ATKINS

Member of the SNC-Lavalin Group

# Oxfordshire Strategic Model - Local Update for Oxford Transport Schemes

## Local Model Validation Report

Oxfordshire County Council

**September 2022**

# Notice

This document and its contents have been prepared and are intended solely as information for Oxfordshire County Council and use in relation to Local Update for Oxford Transport Schemes

Atkins Limited assumes no responsibility to any other party in respect of or arising out of or in connection with this document and/or its contents.

This document has 74 pages including the cover.

## Document history

**Document title:** Local Model Validation Report

**Document reference:** LMVR

| Revision | Purpose description | Originated | Checked | Reviewed | Authorised | Date |
|---|---|---|---|---|---|---|
| Rev 1.0 | First draft | EED | OS | OS | | 02/08/2022 |
| Rev 2.0 | Second draft | EED | OS | AEA | AEA | 12/09/2022 |
| Rev 3.0 | Third draft | | OS | AEA | | 16/09/2022 |
| Rev 4.0 | Final | | OS | AEA | AEA | 22/09/2022 |
| Rev 5.0 | Final | | | OS | AEA | 26/09/2022 |
| Rev 6.0 | Accessibility changes | | SP | OS | AEA | 14/10/2022 |
| | | | | | | |
| | | | | | | |
| | | | | | | |

## Client signoff

| | |
|---|---|
| Client | Oxfordshire County Council |
| Project | Oxfordshire Strategic Model - Local Update for Oxford Transport Schemes |
| Job number | 5213076 |
| Client signature/date | |

# Contents

## Tables

## Figures

# Executive Summary

Oxfordshire County Council (OCC) commissioned Atkins to update the existing 2018 Oxfordshire Strategic Model (OSM) to provide a better representation of traffic in the City of Oxford where various transport measures are proposed. The model network update was based on the 2018 OSM, which now includes an enhanced level of network details in the core model area.

The model represents a neutral weekday (Monday – Thursday) in March 2018. It covers three time periods: the AM peak (08:00 – 09:00), an average hour Inter peak (10:00 – 16:00) and PM peak (17:00 – 18:00).

The model update has utilised data from a range of local sources including traffic counts and TomTom journey time data. The update included amendments to the highway and public transport networks and recalibration of the highway model.

This model update report describes the development of the modelled network and demand matrix and the calibration of the model.

## Summary of Standards Achieved

The highway model has been tested against the criteria published by the Department for Transport for:

- Link flows on individual links;
- Journey time comparison; and
- Model convergence.

### Link Flows

In terms of individual flow accuracy, the model performs strongly across all three time periods. The majority of the individual links used for calibration passed the TAG criteria with 96% of the links in AM peak; 98% in Inter Peak; and PM peak. This demonstrates that the model achieves a good level of fit against observed flows across the study area.

### Journey Times

Modelled journey times on four routes across the model area for all time periods show good correlation with observed journey times with one route failing the TAG criteria out of the 8 two-way observations, and 2 failing for the IP and PM.

### Convergence

The base assignment models have shown to be stable for the three modelled time periods and meet the convergence criteria

## Conclusions

The updated 2018 OSM base year model performs well against the relevant TAG criteria and is deemed suitable to form the basis for development of forecasts for the Oxford schemes including traffic filters.

# 1. Overview

## 1.1. Background

In 2013, Oxfordshire County Council (OCC) commissioned Atkins to develop a suite of multi-modal strategic models to provide evidence to support robust future assessments for funding bids and scheme prioritisation, particularly in regard to transport scheme assessments that meet the Department for Transport (DfT) Transport Appraisal Guidance (TAG).

In specifying the model, there was particular emphasis on developing a model to identify the impact of transport and development in Oxfordshire as well as developing a model that could be used to support business cases and planning applications. The resulting Oxfordshire Strategic Model (OSM) was a new, strategic transport model that has been developed specifically to assess land use and transport interventions in Oxfordshire. The model is multi-modal and TAG compliant to underpin specific requirements of the DfT, and consists of three key elements:

- a Highway Assignment Model (HAM) in SATURN representing vehicle-based movements within and across the Oxfordshire County for weekday morning peak hour (08:00 – 09:00), an average inter-peak hour (10:00 – 16:00) and an evening peak hour (17:00 – 18:00);
- a Public Transport Assignment Model (PTAM) in EMME representing bus and rail-based movements across the same area and for the same time periods, month and year; and
- a multi-modal pivot incremental Variable Demand Model (VDM), coded in EMME, that estimates frequency choice, main mode choice, time period choice, destination choice, and sub-mode choice in response to changes in generalised costs of travel across the 24-hour period (07:00 – 07:00).

In September 2016, OCC commissioned Atkins to update the OSM with the forecasts provided by the NTEM (National Trip End Model) v7.0 dataset. In 2017 the model was updated again to take account of new local planning data, NTEM (v7.2) and TAG Databook (v1.8). In the summer of 2020, the model was further updated following comments from DfT on the Full Business Case report for the A40 Science Transit Phase 2 scheme. The business case was approved by DfT in November 2021.

## 1.2. Study Scope

In the winter of 2021, OCC commissioned Atkins to undertake the modelling for assessing the impact of various transport schemes in Oxford including proposals for traffic filters, a Zero Emission Zone and a workplace parking levy, using the OSM. The scope included a local update of the highway assignment model, which consisted of a review of the highway network in the 2018 model resulting mainly in the adjustments to the journey times in Oxford City. The trip matrices have also been updated using 2018 traffic counts and select link factoring. Furthermore, the parameters of the model were updated with the revised version of the TAG Databook (v1.17) released in November 2021.

To deliver this analysis, it was necessary to ensure that the newly created 2018 base year within the OSM was suitably replicating observed base year traffic flows within the study area (shown in Figure 1-1). The scope of work therefore included the local re-calibration of the highway model for most of the network in Oxford City at a 2018 level.

An update of the public transport model was also undertaken to bring it to a 2018 base year, including a comparison with the public transport demand matrices from another model that is being developed on behalf of OCC.

This report therefore sets out briefly the methodology for the update of the public transport assignment model and gets into significantly more detail about the methodology used for the update of the highway assignment model and its performance against the key validation criteria set out in the TAG guidance. To ensure the highway assignment model is an appropriate tool for its intended purpose, the following have been considered when updating it:

- To represent with a reasonable degree of accuracy the current traffic conditions in the core model area, the base year models are calibrated against TAG criteria, particularly in terms of traffic flows and journey time criteria;
- Highway networks are updated to represent the 2018 base year; and
- Base year matrices updated using traffic counts and the selected OD pair factoring using Select Link Analysis (SLA).


**Figure 1-1 - Area of interest**

## 1.3. Contents of this Report

The report is structured as follows:

- Section 2 describes the key features of the updated models;
- Sections 3 and 4 describe the highway and public transport assignment models, respectively;
- Section 5 defines the standards against which the highway model is validated;
- Section 6 summarises the observed data used for highway model calibration;
- Section 7 describes development of the updated highway network;
- Section 8 describes the car trip matrices development;
- Section 9 contains the procedures used to calibrate the model and the respective results;
- Section 10 describes the public transport model update;
- Section 11 describes the Park and Ride demand update; and
- Section 12 summarises the base year model development/update.

# 2. Key Features of the model

## 2.1. Model Base Year

The OSM has a 2018 base year and represents an average weekday covering a typical, Monday, Tuesday, Wednesday and Thursday in March.

## 2.2. Zoning System

The highway model is part of an integrated modelling suite, which links the VDM to both the highway assignment and public transport assignment models. The zoning system built for OSM is compatible with NTEM and the UK Census Output Areas, which contains demographic information such as number of households etc. In particular, zones in Oxfordshire are aggregated from UK census Output Area zones, attempting to have less than 500 households per zone. This ensures that zones are fine enough in the core study area, with no zone generating a demand of more than 300 pcu[1] per hour, following current best practice. Figure 2-1 shows the zones in the area of interest, i.e. Oxford City.

The resulting number of zones by area is shown in Table 2-1. In total, there are 704 zones covering the whole of Great Britain, with 553 zones falling in Oxfordshire. In particular, all the five P&R sites and major car parks in Oxford are given specific zones, together with two separate airport zones for Heathrow and Gatwick. An additional 121 dummy zones were added as placeholders for future development proposals. The zoning system is identical in both assignment models and the VDM.

**Table 2-1 - OSM Zoning System**

| Area | No. of Zones |
|---|---|
| Oxford | 130 |
| Didcot / Wallingford / Wantage | 42 |
| Bicester | 26 |
| Abingdon | 30 |
| Witney | 25 |
| Banbury | 7 |
| Rest of Oxfordshire | 293 |
| Hinterland | 115 |
| Rest of UK | 36 |
| Total | 704 |

[1] Passenger car unit

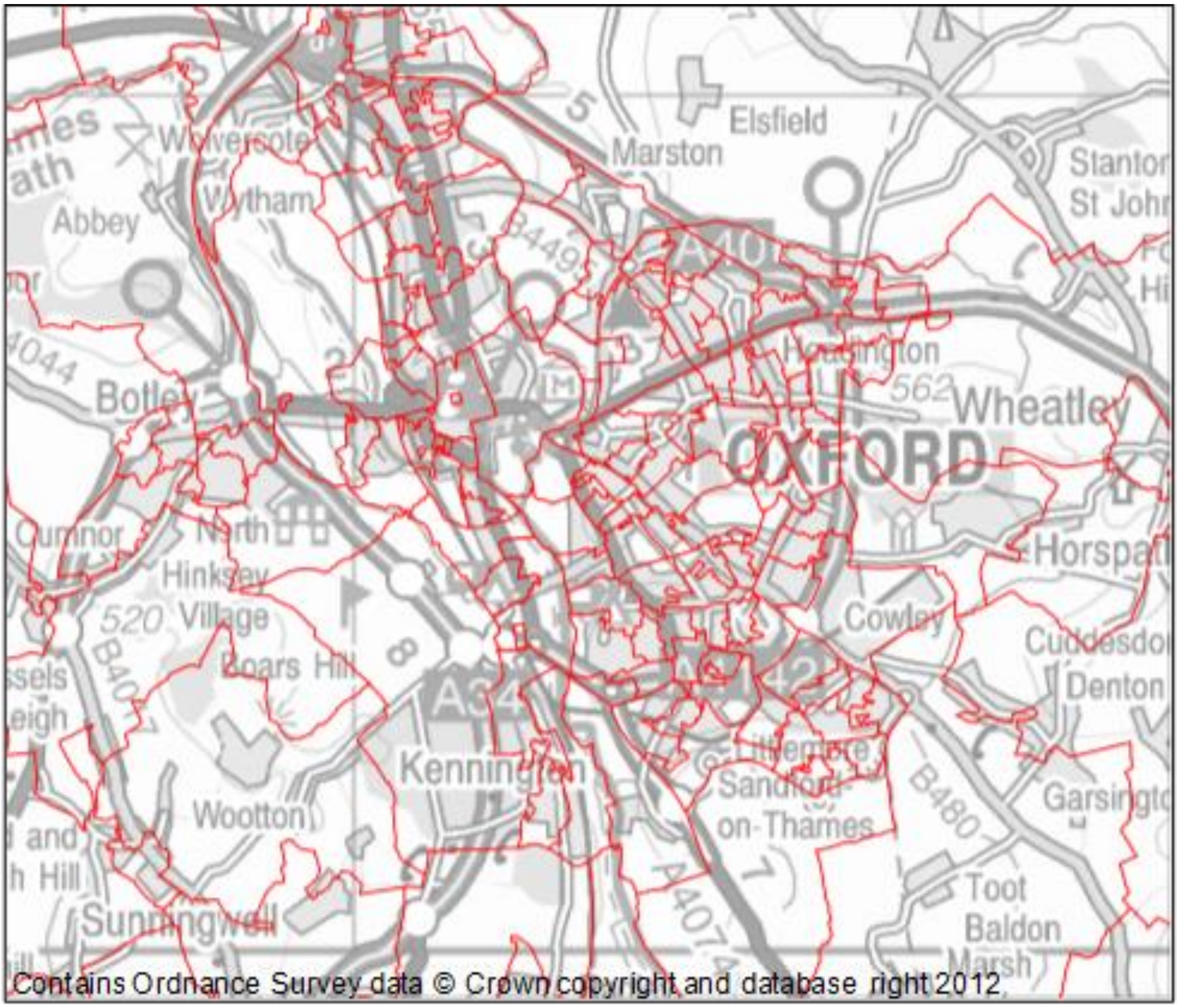



**Figure 2-1 - OSM Zones in Oxford**

## 2.3. Time Periods

Both assignment models include three time periods as shown below in Table 2-2. They represent the AM and PM peak hours, plus a period representing an average Inter-peak hour.

**Table 2-2 - Model Peak Hours**

| Model Time Period | Temporal Coverage |
|---|---|
| AM Peak Hour | 08:00 – 09:00 |
| Average Inter-Peak hour | 10:00 – 16:00 |
| PM Peak Hour | 17:00 – 18:00 |

## 2.4. Additional information

More detailed information about the two assignment models can be found in the “OSM HAM Development Report - Review2021 - Rev 4.0” and “OSM Public Transport Model Report - Update_Jan2021_v5.3 final”, both issued in January 2021 as part of the Full Business Case for A40 Science Transit Phase 2 scheme.

# 3. The highway assignment model

## 3.1. Modelled Area

TAG Unit M3.1 states that the geographic coverage of highway assignment models generally needs to:

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

The modelled area therefore needs to be large enough to include these elements, but within the modelled area the level of detail should vary as follows:

- **Fully Modelled Area (FMA)**: the area over which proposed interventions have influence, and in which junctions are in SATURN simulation, is further subdivided as:
  - **Area of Detailed Modelling (ADM)** – the area over which significant impacts of interventions are certain and the modelling detail in this area would be characterised by: representation of all trip movements; small zones; very detailed networks; and junction modelling (including flow metering and blocking back);
  - **Rest of the Fully Modelled Area** – the area over which the impacts of interventions are considered to be quite likely but relatively weak in magnitude and 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);
- **External Area**: the area where impacts of interventions would be so small as to be reasonably assumed to be negligible and would be characterised by: a SATURN buffer network representing a large proportion of the rest of Great Britain, a partial representation of demand (trips to, from and across the Fully Modelled Area); large zones; skeletal networks and simple speed/flow relationships or fixed speed modelling.

In the OSM, the ADM covers the area bounded by:

- Bicester to the north;
- Wallingford to the east;
- Burford and Witney to the west; and
- Wantage and Didcot to the south.

The FMA covers the rest of Oxfordshire plus some hinterland area including Swindon, Reading, High Wycombe and Stratford-upon-Avon etc. The External Area covers the rest of Great Britain in a skeletal form.

The density of the network structure differs between the FMA and External Area as follows:

- within the FMA, all major A-roads, B-roads and motorway links are represented along with the main residential roads and access roads to major developments and car parks; whereas
- the External Area only included the major A-roads, B-roads and motorway networks with reducing detail further away from the FMA.

The FMA is coded in the SATURN simulation network (with explicit junction modelling) whilst the External Area is coded in SATURN buffer network. The level of detail and accuracy of the network decreases as progression is made from the ADM to the External Area.

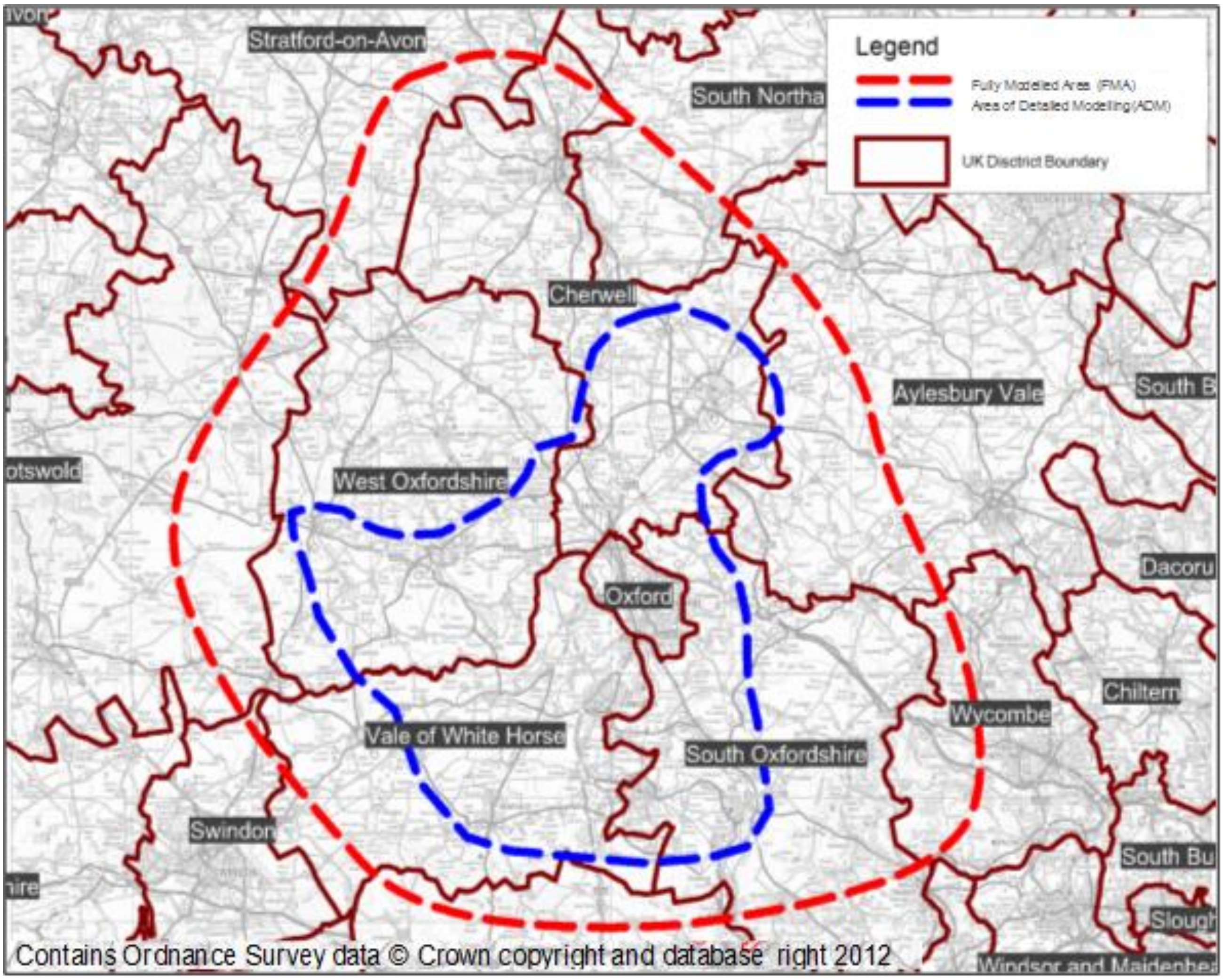



**Figure 3-1 - Area of Detailed Modelling and Fully Modelled Area for the OSM**

## 3.2. Demand Segmentation

User Classes (UC) are used to describe the differing characteristics of vehicle users within the model. It is important that appropriate demand segmentation is applied to the assignment because the vehicle operating cost and value of time varies by different user classes. A total of seven user classes have been used to represent different trip purposes in the model as shown below in Table 3-1.

**Table 3-1 - User Class Definition**

| User Class | Vehicle Type | Purpose |
|---|---|---|
| 1 | Car | Home Based Employer Business |
| 2 | Car | Home Based Other |
| 3 | Car | Home Based Commute |
| 4 | Car | Non - Home Based Employer Business |
| 5 | Car | Non- Home Based Other |
| 6 | Light Goods Vehicles (LGV) | |
| 7 | Heavy Goods Vehicles (HGV) | |

## 3.3. PCU Factors

Passenger Cars Units (PCUs) are used as a standard unit in SATURN for demand and capacities. This allows the effect of longer/slower vehicles that occupy more road space and take longer time to clear junctions to be represented within the model. The vehicle to PCU conversion factors used for the various user classes are summarised in Table 3-2.

**Table 3-2 - PCU Conversion Factors**

| Vehicle Type | Description | PCU Factor |
|---|---|---|
| Car | Private Car | 1.00 |
| Bus | All Bus Types | 2.50 |
| LGV | Goods vehicle using car-based chassis | 1.00 |
| HGV[2] | OGV1 and OGV2 (Rigid and Articulated) | 2.30 |

## 3.4. Assignment Methodology

SATURN version 11.5.05N is used for highway assignment.  SATURN uses the SATALL module to iterate between successive loops of the SATASS module (which assigns the user class matrices to the network in accordance with Wardrop's First Principle of Traffic Equilibrium using the Frank-Wolfe algorithm) and the SATSIM module (which takes the flows derived by SATASS and calculates the revised flow/delay relationships at each junction within the simulated area) until the resulting travel times and flows do not change significantly.

The process starts with SATASS using the free-flow times (without any delays arising from vehicle interactions at the simulated junctions) from the network building program, SATNET. After the first set of path-builds in SATASS, the resulting flows are passed to SATSIM for the turn-based flow/delay curves representing the detailed interactions at each junction to be updated.  These revised flow/delay relationships are passed back to SATASS for the travel time and flows to be recalculated.

In order to cut down on the assignment run time, the SPIDER network function is adopted. "*Network aggregation (SPIDER) is a technique whereby links and/or nodes in the basic assignment network may be combined together into an equivalent set of aggregated*

[2] TAG unit M3.1; Section D.7.2 provides two PCU values for HGV's: either 2.5 for HGVs on motorways and all-purpose dual carriageways or 2.0 for all the other road types.

*links/nodes with the objective of reducing the cpu time required to carry out the basic assignment steps of tree building and loading.*" (SATURN user-manual, para 15.56.1)

## 3.5. Generalised Cost

The route choice within the highway assignment model is modelled using the generalised cost of travel time, vehicle operating cost and tolling / congestion charging in accordance with the TAG Unit A1.3. This is to make it compatible with the demand model which also uses generalised costs. The coefficients for the individual components of generalised costs were calculated using TAG Unit A1.3.

The model base year is 2018 with all monetary values calculated at 2010 prices.

### 3.5.1. Values of Time

Perceived values are used throughout. The process is summarised below:

- equivalent 2018 values are calculated by applying the specified growth in working and non-working values of time (Annual Parameters in TAG Unit A1.3);
- the relative proportions of Car Non-work for 'Other' and 'Commuting' are calculated from the RSI surveys[3];
- the equivalent values for vehicles were calculated by applying the occupancies obtained from the RSI surveys;
- HGV travel is assumed to be in work time; and
- the values are converted from pounds per hour to pence per minute.

### 3.5.2. Vehicle Operating Costs

Vehicle Operating Costs are calculated using TAG A1.3 and defined separately for fuel and non-fuel elements before being combined for the use in the SATURN assignment. Non-fuel costs are only taken into consideration by travellers in work-time, with the split between OGV1 and OGV2 recorded from the RSI surveys.

#### 3.5.2.1. Fuel Costs

The consumption of fuel (in litres per km), adjusted by the fuel efficiency factors, is multiplied by the cost per litre to provide the cost per km in the model base year. Fuel duty for all trip purposes is included in the calculations as a perceived cost as businesses are not able to reclaim it. However, VAT is excluded from the perceived cost of work trips because businesses are able to recover it. For non-work purposes, the perceived cost of the fuel Vehicle Operating Cost was the market price.

#### 3.5.2.2. Non-Fuel Costs

The non-fuel cost element is derived using the formulae set out in TAG A1.3 (Table A1.3.14) and is a function of average network speed. The non-fuel costs are assumed to remain constant, in real terms, over time. As noted above, the non-fuel cost element is only included for work trips.

[3] Detailed information can be found in the "5125364-OSM-Data Collection Report_v3.2.docx" issued in December 2020.

### 3.5.3. Assignment Parameters

The resulting cost coefficients of PPK (pence per km) and PPM (pence per minute) calculated later based on TAG Databook v1.17 November 2021 are presented in Table 3-3 below.

**Table 3-3 - Base Year 2018 PPM and PPK Values by User Class and Time Period**

| User Class | AM Peak | | Inter-Peak | | PM Peak | |
|---|---|---|---|---|---|---|
| | PPM | PPK | PPM | PPK | PPM | PPK |
| Car – Home based EB | 30.65 | 12.73 | 31.40 | 12.73 | 31.09 | 12.73 |
| Car – Home based Other | 14.18 | 6.35 | 15.10 | 6.35 | 14.85 | 6.35 |
| Car – Home based Commute | 20.55 | 6.35 | 20.89 | 6.35 | 20.62 | 6.35 |
| Car – Non-Home based EB | 30.65 | 12.73 | 31.40 | 12.73 | 31.09 | 12.73 |
| Car – Non-Home based Other | 14.18 | 6.35 | 15.10 | 6.35 | 14.85 | 6.35 |
| LGV | 22.21 | 13.98 | 22.21 | 13.98 | 22.21 | 13.98 |
| HGV | 22.12 | 37.97 | 22.12 | 37.97 | 22.12 | 37.97 |

Source: TAG Databook v1.17 released in November 2021

## 3.6. Capacity Restraint

Capacity restraint is modelled in the FMA (i.e. simulation area) predominantly through junction modelling.  All modelled junctions in this area are allocated a junction type, with capacities for each turn, lane allocations and traffic signal timings for roundabouts, priority and signalised junctions respectively. The capacity of a junction is therefore determined by the junction arm capacities.

There are also capacity restraints on the links, through the usage of capacity controls such as speed-flow curves and saturation flows, where appropriate, to simulate observed conditions. However, it should be noted that speed-flow curves are only implemented on a subset of links.

# 4. The Public Transport Assignment Model

## 4.1. Network Structure

The public transport assignment model (PTAM) has been developed to represent two public transport modes:

- bus; and
- rail.

In addition, the model also includes a bus-based Park and Ride mode.

For the bus mode, the OSM PTAM inherits the network structure from the OSM HAM. The rail network has been coded separately to represent all rail lines in the Fully Modelled Area and its hinterland.

## 4.2. Demand segmentation

The public transport assignment uses a single user class.

## 4.3. Assignment Methodology

The Public Transport Assignment Model uses the standard transit assignment implemented in EMME, i.e. a multipath assignment, based on the computation of optimal strategies.

## 4.4. Generalised Cost Formulations and Parameter Values

The generalised cost function used for the public transport assignment routing, measured in units of time (minutes), is given by:

$G_{PT} = V_{wk}*A + V_{wt}*W + T + B$

Where:

- *Vwk* is the weight applied to time spent walking (walk time weight);
- *A* is the total walking time to and from the services and during an interchange;
- *Vwt* is the weight applied to time spent waiting;
- *W* is the total waiting time for all services used on the journey;
- *T* is the total in-vehicle time; and
- *B* is the total boarding penalty applied for each service boarded on the journey.

The public transport assignment model uses parameters based on those provided in TAG Unit M3-2, which in turn are derived from work undertaken by the Institute of Highways and Transportation to establish guidelines for urban transport strategies and further work commissioned by the DfT on the value of travel time savings. Further details, including the various references, may be found in the TAG Unit.

In the OSM demand model framework, the standard transit assignment in EMME (module 5.11 and 5.31) is used for both rail and bus assignment. Typically, the cost inputs for deriving attractive lines in the PT assignments include effective headway and boarding time penalties, as well as the factors and weights in association with each cost element. In the OSM, for the actual line headway for PT assignment a global waiting time factor of 0.5 is assumed (half of the effective headways). This is probably not a major issue for PT assignment if the waiting time for every PT service is treated in the same way. However, with a weight of 2.5[4] against in-vehicle ride time, the waiting time saving from an improved PT service such as increased frequency will be significantly over-estimated.

In view of this, a new approach was implemented based on the PDFH[5] Section B Table B4.8, which shows the average service interval penalties by rail service coverage for a headway from 5 minutes to 180 minutes, as extracted below (see Table 4-2). Assuming there is no boarding penalty applied, it can be reasonably assumed that the penalty is equivalent to passenger's average waiting time[6], combined with the cases when passengers arrive at a stop randomly or pre-planned against timetables.

The parameter values for assignment are set out below.

**Table 4-1 - Assignment Parameters**

| **Parameter** | **Value** |
|---|---|
| Wait time factor | PDFH curve |
| Wait time weight | 2.5 |
| Walk time weight | 2.0 |
| Boarding penalty (*Adjusted as part of the calibration process)* | 0 to 25 |

**Table 4-2 - PDFH waiting time**

**Table B4.8 Average Service Interval Penalties (in minutes) for Different Flow Types**

| | Equivalent Time Penalty | | | | |
|---|---|---|---|---|---|
| Service Interval | London InterCity | Non-London inter-urban | London SE area | Non-London SE area | Non-London urban |
| 5 | 5 | 5 | 5 | 5 | 5 |
| 10 | 10 | 10 | 10 | 10 | 10 |
| 15 | 14 | 14 | 14 | 14 | 14 |
| 20 | 18 | 18 | 19 | 18 | 18 |
| 30 | 24 | 23 | 25 | 24 | 24 |
| 40 | 27 | 26 | 29 | 27 | 28 |
| 60 | 33 | 31 | 36 | 33 | 35 |
| 90 | 43 | 39 | 46 | 43 | 45 |
| 120 | 52 | 47 | 57 | 52 | 55 |
| 180 | 70 | 63 | 78 | 70 | 74 |

Source: Passenger Demand Forecasting Handbook

[4] As suggested in TAG M3.2 Para. 3.1.5, the waiting time weight is 1.5-2.5 times in-vehicle time.
[5] **Passenger Demand Forecasting Handbook**
[6] Note that this is the waiting time in terms of in-vehicle ride time equivalence, i.e. after applying the waiting time to in-vehicle time weight, which is 2.5 assumed in the OSM demand model.

## 4.5. Fares

The public transport sub-mode choice (i.e. Bus vs Rail) is undertaken within the VDM, based on the standard TAG generalised cost formulation (which includes fares). The PTAM (assignment) does not consider the impact of fares. The PTAM determines the route choice (within each mode) and whilst there will be some influence of fares, it is unlikely to be significant, because:

- Bus Services in Oxfordshire are provided principally by Stagecoach, Oxford Bus Company and Thames Travel. Typically, a competitive stage-based fare system with a range of day and season ticket types is provided by each bus operator, which limits passenger's choice to choose alternative routes in order to reduce fare costs. Meanwhile rail fares are distance-based, and the P&R mode has a flat fare system;
- The choice of route is sensitive to the relative difference in the generalised journey costs between route alternatives rather than the absolute journey costs, and the influence of fare is small compared to the weights attached to In-Vehicle Time, Wait Time and penalties for boarding services during interchanges;
- There are several ticket types such as day returns and season tickets which are purchased independently of route choice; and
- The fare differentials between realistic competing routes for the same O-D pair will be small.

Additional information on public transport fares is separately reported within the "OSM Demand Model Development Report - Review 2020_Issued 04012021" (see section 3.4 Generalised Cost Formulation).

## 4.6. Bus Journey Times

The underlining road network is created from the OSM HAM. This enables a linkage to be established between highway travel times and bus travel times such that, in forecasting mode, the impact of increasing or reducing congestion levels on bus travel times is represented.

This linkage also allows the impact on bus journey times of new bus lanes and bus priority measures at junctions to be modelled. At the same time, the HAM models the effects of capacity reduction on general traffic, and the impact that this has, in turn, on bus journey times. Further details of the mechanism used are given in Appendix A of "OSM Public Transport Model Report - Update_Jan2021_v5.3 final" issued in January 2021.

# 5. Highway Model Standards

OSM is a large, county-wide strategic multi-mode model, and it is common to find the need to undertake localised calibration and validation prior to testing a major scheme in the model. The OSM highway assignment model update to assess Oxford schemes has been developed in accordance with guidance in TAG M3.1, Highway Assignment Modelling[7].

## 5.1. Validation Criteria and Acceptability Guidelines

The validation of a highway assignment model should include comparisons of the following:

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

## 5.2. Flow Calibration

Two measures from the TAG Validation criteria have been used for individual link Calibration: (a) flow difference; and (b) the Geoffrey E. Havers (GEH) measure. The traffic flow difference is based on the relative flow difference between modelled flows and observed counts, with three different criteria set depending on the scale of the observed counts. The GEH statistic, which is a form of the Chi-squared statistic that incorporates both relative and absolute errors, and is defined as follows:

GEH =

Where: M is the modelled flow; and

C is the observed flow.

These two measures are broadly consistent and link flows that meet either criterion should be regarded as satisfactory. The validation criteria and acceptability guidelines for the link flows and turning movements as given in TAG Unit M3.1 are defined in Table 5-1 below.

**Table 5-1 - Flow Validation Criterion and Acceptability Guidelines**

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

Source: TAG Unit M3.1 Table 2

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

Regarding flow validation, the following should be noted:[8]

- The above criteria should be applied to both link flows and turning movements;
- The acceptability guideline should be applied to the link flows but may be difficult to achieve for turning movements;
- The comparisons should be presented for cars and all vehicles but not for light and other goods vehicles unless sufficiently accurate link counts have been obtained;
- The comparisons should be presented separately for each modelled period; and
- It is recommended that comparisons using both measures are reported in the model validation report.

## 5.3. Journey Time Validation

Journey time validation compares the percentage difference between modelled and observed journey times, subject to an absolute maximum difference. TAG Unit M3.1 describes the criteria and guidelines, as shown in Table 5-2 below.

**Table 5-2 - Journey Time Validation Criterion and Acceptability Guidelines**

| Criterion | Acceptability Guideline |
|---|---|
| Modelled times along routes should be within 15% of surveyed times (or 1 minute, if higher than 15%) | > 85% of routes |

Source: TAG Unit M3.1 Table 3

Regarding journey time validation, the following should be noted: [9]

- It is expected that separate speed/flow relationship and /or link speeds are used for light and other vehicles; hence comparisons should be presented for light and other vehicles separately; otherwise, the comparisons should be presented for all vehicle types together;[10]
- For validation of journey times by vehicle types, it will be necessary to obtain journey times by vehicle type to a level of accuracy which will allow a meaningful validation; if journey times by vehicle type are not available but separate speed/flow relationships for light and heavy vehicles have been used, a weighted average of the modelled light and heavy vehicle speeds should be compared with the surveyed all-vehicle speed; and
- The comparisons should be presented separately for each modelled period.

[8] TAG Unit M3.1 Highway Assignment Modelling, May 2020 (Page 20).
[9] TAG Unit M3.1 Highway Assignment Modelling, May 2020 (Page 21).
[10] The validation of the journey times in OSM was done for all vehicle types together.

## 5.4. Convergence Measures and Acceptable Values

The most appropriate convergence measures (of proximity and stability) and the values generally considered acceptable for use in establishing a base model as given in TAG Unit M3.1 are reported below in Table 5-3.

**Table 5-3 - Summary of Convergence Measures and Base Model Acceptable Values**

| Measure of Convergence | Base Model Acceptable Values |
|---|---|
| Delta and %GAP | Less than 0.1% or at least stable with convergence fully documented and all other criteria met |
| Percentage of links with flow change (P) < 1% | Four consecutive iterations greater than 98% |
| Percentage of links with cost change (P2) < 1% | Four consecutive iterations greater than 98% |
| Percentage change in total user costs (V) | Four consecutive iterations less than 0.1% (Stochastic User Equilibrium only) |

Source: TAG Unit M3.1 Table 4

# 6. Calibration Data

Model Calibration refers to the process of refining and confirming the values of model parameters and improving origin-destination movements in the demand matrices to improve the overall model performance by benchmarking against the data collated as part of this study.

## 6.1. Data Collection

To help inform an understanding of traffic levels and trip patterns in the study area, a range of data was collected and collated. This data was used to develop the model as well as model calibration. This chapter summarises the data used for model development. The data sources presented in this chapter include:

- Spatial distribution of the commuting trips to Eastern Arc
- Traffic Counts:
  - Automatic Traffic Counts (ATC)
  - Manual Classified Counts (MCC)
- 2018 TomTom journey time data
- 2021 Automatic Number Plate Recognition (ANPR)
- Traffic growth 2013 to 2019.

## 6.2. Spatial distribution of the commuting trips to Eastern Arc

A survey of the major employers in the Eastern Arc was undertaken in October 2017. The survey aimed at identifying the post codes of the employees who were commuting to each of the sites.

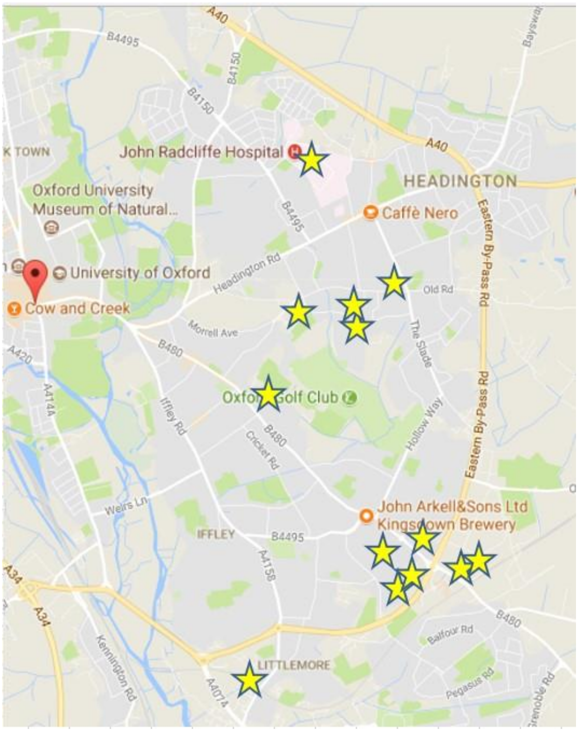



**Figure 6-1 - Location of the employers who answered the survey**

## 6.3. Traffic Data Collated

Traffic count data was required to identify observed traffic flows on key links and junctions in the study area for use in the base model calibration process. Observed traffic count data (one week, two week and one-year Automatic Traffic Counts (ATC) and single day Manual Classified Counts (MCC)) from years 2017 and 2018 was collated from a variety of sources. A summary of the traffic data collated is presented in Table 6-1 below. The geographical location of the traffic count data types is presented in Figure 6-2 It should be noted that the blue stars in the figure represent Air Quality (AQ) monitoring sites, which were used only to understand their proximity to the count sites.

**Table 6-1 - 2019 Traffic Counts Collated as part of the Model Update**

| Count Type | Number of Counts |
|---|---|
| ATC | 16 |
| MCC | 44 |

All the traffic count sites for which data collection was undertaken in 2017 has been adjusted back to a common base year of 2018 based on the adjustment factors already used in OSM. Some of the data allowed forming three concentric cordons (Inner, City Centre and Outer cordons). Given the significant number of sites left outside these cordons, they were used as an ad-hoc set in the calibration.

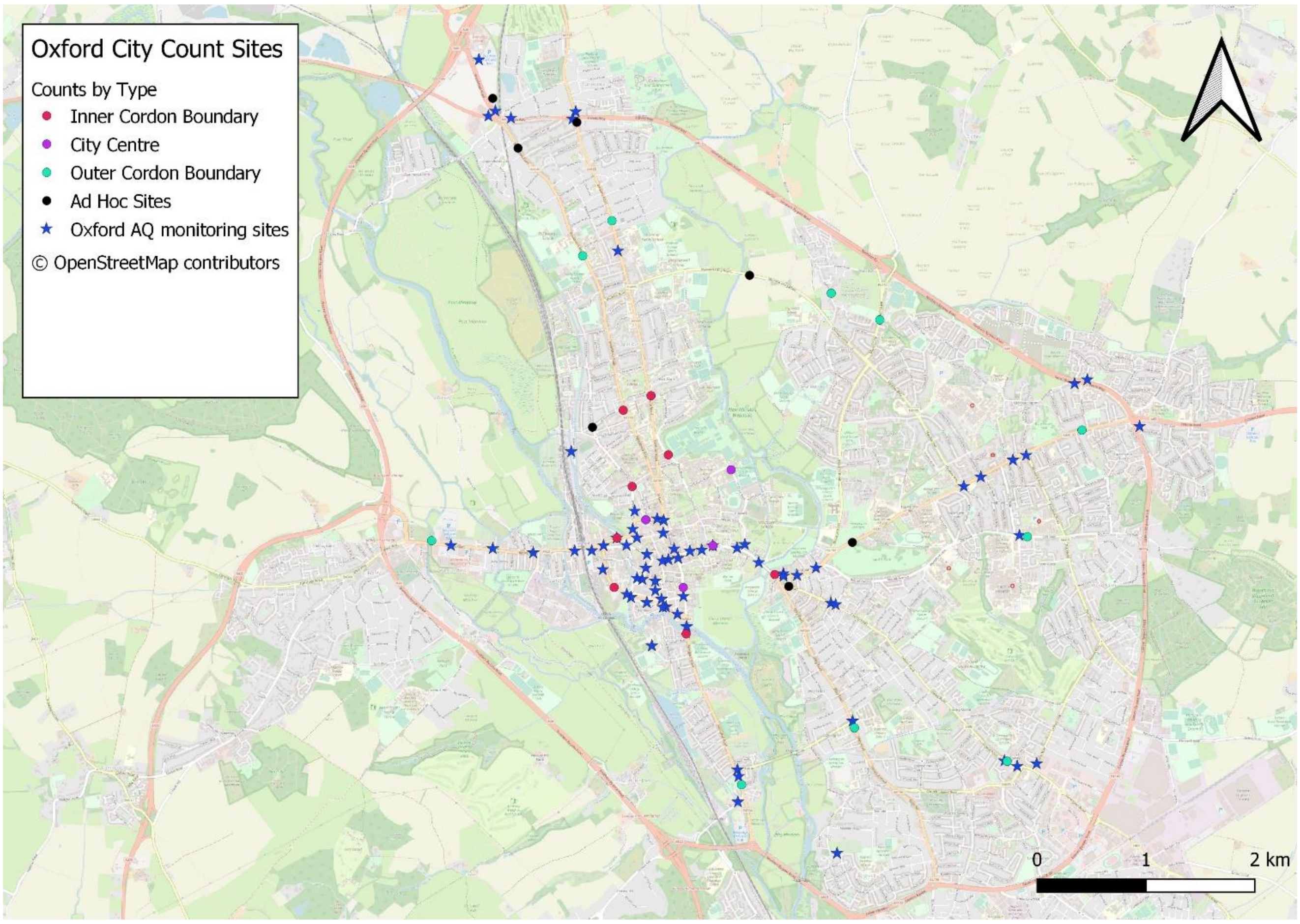



**Figure 6-2 - Traffic Counts Locations**

## 6.4. Journey Time Data

It is a requirement of the model validation process that the modelled speeds fall within an acceptable range of observed speeds. For this purpose, TomTom data was obtained and processed for the analysis of journey times in the study area.

Average neutral weekday data was analysed along 4 routes which are presented graphically in Figure 6-3 below for the month of March 2018 excluding bank and school holidays. Journey time route descriptions are given in Table 6-2. For routes 1, 2 and 3 the median observed time was used. For route 4 the mean observed time was used (the data for this route was obtained and process for a prior study).

**Table 6-2 - Journey Time Routes**

| Journey Time Route | Route Name | Direction | Distance (in KM) |
|---|---|---|---|
| Route 1 | A423/A4144 Kennington Rbt to A40/Banbury Rd Rbt | NB | 8.18 |
| | | SB | 8.26 |
| Route 2 | A420/A34 Botley Interchange to A420/Brewer Street Jct | EB | 3.89 |
| | | WB | 3.87 |
| Route 3 | High Street/Longwall St Jct to A40/A4142/A420 | EB | 4.35 |
| | | WB | 4.38 |
| Route 4 | A40 | EB | 18.67 |
| | | WB | 18.90 |

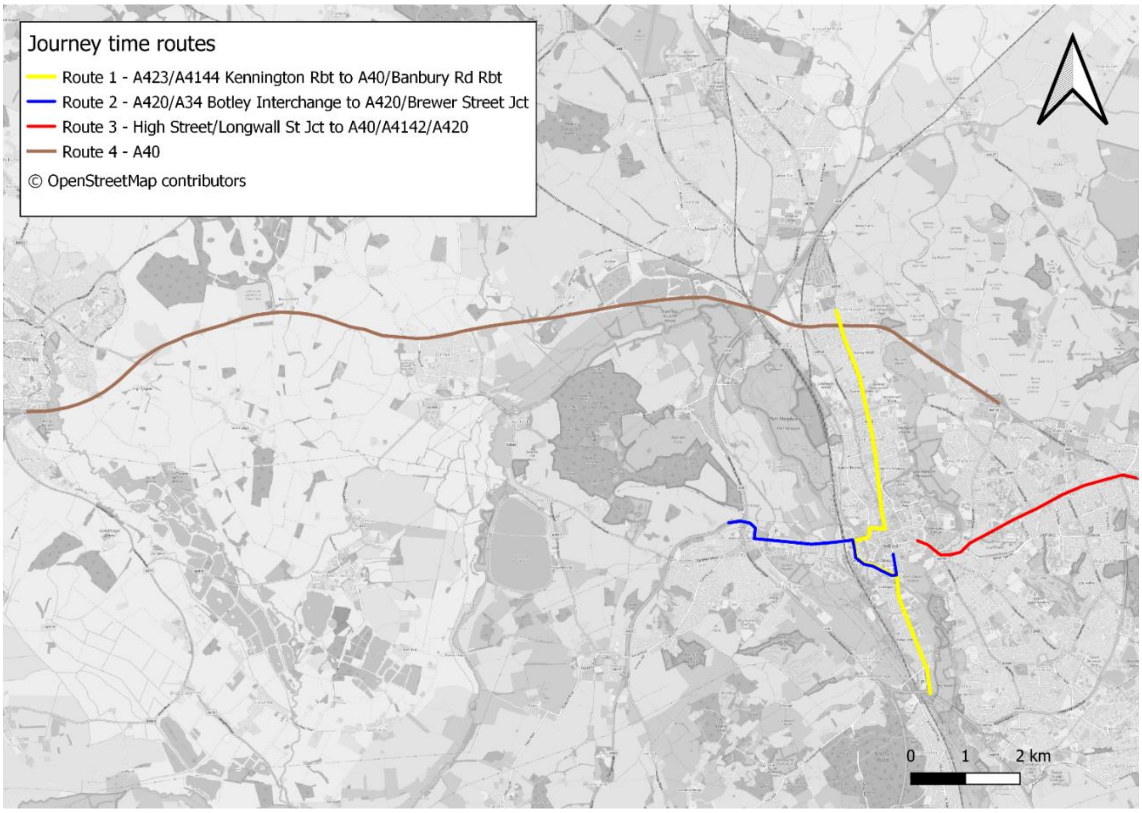



**Figure 6-3 - Journey Time Routes**

## 6.5. ANPR data

The surveys were carried out on 13th and 14th October 2021, and the results are for:

- the AM peak hour of 08:00-09:00;
- Average IP hour (between 1000 and 16:00);
- the PM peak hour of 17:00-18:00.

Figure 6-4 shows the ANPR camera location. In the result tables, “chain_start” is the start camera location and direction, “chain_end” is the destination camera and direction, the count is the average hour over the 2 days, and the “percent of count” is the percentage of vehicles at the start camera matched at the destination camera (or unmatched).

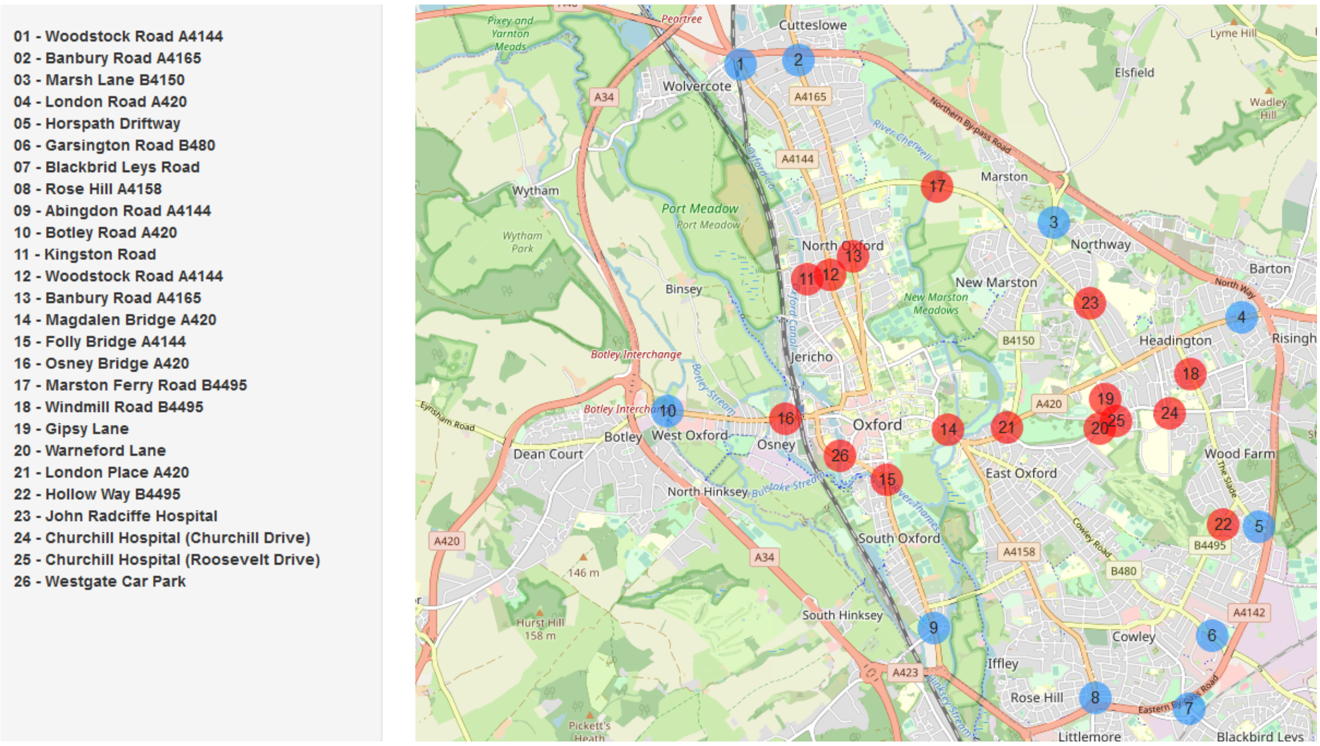



**Figure 6-4 - Location of the ANPR cameras**

# 7. Highway Network Update

## 7.1. Network Coverage

Links were added to the existing network within the area of detailed modelling to ensure the road network was represented in suitable detail. The additional links added as part of the model update are shown in Figure 7-1 below. The majority of changes in the network are in the vicinity of smaller roads and represent a simplification of several local parallel streets, e.g. Jeune St, James St or South Parade. The network was also changed in the vicinity of Westgate Shopping Centre, which opened in 2018.


**Figure 7-1 - Network update on the 2018 Base Year Model**

The existing network coding was reviewed against the latest information available from internet based on 2018 aerial imagery for the following attributes:

- Junction type and layout;
- Number of lanes per arm and turn allocations;
- Turn saturation flows;
- Link lengths;
- Speeds;
- Gap acceptance parameters;
- Speed flow curve;
- Zone centroid connectors; and
- Banned turns.

## 7.2. Junctions

A small number of junctions were added to the network to cater for the additional links to the updated 2018 model. A sample of the junctions were checked for accuracy to model year 2018 conditions.

## 7.3. Free Flow Speed

Free flow speeds were reviewed against the posted speed limit observed from internet based aerial imagery to maintain consistency in the model and to help in the calibration process.

## 7.4. Signal Timings

The signal timings for the signalised junctions were maintained mostly consistent from the 2013 OSM. However, some of the signalised junctions where large delays were observed have been optimised to provide better model performance and/or improve journey time calibration.

## 7.5. Zone Centroid Connectors

Demand is loaded onto the network using centroid connectors at appropriate locations to enable traffic to realistically enter and exit the network. The existing zone centroid connectors in the study area have been retained from the 2013 OSM.

## 7.6. Public transport Routes and Services

The bus routes and frequencies are coded as fixed routes which take away from the capacity available for the general traffic.

## 7.7. Traffic Restrictions

Traffic restrictions coded in the 2013 OSM were updated.

# 8. Trip ends comparison

The results of the survey of the number employees of major employers in the Eastern Arc, undertaken in October 2017, was made available to Atkins. The data did not contain number of trips but as the number of employees bears a strong correlation to the number of commuting trips, this data facilitated a comparison to the trip ends for home-based work trips included in OSM. The survey results were not accompanied by a report explaining details of the survey, sample size, sampling fraction, etc. Given that the biggest employers (Oxford University Hospital Trust, University of Oxford, and BMW) have responded to the survey, the data was considered suitable for a comparison with the modelled demand, although it was not used for calibration of OSM.

For consistency in analysis, both the OSM zones and the answers from the survey have been aggregated at postal district level, shown in the figure below.


**Figure 8-1 - Boundaries of the postal districts in Oxfordshire**

Source: https://en.wikipedia.org/wiki/File:OX_postcode_area_map.svg

Information about the transport mode used by the employees was not available. Consequently, the comparison in OSM was undertaken at aggregated level, over a 12-hour period and for all modes.

Figure 8-2 compares the percentage of employees resident in each postal district with the trip ends for all purposes (and modes) in OSM and shows a very similar pattern. Figure 8-3 compares the percentage of employees resident in each postal district with the trip ends for home-based work (HBW) in OSM and also shows a similar pattern. In both cases, the main differences appear for postal districts OX1, OX3 and OX4. Due to their closeness to Eastern Arc, it is thought that the difference is due to OSM not including pedestrian and cycling trips, which are more likely for short distance journeys thus OSM produces an underestimate of trips.

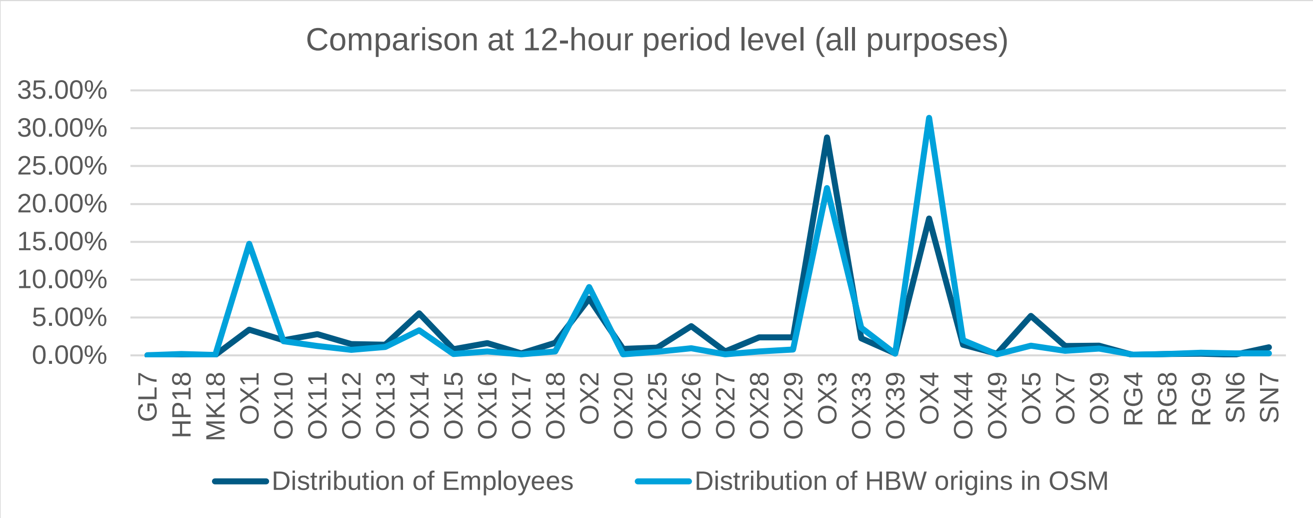



**Figure 8-2 - Comparison of trips at 12-hour period level (all purposes)**

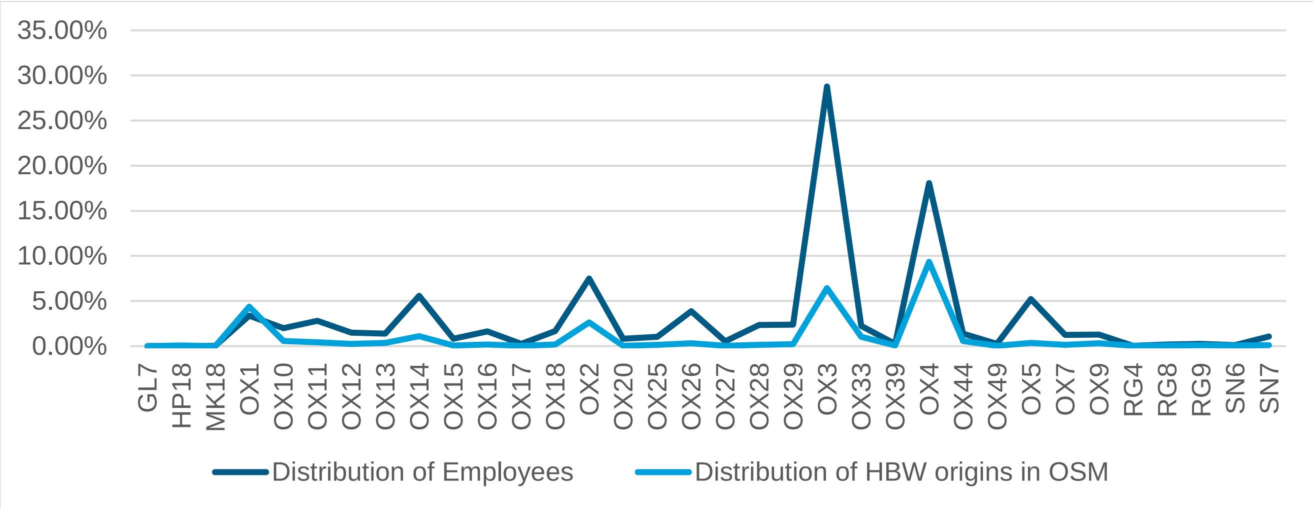



**Figure 8-3 - Comparison of trips at 12-hour period level (HBW)**

# 9. Analysis of growth 2013 to 2019

Aggregated data on the growth in trips was made available by OCC to allow the understanding of the evolution of the growth in demand in Oxfordshire, and how it compares with the modelled results.

A comparison between observed growth and modelled growth was undertaken for the Outer Cordon and the Inner Cordon as defined in Figure 6-2. It should be noted that this comparison was done before performing the final calibration of the HAM, with the objective of understanding whether the calibration was necessary.

Table 9-1 shows the comparison of the observed and modelled data for the Inner Cordon. There are some significant changes on Kingston Rd and Woodstock Rd (blue rows in the table below) which are mainly due to re-routing, not changes in demand, as can be seen in Figure 9-1 and Figure 9-2. By aggregating these two rows together (similar to a screenline), the changes between 2013 and 2019 are significantly closer to the observed ones. For all sites together, the difference between observed and modelled is not high.

**Table 9-1 - Comparison of growth of car trips at the Inner Cordon**

| Site | % Change (observed) | | | | % Change (modelled) | | | |
|---|---|---|---|---|---|---|---|---|
| | 0800 - 0900 | 1100 - 1200 | 1700 - 1800 | 0700 - 1900 | 0800 - 0900 | Average IP | 1700 - 1800 | 0700 - 1900 |
| Banbury Road | -20% | -11% | -15% | -13% | 4% | 31% | 33% | N/A |
| Magdalen Bridge | 20% | 8% | 14% | 14% | -16% | -12% | -7% | N/A |
| Folly Bridge | -17% | -7% | -17% | -11% | -6% | -3% | -3% | N/A |
| Osney Bridge | 0% | 3% | -16% | -2% | 6% | 6% | 21% | N/A |
| Kingston Road | -21% | -8% | -17% | -14% | -70% | -76% | -73% | N/A |
| Woodstock Road | 19% | 5% | 5% | 6% | 221% | 100% | 71% | N/A |
| **All sites** | **-3%** | **-1%** | **-7%** | **-2%** | **-2%** | **3%** | **4%** | **N/A** |
| Kingston Rd + Woodstock Rd | 9% | 2% | 0% | 1% | 6% | 7% | -11% | N/A |

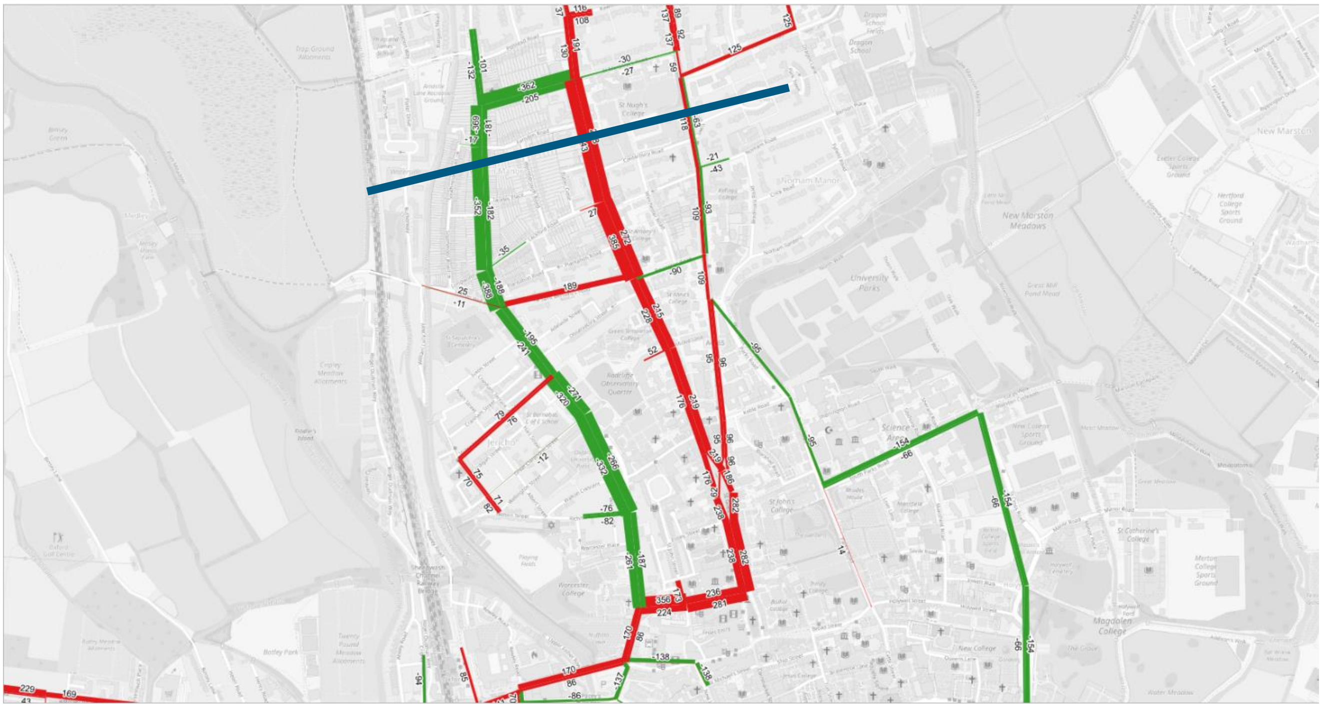


**Figure 9-1 - Changes in routing between 2013 and 2018 models – Inner Cordon – AM peak hour**

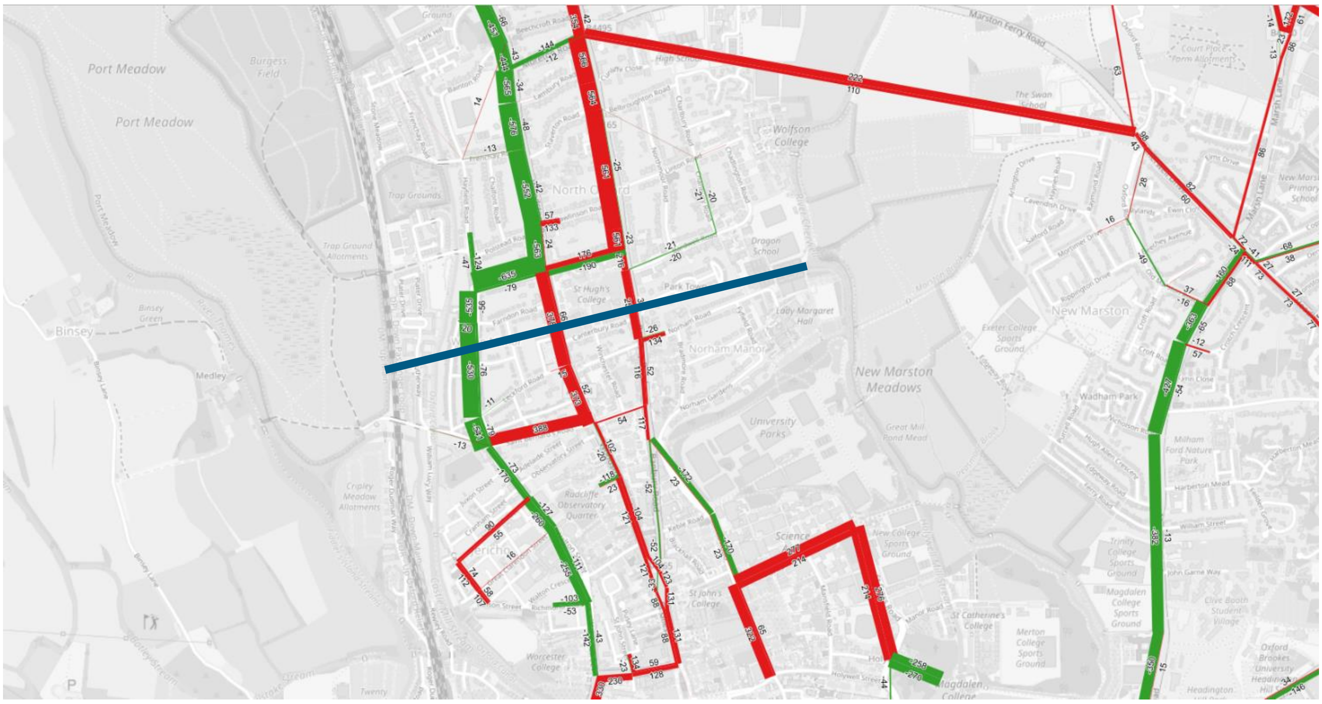


**Figure 9-2 - Changes in routing between 2013 and 2018 models – Inner Cordon – PM peak hour**

Table 9-2 shows the comparison of the observed and modelled data for the Outer Cordon. There are some significant changes on Banbury Rd and Woodstock Rd (blue rows in the table below) which are mainly due to re-routing, not changes in demand, as can be seen in Figure 9-3. By aggregating these two rows together (similar to a screenline), the changes between 2013 and 2019 are significantly closer to the observed ones. For all sites together, the difference between observed and modelled is not high. A similar situation happens for Abingdon Rd and Botley Rd (orange rows in the table below) which are also due to re-routing, not changes in demand. However, this is less obvious from a simple flow difference plot (see Figure 9-4). This specific issue has been analysed in detail during the 2018 calibration.

**Table 9-2 - Comparison of growth of car trips at the Outer Cordon**

| Site | % Change (observed) | | | | % Change (modelled) | | | |
|---|---|---|---|---|---|---|---|---|
| | 0800 - 0900 | 1100 - 1200 | 1700 - 1800 | 0700 - 1900 | 0800 - 0900 | Average IP | 1700 - 1800 | 0700 - 1900 |
| Banbury Road | -2% | -8% | 32% | 2% | -28% | -7% | -21% | N/A |
| Marsh Lane | 6% | -9% | -11% | -8% | 16% | 15% | 6% | N/A |
| The Slade | -2% | 8% | 1% | 4% | -1% | -3% | 7% | N/A |
| Garsington Road | 19% | 3% | -4% | -1% | 8% | 4% | 7% | N/A |
| Rose Hill | 8% | 8% | 10% | 10% | 7% | 5% | 21% | N/A |
| Abingdon Road | -37% | -27% | -27% | -28% | -3% | 0% | -7% | N/A |
| Botley Road | 10% | 2% | 3% | 3% | 13% | 12% | 20% | N/A |
| Woodstock Road | 10% | 7% | -1% | 8% | 41% | 16% | -8% | N/A |
| All sites | 0% | -3% | -2% | -2% | 6% | 6% | 3% | N/A |
| Banbury Rd + Woodstock Rd | 4% | -1% | 13% | 5% | 7% | 6% | -13% | N/A |
| Abingdon Rd + Botley Rd | -16% | -12% | -12% | -12% | 5% | 6% | 6% | N/A |

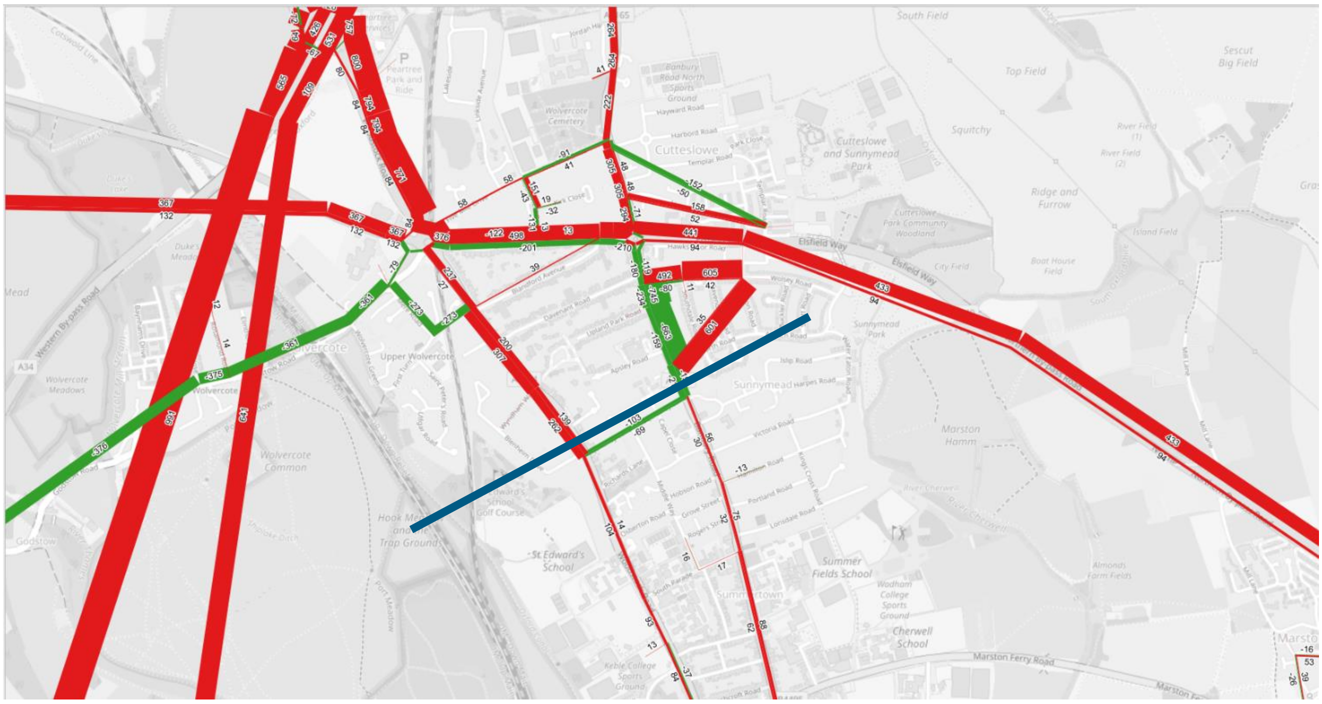



**Figure 9-3 - Changes in routing between 2013 and 2018 models – Woodstock Rd & Banbury Rd – AM peak hour**


**Figure 9-4 - Changes in routing between 2013 and 2018 models – Botley Rd & Abingdon Rd – AM peak hour**

All the coding aspects that influenced the routing (as detailed above) have been addressed during the calibration process that followed. In most cases, the solution was down to signal timing optimisations.

# 10. Highway Trip Matrix Development

This chapter summarises the approach adopted in previous model versions to improve the base year trip matrices, followed by further revisions specifically for the update to model Oxford schemes.

## 10.1. Background to Matrix Building Methodology

The 2018 Present Year Validation (PYV) matrices were used as the starting point for developing the 2018 Oxford model matrices. Additional information on how this scenario was built can be found in the report "OSM HAM Development Report - Review2021 - Rev 4.0" issued in January 2021.

The 2018 PYV matrices were not representing the right level of demand in Oxford City. This task was undertaken prior to the current study A first step in calibration was undertaken in April 2021 and Matrix Estimation (ME) was used for all time periods. The impact of ME was shown to be within TAG requirements in terms of a number of criteria such as matrix totals, trip ends, cell values and trip length distribution.

A summary of the benchmark of criteria reviewed to check the extent of the changes due to ME is given in the table below. Overall, the matrices broadly meet all criteria across all time periods.

**Table 10-1 - Matrix assessment summary (all vehicles)**

| Measure | Significance Criteria | AM | Inter Peak | PM |
|---|---|---|---|---|
| Matrix zonal cell levels | Slope within 0.98<Slope<1.02 | Criteria met | Criteria met | Criteria met |
| | Intercept near zero | Criteria met | Criteria met | Criteria met |
| | $R^2$ in excess of 0.95 | Criteria met | 0.94 | Criteria met |
| Matrix zonal trip ends | Slope within 0.99<Slope<1.01 | Criteria met | Criteria almost met (0.97) | Criteria almost met (0.98) |
| | Intercept near zero | Criteria met | Criteria met | Criteria met |
| | $R^2$ in excess of 0.98 | Criteria met | Criteria met | Criteria met |
| Trip length distributions (trips less than 150km) | Means within 5% | Criteria met | Criteria almost met (5.6%) | Criteria met |
| | Standard deviations within 5% | Criteria met | Criteria met | Criteria not met |
| Sector to sector level matrices | Differences within 5% | n/a | n/a | n/a |

## 10.2. Select Link Infilling

When the present study started, it was felt that further improvement of the calibration was needed, but it was considered more proportionate to undertake selective matrix adjustment than a full matrix estimation (ME). This is especially because it is not prudent to carry out full ME on a matrix that was already subjected to ME. Hence it was agreed to update the demand using select link analysis (SLA) across the model area.

Some modelled links were selected to carry out the SLA adjustment. Those selected links were at the same locations as the observed link counts. For this reason, the observed data was used for calibration only. No additional data was available to also undertake a validation exercise.

The adjustment factors were calculated based on the post-ME flows on those links and the observed counts. These factors were specific to each of the adjusted links and were applied to the demand matrix that resulted from the select link analysis done on the post-ME network.

The matrix totals before and after applying the adjustment factors for all three time periods are presented in

Table 10-2 below. Most changes were within 4%, except for HGV in the PM peak and LGV in the AM and PM peaks.

**Table 10-2 - 2018 Model Update Matrix Totals**

| | | Time Period | | |
|---|---|---|---|---|
| | | **AM** | **Inter Peak** | **PM** |
| **Car** | Prior (PYV) | 96,752 | 70,306 | 114,446 |
| | Post-ME | 95,604 | 70,418 | 114,424 |
| | Post-SLA | 95,418 | 69,439 | 112,388 |
| | % Change to PYV | -1% | -1% | -2% |
| | % Change to post-ME | 0% | -1% | -2% |
| **LGV** | Prior (PYV) | 13,293 | 9,633 | 10,147 |
| | Post-ME | 13,357 | 10,044 | 10,261 |
| | Post-SLA | 12,458 | 9,793 | 9,522 |
| | % Change to PYV | -6% | 2% | -6% |
| | % Change to post-ME | -7% | -2% | -7% |
| **HGV** | Prior (PYV) | 7,219 | 6,414 | 3,429 |
| | Post-ME | 7,240 | 6,700 | 3,400 |
| | Post-SLA | 6,970 | 6,605 | 3,130 |
| | % Change to PYV | -3% | 3% | -9% |
| | % Change to post-ME | -4% | -1% | -8% |
| **Total** | Prior (PYV) | 117,264 | 86,353 | 128,022 |
| | Post-ME | 116,201 | 87,162 | 128,085 |
| | Post-SLA | 114,846 | 85,837 | 125,040 |
| | % Change to PYV | -2% | -1% | -2% |
| | % Change to post-ME | -1% | -2% | -2% |

# 11. Highway Model Calibration

Model Calibration refers to the process of refining and confirming the values of model parameters and improving origin-destination movements in the demand matrices to improve the overall model performance by benchmarking against the data collated as part of this study.

## 11.1. Calibration for Oxford Model Updates

For the Oxford model update, all the available counts were used as link level calibration counts.

As a part of journey time validation, 4 two-way journey time routes were selected to cover the main strategic routes in the study area.

## 11.2. Calibration Procedure

The calibration procedure involved a series of steps designed to improve the performance of the model and ensure it simulates observed 2018 traffic flows. Calibration procedures included the following steps:

- Ensuring network characteristics, such as free-flow speeds and signal phases/timings represent observed conditions;
- Ensuring capacity controls such as speed-flow curves, saturation flows and turn capacities were appropriate to simulate observed conditions;
- Checking the routing of vehicles in the model by verifying routes from the highway model against internet-based route planners.

Each of the above are presented in the following sections. The final section presents the levels of model convergence achieved.

## 11.3. Flow Calibration Results

Table 11-1 shows the results of individual links used in the calibration process which meet TAG criteria for each time period.

**Table 11-1 - Link Calibration Summary**

| Time Period | Inside City Centre Counts passing TAG Criteria | Inner Cordon Boundary Counts passing TAG Criteria | Outer Cordon Boundary Counts passing TAG Criteria | Ad Hoc Links passing TAG Criteria | Total Links passing TAG Criteria |
|---|---|---|---|---|---|
| AM Peak | 100% | 94% | 100% | 94% | 96% |
| Inter Peak | 100% | 100% | 100% | 94% | 98% |
| PM Peak | 100% | 100% | 100% | 94% | 98% |

All the three peaks exceed TAG flow criteria of 85% of links passing with the Inter Peak and PM reaching 98% and AM peak with 96%. Appendix A presents the results of all individual links used in calibration.

Figure 11-1 to Figure 11-3 present the calibration links that are passing/failing the TAG criteria. In all time periods, the link North on Wolvercote Roundabout towards Peartree Interchange fails. However, priority was given during the calibration to the links located inside the ring road, in this specific case, Woodstock Road south of Wolvercote Roundabout.

In AM peak, Magdalen Bridge also fails. Given that the other links in the area pass, it is probable that problem appears due to the spatial distribution of the trips in the area and not the total number of trips. Additionally, the GEH for this particular link is 5.9 so it's failing by a small margin.


**Figure 11-1 - Link Flow Calibration - AM Peak**

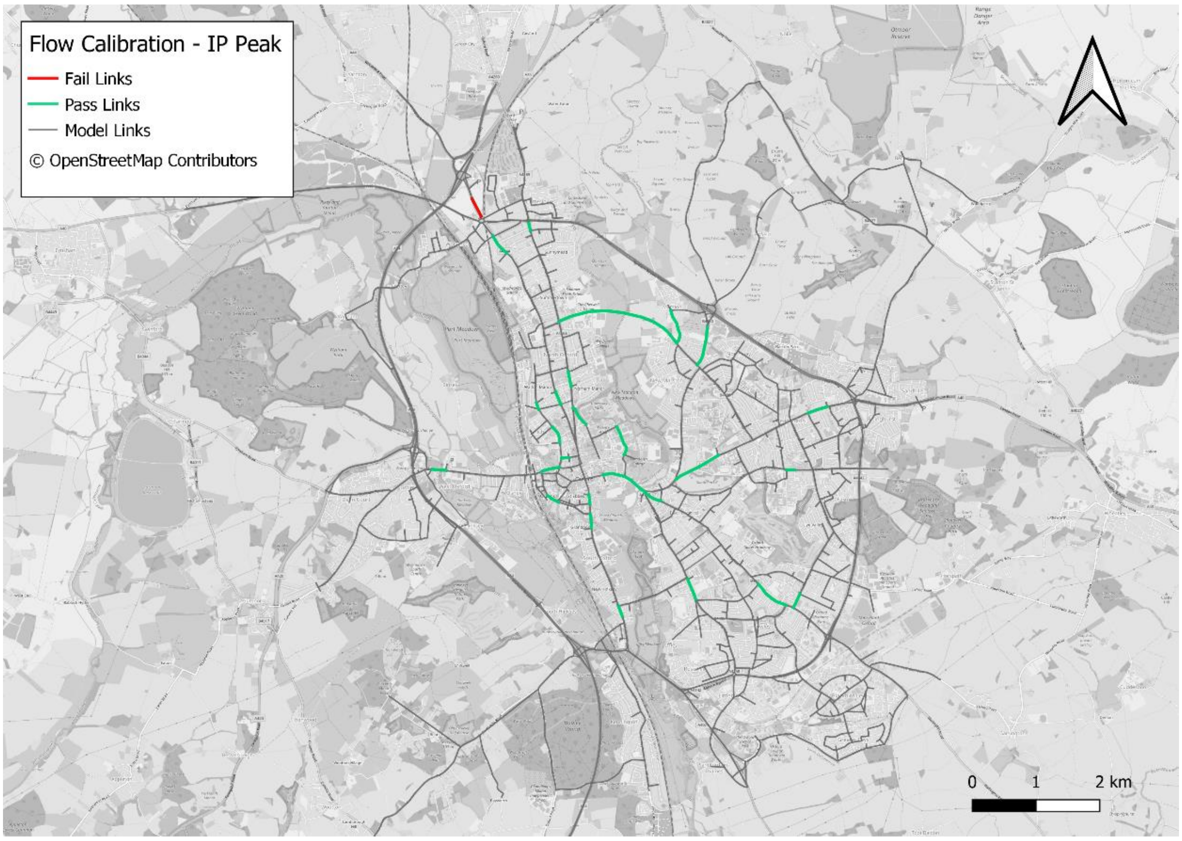



**Figure 11-2 - Link Flow Calibration - Inter Peak**


**Figure 11-3 - Link Flow Calibration - PM Peak**

## 11.4. Journey Time Validation

As described in Section 6.4, all journey time routes were validated against 2018 TomTom journey time data. The journey time routes are originally shown in Figure 6-3 and repeated below for ease of reference.

Modelled journey times are compared against observed data in each of the modelled periods. Summaries of the observed and modelled journey time comparisons for each route are provided for the AM peak, Inter-peak and PM Peak from Table 9-2 to Table 9-4. Time-distance plots for all routes, directions and time periods are presented in Appendix B.

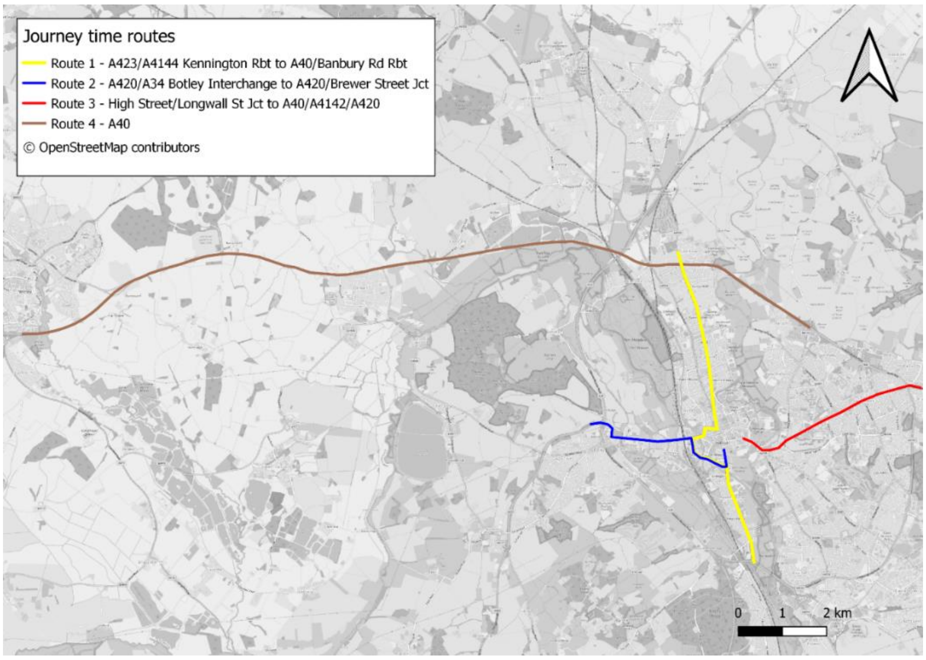



**Figure 11-4 - Journey Time Routes**

**Table 11-2 - AM Peak Journey Time Validation Summary**

| Journey Time Route | Route Name | Direction | Observed (mins) | Obs +15% | Obs - 15% | Modelled (mins) | Pass/Fail |
|---|---|---|---|---|---|---|---|
| Route 1 | A423/A4144 Kennington Rbt to A40/Banbury Rd Rbt | NB | 22 | 25 | 18 | 20 | Pass |
| | | SB | 20 | 23 | 17 | 17. | Pass |
| Route 2 | A420/A34 Botley Interchange to A420/Brewer Street Jct | EB | 12 | 13 | 10 | 12 | Pass |
| | | WB | 8 | 9 | 7 | 9 | Pass |
| Route 3 | High Street/Longwall St Jct to A40/A4142/A420 | EB | 9 | **10.67** | 8 | **10.83** | Criteria almost met |
| | | WB | 15 | 17 | **12.45** | **12.38** | Criteria almost met |
| Route 4 | A40 | EB | 28 | 33 | 24 | 23 | Fail |
| | | WB | 24 | 27 | 20 | 20 | Pass |

**Table 11-3 - Inter Peak Journey Time Validation Summary**

| Journey Time Route | Route Name | Direction | Observed | Obs +15% | Obs - 15% | Modelled | Pass/Fail |
|---|---|---|---|---|---|---|---|
| Route 1 | A423/A4144 Kennington Rbt to A40/Banbury Rd Rbt | NB | 16 | 19 | 14 | 18 | Pass |
| | | SB | 17 | 20 | 15 | 19 | Pass |
| Route 2 | A420/A34 Botley Interchange to A420/Brewer Street Jct | EB | 8 | 9 | 7 | 10 | Fail |
| | | WB | 8 | 9 | 7 | 10 | Fail |
| Route 3 | High Street/Longwall St Jct to A40/A4142/A420 | EB | 9 | **10.36** | 8 | **10.52** | Criteria almost met |
| | | WB | 10 | **11.11** | 8 | **11.38** | Criteria almost met |
| Route 4 | A40 | EB | 18 | 21 | 15 | 20 | Pass |
| | | WB | 18 | 20 | 15 | 20 | Pass |

**Table 11-4 - PM Peak Journey Time Validation Summary**

| Journey Time Route | Route Name | Direction | Observed | Obs +15% | Obs - 15% | Modelled | Pass/Fail |
|---|---|---|---|---|---|---|---|
| Route 1 | A423/A4144 Kennington Rbt to A40/Banbury Rd Rbt | NB | 20 | 23 | 17 | 18 | Pass |
| | | SB | 21 | 25 | 18 | 19 | Pass |
| Route 2 | A420/A34 Botley Interchange to A420/Brewer Street Jct | EB | 9 | 10 | 7 | 9 | Pass |
| | | WB | 11 | 12 | 9 | 10 | Pass |
| Route 3 | High Street/Longwall St Jct to A40/A4142/A420 | EB | 16 | 18 | 13 | 11 | Fail |
| | | WB | 13 | 14 | 11 | 12 | Pass |
| Route 4 | A40 | EB | 24 | 27 | **20.18** | **19.83** | Criteria almost met |
| | | WB | 32 | 37 | 28 | 19 | Fail |

As detailed in the above tables, the modelled journey time routes perform relatively well against TAG criteria for journey time validation, (of 85% within +-15%), by achieving 88% in the AM and 75% in both IP and PM.

## 11.5. Turning movement calibration

The ANPR data was used for the calibration of the turning movements at both ends of Marston Ferry Road, although this is not a requirement for a strategic model of this size. It was assumed that the unmatched trips, i.e. only the entry or the exit was matched with an ANPR camera, started or finished at a zone located in between the cameras. Given the high percentage of unmatched trips, this additional step introduces a degree of uncertainty regarding the observed flows.

**Table 11-5 - Results of turning movements calibration - AM peak hour**

| ANPR | | Turn type | Direction | Observed Counts | | | | Modelled Flow | | | | DMRB | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From | To | | | Car | LGV | HGV | Total | Total | Diff | % Diff | GEH | Flow | GEH |
| 17 | 13 | Left | WB | 271 | 34 | 23 | 328 | 261 | -67 | -20% | 3.9 | ✓ | ✓ |
| 17 | 12_1 | Straight | WB | 94 | 9 | 6 | 109 | 96 | -12 | -11% | 1.2 | ✓ | ✓ |
| 17 | 2 | Right | WB | 65 | 7 | 5 | 77 | 74 | -3 | -4% | 0.4 | ✓ | ✓ |
| 13 | 12_1 | Left | NB | 63 | 1 | 1 | 65 | 41 | -24 | -36% | 3.2 | ✓ | ✓ |
| 13 | 2 | Straight | NB | 164 | 18 | 12 | 193 | 462 | 269 | 139% | 14.8 | ✗ | ✗ |
| 13 | 17 | Right | NB | 202 | 32 | 22 | 255 | 182 | -73 | -29% | 5.0 | ✓ | ✓ |
| 2 | 17 | Left | SB | 169 | 14 | 9 | 192 | 88 | -104 | -54% | 8.8 | ✗ | ✗ |
| 2 | 13 | Straight | SB | 372 | 55 | 37 | 464 | 401 | -63 | -14% | 3.0 | ✓ | ✓ |
| 2 | 12_1 | Right | SB | 128 | 10 | 7 | 145 | 0 | -145 | -100% | 17.0 | ✗ | ✗ |
| 12 | 1 | Straight | NB | 244 | 21 | 14 | 279 | 291 | 12 | 4% | 0.7 | ✓ | ✓ |
| 12 | 2_17_13 | Right | NB | 153 | 26 | 17 | 196 | 123 | -73 | -37% | 5.8 | ✓ | ✗ |
| 1 | 2_17_13 | Left | SB | 170 | 28 | 19 | 217 | 86 | -131 | -60% | 10.6 | ✗ | ✗ |
| 1 | 12 | Straight | SB | 358 | 34 | 23 | 415 | 545 | 130 | 31% | 5.9 | ✗ | ✗ |

**Table 11-6 - Results of turning movements calibration – IP average hour**

| ANPR | | Turn type | Direction | Observed Counts | | | | Modelled Flow | | | | DMRB | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From | To | | | Car | LGV | HGV | Total | Total | Diff | % Diff | GEH | Flow | GEH |
| 17 | 13 | Left | WB | 195 | 43 | 31 | 269 | 227 | -43 | -16% | 2.7 | ✓ | ✓ |
| 17 | 12_1 | Straight | WB | 74 | 19 | 14 | 106 | 105 | -2 | -2% | 0.2 | ✓ | ✓ |
| 17 | 2 | Right | WB | 64 | 12 | 9 | 85 | 120 | 35 | 41% | 3.5 | ✓ | ✓ |
| 13 | 12_1 | Left | NB | 34 | 11 | 8 | 54 | 40 | -14 | -26% | 2.1 | ✓ | ✓ |
| 13 | 2 | Straight | NB | 160 | 41 | 30 | 230 | 321 | 90 | 39% | 5.4 | ✓ | ✗ |
| 13 | 17 | Right | NB | 175 | 30 | 22 | 227 | 254 | 27 | 12% | 1.8 | ✓ | ✓ |
| 2 | 17 | Left | SB | 75 | 14 | 10 | 98 | 53 | -45 | -46% | 5.2 | ✓ | ✗ |
| 2 | 13 | Straight | SB | 237 | 55 | 40 | 332 | 219 | -112 | -34% | 6.8 | ✗ | ✗ |
| 2 | 12_1 | Right | SB | 49 | 11 | 8 | 69 | 0 | -69 | -100% | 11.8 | ✓ | ✗ |
| 12 | 1 | Straight | NB | 226 | 50 | 37 | 313 | 400 | 87 | 28% | 4.6 | ✓ | ✓ |
| 12 | 2_17_13 | Right | NB | 108 | 23 | 17 | 148 | 90 | -59 | -40% | 5.4 | ✓ | ✗ |
| 1 | 2_17_13 | Left | SB | 74 | 24 | 17 | 115 | 74 | -41 | -36% | 4.2 | ✓ | ✓ |
| 1 | 12 | Straight | SB | 219 | 41 | 30 | 291 | 348 | 57 | 20% | 3.2 | ✓ | ✓ |

Table 11-7 - Results of turning movements calibration - PM peak hour

| ANPR | | Turn type | Direction | Observed Counts | | | | Modelled Flow | | | | DMRB | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From | To | | | Car | LGV | HGV | Total | Total | Diff | % Diff | GEH | Flow | GEH |
| 17 | 13 | Left | WB | 217 | 8 | 2 | 227 | 287 | 60 | 26% | 3.7 | ✓ | ✓ |
| 17 | 12_1 | Straight | WB | 101 | 15 | 5 | 120 | 106 | -15 | -12% | 1.4 | ✓ | ✓ |
| 17 | 2 | Right | WB | 139 | 13 | 4 | 157 | 117 | -40 | -25% | 3.4 | ✓ | ✓ |
| 13 | 12_1 | Left | NB | 59 | 3 | 1 | 63 | 52 | -10 | -16% | 1.4 | ✓ | ✓ |
| 13 | 2 | Straight | NB | 211 | 19 | 6 | 236 | 467 | 231 | 98% | 12.3 | × | × |
| 13 | 17 | Right | NB | 234 | 17 | 5 | 257 | 300 | 43 | 17% | 2.6 | ✓ | ✓ |
| 2 | 17 | Left | SB | 82 | 11 | 3 | 97 | 31 | -66 | -68% | 8.2 | ✓ | × |
| 2 | 13 | Straight | SB | 314 | 23 | 7 | 345 | 227 | -118 | -34% | 7.0 | × | × |
| 2 | 12_1 | Right | SB | 65 | 2 | 1 | 68 | 0 | -68 | -100% | 11.6 | ✓ | × |
| 12 | 1 | Straight | NB | 292 | 22 | 7 | 321 | 356 | 35 | 11% | 1.9 | ✓ | ✓ |
| 12 | 2_17_13 | Right | NB | 172 | 15 | 5 | 192 | 92 | -100 | -52% | 8.4 | ✓ | × |
| 1 | 2_17_13 | Left | SB | 85 | 13 | 4 | 102 | 57 | -45 | -44% | 5.0 | ✓ | × |
| 1 | 12 | Straight | SB | 290 | 17 | 5 | 312 | 339 | 28 | 9% | 1.5 | ✓ | ✓ |

## 11.6. Assignment Convergence

The convergence statistics for each modelled time period is summarised below in Table 11-8. Acceptable convergence criteria statistics in line with TAG criteria (see section 5.4) have been achieved are described below:

- Flow Change (%) – Percentage of link Flows differing by < 1% between assignment-simulation loops;
- Delay Change (%) – Turn delays differing by < 1% between assignment and simulation;
- Gap (%) – Wardrop Equilibrium Gap Function post simulation;
- Assignment Convergence – Delta Function (%) / Number of iterations;
- Simulation Convergence – Final average absolute change in CFP (PCU/hr) / Number of iterations; and
- VI (%) – Variational inequality (Should be > 0)

**Table 11-8 - Model Convergence Summary**

| Time Period | Iteration | Flow Change (%) | Delay Change (%) | % Gap | Assignment Convergence | Simulation Convergence | VI (%) |
|---|---|---|---|---|---|---|---|
| AM | 25 | 98.7 | 99.6 | 0.01 | 0.0091/10 | 0.028/3 | 0.00074 |
| | 26 | 98.8 | 99.6 | 0.0086 | 0.0091/10 | 0.031/3 | 0.00067 |
| | 27 | 99.1 | 99.7 | 0.01 | 0.0106/10 | 0.028/3 | 0.00049 |
| | 28 | 99.2 | 99.6 | 0.0069 | 0.0071/10 | 0.026/3 | 0.00048 |
| IP | 14 | 98.7 | 99.8 | 0.0041 | 0.0035/10 | 0.017/7 | 0.00019 |
| | 15 | 98.7 | 99.8 | 0.0044 | 0.0025/10 | 0.014/7 | 0.00007 |
| | 16 | 99 | 99.8 | 0.0031 | 0.0023/10 | 0.015/7 | 0.0001 |
| | 17 | 99.3 | 99.9 | 0.0022 | 0.0026/10 | 0.013/7 | 0.00008 |
| PM | 19 | 98.6 | 99.5 | 0.0056 | 0.0043/10 | 0.052/4 | 0.0007 |
| | 20 | 98.8 | 99.6 | 0.0099 | 0.0048/10 | 0.040/3 | -0.00041 |
| | 21 | 98.7 | 99.6 | 0.0055 | 0.0063/10 | 0.038/7 | 0.00043 |
| | 22 | 98.8 | 99.6 | 0.0051 | 0.0036/10 | 0.044/4 | 0.00051 |

# 12. Public Transport Assignment Model Update

## 12.1. Network update

The road network used in OSM PTM is identical in scope and network structure to the OSM HAM. Additionally, PTM includes a rail network, which is totally independent of the HAM network.

Bus routes coded in the 2013 OSM remain unchanged in the newly created 2018 base year. The main change to the rail network was the opening of the Oxford Parkway station and the start of the service between Oxford and London Marylebone through Bicester.

## 12.2. Demand update

An update of the public transport model was also undertaken to bring it to a 2018 base year. As with the network, the starting point was the bus and rail matrices from the 2013 base year. To obtain the 2018 demand matrices, NTEM growth factors were applied. The factors are differentiated by mode, purpose and sector. Table 12-1 shows the comparison of the aggregated demand for each of the two years, separated by mode. The tables in Appendix C show the growth factors used to arrive at the 2018 demand.

**Table 12-1 - Comparison of matrix totals for bus and rail (Passengers)**

| | | AM peak hour | Inter Peak | PM peak hour |
|---|---|---|---|---|
| Bus | 2013 | 10,688 | 7,807 | 10,306 |
| | 2018 | 9,616 | 7,052 | 9,228 |
| | Change | -10% | -10% | -10% |
| Rail | 2013 | 3,955 | 1,637 | 4,477 |
| | 2018 | 4,236 | 1,914 | 4,870 |
| | Change | 7% | 17% | 9% |

Comparisons have also been made with 2019 data on bus journeys in Oxford. The conclusions of the comparison were:

- A recent analysis of the P&R demand in 2018 (see Chapter 11) showed that OSM is reasonably close to the observed counts;
- The zones representing John Radcliffe Hospital and Oxford Brookes University show a higher number of trips ending there in OSM compared with the 2019 data;
- In the city centre there are differences in the allocation of trips to particular city centre zones. However, given their proximity and pedestrian connectivity, this is unlikely to have an impact on the assignment results;
- PTAM provides a reasonable representation for 2018 bus travel and does not require any additional adjustments.

## 12.3. Assignment

All parameters used for assignment (wait time weight, access time weight, etc.) and the type of assignment remained unchanged from the 2013 model. A detailed description can be found in “OSM Public Transport Model Report - Update_Jan2021_v5.3 final”, issued in April 2021.

## 12.4. Fares

The fares for each mode in 2018 have been estimated by applying real term increases to the 2013 fares. These factors have been based on the analysis of the fares undertaken as part of the A40 FBC study. More details can be found in "OSM Forecasting Report - Update_May2021_v1.0.pdf", issued in May 2021.

# 13. P&R demand update

The Park and Ride data was recalibrated for 2018 to the observed data from P&R sites. OCC provided observed vehicle counts for all the existing P&R sites for 2018. Out of this data, three weeks in March (5th to 23rd of March 2018) were considered as "neutral month" and were used for calibration. For these 3 weeks, the 5-day average was used, given that OSM only models an average weekday.

During the peak hours, and over a 12-hour period, the model provides a good representation of P&R usage.

Table 13-1 to Table 13-4  show a comparison of observed entries and exits at the various sites and compares them with the 2018 modelled data. Greater attention should be given mainly to arrivals in the AM peak and departures in the PM, those being the material flow. At an hourly level, it can be observed that the number of cars using P&R sites compares very well with the counts, both for individual sites and at aggregated level. This implies that the model is producing the correct demand level at each site and thus gives confidence in model predictions.

During the peak hours, and over a 12-hour period, the model provides a good representation of P&R usage.

**Table 13-1 - Comparison of P&R demand - AM Peak (car leg)**

| P&R Site | Vehicles (per hour) (08:00 – 09:00) | | | | | | Vehicles (per period) (07:00 – 10:00) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OUT | | | IN | | | OUT | | | IN | | |
| | Obs. | Model | Diff. | Obs. | Model | Diff. | Obs. | Model | Diff. | Obs. | Model | Diff. |
| **Redbridge** | 15 | 16 | 1 | 213 | 216 | 3 | 45 | 41 | -3 | 539 | 551 | 13 |
| **Seacourt** | 7 | 6 | -1 | 280 | 282 | 3 | 17 | 14 | -3 | 614 | 722 | 107 |
| **Peartree** | 9 | 10 | 2 | 182 | 179 | -3 | 20 | 26 | 6 | 462 | 457 | -5 |
| **Water Eaton** | 18 | 15 | -3 | 232 | 234 | 1 | 57 | 37 | -20 | 648 | 597 | -51 |
| **Thornhill** | 33 | 33 | 0 | 164 | 161 | -3 | 91 | 85 | -6 | 452 | 412 | -40 |
| **Total** | 82 | 80 | -2 | 1,070 | 1,071 | 1 | 231 | 204 | -27 | 2,715 | 2,740 | 24 |

### Table 13-2 - Comparison of P&R demand - IP Peak (car leg)

| P&R Site | Vehicles (per hour) Average hour | | | | | | Vehicles (per period) (10:00 – 16:00) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OUT | | | IN | | | OUT | | | IN | | |
| | Obs. | Model | Diff. | Obs. | Model | Diff. | Obs. | Model | Diff. | Obs. | Model | Diff. |
| **Redbridge** | 53 | 56 | 3 | 51 | 50 | -1 | 318 | 338 | 20 | 303 | 300 | -3 |
| **Seacourt** | 35 | 39 | 4 | 25 | 25 | -0 | 212 | 233 | 21 | 149 | 147 | -2 |
| **Peartree** | 38 | 40 | 2 | 38 | 40 | 2 | 229 | 242 | 13 | 227 | 240 | 13 |
| **Water Eaton** | 58 | 57 | -2 | 67 | 61 | -6 | 350 | 340 | -10 | 402 | 368 | -34 |
| **Thornhill** | 47 | 45 | -1 | 49 | 47 | -2 | 279 | 271 | -9 | 294 | 282 | -12 |
| **Total** | 231 | 237 | 6 | 229 | 223 | -7 | 1,388 | 1,424 | 36 | 1,376 | 1,337 | -39 |

### Table 13-3 - Comparison of P&R demand - PM Peak (car leg)

| P&R Site | Vehicles (per hour) (17:00 – 18:00) | | | | | | Vehicles (per period) (16:00 – 19:00) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OUT | | | IN | | | OUT | | | IN | | |
| | Obs. | Model | Diff. | Obs. | Model | Diff. | Obs. | Model | Diff. | Obs. | Model | Diff. |
| **Redbridge** | 205 | 211 | 5 | 25 | 22 | -3 | 520 | 537 | 17 | 72 | 57 | -14 |
| **Seacourt** | 224 | 221 | -3 | 11 | 12 | 1 | 537 | 562 | 26 | 28 | 31 | 2 |
| **Peartree** | 188 | 173 | -15 | 11 | 16 | 5 | 440 | 441 | 1 | 34 | 40 | 7 |
| **Water Eaton** | 208 | 215 | 7 | 31 | 31 | 0 | 560 | 549 | -11 | 85 | 79 | -6 |
| **Thornhill** | 72 | 72 | -0 | 27 | 28 | 1 | 204 | 182 | -21 | 76 | 71 | -5 |
| **Total** | 897 | 891 | -6 | 105 | 109 | 4 | 2,260 | 2,272 | 12 | 295 | 279 | -16 |

### Table 13-4 - Comparison of P&R demand – 12-hour period (car leg)

| P&R Site | Vehicles (per period) (07:00 – 19:00) | | | | | |
|---|---|---|---|---|---|---|
| | OUT | | | IN | | |
| | Obs. | Model | Diff. | Obs. | Model | Diff. |
| **Redbridge** | 883 | 916 | 34 | 914 | 909 | -5 |
| **Seacourt** | 766 | 810 | 44 | 792 | 900 | 108 |
| **Peartree** | 689 | 710 | 21 | 722 | 737 | 15 |
| **Water Eaton** | 967 | 926 | -41 | 1,136 | 1,044 | -91 |
| **Thornhill** | 574 | 538 | -36 | 823 | 765 | -58 |
| **Total** | 3,879 | 3,900 | 22 | 4,386 | 4,355 | -31 |

# Appendices

# Appendix A. Individual Counts Calibration

## A.1. Individual Counts Calibration – AM Peak

| Location | Direction | Link ID | Obs. | Mod. | Diff | % Diff | GEH | Flow | GEH |
|---|---|---|---|---|---|---|---|---|---|
| OXFORD ST.ALDATES NORTH OF SPEEDWELL STREET | NB | 20080-85019 | 191 | 174 | -17 | -9% | 1.3 | ✓ | ✓ |
| OXFORD ST.ALDATES NORTH OF SPEEDWELL STREET | SB | 85019-20080 | 186 | 148 | -38 | -21% | 3.0 | ✓ | ✓ |
| A420 OXFORD HIGH STREET ALL SOULS | EB | 20386-20385 | 155 | 160 | 4 | 3% | 0.3 | ✓ | ✓ |
| A420 OXFORD HIGH STREET ALL SOULS | WB | 20385-20386 | 162 | 231 | 70 | 43% | 5.0 | ✓ | ✓ |
| OXFORD ST.CROSS ROAD | NB | 20382-20381 | 453 | 545 | 92 | 20% | 4.1 | ✓ | ✓ |
| OXFORD ST.CROSS ROAD | SB | 20381-20382 | 444 | 371 | -73 | -16% | 3.6 | ✓ | ✓ |
| A4144 Beaumont Street | WB | 20291-20290 | 486 | 562 | 77 | 16% | 3.3 | ✓ | ✓ |
| A4144 Beaumont Street | EB | 20290-20291 | 545 | 469 | -76 | -14% | 3.4 | ✓ | ✓ |
| A420 OXPENS | NB | 85194-85198 | 609 | 557 | -52 | -9% | 2.2 | ✓ | ✓ |
| A420 OXPENS | SB | 85198-85194 | 462 | 500 | 39 | 8% | 1.8 | ✓ | ✓ |
| A420 OXFORD MAGDALEN BRIDGE | EB | 20385-20045 | 562 | 531 | -31 | -6% | 1.3 | ✓ | ✓ |
| A420 OXFORD MAGDALEN BRIDGE | WB | 20045-20385 | 963 | 788 | -174 | -18% | 5.9 | × | × |
| A4144 OXFORD FOLLY BRIDGE | NB | 20074-20075 | 629 | 566 | -64 | -10% | 2.6 | ✓ | ✓ |
| A4144 OXFORD FOLLY BRIDGE | SB | 20075-20074 | 369 | 424 | 55 | 15% | 2.8 | ✓ | ✓ |
| A4144 Oxford Woodstock Rd South of Leckford Rd | NB | 20360-85033 | 458 | 365 | -93 | -20% | 4.6 | ✓ | ✓ |
| A4144 Oxford Woodstock Rd South of Leckford Rd | SB | 85033-20360 | 479 | 455 | -25 | -5% | 1.1 | ✓ | ✓ |
| A4144 Oxford Woodstock Rd S of Blandford Ave | NB | 85059-20175 | 461 | 510 | 49 | 11% | 2.2 | ✓ | ✓ |
| A4144 Oxford Woodstock Rd S of Blandford Ave | SB | 20175-85059 | 752 | 800 | 48 | 6% | 1.7 | ✓ | ✓ |
| A4165 Oxford Banbury Rd North of Norham Rd | NB | 85037-20350 | 494 | 419 | -76 | -15% | 3.5 | ✓ | ✓ |

| Location | Direction | Link ID | Obs. | Mod. | Diff | % Diff | GEH | Flow | GEH |
|---|---|---|---|---|---|---|---|---|---|
| A4165 Oxford Banbury Rd North of Norham Rd | SB | 20350-85037 | 701 | 656 | -44 | -6% | 1.7 | ✓ | ✓ |
| A4165 Oxford Banbury Rd South of A40 | NB | 20155-20151 | 567 | 530 | -37 | -6% | 1.6 | ✓ | ✓ |
| A4165 Oxford Banbury Rd South of A40 | SB | 20151-20155 | 771 | 695 | -75 | -10% | 2.8 | ✓ | ✓ |
| Oxford Hythe Bridge Street | EB | 20091-20092 | 435 | 483 | 48 | 11% | 2.2 | ✓ | ✓ |
| Oxford Hythe Bridge Street | WB | 20092-20091 | 538 | 635 | 97 | 18% | 4.0 | ✓ | ✓ |
| Oxford Parks Road | NB | 20375-20370 | 430 | 398 | -33 | -8% | 1.6 | ✓ | ✓ |
| Oxford Parks Road | SB | 20370-20375 | 489 | 555 | 66 | 14% | 2.9 | ✓ | ✓ |
| Site 4, Walton Road, Oxford (Parking Sign) SP 50937 06815 | NB | 85011-20310 | 96 | 80 | -16 | -17% | 1.7 | ✓ | ✓ |
| Site 4, Walton Road, Oxford (Parking Sign) SP 50937 06815 | SB | 20310-85011 | 173 | 116 | -57 | -33% | 4.8 | ✓ | ✓ |
| B4150 Oxford Marsh Lane North of Horseman Close | NB | 20110-16140 | 463 | 497 | 34 | 7% | 1.6 | ✓ | ✓ |
| B4150 Oxford Marsh Lane North of Horseman Close | SB | 16140-20110 | 497 | 569 | 71 | 14% | 3.1 | ✓ | ✓ |
| A4144 Oxford Abingdon Rd South of Weirs Lane | NB | 20071-20070 | 468 | 562 | 94 | 20% | 4.1 | ✓ | ✓ |
| A4144 Oxford Abingdon Rd South of Weirs Lane | SB | 20070-20071 | 741 | 817 | 76 | 10% | 2.7 | ✓ | ✓ |
| A420 Oxford Botley Rd W of Seacourt Car Park | EB | 20240-20245 | 1237 | 1284 | 48 | 4% | 1.3 | ✓ | ✓ |
| A420 Oxford Botley Rd W of Seacourt Car Park | WB | 20245-20240 | 526 | 581 | 55 | 10% | 2.3 | ✓ | ✓ |
| Oxford Old Road | EB | 20430-20435 | 413 | 370 | -43 | -10% | 2.2 | ✓ | ✓ |
| Oxford Old Road | WB | 20435-20430 | 721 | 679 | -41 | -6% | 1.6 | ✓ | ✓ |
| Old Marston,Oxford Road North of Boults Lane | NB | 20520-20515 | 52 | 43 | -8 | -16% | 1.2 | ✓ | ✓ |
| Old Marston,Oxford Road North of Boults Lane | SB | 20515-20520 | 194 | 165 | -29 | -15% | 2.2 | ✓ | ✓ |
| Site 8, A4158, Oxford (LC 50) SP 52919 10169 | NB | 20896-85117 | 476 | 519 | 42 | 9% | 1.9 | ✓ | ✓ |
| Site 8, A4158, Oxford (LC 50) SP 52919 10169 | SB | 85117-20896 | 454 | 481 | 27 | 6% | 1.3 | ✓ | ✓ |
| B480 Oxford Rd near Temple Rd - ATC | EB | 20690-20055 | 332 | 377 | 45 | 14% | 2.4 | ✓ | ✓ |

| Location | Direction | Link ID | Obs. | Mod. | Diff | % Diff | GEH | Flow | GEH |
|---|---|---|---|---|---|---|---|---|---|
| B480 Oxford Rd near Temple Rd - ATC | WB | 20055-20690 | 412 | 436 | 24 | 6% | 1.2 | ✓ | ✓ |
| A420 London Road | WB | 85093-20595 | 479 | 435 | -44 | -9% | 2.1 | ✓ | ✓ |
| A420 London Road | EB | 20595-85093 | 461 | 480 | 19 | 4% | 0.9 | ✓ | ✓ |
| A44 SOUTH OF PEARTREE ROUNDABOUT | NB | 98203-97046 | 868 | 774 | -95 | -11% | 3.3 | ✓ | ✓ |
| A44 SOUTH OF PEARTREE ROUNDABOUT | SB | 97046-98203 | 1074 | 884 | -190 | -18% | 6.1 | × | × |
| B4495 MARSTON FERRY ROAD | EB | 21175-20520 | 401 | 397 | -5 | -1% | 0.2 | ✓ | ✓ |
| B4495 MARSTON FERRY ROAD | WB | 20520-21175 | 494 | 458 | -36 | -7% | 1.7 | ✓ | ✓ |
| Oxford, Kingston Rd South of Leckford Rd | NB | 20320-85031 | 102 | 76 | -26 | -25% | 2.7 | ✓ | ✓ |
| Oxford, Kingston Rd South of Leckford Rd | SB | 85031-20320 | 116 | 72 | -44 | -38% | 4.5 | ✓ | ✓ |
| A420 HEADINGTON RD E OF B4150 | EB | 20040-85075 | 304 | 296 | -9 | -3% | 0.5 | ✓ | ✓ |
| A420 HEADINGTON RD E OF B4150 | WB | 85075-20040 | 309 | 242 | -67 | -22% | 4.0 | ✓ | ✓ |
| Oxford Cowley Rd East of Dawson Street | EB | 20045-50007 | 215 | 168 | -47 | -22% | 3.4 | ✓ | ✓ |
| Oxford Cowley Rd East of Dawson Street | WB | 50007-20045 | 392 | 328 | -63 | -16% | 3.3 | ✓ | ✓ |
| Hollow Way | NB | 20050-20675 | 329 | 300 | -28 | -9% | 1.6 | ✓ | ✓ |
| Hollow Way | SB | 20675-20050 | 459 | 380 | -79 | -17% | 3.9 | ✓ | ✓ |

## A.2. Individual Counts Calibration – Inter Peak

| Location | Direction | Link ID | Obs. | Mod. | Diff | % Diff | GEH | Flow | GEH |
|---|---|---|---|---|---|---|---|---|---|
| OXFORD ST.ALDATES NORTH OF SPEEDWELL STREET | NB | 20080-85019 | 145 | 186 | 41 | 22% | 3.2 | ✓ | ✓ |
| OXFORD ST.ALDATES NORTH OF SPEEDWELL STREET | SB | 85019-20080 | 237 | 176 | -61 | -35% | 4.3 | ✓ | ✓ |
| A420 OXFORD HIGH STREET ALL SOULS | EB | 20386-20385 | 189 | 245 | 55 | 23% | 3.8 | ✓ | ✓ |
| A420 OXFORD HIGH STREET ALL SOULS | WB | 20385-20386 | 186 | 245 | 59 | 24% | 4.0 | ✓ | ✓ |
| OXFORD ST.CROSS ROAD | NB | 20382-20381 | 315 | 333 | 18 | 6% | 1.0 | ✓ | ✓ |
| OXFORD ST.CROSS ROAD | SB | 20381-20382 | 320 | 374 | 54 | 14% | 2.9 | ✓ | ✓ |
| A4144 Beaumont Street | WB | 20291-20290 | 431 | 411 | -20 | -5% | 1.0 | ✓ | ✓ |
| A4144 Beaumont Street | EB | 20290-20291 | 445 | 413 | -32 | -8% | 1.6 | ✓ | ✓ |
| A420 OXPENS | NB | 85194-85198 | 554 | 464 | -90 | -19% | 4.0 | ✓ | ✓ |
| A420 OXPENS | SB | 85198-85194 | 507 | 451 | -56 | -12% | 2.6 | ✓ | ✓ |
| A420 OXFORD MAGDALEN BRIDGE | EB | 20385-20045 | 577 | 618 | 41 | 7% | 1.7 | ✓ | ✓ |
| A420 OXFORD MAGDALEN BRIDGE | WB | 20045-20385 | 671 | 580 | -92 | -16% | 3.7 | ✓ | ✓ |
| A4144 OXFORD FOLLY BRIDGE | NB | 20074-20075 | 528 | 513 | -15 | -3% | 0.7 | ✓ | ✓ |
| A4144 OXFORD FOLLY BRIDGE | SB | 20075-20074 | 514 | 558 | 43 | 8% | 1.9 | ✓ | ✓ |
| A4144 Oxford  Woodstock Rd South of Leckford Rd | NB | 20360-85033 | 431 | 342 | -89 | -26% | 4.5 | ✓ | ✓ |
| A4144 Oxford  Woodstock Rd South of Leckford Rd | SB | 85033-20360 | 302 | 264 | -38 | -14% | 2.3 | ✓ | ✓ |
| A4144 Oxford Woodstock Rd S of Blandford Ave | NB | 85059-20175 | 466 | 526 | 60 | 11% | 2.7 | ✓ | ✓ |
| A4144 Oxford Woodstock Rd S of Blandford Ave | SB | 20175-85059 | 475 | 538 | 63 | 12% | 2.8 | ✓ | ✓ |
| A4165 Oxford Banbury Rd North of Norham Rd | NB | 85037-20350 | 478 | 510 | 32 | 6% | 1.4 | ✓ | ✓ |
| A4165 Oxford Banbury Rd North of Norham Rd | SB | 20350-85037 | 490 | 519 | 29 | 5% | 1.3 | ✓ | ✓ |
| A4165 Oxford Banbury Rd South of A40 | NB | 20155-20151 | 536 | 525 | -11 | -2% | 0.5 | ✓ | ✓ |

| Location | Direction | Link ID | Obs. | Mod. | Diff | % Diff | GEH | Flow | GEH |
|---|---|---|---|---|---|---|---|---|---|
| A4165 Oxford Banbury Rd South of A40 | SB | 20151-20155 | 466 | 432 | -34 | -8% | 1.6 | ✓ | ✓ |
| Oxford Hythe Bridge Street | EB | 20091-20092 | 427 | 484 | 57 | 12% | 2.7 | ✓ | ✓ |
| Oxford Hythe Bridge Street | WB | 20092-20091 | 454 | 534 | 80 | 15% | 3.6 | ✓ | ✓ |
| Oxford Parks Road | NB | 20375-20370 | 398 | 483 | 85 | 18% | 4.0 | ✓ | ✓ |
| Oxford Parks Road | SB | 20370-20375 | 390 | 410 | 20 | 5% | 1.0 | ✓ | ✓ |
| Site 4, Walton Road, Oxford (Parking Sign) SP 50937 06815 | NB | 85011-20310 | 83 | 81 | -2 | -2% | 0.2 | ✓ | ✓ |
| Site 4, Walton Road, Oxford (Parking Sign) SP 50937 06815 | SB | 20310-85011 | 136 | 121 | -15 | -13% | 1.4 | ✓ | ✓ |
| B4150 Oxford Marsh Lane North of Horseman Close | NB | 20110-16140 | 548 | 569 | 21 | 4% | 0.9 | ✓ | ✓ |
| B4150 Oxford Marsh Lane North of Horseman Close | SB | 16140-20110 | 498 | 517 | 19 | 4% | 0.9 | ✓ | ✓ |
| A4144 Oxford Abingdon Rd South of Weirs Lane | NB | 20071-20070 | 482 | 509 | 27 | 5% | 1.2 | ✓ | ✓ |
| A4144 Oxford Abingdon Rd South of Weirs Lane | SB | 20070-20071 | 734 | 770 | 36 | 5% | 1.3 | ✓ | ✓ |
| A420 Oxford Botley Rd W of Seacourt Car Park | EB | 20240-20245 | 842 | 770 | -72 | -9% | 2.5 | ✓ | ✓ |
| A420 Oxford Botley Rd W of Seacourt Car Park | WB | 20245-20240 | 938 | 962 | 24 | 2% | 0.8 | ✓ | ✓ |
| Oxford Old Road | EB | 20430-20435 | 487 | 478 | -9 | -2% | 0.4 | ✓ | ✓ |
| Oxford Old Road | WB | 20435-20430 | 476 | 444 | -32 | -7% | 1.5 | ✓ | ✓ |
| Old Marston,Oxford Road North of Boults Lane | NB | 20520-20515 | 95 | 83 | -12 | -14% | 1.3 | ✓ | ✓ |
| Old Marston,Oxford Road North of Boults Lane | SB | 20515-20520 | 120 | 89 | -31 | -35% | 3.0 | ✓ | ✓ |
| Site 8, A4158, Oxford (LC 50) SP 52919 10169 | NB | 20896-85117 | 442 | 494 | 52 | 11% | 2.4 | ✓ | ✓ |
| Site 8, A4158, Oxford (LC 50) SP 52919 10169 | SB | 85117-20896 | 499 | 495 | -4 | -1% | 0.2 | ✓ | ✓ |
| B480 Oxford Rd near Temple Rd - ATC | EB | 20690-20055 | 363 | 318 | -44 | -14% | 2.4 | ✓ | ✓ |
| B480 Oxford Rd near Temple Rd - ATC | WB | 20055-20690 | 387 | 377 | -10 | -3% | 0.5 | ✓ | ✓ |
| A420 London Road | WB | 85093-20595 | 485 | 463 | -21 | -5% | 1.0 | ✓ | ✓ |

| Location | Direction | Link ID | Obs. | Mod. | Diff | % Diff | GEH | Flow | GEH |
|---|---|---|---|---|---|---|---|---|---|
| A420 London Road | EB | 20595-85093 | 541 | 527 | -14 | -3% | 0.6 | ✓ | ✓ |
| A44 SOUTH OF PEARTREE ROUNDABOUT | NB | 98203-97046 | 1062 | 915 | -147 | -16% | 4.7 | ✓ | ✓ |
| A44 SOUTH OF PEARTREE ROUNDABOUT | SB | 97046-98203 | 1089 | 784 | -305 | -39% | 10.0 | × | × |
| B4495 MARSTON FERRY ROAD | EB | 21175-20520 | 445 | 424 | -22 | -5% | 1.0 | ✓ | ✓ |
| B4495 MARSTON FERRY ROAD | WB | 20520-21175 | 430 | 450 | 20 | 4% | 1.0 | ✓ | ✓ |
| Oxford, Kingston Rd South of Leckford Rd | NB | 20320-85031 | 116 | 125 | 9 | 7% | 0.8 | ✓ | ✓ |
| Oxford, Kingston Rd South of Leckford Rd | SB | 85031-20320 | 69 | 46 | -23 | -49% | 3.0 | ✓ | ✓ |
| A420 HEADINGTON RD E OF B4150 | EB | 20040-85075 | 227 | 250 | 22 | 9% | 1.4 | ✓ | ✓ |
| A420 HEADINGTON RD E OF B4150 | WB | 85075-20040 | 291 | 266 | -25 | -10% | 1.5 | ✓ | ✓ |
| Oxford Cowley Rd East of Dawson Street | EB | 20045-50007 | 259 | 221 | -38 | -17% | 2.5 | ✓ | ✓ |
| Oxford Cowley Rd East of Dawson Street | WB | 50007-20045 | 318 | 246 | -71 | -29% | 4.3 | ✓ | ✓ |
| Hollow Way | NB | 20050-20675 | 329 | 271 | -57 | -21% | 3.3 | ✓ | ✓ |
| Hollow Way | SB | 20675-20050 | 351 | 358 | 7 | 2% | 0.4 | ✓ | ✓ |

## A.3. Individual Counts Calibration – PM Peak

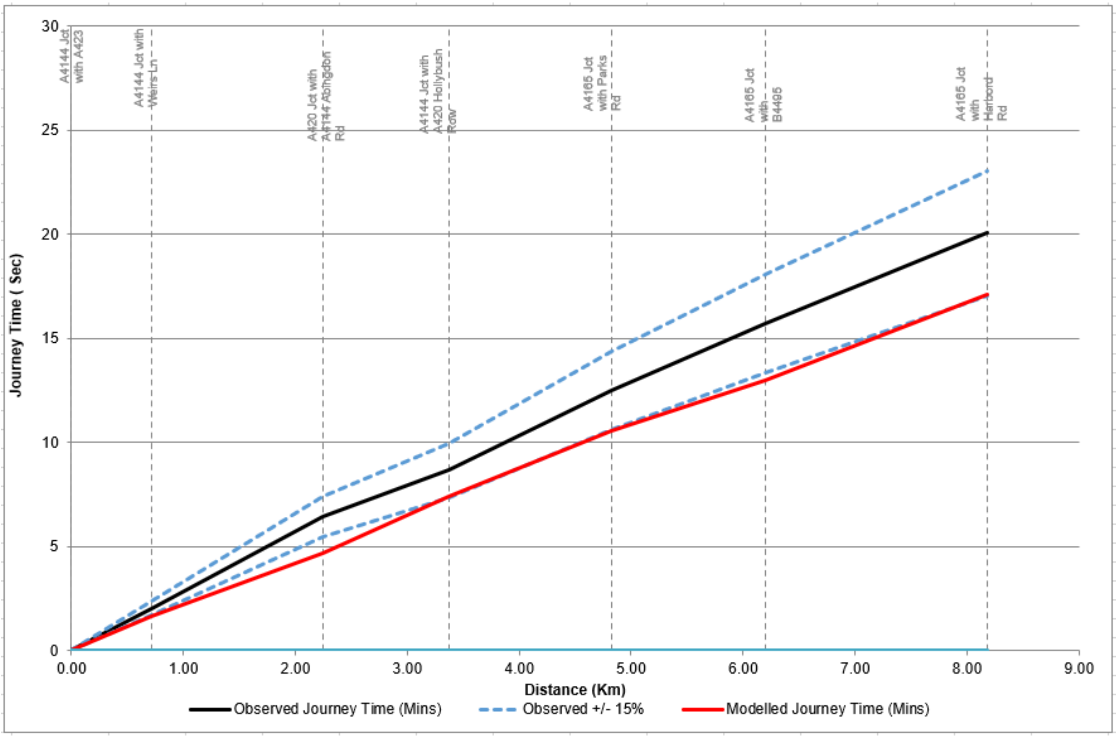
| Location | Direction | Link ID | Obs. | Mod. | Diff | % Diff | GEH | Flow | GEH |
|---|---|---|---|---|---|---|---|---|---|
| OXFORD ST.ALDATES NORTH OF SPEEDWELL STREET | NB | 20080-85019 | 149 | 180 | 30 | 17% | 2.4 | ✓ | ✓ |
| OXFORD ST.ALDATES NORTH OF SPEEDWELL STREET | SB | 85019-20080 | 229 | 239 | 10 | 4% | 0.6 | ✓ | ✓ |
| A420 OXFORD HIGH STREET ALL SOULS | EB | 20386-20385 | 206 | 212 | 7 | 3% | 0.5 | ✓ | ✓ |
| A420 OXFORD HIGH STREET ALL SOULS | WB | 20385-20386 | 186 | 221 | 35 | 16% | 2.5 | ✓ | ✓ |
| OXFORD ST.CROSS ROAD | NB | 20382-20381 | 384 | 441 | 57 | 13% | 2.8 | ✓ | ✓ |
| OXFORD ST.CROSS ROAD | SB | 20381-20382 | 397 | 427 | 30 | 7% | 1.5 | ✓ | ✓ |
| A4144 Beaumont Street | WB | 20291-20290 | 467 | 408 | -58 | -14% | 2.8 | ✓ | ✓ |
| A4144 Beaumont Street | EB | 20290-20291 | 459 | 434 | -25 | -6% | 1.2 | ✓ | ✓ |
| A420 OXPENS | NB | 85194-85198 | 477 | 458 | -19 | -4% | 0.9 | ✓ | ✓ |
| A420 OXPENS | SB | 85198-85194 | 520 | 489 | -31 | -6% | 1.4 | ✓ | ✓ |
| A420 OXFORD MAGDALEN BRIDGE | EB | 20385-20045 | 712 | 639 | -72 | -11% | 2.8 | ✓ | ✓ |
| A420 OXFORD MAGDALEN BRIDGE | WB | 20045-20385 | 736 | 641 | -95 | -15% | 3.6 | ✓ | ✓ |
| A4144 OXFORD FOLLY BRIDGE | NB | 20074-20075 | 420 | 390 | -29 | -8% | 1.5 | ✓ | ✓ |
| A4144 OXFORD FOLLY BRIDGE | SB | 20075-20074 | 550 | 517 | -33 | -6% | 1.4 | ✓ | ✓ |
| A4144 Oxford Woodstock Rd South of Leckford Rd | NB | 20360-85033 | 506 | 443 | -63 | -14% | 2.9 | ✓ | ✓ |
| A4144 Oxford Woodstock Rd South of Leckford Rd | SB | 85033-20360 | 300 | 230 | -70 | -30% | 4.3 | ✓ | ✓ |
| A4144 Oxford Woodstock Rd S of Blandford Ave | NB | 85059-20175 | 621 | 624 | 3 | 1% | 0.1 | ✓ | ✓ |
| A4144 Oxford Woodstock Rd S of Blandford Ave | SB | 20175-85059 | 550 | 622 | 72 | 12% | 3.0 | ✓ | ✓ |
| A4165 Oxford Banbury Rd North of Norham Rd | NB | 85037-20350 | 549 | 549 | -1 | 0% | 0.0 | ✓ | ✓ |
| A4165 Oxford Banbury Rd North of Norham Rd | SB | 20350-85037 | 491 | 507 | 16 | 3% | 0.7 | ✓ | ✓ |
| A4165 Oxford Banbury Rd South of A40 | NB | 20155-20151 | 749 | 676 | -74 | -11% | 2.8 | ✓ | ✓ |

| Location | Direction | Link ID | Obs. | Mod. | Diff | % Diff | GEH | Flow | GEH |
|---|---|---|---|---|---|---|---|---|---|
| A4165 Oxford Banbury Rd South of A40 | SB | 20151-20155 | 503 | 593 | 91 | 15% | 3.9 | ✓ | ✓ |
| Oxford Hythe Bridge Street | EB | 20091-20092 | 392 | 482 | 89 | 19% | 4.3 | ✓ | ✓ |
| Oxford Hythe Bridge Street | WB | 20092-20091 | 449 | 520 | 71 | 14% | 3.2 | ✓ | ✓ |
| Oxford Parks Road | NB | 20375-20370 | 454 | 529 | 75 | 14% | 3.4 | ✓ | ✓ |
| Oxford Parks Road | SB | 20370-20375 | 405 | 504 | 100 | 20% | 4.7 | ✓ | ✓ |
| Site 4, Walton Road, Oxford (Parking Sign) SP 50937 06815 | NB | 85011-20310 | 113 | 89 | -24 | -27% | 2.4 | ✓ | ✓ |
| Site 4, Walton Road, Oxford (Parking Sign) SP 50937 06815 | SB | 20310-85011 | 144 | 153 | 9 | 6% | 0.7 | ✓ | ✓ |
| B4150 Oxford Marsh Lane North of Horseman Close | NB | 20110-16140 | 949 | 1028 | 80 | 8% | 2.5 | ✓ | ✓ |
| B4150 Oxford Marsh Lane North of Horseman Close | SB | 16140-20110 | 512 | 475 | -38 | -8% | 1.7 | ✓ | ✓ |
| A4144 Oxford Abingdon Rd South of Weirs Lane | NB | 20071-20070 | 480 | 572 | 92 | 16% | 4.0 | ✓ | ✓ |
| A4144 Oxford Abingdon Rd South of Weirs Lane | SB | 20070-20071 | 926 | 990 | 64 | 6% | 2.1 | ✓ | ✓ |
| A420 Oxford Botley Rd W of Seacourt Car Park | EB | 20240-20245 | 683 | 598 | -85 | -14% | 3.4 | ✓ | ✓ |
| A420 Oxford Botley Rd W of Seacourt Car Park | WB | 20245-20240 | 1250 | 1148 | -103 | -9% | 3.0 | ✓ | ✓ |
| Oxford Old Road | EB | 20430-20435 | 672 | 671 | -1 | 0% | 0.0 | ✓ | ✓ |
| Oxford Old Road | WB | 20435-20430 | 444 | 352 | -92 | -26% | 4.6 | ✓ | ✓ |
| Old Marston,Oxford Road North of Boults Lane | NB | 20520-20515 | 87 | 65 | -22 | -34% | 2.5 | ✓ | ✓ |
| Old Marston,Oxford Road North of Boults Lane | SB | 20515-20520 | 120 | 110 | -9 | -8% | 0.9 | ✓ | ✓ |
| Site 8, A4158, Oxford (LC 50) SP 52919 10169 | NB | 20896-85117 | 532 | 604 | 72 | 12% | 3.0 | ✓ | ✓ |
| Site 8, A4158, Oxford (LC 50) SP 52919 10169 | SB | 85117-20896 | 588 | 548 | -41 | -7% | 1.7 | ✓ | ✓ |
| B480 Oxford Rd near Temple Rd - ATC | EB | 20690-20055 | 368 | 375 | 7 | 2% | 0.4 | ✓ | ✓ |
| B480 Oxford Rd near Temple Rd - ATC | WB | 20055-20690 | 451 | 367 | -85 | -23% | 4.2 | ✓ | ✓ |
| A420 London Road | WB | 85093-20595 | 342 | 374 | 32 | 9% | 1.7 | ✓ | ✓ |

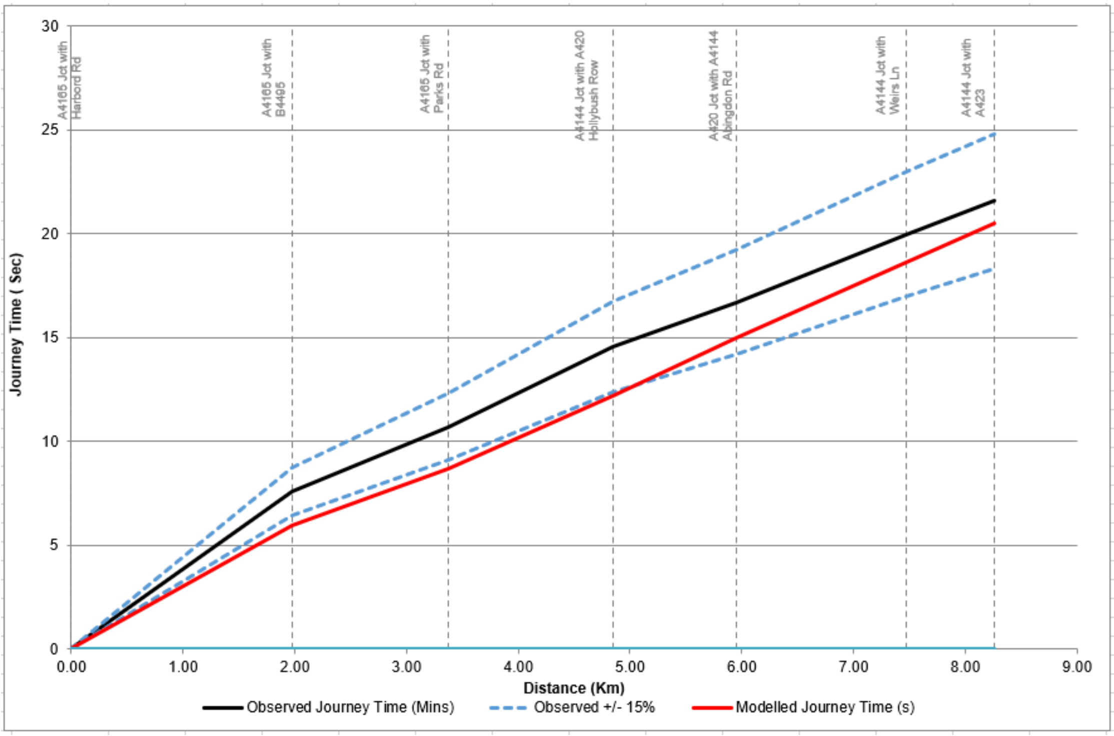
| Location | Direction | Link ID | Obs. | Mod. | Diff | % Diff | GEH | Flow | GEH |
|---|---|---|---|---|---|---|---|---|---|
| A420 London Road | EB | 20595-85093 | 358 | 324 | -34 | -11% | 1.8 | ✓ | ✓ |
| A44 SOUTH OF PEARTREE ROUNDABOUT | NB | 98203-97046 | 1239 | 980 | -259 | -26% | 7.8 | × | × |
| A44 SOUTH OF PEARTREE ROUNDABOUT | SB | 97046-98203 | 1118 | 964 | -154 | -16% | 4.8 | ✓ | ✓ |
| B4495 MARSTON FERRY ROAD | EB | 21175-20520 | 446 | 460 | 14 | 3% | 0.7 | ✓ | ✓ |
| B4495 MARSTON FERRY ROAD | WB | 20520-21175 | 498 | 522 | 24 | 5% | 1.1 | ✓ | ✓ |
| Oxford, Kingston Rd South of Leckford Rd | NB | 20320-85031 | 156 | 105 | -51 | -49% | 4.5 | ✓ | ✓ |
| Oxford, Kingston Rd South of Leckford Rd | SB | 85031-20320 | 70 | 40 | -30 | -76% | 4.1 | ✓ | ✓ |
| A420 HEADINGTON RD E OF B4150 | EB | 20040-85075 | 222 | 198 | -24 | -12% | 1.6 | ✓ | ✓ |
| A420 HEADINGTON RD E OF B4150 | WB | 85075-20040 | 384 | 297 | -87 | -29% | 4.7 | ✓ | ✓ |
| Oxford Cowley Rd East of Dawson Street | EB | 20045-50007 | 306 | 250 | -55 | -22% | 3.3 | ✓ | ✓ |
| Oxford Cowley Rd East of Dawson Street | WB | 50007-20045 | 344 | 271 | -72 | -27% | 4.1 | ✓ | ✓ |
| Hollow Way | NB | 20050-20675 | 402 | 346 | -56 | -16% | 2.9 | ✓ | ✓ |
| Hollow Way | SB | 20675-20050 | 336 | 323 | -12 | -4% | 0.7 | ✓ | ✓ |

# Appendix B. Journey Time Route Graphs

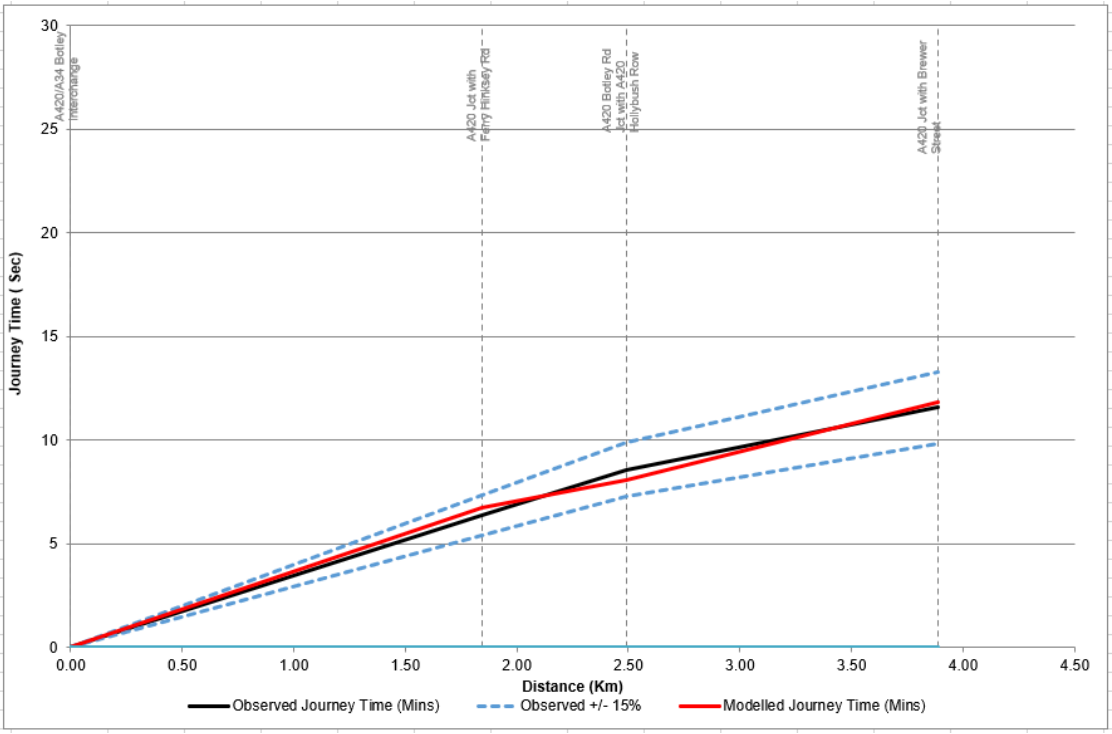
## B.1. Route 1 NB: A423/A4144 Kennington Rbt to A40/Banbury Rd Rbt – AM Peak



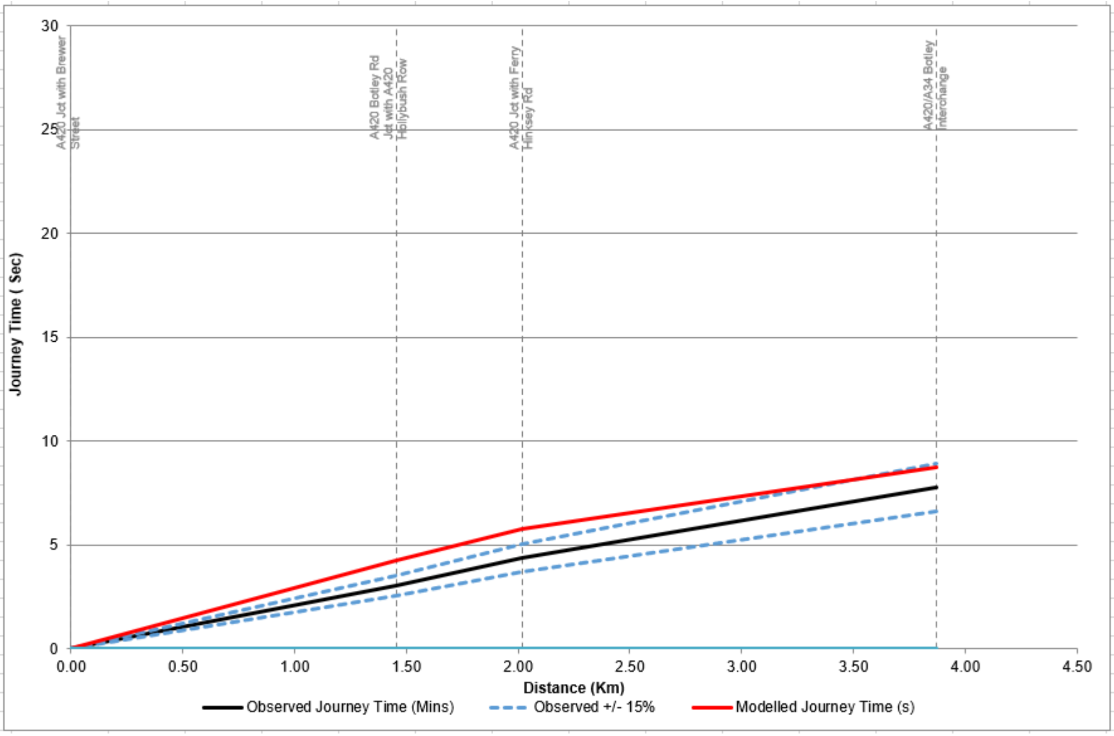

## B.2. Route 1 SB: A423/A4144 Kennington Rbt to A40/Banbury Rd Rbt – AM Peak



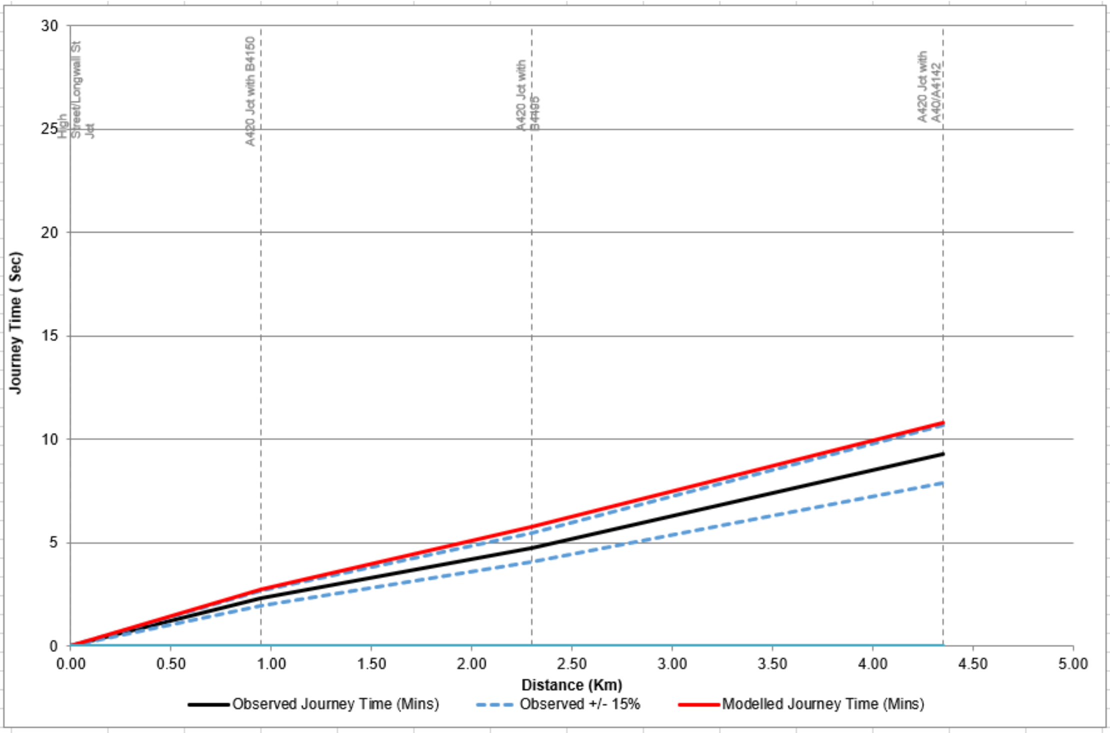
# B.3. Route 2 EB: A420/A34 Botley Interchange to A420/Brewer Street Jct – AM Peak



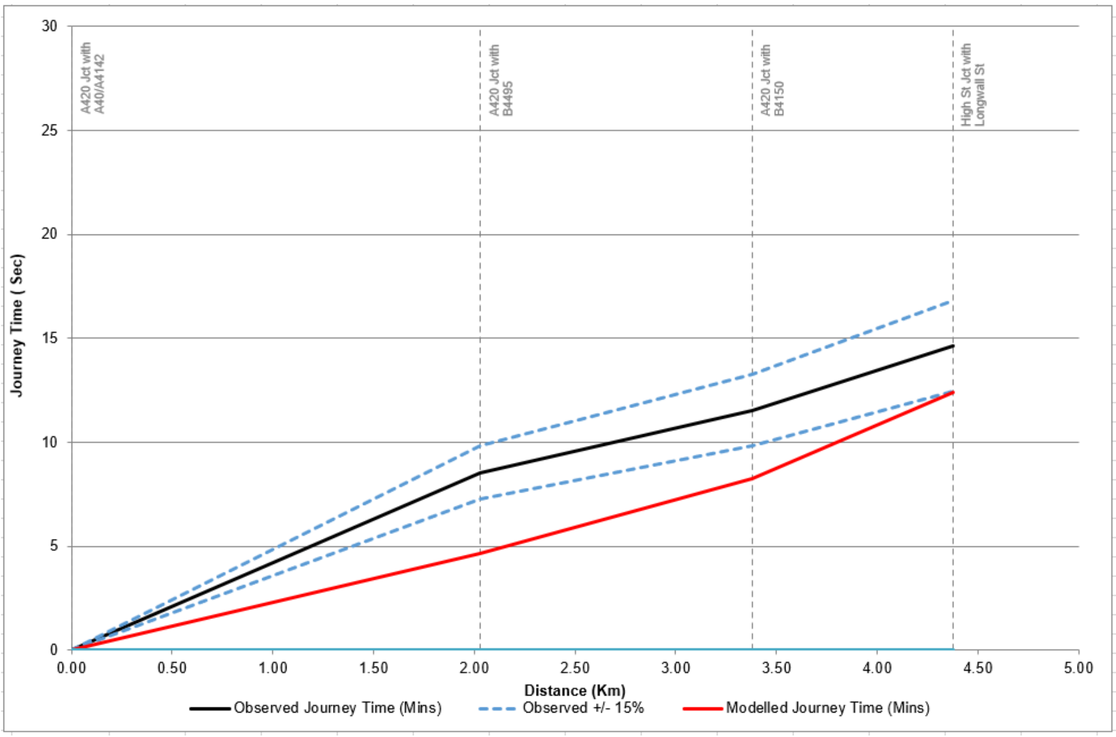

# B.4. Route 2 WB: A420/A34 Botley Interchange to A420/Brewer Street Jct – AM Peak



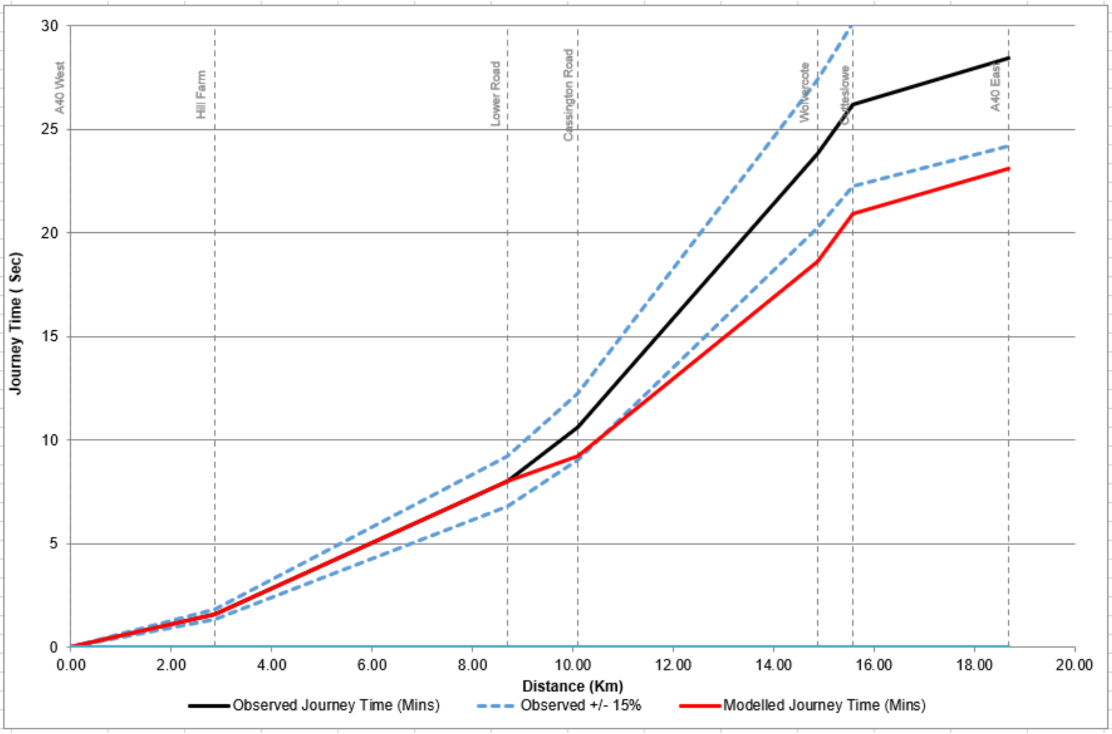
## B.5. Route 3 EB: High Street/Longwall St Jct to A40/A4142/A420 Headington Rbt – AM Peak



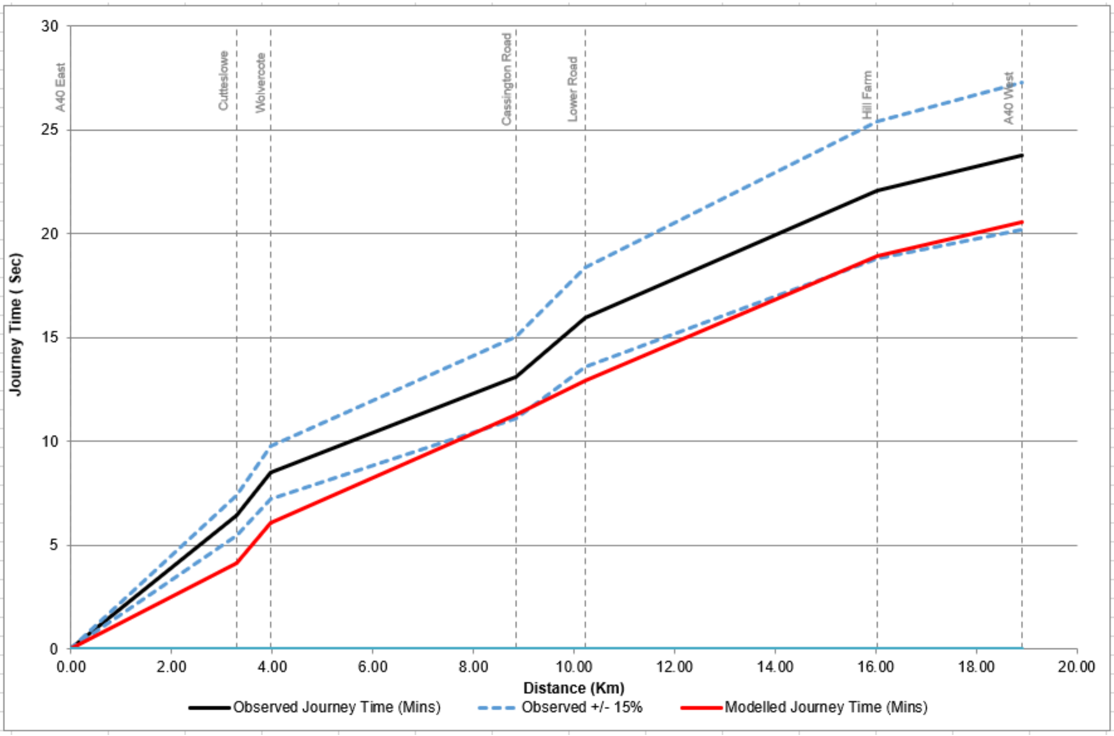

## B.6. Route 3 WB: High Street/Longwall St Jct to A40/A4142/A420 Headington Rbt – AM Peak



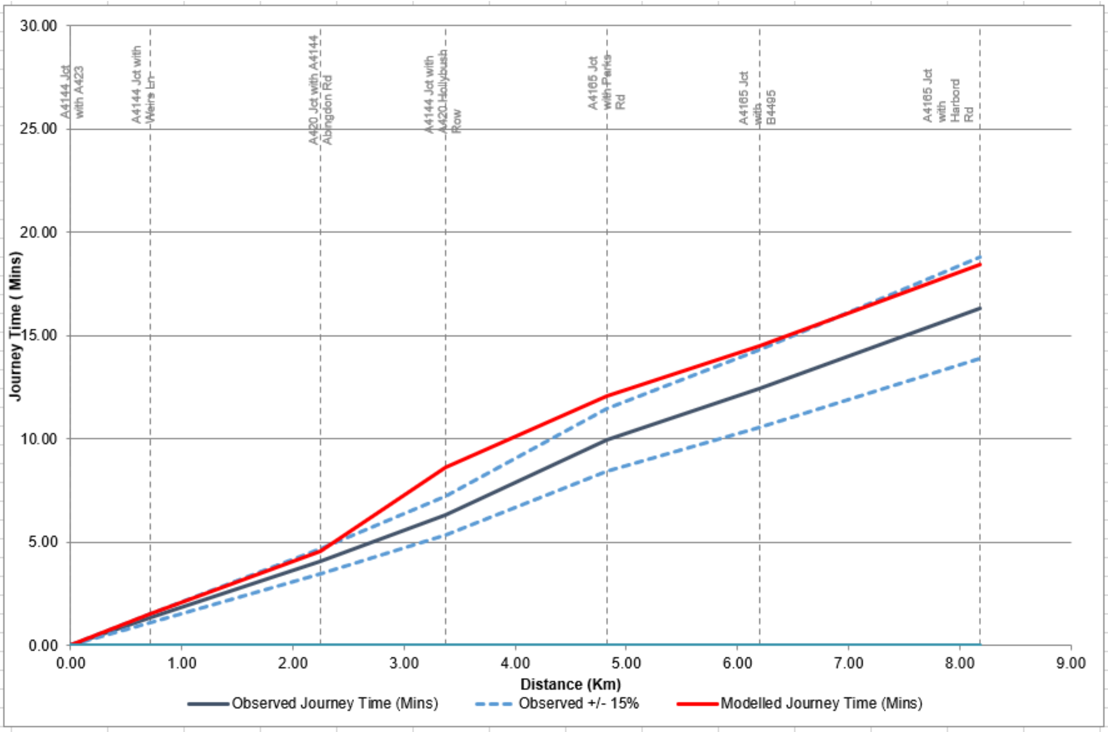
## B.7. Route 4 EB: A40 – AM Peak



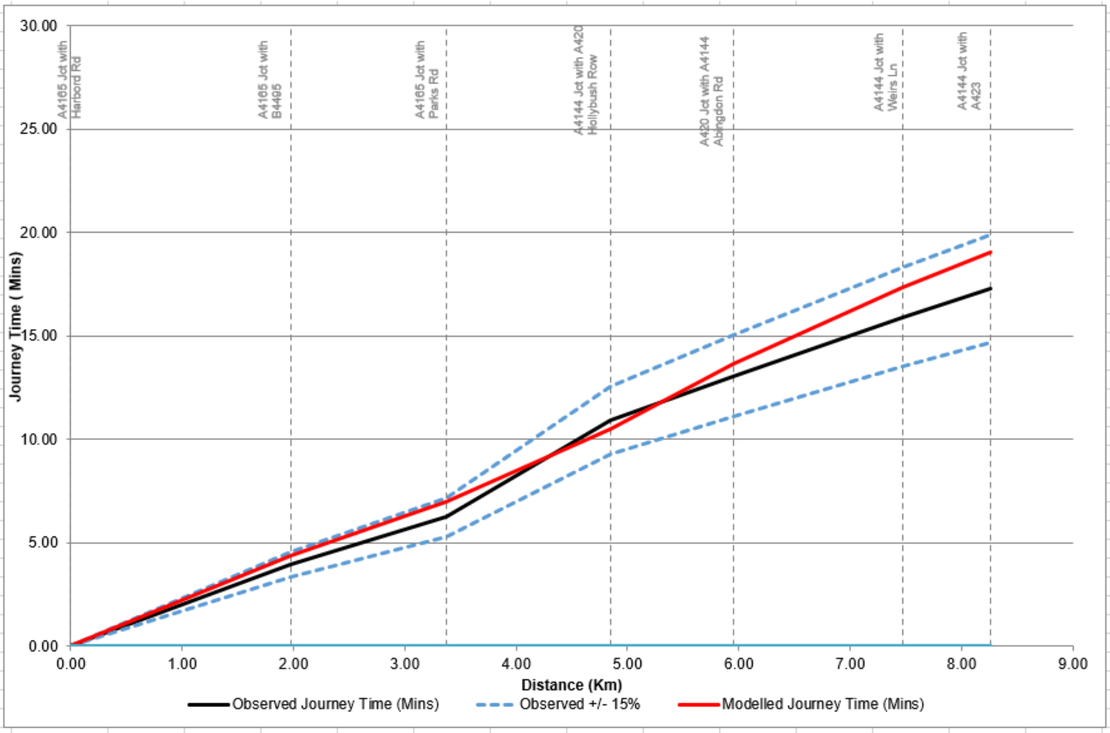

## B.8. Route 4 WB: A40 – AM Peak



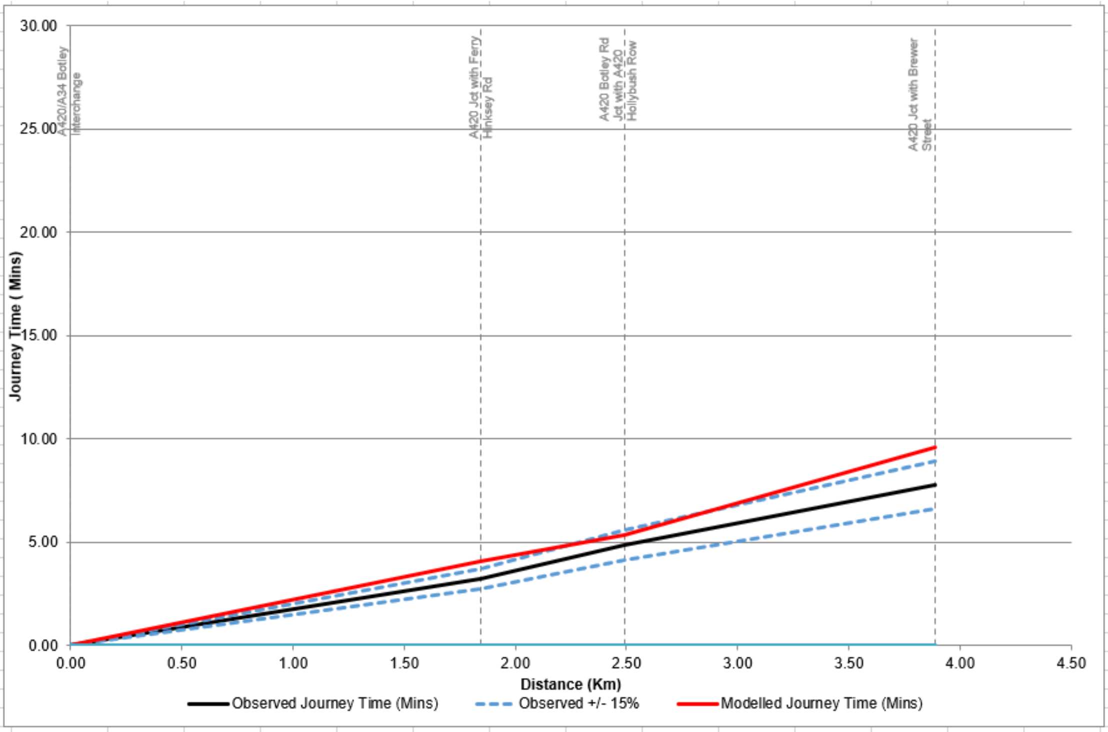
## B.9. Route 1 NB: A423/A4144 Kennington Rbt to A40/Banbury Rd Rbt – Inter Peak



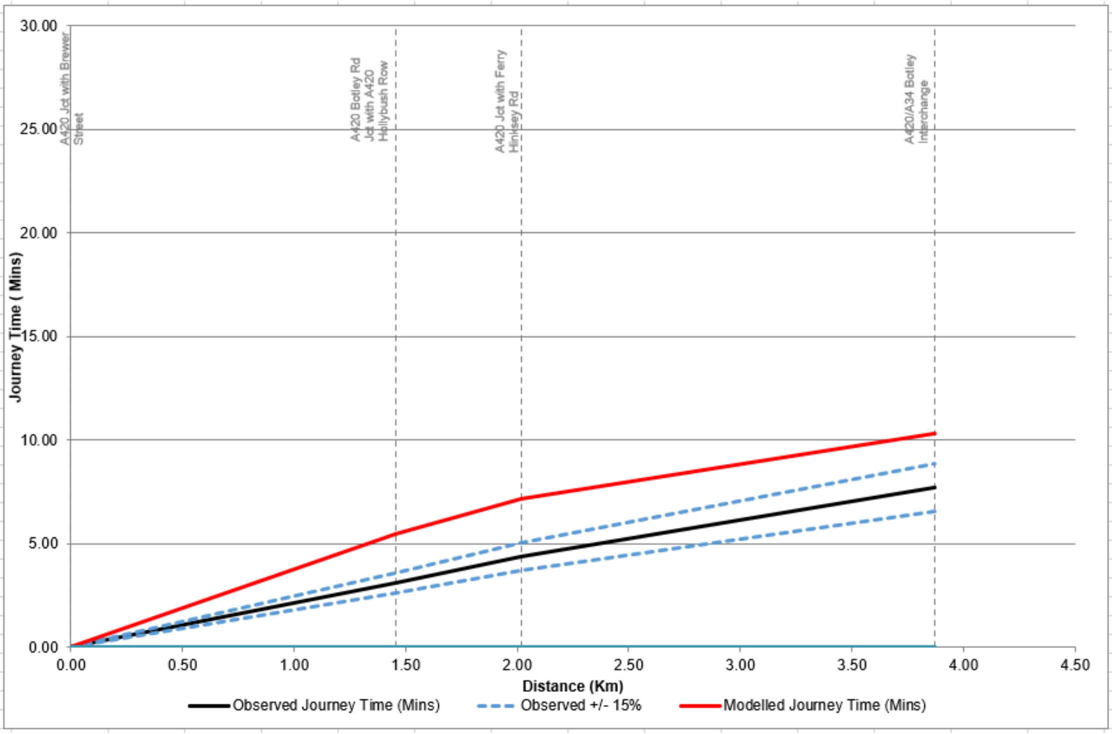

## B.10. Route 1 SB: A423/A4144 Kennington Rbt to A40/Banbury Rd Rbt – Inter Peak



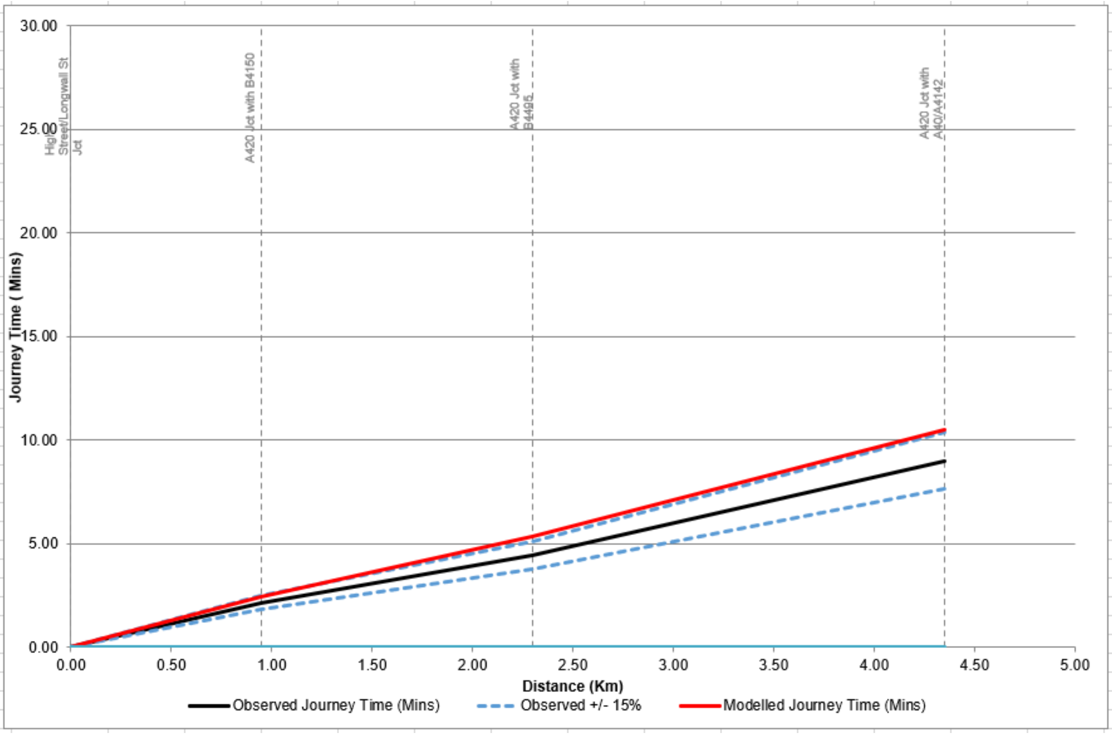
## B.11. Route 2 EB: A420/A34 Botley Interchange to A420/Brewer Street Jct – Inter Peak



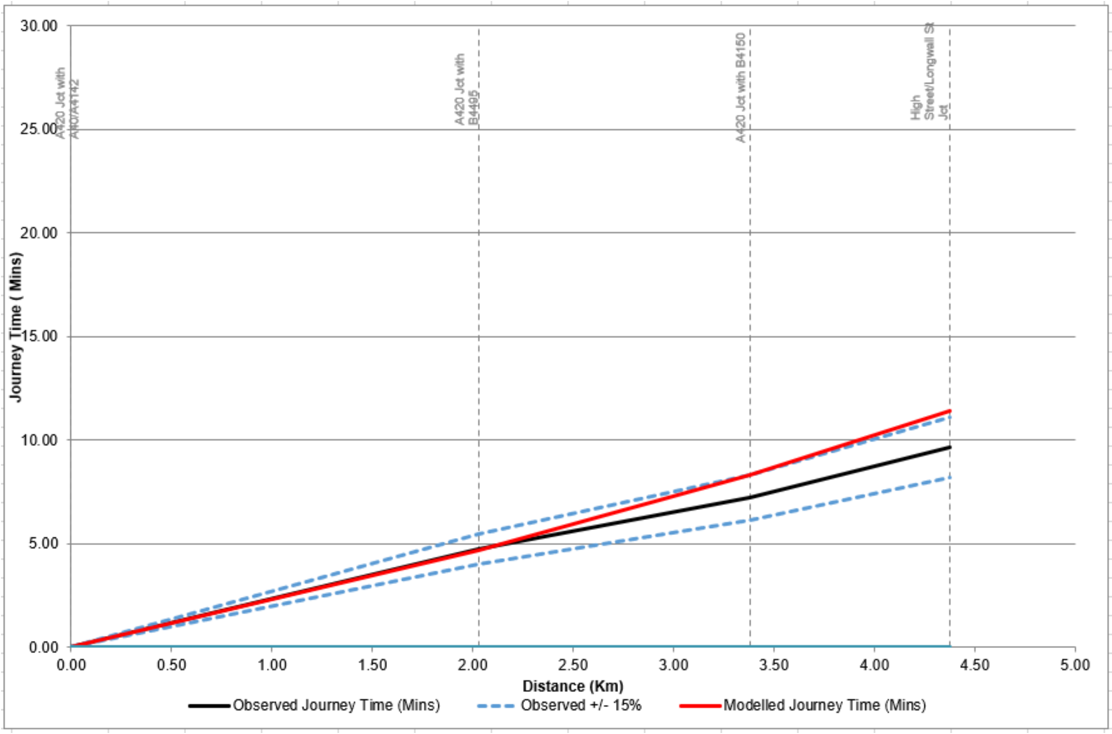

## B.12. Route 2 WB: A420/A34 Botley Interchange to A420/Brewer Street Jct – Inter Peak



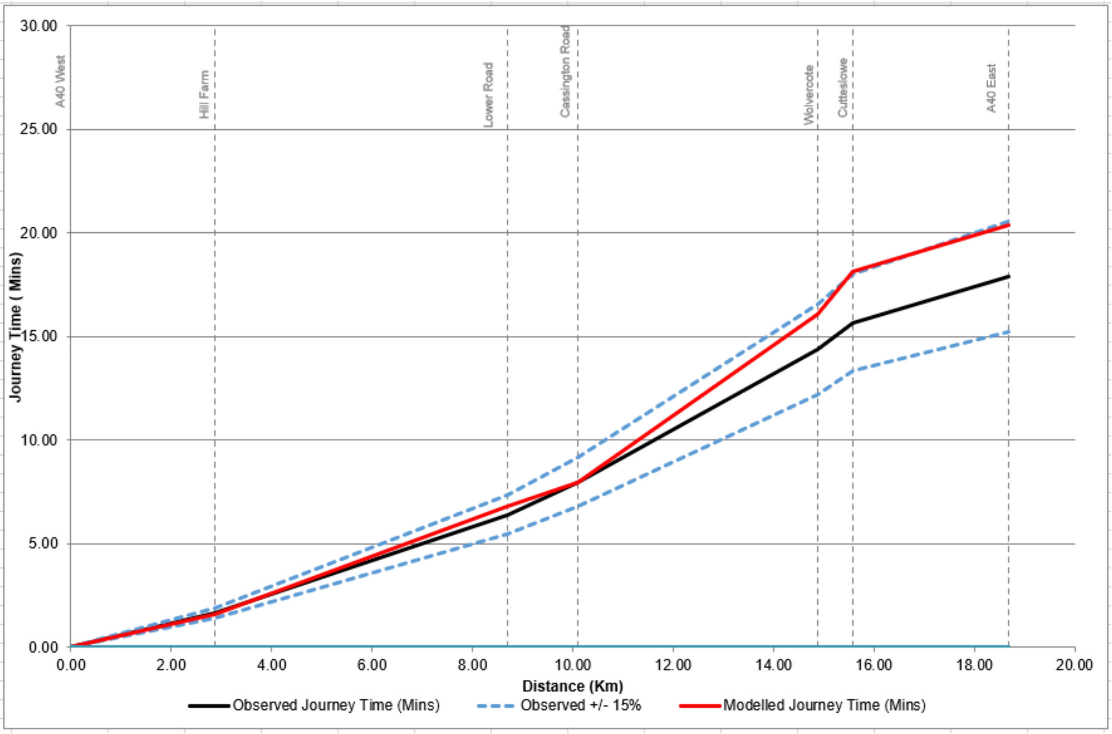
## B.13. Route 3 EB: High Street/Longwall St Jct to A40/A4142/A420 Headington Rbt – Inter Peak



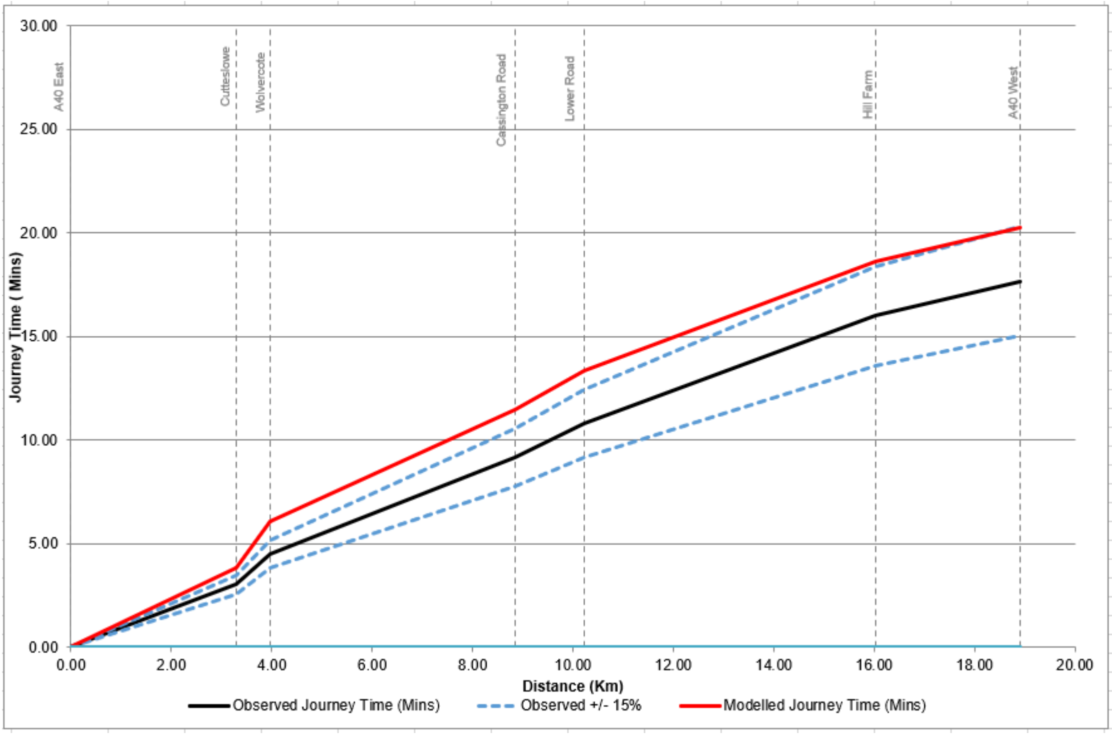

## B.14. Route 3 WB: High Street/Longwall St Jct to A40/A4142/A420 Headington Rbt – Inter Peak



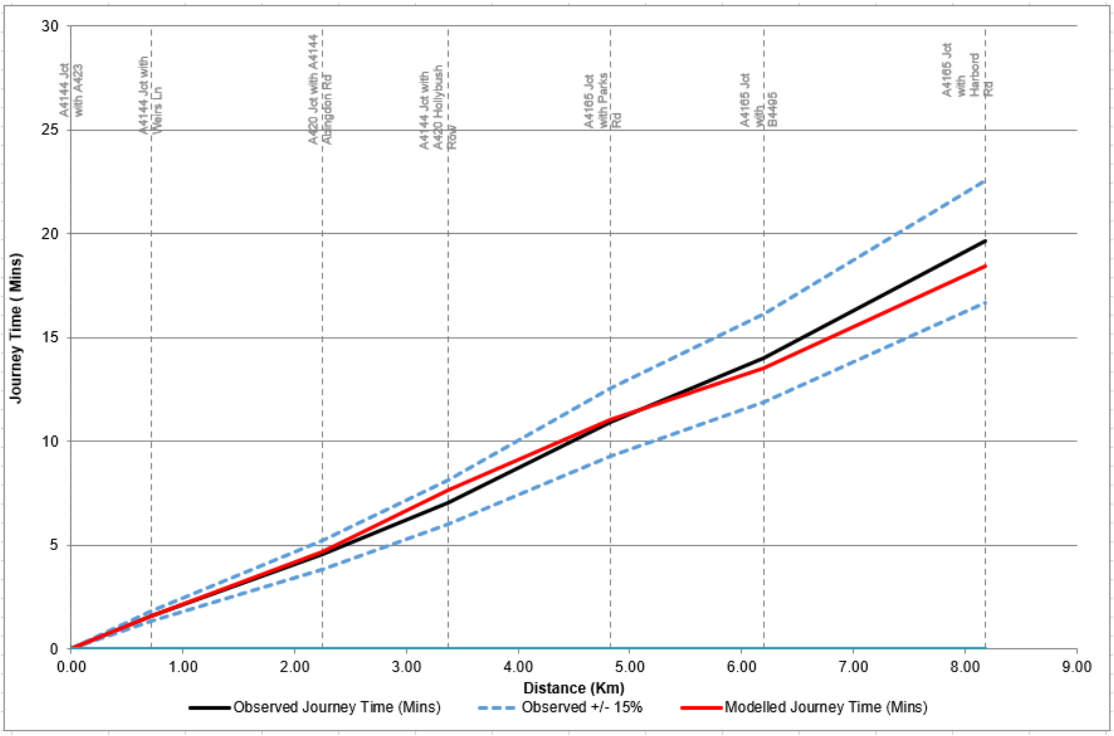
## B.15. Route 4 EB: A40 – Inter Peak



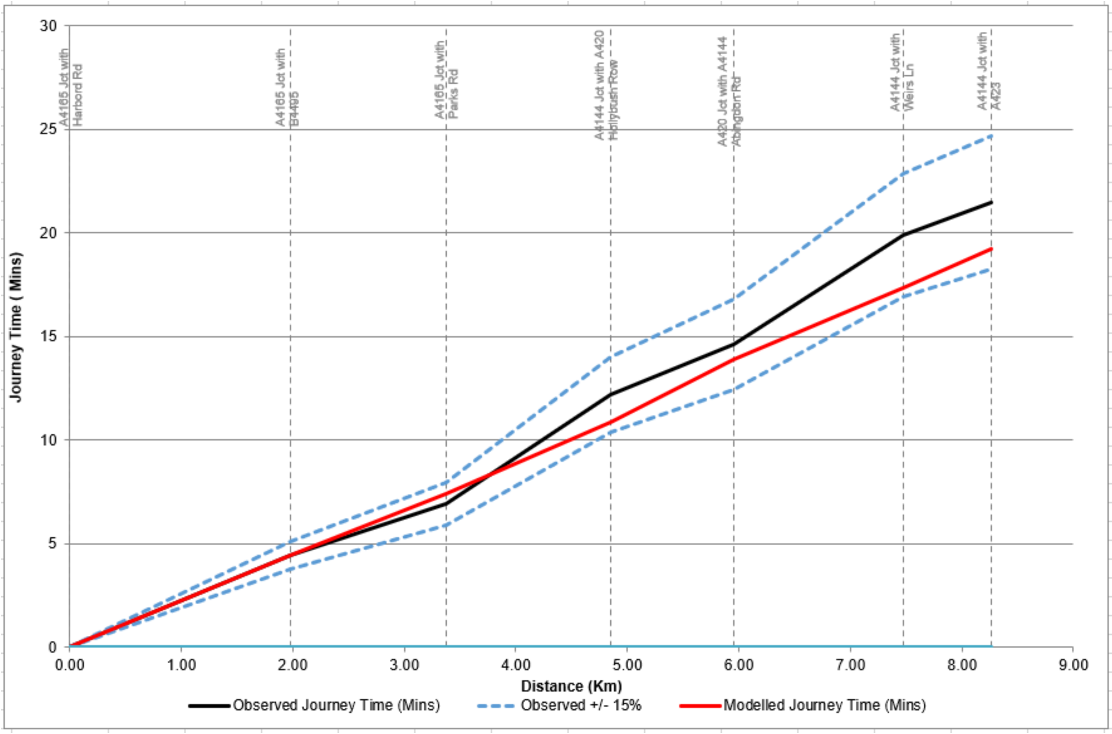

## B.16. Route 4 WB: A40 – Inter Peak



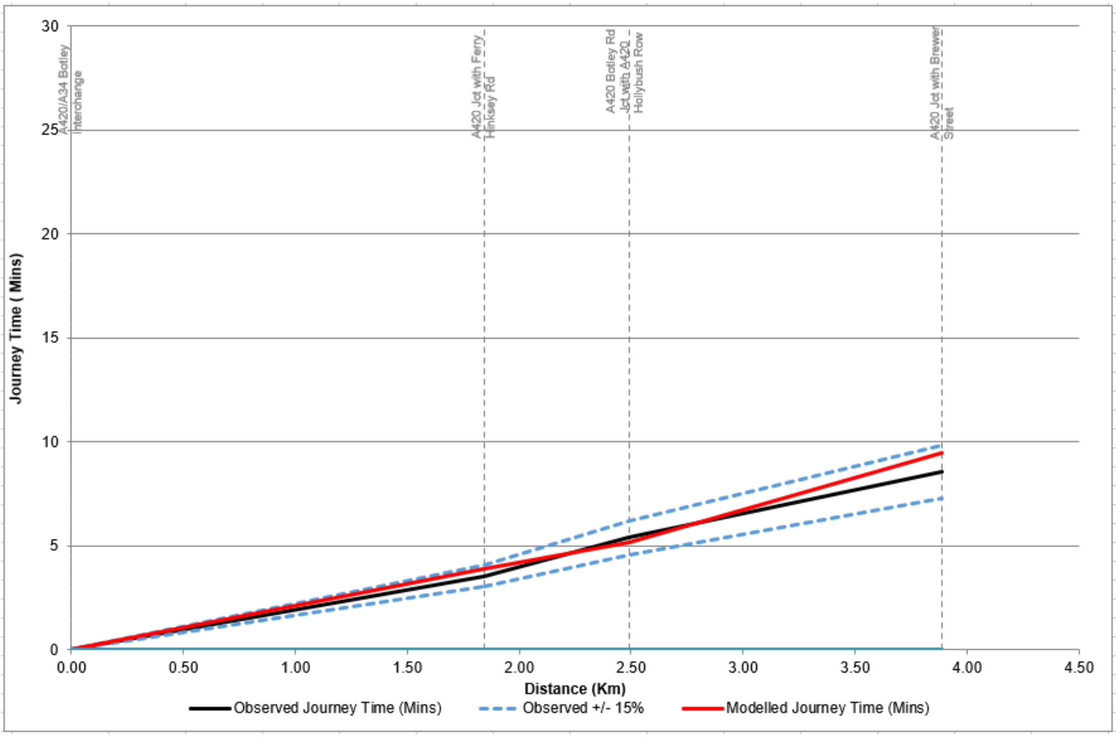
## B.17. Route 1 NB: A423/A4144 Kennington Rbt to A40/Banbury Rd Rbt – PM Peak



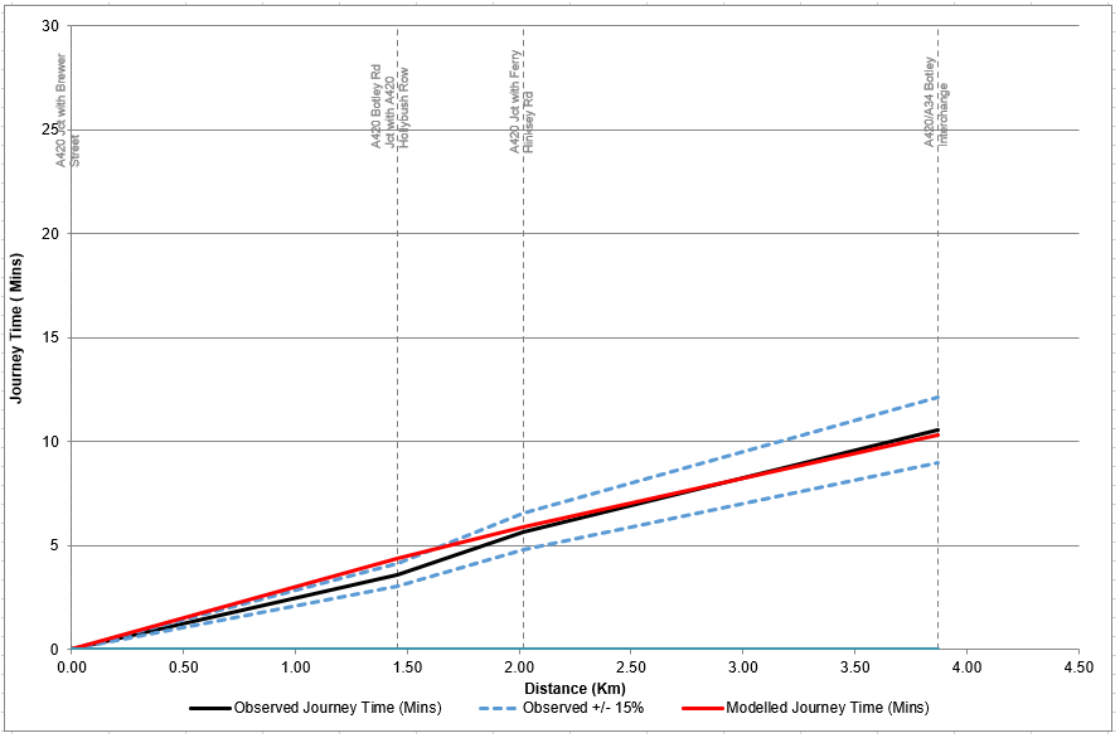

## B.18. Route 1 SB: A423/A4144 Kennington Rbt to A40/Banbury Rd Rbt – PM Peak



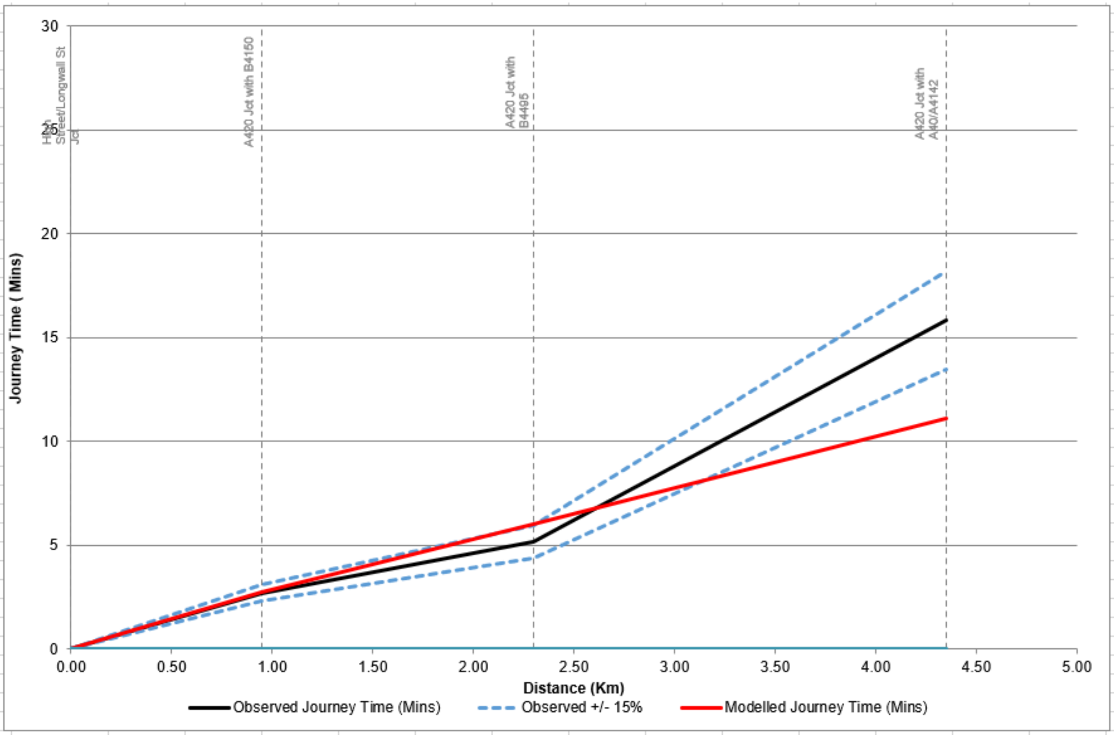
## B.19. Route 2 EB: A420/A34 Botley Interchange to A420/Brewer Street Jct – PM Peak



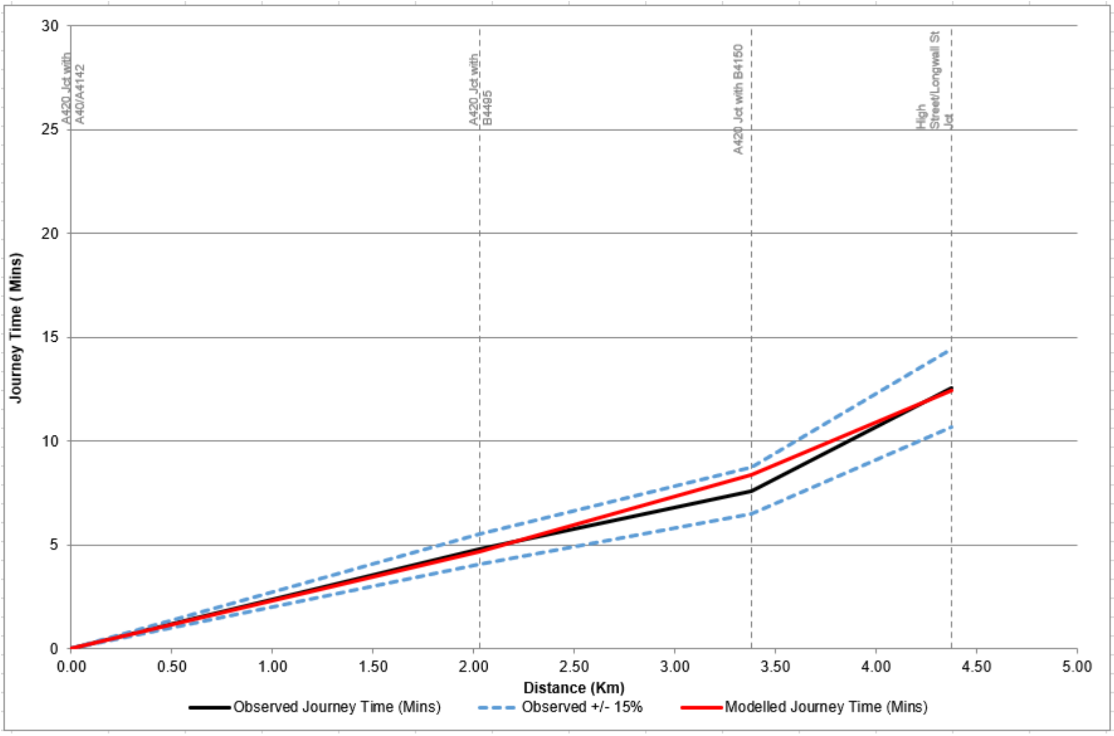

## B.20. Route 2 WB: A420/A34 Botley Interchange to A420/Brewer Street Jct – PM Peak



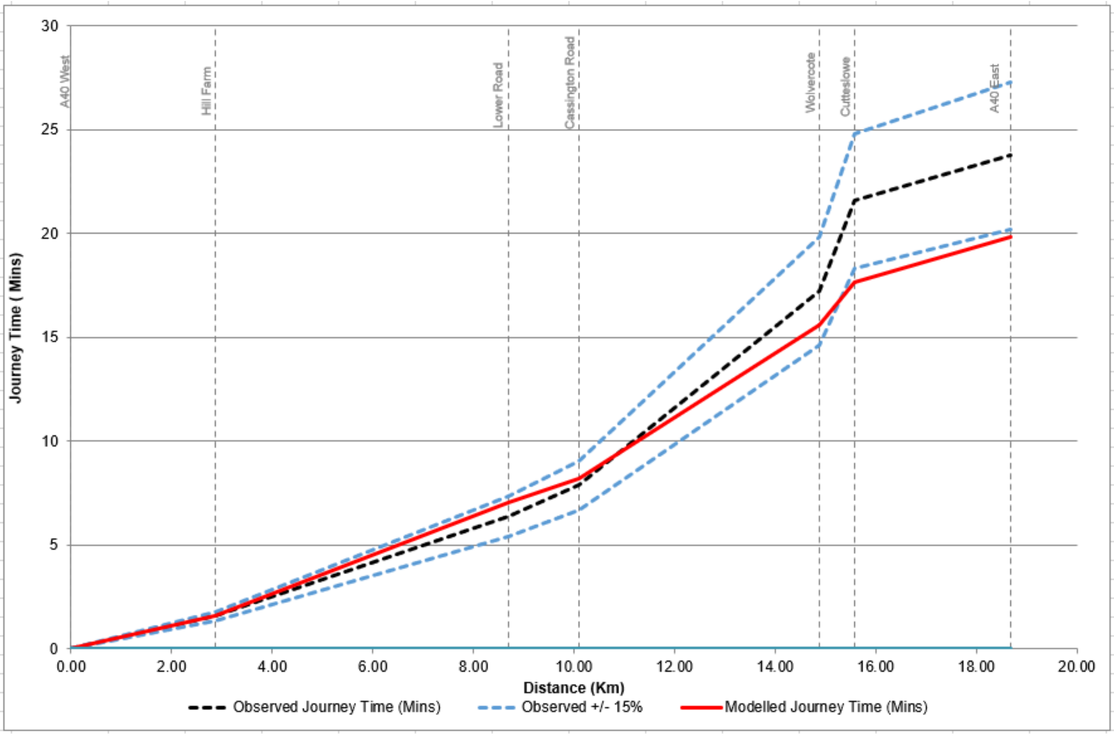
## B.21. Route 3 EB: High Street/Longwall St Jct to A40/A4142/A420 Headington Rbt – PM Peak



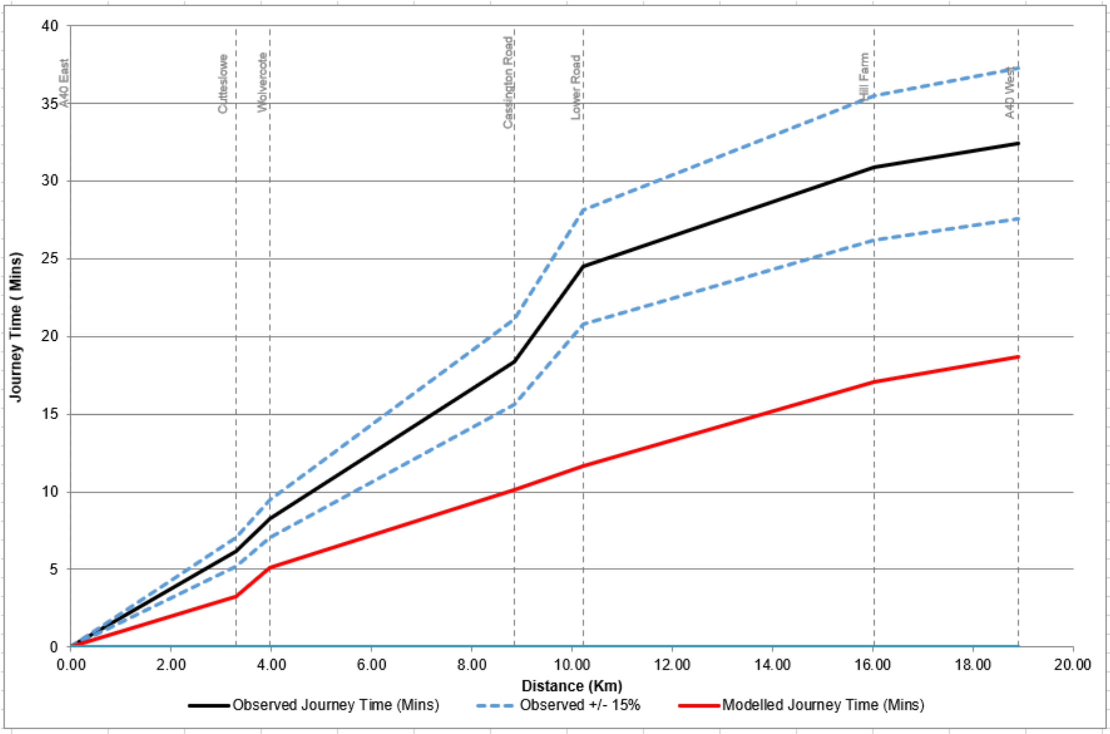

## B.22. Route 3 WB: High Street/Longwall St Jct to A40/A4142/A420 Headington Rbt – PM Peak



## B.23. Route 4 EB: A40 – PM Peak




## B.24. Route 4 WB: A40– PM Peak



# Appendix C. NTEM growth factors for bus and rail

## Table C-1 - Bus - NTEM growth factors between 2013 and 2018

| | | HBEB | | HBW | | HBO | | NHBEB | | NHBO | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sector | Description | Production | Attraction | Production | Attraction | Production | Attraction | Production | Attraction | Production | Attraction |
| 1 | Oxford | 0.957 | 0.979 | 0.955 | 0.934 | 0.937 | 0.953 | 0.964 | 0.968 | 0.962 | 0.976 |
| 2 | Bicester | 1.000 | 1.000 | 0.996 | 0.958 | 1.043 | 0.968 | 1.000 | 1.000 | 0.981 | 0.973 |
| 3 | Abingdon | 1.040 | 1.000 | 0.965 | 0.939 | 1.011 | 0.968 | 0.923 | 1.000 | 0.983 | 0.991 |
| 4 | Most of Vale of White Horse | 1.000 | 0.984 | 0.974 | 0.937 | 1.015 | 0.961 | 1.000 | 0.909 | 0.975 | 0.973 |
| 5 | Wantage/Grove | 1.000 | 1.000 | 0.967 | 0.953 | 1.020 | 0.975 | 1.000 | 1.000 | 1.000 | 1.000 |
| 6 | Didcot | 1.000 | 0.833 | 0.942 | 0.938 | 0.991 | 0.966 | 0.900 | 1.000 | 0.994 | 1.000 |
| 7 | Most of South Oxfordshire | 1.000 | 0.984 | 0.961 | 0.943 | 0.999 | 0.969 | 0.984 | 0.955 | 1.003 | 0.996 |
| 8 | Witney | 1.000 | 1.000 | 0.940 | 0.949 | 0.989 | 0.972 | 1.000 | 0.909 | 0.981 | 0.990 |
| 9 | West Oxfordshire | 0.973 | 1.000 | 0.935 | 0.945 | 1.000 | 0.967 | 1.000 | 1.000 | 0.998 | 0.987 |
| 10 | North Oxford - Kidlington | 1.100 | 1.000 | 1.023 | 0.938 | 1.041 | 0.979 | 1.000 | 1.000 | 0.982 | 1.000 |
| 11 | Most of Cherwell | 1.056 | 1.000 | 1.018 | 0.953 | 1.044 | 0.982 | 0.929 | 1.000 | 1.007 | 1.010 |
| 12 | Banbury | 1.048 | 1.000 | 1.001 | 0.947 | 1.024 | 0.973 | 1.000 | 1.000 | 0.988 | 1.000 |
| 13 | Swindon | 0.983 | 0.964 | 0.945 | 0.929 | 0.986 | 0.978 | 0.959 | 0.952 | 0.980 | 0.993 |
| 14 | Rest of Wiltshire | 0.966 | 0.959 | 0.934 | 0.938 | 0.976 | 0.977 | 0.975 | 0.977 | 1.002 | 1.000 |
| 15 | Gloucestershire | 0.976 | 0.971 | 0.946 | 0.943 | 0.957 | 0.954 | 0.973 | 0.978 | 0.980 | 0.979 |
| 16 | Hereford & Worcester | 0.965 | 0.964 | 0.921 | 0.927 | 0.988 | 0.982 | 0.961 | 0.958 | 0.994 | 0.995 |
| 17 | Warwickshire | 0.964 | 0.992 | 0.929 | 0.955 | 0.983 | 0.987 | 0.984 | 0.994 | 1.009 | 1.009 |
| 18 | West Midlands county | 0.982 | 0.978 | 0.949 | 0.946 | 0.956 | 0.956 | 0.967 | 0.969 | 0.970 | 0.972 |
| 19 | Northamptonshire | 0.986 | 0.973 | 0.944 | 0.937 | 0.993 | 0.979 | 0.970 | 0.974 | 0.998 | 1.006 |
| 20 | Milton Keynes | 1.016 | 1.054 | 0.991 | 1.011 | 1.005 | 0.983 | 1.034 | 1.033 | 1.012 | 1.026 |
| 21 | Buckinghamshire | 0.989 | 0.997 | 0.945 | 0.951 | 0.982 | 0.975 | 0.993 | 0.992 | 1.002 | 1.011 |
| 22 | Rest of Berkshire | 0.987 | 1.005 | 0.950 | 0.961 | 0.971 | 0.974 | 1.005 | 1.000 | 1.005 | 0.996 |
| 23 | Reading | 0.987 | 1.010 | 0.959 | 0.963 | 0.956 | 0.975 | 1.008 | 1.000 | 0.993 | 0.990 |
| 24 | West Berkshire | 0.988 | 1.010 | 0.932 | 0.964 | 0.981 | 0.977 | 1.000 | 1.000 | 1.015 | 0.998 |
| 25 | Greater London | 1.051 | 1.044 | 1.009 | 1.000 | 0.982 | 0.981 | 1.025 | 1.025 | 1.002 | 1.002 |
| 26 | Rest of SE | 0.986 | 0.999 | 0.952 | 0.961 | 0.978 | 0.980 | 0.991 | 0.992 | 1.001 | 0.999 |
| 27 | East of England | 0.986 | 1.011 | 0.948 | 0.966 | 0.995 | 0.999 | 0.994 | 0.997 | 1.014 | 1.017 |
| 28 | Rest of SW | 0.963 | 0.965 | 0.934 | 0.936 | 0.968 | 0.970 | 0.966 | 0.968 | 0.986 | 0.986 |
| 29 | Rest of WM | 0.963 | 0.966 | 0.932 | 0.936 | 0.967 | 0.965 | 0.964 | 0.965 | 0.983 | 0.983 |
| 30 | EM, Northern Regions and Scotland | 0.964 | 0.964 | 0.933 | 0.933 | 0.954 | 0.954 | 0.958 | 0.959 | 0.970 | 0.970 |
| 31 | Wales | 0.959 | 0.959 | 0.927 | 0.927 | 0.966 | 0.966 | 0.957 | 0.957 | 0.978 | 0.978 |

## Table C-2 - Rail - NTEM growth factors between 2013 and 2018

| | | HBEB | | HBW | | HBO | | NHBEB | | NHBO | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sector** | **Description** | **Production** | **Attraction** | **Production** | **Attraction** | **Production** | **Attraction** | **Production** | **Attraction** | **Production** | **Attraction** |
| 1 | Oxford | 1.033 | 1.019 | 1.002 | 0.963 | 0.962 | 0.956 | 0.991 | 0.995 | 0.975 | 0.986 |
| 2 | Bicester | 1.043 | 1.044 | 1.023 | 0.985 | 1.062 | 0.977 | 1.026 | 1.000 | 0.977 | 1.000 |
| 3 | Abingdon | 1.079 | 1.091 | 0.998 | 0.961 | 1.016 | 0.993 | 0.980 | 1.000 | 1.000 | 1.000 |
| 4 | Most of Vale of White Horse | 1.067 | 1.034 | 0.998 | 0.966 | 1.029 | 0.975 | 1.000 | 1.000 | 0.990 | 0.967 |
| 5 | Wantage/Grove | 1.030 | 1.000 | 0.983 | 1.000 | 1.013 | 0.981 | 1.000 | 1.000 | 1.000 | 1.000 |
| 6 | Didcot | 1.019 | 1.053 | 0.975 | 0.982 | 1.022 | 0.986 | 1.000 | 1.000 | 0.985 | 0.968 |
| 7 | Most of South Oxfordshire | 1.048 | 1.041 | 0.988 | 0.972 | 1.020 | 0.994 | 1.000 | 1.000 | 1.019 | 0.997 |
| 8 | Witney | 1.000 | 1.000 | 0.960 | 1.000 | 0.976 | 1.027 | 1.000 | 1.000 | 1.000 | 1.077 |
| 9 | West Oxfordshire | 1.036 | 1.000 | 0.968 | 0.971 | 1.016 | 0.996 | 1.000 | 1.000 | 1.022 | 0.981 |
| 10 | North Oxford - Kidlington | 1.083 | 1.000 | 1.022 | 0.750 | 1.047 | 0.950 | 1.000 | 1.000 | 1.000 | 1.000 |
| 11 | Most of Cherwell | 1.091 | 1.074 | 1.046 | 0.972 | 1.060 | 1.016 | 1.019 | 1.000 | 1.043 | 1.048 |
| 12 | Banbury | 1.099 | 1.051 | 1.032 | 0.979 | 1.080 | 0.986 | 1.014 | 1.000 | 1.011 | 1.031 |
| 13 | Swindon | 1.024 | 0.998 | 0.973 | 0.956 | 1.009 | 1.003 | 0.980 | 0.979 | 0.994 | 1.010 |
| 14 | Rest of Wiltshire | 1.003 | 1.001 | 0.955 | 0.959 | 0.994 | 1.002 | 0.989 | 0.977 | 1.017 | 1.015 |
| 15 | Gloucestershire | 1.024 | 1.024 | 0.977 | 0.976 | 0.982 | 0.976 | 1.001 | 1.003 | 1.001 | 1.000 |
| 16 | Hereford & Worcester | 0.993 | 0.988 | 0.943 | 0.939 | 0.998 | 0.995 | 0.974 | 0.968 | 1.004 | 1.003 |
| 17 | Warwickshire | 1.007 | 1.027 | 0.952 | 0.976 | 0.997 | 1.012 | 1.001 | 1.008 | 1.022 | 1.022 |
| 18 | West Midlands county | 1.016 | 1.011 | 0.977 | 0.972 | 0.973 | 0.970 | 0.992 | 0.993 | 0.989 | 0.991 |
| 19 | Northamptonshire | 1.030 | 1.020 | 0.986 | 0.984 | 1.006 | 1.003 | 0.999 | 1.000 | 1.018 | 1.022 |
| 20 | Milton Keynes | 1.068 | 1.068 | 1.022 | 1.038 | 1.031 | 1.028 | 1.043 | 1.048 | 1.043 | 1.046 |
| 21 | Buckinghamshire | 1.031 | 1.038 | 0.974 | 0.979 | 0.992 | 0.995 | 1.012 | 1.000 | 1.017 | 1.018 |
| 22 | Rest of Berkshire | 1.035 | 1.051 | 0.977 | 0.991 | 0.991 | 0.982 | 1.022 | 1.008 | 1.016 | 1.002 |
| 23 | Reading | 1.045 | 1.057 | 1.007 | 0.995 | 0.977 | 0.983 | 1.032 | 1.020 | 1.012 | 1.001 |
| 24 | West Berkshire | 1.018 | 1.056 | 0.960 | 0.993 | 0.996 | 0.997 | 1.023 | 1.015 | 1.030 | 1.008 |
| 25 | Greater London | 1.084 | 1.077 | 1.028 | 1.023 | 0.992 | 0.991 | 1.040 | 1.039 | 1.020 | 1.023 |
| 26 | Rest of SE | 1.029 | 1.027 | 0.978 | 0.982 | 0.993 | 0.998 | 1.007 | 1.008 | 1.019 | 1.011 |
| 27 | East of England | 1.024 | 1.016 | 0.975 | 0.982 | 1.003 | 1.010 | 1.004 | 1.008 | 1.025 | 1.021 |
| 28 | Rest of SW | 1.007 | 1.009 | 0.965 | 0.965 | 0.987 | 0.987 | 0.990 | 0.991 | 1.001 | 1.001 |
| 29 | Rest of WM | 1.002 | 1.000 | 0.958 | 0.957 | 0.984 | 0.983 | 0.986 | 0.982 | 0.998 | 0.998 |
| 30 | EM, Northern Regions and Scotland | 1.001 | 1.002 | 0.967 | 0.967 | 0.967 | 0.967 | 0.984 | 0.984 | 0.988 | 0.988 |
| 31 | Wales | 0.993 | 0.993 | 0.951 | 0.951 | 0.980 | 0.980 | 0.978 | 0.978 | 0.991 | 0.991 |

Oana Santos
**Atkins Limited**
Woodcote Grove
Ashley Road
Epsom
KT18 5BW

Fax: +44 (0)1372 740055
Direct: +44 (0)1372 756110
oana.santos@atkinsglobal.com