.

Table 7-2 - All Day Trip Length Distribution Coincidence Ratios (1 signifies a perfect fit)

Purpose	Coincidence Ratio			
	I-I trips	I-I and I-E trip	I-I, I-E and E-I trips	All trips
HB Work	0.717	0.998	0.821	0.121
HB Employers Business	0.558	0.976	0.807	0.178
HB Education	0.848	0.985	0.877	0.054
HB Shopping	0.790	0.987	0.830	0.071
HB Other	0.699	0.991	0.873	0.093
NHB Employers Business	0.556	0.995	0.812	0.179
NHB Other	0.713	0.990	0.863	0.094

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

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

Comparisons for each period are provided in Appendix C.

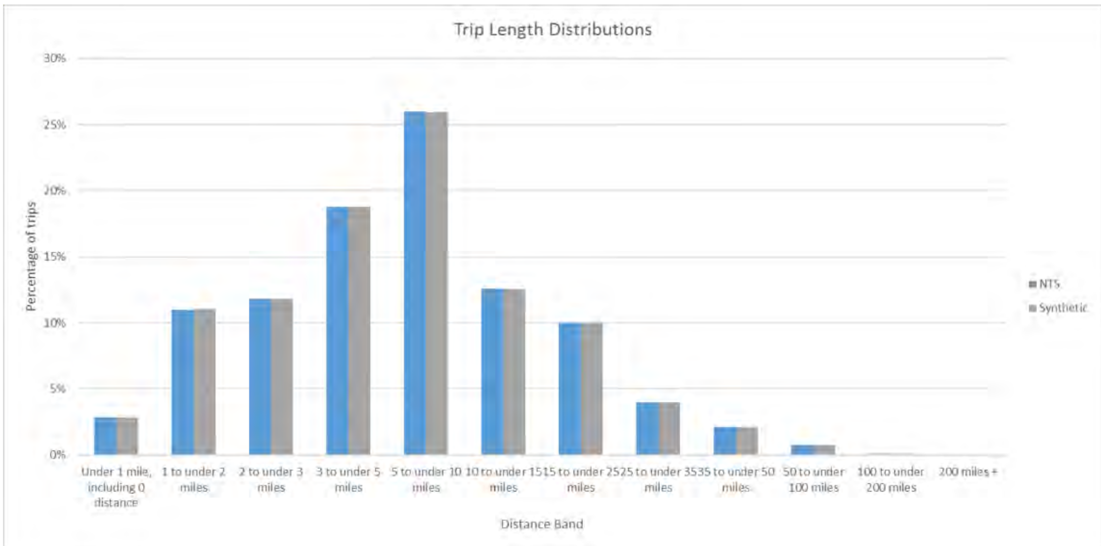

Figure 7-C - Home Based Work – Trip length distribution comparison

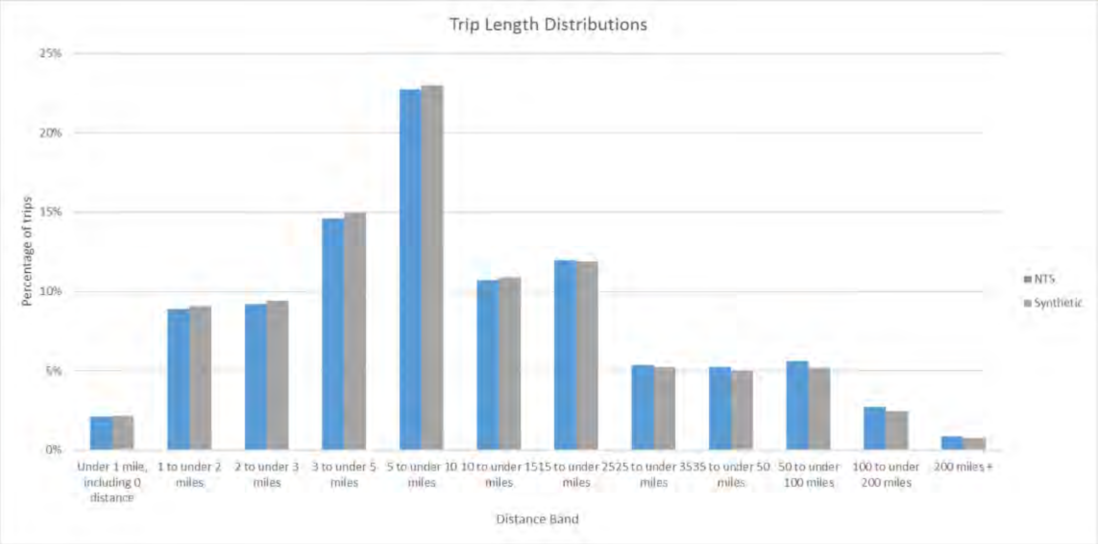

Figure 7-D - Home Based Employers Business – Trip length distribution comparison

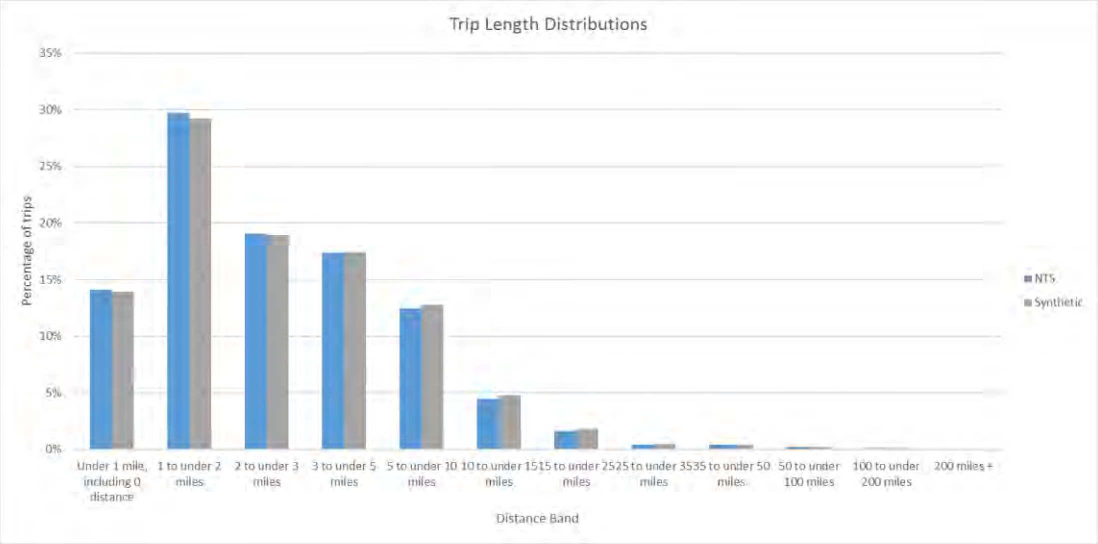

Figure 7-E - Home Based Education – Trip length distribution comparison

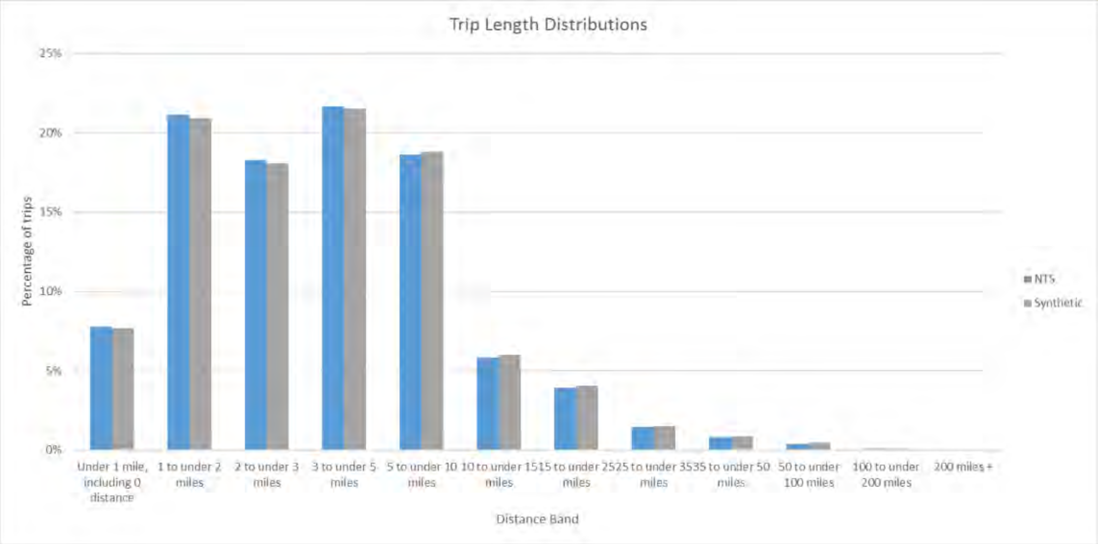

Figure 7-F - Home Based Shopping – Trip Length Distribution Comparison

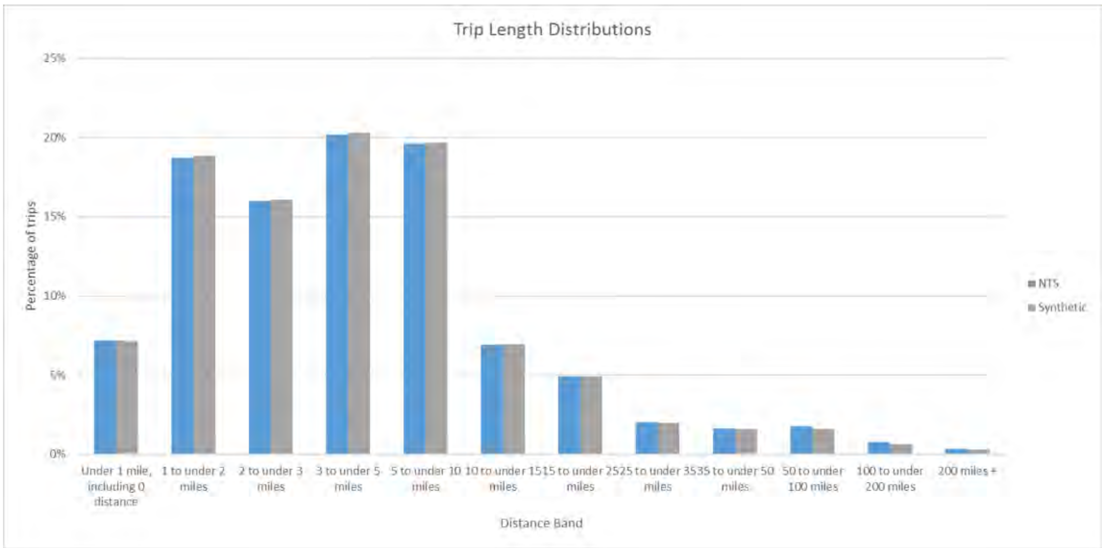

Figure 7-G - Home Based Other – Trip Length Distribution Comparison

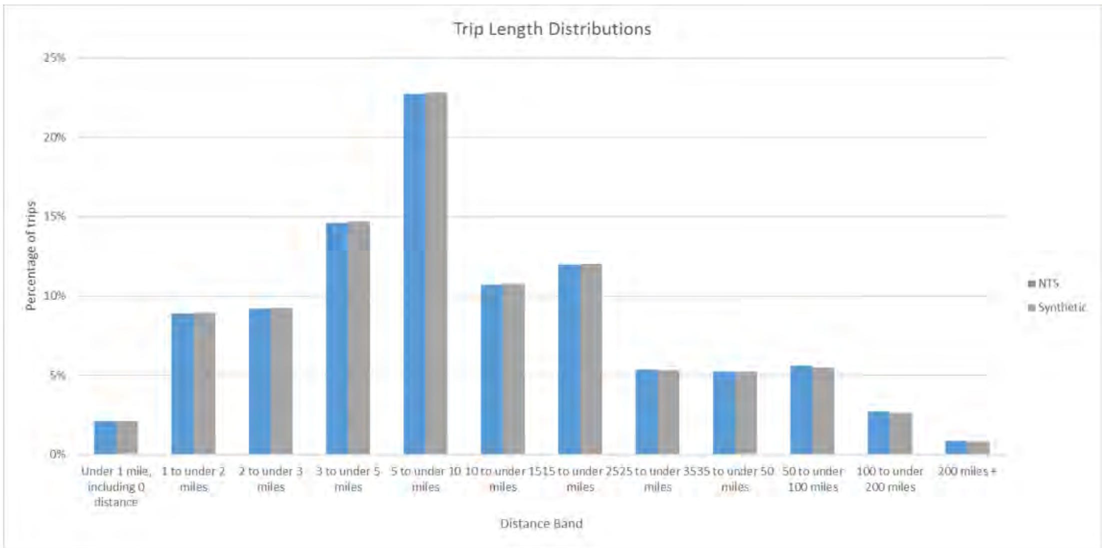

Figure 7-H - Non-Home Based Employers Business – Trip Length Distribution Comparison

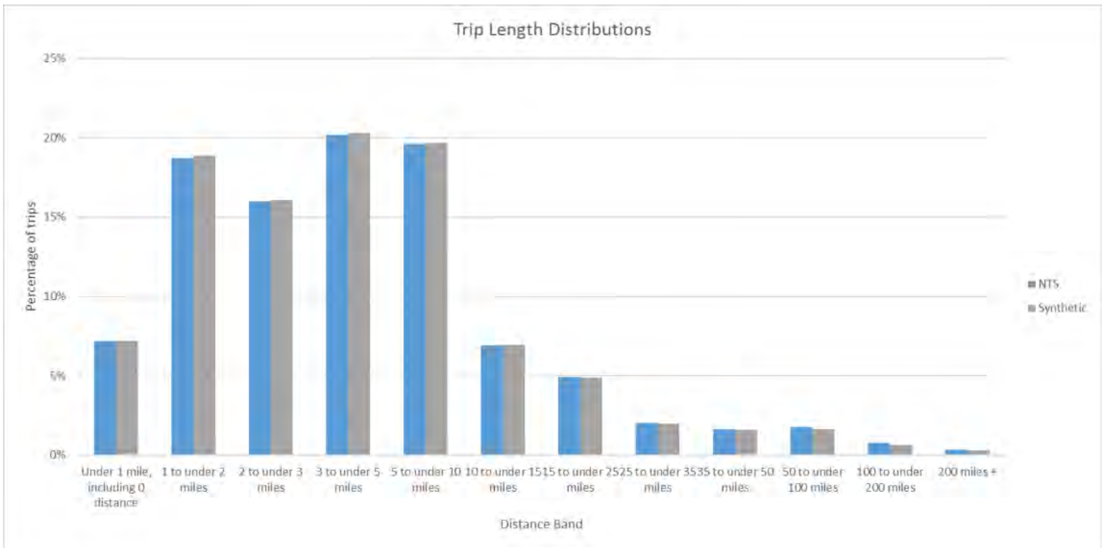

Figure 7-I - Non-Home Based Other – Trip Length Distribution Comparison

The figures and Table 7-2 show a very good fit when Internal to Internal, and Internal to External are considered. As this provides the greatest range of trips covering all distance bands. Furthermore, Table 7-2 shows that including External to Internal trips also provides a close match with NTS.

When shorter range trips (Internal to Internal) are considered in isolation, the fit is not as good due to the lack of longer range trips that are included within the NTS data.

If external to external trips are included, the fit is quite poor. This is because the proportions are heavily skewed towards the longer distance bands due to the size of the external zones, the huge demand for intrazonal and large external to external movements.

(b) Purpose Split

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

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

The comparisons at the RSI cordon level are shown in the figures below, comparisons of other periods and geographies are shown in Appendix D and summary of the Coincidence Ratios for each comparison is shown in Table 7-3.

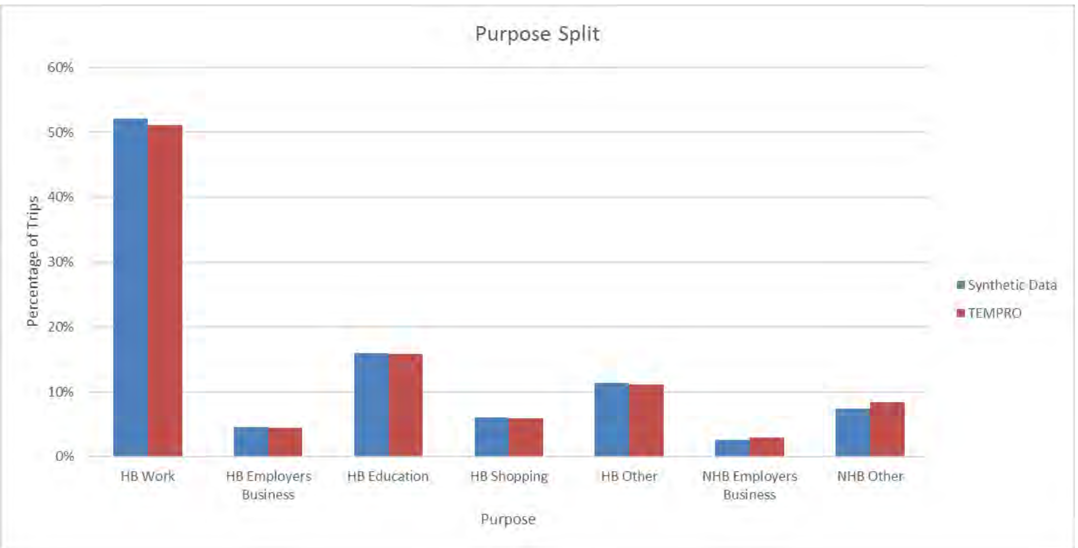

Figure 7-J - AM Peak comparison to TEMPRO purpose splits – RSI Cordon Level

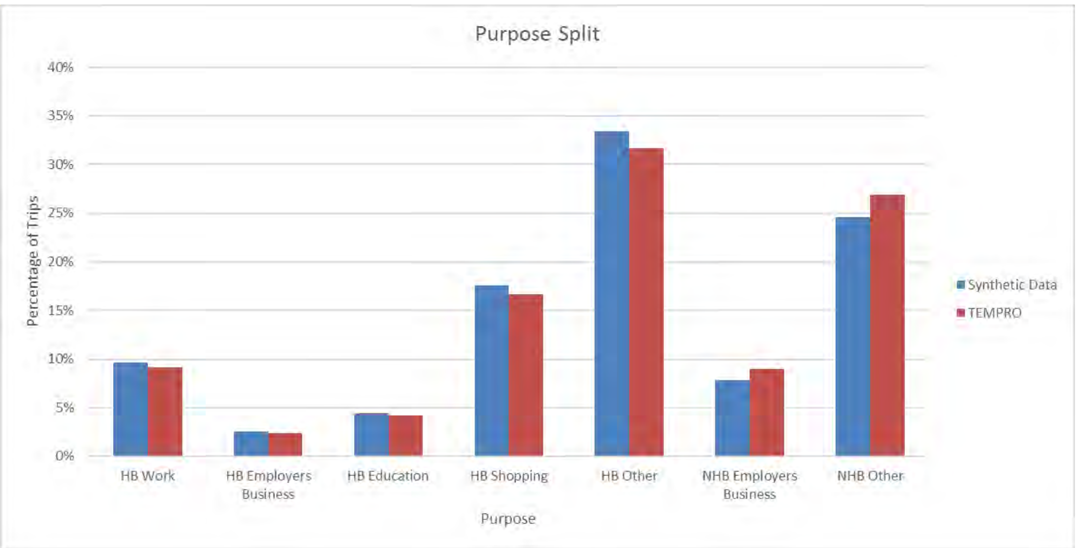

Figure 7-K - Inter Peak comparison to TEMPRO purpose splits – RSI Cordon Level

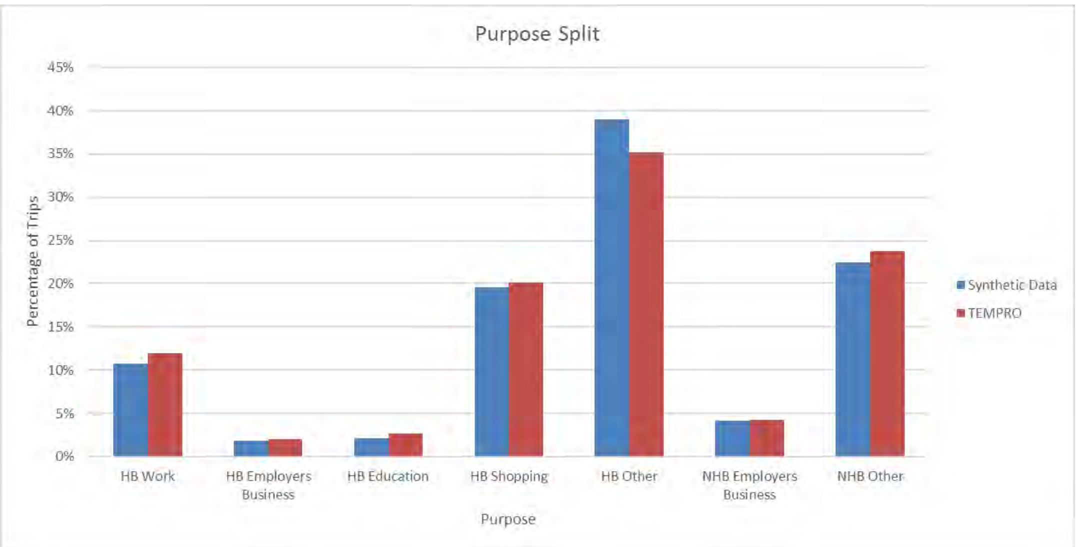

Figure 7-L - PM Peak comparison to TEMPRO purpose splits – RSI Cordon Level

Table 7-3 - Purpose Split Coincidence Ratio

TEMPRO Area	Coincidence Ratio		
	AM	IP	PM
Great Britain	0.999	0.999	0.999
North West England	0.999	0.999	0.999
Lancashire	0.994	0.988	0.988
RSI internal	0.971	0.933	0.925

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