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WERTM SGC Update

Local Model Validation Report

South Gloucestershire

01 November 2023

Notice

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This document has 119 pages including the cover.

Document history

Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
1.0	Issue for client	AB/PJ	PV	DD	MH	04/05/2023
2.0	Updated based on client comments	AB/PJ	PV		MH	30/05/2023
3.0	Updated the reference error in v2.0	AB	PV		MH	01/06/2023
4.0	Updated based on base year model update	AB	PV	TJG	MH	27/10/2023
5.0	Updated based on client comments	AB	PV	TJG	MH	01/11/2023

Client signoff

Client	South Gloucestershire
Project	WERTM SGC Update
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Client signature / date	

Contents

Tables

Figures

1. Introduction

1.1. Background

Atkins was commissioned to undertake a partial update to the West of England Regional Transport Model (WERTM) to improve its accuracy in key areas significant to the South Gloucestershire Council (SGC) Local Plan, including the A38, A4174, North Fringe and A432. WERTM is a multi-modal transport model which utilises SATURN for the Highway Assignment Model (HAM), VISUM for the public transport assignments and variable demand model.

This report sets out the methodology for the update of the highway SATURN model and the performance against the key validation criteria, consistent with Department of Transport (DfT) TAG guidance. This model is referred to as the WERTM-SGC model in this report.

This report is an update from the WERTM_SGC_Update_LMVR_v3 which addressed the National Highways comments on WERTM-SGC model validation report submitted in June 2023.

1.2. Base Model Requirements

The WERTM-SGC model has been commissioned primarily to support the development and implementation of SGC Local plan, A38 and A432 schemes. by taking the West of England Transport Model as a framework and provide a greater SGC, this will enable further understanding of the potential highway impacts of the schemes and developments in the SGC area.

To ensure the model build is appropriate for the proposed uses, the following considerations have been taken into account:

- Ability to represent with a reasonable degree of accuracy the base year traffic conditions using the additional traffic data supplied by SGC within SGC region;
- This will also enable more robust forecast models to be developed based on the updated WERTM-SGC base year models. The Base year models are calibrated and validated against TAG criteria as far as possible in terms of traffic flows and journey times along key routes; and
- To enable the testing of effects of changes from the interventions in future, it is also necessary to ensure that this base model covered an appropriate study area.

1.3. Report Structure

Following this introduction, this report is structured as follows:

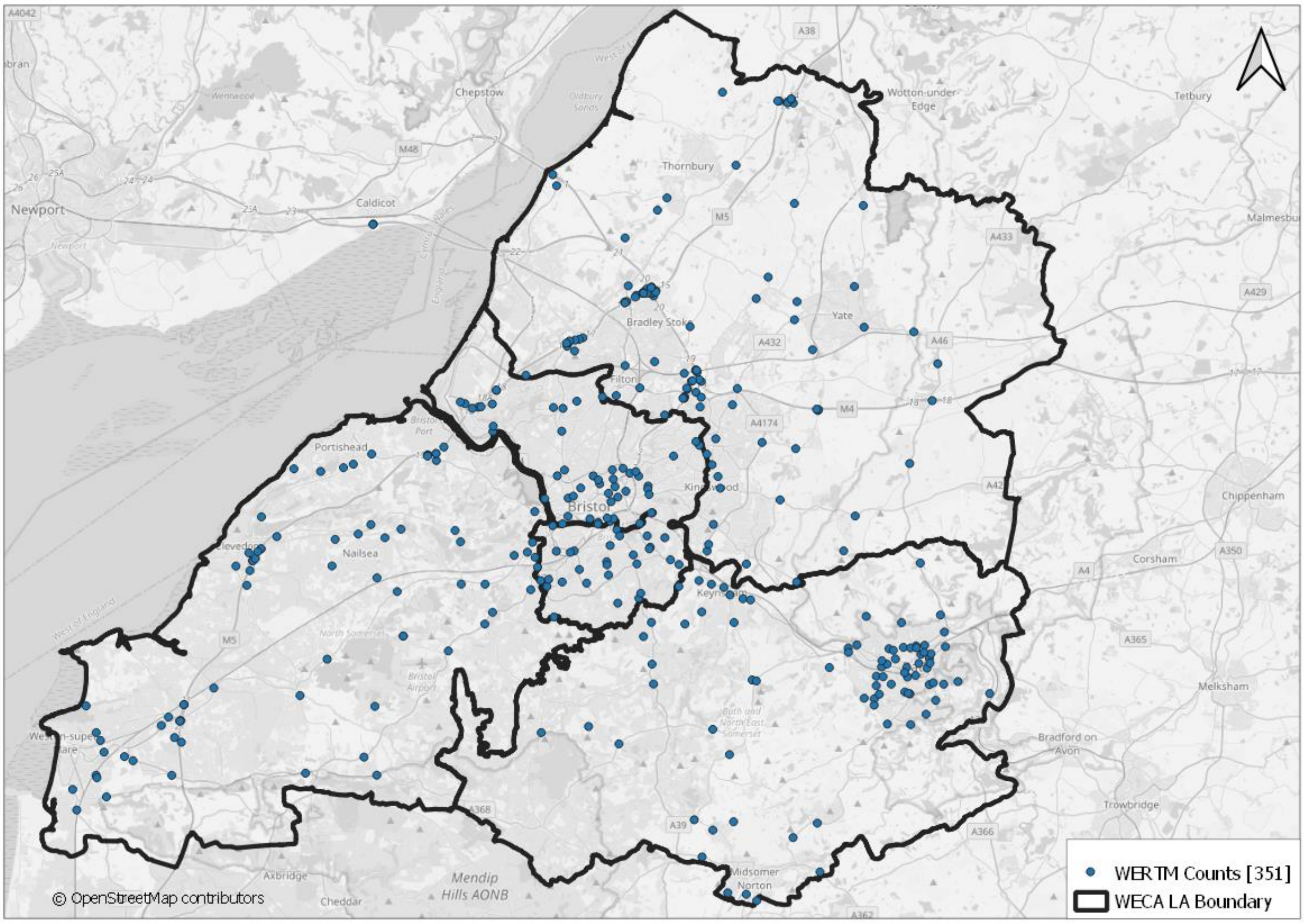
- Section 2 summarises the observed data used for model calibration and validation;
- Section 3 describes the model standards;
- Section 4 summarises the key features of the model;
- Section 5 describes the network development;
- Section 6 describes the procedures used to calibrate the model;
- Section 7 describes the matrix estimation procedure;
- Section 8 presents the calibration and validation results; and
- Section 9 summarises the model development.

2. Data Collation

2.1. Traffic Count Data Collated

Traffic count data was required to derive the observed traffic flows on key links in the study area for use in the base model calibration and validation process. The count data used in this model is only link data and was obtained and collated from two different sources – one from the WERTM model i.e., counts used in development of WERTM model and 2022 count data from SGC. Figure 2-1 below presents the location of 351 counts used in the WERTM model development.

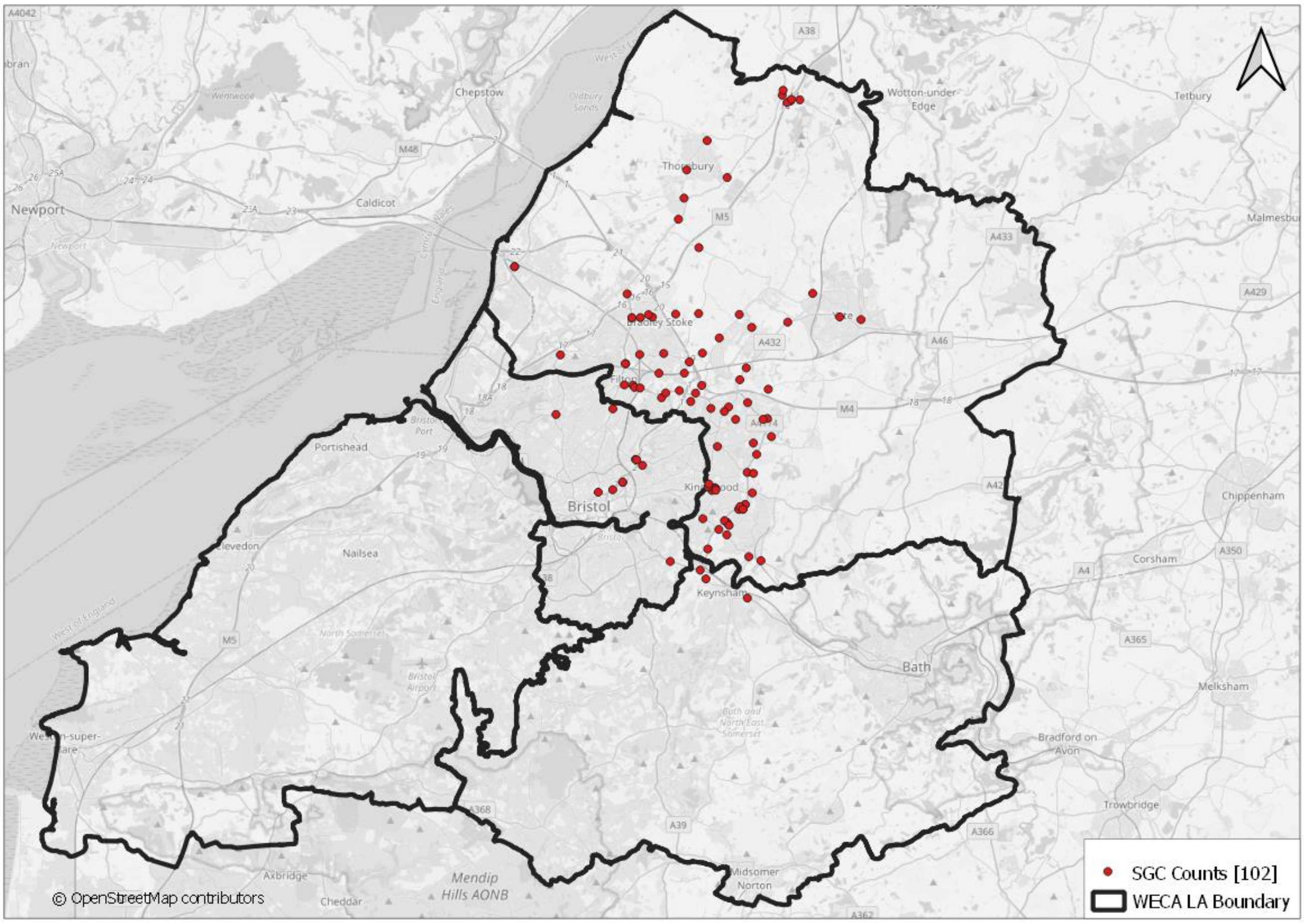
Figure 2-1 - Count sites/data used in WERTM



The count data inherited from WERTM ranged across several years starting from 2012 to 2020. Due to the varying age and durations of surveys, a number of factors have been derived to convert count data to an average weekday (Mon-Thu), neutral months (March, September and October) and 2019. Further details on data collation and processing can be found in section 14.4 of WERTM Model Development and Validation Report, section 7.4 of WERTM Data Collation Report.

In addition to the WERTM model calibration counts, the observed counts from different sources supplied by SGC were collated for the WERTM-SGC model update. Figure 2-2 below presents the location of 102 count sites collated from SGC.

Figure 2-2 - Count sites/data collated from SGC

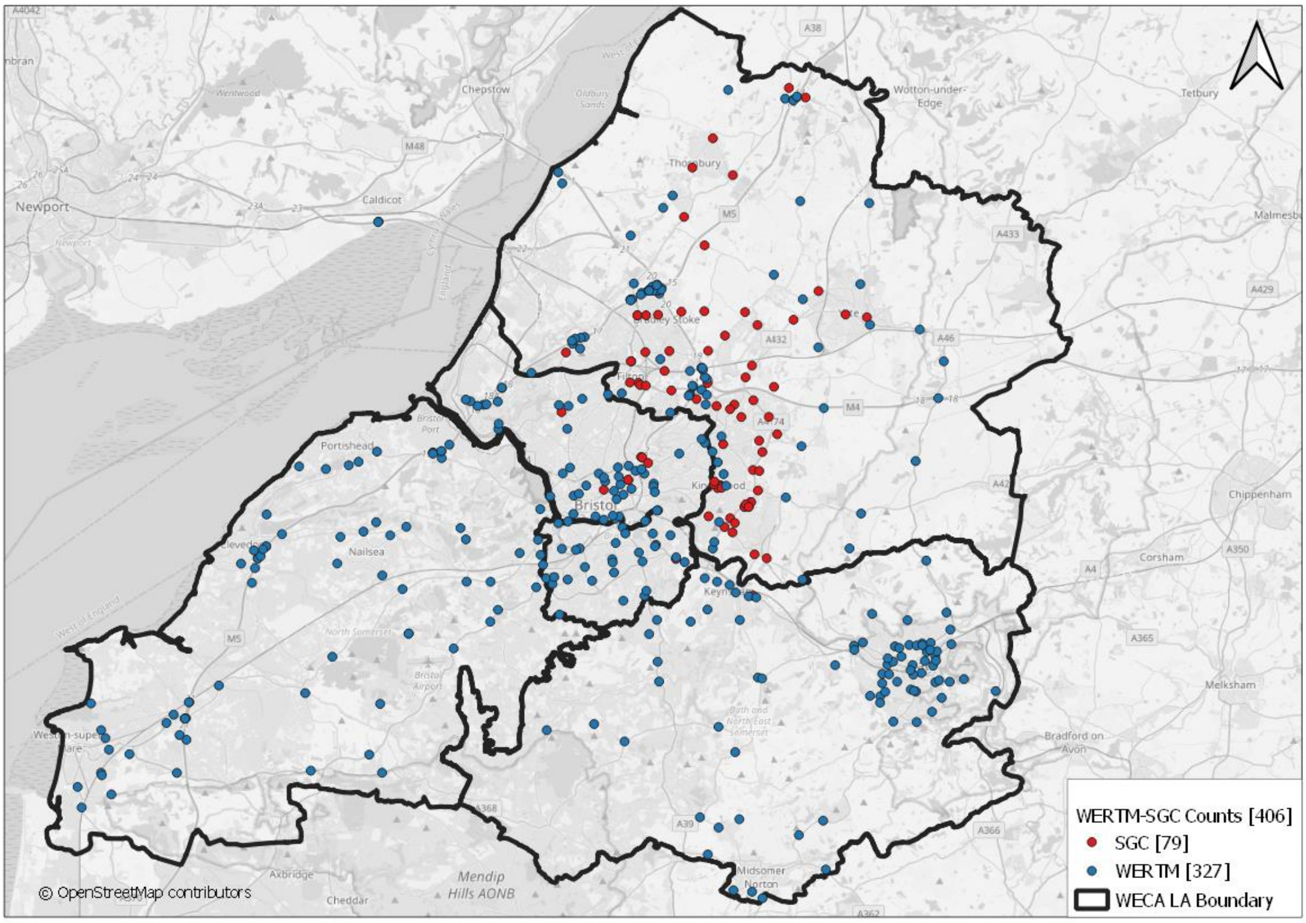


Majority of count data collated from SGC is ranging from September to November 2022. TemPro shows a growth of 2.7% between 2019 and 2022 for an average weekday in SGC. This may not be the case in reality as an increase of 2.7% between 2019 and 2022 in traffic is unlikely due to Covid. Taking this into account and due to the lack of accurate data to develop conversion factors to convert 2022 counts to the model year 2019 it was agreed with SGC to use the 2022 data as is in the model development. During the model development sensitivity analysis was undertaken to understand the impact of change in count data, this is presented in the subsequent sections.

All the ATC sites are processed and used in the model development after removal of outliers in the data sets. A confidence interval is calculated for each hour of the data set using 1% significance level (or 99% confidence level) and outliers i.e., dates with count data falling outside the confidence interval are removed. In addition to this, tidality and the hourly profiles of the count data are also sense checked.

All the counts within SGC boundary from WERTM and SGC were compiled to form a single data set (i.e., 406 counts comprising of 730 links) for the WERTM-SGC model calibration. Figure 2-3 below presents the combined count locations classified by source of the count i.e., WERTM or SGC.

Figure 2-3 - WERTM-SGC Combined Counts classified by source of count



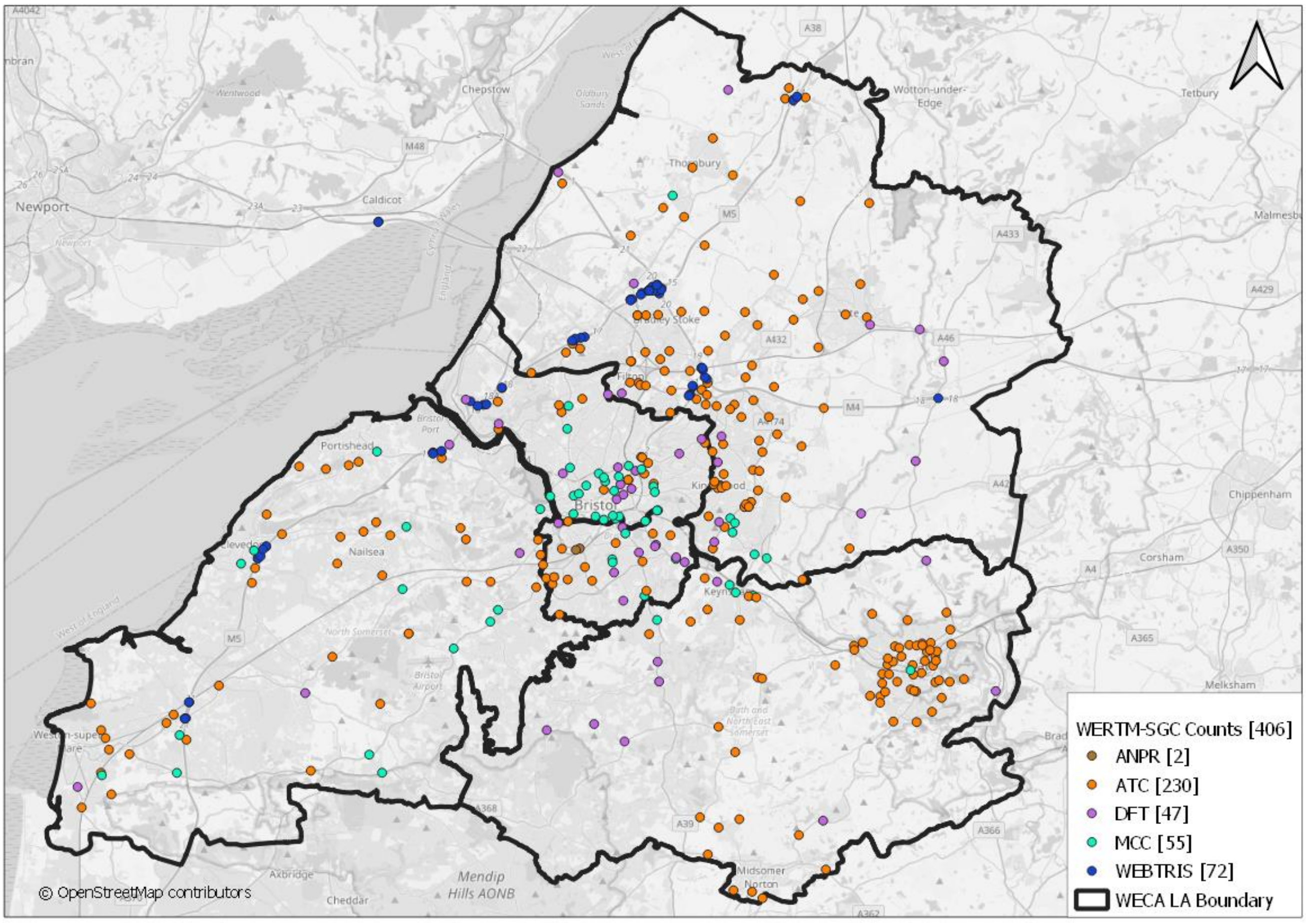
The sources for all the 406 count locations used in WERTM-SGC model development is presented in Table 2-1 below.

Table 2-1 – Count data classification

Type	Description	Number of counts in full model	Number of counts falling in SGC
ANPR	Automatic Number Plate Recognition	2	0
ATC	Automatic Traffic Counts providing vehicle classification and volume of traffic for multiple weeks	230	93
DfT	Single day link level traffic estimates on motorway and 'A' road network, and for some minor roads	47	14
MCC	Single day manual classified counts	55	6
WebTRIS	Traffic flow from permanent counts on all motorways and 'A' roads managed by National Highways, known as the Strategic Road Network, in England	72	41
Total		406	154

Figure 2-4 below presents the count site locations classified by type of count used in model development. Majority of the count locations in SGC are either ATC or WebTRIS which are multiple day counts. This gives the better confidence on the model calibration.

Figure 2-4 – WERTM-SGC Combined Counts classified by type of count



2.2. Journey Time Data

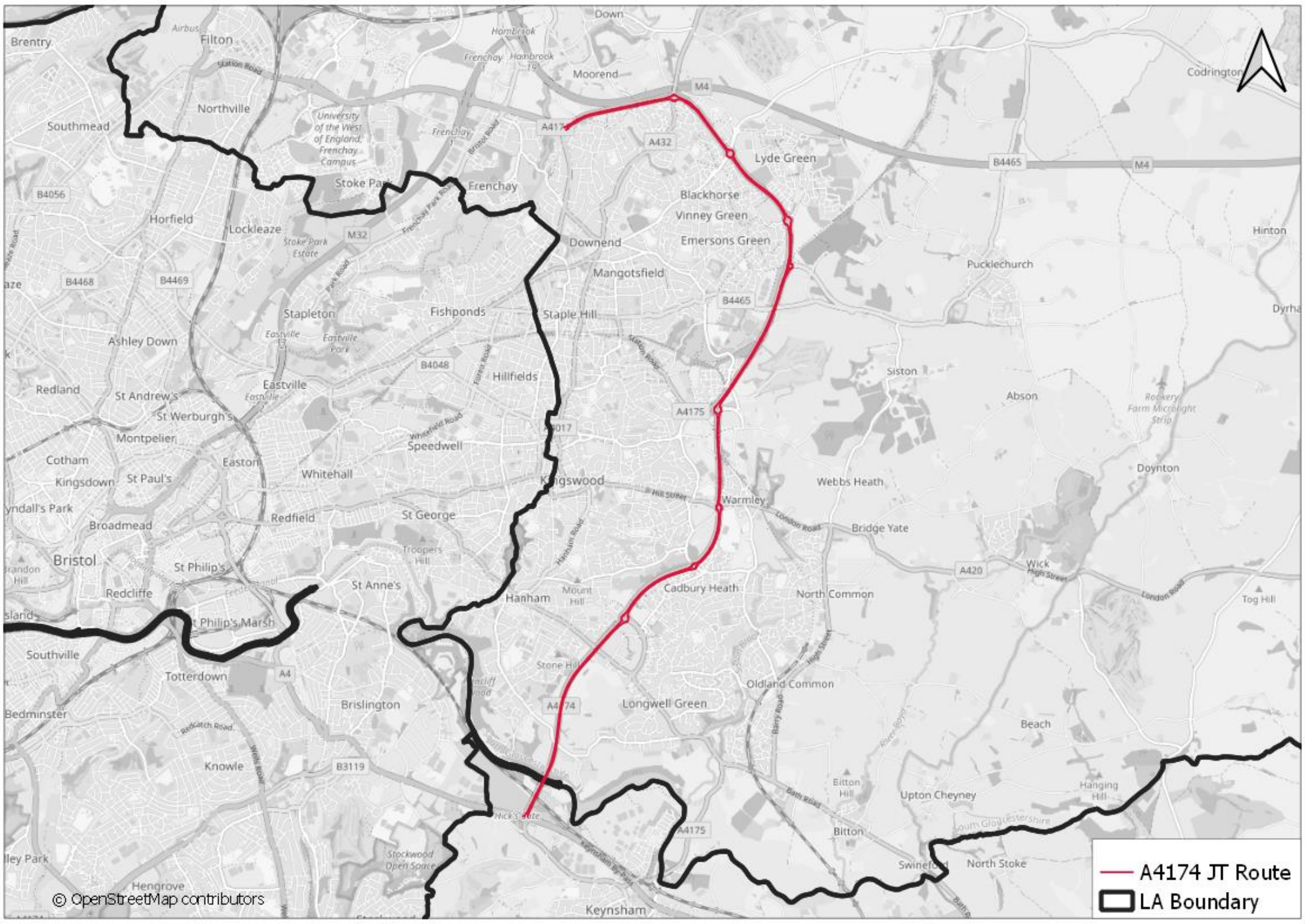
It is a requirement of the model validation process that the modelled speeds/times fall within an acceptable range of observed speeds/times. For this purpose, TomTom data for the base year 2019 was collated and processed for the analysis of journey times in the study area.

Average neutral weekday data was analysed along the A4174 route (shown in Figure 2-5) for the neutral months of 2019 excluding bank and school holidays. Journey time routes descriptions are given in Table 2-2. To provide better granularity in the validation of travel times on the longer route, it has been split into nine shorter segments to aid the validation process, ensuring that travel times can be validated at a more disaggregate level than end-to-end comparisons.

Table 2-2 – A4174 Journey Time Route

Route ID	Description	Distance (Km)
JTR 1 NB	Hick's Gate Roundabout to Bromley Heath Roundabout	12.2
JTR 1 SB	Bromley Heath Roundabout to Hick's Gate Roundabout	12.3

Figure 2-5 – A4174 Journey Time Route



3. Model Standards

The highway assignment model has been developed following the guidance in TAG Unit M3.1, Highway Assignment Modelling[1]. This chapter presents the TAG guidelines or standards to which the model has been calibrated and validated.

3.1. Validation Criteria and Acceptability Guidelines

TAG M3.1 quotes the below text for the validation criteria for a highway assignment model.

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

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

3.2. Trip Matrix Validation

The trip matrix validation measure used for the validation process is the percentage difference between modelled flows and counts. Comparisons at screenline level provide information on the quality of the trip matrices. TAG M3.1 describes the validation criterion and acceptability guideline as shown in Table 3-1.

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

Criterion	Acceptability Guidelines
Differences between modelled flows and counts should be less than 5% of the counts	All or nearly all screenlines (i.e., 95%)

Source: TAG Unit M3.1 Table 1

Regarding the screenline validation, the following should be noted:[2]

- *Screenlines should normally be made up of 5 links or more;*
- *The comparisons for screenlines containing high flow routes such as motorways should be presented both including and excluding such routes;*
- *The comparisons should be presented separately for (a) where data were used to inform matrix development; (b) for screenlines used as constraints in matrix estimation; and (c) screenlines used for independent validation (as noted in para 3.3.1 there may also be a need to report both validation tests and then the extent of change when data are used to refine the model);*
- *The comparisons should be presented by vehicle type (preferably cars, light goods vehicles and other goods vehicles); and*
- *The comparisons should be presented separately for each modelled period.*

3.3. Link Flow and Turning Movement Validation

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

[1] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/938864/tag-m3-1-highway-assignment-modelling.pdf

[2] TAG Unit M3.1 Highway Assignment Modelling May 2020 (Page 19)

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

Where: GEH is the GEH Statistic;

M is the modelled flow; and

C is the observed flow.

These two measures are broadly consistent and link flows that meet either criterion should be regarded as satisfactory.

The validation criteria and acceptability guidelines for the link flows and turning movements as given in TAG Unit M3.1 are defined in Table 3-2

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

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

Source: TAG Unit M3.1 Table 2

Regarding flow validation, the following should be noted:[3]

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

3.4. Journey Time Validation

Journey time validation compares the percentage difference between modelled and observed journey times, subject to an absolute maximum difference. TAG Unit M3.1 describes the criteria and guidelines, as shown in Table 3-3.

Table 3-3 – Journey Time Validation Criterion and Acceptability Guideline

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

Source: TAG Unit M3.1 Table 3

3.5. Convergence Measures and Acceptable Values

The most appropriate convergence measures (of proximity and stability) and the values generally considered acceptable for use in establishing a base model as given in TAG Unit M3.1 is given in Table 3-4

[3] TAG Unit M3.1 Highway Assignment Modelling May 2020 (Page 20)

Table 3-4 – Summary of Convergence Measures and Base Model Acceptable Values

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

Source: TAG Unit M3.1 Table 4

3.6. Intended Impact of Matrix Estimation

TAG Unit M3.1 state that the changes brought by Matrix Estimation (ME) 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 the significance of the changes brought about by matrix estimation may be judged are given in Table 3-5

Table 3-5 – Significance of Matrix Estimation Changes

Measure	Significance Criteria
Matrix zonal cell values	Slope within 0.98 and 1.02 Intercept near zero R2 in excess of 0.95
Matrix zonal trip ends	Slope within 0.99 and 1.01 Intercept near zero R2 in excess of 0.98
Trip length distributions	Means within 5% Standard deviations within 5%
Sector to sector level matrices	Differences within 5%

Source: TAG Unit M3.1 Table – 5

TAG Unit M3.1 states that it is important that the fidelity of the underlying trip matrices is not compromised to meet the validation standards. All exceptions to these criteria should be examined and assessed for their importance for the accuracy of the matrices.

4. Model Data

This section details the specification of the WERTM-SGC model in terms of temporal scope, spatial coverage and the level of network and zoning detail, demonstrating its suitability for its intended purposes. This chapter also sets out the details regarding some of the key characteristics of the model. As the starting point of the model development is WERTM, the model specifications remain same as that of the WERTM defined in its Model Development and Validation Report (MDVR).

4.1. Model Base Year

The model has been built for a base year of 2019, which means that all model inputs are developed based on this year. As specified by TAG, the model represents a neutral weekday excluding the bank and school holidays.

4.2. Modelling Software

The WERTM-SGC highway assignment model has been developed using SATURN version 11.5.05H. SATURN is regarded as the industry standard strategic highway assignment modelling tool used widely for the assessment of highway schemes and can provide robust analysis of small to large infrastructure developments.

4.3. Model Extent

The geographic scope of the model was focused on the four authorities making up the West of England region (Bath & North-East Somerset (B&NES), Bristol City, North Somerset, and South Gloucestershire), and covers all travel movements within, to and from and through the area. Table 4-1 provides the details of geographical extent of WERTM model.

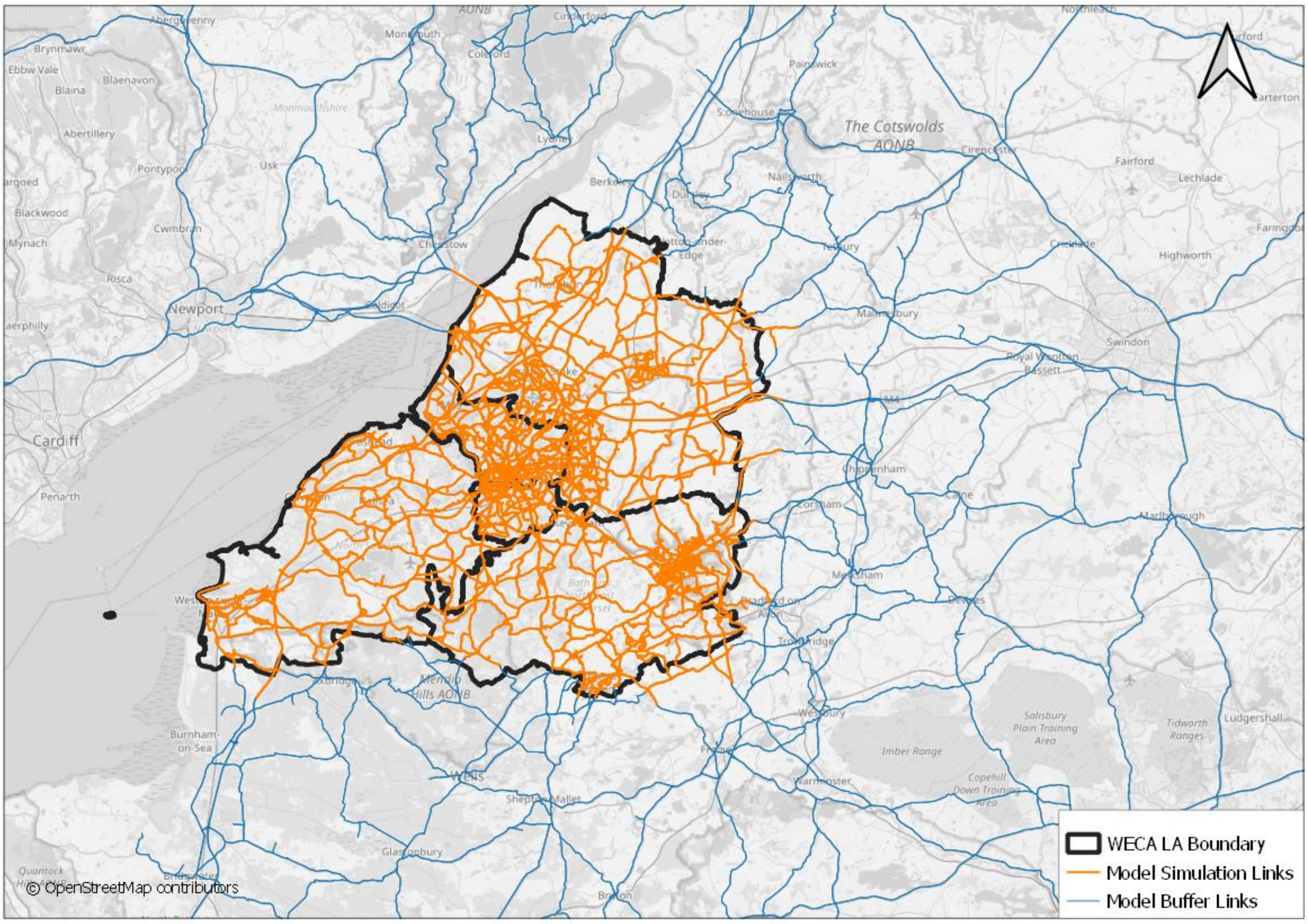
Table 4-1 – Geographical coverage of WERTM

Area Type	Areas Covered	Highway model Detail
Area of Detailed Modelling (AoDM)	Bristol, Bath and North- East Somerset, South Gloucestershire, Eastern region of North Somerset	Coded in simulation with junction delay represented based on significance. Network to include most roads (e.g., all motorways, trunk roads, primary, secondary roads) Tertiary and unclassified roads included where strategic routeing occurs or where required for zone loading. Note, in rural areas, detail is necessarily focussed on strategic (e.g., inter-urban and other important route) corridors.
Rest of Fully Modelled Area (RoFMA)	Rest of North Somerset	Motorway, trunk road, primary and secondary roads. Some tertiary roads where required for zone loading. Primarily speed flow curves on links but with key junctions coded in detail (e.g., those along the M5).
External Area	Extending into Gloucestershire, Sedgemoor, Mendip and Monmouthshire and the rest of UK	Major routes (motorways and A roads) sufficient to join external zones into model and represented as ‘buffer’ network. Link representation only with fixed speeds. Skeletal network of key motorways sufficient to link zones defined at the County or Regional level. Link representation only with fixed speeds.

All the four authorities namely South Gloucestershire, Bristol, Bath & Northeast Somerset, and North Somerset are in Simulation area and rest of the model is buffer as shown in Figure 4-1.

South Gloucestershire is considered as the study area for the WERTM-SGC model development.

Figure 4-1 – WERTM Network extent



4.4. Zoning System

The zoning system representing the spatial properties of geographic areas is a fundamental basis of all aggregate traffic models and has a critical impact on the quality and credibility of model outputs. Zones should be smaller in the simulation area, becoming coarser for the buffer area and progressively much larger for the external area.

Based on the geographic location, the HAM zones were divided into three categories: Area of Detailed Modelling, the Rest of Fully Modelled Area and external area. Whilst there are no functional differences between zones across the areas, the level of detail in the network is progressively reduced the further the distance from the Area of Detailed Modelling they are.

The HAM zoning system was based on Census boundaries and are aggregates of PTAM zones. Zones become progressively larger as distance from the Area of Detailed Modelling increased, using individual, or combinations of, OAs, LSOAs, and MSOAs

Figure 4-2 – WERTM Zoning System

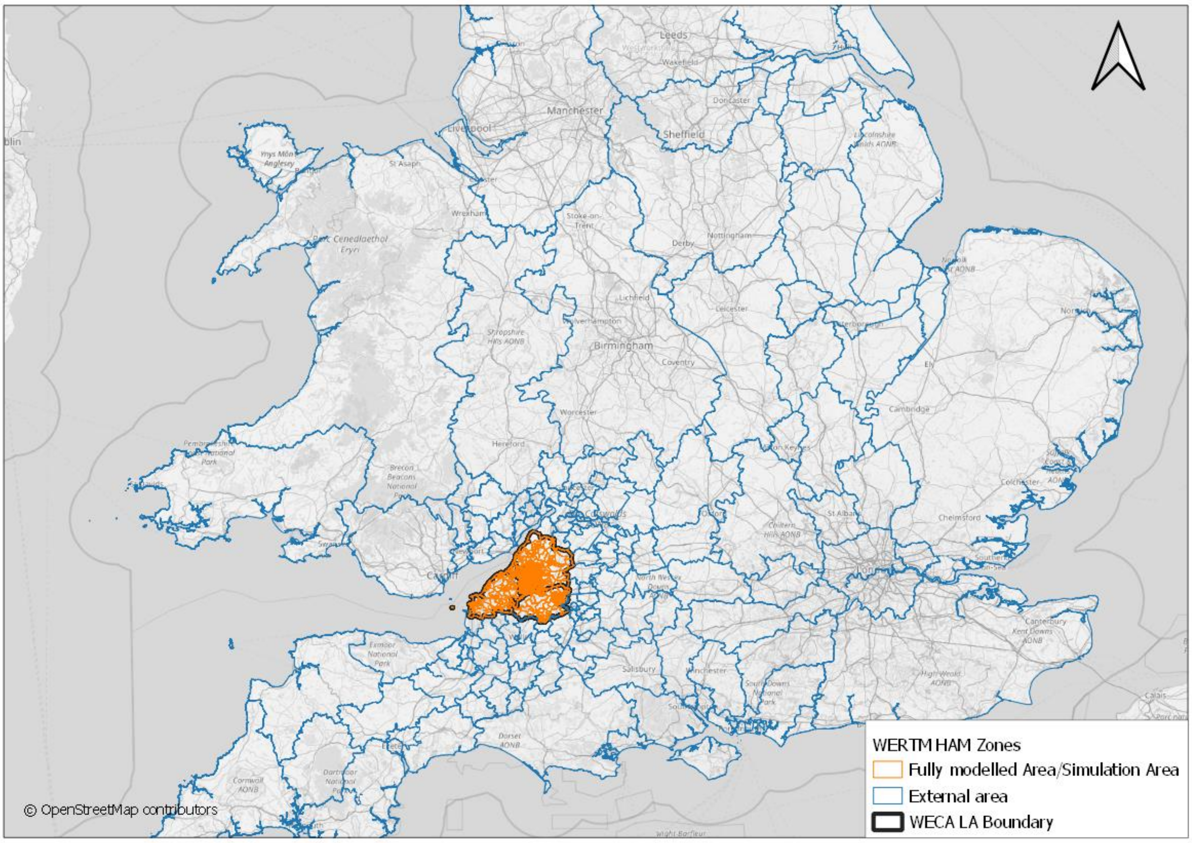
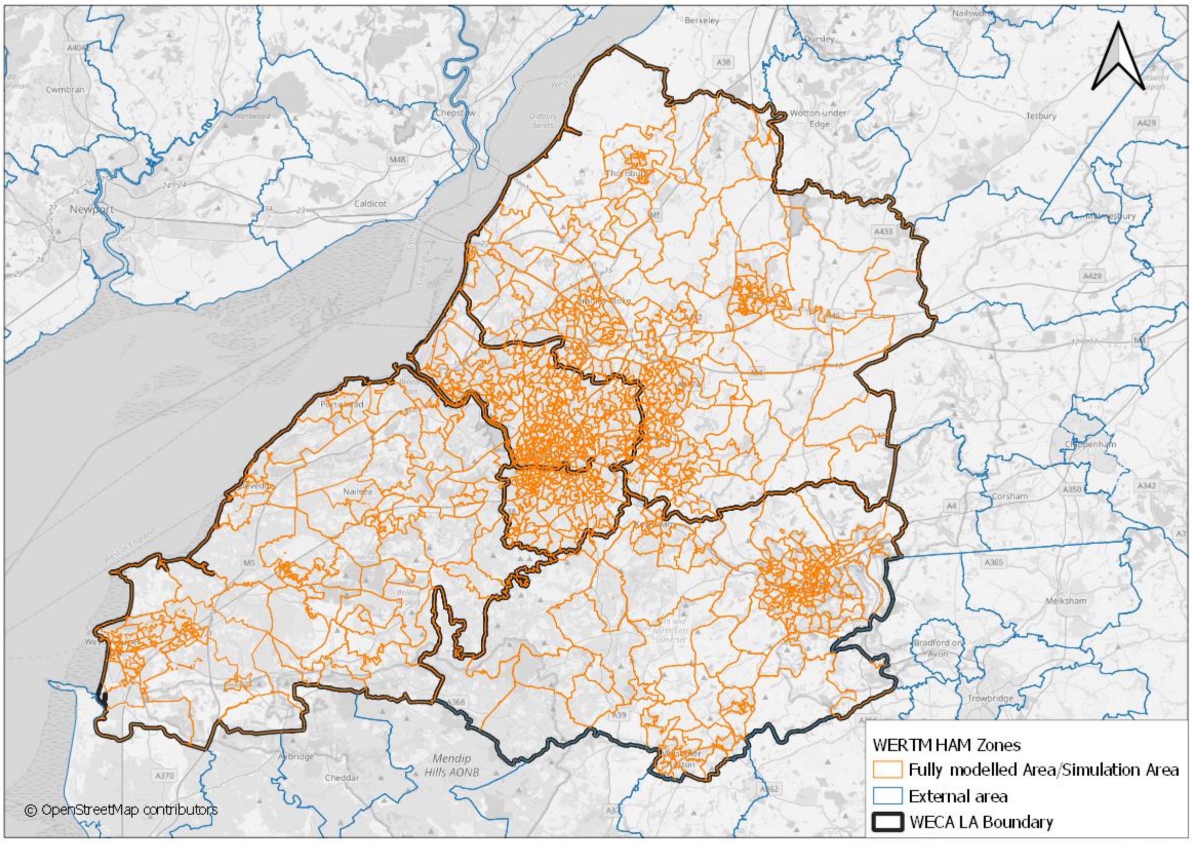


Figure 4-3 – WERTM Zoning System – Simulation Area



4.5. Centroid Connectors

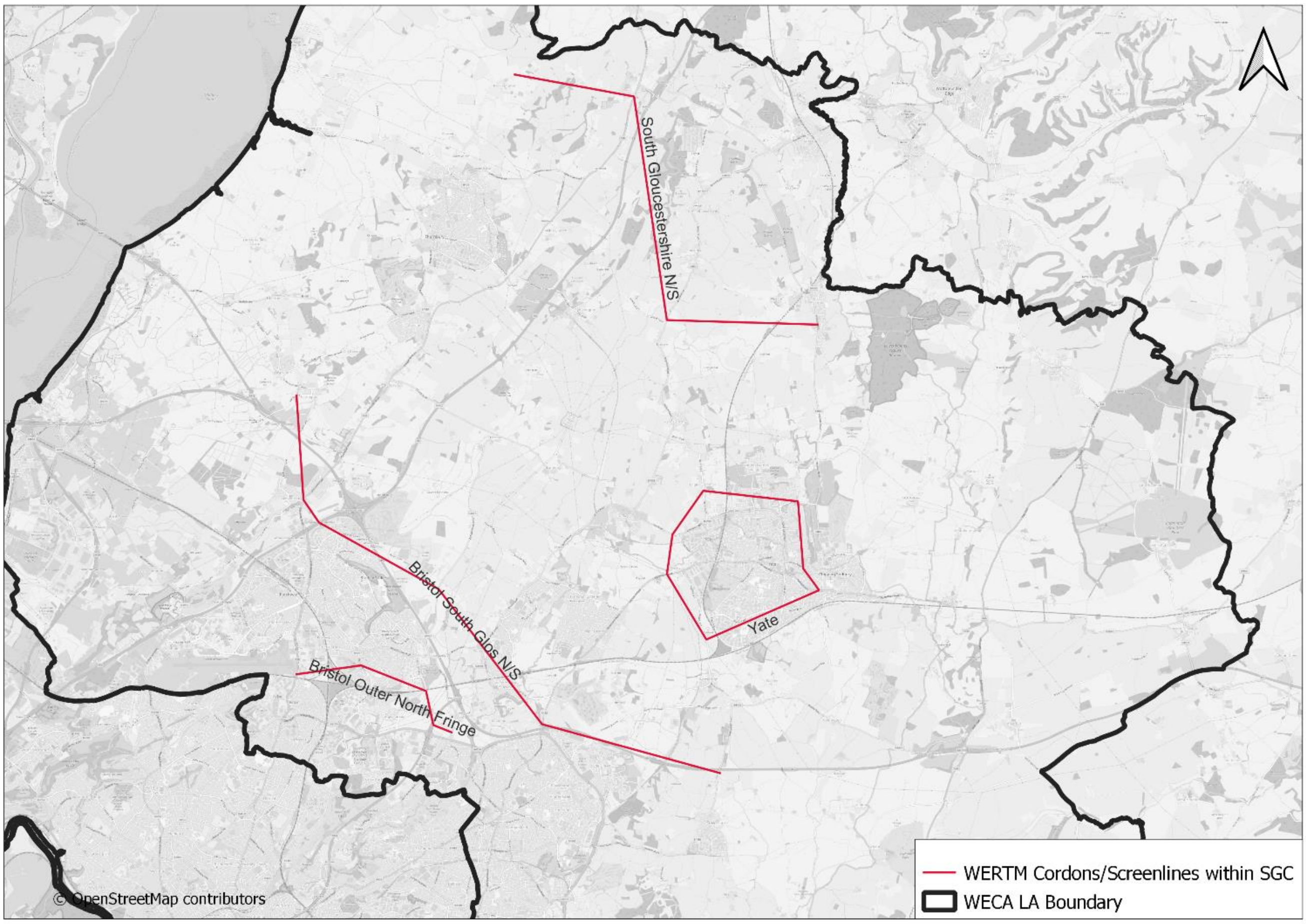
Centroid connectors provide connectivity between zones and the highway link network. Zone centroids are located at the population-weighted centre of each zone, using Census 2011 population and employment data, which ensures a more appropriate distribution of trips onto the network where, for example, population may be located within a small, urbanised area in a larger rural zone.

4.6. Cordon/Screenlines

No screenlines have been separately formed as part of this model development.

In WERTM model development flow constraint is applied at link level rather than cordon/screenlines although calibration screenlines and cordons were defined, all count data is used for calibration and retaining no data for validation as explained in section 25.4 of WERTM MDVR. Similar to WERTM, current model development has also used only link flow constraints. However model performance is checked against one cordon and three screenlines defined in WERTM falling in SGC. Figure 4-4 below presents the one cordon and three screenlines from WERTM within the WERTM-SGC model area.

Figure 4-4 – WERTM Cordons/Screenlines within SGC



4.7. Temporal Coverage

The HAM consists of three peak hour time periods as shown in Table 4-2. They represent the AM and PM peak hours, plus an average hour period representing the Inter-peak.

Table 4-2 - Model Peak Hours

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

The peak hours have been chosen based on analysis of long-term traffic flow data. The purpose of the peak hours are to represent the most congested travel conditions of a neutral weekday. The analysis of the peak hour data can be found in the WERTM Data Collation Report.

For the purposes of the highway assignment, an additional pre-peak model assignment was used to reflect the congested highway conditions at the beginning of the AM (07:00 – 08:00) and PM (16:00 – 17:00) peak hour model assignments. This utilises the 'PASSQ' function of the SATURN program that allows residual queuing on the highway network to be present at the beginning of peak hour assignment and allows for more accurate representation of delay in the model.

The pre-peak models use the same model network as the corresponding peak hour model. No pre-peak model was developed for the inter-peak as this model is an average hour model covering 10:00-16:00 and queues do not persist over extended periods.

4.8. Demand Segmentation

User Classes (UC) are used to differentiate between the differing characteristics of vehicle users within the HAM. It is important that appropriate demand segmentation is applied to the assignment as the vehicle operating costs and values of time vary by different user classes. A total of five user classes have been used to represent the trip purposes in the model as presented in Table 4-3. The first three are sub-categories of car users and the last two represents the trip characteristics of goods vehicles.

Table 4-3 - User Class Definition

User Class	Vehicle Type	Purpose
1	Car	Commuting
2	Car	Employer Business (EB)
3	Car	Other
4	Light Goods Vehicles (LGV)	
5	Heavy Goods Vehicles (HGV)	

4.8.1. PCU Factors

Passenger Car Units (PCUs) are used as a standard unit in SATURN for demand and capacities as opposed to vehicles. This allows the effect of longer/slower vehicles that occupy more road space and take longer time to clear junctions to be represented within the model. The vehicle to PCU conversion factors used for the various user classes are summarised in Table 4-4.

Table 4-4 - PCU Conversion Factors

Vehicle Type	Description	PCU Factor
Car	Private Car	1.00
LGV	Light Goods Vehicles	1.00
HGV	OGV1 and OGV2 (Rigid and Articulated)	2.50

4.9. Assignment Methodology

The assignment of trips to the highway network was undertaken using a standard 'Wardrop User Equilibrium' approach, which seeks to minimise travel costs for all vehicles in the network. The Wardrop User Equilibrium is based on the following proposition:

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

The Wardrop User Equilibrium as implemented in SATURN is based on the 'Frank-Wolfe Algorithm', which employs an iterative process. This process is based on successive 'All or Nothing' assignments, where the certain proportion of flows of successive assignments are combined to minimise an 'Objective Function'. The travel costs are recalculated on each iteration, and then compared to the previous iteration. The process is terminated once successive iteration costs have not changed significantly. This process results in possible multi-routing between any origin-destination pair.

The assignment is based on minimum generalised cost routes where the generalised cost is defined as a linear combination of time and distance as given in Equation 4-1.

Equation 4-1 - Generalised Cost Equation

$$C = PPM * T + PPK * D + M$$

Where: C is the cost in units of pence,

T is time in units of minutes (including any 44444 time penalties),

D is distance in kilometres,

M is monetary change in pence,

PPM specifies "Pence Per Minute"

PPK specifies "Pence Per Kilometre"

4.10. Generalised Cost

The cost of travel is expressed in terms of generalised cost minutes which can be related back to values of time and out-of-pocket costs in accordance with the TAG Unit A1.3[4]. The coefficients for the individual components of generalised costs were calculated using TAG Unit A1.3 (November 2021 v1.17) and are presented in Table 4-5 below. These are consistent with the parameters used in WERTM model development.

As stated in paragraph 2.8.8 of TAG Unit M3.1 - Highway Assignment Modelling, the value of time given in TAG Unit A1.3 for HGVs related to the driver's time and did not consider the influence of owners on the routing of these vehicles and it is possible to apply an owner/operator factor of 2.0 to HGV VoT to take account of the influence of owners on the routeing of these vehicles.

Table 4-5 – Base Year 2019 PPM and PPK Values by User Class and Time Period

User Class	PPM			PPK
	AM	IP	PM	All Day
Car Commute	24.38	24.78	24.46	6.96
Car Business	36.35	37.25	36.88	14.53
Car Other	16.82	17.92	17.61	6.96
LGV	26.35	26.35	26.35	15.85
HGV	52.48	52.48	52.48	47.85

[4] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/603254/webtag-tag-unit-a1-3-user-and-provider-impacts-march-2017.pdf

4.11. Capacity Restraint Mechanisms

In the fully modelled area, speed-flows curves have been used within the model for the car and LGV based user classes where link delays are distinct and significantly in excess of junction delays. These align with relationships provided in TAG unit M3.1.

In order to represent the restricted maximum speed for HGVs on the highway network it is necessary to reduce the maximum (free flow) speed available to the HGV user class in the model. This has been achieved using the CLICKS facility within SATURN.

5. Network Development

5.1. Introduction

WERTM HAM is the starting point/donor model for the WERTM-SGC model development and consists of detailed simulated junctions and links in the immediate study area with lesser detailed network away from the study area. This chapter presents the network updates/improvements carried out on WERTM.

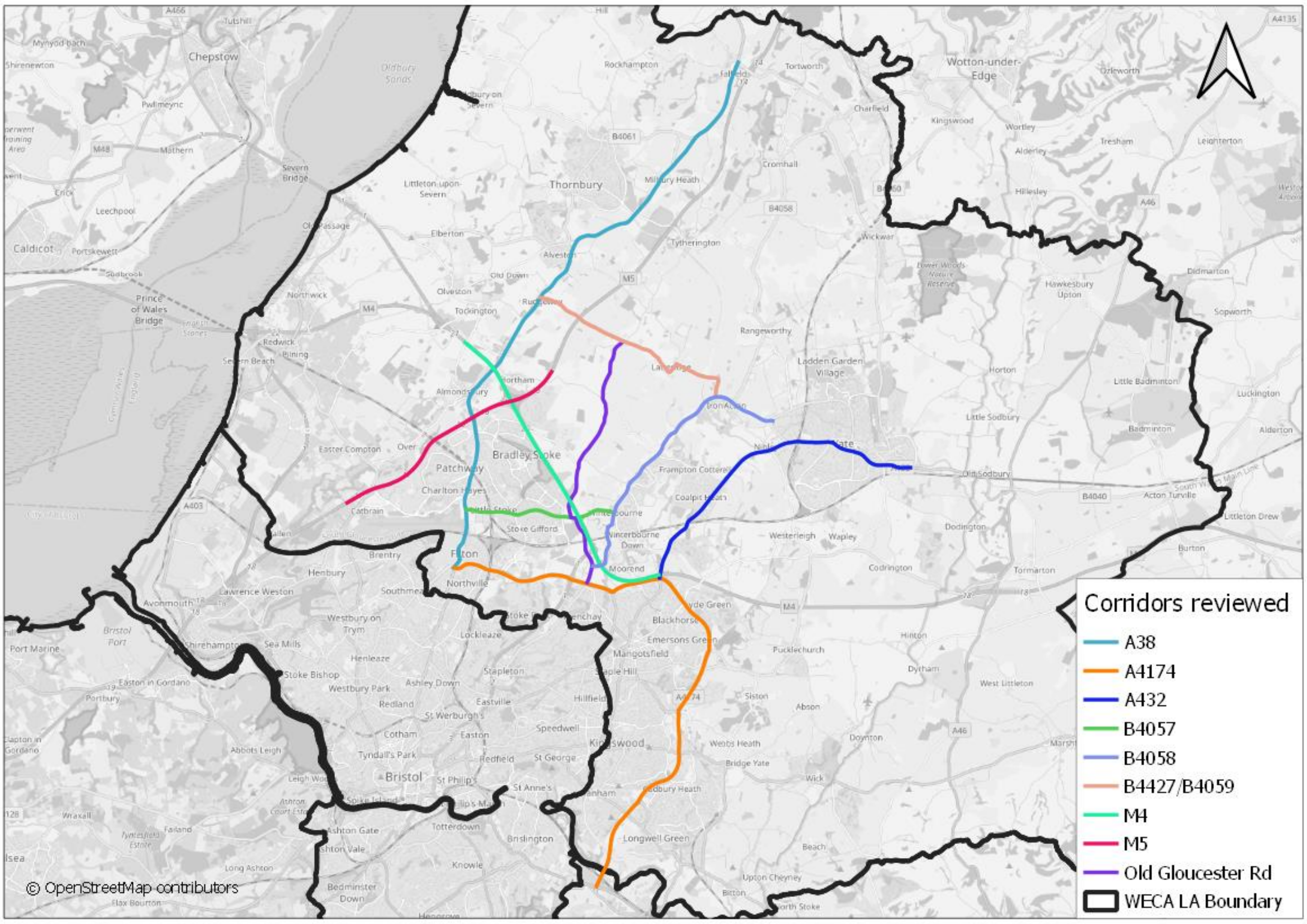
5.2. Network Coverage

Complete South Gloucestershire district is considered as the study area for this model and thus the key corridors of A38N, A4174, North Fringe and A432 were focussed more on during the model development.

5.3. Network Review

Detailed network coding review was undertaken on the key corridors of the model. The corridors considered for review are shown in Figure 5-1.

Figure 5-1 - Corridors Reviewed in WERTM



During this process, the junction and link coding was reviewed against the on-ground conditions using Google Maps and Street View for model year 2019 in conjunction with the WERTM network coding manual for the following attributes:

- Junction type and configuration;
- Number of lanes per arm and turn allocation;
- Turn saturation flows;

- Link lengths;
- Speed;
- Distance;
- Speed flow curve;
- Zone centroid connectors; and
- Banned turns.

In addition to these corridors, a network review was also undertaken in the areas/roads passing through Bradley Stoke, Kingswood, Alveston, Thornbury, Tytherington, local roads connecting Old Gloucester Road to A38, M5J14.

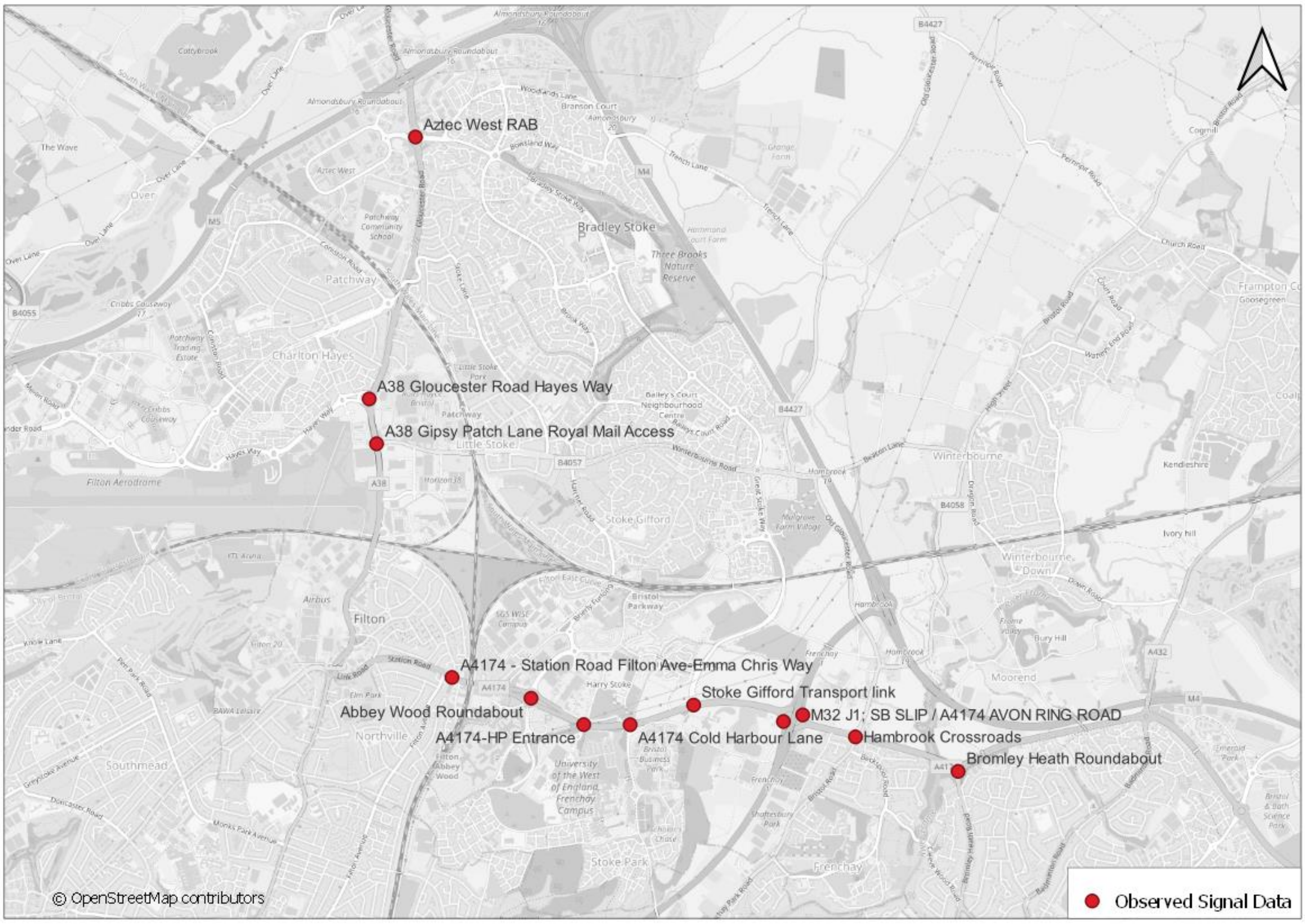
Network consistency checks were undertaken throughout the process to make sure the updates are carried out in all peak models.

Detailed network changes are presented in *WERTM-SGC_Network Updates_TN_v2.0.pdf*

5.4. Signal Timings

Signal timings from WERTM were retained at all junctions except where signal data was received from SGC. Signal times were updated based on the latest observed signal data for the junctions shown in Figure 5-2 below.

Figure 5-2 - Observed Signal Data



6. Calibration and Validation Procedures

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

Model Validation aims to demonstrate that the calibrated model reproduces observed base year traffic conditions. This is done by comparing model outputs with data independent of that used in model calibration.

6.1. Calibration/Validation

For the WERTM-SGC model, count sites presented in 2.1 were used for calibration. Model was validated against the observed journey time along A4174.

6.2. Calibration Procedure

The calibration procedure involved a series of steps designed to improve the performance of the model and ensure it was replicating observed 2019 traffic flows and journey times. Tasks included:

- Ensuring network characteristics, such as free-flow speeds and signal phases/timings represent observed conditions;
- Ensuring capacity controls such as speed-flow curves, saturation flows and turn capacities were appropriate to replicate observed conditions; and
- Once calibration of the initial assignment was carried out, Matrix Estimation (ME) was then applied to ‘fit’ prior trip matrices to traffic flows in the study area.

7. Matrix Estimation

Matrix Estimation (ME) is a process to adjust prior trip matrices so that, when assigned, the model flows are as close to the observed counts.

7.1. Case for Matrix Estimation

TAG unit M3.1 advises that the primary purpose of ME is to refine estimates of trips which have been synthesised i.e., the 'prior' matrices. To check the need to use ME, prior matrix modelled flows in each time period were compared against observed flows. Table 7-1 to Table 7-3 presents the summary of link calibration against prior matrices for all vehicles and cars for each time period.

Table 7-1 - Summary Flow Calibration - AM Peak Prior

District	Number of Links	Passing Flows	Passing GEH	Passing Flows or GEH	Passing Flows (%)	Passing GEH (%)	Passing Flows or GEH (%)	Passing GEH Near (%)	Passing Flows/GEH Near (%)
All Vehicles									
Others	463	193	166	199	42%	36%	43%	52%	52%
SGC	267	130	126	140	49%	47%	52%	64%	64%
All	730	323	292	339	44%	40%	46%	57%	57%
Cars									
Others	463	205	172	215	44%	37%	46%	53%	53%
SGC	267	138	119	140	52%	45%	52%	66%	66%
All	730	343	291	355	47%	40%	49%	58%	58%

Table 7-2 - Summary Flow Calibration - Inter Peak Prior

District	Number of Links	Passing Flows	Passing GEH	Passing Flows or GEH	Passing Flows (%)	Passing GEH (%)	Passing Flows or GEH (%)	Passing GEH Near (%)	Passing Flows/GEH Near (%)
All Vehicles									
Others	463	236	191	244	51%	41%	53%	57%	57%
SGC	267	140	130	153	52%	49%	57%	69%	69%
All	730	376	321	397	52%	44%	54%	61%	61%
Cars									
Others	463	269	198	274	58%	43%	59%	62%	62%
SGC	267	154	138	160	58%	52%	60%	71%	71%
All	730	423	336	434	58%	46%	59%	65%	65%

Table 7-3 - Summary Flow Calibration - PM Peak Prior

District	Number of Links	Passing Flows	Passing GEH	Passing Flows or GEH	Passing Flows (%)	Passing GEH (%)	Passing Flows or GEH (%)	Passing GEH Near (%)	Passing Flows/GEH Near (%)
All Vehicles									
Others	463	186	161	197	40%	35%	43%	51%	51%
SGC	267	133	123	138	50%	46%	52%	64%	64%
All	730	319	284	335	44%	39%	46%	56%	56%
Cars									
Others	463	199	163	205	43%	35%	44%	54%	54%
SGC	267	136	131	144	51%	49%	54%	65%	65%
All	730	335	294	349	46%	40%	48%	58%	58%

Link calibration passing the TAG criterion (passing flows/GEH < 5) in SGC is at 52%, 60% and 54% for cars in AM, IP and PM peaks respectively against the prior matrix. With relaxed criterion (passing flows/GEH < 7.5) link calibration is at 66%, 71% and 65% for cars in AM, IP and PM peaks respectively.

Paragraph 8.3.17 of TAG UNIT M3.1 states that "*matrix estimation should not be allowed to make significant changes to the prior matrices in order that the validation standards are met. In these cases, the limits set out in Table 5 should be respected, the impacts of matrix estimation should be reduced so that they do not become significant, and a lower standard of validation reported. If issues in the process of creating the prior matrices are identified then these should be rectified before running through the model calibration and validation process again*". For the matrix estimation to not make significant changes, prior validation should be at an acceptable level to proceed with matrix estimation. As the link calibration is over 65% for all peaks in prior it is deemed reasonable to proceed with matrix estimation. Also, the impacts of matrix estimation showed that the changes made to prior matrix are acceptable, these are presented in section 7.3.

7.2. Matrix Estimation Procedure

The SATURN modules SATME2 and SATPIJA were used for matrix estimation and in combination attempt to match assigned link flows in the model with observed traffic counts. The matrix estimation process forms part of the calibration process and is designed to modify the origin-destination volumes by reference to the observed traffic counts. Trips are adjusted in the prior matrix to produce the estimated matrix, which is most likely to be consistent with the traffic counts. The equation used may be written as:

Equation 7-1 – Maximum Entropy Equation

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

Where:

T_{ij} is the output matrix of OD pairs ij;

t_{ij} is the prior matrix of OD pairs ij;

X_a is the 'balancing factor' associated with counted link a;

Π_a is the multiplicative equivalent to $\sum for$ summations; and

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

The ME process is dependent on several factors including the quality of the prior matrix, traffic routeing, and the order and consistency of observed traffic counts. It is therefore essential that the process is monitored to ensure the following:

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

ME provides a method by which an initial estimate of the trip matrix can be adjusted in order to reflect observed traffic count data. This process is accomplished within SATURN using the SATPIJA program, which creates a file in which each element represents the proportion (P) of the trips between an OD Pair (IJ) which uses the counted link (A). This file is created for car first followed by LGV and then followed by HGV for the counted link. The SATME2 program then uses the PIJA files to adjust the prior matrix to create the most likely trip matrix consistent with the information contained in the count file. Finally, the output matrix is assigned back to the model network and is compared to the observed count to gauge the degree to which these matches. This process is looped for a number of iterations until satisfactory model calibration is achieved. For the WERTM-SGC model, six iterations are used. In addition, diligence is exercised to ensure that the quality and consistency of the input count data is high.

Matrix estimation was undertaken at complete matrix level with no constraints used and using all count data for calibration.

7.3. Impact of Matrix Estimation

Matrix Estimation (ME) was undertaken to adjust the prior origin-destination (OD) matrix so that the assignment flows in the model on the road network match as closely as possible to observed flows. This process should only result in fine tuning of the matrix to the observed data and should not result in a significant change in prior matrix distribution. To constrain the impact of ME an XAMAX value of 2 was adopted for Cars and an XAMAX value of 5 was adopted for LGV and HGV. This was a change from WERTM where XAMAX of 50 was used for all vehicle classes. This section describes the resulting impact of the ME process on the WERTM-SGC model prior matrices. The criteria for assessing the impact of ME were set out in section 3.6.

7.3.1. Matrix Totals

There is no current guidance set out in TAG unit M3.1 on the acceptability of the amount of change brought about by ME to the matrix totals. A comparison of matrix totals, for all five user classes before and after ME is shown in Table 7-4.

Table 7-4 - Comparison of Matrix Totals - Prior vs Post-ME

Vehicle Class	AM Peak			Inter Peak			PM Peak		
	Prior ME (PCUs)	Post ME (PCUs)	% Change	Prior ME (PCUs)	Post ME (PCUs)	% Change	Prior ME (PCUs)	Post ME (PCUs)	% Change
Car	141,988	145,815	2.70%	116,454	119,150	2.32%	157,368	157,919	0.35%
LGV	30,693	29,269	-4.64%	26,453	25,065	-5.25%	25,958	24,110	-7.12%
HGV	11,731	11,238	-4.21%	10,046	10,677	6.28%	5,596	5,233	-6.48%
Total	184,413	186,321	1.03%	152,953	154,891	1.27%	188,922	187,261	-0.88%

From the above table, it can be observed that for all three time periods, the ME process makes relatively little change to the size of the overall trip matrices. The changes to the overall trip matrix totals are reasonable with the overall number of trips not increasing by more than 5% (though slightly larger changes observed at the individual vehicle class level). The percentage changes in LGV and HGV trips are higher than that of the car trips due to the quality of data used in the development of the LGV and HGV prior matrices.

7.3.2. Matrix Zonal Values

The impact of ME on individual zone to zone movements between the prior and post ME matrices is set out in Table 7-5 for all user classes combined and each vehicle class separately.

Table 7-5 - Matrix Zonal Cell Value Changes - Prior vs Post ME

Measurement		Requirement	AM		IP		PM	
			Value	Pass?	Value	Pass?	Value	Pass?
All Vehicles	Slope	Within 0.98 and 1.02	0.98	Near	1.00	Pass	0.99	Pass
	Intercept	Near 0	0.001	Pass	0.000	Pass	0.000	Pass
	R^2	> 0.95	0.92	Fail	0.93	Fail	0.94	Near
Cars	Slope	Within 0.98 and 1.02	0.99	Pass	1.00	Pass	0.98	Pass
	Intercept	Near 0	0.001	Pass	0.001	Pass	0.001	Pass
	R^2	> 0.95	0.93	Fail	0.92	Fail	0.92	Fail
LGV	Slope	Within 0.98 and 1.02	0.99	Pass	0.99	Pass	0.99	Pass
	Intercept	Near 0	-0.001	Pass	-0.001	Pass	-0.001	Pass
	R^2	> 0.95	0.98	Pass	0.99	Pass	0.99	Pass
HGV	Slope	Within 0.98 and 1.02	0.68	Fail	1.11	Fail	1.00	Pass
	Intercept	Near 0	0.002	Pass	0.000	Pass	0.000	Pass
	R^2	> 0.95	0.35	Fail	0.55	Fail	0.66	Fail

The slope, intercept and R^2 across all time periods indicates that zonal cell values have not changed materially from the prior matrix and meet the required criteria.

The slope and intercept criteria are satisfied or nearly satisfied across all time periods. However, there are several deviations in the coefficient of determination R^2 criteria from the target value. Though the R^2 value is less than 0.95 it is ranging from 0.92 to 0.94 for cars and all vehicles which is reasonable considering the R^2 values of WERTM ranging between 0.68 to 0.87 for cars and all vehicles across peaks. R^2 values for HGVs are far from criteria suggesting larger changes to cell values are brought about by matrix estimation. Most notable is the R^2 and slope for HGVs in the AM peak, which was largely driven by the quality of data used to build HGV matrices.

7.3.3. Matrix Zonal Trip Ends

Table 7-6 presents the impact of ME on the trip end values.

Table 7-6 - Matrix Zonal Trip End Value Changes - Prior vs Post ME

Measurement			Requirement	AM		IP		PM	
				Value	Pass?	Value	Pass?	Value	Pass?
All Vehicles	Slope	Rows	Within 0.99 and 1.01	1.01	Near	1.01	Pass	1.01	Pass
	Intercept		Near 0	-0.07	Pass	0.09	Pass	-0.52	Pass
	R^2		> 0.98	0.96	Near	0.97	Near	0.97	Near
Cars	Slope		Within 0.99 and 1.01	1.03	Near	1.02	Near	1.01	Pass
	Intercept		Near 0	-0.06	Pass	0.01	Pass	-0.25	Pass
	R^2		> 0.98	0.96	Near	0.97	Near	0.97	Near
LGV	Slope		Within 0.99 and 1.01	0.98	Near	0.98	Near	0.98	Near
	Intercept		Near 0	-0.14	Pass	-0.13	Pass	-0.21	Pass
	R^2		> 0.98	0.98	Pass	0.98	Pass	0.98	Pass
HGV	Slope		Within 0.99 and 1.01	0.87	Fail	0.94	Fail	0.99	Near

Measurement			Requirement	AM		IP		PM	
				Value	Pass?	Value	Pass?	Value	Pass?
	Intercept		Near 0	0.17	Pass	0.19	Pass	-0.05	Pass
	R^2		> 0.98	0.77	Fail	0.85	Fail	0.84	Fail
All Vehicles	Slope	Cols	Within 0.99 and 1.01	1.01	Pass	1.00	Pass	1.00	Pass
	Intercept		Near 0	0.03	Pass	1.64	Pass	-0.63	Pass
	R^2		> 0.98	0.97	Near	0.97	Near	0.96	Near
Cars	Slope		Within 0.99 and 1.01	1.02	Pass	0.99	Pass	0.99	Pass
	Intercept		Near 0	1.17	Pass	2.85	Pass	2.01	Pass
	R^2		> 0.98	0.96	Near	0.96	Near	0.95	Fail
LGV	Slope		Within 0.99 and 1.01	0.98	Near	0.98	Near	0.98	Near
	Intercept		Near 0	-0.75	Pass	-0.68	Pass	-1.08	Pass
	R^2		> 0.98	0.98	Pass	0.98	Pass	0.98	Near
HGV	Slope		Within 0.99 and 1.01	0.89	Fail	1.07	Fail	0.94	Fail
	Intercept		Near 0	0.63	Pass	-0.07	Pass	-0.01	Pass
	R^2		> 0.98	0.77	Fail	0.81	Fail	0.84	Fail

From the table, it is evident that the significance criteria relating to origin and destination trip ends were not met for slope and R^2 values for HGVs similar to zonal cell value changes suggesting larger changes are made to HGV matrices.

7.3.4. Matrix Trip Length Distribution

TAG unit M3.1 advises that change in average trip length and standard deviation should not exceed ± 5%. As presented in Table 7-7, changes for all vehicles combined and for separate vehicle classes are well within the criteria for all time periods with very few exceptions.

Table 7-7 - Trip Length Comparison - Prior vs Post ME

Time Period	Measure	Criteria	All Veh	Cars	LGVs	HGVs
AM	Mean	Within 5%	2.69%	4.15%	5.15%	-3.07%
IP			2.32%	3.67%	3.65%	-6.40%
PM			5.26%	6.18%	4.79%	1.25%
AM	Standard Deviation		2.30%	3.62%	2.41%	-0.83%
IP			1.49%	4.29%	1.64%	-5.03%
PM			2.79%	5.91%	1.92%	-3.66%

There is an increase in trips in the shorter distance bands of 0 to 6 km and minor decreases in trips in the medium distance bands ranging from 6 to 40 km. Trip Length Distribution plots for All vehicles and cars for all peaks are presented in 9.2.Appendix D.

In general, the effects of matrix estimation demonstrate that the resulting post ME matrix exhibits less distortion when compared to the WERTM post ME matrix and it maintains the origin-destination (OD) patterns of the original matrix. This is more evident in the impacts on zonal cell values and zonal trip end changes. R^2 values for zonal cell values is greater than 0.92 in WERTM-SGC model whereas it was ranging between 0.68 to 0.87 in WERTM for cars and all vehicles across all peaks. Similarly for the zonal trip ends, R^2 values in WERTM-

SGC model are higher than 0.95 across all peaks for cars and all vehicles whereas it was ranging between 0.8 to 0.95 in WERTM.

8. Calibration and Validation Results

8.1. Overview

The calibration and validation procedures were conducted as set out in Sections 6 and 7, in conjunction with the ME process. An iterative process was undertaken whereby the validation of the model was assessed using comparisons of the modelled and observed data as discussed below. Adjustments were made to the model to reduce the differences between the modelled and observed data.

The model was validated by means of the following comparisons:

- Modelled and observed traffic flows on individual links compared by cars and all vehicles, by time period;
- Modelled and observed journey times along routes, as a check on the quality of the network and the assignment; and
- Route Choice Validation.

Each of these validations is presented in separate sections below. The final section presents the levels of model convergence achieved.

8.2. Flow Calibration Results

In addition to TAG criteria of passing flows/GEH, a relaxed criteria of passing flows/GEH where links with GEH < 7.5 is considered as passing is used as shown in Table 8-1 below. Relaxed or Near criteria included all links with GEH value between 0 and 7.5.

Table 8-1 - GEH Classification

GEH Value	0 to 5	5 to 7.5	>7.5
Classification	Pass	Near	Fail

To understand the model performance in SGC, calibration results are presented for SGC district and all others separately, and for the full model.

Passing TAG criteria in SGC:

- 83%, 89% and 84% passing flows or GEH in AM, IP, and PM respectively for cars in SGC; and
- 83%, 85% and 82% passing flows or GEH in AM, IP, and PM respectively for all vehicles in SGC.

Passing relaxed criteria in SGC:

- 92%, 93% and 89% passing flows or GEH in AM, IP, and PM respectively for cars in SGC; and
- 91%, 92% and 87% passing flows or GEH in AM, IP, and PM respectively for all vehicles in SGC.

83% of links are passing TAG criteria and 89% of links are passing relaxed criteria for cars in SGC across time periods. Table 8-2 to Table 8-4 below shows the level of calibration achieved across the three modelled time periods.

As the 2022 SGC counts were used as is in the model development, a sensitivity analysis was carried out with an adjustment of 2%, 5% and 7.5% of increase and decrease on SGC counts. Impact of the adjustments on calibration across peaks was within ± 1%, ± 2% and ± 3 % change for cars for 2%, 5% and 7.5% adjustment in count values respectively. The results of sensitivity analysis are presented in Appendix F.

Link calibration plots classifying the calibration links in SGC based on GEH value shown in Table 8-1 for all peaks are presented in Figure 8-1 to Figure 8-3. Similar plots for full model at WECA level are presented in Appendix A.

Table 8-2 - Link Calibration Summary - AM Peak Post ME

District	Number of Links	Passing Flows	Passing GEH	Passing Flows or GEH	Passing Flows (%)	Passing GEH (%)	Passing Flows or GEH (%)	Passing GEH & Near (%)	Passing Flows/GEH & Near (%)
All Vehicles									
Others	463	353	323	355	76%	70%	77%	81%	81%
SGC	267	215	215	222	81%	81%	83%	91%	91%
All	730	568	538	577	78%	74%	79%	85%	85%
Cars									
Others	463	363	335	366	78%	72%	79%	84%	85%
SGC	267	218	217	222	82%	81%	83%	91%	92%
All	730	581	552	588	80%	76%	81%	87%	88%

Table 8-3 - Link Calibration Summary - Inter Peak Post ME

District	Number of Links	Passing Flows	Passing GEH	Passing Flows or GEH	Passing Flows (%)	Passing GEH (%)	Passing Flows or GEH (%)	Passing GEH & Near (%)	Passing Flows/GEH & Near (%)
All Vehicles									
Others	463	401	370	402	87%	80%	87%	88%	88%
SGC	267	221	219	228	83%	82%	85%	92%	92%
All	730	622	589	630	85%	81%	86%	90%	90%
Cars									
Others	463	411	381	411	89%	82%	89%	91%	92%
SGC	267	232	232	237	87%	87%	89%	93%	93%
All	730	643	613	648	88%	84%	89%	92%	92%

Table 8-4 - Link Calibration Summary - PM Peak Post ME

District	Number of Links	Passing Flows	Passing GEH	Passing Flows or GEH	Passing Flows (%)	Passing GEH (%)	Passing Flows or GEH (%)	Passing GEH & Near (%)	Passing Flows/GEH & Near (%)
All Vehicles									
Others	463	340	313	346	73%	68%	75%	79%	79%
SGC	267	215	215	220	81%	81%	82%	87%	87%
All	730	555	528	566	76%	72%	78%	82%	82%
Cars									
Others	463	354	324	359	76%	70%	78%	81%	84%
SGC	267	221	219	223	83%	82%	84%	89%	89%
All	730	575	543	582	79%	74%	80%	84%	86%

Figure 8-1 - AM Link Calibration in SGC

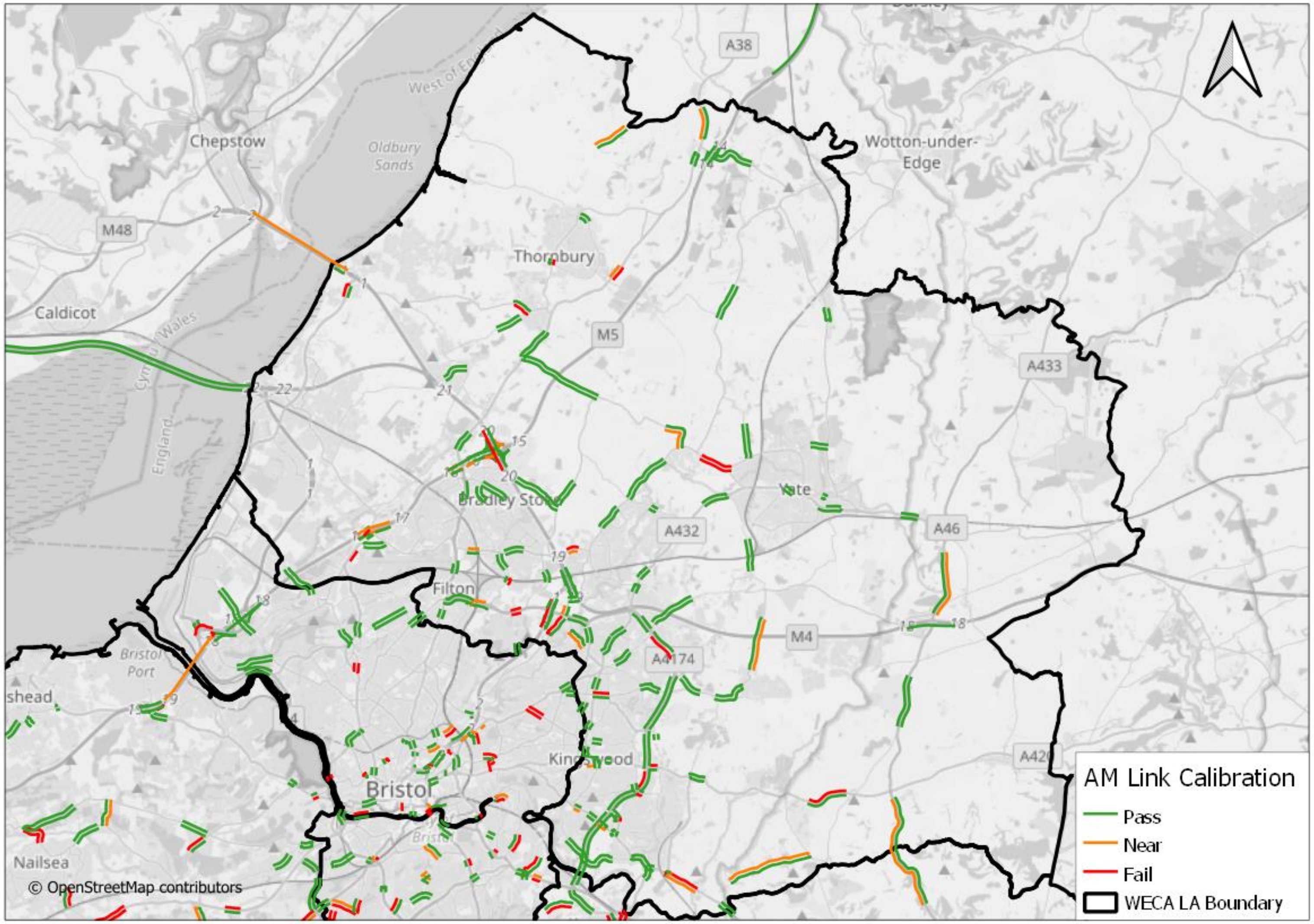


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Figure 8-2 - IP Link Calibration in SGC

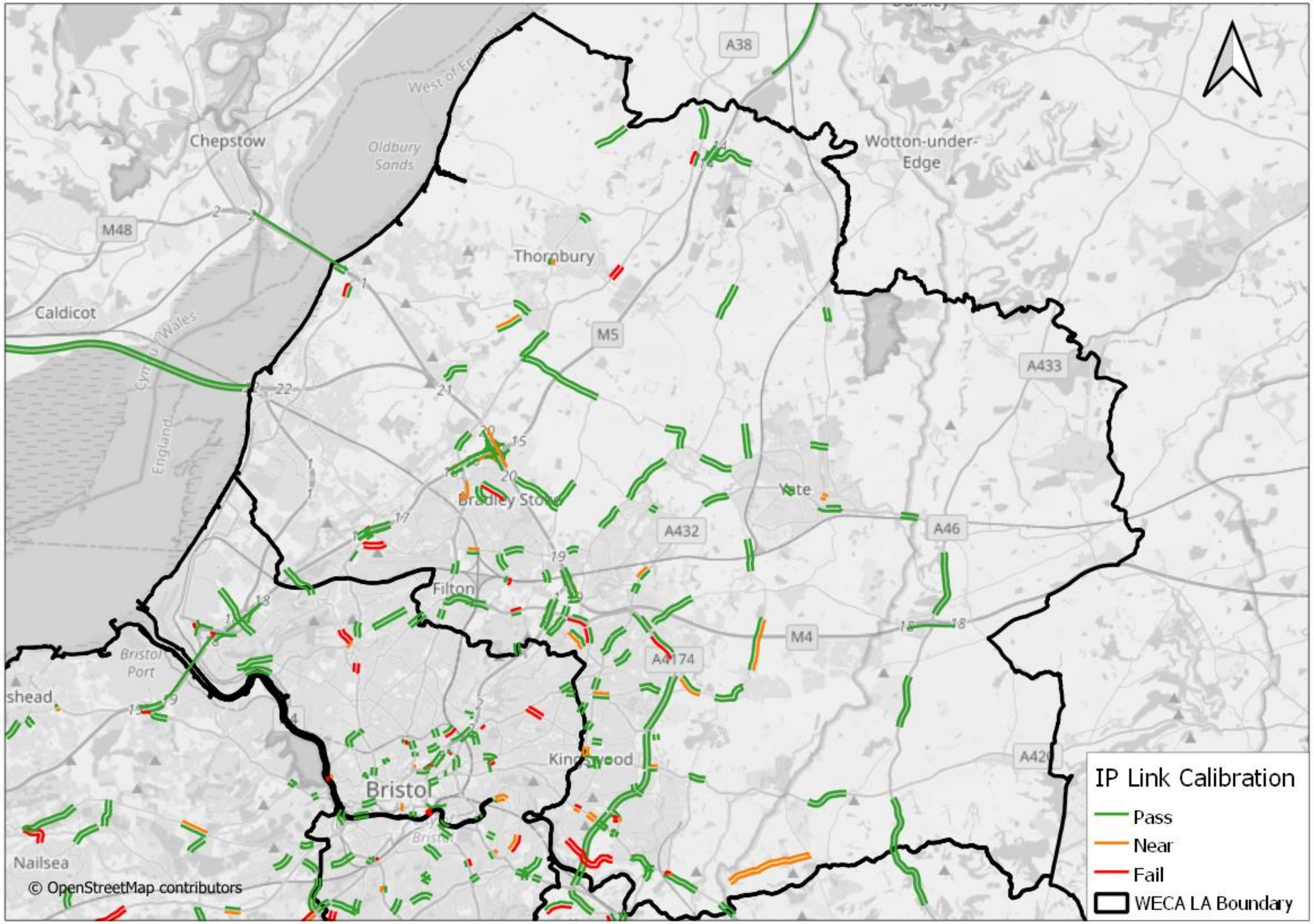

Figure 8-3 - PM Link Calibration in SGC

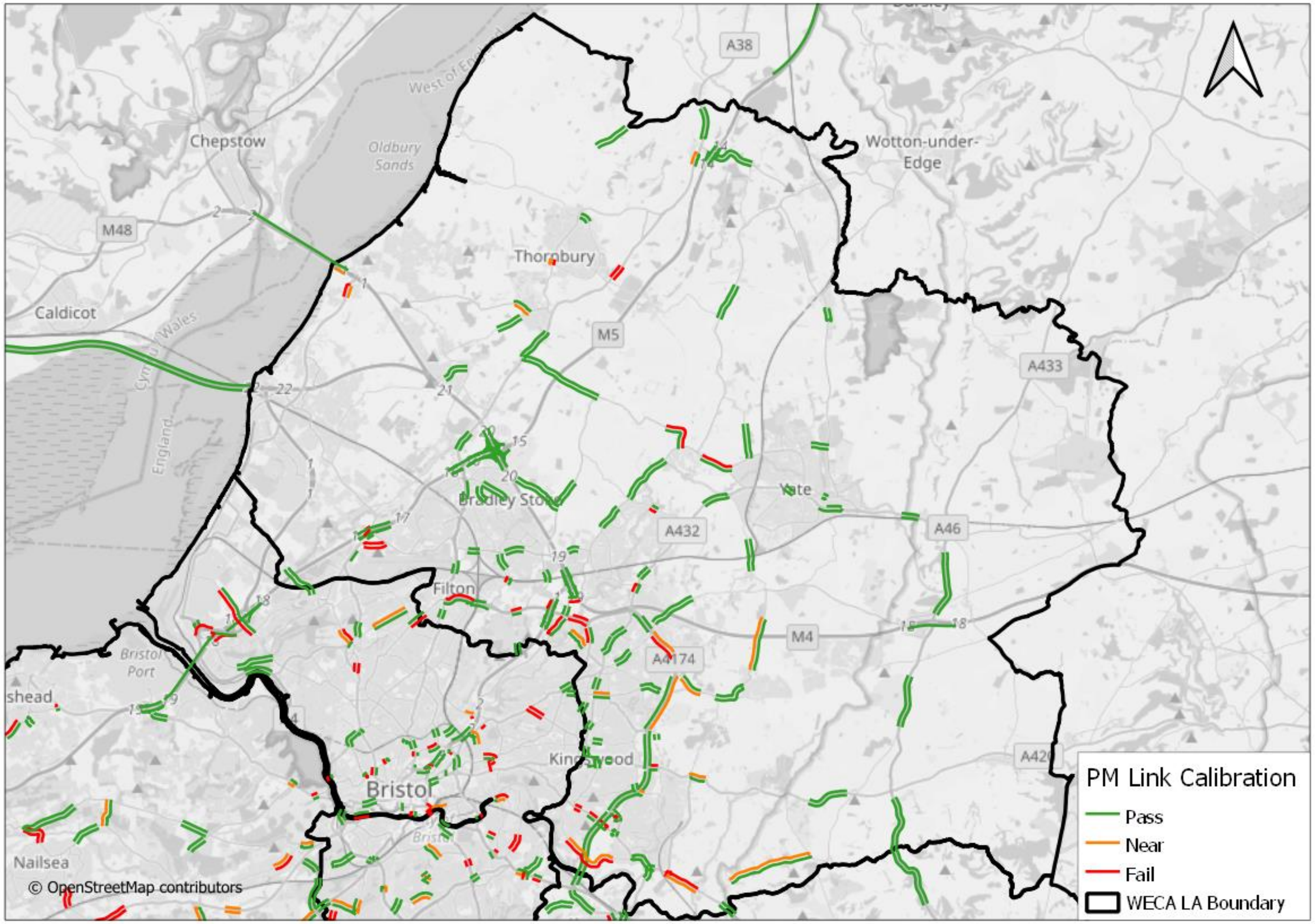

Table 8-5 below presents the calibration summary of only the SGC counts used in matrix estimation in addition to counts from WERTM. Figure 2-3 shows the WERTM and SGC sites used in model development. SGC sites are spread widely on both major roads and local roads in Thornbury, Bradley Stoke, Yate, Filton, Kingswood, Hambrook, along A4174 amongst others, and covers the gaps in WERTM counts. A minimum of 82% calibration was achieved for TAG criteria and 88% for relaxed criteria for cars. This shows that the WERTM-SGC model is well calibrated in SGC area.

Table 8-5 - Link Calibration Summary - SGC Counts

District	Number of Links	Passing Flows	Passing GEH	Passing Flows or GEH	Passing Flows (%)	Passing GEH (%)	Passing Flows or GEH (%)	Passing GEH & Near (%)	Passing Flows/GEH & Near (%)
AM Peak									
All Vehicles	129	99	103	104	77%	80%	81%	88%	88%
Cars	129	104	104	107	81%	81%	83%	90%	91%
Inter Peak									
All Vehicles	129	102	103	106	79%	80%	82%	91%	91%
Cars	129	112	114	114	87%	88%	88%	92%	92%
PM Peak									
All Vehicles	129	100	100	103	78%	78%	80%	83%	83%
Cars	129	104	103	106	81%	80%	82%	87%	88%

8.2.1. WERTM-SGC vs WERTM calibration

Table 8-6 below presents a comparison of link calibration in WERTM and current model for only the sites in SGC that are common between the two models. The comparison is provided for all vehicles and cars using the observed data and model flows from respective models. There is an improvement in calibration in AM peak where as a decrease was observed in IP and PM peaks ranging between 1% to 10%. This is due to the addition of new observed data in matrix estimation; change in XAMAX value from 50 to 2 for car and 5 for goods vehicles which restricts excessive manipulation of OD movements and; network changes in SGC area. Though the comparison shows a reduction in link calibration in IP and PM links for WERTM sites WERTM-SGC model calibration for these sites is still satisfactory with 85% of links passing TAG criteria and 91% of links passing relaxed criteria for cars in SGC across time periods as shown in below table. This is also seconded by the screenline performance presented in section 8.2.3.

Table 8-6 - SGC vs WERTM Link Calibration

Vehicle Class	Number of Links	WERTM-SGC						WERTM					
		Passing Flows/ GEH	% Passing Flows/ GEH	Passing GEH & Near (<7.5)	% Passing GEH & Near	Passing Flows/ GEH & Near	% Passing Flows/ GEH & Near	Passing Flows/ GEH	% Passing Flows/ GEH	Passing GEH & Near (<7.5)	% Passing GEH & Near	Passing Flows/ GEH & Near	% Passing Flows/ GEH & Near
AM Peak													
All Vehicles	138	118	86%	129	93%	129	93%	117	85%	119	86%	120	87%
Cars	138	115	83%	128	93%	128	93%	122	88%	123	89%	124	90%
Inter Peak													
All Vehicles	138	122	88%	128	93%	128	93%	132	96%	136	99%	136	99%
Cars	138	123	89%	129	93%	129	93%	136	99%	137	99%	137	99%
PM Peak													
All Vehicles	138	117	85%	124	90%	124	90%	119	86%	128	93%	128	93%
Cars	138	117	85%	125	91%	125	91%	125	91%	131	95%	131	95%

Table 8-5 and Table 8-6 in conjunction shows that the WERTM-SGC model was calibrated well to support future testing as the calibration has better spread covering majority of roads as opposed to WERTM. Link calibration plots for WERTM are provided in Appendix G for reference.

It is observed that A38 Gloucester Road (east of Thornbury) is failing in all time periods, this is due to less demand in prior/synthetic matrices developed from mobile phone OD data and ME process struggles to manipulate the OD movements sufficiently so that modelled link flows match the observed flows. Such limitations in mobile phone OD data can affect the accuracy of the synthetic matrices developed based on this data, leading to discrepancies when estimating link flows. The challenges in accurately capturing the demand patterns emphasize the need for alternative data sources or methodologies to supplement or refine the OD information and improve the overall modeling accuracy in such cases Given the challenges in refining the matrices, no adjustments have been made to the prior matrix. Furthermore, the A38 links in the south and north directions near Alveston and Falfield exhibit satisfactory performance i.e, these links consistently fall within the passing or near category across all peaks.

Despite the fact that there is a deterioration in link calibration from WERTM to SGC, the summary provided in Table 8-5 and Table 8-6 instills confidence that the model is effectively calibrated. Notably, 85% of the links successfully meet the TAG criteria for cars. The inclusion of SGC counts in the matrix estimation process for both major roads and local roads has influenced the origin-destination (OD) pattern, resulting in a slight variation in the estimated matrix compared to the WERTM estimated matrix. The divergence in link calibration from WERTM to SGC can be attributed to the network modifications implemented alongside the new estimated matrix, which ultimately affect the model assignment.

8.2.2. Motorway Calibration Summary

Link calibration on motorways was analysed and compared with WERTM. Table 8-7 below presents this comparison.

Table 8-7 – WERTM-SGC vs WERTM Motorway Calibration

Road Name	WERTM-SGC							WERTM						
	Total Number of links	Number of links passing GEH/Flow			% of links passing GEH/Flow			Total Number of links	Number of links passing GEH/Flow			% of links passing GEH/Flow		
		AM Peak	Inter Peak	PM Peak	AM Peak	Inter Peak	PM Peak		AM Peak	Inter Peak	PM Peak	AM Peak	Inter Peak	PM Peak
M4	14	10	13	14	71%	93%	100%	14	10	13	13	71%	93%	93%
M5	49	46	44	47	94%	90%	96%	49	46	45	42	94%	92%	86%
M32	8	7	7	8	88%	88%	100%	8	3	8	7	38%	100%	88%
M48	2	1	2	2	50%	100%	100%	2	2	2	2	100%	100%	100%
M49	4	3	4	2	75%	100%	50%	4	2	4	2	50%	100%	50%
All	**77**	**67**	**70**	**73**	**87%**	**91%**	**95%**	**77**	**63**	**72**	**66**	**82%**	**94%**	**86%**

Overall, WERTM-SGC model exhibits improved calibration on motorways with 87%, 91% and 95% of links passing TAG flow criteria compared to 82%, 94% and 86% in WERTM in AM, IP and PM peaks respectively. M5 and M32 in IP and M48 in AM peak have one link less than WERTM that meets the TAG flow criteria, however these links fall within the Near criteria of GEH (5 to 7.5).

8.2.3. Screenline Summary

Although screenline constraints are not used in the matrix estimation, model performance against four screenlines (eight screenlines in both directions) presented in Figure 4-4 was checked for all peaks. Table 8-8 to

Table 8-10 presents the screenline summary for AM, IP and PM peaks respectively. The tables also present the WERTM model performance at these screenlines in terms of % difference between observed and modelled flows, GEH values. The screenlines are performing relatively better in current model except for South Gloucestershire N/S screenline in IP. This is caused by difference in goods vehicles between observed and modelled on A38 NB link at Falfield whereas cars are performing well with a GEH of 0.8.

Table 8-8 - AM Peak Screenline Summary - All Vehicles

Cordon /Screenline	Direction	WERTM-SGC				WERTM		
		Observed Flow	Modelled Flow	% difference	Pass Criteria (<= ± 5%)	Modelled Flow	% difference	Pass Criteria (<= ± 5%)
Bristol Outer North Fringe	NB	8,467	7,835	-7.5%	×	7,754	-7.0%	×
	SB	9,255	9,229	-0.3%	✓	8,144	-5.8%	×
Bristol South Gloucestershire N/S	NB	5,861	6,075	3.7%	✓	6,197	3.1%	✓
	SB	7,048	6,938	-1.6%	✓	7,416	3.7%	✓
South Gloucestershire N/S	NB	1,253	1,400	11.7%	×	1,406	12.1%	×
	SB	1,207	1,289	6.8%	×	1,522	26.2%	×
Yate	IB	3,193	3,124	-2.1%	✓	3,493	3.5%	✓
	OB	3,146	2,896	-8.0%	×	3,285	1.8%	✓

Table 8-9 - Inter Peak Screenline Summary - All Vehicles

Cordon /Screenline	Direction	WERTM-SGC				WERTM		
		Observed Flow	Modelled Flow	% difference	Pass Criteria (<= ± 5%)	Modelled Flow	% difference	Pass Criteria (<= ± 5%)
Bristol Outer North Fringe	NB	6,077	5,925	-2.5%	✓	5,635	-5.4%	×
	SB	5,898	5,837	-1.0%	✓	5,581	-3.1%	✓
Bristol South Gloucestershire N/S	NB	4,783	4,928	3.0%	✓	4,933	3.4%	✓
	SB	4,423	4,608	4.2%	✓	4,445	0.9%	✓
South Gloucestershire N/S	NB	739	1,012	36.9%	×	829	12.2%	×
	SB	770	753	-2.3%	✓	792	2.8%	✓
Yate	IB	2,531	2,489	-1.7%	✓	2,570	0.0%	✓
	OB	2,494	2,356	-5.5%	×	2,563	0.2%	✓

Table 8-10 – PM Peak Screenline Summary – All Vehicles

Cordon /Screenline	Direction	WERTM-SGC				WERTM		
		Observed Flow	Modelled Flow	% difference	Pass Criteria (<= ± 5%)	Modelled Flow	% difference	Pass Criteria (<= ± 5%)
Bristol Outer North Fringe	NB	9,326	8,744	-6.2%	×	7,946	-14.2%	×
	SB	7,431	7,591	2.2%	✓	7,386	-6.4%	×
Bristol South Gloucestershire N/S	NB	6,691	7,029	5.1%	×	6,897	-1.7%	✓
	SB	5,521	5,536	0.3%	✓	5,644	1.0%	✓
South Gloucestershire N/S	NB	1,149	1,348	17.3%	×	1,340	16.6%	×
	SB	1,230	1,218	-0.9%	✓	1,231	0.1%	✓
Yate	IB	3,388	3,208	-5.3%	×	3,372	-3.7%	✓
	OB	3,160	3,067	-3.0%	×	3,254	-2.6%	✓

8.3. Journey Time Validation

As explained in the Section 2.2, A4174 journey time route was validated against 2019 TomTom journey time data. The journey time route is shown in Figure 2-5.

Modelled journey times are compared against observed data in each of the modelled periods. Summaries of the observed and modelled journey time comparisons for each route are provided for the AM peak, Inter-peak and PM peak in Table 8-11. Time-distance plots for the route for both directions and all three time periods are presented in 9.2.Appendix C.

Table 8-11 - Journey Time Validation Summary

Length (Km)	Direction	Observed Time (hh:mm:ss)	Observed +15%	Observed -15%	Modelled Time (hh:mm:ss)	Pass/Fail
AM Peak						
12.2	NB	00:18:44	00:21:32	00:15:55	00:15:04	×
12.3	SB	00:14:41	00:16:54	00:12:29	00:13:55	✓
Inter Peak						
12.2	NB	00:16:11	00:18:37	00:13:45	00:14:51	✓
12.3	SB	00:13:26	00:15:27	00:11:25	00:13:30	✓
PM Peak						
12.2	NB	00:15:31	00:17:51	00:13:12	00:14:13	✓
12.3	SB	00:16:09	00:18:34	00:13:44	00:14:36	✓

Though northbound JT route in AM peak is failing, this is caused by one single section at the end of the route i.e., Wick Wick Roundabout to Bromley Heath Roundabout. With further investigation it is observed that there are delays occurring from M32/A4174 junction and extending back to Wick Wick Roundabout in AM peak on ground resulting in an observed journey time of 5.17 minutes for 1.3 kms from Wick Wick Roundabout to Bromley Heath Roundabout and the model was not able to replicate this. It is recommended that this should be monitored closely during implementation of any schemes in the area.

8.3.1. WERTM-SGC vs WERTM JT Validation

Model performance along JT routes defined in WERTM that are either fully or partially in SGC was monitored and compared against the same from WERTM. A total of 22 routes (44 in both directions) as shown in Figure 8-4 were identified out of which 11 routes each are fully and partially part of SGC area. The observed data for these JT routes were extracted from WERTM dashboard and compared against the WERTM-SGC model data. 9.2.Appendix B presents the summary of observed and modelled journey time comparisons for the 11 full routes in SGC and time-distance plots are presented in 9.2.Appendix C.

Figure 8-4 - JT routes from WERTM

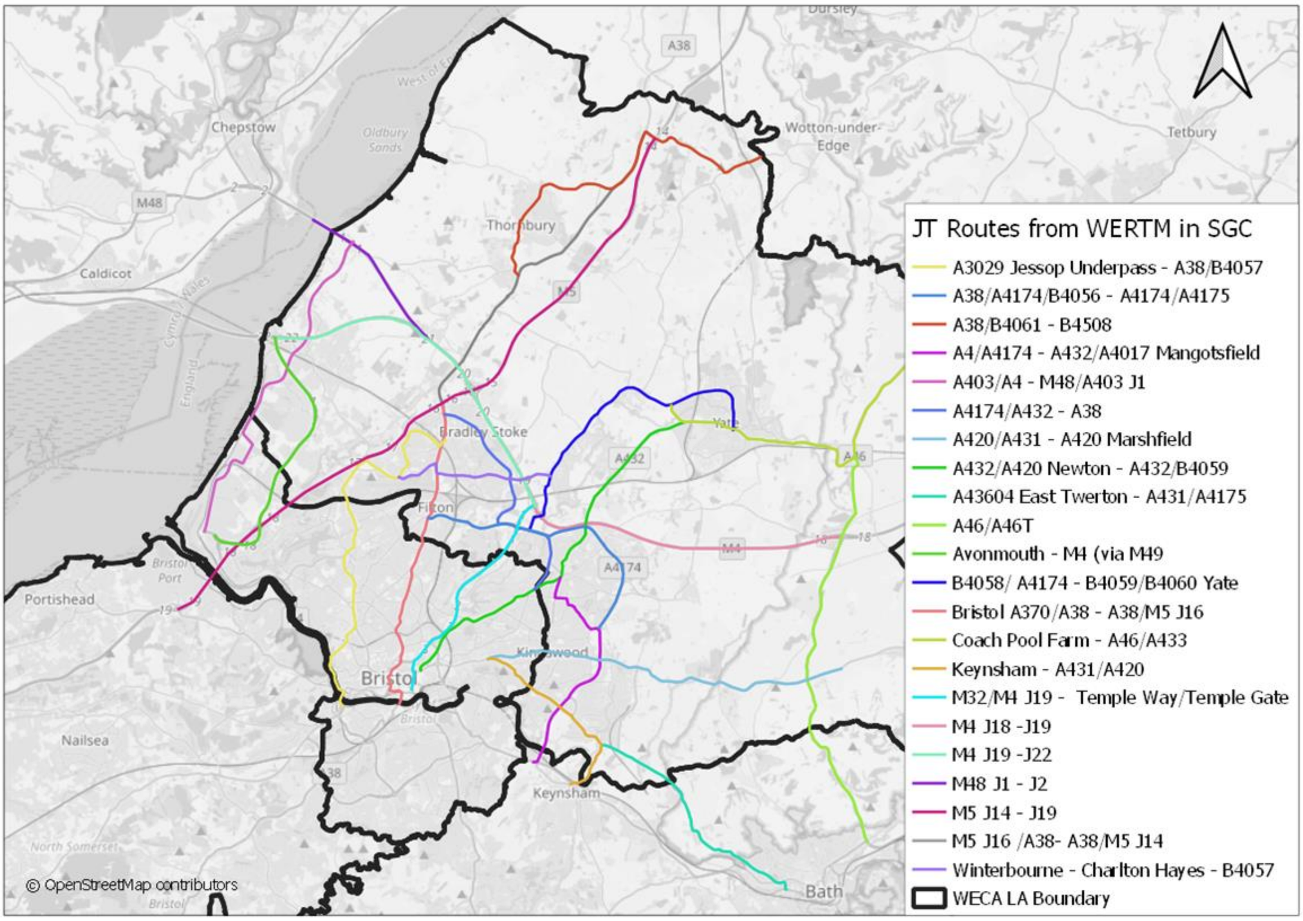

Table 8-12 to Table 8-14 below presents a comparison between SGC and WERTM for all 44 routes and segregated by the extent of route in SGC i.e., fully or partially in SGC. The comparison is provided for the model performance against TAG criteria and relaxed criteria. The WERTM-SGC model exhibits better performance in the Inter-peak, while the AM and PM peaks demonstrate comparable performance between the two models. This indicates that journey times in the WERTM-SGC model have either improved or remained consistent compared to WERTM, with no adverse impact resulting from the model update.

Table 8-12 – WERTM-SGC vs WERTM JT Validation Summary of all routes

All Routes (44)	TAG Criteria (<15% or 1 minute)				Relaxed Criteria (<20% or 1 minute)			
	Number of routes passing		% of routes passing		Number of routes passing		% of routes passing	
Time Period	WERTM-SGC	WERTM	WERTM-SGC	WERTM	WERTM-SGC	WERTM	WERTM-SGC	WERTM
AM	28	29	64%	66%	35	34	80%	77%
IP	40	38	91%	86%	43	41	98%	93%
PM	35	32	80%	73%	41	38	93%	86%

Table 8-13 – WERTM-SGC vs WERTM JT Validation Summary of routes fully in SGC

Routes fully in SGC (22)	TAG Criteria (<15% or 1 minute)				Relaxed Criteria (<20% or 1 minute)			
	Number of routes passing		% of routes passing		Number of routes passing		% of routes passing	
Time Period	WERTM-SGC	WERTM	WERTM-SGC	WERTM	WERTM-SGC	WERTM	WERTM-SGC	WERTM
AM	15	15	68%	68%	17	17	77%	77%
IP	20	19	91%	86%	22	21	100%	95%
PM	17	18	77%	82%	21	22	95%	100%

Table 8-14 – WERTM-SGC vs WERTM JT Validation Summary of routes partially in SGC

Routes partly in SGC (22)	TAG Criteria (<15% or 1 minute)				Relaxed Criteria (<20% or 1 minute)			
	Number of routes passing		% of routes passing		Number of routes passing		% of routes passing	
Time Period	WERTM-SGC	WERTM	WERTM-SGC	WERTM	WERTM-SGC	WERTM	WERTM-SGC	WERTM
AM	13	14	59%	64%	18	17	82%	77%
IP	20	19	91%	86%	21	20	95%	91%
PM	18	14	82%	64%	20	16	91%	73%

8.4. Route Choice Validation

The validity of the route choice has been checked in the model by comparing the modelled routes between selected origins and destinations against the Google journey planner for a neutral weekday. The movements are considered in both directions and for AM and PM peaks. Table 8-15 shows the origin and destination zones selected for route choice validation check. It is to be noted that important corridors internal to SGC are only checked as the model development is focussed on SGC.

Table 8-15 - Zones for Route Validation

Origin Zone Number	Destination Zone Number	Origin Zone Name	Destination Zone name	Comment
10001	12408	Bristol City Centre	B4057, Filton	Model route matches with Google journey planner
12259	12398	Bradley Stoke	Thornbury	Model route matches with Google journey planner. Reverse direction route matches partially
12441	12001	Filton	Yate	Model route matches with Google journey planner for Yate to Filton, there is a deviation for reverse direction where model traverses through Iron Acton and google route traverses via Church Road
12407	12001	Kingswood	Yate	Model route matches with Google journey planner
11303	11001	Bath City Centre	Keynsham	Model route matches with Google journey planner

Route diagrams for these routes are displayed in 9.2.Appendix E. Routes were examined for User Class -1 (Car Commute) and route plots for the same are presented for AM and PM peak.

8.5. Assignment Convergence

The convergence for each time period is summarised in Table 8-16. This shows that all time period models converged within the criteria of 100 loops, AM in 60 loops, IP in 48 and PM in 82 loops. The statistics and their descriptions are as follows:

- Flow Change (%) – Percentage of link Flows differing by < 1% between assignment-simulation loops;
- Delay Change (%) – Turn delays differing by < 1% between assignment and simulation;
- Gap (%) – Wardrop Equilibrium Gap Function post simulation; and
- VI (%) – Variational inequality (Should be > 0).

Table 8-16 - Model Convergence Summary

Time Period	Iteration	Flow Change (%)	Delay Change (%)	% VI	% Gap
AM	57	99.4	99.8	0.00002	0.0180
	58	99.1	99.7	0.00000	0.0120
	59	99.4	99.8	0.00007	0.0170
	60	99.1	99.6	0.00008	0.0190
IP	43	99.0	99.8	-0.00008	0.0057
	44	99.1	99.9	-0.00008	0.0046
	45	99.1	99.9	0.00003	0.0045
	46	99.1	99.8	0.00003	0.0055
PM	75	98.4	99.6	0.00004	0.0140
	76	99.2	99.7	0.00002	0.0150
	77	99.3	99.8	0.00028	0.0120
	78	99.3	99.8	0.00000	0.0150

9. Summary of Model Development

9.1. Summary of Model

Atkins have undertaken a partial update to the West of England Regional Transport Model (WERTM) to improve its accuracy in key areas significant to the South Gloucestershire Council (SGC) Local Plan, including the A38, A4174, North Fringe and A432.

The highway assignment model has been developed to represent the modelled peak hours for AM peak hour (08:00 – 09:00), the average inter-peak hour (10:00 – 16:00) and the PM peak hour (17:00 – 18:00). The AM and PM peak hour models contain a pre-peak assignment to allow the model to contain residual queuing from the preceding peak hours. The model network has been defined to represent the whole of the UK in varying levels of detail. The four authorities within the West of England Combined Authority have been represented by the detailed fully modelled area with the remaining parts of the UK shown in the less detailed external area. The model has utilised count data collated from SGC for 2022 and the data used in WERTM development.

This LMVR has described the development of the modelled network and demand matrix, along with the matrix estimation procedure undertaken. The calibration and validation of the model, and standards achieved, have also been set out.

9.2. Summary of Model Development

The WERTM-SGC model has been tested against the TAG calibration and validation guidance for:

- Model convergence;
- Link flows; and
- Journey time comparison.

Recognising the primary focus of the model development several network updates/improvements were carried out in SGC which included addition of new nodes/link splits for more accuracy, speed and capacity updates amongst others. The prior matrix was assigned, and initial calibration was analysed, 64%, 69% and 64% of links in AM, IP and PM peaks respectively for All vehicles pass the relaxed criteria in SGC.

The matrix estimation process has been detailed to show the impact on multiple elements of the matrix against TAG criteria. It has been shown that the changes made to the matrix during the process are outside the specifications of TAG for HGV whereas for Cars, LGV and All vehicles the changes were within criteria or near the criteria. Though ME has brought changes to matrix it has improved the link calibration to 91%, 92% and 87% in AM, IP, and PM peaks respectively for All vehicles and 92%, 93% and 89% for cars with relaxed criteria in SGC. Model performance was also checked against eight screenlines in SGC where 4 in AM, 2 in IP and 3 in PM peak are beyond the 5% flow difference criteria similar to WERTM model but with lesser difference between the observed and modelled flows suggesting a relatively better model performance in SGC area. Comparing the calibration of motorway links, it is evident that the SGC Update model demonstrates better calibration, with 87% and 95% of motorway links meeting TAG criteria in AM and PM peaks, as opposed to 82% and 86% in the case of WERTM.

Modelled journey time along A4174 exhibits a good match with observed journey times in all peaks except in AM peak for northbound direction primarily due to difficulty in recreating congestion in specific area of the model. However, confidence in the accuracy of journey times is supported by the monitoring of JT routes from WERTM, with 68%, 91%, and 77% of routes meeting the TAG criteria in AM, IP, and PM peaks respectively.

The WERTM-SGC model, on the whole, is suitable for testing the local plan and other schemes due to its robust calibration and validation. With the incorporation of new counts, the model exhibits a more balanced calibration across the SGC area. Notably, this improvement was achieved using a less manipulated matrix, as evident from the post matrix estimation (ME) changes. Furthermore, the model demonstrates good validation in comparison to WERTM concerning screenlines and journey times within the SGC area.

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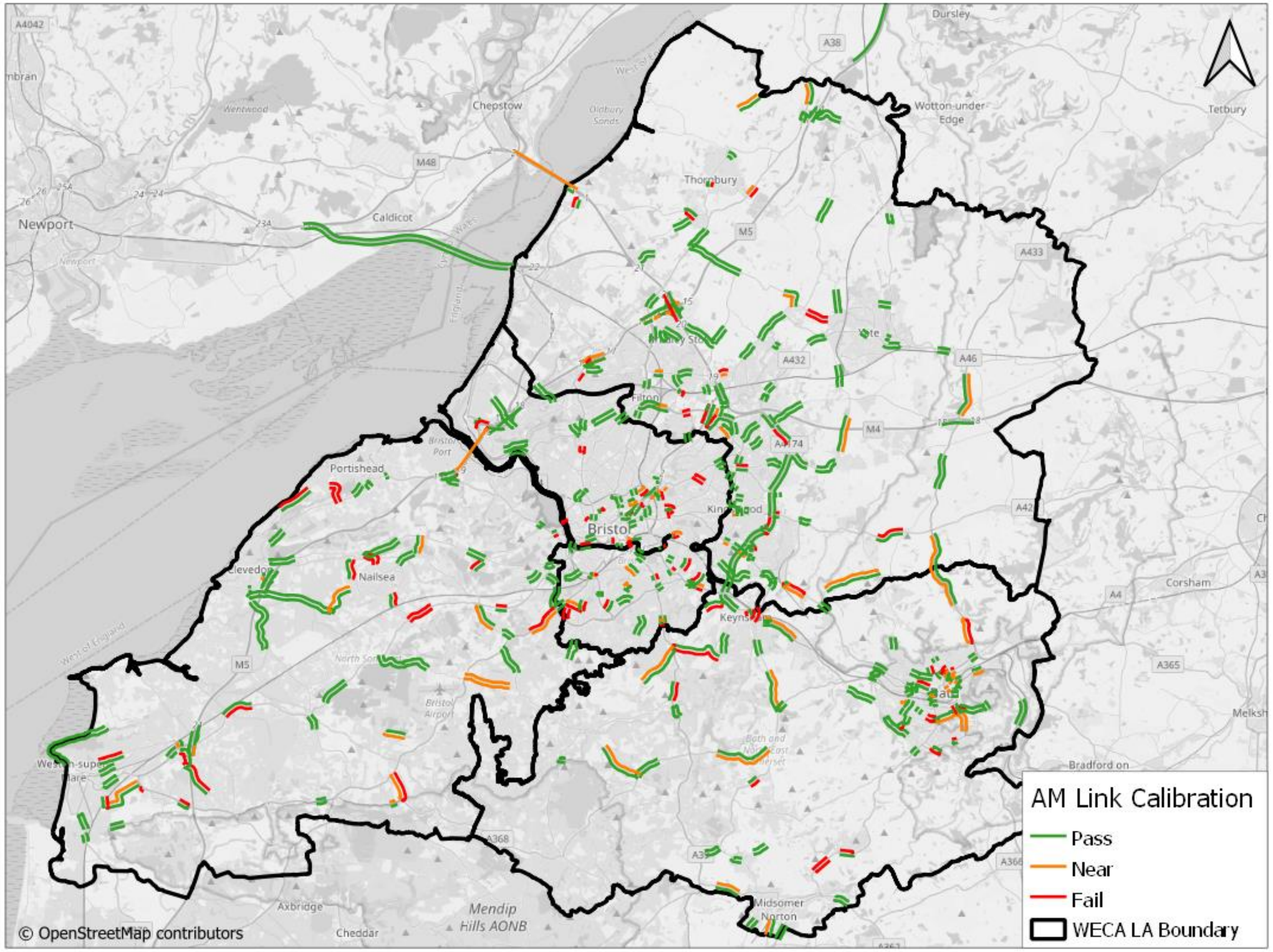
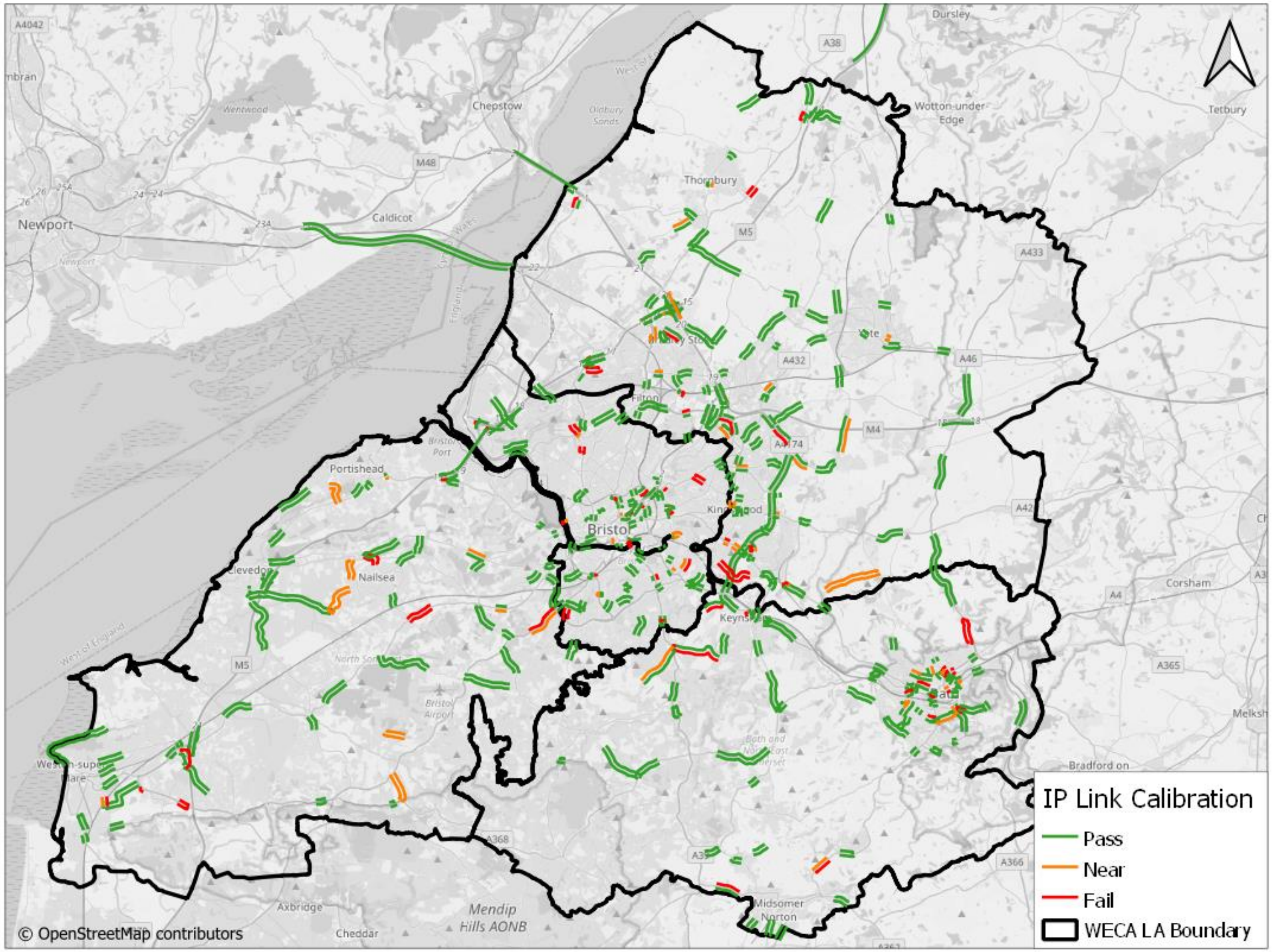
Appendices

Appendix A. Link Calibration Plots

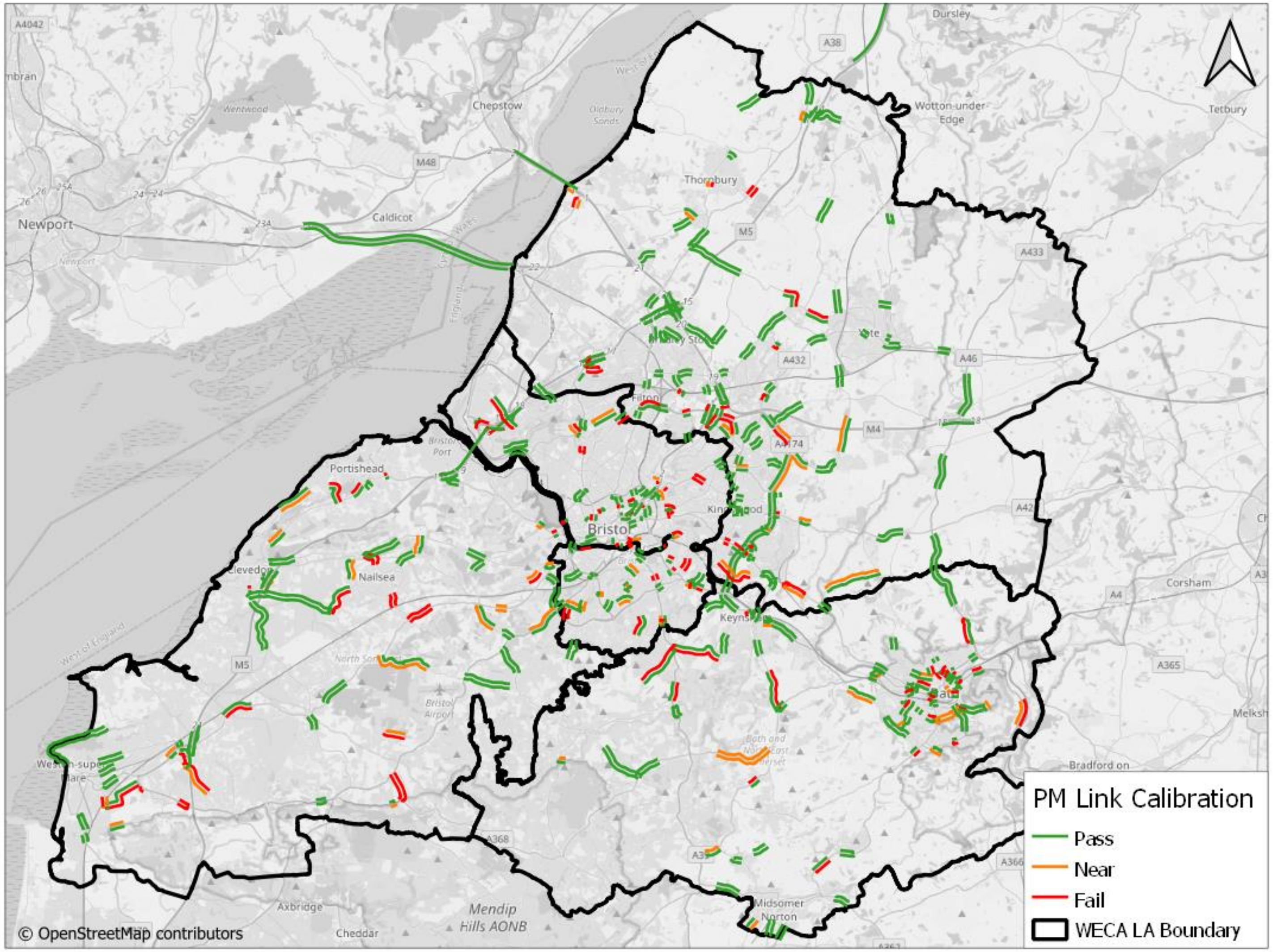
A.1. AM Link Calibration Plot



A.2. IP Link Calibration Plot



A.3. PM Link Calibration Plot



Appendix B. Journey Time Validation

B.1. AM Peak JT Summary

JT Route	Route Name	Length (Km)	Direction	Observed	Obs +15%	Obs - 15%	Modelled	Pass/Fail
Route 1	A4174 Hick's Gate to Bromley Heath Rbt	12.2	NB	00:18:44	00:21:32	00:15:55	00:15:04	✗
		12.3	SB	00:14:41	00:16:54	00:12:29	00:13:55	✓
Route 2	Hambrook to Tormarton Interchange along M4	12.2	EB	00:08:10	00:09:23	00:06:57	00:08:26	✓
		12.2	WB	00:10:10	00:11:42	00:08:39	00:08:11	✗
Route 3	Pilning Interchange to M32 Hambrook along M4	13.6	EB	00:20:40	00:23:46	00:17:34	00:12:39	✗
		13.6	WB	00:09:27	00:10:52	00:08:02	00:09:20	✓
Route 4	A38 /M5 J16 to A38 /B4509 along A38	13.9	NB	00:19:22	00:22:17	00:16:28	00:17:54	✓
		13.9	SB	00:20:23	00:23:26	00:17:19	00:20:54	✓
Route 5	A4174/Filton Rbt to A4174/Siston Hill Rbt along A4174	11.1	EB	00:25:38	00:29:29	00:21:48	00:23:23	✓
		11.1	WB	00:36:47	00:42:18	00:31:16	00:23:07	✗
Route 6	A38/B4061 Thornbury Road to B4058/Wotton Road along B4061-A38	14.2	NB	00:20:18	00:23:20	00:17:15	00:19:41	✓
		14.2	SB	00:20:41	00:23:48	00:17:35	00:20:07	✓
Route 7	A432/A4017 Overndale Road to A38 /Aztec Rbt along A4174	10.1	NB	00:30:35	00:35:10	00:26:00	00:23:06	✗
		10.2	SB	00:19:42	00:22:39	00:16:44	00:21:06	✓
Route 10	B4058/A4174 to A432/B4059 Link Road along B4059-B4060	12.6	NB	00:20:02	00:23:02	00:17:01	00:19:40	✓
		12.7	SB	00:30:45	00:35:22	00:26:08	00:21:44	✗
Route 11	Hayes Way to B4057/Beacon Lane along B4057	6.5	EB	00:11:33	00:13:17	00:09:49	00:14:32	✗
		6.4	WB	00:12:47	00:14:42	00:10:52	00:12:21	✓
Route 13	M48 J1 to M48 J2 along M48	5.1	NB	00:03:14	00:03:43	00:02:45	00:02:46	✓
		4.7	SB	00:03:24	00:03:55	00:02:53	00:02:36	✓

JT Route	Route Name	Length (Km)	Direction	Observed	Obs +15%	Obs - 15%	Modelled	Pass/Fail
Route 16	A4/A4174 to A432/A4017 Mangotsfield	9.2	NB	00:16:46	00:19:17	00:14:16	00:15:32	✓
		9.2	SB	00:17:47	00:20:26	00:15:07	00:14:51	✗
Route 22	Coach Pool Farm to A46/A433	14.5	EB	00:20:33	00:23:38	00:17:28	00:19:02	✓
		14.5	WB	00:19:47	00:22:45	00:16:49	00:20:09	✓

B.2. Inter Peak JT Summary

JT Route	Route Name	Length (Km)	Direction	Observed	Obs +15%	Obs - 15%	Modelled	Pass/Fail
Route 1	A4174 Hick's Gate to Bromley Heath Rbt	12.2	NB	00:16:11	00:18:37	00:13:45	00:14:51	✓
		12.3	SB	00:13:26	00:15:27	00:11:25	00:13:30	✓
Route 2	Hambrook to Tormarton Interchange along M4	12.2	EB	00:08:01	00:09:13	00:06:49	00:07:55	✓
		12.2	WB	00:07:51	00:09:02	00:06:40	00:07:29	✓
Route 3	Pilning Interchange to M32 Hambrook along M4	13.6	EB	00:09:12	00:10:35	00:07:49	00:08:42	✓
		13.6	WB	00:09:20	00:10:44	00:07:56	00:08:23	✓
Route 4	A38 /M5 J16 to A38 /B4509 along A38	13.9	NB	00:17:01	00:19:34	00:14:28	00:17:25	✓
		13.9	SB	00:16:44	00:19:14	00:14:13	00:18:30	✓
Route 5	A4174/Filton Rbt to A4174/Siston Hill Rbt along A4174	11.1	EB	00:16:34	00:19:04	00:14:05	00:19:49	✗
		11.1	WB	00:17:18	00:19:54	00:14:42	00:16:34	✓
Route 6	A38/B4061 Thornbury Road to B4058/Wotton Road along B4061-A38	14.2	NB	00:18:47	00:21:36	00:15:58	00:18:22	✓
		14.2	SB	00:19:41	00:22:38	00:16:44	00:19:42	✓
Route 7	A432/A4017 Overndale Road to A38 /Aztec Rbt along A4174	10.1	NB	00:15:54	00:18:17	00:13:31	00:17:36	✓
		10.2	SB	00:15:27	00:17:46	00:13:08	00:17:57	✗
Route 10	B4058/A4174 to A432/B4059 Link Road along B4059-B4060	12.6	NB	00:18:24	00:21:10	00:15:39	00:18:54	✓
		12.7	SB	00:18:07	00:20:50	00:15:24	00:18:07	✓
		6.5	EB	00:11:31	00:13:15	00:09:47	00:13:03	✓

JT Route	Route Name	Length (Km)	Direction	Observed	Obs +15%	Obs - 15%	Modelled	Pass/Fail
Route 11	Hayes Way to B4057/Beacon Lane along B4057	6.4	WB	00:11:01	00:12:40	00:09:22	00:11:13	✓
Route 13	M48 J1 to M48 J2 along M48	5.1	NB	00:03:15	00:03:44	00:02:46	00:02:46	✓
		4.7	SB	00:03:06	00:03:34	00:02:38	00:02:33	✓
Route 16	A4/A4174 to A432/A4017 Mangotsfield	9.2	NB	00:14:41	00:16:53	00:12:29	00:15:08	✓
		9.2	SB	00:15:37	00:17:57	00:13:16	00:14:12	✓
Route 22	Coach Pool Farm to A46/A433	14.5	EB	00:19:13	00:22:06	00:16:20	00:17:42	✓
		14.5	WB	00:18:01	00:20:43	00:15:19	00:19:12	✓

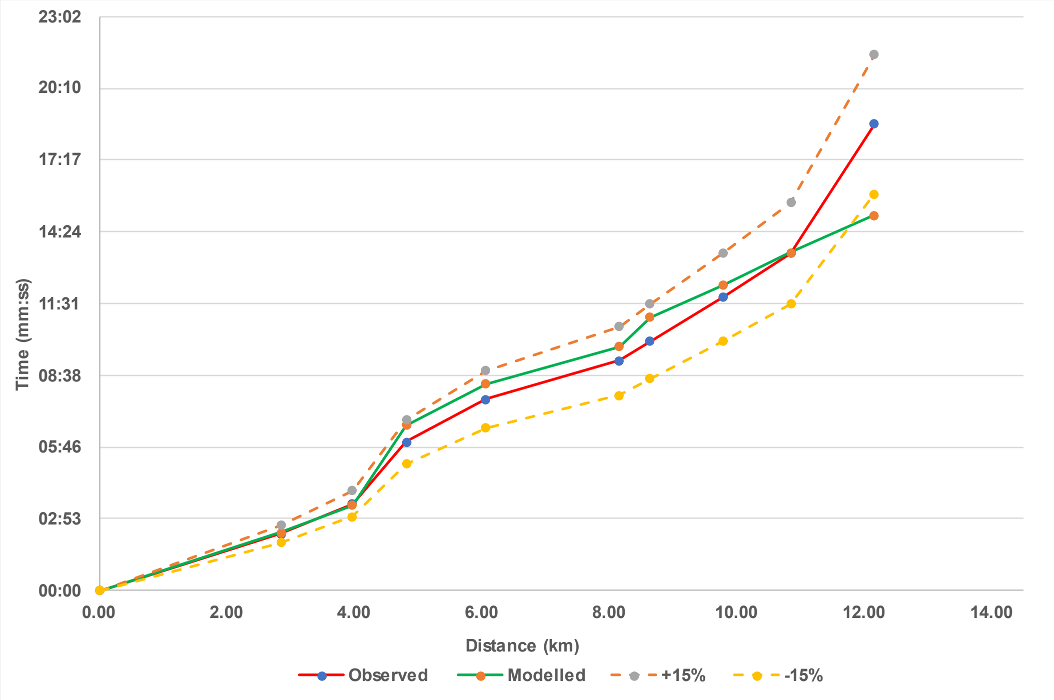
B.3. PM Peak JT Summary

JT Route	Route Name	Length (Km)	Direction	Observed	Obs +15%	Obs - 15%	Modelled	Pass/Fail
Route 1	A4174 Hick's Gate to Bromley Heath Rbt	12.2	NB	00:15:31	00:17:51	00:13:12	00:14:13	✓
		12.3	SB	00:16:09	00:18:34	00:13:44	00:14:36	✓
Route 2	Hambrook to Tormarton Interchange along M4	12.2	EB	00:08:17	00:09:32	00:07:02	00:08:26	✓
		12.2	WB	00:08:59	00:10:20	00:07:38	00:08:17	✓
Route 3	Pilning Interchange to M32 Hambrook along M4	13.6	EB	00:12:25	00:14:17	00:10:33	00:09:52	×
		13.6	SB	00:12:09	00:13:58	00:10:20	00:10:53	✓
Route 4	A38 /M5 J16 to A38 /B4509 along A38	13.9	NB	00:20:50	00:23:57	00:17:42	00:18:26	✓
		13.9	SB	00:19:59	00:22:59	00:17:00	00:19:15	✓
Route 5	A4174/Filton Rbt to A4174/Siston Hill Rbt along A4174	11.1	NB	00:26:17	00:30:14	00:22:21	00:23:30	✓
		11.1	SB	00:24:39	00:28:21	00:20:57	00:19:59	×
Route 6	A38/B4061 Thornbury Road to B4058/Wotton Road along B4061-A38	14.2	NB	00:19:38	00:22:35	00:16:42	00:19:08	✓
		14.2	SB	00:21:34	00:24:48	00:18:20	00:19:04	✓
Route 7	A432/A4017 Overndale Road to A38	10.1	NB	00:22:23	00:25:44	00:19:01	00:21:40	✓
		10.2	SB	00:20:54	00:24:02	00:17:46	00:19:19	✓

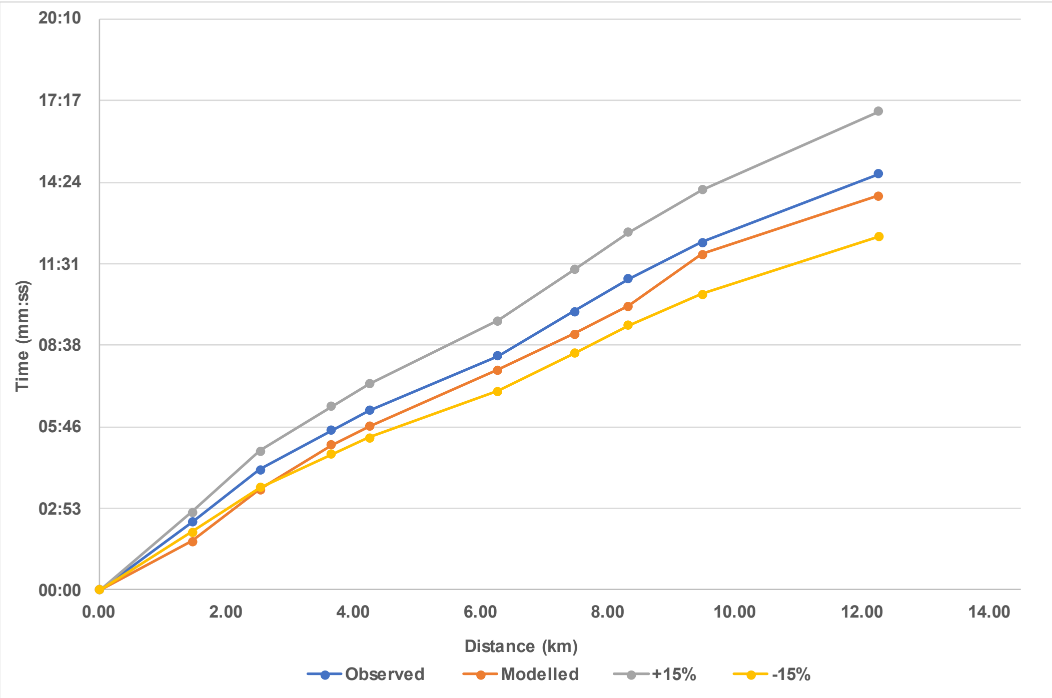
JT Route	Route Name	Length (Km)	Direction	Observed	Obs +15%	Obs - 15%	Modelled	Pass/Fail
	/Aztec Rbt along A4174							
Route 10	B4058/A4174 to A432/B4059 Link Road along B4059-B4060	12.6	NB	00:21:28	00:24:42	00:18:15	00:21:42	✓
		12.7	SB	00:22:21	00:25:42	00:19:00	00:18:58	×
Route 11	Hayes Way to B4057/Beacon Lane along B4057	6.5	NB	00:15:58	00:18:22	00:13:34	00:15:27	✓
		6.4	SB	00:12:43	00:14:38	00:10:49	00:12:10	✓
Route 13	M48 J1 to M48 J2 along M48	5.1	NB	00:03:23	00:03:53	00:02:53	00:02:49	✓
		4.7	SB	00:03:01	00:03:28	00:02:34	00:02:33	✓
Route 16	A4/A4174 to A432/A4017 Mangotsfield	9.2	NB	00:15:46	00:18:07	00:13:24	00:14:08	✓
		9.2	SB	00:19:11	00:22:04	00:16:19	00:15:44	×
Route 22	Coach Pool Farm to A46/A433	14.5	NB	00:22:10	00:25:29	00:18:50	00:18:10	×
		14.5	SB	00:18:38	00:21:26	00:15:50	00:19:11	✓

Appendix C. JT Plots

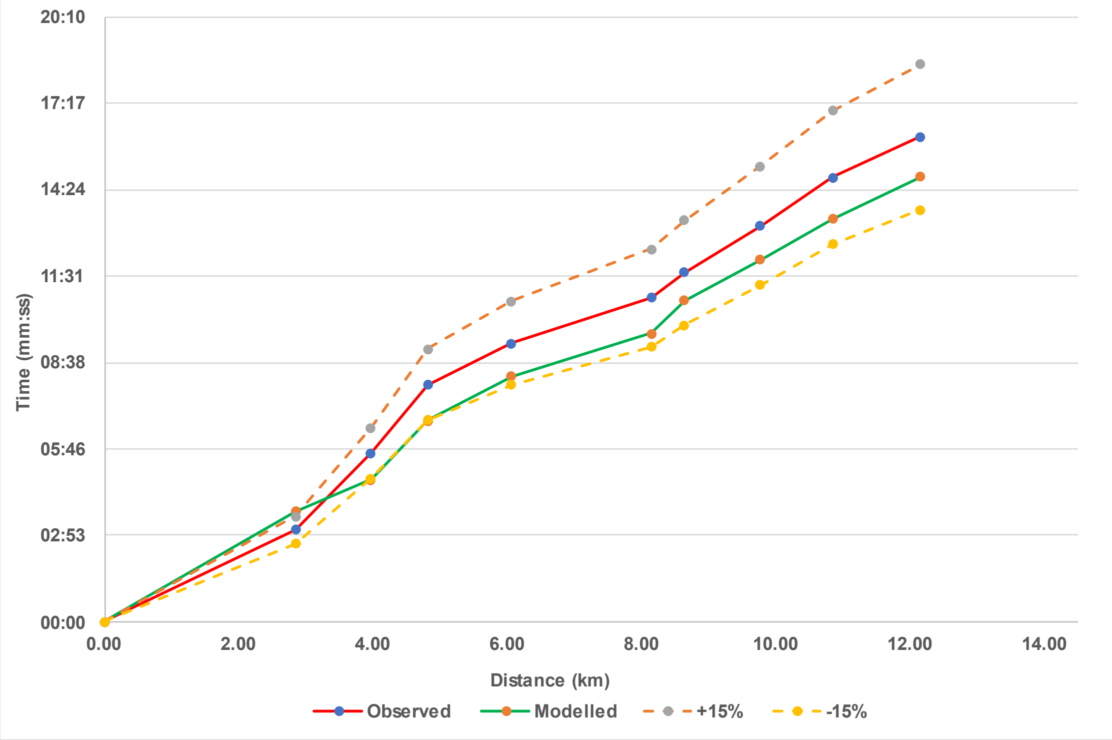
C.1. JTR1 NB – AM Peak



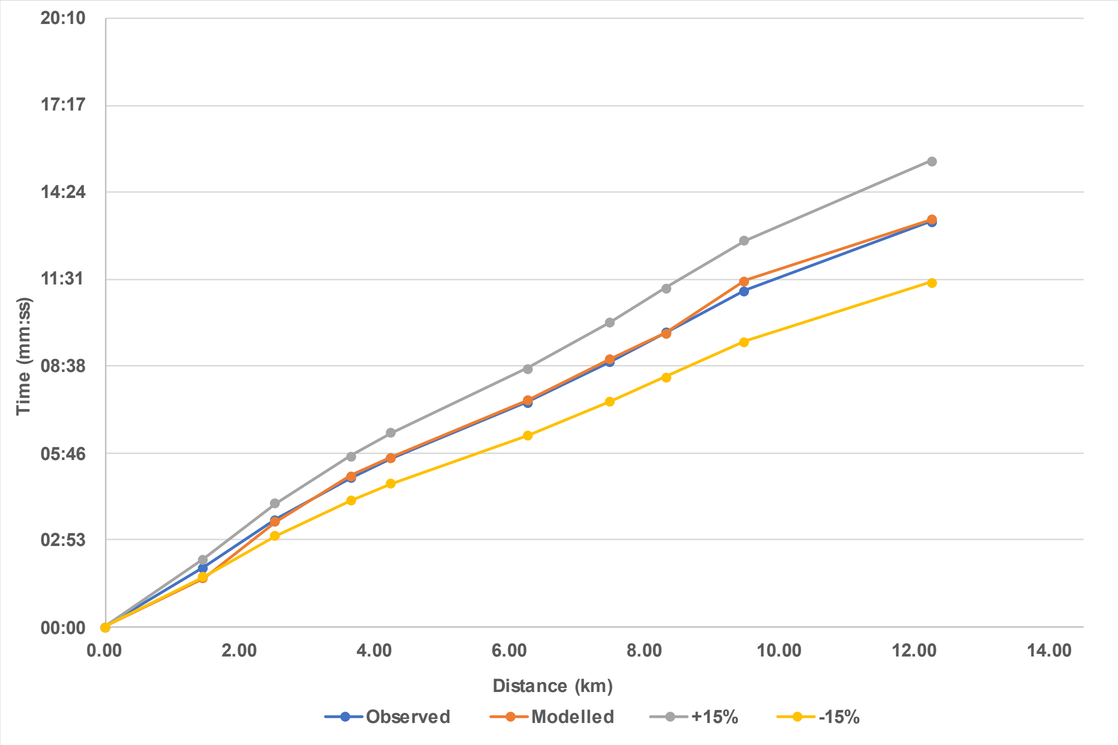
C.2. JTR1 SB – AM Peak



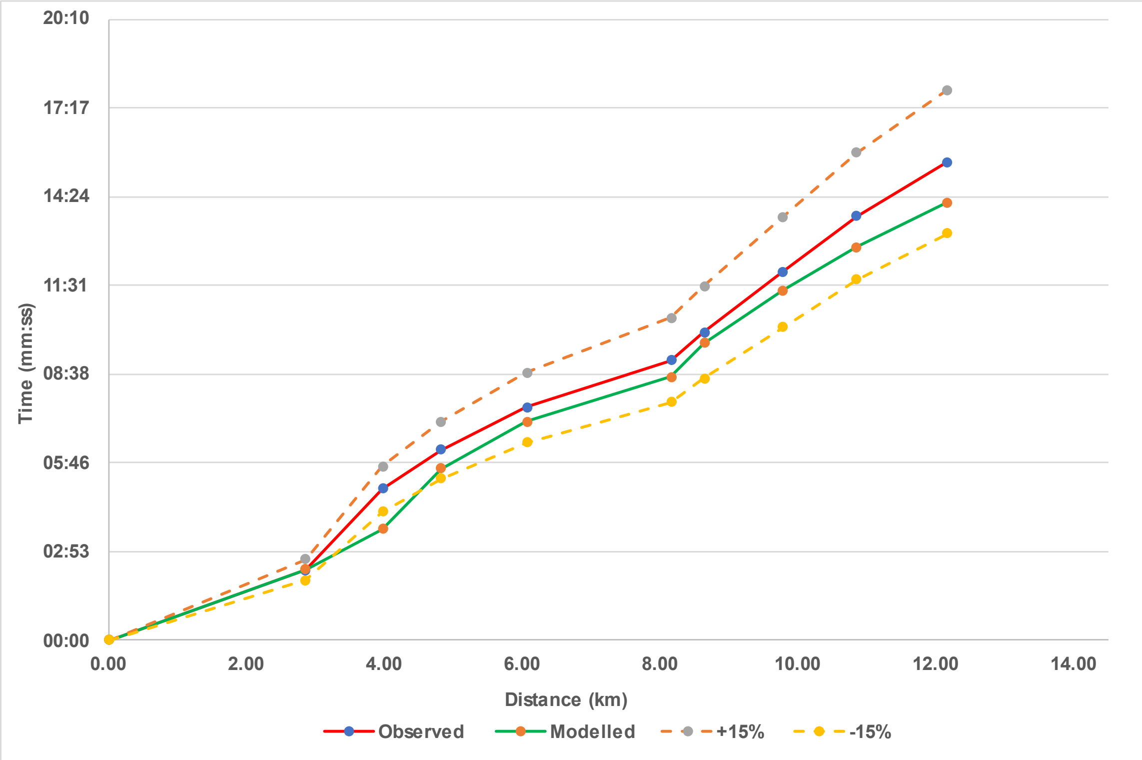
C.3. JTR1 NB – Inter Peak



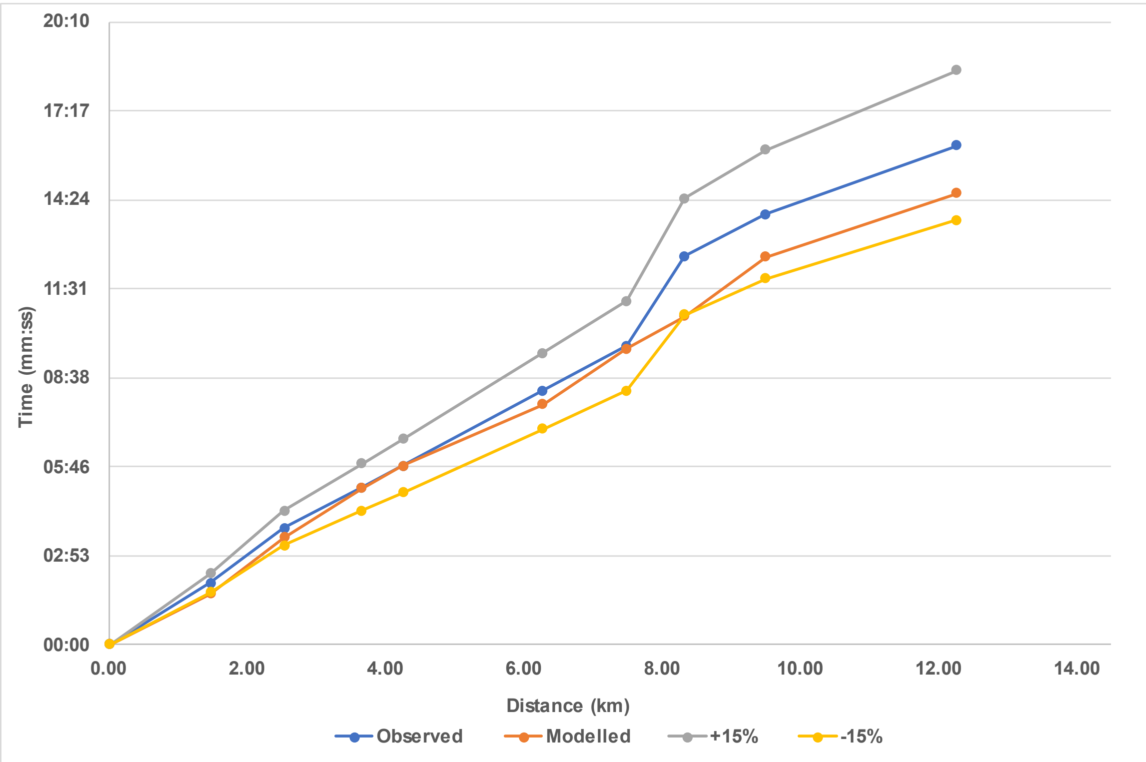
C.4. JTR1 SB – Inter Peak



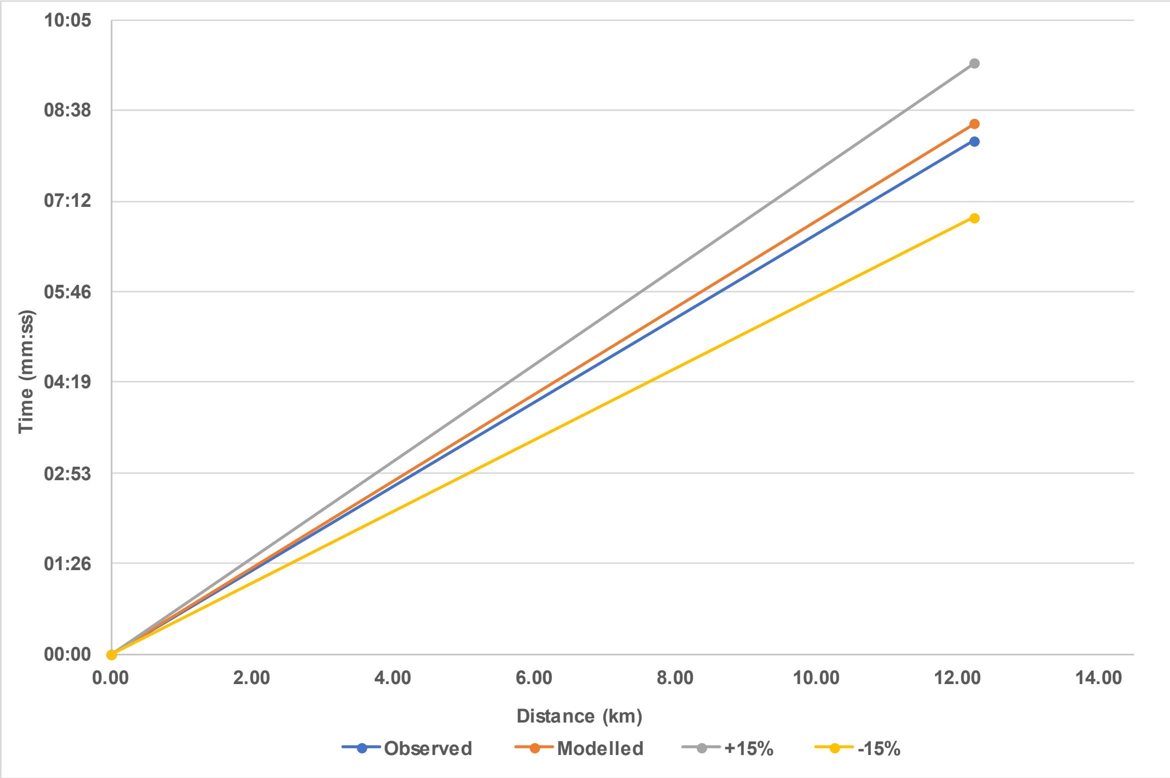
C.5. JTR1 NB – PM Peak



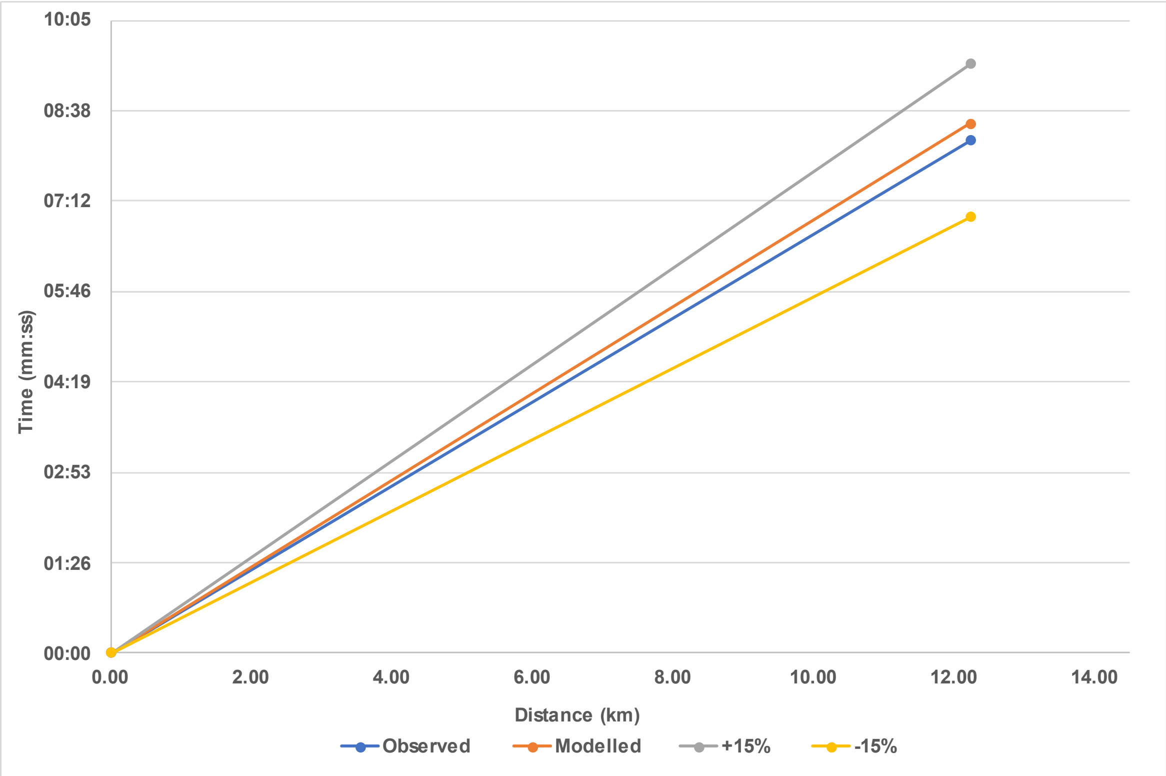
C.6. JTR1 SB – PM Peak



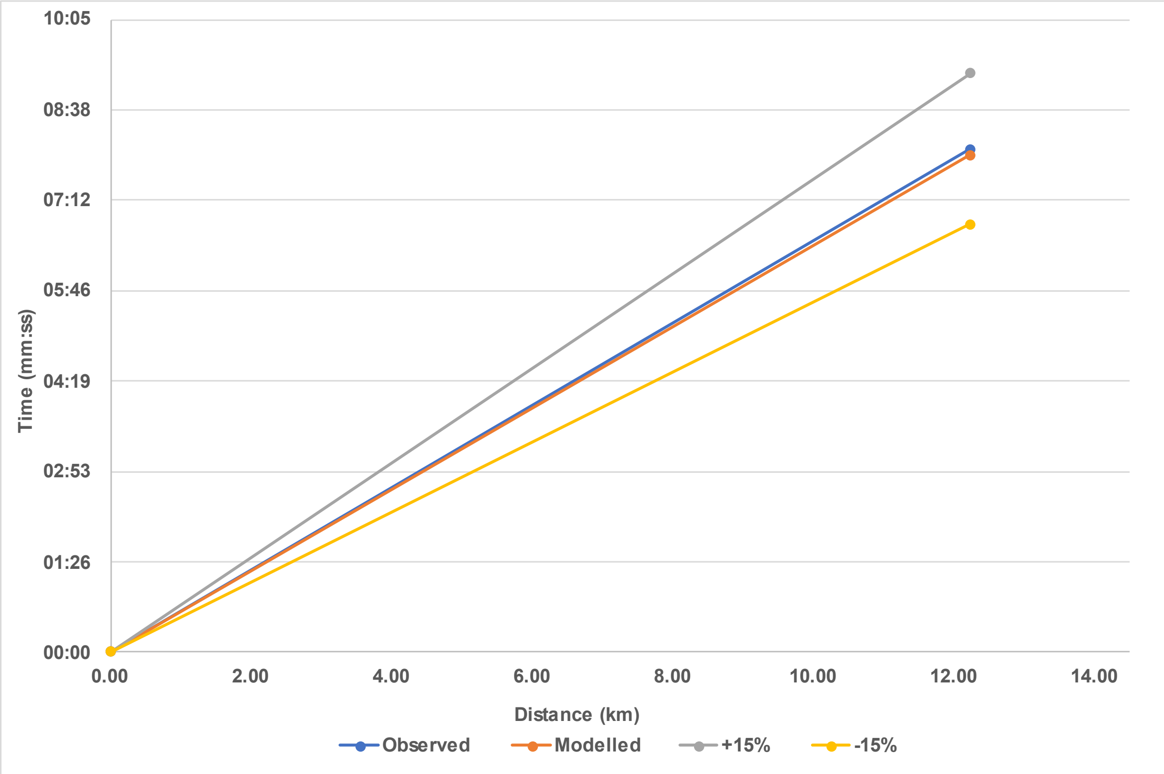
C.7. JTR2 EB – AM Peak



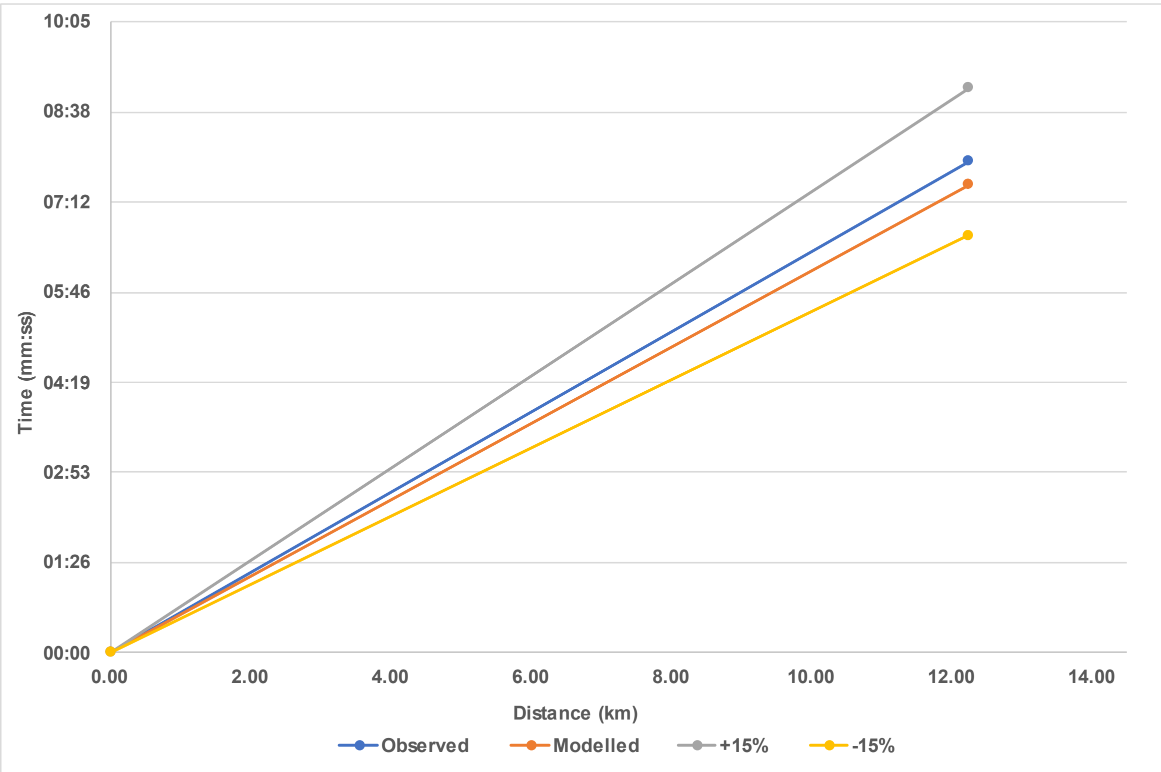
C.8. JTR2 WB – AM Peak



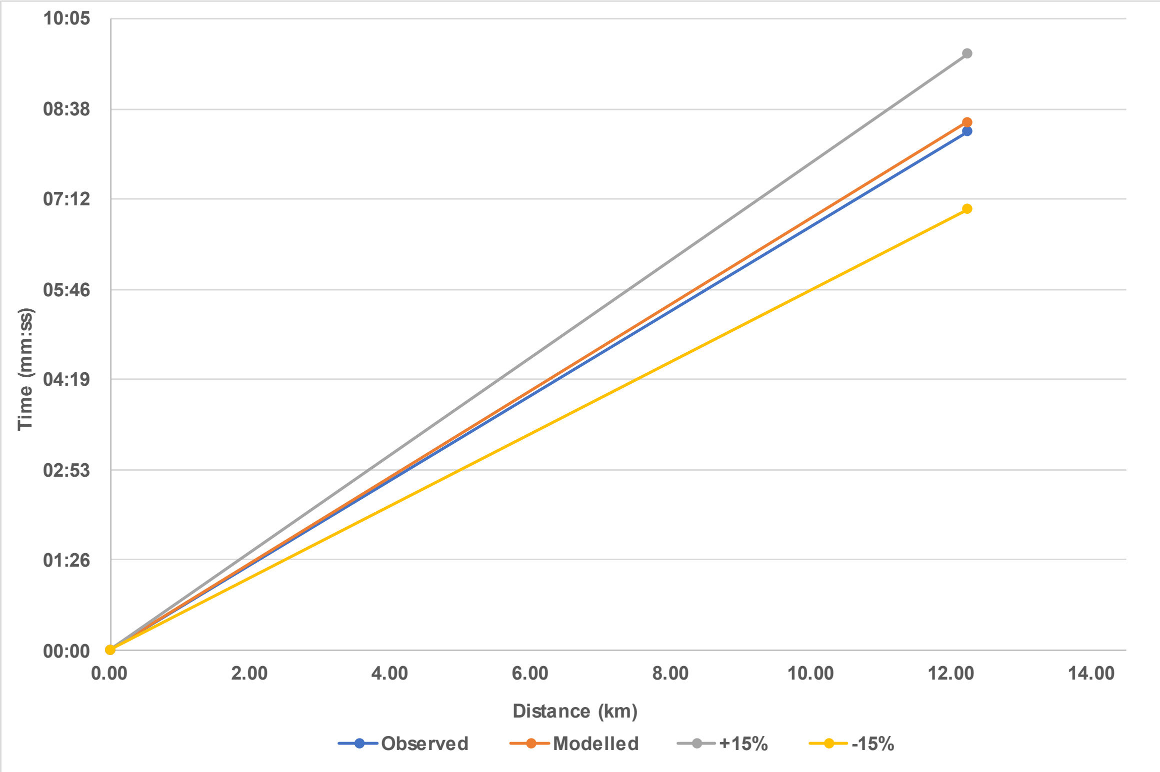
C.9. JTR2 EB – IP Peak



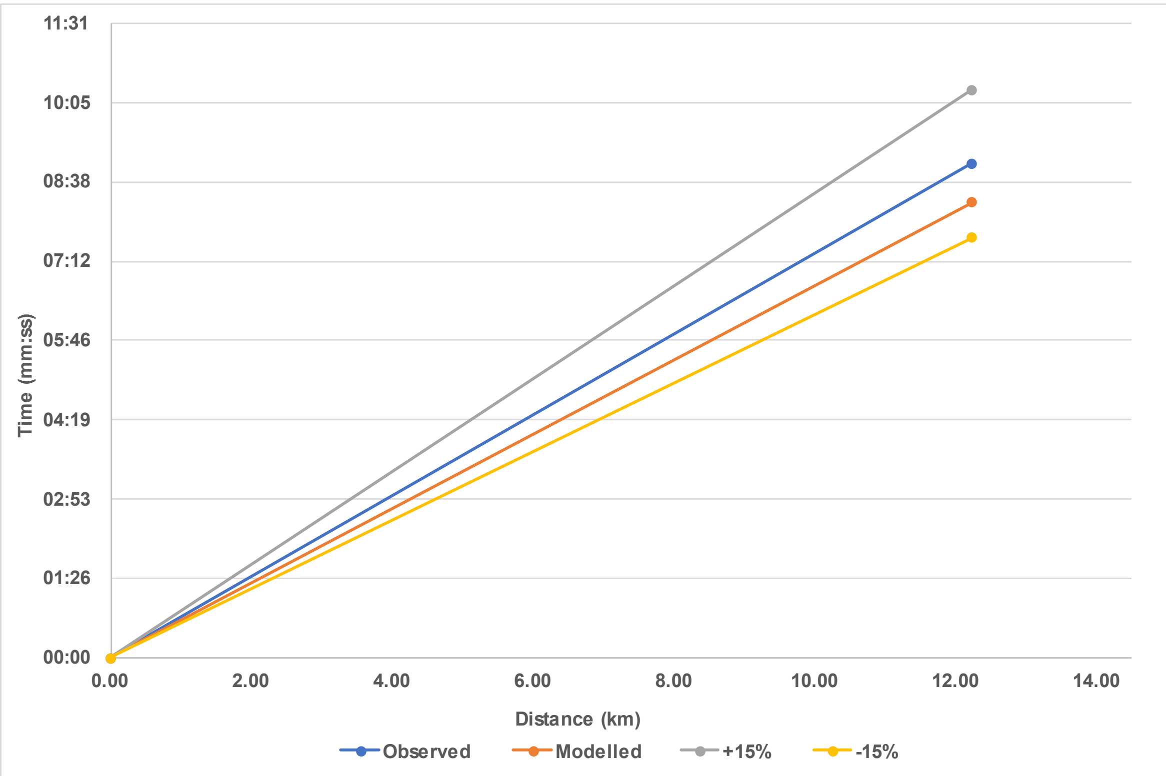
C.10. JTR2 WB – IP Peak



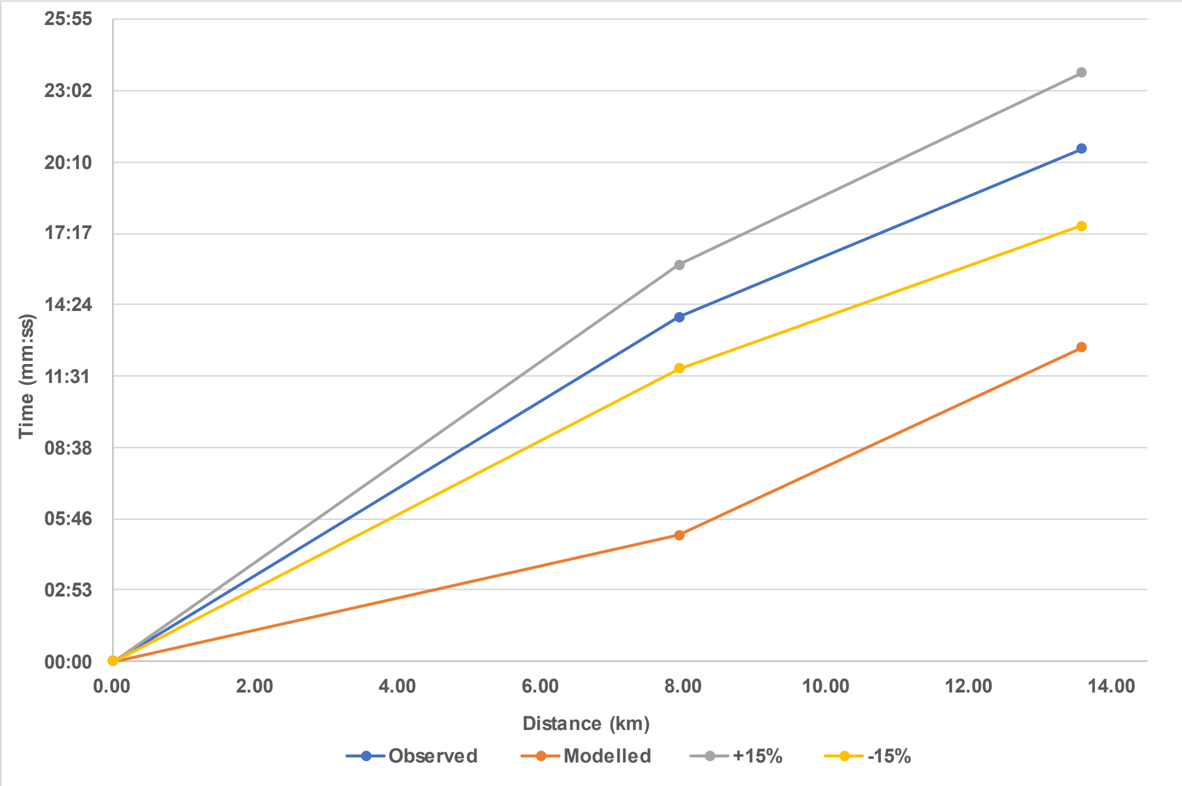
C.11. JTR2 EB – PM Peak



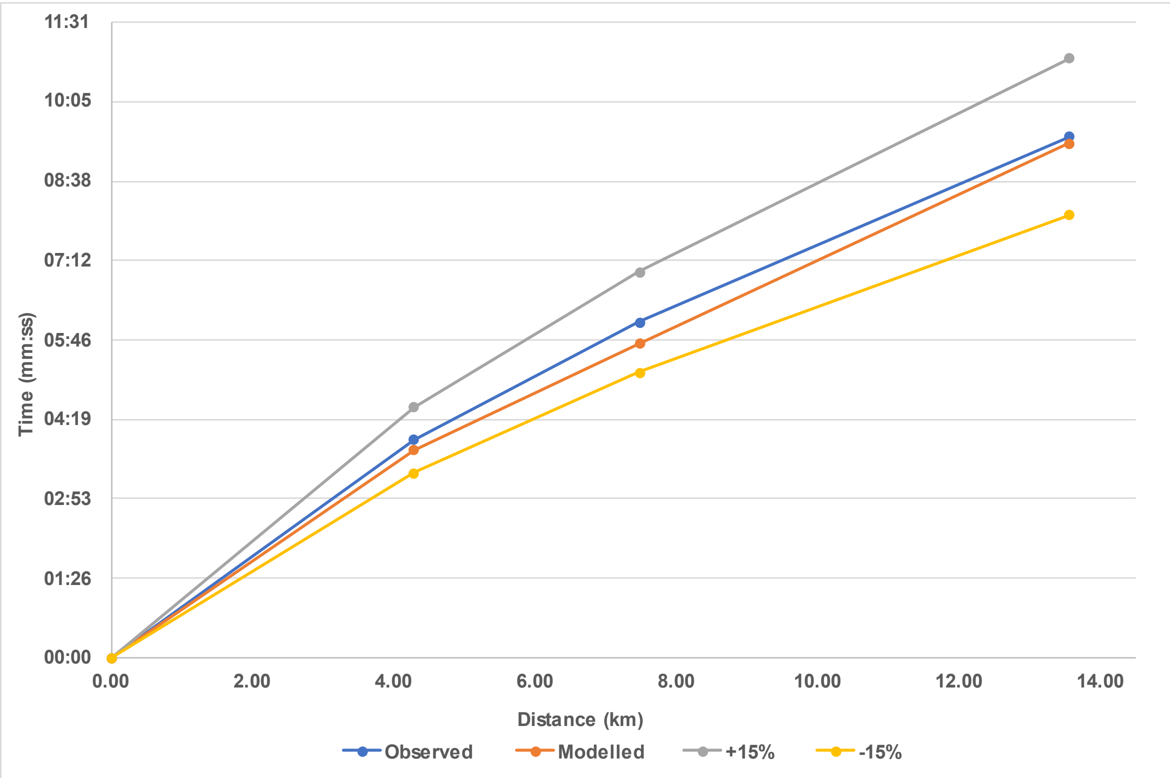
C.12. JTR2 WB – PM Peak



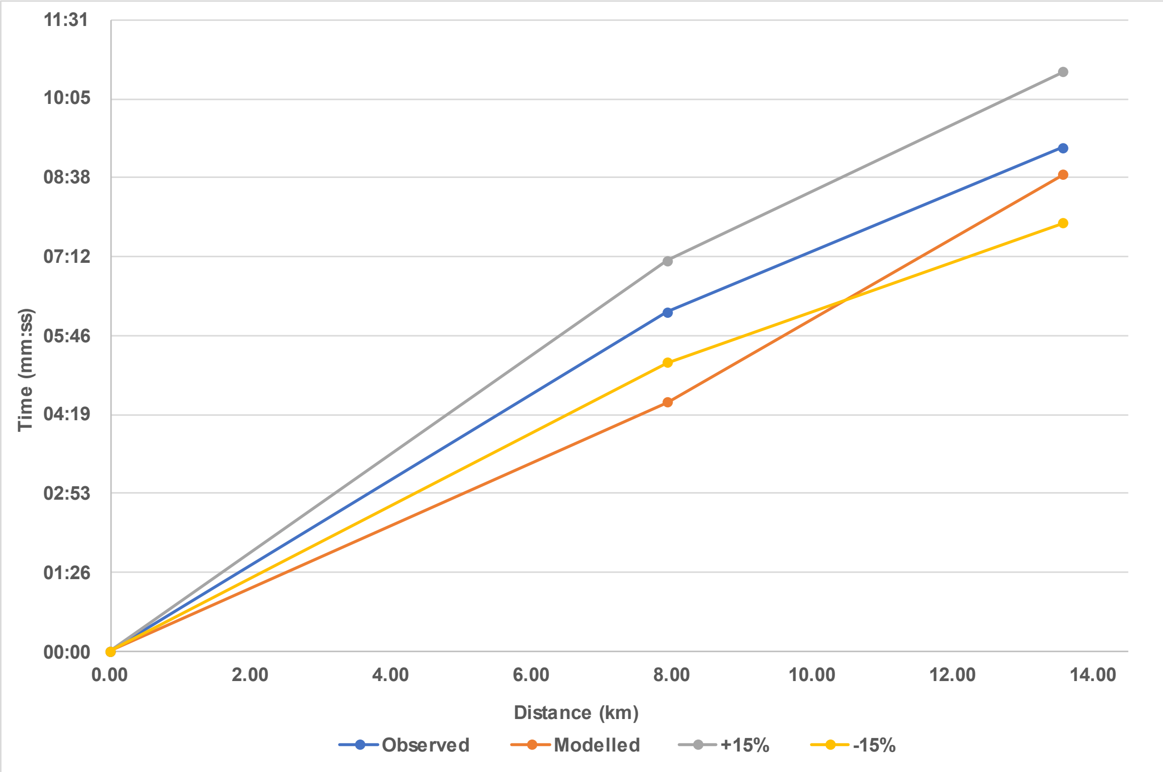
C.13. JTR3 EB – AM Peak



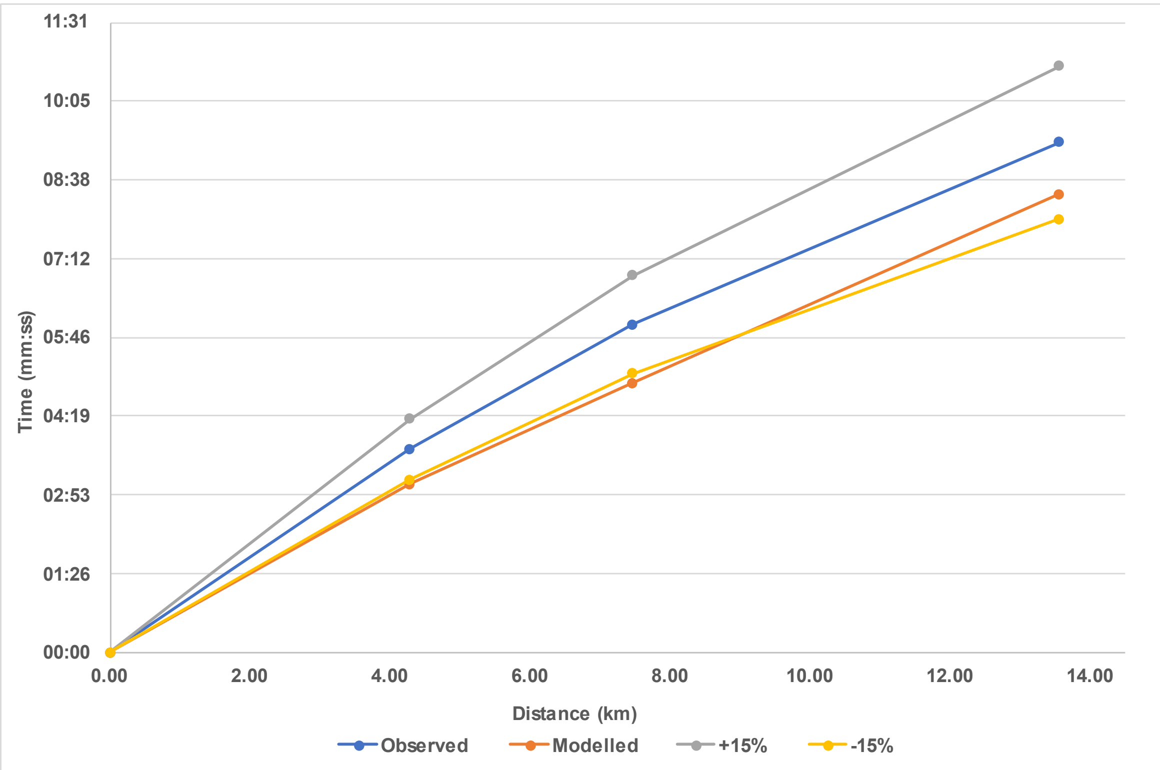
C.14. JTR3 WB – AM Peak



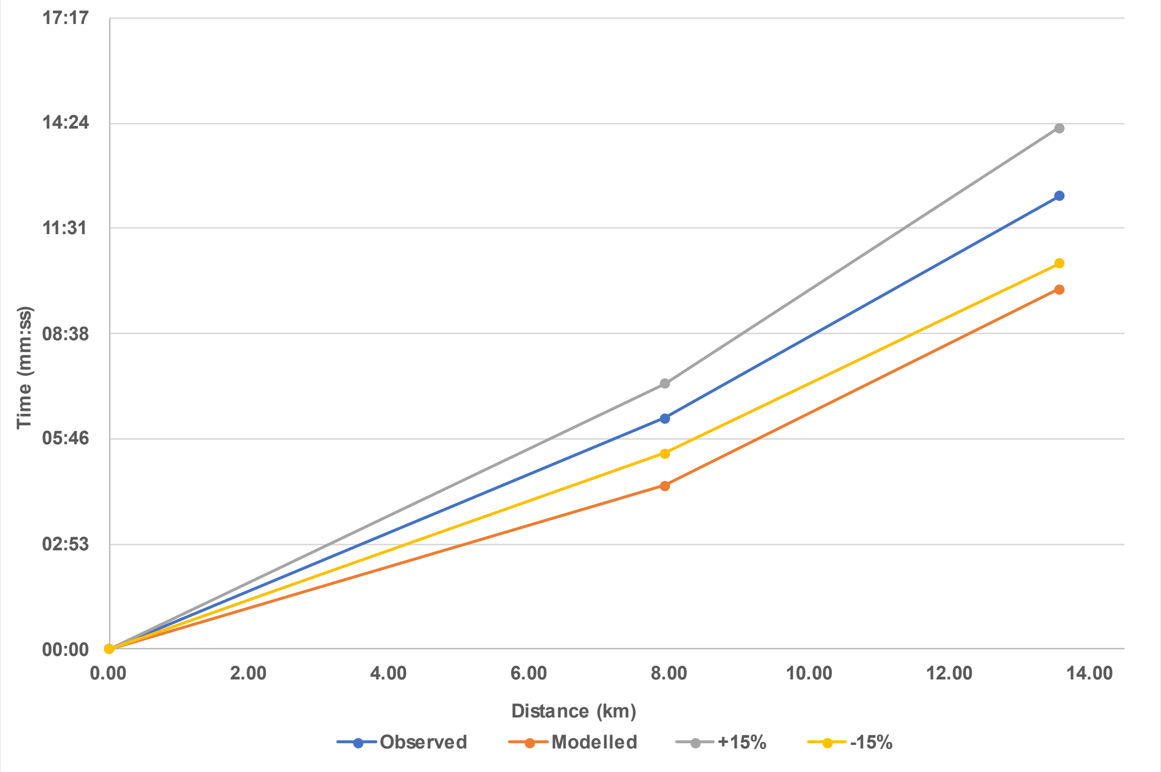
C.15. JTR3 EB – IP Peak



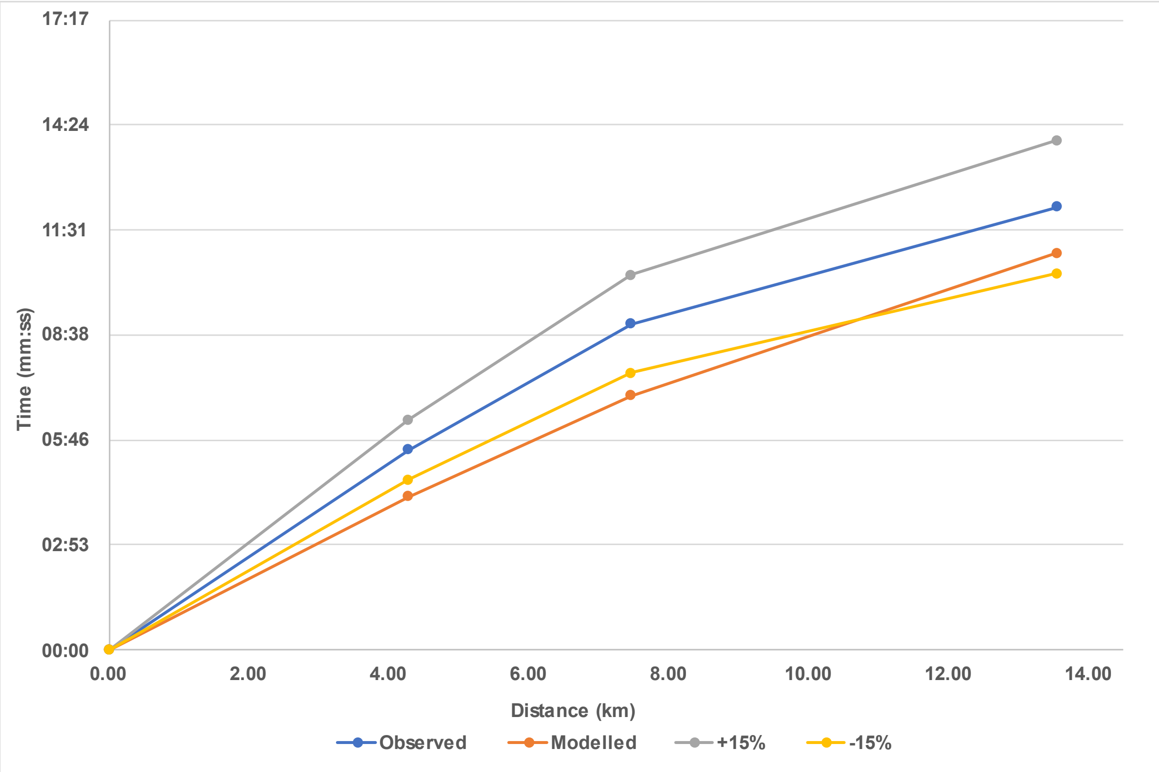
C.16. JTR3 WB – IP Peak



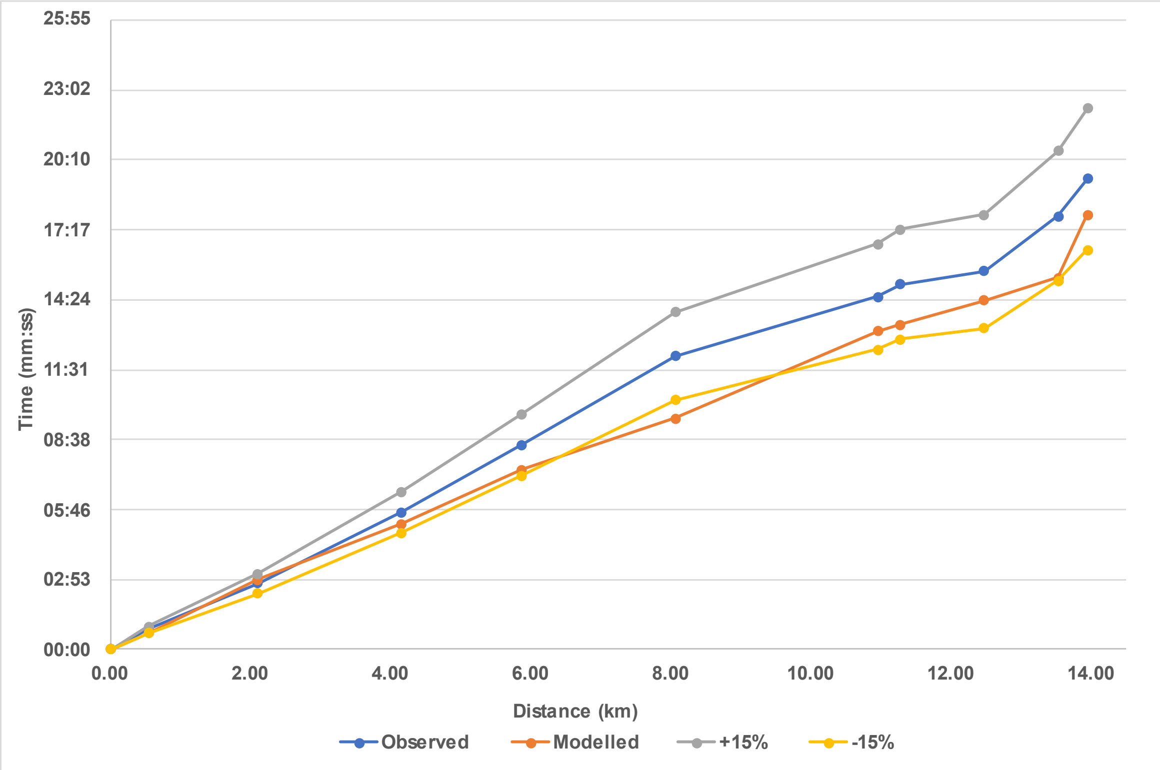
C.17. JTR3 EB – PM Peak



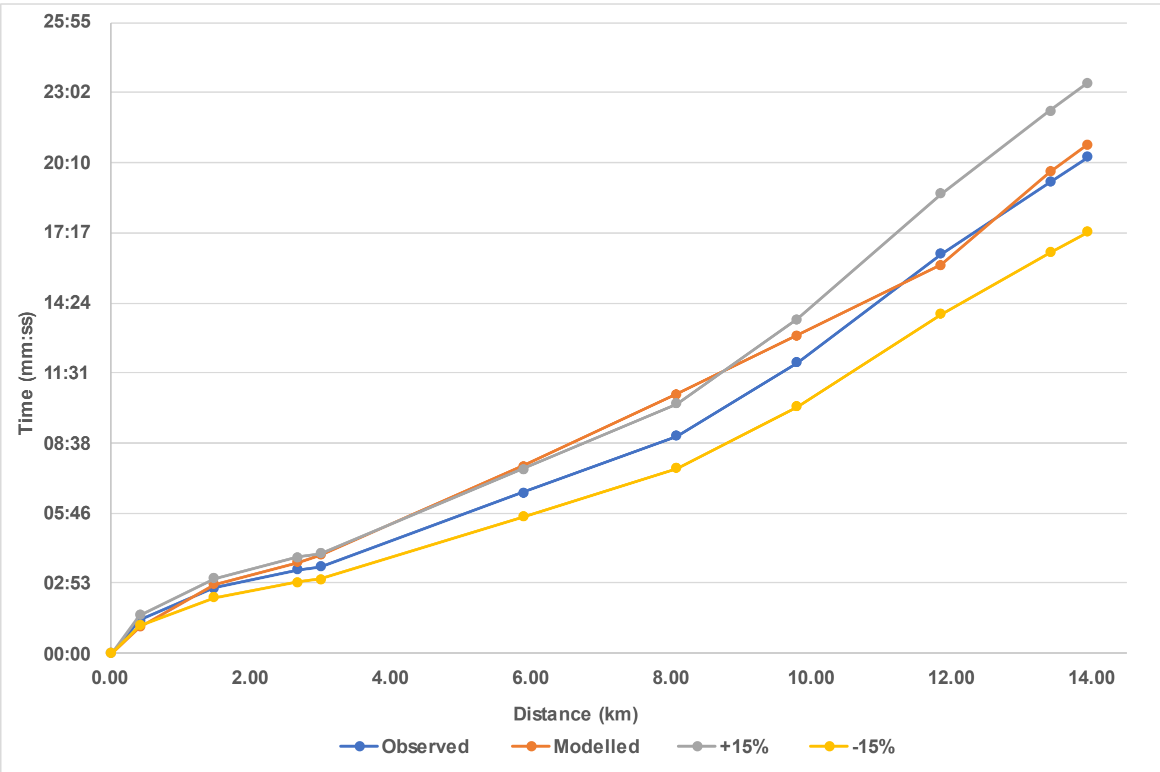
C.18. JTR3 WB – PM Peak



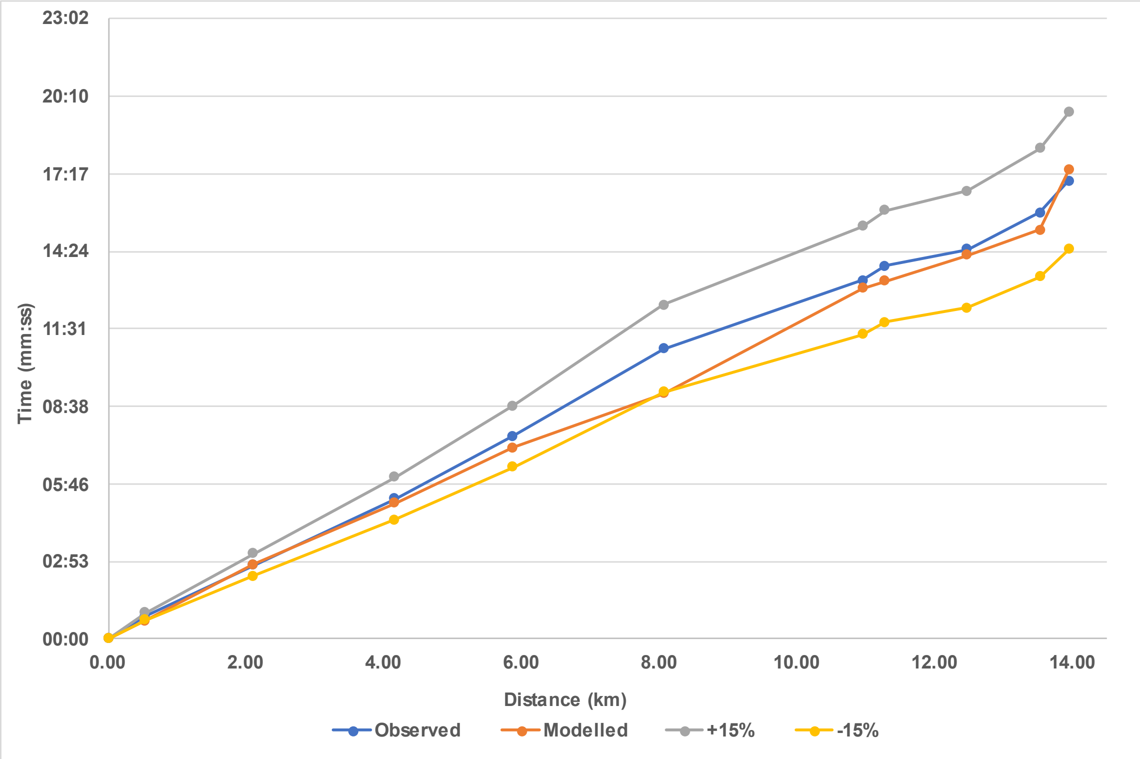
C.19. JTR4 NB – AM Peak



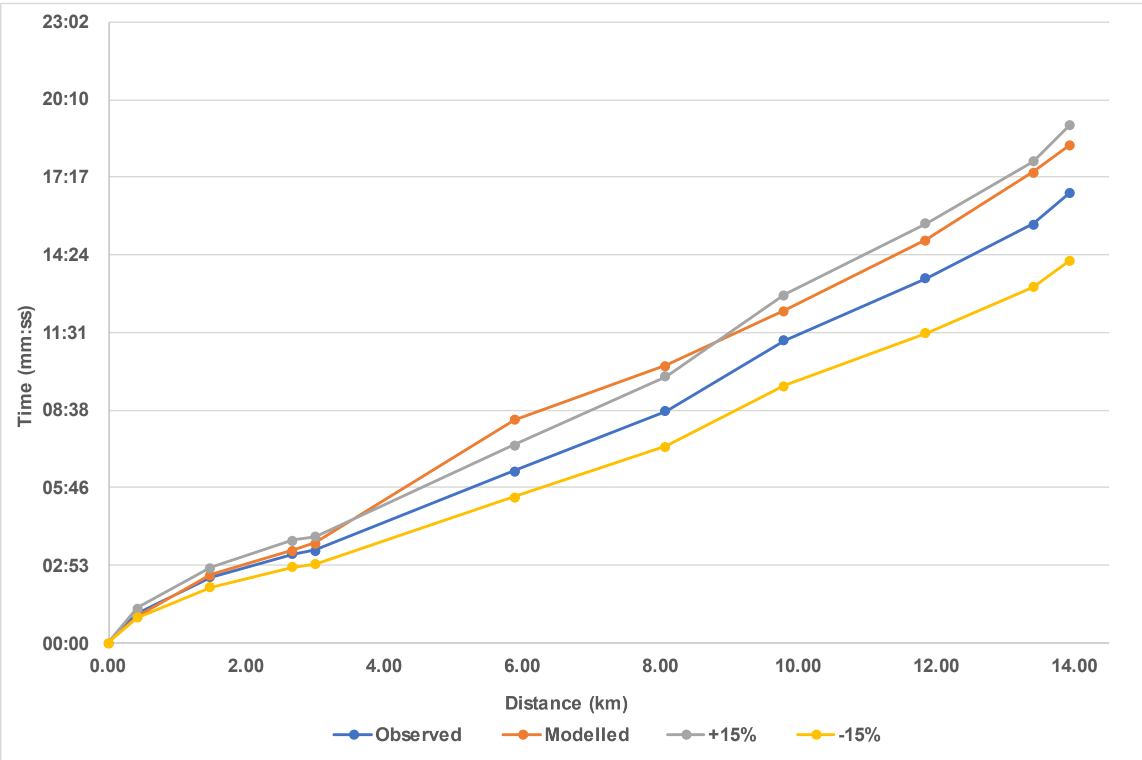
C.20. JTR4 SB – AM Peak



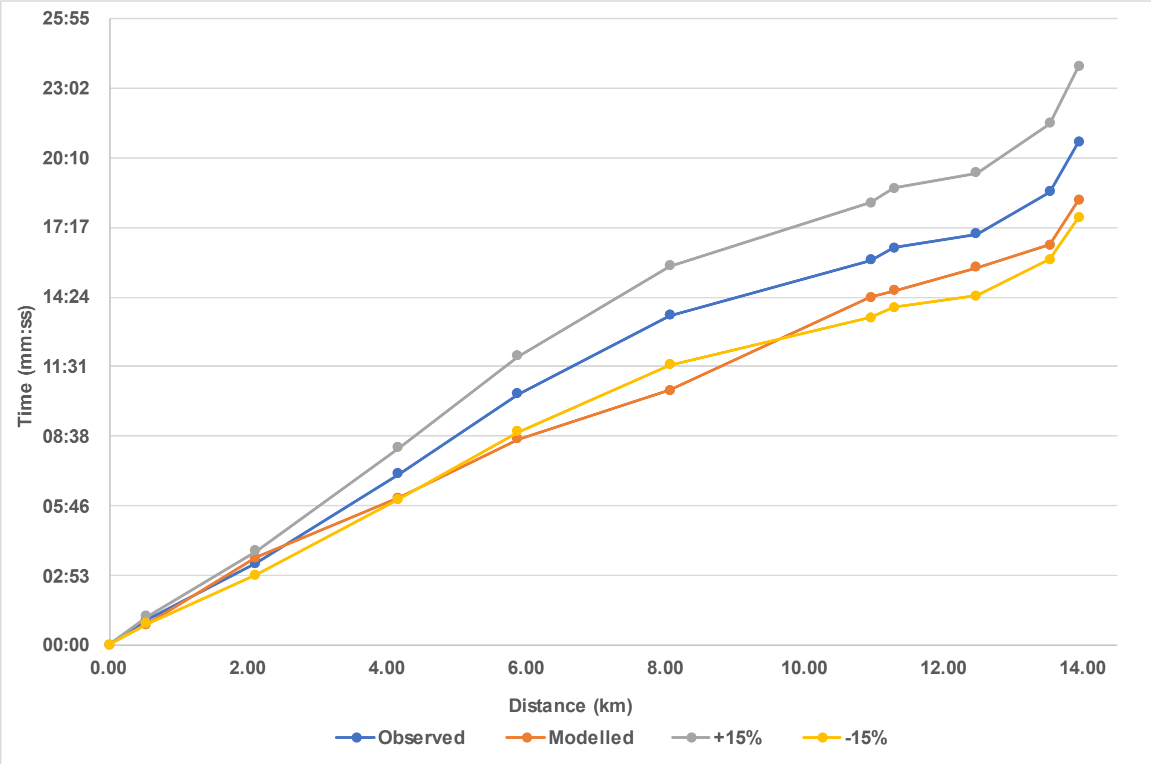
C.21. JTR4 NB – IP Peak



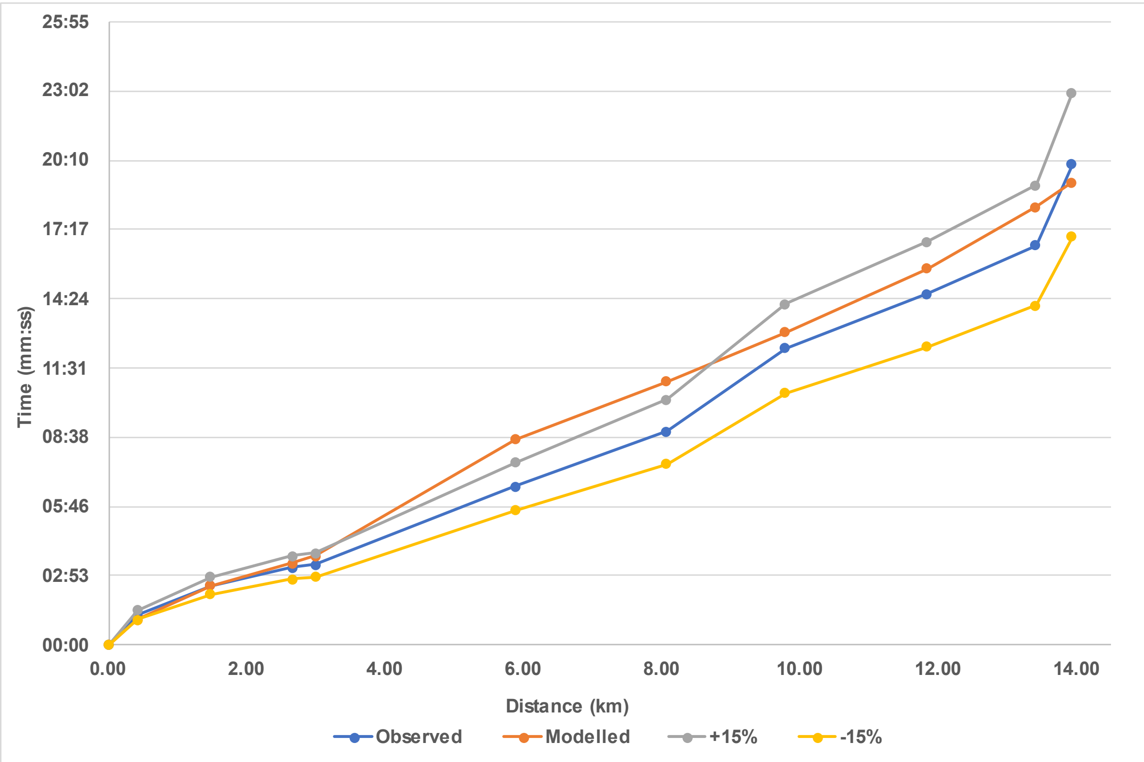
C.22. JTR4 SB – IP Peak



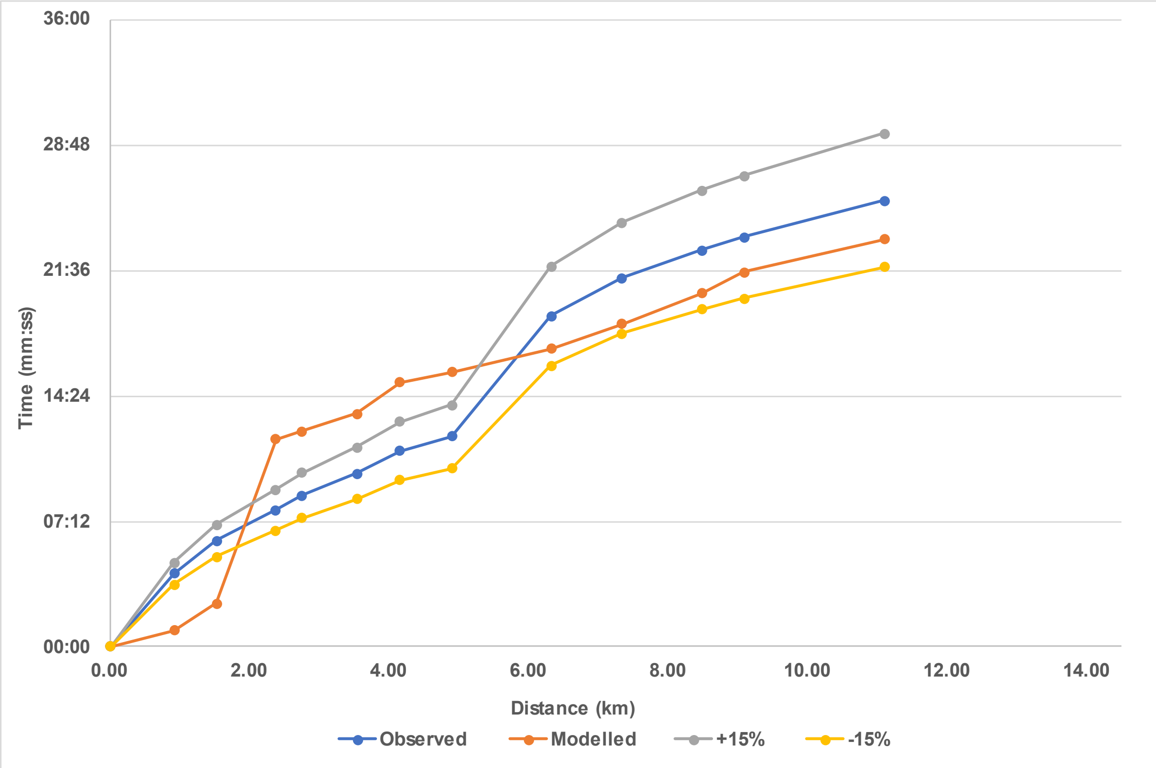
C.23. JTR4 NB – PM Peak



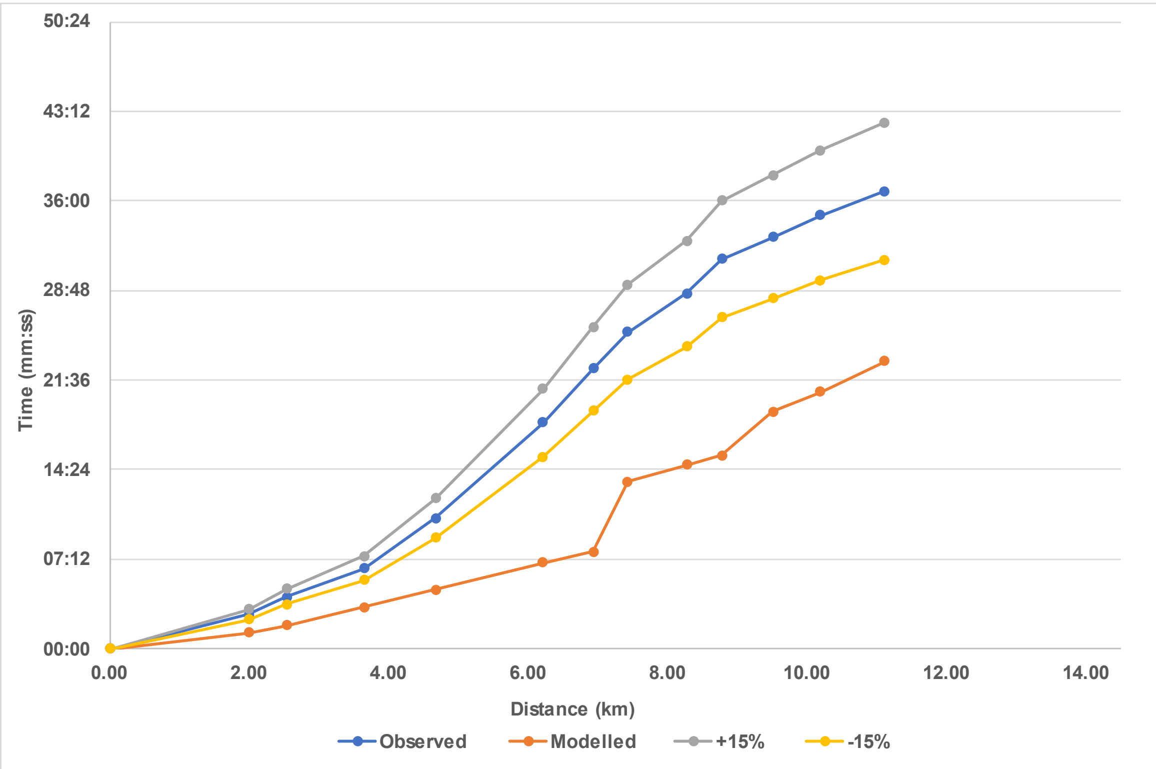
C.24. JTR4 SB – PM Peak



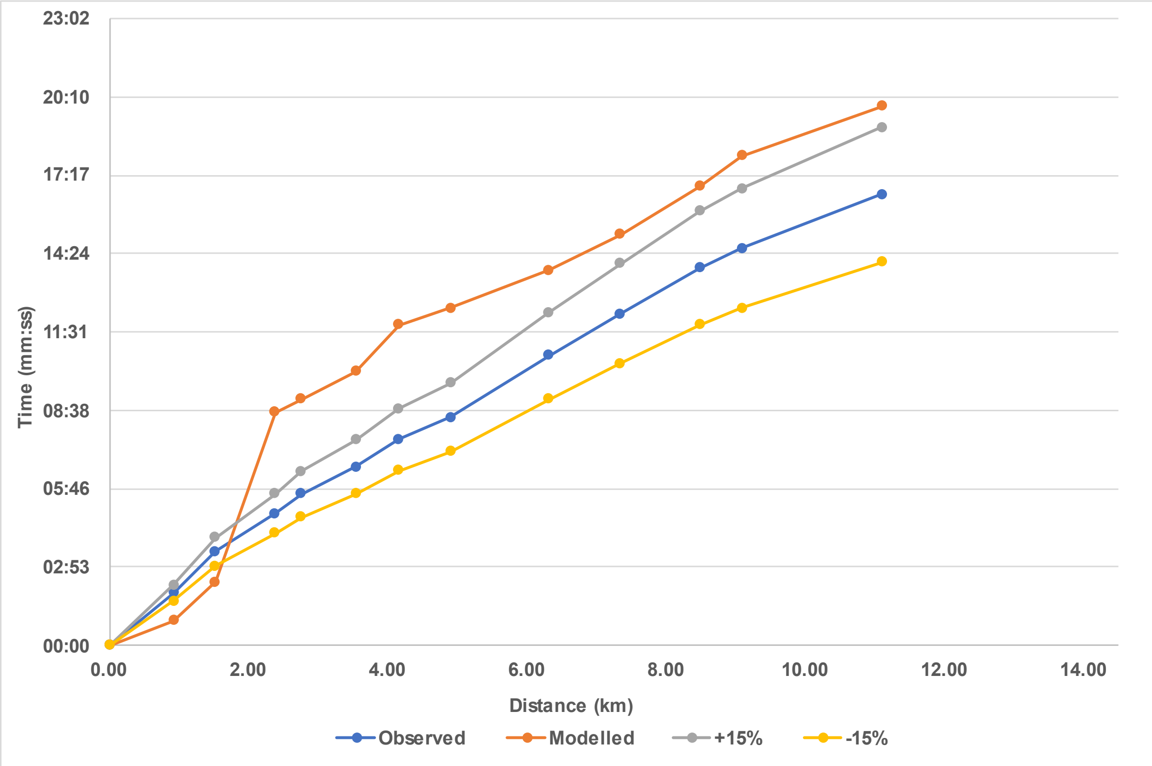
C.25. JTR5 EB – AM Peak



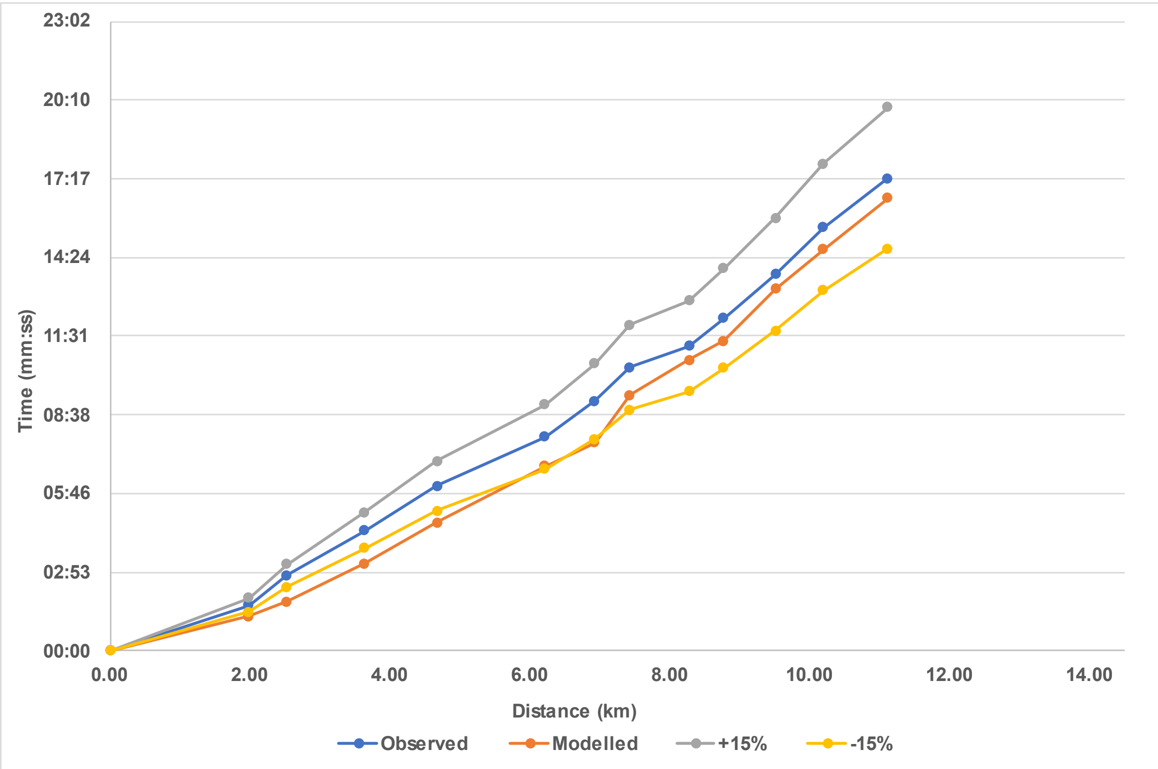
C.26. JTR5 WB – AM Peak



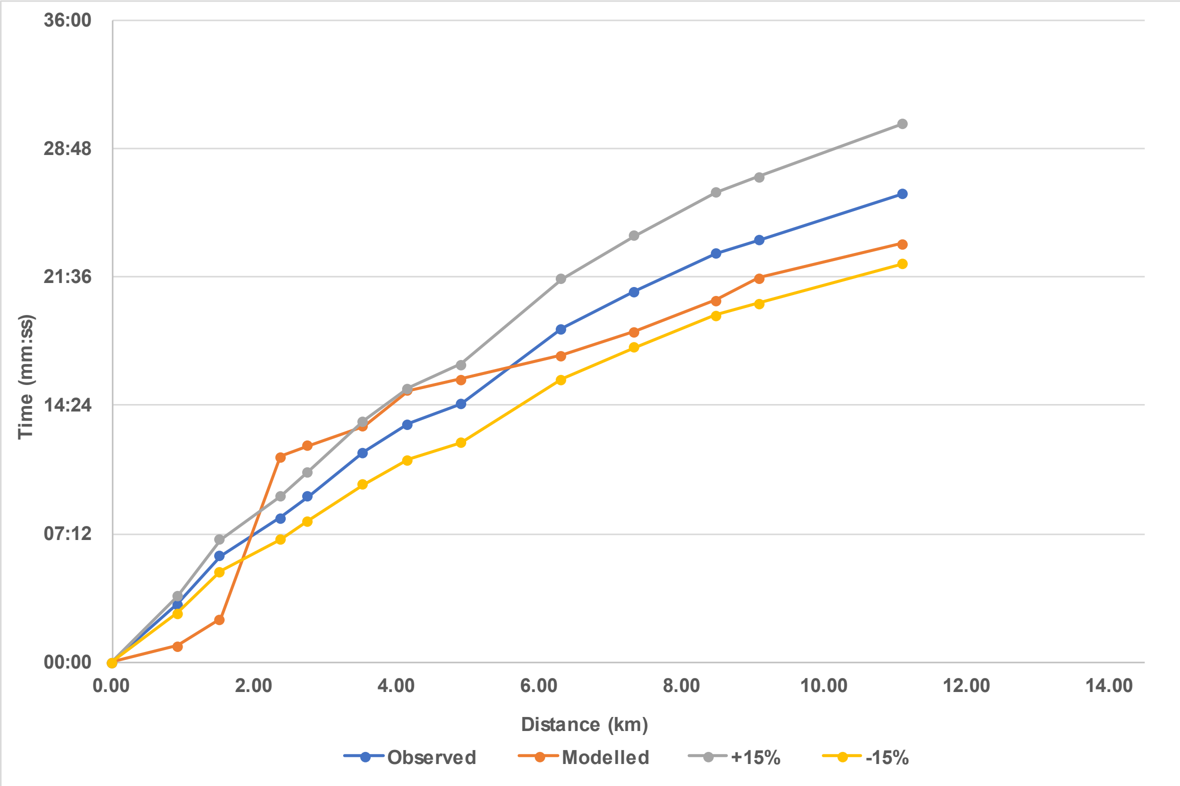
C.27. JTR5 EB – IP Peak



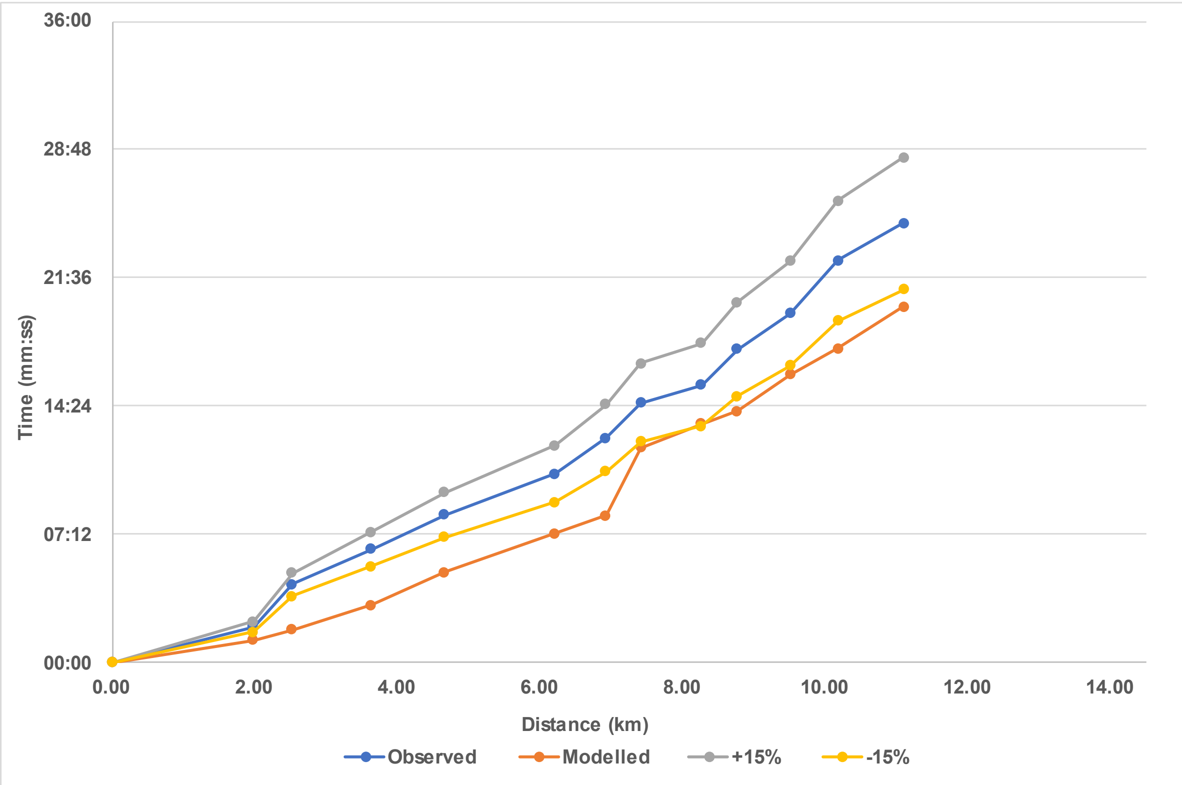
C.28. JTR5 WB – IP Peak



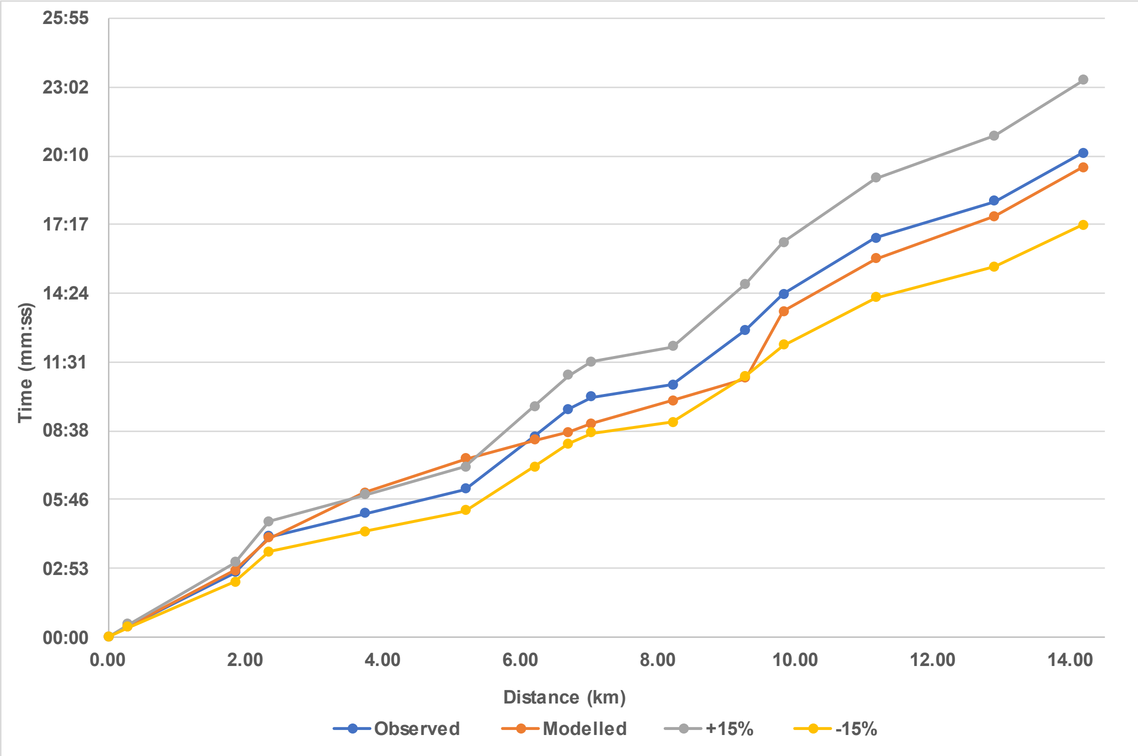
C.29. JTR5 EB – PM Peak



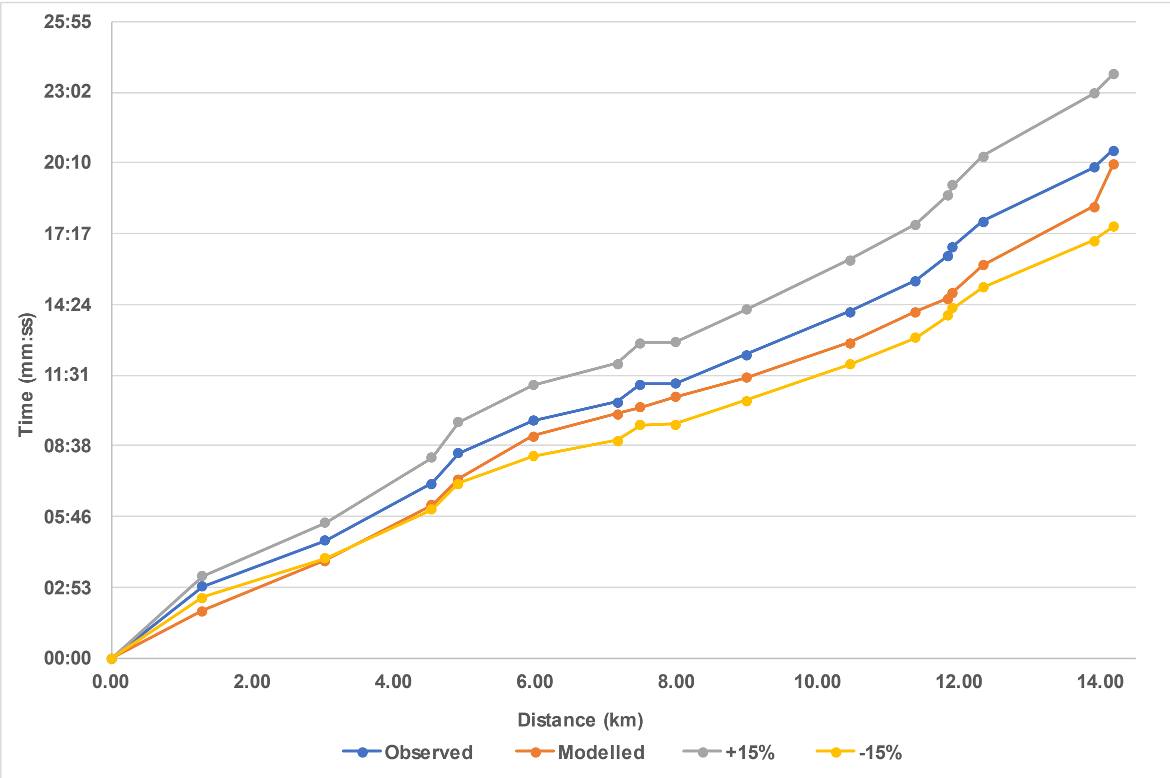
C.30. JTR5 WB – PM Peak



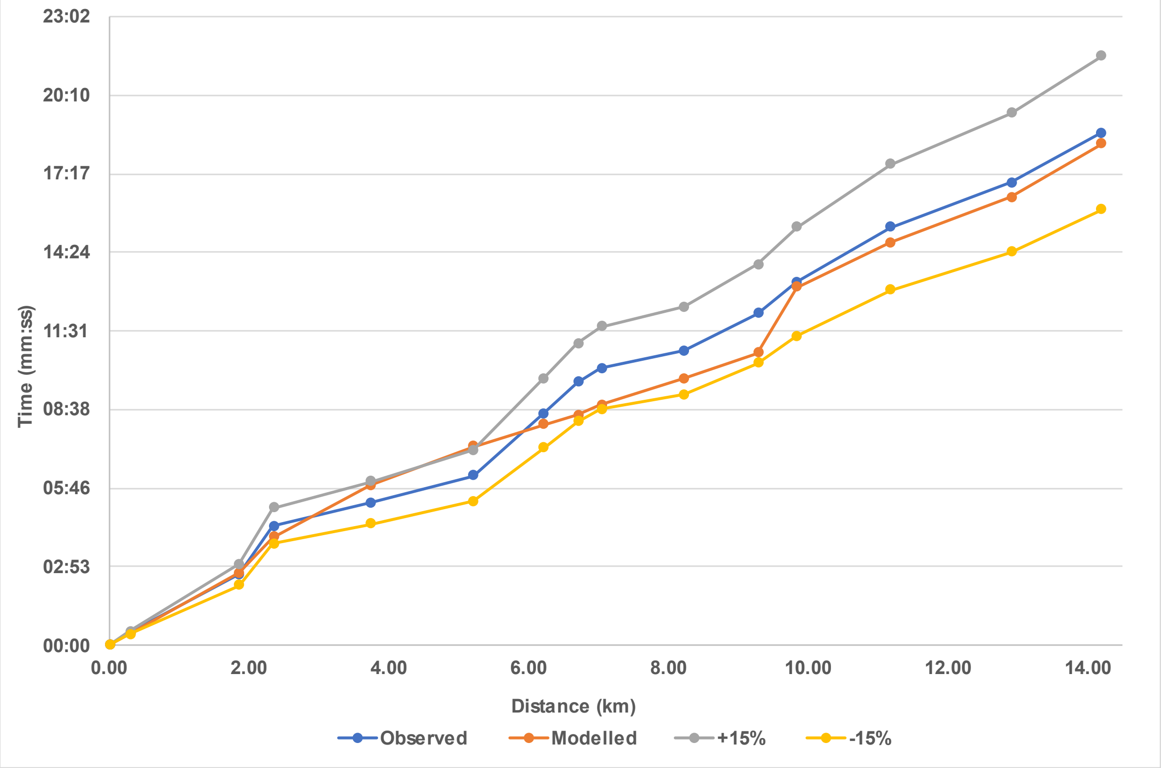
C.31. JTR6 NB – AM Peak



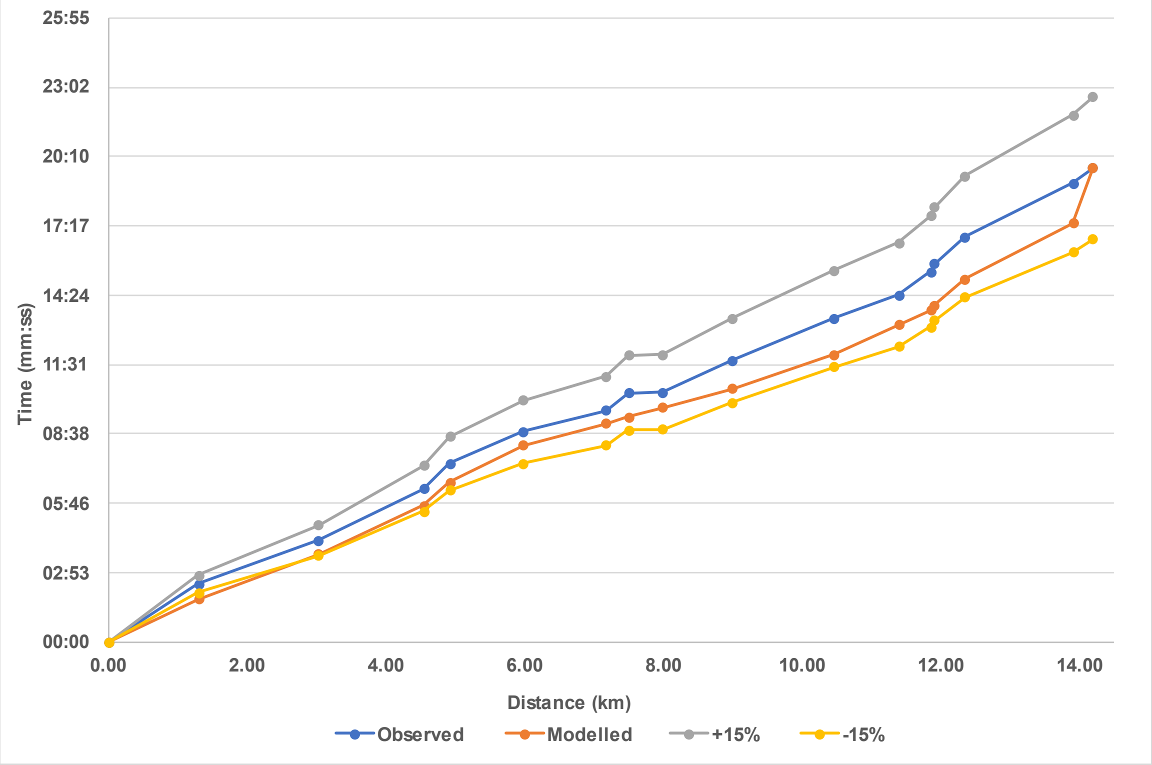
C.32. JTR6 SB – AM Peak



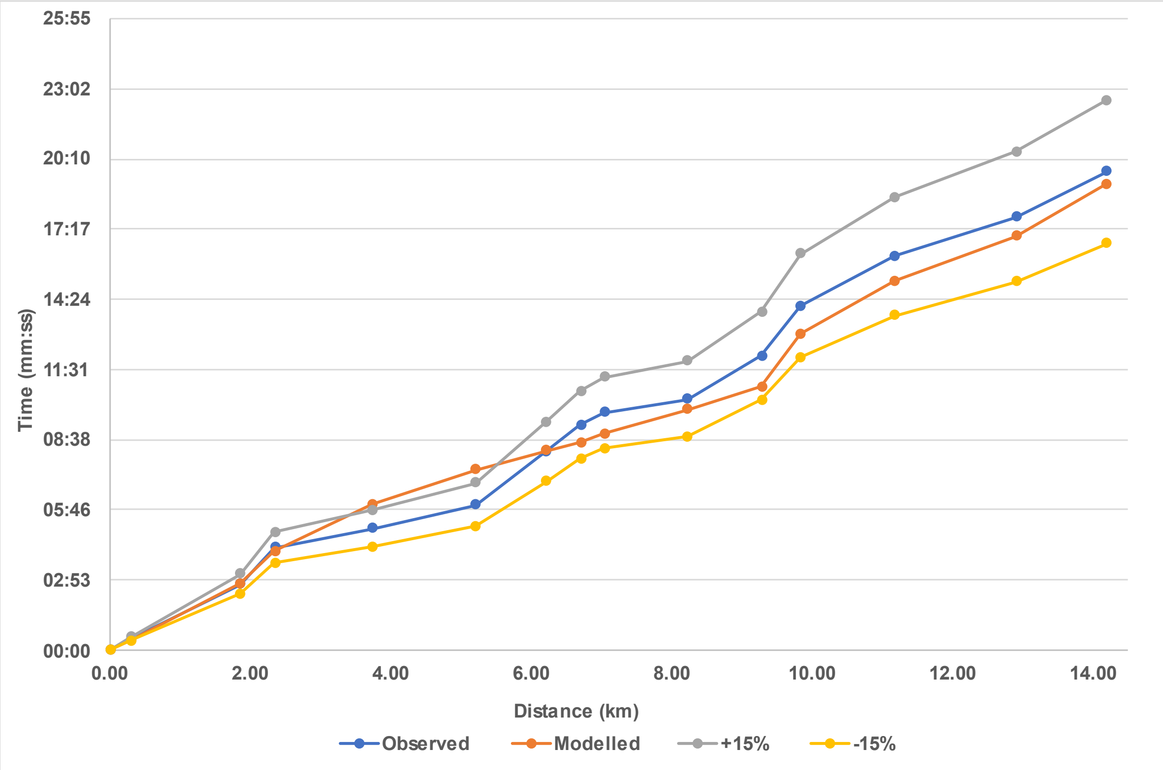
C.33. JTR6 NB – IP Peak



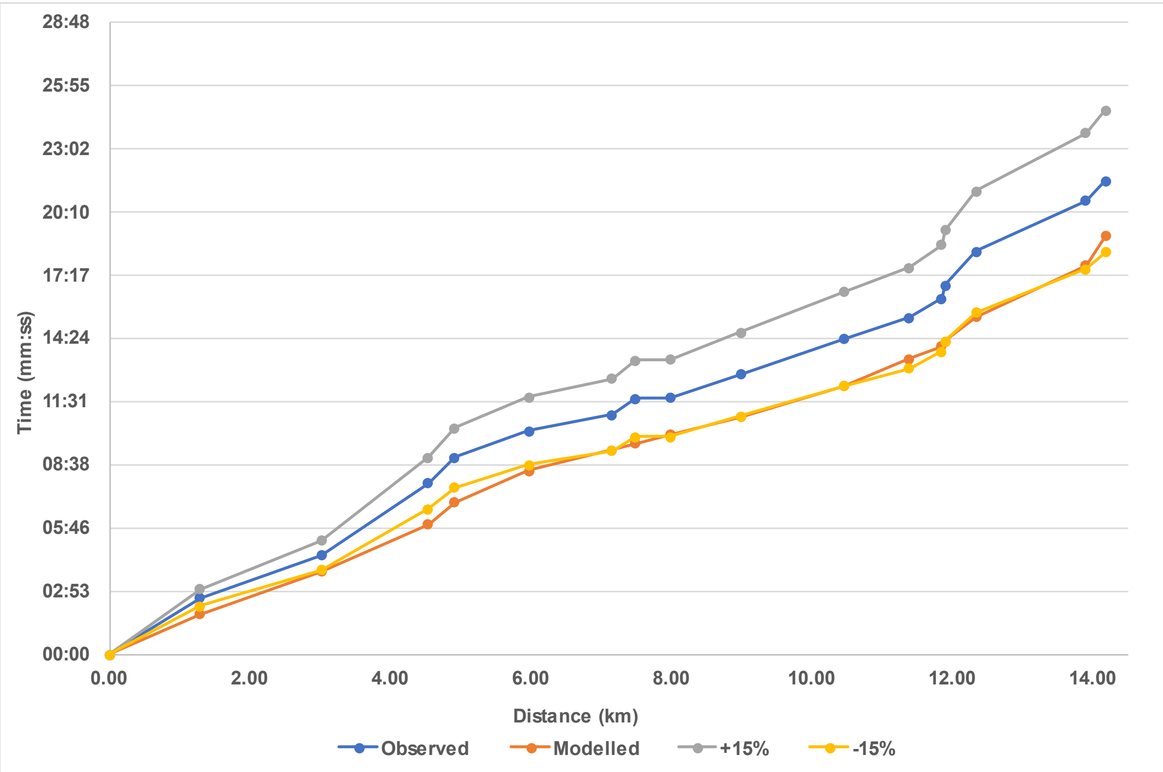
C.34. JTR6 SB – IP Peak



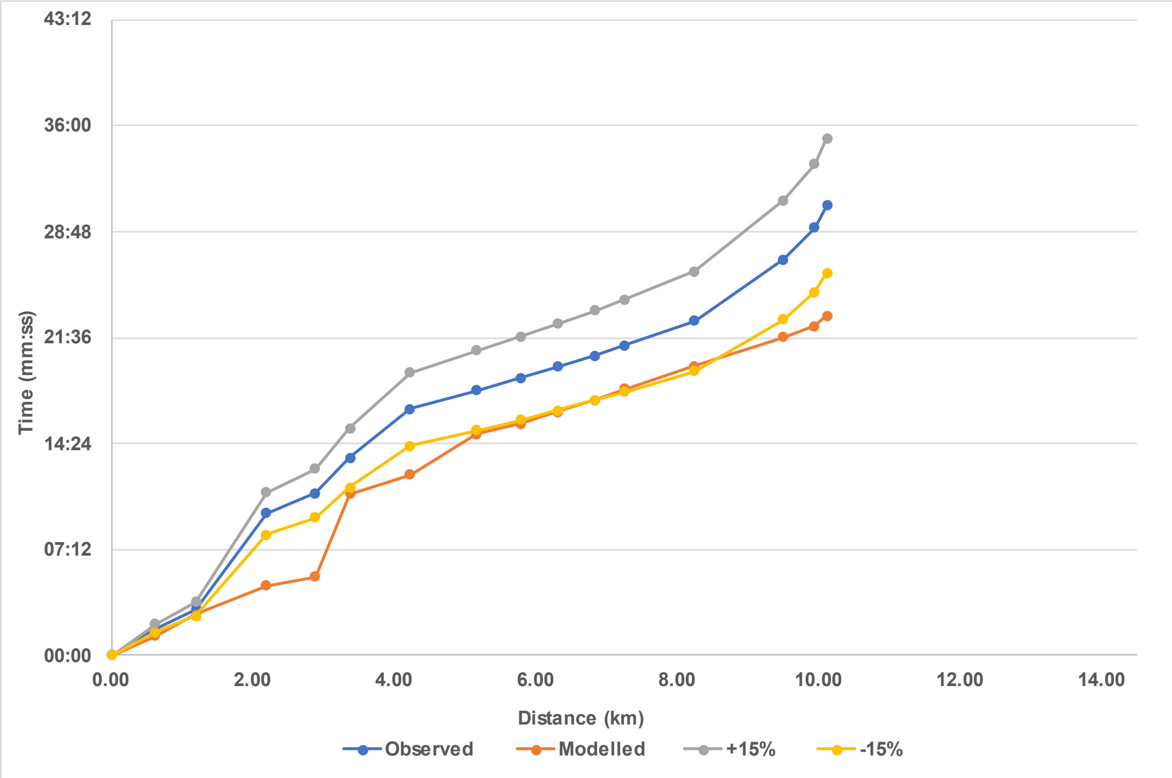
C.35. JTR6 NB – PM Peak



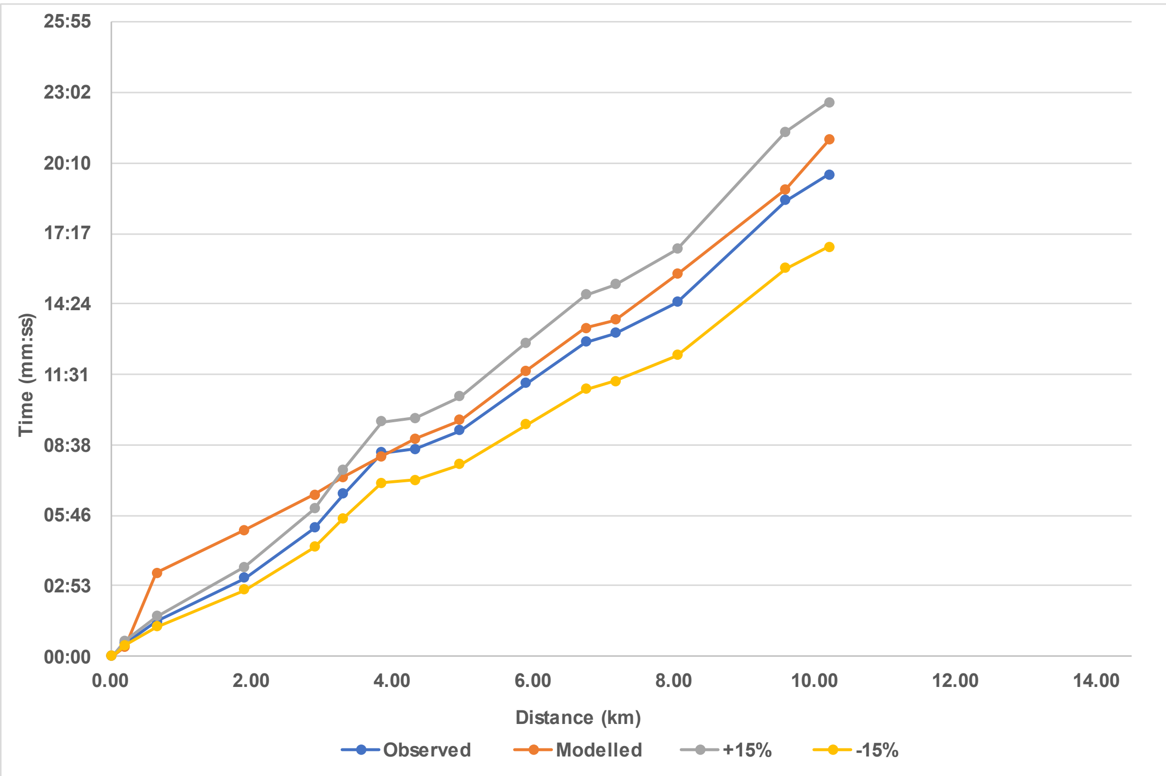
C.36. JTR6 SB – PM Peak



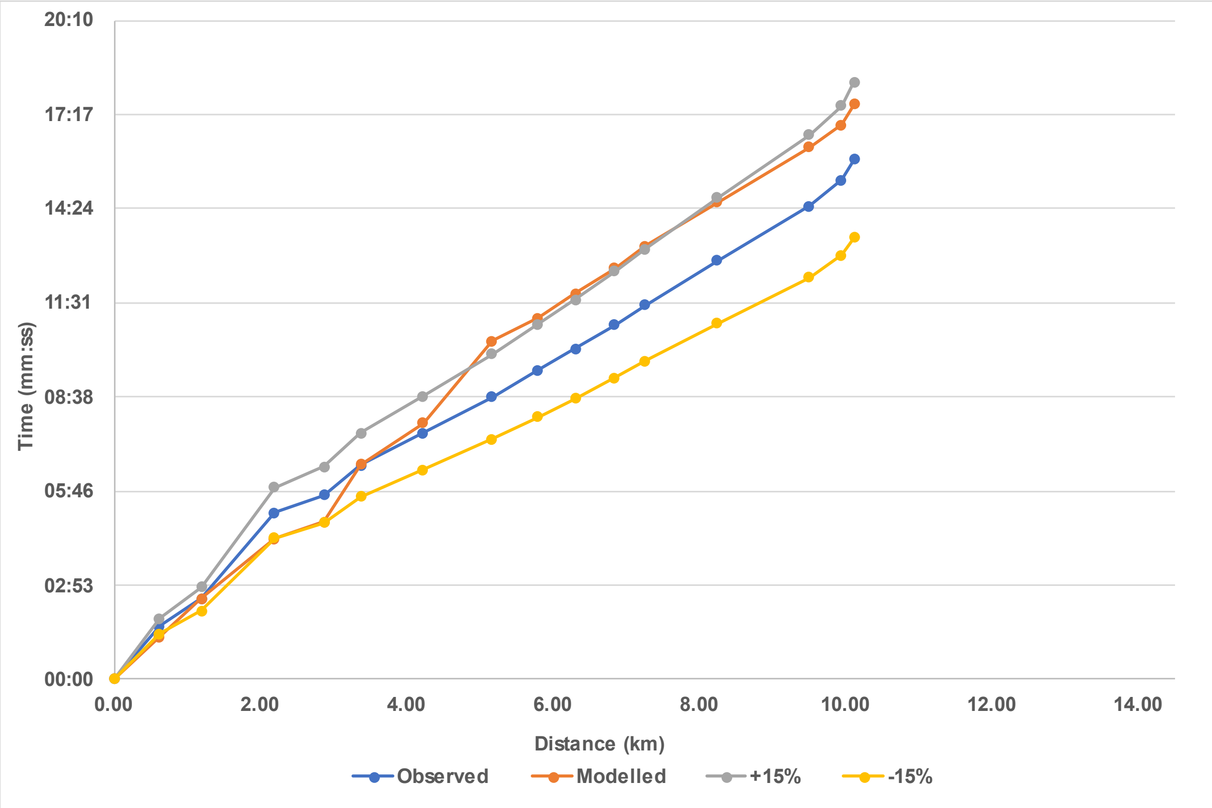
C.37. JTR7 NB – AM Peak



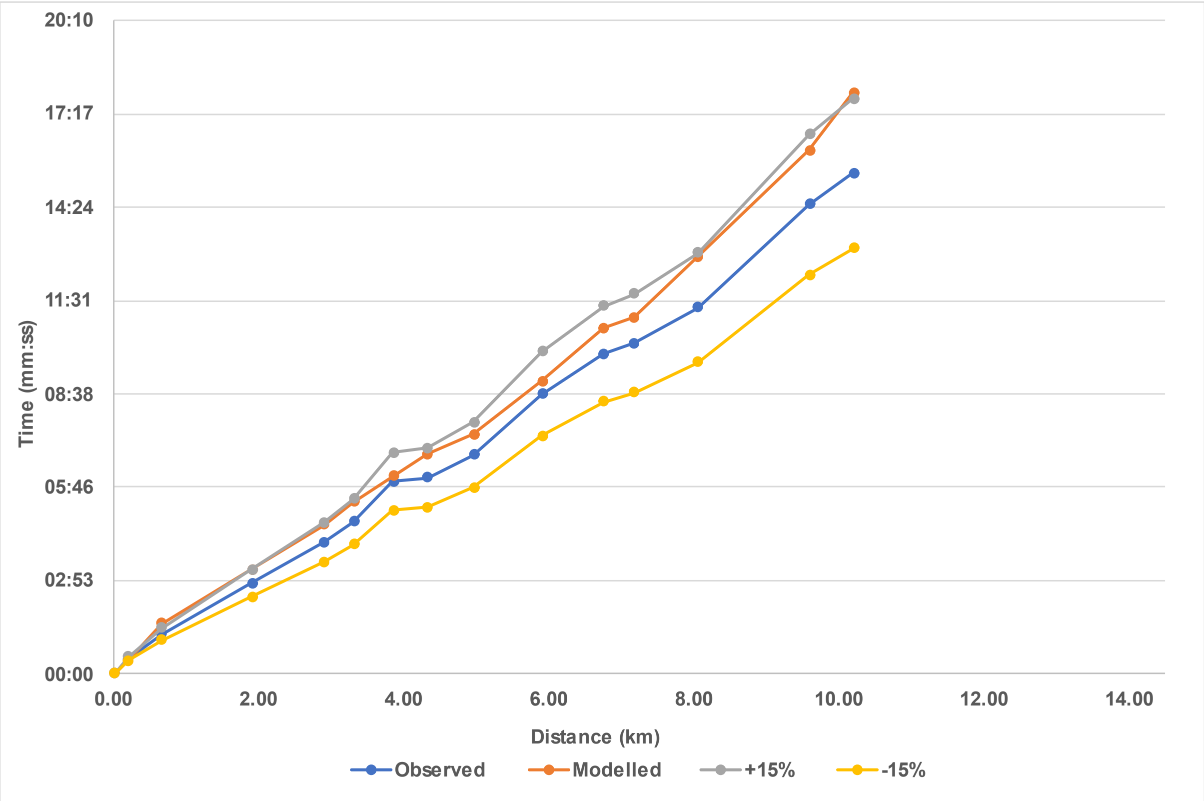
C.38. JTR7 SB – AM Peak



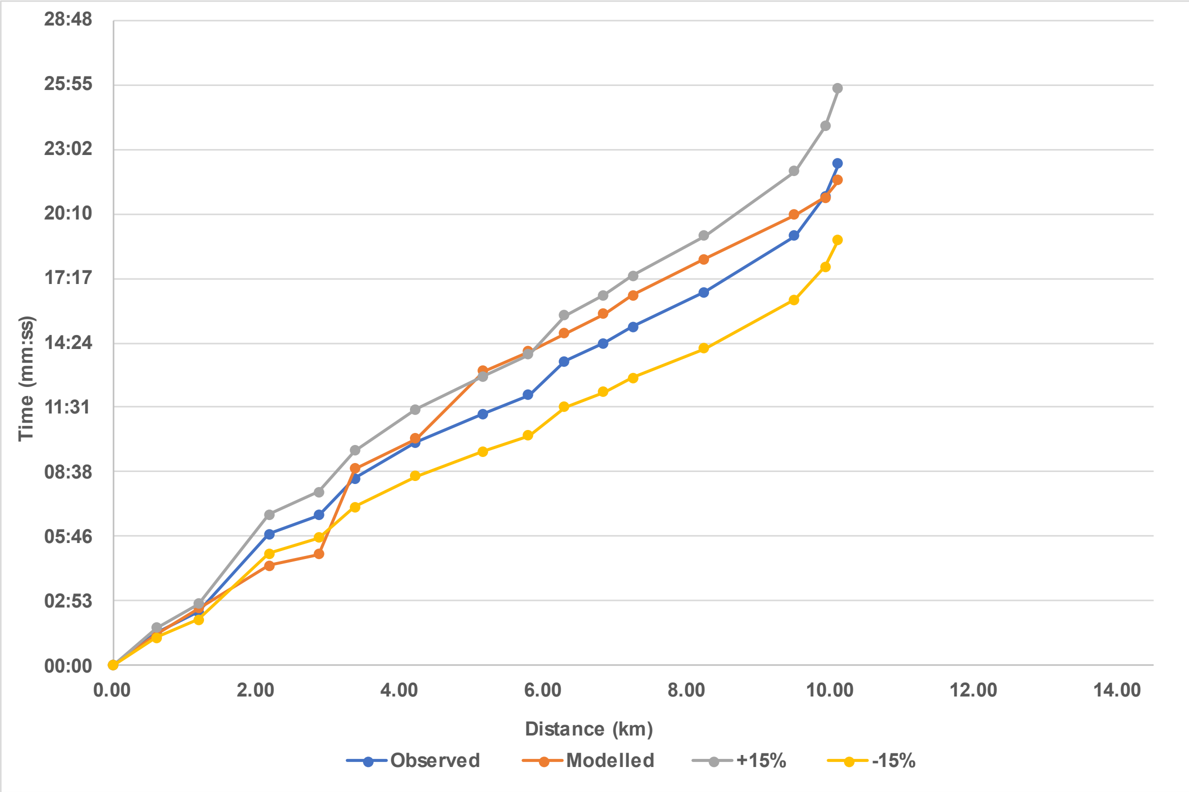
C.39. JTR7 NB – IP Peak



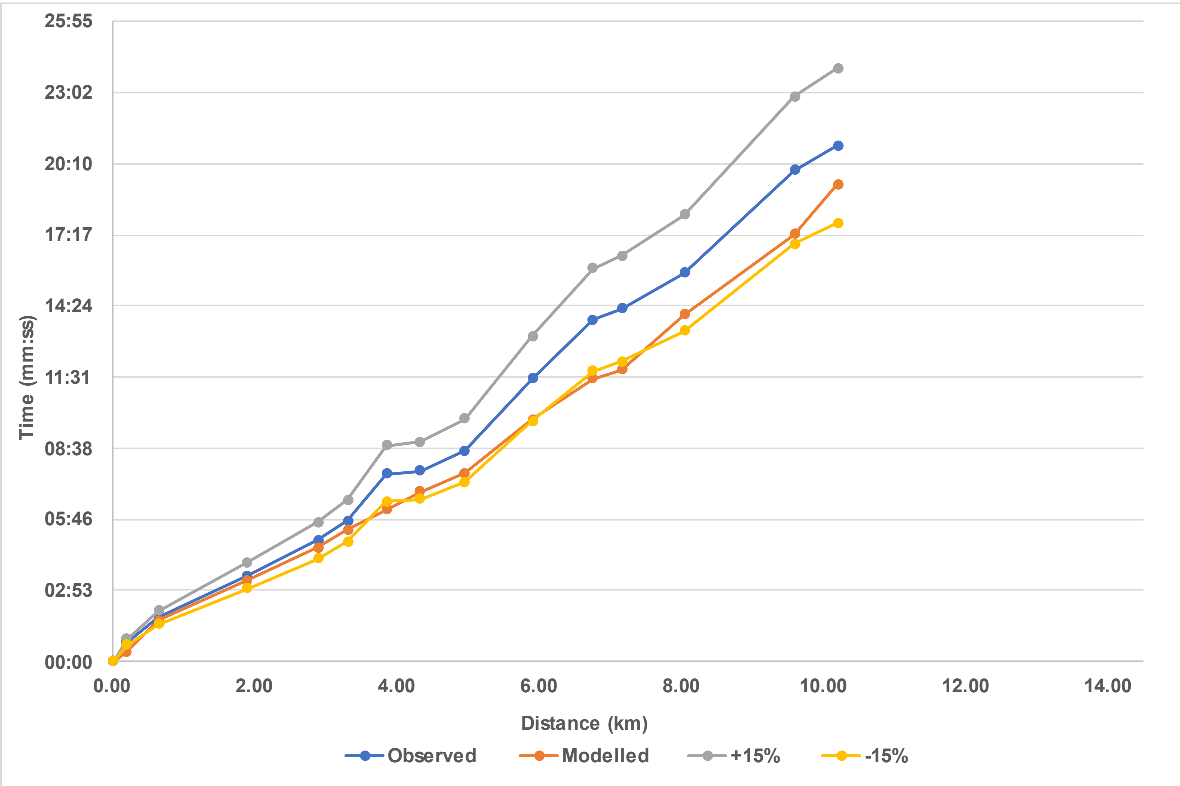
C.40. JTR7 SB – IP Peak



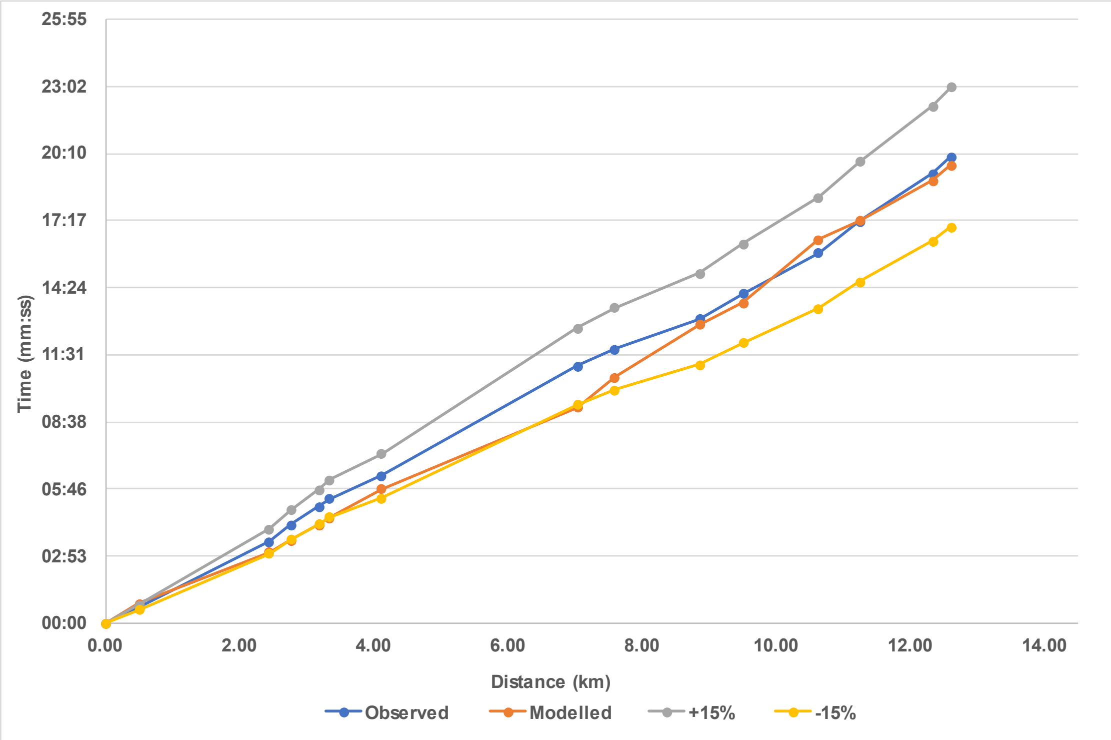
C.41. JTR7 NB – PM Peak



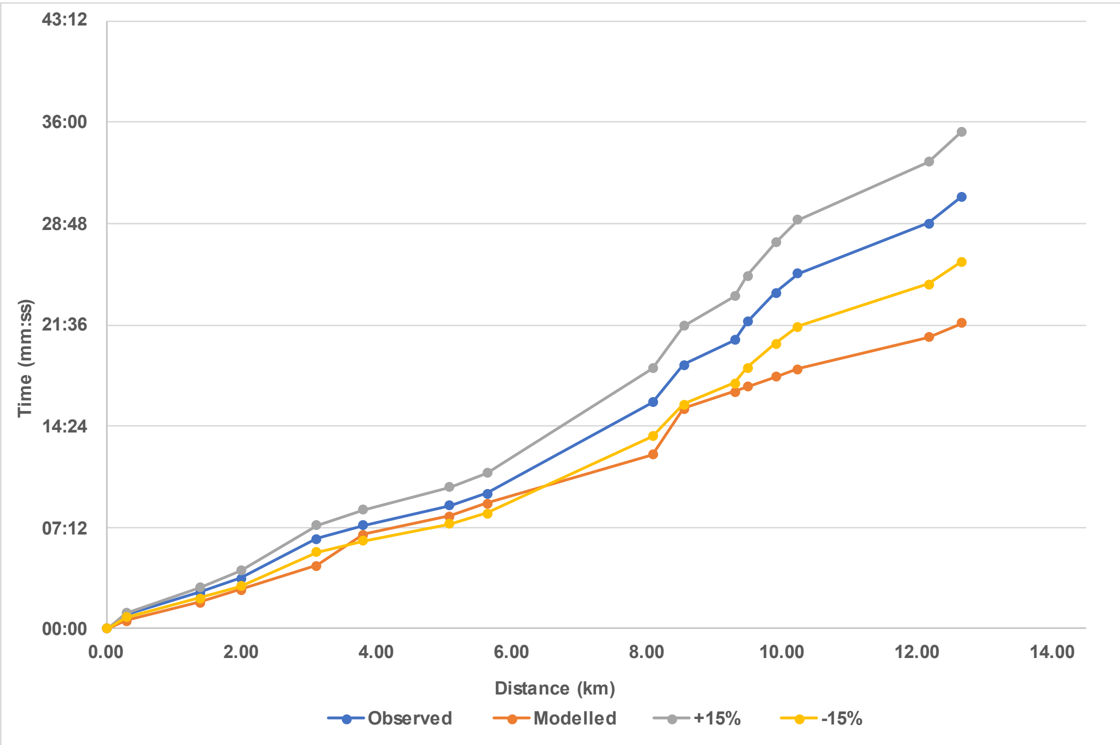
C.42. JTR7 SB – PM Peak



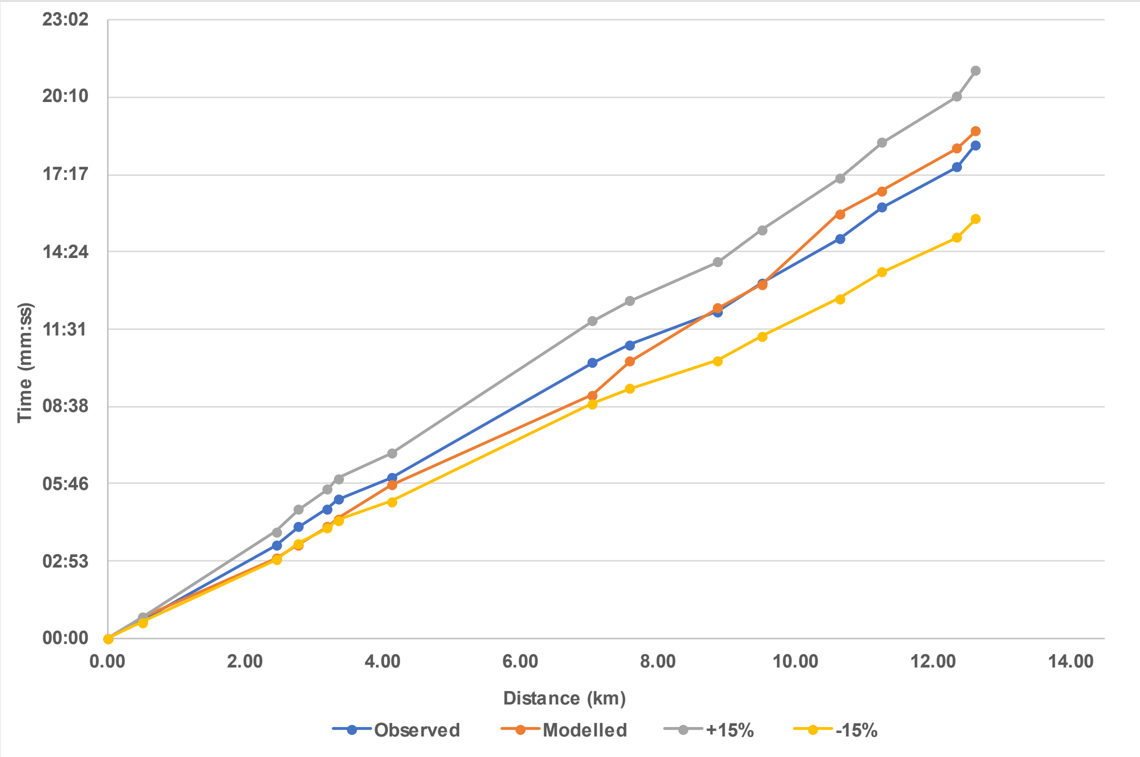
C.43. JTR10 NB – AM Peak



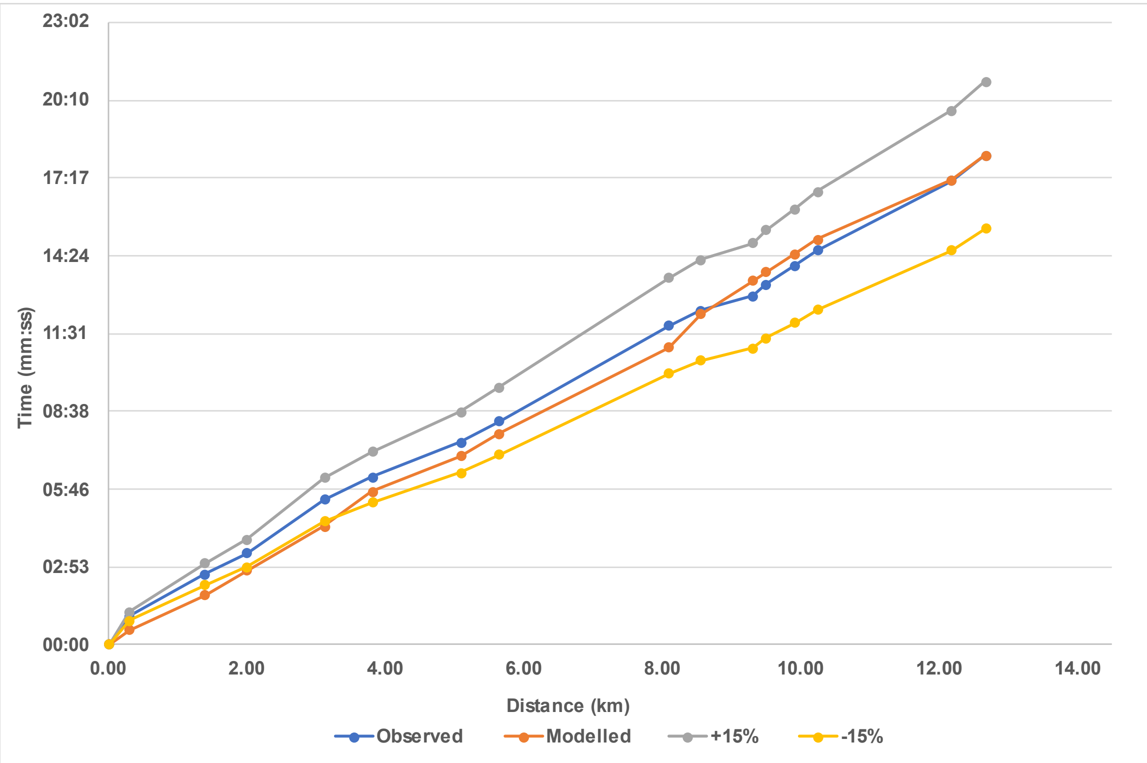
C.44. JTR10 SB – AM Peak



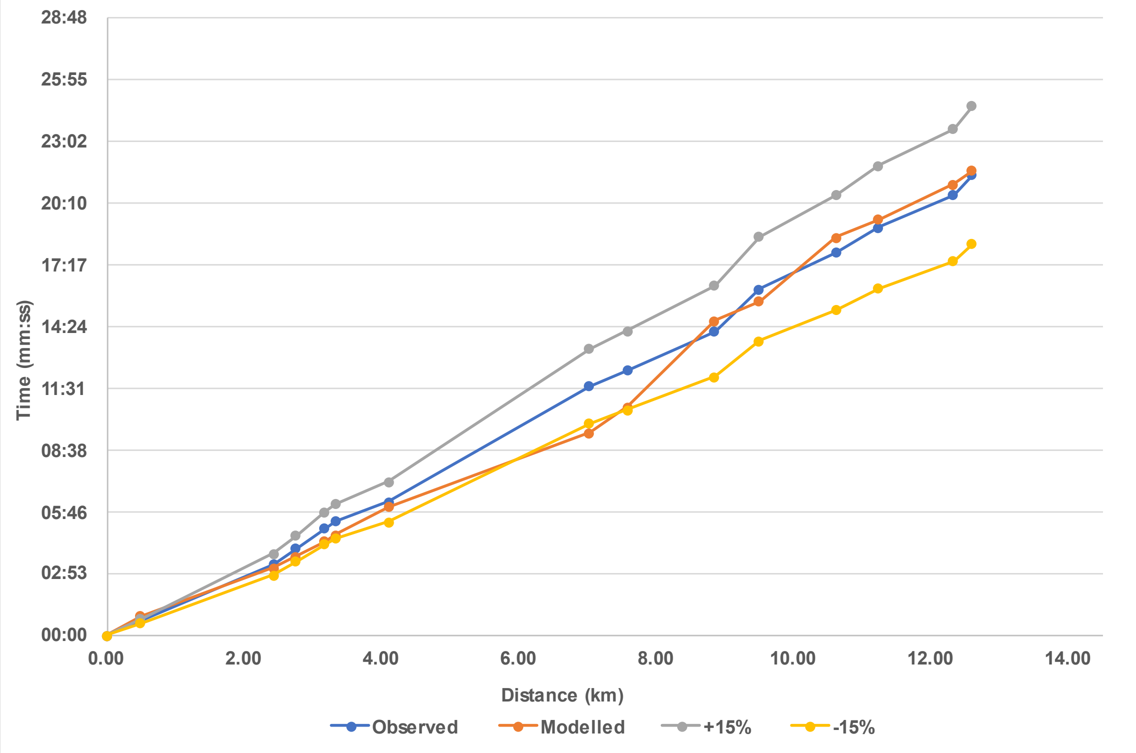
C.45. JTR10 NB – IP Peak



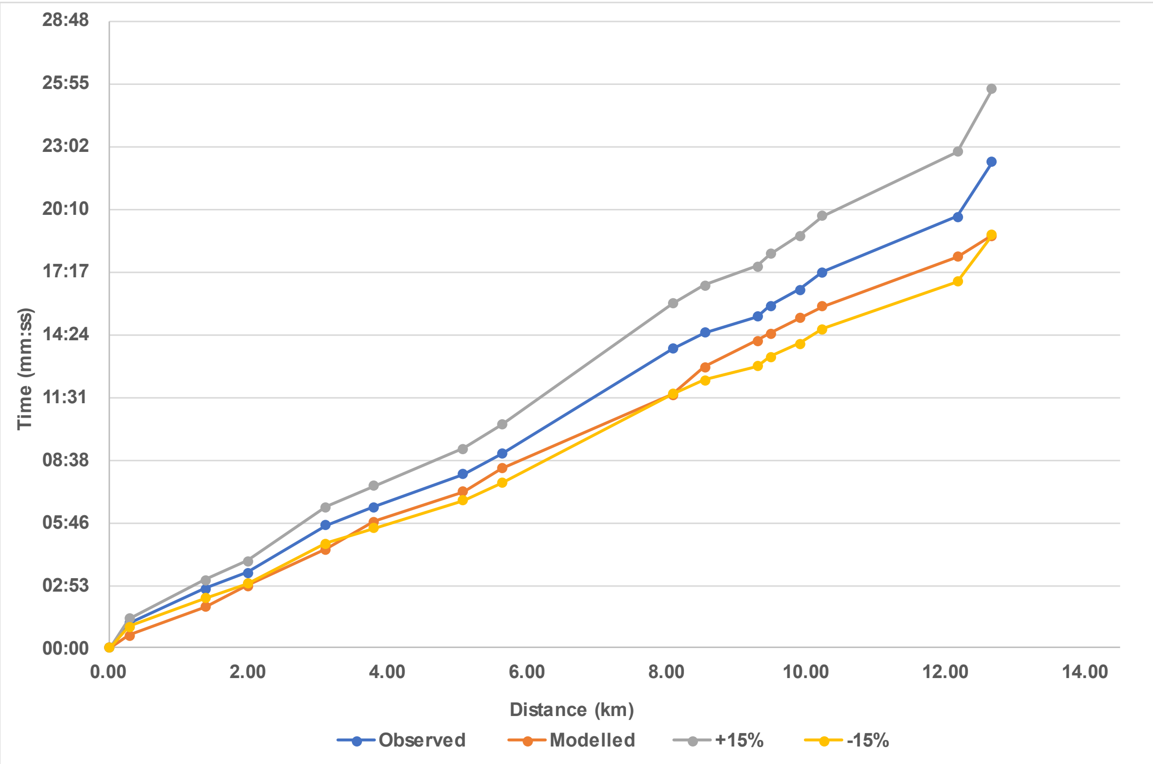
C.46. JTR10 SB – IP Peak



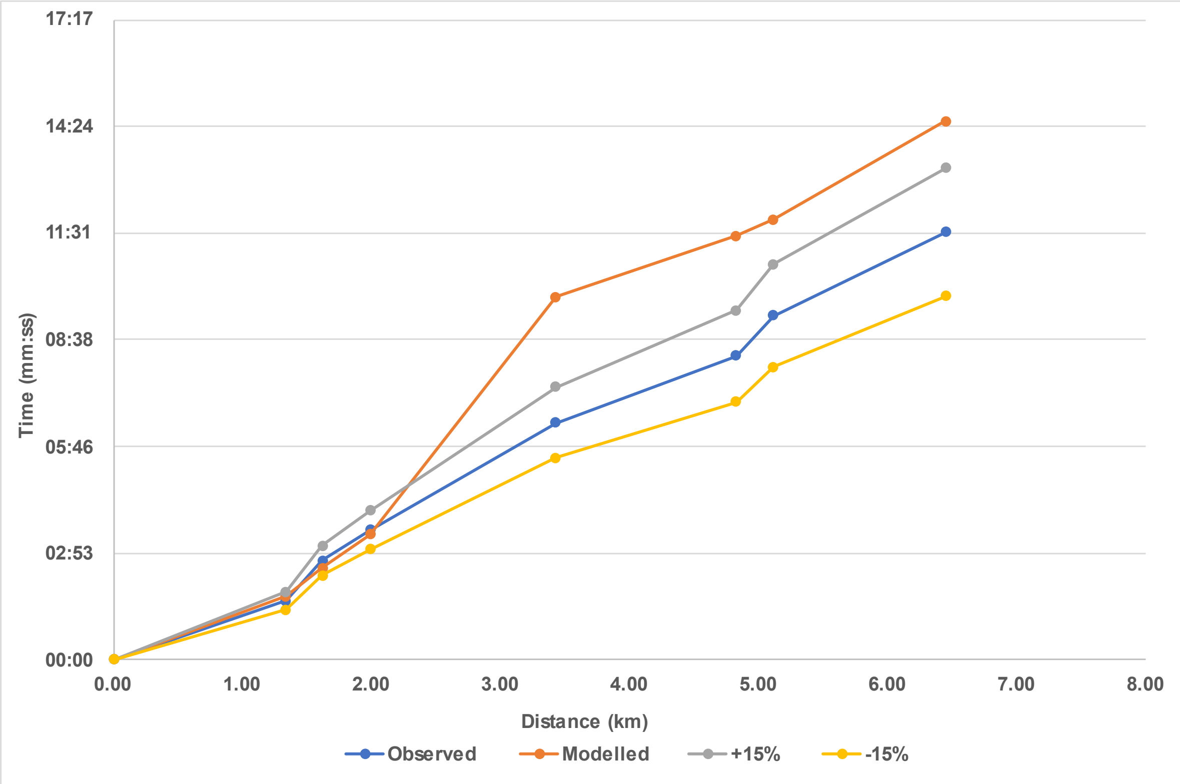
C.47. JTR10 NB – PM Peak



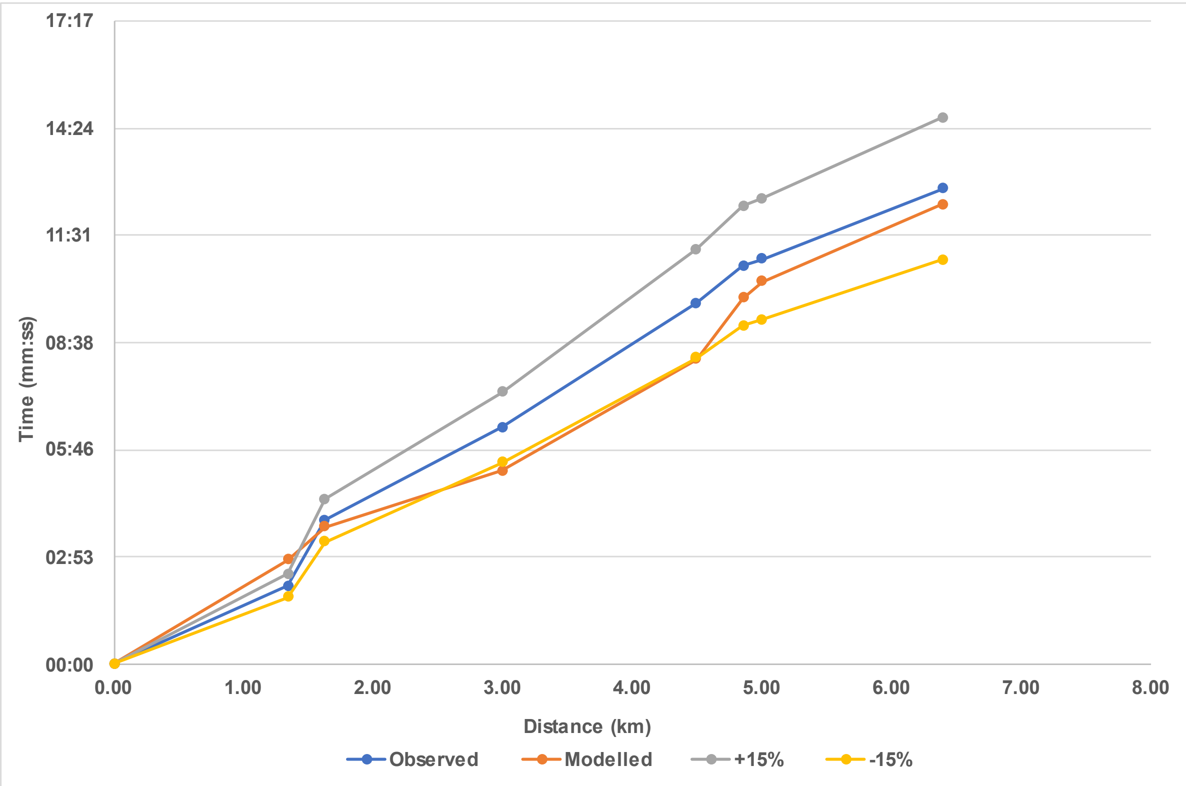
C.48. JTR10 SB – PM Peak



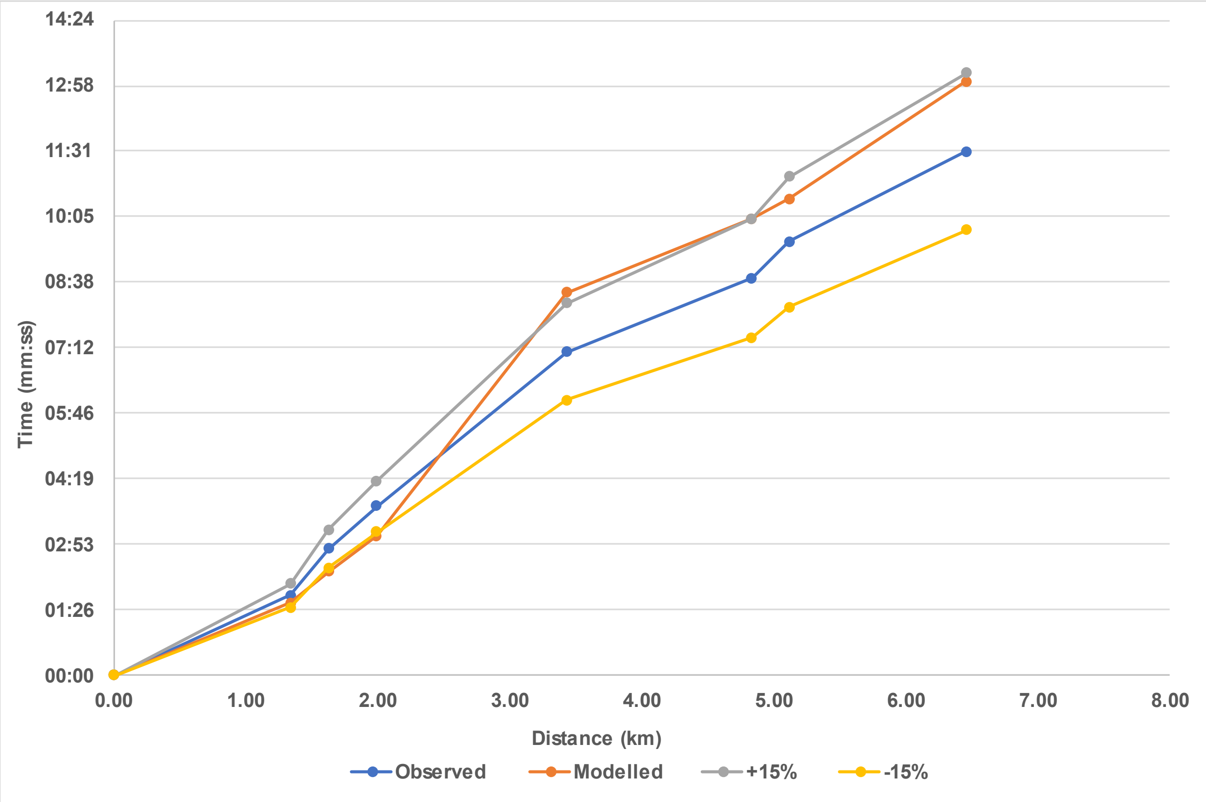
C.49. JTR11 EB – AM Peak



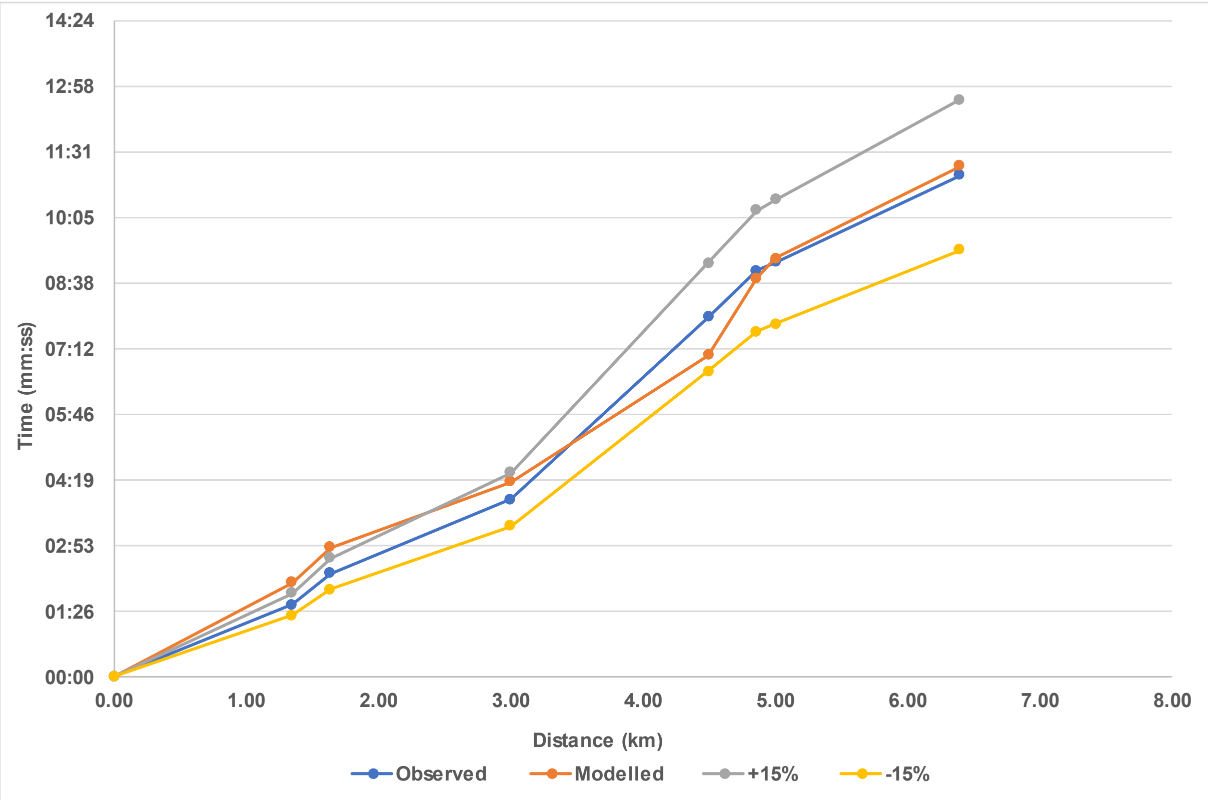
C.50. JTR11 WB – AM Peak



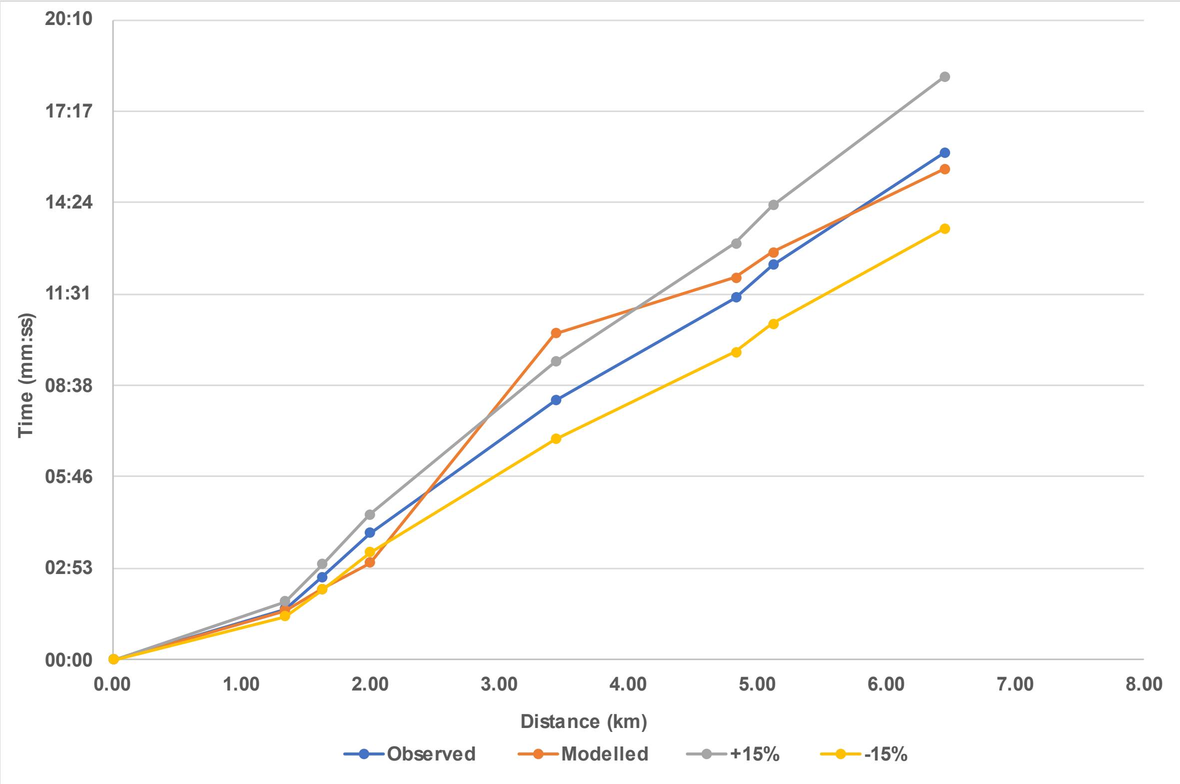
C.51. JTR11 EB – IP Peak



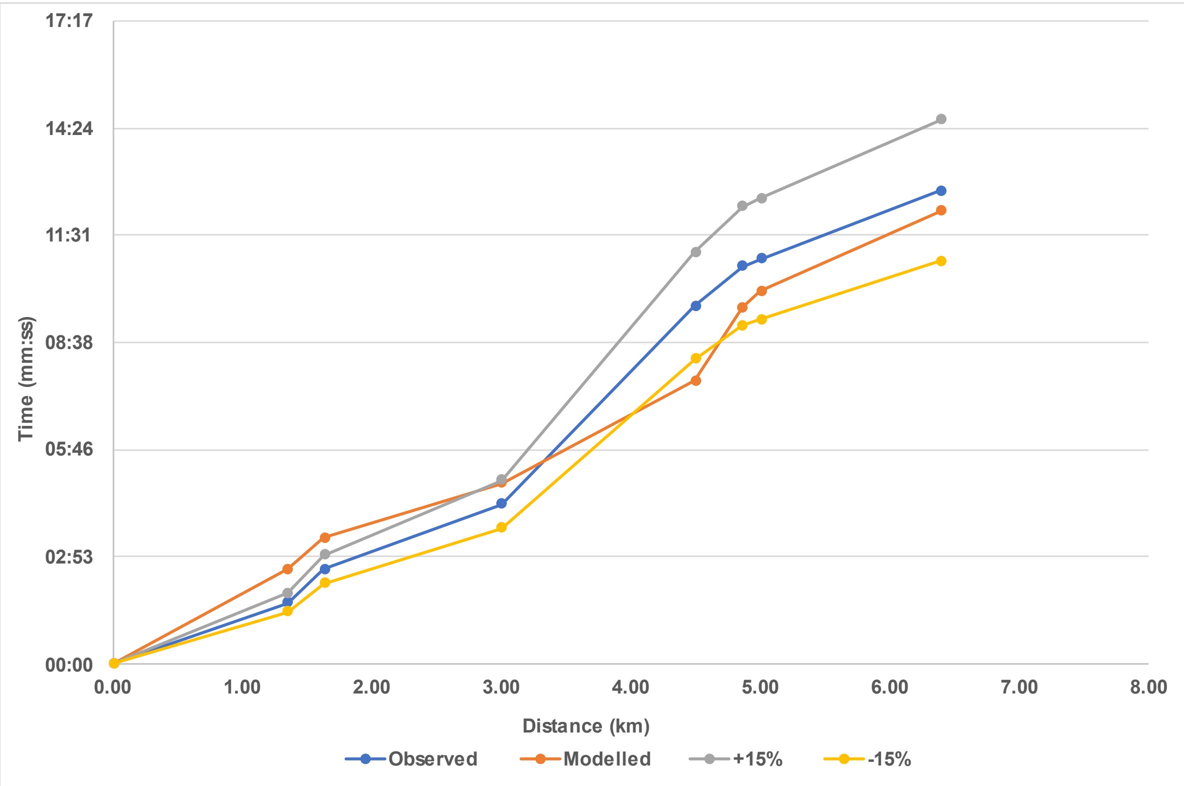
C.52. JTR11 WB – IP Peak



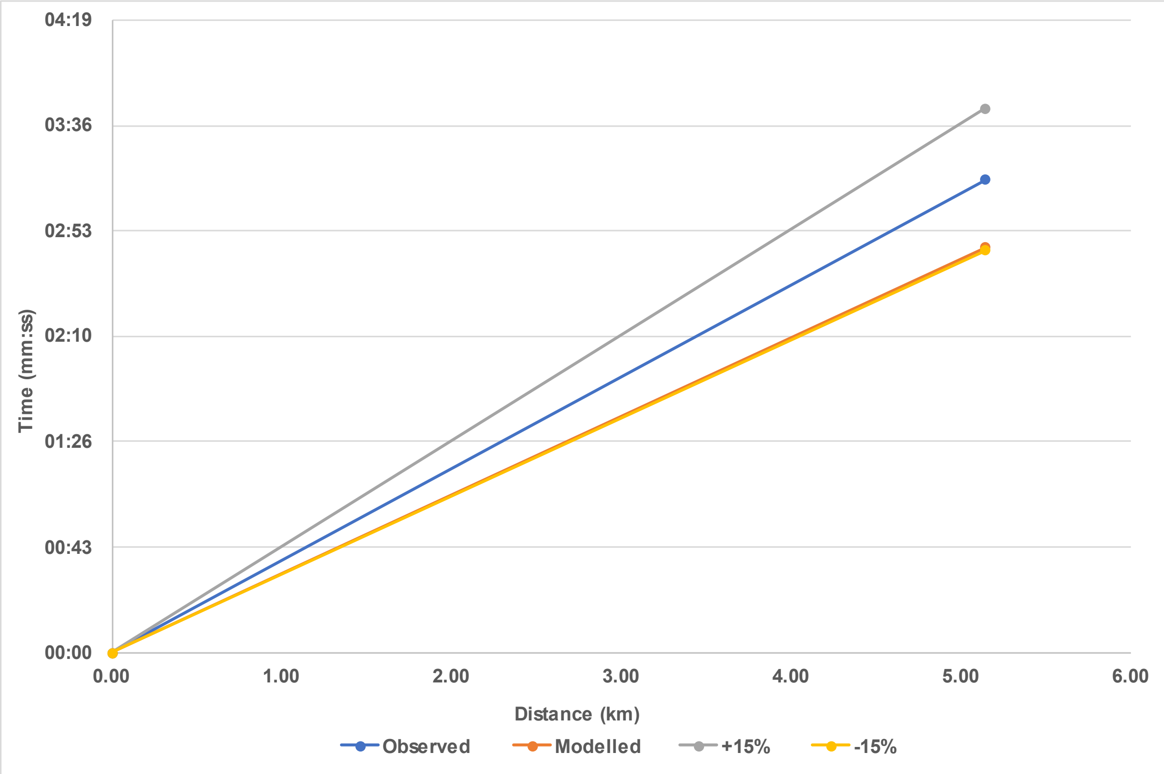
C.53. JTR11 EB – PM Peak



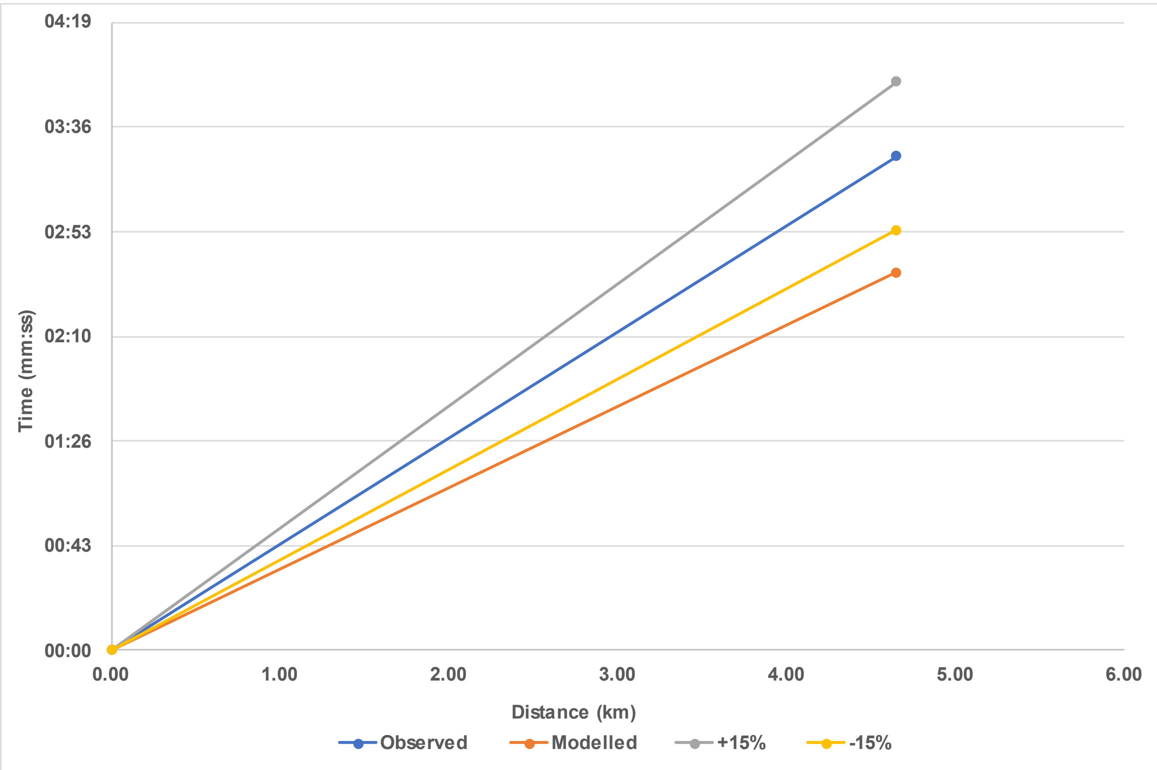
C.54. JTR11 WB – PM Peak



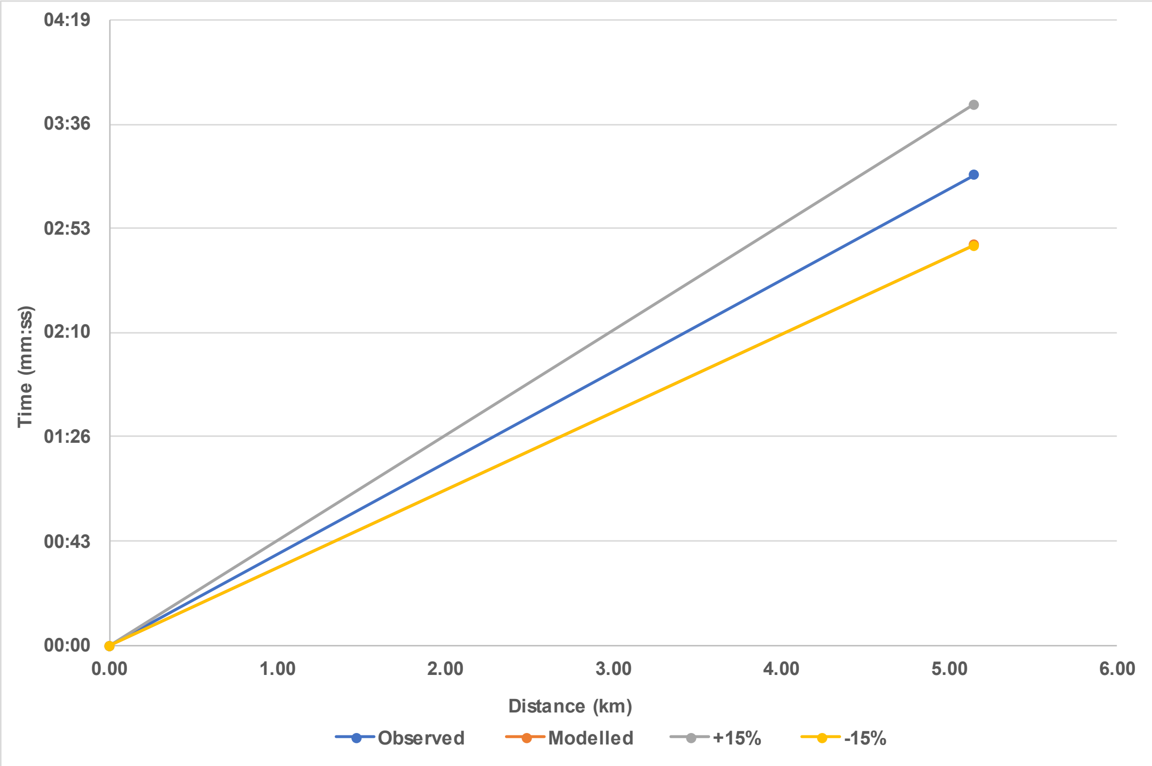
C.55. JTR13 NB – AM Peak



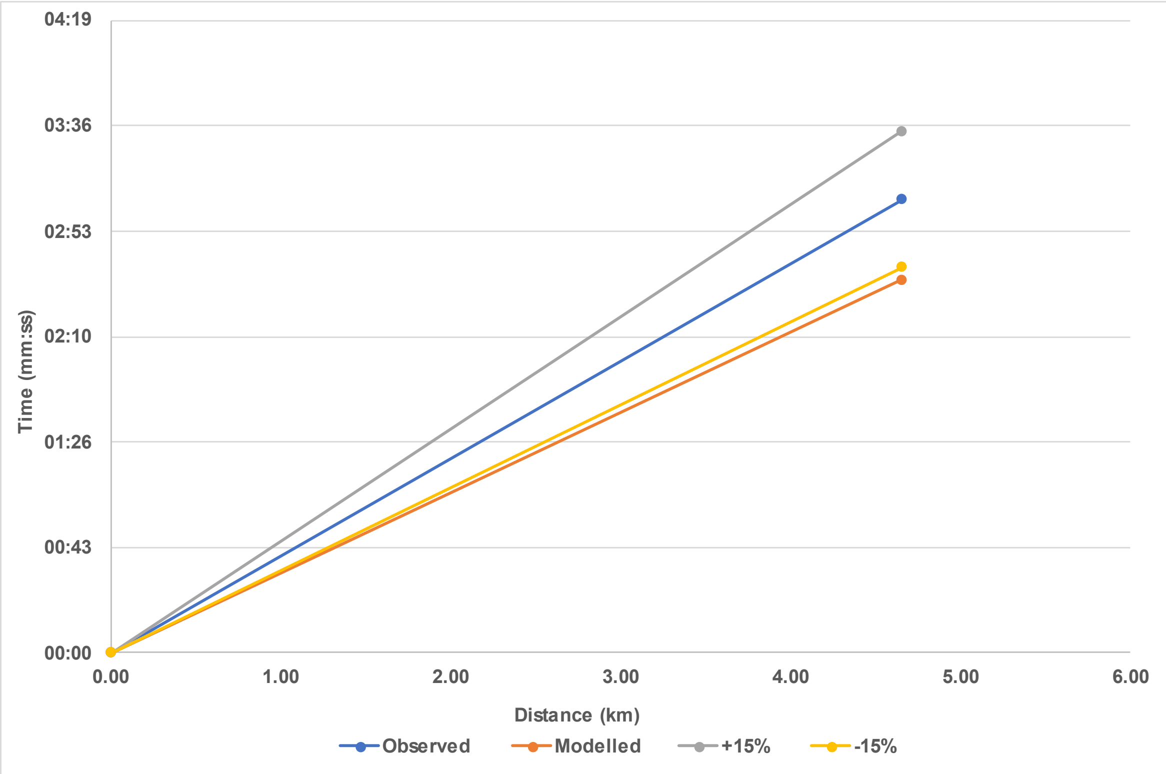
C.56. JTR13 SB – AM Peak



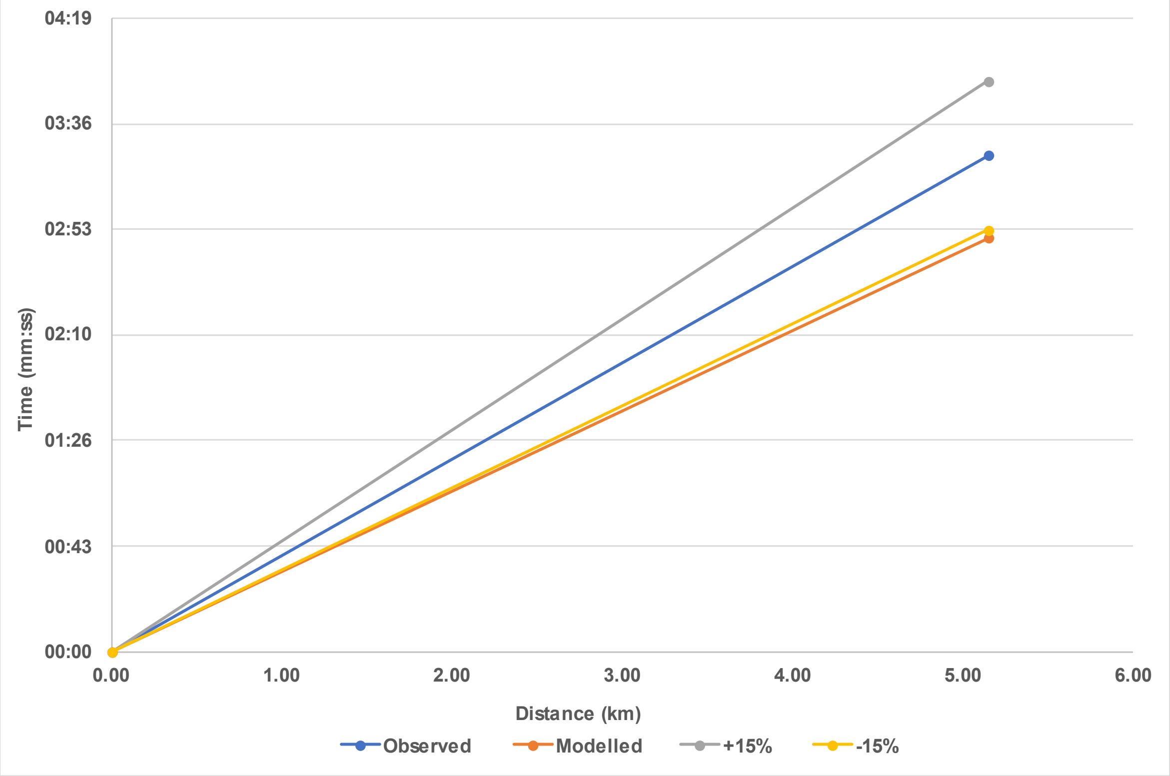
C.57. JTR13 NB – IP Peak



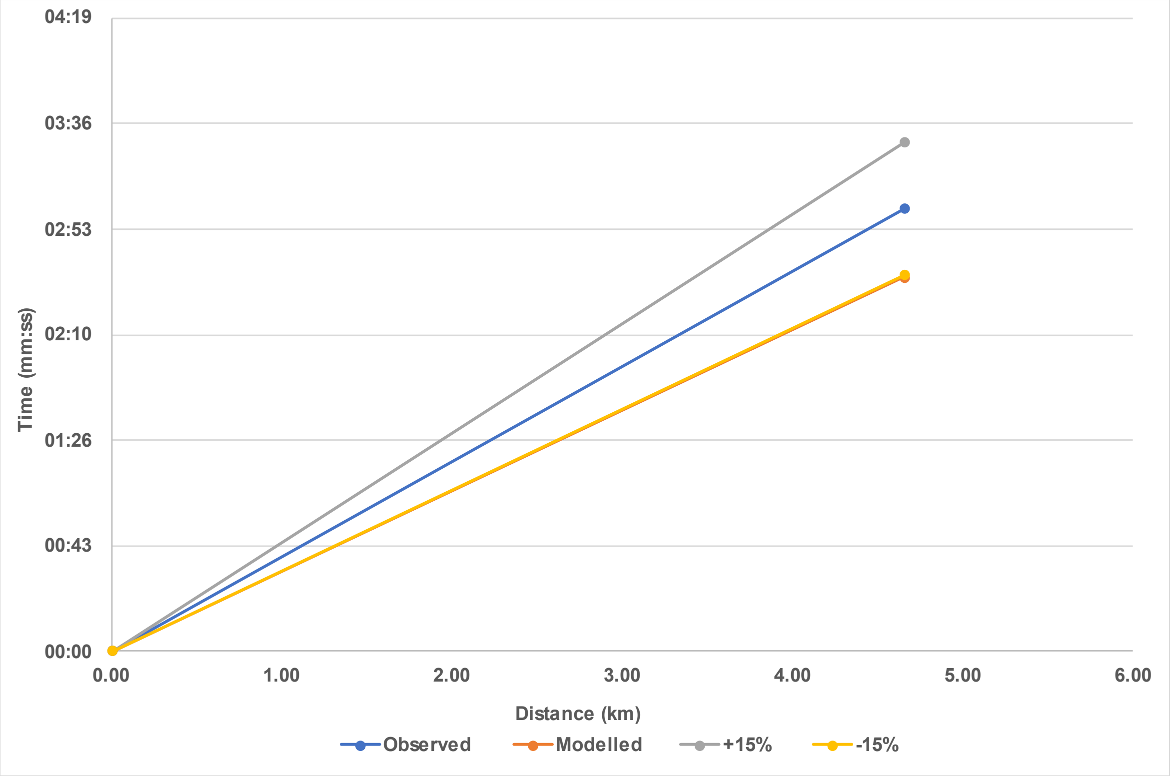
C.58. JTR13 SB – IP Peak



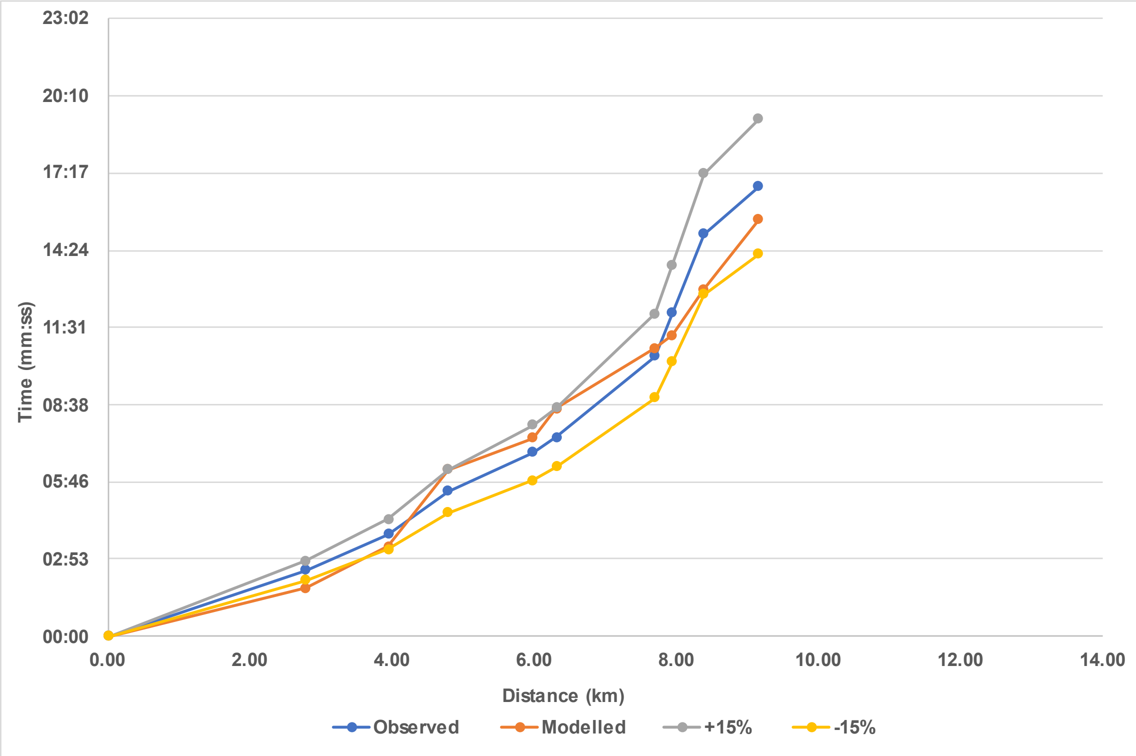
C.59. JTR13 NB – PM Peak



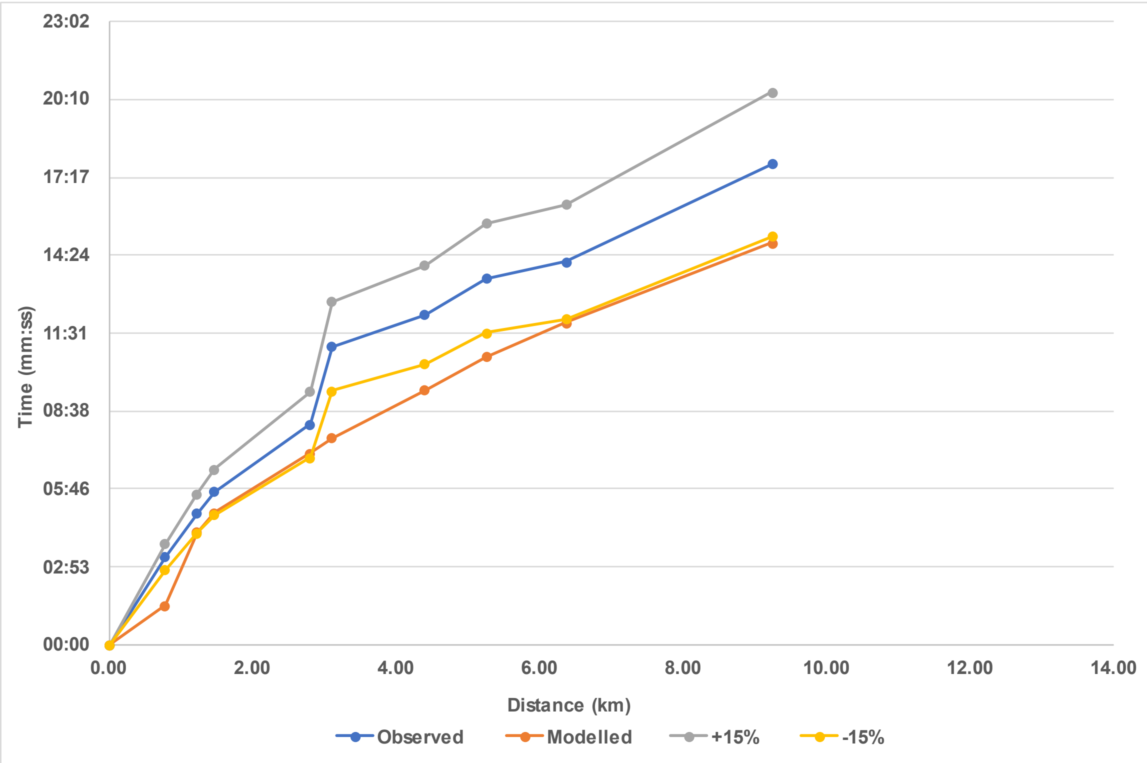
C.60. JTR13 SB – PM Peak



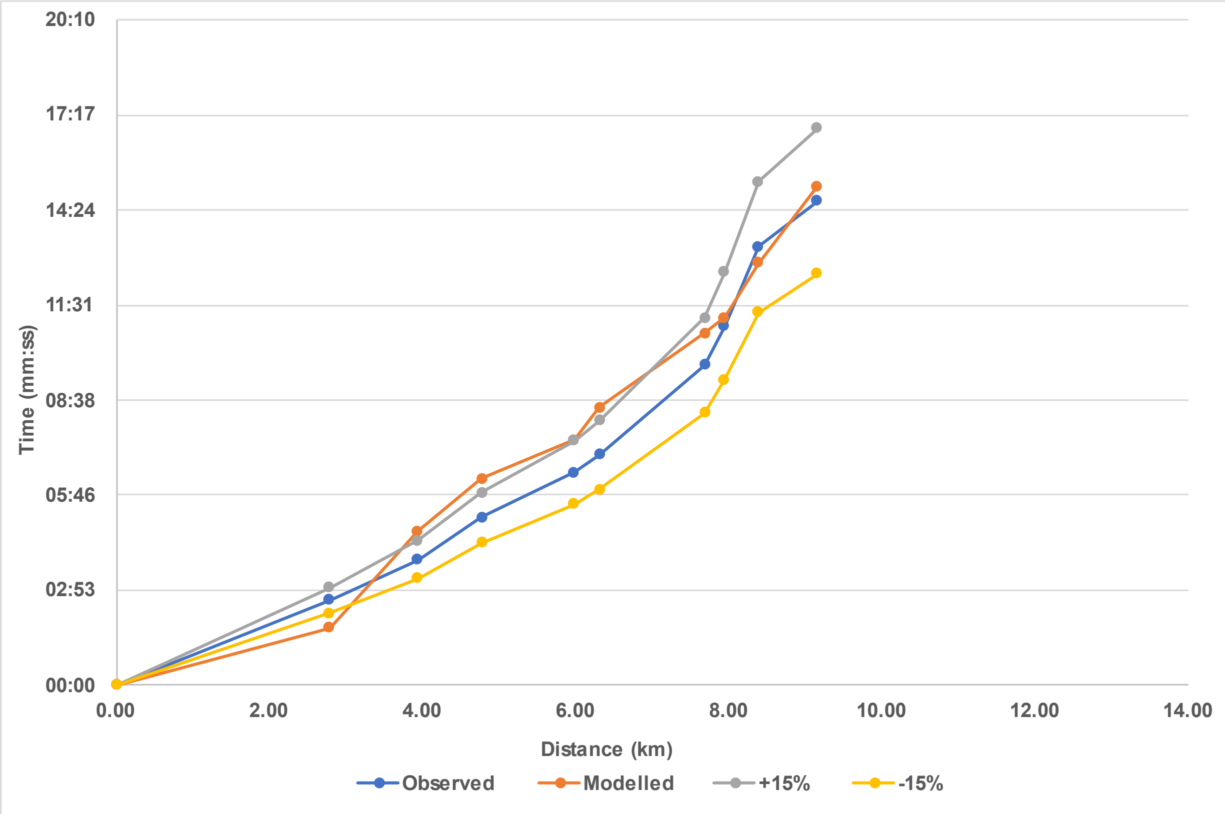
C.61. JTR16 NB – AM Peak



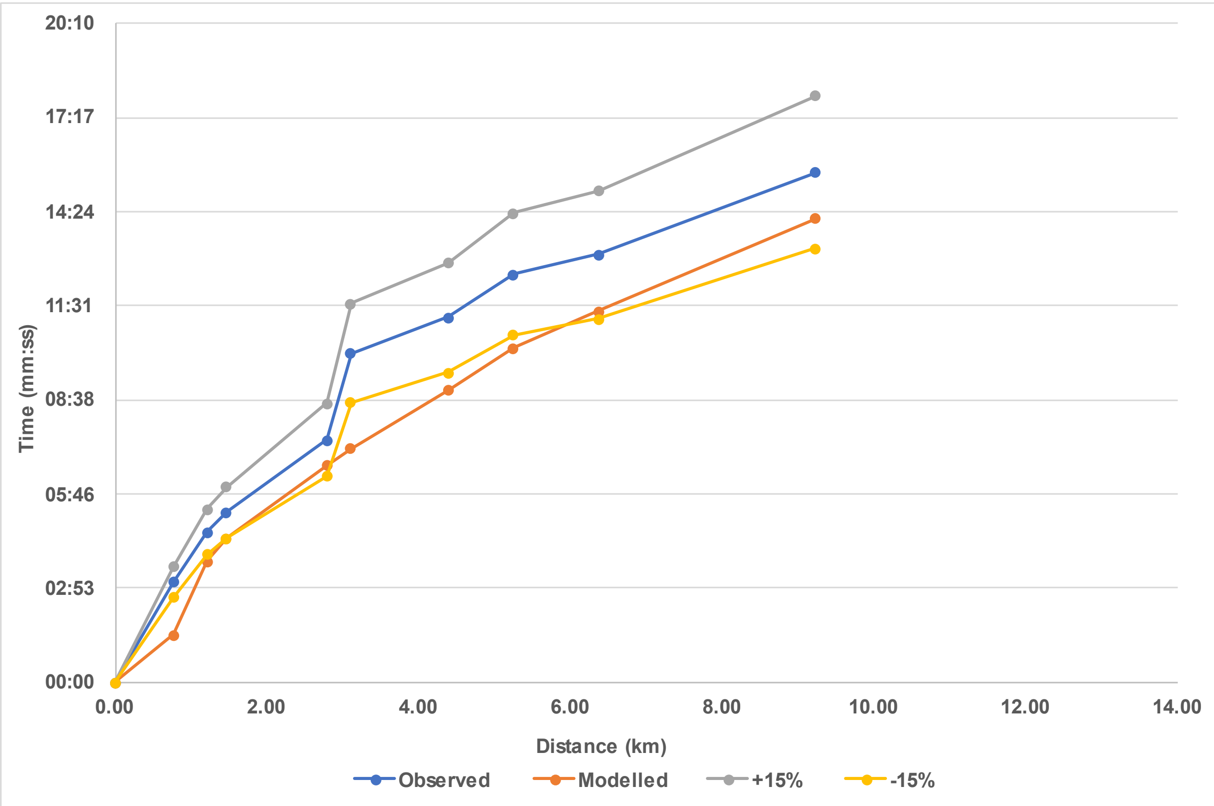
C.62. JTR16 SB – AM Peak



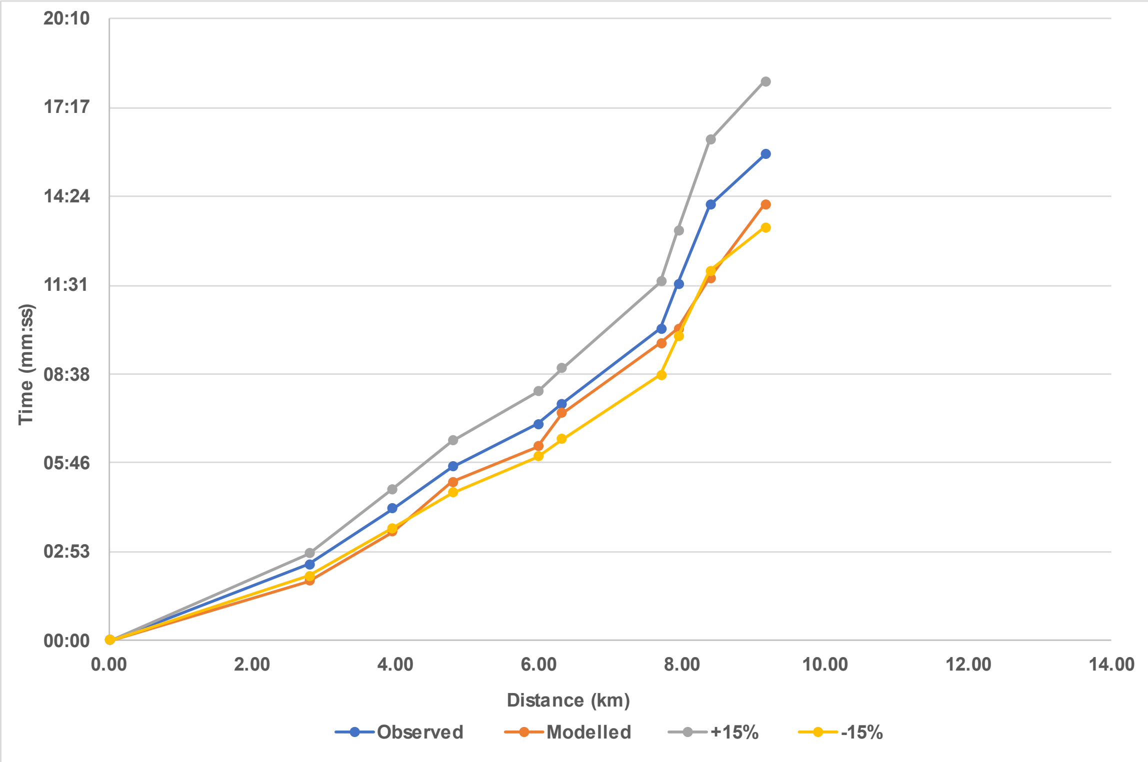
C.63. JTR16 NB – IP Peak



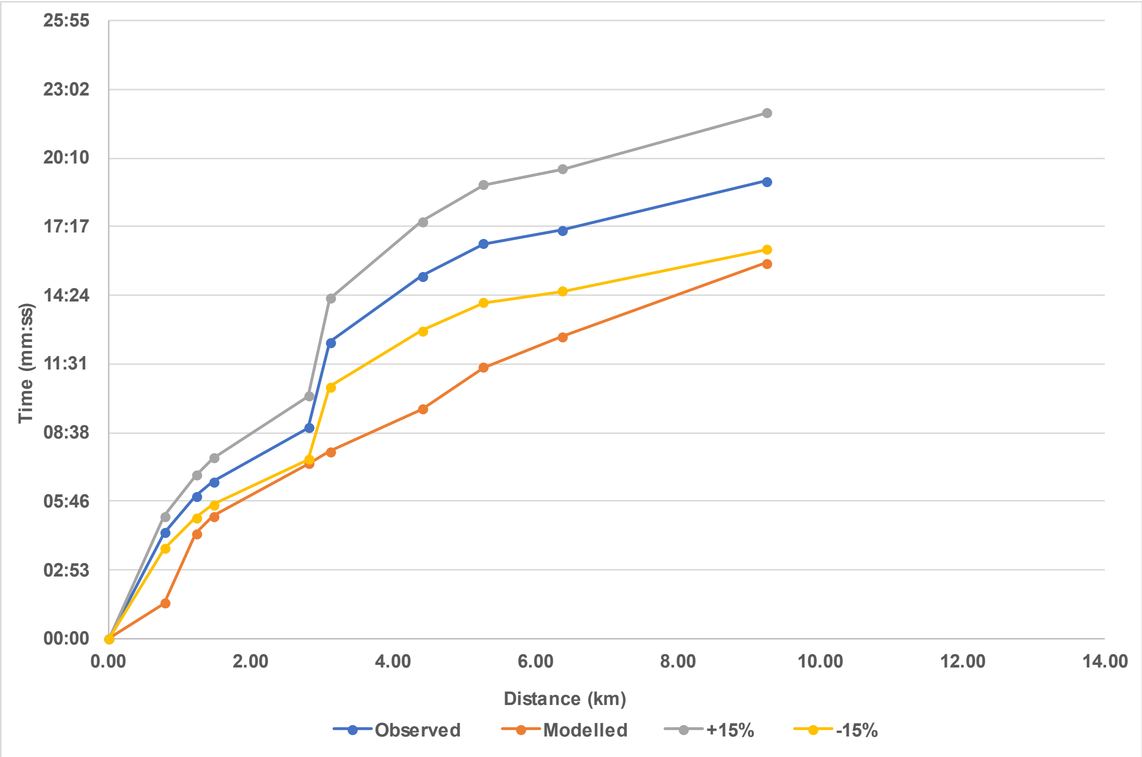
C.64. JTR16 SB – IP Peak



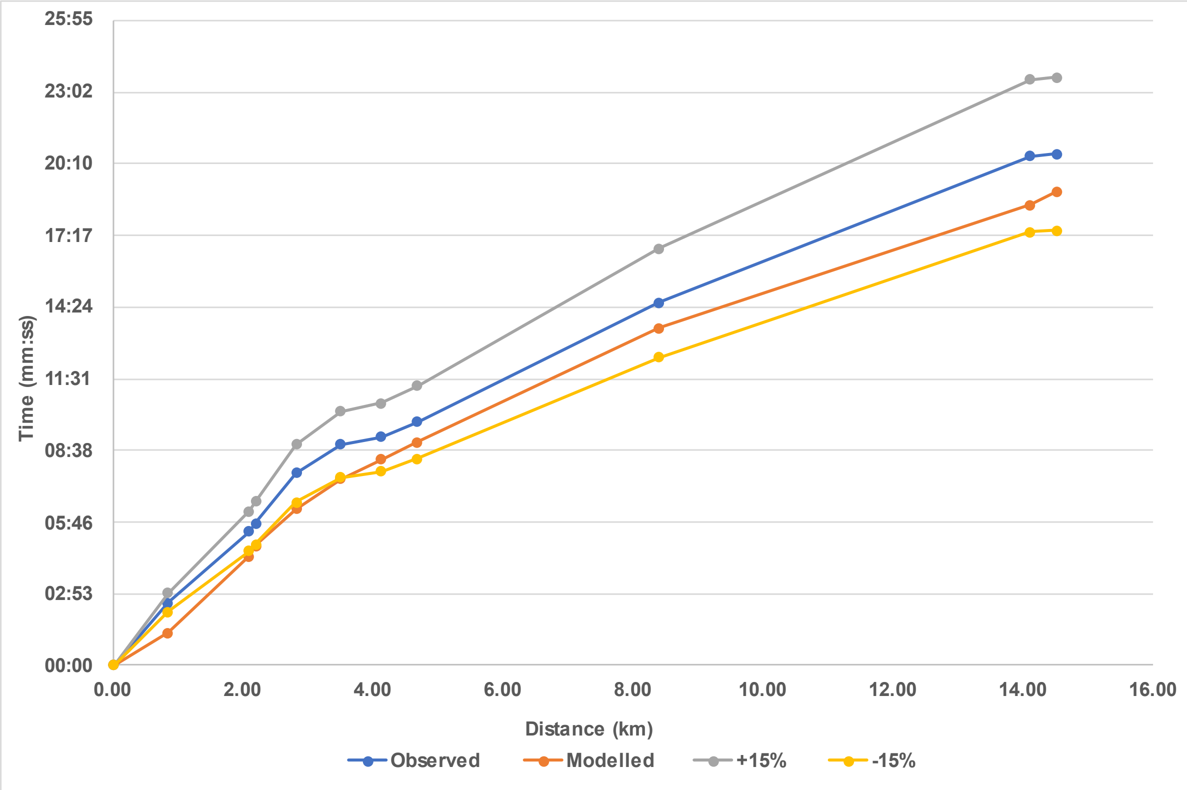
C.65. JTR16 NB – PM Peak



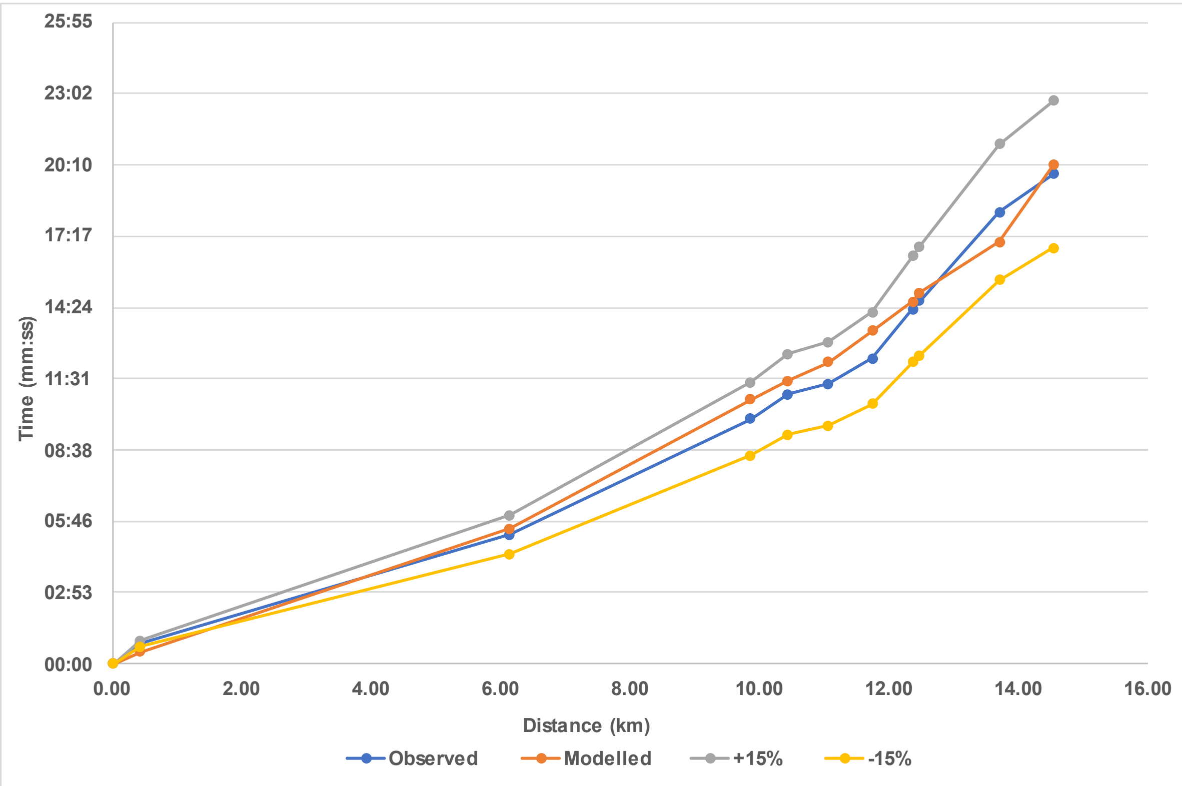
C.66. JTR16 SB – PM Peak



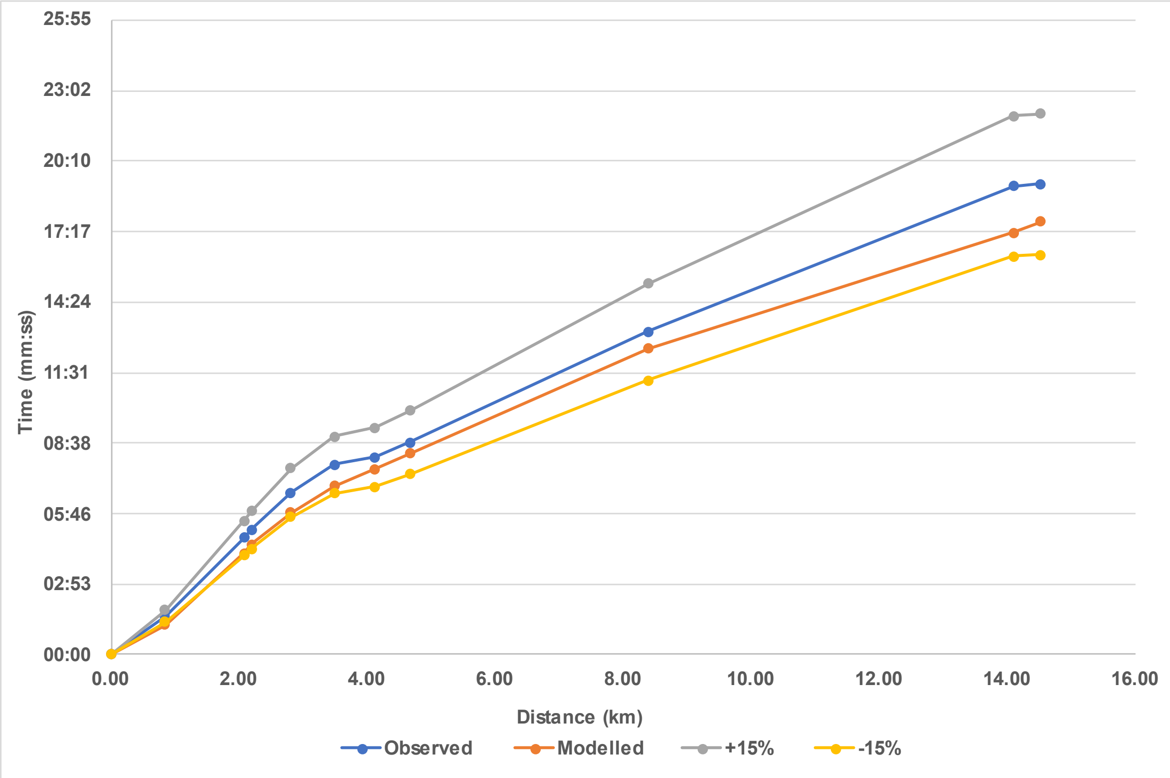
C.67. JTR22 EB – AM Peak



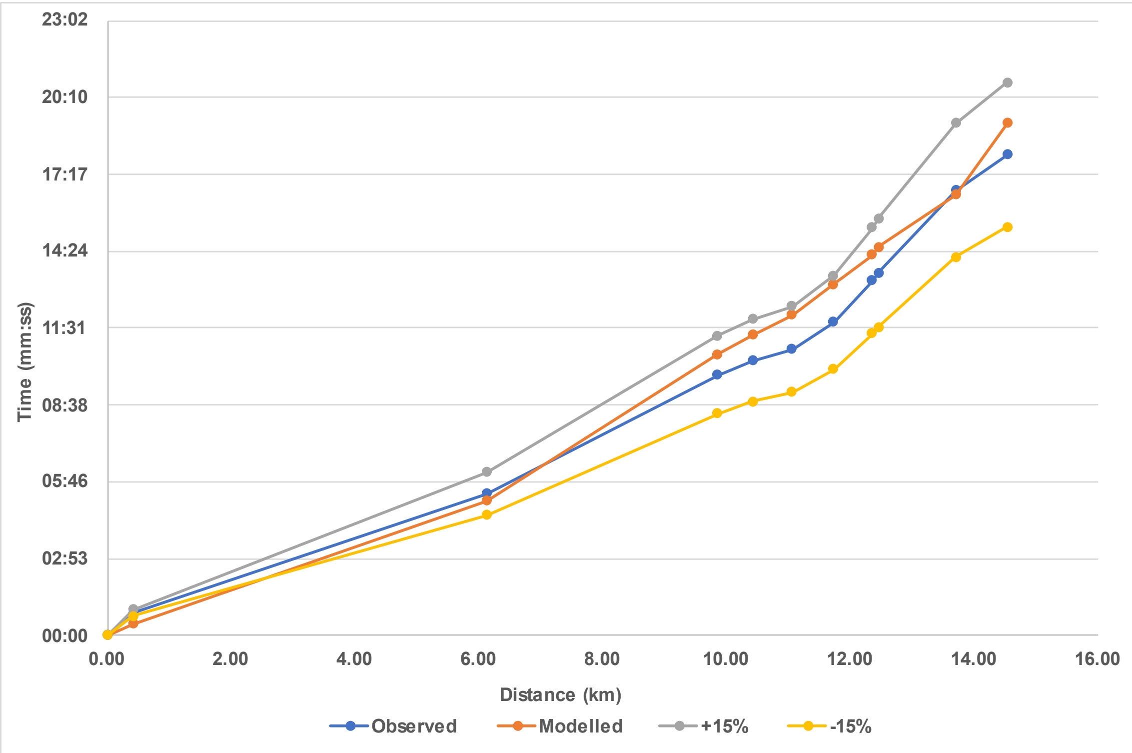
C.68. JTR22 WB – AM Peak



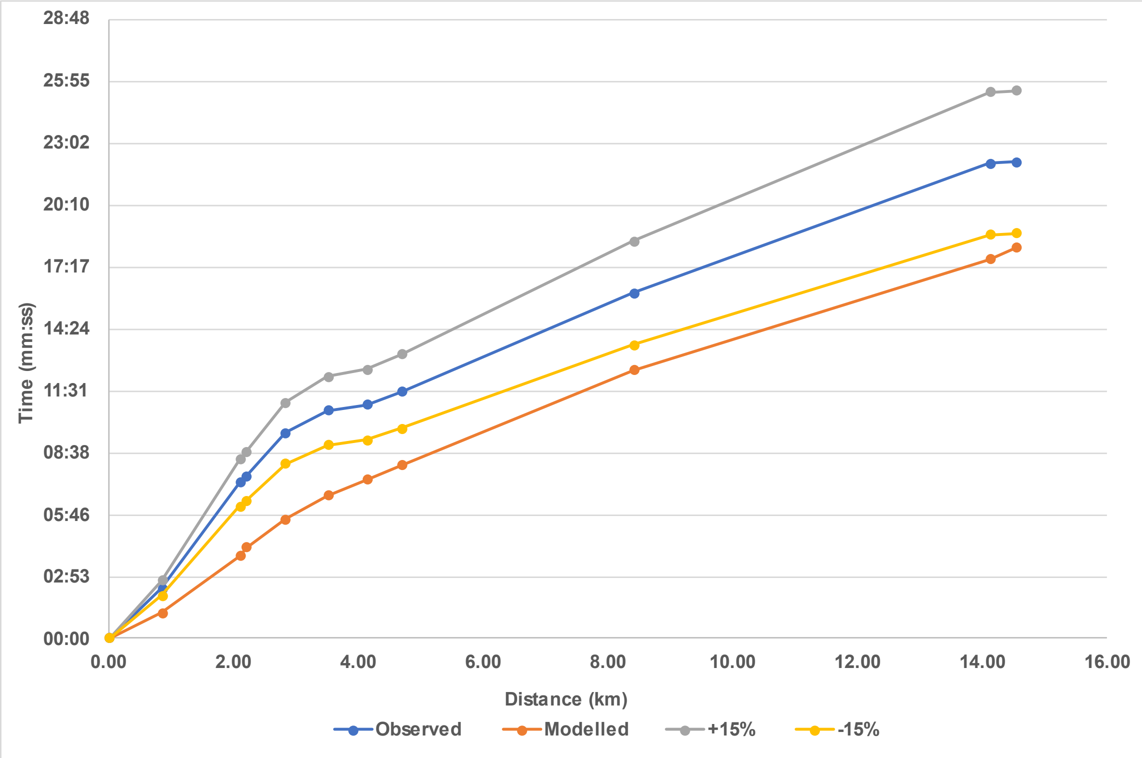
C.69. JTR22 EB – IP Peak



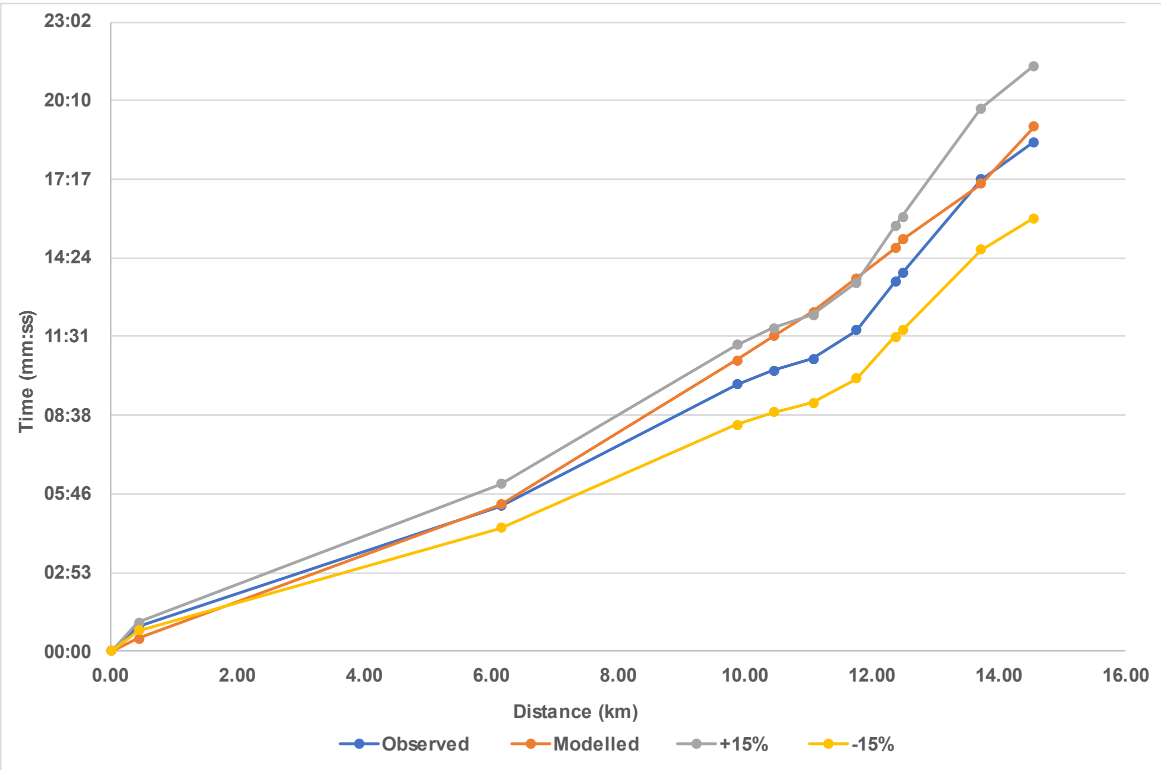
C.70. JTR22 WB – IP Peak



C.71. JTR22 EB – PM Peak

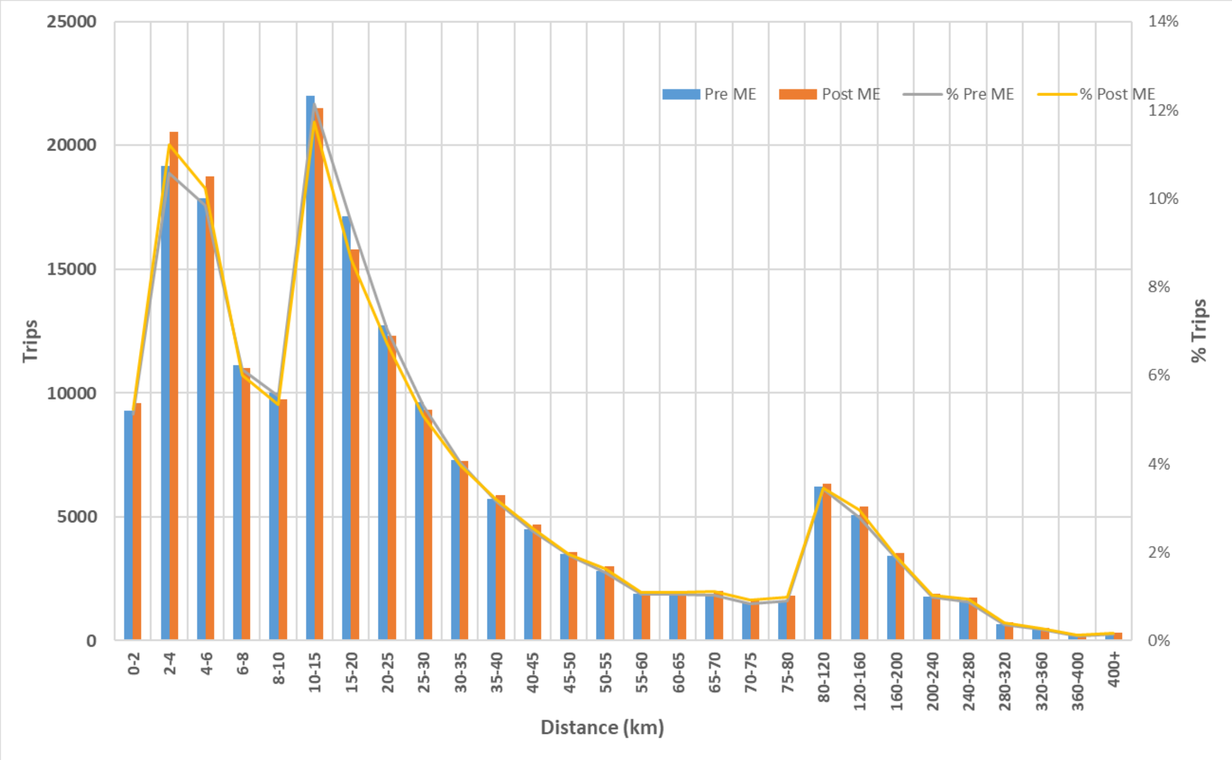


C.72. JTR22 WB – PM Peak

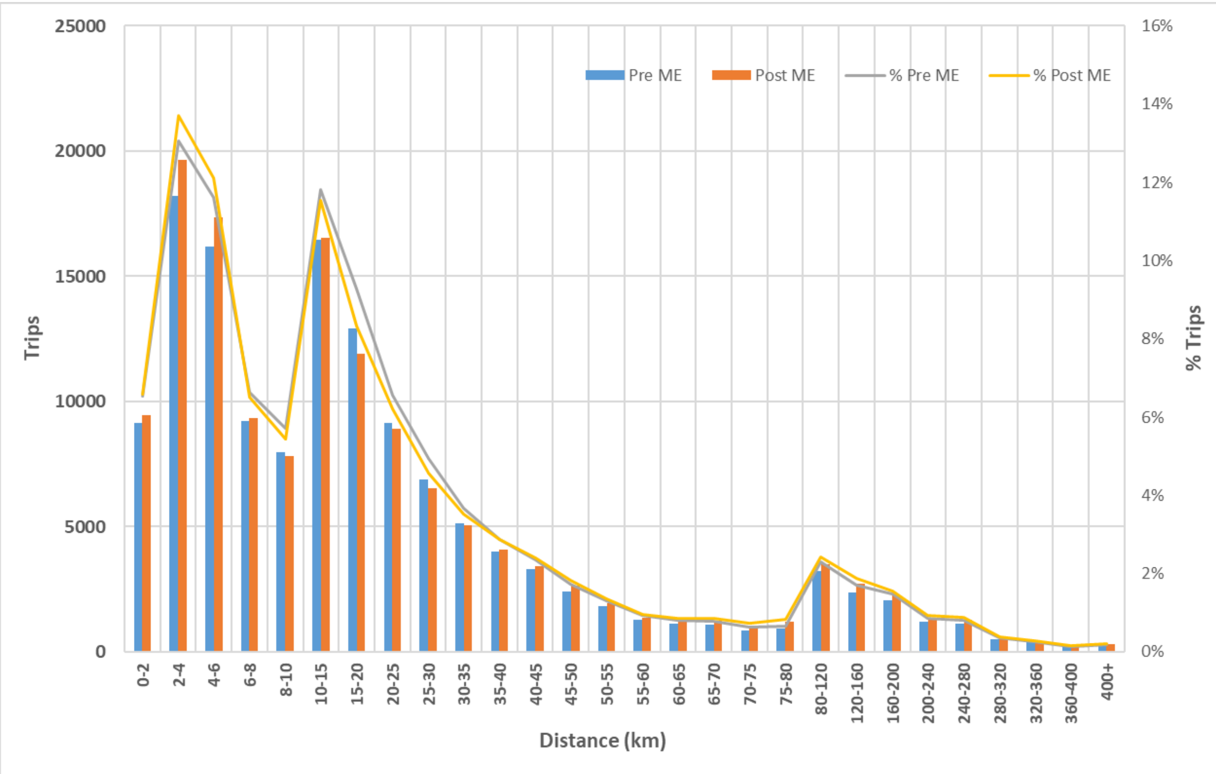


Appendix D. TLD Plots

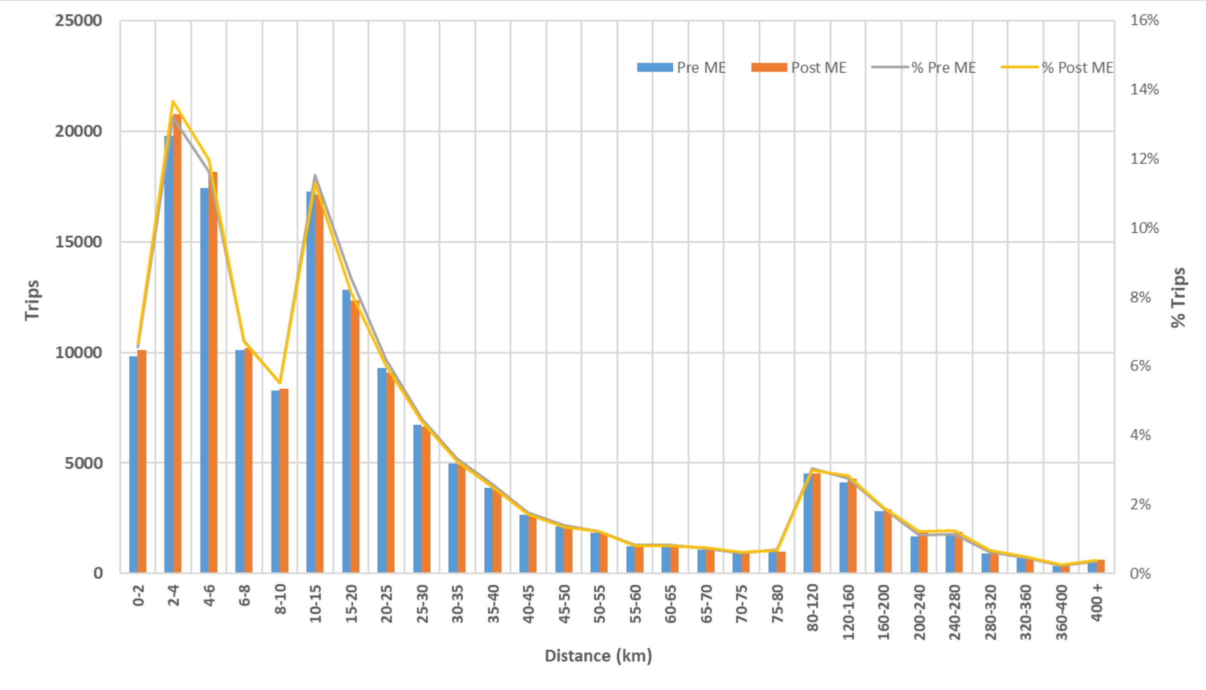
D.1. All vehicles AM Peak



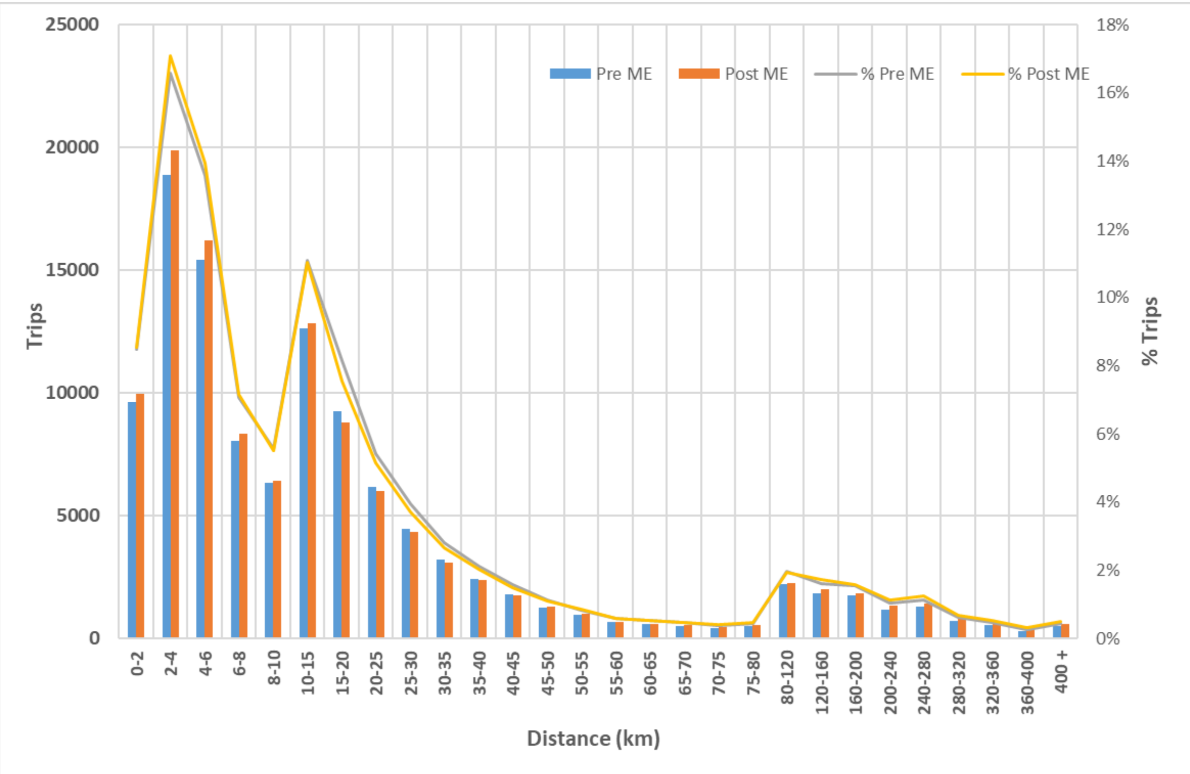
D.2. Cars AM Peak



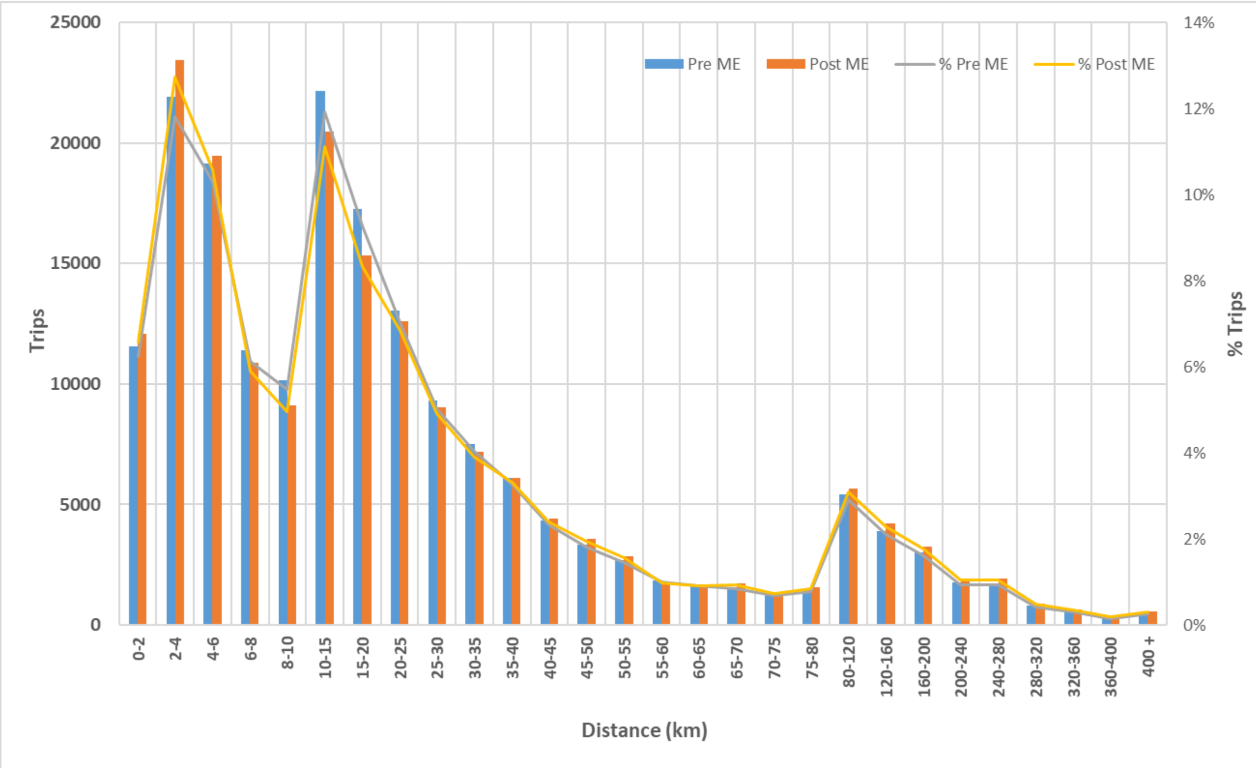
D.3. All Vehicles Inter Peak



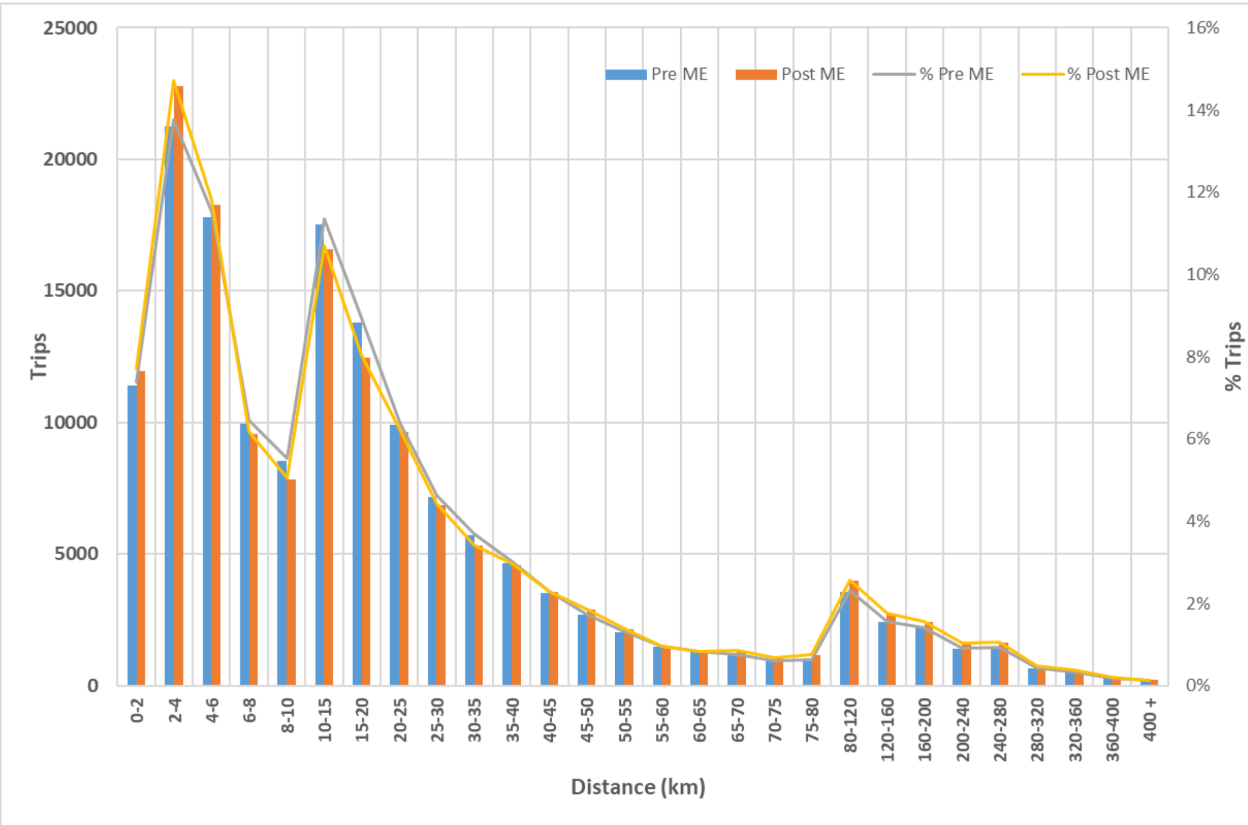
D.4. Cars Inter Peak



D.5. All vehicles PM Peak

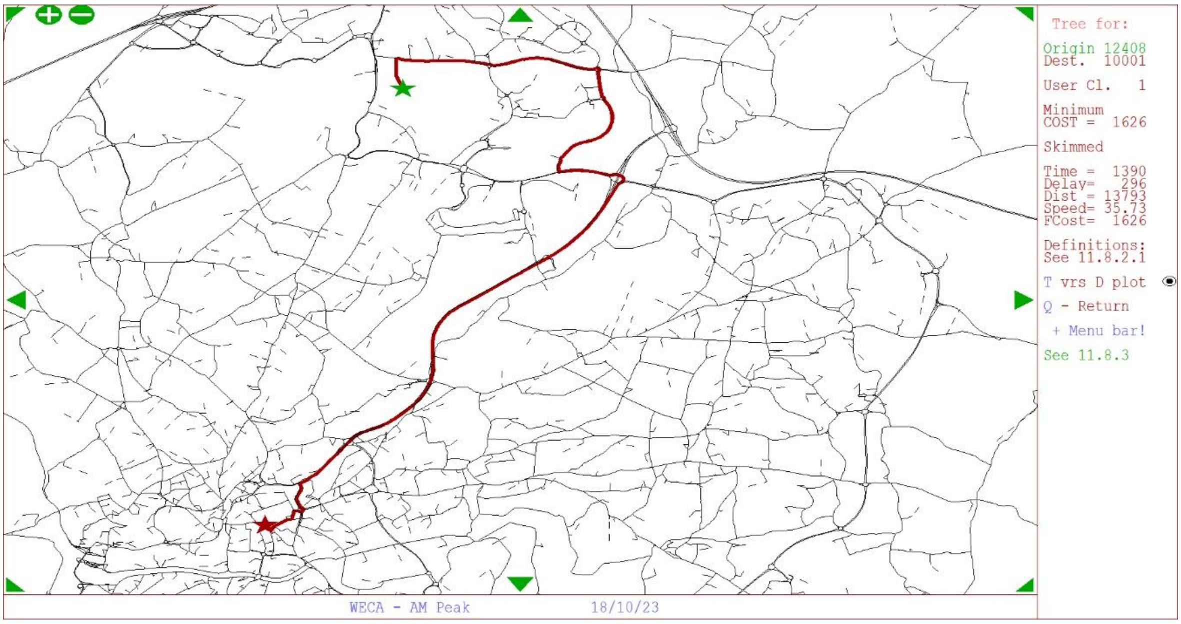


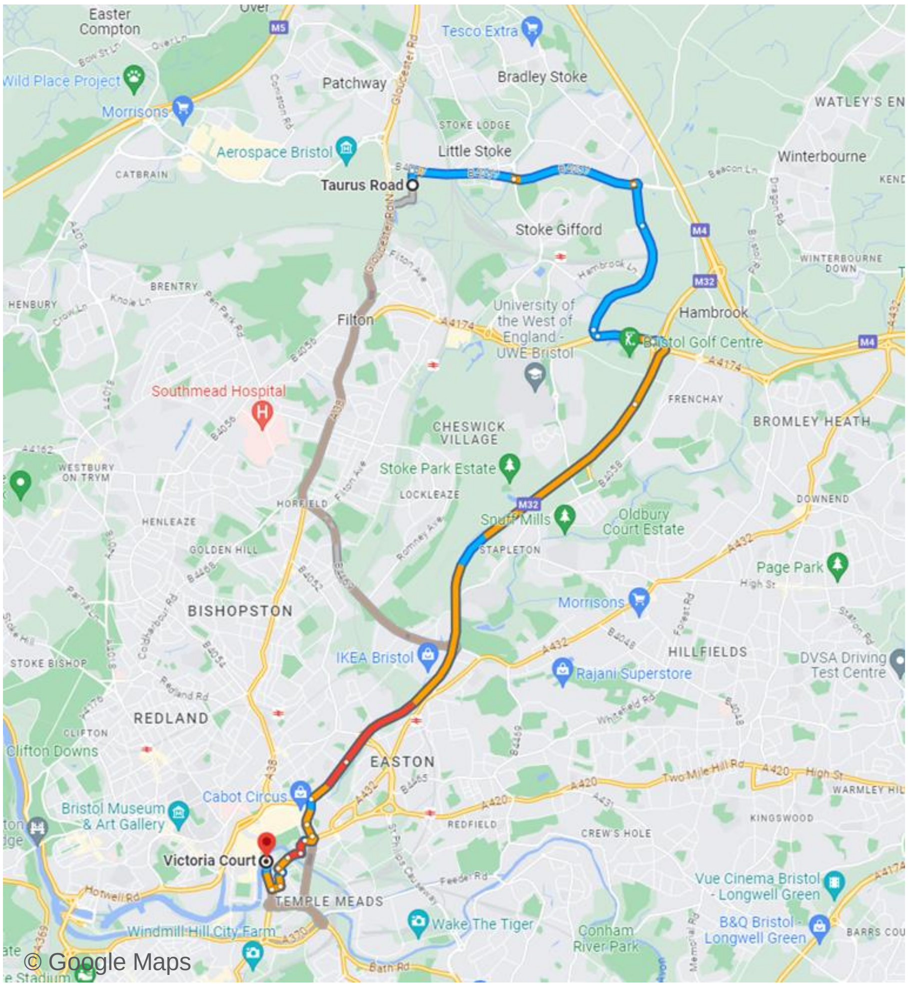
D.6. Cars PM Peak



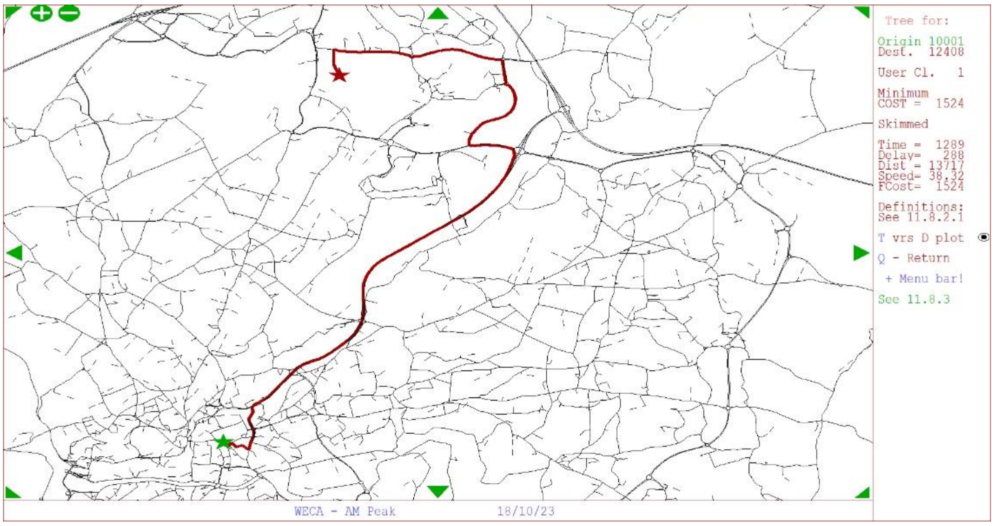
Appendix E. Route Choice validation

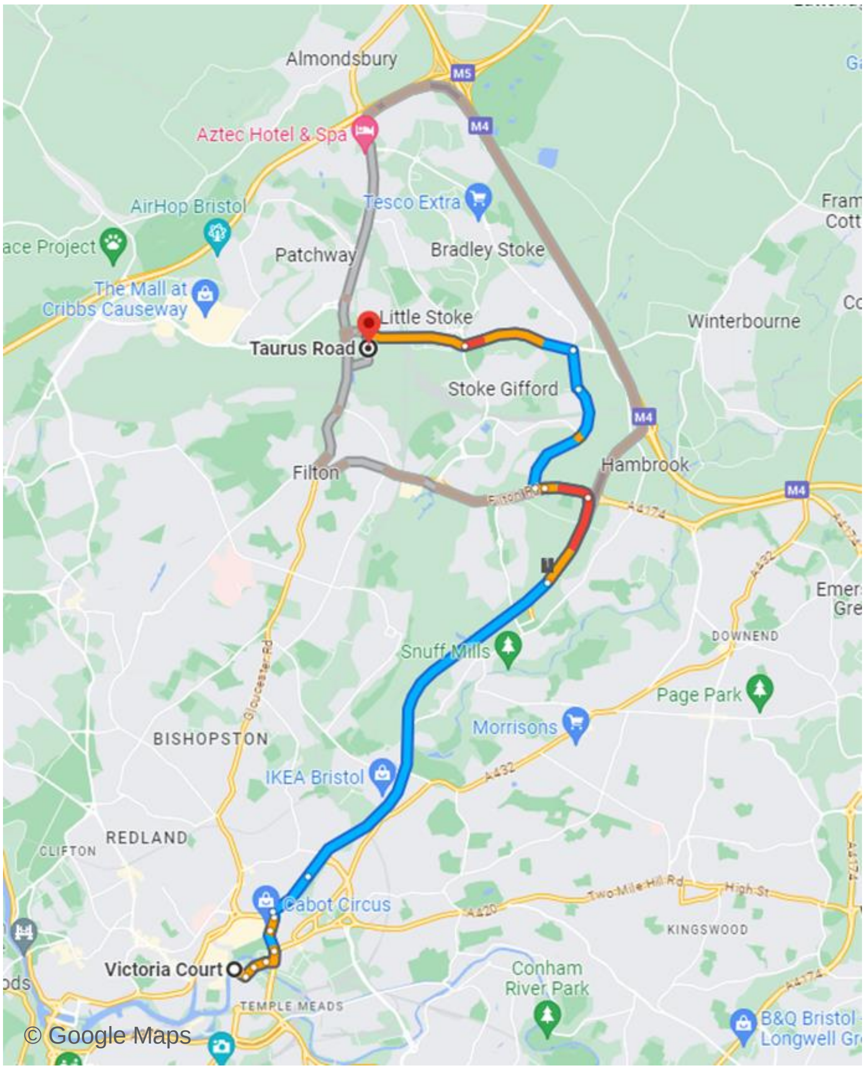
E.1. Filton to Bristol City Centre AM Peak



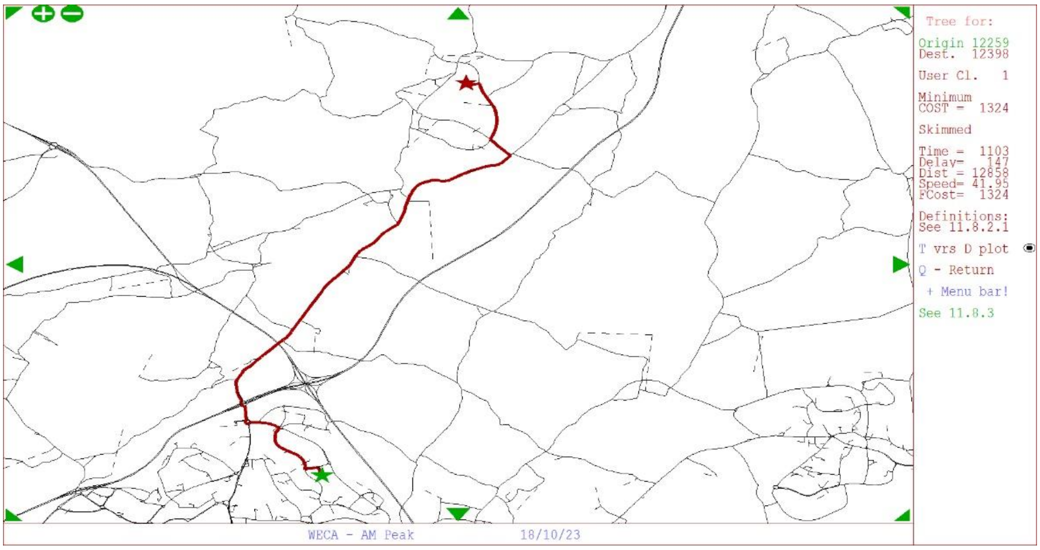


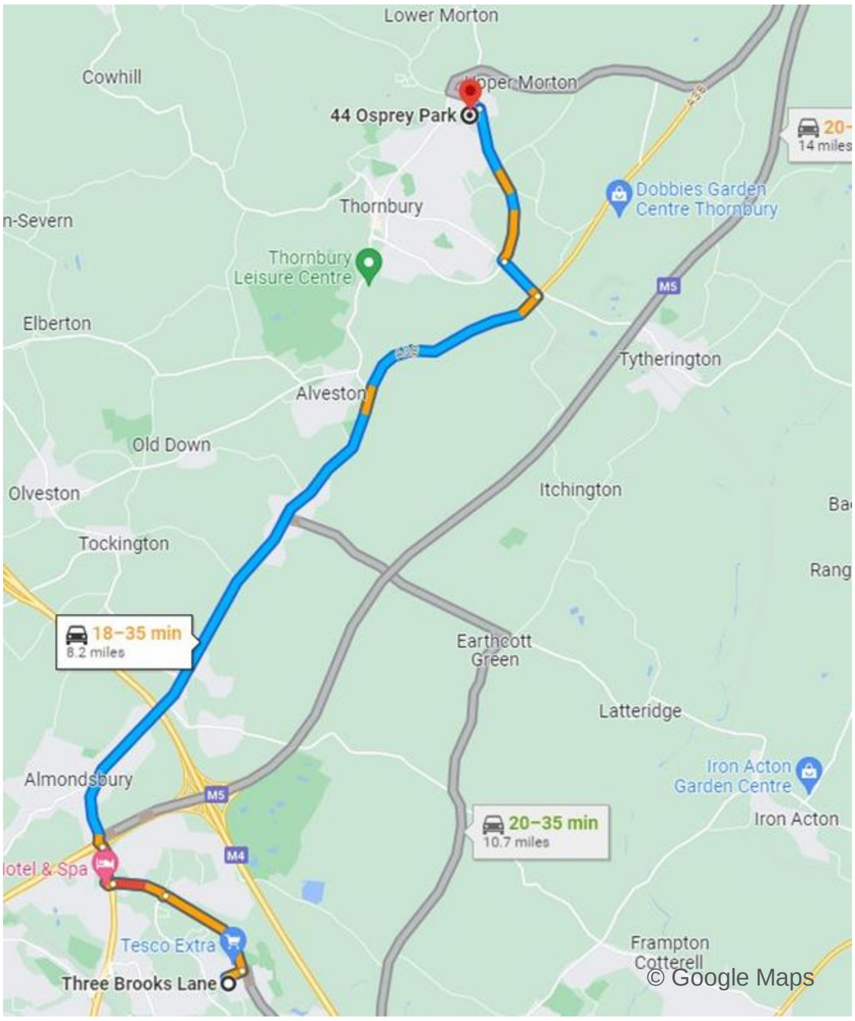
E.2. Bristol City Centre to Filton AM Peak



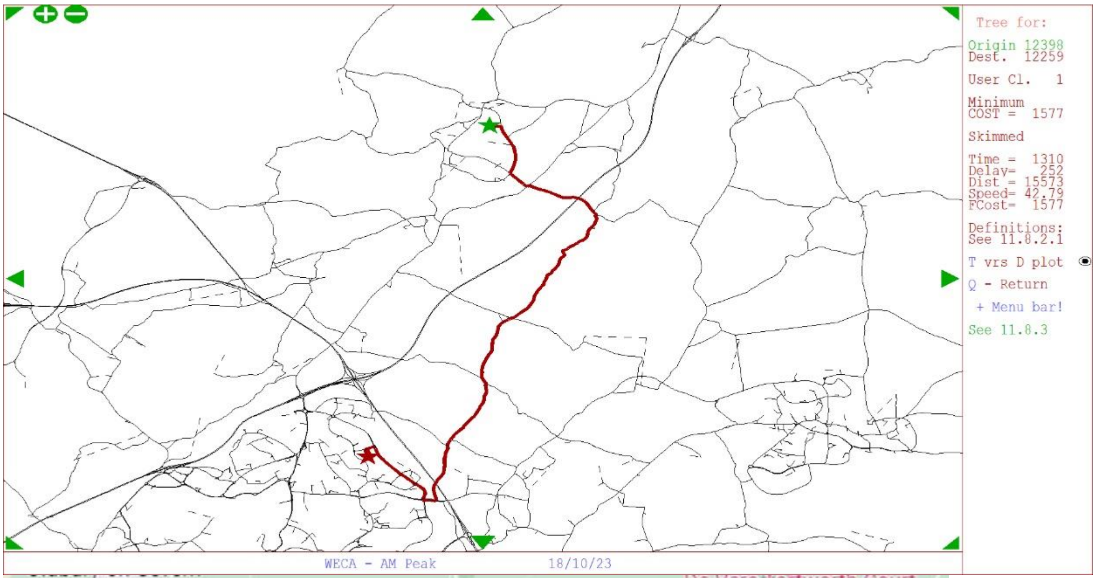


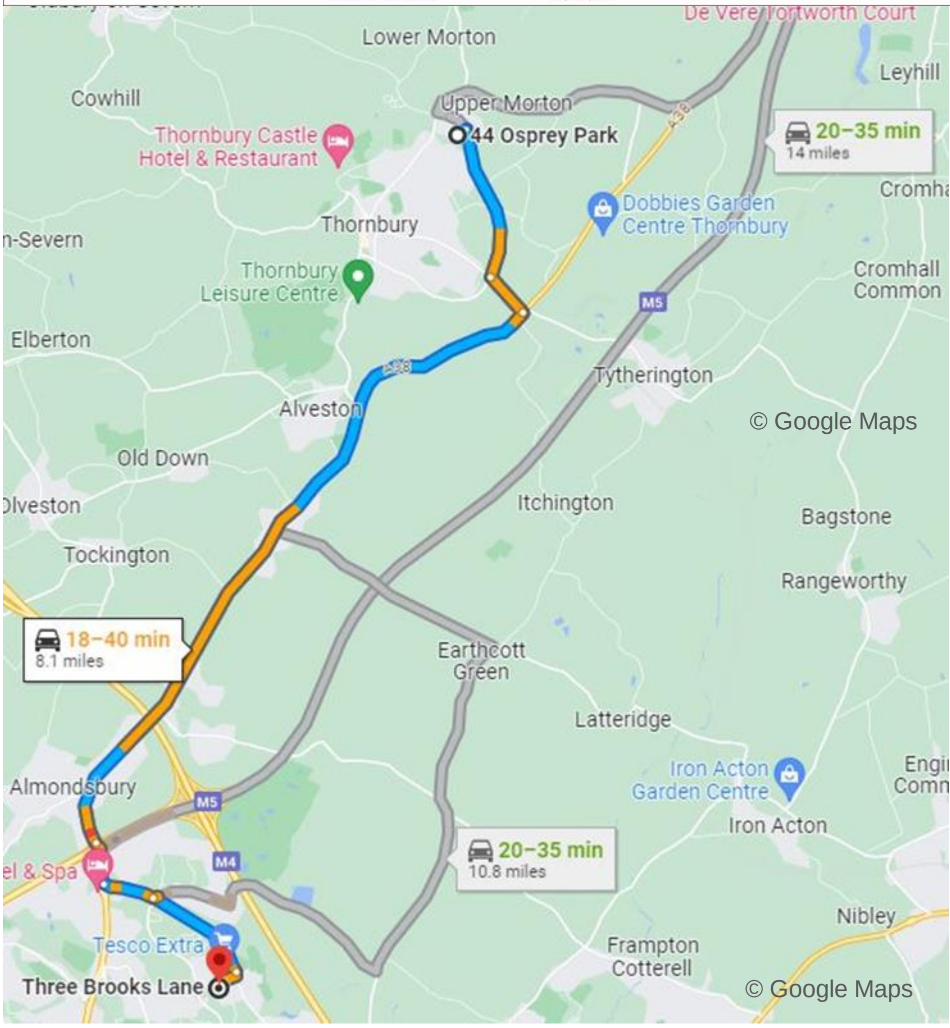
E.3. Bradley Stoke to Thornbury AM Peak



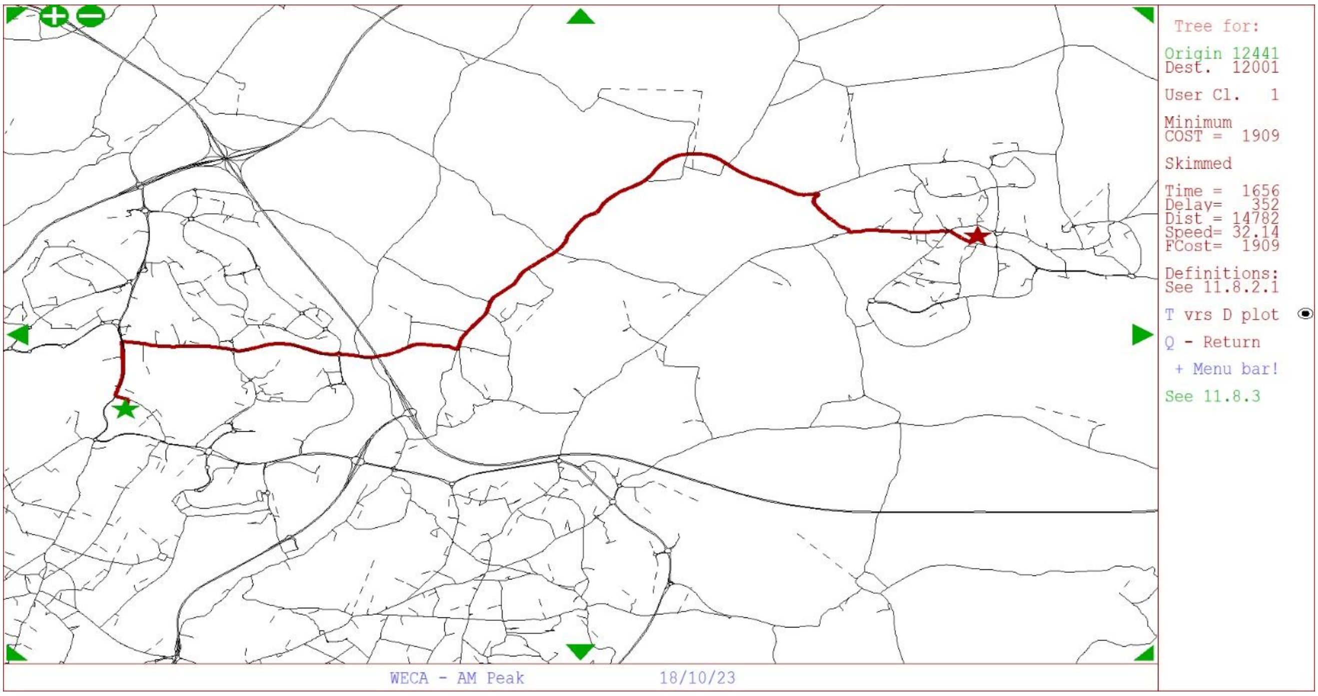


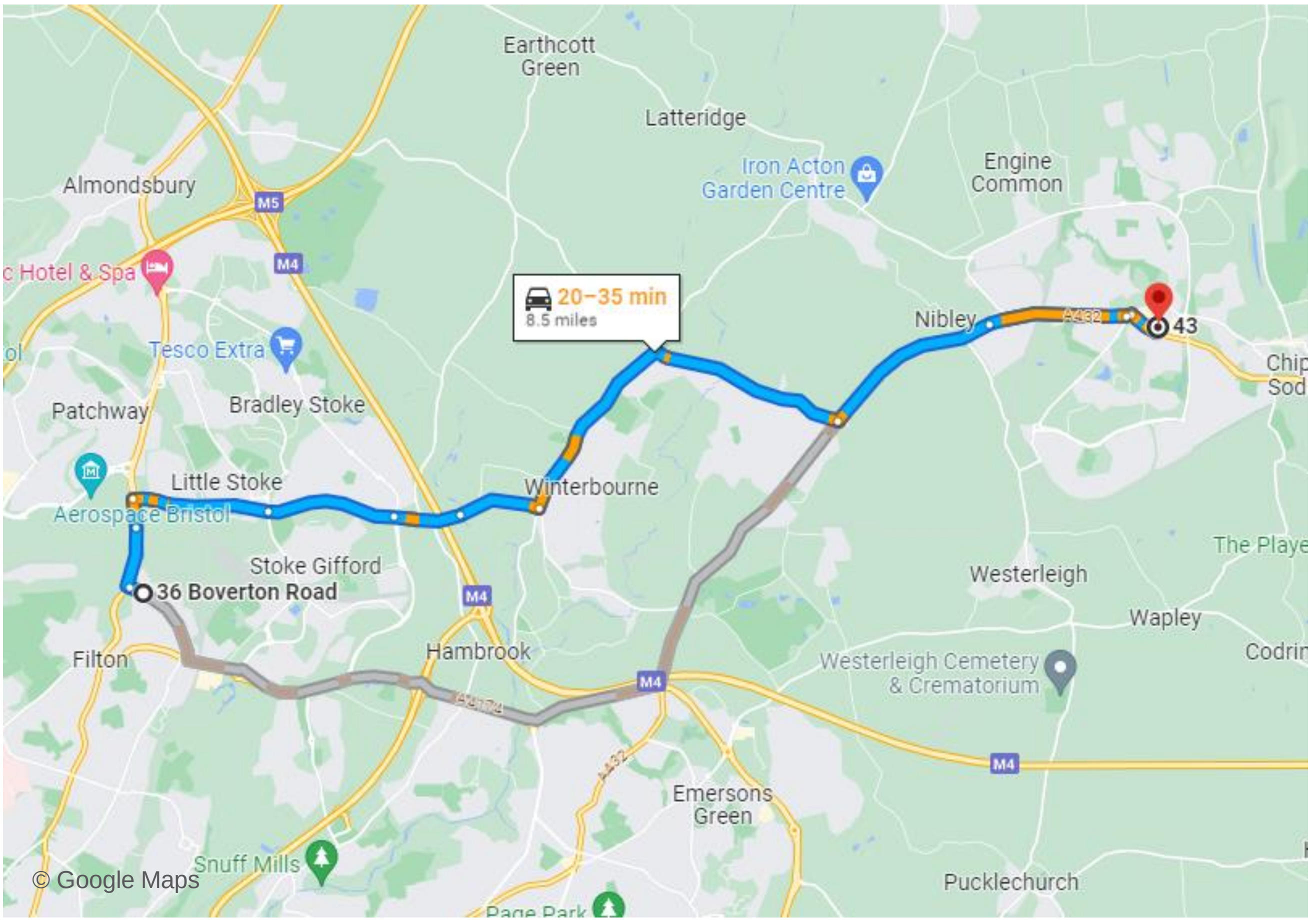
E.4. Thornbury to Bradley Stoke AM Peak



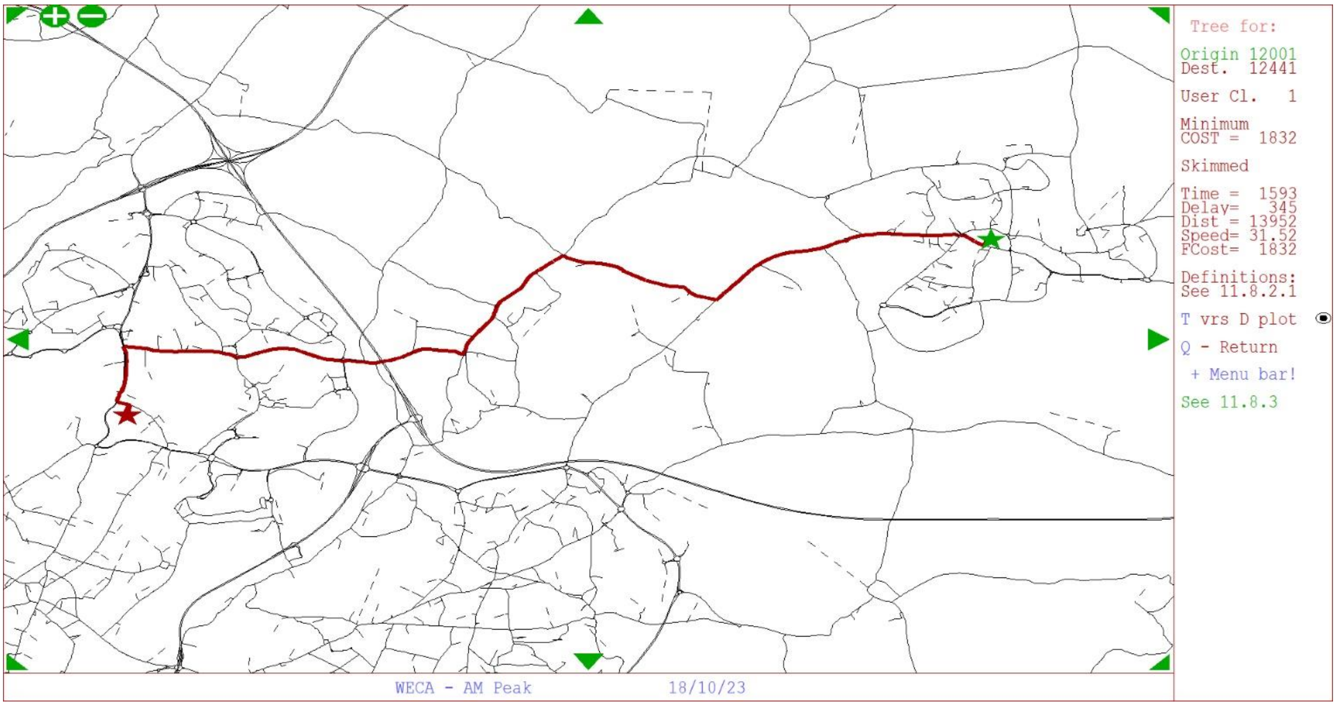


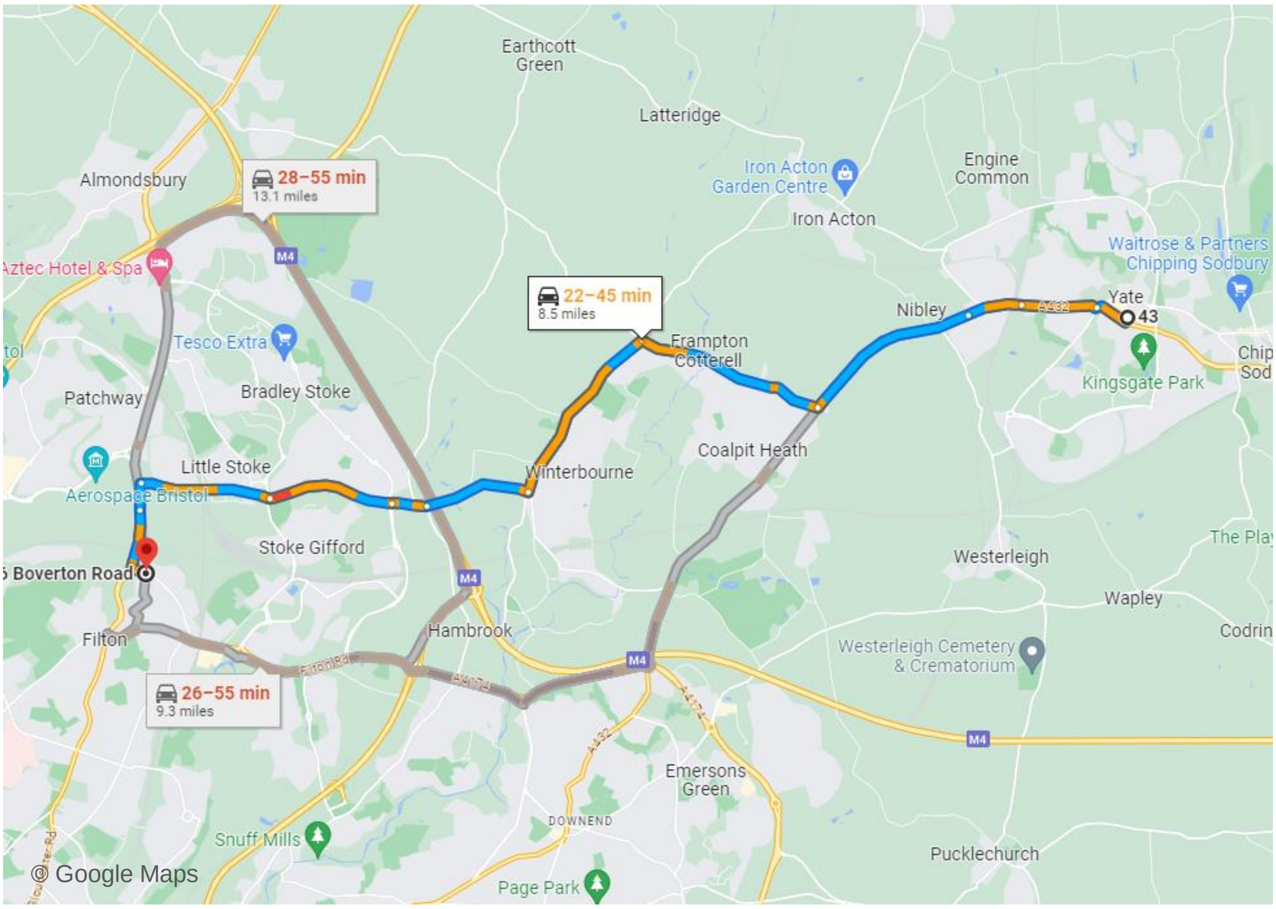
E.5. Filton to Yate AM Peak



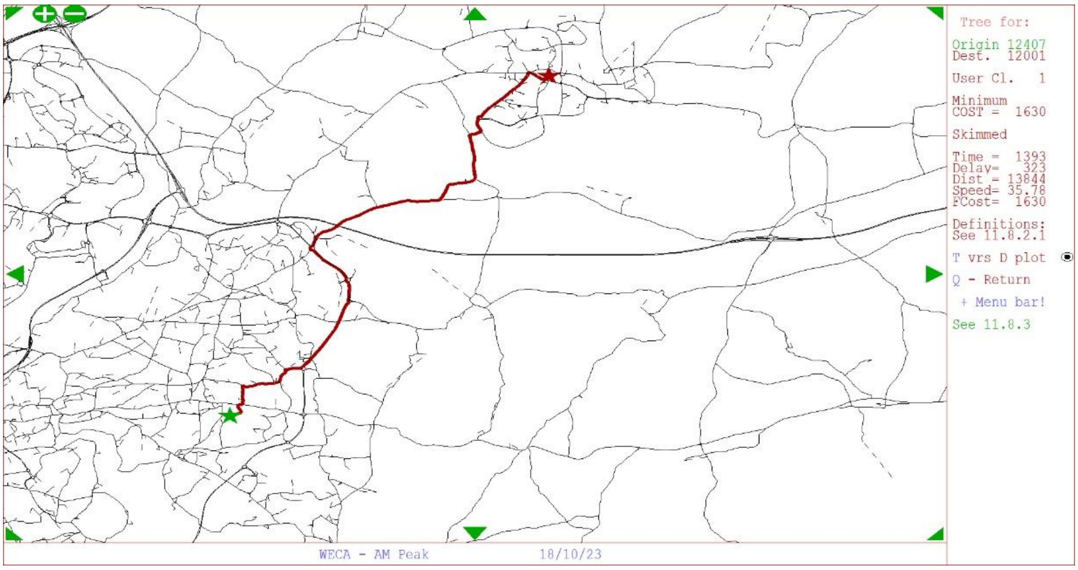


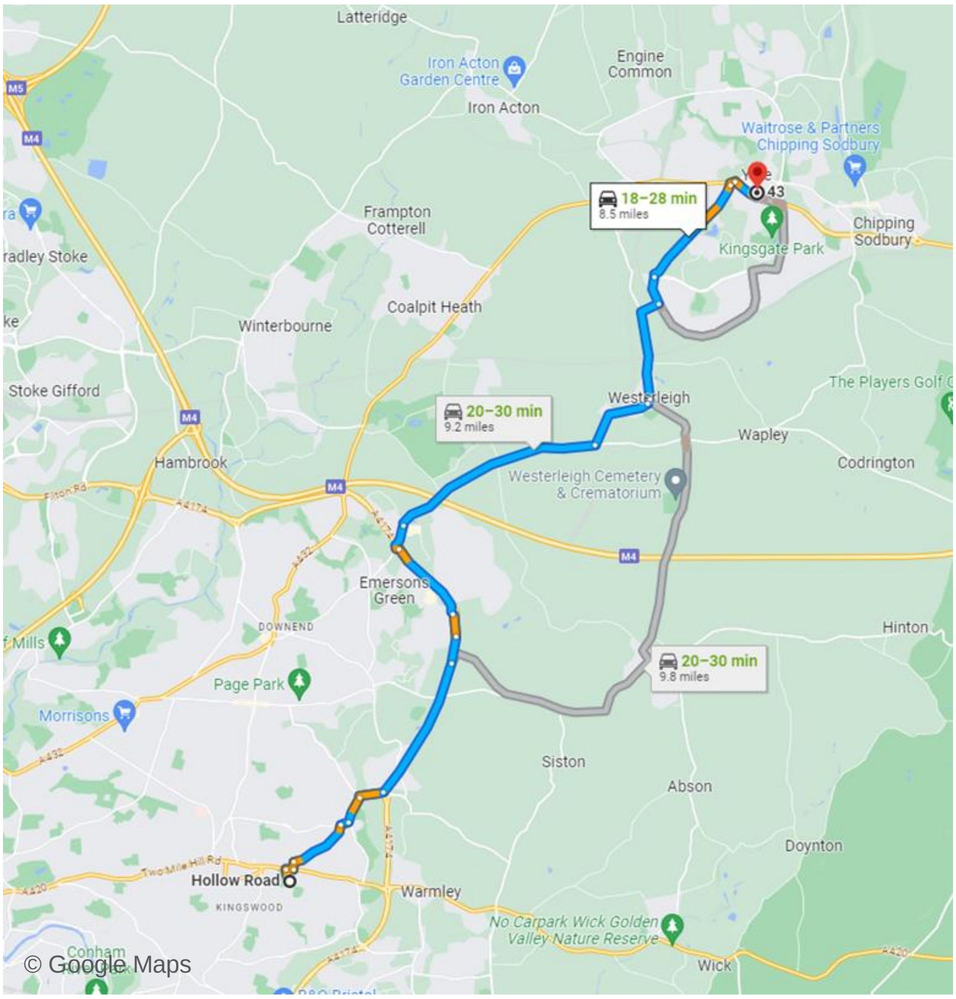
E.6. Yate to Filton AM Peak



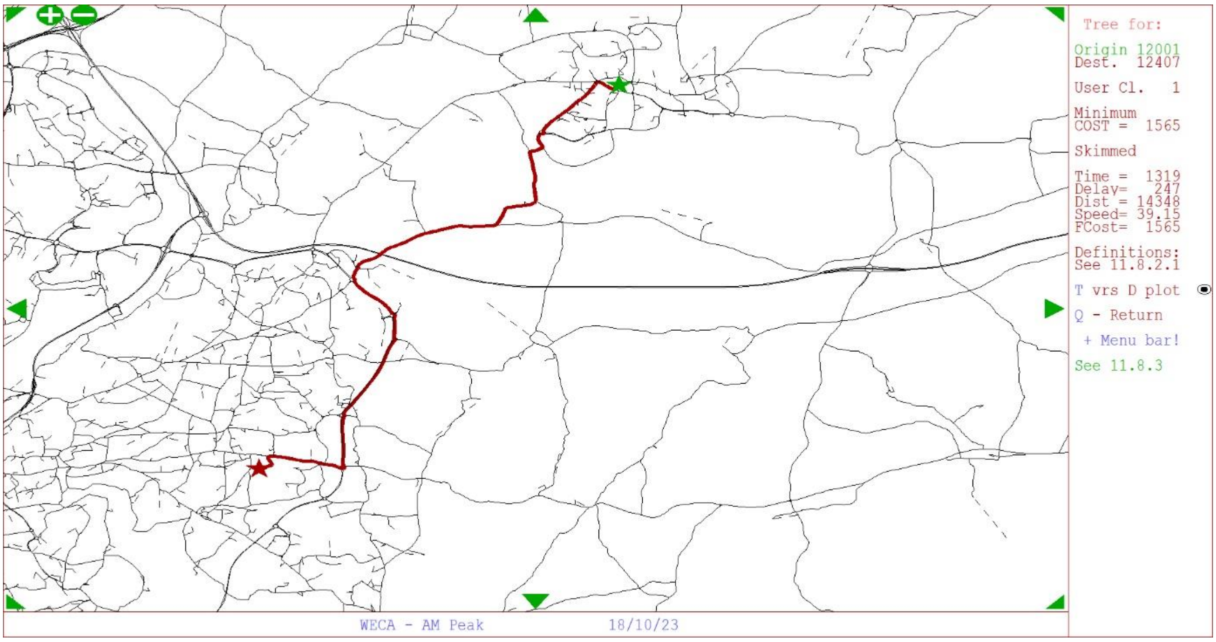


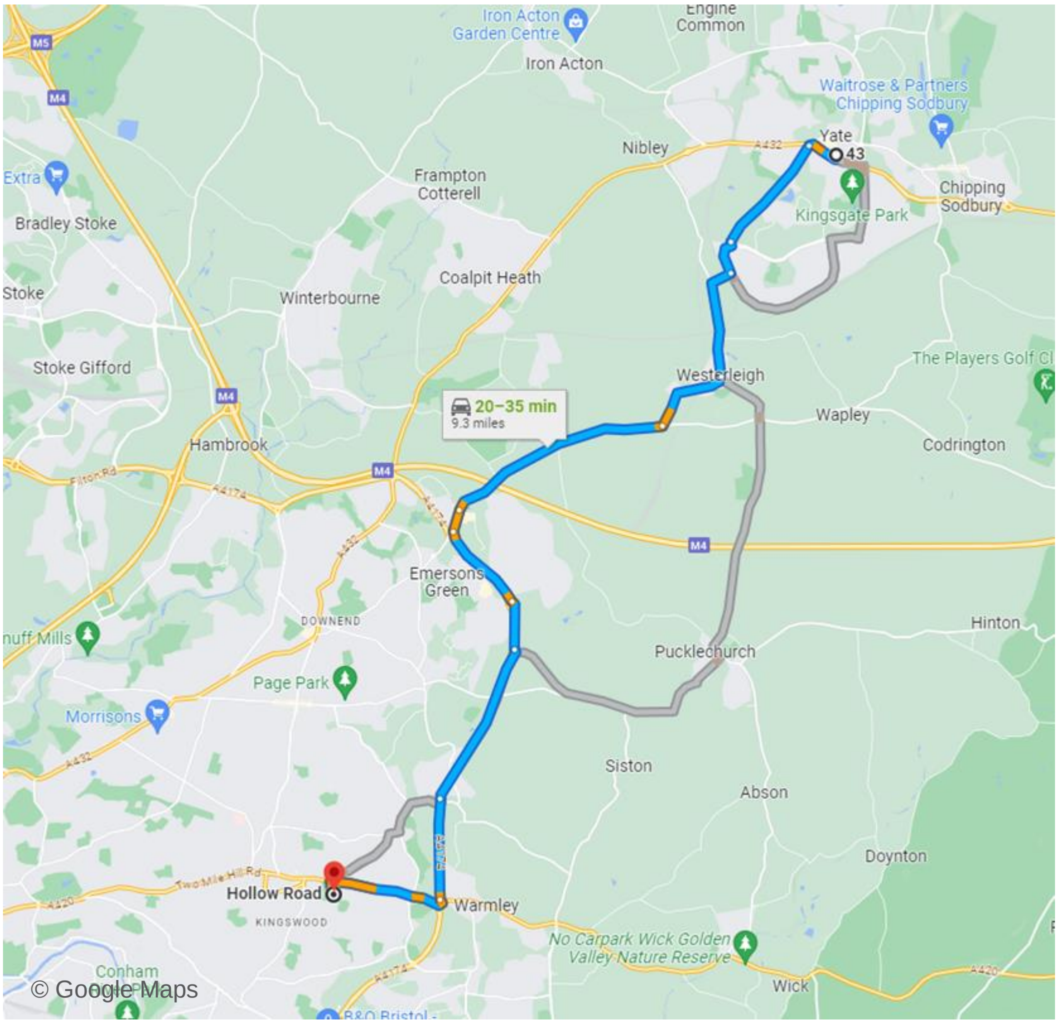
E.7. Kingswood to Yate AM peak



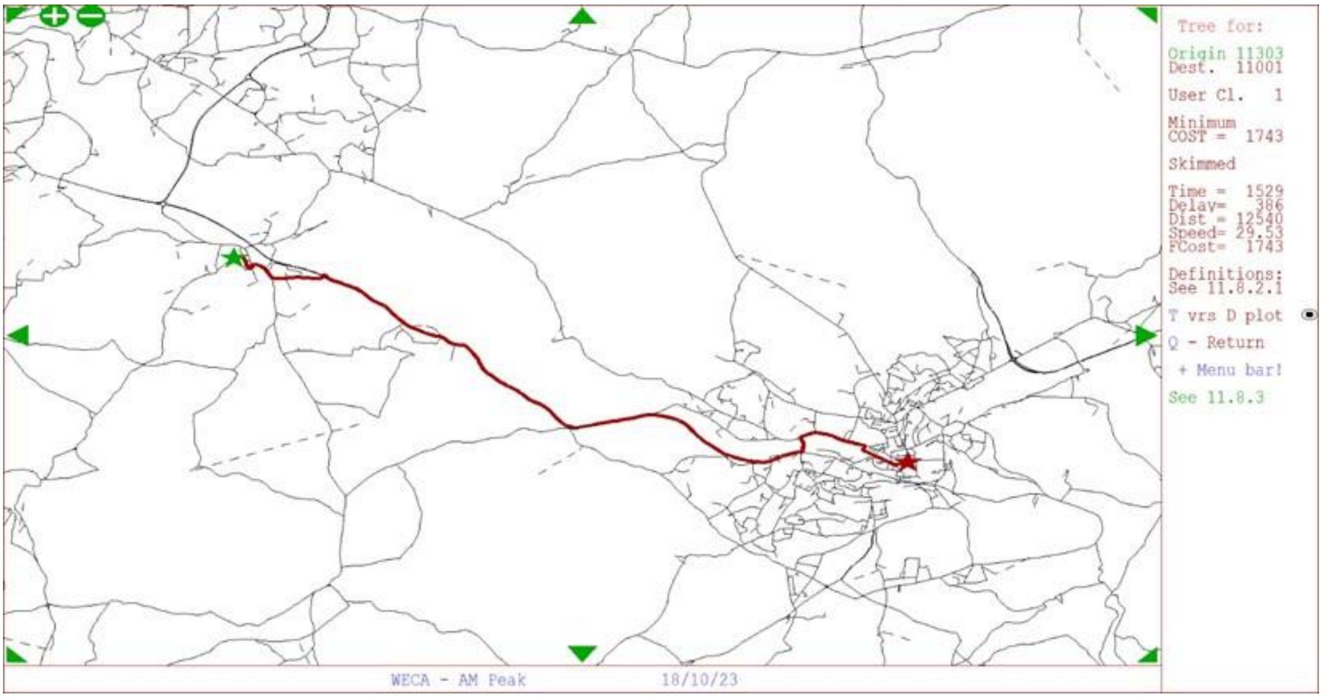


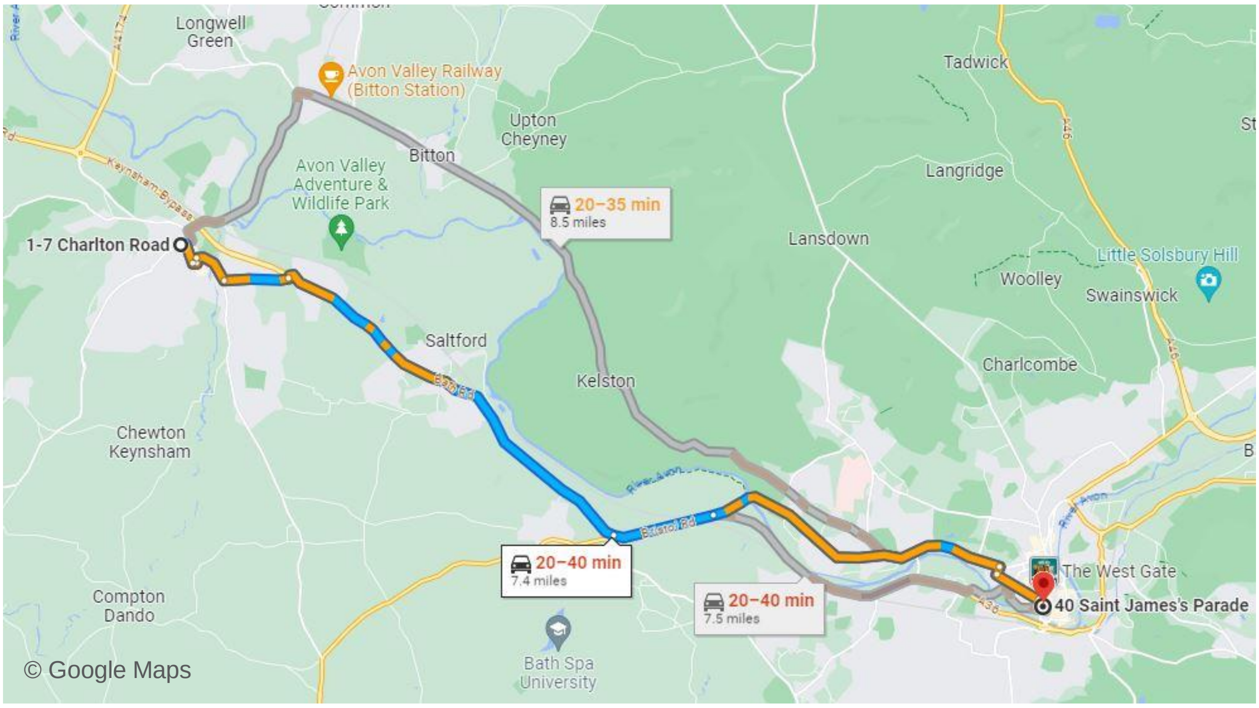
E.8. Yate to Kingswood AM Peak



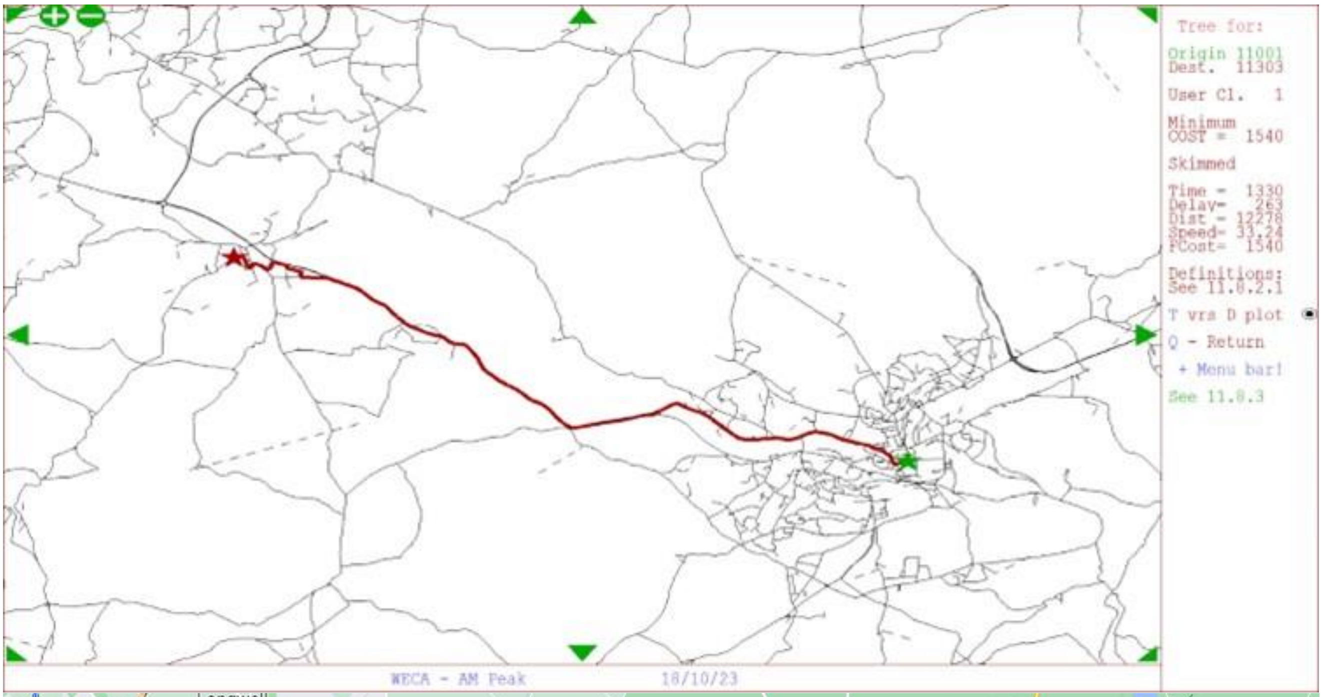


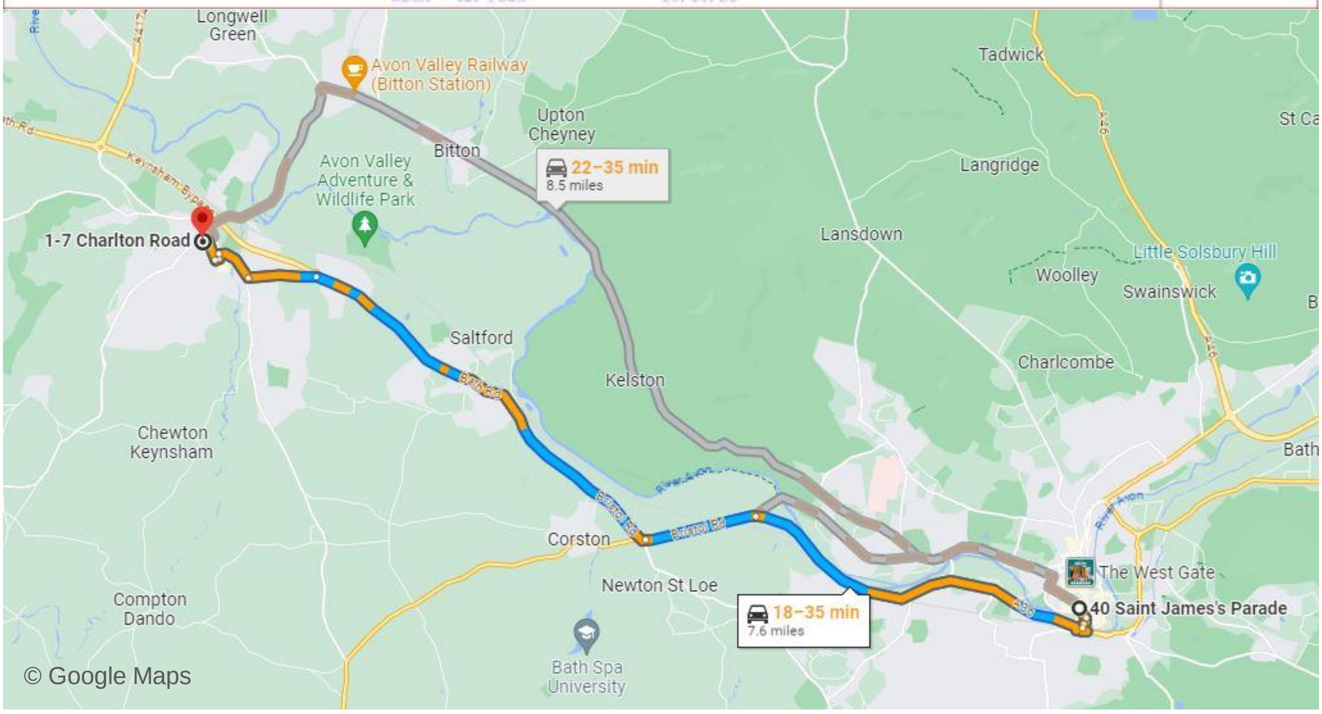
E.9. Keynsham to Bath City Centre AM Peak



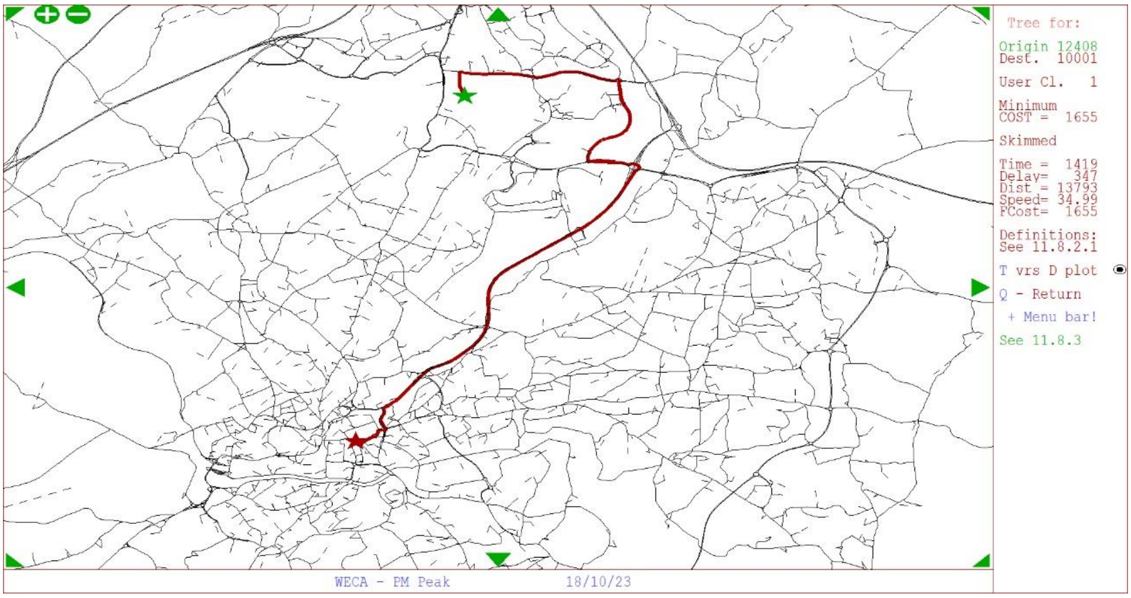


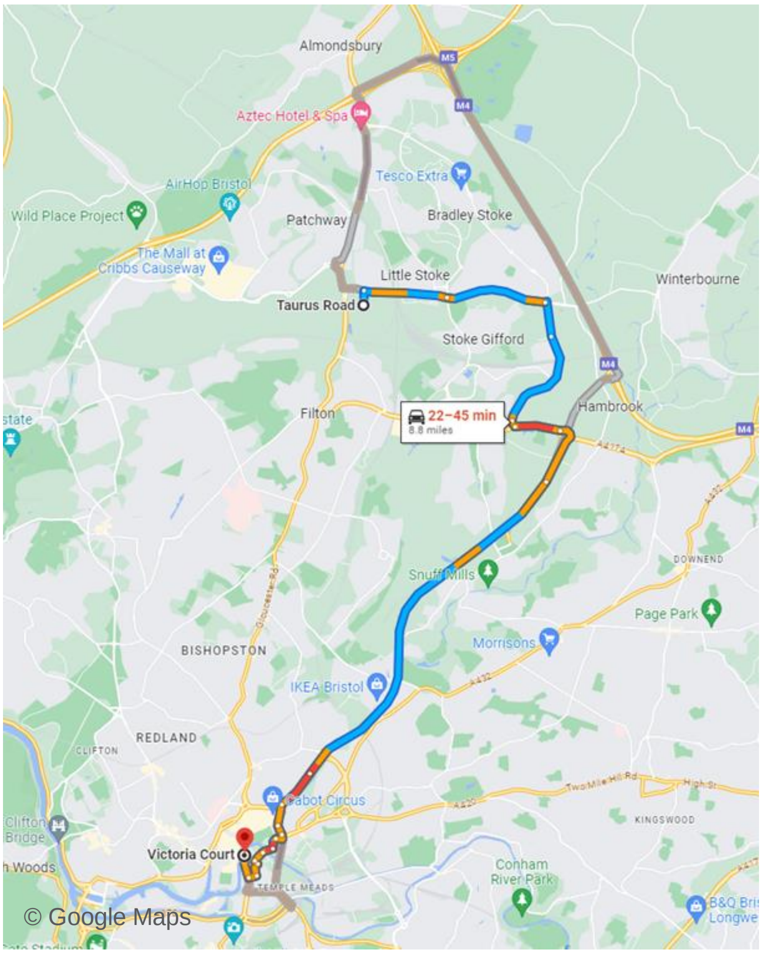
E.10. Bath City Centre to Keynsham AM Peak



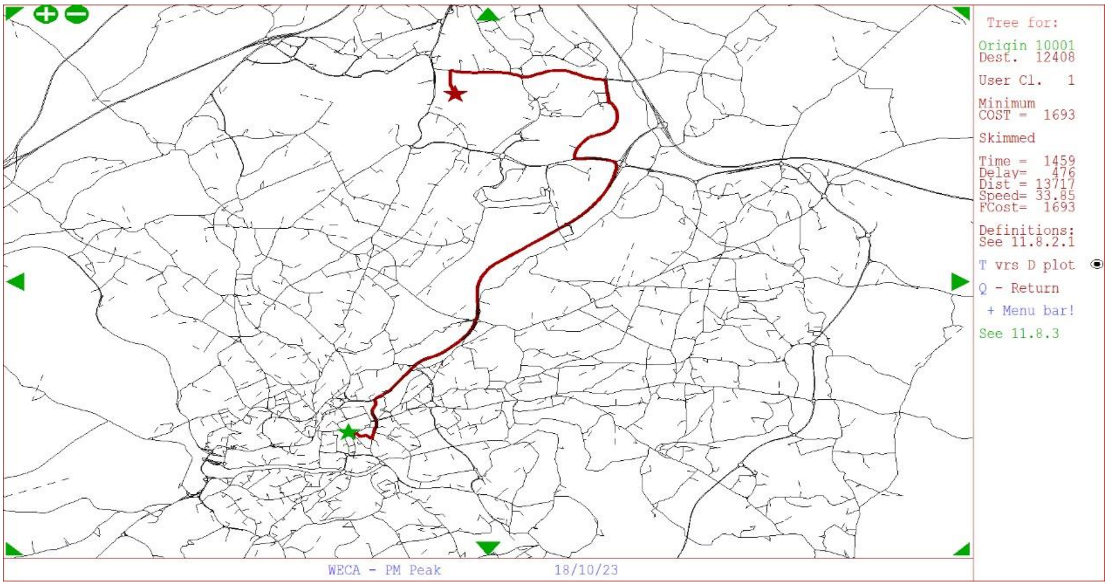


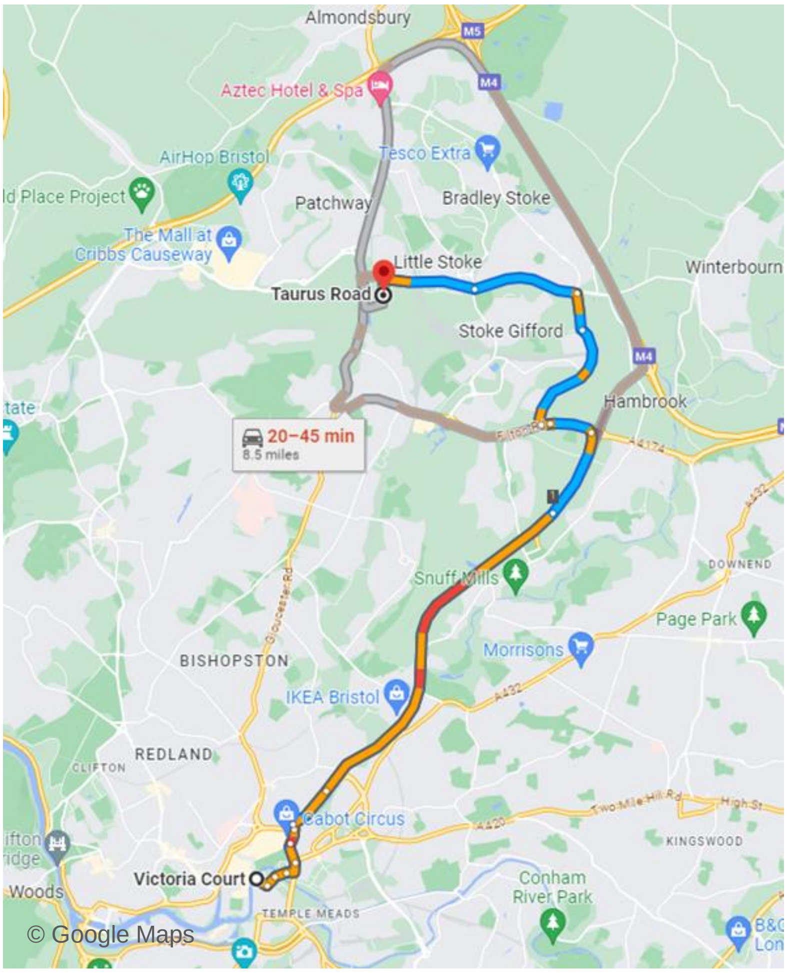
E.11. Filton to Bristol City Centre PM Peak



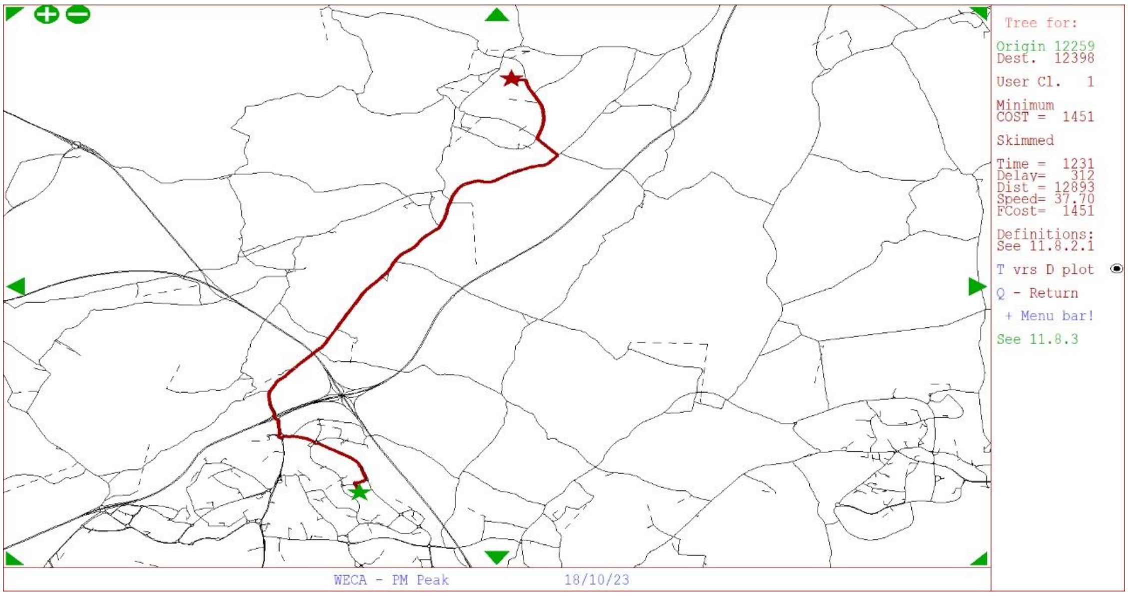


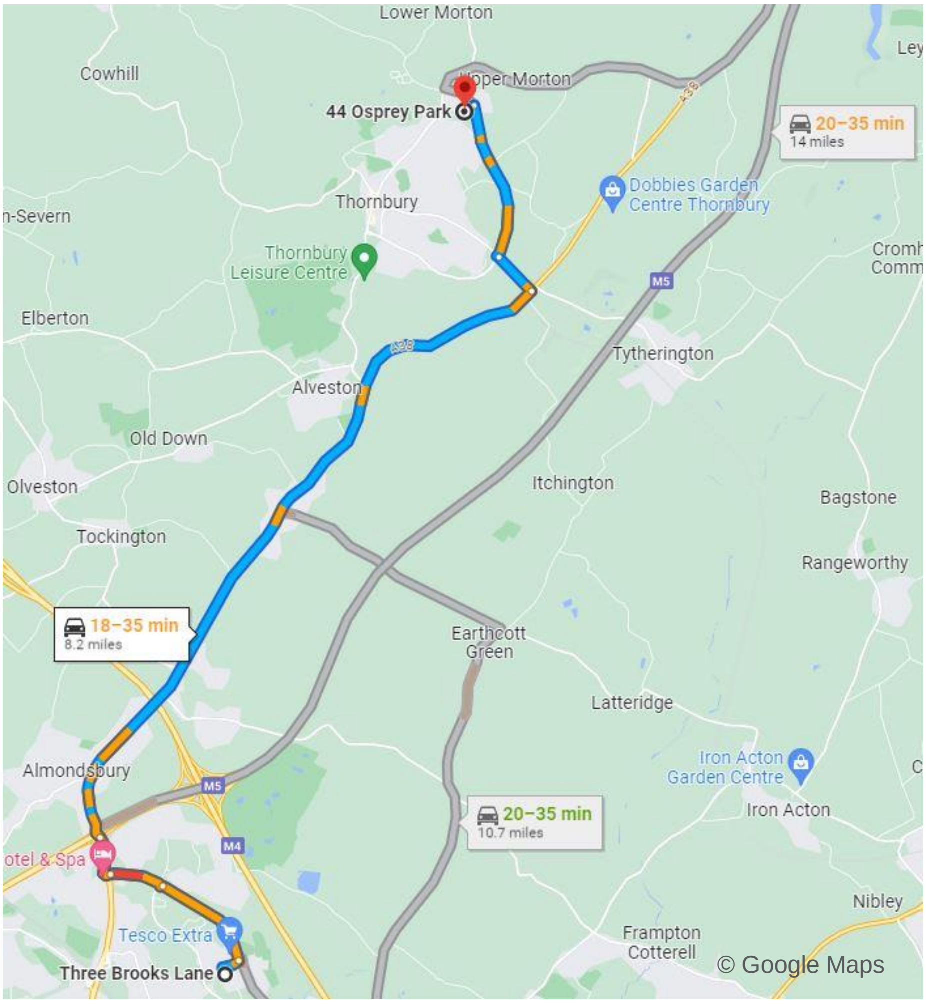
E.12. Bristol City Centre to Filton PM Peak



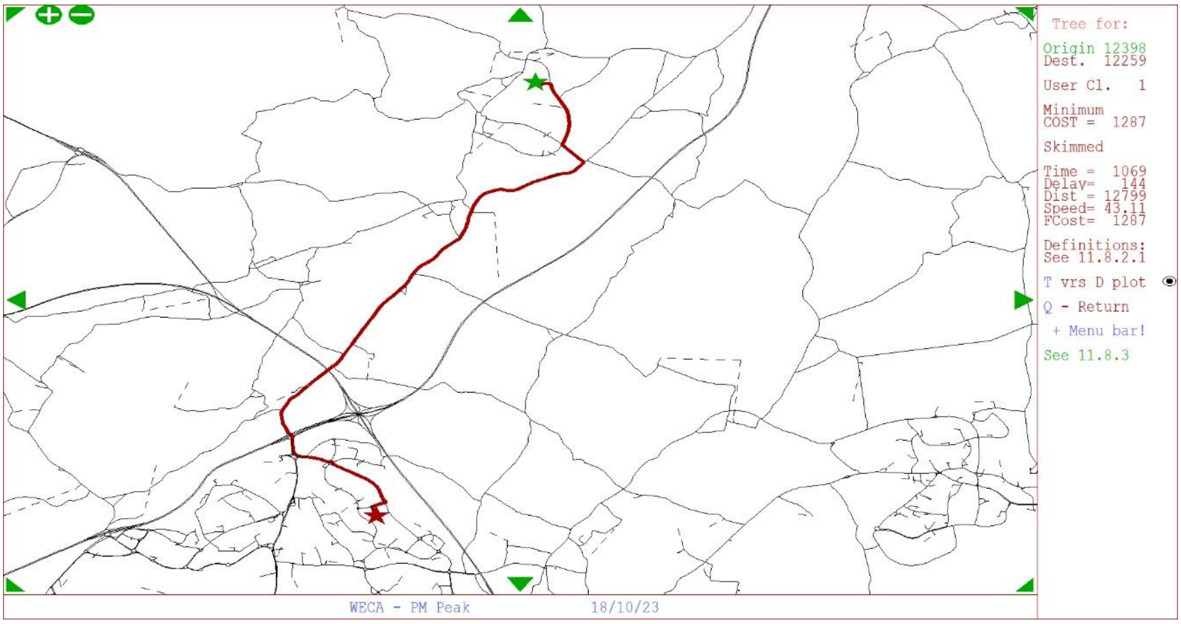


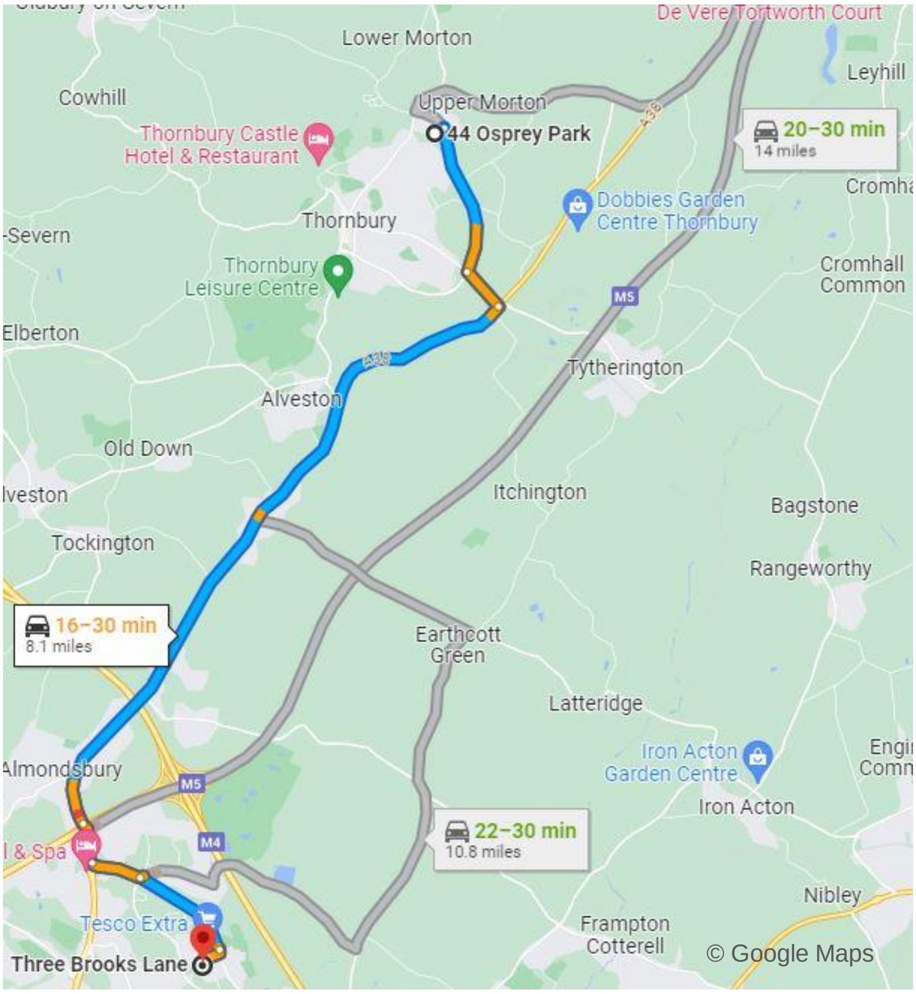
E.13. Bradley Stoke to Thornbury PM Peak



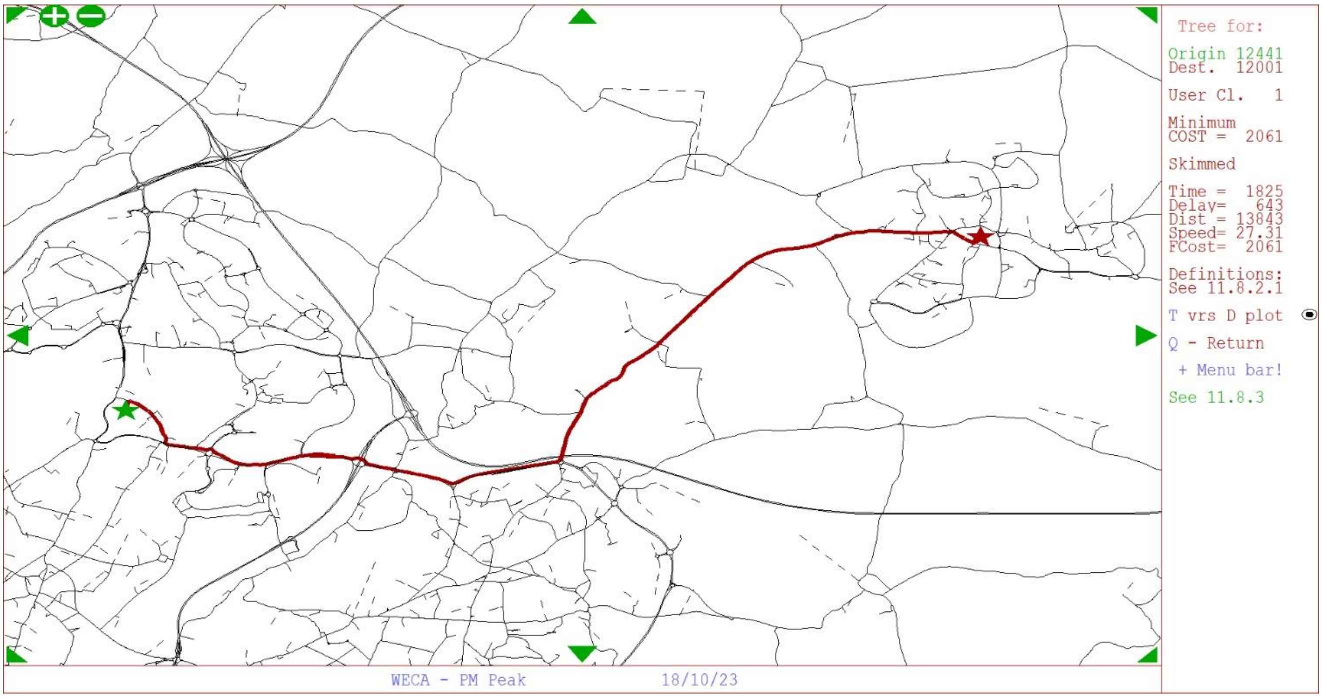


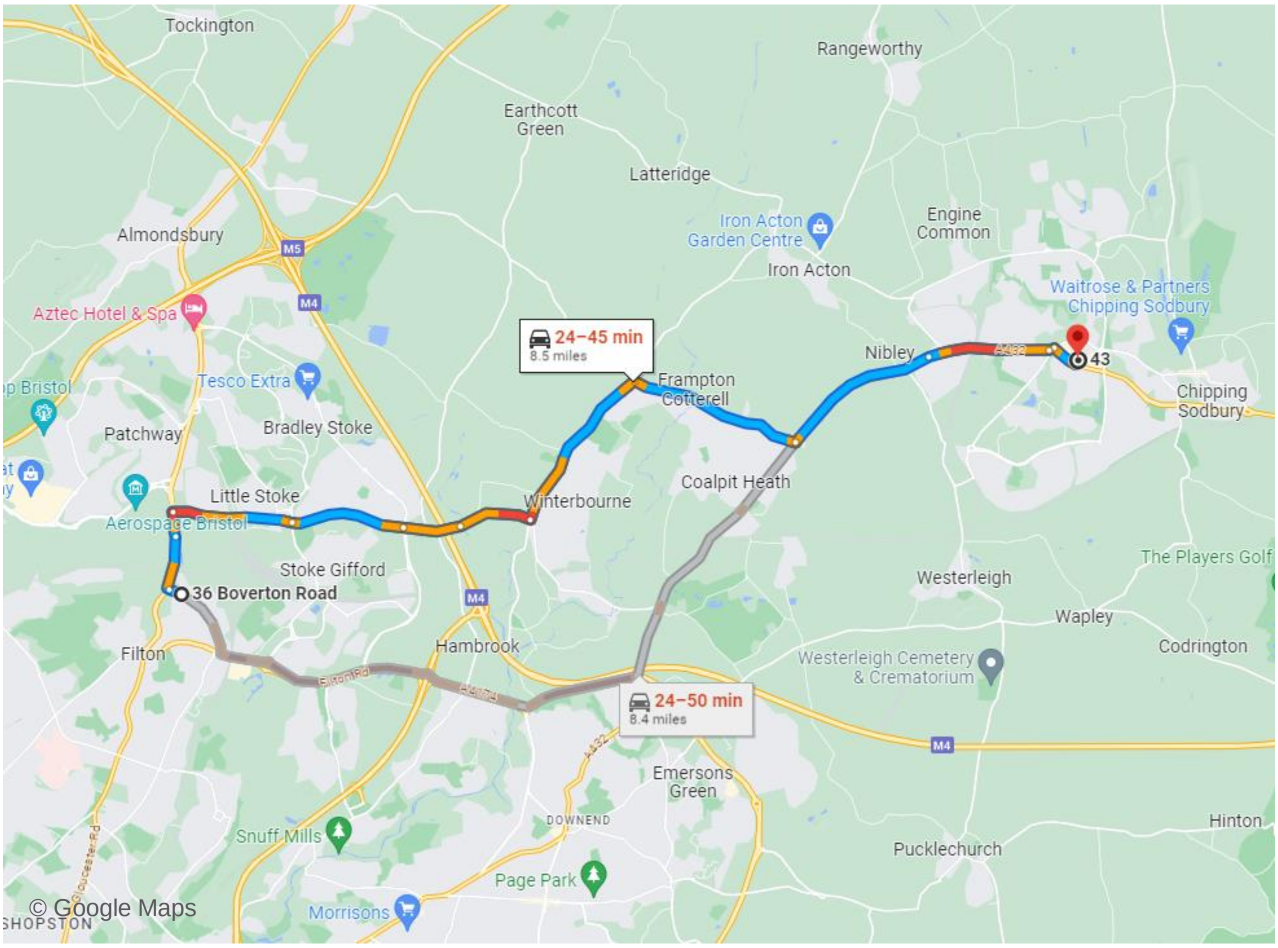
E.14. Thornbury to Bradley Stoke PM Peak



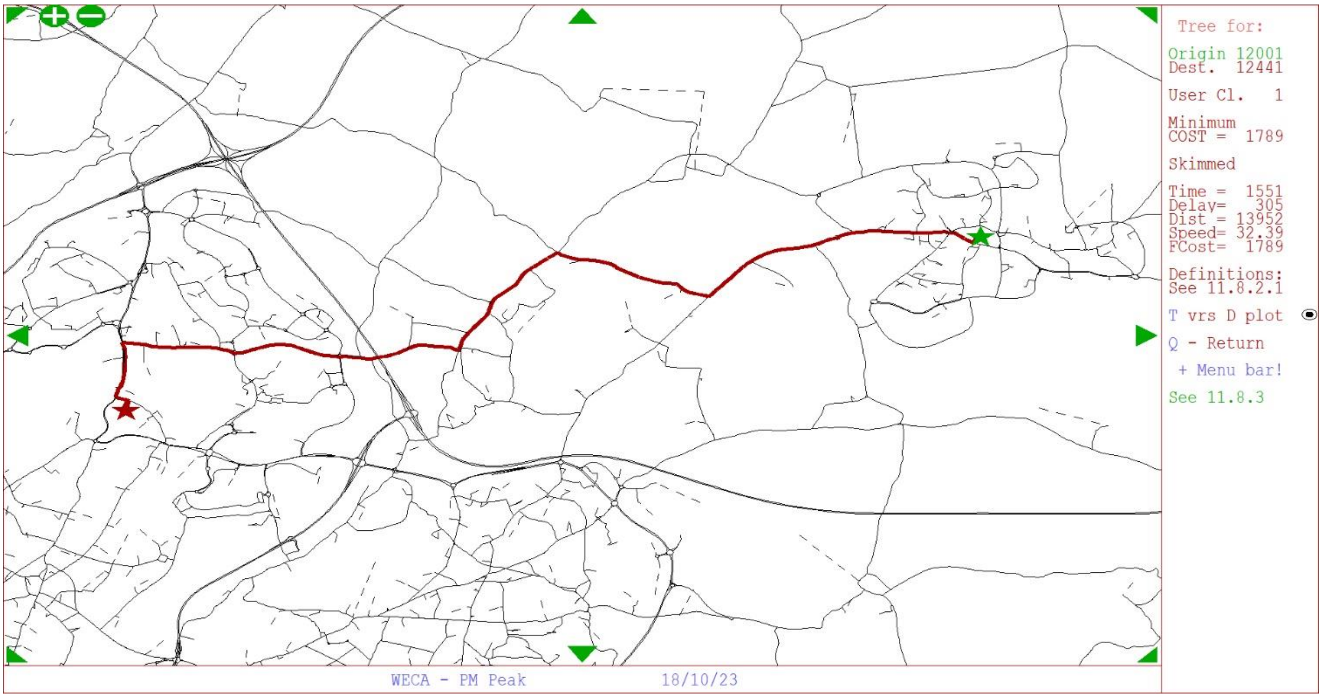


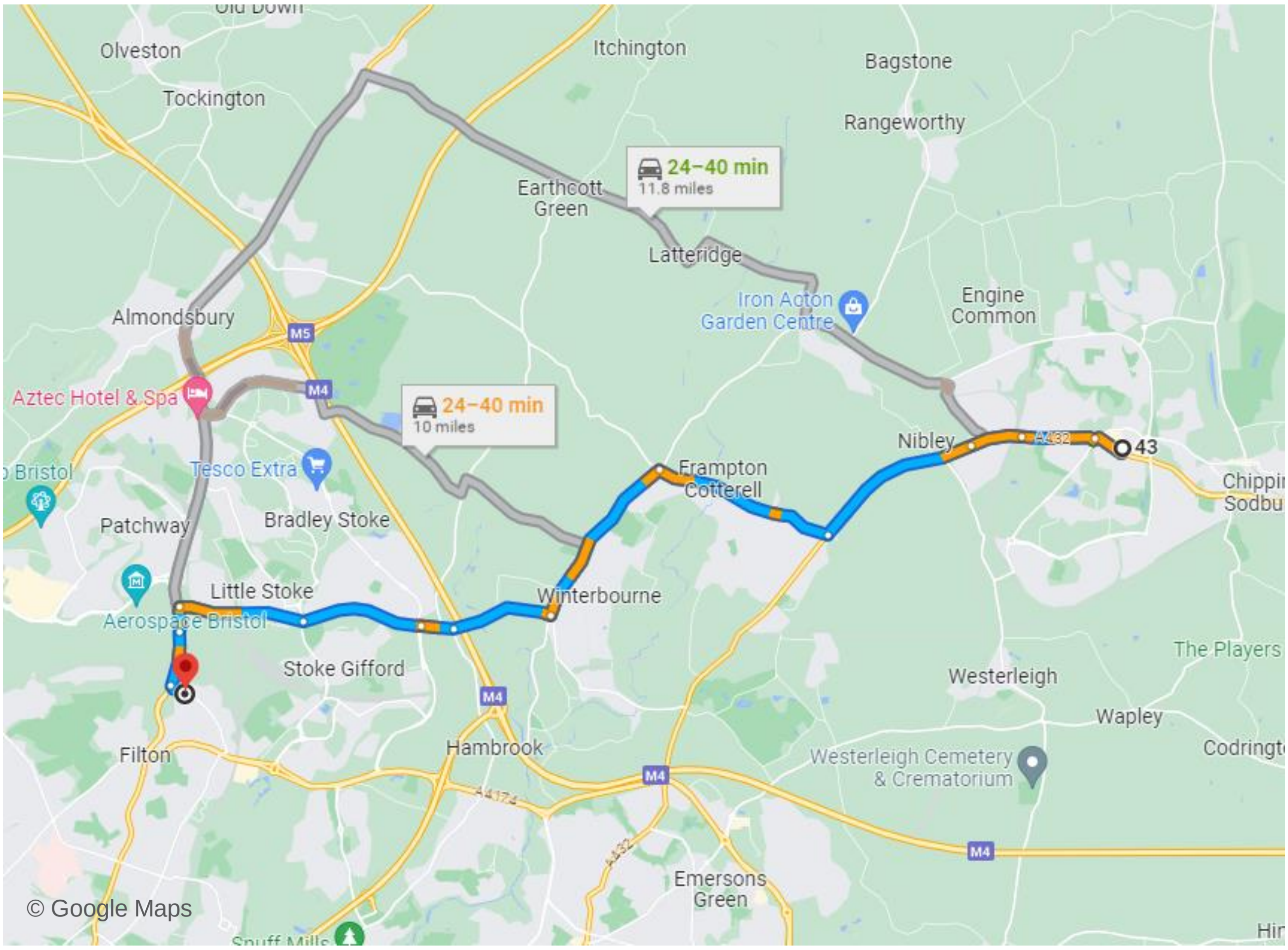
E.15. Filton to Yate PM Peak



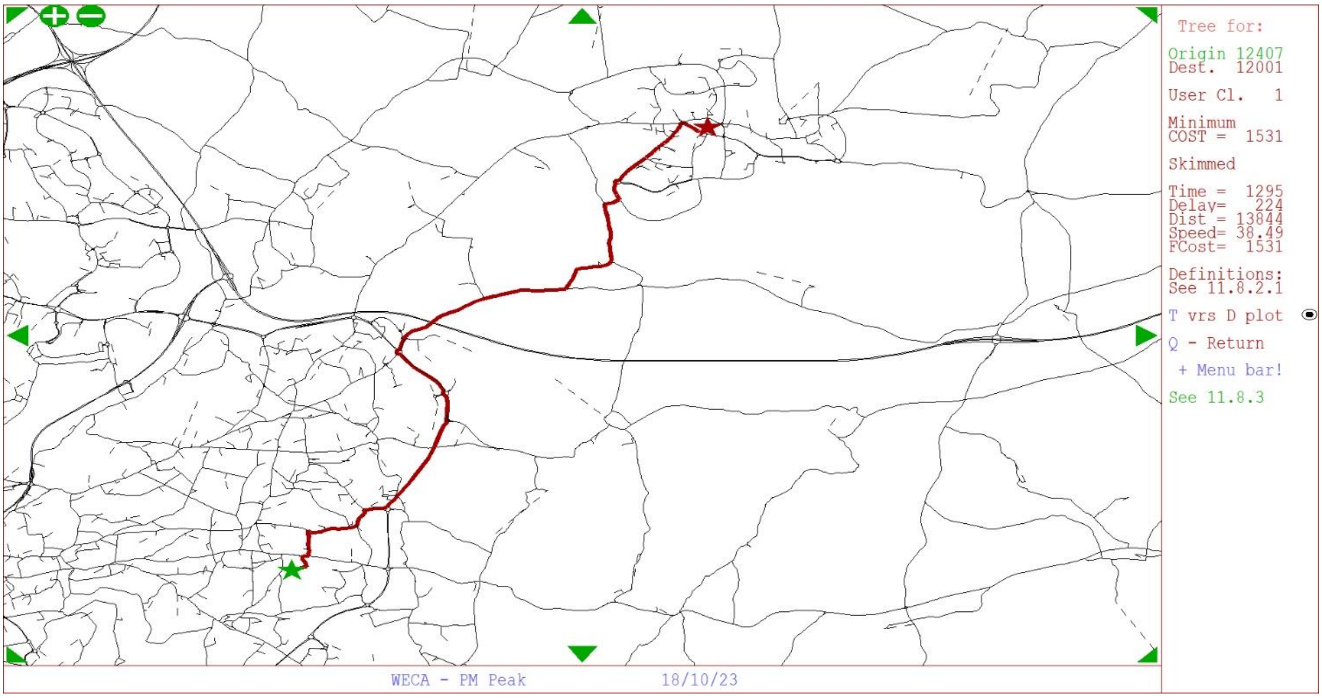


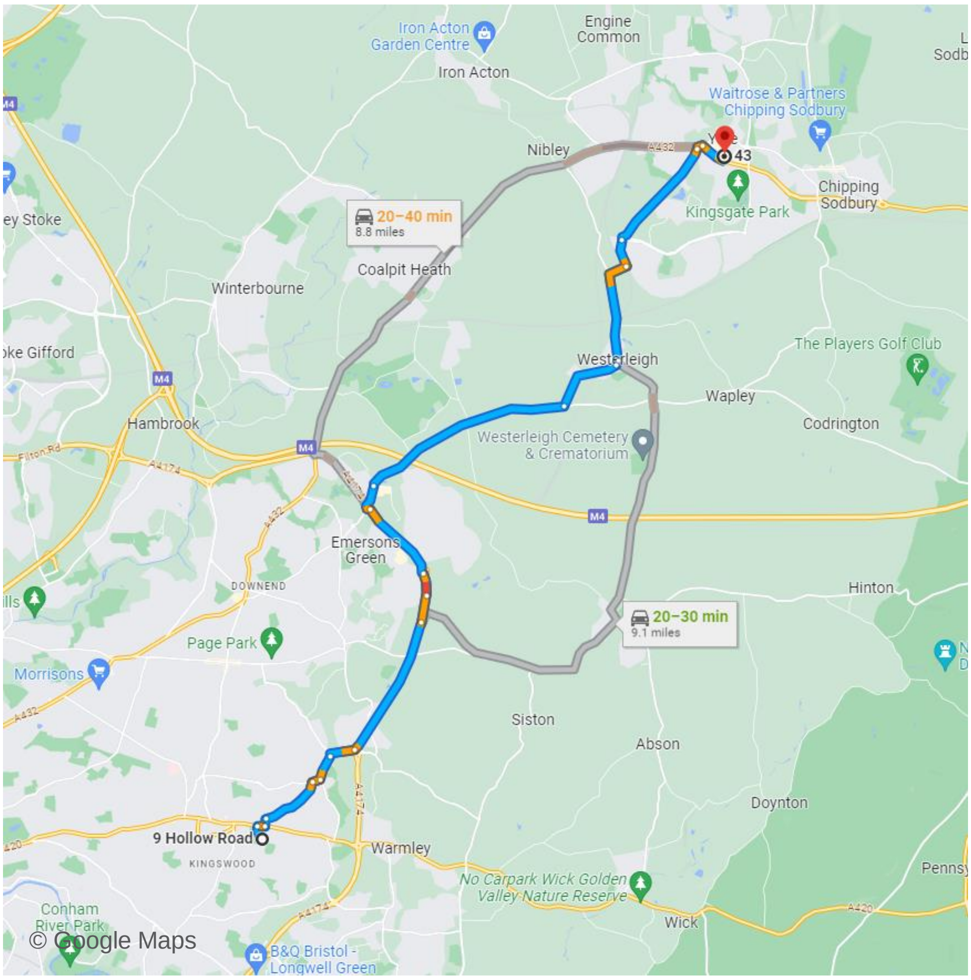
E.16. Yate to Filton PM Peak



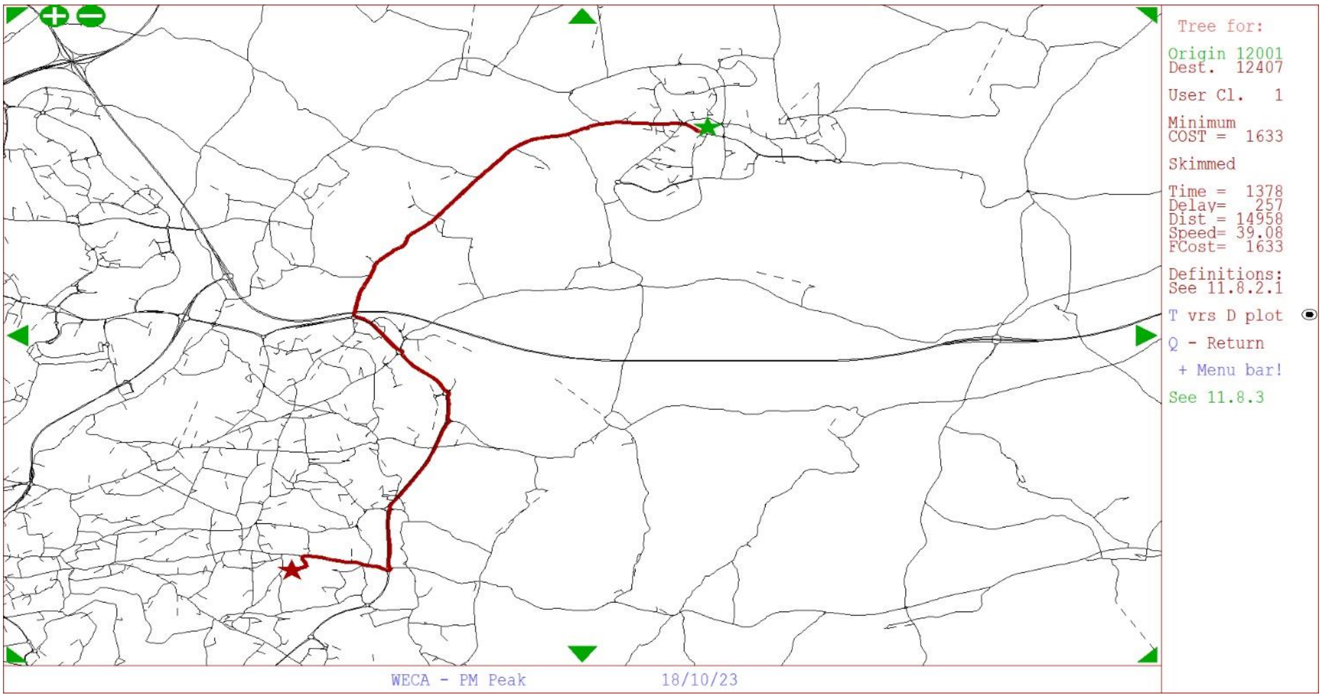


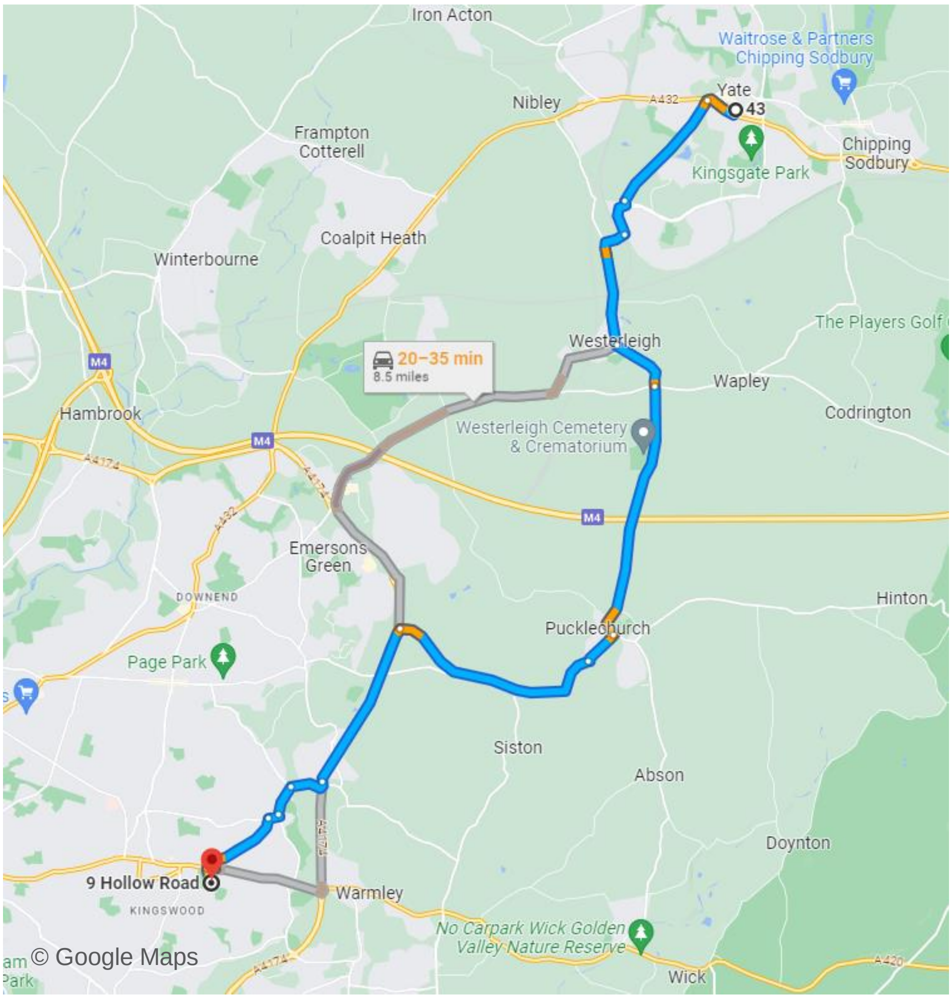
E.17. Kingswood to Yate PM peak



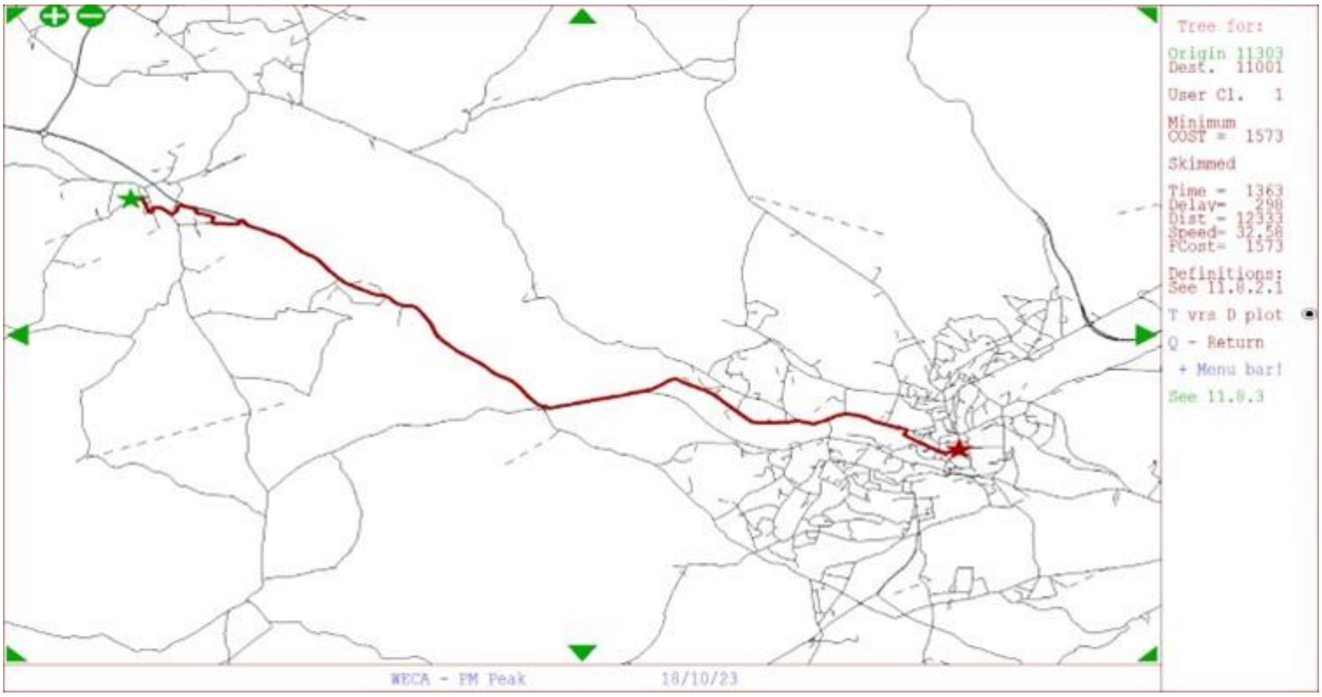


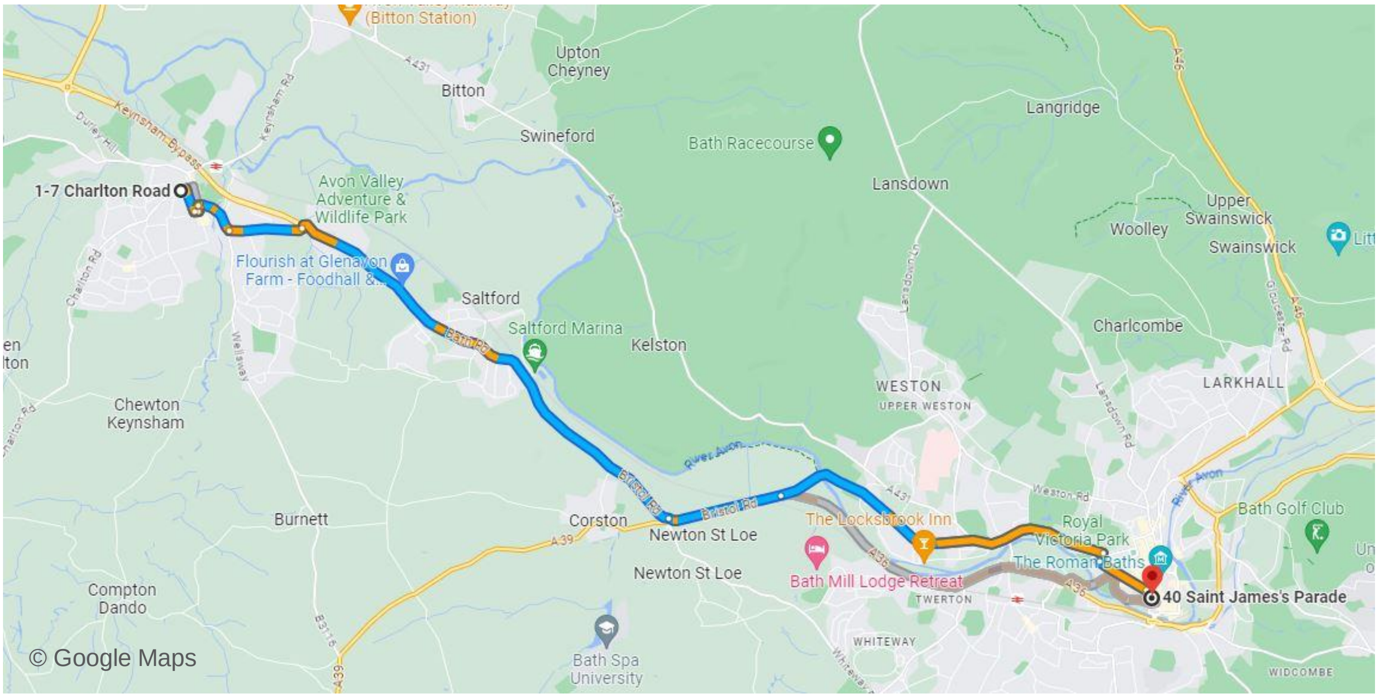
E.18. Yate to Kingswood PM Peak



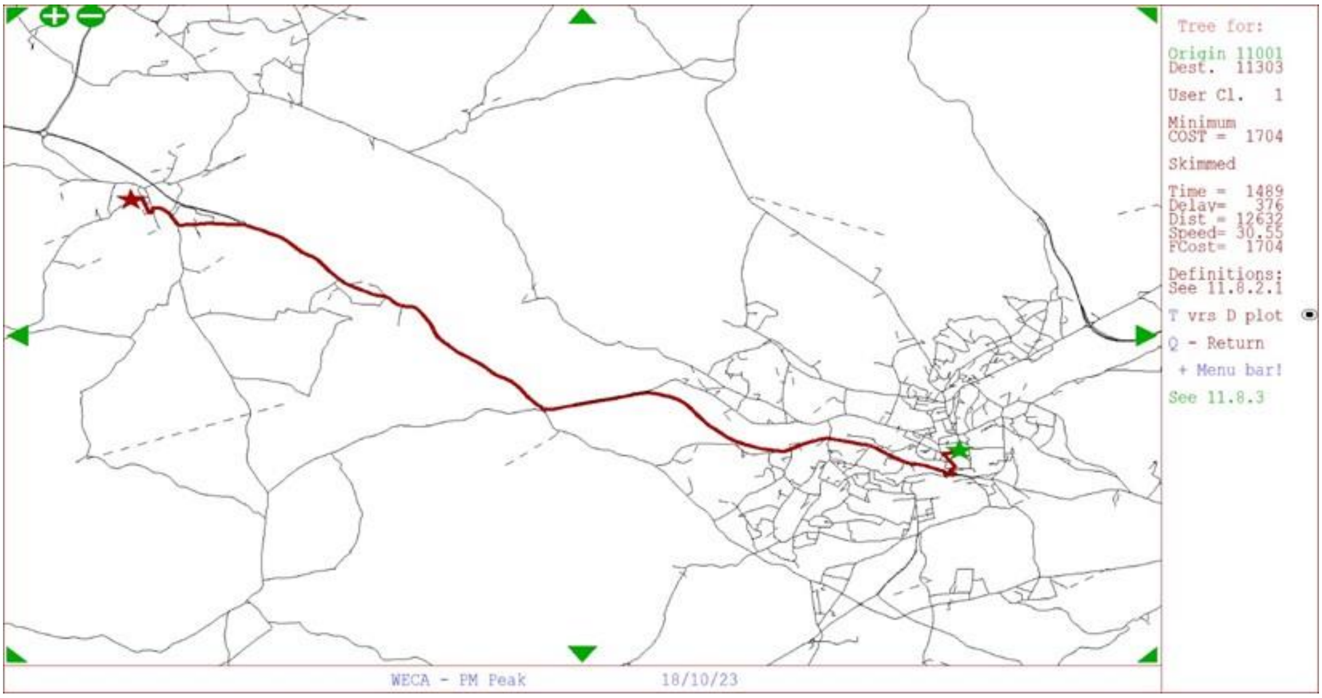


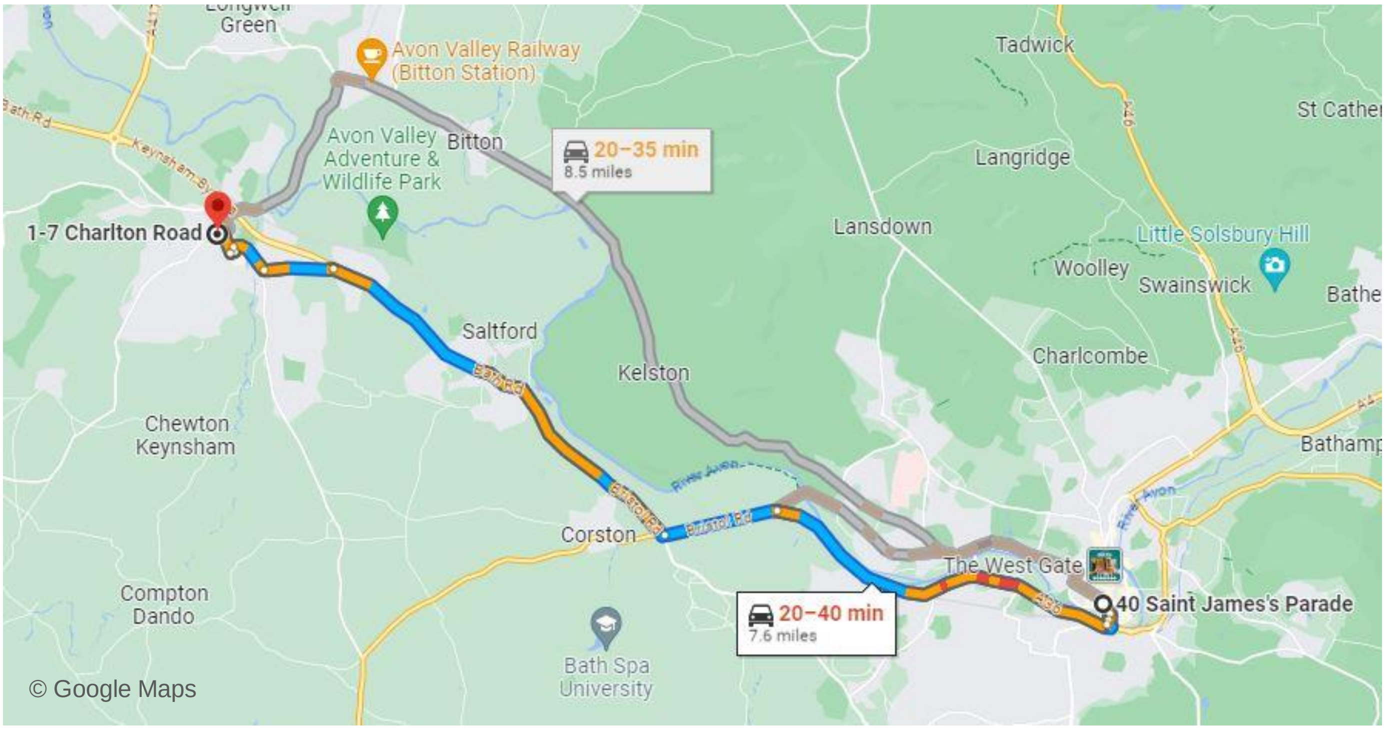
E.19. Keynsham to Bath City Centre PM Peak





E.20. Bath City Centre to Keynsham PM Peak





Appendix F. Sensitivity Analysis on 2022 SGC Counts

Count data collated from SGC is for the year 2022 and is used as is in the model development without converting to model base year 2019. TemPro suggests a 2% growth between 2019 and 2022 in SGC however this may not be the case in reality. Therefore, a sensitivity analysis was conducted on SGC counts by applying an adjustment (both increase and decrease) of 2%, 5% and 7.5% on observed flow data and model performance was recorded in each case. Tables F.1 to F.3 below presents the link calibration summary for cars and all vehicles with 2%, 5% and 7.5% adjustment in SGC counts respectively.

- as expected higher changes are observed with 7.5% increase, highest being a decrease by 5% in link calibration for all vehicles in AM peak falling from 83% to 78%,
- a decrease by 4% in link calibration for all vehicles in PM peak falling from 82% to 78% with 7.5% increase in counts
- though there are 3% reduction in link calibration with 5% change in counts, the actual link calibration is above 80%
- with 2% change in counts the impact on link calibration is very minimal

This shows that the counts used in SGC for 2022 do not have material impact on the model performance.

F.1. Sensitivity Analysis with 2% adjustment in SGC counts

Criteria	Vehicle Class	2022 counts			2% decrease			2% increase		
		AM	IP	PM	AM	IP	PM	AM	IP	PM
TAG	Cars	83%	89%	84%	85%	89%	83%	83%	88%	84%
	All Vehicles	83%	85%	82%	84%	88%	82%	82%	84%	82%
Relaxed	Cars	92%	93%	89%	93%	93%	90%	92%	93%	89%
	All Vehicles	91%	92%	87%	91%	92%	88%	91%	92%	87%

F.2. Sensitivity Analysis with 5% adjustment in SGC counts

Criteria	Vehicle Class	2022 counts			5% decrease			5% increase		
		AM	IP	PM	AM	IP	PM	AM	IP	PM
TAG	Cars	83%	89%	84%	85%	90%	82%	83%	88%	83%
	All Vehicles	83%	85%	82%	84%	89%	82%	80%	82%	80%
Relaxed	Cars	92%	93%	89%	93%	93%	90%	91%	92%	88%
	All Vehicles	91%	92%	87%	91%	93%	89%	89%	91%	85%

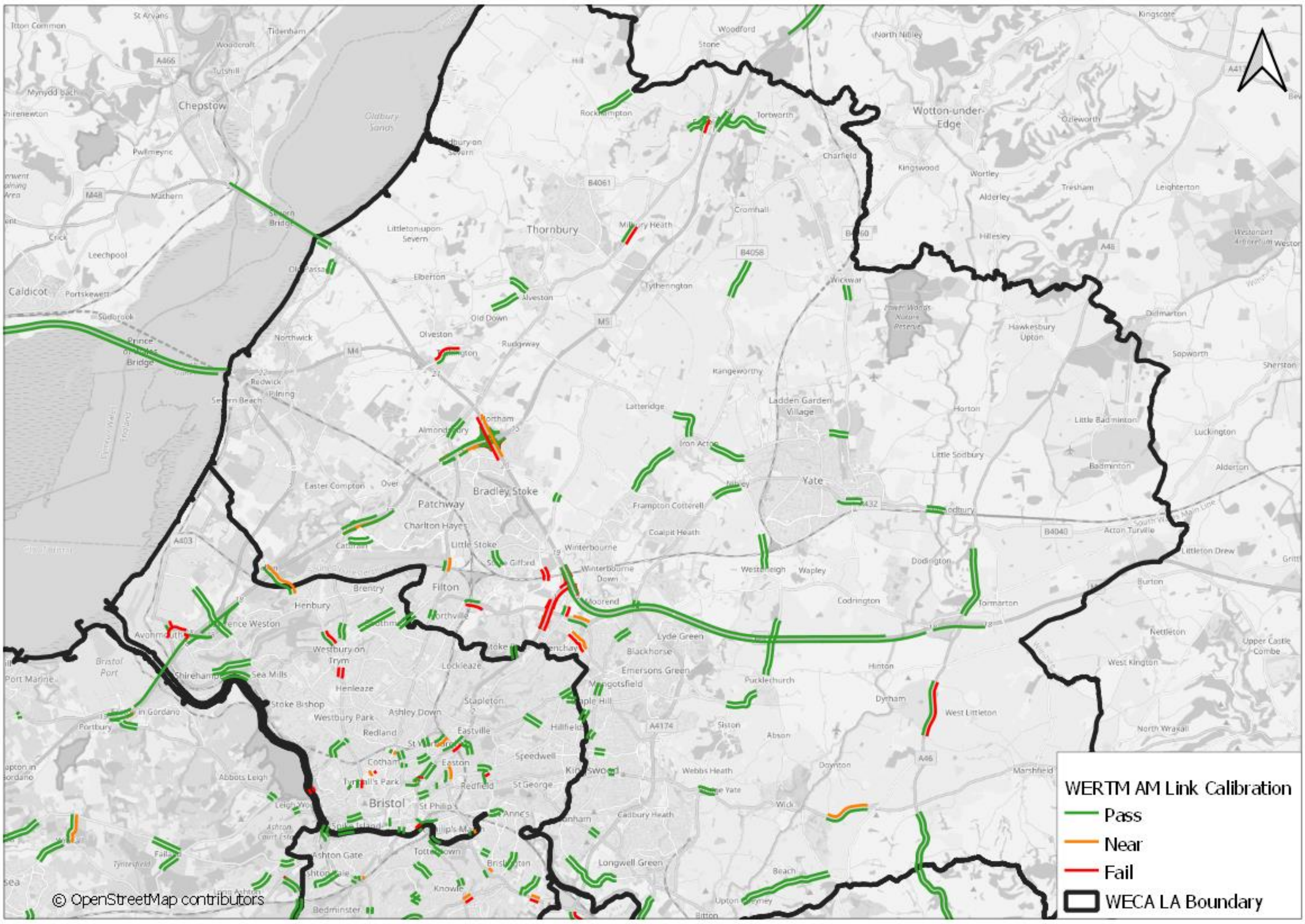
F.3. Sensitivity Analysis with 7.5% adjustment in SGC counts

Criteria	Vehicle Class	2022 counts			7.5% decrease			7.5% increase		
		AM	IP	PM	AM	IP	PM	AM	IP	PM
TAG	Cars	83%	89%	84%	84%	89%	83%	82%	88%	81%

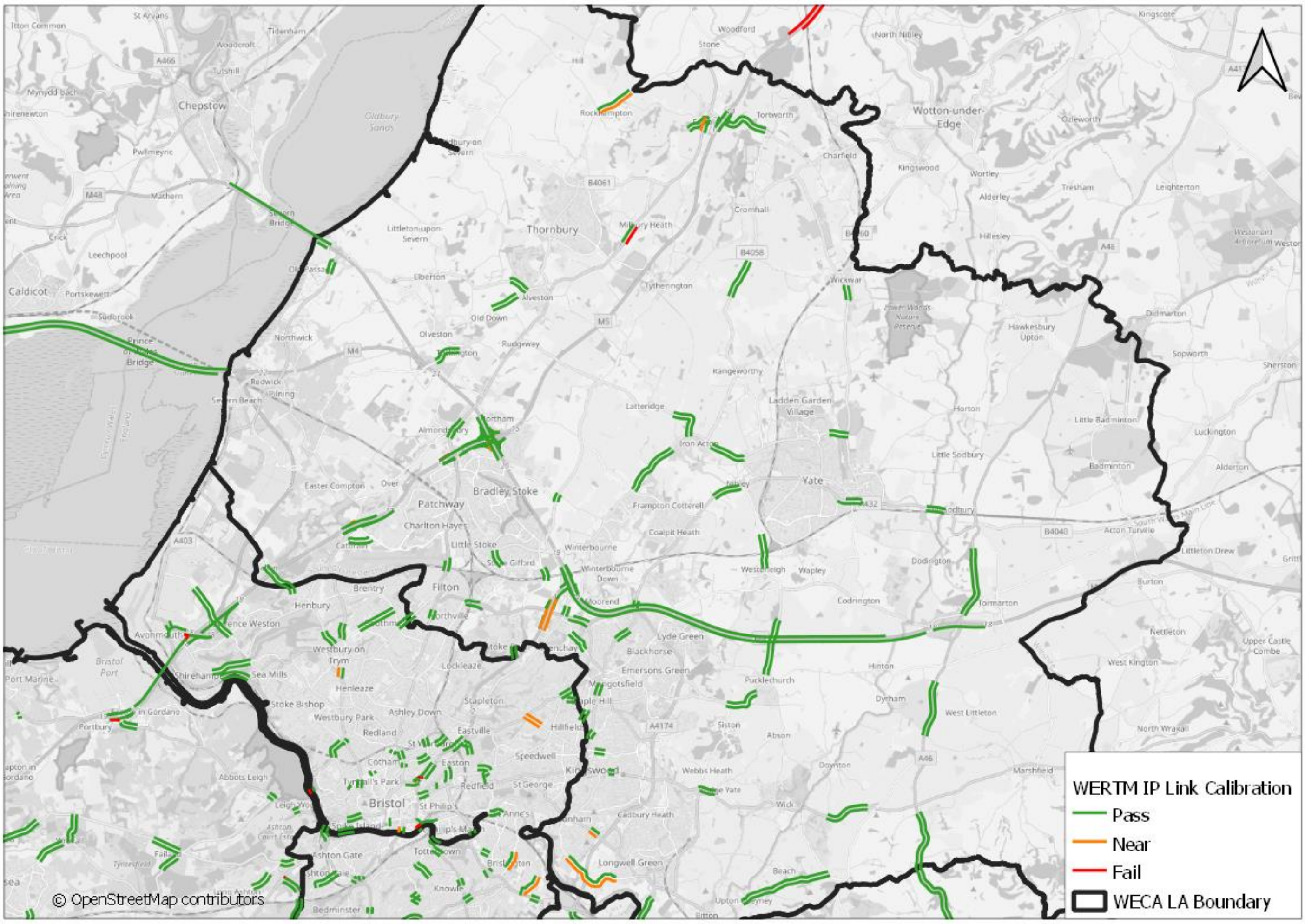
Criteria	Vehicle Class	2022 counts			7.5% decrease			7.5% increase		
		AM	IP	PM	AM	IP	PM	AM	IP	PM
	All Vehicles	83%	85%	82%	84%	89%	81%	78%	82%	78%
Relaxed	Cars	92%	93%	89%	93%	94%	91%	91%	92%	87%
	All Vehicles	91%	92%	87%	92%	93%	90%	88%	90%	85%

Appendix G. WERTM Calibration Plots

G.1. AM Link Calibration



G.2. IP Link Calibration



G.3. PM Link Calibration