T004

Local Model Validation Report

Chelmsford Model Update

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Document Control Sheet

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1 Introduction

1.1 Model Overview

As specialist consultant to Ringway Jacobs, the framework provider to Essex County Council (ECC), Jacobs have been asked to develop the required strategic modelling necessary to provide the evidence base for a Planning Application for the Chelmsford North East Bypass (CNEB) and a potential Outline Business Case (OBC) for a scheme to improve the Army and Navy junction in central Chelmsford. This is to be delivered using an update of the existing Chelmsford Transport Model to a standard sufficient for the purposes outlined above, with due regard to Transport Analysis Guidance (TAG) (as described in the relevant TAG units as of May 2020), to the satisfaction of the Department for Transport (DfT).

Through the Ringway Jacobs framework, a multi-modal strategic transport model for the city of Chelmsford with a base year of 2014 was previously developed by Jacobs to support the Local Plan process and Local Enterprise Partnerships (LEP) funding bids. This was subsequently used in the CNEB Housing Infrastructure Fund (HIF) bid support for ECC which was successfully awarded funds. The model was developed, calibrated, and validated following TAG; however, it was identified that it would need refinements in the context of current and future Army and Navy business case work for the DfT, and the CNEB planning application for ECC. In particular, these refinements pertain to the age of data used within all stages of model development, the extent of the model network, and network changes that have taken place since original validation, in particular the permanent closure of the Army and Navy Flyover. The model update is of particular relevance to the Army and Navy junction, to enable representation of the junction with the Flyover closed (the existing model was developed with the Flyover open), and to CNEB, to extend the detailed model area further to the north and east of Chelmsford. To provide the evidence base for a Planning Application for CNEB and a potential outline business case for a scheme to improve the Army and Navy junction therefore requires an update to the existing Chelmsford Model. This also provides an opportunity to feed any critical updates from past local studies (related to observed data or networks information) back to the Chelmsford Model in order to keep it up to date and increase its utility and quality in each subsequent application.

The model update approach makes use of previous work on the development of the Essex Countywide Strategic Model; that model used mobile network data to formulate the highway demand and will form the basis of the demand for the Chelmsford Model update. The 2017 Essex Countywide Model prior matrices were used as the starting point for the updated Chelmsford Model matrices. Using the matrices provides analytical consistency and removes duplication of work. Most of the network has been retained from the existing Chelmsford Model which was further checked and refined to reflect the scope of the model update. The new model also includes extended network coverage and detail to the north and east of Chelmsford to enable the potential impacts of CNEB to be captured.

1.2 Purpose of this Report

This Base Model Local Model Validation Report (LMVR) summarises the work carried out in the development of the new Chelmsford Traffic Model, including the key design considerations and features of the model, the data sources used in its development, the checks that have been undertaken on the demand and supply components of the model, and the resulting calibration and validation of the model, including assignment details and the inclusion of Variable Demand Modelling (VDM).

This Report demonstrates that the model produces an accurate representation of existing traffic conditions in the vicinity of, and associated with, the CNEB and the Army and Navy scheme proposals, making it suitable for the evaluation of future year scenarios. In order to demonstrate the suitability of the model its level of accuracy has been quantified and described following the advice set out TAG.

The purpose of this Report is therefore to:

- Describe the processes by which the Chelmsford Model has been developed;
- Presents the calibration and validation standards achieved; and
- Demonstrate that the model is a suitable base for the assessment of the CNEB and the Army and Navy scheme.

1.3 Report Structure

The remainder of this report is set out as follows:

- **Section 2 –** Details proposed use of the model and the key design considerations;
- **Section 3 –** Describes the aspired standards to which the model has been developed, namely calibration/validation criteria, acceptability guidelines, and convergence criteria/standards;
- **Section 4 –** Describes the key features of the model;
- **Section 5 –** Details the data used for model calibration and validation;
- **Section 6 –** Describes the processes used in developing the modelled network;
- **Section 7 –** Describes the checks carried out on the modelled network;
- **Section 8 –** Describes the route choice calibration;
- **Section 9 –** Describes the processes used in developing the modelled demand (i.e. trip matrices);
- **Section 10 –** Provides information on the calibration and validation of the trip matrices;
- **Section 11 –** Details the calibration and validation of the assignment, as well as the model outputs;
- **Section 12 –** Details the VDM realism testing; and
- **Section 13 –** Provides an overall summary of the model and its development.

2 Proposed Uses of the Model and Key Model Design Considerations

2.1 Proposed Use of the Model

The updated Chelmsford Model is designed to provide an evidence base for the assessment of the Planning Application for the Chelmsford North East Bypass (CNEB) and an Outline Business Case (OBC) for a scheme to improve the Army and Navy junction in central Chelmsford. A secondary purpose intended for the model is that it can be used for assessments of impacts of other (as yet unspecified) schemes around Chelmsford District.

The Army and Navy junction is a critical part of the Chelmsford transport network and a vital gateway into and out of the city. It operates significantly over capacity in the morning and evening peak periods, leading to delays, unreliable journey times and poor air quality. ECC is committed to identifying a long-term solution to the problems at the Army and Navy junction, and has commissioned Essex Highways to identify and assess potential options in line with the DfT Transport Appraisal Process. This work has become even more vital following the permanent closure of the flyover at the junction in September 2019.

The CNEB scheme has been developed periodically since 2005 as a strategic highway link between the A131 at Deres Bridge and the A12 and Boreham Interchange, with the section north towards Braintree previously developed under a separate scheme.

The study area and the location of these two schemes are shown in Figure 2-1 below:

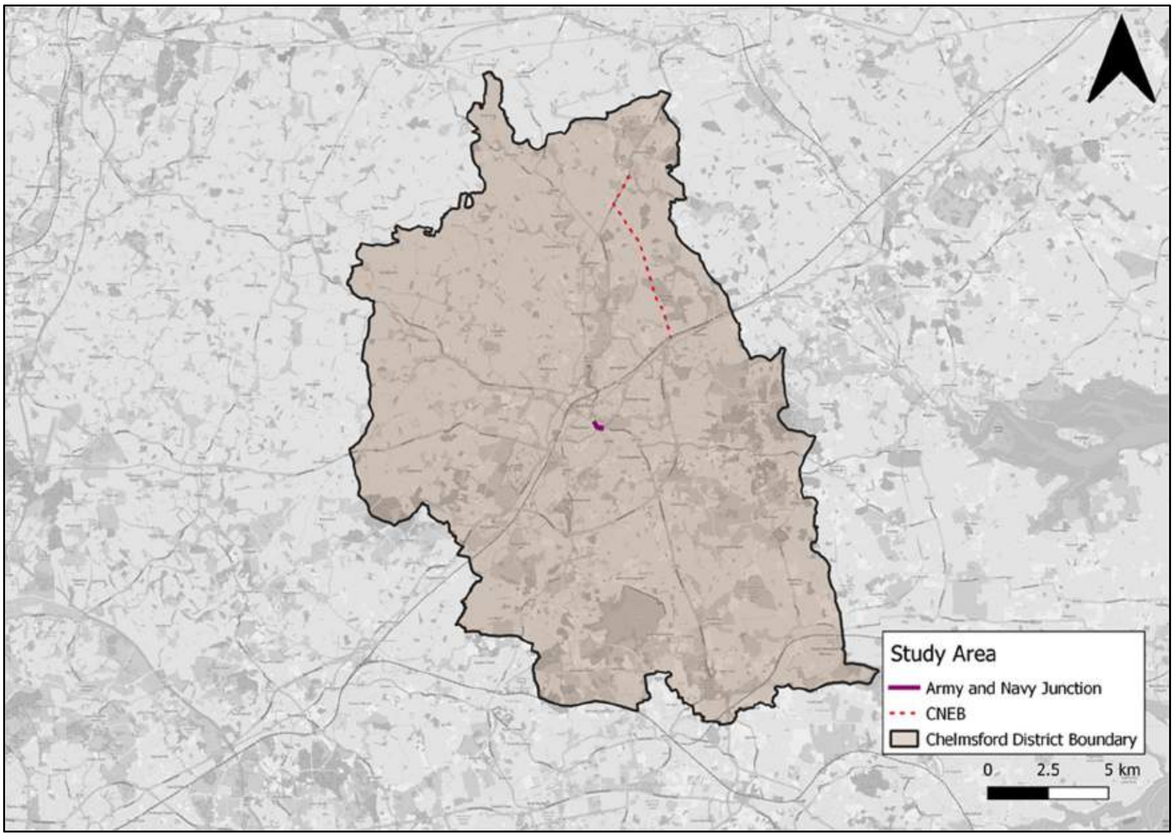


Figure 2-1: Study Area

2.2 Considering the COVID-19 Pandemic in Model Use

The Chelmsford Model has been developed using the latest pre-COVID-19 pandemic data and is calibrated against 2019 conditions. While the pandemic had a profound impact on travel demand by all modes in 2020, and is continuing to affect conditions in 2021, it is not yet clear (at the time of writing) how it will affect longer term trends. Figure 2-2 shows the development of demand for travel by different modes in Great Britain since the start of the pandemic compared with the corresponding period in 2019:

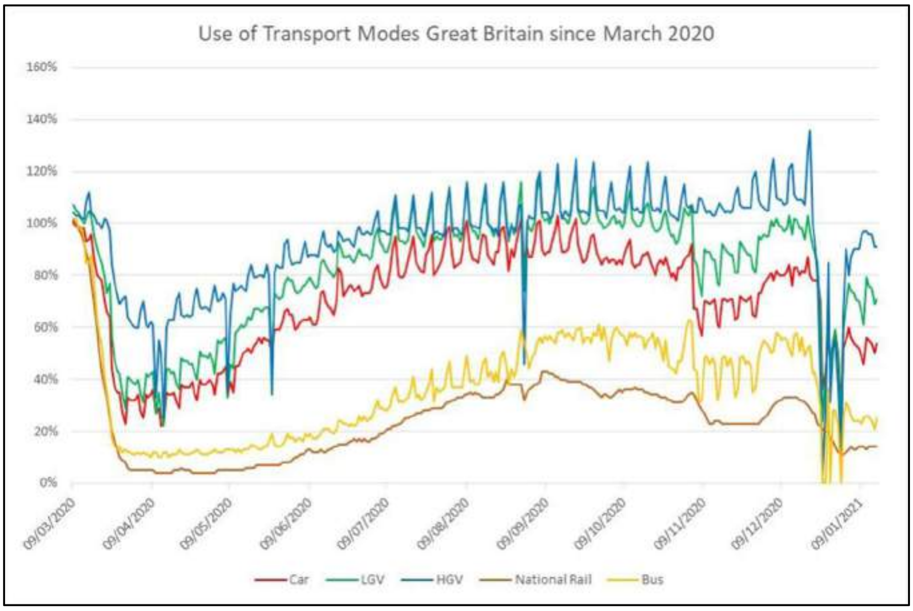


Figure 2-2: Use of Transport Modes in Great Britain since March 2020[1]

Figure 2-2 shows a significant downturn in demand for all modes during periods of national lockdown after March 2020 and again in January 2021. During the summer of 2020, highway demand had recovered with HGV and LGV demand back to pre-pandemic levels and car demand close to pre-pandemic levels. Rail and bus demand continued to lie significantly below normal levels. These trends, however, do not undermine the validity or usefulness of the model set up on the basis of 2019 data because they are considered to be temporary effects driven by external factors rather than fundamental changes in the travel choice processes that the model is calibrated to reproduce. If there are to be long term effects, these will be driven by the input assumptions used to derive future travel demand rather than changes in the behaviour represented by the model's algorithms.

Future travel behaviour may be affected by a combination of:

- Personal concerns;
- Government policy;
- Changes in personal economic circumstances; and
- National or global economic changes.

[1] Source: Jacobs analysis of DfT data from https://www.gov.uk/government/statistics/transport-use-during-the-coronavirus-covid-19-pandemic,

retrieved 22 January 2021.

At this stage, the likely long-term impacts of the pandemic can only be understood through scenario testing. Scenarios should be developed through discussion and consultation with key stakeholders and could consider some of the factors listed in Table 2-1 on the following page:

Pre-Pandemic Habits	Possible Drivers of Personal Behaviour Change	Possible Influencing Factors
Travel to work, dominated by public transport (towns and cities) and car (outside towns and cities)	• Long-term trend towards more remote working • Possible modal shifts	• Higher levels of unemployment • Road space re-allocation • Reductions in public transport capacity • Land use changes
Travel to meetings, both short and long distance	• Possible reduction of face-to-face meetings	• Better availability and quality of online meeting facilities • More cost-conscious and environmentally-friendly corporate travel policies
Visits to bars and restaurants	• Desire to return to normal	• Permanent closure of some bars and restaurants
Visits to friends and families	• Desire to return to normal	• More cost-conscious and environmentally-friendly personal travel behaviour
Visits to theatres and museums	• Desire to return to normal	• Permanent closure of some theatres or museums
High Street shopping	• Lasting reduction due to new online shopping habits	• Increased availability of online shopping facilities • Closure of high street shops
Big summer holiday by air	• Increased environmental awareness	• Reduced airline capacity • Increased environmental taxes
Weekend trips away by air	• As above	• As above

Table 2-1: Influencing Factors for Post-Covid Behaviour Change

In the longer term, some changes in behaviour, together with re-enforcing external factors, could include:

- **Land use:** It is possible that the current travel restrictions lead to a new wave of decentralisation, with different land use patterns and lower densities of development over time. This may be re-enforced by the travel choices people make, with a shift to shorter, local journeys by car or bicycle;
- **Propensity to travel:** We have already seen some reductions in household trip rates in most developed countries over the last few years. This trend may be accelerated;
- **Trip distribution:** Any longer-term changes to population or employment patterns will have an impact on trip distribution; and
- **Economic factors:** Longer term GDP growth may be impacted significantly by the pandemic.

Any such changes can be represented in the Chelmsford Model through the modification of input assumptions on land use, trip rates, cost escalation, and economic growth.

In the first instance, scenario testing may be informed by the scenarios postulated by the Office for Budget Responsibility (OBR) who maintain a set of upside, central and downside forecasts. At the time of writing, their latest advice was issued in the economic and fiscal outlook of 25 November 2020 which is now out of date as it did not anticipate the most recent travel restrictions. However, new advice is expected during 2021.

2.3 Key Model Design Considerations

2.3.1 Study Area

In order to test the strategic impacts of any potential transport development or scheme within the area of interest, the model extends to an area that is sufficient to assess strategic movements and key route choice as well as local movements within Chelmsford. An area of influence test was also undertaken to confirm that the model extent would be appropriate. This is further discussed in Section 4.2.The model has been built with regard to the relevant guidance provided in TAG. Specifically, it was necessary to represent movements on the Essex Yeomanry Way, the A130, the Essex Regiment Way, the A414 Three Mile Hill, the B1008, the Army and Navy Junction and the interaction of these with the rest of the strategic road network, as these are key routes in Chelmsford and the exact stretches of road that are expected to be impacted by the presence of the proposed scheme. These key roads are labelled, in the context of the proposed forecast schemes, in Figure 2-3:

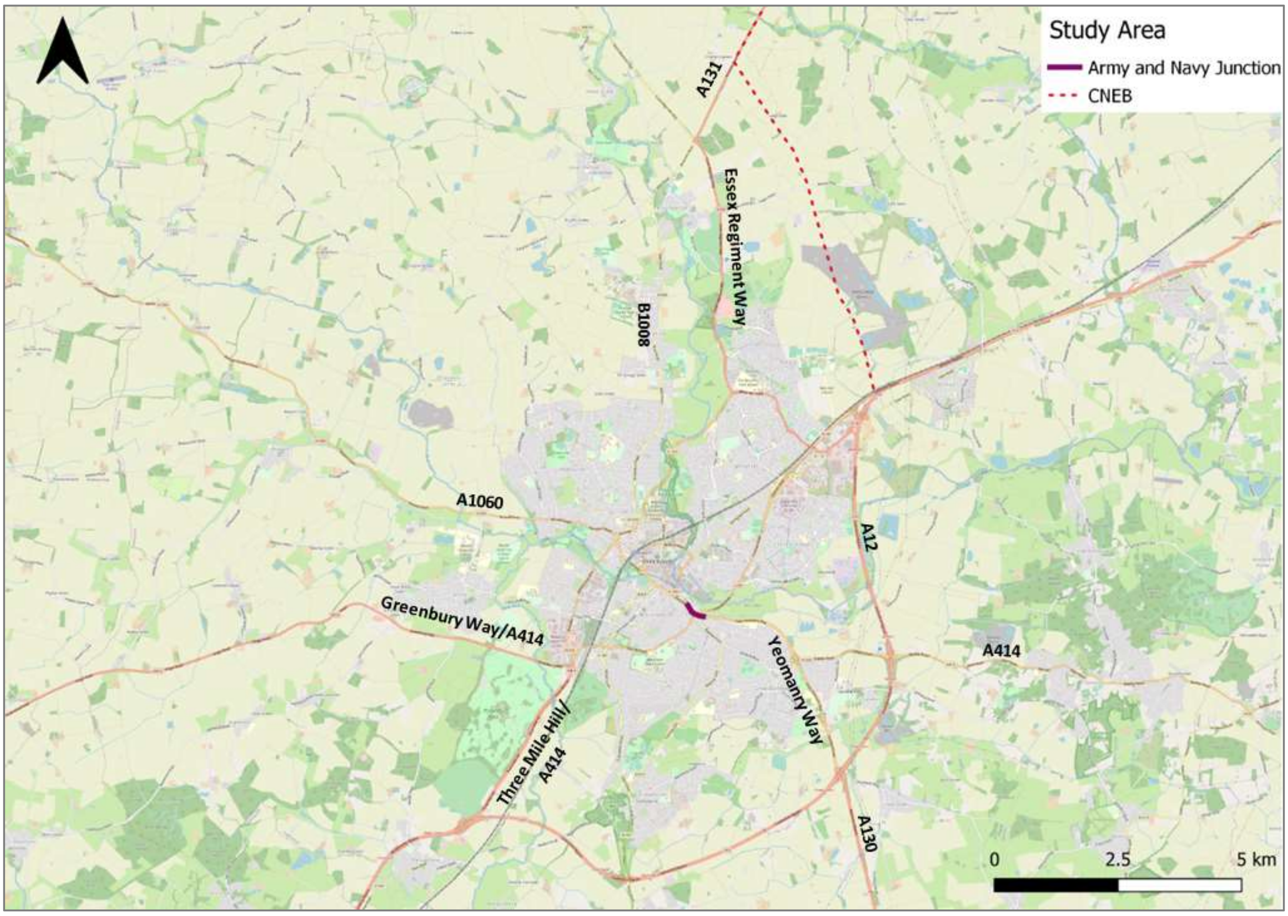


Figure 2-3: Key Routes in Chelmsford

2.3.2 Time Periods

To reflect the impact that the potential schemes have during the busiest parts of the day, a morning peak and evening peak model have been developed. The schemes are considered likely to also have an impact during less busy times of the day and therefore an average inter-peak hour has also been developed.

2.3.3 Modelled Responses

Due to the nature of the schemes being tested and based on the objective of the Chelmsford Model update and proportionality, a public transport (PT) model was developed using a 'light-touch' approach, which assumes that the impacts on PT of any scheme is relatively small.

A Variable Demand Model (VDM) has been developed. This was subject to realism testing to confirm that the demand model predicts changes within acceptable elasticities, in line with TAG Unit 2.1. As such, the primary objective of the PT component of the model is to provide PT generalised costs as inputs to the VDM process.

2.3.4 Software

The model is built using the latest PTV VISUM software version 2020 (this is an upgraded version of the same software as used in the existing Chelmsford Model) platform and utilised the Intersection Capacity Analysis (ICA) module to enable detailed evaluation of junction performance and represent blocking back and queuing (also known as flow metering). This software is widely acknowledged as being appropriate for the development of models of this nature.

2.3.5 Forecast Scenarios

The model is primarily intended to support the Planning Application for CNEB and to inform the business case for the Army and Navy scheme. To this end, two forecast years will be modelled for each scheme:

- The proposed CNEB scheme's opening year (2024), and a final forecast year (2036) to coincide with the end of the currently adopted Chelmsford Local Plan, to provide consistency with previous CNEB-related planning work undertaken, and to comply with the requirements of the current Planning Application and scheme objectives; and

- The proposed Army and Navy scheme's opening year (2026), and a final forecast year (2041), set 15 years after the scheme opening year.

Within each forecast year, scenarios with the scheme in place will be compared with scenarios which exclude the scheme. The forecasts will include those developments and transport schemes which have sufficient certainty of coming forward. To aid this, an Uncertainty Log will be developed. Total growth assumed will be constrained to the National Trip End Model (NTEM) at the district level (Chelmsford), and growth outside of that authority will be derived entirely from the NTEM growth. Assumptions on land use will be consistent across all schemes tested within the same forecast year and growth scenario.

The main intervention to be assessed (either the CNEB, or an improvement scheme at the Army and Navy junction) will be included in a 'Do Something' scenario for each forecast year. The 'Do Minimum' scenario will include only committed transport schemes, as described above. All schemes included in the Do Minimum scenario will also be included in the Do Something. A Model Forecast Report (MFR) will be delivered for the CNEB scheme, and another MFR for the Army and Navy scheme, which document the forecast scenarios in more detail.

3 Model Standards

3.1 Validation Criteria and Acceptability Guidelines

An assessment of the suitability of the Chelmsford Model to assess schemes in the study area has been informed using the criteria set out in TAG Unit M3.1. TAG sets out measures to compare the base year model against observed independent data to quantify the level of fit. The validation of the highway assignment model included comparisons of the following criteria which have been taken from TAG unit M3.1 chapter 3.2:

- 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;
- Assigned turning flows and counts at key junctions in the highway network; and
- Modelled and observed journey times along routes, as a check on the quality of the network and the assignment.

These criteria are further detailed below.

3.1.1 Link Flow Validation

Highways assignment validation is defined as the percentage difference between modelled flows and counts at screenline level within the model. Comparisons at screenline level provide information on the quality of the trip matrices. The criterion and acceptability guidelines are set out in Table 3-1 below:

Criteria	Acceptability Guideline
Differences between modelled flows and counts should be less than 5% of the counts	All or nearly all screenlines

Table 3-1: Screenline Flow Validation Criterion and Acceptability Guideline

TAG specifies the following criteria for screenlines, within unit M3.1 paragraph 3.3.8:

- Screenlines should normally consist of five or more links;
- The comparison of modelled and observed flows for screenlines containing high flow routes (such as motorways) should be presented both with and without such routes;
- The comparison should be presented separately for:
    - Data used to inform matrix development;
    - Other screenlines used as constraints in matrix estimation; and
    - Screenlines used as independent validation.
- The comparison should be presented by vehicle type, i.e. for car, Light Goods Vehicles (LGV) and Heavy Goods Vehicles (HGV) traffic; and
- The comparison should be presented separately for each modelled period.

In addition to validation of total screenline flows, TAG Unit M3.1 (paragraph 3.3.10) also contains guidelines on the validation criteria for individual links or turning movements. Link flow validation will be based on the following measures:

- The absolute and percentage differences between modelled flows and counts; and
- The GEH statistic, which is a form of the Chi-squared statistic that incorporates both relative and absolute errors. The GEH statistic is detailed below:

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

where:

GEH is the GEH statistic;

M is the modelled flow; and

C is the observed count.

The validation criteria and acceptability guidelines for link flows are defined below in Table 3-2. A link should satisfy at least one of the two criteria in the table.

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

Table 3-2: Link Flow and Turning Movement Validation Criteria and Acceptability Guidelines

TAG guidance unit M3.1 paragraph 3.3.12 states that the above comparison of modelled and observed flows should be applied to link flows and turning movements, although acceptability may be difficult to achieve for turning movements. The comparisons should be presented for total vehicle flows and for car flows, but not for LGV and HGV flows unless sufficiently accurate link counts have been obtained. In addition, the above information should be presented by modelled time period.

Data collection sites used in the calibration and validation of the base year model are presented in Section 5.2, and the results of the model validation provided in Chapter 11.

3.1.2 Journey Time Validation

TAG also contains acceptability guidelines for the validation of journey times, in TAG unit M3.1 paragraph 3.3.15. The journey time validation will be presented separately for each modelled period for light vehicles only. The measure which will be used is the percentage difference between modelled and observed journey times, subject to an absolute maximum difference. The acceptability criterion for journey time validation is given below in Table 3-3.

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

Table 3-3: Journey Time Validation Criterion and Guidelines

3.1.3 Checks on Matrix Estimation

Independent validation as specified above quantifies the ability of the model to replicate base year travel conditions within the model area. To enable these conditions to have a sound basis, TAG provides guidance (in unit M3.1 paragraph 8.3.14) as to the acceptable level of change to the highway 'prior' matrices that should result from the application of matrix estimation. The purpose of matrix estimation is to refine trips, but it is important that the effects of matrix estimation are minimised. The changes brought about by matrix estimation should be carefully monitored by the following means:

- Scatter plots of matrix zonal cell values, prior to and post matrix estimation, with regression statistics (slopes, intercepts and R^2 values);
- Scatter plots of zonal trip ends, prior to and post matrix estimation, with regression statistics (slopes, intercepts and R^2 values);
- Trip length distributions, prior to and post matrix estimation, with means and standard deviations; and
- Sector to Sector level matrices, prior to and post matrix estimation, with absolute and percentage changes.

The changes brought about by matrix estimation should not be significant. The criteria by which significance of the changes brought about by matrix estimation may be judged are shown in Table 3-4.

Measure	Significance Criteria
Matrix zonal cell values	Slope within 0.98 and 1.02 Intercept near zero R^2 in excess of 0.95
Matrix zonal trip ends	Slope within 0.99 and 1.01 Intercept near zero R^2 in excess of 0.98
Trip length distributions	Means within 5% Standard deviations within 5%
Sector to sector level matrices	Differences within 5%

Table 3-4: Significance of Matrix Estimation Changes

3.2 Convergence Criteria and Standards

In order for the outcomes of the modelling to be reliable, the stability of the modelled flows needs to be confirmed at the appropriate level. The importance of achieving convergence is related to providing stable, consistent and robust model results. This minimises the chances that, when modelling a scheme, any flow changes which occur do so directly as a result of the scheme rather than as a result of random flow changes due to poor model convergence.

Sufficient iterations should be carried out to achieve an acceptably low value for %GAP (the difference between the costs along the chosen routes and those along the minimum cost routes, summed across the whole network and expressed as a percentage of the minimum costs). GAP is the single most valuable indicator of overall model convergence and the method for calculating GAP (denoted δ) is outlined below with the guideline for GAP being 0.1% or less.

$$\delta = \frac{\sum \boldsymbol{T}_{pij}\,(\boldsymbol{C}_{pij} - \boldsymbol{C}*_{ij})}{\sum \boldsymbol{T}_{ij}\,\boldsymbol{C}*_{ij}}$$

where:

Tpij is the flow on route p from the origin i to destination j;

Tij is the total travel from i to j;

Cpij is the (congested) cost of travel from i to j on path p; and

Cij* is the minimum cost of travel from i to j.

Source: TAG Unit M3.1 paragraph C.2.4

In addition, the model should converge to a point in which routes obey Wardrop's First Principle of Traffic Equilibrium, which TAG unit M3.1 paragraph 2.7.3 defines as:

"Traffic arranges itself on networks such that the cost of travel on all routes used between each OD pair is equal to the minimum cost of travel and all unused routes have equal or greater cost."

This relates to how close the model is to a particular converged solution, which varies depending on the preferences of the user or software package being used.

The gap value therefore represents the excess cost incurred by failing to travel on the route with the lowest generalised cost and is expressed relative to that minimum route cost. The excess cost is summed over each route between each O/D pair and multiplied by the number of trips between each O/D pair. This is divided by the minimum cost summed over each route between each O/D pair, also multiplied by the number of trips between each O/D pair.

For the model to be considered sufficiently well converged, the GAP value must be less than 0.1%. A full summary of the most appropriate convergence measures (of proximity and stability) and the values generally considered acceptable for use in establishing a base model is expressed in Table 3-5 on the following page.

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% (SUE only)

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

Within the model, the "Assignment with ICA" methodology will be used, for which each outer iteration has itself an inner Linear User Cost Equilibrium (LUCE) assignment, which is run to convergence, before flow metering and blocking back is then applied as part of the outer iteration. Subsequent outer iterations then consider the delay caused by flow metering and blocking back when choosing routes. This process therefore includes the "inner iterations" of the equilibrium assignment and the "outer iterations" of the assignment with flow metering and blocking back. The methodology utilised is therefore consistent with the relevant guidance in TAG (Unit M3.1, section 2.7). The assignment methodology is described in more detail in Section 4.8.

3.2.1 Variable Demand Model (VDM) Convergence

Convergence within the VDM is measured through the relative gap between the demand and assignment models, as expressed below:

$$\frac{\sum_{ijctm} C(X_{ijctm})\,|\,D(C(X_{ijctm})) - X_{ijctm}\,|}{\sum_{ijctm} C(X_{ijctm}) X_{ijctm}} * 100$$

where:

X_{ijctm}	is the matrix from the model
$C(X_{ijctm})$	is the cost matrix derived from the current matrix
$D(C(X_{ijctm}))$	is the matrix outputted by the demand model using the above cost and an input
$ijctm$	represents the origin (i), destination (j), user class (c), time period (t) and mode (m) respectively

TAG Unit M2-1 suggests that a relative gap (%GAP) under 0.1% is a favourable level of convergence; if that cannot be reached, a result at least as good as 0.2% is also recommended. The VDM methodology and convergence is further discussed in Section 12.

4 Key Features of the Model

4.1 Summary

The key characteristics of the model are described in Table 4-1 below.

Characteristic	Model Coverage
Model structure	Peak hour highway assignment model 24-hour production-attraction variable demand model
Software platform	VISUM version 2020
Assignment methodology	VISUM Assignment with ICA using the equilibrium LUCE algorithm
Time periods	AM peak hour (07:30 – 08:30), Average inter-peak hour (between 10:00 and 16:00), PM peak hour (17:00 to 18:00)
Trip matrices (private transport modes)	Car Commute, Car Business, Car Other, LGV and HGV
Trip matrices (public transport modes)	Rail/London Underground, Bus
Base year	2019
Forecast year(s)	CNEB – 2024, 2036 Army and Navy – 2026, 2041
Calibration / Validation	To follow TAG guidance
Realism testing	To follow TAG guidance

Table 4-1: Key Model Features

4.2 Fully Modelled Area and External Area

In establishing the geographical coverage of the model, TAG unit M3.1 section 2.2.1 has been followed. This advises of the need to:

- Allow for the strategic re-routing impacts of interventions;
- Allow for areas outside the main area of interest, which are potential alternative destinations, to be properly represented; and
- Represent the full length of trips for the purpose of deriving costs.

The breakdown of the network structure is therefore outlined broadly as:

- Fully Modelled Area:
    - Area of Detailed Modelling; and
    - Rest of the Fully Modelled Area.
- External Area

To check that the model's coverage is appropriate, the scale of the impact of the CNEB and Army and Navy junction improvement schemes were assessed individually by coding a preliminary design for each scheme into the existing Essex Countywide 2036 reference forecast model and running an assignment (an 'area of influence' test). The resulting changes, thereby establishing the extent of reassignment which may occur as a result of the schemes, were examined. The Fully Modelled Area has been designed to cover the area where the flow differences are considered significant. Outside of this area it is assumed that the schemes do not have an influence and the area is not included in the Fully Modelled Area. Flow difference plots from these preliminary assignments are shown in Figure 4-1 and Figure 4-2.

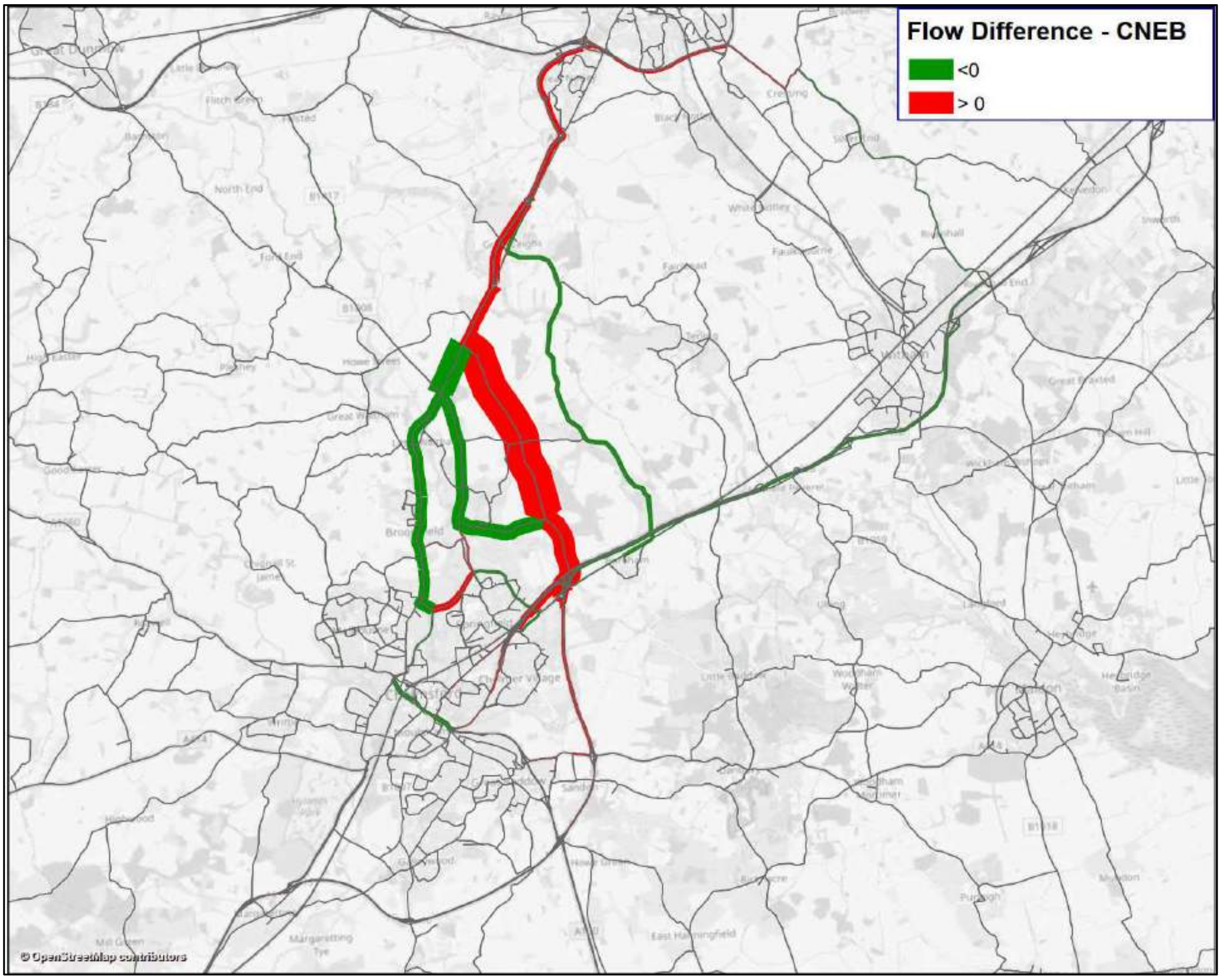


Figure 4-1: CNEB Area of Influence

Figure 4-1 indicates that there is likely to be local reassignment due to the CNEB scheme to the north of Chelmsford, on the competing corridors of A130 Essex Regiment Way and the B1008 Broomfield Road in particular, as well as on the A12.

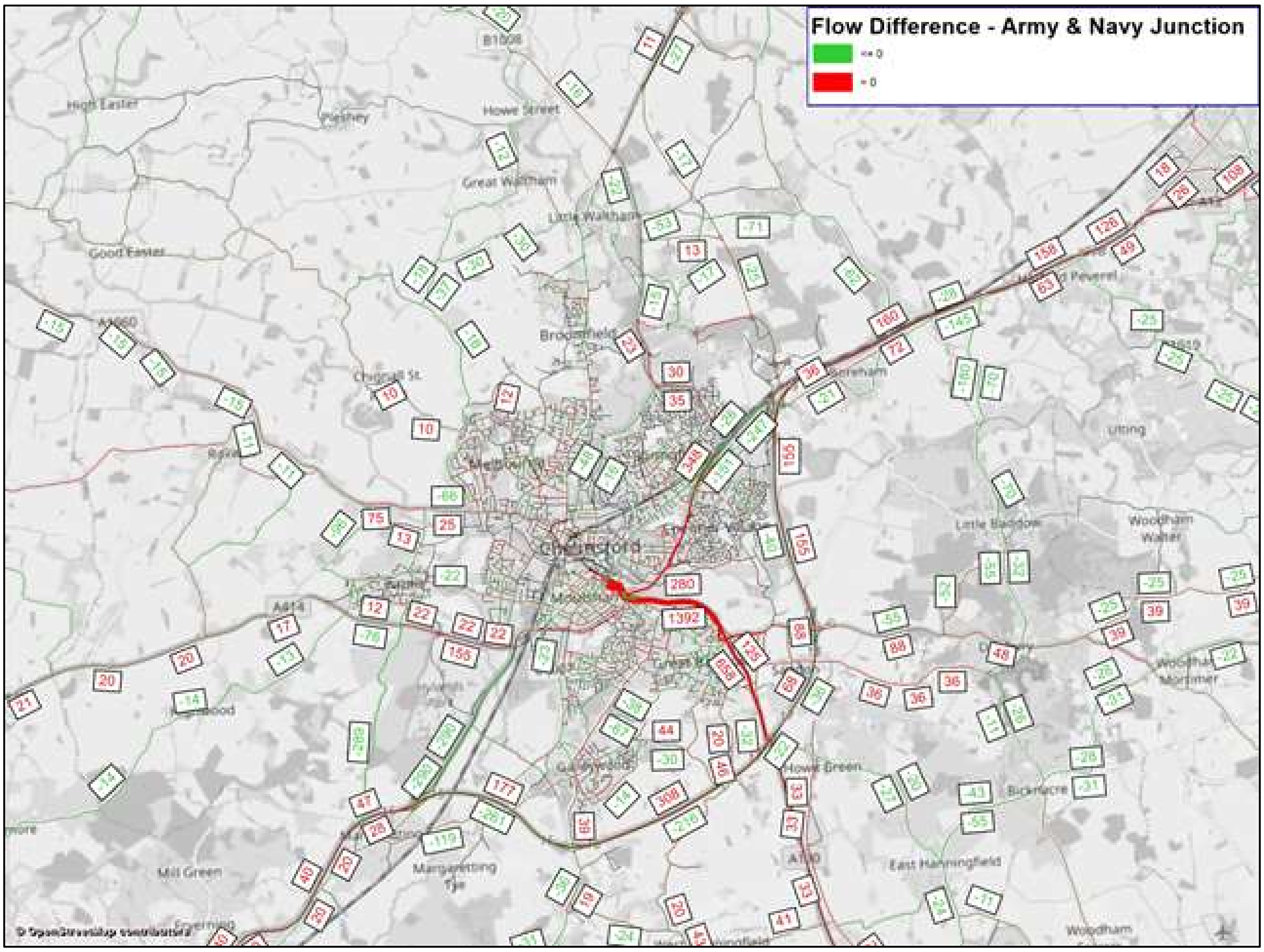


Figure 4-2: Army and Navy Area of Influence

Figure 4-2 indicates that there is likely to be significant impacts due to the Army & Navy scheme as traffic reassigns to corridors that pass through the Army & Navy junction, reducing traffic on competing corridors for travel to the city centre, such as B1137 Springfield Road, the A414 Three Mile Hill/B1007 New London Road corridor, and numerous more minor roads in the city centre.

Figure 4-3 on the next page then shows the breakdown of the network structure for the Chelmsford Model, based on the extent and proposed use of the model.

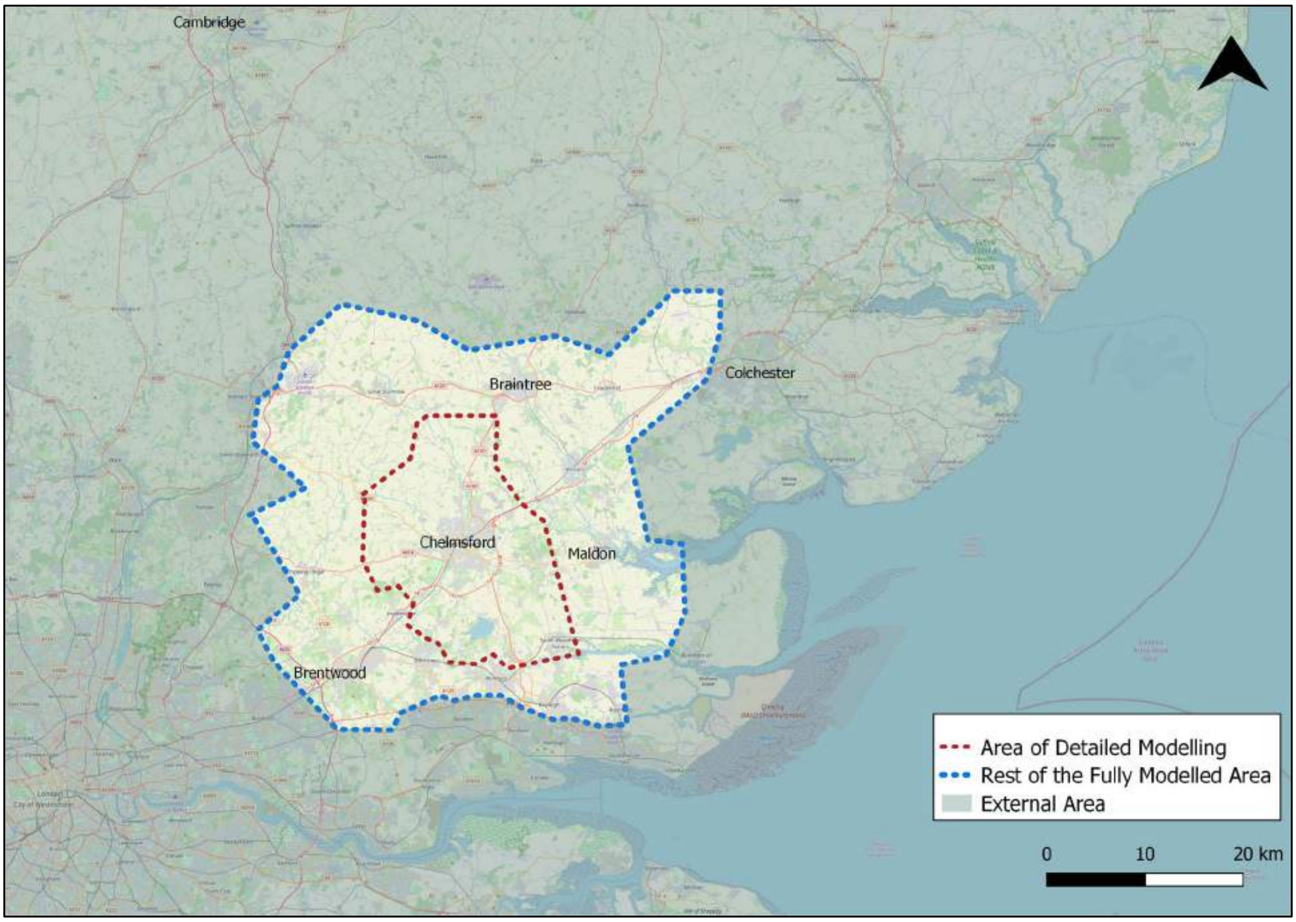


Figure 4-3: Model Coverage for the Chelmsford Model Update

The Chelmsford Model is focussed on the area contained within the Chelmsford City Council administrative area, which coincides with the Area of Detailed Modelling (AoDM). The immediate surrounding area comprising the Rest of the Fully Modelled Area is modelled to a decreasing level of detail based on proximity from Chelmsford, although highway capacity restraint is still considered. The demand included between origin-destination (OD) pairs is the same as in the Essex Countywide Model, which has a larger AoDM that the Chelmsford Model. This implies that the full demand is included in the Chelmsford Model AoDM as well as in the Rest of the Fully Modelled Area. In addition, some of the Chelmsford Model External Area also includes the full demand with only external demand peripheral to Essex and not passing through Essex excluded. The model structure is reflected in the accompanying model zoning system, detailed in Section 4.3 and in the network structure, detailed in Section 4.5.

4.3 Zoning and Sectoring System

4.3.1 Zoning System

The existing Chelmsford Model was used as the basis for the zoning system, which was itself based on aggregations of census boundary areas. However, it has been revised to add further detail in the North of Chelmsford where a large proportion of new housing development is located in the Local Plan and where the new CNEB scheme is located. A total of 14 additional zones were created by splitting large existing zones outside the urban centre. The methodology behind splitting these zones is detailed in Section 6.4. The zone system in the centre of Chelmsford was considered sufficiently detailed for the schemes expected to the assessed.

The updated zone system in the Chelmsford area is shown in Figure 4-4:

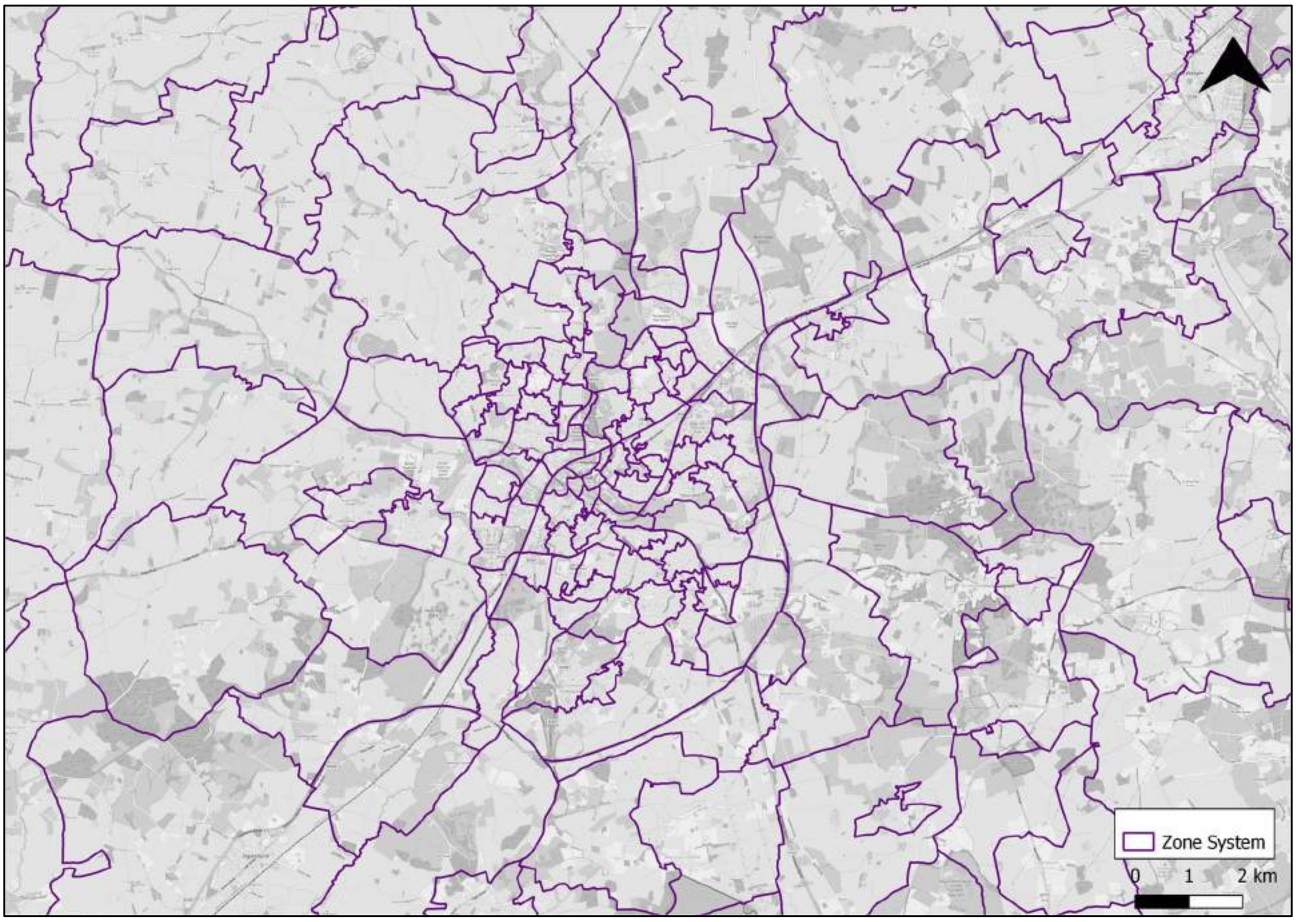


Figure 4-4: Model Zone System in Chelmsford and Surrounding Area

The size of zones within the Area of Detailed Modelling for the revised zone system was examined to check that the zone size was appropriate in accordance with guidance in TAG Unit M3.1 section 2.3. Specifically, the guidance states that: "*the resultant numbers of trips to and from individual zones should be approximately the same for most zones and that the numbers of trips to and from each zone should be some relatively small number, such as 200 or 300 per hour, to avoid unrealistically high loads appearing at some points in the network".* The assessment of the trip end totals for the zones in the Area of Detailed Modelling indicated that the zone size was appropriate. This is demonstrated for the AM peak period in the following figures over the next two pages, and for the other time periods and wider network area in Appendix S.

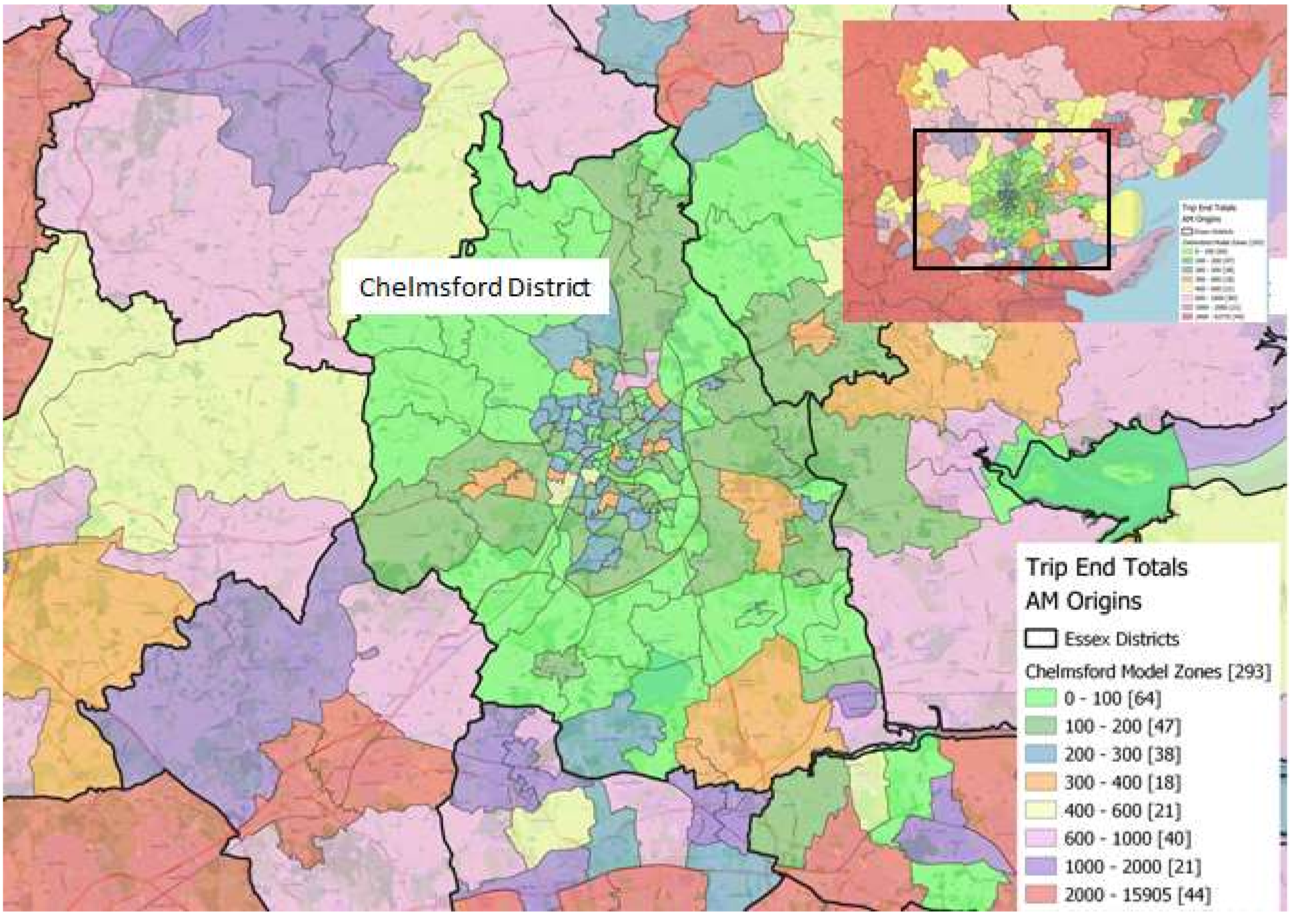


Figure 4-5: Origin Trip End Totals - AM Peak Hour

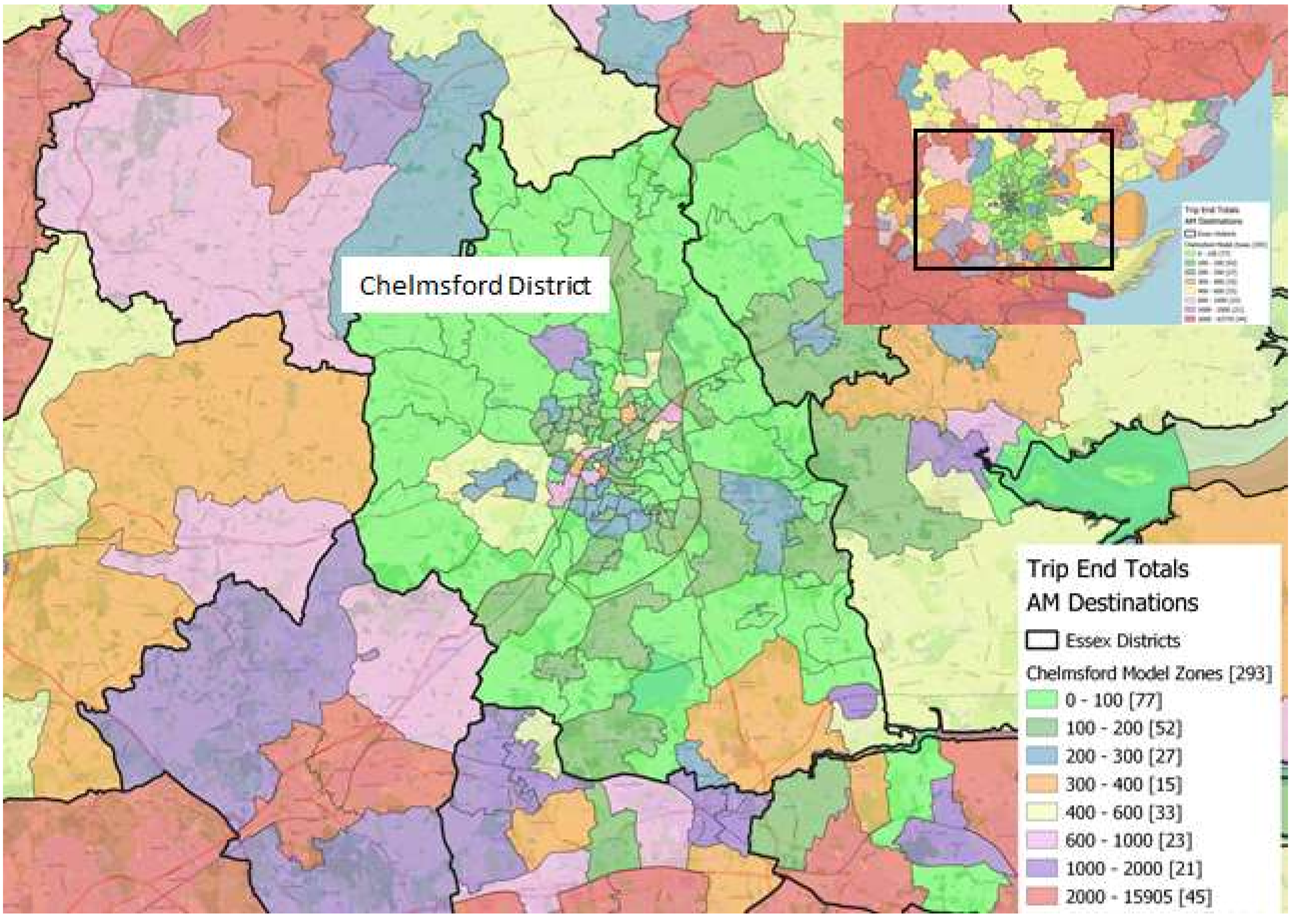


Figure 4-6: Destination Trip End Totals - AM Peak Hour

The above figures highlight that almost all of the zones within the Area of Detailed Modelling, which corresponds to Chelmsford District, have less than 300 trips per hour, with the few exceptions either being located on the periphery of the Chelmsford urban area or specific employment areas (such as Broomfield Hospital) that are already geographically small zones with centroid connectors carefully modelled to provide sensible access.

Figure 4-7 on the next page shows the zone system across the wider area. There are 304 zones in the network. The zone system within the model is hierarchical with higher levels of detail within the Chelmsford Administrative Area, decreasing in detail as the distance from Chelmsford increases.

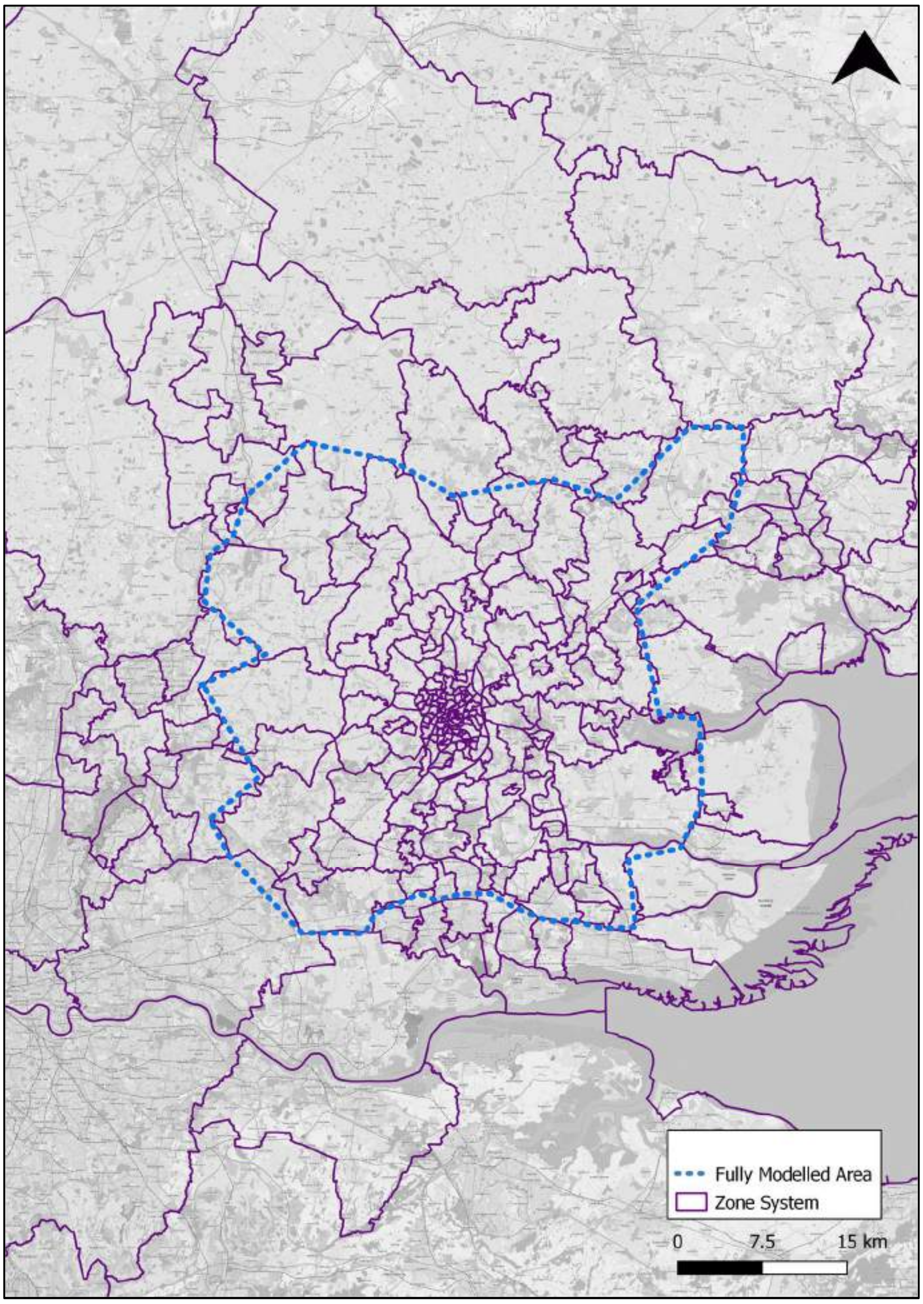


Figure 4-7: Chelmsford Model Zone System

4.3.2 Sectoring System

For ease of reporting and analysis, the zones in the model were aggregated into ‘sectors’. The sectors are shown in Figure 4-8 on the next page.

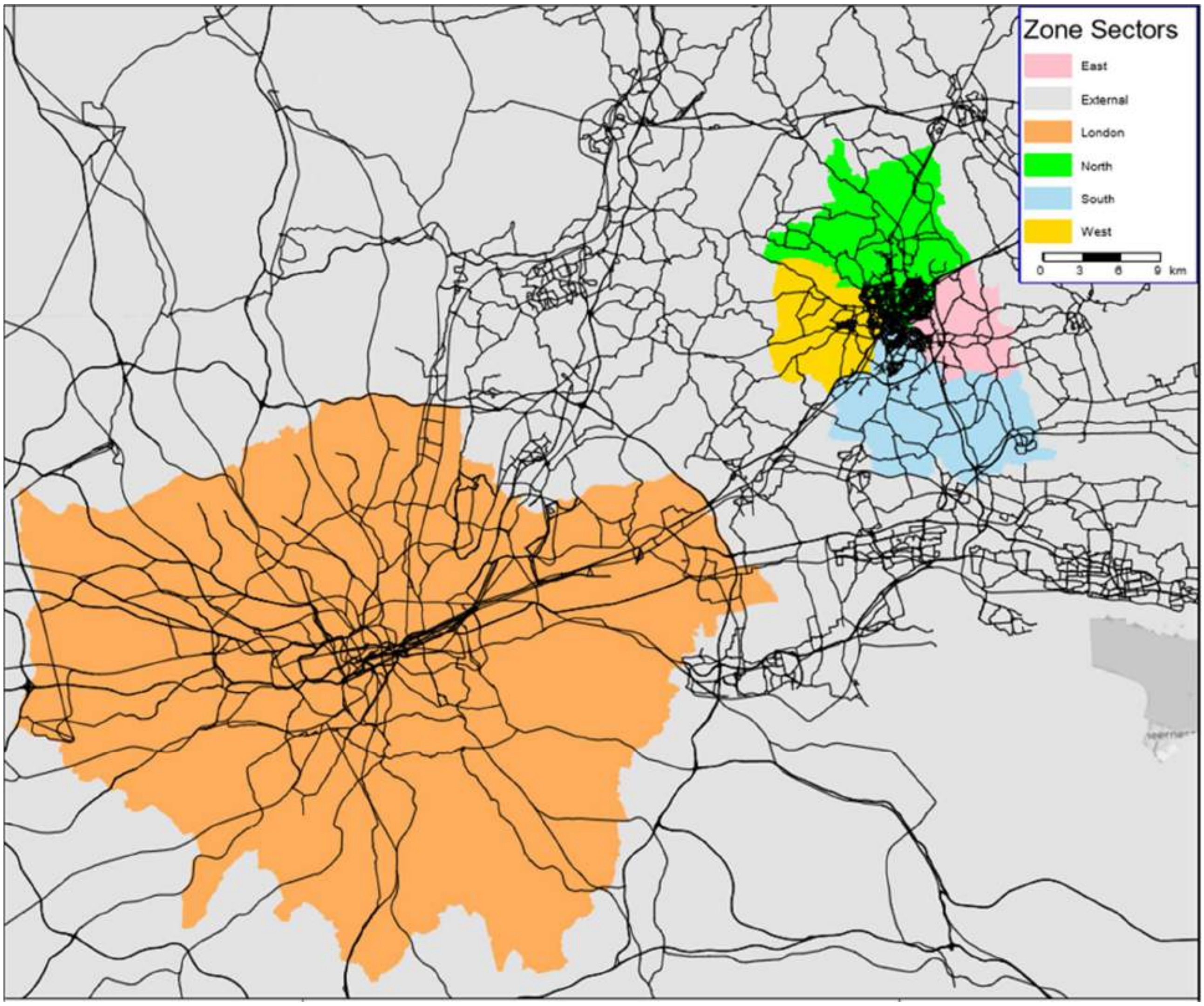


Figure 4-8: Chelmsford Model Sector System

The six sectors identified in Figure 4-8 correspond to the areas identified in Table 4-2:

Sector	Sector Area
1	North
2	East
3	South
4	West
5	London
6	External

Table 4-2: Sector to Area Correspondence

4.4 Centroid Connectors

Trips to and from zones are loaded onto the network from the zone centroid ('centre of gravity' of the zone) using specialised links known as centroid connectors. The points at which these connectors load on to the network was chosen to reflect actual access points and to avoid major junctions. This is illustrated for the Chelmsford area in Figure 4-9 below.

The loading point for each connector was selected, based on professional judgement, as the most representative location for demand generated within the zone to enter and exit the network. For the detailed model area, every effort has been made, where possible, to avoid connectors joining the network at junctions or directly onto main roads. The number of centroid connectors for each zone has been minimised, with most zones having only one connector.

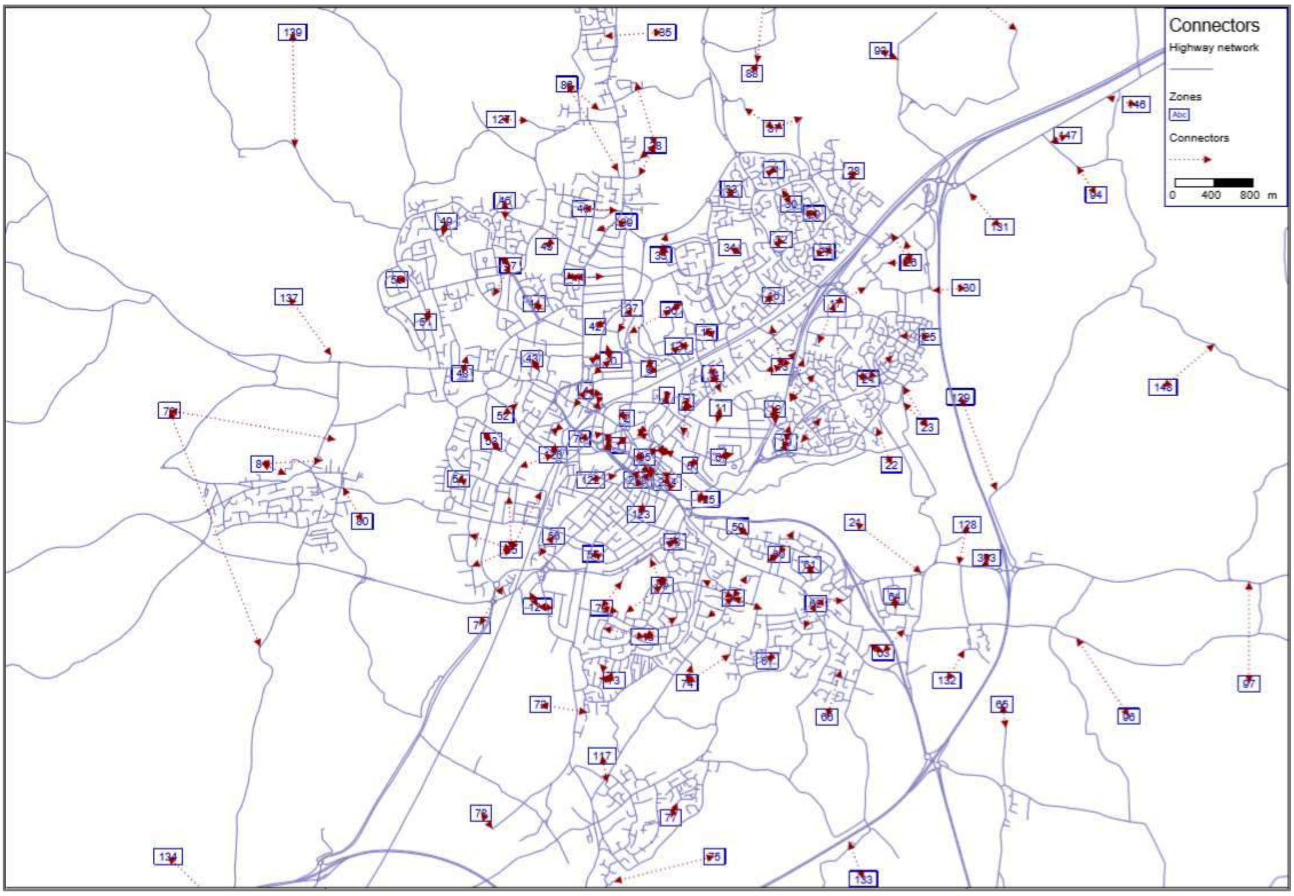


Figure 4-9: Centroid Connectors Modelled in the Chelmsford Area

4.5 Network Structure

In accordance with TAG Unit M3.1 section 2.4, and as alluded to in Section 4.2 of this report, the network for the Chelmsford Model has been developed as a three-tier structure. The level of detail of network coding reduces further away from the Chelmsford City Council administrative boundary, which is also consistent with the boundary for the Area of Detailed Modelling, where the detail within the network and demand matrices is at its greatest, and capacity restraint is modelled on links and junctions. The Rest of the Fully Modelled Area is where the level of detail is not as great, but capacity restraint is still modelled with speed-flow curves on links but without any capacity restraint at junctions. The External Area is where the level of detail is at its lowest, with the network in this area based on a skeleton network of key roads without capacity restraint (i.e. vehicles travel at fixed speeds).

The geographical extents of the three-tiered network structure are shown in Figure 4-10 below. The highway network inside the Chelmsford urban area includes all streets and roads that are to be used by vehicles. The wider Chelmsford administrative area also includes all major and minor roads, with proportional treatment of local streets. Outside of the Chelmsford Administrative Area, major and minor roads are coded while the model gradually reduces its granularity down to only a skeleton network further away from the Essex County boundaries.

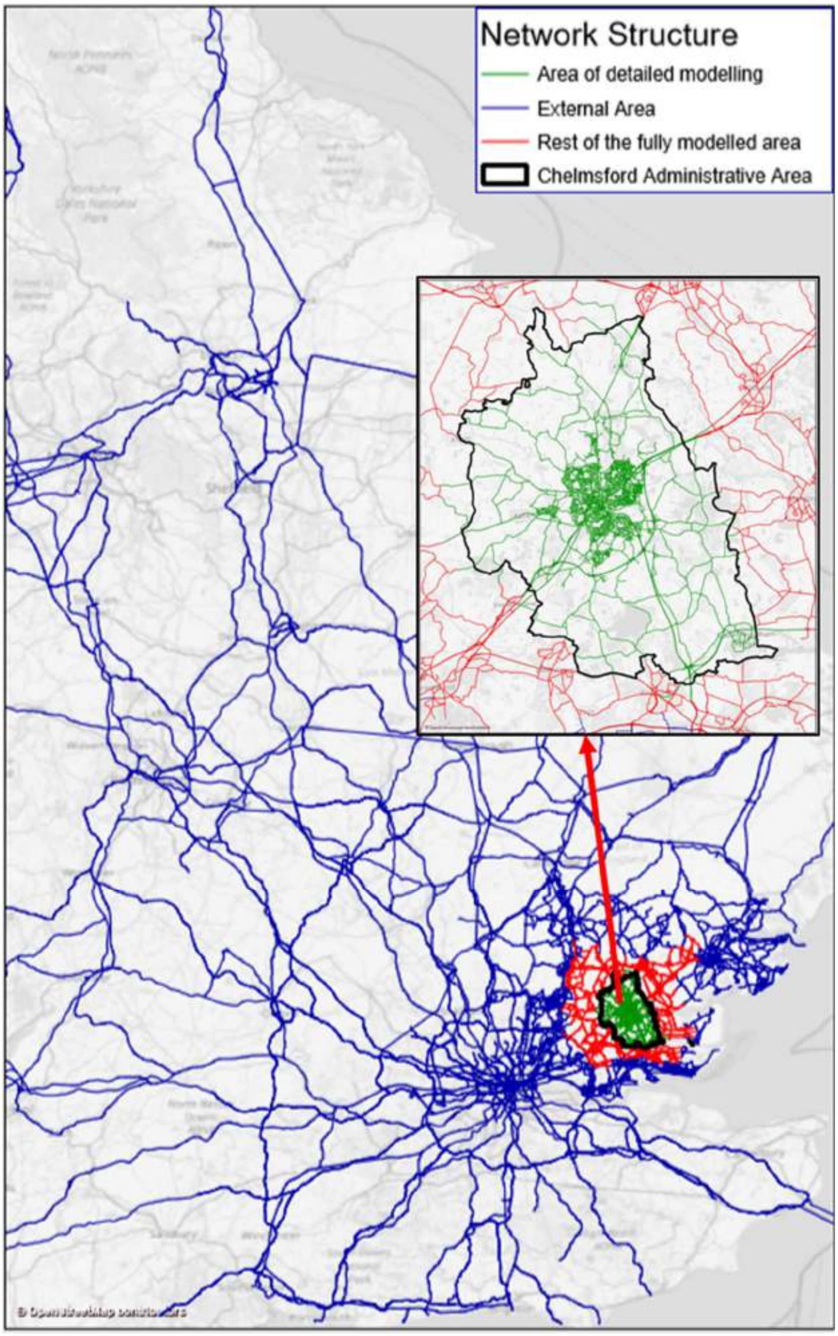


Figure 4-10: Network Structure

The network structure was derived from the previous version of the Chelmsford Model. To better reflect network capacity, updates to the network for this new model were undertaken which included further network coverage and detail in and around the Chelmsford administrative area, and additional junction coding which had not previously been included in the model. The majority of local distributor roads are included; these are necessary to enable trips generated from within residential areas to load on to the wider network appropriately. Figure 4-11 shows the network elements for Chelmsford, where the level of detail of network coding is highest:

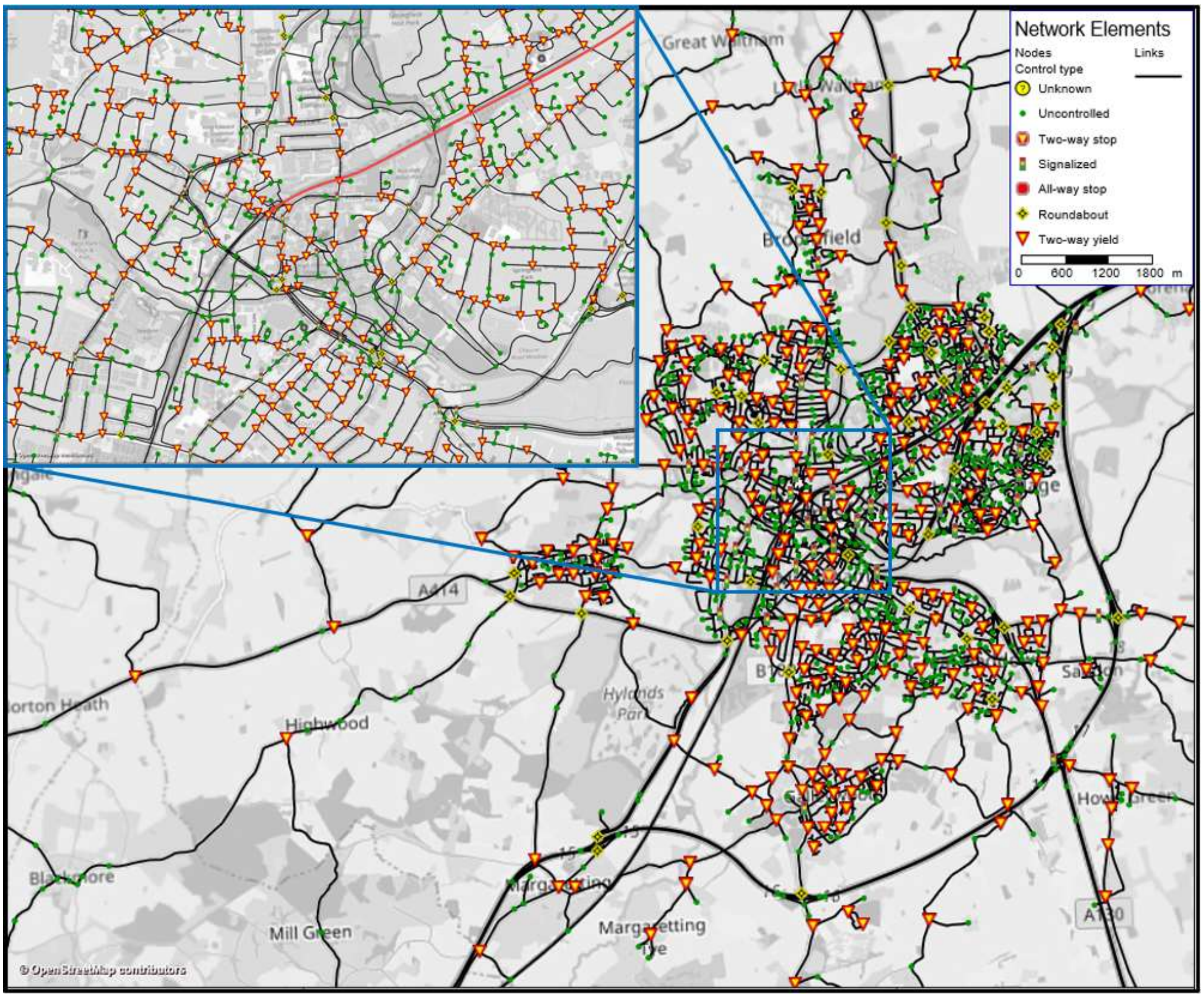


Figure 4-11: Model Network Coverage Around Chelmsford

The process of network development, including the definition of link characteristics, junction coding and the development of the zone system are further detailed in Chapter 6.

4.6 Time Periods

The model was built to represent three time periods, for which ATC count data from in and around the Chelmsford administrative area were used to derive the following peak hours from the peak periods:

- AM peak hour (07:30-08:30);
- PM peak hour (17:00-18:00); and
- Average hour in the interpeak (10:00-16:00).

The peak hours represent the times at which observed traffic volumes were the highest in each peak period, and an average hour for the interpeak model.

4.7 User Classes

For the assignment model, car trips have been segmented into separate Commute (UC1), Business (UC2), and Other (UC3) trip purposes. In addition to this, separate user classes were used for LGV and HGVs.

Additional trip purposes were used in the demand model, with non-home-based car trips incorporated into the Business and Other trip purposes during the assignment. The journey purpose segmentation is similar for public transport modes, however there is further segmentation into 'car available' and 'not available' matrices, consistent with the recommendations set out for demand modelling in TAG Unit M2-1. The segmentation is summarised in Table 4.3:

<table>
<tr><th>Assignment Mode</th><th>Vehicle Class</th><th>Assignment User Class</th><th>Demand Model Trip Purposes</th></tr>
<tr><td rowspan="9">Private Transport</td><td rowspan="7">Car (VC1)</td><td>Car Commute (UC1)</td><td>Home Based Work (HBW)</td></tr>
<tr><td rowspan="2">Car Employer Business (UC2)</td><td>Home Based Employer's Business (HBEB)</td></tr>
<tr><td>Non-Home-Based Employer's Business (NHBEB)</td></tr>
<tr><td rowspan="4">Car Other (UC3)</td><td>Home Based Education (HBED)</td></tr>
<tr><td>Home Based Shopping (HBShop)</td></tr>
<tr><td>Home Based Other (HBO)</td></tr>
<tr><td>Non-Home Based Other (NHBO)</td></tr>
<tr><td>LGV (VC2)</td><td>LGV (UC4)</td><td>-</td></tr>
<tr><td>HGV (VC3)</td><td>HGV (UC5)</td><td>-</td></tr>
<tr><td rowspan="6">Public Transport (Bus, Train, London Underground)</td><td rowspan="6">n/a</td><td rowspan="2">Commute</td><td>Car Available - Home Based Work (HBW)</td></tr>
<tr><td>No Car Available - Home Based Work (HBW)</td></tr>
<tr><td rowspan="4">Employer Business</td><td>Car Available - Home Based Employer's Business (HBEB)</td></tr>
<tr><td>No Car Available - Home Based Employer's Business (HBEB)</td></tr>
<tr><td>Car Available - Non-Home-Based Employer's Business (NHBEB)</td></tr>
<tr><td>No Car Available - Non-Home-Based Employer's Business (NHBEB)</td></tr>
<tr><td rowspan="8">Public Transport (Bus, Train, London Underground)</td><td rowspan="8">n/a</td><td rowspan="8">Other</td><td>Car Available - Home Based Education (HBED)</td></tr>
<tr><td>No Car Available - Home Based Education (HBED)</td></tr>
<tr><td>Car Available - Home Based Shopping (HBShop)</td></tr>
<tr><td>No Car Available - Home Based Shopping (HBShop)</td></tr>
<tr><td>Car Available - Home Based Other (HBO)</td></tr>
<tr><td>No Car Available - Home Based Other (HBO)</td></tr>
<tr><td>Car Available - Non-Home Based Other (NHBO)</td></tr>
<tr><td>No Car Available - Non-Home Based Other (NHBO)</td></tr>
</table>

Table 4-3: Purpose/User Class/Vehicle Class Correspondence

Link flow validation was performed at the level of vehicle class flows. The trip purpose and user class definitions are consistent with the guidance contained in TAG unit M3.1, section 2.6.

Vehicle classes 1 and 2 (cars and LGVs) were assigned a PCU factor of 1.0. Vehicles class 3 (HGVs) was given a PCU factor of 2. This is consistent with guidance in Appendix D of TAG Unit M3.1, which advises use of this factor on road types other than motorways and dual carriageways.

4.8 Assignment Methodology

4.8.1 Highway Assignment

The VISUM software assignment methodology used in the Chelmsford Model is known as “Assignment with ICA”. This means that, when generalised costs are calculated for the purposes of route choice, junction delays are calculated using Intersection Capacity Analysis (ICA) and are included within the generalised cost. In all other VISUM assignment methods junction delays are calculated using volume-delay functions (VDFs) and the ICA is only brought into effect when the assignment is completed.

The “Assignment with ICA” method also means that flow metering and blocking back is calculated. For the assignment with ICA, the Linear User Cost Equilibrium (LUCE) assignment was used as a subordinate assignment procedure with the advantage that there is stable route distribution and the calculation of the blocking back model is considerably faster than using the paths of other assignment methods. Due to the stable route distribution, the blocking back result is also more stable, and convergence is reached much faster. The fundamentals of the LUCE assignment are that, for any node, a user equilibrium shall be reached on all forward edges for the local route choice of drivers heading to a destination zone[2].

The above is consistent with the latest TAG guidance on highway assignment modelling and relevant to the particular scheme.

Within the blocking back model, it is assumed that one PCU takes up 7.0 metres of road space when in a queue.

4.8.2 Public Transport Assignment

The assignment of public transport matrices is also undertaken in VISUM, making use of the timetable-based assignment approach. Timetable-based public transport assignment is a deterministic user equilibrium assignment and the usual choice for public transport networks with long headways. This assignment procedure takes the accurate timetable (precise departure and arrival times) into consideration and is therefore particularly suitable for rural areas or train networks (both of which are significant for this model). Coordination of timetables is also considered, which is important for transfers, and this enables more precision in terms of costs passed to the demand model.

4.9 Generalised Cost Formulations and Parameter Values

The values of time (VOT) used in the model were taken from the TAG Data Book, released in May 2019, which was the latest version of the data book available at the time the model development was started. Similarly, vehicle operating costs (VOC) were based on formulations and parameters within the TAG Data Book. When calculating the VOC, an average network speed of 40 kph was assumed.

[2] PTV VISUM 20 Manual. 2020 PTV AG, Karlsruhe, Germany

The generalised cost definition has been taken from TAG unit M3-1:

$$GC = \mathrm{T} + \frac{\mathrm{VOC \; x \; D}}{\mathrm{VoT}} + \frac{M}{VoT}$$

where:

GC = Generalised costs;
VOC = Vehicle Operating Cost;
VoT = Value of Time;
T = time;
D = distance; and
M = monetary charge.

In this case, the variable '**M**' will be set to zero as there are no toll roads or user charging in the modelled area.

Generalised cost is therefore a time value. It should be noted that the **VoT** and **VOC** values differ by trip purpose and appropriate parameter values are defined based on the values of time (VoT) and vehicle operating costs (VOC) set out in the TAG data book (May 2019, which was the latest version at the time the base model development was undertaken). Parameters have been calculated for each user class (business, commute, other, LGV and HGV). Generalised costs for LGVs, HGVs have a higher emphasis on the distance component than is the case for cars. Recently revised values of time, in which values are considered to vary based on overall trip distance for business users, have been noted. For assignment purposes an average was used in order to simplify the assignment. These are outlined in Table 4-4:

Time Period	User Class	2019 Base Year	
		VoT p/min	VOC p/km
AM	UC1 (Commute)	20.80	6.34
	UC2 (Business)	36.91	12.93
	UC3 (Other)	14.35	6.34
	LGV	25.71	14.25
	HGV	52.97	38.65
IP	UC1 (Commute)	21.14	6.34
	UC2 (Business)	37.82	12.93
	UC3 (Other)	15.29	6.34
	LGV	25.71	14.25
	HGV	52.97	38.65
PM	UC1 (Commute)	20.87	6.34
	UC2 (Business)	37.44	12.93
	UC3 (Other)	15.03	6.34
	LGV	25.71	14.25
	HGV	52.97	38.65

Table 4-4: Generalised Cost Parameters

The generalised cost formulation for public transport is derived from perceived journey time (PJT). This combines a number of different components. Each component is given its own weight or coefficient in order to convert the components to common units and to enable the relative importance of each component for passengers to be reflected. These attributes are:

- In-vehicle time (weighting may vary by mode/vehicle type);
- PuT-Aux ride time;
- Access time (from trip origin to PT stop);
- Egress time (from PT stop to trip destination);
- Origin wait time (time spent waiting for first service on path);
- Transfer walk time (between PT stops);
- Transfer wait time (time spent waiting for subsequent services);
- Number of transfers; and
- Number of operator changes.

The PJT is used within the VISUM public transport assignment to evaluate individual connections during the connection choice. Giving more weight to the component for the number of transfers , for example, results in passengers preferring minimum transfer connections. The components within PJT are all subject to coefficients which can be purpose and/or time-period specific.

The total generalised cost of travel is then:

$$GeneralisedCost_{minutes} = Origin\ Wait\ Time\ Adapted * 2\ (Wait\ Time) + \ PJT + (\frac{Fare_{pence}}{VOT_{ppm}})$$

4.10 Capacity Resistant Mechanisms

4.10.1 Links

Delays along links were calculated according to volume-delay functions which regulate how average travel speeds on a link change with respect to traffic volume. Capacity restraint on links is modelled through the use of speed flow curves. Parameters for volume-delay functions for specific link types are shown in Appendix B and a detailed description of these calculations is given in Section 6.2.2.

4.10.2 Junctions

As previously mentioned in section 4.8, the assignment methodology used “Assignment with ICA” which enables capacity restraint at junctions to be modelled using VISUM’s Intersection Capacity Analysis (ICA) model. This uses the US Highway Capacity Manual as the underlying basis for the capacity restraint and is appropriate for use at priority and signalised junctions. However, for roundabouts the Kimber Method developed by the Transportation Research Laboratory (TRL) will be used.

4.11 Relationship with Other Models

4.11.1 The Previous Chelmsford Model

A multi-modal strategic transport model for the city of Chelmsford with a base year of 2014 was previously developed by Jacobs to support the Local Plan process and Local Enterprise Partnerships (LEP) funding bids. This was subsequently used in the CNEB Housing Infrastructure Fund (HIF) bid support for ECC which was successfully awarded funds. The model was developed, calibrated, and validated following TAG; however, it was identified that it would need refinements in the context of current and future Army and Navy business case work for the DfT, and the CNEB planning application for ECC. In particular, these refinements pertain to the age of data used within all stages of model development, the extent of the model network, and network changes that have taken place since original validation, in particular the permanent closure of the Army and Navy Flyover. The model update is of particular relevance to the Army and Navy junction, to enable representation of the junction with the Flyover closed (the existing model was developed with the Flyover open), and to CNEB, to extend the detailed model area further to the north and east of Chelmsford. To provide the evidence base for a Planning Application for CNEB and a potential outline business case for a scheme to improve the Army and Navy junction therefore requires an update to the existing Chelmsford Model. This also provides an opportunity to feed any critical updates from past local studies (related to observed data or networks information) back to the Chelmsford Model in order to keep it up to date and increase its utility and quality in each subsequent application.

4.11.2 The Essex Countywide Model

A model covering the whole of Essex, known as the Essex Countywide Model has also been recently developed and has coverage of the Chelmsford area. It has a base year of 2017 and has been used as the base for development of other strategic town/region modelling projects. The highway and demand model methodologies within the Essex Countywide Model were developed in line with current best practice set out in TAG and use TEMPro, NTS, and mobile network data. The 2017 Essex Countywide Model highway prior matrices are used as the starting point for the updated Chelmsford Model matrices. Using the matrices provides analytical consistency and removes duplication of work.

4.11.3 Variable Demand Model

The premise of Variable Demand Modelling (VDM) is that any change in travel cost, through traffic intervention or changes in travel demand, is likely to modify travel behaviour. The purpose of VDM is to predict and quantify these changes. VDM establishes, in the absence of the scheme or strategy, the extent of travel suppression in the "without-scheme" case and the relative additional traffic induced in the "with-scheme" case.

A fixed demand approach provides a theoretical forecast of travel for assessment if travel costs remain at the base year levels. If the forecasts show an expected increase in travel which causes increasingly congested conditions, then travel costs will rise. As a result of these travel cost increases, variable demand will cause some trips to divert to other modes or destinations, or to be "suppressed" altogether, giving rise to lower demand forecasts.

As detailed in TAG Unit M2-1 section 6.4.1, the VDM needs to be subjected to realism testing to confirm that the demand model predicts the change in choices within acceptable elasticities. Therefore, as part of work to update the Chelmsford base model to 2019, a VDM was developed and realism testing undertaken. Further detail on the approach taken can be found in Chapter 12.

4.12 Use of Existing Model Information

Following a review of the network and zoning system of the 2014 Chelmsford Model, it was established that additional detail was required in the Fully Modelled Area for the 2019 Model. Highlighted in Table 4-5 below are the risks associated with using previous models and the mitigation methods that have been put in place for this project:

Risk	Mitigation
Parts of the network might be outdated	Model has been updated following review of latest on-ground conditions, updated information from Essex County Council and local knowledge from other sources.
Errors in the model might be carried forward	The network coding has been re-checked.
Zoning system might not be suitable	Identified areas in proximity to the scheme that lack sufficient detail and have split the old zoning system in these areas to provide more granularity.
Existing traffic demand developed from Mobile Network Data may not be sufficiently detailed or representative of trips in Chelmsford	It was decided that it would be more suitable to use the demand from the Essex Countywide Model for development of matrices.

Table 4-5: Risks Associated with the Chelmsford Model (2014) and Mitigation Methods in Place

4.13 Use of Traffic Survey Data

Traffic data is required to improve the understanding of the existing transport conditions in and around Chelmsford and inform the development of the Chelmsford Model update. Traffic data has a direct input into the Model; therefore, it is important that sufficient quantity and quality is available.

For the purpose of this Model update, a number of different types of data have been collected to further develop the Model. The different types of data, quantity, and their uses are set out below in Table 4-6:

Type of Data	Quantity	Overview of Key Uses
Automatic Traffic Counts (ATC)	2 weeks	• Provides traffic volume data by vehicle type, direction and time of day for an agreed point • Collected in order to calibrate and validate the updated model
Manual Classified Counts (MCC)	1 day	
Teletrac Data	March 2019 – November 2019 (July and August excluded)	• Collected in order to validate journey times in the model
Traffic Signal Data	2019 signal controller information	• For updating the model network with the latest signal timing data

Table 4-6: Outline of Traffic Survey Data and its Uses

Further detail on the traffic data used to construct, calibrate, and validate the 2019 Chelmsford Model Update can be found in the Data Collection Report[3].

4.14 Use of Other Data

Additional open source data was collected to inform model development. The different types of data, and a brief description of their source and uses are set out below in Table 4-7:

Type of Data	Source of Data	Overview of Key Uses
Residential and workplace population at Output Area (OA) level	2011 UK Census, accessed via the Nomis data portal website	Converting demand matrices from the Essex Countywide Model zoning system to that of the Chelmsford Model
National Trip End Model (NTEM) 7.2 Car growth factors	Trip End Model Presentation Program (TEMPro) v7.2, the software providing the user interface for accessing NTEM data	Uplifting car matrices from Essex Countywide Model base year of 2017 to required 2019 base year for the Chelmsford Model update
Road Traffic Forecast (RTF) 2018 goods vehicle miles travelled	RTF Scenario 1 produced by DfT	Uplifting goods vehicle matrices from Essex Countywide Model base year of 2017 to required 2019 base year for the Chelmsford Model update

Table 4-7: Outline of Other Data, Sources and Key Uses

These datasets were used in the matrix development process, which is further discussed in Section 9.

[3] Jacobs, 2020, Chelmsford Model Update Data Collection Report

5 Calibration and Validation Data

5.1 Model Data Sources

An array of survey data was collected in order to gain an understanding of traffic conditions in the base year. The data sources used are described in turn below.

5.2 Traffic Counts

Traffic count data described in 4.13 has been used in the Chelmsford Model to adjust the base year matrices and adjust network parameters (calibration), as well as to provide the independent comparisons of the model against observed traffic data (validation). Chapter 10 describes the model calibration and validation process and results in greater detail.

It is important that data used to calibrate the model is independent from data used to validate the model. A total of 124 (71% of the total) counts were used for the purposes of calibration and 50 (29%) retained for the purposes of validation.

Screenlines were created across which the modelled and observed flows are compared to provide insight into the quality of the trip matrices. These screenlines are intended to capture the key movements through the Chelmsford area. The screenlines and location of counts used in the updated Chelmsford Model for calibration and validation are shown in Figure 5.1 below. As can be seen from the figure, a small number of counts do not sit along screenlines and are classed as independent counts. They serve as a means of model calibration or validation at key links in the modelled network, which are not covered by the screenlines.

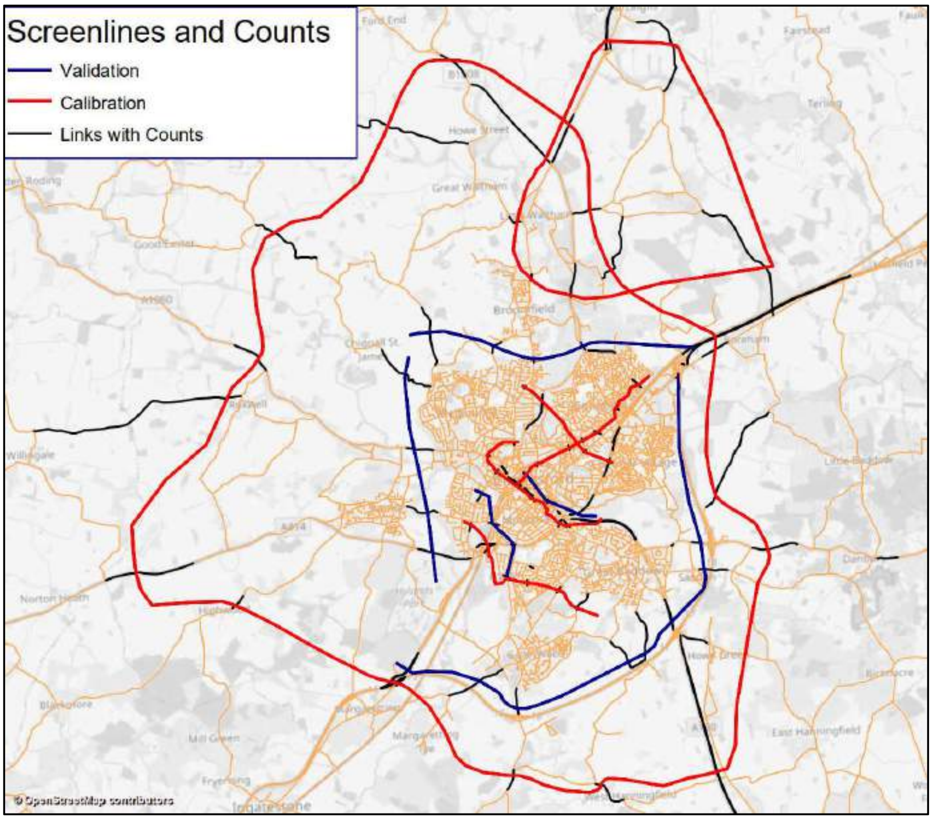


Figure 5-1: Calibration and Validation Counts and Screenlines

5.2.1 Traffic Counts for Calibration

A number of counts, along the defined calibration screenlines, were utilised to calibrate the model. The calibration screenlines and counts are shown in Figure 5-2:

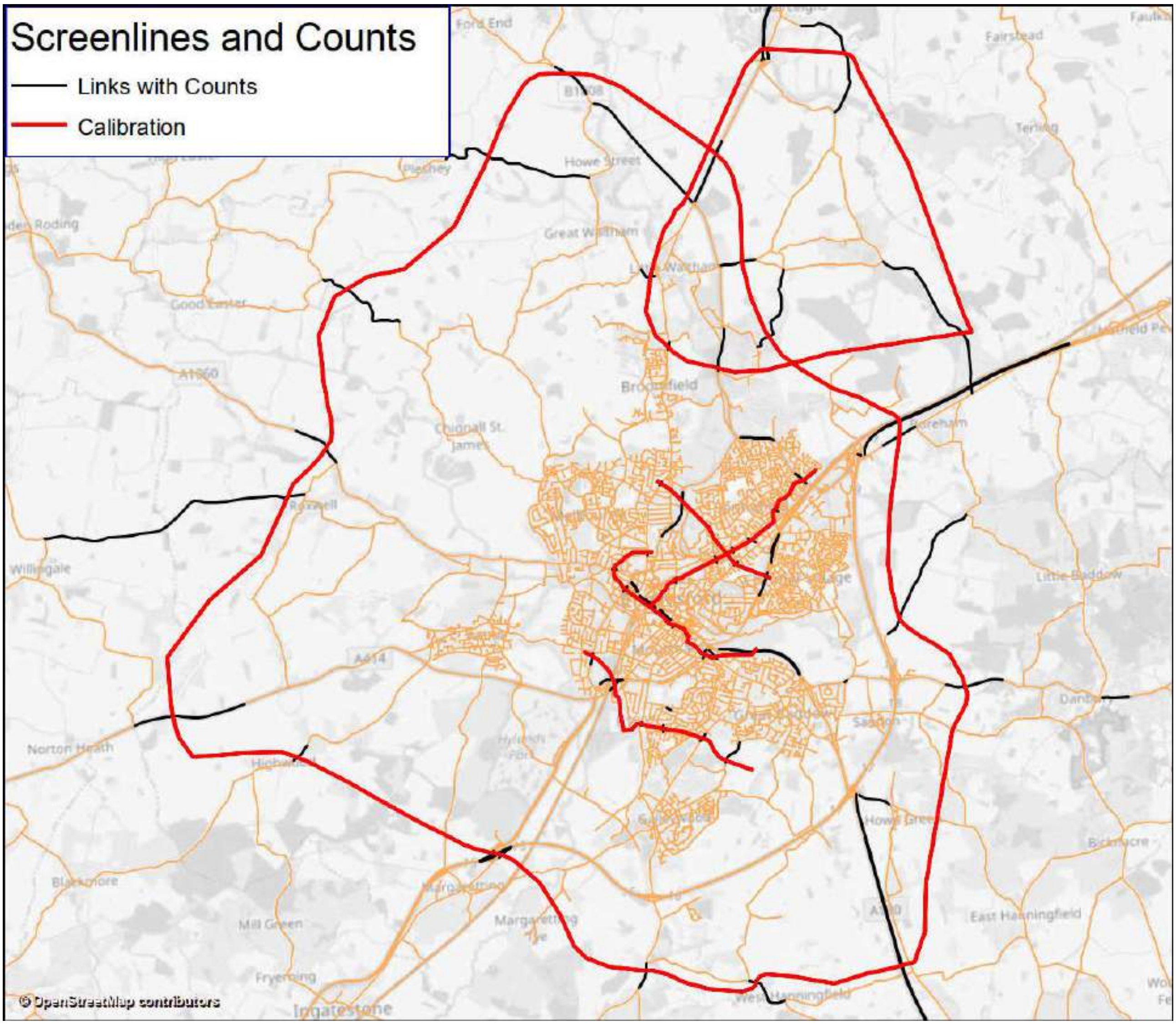


Figure 5-2: Calibration Counts and Screenlines

5.2.2 Traffic Counts for Validation

A series of counts dedicated to validation (i.e. not used in any stages of model calibration) were used in the model, along the defined validation screenlines. The validation screenlines and counts are shown in Figure 5-3:

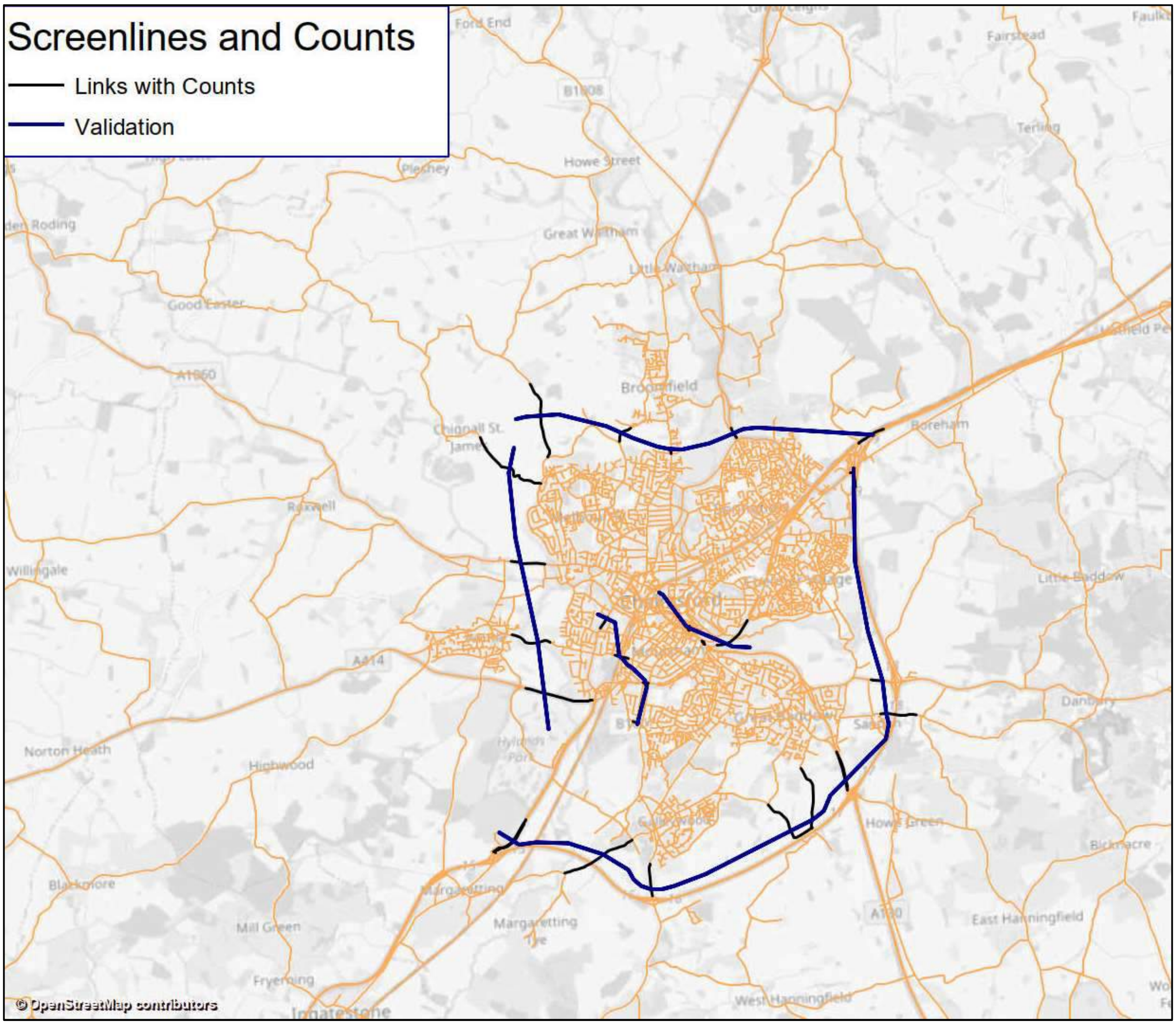


Figure 5-3: Validation Counts and Screenlines

5.3 Journey Time Data

Journey time data is used to check and compare the delays and travel times calculated by the model against observations. Journey time data was collected from Teletrac. Teletrac is a dataset made available to local authorities and is based on data gathered using Satellite Navigation devices installed in cars and other vehicles. Travel times are specified for links in the Integrated Transport Network (ITN). Times along a set route are collated by aggregating the set of ITN links along the route. The routes used for comparing the travel times in the updated Chelmsford Model are depicted in Figure 5-4. There are 14 routes in total.

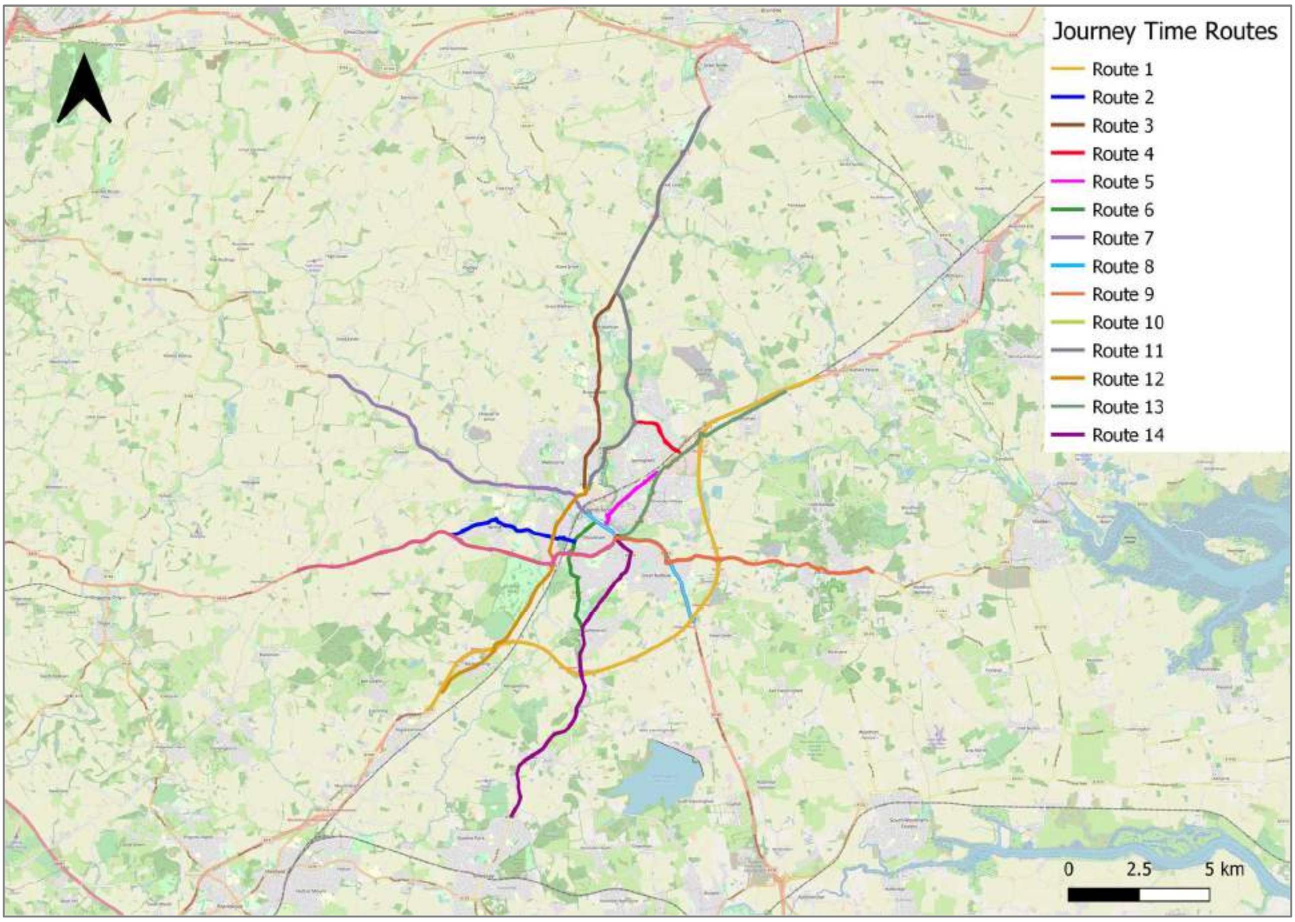


Figure 5-4: Journey Time Routes

TAG unit M3.1 specifies that journey time routes should neither be excessively long (greater than 15km) or too short (less than 3km) and that they should not take longer to travel than about 40 minutes (so as to fit comfortably within the modelled peak hour). All but three routes fall within the distance criteria, though the observed travel times are well within the guidance of 40 minutes. The margin by which these three routes are above and below the suggested journey time route lengths is not deemed to have a detrimental effect on the journey time validation and were included in order to reflect realistic routes undertaken in the study area.

For this study, the journey time data for the year of 2019 was extracted from Teletrac, making sure to avoid non-neutral months and holidays/periods affected by holidays. The length and observed time for all routes is presented in Table 5-1 on the next page.

Route No.	Description	Length (km)	AM Observed time [min:sec]	IP Observed time [min:sec]	PM Observed time [min:sec]
1	A12/Millfield Cottage North --> A12/Ingatestone	18.95	13:27	11:34	13:54
	A12/Ingatestone --> A12/Millfield Cottage North	18.99	14:54	11:51	17:32
2	250 Ongar Road --> Writtle Road/Elm Road	3.89	11:21	08:03	11:01
	Writtle Road/Elm Road --> 250 Ongar Road	3.85	10:53	06:53	10:27
3	A130/Braintree Road --> Parkway Roundabout	6.67	15:26	10:04	11:26
	Parkway Roundabout --> A130/Braintree Road	6.68	12:07	10:00	18:22
4	A130/Nabbotts Farm Roundabout --> A130/1 White Hart Ln	1.85	02:51	03:09	04:41
	A130/1 White Hart Ln --> A130/Nabbotts Farm Roundabout	1.89	04:45	02:40	03:06
5	High Bridge Rd/Odeon Roundabout --> Springfield Rd Roundabout	2.41	05:16	05:18	08:45
	Springfield Rd Roundabout --> High Bridge Rd/Odeon Roundabout	2.38	07:25	05:04	10:47
6	Parkway/New London Rd --> Stock Rd/Beehive Lane	3.98	07:01	06:37	14:21
	Stock Rd/Beehive Lane --> Parkway/New London Rd	3.97	16:40	07:38	10:02
7	Wooden Farm Newland Hall --> Market Roundabout	10.21	16:37	12:13	16:13
	Market Roundabout --> Wooden Farm Newland Hall	10.22	12:21	11:42	11:59
8	Market Roundabout --> A12 J17	5.21	05:44	06:19	08:24
	A12 J17 --> Market Roundabout	5.19	16:16	06:24	12:48
9	Van Dieman's Rd --> Maldon Rd/Cherry Garden Lane	9.18	16:25	13:35	18:25
	Maldon Rd/Cherry Garden Lane --> Van Dieman's Rd	9.27	22:14	12:32	18:08
10	Ongar Rd/Bassett's Lane --> Van Diemnan's Rd\Lady Ln	10.97	12:07	11:15	12:28
	Van Diemnan's Rd\Lady Ln --> Ongar Rd/Bassett's Lane	10.92	15:18	11:09	15:45
11	A131/London Rd --> B1016/B1008	14.05	26:37	13:47	17:11
	B1016/B1008 --> A131/London Rd	13.95	16:30	13:29	19:40
12	Rectory Ln/Meadowside --> B1002/Church Ln	8.69	12:54	12:21	17:51
	B1002/Church Ln --> Rectory Ln/Meadowside	8.66	18:59	12:57	18:29
13	Main Rd/Damasses Ln --> Army and Navy Roundabout	7.69	17:54	10:47	14:38
	Army and Navy Roundabout --> Main Rd/Damasses Ln	7.86	14:08	10:43	13:38
14	Army and Navy Roundabout --> Stock Rd/The Vale	7.00	10:55	09:48	10:49
	Stock Rd/The Vale --> Army and Navy Roundabout	7.05	24:19	12:01	14:29

Table 5-1: Observed Journey Times

6 Network Development

6.1 Network Basis

The basis of the modelled network was the network from the original 2014 Chelmsford Model. The modelled network for that model was originally created using two Ordnance Survey datasets: the Integrated Transport Network (ITN) and Meridian 2. Within the Chelmsford City Council Administrative area and surrounding areas, the ITN network was used as a basis for the modelled network; beyond this, Meridian 2 layers were used.

ITN segregates links into motorways, A-roads, B-roads, minor roads, local streets, private roads, and alleys, in descending order of importance.

The basis of the modelled highway network was built on digital mapping databases, which are combined into a model network using ArcGIS software.

The detailed model network was then imported into VISUM making sure that data on highway network types was retained. The model accommodates all paved inter-urban traffic roads to meet the criteria of including all inter-urban roads.

A total of 69 different highways classes or types were coded in the model, following guidance from COBA Volume 13 Section 1 part 5, classifying roads based on characteristics such as: road class, number of lanes, speeds, and modes allowed. A full list of all the defined link types can be found in Appendix B. The main classes considered in the analysis were:

- Motorways;
- Rural single carriageway;
- Rural double carriageway;
- Urban non-central;
- Urban central;
- Small town;
- Suburban single carriageway;
- Suburban dual carriageway;
- Residential road; and
- Roundabout.

The first three classes were assigned for all-purpose roads and motorways that are generally not subject to a local speed limit. Urban central and non-central were used for roads in large towns or conurbations typically subject to 30 mph speed limits. Small town was used as the link type in small towns or villages, while suburban was used for major routes though towns and cities which are generally subject to 40 mph speed limits. Figure 6-1 on the next page presents an example a link which was allocated to a suburban link type.

Figure 6-1: Suburban Link Type Example

6.2 Links

6.2.1 Link Characteristics

In urban areas, physical properties such as link lengths and number of lanes, speed and capacity were taken from the existing model and checked using recent satellite imagery (Google Earth and Google Street View).

In rural areas, physical properties of the road system were taken from digital mapping data and were checked against recent satellite imagery (Google Earth and Google Street View). Highway attributes data, such as link class, user class restrictions, and turning movement restrictions were also coded using Google Earth, Google Street View, local knowledge and field observations.

As Section 6.1 details, there are 69 unique network link types which have been defined according to their classification under the following attributes:

- Roadway functional class (e.g. motorway, trunk road, residential street);
- Roadway location (urban, suburban, rural);
- Roadway geometry, lane width, number of lanes; and
- User type prohibitions (bus links, HGV, LGV, general traffic, etc.).

6.2.2 Link Speeds and Speed-Flow Relationships

The attributes of modelled links such as number of lanes, capacity and free flow speed are derived from associating each link with a link type defined in the COBA Manual and selected based upon the link's characteristics as described above. The COBA Manual dictates the relationship between speed and traffic flow (or in other terms volume and delay) which are translated into appropriate Volume-Delay Function (VDF) parameters in VISUM, for those link types.

As part of the original Chelmsford Model, the choice of COBA link type to assign to each link was established using the attributes associated within the ITN layer (which formed the basis of network development), and also from inspection of the network in Google Earth, Google Street View and local knowledge. These were reviewed as part of the current model update. The VDF reflects delays on links that result from traffic travelling along a link and are independent of delays that result from junctions.

To establish VDFs as part of the Chelmsford Model update, Highways England's Traffic Appraisal, Modelling and Economics group (TAME) approved Speed Flow Curves (SFCs are equivalent to VDFs but are used in SATURN software), which were adopted in Regional Transport Models (RTMs), were used as a starting point. A correlation exercise was undertaken to fit VDFs to the RTM SFCs for various link types which broadly fall under the following categories:

- Motorway;
- Rural All Purpose;
- Rural Roads;
- Suburban;
- Urban; and
- Small Town.

The travel time on a link in VISUM is determined by different pre-defined VDFs in the software. Based on previous VISUM best practices used in a number of model development studies, a VDF called "BPR2" which was developed by the US Bureau of Public Roads will be used to calculate link delays, and is repeated below:

$$\mathrm{t_{cur}} = \begin{cases} t_0 \left(1 + a.\left(\frac{q}{q_{max}.c}\right)^{b}\right), & \frac{q}{q_{max}.c} \le 1 \\ t_0 \left(1 + a.\left(\frac{q}{q_{max}.c}\right)^{b\prime}\right), & \frac{q}{q_{max}.c} > 1 \end{cases}$$

where:

t_{cur} is the calculated link travel time;

t_o is the link travel time at free flow conditions;

q is the flow on the link;

q_{max} is the link capacity; and

a, b, b', and c are parameters specific to each link type.

In order to reflect some of the delays observed between interchanges on the A12, two additional volume delay functions were created to model appropriate delays. These were necessary because those parts of the network have grade separated junctions in close proximity to each other, which creates a weaving movement. This reduces traffic speeds to a much greater effect than when junctions are spaced further apart; the additional VDFs created replicate this effect.

Appendix A provides further background on the SFC-VDF correlation and the figures on the following pages show curves for the BPR2 VDF for motorways, rural all-purpose carriageways, rural, suburban, urban, and small town link types.

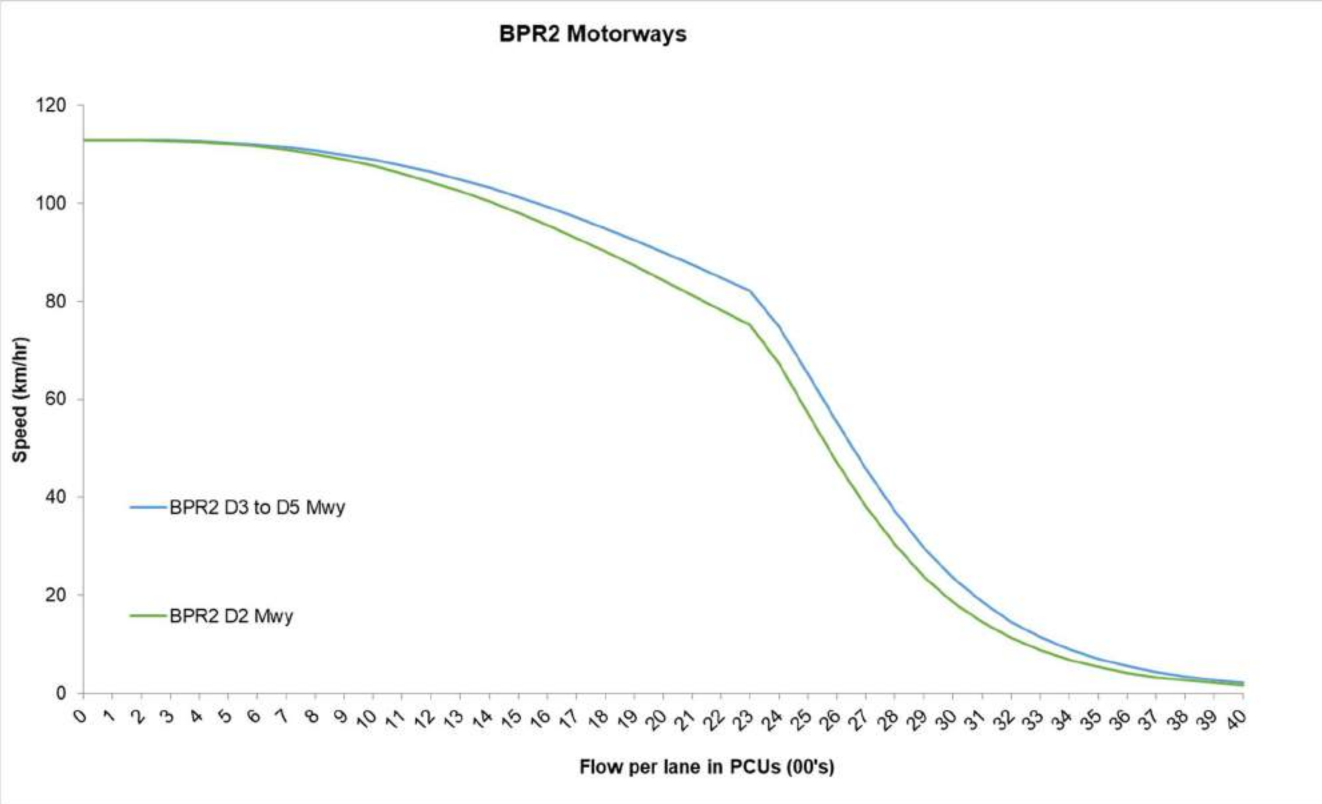


Figure 6-2: VDF Motorway Link Type

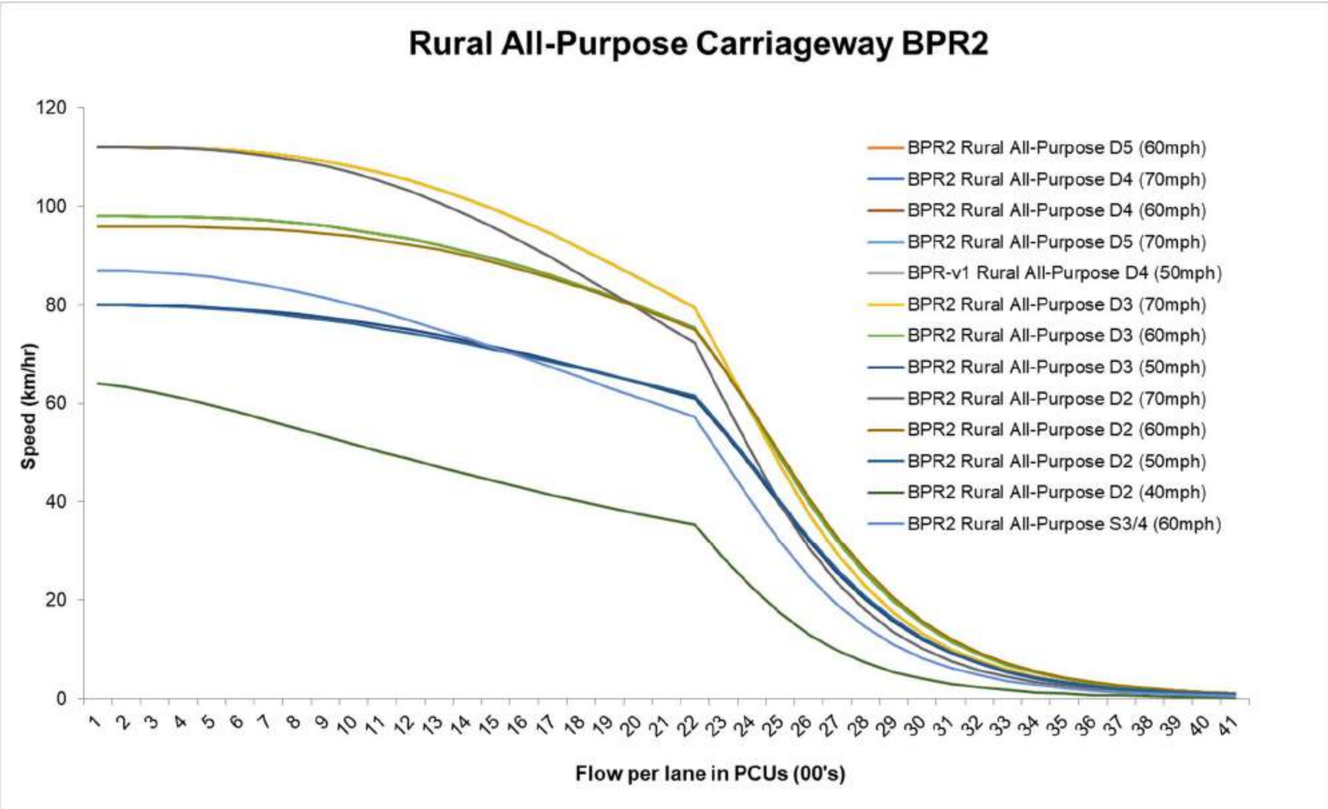


Figure 6-3: VDF Rural All-Purpose Carriageway Link Type

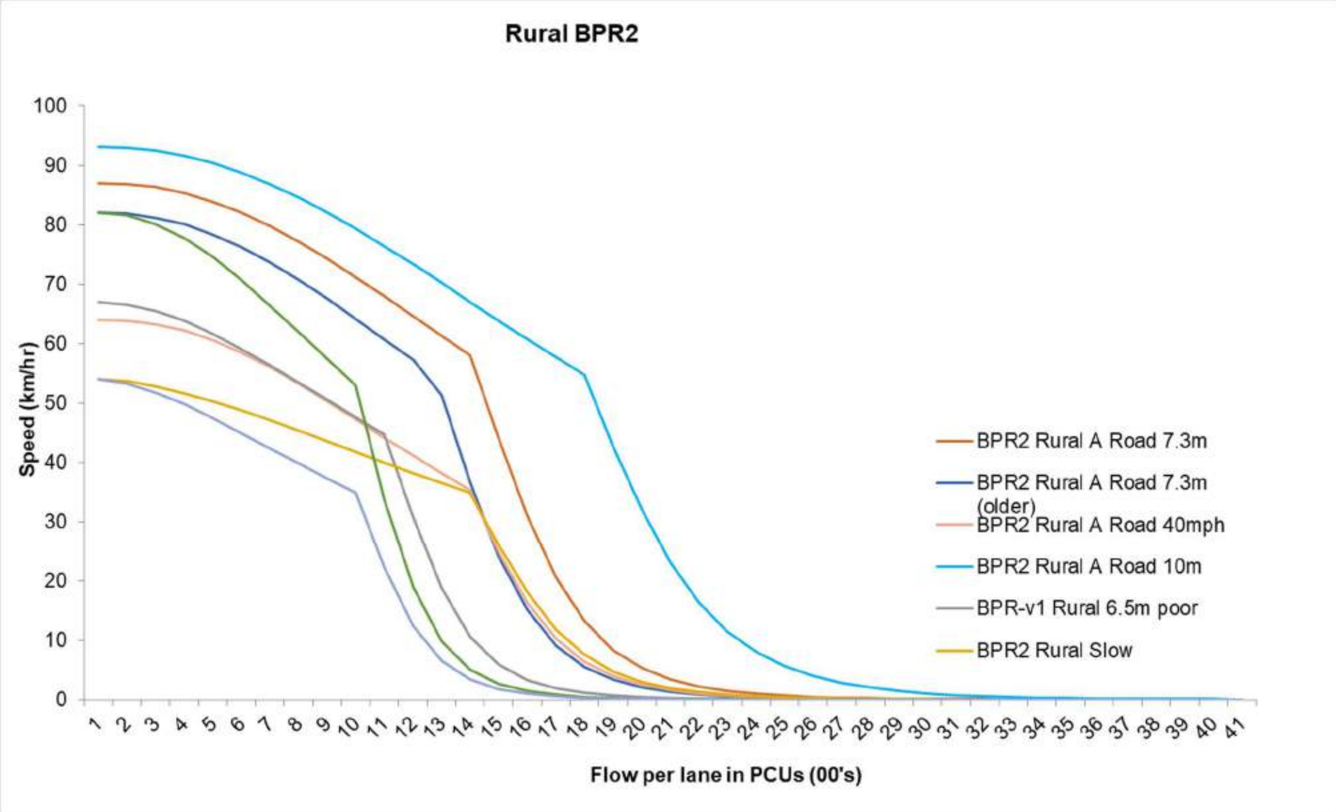


Figure 6-4: VDF Rural Link Type

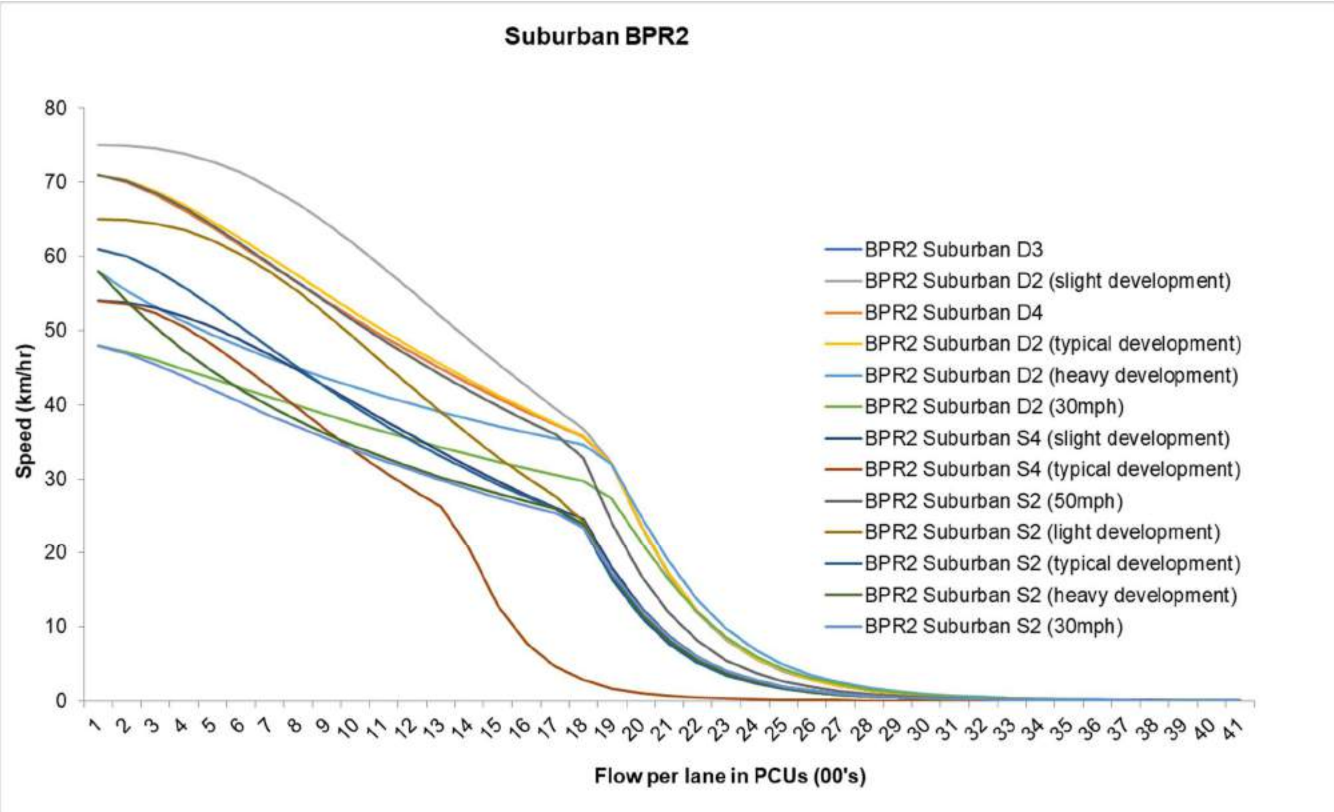


Figure 6-5: VDF Suburban Link Type

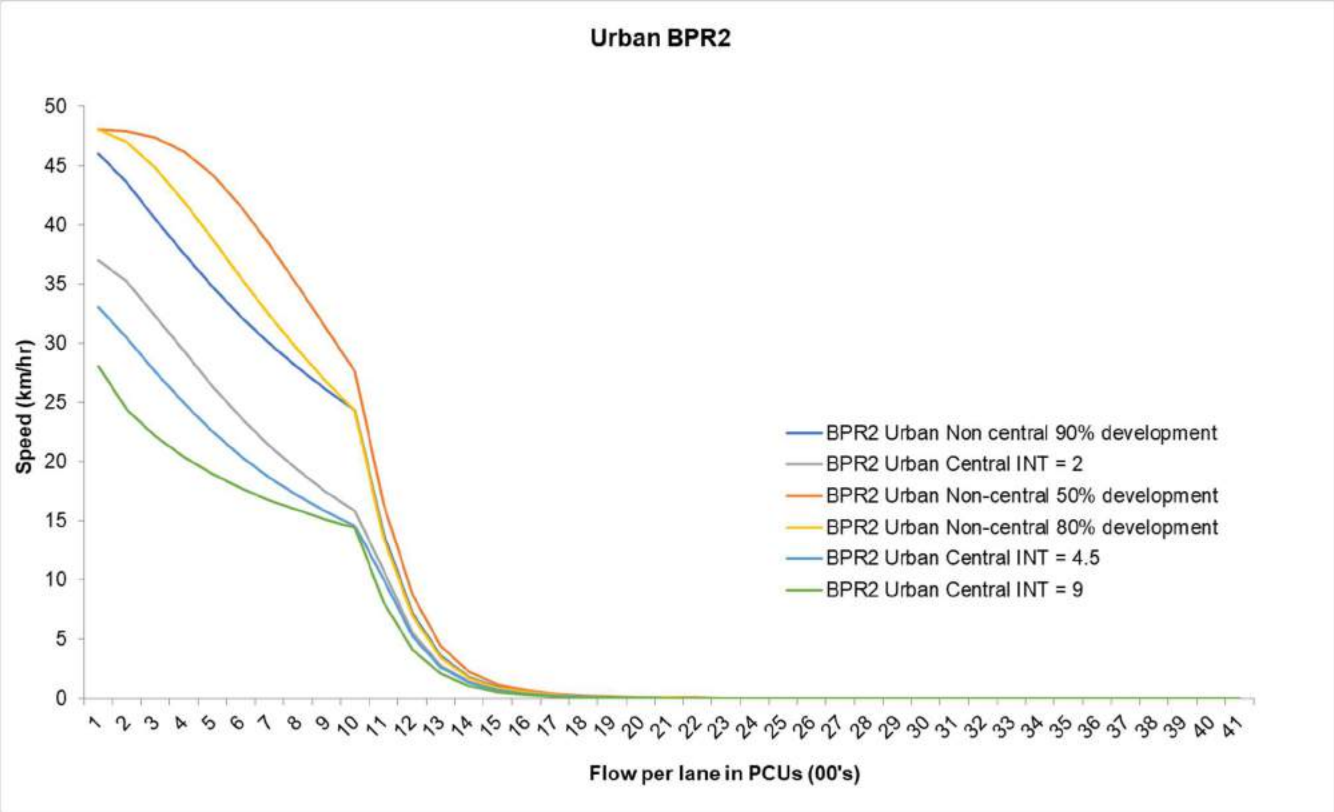


Figure 6-6: VDF Urban Link Type

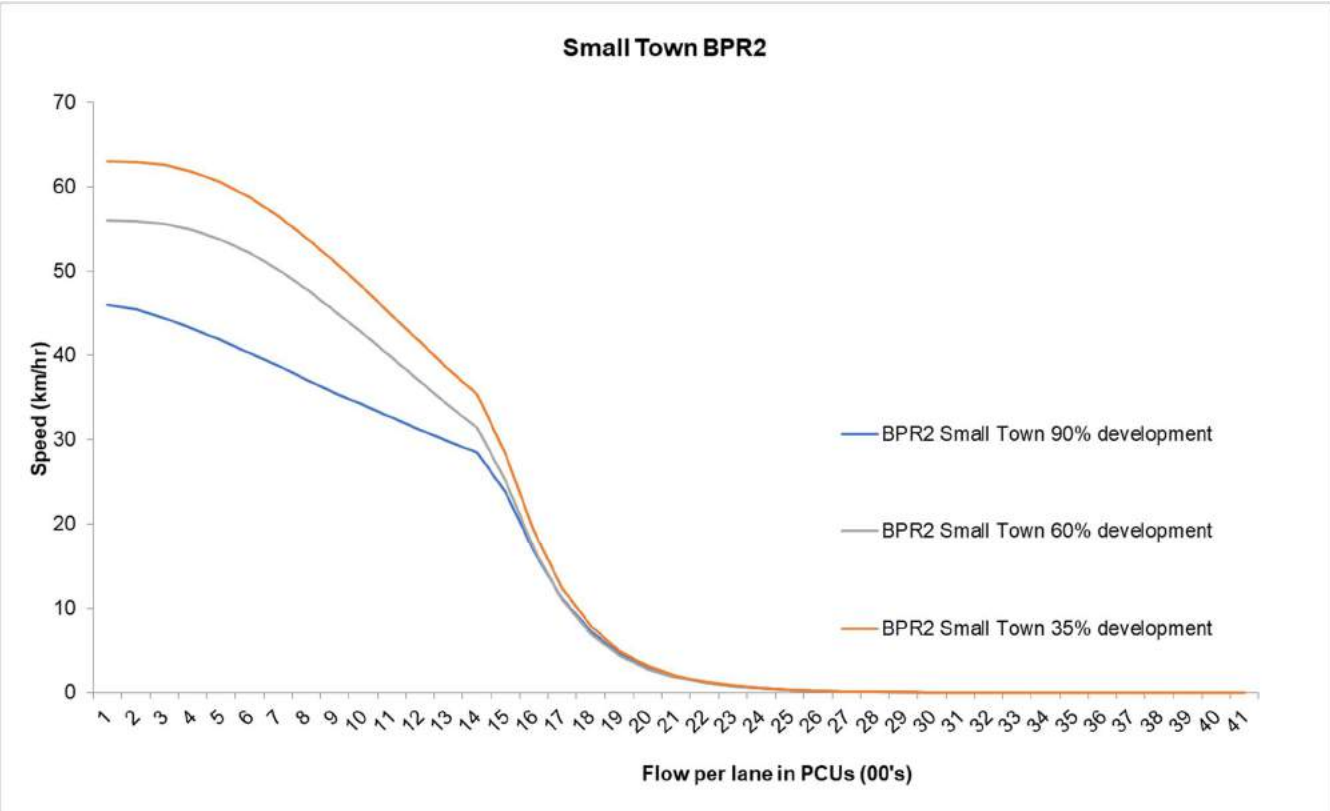


Figure 6-7: VDF Small Town Link Type

Local knowledge was also used to inform link restrictions, such as one-way links or bus only links, as well as height, width, and weight restrictions (e.g. due to bridges) for goods vehicles.

6.3 Junctions

The junctions (known as nodes) in the model are coded as a point of connection between links. Junctions coded into the model study area are defined by a number of attributes, as required by VISUM's Intersection Capacity Analysis (ICA) functionality. The junctions were coded with the following attributes defined:

- Major flow (i.e. which turning movements had priority);
- Banned turns (if any);
- Number of lanes at stop lines;
- Turn type (i.e. straight on, left, right);
- Lane allocations (which turns are made from which lanes); and
- Signal timings (for signalised junctions).

These attributes were coded using local knowledge, Google Earth and Google Street View. They were checked for accuracy in the predecessor Chelmsford Model and were checked again in the updated Chelmsford Model.

The flow/delay relationship for signalised and priority junctions were calculated using VISUM's Intersection Capacity Analysis (ICA) functionality. ICA uses formulae set by the 2010 edition of the Highway Capacity Manual, published by the US Transportation Research Board which is commonly used within VISUM models and has been demonstrated to reproduce observed delays to a high degree of accuracy. The formulae are specific to the junction type. ICA relies on the input attributes identified above, and uses a number of default global values, to calculate the capacity and delay for each movement at a modelled junction. The default values cover aspects such as saturation flows per lane and turn type and gap acceptance values for vehicles on a minor arm. It was found that, for some junctions, the default values required replacement with bespoke values in order to achieve a good match to observed journey time data which can be seen from the journey time validation given in Section 11.7.2. Manual overrides were applied for those junctions by adjusting the critical gap and follow-up times on each node individually depending on the number of accessing lanes.

6.3.1 Signal Timings

As part of the previous Chelmsford Model study, which had a base year of 2014, signal timings were coded in the model based on timing data collected from local authorities. Where necessary, for a few junctions, the latest signal controller information was obtained from ECC as part of network calibration.

An example of the coding of a signalised junction in the model is illustrated in Figure 6-8 on the next page, where the actual junction is shown alongside the signalised junction modelled coding for where Victoria Road meets New Street.

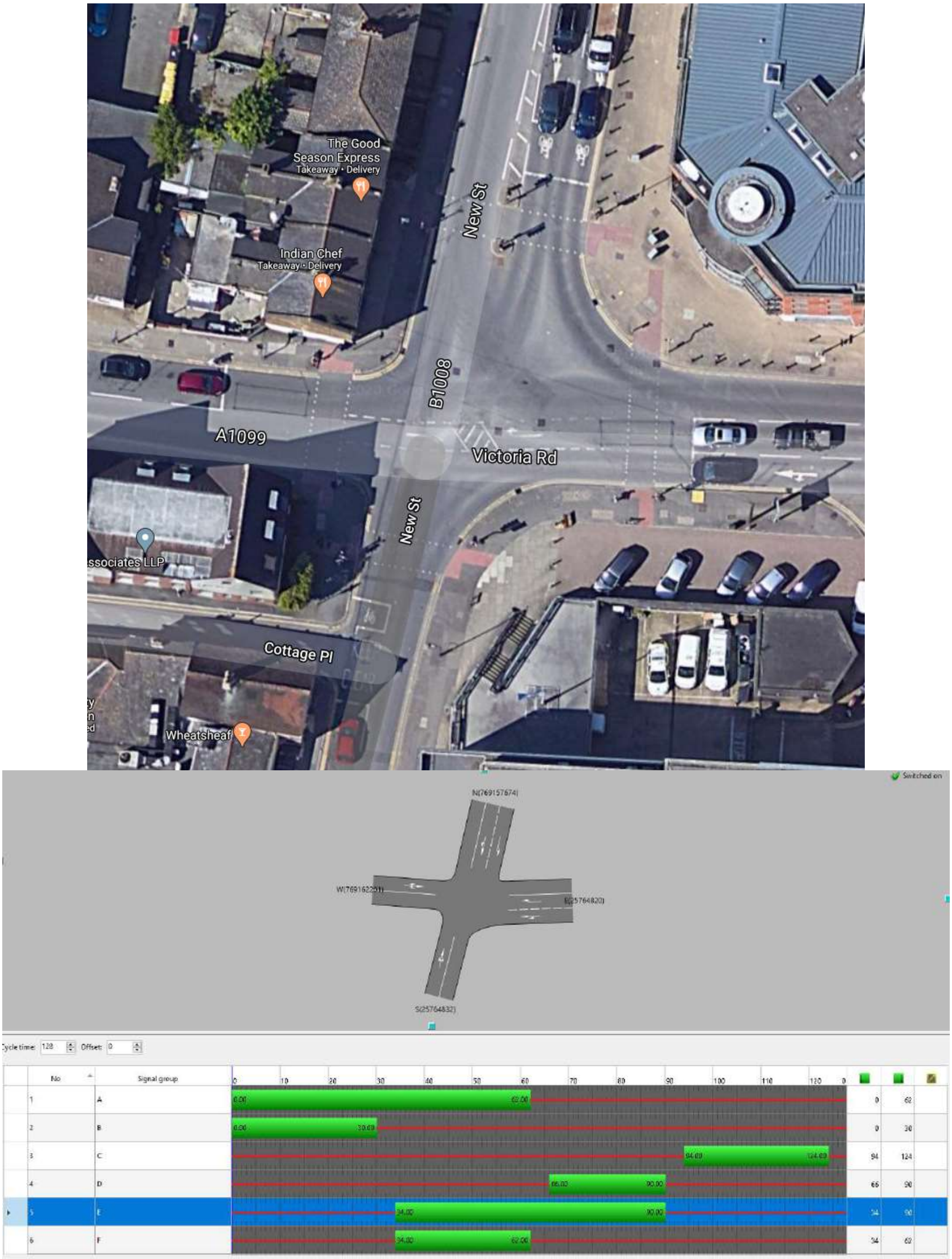


Figure 6-8: Actual Junction and the Equivalent Modelled Signalised Junction

6.3.2 Saturation Flows at Signals and Capacity of Priority Junctions

The saturation flows typically used are 1,900 PCUs per hour per lane for signalised junctions. For priority junctions, the major flows effectively operate without any capacity restriction. Turn capacities on the minor arms are a function of the gap acceptance values and the conflicting traffic volumes; saturation flows are not considered. As an example, using the default gap acceptance values, the following figure illustrates the capacities for a left turn from a minor arm, under differing levels of conflicting flow:

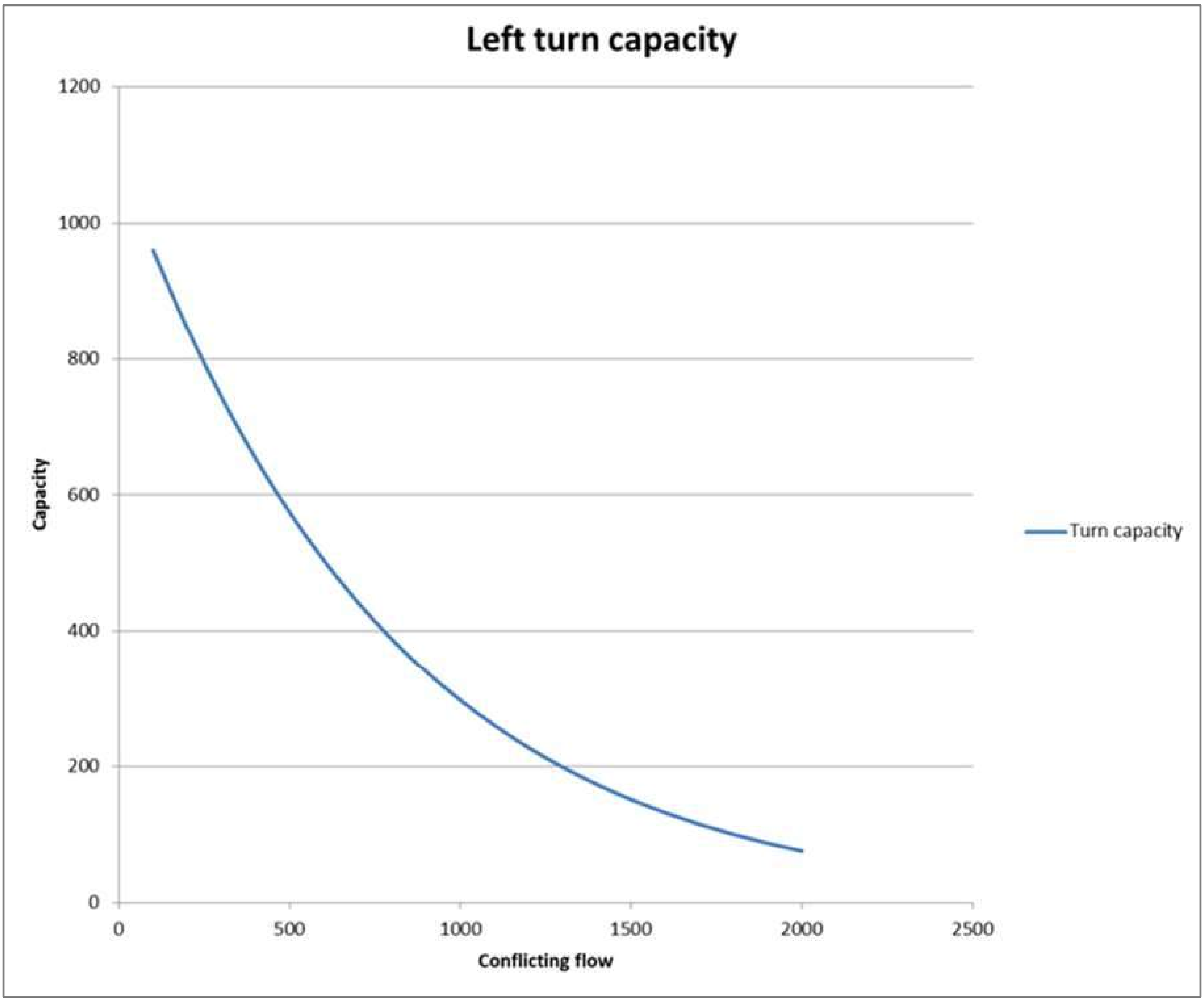


Figure 6-9: Left Turn Capacity

6.3.3 Roundabouts

All roundabouts are modelled as a series of expanded nodes with the exception of some very small mini-roundabouts. The Kimber Method has been utilised to configure roundabouts and the standard dimensions adopted for different approach geometries are detailed in Table 6-1:

<table>
<tr><th colspan="2">Arm</th><th>Approach Half Width (V)
(m)</th><th>Entry Width (E)
(m)</th><th>Flare Length (‘l)
(m)</th><th>Entry Radius (R)
(m)</th><th>Inscribed Roundabout Diameter (D)
(m)</th><th>Entry Conflict Angle (PHI)
(Deg)</th></tr>
<tr><td rowspan="5">**Short flare/ No flare length (<3 cars or 10m)**</td><td>**1 In approach, no flare**</td><td>3.65</td><td>4</td><td>5</td><td>15</td><td rowspan="7">User Defined</td><td>30</td></tr>
<tr><td>**2 In approach, no flare**</td><td>7.30</td><td>8</td><td>5</td><td>15</td><td>30</td></tr>
<tr><td>**3 In approach, no flare**</td><td>10.95</td><td>12</td><td>5</td><td>15</td><td>30</td></tr>
<tr><td>**1 In approach, 2 In entry**</td><td>3.65</td><td>8</td><td>10</td><td>15</td><td>30</td></tr>
<tr><td>**2 In approach, 3 In entry**</td><td>7.30</td><td>12</td><td>10</td><td>15</td><td>30</td></tr>
<tr><td rowspan="2">**Long Flare length (<=10 cars or 60m)**</td><td>**1 In approach, 2 In entry**</td><td>3.65</td><td>8</td><td>30</td><td>15</td><td>30</td></tr>
<tr><td>**2 In approach, 3 In entry**</td><td>7.30</td><td>12</td><td>30</td><td>15</td><td>30</td></tr>
<tr><td>**Multi-Node Roundabout**</td><td>**Circulatory Arm**</td><td>15</td><td>20</td><td>100</td><td>1000</td><td>200</td><td>0</td></tr>
</table>

Table 6-1: Standard Roundabout Parameters to Adopt for TRL Kimber Method

6.4 Zone System

The Chelmsford model update zoning system closely follows that of the 2014 model. The 2014 model’s zoning system was reviewed, and in a small number of cases it was deemed necessary to split zones to increase the granularity of the zone system in these areas. The original zone system boundaries are consistent with census area boundaries, therefore any splitting undertaken follows Output Area (OA) outlines. This allowed the zone system to be split to the highest level of granularity where desired by remaining consistent with OA boundaries could use demographic data to allow for an accurate conversion of the demand matrices to the updated Chelmsford zone system from the Essex Countywide Model, as detailed in section 9.3.

Splitting was mainly undertaken to improve the suitability of the 2019 Model for the planned forecast modelling of the traffic impacts of the CNEB and Army and Navy schemes, by adding more disaggregation into areas surrounding those schemes. Where the boundaries of the 2014 and 2019 zone systems are consistent, and where splitting has been undertaken, can be viewed in Figure 6-10 on the next page.

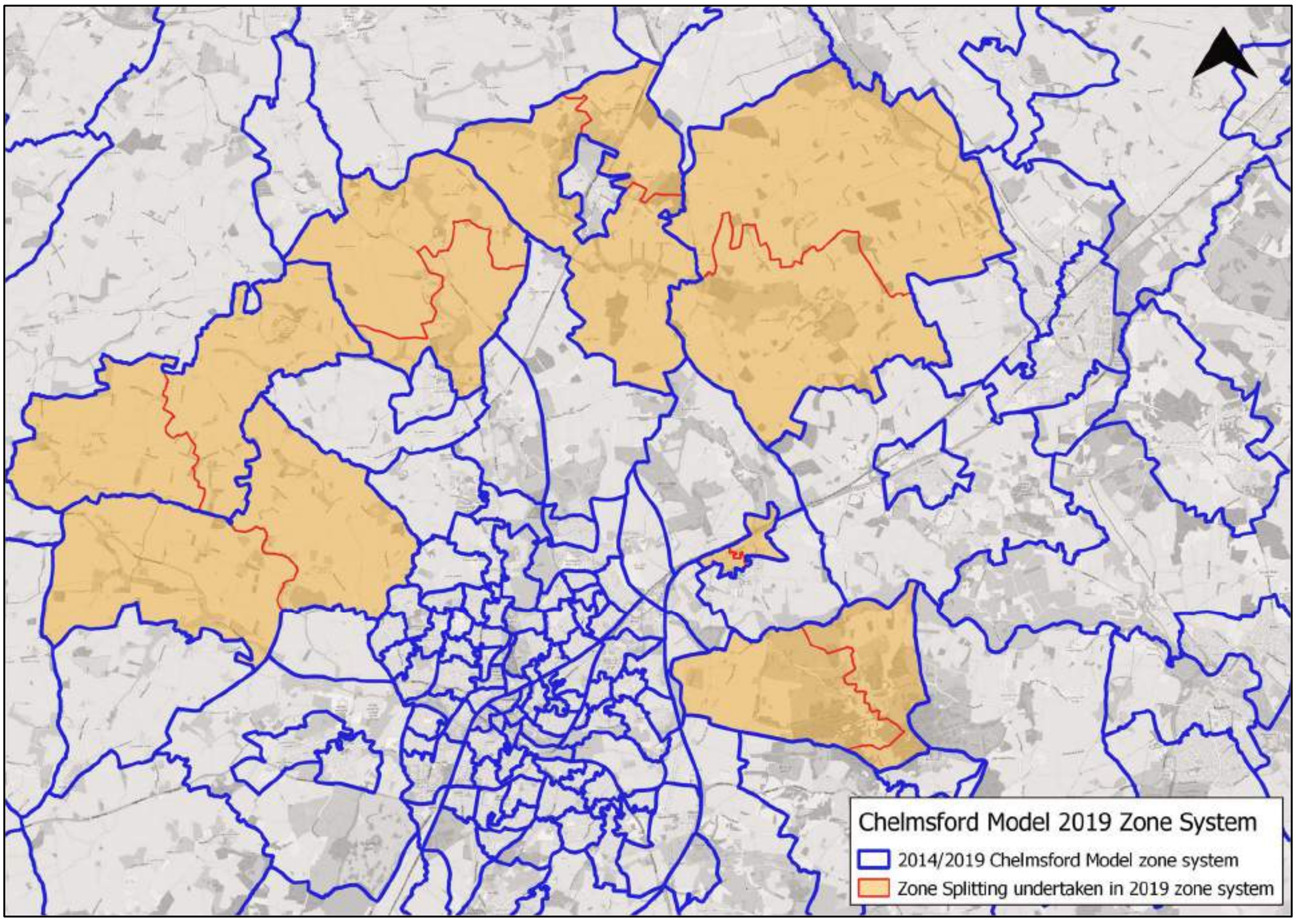


Figure 6-10: Chelmsford 2019 Model Zone System and Zone Splitting

The area immediately to the north of Chelmsford, where model assignment will be most affected by the implementation of the CNEB scheme, has seen five zones split in the 2019 zone system. Similarly, two zones have been split to the east of Chelmsford, to improve the detail of modelling traffic assignment in parts of the network that will be affected by changes at the Army and Navy Flyover.

6.5 Public Transport Network

It is to be noted that, owing to the requirements of public transport (PT) modelling in order to assess the highway-based schemes, a 'light-touch' PT model was developed and the PT network from the existing 2014 Chelmsford Model was retained and no further updates were made as part of the model update. Sections below provide a brief summary of the development of the PT network in the existing 2014 Chelmsford Model. This is intended for the purposes of providing costs and demand inputs to the VDM, rather than the need for a PT model in and of itself.

6.5.1 Bus Stops and Nodes

For the purposes of the PT coding, it was important that all bus stops served by bus routes within the model were included in the PT network. The locations of all these bus stops were specified using ATCO.CIF data, provided by Essex County Council, and transferred into the highway model.

Bus stops were included as highway network nodes, and as they were invariably not located at junctions, new 'dummy nodes' were required in order to accommodate them. These nodes effectively split existing highway links in two and served no purpose within the highway assignment itself, however it enables a single modelled network to serve the purposes of both the highway and public transport assignment, providing a consistent link topology between the two.

The consistent topology is critical when transferring data between the PT and highway assignments, for example when updating PT in-vehicle travel times data from the highway assignment or adding a fixed flow to highway links based on the number of buses and their frequencies.

6.5.2 Rail Links

Railway station details were sourced from National Public Transport Access Nodes (NaPTAN) data. For stations within Essex, all stations were coded. For external areas, only stations connected to zones were coded. Shapefiles of the National Rail network were used to define services while the network was simplified for external model areas.

In addition, in North Scotland or South East England where a station was connected to the outermost zone, and there were other stations and links beyond that point, those stations and links were removed.

7 Network Calibration and Validation

7.1 Network Checking and Calibration

Based on the coded characteristics of each link, a number of checks of the network were made. The first of these was the standard network check offered by the VISUM modelling package, which checked aspects of the model such as network connectivity and illogical coding of junctions.

A network check list informed by advice in TAG Unit M3.1 was created, and the model was checked against each aspect of the list. The list is reproduced in Appendix D. Additional checking focused on the coded attributes of the links, including link speeds, number of lanes and capacity, as detailed below.

Free flow link speeds are a function of the link type (as specified in Appendix B). These speeds were checked by plotting them in VISUM and colouring links according to speed in bands. This plot is shown in Figure 7-1 below for the detailed study area:

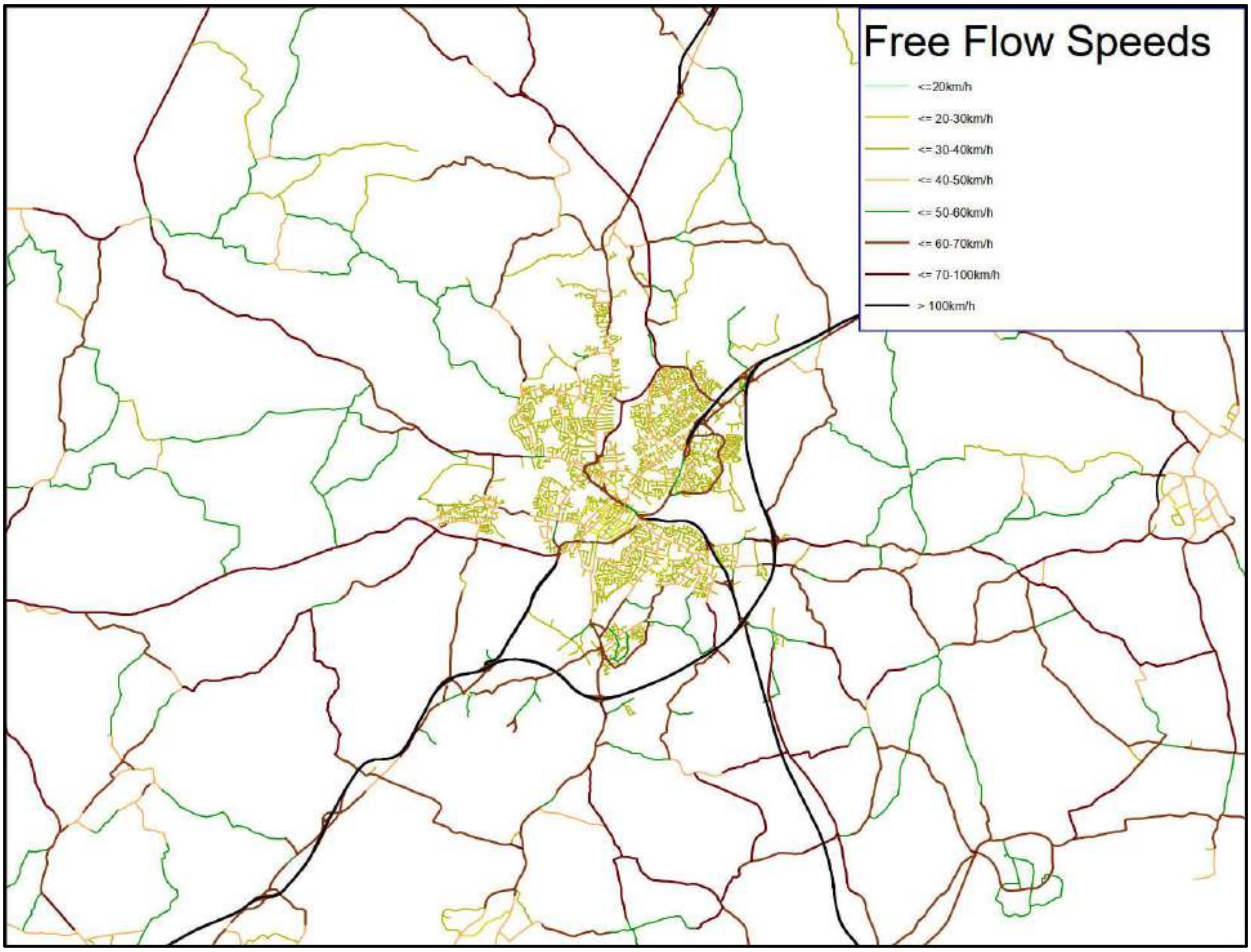


Figure 7-1: Free Flow Speeds In and Around the Chelmsford Area

The plot shows that urban areas in Chelmsford, Witham and Maldon town centres have coded free flow speeds of around 20-30kph on minor residential streets, 40-50kph on more major residential streets, and 50-70kph on main through roads such as the A130. On rural areas the free flow speed is between 70kph and 100kph; these roads are national speed limit roads. Finally, roads such as the A12 have free flow speeds in excess of 100kph, as would be expected on a major dual carriageway.

The coded number of lanes were checked in a similar manner, with this plot shown in Figure 7-2:

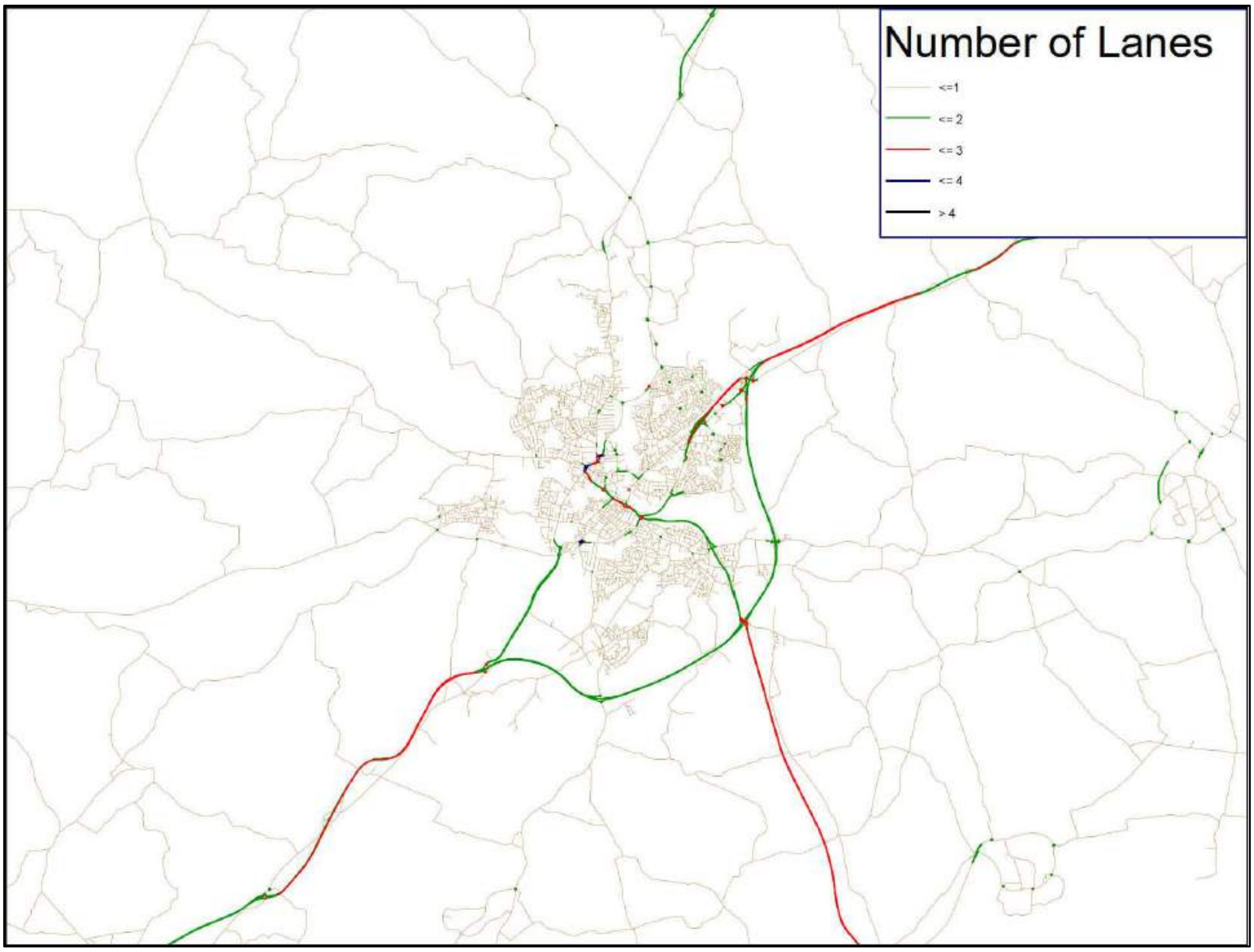


Figure 7-2: Number of Lanes on Each Link in the Model

The plot shows that the majority of the links are coded as a single lane except for the main through routes and some links around the town centre, which have been coded with two or three lanes, as expected from network checks and local knowledge.

Link capacity is again checked in a similar way, as shown in Figure 7-3:

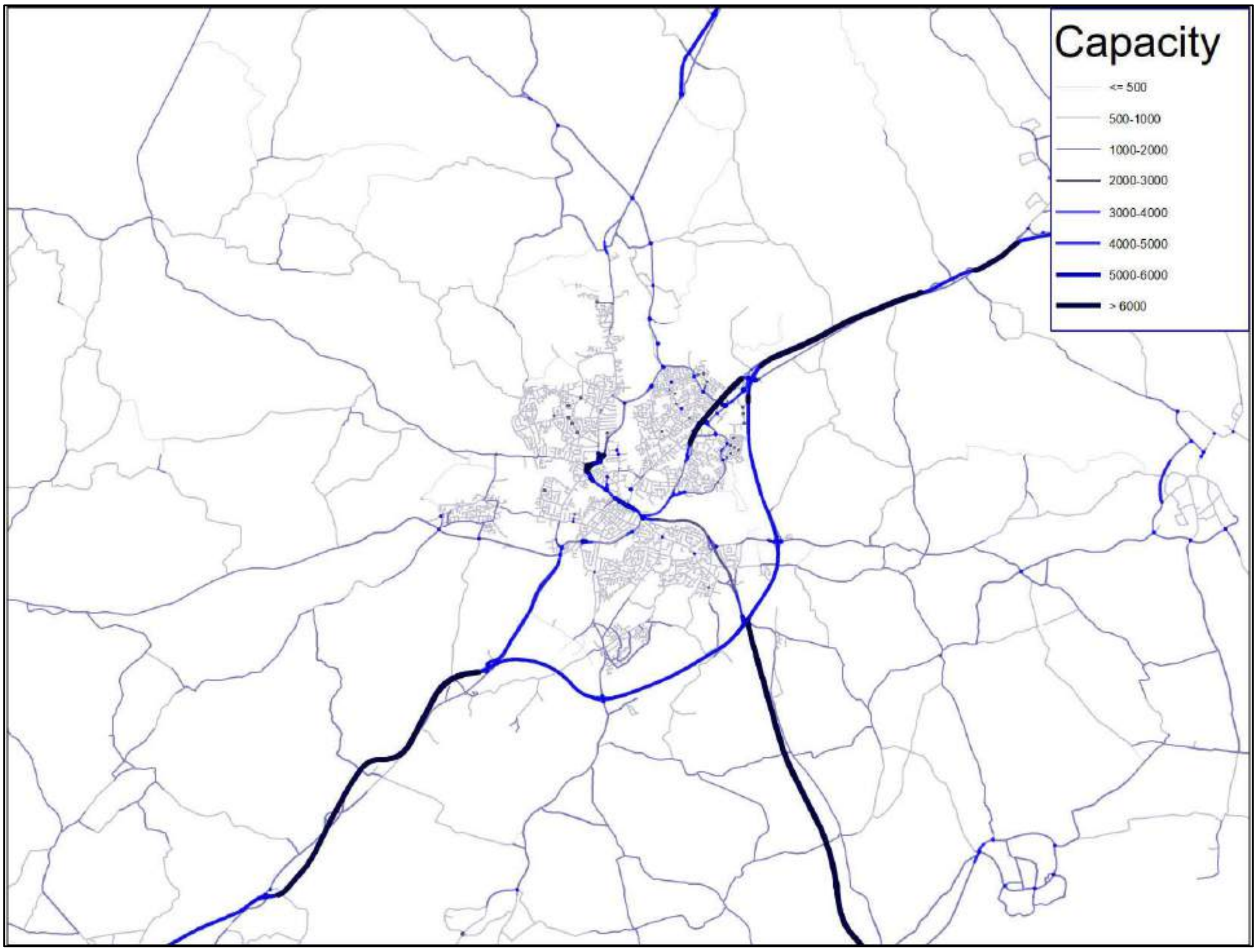


Figure 7-3: Link Capacity in the Model

Urban residential roads show the lowest capacities of around 500 vehicles per hour or less, whilst the A12 has the largest. Main through roads tend to have a capacity between 1,000 and 3,000 vehicles per hour.

Finally, it should be noted that checks were made regarding consistency of coding across all time periods, with only signal timings differing across the periods.

8 Route Choice Calibration

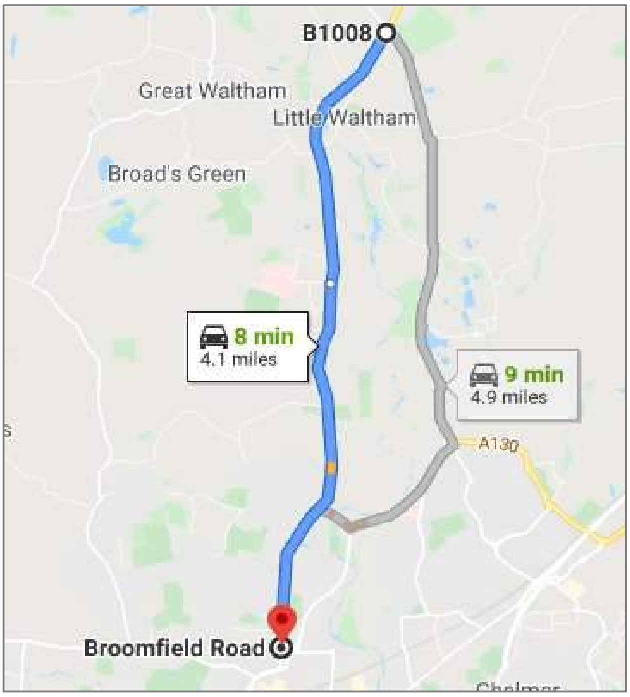
The model was further checked by examining shortest paths and minimum generalised cost routes through the network. These checks were done at an early stage of the model development and again towards the end of the model development process. Major urban areas covered by the network were identified and routes between them checked against GoogleMaps.

A combination of routes were checked for a total of 22 routes, which is in line with guidance on the number of routes to be checked. According to TAG unit M3.1, the number of routes that should be checked is defined by:

$$(\text{number of zones in model})^{0.25} \times \text{number of user classes}$$

The Chelmsford Model has 304 zones and five user classes and therefore 22 routes have been checked, which exceeds the guidance specified in TAG. This exercise was undertaken for the AM peak only. It is noted that, at the time of undertaking these checks using GoogleMaps, travel behaviour was already heavily influenced by COVID related changes. GoogleMaps journey times are also therefore influenced by the reduced levels of traffic and journey times and are not as representative of route choice during the pre-COVID period as they could be. As such, it is considered that the checks undertaken provide some confidence in the model route choice with local knowledge playing a larger role than usual in this process.

Where the route choice was contrary to expectations (as defined by checking against route choices in GoogleMaps), the modelled network was checked and adjusted. Some examples of the route checked in the model are illustrated below, with the modelled route shown in red and equivalent route from Google shown adjacent. A full set of route checks undertaken for the AM peak is presented in Appendix E.



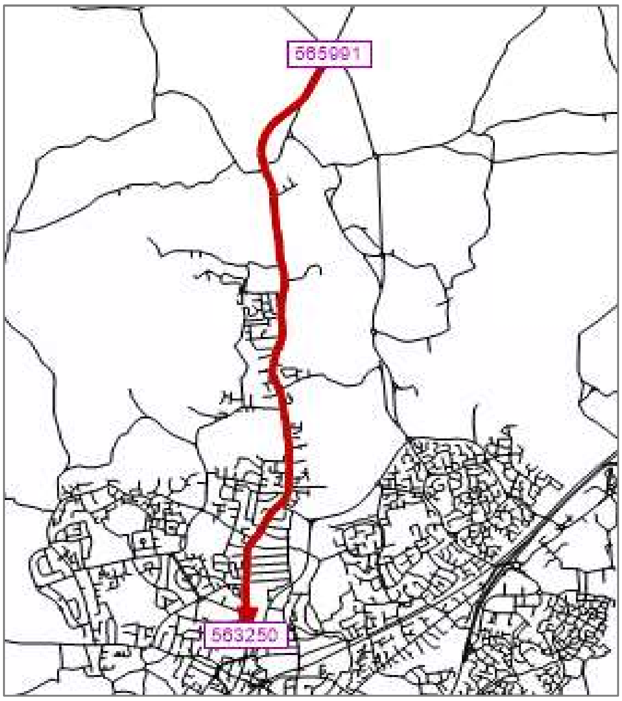


Figure 8-1: Route Choice Checks - Modelled compared to Observed

9 Trip Matrix Development

9.1 Overview

The demand matrices have been derived using the 2017 Essex Countywide Model as the starting point. As the base year for this model is 2019, the Countywide matrices were uplifted based on background growth rates from the DfT's Trip End Modelling Programme (TEMPro), as well as known planning completions between 2017 and 2019. In addition, the matrices were converted from the Countywide zone system to the Chelmsford Model zone system.

9.2 Essex Countywide Model and Use of Mobile Phone Data

The 2017 Essex Countywide Model, which is used as the basis for the development of demand matrices for this model, made use of aggregated and anonymised mobile network data (MND) provided specifically for that study by Telefonica. This development of Essex Countywide matrices was largely driven by this data, however other data sources such as 2011 Census Journey to Work, National Travel Survey data, National Trip End Model and bespoke synthetic matrices were used to augment the MND and to check and correct for its known biases. For example, the nature of MND data means that it does not sufficiently represent short distance trips, and therefore these types of trips needed to be infilled by data from the synthetic matrices.

Figure 9-1 summarises the methodology followed for developing the Essex Countywide matrices:

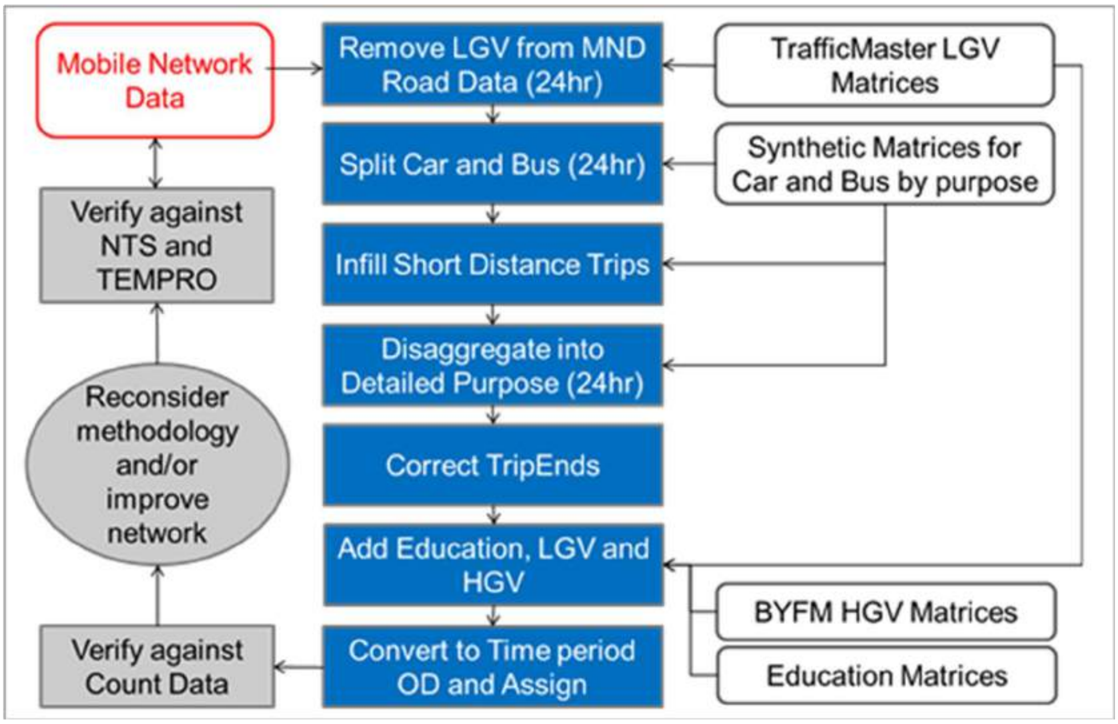


Figure 9-1: Summary of Matrix Building Process for the Essex Countywide Model

The trip matrix development for the Essex Countywide Model, including the processing of raw MND and its verification, is discussed in greater detail in Appendix F. The following summarises the highway matrix development:

- Car matrices were derived from MND as a primary source, with infilling of short distance trips through synthesised data;

- LGV matrices were derived from October - November 2014 and March 2015 Trafficmaster (currently referred as Teletrac) data; and

- HGV matrices were derived from 2006 Base Year Freight Matrices (BYFM).

9.3 Conversion from Essex Countywide Zoning System

The conversion of the prior demand matrices from the Essex Countywide Model zone system to the Chelmsford Model zone system is undertaken through a review and application of 2011 Census data, against the boundaries of the two model zone systems. It is to be noted that the prior matrices from Essex Countywide Model were used - this was because, in anticipation of having to undertake matrix estimation for the Chelmsford Model update, it was important not to ‘correct’ already estimated matrices, thereby distorting the underlying trip patterns significantly.

The matrices from the Essex Countywide Model zone system were aggregated and disaggregated to match the boundaries of the Chelmsford Model zone system. Further away from Chelmsford, where the level of network detail in the Chelmsford Model is lower and zones larger, the Essex Countywide demand was taken directly and simply aggregated to fit the Chelmsford Model zoning system. However, in and around Chelmsford, where the level of network detail is highest in the Chelmsford Model, there was a need to disaggregate the Essex Countywide matrices. The permanent residential population and workplace population, at Output Area (OA) level, was used to translate the demand matrices from the Essex Countywide to the Chelmsford Model zone system. This was facilitated by both zone systems being derived from OA boundaries, so there was a consistent spatial basis for the conversion.

For origin-destination matrices, the census datasets used to disaggregate Essex Countywide demand were dependent on the user class and peak modelled time period, as shown in the following table:

User Class (UC)	Vehicle Class (VC)	AM Matrices		IP Matrices		PM Matrices	
		Origin	Destination	Origin	Destination	Origin	Destination
UC1 (Car Commute)	VC1	Residential Population	Workplace Population	Workplace Population	Residential Population	Workplace Population	Residential Population
UC2 (Car Employer Business)		Residential Population	Workplace Population	Workplace Population	Residential Population	Workplace Population	Residential Population
UC3 (Car Other)		Residential Population	Workplace Population	Workplace Population	Residential Population	Workplace Population	Residential Population
UC4 (LGV)	VC2	Workplace Population	Workplace Population	Workplace Population	Workplace Population	Workplace Population	Workplace Population
UC5 (HGV)	VC3	Workplace Population	Workplace Population	Workplace Population	Workplace Population	Workplace Population	Workplace Population

Table 9-1: Conversion of Origin-Destination Matrices

Across the car user classes, the disaggregation of matrices at trip end level was undertaken using different census datasets depending on the peak period modelled. The origin trip end in the AM peak is disaggregated using the residential population dataset, while in the interpeak and PM peak models the workplace population is used. The reverse is true for the destination trip end.

For LGV and HGV matrices, the disaggregation of matrices was controlled by the workplace population dataset. For goods vehicles, both the origin and destination of a trip are likely to be linked to an employment site.

The demand for the 24hr production-attraction (PA) matrices was also derived from the Essex Countywide Model. The following table shows the census data sets that were used to control the disaggregation of each set of production attraction matrices:

Purpose	User Class (UC)	Vehicle Class (VC)	24 hr PA Matrices	
			Productions	Attractions
Home Based Work (HBW)	UC1	VC1	Residential Population	Workplace Population
Home Based Employer's Business (HBEB)	UC2		Residential Population	Workplace Population
Non-Home-Based Employer's Business (NHBEB)			Workplace Population	Workplace Population
Home Based Education (HBED)	UC3		Residential Population	Workplace Population
Home Based Shopping (HBSh)			Residential Population	Workplace Population
Home Based Other (HBO)			Residential Population	Workplace Population
Non-Home Based Other (NHBO)			Workplace Population	Workplace Population

Table 9-2: Conversion of Production-Attraction Matrices

Home-based matrices were disaggregated based on the residential population census data for the production trip end and workplace population dataset for the attraction trip end. For non-home-based matrices, the matrix disaggregation for both production and attraction trip end was undertaken using the workplace population dataset.

9.4 Developments

Land use is key to establishing travel demand for the area. As discussed in the previous section, land use data has been derived from the previous Countywide Model, which detailed the land uses up to 2017. The land uses for Chelmsford were then updated to a 2019 base year by using planning completions data between 2017 and 2019 from Chelmsford District Council and adjusted growth factors derived from the National Trip End Model (NTEM) v7.2 dataset; these are detailed in the following section.

Developments with a quantum sufficiently large to generate an additional 1,000 weekday trips were modelled explicitly. Trip Rate Information Computer System (TRICS) trip rates were applied to the development quanta and then added to the base zone the development is situated in. The remainder of traffic growth in the model between 2017 and 2019 is covered by growth factors derived from the NTEM dataset. The completions data for developments modelled explicitly between 2017 to 2019 and their locations within the Chelmsford zoning system can be seen in Table 9-3 and viewed in Figure 9-2 on the next page.

Development Name	Development Completions 2017-2019	
	Dwellings	Employment Area (Sqm)
Channels	240	0
Beaulieu Park	440	12500
City Park West	300	3000

Table 9-3: Major Developments in Chelmsford

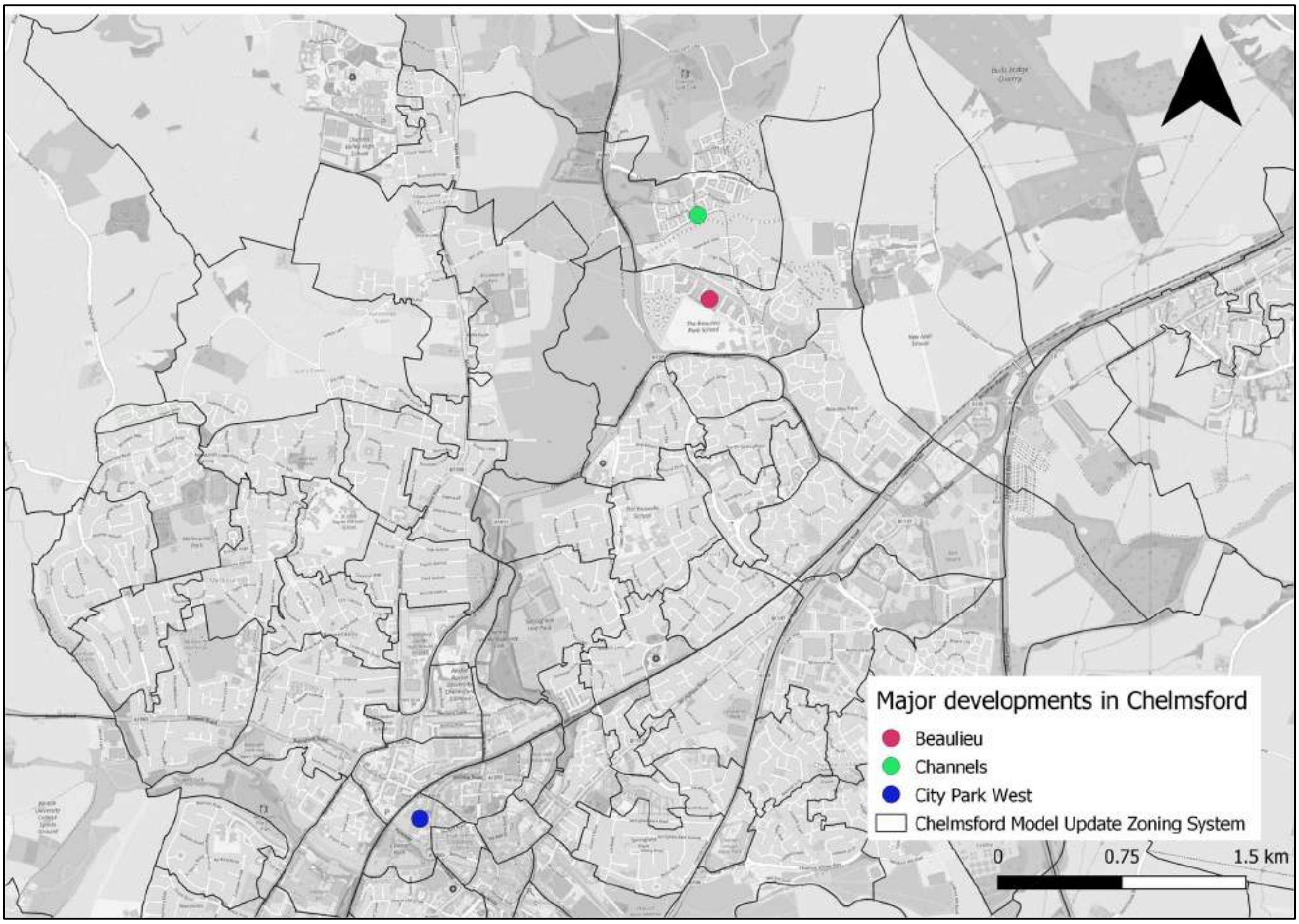


Figure 9-2: Map of Major Developments, Against the Model Zoning System

9.5 TEMPro Uplift

TEMPro version 7.2 provided the NTEM growth factors to be applied to uplift car matrices from 2017 to the required 2019 base year. These factors were calculated after discounting the development sites modelled explicitly, using the TEMPro alternative assumptions menu. Road Traffic Forecast (RTF 2018) growth factors for the East of England region were used to uplift goods vehicle matrices. Factors for each region and user class are listed in the tables on the following page.

AM	UC1/Commute		UC2/Employment		UC3/Other		UC4/LGV		UC5/HGV	
	O	D	O	D	O	D	O	D	O	D
Chelmsford	1.00	1.01	1.01	1.01	1.02	1.02	1.04	1.04	1.01	1.01
Essex	1.02	1.02	1.02	1.02	1.03	1.03	1.04	1.04	1.01	1.01
EAST	1.02	1.02	1.02	1.02	1.03	1.03	1.04	1.04	1.01	1.01
LON	1.03	1.03	1.03	1.03	1.04	1.04	1.04	1.04	1.01	1.01
GB	1.02	1.02	1.02	1.02	1.03	1.03	1.04	1.04	1.01	1.01

Table 9-4: AM TEMPro Growth Factors

IP	UC1/Commute		UC2/Employment		UC3/Other		UC4/LGV		UC5/HGV	
	O	D	O	D	O	D	O	D	O	D
Chelmsford	1.01	1.01	1.01	1.01	1.02	1.02	1.04	1.04	1.01	1.01
Essex	1.02	1.01	1.02	1.02	1.03	1.03	1.04	1.04	1.01	1.01
EAST	1.02	1.02	1.02	1.02	1.03	1.03	1.04	1.04	1.01	1.01
LON	1.03	1.03	1.03	1.03	1.04	1.04	1.04	1.04	1.01	1.01
GB	1.02	1.02	1.02	1.02	1.03	1.03	1.04	1.04	1.01	1.01

Table 9-5: IP TEMPro Growth Factors

PM	UC1/Commute		UC2/Employment		UC3/Other		UC4/LGV		UC5/HGV	
	O	D	O	D	O	D	O	D	O	D
Chelmsford	1.01	1.00	1.01	1.01	1.02	1.02	1.04	1.04	1.01	1.01
Essex	1.02	1.01	1.02	1.02	1.03	1.03	1.04	1.04	1.01	1.01
EAST	1.02	1.02	1.02	1.02	1.03	1.03	1.04	1.04	1.01	1.01
LON	1.02	1.03	1.03	1.03	1.03	1.03	1.04	1.04	1.01	1.01
GB	1.02	1.02	1.02	1.02	1.03	1.03	1.04	1.04	1.01	1.01

Table 9-6: PM TEMPro Growth Factors

9.6 PA Demand – VDM Input

For the VDM, the demand model operates at PA level for home-based trips. Production and attraction growth rates between 2017 and 2019 for rail and bus were also extracted using TEMPro for each journey purpose as discussed in 4.7 and applied to the 2017 Essex Countywide PA matrices.

For cars, the number of households and jobs from the aforementioned developments in Section 9.4 were removed from NTEM planning assumptions, and the growth rates extracted. The growth rates for car were then applied to the respective 2017 PA matrix by purpose.

It is to be noted that for new developments, as explained in Section 9.4, origin-destination trip rates for each modelled peak were obtained from TRICS. These were first converted to 24-hour origin destination based on peak hour to peak period and 12-hour to 24-hour conversion factors obtained from count data.

For housing sites, the 24-hour origin was allocated to ‘outbound’ origin which in turn was allocated to ‘outbound’ production and the 24-hour destination was allocated to ‘inbound’ destination which in turn was allocated to ‘inbound’ production. The final production was obtained by summing ‘inbound’ and ‘outbound’ productions and being a housing site there were no attractions.

Similarly, for employment sites, the 24-hour origin was allocated to ‘outbound’ destination which in turn was allocated to ‘outbound’ attraction and the 24-hour destination was allocated to ‘inbound’ origin which in turn was allocated to ‘inbound’ attraction. The final attraction was obtained by summing ‘inbound’ and ‘outbound’ attractions and being an employment site there were no productions.

The new development PA trips were then added into the PA matrix obtained with no planning application to obtain the final car PA matrix.

To obtain rail and bus PA trips, a similar approach to that of car has been followed, however the growth rates at PA level for each year and purpose were obtained without removing the planning application data

9.7 Adjusted AM Peak Hour

ATC counts from the detailed area of modelling were used to identify the peak (busiest) hours within the peak periods. These are:

- AM peak hour (07:30-08:30);
- PM peak hour (17:00-18:00); and
- Average hour in the interpeak (10:00-16:00).

The above peak hours represent the times at which observed traffic volumes were the highest for the AM (7:00-10:00) and PM (16:00-19:00) time periods, and an average modelled hour for interpeak.

As detailed in the sub-sections above, the demand matrices for the Chelmsford Model are derived from the Essex Countywide Model. This model is consistent with the Chelmsford Model in the interpeak and PM peak hours modelled, however the AM peak hour in the Countywide Model is set at 08:00-09:00 for the AM model. Therefore, an uplift factor based on ATC count data within the area of detailed modelling, was applied to the AM matrices to reflect the demand for the 07:30-08:30 peak hour for Chelmsford.

9.8 Modelling Car Park Demand

As part of the updated Chelmsford 2019 Model, the modelling of separate car park zones was undertaken following the uplift of matrices from 2017 to 2019. The Countywide matrices did not include these zones and thus traffic demand which would use those car parks was instead allocated to the zones surrounding the car parks. An exercise was therefore undertaken to move the appropriate amount of trip generation from the surrounding zones to the car parks.

The map in Figure 9-3 on the next page shows the locations of the car park and park & ride zones added to the Chelmsford Model, with the accompanying table matching each zone number to a named car park.

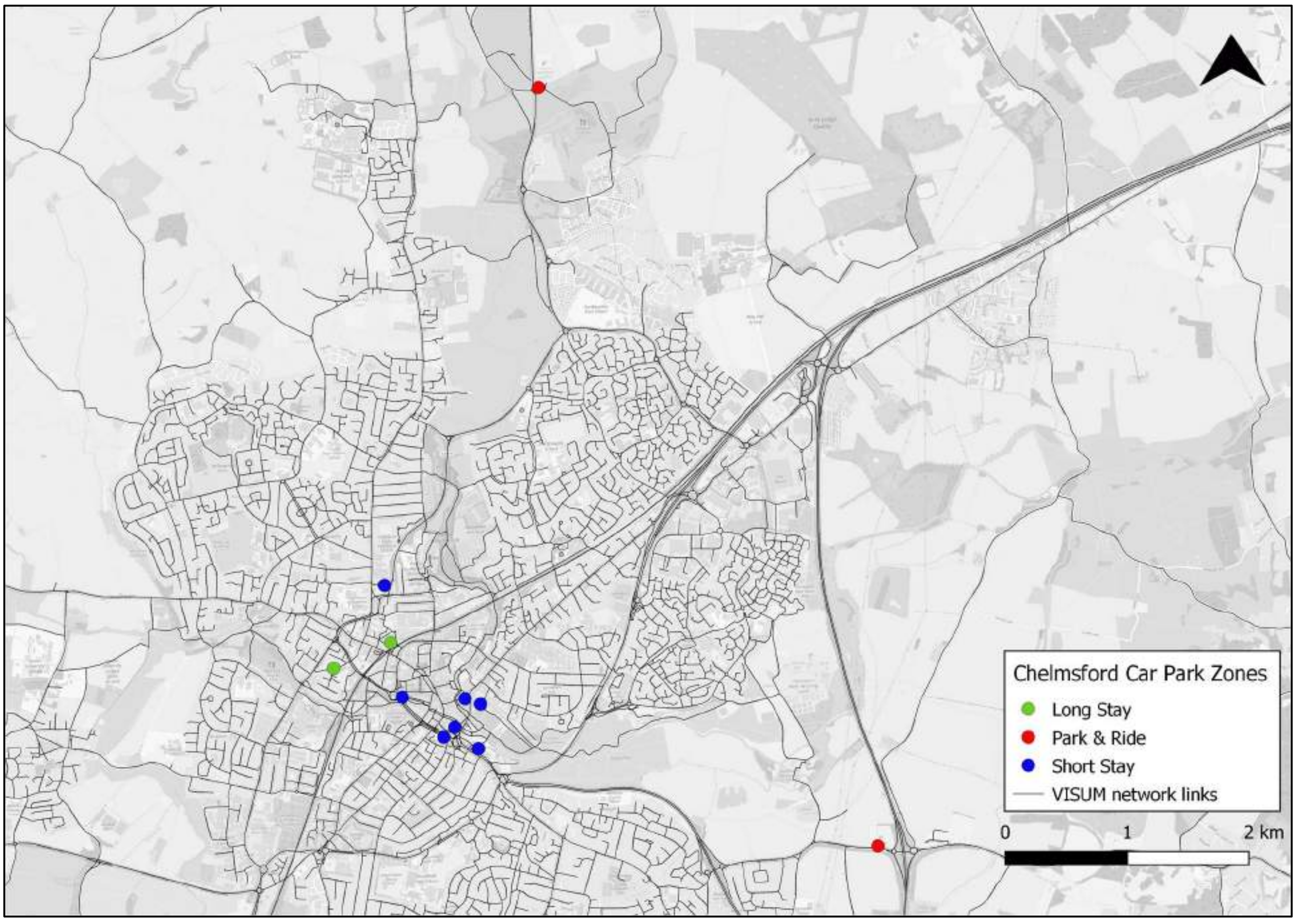


Figure 9-3: Modelled Car Park Zones

Model Zone Number	Car Park Name	Car Park Type
294	Baddow Road	Short Stay
295	Meadows Retail Multistorey	Short Stay
296	Meadows Retail Surface	Short Stay
297	Meadows Multistorey	Short Stay
298	Parkway	Short Stay
299	High Chelmer Multistorey	Short Stay
300	Townfield Street	Long Stay
301	Coval Lane	Long Stay
302	Chelmer Valley Park & Ride	Park & Ride
303	Sandon Park & Ride	Park & Ride
304	Rectory Lane West	Short Stay

Table 9-7: Car Park Zones

Figure 9-3 and Table 9-7 show that the car parks were categorised into whether they had characteristics of a short stay, long stay or park & ride type car park. The following two subheadings provide further detail on how these characteristics influenced the modelling of each.

9.8.1 Park and Ride Car Parks

The demand for the two new car park zones was obtained through the re-allocation of demand from zones within a 3km radius of Chelmsford Station to the two new zones created to represent the park & ride car parks. These zones were chosen for this re-allocation as the two park & ride services primarily deliver passengers from the outskirts of Chelmsford to the town centre. The 3km radius was set to reflect that the majority of onward journeys from the park & ride services in the morning will be taken on foot, or via a short connection by public transport onto another location within Chelmsford town centre. The level of demand to be re-allocated was determined by exit and entry counts at those car parks which were undertaken by Essex Highways. The data is shown in the following table:

Car Park Name	AM Peak Hour		IP Average Hour		PM Peak Hour	
	Entry	Exit	Entry	Exit	Entry	Exit
Chelmer Valley Park & Ride	243	0	21	37	0	159
Sandon Park & Ride	400	0	36	55	1	305

Table 9-8 Entry and Exit Counts, Park & Ride Car Parks

Passenger surveys from ECC were available to model the distribution of trips arriving at park and ride sites in the AM peak and interpeak periods. Modelling the distribution of car trips leaving the park and ride site in the PM peak was then undertaken simply as a reversal of the arrivals surveyed in the AM peak and interpeak periods. Therefore, the distribution of car trips accessing the two park and ride services was modelled consistent with survey data.

9.8.2 Short and Long Stay Car Parks

As above, the demand for the new car park zones was derived through re-allocating a proportion of trips away from zones in Chelmsford town centre. The radius taken for the demand re-allocation was set at 1km, to reflect that the majority of onward trips from the town centre car parks are made via a short walk to destinations immediately in the town centre. The level of demand to be re-allocated was again determined by entry and exit counts at the car park, as detailed in Table 9-9 on the next page.

Car Park Name	AM Peak Hour		IP Average Hour		PM Peak Hour	
	Entry	Exit	Entry	Exit	Entry	Exit
Baddow Road	59	7	47	52	14	76
Coval Lane	95	2	3	9	3	69
High Chelmer Multistorey	203	4	209	180	68	230
Meadows Multistorey	41	2	79	78	29	82
Meadows Retail Multistorey	69	0	25	28	4	80
Meadows Retail Surface	10	1	65	67	17	28
Parkway	15	9	19	16	8	27
Rectory Lane West	159	28	12	16	15	77
Townfield Street	177	3	10	16	6	178

Table 9-9 Entry and Exit Counts, Short and Long Stay Car Parks

The trip distribution for the new car park demand was derived from the town centre zones from which the demand was re-allocated.

9.9 Public Transport Matrices

As with the car matrices, the development of the public transport matrices for the Chelmsford Model update uses the 2017 Essex Countywide Model matrices as a starting point. The main purpose of deriving these matrices was for use in VDM, the realism testing part of which is discussed in detail under Section 11. Given that a detailed PT model was not required in and of itself, a ‘light-touch’ approach was taken to public transport modelling and assignment.

As with the Essex Countywide highway demand matrices, the public transport matrices were processed using MND, with bus and rail matrices prepared separately. In the case of rail, Essex County Council obtained permission from Greater Anglia (GA) and c2c franchises to use their respective versions of MOIRA as a means of validating the demand matrices against an independent dataset. Appendix G explains the development of these matrices in full.

The zoning systems used matches that used for the car user class, therefore the demand also had to be aggregated and disaggregated to conform to the Chelmsford Model zone system. Where zones were disaggregated, census datasets for residential and workplace population were used, consistent with the methodology applied to the car matrices.

After the public transport demand was converted to the Chelmsford zone system, TEMPro growth factors were applied separately to the bus and rail components of the demand to uplift from 2017 to the desired 2019 base year.

10 Trip Matrix Calibration and Validation

The following section outlines the adjustment process to improve the prior demand matrices and describes the resulting calibration of trip matrices through matrix estimation.

10.1 Prior Matrices Adjustments

The prior matrices, derived following the steps described above, were assigned to the Chelmsford network and the assigned flows were compared against observed flows across screenlines. This comparison identified a need for further refinement of the trip matrices. The matrix development steps were reviewed, however since the required refinement was relatively small, it was decided not to revise the matrix development processes. Rather, small-scale adjustments were made to the trip matrices by aggregating into sectors and applying small factors to the sector to sector movements, to make small adjustments to better reflect the identified observed movements across screenlines. The sectors are those defined previously (see Section 4.3.2) with a more detailed map showing Chelmsford in Figure 10-1:

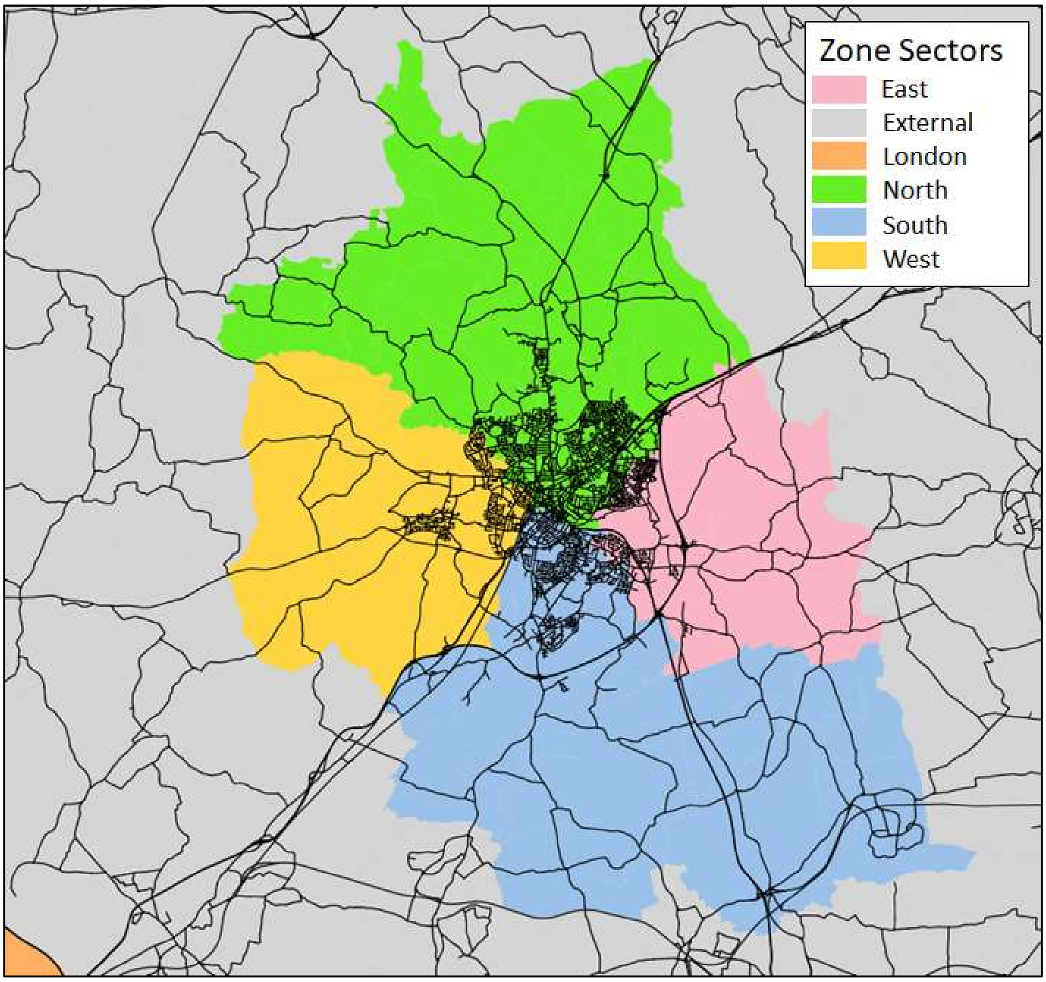


Figure 10-1: Sector Definition - Chelmsford

Checks were carried out to confirm that the adjustments did not significantly change patterns. Table 10-1 on the next page shows the scale of change brought about by the adjustments to the matrix totals.

User Class	AM			IP			PM		
	Initial Prior Matrix	Final Prior Matrix	% Change	Initial Prior Matrix	Final Prior Matrix	% Change	Initial Prior Matrix	Final Prior Matrix	% Change
UC1	155,724	156,199	0.31%	35,777	35,917	0.39%	132,743	133,333	0.44%
UC2	58,856	58,951	0.16%	38,635	38,695	0.16%	54,418	54,531	0.21%
UC3	122,724	123,384	0.54%	155,286	156,193	0.58%	177,395	178,527	0.64%
LGV	128,947	128,947	0.00%	116,968	116,968	0.00%	101,102	101,102	0.00%
HGV	72,503	72,503	0.00%	79,883	79,883	0.00%	39,375	39,375	0.00%
Total	538,755	539,985	0.23%	426,549	427,655	0.26%	505,034	506,869	0.36%

Table 10-1: Prior Matrix Adjustments

The factors used, and the change in trips implied between the initial and final prior matrices on a sector to sector basis, are outlined in the following tables by user class for each time period. Note that this process was only applied to car trips, not LGV or HGV.

OD Sector	Factors – Final / Initial Prior Matrices						Change in Trips (veh/hr)					
Commuter	**North**	**East**	**South**	**West**	**Lon.**	**Ext.**	**North**	**East**	**South**	**West**	**Lon.**	**Ext.**
North	1.15	1.03	1.00	1.17	1.00	1.00	195	3	0	54	0	0
East	1.02	1.00	1.00	1.09	1.00	1.00	6	0	0	7	0	0
South	1.03	1.00	1.00	1.20	1.00	1.00	19	0	0	47	0	0
West	1.16	1.07	1.19	1.41	1.00	1.00	51	2	25	64	0	0
London	1.00	1.00	1.00	1.00	1.00	1.00	0	0	0	0	0	0
External	1.00	1.00	1.00	1.00	1.00	1.00	0	0	0	0	0	0
Business	**North**	**East**	**South**	**West**	**Lon.**	**Ext.**	**North**	**East**	**South**	**West**	**Lon.**	**Ext.**
North	1.16	1.04	1.00	1.19	1.00	1.00	40	1	0	14	0	0
East	1.02	1.00	1.00	1.05	1.00	1.00	1	0	0	1	0	0
South	1.02	1.00	1.00	1.20	1.00	1.00	3	0	0	8	0	0
West	1.17	1.04	1.16	1.43	1.00	1.00	11	0	5	11	0	0
London	1.00	1.00	1.00	1.00	1.00	1.00	0	0	0	0	0	0
External	1.00	1.00	1.00	1.00	1.00	1.00	0	0	0	0	0	0
Other	**North**	**East**	**South**	**West**	**Lon.**	**Ext.**	**North**	**East**	**South**	**West**	**Lon.**	**Ext.**
North	1.13	1.03	1.00	1.26	1.00	1.00	268	4	0	94	0	0
East	1.01	1.00	1.00	1.07	1.00	1.00	4	0	0	3	0	0
South	1.03	1.00	1.00	1.28	1.00	1.00	11	0	0	49	0	0
West	1.17	1.08	1.24	1.33	1.00	1.00	62	2	40	123	0	0
London	1.00	1.00	1.00	1.00	1.00	1.00	0	0	0	0	0	0
External	1.00	1.00	1.00	1.00	1.00	1.00	0	0	0	0	0	0

Table 10-2: Initial Versus Final Sector to Sector Factors and Change in Trips – AM Peak

OD Sector	Factors – Final / Initial Prior Matrices						Change in Trips (veh/hr)					
Commuter	**North**	**East**	**South**	**West**	**Lon.**	**Ext.**	**North**	**East**	**South**	**West**	**Lon.**	**Ext.**
North	1.03	1.00	1.00	1.16	1.00	1.00	8	0	0	15	0	0
East	1.03	1.05	1.16	1.18	1.00	1.00	1	1	5	2	0	0
South	1.00	1.13	1.20	1.37	1.00	1.00	0	6	33	23	0	0
West	1.09	1.12	1.31	1.39	1.00	1.00	7	2	20	16	0	0
London	1.00	1.00	1.00	1.00	1.00	1.00	0	0	0	0	0	0
External	1.00	1.00	1.00	1.00	1.00	1.00	0	0	0	0	0	0
Business	**North**	**East**	**South**	**West**	**Lon.**	**Ext.**	**North**	**East**	**South**	**West**	**Lon.**	**Ext.**
North	1.04	1.00	1.00	1.15	1.00	1.00	6	0	0	8	0	0
East	1.01	1.05	1.12	1.15	1.00	1.00	0	0	2	2	0	0
South	1.00	1.08	1.15	1.31	1.00	1.00	0	2	9	10	0	0
West	1.14	1.10	1.27	1.43	1.00	1.00	5	1	7	8	0	0
London	1.00	1.00	1.00	1.00	1.00	1.00	0	0	0	0	0	0
External	1.00	1.00	1.00	1.00	1.00	1.00	0	0	0	0	0	0
Other	**North**	**East**	**South**	**West**	**Lon.**	**Ext.**	**North**	**East**	**South**	**West**	**Lon.**	**Ext.**
North	1.02	1.00	1.00	1.18	1.00	1.00	42	0	0	80	0	0
East	1.02	1.09	1.21	1.17	1.00	1.00	4	21	50	10	0	0
South	1.00	1.18	1.20	1.40	1.00	1.00	0	51	274	114	0	0
West	1.14	1.11	1.34	1.37	1.00	1.00	48	6	78	128	0	0
London	1.00	1.00	1.00	1.00	1.00	1.00	0	0	0	0	0	0
External	1.00	1.00	1.00	1.00	1.00	1.00	0	0	0	0	0	0

Table 10-3: Initial Versus Final Sector to Sector Factors and Change in Trips – Inter-Peak

OD Sector	Factors – Final / Initial Prior Matrices						Change in Trips (veh/hr)					
Commuter	**North**	**East**	**South**	**West**	**Lon.**	**Ext.**	**North**	**East**	**South**	**West**	**Lon.**	**Ext.**
North	1.19	1.15	1.00	1.08	1.00	1.00	209	44	0	21	0	0
East	1.01	1.00	1.03	1.19	1.00	1.00	1	0	3	6	0	0
South	1.01	1.03	1.13	1.38	1.00	1.00	3	5	57	58	0	0
West	1.10	1.15	1.41	1.32	1.00	1.00	25	10	108	38	0	0
London	1.00	1.00	1.00	1.00	1.00	1.00	0	0	0	0	0	0
External	1.00	1.00	1.00	1.00	1.00	1.00	0	0	0	0	0	0
Business	**North**	**East**	**South**	**West**	**Lon.**	**Ext.**	**North**	**East**	**South**	**West**	**Lon.**	**Ext.**
North	1.19	1.12	1.00	1.07	1.00	1.00	42	8	0	5	0	0
East	1.01	1.00	1.03	1.19	1.00	1.00	0	0	1	3	0	0
South	1.01	1.02	1.08	1.33	1.00	1.00	1	0	6	13	0	0
West	1.14	1.14	1.36	1.36	1.00	1.00	7	3	17	8	0	0
London	1.00	1.00	1.00	1.00	1.00	1.00	0	0	0	0	0	0
External	1.00	1.00	1.00	1.00	1.00	1.00	0	0	0	0	0	0
Other	**North**	**East**	**South**	**West**	**Lon.**	**Ext.**	**North**	**East**	**South**	**West**	**Lon.**	**Ext.**
North	1.13	1.09	1.00	1.09	1.00	1.00	297	40	0	45	0	0
East	1.02	1.00	1.05	1.21	1.00	1.00	4	0	13	15	0	0
South	1.02	1.03	1.13	1.43	1.00	1.00	11	9	189	158	0	0
West	1.17	1.14	1.42	1.34	1.00	1.00	76	10	141	125	0	0
London	1.00	1.00	1.00	1.00	1.00	1.00	0	0	0	0	0	0
External	1.00	1.00	1.00	1.00	1.00	1.00	0	0	0	0	0	0

Table 10-4: Initial Versus Final Sector to Sector Factors and Change in Trips – PM Peak

The factors and impacts on trip totals in the above tables highlight that the changes address the stated issues in that they are largely related to intra-sector movements, that is, increasing short distance trips. In addition, there are some minor adjustments related to the “West” sector between adjacent sectors. These are largely due to a lack of education trips in the matrices to the schools in the west of Chelmsford, which are located at the junction of the south and west sectors.

The impacts of these prior matrix adjustments on model performance with respect to screenlines are outlined in the following table. The screenline locations are described in Section 11.2. The colour in the GEH column indicators whether the screenline improved (green) or not after the factoring process. Also included are overall results across all screenlines and the number of screenlines that pass acceptability criteria. Note that although the screenlines are named based on whether they are calibration (used in matrix estimation) or validation, in this case they are all effectively validation screenlines since this assessment was undertaken prior to any matrix estimation.

ID	Name	AM				IP				PM			
		Initial		Final		Initial		Final		Initial		Final	
		Diff	GEH	Diff	GEH	Diff	GEH	Diff	GEH	Diff	GEH	Diff	GEH
C1	Cal_1-1	-7.8%	9.5	-7.3%	8.8	3.8%	3.3	3.7%	3.2	4.3%	4.5	4.5%	4.8
	Cal_1-2	-10.3%	11.3	-10.0%	11.0	2.0%	1.8	0.8%	0.7	-2.3%	2.6	-2.4%	2.7
C2	Cal_2-1	1.9%	1.2	3.8%	2.3	-1.6%	0.8	-1.4%	0.7	-7.0%	4.4	-5.0%	3.2
	Cal_2-2	-12.7%	8.2	-9.5%	6.1	1.9%	0.9	2.0%	1.0	-5.2%	3.3	-3.4%	2.2
C3	Cal_3-1	-7.3%	4.6	-2.5%	1.5	-19.5%	11.0	-17.4%	9.8	-7.2%	4.5	-5.2%	3.2
	Cal_3-2	-18.5%	11.4	-16.4%	10.1	-5.3%	2.8	-2.6%	1.4	5.2%	3.1	11.2%	6.6
C4	Cal_4-1	-5.6%	4.3	-2.8%	2.1	-11.9%	7.9	-9.6%	6.4	-1.6%	1.1	-0.2%	0.1
	Cal_4-2	-5.3%	3.7	-3.9%	2.7	0.8%	0.5	4.9%	3.1	4.7%	3.4	2.3%	1.7
C5	Cal_5-1	-7.7%	4.0	-6.2%	3.2	-30.5%	15.9	-23.0%	11.7	-17.8%	10.2	-4.8%	2.7
	Cal_5-2	-21.1%	11.8	-18.8%	10.4	-23.7%	12.1	-18.6%	9.4	-11.4%	6.0	-2.3%	1.2
C6	Cal_6-1	-22.6%	14.5	-20.5%	13.1	-9.8%	4.8	-7.7%	3.7	-9.5%	5.0	-8.2%	4.3
	Cal_6-2	-19.4%	10.0	-17.6%	9.0	-21.6%	10.6	-22.8%	11.3	-20.5%	12.2	-16.6%	9.8
V1	Val_1-1	-25.1%	11.0	-14.1%	6.0	-20.2%	7.0	-8.7%	2.9	-22.0%	9.8	-11.1%	4.8
	Val_1-2	-25.3%	10.9	-7.8%	3.2	-25.8%	9.0	-7.7%	2.6	-13.7%	5.5	-3.7%	1.4
V2	Val_2-1	-7.4%	5.4	-7.2%	5.2	1.1%	0.6	-4.0%	2.1	-5.5%	3.7	-5.2%	3.5
	Val_2-2	-4.0%	2.3	-5.1%	2.9	13.7%	6.1	13.5%	6.0	-0.5%	0.3	-4.1%	2.4
V3	Val_3-1	-18.1%	8.4	-15.6%	7.2	-35.5%	17.4	-29.8%	14.3	-25.4%	13.3	-13.9%	7.0
	Val_3-2	-23.3%	12.2	-20.1%	10.5	-27.8%	13.3	-15.6%	7.2	-19.2%	9.5	-9.0%	4.3
V4	Val_4-1	-4.1%	1.8	-4.1%	1.8	-9.5%	4.2	-6.6%	2.9	-1.4%	0.7	-2.5%	1.2
	Val_4-2	2.0%	0.9	3.4%	1.5	-15.9%	7.4	-17.4%	8.1	-17.4%	8.7	-10.7%	5.3
V5	Val_5-1	-22.1%	11.5	-7.6%	3.8	-1.4%	0.6	-1.2%	0.5	-4.1%	1.8	-0.2%	0.1
	Val_5-2	-9.0%	4.9	-4.8%	2.6	-11.0%	5.4	-11.6%	5.7	-6.4%	3.8	-4.7%	2.8
All	**All**	**-10.7%**		**-8.3%**		**-7.8%**		**-5.9%**		**-5.2%**		**-2.7%**	
Fail		**18**	**16**	**15**	**11**	**14**	**14**	**13**	**10**	**15**	**12**	**10**	**8**
Pass		**4**	**6**	**7**	**11**	**8**	**8**	**9**	**12**	**7**	**10**	**12**	**14**
%Pass		**18%**	**27%**	**32%**	**50%**	**36%**	**36%**	**41%**	**55%**	**32%**	**45%**	**55%**	**64%**

Table 10-5: Screenline Comparison for Initial and Final Prior Matrices

The data in the above table highlights the following key points:

- The prior matrix adjustments generally improve the prior matrices based on the comparison with observed flows across screenlines. For example, for the final prior matrices 50% of screenlines have a GEH of less than 4 in the AM peak hour compared to 27% with the initial prior matrices; and

- Traffic flows are low overall across screenlines (e.g. 10.7% low in the AM peak) and generally low across most individual screenlines in the initial prior matrices, which is improved for all three time periods in the final prior matrices, although still low relative to observed flows.

As a further test of the effect of matrix adjustments on trip length distribution, a series of plots have been produced comparing trip length distribution for the initial and final prior matrices, for all car user classes, which are shown in Appendix R. These plots illustrate that there is relatively little change in the trip length distribution and therefore that the effects of adjustments on trip patterns are minimal for cars. As an example, plots showing trip length distribution change for UC1 AM and UC3 PM are shown below:

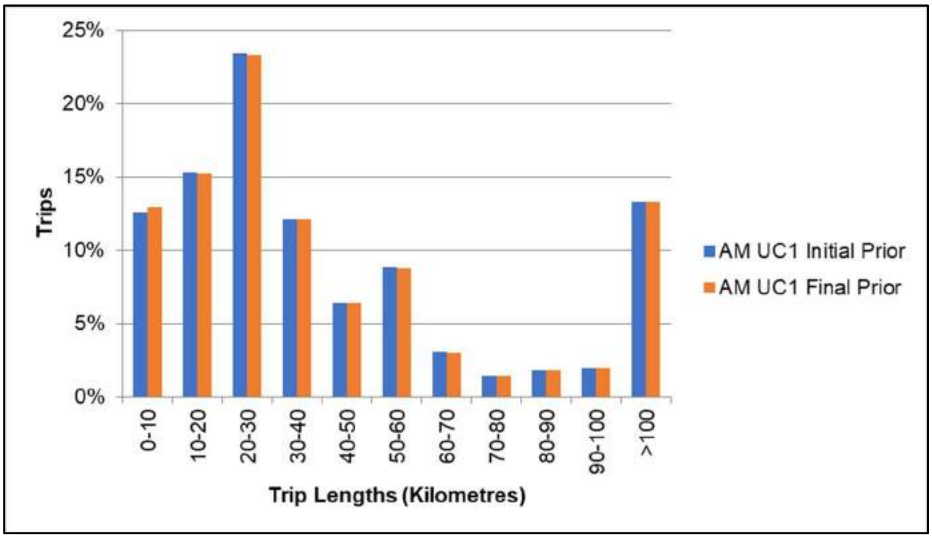


Figure 10-2: Matrix Trip Length Changes, UC1 AM

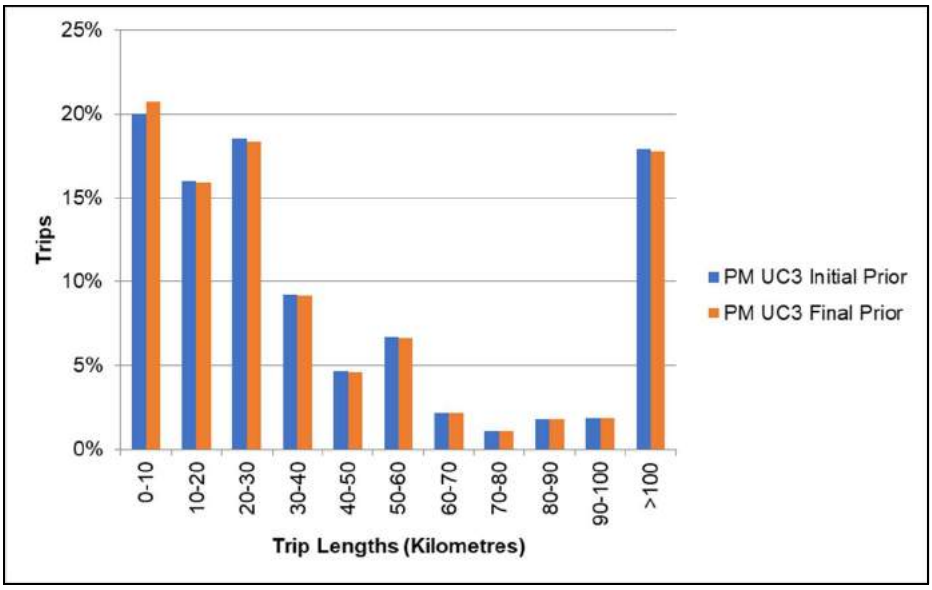


Figure 10-3: Matrix Trip Length Changes, UC3 PM

Figure 10-2 and Figure 10-3 on the previous page reinforce that the primary impact of the sector to sector factoring is to increase short distance car trips as intended.

These adjusted car matrices were taken as “final prior matrices” for matrix estimation. The Matrix Estimation process is described in the following section.

10.2 Matrix Estimation

After an initial assignment and refining of the modelled network, the trip matrices underwent a process of ‘matrix estimation’ whereby trip matrices were adjusted such that the resulting assigned flows better represented current conditions. The “TFlowFuzzy” module within VISUM was used for this process. The process of matrix estimation in general is well understood within the modelling community and will not be expanded upon here. The VISUM manual contains details of the specifics of the TFlowFuzzy process, but in principal it is much the same as any other matrix estimation process in any other transport modelling package.

The available count data is given for cars, LGVs, HGVs, and matrix estimation was undertaken for those vehicle classes separately. With specific reference to car trips, matrix estimation was run on the three user class matrices (commute, business, and other) jointly in a single process. This was done using the modelling procedure for matrix estimation which has the capability to split the car counts into three user class proportions based on the assigned user class volumes on links. The matrix estimation process was applied at the screenline level plus a small number of individual sites. The location of these calibration screenlines is described in Section 11.2. It is important when running matrix estimation processes that the ‘prior’ (to estimation) trip matrices are not distorted such that the underlying trip patterns in the ‘post’ matrices are altered. To test whether this altering process has occurred, the guidelines set out within Table 5 of TAG Unit M3-1 have been applied to the prior- and post-ME matrices, as detailed below in Table 10-6 below:

Measure	Significance Criteria
Matrix zonal cell values	Slope within 0.98 and 1.02 Intercept near zero R^2 in excess of 0.95
Matrix zone trip ends	Slope within 0.99 and 1.01 Intercept near zero R^2 in excess of 0.98
Trip length distributions	Means within 5% Standard deviation within 5%
Sector to sector level matrices	Differences within 5%

Table 10-6: Significance of Matrix Estimation Changes

The significance of matrix estimation for each measure detailed in the above table is described in section 10.2.2 to 10.2.5.

10.2.1 Matrix Totals

There is no current guidance set out in TAG Unit M 3.1 on the acceptability of the amount of change brought about by matrix estimation to the matrix totals. A comparison of the matrix totals before and after the application of matrix estimation to show the impact of matrix estimation is shown in Table 10-7 on the next page.

Vehicle Class	AM			IP			PM		
	Prior	Post ME	% Diff	Prior	Post ME	% Diff	Prior	Post ME	% Diff
Car	338534	340346	0.5%	230805	231412	0.3%	366391	365503	-0.2%
LGV	128947	129040	0.1%	116968	116788	-0.2%	101102	101343	0.2%
HGV	72503	72001	-0.7%	79883	79410	-0.6%	39375	39267	-0.3%
Total	539985	541387	0.3%	427658	427610	0.0%	506869	506113	-0.1%

Table 10-7: Comparison of Matrix Totals - Prior vs Post ME

The table above shows that at a matrix total level across all vehicle classes, changes in the number of trips in the matrix are within 1% for all vehicle types, which demonstrates that matrices post estimation are not significantly altered in terms of total number of trips.

10.2.2 Matrix Zonal Cell Value Changes

The graphs in Figure 10-4 to Figure 10-9 below show for each time period and vehicle type in terms of cars and all vehicles, the cell values of the prior matrix plotted (on the horizontal axis) against the values in the same cell of the post matrix (on the vertical axis). Intrazonals are excluded from the graphs. A trend line, with equation and R^2 value has also been plotted. Graphs for each separate highway user class are presented in Appendix H.

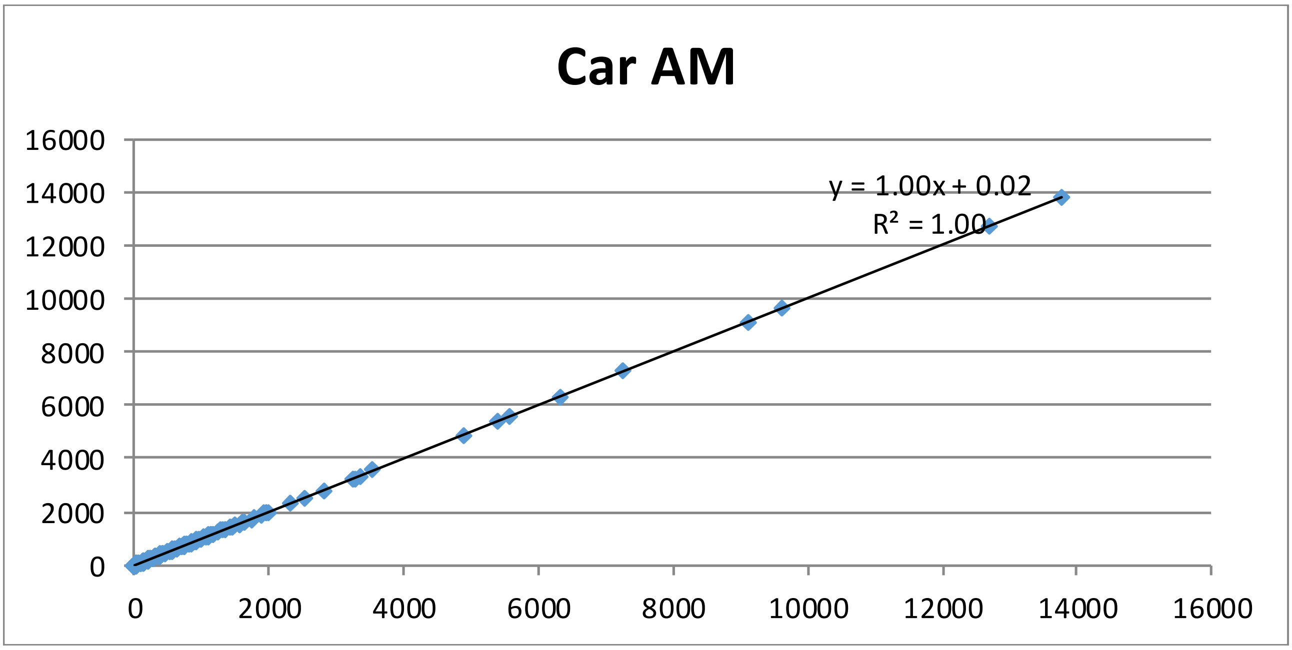


Figure 10-4: Cell Value of Prior Matrix Against Post ME Matrix, Cars AM

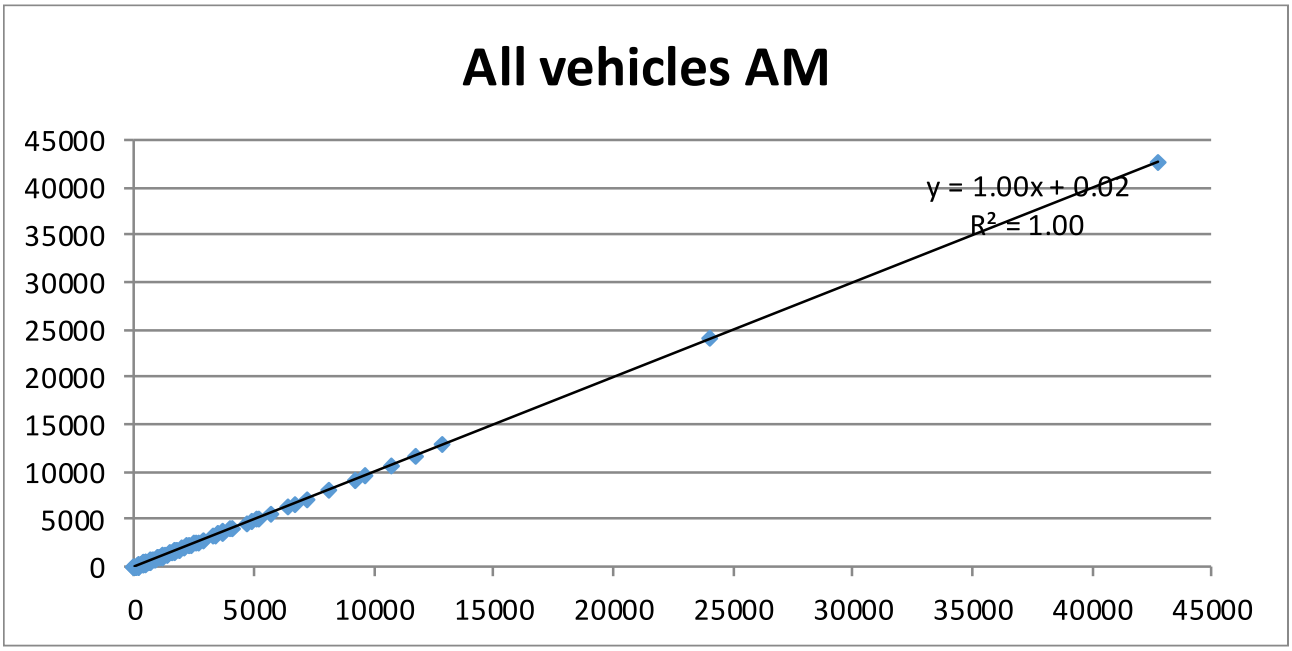


Figure 10-5: Cell Value of Prior Matrix Against Post ME Matrix, All Vehicles AM

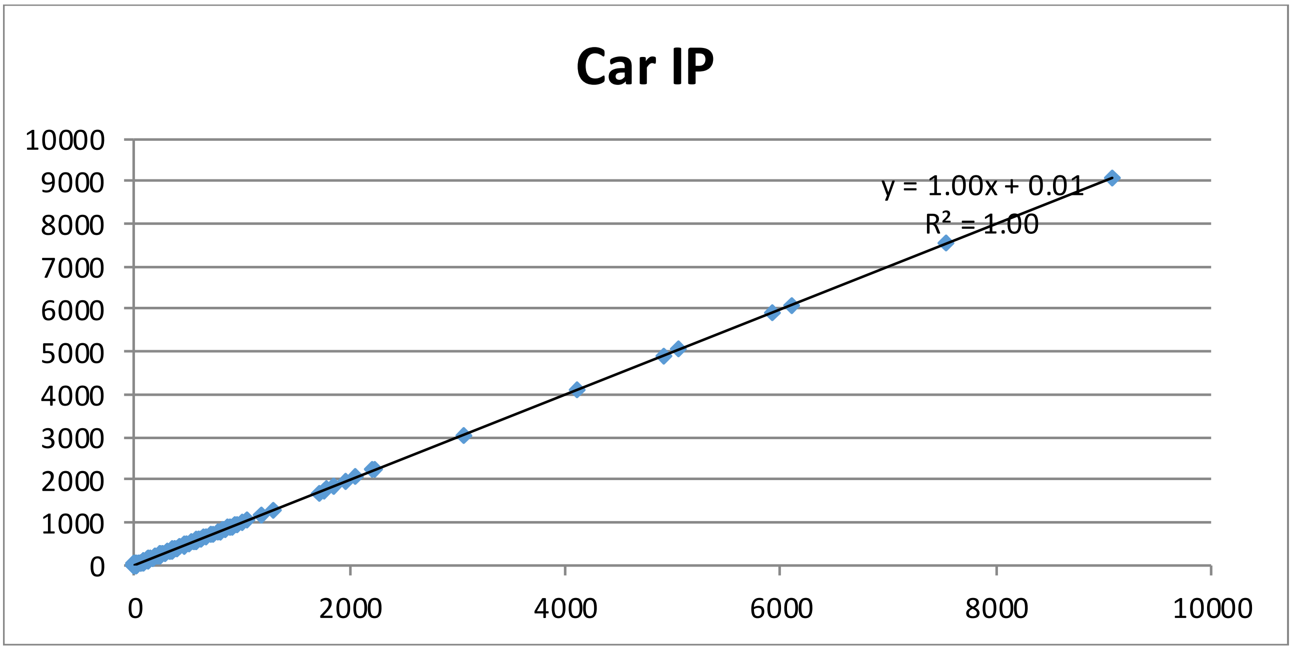


Figure 10-6: Cell Value of Prior Matrix Against Post ME Matrix, Car IP

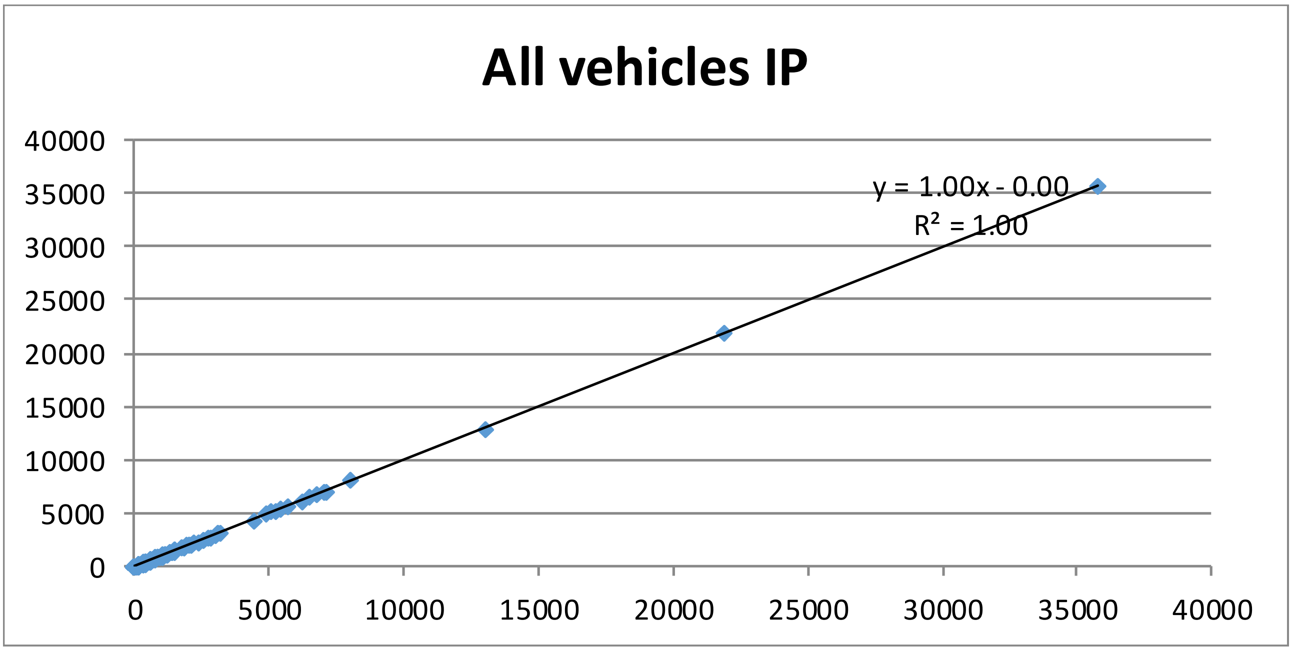


Figure 10-7: Cell Value of Prior Matrix Against Post ME Matrix, All Vehicles IP

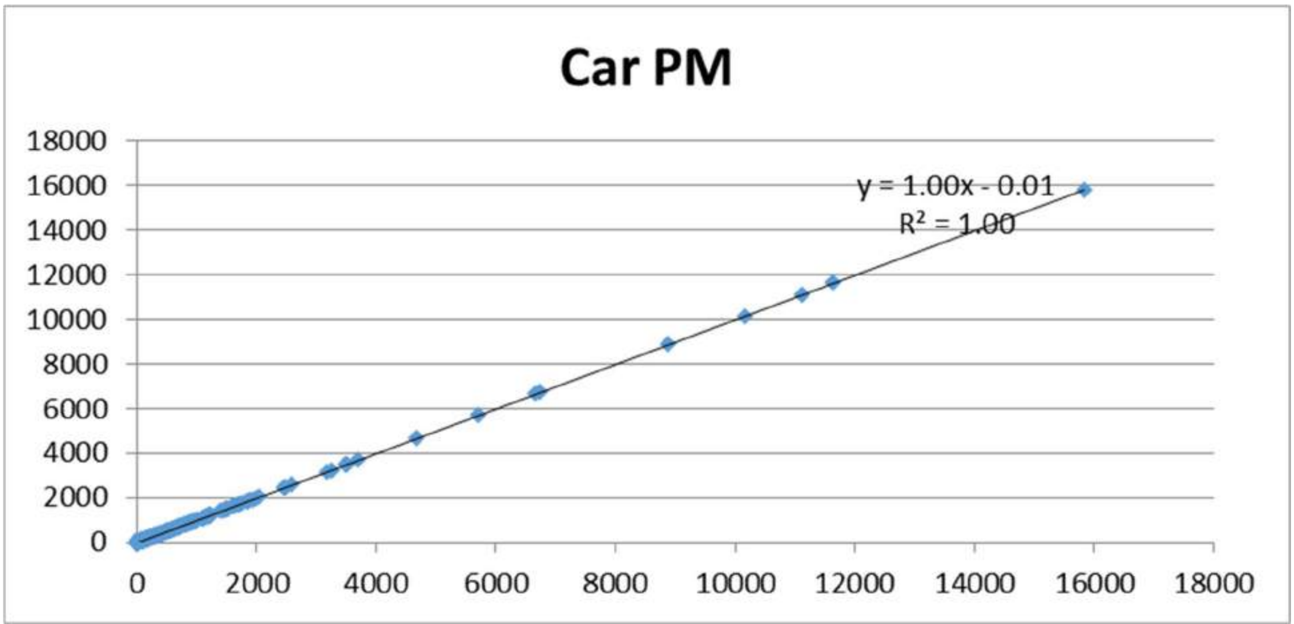


Figure 10-8: Cell Value of Prior Matrix Against Post ME Matrix, Car PM

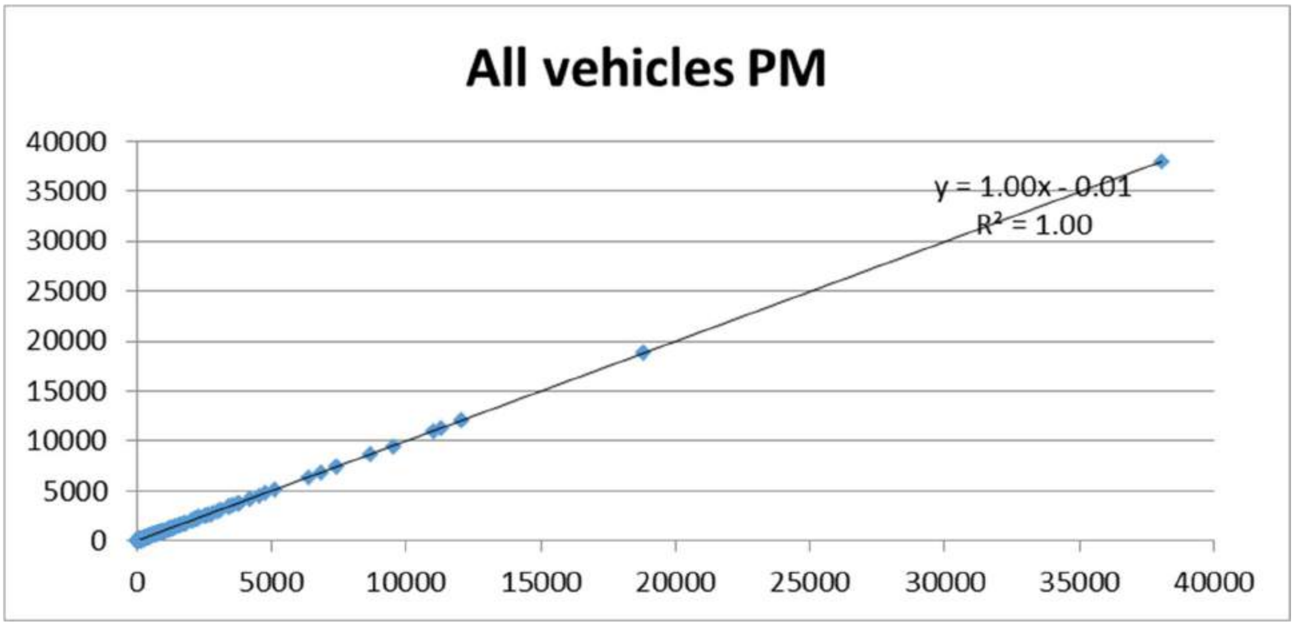


Figure 10-9: Cell Value of Prior Matrix Against Post ME Matrix, All Vehicles PM

The guidance states that the trend line must have a gradient between 0.98 and 1.02, an intercept "close to zero", and an R^2 value exceeding 0.95. Table 10-8 below summarises the data in the graphs and demonstrates that these conditions are met for Cars and all vehicles in the AM and PM peak models. The table also includes data on LGV and HGVs, and again, they meet the conditions.

Zonal Cell Value Summary	AM			IP			PM		
	R^2	Slope	Intercept	R^2	Slope	Intercept	R^2	Slope	Intercept
All Vehicles	1.00	1.00	0.02	1.00	1.00	0.00	1.00	1.00	0.01
Car	1.00	1.00	0.02	1.00	1.00	0.01	1.00	1.00	0.01
Car C	1.00	1.00	0.01	1.00	1.00	0.00	1.00	1.00	0.00
Car EB	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00
Car O	1.00	1.00	0.01	1.00	1.00	0.01	1.00	1.00	0.00
LGV	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00
HGV	1.00	1.00	0.01	1.00	1.00	0.01	1.00	1.00	0.00

Table 10-8: Zonal Cell Value Summary

10.2.3 Matrix Trip End Changes

The check on how much matrix trip ends have been affected by matrix estimation is similar to the check on individual cell values in that the prior and post trip ends must be plotted on a graph and a trend line added. The graphs showing these for cars and all vehicles are below in Figure 10-10 to Figure 10-15. A full set of graphs by individual user class can be found under Appendix I. Intrazonal trips have been excluded from the trip end totals.

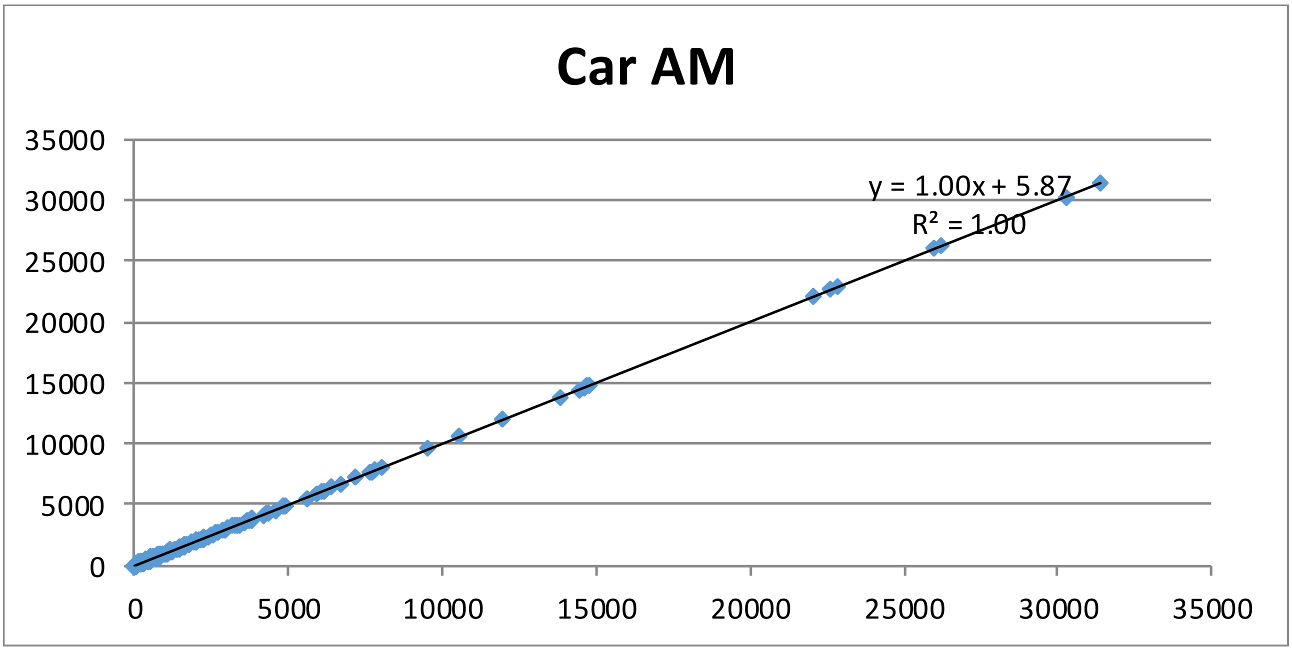


Figure 10-10: Matrix Trip End Changes, Car AM

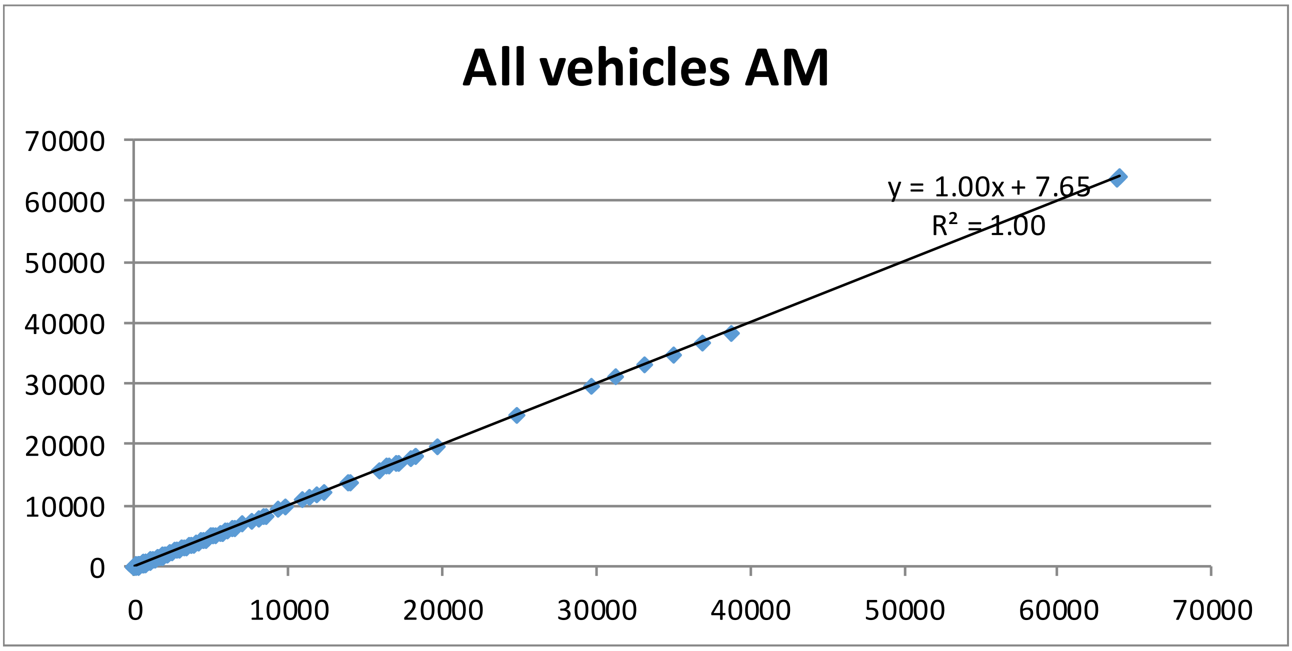


Figure 10-11: Matrix Trip End Changes, All Vehicles AM

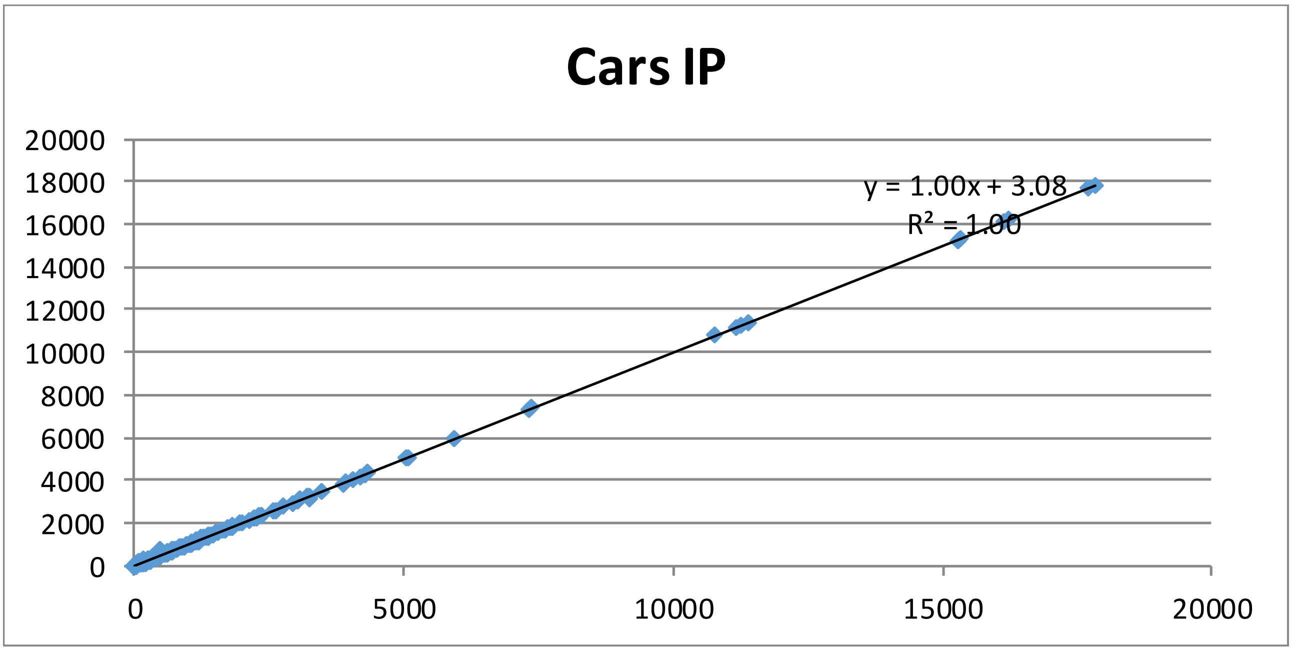


Figure 10-12: Matrix Trip End Changes, Car IP

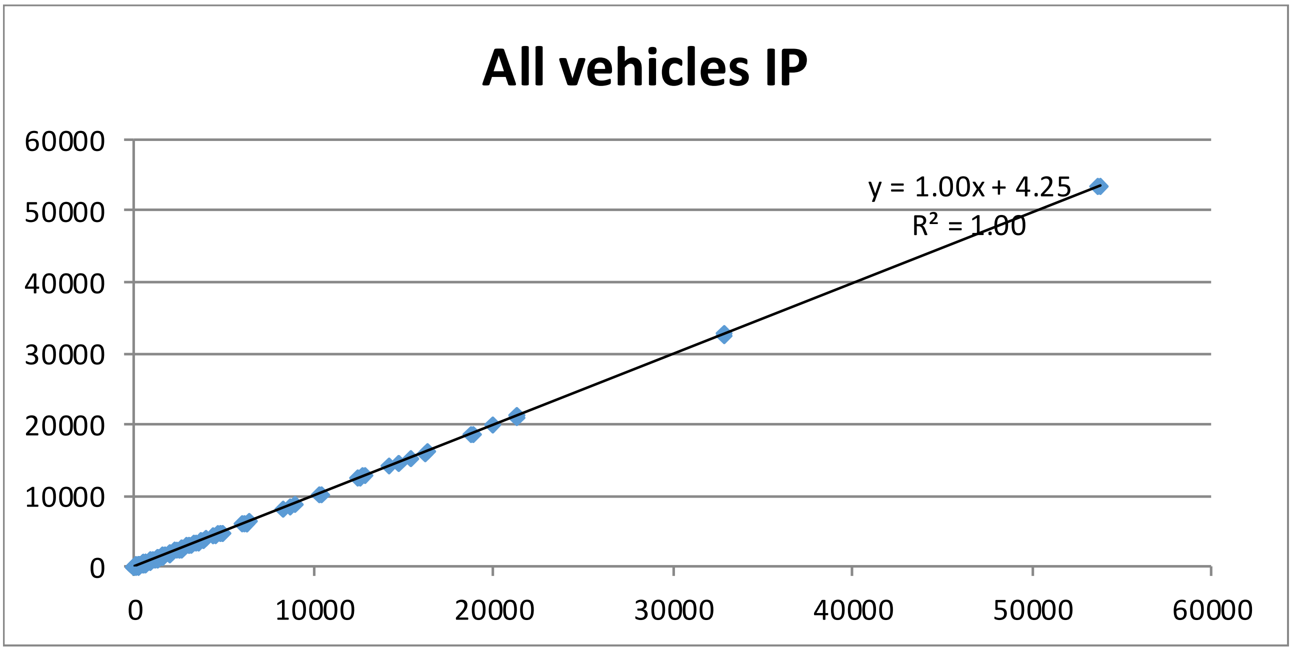


Figure 10-13: Matrix Trip End Changes, All Vehicles IP

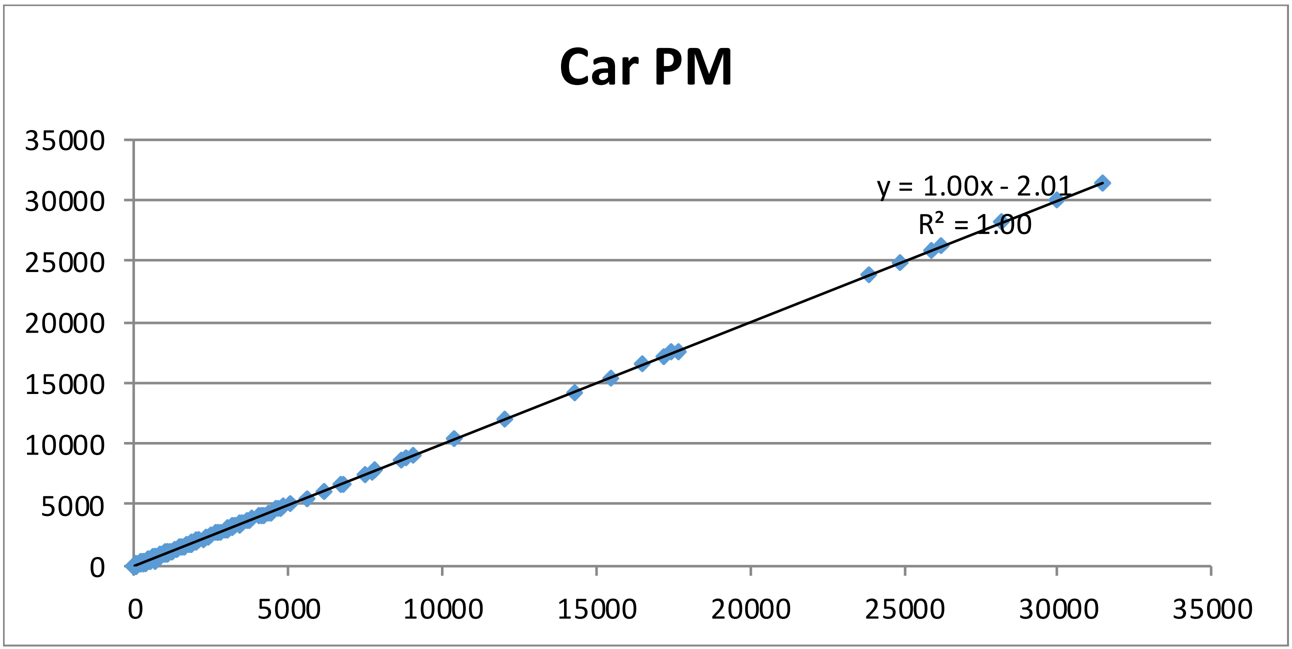


Figure 10-14: Matrix Trip End Changes, Car PM

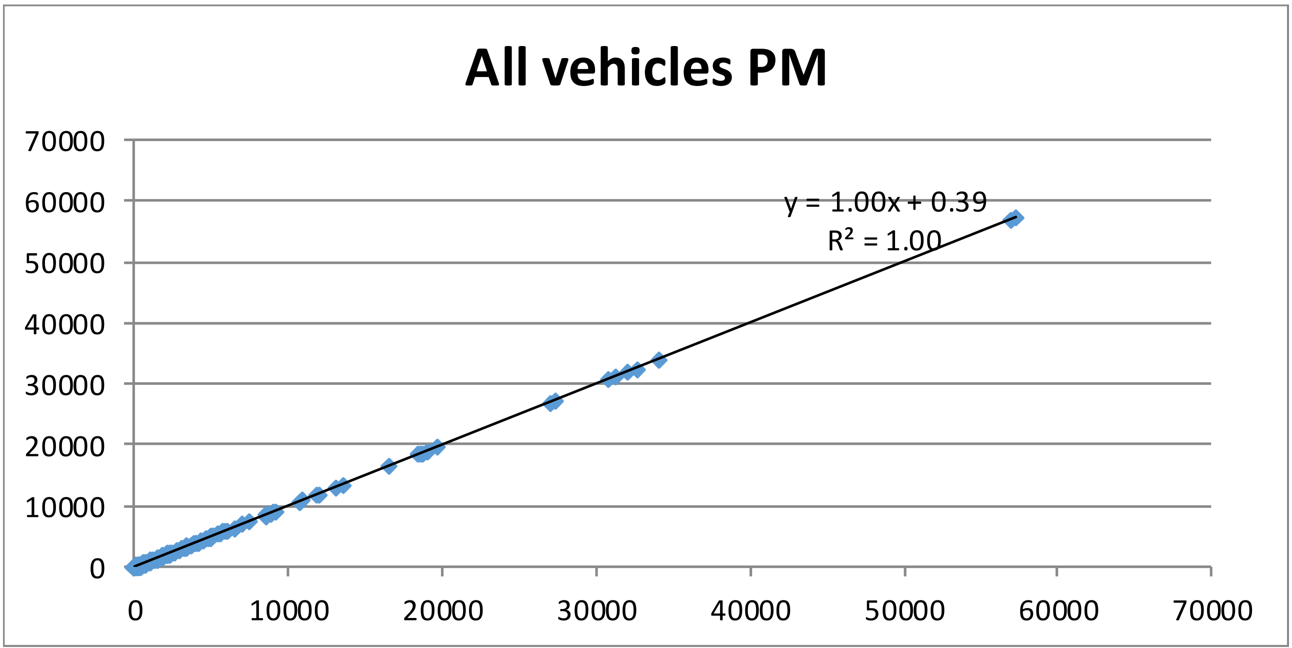


Figure 10-15: Matrix Trip End Changes, All Vehicles PM

The guidance on these trend lines is the following:

- Slope to be within 0.99 and 1.01;
- Intercept "near zero"; and
- R Squared in excess of 0.98.

As with the test on cell values, the R^2 and slope values for all highway user classes meet the TAG criteria stated above, which can be seen in Table 10-9 below. Although the intercept is further from the criteria than for matrix cell values, given the size of the trip end values in the regression graph, these intercepts are still relatively close to zero.

Trip End Summary	AM			IP			PM		
	R^2	Slope	Intercept	R^2	Slope	Intercept	R^2	Slope	Intercept
All Vehicles	1.00	1.00	7.65	1.00	1.00	4.25	1.00	1.00	0.39
Car	1.00	1.00	5.87	1.00	1.00	3.08	1.00	1.00	2.01
Car C	1.00	1.00	2.55	1.00	1.00	0.45	1.00	1.00	1.00
Car EB	1.00	1.00	0.87	1.00	1.00	0.11	1.00	1.00	0.40
Car O	1.00	1.00	2.49	1.00	1.00	2.51	1.00	1.00	0.61
LGV	1.00	1.00	0.69	1.00	1.00	-0.06	1.00	1.00	1.18
HGV	1.00	1.00	1.24	1.00	1.00	-1.11	1.00	1.00	0.20

Table 10-9: Trip End Summary

10.2.4 Trip Length Distributions

For trip length distributions, it is stipulated in TAG that both the mean and standard deviation of the post matrix trip lengths must not differ by more than 5% from those of the prior matrices. The mean and standard deviations for all the matrices (not including intrazonal trips) are summarised in Table 10-10 and Table 10-11 below.

Time and Trip Type	All Vehicles - Prior	All Vehicles - Post	% Change
AM Mean Trip Length	58.16	57.76	-0.68%
AM Standard Deviation	104.01	103.69	-0.30%
IP Mean Trip Length	65.55	64.96	-0.90%
IP Standard Deviation	116.49	116.20	-0.25%
PM Mean Trip Length	53.42	53.14	-0.52%
PM Standard Deviation	95.45	95.28	-0.18%

Table 10-10: Table of Mean Trip Lengths and Standard Deviation, All Vehicles

Time and Trip Type	Car - Prior	Car - Post	% Change
AM Mean Trip Length	40.20	40.12	-0.21%
AM Standard Deviation	66.82	66.75	-0.11%
IP Mean Trip Length	43.94	43.64	-0.67%
IP Standard Deviation	79.07	78.83	-0.30%
PM Mean Trip Length	41.76	41.65	-0.27%
PM Standard Deviation	71.11	71.02	-0.12%

Table 10-11: Table of Mean Trip Lengths and Standard Deviation, Car

The tables above show that the change in mean and standard deviation trip lengths is minimal and well within guidelines for cars and all vehicles across all time periods.

As a further test of the effect of matrix estimation on trip length distribution, a series of plots have been produced comparing trip length distribution for the pre and post estimated matrices, for all car user classes, HGVs and LGVs which are shown in Appendix Q. These plots illustrate that there is relatively little change in the trip length distribution and therefore that the effects of matrix estimation on trip patterns are minimal for cars, LGVs and HGVs. As an example, plots showing trip length distribution change for UC1 AM and UC3 PM are shown below:

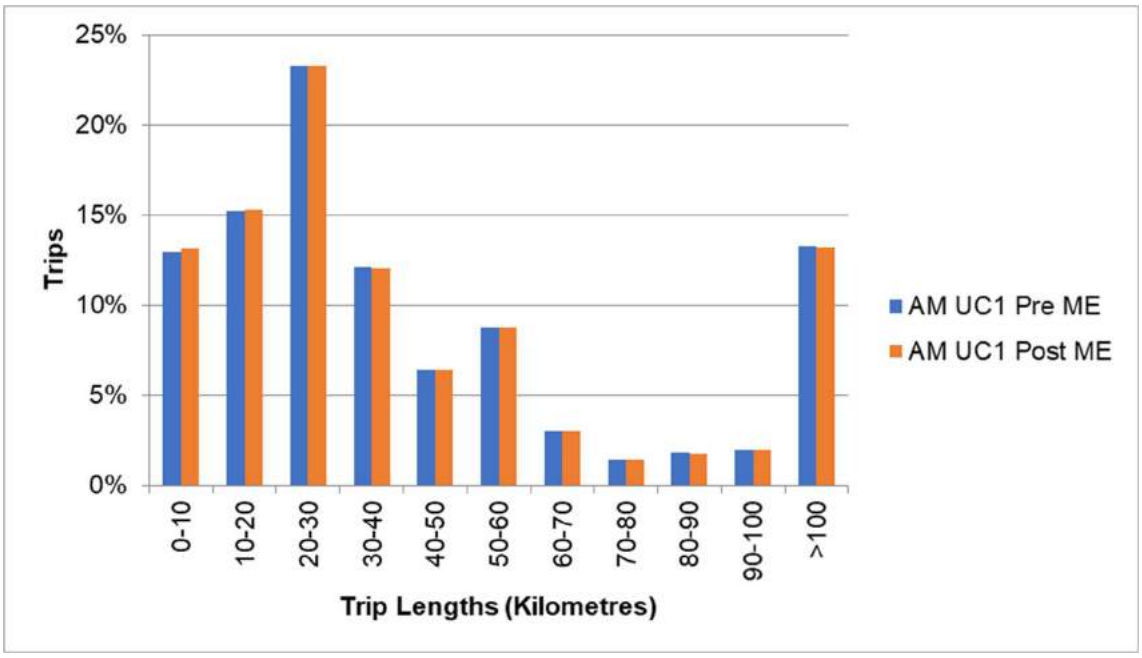


Figure 10-16: Matrix Trip Length Changes, UC1 AM

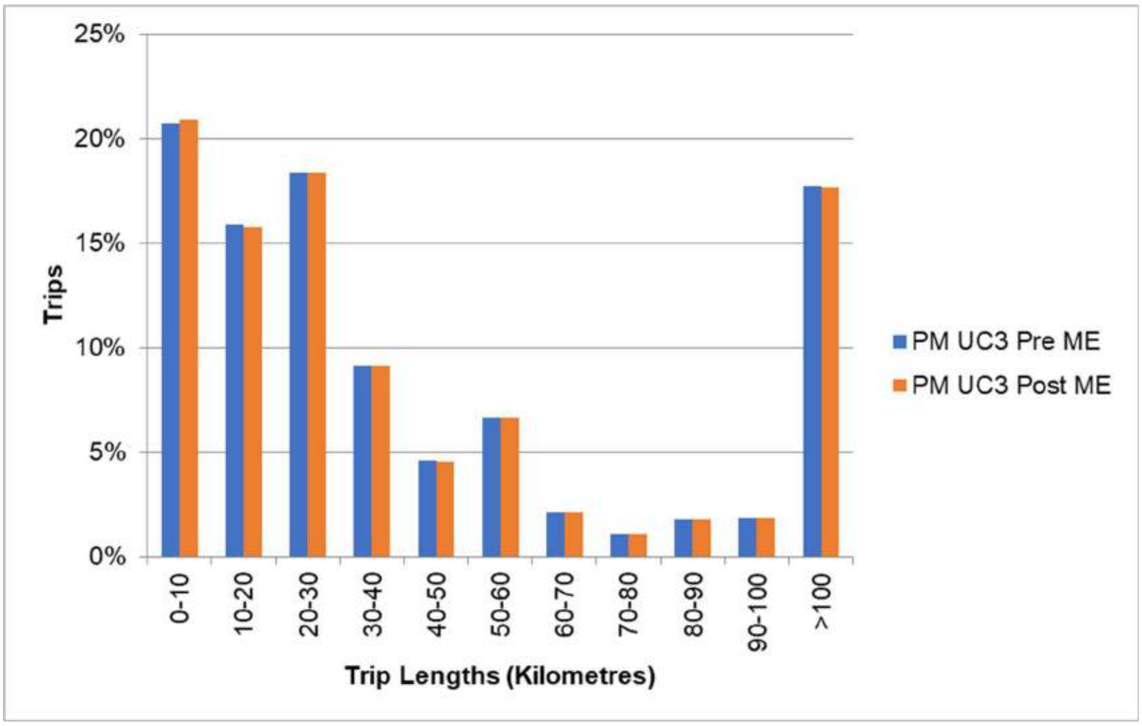


Figure 10-17: Matrix Trip Length Changes, UC3 PM

10.2.5 Sector to Sector Movements

Finally, TAG recommends a check on the matrix cells on a sector basis. The guidelines state that trips should not change by more than 5%. Using the sectors specified in Section 4.3.2 and in the figure below, the percentage and absolute change for each user class and each sector to sector movement as a result of matrix estimation are shown in Appendix J and K respectively. Tables showing the GEH for the change between Prior and Post ME matrices are also shown for all user classes in Appendix L. These provide a better way of scaling the change relative to absolute values.

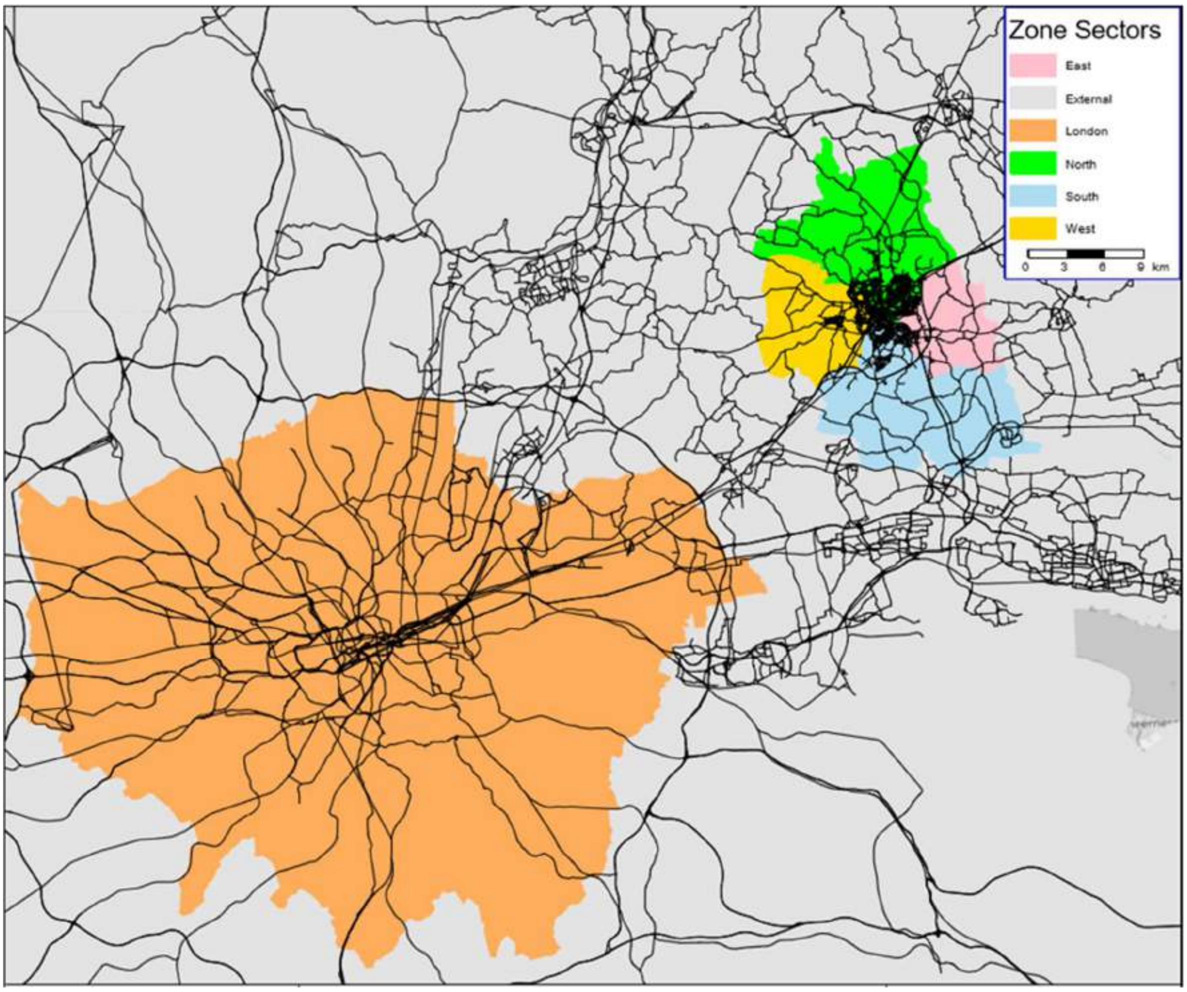


Figure 10-18: Chelmsford Zone Sectoring

The tables in Appendix J show that some of the percentage changes of the sector to sector movements for Cars and All Vehicles clearly exceed the 5% criteria. However, according to the guidelines, the criteria is to be applied regardless of the number of trips in the sector; for sector to sector movements with relatively few trips, it is more difficult to stay within the 5% criteria, although this could have been achieved if larger sectors were selected. Noting that in some cases there are relatively few trips, the tables of changes expressed as GEH values provide greater insight into the significance of some of these percentage changes. As can be seen from Tables in Appendix L, some sectors have changes in GEH values that are within 5 and some are more than 5, but changes overall provide assurance that matrix estimation is not significantly changing the underlying trip patterns.

11 Assignment, Calibration and Validation

11.1 Convergence

A summary of the assignment method used is given in Section 4.8. For ease of reference, the convergence criteria is repeated below in Table 11-1:

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%

Table 11-1: Assignment Convergence Criteria

Convergence statistics for the final base model are shown in Table 11-2 below:

Time Period	Iteration Loop		Proximity Indicator: Gap (%)	Percentage of Links with Flow Change < 1%	Percentage of Links with Cost Change < 1%
AM	Final - 3	14	0.00025	98.12%	99.20%
	Final - 2	15	0.00024	98.50%	99.37%
	Final - 1	16	0.00024	99.23%	99.56%
	Final	17	0.00023	99.40%	99.68%
IP	Final - 3	7	0.00003	99.38%	99.83%
	Final - 2	8	0.00003	99.78%	99.87%
	Final - 1	9	0.00002	99.84%	99.94%
	Final	10	0.00002	99.89%	99.94%
PM	Final - 3	13	0.00022	99.01%	99.55%
	Final - 2	14	0.00021	99.13%	99.64%
	Final - 1	15	0.00021	99.28%	99.60%
	Final	16	0.00020	99.37%	99.65%

Table 11-2: Details of ICA Assignment

The results show that the model has a level of convergence in line with guidance from TAG.

11.2 Screenline Locations

All the counts (calibration and validation) are arranged along screenlines. TAG has a separate criterion for total screenline flows, which is that total modelled flows on all links crossing a screenline must be within 5% of the observed totals.

The calibration and validation screenlines used and the location of the counts used for these screenlines are illustrated in Figure 11-1:

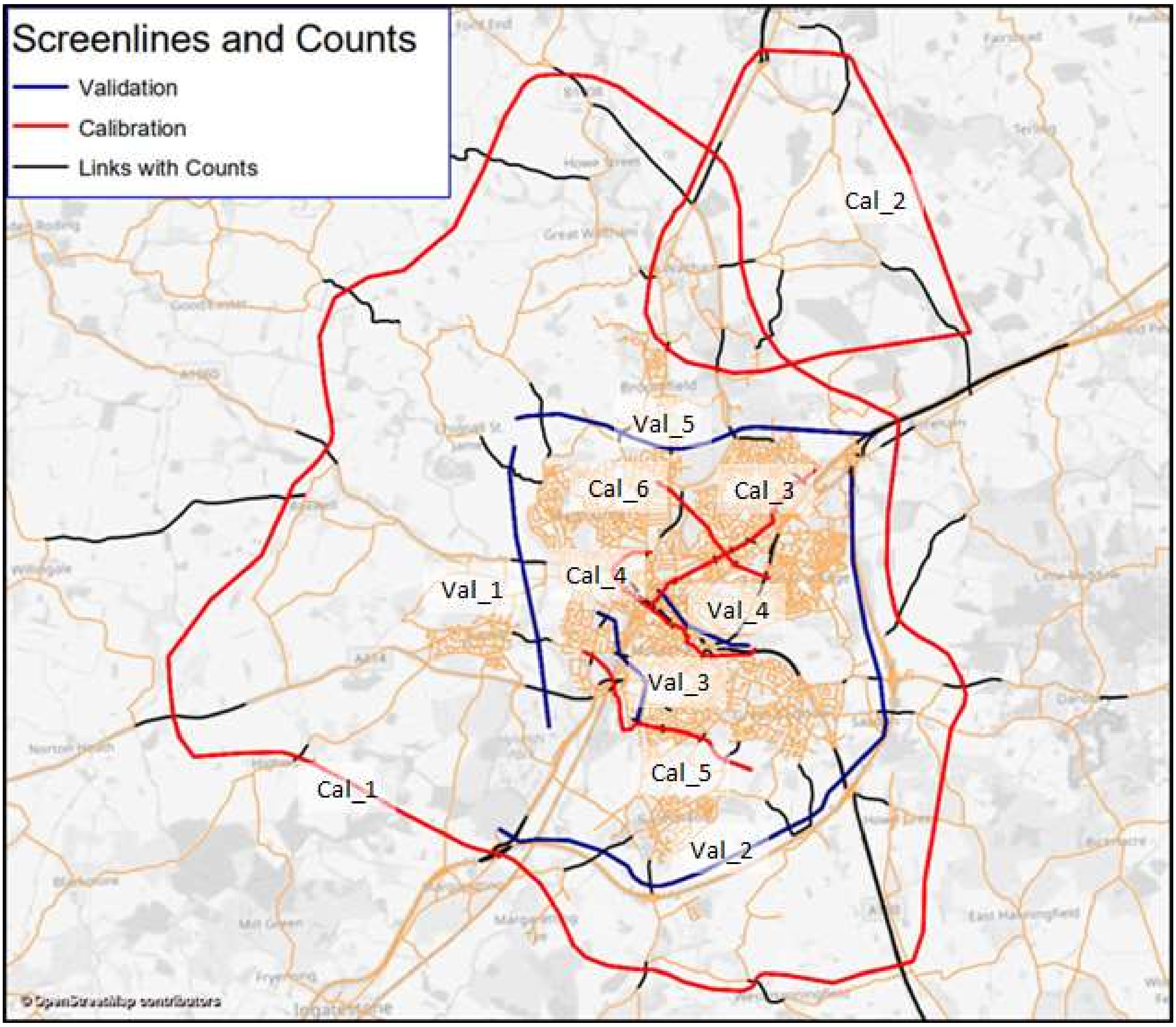


Figure 11-1: Location of Validation and Calibration Screenlines

The following sections now summarise the calibration and validation of the model.

11.3 Count Calibration

The counts used for calibration are those on the calibration screenlines in Figure 11-1. The performance of the model in terms of comparisons with count data are measured in two ways: the first is GEH statistic and the second is made by reference to in Table 3-2 in Chapter 3.

TAG advises that, in ordinary circumstances, the practitioner should aim to reach a state where at least 85% of modelled links have a GEH of less than 5 or satisfy the criterion in Table 3-2. There were 124 calibration counts used in the base year model. The comparison of modelled flows against these calibration counts are summarised below in Table 11-3:

Measure	AM Peak			
	Cars	LGV	HGV	Total Vehicles
No. links with modelled flows meeting criteria	113/124	124/124	124/124	111/124
% links with modelled flows meeting criteria	91%	100%	100%	90%
Measure	**Interpeak**			
	Cars	**LGV**	**HGV**	**Total Vehicles**
No. links with modelled flows meeting criteria	123/124	124/124	124/124	123/124
% links with modelled flows meeting criteria	99%	100%	100%	99%
Measure	**PM Peak**			
	Cars	**LGV**	**HGV**	**Total Vehicles**
No. links with modelled flows meeting criteria	123/124	124/124	124/124	123/124
% links with modelled flows meeting criteria	99%	100%	100%	99%

Table 11-3: Calibration Link Flow Comparison with Observed Flows (Cars, LGV, HGV and Total Vehicles)

The table above shows that the 85% criterion for calibration counts is exceeded for all vehicle classes across all time periods. This is encouraging as it gives confidence that modelled flows are representative of real-life traffic flows. Calibration across all the time periods is fairly consistent, with the inter-peak outperforming the AM and PM peak, which is reflective of the lower levels of congestion in that time period.

A full breakdown of the comparison at the individual count level is included in Appendix M. More detailed information for modelled and observed flow and the GEH statistic by count location is illustrated in Section 11.7, including the areas of the model subject to appraisal around the Army & Navy junction, the city centre, and the area to the north of Chelmsford where the CNEB project is located.

11.4 Screenline Calibration

The performance of the model along the calibration screenlines is summarised Table 11-4 on the next page.

Screenline ID	No. Sites	AM				IP				PM			
		Obs.	Mod.	% Diff.	GEH	Obs.	Mod.	% Diff.	GEH	Obs.	Mod.	% Diff.	GEH
Cal 1 – Inbound	19	16,576	16,498	-0.5%	0.6	9,938	10,441	5.1%	5.0	13,154	13,586	3.3%	3.7
Cal 1 – Outbound	19	13,680	13,700	0.1%	0.2	10,069	10,506	4.3%	4.3	14,802	14,738	-0.4%	0.5
Cal 2 – Inbound	8	4,208	4,295	2.1%	1.3	2,887	2,855	-1.1%	0.6	4,208	4,047	-3.8%	2.5
Cal 2 – Outbound	8	4,386	4,171	-4.9%	3.3	2,962	2,903	-2.0%	1.1	4,371	4,145	-5.2%	3.5
Cal 3 – Inbound	7	4,133	4,087	-1.1%	0.7	3,242	3,189	-1.6%	0.9	4,033	4,038	0.1%	0.1
Cal 3 – Outbound	7	3,842	3,471	-9.7%	6.1	3,077	3,064	-0.4%	0.2	4,044	3,859	-4.6%	2.9
Cal 4 – Inbound	8	6,087	5,862	-3.7%	2.9	4,717	4,740	0.5%	0.3	5,005	5,083	1.6%	1.1
Cal 4 – Outbound	9	5,181	5,131	-1.0%	0.7	4,718	4,806	1.9%	1.3	5,942	5,960	0.3%	0.2
Cal 5 – Inbound	7	2,827	2,958	4.6%	2.4	2,599	2,555	-1.7%	0.9	3,370	3,303	-2.0%	1.2
Cal 5 – Outbound	7	3,128	3,052	-2.4%	1.4	2,592	2,613	0.8%	0.4	2,949	2,841	-3.7%	2.0
Cal 6 – Inbound	4	3,975	3,701	-6.9%	4.4	2,500	2,485	-0.6%	0.3	2,908	2,853	-1.9%	1.0
Cal 6 – Outbound	4	2,671	2,480	-7.2%	3.8	2,435	2,376	-2.4%	1.2	3,471	3,213	-7.4%	4.5
Total – Inbound	**53**	**37,806**	**37,401**	**-1.1%**	**2.1**	**25,883**	**26,265**	**1.5%**	**2.4**	**32,678**	**32,910**	**0.7%**	**1.3**
Total - Outbound	**54**	**32,888**	**32,005**	**-2.7%**	**4.9**	**25,853**	**26,268**	**1.6%**	**2.6**	**35,579**	**34,756**	**-2.3%**	**4.4**
Total	**107**	**70,694**	**69,406**	**-1.8%**	**4.9**	**51,736**	**52,533**	**1.5%**	**3.5**	**68,257**	**67,666**	**-0.9%**	**2.3**

Table 11-4: Calibration Screenline Comparison

The modelled and observed flow differences are met for nearly all screenlines. This gives confidence that the base year model trip matrices provide a robust basis for model assignment and forecasting. Further detail on the screenline calibration is given in Appendix O including a breakdown into individual vehicle classes. In addition, a series of figures is contained in Section 11.7 These present the calibration of the count sites within their respective screenlines for each peak period for total vehicles for the centre of Chelmsford city and for the wider study area. The same figures are also produced by vehicle type (car, LGV and HGV) and can be found in Appendix T.

11.5 Count Validation

Count validation relies on making similar comparisons to the ones made for the count calibration, but against independent counts, i.e. those not used in the model building process up to this point in either the matrix building or the matrix estimation process.

There are 50 counts used in validation, and the model's performance against these counts is summarised in Table 11-5:

Measure	AM Peak			
	Cars	LGV	HGV	Total Vehicles
No. links with modelled flows meeting criteria	43/50	50/50	50/50	43/50
% links with modelled flows meeting criteria	86%	100%	100%	86%
Measure	Interpeak			
	Cars	LGV	HGV	Total Vehicles
No. links with modelled flows meeting criteria	45/50	50/50	50/50	45/50
% links with modelled flows meeting criteria	90%	100%	100%	90%
Measure	PM Peak			
	Cars	LGV	HGV	Total Vehicles
No. links with modelled flows meeting criteria	43/50	50/50	50/50	43/50
% links with modelled flows meeting criteria	86%	100%	100%	86%

Table 11-5: Validation Link Flow Comparison with Observed Flows (Cars, LGV, HGV and Total Vehicles)

The table above shows that the 85% criterion for validation counts is exceed in all time periods and across all vehicle classes, including total vehicles. This gives more confidence that the model is representing base year traffic flows realistically. A full breakdown of the comparison at the individual count level is included in Appendix N. Detailed information for modelled and observed flow and the GEH statistic by count location is illustrated in Section 11.7 for areas of the model subject to appraisal (that is, around the Army & Navy junction, the city centre and the area to the north of Chelmsford where the CNEB project is located). In addition, validation of the turning movements at the Army & Navy junction are presented in the same section.

11.6 Screenline Validation

All the validation counts are arranged across screenlines, as illustrated in Figure 11-1 above. Table 11-6 on the next page shows the performance of validation counts across screenlines.

Screenline ID	No. Sites	AM				IP				PM			
		Obs.	Mod.	% Diff.	GEH	Obs.	Mod.	% Diff.	GEH	Obs.	Mod.	% Diff.	GEH
Val 1 - Inbound	4	1,866	1,762	-5.6%	2.4	1,278	1,229	-3.8%	1.4	1,941	1,812	-6.6%	3.0
Val 1 - Outbound	4	1,865	1,915	2.7%	1.2	1,240	1,222	-1.5%	0.5	1,625	1,602	-1.4%	0.6
Val 2 - Inbound	9	5,770	5,696	-1.3%	1.0	3,381	3,383	0.1%	0.0	4,839	4,391	-9.3%	6.6
Val 2 - Outbound	8	3,678	3,882	5.5%	3.3	2,453	2,864	16.8%	8.0	3,841	4,089	6.5%	3.9
Val 3 – Inbound	4	2,260	2,179	-3.6%	1.7	2,256	2,048	-9.2%	4.5	2,628	2,452	-6.7%	3.5
Val 3 - Outbound	4	2,805	2,598	-7.4%	4.0	2,272	2,112	-7.0%	3.4	2,407	2,246	-6.7%	3.3
Val 4 - Inbound	3	2,205	2,207	0.1%	0.0	2,062	1,931	-6.4%	2.9	2,334	2,343	0.4%	0.2
Val 4 - Outbound	3	2,061	2,080	0.9%	0.4	2,177	2,116	-2.8%	1.3	2,429	2,307	-5.0%	2.5
Val 5 - Inbound	4	2,609	2,491	-4.5%	2.3	1,777	1,808	1.7%	0.7	2,201	2,267	3.0%	1.4
Val 5 - Outbound	5	3,182	3,251	2.2%	1.2	2,639	2,693	2.0%	1.0	3,819	3,712	-2.8%	1.7
Total – Inbound	**24**	**14,710**	**14,335**	**-2.5%**	**3.1**	**10,754**	**10,399**	**-3.3%**	**3.5**	**13,943**	**13,265**	**-4.9%**	**5.8**
Total - Outbound	**24**	**13,591**	**13,726**	**1.0%**	**1.2**	**10,781**	**11,007**	**2.1%**	**2.2**	**14,121**	**13,956**	**-1.2%**	**1.4**
Total	**48**	**28,301**	**28,061**	**-0.8%**	**1.4**	**21,535**	**21,406**	**-0.6%**	**0.9**	**28,064**	**27,221**	**-3.0%**	**5.1**

Table 11-6: Validation Screenline Comparison

Table 11-6 above presents the performance of the Model with respect to the validation counts across screenlines and indicates the following key points:

- In the majority of cases the differences between observed and modelled counts are either below 5% or just above the 5% threshold;
- All screenlines across all time periods have a GEH value less than 4 except for two in the IP and one in the PM peak; and
- In general, as per the prior matrices, the total flows across screenlines are lower than observed, albeit closer to observed than the prior matrices.

A series of figures is contained in Section 11.7 illustrating the validation of the count sites within their respective screenlines for each peak period for total vehicles for the centre of Chelmsford city and for a wider study area as well as the comparison of flow and GEH values by site. This includes a commentary of the screenlines that do not meet the criteria. The same figures are also produced by vehicle type (Car, LGV and HGV) and can be found in Appendix T. Further detail on the screenline validation is given in Appendix O including a breakdown into individual vehicle classes.

11.7 Additional Model Validation and Calibration Data

This section contains figures that illustrate the calibration and validation in a more spatial sense, particularly with reference to the schemes currently envisaged to be appraised using this base year model. This includes the following information:

- Screenline calibration and validation: figures illustrating the location and performance of individual count sites within their respective screenlines in terms of pass or fail, both for the city centre and the wider study area;
- Detailed flow calibration and validation: figures illustrating the modelled flows, observed flows and GEH statistics for individual count sites, in particular for the city centre, area around the Army & Navy junction and the area around the proposed CNEB scheme; and
- Army & Navy turning movement validation.

The figures outlined in the following sections are for total vehicles, i.e., the sum of Car, LGVs and HGVs. The same figures by vehicle type are outlined in Appendix T and Appendix U.

11.7.1 Screenline Calibration and Validation Figures

The figures on the following pages illustrate the location of each individual count site within the screenline and whether it passes or fails the criteria for total vehicle flows. The same figures by vehicle type are outlined in Appendix T.

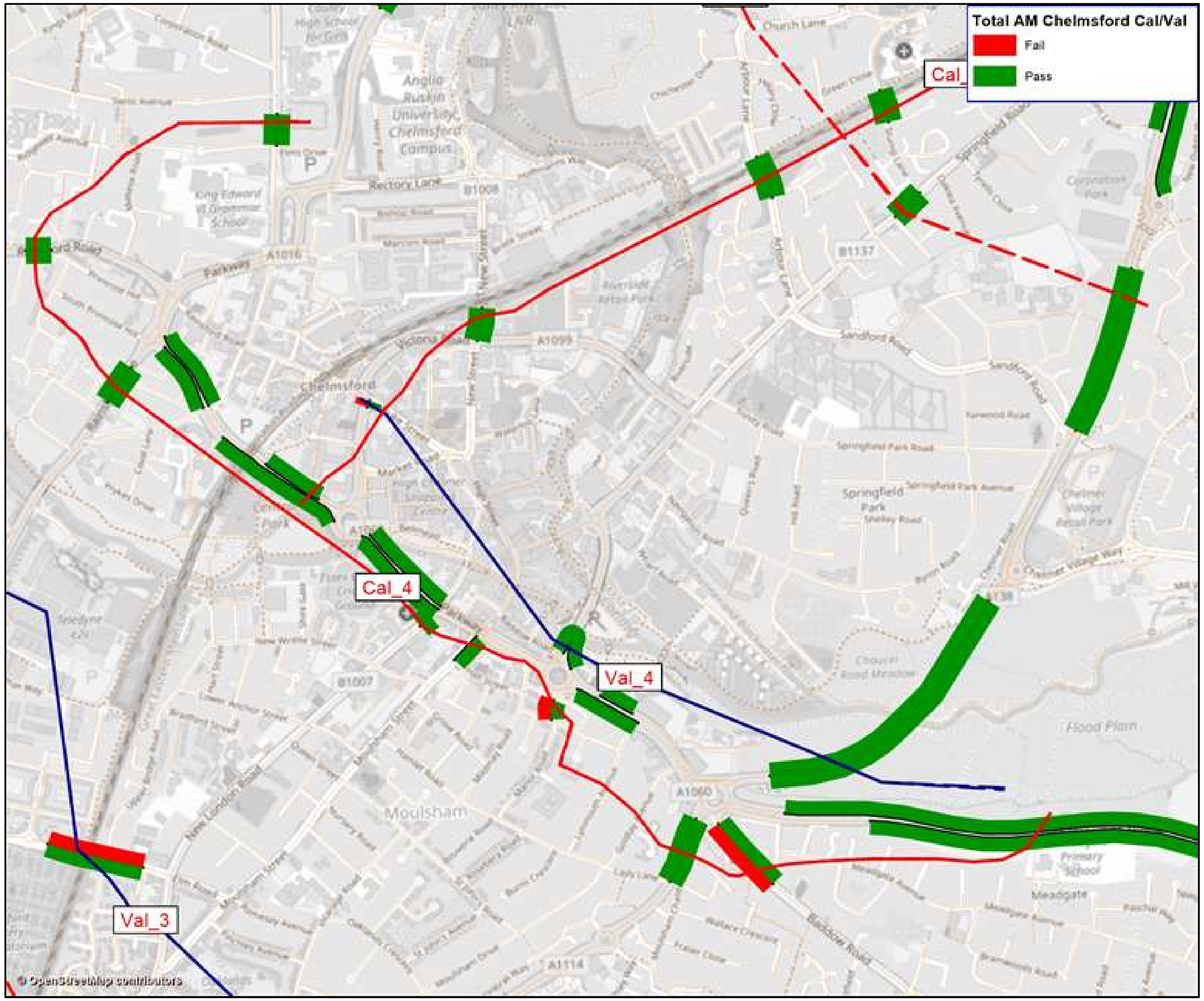


Figure 11-2: Count and Screenline Calibration-Validation - All Vehicles, AM Peak, City Centre

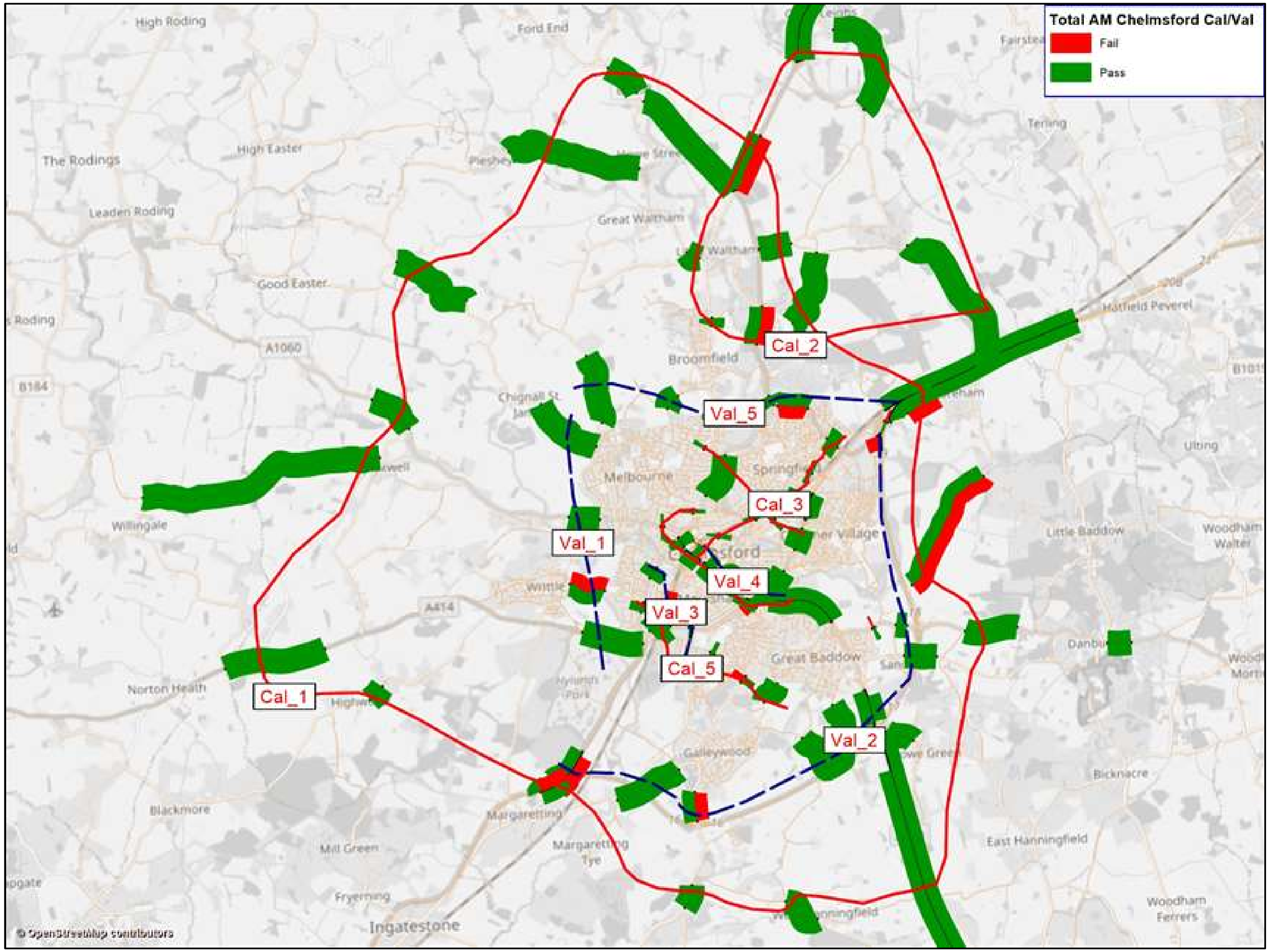


Figure 11-3: Count and Screenline Calibration-Validation - All Vehicles, AM Peak, Wider Chelmsford Area

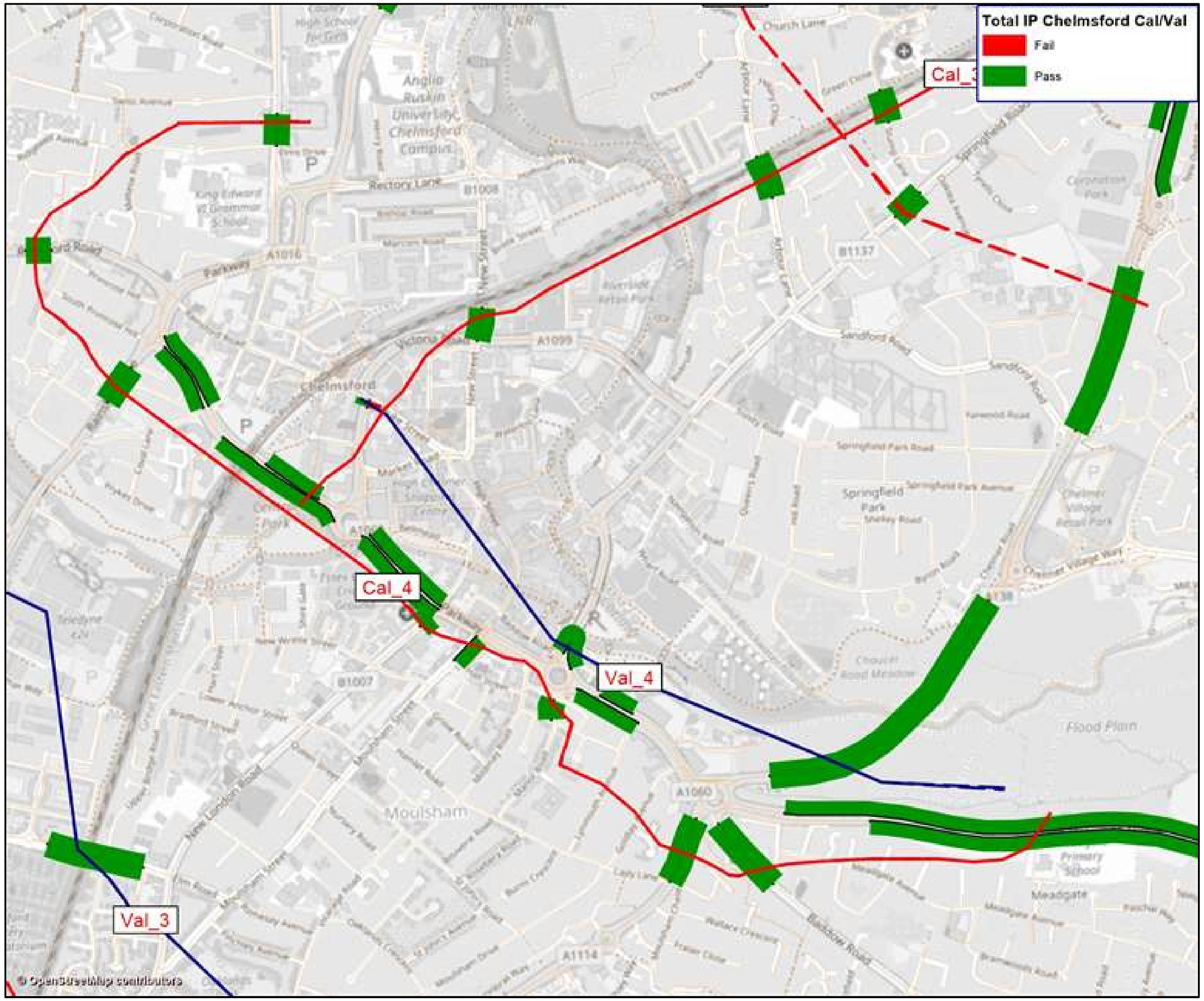


Figure 11-4: Count and Screenline Calibration-Validation - All Vehicles, Inter-Peak, City Centre

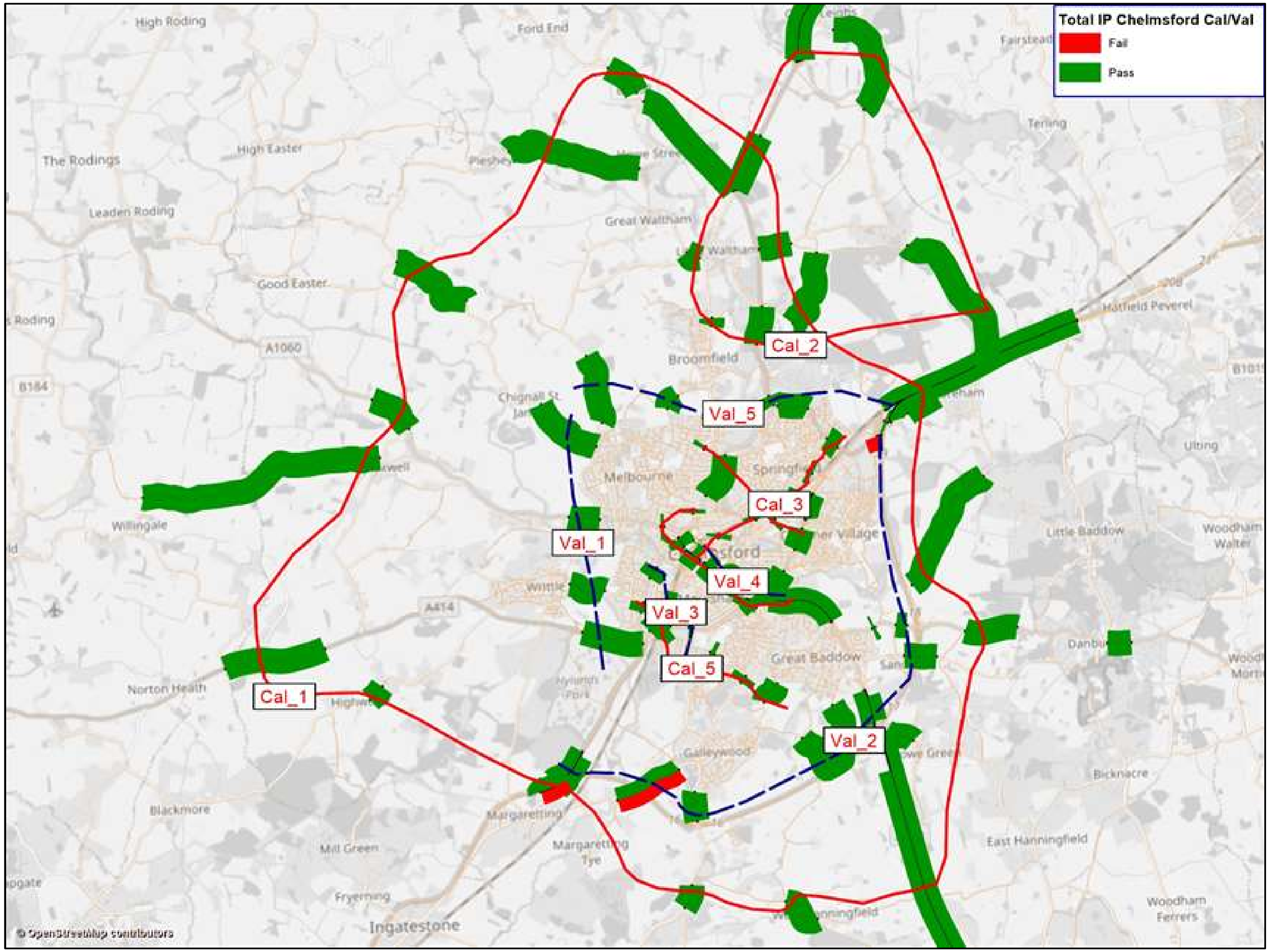


Figure 11-5: Count and Screenline Calibration-Validation - All Vehicles, Inter-Peak, Wider Chelmsford Area

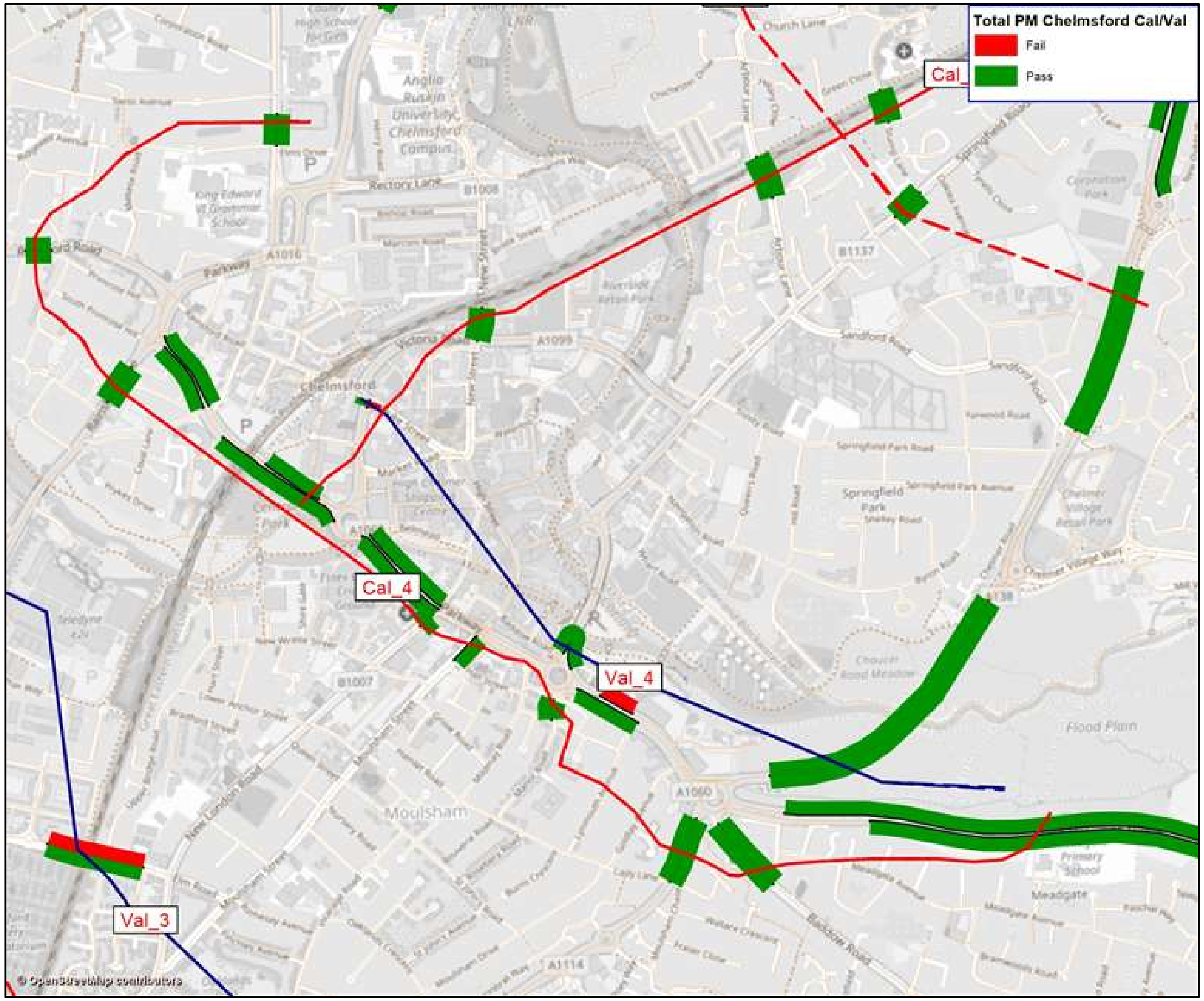


Figure 11-6: Count and Screenline Calibration-Validation - All Vehicles, PM Peak, City Centre

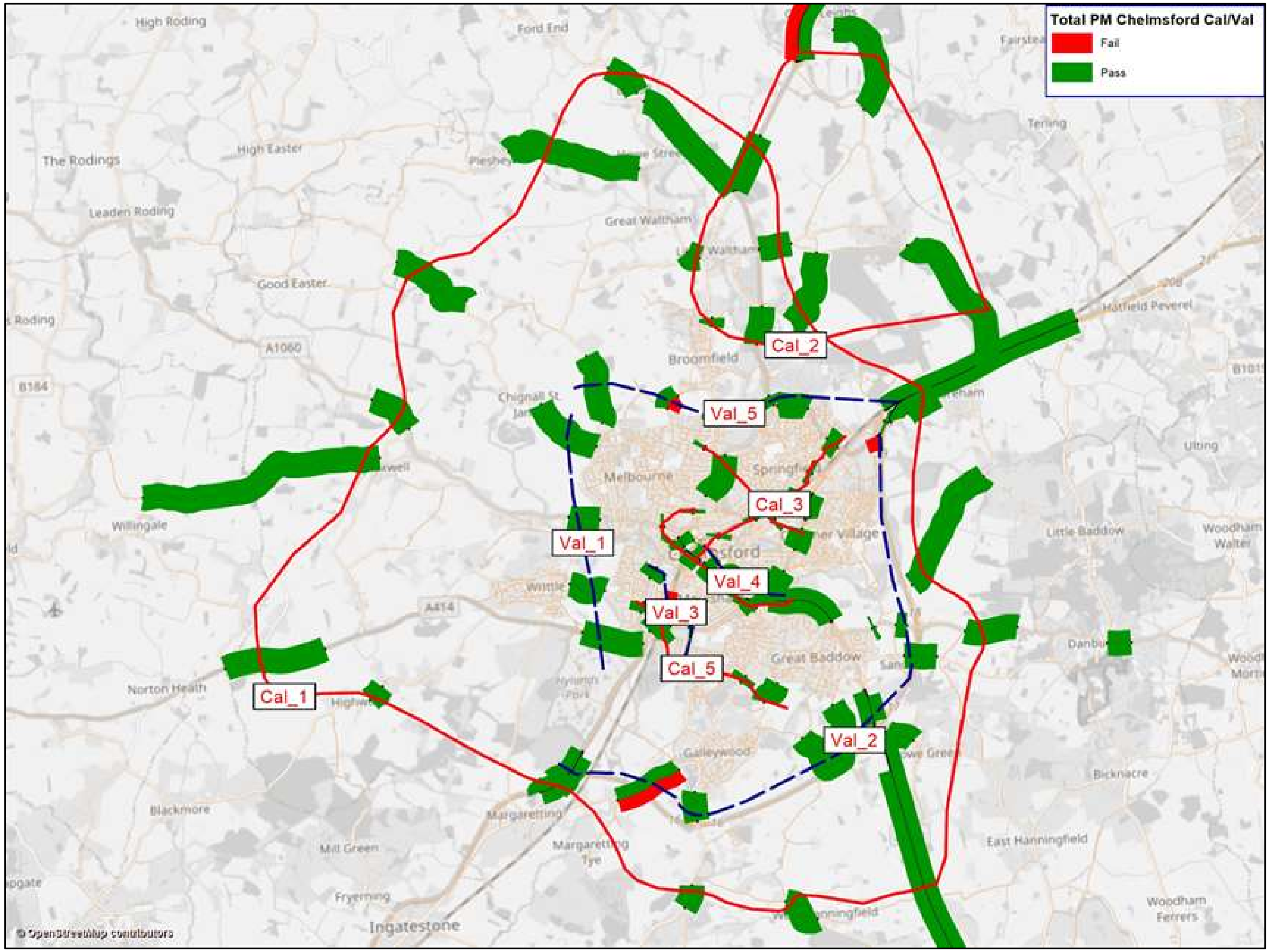


Figure 11-7: Count and Screenline Calibration-Validation - All Vehicles, PM Peak, Wider Chelmsford Area

The information presented in the figures above highlights that the majority of count sites within each screenline pass the criteria for observed versus modelled traffic flows, indicating that the screenline does not just meet the criteria due to very high modelled flows balancing out very low modelled flows. With respect to the three screenlines with a GEH greater than 4 identified in Table 11-6, the above figures highlight the following:

- Validation Screenline 2 inbound PM peak: the main location causing the screenline to not meet the criteria is the off-ramp from the A12 at Boreham interchange (site ID S2.3). Given that the surrounding count sites all meet the criteria it is considered that this is likely to be a local issue related to trips to the large adjacent industrial area and as such, not likely to impact on the schemes currently being assessed by the model.

- Validation Screenline 2 outbound inter-peak: the modelled flow is a little high across most count locations, although all individual sites except one meet the criteria. The exception is a minor road rat-run (Margaretting Road – site ID S2.10) with a difference of 140 vehicles, which is not considered to be a significant problem with respect to the schemes currently being assessed by the model with relatively low inter-peak benefits expected for all schemes.

- Validation Screenline 3 inbound inter-peak: The total screenline modelled flow is low by 160 vehicles with one individual count site, located on B1007 Wood Street (site ID 75487549), not meeting the validation criteria with the flow low by 124 vehicles and a GEH of 5.01. This section of road is very difficult to accurately model in a strategic model, with challenges in meeting both flow and journey criteria, due to the number of local buses that stop regularly along this relatively narrow stretch of road and the disruption this causes to journey times. However, given the location of the site and its purpose serving local trips, it is not considered that this will impact in any significant way on the schemes currently envisaged for appraisal.

11.7.2 Individual Count Site Flow Calibration and Validation Figures

This section presents figures describing the performance of the model against observed data at individual count sites, in particular the areas directly affecting the Army and Navy junction and the future CNEB scheme.

The figures (Figure 11-8 to Figure 11-10) over the following pages show the modelled flows for totals vehicles (sum of Car, LGV and HGV) alongside observed flows and the value of the GEH statistic for the links around the Army and Navy junction. Below these, Figure 11-11 to Figure 11-13 present the area around the CNEB scheme. These same figures are produced by vehicle type and are contained in Appendix U.

Figure 11-8: Modelled Performance for Area Around Army and Navy Junction, AM Peak Hour, Total Vehicles

Figure 11-9: Modelled Performance for Area around Army and Navy Junction, Inter-peak Hour, Total Vehicles

Figure 11-10: Modelled Performance for Area Around Army and Navy Junction, PM Peak Hour, Total Vehicles

The results provide confidence that the Model performs very well with respect to observed traffic flows around the Army & Navy junction and in the city centre in general, in spite of the highly congested nature of the road network. Only two links in the vicinity of the junction have a GEH over 5 as follows:

- Baddow Road approach to the Army & Navy in the AM peak hour: This approach to the Army & Navy junction, with a GEH of 6.9 and modelled flows 142 vehicles less than observed, was extremely difficult to model. It is a local road that runs parallel to Essex Yeomanry Way and is highly congested with queues in excess of 700 metres in the morning peak period. Attempting to balance replicating observed journey times with observed flows was difficult as accurately modelling the observed delay resulted in less than observed traffic flows due to the availability of alternate routes in the modelled network. Anecdotal evidence indicates that driver behaviour in this area largely ignores alternate routes and modes, with drivers simply happy to sit in the queue. In this case, the observed journey times were matched rather than the observed traffic flows.

- Parkway approach to the Army & Navy in the PM peak hour: It is considered that at least part of the source of this error could be due to the opening of a new Aldi supermarket less than 200 metres further along Parkway from the count site in the middle of the survey period. However, this cannot currently be verified due to changed traffic conditions related to COVID. It is noted that trip end totals in the Aldi zone are based on a TA rather than observed values and so although this location does appear to be higher than observed, it is perhaps not as high as indicated due to the opening of the Aldi.

It is to be noted that the modelled flow on Essex Yeomanry Way in the AM peak was based on the flow passing the count site, which is located about 40% of the way along a long (905m) link subject to queueing, rather than the flow exiting on the modelled link.

A review of modelled flows was also undertaken in the area affecting the future CNEB scheme. Figure 11-11 to Figure 11-13 over the following pages show the modelled flows alongside observed flows and the value of the GEH statistic for that link around the proposed CNEB area.

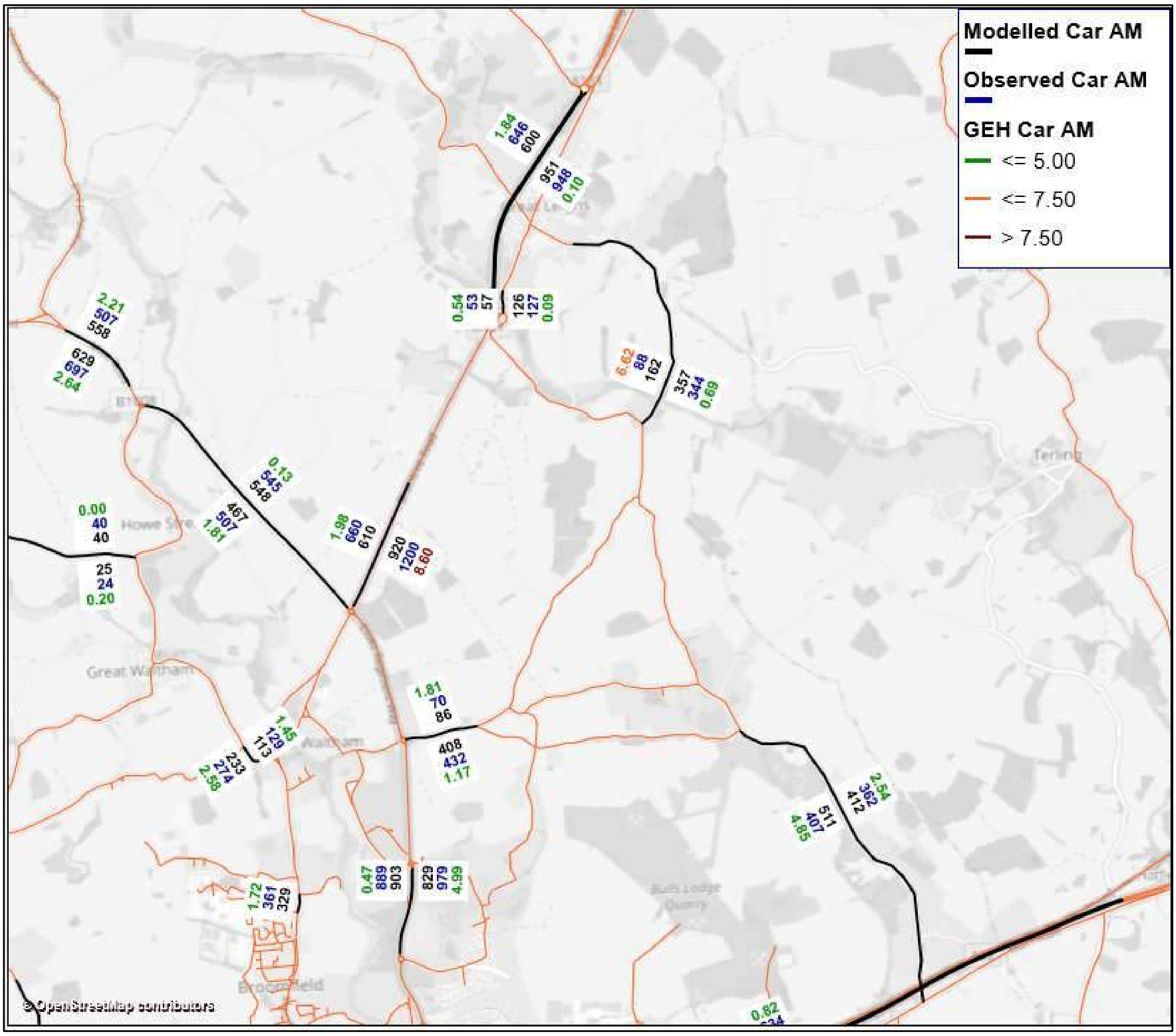


Figure 11-11: Modelled Flows Directly Affecting CNEB, AM

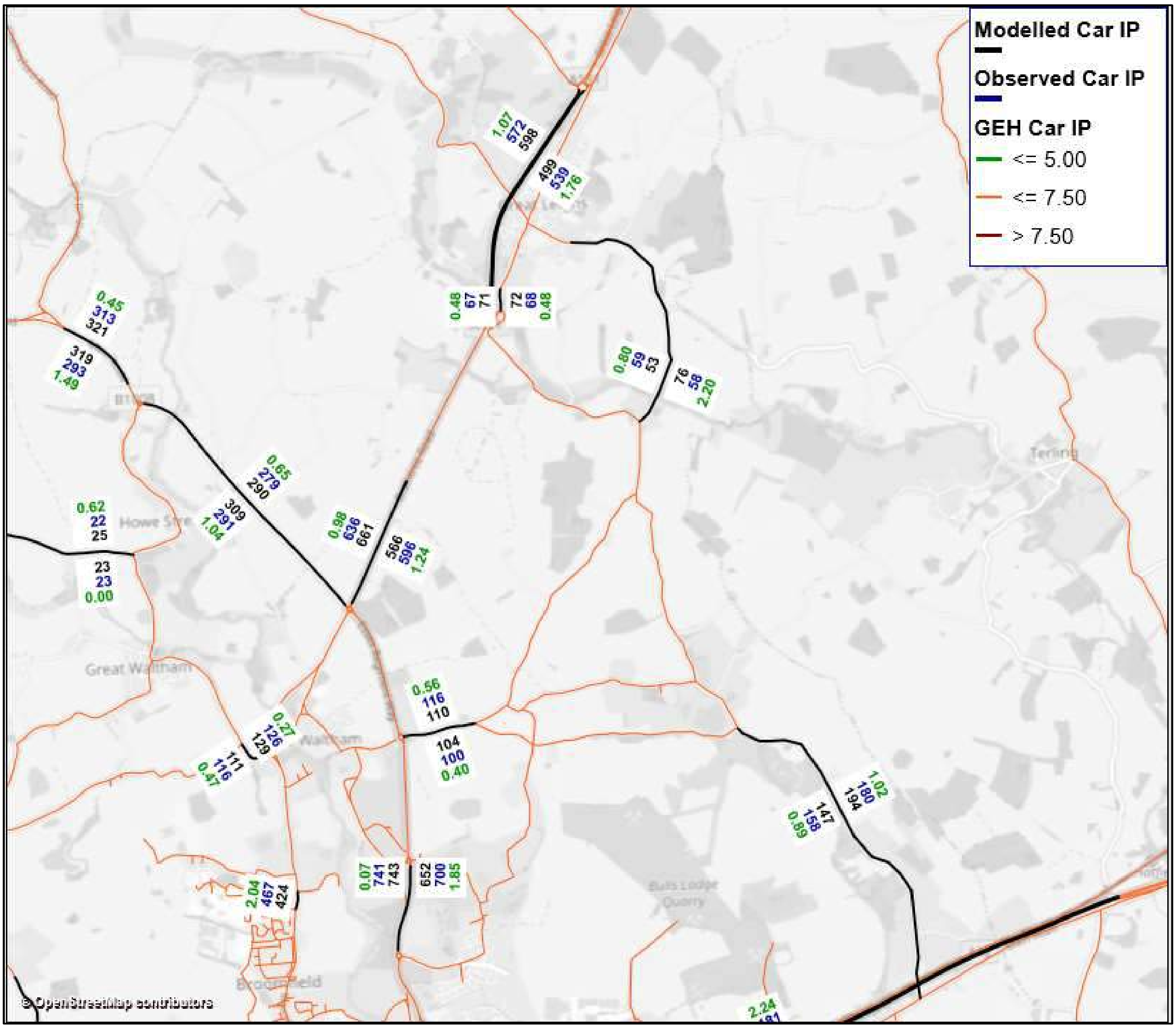


Figure 11-12: Modelled Flows Directly Affecting CNEB, IP

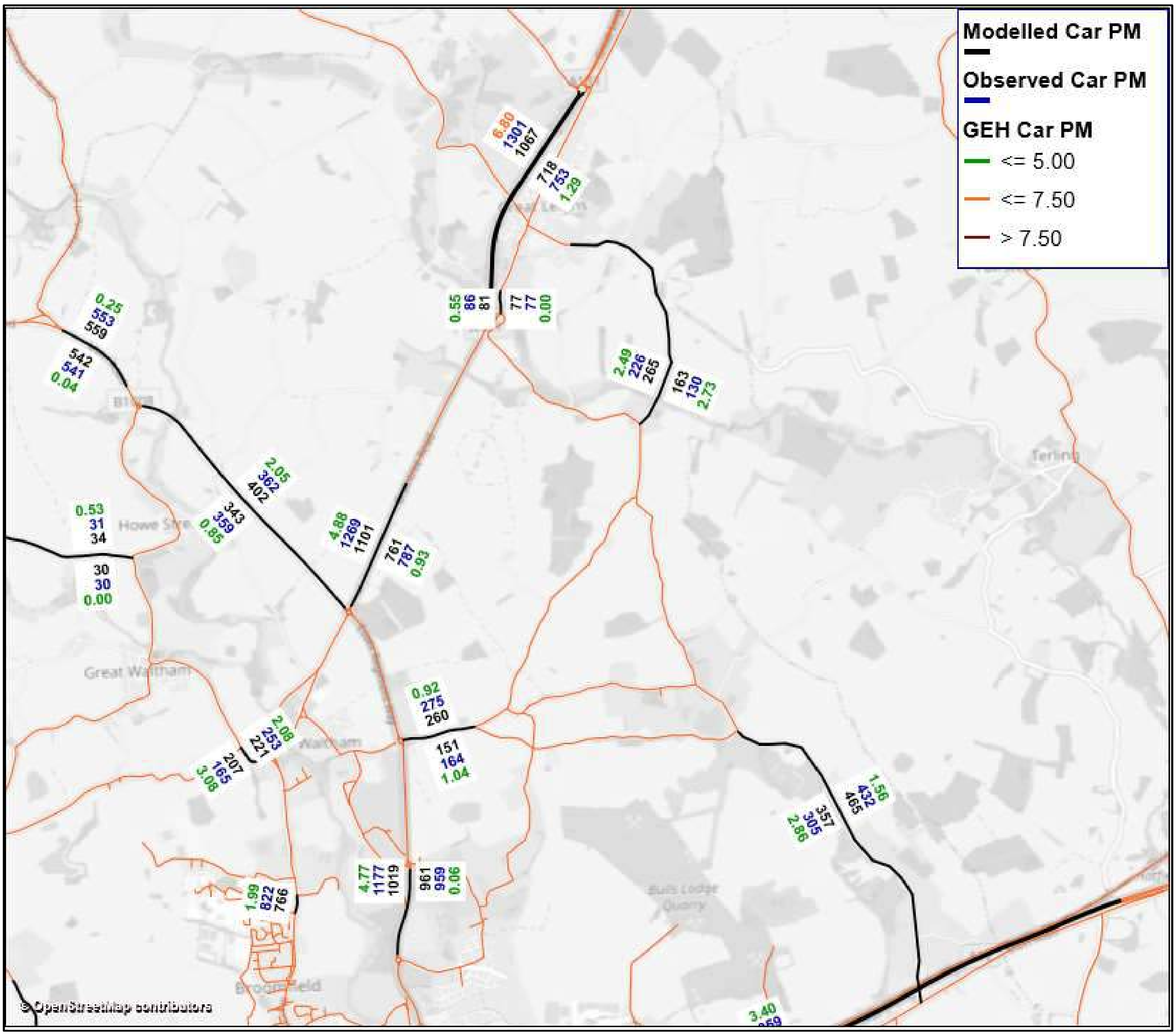


Figure 11-13: Modelled Flows Directly Affecting CNEB, PM

In the vicinity of CNEB too, the results are encouraging, as they give confidence that modelled flows, as a whole, are representative of observed flows. It is to be noted that the GEH on the WB A131 section in the AM peak (Figure 11-11) is above 5. This section of the network was undergoing construction during the data collection period, due to which historic data was used. However, the journey time data covered the construction period and captured delays due to ongoing roadworks. To reflect these, the Model was calibrated to reflect high delays by reducing the turn capacity at the roundabout. As a result of which, there were heavy queued flows which were unable to clear the junction. However, during construction, the observed car count in the morning peak on the link was 903 which is very close to the modelled flow. The network coding, reflecting these roadworks will be removed for the purposes of model forecasting.

11.7.3 Turning Movement Validation at Army & Navy Junction

Table 11-7 on the next page presents the turning movement validation at the Army & Navy junction in terms of difference in flow and GEH values. Turning movements with a GEH greater than 5.0 are highlighted in light red.

Origin / Destination	Difference – Modelled minus Observed (vehicles)						GEH					
	Parkway	Chelmer	EYW	Baddow	Van Diemans	Total	Parkway	Chelmer	EYW	Baddow	Van Diemans	Total
AM Peak												
Parkway	-13	-1	78	90	-28	125	4.6	0.1	2.9	6.6	3.9	3.4
Chelmer Rd	66	-3	-59	-39	108	73	2.9	2.3	4.5	3.1	4.8	2.0
EYW	54	-194	-3	-11	5	-149	1.8	15.8	2.5	4.8	0.5	4.3
Baddow Rd	82	43	-2	0	15	138	4.9	4.3	2.2	0.0	2.4	6.7
Van Diemans Rd	-3	8	-8	-37	-5	-45	0.3	0.4	0.8	6.3	3.1	1.9
Total	186	-146	5	2	96		4.3	4.7	0.1	0.1	3.6	
Inter-Peak												
Parkway	9	-27	36	100	-13	105	2.4	1.3	1.4	5.9	1.9	2.8
Chelmer Rd	-101	-4	-105	19	56	-135	5.7	2.9	8.5	1.3	2.8	4.1
EYW	162	-99	-2	-10	54	105	6.3	8.0	2.2	4.5	4.6	3.4
Baddow Rd	-10	82	-6	0	-40	26	0.6	6.4	3.5	0.0	5.6	1.2
Van Diemans Rd	21	-30	50	-37	-5	0	2.1	1.5	4.4	5.0	3.1	0.0
Total	81	-78	-28	72	53		2.2	2.4	0.9	3.0	2.1	
PM Peak												
Parkway	20	106	83	96	16	321	4.8	4.3	2.6	5.5	2.5	7.1
Chelmer Rd	-25	-3	-120	17	29	-102	1.4	2.3	7.7	0.9	1.4	2.8
EYW	84	-190	-1	-5	15	-97	3.6	16.1	1.3	3.2	1.7	3.5
Baddow Rd	-2	25	-8	0	21	36	0.2	1.9	4.0	0.0	3.2	1.7
Van Diemans Rd	51	-6	54	6	-3	102	7.7	0.4	4.8	0.8	2.4	4.5
Total	128	-67	8	114	77		3.8	1.9	0.2	4.3	3.2	

Table 11-7: Turning Movement Validation – Army & Navy Junction

It should be noted that the level of confidence in turning movement counts is less than for the link count data due to a lower sample size, being single one day count rather than continuous or two week counts. Within this context, the data in the above table indicates that:

- 81.3% (61 out of 75) of turning movements at the junction have a GEH value of less than 5.
- Two turning movement out of 75 have a GEH of greater than 10. These two turning movements are right turns from Essex Yeomanry Way (EYW) to Chelmer Road in both the AM and PM peak hours. This appears to be a matrix related issue, since the alternative route into the Chelmer and Springfield areas via the A12 Boreham Interchange is also modelled low in both the AM and PM peak periods (count ID S2.3). In the context of the A&N options being assessed, this difference is not considered likely to impact significantly on the appraisal of the schemes since the approach arm totals on EYW meet the criteria for all time periods and any impact is likely to increase benefits as the right turn is most likely to impact negatively on the DM much more so than any of all the options.

Given the detailed data presented on modelled flow validation in the vicinity of the Army & Navy as well as the wider network, it is considered that the model provides a sound basis for forecasting for the Army & Navy and other city centre schemes.

Overall, it can be said that the flow calibration and validation results, and their spatial context with respect to the schemes being appraised, indicate that the trip matrices and assignment provide a sound basis for forecast modelling.

11.8 Journey Time Validation

Journey times within the model were checked by comparison of the modelled journey times against the observed times along the routes identified in Section 3.1.2 and Figure 11-14 on the next page. TAG requires that for the total route's length, the modelled journey time from start to finish is within 15% of the observed time, and this must the case for 85% of all journey time routes. However, that simple comparison ignores the fact that modelled and observed journey times could deviate significantly from each other along specific sections of a route, and the overall time could still be within the specified acceptance criteria. To provide rigour in the modelled delays and journey times, the model has been developed in order to check the modelled times with observed times, not just for the total time along the routes, but also at all points of the routes. To that end, distance versus time graphs for the modelled and observed times are also provided in Appendix P.

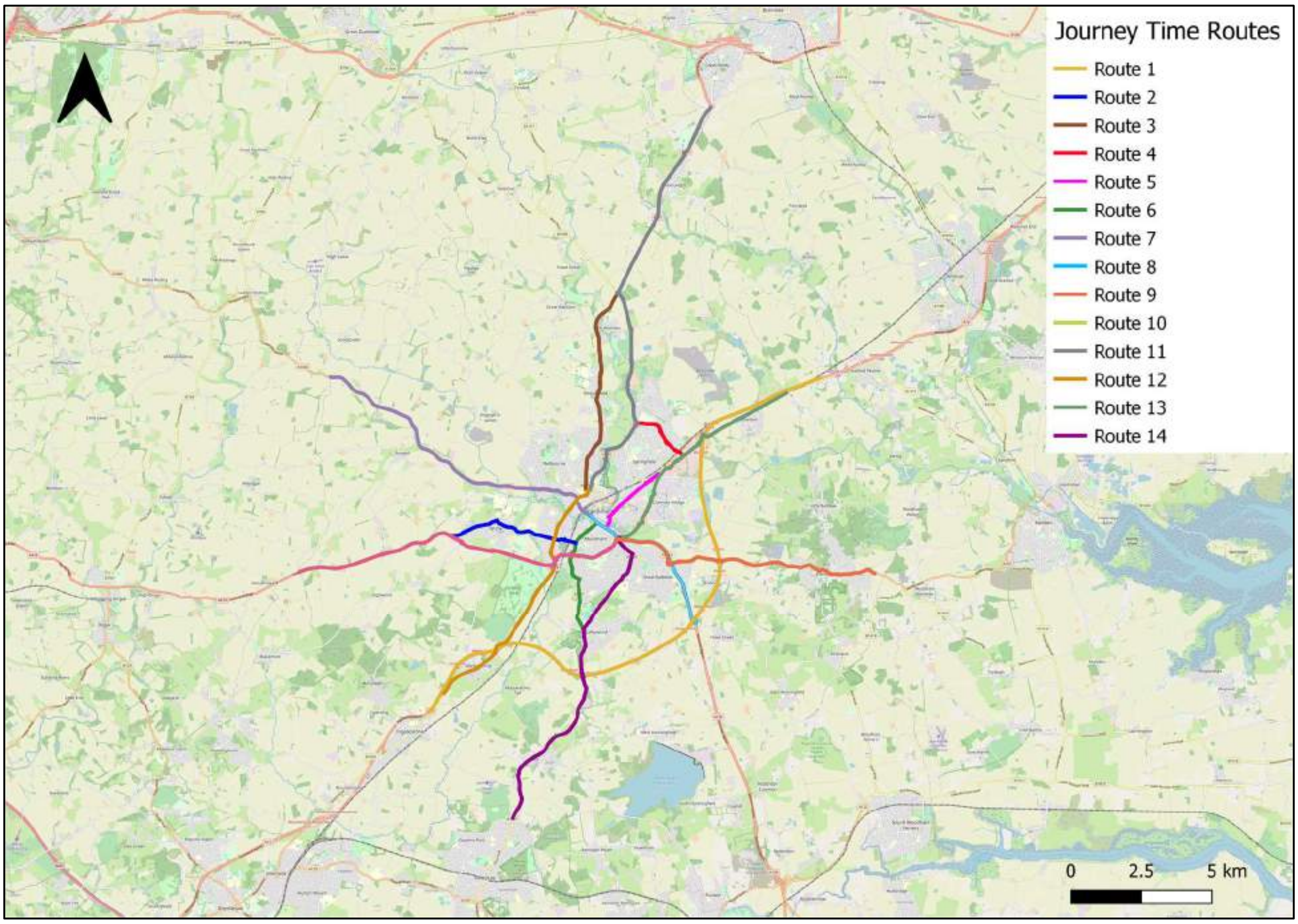


Figure 11-14: Journey Time Routes

A summary of the journey time validation across each time period is given below in Table 11-8.

Time Period	Number of Routes	Number of Routes Within 15%	Total % of Routes Meeting Criteria
AM	28	25	89%
IP	28	28	100%
PM	28	24	86%

Table 11-8: Journey Time Validation Summary

The tables on the following pages summarise the performance of the model in terms of TAG criteria for each route for each time period.

Route No.		Description	AM Observed time	AM Modelled time	Difference
			[min:sec]	[min:sec]	%
1	101	A12/Millfield Cottage North --> A12/Ingatestone	13:27	14:26	7.33%
	102	A12/Ingatestone --> A12/Millfield Cottage North	14:54	14:19	-3.91%
2	201	250 Ongar Road --> Writtle Road/Elm Road	11:21	10:47	-5.02%
	202	Writtle Road/Elm Road --> 250 Ongar Road	10:53	09:26	-13.33%
3	301	A130/Braintree Road --> Parkway Roundabout	15:26	13:05	-15.14%
	302	Parkway Roundabout --> A130/Braintree Road	12:07	12:37	4.20%
4	401	A130/Nabbotts Farm Roundabout --> A130/1 White Hart Ln	02:51	02:33	-10.15%
	402	A130/1 White Hart Ln --> A130/Nabbotts Farm Roundabout	04:45	04:27	-6.23%
5	501	High Bridge Rd/Odeon Roundabout --> Springfield Rd Roundabout	05:16	05:05	-3.31%
	502	Springfield Rd Roundabout --> High Bridge Rd/Odeon Roundabout	07:25	06:35	-11.30%
6	601	Parkway/New London Rd --> Stock Rd/Beehive Lane	07:01	07:55	12.78%
	602	Stock Rd/Beehive Lane --> Parkway/New London Rd	16:40	11:34	-30.61%
7	701	Wooden Farm Newland Hall --> Market Roundabout	16:37	14:17	-14.06%
	702	Market Roundabout --> Wooden Farm Newland Hall	12:21	11:45	-4.86%
8	801	Market Roundabout --> A12 J17	05:44	05:37	-1.89%
	802	A12 J17 --> Market Roundabout	16:16	14:13	-12.56%
9	901	Van Dieman's Rd --> Maldon Rd/Cherry Garden Lane	16:25	14:01	-14.56%
	902	Maldon Rd/Cherry Garden Lane --> Van Dieman's Rd	22:14	21:38	-2.70%
10	1001	Ongar Rd/Bassett's Lane --> Van Diemnan's Rd\Lady Ln	12:07	12:04	-0.46%
	1002	Van Diemnan's Rd\Lady Ln --> Ongar Rd/Bassett's Lane	15:18	16:37	8.71%
11	1101	A131/London Rd --> B1016/B1008	26:37	23:26	-11.99%
	1102	B1016/B1008 --> A131/London Rd	16:30	15:01	-9.02%
12	1201	Rectory Ln/Meadowside --> B1002/Church Ln	12:54	13:57	8.23%
	1202	B1002/Church Ln --> Rectory Ln/Meadowside	18:59	16:12	-14.69%
13	1301	Main Rd/Damasses Ln --> Army and Navy Roundabout	17:54	16:03	-10.38%
	1302	Army and Navy Roundabout --> Main Rd/Damasses Ln	14:08	12:02	-14.86%
14	1401	Army and Navy Roundabout --> Stock Rd/The Vale	10:55	12:01	10.04%
	1402	Stock Rd/The Vale --> Army and Navy Roundabout	24:19	21:02	-13.53%

Table 11-9: Comparison of Modelled Journey Time Against Observed, AM Peak

Route No.		Description	IP Observed time [min:sec]	IP Modelled time [min:sec]	Difference %
1	101	A12/Millfield Cottage North --> A12/Ingatestone	11:34	12:14	5.73%
	102	A12/Ingatestone --> A12/Millfield Cottage North	11:51	12:16	3.47%
2	201	250 Ongar Road --> Writtle Road/Elm Road	08:03	07:38	-5.17%
	202	Writtle Road/Elm Road --> 250 Ongar Road	06:53	07:37	10.88%
3	301	A130/Braintree Road --> Parkway Roundabout	10:04	11:12	11.29%
	302	Parkway Roundabout --> A130/Braintree Road	10:00	09:58	-0.36%
4	401	A130/Nabbotts Farm Roundabout --> A130/1 White Hart Ln	03:09	02:43	-13.54%
	402	A130/1 White Hart Ln --> A130/Nabbotts Farm Roundabout	02:40	02:55	8.78%
5	501	High Bridge Rd/Odeon Roundabout --> Springfield Rd Roundabout	05:18	05:20	0.67%
	502	Springfield Rd Roundabout --> High Bridge Rd/Odeon Roundabout	05:04	04:48	-5.28%
6	601	Parkway/New London Rd --> Stock Rd/Beehive Lane	06:37	07:33	14.24%
	602	Stock Rd/Beehive Lane --> Parkway/New London Rd	07:38	08:10	6.92%
7	701	Wooden Farm Newland Hall --> Market Roundabout	12:13	12:29	2.22%
	702	Market Roundabout --> Wooden Farm Newland Hall	11:42	10:58	-6.29%
8	801	Market Roundabout --> A12 J17	06:19	07:09	13.25%
	802	A12 J17 --> Market Roundabout	06:24	06:20	-0.94%
9	901	Van Dieman's Rd --> Maldon Rd/Cherry Garden Lane	13:35	13:18	-2.07%
	902	Maldon Rd/Cherry Garden Lane --> Van Dieman's Rd	12:32	11:52	-5.34%
10	1001	Ongar Rd/Bassett's Lane --> Van Diemnan's Rd\Lady Ln	11:15	11:29	2.20%
	1002	Van Diemnan's Rd\Lady Ln --> Ongar Rd/Bassett's Lane	11:09	10:42	-4.08%
11	1101	A131/London Rd --> B1016/B1008	13:47	13:51	0.53%
	1102	B1016/B1008 --> A131/London Rd	13:29	13:44	1.86%
12	1201	Rectory Ln/Meadowside --> B1002/Church Ln	12:21	13:56	12.86%
	1202	B1002/Church Ln --> Rectory Ln/Meadowside	12:57	13:36	5.03%
13	1301	Main Rd/Damasses Ln --> Army and Navy Roundabout	10:47	10:11	-5.55%
	1302	Army and Navy Roundabout --> Main Rd/Damasses Ln	10:43	10:41	-0.35%
14	1401	Army and Navy Roundabout --> Stock Rd/The Vale	09:48	08:52	-9.58%
	1402	Stock Rd/The Vale --> Army and Navy Roundabout	12:01	10:27	-13.02%

Table 11-10: Comparison of Modelled Journey Time Against Observed, IP

Route No.		Description	PM Observed time [min:sec]	PM Modelled time [min:sec]	Difference %
1	101	A12/Millfield Cottage North --> A12/Ingatestone	13:54	12:47	-7.96%
	102	A12/Ingatestone --> A12/Millfield Cottage North	17:32	14:04	-19.74%
2	201	250 Ongar Road --> Writtle Road/Elm Road	11:01	11:54	8.01%
	202	Writtle Road/Elm Road --> 250 Ongar Road	10:27	08:56	-14.55%
3	301	A130/Braintree Road --> Parkway Roundabout	11:26	12:13	6.92%
	302	Parkway Roundabout --> A130/Braintree Road	18:22	17:36	-4.25%
4	401	A130/Nabbotts Farm Roundabout --> A130/1 White Hart Ln	04:41	03:04	-34.53%
	402	A130/1 White Hart Ln --> A130/Nabbotts Farm Roundabout	03:06	03:16	5.25%
5	501	High Bridge Rd/Odeon Roundabout --> Springfield Rd Roundabout	08:45	06:30	-25.76%
	502	Springfield Rd Roundabout --> High Bridge Rd/Odeon Roundabout	10:47	10:23	-3.76%
6	601	Parkway/New London Rd --> Stock Rd/Beehive Lane	14:21	09:33	-33.48%
	602	Stock Rd/Beehive Lane --> Parkway/New London Rd	10:02	09:34	-4.52%
7	701	Wooden Farm Newland Hall --> Market Roundabout	16:13	15:37	-3.79%
	702	Market Roundabout --> Wooden Farm Newland Hall	11:59	11:29	-4.24%
8	801	Market Roundabout --> A12 J17	08:24	09:23	11.89%
	802	A12 J17 --> Market Roundabout	12:48	12:06	-5.47%
9	901	Van Dieman's Rd --> Maldon Rd/Cherry Garden Lane	18:25	15:51	-13.91%
	902	Maldon Rd/Cherry Garden Lane --> Van Dieman's Rd	18:08	17:53	-1.30%
10	1001	Ongar Rd/Bassett's Lane --> Van Diemnan's Rd\Lady Ln	12:28	10:59	-11.94%
	1002	Van Diemnan's Rd\Lady Ln --> Ongar Rd/Bassett's Lane	15:45	15:45	-0.03%
11	1101	A131/London Rd --> B1016/B1008	17:11	15:22	-10.56%
	1102	B1016/B1008 --> A131/London Rd	19:40	17:32	-10.84%
12	1201	Rectory Ln/Meadowside --> B1002/Church Ln	17:51	16:38	-6.82%
	1202	B1002/Church Ln --> Rectory Ln/Meadowside	18:29	16:12	-12.38%
13	1301	Main Rd/Damasses Ln --> Army and Navy Roundabout	14:38	13:14	-9.59%
	1302	Army and Navy Roundabout --> Main Rd/Damasses Ln	13:38	12:02	-11.73%
14	1401	Army and Navy Roundabout --> Stock Rd/The Vale	10:49	09:55	-8.31%
	1402	Stock Rd/The Vale --> Army and Navy Roundabout	14:29	14:23	-0.67%

Table 11-11: Comparison of Modelled Journey Time Against Observed, PM Peak

In addition to the comparisons above, Appendix P provides journey time graphs (plotting time against distance for the modelled and observed data) for all routes in the model.

The above tables demonstrate that the TAG criteria are met and exceeded, as more than 85% of the journey times across all peaks are in accordance with the 15% criteria. It is also notable that the differences in times are not consistently positive or negative, suggesting there is no underlying bias of too quick or too slow journey times in the model.

Two routes in the AM and four routes in the PM failed to meet the criteria whilst all routes in the IP met the TAG criteria. Though some routes have failed marginally below the criteria, route 602 in the AM peak and routes 601 and 401 in the PM peak are far from the criteria.

Route 6 (601 in the AM and 602 in the PM peak) is a relatively short route servicing local movements between Galleywood on the southern edge of the Chelmsford urban area and central Chelmsford via a series of schools. The modelled journey time is fast inbound in the morning and slow outbound in the afternoon peak period. The cause of these differences is different in each peak period. In the morning peak hour, the issue is on B1007 Galleywood Road and Wood Street. This section of road is very difficult to accurately model in a strategic model due to the number of local buses that stop regularly along this relatively narrow stretch of road (there are many schools near this location) and the disruption this causes to journey times. In addition, the geometry of the three-arm mini roundabout on this section is unusual with priority not as clear as would normally be the case, leading to hesitation and higher than would be expected delay at this junction. In the PM peak the delay modelled journey time is again fast relative to the observed. The issue is with the difficulty in modelling the signalised junction at New London Road and Writtle Road. There is a high level of conflicts at this junction between buses entering and exiting bus lanes, pedestrians, ‘Keep Clear Boxes’, parking, and direct site accesses. Although significant effort was made to model this intersection, the very high observed delay was not able to be replicated in a strategic model context. In the AM peak, the impact on appraisal is considered to be minimal due to the location of the problem section on Wood Street, which caters to local movements and does not represent a route to those that pass through the A&N junction. In the PM peak, it could be considered that New London Road does provide a competing route to those that pass through the A&N. However, this is a highly congested section of road with a relatively low traffic flow compared to the A&N (559 vehicles in the PM peak hour (Site S4.2)), such that the relatively fast modelled journey time only results in a relatively minor difference between the modelled and observed traffic flows (27 vehicles or a GEH of 1.2) on this section of road. In addition, any minor transfer of traffic from the A&N junction to the New London Road corridor due to the fast modelled journey time is likely to underestimate the benefits of the scheme due to reduced demand at the A&N. Overall, it is considered that the differences on this journey time route are not likely to have any significant impact on the appraisal.

Along route 401, which stretches for 1.85km, the difference between observed and modelled time in percentage terms was relatively high, though the absolute difference was only around 1.5 minutes. Although these routes fail to meet the criteria, the impact of these for the appraisal of Army and Navy or the CNEB is not significant.

More importantly, all routes which traverse through the Army and Navy roundabout have met the criteria – these routes include 8, 9, 10, 13 14. Similarly Route 11, which includes the stretch of road that will be relieved by the presence of the proposed CNEB, has met the criteria as well. The graphs in Appendix P show that there is also a good match in journey times along the whole length of these routes, not just as a comparison of total times. This provides some assurance that the impacts predicted by forecast modelling will have a credible basis.

11.9 Public Transport Model Calibration

The purpose of the public transport model (PT model) is to produce demand matrices and travel cost data (cost skims) for use in the Variable Demand Model (VDM). This function requires the model to provide information about in-vehicle travel time, access/egress time, wait time and interchange time for the AM, Inter-peak and PM peak periods.

The public transport demand matrices were prepared separately for bus and rail trips. This distinction was necessary as surface rail trips can be easily identified within mobile phone data, whilst bus trips are more difficult to distinguish from other road-based trips and required a separate matrix building procedure. This separation also allows bus and rail demand growth to be applied independently. However, the matrices are combined for assignment to the public transport network. This means that the assignment model determines whether the public transport demand uses rail or bus services, or a combination.

The Chelmsford demand model operates at daily (24-hour) Production-Attraction (PA) format and the public transport model provides cost skims for AM peak, Inter-peak and PM peak periods for input into the demand model. The demand model forecasts change in the allocation of demand between rail and car at the total daily level (mode choice).

Nevertheless, the demand model divides the daily PA public transport matrices into time period matrices in Origin-Destination (OD) format, which is further explained in Section 12. These include matrices for AM peak, Inter-peak and PM peak periods consistent with the public transport model time periods as well as the Off-Peak (OP) time period, broken down by Commute, Business and Other journey purposes. These matrices were assigned to the network.

As described in previous sections, owing to the scope of the Chelmsford Model development and that the PT model is only required to provide input to the VDM rather than to assess a public transport scheme, a ‘light-touch’ approach was adopted. No separate calibration / validation exercise was undertaken for the PT model over and above that which was carried out during the development of PT matrices as part of the Essex Countywide Model.

12 Variable Demand Model

12.1 Introduction

The premise of variable demand modelling is that any change in travel cost, through traffic intervention or changes in travel demand, is liable to modify travel behaviour. Proposed highway improvements i.e., CNEB and Army and Navy junction, will likely make journeys quicker and cheaper for existing users and as such users may either re-route from other less appealing roads, change the destination of travel where previously inaccessible locations now become available, or shift travel from public transport to car. To take into account these latter two impacts, a Variable Demand Model (VDM) was developed to provide the basis for robust assessment of future changes in demand due to changes in policy schemes.

The core requirements, as defined by TAG Unit M2-1 paragraph 1.3.1, state that, in the first instance, an assessment of the need for demand model components is required and is defined within the same unit paragraph 2.2.1 as:

"*It may be acceptable to limit the assessment of a scheme to a fixed demand assessment if the following criteria are satisfied:*

- *The scheme is quite modest either spatially or financially and is also quite modest in terms of its effect on travel costs. Schemes with a capital cost of less than £5 million can generally be considered as modest; or the following two points:*
- *There is no congestion or crowding on the network in the forecast year (10 to 15 years after opening), in the absence of the scheme; and*
- *The scheme will have no appreciable effect on travel choices (e.g. mode choice or distribution) in the corridor(s) containing the scheme.*"

Based on all the above factors, the development of a full VDM was considered necessary to assess a number of the key objectives for the proposed CNEB and Army and Navy schemes.

12.2 Model Overview

12.2.1 Overview of Model Structure and Responses

The Chelmsford Model has been built in line with the guidance set out in TAG Unit M2-1 and includes a Variable Demand Model (VDM) operating at a production/attraction (PA) 24-hour level. The model is of an incremental logit form and responds to changes in daily generalised costs. These costs are predicted by the highway and public transport assignment models and then converted to daily weighted average costs taking account of the time period and direction of journey prior to the demand modelling. The resultant demand matrices require conversion to AM, IP and PM single peak hour origin / destination (OD) matrices for re-assignment. The process is repeated until the model converges, i.e. when the changes in demands and costs between iterations are regarded as sufficiently small. This relationship between the Chelmsford Demand Model and Assignment Models is shown in Figure 12-1 on the next page.

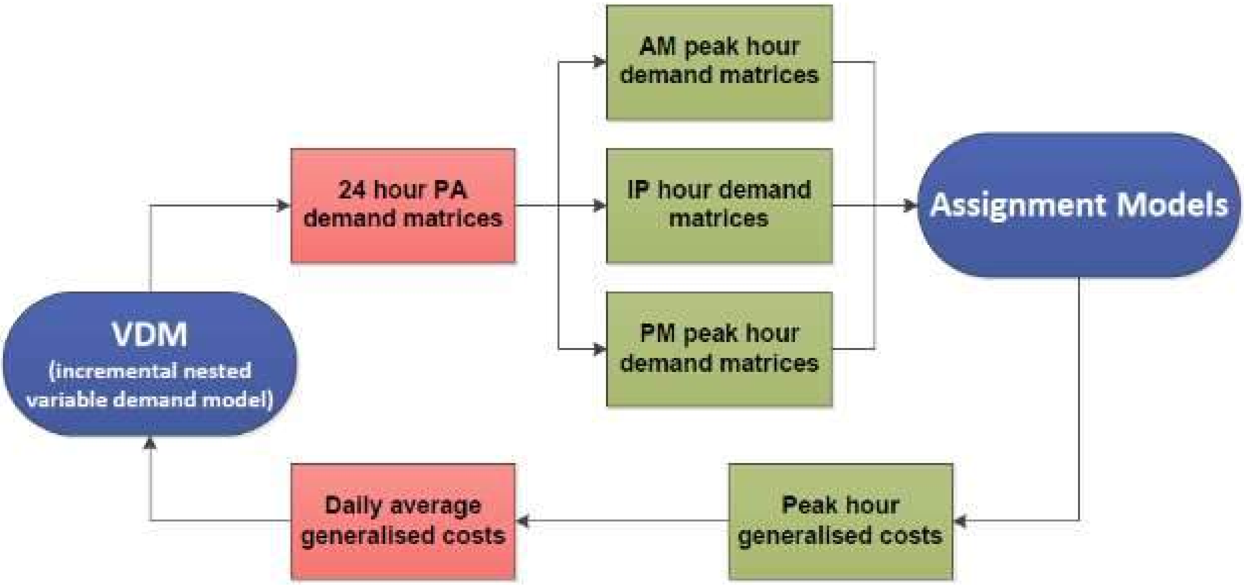


Figure 12-1: Relationship Between Demand Model and Assignment Model

The Chelmsford Demand Model is designed to take account of future strategic and local growth in population and employment and to be capable of predicting likely travel behaviour in terms of mode choice and trip distribution of trips with one or both trip-ends within Chelmsford. The trip distribution response considers the attractiveness of alternative destinations whereas the mode choice response considers demand switching between car and public transport. Since mode choice depends on whether a traveller has a car available for the journey, the model distinguishes between households that have a car available and those that do not.

An external Excel-based Park and Ride was also developed as a bolt-on to the Chelmsford Demand Model. Previously, Park & Ride (P&R) models for Chelmsford and elsewhere in Essex have been successfully developed as multinomial logit choice models. This version of the P&R model follows the same basic structure with updates in terms of observed P&R demand and journey times to better represent the period following the closure of the flyover at the A&N. The development and validation of the base year P&R model is described in detail in the *Chelmsford Park & Ride 2019 Base Model Report* (June 2019).

Cycle, and walk modes do not provide a realistic alternative for strategic journeys across the study area, they are not modelled.

Goods vehicle trips are assumed to be non-responsive to changes in travel costs (with their trip making influenced by other, external, economic factors) and therefore remain fixed within the demand model.

An overview of the demand model choice structure is shown in Figure 12-2 on the next page.

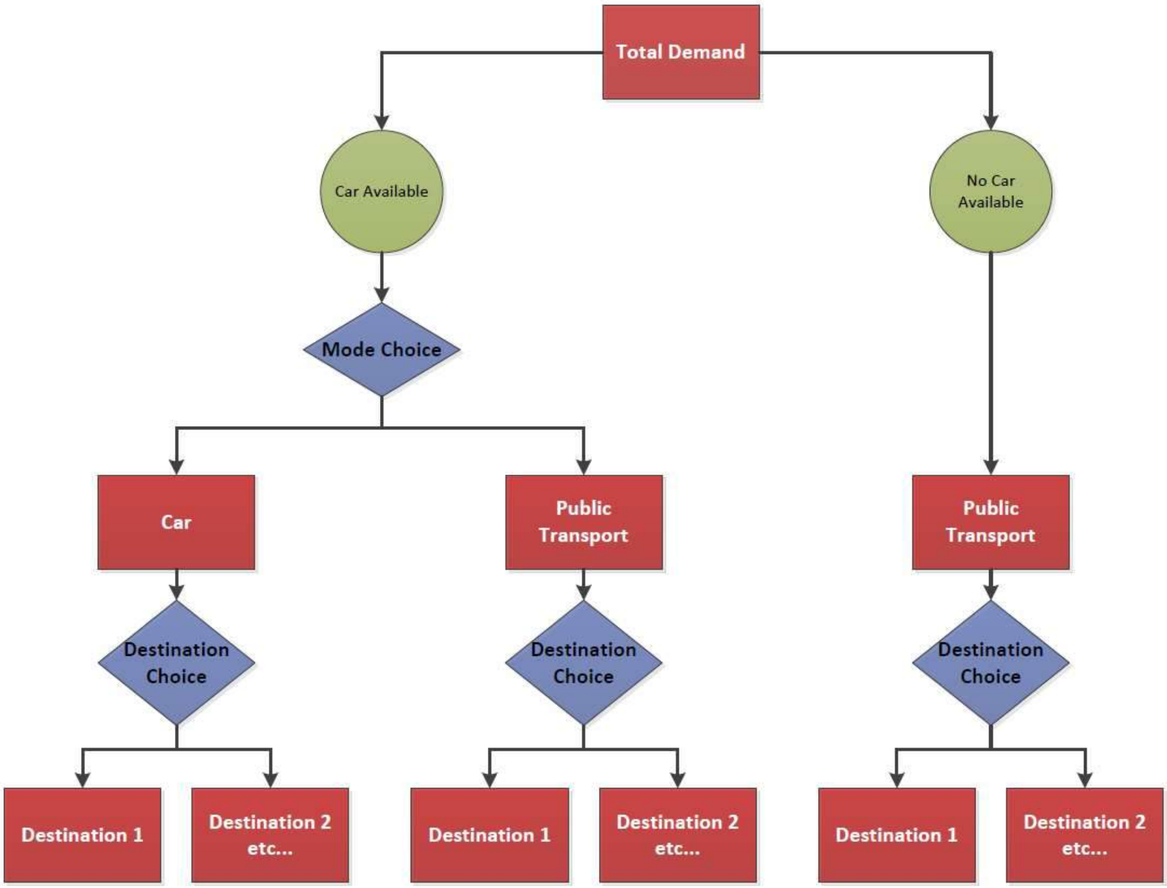


Figure 12-2: Chelmsford Model Choice Structure

VISUM provides a nested demand model structure and enables iteration between demand and supply. The public transport assignment is not capacity constrained and so generalised costs remain fixed through the demand model after initial assignment. The public transport assignment is therefore not repeated within each demand model iteration and is just assigned one final time after demand-supply convergence is reached.

12.2.2 Journey Purposes and Demand Segmentation

The following journey purpose segmentation is used within the Chelmsford Demand Model:

- Home-Based Work (HBW) – travelling from home to work (and any return journeys) – a typical commuting journey (note – this travel purpose does not take place in employers' time);
- Home-Based Employer's Business (HBEB) – travelling from home to a destination where you are in employers' time as soon as you leave the home (and any return journeys);
- Home-Based Other (HBO) – travelling from home to a non-work-related location (other than shopping or education, and any return journeys);
- Home-Based Shopping (HBShop) – travelling from home to a non-work, shopping-related location (and any return journeys);
- Home-Based Education (HBEdu) – travelling from home to an education destination (primary/secondary schools and any return journeys);

- Non-Home-Based Employer's Business (NHBEB) – travelling during employers' time, such as travelling from a place of work to a business meeting, visiting customers etc. and;
- Non-Home-Based Other (NHBO) – travel between two non-home-based locations (for example, from work to shops).

These seven journey purposes have been duplicated across car, public transport car available and public transport no car available modes, giving 21 journey purposes in total. Table 12-1 presents the correspondence between the demand model trip purposes and the assignment user classes:

Assignment Mode	Assignment User Class	Demand Model Trip Purpose
PrT	Car Commute	Home-Based Work – HBW
	Car Employers' Business	Home-Based Employers' Business – HBEB
		Non-Home-Based Employers' Business – NHBEB
	Car Other	Home-Based Other – HBO
		Home-Based Shopping – HBShop
		Home-Based Education – HBEdu
		Non-Home-Based Other – NHBO
	LGV	-
	HGV	-
PuT (Bus, Train, London Underground)	Commute	Car Available - Home-Based Work – HBW
		No Car Available - Home-Based Work – HBW
	Employers' Business	Car Available - Home-Based Employers' Business – HBEB
		No Car Available - Home-Based Employers' Business – HBEB
		Car Available - Non-Home-Based Employers' Business – NHBEB
		No Car Available - Non-Home-Based Employers' Business – NHBEB
	Other	Car Available - Home-Based Other – HBO
		No Car Available - Home-Based Other – HBO
		Car Available - Home-Based Shopping – HBShop
		No Car Available - Home-Based Shopping – HBShop
		Car Available - Home-Based Education – HBEdu
		No Car Available - Home-Based Education – HBEdu
		Car Available - Non-Home-Based Other – NHBO
		No Car Available - Non-Home-Based Other – NHBO

Table 12-1: Journey Purpose / Assignment User Class Correspondence

The model segmentation follows guidance in TAG and is consistent with the segmentation used in the development of the final demand matrices using TEMPro trip-ends and mobile network data. In line with TAG advice, Home-Based Work and Education purpose trips are doubly-constrained within the Model. Other purpose trips are run as a singly-constrained process.

The PT demand was split into car available and non-car available demand segments. Only the PT demand generated by car owning persons was included, so that mode choice is not offered to PT captive travellers, i.e., non-car available demand segment. The PT demand by car ownership data again was obtained from NTEM and the car ownership proportion was applied at origin level, based on the MSOA and the corresponding zone. The presence of this demand facilitates mode shift between car and PT in response to car cost changes experienced by those travellers who have a car available.

12.2.3 Zoning System and Demand Response Areas

The Chelmsford Model zoning system is consistent across the demand model and the highway and public transport assignment models. For the variable demand, the study area is split into three distinct areas reflecting the confidence in the accuracy of the assignment travel cost predictions and determining the responsiveness of the demand model:

- **Internal** – any trip starting and ending in these zones is within the scope of the demand model and hence is fully responsive to cost changes. This area includes all of Chelmsford District and some peripheral areas;
- **Intermediate** – any trip that travels to/from the internal area from/to this area is within the scope of the demand model, but any trip that both starts and ends in these zones is fixed (assumed to be non-responsive); and
- **External** – any trip starting or ending in these zones is fixed within the demand model.

These areas are shown in Figure 12-3 and the treatment of demand model responses by area are summarised within the matrix in Table 12-2:

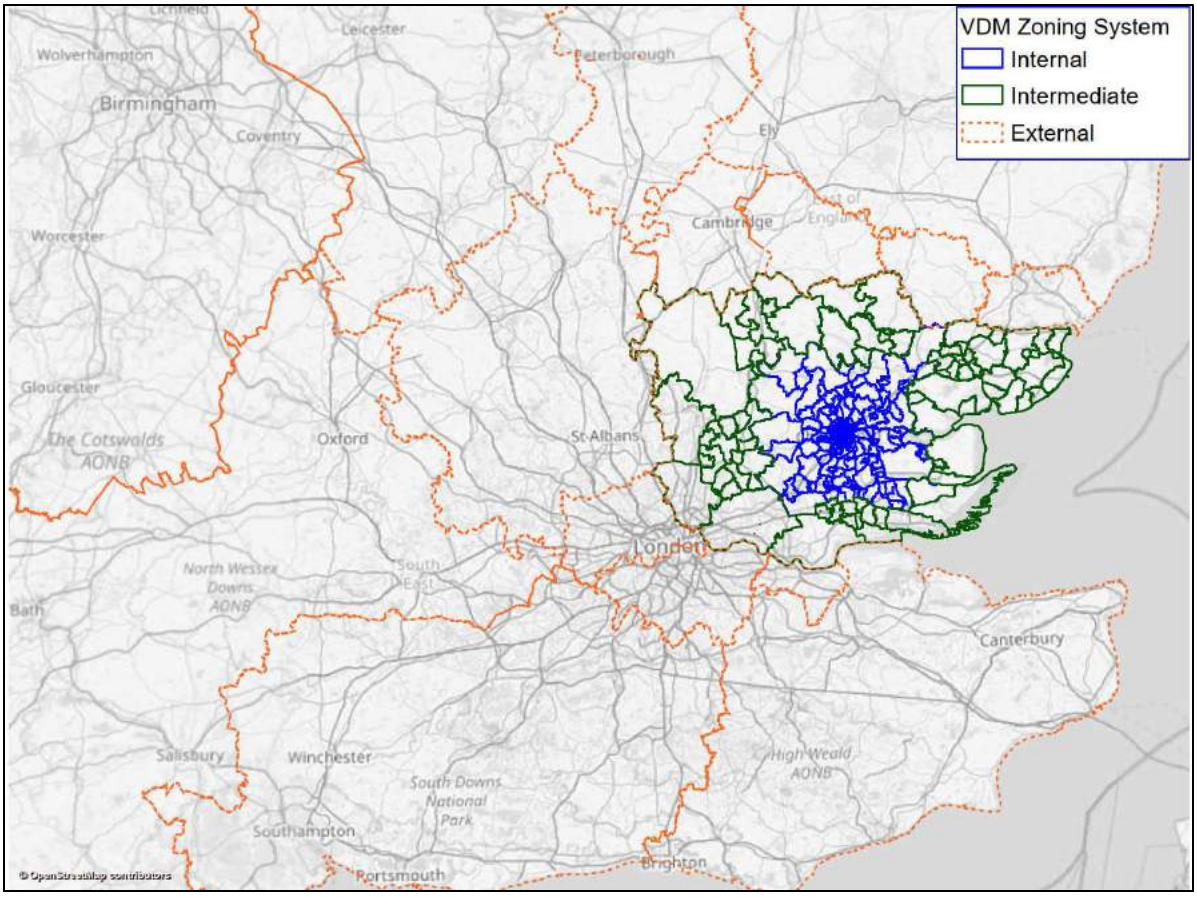


Figure 12-3: Demand Model Zoning System (Demand Responses)

	Internal	Intermediate	External
Internal	Within Scope of Demand Model	Within Scope of Demand Model	Trips Fixed
Intermediate	Within Scope of Demand Model	Trips Fixed	Trips Fixed
External	Trips Fixed	Trips Fixed	Trips Fixed

Table 12-2 – Treatment of Demand Model Responses by Area

Internal to external demand and vice versa is therefore fixed. Since it is well documented that the sensitivity of demand responses to changes in generalised cost reduces with increasing trip length (TAG Unit M2, paragraph 3.3.1) and given the spatial size of the model (all of England, Scotland and Wales), fixing this demand has been used to avoid small percentage changes resulting in large changes in demand for long distance trips to large external zones. It is noted that the realism testing results were all within the acceptable range.

12.3 Demand Model Inputs and Functions

12.3.1 Overview

A detailed schematic of the Chelmsford Demand Model process is shown in Figure 12-4 on the following page.

Within Figure 12-4, the inputs and outputs from the model are shown in **red**. These are:

- Pivot demand matrices for car and public transport representing the base year demand (input);
- Fixed demand matrices for goods vehicles representing the base year demand (input);
- Generalised costs of travel by highway and public transport modes in the base situation (input); and
- Final peak hour assignments (AM, IP and PM) as an output from the demand model.

Model processes, such as matrix conversions and assignments (and the resulting outputs/inputs), are shown in **blue** and nested demand model calculations (containing the choice structure as shown in Figure 12-2 above) are shown in **green**.

The inputs and functions applied during the demand model process are then detailed throughout the rest of this chapter.

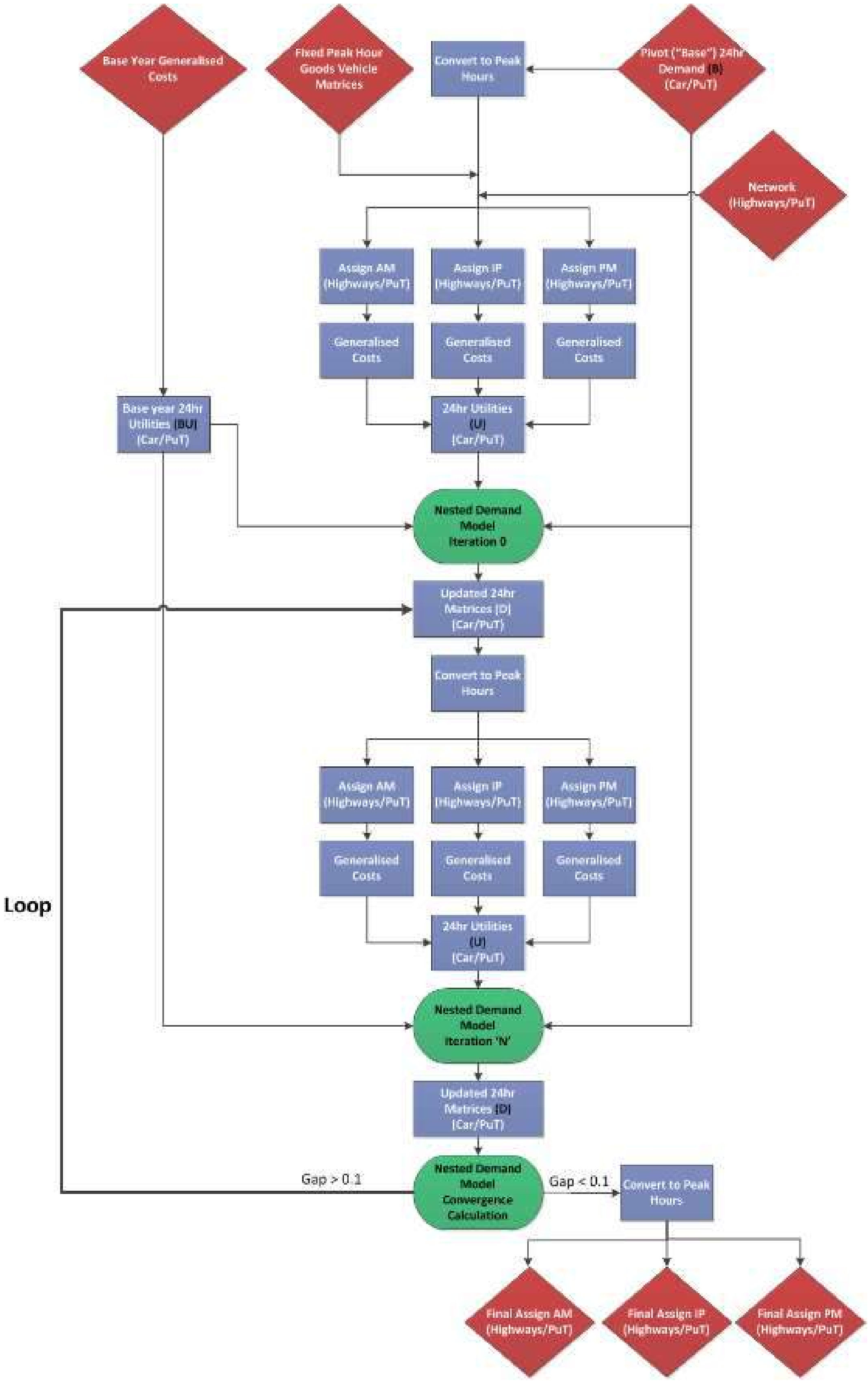


Figure 12-4: Chelmsford Countywide Demand Model Process

12.3.2 Generalised Costs

Within the highway model assignment, two parameters are defined for each user class in order to calculate generalised cost as a combination of journey times and journey distances in standardised units of generalised time. These parameters are:

- Value of Time (VoT) (in pence per minute (ppm)); and
- Vehicle Operating Cost (VOC) (in pence per kilometre (ppk)).

The formula to determine generalised cost is as follows:

$$GeneralisedCost_{minutes} = JourneyTime_{minutes} + \left(\frac{ppk}{ppm}\right) * JourneyDistance_{km}$$

The values of the VoT and VOC parameters used for the Chelmsford Model assignment are based on values in Table 4-4 as discussed in Section 4.9.

Within the public transport assignment, the total generalised cost of travel is then:

$$GeneralisedCost_{minutes} = Origin\ Wait\ Time\ Adapted * 2\ (Wait\ Time) +\ PJT + (\frac{Fare_{pence}}{VOT_{ppm}})$$

Further information on the derivation of this generalised cost is provided in Section 4.9.

12.3.3 Conversion of 24-Hour Demand to Peak Hour

The 24-hour PA model requires processes to convert the daily demand matrices into period origin-destination demand. The car split factors were derived from the mobile phone data and adjusted based on observed proportions from the National Travel Survey (NTS) data. For public transport and non-home-based trips, the NTS proportions were used. Home-based trips, which entail a complete round trip comprising outward and return legs, had a set of outward and return probabilities for each time-period.

Formulations of the conversion between the two demand levels are detailed below:

For home-based purposes:

$${}^{\text{peak}}_{\text{purpose}}\mathbf{D} = {}^{\text{24hr}}_{\text{purpose}}\mathbf{D} * {}^{\text{24hr to peak}}_{\text{purpose}}\mathbf{Outbound\ Factor} + \left[{}^{\text{24hr}}_{\text{purpose}}\mathbf{D} * {}^{\text{24hr to peak}}_{\text{purpose}}\mathbf{Return\ Factor}\right]^{T}$$

And for non-home-based purposes:

$${}^{\text{peak}}_{\text{purpose}}\mathbf{D} = {}^{\text{24hr}}_{\text{purpose}}\mathbf{D} * {}^{\text{24hr to peak}}_{\text{purpose}}\mathbf{Factor}$$

12.3.4 Conversion of Peak Hour Generalised Costs to 24-Hour

The model also needs to undertake conversions from individual peak hour generalised costs to average daily 24-hour costs required by the demand model. This conversion is based on the same factors discussed in Section 12.3.3 explaining conversions of demand from PA 24-hour to peak hour origin and destination.

For each home-based purpose, the weighted average cost represents a total of the peak hour costs multiplied by the corresponding weights of outbound movements in each time-period and the transposed peak hour costs multiplied by the corresponding weights of return movements:

$$ {}^{24\text{hr}}_{\text{purpose}}\mathbf{GC} = \frac{1}{2} * \sum_{AM,IP,PM,OP(=IP)} {}^{\text{peak}}_{\text{purpose}}\mathbf{GC} * {}^{24\text{hr to peak}}_{\text{purpose}}\mathbf{Outbound\ Factor} + \left[{}^{\text{peak}}_{\text{purpose}}\boldsymbol{GC} * {}^{24\text{hr to peak}}_{\text{purpose}}\mathbf{Return\ Factor}\right]^{T} $$

For each non-home-based purpose, the peak hour generalised costs need to be multiplied by the corresponding factors representing a proportion of travel in each time period:

$$ {}^{24\text{hr}}_{\text{purpose}}\mathbf{GC} = \sum_{AM,IP,PM,OP(=IP)} {}^{\text{peak}}_{\text{purpose}}\mathbf{GC} * {}^{24\text{hr to peak}}_{\text{purpose}}\mathbf{Factor} $$

12.3.5 Nested Demand Model Functions

The Chelmsford Model is a nested logit model that follows the recommended TAG hierarchy of choices with destination choice at the bottom level (most sensitive) and mode choice at the top level (least sensitive) as shown in Figure 12-2 above.

Logsums (a measure of the closeness of the origin and the destination of a trip) are calculated and carried up the hierarchy starting from the bottom level to the top level. As the model uses an incremental pivot point approach, the revised mode probabilities are applied to the base (Pivot) demand (starting from the top of the hierarchy) as illustrated in Figure 12-5 for singly-constrained journey purposes:

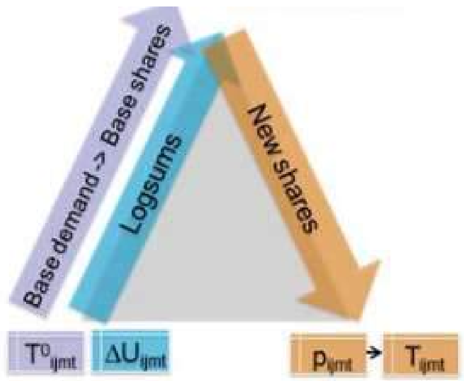


Figure 12-5: Calculation of Logsums and Demand (Incremental Case – Singly-Constrained)

where:

T^0_{ijmt} = Trips between origin i and destination j in the base (pivot) matrix for mode m during time period t;

U_{ijmt} = the utility (defined simply by VISUM as - 1 * generalised cost) for trips between origin i and destination j for mode m during time period t;

ΔU_{ijmt} = the change in utility between forecast and base;

p_{ijmt} = the revised probabilities for trips between origin i and destination j for mode m during time period t; and

T_{ijmt} = revised demand between origin i and destination j for mode m during time period t.

In the case of singly-constrained purposes, log sums are calculated in the following manner:

$$\frac{1}{\lambda}\log\sum_{k}\rho_k^0 e^{\lambda\Delta U_k}$$

where:

k is the index over all alternatives of a choice;

U_k is the utility of alternative *k*;

ΔU_k corresponds to the utility difference between scenario and base case;

ρ_k^0 is the base demand share for alternative *k*; and

λ is the scale parameter at the level.

From the top level downwards demand and new shares of demand, respectively, are then calculated as:

$$\rho * \frac{T_k^0\left(e^{\lambda\Delta U_k}\right)}{\sum_j T_{kj}^0\left(e^{\lambda\Delta U_j}\right)}$$

where:

j is the index over all alternatives of the choice at the level;

T is the demand which is to be divided between the alternatives;

ρ is the new share of demand which is to be divided between the alternatives;

U_k is the utility of alternative *k*;

ΔU_k corresponds to the utility difference between scenario and base case;

T_k^0 is the base demand of alternative *k*; and

λ is the scale parameter at the level.

For doubly constrained journey purposes, the calculation includes an iterative approach with loops between the destination level and the top level of the hierarchy. After each loop the %GAP criterion is checked. If convergence has not been achieved and the maximum number of loops has not been reached, the balancing factors are updated to minimise the differences between the target attraction values and the number of terminating trips for destination zones as illustrated in Figure 12-6 for destination choice on the following page:

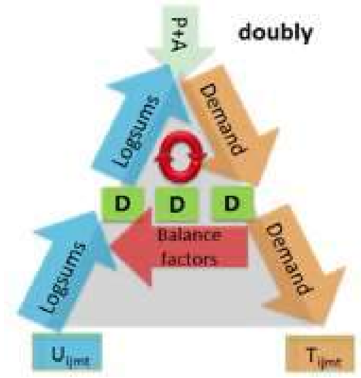


Figure 12-6: Calculation of Logsums and Demand (Incremental Case – Doubly-Constrained)

where:

U_{ijmt} = the utility (defined simply by VISUM as - 1 * generalised cost) for trips between origin i and destination j for mode m during time period t; and

T_{ijmt} = revised demand between origin i and destination j for mode m during time period t.

For doubly-constrained journey purpose trips (home-based work and education), the calculation of Logsums is undertaken in the following manner:

$$\frac{1}{\lambda}\log\sum_{k}\rho_k^0 B_k e^{\lambda \Delta U_k}$$

where:

k is the index over all alternatives of a choice;

U_k is the utility of alternative k;

ΔU_k corresponds to the utility difference between scenario and base case;

ρ_k^0 is the base demand share for alternative k;

B_k is the balancing factor of destination zone k; and

λ is the scale parameter at the level.

Demand is then calculated as:

$$\rho * \frac{B_k T_k^0 \left(e^{\lambda \Delta U_k}\right)}{\sum_j B_j T_{kj}^0 \left(e^{\lambda \Delta U_j}\right)}$$

where:

j is the index over all alternatives of the choice at the level;

T is the demand which is to be divided between the alternatives;

ρ is the new share of demand which is to be divided between the alternatives;

U_k is the utility of alternative *k*;

ΔU_k corresponds to the utility difference between scenario and base case;

T_k^0 is the base demand of alternative *k*;

B_k is the balancing factor of destination zone *k*; and

λ is the scale parameter at the level.

12.3.6 Demand Model Parameters

The demand model parameters control the sensitivity of the model's mode and destination choice responses. These parameters are distribution model sensitivity parameters (λ) and mode choice sensitivity parameters defined by scaling factors (θ) in TAG guidance. Scaling factors represent the ratio of sensitivity parameters from successive levels of the demand model choice structure (e.g. the sensitivity of main mode choice relative to that of destination choice):

$$\theta = \frac{\lambda_{upper}}{\lambda_{lower}}$$

The strength of the sensitivity parameters should be in line with the model hierarchy, i.e. these need to be stronger at lower levels of the model hierarchy than at the higher level. To be consistent with TAG recommended hierarchy of destination choice following main mode choice, the main mode choice scaling parameters should be less than or equal to one. TAG Unit M2-1 Section 5.6 provides a number of illustrative parameter values (minimum, median, and maximum) defined individually by mode and by purpose. VISUM software uses a different definition of parameters and requires the input of λ values for both destination and mode choice (rather than scaling factors). Consequently, the parameter for mode choice has been calculated by solving the above equation for λ_{upper} assuming the value of θ. If different destination choice parameters are used for car and public transport, as in the case of the Chelmsford Model, the required parameter for the mode choice level must therefore be derived from the range of different λ_{upper} values (whilst being cognisant of the need for choice sensitivity parameters to be larger at lower levels of the model hierarchy than at the higher level).

Given the journey purpose segmentation outlined in Section 12.2.2, the Chelmsford Model requires a set of 28 separate λ values (7 for highway trip distribution, 14 for public transport trip distribution (car available and no car available), and 7 for mode choice). For the destination choice, TAG median values by trip purpose and mode were adopted as a starting point for the calibration of the VDM. This is the standard approach recommended for those cases where no locally calibrated data is available. For mode choice, the above equation was solved taking account of the recommended values of θ within TAG. As the public transport destination choice parameters are consistently lower than the equivalent car values, in some case the implied mode choice sensitivity parameters had to be reduced to maintain the model hierarchy.

The resulting initial sensitivity parameters of the VDM model are shown in Table 12-3 on the following page, including comparison of the implied scaling parameters (compared to highway destination choice):

Trip Purpose	**Destination Choice Median Parameter Values**		**Mode Choice Parameter Values**	**Implied Scaling Factor (to highway)**
	Highway	Public Transport		
Home-Based Work	0.065	0.033	0.044	0.680
Home-Based Employers' Business	0.067	0.036	0.030	0.450
Home-Based Other	0.090	0.036	0.048	0.530
Home-Based Shop	0.090	0.036	0.048	0.530
Home-Based Education	0.090	0.036	0.048	0.530
Non-Home-Based Employers' Business	0.081	0.042	0.059	0.730
Non-Home-Based Other	0.077	0.033	0.062	0.810

Table 12-3: Initial Sensitivity Parameters (Before Realism Testing)

These sensitivity parameter values have then been subject to realism testing and refinement as defined by TAG Unit M2-1. This process is detailed in Section 12.4.

12.3.7 Cost Damping

There is strong empirical evidence that the sensitivity of demand responses to changes in generalised cost reduces with increasing trip length. In order to develop a model that meets the requirements of the realism tests specified in Section 12.4, it may be necessary to include this variation. The mechanisms by which this may be achieved are generally referred to as 'cost damping'. TAG prescribes the application of cost damping in those instances where a model fails to yield elasticities within TAG specified ranges.

If cost damping is employed, it should apply to all person demand responses. The same cost damping function should be applied to both car and public transport costs. While the starting position should be that the same cost damping parameter values are used for both modes, it may be necessary to vary the cost damping parameters between the modes in order to achieve satisfactory realism test results. It may also be necessary to vary cost damping parameters by trip purpose. However, these variations by mode and purpose should be avoided unless it is essential to achieve acceptable model performance.

In view of early analyses of the outturn elasticities from the model set up with TAG median parameter values, a decision was taken to employ generalised cost damping as a function of distance, achieved using the following formulation:

$$G' = \left(\frac{d}{k}\right)^{-\alpha} * \left(t + \frac{c}{VOT}\right)$$

where:

G' is the damped generalised cost;

t, c are the trip time and monetary cost, respectively;

VOT is the value of time;

$\left(t + \frac{c}{VOT}\right)$ is the generalised cost;

d is the trip length; and

α and k are parameters that need to be calibrated.

α must be positive and less than 1 and should be determined by experimentation in the course of adjusting a model so that it meets the requirements of realism tests.

k must also be positive and in the same units as d. The ways in which its value may be determined include:

- Set to the mean trip length for the modelled area; or
- Set to the national mean trip length; or
- Experiment to find an appropriate distance such that the results of the realism tests and any necessary model adjustments accord with the advice in TAG.

With this form of cost damping it is also necessary to apply a minimum distance cut-off, below which the cost damping does not apply. The purpose of such a cut-off is to prevent short-distance trips, particularly intra-zonal trips, becoming unduly sensitive to cost changes. When a cut-off is used, it is necessary to specify the distance below which generalised costs would not be reduced, that is the distance, d', up to which $\left(t + \frac{c}{VOT}\right)$ would apply. When a cut-off d' is applied, k effectively needs to be set equal to d', so that G' is a continuous function of d at the cut-off.

TAG Unit M2-1 Paragraph 3.3.15 suggests commonly used parameter values as follows:

α = 0.5;

k = 30 km; and

d' = 30 km.

Following this advice, if necessitated, initial cost damping values of $\alpha = 0.5$ and $k = 30\ km$ will be employed during realism testing and then subject to further refinement as required. However, following initial testing, no cost damping was found to be required.

12.3.8 Demand/Supply Convergence

It is of crucial importance to demonstrate that the whole model system converges to a satisfactory degree, in order to have confidence that the model results are as free from 'noise' as possible.

TAG Unit M2-1 Paragraph 6.3.4 recommends convergence within the VDM to be measured through the relative demand/supply %GAP as defined by:

$$\frac{\sum_a C(X_a{}^n)\,|\,D(C(X_a{}^n)) - X_a{}^n\,|}{\sum_a C(X_a{}^n)\,X_a{}^n} * 100$$

where:

$X_a{}^n$ is cell *a* in the previous assignment matrix for iteration *n*;

$C(X_a{}^n)$ is cell *a* in the generalised costs resulting from assigning that matrix;

$D(C(X_a{}^n))$ is cell *a* in the matrix output by the demand model based on costs $C(X_a{}^n)$; and

a represents every combination of origin, destination, demand segment/user class, time period, and mode.

The %GAP is a measure of how far the current flow is from the equilibrium point and would therefore be 0 in a perfectly converged model. TAG Unit M2-1 Paragraph 6.3.8 states that final %GAP should be below 0.2%. It is also beneficial to monitor and report the %GAP for not only the last iteration of demand and supply, but for several iterations in order to understand the stability of the model. The Chelmsford Model runs until a demand/supply %GAP convergence of 0.1% is achieved and records the %GAP reached at each iteration of the model run for reporting purposes.

12.4 Realism Testing

As detailed in TAG Unit M2-1 section 6.4.1, the Variable Demand Modelling (VDM) needs to be subjected to realism testing to check that the demand model predicts the change in choices within acceptable elasticities.

Realism testing has been undertaken for the VDM to compare the modelled elasticities with standard published values, and to check the responses are in line with expectations. Where they are not, the guidance recommends that the parameter values controlling the model's response should be adjusted until an acceptable response is achieved. This follows the Variable Demand Modelling guidance outlined in TAG Unit M2-1.

The acceptability of the model's responses to changes in costs and journey times are determined by its demand elasticities. For the Chelmsford Model VDM the model tests are expected to demonstrate the VDM responsiveness to changes in car fuel costs and car journey times. The realism tests, required by TAG M2, section 6.4, are the following:

- Fuel cost increase impact on vehicle kilometres (10%, in line with TAG guidance); and
- Change in car journey time impact on trips (due to congestion).

The acceptability of how a demand model responds to changes in costs is through the demand elasticity of the base year model. The demand elasticity calculates the proportional change in demand of changes in costs or time within the calibrated base year model and is calculated using the formula below:

$$e = (log(T^1) - log(T^0))/(log(C^1) - log(C^0))$$

where the superscripts 0 and 1 indicate values of demand, T, and cost, C, before and after the change in cost, respectively. For example, if car fuel costs increase by 10% and trips by car fall by 2%, then the elasticity of car trips with respect to fuel cost would be log (0.98) / log (1.10) = -0.212.

For the purposes of TAG realism tests, demand is in terms of vehicle kilometres (for private modes) or person trips (for public transport).

A number of studies have shown elasticity of car use with respect to fuel cost to be in the region of -0.3, therefore TAG Unit M2-1 -1 paragraph 6.4.14 states that:

- The annual average fuel cost elasticity should lie within the range of -0.25 to -0.35 overall, across all purposes; and
- The annual average fuel cost elasticity should lie on the “right side” of -0.3, taking account of the levels of income, and average trip lengths prevailing in the modelled area.

The Department for Transport (DfT) also suggests that the elasticity value should preferably fall into the appropriate side of the interval, (above or below -0.3), depending on income, mode share and purpose split for the modelled area. The characteristics of the Chelmsford modelled area which influence “right side” are summarised below. Table 12-4 shows the gross disposable household income (GDHI) by region. The income level is higher in Chelmsford than the average UK value[4] which leads to weaker elasticities.

NUTS1 Regions	GDHI per Head (£) 2018	GDHI per Head Index 2018 (UK=100)
United Kingdom	21109	100
England	21609	102.4
North East	16995	80.5
North West	18362	87
Yorkshire and The Humber	17665	83.7
East Midlands	18277	86.6
West Midlands	18222	86.3
East of England	22205	105.2
Chelmsford	23774	112.6
London	29362	139.1
South East	24318	115.2
South West	20907	99
Wales	17100	81
Scotland	19572	92.7
Northern Ireland	17340	82.1

Table 12-4: GDHI Values

[4] https://www.ons.gov.uk/economy/regionalaccounts/grossdisposablehouseholdincome/datasets/regionalgrossdisposablehouseholdincomegdhi
https://www.ons.gov.uk/economy/regionalaccounts/grossdisposablehouseholdincome/datasets/regionalgrossdisposablehouseholdincomebycombinedauthorityandcityregionsoftheuk

Table 12-5 shows the car purpose split and mode shares for average weekday for the study area. The values were derived from NTEM data.

Average Weekday Trip Ends – TEMPro7.2	Purpose Split Cars			Mode Share	
	Work	EB	Other	Car	PT
GB	23%	6%	71%	85%	15%
EAST	23%	6%	71%	90%	10%
Essex	23%	6%	72%	90%	10%
Chelmsford	22%	5%	73%	90%	10%

Table 12-5: Purpose and Mode Share for Chelmsford Modelled Area

The GDHI and the car mode share in Chelmsford is higher than the average UK values, therefore, weaker elasticities are expected.

12.4.1 Car Fuel Cost Elasticity

The car fuel cost elasticity evaluates the percentage change in car vehicle kilometres with respect to the percentage change in fuel cost. TAG states that the calculations should be carried out for a 10% or a 20% fuel cost increase. For the purposes of the Chelmsford Model, these tests have been implemented using a fuel cost increase of 20% and the elasticities have been calculated for both matrix-based and network-based formulations.

The matrix-based approach compares the change in car vehicle kilometres using the car trip matrices and skimmed distance matrices relating to the before and after fuel cost change model runs. The movements included in this calculation relate only to the movements to which the full range of demand responses apply in the demand model (as detailed in Table 12-2 in Section 12.3.1). The calculations have been carried out on both an origin-destination by assignment time period basis and 24-hour production-attraction basis. For the 24-hour production-attractions, the calculations included all trips from the internal to internal and internal to intermediate area, while the origin-destination calculations included all trips in the fully responsive area.

The network-based approach measures changes in car vehicle kilometres accumulated over the model network (links) from the before and after fuel cost change model runs. The network used for this calculation extends to cover the area over which the highway assignment model has been validated but excludes external areas where the model is more approximate. It therefore corresponds to the assignment model simulation network.

12.4.2 Car Journey Time Elasticity

The car journey time elasticity evaluates the change in car trips with respect to a change in journey time. Consistent with TAG guidance, the journey time elasticities have been calculated using a single (un-converged) run of the demand model (because the TAG target elasticities were derived from stated preference data, where the costs of each option and attribute were exogenous). For the purposes of the Chelmsford Model, these tests have been implemented using a journey time increase of 20% and the elasticities have been calculated for the total change in car trips within the demand matrices, using a single run of the demand model.

12.4.3 Public Transport Fares Elasticity

Within the Chelmsford Model, in light of the scope of the model update, no public transport fare elasticity has been undertaken.

12.5 Target Elasticities

Table 12-6 summarises the recommended elasticities that should be achieved by the realism tests that have been carried out for Phase 1 of the Chelmsford Model:

Test	High	Low
Average Fuel Cost (km)	-0.35	-0.25
Car Journey Time (Trips)	-2	0

Table 12-6: Summary of Recommended Elasticity Ranges

12.5.1 Car Fuel Cost Elasticity

The sensitivity (or demand elasticity) exhibited by the model should fall within a range of expected values. TAG M2-1 Paragraph 6.4.14 suggests that:

- The annual average fuel cost elasticity should lie within the range -0.25 to -0.35 (overall, across all purposes); and
- In addition, TAG M2-1 Paragraph 6.4.17 suggests that:
    - The pattern of annual average elasticities shows values for employers' business trips near to -0.1, for discretionary trips near to -0.4, and for commuting somewhere near the average; and
    - The pattern of all-purpose elasticities shows peak period elasticities which are weaker than inter-peak elasticities.

12.5.2 Car Journey Time Elasticity

TAG M2-1 Paragraph 6.4.28 simply states that output elasticities of the car journey times test should be checked to confirm that the model does not produce overly strong output elasticities (not stronger than -2.0).

12.6 Car Fuel Cost Test Results

Realism testing has been undertaken to compare the modelled elasticities with standard published values, and to check that the responses are in line with expectations. In cases where they were not, the parameters were modified according to the advice stated in TAG M2-1 Section 6.5: "the Department considers that analysts should start with the median lambdas and thetas and adopt a cautious, simple and systematic process for modifying these. In general, care should be taken to avoid overcomplicating the adjustments to the median lambdas and thetas. A record of all the changes made and their results should be kept and made available if requested. The aim should be to reduce the chances of peculiar combinations being selected for no good reason. Consistency in matters like this helps the Department interpret appraisals and check results for plausibility. Typically, revised lambdas and thetas which were within +25% of the median illustrative values would be regarded as acceptable and values outside this range would merit investigation".

The demand model calibration was undertaken using the median TAG distribution parameter values presented in Table 12-3 as a starting point. A sequence of model runs required and the decisions made during the calibration are described below.

12.6.1 Run 1 (Median Values)

Run 1 was undertaken with the median parameter settings as shown in Table 12-3 and no cost-damping. It was run iteratively to convergence. The car-kilometre elasticities to fuel cost were calculated in accordance with TAG Unit M2-1 where it is advised to use both matrix and network elasticity calculation methods. The 24-hour internal productions and time period origin-destination elasticity results of Run 1 are shown in Table 12-7 and Table 12-8 respectively:

Time Period	**User Class / Purpose**	**Elasticity**
		Matrix-based
24hr Matrix	HBW	-0.165
	HBEb	-0.096
	HBO	-0.388
	HBShop	-0.413
	HBEdu	-0.172
	NHBEb	-0.097
	NHBO	-0.417
	Total	-0.263

Table 12-7: Run 1 -24-hour Internal-Production Elasticity Results

Time Period	**User Class / Purpose**	**Elasticity**	**Elasticity**
		Matrix-based	Network-based
AM	Commute	-0.141	-0.099
	Employer Business	-0.087	-0.002
	Other	-0.322	-0.166
	Average	-0.182	-0.096
IP	Commute	-0.131	-0.127
	Employer Business	-0.082	-0.038
	Other	-0.300	-0.197
	Average	-0.224	-0.151
PM	Commute	-0.132	-0.108
	Employer Business	-0.066	-0.037
	Other	-0.272	-0.171
	Average	-0.179	-0.121

Table 12-8: Run 1 - Origin-Destination Elasticity Results

From Run 1 it was evident that there was a logical difference between the elasticities by purpose with the home-based other elasticity being the strongest, and employers’ business being the weakest. As expected, the peak period elasticities (AM and PM peak) were weaker than inter-peak elasticities due to a higher proportion of “other” travel.

Overall, the 24-hour elasticity response was weak, especially with regards to Home-Based Other, and Home-Based Work. Sector-based analysis of the elasticity results was carried out which showed the expected smaller and even positive elasticities along the diagonal of the matrix (for short-distance trips) with increased fuel costs but revealed large elasticities in the responses of longer-distance trips. This analysis therefore highlighted the need for distance-based cost-damping (as described in Section 12.3.7 above) for Home-based-Other travel. The cost damping, however, would further weaken the elasticities of Home-based Work and Employers' Business. To address the weak elasticities, the distribution parameters required adjustment. To understand the effects of both changes, the distribution parameter changes were implemented sequentially.

12.6.2 Run 2 (Increased Strength of Responses by 10%)

Based on the results of Run 1, Run 2 implemented a 10% increase to the distribution parameters for car and public transport. No alterations were made to the mode choice parameters which was derived from the median distribution parameters (Table 12-3) and no cost damping introduced.

The 24-hour average demand elasticity was close to -0.3 (total across all purposes), with values for employers' business trips near to -0.1, for discretionary trips near to -0.4, and for commuting on the slightly weaker side of the average. The relative pattern of elasticities showed time-period (AM and PM peak) elasticities being weaker than inter-peak elasticities, as expected. The AM and PM peak elasticities come out weaker than the recommended range of -0.25 to -0.35, but the result was deemed suitable given the overall 24-hour average of -0.293 achieved across all time periods and purposes.

The 24-hour internal productions and peak period origin-destination elasticity results of Run 2 are shown in Table 12-9 and Table 12-10 respectively:

Time Period	User Class / Purpose	Elasticity
		Matrix-based
24hr Matrix	HBW	-0.184
	HBEb	-0.105
	HBO	-0.433
	HBShop	-0.458
	HBEdu	-0.191
	NHBEb	-0.109
	NHBO	-0.465
	Total	-0.293

Table 12-9: Run 1 - 24-hour Internal-Production Elasticity Results

Time Period	User Class / Purpose	Elasticity	Elasticity
		Matrix-based	Network-based
AM	Commute	-0.164	-0.117
	Employer Business	-0.094	-0.007
	Other	-0.365	-0.191
	Average	-0.208	-0.113
IP	Commute	-0.152	-0.146
	Employer Business	-0.094	-0.037
	Other	-0.345	-0.224
	Average	-0.258	-0.171
PM	Commute	-0.158	-0.135
	Employer Business	-0.079	-0.051
	Other	-0.313	-0.211
	Average	-0.209	-0.150

Table 12-10: Run 1 - Origin-Destination Elasticity Results

The results were considered acceptable and Run 2 parameters were used for the subsequent car journey time tests described in Section 12.7.

12.7 Car Journey Time Test Results

In line with guidance, the car journey time elasticity test was conducted as per the formula below:

$$E^{time} = E^{fuel} \frac{aT}{bK}$$

Where K is the total vehicle kilometres, T is the total vehicle hours and a is the cost per hour from the generalised cost function and b is the cost per kilometre.

The 24-hour internal productions and peak period origin-destination elasticity results for the change in car trips with respect to the change in journey times are shown in Table 12-11 and Table 12-12 respectively:

Time Period	User Class / Purpose	Elasticity
		Matrix-based
24hr Matrix	HBW	-0.645
	HBEb	-0.294
	HBO	-1.145
	HBShop	-1.147
	HBEdu	-0.597
	NHBEb	-0.305
	NHBO	-1.122
	Total	-0.866

Table 12-11: 24-hour Internal-Production Car Journey Time Elasticity Results

Time Period	User Class / Purpose	Elasticity
		Matrix-based
AM	Commute	-0.599
	Employer Business	-0.286
	Other	-0.987
	Average	-0.679
IP	Commute	-0.498
	Employer Business	-0.258
	Other	-0.866
	Average	-0.691
PM	Commute	-0.569
	Employer Business	-0.212
	Other	-0.875
	Average	-0.640

Table 12-12: Origin-Destination Car Journey Time Elasticity Results

It is evident that the output elasticities of the car journey time test are suitably within the range suggested by TAG (no stronger than -2.0 for any demand purpose at 24-hour level or any user class at the peak hour assignment level).

12.8 Final Sensitivity Parameters

The final sensitivity parameters (Run 2) used in the Chelmsford Model are summarised in Table 12-13:

Trip Purpose	Destination Choice Median Parameter Values		Mode Choice Parameter Values	Implied Scaling Factor (to Highway)
	Highway	Public Transport		
Home-Based Work	0.072	0.036	0.049	0.680
Home-Based Employers' Business	0.074	0.040	0.033	0.450
Home-Based Other	0.099	0.040	0.052	0.530
Home-Based Shop	0.099	0.040	0.052	0.530
Home-Based Education	0.099	0.040	0.052	0.530
Non-Home-Based Employers' Business	0.089	0.046	0.065	0.730
Non-Home-Based Other	0.085	0.036	0.069	0.810

Table 12-13: Final Sensitivity Parameters

In line with the guidance, the final revised destination and mode choice parameter values lie within +25% of the TAG median illustrative values and are therefore regarded as acceptable.

Realism tests readily converged with a relative gap of 0.09% after 2 iterations. This is in line with TAG M2-1 paragraph 6.3.8.

13 Summary of Model

13.1 Summary of Model Development

To provide the evidence base for a planning application for CNEB and a potential outline business case for a scheme to improve the Army and Navy junction required an update to the existing Chelmsford Model. This update needed to be to a standard sufficient for these purposes, with the arbiter of that potentially being the DfT. It also provided an opportunity to feed any critical updates from local studies (related to observed data or networks information) back to the Chelmsford Model in order to keep it up to date and increase its utility and quality in each subsequent application.

The updated Chelmsford Model is designed to support the assessment of planning applications and business cases, including the application for CNEB and an OBC for a scheme to improve the Army and Navy junction.

The model update approach made use of previous work on the development of the Essex Countywide Strategic Model; that model used mobile network data to formulate the highway demand and formed the base demand for the Chelmsford model update. The 2017 Essex Countywide Model prior matrices were used as the starting point for the updated Chelmsford Model matrices. Using the matrices provides analytical consistency and removes duplication of work.

Most of the network has been retained from the existing Chelmsford Model which was further checked and refined to reflect the scope of the model update. The new model also included extended network coverage and network detail to the north and east of Chelmsford to enable the impacts of CNEB to be fully captured.

The modelled assignment satisfies the TAG criteria for a well converged model. Modelled flows and journey times compare favourably to observed data, both for independent data, and data used as part of the model building process. This is particularly true for observed data in the vicinity of areas likely to be affected by the proposed scheme. Journey times exceed the criteria set out in the guidance, and in the majority of time periods flow validation exceeds the criteria set out in the guidance. The VDM was assessed through realism testing and found to achieve sensible elasticities.

13.2 Summary of Standards Achieved

The standards to which the model aims to conform are set out in Section 3. Table 13-1, on the next page, summarises how the model has actually performed against those standards.

Model Aspect	Criterion	Acceptability Guideline	Actual Model Performance
Matrix validation	Differences between modelled flows and counts should be less than 5% of the counts	All or nearly all screenlines	Criteria is met for nearly all screenlines.
Matrix estimation	Matrix zonal cell values	Slope within 0.98 and 1.02 Intercept near zero R^2 in excess of 0.95	Model meets the criteria for cars and all vehicles.
	Matrix zone trip ends	Slope within 0.99 and 1.01 Intercept near zero R^2 in excess of 0.98	Model meets the criteria for cars and all vehicles.
	Trip length distributions	Means within 5% Standard deviations within 5%	Change in average and standard deviation trip lengths is minimal and well within guidelines for cars and all vehicles.
	Sector to sector level matrices	Differences within 5%	Does not meet the criterion in all time periods.
Assignment convergence	Delta and %GAP	Less than 0.1%	GAP value of less than 0.1% is met in all time periods, and the change in GEH and queue length shows stability in the model.
Link calibration	Individual flows within 100 veh/hr of counts for flows less than 700 veh/hr	> 85% of cases	AM peak: > 85% criteria met for car flows and total vehicles Interpeak: > 85% criteria met for car flows and total vehicles PM peak: > 85% criteria met for car flows and total vehicles In summary, criteria were satisfied in all time periods
	Individual flows within 15% of counts for flows from 700 veh/hr to 2,700 veh/hr	> 85% of cases	
	Individual flows within 400 veh/hr of counts for flows more than 2,700 veh/hr	> 85% of cases	
	GEH < 5 for individual flows	> 85% of cases	
Link validation	Same as for link calibration, but for independent counts		AM peak: > 85% criteria met for car flows and total vehicles Interpeak: > 85% criteria met for car flows and total vehicles PM peak: > 85% criteria met for car flows and total vehicles In summary, criteria were satisfied in all time periods
Journey times	Modelled times along routes should be within 15% of surveyed time, or 1 minute if higher	> 85% of all routes	89%, 100% and 86% of journey time routes in the AM, IP and PM respectively are within the TAG criteria

Table 13-1: Summary of Standards Achieved

13.3 Assessment of Fitness for Purpose

As demonstrated in this LMVR, the Model has been constructed in a manner consistent with guidance and performs well against the standards set out in TAG. Modelled flows and journey times compare favourably to observed data, both for independent data, and data used as part of the model building process.

This should serve to give confidence and provide reassurance that the Model is representative of current conditions. However, it is acknowledged that simply meeting the validation criteria does not in itself qualify the Model to be a suitable tool for assessing the effects of a planning application for CNEB and a potential outline business case for a scheme to improve the Army and Navy junction.

To consider further whether the Model is suitable for those two assessments, the quality of the Model's representation of the observed traffic conditions around those schemes has been considered. It was found that the Model does replicate observed conditions in the vicinity of the two schemes. Given that the model has a very good overall level of validation and that it validates very well in the vicinity of the schemes, and noting that the Model has been developed consistently with TAG, it is considered that the Model is fit for purpose for the assessment of the aforementioned schemes.

A secondary purpose intended for the Model is that it can be used for assessments of impacts of other (as yet unspecified) schemes around Chelmsford. As evidenced by the overall calibration/validation statistics, it is considered that the Model provides a good overall representation of current travel conditions for those areas included within the modelled network and it is therefore considered very likely that the model would be suitable for those purposes as well. However, the suitability of the Model for assessing any specific schemes with a significant impact in the local area should be reviewed once more is known about those schemes; simply because the Model is considered suitable for CNEB and Army and Navy, it does not automatically follow that it would be suitable for other purposes (although it is likely that even if the Model were found not suitable, only relatively minor revisions would be necessary).

Appendix A - Volume Delay Function Technical Note

1.1 Introduction

This technical note sets out the methodology for determining the Volume Delay Functions (VDF) which was applied during the development of the Chelmsford model and for other modelling projects on the VISUM platform. It is anticipated that during model calibration, the parameters will be modified to better fit local conditions.

For links in a highway transport model, the parameters governing speeds, capacities and the relationship between speed and traffic flow (or in other terms volume and delay) are derived from the COBA manual. The link characteristics described in the manual are translated into appropriate Volume-Delay Function (VDF) parameters in VISUM or Speed-Flow Curve (SFC) parameters in SATURN for use in the model development.

In order to have a consistent modelling approach, a correlation exercise between SATURN SFCs and VISUM VDFs was undertaken where the Traffic Appraisal, Modelling and Economics group (TAME) approved Speed Flow Curves that were adopted in Regional Transport Models (RTM) were used as a starting point. SFCs in RTMs were defined for various link types which broadly fall under the following categories:

a) Motorway

b) Rural All Purpose

c) Rural Roads

d) Suburban

e) Urban

f) Small town

The SATURN methodology makes use of three pieces of information from the COBA curve; these are the free flow speed (S_0), the speed (S_1) at intermediate break point where the curve gradient (F) changes, and the Speed (S_2) at Capacity (C). The SATURN power curve made use of these parameters and the best fit value of power N was then determined. As per Section 5 of the SATURN manual, the travel time on a link is determined based on the power law curve below:

$$t = \begin{cases} t_0 + A \cdot (V)^n, & V \leq C \\ t_0 + A \cdot (C)^n + B.\left(\frac{V - C}{C}\right), & V \geq C \end{cases}$$

Where: t is the calculated link travel time, t_0 is the link travel time at free flow conditions, V is the flow on the link, C is the link capacity, and B is a constant which is equal to 30*length of time period modelled which is typically one hour.

The travel time on a link in VISUM is determined by different pre-defined VDFs in the software:

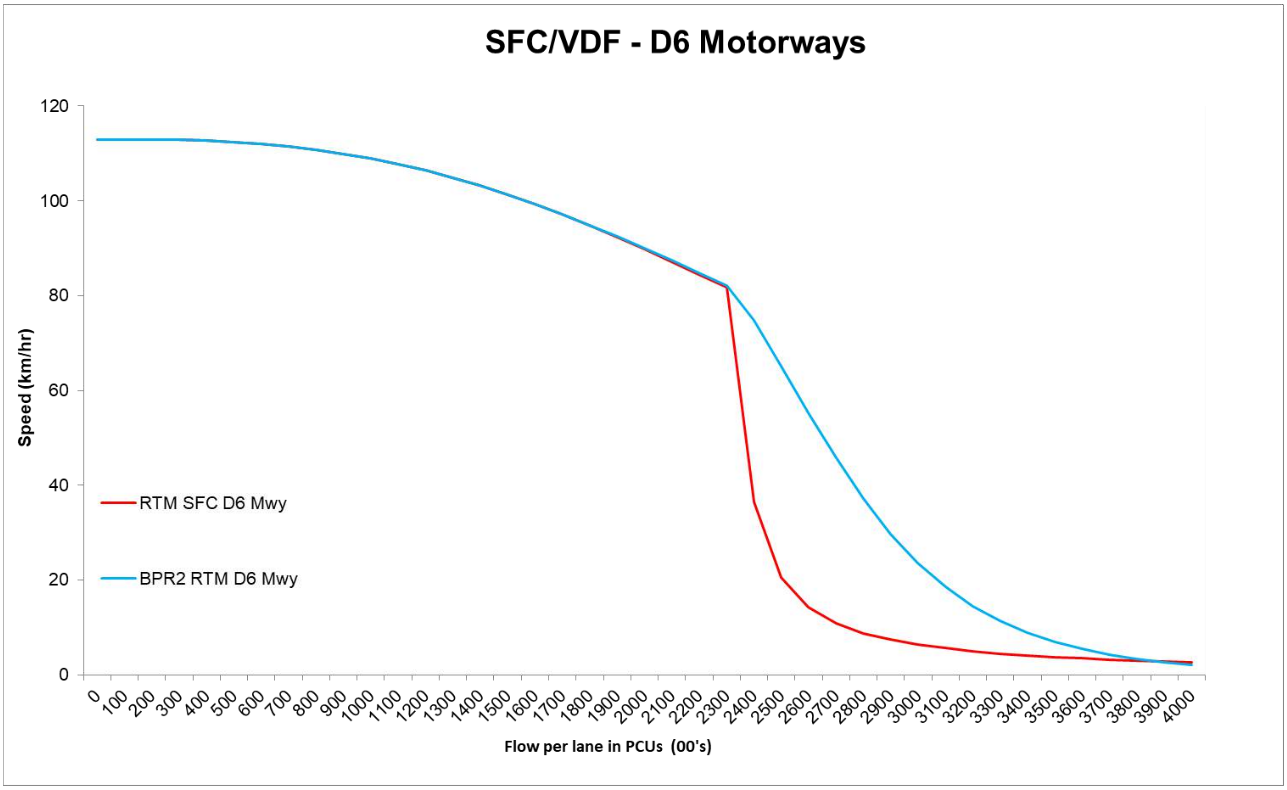
a) Based on previous VISUM best practices that Jacobs have developed, a VDF called "BPR2" (developed by the US Bureau of Public Roads) was used in several model development studies. The BPR2 curve takes the form shown below:

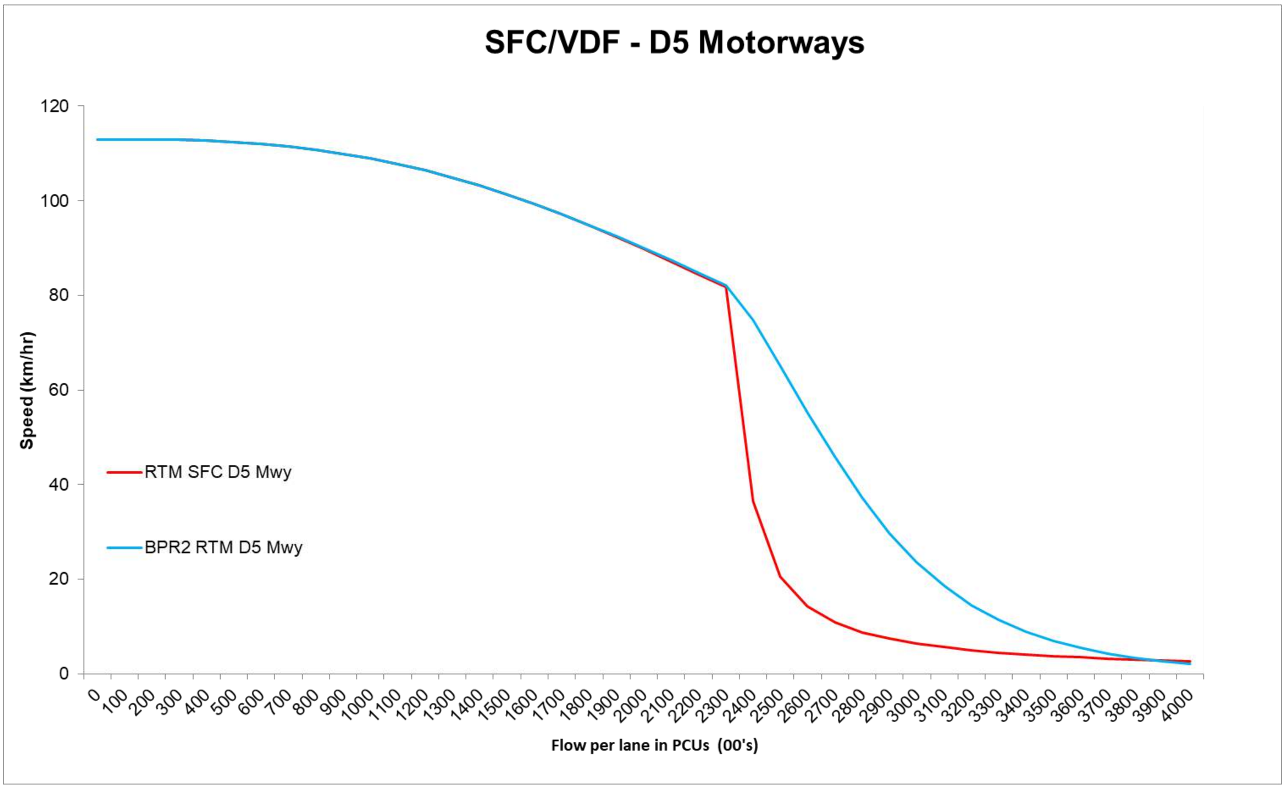
$$t_{cur} = \begin{cases} t_0\left(1 + a \cdot \left(\frac{q}{q_{max} \cdot c}\right)^b\right), & \frac{q}{q_{max} \cdot c} \leq 1 \\ t_0\left(1 + a \cdot \left(\frac{q}{q_{max} \cdot c}\right)^{b'}\right), & \frac{q}{q_{max} \cdot c} > 1 \end{cases}$$

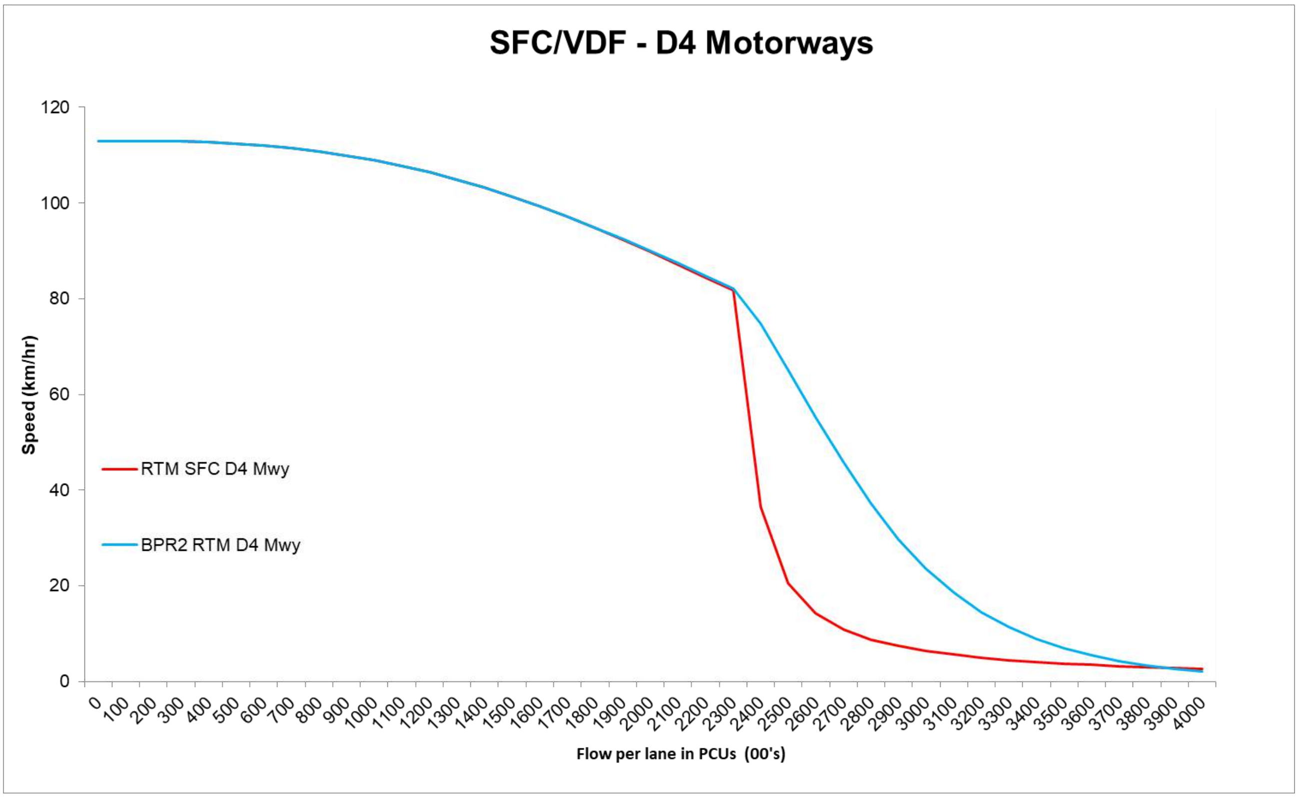
Where: t_{cur} is the calculated link travel time, t_0 is the link travel time at free flow conditions, q is the flow on the link, q_{max} is the link capacity, and a, b, b', and c are parameters specific to each link type.

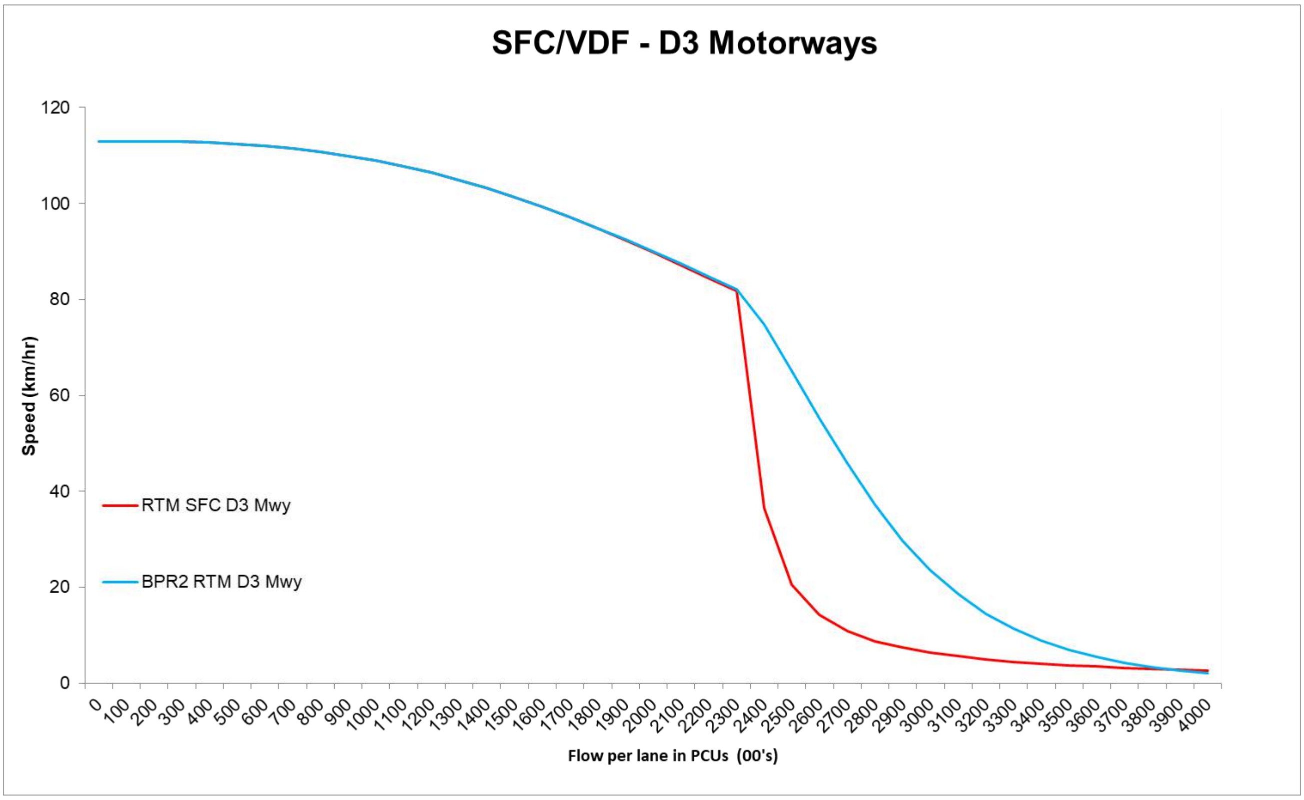
1.2 VDF – SFC Correlation

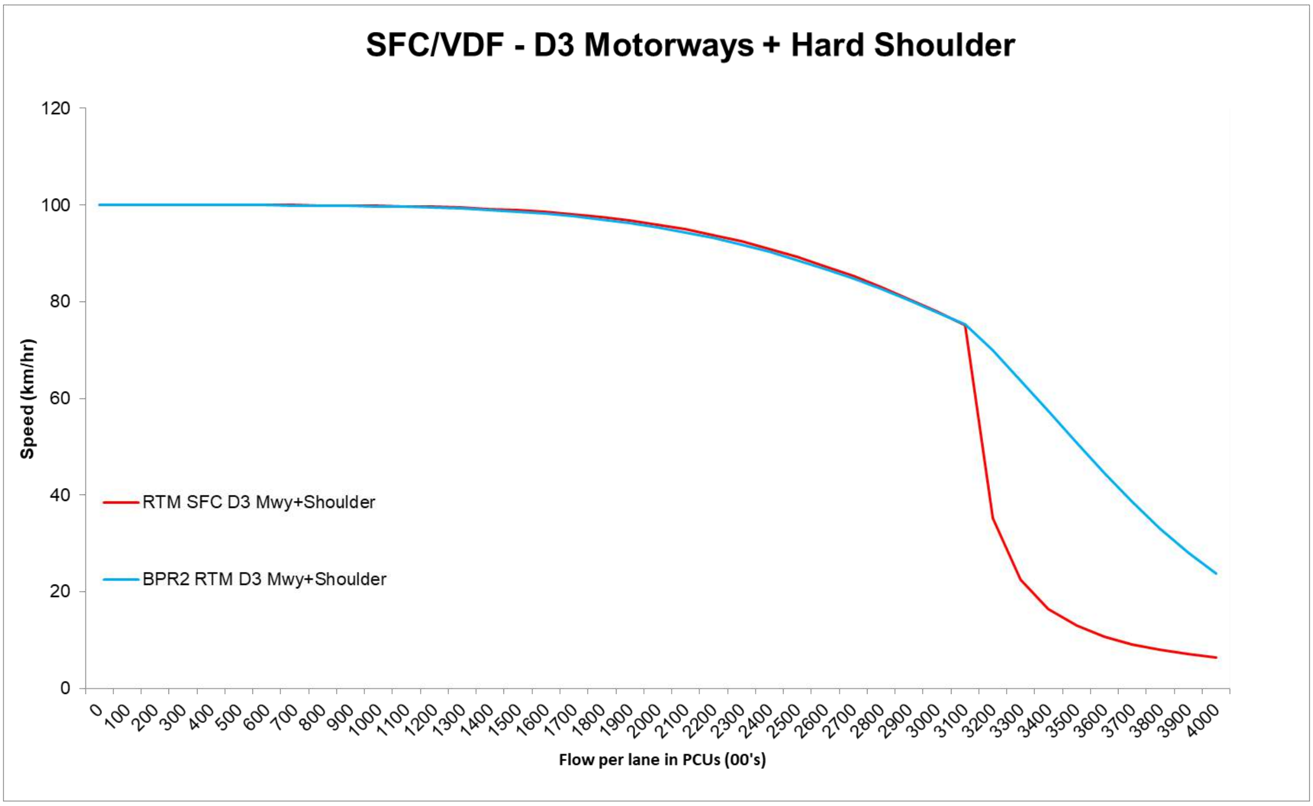
This section illustrates the correlation exercise undertaken to fit VDF to the RTM SFC curves for different link types. The parameters used to fit the individual VDF curve have also been presented.

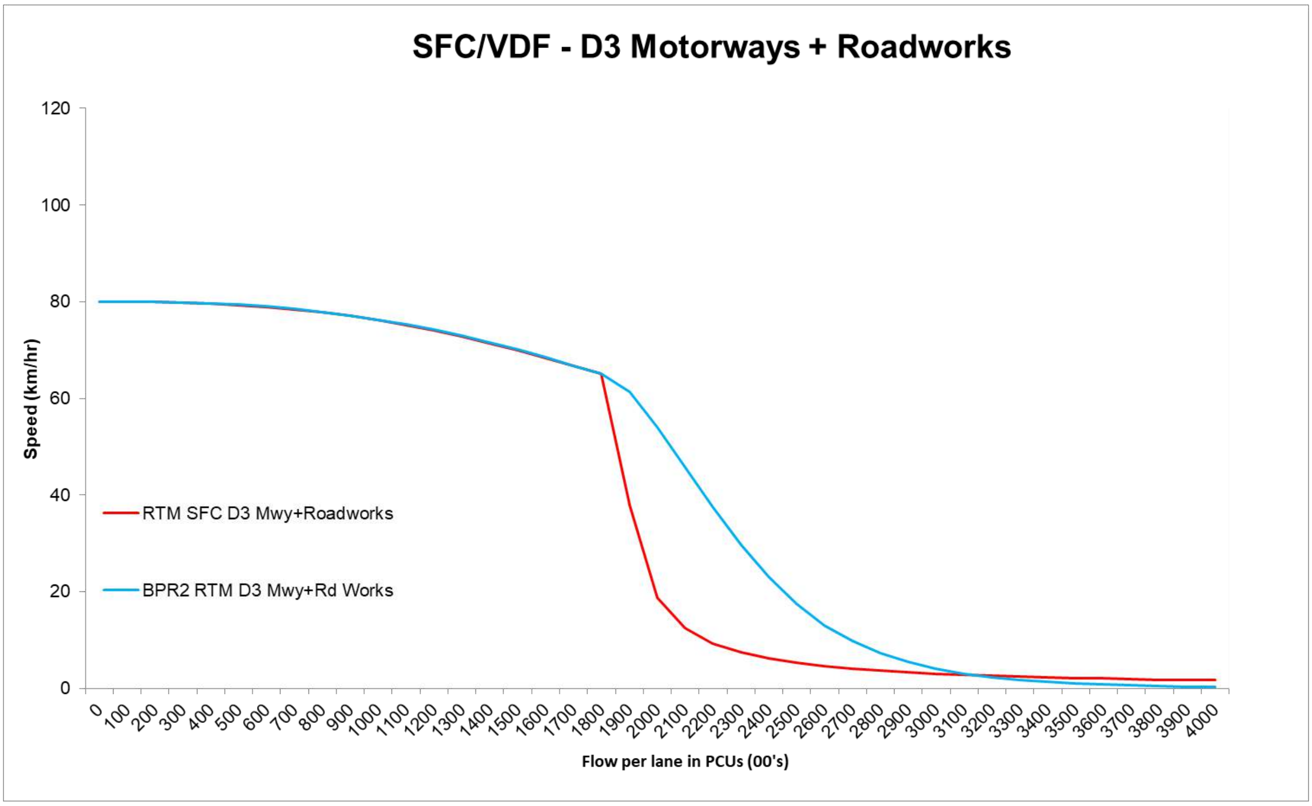

SFC/VDF - D6 Motorways
Speed (km/hr)
120
100
80
60
40
20
0
RTM SFC D6 Mwy
BPR2 RTM D6 Mwy
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400 2500 2600 2700 2800 2900 3000 3100 3200 3300 3400 3500 3600 3700 3800 3900 4000
Flow per lane in PCUs (00's)

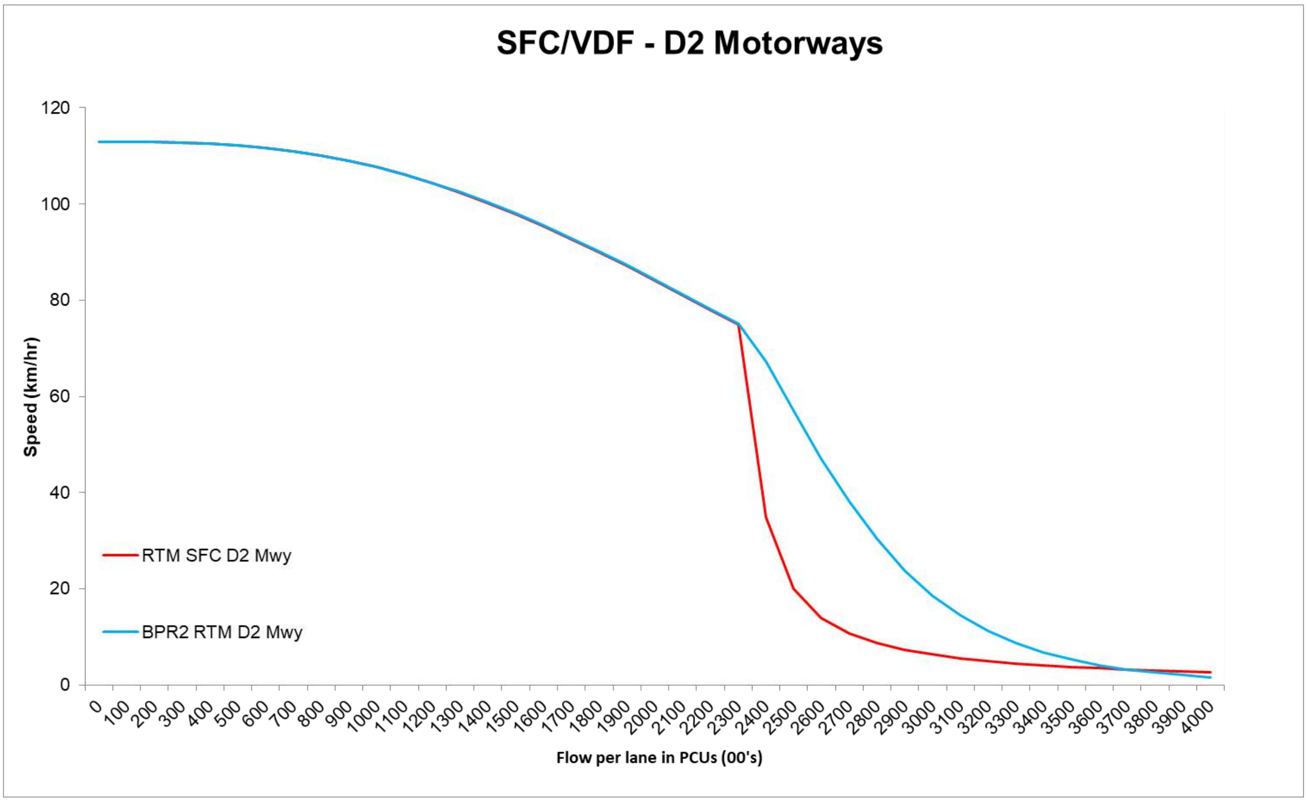

SFC/VDF - D5 Motorways
Speed (km/hr)
120
100
80
60
40
20
0
RTM SFC D5 Mwy
BPR2 RTM D5 Mwy
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400 2500 2600 2700 2800 2900 3000 3100 3200 3300 3400 3500 3600 3700 3800 3900 4000
Flow per lane in PCUs (00's)

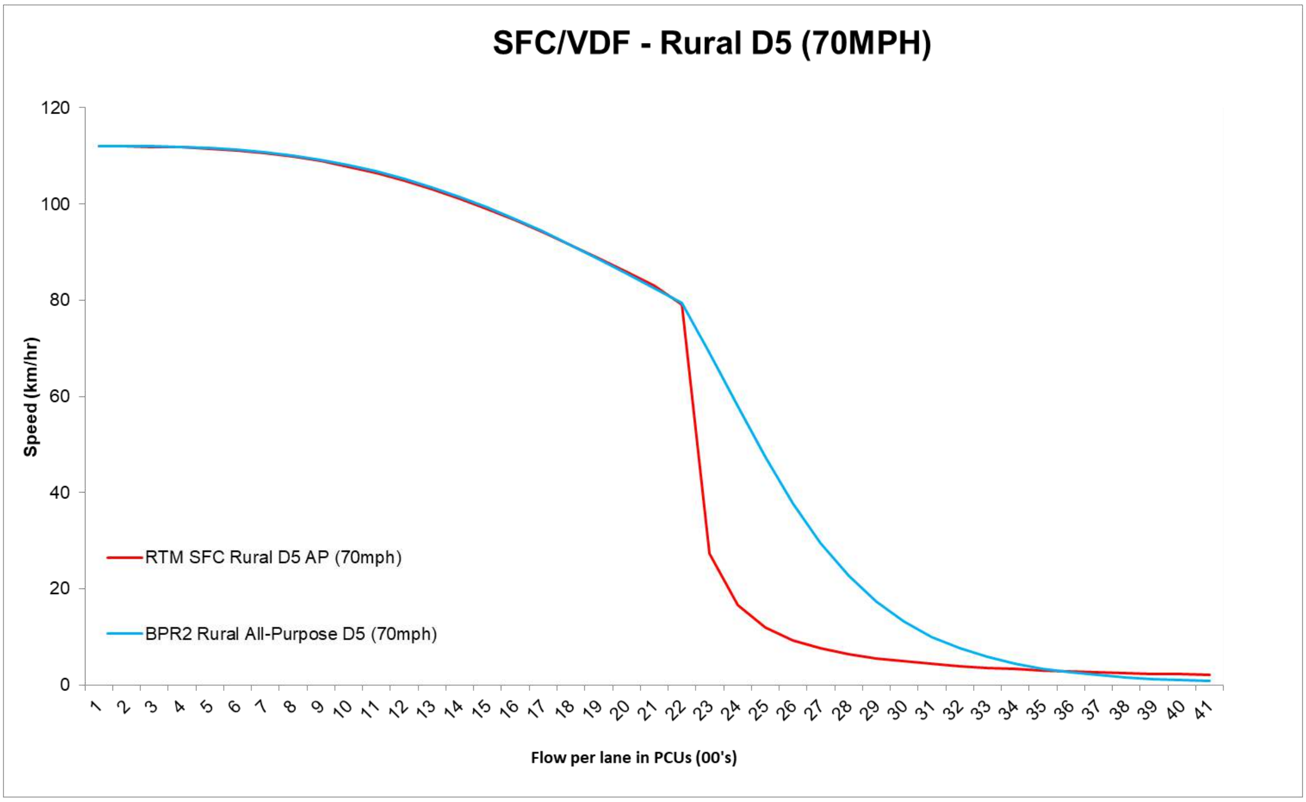

SFC/VDF - D4 Motorways
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM SFC D4 Mwy
BPR2 RTM D4 Mwy
0
20
40
60
80
100
120
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400 2500 2600 2700 2800 2900 3000 3100 3200 3300 3400 3500 3600 3700 3800 3900 4000

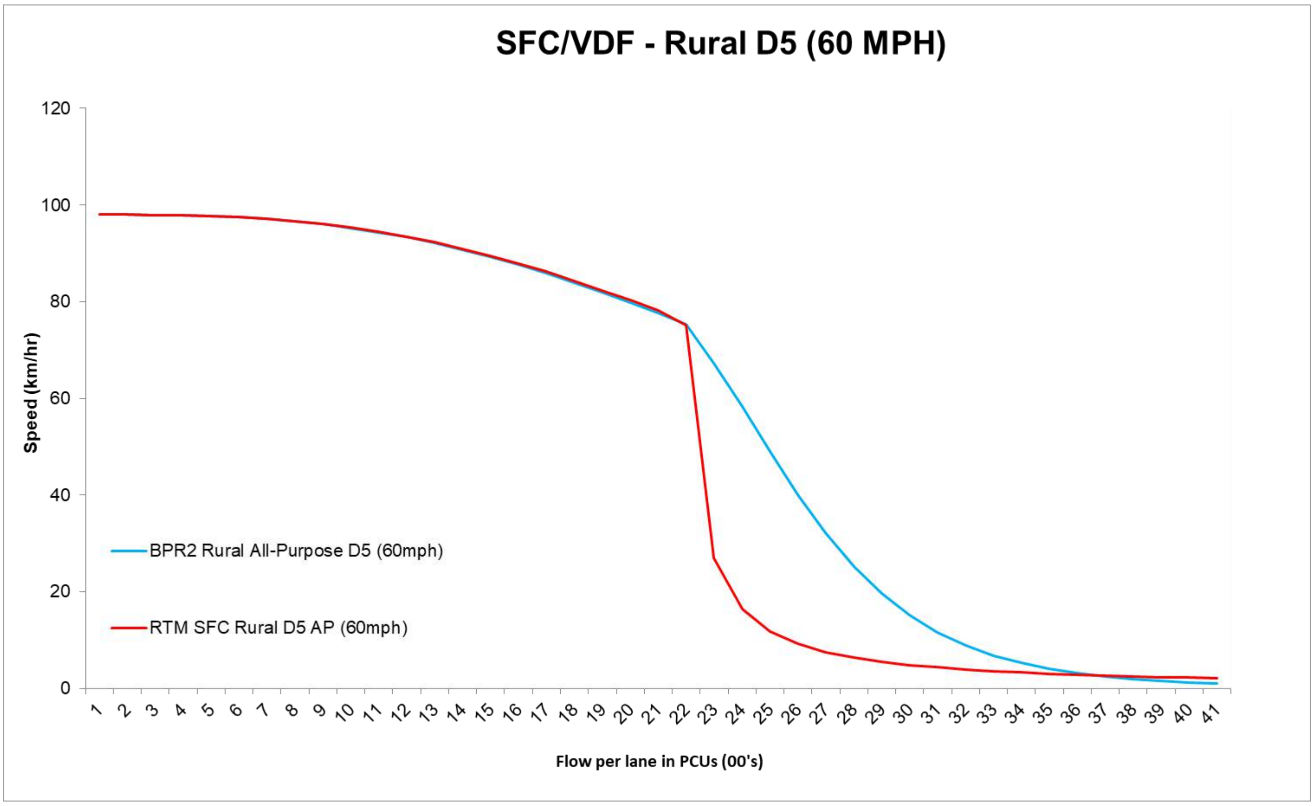

SFC/VDF - D3 Motorways
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM SFC D3 Mwy
BPR2 RTM D3 Mwy
0
20
40
60
80
100
120
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400 2500 2600 2700 2800 2900 3000 3100 3200 3300 3400 3500 3600 3700 3800 3900 4000

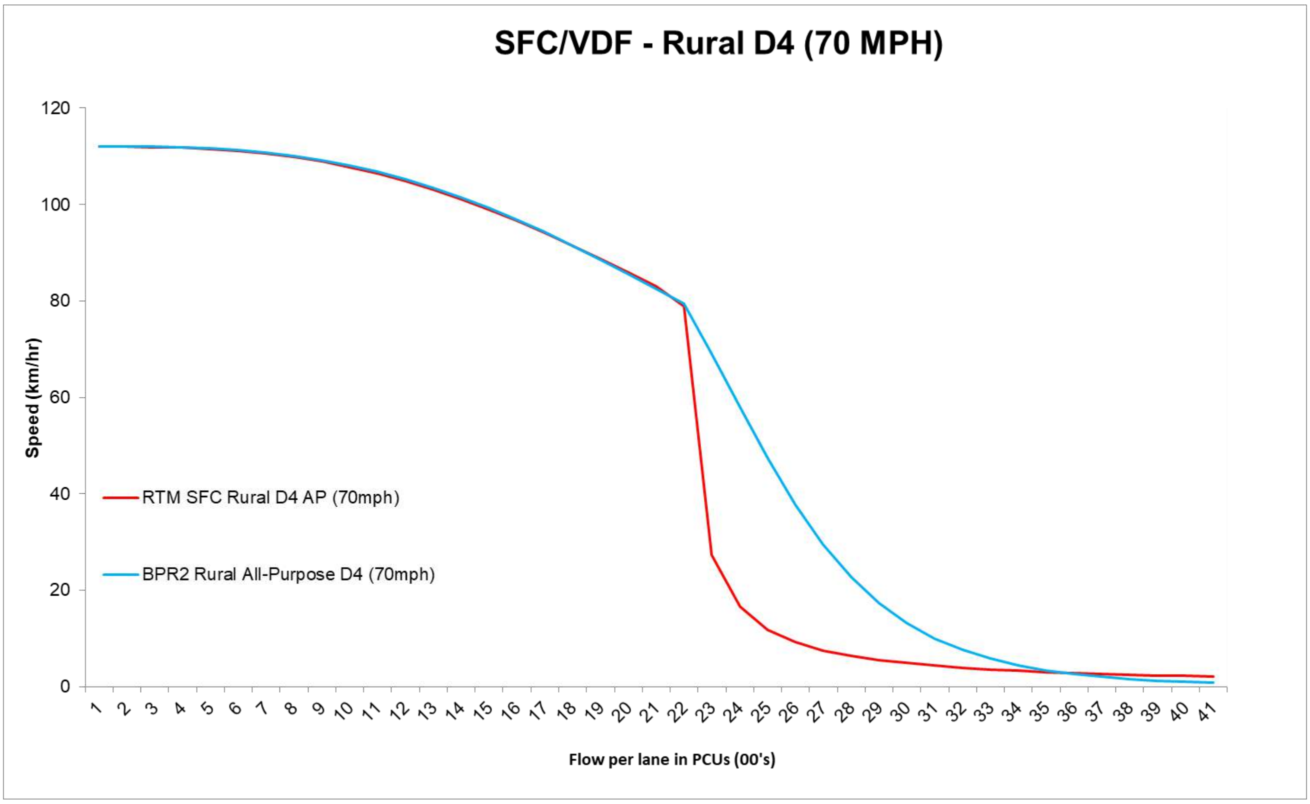

SFC/VDF - D3 Motorways + Hard Shoulder
Speed (km/hr)
120
100
80
60
40
20
0
RTM SFC D3 Mwy+Shoulder
BPR2 RTM D3 Mwy+Shoulder
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000
3100
3200
3300
3400
3500
3600
3700
3800
3900
4000
Flow per lane in PCUs (00's)

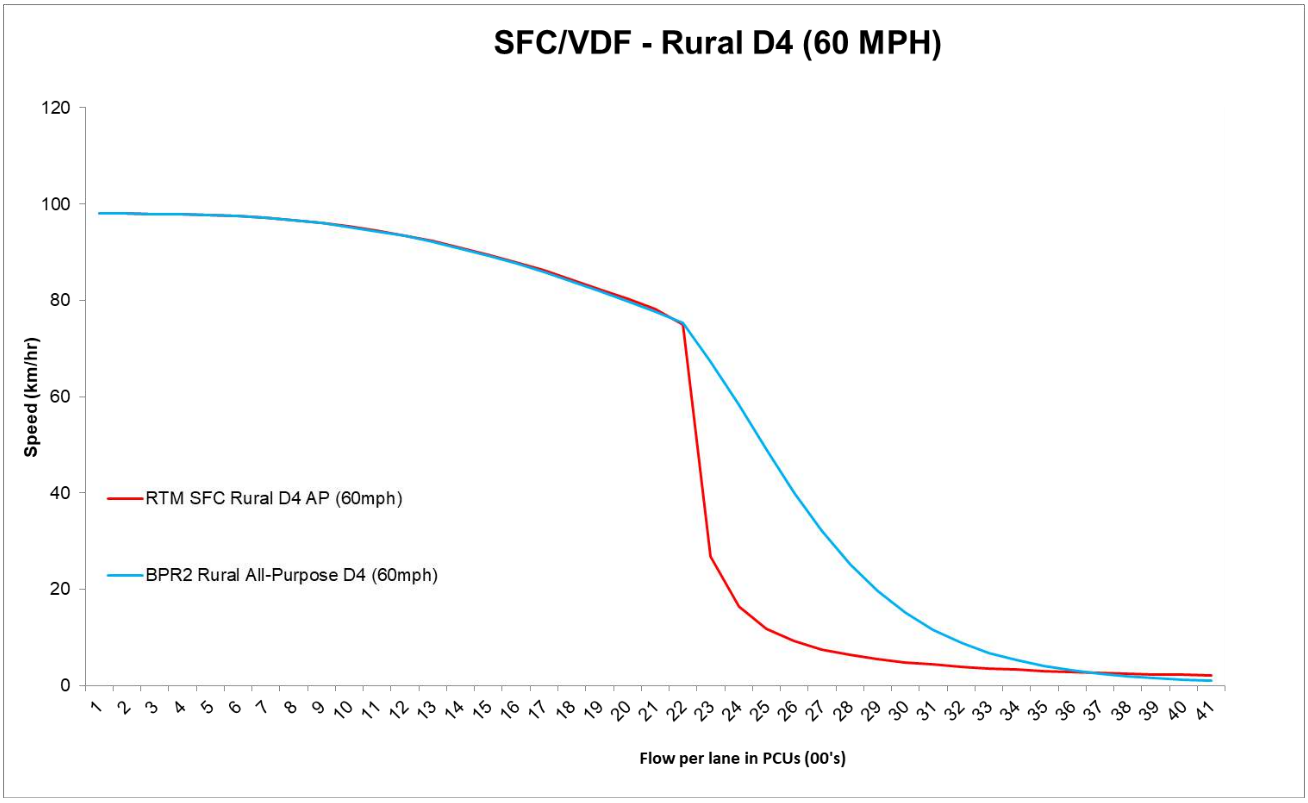

SFC/VDF - D3 Motorways + Roadworks
Speed (km/hr)
120
100
80
60
40
20
0
RTM SFC D3 Mwy+Roadworks
BPR2 RTM D3 Mwy+Rd Works
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000
3100
3200
3300
3400
3500
3600
3700
3800
3900
4000
Flow per lane in PCUs (00's)

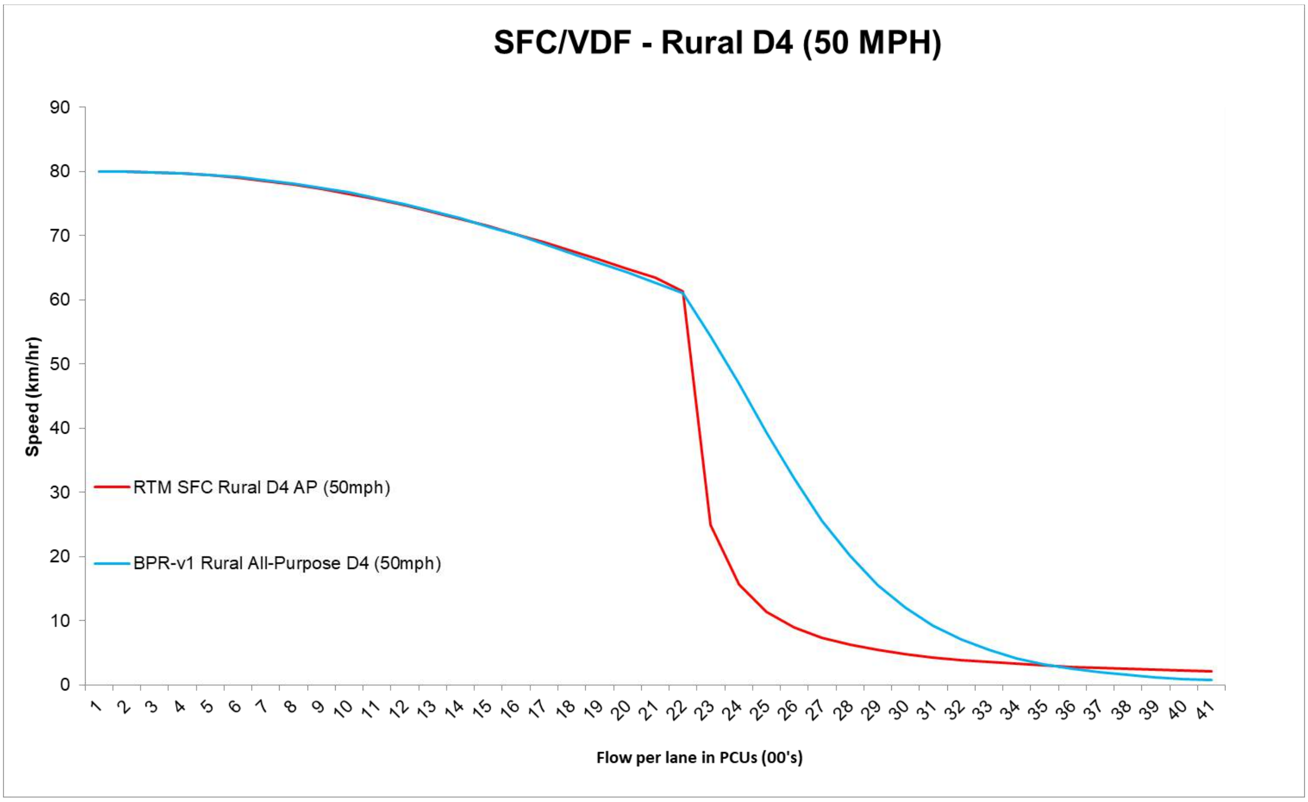

SFC/VDF - D2 Motorways
Speed (km/hr)
120
100
80
60
40
20
0
RTM SFC D2 Mwy
BPR2 RTM D2 Mwy
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000
3100
3200
3300
3400
3500
3600
3700
3800
3900
4000
Flow per lane in PCUs (00's)

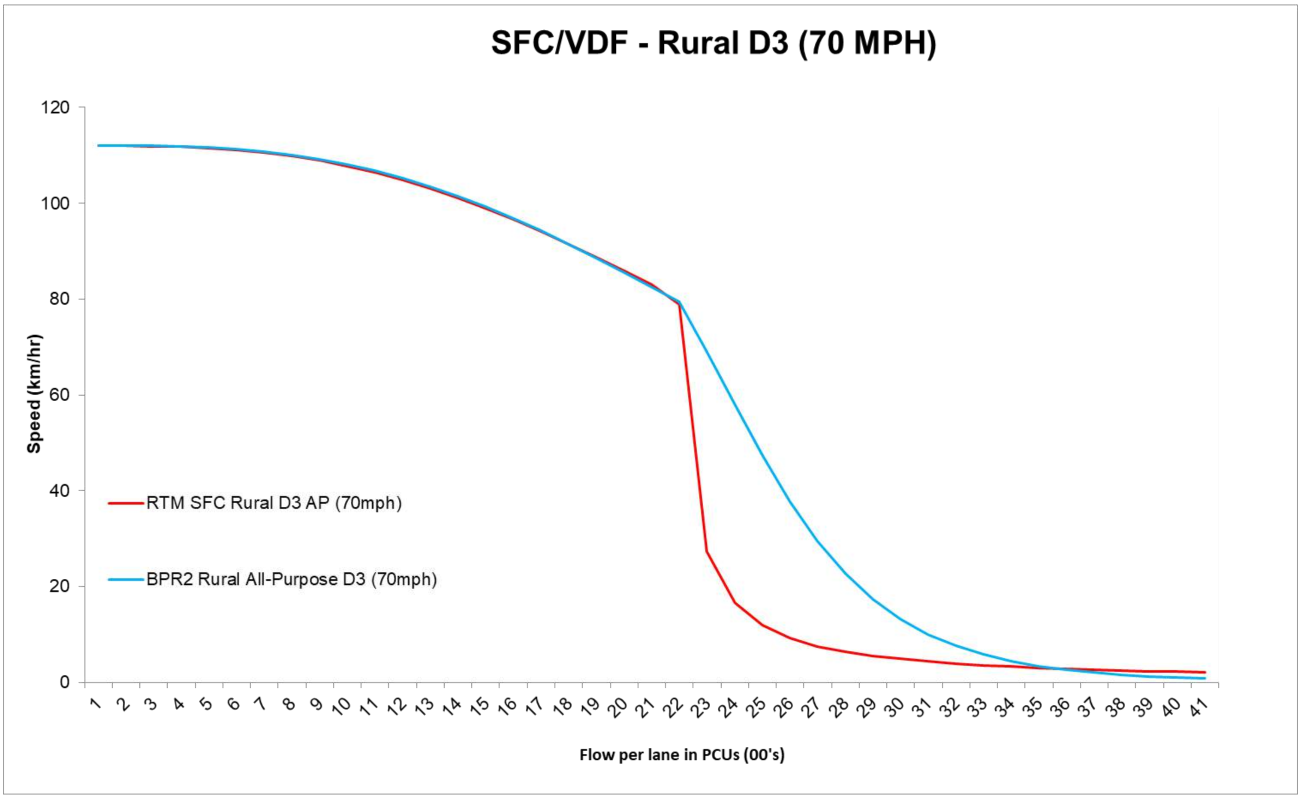

SFC/VDF - Rural D5 (70MPH)
Speed (km/hr)
120
100
80
60
40
20
0
RTM SFC Rural D5 AP (70mph)
BPR2 Rural All-Purpose D5 (70mph)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
Flow per lane in PCUs (00's)

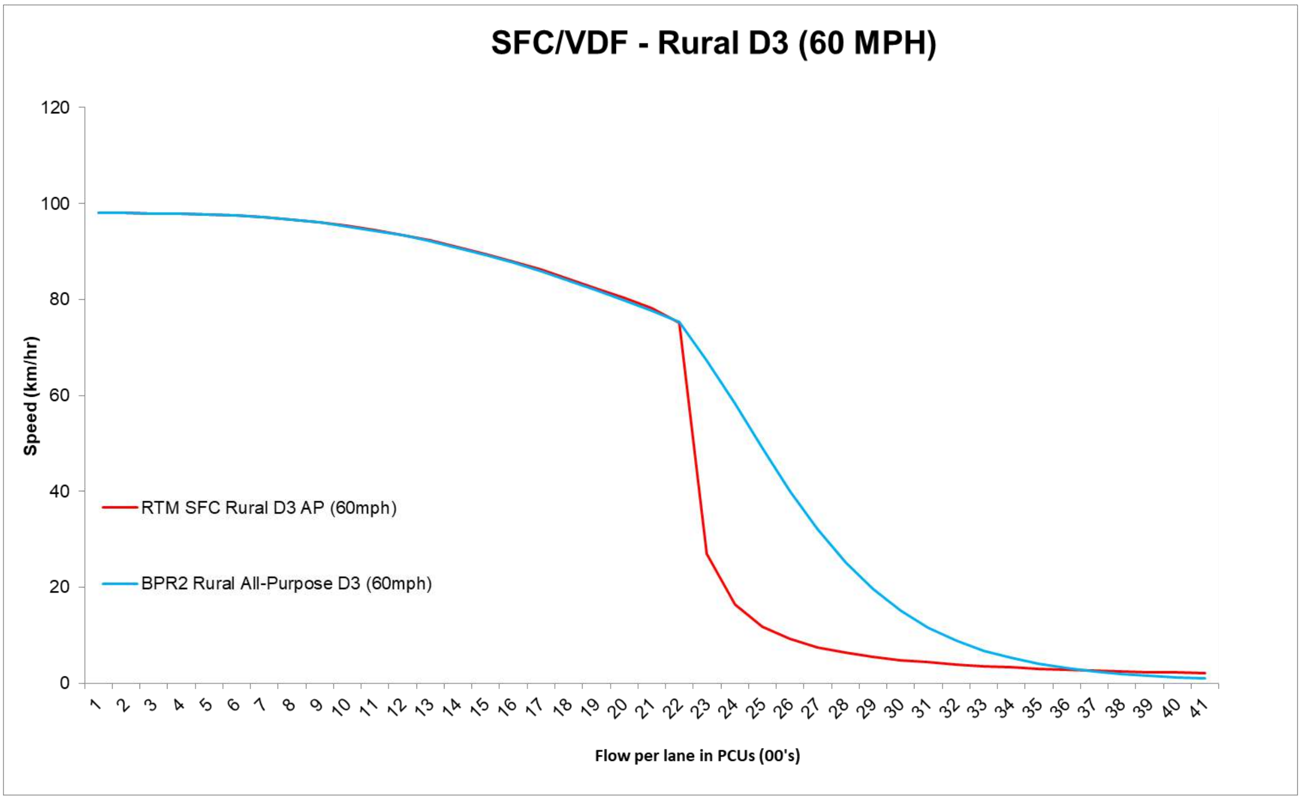

SFC/VDF - Rural D5 (60 MPH)
Speed (km/hr)
Flow per lane in PCUs (00's)
BPR2 Rural All-Purpose D5 (60mph)
RTM SFC Rural D5 AP (60mph)

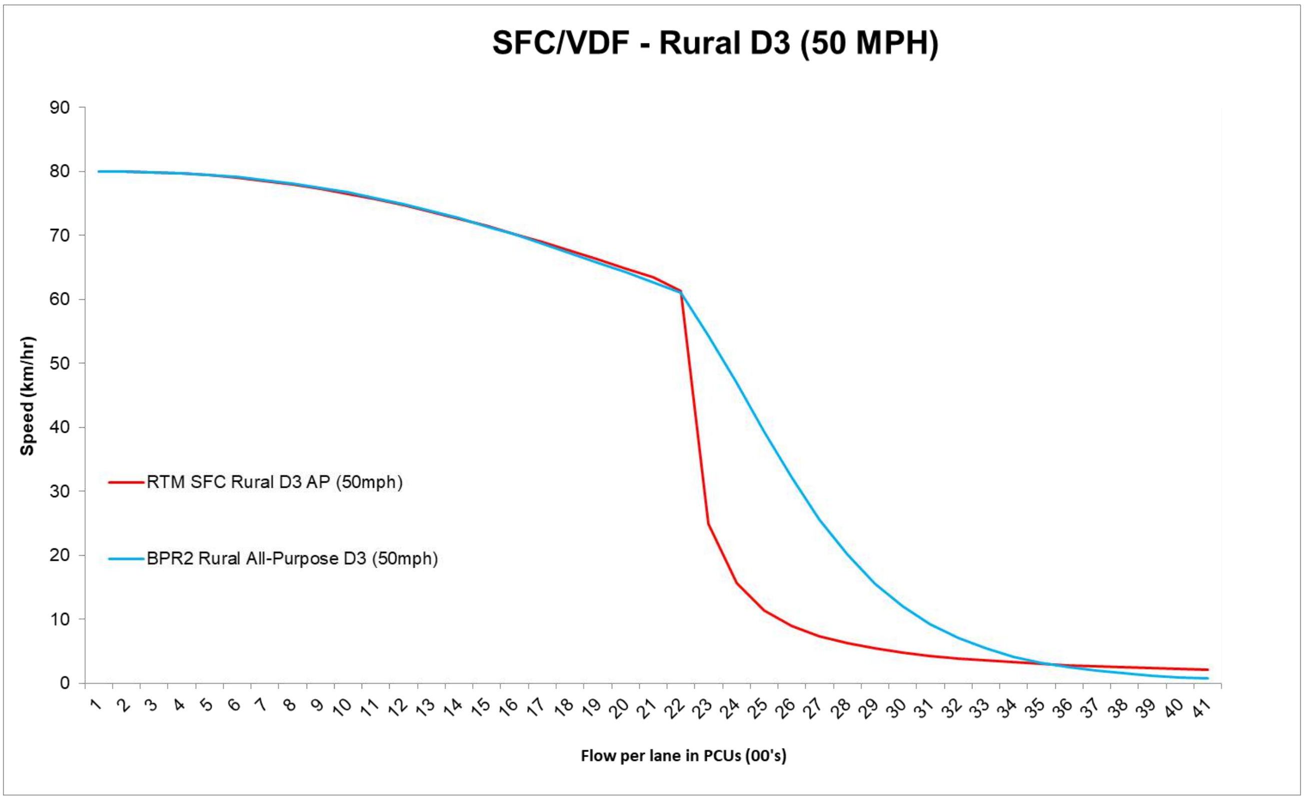

SFC/VDF - Rural D4 (70 MPH)
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM SFC Rural D4 AP (70mph)
BPR2 Rural All-Purpose D4 (70mph)


SFC/VDF - Rural D4 (60 MPH)
Speed (km/hr)
0
20
40
60
80
100
120
RTM SFC Rural D4 AP (60mph)
BPR2 Rural All-Purpose D4 (60mph)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Flow per lane in PCUs (00's)

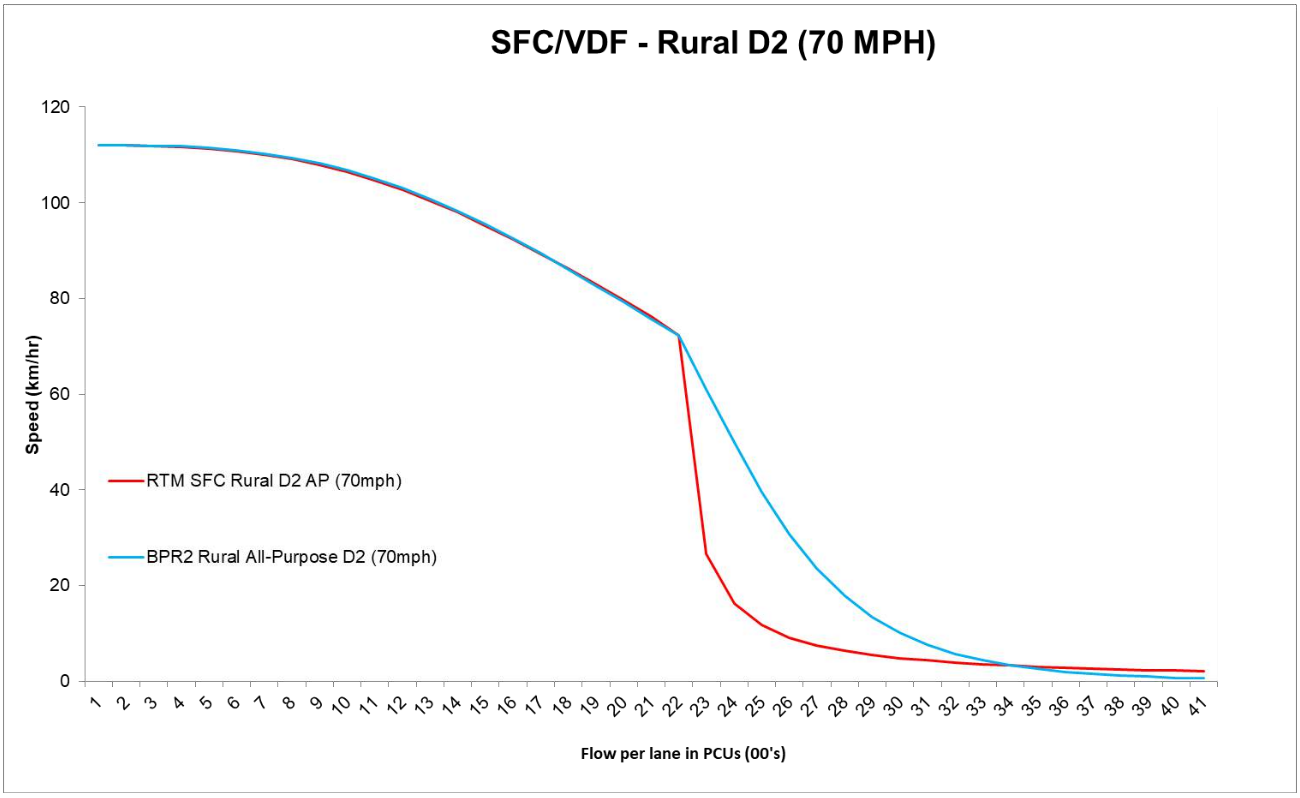

SFC/VDF - Rural D4 (50 MPH)
Speed (km/hr)
0
10
20
30
40
50
60
70
80
90
RTM SFC Rural D4 AP (50mph)
BPR-v1 Rural All-Purpose D4 (50mph)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Flow per lane in PCUs (00's)


SFC/VDF - Rural D3 (70 MPH)
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM SFC Rural D3 AP (70mph)
BPR2 Rural All-Purpose D3 (70mph)

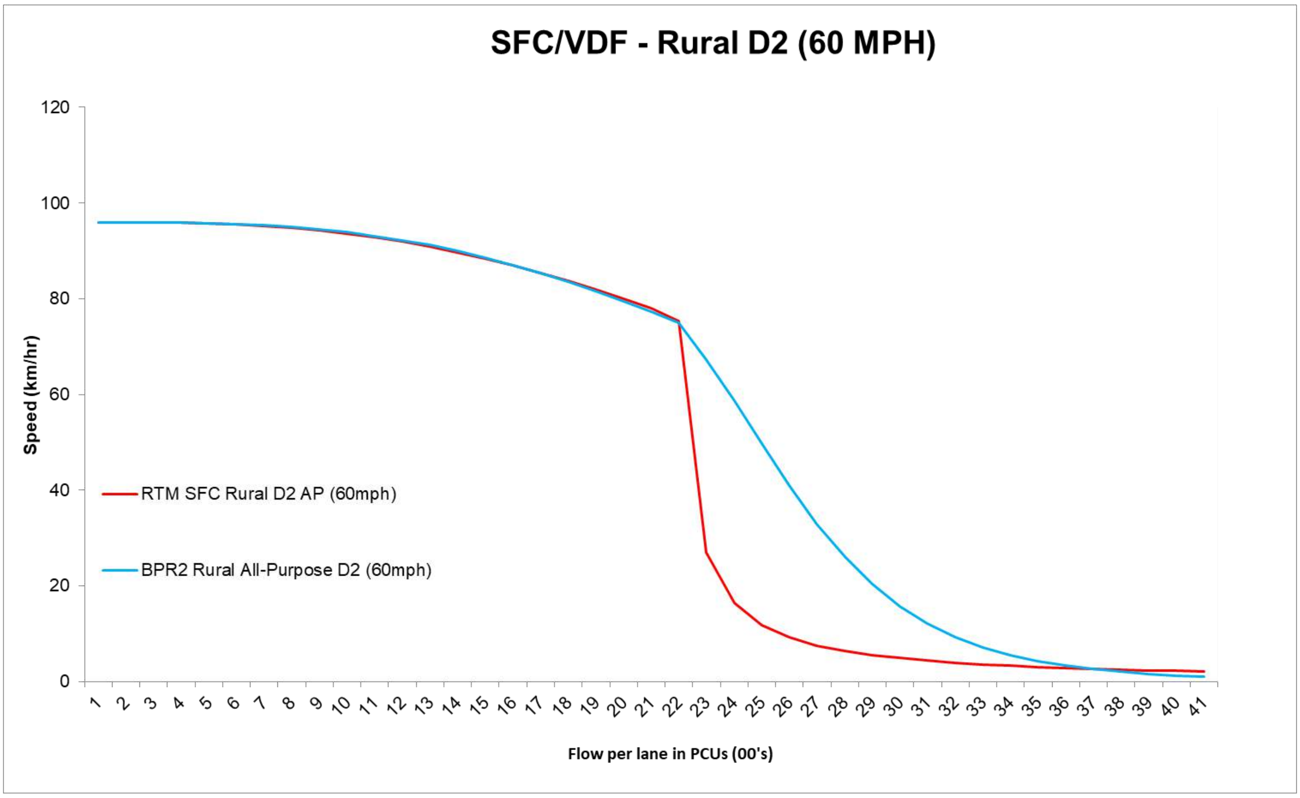

SFC/VDF - Rural D3 (60 MPH)
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM SFC Rural D3 AP (60mph)
BPR2 Rural All-Purpose D3 (60mph)

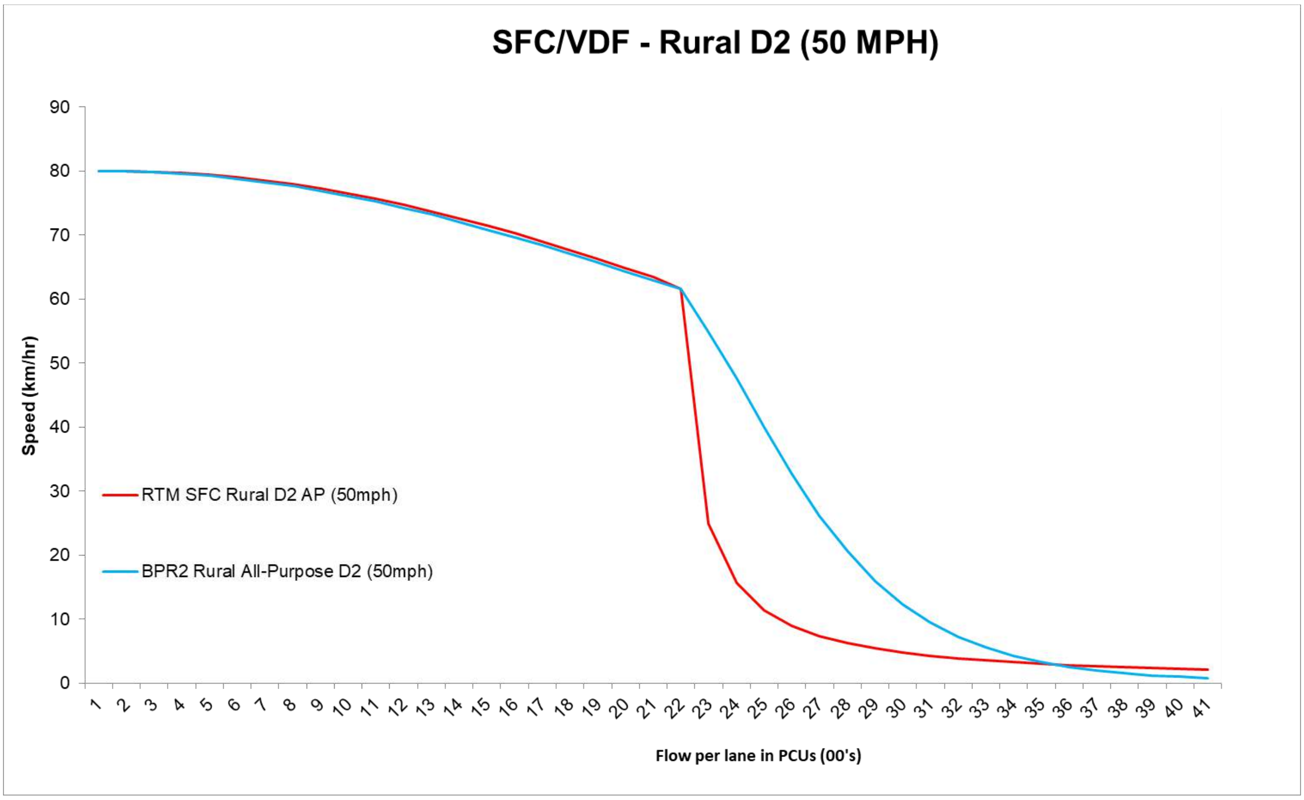


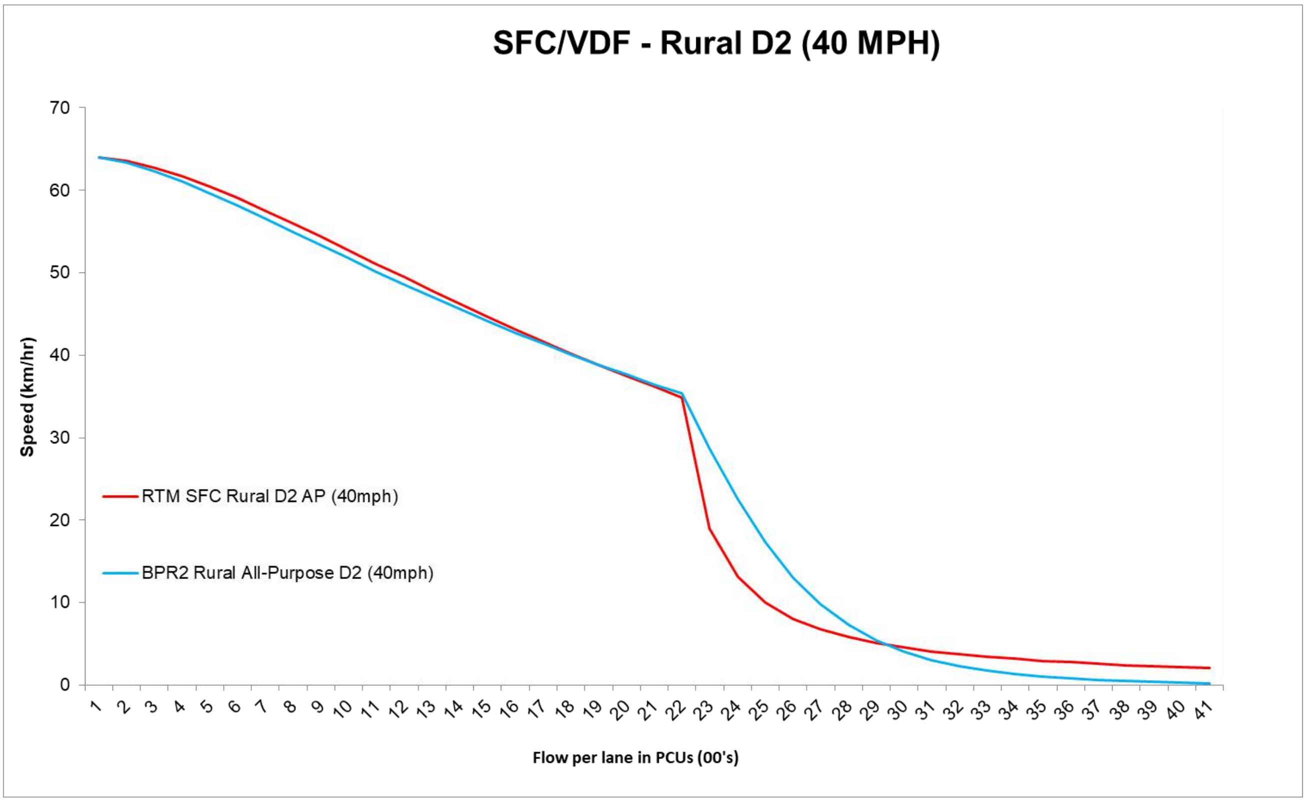
SFC/VDF - Rural D3 (50 MPH)
90
80
70
60
50
40
30
20
10
0
Speed (km/hr)
RTM SFC Rural D3 AP (50mph)
BPR2 Rural All-Purpose D3 (50mph)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Flow per lane in PCUs (00's)

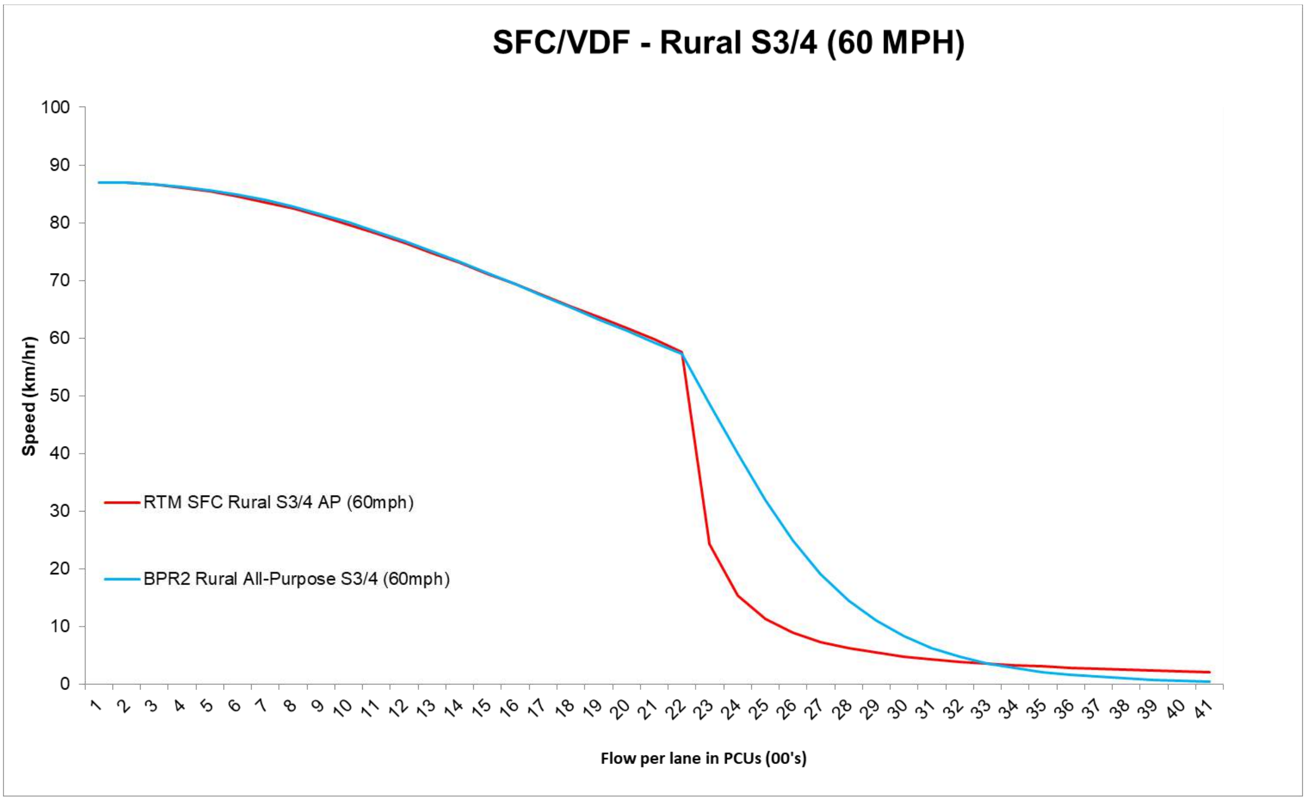


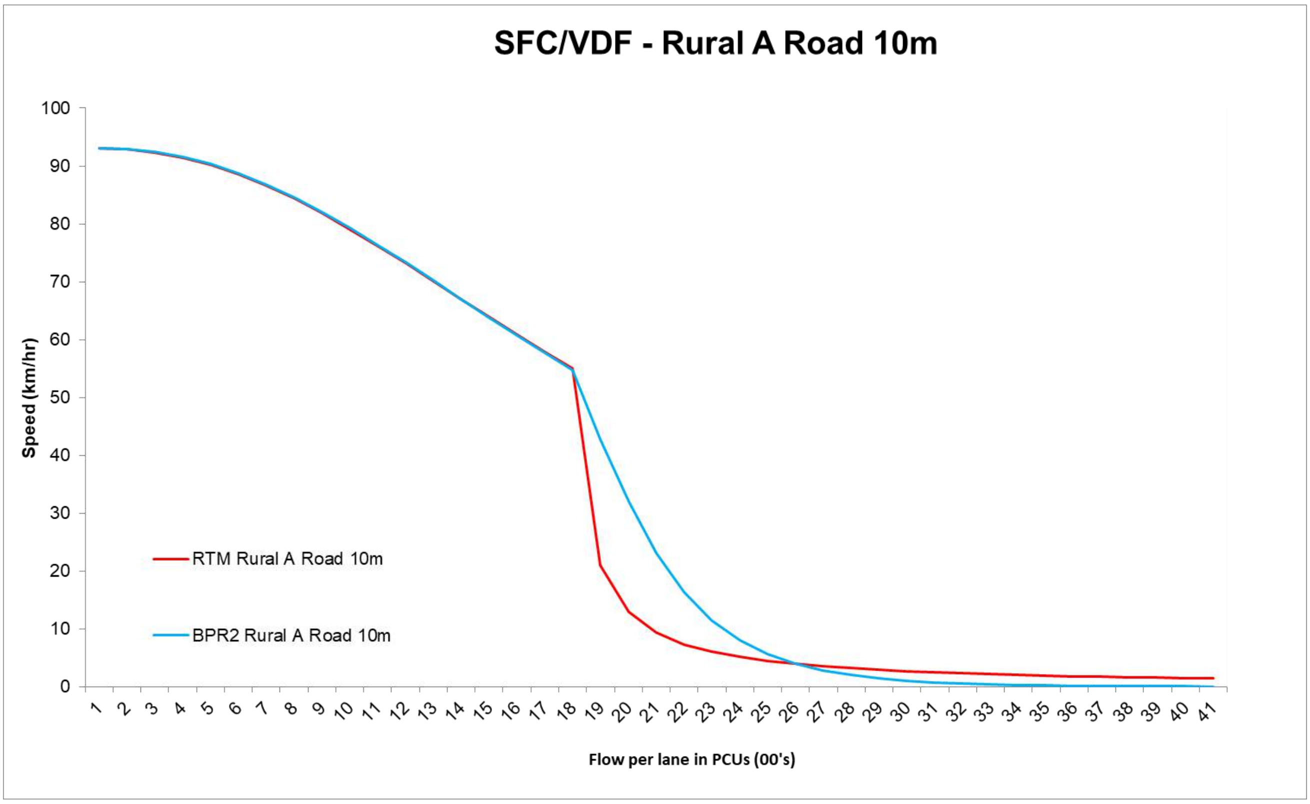
SFC/VDF - Rural D2 (70 MPH)
120
100
80
60
40
20
0
Speed (km/hr)
RTM SFC Rural D2 AP (70mph)
BPR2 Rural All-Purpose D2 (70mph)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Flow per lane in PCUs (00's)


SFC/VDF - Rural D2 (60 MPH)
Speed (km/hr)
0
20
40
60
80
100
120
RTM SFC Rural D2 AP (60mph)
BPR2 Rural All-Purpose D2 (60mph)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Flow per lane in PCUs (00's)

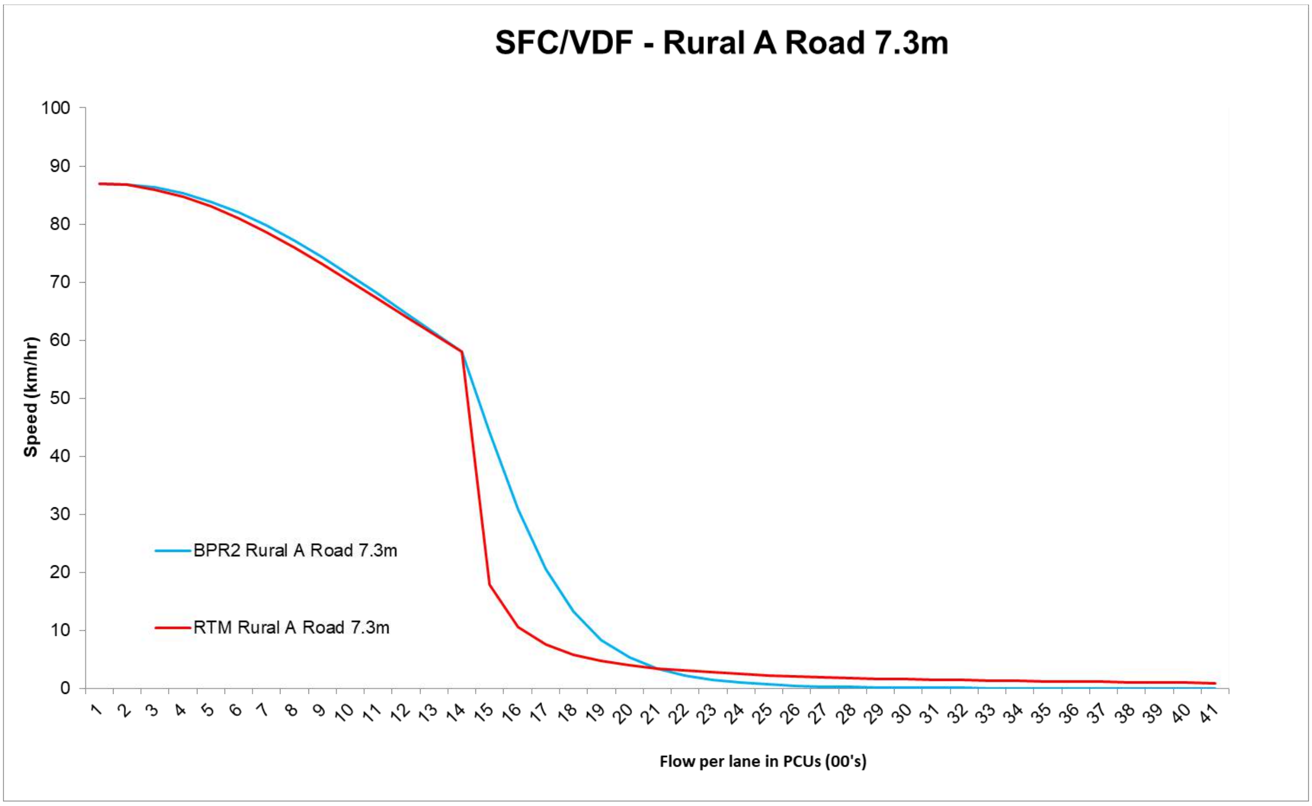

SFC/VDF - Rural D2 (50 MPH)
Speed (km/hr)
0
10
20
30
40
50
60
70
80
90
RTM SFC Rural D2 AP (50mph)
BPR2 Rural All-Purpose D2 (50mph)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Flow per lane in PCUs (00's)


SFC/VDF - Rural D2 (40 MPH)
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM SFC Rural D2 AP (40mph)
BPR2 Rural All-Purpose D2 (40mph)

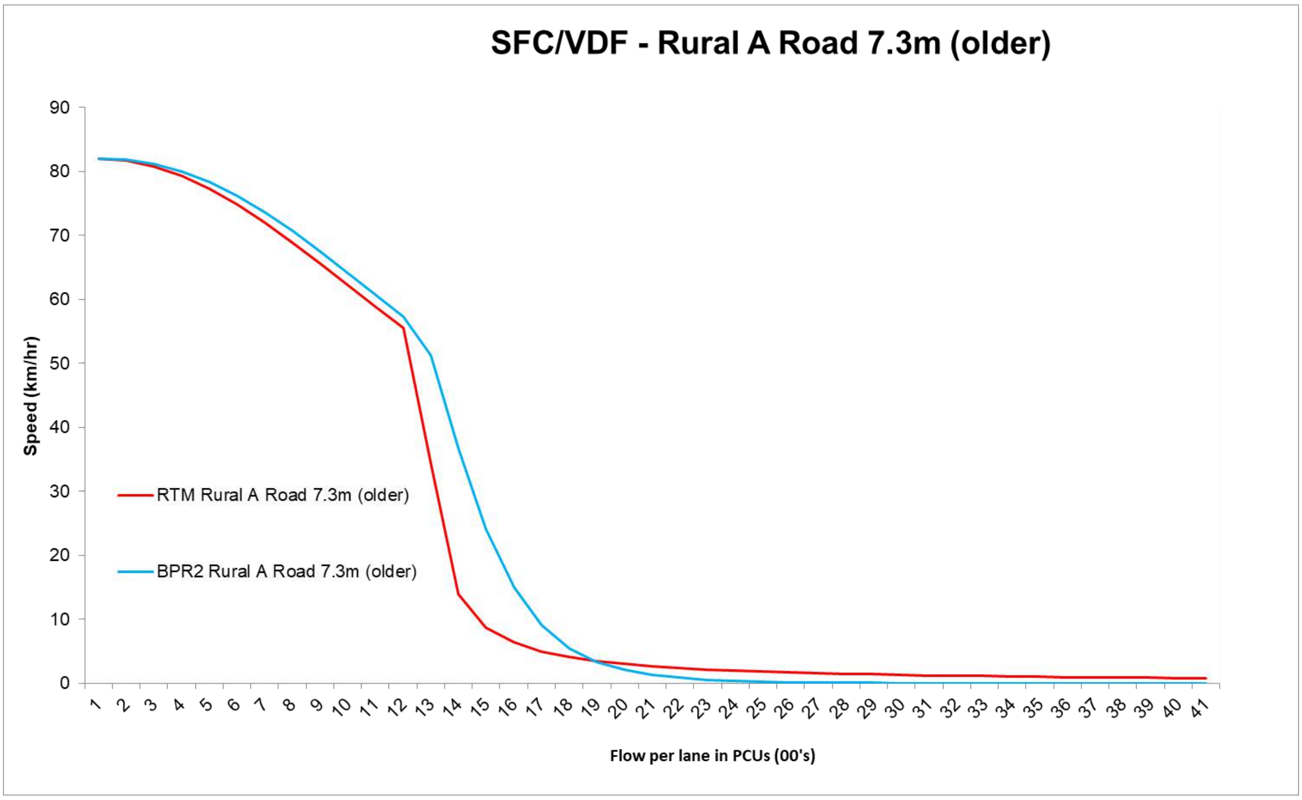

SFC/VDF - Rural S3/4 (60 MPH)
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM SFC Rural S3/4 AP (60mph)
BPR2 Rural All-Purpose S3/4 (60mph)

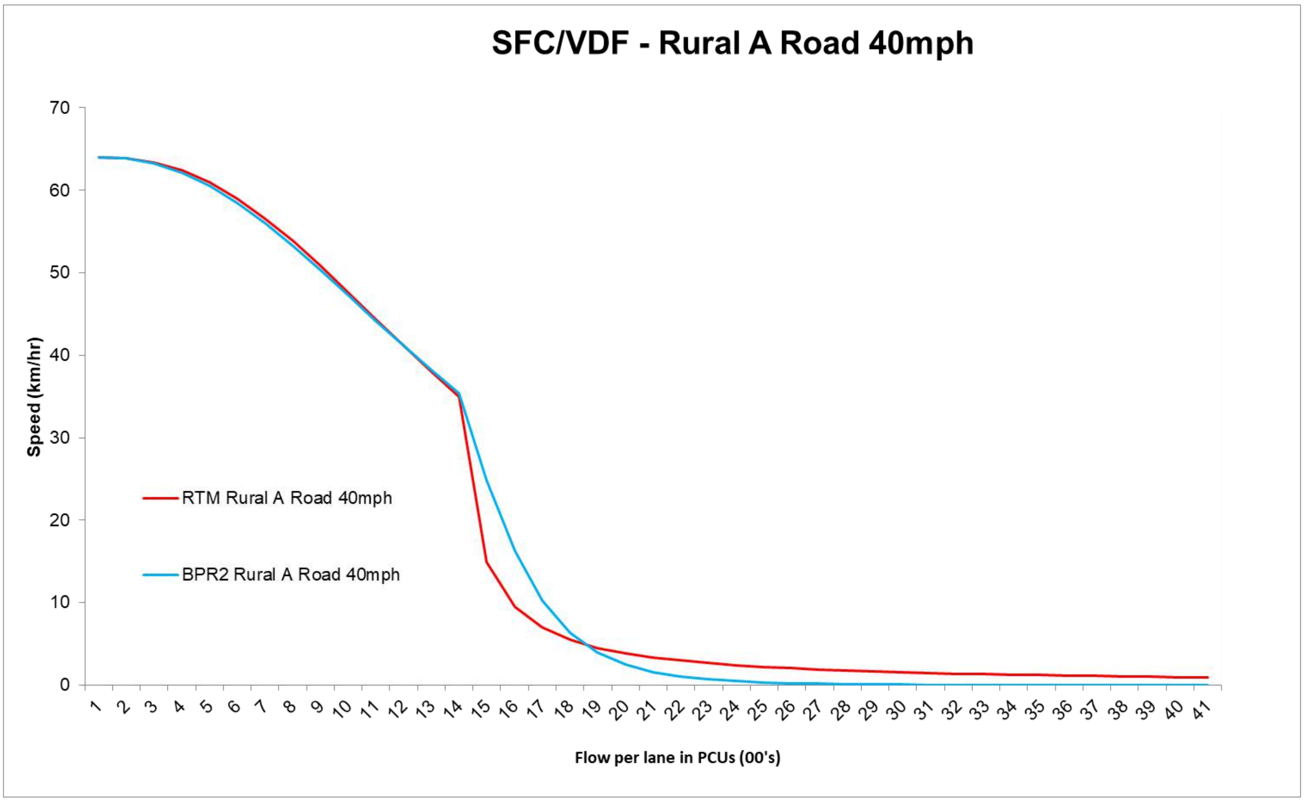


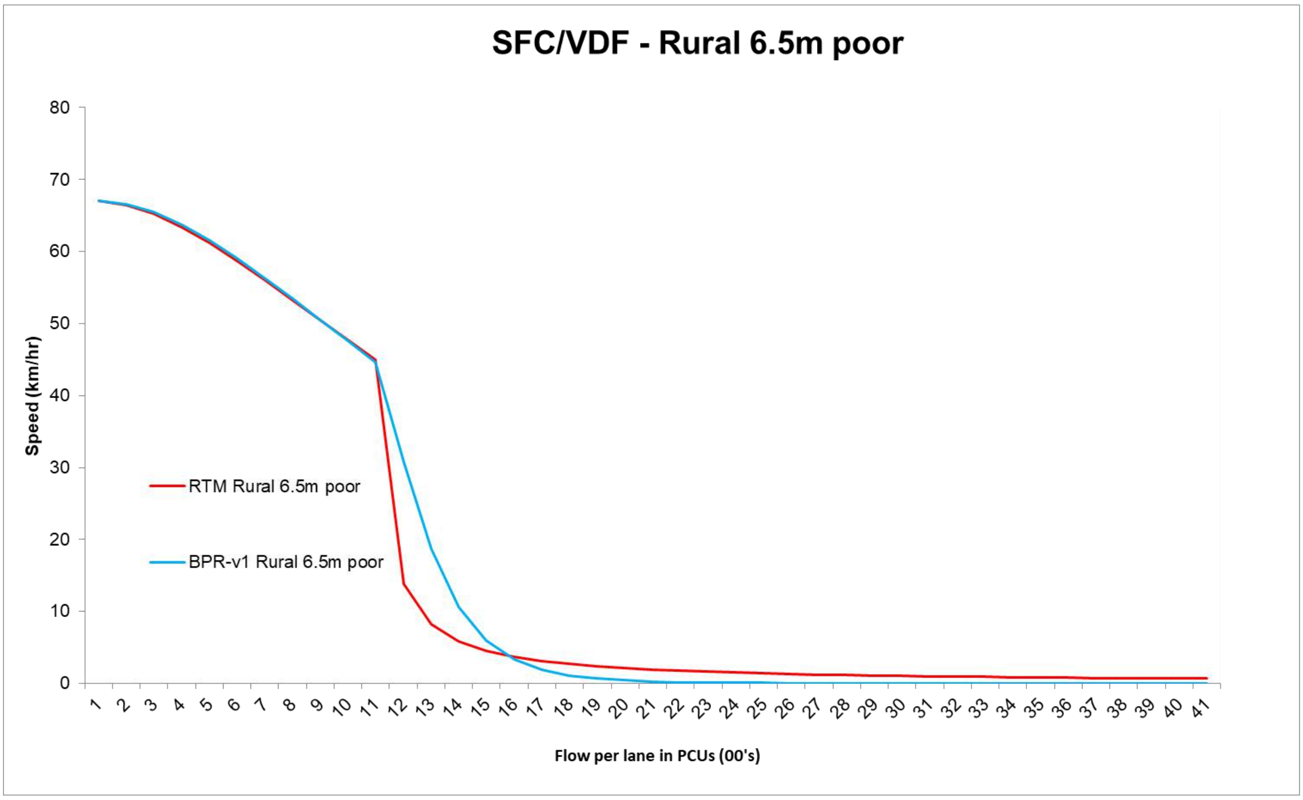
SFC/VDF - Rural A Road 10m
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM Rural A Road 10m
BPR2 Rural A Road 10m

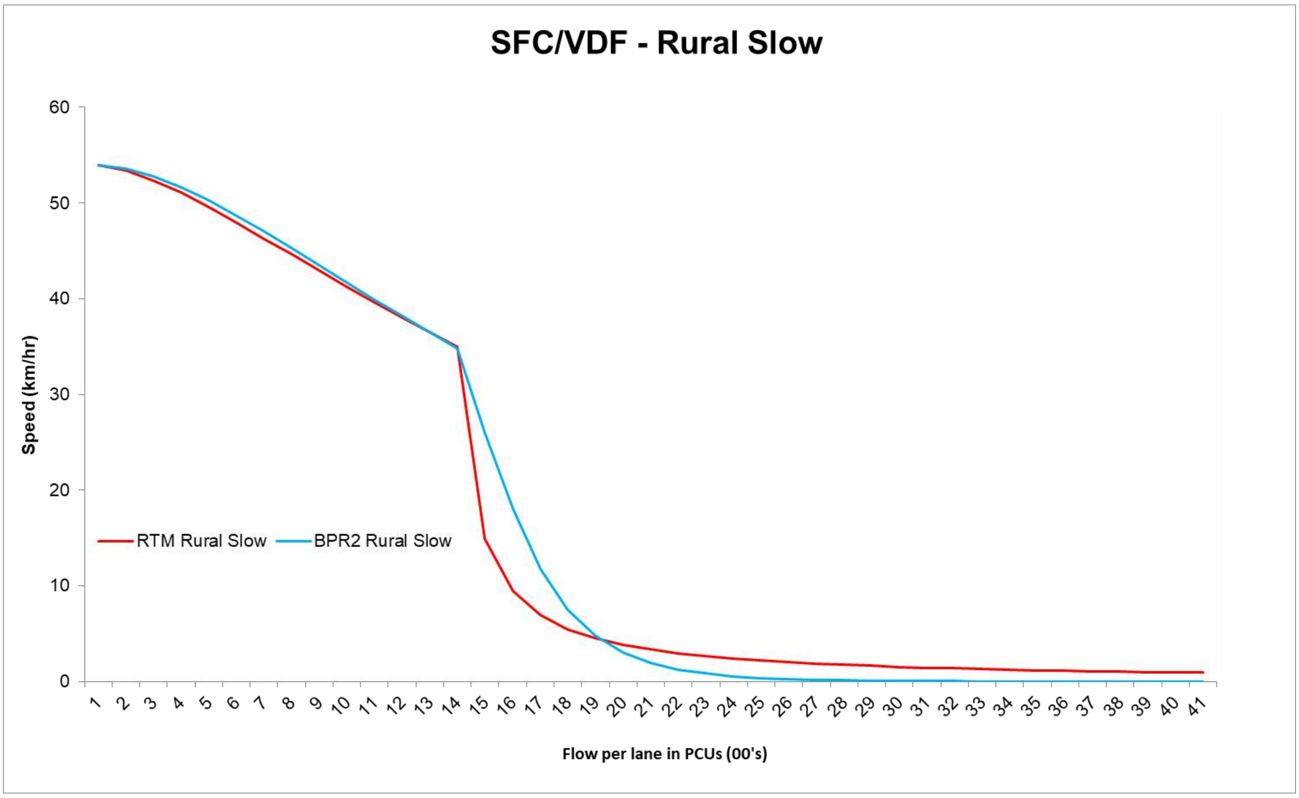


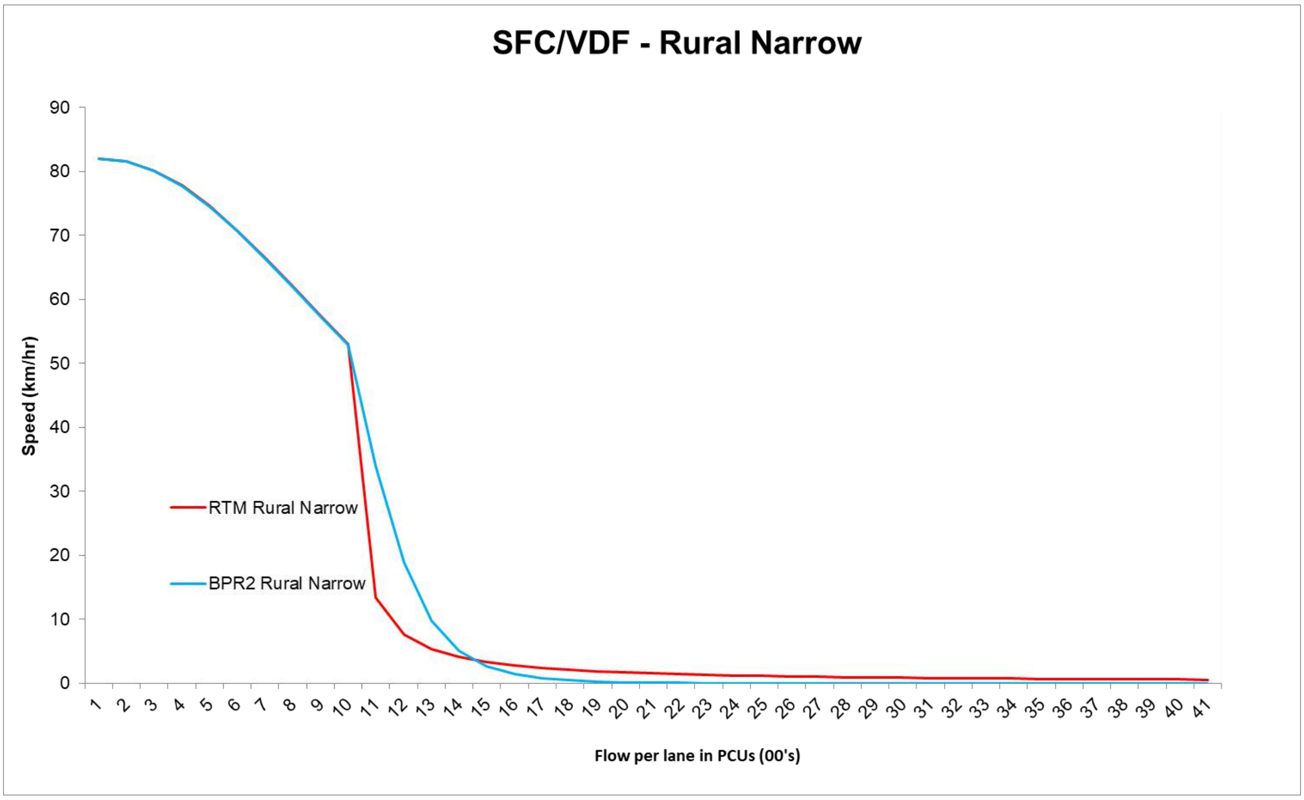
SFC/VDF - Rural A Road 7.3m
Speed (km/hr)
Flow per lane in PCUs (00's)
BPR2 Rural A Road 7.3m
RTM Rural A Road 7.3m

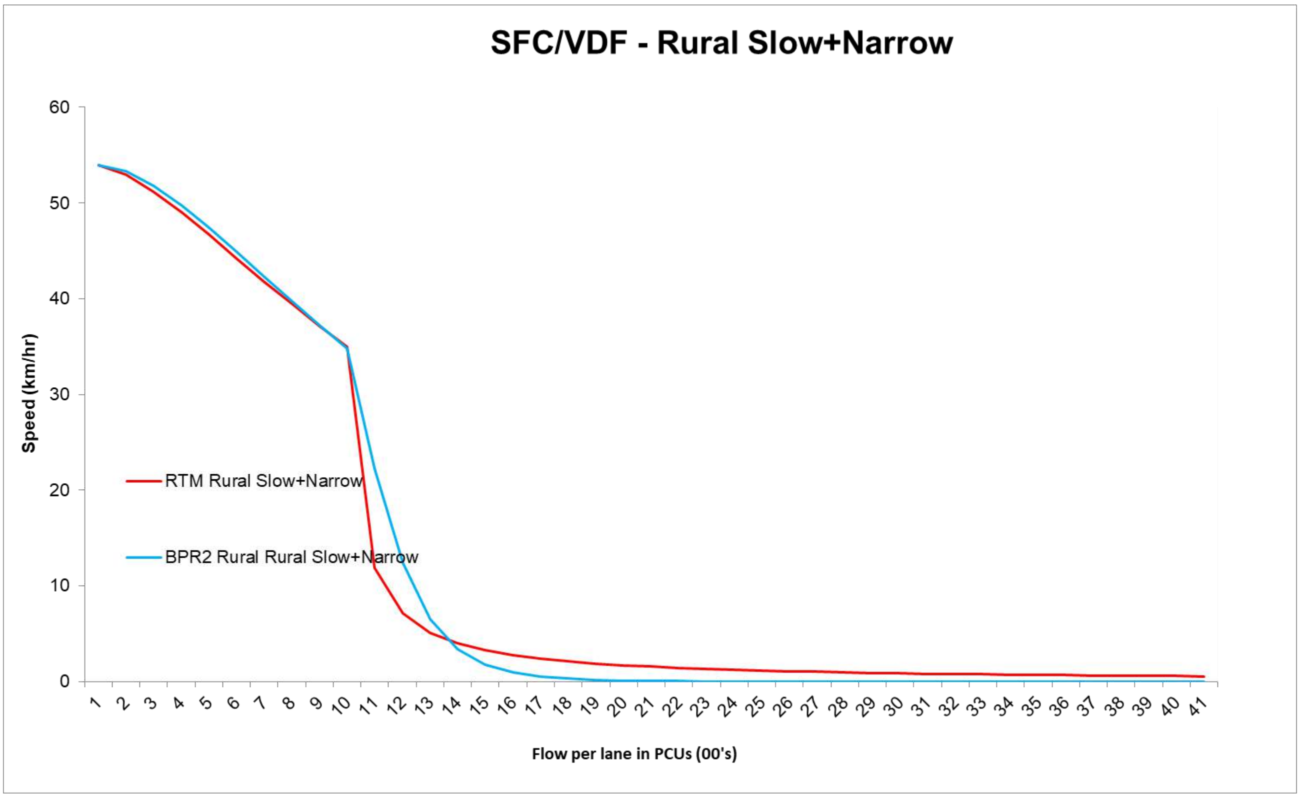

SFC/VDF - Rural A Road 7.3m (older)
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM Rural A Road 7.3m (older)
BPR2 Rural A Road 7.3m (older)

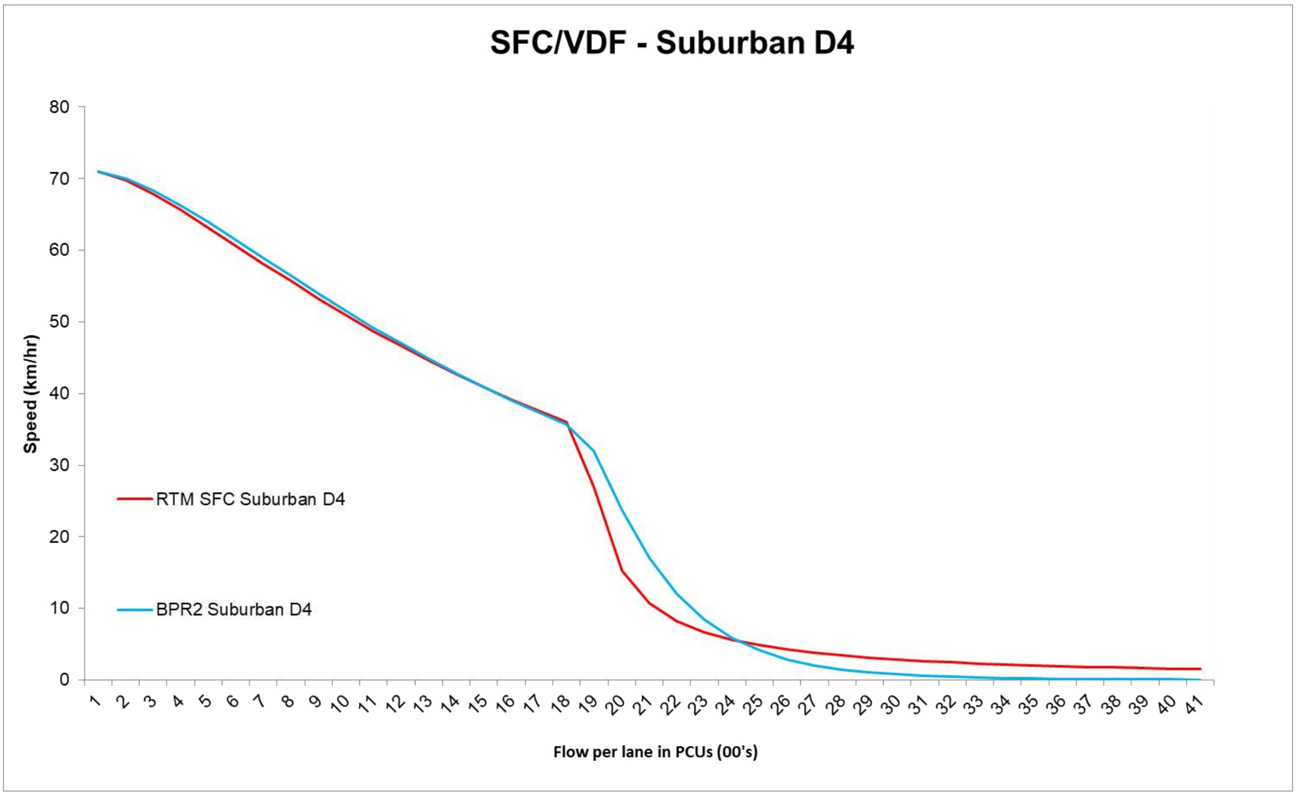

SFC/VDF - Rural A Road 40mph
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM Rural A Road 40mph
BPR2 Rural A Road 40mph


SFC/VDF - Rural 6.5m poor
Speed (km/hr)
80
70
60
50
40
30
20
10
0
RTM Rural 6.5m poor
BPR-v1 Rural 6.5m poor
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Flow per lane in PCUs (00's)


SFC/VDF - Rural Slow
Speed (km/hr)
60
50
40
30
20
10
0
RTM Rural Slow
BPR2 Rural Slow
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Flow per lane in PCUs (00's)


SFC/VDF - Rural Narrow
Speed (km/hr)
RTM Rural Narrow
BPR2 Rural Narrow
Flow per lane in PCUs (00's)


SFC/VDF - Rural Slow+Narrow
Speed (km/hr)
RTM Rural Slow+Narrow
BPR2 Rural Rural Slow+Narrow
Flow per lane in PCUs (00's)


SFC/VDF - Suburban D4
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM SFC Suburban D4
BPR2 Suburban D4
0
10
20
30
40
50
60
70
80
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
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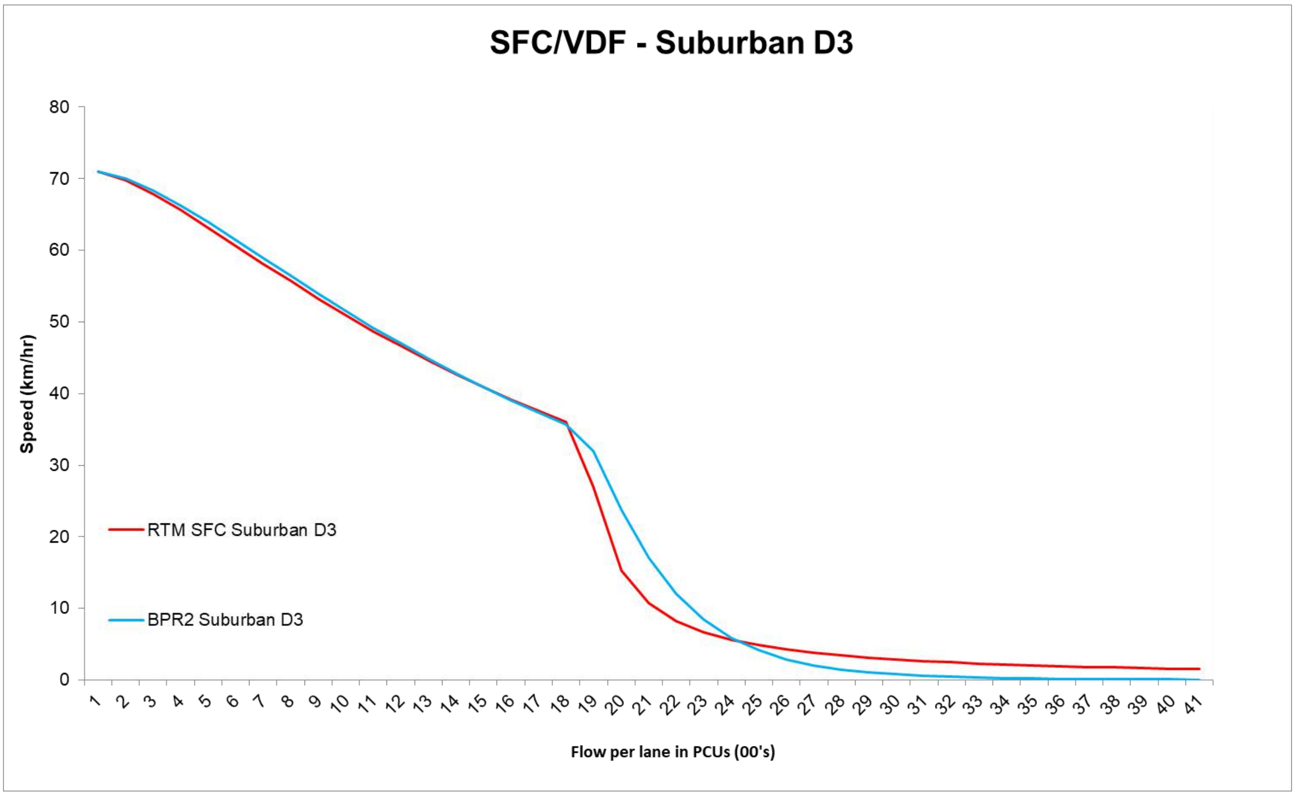
37
38
39
40
41


SFC/VDF - Suburban D3
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM SFC Suburban D3
BPR2 Suburban D3
0
10
20
30
40
50
60
70
80
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
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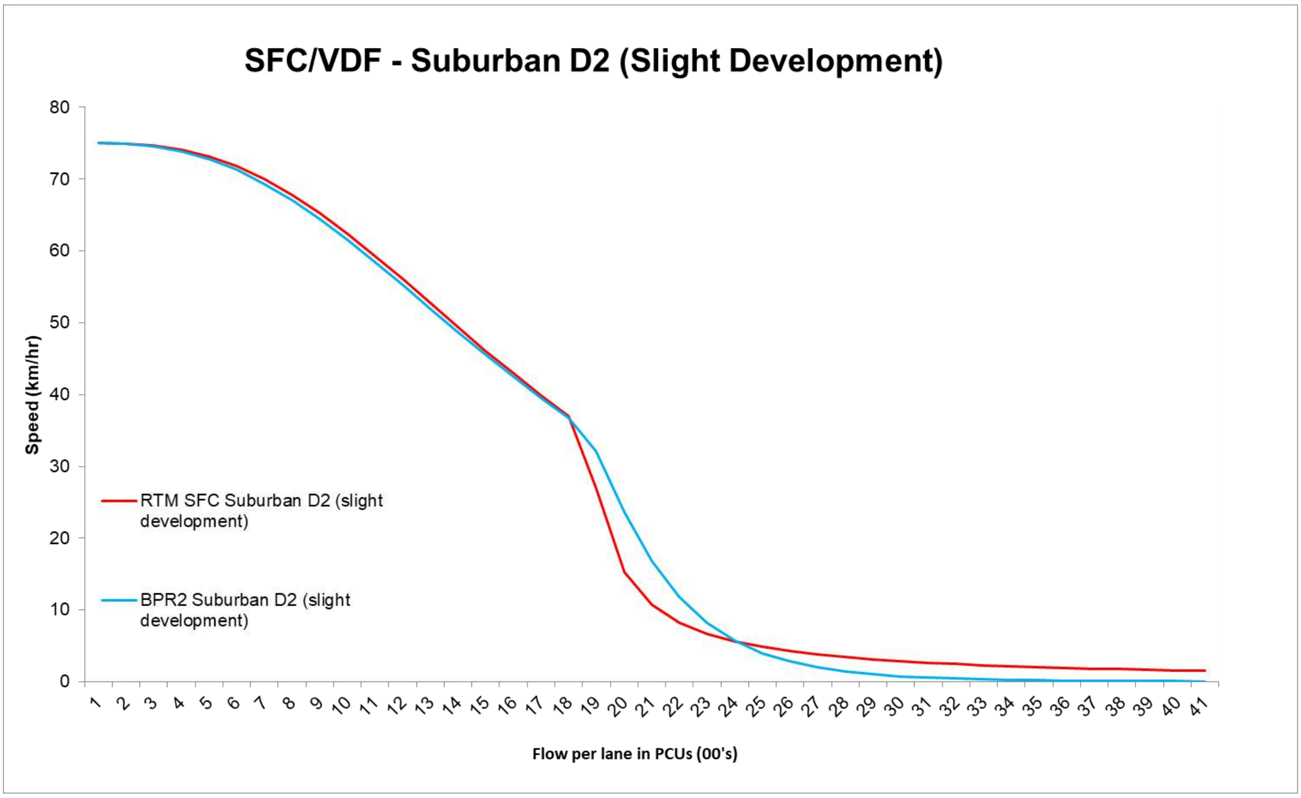
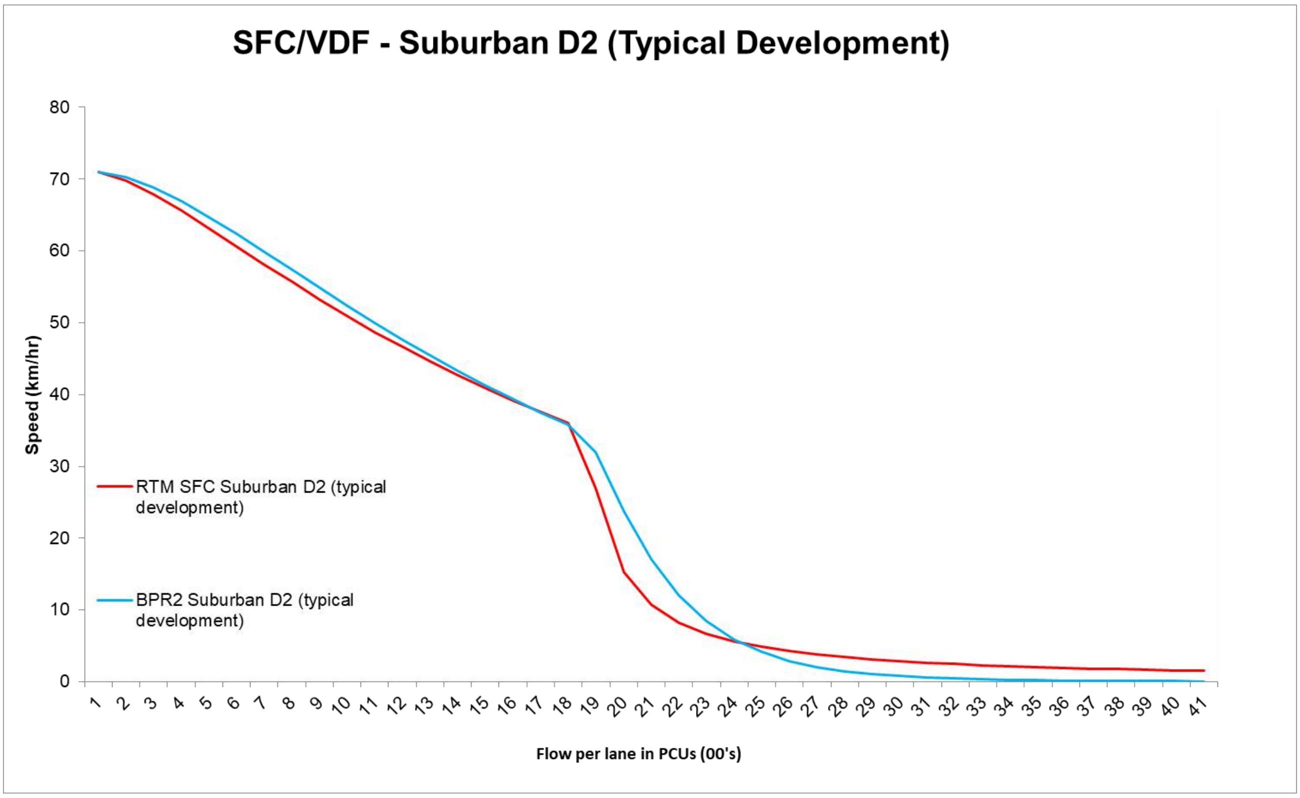
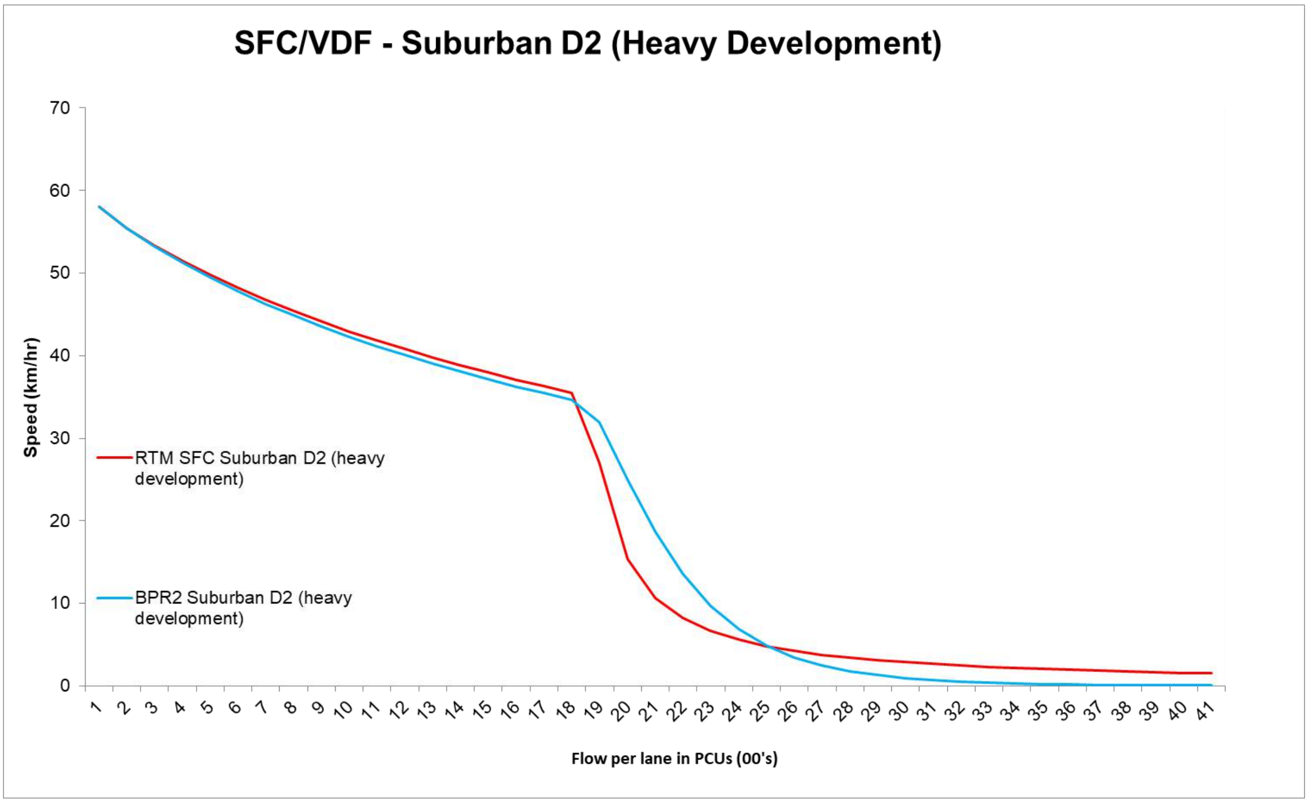
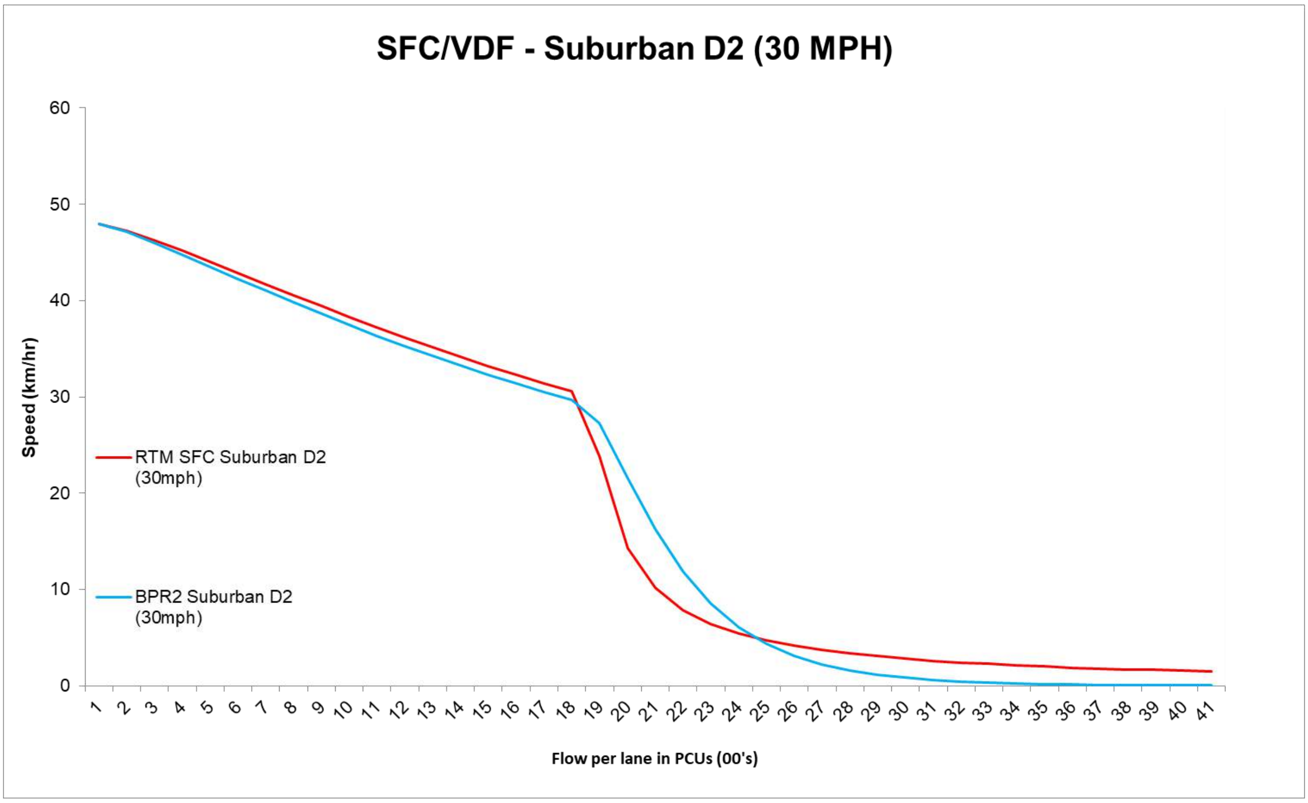
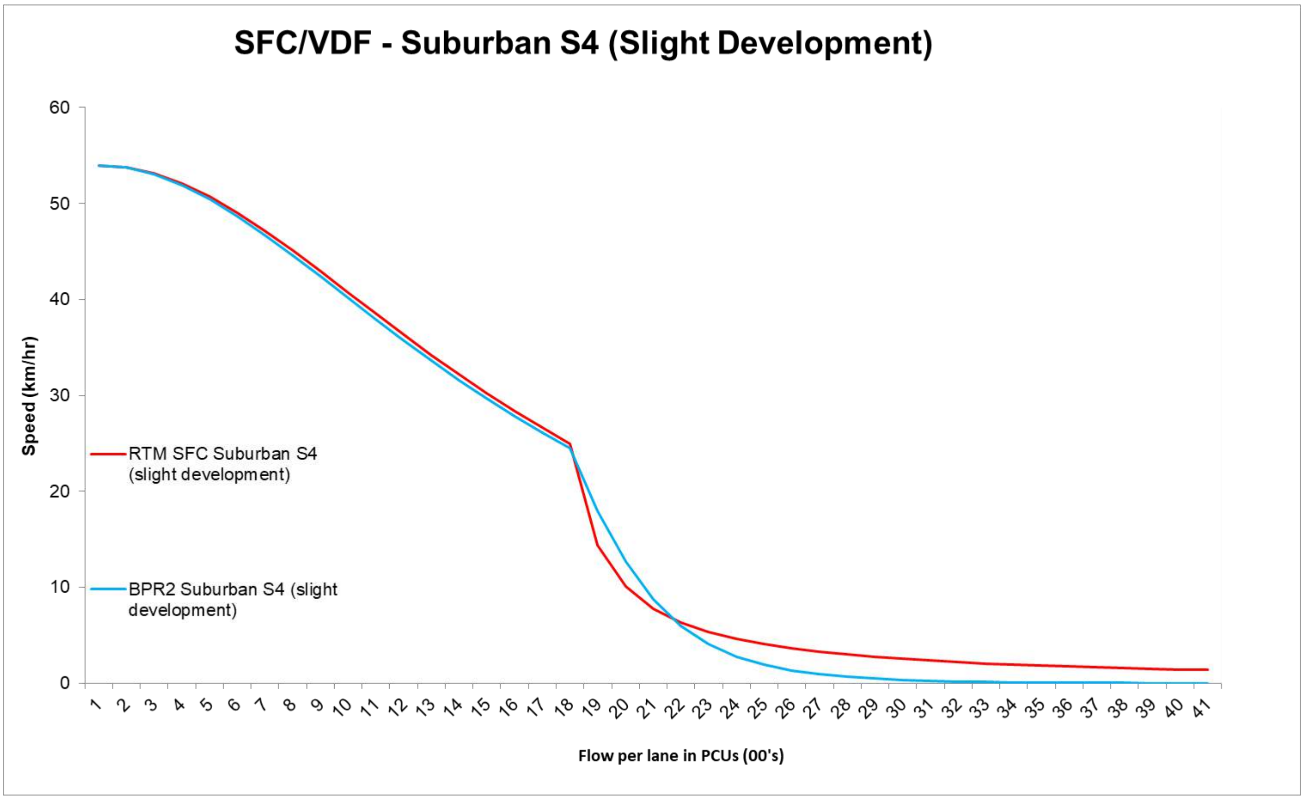
37
38
39
40
41

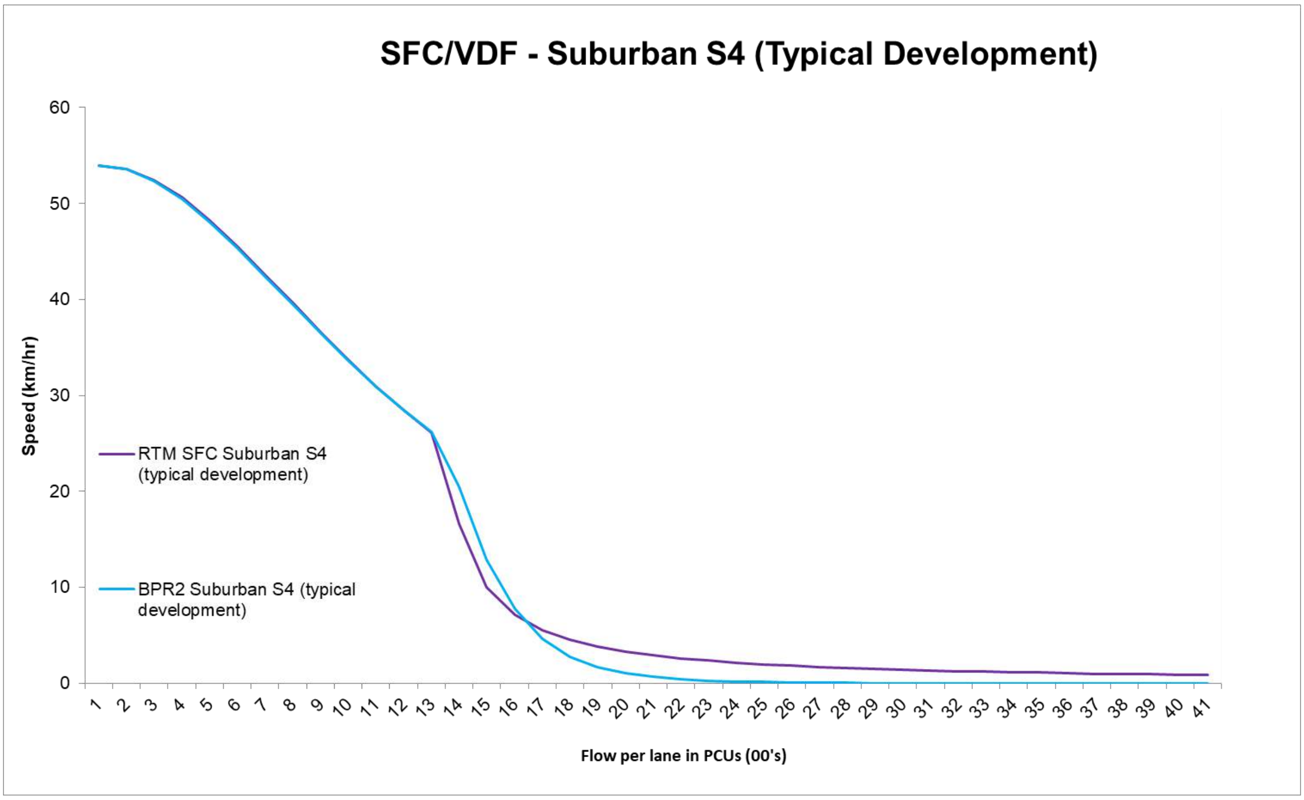

SFC/VDF - Suburban D2 (Slight Development)
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM SFC Suburban D2 (slight development)
BPR2 Suburban D2 (slight development)

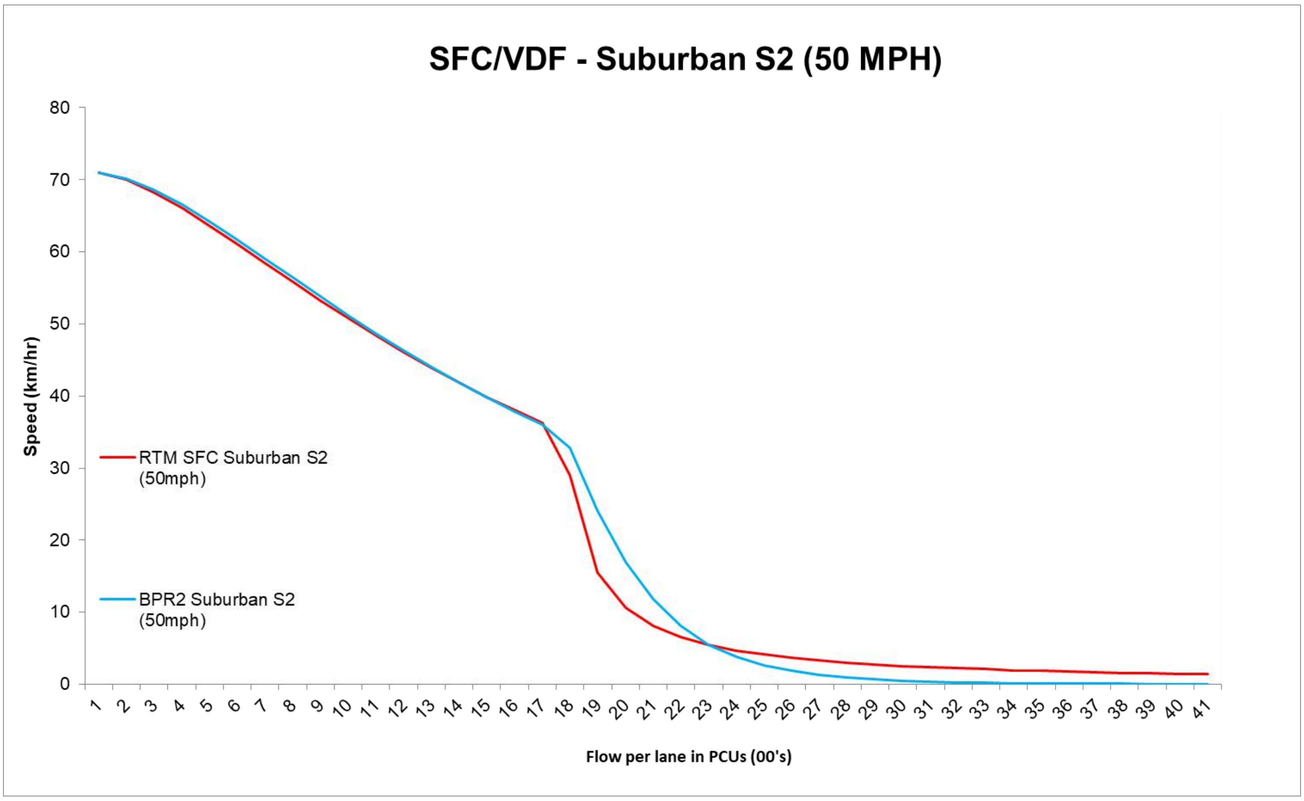

SFC/VDF - Suburban D2 (Typical Development)
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM SFC Suburban D2 (typical development)
BPR2 Suburban D2 (typical development)


SFC/VDF - Suburban D2 (Heavy Development)
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM SFC Suburban D2 (heavy development)
BPR2 Suburban D2 (heavy development)

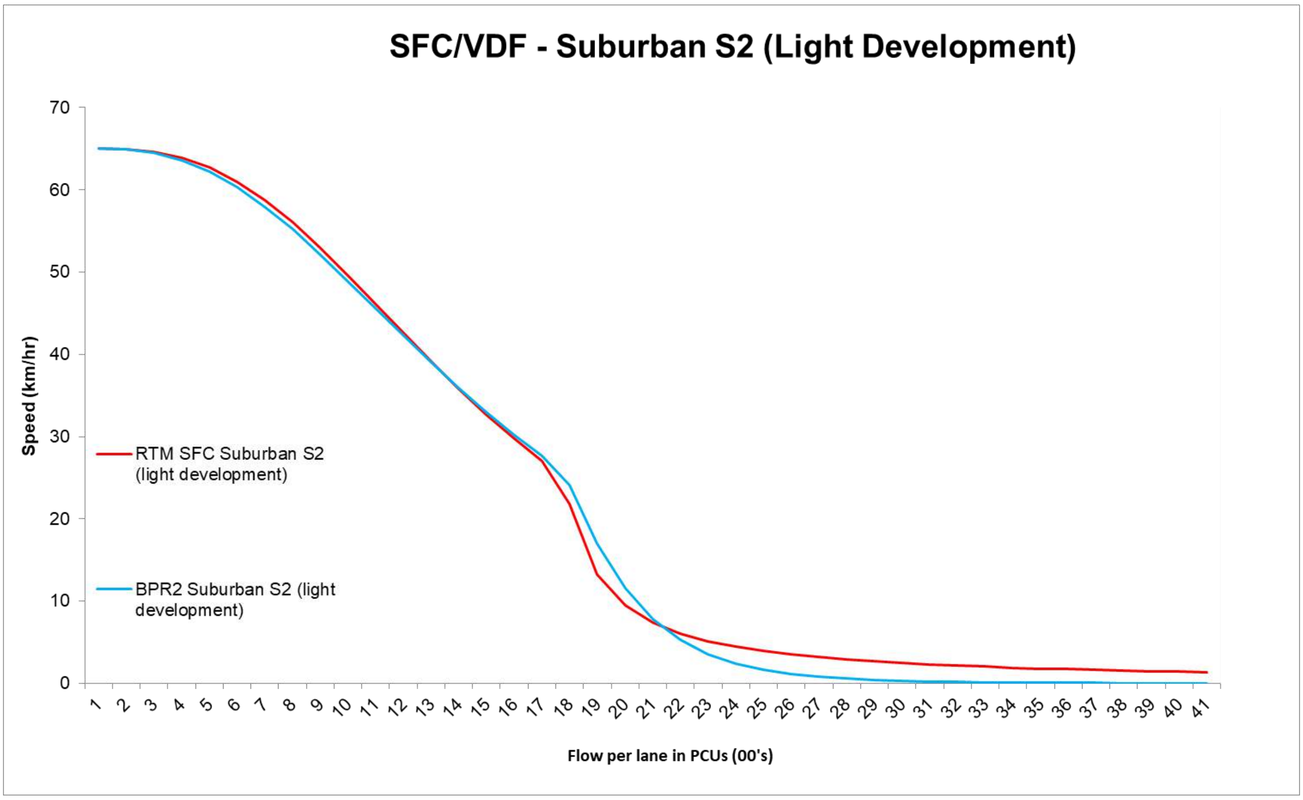

SFC/VDF - Suburban D2 (30 MPH)
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM SFC Suburban D2 (30mph)
BPR2 Suburban D2 (30mph)


SFC/VDF - Suburban S4 (Slight Development)
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM SFC Suburban S4 (slight development)
BPR2 Suburban S4 (slight development)
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41

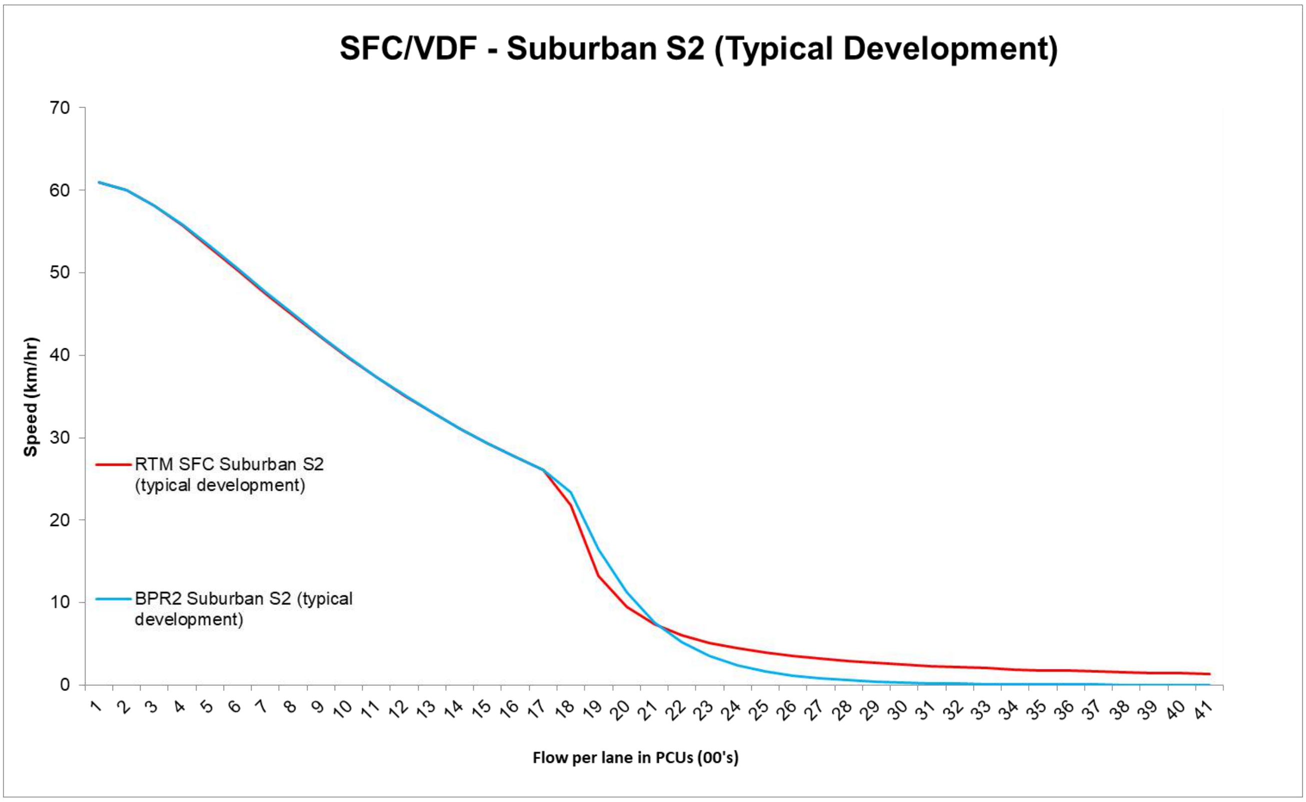

SFC/VDF - Suburban S4 (Typical Development)
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM SFC Suburban S4 (typical development)
BPR2 Suburban S4 (typical development)
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41



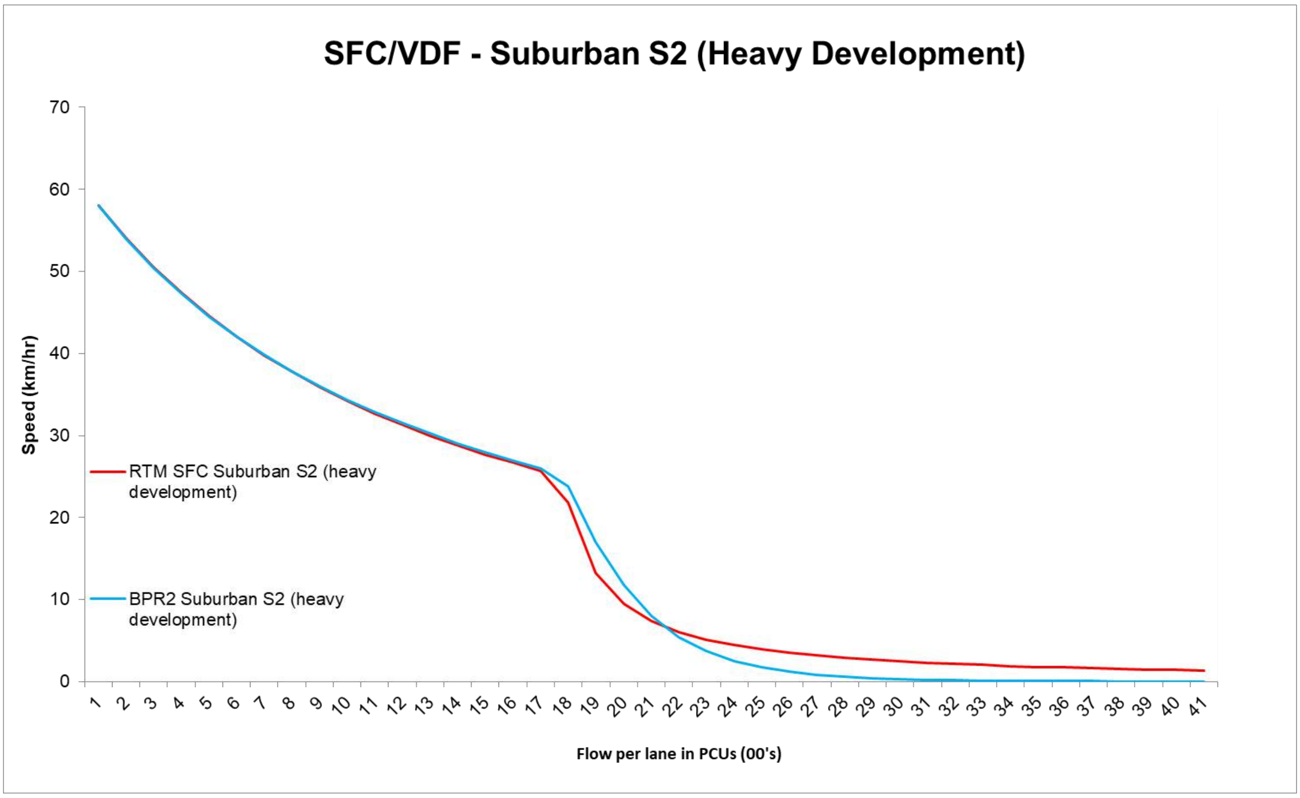
SFC/VDF - Suburban S2 (50 MPH)
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM SFC Suburban S2 (50mph)
BPR2 Suburban S2 (50mph)



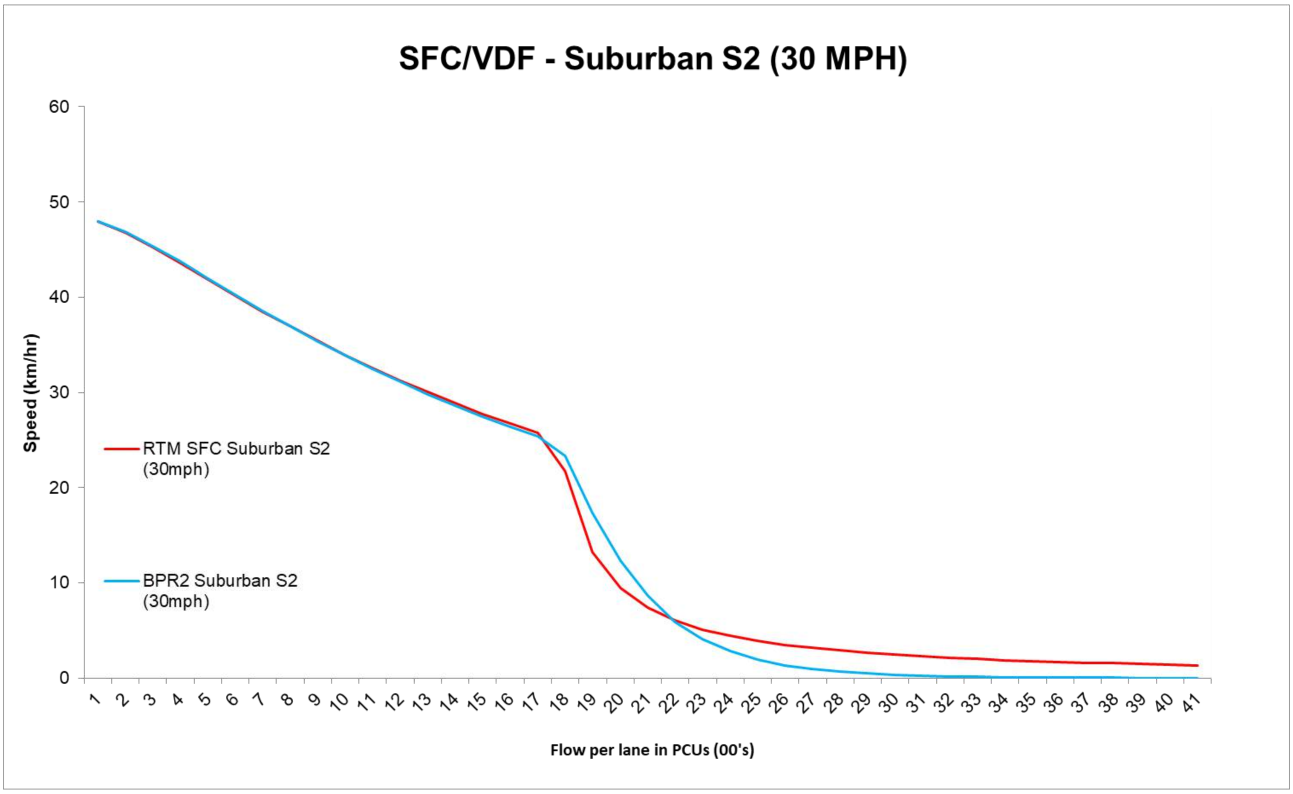
SFC/VDF - Suburban S2 (Light Development)
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM SFC Suburban S2 (light development)
BPR2 Suburban S2 (light development)

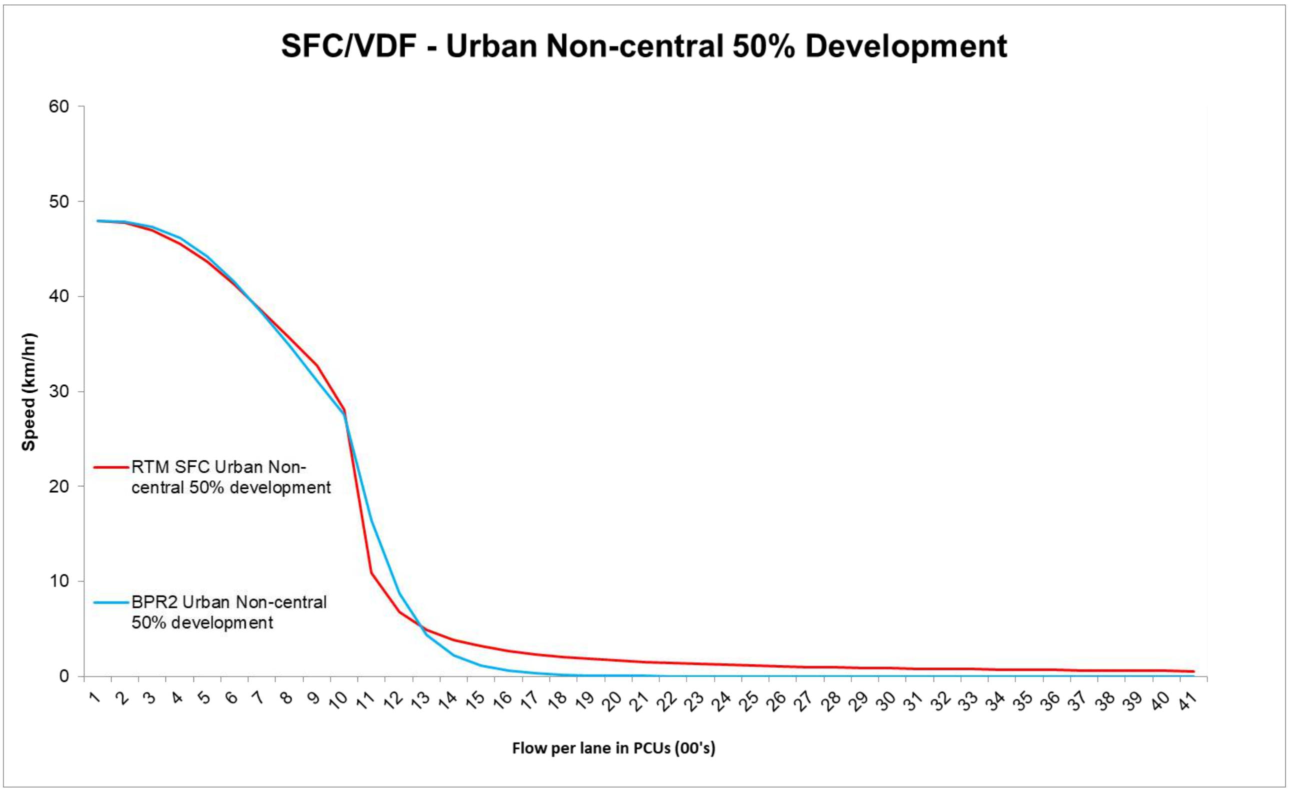


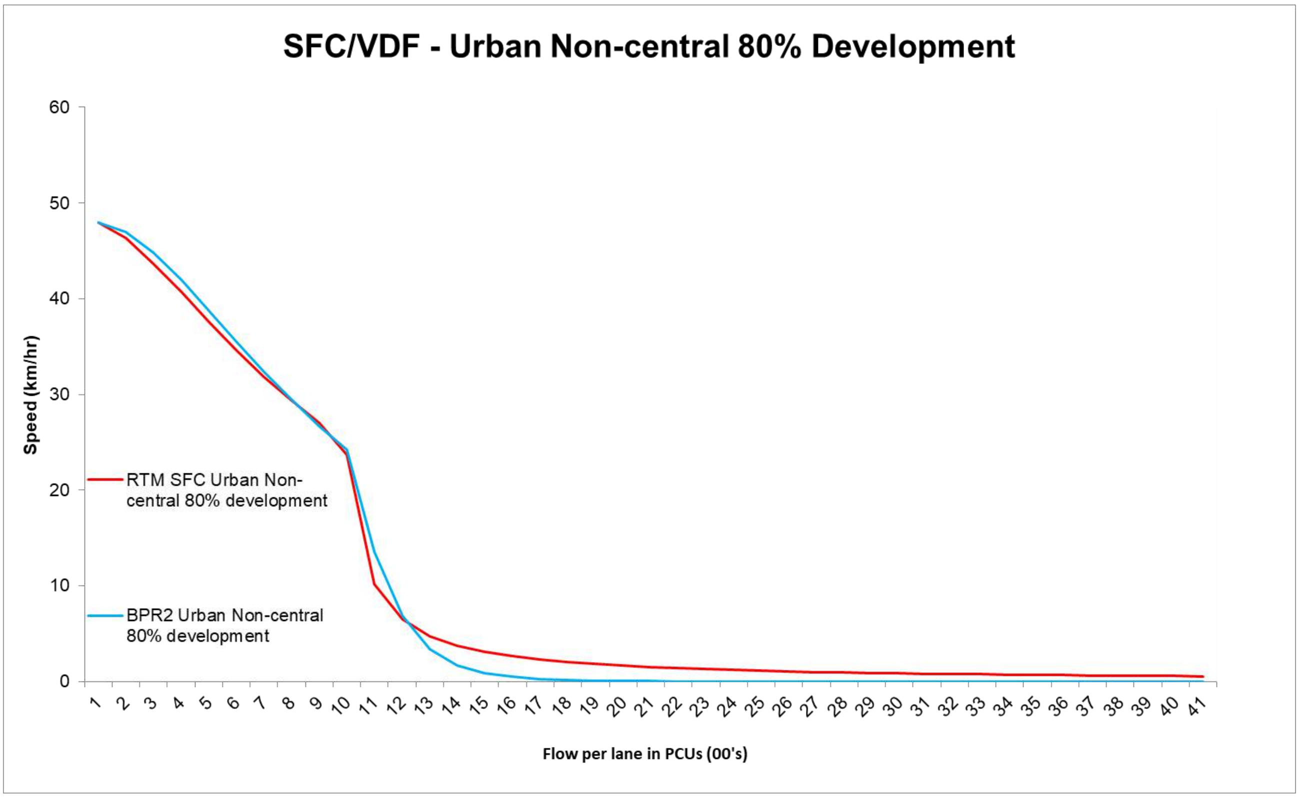
SFC/VDF - Suburban S2 (Typical Development)
Speed (km/hr)
70
60
50
40
30
20
10
0
RTM SFC Suburban S2 (typical development)
BPR2 Suburban S2 (typical development)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Flow per lane in PCUs (00's)



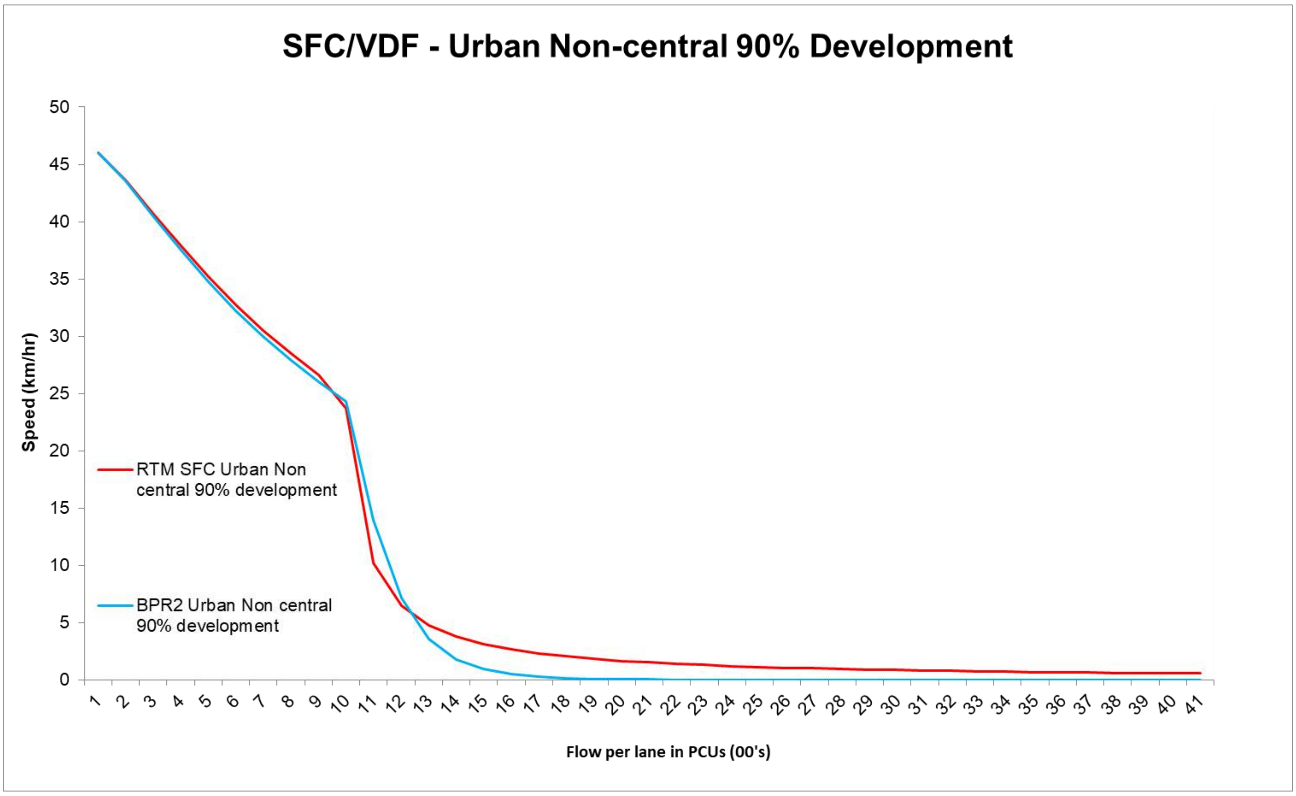
SFC/VDF - Suburban S2 (Heavy Development)
Speed (km/hr)
70
60
50
40
30
20
10
0
RTM SFC Suburban S2 (heavy development)
BPR2 Suburban S2 (heavy development)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Flow per lane in PCUs (00's)


SFC/VDF - Suburban S2 (30 MPH)
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM SFC Suburban S2 (30mph)
BPR2 Suburban S2 (30mph)
0
10
20
30
40
50
60
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41

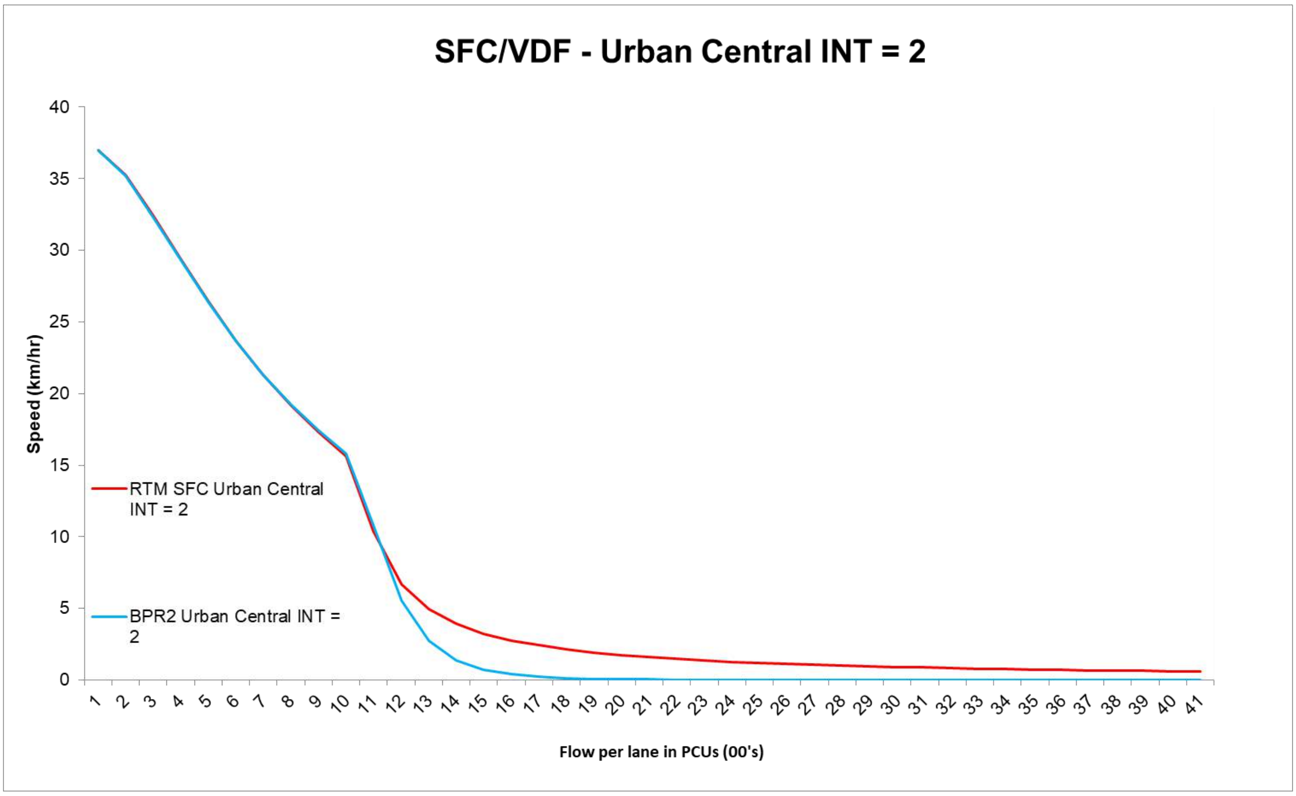

SFC/VDF - Urban Non-central 50% Development
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM SFC Urban Non-central 50% development
BPR2 Urban Non-central 50% development
0
10
20
30
40
50
60
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41

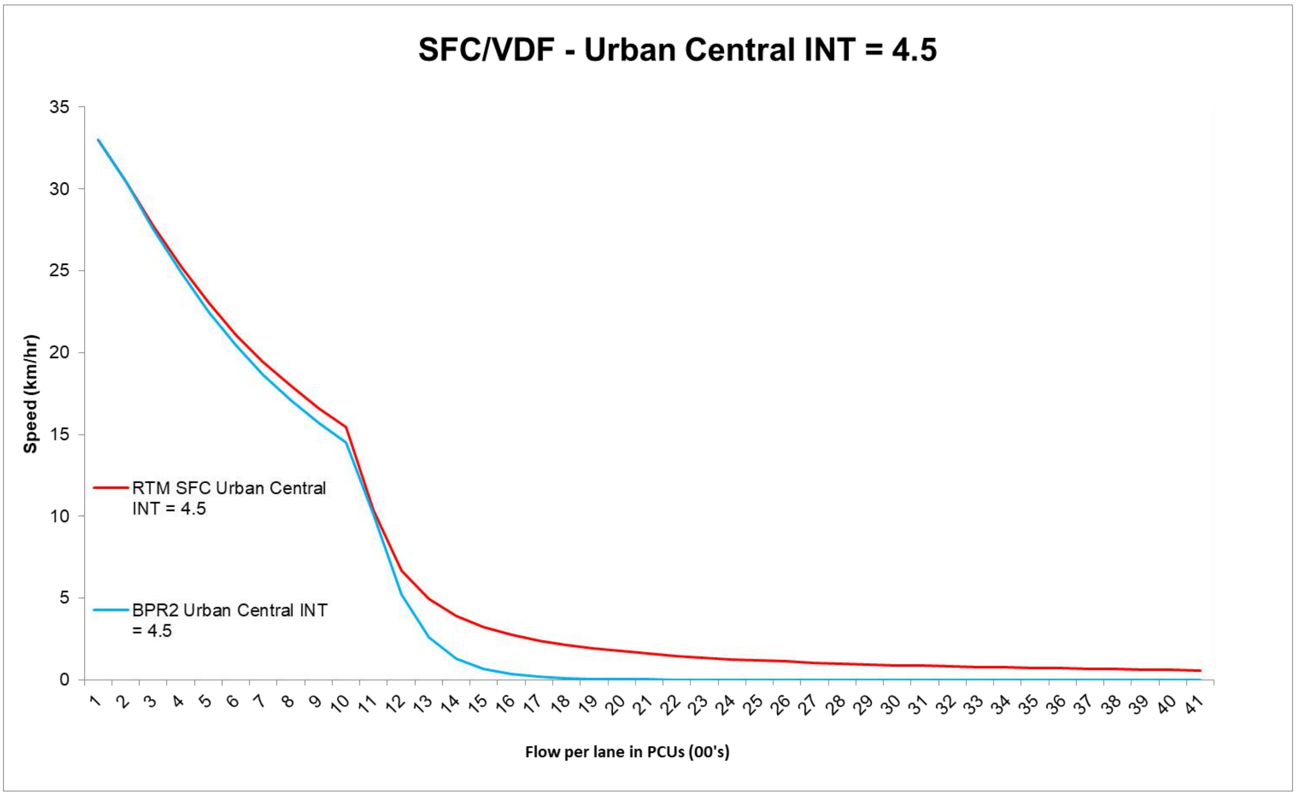


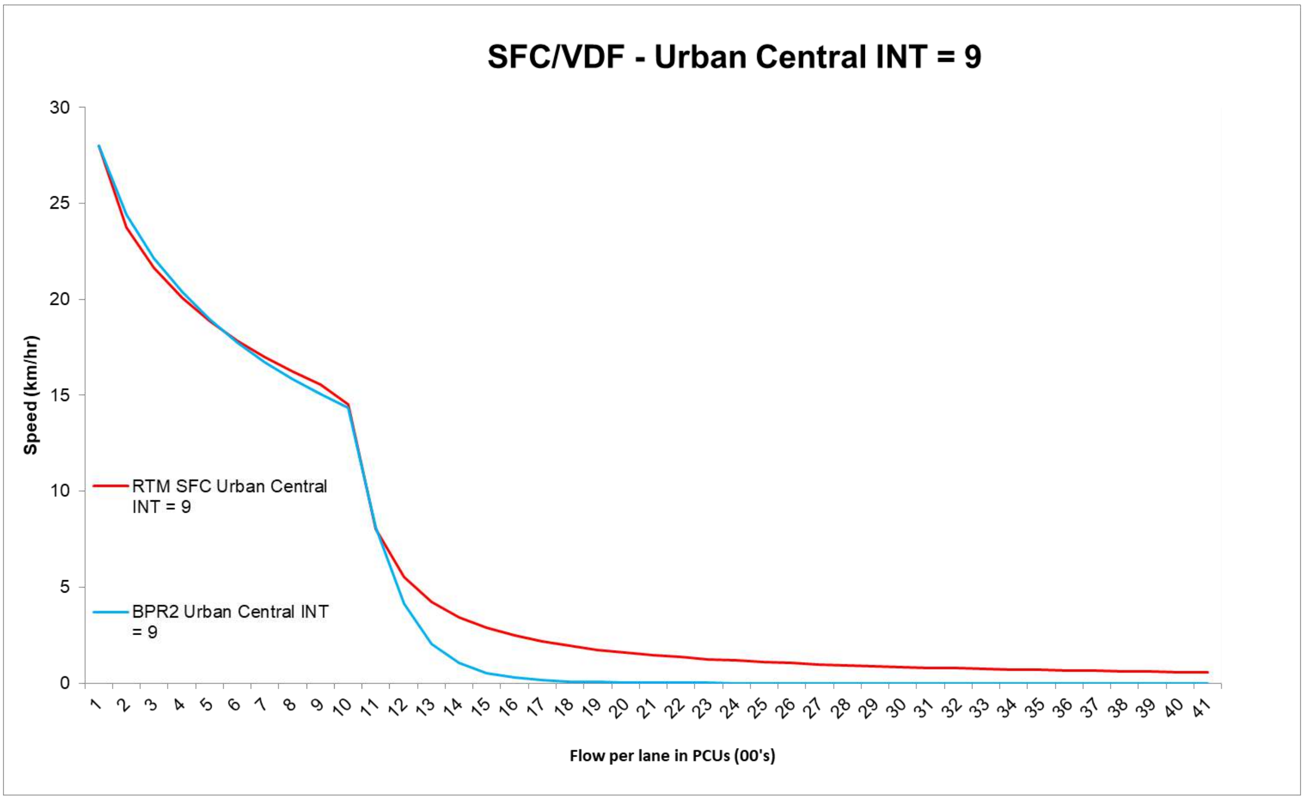
SFC/VDF - Urban Non-central 80% Development
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM SFC Urban Non-central 80% development
BPR2 Urban Non-central 80% development

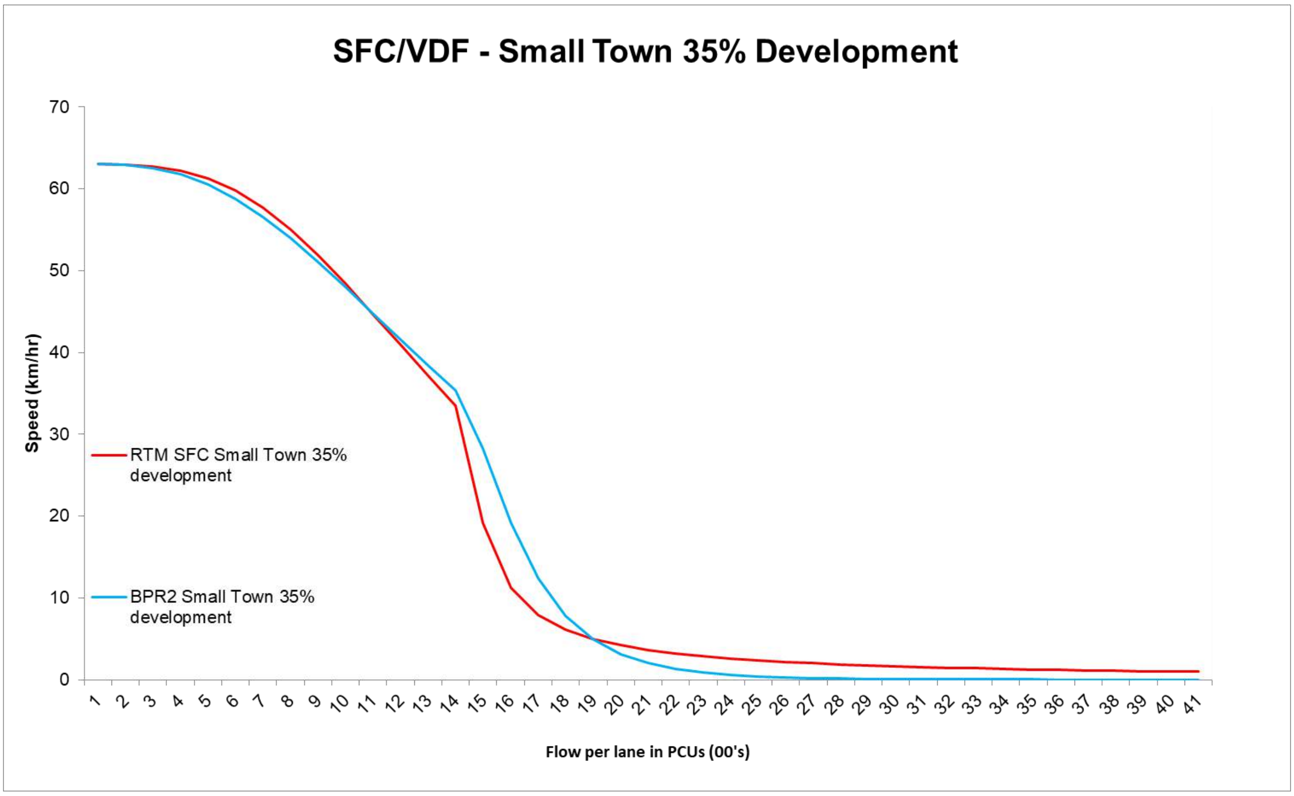


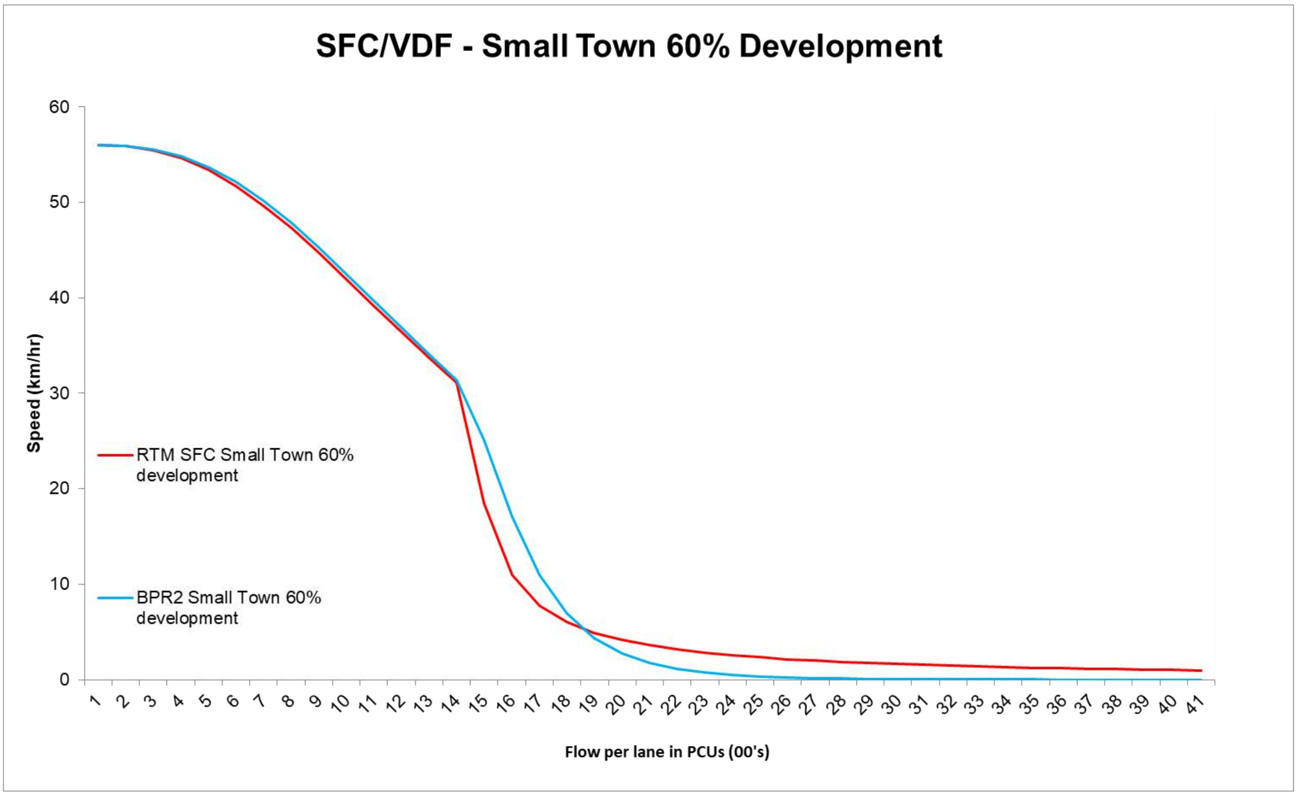
SFC/VDF - Urban Non-central 90% Development
Speed (km/hr)
Flow per lane in PCUs (00's)
RTM SFC Urban Non central 90% development
BPR2 Urban Non central 90% development

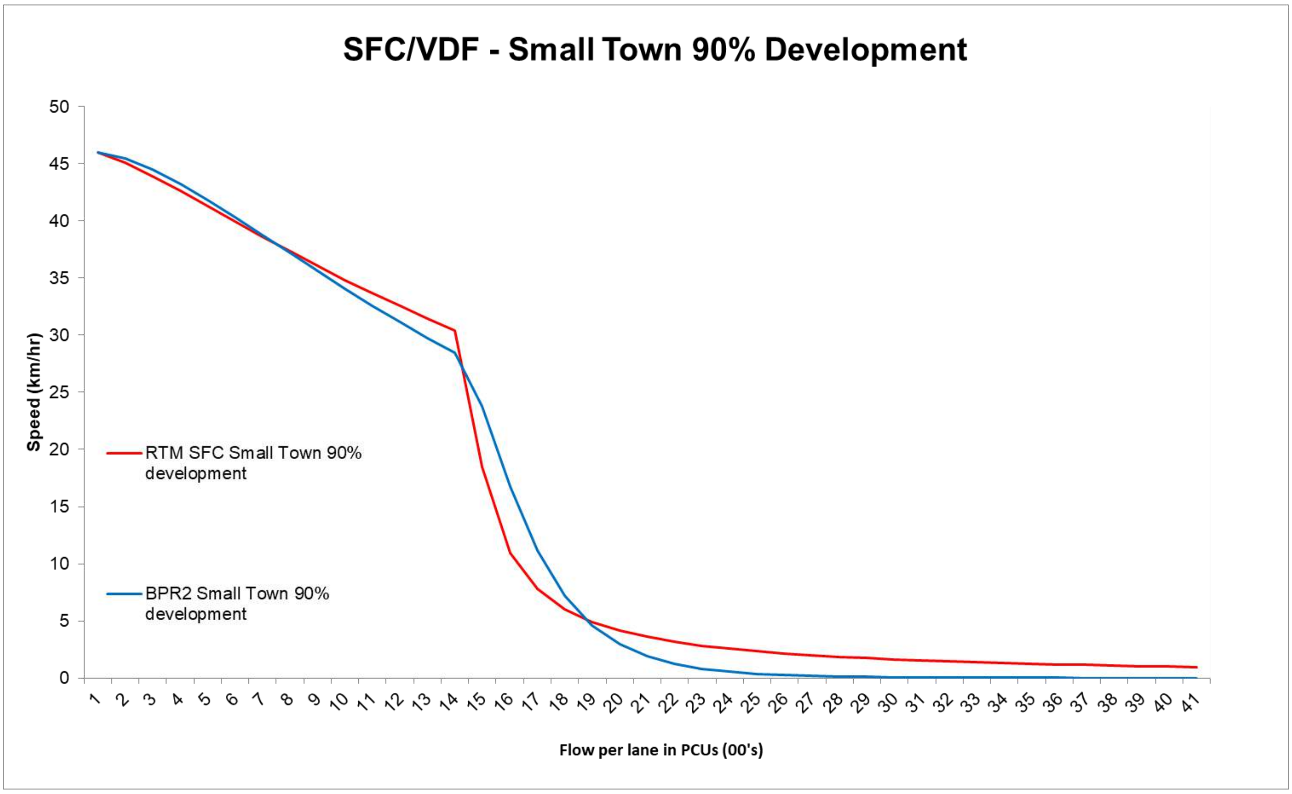

SFC/VDF - Urban Central INT = 2
40
35
30
25
20
15
10
5
0
Speed (km/hr)
RTM SFC Urban Central INT = 2
BPR2 Urban Central INT = 2
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Flow per lane in PCUs (00's)


SFC/VDF - Urban Central INT = 4.5
35
30
25
20
15
10
5
0
Speed (km/hr)
RTM SFC Urban Central INT = 4.5
BPR2 Urban Central INT = 4.5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Flow per lane in PCUs (00's)


SFC/VDF - Urban Central INT = 9
Speed (km/hr)
RTM SFC Urban Central INT = 9
BPR2 Urban Central INT = 9
Flow per lane in PCUs (00's)


SFC/VDF - Small Town 35% Development
Speed (km/hr)
RTM SFC Small Town 35% development
BPR2 Small Town 35% development
Flow per lane in PCUs (00's)


SFC/VDF - Small Town 60% Development
Speed (km/hr)
RTM SFC Small Town 60% development
BPR2 Small Town 60% development
Flow per lane in PCUs (00's)


SFC/VDF - Small Town 90% Development
Speed (km/hr)
RTM SFC Small Town 90% development
BPR2 Small Town 90% development
Flow per lane in PCUs (00's)

Appendix B – Link Types and Parameters

Link type No.	Description	Available Transport System	No. Lanes	Cap (pcus/hr)	Free-flow speed (kph)	Volume-dalay function parameters				
						a	b	a'	b'	c
0	Blocked opposite direction		0	0	0	1	1	1	1	1
1	Rural dual 6 motorway	B,Cco,Ceb,Co,HGV,LGV	6	13980	113	0.39	2.78	2.25	7.4	1
2	Rural dual 5 motorway	B,Cco,Ceb,Co,HGV,LGV	5	11650	113	0.39	2.78	2.25	7.4	1
3	Rural dual 4 motorway	B,Cco,Ceb,Co,HGV,LGV	4	9320	113	0.39	2.78	2.25	7.4	1
4	Rural dual 3 motorway	B,Cco,Ceb,Co,HGV,LGV	3	6990	113	0.39	2.78	2.25	7.4	1
5	Rural dual 2 motorway	B,Cco,Ceb,Co,HGV,LGV	2	4659	113	0.52	2.78	2.25	7.4	1
6	Rural dual 1 motorway slip	B,Cco,Ceb,Co,HGV,LGV	1	1680	65	1.52	2.45	1.85	7.8	1
7	Roundabout Circulate 4	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	4	5000	48	1	1	1	1	1
8	Roundabout Circulate 3	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	3	4680	48	1	1	1	1	1
9	Roundabout Circulate 2	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	2	3780	48	1	1	1	1	1
10	Roundabout Circulate 1	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	2250	48	1	1	1	1	1
11	Rural carriageway typical 3 lanes	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	3	6300	112	0.39	2.78	2.25	7.4	1
12	Rural carriageway typical 2 lanes	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	2	4200	112	0.39	2.78	2.25	7.4	1
13	Rural single carriageway 10m good	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	1900	105	0.7	2.2	2.2	7.4	1
14	Rural single carriageway 10m typical	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	1700	93	0.7	2.2	2.2	7.4	1
15	Rural single carriageway 7.3m good	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	1300	87	0.5	2.2	2.2	7.4	1
16	Rural single carriageway 7m typical	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	1176	84	0.5	2.2	2.2	7.4	1
17	Rural single carriageway 6.5m bad	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	1000	67	0.5	1.9	1.78	6.6	1
18	Rural single carriageway 5m awful HGV ban	B,Cco,Ceb,Co,Cycle,LGV,W	1	900	54	0.55	1.7	2.1	5	1
19	Rural single carriageway 5m awful	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	900	54	0.55	1.7	2.1	5	1
20	Rural single carriageway 5m extremely bad	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	250	32	0.55	1.7	2.1	5	1
21	Rural single carriageway 7.3m good 2 lanes	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	2	2600	87	0.5	2.2	2.2	7.4	1
22	Rural single carriageway 7.3m good 3 lanes	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	3	3900	87	0.5	2.2	2.2	7.4	1
23	Rural carriageway typical 2 lanes (A12)	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	2	4200	112	1.5	2.78	2.25	7.4	1
24	Rural single carriageway 7.3m good 2 lanes (A1114)	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	2	2600	87	0.5	2.2	9	7.8	1
25	Suburban dual 4 slight development	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	4	6720	65	1.52	2.45	1.85	7.8	1
26	Suburban dual 3 slight development	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	3	5040	65	1.52	2.45	1.85	7.8	1
27	Suburban dual 4 heavy development	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	4	6720	58	1.29	1.01	1.65	7.8	1
28	Suburban dual 3 heavy development	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	3	5040	58	1.29	1.01	1.65	7.8	1
29	Suburban dual 2 slight development	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	2	3360	65	1.52	2.45	1.85	7.8	1
30	Suburban dual 2 typical development	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	2	3360	61	1.45	1.6	1.65	7.8	1
31	Suburban dual 2 heavy development	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	2	3360	58	1.29	1.01	1.65	7.8	1
32	Suburban single slight development	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	1680	65	1.52	2.45	1.85	7.8	1
33	Suburban single slight development HGV ban	B,Cco,Ceb,Co,Cycle,LGV,W	1	1680	65	1.52	2.45	1.85	7.8	1
34	Suburban single typical development	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	1680	61	1.45	1.6	1.65	7.8	1
35	Suburban single typical development HGV ban	B,Cco,Ceb,Co,Cycle,LGV,W	1	1680	61	1.45	1.6	1.65	7.8	1
36	Suburban single heavy development	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	1680	58	1.29	1.01	1.65	7.8	1
37	Suburban single heavy development HGV ban	B,Cco,Ceb,Co,Cycle,LGV,W	1	1680	58	1.29	1.01	1.65	7.8	1
38	Urban non-central 80% development 3 lanes	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	3	2688	48	0.98	1.74	2.99	3.45	1
39	Urban non-central 80% development 2 lanes	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	2	1792	48	0.98	1.74	2.99	3.45	1
40	Urban non-central 80% development 2 lanes HGV ban	B,Cco,Ceb,Co,Cycle,LGV,W	2	1792	48	0.98	1.74	2.99	3.45	1
41	Urban non-central 50% development	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	896	48	0.74	2.65	3.06	3.45	1
42	Urban non-central 50% development HGV ban	B,Cco,Ceb,Co,Cycle,LGV,W	1	896	48	0.74	2.65	3.06	3.45	1
43	Urban non-central 80% development	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	896	48	0.98	1.74	2.99	3.45	1
44	Urban non-central 80% development HGV ban	B,Cco,Ceb,Co,Cycle,LGV,W	1	896	48	0.98	1.74	2.99	3.45	1
45	Urban non-central 100% development	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	896	46	0.89	1.25	2.95	3.45	1
46	Urban non-central 100% development HGV ban	B,Cco,Ceb,Co,Cycle,LGV,W	1	896	46	0.89	1.25	2.95	3.45	1
47	Urban central INT = 2	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	944	37	1.44	1.48	2.45	3.45	1
48	Urban central INT = 2 HGV ban	B,Cco,Ceb,Co,Cycle,LGV,W	1	944	37	1.44	1.48	2.45	3.45	1
49	Urban central INT = 4.5	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	944	33	1.35	1.24	2.05	3.45	1
50	Urban central INT = 4.5 HGV ban	B,Cco,Ceb,Co,Cycle,LGV,W	1	944	33	1.35	1.24	2.05	3.45	1
51	Urban central INT = 9	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	896	28	0.95	0.85	1.96	3.45	1
52	Urban central INT = 9 HGV ban	B,Cco,Ceb,Co,Cycle,LGV,W	1	896	28	0.95	0.85	1.96	3.45	1
53	Small town 35% development	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	1344	63	0.85	2.49	2.95	2.99	1
54	Small town 60% development	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	1344	56	0.85	2.46	2.35	3.1	1
55	Small town 90% development	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	1344	46	0.65	1.54	1.95	3.05	1
56	Residential Road	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	944	33	1.35	1.24	2.05	3.45	1
57	Single track road	B,Cco,Ceb,Co,Cycle,LGV,W	1	200	32	4	0.3	2.5	5	1
58	Car Park	Cco,Ceb,Co,Cycle,LGV	1	100	48	1	1	1	1	1
59	Bus only	B,Cycle,W	1	99999	48	1	1	1	1	1
60	LU LinkS	U	1	99999	50	1	1	1	1	1
61	Rail Link	C+Train,Cycle+Train,T	1	99999	50	1	1	1	1	1
62	Walk Links	B,Cycle,W	1	99999	5	1	1	1	1	1
63	Walk Links (Cycle dismount)	B,Cycle,W	1	99999	50	1	1	1	1	1
64	Walk Links Stations Access (Cycle dismount)	Cycle,W	1	99999	50	1	1	1	1	1
65	Cycling Paths	B,Cycle,W	1	99999	50	1	1	1	1	1
66	External Links (30mph)	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	99999	48	1	1	1	1	1
67	External Links (70mph)	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	99999	113	1	1	1	1	1
68	Spigot	B,Cco,Ceb,Co,Cycle,HGV,LGV,W	1	99999	50	1	1	1	1	1

Appendix C – Kimber Guidance

Standard Dimensions to Adopt for TRL/Kimber Method

ARM		Approach half width (V) (m)	Entry width (E) (m)	Flare Length ('l) (m)	Entry Radius (R) (m)	Inscribed Roundabout Diameter (D) (m)	Entry Conflict Angle (PHI) (Deg)
Short flare /No flare length (<3 cars or 10m)	1 ln approach, no flare	3.65	4	5	15	User Defined	30
	2 ln approach, no flare	7.30	8	5	15		30
	3 ln approach, no flare	10.95	12	5	15		30
	1 ln approach, 2 ln entry	3.65	8	10	15		30
	2 ln approach, 3 ln entry	7.30	12	10	15		30
Long Flare length (<= 10 cars or 60m)	1 ln approach, 2 ln entry	3.65	8	30	15		30
	2 ln approach, 3 ln entry	7.30	12	30	15		30
Multi-Node Roundabout	Circulatory Arm	15	20	100	1000	200	0

- For roundabouts with flare length >60m, assign as a new lane (i.e. for an approach with 1 lane with 100m flare, use dimensions for 2 lane, no flare)
- Modellers should measure roundabouts using google maps or a similar tool to measure Inscribed Roundabout Diameter, which is the largest diameter across the roundabout (from outside edge to outside edge)

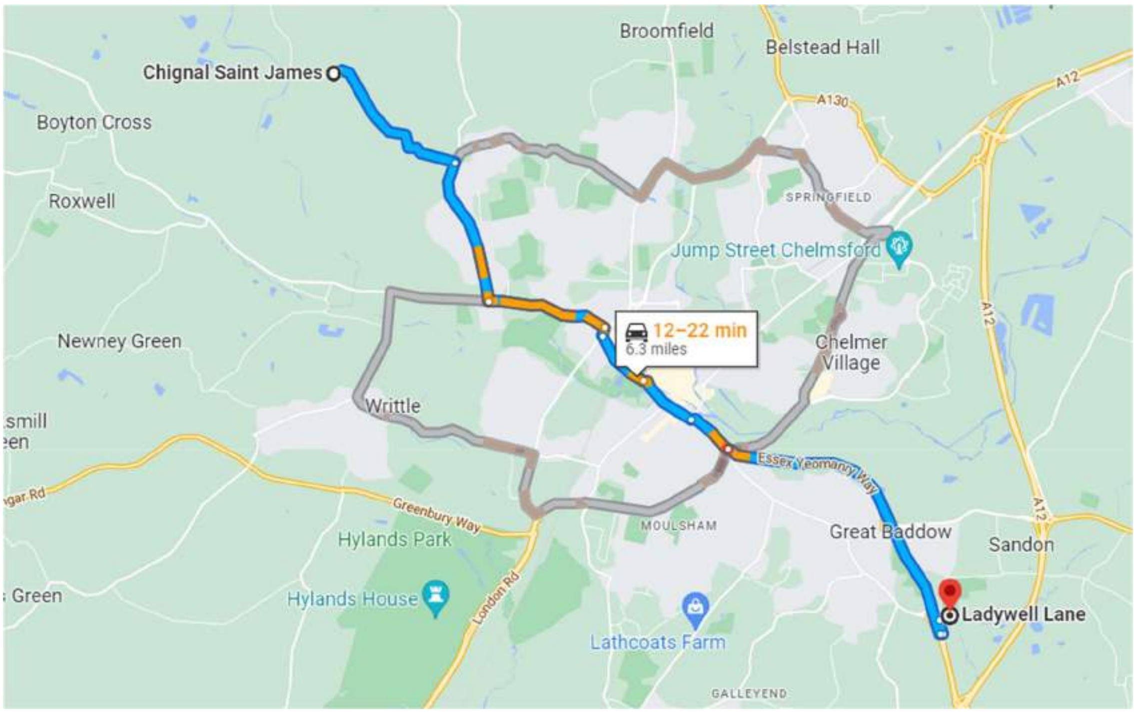
Appendix D – Network Checklist

<table>
<tr><th>Chelmsford Model VISUM checklist</th><th>Description</th><th>Checker RS</th><th>Reviewer TK</th><th>Comments RS</th><th>Based on version file:</th></tr>
<tr><td rowspan="3">Network settings</td><td>Network parameters
Scale, Units, direction of traffic, model periods, other settings all appropriate</td><td>ok</td><td>ok</td><td>Settings show left-hand traffic, metric units, all looks ok.</td><td rowspan="20">\\GBLON7VS01.europe.jacobs.com\Projects\UNIF\Projects\B355393A - Enhanced Countywide Model\2. Technical\Data\Base Model\VISUM\VER\AM\South_Essex_Base_AM_2019.ver</td></tr>
<tr><td>TSys/Modes/DSegs
Appropriate. Correct parameter and factor values. Correct PCU factors for private transport systems</td><td>ok</td><td>ok</td><td>The PCU factor for HGV is 2.50. The rest are 1.00.</td></tr>
<tr><td>Link types
Range of link types look sufficient
Parameter values are sensible</td><td>ok</td><td>ok</td><td>The majority of the link types have previously been used in Regional Transport models, which were used as a starting point.</td></tr>
<tr><td rowspan="7">General procedure settings - PrT settings</td><td>Volume-delay functions
Check attributes and assignment to link types</td><td>ok</td><td>ok</td><td>The volume-delay functions' (BPR2) parameters were calculated based on previous Regional Transport Models.</td></tr>
<tr><td>Impedance
Check calculation</td><td>ok</td><td>ok</td><td>Impedance values are based on "\\GBLON7VS01.europe.jacobs.com\Projects\UNIF\Projects\B355393A - Enhanced Countywide Model\2. Technical\Data\Base Model\VISUM\VER\VoT_and_VOC_from_TAG_Databook_1.13_May2020.xls" spreadsheet, which includes the following 2019 impedance values (length parameter):
<table>
<tr><th>2019 Impendance Values</th><th>AM</th><th>IP</th><th>PM</th></tr>
<tr><td>Commute</td><td>0.0186</td><td>0.0175</td><td>0.0185</td></tr>
<tr><td>Business</td><td>0.0262</td><td>0.0244</td><td>0.0258</td></tr>
<tr><td>Other</td><td>0.0270</td><td>0.0242</td><td>0.0258</td></tr>
<tr><td>LGV</td><td>0.0609</td><td>0.0577</td><td>0.0609</td></tr>
<tr><td>HGV</td><td>0.0398</td><td>0.0386</td><td>0.0398</td></tr>
</table></td></tr>
<tr><td>Assignment
Check preload calculations</td><td>ok</td><td>ok</td><td>No preloads ("Basic Volume") have been set.</td></tr>
<tr><td>Node impedances
Check correct settings in use and parameters plausible</td><td>ok</td><td>ok</td><td>Node Impedance is based on Intersection Capacity Analysis (ICA)</td></tr>
<tr><td>Signal cycle and split optimisation
Check if in use</td><td>ok</td><td>ok</td><td>Signal optimisation was not used.</td></tr>
<tr><td>Blocking back model
Check if in use</td><td>ok</td><td>ok</td><td>Setting are: 7m (average space required per car unit) and 20 (number of shares for the flow distribution). The model do NOT use the link capacity for the blocking back model and exploits capacities evenly (faster).</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td rowspan="2">General procedure settings - PuT settings</td><td>Assignment
Check</td><td>ok</td><td>ok</td><td rowspan="2">Timetable-based</td></tr>
<tr><td>Revenues
Check if in use</td><td>ok</td><td>ok</td></tr>
<tr><td rowspan="2">General procesdure settings</td><td>Analysis time slots
Check appropriate</td><td>ok</td><td>ok</td><td>No calendar used in VISUM settings. The analysis period for each model corresponds to the time period for which the demand imported to the model is calculated, so either for AM Peak, Inter-Peak or PM Peak.</td></tr>
<tr><td>Volumes
Check</td><td>ok</td><td>ok</td><td></td></tr>
<tr><td rowspan="2">Zones</td><td>Zone boundaries
Have zone boundaries been correctly positioned and of appropriate size? Zones should generate similar numbers of trips and should not cover more than one land use if this can be avoided. Natural barriers such as rivers, motorways and railway lines should be used where possible. If the model is multi-modal, ensure that zoning takes into account of bus and rail catchments.</td><td>ok</td><td>ok</td><td>A new 332-zone system was created for South Essex Base Model. The demand calculation is based on the Essex Countywide Model matrices, which were converted into a new South Essex 332-zone system, following an automated procedure of disaggregation and aggregation through SATURN/VISUM softwares and VBA. Appropriate checks were done to ensure that the conversion was done correctly. Additional connectors and pre-set proportions were defined in some of the model's zones, in order to efficienty represent the distribution of trips.</td></tr>
<tr><td>Centroids and connection
Do zones load onto the
network in appropriate
places? If matrix estimation is to be used, then zones should not "straddle"
count locations</td><td>ok</td><td>ok</td><td>Connectors load onto sensible places.</td></tr>
<tr><td>Links</td><td>Topography
Check layout matches map background, shaping reasonable; parameters correctly applied according to link type, link lengths have been correctly calculated by VISUM. Allowed modes correct.
L1:Visual check of topography only</td><td>ok</td><td>ok</td><td>Multiple checks have been done for the roads located within our simulation area (territory), using Google Maps or Google Earth street view tool for coding and checks.</td></tr>
<tr><td rowspan="2">Nodes</td><td>Turns
Check banned turns are
appropriate - eg, no
inappropriate turns on exploded roundabouts or grade separated junctions.
Specific banned turns match layout on ground</td><td>ok</td><td>ok</td><td>Multiple checks have been done for banned turns (roundabouts, slip roads, grade seperated junctions).</td></tr>
<tr><td>Junction layout and control
Matches layout on the ground with an appropriate degree of detail
Signal settings are correct</td><td>ok</td><td>ok</td><td>Junction layouts and control types represent the reality with an appropriate degree of detail within our simulation area. Google Maps or Google Earth street view tool was used for coding and checks.</td></tr>
</table>

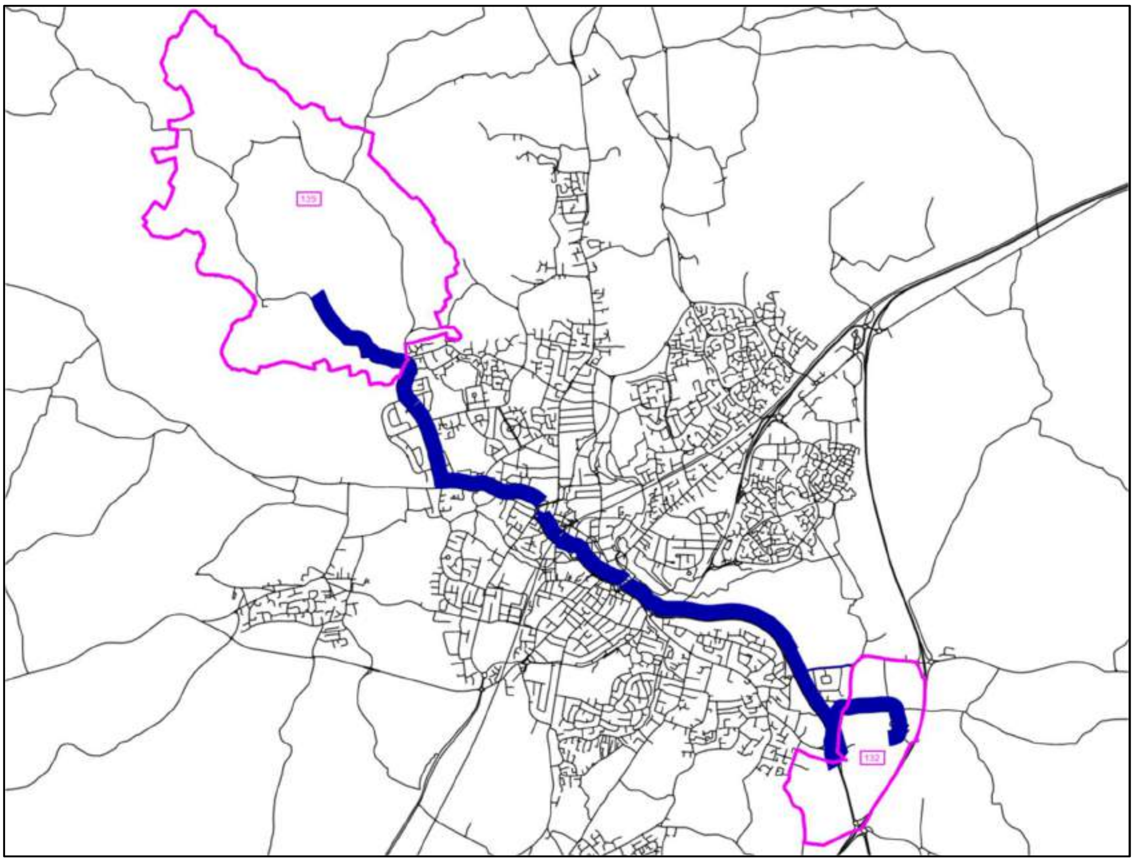
Appendix E – Route Checking

A&N Route Checking – AM (07:30AM)

1. Chignal St James to Ladywell Lane



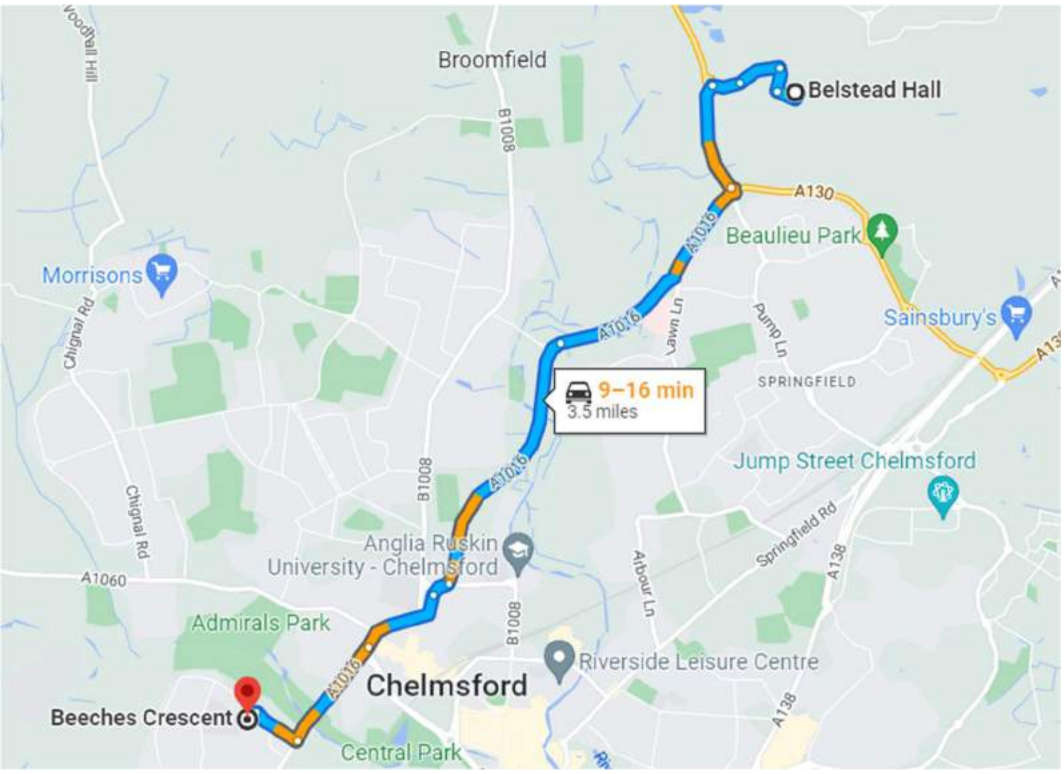
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



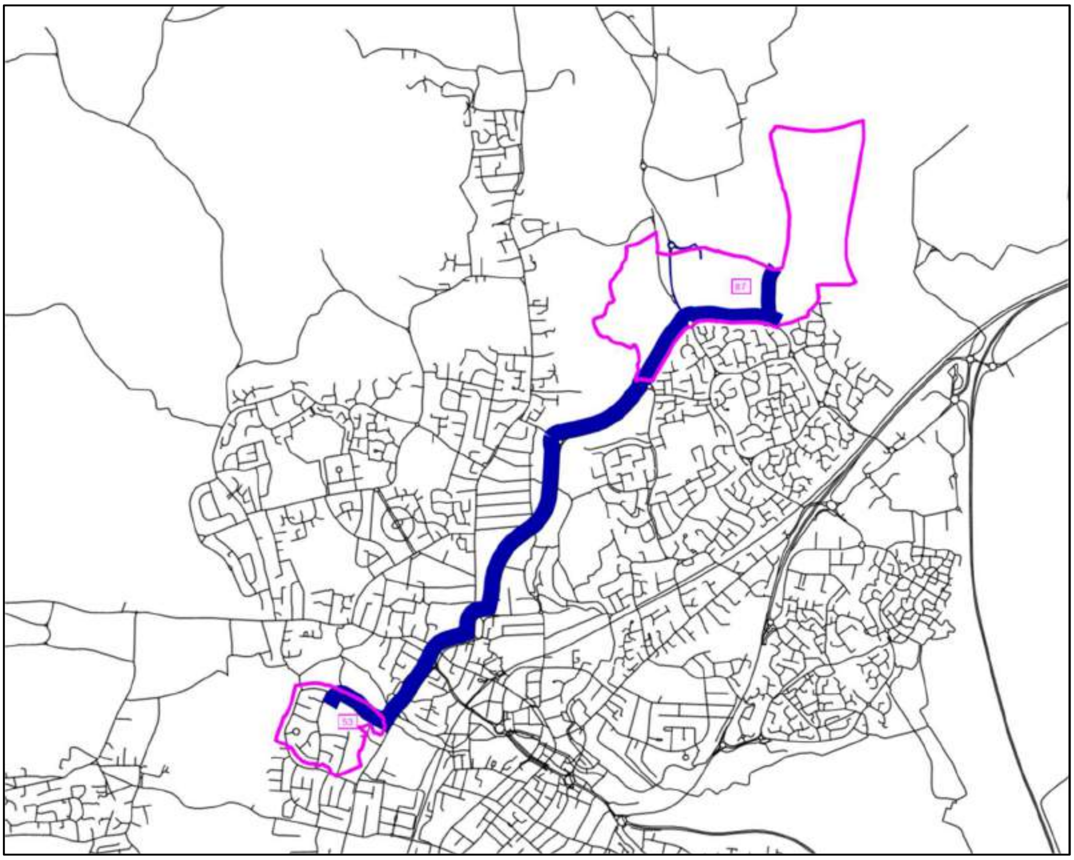
VISUM Model, 2019. AM peak.

A&N Route Checking – AM (07:30AM)

2. Belstead Hall to Beeches Crescent



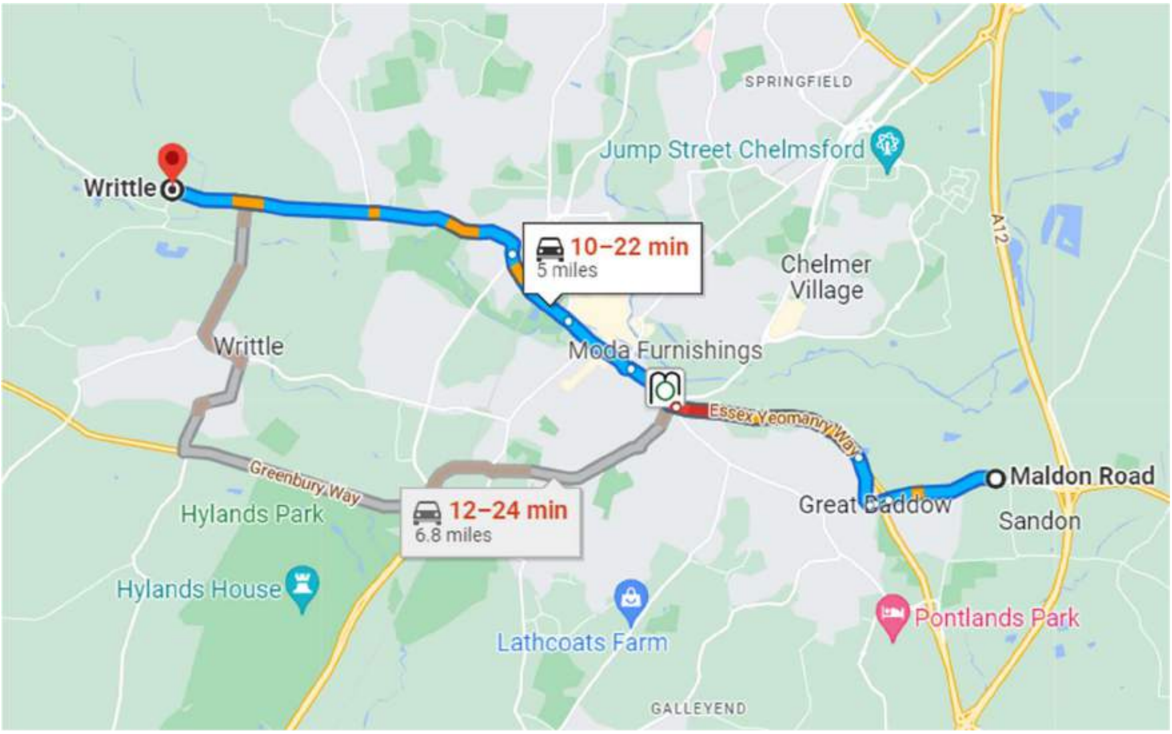
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



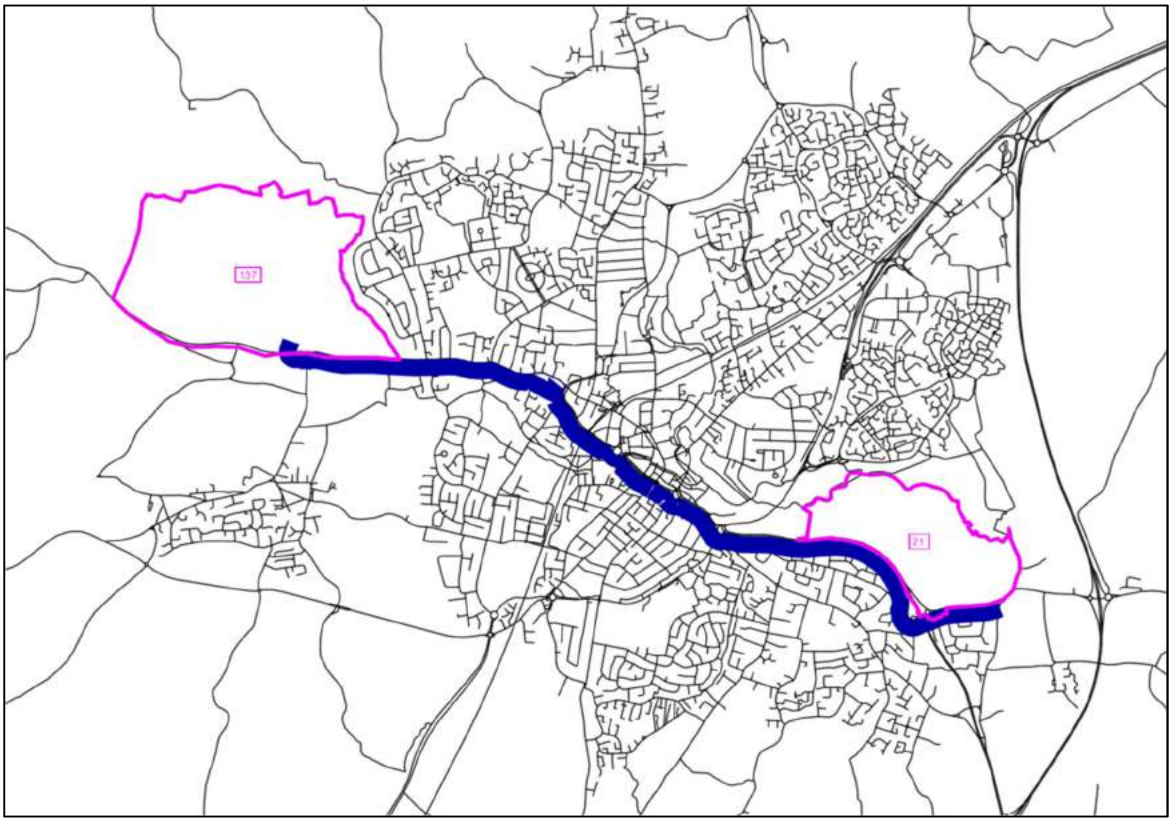
VISUM Model, 2019. AM peak.

A&N Route Checking – AM (07:30AM)

3. Maldon Road to Writtle



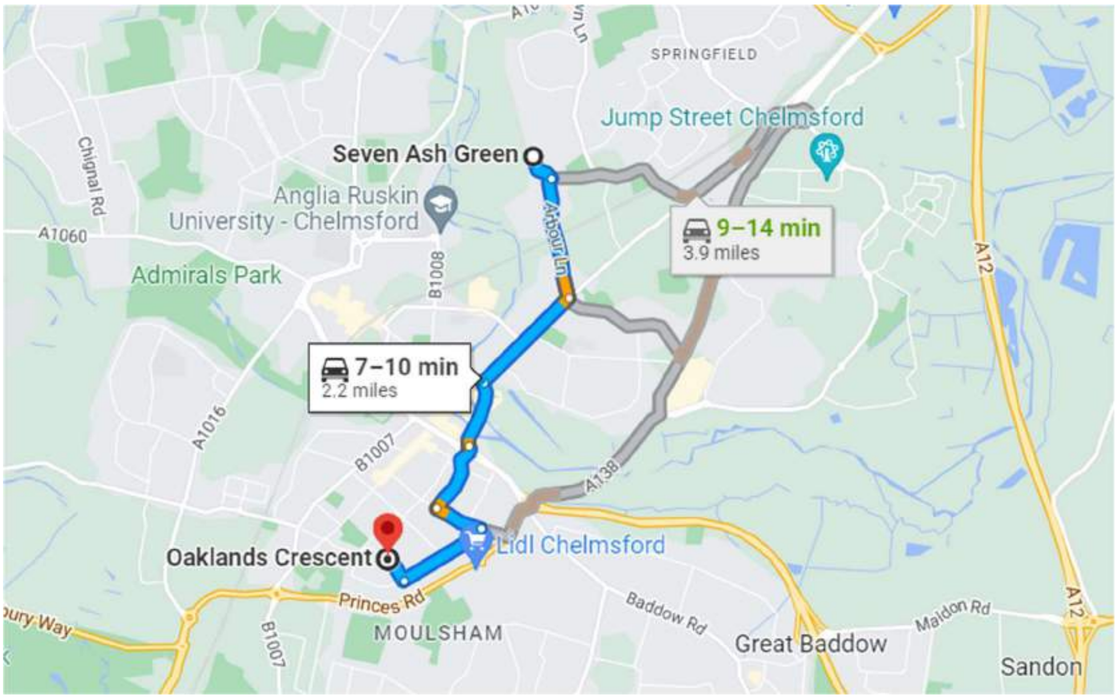
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



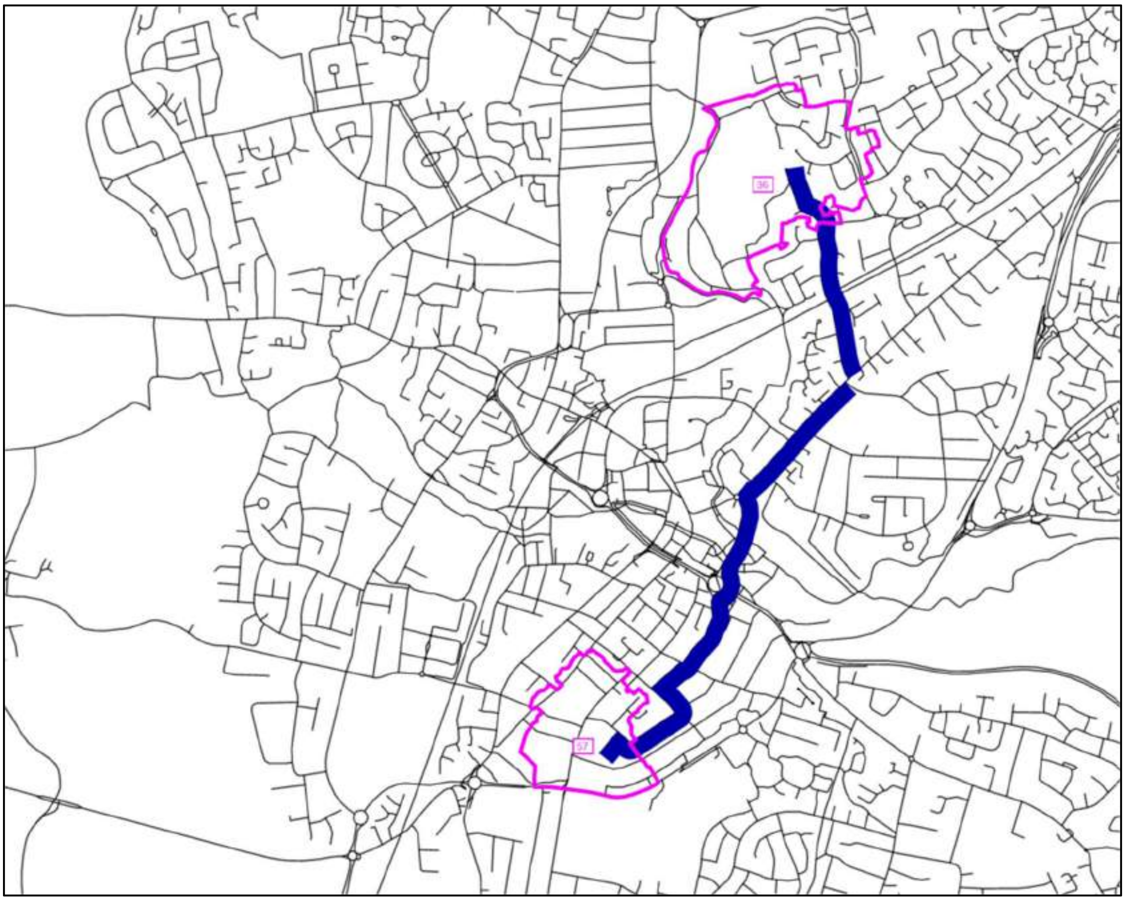
VISUM Model, 2019. AM peak.

A&N Route Checking – AM (07:30AM)

4. Seven Ash Green to Oaklands Crescent



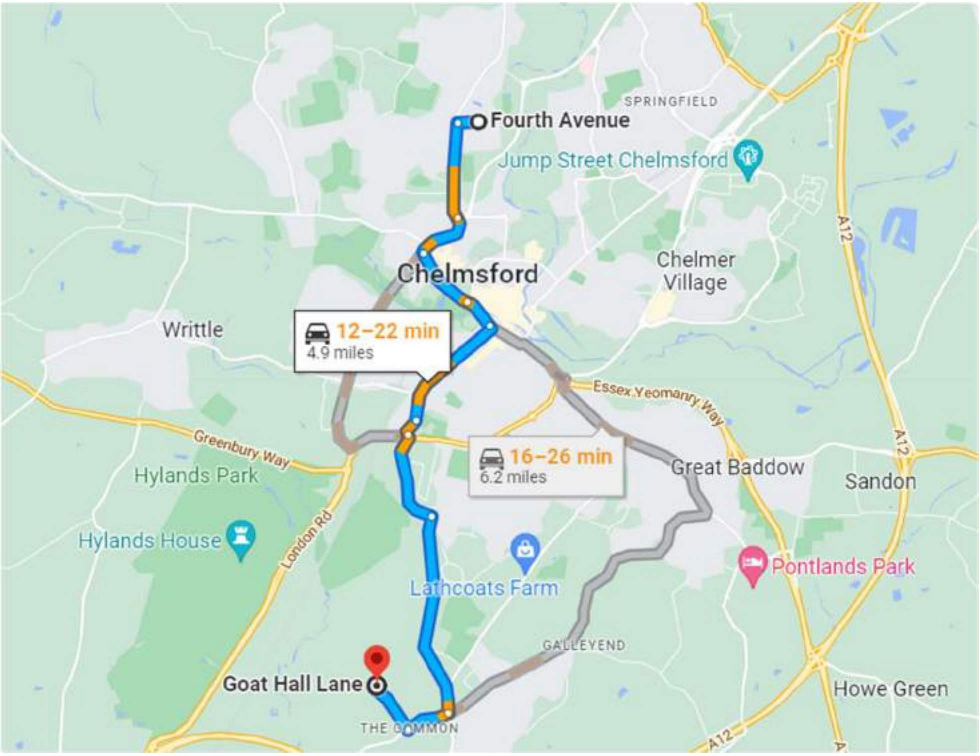
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



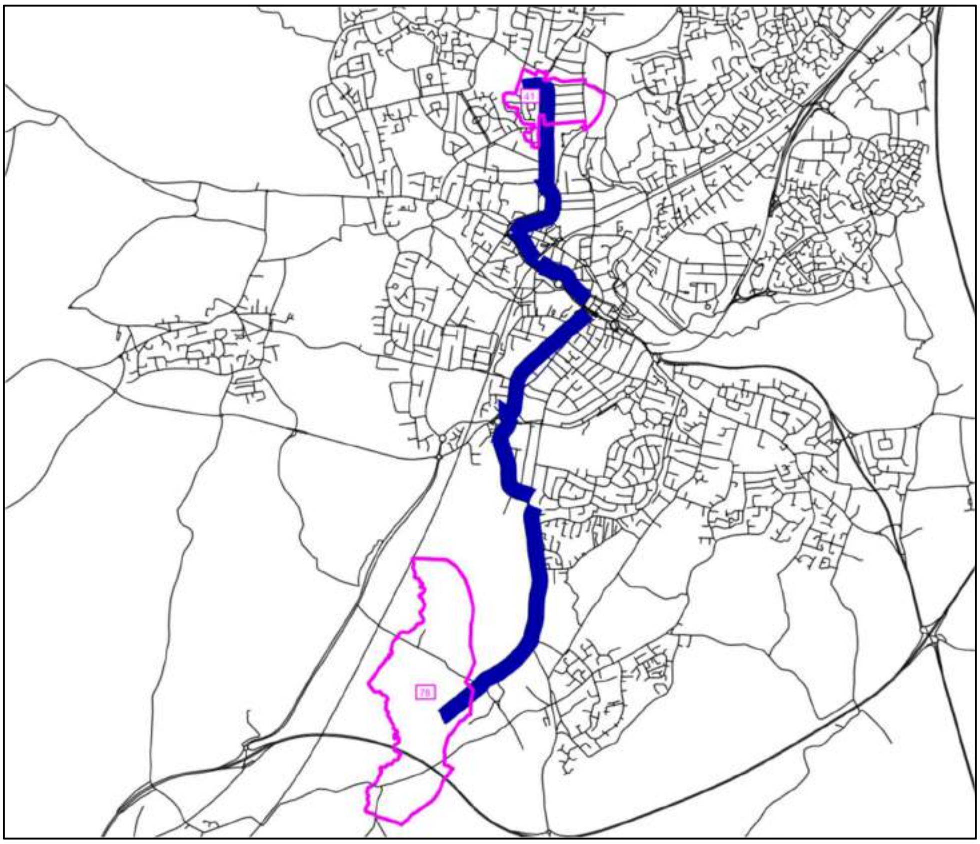
VISUM Model, 2019. AM peak.

A&N Route Checking – AM (07:30AM)

5. Fourth Avenue to Goat Hall Lane



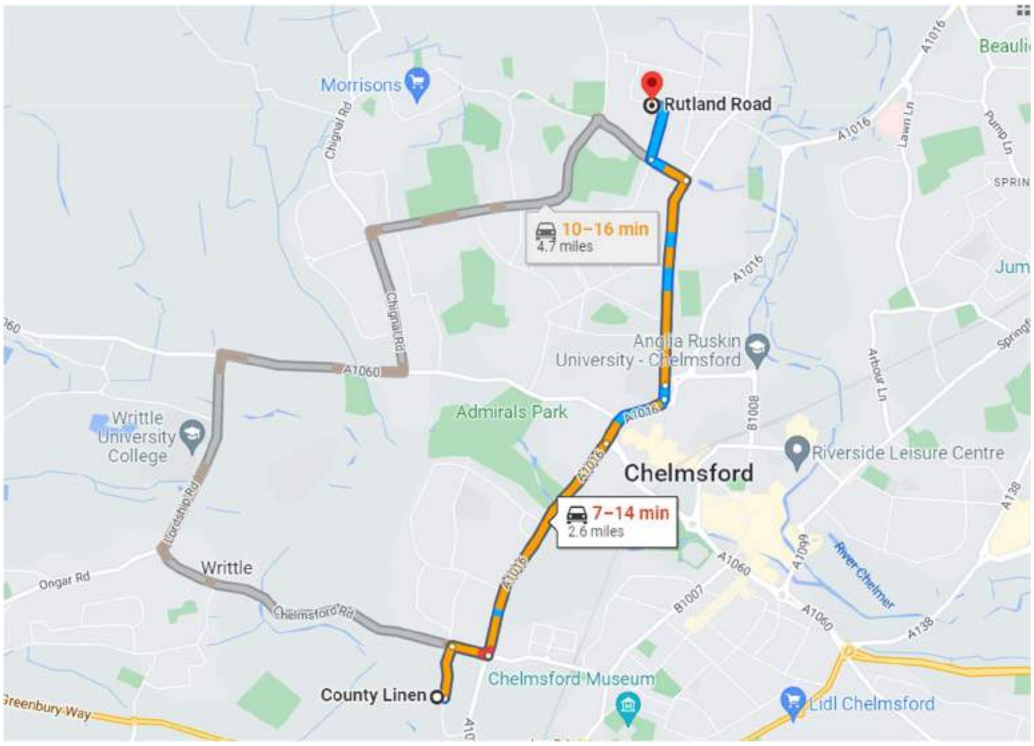
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



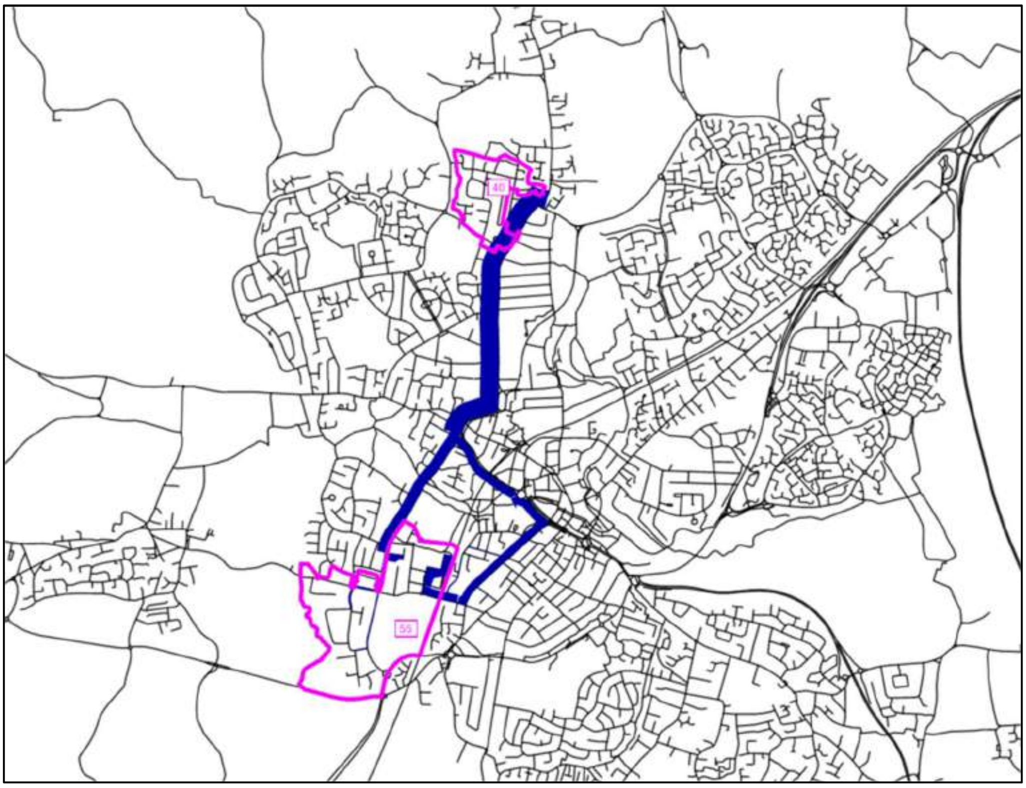
VISUM Model, 2019. AM peak.

A&N Route Checking – AM (07:30AM)

6. County Linen Services to Rutland Road



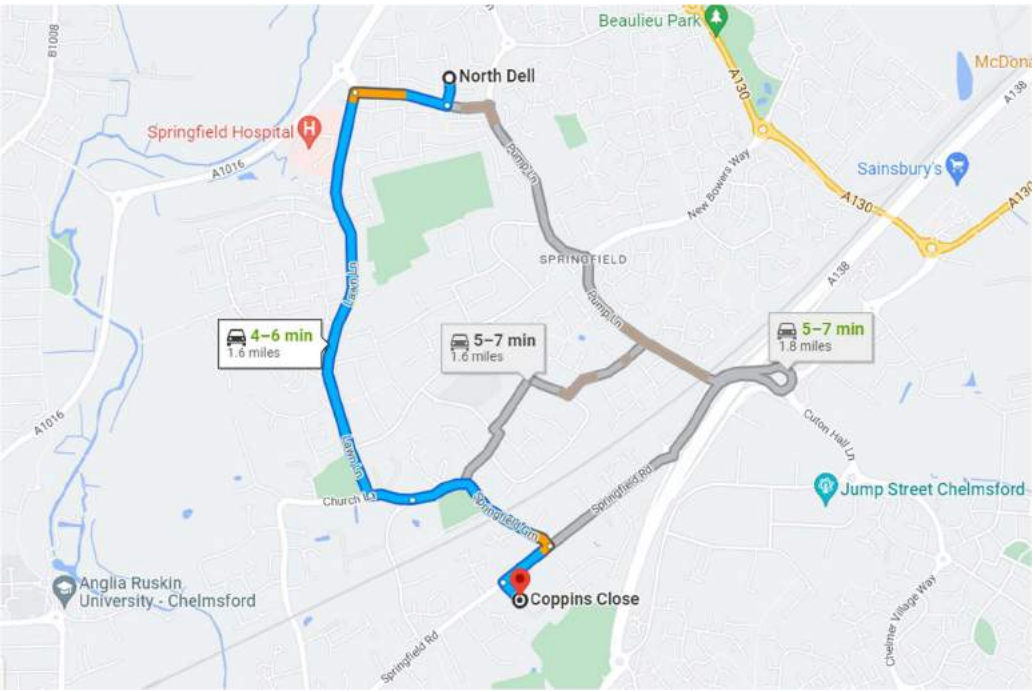
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



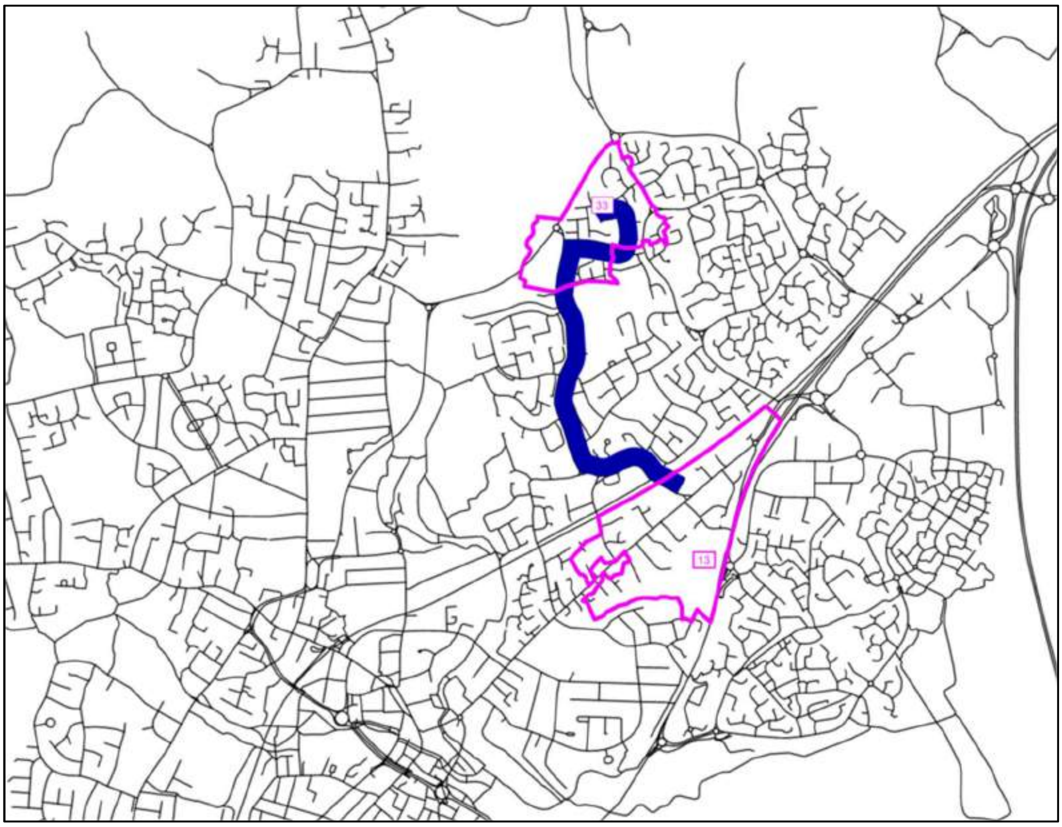
VISUM Model, 2019. AM peak.

A&N Route Checking – AM (07:30AM)

7. North Dell to Coppins Close



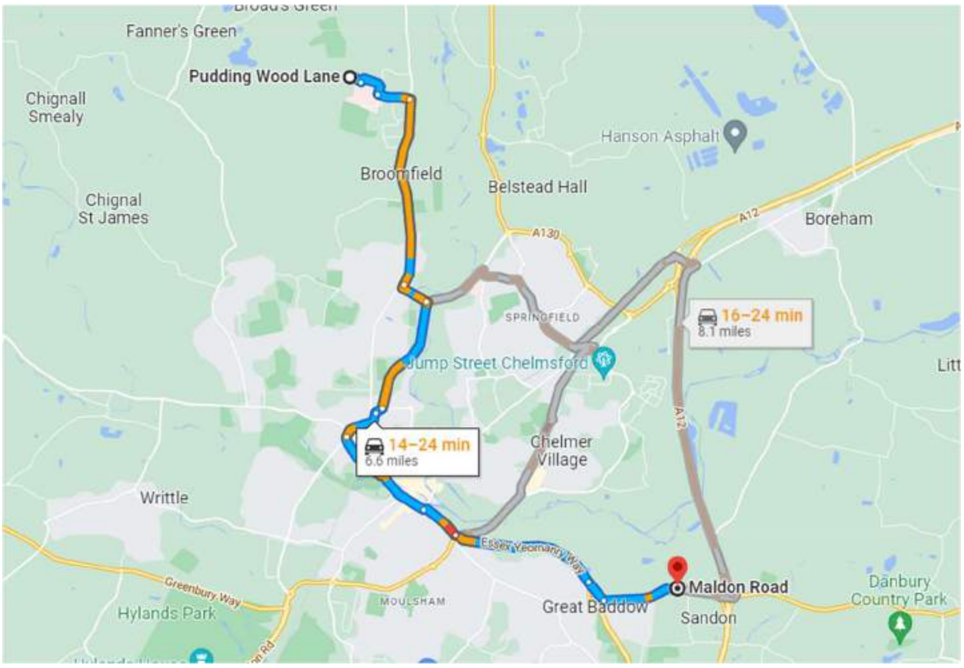
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



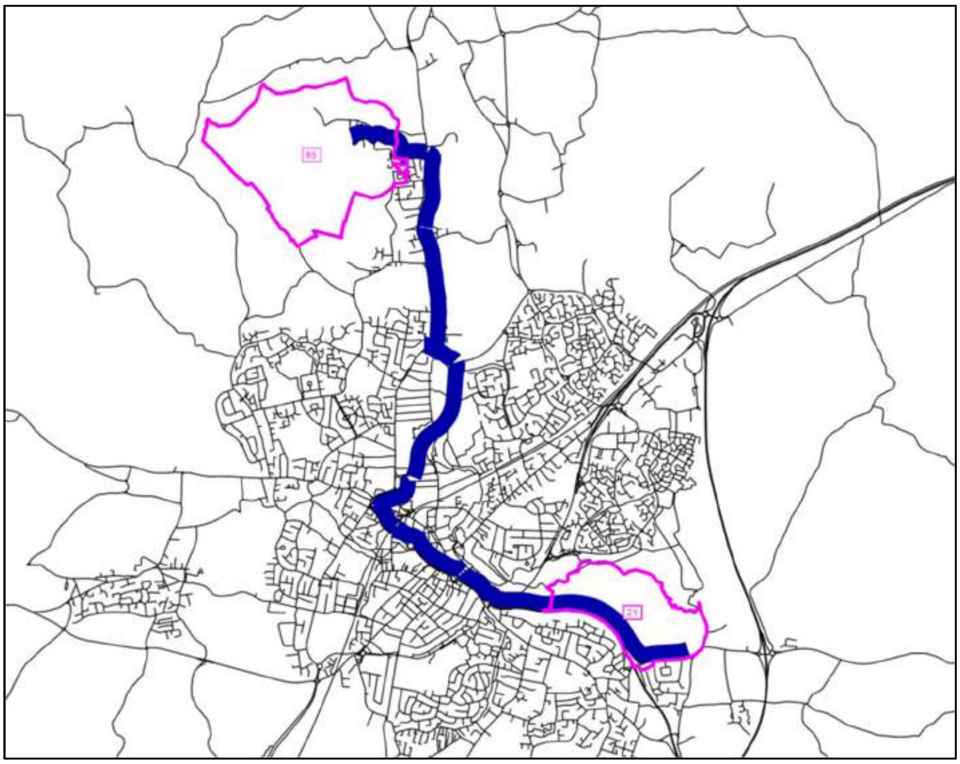
VISUM Model, 2019. AM peak.

A&N Route Checking – AM (07:30AM)

8. Pudding Wood Lane to Maldon Road



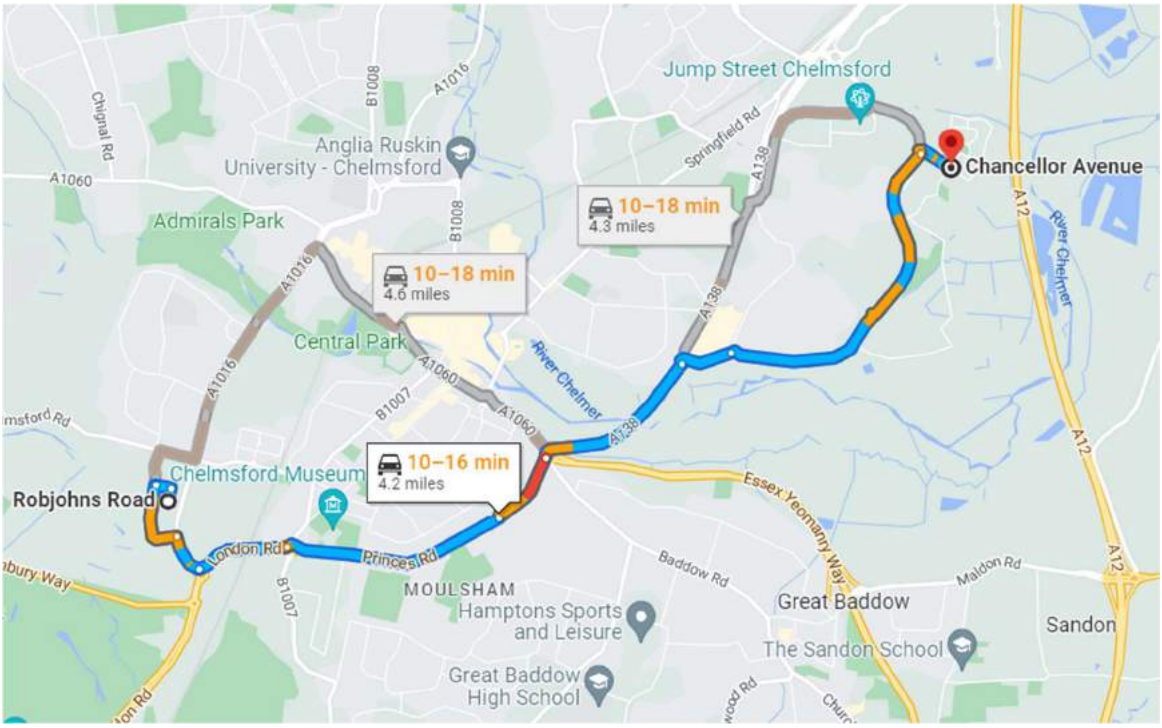
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



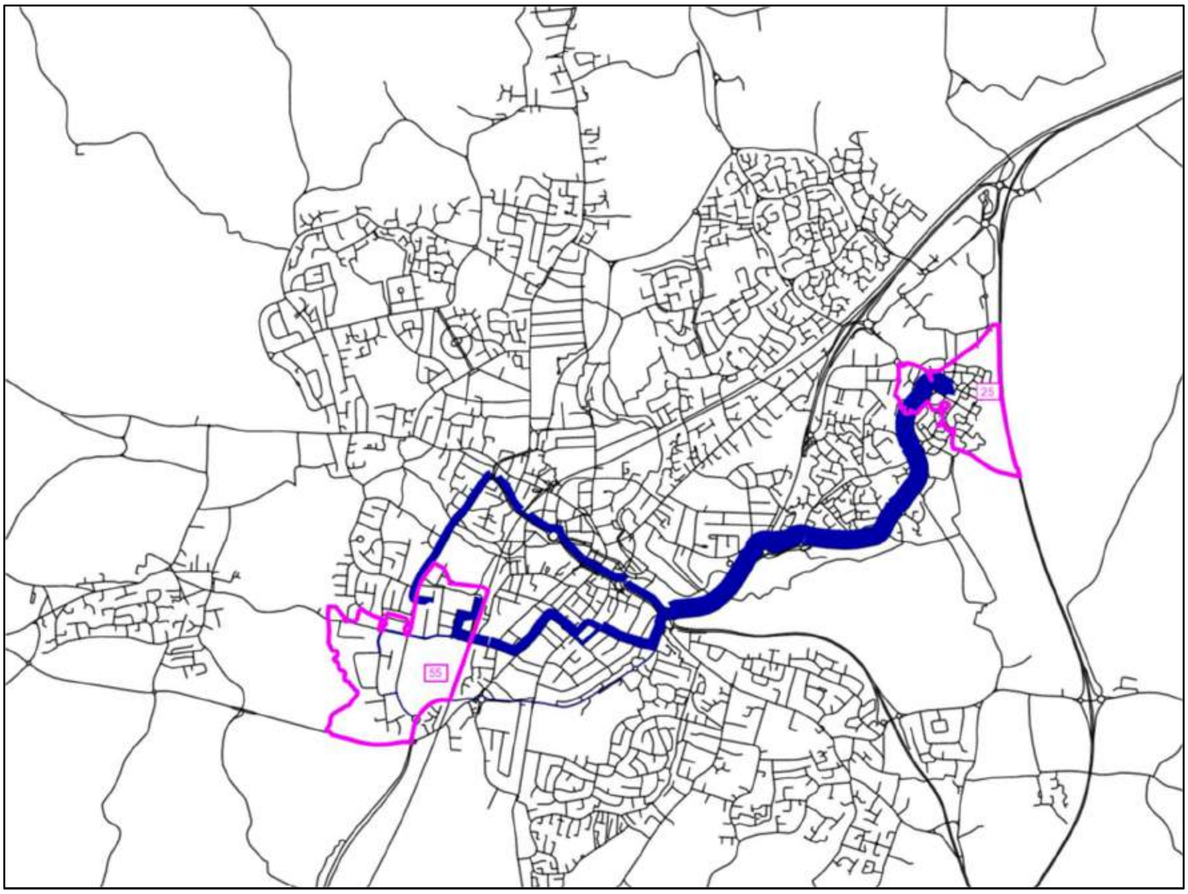
VISUM Model, 2019. AM peak.

A&N Route Checking – AM (07:30AM)

9. Robjohns Road to Chancellor Avenue



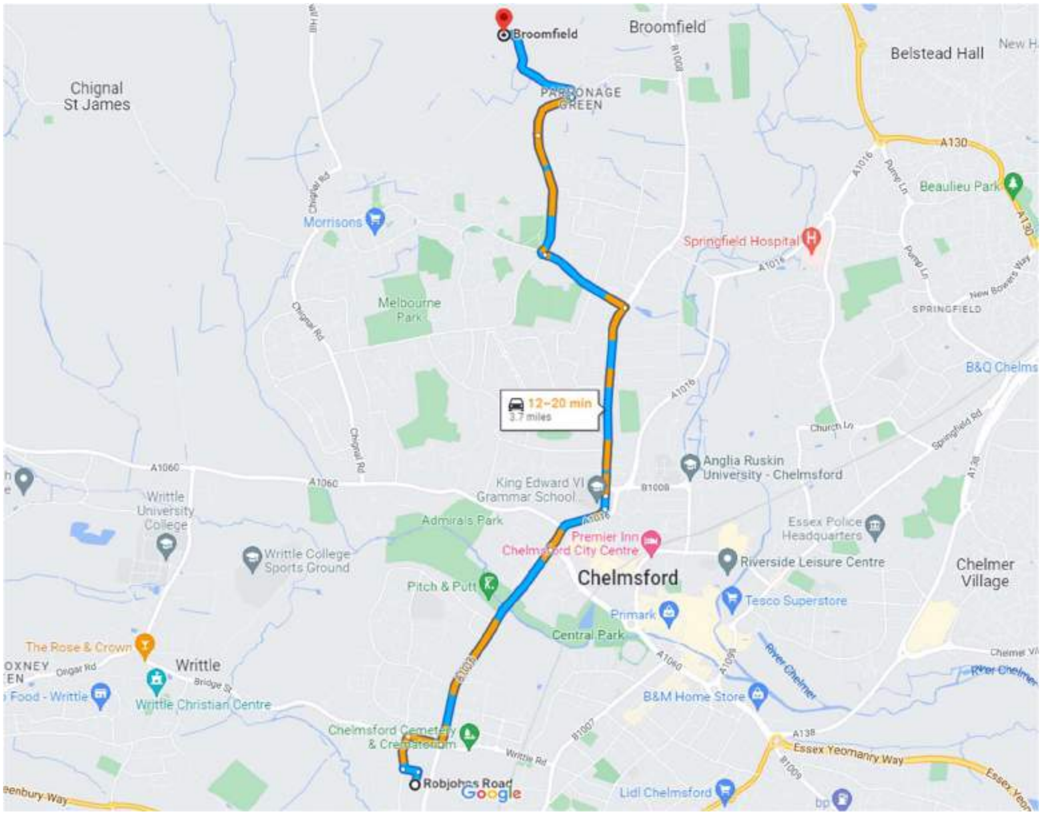
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



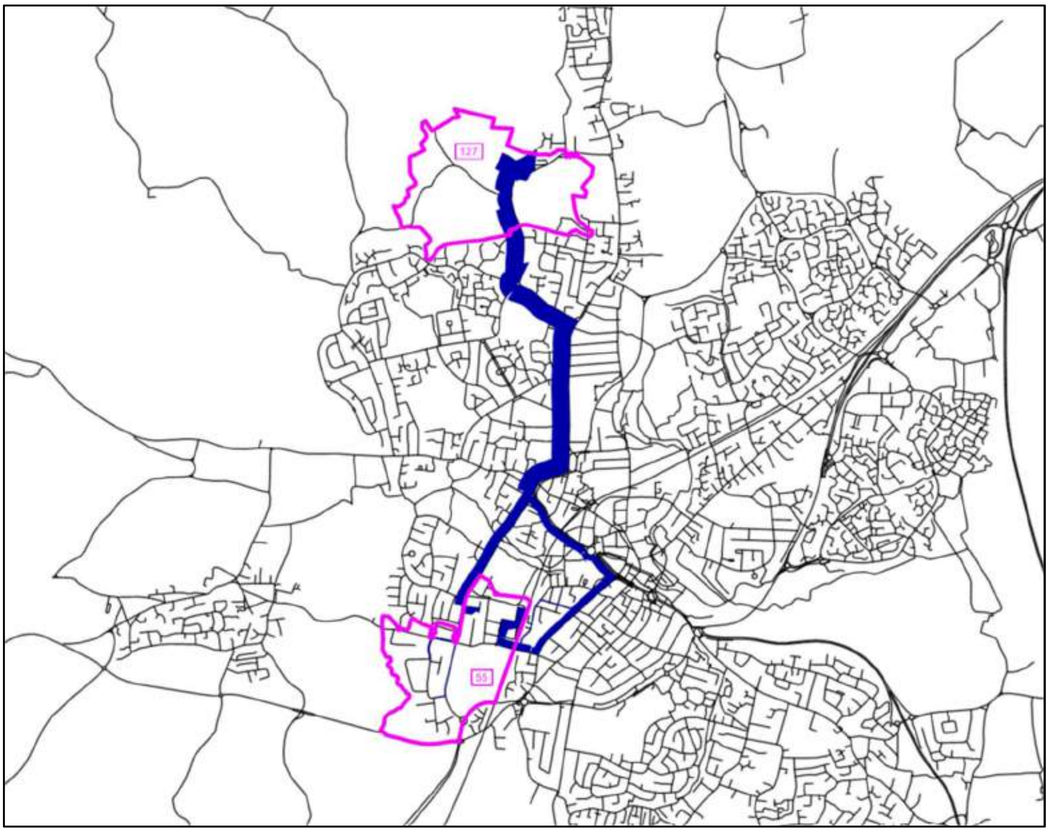
VISUM Model, 2019. AM peak.

A&N Route Checking – AM (07:30AM)

10. Robjohns Road to Broomfield



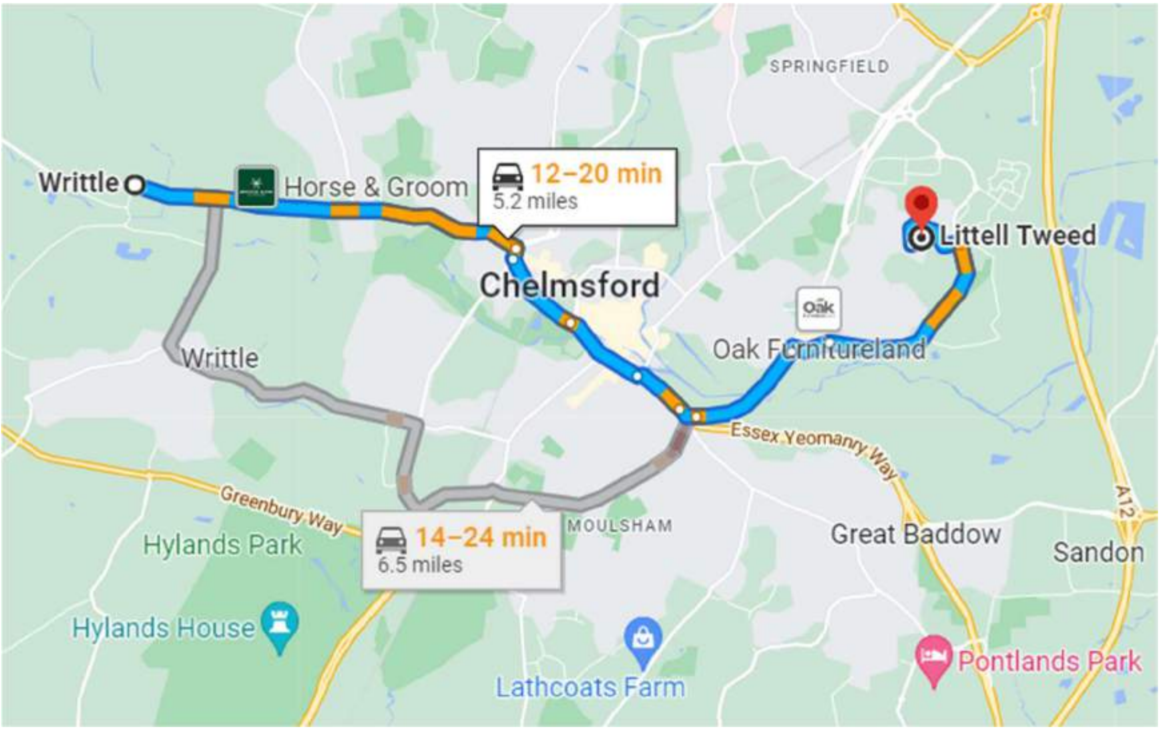
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



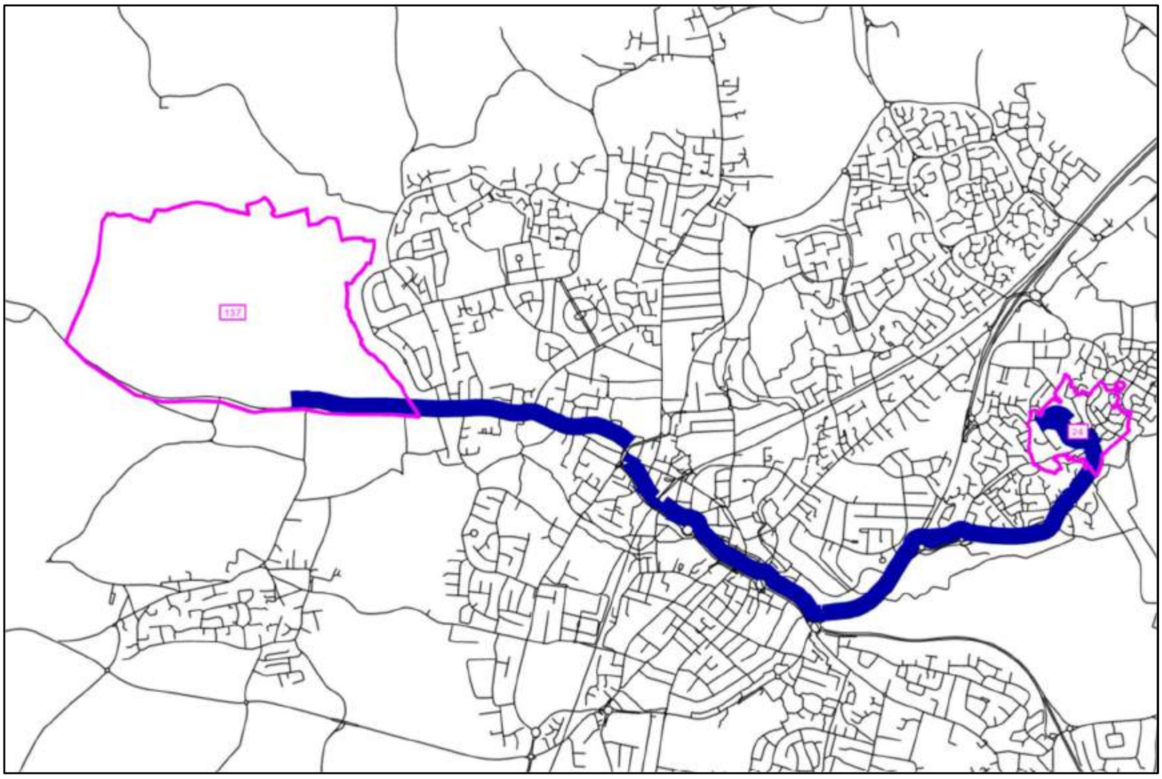
VISUM Model, 2019. AM peak.

A&N Route Checking – AM (07:30AM)

11. Writtle to Littell Tweed



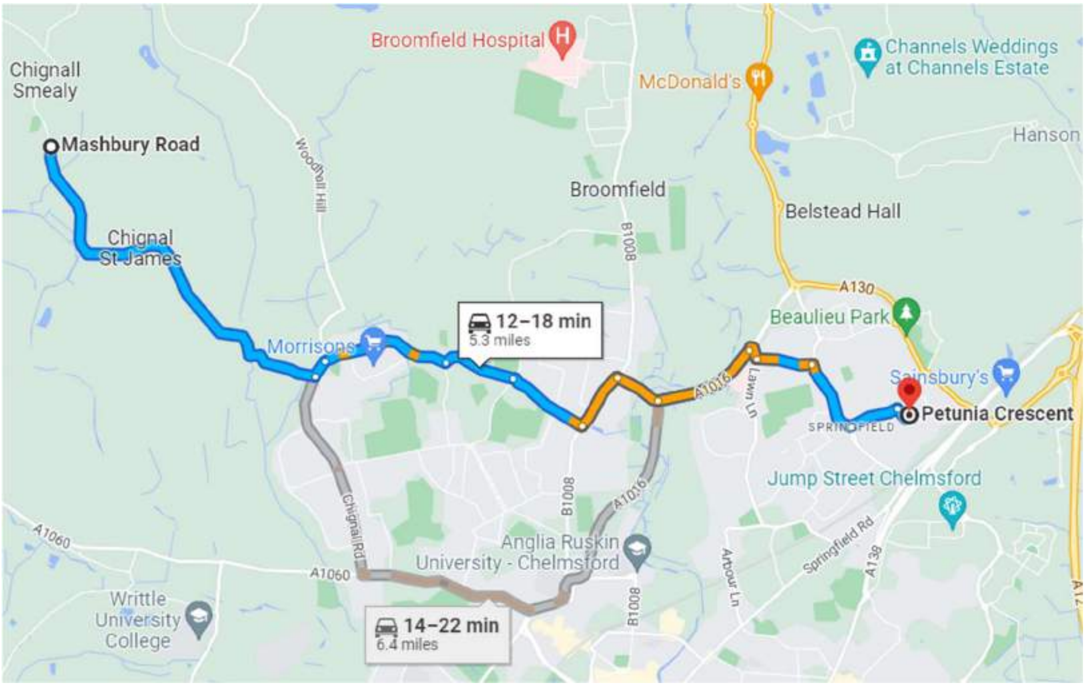
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



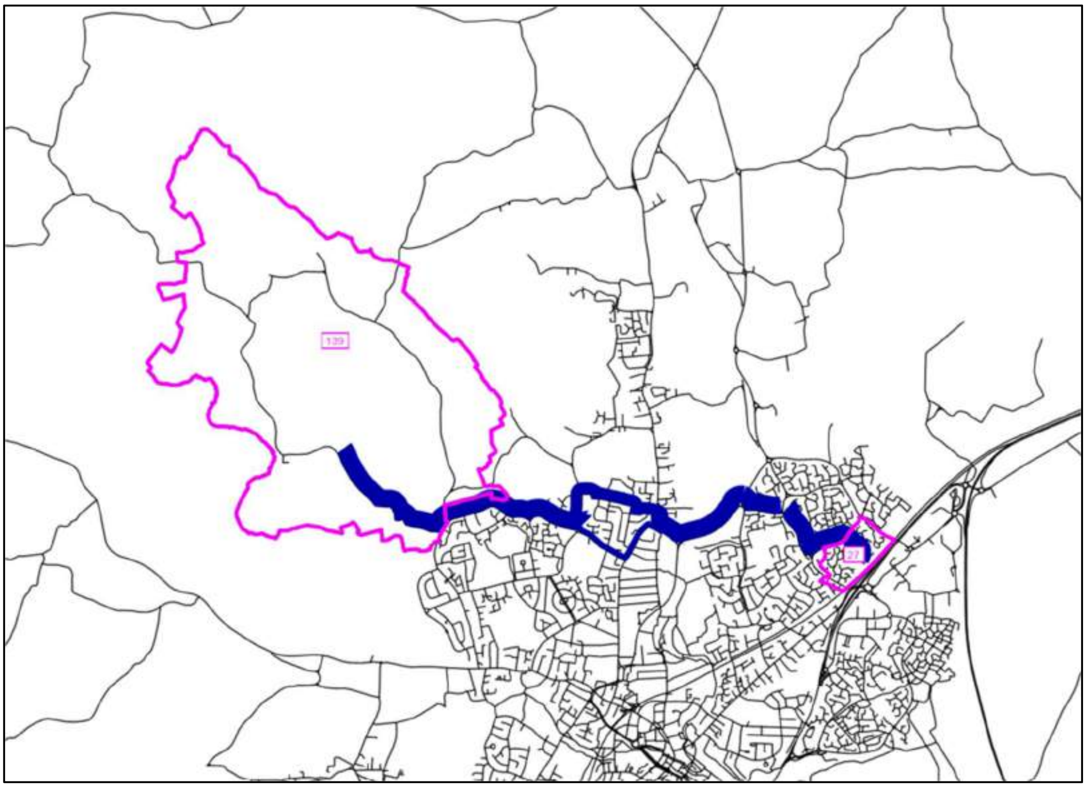
VISUM Model, 2019. AM peak.

A&N Route Checking – AM (07:30AM)

12. Mashbury Road to Petunia Crescent



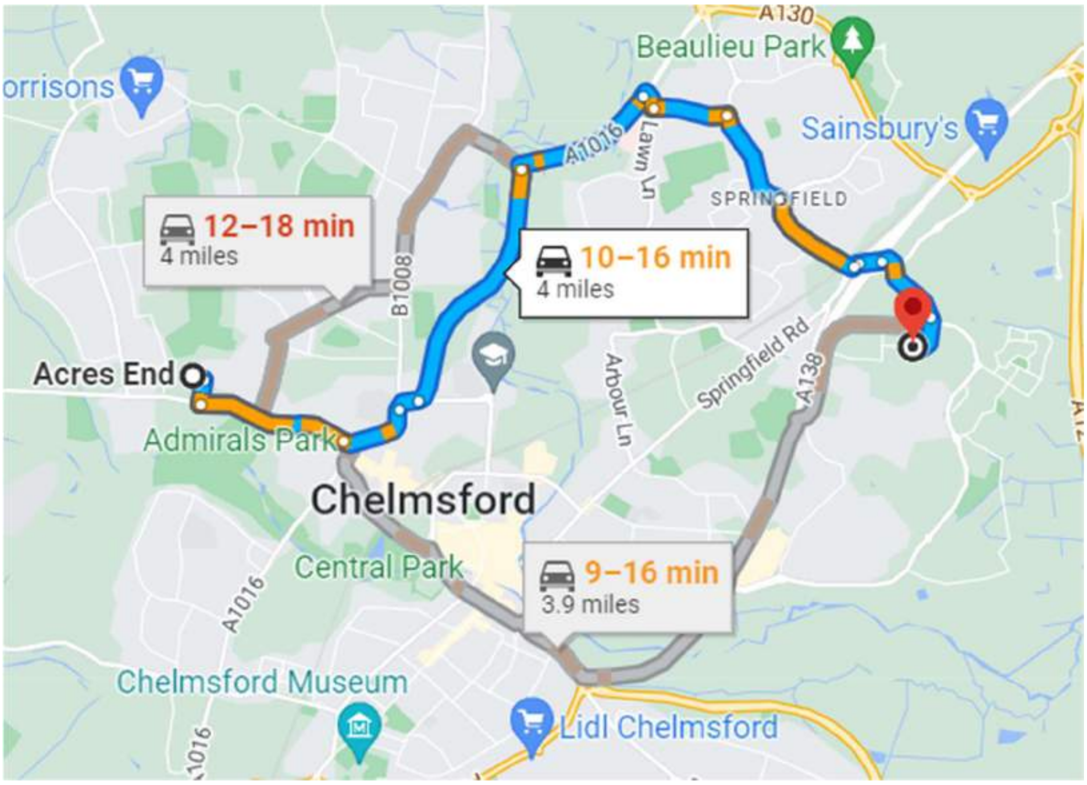
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



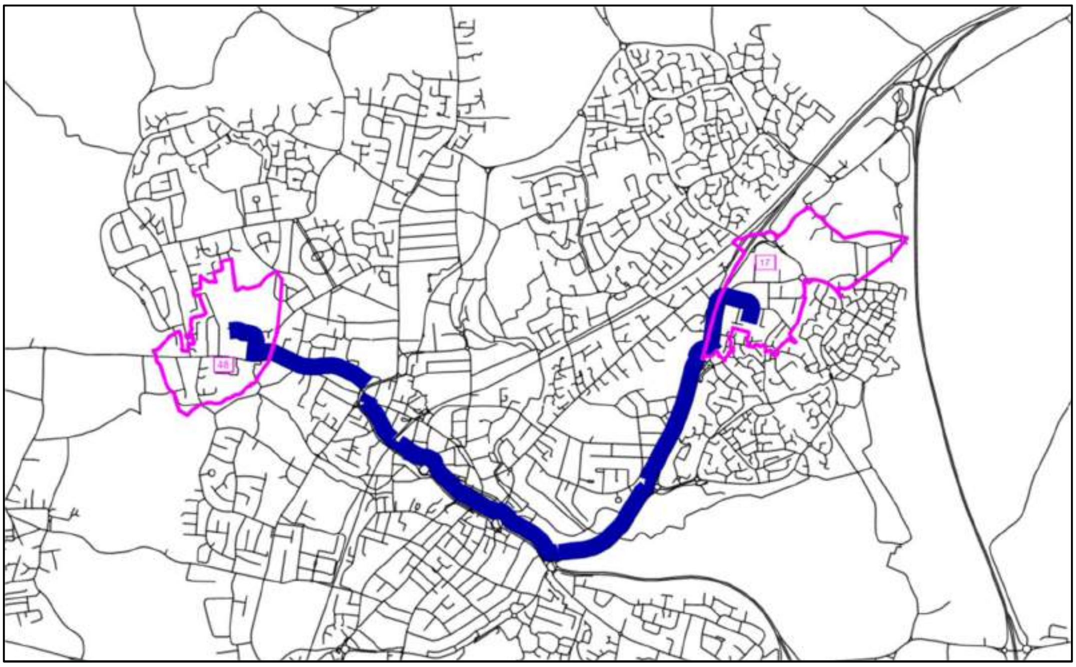
VISUM Model, 2019. AM peak.

A&N Route Checking – AM (07:30AM)

13. Acres End to Richmond Road



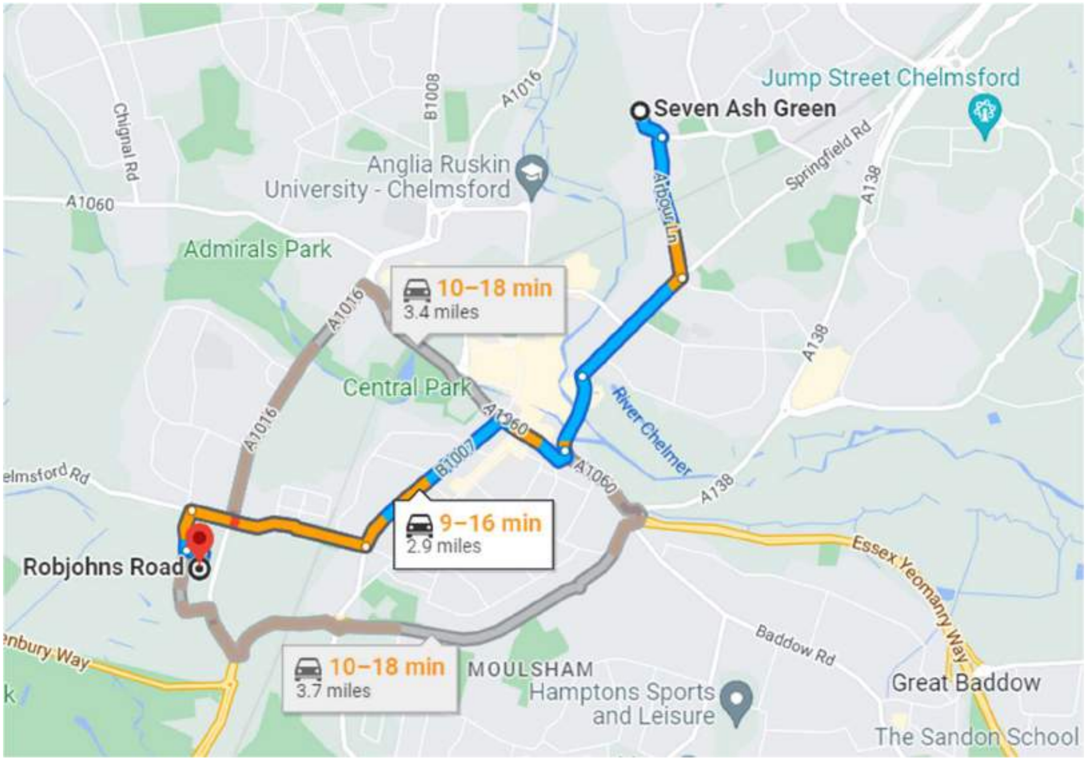
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



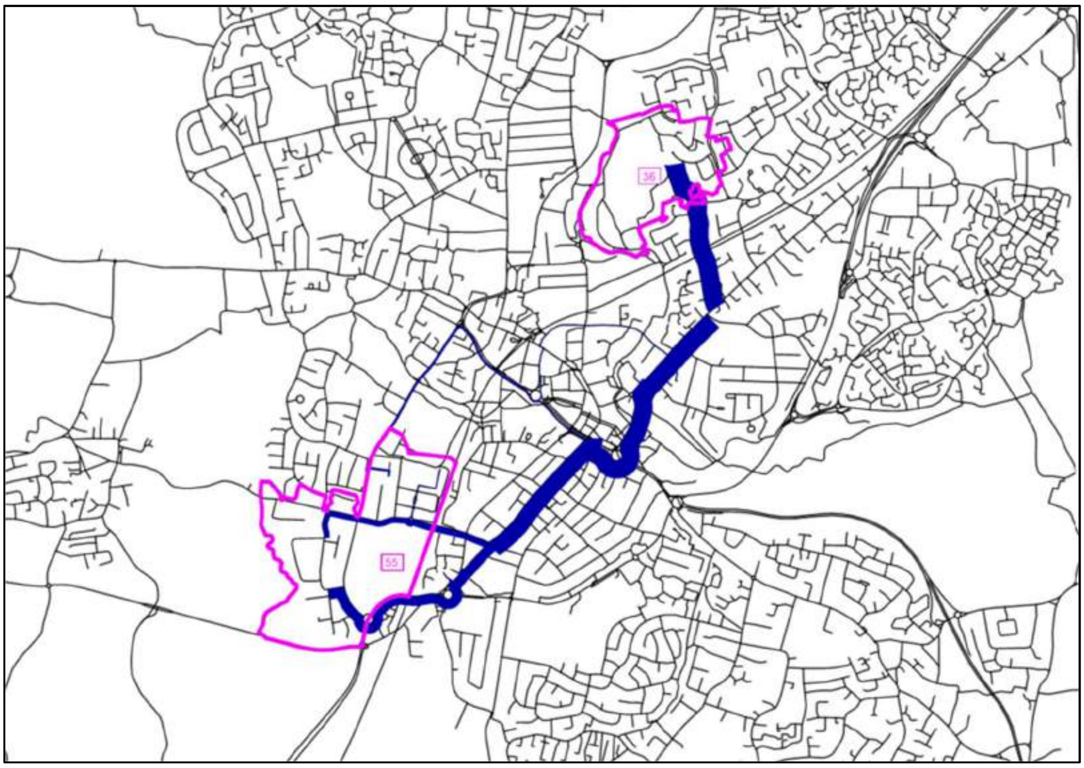
VISUM Model, 2019. AM peak.

A&N Route Checking – AM (07:30AM)

14. Seven Ash Green to Robjohns Road



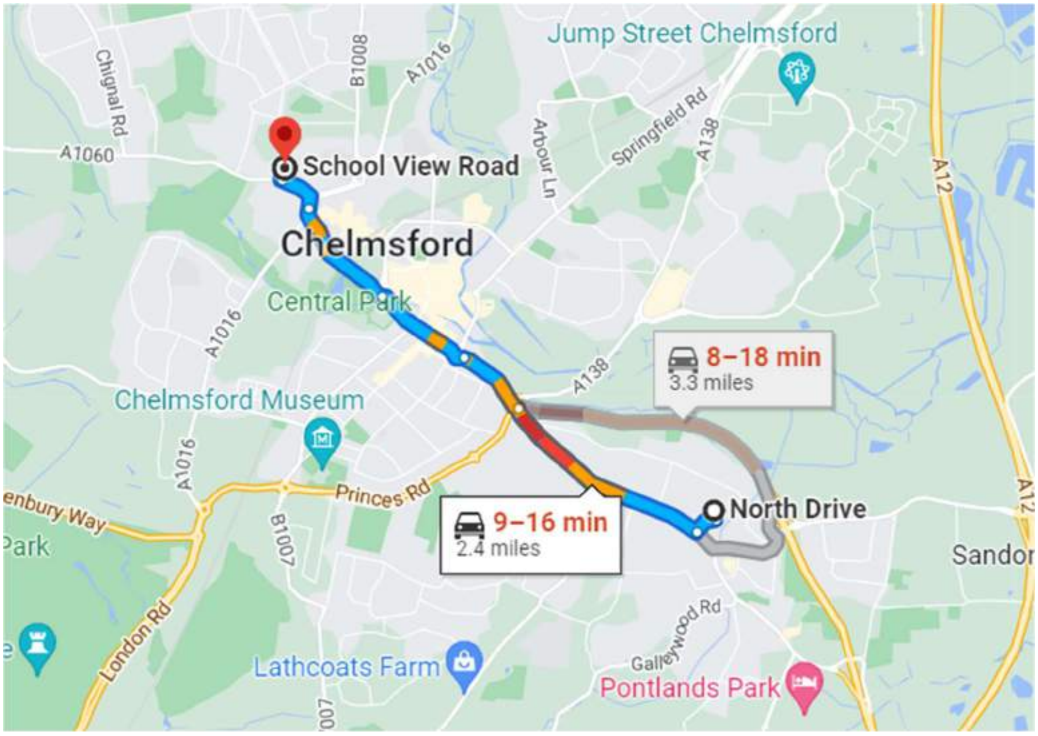
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



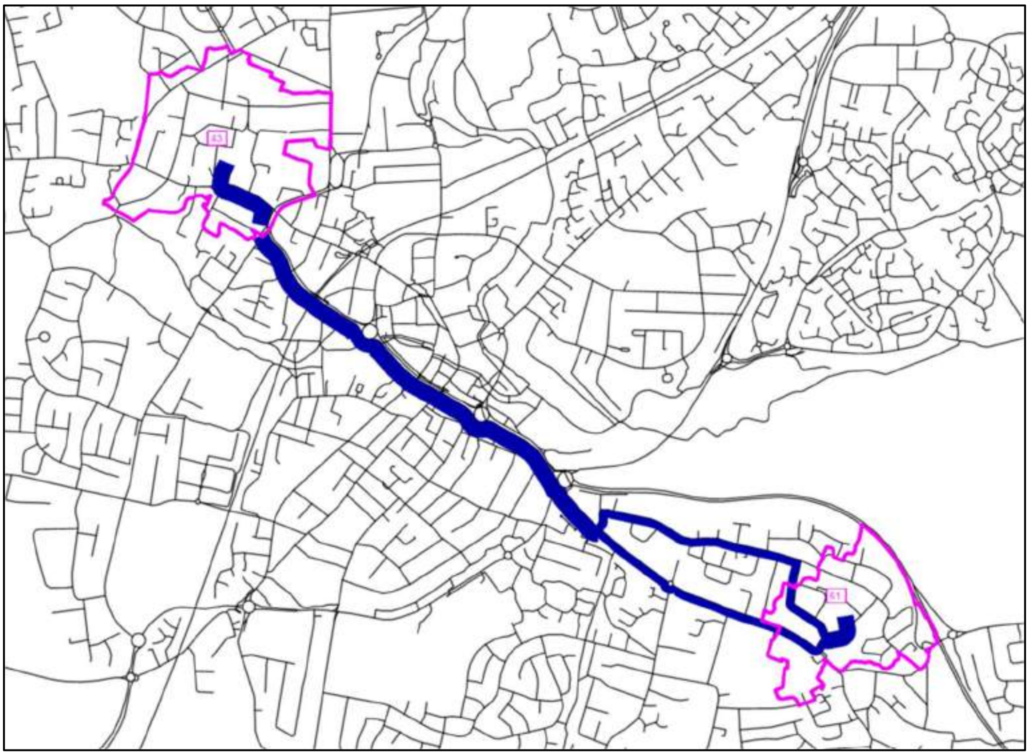
VISUM Model, 2019. AM peak.

A&N Route Checking – AM (07:30AM)

15. North Drive to School View Road



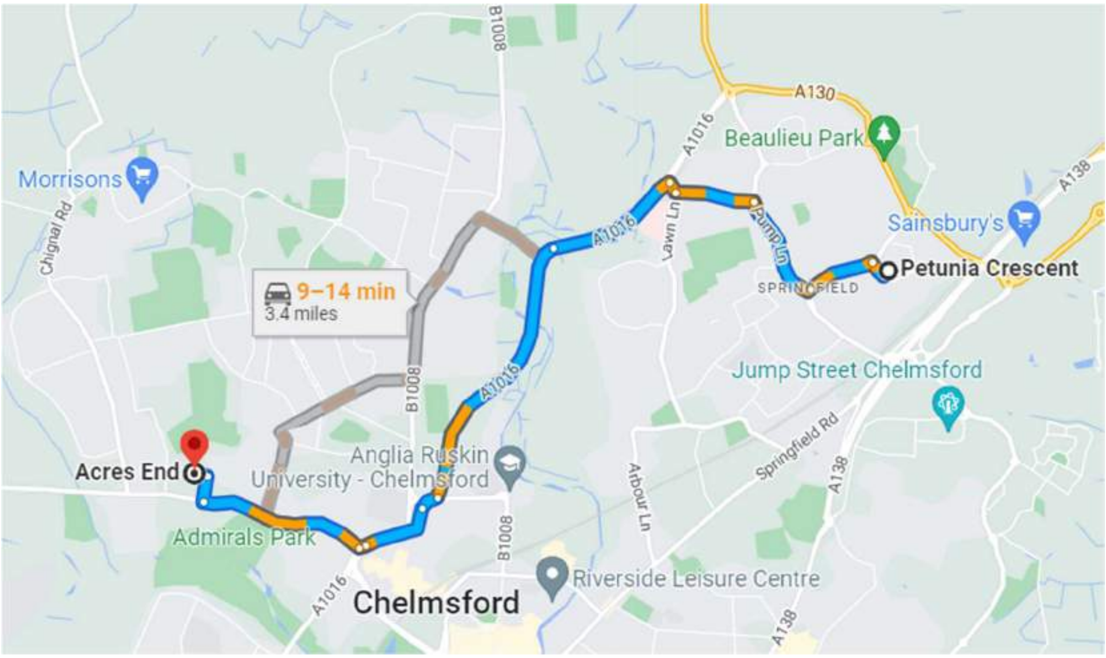
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



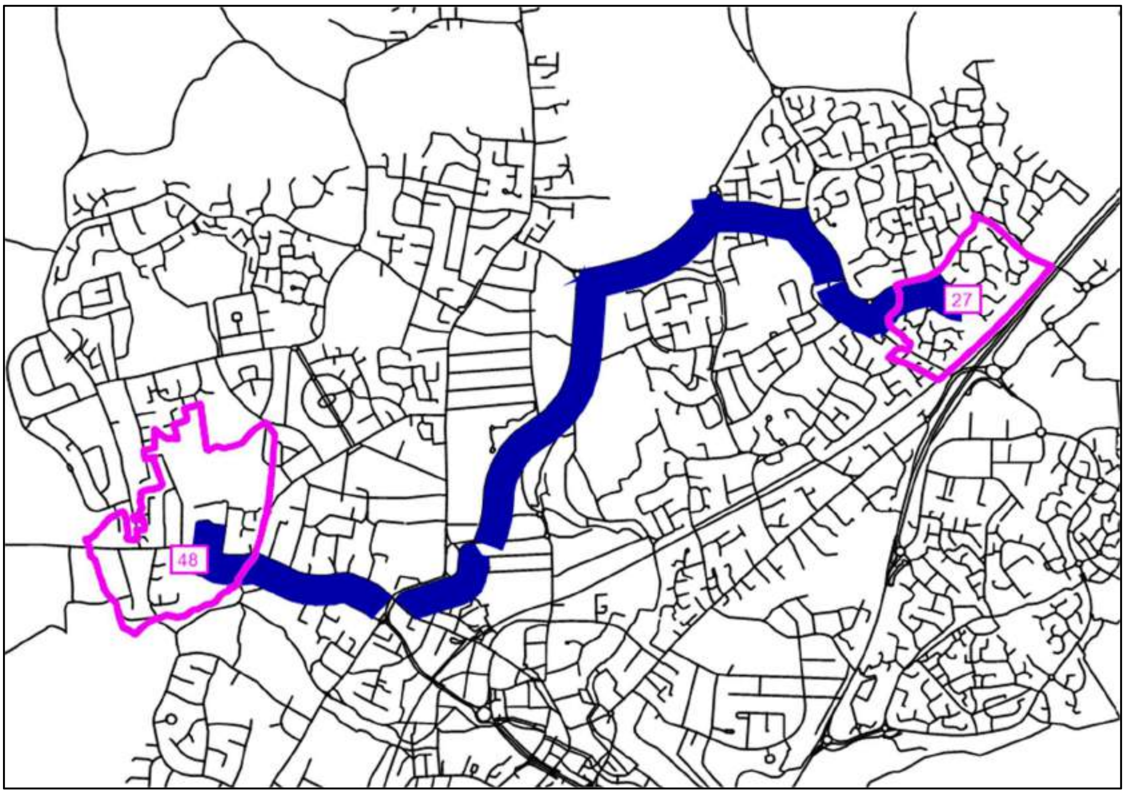
VISUM Model, 2019. AM peak.

A&N Route Checking – AM (07:30AM)

16. Petunia Crescent to Acres End



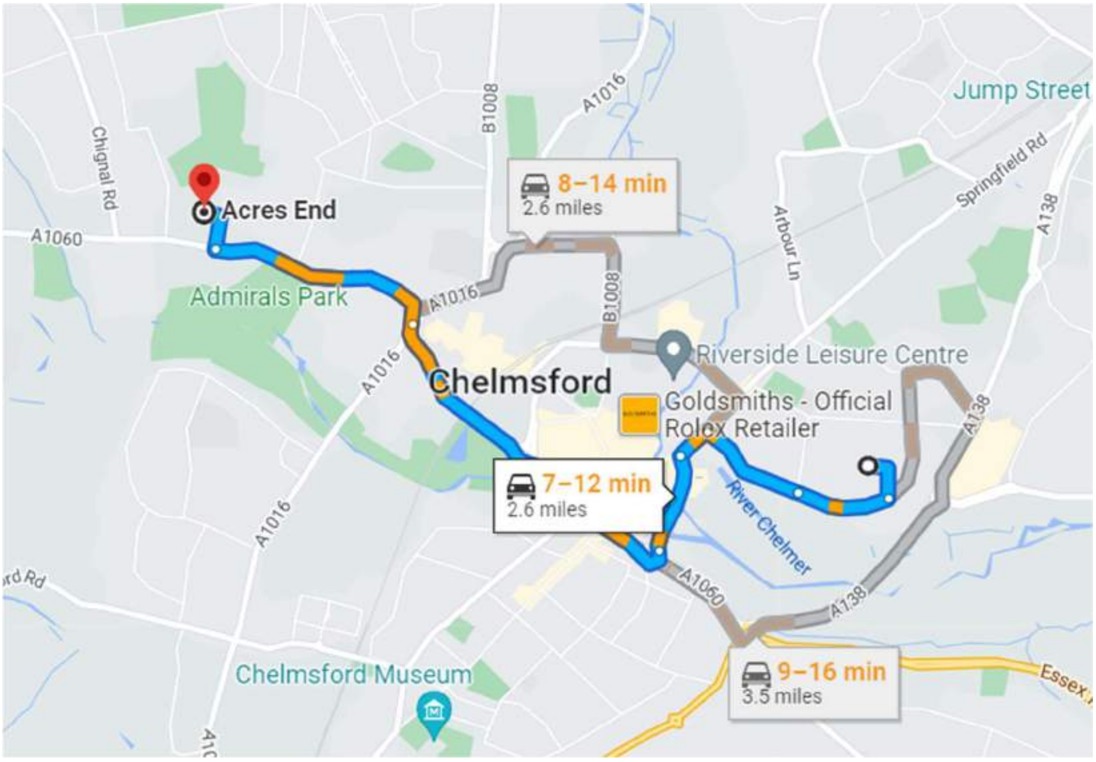
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



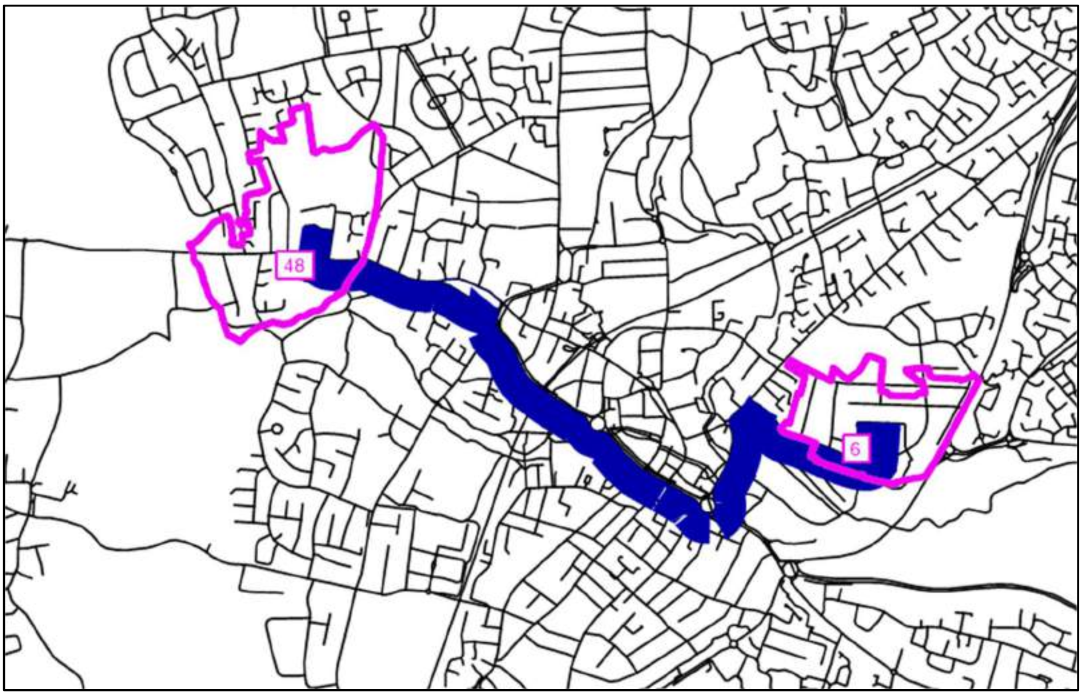
VISUM Model, 2019. AM peak.

A&N Route Checking – AM (07:30AM)

17. Morris Road to Acres End



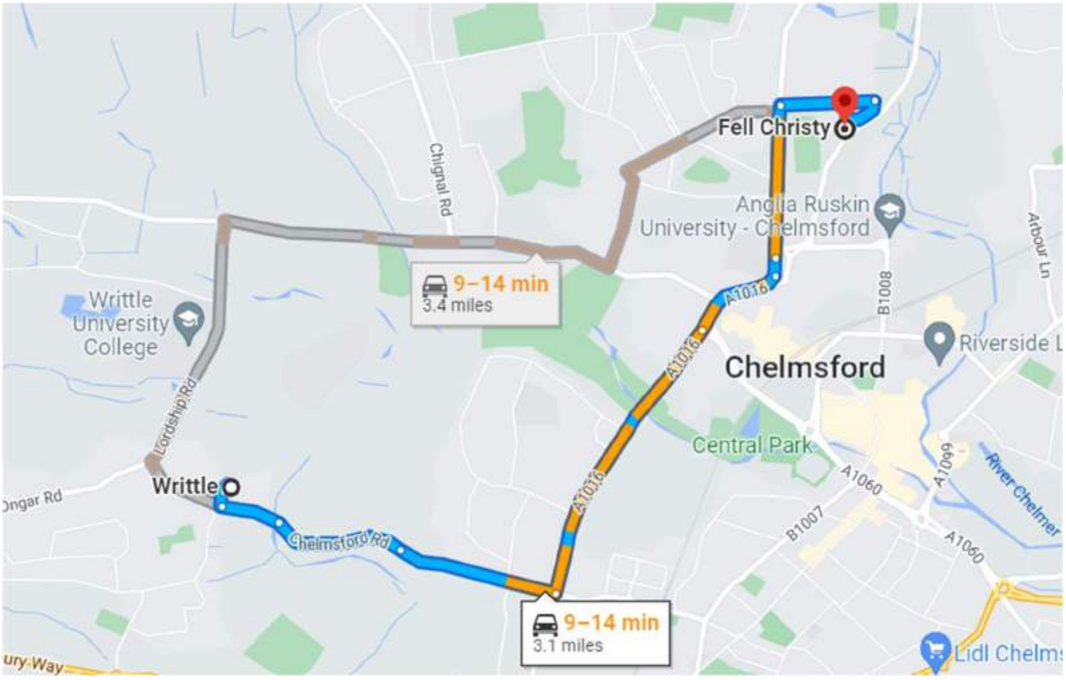
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



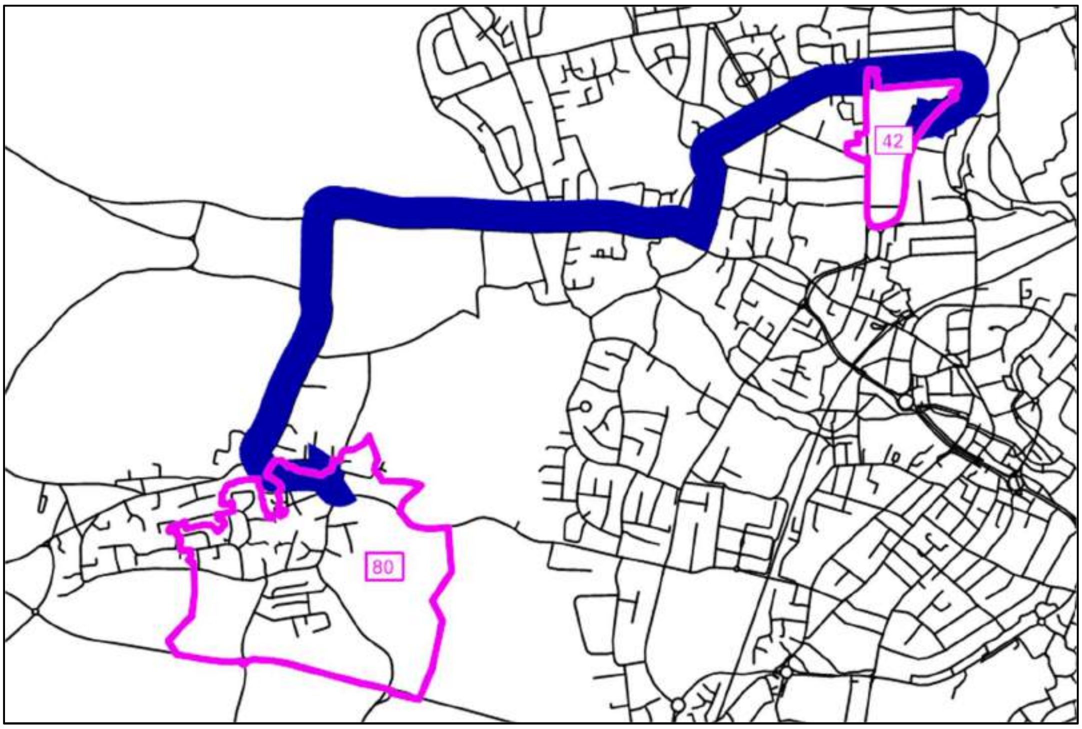
VISUM Model, 2019. AM peak.

A&N Route Checking – AM (07:30AM)

18. Writtle to Fell Christy



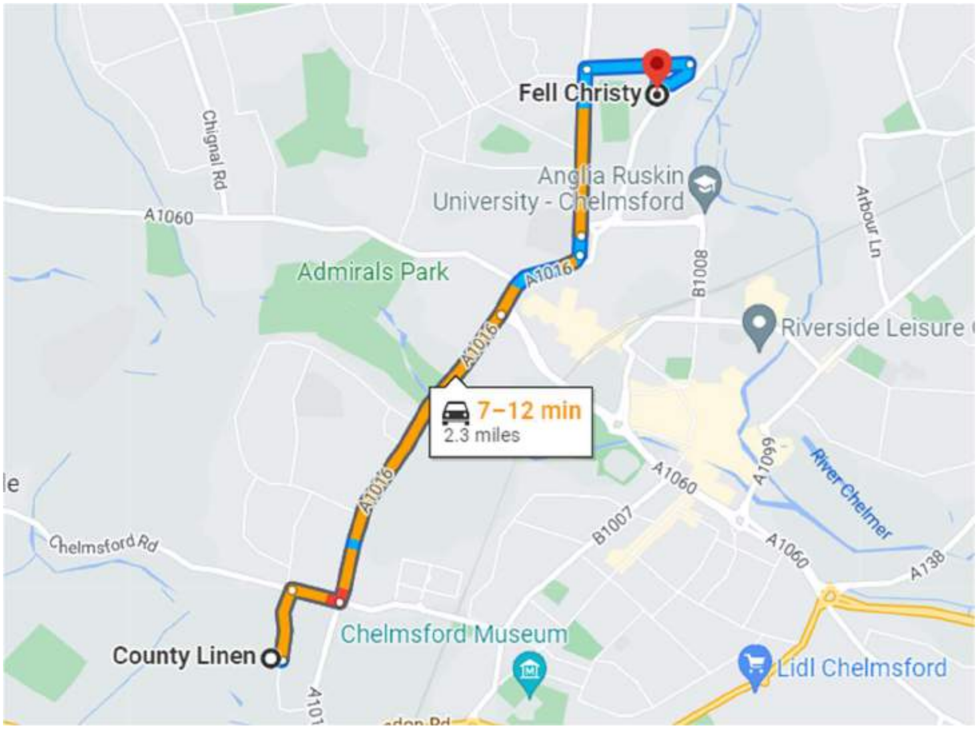
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



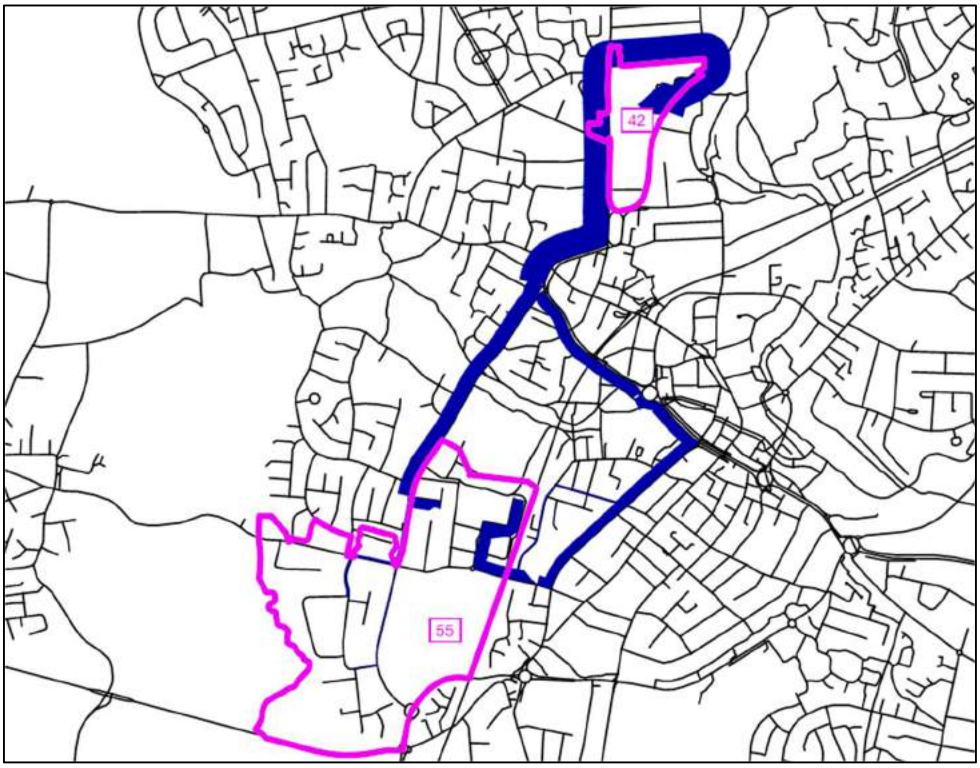
VISUM Model, 2019. AM peak.

A&N Route Checking – AM (07:30AM)

19. County Linen Services to Fell Christy



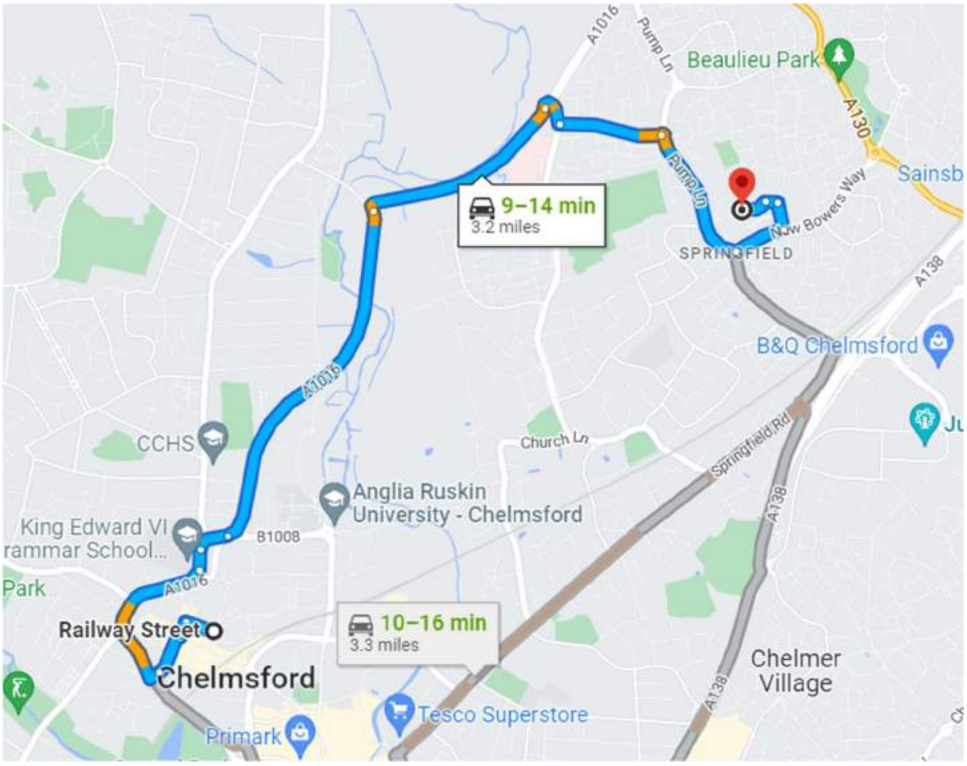
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



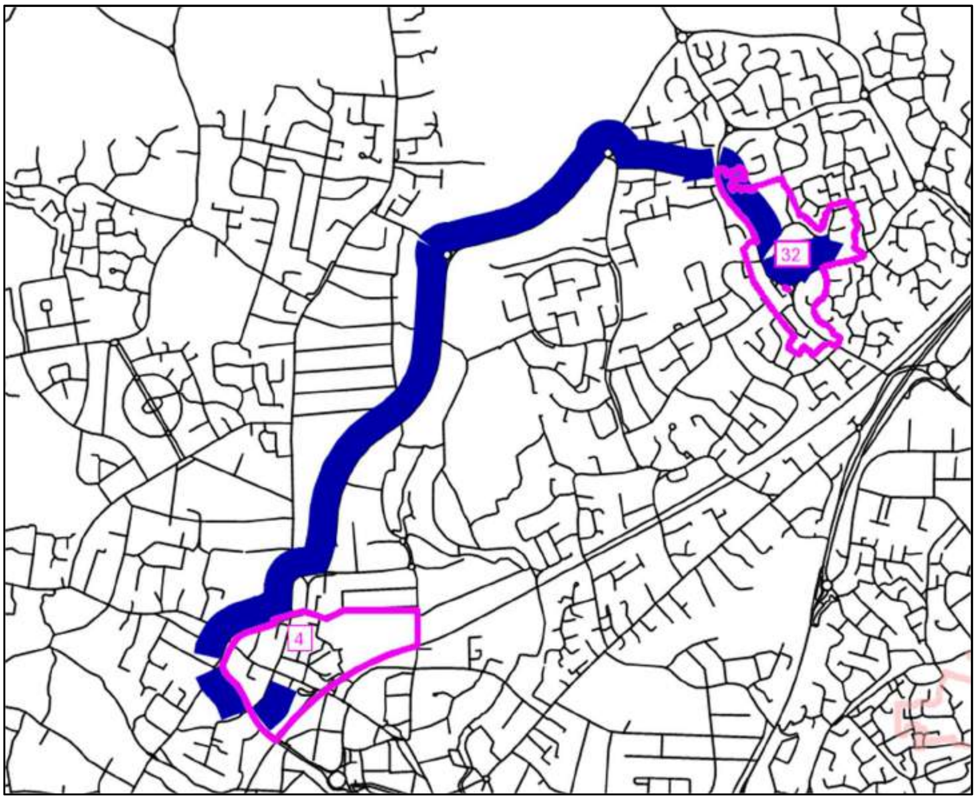
VISUM Model, 2019. AM peak.

A&N Route Checking – AM (07:30AM)

20. Railway Street to Bonnington Chase



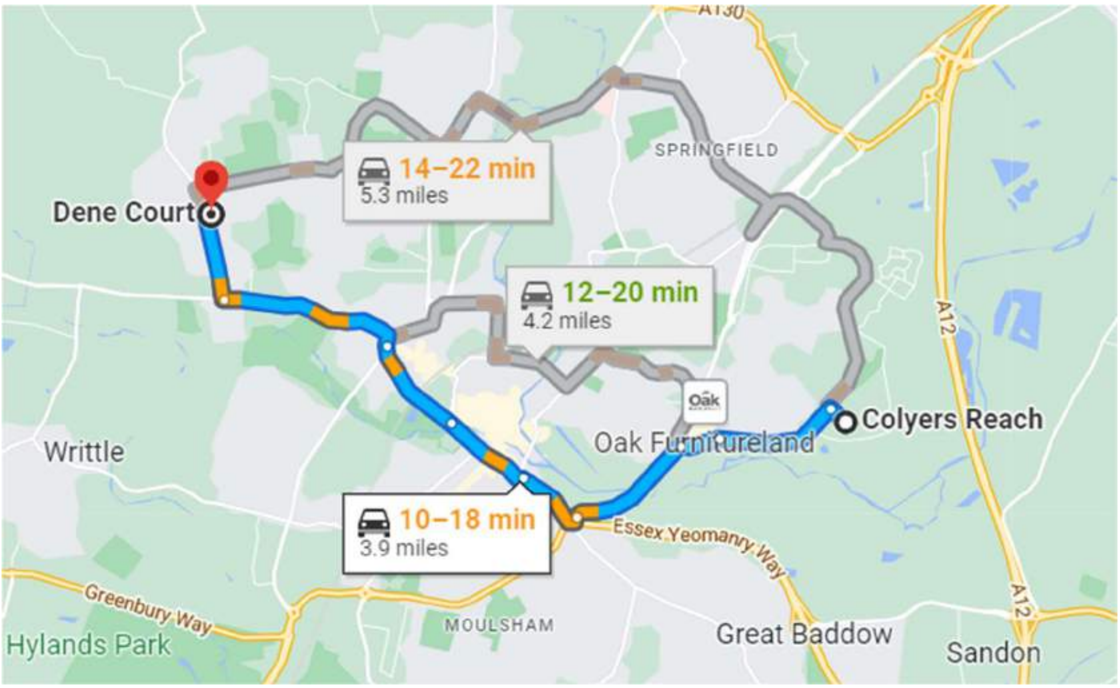
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



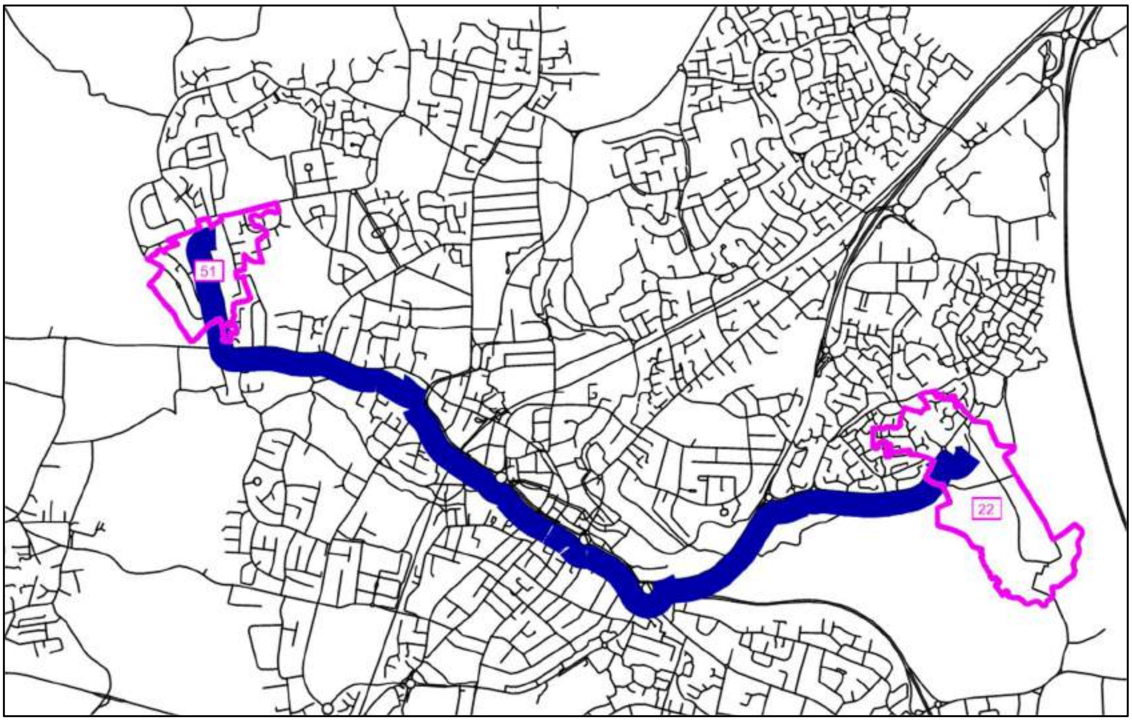
VISUM Model, 2019. AM peak.

A&N Route Checking – AM (07:30AM)

21. Colyers Reach to Dene Court



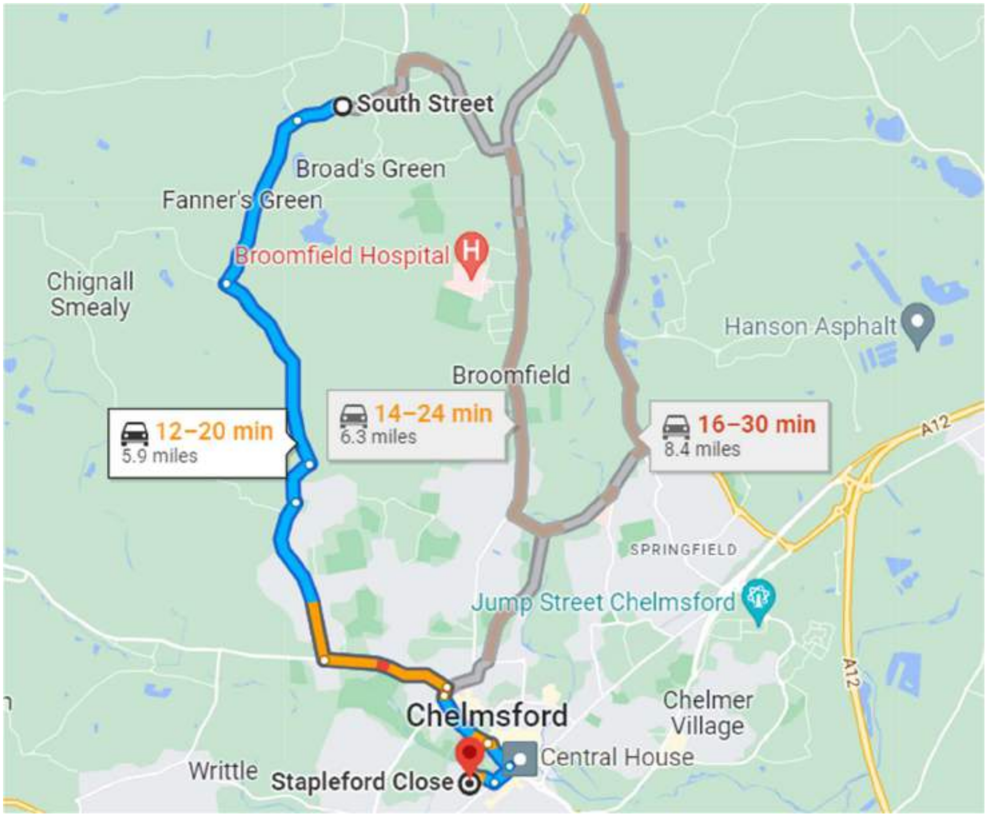
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



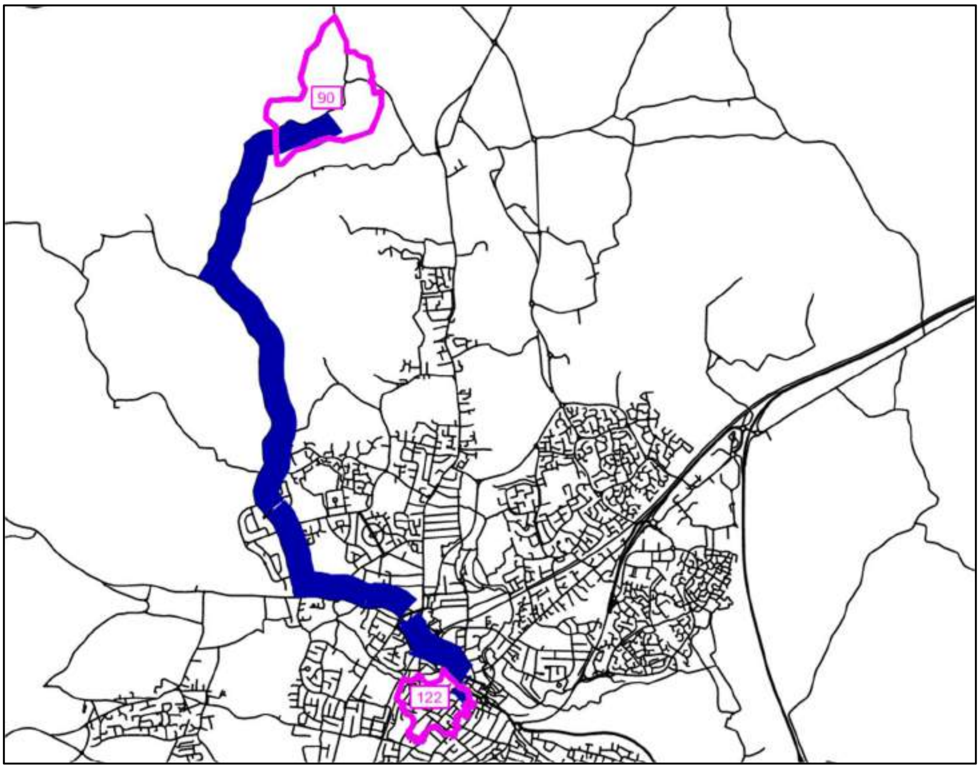
VISUM Model, 2019. AM peak.

A&N Route Checking – AM (07:30AM)

22. South Street to Stapleford Close



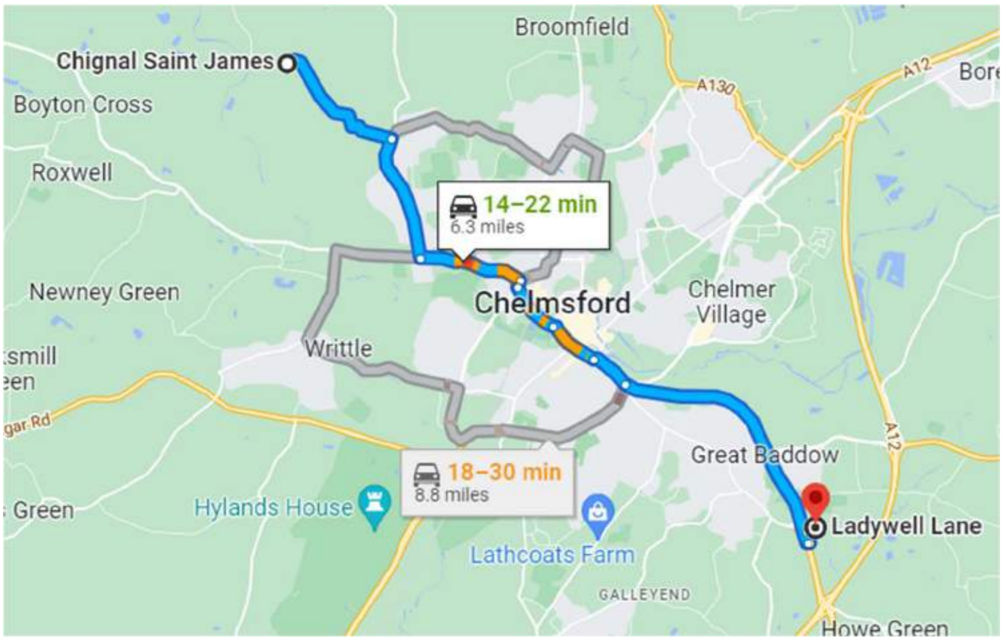
Google Maps, 2022. Typical Tuesday for the AM period (set to depart at 07:30AM)



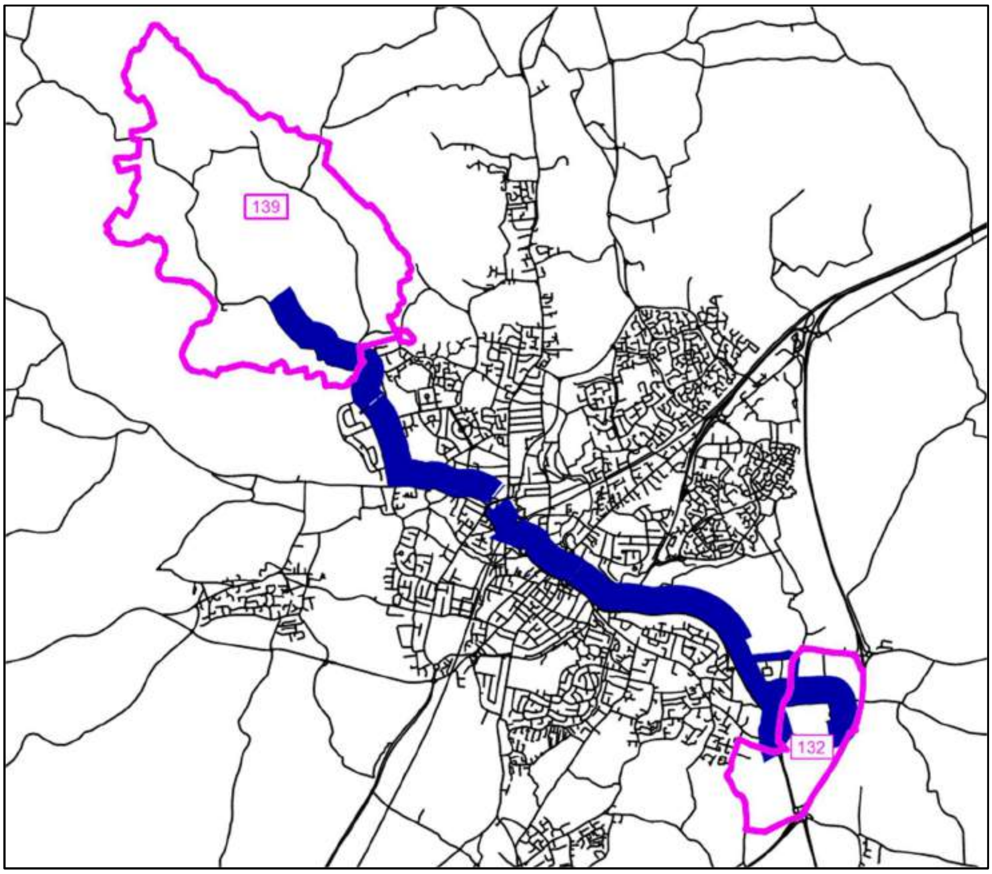
VISUM Model, 2019. AM peak.

A&N Route Checking – IP (12:00)

1. Chignal Saint James to Ladywell Lane



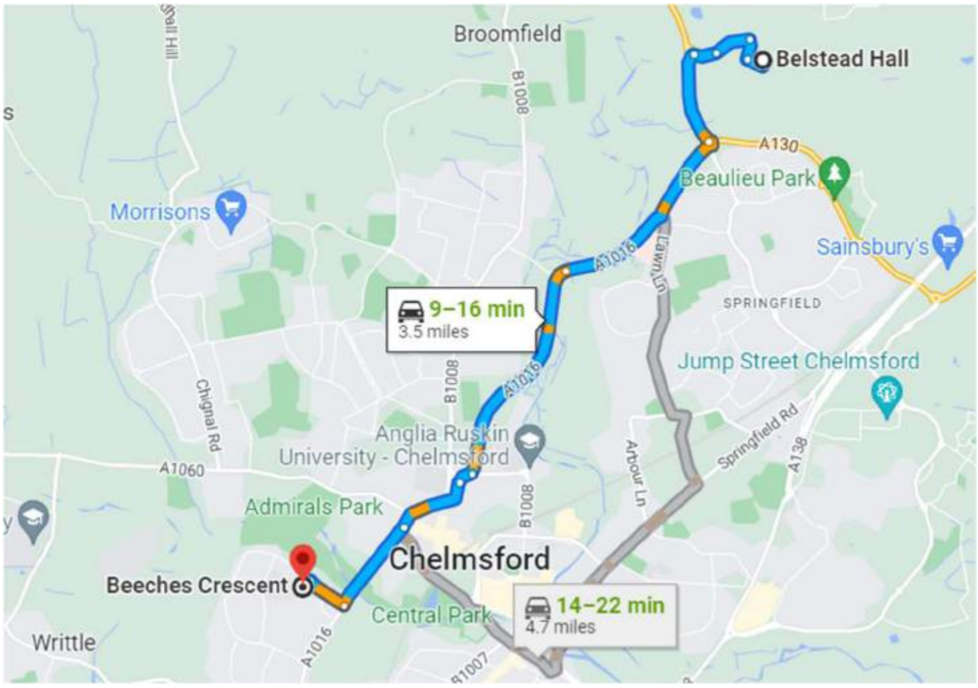
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



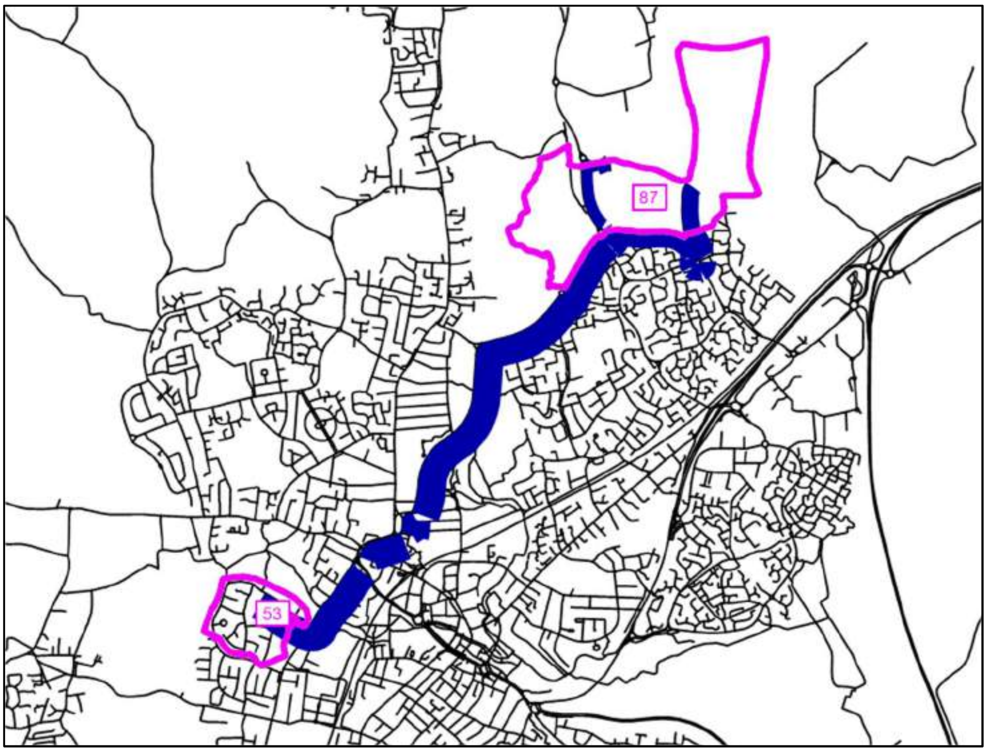
VISUM Model, 2019. IP.

A&N Route Checking – IP (12:00)

2. Belstead Hall to Beeches Crescent



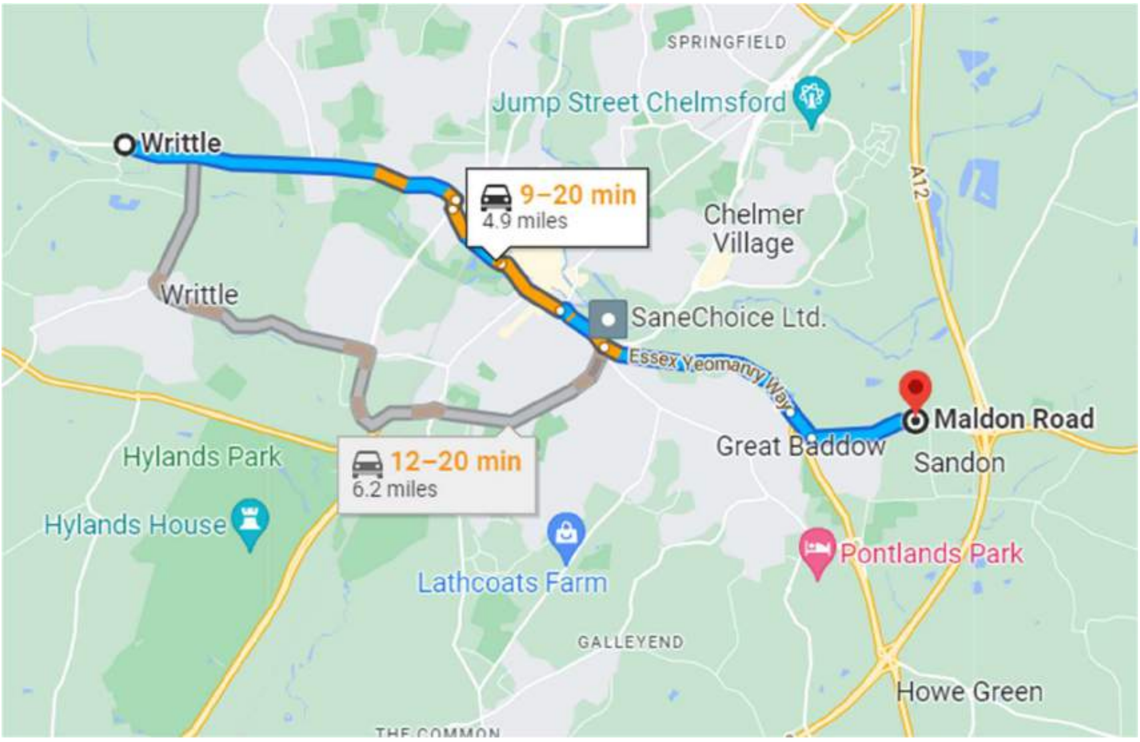
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



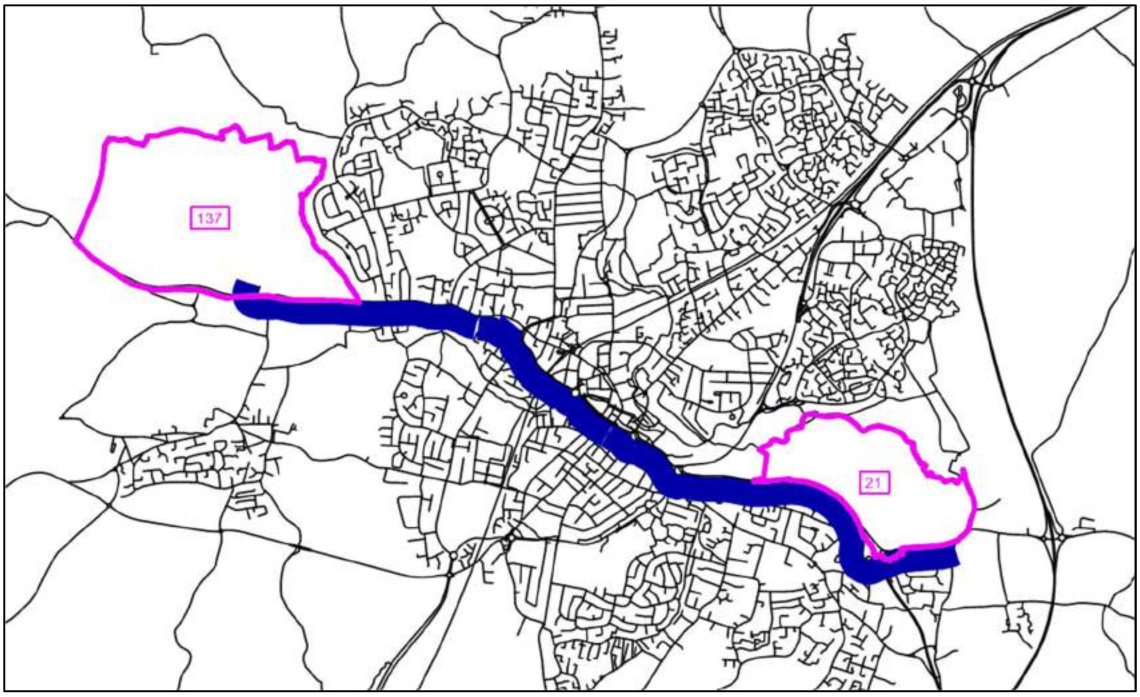
VISUM Model, 2019. IP.

A&N Route Checking – IP (12:00)

3. Maldon Road to Writtle



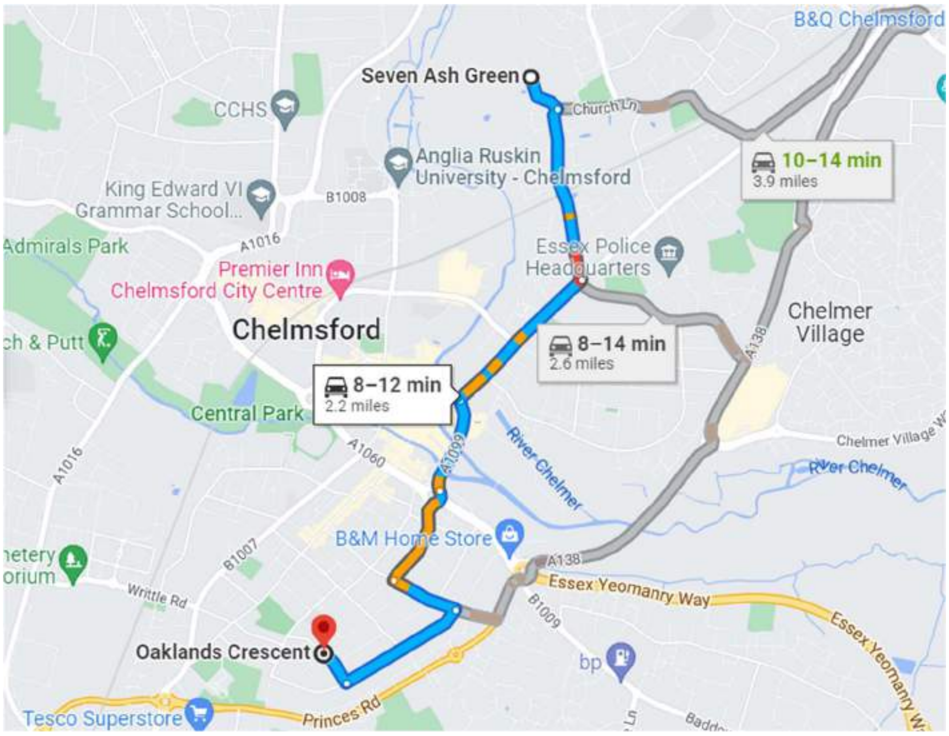
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



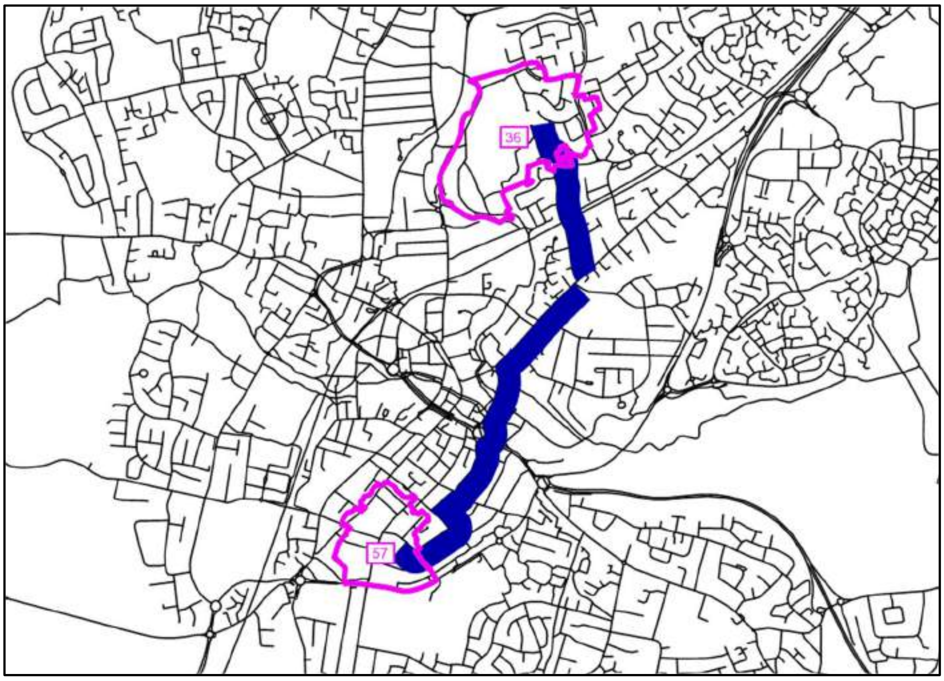
VISUM Model, 2019. IP.

A&N Route Checking – IP (12:00)

4. Seven Ash Green to Oaklands Crescent



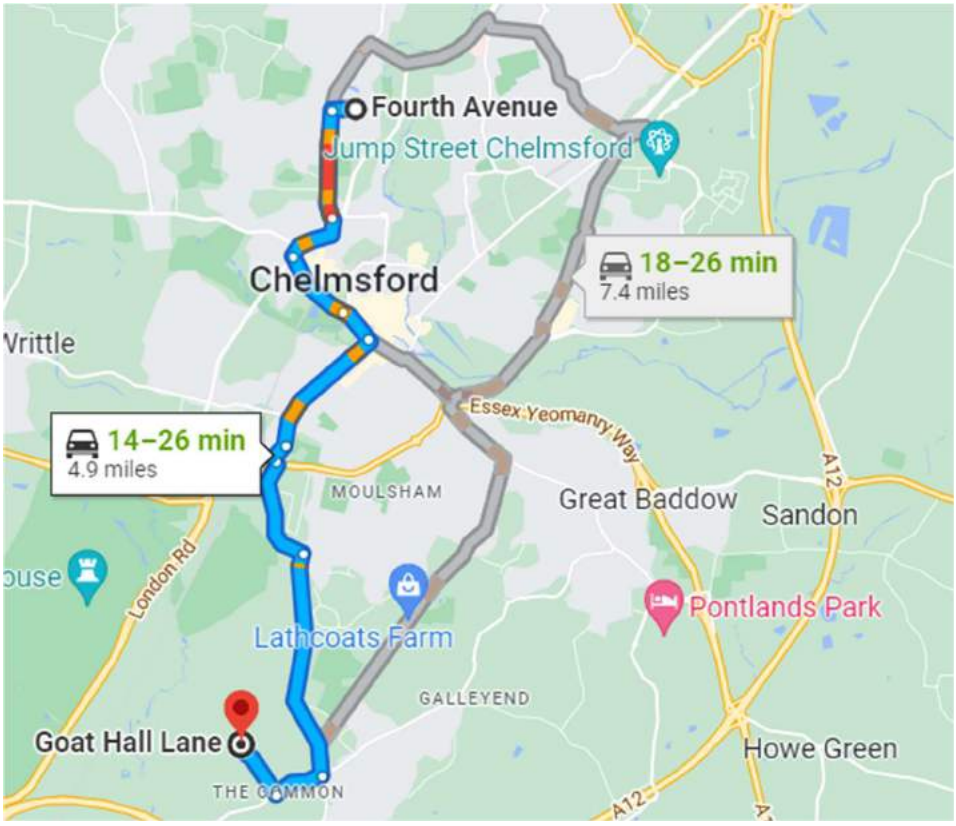
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



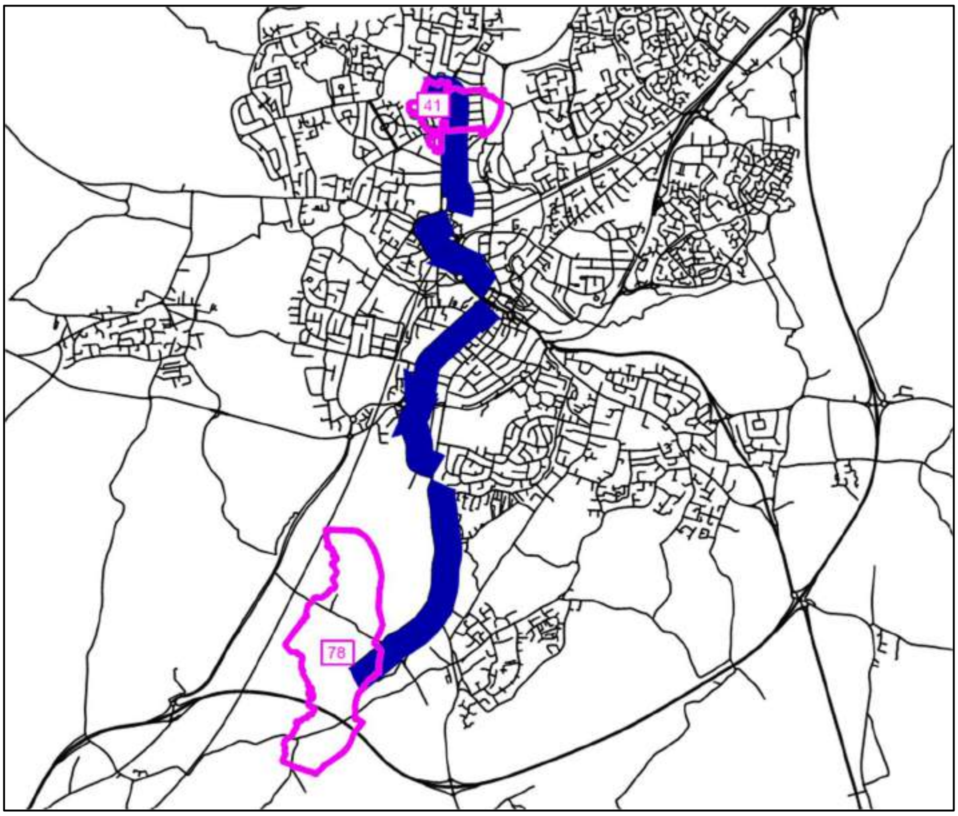
VISUM Model, 2019. IP.

A&N Route Checking – IP (12:00)

5. Fourth Avenue to Goat Hall Lane



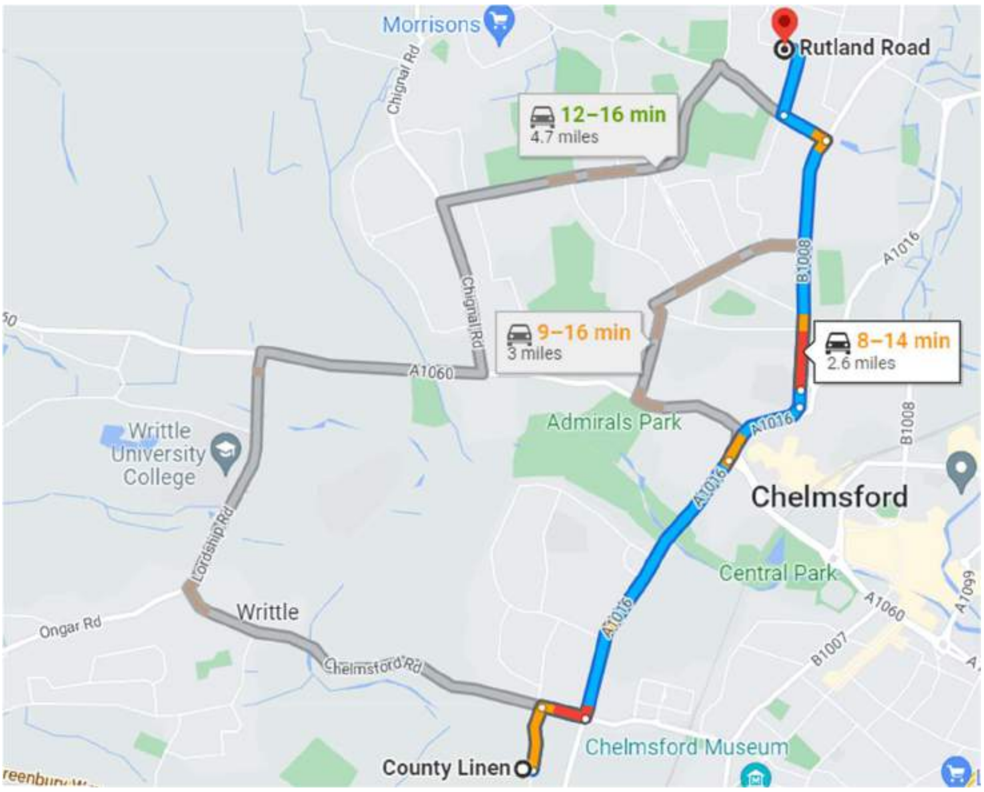
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



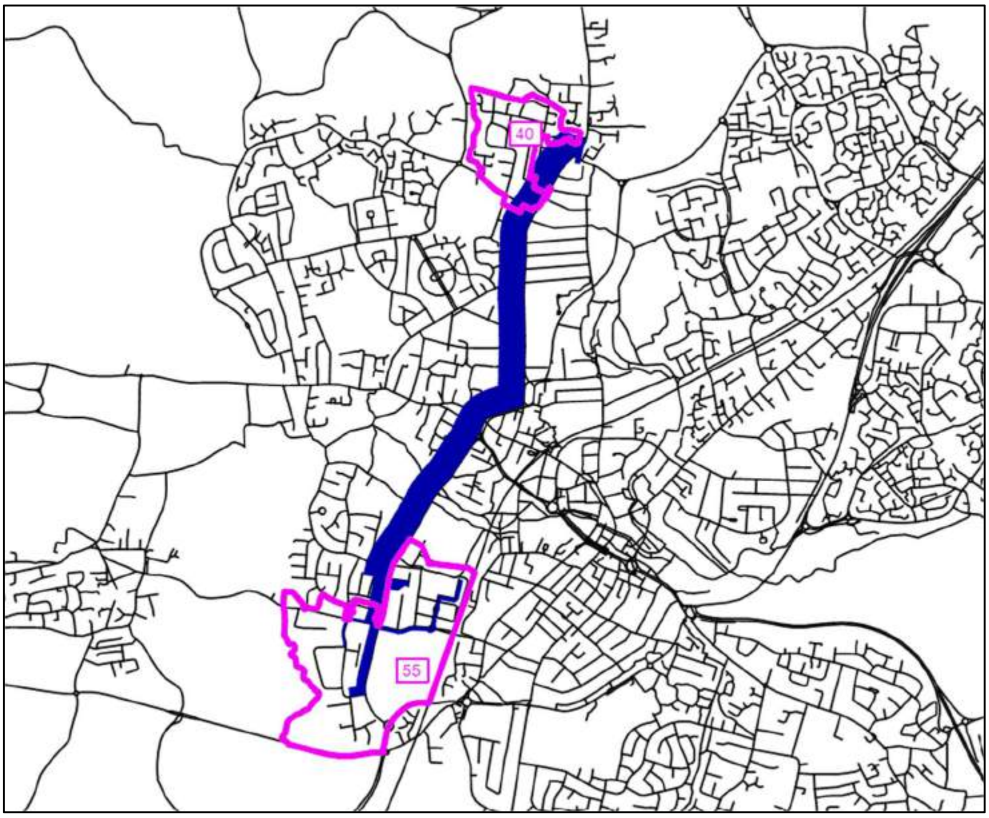
VISUM Model, 2019. IP.

A&N Route Checking – IP (12:00)

6. County Linen Services to Rutland Road



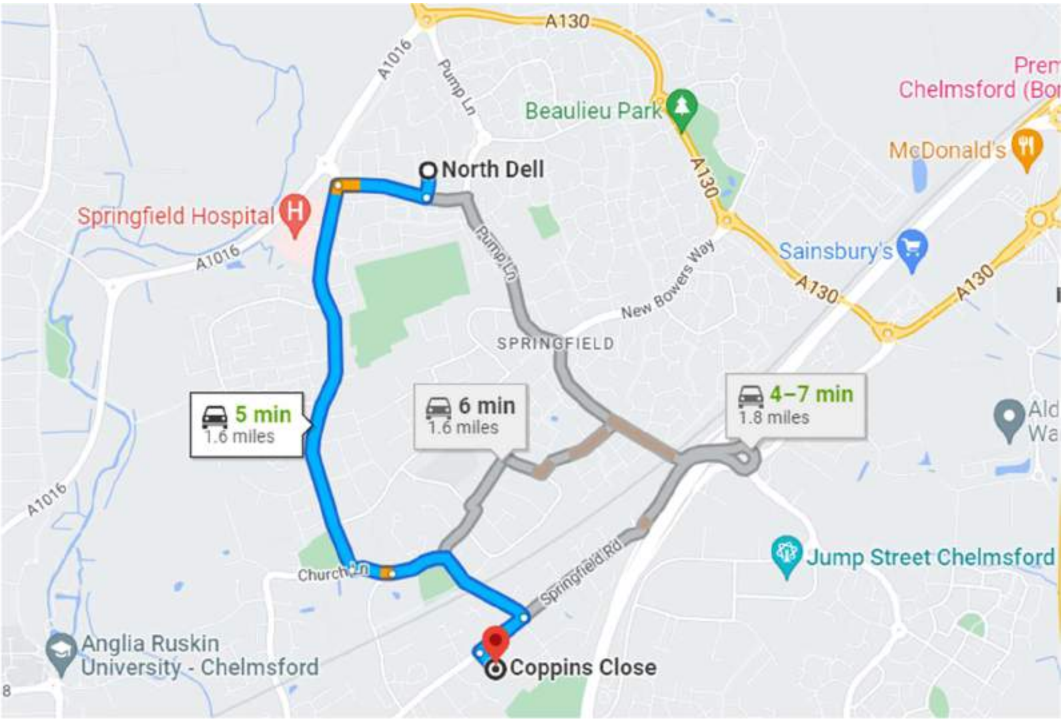
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



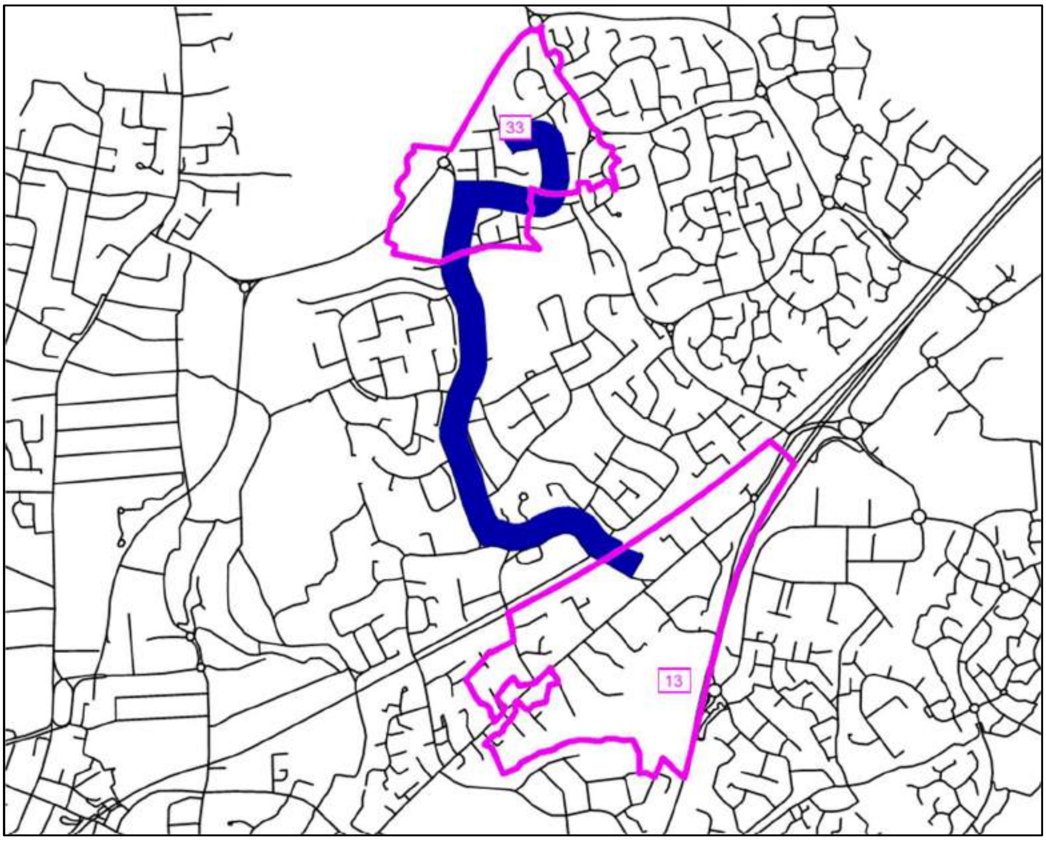
VISUM Model, 2019. IP.

A&N Route Checking – IP (12:00)

7. North Dell to Coppins Close



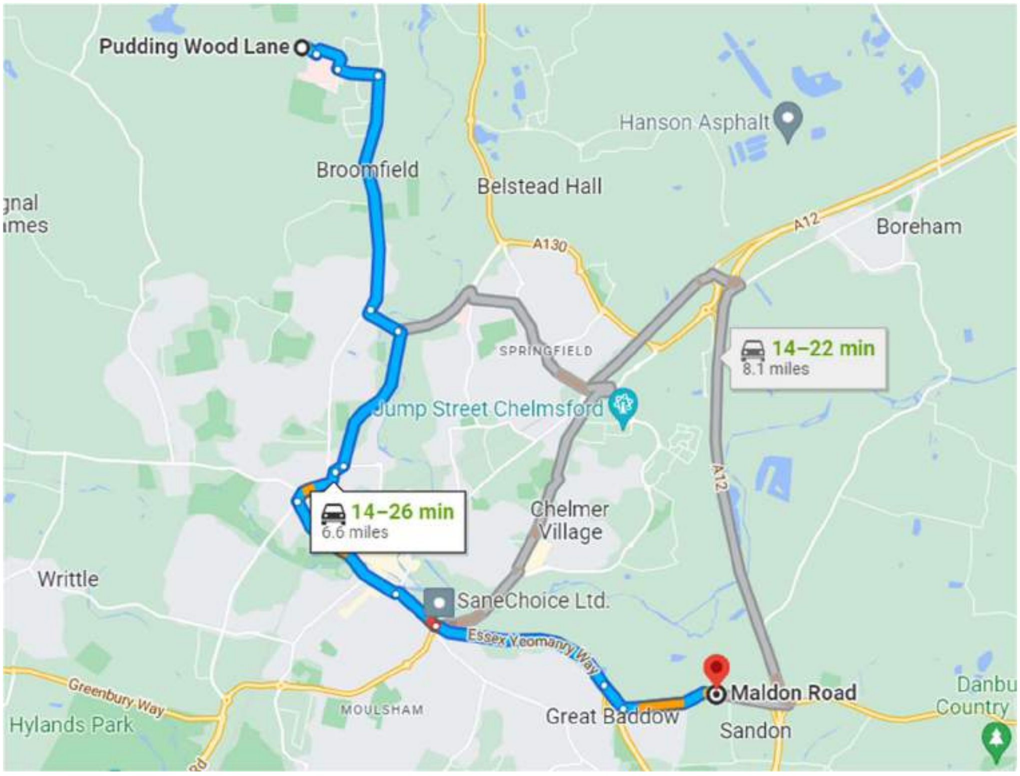
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



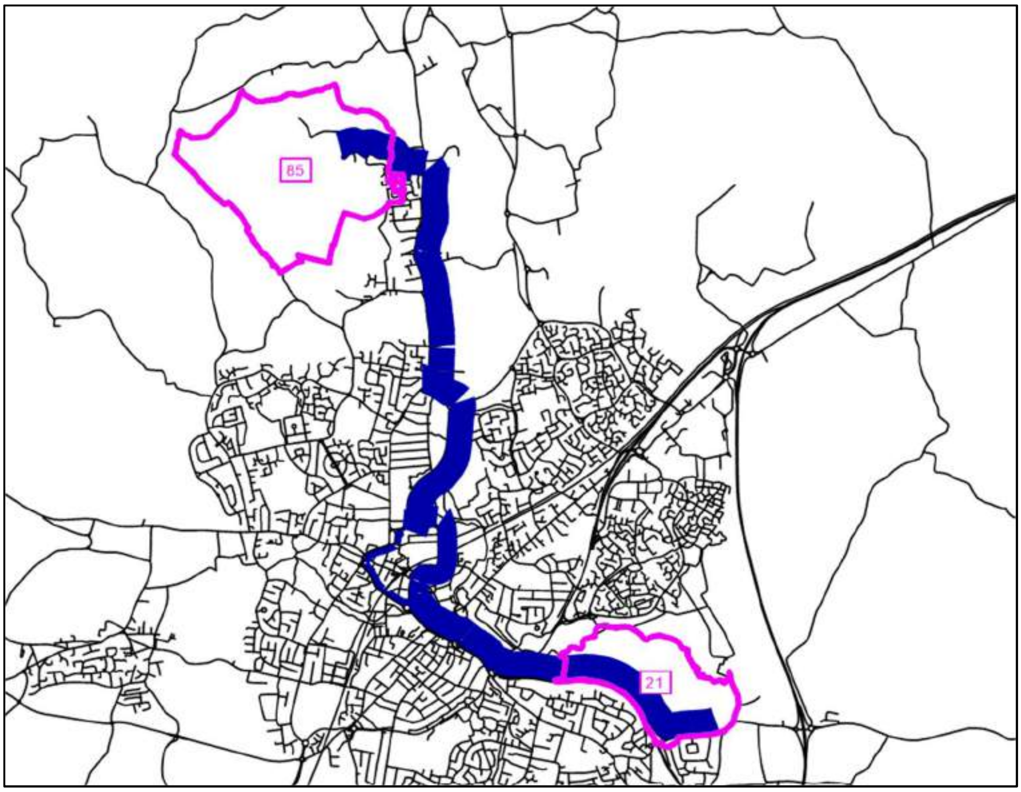
VISUM Model, 2019. IP.

A&N Route Checking – IP (12:00)

8. Pudding Wood Lane to Maldon Road



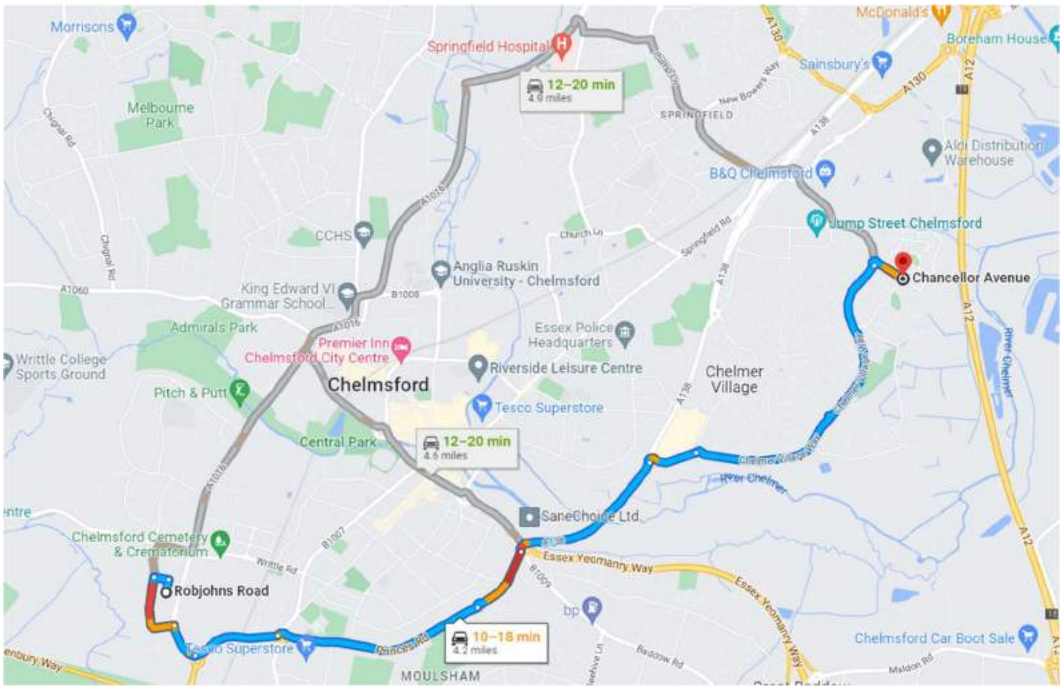
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



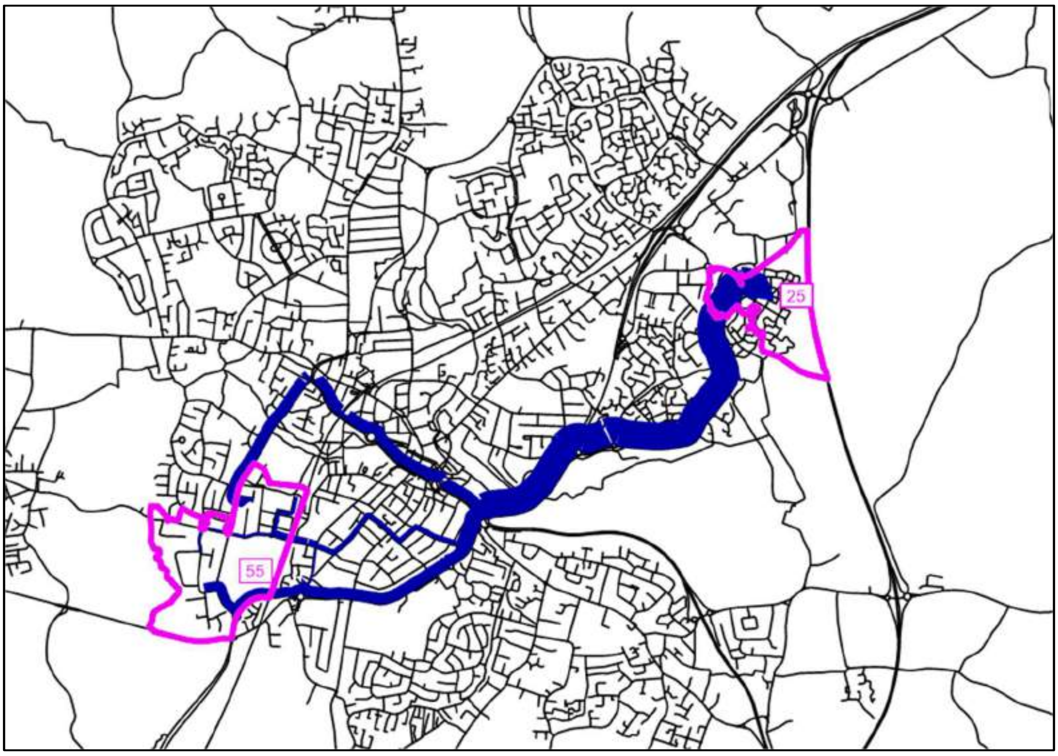
VISUM Model, 2019. IP.

A&N Route Checking – IP (12:00)

9. Robjohns Road to Chancellor Avenue



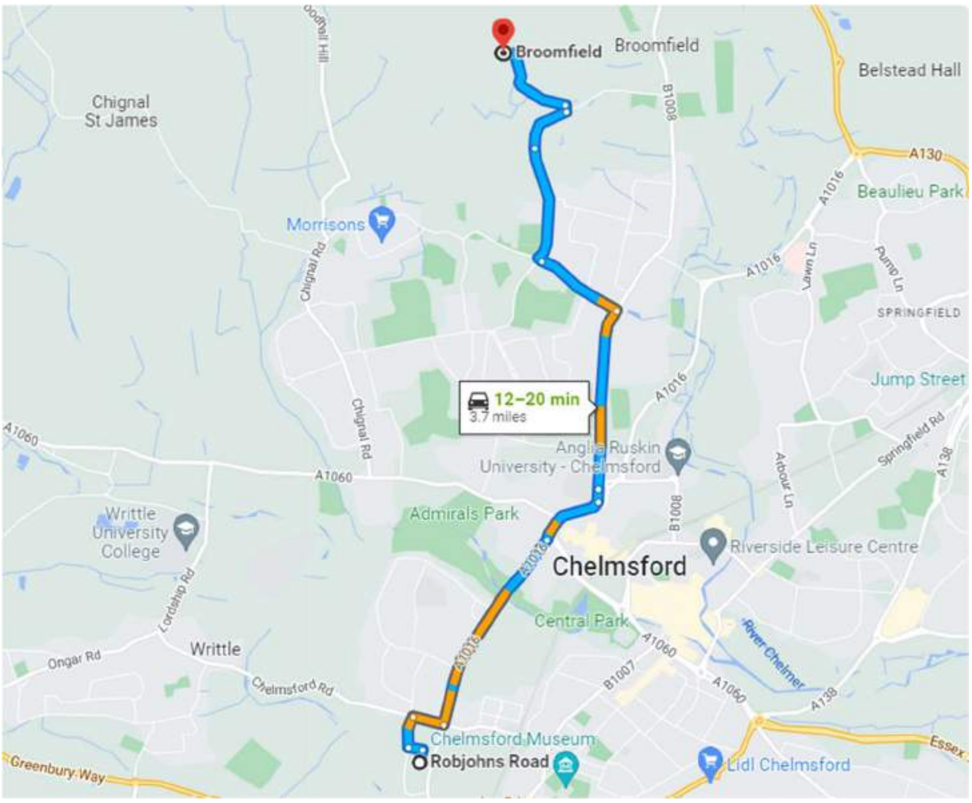
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



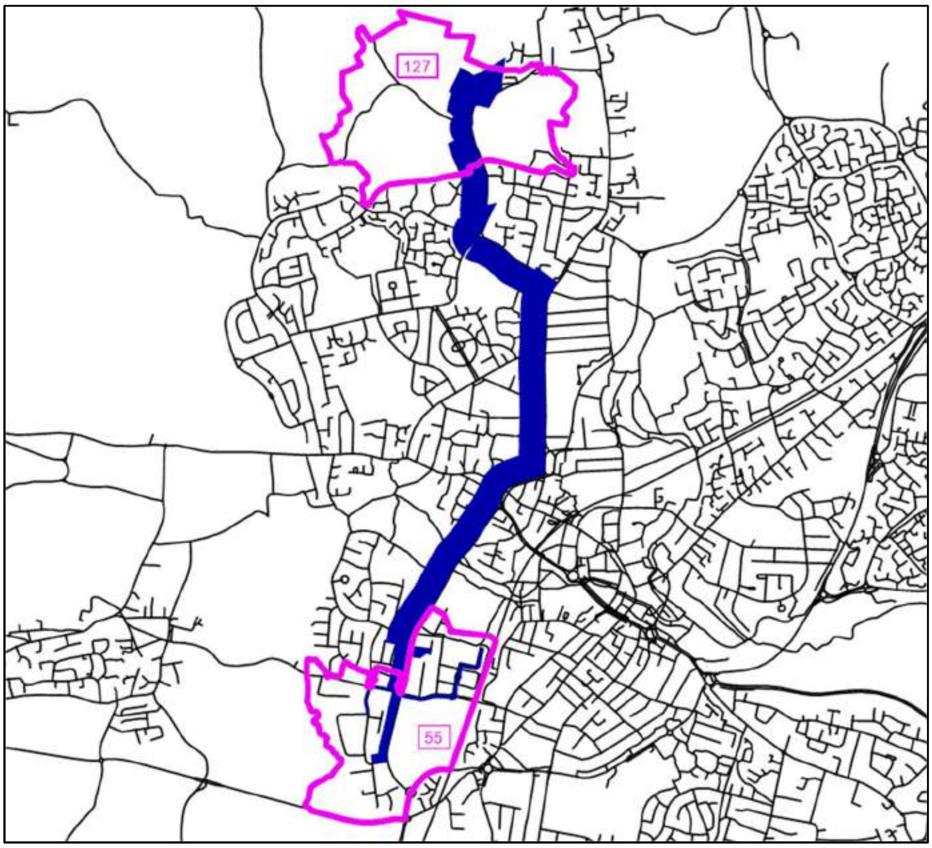
VISUM Model, 2019. IP.

A&N Route Checking – IP (12:00)

10. Robjohns Road to Broomfield



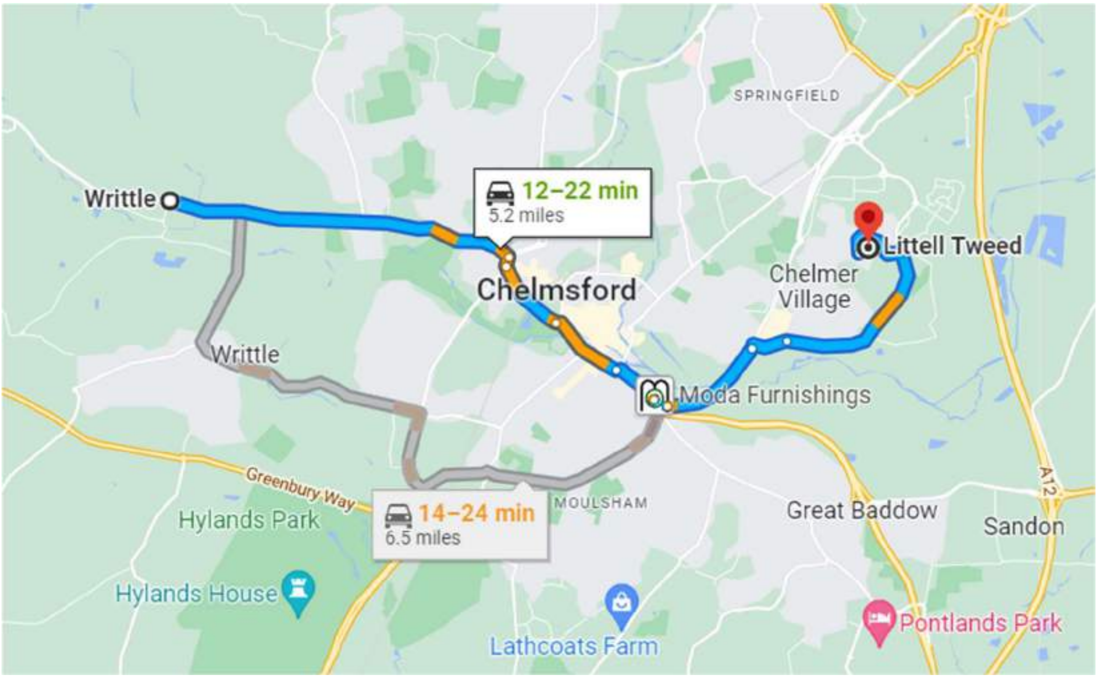
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



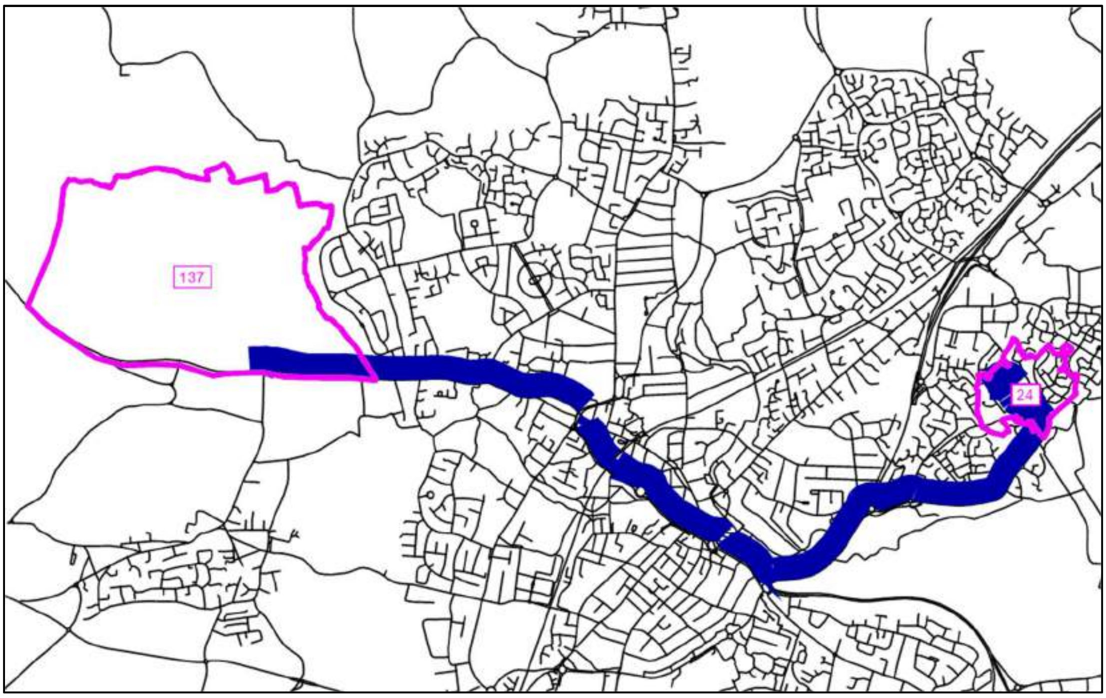
VISUM Model, 2019. IP.

A&N Route Checking – IP (12:00)

11. Writtle to Littell Tweed



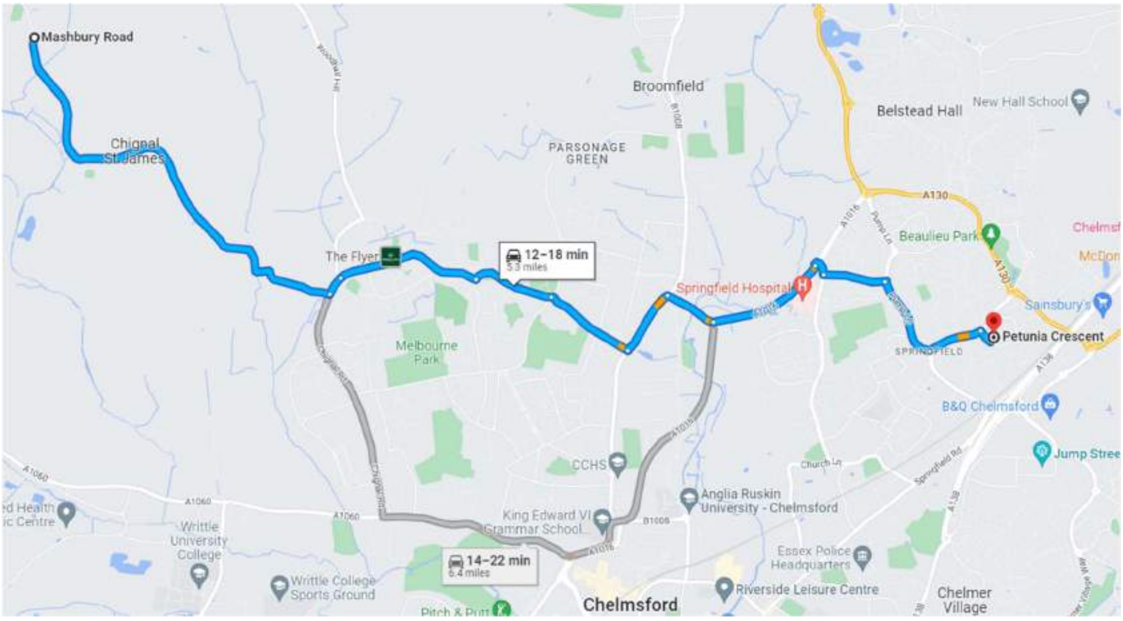
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



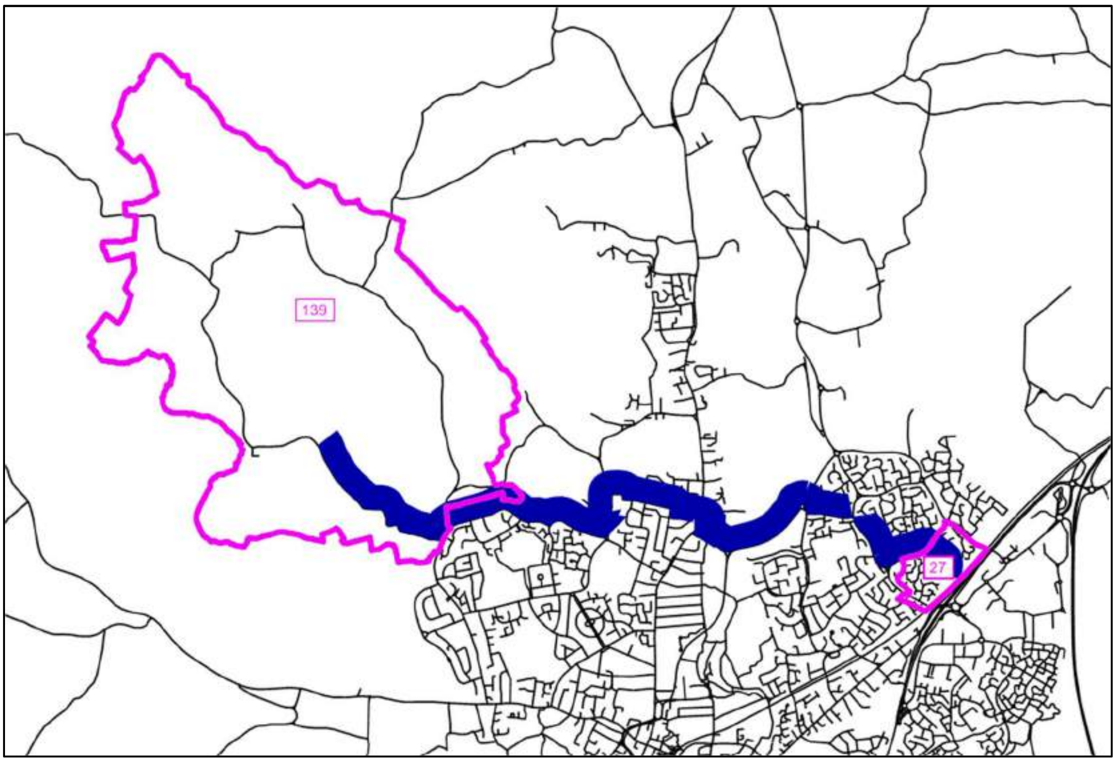
VISUM Model, 2019. IP.

A&N Route Checking – IP (12:00)

12. Mashbury Road to Petunia Crescent



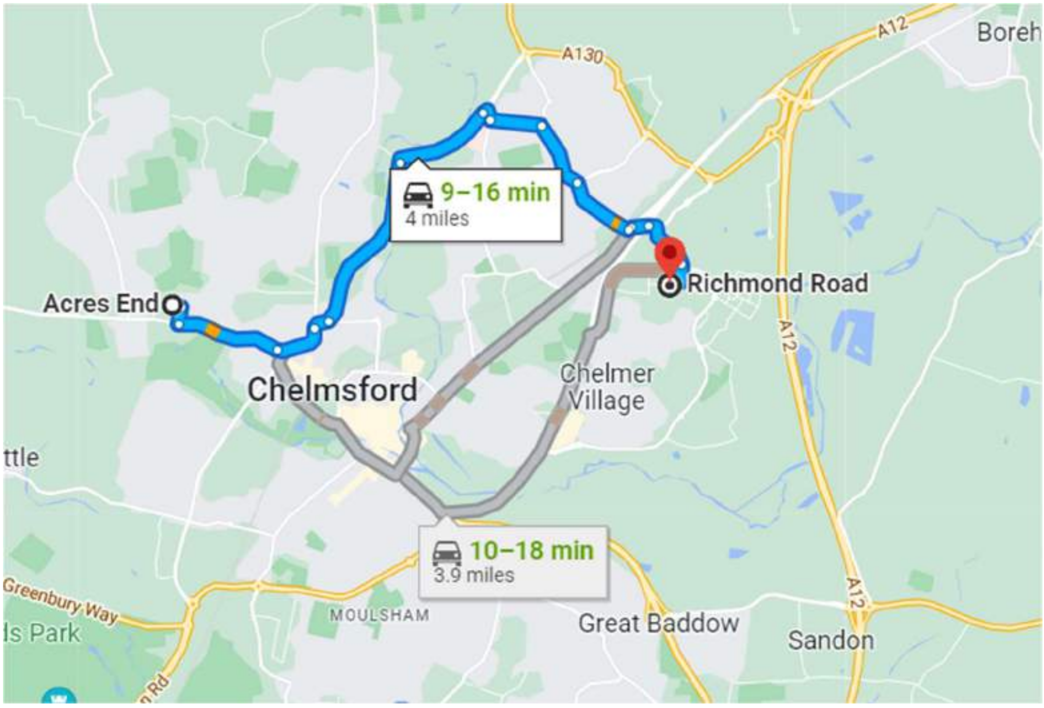
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



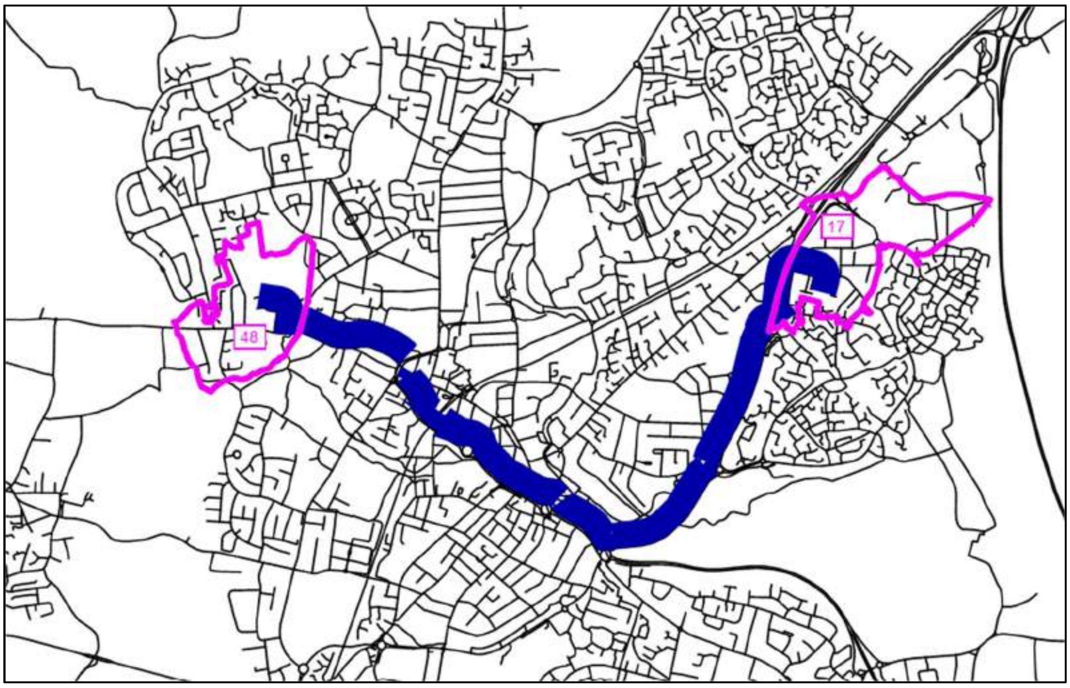
VISUM Model, 2019. IP.

A&N Route Checking – IP (12:00)

13. Acres End to Richmond Road



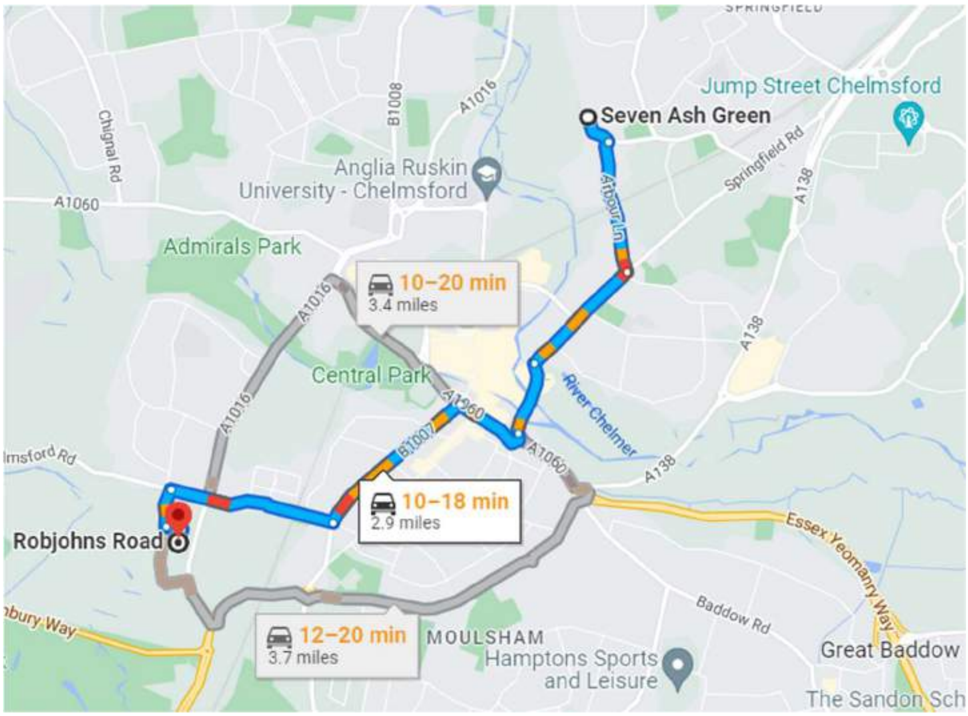
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



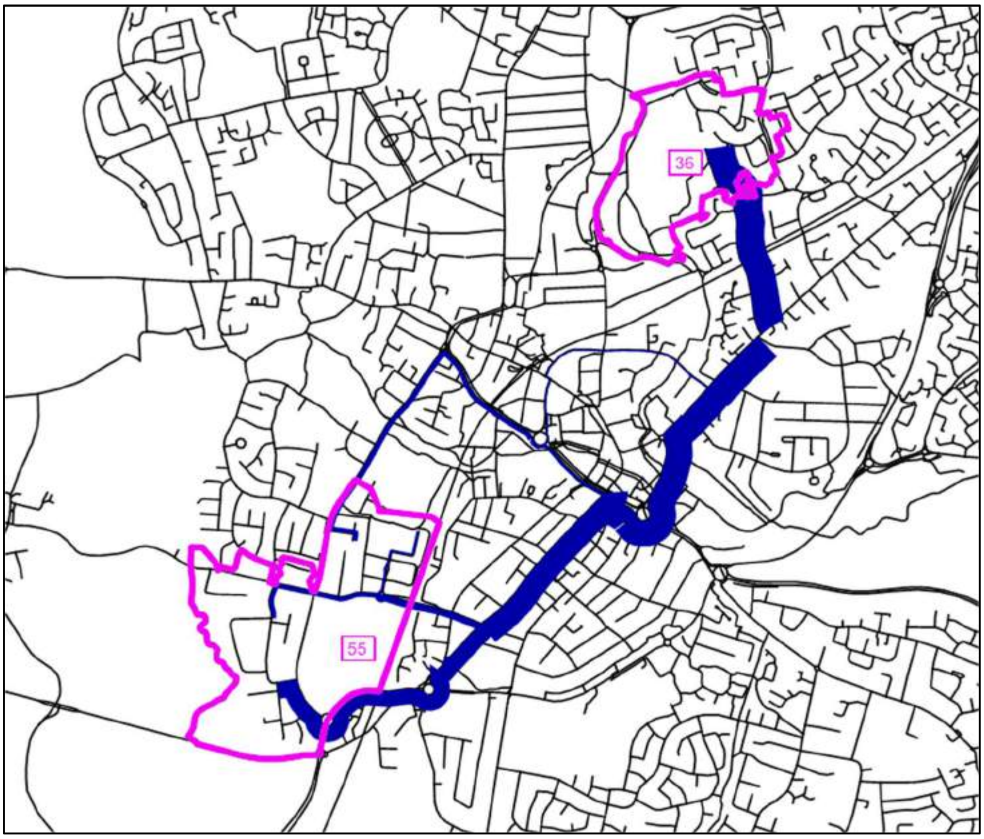
VISUM Model, 2019. IP.

A&N Route Checking – IP (12:00)

14. Seven Ash Green to Robjohns Road



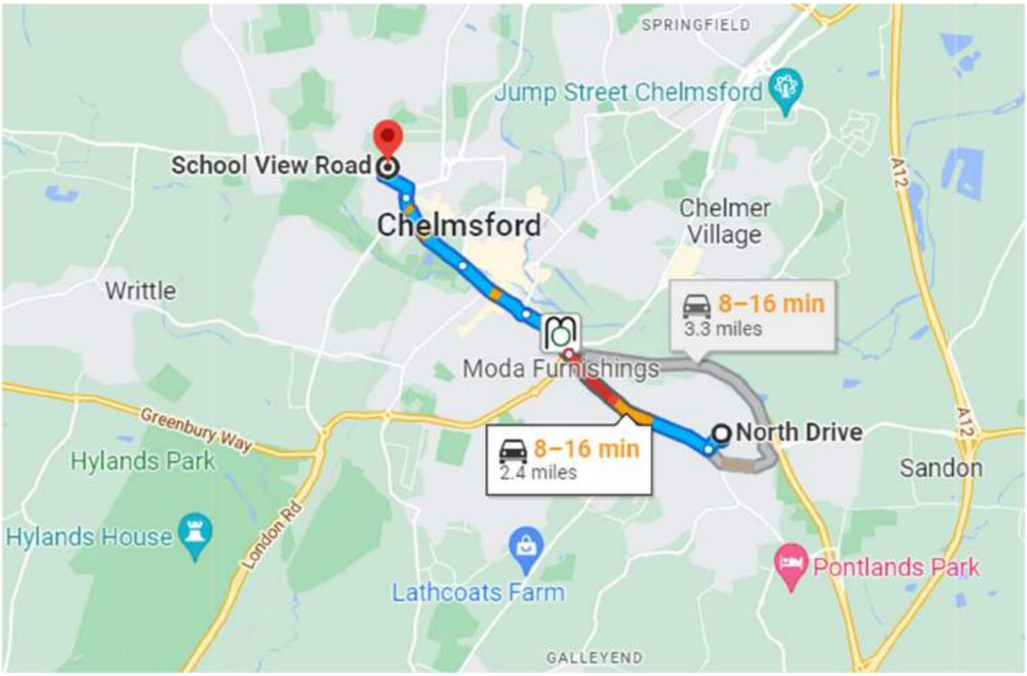
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



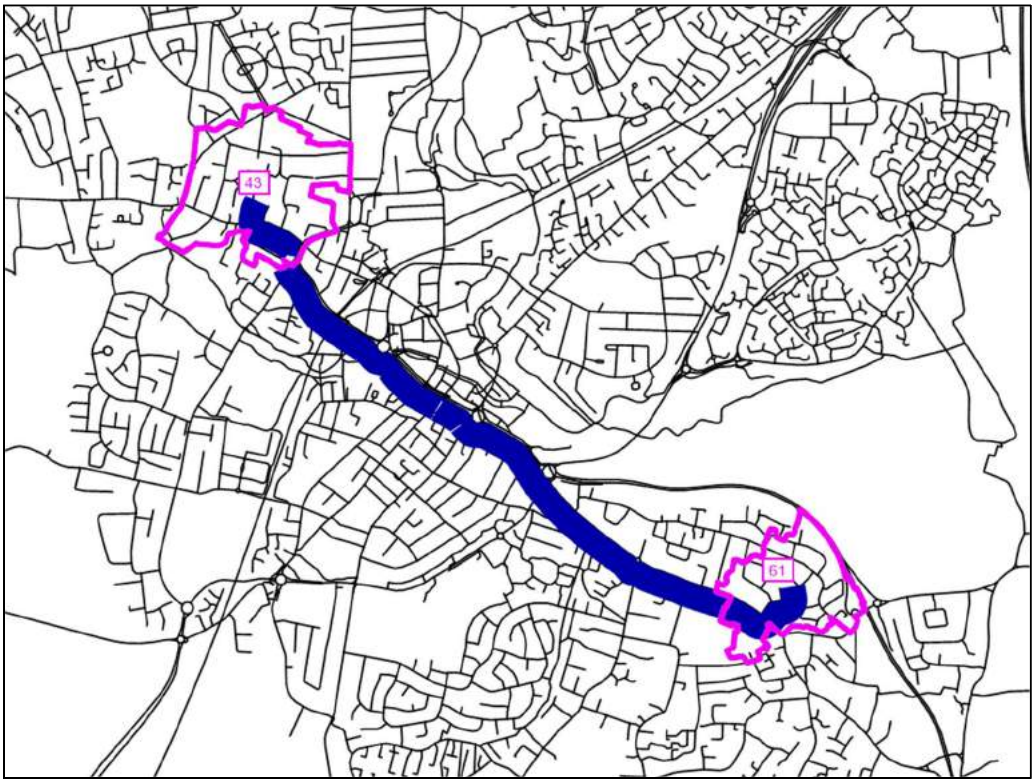
VISUM Model, 2019. IP.

A&N Route Checking – IP (12:00)

15. North Drive to School View Road



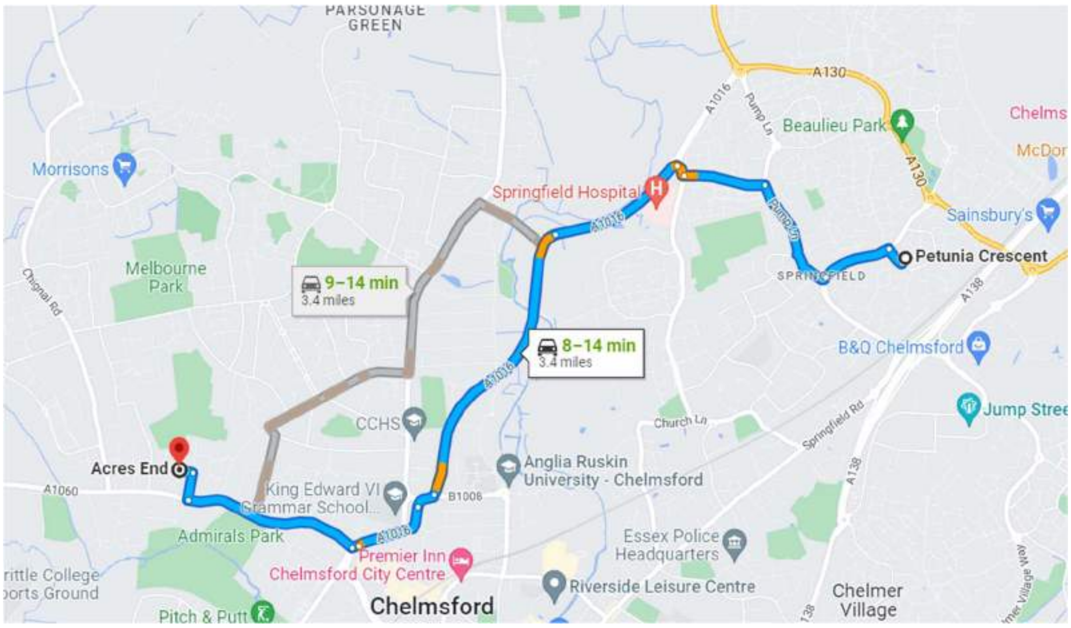
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



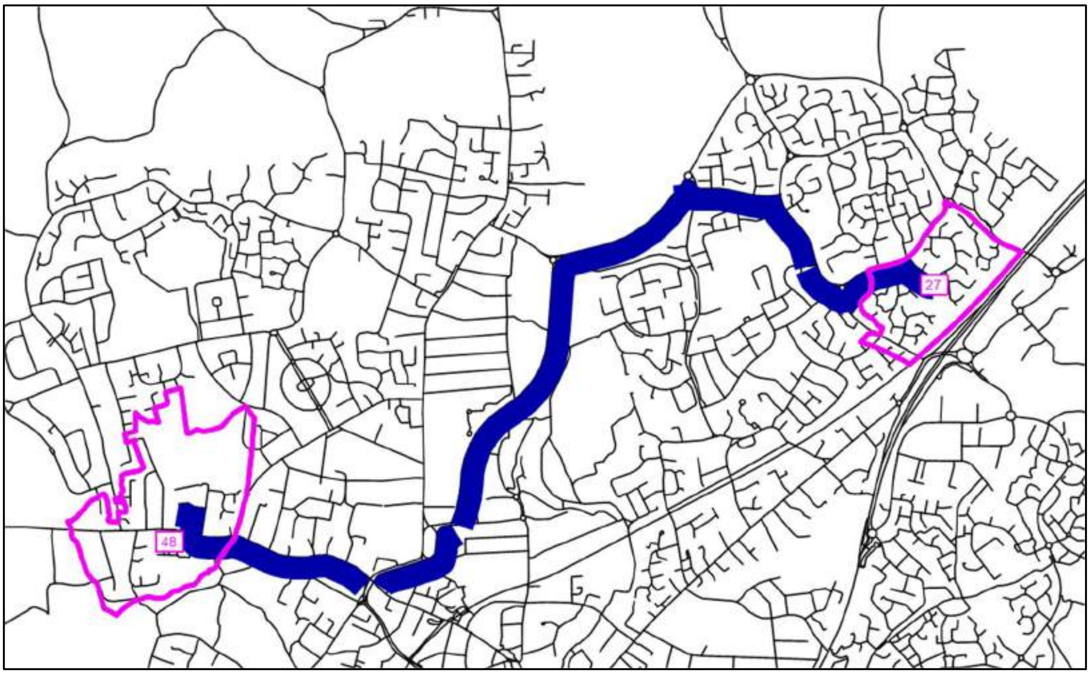
VISUM Model, 2019. IP.

A&N Route Checking – IP (12:00)

16. Petunia Crescent to Acres End



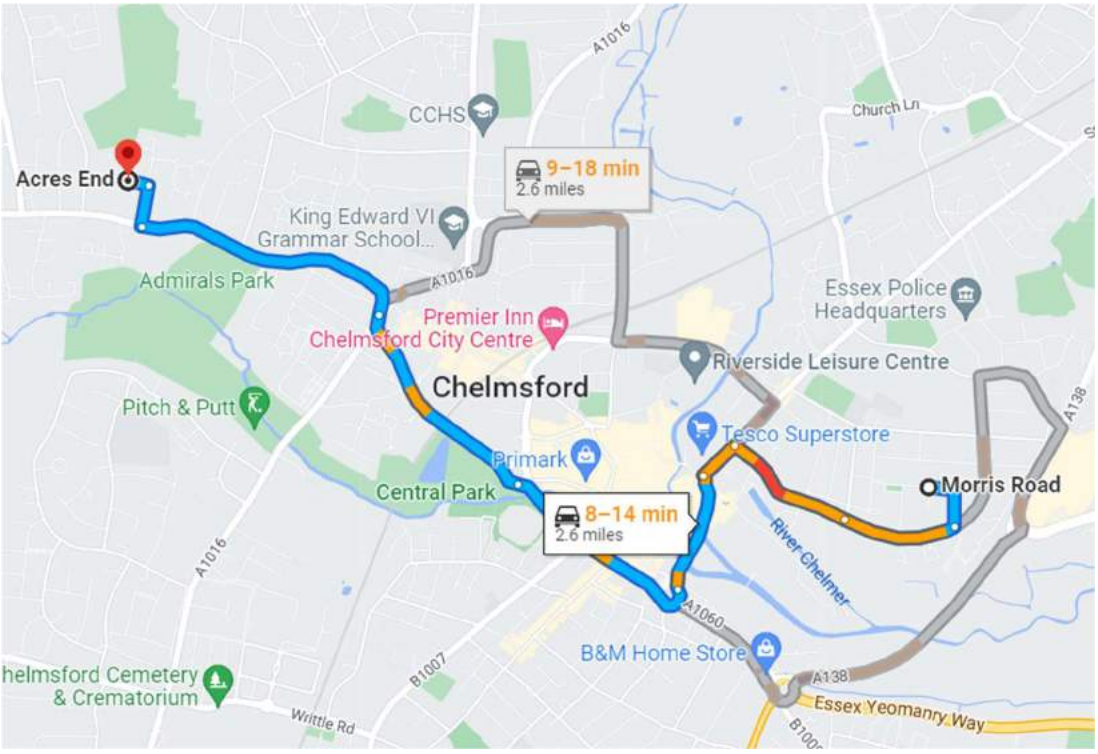
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



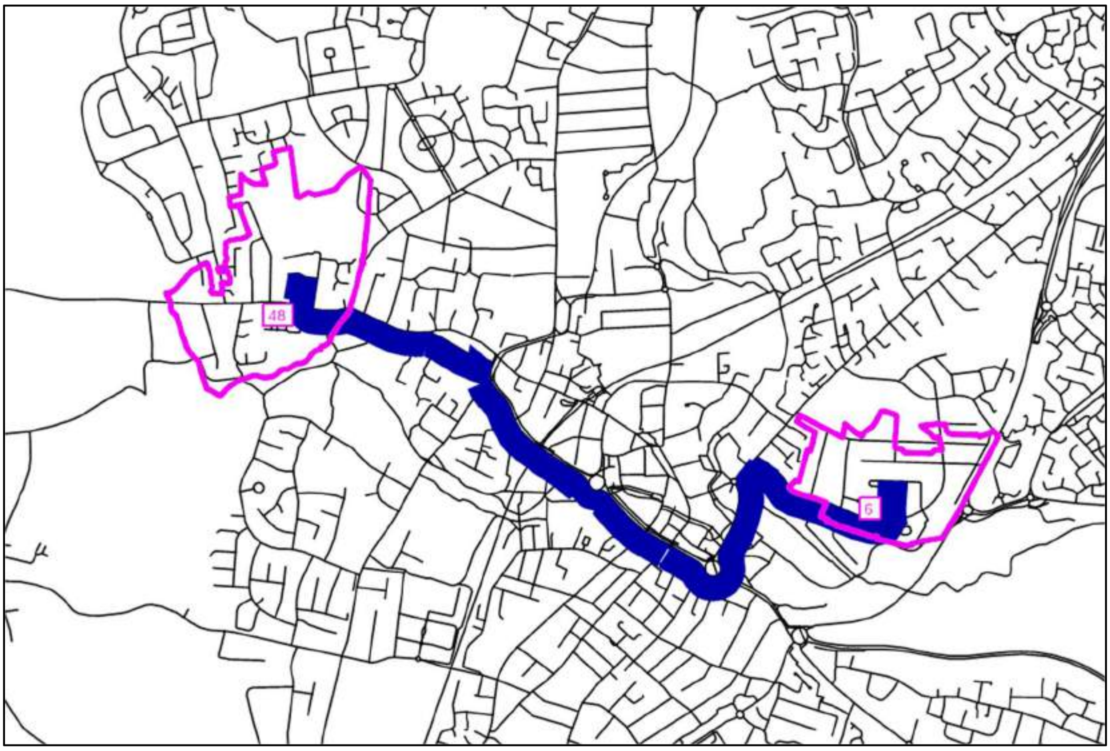
VISUM Model, 2019. IP.

A&N Route Checking – IP (12:00)

17. Morris Road to Acres End



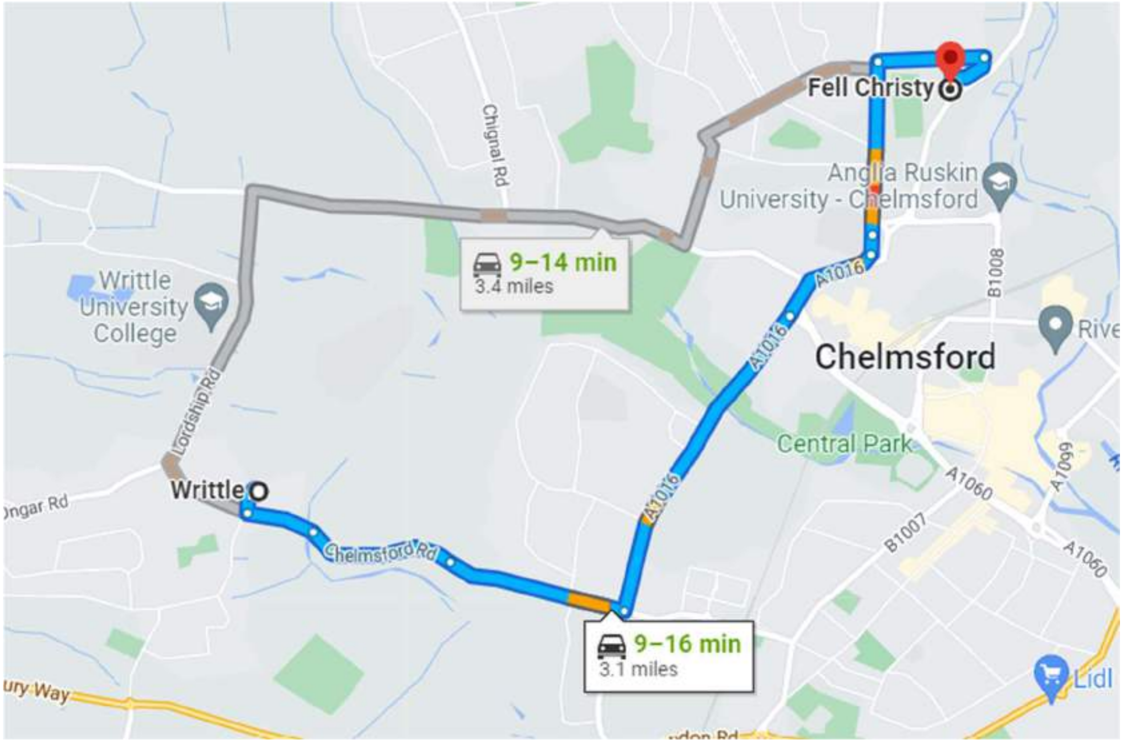
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



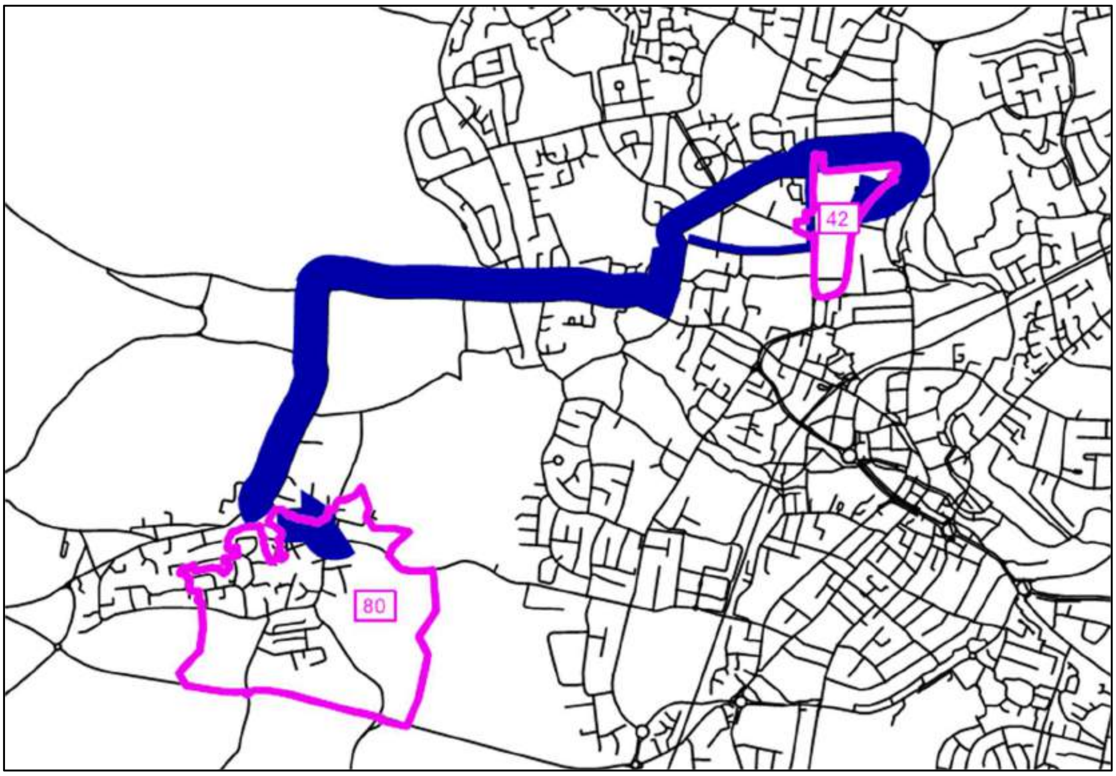
VISUM Model, 2019. IP.

A&N Route Checking – IP (12:00)

18. Writtle to Fell Cristy



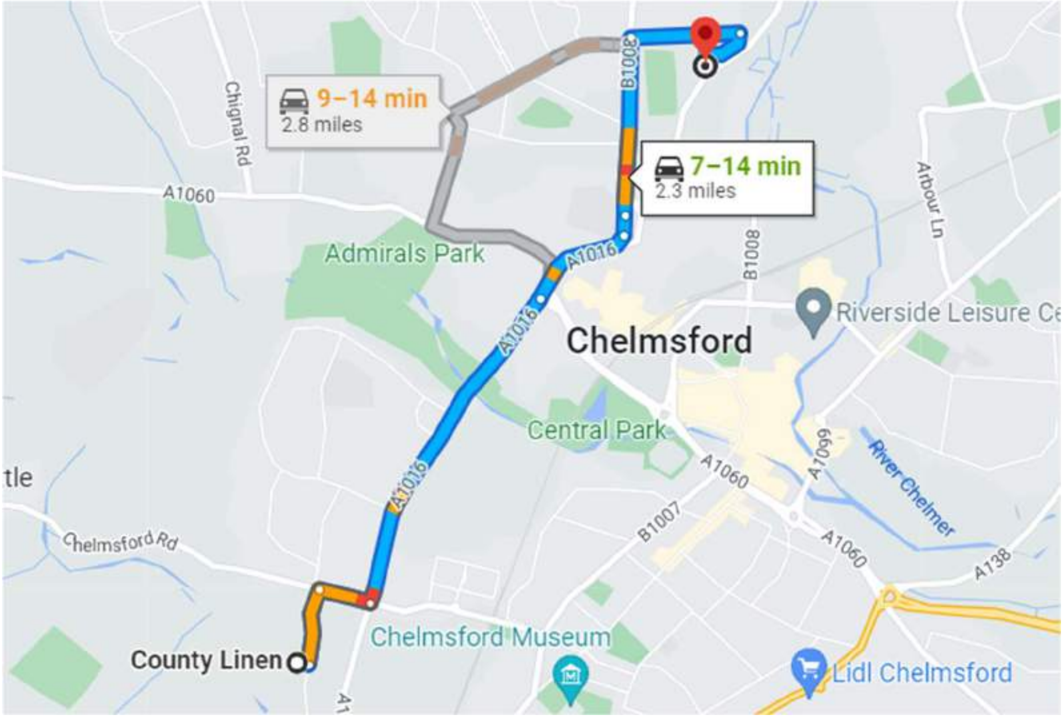
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



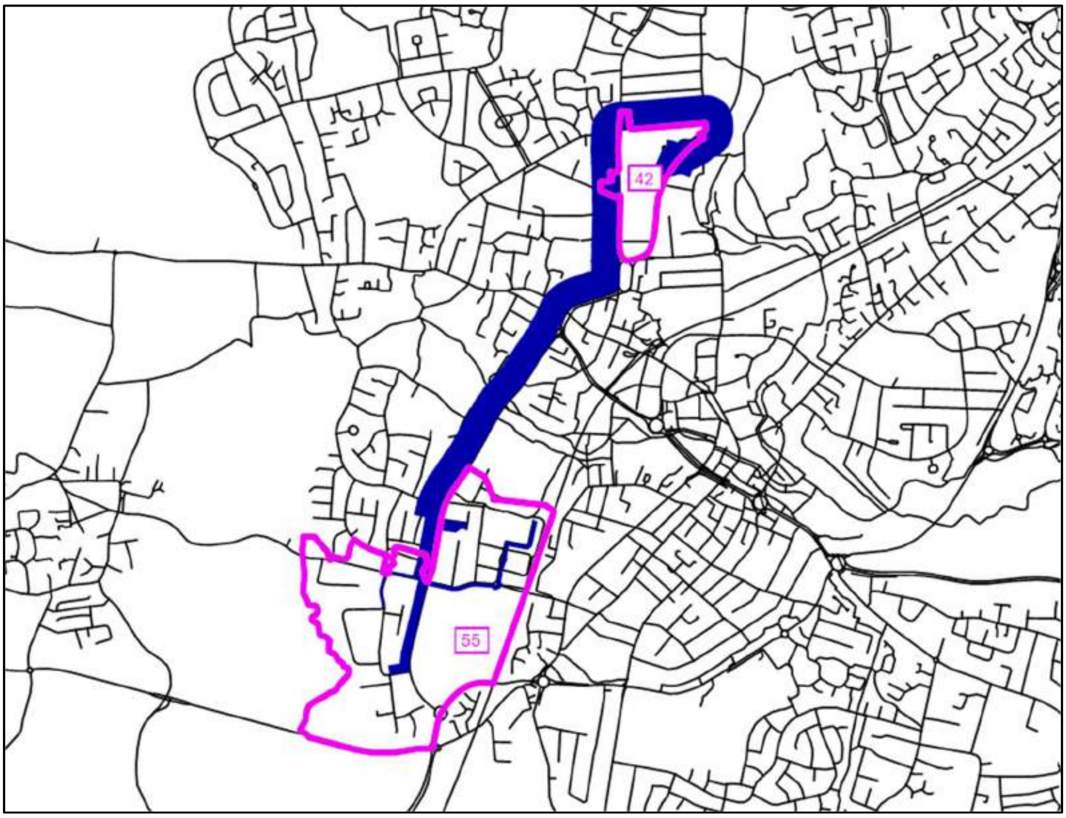
VISUM Model, 2019. IP.

A&N Route Checking – IP (12:00)

19. County Linen Services to Fell Cristy



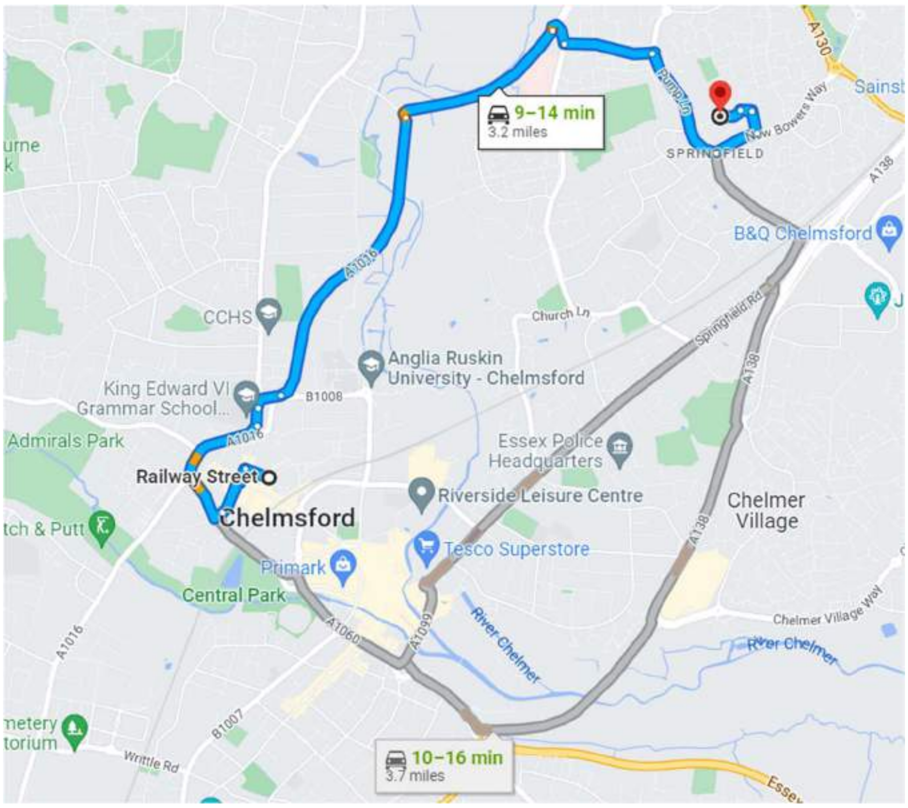
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



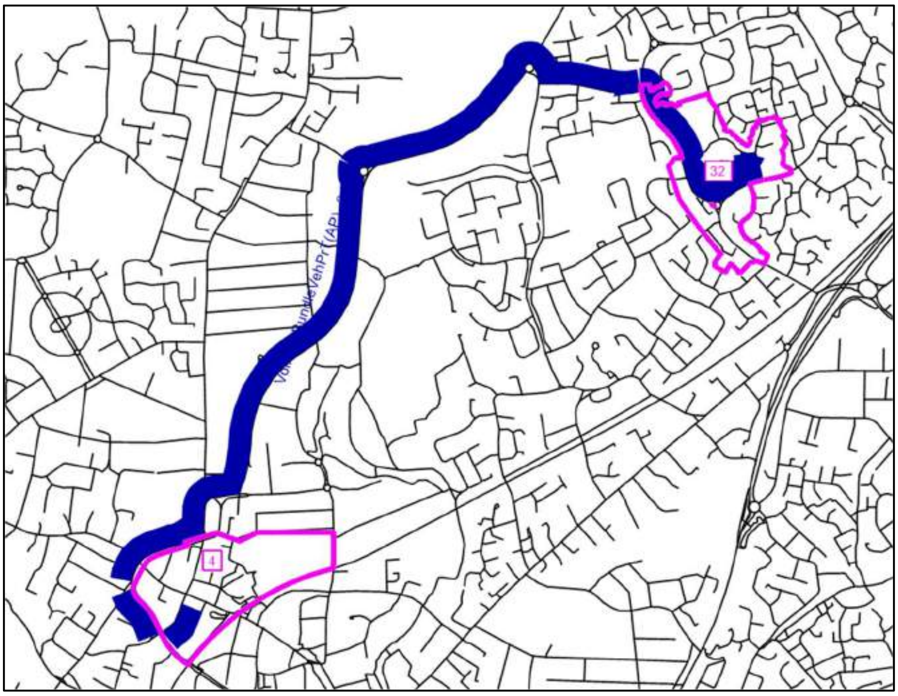
VISUM Model, 2019. IP.

A&N Route Checking – IP (12:00)

20. Railway Street to Bonnington Chase



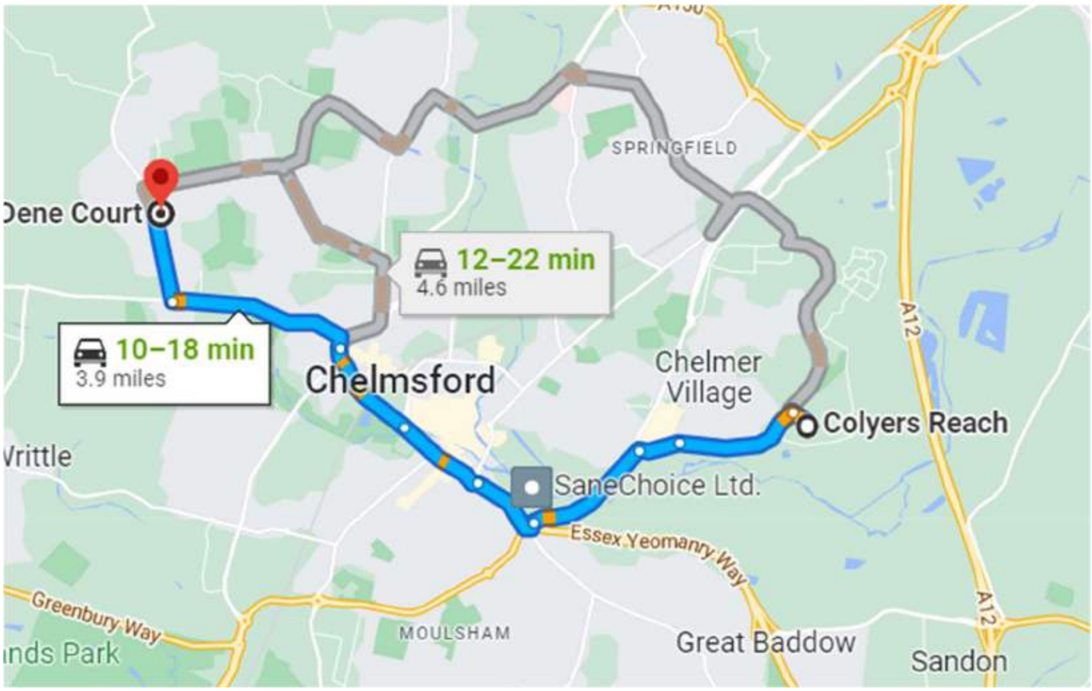
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



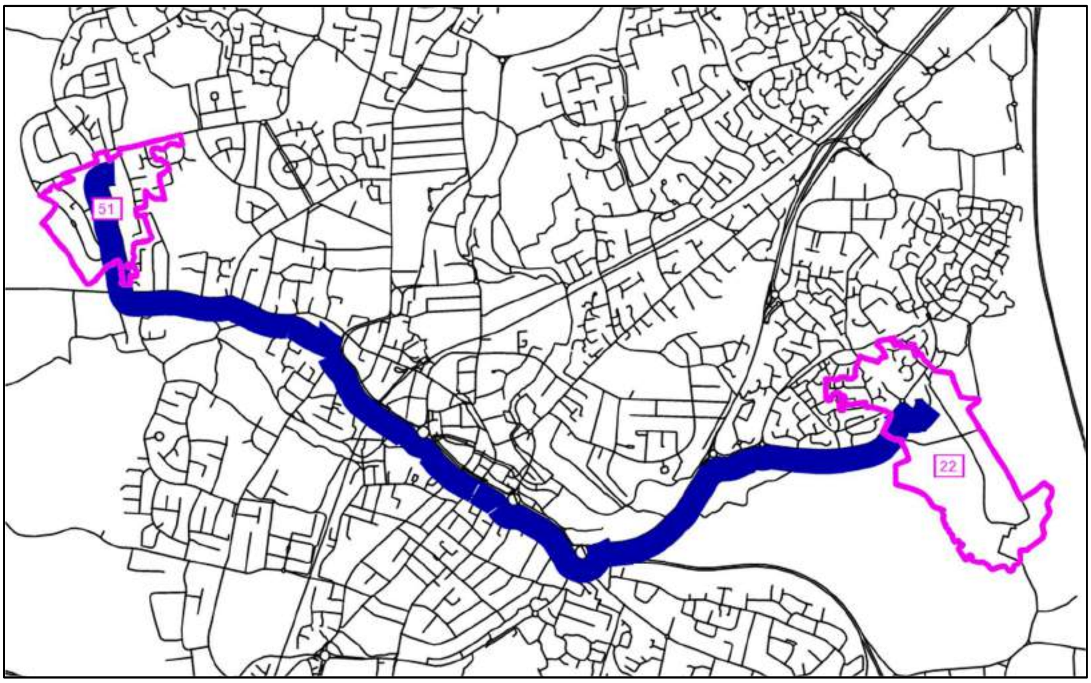
VISUM Model, 2019. IP.

A&N Route Checking – IP (12:00)

21. Colyers Reach to Dene Court



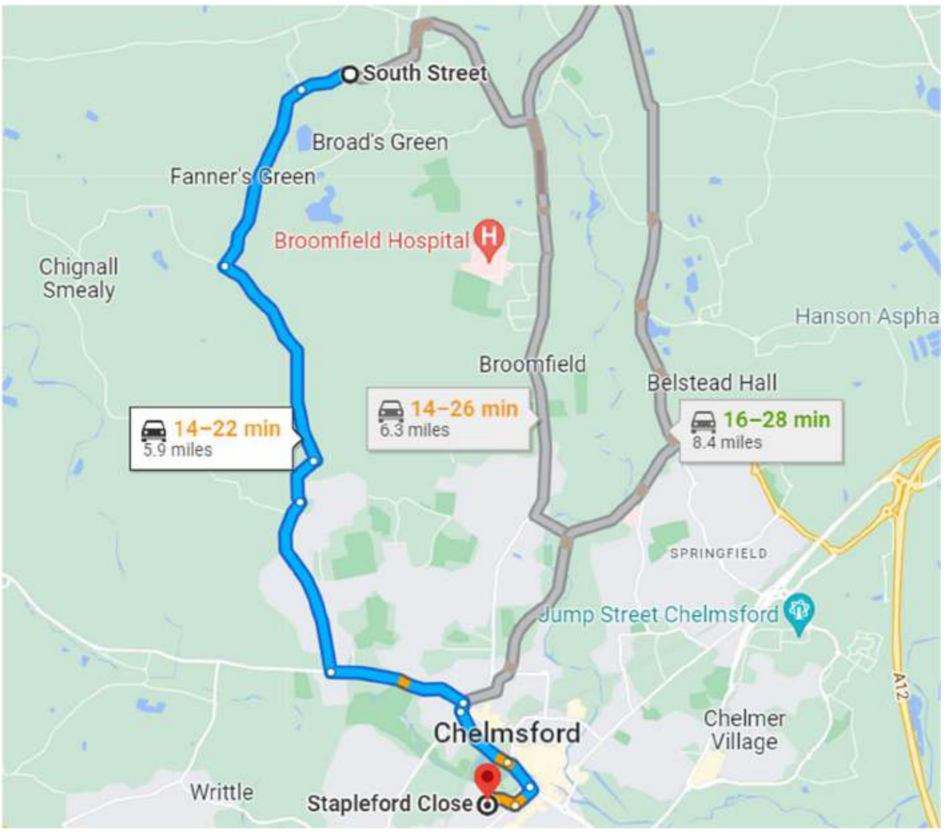
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



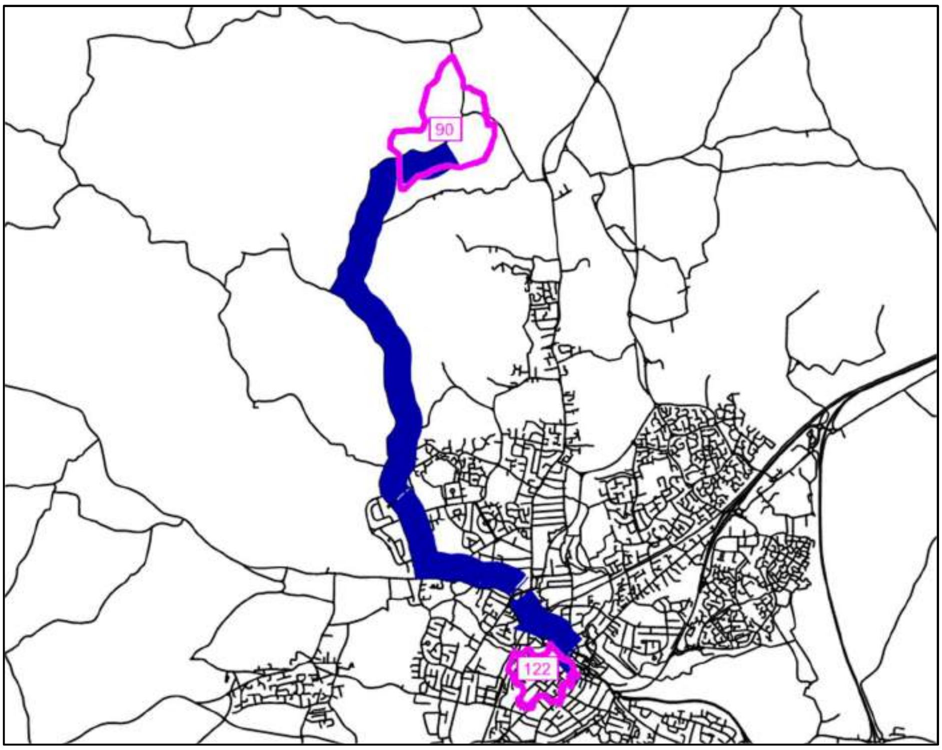
VISUM Model, 2019. IP.

A&N Route Checking – IP (12:00)

22. South Street to Stapleford Close



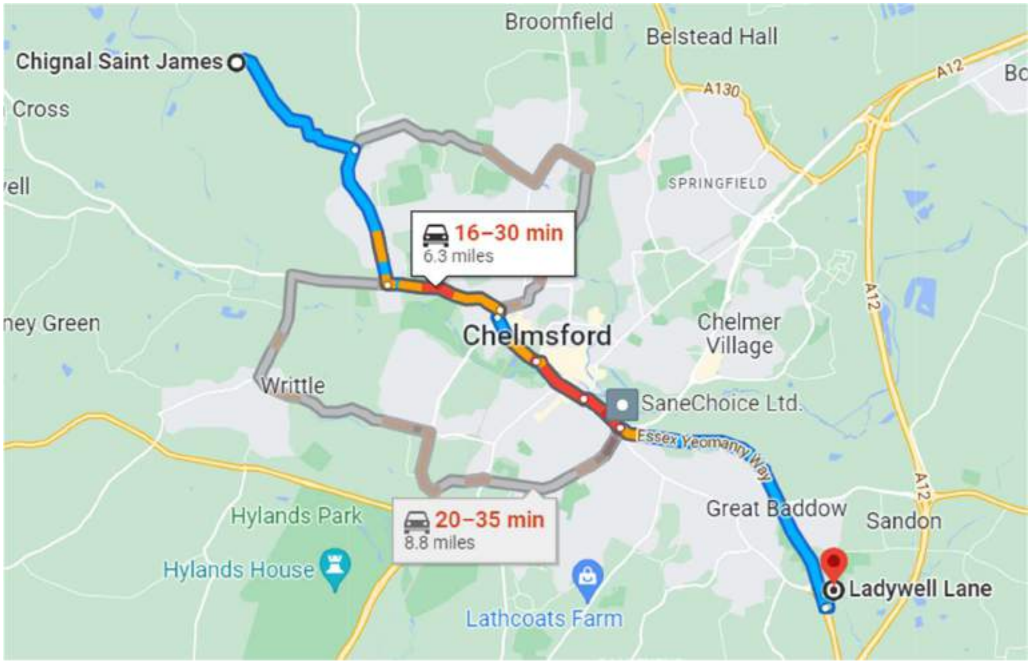
Google Maps, 2022. Typical Tuesday for the IP period (set to depart at 12:00)



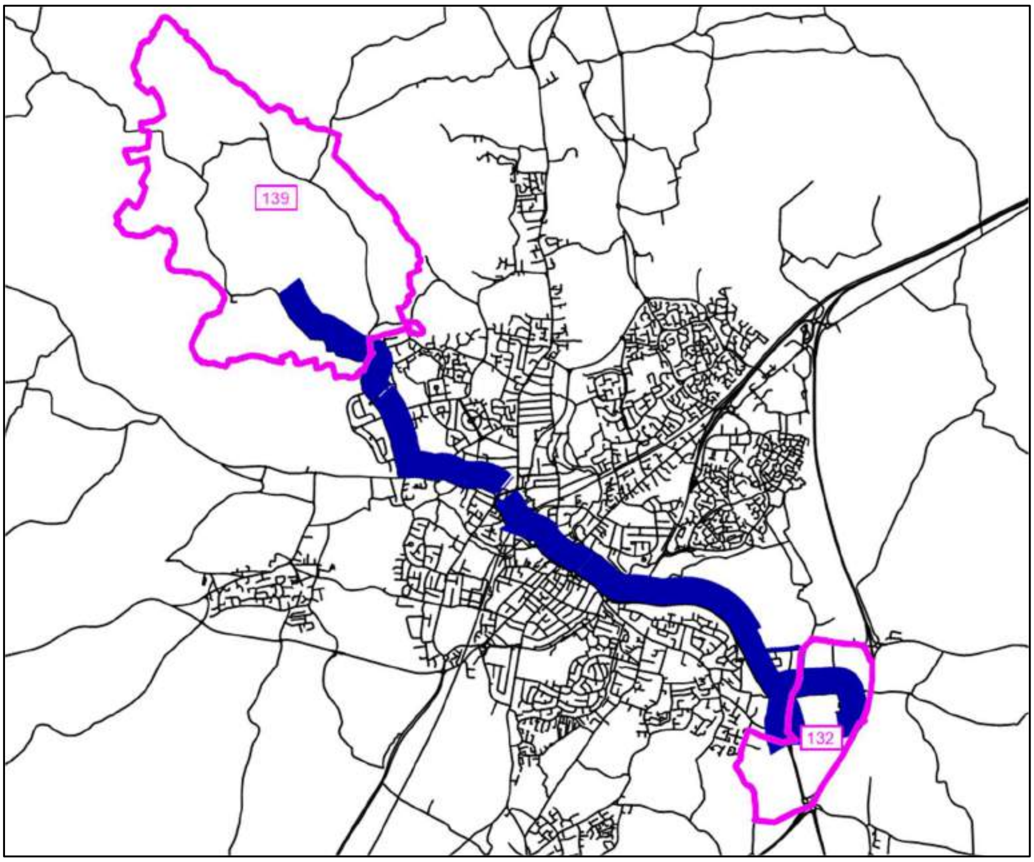
VISUM Model, 2019. IP.

A&N Route Checking. PM (16:00)

1. Chignal Saint James to Ladywell Lane



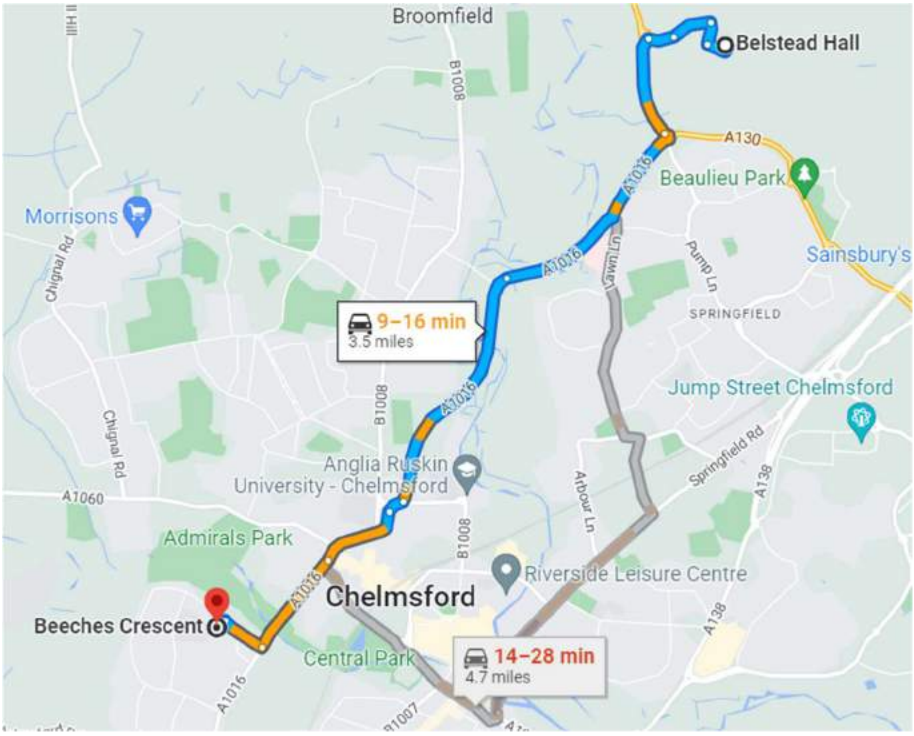
Google Maps, 2022. Typical Tuesday for the PM period (set to depart at 16:00)



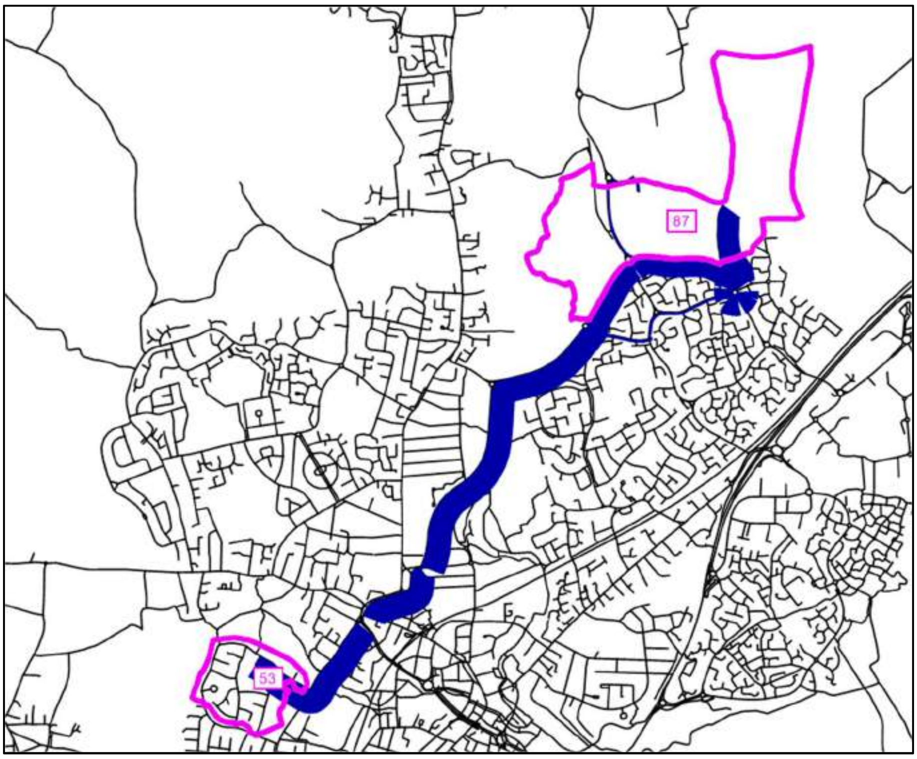
VISUM Model, 2019. PM.

A&N Route Checking. PM (16:00)

2. Belstead Hall to Beeches Crescent



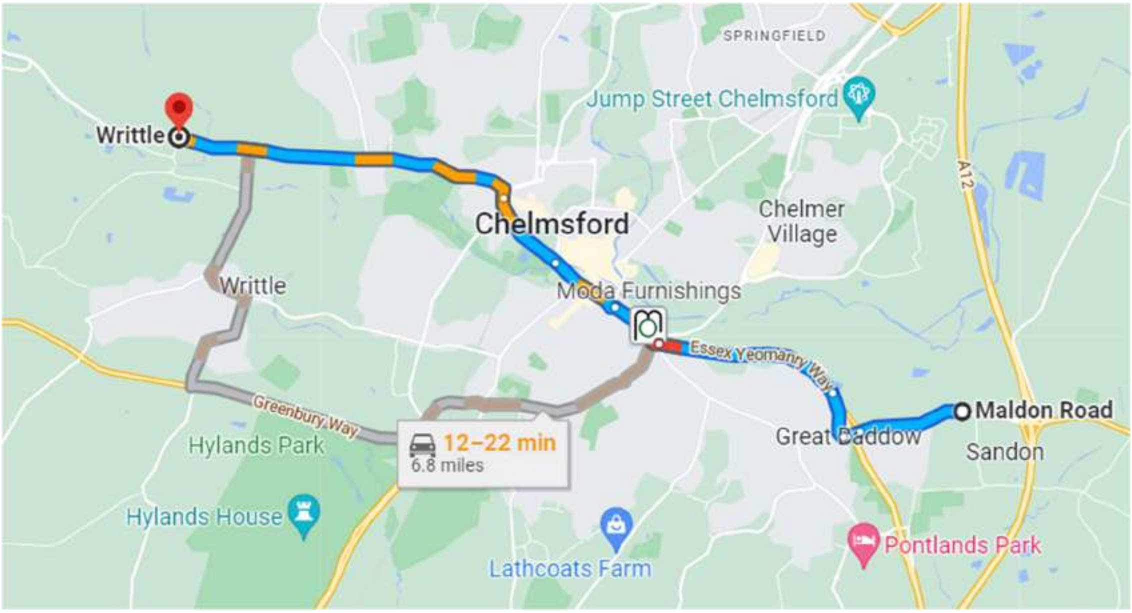
Google Maps, 2022. Typical Tuesday for the PM period (set to depart at 16:00)



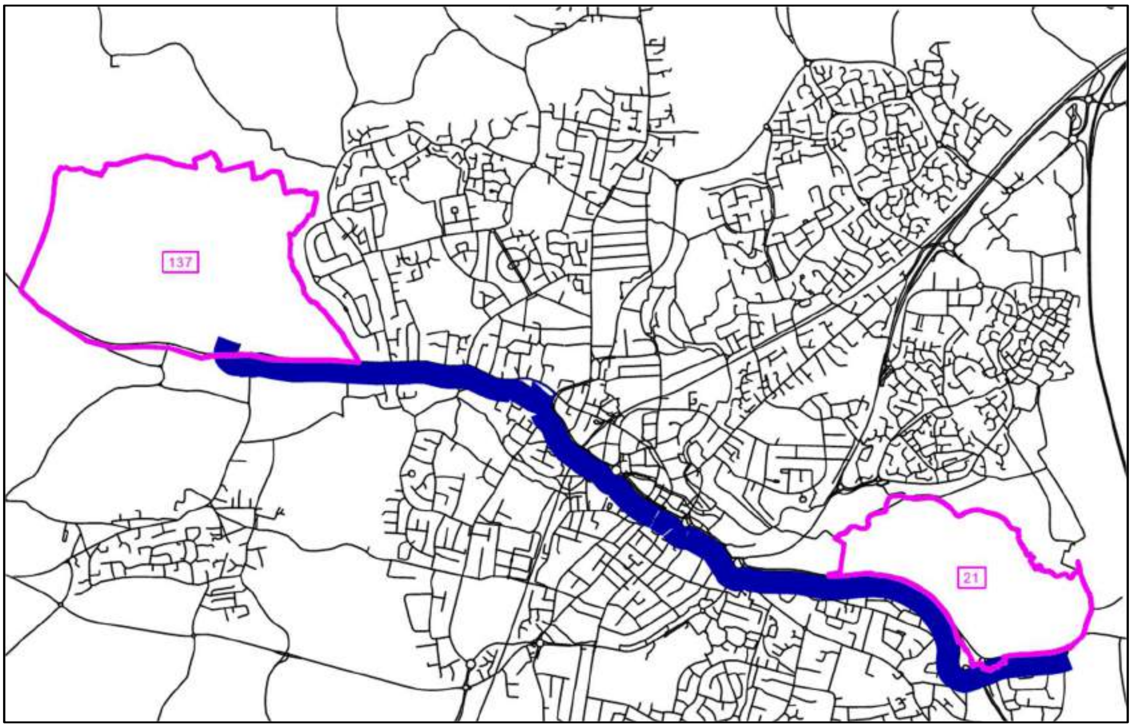
VISUM Model, 2019. PM.

A&N Route Checking. PM (16:00)

3. Maldon Road to Writtle



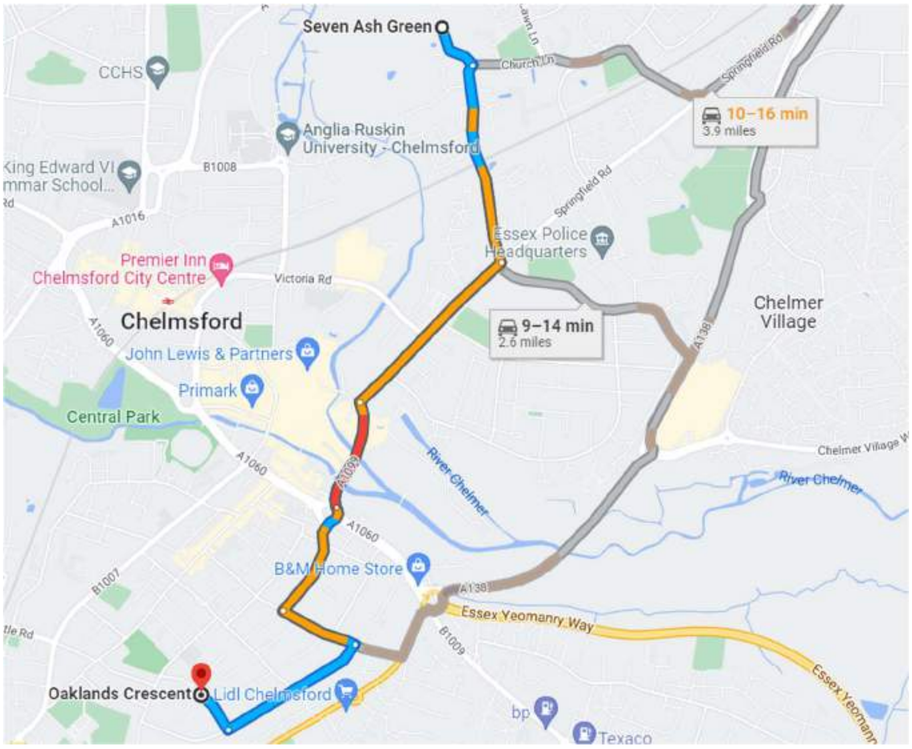
Google Maps, 2022. Typical Tuesday for the PM period (set to depart at 16:00)



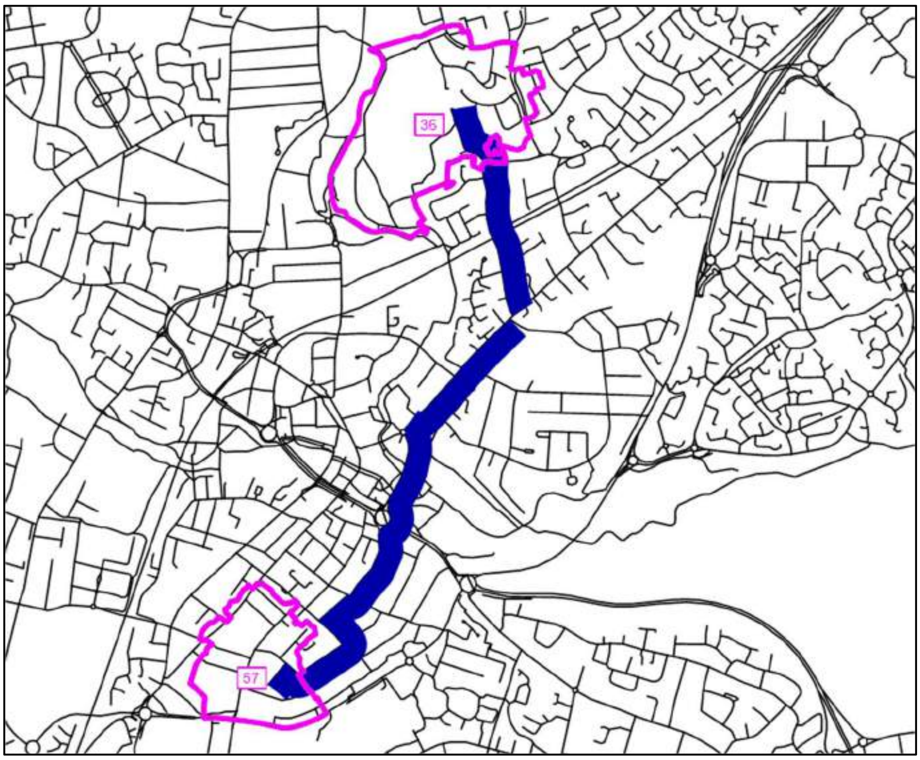
VISUM Model, 2019. PM.

A&N Route Checking. PM (16:00)

4. Seven Ash Green to Oaklands Crescent



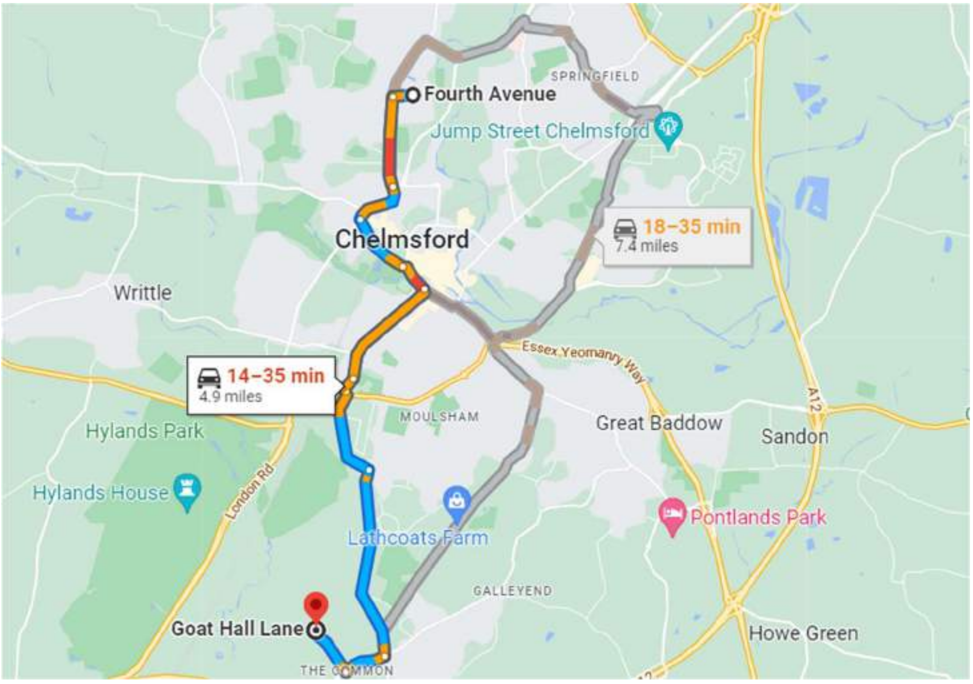
Google Maps, 2022. Typical Tuesday for the PM period (set to depart at 16:00)



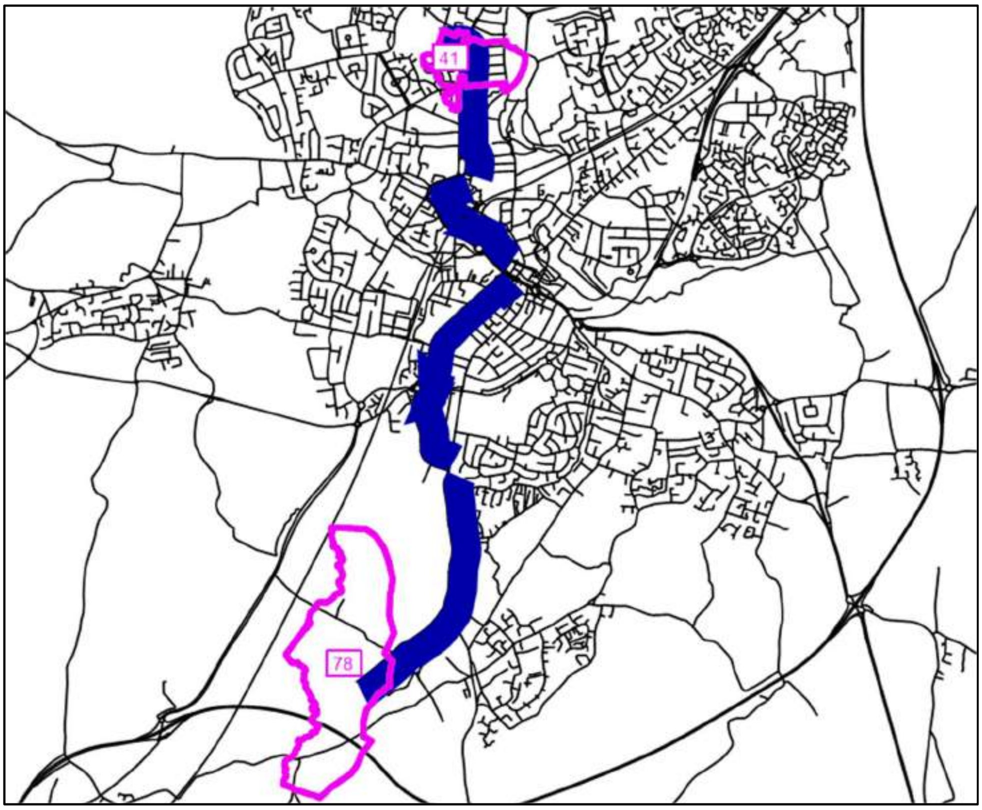
VISUM Model, 2019. PM.

A&N Route Checking. PM (16:00)

5. Fourth Avenue to Goat Hall Lane



Google Maps, 2022. Typical Tuesday for the PM period (set to depart at 16:00)

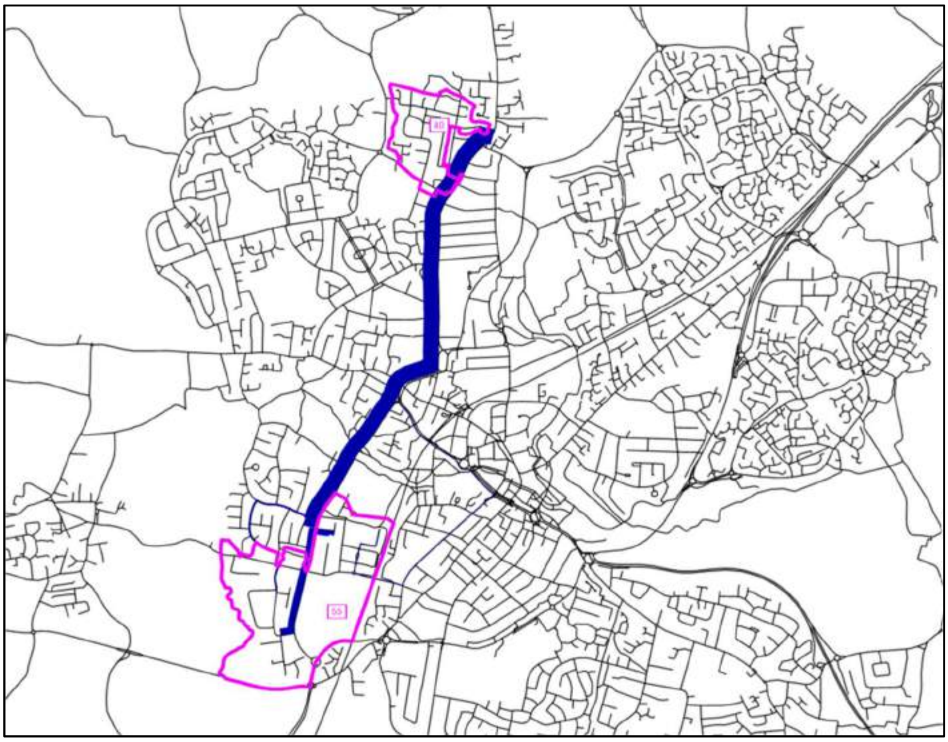


VISUM Model, 2019. PM.

A&N Route Checking. PM (16:00)

6. County Linen Services to Rutland Road

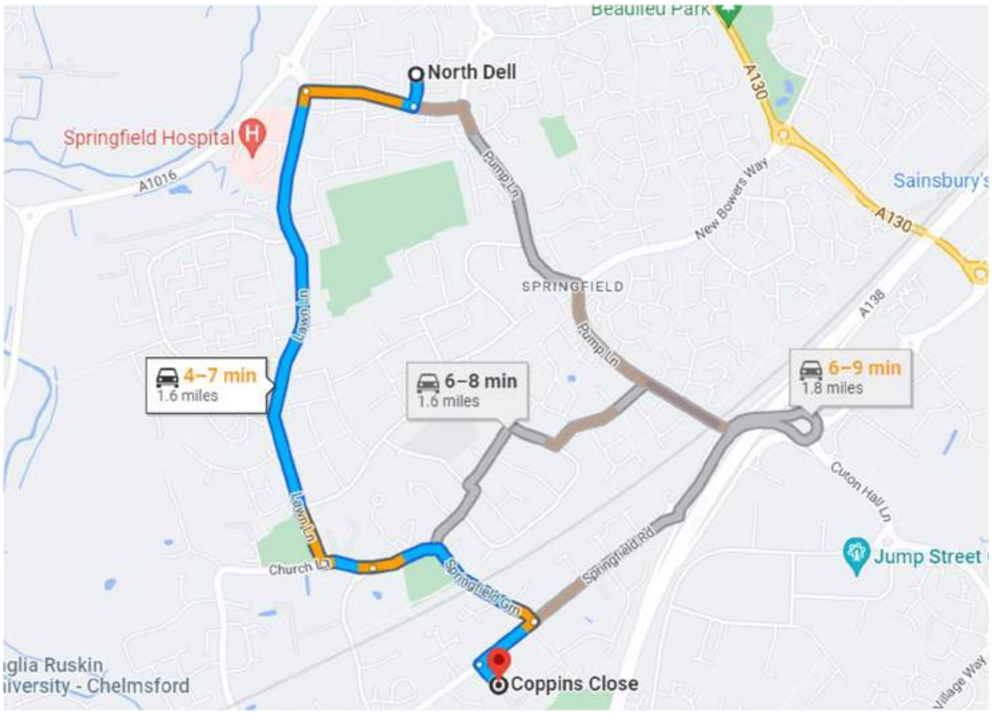
Google Maps, 2022. Typical Tuesday for the PM period (set to depart at 16:00)



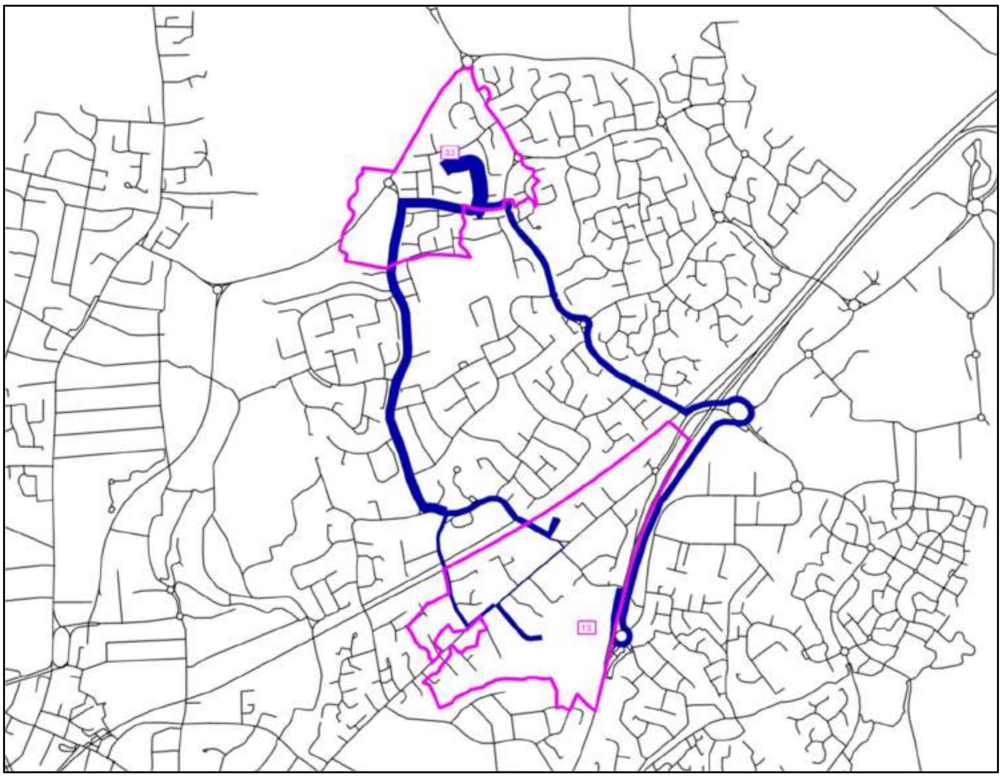
VISUM Model, 2019. PM.

A&N Route Checking. PM (16:00)

7. North Dell to Coppins Close



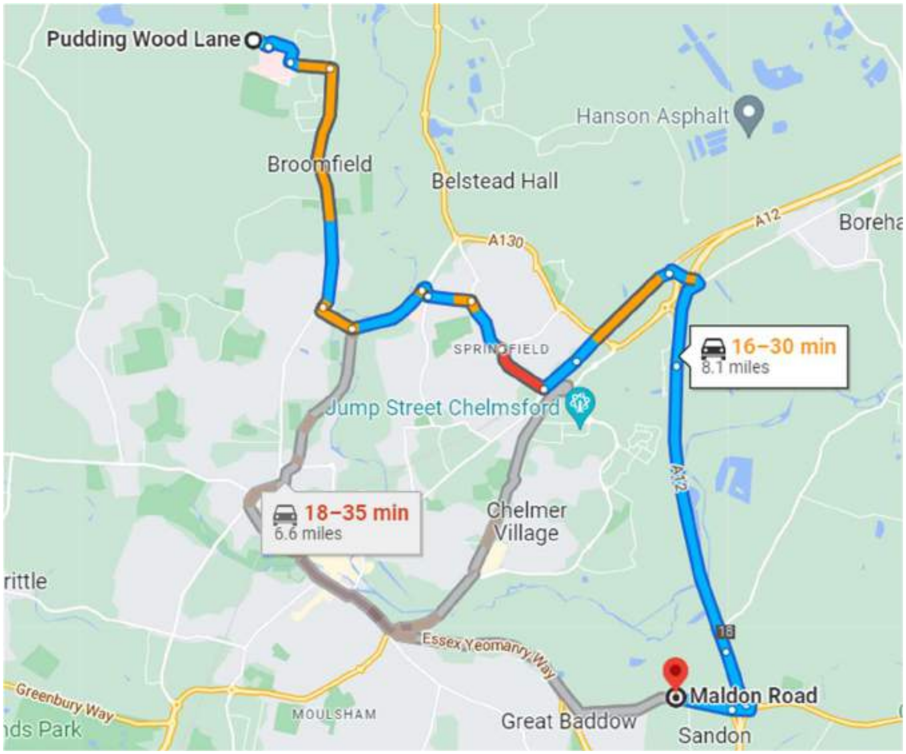
Google Maps, 2022. Typical Tuesday for the PM period (set to depart at 16:00)



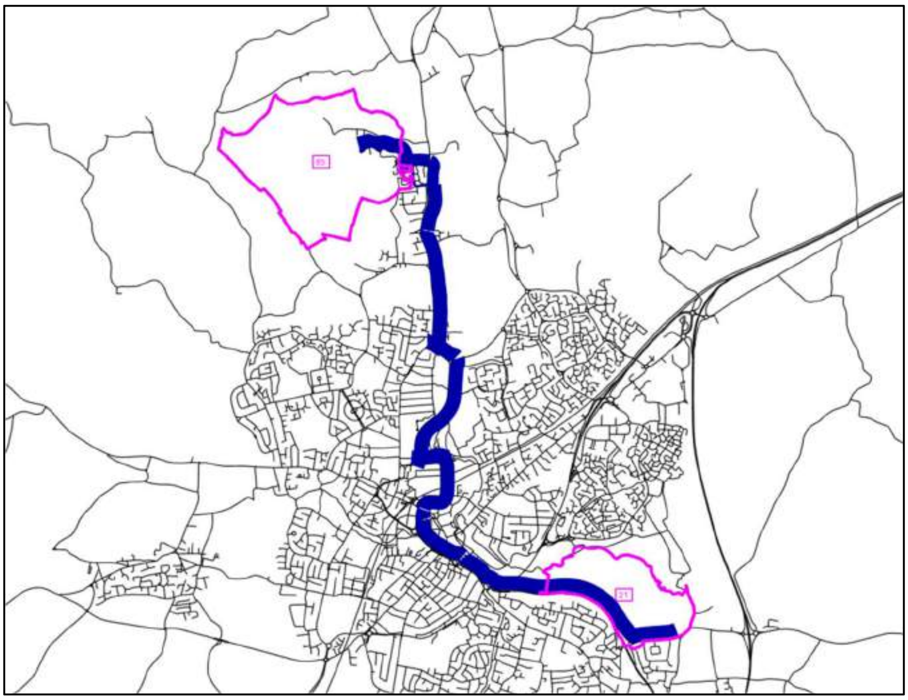
VISUM Model, 2019. PM.

A&N Route Checking. PM (16:00)

8. Pudding Wood Lane to Maldon Road



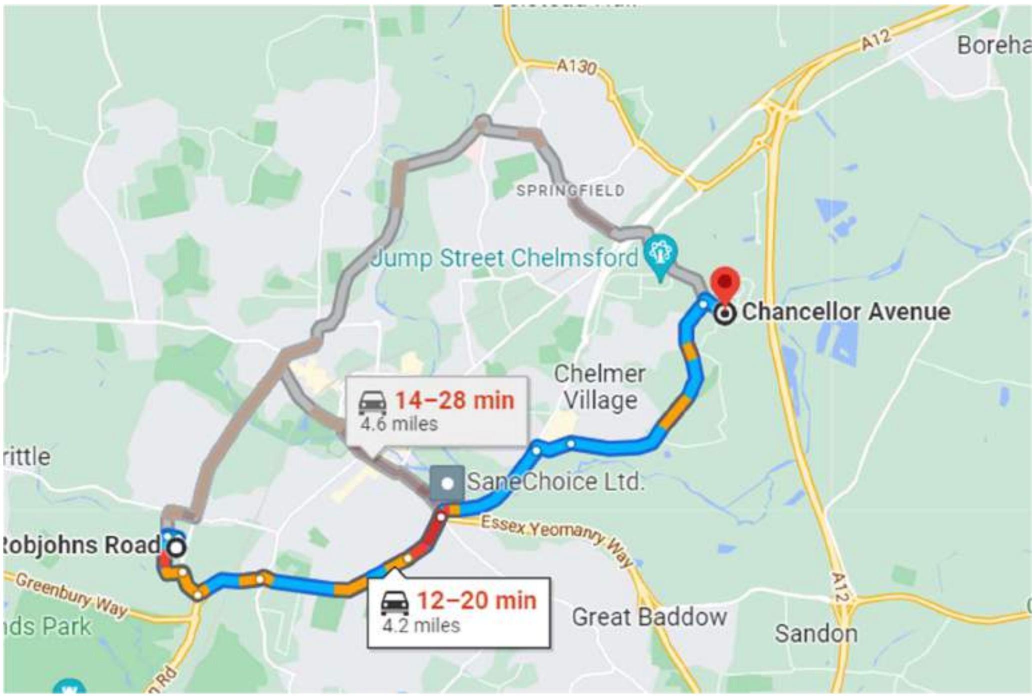
Google Maps, 2022. Typical Tuesday for the PM period (set to depart at 16:00)



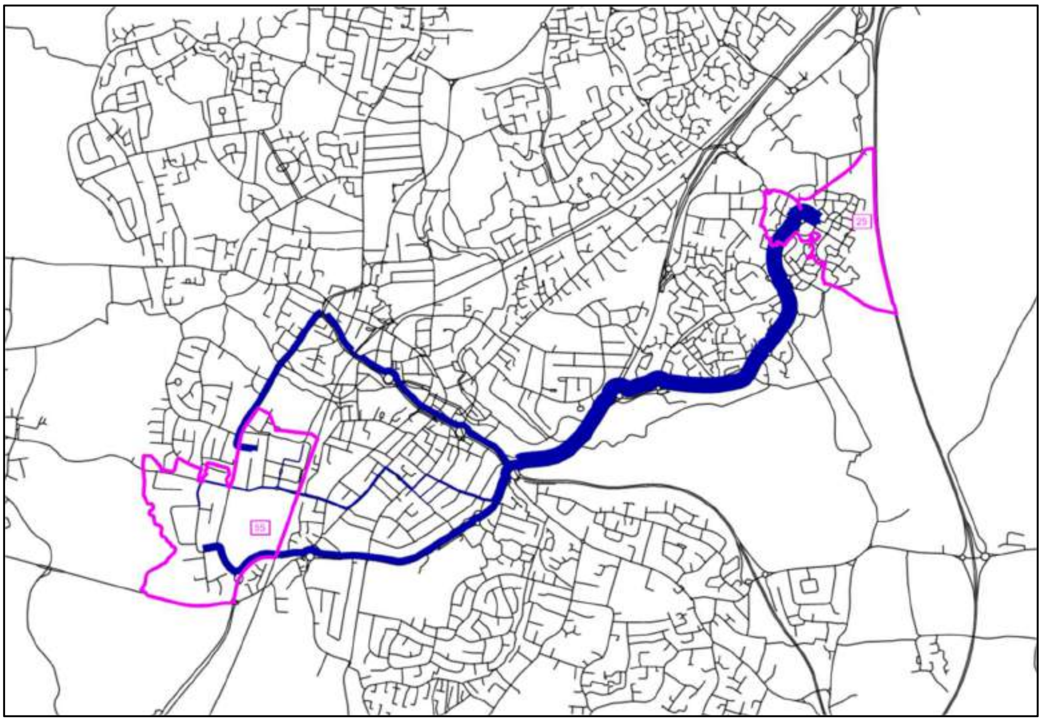
VISUM Model, 2019. PM.

A&N Route Checking. PM (16:00)

9. Robjohns Road to Chancellor Avenue



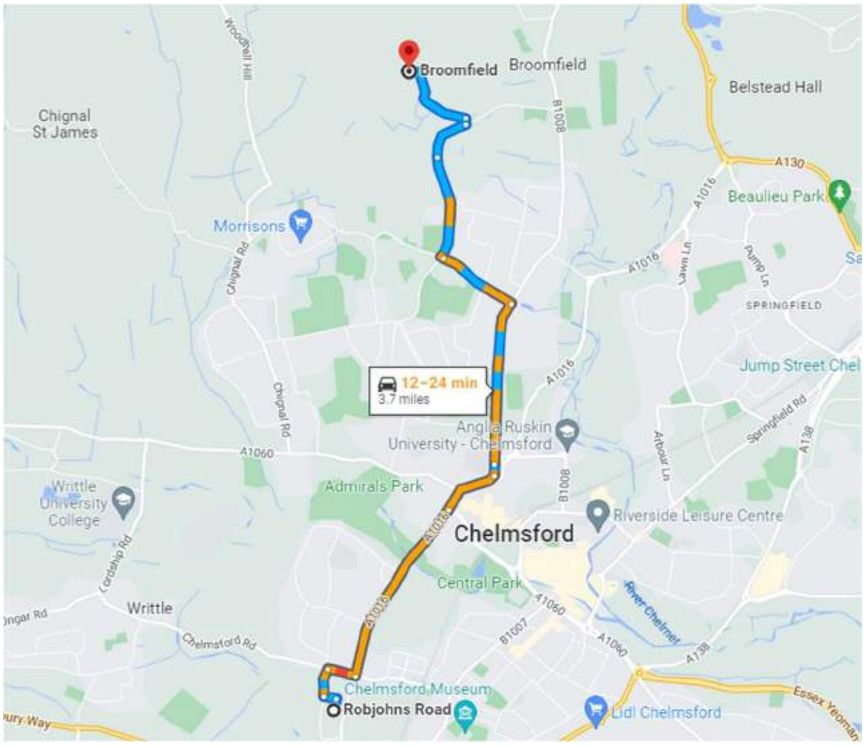
Google Maps, 2022. Typical Tuesday for the PM period (set to depart at 16:00)



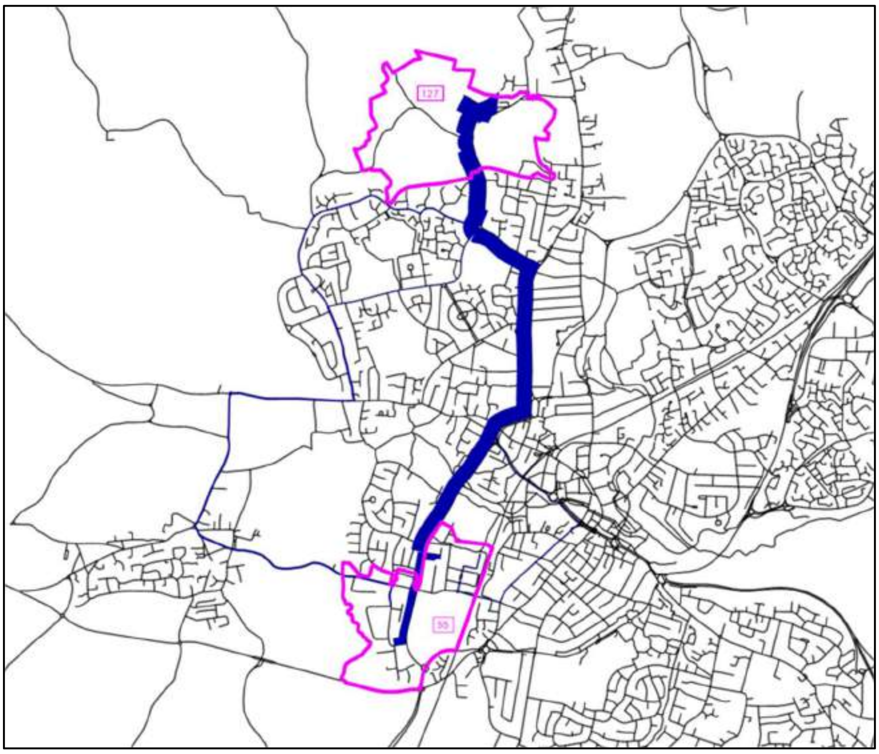
VISUM Model, 2019. PM.

A&N Route Checking. PM (16:00)

10. Robjohns Road to Broomfield



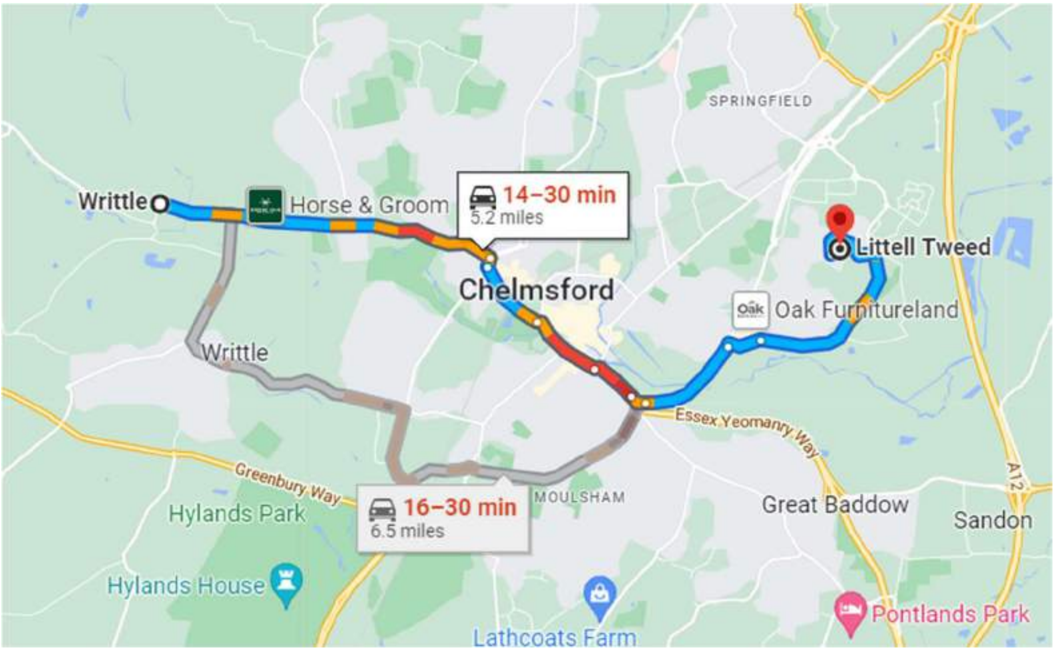
Google Maps, 2022. Typical Tuesday for the PM period (set to depart at 16:00)



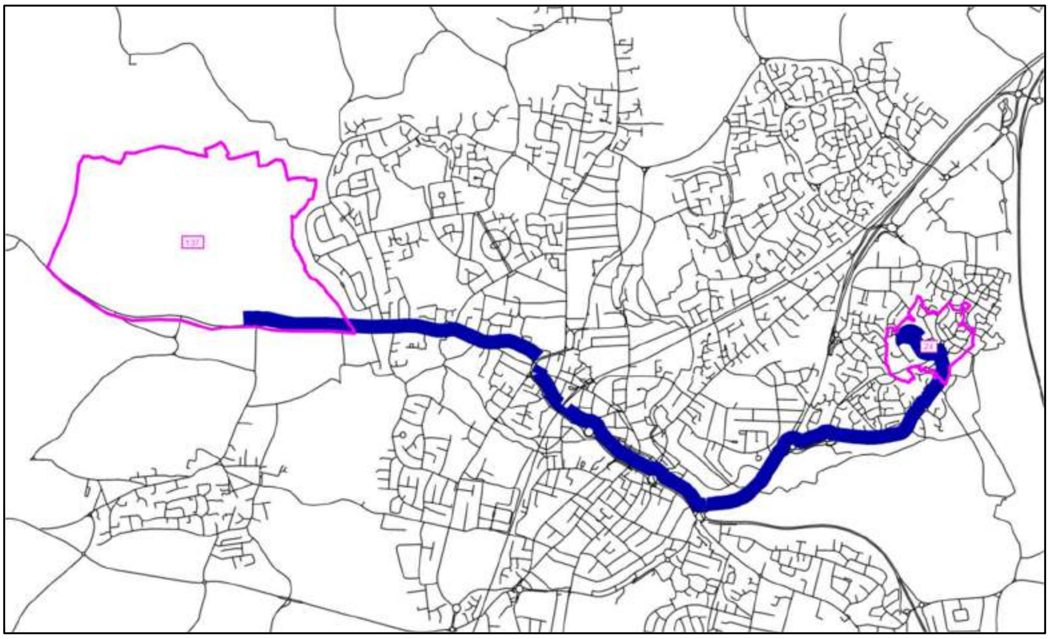
VISUM Model, 2019. PM.

A&N Route Checking. PM (16:00)

11. Writtle to Littell tweed



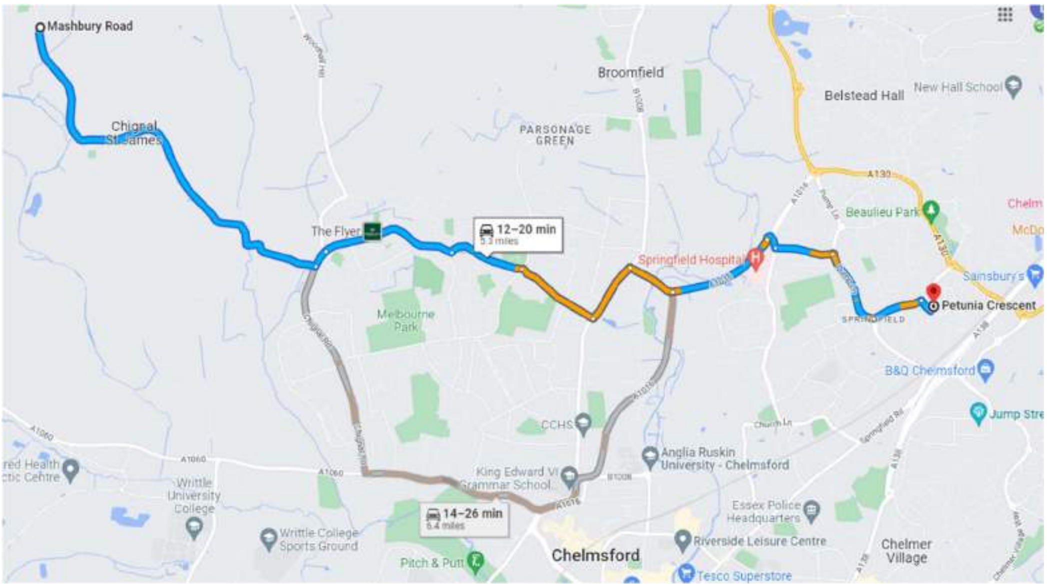
Google Maps, 2022. Typical Tuesday for the PM period (set to depart at 16:00)



VISUM Model, 2019. PM.

A&N Route Checking. PM (16:00)

12. Mashbury Road to Petunia Crescent



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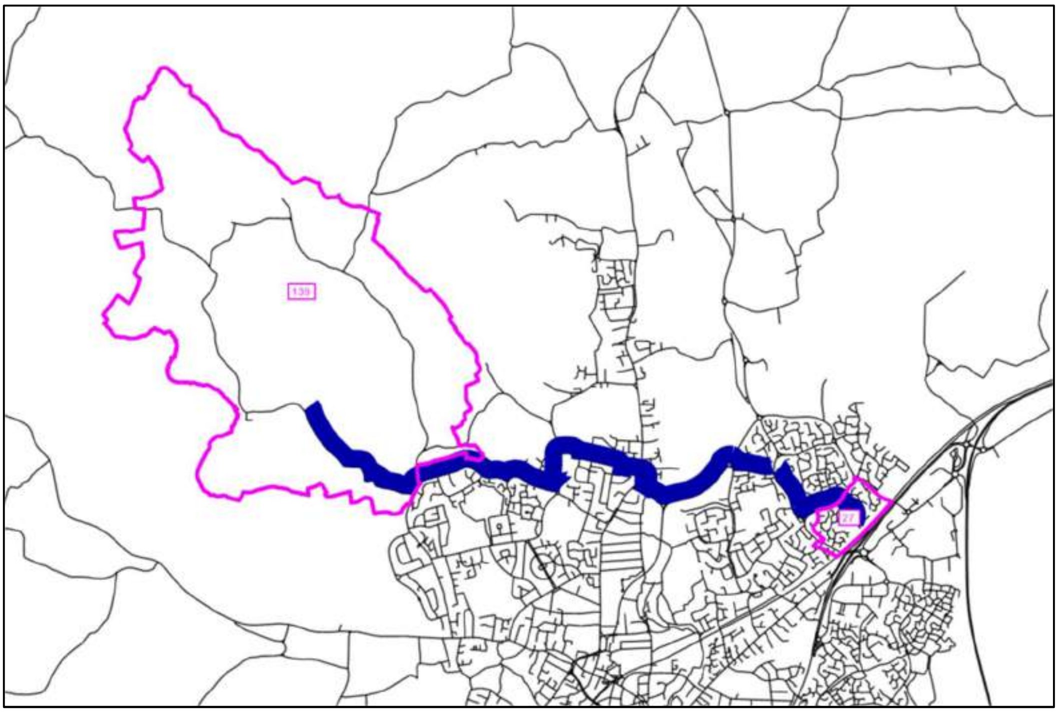
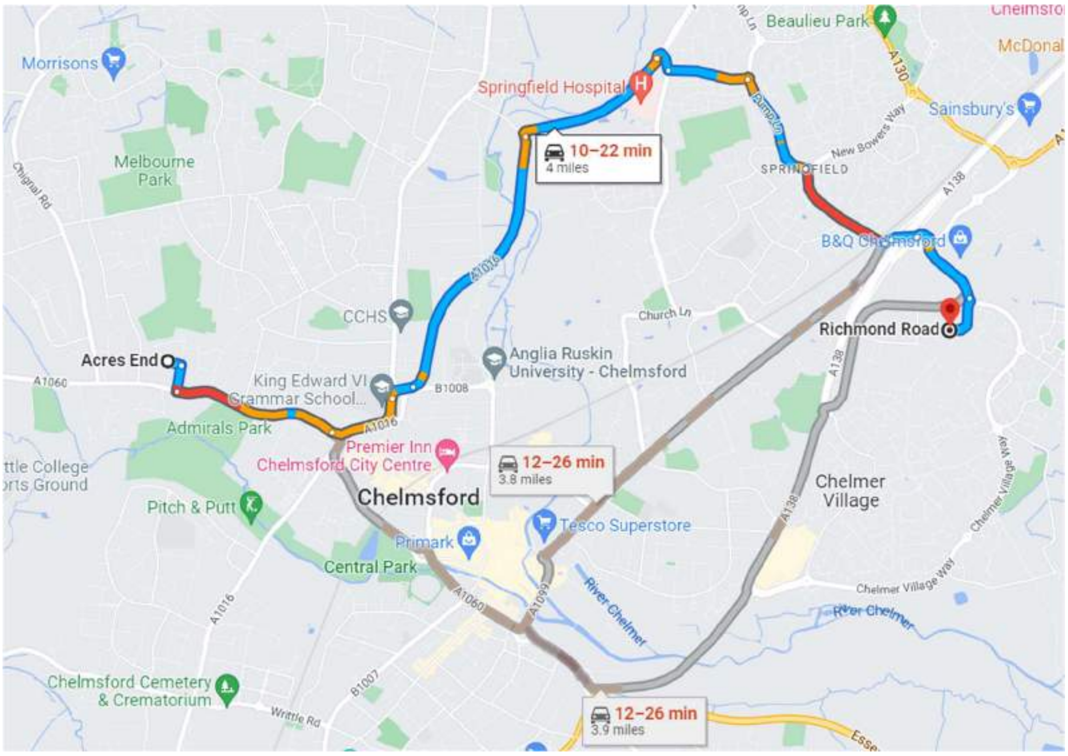


VISUM Model, 2019. PM.

A&N Route Checking. PM (16:00)

13. Acres End to Richmond Road



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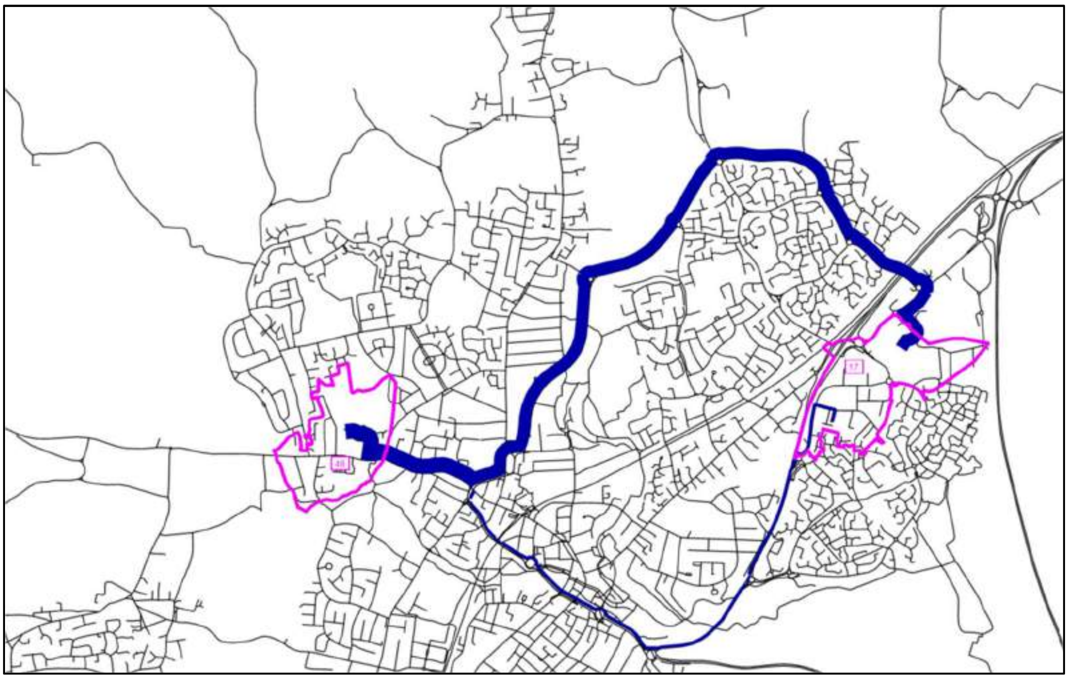
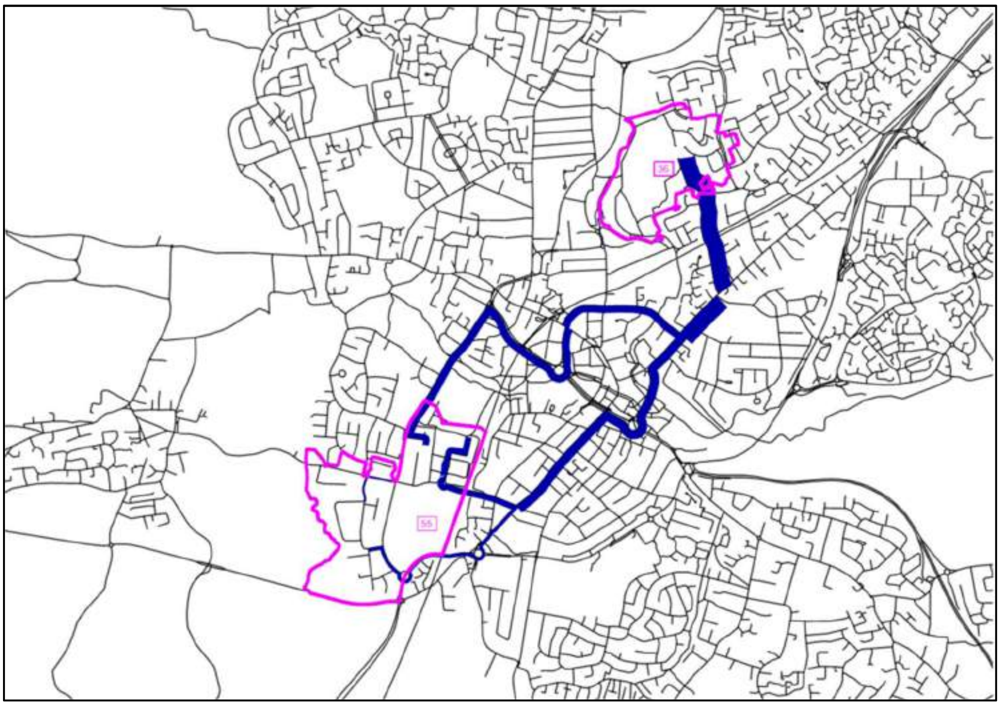


VISUM Model, 2019. PM.

A&N Route Checking. PM (16:00)

14. Seven Ash Green to Robjohns Road

Google Maps, 2022. Typical Tuesday for the PM period (set to depart at 16:00)



VISUM Model, 2019. PM.

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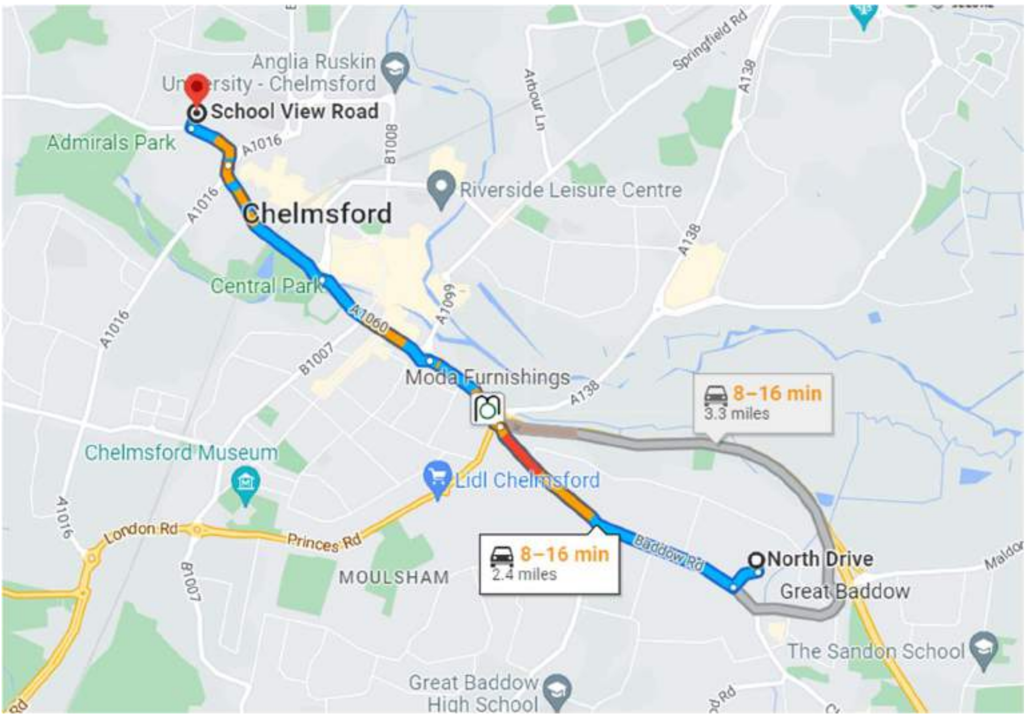
15. North Drive to School View Road



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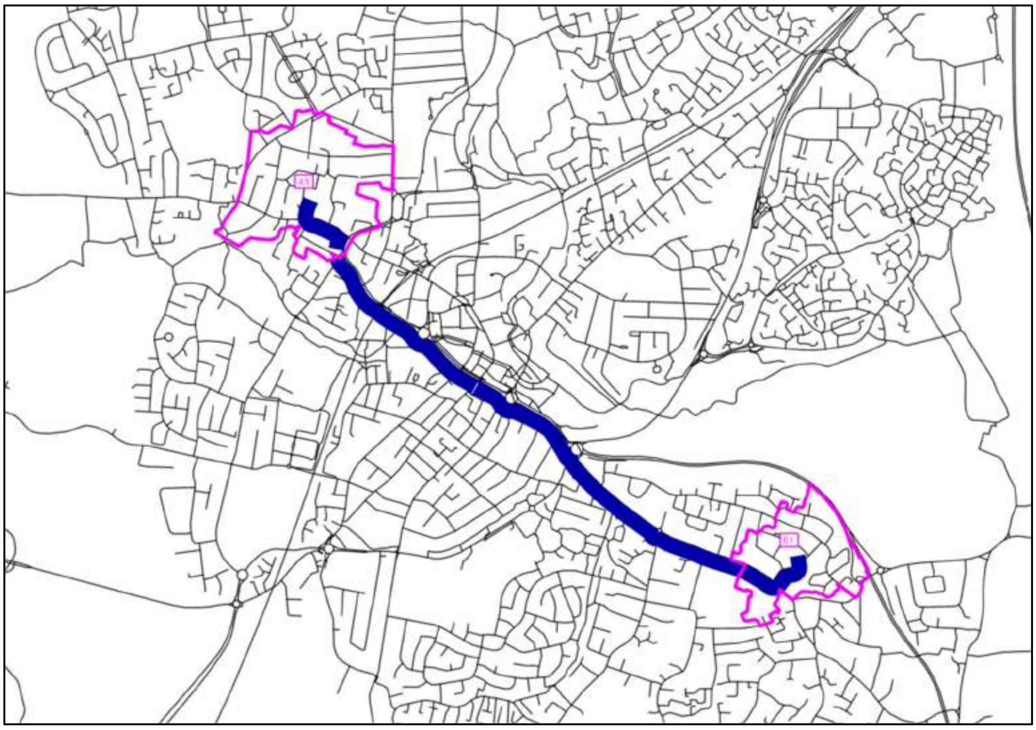
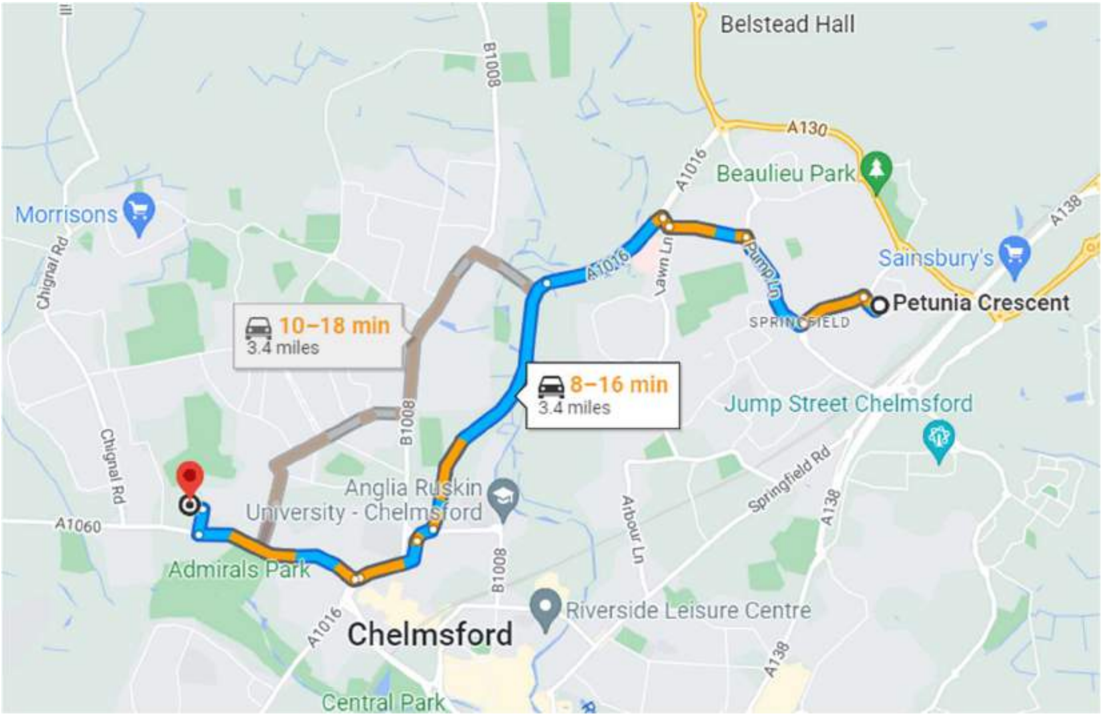


VISUM Model, 2019. PM.

A&N Route Checking. PM (16:00)

16. Petunia Crescent to Acres End



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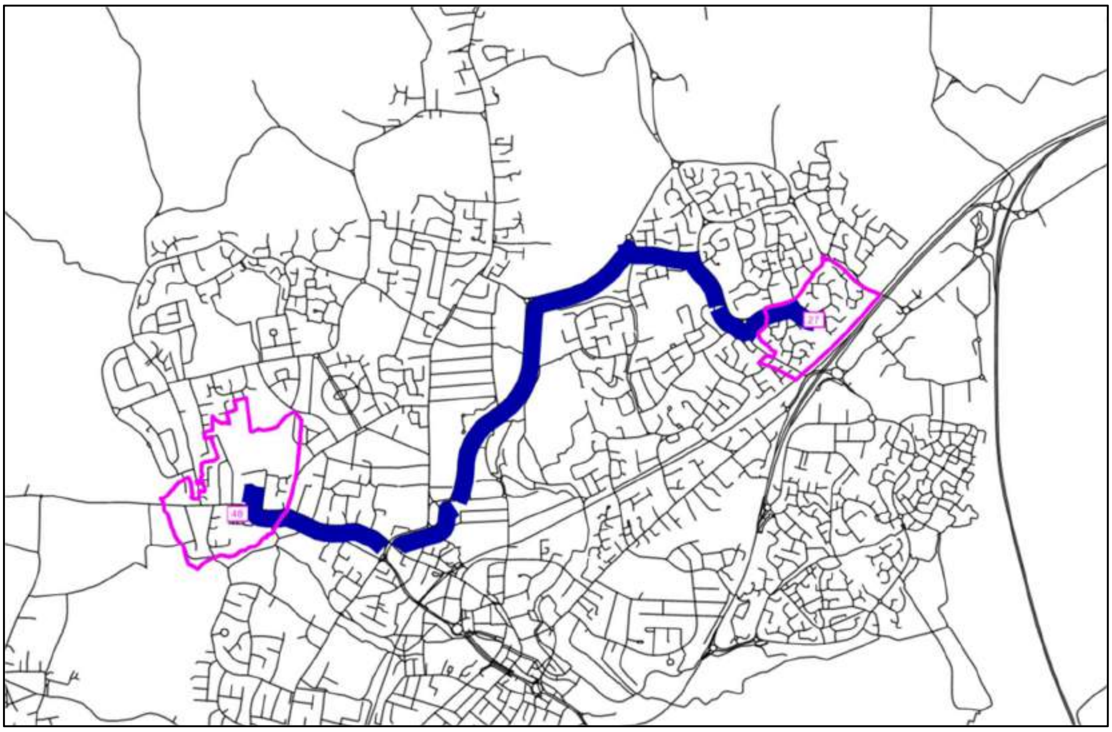
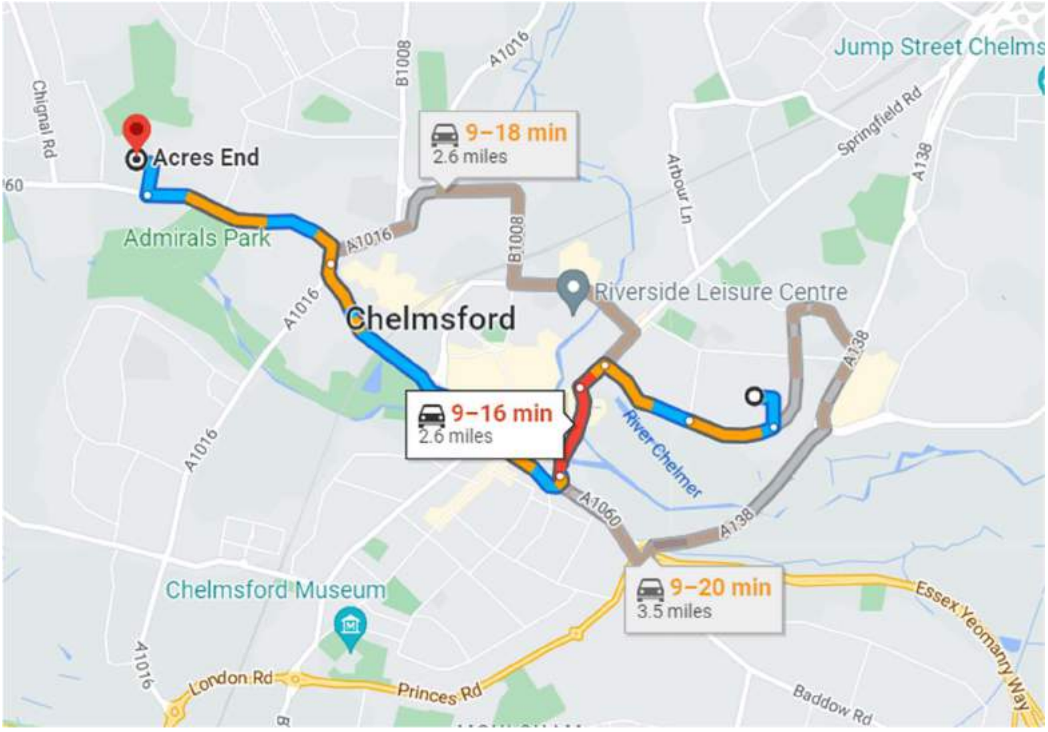


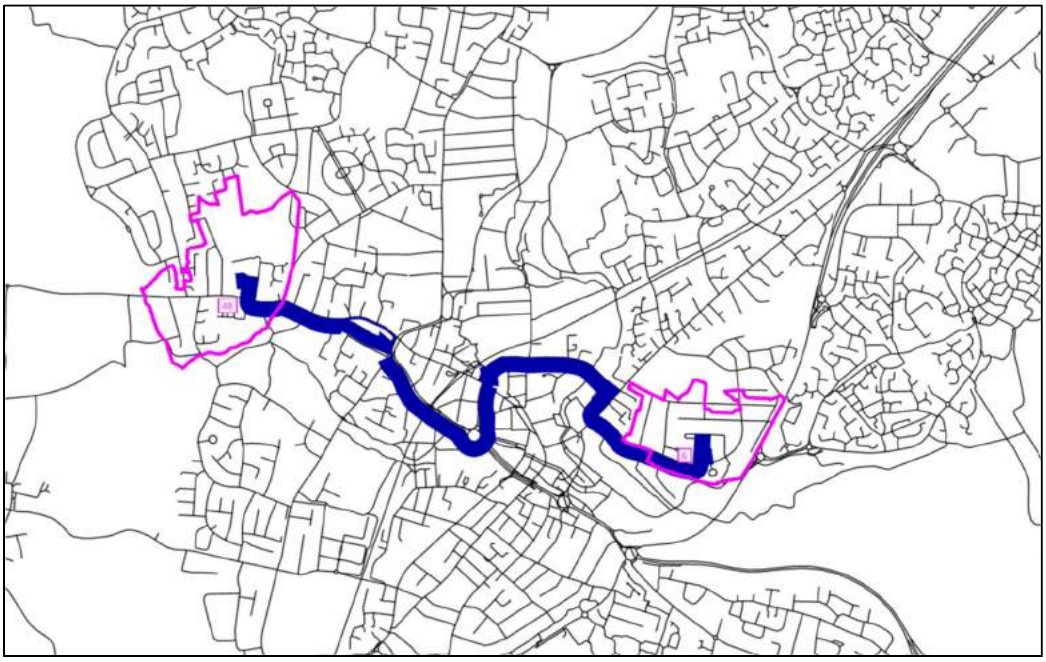
VISUM Model, 2019. PM.

A&N Route Checking. PM (16:00)

17. Morris Road to Acres End



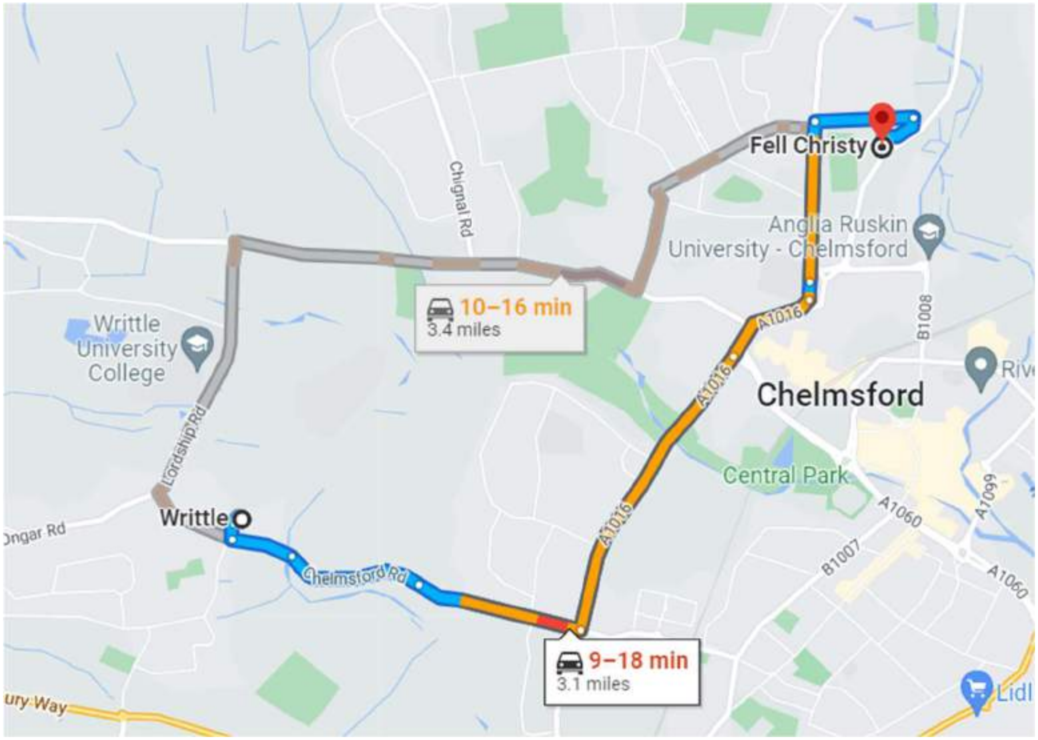
Google Maps, 2022. Typical Tuesday for the PM period (set to depart at 16:00)



VISUM Model, 2019. PM.

A&N Route Checking. PM (16:00)

18. Writtle to Fell Christy



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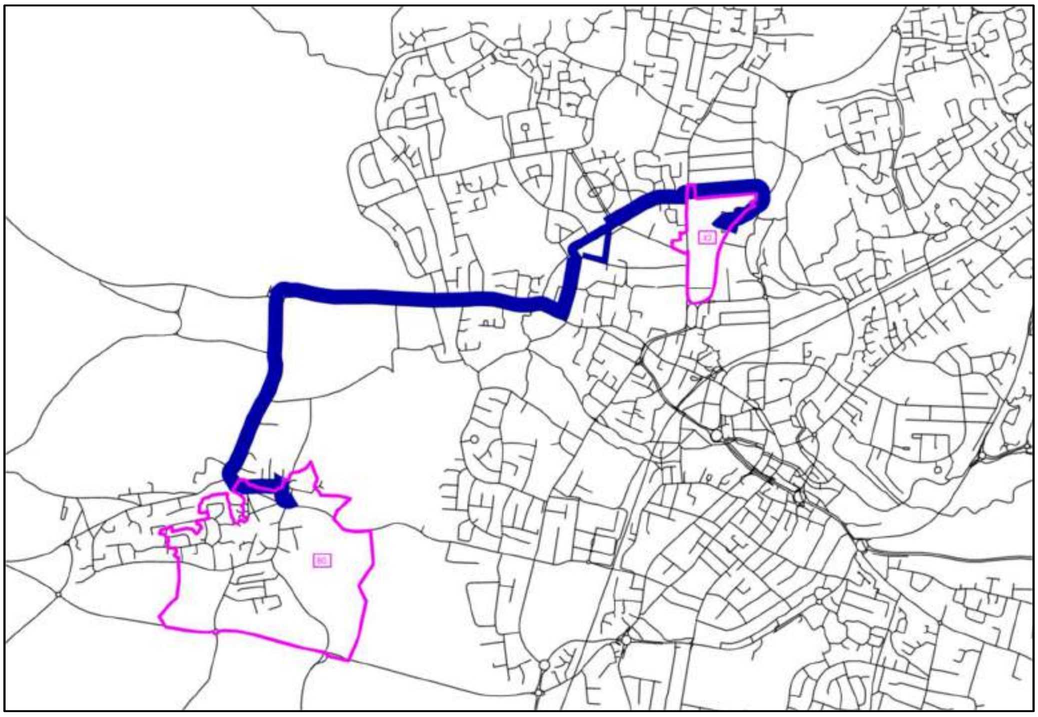
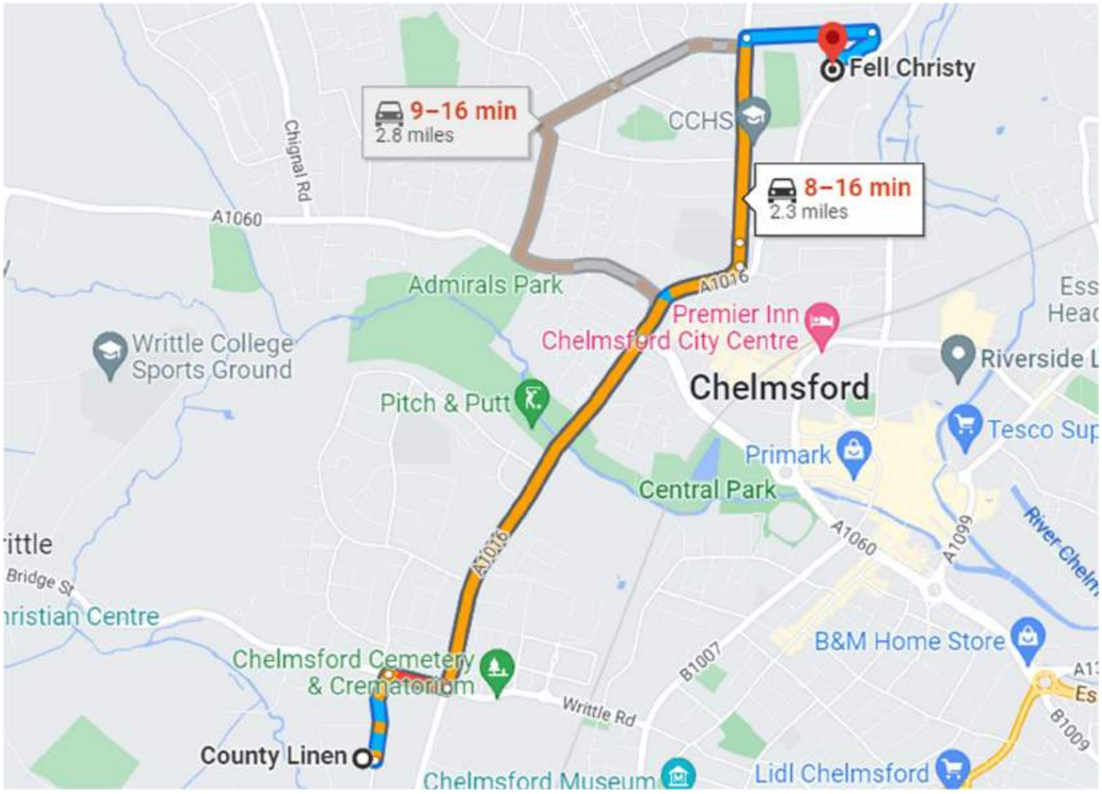


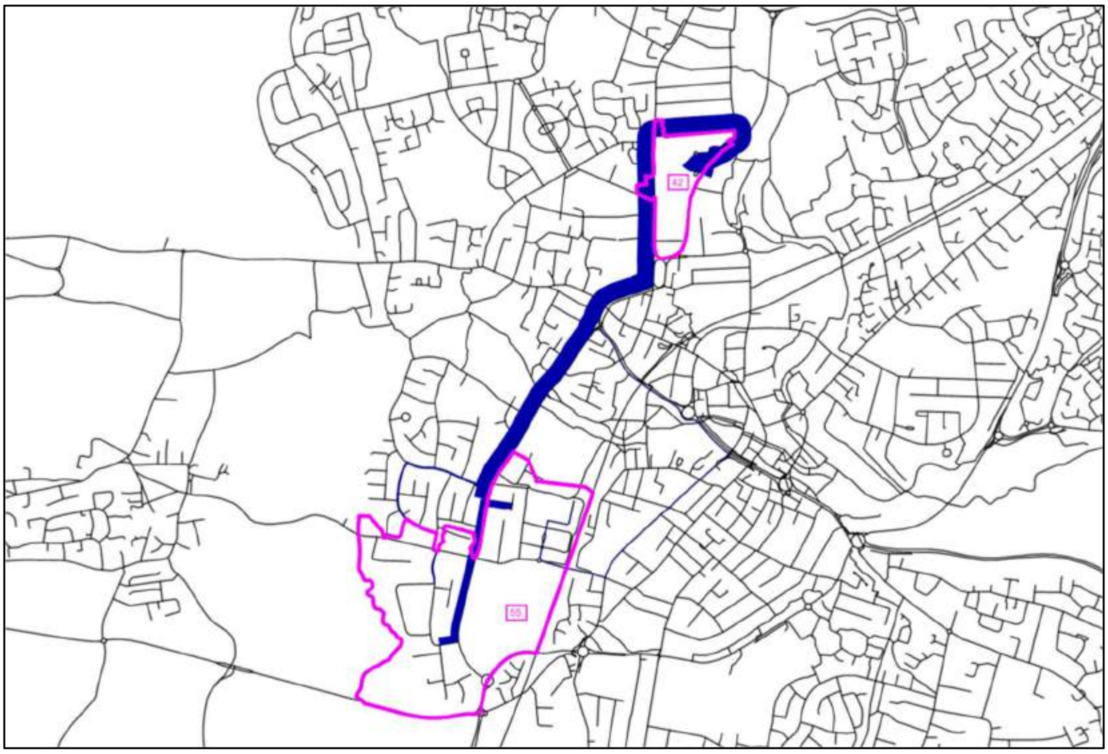
VISUM Model, 2019. PM.

A&N Route Checking. PM (16:00)

19. County Linen Services to Fell Christy



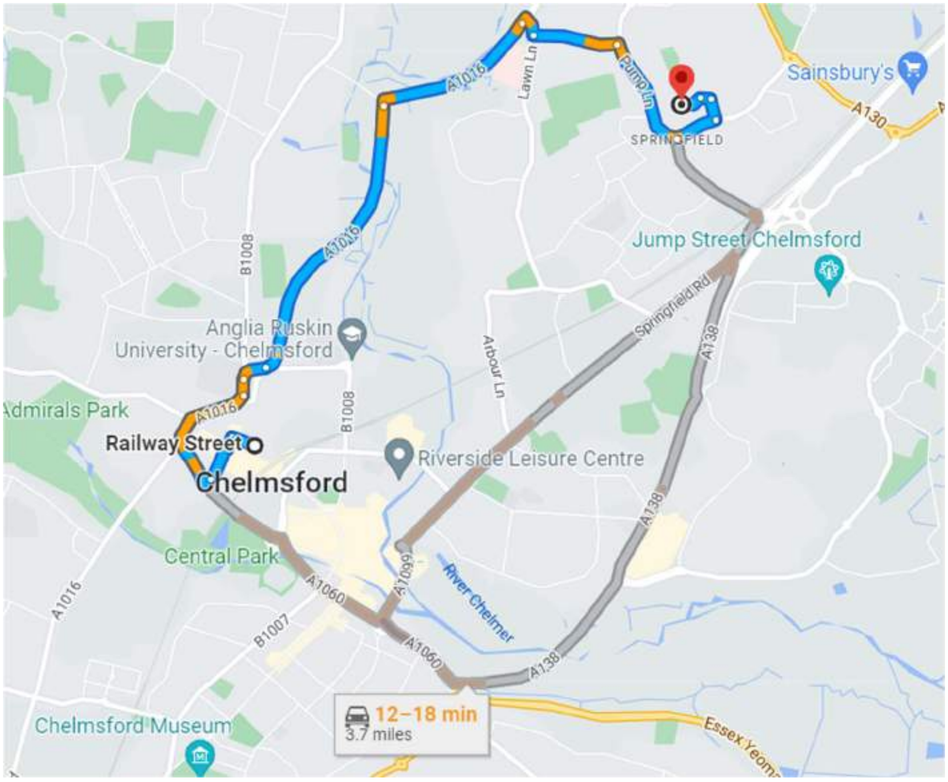
Google Maps, 2022. Typical Tuesday for the PM period (set to depart at 16:00)



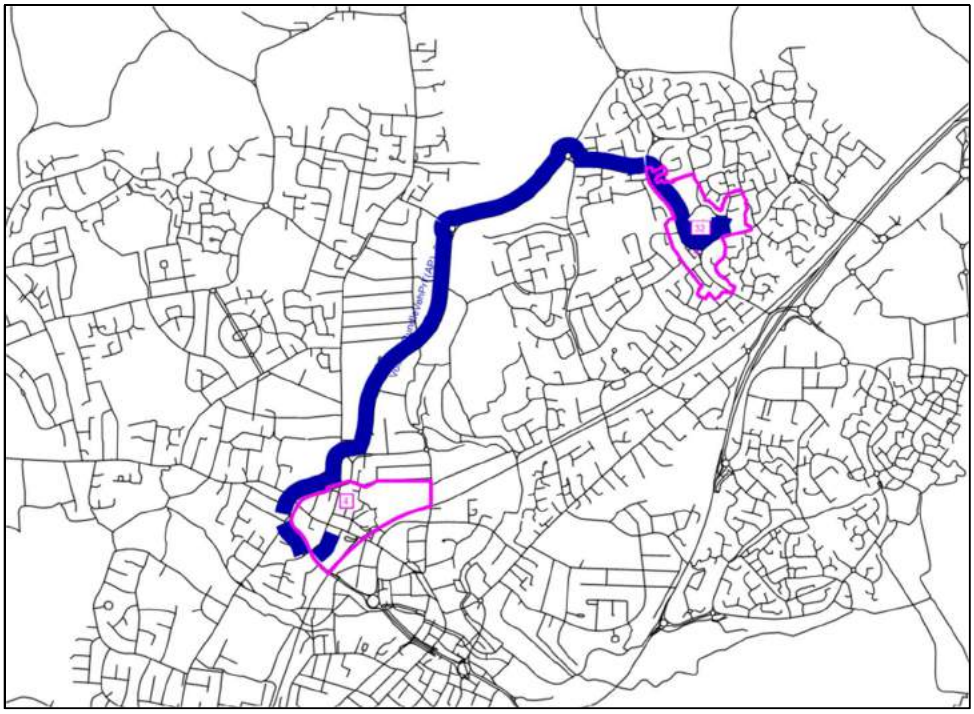
VISUM Model, 2019. PM.

A&N Route Checking. PM (16:00)

20. Railway Street to Bonnington Chase



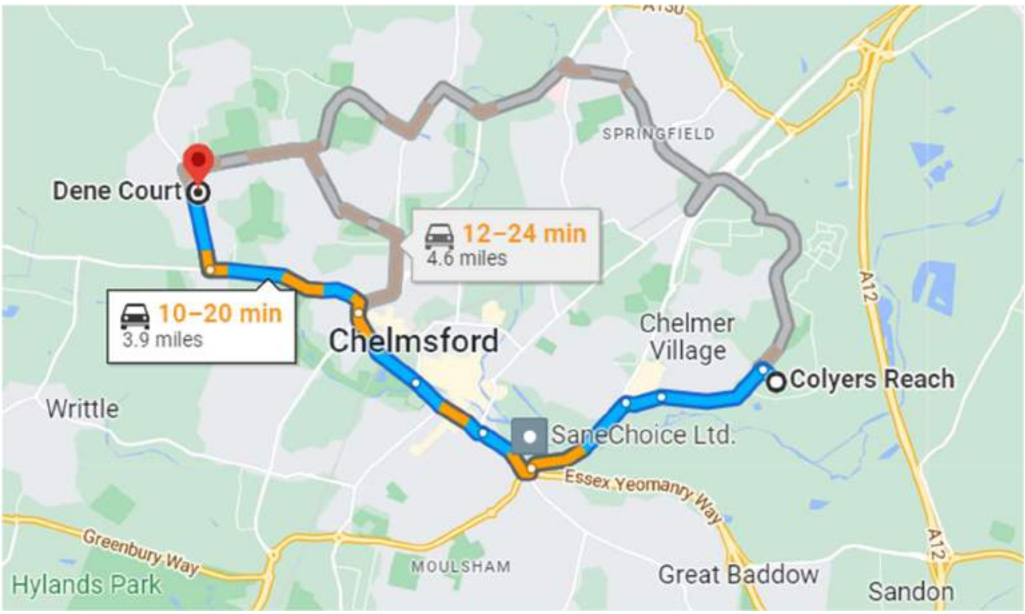
Google Maps, 2022. Typical Tuesday for the PM period (set to depart at 16:00)



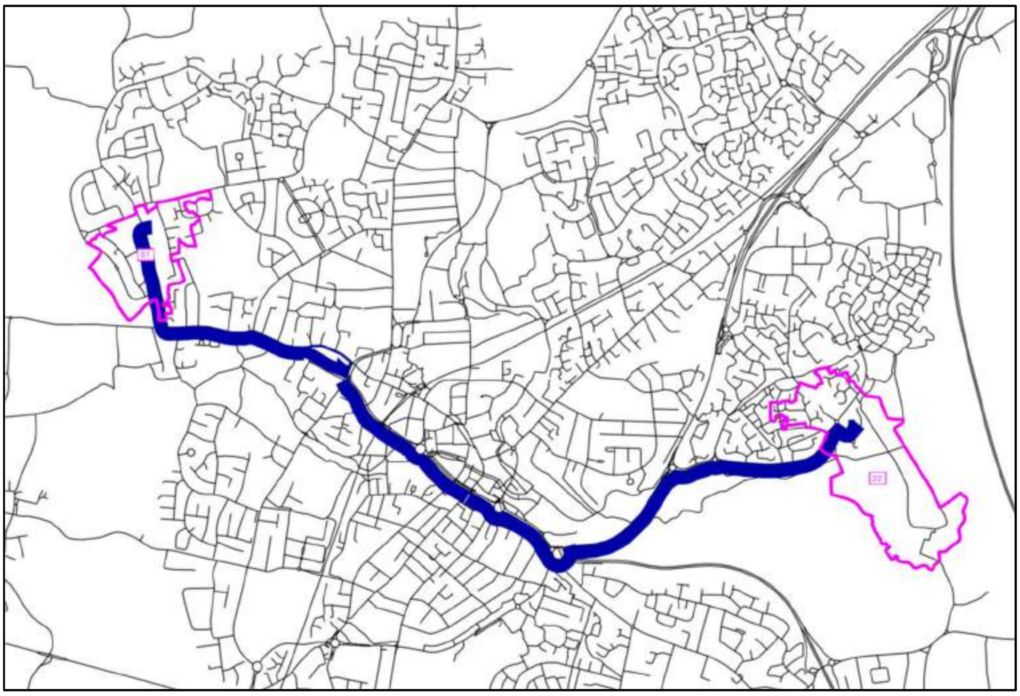
VISUM Model, 2019. PM.

A&N Route Checking. PM (16:00)

21. Colyers Reach to Dene Court



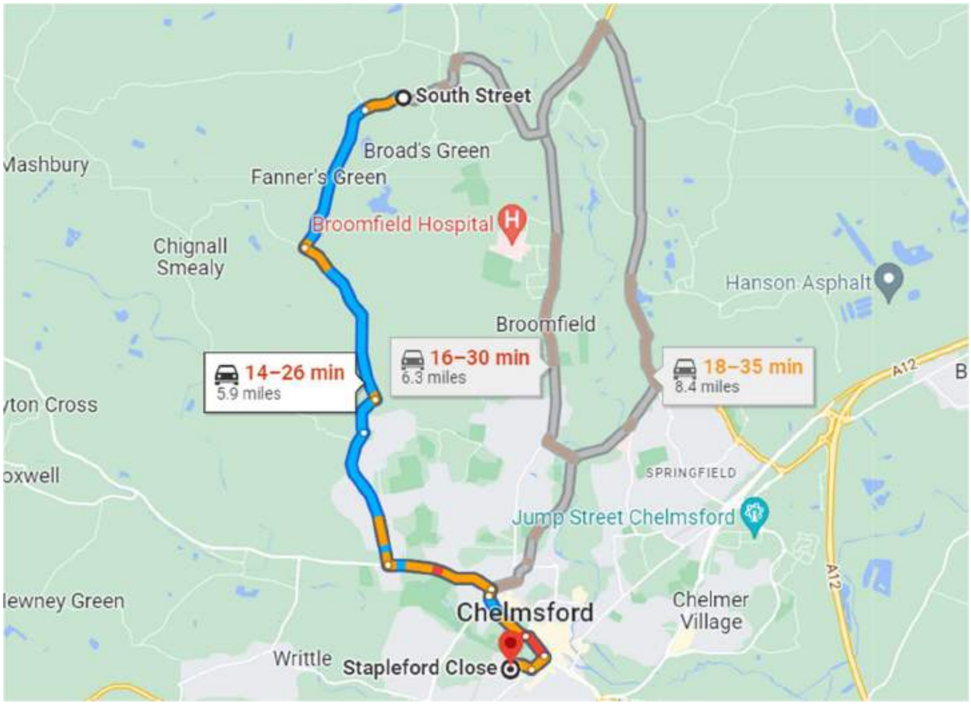
Google Maps, 2022. Typical Tuesday for the PM period (set to depart at 16:00)



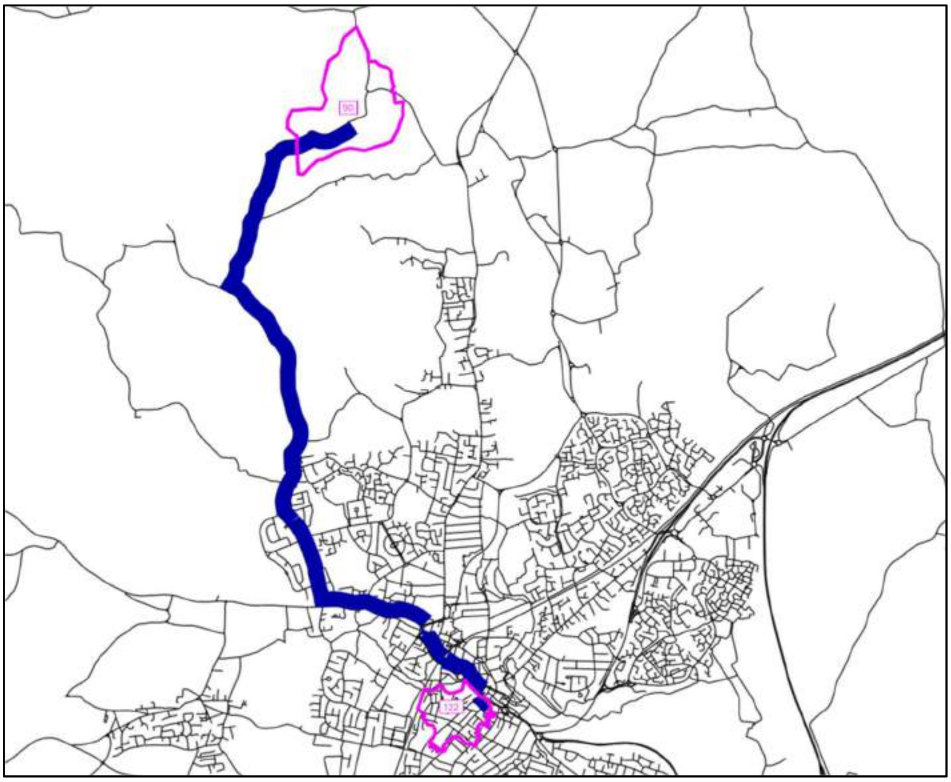
VISUM Model, 2019. PM.

A&N Route Checking. PM (16:00)

22. South Street to Stapleford Close



Google Maps, 2022. Typical Tuesday for the PM period (set to depart at 16:00)



VISUM Model, 2019. PM.

Appendix F – Essex Countywide Highway Matrix Development

Introduction

This chapter summarises the base year Essex countywide highway prior matrix development, and this section is taken from the Essex Countywide LMVR. This process was largely driven by the use of aggregated and anonymised mobile network data (MND) provided specifically for this study by Telefonica. Other data sources such as 2011 Census Journey to Work (JTW), National Travel Survey data (NTS), National Trip End Model (NTEM v7.2) and bespoke synthetic matrices were used to augment the MND and to correct for known biases. The education matrices were derived from the school survey data collected by ECC in 2016. The Heavy Goods Vehicle matrices (HGVs) were derived from the DfT's Base Year Freight Model (BYFM) with supplementary information for Light Goods Vehicle (LGV) movements obtained from TrafficMaster OD data.

This chapter details the MND verification methods, synthetic matrix building, and data merging approach.
WebTAG Guidance

Recognising that base year matrix building is a developing area of research, the DfT's guidance set out in WebTAG Unit M3 Appendix B is relatively flexible. The key recommendations are summarised below:

- The guidance advises to begin with a wholly synthetic model, which makes minimal, but reasonable, assumptions to produce initial Production/Attraction (P/A) matrices at the required level of detail.
- The initial synthetic model should start off with the all-day zonal productions and attractions implied by NTEM for each purpose (or, better, make use of the underlying car ownership and trip end functions applied to local data on population, households and employment).
- The matrix cells should then be filled by means of a standard gravity model that should be constrained to reproduce (at least) average trip length for the journey purpose (taken either from local sources or national sources such as NTS). Next, factors giving modal choice and time of day (again, available as part of the NTEM database, although local data is preferred where possible) can be applied. In this way the complete prior matrix is built up by mode and time period, distinguishing the outbound and return portions of home-based purposes.
- The process of "introducing observed data" must then make allowance for the statistical accuracy of that data and preserve key features of the prior matrix (e.g. the total productions and the average trip length). Therefore, there is often a need for an iterative process which attempts to re-impose some features as "constraints".

These broad principles were followed in the development of the Phase 2 Countywide demand matrices.

Although at the time when this work was undertaken, the use of MND in matrix development was becoming a relatively common practice, no formal guidance was available. Therefore, the approach adopted in the development of the Countywide trip matrices was informed by the experience gained by Jacobs and others from a number of flagship projects in the UK, such as Transport for London's Project Estimating Demand using Mobile Network Data (EDMoND) and Highways England's Trip Information System (TIS) database and Regional Traffic Models (RTMs). These were considered good examples of matrix development methods using various matrix verification and validation criteria. The existing data sources were used to establish biases in the MND matrices and to determine the best approach for correcting these through the use of the synthetic matrices.

Raw MND Processing

MND Specification

Telefonica (O2) is a mobile network operator with a UK market share of approximately 30%. It operates a network which provides continuous nationwide coverage to each customer phone (device). The devises generate “events” as they communicate with the national cell network. Telefonica collects these events to build valuable datasets which describe the movement and flow of O2 users across the UK. Devices are tracked anonymously and can be associated with attributes derived from the user’s contract (age, gender, contract type and billing address) or their observed behaviour (affluence, lifestyle, home and work location and other points of interest). In aggregate, therefore, mobile phone data provides an effective insight into the movement patterns of the UK population.

Compared to the traditional transport data sources MND has a higher sample size, wider geographical coverage, and the ability to capture day-to-day variability. However, to build transport model demand matrices it needs to be augmented by other data sources to overcome a number of known limitations related to the expansion of mobile phone data samples: detection of short distance trips, spatial resolution, identification of mode and purpose, vehicle type and vehicle occupancy.

The data collected for the Countywide Model included 32 days defined as “neutral” (i.e. Mondays to Thursdays, excluding bank holidays and school holidays) in March, April and May 2017. The resulting anonymised and aggregated dataset represented observed movements with one or both trip ends within the model study area (shown in the figure below) as well as all trips that penetrated the model study area cordon.

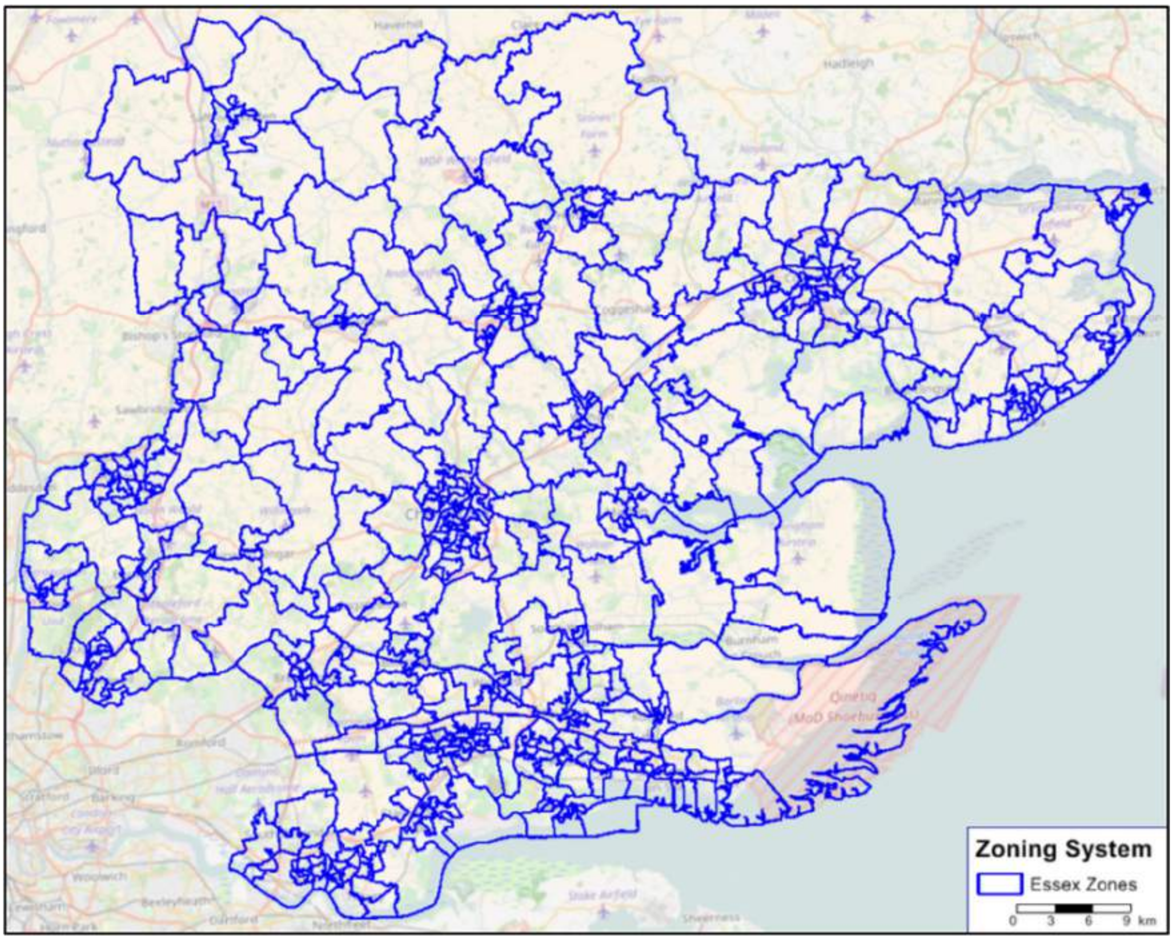


Figure F. 1: Zoning System – Essex

The matrices were supplied in expanded form, representing trips made by the whole UK population on an average weekday. The expansion was based on the ratio of Middle Layer Super Output Area (MSOA) population to the number of phones with a home location in that MSOA. All journeys were allocated a time, purpose, and mode and split into their individual legs to create the OD matrix outputs segmented by:

- Mode:
  - Road (car and van drivers and passengers, motorcyclists, taxi passengers, LGV drivers, bus, coach);
  - HGV; and
  - Rail.
- Trip Purpose:
  - Home-based work outbound (HBW_OB), i.e. commuting trips starting from home;
  - Home-based work inbound (HBW_IB), i.e. commuting trips returning home;

- Home-based other outbound (HBO+_OB), i.e. all non-work-related trips starting from home;
- Home-based other inbound (HBO+_IB), i.e. all non-work-related trips returning home;
- Non-home-based work (NHBW); i.e. trips that start in non-home location with one trip end identified as a work-related place of interest; and
- Non-Home-based other (NHBO), i.e. all other trips that start in non-home location.

- Time period (according to their start time or the time they entered the model cordon):
  - AM peak (07:00-10:00);
  - Inter-peak (10:00-16:00);
  - PM peak (16:00-19:00); and
  - Off-peak (19:00-07:00).

Data Processing

To process the data, Telefonica used its established bespoke methodologies to infer various aspects of travel demand from a series of mobile phone events. The processing steps involved a series of rules and assumptions which were informed by Telefonica's previous experience and verified through various checks described in section 0.

Once raw event data had been collected and verified, the records were converted to person trips, with a defined start time, end time and location. This was done using both the times of dwell (a time when a user was stationary in one distinct place) and times of movement. The dataset was then cleaned to remove invalid users and erroneous records.

The definition of basic trip purposes was primarily based on inferred home and work locations of mobile phone users using the information about their regular overnight and weekday dwells. This enabled a distinction to be made between home-based and non-home-based trips and allowed the identification of potential commuting trips showing repeat patterns of journeys between home and work. As it was not possible to define rules to infer other trip purposes such as employers' business, escort, shopping, and leisure trips, these were combined in a single ("other") category. This category is referred as "HBO+" in this report.

It was also not possible to identify Education trips as a separate category. Tertiary education trips are likely to be included in the home-based work category due to a similar pattern of travel. The majority of secondary and primary education trips were simply not captured by the data, either because they are too short or because they are made by users who do not carry phones.

The route and characteristics of each journey were also analysed to allocate the journey to one of the following modes:

- Air – journeys with a high speed between two airports. These trips were removed from the final matrix;
- Rail – journeys which followed the rail network, and which exhibited 'clustering';

- Walk/cycle – short and slow trips were allocated to walk/cycle and removed from the matrix. In general, most walk and some cycle trips were too short to detect using mobile data; and

- Road – any remaining trips were allocated to the road matrix, which also included coach, bus, HGV and LGV trips as well as car trips. The last step was to classify and segment HGV journeys.

It is important to point out that both purpose and mode classifications were based on a set of deterministic rules, which are subject to errors and uncertainty. Further errors were introduced through stochastic rounding to preserve personal data. In the context of an origin-destination matrix, this was achieved by creating an average result representing multiple days of observations, and by rounding results to integer values.

Provisional Data Checks

Prior to releasing the data, Telefonica carried out a range of validation checks which suggested that the mobile data provided is internally consistent. The home-based trips showed a reasonable degree of correlation with 2011 Census as well as a satisfactory symmetry between home-based outbound and return trips.

The process, however, highlighted a number of biases, all of which are recognised limitations of mobile phone data in representing short distance and education trips. These checks were not exhaustive and further comparisons were undertaken by the study team prior to using MND in the demand matrix building process.

The key findings from the provisional data checks are summarised below:

- A high-level comparison with the DfT's TEMPro data, shown in Figure F. 2, suggests that HBW and HBO+ road travel is underestimated in MND, whilst the number of non-home-based trips in MND is significantly higher than in TEMPro. As a result, the non-home-based travel represents a higher share of the overall demand compared to the DfT's forecast.

Figure F. 2: Comparison of Total Daily MND Demand Totals to TEMPro (Internal Productions)

Home-based trips tend to be shorter than non-home-based trips, and so they are more likely to be missing in the mobile phone data, which could explain these results. The difference in non-home-based demand could be due to under-reporting of non-home-based travel in NTS/TEMPro and due to the MND including LGV (and possibly HGV) trips which are not included in TEMPro but could be identified as HNBW road travel in MND.

A similar comparison for rail trips suggests a significantly higher number of rail trips in MND compared to TEMPro for all purposes. Due to TEMPro rail forecasts being subject to various limitations, MND was considered more reliable for the purpose of matrix building. Therefore, no TEMPro based constraints were considered necessary. The rail demand was subject to further validation against independent data as described in Appendix G of this report.

- Comparisons of the all-day road trip ends by MND purpose against the average weekday trip ends from TEMPro are shown (on the following pages) in Figure F. 3 for the internal productions by zones and in Figure F. 4 by sectors.

  As explained above, MND underrepresents short distance travel but includes LGVs. Therefore, MND is not directly comparable with TEMPro which covers all distance trips but not LGVs. However, assuming that the proportion of LGVs is relatively low, and the short distance demand is consistently underrepresented by zone/area, a comparison between the two data sources could identify and highlight significant errors or biases.

  Despite the MND demand being lower, the zonal regression plots show a good correlation to TEMPro trip ends for the home-based purposes with R^2 values being just under 0.95. Considering a lower level of confidence in TEMPro forecasts for non-home-based travel (especially at a zone level) and the limitations of the MND mode/purpose detection, it is not surprising to see lower R^2 values for NHBW and NHBO (i.e. 0.81 and 0.61 respectively). As the confidence in both MND and TEMPro forecasts increases at a more aggregate sector level, the correlation for all purposes improves with all R^2 values being above 0.90.

  The home-based trip ends were also checked for symmetry to verify that the amount of outbound travel from home was consistent with the inbound demand returning home on an average week day. As expected, this comparison demonstrated a high degree of correlation.

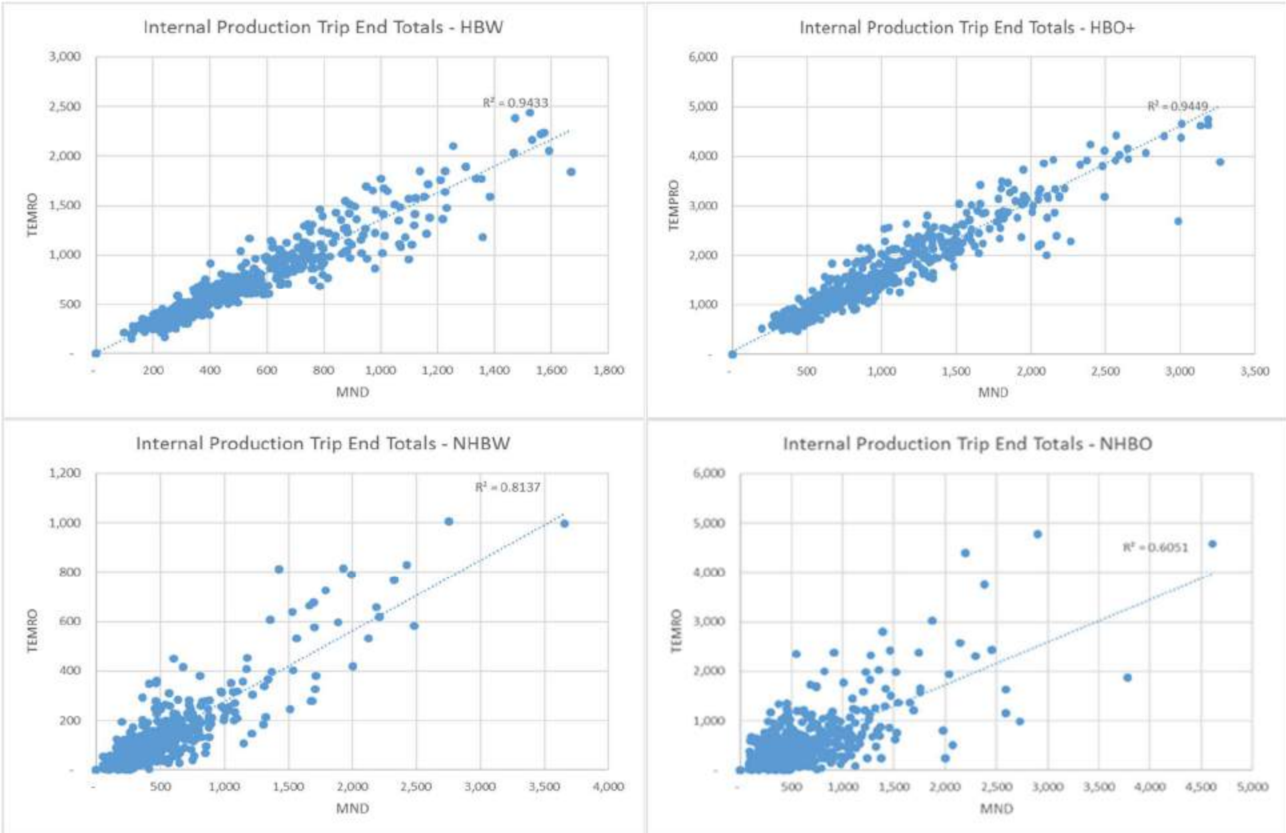


Figure F. 3: Comparison of MND Trip Ends to TEMPro (Internal Productions by Zone)

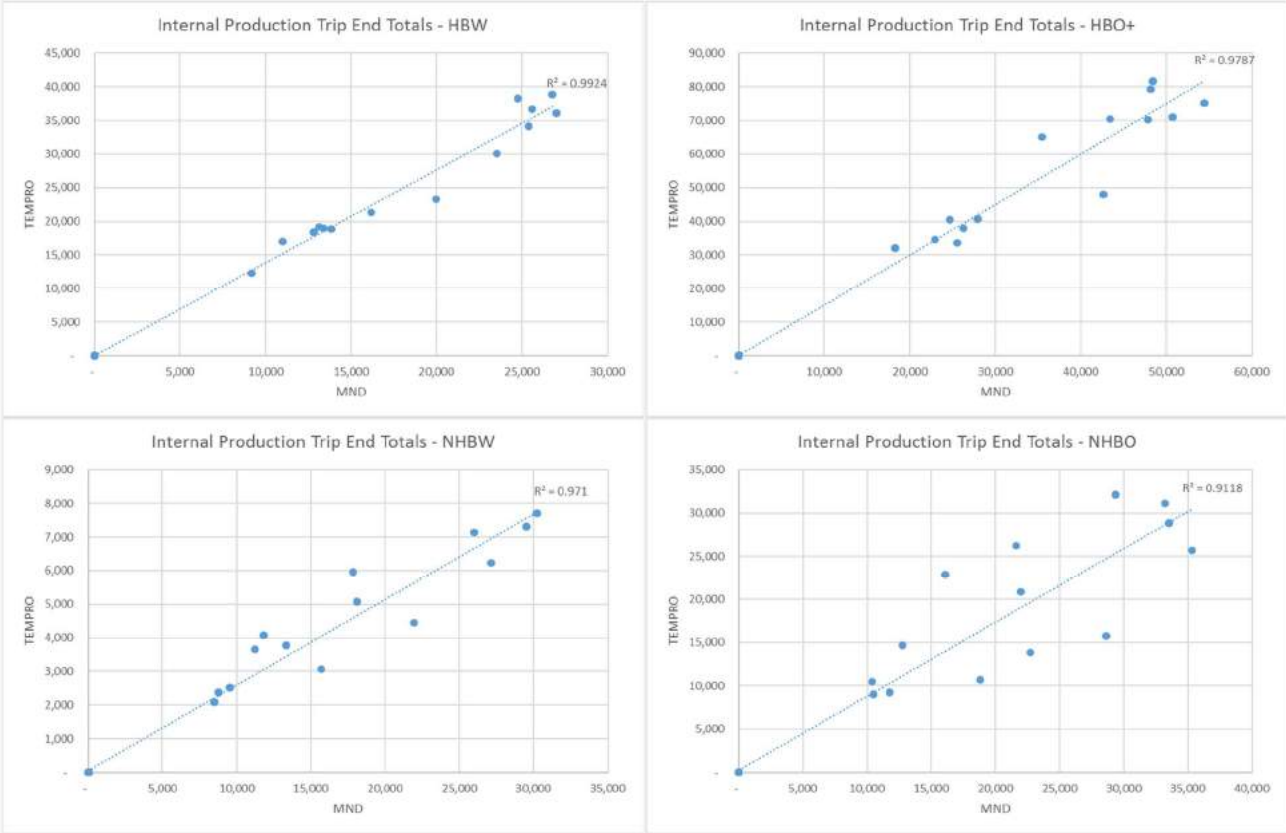


Figure F. 4: Comparison of MND Trip Ends to TEMPro (Internal Productions by Sector)

- Figure F. 5 compares the MND HBW trip distribution patterns against 2011 JTW census data for sector-to-sector movements. Figure F. 6 then shows the same data compared by sector production and attraction. Despite MND demand being lower than the JWT figures, the MND captures the overall pattern of commute travel suggested by the 2011 Census.

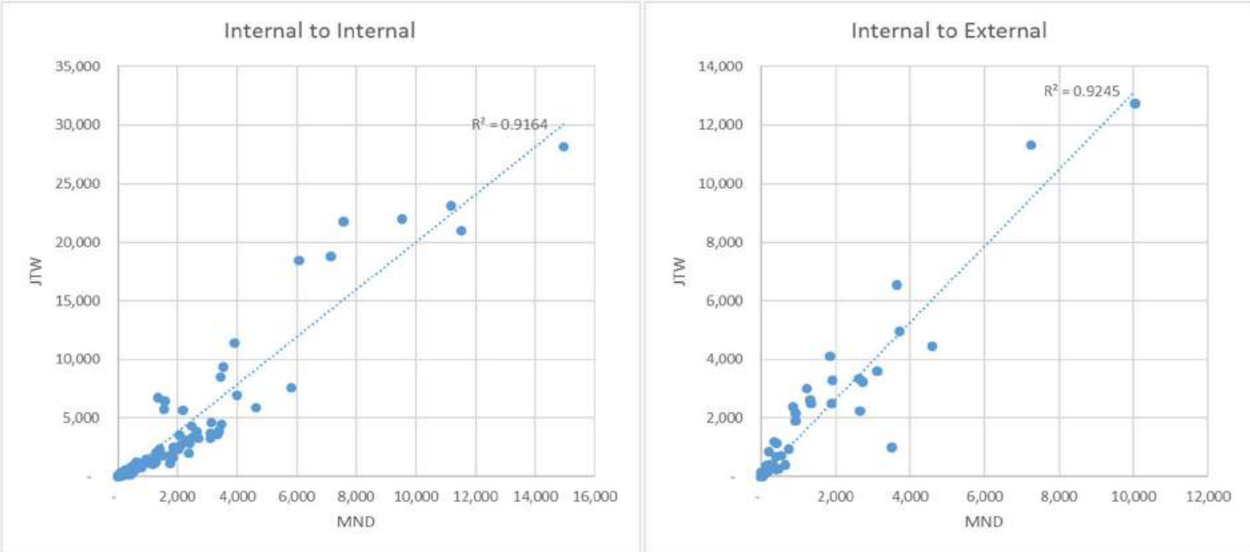


Figure F. 5: Comparison of MND Road Demand to JTW Car Demand (Sector to Sector Movements)

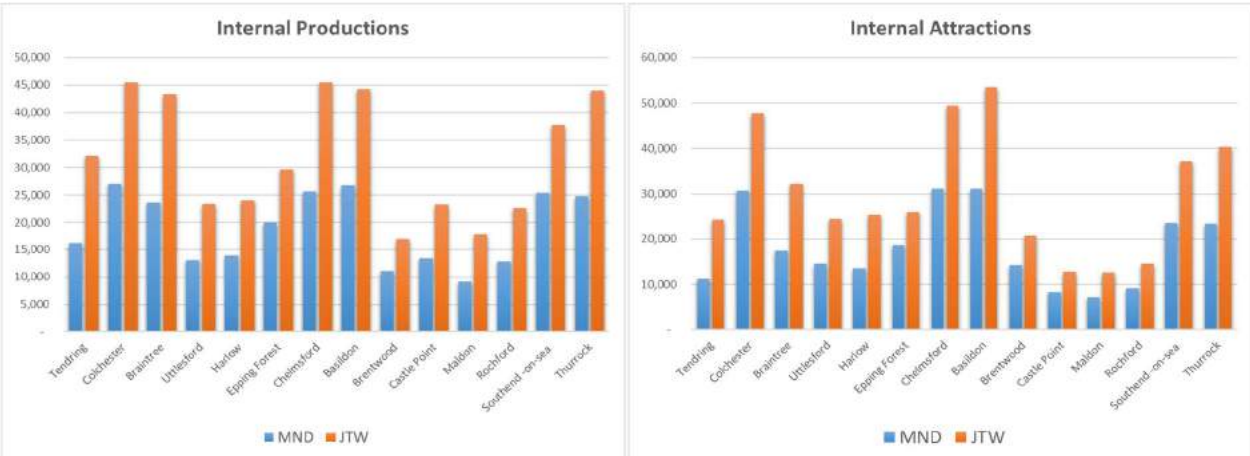


Figure F. 6: Comparison of MND Road Demand to JTW Car Demand (Internal Productions and Attractions)

- Figure F. 7 (on the following page) compares the MND road trip length distributions (TLDs) to NTS TLDs representing the total of car and bus travel by purpose. These confirm that short trips below a certain cut off (of approximately 5 miles) are underrepresented in the mobile phone data. This analysis was also repeated for the urban areas (using the NTS definitions) to determine if the distance cut off differed with the increased density of the mobile phone masts. However, the results were inconclusive, due to a low sample and spatial accuracy of the NTS data for Essex.

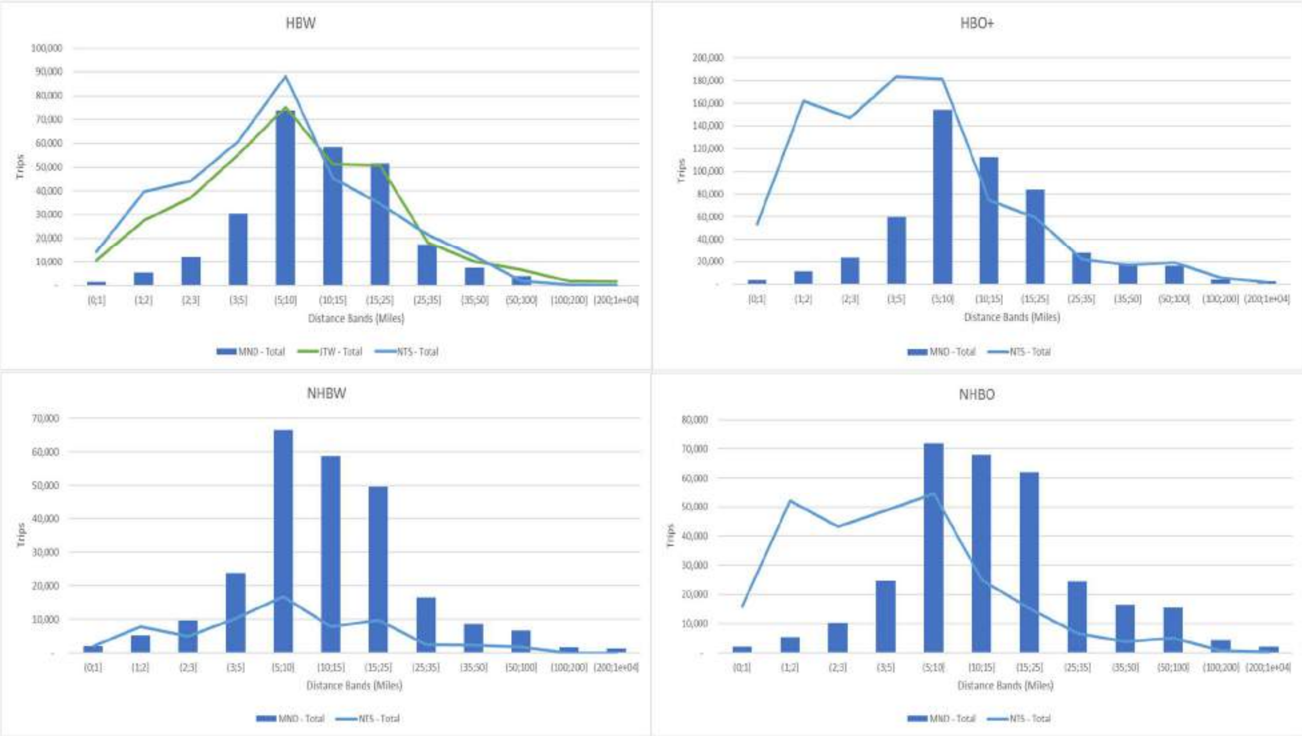


Figure F. 7: Comparison of MND Road Trip Length Distributions to NTS (Internal Productions)

- Finally, comparisons of time of day profiles to NTS showed an underestimation of travel between 8 and 9am in the morning and between 3 and 4pm in the interpeak. This could potentially be explained by education trips not being represented in the mobile phone data.

The provisional data check analysis described above confirmed that MND was representative of observed travel but was subject to a number of limitations such as underreporting of short and education trips. It also contained limited information on trip purposes and road modes. The identified issues and biases were corrected as part of the iterative matrix adjustment process described in section 0. After each round of adjustments, the verification tests were repeated to confirm that the issues were addressed and to determine if further adjustments were required. To inform this process, it was necessary to process secondary data for education trips, LGVs and HGVs and to develop synthetic matrices for personal travel made by car and bus.

Synthetic Car and Bus Matrices

Gravity Model Specification

Synthetic demand matrices were used to infill short distance trips missing from mobile phone data and to support the segmentation of the MND road matrices by vehicle type and trip purpose. The synthetic trip ends were also used to correct biases in MND at a detailed geographical level.

The synthetic matrix development followed a conventional approach of trip generation and trip distribution using a bespoke gravity model for personal car and public transport trips. In line with WebTAG, the matrices were built in the Production-Attraction (PA) form for all-day travel using the segmentation consistent with the

Countywide demand model as described in Section 4.7. The main principle of the gravity model was to obtain a trip matrix consistent with NTEM trip ends and the observed trip length distribution (TLD) from NTS. The gravity models developed in Phase 1 were updated to reflect the latest trip end estimates based on NTEM v7.2 (updated March 2017) and to include bus travel as a distinct mode to support further segmentation of the MND road demand into car and bus trips.

Only movements with one or both trip end in the study area were modelled in the gravity models. The external to external movements were omitted due to the lower level of zone and network details in the external area. The MND was expected to provide higher quality data for these longer distance movements. The production trip ends for the external movements were scaled down based on the aggregated JTW data for the HBW purpose and NTS data for all other purposes.

No rail gravity model was envisaged at the start of this project as the proportion of short distance travel made by rail is significantly lower compared to the proportion of short trips made by bus and car. Furthermore, TEMPro forecasts for rail were considered unreliable and therefore not suitable for generating synthetic demand. In the end, a simplified version of the rail gravity model was used to generate a starting point for short distance rail demand infilling. This process is discussed in Appendix G of this report.

The gravity model formulation, the preparation of inputs, and the resulting synthetic matrices are discussed in the following sections.

Gravity Model Formulation

The synthesised trips obtained from the gravity model have the general form:

$$T_{ij} = P_i A_j k_i l_j f(c_{ij})$$

Where:

- T_{ij} represents trips between production zone i and attraction zone j;
- P_i represents trip productions;
- A_i represents trip attractions;
- c_{ij} is the cost of the trip from production zone i to attraction zone j;
- k_i and l_j are 'balancing factors' which are calculated in matrix preparation and ensure that row and column totals of the matrix match the production and attraction targets; and
- $f(c_{ij})$ is a deterrence function.

The deterrence function is a function of travel costs and introduces disincentive to travel with increasing cost of travel. They have one or more parameters to be calibrated and the number of these defines their degree of freedom with more parameters making it easier to obtain a closer fit with the observed trip length distribution. While several different deterrence functions were tried in Phase 1, it was found that the log normal distribution (equation 1) performed best and, thus, was used in Phase 2:

$$f(c_{ij}) = \frac{1}{c_{ij}\sigma\sqrt{2\pi}} exp\left(-\frac{\left(ln(c_{ij}) - \mu\right)^2}{2\sigma^2}\right) \tag{1}$$

where μ and σ are calibration coefficients.
The parameters were determined by solving the log normal distribution formulae for the mean and the variance (equations 2 and 3 respectively):

$$\mu = exp\left(M + \frac{S^2}{2}\right) \tag{2}$$

$$\sigma^2 = exp(S^2 + 2M) * \left(e^{S^2} - 1\right) \tag{3}$$

where M and S were defined to be the mean number of trips weighted by the midpoint of the distance bands used in the TLDs and the square root of the variance of the TLDs, respectively.

Trip Ends

Production-Attraction (PA) trip end data from NTEM for the base year (2017) was extracted from TEMPro Version 7.2 for all modelled journey purposes listed in Table 4.3 except Home-based Education. Synthesised education matrices were obtained from school census travel data collected by ECC for schools in the county and those unitary authorities in the area (see Section 0 for more detail).

TEMPro car and bus data was obtained for MSOAs for the average weekday. Trip ends for the larger zones in the model were formed by aggregating values over constituent MSOAs. For smaller zones, which required splitting MSOAs, 2011 Census data (resident and workplace population) and the Code Point dataset (for November 2010, which gives splits for both domestic and non-domestic postcodes) were used, as detailed in the table below:

Purpose	Production Split Factors	Attraction Split Factors
HB Commute	Census – resident population	Census – workplace population
HB Employers Business	Census – resident population	Census – workplace population
HB Other	Code Point – domestic	Code Point – domestic & non-domestic
HB Shop	Census – resident population	Code Point – non-domestic
NHB Employers Business	Code Point – non-domestic	Census – workplace population
NHB Other	Code Point – non-domestic	Code Point – non-domestic

Table 1 – Factors Used in Splitting MSOA Trip-Ends to Smaller Zones

Generalised Costs

Car costs for the gravity model represented daily average costs taking account of outbound and return journeys. These were produced using the final Phase 1 model. The Phase 1 matrices for Commute, Employer Business and Other user classes were assigned to the road network in all time periods to calculate generalised costs including time, distance and Dartford Crossing toll components. A correlation between the demand model purposes and the assignment user classes is provided in Table 4.3. The OD pairs with no cost, e.g. intra-zonal, were set to be half the minimum cost for their production zone. Daily generalised cost skims (for use in the 24-hour PA demand model) were obtained by weighting the period-specific skims by their appropriate proportions to obtain a daily average. For home-based trips the outward and returning costs are averaged to give the cost used in demand modelling.

The bus skims used in the gravity model were based on perceived journey times derived from the Phase1 multimodal public transport assignment in VISUM. To identify OD pairs that had a bus option available to them, the probability of an individual using either bus or rail within each zone pair was obtained from VISUM skims. Each OD pair was classified into one of “Rail”, “Bus”, “Competitive” or “N/A”. If the proportion of trips taking Rail was greater than 0.95 the OD pair was classified as “Rail”. If the proportion of trips taking Bus was greater than 0.95 it was classified as “Bus”. If the probability of taking both Bus and Rail was 0 it was classified as “N/A”. Otherwise it was “Competitive”. As no bus network was modelled outside Essex, only internal to internal demand was represented in the bus gravity models.

Trip Length Distribution (TLD)

The NTS database was queried to produce observed TLDs with which to estimate the parameters of the deterrence function (equations (2) and (3)). For car these were generated for productions inside Essex to all attractions and for bus they were produced for Essex to Essex trips only.

Gravity Model Results

The coefficients of the deterrence function were revised to improve the fit to the observed NTS trip length patterns. The focus was on achieving a good match between the modelled and observed patterns for shorter distance bands while maintaining the overall TLDs as close as possible to the observed NTS values. It should be noted that the NTS data itself is subject to limitations and low data samples (especially for minor modes and purposes) and therefore was not considered fully reliable.

The comparisons of the modelled and observed TLDs for car are shown in Figure F. 8. They demonstrate a relatively close match for shorter distance bands especially for the home-based purposes.

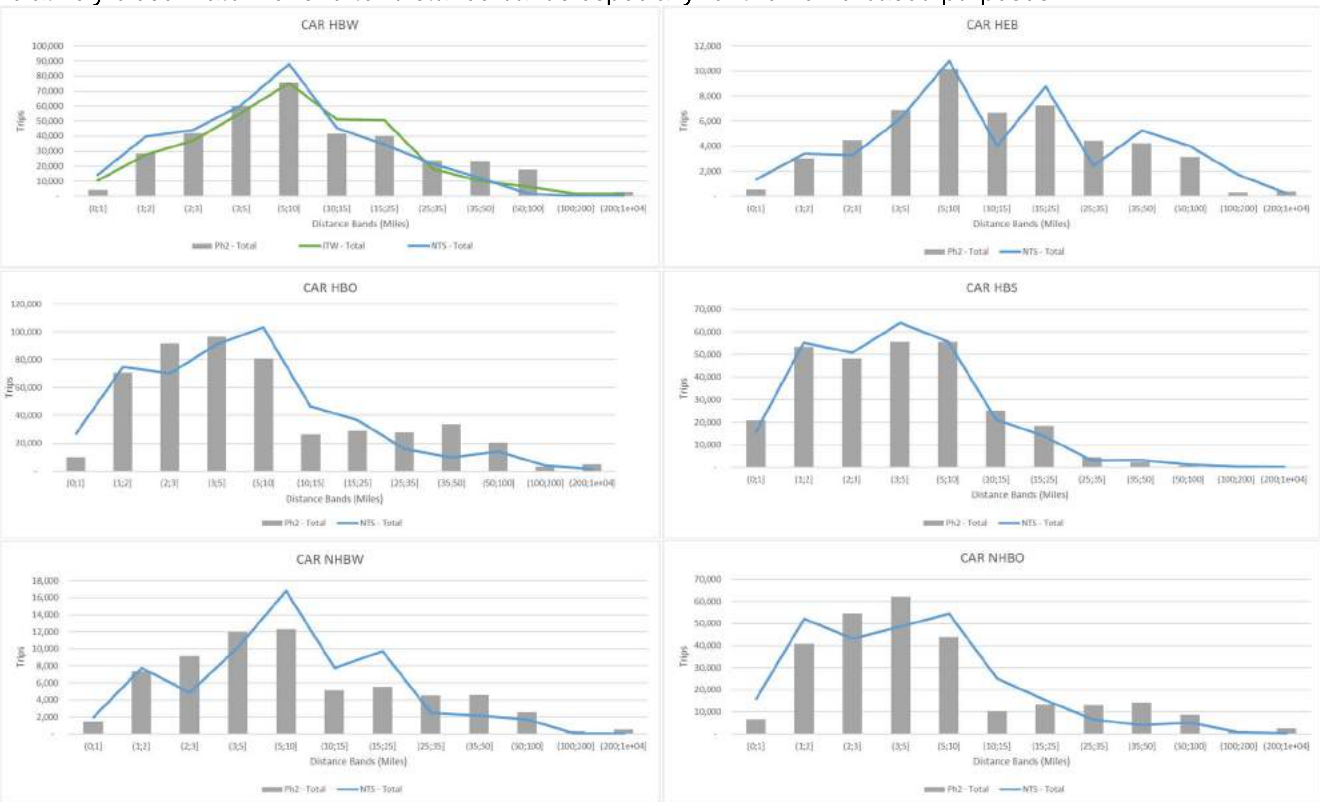


Figure F. 8: Synthetic Car TLDs vs NTS (Internal Productions)

The home-based work demand was also compared to 2011 Census JTW data at a sector level, as shown in Figure F. 9 on the following page. This comparison suggests a close correlation between the synthetic and observed sector-to-sector movements.

Figure F. 10 then compares the HBW synthetic demand by production and attraction to the corresponding JWT figures. Despite the overall patterns being similar, synthetic demand (based on TEMPro) suggests less HBW car travel than recorded in the Census. This could be explained by the reduction in car travel between 2011 and 2017 as well as by the differences in the data definitions.

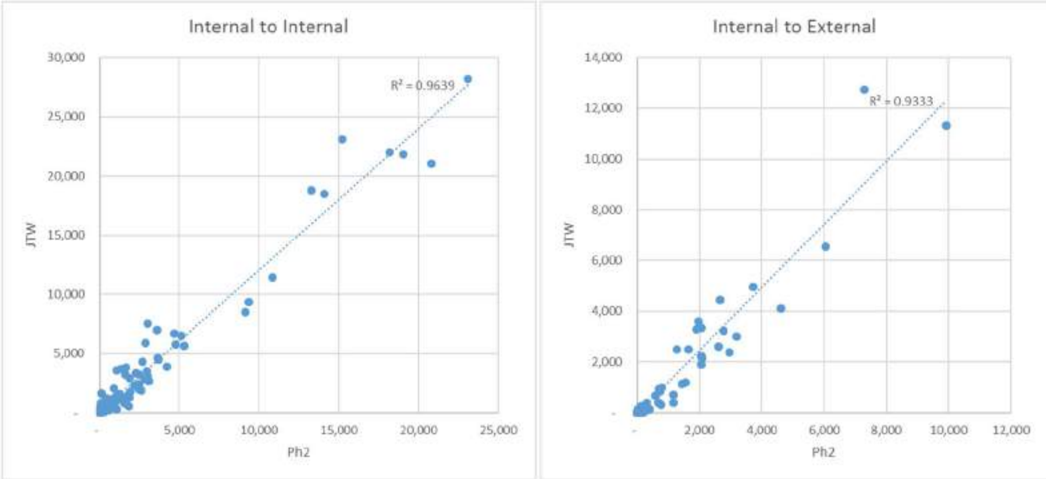


Figure F. 9: Comparison of Synthetic Car HBW Demand to JTW Car Demand (Sector to Sector Movements)

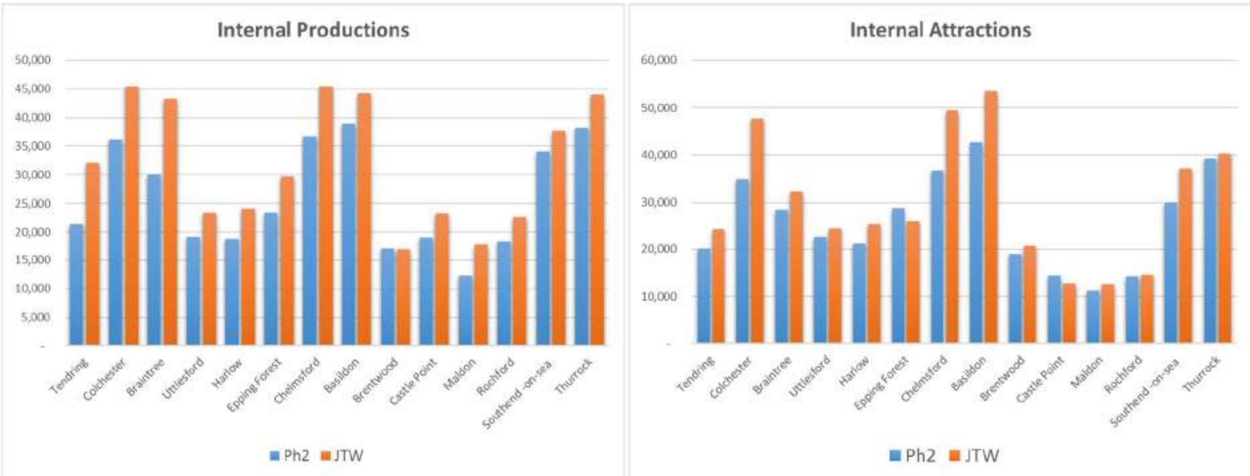


Figure F. 10: Comparison of Synthetic Car HBW Demand to JTW Car Demand (Internal Production and Attractions)

Education 24-hour Travel Patterns

Home-based educational car trips were based on the school survey data collected by Essex County Council. School trips were divided into two distinct sets, corresponding to primary and secondary education. The origin-destination patterns from the 2016 dataset formed the basis of pupil travel. Average mode splits were calculated for primary and for secondary school trips and were applied to the total trip matrices.

HGV Matrices

Although MND matrices were also available for HGVs, their quality was considered low. The use of TrafficMaster data for HGVs was also dismissed due to unacceptably low HGV samples. Consequently, the

HGV demand was created using the aggregated DfT's Base Year Freight Model (BYFM) data. The matrices were subsequently adjusted to match the observed link counts.

The BYFM dataset contained modelled freight movements for 2006, using a zoning system which included local authorities, ports, airports, and major distribution hubs. The matrices represented trips carrying goods on an average day and contained 996,000 HGV trips in total. Although the BYFM trip patterns do not reflect any changes in distribution hub locations since 2006, or take account of the new London Gateway container port, they were still considered to be the best source of data available for this study.

The BYFM trips were allocated to the Countywide model zones using simple proportions of origin zone in each district, and similarly for destination. The proportions were based on Workplace populations from the 2011 Census and calculated as the ratio of model zone to district totals. The ports, airports and distribution hubs were allocated to the model zone where they are located. Some allowances were made for growth in HGV movements between 2006 and 2016 and empty vehicle returning movements.

During the highway model calibration, a relatively large changes to the HGV prior matrices was found. This is not unusual for a strategic model and was considered acceptable due to low quality of the input data for goods vehicles. However, we recommend revisiting the HGV matrix development should new quality freight data become available in the future.

LGV Matrices

The LGV matrices were developed form the DfT's TrafficMaster dataset (October - November 2014 and March 2015) covering the South East region. This data was automatically collected from drivers of vehicles equipped with satellite navigation or anti-theft tracker devices that switch on when the engine is switched on and switch off when the engine is off. The start and end locations were available at MSOA level making it straightforward to convert the data into the Countywide zoning system.

It is recognised that the population of GPS-equipped vehicles may not be representative of the whole LGV vehicle fleet and the driving patterns of those owning GPS-equipped vehicles may also not be typical. While potential sample bias of the dataset is acknowledged as a limitation, alternative data sources were not available at the time of the Countywide model development and therefore TrafficMaster was considered to be the best source for the development of the prior matrices of LGVs.

The TrafficMaster data was cleaned to remove short trips below 1km to address the trip length bias and to remove short trips related to internal movements around depos. A comparison of the TrafficMaster raw and adjusted trip-length distributions to NTS is shown in Figure F. 11. It demonstrates a reasonable match between the two datasets. Although the NTS LGV data has its own limitations and is based on a low sample, it did not suggest any apparent bias in the TrafficMaster trip length distribution for longer trips. Therefore, no further adjustment to the trip length distribution was made.

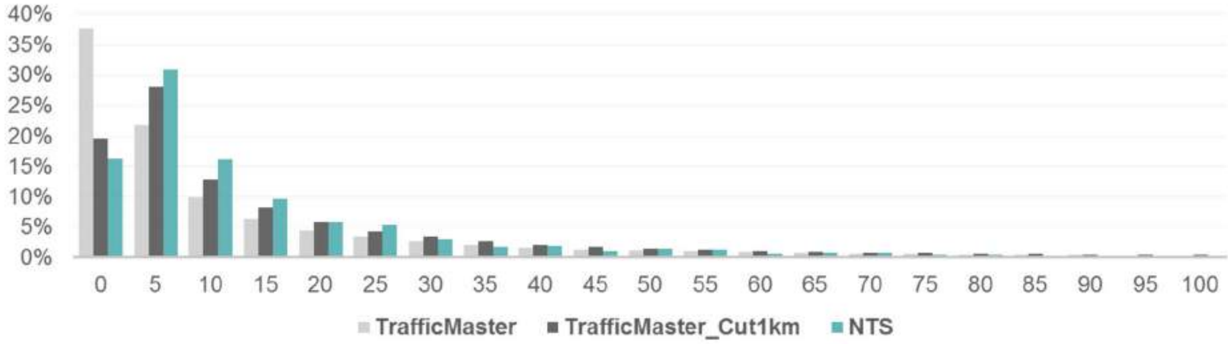


Figure F. 11: Comparison of Trip Length Distributions: TrafficMaster LGV (Before and After Data Cleaning) vs NTS LGV

The LGV data was supplemented by a portion of synthetic demand representing personal travel which was used as a proxy for self-employed and mobile (or flexible workplace) workers. From NTS it was found that 1.5% of HBW trips and 0.6% of HBO trips were LGVs rather than cars. As such, these proportions of car trips were moved to LGV for each purpose.

To enable the substitution of LGVs from the daily MND demand for road, the process of translating the TrafficMaster data into the LGV matrix was undertaken at 24hr level. These matrices were subsequently converted to the individual time periods using the time of day factors based on the LGV counts for the study area.

The resulting matrices were then assigned to the Phase 1 network and the modelled LGV flows were compared against counts along long screenlines. The matrices were adjusted using factors derived from the count data across a selection of screenlines to obtain the best match to observed flows.

Matrix Building through Data Merging

Summary of the Approach

Following the initial data verification checks, MND was chosen as a primary data source for the Countywide matrix building. This approach recognises MND's higher sample size, wider geographical coverage, and the ability to capture day-to-day variability. To infill the identified gaps, the MND matrices were combined with the synthetic demand and alternative data sources for education, LGV, and HGV trips.

The process also involved additional mode and purpose segmentation in order to create the demand segments required by the Essex Countywide demand model. To meet these requirements, and to maintain the link with land-use and demographic data, the prior MND-based matrices were first developed at an all-day level in a PA format and then converted to the time period OD format and – for car – from person trips to vehicles.

The verification checks were repeated throughout the process to ensure that the overall patterns of trips in the resulting matrices were consistent with TEMPro and NTS and to identify any further sources of bias to be addressed in the subsequent iterations. A comparison of the assignment results with the observed volumetric (e.g. traffic count survey) data was also introduced. The optimisation method was based on minimising the inconsistencies between the assigned prior matrix and the observed data through the modification of assumptions utilised in data merging and various conversions between daily PA and time period OD.

Figure F. 12 provides an overview of the matrix development exercise, which was an iterative process informed by extensive data verification checks. The following sections provide more details on the individual steps.

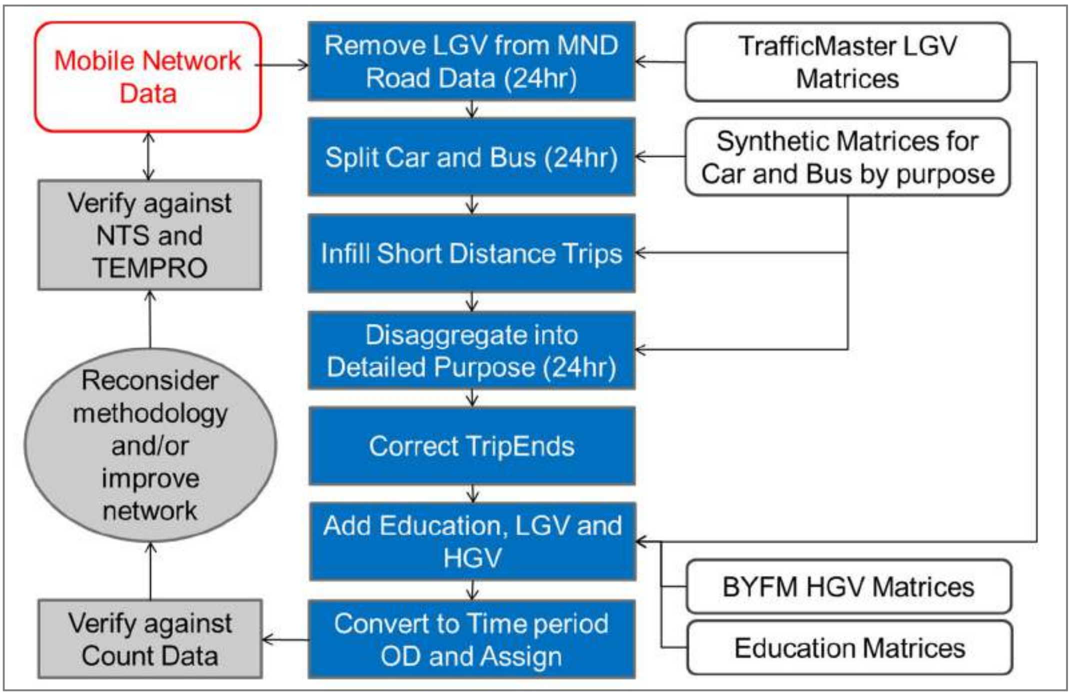


Figure F. 12: An Overview of the Final Matrix Building Process

Removal of LGV from MND Road

As described in Section 0, TrafficMaster (augmented with synthetic car data) was used to create prior demand matrices for LGVs. These matrices were also used to inform the removal of LGVs from the MND road demand into the combined car and bus travel and LGV trips.

Prior to the removal of LGVs, the matrix building process was run through all other steps to produce matrices of LGVs and Car combined into a single user class. These were assigned to check that the overall level of flows resulting from MND were sensible and to identify any issues related to time of day and person to vehicle conversions. The removal of LGVs was then performed at an MSOA level (consistent with the raw TrafficMaster data) for all movements with one or both trip ends in the internal area.

As explained in Section 0, the TrafficMaster LGV data only represents a small percentage of the national fleet, therefore an expansion of the dataset was required. The resulting “unadjusted” LGV matrix representing 3 months’ worth of data was found to be too high when compared to observed counts. As a result, the LGV matrix was scaled down to be more in line with the observed data. To factor the LGV matrix, the proportion of trips required to match prior matrices to post matrices was calculated at sector production level outside London and sector to sector inside London. These proportions were then applied to the raw LGV TrafficMaster matrix. The scaled TrafficMaster LGV data was used in the matrix building iterations to remove LGV data from MND while achieving the best possible validation results.

Inconsistencies in the data definition and the zoning systems between MND and TrafficMaster meant the TrafficMaster data could not be used to disaggregate MND for the external-to-external movements.

Therefore, for all areas except London to London, observed count data was used to determine the average vehicle type proportions. It was assumed the that proportion of LGV in the overall traffic was 10% with 2% of these bus trips and the remaining 98% being car. For London to London trips it was understood that the vehicle type proportions were likely to be different to areas in Essex. For example, one might expect to see higher public transport shares, especially where it involved crossing the River Thames. To determine these vehicle type shares London Travel Demand Survey (LTDS) data was used, taking into consideration whether the trips crossed the River Thames.

Split of Car and Bus

Following the removal of the LGVs from the MND matrices and scaling the external to external trips, the next step was to separate the remaining road trips into bus and car journeys. As the Countywide Model network does not contain bus routes outside of Essex, the bus matrices only included internal movements.

In order to remove bus trips from MND, an estimate of bus and rail mode shares for each OD movement was derived from the synthetic matrices. This approach took account of differences in mode share by area as well as accessibility effects. Checks were carried out to ensure that the distribution of shares is sensible (i.e. no outliers) and that the overall mode shares by sector were in line with those suggested by TEMPro trip ends.

Short Distance Corrections

When comparing MND to NTS, the trip length distribution highlighted an underrepresentation of short trips. An example comparison for HBW trip length distributions including JTW, NTS, synthetic (Phase 2) and MND is shown in Figure F. 13 on the following page. This bias was corrected by infilling short trips using the developed synthetic matrices. The infilling was undertaken separately for each mobile phone trip purpose and mode.

Following initial testing, the distance threshold for infilling was defined as 7km (including intrazonal distances) for all modes and purposes. To retain as much MND as possible, whilst increasing the amount of short distance travel, the available MND records were retained in infilling. It involved expanding MND to match the production trip end totals from the gravity model (which were normalised to NTS) and taking a proportion of MND and synthetic trips based on how much infilling was required. As there were no reliable estimates for the external production, those short distance trips were replaced with the synthetic estimates.

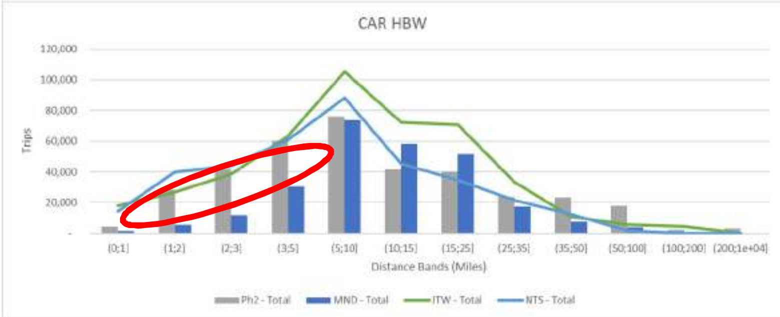


Figure F. 13: Comparison of Trip Length Distributions for HBW Showing the Underestimation of Short Trips in MND

Detailed Purpose Segmentation

The key objective of the detailed purpose segmentation was to create matrices compatible with the Countywide demand model segments (24hr PA) and with the assignment model user classes (time period OD). As described previously, the provisional MND was available for the following trip purposes: HBW, HBO+, NHBW and NHBO. As part of this step the HBO+ demand was segmented further into Other (HBO), Shopping (HBS) and Employer's Business (HBE) using the purpose shares based on the synthetic matrices for bus and car. The splits were applied at a zone level to reflect differences in trip length distribution by purpose whilst maintaining the purpose split at trip end level, reflecting planning data and land use. Whilst the resulting trip length distributions were different for each disaggregate trip purpose, the MND trip length distribution was retained at an aggregate level. For the external to external area NTS purpose splits were used.

The comparisons of the resulting TLDs to NTS data for car purposes can be seen in Figure F. 14.

Figure F. 14: Prior Car Demand TLDs vs NTS (Internal Productions)

Trip End Corrections

The spatial accuracy of MND is limited due to possible trip allocation and expansion errors. Therefore, some form of constraining to TEMPro trip ends was necessary to maintain consistency with land use and planning data. Recognising that TEMPro itself is subject to uncertainty and error, the constraining was applied to bring the trip end totals to within 10% of the target value.

The verification tests highlighted higher trip rates for the MND non-home-based travel compared to those implied by TEMPro/NTS. Following the assignment screenline validation checks (which suggested that the higher trip rates were producing better validation results) it was decided against scaling those to match TEMPro (as non-home-based travel could be underreported in NTS). Instead, the non-homebased trip ends were constrained to TEMPro trip end distributions keeping the overall number of trips as suggested by MND.

The resulting demand totals for the internal Essex productions are shown in Figure F. 15. These are compared to the synthetic demand and raw MND and plotted against the TEMPro targets for car and bus as well as TrafficMaster LGV values.

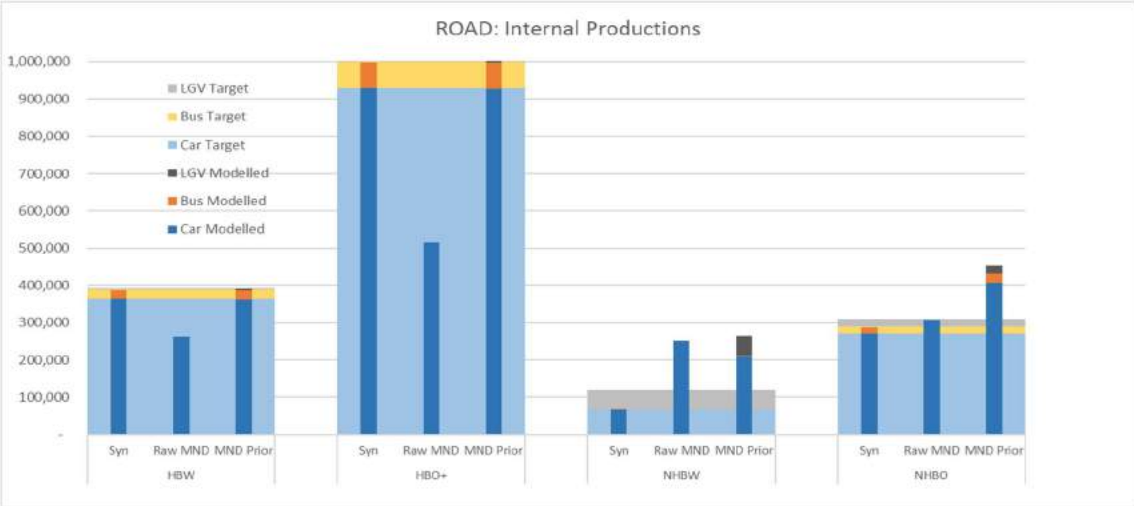


Figure F. 15: Total Daily Demand in Prior Matrices, Synthetic and MND (Internal Productions)

Comparisons of the trip ends in the resulting car matrices (by purpose) against the average weekday trip ends from TEMPro are shown in Figure F. 16 on the following page. Figure F. 17 then shows the same comparison for bus (all purposes combined).

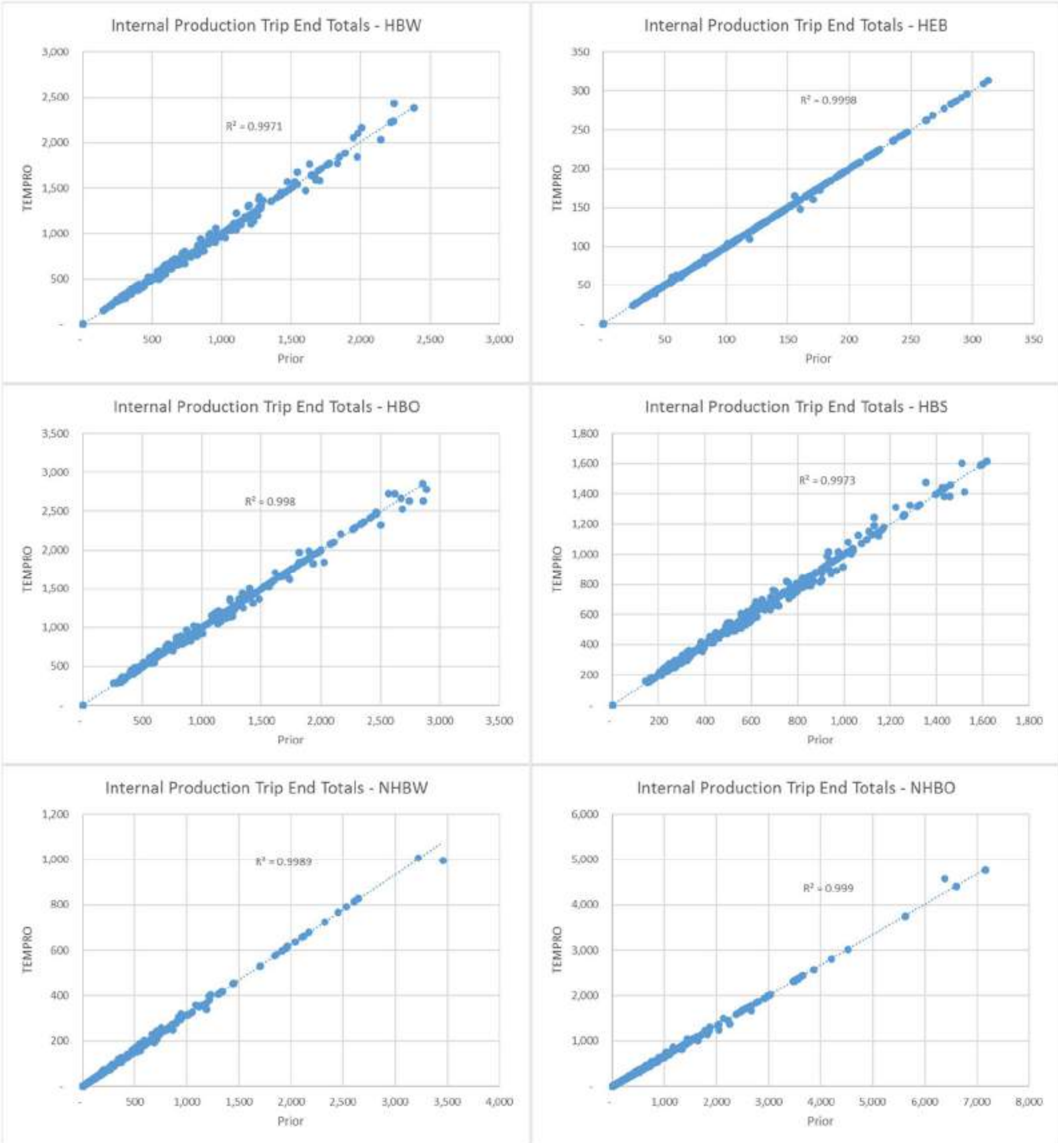


Figure F. 16: Comparison of Prior Car Demand Totals to TEMPro (Internal Productions by Zone)

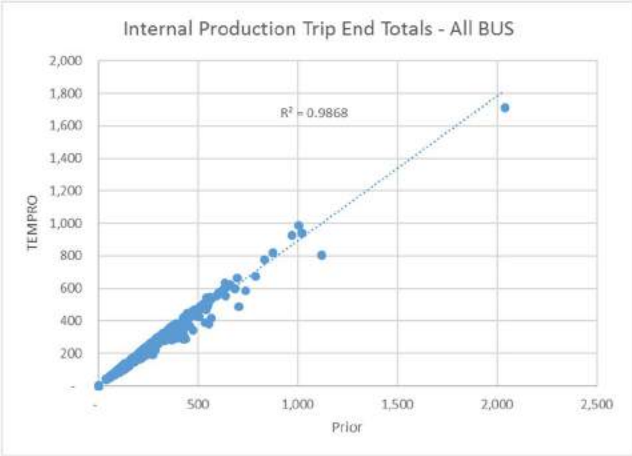


Figure F. 17: Comparison of Prior Bus Demand Totals to TEMPro (Internal Productions by Zone)

LGV, HGV and Education

Prior to assignment, LGV, HGV and Education matrices were included in the data set. The development of these matrices is discussed in Sections 0, 0 and 0 of this report.

PA to OD and Time Period Conversions

The assignment models consider the AM, Inter-peak and PM periods individually. Thus, there was a need to convert the resulting demand at 24-hour (PA) level to time period specific (OD) format.
The initial set of time period allocation factors for car was derived from MND records using their time period stamps and trip directions (outbound and inbound). The factors were calculated at 4x4 sector level (Internal, Buffer, London and External) and by the MND purpose (HBW, HBO+, HBE and NHB). The peak hour factors to convert time period demand to the highway assignment modelled peak hour were derived from traffic count data. The person trip to vehicle conversions used WebTAG Databook car occupancy factors by purpose.

To verify the time period allocation, the resulting car matrices were assigned and the modelled screenline flows were compared to the observed values by time period. The results from initial iterations showed that at a 12-hour level there was a general underestimation of flows over nearly all screenlines. This indicated that the MND time period allocation was overestimating the demand in the off-peak period (19:00-07:00). To improve the assignment results, the NTS global factors were used to adjust the MND factors and to reduce the proportion of travel allocated to the off-peak period. This was done by scaling the overall amount of travel in each time period while retaining the MND distributions at a sector level.

For public transport and non-home-based travel, the NTS proportions were used. The NTS information on the purpose splits within each time period was also used to disaggregate the time period conversion factors to enable conversions of the segmented HBO+ matrices. The approach ensured that the overall demand allocated to each time period remained the same as for the aggregate purpose with the individual sub-purpose factors reflecting time-period specific purpose splits.

The LGV and HGV time of day conversion factors were derived from the Essex traffic count database.

Final Prior Matrices

The verification process focussed on correcting for biases and inconsistencies with the secondary NTS and TEMPro data while keeping the integrity of the MND trip patterns and distributions. Further adjustments to the car matrices were necessary to improve the assignment performance at a local level.

A significant overestimation of car flows at the Dartford Crossing was evident in all time periods and was considered to be a false MND trip detection/allocation for the movements crossing the River Thames. Following the analysis, it was decided to scale the car matrix for trips going to and coming from Thurrock, London and Kent that used the Dartford Crossing. For OD pairs that travelled northbound a factor of 0.85 was used. For OD pairs that travelled southbound a factor of 0.7 was used.

The resulting car demand matrices represented a significant improvement upon the synthetic demand used in Phase 1 modelling. The difference between the observed and modelled car flows in the prior matrices were within 20% for all screenlines in all three time periods, as shown in Figure F. 18, Figure F. 19, and Figure F. 20 for the AM, Inter-peak and PM respectively.

In line with normal practice, a matrix estimation process was used to improve the quality of fit of flows to counts.

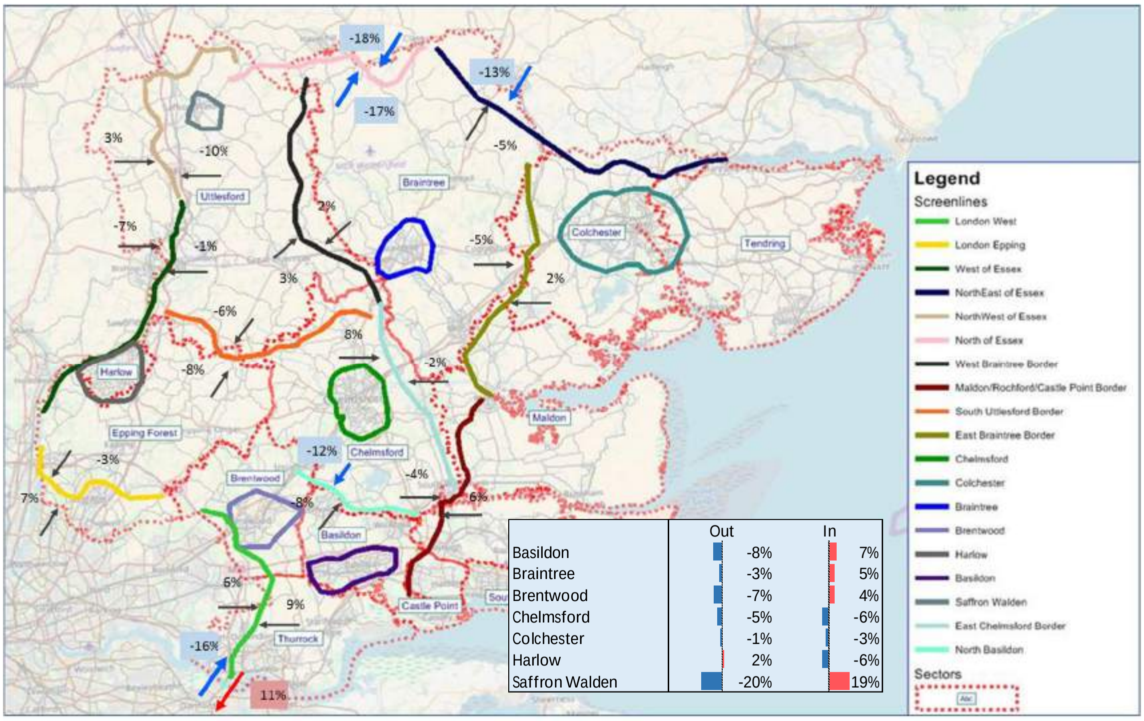


Figure F. 18: Validation Screenlines, Prior Car Demand vs Observed Counts (AM Peak Hour)

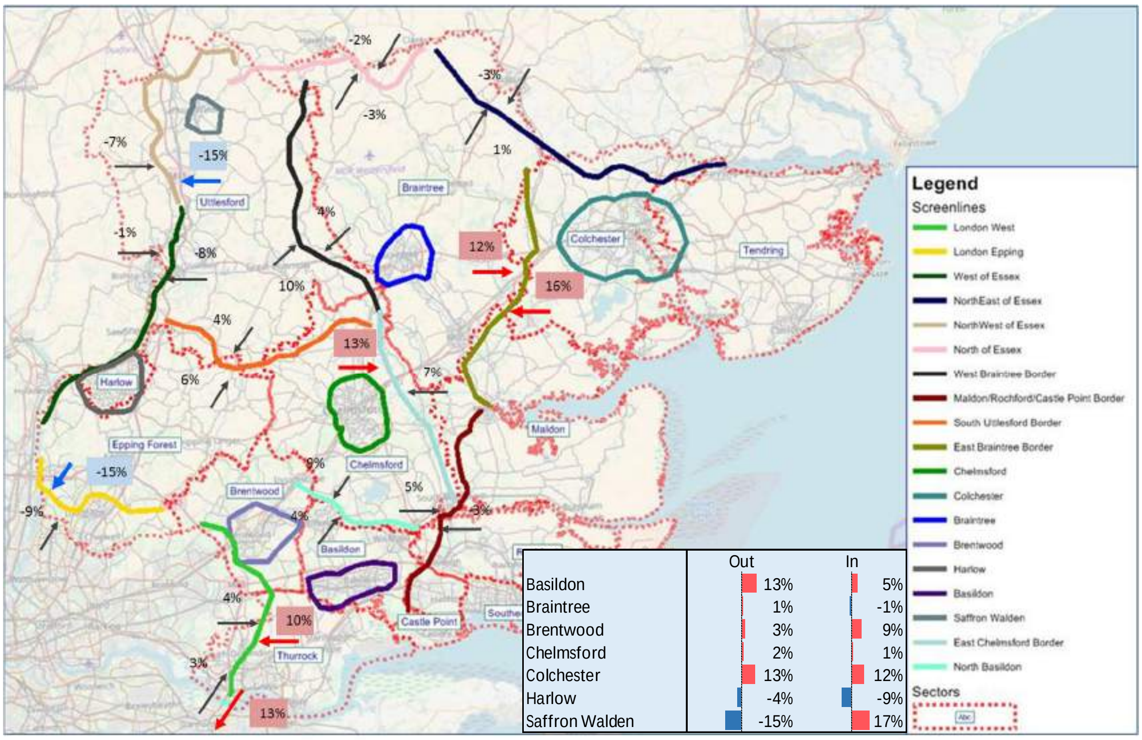


Figure F. 19: Validation Screenlines, Prior Car Demand vs Observed Counts (Inter-Peak Hour)

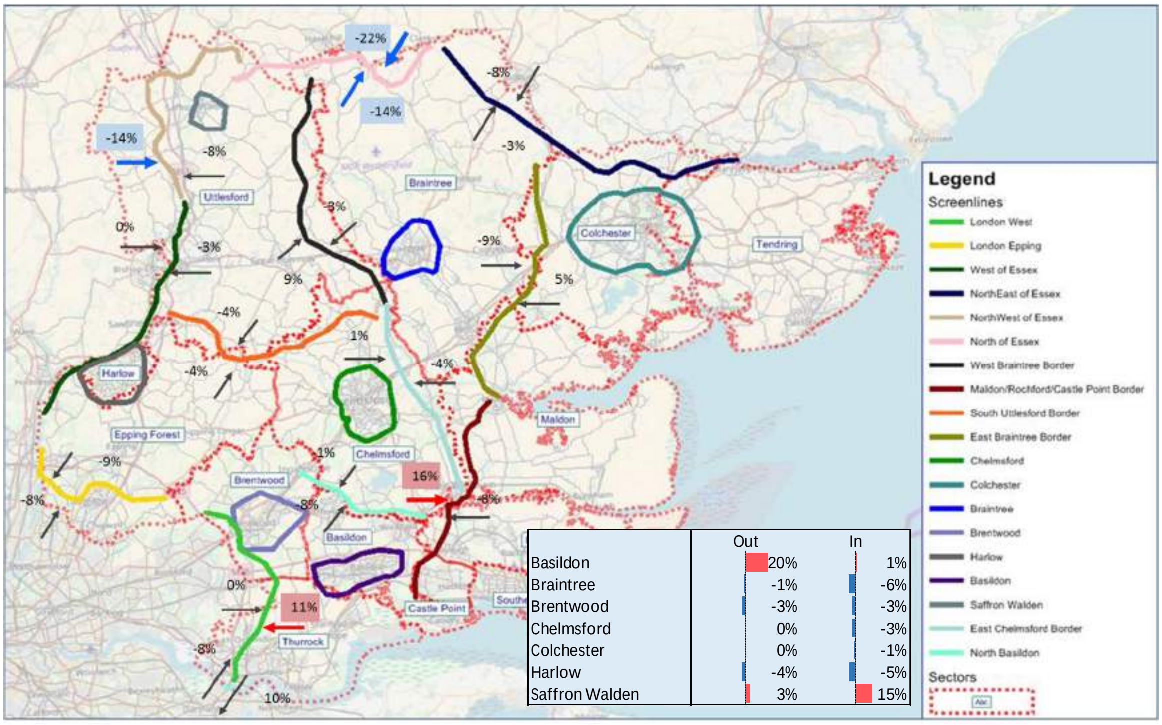


Figure F. 20: Validation Screenlines, Prior Car Demand vs Observed Counts (PM Peak Hour)

Appendix G – Essex Countywide PT Matrix Development

Overview

This chapter summarises the base year Essex countywide PT prior matrix development, and this section is taken from the Essex Countywide LMVR. The purpose of the public transport model (PT model) is to produce demand matrices and travel cost data (cost skims) for use in the Variable Demand Model (VDM). This function requires the model to provide information about in-vehicle travel time, access/egress time, wait time and interchange time for the AM, Inter-peak and PM peak periods.

VDM also requires the representation of the monetary cost of travel by public transport. Public transport fares are based on the travel distance output from the public transport model and estimated using observed relationships between the fare payed and distance travelled. This model functionality is appropriate for the purposes of the Essex Countywide model and follows industry standard for this type of models (Highways England (HE) adopted a similar approach in their Regional Traffic Models (RTMs)).

The Phase 2 Essex Countywide PT model builds on the networks developed as part of Phase 1. The primary focus of Phase 2 work was to incorporate new demand matrices derived from Mobile Network Data (MND). Following the update of the demand matrices, and small modifications of the assignment algorithm in Phase 2, benchmarks of the total public transport demand were completed to confirm the suitability of the model for use as part of the strategic variable demand model.

The remainder of this chapter describes:

- the review and minor updates of the Phase 1 model processes;
- the process of incorporating new matrices based on MND and initial review of the results;
- adjustments of the MND process to develop public transport matrices;
- benchmarks of the total public transport demand; and
- preparation of inputs into the demand model.

Review of the Phase 1 Model

The review of Phase 1 public transport model covered the assignment process used in the model. The purpose of the review was to understand if any refinements need to be made in the existing Phase 1 algorithm to improve the transparency of cost skims derived for input into the demand model.

The review considered elements of the generalised cost skimmed as part of the assignment process, their appropriateness, transparency of computation, impact on run times and their contribution to the overall modelling process. It identified that the assignment should be simplified in the following areas:

- estimation of fares for input into the demand model; and
- exclusion of capacity restraint in the public transport assignment.

The Phase 1 procedure to estimate fares relied on a complex set of passing points used to calculate the fare (a bespoke method used within the VISUM software). The method to set these points in VISUM is not easy to update or amend. Given that fare inputs are only necessary for VDM[1], fares can be estimated outside of the model in a more transparent and consistent way. The most common approach to modelling public transport fares is to estimate a relationship between the fare and distance, where the in-vehicle distance is derived from the assignment. The details of the derivation of fares are described later in this report.

The draft specification for the Countywide model considered capacity constraints on public transport services (crowding). However, crowding is only a major issue on rail services as they approach Central London, and this is not an important consideration in the context of the countywide models. Crowding on buses is also not an issue. Given limited value that the modelling of crowding would bring to the overall modelling system and considerable complexity associated with this procedure, its inclusion was not justified. Not only, the application of the evidence-based crowding penalties may be limited by the functionality of the VISUM software, the run times required for the model to achieve convergence would be prohibitive, given considerable run times needed for a single iteration of the VISUM PT assignment. Crowding procedure was therefore not added to the model.

The issue of model run times was also considered. The long run times of the current assignment procedure are driven by the detailed timetable-based assignment. A conversion of the procedure into a simpler frequency-based procedure was considered, but not implemented due to the complexity and technical risks associated with the conversion. The timetable-based assignment procedure was therefore retained, which is acceptable in the absence of crowding.

During the review of the assignment procedure some observations related to the format of the timetables were made: VISUM software calculates train journey times based on line speed. In case of the stopping and fast services sharing the same line (as is the case in Essex), the average speed may be weighted towards the slow trains, potentially overstating travel times on the fast, inter-city services. To mitigate this, rail journey times coded in Phase 1 for the main services groups (such as London-Norwich, London-Ipswich, London-Colchester, etc.) were compared with 2017 MOIRA timetables and adjusted where appropriate with factors based on average journey times for the key service groups extracted from the MOIRA timetables.

Mobile Network Data

The process of the development of demand matrices for highway and public transport models is described in Appendix F. In this section, only the key features of the public transport demand matrices derived from MND are summarised.

The public transport demand matrices were prepared separately for bus and rail[2] trips. This distinction was necessary as surface rail trips can be easily identified within mobile phone data, whilst bus trips are more difficult to distinguish from other road-based trips[3] and required a separate matrix building procedure. This separation also allows bus and rail demand growth to be applied independently.

However, the matrices are added together for assignment to the public transport network. This means that the assignment model determines whether the public transport demand uses rail or bus only services. Given that the rail network is relatively sparse (it is based on three main lines: Great Eastern Mainline, Essex Thameside lines and the Cambridge Line) and the bus services cover primarily networks within individual towns, the rail (longer-distance) and bus (primarily local) trips are distinct and the shape of the network does not offer many opportunities for a mis-allocation of demand between modes. This was verified by testing the

[1] Given the limited density of the public transport networks, fares are not expected to influence the choice of route.
[2] Where rail trips are those trips, which use rail as the main mode, but bus may still be used for access.
[3] The process of the development of bus trips is covered separately.

assignment of rail and bus demand individually, which confirmed that the allocation of the bus and rail demand to modes is sufficiently accurate.

Mode	Rail Matrix Assignment	Bus Matrix Assignment
Bus and Walk	2.07%	**90.98%**
Bus, Rail	5.72%	5.28%
Bus, Rail, Underground	9.82%	0.08%
Bus, Underground	4.22%	0.59%
Rail	24.72%	2.84%
Rail, Underground	45.47%	0.04%
Underground	7.99%	0.19%
Sum Rail	**97.94%**	N/A

Table G. 1: Results of Individual Assignment of Rail and Bus Demand

The Countywide demand model operates at daily (24-hour) Production-Attraction (PA) format (see the *Phase 2 Variable Demand Model Report*[4] for more details) and the public transport model provides cost skims for AM peak, Inter-peak and PM peak periods for input into the demand model. The demand model forecasts change in the allocation of demand between rail and car at the total daily level (mode choice) and it is important that the daily public transport demand input into the model is robust. Given that crowding is not modelled in the Countywide model it is not strictly necessary to assign public transport demand to the network.

Nevertheless, the demand model divides the daily PA public transport matrices into time period matrices in Origin-Destination (OD) format (the process of converting daily PA into time period OD matrices is described in a separate chapter). These include matrices for AM peak, Inter-peak and PM peak periods consistent with the public transport model time periods as well as the Off-Peak (OP) time period, broken down by Commute, Business and Other journey purposes. These matrices were assigned to the network to perform high-level checks of the total demand present on the public transport network across the day and formed part of matrix validation. In addition, high-level validation of sectored public transport matrices was performed. The independent data, initial comparisons, the process of matrix adjustments and the final comparisons are described in the following sections.

Independent Data

Independent observed data on the volume of passenger trips on bus and rail services is usually unavailable. In case of bus, the data is held by bus operators and not shared due to the commercial confidentiality of revenue estimates. Similarly, in case or rail data confidentiality clauses prevent sharing or collection of reliable data.

However, in case of rail, Essex County Council obtained a permission from Greater Anglia (GA) and c2c franchises to use their respective versions of MOIRA. These excluded revenue figures but provided estimates of passenger journeys derived from ticket sales for the period from September 2016 to September 2017. This data was used in two ways:

[4] Essex Countywide Model – Phase 2 Variable Demand Model Report v1.0, Jacobs (March 2019)

- Sum of journeys traversing certain points on the network across the day was used to benchmark total demand assigned to those links in the model in all tie periods; and

- Estimates of station-to-station journeys were converted into a sectored matrix, using the assumption that the demand using a station originates near this station. It is of course possible that passengers may reside in the neighbouring sectors but given their size the inaccuracy is expected to be negligible for the purposes of high-level comparisons.

In case of bus, Essex County Council is in a possession of high-level bus usage statistics, which include the total annual number of bus boardings and alightings in the town centres of Basildon, Harlow, Chelmsford, Colchester and Braintree. This data was used to benchmark modelled bus boardings with the same approximate coverage.

The next section summarises the initial comparisons of the MND matrices for rail and the subsequent adjustments of the rail matrix.

PT Matrix Adjustments

The daily PT matrix derived from MND was sectored using standard Essex Countywide sector definitions[5]. This data was compared to sectored MOIRA journeys described in the earlier sections. The comparison was performed at the daily (24 hour) OD (Origin-Destination) level as MOIRA flows cannot be broken down by time period or direction. For the purposes of the comparison, the two-way MOIRA flows are simply divided by two as they are expected to be symmetrical over the 24-hour period. The comparison is presented in Table G. 2 below.

Daily Trips	MOIRA	MND	Absolute Difference	% Difference
Essex to London	104,171	105,090	919	0.9%
London to Essex	104,171	102,459	-1,712	-1.6%
Within Essex	38,557	15,405	-23,152	-60.0%
TOTAL	**246,898**	**222,954**	**-23,944**	**-9.7%**

Table G. 2: Comparison Between Modelled and MOIRA Trips

The comparison shows that MND correctly estimates the volume of rail trips on the major flows between Essex and London (the difference between MND estimates and MOIRA is within 2%). This is expected as trips by rail to London follow a very distinct geographical pattern and should be easy to detect on the mobile network data.

However, MND shows a significant gap in the estimate of the number of rail journeys made within Essex. When compared with MOIRA, MND estimates show 60% fewer trips. Some of this difference may be attributable to the approximation of the location of the rail trips in MOIRA (assumptions about the home origin of trips, described in the previous section). However, these inaccuracies are likely to be small and would not explain such a large difference fully.

[5] Essex is divided into sectors based on District boundaries.

Another reason for such a large difference may be a mis-allocation between rail and other modes in areas where rural rail services have low speeds and run parallel to local roads (which means that they will be more difficult to distinguish from the road trips). Whilst any such potential mis-allocation is likely to be small in absolute terms and therefore negligible for the estimates of car trips it may be detectable on rail due to the generally smaller volume of rural rail trips. Other reasons may include general difficulties with estimating short trips by mobile phone data or assumptions about the expansion of rail trips detected in the mobile phone data sample to full population in rural areas.

To close this gap the MND matrices were infilled with short distance internal Essex trips. The estimates of these trips were derived with the use of a simplified gravity model. The gravity model used the following information:

- Travel times by public transport;
- Rail trip length distribution in Essex derived from the National Travel Survey (NTS); and
- NTEM rail trip ends and MOIRA journeys targets.

The cost skims from the PT model include travel time by both rail and bus. However, not all PT journey opportunities will be relevant to rail travel and these cost skims should be excluded from the gravity model (journeys likely to be taken solely by bus are assumed to have infinite costs and therefore would not attract any rail trips in the rail gravity model).

The NTS contains a relatively small sample of records containing information about the rail travel in Essex. To improve the reliability of the trip length distribution estimates, the data for all time periods and journey purposes (within Essex only) was combined into a single daily dataset. This allowed overcoming the small sample issue and, given that the analysis excluded large London-bound commuting flows, was judged to be appropriate for use in intra-Essex gravity model[6].

The gravity model was then applied to the rail trip ends derived from TEMPro. However, TEMPro is known to under-represent the volume of rail travel. The rail trips distributed using intra-Essex rail gravity model were therefore normalised the total of intra-Essex journeys estimated with the use of MOIRA outputs. The distribution of the normalised intra-Essex trips maintains the distribution achieved by the gravity model and calibrated to NTS data. This is depicted in Figure G. 1 below.

[6] The sparsity of the rail network in Essex and the limited distance over which intra-Essex trips can be made means that variations between journey purposes and time periods are not likely to be significant.

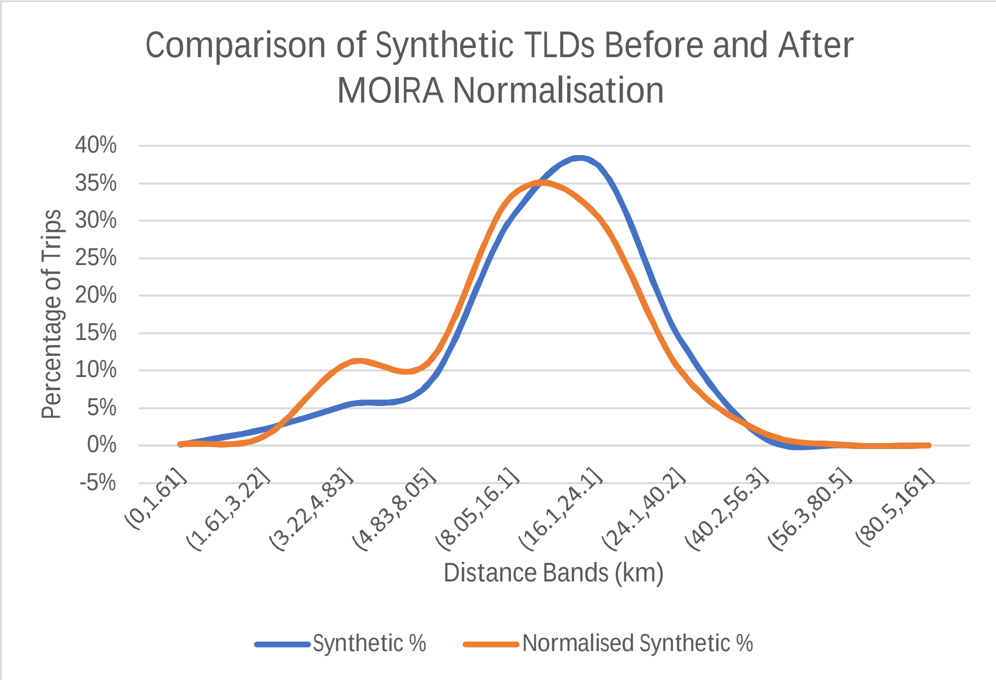


Figure G. 1: Comparison of Trip Length Distribution Between Synthetic Data and the Output from the Normalisation to MOIRA

Validation of the Rail Matrix

Following the amendments of the rail matrix described in the earlier section, the daily rail demand flows were validated in two steps:

- The sectored 24 OD rail matrix was compared with the sectored station-to-station journeys extracted from MOIRA to distribution of the main rail flows (particularly between Essex and London); and
- The assigned AM, IP, PM and OP demand flows traversing the cordon around London were compared with the two-way daily flows extracted from MOIRA.

At an aggregated level, the adjusted MND flows compared very well with the MOIRA data. Table G. 3: Comparison Between Modelled and MOIRA Trips Post Infill

and Table G. 4: Comparison of Moira and Adjusted MND for Origins and Destinations below shows the same key sectors presented in Table G. 3 before the adjustment. It shows a considerable improvement in the total number of rail trips modelled within a day between Essex and London as well as within Essex.

Daily Trips	MOIRA	MND	Absolute Difference	% Difference
Essex to London	104,171	105,090	919	0.9%
London to Essex	104,171	102,459	-1,712	-1.6%
Within Essex	38,557	38,514	-43	-0.1%
TOTAL	**246,898**	**246,063**	**-836**	**-0.3%**

Table G. 3: Comparison Between Modelled and MOIRA Trips Post Infill

Individual sector-to-sector flows show some differences in the distribution of the rail trips at a more granular level. However, the figures are small in absolute terms and presented in Appendix E for completeness. It is more instructive to compare sectored trip ends within Essex which show all flows that originate or have a destination in a particular sector (Table G. 4 below).

Sector	Sector Name	Origin			Destination		
		Moira	Adjusted MND	% Diff	Moira	Adjusted MND	% Diff
101	Tendring	6,147	8,185	33.16%	6,147	8,094	31.68%
102	Colchester	12,784	17,576	37.48%	12,784	18,346	43.50%
103	Braintree	9,124	8,109	-11.13%	9,124	7,336	-19.60%
104	Uttlesford	19,132	4,919	-74.29%	19,132	4,225	-77.92%
105	Harlow	4,239	5,994	41.40%	4,239	4,226	-0.31%
106	Epping Forest	261	114	-56.36%	261	94	-64.02%
107	Chelmsford	18,056	19,408	7.49%	18,056	18,872	4.52%
108	Basildon	23,867	22,566	-5.45%	23,867	23,804	-0.26%
109	Brentwood	15,615	22,587	44.65%	15,615	22,859	46.39%
110	Castle Point	7,628	4,225	-44.61%	7,628	3,888	-49.03%
111	Maldon	1,069	673	-37.04%	1,069	544	-49.11%
112	Rochford	7,425	6,501	-12.45%	7,425	5,444	-26.68%
113	Southend -on-sea	27,061	14,008	-48.24%	27,061	13,813	-48.96%
114	Thurrock	21,779	10,868	-50.10%	21,779	12,364	-43.23%
	Subtotal	**174,187**	**145,733**	**-16.34%**	**174,187**	**143,909**	**-17.38%**

Table G. 4: Comparison of Moira and Adjusted MND for Origins and Destinations

Table G. 4 shows a reasonable overall comparison, but there some differences between MND-based matrices with intra-Essex adjustment and MOIRA. Smaller differences are likely to arise from differences in the allocation of trips to sectors in MND (home origin) and MOIRA data (station location). Larger differences can be observed for sectors which lay just outside of the boundary of London (Epping Forest, Brentwood and Thurrock) and the Uttlesford and Southend-on-Sea sectors which contain airports (Stansted Airport and Southend Airport).

The MND for rail captures flows on London Underground and TfL Rail services, which cross the boundary of Greater London Authority into Essex, whilst MOIRA contains only National Rail flows. In these areas the comparison is not valid, but it should be noted that it is the intention of the Countywide model to capture trips by all public transport modes and this feature of the data is desirable.

The MND-based matrices do not capture all flows to the airports (Uttlesford and Southend-on-Sea sectors). This is because mobile phones registered to foreign users will not be picked up by this data. Whilst the number of journeys made by overseas visitors across the country is negligible, it tends to be concentrated on journeys to airports by public transport and results in differences when compared with MOIRA. However, as airport flows are not modelled within the Countywide variable demand model and crowding is not modelled the absence of overseas passenger airport flows has no consequence.

The analysis of the matrices against the only available independent source of data shows satisfactory correlation, but it should be noted that the comparisons have some limitation due to the nature of both datasets and assumptions that need to be made in undertaking the comparisons.

Following the comparison of the rail matrices, it was desirable to check the demand loads appropriately to rail corridors across the day. The AM, IP, PM and OP MND-based adjusted matrices were assigned to the VISUM network and link flows across a screenline around London depicted in Figure G. 2

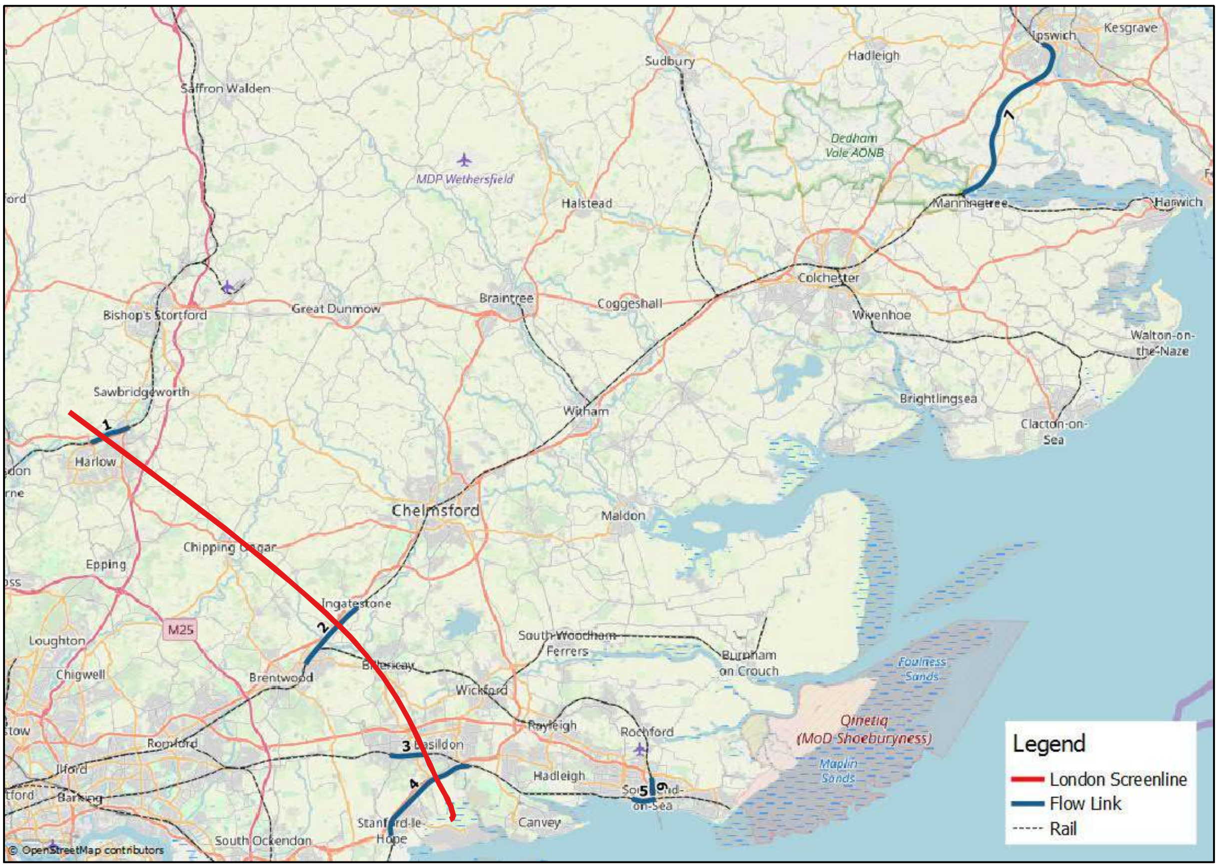


Figure G. 2: Rail Screenlines

The London screenline depicted in Figure G. 2 was chosen as it captures all demand crossing from Essex into London, which is approximately two-thirds of all rail demand modelled in the Essex Countywide Model. The purpose of the link flows is to validate the key strategic movements in the matrix rather than the assignment flows as only the daily two-way data was available from MOIRA. The comparison of the selected rail links on this screenline is presented in Table G. 5 below.

From	To	Flow Link	MOIRA demand	MND demand	Percentage difference	Operator
Harlow Mill	Harlow Town	1	42,964	28,761	49.38%	GA
Ingatestone	Shenfield	2	71,634	78,277	-8.49%	GA
Basildon	Laindon	3	45,420	49,653	-8.52%	c2c
Pitsea	Stanford-le-Hope	4	2,704	1,293	109.14%	c2c
Sum of Flow Across London Screenline			**162,722**	**157,984**	**2.00%**	

Table G. 5: Link Flow Validation Across London Screenline

The table shows very good comparison for flows on Great Eastern Mainline (Ingatestone to Shenfield) and Essex Thameside lines (Basildon to Laindon). The comparison is worse on the Cambridge (Harlow Mill to Harlow Town) lines, which is likely driven by the fact that this line is on the border between Essex, Hertfordshire and Cambridgeshire and carries some passenger flows not modelled in the Countywide Model. However, overall the comparison corroborates the findings from Table G. 3 and Table G. 4 showing sectored comparisons.

From	To	Flow Link	MOIRA demand	MND demand	Percentage difference	Operator
Westcliff	Southend Central	5	18,530	14,762	25.53%	c2c
Prittlewell	Southend Victoria	6	11,620	1,909	508.68%	GA
Manningtree	Ipswich	7	16,652	22,123	-24.73%	GA

Table G. 6: Non-London Link Flow Validation

In addition to the Essex to London screenline, a small number of links on other parts of the network were checked (Table G. 6). The performance is less good in areas where travel to airports may be a significant proportion of the rail travel (flows around Southend: Pitsea to Stanford Le Hope and Prittlewell to Southend Victoria and Westcliff to Southend Central (Table G. 5 and Table G. 6) where the low speed of the rail lines may contribute to difficulties with the detection of rail trips in the mobile phone data.

To further understand the performance of the MND-based matrix, the matrices were assigned to the network to enable the calculation of passengers boarding rail services (station entries) and passengers alighting the rail services (station exits). These were then compared with station usage data extracted from the Office of Rail and Road website.

The data comes as a total of entries and exits on weekdays across for a full year and it is assumed that the total number of entries and exits is symmetrical. The figures were divided by 252 to convert from annual weekday total to average day. For ease of comparisons the figures were aggregated to sector level (all stations located in the districts are taken as total). This is sufficient for strategic matrix comparisons as in most sectors, there is a dominant main rail station with best level-of-service, whilst smaller stations often feed demand to larger stations. The comparison is summarised in Table G. 4 and shows that there is a good fit between station usage and boarders and alighters for most sectors. However, notable differences can be seen in sectors that contain airports (Southend and Uttlesford) or flows from districts located close to London such as Harlow or Brentwood where MND is likely to be picking up TfL Rail passengers not included in the Station Usage data (which in turn is based on National Rail's LENNON database of ticket sales).

Other differences may suggest significant percentage differences but are small in absolute terms (it should be noted that these are all-day figures). The only exception is Thurrock, which shows low figures in MND when compared with Station Usage (related primarily to the southern branch of c2c). To fully understand the performance of the model in this part of Essex additional data collection would likely be required to verify if the difference is a feature of the ticket sales data (MOIRA) or MND whether further refinements to the model would be required.

High-Level Bus Validation

In addition to the assessment of the strategic flows in the rail matrix, the performance of the synthetic bus trip matrices was assessed against the available bus data. The synthetic bus matrices were assigned to the network, which allowed the extraction of bus boarders and alighters in the urban areas across Essex.

These figures were then compared, at high-level, with bus data obtained from Essex County Council. The availability of bus data is limited and the only figure available are annual bus boardings and alightings in town centres of Chelmsford, Basildon, Harlow, Colchester and Braintree. The counts were all-week annual total and were converted to average weekday with the assumed annualisation factor of 300.

The assigned data from areas corresponding to this data was extracted from the model and the figures compared against the observed data. The definition of geographic coverage for the observed high-level bus data is approximate and it is therefore difficult to make definite conclusions about the performance of the modelled data which is split into time periods and represent an average weekday. However, some comparisons are possible and are presented in Table G. 7 and Figure G. 3 below:

Annual Trips	'Observed'	Modelled	Absolute Difference	% Difference
Chelmsford	8,810,725	8,115,000	-695,725	-7.90%
Basildon	5,422,664	6,356,100	933,436	17.21%
Colchester	8,711,144	8,689,500	-21,644	-0.25%
Harlow	3,324,686	4,999,200	1,674,514	50.37%
Braintree	1,470,976	2,125,500	654,524	44.50%

Table G. 7: Daily Trips - 'Observed' v Modelled

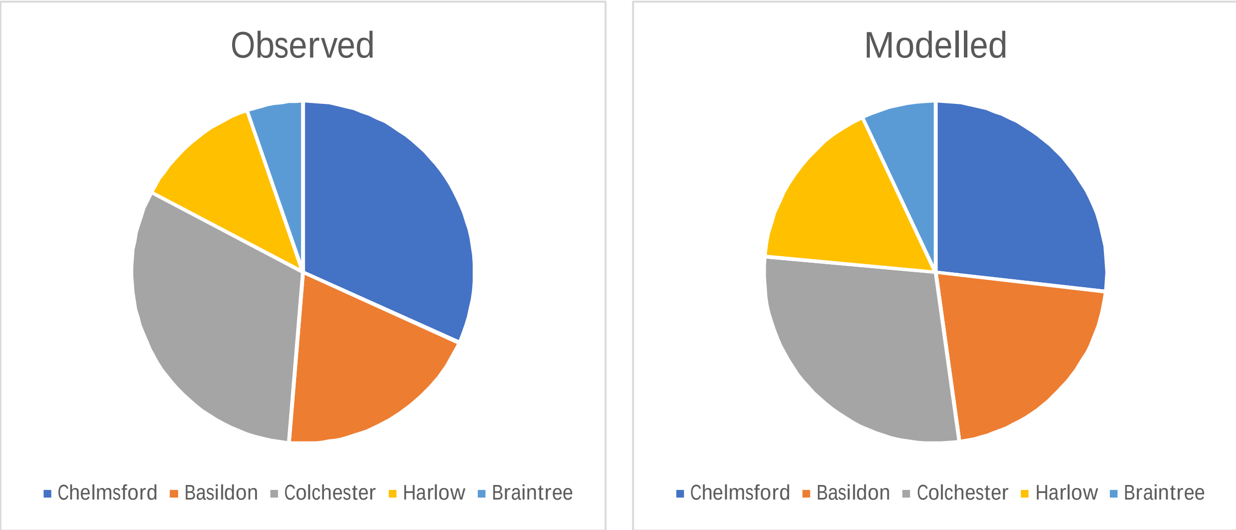
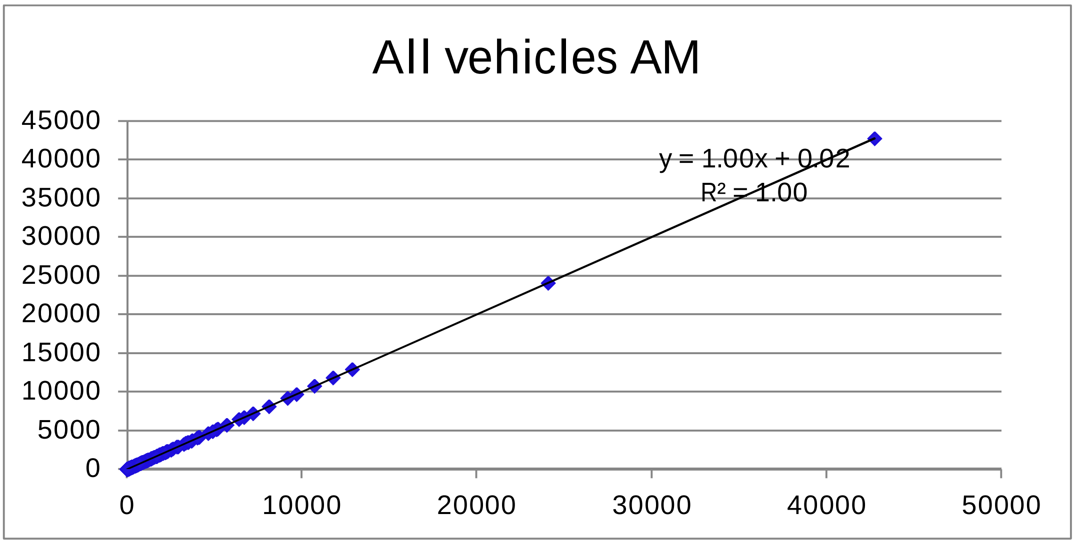


Figure G. 3: Daily Trips – ‘Observed’ v Modelled

The comparisons show that broadly the right level of bus demand is captured in Chelmsford, Basildon and Colchester. The modelled data appears to be higher than observed in Harlow and Braintree. However, it is difficult to determine the comparison of the comparisons without independent verification and comprehensive public transport surveys for these areas.

Appendix H – Matrix Zonal Cell Value Changes

AM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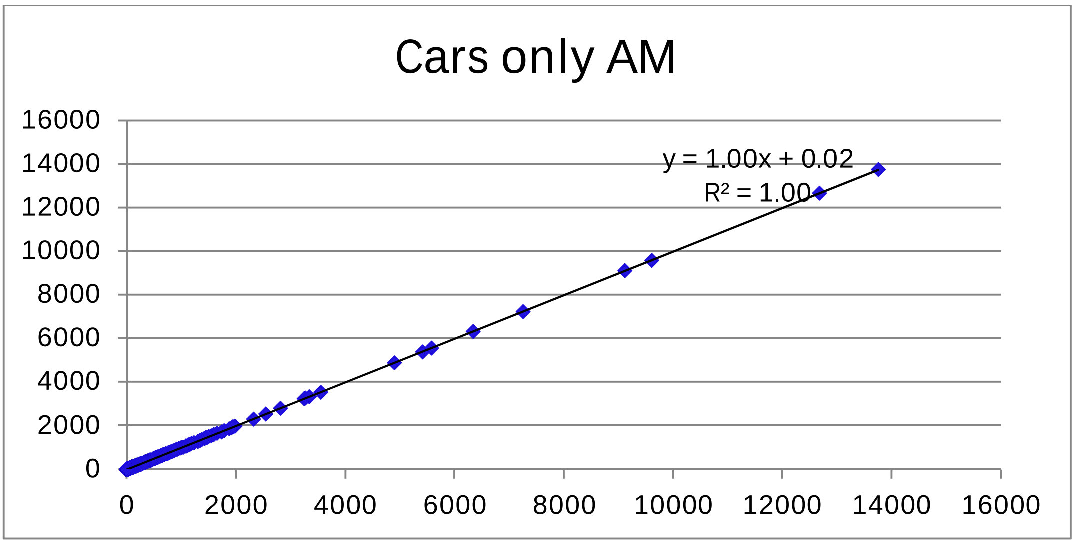
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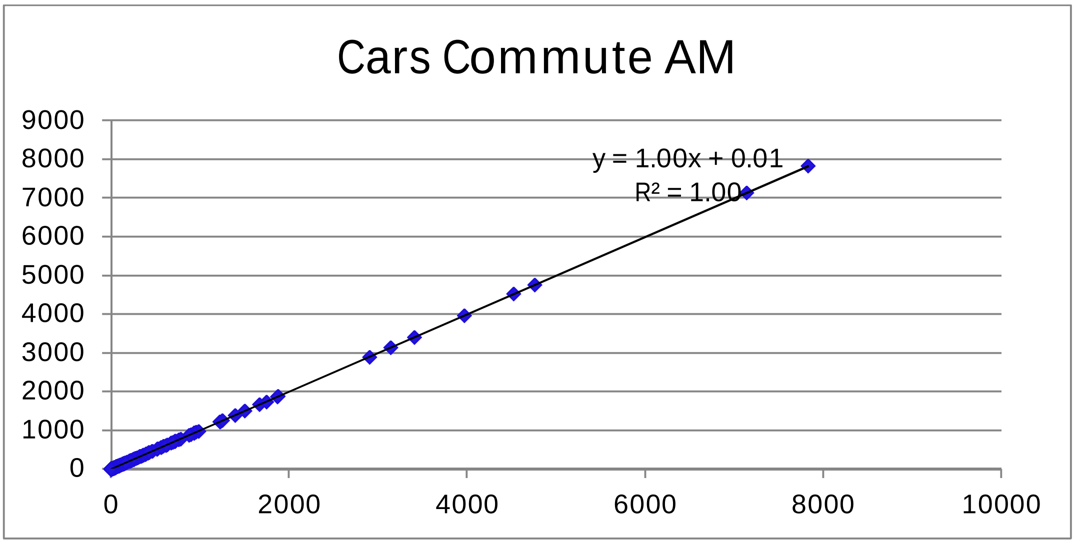
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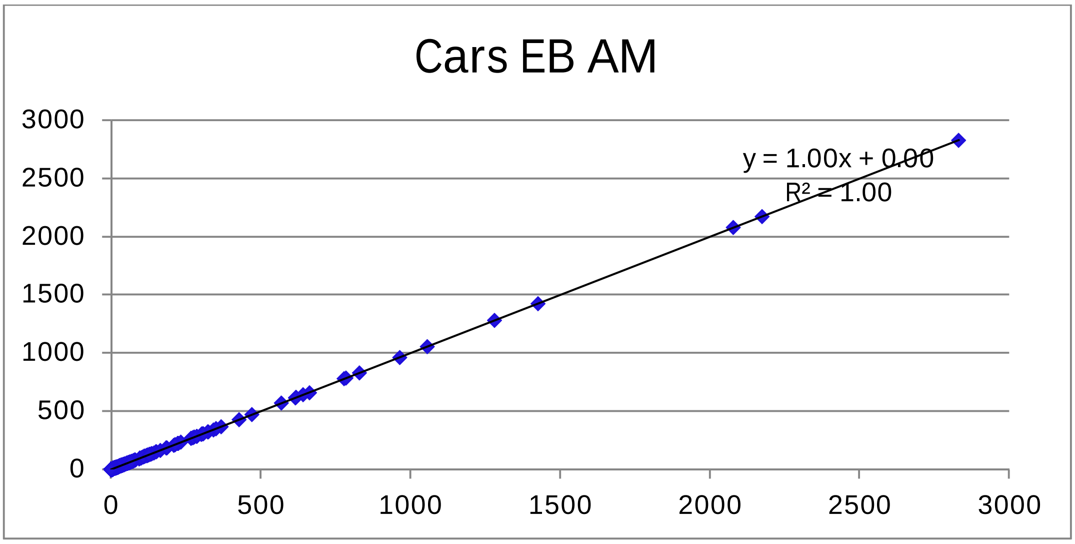
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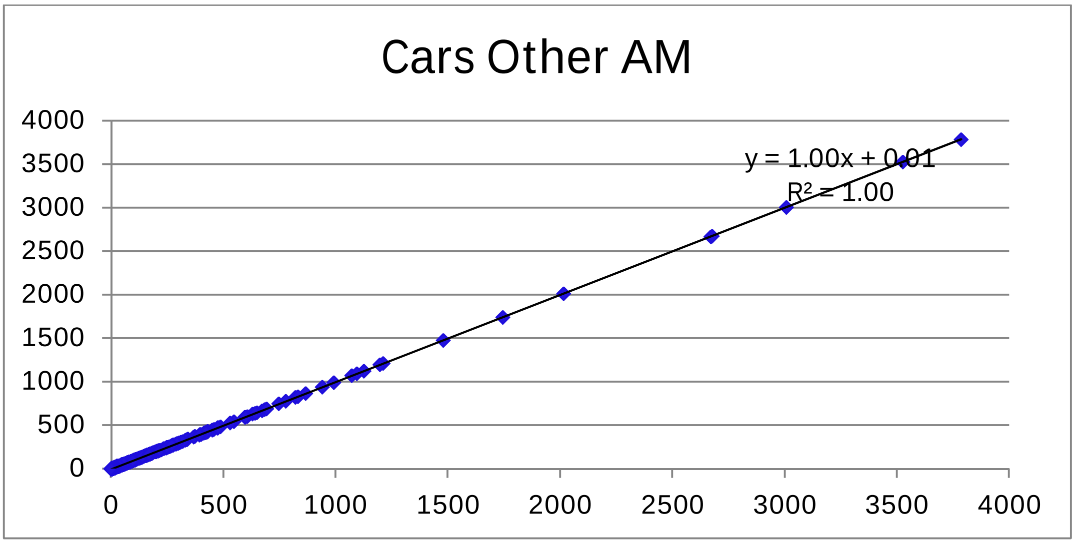
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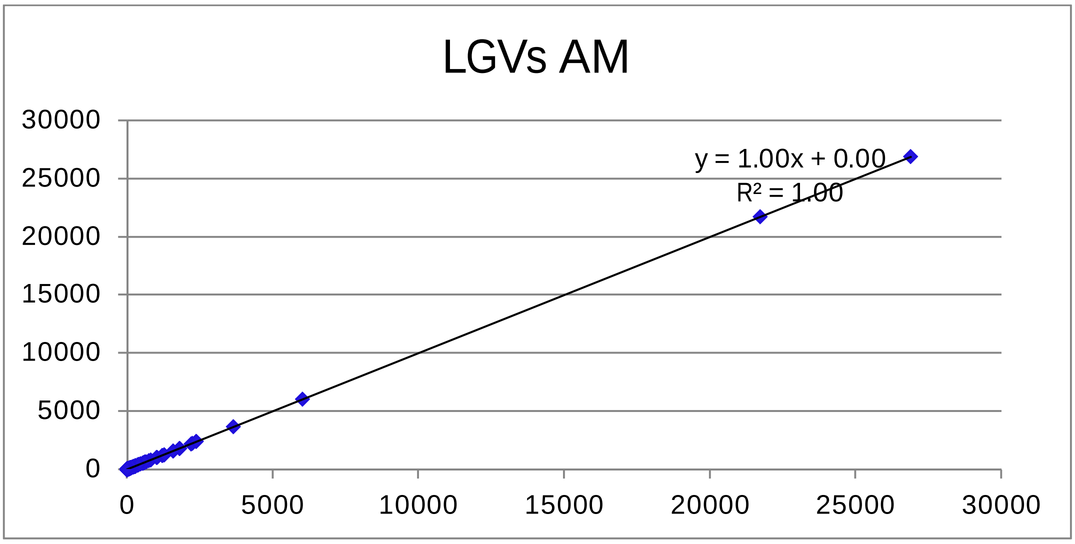
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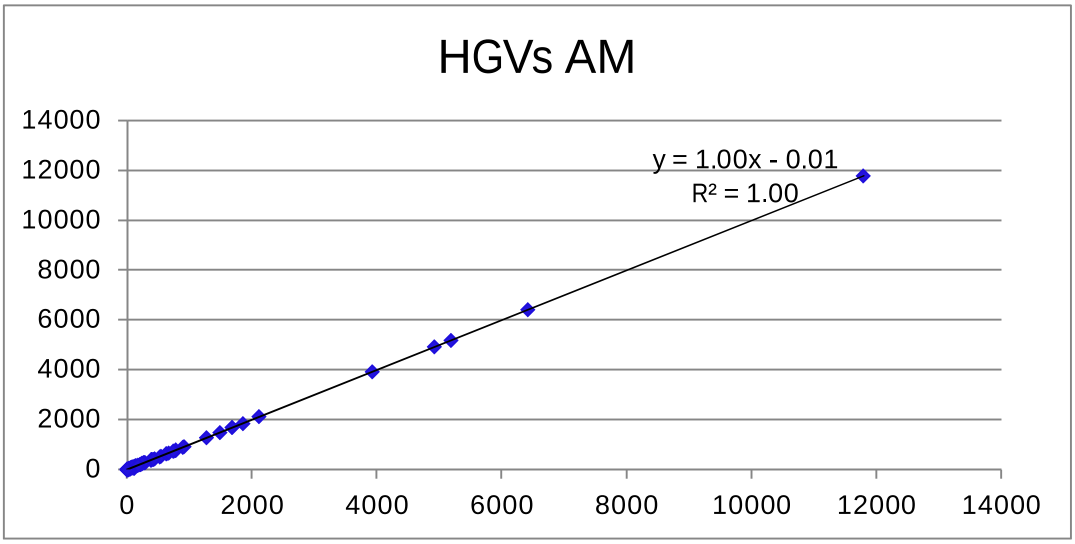
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14000

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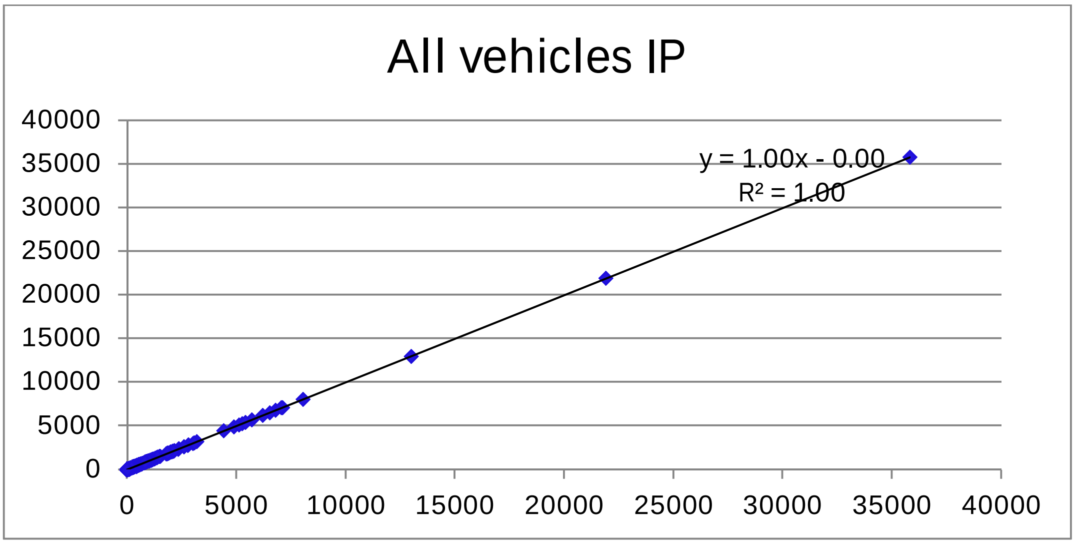
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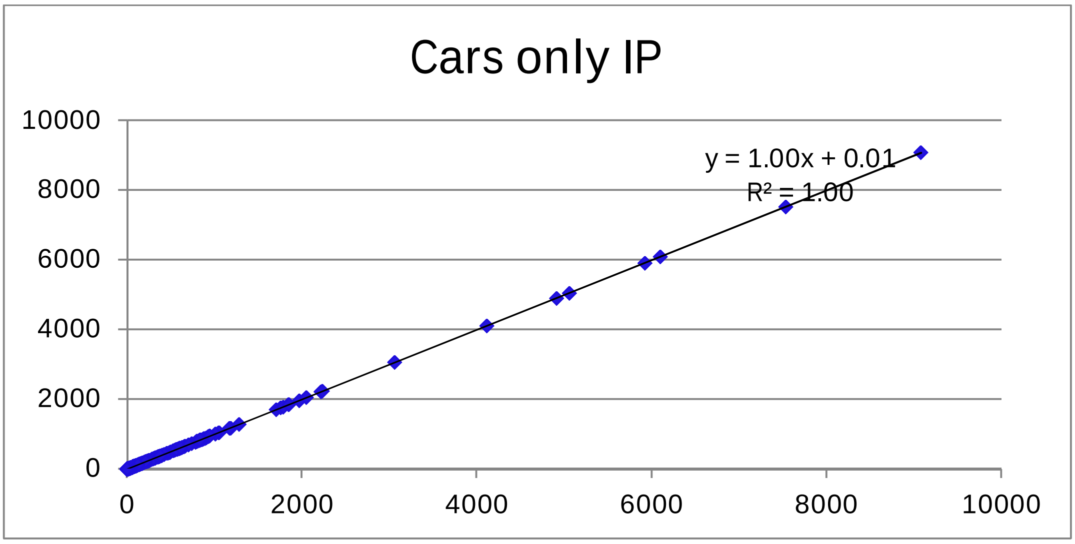
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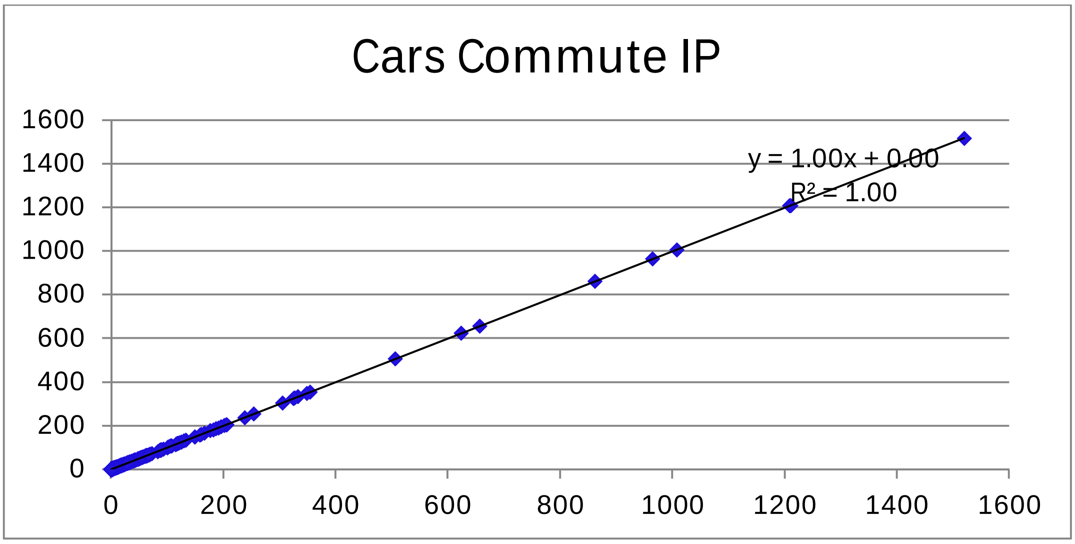
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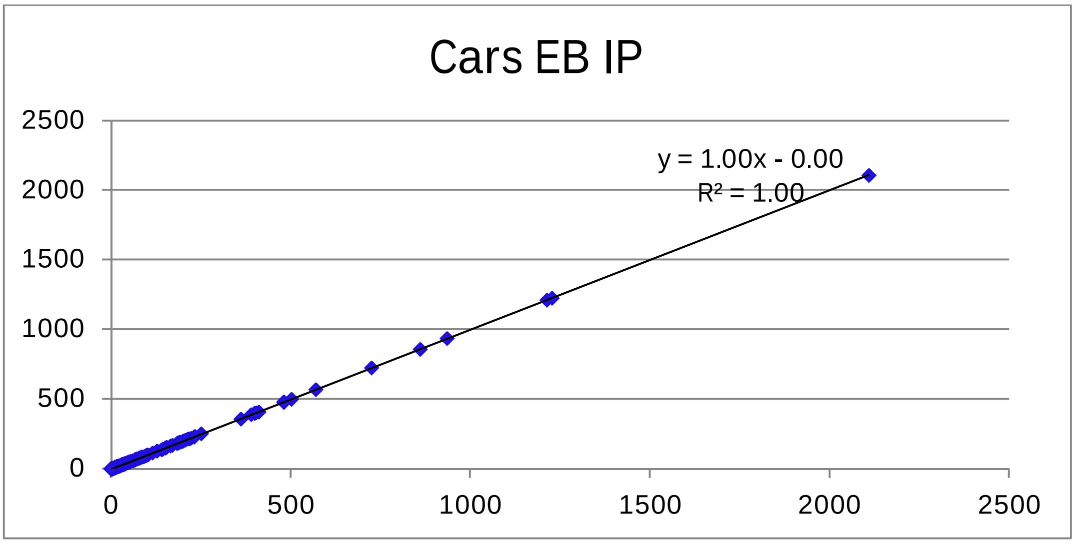
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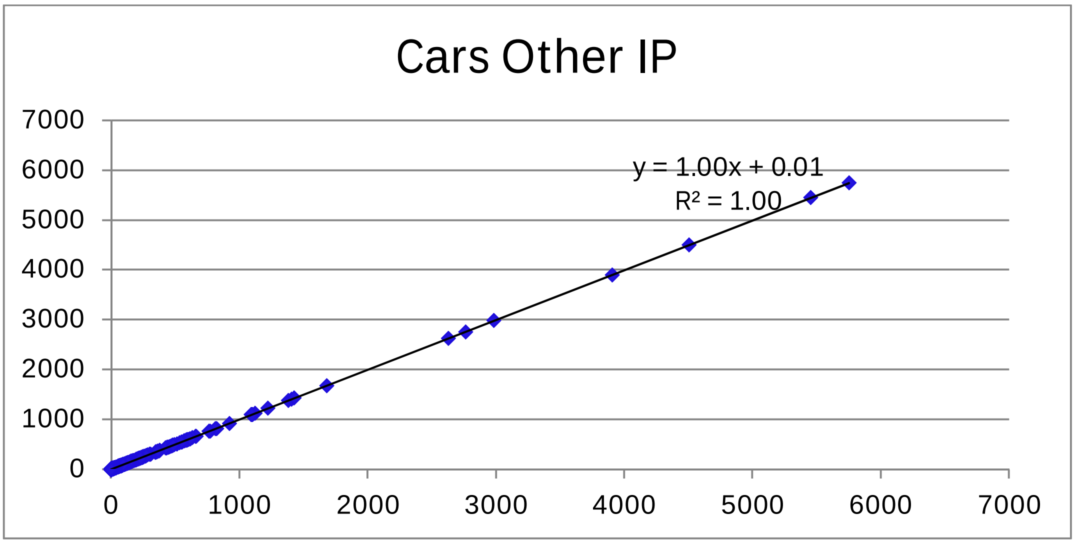
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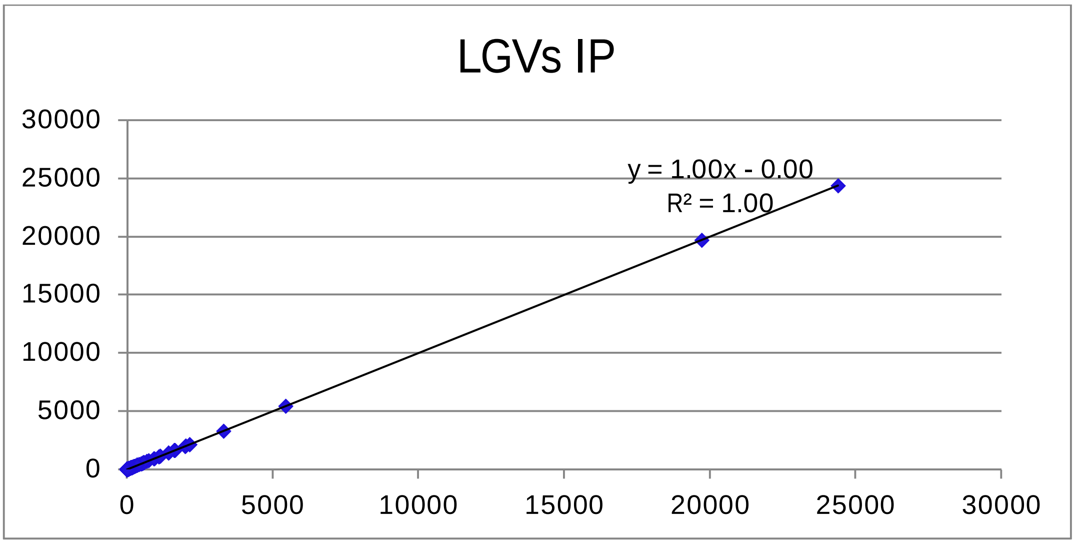
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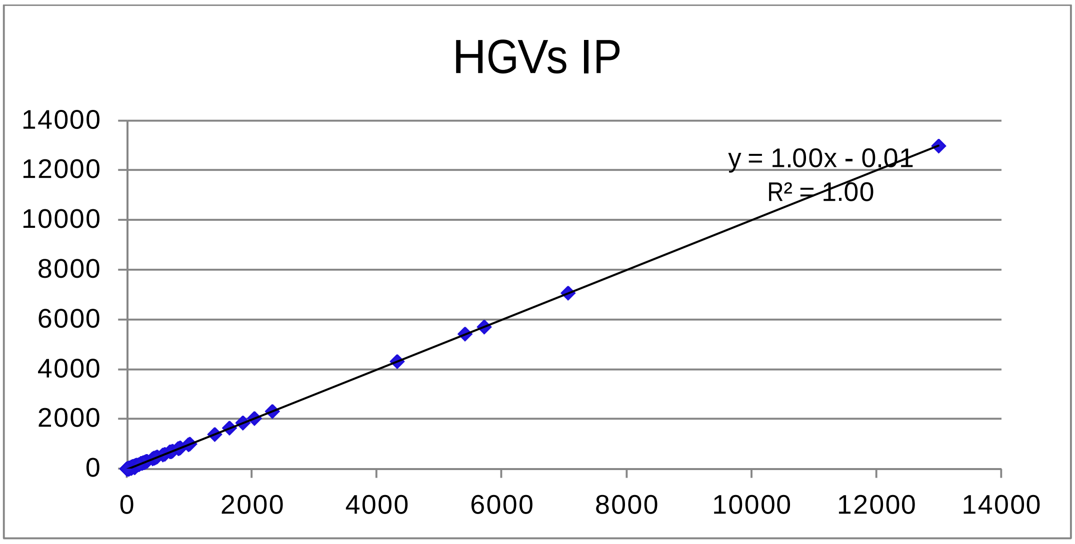
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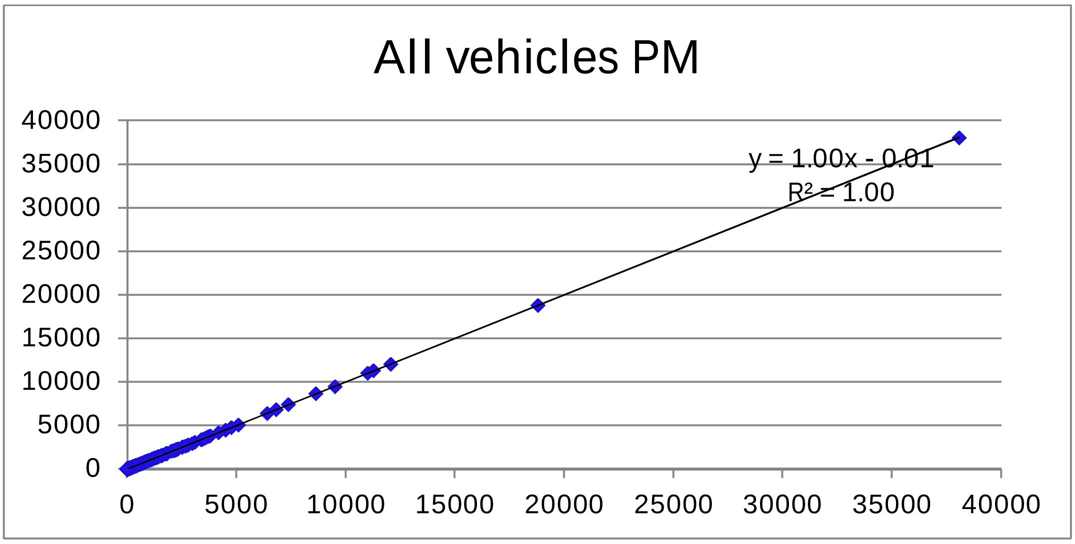
PM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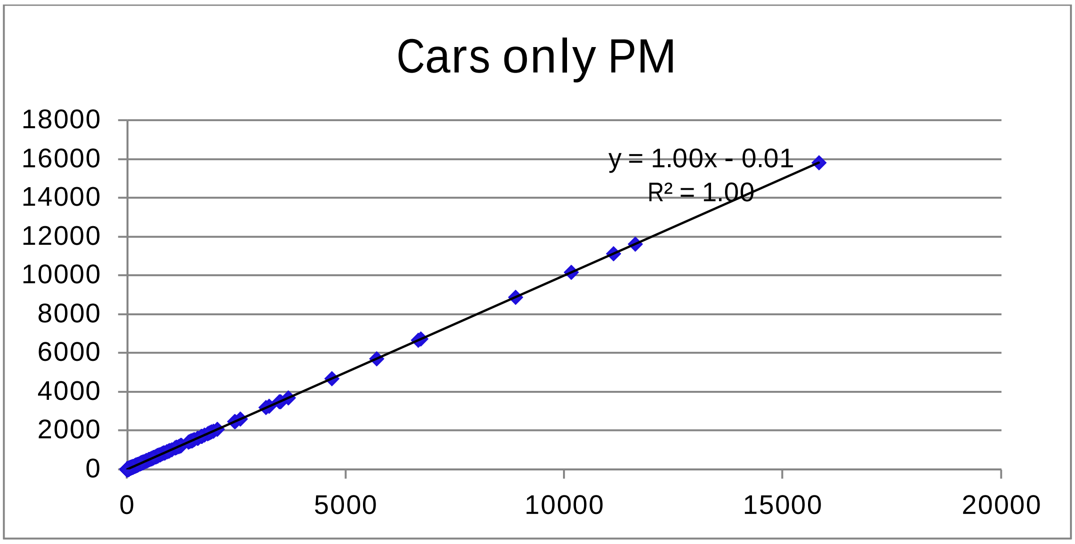
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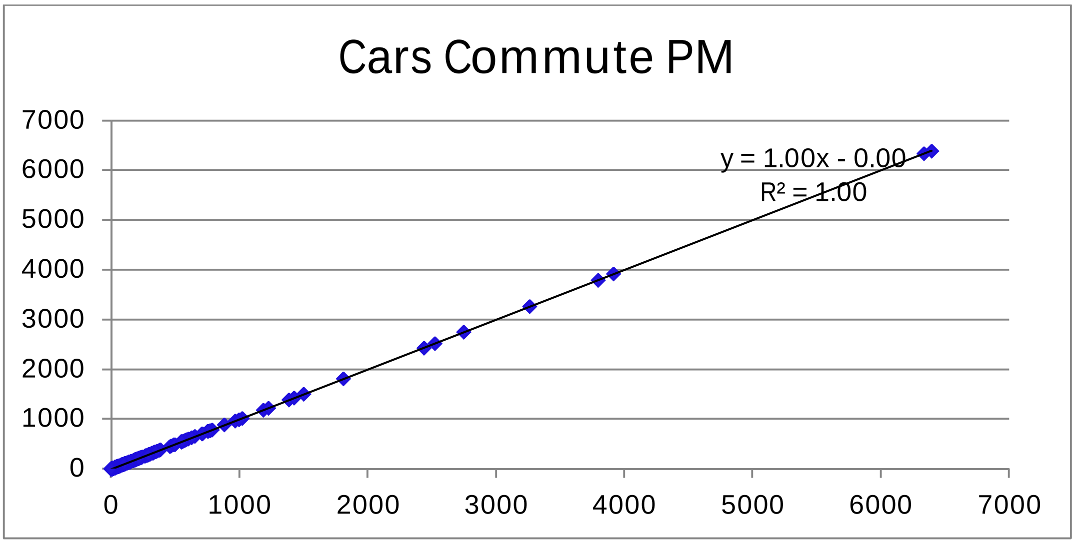
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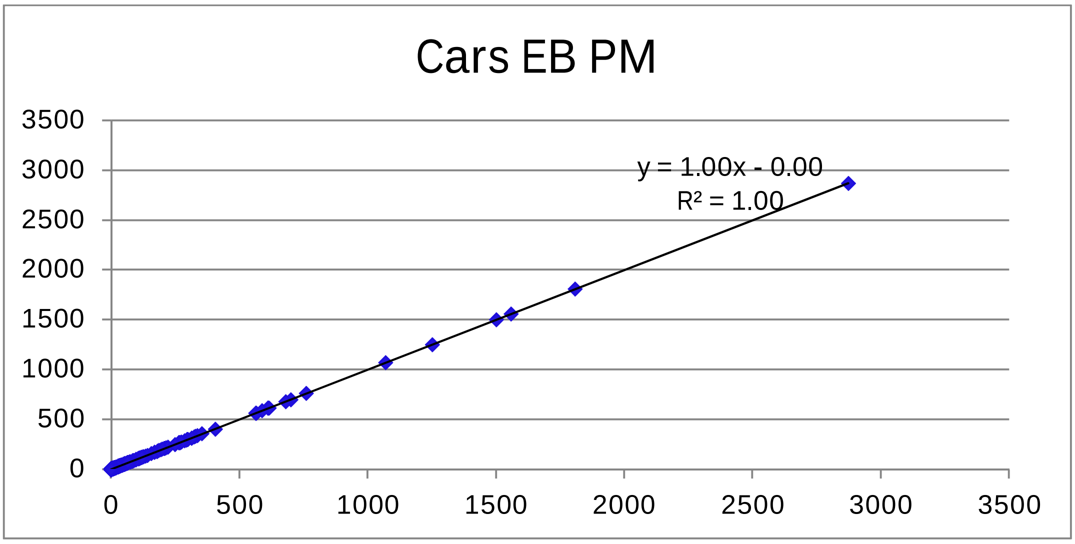
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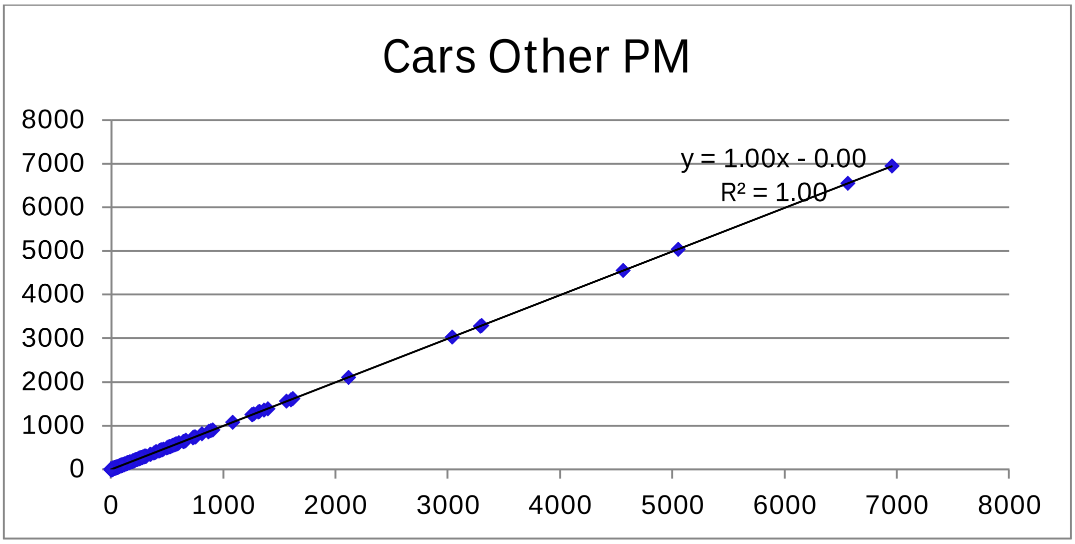
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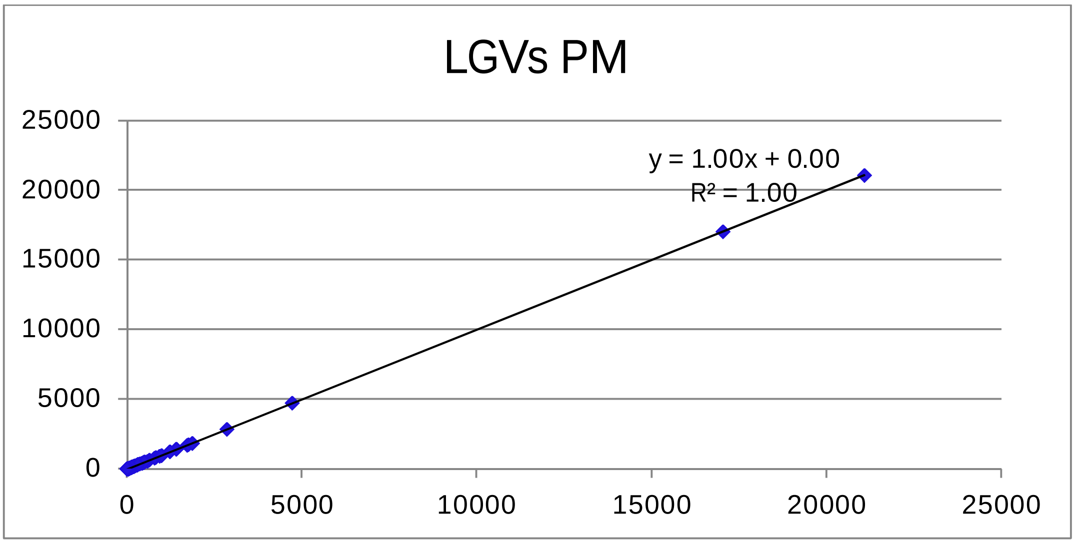
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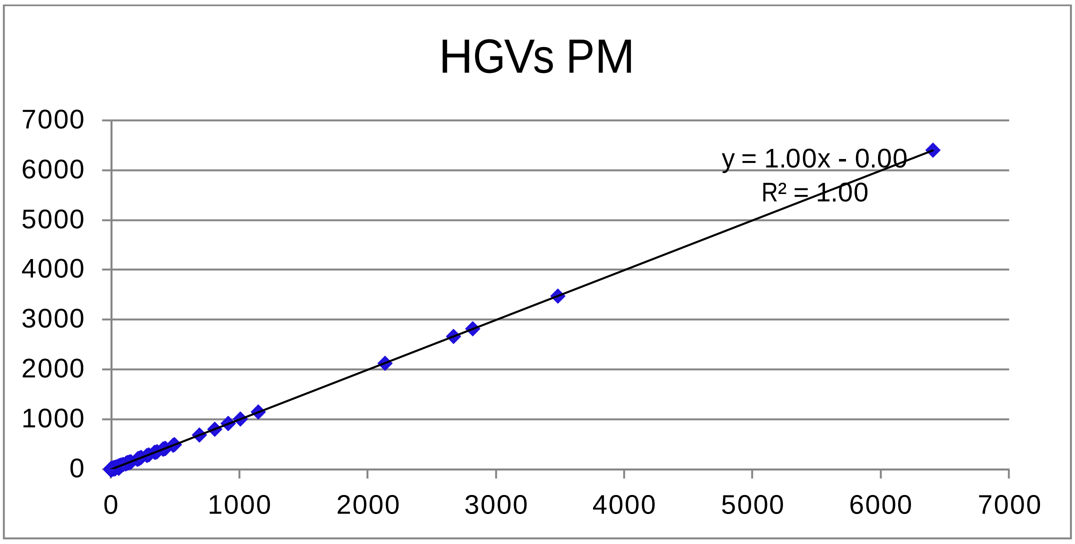
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Appendix I – Matrix Trip End Changes

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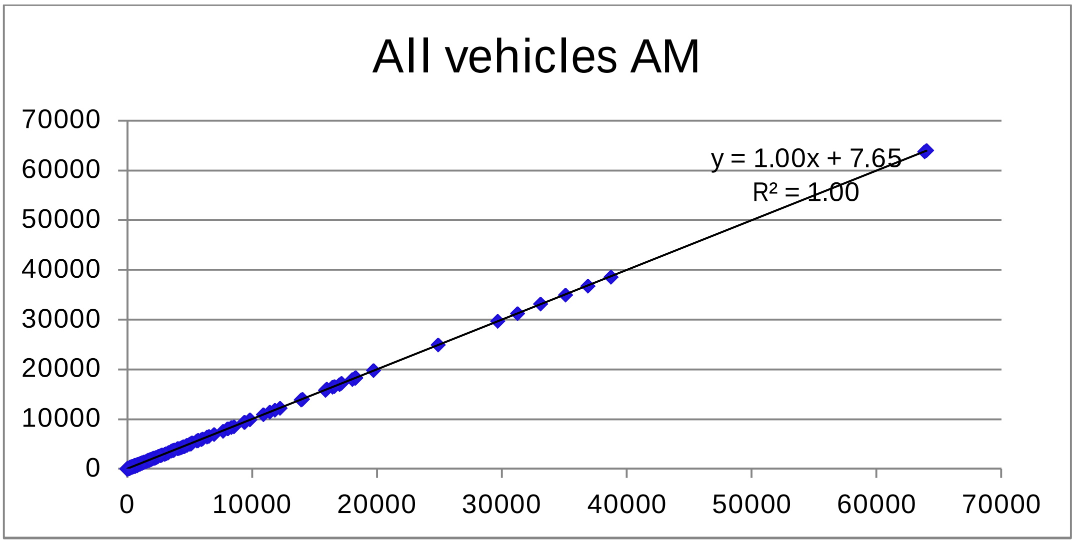
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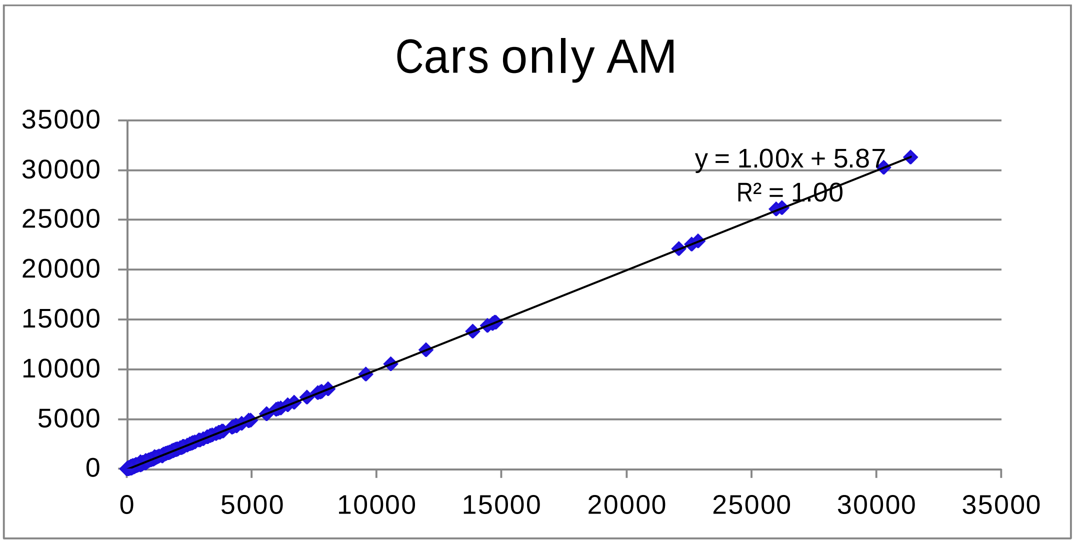
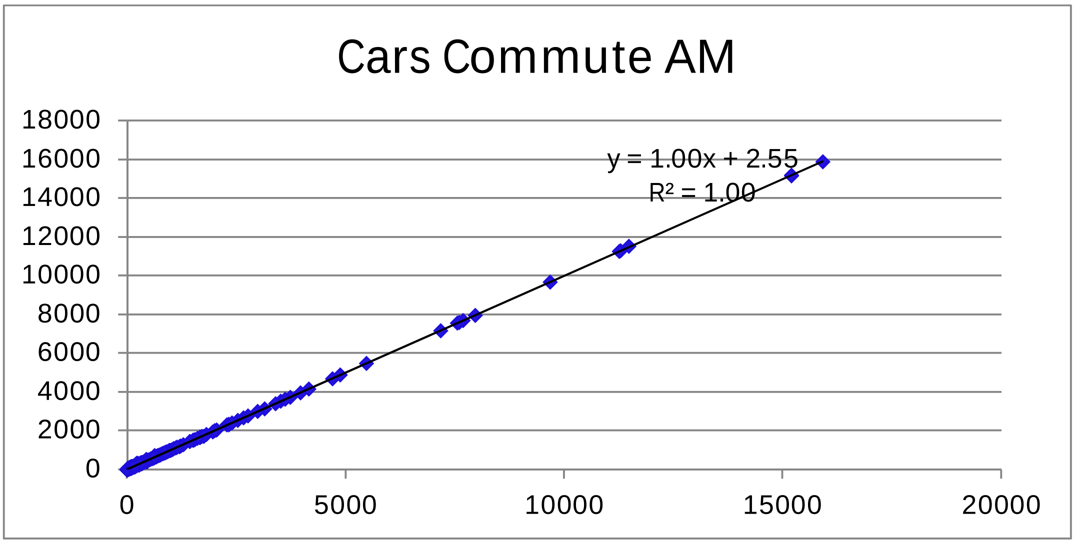
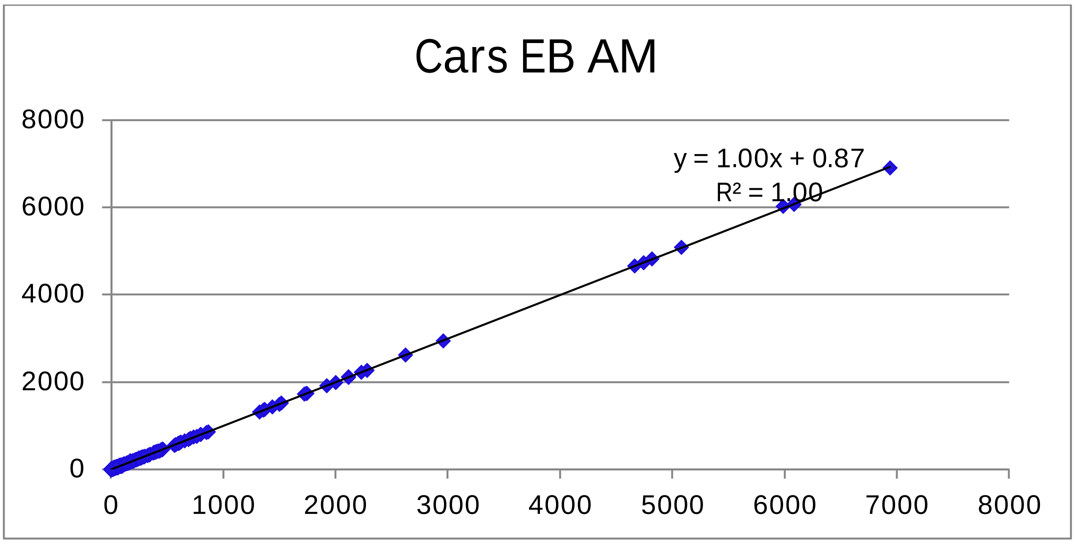
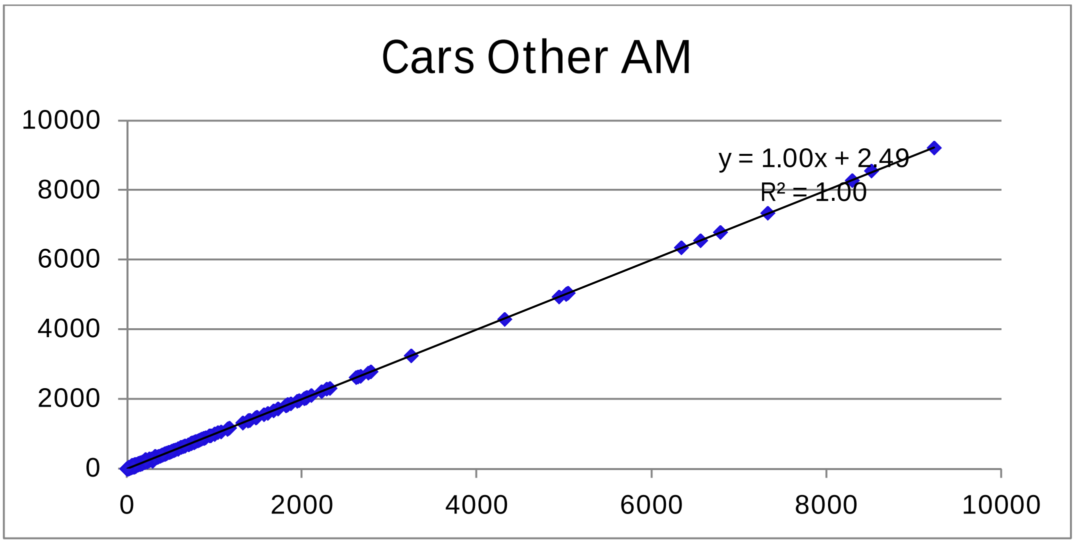
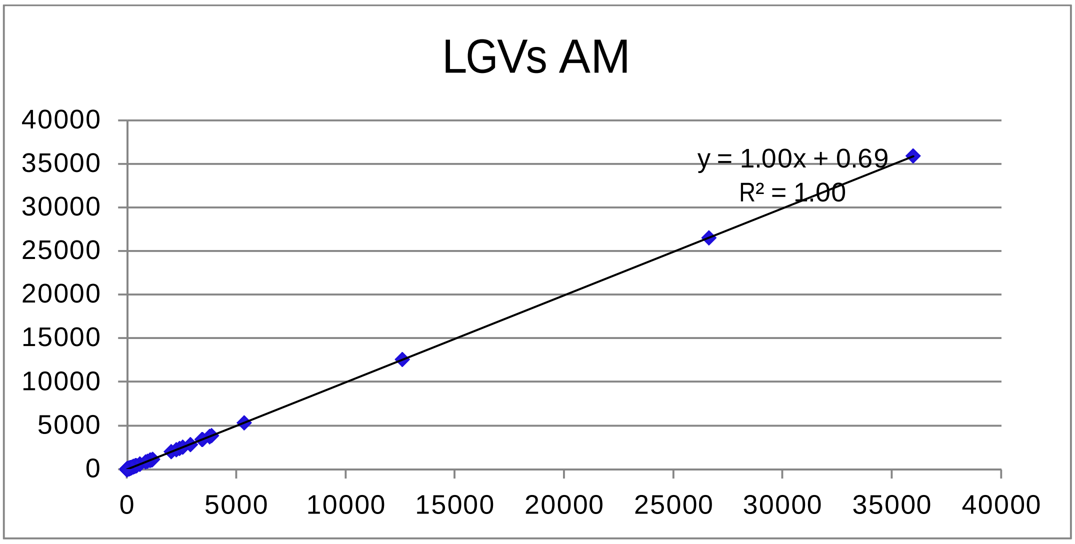
50000
60000
70000

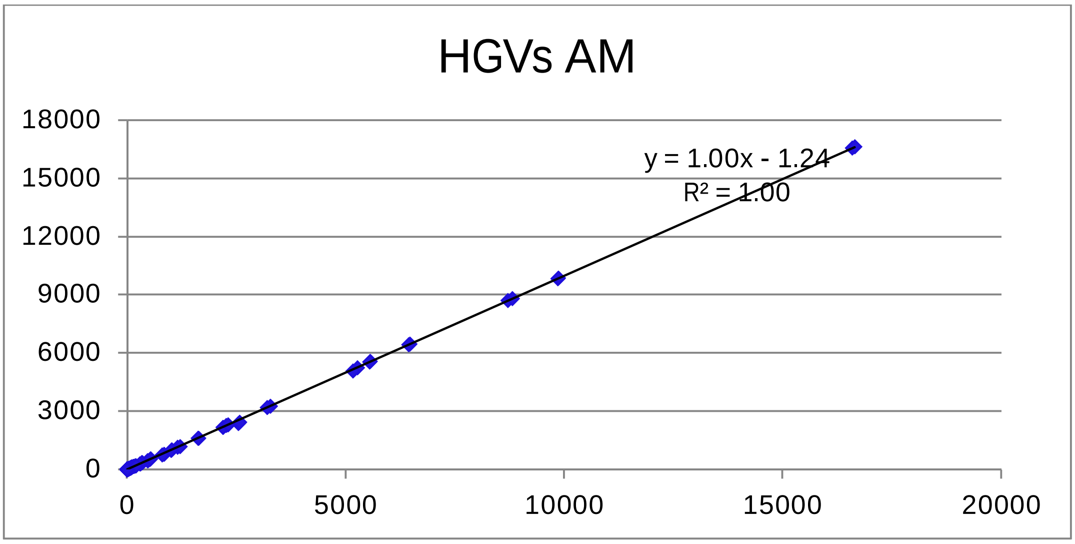

Cars only AM
y = 1.00x + 5.87
R² = 1.00
35000
30000
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000
30000
35000


Cars Commute AM
y = 1.00x + 2.55
R² = 1.00
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
5000
10000
15000
20000


Cars EB AM
y = 1.00x + 0.87
R² = 1.00
0
2000
4000
6000
8000
0
1000
2000
3000
4000
5000
6000
7000
8000

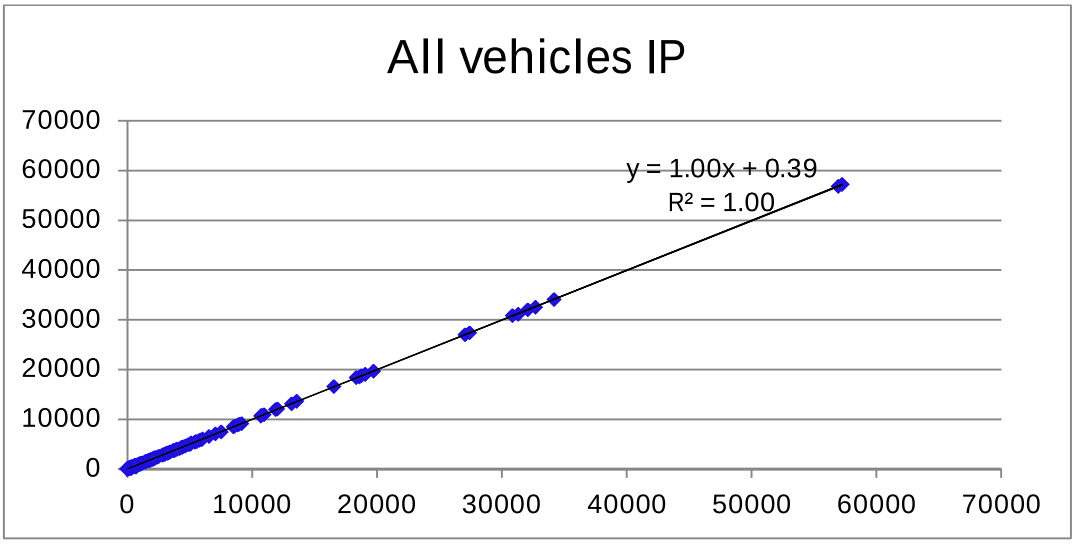

Cars Other AM
y = 1.00x + 2.49
R² = 1.00
0
2000
4000
6000
8000
10000
0
2000
4000
6000
8000
10000


LGVs AM
y = 1.00x + 0.69
R² = 1.00
0
5000
10000
15000
20000
25000
30000
35000
40000
0
5000
10000
15000
20000
25000
30000
35000
40000

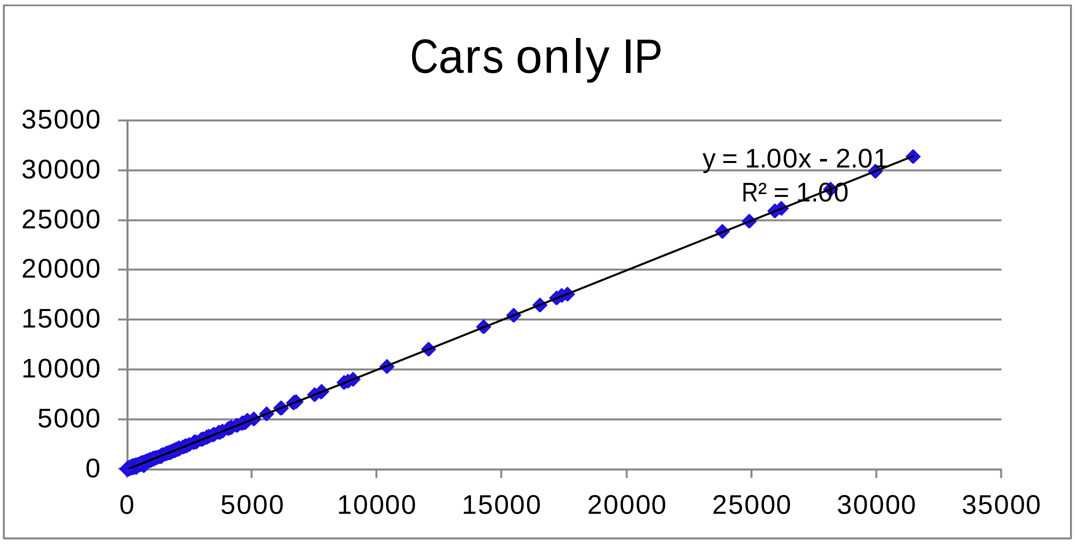


HGVs AM
y = 1.00x - 1.24
R² = 1.00
18000
15000
12000
9000
6000
3000
0
0
5000
10000
15000
20000

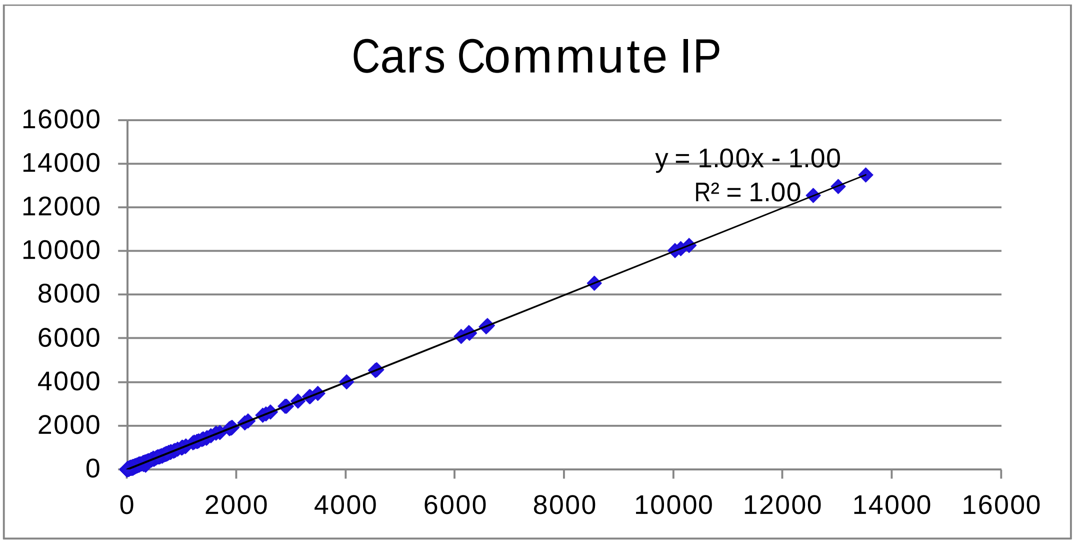
IP

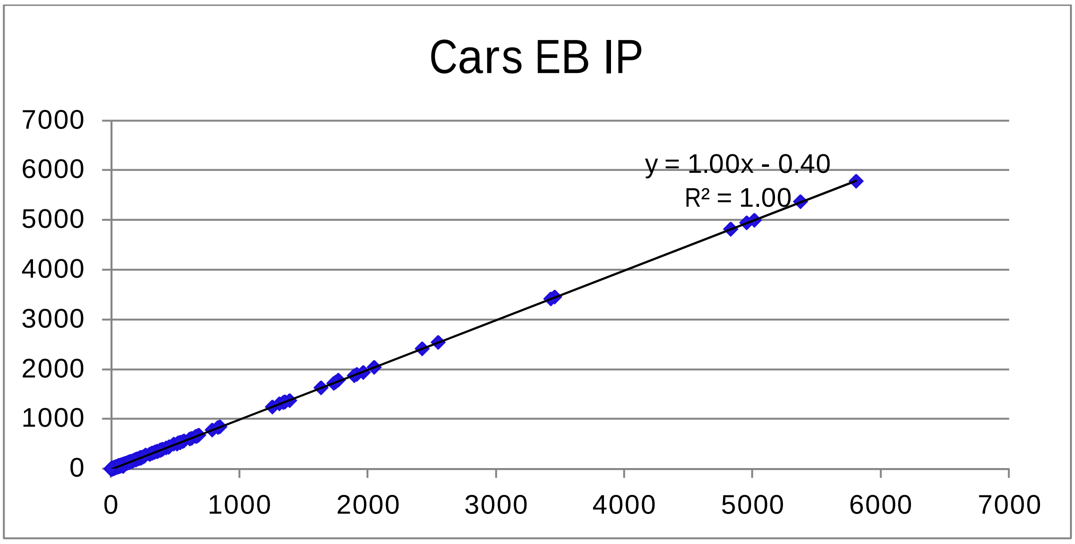


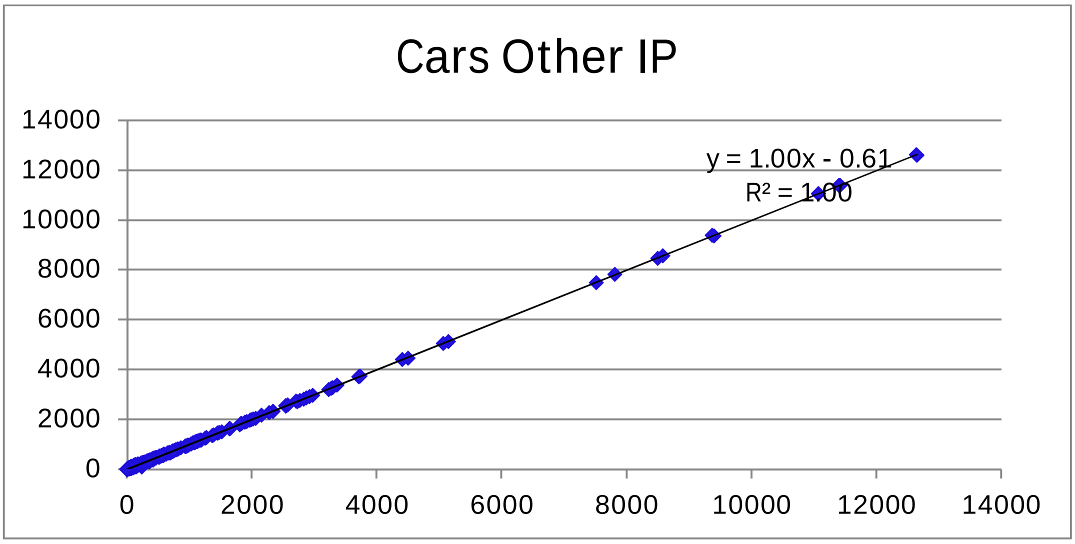
All vehicles IP
y = 1.00x + 0.39
R² = 1.00
70000
60000
50000
40000
30000
20000
10000
0
0
10000
20000
30000
40000
50000
60000
70000

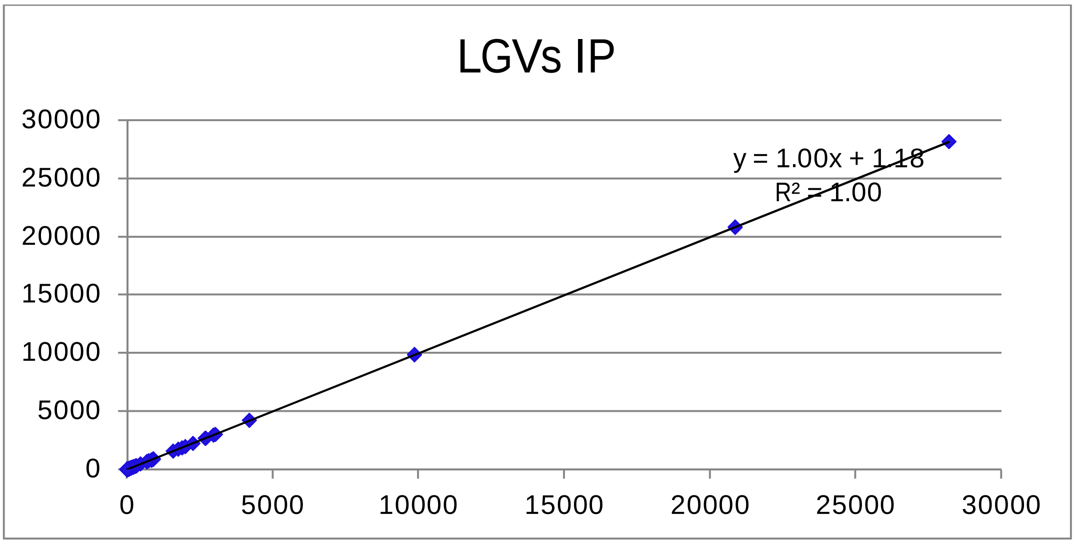


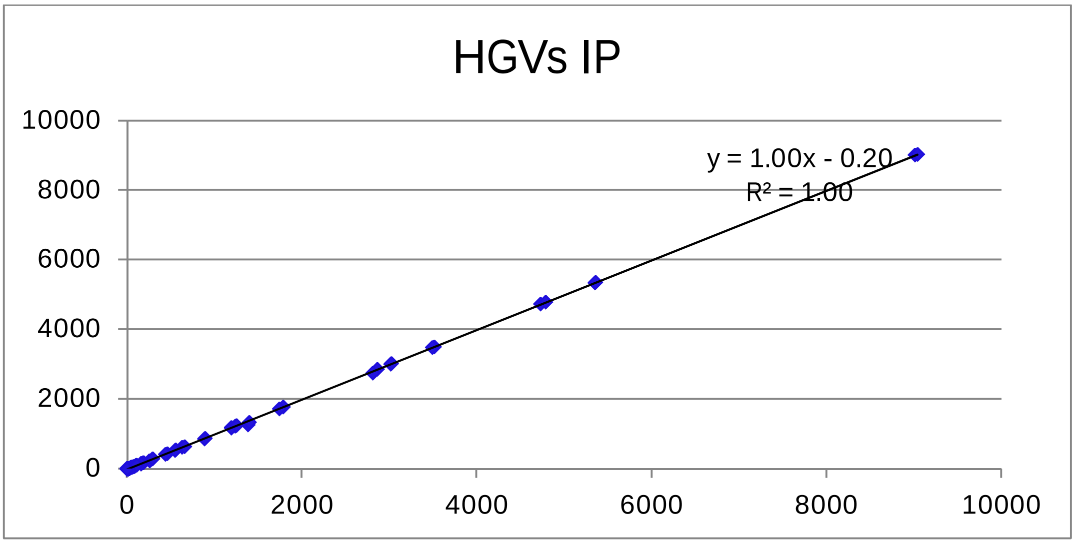
Cars only IP
y = 1.00x - 2.01
R² = 1.00
35000
30000
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000
30000
35000


Cars Commute IP
y = 1.00x - 1.00
R² = 1.00
16000
14000
12000
10000
8000
6000
4000
2000
0
0
2000
4000
6000
8000
10000
12000
14000
16000

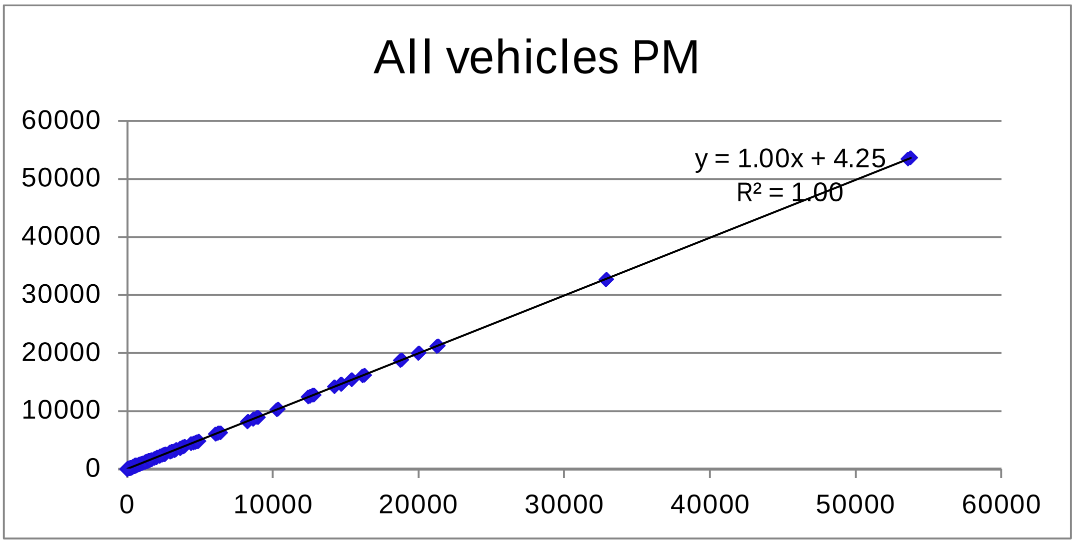

Cars EB IP
y = 1.00x - 0.40
R² = 1.00
7000
6000
5000
4000
3000
2000
1000
0
0
1000
2000
3000
4000
5000
6000
7000

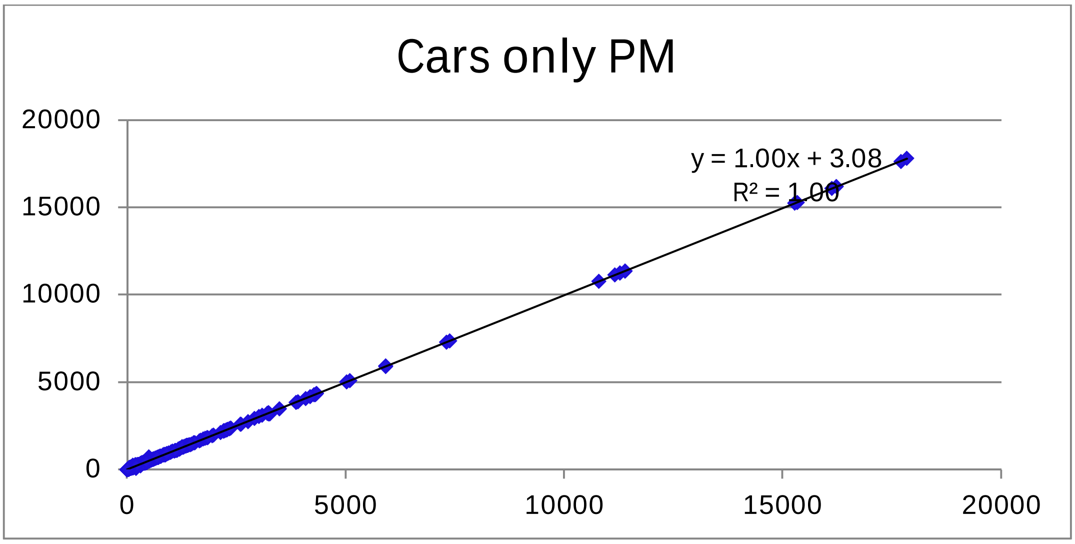

Cars Other IP
y = 1.00x - 0.61
R² = 1.00
14000
12000
10000
8000
6000
4000
2000
0
0
2000
4000
6000
8000
10000
12000
14000

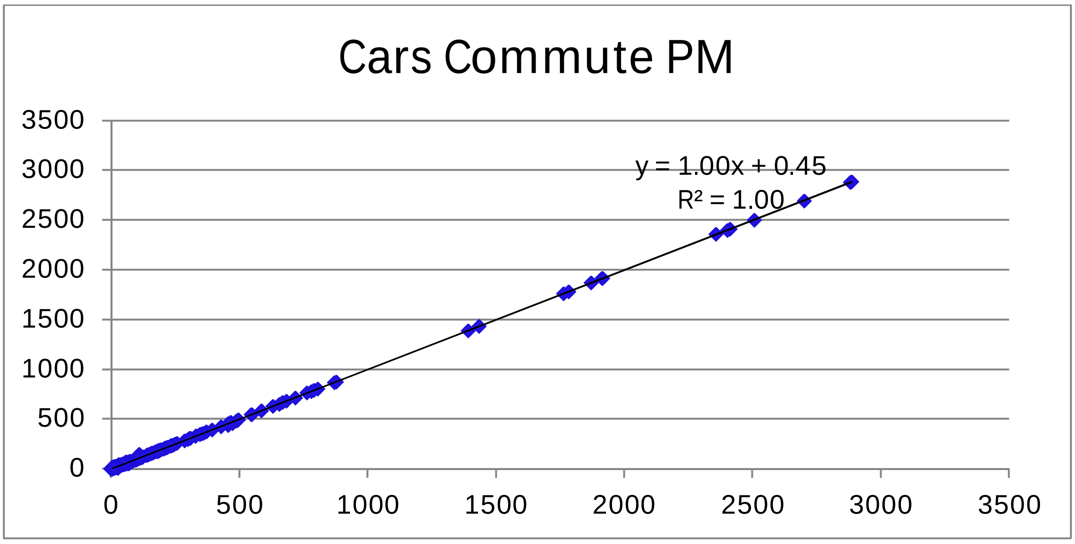

LGVs IP
y = 1.00x + 1.18
R² = 1.00
30000
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000
30000

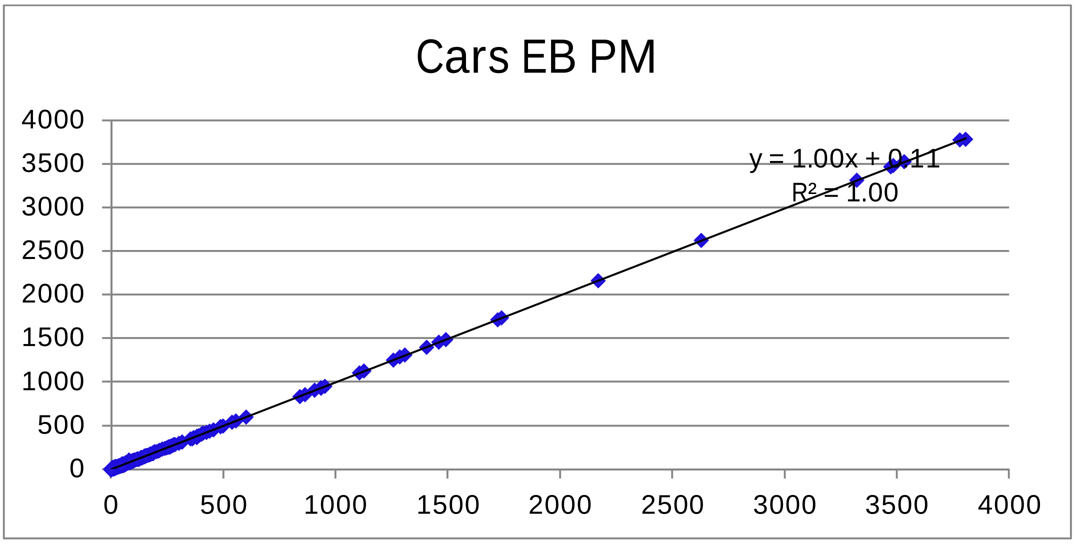

HGVs IP
y = 1.00x - 0.20
R² = 1.00
10000
8000
6000
4000
2000
0
0
2000
4000
6000
8000
10000

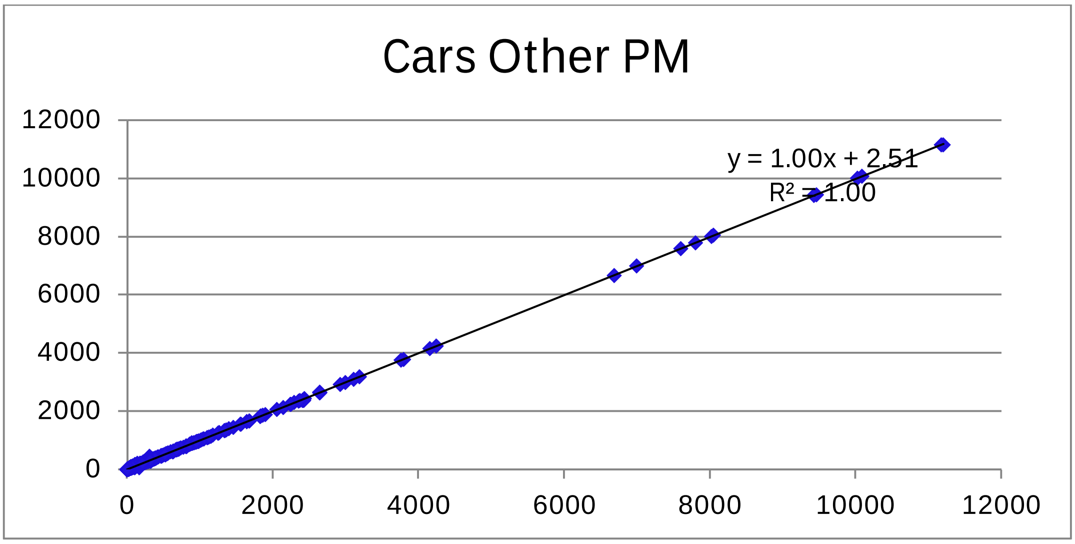
PM

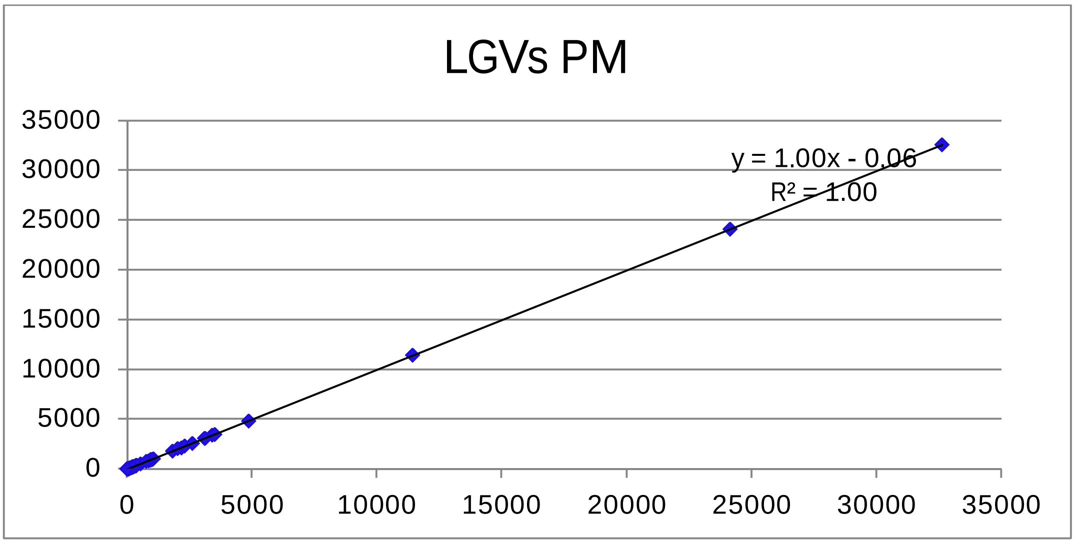

All vehicles PM
y = 1.00x + 4.25
R² = 1.00
60000
50000
40000
30000
20000
10000
0
0
10000
20000
30000
40000
50000
60000

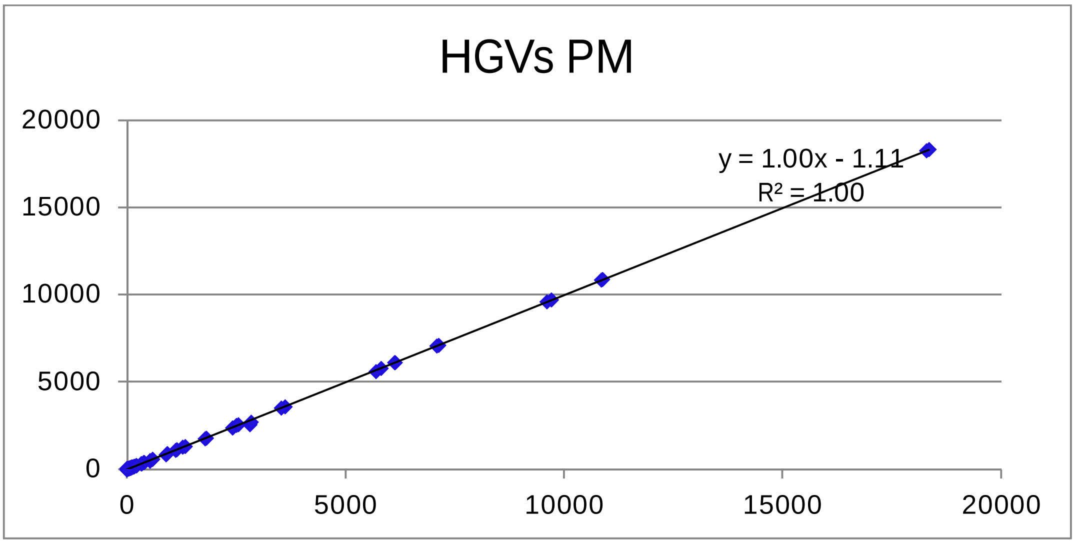

Cars only PM
y = 1.00x + 3.08
R² = 1.00
20000
15000
10000
5000
0
0
5000
10000
15000
20000


Cars Commute PM
y = 1.00x + 0.45
R² = 1.00
3500
3000
2500
2000
1500
1000
500
0
0
500
1000
1500
2000
2500
3000
3500


Cars EB PM
y = 1.00x + 0.11
R² = 1.00
4000
3500
3000
2500
2000
1500
1000
500
0
0
500
1000
1500
2000
2500
3000
3500
4000


Cars Other PM
y = 1.00x + 2.51
R² = 1.00
12000
10000
8000
6000
4000
2000
0
0
2000
4000
6000
8000
10000
12000


LGVs PM
y = 1.00x - 0.06
R² = 1.00
35000
30000
25000
20000
15000
10000
5000
0
0
5000
10000
15000
20000
25000
30000
35000


HGVs PM
y = 1.00x - 1.11
R² = 1.00
20000
15000
10000
5000
0
0
5000
10000
15000
20000

Appendix J - % Changes Sector to Sector

% Change Commute	North	East	South	West	London	External
North	15.32%	24.21%	3.54%	11.76%	23.24%	12.45%
East	23.59%	16.67%	15.43%	14.57%	23.53%	6.11%
South	-28.14%	12.16%	8.99%	11.79%	5.73%	-1.00%
West	12.84%	20.06%	21.34%	5.65%	5.24%	2.35%
London	-13.73%	1.26%	0.95%	-17.14%	0.00%	-0.16%
External	-2.50%	-1.36%	3.49%	16.12%	0.22%	-0.07%

Table 1: Percentage Change Commute AM

% Change Business	North	East	South	West	London	External
North	17.21%	33.68%	9.15%	6.70%	12.93%	10.53%
East	29.02%	31.59%	23.51%	20.90%	25.29%	6.82%
South	-19.79%	19.27%	4.05%	13.92%	13.01%	-0.71%
West	18.62%	36.60%	16.56%	5.79%	14.97%	7.16%
London	-13.55%	-12.88%	-3.16%	-13.83%	0.00%	-0.27%
External	-1.23%	-7.97%	4.42%	12.79%	0.73%	-0.06%

Table 2: Percentage Change Business AM

% Change Other	North	East	South	West	London	External
North	12.38%	23.91%	-1.06%	5.22%	13.51%	11.15%
East	14.52%	3.92%	10.45%	12.08%	29.12%	4.52%
South	-39.07%	6.99%	7.43%	11.24%	8.88%	1.79%
West	13.01%	17.65%	19.01%	5.01%	14.42%	7.88%
London	-14.09%	-14.59%	-3.39%	-0.69%	0.00%	-0.21%
External	-4.46%	-7.13%	5.05%	12.53%	0.37%	-0.03%

Table 3: Percentage Change Other AM

% Change LGV	North	East	South	West	London	External
North	28.11%	45.15%	5.92%	11.64%	-8.96%	13.35%
East	29.69%	22.43%	24.53%	2.76%	4.24%	17.19%
South	-2.33%	15.61%	10.10%	19.04%	14.45%	8.93%
West	35.00%	32.90%	29.04%	23.52%	30.51%	28.38%
London	-50.01%	-55.81%	-18.91%	-21.84%	0.00%	-1.33%
External	9.10%	18.04%	7.66%	3.45%	-0.88%	-0.20%

Table 4: Percentage Change LGV AM

% Change HGV	North	East	South	West	London	External
North	29.94%	47.49%	-42.06%	5.88%	-133.24%	-19.95%
East	43.54%	54.64%	25.80%	-47.14%	64.58%	57.02%
South	-16.32%	6.93%	-48.19%	-69.60%	-0.16%	-10.76%
West	47.66%	4.30%	-91.24%	11.35%	3.07%	-10.56%
London	-117.28%	18.37%	-45.64%	-14.29%	0.00%	-3.42%
External	-10.72%	62.51%	-43.81%	-9.64%	-3.77%	-0.46%

Table 5: Percentage Change HGV AM

% Change Commute	North	East	South	West	London	External
North	25.23%	9.91%	-11.21%	13.00%	6.13%	-1.15%
East	29.69%	7.63%	11.98%	24.08%	26.38%	14.30%
South	2.32%	-6.63%	1.77%	19.78%	8.19%	-1.15%
West	24.62%	16.38%	34.87%	13.79%	0.61%	2.58%
London	-14.55%	-4.14%	-5.60%	-10.54%	0.00%	-0.46%
External	-13.24%	-9.94%	-3.73%	-5.17%	-0.23%	-0.22%

Table 6: Percentage Change Commute IP

% Change Business	North	East	South	West	London	External
North	28.76%	8.93%	-14.52%	12.63%	7.65%	0.17%
East	33.39%	13.87%	19.32%	27.85%	25.16%	14.22%
South	3.39%	-11.96%	-6.88%	21.23%	12.39%	0.63%
West	28.81%	16.25%	39.75%	16.92%	-4.05%	3.49%
London	-17.40%	-11.81%	-4.35%	-19.49%	0.00%	-0.49%
External	-12.05%	-11.26%	-3.50%	-8.29%	-0.46%	-0.27%

Table 7: Percentage Change Business IP

% Change Other	North	East	South	West	London	External
North	22.89%	10.66%	-12.82%	8.05%	9.33%	-1.98%
East	22.69%	1.34%	5.09%	2.02%	23.92%	6.25%
South	0.84%	-2.32%	0.97%	17.91%	5.57%	-0.13%
West	22.05%	14.97%	36.60%	12.39%	-0.85%	-0.69%
London	-19.25%	-12.10%	-5.74%	-8.47%	0.00%	-0.33%
External	-14.57%	-10.32%	-3.23%	-9.84%	-0.34%	-0.15%

Table 8: Percentage Change Other IP

% Change LGV	North	East	South	West	London	External
North	37.94%	30.10%	11.88%	27.67%	-3.31%	19.39%
East	39.67%	13.73%	18.61%	33.19%	-46.43%	15.52%
South	18.14%	16.10%	6.23%	19.83%	-7.74%	2.64%
West	33.03%	12.67%	30.32%	22.63%	21.58%	16.85%
London	-50.72%	-103.89%	-55.93%	-18.51%	0.00%	-1.67%
External	-16.65%	-3.48%	-6.39%	-7.57%	-1.77%	-0.28%

Table 9: Percentage Change LGV IP

% Change HGV	North	East	South	West	London	External
North	62.27%	59.72%	-70.70%	14.48%	-126.14%	17.92%
East	34.84%	58.06%	28.95%	-17.59%	54.06%	58.20%
South	-41.95%	25.93%	-34.58%	-31.06%	-6.49%	-5.84%
West	37.36%	19.72%	-98.49%	14.73%	19.76%	0.85%
London	-99.10%	47.58%	-25.00%	-18.59%	0.00%	-3.03%
External	-4.68%	43.50%	-37.18%	-12.91%	-4.28%	-0.46%

Table 10: Percentage Change HGV IP

% Change Commute	North	East	South	West	London	External
North	6.59%	12.10%	-47.42%	-9.69%	-26.33%	0.70%
East	0.64%	11.80%	4.96%	-30.06%	19.18%	17.10%
South	-22.72%	-6.31%	-5.84%	-23.45%	-4.66%	-1.65%
West	6.59%	-8.82%	14.34%	-2.55%	4.20%	3.85%
London	-3.35%	2.46%	7.73%	9.20%	0.00%	-0.11%
External	-7.93%	-7.89%	1.32%	-7.65%	-0.27%	-0.23%

Table 11: Percentage Change Commute PM

% Change Business	North	East	South	West	London	External
North	11.07%	18.23%	-56.29%	-12.80%	-17.42%	3.38%
East	14.63%	23.89%	18.62%	-12.94%	31.28%	22.39%
South	-31.26%	-1.20%	-17.21%	-30.18%	-2.81%	-2.13%
West	4.05%	-3.25%	7.67%	-4.19%	12.97%	1.63%
London	-1.46%	5.91%	12.71%	2.83%	0.00%	-0.12%
External	-6.85%	-8.75%	1.65%	-7.59%	-0.73%	-0.42%

Table 12: Percentage Change Business PM

% Change Other	North	East	South	West	London	External
North	11.63%	17.73%	-46.67%	-3.75%	-27.36%	-2.61%
East	-2.93%	7.64%	-3.75%	-40.20%	11.84%	6.56%
South	-22.17%	-2.70%	-2.81%	-20.86%	-12.63%	-0.76%
West	7.34%	-6.85%	12.20%	-0.45%	6.99%	0.68%
London	2.96%	11.19%	8.20%	10.78%	0.00%	-0.06%
External	-5.47%	-8.90%	-0.13%	-2.82%	-0.41%	-0.16%

Table 13: Percentage Change Other PM

% Change LGV	North	East	South	West	London	External
North	39.30%	48.42%	41.27%	31.51%	12.18%	31.45%
East	50.44%	33.02%	35.42%	19.07%	-2.05%	31.49%
South	21.30%	26.32%	19.03%	26.78%	7.73%	18.68%
West	50.17%	34.99%	66.75%	38.05%	36.54%	36.17%
London	-50.19%	-34.11%	-22.18%	-19.96%	0.00%	-0.98%
External	-14.97%	1.47%	3.92%	-14.74%	-1.73%	-0.27%

Table14: Percentage Change LGV PM

% Change HGV	North	East	South	West	London	External
North	36.43%	70.79%	34.69%	31.21%	-47.65%	21.24%
East	34.60%	52.29%	25.74%	-142.40%	77.83%	65.06%
South	19.65%	42.22%	5.04%	-52.61%	21.69%	4.88%
West	73.24%	65.07%	24.84%	58.49%	16.96%	20.98%
London	25.25%	74.66%	13.95%	-60.20%	0.00%	-2.68%
External	27.38%	62.22%	-6.78%	-32.99%	-4.05%	-0.47%

Table 15: Percentage Change HGV PM

Appendix K – Absolute Changes Sector to Sector

Absolute Change Commute	North	East	South	West	London	External
North	235	32	12	42	37	145
East	92	11	29	13	15	31
South	-137	14	47	31	10	-13
West	48	8	37	9	3	8
London	-17	0	1	-6	0	-13
External	-51	-4	45	101	24	-70

Table 1: Absolute Change Commute AM

Absolute Change Business	North	East	South	West	London	External
North	50	20	9	5	12	75
East	26	5	9	6	7	15
South	-20	5	3	7	9	-4
West	14	6	6	2	5	14
London	-12	-2	-2	-3	0	-14
External	-9	-9	20	28	35	-20

Table 2: Absolute Change Business AM

Absolute Change Other	North	East	South	West	London	External
North	295	45	-3	20	12	87
East	57	11	23	5	13	14
South	-111	12	99	23	10	13
West	55	6	39	19	6	16
London	-10	-2	-2	0	0	-15
External	-41	-16	37	28	29	-27

Table 3: Absolute Change Other AM

Absolute Change LGV	North	East	South	West	London	External
North	92	28	4	5	-2	44
East	15	11	9	0	0	25
South	-1	5	19	6	4	30
West	22	3	10	12	4	38
London	-7	-2	-4	-2	0	-83
External	29	26	25	3	-55	-222

Table 4: Absolute Change LGV AM

Absolute Change HGV	North	East	South	West	London	External
North	7	2	-2	0	-19	-25
East	2	0	0	0	10	30
South	-1	0	-1	-1	0	-8
West	3	0	-1	0	0	-3
London	-22	1	-6	-1	0	-79
External	-15	39	-24	-3	-85	-300

Table 5: Absolute Change HGV AM

Absolute Change Commute	North	East	South	West	London	External
North	99	8	-14	14	2	-5
East	15	1	5	4	2	15
South	2	-3	3	15	2	-4
West	24	4	35	7	0	3
London	-3	0	-2	-1	0	-9
External	-39	-11	-12	-5	-4	-50

Table 6: Absolute Change Commute IP

Absolute Change Business	North	East	South	West	London	External
North	60	4	-10	8	4	1
East	15	1	4	4	3	15
South	2	-2	-4	9	5	2
West	15	3	18	4	-1	5
London	-7	-1	-1	-3	0	-14
External	-50	-14	-11	-11	-14	-61

Table 7: Absolute Change Business IP

Absolute Change Other	North	East	South	West	London	External
North	529	42	-55	40	9	-24
East	66	3	13	1	8	25
South	4	-6	13	63	6	-1
West	97	10	134	48	0	-2
London	-12	-3	-5	-3	0	-30
External	-149	-45	-32	-28	-32	-151

Table 8: Absolute Change Other IP

Absolute Change LGV	North	East	South	West	London	External
North	128	13	7	14	-1	62
East	20	6	6	3	-2	20
South	12	5	10	6	-1	8
West	18	1	10	10	2	18
London	-7	-3	-7	-1	0	-94
External	-37	-4	-17	-6	-100	-279

Table 9: Absolute Change LGV IP

Absolute Change HGV	North	East	South	West	London	External
North	27	4	-4	1	-21	36
East	1	1	1	0	7	35
South	-3	0	-1	-1	-1	-5
West	2	0	-1	0	2	0
London	-22	6	-5	-2	0	-78
External	-8	20	-24	-5	-105	-334

Table 10: Absolute Change HGV IP

Absolute Change Commute	North	East	South	West	London	External
North	78	39	-162	-23	-28	12
East	1	6	5	-7	4	57
South	-50	-8	-25	-30	-4	-17
West	17	-6	44	-3	2	18
London	-4	1	12	4	0	-11
External	-64	-29	15	-20	-21	-179

Table 11: Absolute Change Commute PM

Absolute Change Business	North	East	South	West	London	External
North	28	15	-37	-7	-12	24
East	6	3	4	-2	5	32
South	-20	0	-10	-9	-1	-9
West	2	-1	4	-1	4	3
London	-1	1	7	1	0	-5
External	-37	-16	8	-12	-34	-127

Table 12: Absolute Change Business PM

Absolute Change Other	North	East	South	West	London	External
North	313	98	-189	-18	-19	-34
East	-8	20	-9	-20	3	29
South	-98	-7	-41	-64	-11	-9
West	35	-4	47	-2	3	2
London	3	4	10	5	0	-6
External	-68	-42	-1	-9	-40	-190

Table 13: Absolute Change Other PM

Absolute Change LGV	North	East	South	West	London	External
North	117	25	32	14	2	103
East	27	15	12	1	0	43
South	12	8	31	7	1	55
West	32	3	40	19	4	43
London	-6	-1	-3	-1	0	-48
External	-29	1	10	-10	-84	-236

Table 14: Absolute Change LGV PM

Absolute Change HGV	North	East	South	West	London	External
North	5	3	2	1	-6	22
East	1	0	0	0	10	23
South	1	0	0	0	3	2
West	5	1	0	1	1	5
London	7	10	2	-2	0	-34
External	31	21	-3	-5	-49	-167

Table 15: Absolute Change HGV PM

Appendix L – GEH Values Sector to Sector

GEH Change - Commute	North	East	South	West	London	External
North	6.25	2.98	0.64	2.28	3.14	4.39
East	4.96	1.44	2.19	1.43	2.03	1.39
South	5.81	1.37	2.11	1.98	0.76	0.37
West	2.57	1.3	2.95	0.74	0.37	0.43
London	1.47	0.05	0.09	0.99	0	0.14
External	1.12	0.25	1.27	4.2	0.23	0.23

Table 1: GEH Commute AM

GEH Change - Business	North	East	South	West	London	External
North	3.08	2.84	0.93	0.59	1.29	2.89
East	2.99	1.33	1.55	1.16	1.45	1.03
South	1.9	1.02	0.35	1.01	1.12	0.16
West	1.72	1.67	1.04	0.31	0.91	1
London	1.23	0.46	0.23	0.65	0	0.19
External	0.34	0.85	0.96	1.96	0.51	0.11

Table 2: GEH Business AM

GEH Change - Other	North	East	South	West	London	External
North	6.24	3.49	0.17	1.03	1.31	3.2
East	2.98	0.66	1.58	0.84	2.11	0.81
South	6.03	0.93	2.76	1.64	0.95	0.49
West	2.76	1.04	2.85	1	0.96	1.15
London	1.16	0.55	0.26	0.04	0	0.18
External	1.34	1.04	1.39	1.95	0.33	0.1

Table 3: GEH Other AM

GEH Change - LGV	North	East	South	West	London	External
North	5.49	4.06	0.47	0.81	0.39	2.51
East	2.26	1.68	1.62	0.07	0.11	2.16
South	0.18	0.95	1.41	1.12	0.77	1.68
West	3.04	1.07	1.88	1.8	1.19	3.56
London	1.73	1.03	0.79	0.56	0	1.05
External	1.66	2.29	1.42	0.35	0.7	0.67

Table 4: GEH LGV AM

GEH Change - HGV	North	East	South	West	London	External
North	1.52	1.15	0.9	0.12	3.95	2.13
East	1	0.57	0.35	0.26	3.01	4.93
South	0.41	0.08	0.72	0.64	0.01	0.88
West	1.46	0.03	0.76	0.12	0.09	0.59
London	4	0.53	1.55	0.4	0	1.63
External	1.23	5.96	2.95	0.55	1.77	1.17

Table 5: GEH HGV AM

GEH Change - Commute	North	East	South	West	London	External
North	5.34	0.89	1.24	1.39	0.34	0.25
East	2.3	0.32	0.77	1.05	0.72	1.51
South	0.24	0.43	0.23	1.82	0.4	0.21
West	2.62	0.81	3.83	0.99	0.02	0.29
London	0.67	0.12	0.29	0.31	0	0.2
External	2.21	1.02	0.67	0.51	0.09	0.33

Table 6: GEH Commute IP

GEH Change - Business	North	East	South	West	London	External
North	4.5	0.64	1.14	1.02	0.59	0.04
East	2.41	0.43	0.93	1.2	0.9	1.5
South	0.29	0.52	0.5	1.42	0.8	0.11
West	2.25	0.67	2.98	0.83	0.17	0.4
London	1.04	0.39	0.25	0.69	0	0.26
External	2.38	1.2	0.61	0.92	0.25	0.41

Table 7: GEH Business IP

GEH Change - Other	North	East	South	West	London	External
North	11.69	2.18	2.57	1.83	0.95	0.69
East	4.1	0.21	0.82	0.15	1.48	1.26
South	0.18	0.38	0.36	3.51	0.57	0.04
West	4.9	1.25	7.75	2.52	0.05	0.12
London	1.48	0.62	0.53	0.49	0	0.31
External	4.51	2.09	1.01	1.61	0.33	0.47

Table 8: GEH Other IP

GEH Change - LGV	North	East	South	West	London	External
North	7.75	2.18	0.95	2.11	0.14	3.66
East	3.18	0.91	1.11	1.04	0.85	1.83
South	1.53	0.94	0.8	1.12	0.33	0.45
West	2.66	0.33	1.89	1.64	0.74	1.81
London	1.65	1.46	1.79	0.47	0	1.25
External	2.38	0.35	1.02	0.67	1.32	0.88

Table 9: GEH LGV IP

GEH Change - HGV	North	East	South	West	London	External
North	4.98	1.79	1.37	0.33	4.02	2.66
East	0.76	0.67	0.43	0.12	2.24	5.38
South	0.94	0.37	0.59	0.37	0.27	0.52
West	1.06	0.18	0.83	0.17	0.7	0.05
London	3.79	1.95	1.01	0.53	0	1.53
External	0.59	3.32	2.73	0.76	2.1	1.24

Table 10: GEH HGV IP

GEH Change - Commute	North	East	South	West	London	External
North	2.3	2.25	7.88	1.45	2.54	0.29
East	0.06	0.89	0.49	1.37	0.87	3.27
South	3.21	0.7	1.2	2.49	0.4	0.53
West	1.07	0.69	2.62	0.27	0.28	0.83
London	0.34	0.17	0.99	0.65	0	0.11
External	2.2	1.48	0.45	1.22	0.23	0.63

Table 11: GEH Commute PM

GEH Change - Business	North	East	South	West	London	External
North	1.8	1.73	4.02	0.93	1.41	0.92
East	0.95	0.88	0.94	0.44	1.42	2.83
South	2.35	0.06	1.27	1.55	0.19	0.42
West	0.3	0.14	0.55	0.19	0.72	0.22
London	0.12	0.27	1	0.14	0	0.08
External	1.57	1.15	0.36	0.95	0.49	0.73

Table 12: GEH Business PM

GEH Change - Other	North	East	South	West	London	External
North	6.22	4.36	8.45	0.81	2.11	0.94
East	0.48	1.27	0.58	2.61	0.66	1.4
South	4.43	0.45	1.06	3.47	1.15	0.26
West	1.63	0.54	2.47	0.09	0.45	0.12
London	0.28	0.73	0.91	0.76	0	0.06
External	1.9	1.9	0.04	0.5	0.41	0.55

Table 13: GEH Other PM

GEH Change - LGV	North	East	South	West	London	External
North	7.57	4.01	4.08	2.32	0.56	6.19
East	4.29	2.43	2.32	0.48	0.05	4.01
South	1.72	1.57	2.53	1.5	0.35	3.38
West	4.6	1.03	6.33	2.99	1.35	4.36
London	1.52	0.63	0.8	0.46	0	0.69
External	2.02	0.14	0.63	1.16	1.2	0.8

Table 14: GEH LGV PM

GEH Change - HGV	North	East	South	West	London	External
North	1.45	1.83	0.98	0.58	1.51	2.28
East	0.53	0.39	0.26	0.39	3.56	4.73
South	0.48	0.51	0.08	0.39	0.81	0.33
West	2.52	0.74	0.31	0.76	0.41	1.11
London	1.45	3.41	0.52	0.96	0	0.95
External	3.14	4.35	0.42	1.19	1.4	0.88

Table 15: GEH HGV PM

Appendix M – Calibration Count Summary

AM

Screenline	ID	BOUND	DIR	AM Count Data				AM Model Data				Absolute differences				%age Difference				GEH or Criteria 1			
				Car	LGV	HGV	Total	Car	LGV	HGV	Total	Car	LGV	HGV	Total	Car	LGV	HGV	Total	Car	LGV	HGV	Total
	A12 Jnc 19 SB off-slip A12_6262_1_SB	SB		1537	115	113	1765	1455	102	82	1639	-82	-13	-31	-126	-5%	-11%	-27%	-7%	Pass	Pass	Pass	Pass
Cal_6	VS1.1_NB	NB	2	723	56	10	789	672	52	9	733	-51	-4	-1	-56	-7%	-7%	-10%	-7%	Pass	Pass	Pass	Pass
Cal_6	VS1.1_SB	SB	1	581	54	9	644	538	43	10	591	-43	-11	1	-53	-7%	-20%	11%	-8%	Pass	Pass	Pass	Pass
Cal_6	VS1.4_SWB	SWB	1	592	27	7	626	628	24	13	665	36	-3	6	39	6%	-11%	86%	6%	Pass	Pass	Pass	Pass
Cal_6	VS1.4_NEB	NEB	2	240	19	5	264	236	21	6	263	-4	2	1	-1	-2%	11%	20%	0%	Pass	Pass	Pass	Pass
	S5.1_NB	NB		1512	81	20	1613	1311	82	17	1410	-201	1	-3	-203	-13%	1%	-15%	-13%	Pass	Pass	Pass	Pass
Cal_4	S6.3_NB	NB	1	364	16	0	380	228	10	1	239	-136	-6	1	-141	-37%	-38%		-37%	Fail	Pass	Pass	Fail
Cal_4	S6.3_SB	SB	2	129	6	0	135	115	3	0	118	-14	-3	0	-17	-11%	-50%	0%	-13%	Pass	Pass	Pass	Pass
Cal_5	VS2.3_NB	NB	1	81	6	0	87	92	8	0	100	11	2	0	13	14%	33%	0%	15%	Pass	Pass	Pass	Pass
Cal_5	VS2.3_SB	SB	2	83	4	0	87	83	5	1	89	0	1	1	2	0%	25%		2%	Pass	Pass	Pass	Pass
Cal_1	A12 Jnc 15 SB off-slip A12_6254_1_SB	SB	2	915	35	30	980	740	34	18	792	-175	-1	-12	-188	-19%	-3%	-40%	-19%	Fail	Pass	Pass	Fail
Cal_1	A12 Jnc 15 NB off-slip A12_6253_1_NB	NB	1	801	65	52	918	851	76	63	990	50	11	11	72	6%	17%	21%	8%	Pass	Pass	Pass	Pass
Cal_4	AN1.3_WB	WB	1	1475	72	12	1559	1295	58	13	1366	-180	-14	1	-193	-12%	-19%	8%	-12%	Pass	Pass	Pass	Pass
Cal_4	AN1.3_EB	EB	2	860	99	12	971	866	85	21	972	6	-14	9	1	1%	-14%	75%	0%	Pass	Pass	Pass	Pass
Cal_4	S5.3_WB	WB	2	448	74	13	535	441	66	11	518	-7	-8	-2	-17	-2%	-11%	-15%	-3%	Pass	Pass	Pass	Pass
Cal_4	S5.3_EB	EB	1	784	45	20	849	794	45	12	851	10	0	-8	2	1%	0%	-40%	0%	Pass	Pass	Pass	Pass
Cal_1	C1.17_SEB	SEB	1	507	85	21	613	559	74	24	657	52	-11	3	44	10%	-13%	14%	7%	Pass	Pass	Pass	Pass
Cal_1	C1.17_NWB	NWB	2	697	72	19	788	629	69	25	723	-68	-3	6	-65	-10%	-4%	32%	-8%	Pass	Pass	Pass	Pass
Cal_1	A12_6254_2_SB	SB	2	1877	263	266	2406	1995	338	261	2594	118	75	-5	188	6%	29%	-2%	8%	Pass	Pass	Pass	Pass
Cal_2	17241-02_NB	NB	1	889	107	44	1040	904	102	47	1053	15	-5	3	13	2%	-5%	7%	1%	Pass	Pass	Pass	Pass
Cal_2	17241-02_SB	SB	2	979	116	40	1135	829	78	37	944	-150	-38	-3	-191	-15%	-33%	-8%	-17%	Pass	Pass	Pass	Fail
	S2.2_EB	EB		960	134	86	1180	779	117	76	972	-181	-17	-10	-208	-19%	-13%	-12%	-18%	Fail	Pass	Pass	Fail
	S2.2_WB	WB		1685	119	42	1846	1655	122	50	1827	-30	3	8	-19	-2%	3%	19%	-1%	Pass	Pass	Pass	Pass
Cal_2	C2.7_SB	SB	1	545	30	20	595	549	43	23	615	4	13	3	20	1%	43%	15%	3%	Pass	Pass	Pass	Pass
Cal_2	C2.7_NB	NB	2	507	68	27	602	468	63	24	555	-39	-5	-3	-47	-8%	-7%	-11%	-8%	Pass	Pass	Pass	Pass
Cal_2	C2.6_EB	EB	2	274	13	2	289	232	11	3	246	-42	-2	1	-43	-15%	-15%	50%	-15%	Pass	Pass	Pass	Pass
Cal_2	C2.6_WB	WB	1	129	10	3	142	114	15	2	131	-15	5	-1	-11	-12%	50%	-33%	-8%	Pass	Pass	Pass	Pass
Cal_1	A12_6253_2_NB	NB	1	1366	196	246	1808	1618	290	238	2146	252	94	-8	338	18%	48%	-3%	19%	Fail	Pass	Pass	Fail
Cal_3	S3.6_NB	NB	2	376	18	6	400	345	16	12	373	-31	-2	6	-27	-8%	-11%	100%	-7%	Pass	Pass	Pass	Pass
Cal_3	S3.6_SB	SB	1	479	21	4	504	452	22	7	481	-27	1	3	-23	-6%	5%	75%	-5%	Pass	Pass	Pass	Pass
Cal_2	16342-02_NB	NB	1	361	26	4	391	328	25	6	359	-33	-1	2	-32	-9%	-4%	50%	-8%	Pass	Pass	Pass	Pass
Cal_2	16342-02_SB	SB	2	979	43	5	1027	952	35	8	995	-27	-8	3	-32	-3%	-19%	60%	-3%	Pass	Pass	Pass	Pass
Cal_5	VS2.2_NEB	NEB	1	274	23	2	299	383	28	2	413	109	5	0	114	40%	22%	0%	38%	Fail	Pass	Pass	Fail
Cal_5	VS2.2_SWB	SWB	2	293	25	6	324	305	26	6	337	12	1	0	13	4%	4%	0%	4%	Pass	Pass	Pass	Pass
	72497250 A138 CHELMER RD,N OF NEW DUKES WAY RAB,CHELMSFORD_SB	SB		1109	121	21	1251	1023	99	16	1138	-86	-22	-5	-113	-8%	-18%	-24%	-9%	Pass	Pass	Pass	Pass
Cal_3	S3.1_SEB	SEB	1	842	46	39	927	715	54	39	808	-127	8	0	-119	-15%	17%	0%	-13%	Pass	Pass	Pass	Pass
Cal_3	S3.1_NWB	NWB	2	825	119	74	1018	732	109	66	907	-93	-10	-8	-111	-11%	-8%	-11%	-11%	Pass	Pass	Pass	Pass
Cal_1	C1.6_SB	SB	2	1704	233	120	2057	1702	225	99	2026	-2	-8	-21	-31	0%	-3%	-18%	-2%	Pass	Pass	Pass	Pass
Cal_3	S3.5_NB	NB	2	132	15	1	148	139	15	0	154	7	0	-1	6	5%	0%	-100%	4%	Pass	Pass	Pass	Pass
Cal_3	S3.5_SB	SB	1	157	11	0	168	246	16	0	262	89	5	0	94	57%	45%	0%	56%	Pass	Pass	Pass	Pass
Cal_3	S3.4_NB	NB	2	43	2	1	46	49	5	1	55	6	3	0	9	14%	150%	0%	20%	Pass	Pass	Pass	Pass
Cal_3	S3.4_SB	SB	1	192	10	1	203	183	5	1	189	-9	-5	0	-14	-5%	-50%	0%	-7%	Pass	Pass	Pass	Pass
Cal_3	S3.3_NWB	NWB	2	338	29	0	367	297	21	0	318	-41	-8	0	-49	-12%	-28%	0%	-13%	Pass	Pass	Pass	Pass
Cal_3	S3.3_SEB	SEB	1	227	14	0	241	195	11	0	206	-32	-3	0	-35	-14%	-21%	0%	-15%	Pass	Pass	Pass	Pass
Cal_6	VS1.5_NB	NB	2	662	85	19	766	665	74	27	766	3	-11	8	0	0%	-13%	42%	0%	Pass	Pass	Pass	Pass
Cal_6	VS1.5_SB	SB	1	1125	118	26	1269	1029	110	18	1157	-96	-8	-8	-112	-9%	-7%	-31%	-9%	Pass	Pass	Pass	Pass
	72497250 A138 CHELMER RD,N OF NEW DUKES WAY RAB,CHELMSFORD_NB	NB		735	105	23	863	750	87	29	866	15	-18	6	3	2%	-17%	26%	0%	Pass	Pass	Pass	Pass
Cal_4	S4.2_SWB	SWB	2	564	24	2	590	550	31	6	587	-14	7	4	-3	-2%	29%	200%	-1%	Pass	Pass	Pass	Pass
Cal_4	S4.2_NEB	NEB	1	652	26	7	685	709	39	12	760	57	13	5	75	9%	50%	71%	11%	Pass	Pass	Pass	Pass
Cal_4	S4.1_SWB	SWB	2	174	13	2	189	207	13	0	220	33	0	-2	31	19%	0%	-100%	16%	Pass	Pass	Pass	Pass
Cal_4	AN1.4_NWB	NWB	1	323	33	0	356	457	36	5	498	134	3	5	142	41%	9%		40%	Fail	Pass	Pass	Fail
Cal_4	AN1.4_SEB	SEB	2	335	38	11	384	333	46	6	385	-2	8	-5	1	-1%	21%	-45%	0%	Pass	Pass	Pass	Pass
Cal_5	VS2.5_NB	NB	1	110	3	0	113	112	9	1	122	2	6	1	9	2%	200%		8%	Pass	Pass	Pass	Pass
Cal_5	VS2.5_SB	SB	2	46	3	0	49	54	10	1	65	8	7	1	16	17%	233%		33%	Pass	Pass	Pass	Pass
Cal_2	C2.8_SB	SB	1	948	92	31	1071	951	66	24	1041	3	-26	-7	-30	0%	-28%	-23%	-3%	Pass	Pass	Pass	Pass
Cal_2	C2.8_NB	NB	2	646	96	22	764	599	86	22	707	-47	-10	0	-57	-7%	-10%	0%	-7%	Pass	Pass	Pass	Pass
Cal_3	S3.2_NWB	NWB	2	391	41	3	435	362	34	6	402	-29	-7	3	-33	-7%	-17%	100%	-8%	Pass	Pass	Pass	Pass
Cal_3	S3.2_SEB	SEB	1	723	60	5	788	701	50	8	759	-22	-10	3	-29	-3%	-17%	60%	-4%	Pass	Pass	Pass	Pass
	S5.1_SB	SB		1128	96	21	1245	1211	96	24	1331	83	0	3	86	7%	0%	14%	7%	Pass	Pass	Pass	Pass
	Ind2_NWB	NWB		2149	116	21	2286	2085	108	26	2219	-64	-8	5	-67	-3%	-7%	24%	-3%	Pass	Pass	Pass	Pass
	Ind2_SEB	SEB		1816	126	27	1969	1830	133	33	1996	14	7	6	27	1%	6%	22%	1%	Pass	Pass	Pass	Pass
Cal_1	C1.13_WB	WB	2	37	4	1	42	0	0	1	1	-37	-4	0	-41	-100%	-100%	0%	-98%	Pass	Pass	Pass	Pass
Cal_1	C1.13_EB	EB	1	49	1	3	53	0	0	1	1	-49	-1	-2	-52	-100%	-100%	-67%	-98%	Pass	Pass	Pass	Pass
Cal_1	C1.12_WB	WB	2	648	121	29	798	586	104	31	721	-62	-17	2	-77	-10%	-14%	7%	-10%	Pass	Pass	Pass	Pass
Cal_1	C1.12_EB	EB	1	411	65	21	497	451	68	17	536	40	3	-4	39	10%	5%	-19%	8%	Pass	Pass	Pass	Pass
Cal_4	S5.4_NB	NB	2	617	36	8	661	590	38	9	637	-27	2	1	-24	-4%	6%	13%	-4%	Pass	Pass	Pass	Pass
Cal_4	S5.4_SB	SB	1	617	46	3	666	609	40	2	651	-8	-6	-1	-15	-1%	-13%	-33%	-2%	Pass	Pass	Pass	Pass
	C1.5_EB	EB		233	50	9	292	264	49	13	326	31	-1	4	34	13%	-2%	44%	12%	Pass	Pass	Pass	Pass
	C1.5_WB	WB		428	68	11	507	492	64	18	574	64	-4	7	67	15%	-6%	64%	13%	Pass	Pass	Pass	Pass
	76947695 MALDON ROAD ANT JUNCT MOLRAMS LANE - SANDON_WB	WB		623	67	10	700	577	44	3	624	-46	-23	-7	-76	-7%	-34%	-70%	-11%	Pass	Pass	Pass	Pass
	76947695 MALDON ROAD ANT JUNCT MOLRAMS LANE - SANDON_EB	EB		577	48	4	629	444	43	2	489	-133	-5	-2	-140	-23%	-10%	-50%	-22%	Fail	Pass	Pass	Fail
Cal_5	VS2.1_SB	SB	2	203	24	1	228	168	18	4	190	-35	-6	3	-38	-17%	-25%	300%	-17%	Pass	Pass	Pass	Pass
Cal_5	VS2.1_NB	NB	1	231	15	3	249	204	15	2	221	-27	0	-1	-28	-12%	0%	-33%	-11%	Pass	Pass	Pass	Pass
Cal_5	VS2.4_NB	NB	1	489	28	3	520	337	24	1	362	-152	-4	-2	-158	-31%	-14%	-67%	-30%	Fail	Pass	Pass	Fail
Cal_5	VS2.4_SB	SB	2	359	23	6	388	325	22	2	349	-34	-1	-4	-39	-9%	-4%	-67%	-10%	Pass	Pass	Pass	Pass
Cal_5	VS2.7_SB	SB	2	633	72	18	723	573	53	16	642	-60	-19	-2	-81	-9%	-26%	-11%	-11%	Pass	Pass	Pass	Pass
Cal_5	VS2.7_NB	NB	1	484	58	15	557	555	54	24	633	71	-4	9	76	15%	-7%	60%	14%	Pass	Pass	Pass	Pass
Cal_1	C1.2_NEB	NEB	2	174	35	9	218	165	31	7	203	-9	-4	-2	-15	-5%	-11%	-22%	-7%	Pass	Pass	Pass	Pass
Cal_1	C1.2_SWB	SWB	1	604	52	13	669	491	44	8	543	-113	-8	-5	-126	-19%	-15%	-38%	-19%	Pass	Pass	Pass	Fail
Cal_1	C1.4_EB	EB	2	542	79	19	640	564	96	13	673	22	17	-6	33	4%	22%	-32%	5%	Pass	Pass	Pass	Pass
Cal_1	C1.4_WB	WB	1	1110	88	39	1237	1035	79	30	1144	-75	-9	-9	-93	-7%	-10%	-23%	-8%	Pass	Pass	Pass	Pass
Cal_2	C2.9_SB	SB	1	127	3	2	132	126	3	0	129	-1	0	-2	-3	-1%	0%	-100%	-2%	Pass	Pass	Pass	Pass
Cal_2	C2.9_NB	NB	2	53	9	1	63	57	6	1	64	4	-3	0	1	8%	-33%	0%	2%	Pass	Pass	Pass	Pass
Cal_1	C1.18_NEB	NEB	2	660	85	28	773	610	82	24	716	-50	-3	-4	-57	-8%	-4%	-14%	-7%	Pass	Pass	Pass	Pass
Cal_1	C1.18_SWB	SWB	1	1200	78	39	1317	920	52	19	991	-280	-26	-20	-326	-23%	-33%	-51%	-25%	Fail	Pass	Pass	Fail
Cal_1	C1.8_NB	NB	1	797	71	12	880	777	79	12	868	-20	8	0	-12	-3%	11%	0%	-1%	Pass	Pass	Pass	Pass
Cal_1	C1.8_SB	SB	2	787	95	11	893	818	99	11	928	31	4	0	35	4%	4%	0%	4%	Pass	Pass	Pass	Pass
	68606861 A414 MALDON ROAD-194M E OF GAY BOWERS LANE-DANBURY_EB	EB		408	78	30	516	466	100	28	594	58	22	-2	78	14%	28%	-7%	15%	Pass	Pass	Pass	Pass
	68606861 A414 MALDON ROAD-194M E OF GAY BOWERS LANE-DANBURY_WB	WB		752	90	32	874	841	93	28	962	89	3	-4	88	12%	3%	-13%	10%	Pass	Pass	Pass	Pass
	03006133 A130 WHITE HART LANE C'FORD 450m E Nabbotts Fm RAB_EB	EB		664	74	43	781	542	71	43	656	-122	-3	0	-125	-18%	-4%	0%	-16%	Pass	Pass	Pass	Pass
	03006133 A130 WHITE HART LANE C'FORD 450m E Nabbotts Fm RAB_WB	WB		585	71	53	709	446	71	50	567	-139	0	-3	-142	-24%	0%	-6%	-20%	Fail	Pass	Pass	Fail
Cal_1	C1.15_SEB	SEB	1	17	0	0	17	18	3	0	21	1	3	0	4	6%		0%	24%	Pass	Pass	Pass	Pass
Cal_1	C1.15_NWB	NWB	2	7	0	0	7	17	3	1	21	10	3	1	14	143%			200%	Pass	Pass	Pass	Pass
Cal_1	C1.16_WB	WB	2	24	5	0	29	26	5	1	32	2	0	1	3	8%	0%		10%	Pass	Pass	Pass	Pass
Cal_1	C1.16_EB	EB	1	40	1	0	41	41	2	1	44	1	1	1	3	3%	100%		7%	Pass	Pass	Pass	Pass
Cal_1	C1.7_EB	EB	2	78	15	1	94	84	22	7	113	6	7	6	19	8%	47%	600%	20%	Pass	Pass	Pass	Pass
Cal_1	C1.7_WB	WB	1	139	22	1	162	125	19	5	149	-14	-3	4	-13	-10%	-14%	400%	-8%	Pass	Pass	Pass	Pass
Cal_3	S3.7_NWB	NWB	2	1333	77	18	1428	1173	72	17	1262	-160	-5	-1	-166	-12%	-6%	-6%	-12%	Pass	Pass	Pass	Pass
Cal_1	C1.14_NWB	NWB	2	305	62	6	373	299	57	11	367	-6	-5	5	-6	-2%	-8%	83%	-2%	Pass	Pass	Pass	Pass
Cal_1	C1.14_SB	SB	1	376	31	8	415	330	29	8	367	-46	-2	0	-48	-12%	-6%	0%	-12%	Pass	Pass	Pass	Pass
Cal_1	C1.11_SWB	SWB	2	73	9	0	82	85	9	1	95	12	0	1	13	16%	0%		16%	Pass	Pass	Pass	Pass
Cal_1	C1.11_NEB	NEB	1	113	12	3	128	135	9	0	144	22	-3	-3	16	19%	-25%	-100%	13%	Pass	Pass	Pass	Pass
Cal_4	AN1.5_NB	NB	1	479	71	14	564	451	60	20	531	-28	-11	6	-33	-6%	-15%	43%	-6%	Pass	Pass	Pass	Pass
Cal_4	AN1.5_SB	SB	2	558	73	16	647	649	75	14	738	91	2	-2	91	16%	3%	-13%	14%	Pass	Pass	Pass	Pass
Cal_1	C1.1_WB	WB	1	3676	372	243	4291	3724	437	281	4442	48	65	38	151	1%	17%	16%	4%	Pass	Pass	Pass	Pass
Cal_5	VS2.6_WB	WB	2	1175	132	22	1329	1241	117	22	1380	66	-15	0	51	6%	-11%	0%	4%	Pass	Pass	Pass	Pass
Cal_5	VS2.6_EB	EB	1	882	103	17	1002	975	98	34	1107	93	-5	17	105	11%	-5%	100%	10%	Pass	Pass	Pass	Pass
Cal_3	S3.7_SEB	SEB	1	1163	112	27	1302	1248	106	28	1382	85	-6	1	80	7%	-5%	4%	6%	Pass	Pass	Pass	Pass
Cal_1	C1.6_NB	NB	1	2294	333	108	2735	2199	294	96	2589	-95	-39	-12	-146	-4%	-12%	-11%	-5%	Pass	Pass	Pass	Pass
Cal_1	C1.1_EB	EB	2	2634	358	227	3219	2676	406	249	3331	42	48	22	112	2%	13%	10%	3%	Pass	Pass	Pass	Pass
Cal_1	C1.3_NB	NB	2	170	24	2	196	235	21	6	262	65	-3	4	66	38%	-13%	200%	34%	Pass	Pass	Pass	Pass
Cal_1	C1.3_SB	SB	1	275	20	2	297	380	40	8	428	105	20	6	131	38%	100%	300%	44%	Fail	Pass	Pass	Fail
Cal_2	C2.2_SB	SB	2	362	34	8	404	412	57	11	480	50	23	3	76	14%	68%	38%	19%	Pass	Pass	Pass	Pass
Cal_2	C2.2_NB	NB	1	407	48	11	466	510	42	10	562	103	-6	-1	96	25%	-13%	-9%	21%	Pass	Pass	Pass	Pass
Cal_1	C1.20_EB	EB	2	2	2	1	5	0	0	0	0	-2	-2	-1	-5	-100%	-100%	-100%	-100%	Pass	Pass	Pass	Pass
Cal_1	C1.20_WB	WB	1	33	2	0	35	0	0	0	0	-33	-2	0	-35	-100%	-100%	0%	-100%	Pass	Pass	Pass	Pass
Cal_1	C1.19_EB	EB	2	70	8	2	80	87	11	4	102	17	3	2	22	24%	38%	100%	28%	Pass	Pass	Pass	Pass
Cal_1	C1.19_WB	WB	1	432	25	6	463	407	25	6	438	-25	0	0	-25	-6%	0%	0%	-5%	Pass	Pass	Pass	Pass
Cal_6	VS1.2_SB	SB	1	1364	52	20	1436	1238	36	14	1288	-126	-16	-6	-148	-9%	-31%	-30%	-10%	Pass	Pass	Pass	Pass
Cal_6	VS1.2_NB	NB	2	788	40	24	852	658	40	20	718	-130	0	-4	-134	-16%	0%	-17%	-16%	Pass	Pass	Pass	Pass
Cal_2	C2.1_NB	NB	2	88	13	1	102	161	16	3	180	73	3	2	78	83%	23%	200%	76%	Pass	Pass	Pass	Pass
Cal_2	C2.1_SB	SB	1	344	25	2	371	356	43	6	405	12	18	4	34	3%	72%	200%	9%	Pass	Pass	Pass	Pass
Cal_4	S5.2_NB	NB	1	889	104	35	1028	844	93	29	966	-45	-11	-6	-62	-5%	-11%	-17%	-6%	Pass	Pass	Pass	Pass
Cal_4	S5.2_SB	SB	2	1000	53	16	1069	910	34	12	956	-90	-19	-4	-113	-9%	-36%	-25%	-11%	Pass	Pass	Pass	Pass

GEH or Criteria 1	Car	LGV	HGV	Total
	91%	100%	100%	90%
Fail	11	0	0	13
Pass	113	124	124	111

IP

Screenline	ID	BOUND	DIR	IP Count Data Car	LGV	HGV	Total	IP Model Data Car	LGV	HGV	Total	Absolute differences Car	LGV	HGV	Total	%age Difference Car	LGV	HGV	Total	GEH or Criteria 1 Car	LGV	HGV	Total
	A12 Jnc 19 SB off-slip A12_6262_1_SB	SB		580	46	55	681	600	60	44	704	20	14	-11	23	3%	30%	-20%	3%	Pass	Pass	Pass	Pass
Cal_6	VS1.1_NB	NB	2	523	61	12	596	509	47	10	566	-14	-14	-2	-30	-3%	-23%	-17%	-5%	Pass	Pass	Pass	Pass
Cal_6	VS1.1_SB	SB	1	511	58	9	578	455	41	9	505	-56	-17	0	-73	-11%	-29%	0%	-13%	Pass	Pass	Pass	Pass
Cal_6	VS1.4_SWB	SWB	1	306	22	6	334	354	29	11	394	48	7	5	60	16%	32%	83%	18%	Pass	Pass	Pass	Pass
Cal_6	VS1.4_NEB	NEB	2	310	23	5	338	309	22	14	345	-1	-1	9	7	0%	-4%	180%	2%	Pass	Pass	Pass	Pass
	S5.1_NB	NB		1015	89	23	1127	1040	91	21	1152	25	2	-2	25	2%	2%	-9%	2%	Pass	Pass	Pass	Pass
Cal_4	S6.3_NB	NB	1	100	9	0	109	100	7	1	108	0	-2	1	-1	0%	-22%		-1%	Pass	Pass	Pass	Pass
Cal_4	S6.3_SB	SB	2	88	9	0	97	97	5	1	103	9	-4	1	6	10%	-44%		6%	Pass	Pass	Pass	Pass
Cal_5	VS2.3_NB	NB	1	42	3	1	46	62	6	1	69	20	3	0	23	48%	100%	0%	50%	Pass	Pass	Pass	Pass
Cal_5	VS2.3_SB	SB	2	46	4	0	50	53	7	1	61	7	3	1	11	15%	75%		22%	Pass	Pass	Pass	Pass
Cal_1	A12 Jnc 15 SB off-slip A12_6254_1_SB	SB	2	251	16	19	286	225	15	10	250	-26	-1	-9	-36	-10%	-6%	-47%	-13%	Pass	Pass	Pass	Pass
Cal_1	A12 Jnc 15 NB off-slip A12_6253_1_NB	NB	1	413	49	42	504	445	61	40	546	32	12	-2	42	8%	24%	-5%	8%	Pass	Pass	Pass	Pass
Cal_4	AN1.3_WB	WB	1	808	91	23	922	905	93	29	1027	97	2	6	105	12%	2%	26%	11%	Pass	Pass	Pass	Pass
Cal_4	AN1.3_EB	EB	2	841	89	23	953	812	88	29	929	-29	-1	6	-24	-3%	-1%	26%	-3%	Pass	Pass	Pass	Pass
Cal_4	S5.3_WB	WB	2	474	54	23	551	440	49	19	508	-34	-5	-4	-43	-7%	-9%	-17%	-8%	Pass	Pass	Pass	Pass
Cal_4	S5.3_EB	EB	1	503	64	26	593	492	58	22	572	-11	-6	-4	-21	-2%	-9%	-15%	-4%	Pass	Pass	Pass	Pass
Cal_1	C1.17_SEB	SEB	1	313	51	24	388	322	55	30	407	9	4	6	19	3%	8%	25%	5%	Pass	Pass	Pass	Pass
Cal_1	C1.17_NWB	NWB	2	293	57	22	372	319	56	27	402	26	-1	5	30	9%	-2%	23%	8%	Pass	Pass	Pass	Pass
Cal_1	A12_6254_2_SB	SB	2	1157	168	250	1575	1421	206	247	1874	264	38	-3	299	23%	23%	-1%	19%	Fail	Pass	Pass	Fail
Cal_2	17241-02_NB	NB	1	741	95	54	890	743	100	60	903	2	5	6	13	0%	5%	11%	1%	Pass	Pass	Pass	Pass
Cal_2	17241-02_SB	SB	2	700	89	52	841	652	91	46	789	-48	2	-6	-52	-7%	2%	-12%	-6%	Pass	Pass	Pass	Pass
	S2.2_EB	EB		619	81	73	773	628	79	65	772	9	-2	-8	-1	1%	-2%	-11%	0%	Pass	Pass	Pass	Pass
	S2.2_WB	WB		719	83	41	843	762	86	49	897	43	3	8	54	6%	4%	20%	6%	Pass	Pass	Pass	Pass
Cal_2	C2.7_SB	SB	1	279	46	21	346	290	50	30	370	11	4	9	24	4%	9%	43%	7%	Pass	Pass	Pass	Pass
Cal_2	C2.7_NB	NB	2	291	42	20	353	309	46	25	380	18	4	5	27	6%	10%	25%	8%	Pass	Pass	Pass	Pass
Cal_2	C2.6_EB	EB	2	116	12	4	132	110	11	3	124	-6	-1	-1	-8	-5%	-8%	-25%	-6%	Pass	Pass	Pass	Pass
Cal_2	C2.6_WB	WB	1	126	12	4	142	129	15	6	150	3	3	2	8	2%	25%	50%	6%	Pass	Pass	Pass	Pass
Cal_1	A12_6253_2_NB	NB	1	1263	192	331	1786	1433	224	325	1982	170	32	-6	196	13%	17%	-2%	11%	Pass	Pass	Pass	Pass
Cal_3	S3.6_NB	NB	2	340	27	8	375	291	23	12	326	-49	-4	4	-49	-14%	-15%	50%	-13%	Pass	Pass	Pass	Pass
Cal_3	S3.6_SB	SB	1	414	32	8	454	423	30	12	465	9	-2	4	11	2%	-6%	50%	2%	Pass	Pass	Pass	Pass
Cal_2	16342-02_NB	NB	1	467	36	5	508	424	35	18	477	-43	-1	13	-31	-9%	-3%	260%	-6%	Pass	Pass	Pass	Pass
Cal_2	16342-02_SB	SB	2	420	37	5	462	378	28	5	411	-42	-9	0	-51	-10%	-24%	0%	-11%	Pass	Pass	Pass	Pass
Cal_5	VS2.2_NEB	NEB	1	215	17	2	234	226	20	4	250	11	3	2	16	5%	18%	100%	7%	Pass	Pass	Pass	Pass
Cal_5	VS2.2_SWB	SWB	2	234	16	4	254	257	20	7	284	23	4	3	30	10%	25%	75%	12%	Pass	Pass	Pass	Pass
	72497250 A138 CHELMER RD,N OF NEW DUKES WAY RAB,CHELMSFORD_SB	SB		666	82	22	770	627	72	22	721	-39	-10	0	-49	-6%	-12%	0%	-6%	Pass	Pass	Pass	Pass
Cal_3	S3.1_SEB	SEB	1	648	70	60	778	552	57	49	658	-96	-13	-11	-120	-15%	-19%	-18%	-15%	Pass	Pass	Pass	Pass
Cal_3	S3.1_NWB	NWB	2	746	85	58	889	783	92	63	938	37	7	5	49	5%	8%	9%	6%	Pass	Pass	Pass	Pass
Cal_1	C1.6_SB	SB	2	1211	214	130	1555	1202	196	112	1510	-9	-18	-18	-45	-1%	-8%	-14%	-3%	Pass	Pass	Pass	Pass
Cal_3	S3.5_NB	NB	2	146	10	1	157	167	12	0	179	21	2	-1	22	14%	20%	-100%	14%	Pass	Pass	Pass	Pass
Cal_3	S3.5_SB	SB	1	122	12	1	135	151	8	0	159	29	-4	-1	24	24%	-33%	-100%	18%	Pass	Pass	Pass	Pass
Cal_3	S3.4_NB	NB	2	30	3	0	33	33	3	0	36	3	0	0	3	10%	0%	0%	9%	Pass	Pass	Pass	Pass
Cal_3	S3.4_SB	SB	1	99	6	0	105	81	11	1	93	-18	5	1	-12	-18%	83%		-11%	Pass	Pass	Pass	Pass
Cal_3	S3.3_NWB	NWB	2	184	23	1	208	176	19	0	195	-8	-4	-1	-13	-4%	-17%	-100%	-6%	Pass	Pass	Pass	Pass
Cal_3	S3.3_SEB	SEB	1	148	14	1	163	158	12	0	170	10	-2	-1	7	7%	-14%	-100%	4%	Pass	Pass	Pass	Pass
Cal_6	VS1.5_NB	NB	2	682	78	22	782	690	88	23	801	8	10	1	19	1%	13%	5%	2%	Pass	Pass	Pass	Pass
Cal_6	VS1.5_SB	SB	1	773	77	23	873	800	78	23	901	27	1	0	28	3%	1%	0%	3%	Pass	Pass	Pass	Pass
	72497250 A138 CHELMER RD,N OF NEW DUKES WAY RAB,CHELMSFORD_NB	NB		762	96	26	884	728	94	24	846	-34	-2	-2	-38	-4%	-2%	-8%	-4%	Pass	Pass	Pass	Pass
Cal_4	S4.2_SWB	SWB	2	455	37	6	498	467	38	12	517	12	1	6	19	3%	3%	100%	4%	Pass	Pass	Pass	Pass
Cal_4	S4.2_NEB	NEB	1	561	40	7	608	533	41	13	587	-28	1	6	-21	-5%	3%	86%	-3%	Pass	Pass	Pass	Pass
Cal_4	S4.1_SWB	SWB	2	144	15	1	160	180	23	0	203	36	8	-1	43	25%	53%	-100%	27%	Pass	Pass	Pass	Pass
Cal_4	AN1.4_NWB	NWB	1	413	43	5	461	438	49	5	492	25	6	0	31	6%	14%	0%	7%	Pass	Pass	Pass	Pass
Cal_4	AN1.4_SEB	SEB	2	483	46	6	535	553	50	6	609	70	4	0	74	14%	9%	0%	14%	Pass	Pass	Pass	Pass
Cal_5	VS2.5_NB	NB	1	28	2	0	30	38	8	1	47	10	6	1	17	36%	300%		57%	Pass	Pass	Pass	Pass
Cal_5	VS2.5_SB	SB	2	22	2	0	24	36	9	1	46	14	7	1	22	64%	350%		92%	Pass	Pass	Pass	Pass
Cal_2	C2.8_SB	SB	1	539	67	40	646	499	65	30	594	-40	-2	-10	-52	-7%	-3%	-25%	-8%	Pass	Pass	Pass	Pass
Cal_2	C2.8_NB	NB	2	572	77	47	696	598	75	42	715	26	-2	-5	19	5%	-3%	-11%	3%	Pass	Pass	Pass	Pass
Cal_3	S3.2_NWB	NWB	2	444	36	2	482	392	29	8	429	-52	-7	6	-53	-12%	-19%	300%	-11%	Pass	Pass	Pass	Pass
Cal_3	S3.2_SEB	SEB	1	478	47	2	527	520	58	8	586	42	11	6	59	9%	23%	300%	11%	Pass	Pass	Pass	Pass
	S5.1_SB	SB		875	73	21	969	837	73	28	938	-38	0	7	-31	-4%	0%	33%	-3%	Pass	Pass	Pass	Pass
	Ind2_NWB	NWB		1384	113	29	1526	1381	125	40	1546	-3	12	11	20	0%	11%	38%	1%	Pass	Pass	Pass	Pass
	Ind2_SEB	SEB		1706	131	35	1872	1791	136	39	1966	85	5	4	94	5%	4%	11%	5%	Pass	Pass	Pass	Pass
Cal_1	C1.13_WB	WB	2	26	4	1	31	0	0	1	1	-26	-4	0	-30	-100%	-100%	0%	-97%	Pass	Pass	Pass	Pass
Cal_1	C1.13_EB	EB	1	27	4	0	31	0	0	1	1	-27	-4	1	-30	-100%	-100%		-97%	Pass	Pass	Pass	Pass
Cal_1	C1.12_WB	WB	2	289	63	26	378	332	68	29	429	43	5	3	51	15%	8%	12%	13%	Pass	Pass	Pass	Pass
Cal_1	C1.12_EB	EB	1	300	67	23	390	323	70	28	421	23	3	5	31	8%	4%	22%	8%	Pass	Pass	Pass	Pass
Cal_4	S5.4_NB	NB	2	527	48	6	581	550	48	7	605	23	0	1	24	4%	0%	17%	4%	Pass	Pass	Pass	Pass
Cal_4	S5.4_SB	SB	1	472	38	6	516	426	32	2	460	-46	-6	-4	-56	-10%	-16%	-67%	-11%	Pass	Pass	Pass	Pass
	C1.5_EB	EB		219	39	9	267	223	37	16	276	4	-2	7	9	2%	-5%	78%	3%	Pass	Pass	Pass	Pass
	C1.5_WB	WB		206	41	9	256	213	40	20	273	7	-1	11	17	3%	-2%	122%	7%	Pass	Pass	Pass	Pass
	76947695 MALDON ROAD ANT JUNCT MOLRAMS LANE - SANDON_WB	WB		371	47	7	425	379	43	2	424	8	-4	-5	-1	2%	-9%	-71%	0%	Pass	Pass	Pass	Pass
	76947695 MALDON ROAD ANT JUNCT MOLRAMS LANE - SANDON_EB	EB		417	37	6	460	411	33	3	447	-6	-4	-3	-13	-1%	-11%	-50%	-3%	Pass	Pass	Pass	Pass
Cal_5	VS2.1_SB	SB	2	151	14	3	168	135	11	4	150	-16	-3	1	-18	-11%	-21%	33%	-11%	Pass	Pass	Pass	Pass
Cal_5	VS2.1_NB	NB	1	155	17	2	174	150	15	3	168	-5	-2	1	-6	-3%	-12%	50%	-3%	Pass	Pass	Pass	Pass
Cal_5	VS2.4_NB	NB	1	413	33	9	455	376	32	4	412	-37	-1	-5	-43	-9%	-3%	-56%	-9%	Pass	Pass	Pass	Pass
Cal_5	VS2.4_SB	SB	2	452	30	7	489	413	21	3	437	-39	-9	-4	-52	-9%	-30%	-57%	-11%	Pass	Pass	Pass	Pass
Cal_5	VS2.7_SB	SB	2	535	65	24	624	478	64	22	564	-57	-1	-2	-60	-11%	-2%	-8%	-10%	Pass	Pass	Pass	Pass
Cal_5	VS2.7_NB	NB	1	535	65	23	623	494	49	18	561	-41	-16	-5	-62	-8%	-25%	-22%	-10%	Pass	Pass	Pass	Pass
Cal_1	C1.2_NEB	NEB	2	287	28	15	330	263	25	10	298	-24	-3	-5	-32	-8%	-11%	-33%	-10%	Pass	Pass	Pass	Pass
Cal_1	C1.2_SWB	SWB	1	351	43	15	409	333	37	11	381	-18	-6	-4	-28	-5%	-14%	-27%	-7%	Pass	Pass	Pass	Pass
Cal_1	C1.4_EB	EB	2	584	60	39	683	635	77	30	742	51	17	-9	59	9%	28%	-23%	9%	Pass	Pass	Pass	Pass
Cal_1	C1.4_WB	WB	1	582	66	40	688	651	76	31	758	69	10	-9	70	12%	15%	-23%	10%	Pass	Pass	Pass	Pass
Cal_2	C2.9_SB	SB	1	68	11	3	82	72	7	1	80	4	-4	-2	-2	6%	-36%	-67%	-2%	Pass	Pass	Pass	Pass
Cal_2	C2.9_NB	NB	2	67	11	3	81	71	9	2	82	4	-2	-1	1	6%	-18%	-33%	1%	Pass	Pass	Pass	Pass
Cal_1	C1.18_NEB	NEB	2	636	80	47	763	660	80	43	783	24	0	-4	20	4%	0%	-9%	3%	Pass	Pass	Pass	Pass
Cal_1	C1.18_SWB	SWB	1	596	73	44	713	565	73	40	678	-31	0	-4	-35	-5%	0%	-9%	-5%	Pass	Pass	Pass	Pass
Cal_1	C1.8_NB	NB	1	417	57	14	488	479	60	15	554	62	3	1	66	15%	5%	7%	14%	Pass	Pass	Pass	Pass
Cal_1	C1.8_SB	SB	2	415	49	12	476	473	59	12	544	58	10	0	68	14%	20%	0%	14%	Pass	Pass	Pass	Pass
	68606861 A414 MALDON ROAD-194M E OF GAY BOWERS LANE-DANBURY_EB	EB		478	72	34	584	550	91	34	675	72	19	0	91	15%	26%	0%	16%	Pass	Pass	Pass	Pass
	68606861 A414 MALDON ROAD-194M E OF GAY BOWERS LANE-DANBURY_WB	WB		472	69	34	575	531	81	30	642	59	12	-4	67	13%	17%	-12%	12%	Pass	Pass	Pass	Pass
	03006133 A130 WHITE HART LANE C'FORD 450m E Nabbotts Fm RAB_EB	EB		627	94	65	786	588	68	48	704	-39	-26	-17	-82	-6%	-28%	-26%	-10%	Pass	Pass	Pass	Pass
	03006133 A130 WHITE HART LANE C'FORD 450m E Nabbotts Fm RAB_WB	WB		644	78	63	785	629	73	58	760	-15	-5	-5	-25	-2%	-6%	-8%	-3%	Pass	Pass	Pass	Pass
Cal_1	C1.15_SEB	SEB	1	9	2	0	11	11	2	1	14	2	0	1	3	22%	0%		27%	Pass	Pass	Pass	Pass
Cal_1	C1.15_NWB	NWB	2	8	1	0	9	12	2	1	15	4	1	1	6	50%	100%		67%	Pass	Pass	Pass	Pass
Cal_1	C1.16_WB	WB	2	23	4	1	28	23	3	1	27	0	-1	0	-1	0%	-25%	0%	-4%	Pass	Pass	Pass	Pass
Cal_1	C1.16_EB	EB	1	22	3	1	26	25	3	2	30	3	0	1	4	14%	0%	100%	15%	Pass	Pass	Pass	Pass
Cal_1	C1.7_EB	EB	2	48	9	2	59	49	11	5	65	1	2	3	6	2%	22%	150%	10%	Pass	Pass	Pass	Pass
Cal_1	C1.7_WB	WB	1	41	8	1	50	47	7	5	59	6	-1	4	9	15%	-13%	400%	18%	Pass	Pass	Pass	Pass
Cal_3	S3.7_NWB	NWB	2	833	80	20	933	862	78	21	961	29	-2	1	28	3%	-3%	5%	3%	Pass	Pass	Pass	Pass
Cal_1	C1.14_NWB	NWB	2	148	26	11	185	127	26	18	171	-21	0	7	-14	-14%	0%	64%	-8%	Pass	Pass	Pass	Pass
Cal_1	C1.14_SB	SB	1	145	26	14	185	138	26	14	178	-7	0	0	-7	-5%	0%	0%	-4%	Pass	Pass	Pass	Pass
Cal_1	C1.11_SWB	SWB	2	70	9	4	83	66	6	1	73	-4	-3	-3	-10	-6%	-33%	-75%	-12%	Pass	Pass	Pass	Pass
Cal_1	C1.11_NEB	NEB	1	63	10	3	76	63	7	0	70	0	-3	-3	-6	0%	-30%	-100%	-8%	Pass	Pass	Pass	Pass
Cal_4	AN1.5_NB	NB	1	582	70	14	666	586	73	16	675	4	3	2	9	1%	4%	14%	1%	Pass	Pass	Pass	Pass
Cal_4	AN1.5_SB	SB	2	542	58	15	615	589	61	20	670	47	3	5	55	9%	5%	33%	9%	Pass	Pass	Pass	Pass
Cal_1	C1.1_WB	WB	1	2019	305	231	2555	2156	320	258	2734	137	15	27	179	7%	5%	12%	7%	Pass	Pass	Pass	Pass
Cal_5	VS2.6_WB	WB	2	866	93	24	983	935	102	34	1071	69	9	10	88	8%	10%	42%	9%	Pass	Pass	Pass	Pass
Cal_5	VS2.6_EB	EB	1	910	108	19	1037	917	103	28	1048	7	-5	9	11	1%	-5%	47%	1%	Pass	Pass	Pass	Pass
Cal_3	S3.7_SEB	SEB	1	970	85	25	1080	943	83	32	1058	-27	-2	7	-22	-3%	-2%	28%	-2%	Pass	Pass	Pass	Pass
Cal_1	C1.6_NB	NB	1	1101	218	134	1453	1125	212	116	1453	24	-6	-18	0	2%	-3%	-13%	0%	Pass	Pass	Pass	Pass
Cal_1	C1.1_EB	EB	2	2181	411	302	2894	2287	410	329	3026	106	-1	27	132	5%	0%	9%	5%	Pass	Pass	Pass	Pass
Cal_1	C1.3_NB	NB	2	64	10	3	77	41	7	5	53	-23	-3	2	-24	-36%	-30%	67%	-31%	Pass	Pass	Pass	Pass
Cal_1	C1.3_SB	SB	1	53	7	1	61	46	4	5	55	-7	-3	4	-6	-13%	-43%	400%	-10%	Pass	Pass	Pass	Pass
Cal_2	C2.2_SB	SB	2	180	30	10	220	194	40	30	264	14	10	20	44	8%	33%	200%	20%	Pass	Pass	Pass	Pass
Cal_2	C2.2_NB	NB	1	158	28	12	198	146	30	18	194	-12	2	6	-4	-8%	7%	50%	-2%	Pass	Pass	Pass	Pass
Cal_1	C1.20_EB	EB	2	5	2	0	7	0	0	0	0	-5	-2	0	-7	-100%	-100%	0%	-100%	Pass	Pass	Pass	Pass
Cal_1	C1.20_WB	WB	1	4	2	0	6	0	0	0	0	-4	-2	0	-6	-100%	-100%	0%	-100%	Pass	Pass	Pass	Pass
Cal_1	C1.19_EB	EB	2	116	77	85	278	110	62	71	243	-6	-15	-14	-35	-5%	-19%	-16%	-13%	Pass	Pass	Pass	Pass
Cal_1	C1.19_WB	WB	1	100	13	5	118	103	12	5	120	3	-1	0	2	3%	-8%	0%	2%	Pass	Pass	Pass	Pass
Cal_6	VS1.2_SB	SB	1	639	53	23	715	605	57	23	685	-34	4	0	-30	-5%	8%	0%	-4%	Pass	Pass	Pass	Pass
Cal_6	VS1.2_NB	NB	2	642	52	25	719	597	49	18	664	-45	-3	-7	-55	-7%	-6%	-28%	-8%	Pass	Pass	Pass	Pass
Cal_2	C2.1_NB	NB	2	59	59	59	177	54	45	39	138	-5	-14	-20	-39	-8%	-24%	-34%	-22%	Pass	Pass	Pass	Pass
Cal_2	C2.1_SB	SB	1	58	12	5	75	75	10	2	87	17	-2	-3	12	29%	-17%	-60%	16%	Pass	Pass	Pass	Pass
Cal_4	S5.2_NB	NB	1	737	79	26	842	727	72	20	819	-10	-7	-6	-23	-1%	-9%	-23%	-3%	Pass	Pass	Pass	Pass
Cal_4	S5.2_SB	SB	2	630	73	25	728	574	69	19	662	-56	-4	-6	-66	-9%	-5%	-24%	-9%	Pass	Pass	Pass	Pass

GEH or Criteria 1	Car	LGV	HGV	Total
	99%	100%	100%	99%
Fail	1	0	0	1
Pass	123	124	124	123

PM

Screenline	ID	BOUND	DIR	PM Count Data				PM Model Data				Absolute differences				%age Difference				GEH or Criteria 1			
				Car	LGV	HGV	Total	Car	LGV	HGV	Total	Car	LGV	HGV	Total	Car	LGV	HGV	Total	Car	LGV	HGV	Total
	A12 Jnc 19 SB off-slip A12_6262_1_SB	SB		830	44	48	922	818	49	35	902	-12	5	-13	-20	-1%	11%	-27%	-2%	Pass	Pass	Pass	Pass
Cal_6	VS1.1_NB	NB	2	700	52	6	758	650	43	11	704	-50	-9	5	-54	-7%	-17%	83%	-7%	Pass	Pass	Pass	Pass
Cal_6	VS1.1_SB	SB	1	674	52	4	730	587	40	4	631	-87	-12	0	-99	-13%	-23%	0%	-14%	Pass	Pass	Pass	Pass
Cal_6	VS1.4_SWB	SWB	1	315	12	1	328	319	15	4	338	4	3	3	10	1%	25%	300%	3%	Pass	Pass	Pass	Pass
Cal_6	VS1.4_NEB	NEB	2	421	15	2	438	379	23	7	409	-42	8	5	-29	-10%	53%	250%	-7%	Pass	Pass	Pass	Pass
	S5.1_NB	NB		1644	66	3	1713	1622	68	12	1702	-22	2	9	-11	-1%	3%	300%	-1%	Pass	Pass	Pass	Pass
Cal_4	S6.3_NB	NB	1	233	10	0	243	244	6	0	250	11	-4	0	7	5%	-40%	0%	3%	Pass	Pass	Pass	Pass
Cal_4	S6.3_SB	SB	2	103	5	0	108	110	3	0	113	7	-2	0	5	7%	-40%	0%	5%	Pass	Pass	Pass	Pass
Cal_5	VS2.3_NB	NB	1	70	5	0	75	65	6	1	72	-5	1	1	-3	-7%	20%		-4%	Pass	Pass	Pass	Pass
Cal_5	VS2.3_SB	SB	2	61	3	0	64	60	3	1	64	-1	0	1	0	-2%	0%		0%	Pass	Pass	Pass	Pass
Cal_1	A12 Jnc 15 SB off-slip A12_6254_1_SB	SB	2	376	8	8	392	374	12	2	388	-2	4	-6	-4	-1%	50%	-75%	-1%	Pass	Pass	Pass	Pass
Cal_1	A12 Jnc 15 NB off-slip A12_6253_1_NB	NB	1	600	42	25	667	657	46	40	743	57	4	15	76	10%	10%	60%	11%	Pass	Pass	Pass	Pass
Cal_4	AN1.3_WB	WB	1	767	46	5	818	773	41	10	824	6	-5	5	6	1%	-11%	100%	1%	Pass	Pass	Pass	Pass
Cal_4	AN1.3_EB	EB	2	1411	70	5	1486	1335	76	12	1423	-76	6	7	-63	-5%	9%	140%	-4%	Pass	Pass	Pass	Pass
Cal_4	S5.3_WB	WB	2	686	113	19	818	653	94	13	760	-33	-19	-6	-58	-5%	-17%	-32%	-7%	Pass	Pass	Pass	Pass
Cal_4	S5.3_EB	EB	1	608	35	15	658	625	39	10	674	17	4	-5	16	3%	11%	-33%	2%	Pass	Pass	Pass	Pass
Cal_1	C1.17_SEB	SEB	1	553	43	6	602	560	39	10	609	7	-4	4	7	1%	-9%	67%	1%	Pass	Pass	Pass	Pass
Cal_1	C1.17_NWB	NWB	2	541	60	9	610	542	59	15	616	1	-1	6	6	0%	-2%	67%	1%	Pass	Pass	Pass	Pass
Cal_1	A12_6254_2_SB	SB	2	1552	160	190	1902	1782	204	163	2149	230	44	-27	247	15%	28%	-14%	13%	Pass	Pass	Pass	Pass
Cal_2	17241-02_NB	NB	1	1177	84	17	1278	1019	74	21	1114	-158	-10	4	-164	-13%	-12%	24%	-13%	Pass	Pass	Pass	Pass
Cal_2	17241-02_SB	SB	2	959	73	18	1050	961	63	19	1043	2	-10	1	-7	0%	-14%	6%	-1%	Pass	Pass	Pass	Pass
	S2.2_EB	EB		881	123	79	1083	911	121	68	1100	30	-2	-11	17	3%	-2%	-14%	2%	Pass	Pass	Pass	Pass
	S2.2_WB	WB		845	59	21	925	937	69	35	1041	92	10	14	116	11%	17%	67%	13%	Pass	Pass	Pass	Pass
Cal_2	C2.7_SB	SB	1	362	20	13	395	402	30	10	442	40	10	-3	47	11%	50%	-23%	12%	Pass	Pass	Pass	Pass
Cal_2	C2.7_NB	NB	2	359	48	19	426	344	45	14	403	-15	-3	-5	-23	-4%	-6%	-26%	-5%	Pass	Pass	Pass	Pass
Cal_2	C2.6_EB	EB	2	165	8	1	174	208	19	2	229	43	11	1	55	26%	138%	100%	32%	Pass	Pass	Pass	Pass
Cal_2	C2.6_WB	WB	1	253	20	6	279	221	17	2	240	-32	-3	-4	-39	-13%	-15%	-67%	-14%	Pass	Pass	Pass	Pass
Cal_1	A12_6253_2_NB	NB	1	2139	202	262	2603	2240	231	228	2699	101	29	-34	96	5%	14%	-13%	4%	Pass	Pass	Pass	Pass
Cal_3	S3.6_NB	NB	2	438	21	7	466	371	18	8	397	-67	-3	1	-69	-15%	-14%	14%	-15%	Pass	Pass	Pass	Pass
Cal_3	S3.6_SB	SB	1	538	24	4	566	564	23	8	595	26	-1	4	29	5%	-4%	100%	5%	Pass	Pass	Pass	Pass
Cal_2	16342-02_NB	NB	1	822	43	1	866	766	35	9	810	-56	-8	8	-56	-7%	-19%	800%	-6%	Pass	Pass	Pass	Pass
Cal_2	16342-02_SB	SB	2	475	41	1	517	419	30	3	452	-56	-11	2	-65	-12%	-27%	200%	-13%	Pass	Pass	Pass	Pass
Cal_5	VS2.2_NEB	NEB	1	334	29	3	366	335	31	4	370	1	2	1	4	0%	7%	33%	1%	Pass	Pass	Pass	Pass
Cal_5	VS2.2_SWB	SWB	2	291	25	6	322	316	28	8	352	25	3	2	30	9%	12%	33%	9%	Pass	Pass	Pass	Pass
	72497250 A138 CHELMER RD,N OF NEW DUKES WAY RAB,CHELMSFORD_SB	SB		963	72	9	1044	984	78	19	1081	21	6	10	37	2%	8%	111%	4%	Pass	Pass	Pass	Pass
Cal_3	S3.1_SEB	SEB	1	831	45	39	915	707	41	30	778	-124	-4	-9	-137	-15%	-9%	-23%	-15%	Pass	Pass	Pass	Pass
Cal_3	S3.1_NWB	NWB	2	965	139	87	1191	947	121	65	1133	-18	-18	-22	-58	-2%	-13%	-25%	-5%	Pass	Pass	Pass	Pass
Cal_1	C1.6_SB	SB	2	2413	165	62	2640	2280	142	51	2473	-133	-23	-11	-167	-6%	-14%	-18%	-6%	Pass	Pass	Pass	Pass
Cal_3	S3.5_NB	NB	2	196	22	1	219	224	19	0	243	28	-3	-1	24	14%	-14%	-100%	11%	Pass	Pass	Pass	Pass
Cal_3	S3.5_SB	SB	1	160	11	0	171	208	12	0	220	48	1	0	49	30%	9%	0%	29%	Pass	Pass	Pass	Pass
Cal_3	S3.4_NB	NB	2	46	2	1	49	52	3	0	55	6	1	-1	6	13%	50%	-100%	12%	Pass	Pass	Pass	Pass
Cal_3	S3.4_SB	SB	1	134	7	1	142	108	3	1	112	-26	-4	0	-30	-19%	-57%	0%	-21%	Pass	Pass	Pass	Pass
Cal_3	S3.3_NWB	NWB	2	335	29	0	364	295	19	0	314	-40	-10	0	-50	-12%	-34%	0%	-14%	Pass	Pass	Pass	Pass
Cal_3	S3.3_SEB	SEB	1	233	14	0	247	215	11	0	226	-18	-3	0	-21	-8%	-21%	0%	-9%	Pass	Pass	Pass	Pass
Cal_6	VS1.5_NB	NB	2	943	122	28	1093	889	82	20	991	-54	-40	-8	-102	-6%	-33%	-29%	-9%	Pass	Pass	Pass	Pass
Cal_6	VS1.5_SB	SB	1	969	102	23	1094	939	103	22	1064	-30	1	-1	-30	-3%	1%	-4%	-3%	Pass	Pass	Pass	Pass
	72497250 A138 CHELMER RD,N OF NEW DUKES WAY RAB,CHELMSFORD_NB	NB		1199	89	11	1299	1088	86	19	1193	-111	-3	8	-106	-9%	-3%	73%	-8%	Pass	Pass	Pass	Pass
Cal_4	S4.2_SWB	SWB	2	499	21	2	522	525	26	8	559	26	5	6	37	5%	24%	300%	7%	Pass	Pass	Pass	Pass
Cal_4	S4.2_NEB	NEB	1	779	32	8	819	764	33	8	805	-15	1	0	-14	-2%	3%	0%	-2%	Pass	Pass	Pass	Pass
Cal_4	S4.1_SWB	SWB	2	121	9	1	131	133	16	0	149	12	7	-1	18	10%	78%	-100%	14%	Pass	Pass	Pass	Pass
Cal_4	AN1.4_NWB	NWB	1	400	41	0	441	434	43	5	482	34	2	5	41	9%	5%		9%	Pass	Pass	Pass	Pass
Cal_4	AN1.4_SEB	SEB	2	595	68	19	682	684	68	9	761	89	0	-10	79	15%	0%	-53%	12%	Pass	Pass	Pass	Pass
Cal_5	VS2.5_NB	NB	1	31	1	0	32	39	6	0	45	8	5	0	13	26%	500%	0%	41%	Pass	Pass	Pass	Pass
Cal_5	VS2.5_SB	SB	2	23	2	0	25	37	7	0	44	14	5	0	19	61%	250%	0%	76%	Pass	Pass	Pass	Pass
Cal_2	C2.8_SB	SB	1	753	58	9	820	719	46	6	771	-34	-12	-3	-49	-5%	-21%	-33%	-6%	Pass	Pass	Pass	Pass
Cal_2	C2.8_NB	NB	2	1301	48	29	1378	1067	38	18	1123	-234	-10	-11	-255	-18%	-21%	-38%	-19%	Fail	Pass	Pass	Fail
Cal_3	S3.2_NWB	NWB	2	500	53	3	556	435	39	12	486	-65	-14	9	-70	-13%	-26%	300%	-13%	Pass	Pass	Pass	Pass
Cal_3	S3.2_SEB	SEB	1	635	53	4	692	714	67	7	788	79	14	3	96	12%	26%	75%	14%	Pass	Pass	Pass	Pass
	S5.1_SB	SB		1084	54	4	1142	1049	64	13	1126	-35	10	9	-16	-3%	19%	225%	-1%	Pass	Pass	Pass	Pass
	Ind2_NWB	NWB		1784	90	3	1877	1696	83	16	1795	-88	-7	13	-82	-5%	-8%	433%	-4%	Pass	Pass	Pass	Pass
	Ind2_SEB	SEB		2096	98	7	2201	2254	104	18	2376	158	6	11	175	8%	6%	157%	8%	Pass	Pass	Pass	Pass
Cal_1	C1.13_WB	WB	2	38	4	1	43	0	0	0	0	-38	-4	-1	-43	-100%	-100%	-100%	-100%	Pass	Pass	Pass	Pass
Cal_1	C1.13_EB	EB	1	42	1	3	46	0	0	0	0	-42	-1	-3	-46	-100%	-100%	-100%	-100%	Pass	Pass	Pass	Pass
Cal_1	C1.12_WB	WB	2	415	46	8	469	448	46	14	508	33	0	6	39	8%	0%	75%	8%	Pass	Pass	Pass	Pass
Cal_1	C1.12_EB	EB	1	662	82	8	752	609	81	12	702	-53	-1	4	-50	-8%	-1%	50%	-7%	Pass	Pass	Pass	Pass
Cal_4	S5.4_NB	NB	2	821	48	10	879	813	43	13	869	-8	-5	3	-10	-1%	-10%	30%	-1%	Pass	Pass	Pass	Pass
Cal_4	S5.4_SB	SB	1	479	36	3	518	464	29	1	494	-15	-7	-2	-24	-3%	-19%	-67%	-5%	Pass	Pass	Pass	Pass
	C1.5_EB	EB		268	58	11	337	305	50	15	370	37	-8	4	33	14%	-14%	36%	10%	Pass	Pass	Pass	Pass
	C1.5_WB	WB		221	35	6	262	253	39	15	307	32	4	9	45	14%	11%	150%	17%	Pass	Pass	Pass	Pass
	76947695 MALDON ROAD ANT JUNCT MOLRAMS LANE - SANDON_WB	WB		492	47	2	541	459	34	1	494	-33	-13	-1	-47	-7%	-28%	-50%	-9%	Pass	Pass	Pass	Pass
	76947695 MALDON ROAD ANT JUNCT MOLRAMS LANE - SANDON_EB	EB		599	35	2	636	541	43	1	585	-58	8	-1	-51	-10%	23%	-50%	-8%	Pass	Pass	Pass	Pass
Cal_5	VS2.1_SB	SB	2	206	25	1	232	178	20	3	201	-28	-5	2	-31	-14%	-20%	200%	-13%	Pass	Pass	Pass	Pass
Cal_5	VS2.1_NB	NB	1	291	19	3	313	248	15	2	265	-43	-4	-1	-48	-15%	-21%	-33%	-15%	Pass	Pass	Pass	Pass
Cal_5	VS2.4_NB	NB	1	490	28	3	521	444	28	4	476	-46	0	1	-45	-9%	0%	33%	-9%	Pass	Pass	Pass	Pass
Cal_5	VS2.4_SB	SB	2	616	40	10	666	546	35	4	585	-70	-5	-6	-81	-11%	-13%	-60%	-12%	Pass	Pass	Pass	Pass
Cal_5	VS2.7_SB	SB	2	554	63	16	633	514	37	11	562	-40	-26	-5	-71	-7%	-41%	-31%	-11%	Pass	Pass	Pass	Pass
Cal_5	VS2.7_NB	NB	1	622	74	19	715	594	63	19	676	-28	-11	0	-39	-5%	-15%	0%	-5%	Pass	Pass	Pass	Pass
Cal_1	C1.2_NEB	NEB	2	530	107	28	665	491	77	21	589	-39	-30	-7	-76	-7%	-28%	-25%	-11%	Pass	Pass	Pass	Pass
Cal_1	C1.2_SWB	SWB	1	424	37	9	470	432	39	6	477	8	2	-3	7	2%	5%	-33%	1%	Pass	Pass	Pass	Pass
Cal_1	C1.4_EB	EB	2	897	131	31	1059	868	116	22	1006	-29	-15	-9	-53	-3%	-11%	-29%	-5%	Pass	Pass	Pass	Pass
Cal_1	C1.4_WB	WB	1	656	52	23	731	737	65	17	819	81	13	-6	88	12%	25%	-26%	12%	Pass	Pass	Pass	Pass
Cal_2	C2.9_SB	SB	1	77	2	1	80	77	3	0	80	0	1	-1	0	0%	50%	-100%	0%	Pass	Pass	Pass	Pass
Cal_2	C2.9_NB	NB	2	86	15	2	103	80	8	1	89	-6	-7	-1	-14	-7%	-47%	-50%	-14%	Pass	Pass	Pass	Pass
Cal_1	C1.18_NEB	NEB	2	1269	48	21	1338	1100	43	17	1160	-169	-5	-4	-178	-13%	-10%	-19%	-13%	Pass	Pass	Pass	Pass
Cal_1	C1.18_SWB	SWB	1	787	61	11	859	761	47	8	816	-26	-14	-3	-43	-3%	-23%	-27%	-5%	Pass	Pass	Pass	Pass
Cal_1	C1.8_NB	NB	1	706	96	24	826	718	93	16	827	12	-3	-8	1	2%	-3%	-33%	0%	Pass	Pass	Pass	Pass
Cal_1	C1.8_SB	SB	2	819	97	23	939	851	97	17	965	32	0	-6	26	4%	0%	-26%	3%	Pass	Pass	Pass	Pass
	68606861 A414 MALDON ROAD-194M E OF GAY BOWERS LANE-DANBURY_EB	EB		853	83	10	946	843	93	14	950	-10	10	4	4	-1%	12%	40%	0%	Pass	Pass	Pass	Pass
	68606861 A414 MALDON ROAD-194M E OF GAY BOWERS LANE-DANBURY_WB	WB		509	60	8	577	590	73	12	675	81	13	4	98	16%	22%	50%	17%	Pass	Pass	Pass	Pass
	03006133 A130 WHITE HART LANE C'FORD 450m E Nabbotts Fm RAB_EB	EB		869	72	23	964	761	50	22	833	-108	-22	-1	-131	-12%	-31%	-4%	-14%	Pass	Pass	Pass	Pass
	03006133 A130 WHITE HART LANE C'FORD 450m E Nabbotts Fm RAB_WB	WB		839	47	17	903	762	51	22	835	-77	4	5	-68	-9%	9%	29%	-8%	Pass	Pass	Pass	Pass
Cal_1	C1.15_SEB	SEB	1	11	0	0	11	16	2	0	18	5	2	0	7	45%		0%	64%	Pass	Pass	Pass	Pass
Cal_1	C1.15_NWB	NWB	2	13	0	0	13	16	3	0	19	3	3	0	6	23%		0%	46%	Pass	Pass	Pass	Pass
Cal_1	C1.16_WB	WB	2	30	6	0	36	30	4	0	34	0	-2	0	-2	0%	-33%	0%	-6%	Pass	Pass	Pass	Pass
Cal_1	C1.16_EB	EB	1	31	1	0	32	33	2	0	35	2	1	0	3	6%	100%	0%	9%	Pass	Pass	Pass	Pass
Cal_1	C1.7_EB	EB	2	166	31	2	199	139	34	6	179	-27	3	4	-20	-16%	10%	200%	-10%	Pass	Pass	Pass	Pass
Cal_1	C1.7_WB	WB	1	51	8	0	59	78	7	5	90	27	-1	5	31	53%	-13%		53%	Pass	Pass	Pass	Pass
Cal_3	S3.7_NWB	NWB	2	1120	64	15	1199	1160	59	12	1231	40	-5	-3	32	4%	-8%	-20%	3%	Pass	Pass	Pass	Pass
Cal_1	C1.14_NWB	NWB	2	281	57	5	343	265	52	8	325	-16	-5	3	-18	-6%	-9%	60%	-5%	Pass	Pass	Pass	Pass
Cal_1	C1.14_SB	SB	1	315	26	7	348	301	25	7	333	-14	-1	0	-15	-4%	-4%	0%	-4%	Pass	Pass	Pass	Pass
Cal_1	C1.11_SWB	SWB	2	85	11	0	96	83	9	0	92	-2	-2	0	-4	-2%	-18%	0%	-4%	Pass	Pass	Pass	Pass
Cal_1	C1.11_NEB	NEB	1	73	8	2	83	92	8	0	100	19	0	-2	17	26%	0%	-100%	20%	Pass	Pass	Pass	Pass
Cal_4	AN1.5_NB	NB	1	388	58	12	458	483	65	20	568	95	7	8	110	24%	12%	67%	24%	Pass	Pass	Pass	Pass
Cal_4	AN1.5_SB	SB	2	494	65	14	573	540	63	18	621	46	-2	4	48	9%	-3%	29%	8%	Pass	Pass	Pass	Pass
Cal_1	C1.1_WB	WB	1	2707	246	114	3067	2875	260	132	3267	168	14	18	200	6%	6%	16%	7%	Pass	Pass	Pass	Pass
Cal_5	VS2.6_WB	WB	2	890	100	17	1007	906	100	27	1033	16	0	10	26	2%	0%	59%	3%	Pass	Pass	Pass	Pass
Cal_5	VS2.6_EB	EB	1	1187	139	22	1348	1246	123	30	1399	59	-16	8	51	5%	-12%	36%	4%	Pass	Pass	Pass	Pass
Cal_3	S3.7_SEB	SEB	1	1161	112	27	1300	1202	95	22	1319	41	-17	-5	19	4%	-15%	-19%	1%	Pass	Pass	Pass	Pass
Cal_1	C1.6_NB	NB	1	1533	129	54	1716	1593	148	47	1788	60	19	-7	72	4%	15%	-13%	4%	Pass	Pass	Pass	Pass
Cal_1	C1.1_EB	EB	2	2959	403	128	3490	3147	389	143	3679	188	-14	15	189	6%	-3%	12%	5%	Pass	Pass	Pass	Pass
Cal_1	C1.3_NB	NB	2	229	33	2	264	247	26	6	279	18	-7	4	15	8%	-21%	200%	6%	Pass	Pass	Pass	Pass
Cal_1	C1.3_SB	SB	1	95	7	1	103	77	11	8	96	-18	4	7	-7	-19%	57%	700%	-7%	Pass	Pass	Pass	Pass
Cal_2	C2.2_SB	SB	2	432	41	10	483	465	45	11	521	33	4	1	38	8%	10%	10%	8%	Pass	Pass	Pass	Pass
Cal_2	C2.2_NB	NB	1	305	36	8	349	357	35	6	398	52	-1	-2	49	17%	-3%	-25%	14%	Pass	Pass	Pass	Pass
Cal_1	C1.20_EB	EB	2	6	6	2	14	0	0	0	0	-6	-6	-2	-14	-100%	-100%	-100%	-100%	Pass	Pass	Pass	Pass
Cal_1	C1.20_WB	WB	1	4	0	0	4	0	0	0	0	-4	0	0	-4	-100%	0%	0%	-100%	Pass	Pass	Pass	Pass
Cal_1	C1.19_EB	EB	2	275	13	2	290	260	14	3	277	-15	1	1	-13	-5%	8%	50%	-4%	Pass	Pass	Pass	Pass
Cal_1	C1.19_WB	WB	1	164	11	0	175	151	12	4	167	-13	1	4	-8	-8%	9%		-5%	Pass	Pass	Pass	Pass
Cal_6	VS1.2_SB	SB	1	725	28	3	756	789	24	7	820	64	-4	4	64	9%	-14%	133%	8%	Pass	Pass	Pass	Pass
Cal_6	VS1.2_NB	NB	2	1129	48	5	1182	1056	46	7	1109	-73	-2	2	-73	-6%	-4%	40%	-6%	Pass	Pass	Pass	Pass
Cal_2	C2.1_NB	NB	2	226	13	1	240	265	17	3	285	39	4	2	45	17%	31%	200%	19%	Pass	Pass	Pass	Pass
Cal_2	C2.1_SB	SB	1	130	11	0	141	163	23	6	192	33	12	6	51	25%	109%		36%	Pass	Pass	Pass	Pass
Cal_4	S5.2_NB	NB	1	908	106	36	1050	868	92	26	986	-40	-14	-10	-64	-4%	-13%	-28%	-6%	Pass	Pass	Pass	Pass
Cal_4	S5.2_SB	SB	2	695	37	11	743	672	25	8	705	-23	-12	-3	-38	-3%	-32%	-27%	-5%	Pass	Pass	Pass	Pass

GEH or Criteria 1	Car	LGV	HGV	Total
	99%	100%	100%	99%
Fail	1	0	0	1
Pass	123	124	124	123

Appendix N – Validation Count Summary

AM

Pass

Screenline	ID	BOUND	DIR	AM Count Data				AM Model Data				Absolute differences				%age Difference				GEH or Criteria 1			
				Car	LGV	HGV	Total	Car	LGV	HGV	Total	Car	LGV	HGV	Total	Car	LGV	HGV	Total	Car	LGV	HGV	Total
Val_2	S2.3_NB	NB	1	1069	91	143	1303	845	107	48	1000	-224	16	-95	-303	-21%	18%	-66%	-23%	Fail	Pass	Pass	Fail
	AN1.1_WB	WB		1656	72	15	1743	1817	85	21	1923	161	13	6	180	10%	18%	40%	10%	Pass	Pass	Pass	Pass
Val_2	S2.8_SB	SB	2	21	1	0	22	17	2	1	20	-4	1	1	-2	-19%	100%		-9%	Pass	Pass	Pass	Pass
Val_2	S2.8_NB	NB	1	21	3	0	24	11	3	1	15	-10	0	1	-9	-48%	0%		-38%	Pass	Pass	Pass	Pass
Val_4	S6.1_NB	NB	2	436	36	7	479	445	31	7	483	9	-5	0	4	2%	-14%	0%	1%	Pass	Pass	Pass	Pass
Val_3	68686869 A1016 WATERHOUSE LN-	NB	1	754	119	52	925	726	71	25	822	-28	-48	-27	-103	-4%	-40%	-52%	-11%	Pass	Pass	Pass	Pass
Val_3	68686869 A1016 WATERHOUSE LN-	SB	2	676	93	21	790	752	43	14	809	76	-50	-7	19	11%	-54%	-33%	2%	Pass	Pass	Pass	Pass
Val_5	S1.1_SB	SB	1	1196	85	55	1336	1158	86	40	1284	-38	1	-15	-52	-3%	1%	-27%	-4%	Pass	Pass	Pass	Pass
Val_5	S1.1_NB	NB	2	891	102	65	1058	899	111	51	1061	8	9	-14	3	1%	9%	-22%	0%	Pass	Pass	Pass	Pass
Val_1	S1.8_EB	EB	1	474	55	17	546	496	64	6	566	22	9	-11	20	5%	16%	-65%	4%	Pass	Pass	Pass	Pass
Val_1	S1.8_WB	WB	2	575	81	23	679	644	60	7	711	69	-21	-16	32	12%	-26%	-70%	5%	Pass	Pass	Pass	Pass
Val_2	S2.10_EB	EB	1	34	7	1	42	31	7	8	46	-3	0	7	4	-9%	0%	700%	10%	Pass	Pass	Pass	Pass
Val_2	S2.10_WB	WB	2	118	10	0	128	167	29	17	213	49	19	17	85	42%	190%		66%	Pass	Pass	Pass	Pass
Val_5	S1.3_NEB	NEB	2	166	6	0	172	229	7	4	240	63	1	4	68	38%	17%		40%	Pass	Pass	Pass	Pass
Val_5	S1.3_SB	SB	1	289	20	2	311	213	14	0	227	-76	-6	-2	-84	-26%	-30%	-100%	-27%	Pass	Pass	Pass	Pass
Val_4	S6.1_SB	SB	1	546	59	10	615	630	38	6	674	84	-21	-4	59	15%	-36%	-40%	10%	Pass	Pass	Pass	Pass
Val_5	S2.1_EB	EB	2	849	102	42	993	865	97	23	985	16	-5	-19	-8	2%	-5%	-45%	-1%	Pass	Pass	Pass	Pass
Val_3	77367737 A1114 PRINCES RD 53M V	EB	1	412	38	11	461	380	59	26	465	-32	21	15	4	-8%	55%	136%	1%	Pass	Pass	Pass	Pass
Val_3	77367737 A1114 PRINCES RD 53M V	WB	2	585	71	11	667	576	67	14	657	-9	-4	3	-10	-2%	-6%	27%	-1%	Pass	Pass	Pass	Pass
Val_2	S2.6_NB	NB	1	1073	70	17	1160	1077	128	38	1243	4	58	21	83	0%	83%	124%	7%	Pass	Pass	Pass	Pass
Val_1	S1.6_WB	WB	2	796	78	14	888	748	89	25	862	-48	11	11	-26	-6%	14%	79%	-3%	Pass	Pass	Pass	Pass
Val_1	S1.6_EB	EB	1	650	66	15	731	686	49	21	756	36	-17	6	25	6%	-26%	40%	3%	Pass	Pass	Pass	Pass
Val_2	S2.11_WB	WB	2	912	52	114	1078	1114	119	30	1263	202	67	-84	185	22%	129%	-74%	17%	Fail	Pass	Pass	Fail
Val_2	S2.11_EB	EB	1	1384	69	146	1599	1441	115	65	1621	57	46	-81	22	4%	67%	-55%	1%	Pass	Pass	Pass	Pass
Val_2	S2.4_WB	WB	1	544	49	7	600	668	51	3	722	124	2	-4	122	23%	4%	-57%	20%	Fail	Pass	Pass	Pass
Val_2	S2.4_EB	EB	2	748	71	6	825	701	53	5	759	-47	-18	-1	-66	-6%	-25%	-17%	-8%	Pass	Pass	Pass	Pass
Val_3	75487549 B1007 WOOD STREET, W/	EB	1	574	74	9	657	525	41	2	568	-49	-33	-7	-89	-9%	-45%	-78%	-14%	Pass	Pass	Pass	Pass
Val_3	75487549 B1007 WOOD STREET, W/	WB	2	969	148	8	1125	799	51	1	851	-170	-97	-7	-274	-18%	-66%	-88%	-24%	Fail	Pass	Pass	Fail
Val_5	S1.2_NB	NB	2	799	35	6	840	778	39	9	826	-21	4	3	-14	-3%	11%	50%	-2%	Pass	Pass	Pass	Pass
Val_5	S1.2_SB	SB	1	691	30	3	724	736	34	11	781	45	4	8	57	7%	13%	267%	8%	Pass	Pass	Pass	Pass
Val_3	S3.8_WB	WB	2	204	19	0	223	255	24	2	281	51	5	2	58	25%	26%		26%	Pass	Pass	Pass	Pass
Val_3	S3.8_EB	EB	1	204	11	2	217	284	36	4	324	80	25	2	107	39%	227%	100%	49%	Pass	Pass	Pass	Fail
Val_2	S2.9_NB	NB	1	427	46	10	483	507	47	3	557	80	1	-7	74	19%	2%	-70%	15%	Pass	Pass	Pass	Pass
Val_2	S2.9_SB	SB	2	691	61	6	758	543	37	9	589	-148	-24	3	-169	-21%	-39%	50%	-22%	Fail	Pass	Pass	Fail
Val_1	S1.7_WB	WB	2	243	36	2	281	268	38	8	314	25	2	6	33	10%	6%	300%	12%	Pass	Pass	Pass	Pass
Val_1	S1.7_EB	EB	1	514	41	4	559	359	26	4	389	-155	-15	0	-170	-30%	-37%	0%	-30%	Fail	Pass	Pass	Fail
Val_1	S1.5_NWB	NWB	2	15	2	0	17	22	5	1	28	7	3	1	11	47%	150%		65%	Pass	Pass	Pass	Pass
Val_1	S1.5_SEB	SEB	1	30	0	0	30	45	5	1	51	15	5	1	21	50%			70%	Pass	Pass	Pass	Pass
Val_2	S2.5_WB	WB	1	478	23	1	502	391	37	29	457	-87	14	28	-45	-18%	61%	2800%	-9%	Pass	Pass	Pass	Pass
Val_2	S2.5_EB	EB	2	131	9	3	143	166	26	23	215	35	17	20	72	27%	189%	667%	50%	Pass	Pass	Pass	Pass
Val_2	S2.6_SB	SB	2	586	59	12	657	605	102	50	757	19	43	38	100	3%	73%	317%	15%	Pass	Pass	Pass	Pass
Val_4	81038104_SB	SB	1	1221	136	23	1380	1266	121	19	1406	45	-15	-4	26	4%	-11%	-17%	2%	Pass	Pass	Pass	Pass
Val_4	81038104_NB	NB	2	890	113	23	1026	758	92	28	878	-132	-21	5	-148	-15%	-19%	22%	-14%	Pass	Pass	Pass	Pass
Val_2	S2.7_NB	NB	1	48	9	0	57	28	5	2	35	-20	-4	2	-22	-42%	-44%		-39%	Pass	Pass	Pass	Pass
Val_2	S2.7_SB	SB	2	57	9	1	67	50	13	1	64	-7	4	0	-3	-12%	44%	0%	-4%	Pass	Pass	Pass	Pass
Val_5	S1.4_NB	NB	2	102	16	1	119	121	15	3	139	19	-1	2	20	19%	-6%	200%	17%	Pass	Pass	Pass	Pass
Val_5	S1.4_SB	SB	1	213	23	2	238	169	25	5	199	-44	2	3	-39	-21%	9%	150%	-16%	Pass	Pass	Pass	Pass
Val_4	Ind_SB	SB	1	203	5	2	210	107	12	8	127	-96	7	6	-83	-47%	140%	300%	-40%	Pass	Pass	Pass	Pass
Val_4	Ind_NB	NB	2	525	25	6	556	652	47	20	719	127	22	14	163	24%	88%	233%	29%	Fail	Pass	Pass	Fail
	AN1.1_EB	EB		1103	128	26	1257	1227	120	35	1382	124	-8	9	125	11%	-6%	35%	10%	Pass	Pass	Pass	Pass

GEH or Criteria 1	Car	LGV	HGV	Total
	86%	100%	100%	86%
Fail	7	0	0	7
Pass	43	50	50	43

IP

Screenline	ID	BOUND	DIR	IP Count Data				IP Model Data				Absolute differences				%age Difference				GEH or Criteria 1			
				Car	LGV	HGV	Total	Car	LGV	HGV	Total	Car	LGV	HGV	Total	Car	LGV	HGV	Total	Car	LGV	HGV	Total
Val_2	S2.3_NB	NB	1	681	67	129	877	478	89	74	641	-203	22	-55	-236	-30%	33%	-43%	-27%	Fail	Pass	Pass	Fail
	AN1.1_WB	WB		1185	103	25	1313	1250	111	36	1397	65	8	11	84	5%	8%	44%	6%	Pass	Pass	Pass	Pass
Val_2	S2.8_SB	SB	2	10	2	1	13	5	1	1	7	-5	-1	0	-6	-50%	-50%	0%	-46%	Pass	Pass	Pass	Pass
Val_2	S2.8_NB	NB	1	8	2	1	11	10	2	1	13	2	0	0	2	25%	0%	0%	18%	Pass	Pass	Pass	Pass
Val_4	S6.1_NB	NB	2	568	40	8	616	673	29	7	709	105	-11	-1	93	18%	-28%	-13%	15%	Pass	Pass	Pass	Pass
Val_3	68686869 A1016 WATERHOUSE LN-	NB	1	604	106	38	748	594	62	18	674	-10	-44	-20	-74	-2%	-42%	-53%	-10%	Pass	Pass	Pass	Pass
Val_3	68686869 A1016 WATERHOUSE LN-	SB	2	538	98	34	670	585	70	22	677	47	-28	-12	7	9%	-29%	-35%	1%	Pass	Pass	Pass	Pass
Val_5	S1.1_SB	SB	1	787	101	71	959	789	101	48	938	2	0	-23	-21	0%	0%	-32%	-2%	Pass	Pass	Pass	Pass
Val_5	S1.1_NB	NB	2	807	92	68	967	818	114	63	995	11	22	-5	28	1%	24%	-7%	3%	Pass	Pass	Pass	Pass
Val_1	S1.8_EB	EB	1	399	59	23	481	405	65	12	482	6	6	-11	1	2%	10%	-48%	0%	Pass	Pass	Pass	Pass
Val_1	S1.8_WB	WB	2	395	56	24	475	340	41	12	393	-55	-15	-12	-82	-14%	-27%	-50%	-17%	Pass	Pass	Pass	Pass
Val_2	S2.10_EB	EB	1	43	4	1	48	29	4	12	45	-14	0	11	-3	-33%	0%	1100%	-6%	Pass	Pass	Pass	Pass
Val_2	S2.10_WB	WB	2	39	3	1	43	138	25	20	183	99	22	19	140	254%	733%	1900%	326%	Pass	Pass	Pass	Fail
Val_5	S1.3_NEB	NEB	2	124	11	0	135	94	11	5	110	-30	0	5	-25	-24%	0%		-19%	Pass	Pass	Pass	Pass
Val_5	S1.3_SB	SB	1	120	9	1	130	179	13	0	192	59	4	-1	62	49%	44%	-100%	48%	Pass	Pass	Pass	Pass
Val_4	S6.1_SB	SB	1	684	43	10	737	558	47	8	613	-126	4	-2	-124	-18%	9%	-20%	-17%	Fail	Pass	Pass	Pass
Val_5	S2.1_EB	EB	2	741	93	55	889	853	138	37	1028	112	45	-18	139	15%	48%	-33%	16%	Pass	Pass	Pass	Pass
Val_3	77367737 A1114 PRINCES RD 53M V	EB	1	515	45	12	572	484	68	18	570	-31	23	6	-2	-6%	51%	50%	0%	Pass	Pass	Pass	Pass
Val_3	77367737 A1114 PRINCES RD 53M V	WB	2	581	65	14	660	497	56	20	573	-84	-9	6	-87	-14%	-14%	43%	-13%	Pass	Pass	Pass	Pass
Val_2	S2.6_NB	NB	1	610	71	22	703	648	102	52	802	38	31	30	99	6%	44%	136%	14%	Pass	Pass	Pass	Pass
Val_1	S1.6_WB	WB	2	407	47	21	475	436	64	37	537	29	17	16	62	7%	36%	76%	13%	Pass	Pass	Pass	Pass
Val_1	S1.6_EB	EB	1	427	53	22	502	431	54	31	516	4	1	9	14	1%	2%	41%	3%	Pass	Pass	Pass	Pass
Val_2	S2.11_WB	WB	2	686	45	96	827	777	110	45	932	91	65	-51	105	13%	144%	-53%	13%	Pass	Pass	Pass	Pass
Val_2	S2.11_EB	EB	1	643	45	101	789	748	75	41	864	105	30	-60	75	16%	67%	-59%	10%	Pass	Pass	Pass	Pass
Val_2	S2.4_WB	WB	1	399	40	9	448	413	49	3	465	14	9	-6	17	4%	23%	-67%	4%	Pass	Pass	Pass	Pass
Val_2	S2.4_EB	EB	2	425	38	10	473	489	45	7	541	64	7	-3	68	15%	18%	-30%	14%	Pass	Pass	Pass	Pass
Val_3	75487549 B1007 WOOD STREET, W/	EB	1	674	63	8	745	539	31	3	573	-135	-32	-5	-172	-20%	-51%	-63%	-23%	Fail	Pass	Pass	Fail
Val_3	75487549 B1007 WOOD STREET, W/	WB	2	605	63	6	674	508	38	4	550	-97	-25	-2	-124	-16%	-40%	-33%	-18%	Pass	Pass	Pass	Fail
Val_5	S1.2_NB	NB	2	537	44	4	585	445	40	9	494	-92	-4	5	-91	-17%	-9%	125%	-16%	Pass	Pass	Pass	Pass
Val_5	S1.2_SB	SB	1	578	44	5	627	567	38	15	620	-11	-6	10	-7	-2%	-14%	200%	-1%	Pass	Pass	Pass	Pass
Val_3	S3.8_WB	WB	2	244	21	3	268	286	23	3	312	42	2	0	44	17%	10%	0%	16%	Pass	Pass	Pass	Pass
Val_3	S3.8_EB	EB	1	177	13	1	191	209	19	3	231	32	6	2	40	18%	46%	200%	21%	Pass	Pass	Pass	Pass
Val_2	S2.9_NB	NB	1	334	42	8	384	379	37	6	422	45	-5	-2	38	13%	-12%	-25%	10%	Pass	Pass	Pass	Pass
Val_2	S2.9_SB	SB	2	348	40	8	396	301	31	7	339	-47	-9	-1	-57	-14%	-23%	-13%	-14%	Pass	Pass	Pass	Pass
Val_1	S1.7_WB	WB	2	242	26	3	271	236	23	8	267	-6	-3	5	-4	-2%	-12%	167%	-1%	Pass	Pass	Pass	Pass
Val_1	S1.7_EB	EB	1	244	26	2	272	183	18	5	206	-61	-8	3	-66	-25%	-31%	150%	-24%	Pass	Pass	Pass	Pass
Val_1	S1.5_NWB	NWB	2	16	2	1	19	20	4	1	25	4	2	0	6	25%	100%	0%	32%	Pass	Pass	Pass	Pass
Val_1	S1.5_SEB	SEB	1	19	3	1	23	19	5	1	25	0	2	0	2	0%	67%	0%	9%	Pass	Pass	Pass	Pass
Val_2	S2.5_WB	WB	1	74	11	2	87	78	15	9	102	4	4	7	15	5%	36%	350%	17%	Pass	Pass	Pass	Pass
Val_2	S2.5_EB	EB	2	94	12	2	108	137	23	28	188	43	11	26	80	46%	92%	1300%	74%	Pass	Pass	Pass	Pass
Val_2	S2.6_SB	SB	2	491	55	17	563	517	95	35	647	26	40	18	84	5%	73%	106%	15%	Pass	Pass	Pass	Pass
Val_4	81038104_SB	SB	1	1042	99	25	1166	909	97	25	1031	-133	-2	0	-135	-13%	-2%	0%	-12%	Pass	Pass	Pass	Pass
Val_4	81038104_NB	NB	2	1024	94	24	1142	929	113	24	1066	-95	19	0	-76	-9%	20%	0%	-7%	Pass	Pass	Pass	Pass
Val_2	S2.7_NB	NB	1	24	8	2	34	22	5	2	29	-2	-3	0	-5	-8%	-38%	0%	-15%	Pass	Pass	Pass	Pass
Val_2	S2.7_SB	SB	2	22	6	2	30	17	7	1	25	-5	1	-1	-5	-23%	17%	-50%	-17%	Pass	Pass	Pass	Pass
Val_5	S1.4_NB	NB	2	55	6	2	63	52	11	3	66	-3	5	1	3	-5%	83%	50%	5%	Pass	Pass	Pass	Pass
Val_5	S1.4_SB	SB	1	52	7	2	61	43	11	4	58	-9	4	2	-3	-17%	57%	100%	-5%	Pass	Pass	Pass	Pass
Val_4	Ind_SB	SB	1	144	11	4	159	257	17	13	287	113	6	9	128	78%	55%	225%	81%	Fail	Pass	Pass	Fail
Val_4	Ind_NB	NB	2	377	34	8	419	259	48	34	341	-118	14	26	-78	-31%	41%	325%	-19%	Fail	Pass	Pass	Pass
	AN1.1_EB	EB		1219	111	29	1359	1311	113	39	1463	92	2	10	104	8%	2%	34%	8%	Pass	Pass	Pass	Pass

GEH or Criteria 1	Car	LGV	HGV	Total
	90%	100%	100%	90%
Fail	5	0	0	5
Pass	45	50	50	45

PM

Pass

Screenline	ID	BOUND	DIR	PM Count Data				PM Model Data				Absolute differences				%age Difference				GEH or Criteria 1			
				Car	LGV	HGV	Total	Car	LGV	HGV	Total	Car	LGV	HGV	Total	Car	LGV	HGV	Total	Car	LGV	HGV	Total
Val_2	S2.3_NB	NB	1	973	59	102	1134	703	82	85	870	-270	23	-17	-264	-28%	39%	-17%	-23%	Fail	Pass	Pass	Fail
	AN1.1_WB	WB		1073	59	3	1135	1124	70	14	1208	51	11	11	73	5%	19%	367%	6%	Pass	Pass	Pass	Pass
Val_2	S2.8_SB	SB	2	13	1	0	14	9	2	0	11	-4	1	0	-3	-31%	100%	0%	-21%	Pass	Pass	Pass	Pass
Val_2	S2.8_NB	NB	1	31	4	0	35	19	3	0	22	-12	-1	0	-13	-39%	-25%	0%	-37%	Pass	Pass	Pass	Pass
Val_4	S6.1_NB	NB	2	477	39	8	524	545	21	4	570	68	-18	-4	46	14%	-46%	-50%	9%	Pass	Pass	Pass	Pass
Val_3	68686869 A1016 WATERHOUSE LN-!	NB	1	646	71	18	735	564	67	20	651	-82	-4	2	-84	-13%	-6%	11%	-11%	Pass	Pass	Pass	Pass
Val_3	68686869 A1016 WATERHOUSE LN-!	SB	2	628	63	16	707	712	38	11	761	84	-25	-5	54	13%	-40%	-31%	8%	Pass	Pass	Pass	Pass
Val_5	S1.1_SB	SB	1	1009	71	46	1126	1002	65	19	1086	-7	-6	-27	-40	-1%	-8%	-59%	-4%	Pass	Pass	Pass	Pass
Val_5	S1.1_NB	NB	2	1165	133	85	1383	1182	85	23	1290	17	-48	-62	-93	1%	-36%	-73%	-7%	Pass	Pass	Pass	Pass
Val_1	S1.8_EB	EB	1	651	59	7	717	635	97	7	739	-16	38	0	22	-2%	64%	0%	3%	Pass	Pass	Pass	Pass
Val_1	S1.8_WB	WB	2	472	31	7	510	387	24	9	420	-85	-7	2	-90	-18%	-23%	29%	-18%	Pass	Pass	Pass	Pass
Val_2	S2.10_EB	EB	1	124	24	3	151	101	20	7	128	-23	-4	4	-23	-19%	-17%	133%	-15%	Pass	Pass	Pass	Pass
Val_2	S2.10_WB	WB	2	43	4	0	47	159	25	10	194	116	21	10	147	270%	525%		313%	Fail	Pass	Pass	Fail
Val_5	S1.3_NEB	NEB	2	221	8	0	229	167	7	3	177	-54	-1	3	-52	-24%	-13%		-23%	Pass	Pass	Pass	Pass
Val_5	S1.3_SB	SB	1	150	10	1	161	276	7	0	283	126	-3	-1	122	84%	-30%	-100%	76%	Fail	Pass	Pass	Fail
Val_4	S6.1_SB	SB	1	553	59	10	622	484	31	5	520	-69	-28	-5	-102	-12%	-47%	-50%	-16%	Pass	Pass	Pass	Pass
Val_5	S2.1_EB	EB	2	1376	68	23	1467	1310	111	10	1431	-66	43	-13	-36	-5%	63%	-57%	-2%	Pass	Pass	Pass	Pass
Val_3	77367737 A1114 PRINCES RD 53M V	EB	1	440	21	4	465	460	75	24	559	20	54	20	94	5%	257%	500%	20%	Pass	Pass	Pass	Pass
Val_3	77367737 A1114 PRINCES RD 53M V	WB	2	590	37	6	633	506	65	18	589	-84	28	12	-44	-14%	76%	200%	-7%	Pass	Pass	Pass	Pass
Val_2	S2.6_NB	NB	1	800	49	4	853	719	43	29	791	-81	-6	25	-62	-10%	-12%	625%	-7%	Pass	Pass	Pass	Pass
Val_1	S1.6_WB	WB	2	680	38	4	722	667	85	19	771	-13	47	15	49	-2%	124%	375%	7%	Pass	Pass	Pass	Pass
Val_1	S1.6_EB	EB	1	825	72	8	905	772	39	13	824	-53	-33	5	-81	-6%	-46%	63%	-9%	Pass	Pass	Pass	Pass
Val_2	S2.11_WB	WB	2	1205	55	81	1341	1115	127	32	1274	-90	72	-49	-67	-7%	131%	-60%	-5%	Pass	Pass	Pass	Pass
Val_2	S2.11_EB	EB	1	908	50	80	1038	998	65	41	1104	90	15	-39	66	10%	30%	-49%	6%	Pass	Pass	Pass	Pass
Val_2	S2.4_WB	WB	1	588	53	8	649	520	37	1	558	-68	-16	-7	-91	-12%	-30%	-88%	-14%	Pass	Pass	Pass	Pass
Val_2	S2.4_EB	EB	2	553	52	5	610	633	62	3	698	80	10	-2	88	14%	19%	-40%	14%	Pass	Pass	Pass	Pass
Val_3	75487549 B1007 WOOD STREET, W/	EB	1	1075	103	5	1183	827	62	4	893	-248	-41	-1	-290	-23%	-40%	-20%	-25%	Fail	Pass	Pass	Fail
Val_3	75487549 B1007 WOOD STREET, W/	WB	2	694	54	1	749	620	38	4	662	-74	-16	3	-87	-11%	-30%	300%	-12%	Pass	Pass	Pass	Pass
Val_5	S1.2_NB	NB	2	558	24	4	586	582	41	13	636	24	17	9	50	4%	71%	225%	9%	Pass	Pass	Pass	Pass
Val_5	S1.2_SB	SB	1	739	32	3	774	726	28	6	760	-13	-4	3	-14	-2%	-13%	100%	-2%	Pass	Pass	Pass	Pass
Val_3	S3.8_WB	WB	2	291	27	0	318	210	22	2	234	-81	-5	2	-84	-28%	-19%		-26%	Pass	Pass	Pass	Pass
Val_3	S3.8_EB	EB	1	230	13	2	245	317	30	2	349	87	17	0	104	38%	131%	0%	42%	Pass	Pass	Pass	Fail
Val_2	S2.9_NB	NB	1	689	74	15	778	661	27	7	695	-28	-47	-8	-83	-4%	-64%	-53%	-11%	Pass	Pass	Pass	Pass
Val_2	S2.9_SB	SB	2	437	39	4	480	387	43	9	439	-50	4	5	-41	-11%	10%	125%	-9%	Pass	Pass	Pass	Pass
Val_1	S1.7_WB	WB	2	319	47	3	369	334	34	4	372	15	-13	1	3	5%	-28%	33%	1%	Pass	Pass	Pass	Pass
Val_1	S1.7_EB	EB	1	273	22	2	297	198	14	2	214	-75	-8	0	-83	-27%	-36%	0%	-28%	Pass	Pass	Pass	Pass
Val_1	S1.5_NWB	NWB	2	21	3	0	24	35	4	0	39	14	1	0	15	67%	33%	0%	63%	Pass	Pass	Pass	Pass
Val_1	S1.5_SEB	SEB	1	22	0	0	22	31	4	0	35	9	4	0	13	41%		0%	59%	Pass	Pass	Pass	Pass
Val_2	S2.5_WB	WB	1	114	5	0	119	144	16	14	174	30	11	14	55	26%	220%		46%	Pass	Pass	Pass	Pass
Val_2	S2.5_EB	EB	2	298	20	7	325	378	22	15	415	80	2	8	90	27%	10%	114%	28%	Pass	Pass	Pass	Pass
Val_2	S2.6_SB	SB	2	946	40	4	990	891	87	28	1006	-55	47	24	16	-6%	118%	600%	2%	Pass	Pass	Pass	Pass
Val_4	81038104_SB	SB	1	1353	72	6	1431	1149	122	23	1294	-204	50	17	-137	-15%	69%	283%	-10%	Fail	Pass	Pass	Pass
Val_4	81038104_NB	NB	2	1243	51	10	1304	1073	81	20	1174	-170	30	10	-130	-14%	59%	100%	-10%	Pass	Pass	Pass	Pass
Val_2	S2.7_NB	NB	1	69	13	0	82	43	5	1	49	-26	-8	1	-33	-38%	-62%		-40%	Pass	Pass	Pass	Pass
Val_2	S2.7_SB	SB	2	28	5	1	34	34	15	1	50	6	10	0	16	21%	200%	0%	47%	Pass	Pass	Pass	Pass
Val_5	S1.4_NB	NB	2	132	21	1	154	166	11	1	178	34	-10	0	24	26%	-48%	0%	16%	Pass	Pass	Pass	Pass
Val_5	S1.4_SB	SB	1	125	14	1	140	123	13	2	138	-2	-1	1	-2	-2%	-7%	100%	-1%	Pass	Pass	Pass	Pass
Val_4	Ind_SB	SB	1	271	7	3	281	498	22	9	529	227	15	6	248	84%	214%	200%	88%	Fail	Pass	Pass	Fail
Val_4	Ind_NB	NB	2	567	27	7	601	484	57	22	563	-83	30	15	-38	-15%	111%	214%	-6%	Pass	Pass	Pass	Pass
	AN1.1_EB	EB		1784	73	6	1863	2073	100	19	2192	289	27	13	329	16%	37%	217%	18%	Fail	Pass	Pass	Fail

GEH or Criteria 1	Car	LGV	HGV	Total
	86%	100%	100%	86%
Fail	7	0	0	7
Pass	43	50	50	43

Appendix O – Screenline Summary

AM	Car

	AM	Screenline Modelled vs Observed by Direction			Car					
Screenline ID	Purpose	Screenline Name	AM Count Data	AM Model Data	% (Actual Flow)					No. of Counts
					Diff	<5%	<7.5%	<10%	% Criteria	
C1	Calibration	Cal_1-1	14240	14061	-1.3%	Pass	Pass	Pass	Pass	19
	Calibration	Cal_1-2	11404	11318	-0.8%	Pass	Pass	Pass	Pass	19
C2	Calibration	Cal_2-1	3750	3838	2.3%	Pass	Pass	Pass	Pass	8
	Calibration	Cal_2-2	3888	3710	-4.6%	Pass	Pass	Pass	Pass	8
C3	Calibration	Cal_3-1	3783	3740	-1.1%	Pass	Pass	Pass	Pass	7
	Calibration	Cal_3-2	3438	3097	-9.9%	Fail	Fail	Pass	Fail	7
C4	Calibration	Cal_4-1	5583	5387	-3.5%	Pass	Pass	Pass	Pass	8
	Calibration	Cal_4-2	4685	4661	-0.5%	Pass	Pass	Pass	Pass	9
C5	Calibration	Cal_5-1	2551	2658	4.2%	Pass	Pass	Pass	Pass	7
	Calibration	Cal_5-2	2792	2749	-1.5%	Pass	Pass	Pass	Pass	7
C6	Calibration	Cal_6-1	3662	3433	-6.3%	Fail	Pass	Pass	Pass	4
	Calibration	Cal_6-2	2413	2231	-7.5%	Fail	Fail	Pass	Fail	4
V1	Validation	Val_1-1	1668	1586	-4.9%	Pass	Pass	Pass	Pass	4
	Validation	Val_1-2	1629	1682	3.3%	Pass	Pass	Pass	Pass	4
V2	Validation	Val_2-1	5078	4999	-1.6%	Pass	Pass	Pass	Pass	9
	Validation	Val_2-2	3264	3365	3.1%	Pass	Pass	Pass	Pass	8
V3	Validation	Val_3-1	1944	1915	-1.5%	Pass	Pass	Pass	Pass	4
	Validation	Val_3-2	2434	2382	-2.1%	Pass	Pass	Pass	Pass	4
V4	Validation	Val_4-1	1970	2003	1.7%	Pass	Pass	Pass	Pass	3
	Validation	Val_4-2	1851	1855	0.2%	Pass	Pass	Pass	Pass	3
V5	Validation	Val_5-1	2389	2276	-4.7%	Pass	Pass	Pass	Pass	4
	Validation	Val_5-2	2807	2892	3.0%	Pass	Pass	Pass	Pass	5

	<5%	<7.5%	<10%	% Criteria
Fail	3	2	0	2
Pass	19	20	22	20
Total	22	22	22	22
%	86%	91%	100%	**91%**

AM	Total

	AM	Screenline Modelled vs Observed by Direction			Total						
Screenline ID	Purpose	Screenline Name	AM Count Data	AM Model Data	% (Actual Flow)					No. of Counts	
					Diff	<5%	<7.5%	<10%	% Criteria		
C1	Calibration	Cal_1-1	16576	16498	-0.5%	Pass	Pass	Pass	Pass	19	-78
	Calibration	Cal_1-2	13680	13700	0.1%	Pass	Pass	Pass	Pass	19	20
C2	Calibration	Cal_2-1	4208	4295	2.1%	Pass	Pass	Pass	Pass	8	87
	Calibration	Cal_2-2	4386	4171	-4.9%	Pass	Pass	Pass	Pass	8	-215
C3	Calibration	Cal_3-1	4133	4087	-1.1%	Pass	Pass	Pass	Pass	7	-46
	Calibration	Cal_3-2	3842	3471	-9.7%	Fail	Fail	Pass	Fail	7	-371
C4	Calibration	Cal_4-1	6087	5862	-3.7%	Pass	Pass	Pass	Pass	8	-225
	Calibration	Cal_4-2	5181	5131	-1.0%	Pass	Pass	Pass	Pass	9	-50
C5	Calibration	Cal_5-1	2827	2958	4.6%	Pass	Pass	Pass	Pass	7	131
	Calibration	Cal_5-2	3128	3052	-2.4%	Pass	Pass	Pass	Pass	7	-76
C6	Calibration	Cal_6-1	3975	3701	-6.9%	Fail	Pass	Pass	Pass	4	-274
	Calibration	Cal_6-2	2671	2480	-7.2%	Fail	Pass	Pass	Pass	4	-191
V1	Validation	Val_1-1	1866	1762	-5.6%	Fail	Pass	Pass	Pass	4	-104
	Validation	Val_1-2	1865	1915	2.7%	Pass	Pass	Pass	Pass	4	50
V2	Validation	Val_2-1	5770	5696	-1.3%	Pass	Pass	Pass	Pass	9	-74
	Validation	Val_2-2	3678	3882	5.5%	Fail	Pass	Pass	Fail	8	204
V3	Validation	Val_3-1	2260	2179	-3.6%	Pass	Pass	Pass	Pass	4	-81
	Validation	Val_3-2	2805	2598	-7.4%	Fail	Pass	Pass	Pass	4	-207
V4	Validation	Val_4-1	2205	2207	0.1%	Pass	Pass	Pass	Pass	3	2
	Validation	Val_4-2	2061	2080	0.9%	Pass	Pass	Pass	Pass	3	19
V5	Validation	Val_5-1	2609	2491	-4.5%	Pass	Pass	Pass	Pass	4	-118
	Validation	Val_5-2	3182	3251	2.2%	Pass	Pass	Pass	Pass	5	69

	<5%	<7.5%	<10%	% Criteria
Fail	6	1	0	2
Pass	16	21	22	20
Total	22	22	22	22
%	73%	95%	100%	**91%**

IP	Car

	IP	Screenline Modelled vs Observed by Direction			Car					
Screenline ID	Purpose	Screenline Name	AM Count Data	AM Model Data	% (Actual Flow)					No. of Counts
					Diff	<5%	<7.5%	<10%	% Criteria	
C1	Calibration	Cal_1-1	7819	8265	5.7%	Fail	Pass	Pass	Fail	19
	Calibration	Cal_1-2	7812	8245	5.5%	Fail	Pass	Pass	Fail	19
C2	Calibration	Cal_2-1	2436	2378	-2.4%	Pass	Pass	Pass	Pass	8
	Calibration	Cal_2-2	2405	2366	-1.6%	Pass	Pass	Pass	Pass	8
C3	Calibration	Cal_3-1	2879	2828	-1.8%	Pass	Pass	Pass	Pass	7
	Calibration	Cal_3-2	2723	2704	-0.7%	Pass	Pass	Pass	Pass	7
C4	Calibration	Cal_4-1	4176	4207	0.7%	Pass	Pass	Pass	Pass	8
	Calibration	Cal_4-2	4184	4262	1.9%	Pass	Pass	Pass	Pass	9
C5	Calibration	Cal_5-1	2298	2263	-1.5%	Pass	Pass	Pass	Pass	7
	Calibration	Cal_5-2	2306	2307	0.0%	Pass	Pass	Pass	Pass	7
C6	Calibration	Cal_6-1	2229	2214	-0.7%	Pass	Pass	Pass	Pass	4
	Calibration	Cal_6-2	2157	2105	-2.4%	Pass	Pass	Pass	Pass	4
V1	Validation	Val_1-1	1089	1038	-4.7%	Pass	Pass	Pass	Pass	4
	Validation	Val_1-2	1060	1032	-2.6%	Pass	Pass	Pass	Pass	4
V2	Validation	Val_2-1	2816	2805	-0.4%	Pass	Pass	Pass	Pass	9
	Validation	Val_2-2	2115	2383	12.7%	Fail	Fail	Fail	Fail	8
V3	Validation	Val_3-1	1970	1826	-7.3%	Fail	Pass	Pass	Pass	4
	Validation	Val_3-2	1968	1876	-4.7%	Pass	Pass	Pass	Pass	4
V4	Validation	Val_4-1	1870	1724	-7.8%	Fail	Fail	Pass	Pass	3
	Validation	Val_4-2	1969	1861	-5.5%	Fail	Pass	Pass	Pass	3
V5	Validation	Val_5-1	1537	1578	2.7%	Pass	Pass	Pass	Pass	4
	Validation	Val_5-2	2264	2262	-0.1%	Pass	Pass	Pass	Pass	5

	<5%	<7.5%	<10%	% Criteria
Fail	6	2	1	3
Pass	16	20	21	19
Total	22	22	22	22
%	73%	91%	95%	**86%**

IP	Total

	IP	Screenline Modelled vs Observed by Direction			Total					
Screenline ID	Purpose	Screenline Name	AM Count Data	AM Model Data	% (Actual Flow)					No. of Counts
					Diff	<5%	<7.5%	<10%	% Criteria	
C1	Calibration	Cal_1-1	9938	10441	5.1%	Fail	Pass	Pass	Fail	19
	Calibration	Cal_1-2	10069	10506	4.3%	Pass	Pass	Pass	Pass	19
C2	Calibration	Cal_2-1	2887	2855	-1.1%	Pass	Pass	Pass	Pass	8
	Calibration	Cal_2-2	2962	2903	-2.0%	Pass	Pass	Pass	Pass	8
C3	Calibration	Cal_3-1	3242	3189	-1.6%	Pass	Pass	Pass	Pass	7
	Calibration	Cal_3-2	3077	3064	-0.4%	Pass	Pass	Pass	Pass	7
C4	Calibration	Cal_4-1	4717	4740	0.5%	Pass	Pass	Pass	Pass	8
	Calibration	Cal_4-2	4718	4806	1.9%	Pass	Pass	Pass	Pass	9
C5	Calibration	Cal_5-1	2599	2555	-1.7%	Pass	Pass	Pass	Pass	7
	Calibration	Cal_5-2	2592	2613	0.8%	Pass	Pass	Pass	Pass	7
C6	Calibration	Cal_6-1	2500	2485	-0.6%	Pass	Pass	Pass	Pass	4
	Calibration	Cal_6-2	2435	2376	-2.4%	Pass	Pass	Pass	Pass	4
V1	Validation	Val_1-1	1278	1229	-3.8%	Pass	Pass	Pass	Pass	4
	Validation	Val_1-2	1240	1222	-1.5%	Pass	Pass	Pass	Pass	4
V2	Validation	Val_2-1	3381	3383	0.1%	Pass	Pass	Pass	Pass	9
	Validation	Val_2-2	2453	2864	16.8%	Fail	Fail	Fail	Fail	8
V3	Validation	Val_3-1	2256	2048	-9.2%	Fail	Fail	Pass	Fail	4
	Validation	Val_3-2	2272	2112	-7.0%	Fail	Pass	Pass	Pass	4
V4	Validation	Val_4-1	2062	1931	-6.4%	Fail	Pass	Pass	Pass	3
	Validation	Val_4-2	2177	2116	-2.8%	Pass	Pass	Pass	Pass	3
V5	Validation	Val_5-1	1777	1808	1.7%	Pass	Pass	Pass	Pass	4
	Validation	Val_5-2	2639	2693	2.0%	Pass	Pass	Pass	Pass	5

	<5%	<7.5%	<10%	% Criteria
Fail	5	2	1	3
Pass	17	20	21	19
Total	22	22	22	22
%	77%	91%	95%	**86%**

PM	Car

	PM	Screenline Modelled vs Observed by Direction			Car					
					% (Actual Flow)					
Screenline ID	Purpose	Screenline Name	AM Count Data	AM Model Data	Diff	<5%	<7.5%	<10%	% Criteria	No. of Counts
C1	Calibration	Cal_1-1	11553	11930	3.3%	Pass	Pass	Pass	Pass	19
	Calibration	Cal_1-2	12894	12923	0.2%	Pass	Pass	Pass	Pass	19
C2	Calibration	Cal_2-1	3879	3724	-4.0%	Pass	Pass	Pass	Pass	8
	Calibration	Cal_2-2	4003	3809	-4.8%	Pass	Pass	Pass	Pass	8
C3	Calibration	Cal_3-1	3692	3718	0.7%	Pass	Pass	Pass	Pass	7
	Calibration	Cal_3-2	3600	3484	-3.2%	Pass	Pass	Pass	Pass	7
C4	Calibration	Cal_4-1	4562	4655	2.0%	Pass	Pass	Pass	Pass	8
	Calibration	Cal_4-2	5425	5465	0.7%	Pass	Pass	Pass	Pass	9
C5	Calibration	Cal_5-1	3025	2971	-1.8%	Pass	Pass	Pass	Pass	7
	Calibration	Cal_5-2	2641	2557	-3.2%	Pass	Pass	Pass	Pass	7
C6	Calibration	Cal_6-1	2683	2634	-1.8%	Pass	Pass	Pass	Pass	4
	Calibration	Cal_6-2	3193	2974	-6.9%	Fail	Pass	Pass	Pass	4
V1	Validation	Val_1-1	1771	1636	-7.6%	Fail	Fail	Pass	Fail	4
	Validation	Val_1-2	1492	1423	-4.6%	Pass	Pass	Pass	Pass	4
V2	Validation	Val_2-1	4296	3908	-9.0%	Fail	Fail	Pass	Fail	9
	Validation	Val_2-2	3523	3608	2.4%	Pass	Pass	Pass	Pass	8
V3	Validation	Val_3-1	2391	2168	-9.3%	Fail	Fail	Pass	Fail	4
	Validation	Val_3-2	2203	2048	-7.0%	Fail	Pass	Pass	Pass	4
V4	Validation	Val_4-1	2177	2131	-2.1%	Pass	Pass	Pass	Pass	3
	Validation	Val_4-2	2287	2102	-8.1%	Fail	Fail	Pass	Pass	3
V5	Validation	Val_5-1	2023	2127	5.1%	Fail	Pass	Pass	Pass	4
	Validation	Val_5-2	3452	3407	-1.3%	Pass	Pass	Pass	Pass	5

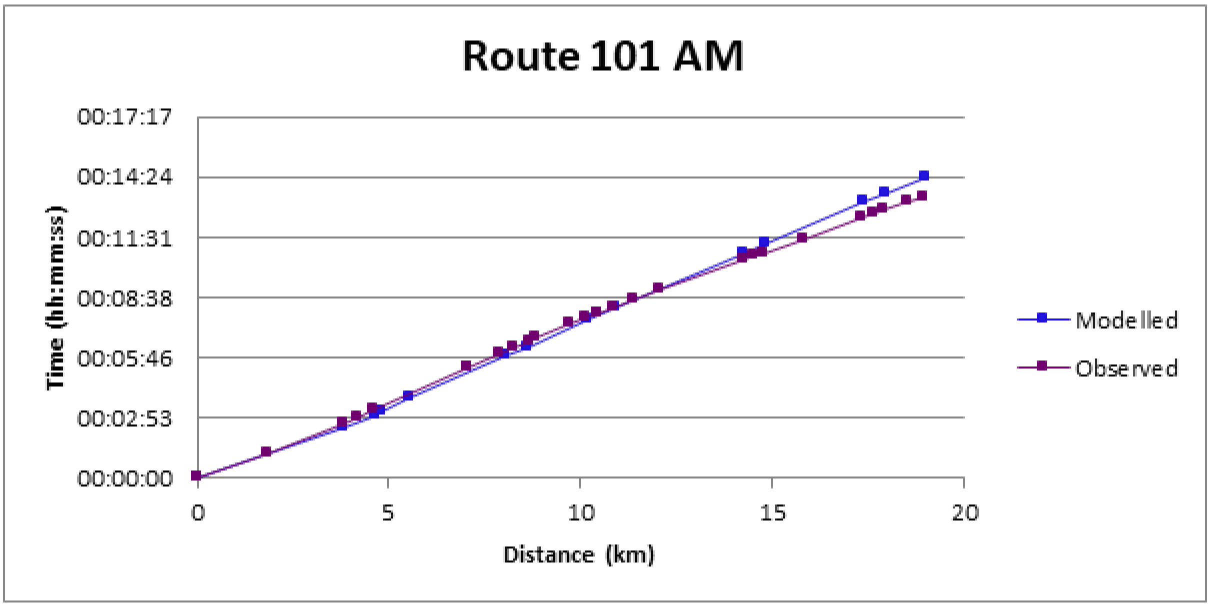
	<5%	<7.5%	<10%	% Criteria
Fail	7	4	0	3
Pass	15	18	22	19
Total	22	22	22	22
%	68%	82%	100%	**86%**

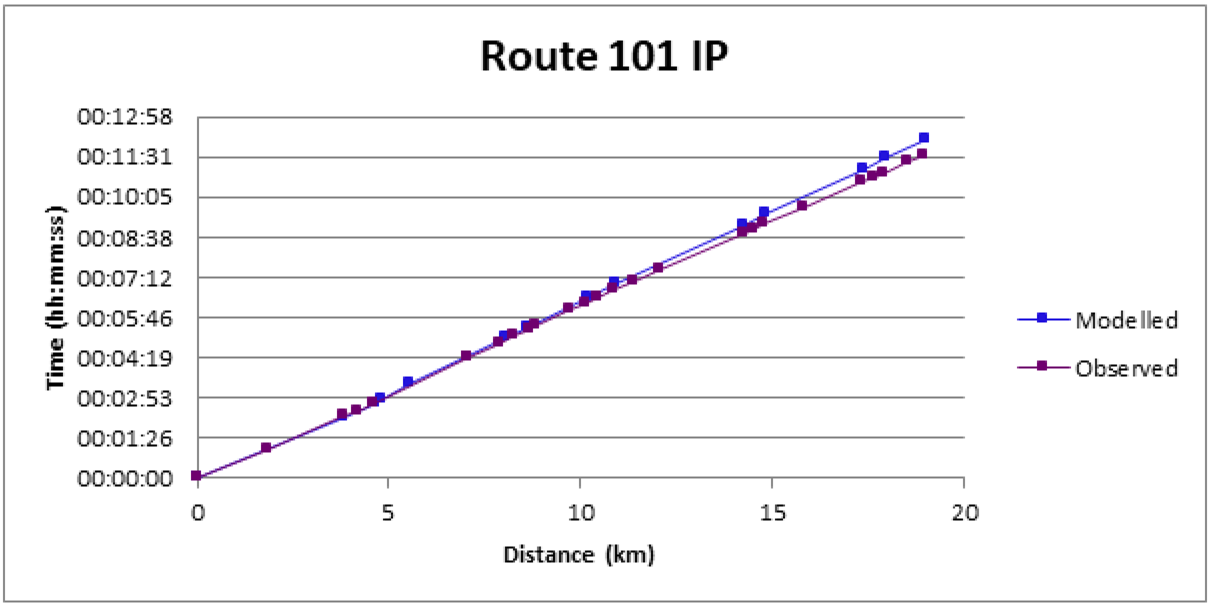
PM	Total

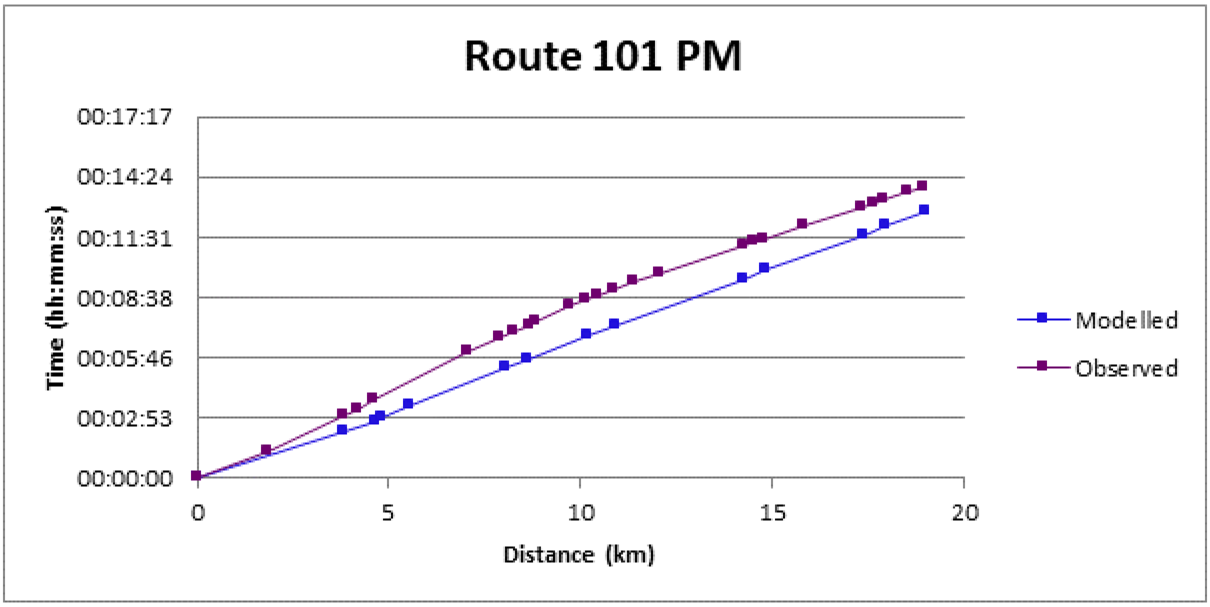
	PM	Screenline Modelled vs Observed by Direction			Total					
					% (Actual Flow)					
Screenline ID	Purpose	Screenline Name	AM Count Data	AM Model Data	Diff	<5%	<7.5%	<10%	% Criteria	No. of Counts
C1	Calibration	Cal_1-1	13154	13586	3.3%	Pass	Pass	Pass	Pass	19
	Calibration	Cal_1-2	14802	14738	-0.4%	Pass	Pass	Pass	Pass	19
C2	Calibration	Cal_2-1	4208	4047	-3.8%	Pass	Pass	Pass	Pass	8
	Calibration	Cal_2-2	4371	4145	-5.2%	Fail	Pass	Pass	Fail	8
C3	Calibration	Cal_3-1	4033	4038	0.1%	Pass	Pass	Pass	Pass	7
	Calibration	Cal_3-2	4044	3859	-4.6%	Pass	Pass	Pass	Pass	7
C4	Calibration	Cal_4-1	5005	5083	1.6%	Pass	Pass	Pass	Pass	8
	Calibration	Cal_4-2	5942	5960	0.3%	Pass	Pass	Pass	Pass	9
C5	Calibration	Cal_5-1	3370	3303	-2.0%	Pass	Pass	Pass	Pass	7
	Calibration	Cal_5-2	2949	2841	-3.7%	Pass	Pass	Pass	Pass	7
C6	Calibration	Cal_6-1	2908	2853	-1.9%	Pass	Pass	Pass	Pass	4
	Calibration	Cal_6-2	3471	3213	-7.4%	Fail	Pass	Pass	Pass	4
V1	Validation	Val_1-1	1941	1812	-6.6%	Fail	Pass	Pass	Pass	4
	Validation	Val_1-2	1625	1602	-1.4%	Pass	Pass	Pass	Pass	4
V2	Validation	Val_2-1	4839	4391	-9.3%	Fail	Fail	Pass	Fail	9
	Validation	Val_2-2	3841	4089	6.5%	Fail	Pass	Pass	Fail	8
V3	Validation	Val_3-1	2628	2452	-6.7%	Fail	Pass	Pass	Pass	4
	Validation	Val_3-2	2407	2246	-6.7%	Fail	Pass	Pass	Pass	4
V4	Validation	Val_4-1	2334	2343	0.4%	Pass	Pass	Pass	Pass	3
	Validation	Val_4-2	2429	2307	-5.0%	Fail	Pass	Pass	Pass	3
V5	Validation	Val_5-1	2201	2267	3.0%	Pass	Pass	Pass	Pass	4
	Validation	Val_5-2	3819	3712	-2.8%	Pass	Pass	Pass	Pass	5

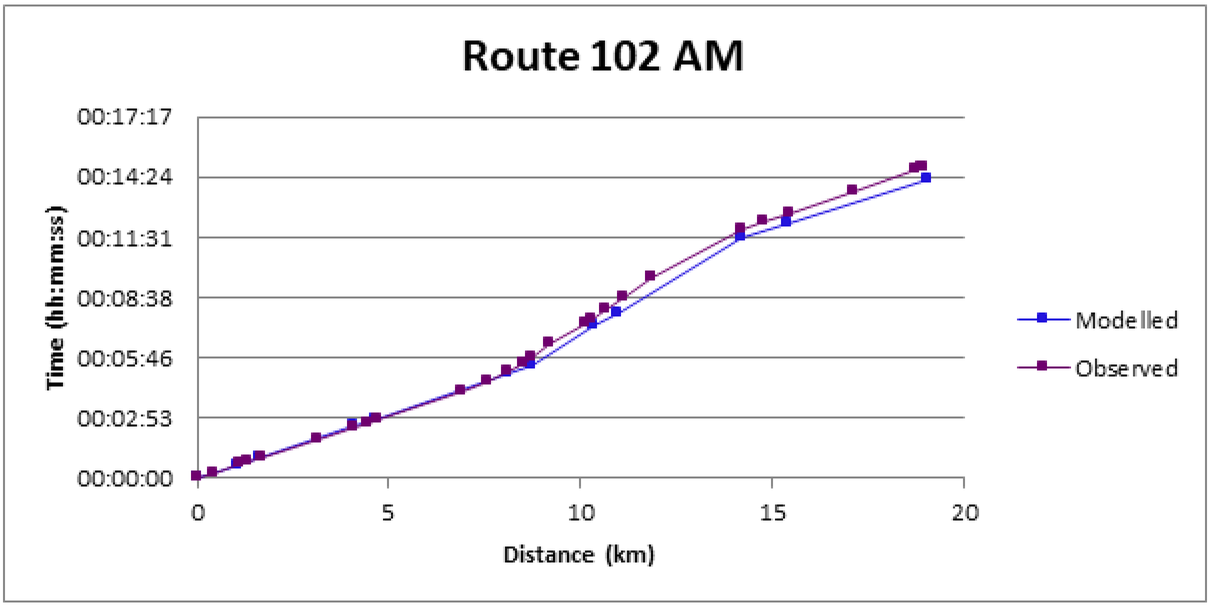
	<5%	<7.5%	<10%	% Criteria
Fail	8	1	0	3
Pass	14	21	22	19
Total	22	22	22	22
%	64%	95%	100%	**86%**

Appendix P – Journey Time Validation

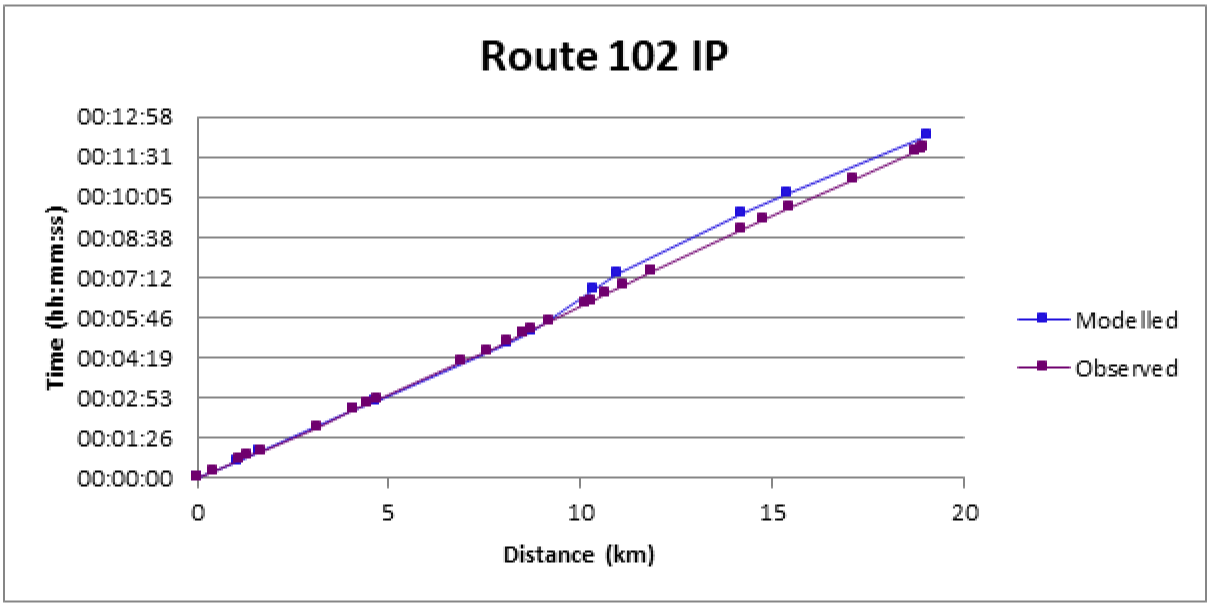

Route 101 AM
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
Time (hh:mm:ss)
0
5
10
15
20
Distance (km)
Modelled
Observed


Route 101 IP
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
5
10
15
20
Distance (km)
Modelled
Observed

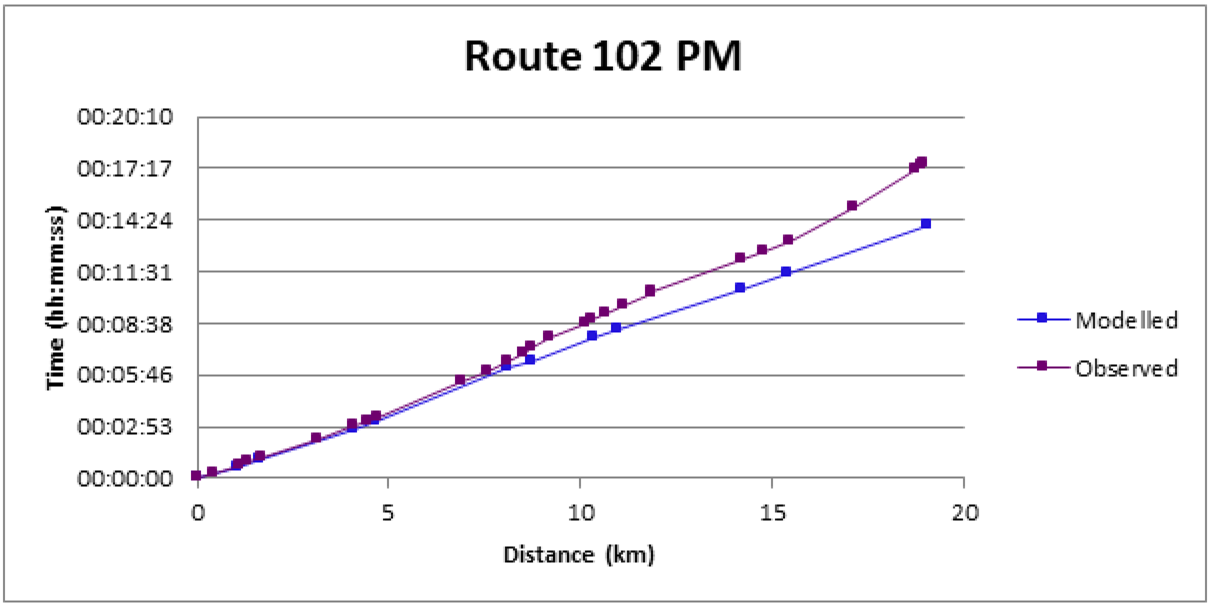

Route 101 PM
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
Time (hh:mm:ss)
0
5
10
15
20
Distance (km)
Modelled
Observed



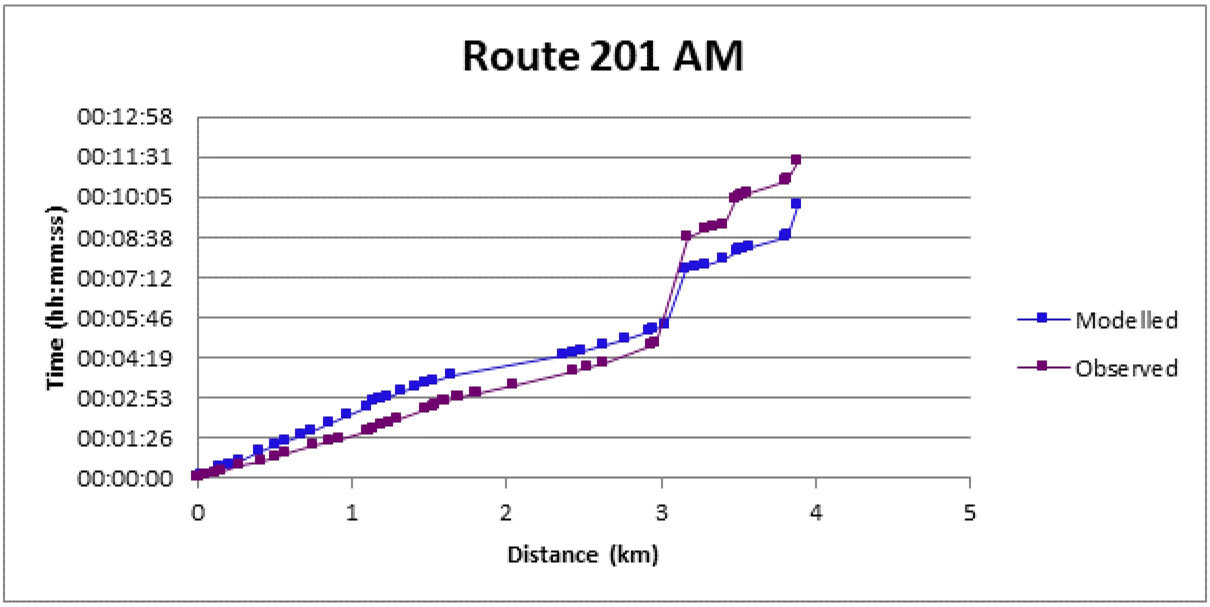
Route 102 AM
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
Time (hh:mm:ss)
0
5
10
15
20
Distance (km)
Modelled
Observed

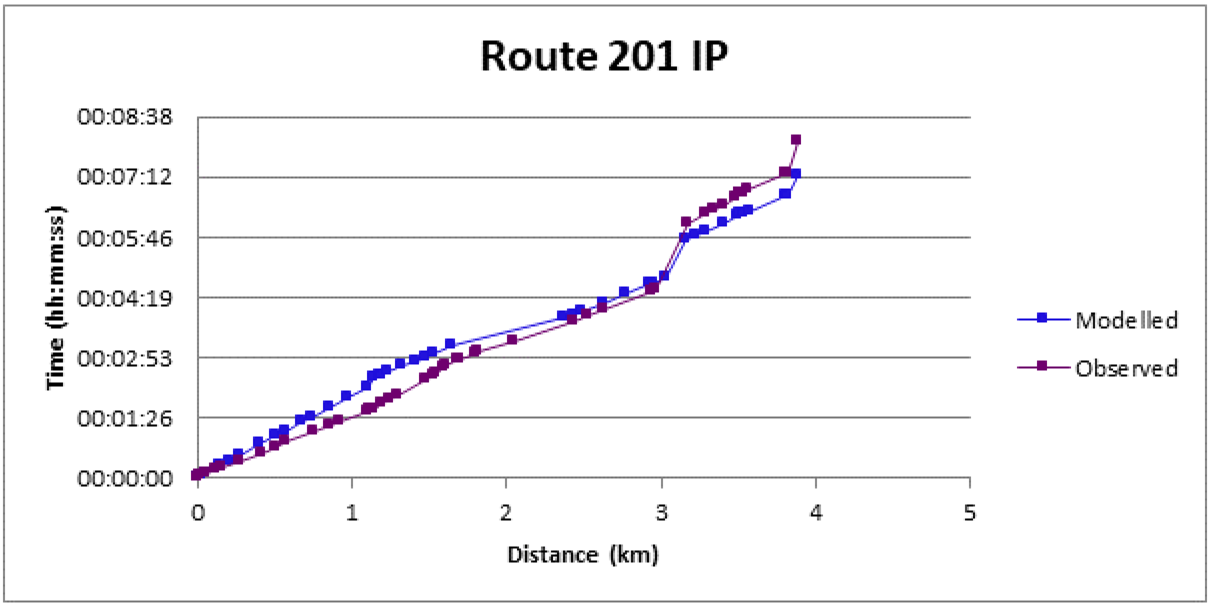


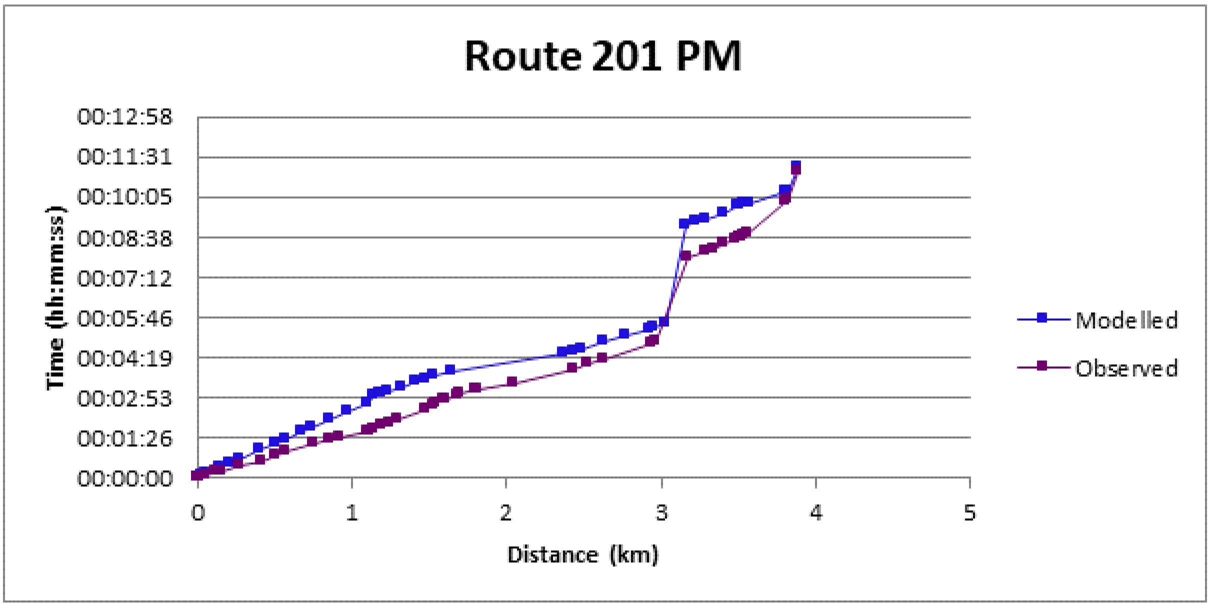
Route 102 IP
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
5
10
15
20
Distance (km)
Modelled
Observed

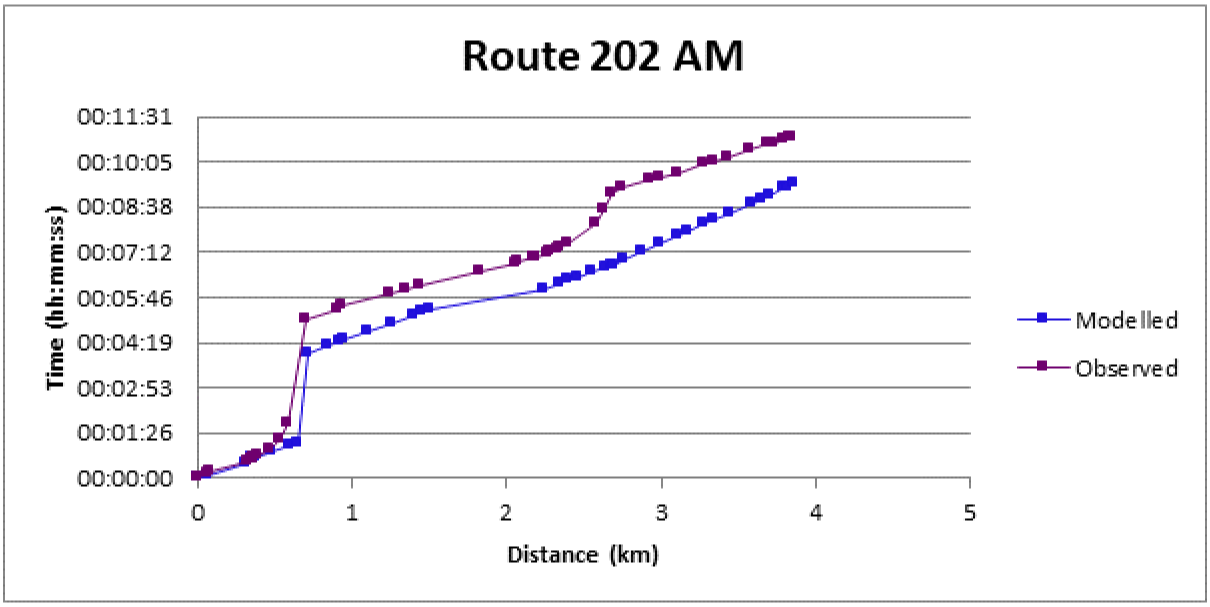


Route 102 PM
00:20:10
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
Time (hh:mm:ss)
0
5
10
15
20
Distance (km)
Modelled
Observed

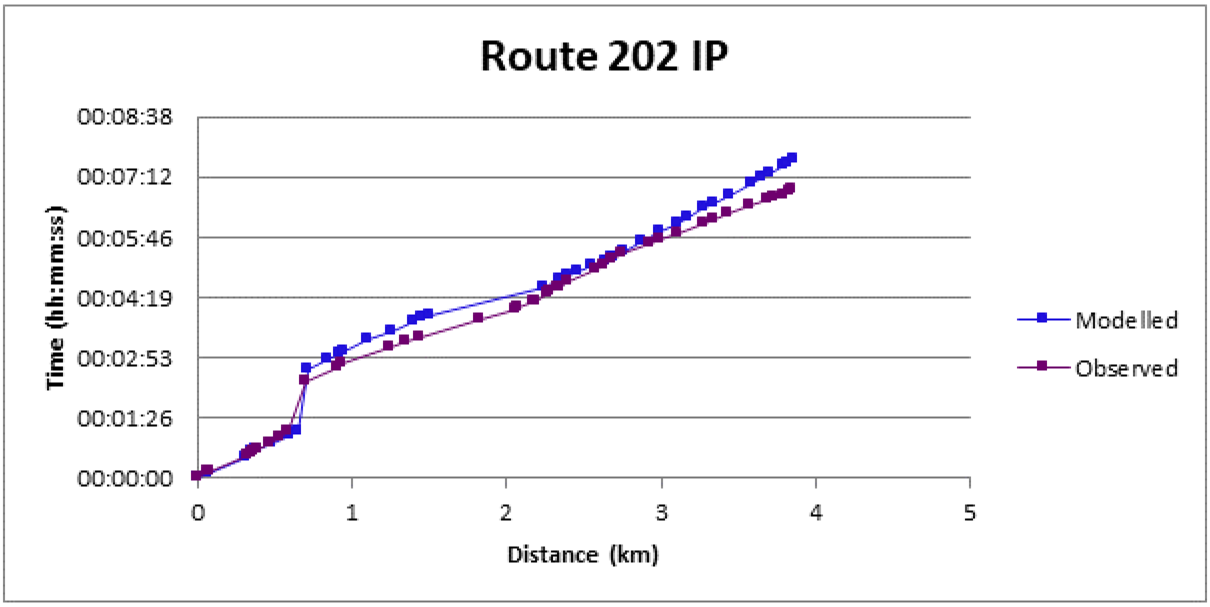

Route 201 AM
Time (hh:mm:ss)
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
0
1
2
3
4
5
Distance (km)
Modelled
Observed


Route 201 IP
Time (hh:mm:ss)
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
0
1
2
3
4
5
Distance (km)
Modelled
Observed

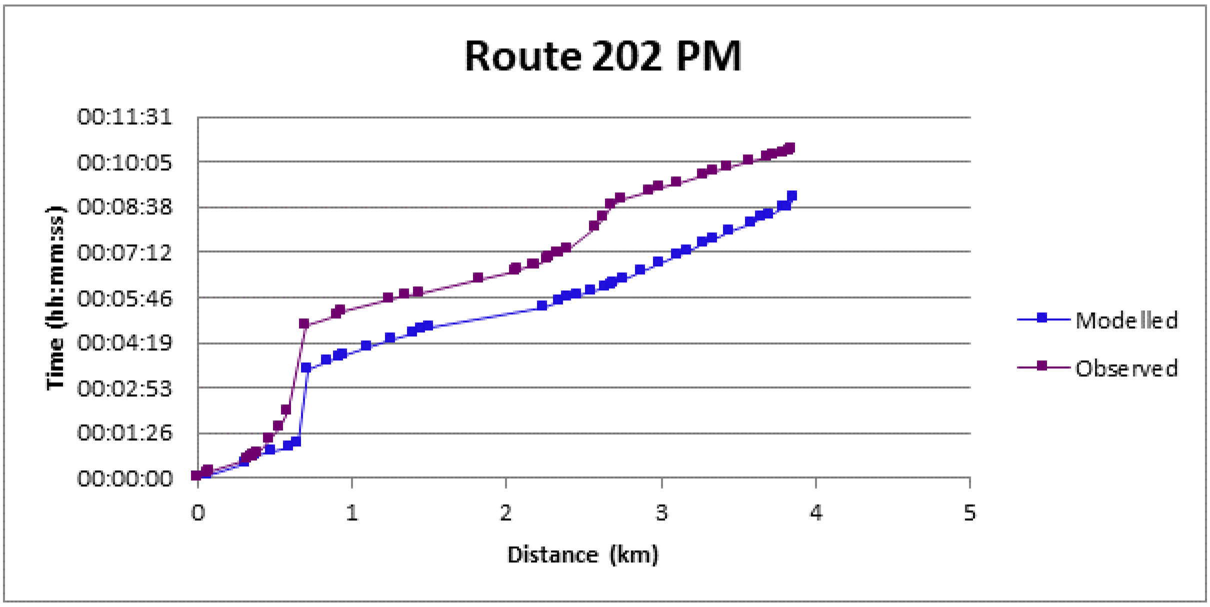

Route 201 PM
Time (hh:mm:ss)
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
0
1
2
3
4
5
Distance (km)
Modelled
Observed



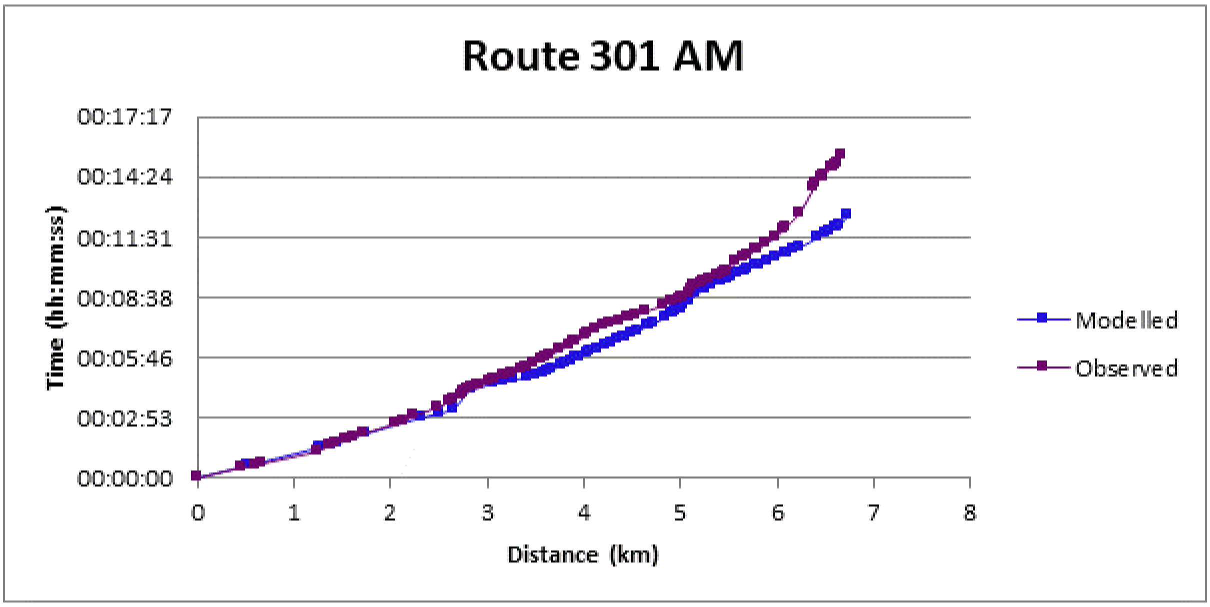
Route 202 AM
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
1
2
3
4
5
Distance (km)
Modelled
Observed



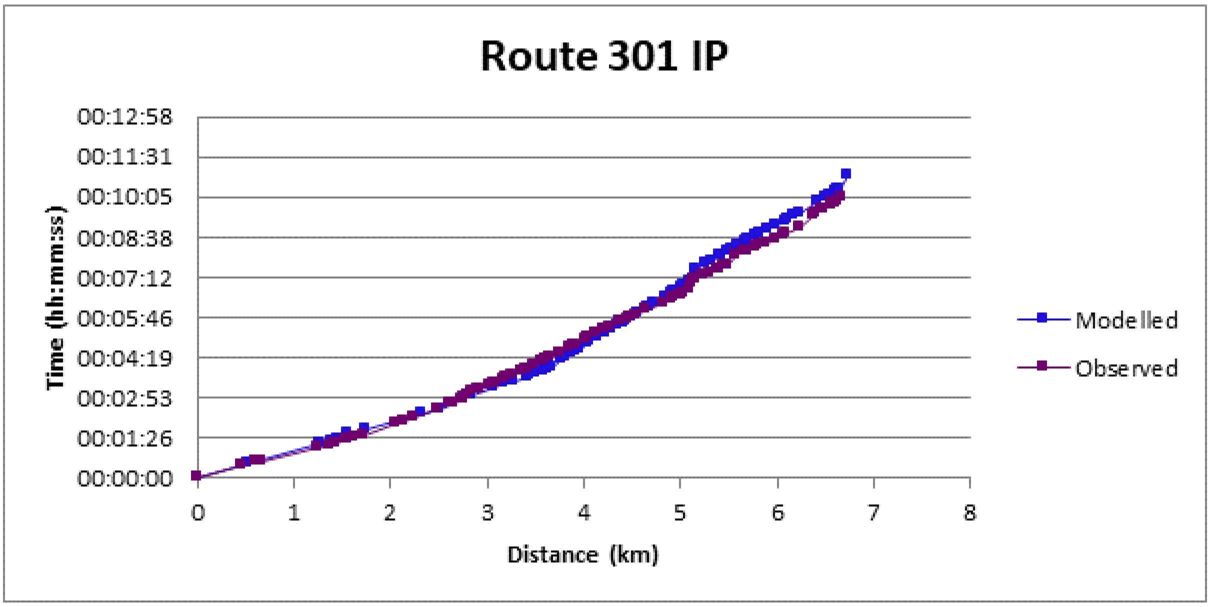
Route 202 IP
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
1
2
3
4
5
Distance (km)
Modelled
Observed



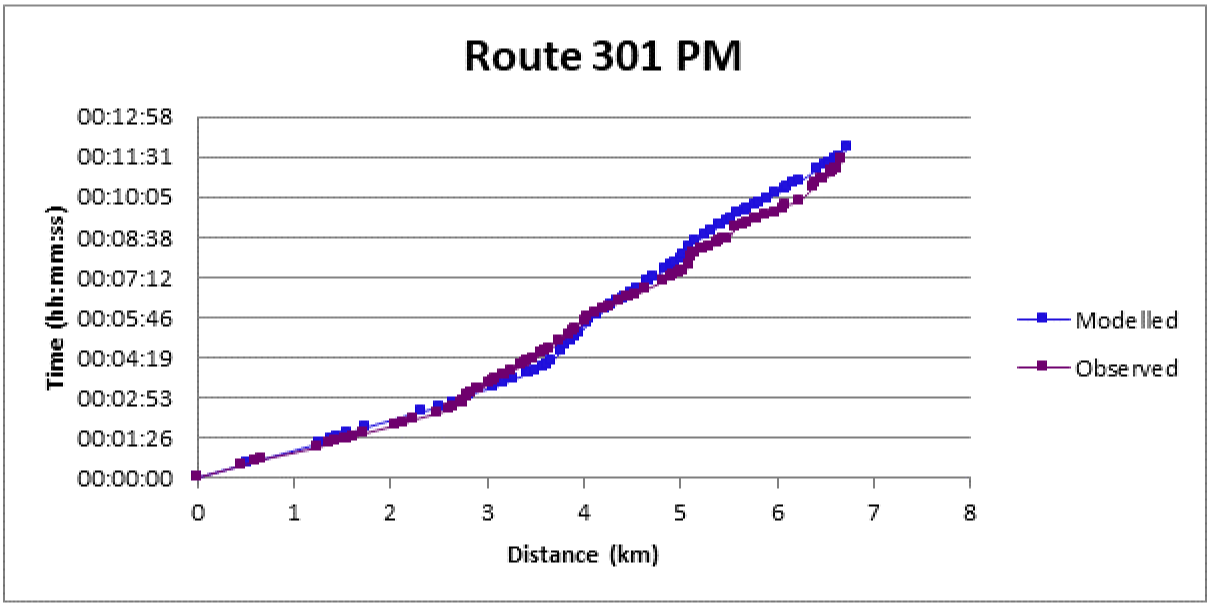
Route 202 PM
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
1
2
3
4
5
Distance (km)
Modelled
Observed



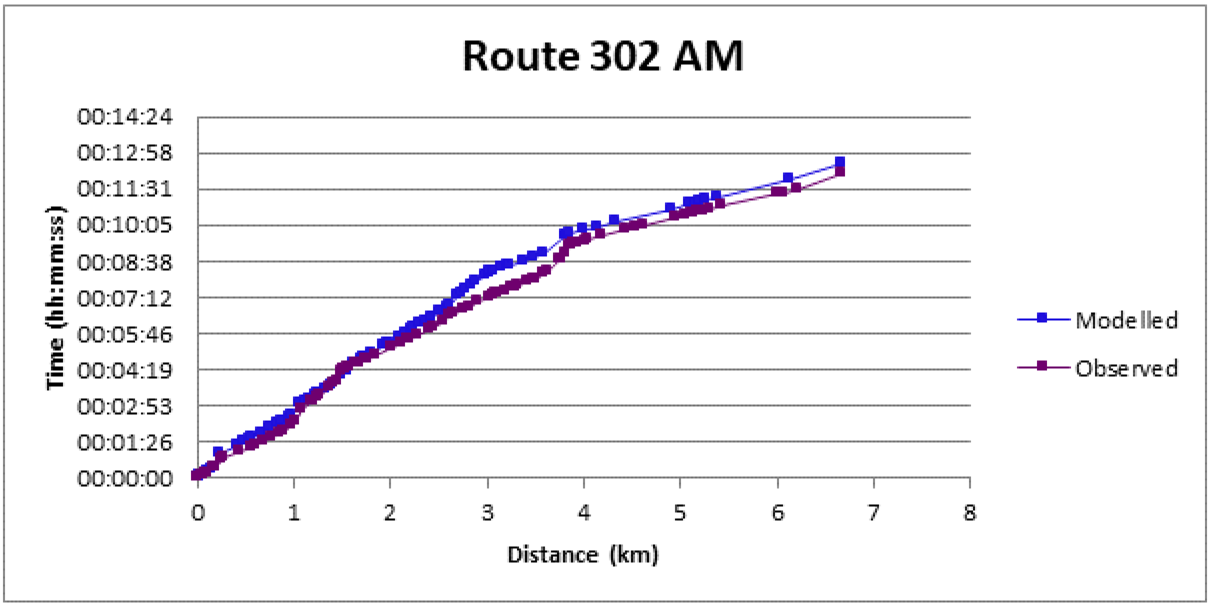
Route 301 AM
Time (hh:mm:ss)
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
0
1
2
3
4
5
6
7
8
Distance (km)
Modelled
Observed

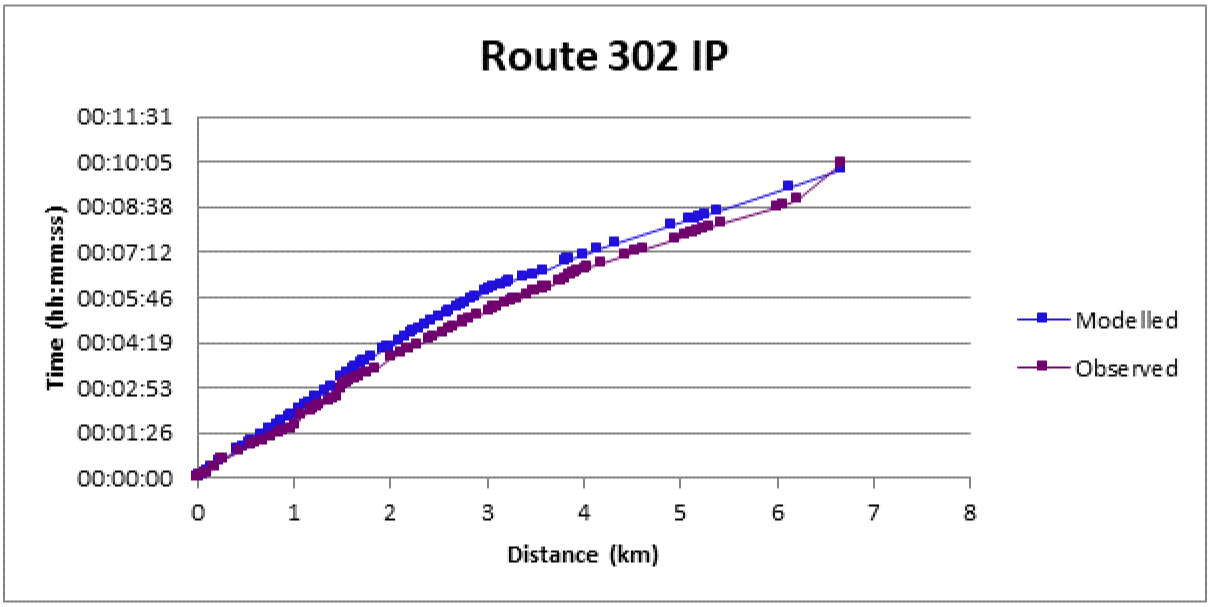


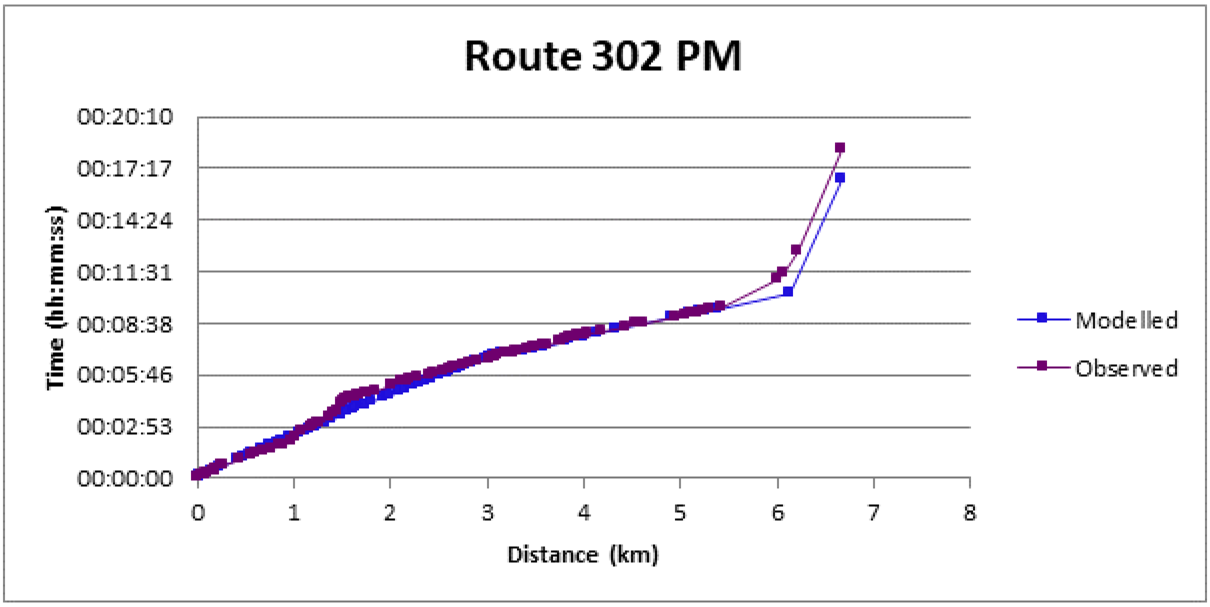
Route 301 IP
Time (hh:mm:ss)
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
0
1
2
3
4
5
6
7
8
Distance (km)
Modelled
Observed

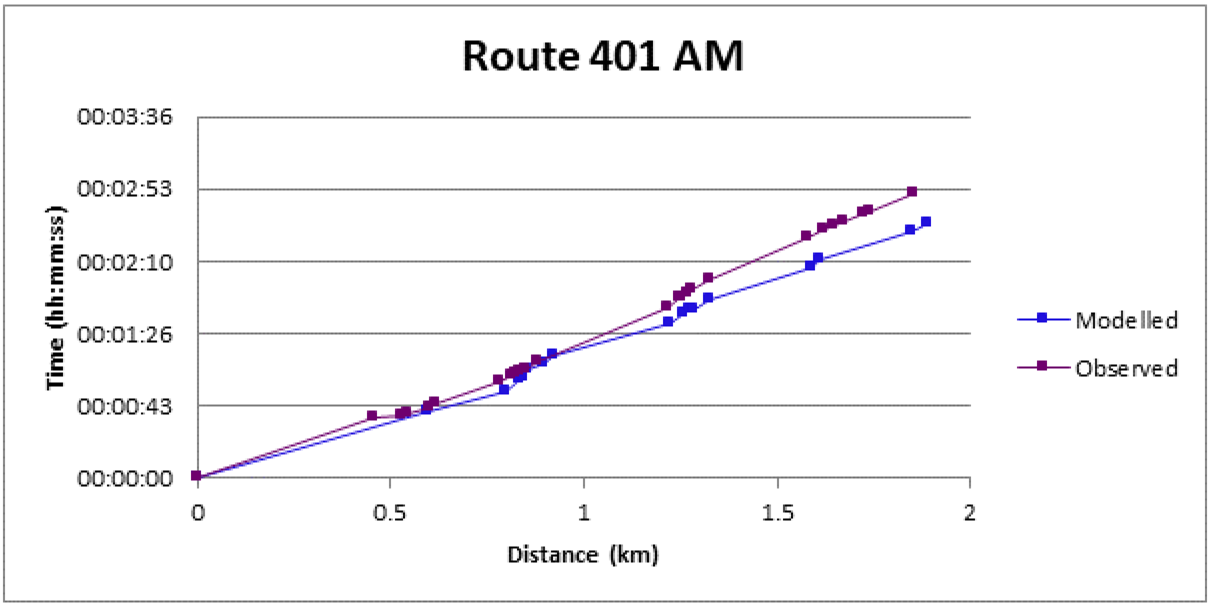


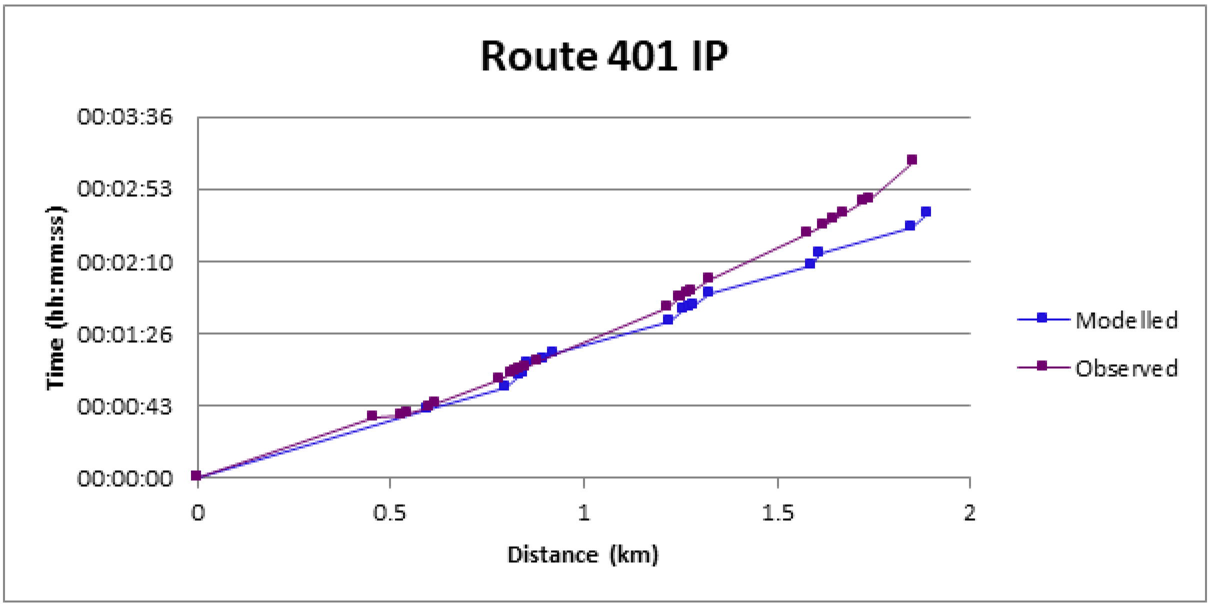
Route 301 PM
Time (hh:mm:ss)
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
0
1
2
3
4
5
6
7
8
Distance (km)
Modelled
Observed

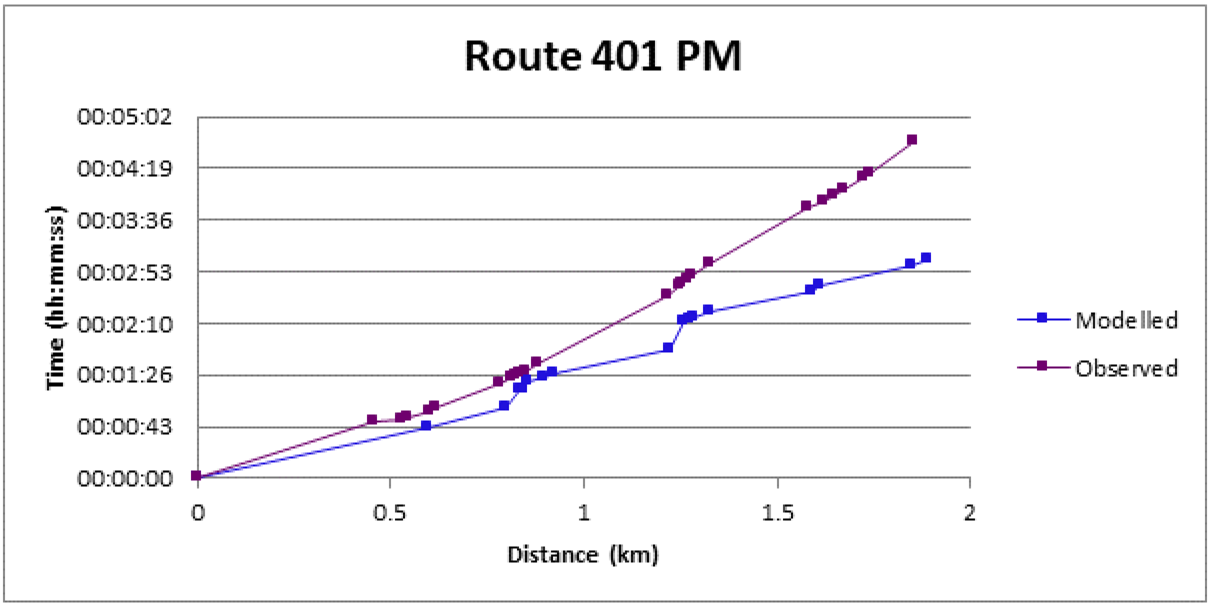

Route 302 AM
00:14:24
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
1
2
3
4
5
6
7
8
Distance (km)
Modelled
Observed

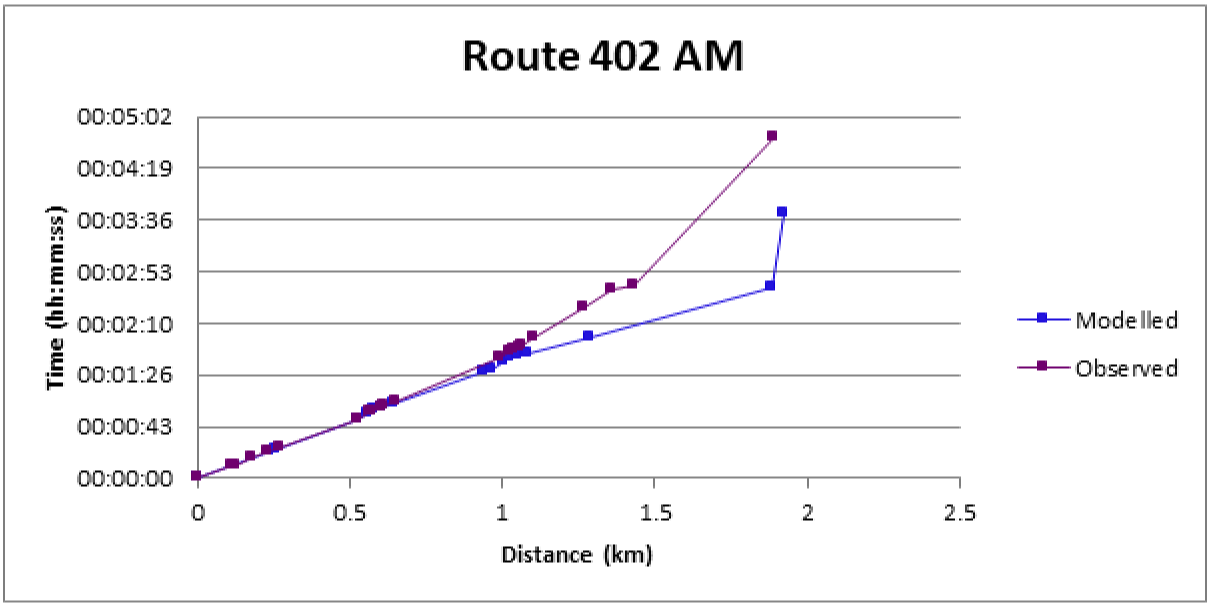

Route 302 IP
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
1
2
3
4
5
6
7
8
Distance (km)
Modelled
Observed


Route 302 PM
00:20:10
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
Time (hh:mm:ss)
0
1
2
3
4
5
6
7
8
Distance (km)
Modelled
Observed

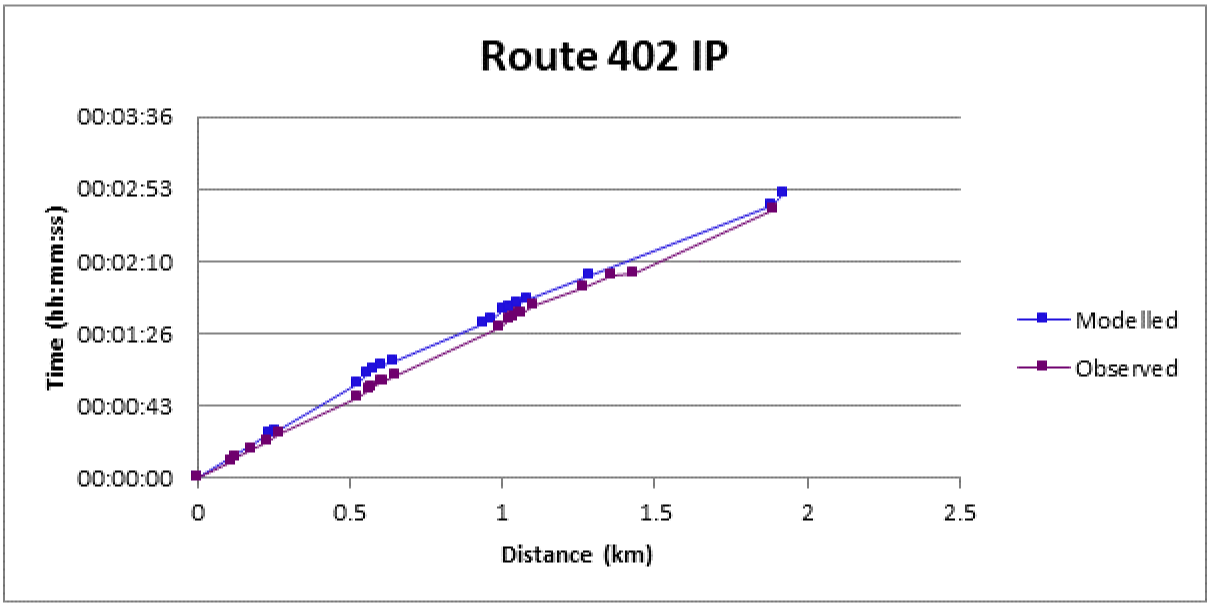

Route 401 AM
Time (hh:mm:ss)
00:03:36
00:02:53
00:02:10
00:01:26
00:00:43
00:00:00
0
0.5
1
1.5
2
Distance (km)
Modelled
Observed


Route 401 IP
Time (hh:mm:ss)
00:03:36
00:02:53
00:02:10
00:01:26
00:00:43
00:00:00
0
0.5
1
1.5
2
Distance (km)
Modelled
Observed

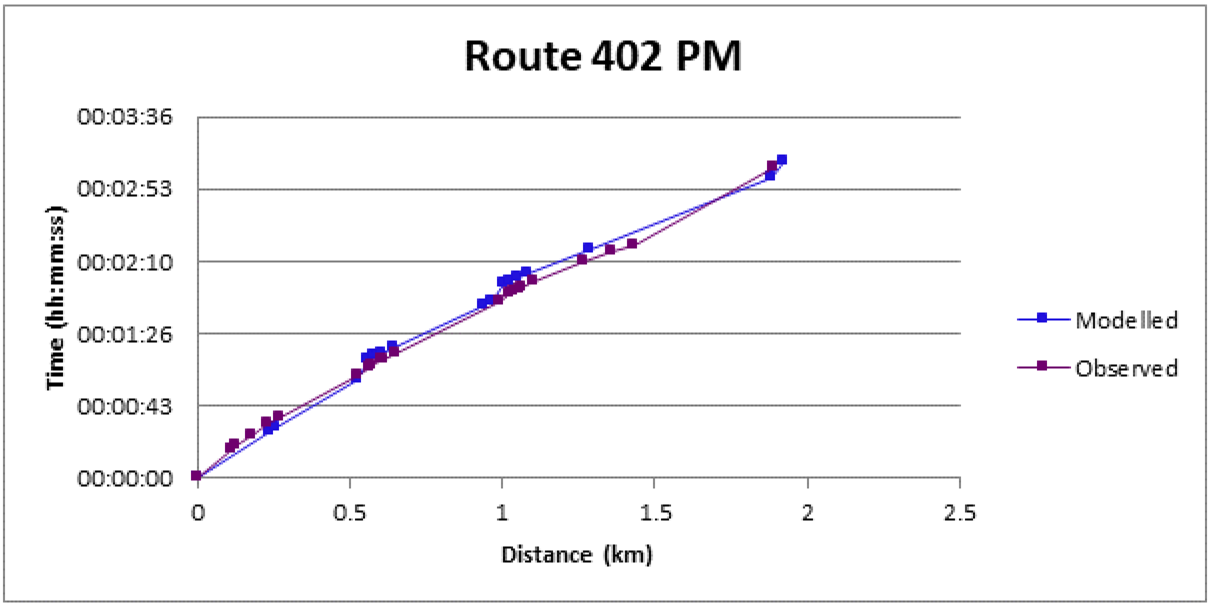

Route 401 PM
Time (hh:mm:ss)
00:05:02
00:04:19
00:03:36
00:02:53
00:02:10
00:01:26
00:00:43
00:00:00
0
0.5
1
1.5
2
Distance (km)
Modelled
Observed



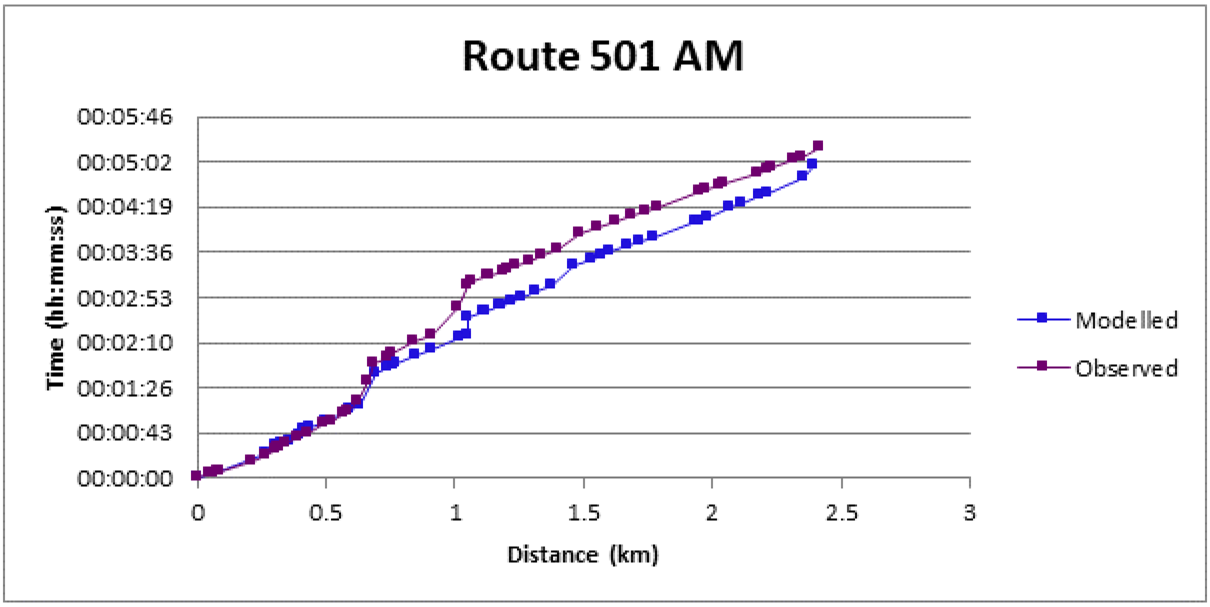
Route 402 AM
Time (hh:mm:ss)
00:05:02
00:04:19
00:03:36
00:02:53
00:02:10
00:01:26
00:00:43
00:00:00
0
0.5
1
1.5
2
2.5
Distance (km)
Modelled
Observed

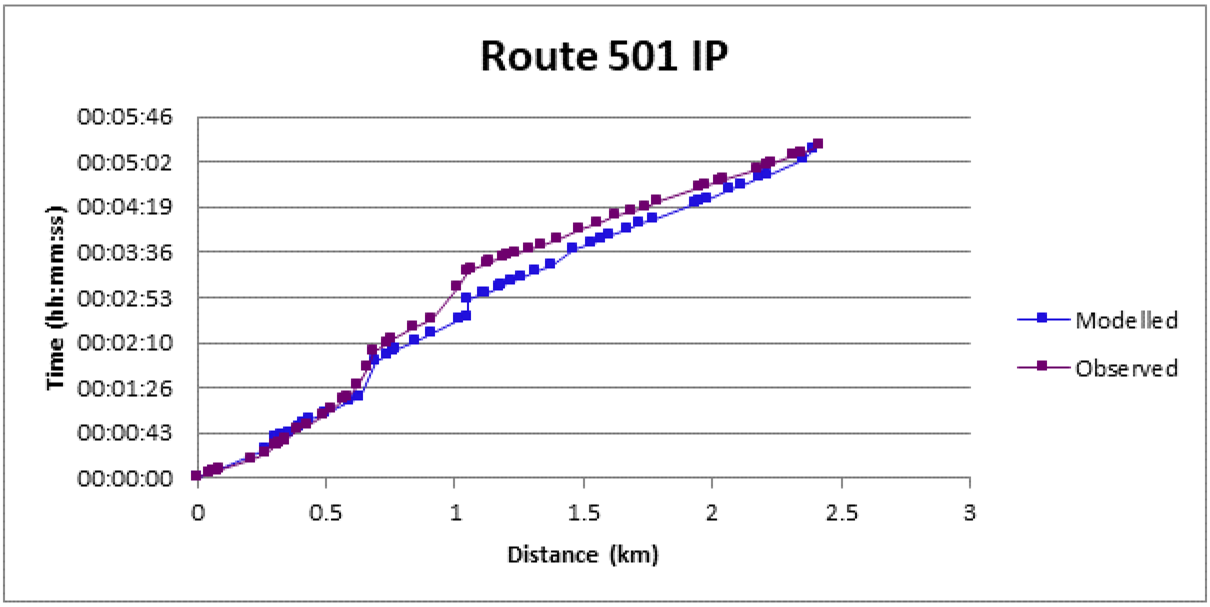


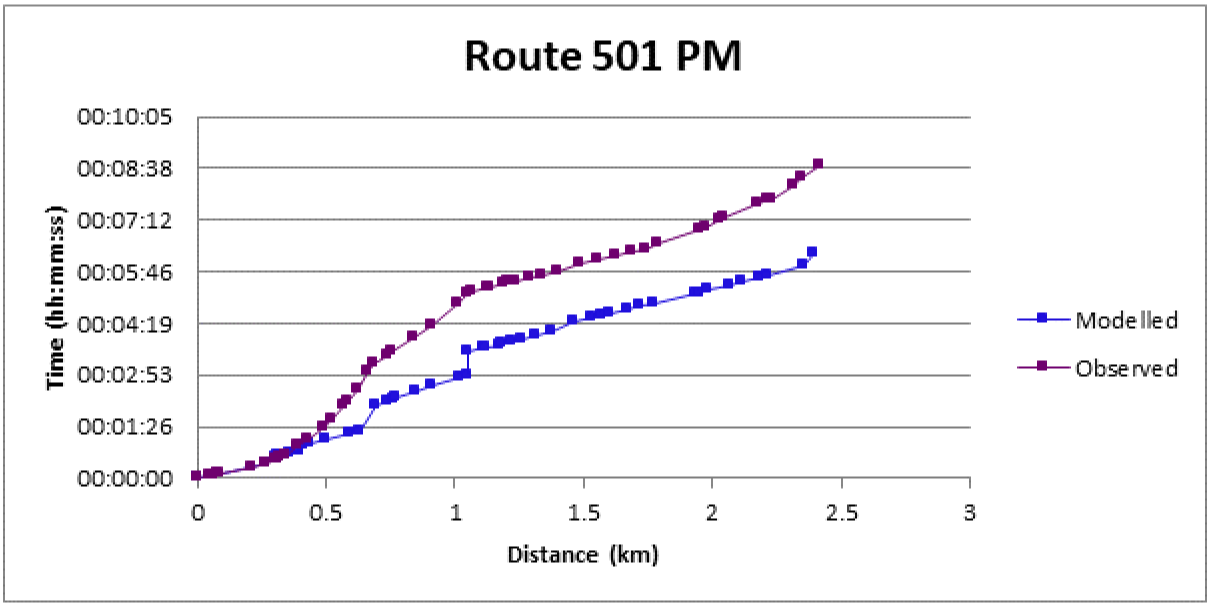
Route 402 IP
Time (hh:mm:ss)
00:03:36
00:02:53
00:02:10
00:01:26
00:00:43
00:00:00
0
0.5
1
1.5
2
2.5
Distance (km)
Modelled
Observed

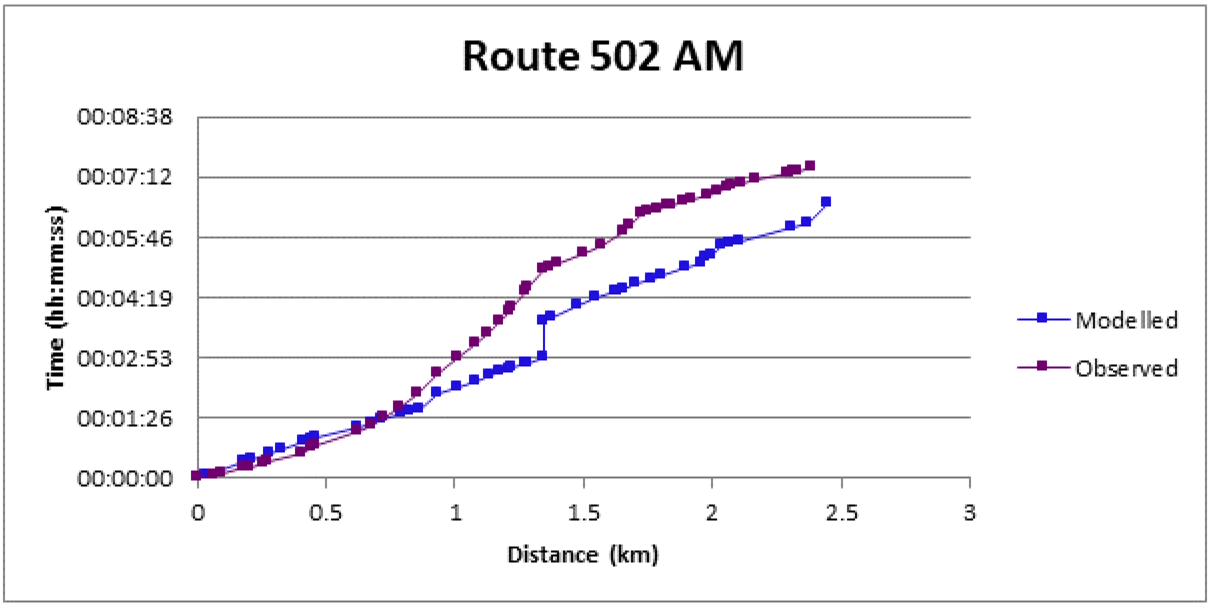


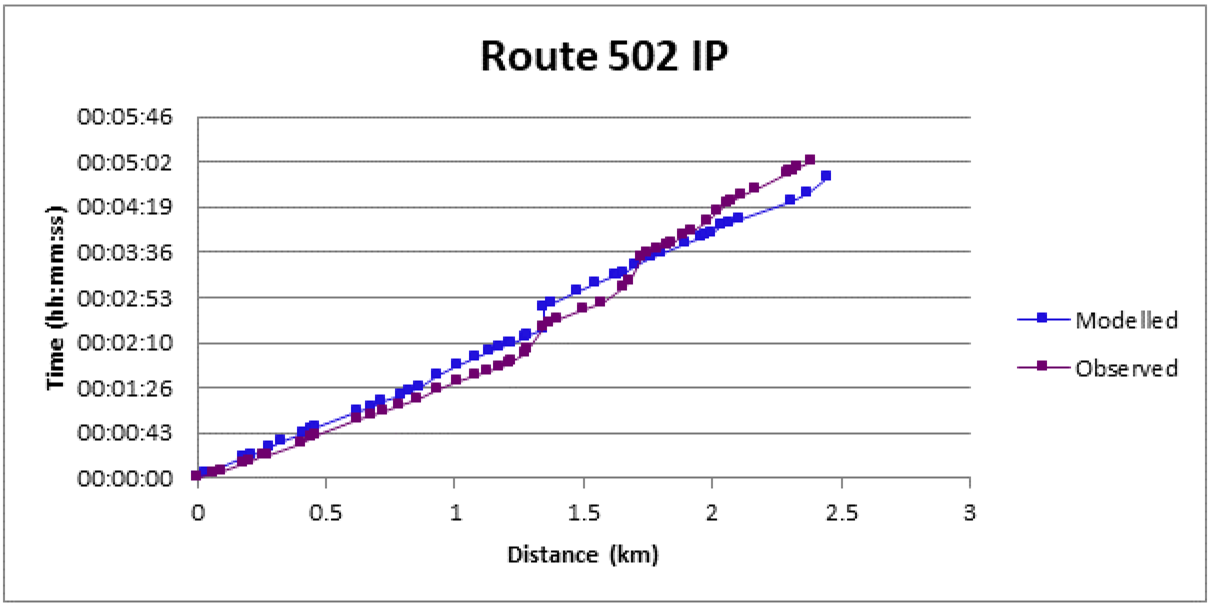
Route 402 PM
Time (hh:mm:ss)
00:03:36
00:02:53
00:02:10
00:01:26
00:00:43
00:00:00
0
0.5
1
1.5
2
2.5
Distance (km)
Modelled
Observed


Route 501 AM
00:05:46
00:05:02
00:04:19
00:03:36
00:02:53
00:02:10
00:01:26
00:00:43
00:00:00
Time (hh:mm:ss)
0
0.5
1
1.5
2
2.5
3
Distance (km)
Modelled
Observed


Route 501 IP
00:05:46
00:05:02
00:04:19
00:03:36
00:02:53
00:02:10
00:01:26
00:00:43
00:00:00
Time (hh:mm:ss)
0
0.5
1
1.5
2
2.5
3
Distance (km)
Modelled
Observed


Route 501 PM
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
0.5
1
1.5
2
2.5
3
Distance (km)
Modelled
Observed


Route 502 AM
Time (hh:mm:ss)
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
0
0.5
1
1.5
2
2.5
3
Distance (km)
Modelled
Observed


Route 502 IP
Time (hh:mm:ss)
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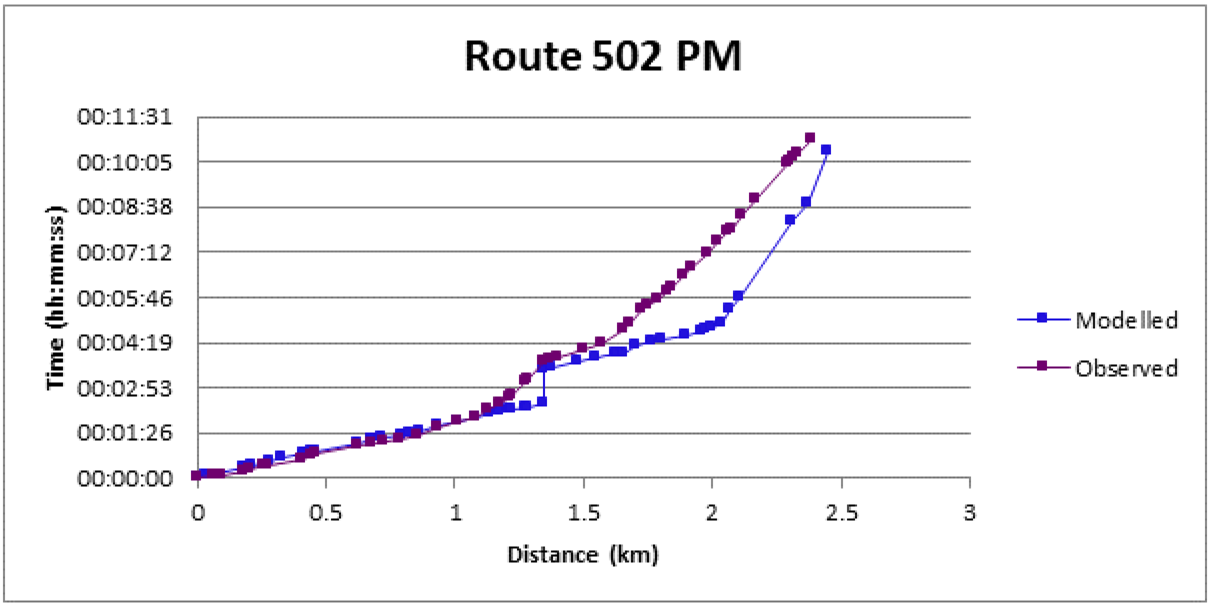
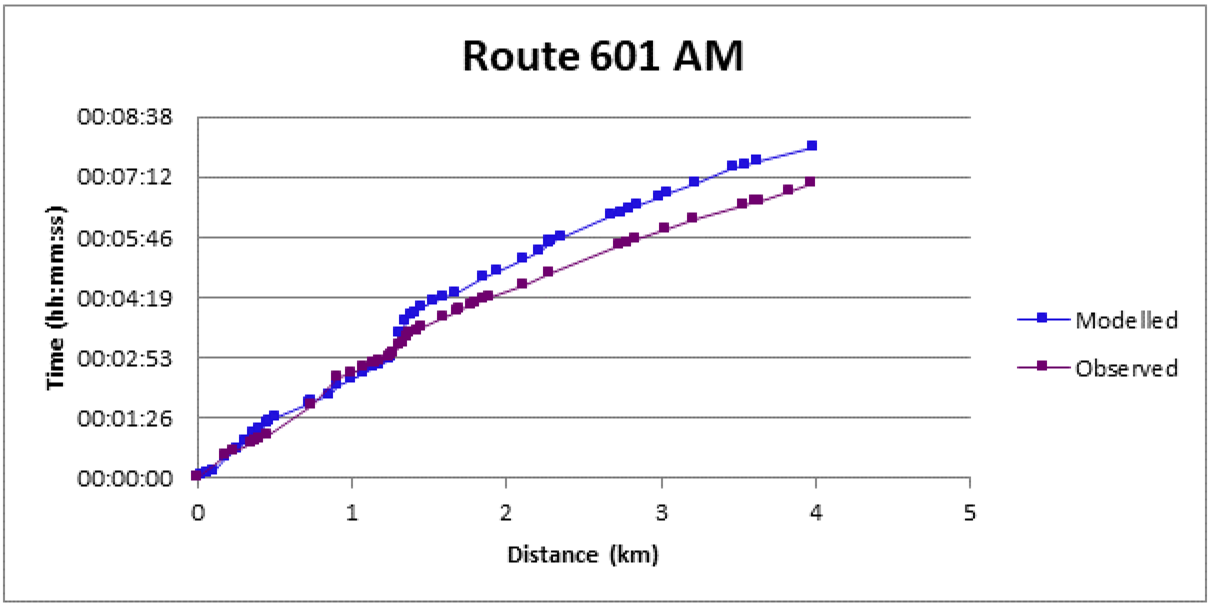
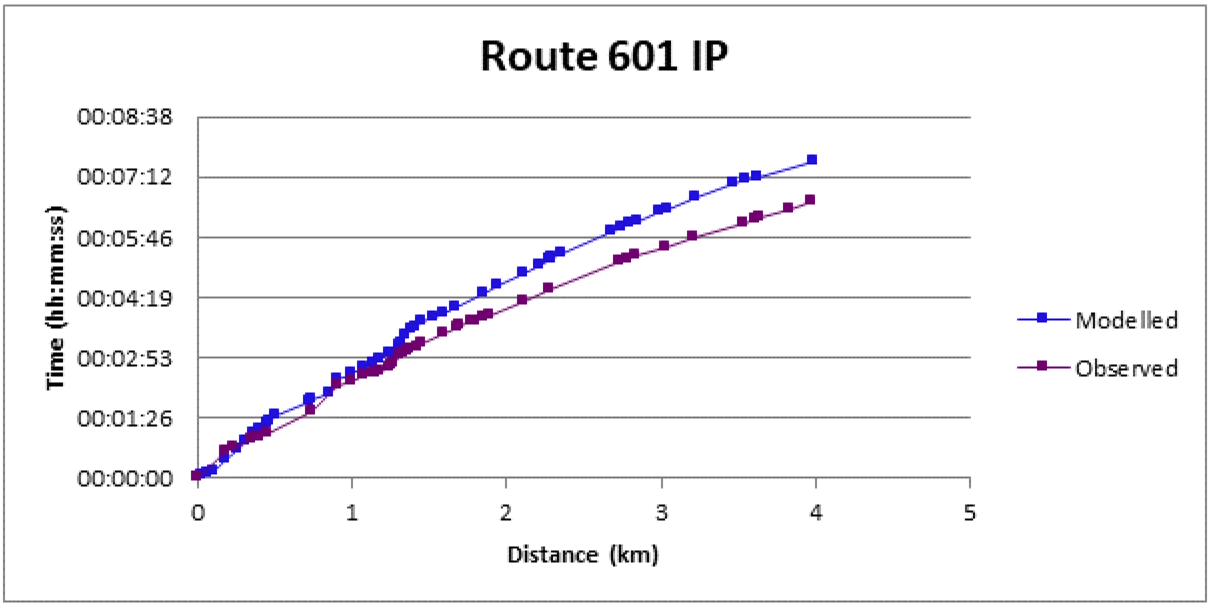
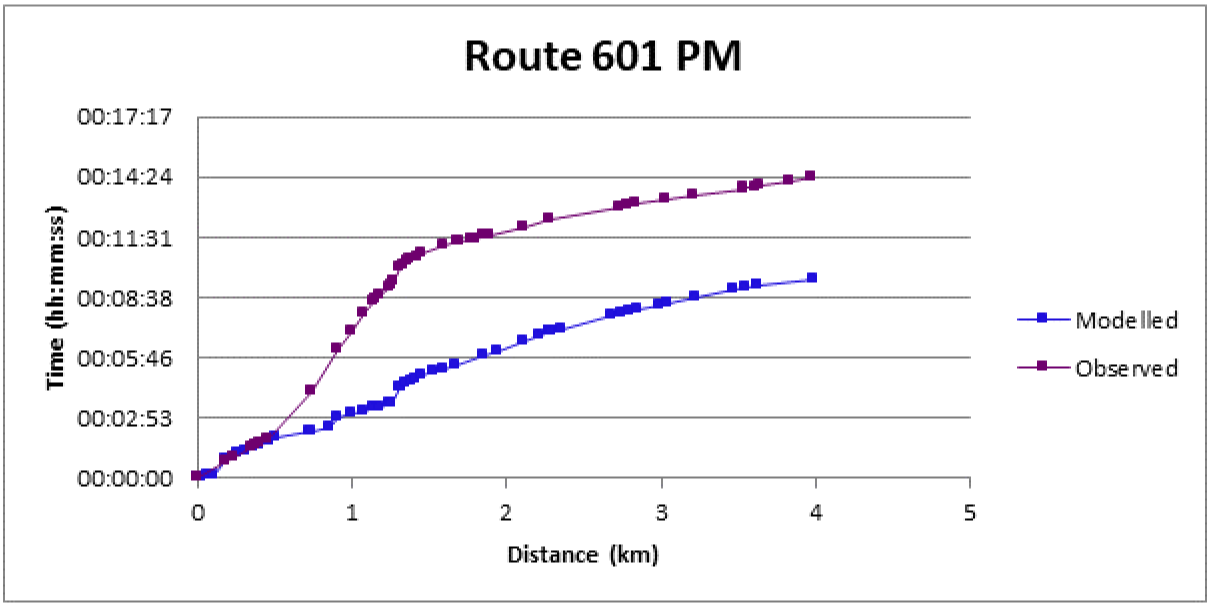
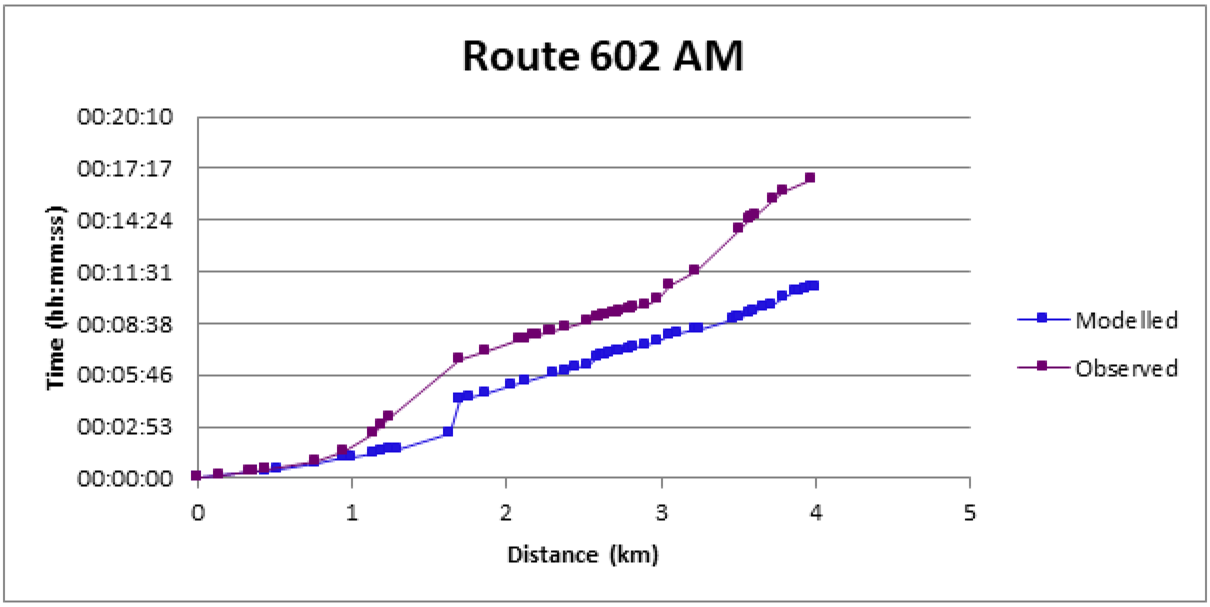
00:05:02
00:04:19
00:03:36
00:02:53
00:02:10
00:01:26
00:00:43
00:00:00
0
0.5
1
1.5
2
2.5
3
Distance (km)
Modelled
Observed


Route 502 PM
Time (hh:mm:ss)
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
0
0.5
1
1.5
2
2.5
3
Distance (km)
Modelled
Observed

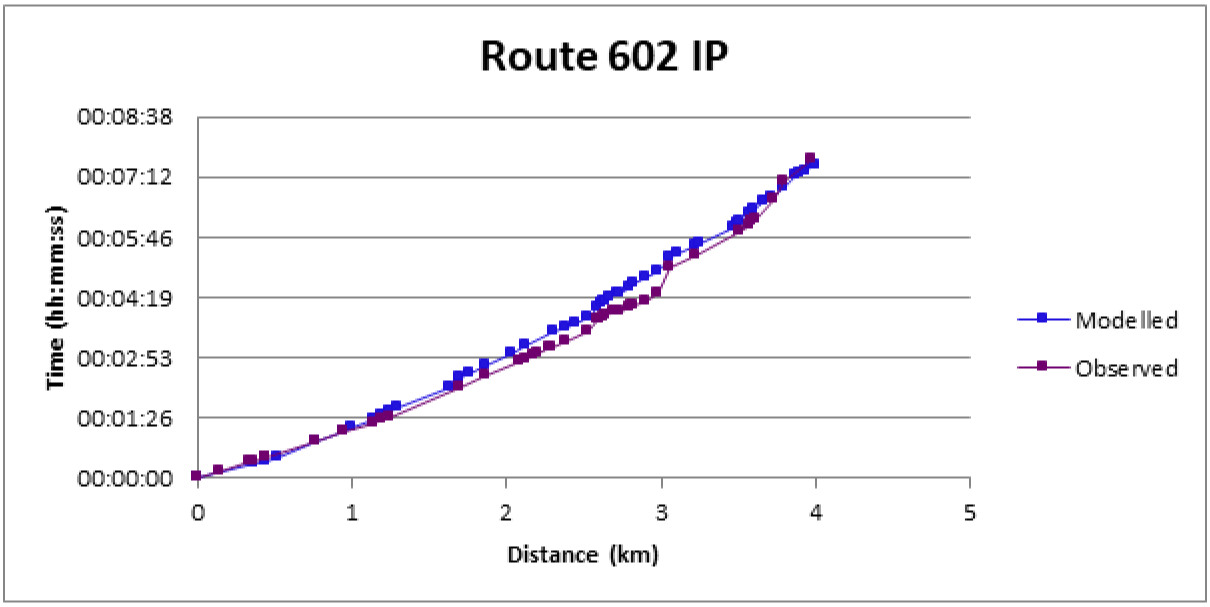

Route 601 AM
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
1
2
3
4
5
Distance (km)
Modelled
Observed


Route 601 IP
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
1
2
3
4
5
Distance (km)
Modelled
Observed

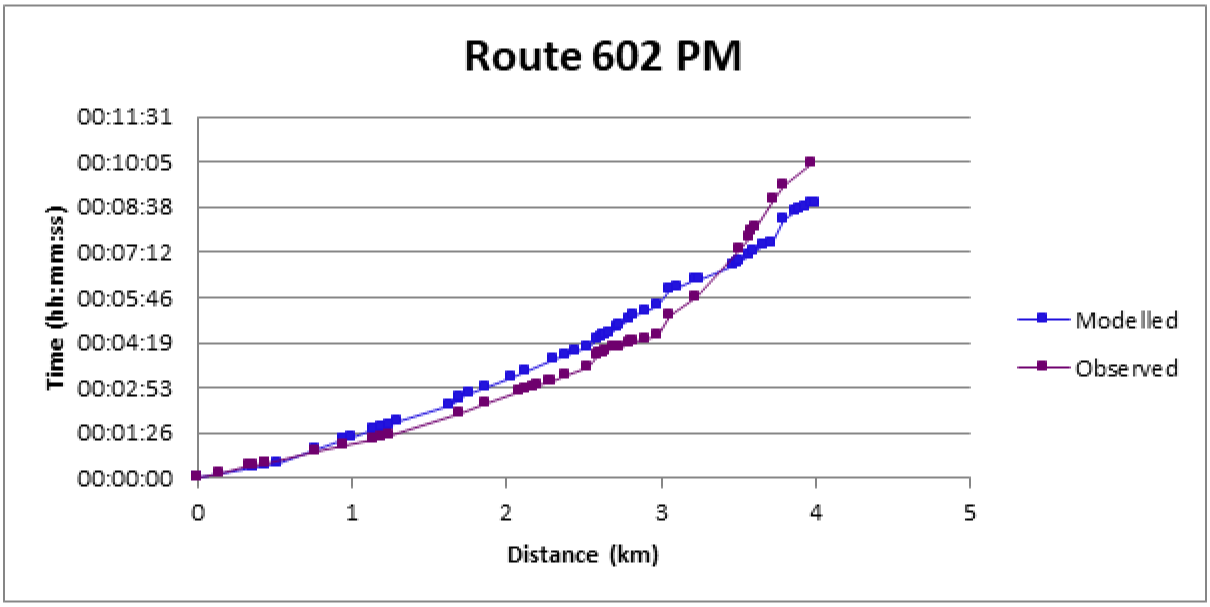

Route 601 PM
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
Time (hh:mm:ss)
0
1
2
3
4
5
Distance (km)
Modelled
Observed



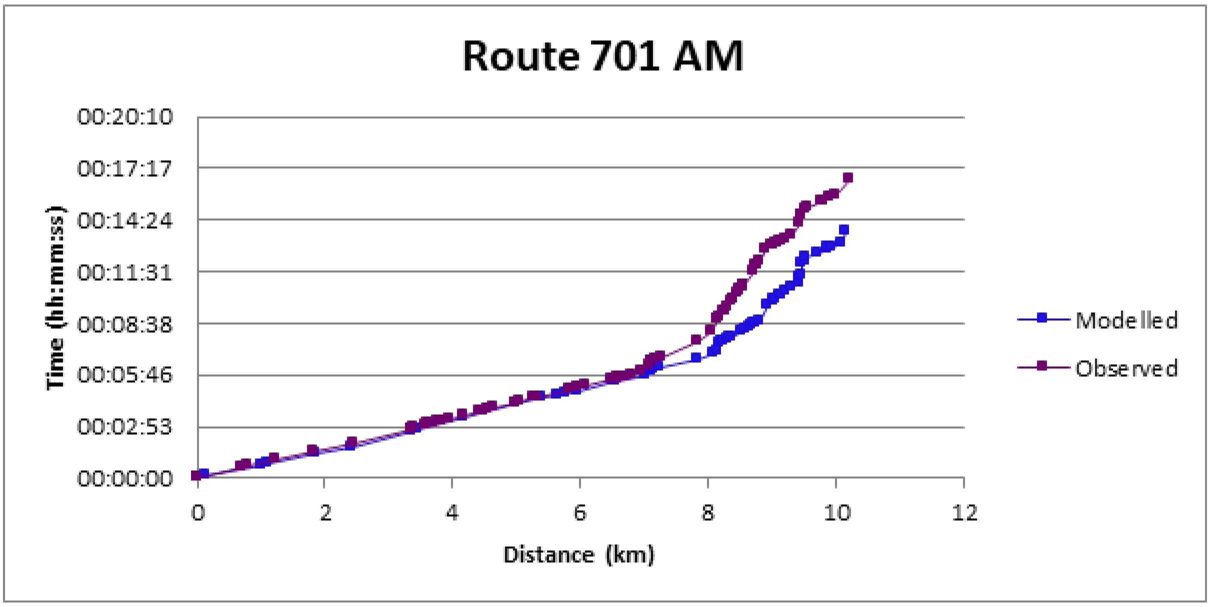
Route 602 AM
00:20:10
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
Time (hh:mm:ss)
0
1
2
3
4
5
Distance (km)
Modelled
Observed



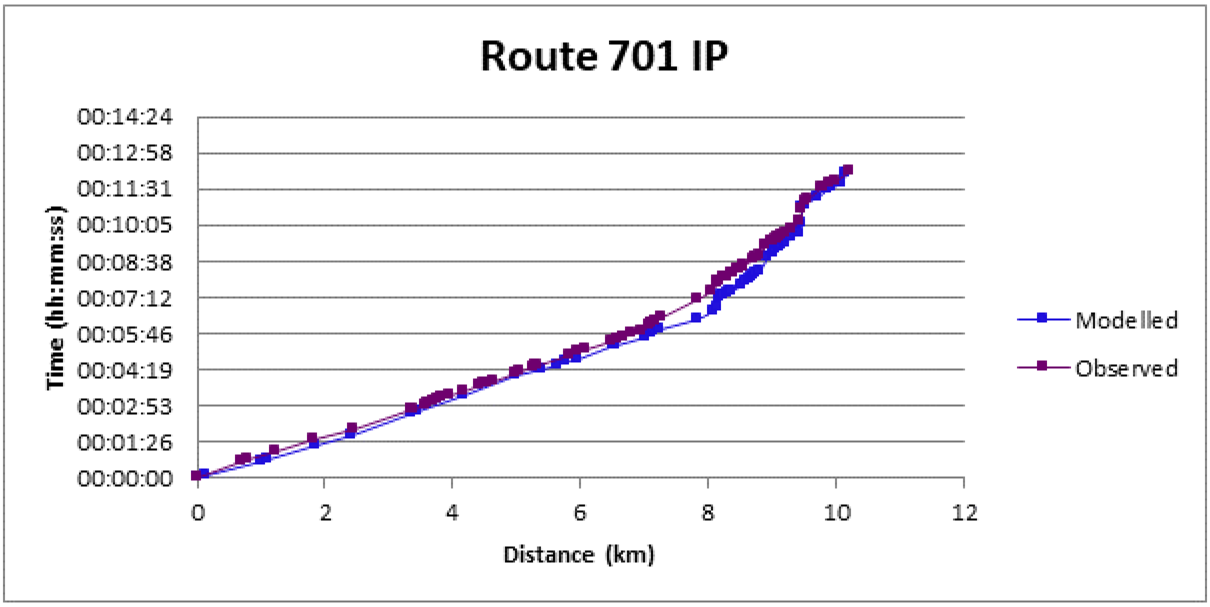
Route 602 IP
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
1
2
3
4
5
Distance (km)
Modelled
Observed



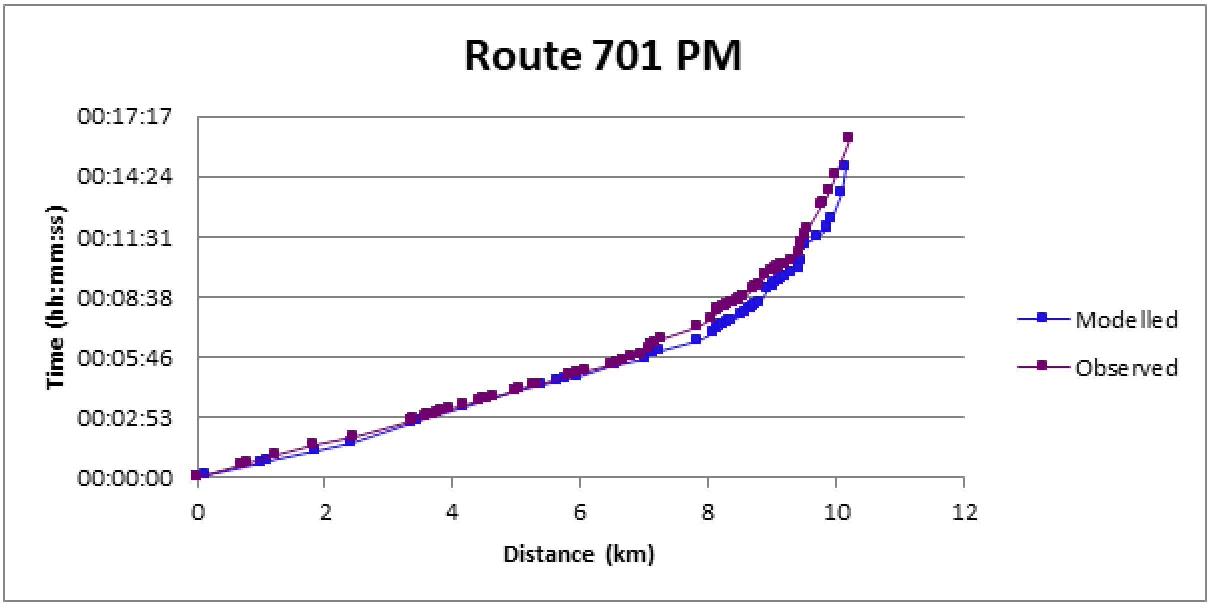
Route 602 PM
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
1
2
3
4
5
Distance (km)
Modelled
Observed



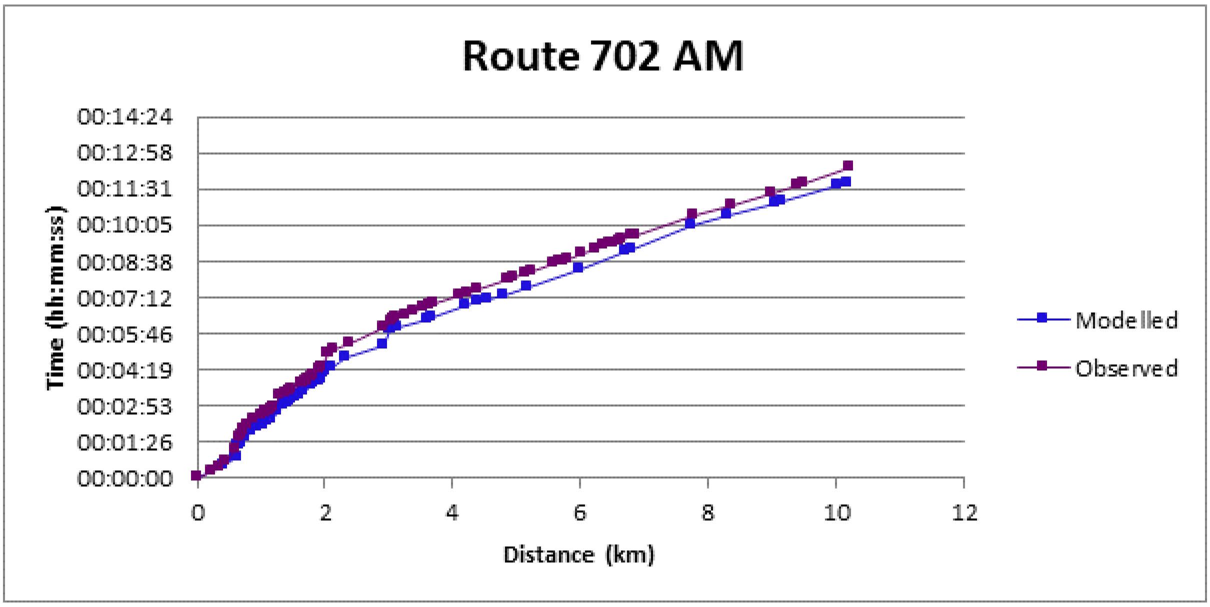
Route 701 AM
00:20:10
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
Time (hh:mm:ss)
0
2
4
6
8
10
12
Distance (km)
Modelled
Observed

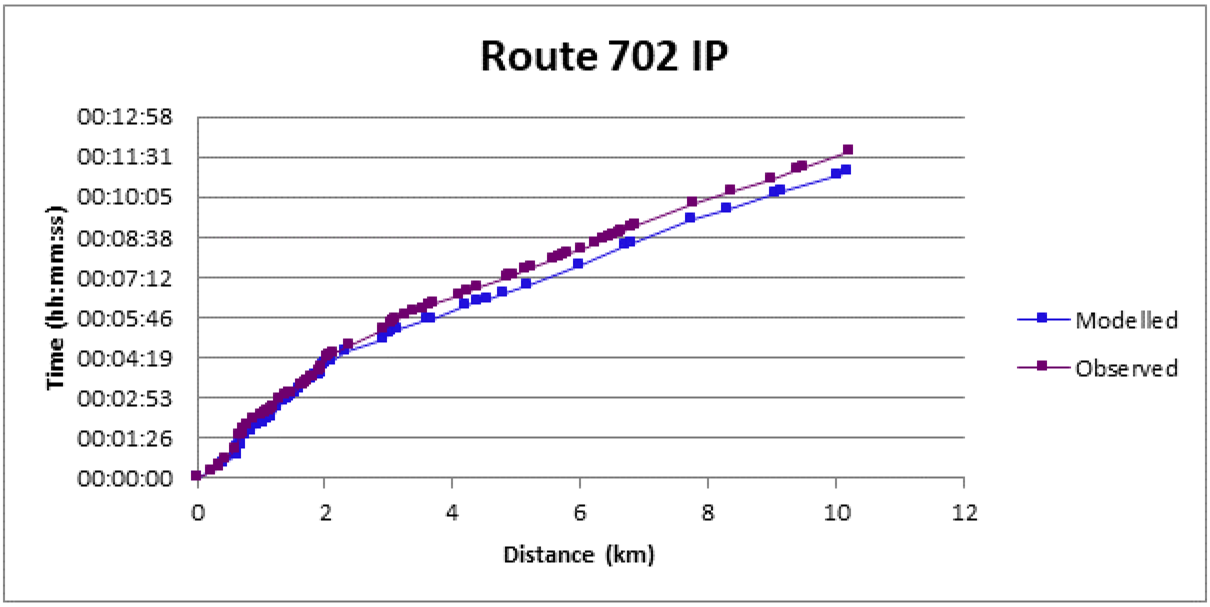


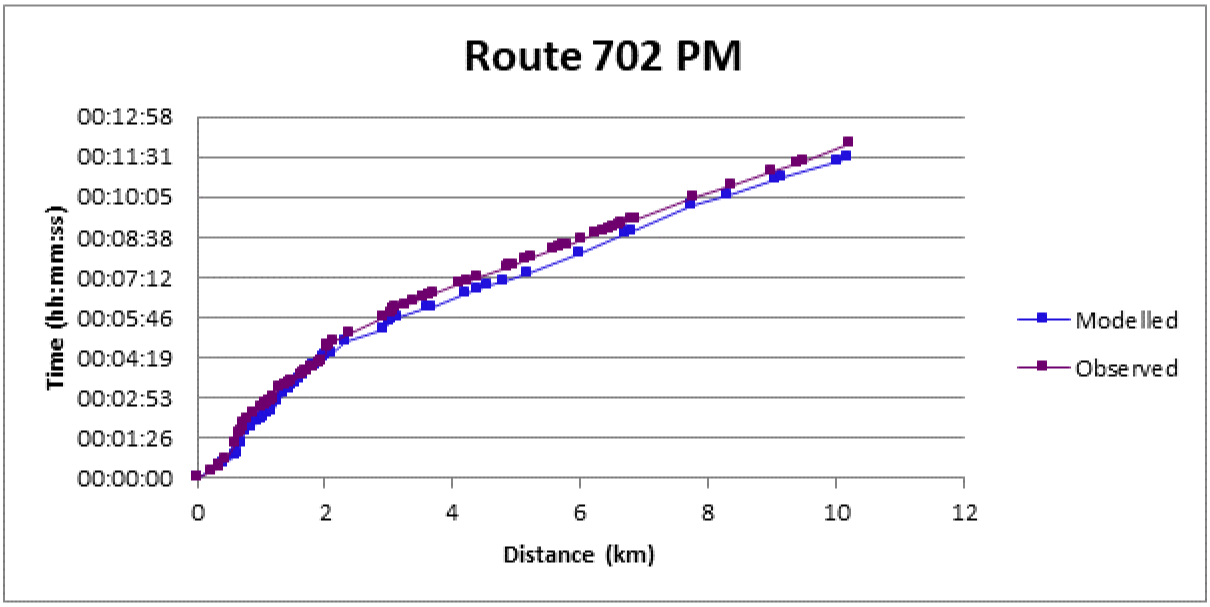
Route 701 IP
00:14:24
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
2
4
6
8
10
12
Distance (km)
Modelled
Observed

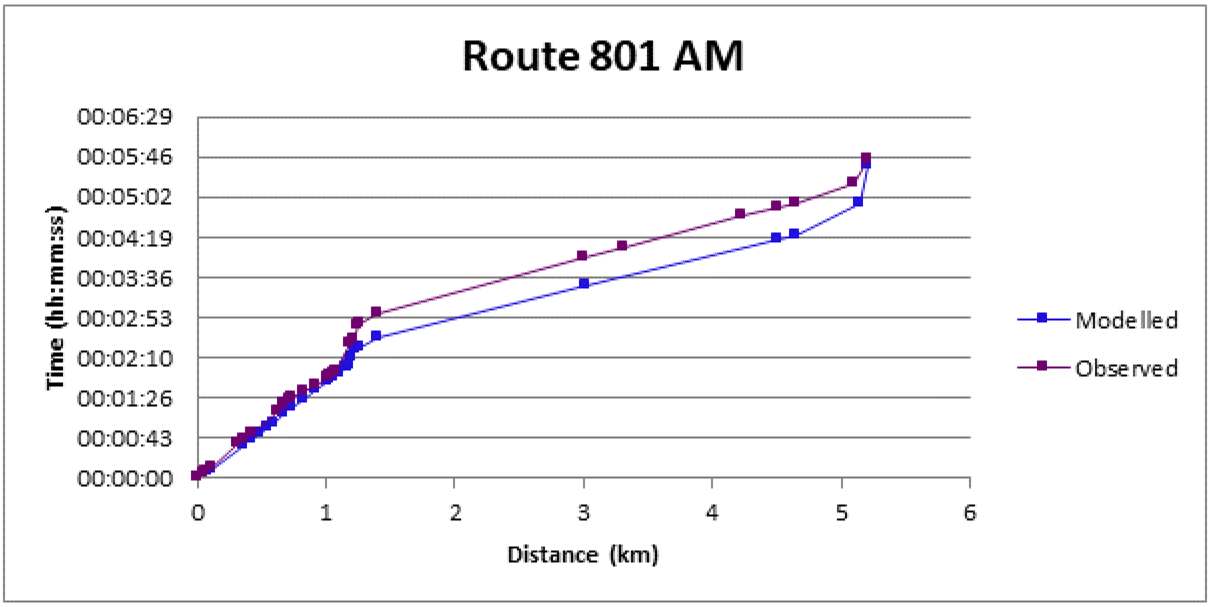


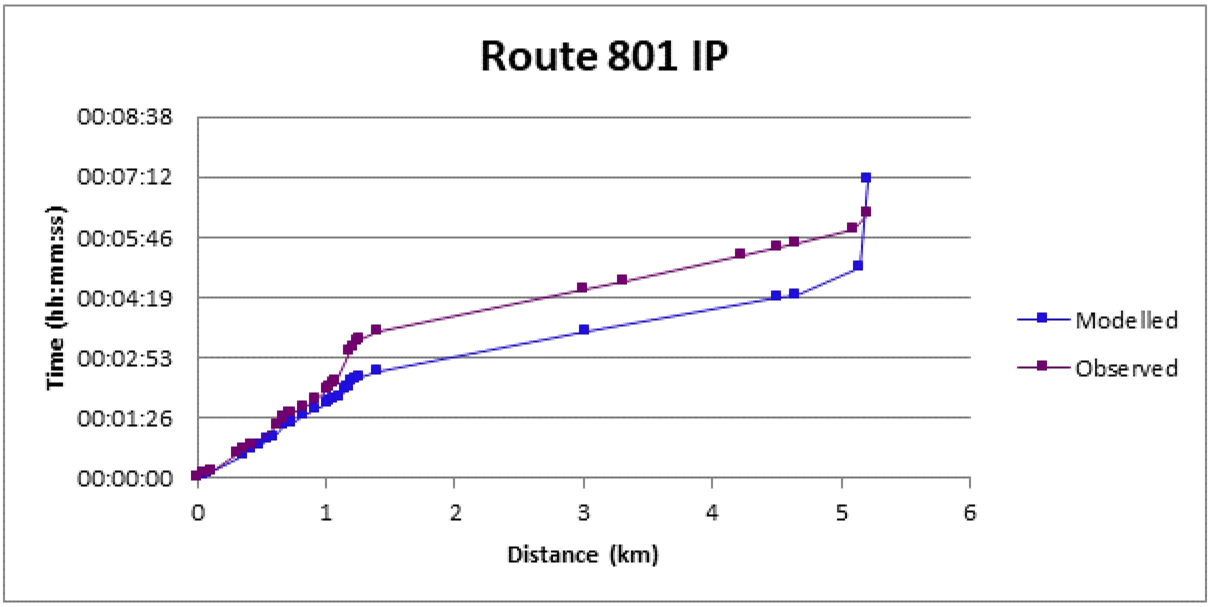
Route 701 PM
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
Time (hh:mm:ss)
0
2
4
6
8
10
12
Distance (km)
Modelled
Observed

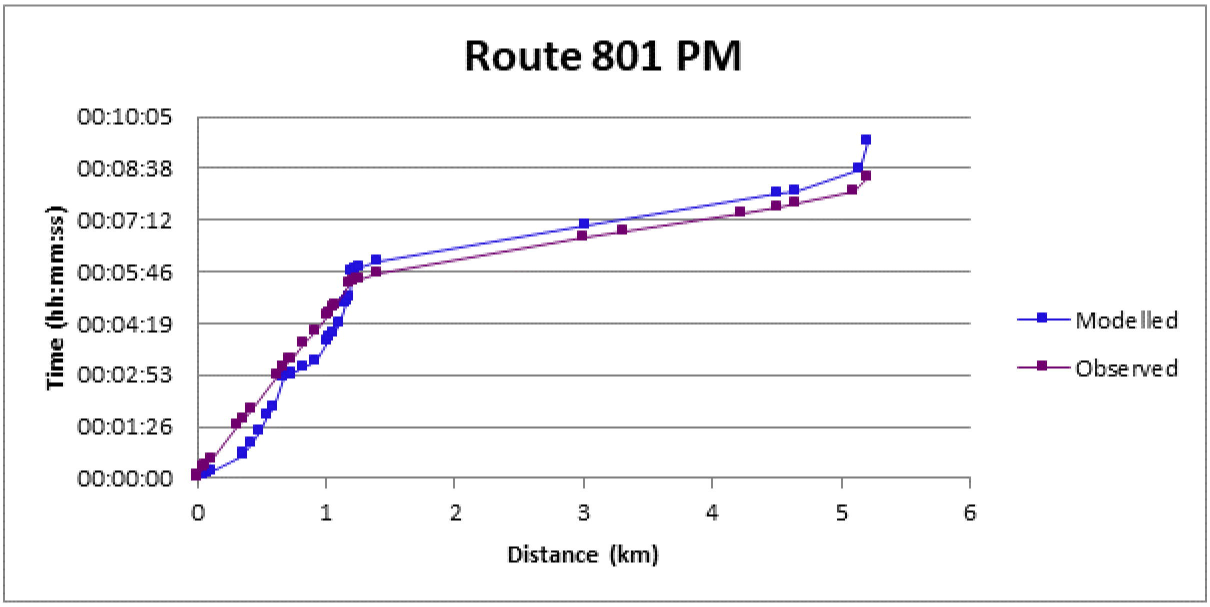

Route 702 AM
Time (hh:mm:ss)
00:14:24
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
0
2
4
6
8
10
12
Distance (km)
Modelled
Observed

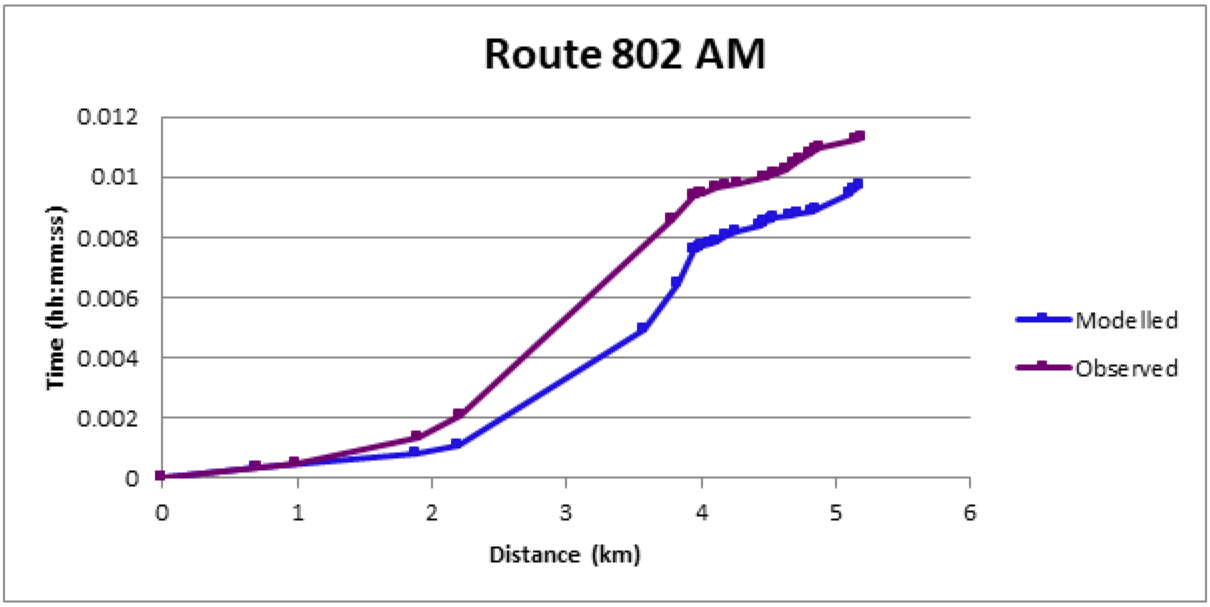

Route 702 IP
Time (hh:mm:ss)
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
0
2
4
6
8
10
12
Distance (km)
Modelled
Observed

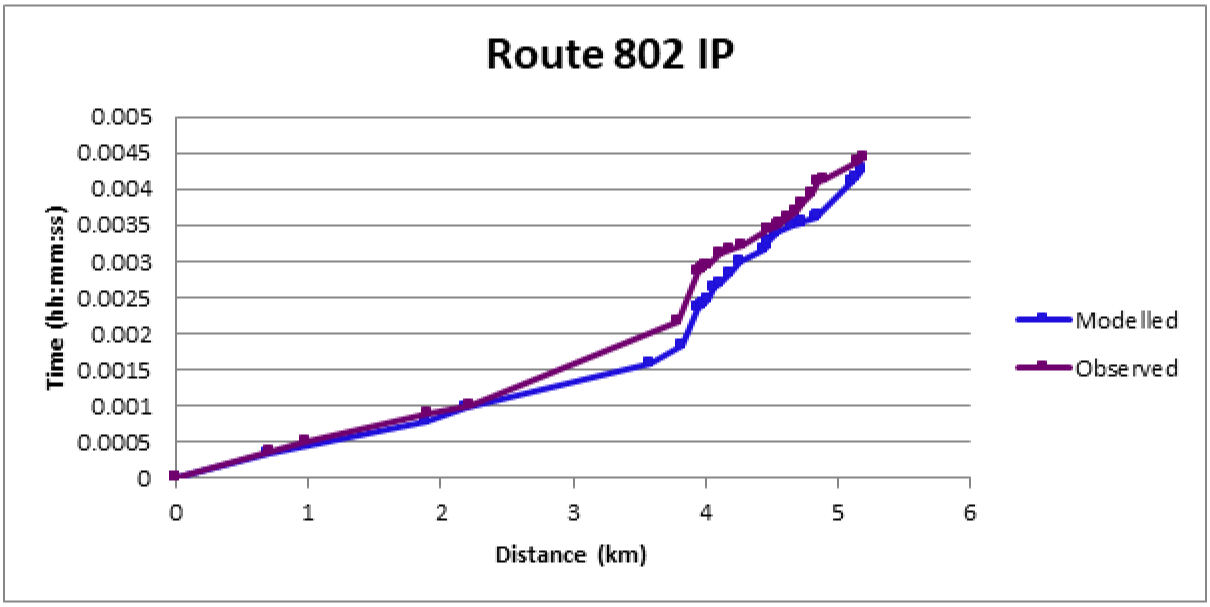

Route 702 PM
Time (hh:mm:ss)
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
0
2
4
6
8
10
12
Distance (km)
Modelled
Observed

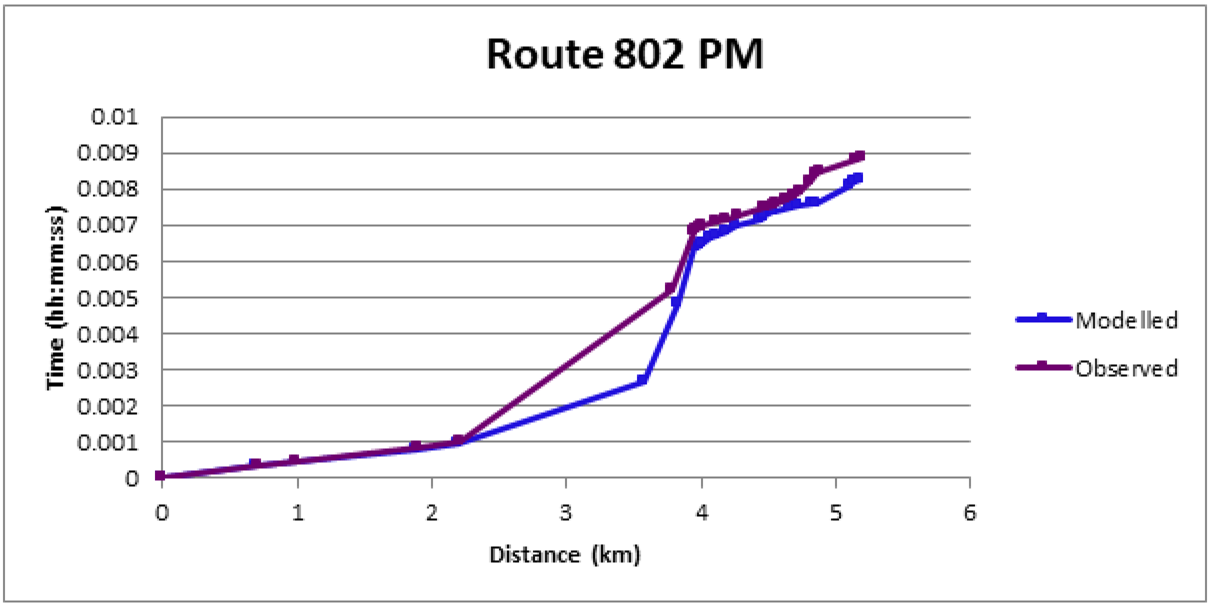

Route 801 AM
00:06:29
00:05:46
00:05:02
00:04:19
00:03:36
00:02:53
00:02:10
00:01:26
00:00:43
00:00:00
Time (hh:mm:ss)
0
1
2
3
4
5
6
Distance (km)
Modelled
Observed

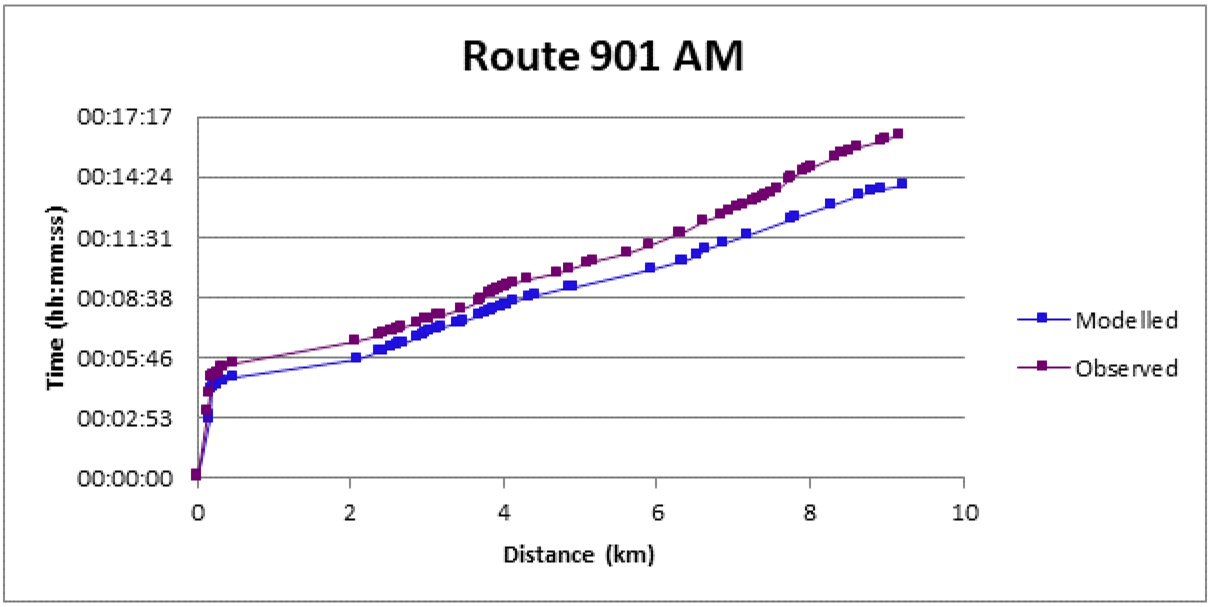

Route 801 IP
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
1
2
3
4
5
6
Distance (km)
Modelled
Observed

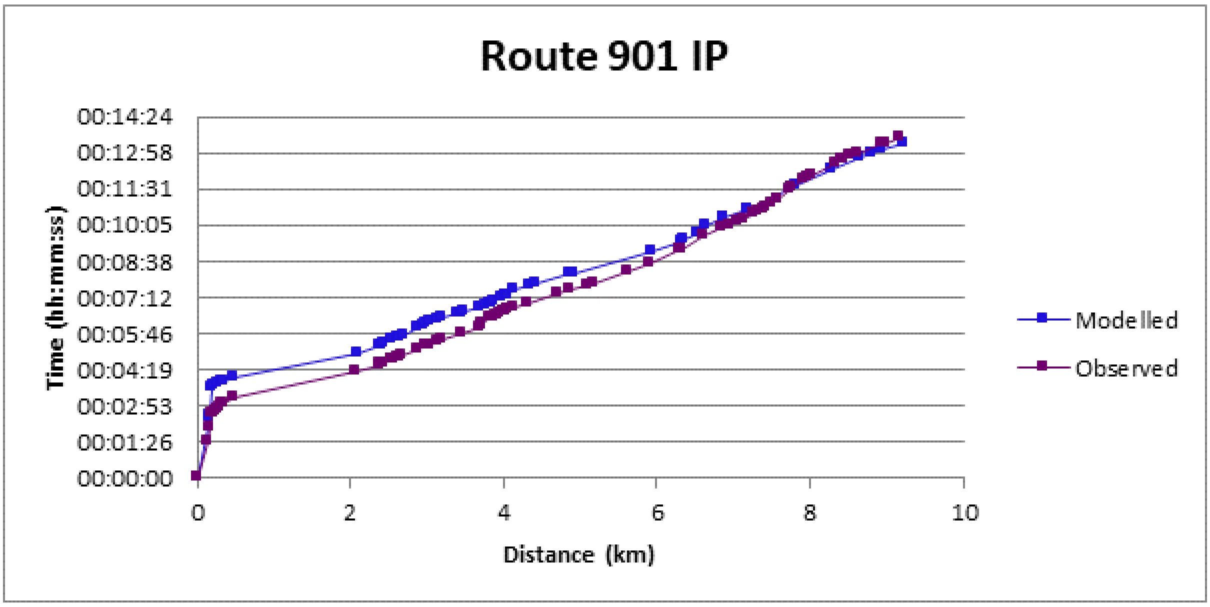

Route 801 PM
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
1
2
3
4
5
6
Distance (km)
Modelled
Observed

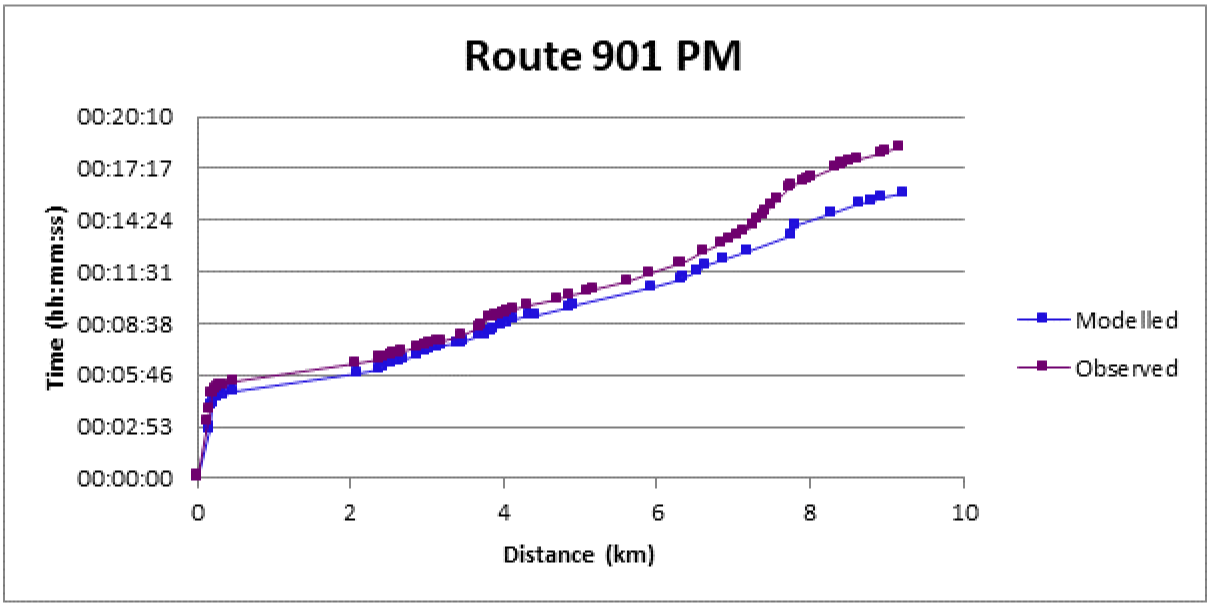

Route 802 AM
Time (hh:mm:ss)
0.012
0.01
0.008
0.006
0.004
0.002
0
0
1
2
3
4
5
6
Distance (km)
Modelled
Observed

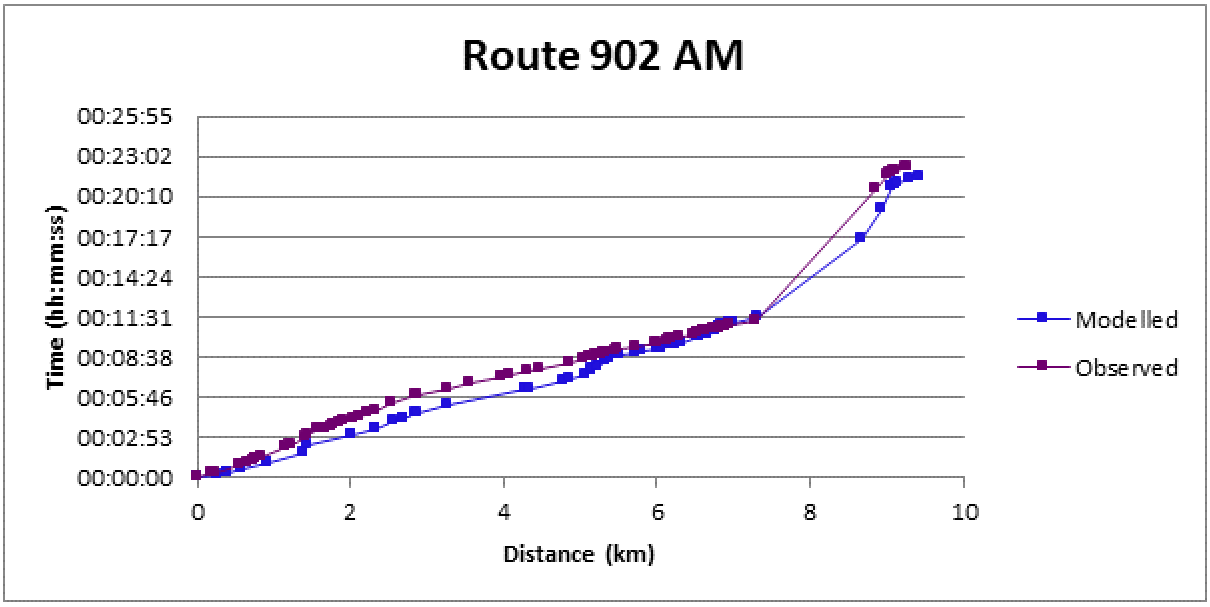

Route 802 IP
Time (hh:mm:ss)
0.005
0.0045
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
0
1
2
3
4
5
6
Distance (km)
Modelled
Observed

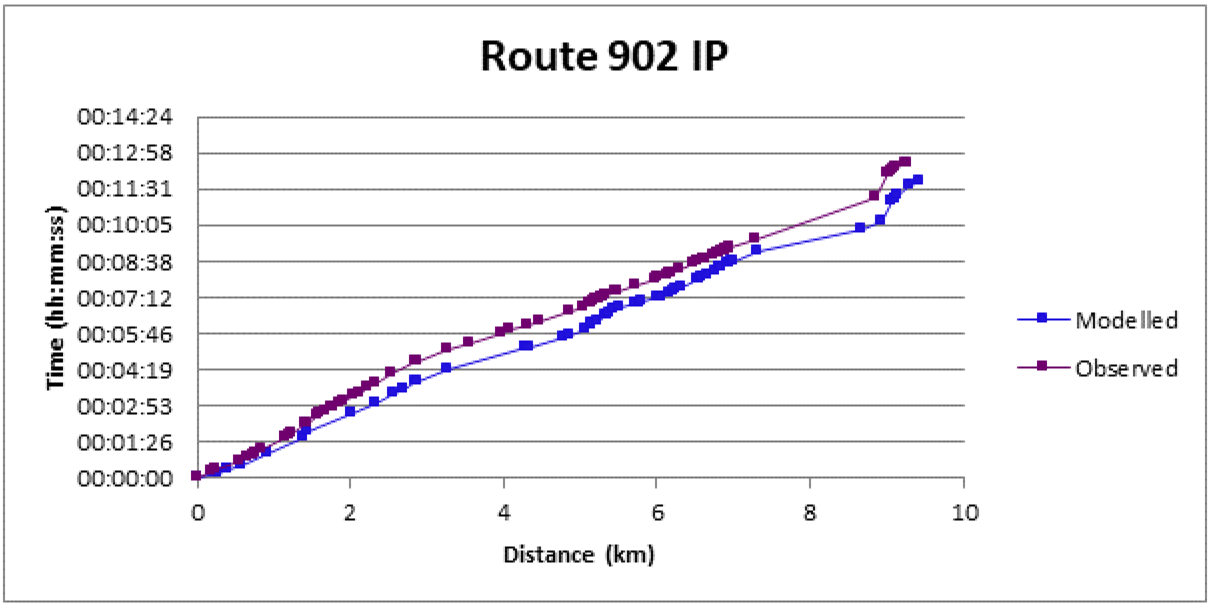

Route 802 PM
Time (hh:mm:ss)
0.01
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
0
1
2
3
4
5
6
Distance (km)
Modelled
Observed

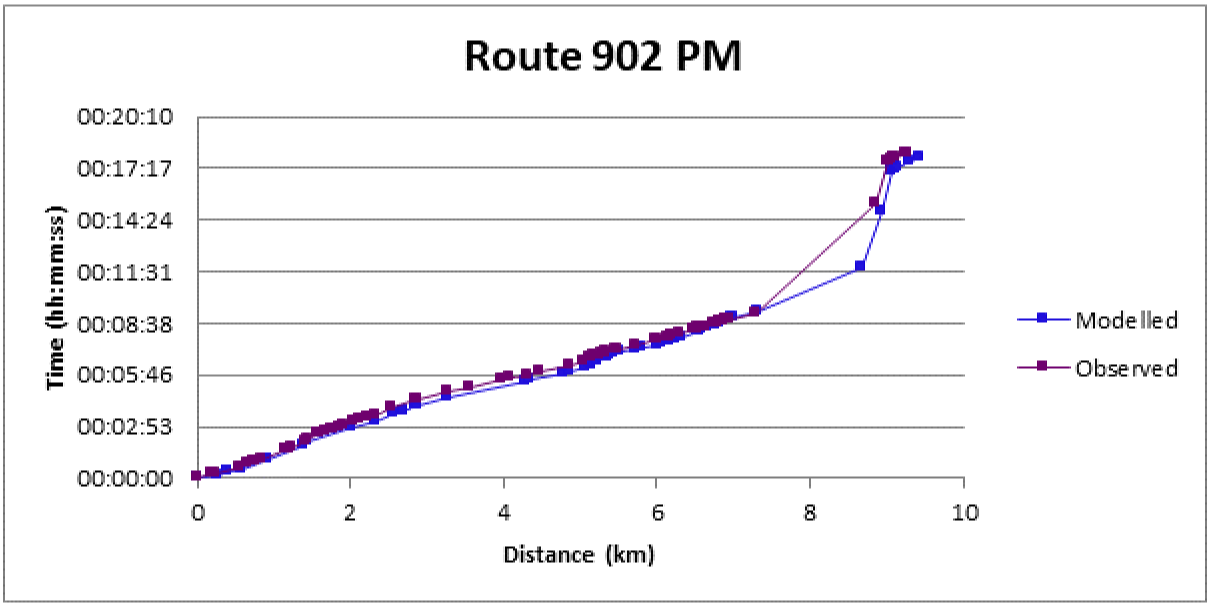

Route 901 AM
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
Time (hh:mm:ss)
0
2
4
6
8
10
Distance (km)
Modelled
Observed

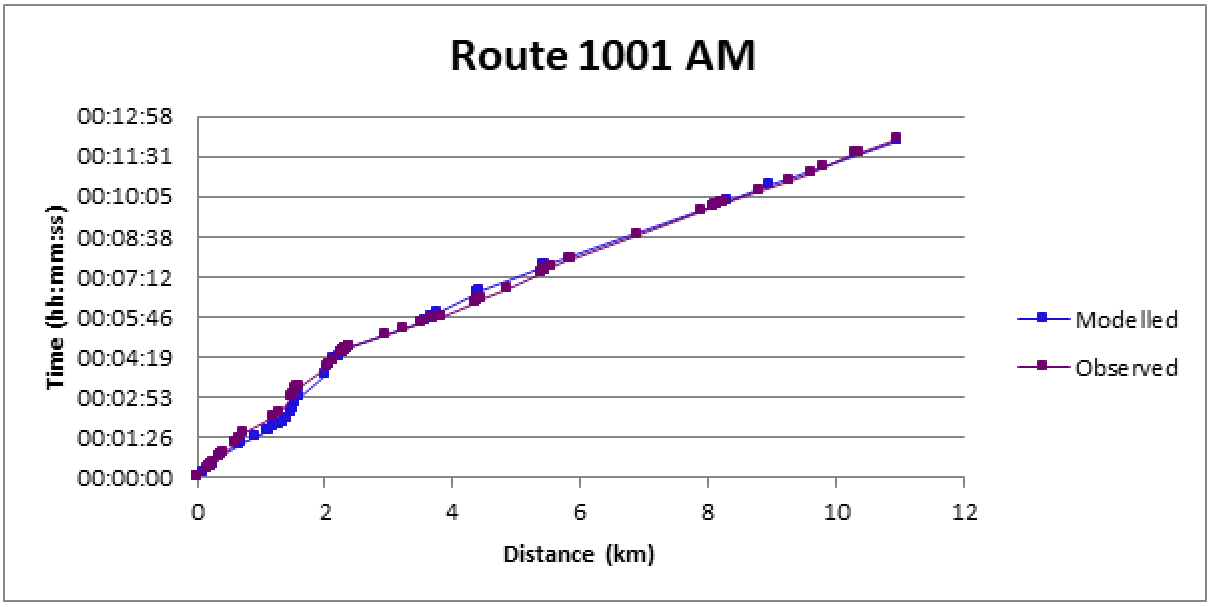

Route 901 IP
00:14:24
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
2
4
6
8
10
Distance (km)
Modelled
Observed

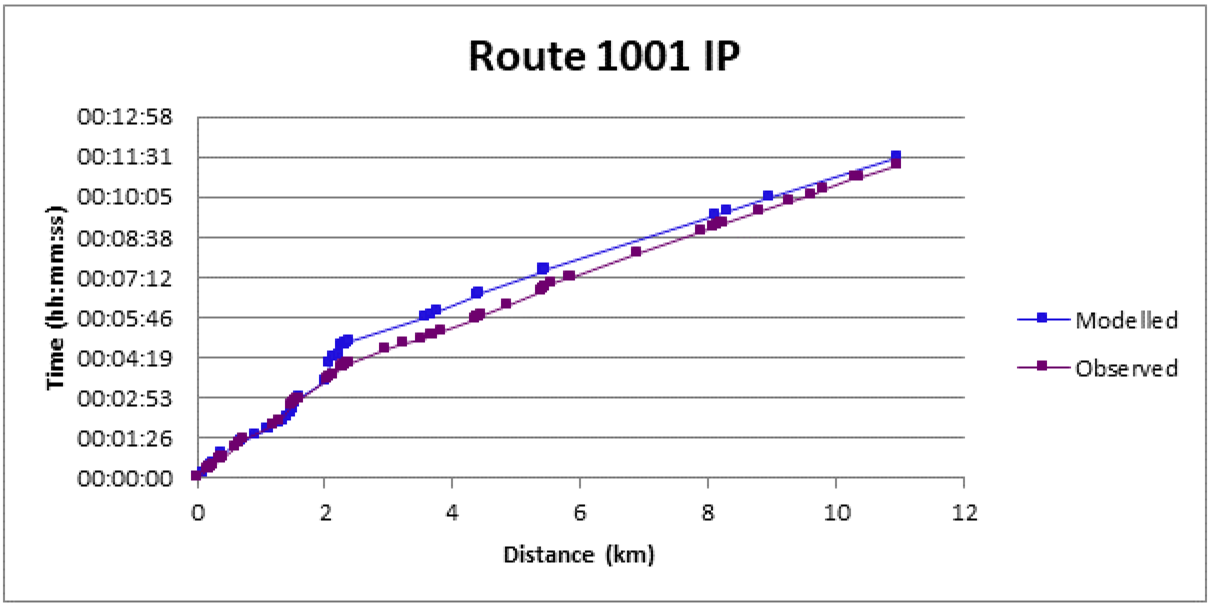

Route 901 PM
00:20:10
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
Time (hh:mm:ss)
0
2
4
6
8
10
Distance (km)
Modelled
Observed

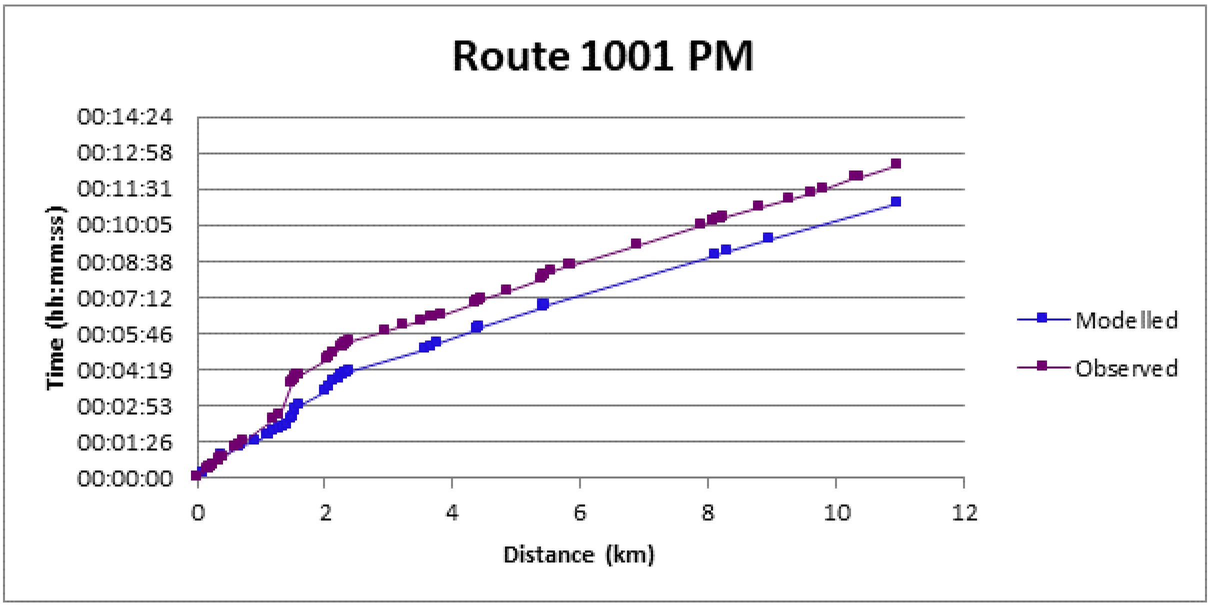

Route 902 AM
00:25:55
00:23:02
00:20:10
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
Time (hh:mm:ss)
0
2
4
6
8
10
Distance (km)
Modelled
Observed

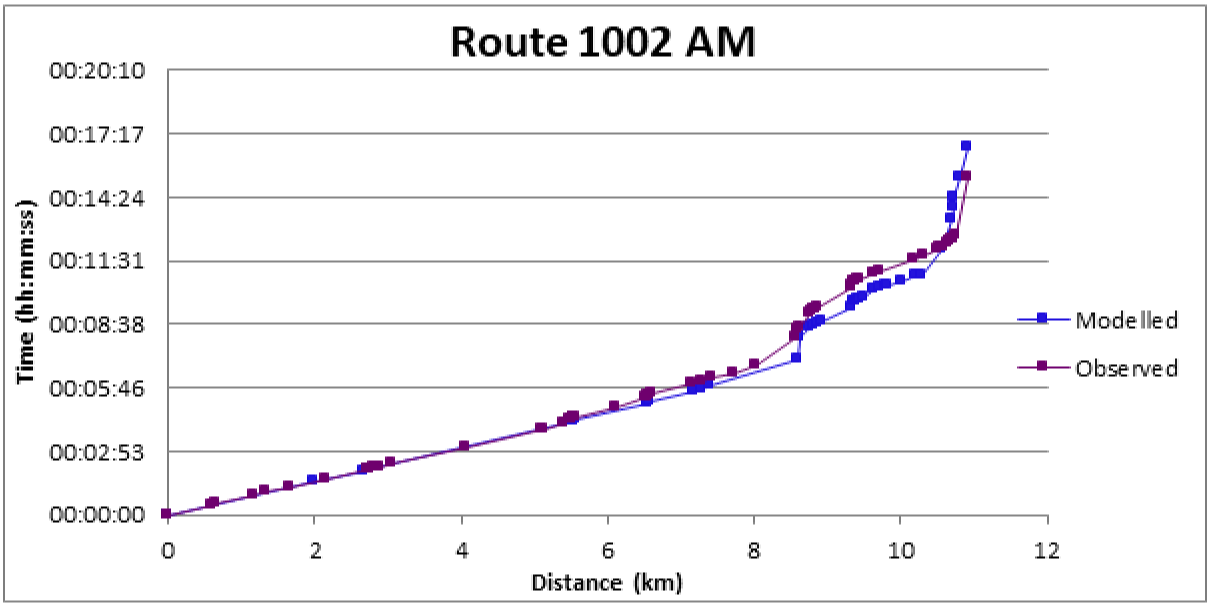

Route 902 IP
00:14:24
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
2
4
6
8
10
Distance (km)
Modelled
Observed

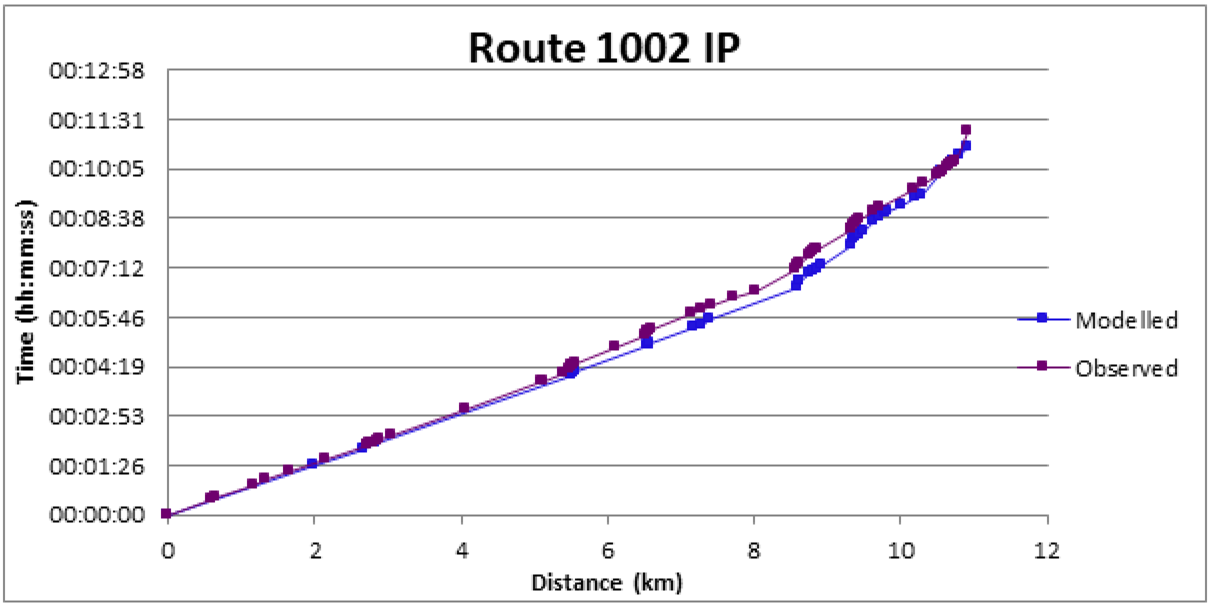

Route 902 PM
00:20:10
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
Time (hh:mm:ss)
0
2
4
6
8
10
Distance (km)
Modelled
Observed

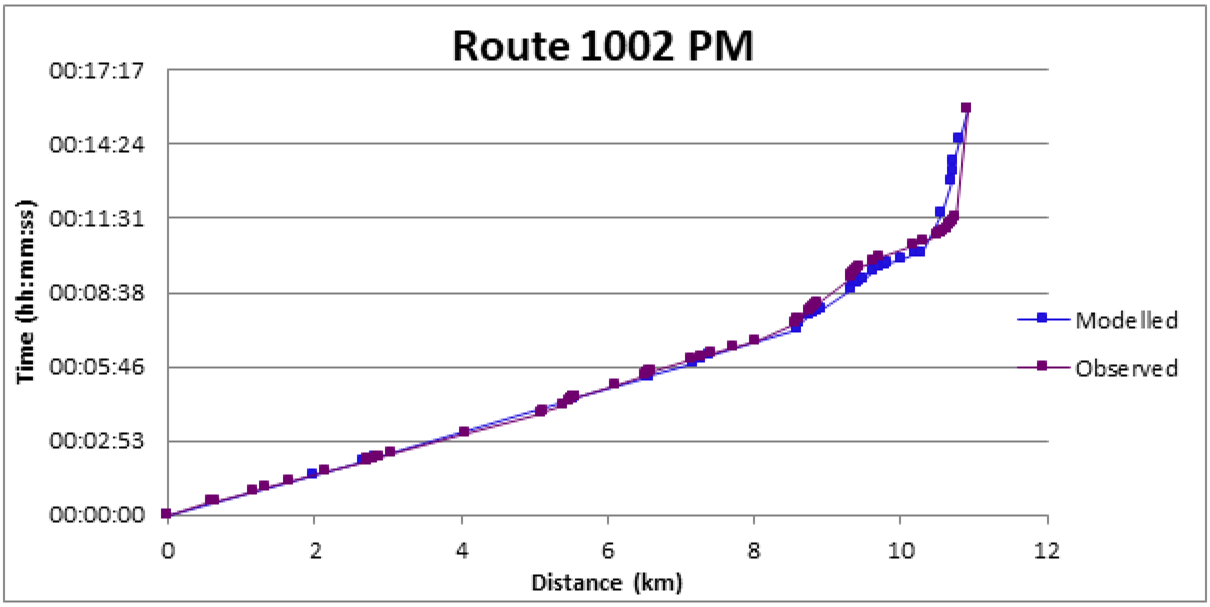

Route 1001 AM
Time (hh:mm:ss)
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
0
2
4
6
8
10
12
Distance (km)
Modelled
Observed

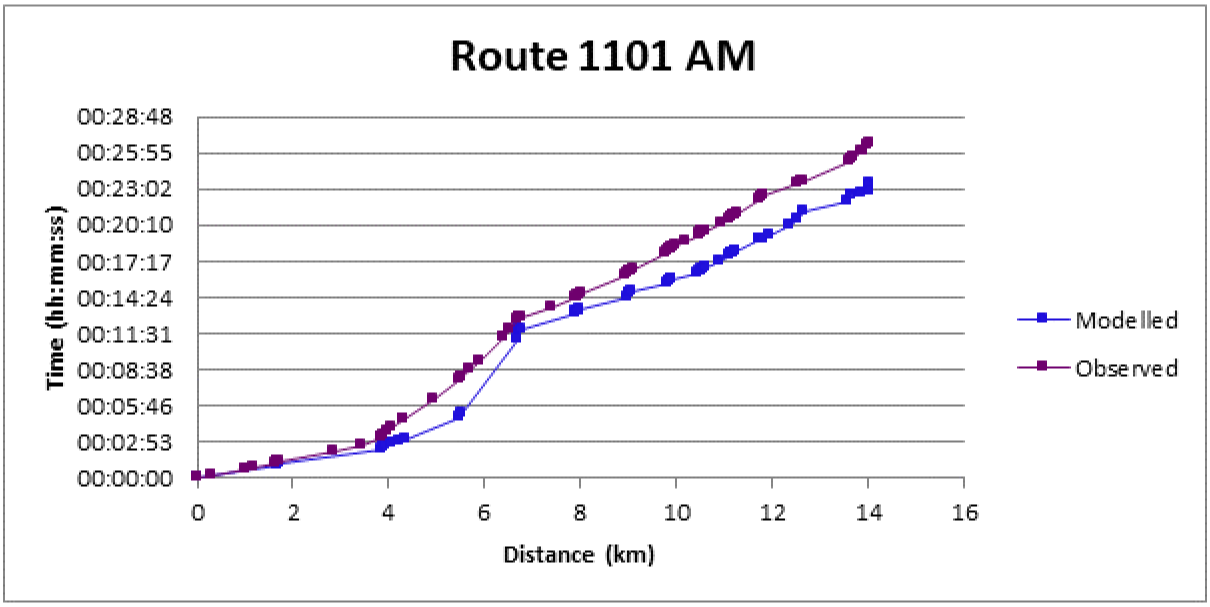

Route 1001 IP
Time (hh:mm:ss)
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
0
2
4
6
8
10
12
Distance (km)
Modelled
Observed

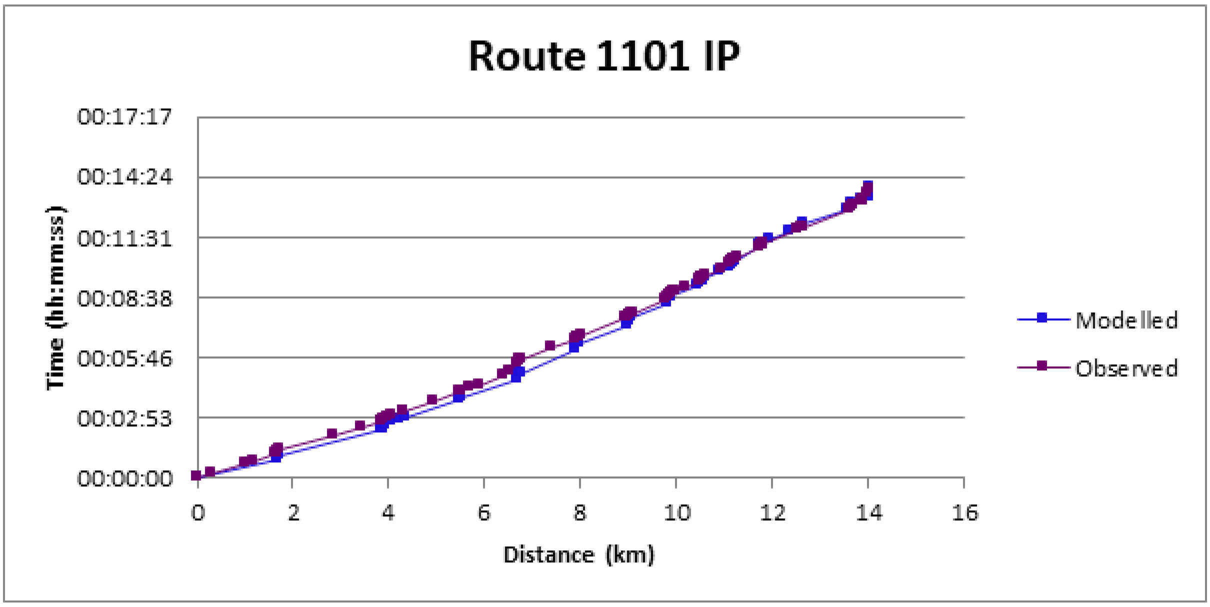

Route 1001 PM
Time (hh:mm:ss)
00:14:24
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
0
2
4
6
8
10
12
Distance (km)
Modelled
Observed

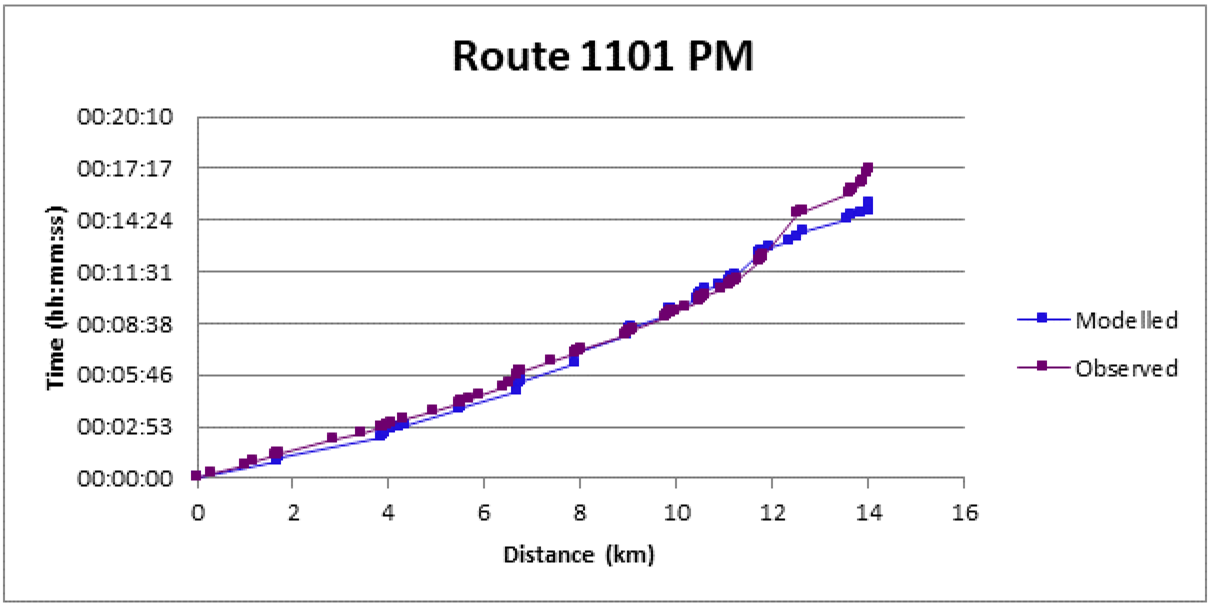

Route 1002 AM
Time (hh:mm:ss)
00:20:10
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
0
2
4
6
8
10
12
Distance (km)
Modelled
Observed


Route 1002 IP
Time (hh:mm:ss)
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
0
2
4
6
8
10
12
Distance (km)
Modelled
Observed

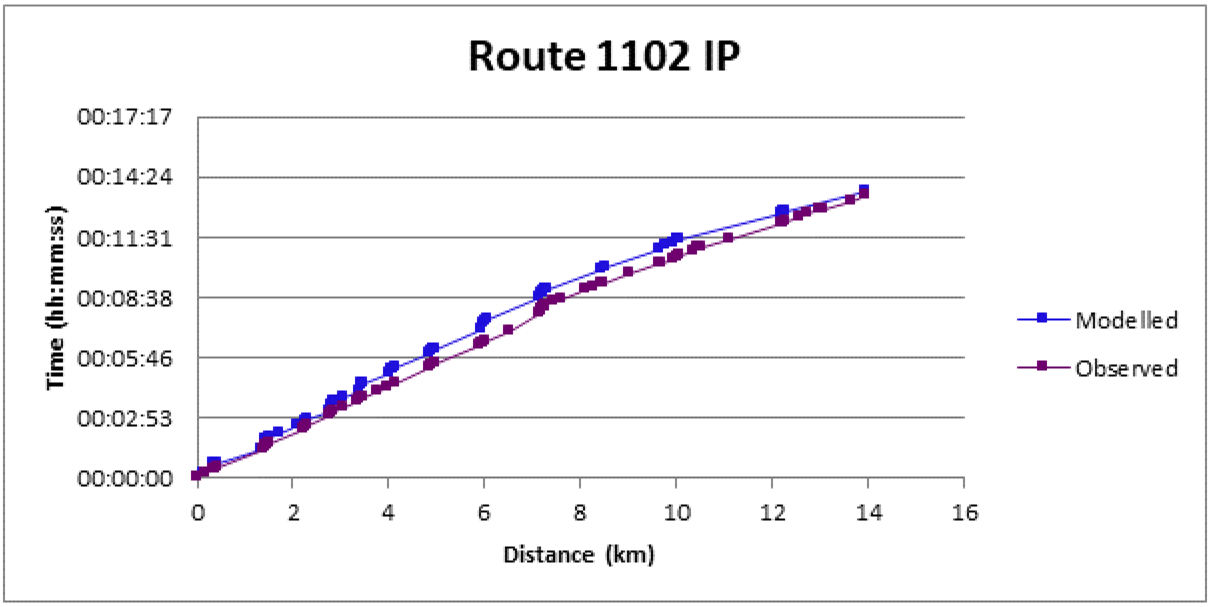

Route 1002 PM
Time (hh:mm:ss)
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
0
2
4
6
8
10
12
Distance (km)
Modelled
Observed

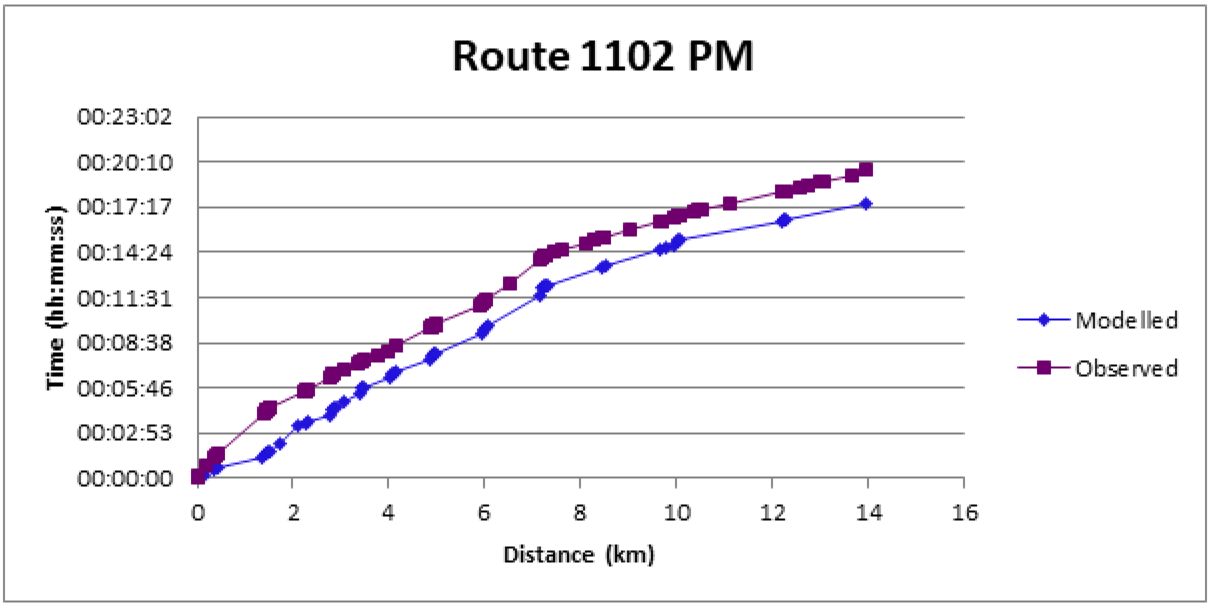

Route 1101 AM
00:28:48
00:25:55
00:23:02
00:20:10
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
Time (hh:mm:ss)
0
2
4
6
8
10
12
14
16
Distance (km)
Modelled
Observed


Route 1101 IP
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
Time (hh:mm:ss)
0
2
4
6
8
10
12
14
16
Distance (km)
Modelled
Observed

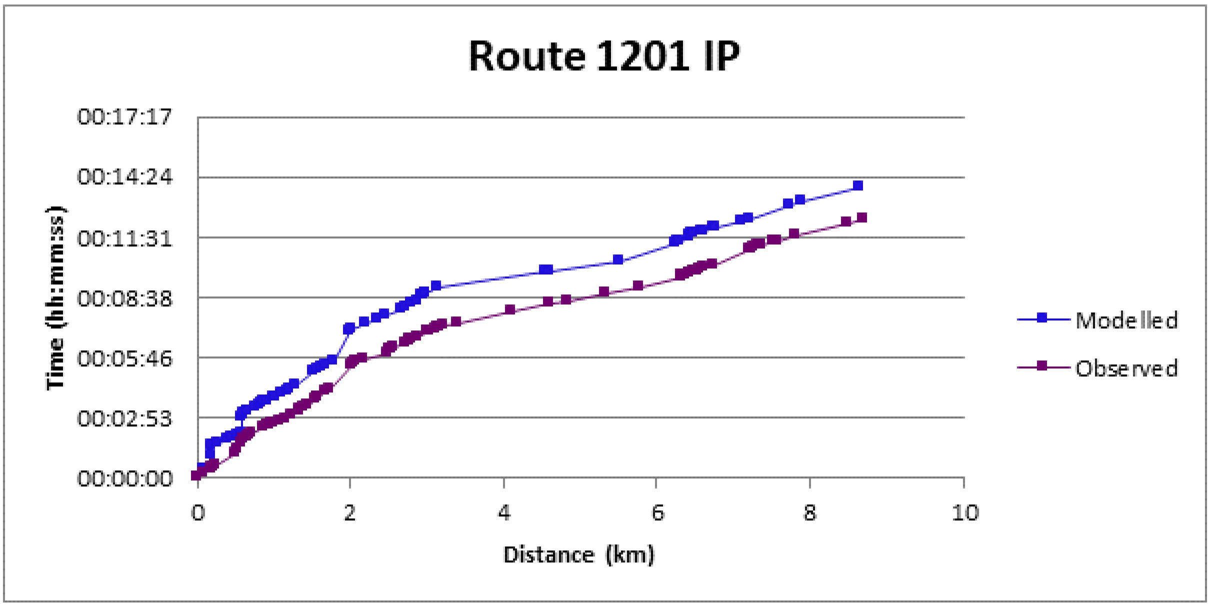

Route 1101 PM
00:20:10
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
Time (hh:mm:ss)
0
2
4
6
8
10
12
14
16
Distance (km)
Modelled
Observed

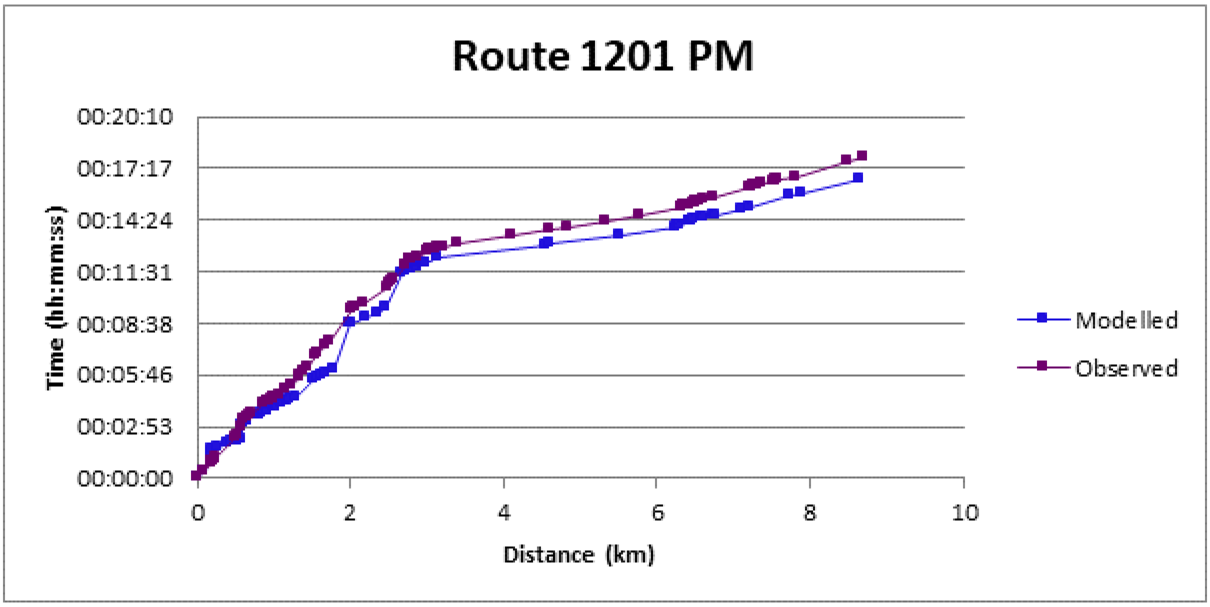

Route 1102 AM
Time (hh:mm:ss)
00:20:10
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
0
2
4
6
8
10
12
14
16
Distance (km)
Modelled
Observed

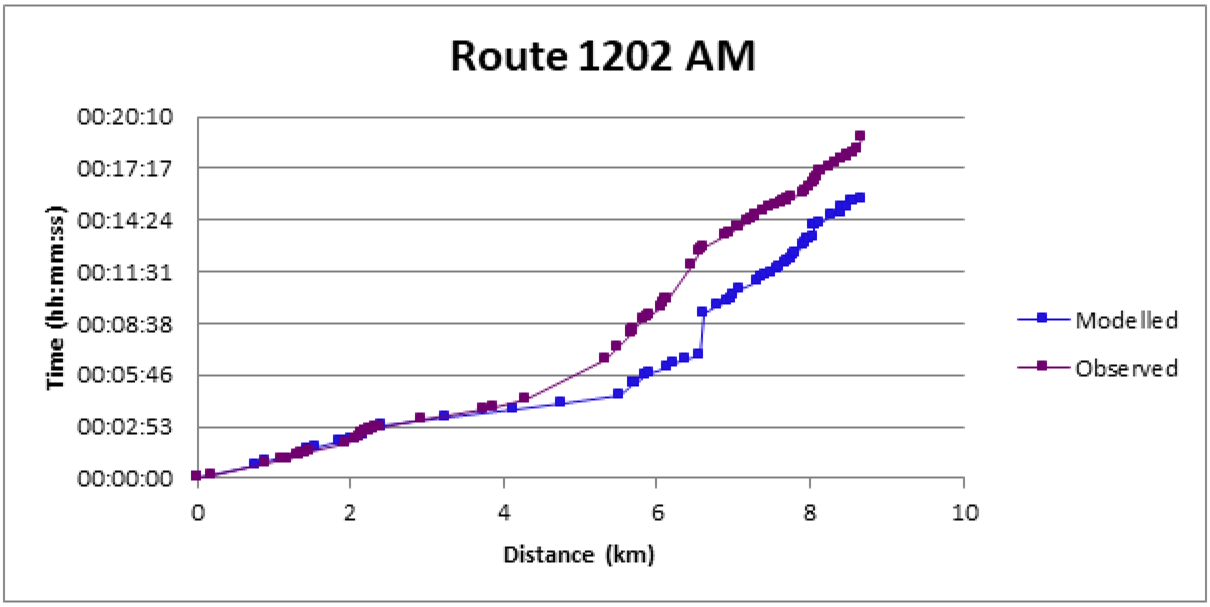

Route 1102 IP
Time (hh:mm:ss)
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
0
2
4
6
8
10
12
14
16
Distance (km)
Modelled
Observed

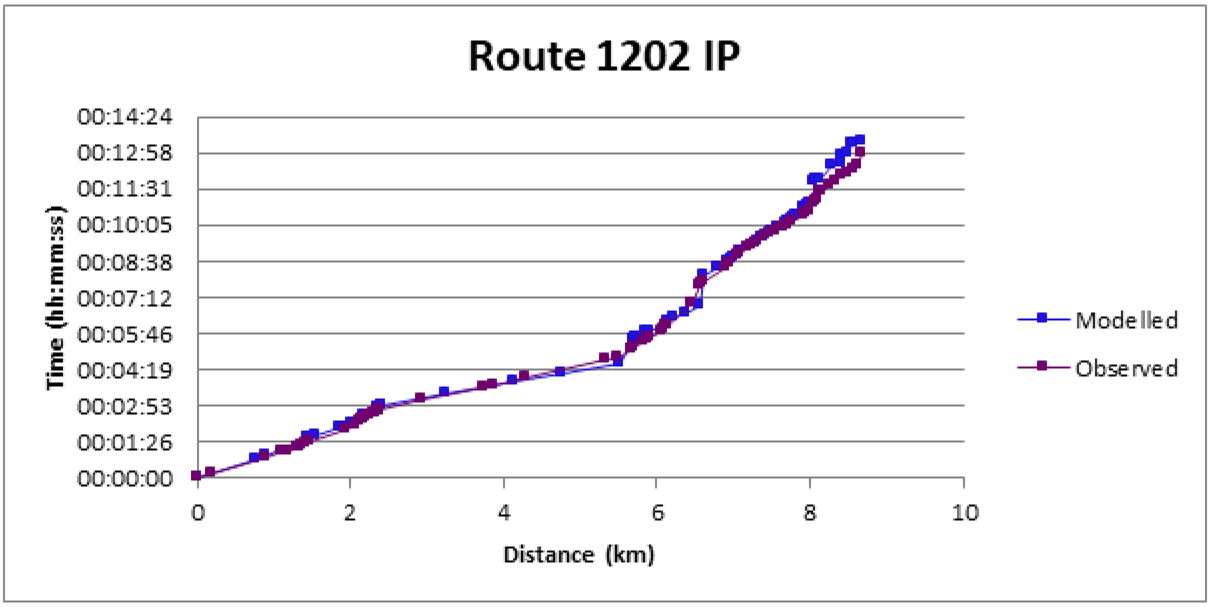

Route 1102 PM
Time (hh:mm:ss)
00:23:02
00:20:10
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
0
2
4
6
8
10
12
14
16
Distance (km)
Modelled
Observed

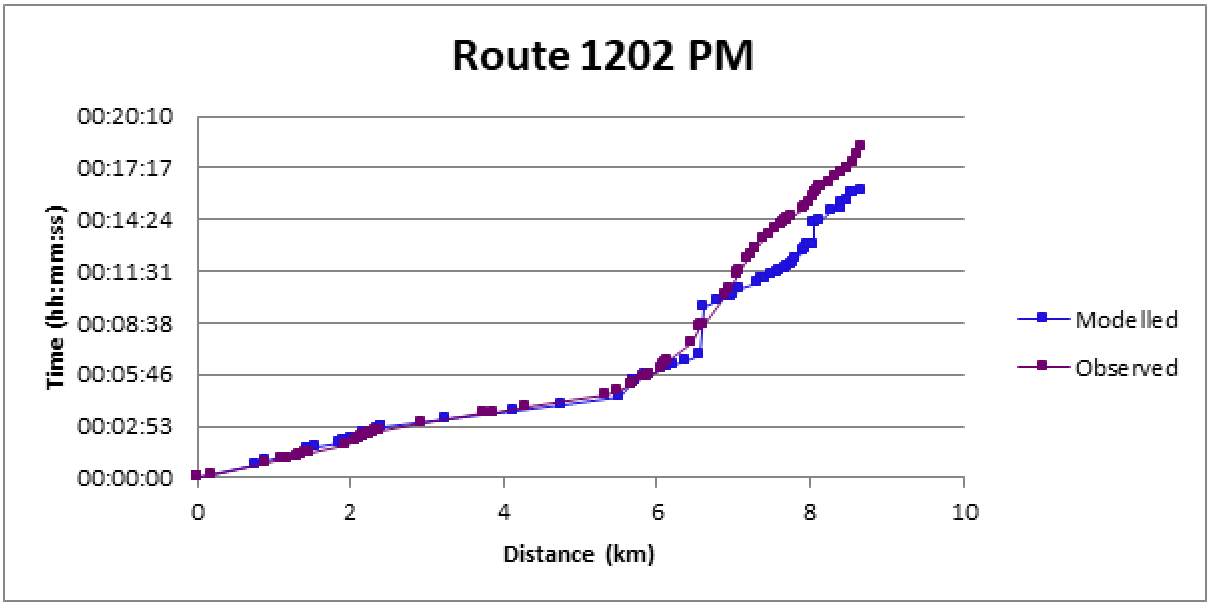

Route 1201 AM
Time (hh:mm:ss)
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
0
2
4
6
8
10
Distance (km)
Modelled
Observed

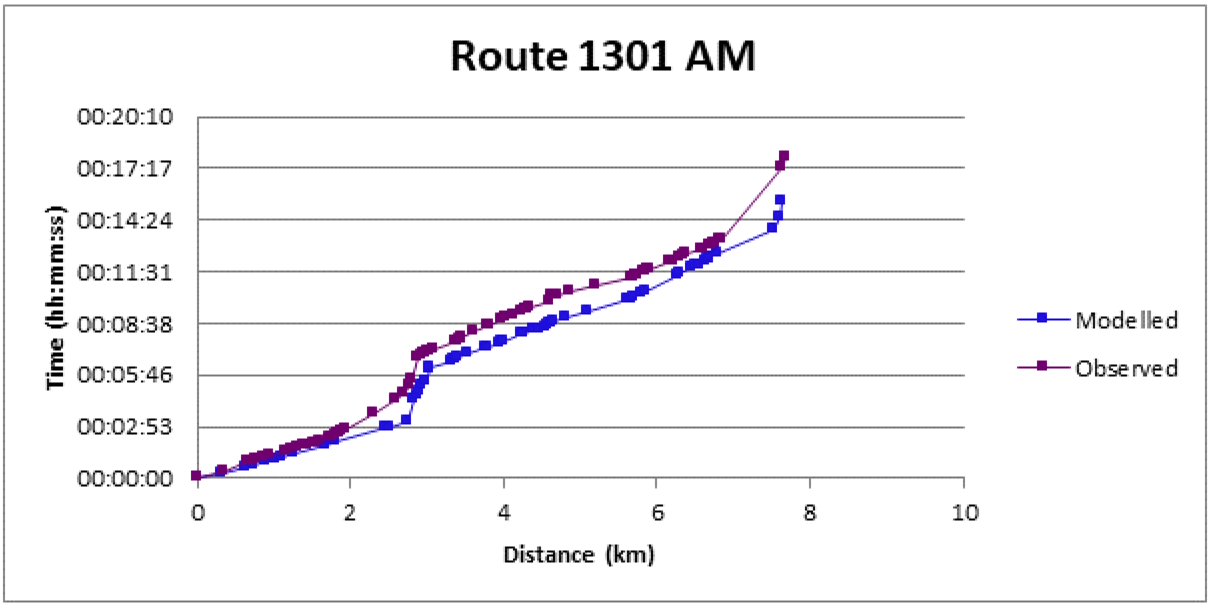

Route 1201 IP
Time (hh:mm:ss)
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
0
2
4
6
8
10
Distance (km)
Modelled
Observed

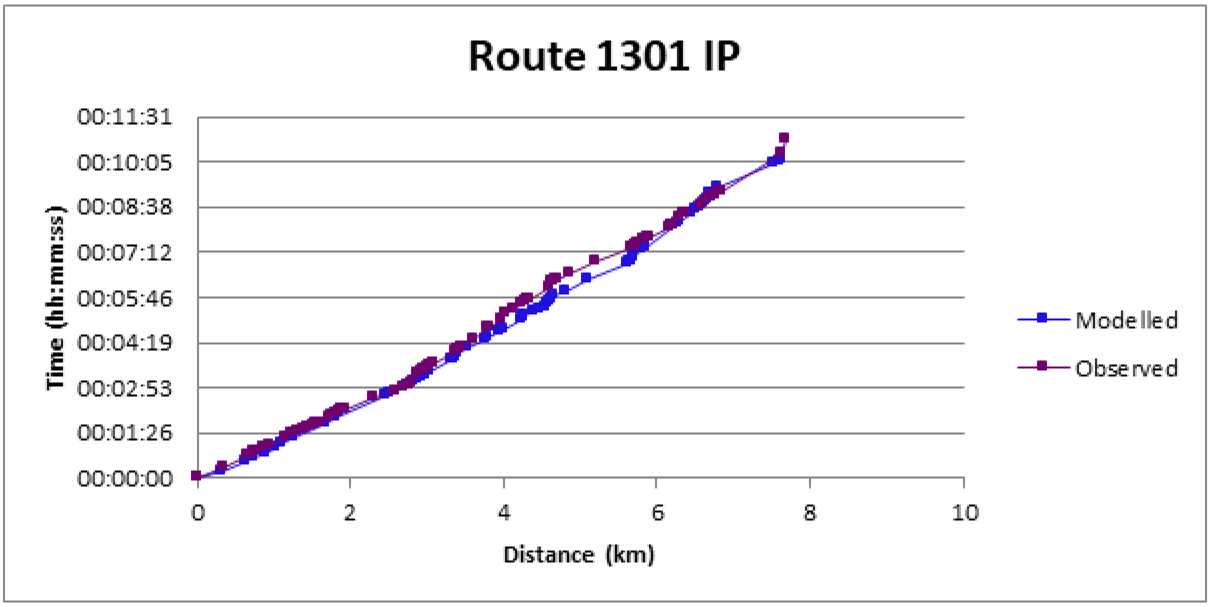

Route 1201 PM
Time (hh:mm:ss)
00:20:10
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
0
2
4
6
8
10
Distance (km)
Modelled
Observed

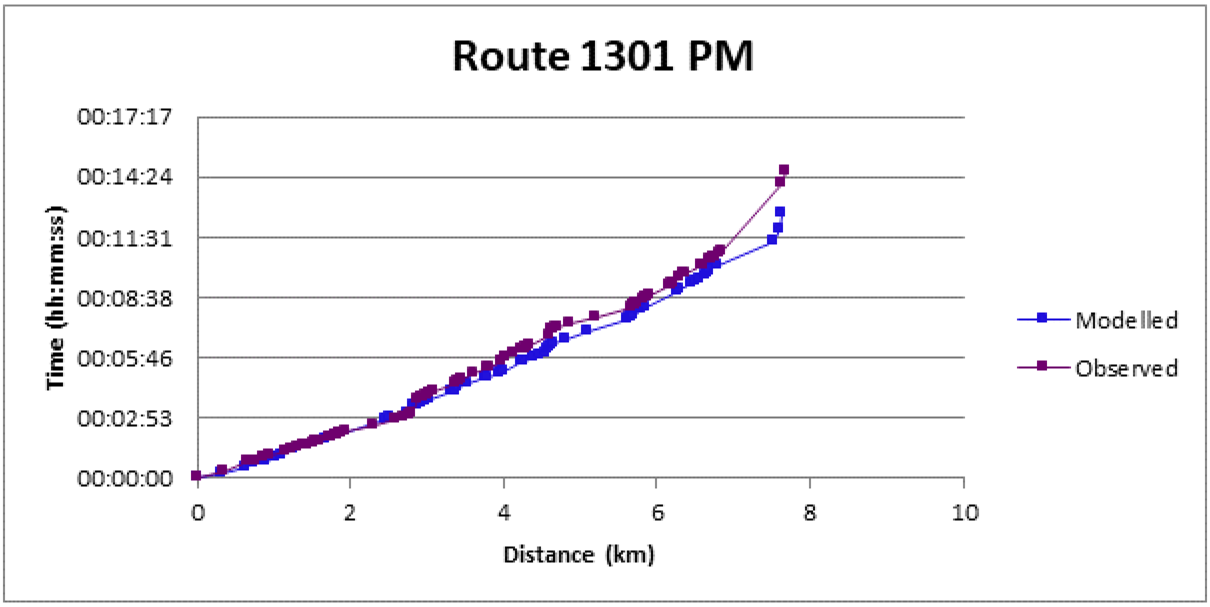

Route 1202 AM
00:20:10
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
Time (hh:mm:ss)
0
2
4
6
8
10
Distance (km)
Modelled
Observed

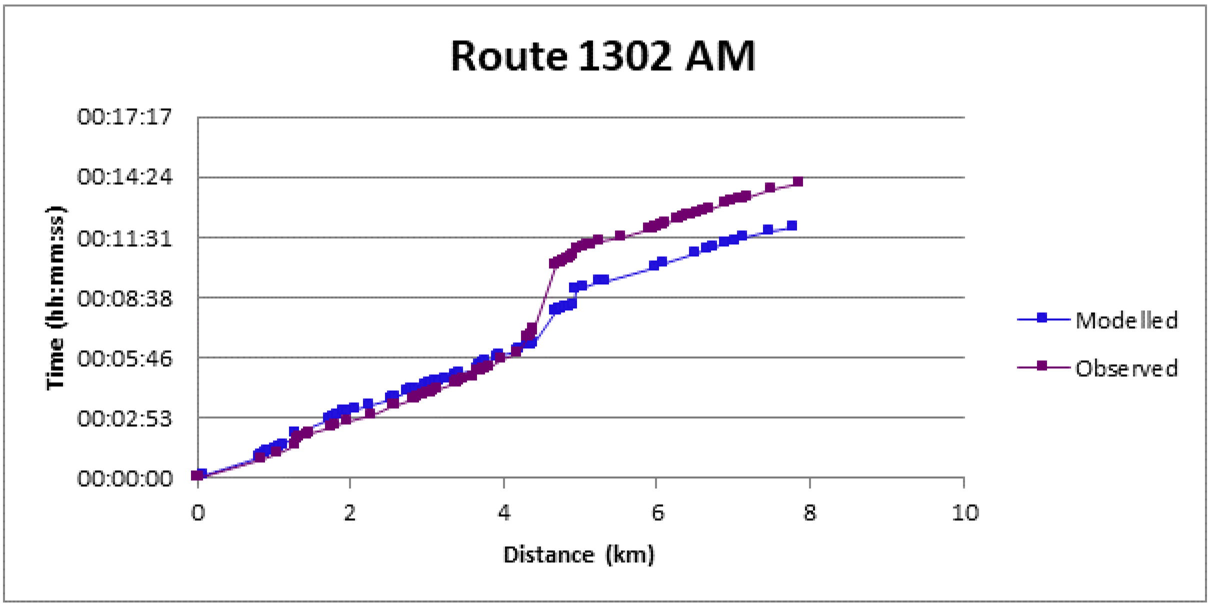

Route 1202 IP
00:14:24
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
2
4
6
8
10
Distance (km)
Modelled
Observed

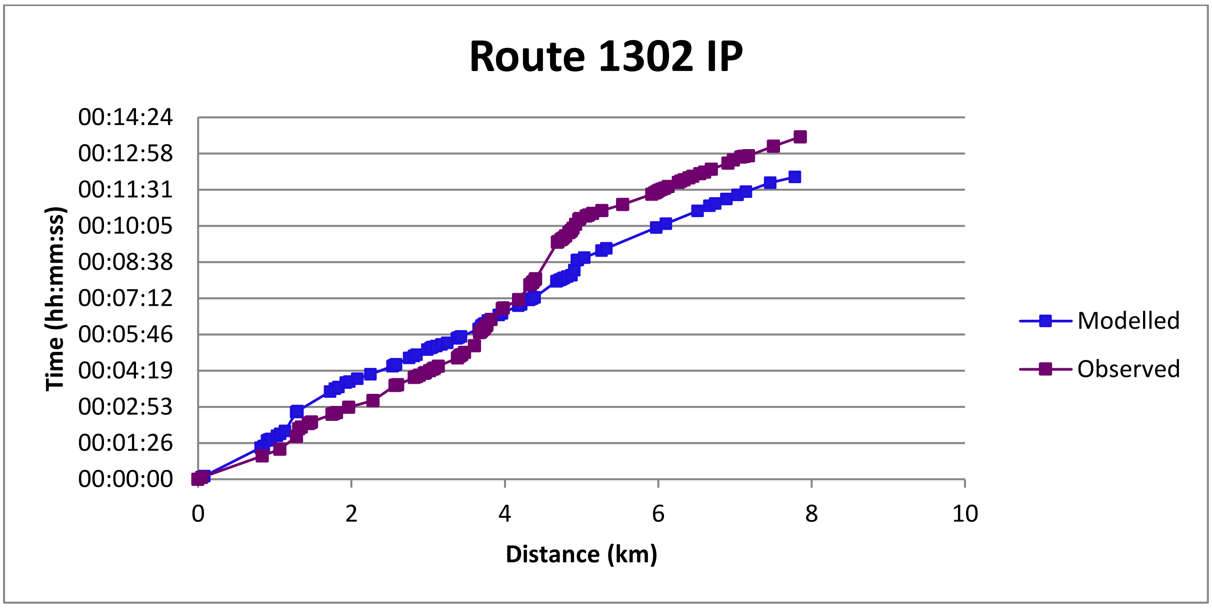

Route 1202 PM
00:20:10
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
Time (hh:mm:ss)
0
2
4
6
8
10
Distance (km)
Modelled
Observed

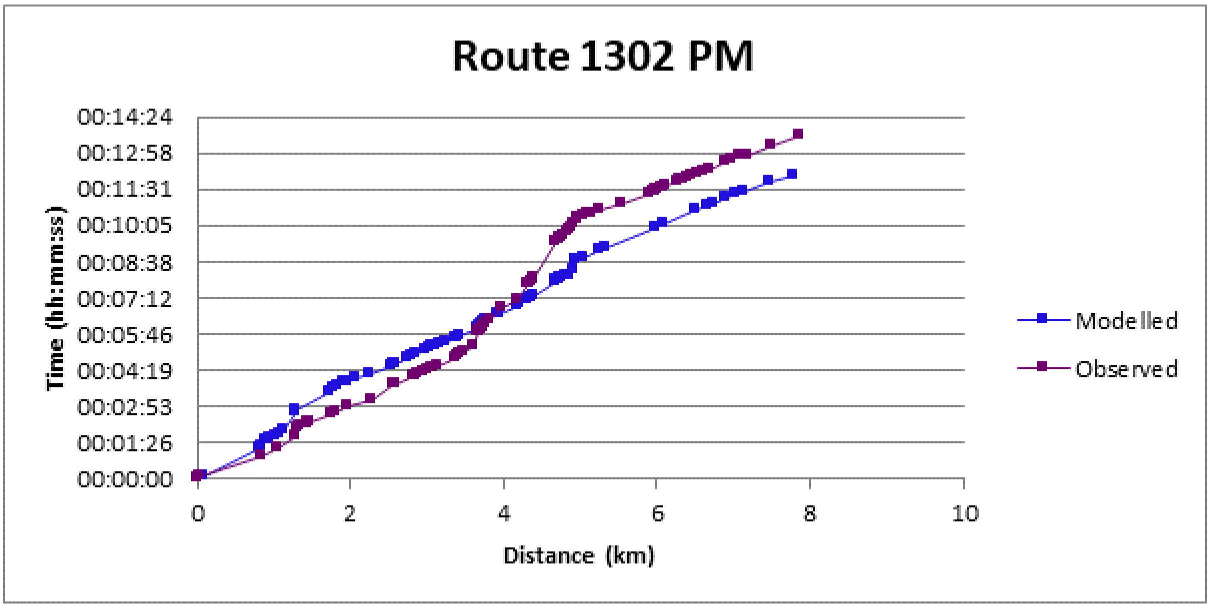

Route 1301 AM
00:20:10
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
Time (hh:mm:ss)
0
2
4
6
8
10
Distance (km)
Modelled
Observed

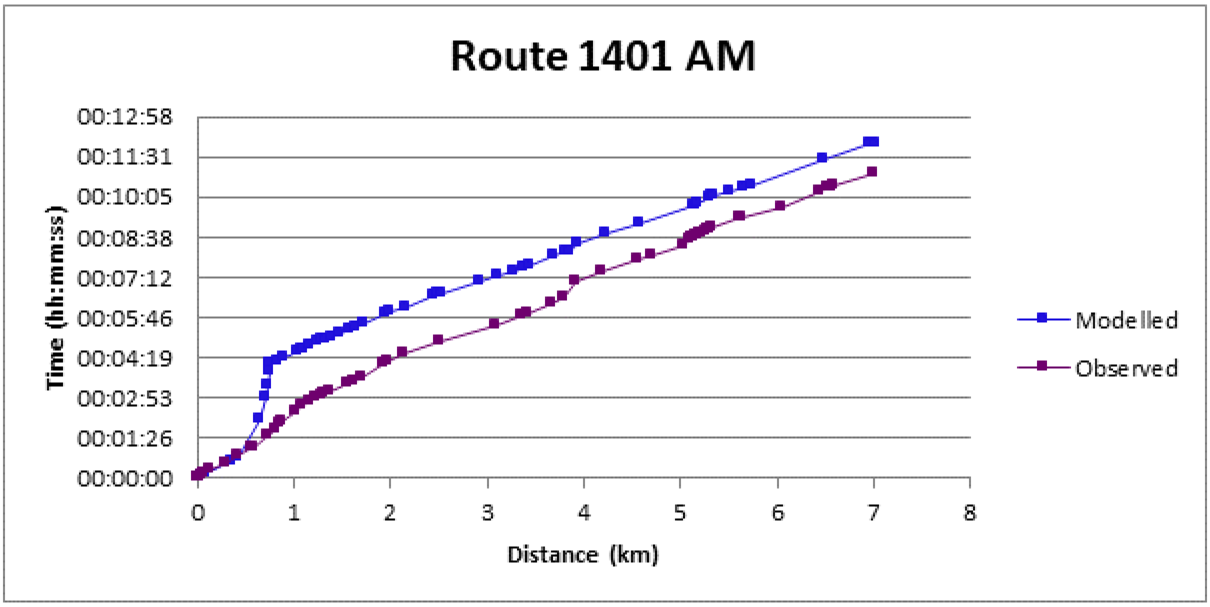

Route 1301 IP
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
2
4
6
8
10
Distance (km)
Modelled
Observed

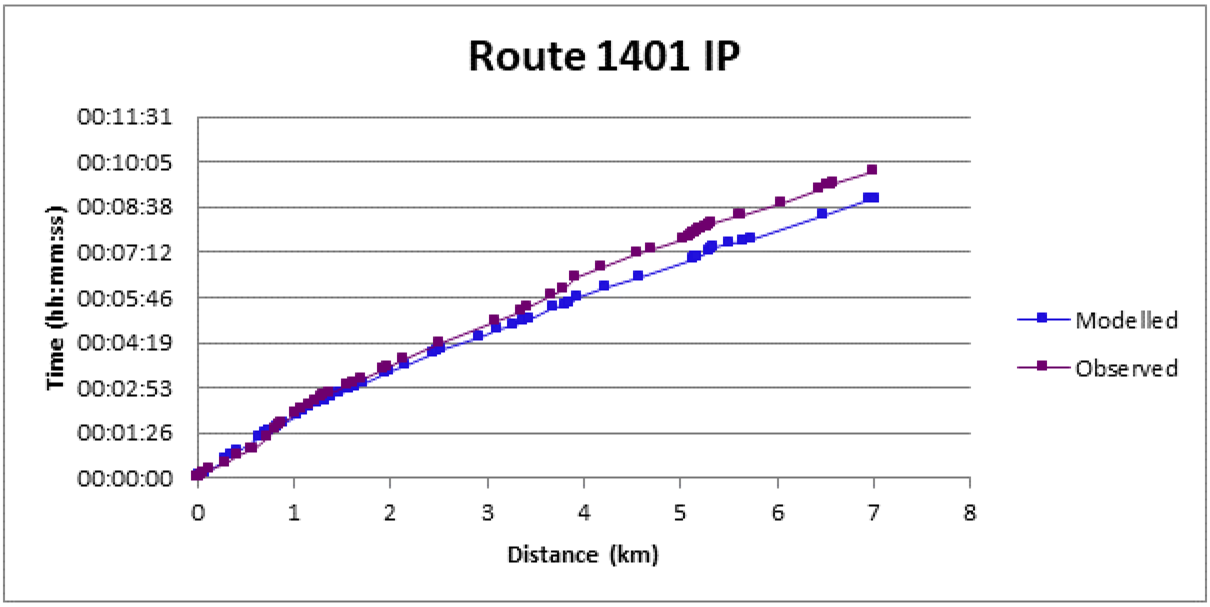

Route 1301 PM
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
Time (hh:mm:ss)
0
2
4
6
8
10
Distance (km)
Modelled
Observed

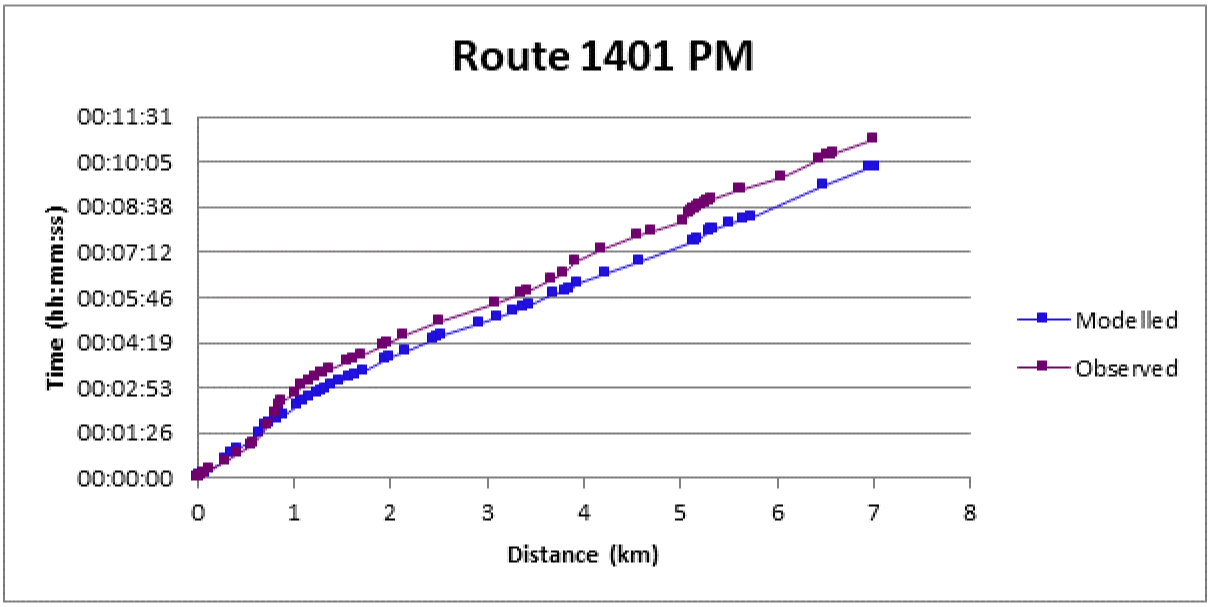

Route 1302 AM
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
Time (hh:mm:ss)
0
2
4
6
8
10
Distance (km)
Modelled
Observed

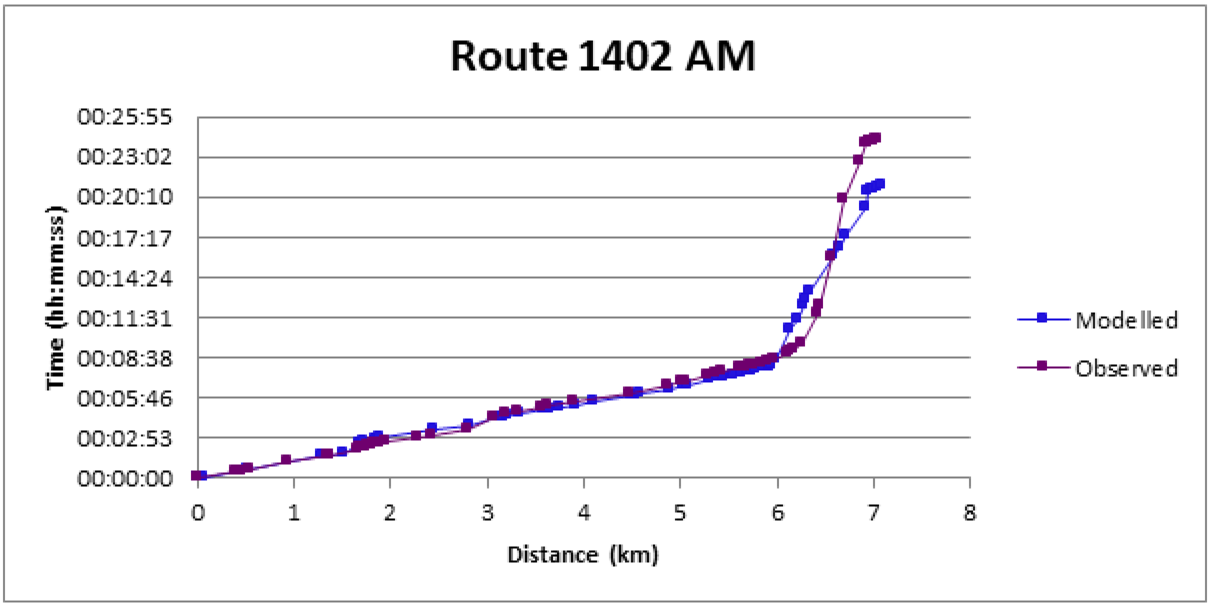

Route 1302 IP
00:14:24
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
2
4
6
8
10
Distance (km)
Modelled
Observed


Route 1302 PM
00:14:24
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
2
4
6
8
10
Distance (km)
Modelled
Observed

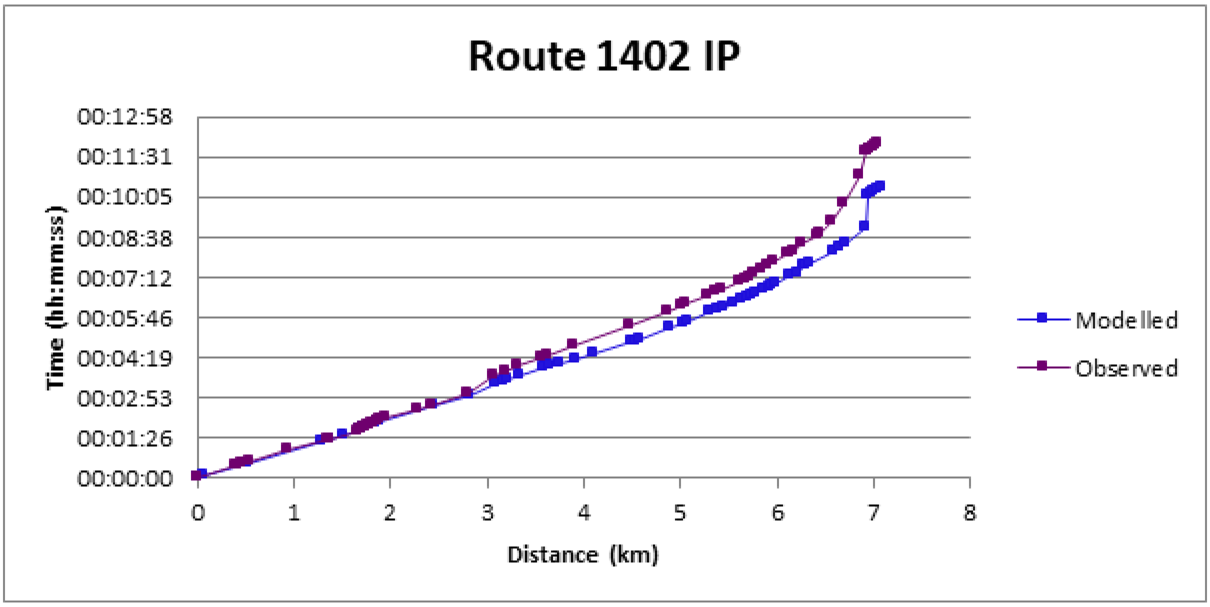

Route 1401 AM
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
1
2
3
4
5
6
7
8
Distance (km)
Modelled
Observed


Route 1401 IP
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
1
2
3
4
5
6
7
8
Distance (km)
Modelled
Observed

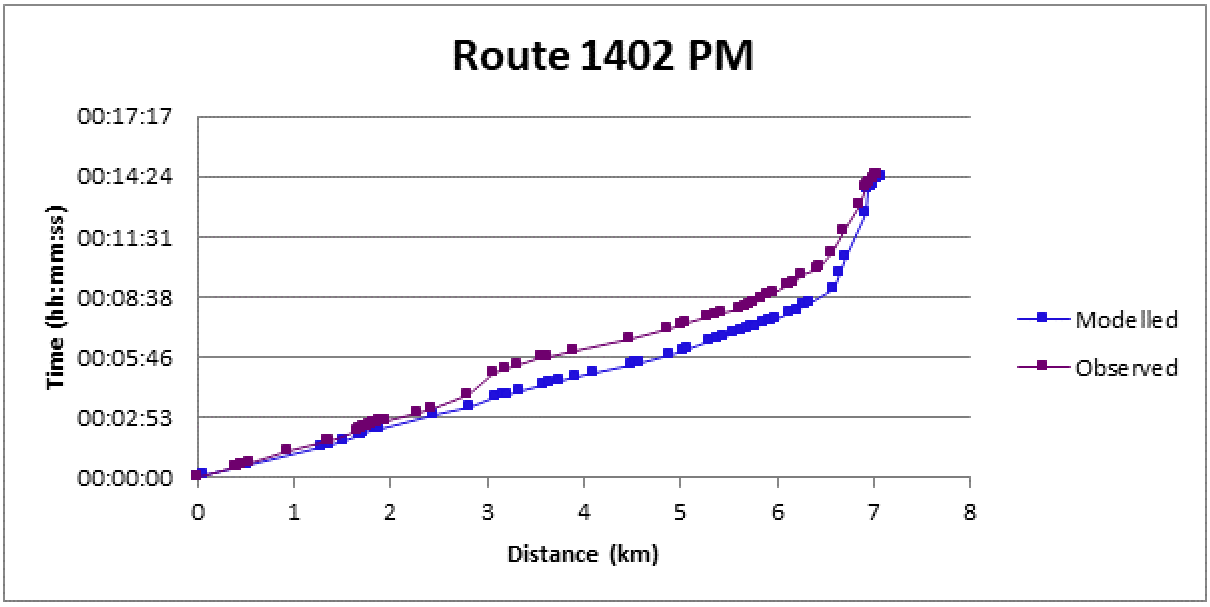

Route 1401 PM
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
Time (hh:mm:ss)
0
1
2
3
4
5
6
7
8
Distance (km)
Modelled
Observed



Route 1402 AM
Time (hh:mm:ss)
00:25:55
00:23:02
00:20:10
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
0
1
2
3
4
5
6
7
8
Distance (km)
Modelled
Observed



Route 1402 IP
Time (hh:mm:ss)
00:12:58
00:11:31
00:10:05
00:08:38
00:07:12
00:05:46
00:04:19
00:02:53
00:01:26
00:00:00
0
1
2
3
4
5
6
7
8
Distance (km)
Modelled
Observed



Route 1402 PM
Time (hh:mm:ss)
00:17:17
00:14:24
00:11:31
00:08:38
00:05:46
00:02:53
00:00:00
0
1
2
3
4
5
6
7
8
Distance (km)
Modelled
Observed

Appendix Q – Matrix Trip Length Changes (Pre ME vs Post ME)

- AM

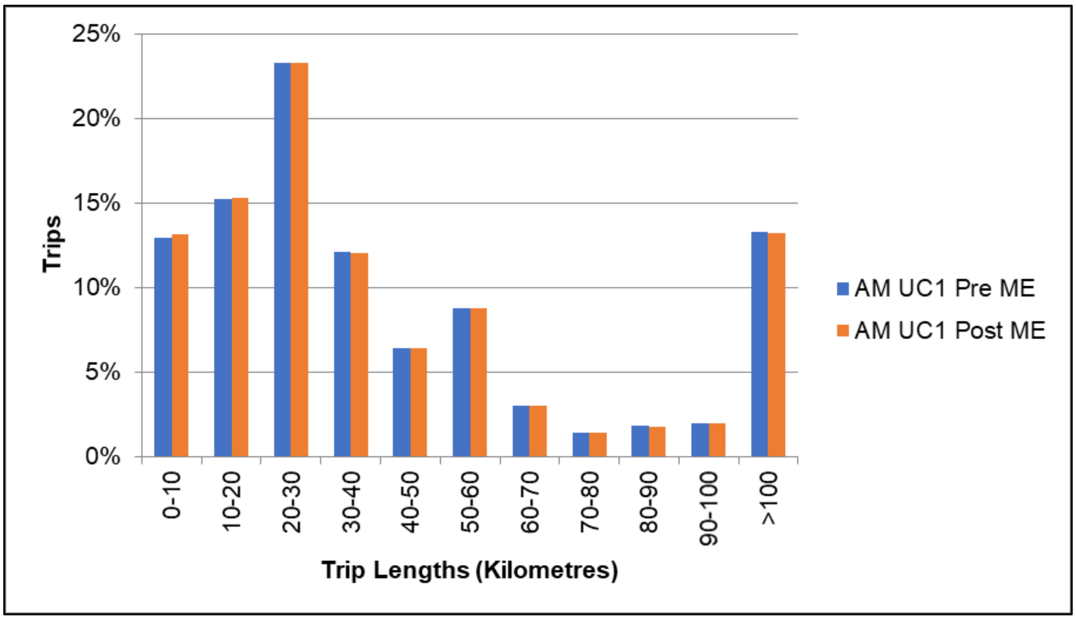


Figure R. 1: Matrix trip changes, UC1 AM

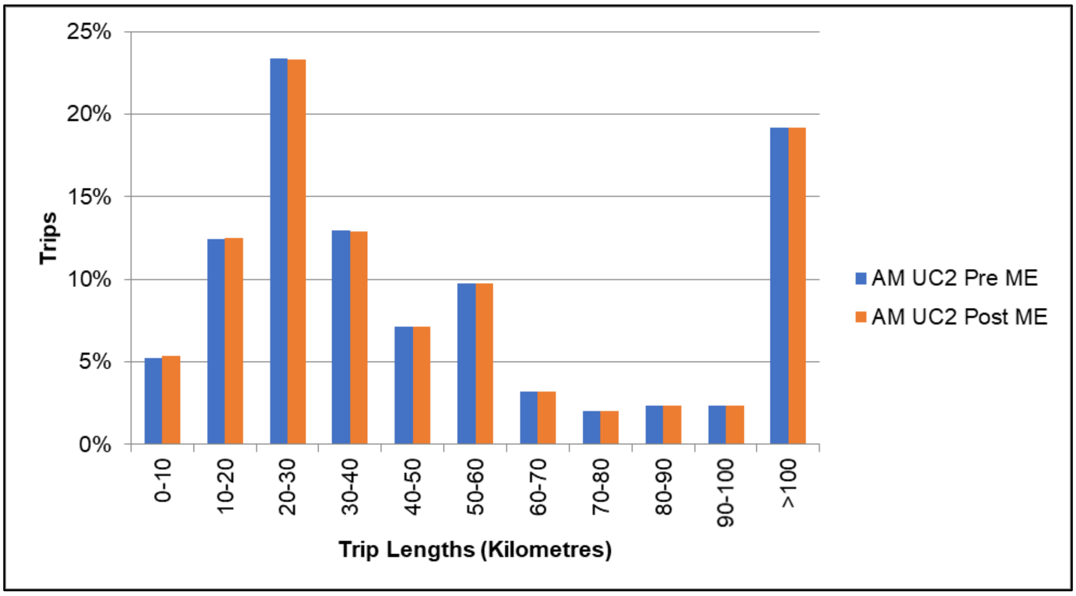


Figure R. 2: Matrix trip changes, UC2 AM

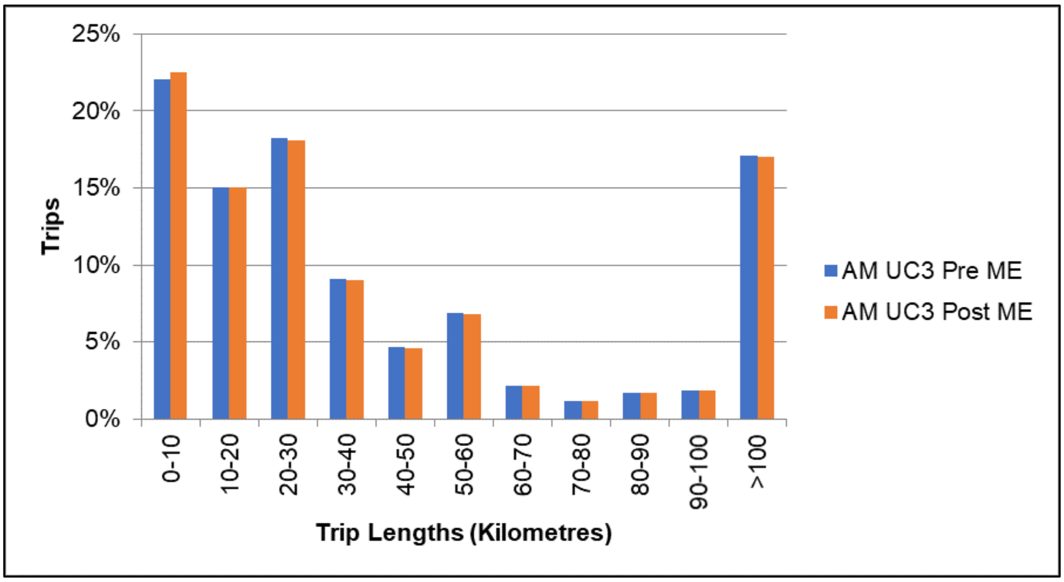


Figure R. 3: Matrix trip changes, UC3 AM

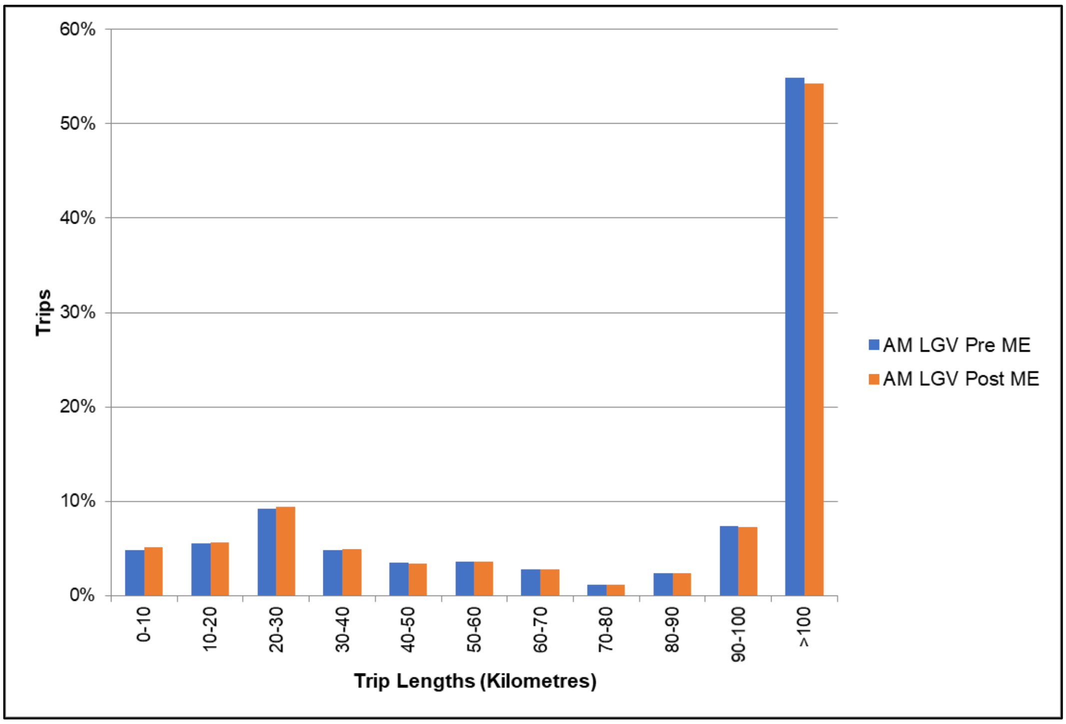


Figure R. 4: Matrix trip changes, LGV AM

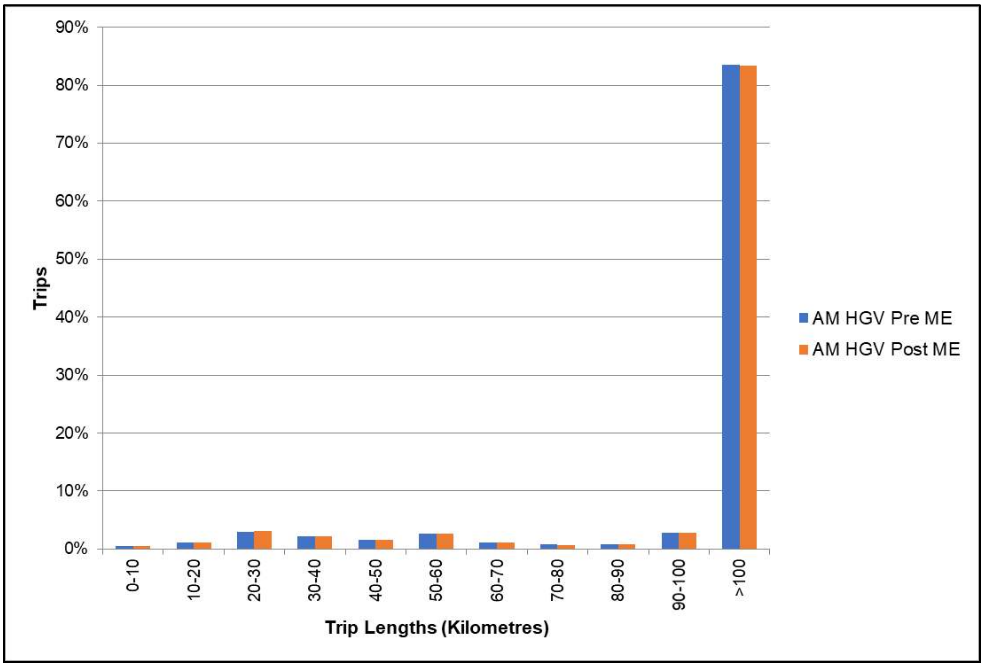


Figure R. 5: Matrix trip changes, HGV AM

- IP

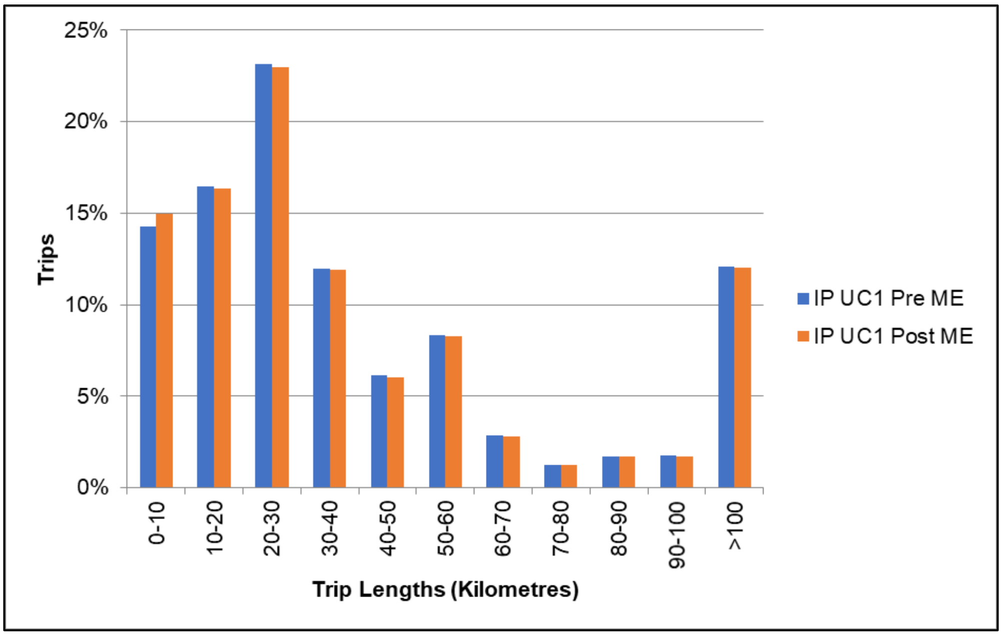


Figure R. 6: Matrix trip changes, UC1 IP

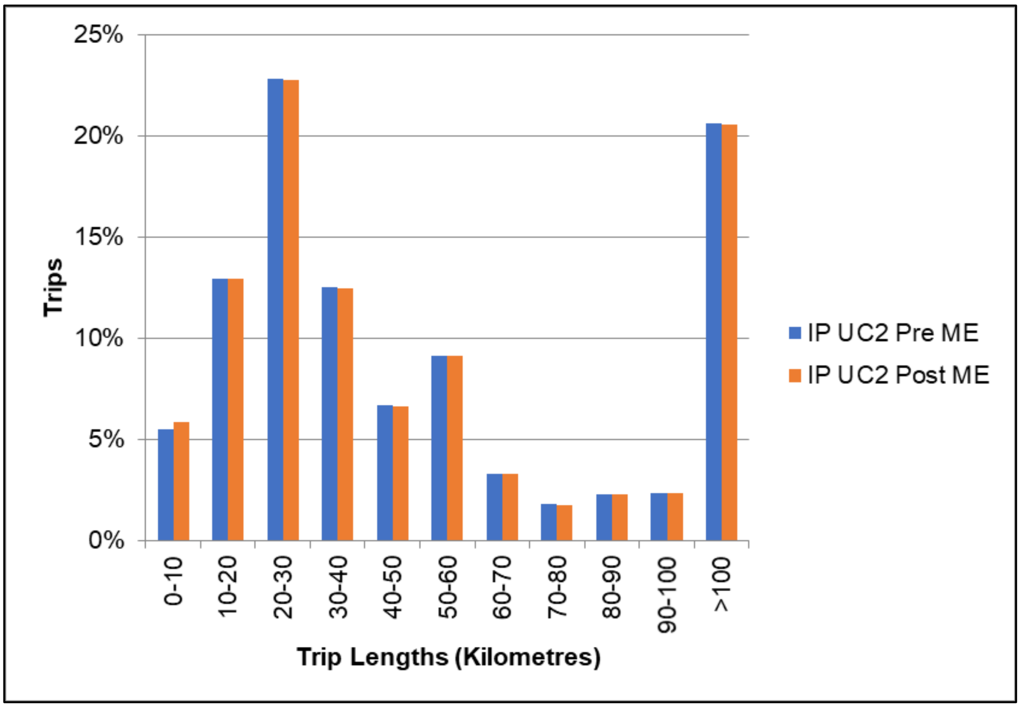


Figure R. 7: Matrix trip changes, UC2 IP

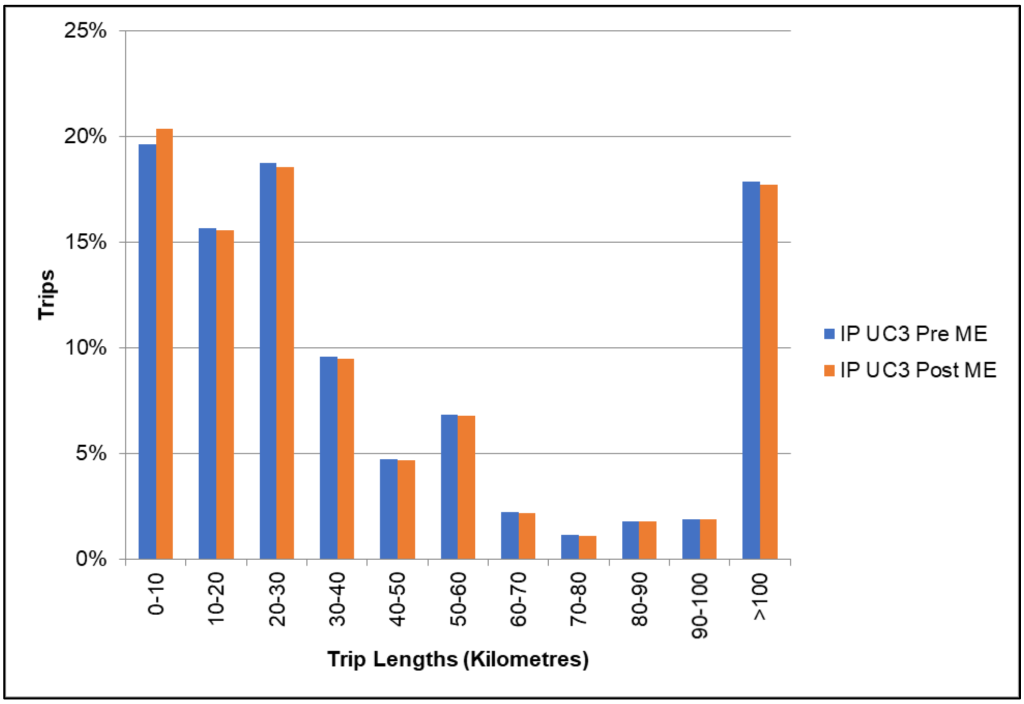


Figure R. 8: Matrix trip changes, UC3 IP

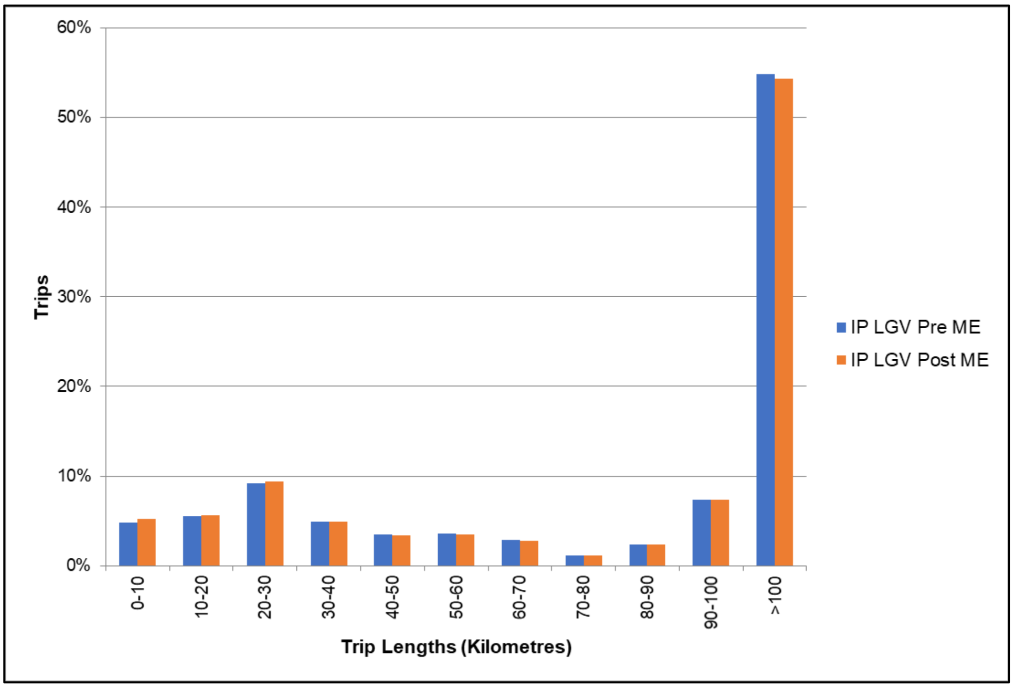


Figure R. 9: Matrix trip changes, LGV IP

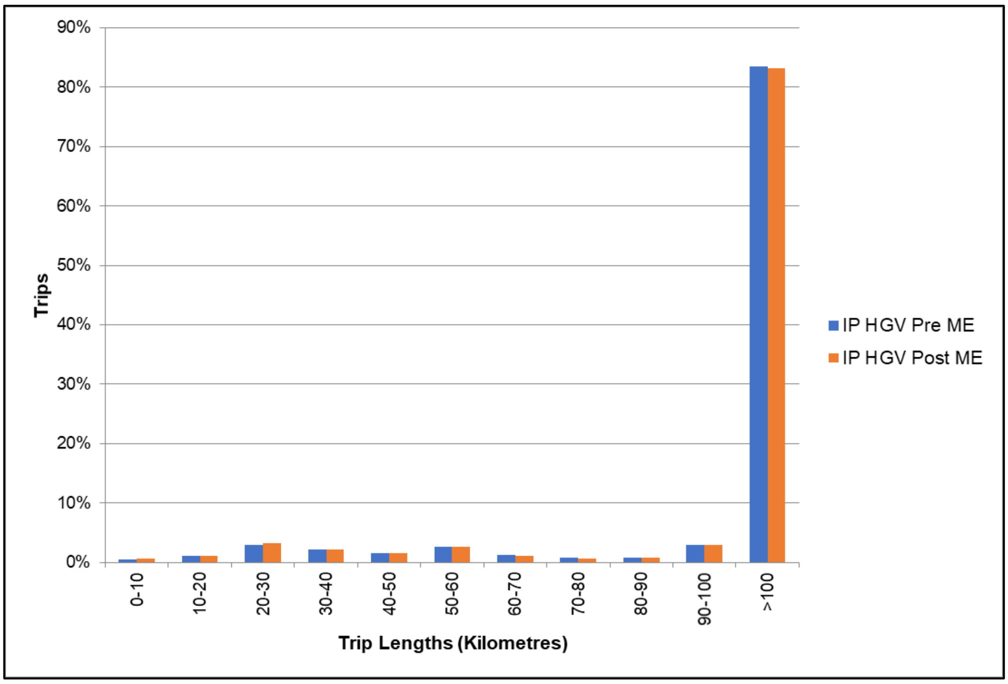


Figure R. 10: Matrix trip changes, HGV IP

- PM

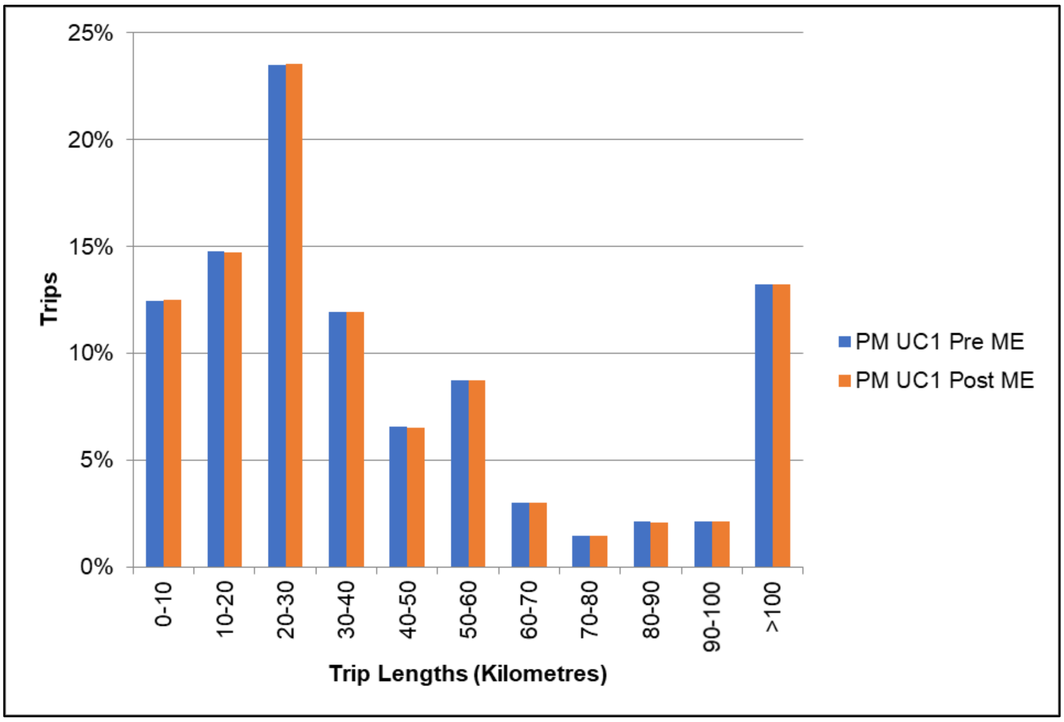


Figure R. 11: Matrix trip changes, UC1 PM

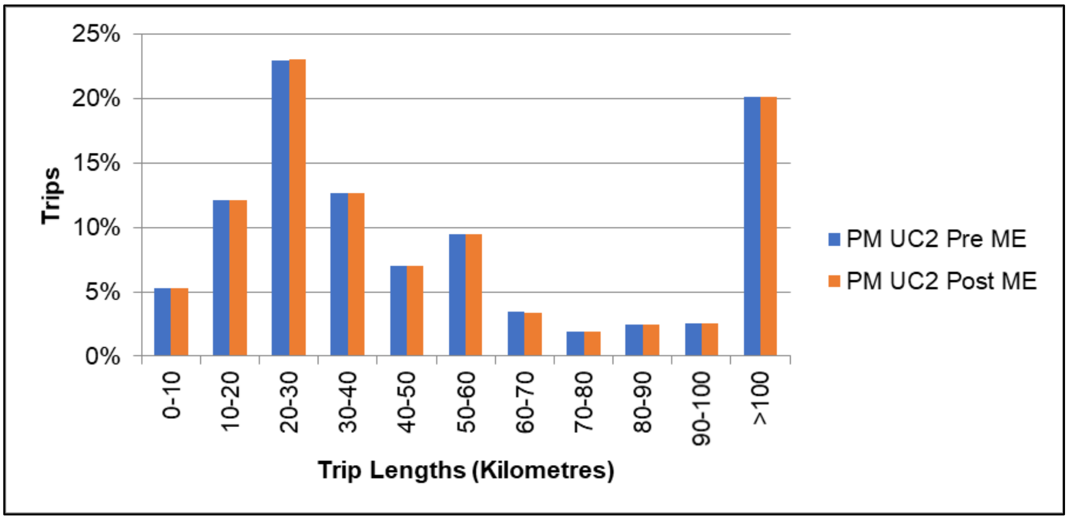


Figure R. 12: Matrix trip changes, UC2 PM

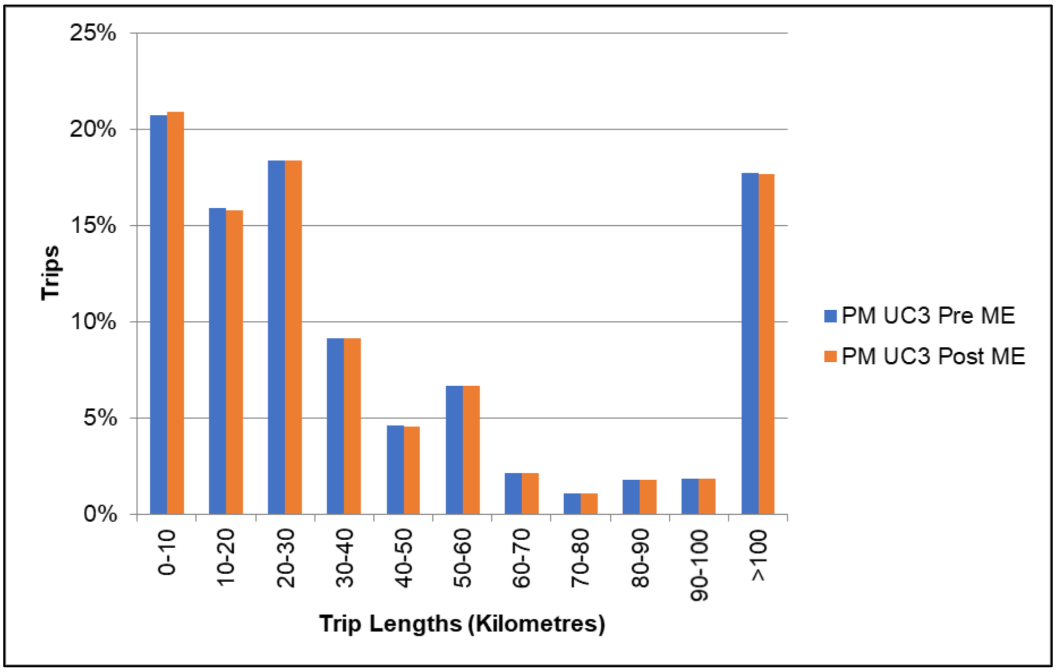


Figure R. 13: Matrix trip changes, UC3 PM

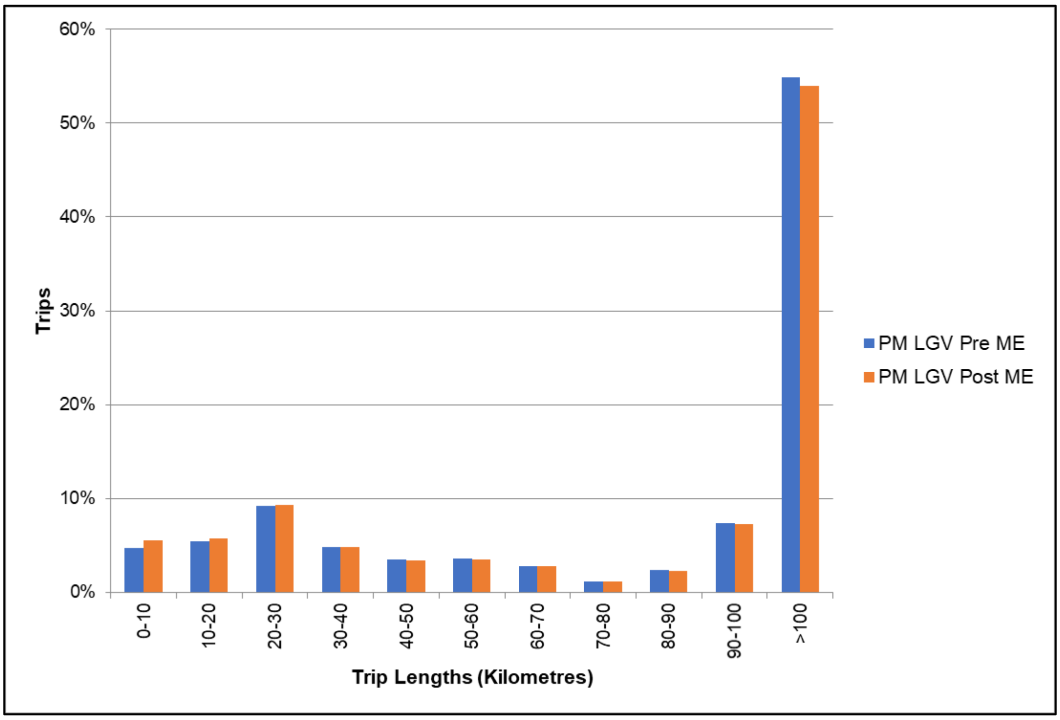


Figure R. 14: Matrix trip changes, LGV PM

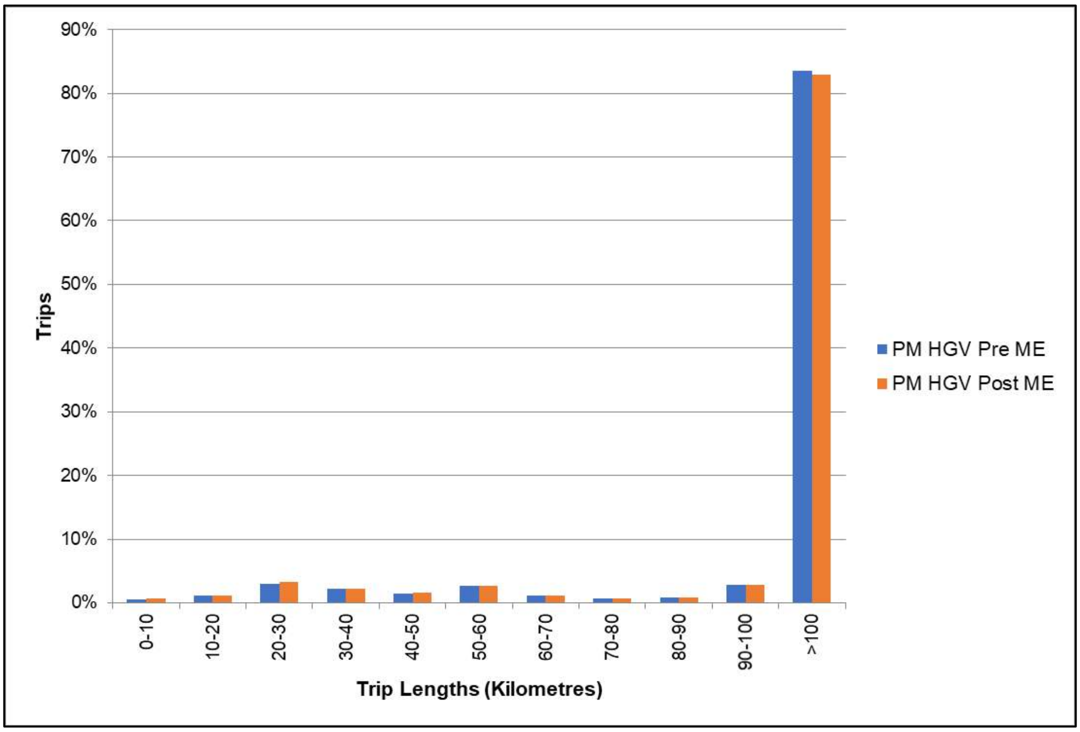


Figure R. 15: Matrix trip changes, HGV PM

Appendix R – Matrix Trip Length Changes (Initial Prior vs Final Prior)

- AM

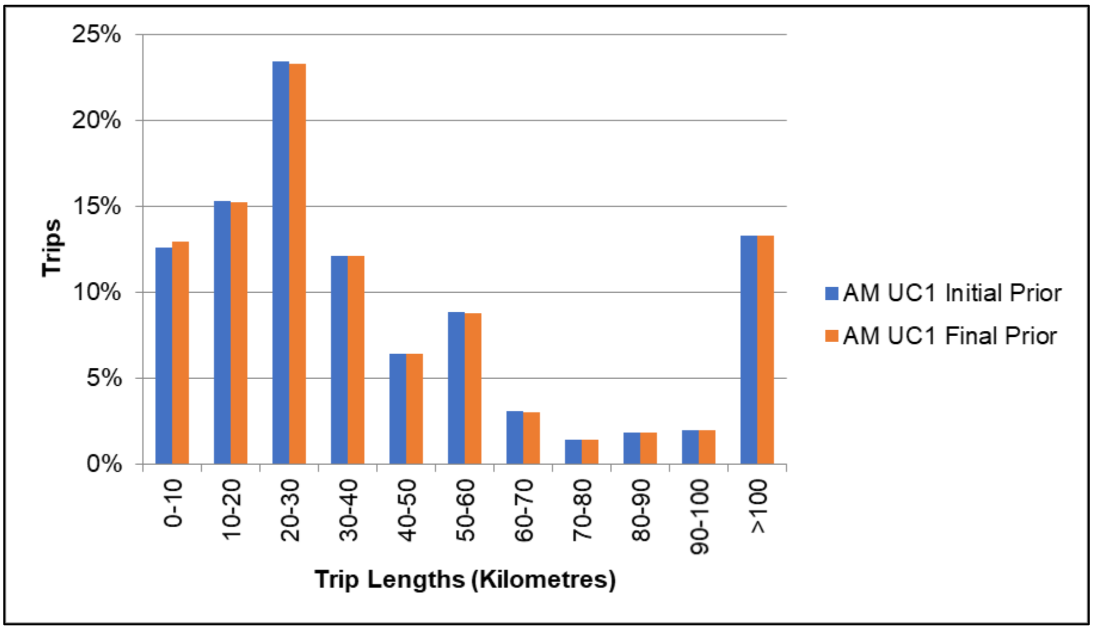


Figure R. 1: Matrix trip changes, UC1 AM

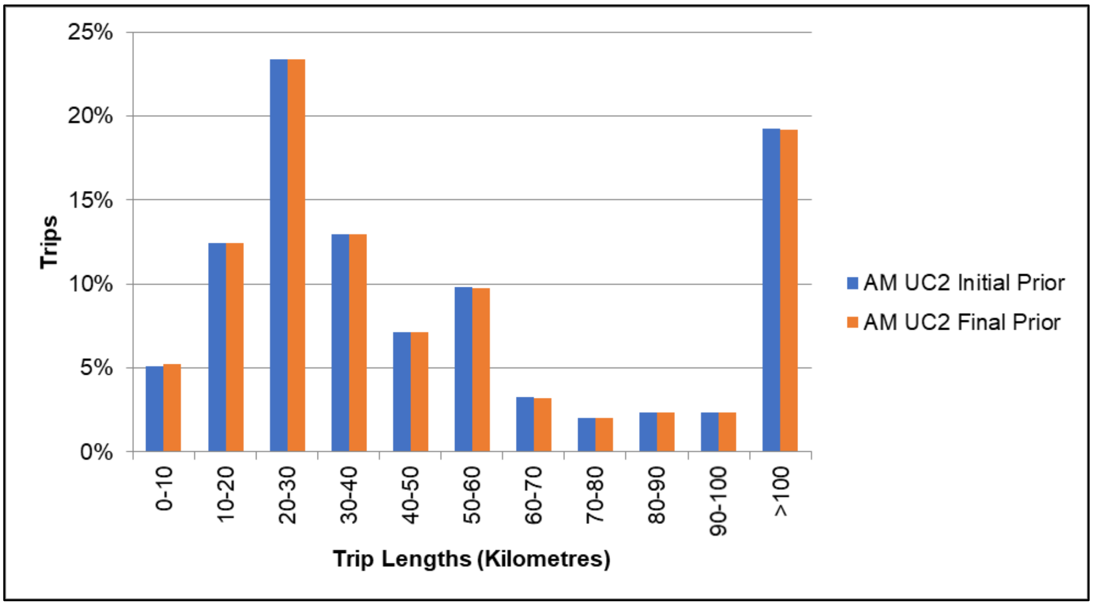


Figure R. 2: Matrix trip changes, UC2 AM

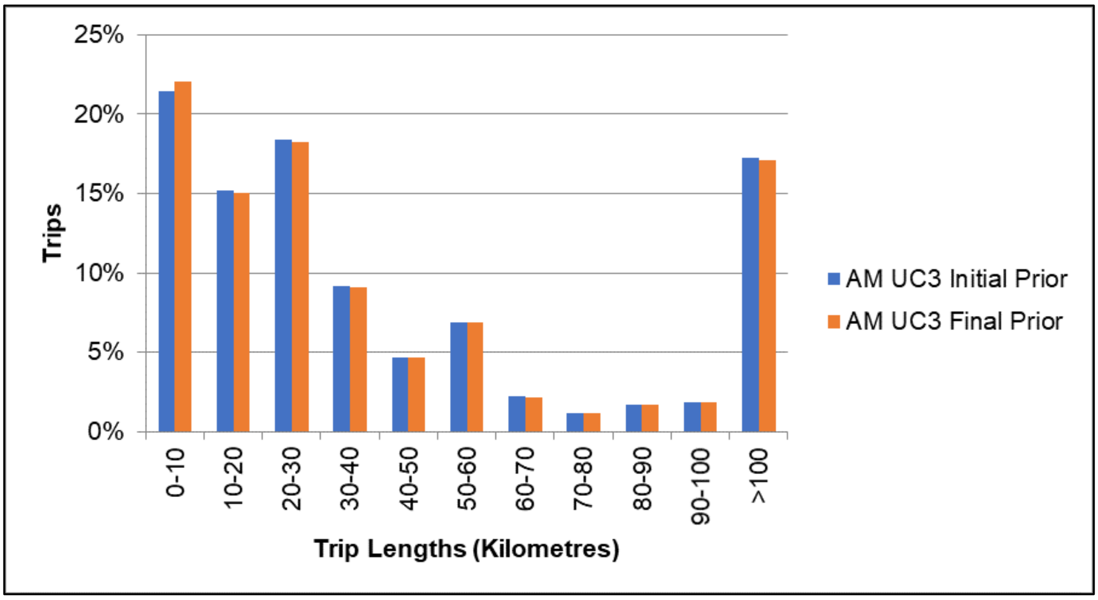


Figure R. 3: Matrix trip changes, UC3 AM

- IP

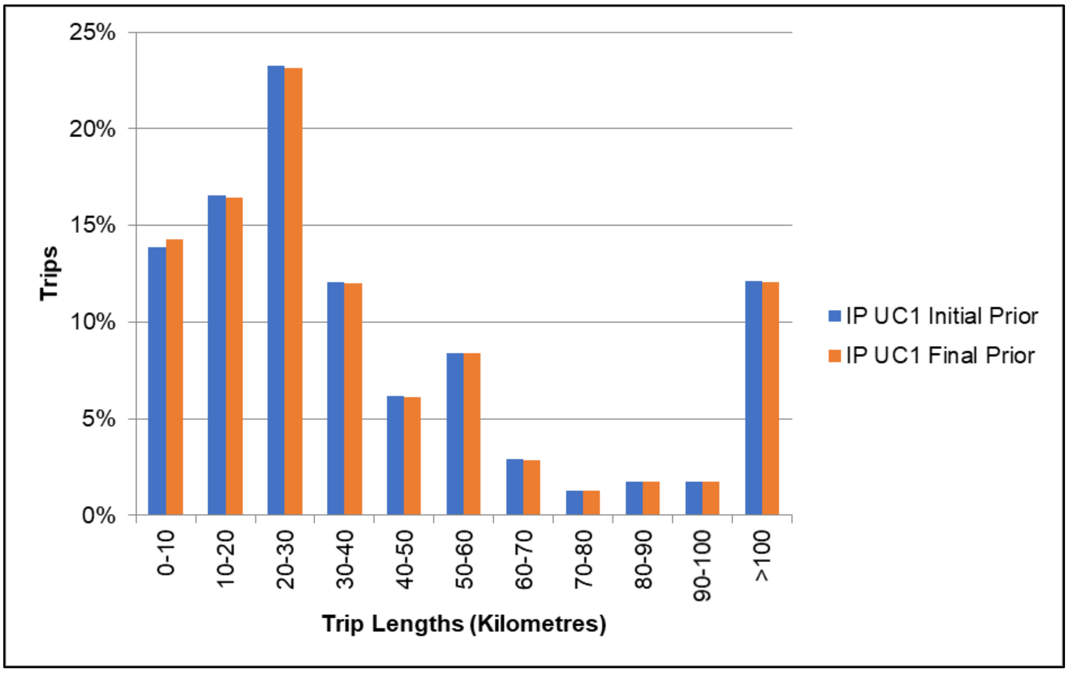


Figure R. 4: Matrix trip changes, UC1 IP

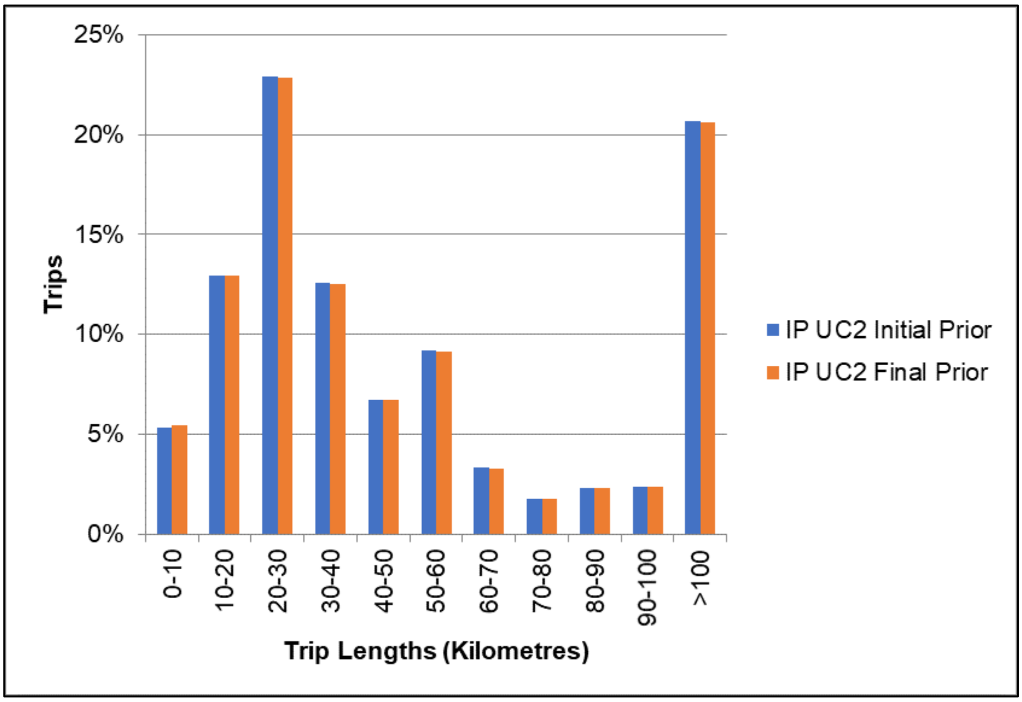


Figure R. 5: Matrix trip changes, UC2 IP

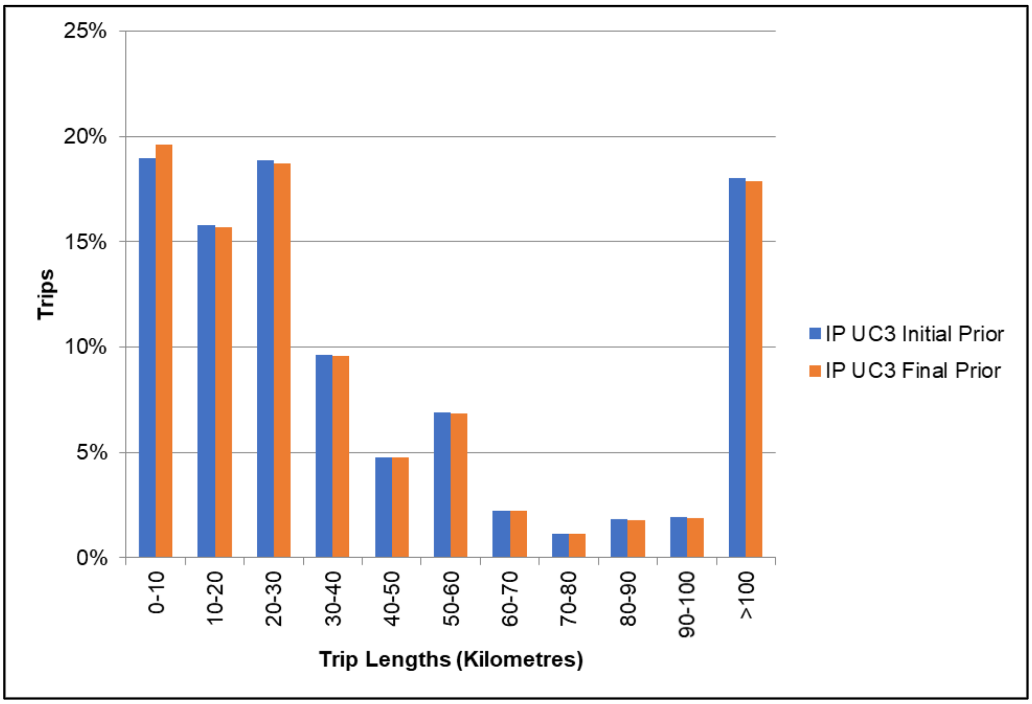


Figure R. 6: Matrix trip changes, UC3 IP

- PM

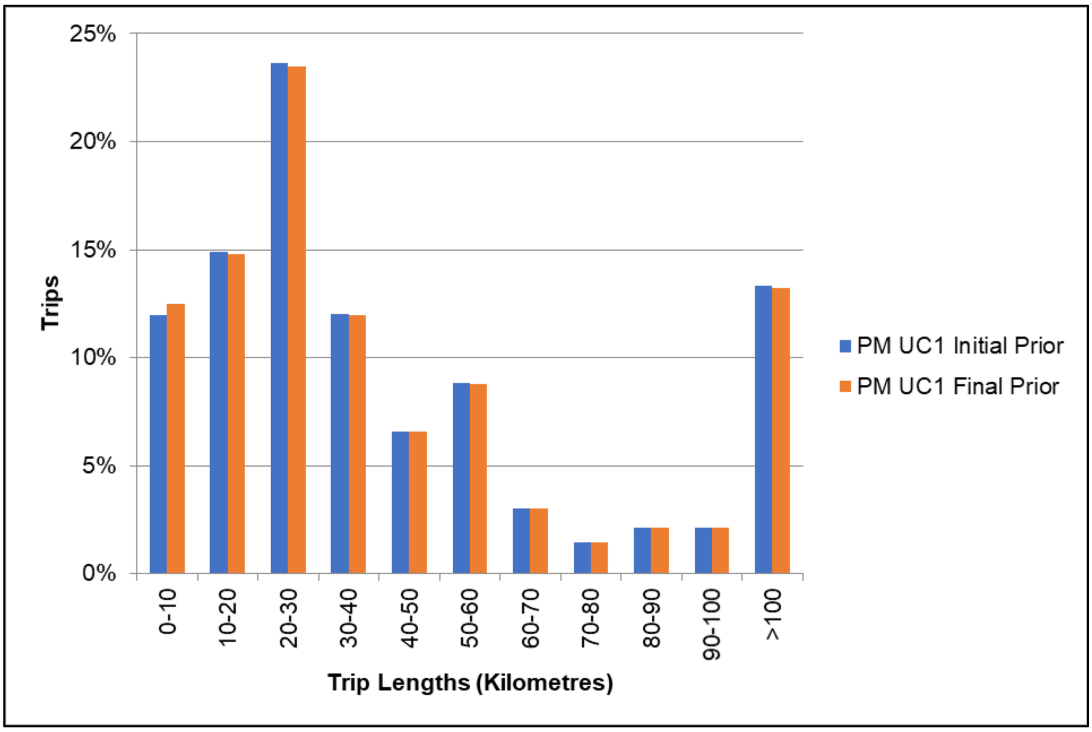


Figure R. 7: Matrix trip changes, UC1 PM

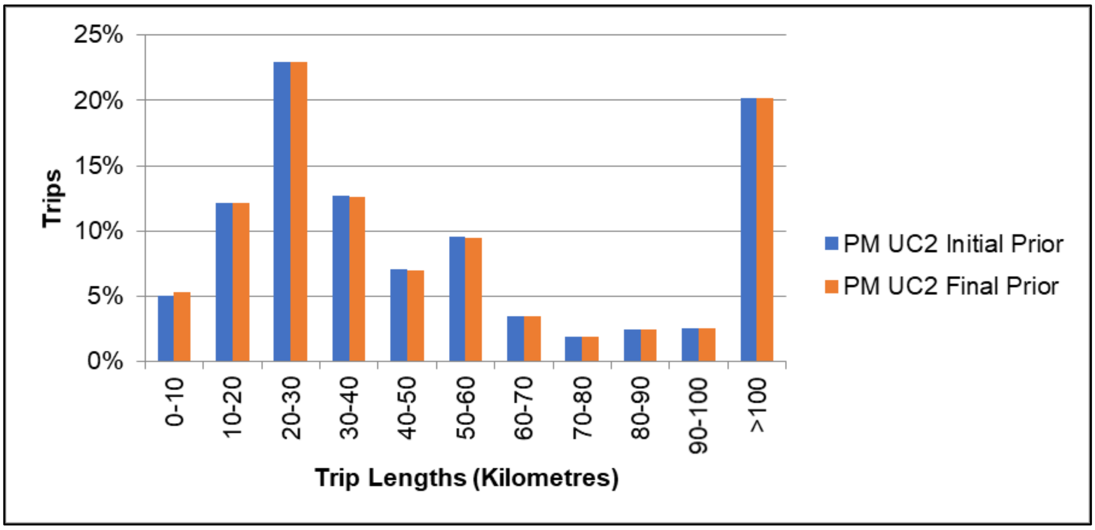


Figure R. 8: Matrix trip changes, UC2 PM

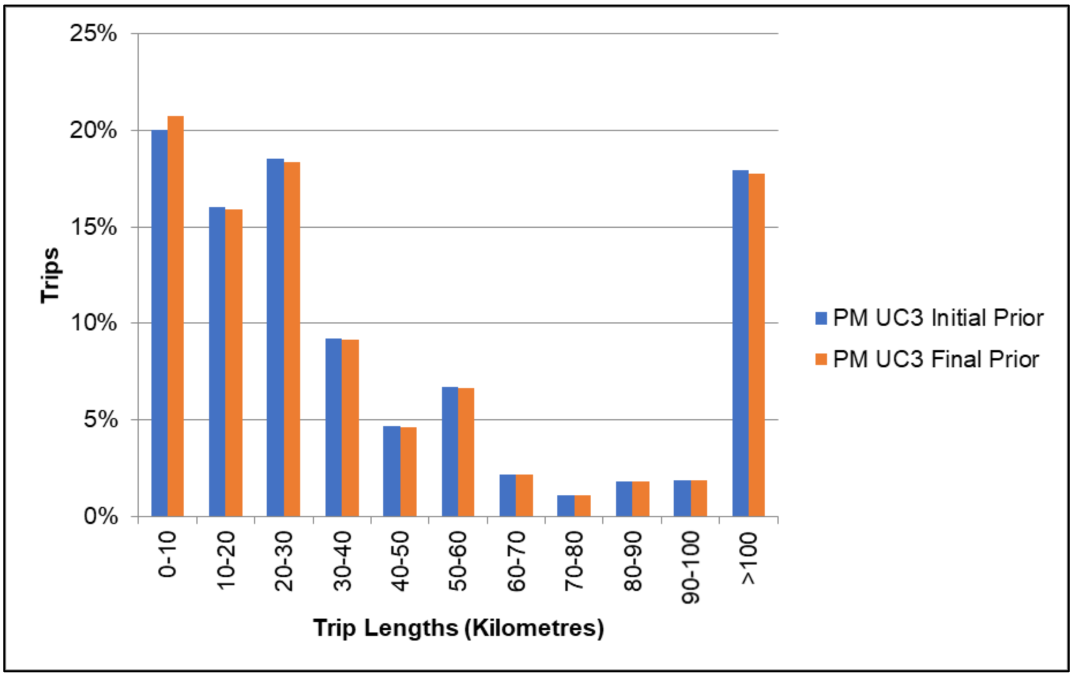
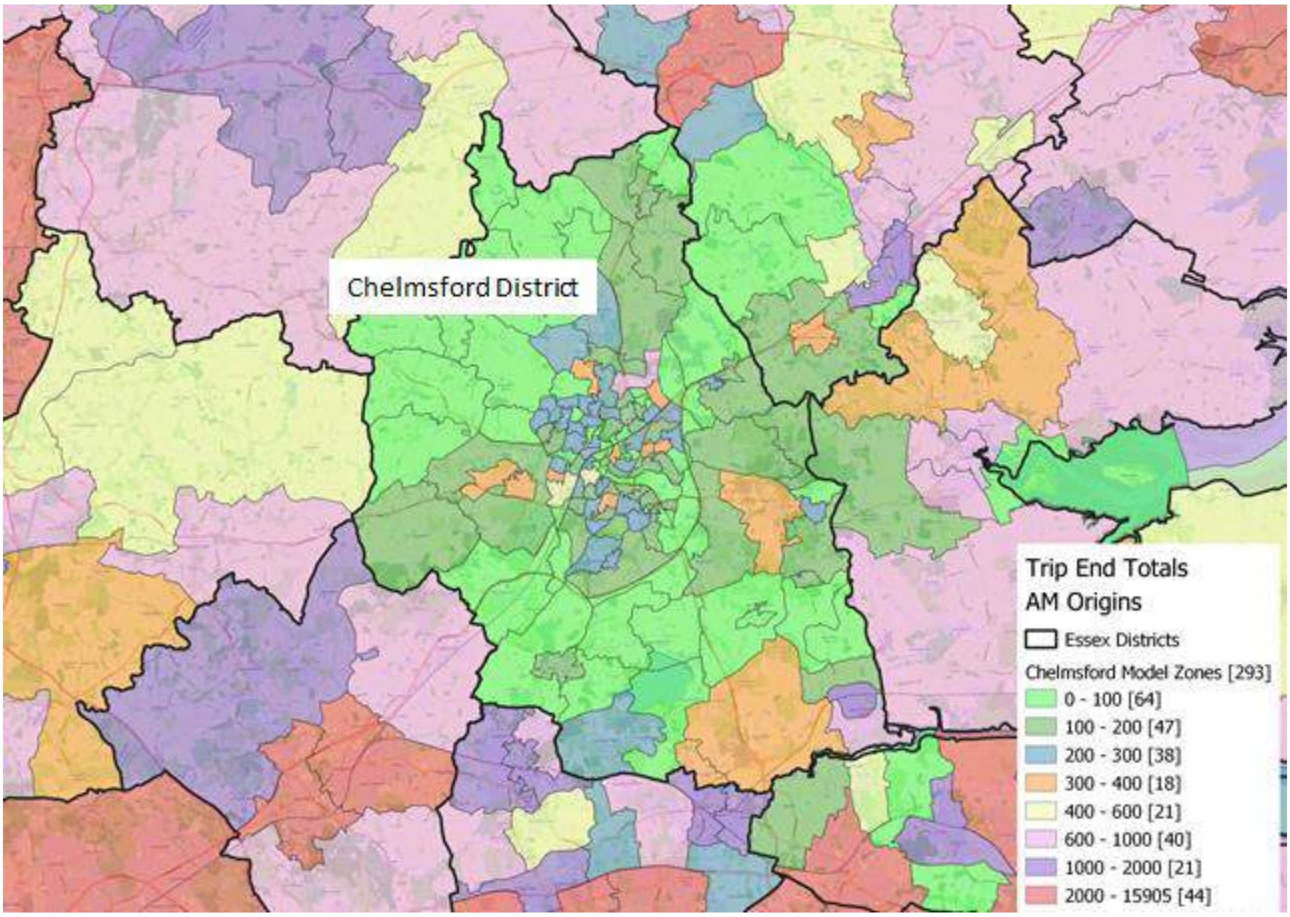
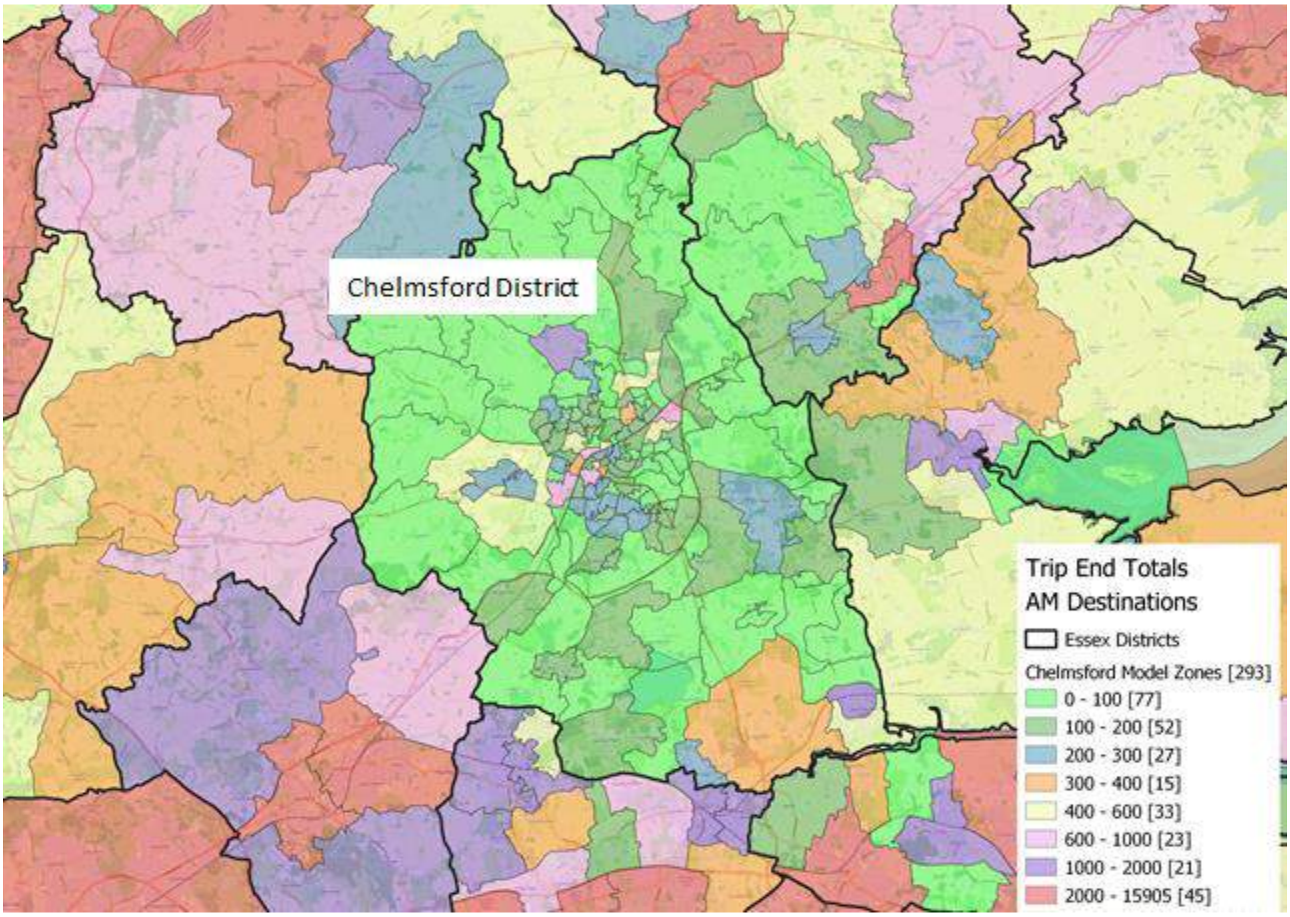
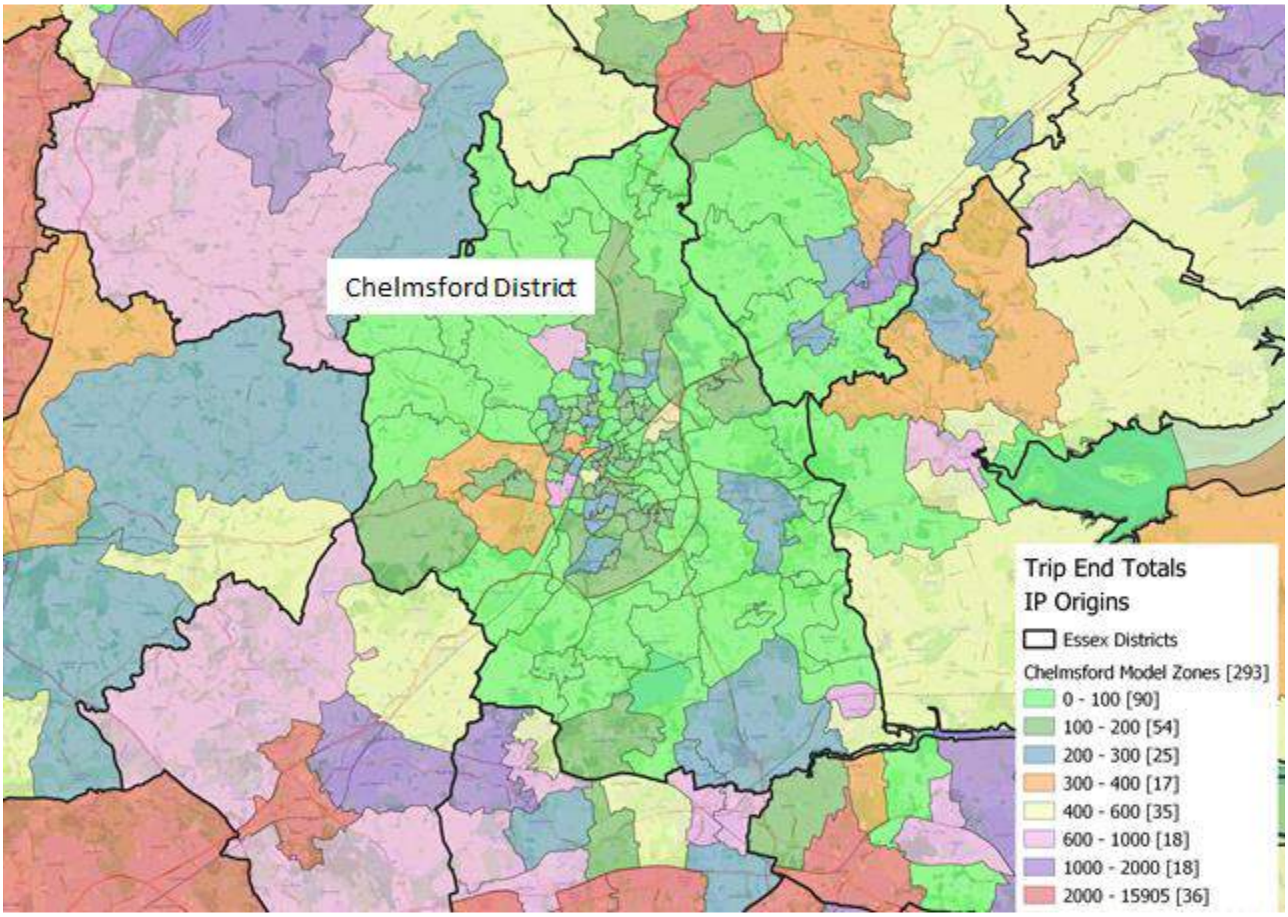


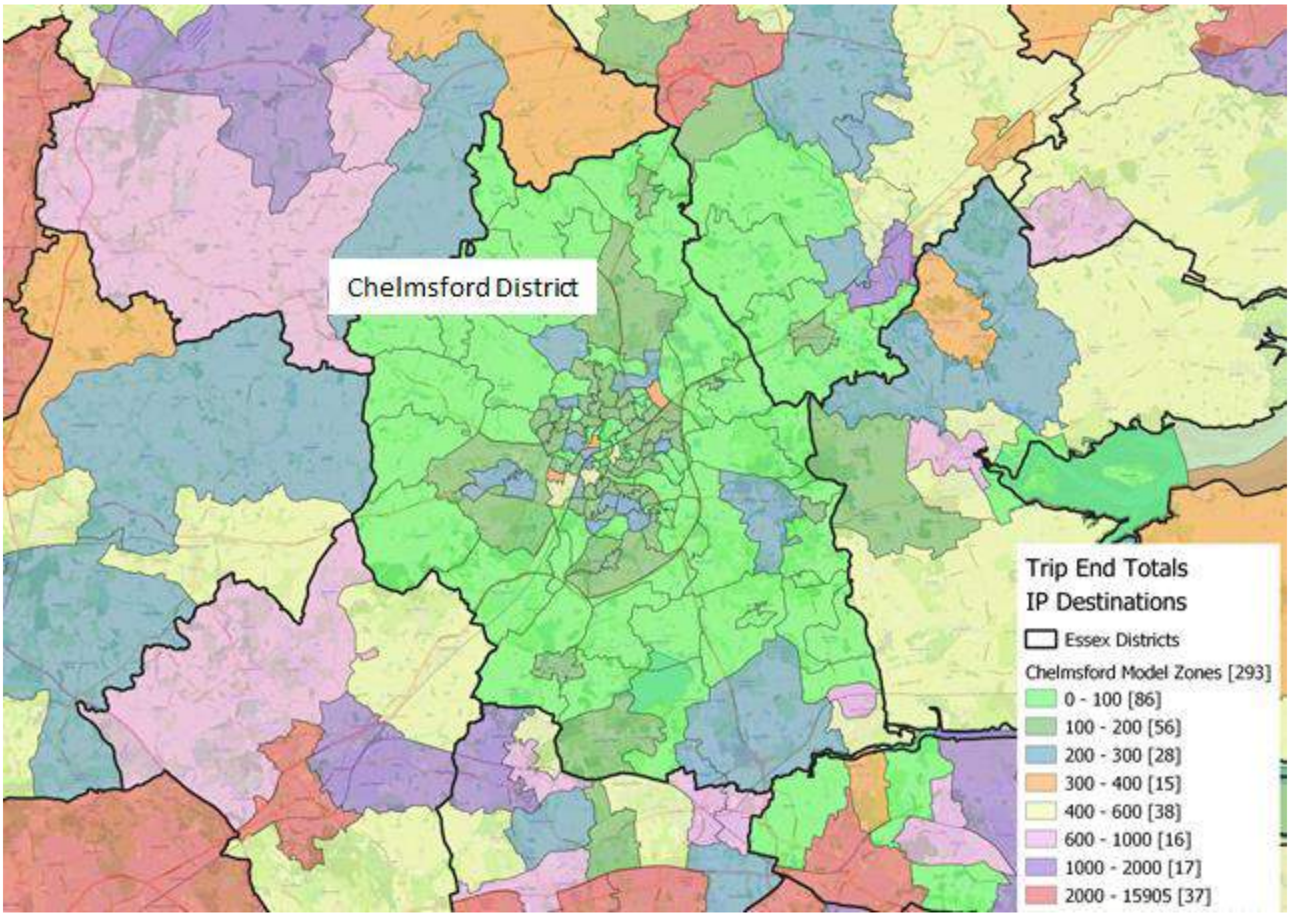
Figure R. 9: Matrix trip changes, UC3 PM

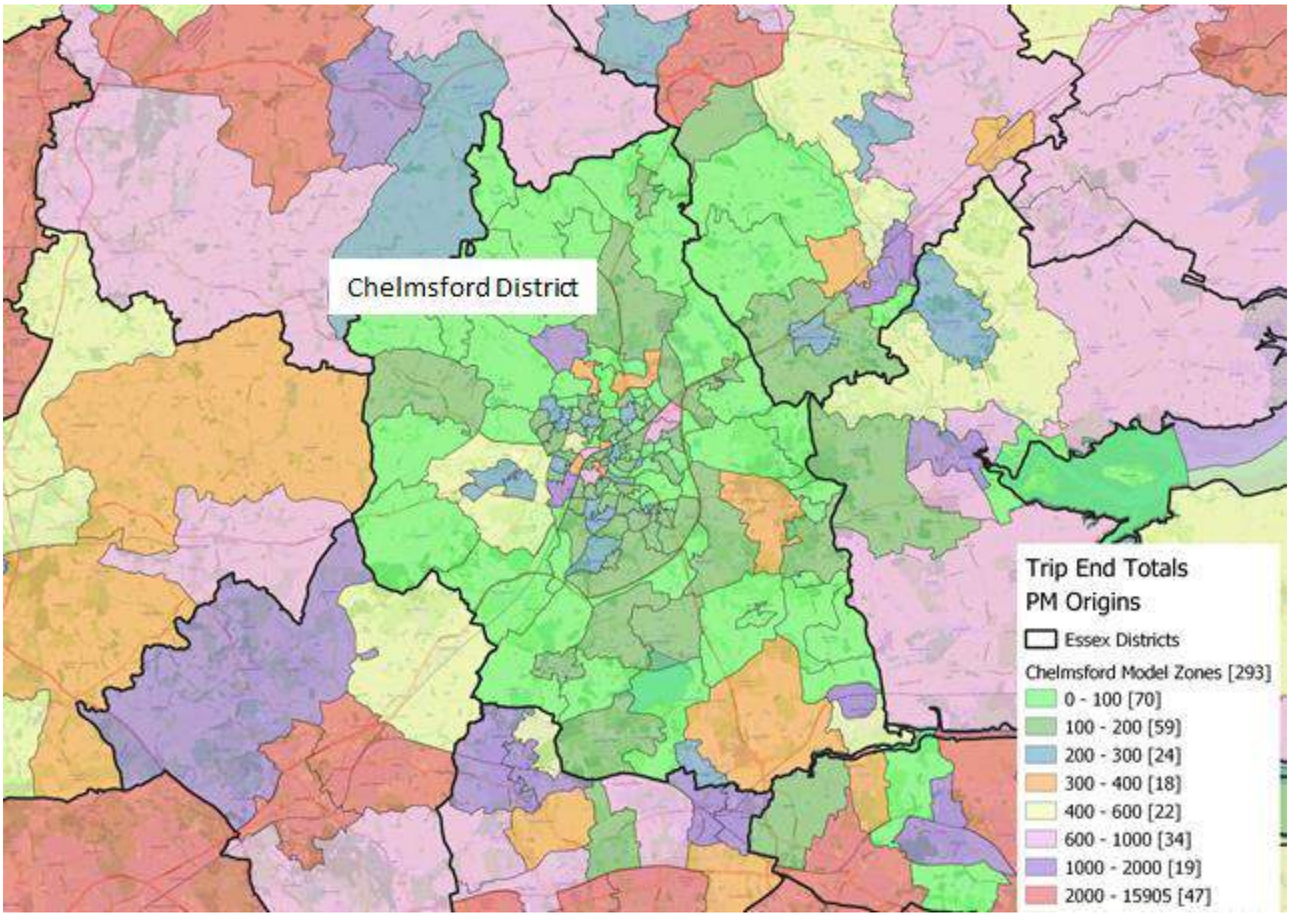
Appendix S – Zone Size Check (Trip End Totals)

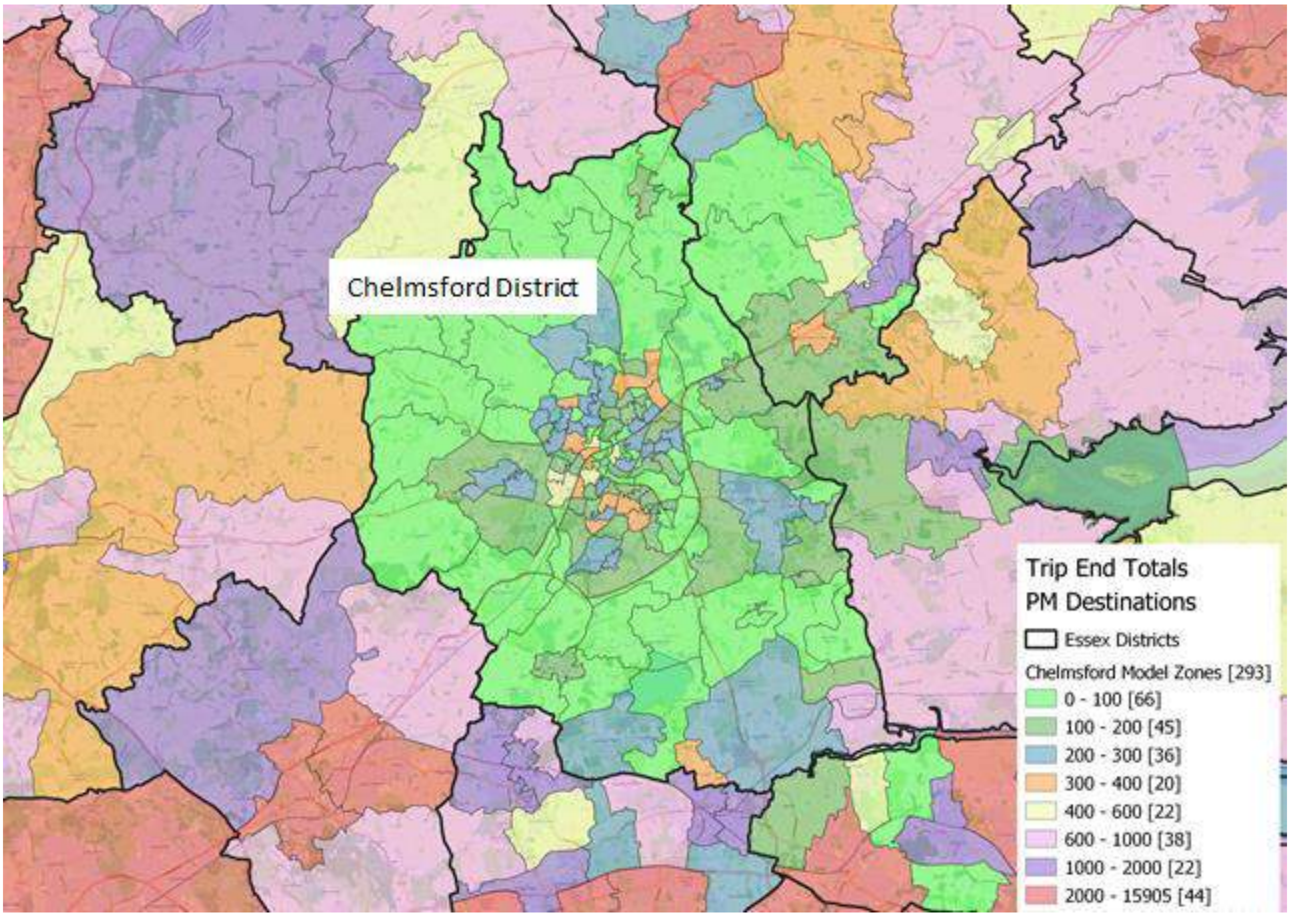

Chelmsford District
Trip End Totals
AM Origins
Essex Districts
Chelmsford Model Zones [293]
0 - 100 [64]
100 - 200 [47]
200 - 300 [38]
300 - 400 [18]
400 - 600 [21]
600 - 1000 [40]
1000 - 2000 [21]
2000 - 15905 [44]

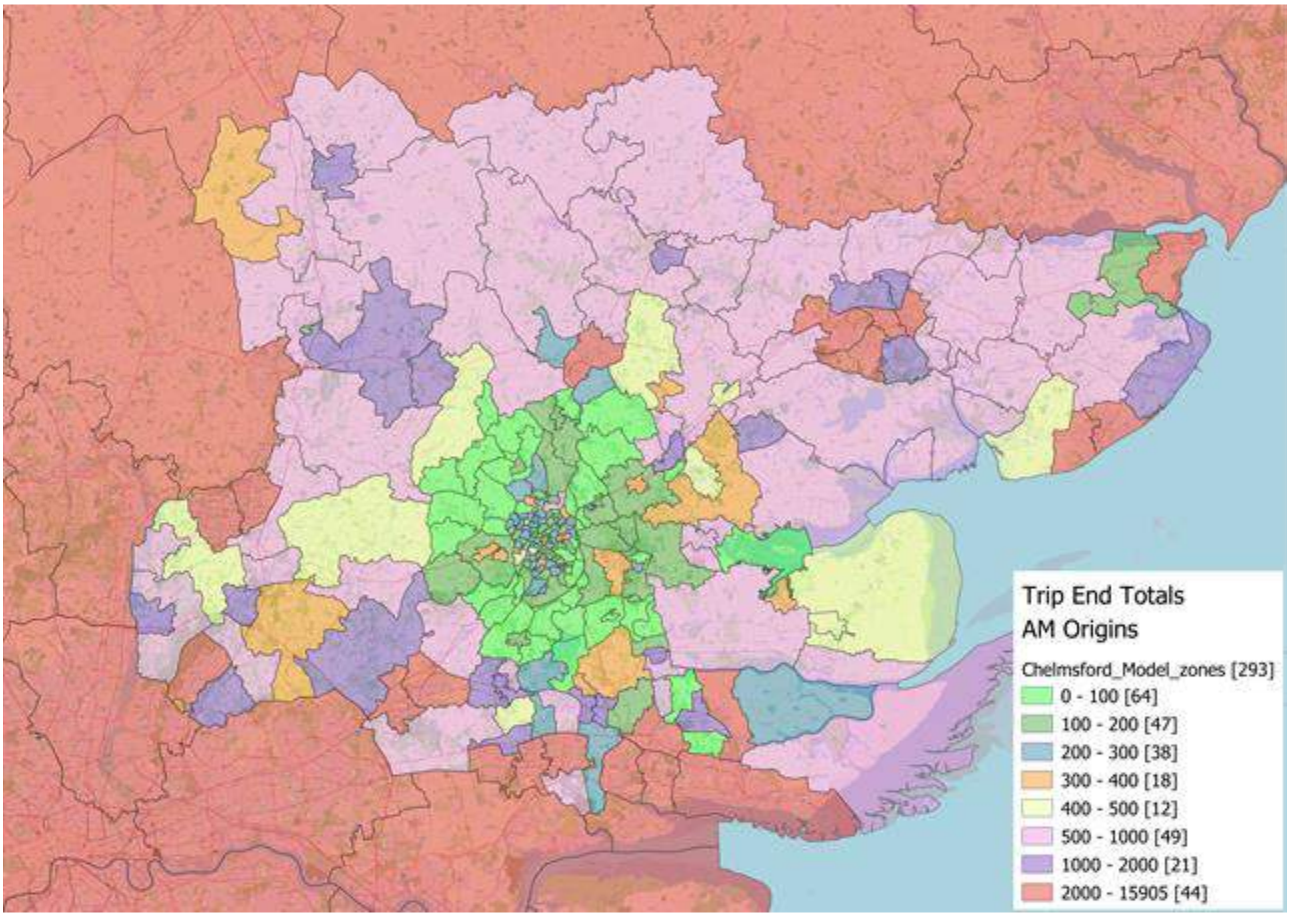

Chelmsford District
Trip End Totals
AM Destinations
Essex Districts
Chelmsford Model Zones [293]
0 - 100 [77]
100 - 200 [52]
200 - 300 [27]
300 - 400 [15]
400 - 600 [33]
600 - 1000 [23]
1000 - 2000 [21]
2000 - 15905 [45]

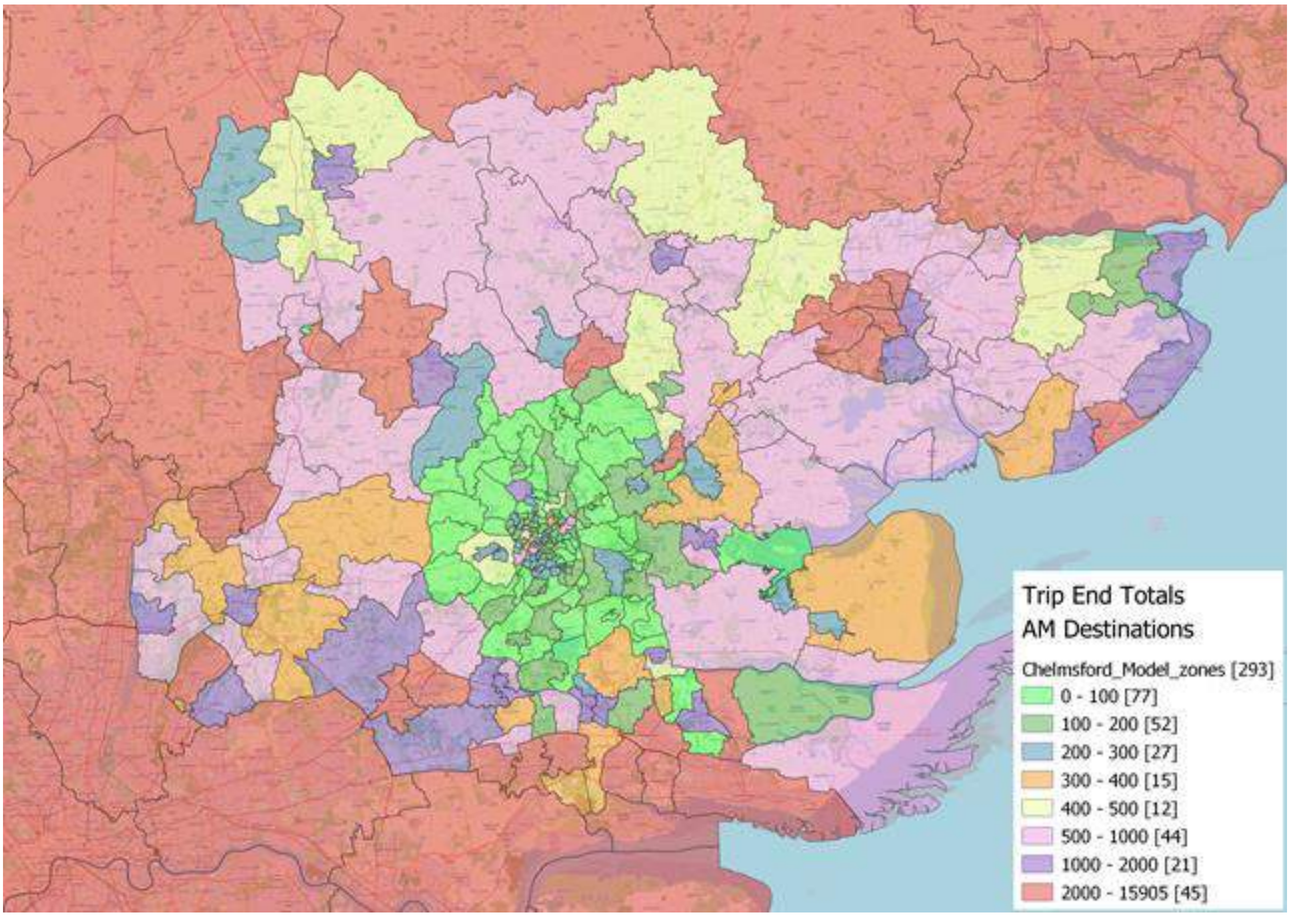

Chelmsford District
Trip End Totals
IP Origins
Essex Districts
Chelmsford Model Zones [293]
0 - 100 [90]
100 - 200 [54]
200 - 300 [25]
300 - 400 [17]
400 - 600 [35]
600 - 1000 [18]
1000 - 2000 [18]
2000 - 15905 [36]


Chelmsford District
Trip End Totals
IP Destinations
Essex Districts
Chelmsford Model Zones [293]
0 - 100 [86]
100 - 200 [56]
200 - 300 [28]
300 - 400 [15]
400 - 600 [38]
600 - 1000 [16]
1000 - 2000 [17]
2000 - 15905 [37]

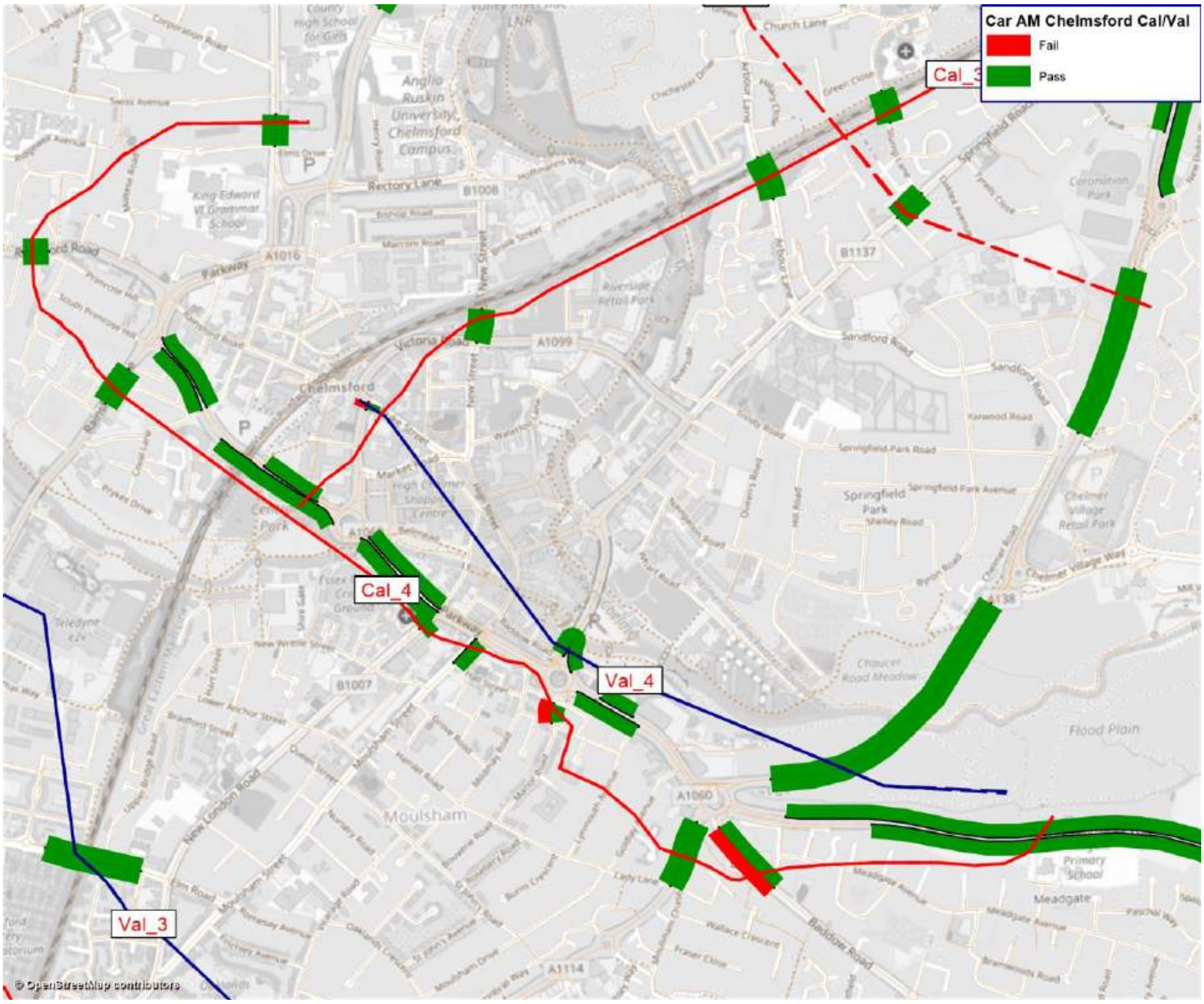

Chelmsford District
Trip End Totals
PM Origins
Essex Districts
Chelmsford Model Zones [293]
0 - 100 [70]
100 - 200 [59]
200 - 300 [24]
300 - 400 [18]
400 - 600 [22]
600 - 1000 [34]
1000 - 2000 [19]
2000 - 15905 [47]


Chelmsford District
Trip End Totals
PM Destinations
Essex Districts
Chelmsford Model Zones [293]
0 - 100 [66]
100 - 200 [45]
200 - 300 [36]
300 - 400 [20]
400 - 600 [22]
600 - 1000 [38]
1000 - 2000 [22]
2000 - 15905 [44]

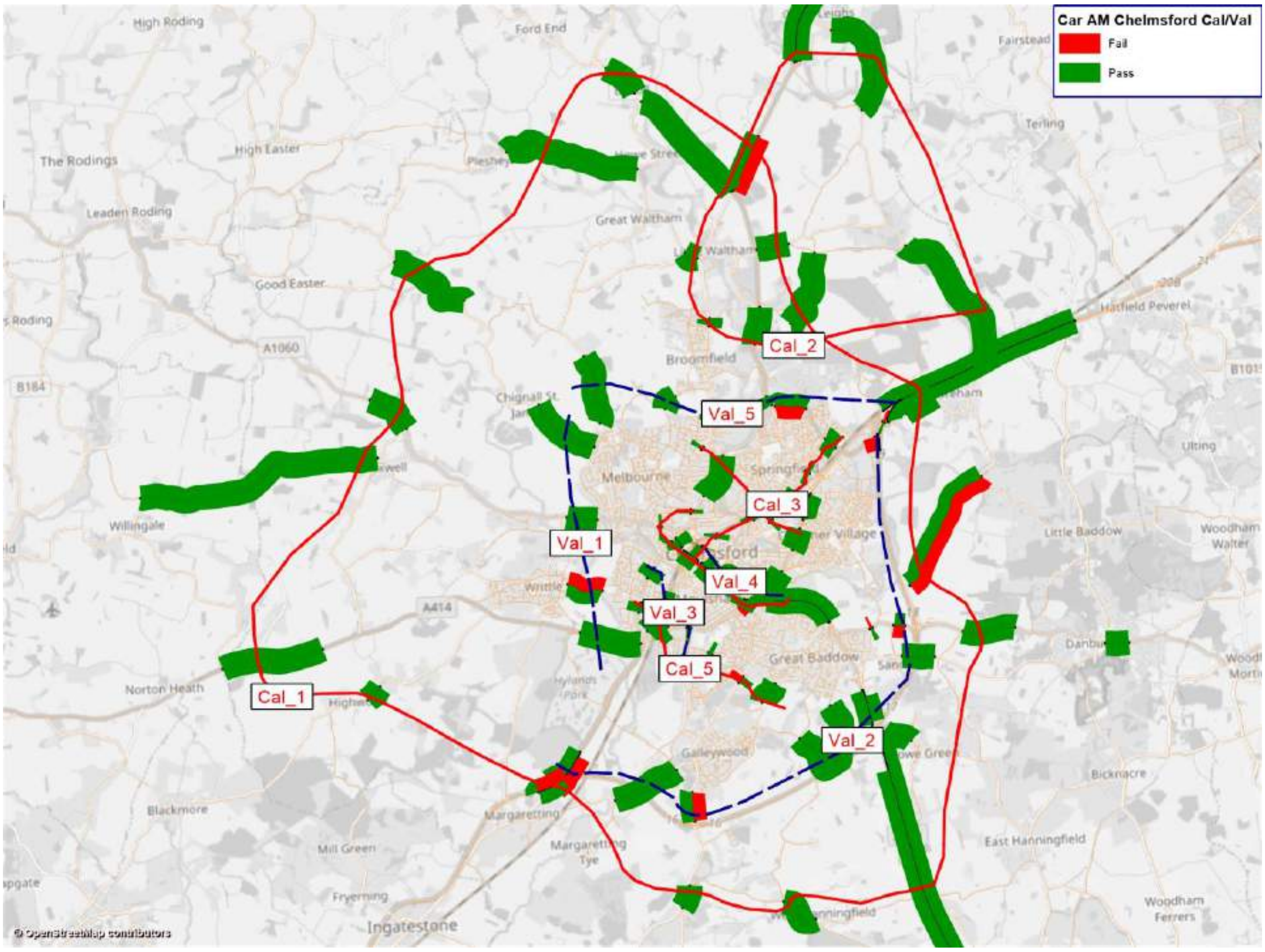

Trip End Totals
AM Origins
Chelmsford_Model_zones [293]
0 - 100 [64]
100 - 200 [47]
200 - 300 [38]
300 - 400 [18]
400 - 500 [12]
500 - 1000 [49]
1000 - 2000 [21]
2000 - 15905 [44]


Trip End Totals
AM Destinations
Chelmsford_Model_zones [293]
0 - 100 [77]
100 - 200 [52]
200 - 300 [27]
300 - 400 [15]
400 - 500 [12]
500 - 1000 [44]
1000 - 2000 [21]
2000 - 15905 [45]

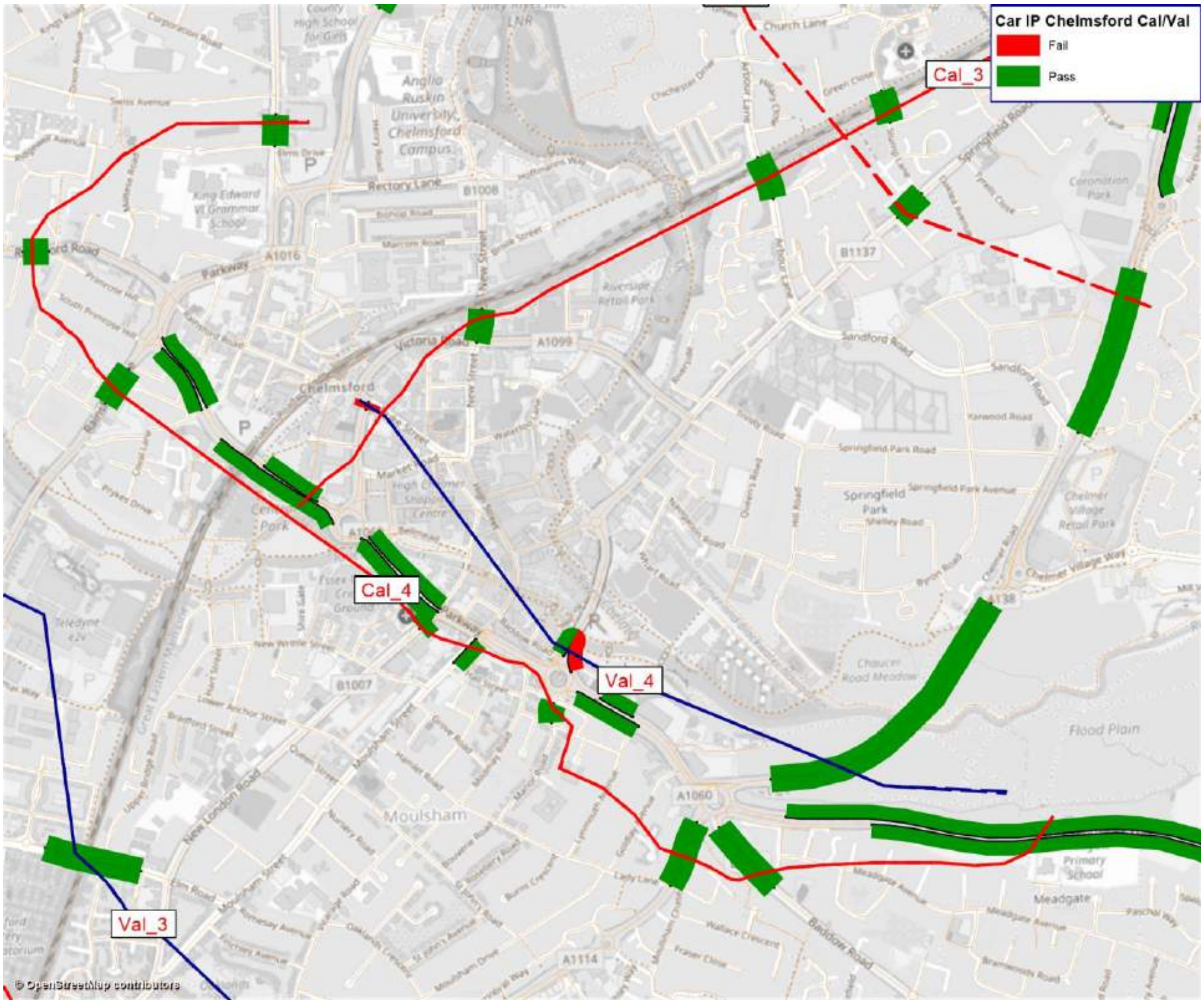
Appendix T – Model Validation and Calibration Figures: Individual Sites within Screenlines

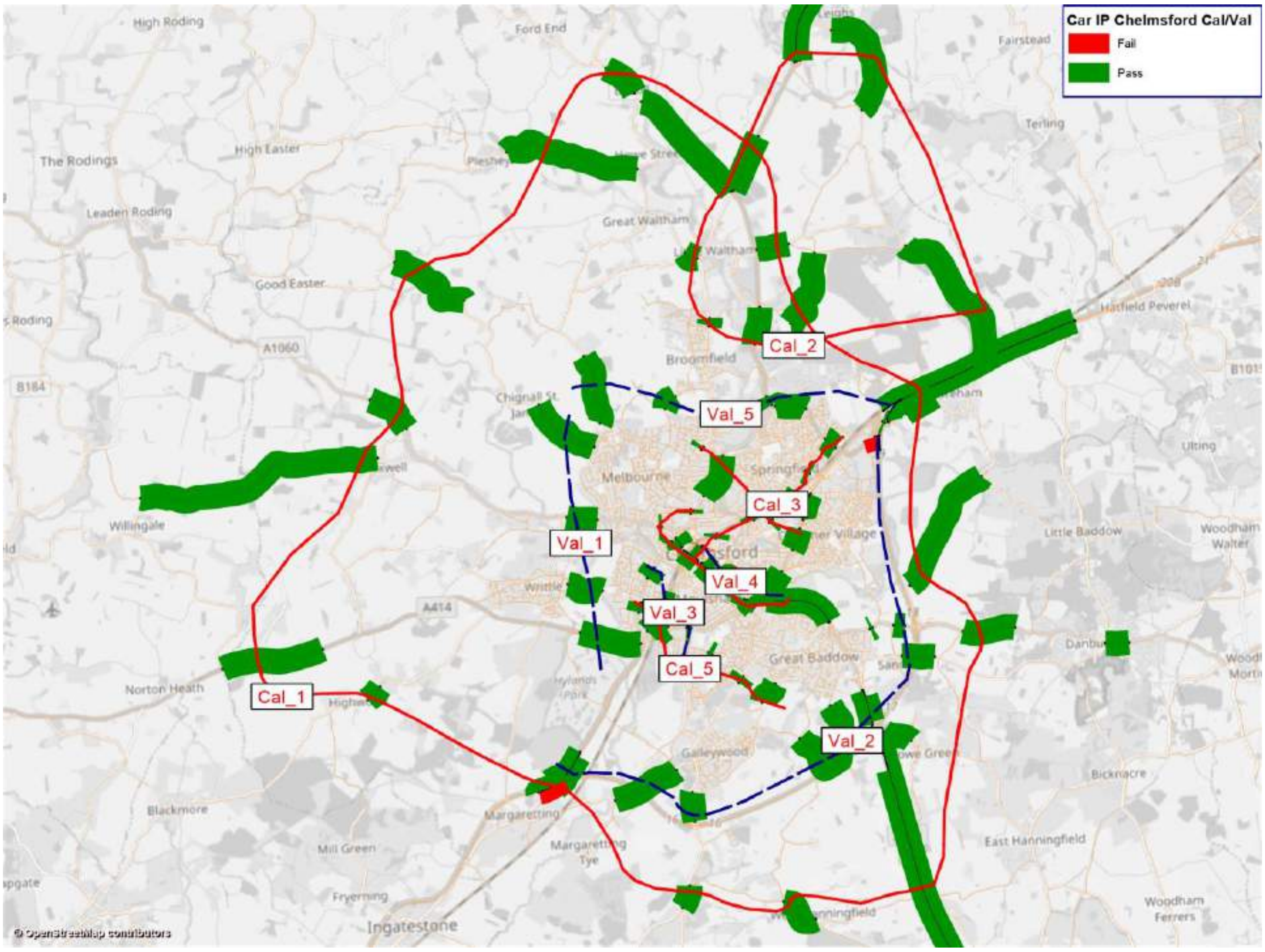


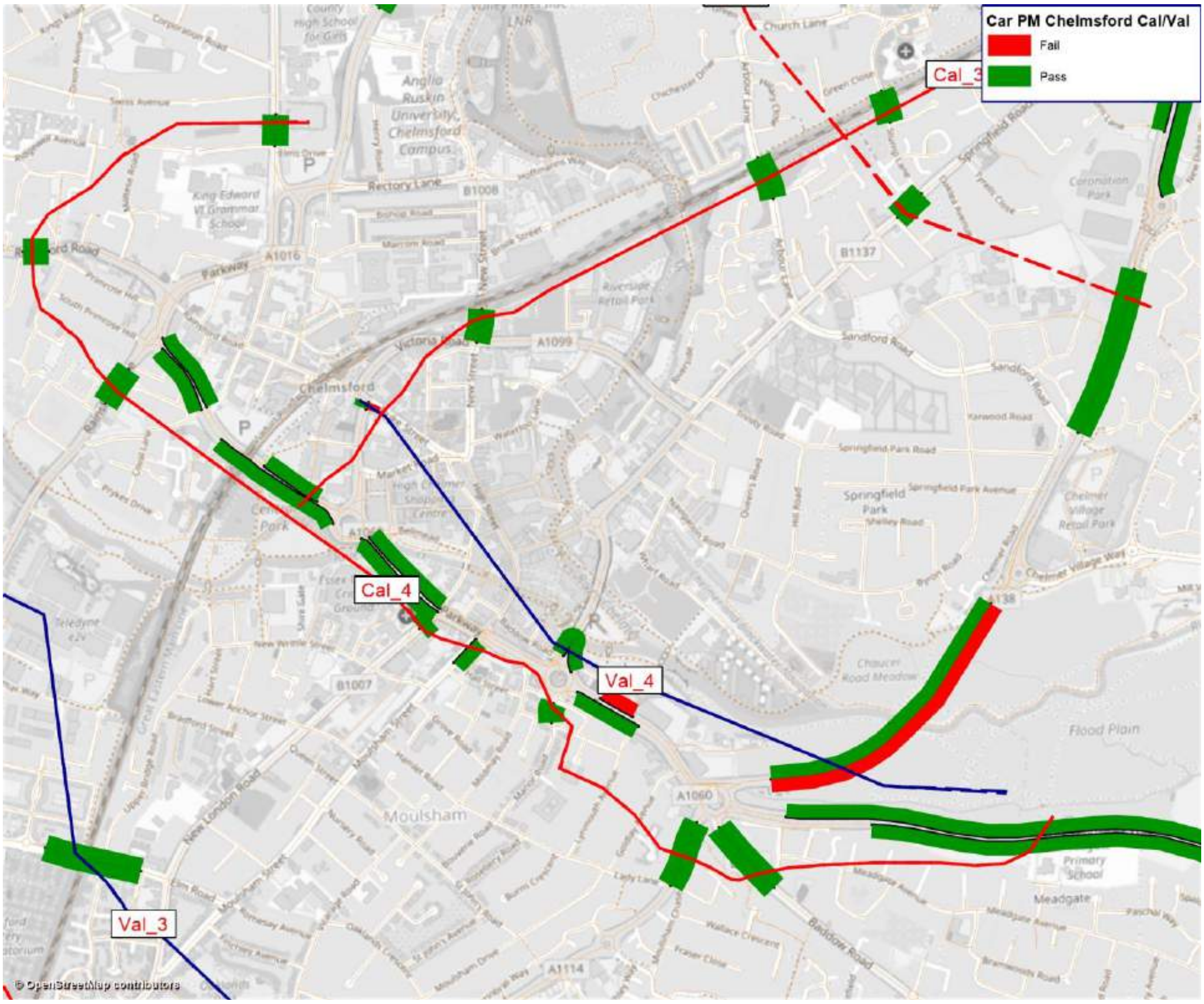
Car AM Chelmsford Cal/Val
Fail
Pass
Cal_3
Cal_4
Val_4
Val_3
© OpenStreetMap contributors

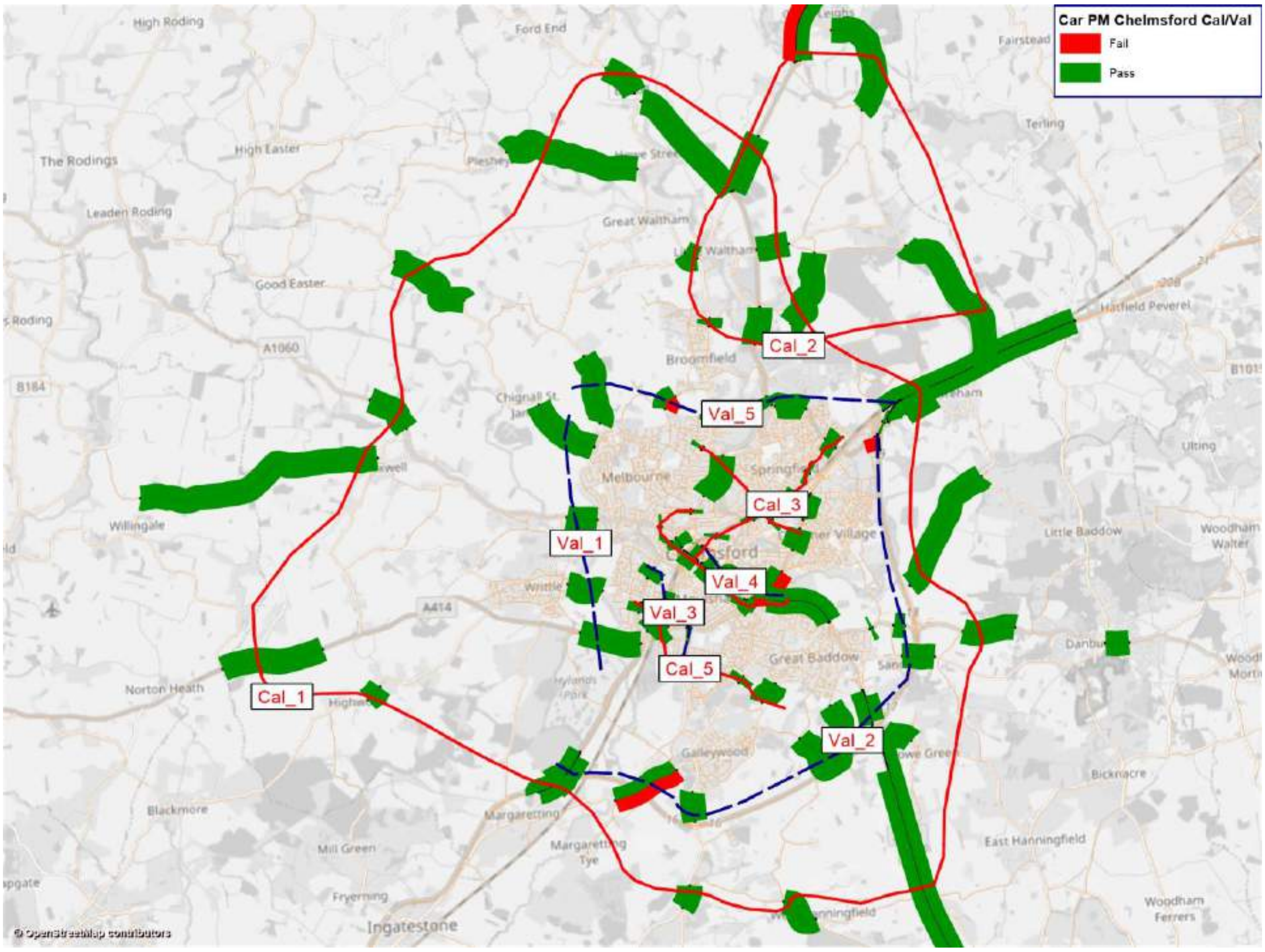


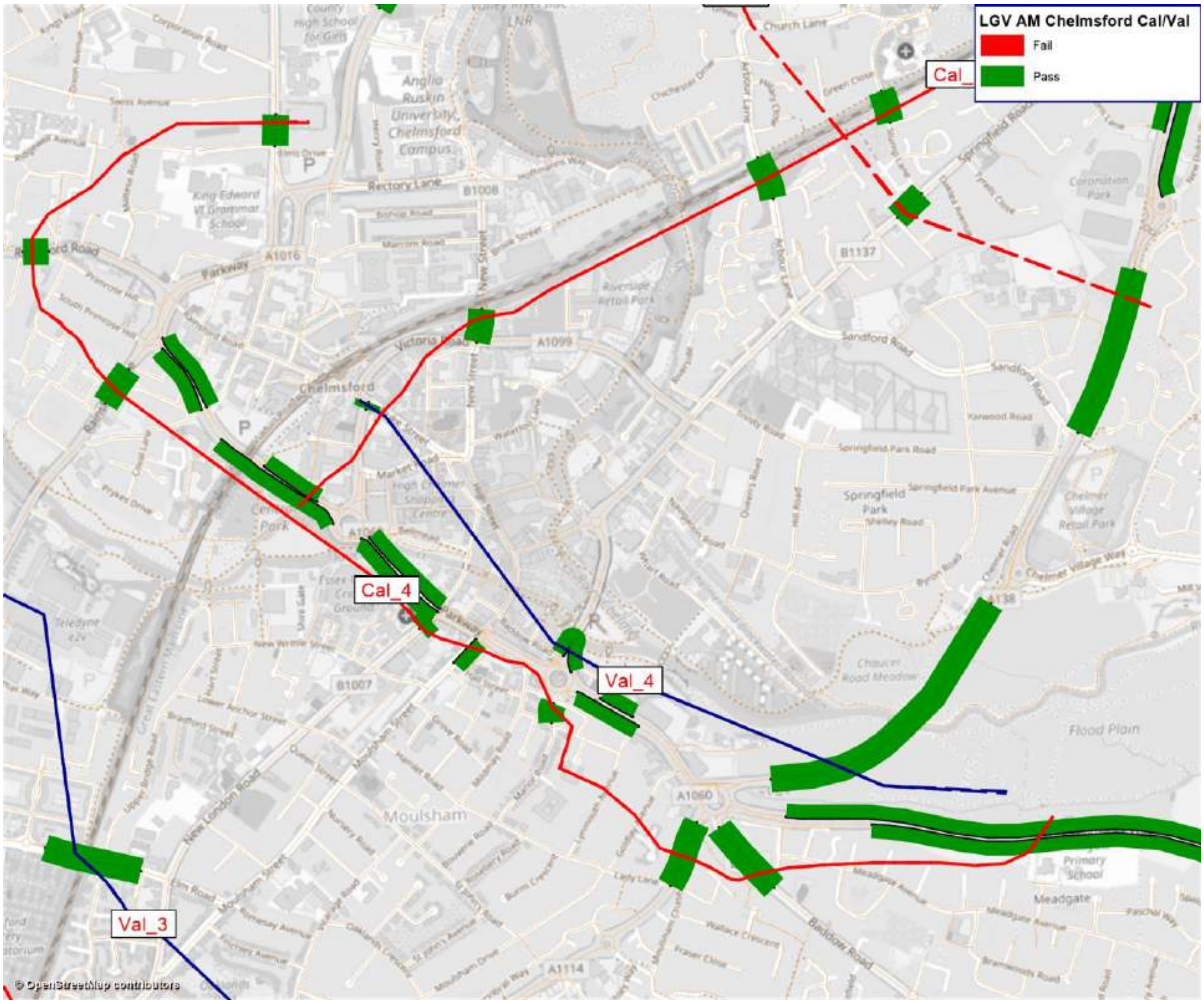
Car AM Chelmsford Cal/Val
Fail
Pass
Cal_1
Cal_2
Cal_3
Cal_5
Val_1
Val_2
Val_3
Val_4
Val_5
© OpenStreetMap contributors


Car IP Chelmsford Cal/Val
Fail
Pass
Cal_3
Cal_4
Val_4
Val_3
© OpenStreetMap contributors

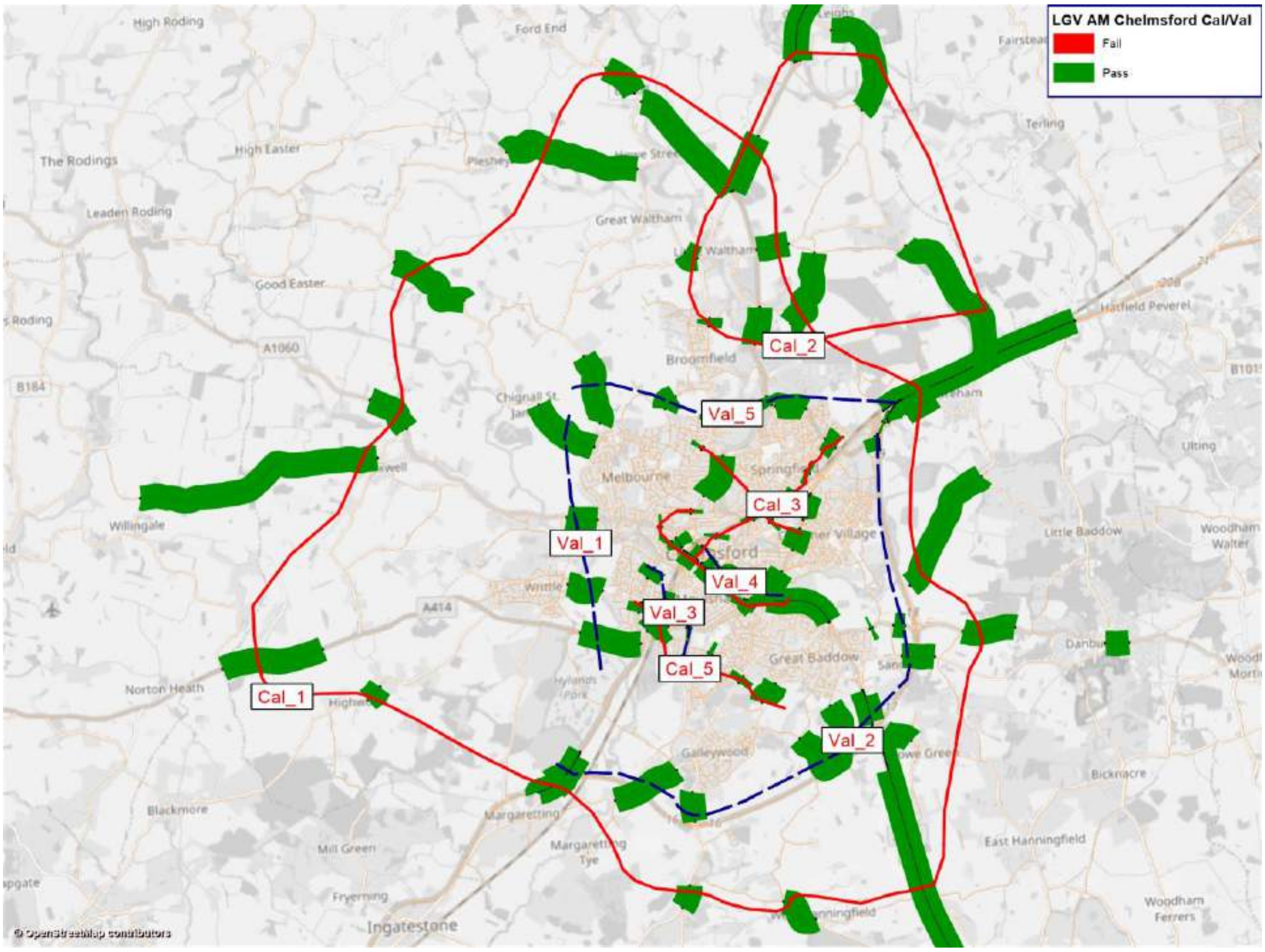

Car IP Chelmsford Cal/Val
Fail
Pass
Cal_1
Cal_2
Cal_3
Cal_5
Val_1
Val_2
Val_3
Val_4
Val_5
© OpenStreetMap contributors


Car PM Chelmsford Cal/Val
Fail
Pass
Cal_3
Cal_4
Val_4
Val_3
© OpenStreetMap contributors

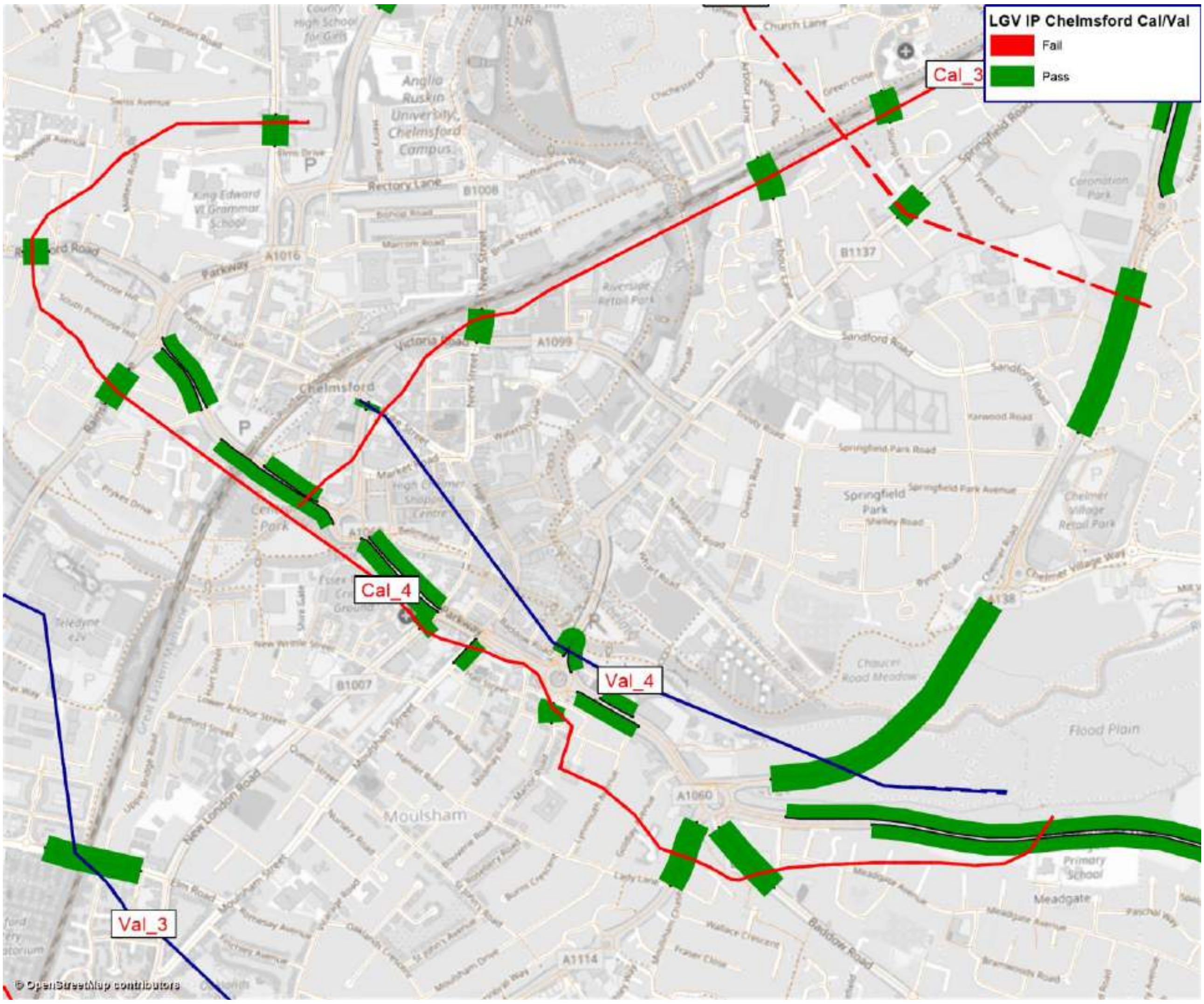

Car PM Chelmsford Cal/Val
Fail
Pass
Cal_1
Cal_2
Cal_3
Cal_5
Val_1
Val_2
Val_3
Val_4
Val_5
© OpenStreetMap contributors

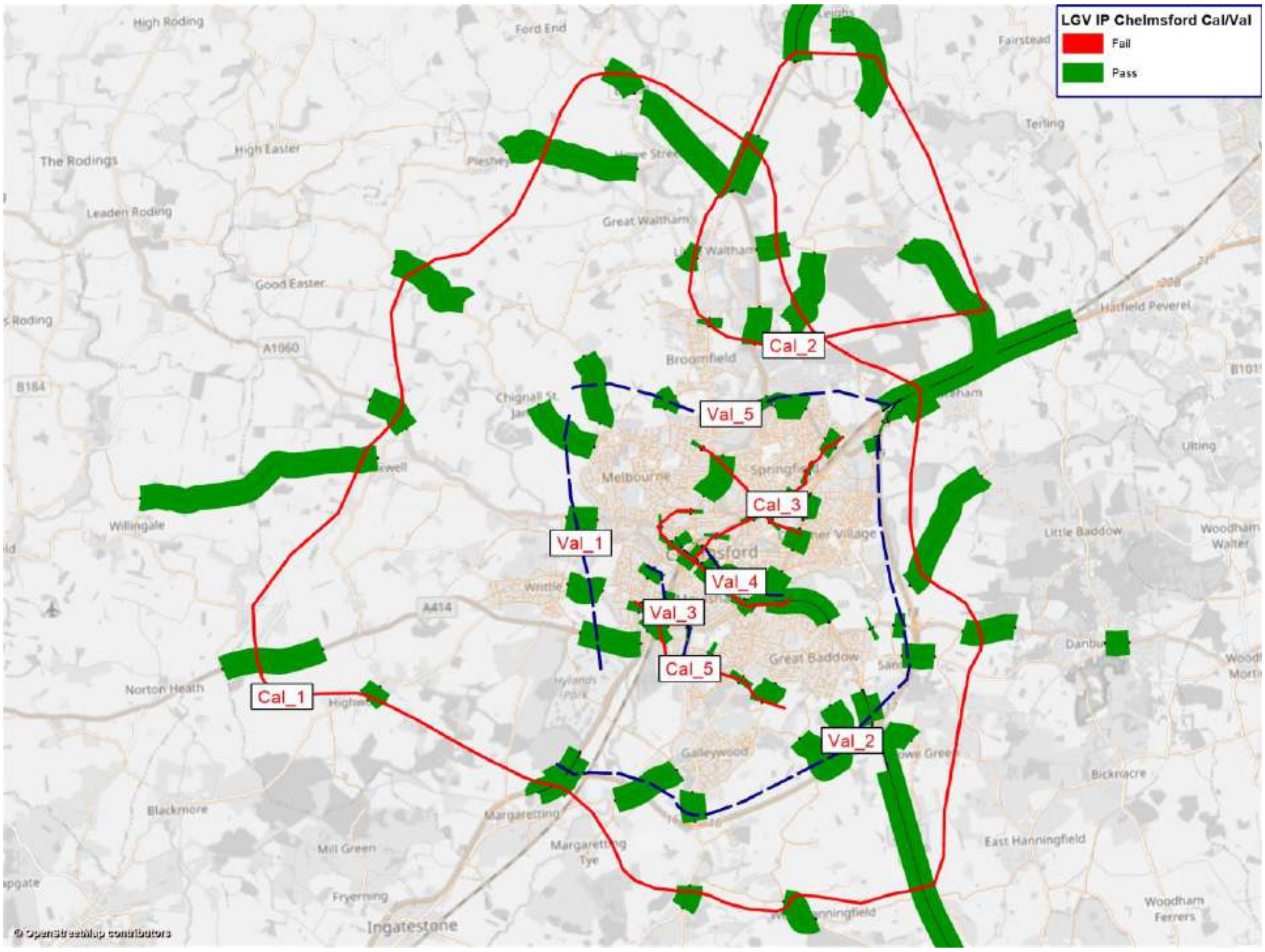


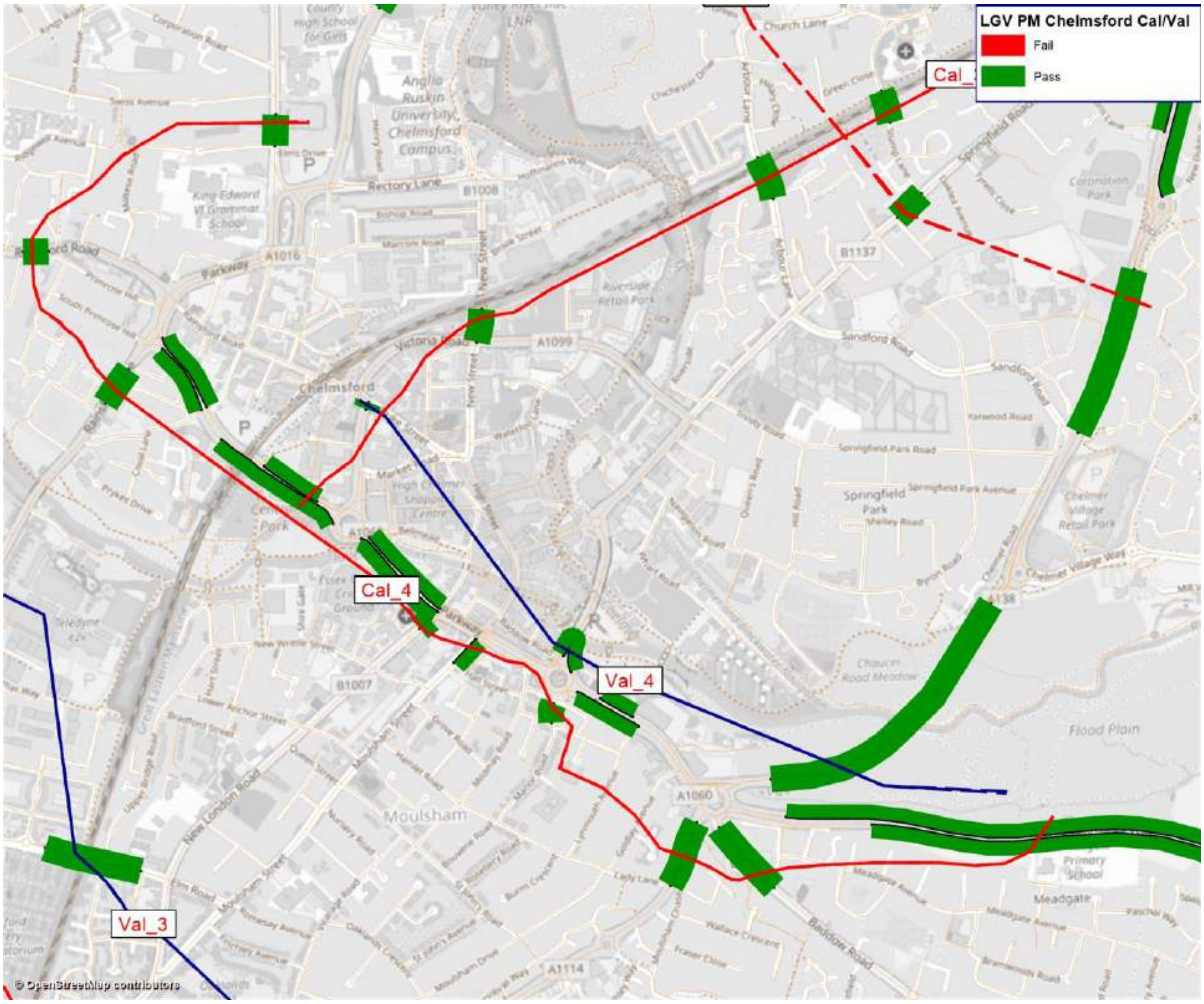
LGV AM Chelmsford Cal/Val
Fail
Pass
Cal_4
Val_4
Val_3
© OpenStreetMap contributors

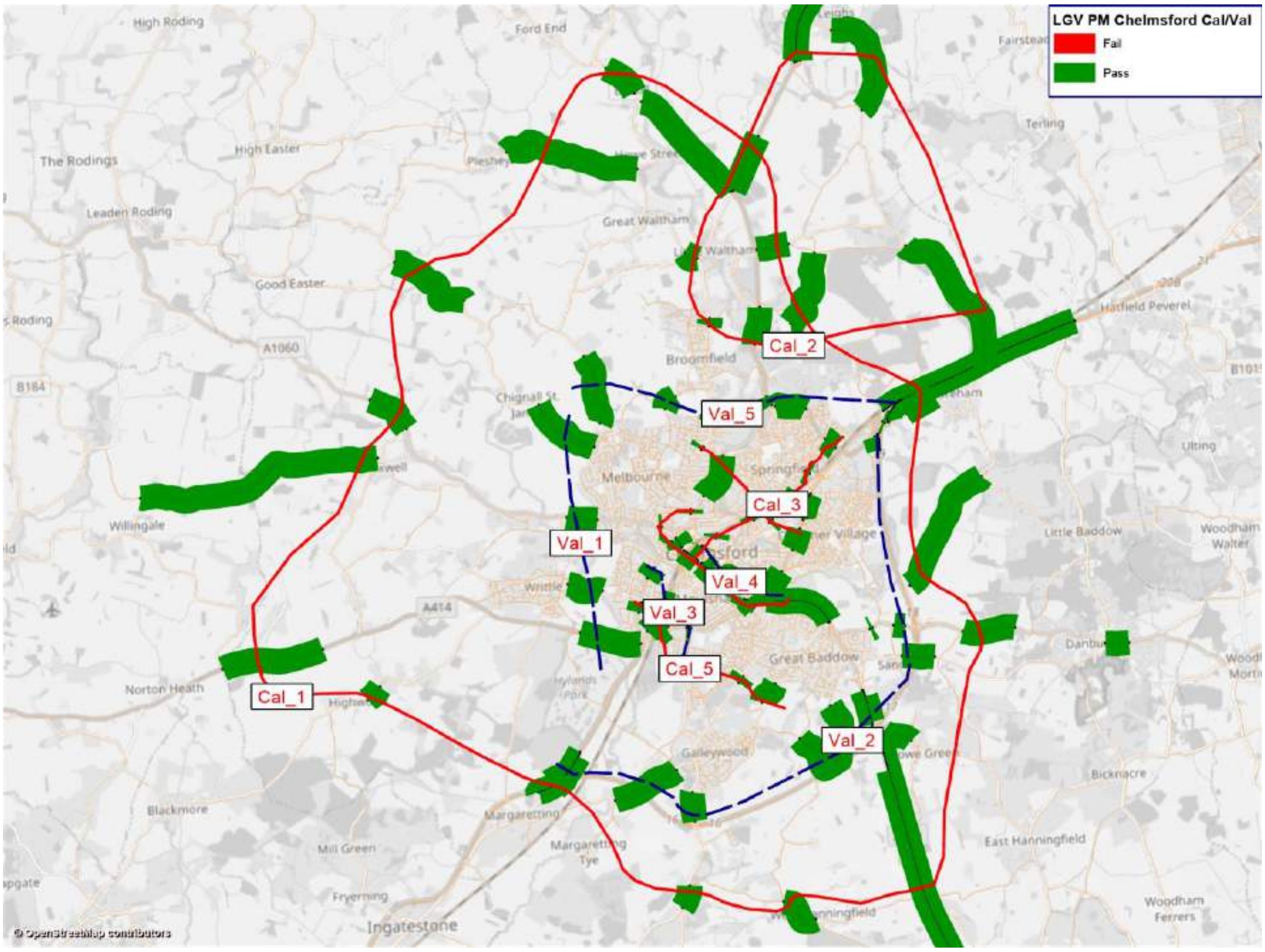


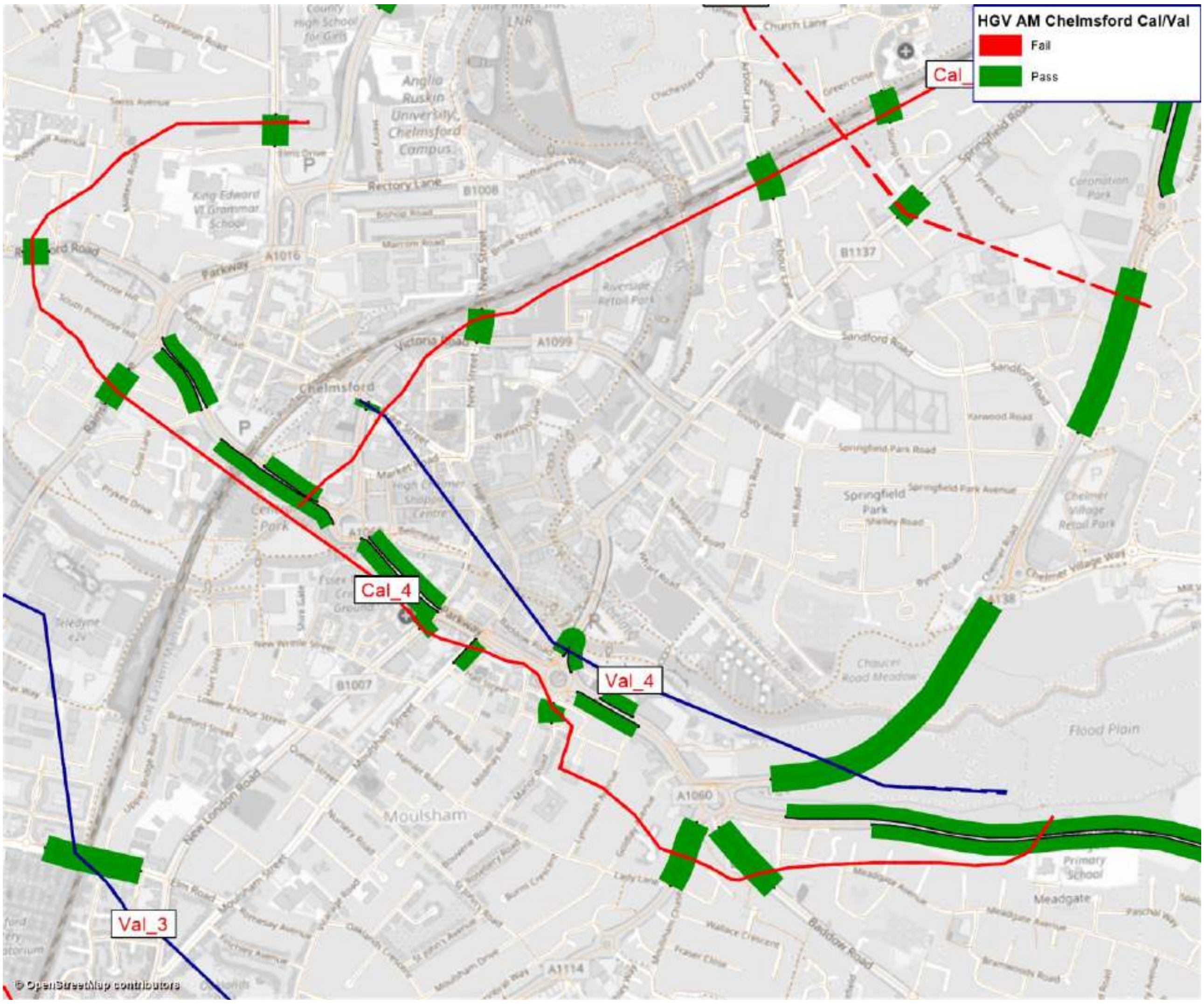
LGV AM Chelmsford Cal/Val
Fail
Pass
Cal_1
Cal_2
Cal_3
Cal_5
Val_1
Val_2
Val_3
Val_4
Val_5
© OpenStreetMap contributors

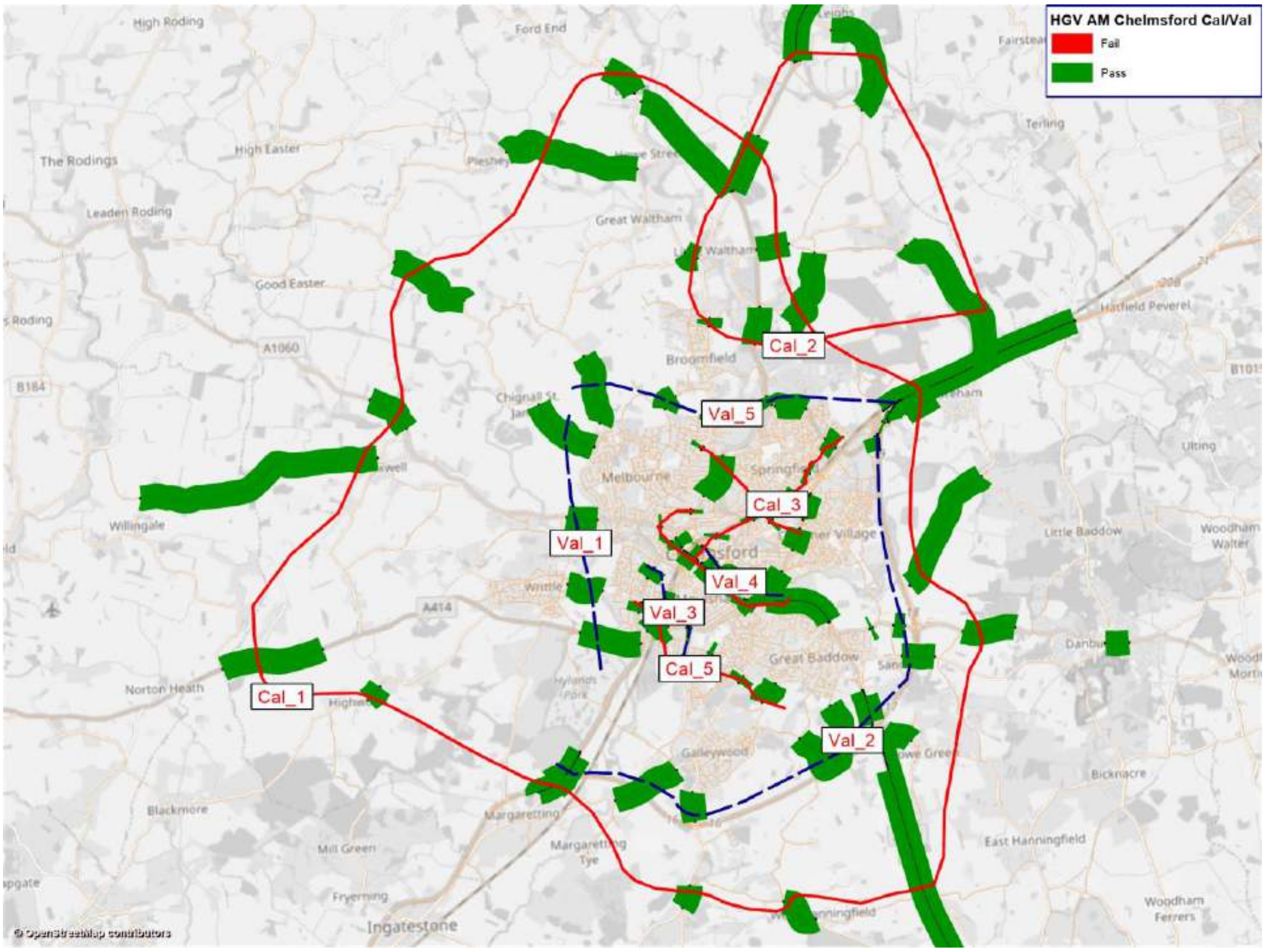

LGV IP Chelmsford Cal/Val
Fail
Pass
Cal_3
Cal_4
Val_3
Val_4
© OpenStreetMap contributors


LGV IP Chelmsford Cal/Val
Fail
Pass
Cal_1
Cal_2
Cal_3
Cal_5
Val_1
Val_2
Val_3
Val_4
Val_5
© OpenStreetMap contributors

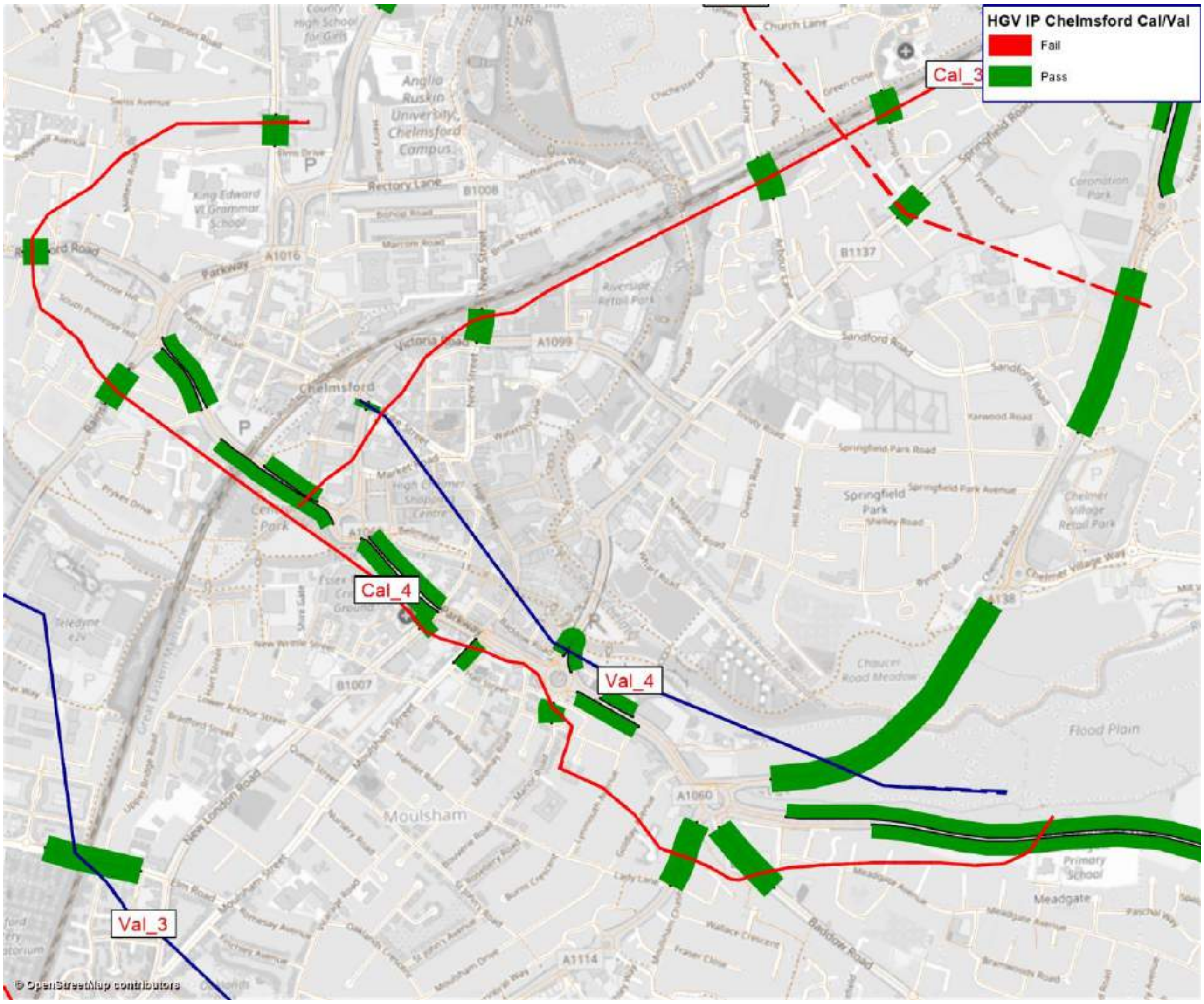

LGV PM Chelmsford Cal/Val
Fail
Pass
Cal_4
Val_4
Val_3
© OpenStreetMap contributors

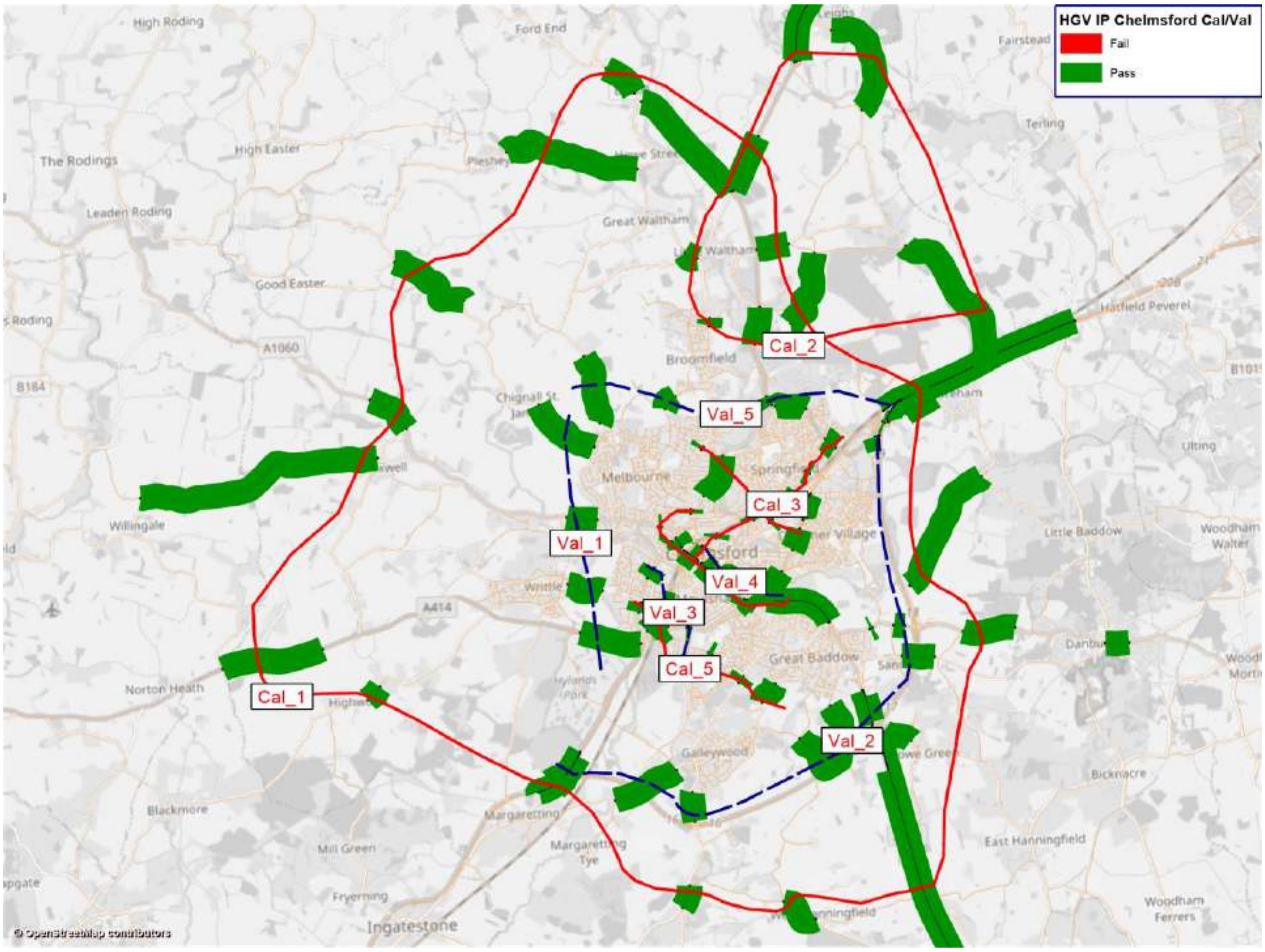

LGV PM Chelmsford Cal/Val
Fail
Pass
Cal_1
Cal_2
Cal_3
Cal_4
Cal_5
Val_1
Val_2
Val_3
Val_4
Val_5
© OpenStreetMap contributors

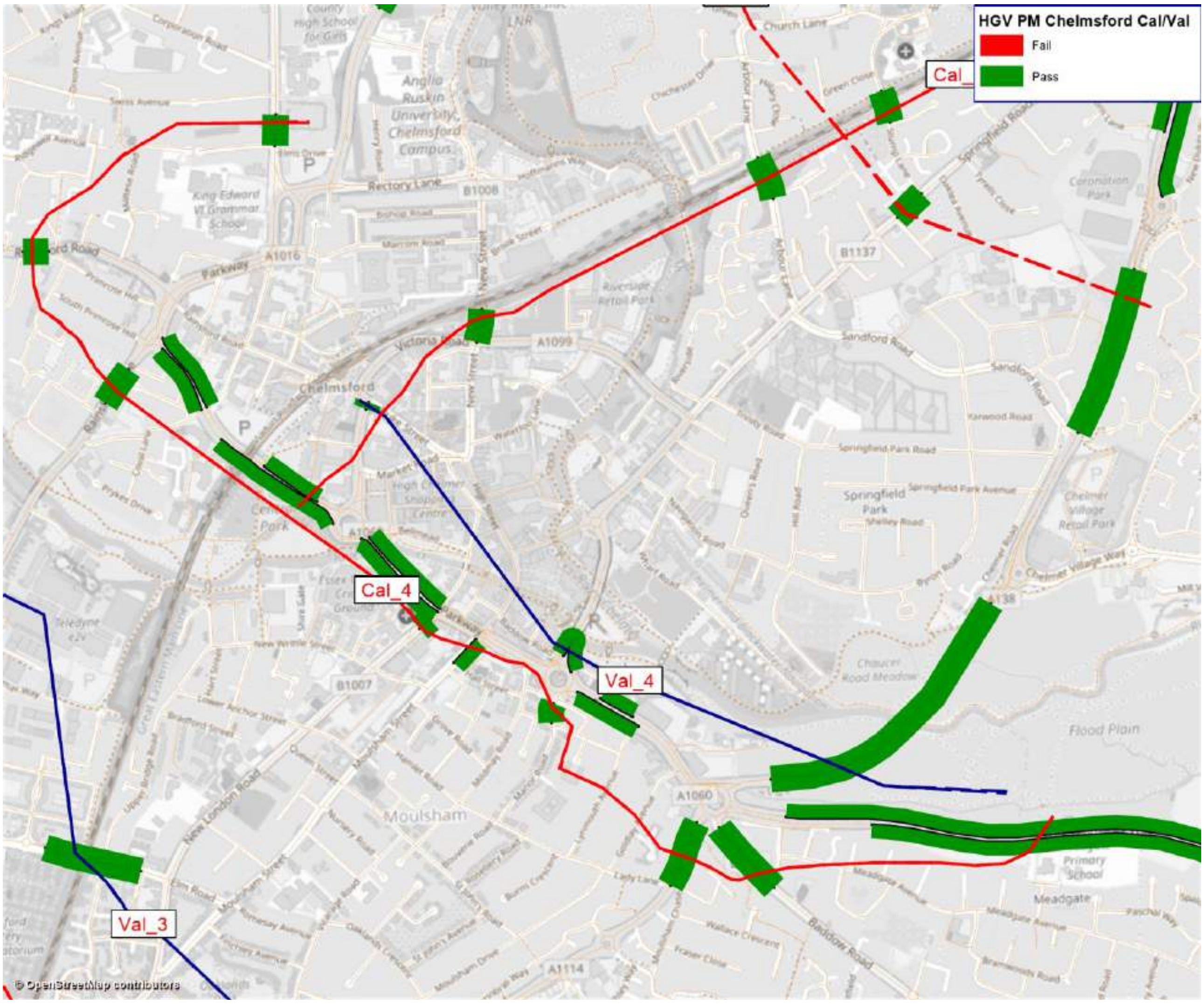

HGV AM Chelmsford Cal/Val
Fail
Pass
Cal_
Cal_4
Val_4
Val_3
© OpenStreetMap contributors

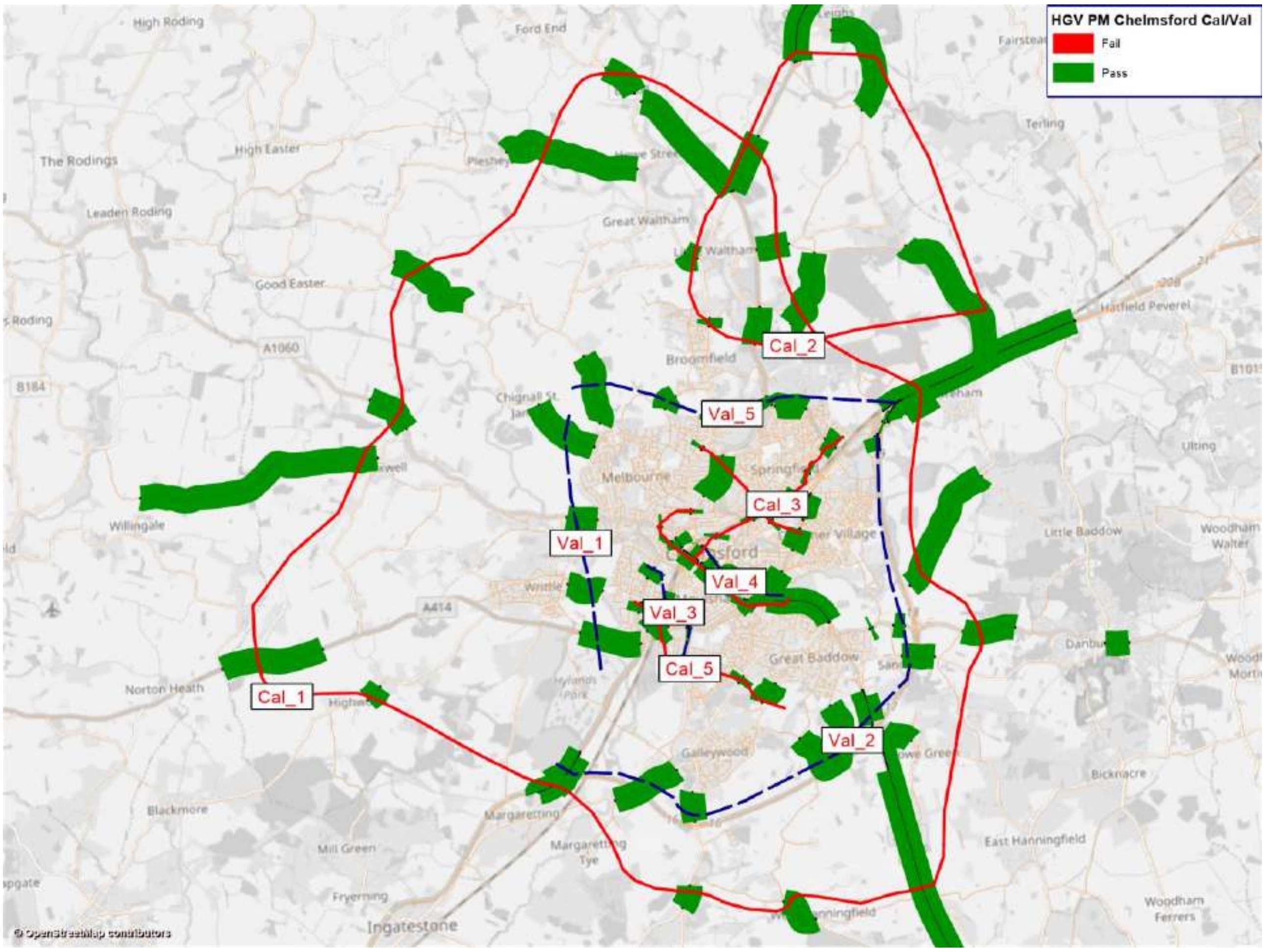


HGV AM Chelmsford Cal/Val
Fail
Pass
Cal_1
Cal_2
Cal_3
Cal_5
Val_1
Val_2
Val_3
Val_4
Val_5
© OpenStreetMap contributors


HGV IP Chelmsford Cal/Val
Fail
Pass
Cal_3
Cal_4
Val_4
Val_3
Chelmsford
Springfield Park
Moulsham
Flood Plain
Anglia Ruskin University Chelmsford Campus
King Edward VI Grammar School
Rectory Lane
Victoria Road
New Street
Parkway
A1016
A1099
A1060
A1114
B1007
B1008
B1137
Baddow Road
Sandford Road
Springfield Park Road
Chelmer Village Way
Church Lane
New London Road
Meadgate
© OpenStreetMap contributors


HGV IP Chelmsford Cal/Val
Fail
Pass
Cal_1
Cal_2
Cal_3
Cal_5
Val_1
Val_2
Val_3
Val_4
Val_5
High Roding
Ford End
Fairstead
Terling
The Rodings
High Easter
Pleshey
Leaden Roding
Great Waltham
Good Easter
A1060
Broomfield
Hatfield Peverel
B184
Chignall St
Melbourne
Ulting
Willingale
Little Baddow
Woodham Walter
Writtle
A414
Great Baddow
Norton Heath
Galleywood
Bicknacre
Blackmore
Margaretting
Margaretting Tye
East Hanningfield
Mill Green
Fryerning
Ingatestone
Woodham Ferrers
© OpenStreetMap contributors


HGV PM Chelmsford Cal/Val
Fail
Pass
Cal_4
Val_4
Val_3
© OpenStreetMap contributors


HGV PM Chelmsford Cal/Val
Fail
Pass
Cal_1
Cal_2
Cal_3
Cal_5
Val_1
Val_2
Val_3
Val_4
Val_5
© OpenStreetMap contributors

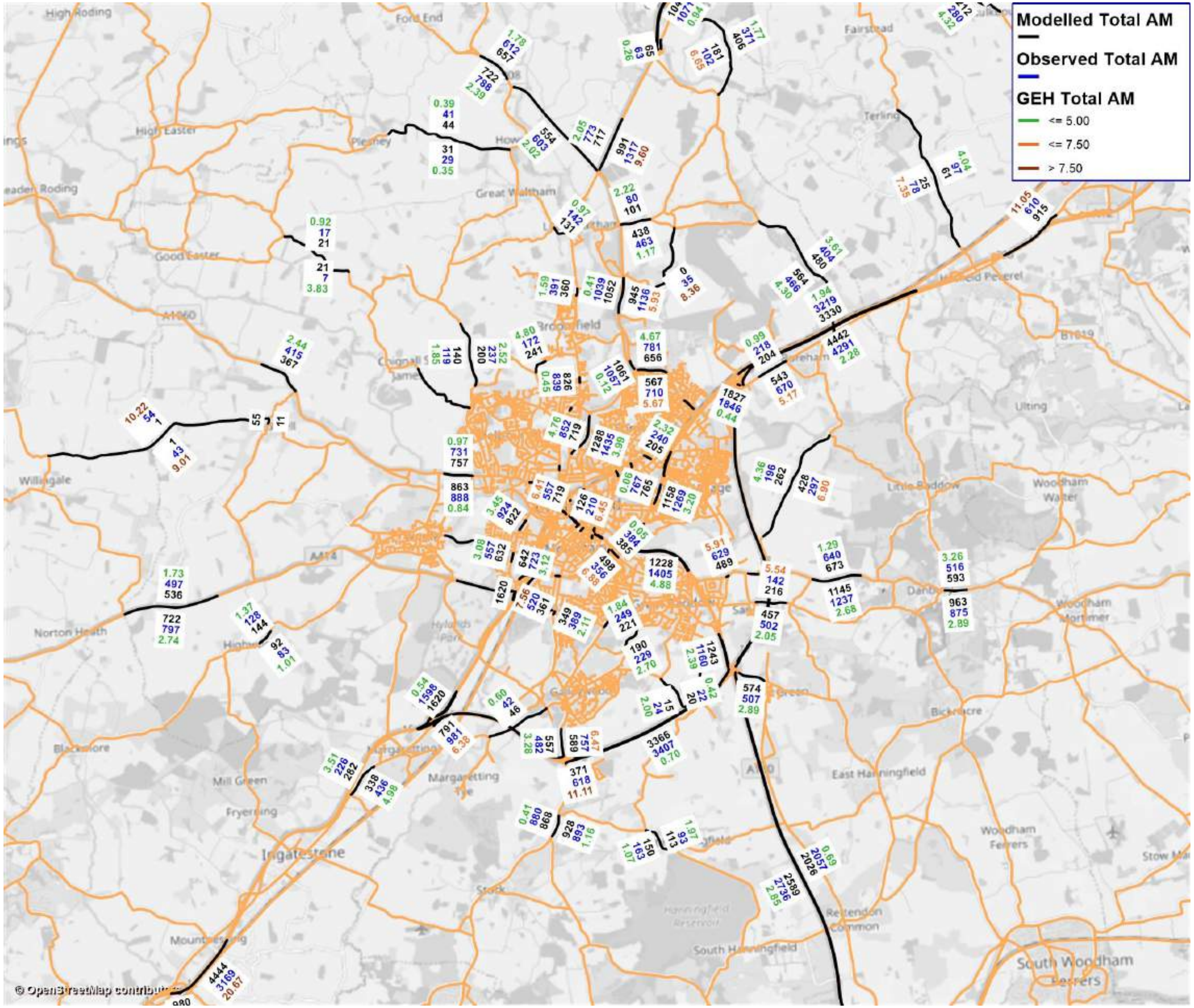
Appendix U – Model Validation and Calibration Figures: Individual Site Data

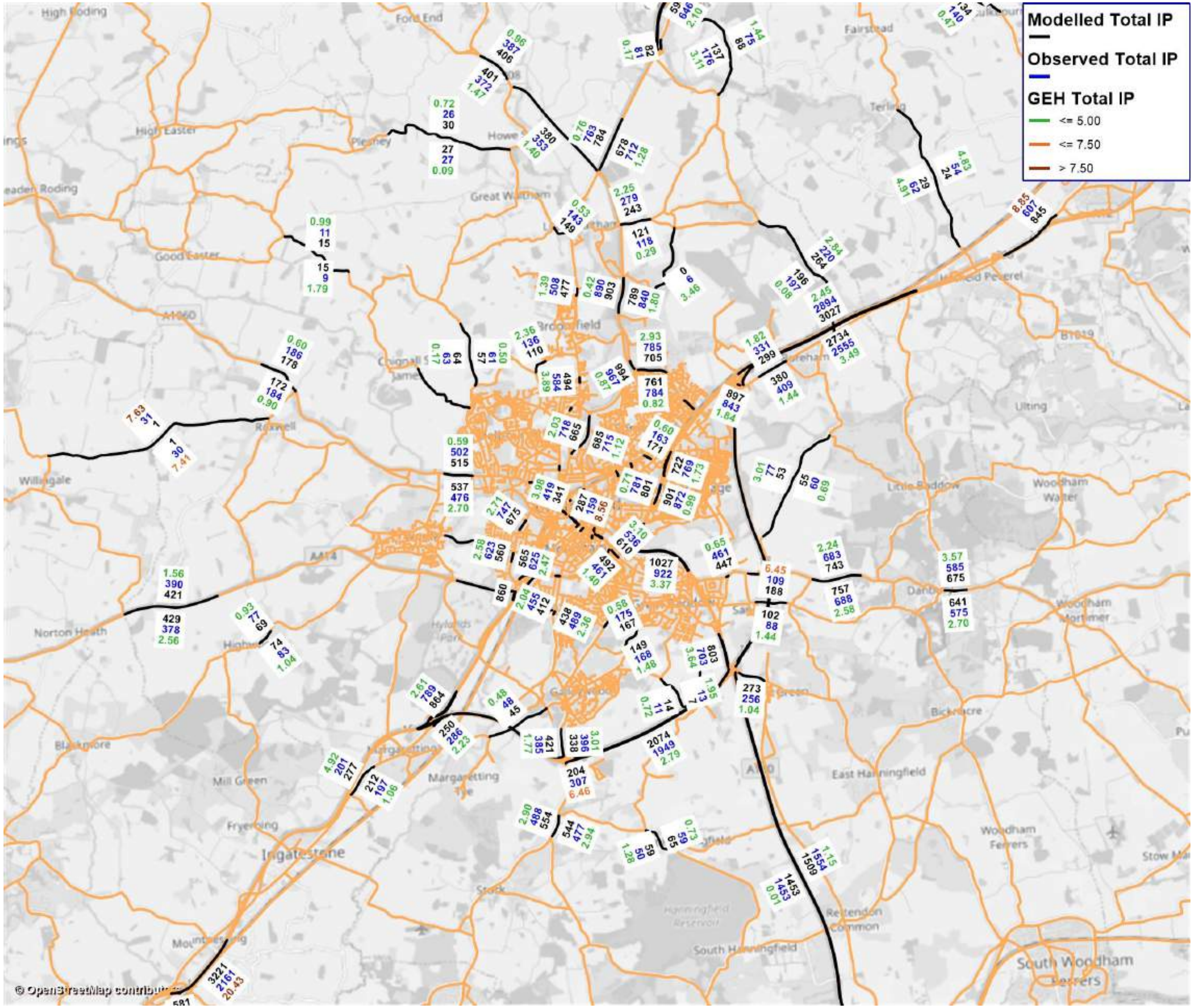

Modelled Total AM
Observed Total AM
GEH Total AM
<= 5.00
<= 7.50
> 7.50
Springfield Park Road
Springfield Park Avenue
Springfield Park
Chaucer Road Meadow
Flood Plain
Chelmer Village Retail Park
Meadgate Primary School
Moulsham
High Chelmer Shopping Centre
Central Park
Essex Cour Cricket Ground
B1007
A1060
New Writtle Street
Lower Anchor Street
Moulsham Street
Chelmer and Blackwater Navigation
0.04
971
972
1228
1405
4.88
4.87
1027
877
1406
1379
0.72
3.36
1350
1476
1865
1744
2.85
© OpenStreetMap contributors

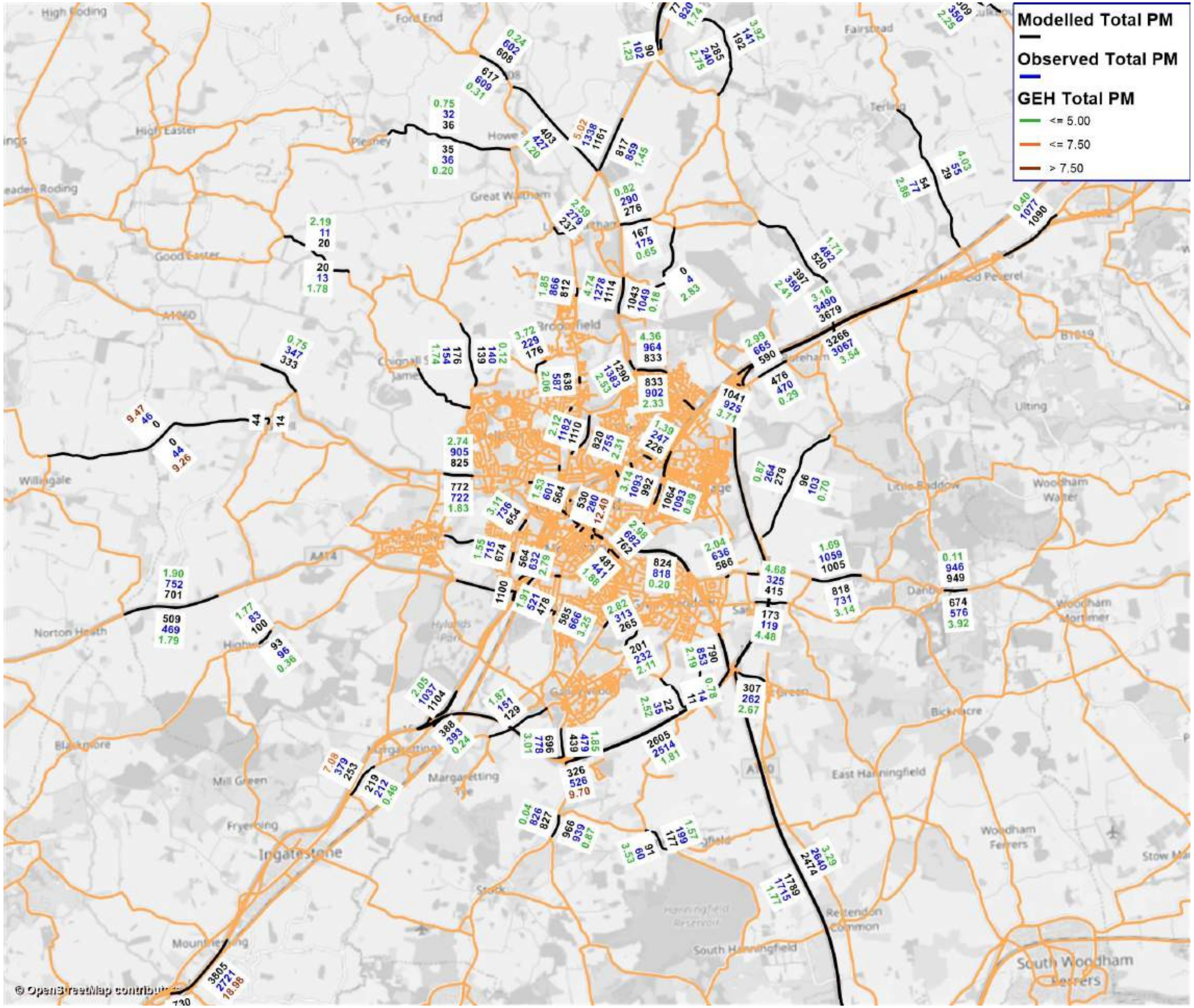

Modelled Total IP
Observed Total IP
GEH Total IP
<= 5.00
<= 7.50
> 7.50
Springfield Park
Chaucer Road Meadow
Flood Plain
Moulsham
High Chelmer Shopping Centre
Central Park
Essex County Cricket Ground
Chelmer Village Retail Park
Meadgate Primary School
© OpenStreetMap contributors

RINGWAY JACOBS

Essex County Council


Modelled Total AM
Observed Total AM
GEH Total AM
<= 5.00
<= 7.50
> 7.50
High Roding
High Easter
Pleshey
Good Easter
Great Waltham
Broomfield
Terling
Fairstead
Ulting
Little Baddow
Woodham Walter
Woodham Mortimer
Willingale
Norton Heath
Blackmore
Mill Green
Fryerning
Ingatestone
Margaretting
Stock
East Hanningfield
South Hanningfield
Woodham Ferrers
South Woodham Ferrers
Bicknacre
Rettendon Common
Hanningfield Reservoir
© OpenStreetMap contributors

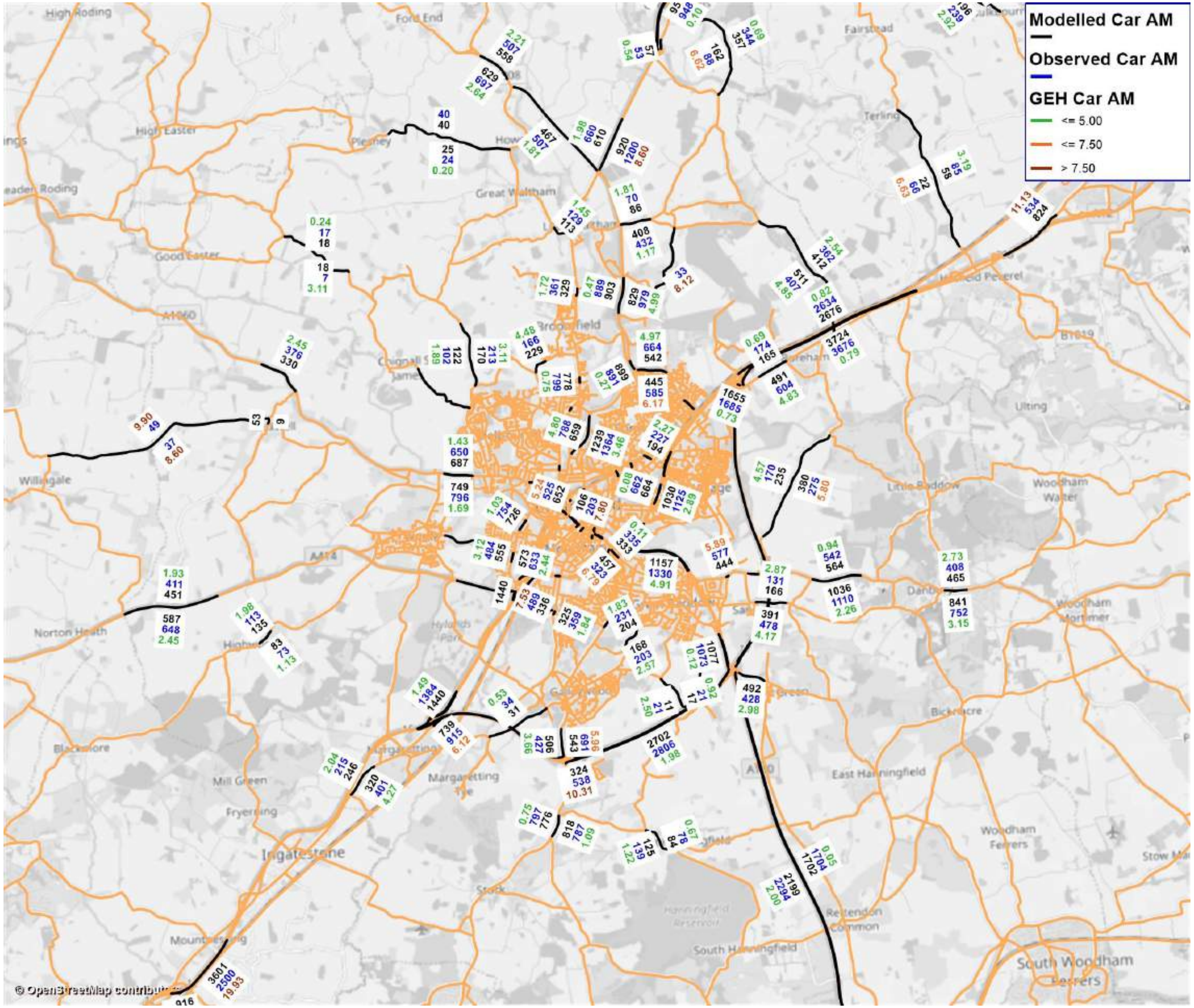

Modelled Total IP
Observed Total IP
GEH Total IP
<= 5.00
<= 7.50
> 7.50
© OpenStreetMap contributors


Modelled Total PM
Observed Total PM
GEH Total PM
<= 5.00
<= 7.50
> 7.50
High Roding
Ford End
High Easter
Pleshey
Good Easter
Great Waltham
Broomfield
Chignall St James
Willingale
Norton Heath
Blackmore
Mill Green
Fryerning
Ingatestone
Margaretting
Stock
Terling
Fairstead
Hatfield Peverel
Boreham
Ulting
Little Baddow
Woodham Walter
Woodham Mortimer
Bicknacre
East Hanningfield
South Hanningfield
Hanningfield Reservoir
Woodham Ferrers
Rettendon Common
South Woodham Ferrers
Stow Maries
Mountnessing
A1060
A414
A130
B1019
© OpenStreetMap contributors

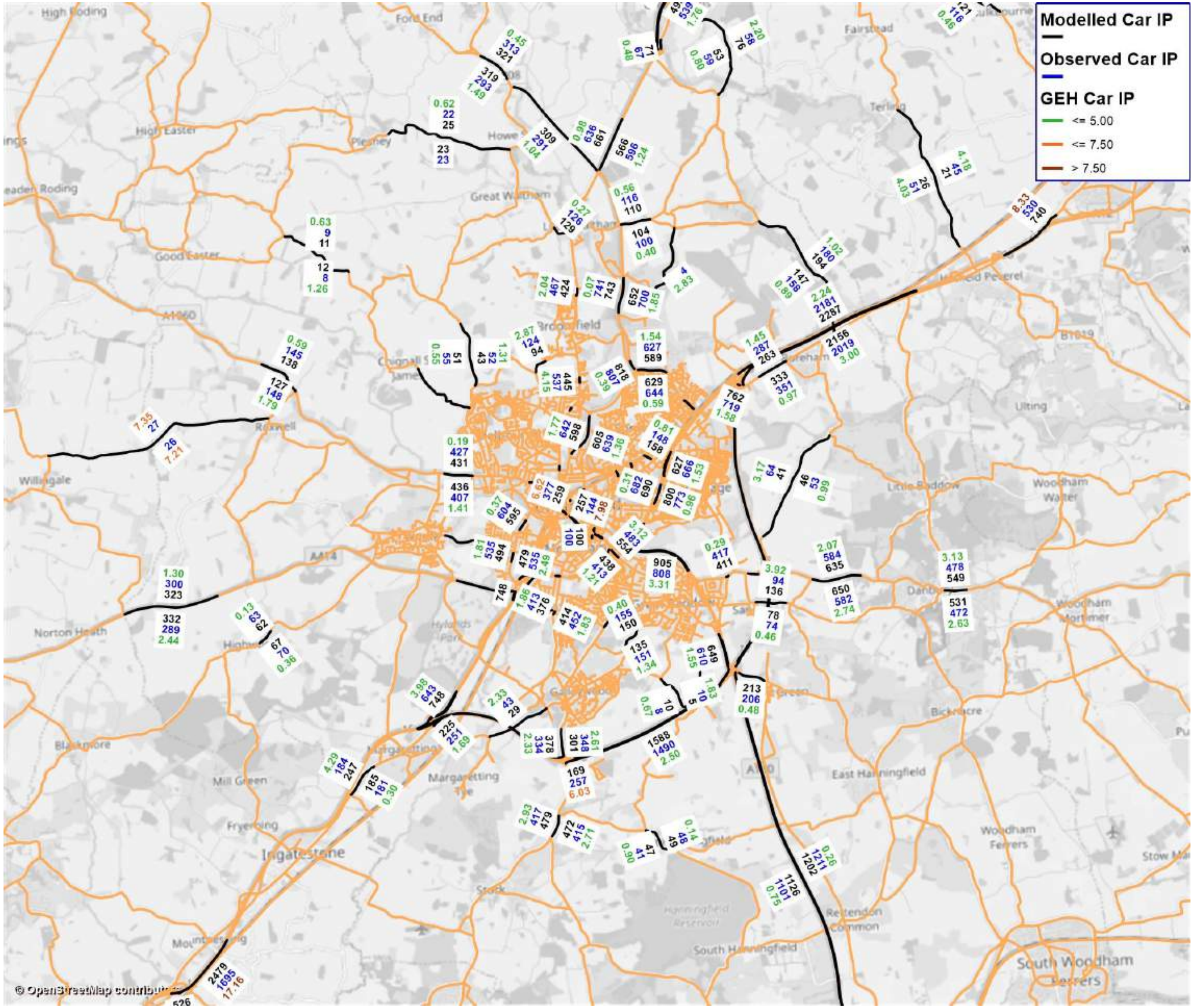
RINGWAY JACOBS | Essex County Council

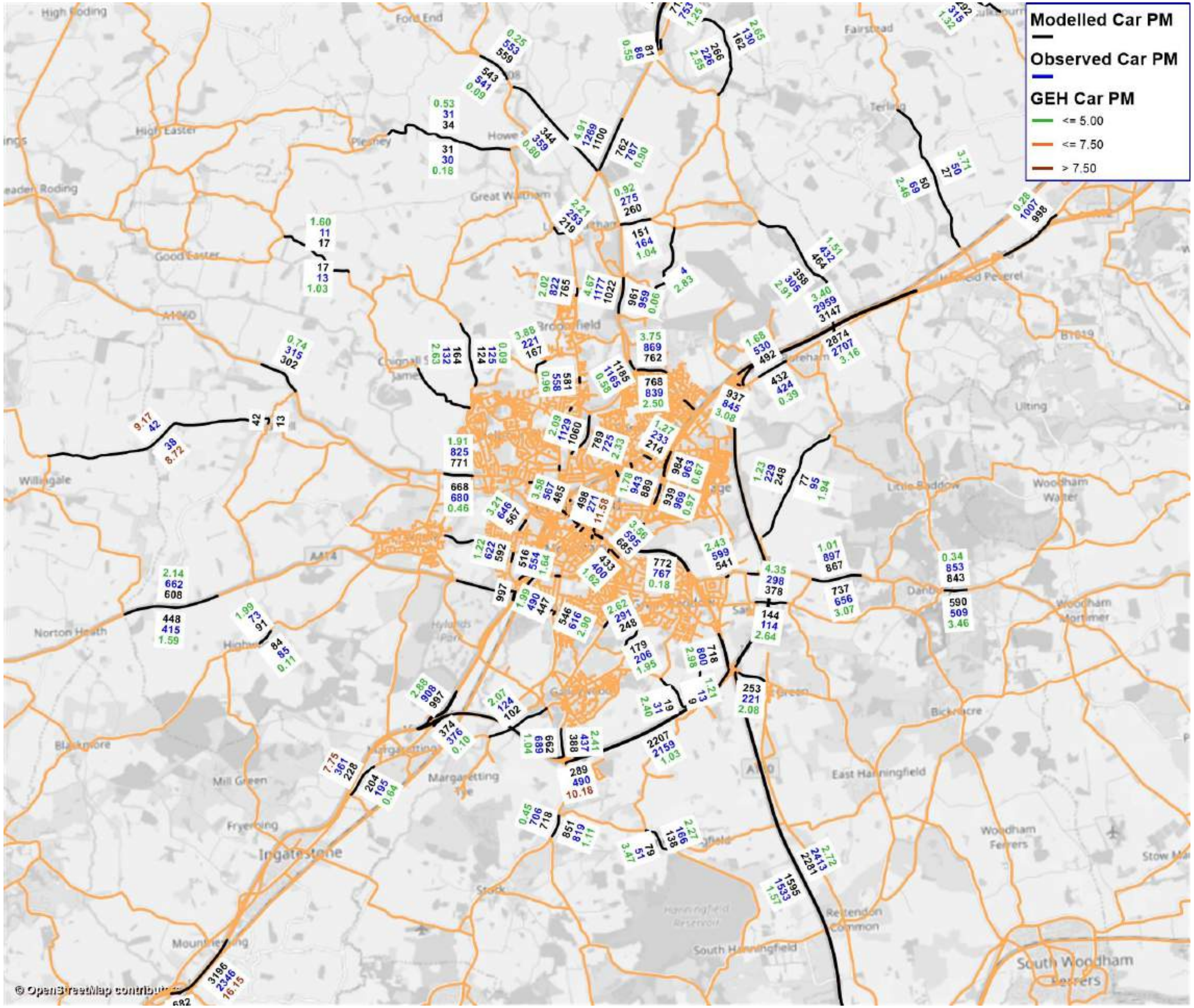

Modelled Car IP
Observed Car IP
GEH Car IP
<= 5.00
<= 7.50
> 7.50
© OpenStreetMap contributors


Modelled Car PM
Observed Car PM
GEH Car PM
<= 5.00
<= 7.50
> 7.50
Springfield Park
Chaucer Road Meadow
Flood Plain
Moulsham
High Chelmer Shopping Centre
Essex County Cricket Ground
Central Park
Chelmer Village Retail Park
Meadgate Primary School
A1060
B1007
A138
Springfield Park Road
Springfield Park Avenue
Yarwood Road
Shire Gate
© OpenStreetMap contributors



RINGWAY JACOBS | Essex County Council

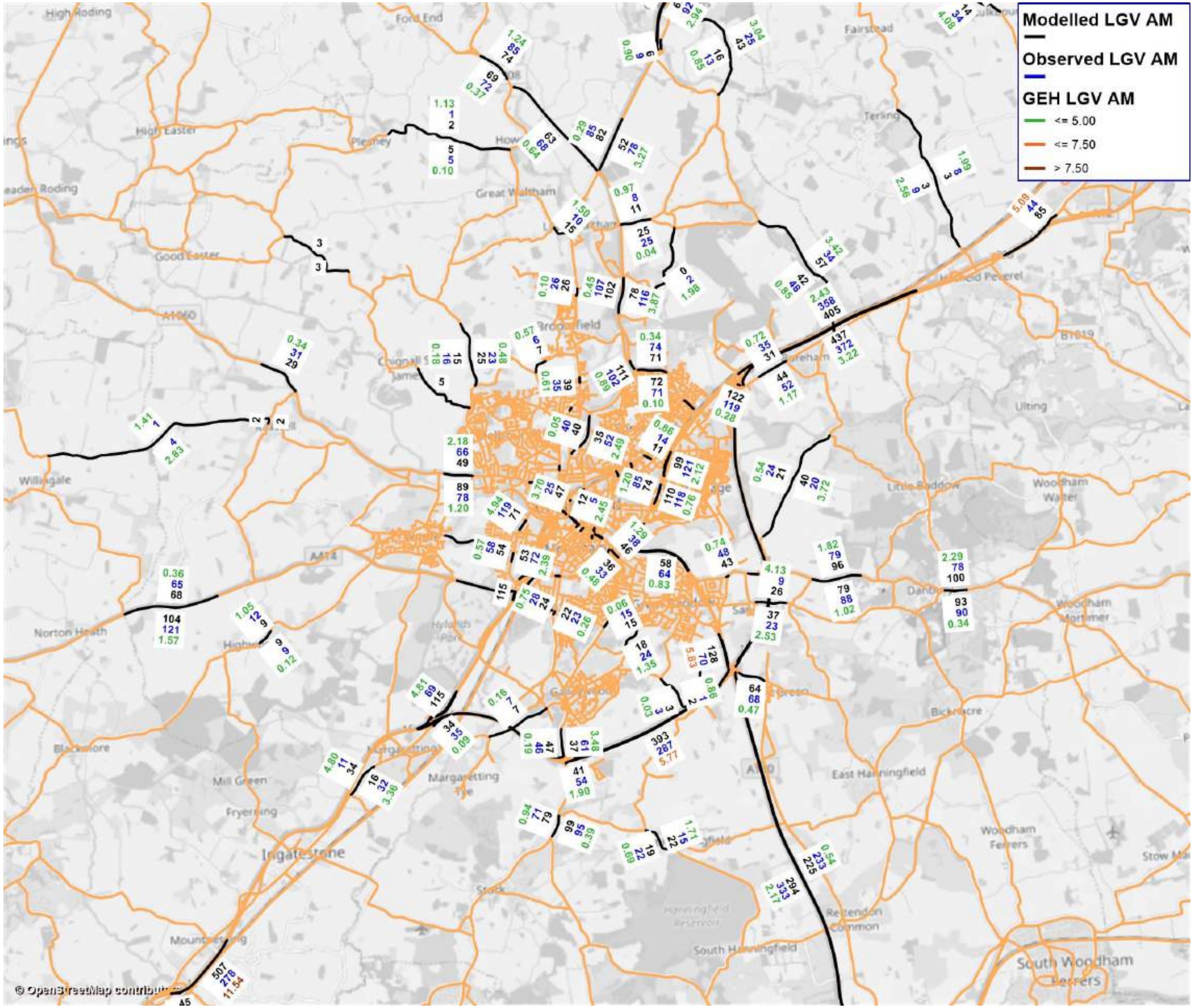

Modelled Car IP
Observed Car IP
GEH Car IP
<= 5.00
<= 7.50
> 7.50
© OpenStreetMap contributors

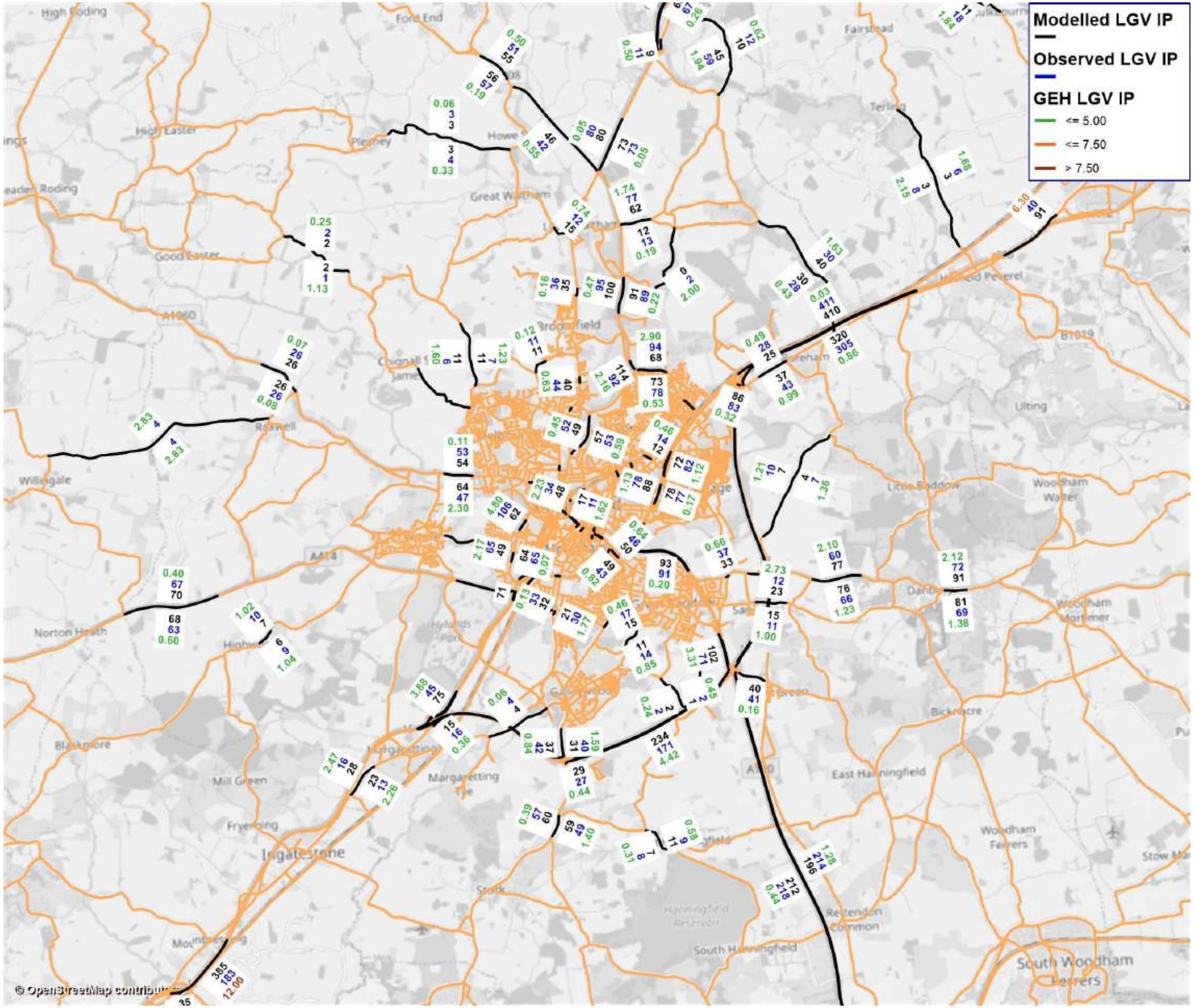

Modelled Car PM
Observed Car PM
GEH Car PM
<= 5.00
<= 7.50
> 7.50
© OpenStreetMap contributors

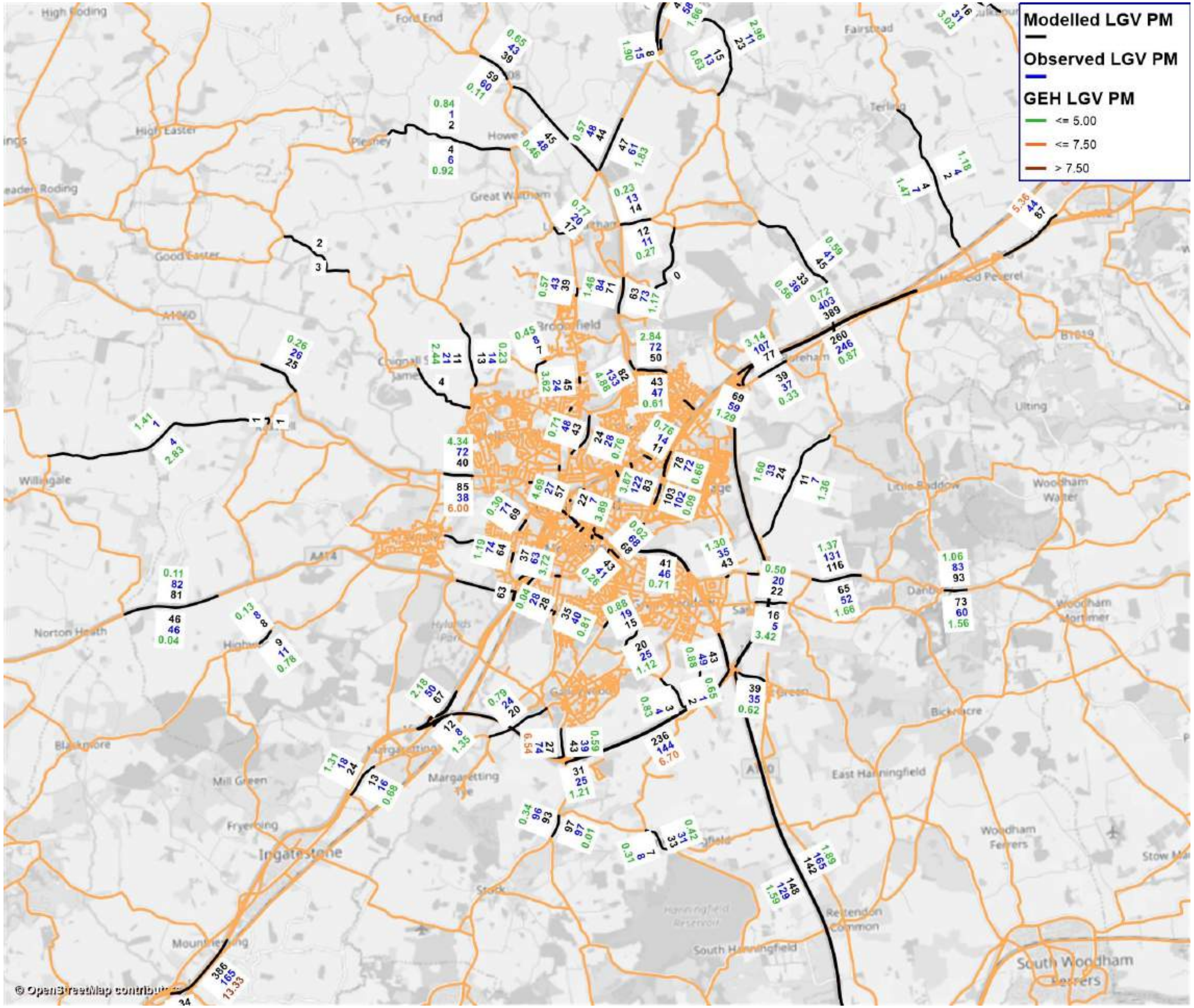
Ringway Jacobs | Essex County Council

Modelled LGV IP
Observed LGV IP
GEH LGV IP
<= 5.00
<= 7.50
> 7.50
© OpenStreetMap contributors


Modelled LGV PM
Observed LGV PM
GEH LGV PM
<= 5.00
<= 7.50
> 7.50
Chelmsford
Central Park
High Chelmer Shopping Centre
Essex County Cricket Ground
Springfield Park
Chelmer Village Retail Park
Chaucer Road Meadow
Flood Plain
Moulsham
Meadgate Primary School
B1007
A1060
A138
© OpenStreetMap contributors


Modelled LGV AM
Observed LGV AM
GEH LGV AM
<= 5.00
<= 7.50
> 7.50
High Roding
Ford End
Fairstead
Terling
High Easter
Pleshey
Good Easter
Ulting
Norton Heath
Blackmore
Mill Green
Margaretting
East Hanningfield
Woodham Ferrers
Ingatestone
South Hanningfield
South Woodham Ferrers
© OpenStreetMap contributors

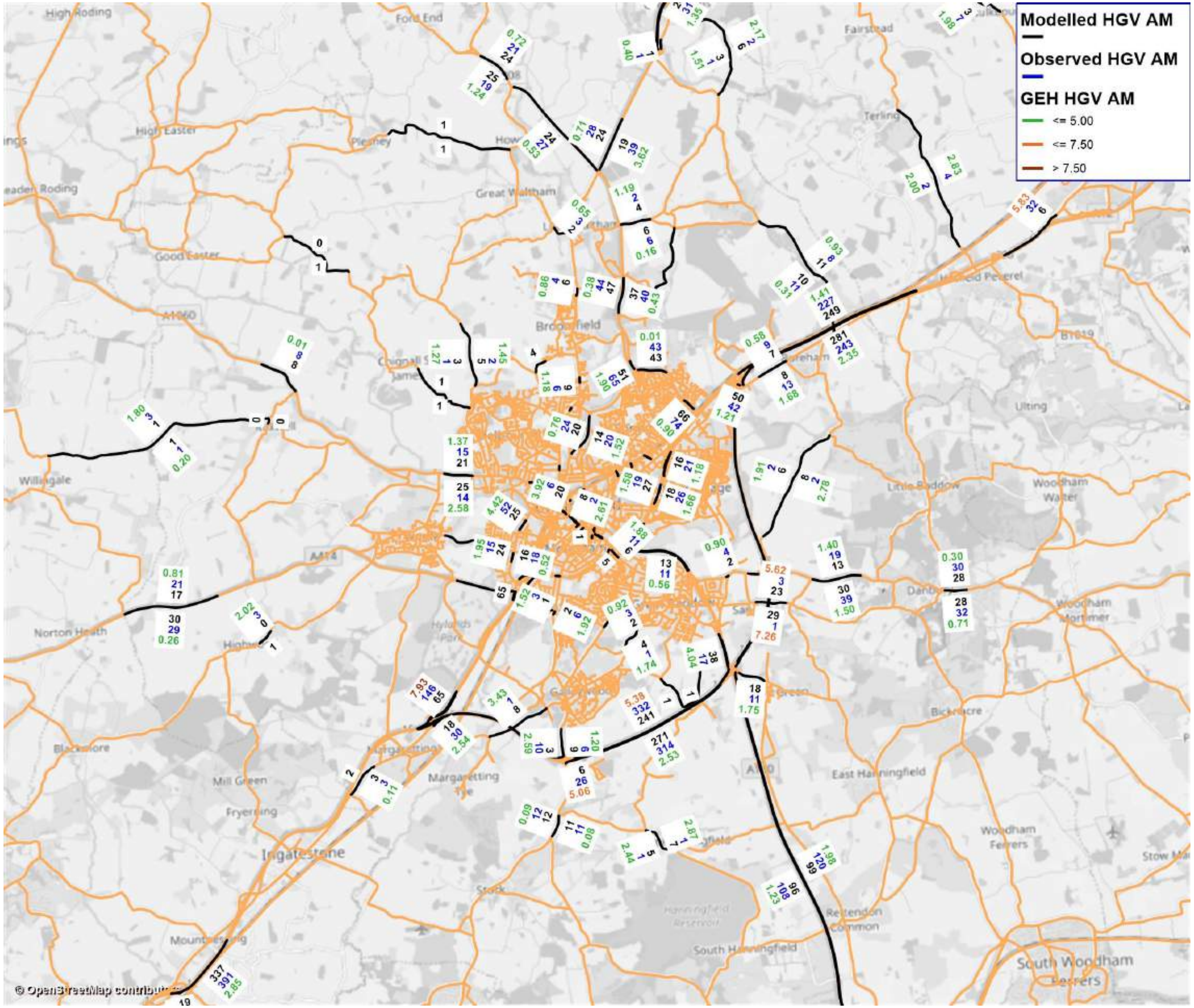

Modelled LGV IP
Observed LGV IP
GEH LGV IP
<= 5.00
<= 7.50
> 7.50
© OpenStreetMap contributors

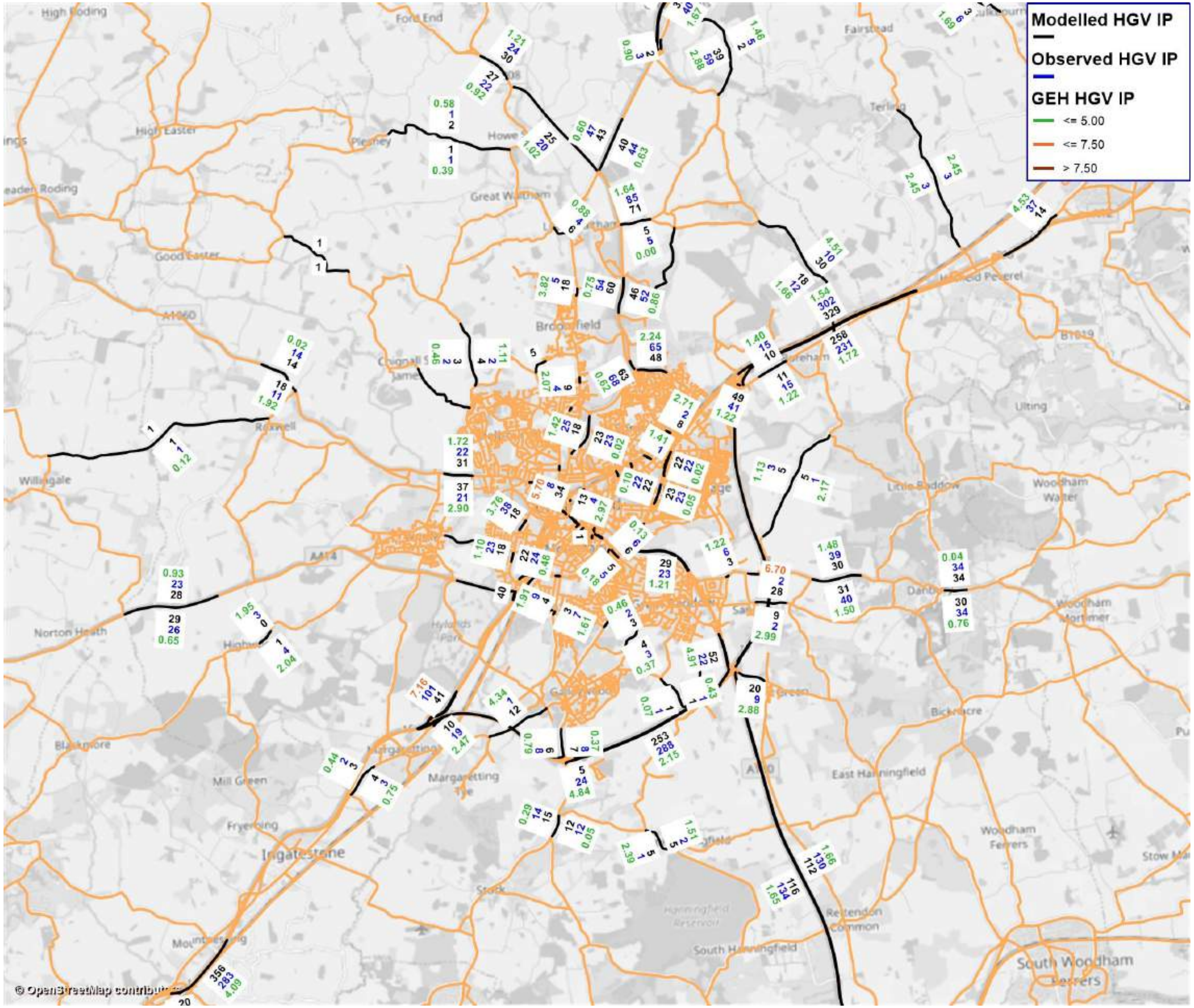

Modelled LGV PM
Observed LGV PM
GEH LGV PM
<= 5.00
<= 7.50
> 7.50
Ingatestone
South Woodham Ferrers
Broomfield
Great Waltham
Pleshey
High Easter
Good Easter
Writtle
Margaretting
Stock
Boreham
Danbury
Little Baddow
Woodham Mortimer
Woodham Walter
East Hanningfield
South Hanningfield
Rettendon Common
Hatfield Peverel
Terling
Fairstead
Ulting
Bicknacre
Woodham Ferrers
Norton Heath
Willingale
Blackmore
Mill Green
Fryerning
Mountnessing
Hanningfield Reservoir
Hylands Park
Galleywood
Chignall St James
Howe Street
Ford End
High Roding
Leaden Roding
A1060
A414
A130
B1019
© OpenStreetMap contributors


Modelled HGV AM
Observed HGV AM
GEH HGV AM
<= 5.00
<= 7.50
> 7.50
Springfield Park
Chaucer Road Meadow
Flood Plain
Moulsham
B1007
A1060
High Chelmer Shopping Centre
Essex County Cricket Ground
Central Park
Meadgate Primary School
Chelmer Village Retail Park


Modelled HGV IP
Observed HGV IP
GEH HGV IP
<= 5.00
<= 7.50
> 7.50
Springfield Park
Chaucer Road Meadow
Flood Plain
Moulsham
A1060
B1007
A138
© OpenStreetMap contributors


Modelled HGV PM
Observed HGV PM
GEH HGV PM
<= 5.00
<= 7.50
> 7.50


Modelled HGV AM
Observed HGV AM
GEH HGV AM
<= 5.00
<= 7.50
> 7.50
Ingatestone
South Woodham Ferrers



Modelled HGV IP
Observed HGV IP
GEH HGV IP
<= 5.00
<= 7.50
> 7.50
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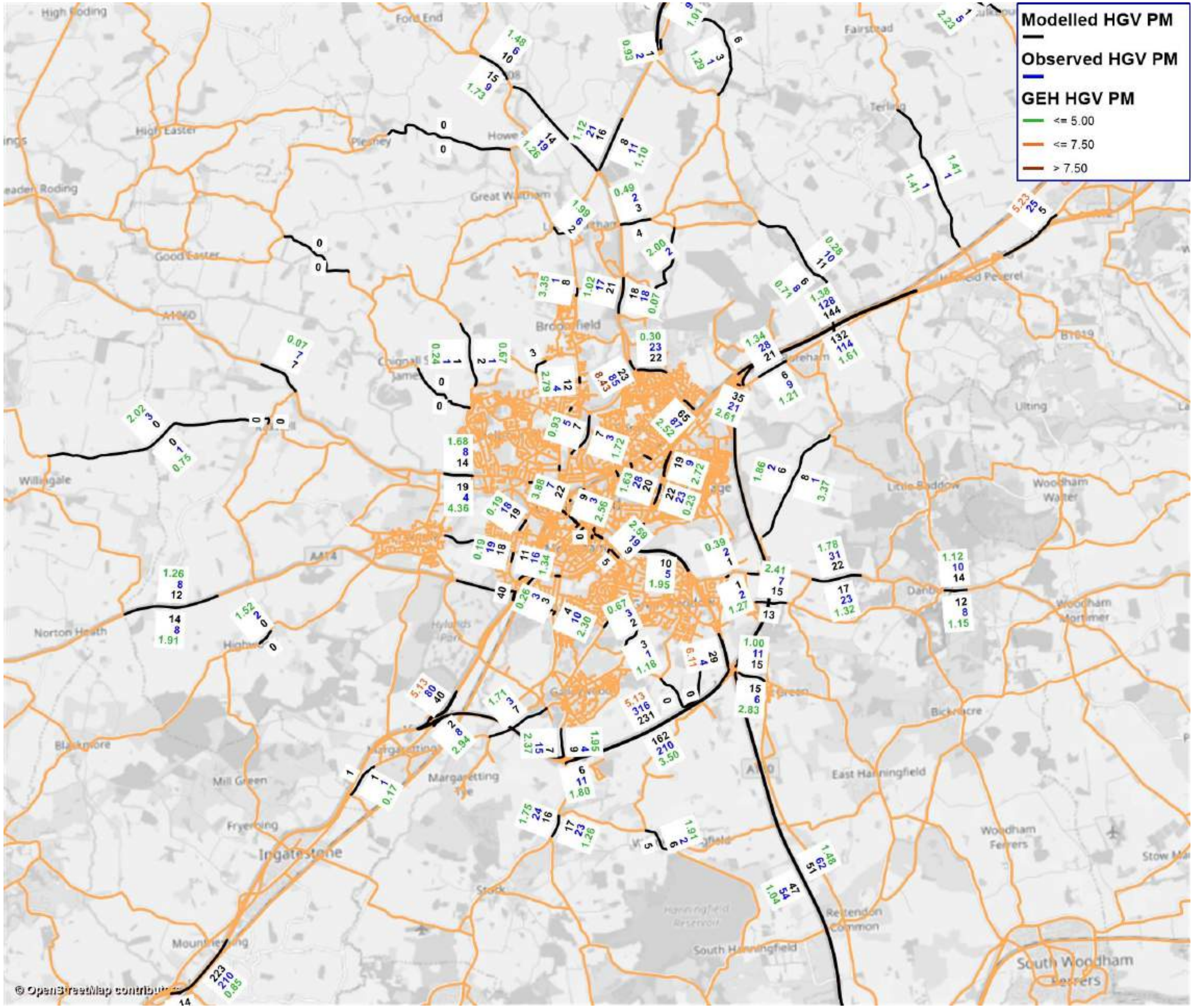
Modelled HGV PM
Observed HGV PM
GEH HGV PM
<= 5.00
<= 7.50
> 7.50
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