Wokingham Borough Council

# WOKINGHAM STRATEGIC TRANSPORT MODEL 4 (WSTM4)

## Local Model Validation Report

70014995
MAY 2018

PUBLIC

Wokingham Borough **Council**

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## Local Model Validation Report

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# 1 INTRODUCTION

## 1.1 BACKGROUND

1.1.1. In 2008 WSP was appointed as the Highways and Transport Term consultant for Wokingham Borough Council (WBC). This included the use and on-going maintenance of the Wokingham Strategic Transport Model (WSTM) and its use to support transport policies and scheme development. Since this appointment WSP have completed two model updates and in Autumn 2015 was commissioned to progress a third:

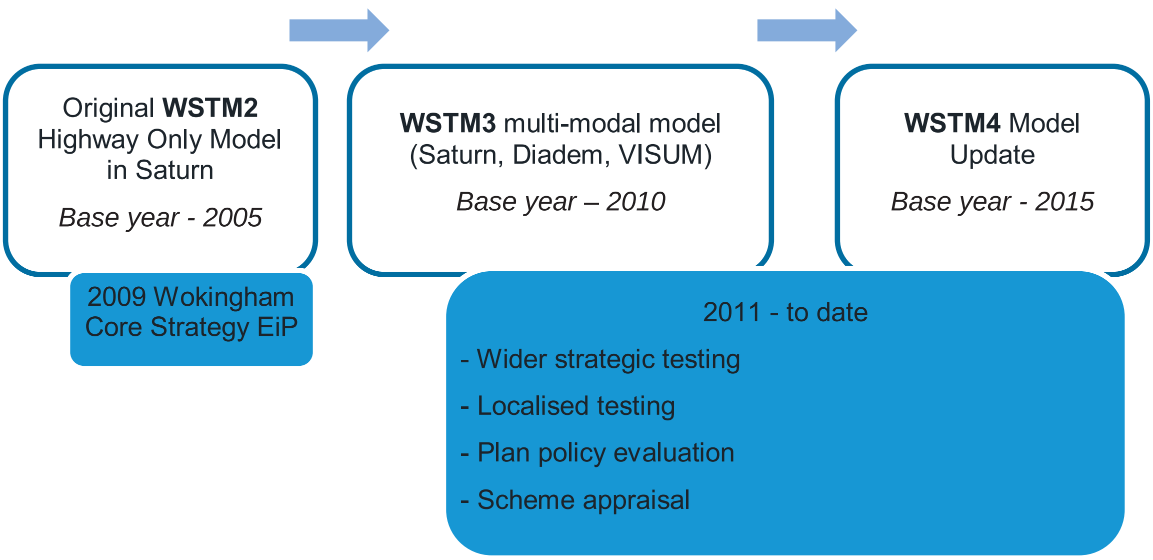
- WSTM2 - update of forecast scenarios to include details of Strategic Development Locations (SDLs) and mitigation measures
- WSTM3 - Update to a 2010 model base year from 2005, compliance with DfT Transport Analysis Guidance, integration of a Public Transport model in VISUM and a Variable Demand Model (VDM) developed using DIADEM
- WSTM4 - Commissioned in 2015 to update the model base year to 2015 to support strategic and local planning for the next plan period. The model software platform has been changed to VISUM.

1.1.2. The WSTM3 has been used for wider strategic testing, localised testing, plan policy evaluation and scheme appraisal within Wokingham Borough shaping transport planning policies and strategies. This has included:

- Park and Ride Strategy Action Plan
- Wokingham Town Centre Parking Strategy
- Wokingham LSTF programme evaluation along the A329 corridor
- Public consultation on locally significant schemes for Arborfield Relief Road, North Wokingham Distributor Road, South Wokingham Relief Road
- DfT's LSTF funding (£2.75m) and funding from the Local Pinch Point Fund for:
- A329 Coppid Beech Junction Improvement (£1.859m of £2.655m total scheme cost)
- Station Link Road (£2.650m of £3.786m total scheme cost)
- Section 106 contributions from developers:
- Hatch Farm Dairies development to Winnersh Relief Road Phase 1
- South of the M4 J10 development to Eastern Relief Road (ERR) east of Shinfield
- Initial assessment of the viability for a Third Thames Crossing to support transport objectives of Wokingham and Reading Borough Councils
- Business Case development and Planning Applications for the Arborfield Cross Relief Road (ACRR), South Wokingham Distributor Road (SWDR) and North Wokingham Distributor Road (NWDR).

1.1.3. Figure 1 shows the chronology of the development of the Wokingham Strategic Transport Model.

**Figure 1 – WSTM Development Chronology**



1.1.4. The development of the WSTM4 base year model was completed in 2016 and was fully reported in the Local Model Validation Report, March 2017.

1.1.5. Testing of multiple future year 'with a scheme' and 'without a scheme' scenarios highlighted issues around model's stability. The 'Equilibrium_Lohse' assignment procedure in PTV's VISUM used to assign car demand often produced models which did not meet the convergence criteria, and hence could not be used as a robust basis for any assessment.

1.1.6. The WSTM4 was developed in VISUM 15, which was the latest version of the software available at the time of the model development. Since then PTV has implemented a number of software updates. VISUM 17 includes a new private transport assignment procedure called 'Equilibrium assignment Bi-conjugate Frank-Wolfe'. The implementation is mainly motivated as a better converging alternative to the 'Equilibrium_Lohse' assignment.

1.1.7. Assigning traffic to the network using the new assignment procedure addresses model convergence issues and produces more stable and expected results. On this basis and after discussions with WBC a decision has been made to update WSTM4 to VISUM 17.

1.1.8. As a result of the version change, the base year model validation fell slightly short of the DfT's TAG validation threshold, meaning that a model revalidation was required. This document provides an update to the LMVR (Highway only).

## 1.2 PROPOSED USES OF THE MODEL

1.2.1. The updated WSTM4 model will serve as a robust and up to date basis:

- for scheme and development assessments in Wokingham borough (including funding applications)
- in negotiations with the adjacent authorities, the Highways England and Network Rail
- for assessing car parks management and re-development proposals in the borough
- for the assessment of a new bridge across the River Thames east of Reading and the development of the Strategic Outline Business Case (SOBC) for the scheme.

1.2.2. The model purposes were drawn up in consultation with the relevant parties at WBC during winter and spring 2015. The public transport (PT) model is required to ensure compliance with Department for Transport (DfT) TAG guidance and to test enhanced public transport (PT) priority in relation to the new bridge east of Reading; however it was agreed during the consultation that the model will not be used for testing any PT transport strategies in Wokingham borough.

1.2.3. It should be made clear from the outset that the model development described in this report is proportionate to the intended application of the model.

1.2.4. The model will also be available to private developers to test the impacts of developments on the transport network in Wokingham borough. However, it should be noted that the model will be strategic in nature and local junction validation may be required if model outputs are to be used in detailed junction assessment. Private developers will need to discuss their individual requirements with the Council.

## 1.3 GUIDANCE

1.3.1. The model development has been guided by the following units of the DfT's TAG guidance:

- Unit M1 "Principles of Modelling and Forecasting"(January 2014)
- Unit M1.2 "Data Sources and Surveys" (January 2014)
- Unit M2 "Variable Demand Modelling" (January 2014)
- Unit M3.1 "Highway Assignment Modelling" (January 2014)
- Unit M3.2 "Public Transport Assignment" (January 2014)
- Unit M5.1 "Modelling Parking and Park and Ride" (January 2014).

## 1.4 REPORT PURPOSE AND STRUCTURE

1.4.1. This report details the development, calibration and validation of the WSTM4 base year model. The structure of this Local Model Validation Report (LMVR) is as follows:

- Chapter 2 summarises key features of the WSTM4
- Chapter 3 describes the highway network development
- Trip matrix development is outlined in Chapter 4
- Model calibration and validation is dealt with in Chapter 5

- Chapter 6 concludes the report.

# 2 KEY FEATURES OF WSTM4

## 2.1 MODELLED AREA

2.1.1. The WSTM4 Fully Modelled Area, formerly referred to as study area, is shown in Figure 2. As defined in the DfT's TAG, the Fully Modelled Area is the area over which proposed interventions are likely to have influence. In the WSTM4 the area is bounded by the M40 in the north, by the M25 in the east, by the M3 in the south and by the A339 and A34 in the west. The Fully Modelled Area is chosen to build a traffic model that covers a sufficient area to accurately model the reassignment and redistribution effects that are likely to be produced by new development and infrastructure schemes in Wokingham borough and by the new bridge east of Reading.

2.1.2. The fully modelled area is further subdivided into:

- Area of Detailed Modelling as shown in Figure 2. This is the area over which significant impacts of interventions are certain. Modelling detail in this area would be characterised by representation of all trip movements, small zones, very detailed networks and junction modelling
- Rest of the Fully Modelled Area. This is the area over which the impacts of interventions are considered to be quite likely but relatively weak in magnitude. It would be characterised by: representation of all trip movements, somewhat larger zones and less network detail than for the Area of Detailed Modelling, and speed/flow modelling (primarily link-based but possibly also including a representation of strategically important junctions)
- The rest of the UK represents the External Area. In this area impacts of interventions are likely to be negligible. The External Area is characterised by skeletal networks and simple speed/flow relationships or fixed speed modelling and a partial representation of demand (trips to, from and across the Fully Modelled Area).

## 2.2 ZONING SYSTEM

2.2.1. The zone plan in the WSTM4 was devised to give a fine level of detail in the urban areas of Wokingham, Bracknell Forest, Reading and South Oxfordshire. The zones are coarser outside of the Area of Detailed Modelling and ultimately covering the whole of the UK (excluding Northern Ireland) in 643 zones. Compatibility between WSTM4 and TEMPRO v. 6.21 zone boundaries was ensured. Car parks and Park and Ride (P&R) sites in Wokingham, Reading and Bracknell Forest boroughs are modelled as separate zones.

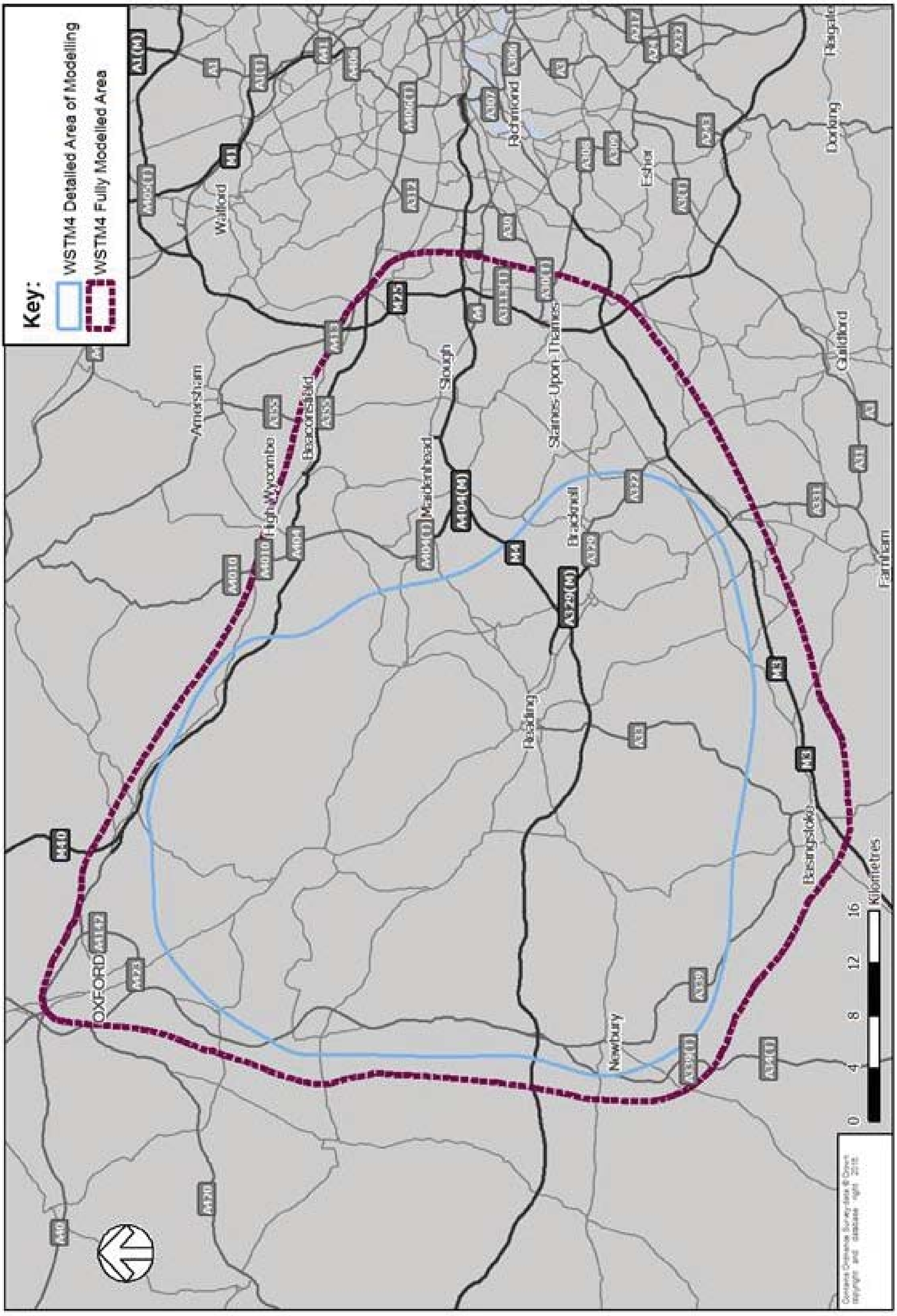
2.2.2. The WSTM4 zone boundaries are shown in Figure 3 and Figure 4.

## 2.3 WSTM4 SECTORING SYSTEM

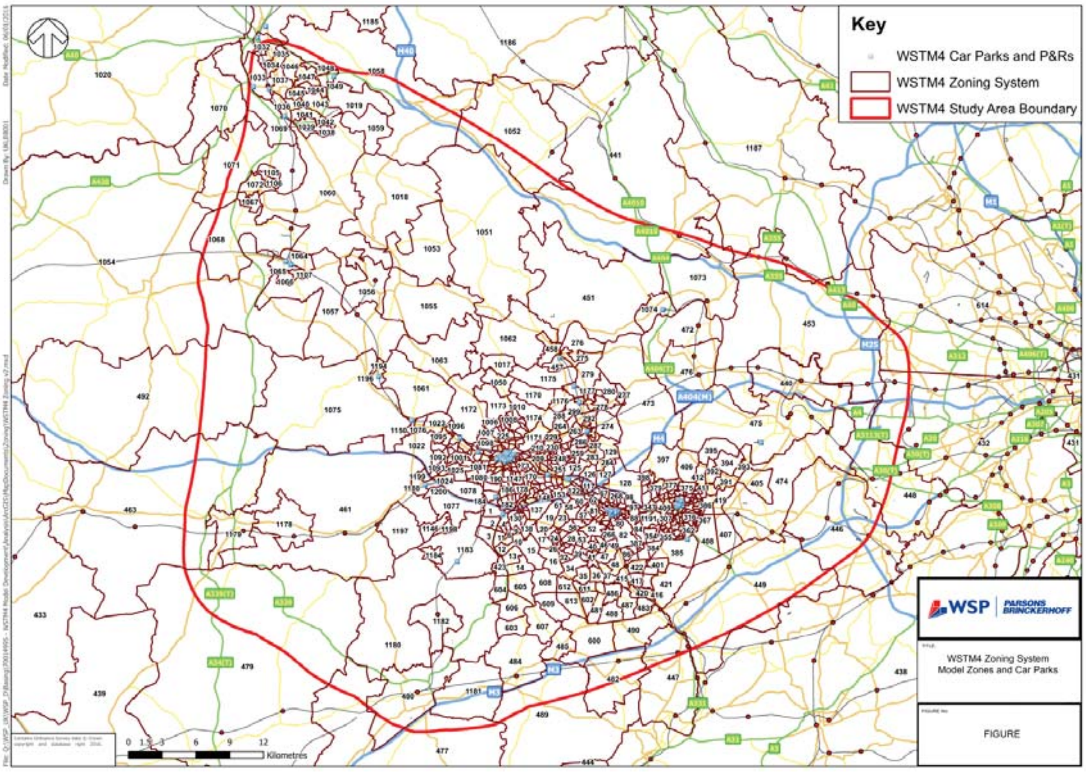
2.3.1. The WSTM4 zones have been aggregated into 32 sectors, which are shown in Figure 5 and Figure 6. Sectoring systems are normally used as a means of keeping track of the basic movements around the model, and for basic analysis within the model.

[1] The latest version available at the time of the model development

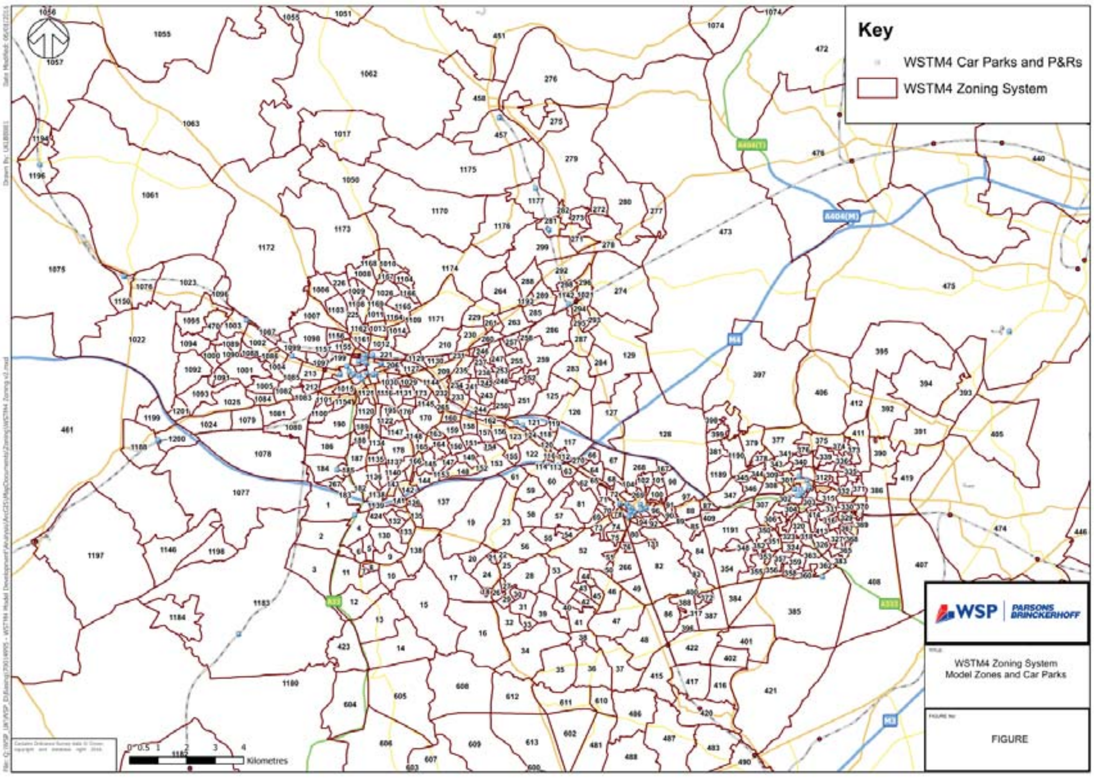
**Figure 2 – WSTM4 Fully Modelled Area**



# Figure 3 – WSTM4 Zoning – Fully Modelled Area




# Figure 4 – WSTM4 Zoning System: Wokingham, Reading and Bracknell Forest Boroughs



## Figure 5 – WSTM4 Sectors (1)

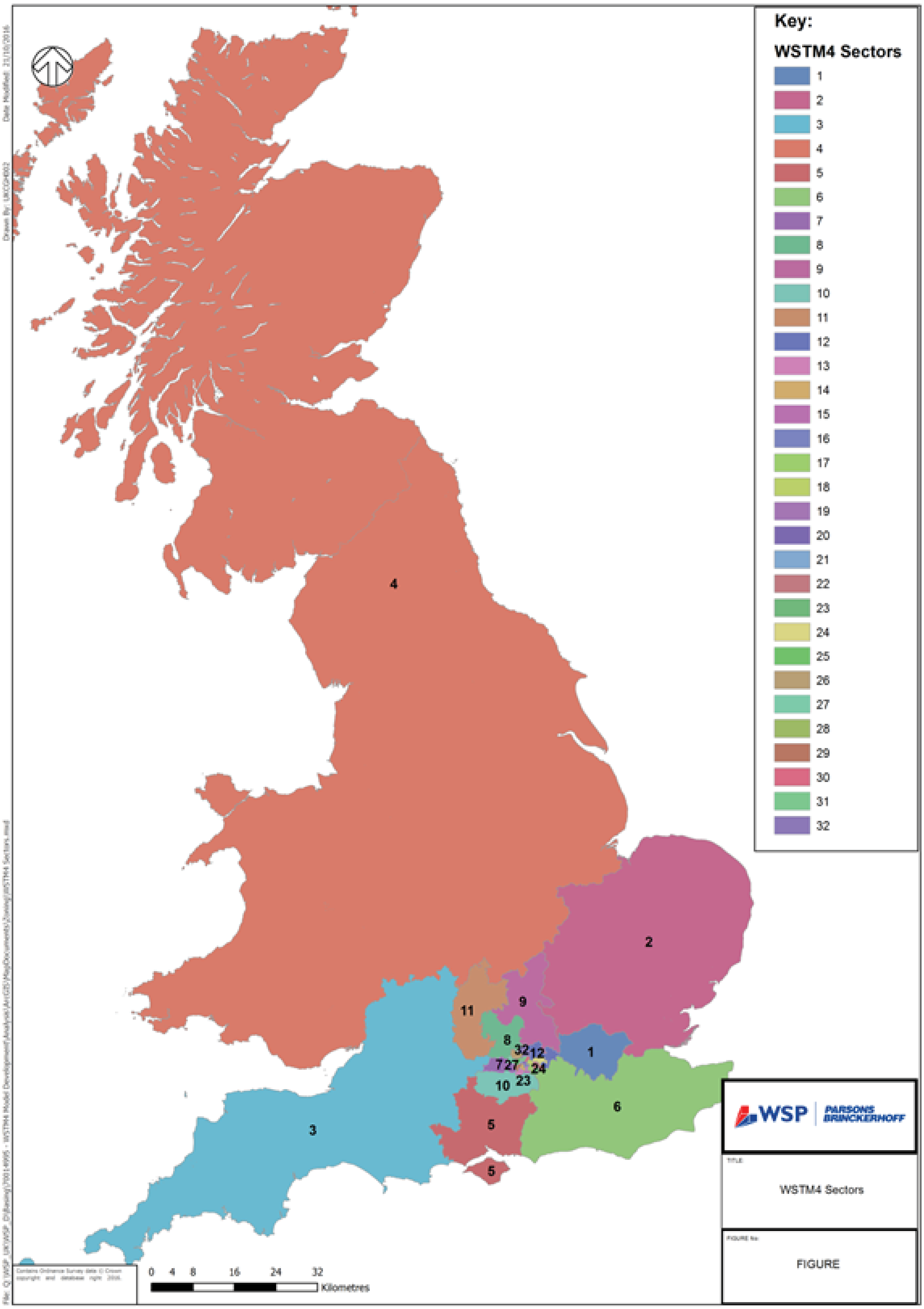
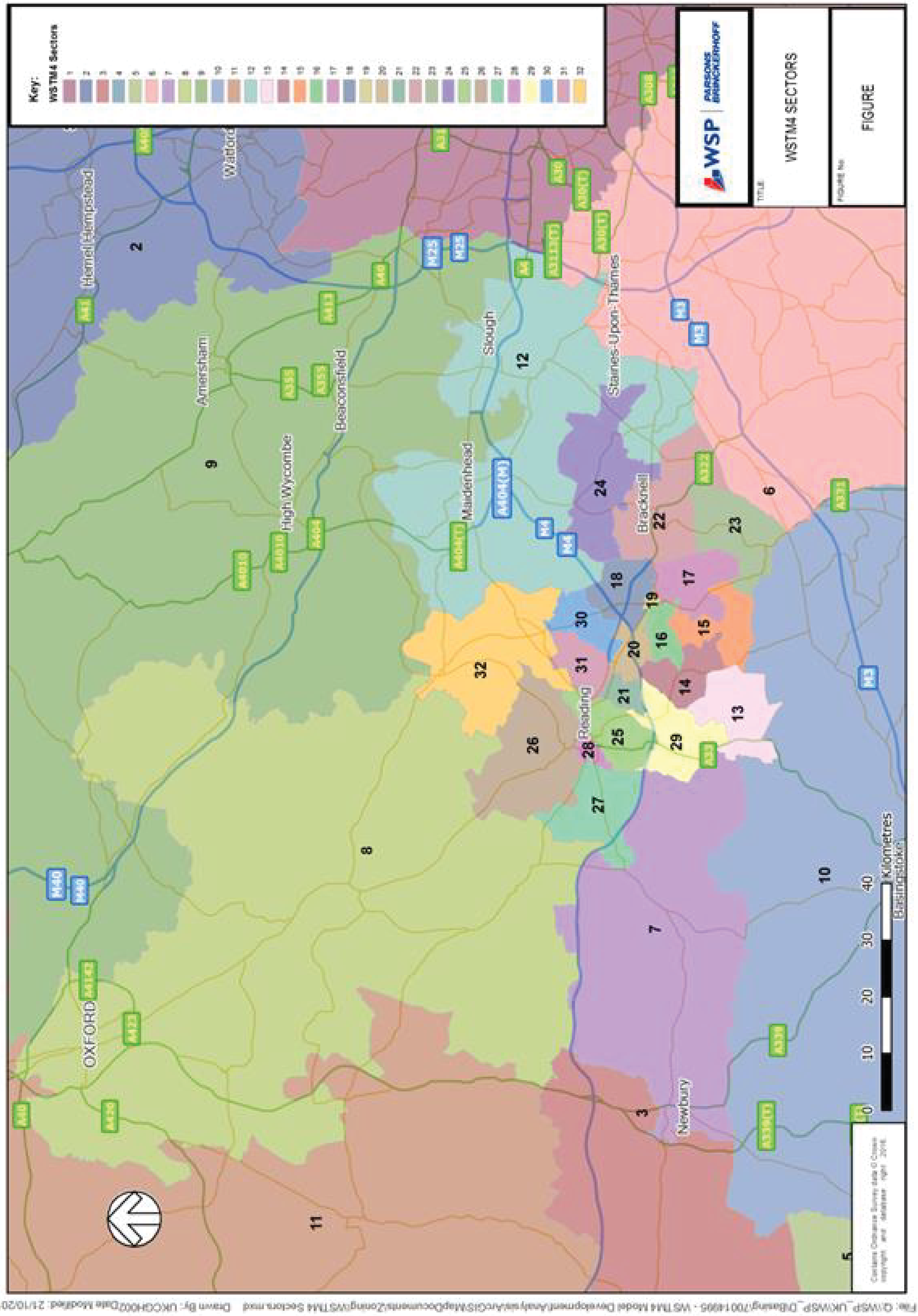


**Figure 6 – WSTM4 Sectors (2)**



## 2.4 MODEL YEARS

2.4.1. The base year of the updated WSTM4 is 2015.

## 2.5 TIME PERIODS

2.5.1. The base year models have been developed for the following time periods:

- average Weekday (Monday to Thursday) AM peak hour (08:00 - 09:00)
- average Weekday (Monday to Thursday) Inter peak hour (average 10:00 – 16:00)
- average Weekday (Monday to Thursday) PM peak hour (17:00 - 18:00).

2.5.2. The modelled time periods have been used because traffic data analysis shows that 08:00-09:00 and 17:00-18:00 are the busiest hours within the Fully Modelled Area. For the Inter peak period (average 10:00-16:00) the traffic flow is reasonably consistent throughout the period therefore average Inter peak values were used.

## 2.6 MODEL STRUCTURE AND DEMAND SEGMENTATION

2.6.1. WSTM4 has inherited the WSTM3 model structure and consists of the following sub-models:

- Highway model
- Public Transport (PT) model
- Variable Demand Model (VDM).

2.6.2. The highway model includes five user classes:

- Car Work
- Car Commuting
- Car Other
- LGV
- HGV.

2.6.3. This is consistent with advice presented in Section 2.6 of TAG Unit M3.1 (January 2014)

2.6.4. PT model user classes include:

- PT Work
- PT Commuting
- PT Other.

2.6.5. All PT matrices are split by car availability i.e. into car available (CA) and non-car available (nCA).

2.6.6. To summarise, the trip matrices are segmented as indicated below:

- Time period: AM peak hour, Inter-peak period, and PM peak period
- Mode: Private vehicle and Public transport
- Vehicle types: Light vehicles and Heavy vehicles
- Purpose: Work, Commuting and Other
- Car availability: Car available and No car available (public transport only).

## 2.7 SOFTWARE PLATFORM

2.7.1. SATURN has been successfully used as a platform for the WBC highway model since 2008. However, it is being overtaken in functionality by new developing products. SATURN's modelling options interface, functionality and visual display are limited and there are less prospects for further development and improvements.

2.7.2. For the April 2018 WSTM4 model update PTV's VISUM 17.01-04 is used, a software program for traffic and transport analyses and forecasts. The use of a single software platform has combined the highway, PT and VDM models in one suite and allowed GIS - based data management.

# 3 HIGHWAY NETWORK DEVELOPMENT

## 3.1 NETWORK DATA, CODING AND CHECKING

3.1.1. The 2010 WSTM3 SATURN network has been converted to VISUM. The converted network has been updated to take account of any changes that have occurred since the original WSTM3 was built. The already detailed WSTM3 network in Wokingham Borough and Bracknell Forest was further refined in Reading town centre, South Oxfordshire and areas around the proposed location on the New Thames Crossing east of Reading.

3.1.2. There is an inbuilt procedure within VISUM, which undertakes checks on all elements of the network coding within the model and highlights any coding errors. WSP have gone through these coding warnings, some of which have come about as a result of the change in software, and resolved all the issues identified.

3.1.3. The network was verified through the use of Google and OS maps, site visits and aerial photography. In particular, checks were carried out to verify:

- Node co-ordinates
- Link length
- Speed/flow relationship
- Link type
- Link capacity
- One way/two way operation
- Length and position of flares
- Any observed turn delays
- Location of public transport routes
- Access points.

3.1.4. Traffic loads onto the model network from zones in the form of centroid connectors. The centroid zone connectors in the updated WSTM4 have been reviewed and refined to realistically represent the way in which traffic joins the road network. In the Area of Detailed Modelling, where the zoning system is fine, specific access roads from residential and commercial areas have been used as a basis for connecting zones to the network via centroid connectors.

3.1.5. Zones in the External Area, which have a large geographical coverage and significant demand associated with them, have been generally connected to major routes to enter the network.

## 3.2 JUNCTIONS: FLOW/DELAY RELATIONSHIPS, SIGNAL TIMINGS, SATURATION FLOWS

3.2.1. Each junction included in the Fully Modelled Area required several parameters:

- Geometries
- Legs, lanes, and lane turns
- Junction control type (two-way stop, two-way yield, signalised, roundabout, uncontrolled)
- Turn types (Right turn; Straight ahead; Left turn; U-turn)
- Signal times, stages and phases
- Method of impedance at junctions.

3.2.2. All junctions within the Area of Detailed Modelling are modelled in detail. Every junction in this area uses the Node Impedance Calculation (ICA) to calculate the Method of Impedance at nodes. This is the PTV recommended method to be adopted on strategic models. ICA provides a model suitable for long term horizon planning with the added value that it can be used for operational planning. ICA was used for calculating junction capacities and delays based on junction geometry and layout input into the model, and did not require the saturation flows to be input explicitly.

3.2.3. For junctions outside the Area of Detailed Modelling the less complex ‘Turns Volume Delay Function (VDF)’ model was used. This required entering saturation flow, time (t0) and turn type.

3.2.4. The default capacity per lane adopted for two-way stop junctions using turn VDF were:

- Major straight ahead movement (unopposed) – 1,980 veh/hr

- Major left turn movement (unopposed) – 1,500 veh/hr
- Major right turn movement (opposed) - 745 veh/hr
- Minor left turn movement (opposed) – 700 veh/hr
- Minor right turn movement (opposed) - 600 veh/hr
- Minor straight ahead movement (opposed) – 600 veh/hr.

3.2.5. Default capacities at signalised junctions using turn VDF were set to:

- Straight ahead movement – 1,980 veh/hr
- Left or right turn movement – 1,740 veh/hr.

3.2.6. Up-to-date signal data was obtained from Wokingham and Reading Borough Councils for use in the model update.

3.2.7. Default saturation flows at roundabouts using turn VDF are set to the values shown in Table 1.

**Table 1 – Roundabout Saturation Flows**

| APPROACH LANES | NUMBER OF ENTRY LANES | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Single (3.5m) | 1,130 | 1,670 | 2,030 | |
| Single (5.0m) | 1,510 | 1,940 | 2,250 | 2,450 |
| Dual 2 lane | | 2,200 | 2,780 | 3,190 |
| Dual Lane | | | 3,330 | 3,940 |

## 3.3 LINKS: SPEED/FLOW RELATIONSHIPS, FIXED SPEEDS

3.3.1. The link information (free flow speed, number of lanes, capacity) was reviewed and updated to June 2016 travel conditions typically using Google maps and local knowledge.

3.3.2. Table 2 shows the link types and associated capacity and free flow speed which were assigned to links within the WSTM4.

**Table 2 – WSTM4 Link Types**

| LINK TYPE NUMBER | DESCRIPTION | CAPACITY (VEHICLES) | FREE FLOW SPEED |
|---|---|---|---|
| 1 | Motorway (4 lanes) | 8,760 | 101km/h |
| 2 | Motorway (3 lanes) | 6,570 | 114km/h |
| 7 | Rural - S10 (Good) | 4,020 | 93km/h |
| 10 | Rural - S7.3 (Typical) | 1,640 | 74km/h |
| 12 | Rural - S6.5 (Poor) | 1,640 | 64km/h |
| 26 | Urban - Non-central (Good) | 1,560 | 44km/h |
| 28 | Urban - Non-central (Typical) | 740 | 33km/h |
| 30 | Urban - Non-central (Poor) | 450 | 24km/h |
| 31 | Small Town | 1,200 | 93km/h |
| 34 | Country Lane | 1,200 | 46km/h |
| 50 | Motorway (5 lanes) | 10,950 | 101km/h |
| 51 | Motorway (6 lanes) | 13,140 | 101km/h |
| 96 | On-street parking | 99,999 | 50km/h |
| 97 | Walk link | | 4km/h |

| LINK TYPE NUMBER | DESCRIPTION | CAPACITY (VEHICLES) | FREE FLOW SPEED |
|---|---|---|---|
| 98 | Zone Access | 99,999 | 50km/h |

3.3.3. Following guidance in TAG unit M3:1 (January 2014) the links with a length of less than 200m in the Area of Detailed modelling were allocated fixed cruise speeds rather than link-based speed/flow relationships. The fixed cruise speeds are time specific and were derived from TrafficMaster journey time data.

## 3.4 ASSIGNMENT METHODOLOGY

3.4.1. The WSTM4 used assignment with ICA for the assignment of all user classes. This is the latest assignment algorithm developed by PTV, by which the assignment procedure itself calculates capacities on turns, based on junction geometry and flow levels, rather than being manually defined.

3.4.2. Traffic demand was assigned separately for Car (Car Work, Car Commuting, and Car Other), Light Goods Vehicles (LGV) and Heavy Goods Vehicles (HGV). In order that the route choice of HGV was realistic and for the most part limited to strategic and major roads, the HGV were assigned first onto an unloaded network. This was then followed by the assignment of LGV and then Cars.

3.4.3. LGV and HGV used the subordinate procedure Equilibrium assignment and Cars used Equilibrium assignment Bi-conjugate Frank-Wolfe. Figure 7 to Figure 12 show the chosen assignment procedure parameters.

**Figure 7 – Assignment with ICA – Equilibrium Assignment Procedure Parameters Input**

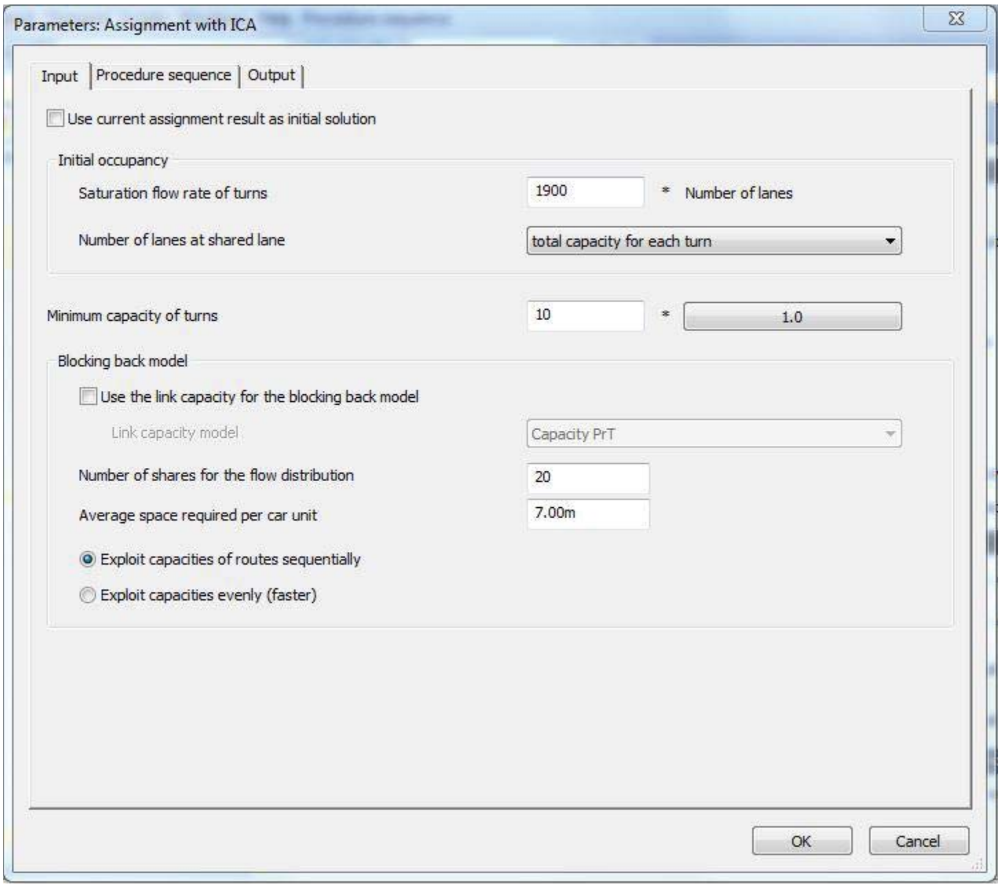


**Figure 8 – Assignment with ICA – Equilibrium Assignment Procedure Parameters Procedure sequence**

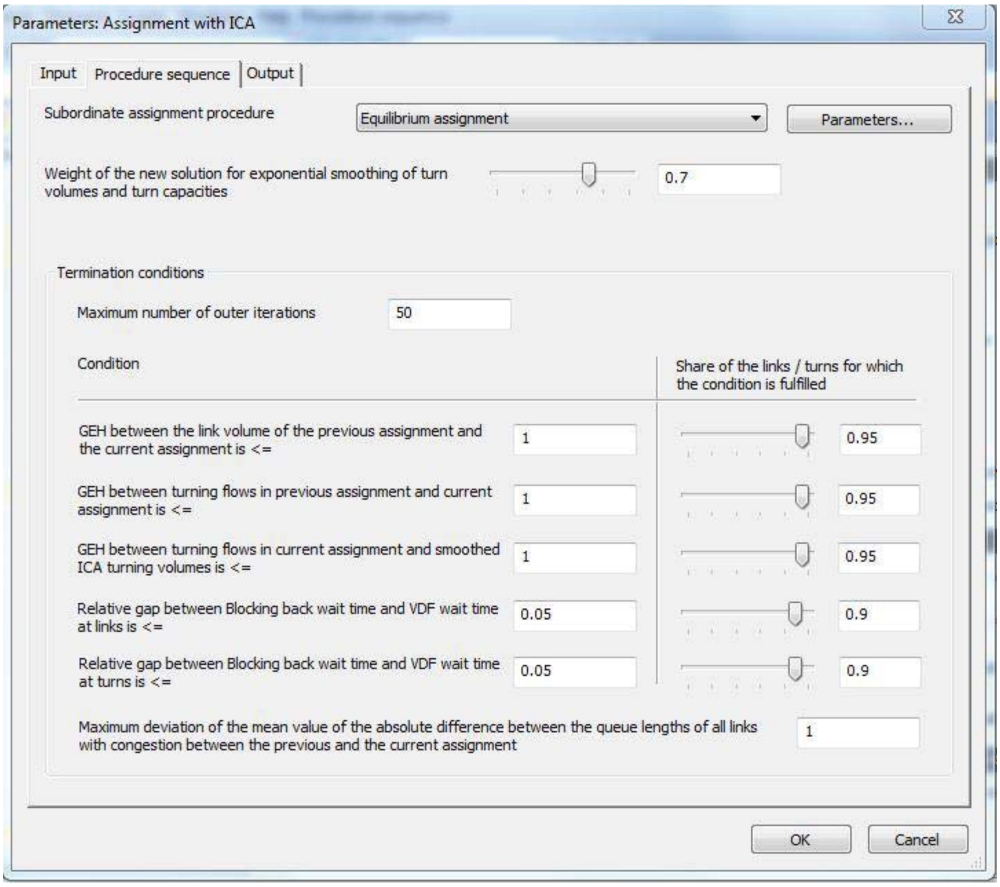
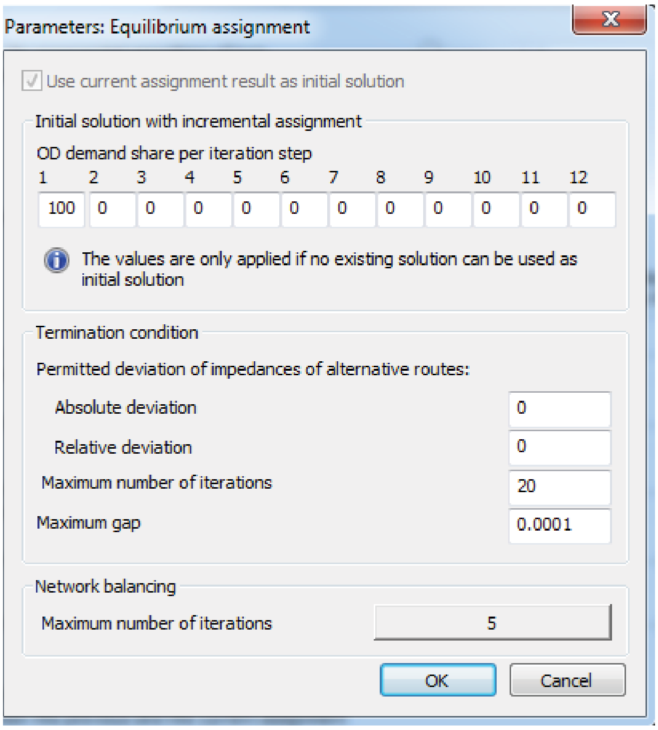



**Figure 9 – Assignment with ICA – Equilibrium Assignment Parameters**



### Figure 10 – Assignment with ICA – Equilibrium Bi-conjugate Frank-Wolfe Procedure Parameters Input

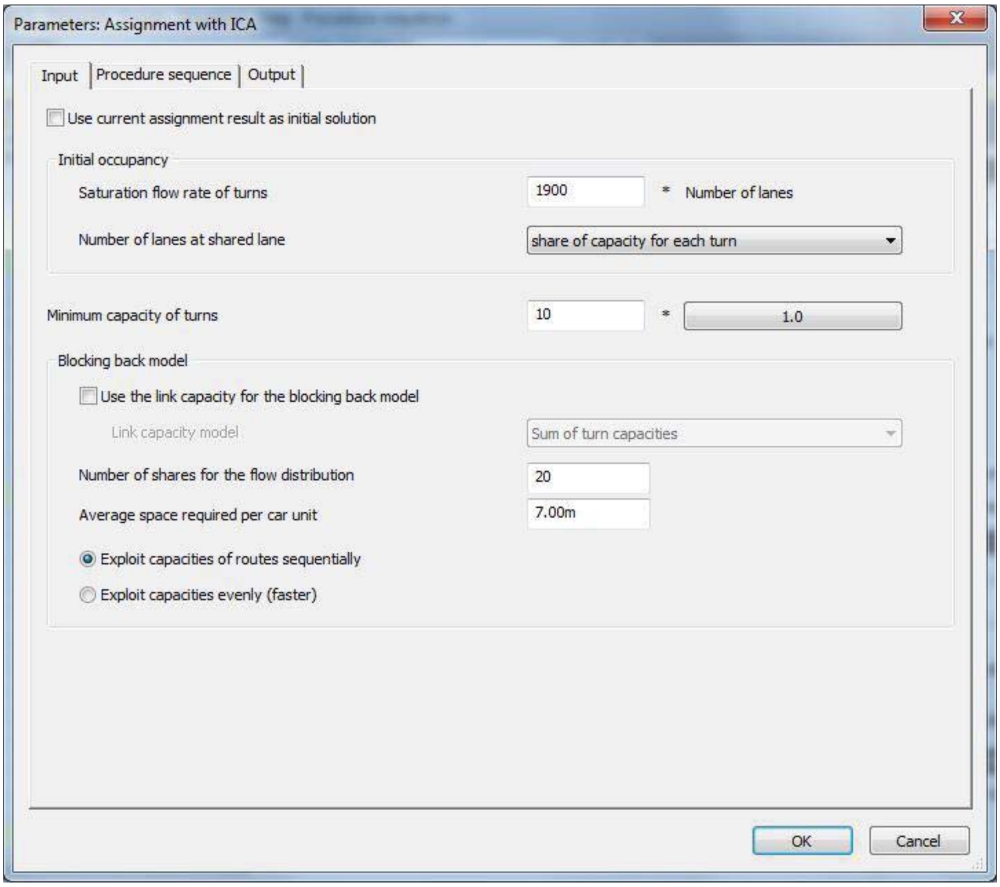


**Figure 11 – Assignment with ICA – Equilibrium Bi-conjugate Frank-Wolfe Procedure Parameters Procedure Sequence**

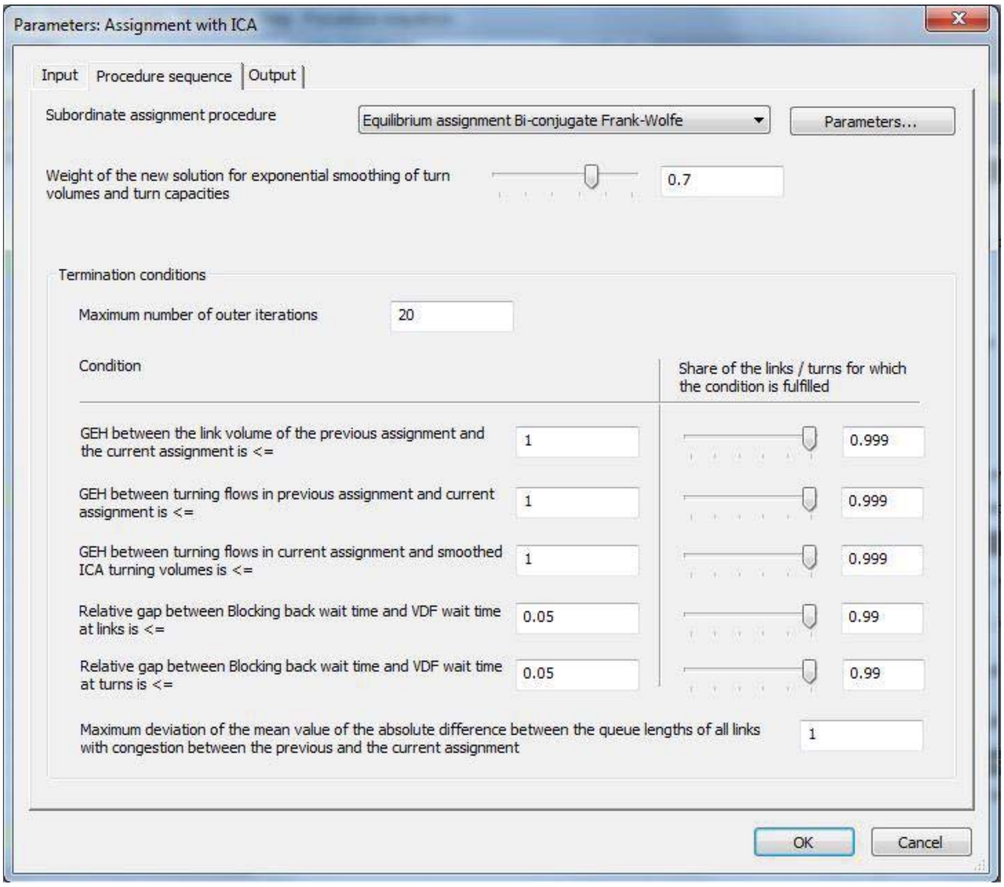
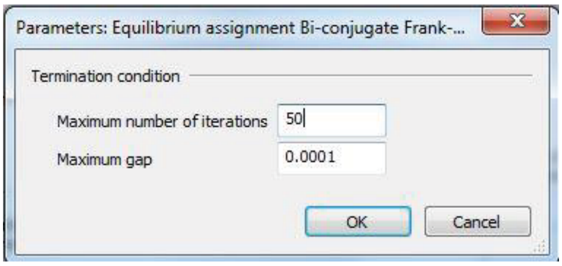



**Figure 12 – Assignment with ICA – Equilibrium Bi-conjugate Frank-Wolfe Parameters**




## 3.5 GENERALISED COST FORMULATIONS AND PARAMETER VALUES

3.5.1. Each private transport system in VISUM (car, LGV, HGV) has a defined cost-function which is usually a combination of time and distance, and any tolls or charges that may be in place in certain routes. The cost-function determines the overall cost of each available path between an OD pair, thus affecting the balance of trips on each path.

3.5.2. Highway generalised cost is defined as follows:

$$G_{CAR} = t_{ride} + \frac{d * VOC}{(occ * VOT)} + \frac{c_{park}}{(occ * VOT)}$$

where:

**t**ride is the total time spent in vehicle (minutes)

**d** is the total distance travelled in the car (kilometres)

**VOC** is the vehicle operating cost (pence per km)

**occ** is the occupancy

**VOT** is the value of time (pence per minute)

**c**park is the parking cost, including any tolls (pence).

3.5.3. The DfT TAG Databook (November 2016[2]) provided suitable values of time (VOT) and vehicle operating costs (VOC) to calculate cost function coefficients for different vehicle types. Within the 'Impedance' function in VISUM, the cost coefficients of time and distance were input in hundredths of seconds and hundredths of meters respectively, as shown in Table 3.

**Table 3 - Generalised Cost Parameters**

| DEMAND SEGMENT | AM PEAK | | INTER PEAK | | PM PEAK | |
|---|---|---|---|---|---|---|
| | Time | Distance | Time | Distance | Time | Distance |
| Car Commuting | 33.3316 | 0.5635 | 33.8735 | 0.5635 | 33.4465 | 0.5635 |
| Car Work | 49.7022 | 0.4696 | 50.931 | 0.4696 | 50.4195 | 0.4696 |
| Car Other | 22.9962 | 0.5635 | 24.4964 | 0.5635 | 24.0818 | 0.5635 |
| LGV | 35.1303 | 0.5568 | 35.1303 | 0.5568 | 35.1303 | 0.5568 |
| HGV | 35.6642 | 2.6367 | 35.6642 | 2.6367 | 35.6642 | 2.6367 |

3.5.4. A more complete model of car generalised cost includes a weighted element representing the walk distance to the car. However, since these distances tend to be very short, and do not feature in drivers' interpretations of the cost of travel, they were excluded.

[2] Forthcoming change to TAG announced in July 2016 during model development to reflect updated values of travel time

# 4 TRIP MATRIX DEVELOPMENT

## 4.1 INTRODUCTION

4.1.1. Traditionally Origin and Destination (OD) matrices are developed from a range of data sources, e.g. Census data, Road Side Interviews, travel diaries and other. Getting this information in large quantities and in the context of an urban area may be disruptive to highway users. The growth of technology has led to an increase in the type and amount of data automatically created and collected about people and freight movements. The vast majority of travellers today use mobile phones, which generate vast amounts of data. Every time a traveller's mobile phone talks to the network (texts, phone calls, pings, etc.) a record with the time and approximate location of the event is generated. The continuous recording of travel behaviour allows generating OD matrices of a high resolution.

4.1.2. For the WSTM4 development, WSP requested Citi Logik to capture Vodafone MND data and prepare initial OD matrices for the WSTM4 Fully Modelled Area. This MND supplemented with the existing data sources such as 2011 Census Data, TrafficMaster data, etc. has been used as the basis for the trip matrix development to match the WSTM4 model specification.

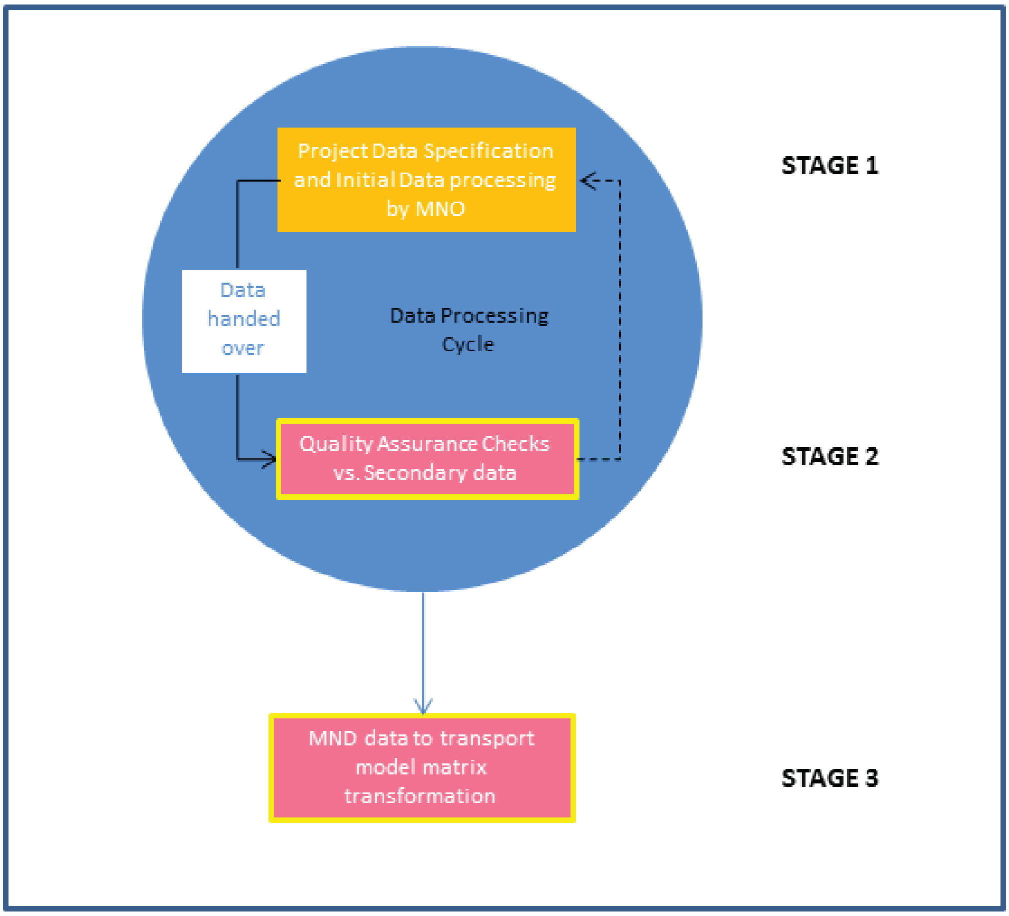
4.1.3. Citi Logik is partnered with Vodafone, which has over 19.5 million UK customers, to develop demand insights and predictive analytics derived from anonymised mobile phone network data in compliance with UK data privacy laws and future EU regulations. Citi Logik has developed a platform to collect and interpret the Vodafone data to process space and time information to inform a transport model development. Given the nature of MND, it is generally better at identifying longer trips and those where the user dwells at their destination for a longer period of time. MND also has limits on detailed information as we cannot directly learn about every individual's travel motives (trip purpose) or directly ask questions, for example, about income band. For these reason, the data need to be combined with other data sources prior to application.

4.1.4. WSP has researched this field and developed a robust methodology to produce a set of prior demand matrices from MND. It should be noted that there is currently no guidance available on the use of MND. We were engaged in the work Catapult was undertaking for the DfT to produce guidance to support the clear and consistent use of MND in transport modelling and appraisal and the work undertaken for the Highways England on the Regional Model Matrix Development and have applied knowledge gained to the development of the WSTM4 trip matrices.

## 4.2 OVERVIEW OF THE METHODOLOGY

Development of the WSTM4 demand matrices from MND follows three main stages as shown in Figure 13.

**Figure 13 – Approach Overview**




Source: "Utilising mobile phone data for transport modelling", 2016, Catapult

## 4.3 STAGE 1. INITIAL PROCESSING OF MND

4.3.1. At Stage 1 MND is captured and undergoes initial processing by Citi Logik. This included generation of travel demand matrices at the aggregated WSTM4 zone level (WSTM4 MND sectors) and segmentation of trips by day of the week, time of the day, mode, purpose and direction in order to allow the development of travel demand matrices for the Fully Modelled Area.

4.3.2. Through the network topology and behaviour, people's movements are accurately located in space and time, which is processed to derive OD movements. For data security and privacy reasons, the data is provided by Citi Logik to WSP at an aggregated level so that individuals cannot be traced. Typically in dense urban and urban fringe areas Citi Logik is able to allocate mobile phone signals to areas similar to Lower Super Output Areas (LSOA) in size, whereas in rural areas the signals can be accurately allocated to areas, which can combine a number of LSOA.

4.3.3. Position information is obtained from both active and inactive phones as they switch between adjacent mobile network cells. Active phones are more likely to be used by people travelling on foot, by public transport or as car passengers. Inactive phone positions, derived as phones switch cells, are usually typical to car drivers.

4.3.4. Data has been provided for all movements to, from, within and passing through the Fully Modelled Area.

4.3.5. Monday to Thursday data has been provided for the period between 10 November 2015 and 22 November 2015 for the following time periods:

- AM peak period (07:00-10:00)
- Interpeak period (10:00-16:00)
- PM peak period (16:00-19:00)
- Off-peak (19:00-07:00).

4.3.6. Trips have been allocated to the following modes:

- Motorised (Cars/LGV/HGV/Bus)
- Rail
- Slow [3]
- Static[4].

4.3.7. Matrices have been disaggregated to the following purpose segmentation:

- HBW: Home to Work
- HBO: Home to Other place (not Work)
- NHB: From Elsewhere (not home) to Work and other places
- Unknown.

4.3.8. The MND data has been expanded to the total adult population.

4.3.9. The output of this stage is expanded OD matrices at MND sector level. There are 236 MND sectors in total, which represent an aggregation of the WSTM4 zones.

4.3.10. Vodafone privacy rules have been applied to the OD trip data, meaning that all values lower than 15 in the output files were set to 15, thus protecting mobile users' privacy. Such a high threshold applied to the OD data may result in unrealistically high demand for a large number of movements and distort the distribution of trips. To address this data limitation imposed by the privacy rules, WSP have requested and been provided with the trip end information for each demand segment for subsequent furnessing of the matrices and controlling of trip ends to the true values.

4.3.11. Further details about the initial data processing undertaken by CitiLogik are provided in Appendix A-1.

## 4.4 STAGE 2 - MND VERIFICATION

4.4.1. The OD matrices estimated from MND have certain strengths compared to conventional sources of OD information: data is collected from a large percentage of the population, capturing day-to-day variability of trips. However, MND is a relatively new data type which is not collected exclusively for the purpose of transport planning and one should be aware of and recognise potential limitations of using mobile phone data in the following aspects:

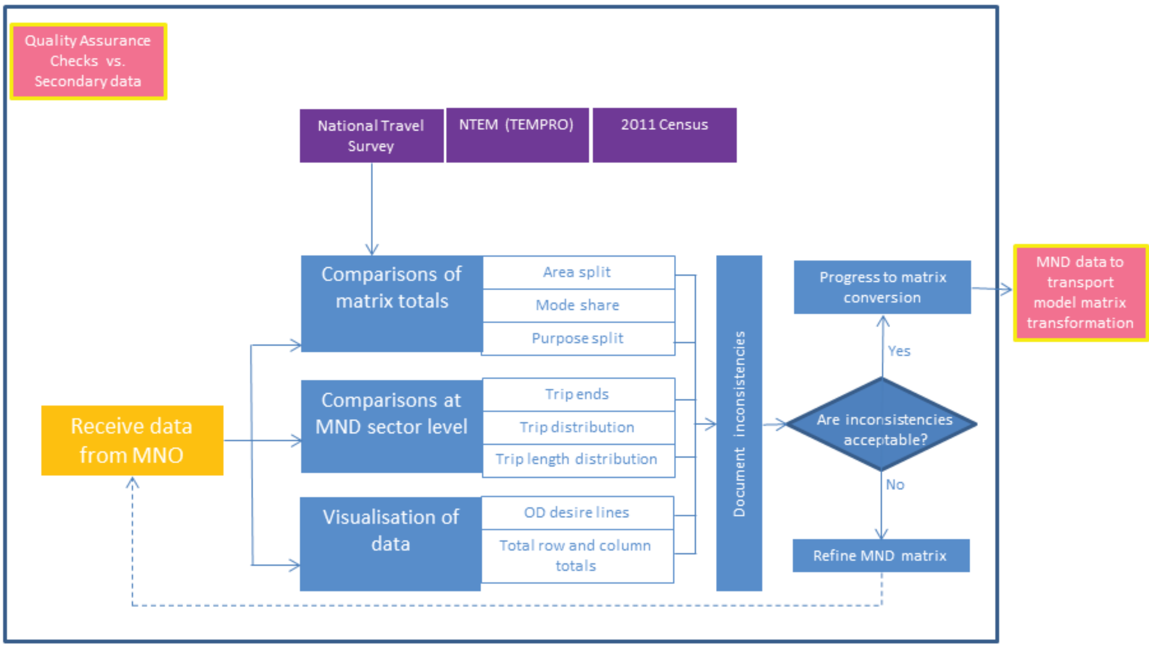
- spatial resolution and data accuracy
- identification of short trips
- identification of mode, vehicle type and vehicle occupancy
- identification of trip purpose
- expansion of mobile phone data sample.

4.4.2. To gain confidence that the overall pattern of trips produced from MND is reasonable and to identify any potential issues associated with the initial processing of MND undertaken by Citi Logik, it is important to compare the MND with alternative well-established data sources. Any issues identified at this stage are fed back to Citi Logik for further refinement of the process or addressed during the follow up stages of matrix building.

Figure 14 provides an overview of the MND verification process.

[3] The Slow mode is not represented in the model and therefore has been excluded from further analysis
[4] Though Static trips were provided, this segment of data has been excluded from any further analysis due to its limited value for building demand matrices

Figure 14 – MND Verification Process




Source: adapted from "Utilising mobile phone data for transport modelling", 2016, Catapult

4.4.3. Various tests have been undertaken to validate trip matrices developed on the basis of Vodafone customers' movements for the WSTM4 modelled area. Appendix A-2 has described the results of the MND verification. The following conclusions can be drawn from that process:

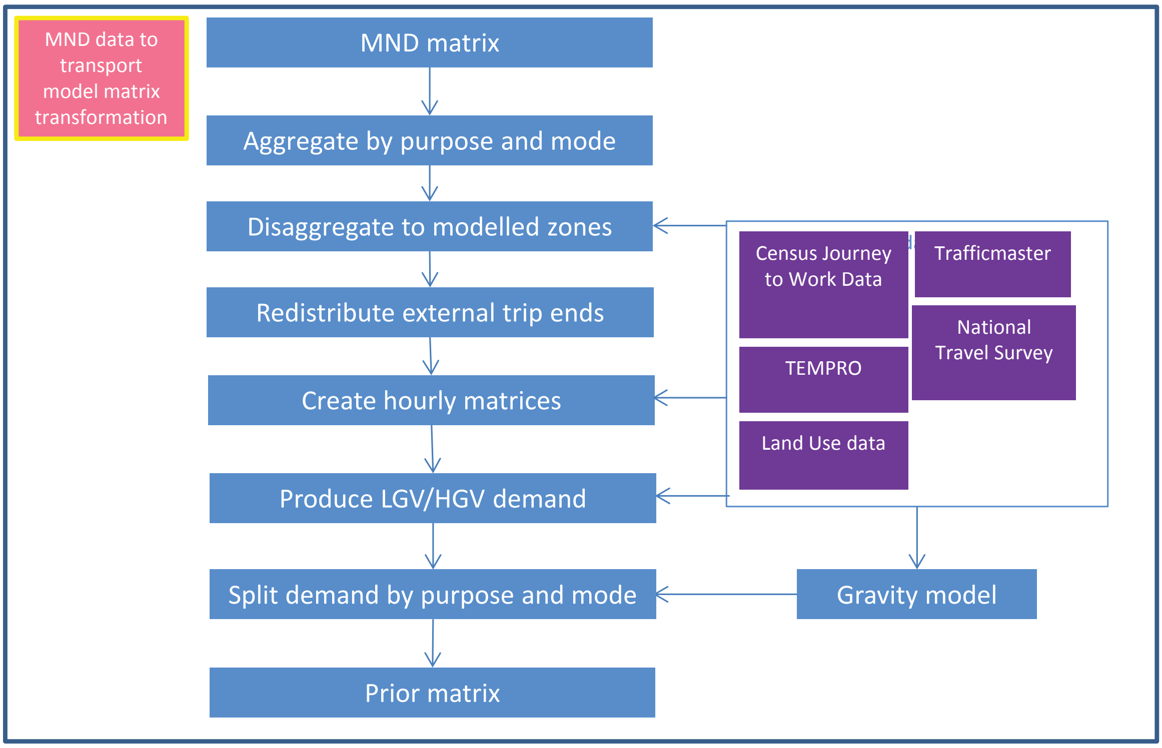
- The combined Motorised and Rail demand is reasonably robust in terms of overall trip distribution, time split and representation of short-distance trips
- A good symmetry is observed confirming the realism of the demand observed by MND analysis
- Trips to/from WSTM MND sectors correlate well with the 2011 Census population
- Mode or purpose split is not represented within MND with a high degree of accuracy.

4.4.4. A comprehensive verification process has been undertaken by WSP The analysis confirms that despite a number of potential issues outlined above the MND data accurately represents observed trip patterns and can be used as a basis for prior matrix development.

## 4.5 STAGE 3. PRIOR MATRIX DEVELOPMENT TO THE WSTM4 MODEL SPECIFICATION

4.5.1. Development of initial demand matrices to the WSTM4 specification requires the use of other post-processing techniques, which are outlined in Figure 15.

Figure 15 - MND Matrices to WSTM4 Matrices Process Overview




Source: adapted from "Utilising mobile phone data for transport modelling", 2016, Catapult

4.5.2. The following key steps need to be completed in order to develop prior matrices from the MND matrices obtained at Stage 2.

- Aggregate MND demand matrices by purpose and mode
- Disaggregate demand from WSTM4 MND sectors to WSTM4 zones
- Refine the distribution of External trip ends
- Produce hourly matrices from peak period demand
- LGV and HGV trips
- Split the demand by purpose and mode using a gravity model.

4.5.3. The methodology uses VISUM at each step of calculation and matrix manipulation which helps to build a very efficient process when working with large matrices. All the matrix development steps are included in a procedure sequence, which can be saved and transferred to other VISUM version files and projects if required. Background calculations are also undertaken using a set of extra spreadsheets.

4.5.4. The process will produce a set of prior demand matrices matching the WSTM4 specification:

- Time period: AM peak, Interpeak and PM peak hours
- Mode and vehicle type: Car, Public Transport, LGV and HGV
- Purpose split: Commuting (including Education), Employee's Business, Other.

## 4.6 AGGREGATION OF MND RAW MATRICES

4.6.1. The MND matrices originally were produced with a time, purpose and mode split. However the verification process highlighted that mode or purpose split are not represented within MND with a high degree of accuracy. Therefore the MND matrices were aggregated by purpose and mode to be then disaggregated using an alternative approach described further in this section.

## 4.7 DISAGGREGATION OF DEMAND FROM WSTM4 MND SECTORS TO WSTM4 ZONES

4.7.1. The original MND matrices were provided at the WSTM4 MND sector level, which represented an aggregation of the WSTM4 zones. The WSTM4 zones are nested within the MND sectors and the zone boundaries completely match with each other. The WSTM4 has a zone system of 643 zones whereas the MND sectoring contains 236 zones in total. The mismatch in the number of zones means that a disaggregation of original MND demand to the WSTM4 zones had to be carried out.

4.7.2. The disaggregation has followed the methodology originally developed by WSP for Transport for London (TfL) to split spatially coarse LTS trip ends into smaller LoHAM zoning system. The methodology utilises the following land use data:

- Numbers of domestic delivery addresses from Ordnance Survey Codepoint data
- Workplace population from 2011 Census information
- Edubase pupil number data.

4.7.3. Domestic delivery addresses, workplace population and Edubase pupil numbers have been assigned to the WSTM4 zones based on the centroids of their respective layers. The MND matrices have been disaggregated using a combination of datasets using the weighting factors from the work carried out for TfL in London.

4.7.4. The methodology behind carrying out this correspondence process in this manner is that the determination of how many trips would be expected to come out of any specific area within these initial zones should be based on a relevant dataset. For example, morning trips should have predominantly origins of homes, and destinations of workplaces (which in this case include places of education). This enables an initial sector that contains say a large residential area, and a large employment area, but where the final zones have these two areas as separate zones, to be split in a way that means the final trip matrices make a lot more sense, than just splitting proportionally by area in all cases.

## 4.8 REFINEMENT OF THE DISTRIBUTION OF EXTERNAL TRIP ENDS

4.8.1. Due to the data collection method the true trip ends of the external movements are unknown with the trip ends allocated to an external zone closest to the boundary of the modelled area. To ensure a much more precise cost and skim calculation of such trips the external trip ends need to be redistributed and this was undertaken based on the 2011 JTW data.

4.8.2. Destination trips ends were refined using the JTW destination trip end distribution for all time periods. The JTW data provides information about a single direction only i.e. home to work, and therefore the data was transposed for the purpose of adjusting the External origin trip ends of the MND data.

4.8.3. The above approach has been applied to Internal-External and External- Internal movements. The trip ends of the External-External movements (except London-based) were not refined further as these trips are fixed within the variable demand model and the knowledge of the true trip ends will not make any difference to the results.

## 4.9 CREATION OF HOURLY MATRICES

4.9.1. Creating hourly matrices is a single step where overall factors are used to factor down the peak period matrices into hourly matrices. The factors have been derived from NTS and are as follows:

- AM peak: 0.506
- IP average: 1/6
- PM peak: 0.370.

## 4.10 LGV AND HGV TRIPS

4.10.1. Trafficmaster OD data was obtained from the DfT covering a period between September 2014 and August 2015. This data includes information on LGV and HGV movements between 2011 Census LSOA boundaries. The DfT were able to provide this data using the same cordon provided to Citi Logik for the MND collection, which ensured the consistency between the two datasets.

4.10.2. Matrices were then built from the Trafficmaster data for LGV and HGV trips and the following occupancy factors have been applied to produced vehicle trip matrices to ensure consistency with the WSTM4 specification:

- LGV: 1.23 person/vehicle
- HGV: 1.00 person/vehicle.

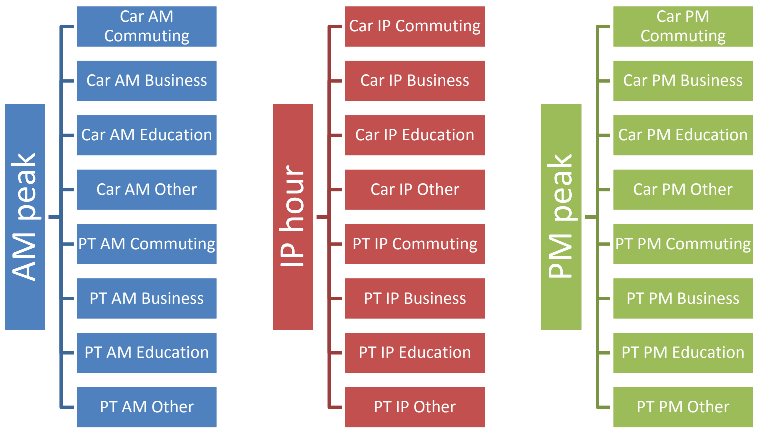
4.10.3. The HGV and LGV matrices were then assigned in the highway model, with the results compared against screenlines. It is a known limitation of Trafficmaster OD data that the sample size is low, therefore once the assignment of these vehicle types was carried out, the flows were initially scaled up using 'flow bundle' analysis to ensure the flows matched observed counts. The LGV and HGV matrices were then run through matrix estimation to produce final LGV and HGV matrices.

4.10.4. The resultant LGV and HGV trip matrices were then subtracted from the MND matrices. The remaining MND demand represents car, bus and rail combined matrices.

## SPLIT THE DEMAND BY PURPOSE AND MODE

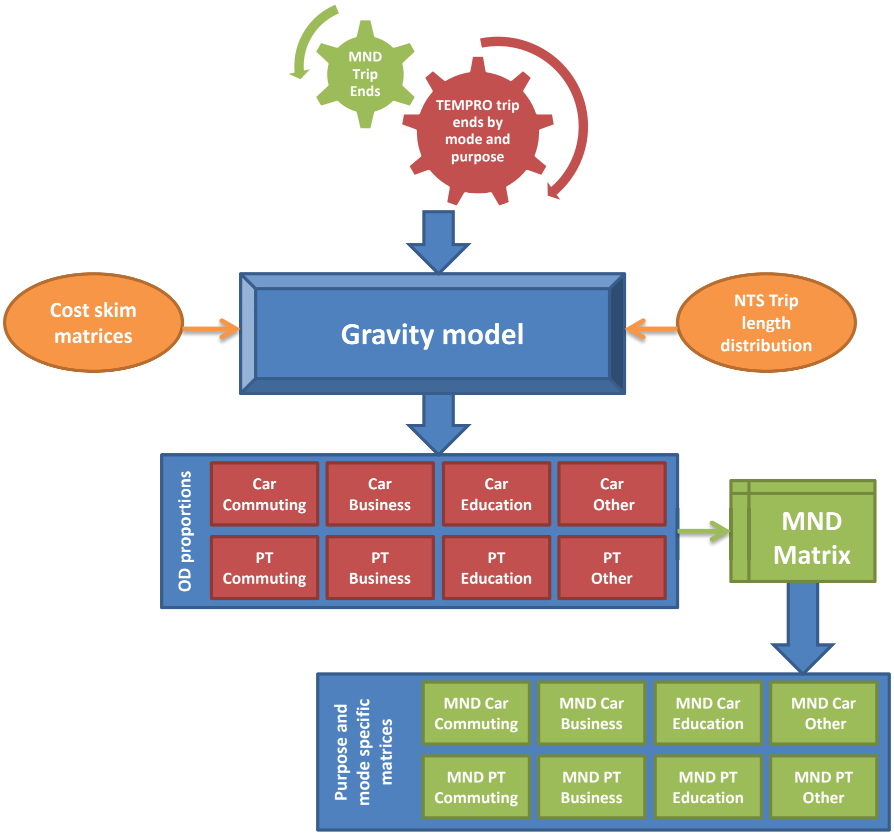
4.10.5. A gravity model has been developed to split the combined demand by purpose (Commuting, Education, Employer's Business and Other) and by mode (public transport and car). The Commuting and Education purposes were later combined to form a single Commuting purpose. The outputs of the gravity model are used to produce mode and purpose specific proportions for individual OD relations, which are then applied to the combined MND matrices to calculate car and public transport matrices as shown in Figure 16.

**Figure 16 – Gravity model to split matrices by purpose and mode**




4.10.6. Development of purpose and mode specific demand matrices requires the use of the method and steps which are outlined in Figure 17. The same approach has been applied to all time periods.

**Figure 17 - Outline of how the gravity model is used for mode and purpose split**




4.10.7. The MND trip ends from the combined matrices were split using mode and purpose specific proportions extracted from TEMPRO v 6.2 to produce target trip ends for the gravity model. The trip length distribution data for the gravity model calibration comes from the NTS and varies by journey purpose and mode. The daily averages were used for each time period as it was found that there is no significant difference in individual time periods in the modelled area.

4.10.8. The cost for the gravity model represents uncongested generalised cost matrices produced from assigning LGV/HGV matrices for highway and dummy low value matrices for the public transport. These costs are used directly as utility functions in VISUM trip distribution procedure.

4.10.9. The intra-zonal trips have been initialised prior to running the gravity model and will not be taken into account at any further stages. The External-External movements have been excluded from the gravity model and were split by mode and purpose using a set of factors calculated using TEMPRO v 6.2. The factors are reproduced in Table 4.

**Table 4 – External factors to mode and purpose split**

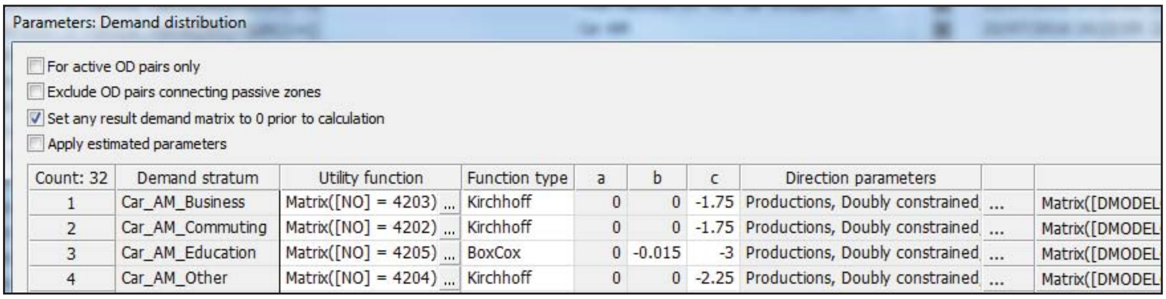
| EXTERNAL FACTORS | | | |
|---|---|---|---|
| Period | Purpose | Factor (Car) | Factor (PT) |
| AM | Commuting | 0.416 | 0.075 |
| | Business | 0.053 | 0.003 |
| | Education | 0.160 | 0.062 |
| | Other | 0.209 | 0.021 |
| IP | Commuting | 0.142 | 0.019 |
| | Business | 0.058 | 0.003 |
| | Education | 0.089 | 0.025 |
| | Other | 0.577 | 0.088 |
| PM | Commuting | 0.320 | 0.052 |
| | Business | 0.049 | 0.004 |

**EXTERNAL FACTORS**

| | | | |
|---|---|---|---|
| | Education | 0.043 | 0.012 |
| | Other | 0.479 | 0.042 |
| OP | Commuting | 0.044 | 0.003 |
| | Business | 0.015 | 0.002 |
| | Education | 0.337 | 0.018 |
| | Other | 0.553 | 0.030 |

4.10.10. The gravity model was set up in VISUM using the parameters shown in Figure 18.

**Figure 18 – Gravity model in VISUM**

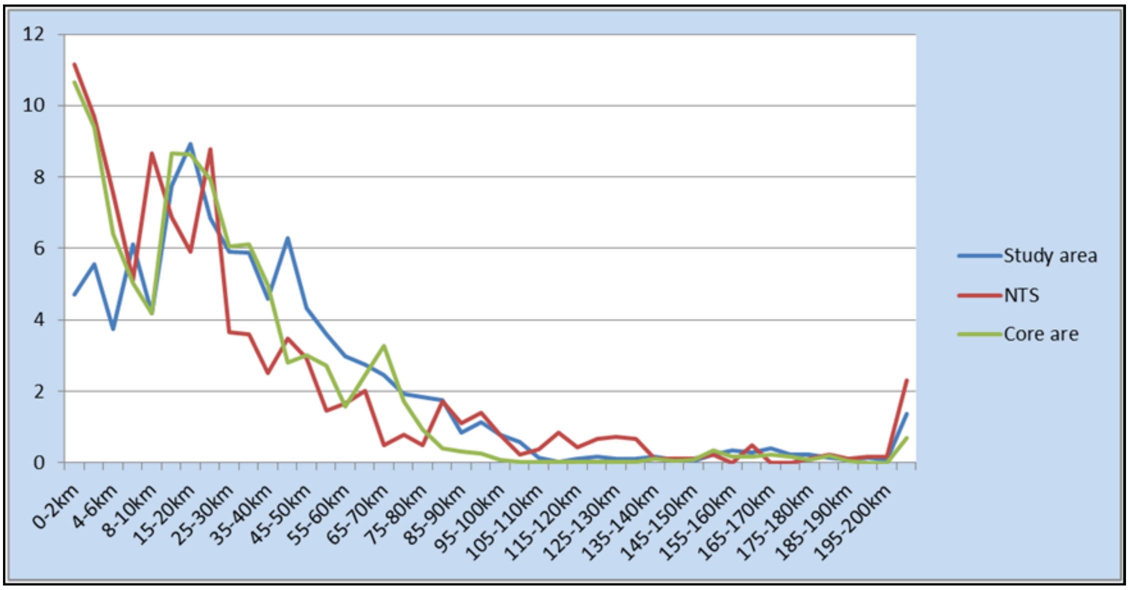



4.10.11. The trip distribution functions are the same for each time period including the function type and parameters as well:

- Car Commuting: f(U)=U^c, c=-1.75 (Kirchhoff)
- Car Business: f(U)=U^c, c=-1.75 (Kirchhoff)
- Car Education: f(U)=e^[c(U^b-1)], b=-0.015; c=-1.75 (Box-Cox)
- Car Other: f(U)=U^c, c=-2.25 (Kirchhoff)
- PT Commuting: f(U)=e^[c(U^b-1)], b=0.1; c=-0.5 (Box-Cox)
- PT Business: f(U)=e^[c(U^b-1)], b=-0.15; c=-0.15 (Box-Cox)
- PT Education: f(U)=e^[c(U^b-1)], b=-0.2; c=-7 (Box-Cox)
- PT Other: f(U)=U^c, c=-3 (Kirchhoff).

4.10.12. The functions and their parameters have been calibrated using a trip length distribution comparison spreadsheet with NTS data including 44 distance bands and graphical analysis. The comparison has been undertaken for the whole modelled area and for the core modelled area covering the high density urban areas of Reading, Wokingham and Bracknell, the fine zone structure within this area will ensure the short distance trips are present within the demand matrices. An example of the trip length distribution calibration is presented in Figure 19.

**Figure 19 – Example of a trip length distribution calibration diagram**




4.10.13. The mode and purpose specific MND matrices were produced by applying the following formula:

[MND CAR AM COMMUTING] = [GRAVITY MODEL CAR AM COMMUTING] / [GRAVITY MODEL AM TOTAL] * [MND AM TOTAL]

4.10.14. The MND car matrices were finally converted from person trips to vehicle trips using different factors for each journey purpose. Factors were derived from TAG Databook Table A.1.3.3 (2015, version 1.45) and are shown below:

- Commuting:1.15
- Business: 1.21
- Other: 1.72.

[5] The latest version available at the time of matrix development, as the model build progressed, November 2016 values were used following advice from DfT

# 5 HIGHWAY MODEL CALIBRATION AND VALIDATION

## 5.1 INTRODUCTION

5.1.1. Calibration of the 2015 WSTM4 highway model involves ensuring the model represents the on-site observed conditions by adjusting model inputs and parameters. The process involves examination of the network, checking for errors, and improving the performance of the model in terms of comparisons with observed data. Calibration statistics will be presented using the DfT TAG criteria.

5.1.2. Model validation is a comparison of model output data with observed data to assess the accuracy of the model and is therefore very similar to model calibration. The difference between the two is that validation data is independent from model development data i.e. it is not used at any stage within the model development.

## 5.2 APPROACH OVERVIEW

5.2.1. Calibration and validation is undertaken for the four main components of the model:

- Network calibration and validation
- Route choice calibration and validation
- Trip matrix calibration and validation
- Assignment calibration and validation.

5.2.2. Each of the tasks above is linked with each other and it is often a combination of all that are required to address each problem identified by the calibration and validation process. Each of the tasks is considered further in this section in turn.

### DATA

5.2.3. Several sources of already available data have been utilised, these are:

- TRADS data from the Highways England's HATRIS website
- Local Authorities permanent Automatic Traffic Counts (ATC)
- Previously collected Manual Classified Counts (MCC) data in Wokingham
- Additional ATC and MCC collected during September / October 2015.

All the survey locations, which have been utilised in the model calibration or validation, are graphically shown in Figure 20 and Figure 21.

**Figure 20 – Survey Locations (1)**

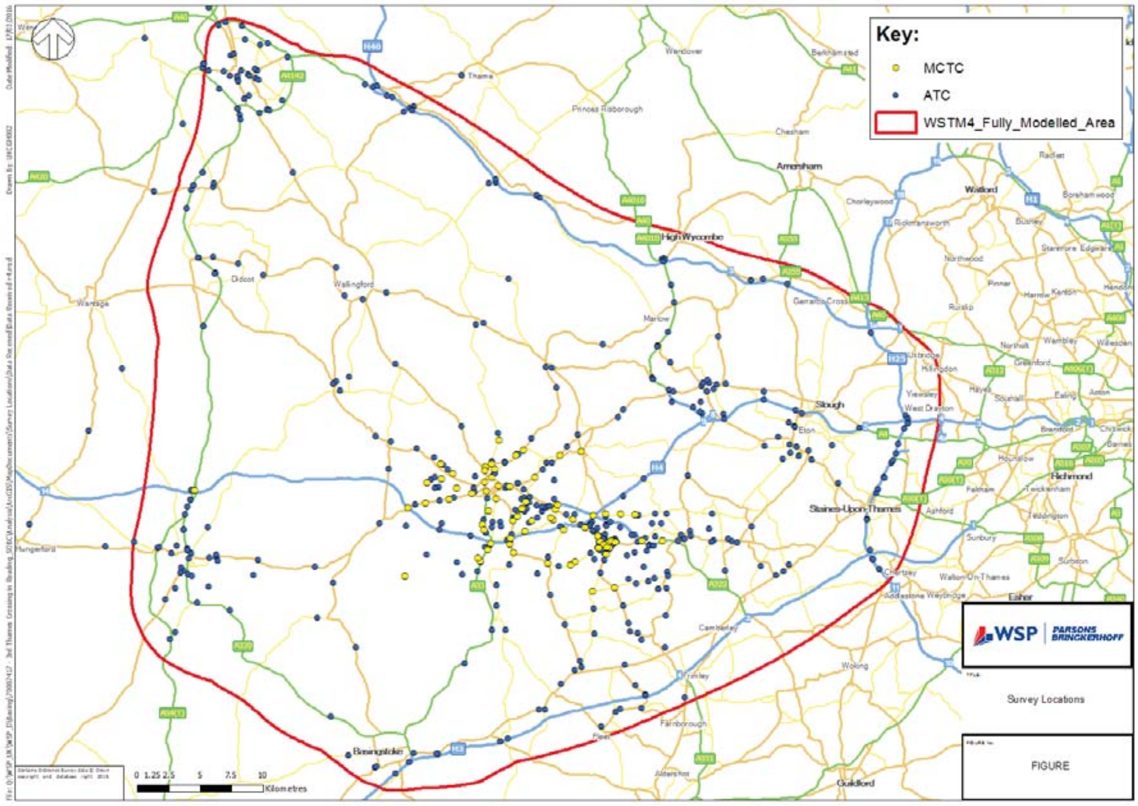
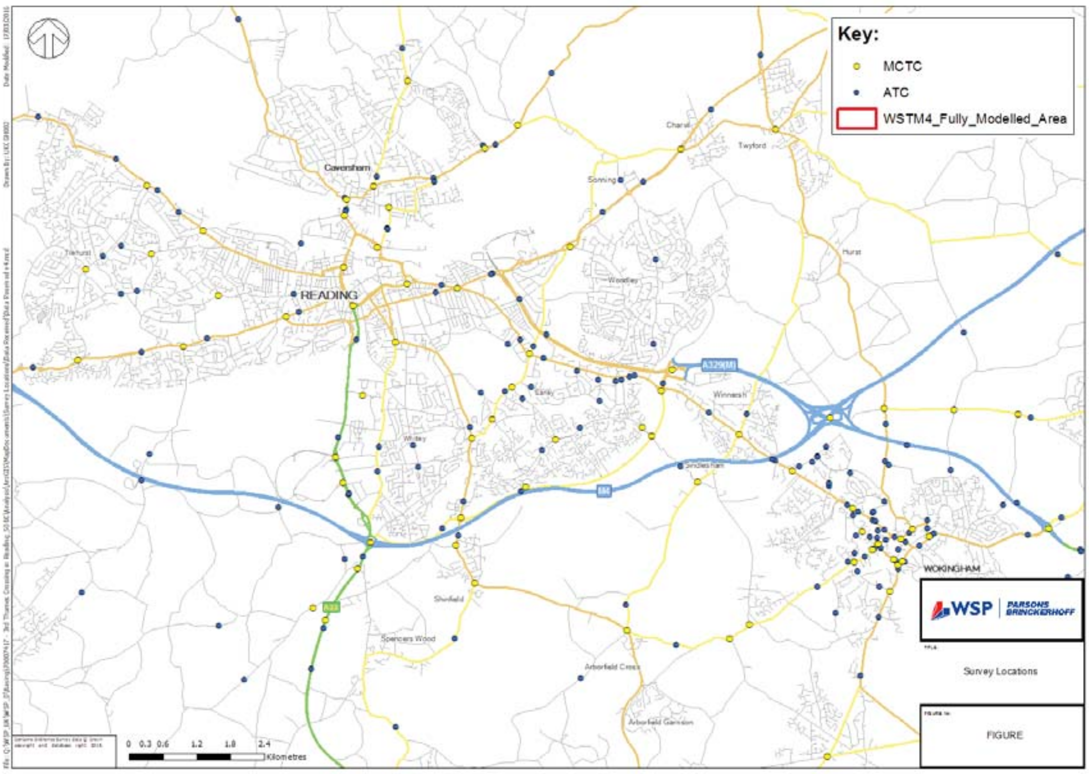



**Figure 21 – Survey Locations (2)**



5.2.4. Journey time data was obtained through TrafficMaster via the DfT for the period between September 2014 and August 2015 and was used to derive travel times for key routes through the model. Information was taken for an average weekday drawn from a two weeks' worth of data, for the closest available period to the other traffic survey data.

5.2.5. The accuracy of the data has been calculated and reported in the "WSTM4 Data Collection Report" (February 2017).

5.2.6. Figure 22 and Figure 23 show the location of the journey time routes used in the WSTM4.

**Figure 22 – Journey Time Routes (1)**

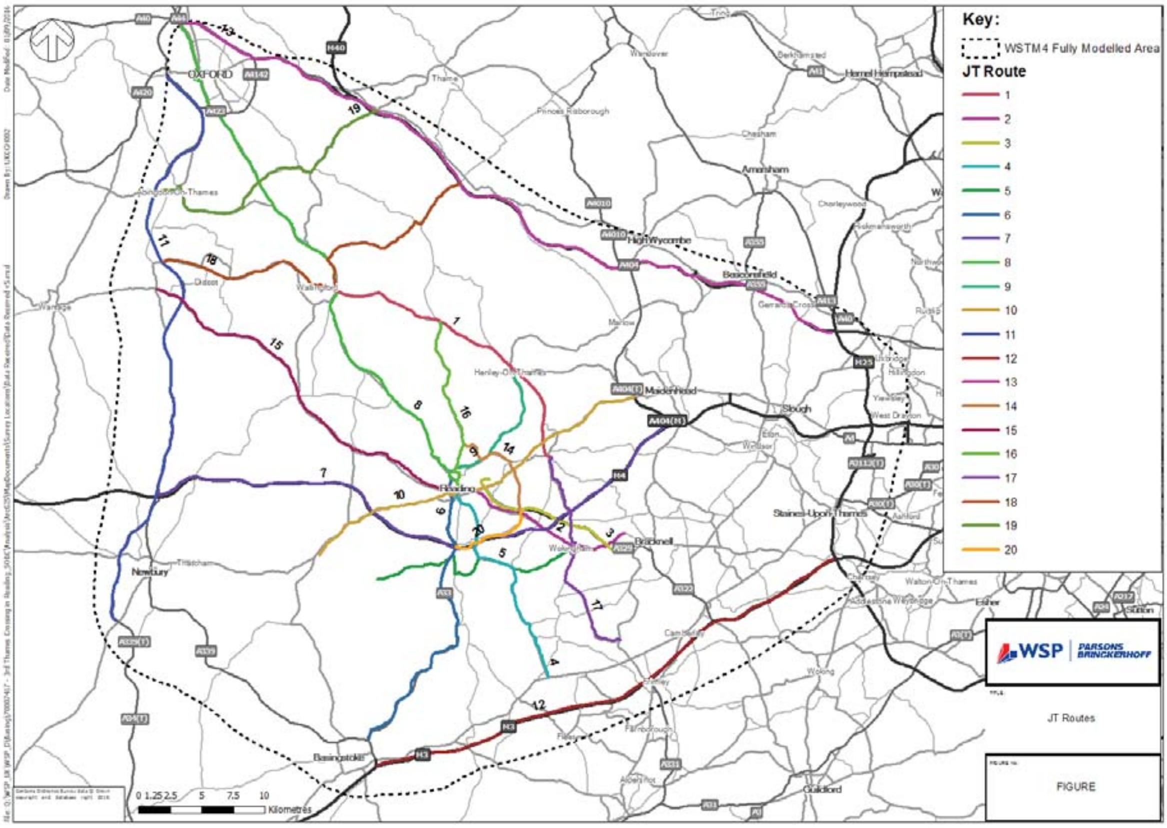
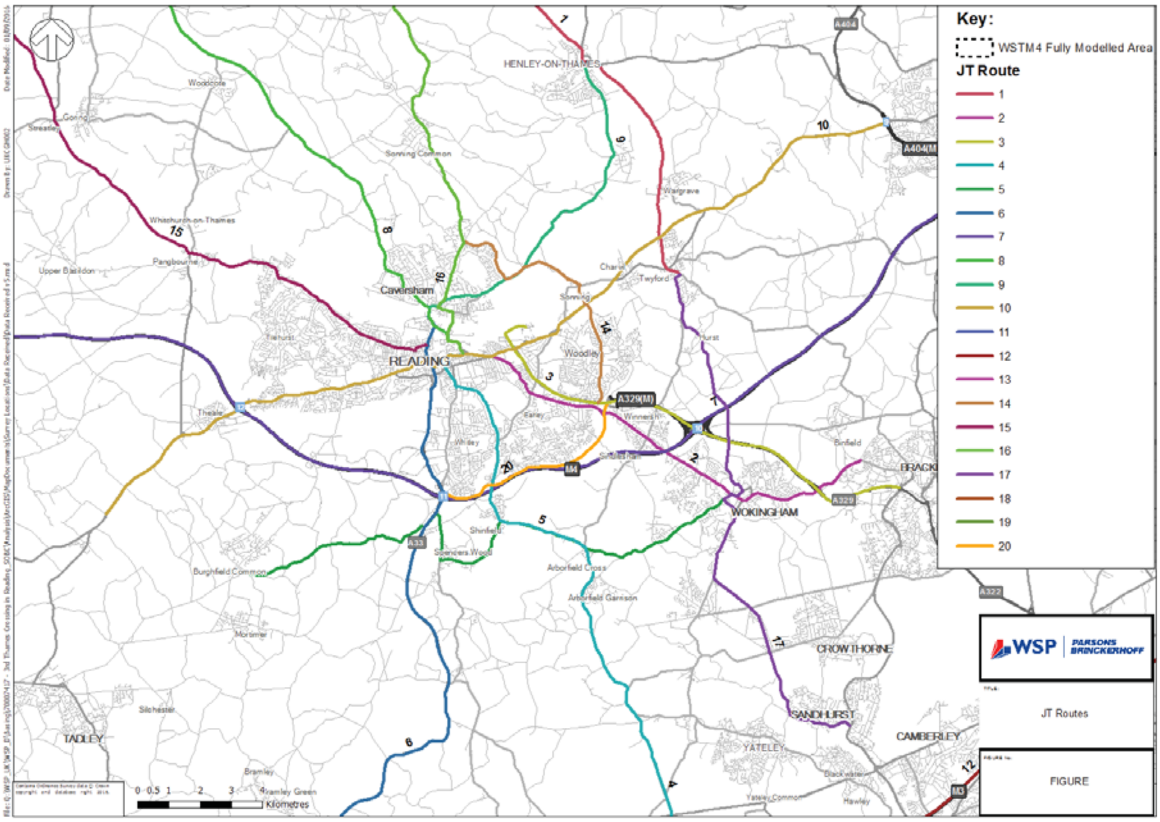


**Figure 23 – Journey Time Routes (2)**




## NETWORK CALIBRATION

5.2.7. Following the creation of the network as outlined in Chapter 4, an initial assignment has been carried out prior to any adjustment of the demand matrices. The results have been compared against observed flows, speeds and delays to identify any further areas which may require adjustment to the network coding. In particular, the following instances have been checked:

- Turn / link capacity is less than observed count
- Calculated delays significantly greater than observed delays
- Modelled flows significantly above observed flows
- Modelled delays unacceptably lower than observed delays.

5.2.8. Remedial action on the network coding was undertaken where the above were identified; changes have only been made that are in accordance with direct observations of actual network properties.

## NETWORK VALIDATION

5.2.9. Validation of the final network in isolation of the development of the final trip matrix was not possible, but high level checks were undertaken following development of initial trip matrices to investigate modelled journey times on routes that differ from observed times by more than 25%.

5.2.10. Network validation has been confirmed through presentation of time/distance graphs for each modelled journey time route, as discussed below.

## ROUTE CHOICE CALIBRATION

5.2.11. At various stages of model development, the minimum cost routes for a range of selected O-D pairs were plotted and checked for plausibility. Modelled route choice depends on:

- Zone size
- Network structure
- Centroid connectors
- Trip matrix accuracy

- Representation of speeds and delays
- Junction coding accuracy.

5.2.12. Where routes were found to be implausible one or more of the above aspects have been adjusted.

## ROUTE CHOICE VALIDATION

5.2.13. Sense checks were carried out on a number of strategic and local routes across the study area. In particular, motorway route choice was checked so that key strategic routes were chosen rather than short-cuts.

5.2.14. Following calibration and validation of the model, information has been presented for a selected number of origin-destination pairs to demonstrate that the routing is logical. To some extent this is not true validation, as there is no empirical data to act as a benchmark, but selected routes plotted from VISUM have been compared to equivalent routes prepared using Google Maps, supported by a commentary discussing the feasibility of each route.

5.2.15. Routes selected focus on important centres of population or employment, or through key intersections. They:

- Relate to significant numbers of trips
- Are of significant length
- Pass through key areas of interest
- Include both directions of travel
- Link different compass areas
- Coincide with journey time routes, where appropriate.

## TRIP MATRIX CALIBRATION

5.2.16. Following the development of the prior trip matrices, matrix estimation techniques have been undertaken.

5.2.17. Matrix estimation, T-Flow Fuzzy in VISUM, was used on all calibration screenlines, cordons and counts. Within the matrix estimation procedure in VISUM it is possible to use both screenlines and individual links for matrix estimation. This was undertaken once to the prior matrix to derive final WSTM4 results.

5.2.18. Guidance presented in section 8.3 of TAG Unit M3.1 (January 2014) was followed. In particular:

- Counts used in matrix estimation were derived from a minimum 2-week ATC
- Count constraints were grouped at a screenline level
- Constraints were only applied to directly observed counts, e.g. all car user classes were grouped to a single "car" constraint.

5.2.19. To ensure that matrix estimation was a controlled process, due care and attention was given to the requirements set out in TAG to monitor the impacts of matrix estimation. Information has been therefore presented on:

- Regression statistics at trip end level
- Trip length distributions with means and standard deviations.

## TRIP MATRIX VALIDATION

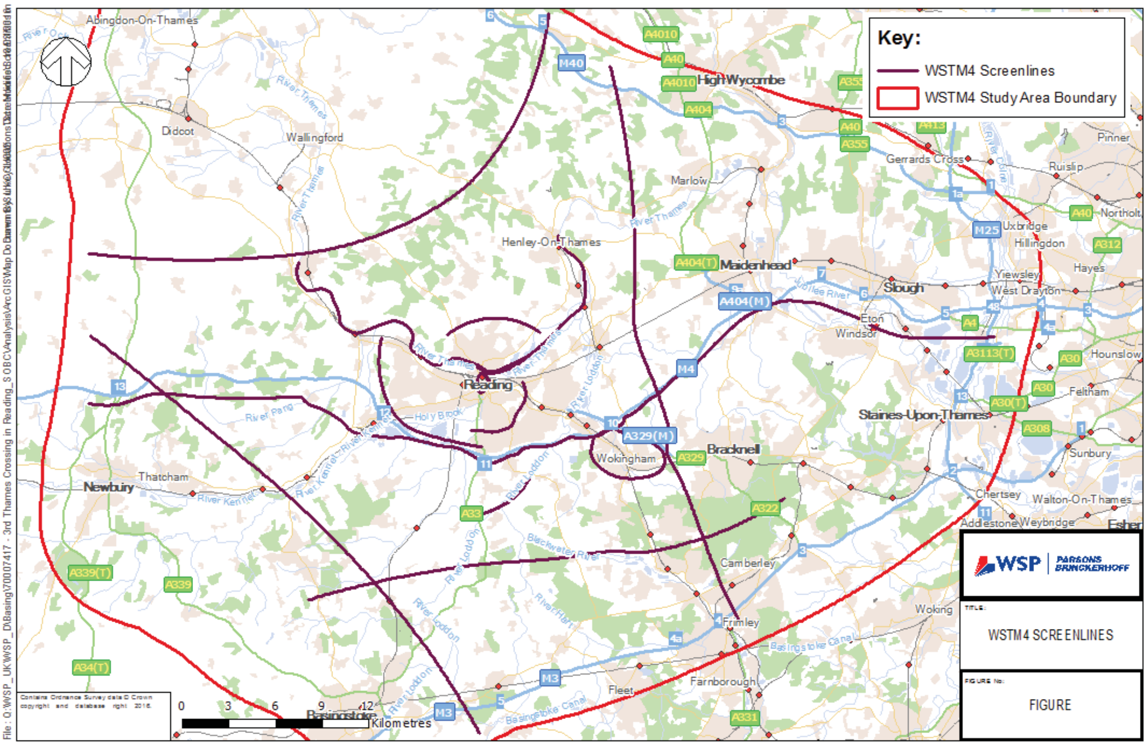
5.2.20. Information has been presented for both the prior and post matrix estimation matrices on the following:

- Screenlines and cordons of counts used in matrix estimation.

5.2.21. In accordance with the requirements presented in section 3.2 of TAG Unit M3.1 (January 2014), screenline totals are presented for each vehicle type. Total modelled flows across screenlines for each vehicle type should be within 5% of observed flows. TAG recommends that this should apply to "all, or nearly all" screenlines. We have applied a threshold of 85% of screenline totals to meet this criterion.

5.2.22. From the data that is available, the following screenlines were used for the WSTM4 which are illustrated in Figure 24.

**Figure 24 – Highway Model Screenlines**




## ASSIGNMENT CALIBRATION

5.2.23. Assignment calibration simply involves further steps to identify any issues that are preventing an acceptable level of calibration of the network, route choice and trip matrix, as outlined above. This included:

- Checking appropriateness of centroid connectors
- Production of forests to understand nature of competing routes between OD pairs
- Checking representation of queues on surveyed journey time routes.

5.2.24. A few additional changes were required to signal times, saturation flows, lane use, etc. to resolve the assignment calibration issues identified.

## ASSIGNMENT VALIDATION

5.2.25. In addition to the calibration/validation aspects described above, final validation of the model has been confirmed through presentation of modelled and observed data for the following:

- Traffic flows on links – In addition to the screenline information flows have been presented on individual links for cars, LGV and HGV
- Journey times – Information presented along whole routes, with means and 95% confidence intervals, supplemented with time/distance graphs
- Turning movements – Information presented for key junctions, aggregated across all vehicle types. Since these are obtained from single day MCC, they did not achieve the same standards as link flows derived from ATC.

# 5.3 SUMMARY OF CALIBRATION AND VALIDATION CRITERIA

5.3.1. TAG Unit M3.1 'Highway Assignment Modelling' (January 2014) highlights the tests that must be passed in the calibration and validation of link, turning count, screenlines and journey time data Acceptability criteria are given in Table 5.

**Table 5 – Acceptable Criteria**

| CRITERIA | DESCRIPTION OF CRITERIA | ACCEPTABILITY GUIDELINE |
|---|---|---|
| Links / Turns (1) | Individual flows within 100 veh/hr of counts for flows less than 700 veh/hr | > 85% of cases |
| | Individual flows within 15% of counts for flows from 700 veh/hr to 2,700 veh/hr | > 85% of cases |
| | Individual flows within 400 veh/hr of counts for flows more than 2,700 veh/hr | > 85% of cases |
| Links / Turns (2) | GEH < 5 for individual flows | > 85% of cases |
| Screenlines | Differences should be less than 5% of counts | All or nearly all screenlines |
| Journey Times | Modelled times along routes should be within 15% of surveyed times (or minute, if higher than 15%) | > 85% of routes |

5.3.2. In addition for individual flows, the criterion for passing the assessment is based upon a GEH comparison between modelled and observed flow. GEH is a modified Chi-squared statistic comparing relative differences between observed and modelled flows and a value of less than 5 is considered a close match. Using the GEH parameter ensures that the test is appropriate for both small and large flows within the matrix.

5.3.3. TAG Unit M3.1 (January 2014) states that the absolute and percentage differences between modelled flows and observed counts and the GEH measures are broadly consistent and links flows that meet either criterion should be regarded as satisfactory.

## 5.4 PRIOR MATRIX PERFORMANCE

5.4.1. Significant work and investigations were undertaken to ensure the prior matrix performance within the WSTM4 was as good as possible prior to using matrix estimation. The aim was to ensure calibration counts achieved around 50% of counts meeting flow or GEH criteria.

5.4.2. Table 6, Table 7 and Table 8 present the WSTM4 highway model matrix performance for the three time periods with Figure 25, Figure 26 and Figure 27 presenting the link performance graphically. All links meeting flow or GEH link based criteria are coloured green, those not meeting flow criteria but have a GEH between 5 and 10 are orange and those with GEH > 10 are red.

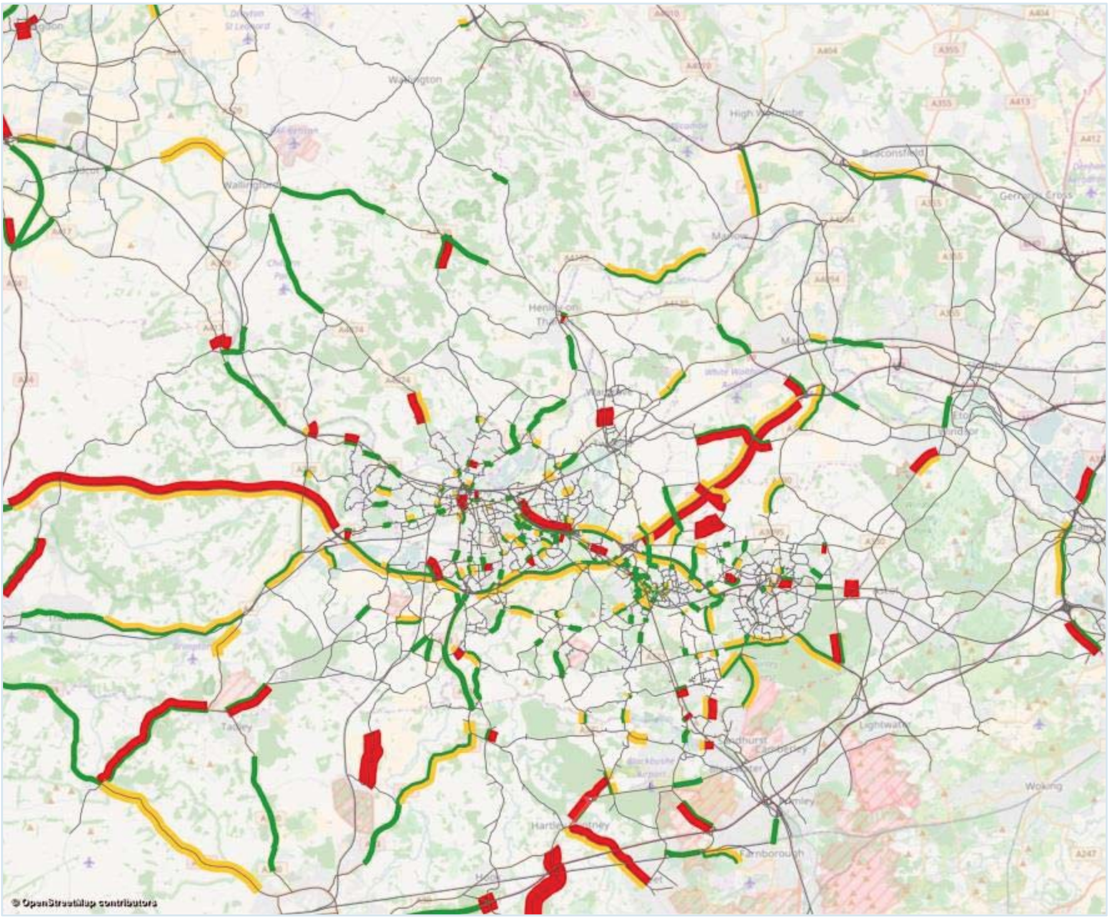
**Table 6 - WSTM4 AM peak Prior Matrix Performance Link Statistics**

| Criteria and Measure | | Acceptability Guideline | AM Peak | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ALL | | | | | | CAR | | | | | |
| | | | CALIBRATION | | | VALIDATION | | | CALIBRATION | | | VALIDATION | | |
| Flow Criteria | | | | | | | | | | | | | | |
| Observed | Modelled | | Total Counts | Meet Criteria | % | Total Counts | Meet Criteria | % | Total Counts | Meet Criteria | % | Total Counts | Meet Criteria | % |
| < 700 pph | ±100 vph | > 85 % of links | 289 | 146 | 51% | 117 | 95 | 81% | 325 | 174 | 54% | 123 | 93 | 76% |
| 700 - 2,700 vph | ±15% | > 85 % of links | 165 | 91 | 55% | 35 | 29 | 83% | 136 | 83 | 61% | 29 | 24 | 83% |
| > 2,700 vph | ±400 vph | > 85 % of links | 28 | 11 | 39% | 2 | 1 | 50% | 21 | 17 | 81% | 2 | 2 | 100% |
| GEH Criteria | | | | | | | | | | | | | | |
| GEH Statistic for individual links < 5 | | > 85 % of links | 482 | 230 | 48% | 154 | 110 | 71% | 482 | 256 | 53% | 154 | 114 | 74% |
| Flow or GEH Criteria | | | | | | | | | | | | | | |
| Above Flow Criteria or GEH Criteria are met | | > 85 % of links | 482 | 260 | 54% | 154 | 131 | 85% | 482 | 284 | 59% | 154 | 125 | 81% |

| GEH Range | ALL | | | | | | CAR | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CALIBRATION | | VALIDATION | | COMBINED | | CALIBRATION | | VALIDATION | | COMBINED | |
| GEH < 2 | 100 | 21% | 45 | 29% | 145 | 23% | 119 | 25% | 49 | 32% | 168 | 26% |
| GEH < 4 | 196 | 41% | 92 | 60% | 288 | 45% | 212 | 44% | 89 | 58% | 301 | 47% |
| GEH < 6 | 269 | 56% | 126 | 82% | 395 | 62% | 289 | 60% | 125 | 81% | 414 | 65% |
| GEH < 8 | 338 | 70% | 140 | 91% | 478 | 75% | 349 | 72% | 136 | 88% | 485 | 76% |
| GEH < 10 | 388 | 80% | 144 | 94% | 532 | 84% | 388 | 80% | 149 | 97% | 537 | 84% |
| GEH <5 | 230 | 48% | 110 | 71% | 340 | 53% | 256 | 53% | 114 | 74% | 370 | 58% |

| Screenlines | Flow < 5% | | | | | | | | GEH < 4 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ALL | | Car | | LGV | | HGV | | ALL | | Car | | LGV | | HGV | |
| 26 | 6 | 23% | 7 | 27% | 0 | 0% | 0 | 0% | 6 | 23% | 8 | 31% | 0 | 0% | 0 | 0% |

**Figure 25 – WSTM4 AM peak Prior Matrix Performance**




## Table 7 - WSTM4 Inter peak Prior Matrix Performance Link Statistics

| Criteria and Measure | | Acceptability Guideline | Inter peak ALL CALIBRATION Total Counts | ALL CALIBRATION Meet Criteria | ALL CALIBRATION % | ALL VALIDATION Total Counts | ALL VALIDATION Meet Criteria | ALL VALIDATION % | CAR CALIBRATION Total Counts | CAR CALIBRATION Meet Criteria | CAR CALIBRATION % | CAR VALIDATION Total Counts | CAR VALIDATION Meet Criteria | CAR VALIDATION % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Flow Criteria** | | | | | | | | | | | | | | |
| **Observed** | **Modelled** | | | | | | | | | | | | | |
| < 700 pph | ±100 vph | > 85 % of links | 377 | 213 | 56% | 132 | 98 | 74% | 398 | 253 | 64% | 144 | 114 | 79% |
| 700 - 2,700 vph | ±15% | > 85 % of links | 89 | 48 | 54% | 20 | 12 | 60% | 75 | 42 | 56% | 8 | 5 | 63% |
| > 2,700 vph | ±400 vph | > 85 % of links | 16 | 10 | 63% | 2 | 1 | 50% | 9 | 5 | 56% | 2 | 2 | 100% |
| **GEH Criteria** | | | | | | | | | | | | | | |
| GEH Statistic for individual links < 5 | | > 85 % of links | 482 | 238 | 49% | 154 | 86 | 56% | 482 | 250 | 52% | 154 | 89 | 58% |
| **Flow or GEH Criteria** | | | | | | | | | | | | | | |
| Above Flow Criteria or GEH Criteria are met | | > 85 % of links | 482 | 281 | 58% | 154 | 114 | 74% | 482 | 307 | 64% | 154 | 124 | 81% |

| GEH Range | ALL CALIBRATION | | ALL VALIDATION | | ALL COMBINED | | CAR CALIBRATION | | CAR VALIDATION | | CAR COMBINED | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GEH < 2 | 96 | 20% | 38 | 25% | 134 | 21% | 92 | 19% | 37 | 24% | 129 | 20% |
| GEH < 4 | 191 | 40% | 69 | 45% | 260 | 41% | 201 | 42% | 77 | 50% | 278 | 44% |
| GEH < 6 | 273 | 57% | 95 | 62% | 368 | 58% | 285 | 59% | 103 | 67% | 388 | 61% |
| GEH < 8 | 338 | 70% | 119 | 77% | 457 | 72% | 352 | 73% | 126 | 82% | 478 | 75% |
| GEH < 10 | 383 | 79% | 134 | 87% | 517 | 81% | 399 | 83% | 144 | 94% | 543 | 85% |
| GEH <5 | 238 | 49% | 86 | 56% | 324 | 51% | 250 | 52% | 89 | 58% | 339 | 53% |

| Screenlines | Flow < 5% ALL | | Flow < 5% Car | | Flow < 5% LGV | | Flow < 5% HGV | | GEH < 4 ALL | | GEH < 4 Car | | GEH < 4 LGV | | GEH < 4 HGV | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 | 4 | 15% | 11 | 42% | 4 | 15% | 1 | 4% | 7 | 27% | 14 | 54% | 16 | 62% | 7 | 27% |

**Figure 26 - WSTM4 Inter peak Prior Matrix Performance**

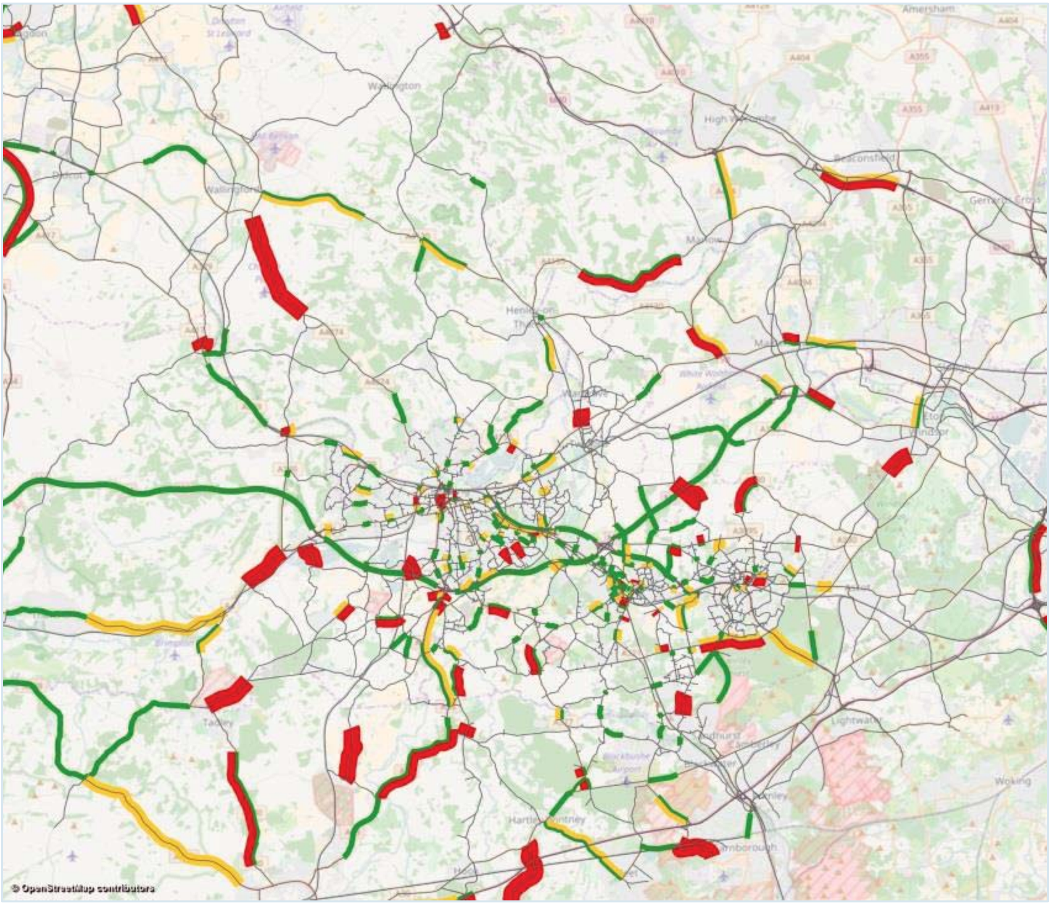


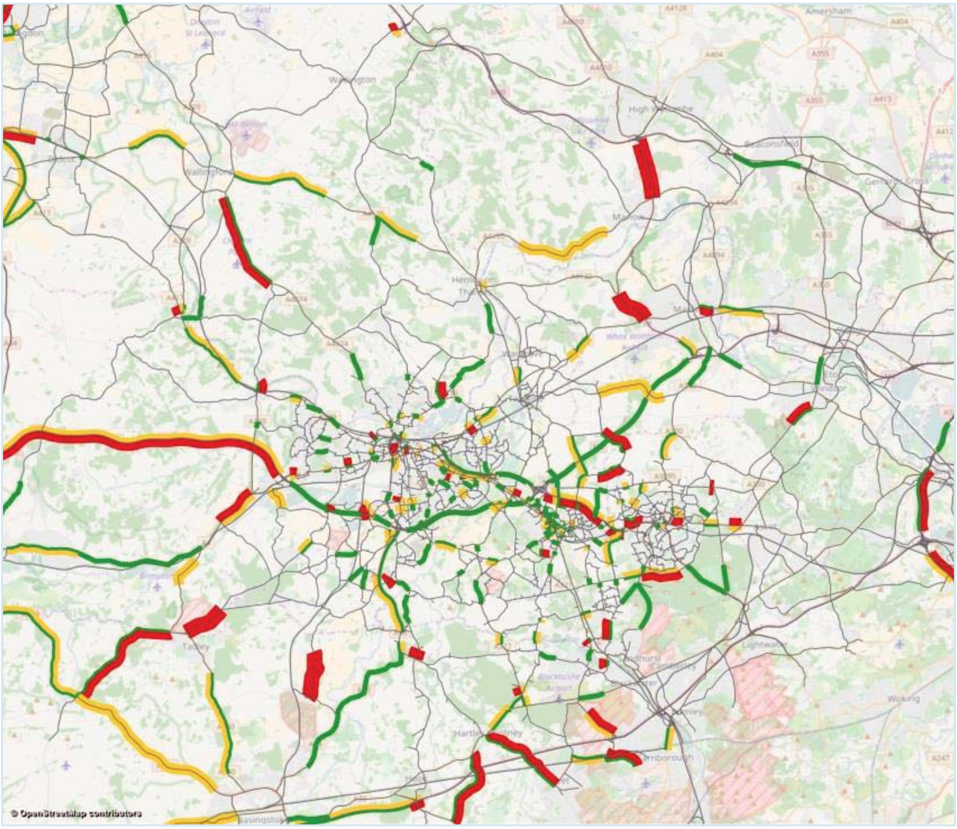
**Table 8 - WSTM4 PM peak Prior Matrix Performance Link Statistics**

| Criteria and Measure | | Acceptability Guideline | PM Peak – ALL – CALIBRATION Total Counts | Meet Criteria | % | ALL – VALIDATION Total Counts | Meet Criteria | % | CAR – CALIBRATION Total Counts | Meet Criteria | % | CAR – VALIDATION Total Counts | Meet Criteria | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Flow Criteria** | | | | | | | | | | | | | | |
| Observed | Modelled | | | | | | | | | | | | | |
| < 700 pph | ±100 vph | > 85 % of links | 285 | 153 | 54% | 115 | 91 | 79% | 303 | 183 | 60% | 117 | 91 | 78% |
| 700 - 2,700 vph | ±15% | > 85 % of links | 172 | 84 | 49% | 37 | 25 | 68% | 157 | 80 | 51% | 35 | 26 | 74% |
| > 2,700 vph | ±400 vph | > 85 % of links | 25 | 16 | 64% | 2 | 0 | 0% | 22 | 13 | 59% | 2 | 2 | 100% |
| **GEH Criteria** | | | | | | | | | | | | | | |
| GEH Statistic for individual links < 5 | | > 85 % of links | 482 | 238 | 49% | 154 | 93 | 60% | 482 | 259 | 54% | 154 | 103 | 67% |
| **Flow or GEH Criteria** | | | | | | | | | | | | | | |
| Above Flow Criteria or GEH Criteria are met | | > 85 % of links | 482 | 270 | 56% | 154 | 117 | 76% | 482 | 290 | 60% | 154 | 124 | 81% |

| GEH Range | ALL – CALIBRATION | | ALL – VALIDATION | | ALL – COMBINED | | CAR – CALIBRATION | | CAR – VALIDATION | | CAR – COMBINED | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GEH < 2 | 98 | 20% | 50 | 32% | 148 | 23% | 106 | 22% | 58 | 38% | 164 | 26% |
| GEH < 4 | 201 | 42% | 82 | 53% | 283 | 44% | 224 | 46% | 88 | 57% | 312 | 49% |
| GEH < 6 | 276 | 57% | 109 | 71% | 385 | 61% | 288 | 60% | 117 | 76% | 405 | 64% |
| GEH < 8 | 345 | 72% | 127 | 82% | 472 | 74% | 357 | 74% | 129 | 84% | 486 | 76% |
| GEH < 10 | 395 | 82% | 141 | 92% | 536 | 84% | 398 | 83% | 145 | 94% | 543 | 85% |
| GEH <5 | 238 | 49% | 93 | 60% | 331 | 52% | 259 | 54% | 103 | 67% | 362 | 57% |

| Screenlines | Flow < 5% – ALL | | Car | | LGV | | HGV | | GEH < 4 – ALL | | Car | | LGV | | HGV | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 | 12 | 46% | 12 | 46% | 6 | 23% | 1 | 4% | 14 | 54% | 10 | 38% | 15 | 58% | 16 | 62% |

**Figure 27 - WSTM4 PM peak Prior Matrix Performance**



## 5.5 FINAL MODEL PERFORMANCE

5.5.1. This section of the report presents the WSTM4 highway assignment model final performance and is split into the following sub-sections:

- Count calibration
- Count validation
- Screenlines and cordons
- Journey times
- Junction validation
- Route validation
- Impact of matrix estimation.

### COUNT CALIBRATION

**5.5.2.** Table 9 and Figure 28 show the final calibration performance of the WSTM4 AM peak. Table 9 shows that TAG criteria are met for car and total flow. Figure 28 graphically presents the performance. All counts meeting flow or GEH criteria are coloured in green, those not meeting the flow criteria but have a GEH between 5 and 10 are orange and those with a GEH > 10 are red. Appendix B-1 contains the tables of individual link performance in the AM peak, Inter peak and PM peak.

**Table 9 - WSTM4 AM peak Calibration Final Performance Link Statistics**

| Criteria and Measure | | Acceptability Guideline | AM Peak | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | ALL | | | Car | | |
| Flow Criteria | | | Total Counts | Meet Criteria | % | Total Counts | Meet Criteria | % |
| Observed | Modelled | | | | | | | |
| < 700 pph | ±100 vph | > 85 % of links | 289 | 249 | 86% | 325 | 283 | 87% |
| 700 - 2,700 vph | ±15% | > 85 % of links | 165 | 141 | 85% | 136 | 117 | 86% |
| > 2,700 vph | ±400 vph | > 85 % of links | 28 | 27 | 96% | 21 | 21 | 100% |
| GEH Criteria | | | | | | | | |
| GEH Statistic for individual links < 5 | | > 85 % of links | 482 | 411 | 85% | 482 | 414 | 86% |
| Flow or GEH Criteria | | | | | | | | |
| Above Flow Criteria or GEH Criteria are met | | > 85 % of links | 482 | 428 | 89% | 482 | 431 | 89% |

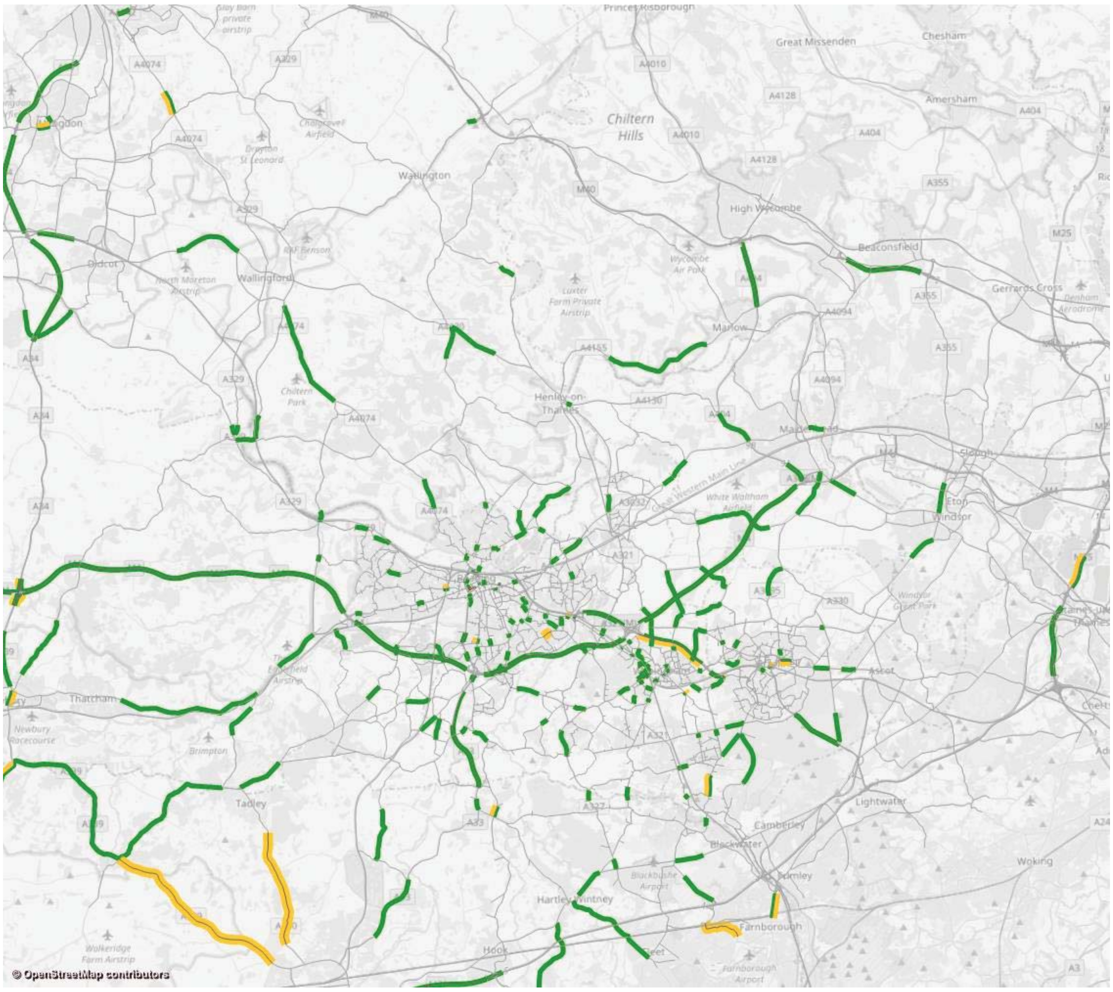
**Figure 28 - WSTM4 AM peak Calibration Final Performance**


5.5.3. Table 10 and Figure 29 show the final calibration performance of the WSTM4 Inter peak. Table 10 shows that TAG criteria are met for car and total vehicles. Figure 29 graphically presents the performance. All counts meeting flow or GEH criteria are coloured in green, those not meeting the flow criteria but have a GEH between 5 and 10 are orange and those with a GEH > =10 are red.

**Table 10 - WSTM4 Inter peak Calibration Final Performance Link Statistics**

| Criteria and Measure | | Acceptability Guideline | Interpeak ALL | | | Interpeak Car | | |
|---|---|---|---|---|---|---|---|---|
| **Flow Criteria** | | | **Total Counts** | **Meet Criteria** | **%** | **Total Counts** | **Meet Criteria** | **%** |
| **Observed** | **Modelled** | | | | | | | |
| < 700 pph | ±100 vph | > 85 % of links | 377 | 339 | 90% | 398 | 374 | 94% |
| 700 - 2,700 vph | ±15% | > 85 % of links | 89 | 80 | 90% | 75 | 65 | 87% |
| > 2,700 vph | ±400 vph | > 85 % of links | 16 | 15 | 94% | 9 | 9 | 100% |
| **GEH Criteria** | | | | | | | | |
| GEH Statistic for individual links < 5 | | > 85 % of links | 482 | 411 | 85% | 482 | 437 | 91% |
| **Flow or GEH Criteria** | | | | | | | | |
| Above Flow Criteria or GEH Criteria are met | | > 85 % of links | 482 | 439 | 91% | 482 | 456 | 95% |

**Figure 29 - WSTM4 Inter peak Calibration Final Performance**




5.5.4. The calibration final performance for the PM peak is shown below. Table 11 shows that TAG criteria are met for car and for the total vehicles. Figure 30 graphically presents the performance.

**Table 11 - WSTM4 PM peak Calibration Final Performance Link Statistics**

| Criteria and Measure | | Acceptability Guideline | PM Peak | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | CALIBRATION | | | CALIBRATION | | |
| Flow Criteria | | | Total Counts | Meet Criteria | % | Total Counts | Meet Criteria | % |
| Observed | Modelled | | | | | | | |
| < 700 pph | ±100 vph | > 85 % of links | 285 | 247 | 87% | 304 | 266 | 88% |
| 700 - 2,700 vph | ±15% | > 85 % of links | 172 | 148 | 86% | 156 | 133 | 85% |
| > 2,700 vph | ±400 vph | > 85 % of links | 25 | 24 | 96% | 22 | 21 | 95% |
| GEH Criteria | | | | | | | | |
| GEH Statistic for individual links < 5 | | > 85 % of links | 482 | 411 | 85% | 482 | 410 | 85% |
| Flow or GEH Criteria | | | | | | | | |
| Above Flow Criteria or GEH Criteria are met | | > 85 % of links | 482 | 431 | 89% | 482 | 431 | 89% |

**Figure 30 - WSTM4 PM peak Calibration Final Performance**


## COUNT VALIDATION

5.5.5. Table 12 provides a summary of the final validation performance of the WSTM4 AM Peak highway assignment and shows that TAG criteria is met for the car and total vehicles.

5.5.6. The performance is graphically presented in Figure 31. All counts meeting either flow or GEH criteria are coloured in green, those not meeting the flow criteria but have a GEH between 5 and 10 are orange and those with a GEH >= 10 are red. Appendix B-2 contains the tables of individual link performance during the AM peak, Inter peak and PM peak.

**Table 12 - WSTM4 AM peak Validation Final Performance Link Statistics**

| Criteria and Measure | | Acceptability Guideline | AM Peak | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | ALL | | | Car | | |
| Flow Criteria | | | Total Counts | Meet Criteria | % | Total Counts | Meet Criteria | % |
| Observed | Modelled | | | | | | | |
| < 700 pph | ±100 vph | > 85 % of links | 117 | 100 | 85% | 123 | 106 | 86% |
| 700 - 2,700 vph | ±15% | > 85 % of links | 35 | 30 | 86% | 29 | 26 | 90% |
| > 2,700 vph | ±400 vph | > 85 % of links | 2 | 2 | 100% | 2 | 2 | 100% |
| GEH Criteria | | | | | | | | |
| GEH Statistic for individual links < 5 | | > 85 % of links | 154 | 125 | 81% | 154 | 122 | 79% |
| Flow or GEH Criteria | | | | | | | | |
| Above Flow Criteria or GEH Criteria are met | | > 85 % of links | 154 | 138 | 90% | 154 | 137 | 89% |

**Figure 31 - WSTM4 AM peak Validation Final Performance**


5.5.7. Table 13 and Figure 32 show the final validation performance of the WSTM4 Inter Peak highway assignment. Table 13 shows that TAG criteria are met for the car and total vehicles. Figure 32 graphically presents the performance. All counts meeting either flow or GEH criteria are coloured in green, those not meeting flow criteria but which have a GEH between 5 and 10 are orange and those with a GEH >= 10 are red.

**Table 13 - WSTM4 Inter peak Validation Final Performance Link Statistics**

| Criteria and Measure | | Acceptability Guideline | Interpeak | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | ALL | | | Car | | |
| Flow Criteria | | | Total Counts | Meet Criteria | % | Total Counts | Meet Criteria | % |
| Observed | Modelled | | | | | | | |
| < 700 pph | ±100 vph | > 85 % of links | 132 | 115 | 87% | 144 | 128 | 89% |
| 700 - 2,700 vph | ±15% | > 85 % of links | 20 | 18 | 90% | 8 | 8 | 100% |
| > 2,700 vph | ±400 vph | > 85 % of links | 2 | 2 | 100% | 2 | 2 | 100% |
| GEH Criteria | | | | | | | | |
| GEH Statistic for individual links < 5 | | > 85 % of links | 154 | 105 | 68% | 154 | 105 | 68% |
| Flow or GEH Criteria | | | | | | | | |
| Above Flow Criteria or GEH Criteria are met | | > 85 % of links | 154 | 137 | 89% | 154 | 139 | 90% |

**Figure 32 - WSTM4 Inter peak Validation Final Performance**


5.5.8. Table 14 and Figure 33 show the final validation performance of the WSTM4 PM Peak highway assignment. Table 14 shows that TAG criteria are met for the car and total vehicles. Figure 33 graphically presents the performance. All counts meeting either flow or GEH criteria are coloured in green, those not meeting flow criteria but have a GEH between 5 and 10 are orange and those with a GEH >= 10 are red.

**Table 14 - WSTM4 PM peak Validation Final Performance Link Statistics**

| Criteria and Measure | | Acceptability Guideline | PM Peak | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | ALL | | | Car | | |
| Flow Criteria | | | Total Counts | Meet Criteria | % | Total Counts | Meet Criteria | % |
| Observed | Modelled | | | | | | | |
| < 700 pph | ±100 vph | > 85 % of links | 115 | 99 | 86% | 117 | 103 | 88% |
| 700 - 2,700 vph | ±15% | > 85 % of links | 37 | 33 | 89% | 35 | 31 | 89% |
| > 2,700 vph | ±400 vph | > 85 % of links | 2 | 2 | 100% | 2 | 2 | 100% |
| GEH Criteria | | | | | | | | |
| GEH Statistic for individual links < 5 | | > 85 % of links | 154 | 113 | 73% | 154 | 116 | 75% |
| Flow or GEH Criteria | | | | | | | | |
| Above Flow Criteria or GEH Criteria are met | | > 85 % of links | 154 | 135 | 88% | 154 | 137 | 89% |

Figure 33 - WSTM4 PM Peak Validation Final Performance


## SCREENLINE AND CORDON PERFORMANCE

5.5.9. The WSTM4 has 26 screenlines and cordons. Table 15 to Table 17 show the screenline and cordon statistics for all the individual classes in the WSTM4 for AM peak, Inter peak and PM peak.

Table 15 - WSTM4 AM Peak Screenline and Cordon Performance Summary

| | Flow < 5% | | | | | | | | GEH < 4 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Screenlines | ALL | | Car | | LGV | | HGV | | ALL | | Car | | LGV | | HGV | |
| 26 | 23 | 88% | 23 | 88% | 15 | 58% | 3 | 12% | 23 | 88% | 24 | 92% | 23 | 88% | 22 | 85% |

Table 16 - WSTM4 Inter Peak Screenline and Cordon Performance Summary

| | Flow < 5% | | | | | | | | GEH < 4 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Screenlines | ALL | | Car | | LGV | | HGV | | ALL | | Car | | LGV | | HGV | |
| 26 | 24 | 92% | 23 | 88% | 13 | 50% | 6 | 23% | 24 | 92% | 26 | 100% | 25 | 96% | 22 | 85% |

**Table 17 – WSTM4 PM Peak Screenline and Cordon Performance Summary**

| Screenlines | Flow < 5% | | | | | | | | GEH < 4 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ALL | | Car | | LGV | | HGV | | ALL | | Car | | LGV | | HGV | |
| 26 | 24 | 92% | 22 | 85% | 13 | 50% | 8 | 31% | 23 | 88% | 24 | 92% | 24 | 92% | 24 | 92% |

5.5.10. The tables show that the screenlines and cordons for car, LGV, HGV and total vehicles meet the GEH criteria. Car and total vehicles also meet the flow criteria. Due to the fact that LGV and HGV observations along the screenlines and cordons in the study area are limited, the flow criteria were not achievable, however analysis of LGV and HGV flows shows that more than 85% of screenlines meet the GEH criteria.

5.5.11. Detailed performance of each calibration screenline/ cordon for each time period by vehicle class can be found in Appendix B-3. The same Appendix provides the detailed screenline and cordon performance tables, outlining the performance of individual counts.

## JOURNEY TIMES

5.5.12. There are 40 one way journey time routes which are assessed within the model. Figure 22 and Figure 23 presented the routes within the WSTM4.

5.5.13. Table 18 summarises the journey time performance for all the routes across the WSTM4. The modelled journey times were compared against the median of observed journey times as this reduces the impact of extreme outliers. The details of the journey time performance for each time period can be found in Table 19 to Table 21. Appendix B-4 contains the individual journey time graphs.

**Table 18 - WSTM4 Journey Time Performance**

| Journey Time Routes | Routes Passed | | | | | |
|---|---|---|---|---|---|---|
| | AM Peak | | Inter Peak | | PM Peak | |
| 40 | 38 | 95% | 35 | 88% | 35 | 88% |

5.5.14. Table 18 shows that all journey time routes meet the TAG criteria with 38 routes out of a total of 40 routes in the AM peak and 35 routes out of a total of 40 routes in the Inter peak and PM peak fall within 15% or 1 minute of the observed journey times.

Table 19 - AM Peak Journey Time Performance

| | | |
|---|---|---|
| Routes | 40 | |
| Passed | 38 | 95% |

| ID | Name | AM Peak Observed (s) | Modelled (s) | Diff | % | Pass? |
|---|---|---|---|---|---|---|
| 1 | JT 1 EB | 1882 | 1799 | -82 | -4% | Yes |
| 2 | JT 1 WB | 1944 | 1765 | -179 | -9% | Yes |
| 3 | JT 2 EB | 1594 | 1776 | 182 | 11% | Yes |
| 4 | JT 2 WB | 1787 | 1793 | 6 | 0% | Yes |
| 5 | JT 3 EB | 634 | 639 | 5 | 1% | Yes |
| 6 | JT 3 WB | 721 | 685 | -35 | -5% | Yes |
| 7 | JT 4 EB | 2094 | 1870 | -224 | -11% | Yes |
| 8 | JT 4 WB | 2204 | 2082 | -122 | -6% | Yes |
| 9 | JT 5 EB | 1726 | 1504 | -222 | -13% | Yes |
| 10 | JT 5 WB | 1539 | 1459 | -80 | -5% | Yes |
| 11 | JT 6 NB | 2174 | 2348 | 175 | 8% | Yes |
| 12 | JT 6 SB | 2469 | 2646 | 177 | 7% | Yes |
| 13 | JT 7 EB | 1818 | 1633 | -184 | -10% | Yes |
| 14 | JT 7 WB | 1600 | 1607 | 7 | 0% | Yes |
| 15 | JT 8 NB | 3692 | 3665 | -27 | -1% | Yes |
| 16 | JT 8 SB | 4300 | 3697 | -603 | -14% | Yes |
| 17 | JT 9 NB | 1187 | 1150 | -37 | -3% | Yes |
| 18 | JT 9 SB | 1299 | 1138 | -161 | -12% | Yes |
| 19 | JT 10 EB | 3265 | 3010 | -255 | -8% | Yes |
| 20 | JT 10 WB | 2944 | 3248 | 304 | 10% | Yes |
| 21 | JT 11 NB | 1901 | 1624 | -277 | -15% | Yes |
| 22 | JT 11 SN | 1863 | 1625 | -238 | -13% | Yes |
| 23 | JT 12 EB | 1570 | 1495 | -75 | -5% | Yes |
| 24 | JT 12 WB | 1359 | 1404 | 46 | 3% | Yes |
| 25 | JT 13 EB | 2338 | 2125 | -214 | -9% | Yes |
| 26 | JT 13 WB | 2890 | 2102 | -788 | -27% | No |
| 27 | JT 14 NB | 1102 | 1388 | 286 | 26% | No |
| 28 | JT 14 SB | 1274 | 1134 | -140 | -11% | Yes |
| 29 | JT 15 EB | 2454 | 2230 | -224 | -9% | Yes |
| 30 | JT 15 WB | 2510 | 2185 | -326 | -13% | Yes |
| 31 | JT 16 NB | 1591 | 1510 | -81 | -5% | Yes |
| 32 | JT 16 SB | 1742 | 1741 | -1 | 0% | Yes |
| 33 | JT 17 NB | 2070 | 1774 | -296 | -14% | Yes |
| 34 | JT 17 SB | 1830 | 1791 | -39 | -2% | Yes |
| 35 | JT 18 EB | 2405 | 2223 | -182 | -8% | Yes |
| 36 | JT 18 WB | 2440 | 2242 | -198 | -8% | Yes |
| 37 | JT 19 EB | 1848 | 1943 | 94 | 5% | Yes |
| 38 | JT 19 WB | 1776 | 1833 | 57 | 3% | Yes |
| 39 | JT 20 EB | 772 | 676 | -95 | -12% | Yes |
| 40 | JT 20 WB | 550 | 503 | -47 | -9% | Yes |

### Table 20 - Inter Peak Journey Time Performance

| | | |
|---|---|---|
| Routes | 40 | |
| Passed | 35 | 88% |

| ID | Name | Observed (s) | Modelled (s) | Diff | % | Pass? |
|---|---|---|---|---|---|---|
| | | Interpeak | | | | |
| 1 | JT 1 EB | 1719 | 1590 | -130 | -8% | Yes |
| 2 | JT 1 WB | 1701 | 1636 | -65 | -4% | Yes |
| 3 | JT 2 EB | 1370 | 1494 | 124 | 9% | Yes |
| 4 | JT 2 WB | 1295 | 1480 | 184 | 14% | Yes |
| 5 | JT 3 EB | 610 | 589 | -21 | -3% | Yes |
| 6 | JT 3 WB | 633 | 599 | -34 | -5% | Yes |
| 7 | JT 4 EB | 1868 | 1643 | -225 | -12% | Yes |
| 8 | JT 4 WB | 1536 | 1716 | 180 | 12% | Yes |
| 9 | JT 5 EB | 1347 | 1303 | -44 | -3% | Yes |
| 10 | JT 5 WB | 1307 | 1346 | 39 | 3% | Yes |
| 11 | JT 6 NB | 1761 | 2019 | 258 | 15% | Yes |
| 12 | JT 6 SB | 1814 | 2069 | 255 | 14% | Yes |
| 13 | JT 7 EB | 1478 | 1558 | 79 | 5% | Yes |
| 14 | JT 7 WB | 1600 | 1504 | -96 | -6% | Yes |
| 15 | JT 8 NB | 3077 | 3282 | 205 | 7% | Yes |
| 16 | JT 8 SB | 3175 | 3219 | 43 | 1% | Yes |
| 17 | JT 9 NB | 1013 | 967 | -46 | -5% | Yes |
| 18 | JT 9 SB | 991 | 991 | 0 | 0% | Yes |
| 19 | JT 10 EB | 2207 | 2428 | 221 | 10% | Yes |
| 20 | JT 10 WB | 2169 | 2571 | 402 | 19% | No |
| 21 | JT 11 NB | 1686 | 1598 | -88 | -5% | Yes |
| 22 | JT 11 SN | 1681 | 1604 | -77 | -5% | Yes |
| 23 | JT 12 EB | 1284 | 1434 | 150 | 12% | Yes |
| 24 | JT 12 WB | 1335 | 1398 | 63 | 5% | Yes |
| 25 | JT 13 EB | 2079 | 2075 | -4 | 0% | Yes |
| 26 | JT 13 WB | 2144 | 2105 | -39 | -2% | Yes |
| 27 | JT 14 NB | 817 | 957 | 140 | 17% | No |
| 28 | JT 14 SB | 823 | 937 | 114 | 14% | Yes |
| 29 | JT 15 EB | 2091 | 2077 | -14 | -1% | Yes |
| 30 | JT 15 WB | 2279 | 2138 | -140 | -6% | Yes |
| 31 | JT 16 NB | 1274 | 1353 | 79 | 6% | Yes |
| 32 | JT 16 SB | 1423 | 1721 | 298 | 21% | No |
| 33 | JT 17 NB | 1495 | 1572 | 77 | 5% | Yes |
| 34 | JT 17 SB | 1564 | 1589 | 24 | 2% | Yes |
| 35 | JT 18 EB | 2144 | 1722 | -422 | -20% | No |
| 36 | JT 18 WB | 2171 | 1738 | -432 | -20% | No |
| 37 | JT 19 EB | 1577 | 1657 | 80 | 5% | Yes |
| 38 | JT 19 WB | 1483 | 1643 | 161 | 11% | Yes |
| 39 | JT 20 EB | 422 | 406 | -16 | -4% | Yes |
| 40 | JT 20 WB | 411 | 417 | 6 | 1% | Yes |

Table 21 - PM Peak Journey Time Performance

| | | |
|---|---|---|
| Routes | 40 | |
| Passed | 35 | 88% |

| | | PM Peak | | | | |
|---|---|---|---|---|---|---|
| ID | Name | Observed (s) | Modelled (s) | Diff | % | Pass? |
| 1 | JT 1 EB | 1871 | 1647 | -225 | -12% | Yes |
| 2 | JT 1 WB | 1866 | 1656 | -210 | -11% | Yes |
| 3 | JT 2 EB | 1473 | 1798 | 325 | 22% | No |
| 4 | JT 2 WB | 1710 | 1916 | 206 | 12% | Yes |
| 5 | JT 3 EB | 654 | 641 | -13 | -2% | Yes |
| 6 | JT 3 WB | 698 | 621 | -77 | -11% | Yes |
| 7 | JT 4 EB | 2086 | 1989 | -97 | -5% | Yes |
| 8 | JT 4 WB | 2290 | 2239 | -51 | -2% | Yes |
| 9 | JT 5 EB | 1485 | 1412 | -73 | -5% | Yes |
| 10 | JT 5 WB | 1400 | 1517 | 117 | 8% | Yes |
| 11 | JT 6 NB | 2576 | 2703 | 127 | 5% | Yes |
| 12 | JT 6 SB | 2452 | 2559 | 107 | 4% | Yes |
| 13 | JT 7 EB | 1576 | 1700 | 124 | 8% | Yes |
| 14 | JT 7 WB | 1794 | 1647 | -147 | -8% | Yes |
| 15 | JT 8 NB | 4308 | 3831 | -477 | -11% | Yes |
| 16 | JT 8 SB | 3907 | 3917 | 10 | 0% | Yes |
| 17 | JT 9 NB | 1065 | 1037 | -29 | -3% | Yes |
| 18 | JT 9 SB | 1035 | 1115 | 79 | 8% | Yes |
| 19 | JT 10 EB | 3014 | 3186 | 172 | 6% | Yes |
| 20 | JT 10 WB | 2848 | 3217 | 368 | 13% | Yes |
| 21 | JT 11 NB | 1667 | 1620 | -47 | -3% | Yes |
| 22 | JT 11 SN | 1746 | 1646 | -100 | -6% | Yes |
| 23 | JT 12 EB | 1288 | 1441 | 153 | 12% | Yes |
| 24 | JT 12 WB | 1426 | 1527 | 101 | 7% | Yes |
| 25 | JT 13 EB | 2483 | 2100 | -383 | -15% | No |
| 26 | JT 13 WB | 2484 | 2112 | -372 | -15% | Yes |
| 27 | JT 14 NB | 1258 | 1196 | -62 | -5% | Yes |
| 28 | JT 14 SB | 1259 | 1142 | -117 | -9% | Yes |
| 29 | JT 15 EB | 2335 | 2228 | -107 | -5% | Yes |
| 30 | JT 15 WB | 2372 | 2307 | -64 | -3% | Yes |
| 31 | JT 16 NB | 1702 | 1721 | 19 | 1% | Yes |
| 32 | JT 16 SB | 1509 | 1756 | 247 | 16% | No |
| 33 | JT 17 NB | 1826 | 1750 | -76 | -4% | Yes |
| 34 | JT 17 SB | 1771 | 1783 | 13 | 1% | Yes |
| 35 | JT 18 EB | 2483 | 1838 | -645 | -26% | No |
| 36 | JT 18 WB | 2639 | 2259 | -380 | -14% | Yes |
| 37 | JT 19 EB | 1940 | 1969 | 29 | 2% | Yes |
| 38 | JT 19 WB | 1869 | 1843 | -26 | -1% | Yes |
| 39 | JT 20 EB | 585 | 543 | -42 | -7% | Yes |
| 40 | JT 20 WB | 708 | 562 | -146 | -21% | No |

5.5.15. The comparison of the modelled and observed journey times shows that average observed travel times and delays have been reflected well in the AM peak, Inter peak and PM peak hour models.

## JUNCTION VALIDATION

5.5.16. Model's performance has been assessed at 74 junctions in the AM peak and PM peak hours and at 68 junctions in the Inter Peak. The sites are graphically represented in Figure 34. Most of the surveyed junctions currently operate at capacity and are likely to be impacted by the additional traffic generated in the future. The observed and modelled turning movement validation statistics for these sites are summarised in Table 22 and the detailed statistics of each of the junctions is presented in Appendix B-5.

**Figure 34 - WSTM4 Location of junctions**

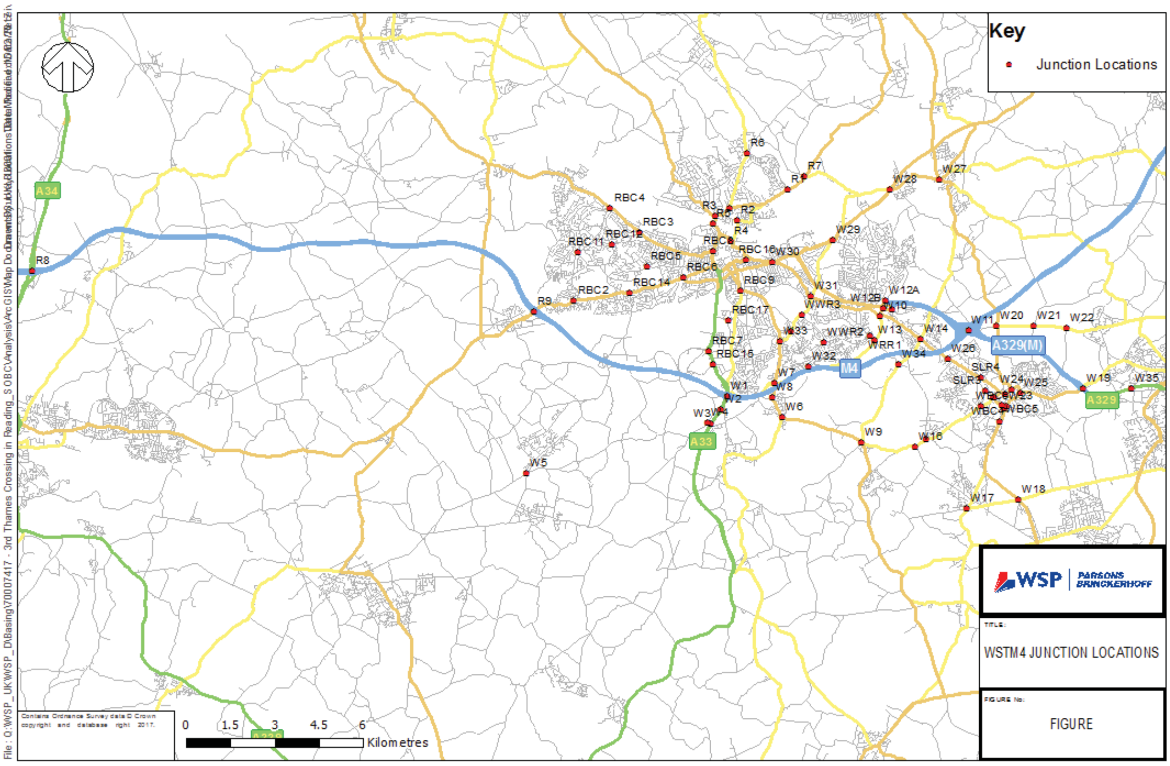



**Table 22 – Junction validation summary statistics**

| | AM Peak | | Inter Peak | | PM Peak | |
|---|---|---|---|---|---|---|
| Total number of junctions | 74 | | 68 | | 74 | |
| At least 75% of all turns at these junctions demonstrate a good correlation between observed and modelled flows with GEH being less than 7.5 | 67 | 91% | 63 | 93% | 66 | 89% |

5.5.17. The GEH value for turning movements has been relaxed slightly to 7.5 with 91%, 93% and 89% of all junctions in the AM peak, Inter peak and PM peak having at least 75% of turning movements, which demonstrate a good correlation between observed and modelled flows. This is a very good result considering the size and strategic nature of the model.

## ROUTE VALIDATION

5.5.18. The calibration of a model crucially relies on traffic entering the detailed modelling area at the correct points and on the correct routes. The 'Shortest Route Path' function in VISUM plots all the routes used within the network for trips between two zones. By using this function for many zone pairs throughout the study area, routes used by traffic were examined to ensure they are reasonable and resemble probable routes used by vehicles in the base traffic situation.

5.5.19. The routes used in each situation are the lowest cost routes available between the two zones obtained from an unassigned scenario (i.e. no delays in the network created by the presence of traffic).

5.5.20. To check that the assigned routes in the model were feasible and in accordance with common sense, 'paths' were built between the following origin-destination pairs.

- OD 1: Wokingham Town Centre to North Caversham

- OD 2: Spencers Wood to Wokingham
- OD 3: Eversley to Whitley
- OD 4: Crowthorne to Twyford
- OD 5: Bracknell to Earley
- OD 6: Jennets Park to Thames Valley Business Park
- OD 7: Binfield to Oxford
- OD 8: Lower Earley to Basingstoke
- OD 9: Henley to Reading.

5.5.21. During the route validation exercise a number of changes were made to the network attributes where the routes were not found reasonable. The resultant AM peak hour shortest path routes from the models compared to “Google Maps” are included in Appendix B-6. All final paths appear to be reasonable and representative of actual drivers likely route choices.

### MODEL CONVERGENCE

5.5.22. Each user class is assigned over a number of iterations until a level of stability or ‘convergence’ is achieved. The TAG-recommended convergence criteria, which is a pre-set set within VISUM, is set out in Table 23.

**Table 23 – TAG Convergence Criteria**

| Measure of convergence | Acceptable value |
|---|---|
| Delta' or % GAP | Less than 0.1% or at least stable with convergence fully documented and all other criteria met |
| Percentage of links (non-ICA) or turns (ICA) with flow change < set threshold ('P') | Four consecutive iterations greater than 98% |

5.5.23. The results of the assignment are shown in Table 24 for each modelled time period. These demonstrate that the vehicle classes converge ‘naturally’, i.e. according to the settings.

**Table 24 – WSTM4 Convergence Results**

| | AM Peak | | | Interpeak | | | PM Peak | | |
|---|---|---|---|---|---|---|---|---|---|
| Mode | Iteration | Delta | %Flow | Iteration | Delta | %Flow | Iteration | Delta | %Flow |
| ICA | 15 | 0.00127897 | 0.99726349 | 7 | 0.00087660 | 0.99139953 | 11 | 0.00111635 | 0.98944488 |
| | 16 | 0.00110387 | 0.99452697 | 8 | 0.00064003 | 0.98553557 | 12 | 0.00113775 | 0.99374511 |
| | 17 | 0.00172152 | 0.99583008 | 9 | 0.00100076 | 0.98762054 | 13 | 0.00102923 | 0.99452697 |
| | 18 | 0.00115362 | 0.99622101 | 10 | 0.00093372 | 0.99569977 | 14 | 0.00100117 | 0.99530884 |
| | 19 | 0.00116382 | 0.99583008 | 11 | 0.00077971 | 0.99934845 | 15 | 0.00108985 | 0.99504821 |
| | 20 | 0.00116011 | 0.99713318 | 12 | 0.00078519 | 1.00000000 | 16 | 0.00108263 | 0.99817566 |
| Measure of convergence | | | | | | | | | |
| Delta (GAP) | Pass | | | Pass | | | Pass | | |
| Percentage of links (non-ICA) or turns (ICA) with flow change < set threshold | Pass | | | Pass | | | Pass | | |

## 5.6 IMPACT OF MATRIX ESTIMATION

### REGRESSION STATISTICS AT TRIP END LEVEL

5.6.1. Table 25 to Table 27 present the AM peak, Inter peak and PM peak pre and post matrix estimation statistics. TAG guidance suggests that the following criteria is met between the pre and post matrix estimation matrix zonal trip ends:

- Gradient is within 0.99 and 1.01
- Intercept is near zero
- R2 is in excess of 0.98.

**5.6.2.** The statistics indicates that the matrix estimation procedure has not fundamentally changed the prior matrix.

Table 25 – AM peak Pre and Post Matrix Estimation Statistics

| Purpose | Gradient | Intercept | $R^2$ |
|---|---|---|---|
| Car - Commuting | 0.96 | -0.0042 | 0.96 |
| Car - Employers' Business | 0.94 | 0.0003 | 0.94 |
| Car - Other | 0.96 | 0.0004 | 0.96 |

Table 26 – Inter peak Pre and Post Matrix Estimation Statistics

| Purpose | Gradient | Intercept | $R^2$ |
|---|---|---|---|
| Car - Commuting | 0.96 | -0.0001 | 0.99 |
| Car - Employers' Business | 0.99 | -0.0001 | 0.98 |
| Car - Other | 0.94 | 0.0052 | 0.97 |

Table 27 – PM peak Pre and Post Matrix Estimation Statistics

| Purpose | Gradient | Intercept | $R^2$ |
|---|---|---|---|
| Car - Commuting | 0.96 | 0.0047 | 0.96 |
| Car - Employers' Business | 1.04 | -0.0018 | 0.99 |
| Car - Other | 1.01 | -0.0042 | 0.96 |

## TRIP LENGTH DISTRIBUTION

5.6.3. The trip length distribution for the prior and final matrices for each demand segment with each time period has been calculated. The trip distribution graphs are shown in Figure 35 to Figure 49.

5.6.4. All the graphs show that there are only very small changes in trip length distribution between the prior and final matrices.

**Figure 35 - AM Peak Trip Length Distribution Car Commuting**

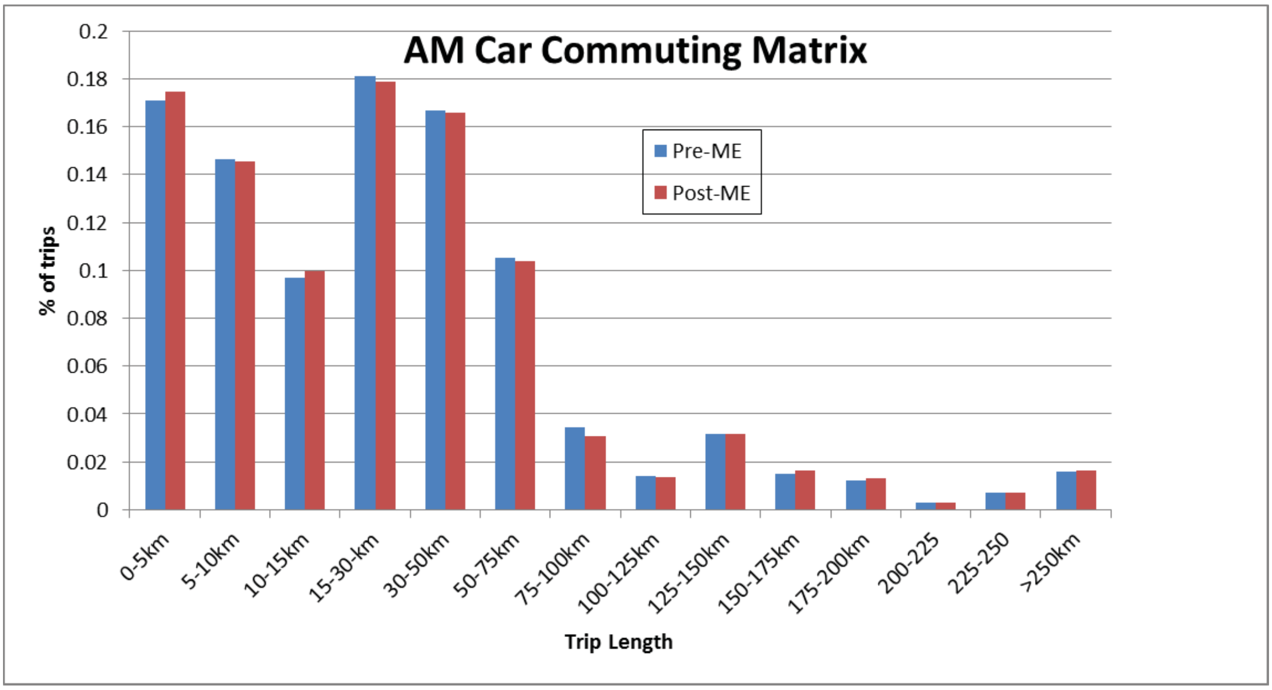


Figure 36 - AM Peak Trip Length Distribution Car Business

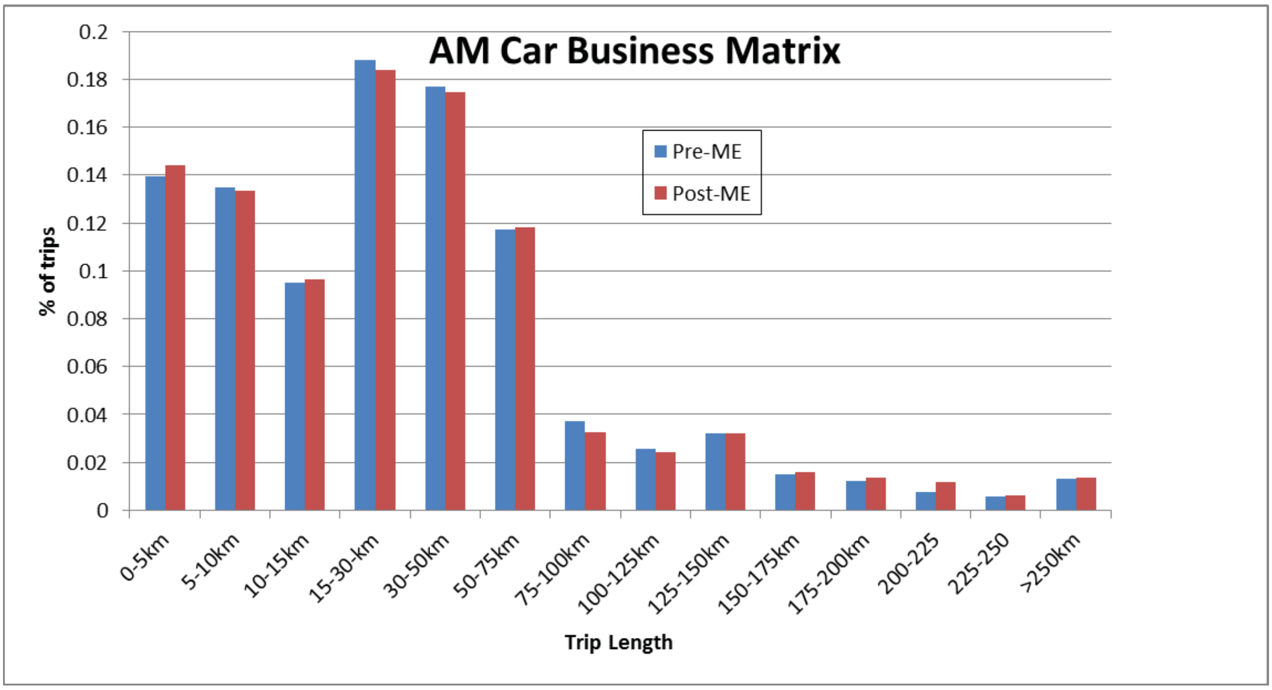



Figure 37 - AM Peak Trip Length Distribution Car Other

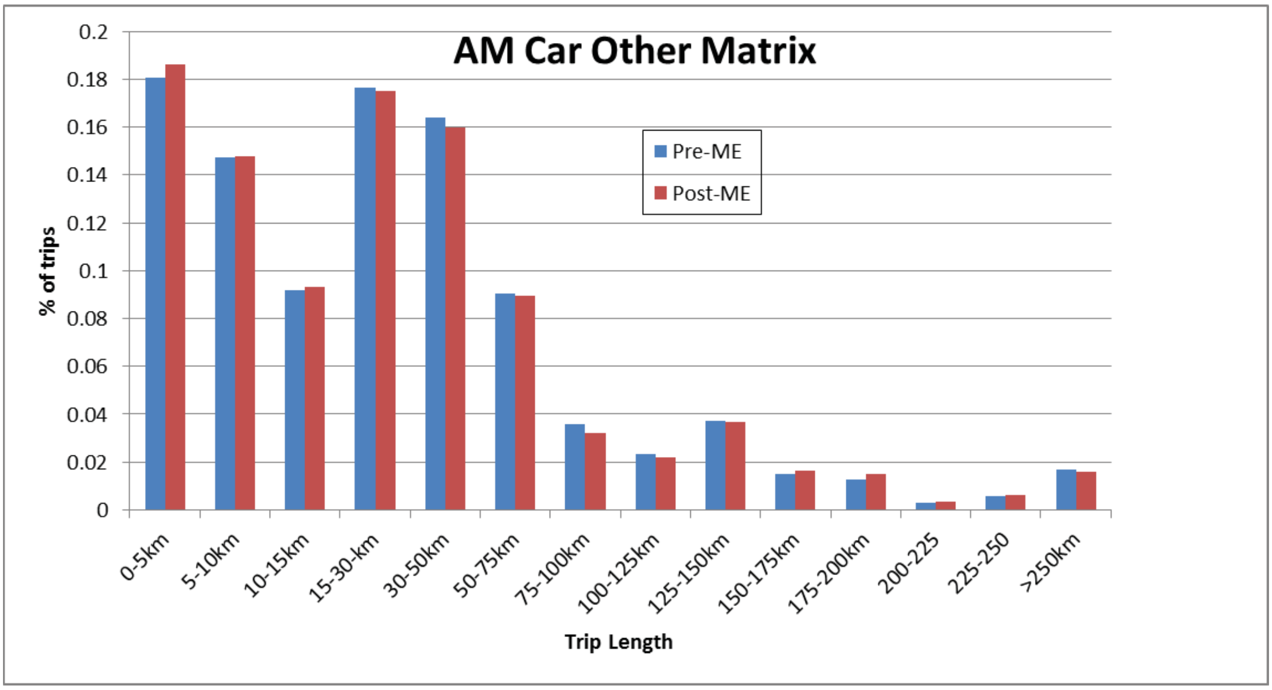


**Figure 38 - AM Peak Trip Length Distribution LGV**

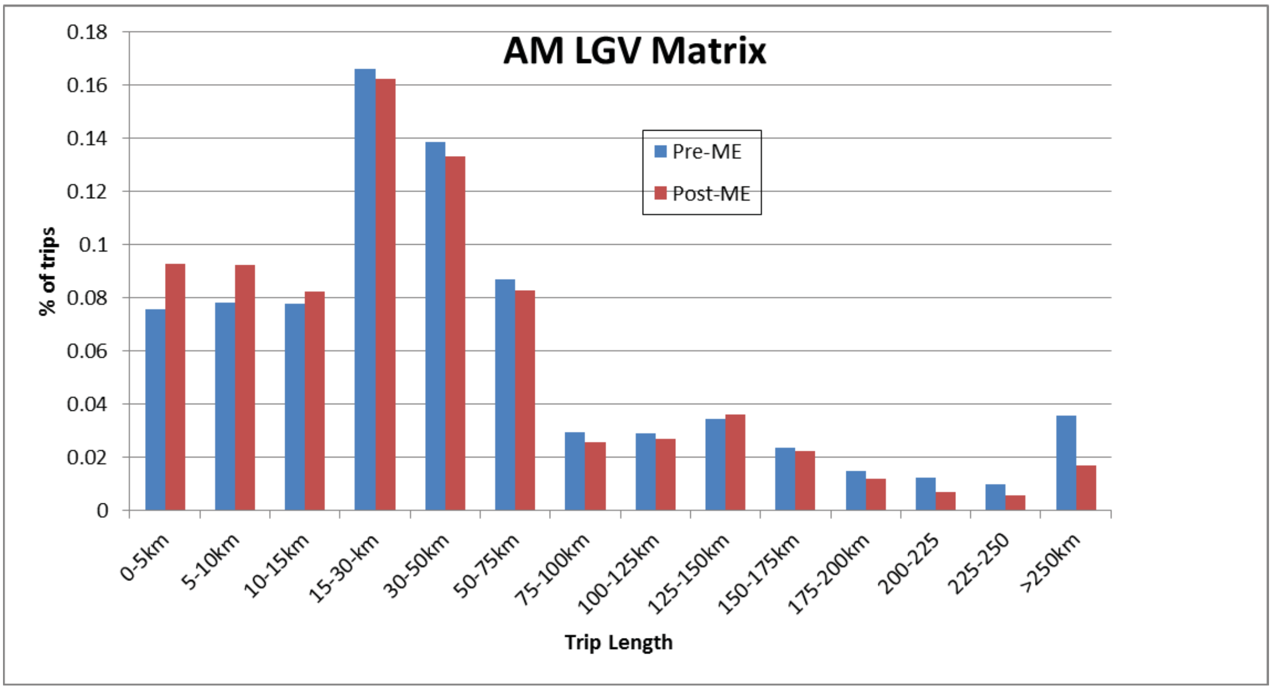



**Figure 39 - AM Peak Trip Length Distribution HGV**

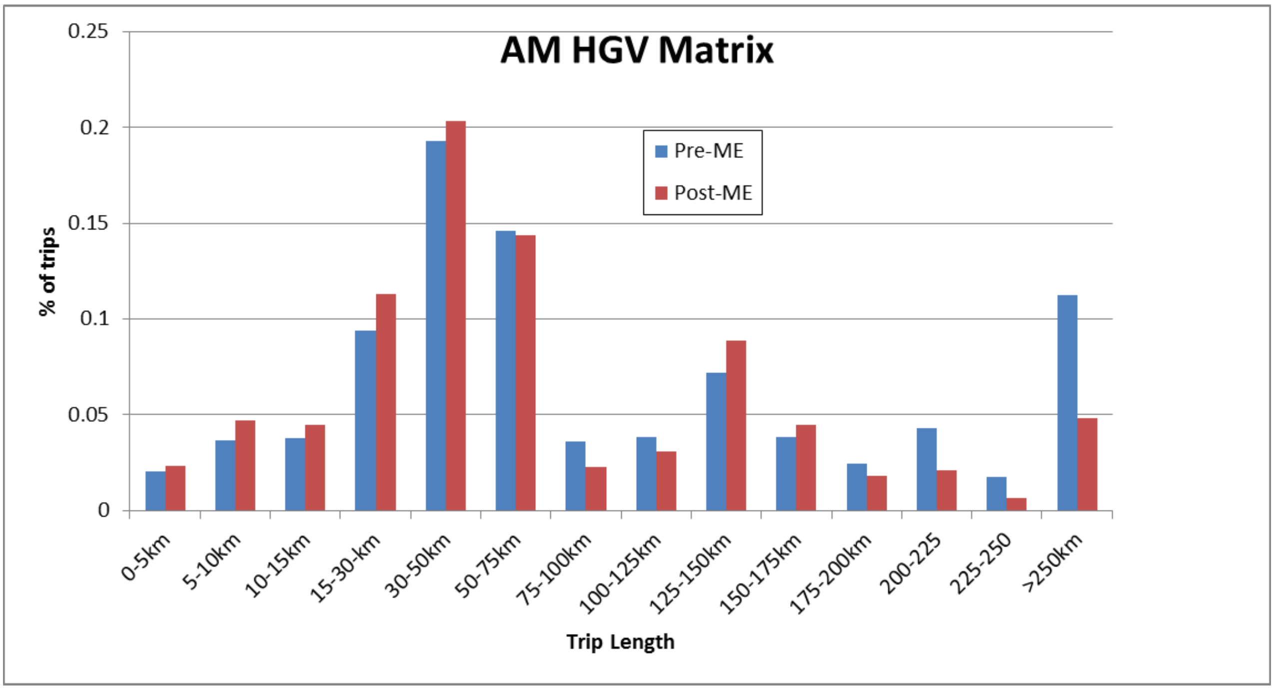


**Figure 40 - Inter Peak Trip Length Distribution Car Commuting**

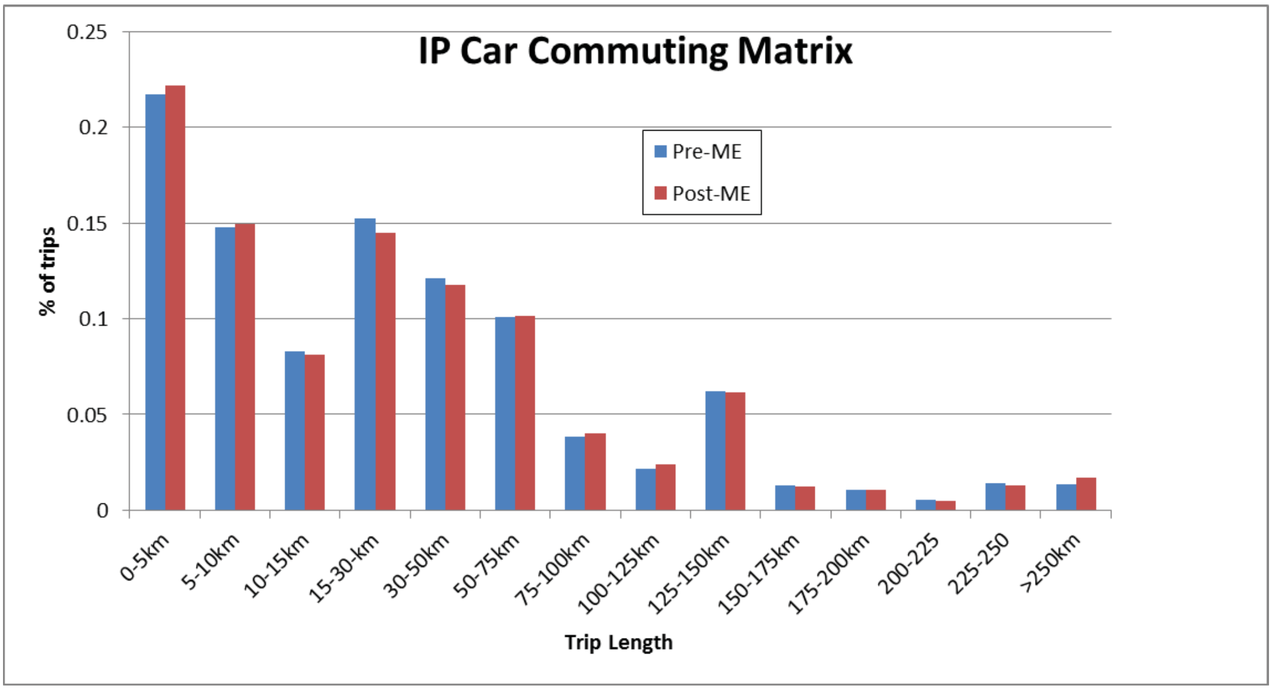



**Figure 41 - Inter Peak Trip Length Distribution Car Business**

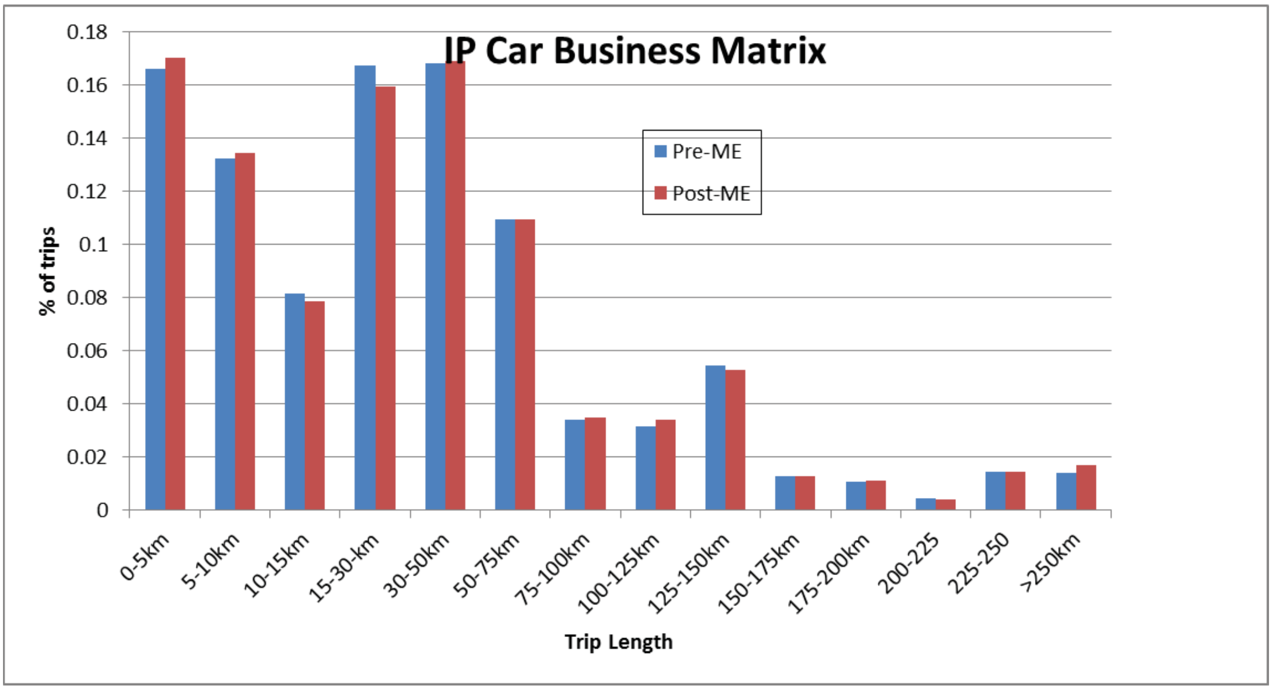


Figure 42 - Inter Peak Trip Length Distribution Car Other

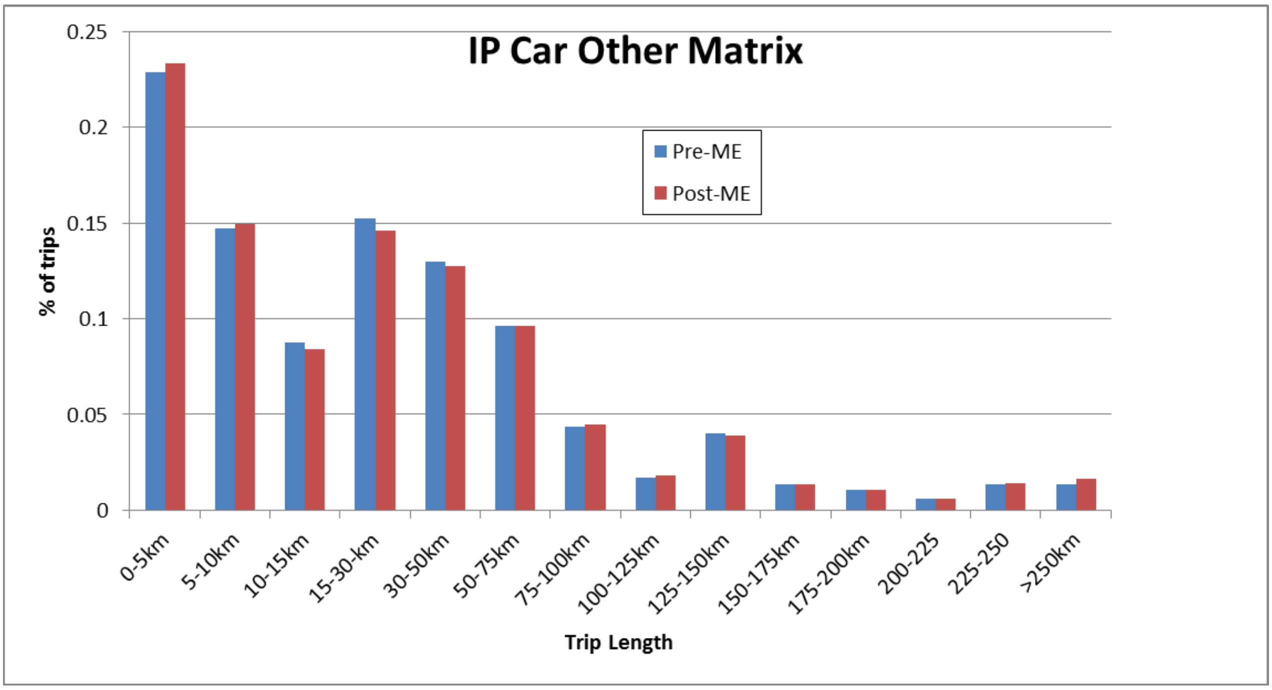



Figure 43 - Inter Peak Trip Length Distribution LGV

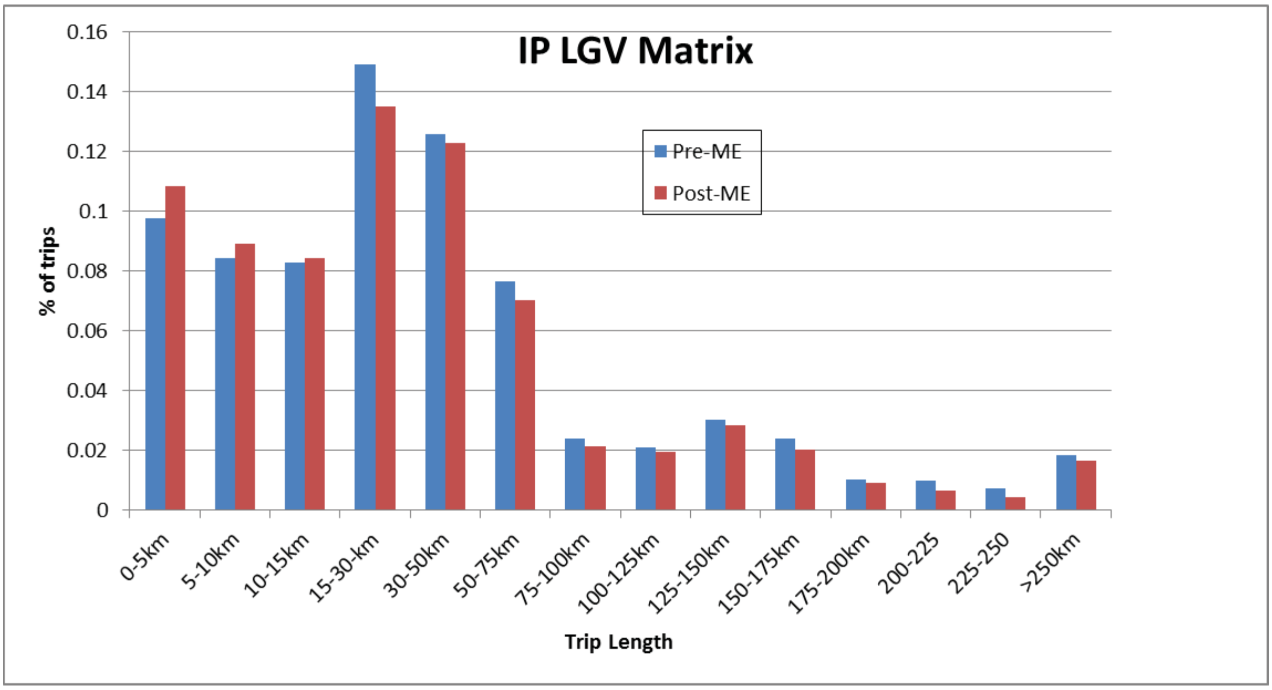


**Figure 44 - Inter Peak Trip Length Distribution HGV**

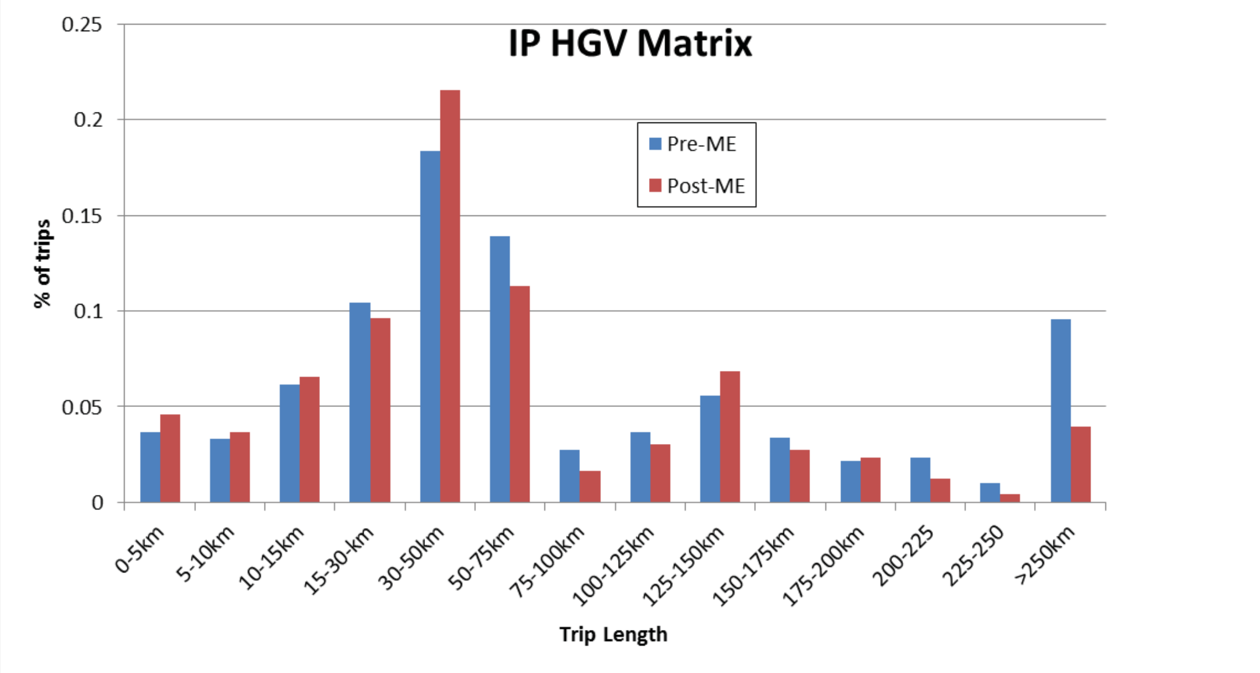



**Figure 45 - PM Peak Trip Length Distribution Car Commuting**

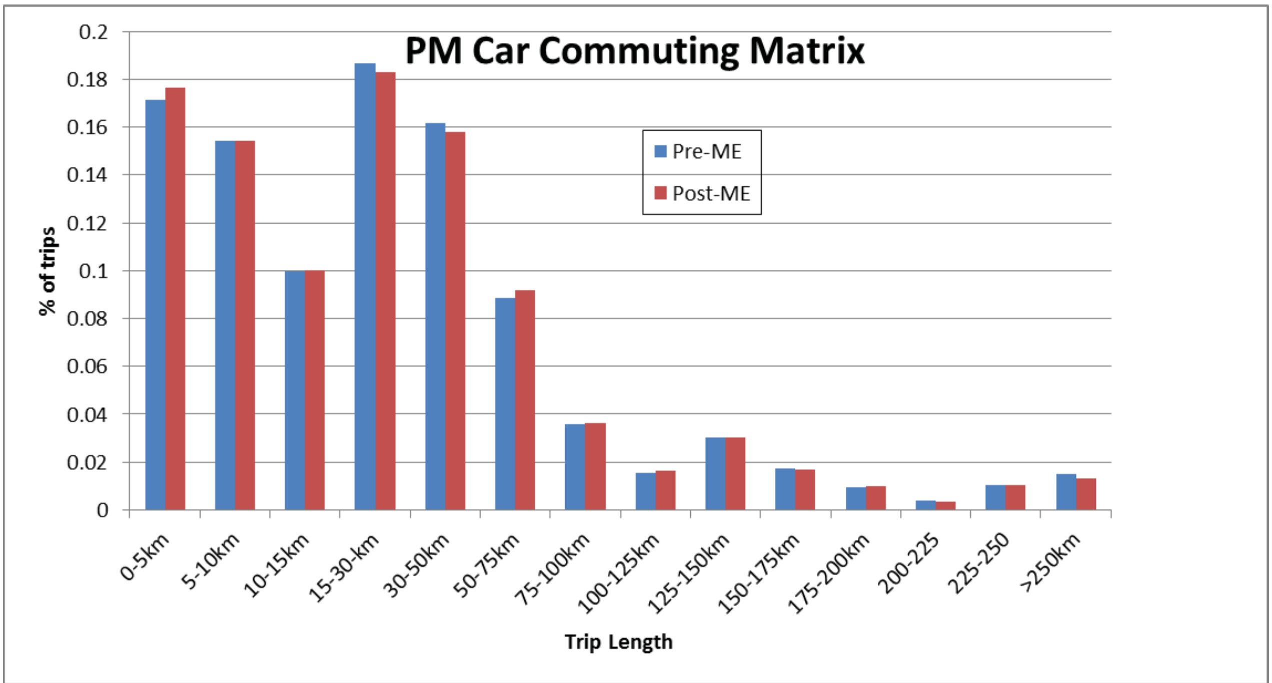


**Figure 46 - PM Peak Trip Length Distribution Car Business**

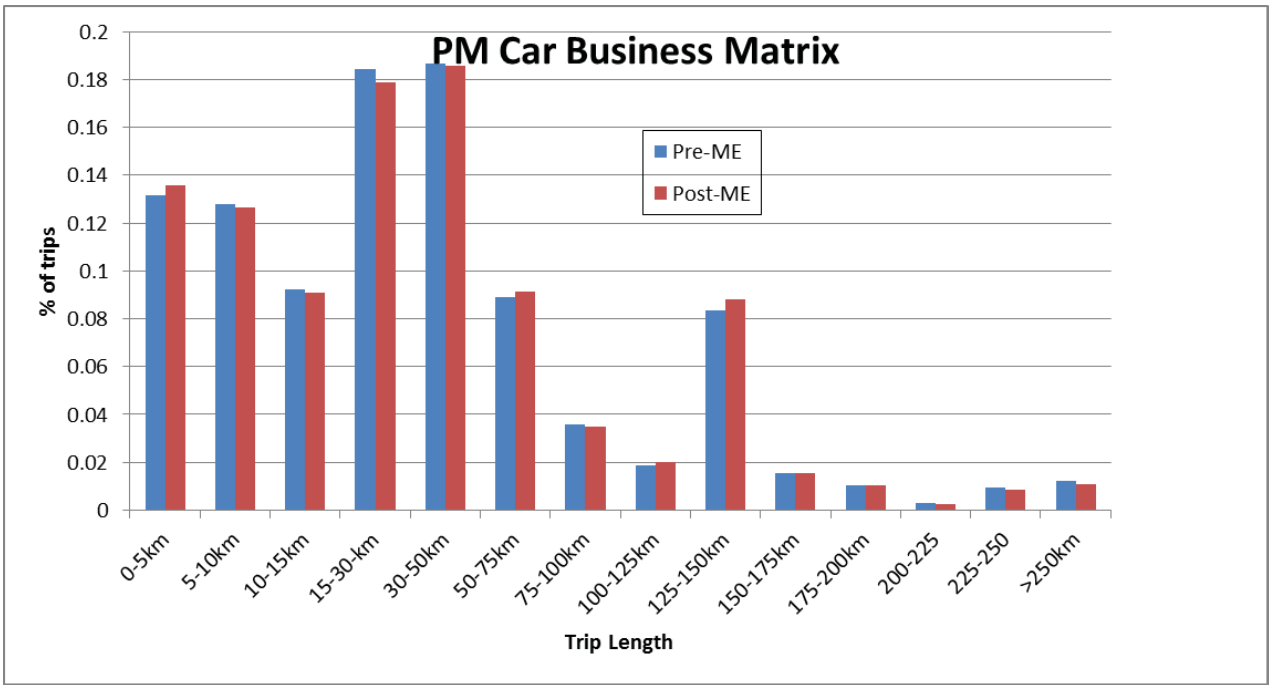



**Figure 47 - PM Peak Trip Length Distribution Car Other**

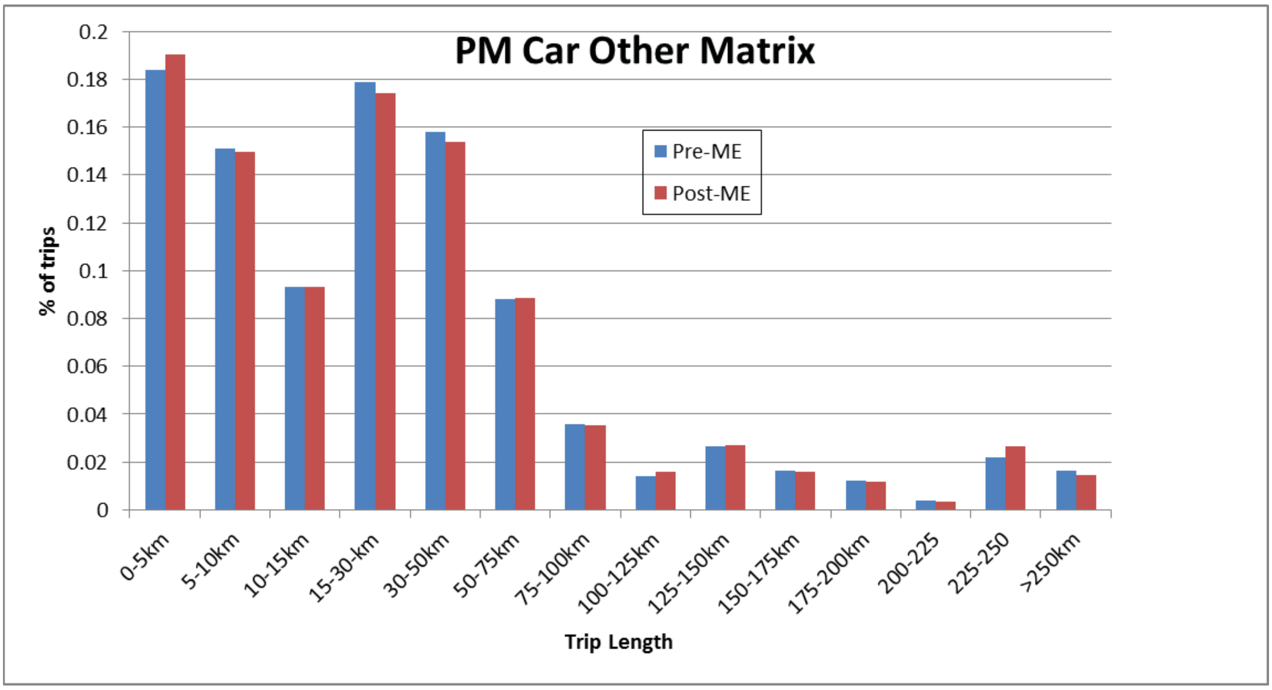


**Figure 48 - PM Peak Trip Length Distribution LGV**

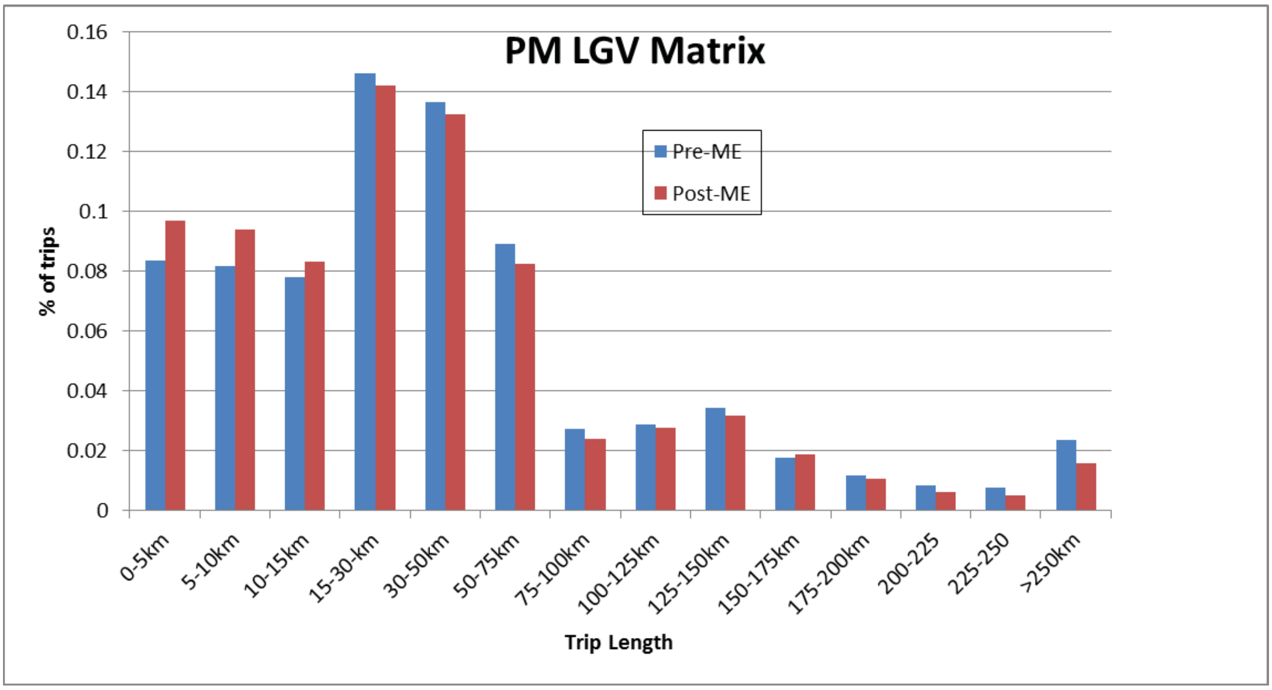
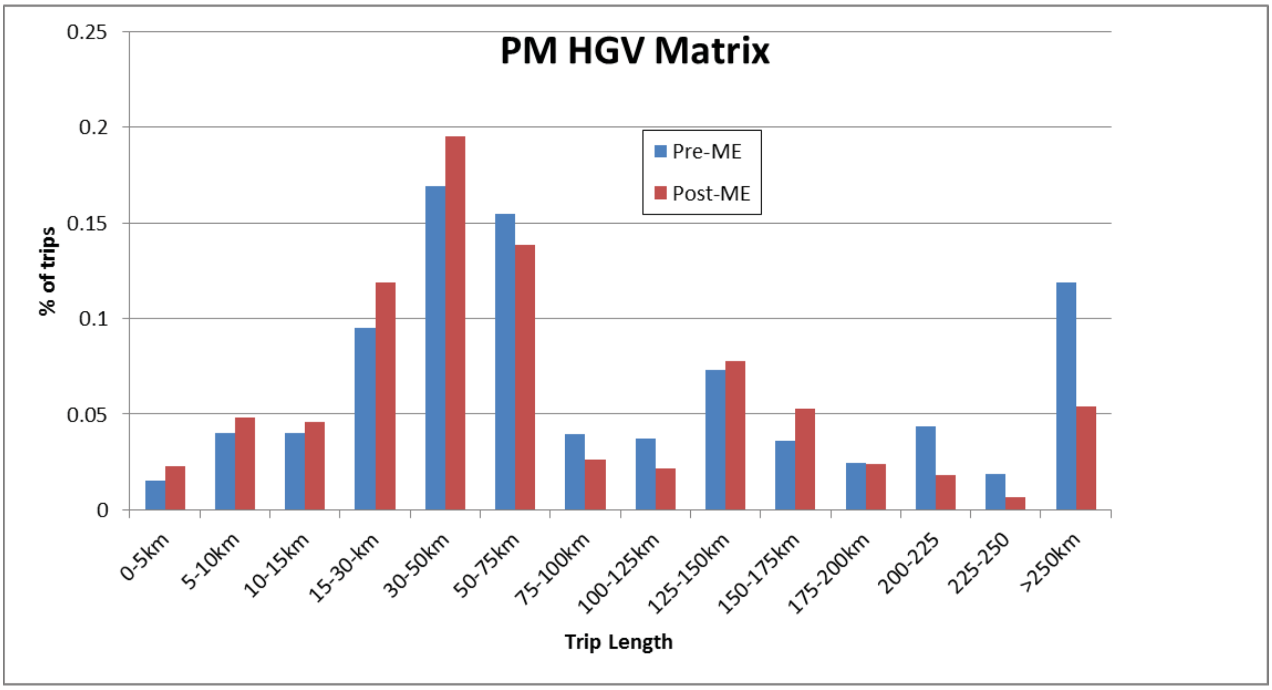



**Figure 49 - PM Peak Trip Length Distribution HGV**




5.6.5. Table 28 to Table 30 present the mean and standard deviation values of the trip matrices pre and post matrix estimation. The mean and standard deviations values are very similar pre and post matrix estimation. TAG criteria expect differences to be less than 5. The AM, inter PM peak data meet Tag Guidance for cars all purposes.

**Table 28 - WSTM4 Trip Mean Values – AM Peak**

| | Mean Values | | | Standard Deviation | | |
|---|---|---|---|---|---|---|
| Purpose | Pre - ME | Post - ME | % change | Pre - ME | Post - ME | % change |
| Car - Commuting | 40.19 | 40.22 | 0.08% | 6.26 | 6.34 | 1.31% |
| Car - Employers' Business | 42.80 | 43.65 | 1.97% | 6.54 | 6.61 | 0.98% |
| Car - Other | 40.83 | 40.71 | -0.29% | 6.39 | 6.38 | -0.15% |

**Table 29 - WSTM4 Trip Mean Values – Inter Peak**

| | Mean Values | | | Standard Deviation | | |
|---|---|---|---|---|---|---|
| Purpose | Pre - ME | Post - ME | % change | Pre - ME | Post - ME | % change |
| Car - Commuting | 43.88 | 44.59 | 1.61% | 6.55 | 6.68 | 1.97% |
| Car - Employers' Business | 46.03 | 46.53 | 1.08% | 6.78 | 6.82 | 0.54% |
| Car - Other | 41.00 | 41.69 | 1.69% | 6.40 | 6.46 | 0.84% |

**Table 30 - WSTM4 Trip Mean Values –PM Peak**

| | Mean Values | | | Standard Deviation | | |
|---|---|---|---|---|---|---|
| Purpose | Pre - ME | Post - ME | % change | Pre - ME | Post - ME | % change |
| Car - Commuting | 39.73 | 39.30 | -1.07% | 6.22 | 6.27 | 0.74% |
| Car - Employers' Business | 46.05 | 46.06 | 0.02% | 6.79 | 6.79 | 0.01% |
| Car - Other | 42.18 | 42.52 | 0.81% | 6.49 | 6.52 | 0.40% |

# 6 CONCLUSIONS

6.1.1. WSTM4 is the forth update of the Wokingham Strategic Transport Model. The WSTM4 reflects 2015 travel conditions and has been developed to support strategic and local planning for the next plan period up to 2036. The previous version WSTM3 (2010 based) has been used for wider strategic testing, localised testing, plan policy evaluation and scheme appraisal within Wokingham Borough shaping transport planning policies and strategies.

6.1.2. The updated WSTM4 model will serve as a robust and up to date basis:

- for scheme and development assessments in Wokingham borough (including funding applications)
- in negotiations with the adjacent authorities, the Highways England and Network Rail
- for assessing car parks management and re-development proposals in the borough
- for the assessment of a new bridge across the River Thames east of Reading and the development of the Strategic Outline Business Case (SOBC) for the scheme.

6.1.3. The model development has been guided by the following units of the DfT TAG guidance:

- Unit M1 “Principles of Modelling and Forecasting”(January 2014)
- Unit M1.2 “Data Sources and Surveys” (January 2014)
- Unit M2 “Variable Demand Modelling” (January 2014and November 2016 update)6
- Unit M3.1 “Highway Assignment Modelling” (January 2014)
- Unit M3.2 “Public Transport Assignment” (January 2014)
- Unit M5.1 “Modelling Parking and Park and Ride” (January 2014).

6.1.4. The WSTM4 Fully Modelled Area is bounded by the M40 in the north, by the M25 in the east, by the M3 in the south and by the A339 and A34 in the west.

6.1.5. The base year models have been developed for the following time periods:

- average Weekday (Monday to Thursday) AM peak hour (08:00 - 09:00)
- average Weekday (Monday to Thursday) Inter peak hour (average 10:00 – 16:00)
- average Weekday (Monday to Thursday) PM peak hour (17:00 - 18:00).

6.1.6. WSTM4 has inherited the WSTM3 model structure and consists of the following sub-models:

- Highway model
- Public Transport (PT) model
- Variable Demand Model (VDM).

6.1.7. The WSTM4 has been developed using PTV’s VISUM 17.01-04, a software program for traffic and transport analyses and forecasts. The use of a single software platform has combined the highway, PT and VDM models in one suite and allowed GIS - based data management.

6.1.8. The highway and public transport networks have been updated to take account of any changes that have occurred since the original WSTM3 was built. The already detailed WSTM3 network in Wokingham Borough and Bracknell Forest was further refined in Reading town centre, South Oxfordshire and areas around the proposed location on the New Thames Crossing east of Reading.

6.1.9. The demand matrix development has been informed by the Vodafone’s Mobile Network Data (MND) and 2011 Census. It should be noted that there is currently no guidance available on the use of MND. We were engaged in the work TS Catapult was undertaking for the DfT to produce guidance to support the clear and consistent use of MND in transport modelling and appraisal and the work undertaken for the Highways England on the Regional Model Matrix Development and have applied knowledge gained to the development of the WSTM4 trip matrices. A comprehensive verification process of the MND has been undertaken. The analysis confirmed that despite a number of data weaknesses the MND accurately represents observed trip patterns and can be used as a basis for prior matrix development.

6.1.10. Calibration and validation of the highway model was undertaken for the four main components of the model:

- Network calibration and validation
- Route choice calibration and validation
- Trip matrix calibration and validation
- Assignment calibration and validation.

6.1.11. The performance of the final highway assignment model has been examined through comparison of modelled and observed total counts on links, screenlines and cordons, junction turning counts as well as journey times along selected routes and routing comparison. In addition, the impact of matrix estimation on the prior demand matrix has been evaluated.

6.1.12. The WSTM4 highway model calibration process was undertaken successfully and has produced a high standard and quality of results for all three modelled time periods. It has been shown that the prior trip matrices were improved by the use of matrix estimation techniques and that this process did not significantly alter the integrity of the prior trip matrices. The calibration and validation levels achieved coupled with the quantity of traffic data included in the highway model for each time period meet the DfT's TAG criteria.

6.1.13. The validation of the public transport model has shown that the WSTM4 public transport model is able to closely match the journey itineraries and times provided by Travelline to travellers and can replicate the general scale of patronage along Reading centred lines and at selected rail stations and bus stops.

6.1.14. It has been confirmed through a series of realism tests on the Variable Demand Model that WSTM4 exhibits realistic behaviour in response to specific changes in generalised cost components, i.e. car fuel cost, public transport fares and car journey time.

6.1.15. It can be concluded that overall the Wokingham Strategic Transport Model 4 (WSTM4) is a robust tool suitable to be used for traffic forecasting, development and scheme assessment.