South Bristol Link
HAM Validation Report

April 2013

Plan Design Enable

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Table of contents

Tables

Figures

1. Introduction

1.1. Background

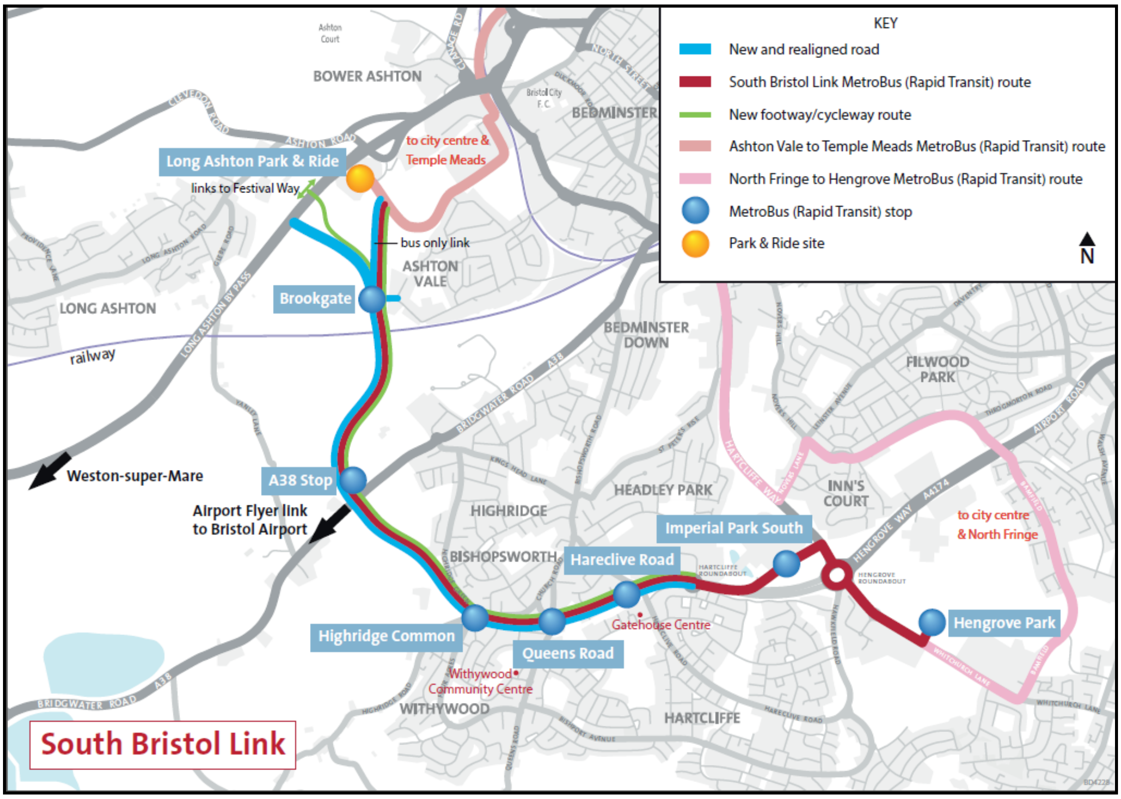
The West of England Partnership Organisation (WEPO) local authorities: Bath and North East Somerset (B&NES), Bristol City (BCC), North Somerset Council (NSC) and South Gloucestershire Council (SGC) are delivering the South Bristol Link (SBL), a major transport scheme to address current and future transport problems in the south Bristol area. Atkins was appointed in April 2010 to undertake Lot 1 – Environmental Impact, of the South Bristol Link package, promoted by North Somerset Council.

1.2. The Scheme

The proposed development comprises the construction of a section of highway 4.45 kilometres in length from the A370 Long Ashton bypass within North Somerset to the Hartcliffe (Cater Road) Roundabout within the Bishopsworth area of South Bristol. This incorporates the minor realignment of sections of existing highway at Highridge Green, King George's Road and Whitchurch Lane. The entire route is to be classed as an Urban All-Purpose Road (UAP) in accordance with TA 79/99.

The route includes the construction of new junctions with the A370, Brookgate Road, A38, Highridge Road, Queens Road and Hareclive Road. New bridges will be constructed to cross Ashton Brook, Colliter's Brook and to pass under the Bristol to Taunton Railway Line. The route corridor will incorporate a bus-only link to connect with the Ashton Vale to Temple Meads (AVTM) spur into the Long Ashton Park and Ride site, and dedicated bus lanes between the railway and the new A38 roundabout junction. New bus stops and shelters, and a continuous shared cycleway and footway will be provided along the route corridor. Associated proposals include drainage facilities, landscaping and planting.

Figure 1. SBL Scheme



The route will form part of the West of England rapid transit network (Metro Bus) and will be used by buses and other motorised vehicles. The route will link with the AVTM at the Long Ashton Park and Ride site, and within the South Bristol section, once buses have reached the Hartcliffe Roundabout, services will follow existing roads via Hengrove Way to Imperial Park and onwards to Whitchurch Lane and Hengrove Park.

A suite of models termed the Greater Bristol Modelling Framework (GBMF) covers the WoE's main urban areas. These Variable Demand Models follow the latest DfT guidance, and have been used for the assessment of a range of potential transport interventions in the sub-region. The SBL model is the component of the GBMF that focuses on the main urban area of South Bristol.

The SBL modelling system was developed to represent travel conditions in 2012 and consisted of three key elements:

- a Highway Assignment Model (HAM) representing vehicle-based movements across the Greater Bristol Area for a 2012 spring weekday morning peak hour (08:00 – 09:00), an average inter-peak hour (10:00 – 16:00) and an evening peak hour (17:00 – 18:00);
- a Public Transport Assignment Model (PTAM) representing bus and rail-based movements across the same area and time periods; and
- a five-stage multi-modal Variable Demand Model that forecasts changes in trip frequency and choice of main mode, time period of travel, and destination, and sub-mode choice, in response to changes in generalised costs across the 24-hour period (07:00 – 07:00).

This report describes the development of the SBL Highway Assignment Model and its validation.

1.3. Scope of Report

This Model Development Report consists of eleven sections. Following this introductory section:

- Section two outlines the uses of the Highway Assignment Model;
- Section three outlines the model standards;
- Section four the key features of the model;
- Section five describes the data collected and collated for the calibration and validation;
- Section six summarises the development of the highway network;
- Section seven describes the development of the trip matrix;
- Section eight provides the network and route calibration and validation;
- Section nine describes the trip matrix calibration and validation;
- Section ten summarises the calibration and validation of the assignment;
- Section eleven summarises the development of the model and discusses its fitness for purpose.

Supplementary information is provided in five Appendices:

- Appendix A details the matrix development;
- Appendix B demonstrates the accuracy of the partial matrices;
- Appendix C shows the route choice validation;
- Appendix D provides the matrix estimation changes; and
- Appendix E summarises the journey time validation.

2. Proposed Uses of the Model and Key Model Design Considerations

2.1. Background and Nomenclature

In 2006 Atkins was commissioned by the West of England Partnership Organisation (Bristol City Council, North Somerset Council and South Gloucestershire Council) to update the Greater Bristol modelling framework. This produced the following, fully integrated modelling system, with a 2006 base year:

- GBATS3 Demand Model (GBATS3 2006 DM)

- GBATS3 Highway Assignment Model (GBATS3 2006 HAM)
- GBATS3 Public Transport Assignment Model (GBATS3 2006 PTAM)

The SBL Major Scheme submission in 2010 involved updates to these models, notably changing the base year to 2009 and enhancing the detail in south Bristol resulting in an increase in the number of zones in the HAM to 650 whilst the DM and PTAM retained the GBATS3 600 zone structure (further details of this are presented below). The model nomenclature reflects these changes as follows:

- GBATS3 Demand Model (GBATS3 2009 DM)
- GBATS3 SBL Highway Assignment Model (GBATS3 SBL 2009 HAM)
- GBATS3 Public Transport Assignment Model (GBATS3 2009 PTAM)

The SBL BAFB submission in 2011 involved further updates to the HAM only and the model nomenclature became:

- GBATS3 Demand Model (GBATS3 2009 DM)
- GBATS3 SBL Highway Assignment Model (GBATS3 SBL 2009 v2 HAM)
- GBATS3 Public Transport Assignment Model (GBATS3 2009 PTAM)

To support the SBL Planning Application there have been further updates to the modelling structure to ensure that the impact of the country’s economic position on traffic flows are realistically modelled and that the model follows the latest advice on best practice model development. The model nomenclature followed in this report is:

- GBATS3 Demand Model (GBATS3 2012 DM)
- GBATS3 SBL Highway Assignment Model (GBATS3 SBL 2012 HAM)
- GBATS3 Public Transport Assignment Model (GBATS3 2012 PTAM)

2.2. Proposed Uses of the Model

The SBL 2012 model will be used to access the South Bristol Link scheme. There would be a core scenario proposed for testing (provided 07/12/12) using 2016 and 2031 forecast years, and a sensitivity test using alternative frequencies for the Rapid Transit.

2.3. Key Model Design Considerations

The principal objective of the SBL HAM was to represent appropriately travel conditions on the highway network for the appraisal of the SBL scheme. The HAM should provide:

- changes in the travel cost between the base year and forecast years for input to the SBL Demand Model;
- changes in traffic flows in the SBL corridor for input to the environmental appraisal; and
- changes in travel costs for input to the economic appraisal.

3. Model Standards

3.1. Validation Criteria and Acceptability Guidelines

Validation and convergence standards for highway assignment models are specified in TAG Unit 3.19. In general, the advice in TAG Unit 3.19 applies to models created for both general and specific purposes; however, in the case of models created for the assessment of specific interventions such as SBL, ‘*it will be natural to pay greater attention to validation quality in the vicinity of the interventions*’.

The unit states that it is important that the fidelity of the underlying trip matrices is not compromised in order to meet the validation standards.

3.1.1. Trip Matrix Validation

For trip matrix validation, the measure which should be used is the percentage difference between modelled flows and counts. Comparisons at screenline level provide information on the quality of the trip matrices. TAG Unit 3.19 describes the validation criterion and acceptability guideline as shown in Table 1.

Table 1. Screenline Flow Validation Criterion and Acceptability Guideline

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

Source: TAG Unit 3.19 Table 1

With regard to screenline validation, the following should be noted:

- 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) roadside interview screenlines; (b) the other screenlines used as constraints in matrix estimation (excluding the roadside interview screenlines even though they have been used as constraints in matrix estimation); and (c) screenlines used for independent validation;
- 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.

For this model the comparisons for screenlines containing motorways was not applicable and any comparisons were made separately for the three types of screenlines and by cars, light goods vehicles and other goods vehicles for each of the three modelled time periods. The shortest screenline consisted of five links and the longest non-roadside interview screenline consisted of ten links. The RSI screenlines consisted of a greater number of links.

3.1.2. Link Flow and Turning Movement Validation

The two measures which should be used for the individual link (and turning movement) validation are flow and GEH. The flow measure is based on the relative flow difference between modelled flows and observed counts , with three different criteria set depending on the observed flows. The GEH measure uses the GEH statistic as defined below:

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

where GEH is the GEH statistic
M is the modelled flow, and
C is the observed flow

TAG Unit 3.19 describes the Link Flow and Turning Movements Validation Criteria and Acceptability Guidelines as shown in Table 2.

Table 2. Link Flow and Turning Movements Validation Criteria and Acceptability Guidelines

Criteria and Measures	Acceptability Guideline

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

Source: TAG Unit 3.19 Table 2

With regard to flow validation, the following should be noted:

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

No turning movements were counted for this model. The accuracy of the counts is not sufficient to enable flow and GEH criteria to be examined separately for light and other goods vehicles. All criteria and measures for car and total vehicles for all three time periods separately will be reported later in this report.

3.1.3. Journey Time Validation Criterion and Acceptability Guidelines

For journey time validation, the measure which should be used is the percentage difference between modelled and observed journey times, subject to an absolute maximum difference. TAG Unit 3.19 describes the Journey Time Validation Criterion and Acceptability Guideline as shown in Table 3.

Table 3. Journey Time Validation Criterion and Acceptability Guideline

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

Source: TAG Unit 3.19 Table 3

With regard to the journey time validation, the comparisons should be presented separately for each modelled period.

There was no disaggregation of journey time data to enable validation by vehicle type and a single speed/flow relationship was applied to all vehicle types so the validation will be performed for total vehicles only.

3.1.4. Matrix Comparisons

The screenline (or cordon) comparison between modelled flows and counts is used to demonstrate the quality of the trip matrices by checking the overall volumes of trips across the modelled area. The changes introduced by the application of matrix estimation should be understood and may be assessed using TAG Unit 3.19 Table 5, below.

Table 4. Significance of Matrix Estimation Changes

Measure	Significance Criteria
Matrix zonal cell levels	Slope within 0.98<Slope<1.02 Intercept near zero R^2 in excess of 0.95

Matrix zonal trip ends	Slope within 0.99<Slope<1.01 Intercept near zero R^2 in excess of 0.98
Trip length distributions	Means within 5% Standard deviations within 5%
Sector to sector level matrices	Differences within 5%

Source: TAG Unit 3.19 Table 5

The unit states that it is important that the fidelity of the underlying trip matrices is not compromised in order to meet the validation standards. All exceedances of these criteria should be examined and assessed for their importance for the accuracy of the matrices in the Fully Modelled Area.

The comparisons should be presented by vehicle type (preferably cars, light goods vehicles and other goods vehicles). The comparisons should also be presented separately for each modelled period or hour.

3.2. Convergence Criteria and Standards

The advice on model convergence was set out in TAG Unit 3.19 Table 4 and is reproduced below. A more stringent set of standards were adopted for the HAM with a target of 99% of links satisfying the convergence measure rather than suggested 98% of links.

Table 5. Summary of Convergence Criteria

Convergence Measures	Type	Base Model Acceptable Values
Delta & %GAP	Proximity	Less than 0.1% or at least stable with convergence fully documented and all other criteria met
Percentage of links with flow change[2] (P1) < 1%	Stability	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 3.19 Table 5

3.3. Interpretation of the Guidelines

TAG Unit 3.19 states that the achievement of the validation acceptability guidelines specified in Table 1, Table 2 and Table 3 (of TAG Unit 3.19) does not guarantee that a model is ‘fit for purpose’ and likewise a failure to meet the specified validation standards does not mean that a model is not ‘fit for purpose’. Furthermore, in some models, particularly models of large congested areas, it may be difficult to achieve the link flow and journey time validation acceptability guidelines set out in Table 2 and Table 3 (of TAG Unit 3.19) without matrix estimation bringing about changes greater than the limits shown in Table 5 (of TAG Unit 3.19). In these cases, the limits set out in Table 5 (of TAG Unit 3.19) 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. In other words, matrix estimation should not be allowed to make significant changes to the prior matrices in order that the validation standards are met.

4. Key Features of the Model

4.1. Base Year

The SBL modelling system has a 2012 base year and represents the travel conditions for a typical March weekday.

4.2. Modelled Area

TAG Unit 3.19 states that the geographic coverage of highway assignment models generally needs to: allow for the strategic re-routeing impacts of interventions; ensure that areas outside the main area of interest, which are potential alternative destinations, are properly represented; and ensure that the full lengths of trips are represented for the purpose of deriving costs. The modelled area therefore needs to large enough to include these elements, but within the modelled area the level of detail should vary as follows:

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

In the SBL model the Area of Detailed Modelling (ADM) is South Bristol and can be seen in Figure 2, more specifically it is the area that is bounded by the:

- River Avon to the north;
- A37 to the east;
- A369 to the west; and
- B3130 to the south.

The Fully Modelled Area (FMA) covers the urban area commonly referred to as Greater Bristol and shown in Figure 3.

The External Area covers the rest of Great Britain in a skeletal form and the relationship between the ADM, FMA and External Area is shown in Figure 4.

Figure 2. SBL Area of Detailed Modelling

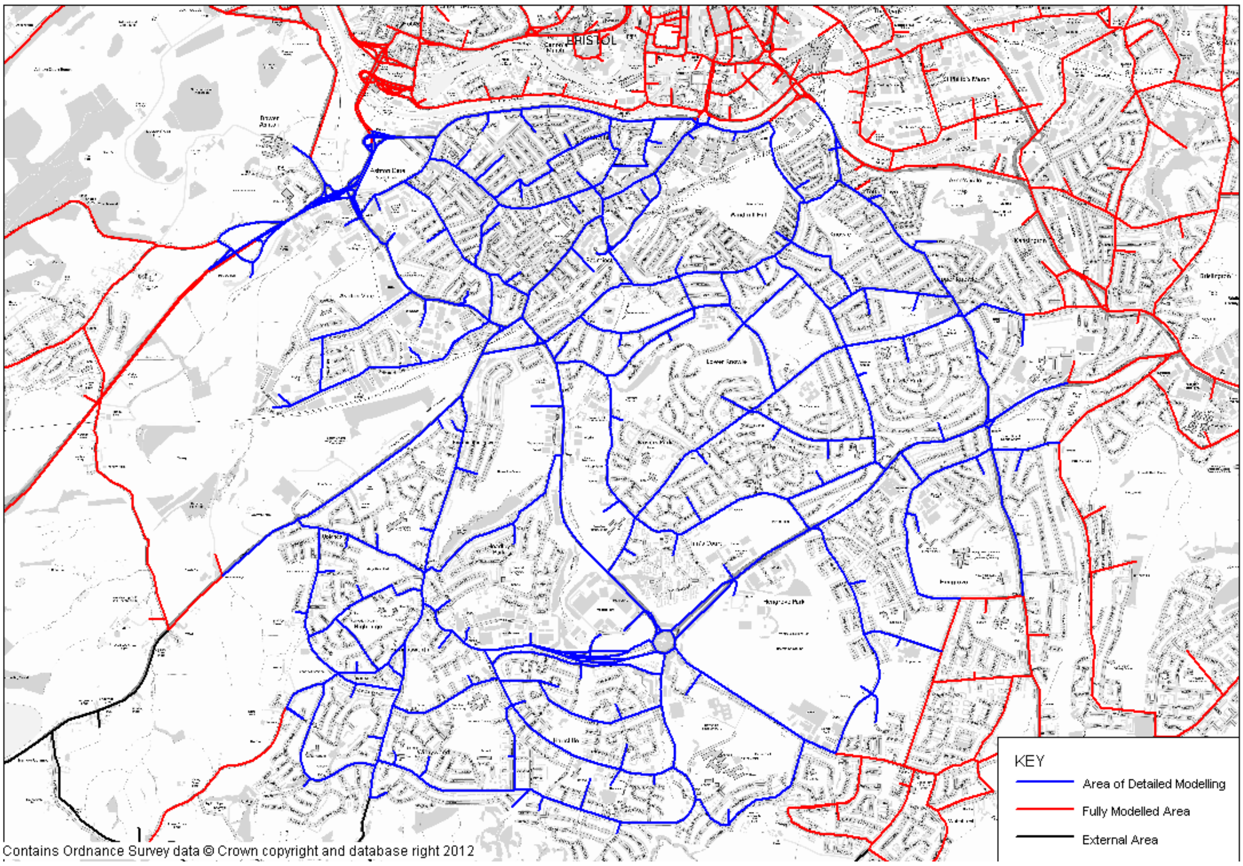


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Figure 3. SBL Fully Modelled Area

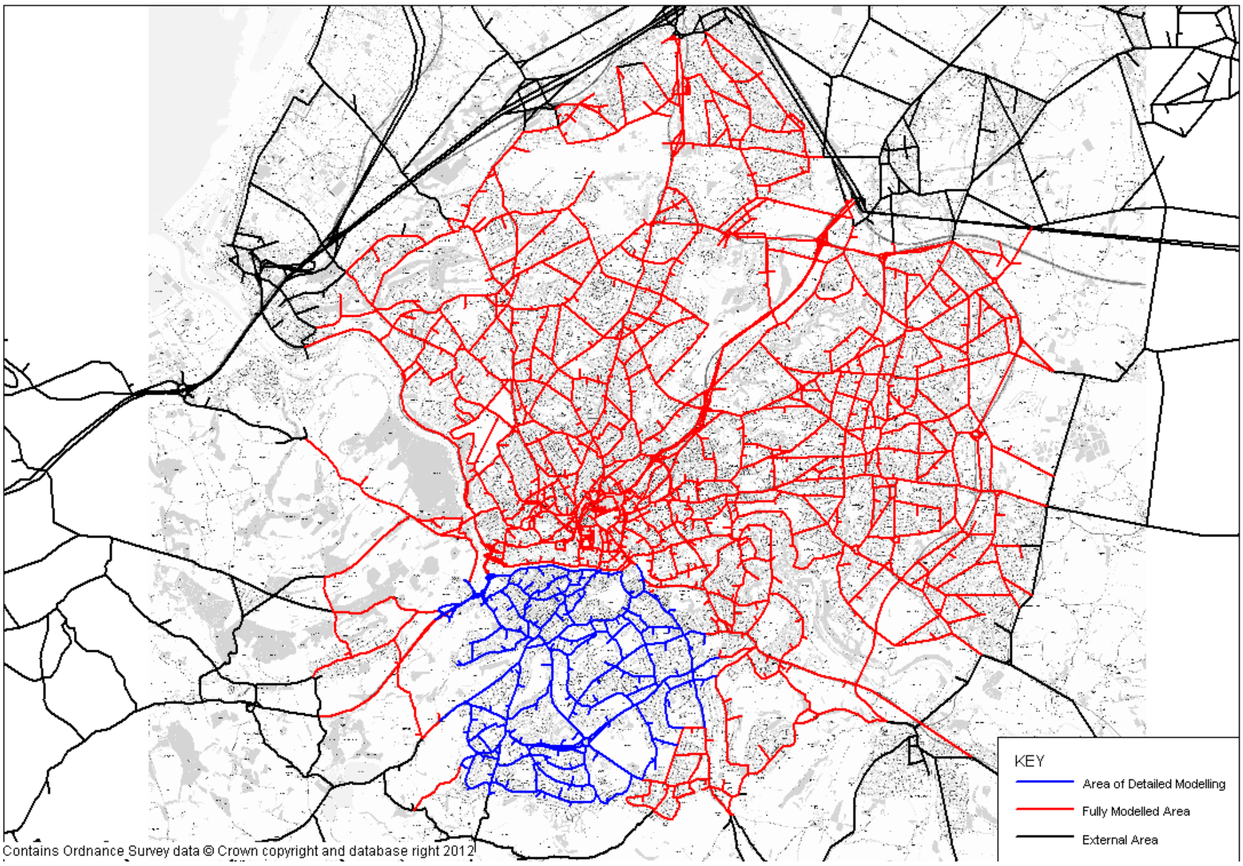

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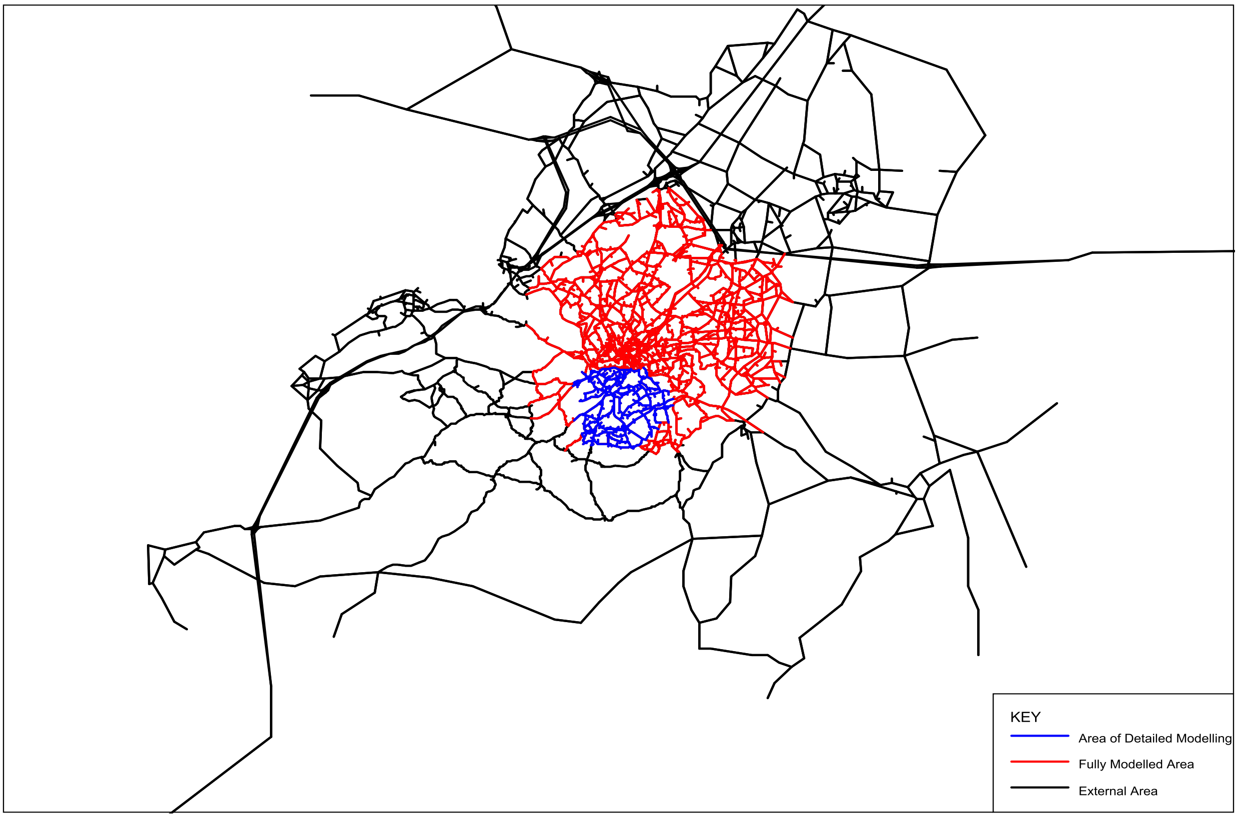
Figure 4. SBL External Area



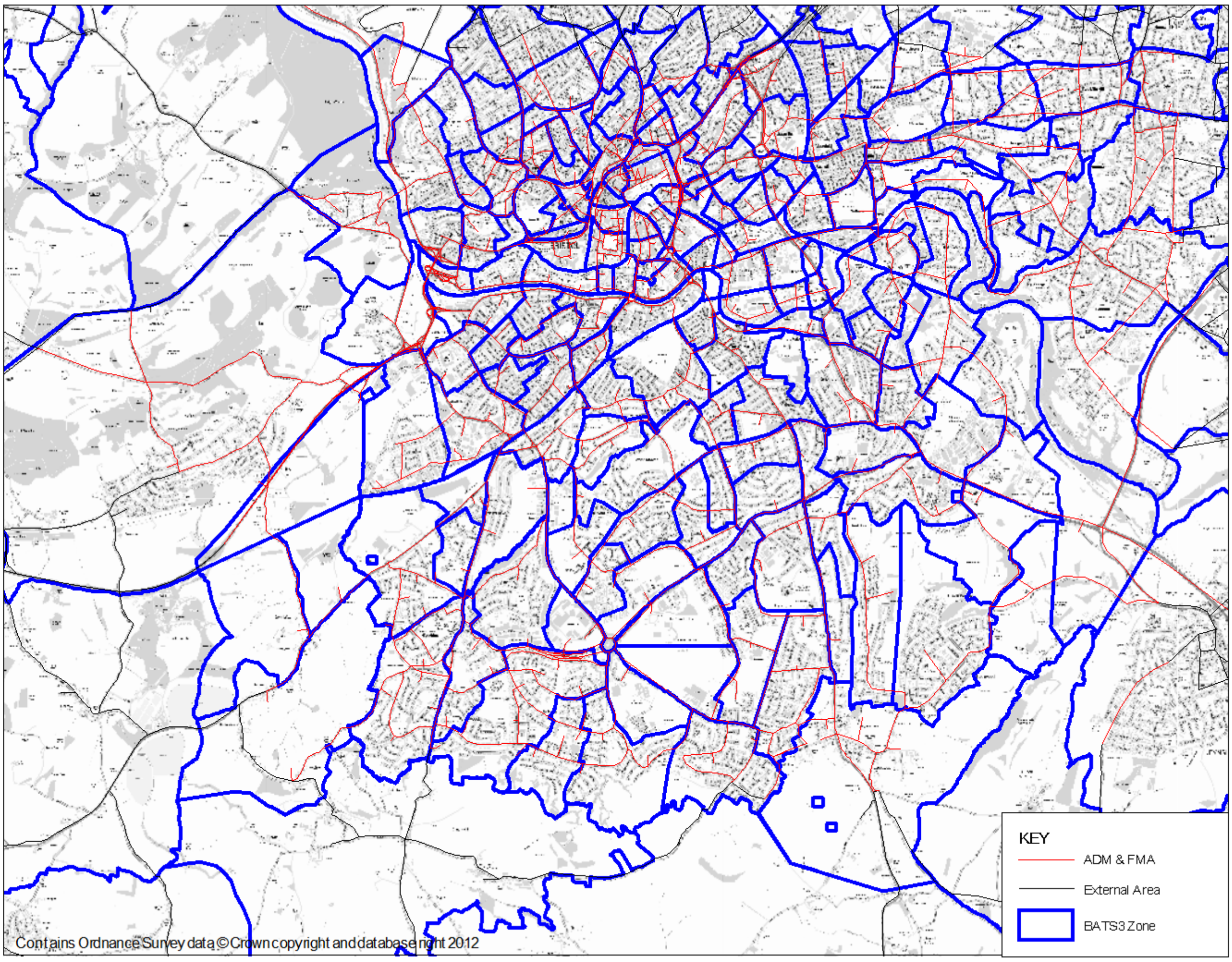
4.3. Zoning System

As described above, the GBATS3 SBL 2012 HAM is part of an integrated modelling suite, which links the GBATS3 Demand Model to both the highway assignment and public transport assignment models. The modelling suite operates two zoning systems: one for the GBATS3 Demand Model and GBATS3 Public Transport Assignment Model and another for the SBL Highway Assignment Model. Both are described below.

4.3.1. G-BATS3 Zoning System

The G-BATS3 modelling suite zoning system comprises 600 zones covering the whole of Great Britain. A detailed zoning system was developed to represent the Greater Bristol Urban area and its surroundings. This zone system is used within the public transport assignment model and the demand model and is shown in Figure 5.

Figure 5. G-BATS3 Modelling Suite Zone System



4.3.2. SBL Zoning System

The SBL HAM zoning system is based on the G-BATS3 modelling suite zoning system, but has been enhanced in the ADM to take account of the SBL scheme alignment. This has increased the total number of zones from 600 to 632. The new zones were formed by subdividing G-BATS3 zones as this facilitates the transfer of data between the SBL HAM and the SBL demand model. The numbers of zones by area are shown in Table 6.

Table 6. G-BATS3 and SBL HAM Zoning Systems by Sub-Area

Area	SBL HAM	GBATS3
Bristol	287	274
North Somerset	63	62
B&NES	36	36
South Gloucestershire	162	162
External	46	46
Unallocated in base year	38	20
Totals	632	600

The SBL HAM and G-BATS3 modelling suite zone systems are shown Figure 6. Note that the zoning is unchanged from that used for G-BATS3 outside of the SBL ADM.

Figure 6. G-BATS3 Modelling Suite and SBL HAM Zoning System

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4.4. Network Structure

The network structure was developed from the GBATS3 2009 SBL v2 HAM. The density of the network structure differed between the FMA and External Area as follows:

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

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

4.4.1. Link Coding

The link coding includes link length and road standard. The link lengths of roads were based on measurements taken from GIS. Within the FMA the links were classified by road type and designated speed limit. For the buffer network the standard Cost Benefit Analysis (COBA) definitions were applied.

4.4.2. Signal Timings

Bristol City Council, along with North Somerset Council, conducted a review of the signal timings within the ADM. Current signal timing data were updated for the existing and newly designated junctions using the information provided by the two local authorities.

4.4.3. Link Speeds

The link speeds in the SBL ADM highway network were coded using TomTom journey time data disaggregated by road type for the hours 7pm to 7am to reflect the cruise speed as defined in TAG Unit 3.19:

> *"Cruise Speed - the speed of traffic on links between queues at modelled junctions. The cruise speed is dependent on the attributes of the link and activity levels alongside and crossing the link. It is not related to flow to any significant degree and is not necessarily equal to the speed limit".*

The cruise speeds were applied to all links within the SBL ADM based on link classification. The cruise speeds were maintained at the same level in all time periods as there were the fifth percentile speeds across the different time periods we very similarly for all routes – indicating little change in conditions affect cruise speed during the modelled peaks.

The centroid connectors enabled the zones to be attached on to the link network. The centroid connectors were coded in the SATURN buffer with:

- specific entry / exit junctions from local access roads onto the main road network from self-contained residential areas, business parks, retail areas and car parks for example; or
- selected junctions representing multiple access points (i.e. removing the need to explicitly code every junction on each link).

Judgement was used to determine the number of centroid connectors required from each zone to represent locations where the traffic from the zones was likely to load in reality, using as many or as few zone connectors as was considered appropriate.

4.5. Time Periods

The SBL HAM represents three time periods, namely the morning and evening peak hours and an average inter-peak hour. The three periods explicitly modelled were:

- Morning Peak hour 08:00 – 09:00;
- Average Inter-Peak hour 10:00 – 16:00; and
- Evening Peak hour 17:00 - 18:00.

For the morning peak and evening peak hour, a previous shoulder peak period was also modelled (although this was not separately validated), and queues which build up during this period were carried over to the start of the peak hour using the SATURN PASSQ option.

4.6. User Classes

The SBL HAM represents highway demand with three user classes as detailed below:

- cars;
- light goods vehicles; and
- heavy goods vehicles.

Scheduled local bus services are represented separately.

In forecasting mode, further segmentation is applied for use in the SBL Demand Model with highway demand split into six user classes namely:

- Car Non-Work Low, Medium and High Income bands (3 user classes in total);
- Car Work;
- Light Goods Vehicles; and
- Other Goods Vehicles.

4.6.1. PCU Factors

The SBL HAM uses passenger car units (pcus) rather than vehicles as its standard unit for demand and capacities. This allows the effects of longer/slower vehicles that occupy more road space and take longer to clear junctions to be represented. The conversion factors used for the various vehicle types are summarised below in Table 7.

Table 7. Vehicle to PCU Conversion Factors

Vehicle Type	Equivalent PCUs	Comment
Car	1.0	Private cars
LGV	1.0	Goods vehicles using car-based chassis
HGV	2.3[1]	For both OGV1 & OGV2 vehicle types
PSV / Bus	3.0	Scheduled coach and local bus services

Note: All demand matrices used in the assignment represented demand in pcus per hour rather than vehicles.

4.7. Assignment Methodology

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

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

4.8. Generalised Cost Formulations and Parameter Values

The route choice within the SBL HAM was modelled using the generalised cost of travel time, vehicle operating cost and tolling / congestion charging in accordance with the TAG Unit 3.19, section 2.8. The coefficients for the individual components of generalised costs were calculated using TAG Unit 3.5.6 (April 2011).

The model base year was 2012 with all monetary values calculated at 2002 prices.

4.8.1. Values of Time

Perceived values are used throughout. Note that, in the case of HGVs, and cars and LGVs in work time, the perceived and resource values are the same. The process is summarised below:

- equivalent 2012 values were calculated by applying the specified growth in working and non-working values of time (Table 3 in TAG Unit 3.5.6) together with the change in prices using the RPI index;
- the relative proportions of Car Non-work for 'Other' and 'Commuting' were calculated from the RSI surveys;
- the equivalent values for vehicles were calculated by applying the occupancies obtained from the 2012 RSI surveys;

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[1] TAG Unit 3.19c provides two pcu values for HGVs: either 2.3 pcus for motorways and all-purpose dual carriageways or 2.0 pcus for all other road types. The motorway network around the Bristol conurbation influences the distribution of through movements on the local road network so the higher value was used throughout – only one value may be used within the model.

- HGV travel was assumed to be in work time with the split between OGV1 and OGV2 recorded from the RSI surveys; and
- the values were converted from £ per hour to p/min.

4.8.2. Vehicle Operating Costs

Vehicle Operating Costs were calculated using TAG 3.5.6 (April 2011) and defined separately for fuel and non-fuel elements before being combined for the use in the SATURN assignment. Non-fuel costs were only taken into consideration by travellers in work-time.

4.8.2.1. Fuel Costs

The consumption of fuel (in litres per km), adjusted by the fuel efficiency factors, was multiplied by the cost per litre to provide the cost per km in the model base year (2012). Fuel duty was included in the calculations as a perceived cost as businesses are not able to reclaim it. However, VAT was excluded because businesses are able to recover it. For non-work purposes, the perceived cost of the fuel Vehicle Operating Cost was the market price. LGV fuel costs were derived using the same work/non-work proportions used to calculate their average Value of Time.

4.8.2.2. Non-Fuel Costs

The non-fuel cost element was derived using formulae set out in TAG 3.5.6 Table 15 and was a function of average network speed. The cost was calculated using the same average network speeds above and the fuel costs converted from 2006 to 2002 prices. No further adjustments were required as the non-fuel costs were assumed to remain constant, in real terms, over time. As noted above, the non-fuel cost element was only included for work trips.

4.8.3. Assignment Parameters

The resulting assignment parameters are summarised below in Table 8.

Table 8. Generalised Cost Parameter Coefficients

Time Period	Cars		Light Goods Vehicles		Heavy Goods Vehicles	
	Time (PPM)	Distance (PPK)	Time (PPM)	Distance (PPK)	Time (PPM)	Distance (PPK)
AM Peak (08:00-09:00)	14.36	6.49	17.52	12.26	30.56	35.46
Inter-Peak (10:00-16:00)	17.27	6.76	17.52	12.10	29.53	34.53
PM Peak (17:00-18:00)	13.70	6.51	17.52	12.45	30.67	34.85

Note: All values in pence (2002 prices).

4.9. Capacity Restraint

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

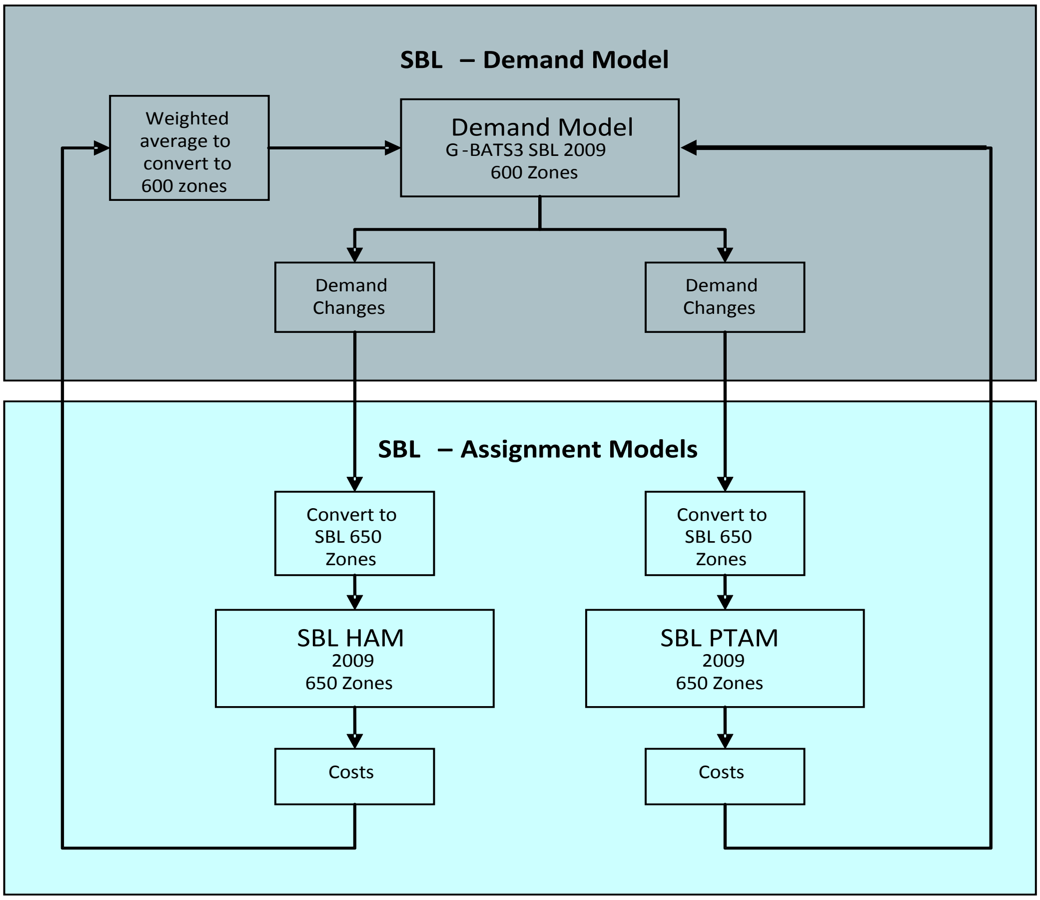
The only exception to this occurred on the A370 where the use of a COBA speed/flow curve was found to be the best way to replicate the capacity constraint (and hence delay) occurring where the highway merges from two lanes to a single lane carriageway to the south West of Long Ashton.

4.10. Links with Demand Model and Public Transport Assignment Model

The SBL HAM is fully integrated within the G-BATS3 demand modelling system, although the zone conversion from 600 zones to 632 zones means that the SBL modelling suite includes additional conversion processes between the demand model and the HAM.

The SBL HAM provides highway transport costs to the demand model, which in turn provides trip matrices for the SBL HAM. The relationship between the elements of the modelling system is shown in Figure 7.

Figure 7. SBL Modelling System



The SBL PTAM is closely integrated with the SBL HAM as they share the same network and zoning hierarchy. This common structure enabled the automated transfer of link and turn time data from the SBL HAM to the PTAM.

The bus services represented in the SBL PTAM are automatically transferred to the HAM to ensure that the impact of buses on other highway traffic is taken into account. However, the zone centroid connectors were not shared between the two models, reflecting the different access points to the network.

4.11. Modelling Software

The HAM uses SATURN version 11.1.09 whilst both the Demand Model and PTAM use INRO EMME2 version 9.6.

5. Calibration and Validation Data

5.1. Overview

The model calibration and validation was undertaken using two types of survey data namely traffic counts and journey times.

Traffic counts were required for:

- expanding new roadside interviews;
- re-expanding old roadside interviews;
- calibrating trip matrices by means of matrix estimation; and
- validating the model.

Journey times were required for:

- calibrating cruise speeds (speeds between junction queues); and
- validating the model.

Traffic counts may be obtained by automatic means (Automatic Traffic Counts, ATCs) or manually (Manual Classified Counts, MCCs). It should be noted that a minimum requirement for traffic count used in the model is a five day ATC and that any MCC data should be accompanied by at least a seven day ATC covering the period of the MCC collection. For two sites the data received was incomplete due to cars parking on the ATC tubes so less than seven days' data is available.

Journey times were be obtained by commercial sources such TomTom and verified for accuracy in the Cumberland Basin, in particular the B3128 and A370 between Long Ashton and the River Avon, using moving observed method.

In selecting the appropriate type of count and source of journey times, two factors were considered:

- the accuracy of the data; and
- the need for information by vehicle type.

The following 95% confidence intervals for traffic counts was assumed:

- Automatic Traffic Counts: total vehicles: ± 5%;
- Manual Classified Counts15: total vehicles: ± 10%;
- Cars and taxis: ± 10%; Light goods vehicles: ± 24%;
- Other goods vehicles: ± 28%; and
- All goods vehicles: ± 18%.

5.2. Traffic Counts at Roadside Interview Sites

For the model, a combination of existing roadside interviews from 2001, 2006 and 2009 have been used in conjunction with five new 2012 roadside interview sites (Table 9 and Figure 8). The data were used in such a way that those locations in the core modelled area used newer data and the older data sets were used to supplement a wider model area:

- 2012 RSIs defined a South Bristol (Inner) Cordon
- 2009 RSIs to supplement 2012 data to form the Inner Cordon
- 2006 RSIs to supplement a Bristol (Outer) Cordon
- 2001 RSIs defined the Outer Cordon.

All of the RSI sites included a survey day MCC and an accompanying two week ATC. All the pre-2012 RSI sites were updated with a two week ATC collected in 2012 and conducted at the original survey location. The survey data was expanded using the survey day MCC and new ATC. The ATCs were classified by car/LGV and OGV1/2 and upon receipt checked for any errors (such as under-reporting of flows).

Table 9. RSI Site Descriptions

Site Ref	Road No	Road Name	Interview Direction	Date of Survey
Site 1	A38	Bedminster Down Road	Northbound	13/03/2012
Site 2	Unclassified	Headley Lane	Northbound	13/03/2012
Site 3a	A4174	Hartcliffe Way	North-westbound	14/03/2012
Site 6	Unclassified	Longway Avenue	Southbound	14/03/2012
Site 7	Unclassified	Queen’s Road	Northbound	14/03/2012
Site 14	Unclassified	Whitchurch Lane	Westbound	27/07/2009
Site 12	A38	Bridgwater Road	Southbound	04/07/2009
Site 29	B3128	Ashton Road	Eastbound	05/11/2009
Site 27	A369	Abbots Leigh Road	Eastbound	04/11/2009
Site 13	A4174	Hengrove Way	Southbound	28/07/2006
Site	A370	Long Ashton By-pass	Northbound	11/07/2006
Site 14	A4	Portway	Southbound	19/06/2001
Site 18	A4018	Westbury Road	Southbound	03/07/2001
Site 19	A432	Stapleton Road	Southbound	03/07/2001
Site 17	A4320	St Phillips Causeway	Northbound	28/06/2001
Site 27	A4	Bath Road	Northbound	17/07/2001
Site 21	A4174	Callington Road	Westbound	05/07/2001
Site 23	A37	Wells Road	Northbound	10/07/2001

Additional two week ATCs were conducted in 2012 at almost all sites crossing the cordons that were not covered by an RSI site in order to create complete cordons for use in matrix building (Figure 9). The exceptions to this were links where the flow was anticipated to be less than 100 vehicles per hour based on nearby counts on nearby roads of a similar nature or gazetteer data indicating that a limited number of residencies would produce trips along that road. Flow on these roads was estimated and are marked as such in Figure 9, and tabulated in Table 10.

The model represents an average weekday in March 2012 and requires all input data to represent such a consistent point in time. As the majority of the data used for matrix development was collected in Spring 2012, any data used outside of this period was factored using seasonality and annual factors. These factors were derived from a number of long-term ATC induction loops built into the road in the south Bristol area.

Figure 8. **RSI Site Locations**

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Figure 9. RSI Cordon Counts Data

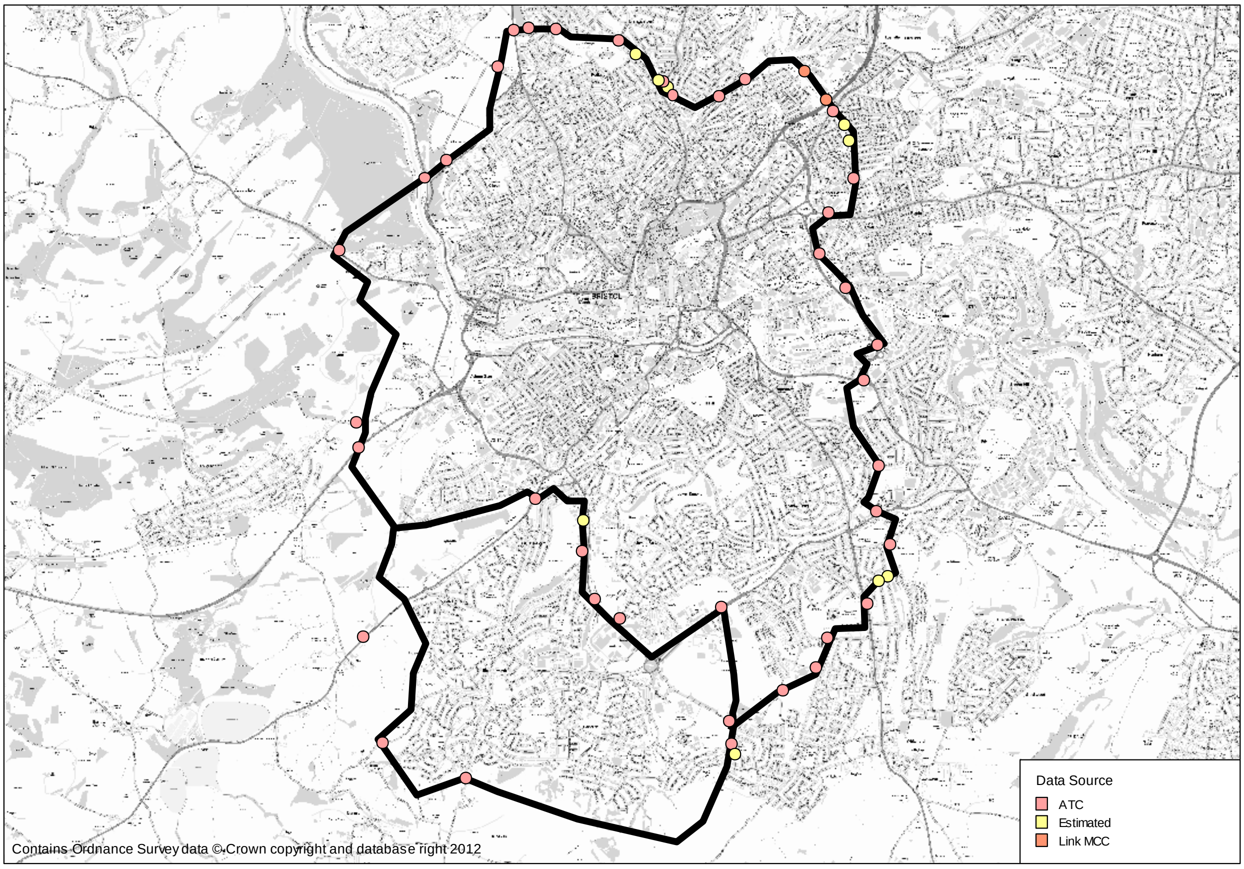


Table 10. Source of Cordon Data

Description	Source
Whitchurch Lane (west of Longway Ave)	ATC
Longway Ave/Witch Hazel Rd	ATC
Goodwin Drive	Estimate
Queens Rd	ATC
Highridge Rd	ATC
A38 Bridgewater Rd, east of Yanley Lane	ATC
A38 Bedminster Down Rd	ATC
Vale Lane	Estimate
Headley Lane	ATC
Hartcliffe Way	ATC
Novers Lane	ATC
Hengrove Way eastbound	ATC
A370 Long Ashton Bypass	ATC
B3128 Ashton Rd	ATC
Abbots Leigh Road	ATC

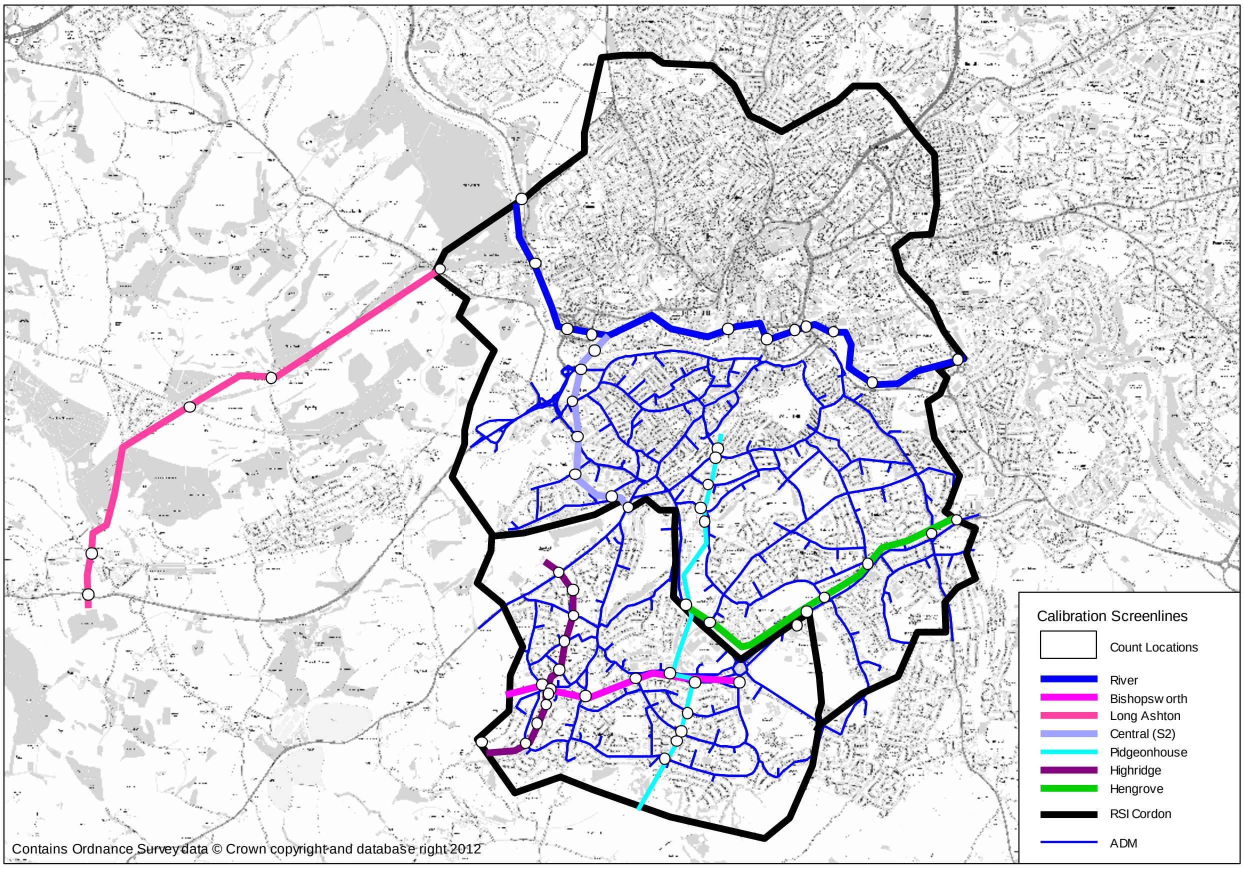
Description	Source
A4 Portway	ATC
Ladies Mile	ATC
Stoke Rd	ATC
Westbury Rd (south of Pary's Lane)	ATC
Coldharbour Rd	ATC
Cranbrook Rd	ATC
Kersteman Rd	Estimate
Elton Rd	Estimate
Gloucester Rd	ATC
North Rd	Estimate
Cromwell Rd	ATC
Chesterfield Rd	ATC
Ashley Hill	ATC
Glenfrome Rd	Link MCC (ATC collected at later date to verify MCC)
M32	Link MCC
Stapleton Rd	ATC
St Marks Rd	Estimate
All Hallows Rd	Estimate
Easton Rd	ATC
Lawrence Hill	ATC
Day's Rd	ATC
Feeder Rd	ATC
St Phillips Causeway (bridge)	ATC
Bath Rd	ATC
Talbot Rd	ATC
Callington Rd	ATC
W Town Lane	ATC
Hazelbury Rd	Estimate
Kinsale Rd	Estimate
Wells Rd	ATC
New Fosseway Rd	ATC
Oatlands Ave	ATC
Bamfield	ATC
Westbury Park	ATC

5.3. Traffic Counts at Calibration Screenlines

Additional traffic counts forming a number of screenlines across the area of detailed modelling were also conducted. Again, two week ATC were used and any data used, but not collected in March 2012, adjusted using the using seasonality and annual factors described above.

The majority of screenlines formed cross the inner cordon and were designed to help synthesise the number of intra-sector trips which would not have been picked up during the RSI process. In total there were three calibration screenlines within the inner cordon: two dissecting the cordon vertically and the third dissecting it horizontally; which split the cordon into six smaller sections. There were four further screenlines (or extensions of those described above) that are located outside of the inner cordon but within the ADM and again these existed to improve the synthesis of intra-sector trips (Figure 10).

Figure 10. Calibration Screenlines



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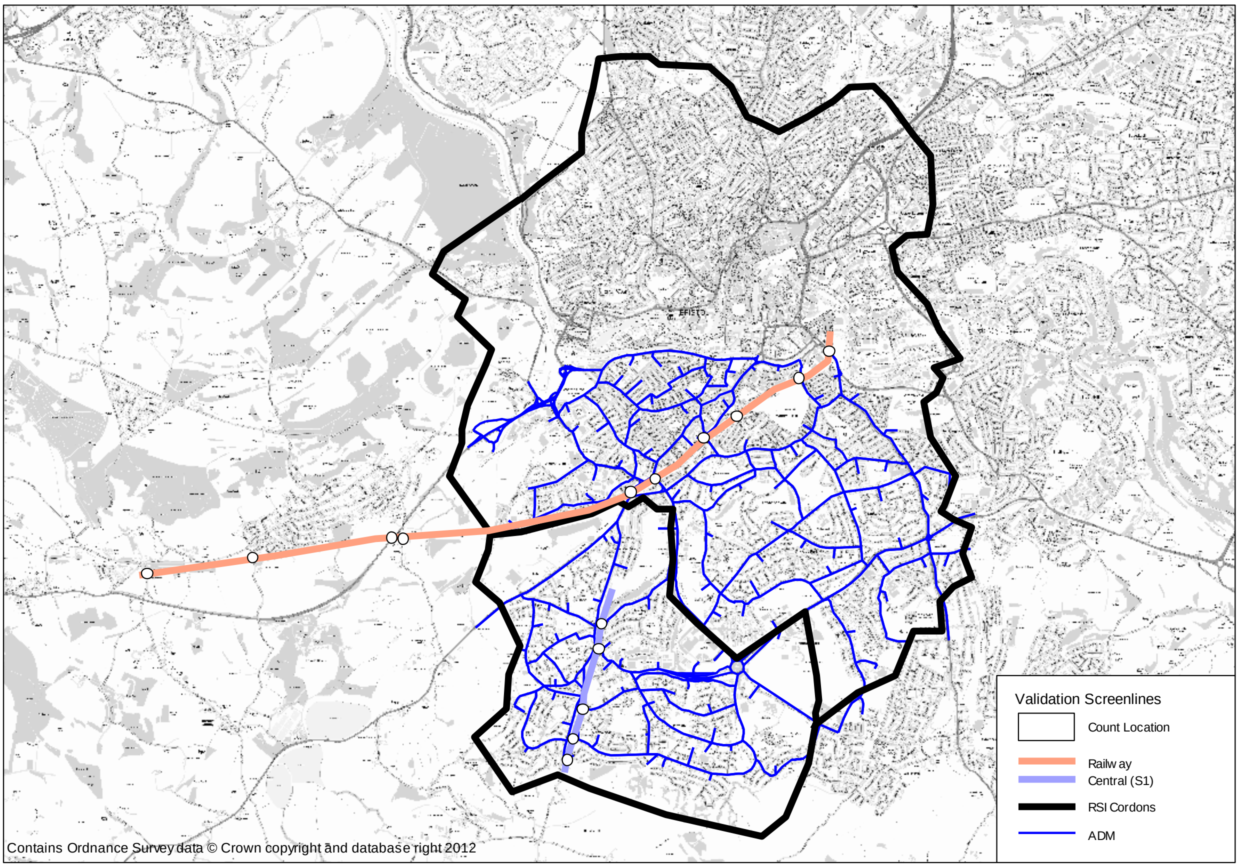
5.4. Traffic Counts at Validation Screenlines

There were two further screenlines which had counts collected for this model which were reserved for model validation (Figure 11). The first split the inner cordon in half and validated the east/west movements, and the second followed the railway and validated the movements north/south. Again, two week ATCs were used and any data used but not collected in March 2012 adjusted using the using seasonality and annual factors described above.

Figure 11. Validation Screenlines



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5.5. Journey Time Surveys

Journey Time data was obtained from TomTom forming five routes (in both directions) across the south Bristol area; reflecting routes that would be impacted by the scheme (Figure 12). The data was selected to cover journeys in the same time periods as the modelled hours and included data from Monday to Friday in neutral months within the period 01/04/2011 to 12/11/2011, which was a total of 117 days.

As advised in TAG Unit 3.10 (Para 4.6.1), moving observer data were collected to verify the accuracy of the TomTom data used for journey time validation. The route selected was between Long Ashton and the Cumberland Basin and six runs were undertaken in both directions along the route in all three modelled time periods. This was then compared to the TomTom data and end to end journey times by both methods provided a close match; with the routes differing by a maximum of 25 seconds and majority differing by less than 10 seconds (Table 11).

Figure 12. Journey Time Routes

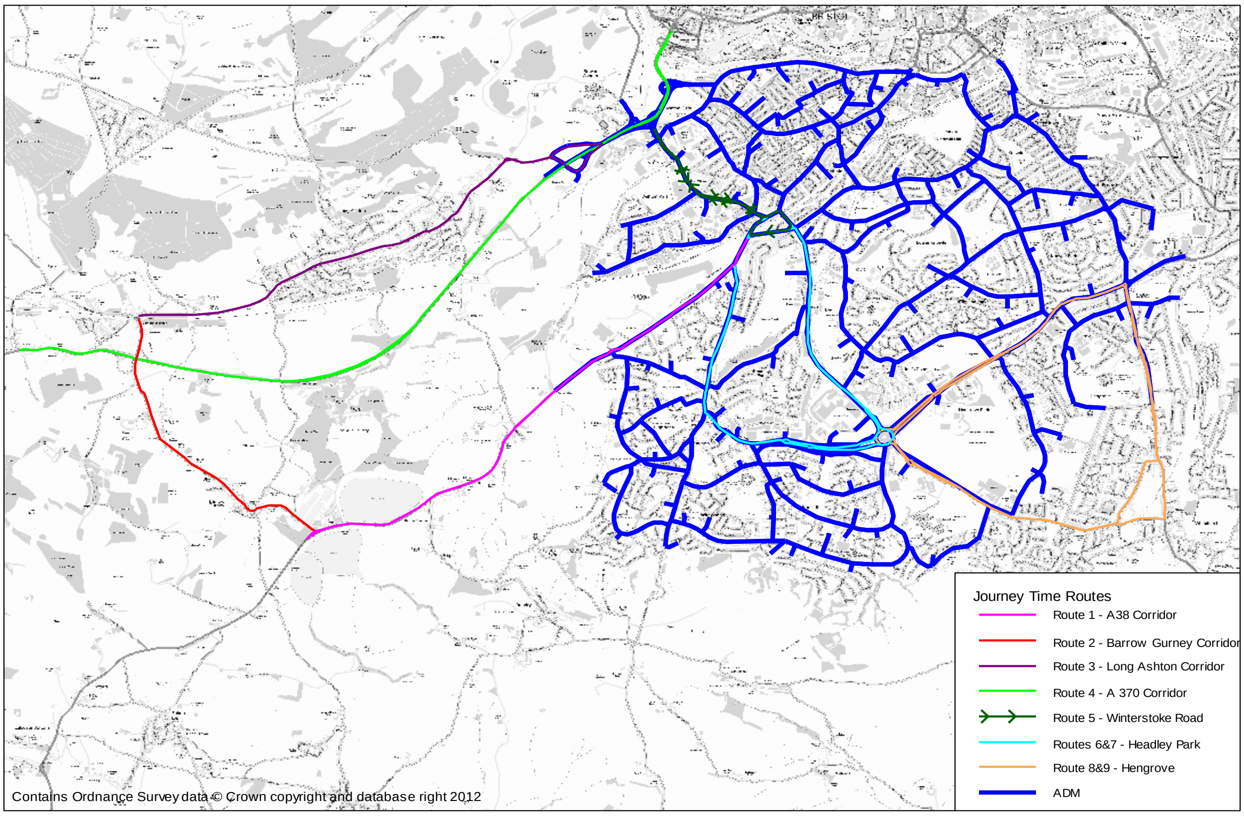


Table 11. Verification of TomTom data

Time Period	Direction	TomTom (H:mm:ss)	Moving Observer (H:mm:ss)	Difference (m:ss)
Morning Peak	Inbound	0:06:43	0:06:44	0:01
	Outbound	0:02:46	0:02:36	-0:10
Inter-Peak	Inbound	0:02:38	0:02:44	0:06
	Outbound	0:02:50	0:02:25	-0:25
Evening Peak	Inbound	0:02:38	0:02:54	0:16
	Outbound	0:03:08	0:03:03	-0:05

6. Network Development

6.1. Fully Modelled and External Areas

The SBL modelled area covered the Greater Bristol urban area and its environs, extending approximately to the boundary of the former county of Avon. The FMA was bounded:

- in the west by the M5;
- in the north by the M4 with an extension along the A432 to Yate;
- in the east by the A4174 outer ring road with an extension to include Keynsham and Cadbury Heath; and
- in the south by the edge of the Bristol City boundary, running in an arc from the A4/A4174 junction to the A370 at Long Ashton.

Within the FMA, the ADM was bounded by the:

- River Avon to the north;
- A37 to the east;
- A369 to the west; and
- B3130 to the south.

The FMA and External Area were shown earlier in Figure 3 and Figure 4.

6.2. Link Structure and Coding

6.2.1. Link Coding

As part of the GBATS3 SBL 2009 v2 HAM development process all links in FMA were allocated distances derived from GIS based analysis of mapping to provide an estimation of road lengths.

The road classification system was used to apply cruise speeds to the network. Using commercial available ITIS journey time data for routes in south Bristol each link was assigned a road classes and then was allocated a cruise speed determined from the TomTom data. These cruise speeds take account of the variations link based delays that may not be flow dependent, such as buses stopping, accesses and road geometry.

Within the ADM the link coding was updated for the GBATS3 SBL 2012 HAM. Additional links were added to the model in south Bristol and cruise speeds were fully revised using the latest TomTom data.

TomTom data were provided for all neutral months in 2011 (April, May, June, September, October and November) by time period (8am to 9am, 10am to 4pm, 5pm to 6pm and 7pm to 7am). The cruise speed by link type was determined by calculating the mean between-junction link speeds on all links during the 7pm to 7am period. During this period of low flow the average between-junction link speed was considered to include only those delays that were not junction or flow dependent.

The relationship between link types and cruise speeds across the FMA are shown in Table 12. In the remainder of the FMA (north Bristol) the cruise speeds were retained from the GBATS3 SBL 2009 v2 HAM model.

Table 12. Cruise Speed in SBL ADM

Road Class	Cruise Speed (kph)
A-road with speed limit of 30mph (48kph)	44
A-road with speed limit of 40mph (64kph)	60
A-road with speed limit of 50mph (80kph)	72
A-road with speed limit of 60mph (96kph)	85

Road Class	Cruise Speed (kph)
B-road with speed limit of 20mph (32kph)	32
B-road with speed limit of 30mph (48kph)	43
B-road with speed limit of 40mph (64kph)	53
B-road with speed limit of 50mph (80kph)	72
B-road with speed limit of 60mph (96kph)	87
Distributor with speed limit of 32kph	32
Distributor with speed limit of 30mph (48kph)	43
Distributor with speed limit of 40mph (64kph)	58
Distributor with speed limit of 50mph (80kph)	72
Distributor with speed limit of 60mph (96kph)	87
Residential with speed limit of 20mph (32kph)	32
Residential with speed limit of30mph (48kph)	35
Residential with speed limit of 40mph (64kph)	47
Residential with speed limit of 30mph (48kph) with traffic calming	32

6.2.2. Junction Coding

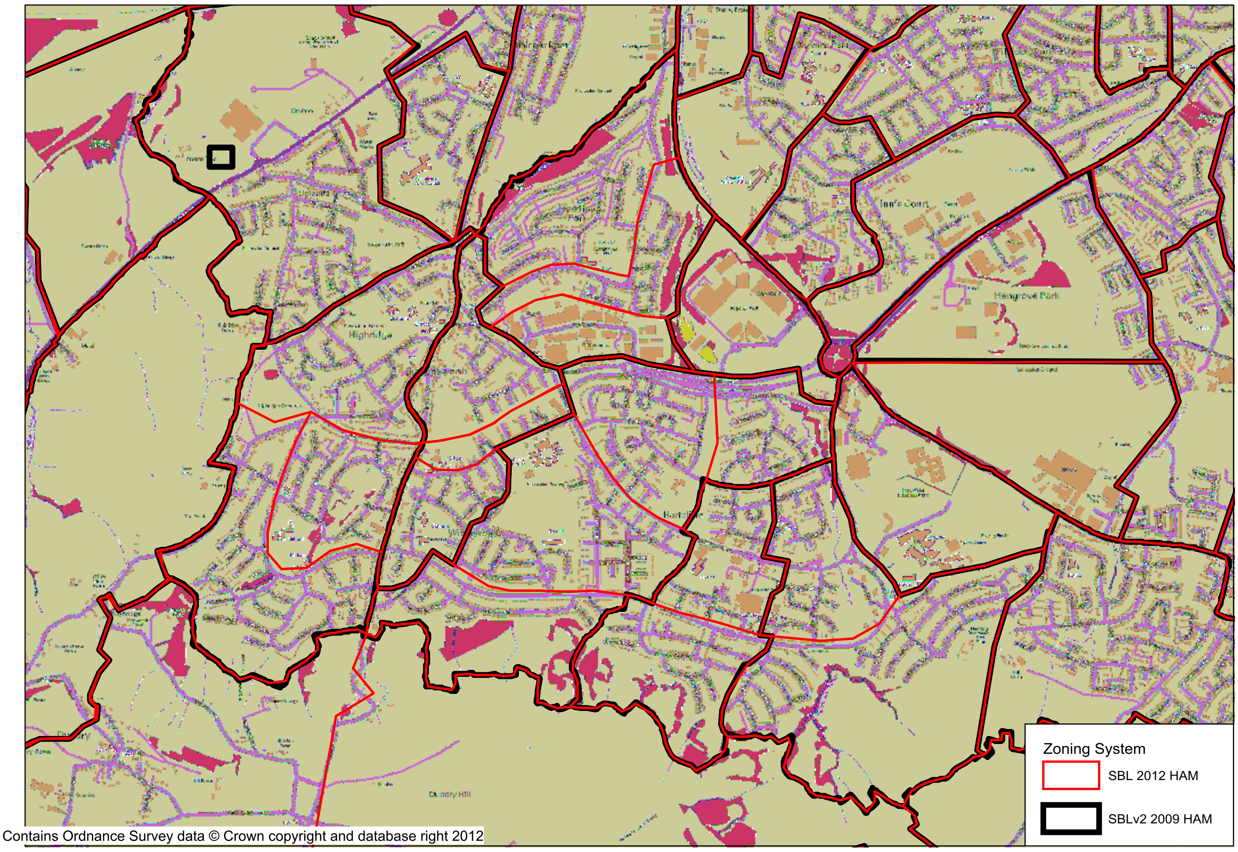
The coding of junctions within SATURN requires information on the lane layout and usage, turn capacities, signal timings, roundabout circulating capacities, and major-minor road priority, etc. Within the ADM the junction coding was updated for the GBATS3 SBL 2012 HAM. This included the use of web-based imagery and site visits and updated signal times for all signal controlled junctions across the ADM in the form of average green and inter green times calculated from Bristol City Council SCOOT data.

The remaining priority junctions were allocated standard generic default capacities on the basis of the road class of major-minor nature of priority junctions.

6.2.3. Modifications to the Zone System

A number of zones in south Bristol were modified in the GBATS3 SBL 2012 HAM to increase the level of detail within the area and are shown in Figure 13.

Figure 13. Zone Modifications between GBATS3 SBLv2 2009 HAM and GBATS3 SBL 2012 HAM



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6.2.4. External Centroid Connectors

All external centroid connectors were coded with representative lengths from their zone centroid to the connection point on the network. The journey distances were calculated using internet-based journey planner Transport Direct.

7. Trip Matrix Development

7.1. Matrix Development Process

7.1.1. Introduction

This chapter describes the many stages associated with the development of a HAM matrix. The process is detailed and is summarised in this chapter and supporting evidence provided in appendices. The trip matrix development process was different for Car/LGV and HGV when building the synthetic matrix due to the availability of the survey data, each method is detailed in the following sections. The matrix development process involved the following steps:

Travel demand data

- collection, editing and expansion of intercept (RSI) survey data;
- collection, editing and reconciliation of count data;
- synthesis of matrix cell values in the non-interviewed directions;

Partial matrices

- creation of partial trip matrices;
- analysis of the accuracy of the partial trip matrices at sector level;

Synthetic matrices

- synthesis of complete car and LGV ‘prior’ trip matrices:

External trips

- assembly of matrices of external to external movements.

Merging sources

- assembly of prior matrices of trips by light goods vehicles (LGVs) and heavy goods vehicles (HGVs);
- adjustments to the prior trip matrices in the light of the comparisons between modelled flows and counts across screenlines and cordons;

Matrix estimation

- matrix estimation to ensure greater consistency of the trip matrices with the count data;
- adjustments to the prior trip matrices if the magnitudes of the changes brought about by matrix estimation are regarded as significant; and
- adjustments to the prior trip matrices in the light of the journey time validations.

7.1.2. Checking

At various key stages of constructing the prior trip matrices checks were required to ensure that the process has derived accurate trip movements. The checks are specified below (Table 13). The aims of these tests and the consequent adjustments are:

- to detect errors at each stage which otherwise might remain undetected and be compensated for, erroneously, by matrix estimation;
- to ensure that the prior trip matrices are reasonably close to the count data, so as to limit the scale of the changes that matrix estimation will bring about; and
- to maximise transparency by making explicit the factors or adjustments that need to be applied to the various inputs and outputs which are necessary to bring the matrices in line with the counts.

Table 13. Prior Trip Matrix Development Tests

Stage	Test	Comparison	Measure	Criterion	Acceptability guideline
Partial trip matrices	A	Flows and counts of trips across RSI cordons, for the modelled hours separately.	Flow differences	< 5%	All or nearly all
Synthetic trip matrices	B1	Flows and counts of trips across RSI cordons, for the modelled hours separately, with 3D Furness.	Flow differences	< 5%	All or nearly all
	B2	Flows and counts of trips across RSI cordons, for the modelled hours separately, with 2D Furness.	Flow differences	<7. 5%	All or nearly all
Prior trip matrices	C	Total assigned flows and total counts in both directions across RSI cordons and calibration and validation screenlines, for each modelled hour.	Flow differences	< 7.5%	All or nearly all

Notes: A - Test A should be done without an assignment. B - Test B1 should be conducted following application of the three-dimensional Furness, and Test B2 following a two-dimensional Furness. C - Test C requires assignments

Tests A and B were undertaken for RSI cordons; with the counts on the cordons be adjusted to relate to trips that started or ended inside the cordon (by factoring the count by the ratio of expanded trips with a start or end inside the enclosure to the total trips (including wholly internal and through trips).Test C was undertaken by comparing assigned flows with traffic counts. Each stage involved an iterative process of adjustments and refinements to meet the tests described above and to reduce the impact of matrix estimation.

7.2. Travel Demand Data

7.2.1. Data sources

Since 2001 a number of different RSI surveys have been undertaken in central and south Bristol that provided a data source for the GBATS3 SBL 2012 HAM. These include:

- GBATS2 surveys forming a Bristol cordon in 2001;
- GBATS3 surveys providing infill data in 2006;
- GBATS3 SBL 2009 surveys providing infill data in 2009; and
- GBATS3 SBL 2012 surveys.

These surveys enabled two cordons to be formed: an inner cordon around Bedminster Down, Highridge, Hartcliffe and Bishopsworth and an outer cordon that shares a southern boundary with the inner cordon but extends north to include to rail line between Bristol Temple Meads and Clifton Down. Details of which were present in section 5.

Details of the survey and count data on each road split by the inner cordon are shown in Table 14 and the outer cordon in Table 15. For those roads along the cordons that were not surveyed due to low flows (less than 100 vehs/hour), one of two options were used to obtain data to ensure that the cordons were derived without any gaps. For roads that were modelled, select link data (SLD) were obtained from the previous GBATS3 SBL 2009 v2 HAM model and controlled to the specific count (or estimated count) of that link. For those roads not in the model, infilling was undertaken using RSI data from an adjacent site but was expanded to the specific count (or estimated count) of that road.

Table 14. Data Sources for the Inner RSI Cordon

Cordon / Screenline	Description	Partial Matrix Source	Year	Month	Count Type
Inner Cordon	Whitchurch Lane (west of Longway Ave)	2009 RSI -	2012	March	ATC
Inner Cordon	Longway Ave/Witch Hazel Rd	2012 RSI	2012	March	ATC
Inner Cordon	Goodwin Drive	Infill			Estimate
Inner Cordon	Queens Rd	2012 RSI	2012	March	ATC
Inner Cordon	Highridge Rd	Infill	2012	March	ATC
Inner Cordon	A38 Bridgewater Rd, east of Yanley Lane	2009 RSI	2012	March	ATC
Inner Cordon	A38 Bedminster Down Rd	2012 RSI	2012	March	ATC
Inner Cordon	Vale Lane	Infill			Estimate
Inner Cordon	Headley Lane	2012 RSI	2012	March	ATC
Inner Cordon	Hartcliffe Way	2012 RSI	2012	March	ATC
Inner Cordon	Novers Lane	Infill	2012	March	ATC
Inner Cordon	Hengrove Way westbound	2006 RSI	2012	March	ATC

Table 15. Data Sources for the Outer RSI Cordon

Cordon / Screenline	Description	Partial Matrix Source	Year	Month	Count Type
Outer Cordon	Whitchurch Lane (west of Longway Ave)	2009 RSI	2012	March	ATC
Outer Cordon	Longway Ave/Witch Hazel Rd	2012 RSI	2012	March	ATC
Outer Cordon	Goodwin Drive	Infill			Estimate
Outer Cordon	Queens Rd	2012 RSI	2012	March	ATC
Outer Cordon	Highridge Rd	Infill	2012	March	ATC
Outer Cordon	A38 Bridgewater Rd, east of Yanley Lane	2009 RSI	2012	March	ATC
Outer Cordon	A370 Long Ashton Bypass	2006 RSI	2012	March	ATC
Outer Cordon	B3128 Ashton Rd	2009 RSI	2012	March	ATC
Outer Cordon	Abbots Leigh Road	2009 RSI	2012	March	ATC
Outer Cordon	A4 Portway	2001 RSI	2012	March	ATC
Outer Cordon	Ladies Mile	Infill	2012	April	ATC
Outer Cordon	Stoke Rd	Infill	2012	April	ATC
Outer Cordon	Westbury Rd (south of Pary's Lane)	2001 RSI - Non Interview	2012	March	ATC
Outer Cordon	Westbury Park	Infill	2012	April	ATC

Cordon / Screenline	Description	Partial Matrix Source	Year	Month	Count Type
Outer Cordon	Coldharbour Rd	SLA	2012	April	ATC
Outer Cordon	Cranbrook Rd	SLA	2009	June	ATC
Outer Cordon	Kersteman Rd	Infill			Estimate
Outer Cordon	Elton Rd	Infill			Estimate
Outer Cordon	Gloucester Rd	SLA	2012	April	ATC
Outer Cordon	North Rd	Infill			Estimate
Outer Cordon	Cromwell Rd	Infill	2012	April	ATC
Outer Cordon	Chesterfield Rd	Infill	2012	April	ATC
Outer Cordon	Ashley Hill	SLA	2012	April	ATC
Outer Cordon	Mina Rd	Infill			Estimate
Outer Cordon	Glenfrome Rd	Infill	2009	June	MCC_L
Outer Cordon	M32	SLA	2009	June	MCC_L
Outer Cordon	Stapleton Rd	2001 RSI	2012	April	ATC
Outer Cordon	St Marks Rd	Infill			Estimate
Outer Cordon	All Hallows Rd	Infill			Estimate
Outer Cordon	Easton Rd	SLA	2012	April	ATC
Outer Cordon	Lawrence Hill	SLA	2012	April	ATC
Outer Cordon	Day's Rd	Infill	2012	April	ATC
Outer Cordon	Feeder Rd	Infill	2012	January	ATC
Outer Cordon	St Phillips Causeway (bridge)	2001 RSI	2012	April	ATC
Outer Cordon	Bath Rd	2001 RSI	2012	April	ATC
Outer Cordon	Talbot Rd	Infill	2012	April	ATC
Outer Cordon	Callington Rd	2001 RSI	2009	April	ATC
Outer Cordon	W Town Lane	SLA	2012	April	ATC
Outer Cordon	Hazelbury Rd	Infill			Estimate
Outer Cordon	Kinsale Rd	Infill			Estimate
Outer Cordon	Wells Rd	2001 RSI	2012	March	ATC
Outer Cordon	New Fosseway Rd	Infill	2012	April	ATC
Outer Cordon	Oatlands Ave	Infill	2009	October	ATC
Outer Cordon	Bamfield	Infill	2012	April	ATC

7.2.2. Data processing

The 2012 ATC data was collected for a continuous two week period. The data was classified into Cars/LGVs, OGV1 and OGV2 and processed to obtain the average weekday (Mon-Fri) flows by available vehicle type where the OGV1 and OGV2 data were combined to provide data for HGV. At each of the 2012 RSI sites, an additional MCC was conducted on the day of the survey.

The older RSI site data were typically accompanied by an MCC, so were updated with a new ATC only. However, the 2001 RSI data had no MCC data available in the non-interview direction and for these the sites the average vehicle type split from all of the RSI sites was assumed and are shown in Table 16 by vehicle type and time period.

Table 16. Average Vehicle Profile by Time of Day from MCC Sites associated with RSIs

Time Period	Cars	LGV	HGV	PSV	Total
AM	78.7%	13.1%	3.7%	1.3%	96.7%
IP	77.1%	13.8%	5.2%	1.7%	97.7%
PM	84.4%	9.8%	1.6%	1.1%	96.8%

Note: Motorcycles and pedal cycles were also counted and disregarded in the model but the split of data reflects their existence in the counts – hence the sum is not 100%):

The model represents a single consistent point in time. Since the data used for GBATS3 SBL 2012 HAM were collected between 2008[2] and 2012, factors were needed to account for monthly and yearly variations between the sites. To do this there are sites on the A370 and A38 which are critical links along the scheme and where traffic levels are continuously monitored. Information from these sites enabled factors to be determined to normalise the data to the model base of March 2012. The seasonal factors (SF) were used to adjust counts between months Table 17 whilst the growth factors (GF) were used to adjust counts between years Table 18.

Table 17. Seasonal (month to month) Factors

Month	Seasonal Factor (SF)
January	0.91
February	1.00
March	1.00
April	0.98
May	1.00
June	1.01
July	1.02
August	0.99
September	1.03
October	1.00
November	1.01
December	0.91

---

[2] It was necessary to use 2008 data for one location on the river screenline (Brunel Way) because the 2012 count data received was very low and when checked it was much lower than the old count, time did not allow the collection of more data to verify which was correct, It is believed that the 2012 count was low because it was collected using tubes placed across the road and this area is known to queue and hence would not accurately collect data.

Table 18. Growth (year to year) Factors

Year	Growth Factor (GF)
2012	1
2011	1.03
2010	1.01
2009	0.98
2008	0.98

The data were collected in vehicles and model assignment uses PCU so the factors in Table 7 were applied. A detailed description of the RSI processing is provided in Appendix A and this covers the approaches to each of the different surveys. A summary of records by cordon, direction and time period is shown in Table 19.

Table 19. Summary of Unexpanded RSI records

Cordon	Direction	AM (0700 -1000)	IP (1000-1600)	PM (1600-1900)	Total (12 hours)
Inner cordon	Inbound	683	1,304	819	2,806
	Outbound	973	1,744	873	3,590
	Total	**1,656**	**3,048**	**1,692**	**6,396**
Outer cordon	Inbound	3,096	5,748	3,065	11,909
	Outbound	234	370	203	807
	Total	**3,330**	**6,118**	**3,268**	**12,716**

Note: 4 RSI sites are located on both the Inner and Outer cordons with the trips included in both cordon summaries

7.2.3. RSI Expansion

The RSI interviews from various years were expanded to a common March 2012 base. The methodology for carrying out the expansion was as follows:

$$T^{M}_{ijpct} = \tilde{T}^{M}_{ijpcT}\left(\frac{T^{M}_{vt}}{\sum\limits_{ijp(c\in v)}\tilde{T}^{M}_{ijpcT}}\right)\left(\frac{T^{M}_{t}}{\sum\limits_{v}T^{M}_{vt}}\right) \text{ and hence } \sum_{ijpc}T^{M}_{ijpct} = T^{M}_{t}$$

where $\tilde{T}^{M}_{ijpcT}$ Vehicles intercepted (interviewed) at RSI site *M* with trip purpose *p*, traveller type *c* in time period *T,* collected in different years (2001, 2006, 2009 and 2012)

T^{M}_{vt} Manual classified counts (MCC) at RSI site *M* by vehicle type (cars & LGVs here) on same day and in same direction as RSI survey above in assignment hour *t* and $t \in T$ the RSI period above

T^{M}_{t} Automatic traffic counts (ATC) at RSI site *M* in Spring 2012 of all *light* vehicles in time period *t,* where *t* is the average for the hour across two weeks (10 consecutive weekdays) of data and $t \in T$ above

The RSI data available permitted the calculation of expansion factors for all 22 sites in all three time periods for the cars and LGVs. For HGVs only 14 of the 22 sites had HGV interviews in all time periods. Three sites had no interviews, three had interviews in only one time period and the remaining two sites had interviews in two of the time periods. Thus only 74% of the sites by time period have expansion factors. It was necessary to infill these sites with data from neighbouring equivalent sites, this process is explained after Table 20.

The range of expansion factors (prior to infilling HGVs) obtained for each vehicle type and time period is shown in Table 20.

Table 20. Summary of Expansion factors for RSI interviews to Assignment Hours

Time Period	Details	Car	LGV	HGV	All veh types
Morning Peak	Count of Expansion Factor	22	22	16	60
	Min of Expansion Factor	0.5	0.5	1.8	0.5
	Max of Expansion Factor	6.3	50.6	34.5	50.6
	Average of Expansion Factor	2.8	5.7	10.4	5.9
	StdDev of Expansion Factor	1.39	10.4	10.5	8.8
Inter-Peak	Count of Expansion Factor	22	22	19	63
	Min of Expansion Factor	0.4	0.5	0.8	0.4
	Max of Expansion Factor	1.8	3.1	42	42
	Average of Expansion Factor	1.1	1.2	7.1	3
	StdDev of Expansion Factor	0.5	0.7	9.8	6
Evening Peak	Count of Expansion Factor	22	22	14	58
	Min of Expansion Factor	0.7	0.7	1.1	0.7
	Max of Expansion Factor	16.4	17.1	36.6	36.6
	Average of Expansion Factor	3.0	3.6	11.3	5.2
	StdDev of Expansion Factor	3.2	3.7	13.1	7.7
Total	Total Count of Expansion Factor	66	66	49	181
	Total Min of Expansion Factor	0.4	0.5	0.8	0.4
	Total Max of Expansion Factor	16.4	50.6	42	50.6
	Total Average of Expansion Factor	2.3	3.5	9.4	4.7
	Total StdDev of Expansion Factor	2.2	6.6	11	7.6

Note: 100% sample would give expansion factor of 0.3333. So 10% sample would give expansion factor of 3.33. HGVs subsequently in filled were there were no records at a site to give expansion factors for all sites this is detailed in the main text below.

The RSI sites where there were no RSI records for HGVs in one or more time periods are shown in Table 21 below. To accommodate those sites where there were no HGV hourly records, the interview records obtained across the 12 hours for the same site were expanded to the hourly HGV count for that site. The relatively low numbers of HGVs, and poor sampling still meant that there were some RSI sites whereby no interview records had been captured over the 12 hours, though a HGV count was recorded. For these sites records were copied from a neighbouring RSI site (with HGV records) that might be expected to have similar trip patterns.

Table 21. RSI Sites Missing HGV Data in One or More Time Periods

Site / road	Morning Peak	Inter-Peak	Evening Peak	Solution
Queen’s Road	No data	No data	No data	Copy data from Longway Ave, Witch Hazel Road
Queen’s Road	No data	No data	No data	Copy data from Longway Ave, Witch Hazel Road
A370 Long Ashton Bypass	No data	No data	No data	Copy data from Transposed RSI) A38 Bridgewater Road
Whitchurch Lane (west of Longway Ave)	No data		No data	Use inter-peak data
Headley Lane	No data		No data	Use inter-peak data
Whitchurch Lane (west of Longway Ave)	No data		No data	Use inter-peak data
Hartcliffe Way			No data	Use morning peak and inter-peak data
Westbury Rd (south of Pary's Lane)			No data	Use morning peak and inter-peak data

7.2.4. Estimation of Missing Cordon Data

7.2.4.1. Flow Volumes

The RSI data exclude a number of minor roads crossing the cordons and in these cases traffic volumes were estimated for the three assignment hours. Where the link crossing the cordon is in the SATURN network the flow could be taken from the previous version of the GBATS3 SBL 2009 v2 HAM. In cases where the link is not explicitly in the SATURN network the traffic using this route was estimated based on traffic counts for neighbouring roads of a similar function and nature. Details of this are contained in Appendix A.

7.2.4.2. OD patterns

In cases where there was no RSI information available for a road crossing the cordon, the pattern of trips was estimated as follows:

- For main road links (A and B roads) the trip pattern for light and heavy vehicles was obtained by carrying out a select link analysis (SLA) on the link from the most appropriate existing assignment model (GBATS3 SBL 2009 v2 HAM for those links south of the river Avon and South Gloucester Core Strategy model (SGCS 2011) for those links north of the river) and time period. A large number of trip records were generated through this process and to reduce processing time only those zone pairs with > 0.1 trips were used;
- For minor road links information was taken from one, or several, nearby distributor road RSI sites for the appropriate time period using unexpanded interview data. The purpose and vehicle profiles were also taken from the RSI sites;
- For local distributor roads the pattern of trip ends within the cordon were taken from a nearby distributor road with data and the pattern of trip ends outside the cordon limited to exclude any longer distance strategic trips; and
- For minor residential roads, the trip ends within the cordon were again taken from a nearby distributor road, but the trip ends outside the cordon limited to the local area. If appropriate nearby RSI data was not readily identified, the pattern of ODs for local distributor roads crossing the cordon was derived from SLA of the most appropriate model.

This process will generate matrices by purpose and traveller / vehicle type:

$$T^{N}_{ijpct} = T^{N}_{t}\left(\frac{T^{M}_{ijpct}}{\sum_{ijpc} T^{M}_{ijpct}}\right)$$

where adjacent RSI is used and the ij pairs surveyed have been filtered appropriately.

or

$$T^{N}_{ijpct} = T^{N}_{t}\left(\frac{\hat{T}^{L}_{ijt}}{\sum_{ij} \hat{T}^{L}_{ijt}}\right)\left(\frac{T^{M}_{pct}}{\sum_{pc} T^{M}_{pct}}\right)$$

when SLA is used for ODs and combined with purpose and traveller / vehicle type from RSI

Where

N is the site without RSI data to be estimated from filtered RSI data at site M.

L is the link crossing the cordon at site N used for SLA.

7.2.4.3. Non-survey direction

To produce non-survey direction movements the survey records in each time period T were transposed and allocated to a most likely return time period based on the trip purpose and direction (to/from home). The allocations are shown in Table 22 and are typically the other peak period for peak trips and the same period for inter-peak trips.

Table 22. Allocation of Transposed Interviews to Time Periods

Time period	Purpose	Interview direction	Transpose time period
Morning peak	All HB purposes except Educ	From home	Evening peak
	HB Educ	From home	Inter-peak
	All HB purposes	To home	Morning peak
	NHB purposes and LGVs	NHB, LGV	Evening peak
Inter-peak	All purposes	HB from / to home, NHB & LGV	Inter-peak
Evening peak	All purposes	HB from / to home, NHB & LGV	Morning peak

The transposed records from interview time period (w), were then scaled to:

- Match the overall ATC count totals for light vehicles at the site in the non surveyed direction (M’) during time period for which transposed trips were being calculate (u)

$$\tilde{T}^{M'}_{ijpcu} = T'^{M}_{ijpcw}\left(\frac{T^{M'}_{u}}{\sum_{ijpc} T'^{M}_{ijpcw}}\right)$$

- Match the purpose and traveller type / vehicle type profiles of the surveyed RSIs across the entire cordon (i.e. inbound + outbound) in the time period of interest, u. Analysis of the RSI data indicated little variation for trips inbound / outbound once the trip purpose and trip direction (to / from home) by time period had been taken into account. This level of disaggregation also resulted in small sample sizes particularly for business and education trips.

Once again if there were no HGV hourly records then 12 hour records were used.

The processing of travel demand data concluded with estimates (via observation and infilling) of movements in both directions at each cordon crossing point scaled to ATC count data. The data can be aggregated to form inner and outer cordons in inbound and outbound directions.

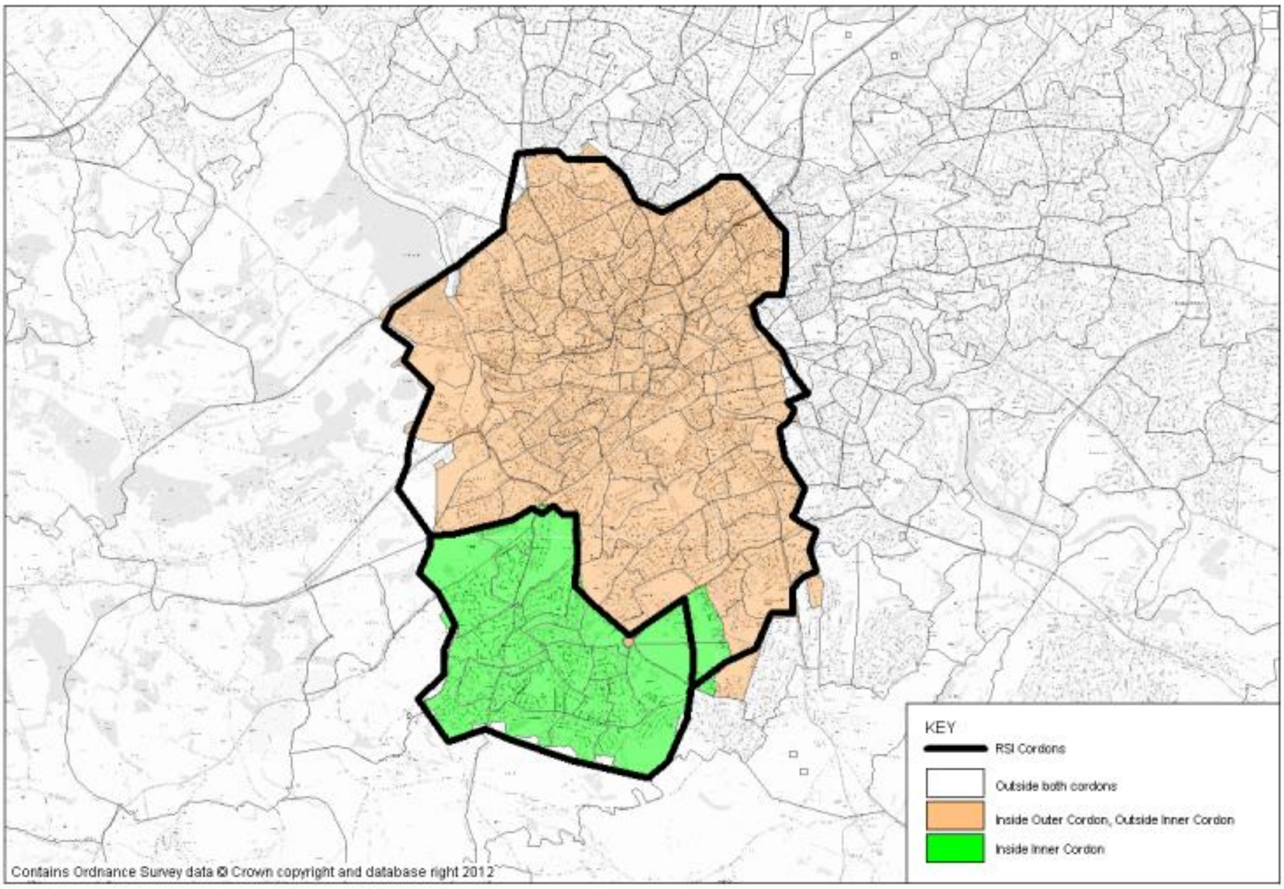
7.3. Partially Observed Trip Matrices from Surveys

7.3.1. Combining Data Sources

As described above, the RSI surveys form two cordons: an inner, south Bristol cordon relating to the scheme and an outer, south and central Bristol cordon (Figure 14). These two cordons enabled the model to be divided into the following three sectors:

- inside the south Bristol cordon;
- outside the south Bristol cordon but inside the south and central Bristol cordon; and
- outside the south and central Bristol cordon.

Figure 14. Bristol Cordons



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The ERICA5 manual provides guidance on merging data for the same origin and destination that has been observed at two or more independent screenlines or cordons. However, the SBL cordons are not independent (they have some sites in common). Furthermore, as the smaller cordon generally surrounds the scheme and has more recent data the approach adopted defines data from the inner cordon as taking precedence over data from the outer cordon. Hence all movements which have one, and only one end within the south Bristol cordon were represented by data from the 2009/2012 RSI surveys defining this inner cordon. Data from the outer cordon RSIs (mainly 2001, though some 2006 and 2009 / 2012 data where common with inner cordon) with a trip end within the inner cordon were discarded and not form part of the partial matrix. The rules regarding merging the data sources are summarised in Table 23 below.

Table 23. RSI Merging Rules

Origin \ Destination	Area 1	Area 2	Area 3
Area 1 - within inner cordon	No / partial data	Inner cordon	Inner cordon
Area 2 - between inner and outer cordons	Inner cordon	No / partial data	Outer cordon
Area 3 - outside outer cordon	Inner cordon	Outer cordon	No / partial data

7.3.2. Summary of results obtained

Following the merging process described above, the number of movements by data source, time period and vehicle type are shown in Table 24. For the inner cordon 83% of the trips are obtained from RSI and transposed RSI data with the remaining obtained from infilling. Directly observed data accounts for 26% of the trips overall; whilst combined the RSI and transposed RSI based data accounts for 48% of the trips in total the partial matrix.

Table 24. Partial Matrix Trip Vehicle Trip Volumes by Hour and Data Source

Time Period	Vehicle Type	Source of Trip Information				Total
		RSI	Transpose	SLA	Infill	
Inner Cordon						
Morning peak period (07:00-10:00)	Car	2,156	1,930	0	1,054	5,140
	LGV	453	367	0	169	989
	HGV	116	118	0	11	245
	All	2,725	2,416	0	1,235	6,376
Inter-Peak period (10:00-16:00)	Car	1,755	2,020	0	779	4,554
	LGV	304	366	0	148	818
	HGV	182	228	0	6	416
	All	2,241	2,614	0	933	5,788
Evening peak period (16:00-19:00)	Car	2,153	2,904	0	1,064	6,121
	LGV	246	430	0	140	816
	HGV	81	94	0	2	177
	All	2,479	3,429	0	1,205	7,113
Outer Cordon						
Morning peak period (07:00-10:00)	Car	6,484	3,342	10,355	5,875	26,056
	LGV	1,038	490	1,537	713	3,778
	HGV	506	246	678	189	1,619
	All	8,028	4,078	12,570	6,776	31,452
Inter-Peak period (10:00-16:00)	Car	4,736	3,405	6,902	4,734	19,777
	LGV	828	642	1,301	807	3,578
	HGV	533	371	729	274	1,907
	All	6,098	4,418	8,932	5,816	25,264

Time Period	Vehicle Type	Source of Trip Information				Total
Evening peak period (16:00-19:00)	Car	6,211	5,986	11,214	6,371	29,782
	LGV	707	606	1,144	552	3,009
	HGV	228	202	344	69	843
	All	7,147	6,795	12,702	6,992	33,636
Total						
Morning peak period (07:00-10:00)	Car	8,640	5,272	10,355	6,929	31,197
	LGV	1,491	857	1,537	882	4,767
	HGV	622	364	678	200	1,864
	All	10,753	6,494	12,570	8,011	37,828
Inter-Peak period (10:00-16:00)	Car	6,491	5,425	6,902	5,514	24,331
	LGV	1,133	1,008	1,301	955	4,397
	HGV	715	599	729	280	2,323
	All	8,338	7,032	8,932	6,749	31,051
Evening peak period (16:00-19:00)	Car	8,364	8,890	11,214	7,435	35,903
	LGV	953	1,036	1,144	692	3,825
	HGV	309	297	344	71	1,020
	All	9,626	10,223	12,702	8,197	40,748

Having built the partial matrices these were compared with the count data using Test A (Table 25) to ensure that the data had been processed correctly and to ensure the merging / filtering process had resulted in matrices closely reflecting the count data for the cordon crossing movements.

Table 25. Matrix Development Test A

Comparison	Measure	Criterion	Acceptability guideline
Flows and counts of trips across RSI cordons, for the modelled hours separately.	Flow differences	< 5%	All or nearly all

The results of Test A for the inner and outer cordons for each time period are shown in Table 26. The counts on each cordon had to be adjusted so that they relate to trips either starting or ending within the cordons only. For the inner cordon the criterion is completely satisfied, only the comparisons for some of the outer cordon fall below the counts.

Table 26. Test A Results

Screenline		Direction	Morning Peak		Inter-Peak		Evening Peak	
			Car	LGV	Car	LGV	Car	LGV
RSI Cordon	Inner Cordon	Inbound	2%	2%	4%	3%	3%	2%
		Outbound	3%	2%	4%	4%	4%	3%
	Outer Cordon	Inbound	-7%	-9%	-2%	-6%	-4%	-14%
		Outbound	-6%	-13%	-5%	-7%	-6%	-11%

7.3.3. Accuracy of Partial Matrices at Sector Level

The partial matrices were not statistically reliable on a cell by cell basis (at zone level) for car trips segmented into purposes. Appendix B describes in detail how the accuracy of the partial matrices at a sector level were assessed. This information is required to produce statistically reliable sector level constraints for gravity modelling. These constraints apply to car and LGV trips; the limited HGV data means that such an assessment should instead be used to determine at what level of detail the partial trip matrices can be reliably used to adjust / constrain the HGV matrices from the GBATS3 SBL 2009 v2 HAM.

The first stage of this process was to determine whether the 3x3 sector system used within the partial matrix build would allow gravity modelling to be undertaken by trip purpose. Analysis suggested that it would be difficult to find a detailed sector system using any purpose segmentation. Since spatial detail is more important in a highway assignment model (as opposed to a demand model where purpose segmentation would be more important) , only the vehicle types car and LGV were considered for gravity modelling. This was also supported by the trip end data being only available for light vehicles combined. By combining purposes and considering only car and LGV trips it was possible to disaggregate the 3x3 sector system into additional sectors.

A 12 (sub) sector system resulted from this process with the 12 areas identified as shown in Figure 15 below. This level of disaggregation was not applied uniformly for all movements, rather for the movements between sectors 1 and 2 and 1 and 3 north of the river, the 12 sectors were aggregated back to 8. For movements between sectors 2 and 3 this maximum level of detail was retained. The relationship between sector movements and the sector system used is shown in Table 27.

Figure 15. Sector System for Gravity Modelling and Analysis

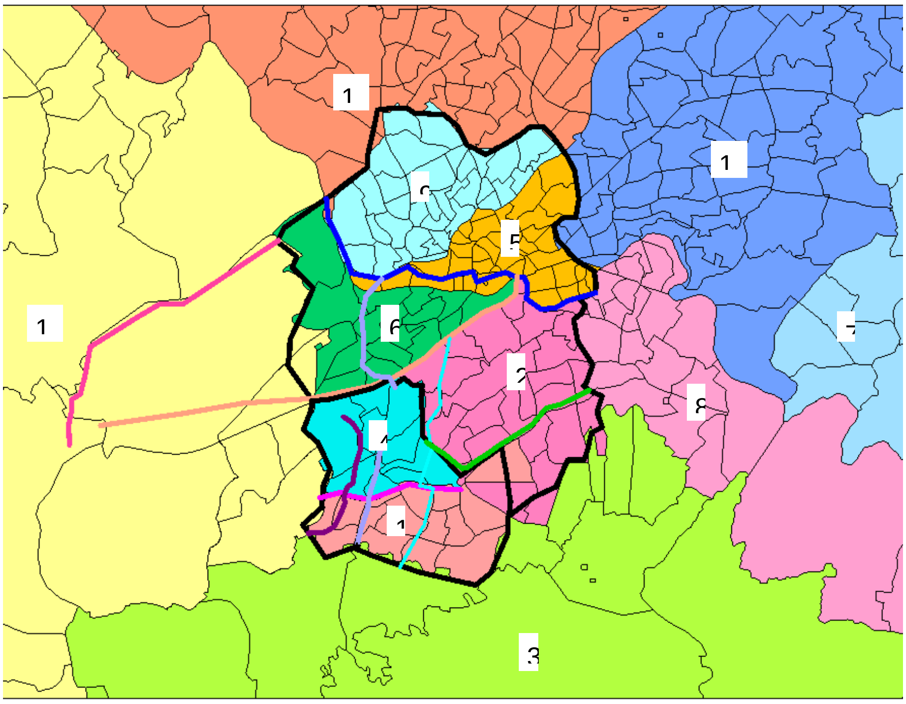


Table 27. Sector Relationship

3 Sector System	8 Sector System	12 Sector System	1	4	2	6	5	9	3	7	11	12	10	8
1	1	1	12	12	8	8	8	8	12	8			12	12
	4	4	12	12					12	8			12	12
2	2	2	8	8	12	12	12	12	12	12	12	12	12	12
		6			12	12	12	12	12	12	12	12	12	12
	5	5	8	8	12	12	12	12	12	12	12	12	12	12
		9			12	12	12	12	12	12	12	12	12	12
3	3	3	12	12	12	12	12	12	12	12	12	12	12	12
	7	7	8	8	12	12	12	12	12	12	12	12	12	12
		11			12	12	12	12	12	12	12	12	12	12
		12			12	12	12	12	12	12	12	12	12	12
	10	10	12	12	12	12	12	12	12	12	12	12	12	12
	8	8	12	12	12	12	12	12	12	12	12	12	12	12

7.4. Trip Synthesis

7.4.1. Introduction

Trip matrices derived from the RSI survey data were partial and movements not intercepted in the surveys were missing creating a lumpy matrix: observed movements have a large number of trips (governed by the number of observations and the expansion factor) and unobserved movements are zero.

To resolve these problems, synthetic matrices, based on the partially observed data were developed. These matrices had the advantage of including estimates of the movements not intercepted in the surveys and smoothing out the lumpiness in observed data.

The creation of synthetic matrices is a four stage process, and results in matrices that match the partially observed matrix movements at a sector to sector level as follows:

- assembly of synthesised trip ends;
- assembly of generalised cost matrices;
- assembly of trip cost distributions from the partial matrices; and
- trip matrix synthesis using either a gravity model or a destination choice model, including constraints to the partial matrices.

7.4.2. Assembly of Synthesised Trip Ends

Since the matrices from the existing validated highway assignment models were in the dimensions required (assignment hours and OD format), these were identified as the most convenient source for the full set of synthetic trip ends. It was necessary to split the trip ends from light vehicles into car and LGV, this was obtained from using split factors from the RSI MCC data. Two potential parent highway assignment models have been identified to provide the trip ends:

- the previous BAFB version of the SBL model (GBATS3 SBL 2009 v2 HAM) which validates in the South Bristol area of interest;
- the South Gloucestershire Core Strategy model (SGCS 2011) where the validation was focused north of the river.

Trip ends were taken from both of these models with the intention of focusing on the validation areas of each as the most reliable source. Thus trip ends for zones north of the river were initially taken from the SGCS 2011 model, while those south of the river were taken from the GBATS3 SBL 2009 v2 HAM. The total light vehicle trip ends from the two source models *before* any processing for GBATS3 SBL 2012 HAM are shown in Table 28:

Table 28. Numbers of Light Vehicle Trip Ends in Source Models

Time Period	Area	GBATS3 SBL 2009 v2 HAM		SGCS 2011 HAM	
		Origins	Destinations	Origins	Destinations
Morning peak hour	North of river	67,763	71,622	99,551	102,959
	South of river	40,462	36,603	47,405	43,996
	Total trip ends	**108,225**	**108,225**	**146,955**	**146,955**
Inter-peak hour	North of river	65,186	65,509	78,692	78,936
	South of river	36,203	35,880	36,120	35,876
	Total trip ends	**101,389**	**101,389**	**114,812**	**114,812**
Evening peak hour	North of river	72,097	69,029	95,889	93,868
	South of river	43,122	46,190	43,463	45,485
	Total trip ends	**115,220**	**115,220**	**139,353**	**139,353**

It should be noted that there are significant differences in the numbers of trips in the two models – more than might be expected from the change in base year (2009 to 2011). TEMPRO 6.2 was used to factor 2009 and 2011 trip ends to 2012. Examination of the two models' trip ends suggested that the use of SGCS 2011 trip ends for zones north of the river would be too large within the outer cordon so instead GBATS3 SBL 2009 v2 HAM trip ends were used. Post gravity model synthetic matrix tests (early equivalents of Test C results) led to further alterations to the trip ends used as input to the gravity model to match the calibration screenline counts.

7.4.3. Assembly of generalised cost matrices

As for the trip ends, the sources of the generalised costs are the GBATS3 SBL 2009 v2 HAM and SGCS 2011 HAMs. The inter-zonal times and distances are skimmed from each of the source models. The model used to provide costs for specific movements is shown in Table 29.

Table 29. Source of Initial Time and Distance Skims and Initial Trip Ends

Location	South River	North River	Total
South River	Time & distance skims from GBATS SBL 2009 v2 HAM	Time & distance skims from GBATS SBL 2009 v2 HAM	Trip ends from GBATS SBL 2009 v2 HAM
North River	Time & distance skims from GBATS SBL 2009 v2 HAM	Time & distance skims from SGCS 2011	Trip ends from SGCS 2011
Total	Trip ends from GBATS SBL 2009 v2 HAM	Trip ends from SGCS 2011	

Note: Repeated for each of 3 time periods (Morning peak, Inter-Peak and Evening peak).

The two models have different base years and the costs from the two models were converted to reflect March 2012. This involved calculating the values of time and distance as described in TAG Unit 3.5.6 (DfT April 2011). The following assumptions were made to calculate the values of time and distance:

- vehicle occupancies were extracted from the 2012 RSIs by time period vehicle type and, for car, by purpose;
- average speeds were derived from GBATS SBL 2009 v2 HAM; and
- trip purpose and vehicle type were derived from the partial matrix.

Intra-zonal costs were assumed to be 80% of the minimum (non-zero) inter-zonal trip cost for the particular origin zone. The same principle was applied for any other zero cost inter-zonal trips (both origin and destination were new zones).

7.4.4. Trip Cost Distributions

Trip cost distributions were produced for cars and LGVs for each of the 3 assignment hours. The trip cost distributions show the number of trips from the partial matrices in bands of generalised cost minutes. The trip cost distributions enable initial starting parameters in the gravity model to be estimated

As part of the validation of the gravity model the trip cost distributions were compared to the output of the gravity model (the synthetic matrix) to ensure that there is little change to the trip lengths as a result of the synthesis.

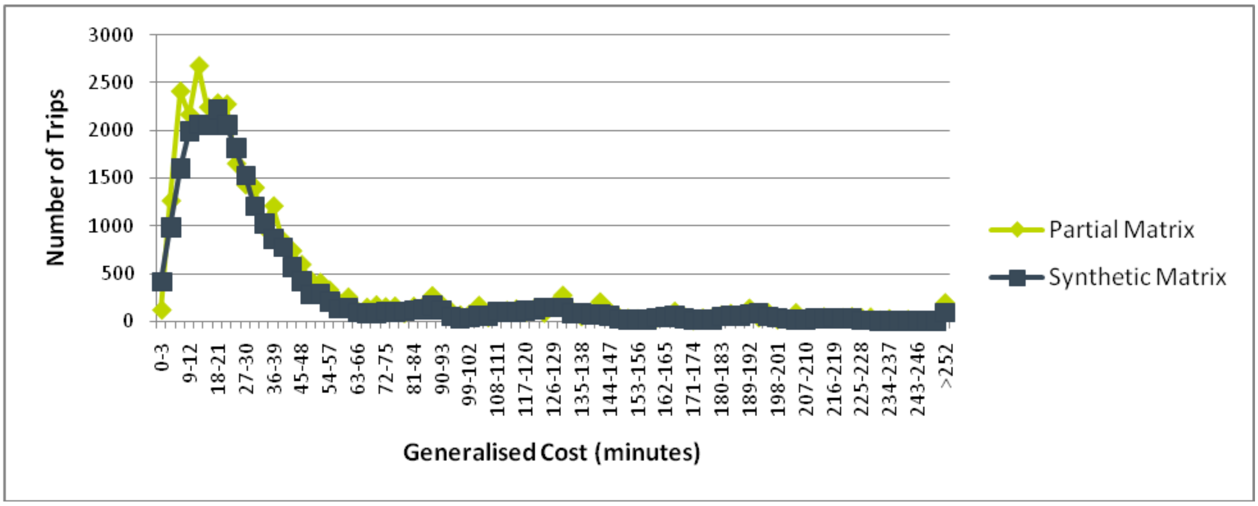
7.4.5. Trip Matrix Synthesis

The first stage of gravity modelling is calibration and this is where Tanner[3] function parameters are estimated to best match the partial matrices based on the generalised cost. The second stage is to use the parameters found in the calibration stage with the trip ends to obtain a synthetic matrix.

Assignment results equivalent to those of Prior Matrix Test C were produced and at this point revisions were made to the trip ends in order to improve the flow differences between the model assigned flows and counts across the two RSI cordons and the steps above repeated until the required level of acceptance was achieved.

The calibrated synthetic matrix was compared to the partial matrix to check that there were little changes to the trip costs as a result of the synthesis. The comparisons are shown in Figure 16 to Figure 21 below. The calibrated synthetic matrix is similar to the partial matrix except for the peak trip ends in all cases.

Figure 16. Trip Cost Distribution – Morning Peak - Car



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[3] The Tanner function produces a new trip matrix to reflect the change in demand bought about from the trip ends using the generalised cost (distance) of movements between two zones. Essentially the higher the generalised cost the lower the trips.

Figure 17. Trip Cost Distribution – Inter-Peak - Car

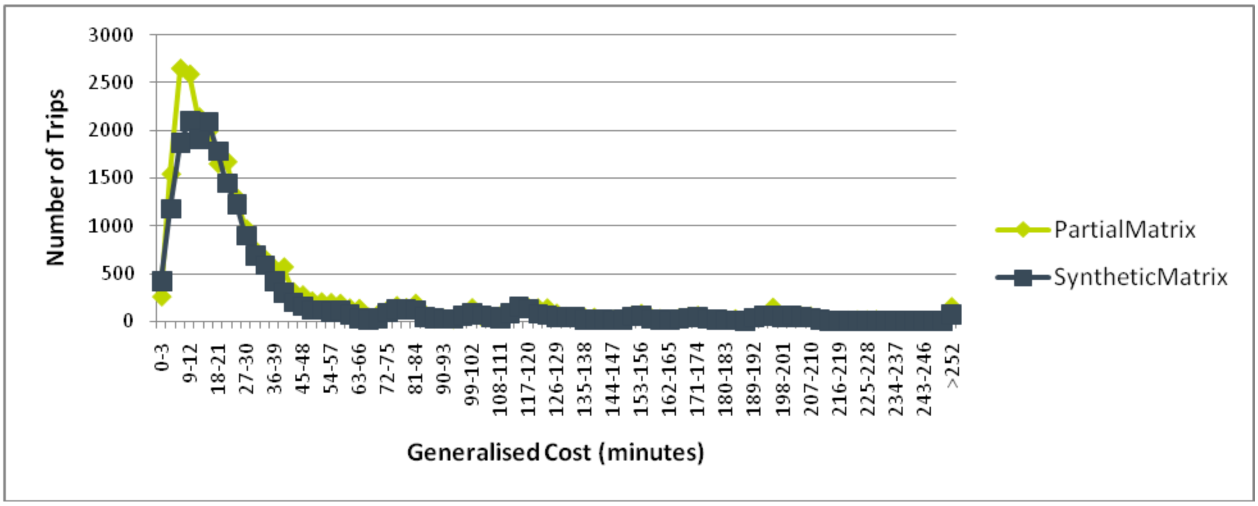


Figure 18. Trip Cost Distribution – Evening Peak - Car

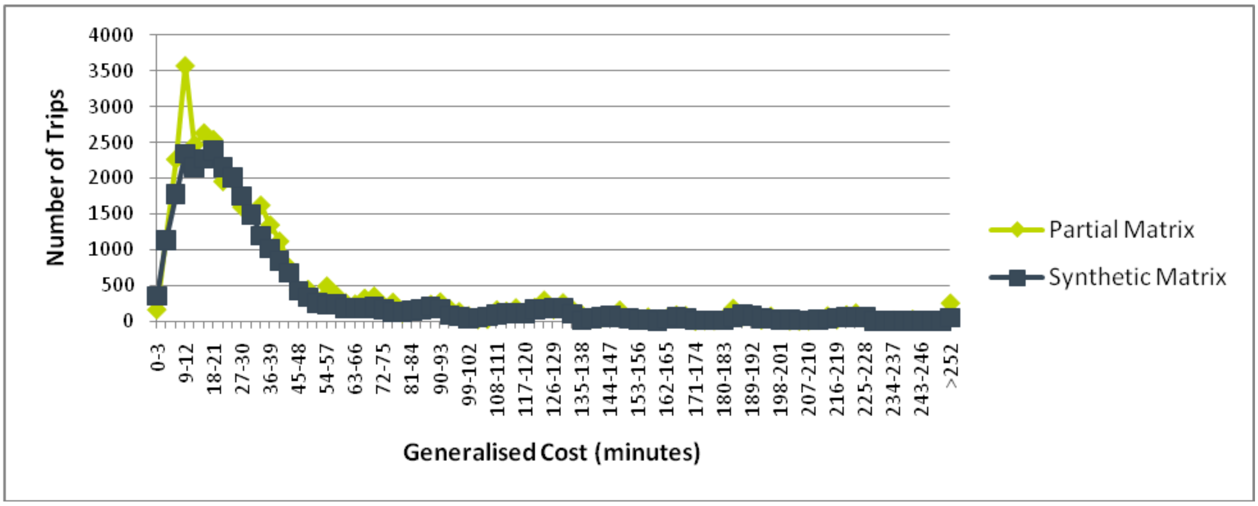


Figure 19. Trip Cost Distribution – Morning Peak - LGV

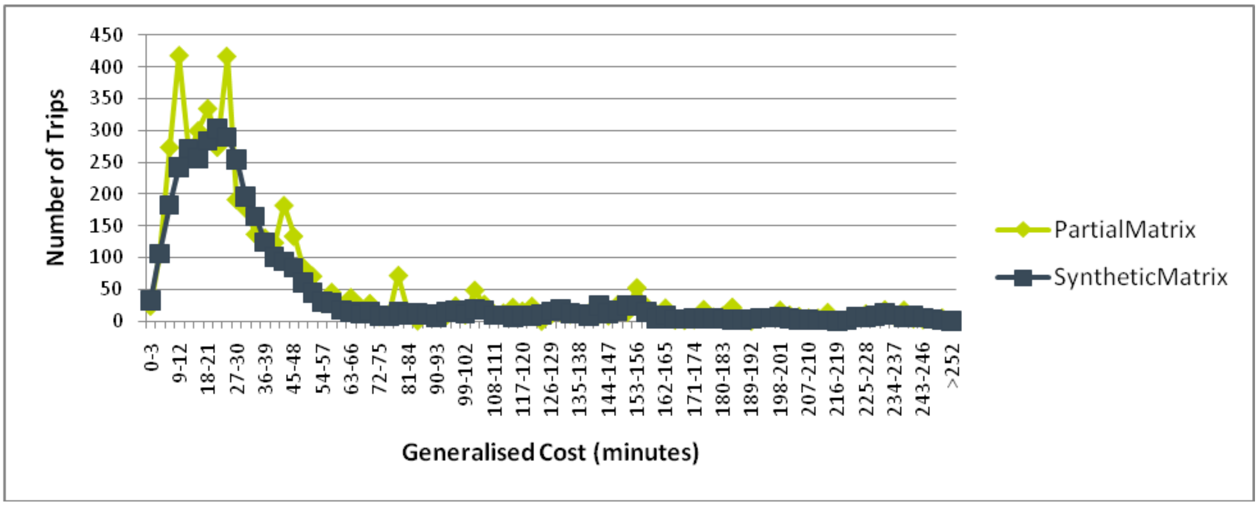


Figure 20. Trip Cost Distribution – Inter-Peak - LGV

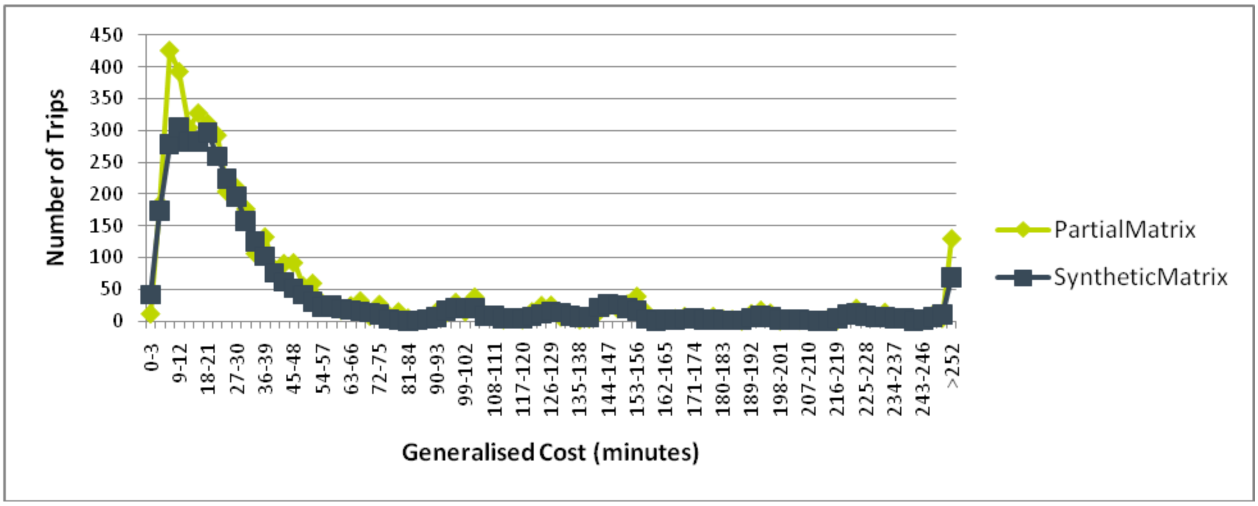
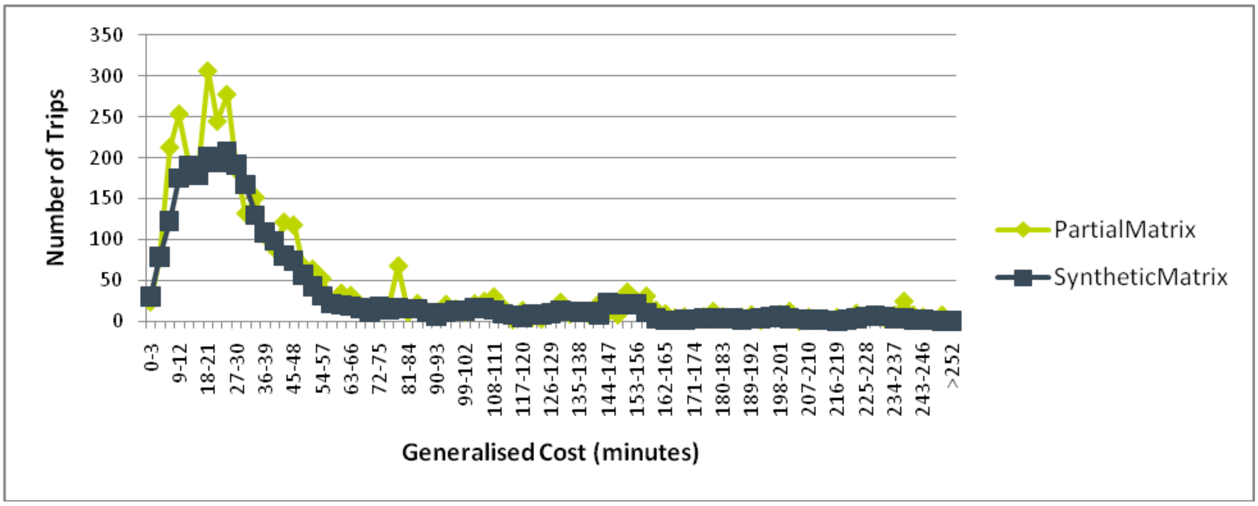


Figure 21. Trip Cost Distribution – Evening Peak - LGV



Having built the synthetic matrices these were compared with the count data using Test B (Table 30) to ensure that the data had been processed correctly and to ensure the merging / filtering process had resulted in matrices closely reflecting the count data for the cordon crossing movements.

Table 30. Prior Trip Matrix Test B

Comparison	Measure	Criterion	Acceptability guideline
Flows and counts of trips across RSI cordons, for the modelled hours separately.	Flow differences	< 5%	All or nearly all

The results of Tests B1 and B2 for the inner and outer cordons for each time period are shown in Table 31 and Table 32. For Test B1 all flow differences fall below the criteria except the outer cordon inbound for inter peak car, due to the use of SGCS 2011 trip ends for zones north of the river and outside the cordons and them being greater than the GBATS SBL 2009 v2 HAM. As the acceptability is met and the failing difference is with the outer cordon and hence is of less importance on the scheme the 3D-furness matrix is deemed suitable for use.

Table 31. Test B1 Results

Screenline		Direction	Morning Peak		Inter-Peak		Evening Peak	
			Car	LGV	Car	LGV	Car	LGV
RSI Cordon	Inner Cordon	Inbound	2%	2%	3%	3%	3%	2%
		Outbound	3%	2%	4%	4%	4%	3%
	Outer Cordon	Inbound	3%	4%	9%	4%	5%	5%
		Outbound	1%	-3%	4%	2%	3%	3%

Table 32. Test B2 Results

Screenline		Direction	Morning Peak		Inter-Peak		Evening Peak	
			Car	LGV	Car	LGV	Car	LGV
RSI Cordon	Inner Cordon	Inbound	-2%	10%	2%	1%	-7%	-3%
		Outbound	4%	22%	3%	-3%	-7%	4%
	Outer Cordon	Inbound	-3%	7%	-5%	-11%	-19%	-8%
		Outbound	-4%	2%	-6%	-4%	-15%	18%

7.5. External Movements

External movements include movements to and from zones outside the outer cordon, some of which would pass through the cordons and exist in the partial matrix (and hence synthetic matrix). In order to infill the remaining matrix the validated GBATS SBL 2009 v2 HAM and SGCS 2011 matrices were used. The external to external movements from the GBATS SBL 2009 v2 HAM matrix where the value was greater than that of the partial matrix value for the zone pairs south of the river were substituted into the matrix and for likewise the external to external movements from the SGCS 2011 model were used where a trip end was north of the river. In order to complete this it was necessary to split user class one (car and light goods vehicles combined) from the GBATS SBL 2009 v2 HAM and SGCS 2011 matrices into Car and light goods vehicles using the partial matrix split by time period for the external to external trips only. This method ensured that no external to external movements that cross the cordons picked up from the surveys were removed.

7.6. HGV matrices

No gravity modelling was performed when developing the HGV matrices, the remaining process was the same as that for car and LGV The steps to produce the matrices were as follows:

- The HGV partial matrices were developed by expanding the period records to the hourly count. Table 21 details the instances where this resulted in no records being expanded to a count. For these, if possible, a 12 hour collection of records was expanded to the hourly count and in the remaining instances records were borrowed from neighbouring sites.
- The partial HGV matrices were then sectored using the 12 sector system, obtained in from the confidence testing detailed above, for each time period.

- The existing HGV demand from the GBATS SBL 2009 v2 HAM and SGCS 2011 models were combined such that demand south of the river Avon was taken from GBATS SBL 2009 v2 HAM and north of the river Avon from SGCS 2011 (identical way to the cost skims were, as explained earlier in Table 29).
- These derived HGV matrices were controlled to the sectored partial matrix totals.

7.7. Prior Matrix Creation

The prior trip matrices were assigned and the assigned flows were compared to the count flows for each screenline and cordon using Test C (Table 34). If a screenline failed to meet the criterion of having a flow difference of less than 7.5% then any sector pairs found to have movements crossing it were altered to match the observed flow. This was an iterative process due to the close proximity of the screenlines within the inner cordon and the best prior matrix results for the cordon are shown below in Table 34. The results of Test C on the screenlines can be seen in Table 36 in the chapter detailing the calibration.

Table 33. Prior Trip Matrix Test C

Comparison	Measure	Criterion	Acceptability guideline
Total assigned flows and total counts in both directions across RSI cordons and screenlines, for each modelled hour.	Flow differences	< 7.5%	All or nearly all

The results of Test C for the inner and outer cordons for each time period are shown in Table 34 for the actual flows and Table 35 for the demand flows. All flow differences fall below the criteria except the inner cordon inbound for morning peak car on the cordons, for the screenlines there are more that fail.

Table 34. Test C Results – Actual Flow

Screenline		Direction	AM		IP		PM	
			Car	LGV	Car	LGV	Car	LGV
RSI Cordon	Inner Cordon	Inbound	9%	0%	2%	3%	-2%	0%
		Outbound	0%	2%	1%	4%	1%	1%
	Outer Cordon	Inbound	2%	2%	2%	2%	0%	3%
		Outbound	1%	3%	1%	3%	1%	3%
Screenline	Central (S2)	Westbound	-7%	0%	2%	8%	-6%	3%
		Eastbound	13%	8%	5%	10%	6%	25%
	River	Northbound	-3%	-9%	5%	5%	-4%	7%
		Southbound	-1%	-1%	-5%	-4%	-12%	-9%
	Bishopsworth	Northbound	-7%	-27%	-18%	-26%	-38%	-44%
		Southbound	2%	-11%	-11%	2%	-17%	-24%
	Hengrove	Northbound	-3%	-9%	1%	-13%	21%	4%
		Southbound	-1%	-18%	-6%	-19%	-9%	-26%
	Pidgeonhouse	Westbound	4%	-6%	-11%	-3%	-2%	-3%
		Eastbound	-19%	-32%	-27%	-37%	-37%	-39%
	Highridge	Westbound	-23%	-32%	-26%	-23%	-13%	-19%
		Eastbound	8%	-15%	-4%	-11%	-7%	-8%
	Long Ashton	Inbound	-7%	-5%	-4%	1%	-11%	-10%

		Outbound	-8%	0%	0%	6%	-8%	-4%

Table 35. Test C Results – Demand Flow

Screenline		Direction	AM		IP		PM	
			Car	LGV	Car	LGV	Car	LGV
RSI Cordon	Inner Cordon	Inbound	9%	0%	2%	3%	-3%	-1%
		Outbound	0%	2%	1%	4%	0%	1%
	Outer Cordon	Inbound	1%	2%	2%	2%	-1%	1%
		Outbound	0%	2%	1%	3%	-1%	1%
Screenline	Central (S2)	Westbound	-8%	-1%	2%	8%	-7%	1%
		Eastbound	13%	8%	5%	10%	5%	23%
	River	Northbound	-4%	-10%	5%	5%	-5%	6%
		Southbound	-1%	-2%	-5%	-4%	-13%	-10%
	Bishopsworth	Northbound	-7%	-27%	-18%	-26%	-38%	-44%
		Southbound	2%	-11%	-11%	2%	-18%	-24%
	Hengrove	Northbound	-3%	-9%	1%	-13%	19%	1%
		Southbound	-1%	-19%	-6%	-19%	-10%	-27%
	Pidgeonhouse	Westbound	4%	-7%	-11%	-3%	-3%	-4%
		Eastbound	-19%	-32%	-27%	-37%	-37%	-39%
	Highridge	Westbound	-23%	-32%	-26%	-23%	-14%	-20%
		Eastbound	8%	-15%	-4%	-11%	-8%	-8%
	Long Ashton	Inbound	-7%	-6%	-4%	1%	-11%	-10%
		Outbound	-8%	0%	0%	6%	-9%	-5%

8. Network Calibration and Validation

8.1. Network Calibration

The SBL highway network was developed from the earlier GBATS SBL 2009 v2 HAM model and updated to a 2012 base year, as described in Section 6. A number of checks were undertaken on the network coding including:

- reviewing the warnings produced by SATNET, the SATURN network building software;
- the coded link distances versus crow-fly distances;
- coded link speeds and speed-flow curves; and
- coded junction saturation flows.

Link distances were compared to crow-fly link lengths and those greater than 1.3 times the crow-fly distance were inspected. Excluding the links that represent centroid connector stubs, those links representing expanded junctions and those with a difference of less than 10 metres (to account for any loss of accuracy when assigning co-ordinates to a node) 3% of links in South Bristol are outside of the criteria.

During the model calibration, there were a large number of changes undertaken principally at the individual junction level to improve the overall performance of the model. These included the following:

- **Counts in excess of capacity** – where an observed count was noticeably higher than the coded network capacity the capacities where checked and amended if necessary;
- **Excessive junction delays** – the largest overall delays, and the largest differences between the link travel times and the moving car observer data were checked and junction coding checked;
- **Low flows** – where the modelled flow was substantially below that counted; this revealed locations where traffic was either restricted at an upstream junction or where a competing route was more attractive; and
- **Poor reproduction of observed travel times** - detailed comparisons of modelled travel times against the observed journey time routes revealed locations where additional modifications to signal settings were necessary in order to replicate the observed levels of delay.

8.2. Route Choice Calibration and Validation

The accuracy of the assignment depends on the network structure, the trip matrix and the realism of modelled routes. Checks undertaken on the model prior to assignment to confirm the network was suitable for the matrix development.

8.2.1. Route Choice Calibration

The ability of model to robustly represent route choice within the network depends on:

- correct zone sizing and definition, network structure and the realism of the zone connections to the modelled network (centroid connectors);
- the accuracy of the network coding and the appropriateness of the simplifications adopted;
- the accuracy with which delays at junctions and link cruise speeds are modelled, which in turn is dependent not only on data and/or coding accuracy but also on the appropriateness of the approximations inherent in the junction flow/delay and link speed/flow relationships; and
- how accurately the trip matrices have been built, which, when assigned, will impact on the route choice process (via the flow/delay and speed/flow relationships).

During the route choice calibration process, any issues such as these, which arose from incorrect or doubtful route choices, were examined in detail, and where appropriate corrections/changes to the junction coding are implemented.

8.2.2. Route Choice Validation

No specific criterion exists for validating route choices within a modelled network. However, it is common practice to undertake to review the routing chosen by the model between key locations and TAG Unit 3.19 suggests that the number of routs (OD pairs) should be estimated as:

$$\text{Number of OD pairs} = (\text{number of zones})^{0.25} \text{ x the number of user classes}$$

This equates to approximately 15 routes (five routes for each time period). The analysis of the routes selected did not highlight any errors in the underlying network coding. Further information may be found in Appendix C .

9. Trip Matrix Calibration

9.1. Case for Matrix Estimation

TAG Unit 3.19 advises that the primary purpose of matrix estimation is to refine estimates of trips not intercepted in surveys which have been synthesised, usually by means of a gravity model. The development of the prior matrix was described in the previous section and the modelled flows were compared to the observed counts for the calibration cordons and screenlines to determine whether further matrix calibration was required using matrix estimation.

The comparison of the observed and modelled flows across the screenlines is summarised in Table 36 and showed that the replication of the observed cordon and screenline flows was outside the TAG Unit 3.19 targets (as defined in Table 1 for total screenline flow) for all three time periods. As such, matrix estimation was applied to the prior trip matrix to improve the matrix calibration and the following principles were adopted:

- the effects of matrix estimation were minimised;
- count constraints were usually grouped and applied at the short screenline level;
- counts used as constraints in matrix estimation were usually derived from two-week ATCs; and
- constraints were applied at the car, LGV and HGV level.

9.2. Application of Matrix Estimation

The SATURN modules SATME2 and SATPIJA are used for matrix estimation and in combination attempt to match assigned link flows in the model with observed traffic counts. Checks were made to ensure that the overall trip distribution of the original trip matrix was maintained.

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 matrix to produce the estimated matrix, which is most likely to be consistent with the traffic counts. The equation used was:

$$T_{ij} = tij \prod_a X_a^{Pija}$$

where:

- T_{ij} is the output matrix of OD pairs ij;
- tij is the prior matrix of OD pairs ij;
- $\prod_a$ is the product over all counted links a;
- X_a is the balancing factor associated with counted link;
- ^{Pija} is the fraction of trips from i to j using link a.

The changes brought about by matrix estimation should be monitored by the following means:

- scatter plots of matrix zonal cell values, prior to and post matrix estimation, with regression statistics (slopes, intercepts and R2 values);
- scatter plots of zonal trip ends, prior to and post matrix estimation, with regression statistics (slopes, intercepts and R2 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 matrix estimation process was examined to ensure that the estimated matrix converged to a stable solution. The post matrix should reflect more closely the pattern of observed traffic on the network and, as such, provide an improved representation of travel patterns in the area.

The key advice in TAG Unit 3.19, shown in Table 4, is that the changes brought about by matrix estimation should not be significant and that all exceedances of these criteria should be examined and assessed for their importance for the accuracy of the matrices in the FMA or the area of influence of the scheme to be assessed.

Table 36. Summary of Cordon and Screenline Validation (Prior Matrix)

Screenline		Direction	AM				IP				PM			
			Car	LGV	HGV	Total	Car	LGV	HGV	Total	Car	LGV	HGV	Total
RSI Cordon	Inner Cordon	Inbound	9%	0%	-14%	6%	2%	3%	-3%	1%	-2%	0%	-15%	-2%
		Outbound	0%	2%	-18%	-1%	1%	4%	-3%	0%	1%	1%	-13%	0%
	Outer Cordon	Inbound	2%	2%	-3%	1%	2%	2%	1%	1%	0%	3%	-3%	0%
		Outbound	1%	3%	-2%	1%	1%	3%	-8%	0%	1%	3%	-4%	0%
Matrix Estimation Screenline	Central (S2)	Westbound	-7%	0%	17%	-6%	2%	8%	35%	3%	-6%	3%	21%	-5%
		Eastbound	13%	8%	23%	12%	5%	10%	38%	6%	6%	25%	25%	8%
	River	Northbound	-3%	-9%	3%	-3%	5%	5%	1%	5%	-4%	7%	-1%	-2%
		Southbound	-1%	-1%	-2%	-1%	-5%	-4%	4%	-4%	-12%	-9%	-1%	-12%
	Bishopsworth	Northbound	-7%	-27%	87%	-8%	-18%	-26%	96%	-16%	-38%	-44%	47%	-37%
		Southbound	2%	-11%	114%	3%	-11%	2%	64%	-6%	-17%	-24%	91%	-16%
	Hengrove	Northbound	-3%	-9%	40%	-2%	1%	-13%	44%	0%	21%	4%	40%	20%
		Southbound	-1%	-18%	62%	-2%	-6%	-19%	50%	-7%	-9%	-26%	31%	-10%
	Pidgeonhouse	Westbound	4%	-6%	10%	2%	-11%	-3%	50%	-8%	-2%	-3%	2%	-2%
		Eastbound	-19%	-32%	37%	-20%	-27%	-37%	33%	-27%	-37%	-39%	85%	-36%
	Highridge	Westbound	-23%	-32%	-25%	-24%	-26%	-23%	-9%	-25%	-13%	-19%	-68%	-14%
		Eastbound	8%	-15%	-60%	3%	-4%	-11%	-65%	-7%	-7%	-8%	-54%	-7%
	Long Ashton	Inbound	-7%	-5%	0%	-7%	-4%	1%	8%	-3%	-11%	-10%	-18%	-11%
		Outbound	-8%	0%	-43%	-9%	0%	6%	-2%	0%	-8%	-4%	3%	-8%

9.3. Changes due to Matrix Estimation

9.3.1. Matrix Totals

A comparison of the total number of trips before and after application of the matrix estimation process is shown in Table 37. The matrix estimation process typically changed the overall number of trips in the car and light goods vehicle matrices by less than +2% in all three time periods. The HGV matrix has changed by up to - 2% in the two peak hour models and reduced by 2% (<100 pcus/h) in the Inter-peak matrix.

Table 37. Comparison of Matrix Totals - Prior versus Post ME2

Time Period	Car			LGV			HGV		
	Prior	Post ME2	% Change	Prior	Post ME2	% Change	Prior	Post ME2	% Change
AM	96,104	96,722	0.6%	15,387	15,546	1.0%	13,389	13,197	-1.4%
IP	74,619	75,131	0.7%	13,704	13,765	0.4%	14,806	14,486	-2.2%
PM	98,063	99,521	1.5%	11,154	11,330	1.6%	7,403	7,314	-1.2%

Units: pcu/h

9.3.2. Matrix Zonal Cell Values

The changes are the matrix zonal level are summarised below in Table 38 whilst Figure 22 to Figure 23 show the scatter plots, for all vehicles combined. The analysis is presented for the whole geographic area of the matrix and also for all trips to, from and through south Bristol but excluding those trips that are between zones that are north of the River Avon. The analysis shows that in all but a very few instances the impact of matrix estimation at a cell to cell level across the whole matrix is within benchmark criteria. Considering a matrix that excludes trips exclusively in north Bristol reveals that the matrix meets slope and intercept whilst narrowly missing the R^2>0.95 criteria in the morning and evening peaks.

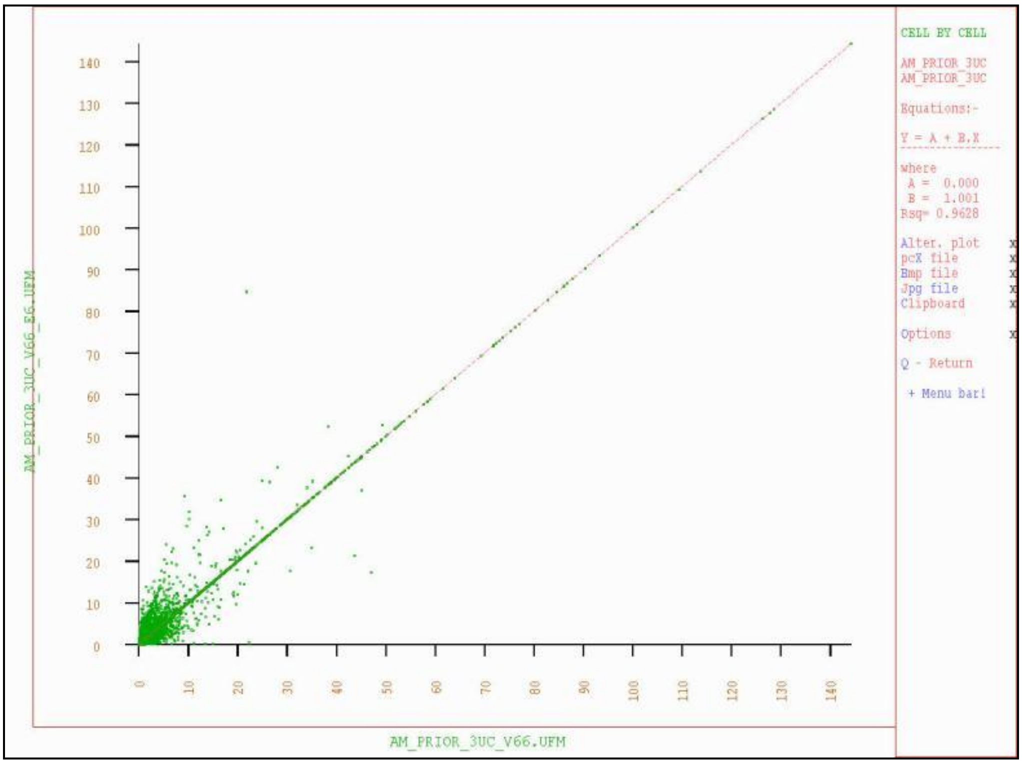
Table 38. Matrix Zonal Cell Regression Analysis

Time	Matrix	Significance criteria		Total	Car	LGV	HGV
Morning peak (08:00-09:00)	Whole Matrix	Slope	0.98<Slope<1.02	1.00	1.01	0.99	0.98
		Intercept	near 0	0.00	0.00	0.00	0.00
		R^2	>0.95	0.96	0.96	0.93	0.97
	Matrix excluding trips exclusively in the north of Bristol	Slope	0.98<Slope<1.02	1.00	1.01	0.99	0.98
		Intercept	near 0	0.00	0.00	0.00	0.00
		R^2	>0.95	0.94	0.93	0.90	0.96
Inter-peak (ave hr 10:00-16:00)	Whole Matrix	Slope	0.98<Slope<1.02	1.00	1.01	1.00	0.99
		Intercept	near 0	0.00	0.00	0.00	0.00
		R^2	>0.95	0.98	0.98	0.97	0.96
	Matrix excluding trips exclusively in the north of Bristol	Slope	0.98<Slope<1.02	1.00	1.01	1.01	0.99
		Intercept	near 0	0.00	0.00	0.00	0.00
		R^2	>0.95	0.97	0.98	0.95	0.95

Time	Matrix	Significance criteria		Total	Car	LGV	HGV
Evening peak (17:00-18:00)	Whole Matrix	Slope	0.98<Slope<1.02	1.00	1.00	1.00	0.99
		Intercept	near 0	0.00	0.00	0.00	0.00
		R^2	>0.95	0.96	0.95	0.90	0.99
	Matrix excluding trips exclusively in the north of Bristol	Slope	0.98<Slope<1.02	1.00	1.01	1.00	0.99
		Intercept	near 0	0.00	0.00	0.00	0.00
		R^2	>0.95	0.93	0.93	0.85	0.98

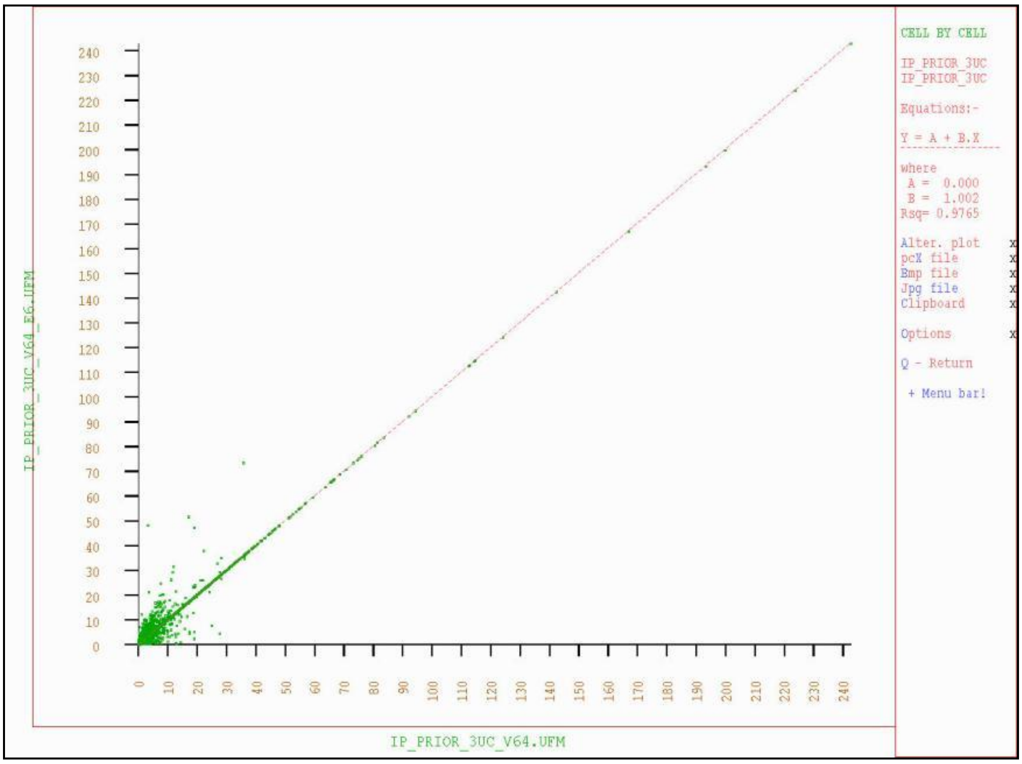
Note: Near zero assumed to be <5 considering mean trip end is 61

Figure 22. Matrix Zonal Cell Scatter Plot - Morning Peak (All Vehicles)



Units: pcu/h

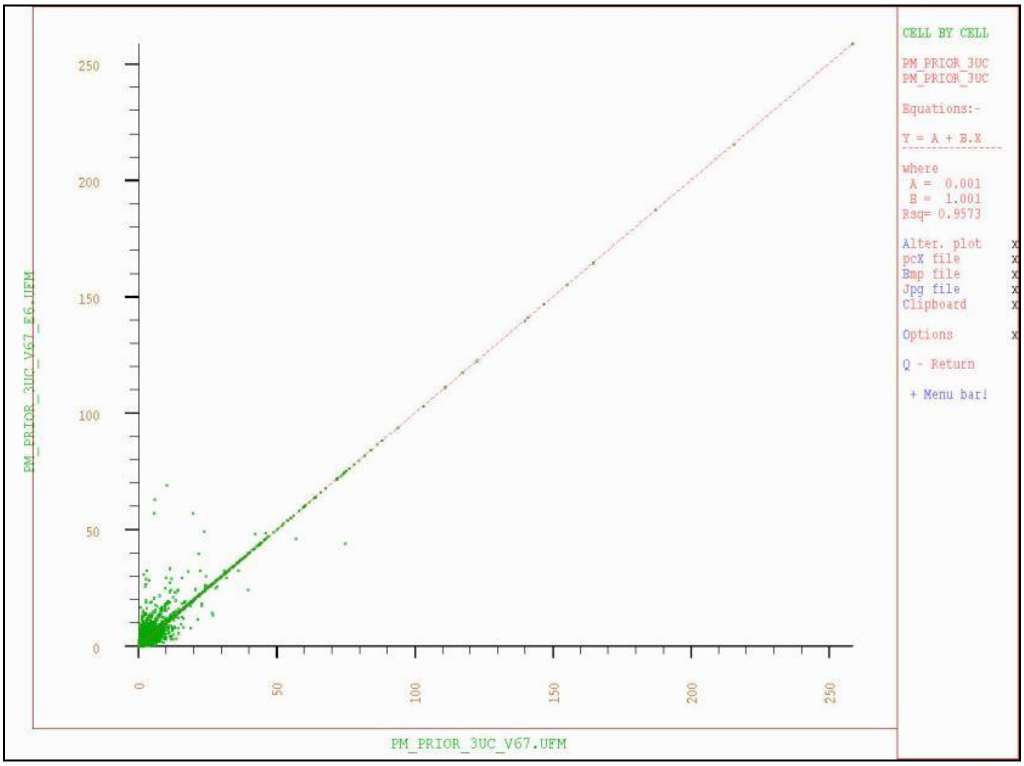
Figure 23. Matrix Zonal Cell Scatter Plot - Inter Peak (All Vehicles)



```
CELL BY CELL

IP_PRIOR_3UC
IP_PRIOR_3UC

Equations:-

Y = A + B.X

where
 A =  0.000
 B =  1.002
Rsq= 0.9765
```

Units: pcu/h

Figure 24. Matrix Zonal Cell Scatter Plot – Evening Peak (All Vehicles)



```
CELL BY CELL

PM_PRIOR_3UC
PM_PRIOR_3UC

Equations:-

Y = A + B.X

where
 A =  0.001
 B =  1.001
Rsq= 0.9573
```

Units: pcu/h

9.3.3. Matrix Zonal Trip Ends

The changes are the matrix zonal trip end level are summarised below in Table 39 whilst Figure 25 to Figure 27 shows the scatter plots, for all vehicles combined. The analysis is presented for the whole geographic area of the matrix and also for all trips to, from and through south Bristol but excluding those trips that are between zones that are north of the River Avon. The analysis is also presented for all vehicle types.

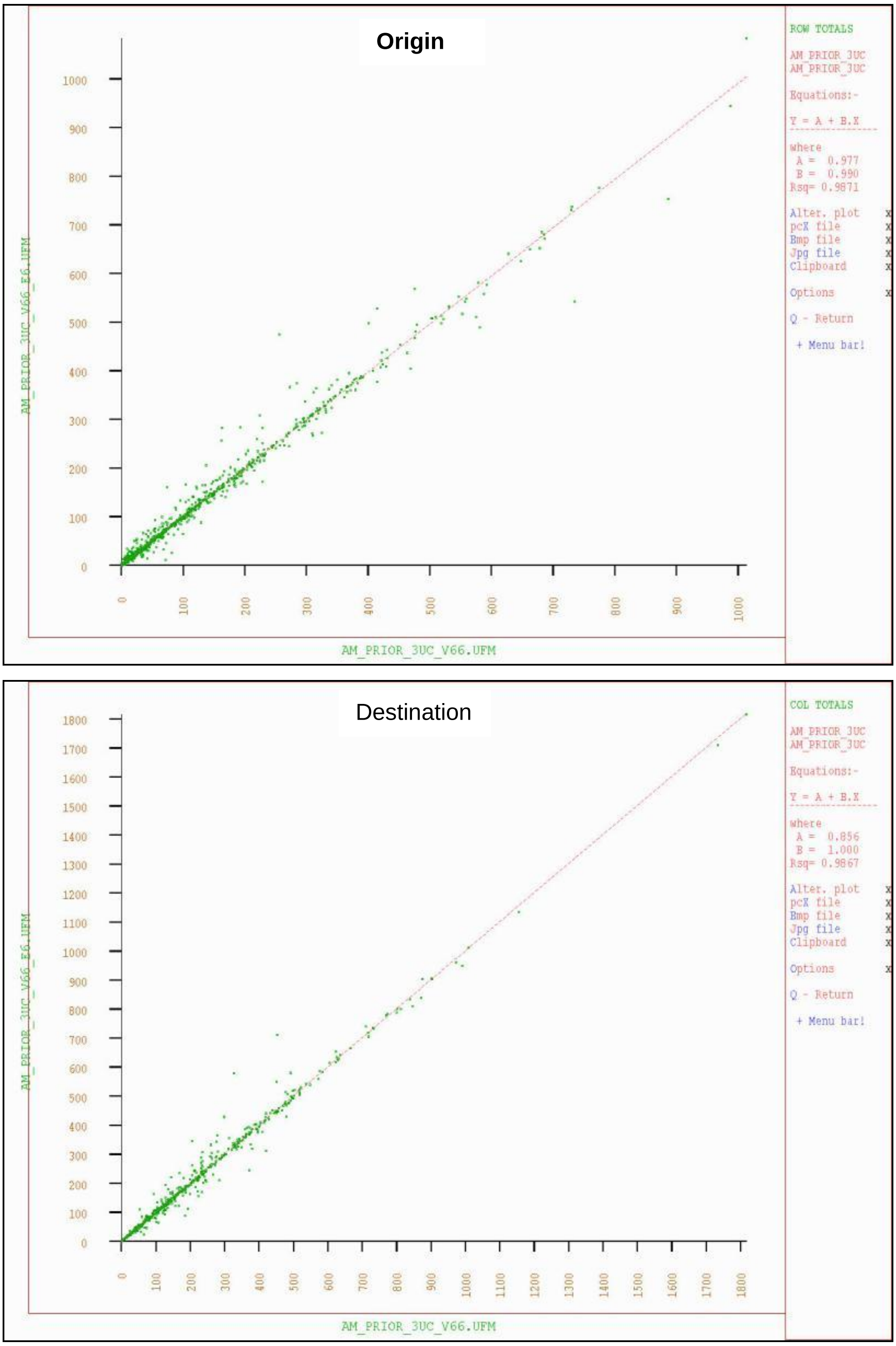
The analysis shows that in all but a very few instances the impact of matrix estimation at a zonal trip end level across the whole matrix and, specifically to SBL, a matrix excluding trips exclusively in the north of Bristol is within benchmark criteria.

Table 39. Trip End Level Regression Analysis

Time	All or part of matrix		Significance criteria		Total	Car	LGV	HGV
Morning peak (08:00-09:00)	Whole Matrix	Origin	Slope	0.99<Slope<1.01	0.99	0.98	1.00	1.00
			Intercept	near 0	0.98	3.86	0.38	-0.25
			R^2	>0.98	0.99	0.98	0.98	0.99
		Destination	Slope	0.99<Slope<1.01	1.00	1.00	1.00	1.00
			Intercept	near 0	0.86	1.32	0.30	-0.23
			R^2	>0.98	0.99	0.98	0.98	0.99
	Matrix excluding trips exclusively in the north of Bristol	Origin	Slope	0.99<Slope<1.01	0.99	0.98	1.00	0.99
			Intercept	near 0	0.76	2.57	0.30	-0.17
			R^2	>0.98	0.98	0.97	0.97	0.99
		Destination	Slope	0.99<Slope<1.01	1.01	1.01	1.01	0.99
			Intercept	near 0	-0.09	0.06	0.17	-0.16
			R^2	>0.98	0.98	0.97	0.95	0.99
Inter-Peak (ave hr 10:00-16:00)	Whole Matrix	Origin	Slope	0.99<Slope<1.01	1.00	1.00	0.99	0.99
			Intercept	near 0	0.00	0.78	0.24	-0.51
			R^2	>0.98	0.99	0.99	0.98	0.99
		Destination	Slope	0.99<Slope<1.01	1.00	1.01	1.00	0.99
			Intercept	near 0	-0.15	-0.04	0.16	-0.29
			R^2	>0.98	0.99	0.98	0.98	0.99
	Matrix excluding trips exclusively in the north of Bristol	Origin	Slope	0.99<Slope<1.01	1.00	1.00	0.99	1.00
			Intercept	near 0	0.00	0.60	0.24	-0.49
			R^2	>0.98	0.99	0.99	0.98	0.99
		Destination	Slope	0.99<Slope<1.01	1.01	1.01	1.01	0.99
			Intercept	near 0	-0.18	-0.30	0.03	-0.33
			R^2	>0.98	0.99	0.98	0.96	0.99

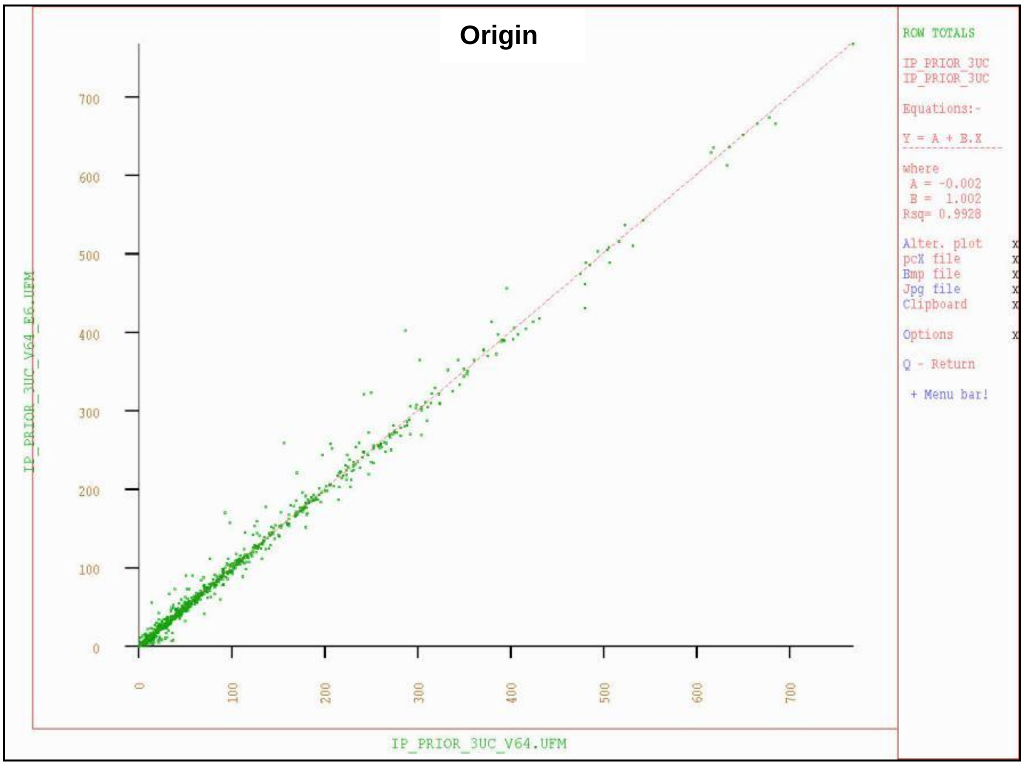
Time	All or part of matrix		Significance criteria		Total	Car	LGV	HGV
Evening peak (17:00-18:00)	Whole Matrix	Origin	Slope	0.99<Slope<1.01	1.00	0.99	0.98	1.00
			Intercept	near 0	0.96	3.95	0.63	-0.16
			R^2	>0.98	0.99	0.98	0.97	1.00
		Destination	Slope	0.99<Slope<1.01	1.02	1.02	1.00	1.00
			Intercept	near 0	-0.66	-0.73	0.24	-0.15
			R^2	>0.98	0.98	0.98	0.96	1.00
	Matrix excluding trips exclusively in the north of Bristol	Origin	Slope	0.99<Slope<1.01	1.00	1.00	0.99	1.00
			Intercept	near 0	0.81	3.07	0.41	-0.14
			R^2	>0.98	0.98	0.97	0.95	1.00
		Destination	Slope	0.99<Slope<1.01	1.04	1.04	1.02	1.00
			Intercept	near 0	-1.50	-1.71	0.11	-0.12
			R^2	>0.98	0.97	0.97	0.94	1.00

Figure 25. Origin / Destination Trip End Scatter Plot - Morning Peak (All Vehicles)

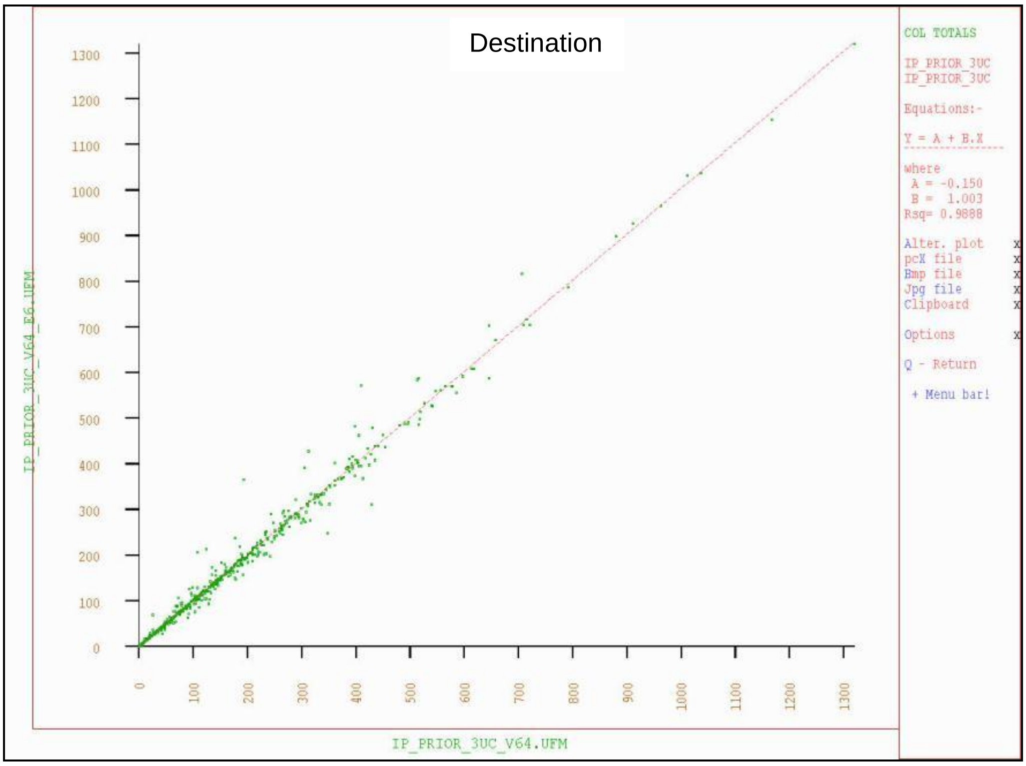


Units: pcu/h

Figure 26. Origin / Destination Trip End Scatter Plot - Inter-Peak (All Vehicles)



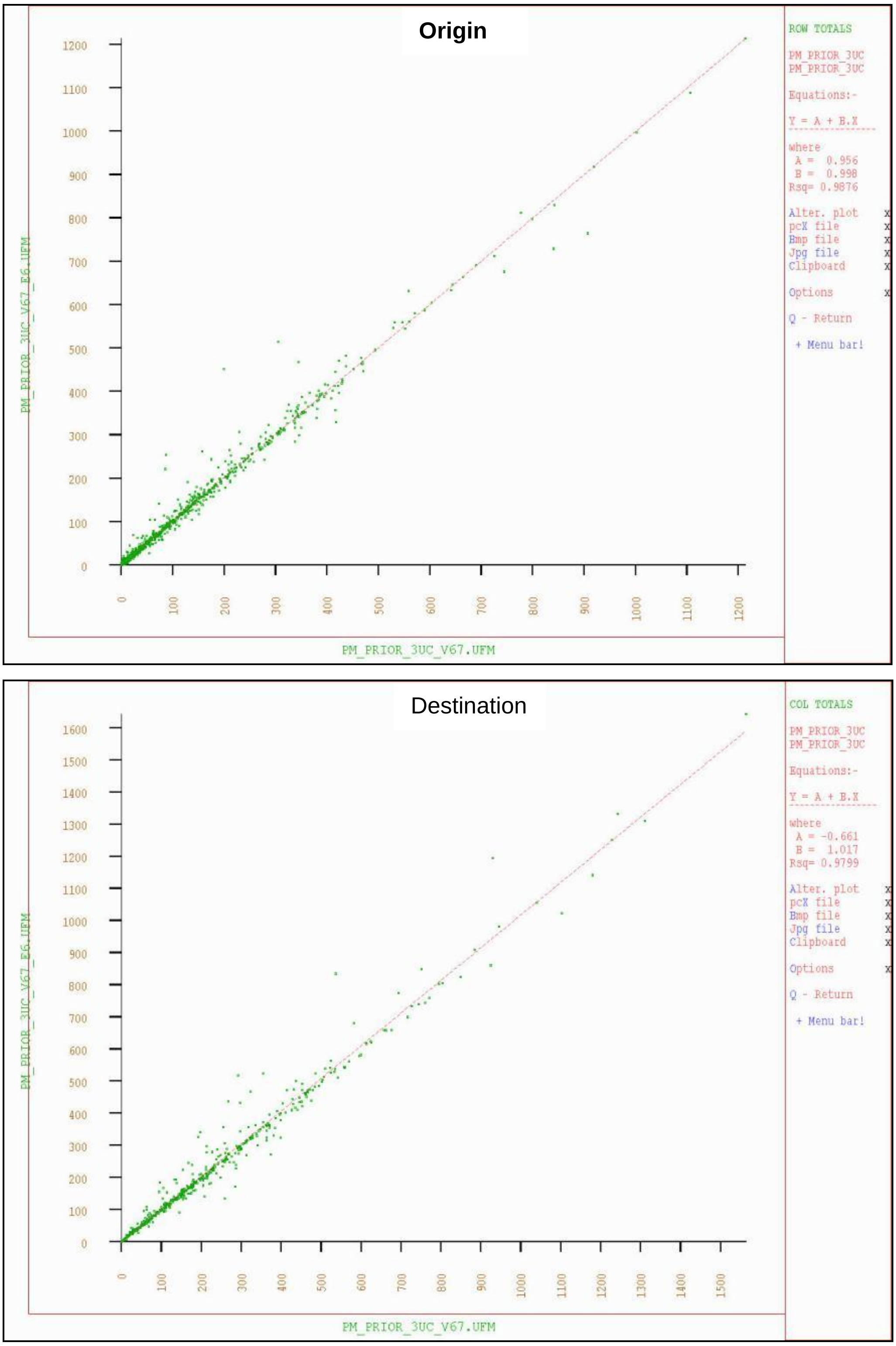
```
ROW TOTALS
IP_PRIOR_3UC
IP_PRIOR_3UC
Equations:-
Y = A + B.X
where
 A = -0.002
 B =  1.002
Rsq= 0.9928
```



```
COL TOTALS
IP_PRIOR_3UC
IP_PRIOR_3UC
Equations:-
Y = A + B.X
where
 A = -0.150
 B =  1.003
Rsq= 0.9888
```

Units: pcu/h

Figure 27. Origin / Destination Trip End Scatter Plot – Evening Peak (All Vehicles)



Units: pcu/h

9.3.4. Trip Length Distribution

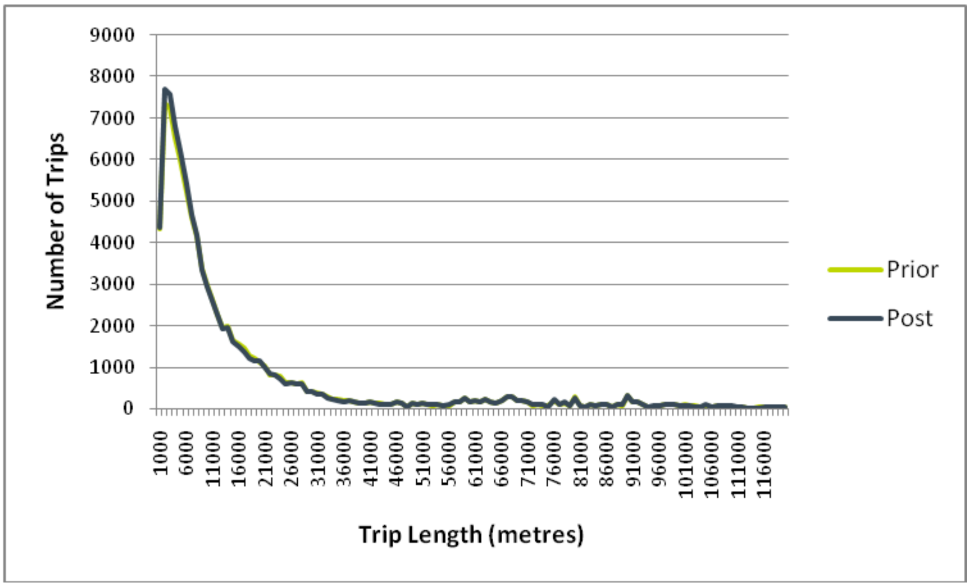
The changes in the average trip length distribution resulting from matrix estimation by time period and user class is summarised below in Table 40 whilst Figure 28 to Figure 36 compare the trip length distributions for the pre and post matrix estimation matrices for each time period and vehicle class.

The analysis shows that in all cases the impact of matrix estimation on trip length distribution is within benchmark criteria.

Table 40. Comparison of Trip Length Distributions - Prior versus Post ME2

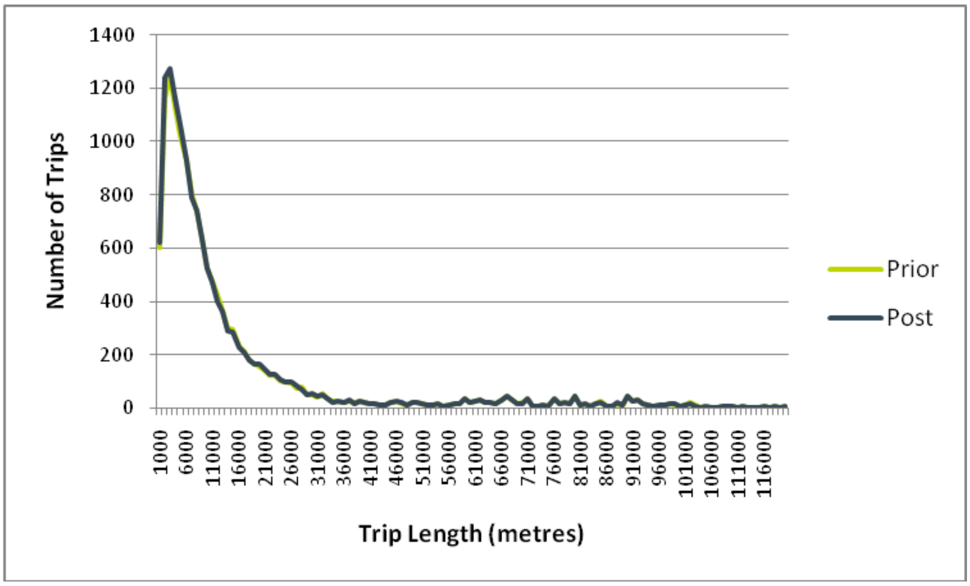
Time	Significance criteria		Car	LGV	HGV
Morning peak (08:00-09:00)	Difference in means	<5%	-1.8%	-1.0%	1.5%
	Difference in standard deviation	<5%	-0.5%	-0.4%	0.3%
Inter-peak (ave hr 10:00-16:00)	Difference in means	<5%	-0.8%	-1.1%	2.1%
	Difference in standard deviation	<5%	-0.3%	0.0%	0.2%
Evening peak (17:00-18:00)	Difference in means	<5%	-1.0%	-1.5%	1.8%
	Difference in standard deviation	<5%	-0.4%	-0.4%	0.2%

Figure 28. Trip Length Distribution for Morning Peak (UC1 Car)



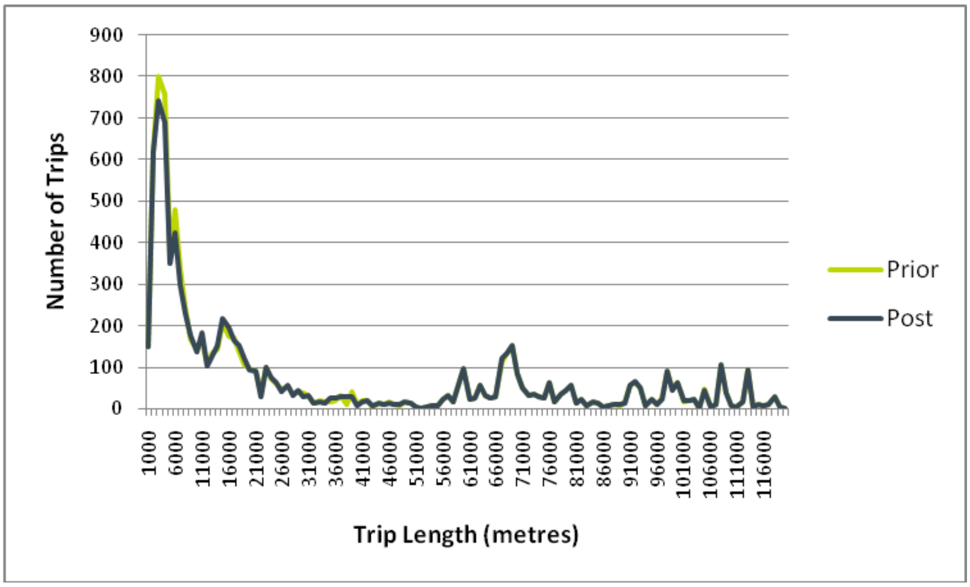
Units: pcu/h

Figure 29. Trip Length Distribution for Morning Peak (UC2 LGV)



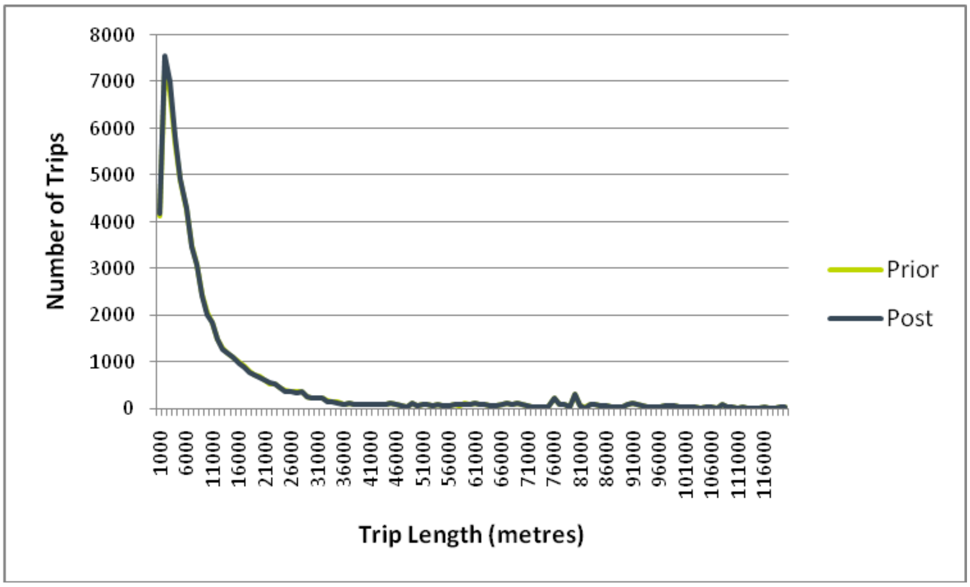
Units: pcu/h

Figure 30. Trip Length Distribution for Morning Peak (UC3 HGV)



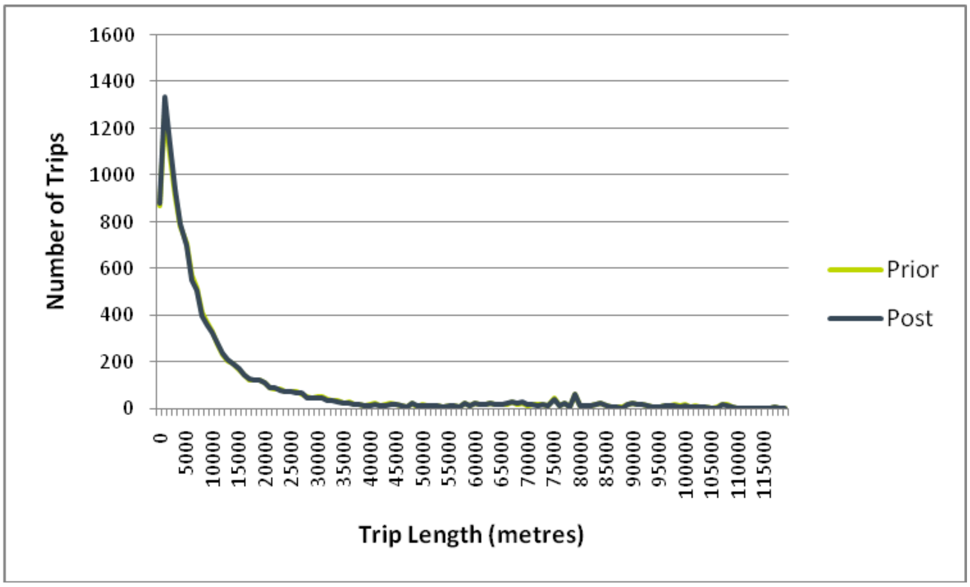
Units: pcu/h

Figure 31. Trip Length Distribution for Inter-Peak (UC1 Car)



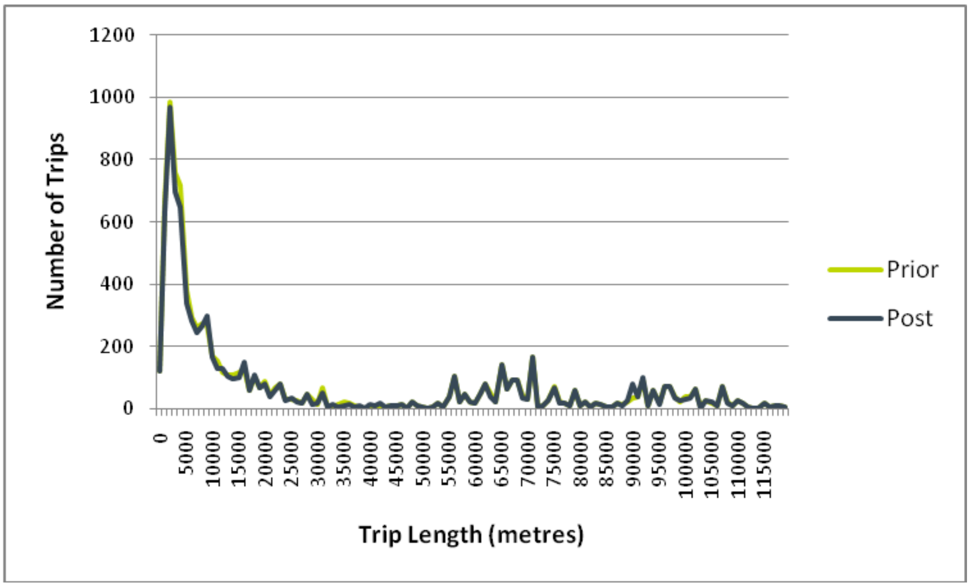
Units: pcu/h

Figure 32. Trip Length Distribution for Inter-Peak (UC2 LGV)



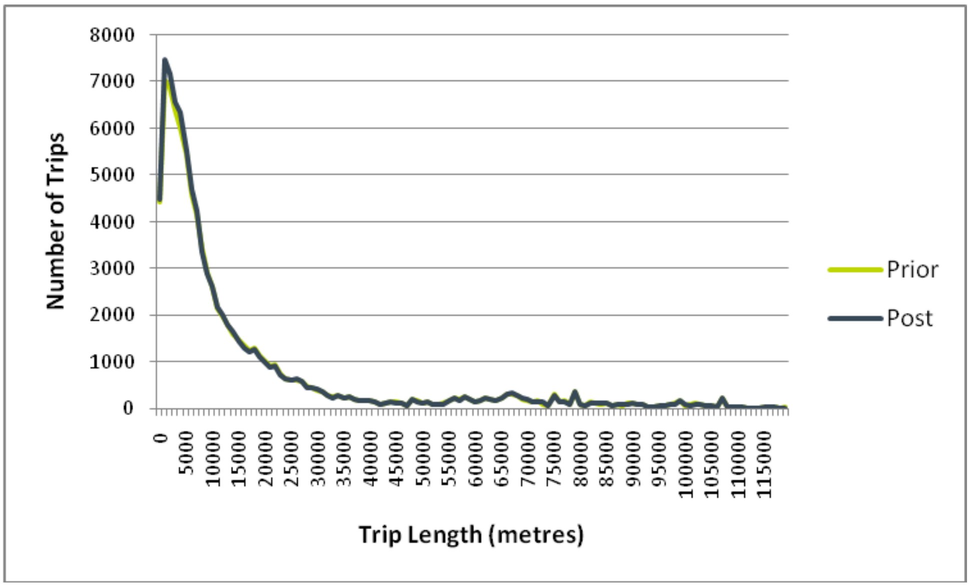
Units: pcu/h

Figure 33. Trip Length Distribution for Inter-Peak (UC3 HGV)



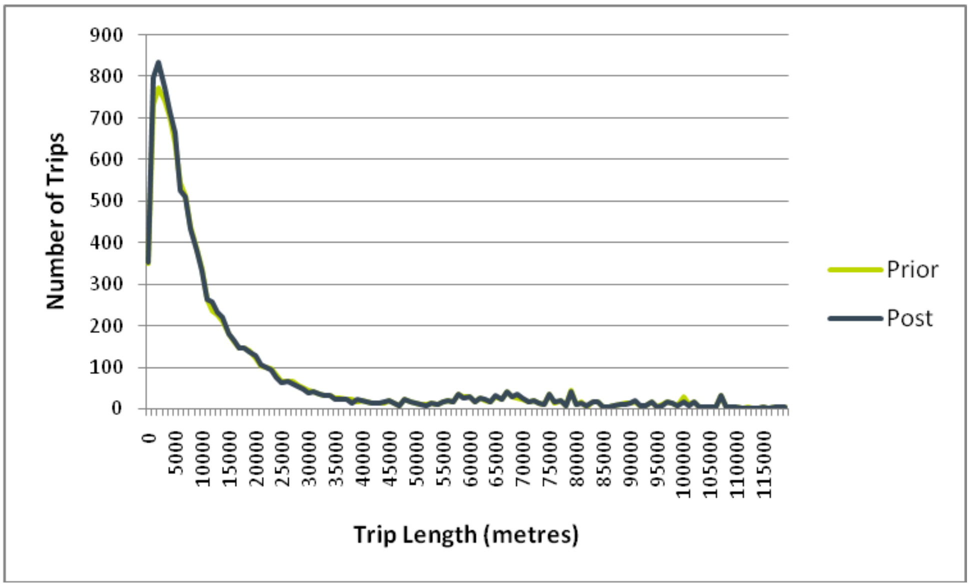
Units: pcu/h

Figure 34. Trip Length Distribution for Evening Peak (UC1 Car)



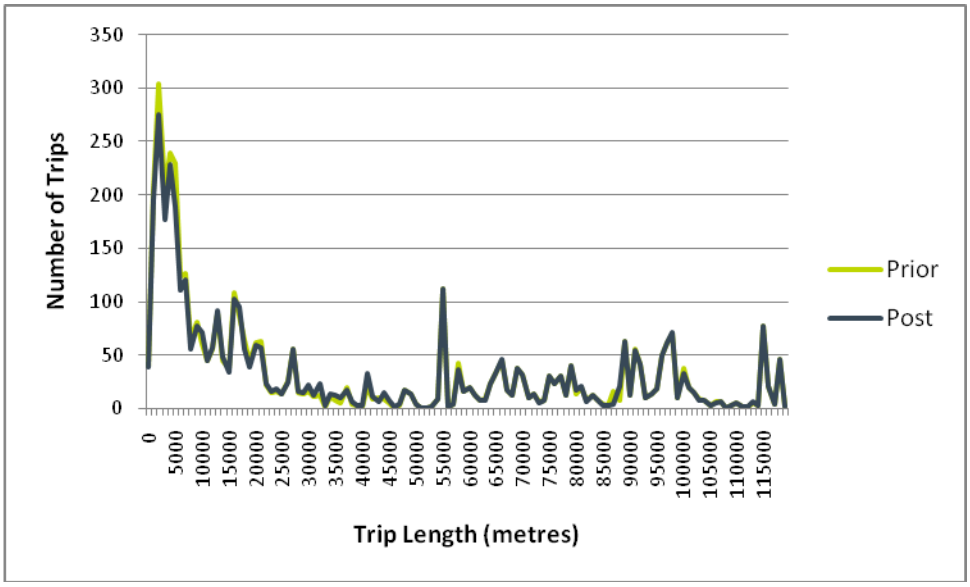
Units: pcu/h

Figure 35. Trip Length Distribution for Evening Peak (UC2 LGV)



Units: pcu/h

Figure 36. Trip Length Distribution for Evening Peak (UC3 HGV)



Units: pcu/h

9.3.5. Sector-to-Sector Changes

The matrix changes made by matrix estimation at the sector level are tabulated in more detail as part of Appendix D. The changes are presented by time period, and by user class (i.e. Car, LGV and HGV and All Vehicles), showing the absolute values, differences and percentage differences.

The analysis shows a number of sectors where the changes are greater than 5%. To put the impact of matrix estimation into context, our analysis focuses on those sectors that contained more than 1% of the total prior matrix for each vehicle type and time period. By focusing upon those sectors that contained at least 1% of the total prior matrix (960 car trips in the Morning Peak, 750 car trips in the Inter-Peak and 980 car trips in the Evening Peak) the analysis typically includes only 25% of the 64 sector to sector movements (i.e. 75% of the sectors have less than 1% of the matrix total). The number and location of each exceedance by time period and vehicle type is presented below:

- Morning peak hour – cars
    - Sector 1 to sector 1 – 12% change – within inner cordon so no observed movements
    - Sector 3 to sector 3 – 18% change – within outer cordon so limited observed movements
    - Sector 8 to sector 4 – 12% change – external to within outer cordon – Highridge screenline westbound in the prior had a shortage of trips
    - Sectors 6-8, 7-6 and 8-6 – maximum change of 8% – limited observed movements
- Morning peak hour –LGV
    - Sector 1 to sector 1 – 25% change – within inner cordon so no observed movements
    - Sector 3 to sector 3 – 30% change – within outer cordon so limited observed movements
    - Sector 5 to sector 5 – 6% change – within outer cordon so limited observed movements
    - Sector 6 to sector 3 – 9% change – external to within outer cordon – Hengrove screenline southbound in the prior had a shortage of trips
    - Sector 8 to sector 5 – 14% change – external to within outer cordon – Outer cordon inbound in the prior needs a reduction in trips
    - Sector 8-6 – 10% change – external movements so limited observed movements
- Morning peak hour – HGV
    - Sector 4 to sector 7 – 8% change – external to outer cordon – Pidgeonhouse screenline eastbound had too many trips in the prior

  - Sector 8-7 and8-8 – maximum change 9% – external movements so limited observed movements

- Inter-peak hour – cars
  - Sector 1 to sector 1 – 22% change – within inner cordon so no observed movements
  - Sector 3 to sector 3 – 6% change – within outer cordon so limited observed movements
  - Sector 6 to sector 4 – 6% change – external to within outer cordon – Inner cordon inbound and Central (S2) had too many trips in the prior
- Inter-peak hour –LGV
  - Sector 1 to sector 1 – 29% change – within outer cordon so limited observed movements
  - Sector 3 to sector 3 – 12% change – within outer cordon so limited observed movements
  - Sector 6 to sector 3 – 16% change – external to within outer cordon – Hengrove screenline southbound had a shortage of trips in the prior
  - Sector 6-8– 6% change – external movements so limited observed movements
- Inter-peak hour – HGV
  - Sector 4 to sector 5 – 35% change – within outer cordon so limited observed movements
  - Sector 5 to sector 5 – 43% change – within outer cordon so limited observed movements
  - Sector 7-8– 9 % change – external movements so limited observed movements

- Evening peak hour – cars
  - Sector 1 to sector 1 – 12% change – within inner cordon so no observed movements
  - Sector 3 to sector 3 – 11% change – within outer cordon so limited observed movements
  - Sector 4 to sector 8 – 32% change –within outer cordon to external– Pidgeonhouse screenline eastbound had a shortage of trips in the prior
  - Sector 7 to sector 4 – 8% change – external to within outer cordon
- Evening peak hour –LGV
  - Sector 3 to sector 3 – 26% change – within outer cordon so limited observed movements
  - Sector 5 to sector 5 – 12% change – within outer cordon so limited observed movements
  - Sector 7 to sector 3 – 14% change – external movements so limited observed movements
  - Sector 7 to sector 4 – 13% change – external to within outer cordon – Pidgeonhouse screenline westbound and river screenline southbound had too few trips in the prior
  - Sector 4 to sector 8 – 7% change –within outer cordon to external– Pidgeonhouse screenline eastbound had too few trips in the prior
- Evening peak hour – HGV
  - Sector 7 to sector 8 – 6% change – external movements so limited observed movements

The incidence of exceedances of the benchmark criteria at a sector to sector level is a result of small changes at a cell to cell level combining to form larger change at a sector level. Furthermore, the screenlines used in matrix estimation are close together and likely to include a number of incidences of one vehicle trip making multiple crossings of screenlines. Such incidences would be unknown in the matrix estimation process and consequently, matrix estimation could have resulted in generating more, shorter trips rather than one longer one. This would result in a greater change in the number of trips generated by matrix estimation than would actually be the case.

9.4. Trip Matrix Validation

9.4.1. Traffic flow

Validation of the post matrix estimation matrices was undertaken by comparing total screenline and cordon modelled flows and counts by vehicle type and time period. The assessment criteria follows those defined in TAG Unit 3.19 Table 1, which states that differences between modelled flows and counts should be less than 5% of the counts for all or nearly all screenlines. The focus of the validation effort was on cars and all vehicles as cars represent typically 80% to 90% of flow on roads in the area of detailed modelling. The results of this assessment are shown in Table 41 and are summarised below.

- In the morning peak
  - all of the roadside interview cordons meet acceptability guidelines
  - all 14 of the matrix estimation screenlines (seven screenlines in two directions) meet acceptability guidelines
  - two of the four validation screenlines (two screenlines in two directions) meet acceptability guidelines. .
- In the inter-peak:
  - all of the roadside interview cordons meet acceptability guidelines
  - all of the matrix estimation screenlines meet acceptability guidelines
  - all of the validation screenlines meet acceptability guidelines for cars and three out of four meet acceptability guidelines for all vehicles and the one that fails has a 6% difference for all vehicles
- In the evening peak:
  - all of the roadside interview cordons meet acceptability guidelines
  - 12 out of 14 of the matrix estimation screenlines meet acceptability guidelines
  - two of the four validation screenlines (two screenlines in two directions) meet acceptability guidelines; with one of those failing doing so marginally with a difference of 5.1%.

Table 36 presented the validation of the prior trip matrices and that showed that whilst the roadside interview cordons met acceptability guidelines, matrix estimation was required to improve the validation of the prior matrix against screenlines. The impact of matrix estimation has improved trip matrix validation with all or nearly all of the roadside interview cordons and matrix estimation screenlines meeting acceptability guidelines.

The performance of the post matrix estimation trip matrices against independent validation screenlines is more mixed, with the inter-peak performing much better than the peak periods. The performance of the validation screenlines in the morning and evening peaks was a compromise between achieving a screenline and link flow calibration and validation whilst minimising the impact of matrix estimation.

The two validation screenlines have different geographic scopes. The central validation screenline intersects east-west movements across the scheme alignment in south Bristol whilst the railway screenline intersects north-south movements across the whole of area of detailed modelling.

The performance of central independent validation screenline was the hardest to achieve an acceptable validation standard, with adjacent screenlines and routing across multiple screenlines causing a particular problem. Whilst the performance varies from a -9% difference in the morning peak to a 16% difference in the evening peak for total vehicle the actual difference in all vehicle flow is quite small, ranging from 36pcu to 190pcu. In deciding to accept the performance of the central independent validation screenline the high level of performance of the adjacent Highridge and Pigeonhouse matrix estimation screenlines, in which cars and all vehicle met acceptability guidelines, provided reassurance that the right level of traffic was travelling east-west at two other locations in south Bristol in the scheme corridor.

The performance of the railway independent validation screenline meets acceptability guidelines for flow for cars and all vehicles in both directions the inter-peak, the flow is within 6% difference for cars and all vehicles in both directions the evening peak and meets acceptability guidelines for cars and all vehicles southbound in morning peak. The main exception is therefore northbound movements in the morning peak, which have a -10% difference for cars and -7% difference for all vehicles. The locations where the difference is greatest are Cattle Market Road and St John’s Lane both of which are not a concern for SBL.

Table 41. Summary of Cordon and Screenline Validation (Post Matrix Estimation Matrix)

Screenline		Direction	Morning Peak				Inter-Peak				Evening Peak			
			Car	LGV	HGV	Total	Car	LGV	HGV	Total	Car	LGV	HGV	Total
RSI Cordon	Inner Cordon	Inbound	2%	2%	-22%	0%	1%	0%	-3%	0%	1%	2%	-16%	0%
		Outbound	-1%	-2%	-15%	-2%	-1%	1%	-4%	-2%	-1%	-3%	-16%	-2%
	Outer Cordon	Inbound	0%	1%	-1%	0%	0%	0%	0%	0%	-1%	1%	-1%	-1%
		Outbound	0%	0%	0%	0%	0%	1%	-7%	0%	0%	1%	-3%	0%
Matrix Estimation Screenline	Central (S2)	Westbound	0%	-1%	0%	-1%	0%	1%	0%	-1%	-1%	2%	7%	-1%
		Eastbound	1%	-2%	21%	0%	0%	0%	1%	-1%	1%	9%	-4%	1%
	River	Northbound	-2%	-10%	6%	-3%	-1%	4%	-10%	0%	-2%	15%	0%	0%
		Southbound	-1%	-10%	-17%	-3%	0%	-8%	-11%	-2%	0%	-12%	-4%	-2%
	Bishopsworth	Northbound	-6%	0%	-21%	-5%	0%	0%	-9%	1%	0%	-1%	11%	1%
		Southbound	0%	0%	-32%	1%	0%	0%	-1%	1%	-1%	1%	-18%	-1%
	Hengrove	Northbound	-2%	0%	6%	-1%	0%	0%	0%	0%	0%	-2%	21%	0%
		Southbound	0%	7%	9%	2%	0%	0%	1%	0%	-2%	-2%	2%	-2%
	Pidgeonhouse	Westbound	0%	-3%	-2%	-1%	0%	1%	0%	0%	-1%	3%	8%	0%
		Eastbound	0%	-5%	13%	-1%	0%	0%	1%	0%	-1%	-4%	25%	-1%
	Highridge	Westbound	-1%	0%	-23%	-1%	0%	-1%	-1%	0%	-5%	-13%	-24%	-6%
		Eastbound	0%	0%	-5%	0%	0%	-2%	-17%	-1%	0%	1%	-1%	1%
	Long Ashton	Inbound	0%	0%	-1%	-1%	0%	0%	1%	0%	1%	3%	3%	1%
		Outbound	0%	1%	-17%	-1%	0%	0%	0%	-1%	-7%	3%	9%	-6%
Validation	Central (S1)	Westbound	-11%	-7%	21%	-9%	3%	10%	5%	6%	10%	47%	2%	16%
		Eastbound	-5%	5%	22%	-2%	3%	9%	-39%	4%	-8%	2%	62%	-5%
	Railway	Northbound	-10%	9%	27%	-7%	-1%	3%	10%	-1%	-6%	10%	-3%	-4%
		Southbound	4%	13%	-7%	5%	-1%	7%	-1%	0%	4%	12%	10%	5%

10. Assignment Calibration and Validation

10.1. Overview

The assignment calibration and validation was undertaken in conjunction with the matrix estimation process previously described in section 9. 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. These adjustments were undertaken as part of the model calibration and were described earlier in this report and included:

- revisions to the network coding (as described in section 6 and 8) including local revisions to the junction coding, typically focussed on the signal timings; and
- revisions to the demand matrices (as described in Section 9).

The model was validated by means of the following comparisons:

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

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

10.2. Traffic Flows on Links

Assignment validation was undertaken by comparing modelled flows and counts on individual links by vehicle type and time period. The assessment criterion follows those defined in TAG Unit 3.19 Table 2, which states that 85% of the criteria should meet acceptability guidelines for flow criteria and GEH criteria.

The focus of the validation effort was on cars and all vehicles as cars represent typically 80% to 90% of flow on roads in the ADM. The counts of LGVs and HGVs are not sufficiently accurate for validation of individual link flows.

The assessment of traffic flows on links was undertaken at a range of geographic levels:

- within sector 1 – the urban area of south Bristol surrounding the scheme;
- south of the River Avon (excluding Long Ashton) – the ADM;
- within sectors 1 or 2 – the area covered by RSI surveys, including the city centre to the north of the river; and
- all links – the area within sectors 1 or 2 and counts around Long Ashton

The results need to be considered in the context that traffic counts were predominantly entered into matrix estimation as mini-screenlines, as TAG Unit 3.19 advises, and seldom as individual link counts. This controls the application of matrix estimation but limits the ability of matrix estimation to match individual links counts. As such, the TAG Unit 3.19 acceptability guidelines are very challenging at a link level.

10.2.1. Morning Peak

Morning peak link flow validation is shown in Table 42. Link flow validation with sector 1, the urban area of south Bristol immediately around the scheme, meets acceptability guidelines for TAG flow criteria for cars and all vehicles and meets acceptability guidelines for TAG GEH criteria for cars whilst just missing the acceptability guidelines for TAG criteria for all vehicles.

South of the River Avon covers the ADM and link flow validation almost meets acceptability guidelines for TAG flow criteria for cars (84%) and all vehicles (78%) but falls short of the acceptability guidelines for GEH criteria.

The link flow validation of independent validation counts demonstrates that 85% of links meet the TAG acceptability guidelines.

Table 42. Morning Peak Link Flow Validation

Count source	Location	Number of counts	Flow criteria (% pass)		GEH criteria	
			Car	Total	Car	Total
RSI and Matrix Estimation Links	Within sector 1	64	98%	92%	83%	80%
	South of the River Avon	115	84%	78%	76%	71%
	Within sectors 1 or 2	155	79%	73%	72%	66%
	All links	163	80%	74%	72%	67%
Validation	Total	26	85%	81%	73%	81%
Total	Total	189	81%	75%	72%	69%

Inter-peak link flow validation is shown in Table 43. Link flow validation with sector 1, the urban area of south Bristol immediately around the scheme, meets acceptability guidelines for TAG flow and GEH criteria for cars and all vehicles South of the River Avon covers the area of detailed modelling and link flow validation also meets acceptability guidelines for TAG flow and GEH criteria for cars and all vehicles.

The link flow validation of independent validation counts meets acceptability guidelines for TAG flow and GEH criteria.

Table 43. Inter-Peak Link Flow Validation

Count source	Location	Number of counts	Flow criteria (% pass)		GEH criteria	
			Car	Total	Car	Total
Calibration	Within sector 1	64	100%	94%	83%	86%
	South of the River Avon	115	94%	89%	81%	77%
	Within sectors 1 or 2	155	86%	80%	75%	71%
	All links	163	87%	80%	77%	72%
Validation	Total	26	96%	85%	92%	88%
Total	Total	189	88%	81%	79%	74%

Evening peak link flow validation is shown in Table 44. Link flow validation with sector 1, the urban area of south Bristol immediately around the scheme, meets acceptability guidelines for TAG flow criteria for cars and all vehicles and almost meets acceptability guidelines for TAG GEH criteria for cars and all vehicles. South of the River Avon covers the area of detailed modelling and link flow validation almost meets acceptability guidelines for TAG flow criteria for cars (83%) and all vehicles (79%) but falls short of the acceptability guidelines for GEH criteria.

The validation at the independent counts sites does not meet the TAG acceptability guidelines in all models. In deciding to accept this level of independent link flow validation the performance of the model at a screenline level was considered suitable and, analysis did reveal that combining the counts into mini-screenlines improved validation of the independent validation counts although this was not considered in the final matrix as this is against WebTAG 3.19 advice.

Sensitivity tests based upon the final forecasts will be undertaken to further support this argument.

Table 44. Evening Peak Link Flow Validation

Count source	Location	Number of counts	Flow criteria (% pass)		GEH criteria	
			Car	Total	Car	Total
Calibration	Within sector 1	64	92%	91%	83%	81%
	South of the River Avon	115	83%	79%	77%	73%
	Within sectors 1 or 2	155	77%	73%	72%	68%
	All links	163	76%	72%	71%	67%
Validation	Total	26	73%	69%	58%	46%
Total	Total	189	76%	71%	69%	65%

10.3. Journey Time Validation

10.3.1. 2011 Dataset

The modelled journey time values were compared with the TomTom derived journey times representing 2011. Section 5.5 describes how these data were checked for consistency between 2011 and 2012 on the A370 between Long Ashton and the River Avon. Summaries of the overall modelled and observed journey time comparisons for each route in the three modelled time periods are provided below in Table 45 to Table 47. The detailed representation of individual route sections, which highlights any outlying observed and modelled times, is provided in Appendix E.

10.3.2. Morning Peak

Table 45 shows that 93% (13/14) of the journey time routes in the morning peak hour model routes are within +/- 15% of the observed journey times.

Route 1 northbound fails to meet the criteria for the last 1 km of the route (on the approach to Parson Street gyratory). The count on Bridgewater Road shows that the assigned flow was 3% (28 vehicles) less than the count which is within acceptable limits. The use of route specific cruise speeds would have enabled a better match to the journey time data but this was not the basis on which the model was built. As the flow validation in the area is good the failure of the journey time route is not of concern.

Overall the model performs well, replicating the observed journey times to TAG Unit 3.19 standards.

Table 45. Comparison of Observed and Modelled Journey Time - Morning Peak

Route No.	Route Description	Morning Peak (08:00 - 09:00)					
		Direction	Route Journey Time		Diff in seconds	% Diff	Within 15% (or 60secs if higher)
			Observed (mean)	Modelled			
Route 1	A38 Corridor	NB	00:07:46	00:06:12	-94	-20%	×
		SB	00:05:37	00:05:43	6	2%	✓
Route 2	Barrow Gurney Corridor	NB	00:04:37	00:05:07	30	11%	✓
		SB	00:05:04	00:04:58	-6	-2%	✓
Route 3	Long Ashton Corridor	NB	00:10:02	00:08:44	-78	-13%	✓
		SB	00:07:10	00:06:41	-29	-7%	✓
Route 4	A370 Corridor	NB	00:10:02	00:08:44	-78	-13%	✓
		SB	00:05:11	00:05:28	17	5%	✓
Route 5	Winterstoke Road	SB	00:03:47	00:03:22	-25	-11%	✓
		NB	00:06:57	00:06:26	-31	-7%	✓
Route 6	Headley Park	CW	00:14:38	00:12:59	-99	-11%	✓
Route 7		ACW	00:12:47	00:11:06	-101	-13%	✓
Route 8	Hengrove	CW	00:16:47	00:15:44	-63	-6%	✓
Route 9		ACW	00:16:32	00:16:59	27	3%	✓

10.3.3. Inter Peak

Table 46 shows that 93% (13/14) of the journey time routes in the inter-peak hour model are within +/- 15% of the observed journey times.

The route which fails to meet the criterion is Route 5 northbound. The main delay occurs at the superstore entrance.. The flows on Winterstoke Road show a deficit of traffic of 4% (39 vehicles) so the exceedance of the journey time validation criterion along this stretch of the journey time route is not of concern.

Table 46. Comparison of Observed and Modelled Journey Time – Inter-Peak

Route No.	Route Description	Inter-Peak (10:00-16:00)					
		Direction	Route Journey Time		Diff in seconds	% Diff	Within 15% (or 60secs if higher)
			Observed (mean)	Modelled			
Route 1	A38 Corridor	NB	00:05:44	00:06:04	20	6%	✓
		SB	00:05:34	05:45	11	3%	✓
Route 2	Barrow Gurney Corridor	NB	00:04:02	00:04:11	9	4%	✓
		SB	00:04:30	00:04:52	22	8%	✓
Route 3	Long Ashton Corridor	NB	00:06:55	00:06:21	-34	-8%	✓
		SB	00:06:42	00:06:38	-4	-1%	✓
Route 4	A370 Corridor	NB	00:06:19	00:06:36	17	4%	✓
		SB	00:05:11	00:05:30	19	6%	✓
Route 5	Winterstoke Road	SB	00:03:22	00:03:23	1	0%	✓
		NB	00:04:12	00:05:21	69	27%	×
Route 6	Headley Park	CW	00:12:27	00:13:34	67	9%	✓
Route 7		ACW	00:10:21	00:11:06	45	7%	✓
Route 8	Hengrove	CW	00:15:03	00:14:49	-14	-2%	✓
Route 9		ACW	00:14:29	00:14:30	1	0%	✓

10.3.4. Evening Peak

Table 47 shows that 93% (13/14) of the journey time routes in the evening peak hour model are within +/-15% of the observed journey times. The one that fails (route 5 northbound) is slightly too quick but the difference is less than 60 seconds.

The route which fails to meet the criterion is Route 5 northbound, the approach to the superstore entrance is missing 20 seconds of delay, due to the positioning of the connectors.. The flows along Winterstoke Road are -3% (-29 vehicles) when compared to the counts which suggests the exceedance of the journey time validation criterion is not of concern.

Table 47. Comparisons of Observed and Modelled Journey Times – Evening Peak

Route No.	Route Description	Evening Peak (17:00 - 18:00)					
		Direction	Route Journey Time		Diff in seconds	% Diff	Within 15% (or 60secs if higher)
			Observed (mean)	Modelled			
Route 1	A38 Corridor	NB	00:06:35	00:06:25	-10	-3%	✓
		SB	00:06:11	05:54	-17	-5%	✓
Route 2	Barrow Gurney Corridor	NB	00:04:59	00:04:15	-44	-15%	✓
		SB	00:06:07	00:06:30	23	6%	✓
Route 3	Long Ashton Corridor	NB	00:06:57	00:06:29	-28	-7%	✓
		SB	00:06:56	00:07:12	16	4%	✓
Route 4	A370 Corridor	NB	00:06:23	00:06:43	20	5%	✓
		SB	00:05:34	00:05:52	18	5%	✓
Route 5	Winterstoke Road	SB	00:04:15	00:03:36	-39	-15%	✓
		NB	00:05:48	00:04:52	-56	-16%	✗
Route 6	Headley Park	CW	00:14:54	00:14:42	-12	-1%	✓
Route 7		ACW	00:12:16	00:12:30	14	2%	✓
Route 8	Hengrove	CW	00:18:12	00:15:56	-136	-12%	✓
Route 9		ACW	00:18:22	00:16:14	-128	-12%	✓

10.4. Model Convergence

The convergence for each model period is summarised in Table 48 below and shows that the three models have achieved a high level of convergence. They are stable for at least four consecutive assignment-simulation loops and the delta values (as reported by the %GAP statistic in SATURN) comfortably exceed the targets specified in the TAG Unit 3.19.

Table 48. Model Convergence

Time Period	Assignment - Simulation Loop	Delta (%)* (δ)	% Flow Change (P within +/-1%)
Morning Peak	37	0.01%	98.7%
	38	0.01%	98.8%
	39	0.01%	98.7%
	40	0.02%	98.6%
Inter-Peak	15	0.01%	98.7%
	16	0.01%	98.8%
	17	0.01%	98.7%
	18	0.00%	99.2%
Evening Peak	12	0.05%	98.7 %
	13	0.05%	98.9%
	14	0.04%	99.1%
	15	0.04%	99.2%

Note: * as measured by the SATURN %GAP measures

11. Conclusion

The model has been validated using the measures and criteria recommended in TAG Unit 3.19. The following comparisons between modelled and observed data have been reported:

- total flows for cordons and screenlines (counts on which were used as constraints in the matrix estimation – calibration counts);
- flows on individual links which did not feature in the matrix estimation (independent counts); and
- journey times in the SBL corridor.

The models have been built following best practice and have adopted processes that have ensured that the matrix has retained its integrity with the observed data and that matrix estimation has been applied in a controlled and limited way.

The analysis shows that the three models:

- either meet, or are very close to, the acceptability guidelines regarding the impact of matrix estimation at a cell, trip and matrix level, although not at a sector level;
- either meet, or are very close to, the acceptability guidelines at the cordon and screenline level at the individual calibration sites, and at the independent validation sites; and
- the models either meet, or are very close to, the acceptability guidelines for journey times.

All three models are stable and achieve acceptable levels of convergence.

Sensitivity tests will be undertaken to confirm model fitness for purpose

Appendices

Appendix A. Matrix Development

A.1. Expansion of RSI data

Source data

Four sets of RSI data have been used in building the partial matrices for the GBATS3 SBL 2012 HAM model.

- 2001 RSIs forming a wider Bristol (outer) cordon
- 2006 RSIs to provide data for M32, Hengrove Way and the A370 Long Ashton bypass
- 2009 RSIs to supplement 2012 data to form a South Bristol (inner) cordon
- 2012 RSIs to complete a South Bristol (inner) cordon

Each of these RSIs had accompanying manually classified counts (MCCs) at the same site on the same day. In addition the 2001 surveys have MCCs carried out at on a different day. There were also automatic traffic counts (ATCs) at the RSIs from the original survey year, plus new ATC data collected in 2012.

Issues / variations

The 2001 RSI data was previously[4] processed for two hour peak periods – the peak hour plus 30 minute shoulders each side (07:30 – 09:30, 16:30-18:30).

The MCC data collected on the RSI survey day was only collected in the interview direction and is available for one hour periods (07:00-08:00, 08:00-09:00 etc). Thus this MCC data is not readily available for time periods consistent with the processed RSI data. Additional MCC data is also available for a non survey day in both the interview and non-interview direction. This is summarised in 30 minute periods however there is no distinction between cars and LGVs. The RSI data for the additional half hours was found and added to the 2001 RSI data set (at the BATS1 zone level).

The 2001 RSI data was only available in zone, not OS Grid Reference (OSGR) format. It was converted from BATS1 zones to BATS3 zones then to GBATS3 SBL 2012 HAM zones before an expansion process. This zone conversion process resulted in an RSI dataset with a large number of records (> 50,000) containing small fractions of trips. The interview dataset (prior to expansion) was therefore filtered to retain only those records where the trip volume was >0.1. This eliminated more than 30,000 records and lost just under 1000 trips (~9% of the data), prior to expansion.

The 2006, 2009 and 2012 RSI data were available with OSGRs on the origins and destinations. This RSI data was thus zoned to the SBL3 zones by overlaying the co-ordinates with the zone boundaries.

Both the SBL and SGCS models have excluded motorcycles and buses when building the matrices so the same process will be adopted for the reprocessing of 2001 and 2006/09 RSI data and the processing of the 2012 RSI data.

Three of the 2001 RSI sites were not located on the cordons so filtering of the records was required to eliminate trips for zone pairs which would not (or would be unlikely) to cross the cordon. For the A4 Portway records which had a destination in the Stoke Bishop and Sneyd Park area were removed from the dataset as they would not cross the cordon. The survey conducted on A4 Bath Road was located east of the Bath road and St Phillips Causeway split whilst the cordon crossed the two individual roads. This meant that records from the Bath Road site were filtered so that trips that would not logically use Bath Road were removed. This was done because there was another RSI on St Phillips Causeway at the cordon crossing point and using both datasets risked double counting, and the use of St Phillips Causeway captured trips crossing the cordon point and hence was more accurate. Therefore trips which had destinations to zones to the north and east of A4320 St Phillips Causeway and bounded by the river and A38 Gloucester road were excluded, as were long distance trips which would most certainly use the A4320 rather than go into the city centre and back out again. For the Callington Road site any trips with a destination in the zone representing Callington Road Hospital and Tesco supermarket were removed because they would not cross the cordon.

In all three cases the count being used to expand the filtered RSI dataset was located on the cordon so the two datasets are consistent.

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[4] For earlier versions of the Bristol model

The 2001 RSI data has no information (or at least none available) on the number of occupants in each vehicle. This information is not required for the HAM base matrices but is required to define person trip to vehicle trip conversions for the interface between the BATS demand model and the HAM. Occupancies for 2001 were estimated from the 2006, 2009 and 2012 RSI data for each time period, trip purpose (including purpose direction: from / to home and NHB). Having taken these dimensions into account little variation was found to exist between the vehicles crossing the cordons inbound and outbound. If the purpose profile varies by RSI site, then the occupancies will also vary. Similarly if a particular zone generates or attracts mainly one purpose of journey (e.g. education or commuting) this will be taken into account. No other spatial variation was considered possible from the data available.

A.2. Estimation of missing cordon data

Flow Volumes

The RSI data necessarily excludes a number of the routes crossing the cordons. In the majority of cases, the volume of trips crossing the cordons will be available from ATC data. In a few cases the volumes need to be estimated for the three assignment hours (08:00-09:00, average hour 10:00-16:00 and 17:00-18:00). Only two sites on the inner cordon are missing volumes (Goodwin Drive and Vale Lane). Goodwin Drive is not explicitly represented in the SATURN highway network. Traffic on this route would be represented in the model as movements on Longway Avenue. Vale Lane is the only modelled link on the Inner cordon where a flow estimate is required. There were several sites on the outer cordon where volumes were estimated some with links in the model, others not explicitly represented.

Where the link crossing the cordon is in the SATURN network the flow could be taken from the previous version of the model. In cases where the link is not explicitly in the SATURN network the traffic using this route should be on other modelled links thereby increasing their flow. Estimates of the flow for missing links are either based on estimates of residential activity for residential distributor roads, or from nearby roads of a similar nature where count data does exist.

Where data has been inferred from a neighbouring road / link, the vehicle split has also been taken from that site. Where a GBATS3 SBL 2009 v2 HAM link flow has been used the numbers of HGVs are taken directly and the light vehicles from the GBATS3 SBL 2009 v2 HAM model split into cars and LGVs using the average split by time period derived from the RSI data. Where the flow has been estimated on the basis of trip generation, and in cases where the roads are very minor and a nominal flow has been assumed; it has also been assumed that there will be no HGVs and the car/LGV split will again be the average from the RSI data collected.

The table below shows the approach adopted for the roads without count data.

Table 1: Source of flow volumes for cordon roads not counted

Cordon	Road	Link in model	Source of flow estimate
Inner	Vale Lane	Yes	Flow = 50% Headley Lane flow.
Inner & Outer	Goodwin Drive	No	50% of Longway Ave (same vehicle split)
Outer	Kersteman Road	Yes	GBATS3 SBL 2009 v2 HAM link Generic LGV / car split by time period 0% HGVs
Outer	Elton Road	No	50% of Kersteman Road (same vehicle split)
Outer	North Road	No	Use Chesterfield Road flows
Outer	Mina Road	No	Commercial – estimate from Gazetteer and trip rates. Generic LGV / car split by time period. 0% HGVs
Outer	St Marks Road	No	Nominal 100 per hour. Generic LGV / car split by time period 0% HGVs
Outer	All Hallows Road	No	Low – nominal 50 per hour. Generic LGV / car split by time period. 0% HGVs
Outer	Hazelbury Road	No	Gazetteer and trip generation rates, Generic LGV / car split by time period. 0% HGVs
Outer	Kinsale Road	No	50% of Hazelbury Road (same vehicle split)

Appendix B. Accuracy of Partial Matrix

B.1. Accuracy of partial matrices at sector level (Step 5)

The partial matrices created are not statistically reliable on a cell by cell basis at zone level for trips segmented into various purposes. It was necessary to look at how the partial matrices could be aggregated both spatially and across demand segments to provide statistically reliable sector level matrices for use in the gravity modelling. This applies to car and LGV trips to produce constraints for the gravity modelling. For HGVs this process was used to determine at what level of detail the partial trip matrices can be reliably used to adjust / constrain the HGV matrices from the GBATS3 SBL 2009 v2 HAM model.

There are two sources of error introduced: errors as a result of sampling only a fraction of the trips taking place, and errors associated with the way in which the data was collected and then adjusted to provide estimates of the trips taking place. The variance associated with these two sources of error are referred to as sampling variance and non sampling variance. The way these are measured is described for each in turn.

Sampling Variance

The formula used to calculate the sampling variance of a matrix cell estimate, using the simplified formulation from the DfT's MATVAL program and set out in the ERICA 5 Manual (and reproduced here) is:

$$\operatorname{var}(N) = \frac{Q(Q-q)}{q^2}x \qquad or \qquad \operatorname{var}(N) = \frac{Q}{q}\left(\frac{Q}{q}-1\right)x$$

Where: Q is the counted flow within a period,

q is the number of vehicles interviewed,

x is the number of vehicles in the category of interest (i.e. with a particular purpose, origin & destination).

N is the estimate of trips in this category over the period.

This is linear in x, with the consequence that the variance of any pooled set of trips is equal to the sum of the variances associated with each individual observed trip (case x=1). This sampling variance is a simple function of the sample fraction q/Q.

When working with individual interview records the sampling variance associated with each cordon crossing location (with an expansion factor) can be calculated as:

$$\operatorname{var}(N) = \frac{Q}{q}\left(\frac{Q}{q}-1\right) \text{ or } \operatorname{var}(N) = f\left(f-1\right)$$

Where *f* is the expansion factor from the RSI time period (3 or 6 hour) to the count period (3 or 6 hour).

There were a number of cordon crossing sites without RSI data. For these the OD flow volumes are estimated based on either select link analysis (SLA) from an earlier model combined with new count data, or from a sample of RSI records for adjacent sites factored to count data.

In these instances, there is in theory no sampling so the sampling variance should be zero. In practice the sampling variance was calculated using the expansion factors obtained to scale from the SLA volumes to the base year counts.

Non sampling variance

This relates to variations introduced specific to the way the data has been collected and adjusted (scaled) in order to estimate the partial matrices. Every adjustment (scaling) applied introduced further error and hence increased the variance.

The TAM and ERICA manuals identify a number of sources of error including:

- Day-to-day variation in flow – use of single day v week v two week surveys

- Mechanical/Human counter error
- The assumption of reversibility if the wrong direction was surveyed
- The age of the data
- Seasonal variation.

In addition data has been estimated from select link analyses of earlier model runs and in filled data by assuming records from the RSI sites available can be transferred to a nearby non-interviewed site.

The possible values of C (coefficient of variation) to be used to estimate the non sampling, site specific variances obtained from the TAM and ERICA manuals are shown in Table 49 below, together with the assumptions proposed for use in determining the variance for ODs in the GBATS3 SBL 2012 HAM partial matrices.

Table 49. Site specific variance factors

ID	**Source of error**	**C (TAM)**	**$1000C^2$ (ERICA)**	**$1000C^2$ GBATS3 SBL 2012 HAM**
a1	If interviews have been factored to a manual classified count - for cars - for LGVs - for HGVs	 0.05 0.12 0.14	 2.5 - -	 2.5 14.4 19.6
a2	If interviews have been factored to an automatic traffic count (ATC	0.025	0.5	0.625
b1	if total site flow is based on a 1-day count		1	1
b2	if total site flow based on a 1-week count		0.5	0.5
b3	if total site flow based on 2 weeks or more of data		0	0
c1	if the survey day-of-week to average weekday factor (which may be equal to 1.0) is based on national or regional data		1.5	01.5
c2	if the survey day-of-week to average weekday factor is based on local data		0	0
d1	if a regional or national factor (which may be equal to 1.0) has been applied to convert to a different month		2.5	2.5
d2	if the data was collected in the correct month or a local conversion factor is available		0	0
e1	for every year between RSI data collection and model base, if a regional or national growth factor (which may be equal to 1.0) has been applied		6	6
e2	if a local growth factor is available		0	2
f1	if reversibility has been assumed		10	10
f2	if interviews are factored to a reverse direction count		5	5
f3	for the interviewed direction		0	0
g1	For every year between RSI data collection and model base			2
h1	Where no RSI available and OD data estimated			32*

*Majority of the sites where this value would apply filtered 2001 RSI data or SLA were used, the data used is therefore 11 years old and in terms of the other factors this would mean a factor of 22 (from g1) giving a minimum accepted value, a factor of 10 was also applied to account for the transferring of data. This then largely gives a site specific variance which is greater than those where OD data is known reflecting the potential errors in the data set.

For SBL, the adjustments made which impact on the variance of the estimates include:

- Transposing RSI data and scaling using the reverse direction counts

- Using old RSI data (from 2001, 2006 and 2009)
- Seasonal and annual growth adjustments to counts to the March 2012 base month
- Scaling RSIs to both MCCs (for veh types) and ATCs (for volumes)
- To account for infilling / where no count data was available

All these adjustments are applied and the results added together so the non sampling variance is equal to the sum of the C^2 values.

Variance and Confidence Intervals for OD estimates

Having estimated both the sampling and non sampling variance of the site (cordon crossing) estimates of OD flows passing through these sites, these were combined to give an estimate of the variance for each OD pair based on the flow contributions from the different cordon crossing sites. Adopting the approach used in ERICA, it was assumed that the OD flows from different sites are independent (no correlation).

The variance of the estimated flow then becomes:

$$Var(N) = f(f-1)x + QfxC^2 + \text{product term (neglected)}$$

Where: $f=Q/q$ (the expansion factor for the period) as defined above

Q is the traffic count (by vehicle type) within the period

C^2 is the non sample variance (site specific) calculated using the factors defined in Table 49 above.

x is the number of vehicles in the category of interest (i.e. with a particular purpose, origin & destination

The variance of the OD pair was calculated as the sum of the variances of the different sources of trips contributing to the volume of that OD pair. Similarly the variance of sector to sector matrices was the sum of the variances of the zone pairs within the sector pair. The 95% confidence intervals for sector pairs were then calculated from the sector to sector volumes and variances. This enabled the definition of sectors such that the 95% confidence intervals for the flows for all sector pairs are between 20% and 30% of the flow volumes (for cars and LGVs).

Definition of these sectors began from an examination of the 3x3 sector system used within the partial matrix build, looking at total car trips and splitting into car work and car non work, this led to the ratios shown in Table 50 to Table 52 below.

In each case the Intra sector movements (1-1 etc) were not of interest since there was only partial information and the inter sector cells are shaded based on the value of the ratio of the 95% confidence interval to the number of trips. The shading is as follows:

Shade	Value of ratio	Interpretation
🟦	< 0.2	Data could be further disaggregated
🟥	> 0.3	Pushing limits of data reliability – too much disaggregation
🟩	between 0.2 and 0.3	Ratio within desired bounds

Table 50. 3x3 sector definition for all car trips

Origin Sector	AM			IP			PM		
	1	2	3	1	2	3	1	2	3
1 Inside Inner	0.38	0.13	0.04	0.21	0.10	0.03	0.35	0.06	0.02
2 Between cordons	0.13	0.05	0.01	0.12	0.05	0.01	0.15	0.06	0.01
3 Outside Outer	0.03	0.00	0.00	0.03	0.01	0.00	0.03	0.01	0.00

Table 51. 3x3 for Non Work car trips

Origin Sector	AM			IP			PM		
	1	2	3	1	2	3	1	2	3
1 Inside Inner	0.48	0.23	0.05	4.62	0.31	0.11	0.70	0.23	0.04
2 Between cordons	0.25	0.06	0.02	0.68	0.22	0.03	0.38	0.14	0.01
3 Outside Outer	0.04	0.01	0.00	0.11	0.03	0.02	0.07	0.02	0.01

Table 52. 3x3 for Work car trips

Origin Sector	AM			IP			PM		
	1	2	3	1	2	3	1	2	3
1 Inside Inner		3.47	1.00	1.34	1.12	0.35		4.37	0.37
2 Between cordons	3.03	0.53	0.16	1.16	0.40	0.04	2.26	0.69	0.07
3 Outside Outer	0.34	0.03	0.05	0.28	0.04	0.02	0.95	0.12	0.05

This process demonstrated that it was difficult to find a detailed sector system using any purpose segmentation since even the non work (commuting + other) trips have ratios higher than desired for the movements between sectors 1 and 2 in the inter peak. Since more weight is attached to the spatial detail only the vehicle types (car and LGV) were considered for gravity modelling. Since the ratios for the 3x3 sectors without any purpose disaggregation shown in Table 50 are sufficiently small it should be possible to disaggregate to additional sectors while still retaining confidence in the sector to sector movements.

The process adopted for further disaggregation was to take each of the initial 3 sectors above in turn and consider splitting them into two or three sub sectors – while leaving the other sectors as they were. This process aimed to demonstrate the bounds of the level of detail possible and for cars suggested that:

- Sector 1 (within Inner cordon) could be split into 2 sub sectors but using 3 generated ratios larger than 0.3 in a few cases (particularly for movements to / from sector 2) suggesting that when combined with sub divisions of the outer areas this would stretch the data too far.
- Sector 2 (between cordons) could just about be split into 4 sectors without disaggregation of sectors 1 and 3. A division into two areas (north and south of the river) retained good confidence in the data.
- Sector 3 could be sub divided into around 6 areas and retain confidence in the data for movements for sector 2. However for movements to sector 1 a division into two or three areas was the best that could be achieved.

The resulting ratios of the 95% confidence interval to the number of car trips for each time period are shown in Table 53 to Table 55 below, using the 12 sector shown in Figure 15. The same shading by ratio range is adopted as shown above. In this case the values in the pink cells (denoting the data is being stretched) are generally (but not always) only slightly greatly than 0.3 and hence deemed acceptable.

Table 53. Ratio of 95% Confidence Interval / Trips – Car trips AM peak

95% CI / TRIPS		Inner		Outer				External					
		1	4	2	6	5	9	3	8	10	7	11	12
Inner	1			0.13		0.26		0.24	0.26	0.29	0.20		
	4			0.29		0.33		0.41	0.40	0.28	0.34		
Outer	2	0.32	0.25					0.31	0.20	0.29	0.26	0.05	0.53
	6							0.26	0.97	0.12	0.11	0.13	0.48
	5	0.51	0.32					1.12	0.42	1.01	0.27	0.12	0.18
	9							0.41	0.27	0.09	0.03	0.05	0.44
External	3	0.19	0.30	0.09	0.18	0.06	0.13						
	8	0.21	0.39	0.13	0.50	0.07	0.15						
	10	0.20	0.12	0.23	0.09	0.05	0.05						
	7	0.15	0.10	0.29	0.28	0.03	0.07						
	11			0.35	0.31	0.05	0.02						
	12			0.20	0.25	0.02	0.10						

Table 54. Ratio of 95% Confidence Interval / Trips – Car trips Inter Peak

95% CI / TRIPS		Inner		Outer				External					
		1	4	2	6	5	9	3	8	10	7	11	12
Inner	1			0.11		0.29		0.19	0.38	0.36	0.20		
	4			0.24		0.23		0.20	0.28	0.21	0.13		
Outer	2	0.25	0.25					0.15	0.21	0.23	0.39	0.30	0.22
	6							0.41	0.71	0.11	0.44	0.24	0.57
	5	0.44	0.31					0.18	0.09	0.20	0.13	0.10	0.05
	9							0.29	0.17	0.10	0.17	0.03	0.30
External	3	0.22	0.17	0.17	0.25	0.13	0.22						
	8	0.42	0.30	0.25	0.47	0.09	0.22						
	10	0.32	0.15	0.16	0.10	0.14	0.07						
	7	0.23	0.15	0.35	0.15	0.07	0.20						
	11			0.33	0.24	0.07	0.05						
	12			0.43	0.44	0.06	0.15						

Table 55. Ratio of 95% Confidence Interval / Trips – Car trips PM peak

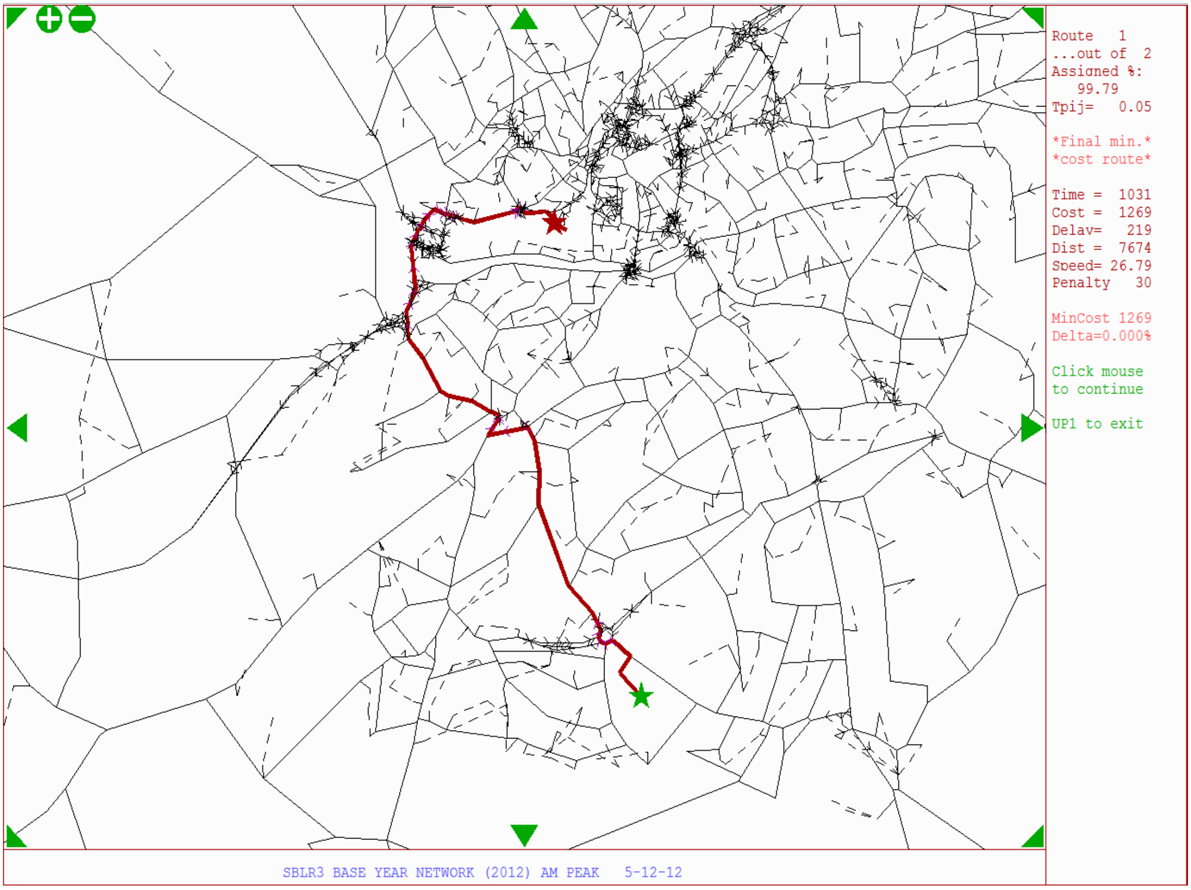
95% CI / TRIPS		Inner		Outer				External					
		1	4	2	6	5	9	3	8	10	7	11	12
Inner	1			0.21		0.30		0.19	0.24	0.28	0.15		
	4			0.13		0.20		0.16	0.39	0.16	0.13		
Outer	2	0.13	0.31					0.18	0.22	0.30	0.41	0.30	0.30
	6							0.24	0.36	0.13	0.15	0.38	0.09
	5	0.30	0.21					0.12	0.07	0.08	0.03	0.06	0.02
	9							0.21	0.15	0.06	0.12	0.04	0.40
External	3	0.18	0.17	0.11	0.30	0.27	0.33						
	8	0.26	0.30	0.13	0.42	0.24	0.18						
	10	0.22	0.29	0.13	0.10	0.27	0.06						
	7	0.29	0.29	0.10	0.11	0.12	0.04						
	11			0.08	0.14	0.07	0.07						
	12			0.26	0.52	0.08	0.26						

Appendix C. Route Choice Validation

Route choice plots are presented below between a range of origin and destination pairs.

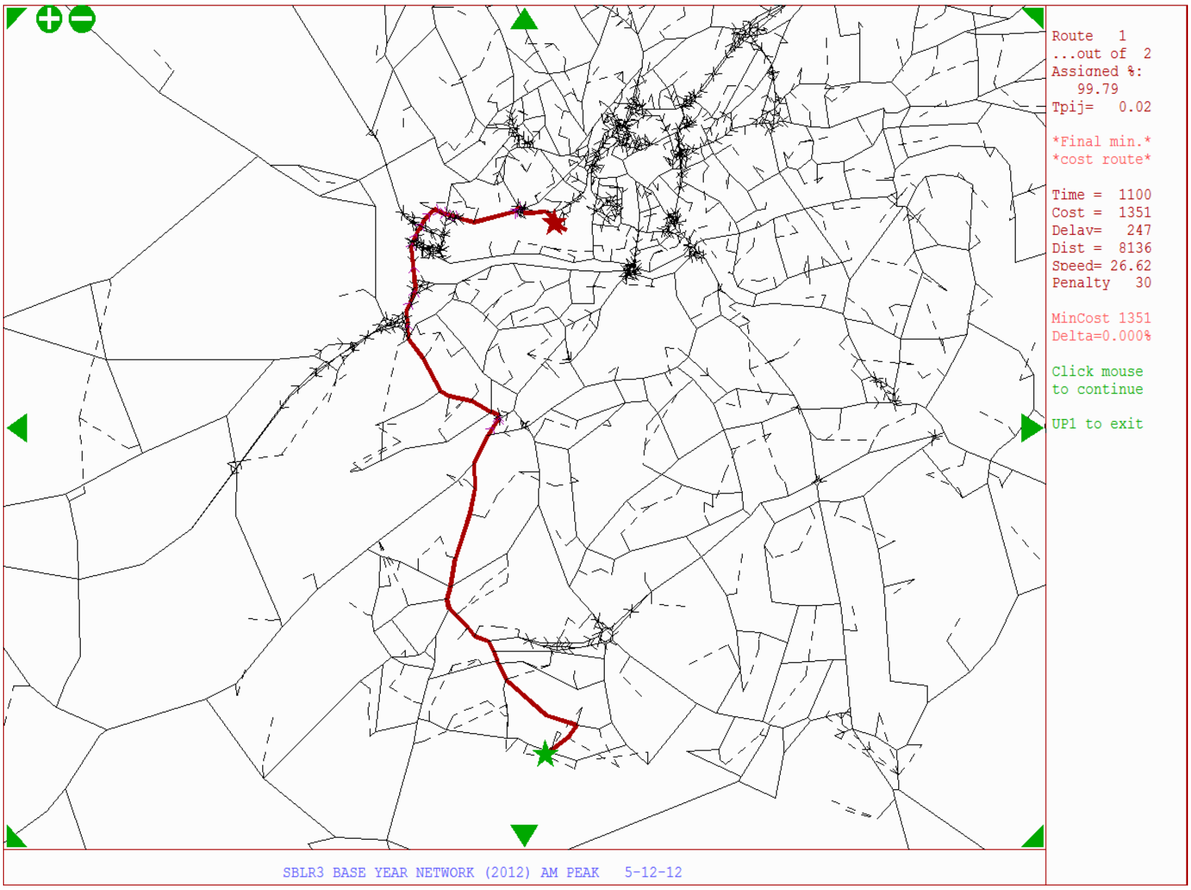
C.1. Prior Assignment

C.1.1. Morning Peak



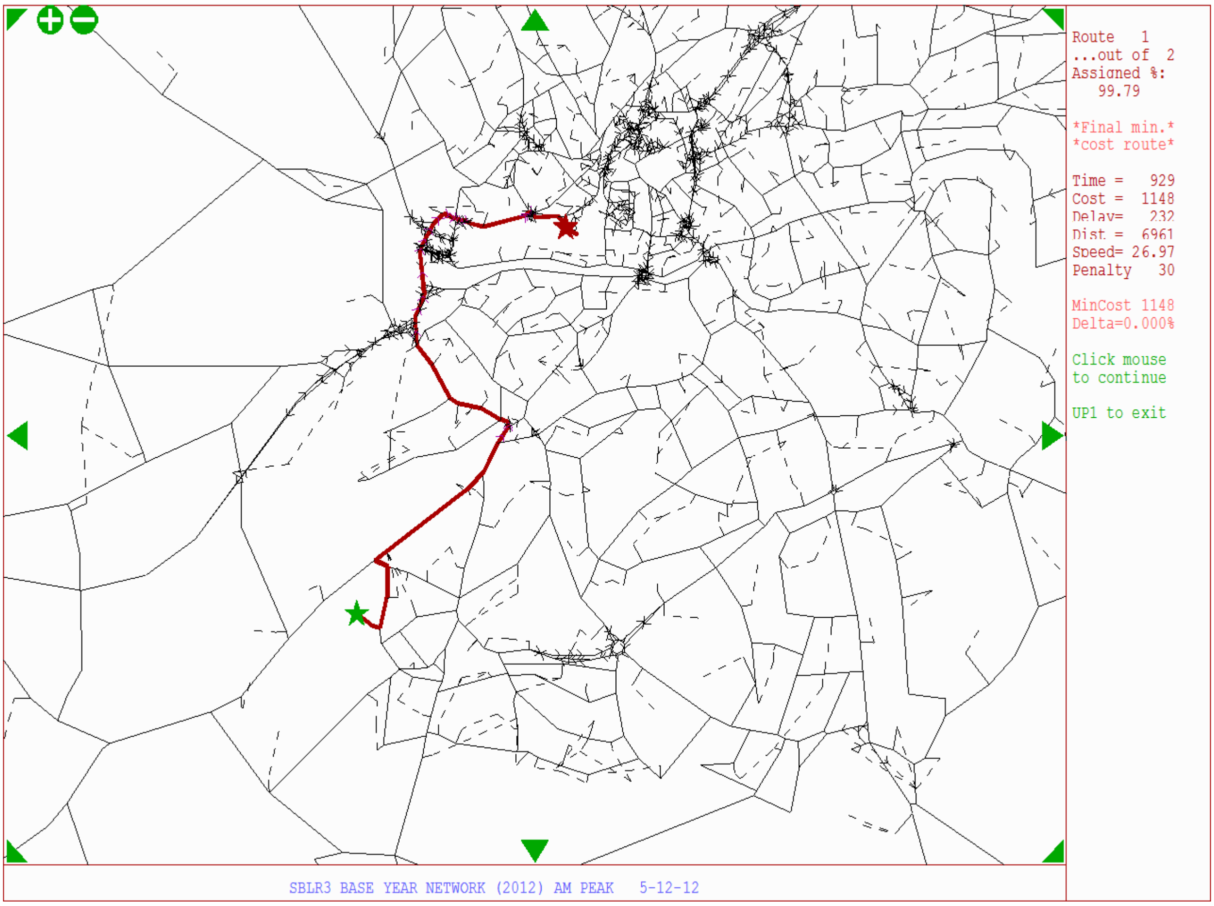
```
Route   1
...out of  2
Assigned %:
   99.79
Tpij=   0.05

*Final min.*
*cost route*

Time =  1031
Cost =  1269
Delay=   219
Dist =  7674
Speed= 26.79
Penalty   30

MinCost 1269
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

SBLR3 BASE YEAR NETWORK (2012) AM PEAK   5-12-12



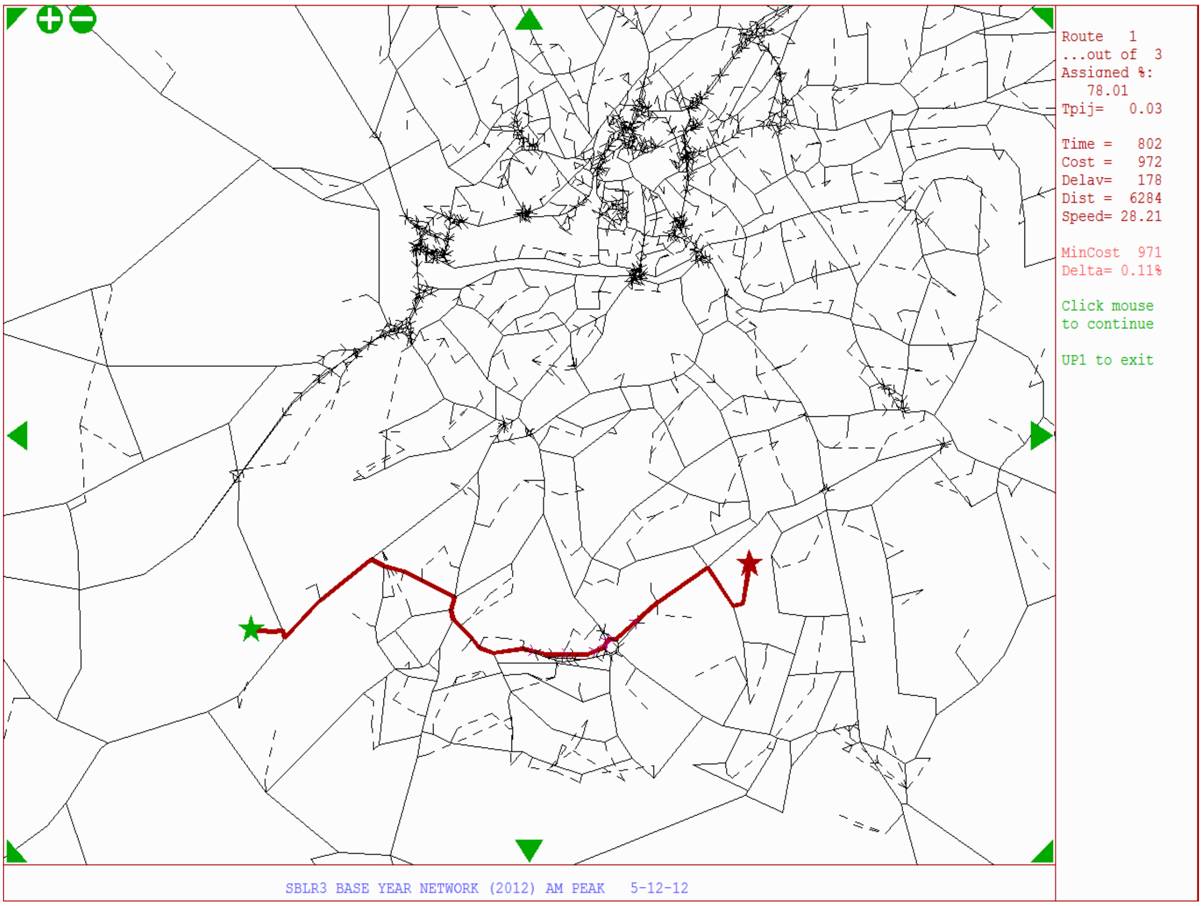
```
Route   1
...out of  2
Assigned %:
   99.79
Tpij=   0.02

*Final min.*
*cost route*

Time =   1100
Cost =   1351
Delay=    247
Dist =   8136
Speed= 26.62
Penalty   30

MinCost 1351
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

SBLR3 BASE YEAR NETWORK (2012) AM PEAK   5-12-12



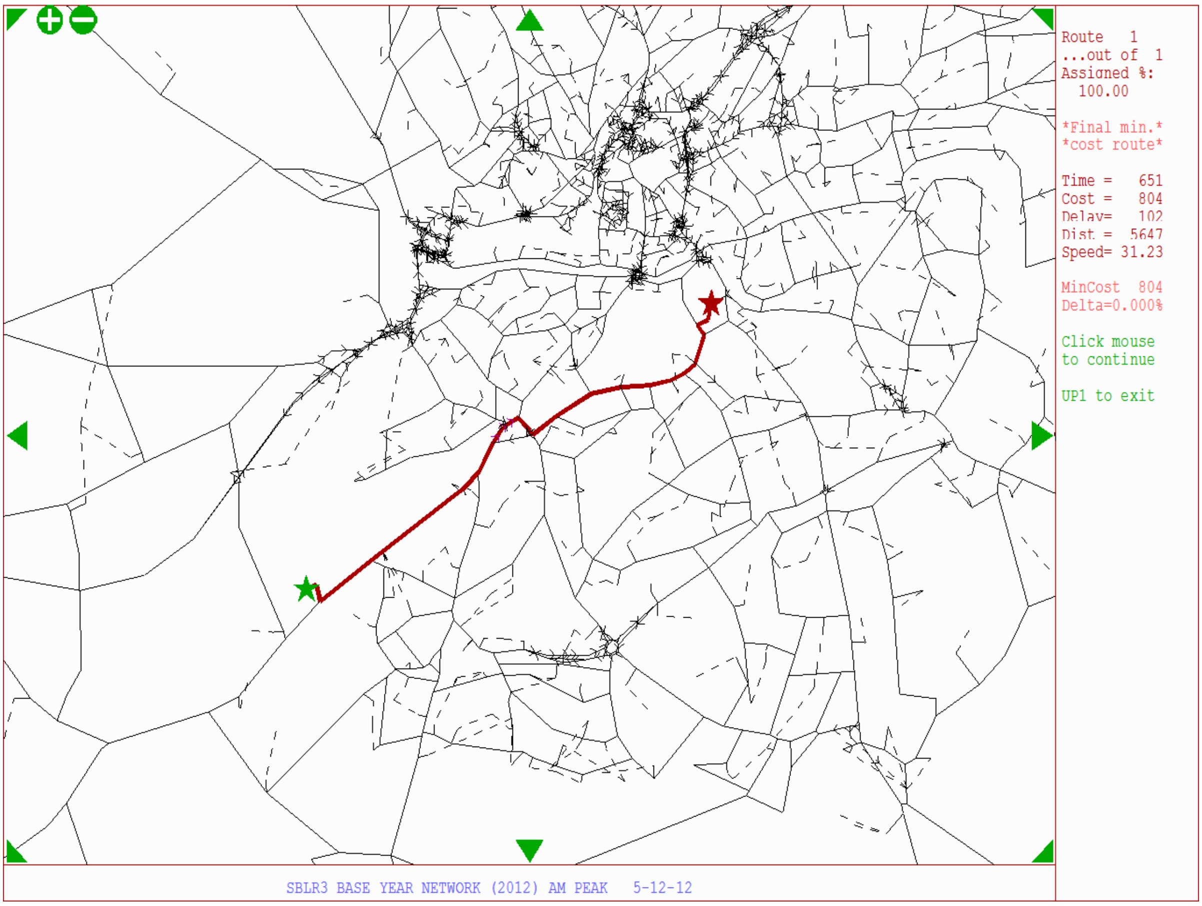
```
Route   1
...out of  2
Assigned %:
   99.79

*Final min.*
*cost route*

Time =    929
Cost =   1148
Delay=    232
Dist =   6961
Speed= 26.97
Penalty   30

MinCost 1148
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

SBLR3 BASE YEAR NETWORK (2012) AM PEAK   5-12-12



```
Route    1
...out of  3
Assigned %:
   78.01
Tpij=   0.03

Time =    802
Cost =    972
Delav=    178
Dist =   6284
Speed= 28.21

MinCost  971
Delta= 0.11%

Click mouse
to continue

UP1 to exit
```

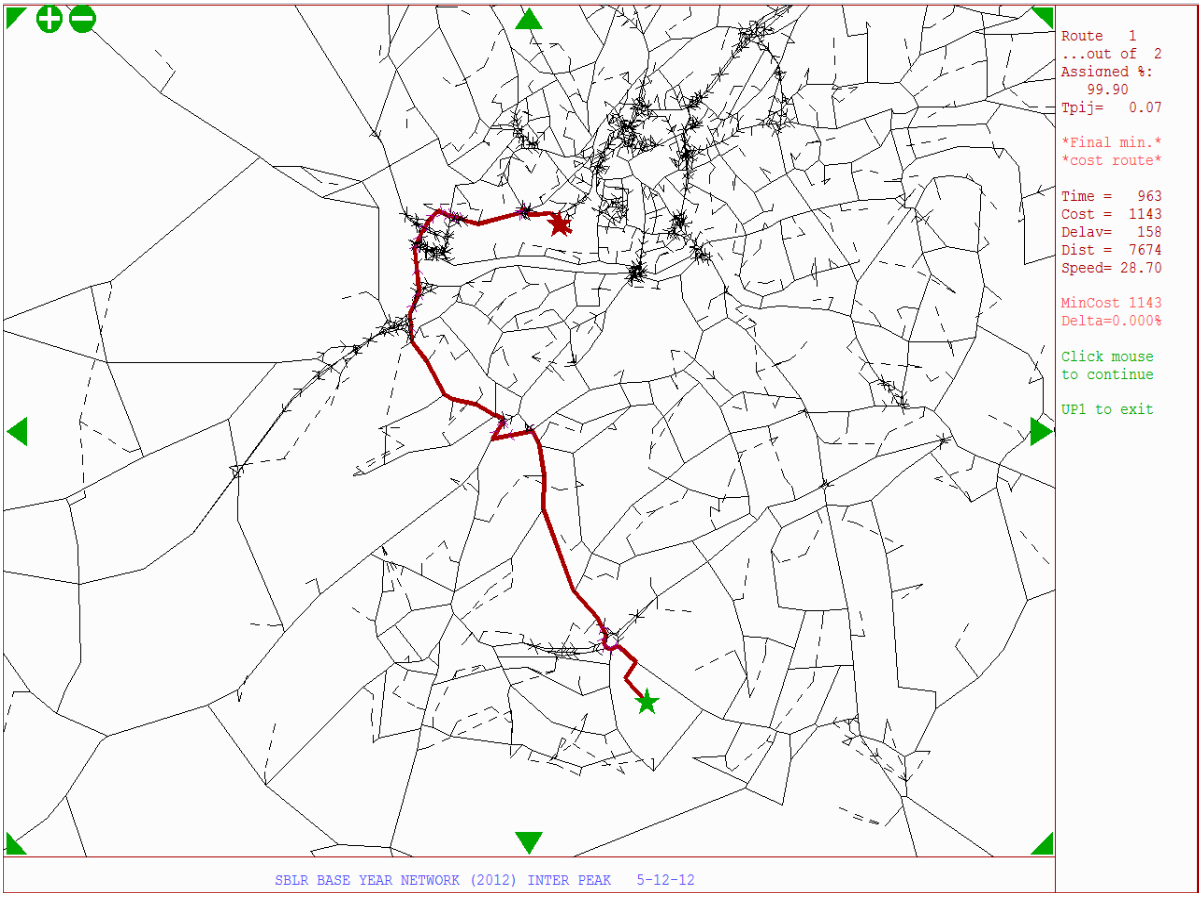
```
SBLR3 BASE YEAR NETWORK (2012) AM PEAK   5-12-12
```



```
Route    1
...out of  1
Assigned %:
  100.00

*Final min.*
*cost route*

Time =    651
Cost =    804
Delav=    102
Dist =   5647
Speed= 31.23

MinCost  804
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

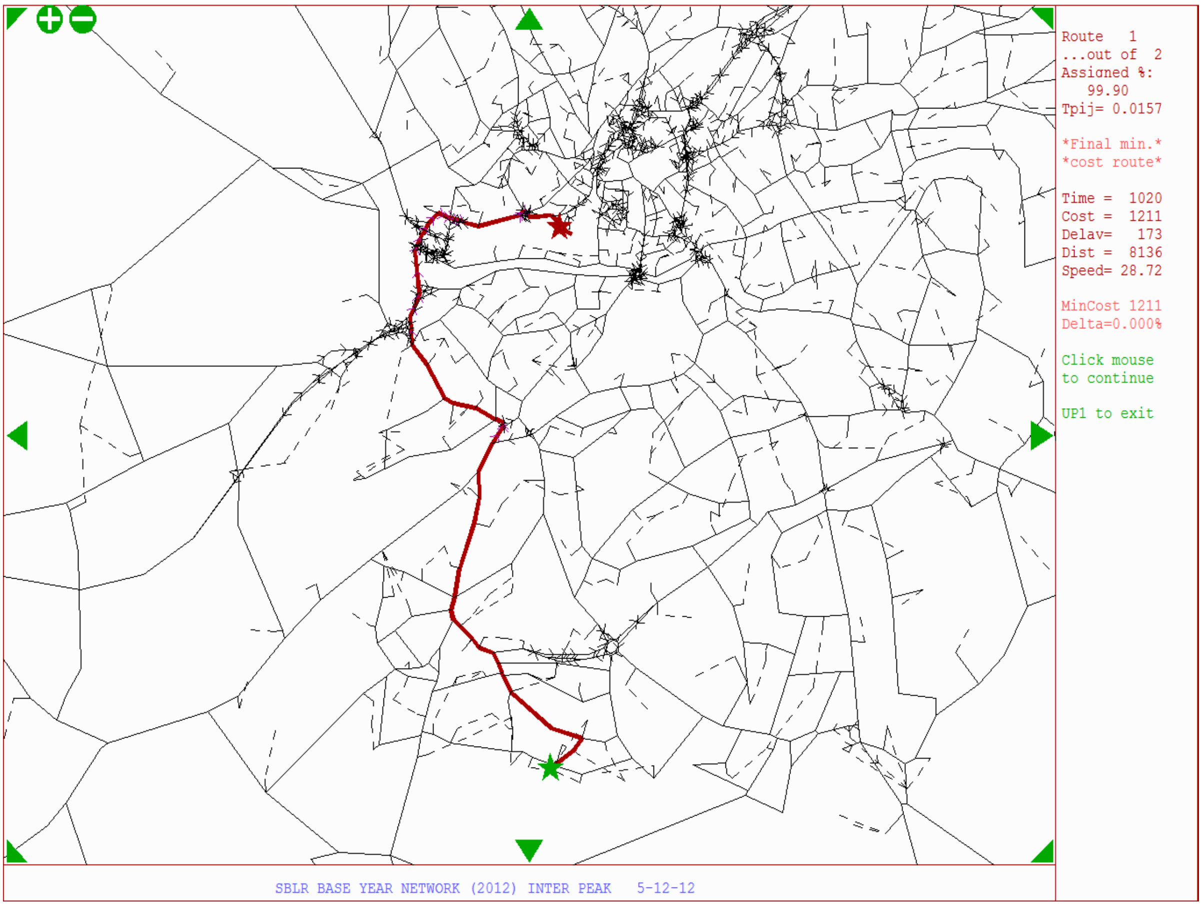
```
SBLR3 BASE YEAR NETWORK (2012) AM PEAK   5-12-12
```

C.1.2. Inter-Peak



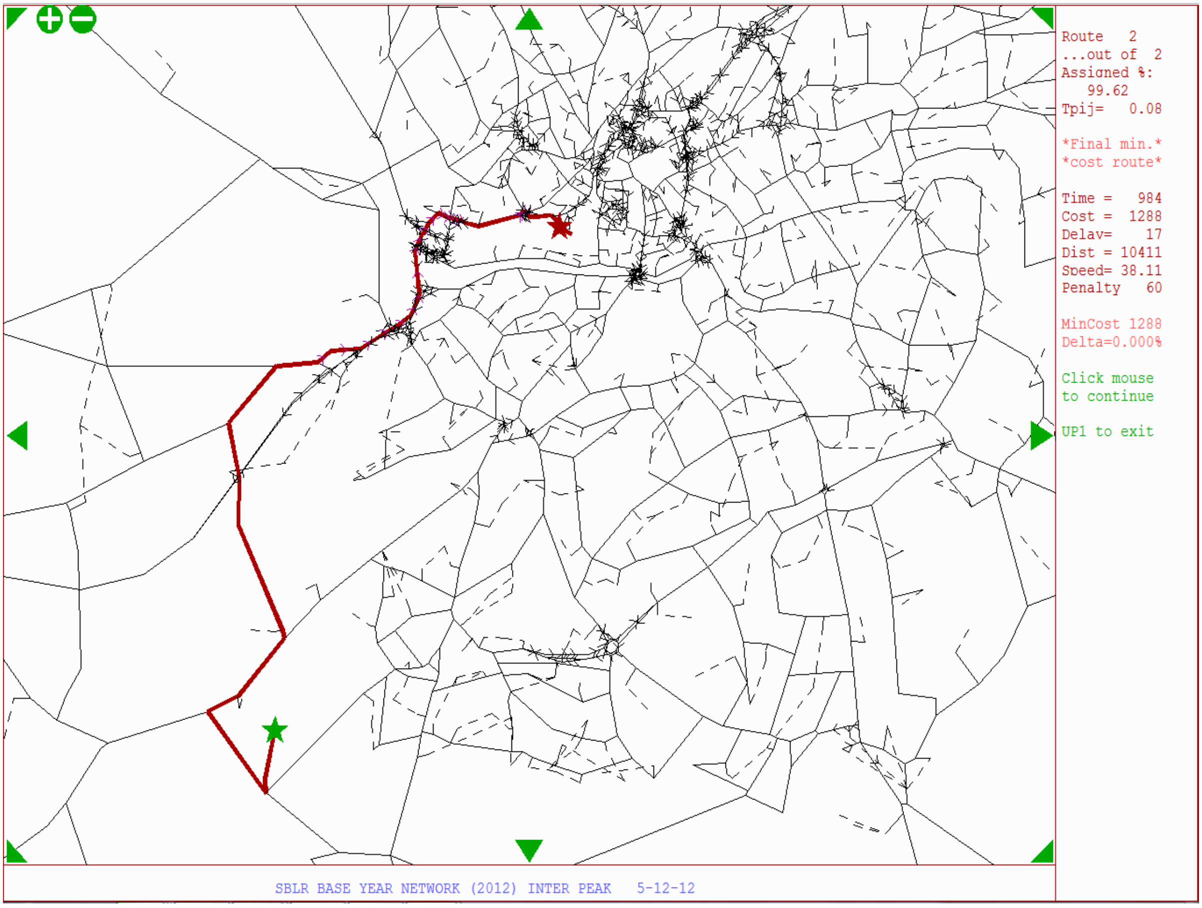
```
Route   1
...out of  2
Assigned %:
   99.90
Tpij=   0.07

*Final min.*
*cost route*

Time =   963
Cost =  1143
Delay=   158
Dist =  7674
Speed= 28.70

MinCost 1143
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

```
SBLR BASE YEAR NETWORK (2012) INTER PEAK   5-12-12
```



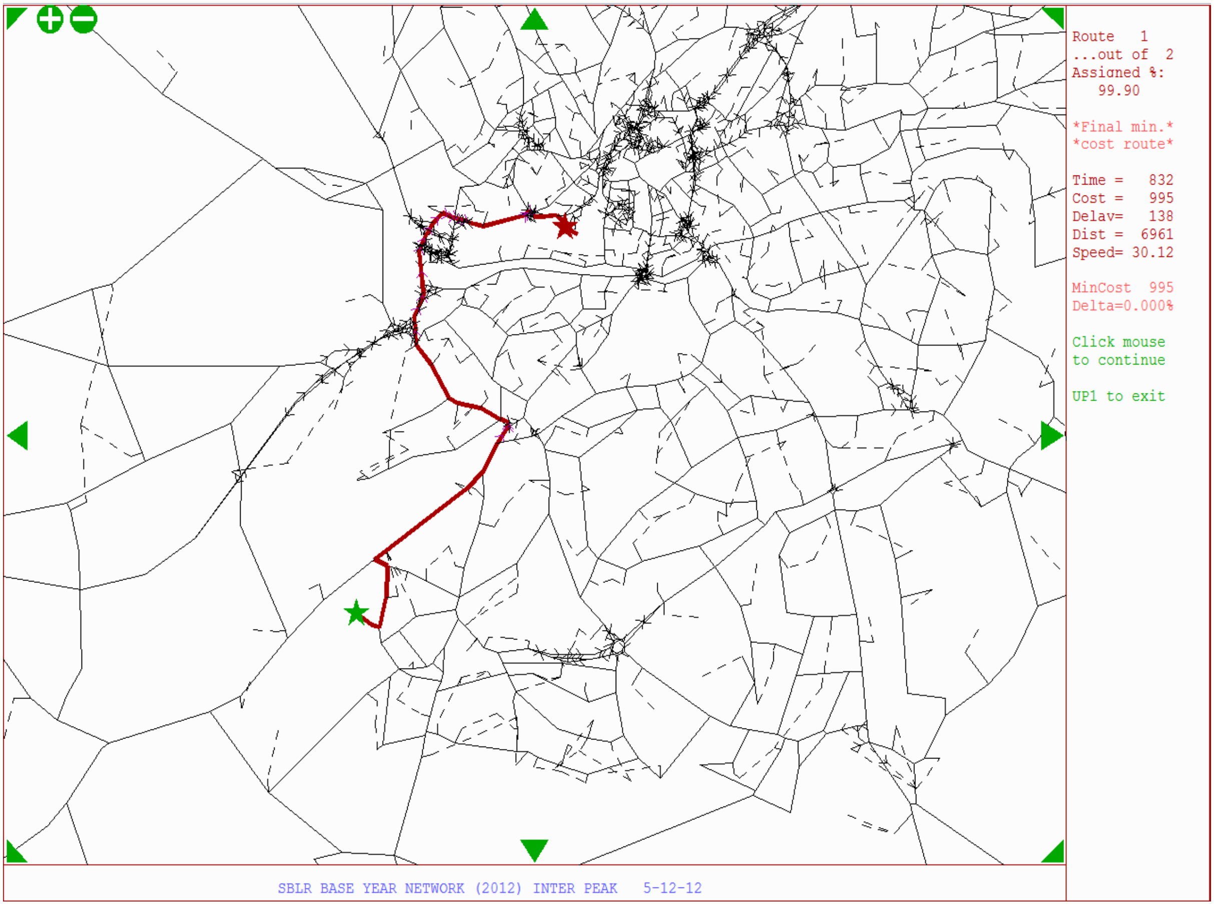
```
Route   1
...out of  2
Assigned %:
   99.90
Tpij= 0.0157

*Final min.*
*cost route*

Time =  1020
Cost =  1211
Delay=   173
Dist =  8136
Speed= 28.72

MinCost 1211
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

```
SBLR BASE YEAR NETWORK (2012) INTER PEAK   5-12-12
```



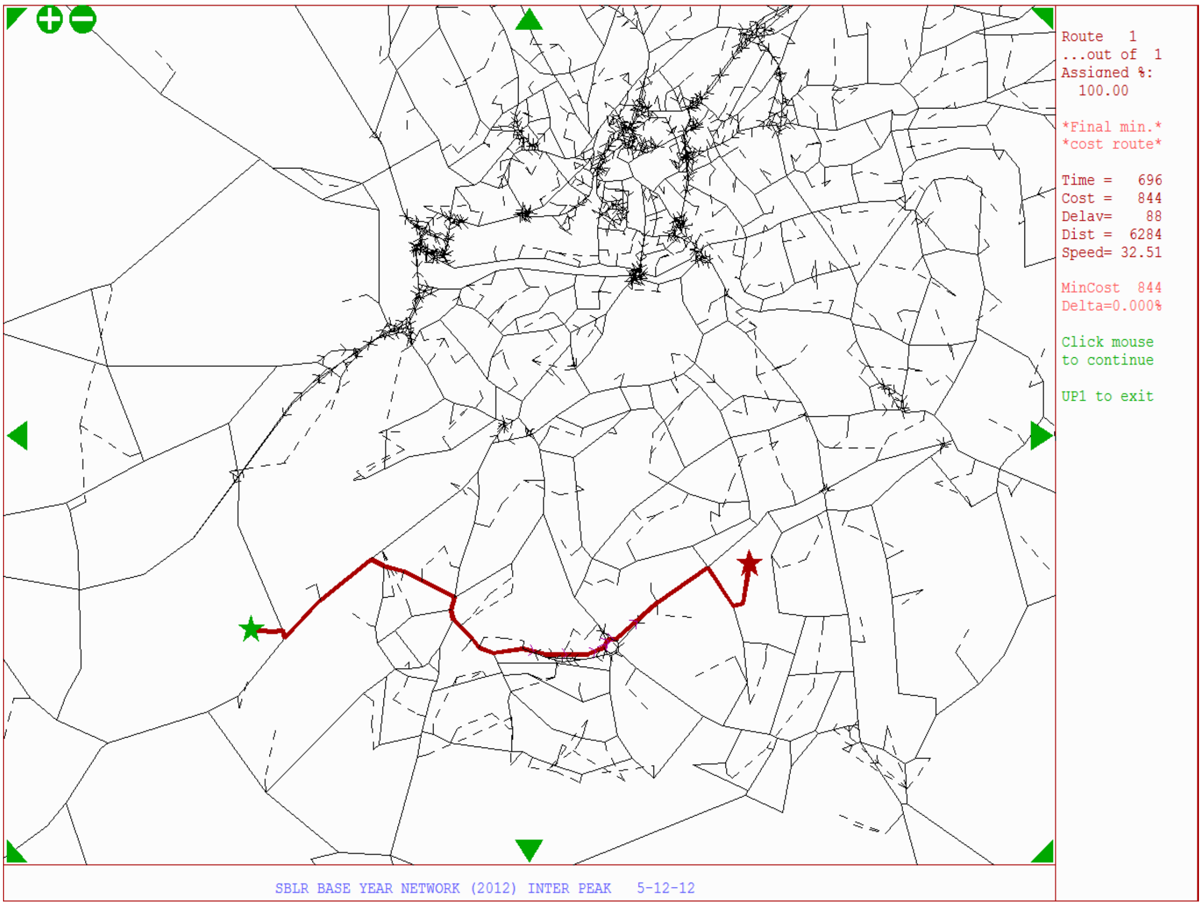
```
Route   2
...out of  2
Assigned %:
   99.62
Tpij=   0.08

*Final min.*
*cost route*

Time =   984
Cost =  1288
Delay=    17
Dist = 10411
Speed= 38.11
Penalty   60

MinCost 1288
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

SBLR BASE YEAR NETWORK (2012) INTER PEAK   5-12-12

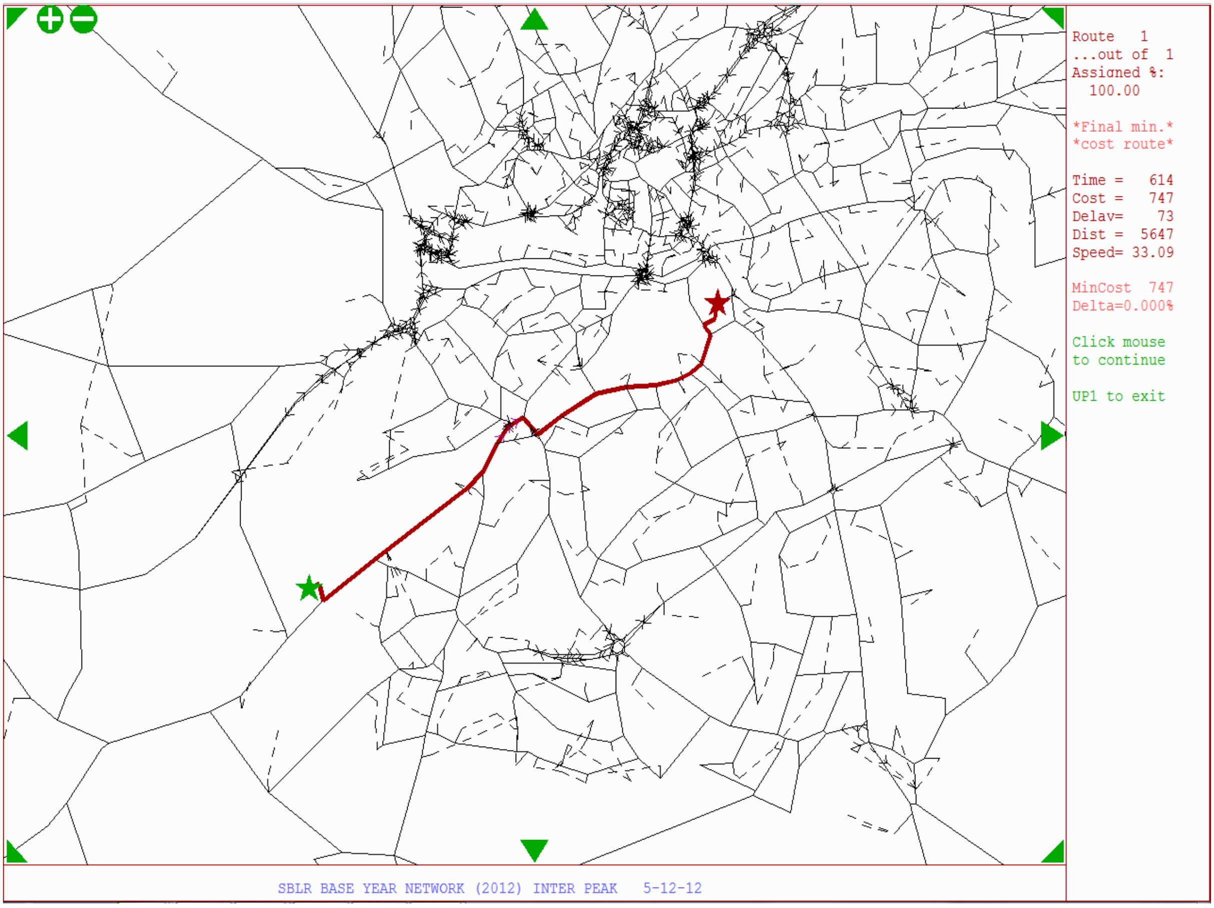


```
Route   1
...out of  2
Assigned %:
   99.90

*Final min.*
*cost route*

Time =   832
Cost =   995
Delay=   138
Dist =  6961
Speed= 30.12

MinCost  995
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

SBLR BASE YEAR NETWORK (2012) INTER PEAK   5-12-12

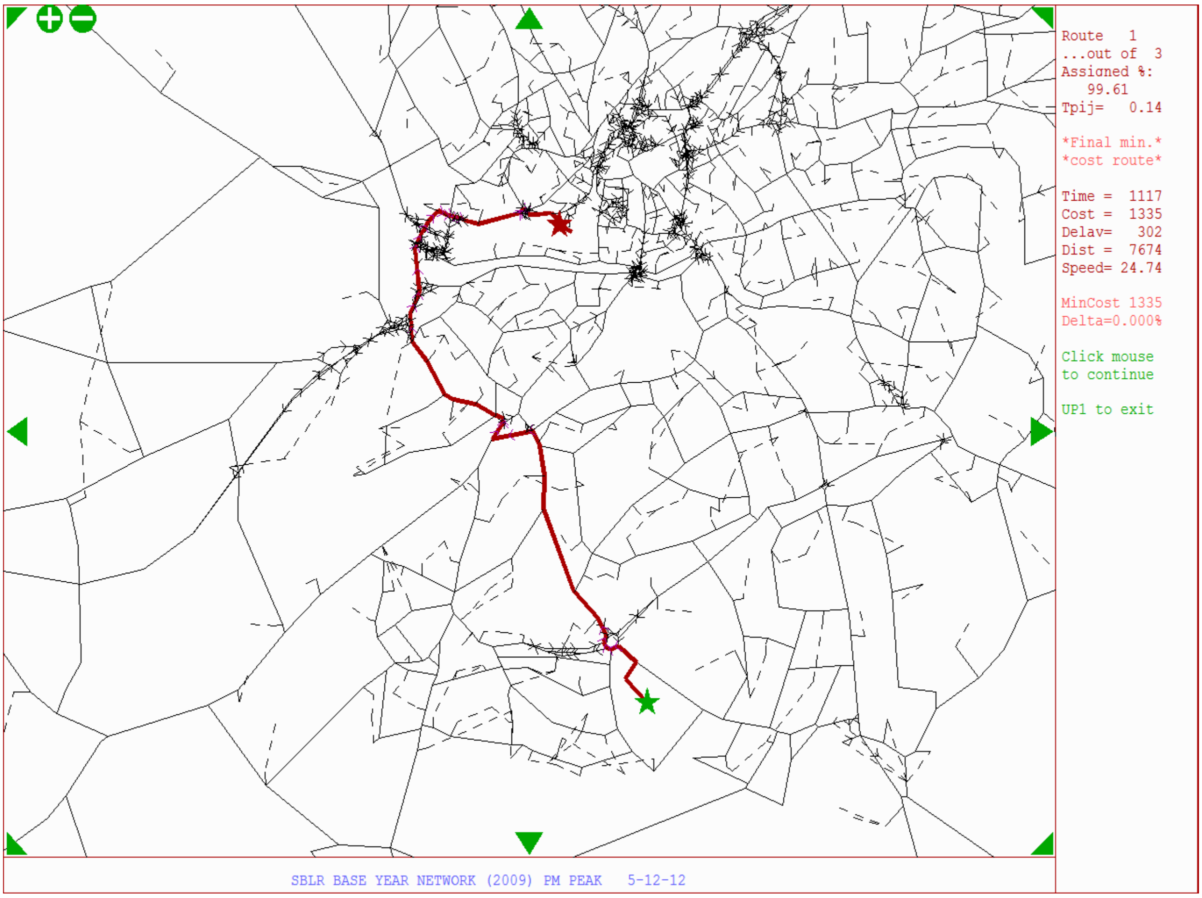


```
Route   1
...out of  1
Assigned %:
  100.00

*Final min.*
*cost route*

Time =   696
Cost =   844
Delav=    88
Dist =  6284
Speed= 32.51

MinCost  844
Delta=0.000%

Click mouse
to continue

UP1 to exit
```



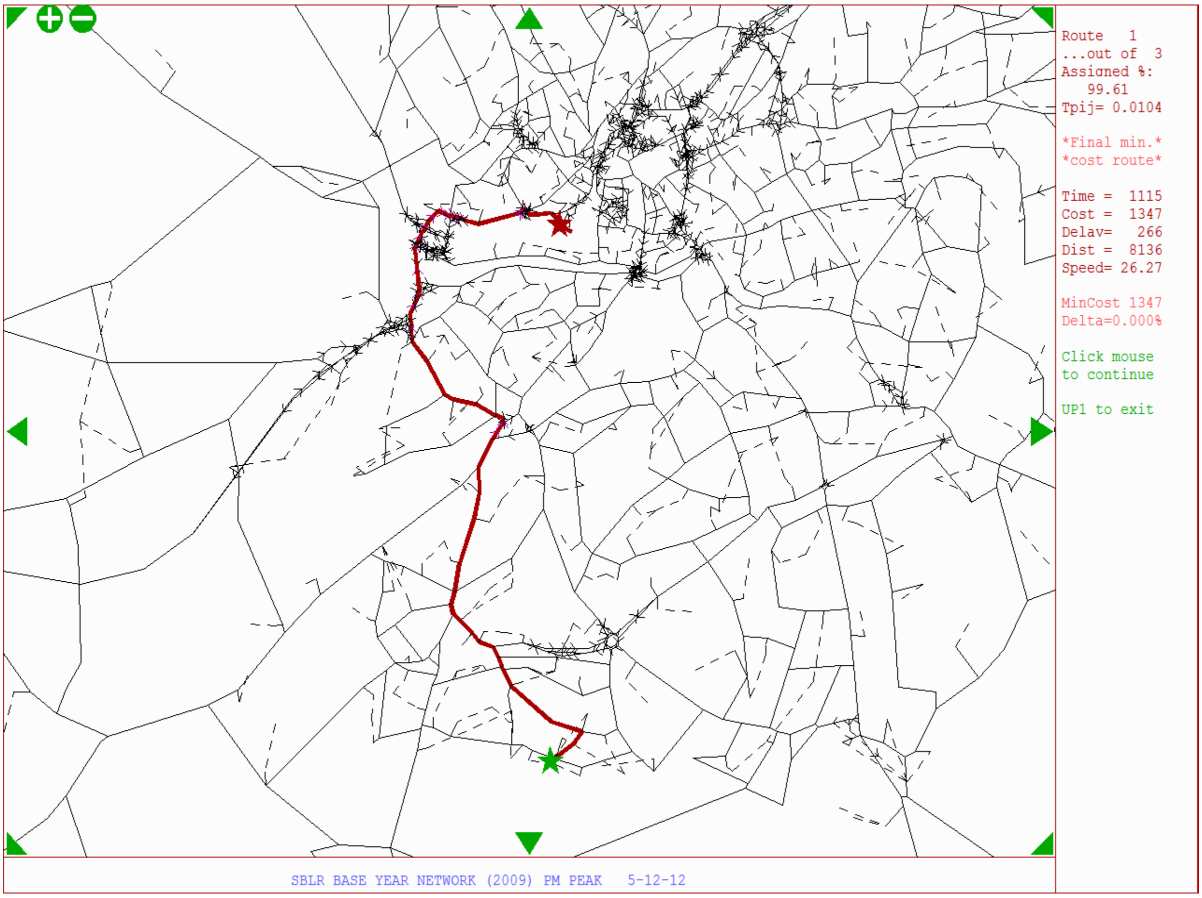
```
Route   1
...out of  1
Assigned %:
  100.00

*Final min.*
*cost route*

Time =   614
Cost =   747
Delav=    73
Dist =  5647
Speed= 33.09

MinCost  747
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

C.1.3. Evening Peak



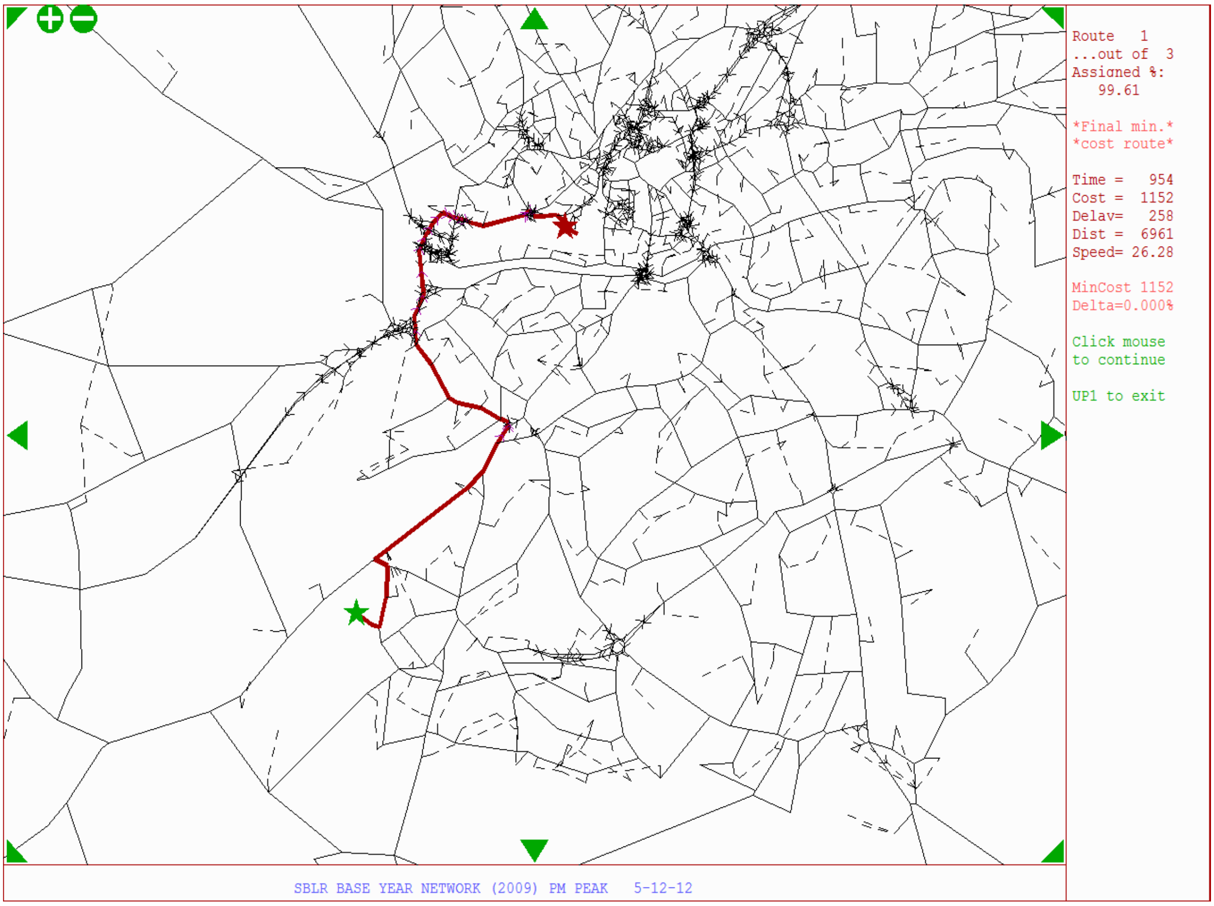
```
Route   1
...out of  3
Assigned %:
   99.61
Tpij=   0.14

*Final min.*
*cost route*

Time =  1117
Cost =  1335
Delav=   302
Dist =  7674
Speed= 24.74

MinCost 1335
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

SBLR BASE YEAR NETWORK (2009) PM PEAK   5-12-12

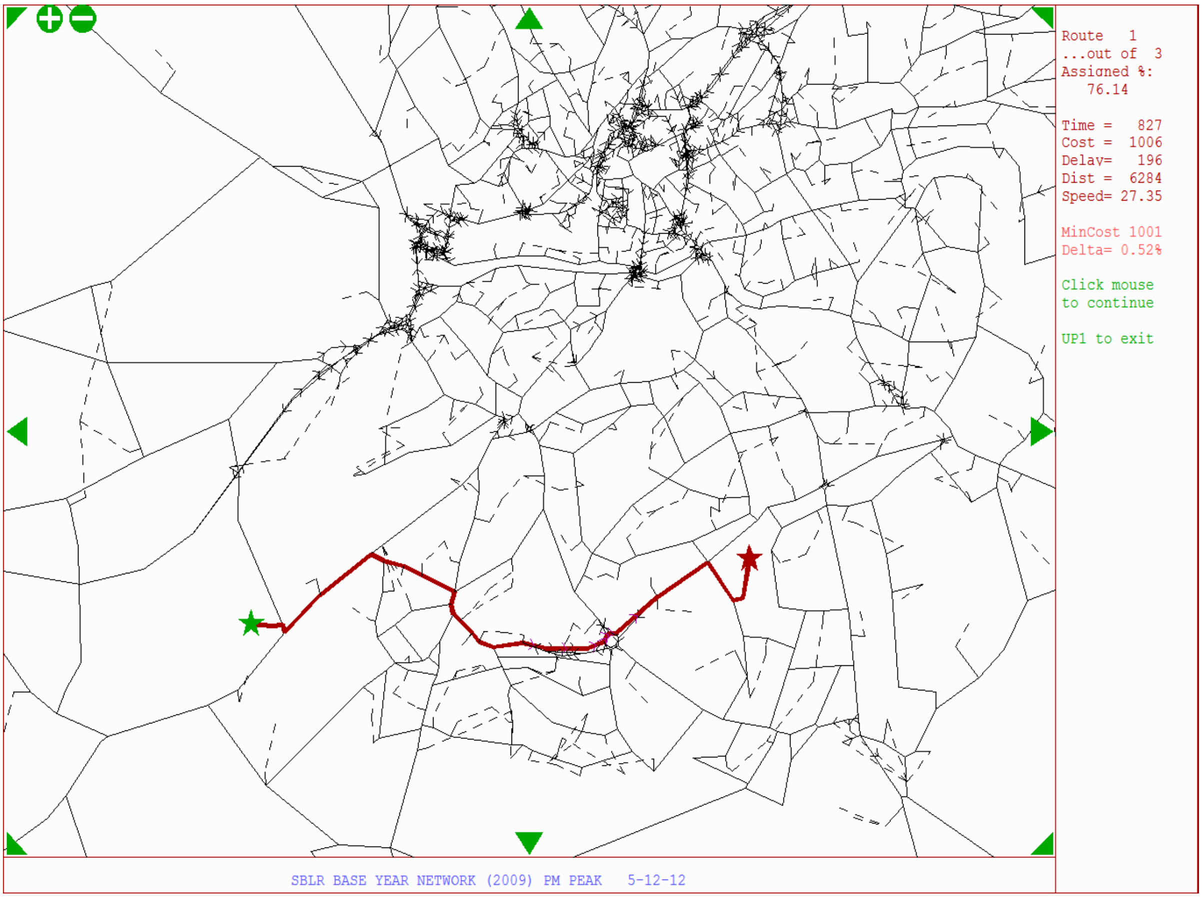


```
Route   1
...out of  3
Assigned %:
   99.61
Tpij= 0.0104

*Final min.*
*cost route*

Time =  1115
Cost =  1347
Delav=   266
Dist =  8136
Speed= 26.27

MinCost 1347
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

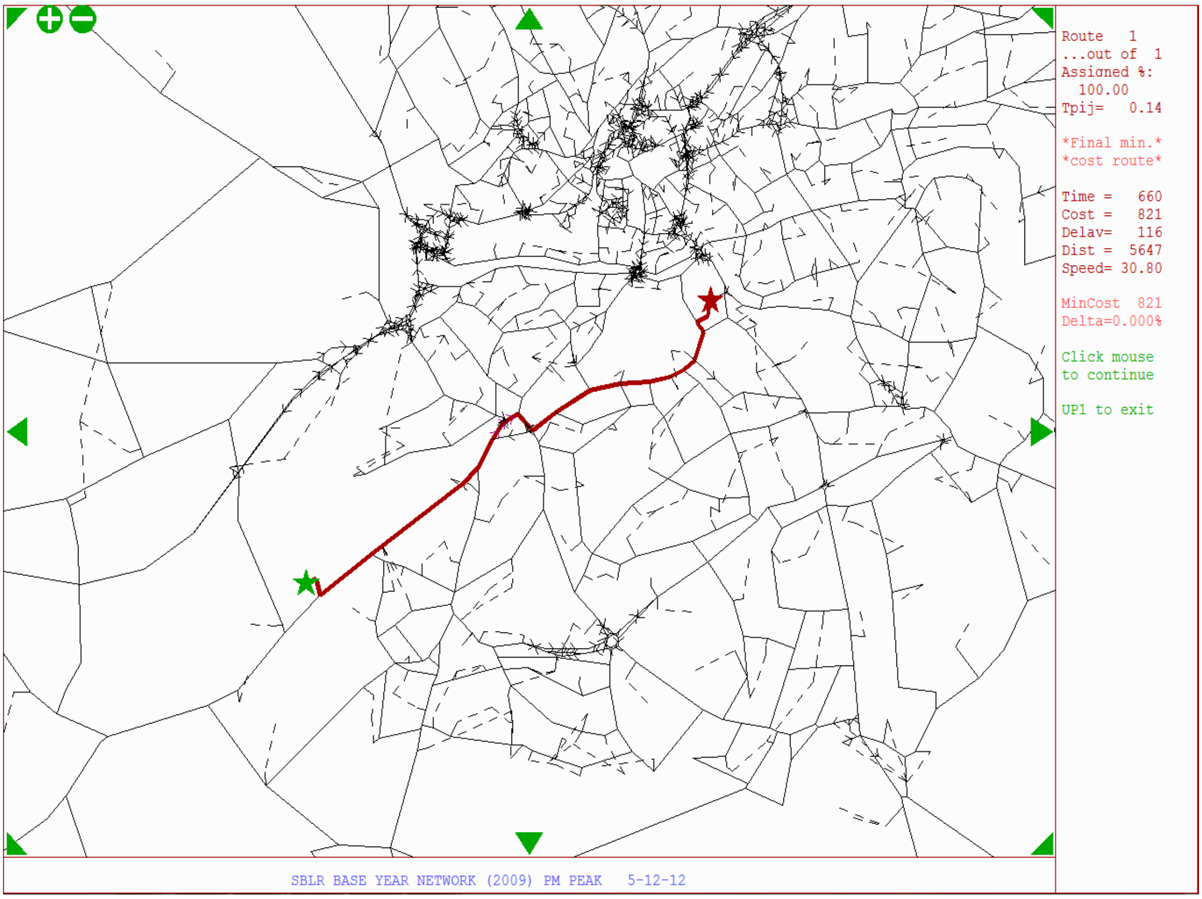
SBLR BASE YEAR NETWORK (2009) PM PEAK   5-12-12



```
Route   1
...out of  3
Assigned %:
   99.61

*Final min.*
*cost route*

Time =    954
Cost =   1152
Delay=    258
Dist =   6961
Speed= 26.28

MinCost 1152
Delta=0.000%

Click mouse
to continue

UP1 to exit
```



```
Route   1
...out of  3
Assigned %:
   76.14

Time =    827
Cost =   1006
Delay=    196
Dist =   6284
Speed= 27.35

MinCost 1001
Delta= 0.52%

Click mouse
to continue

UP1 to exit
```

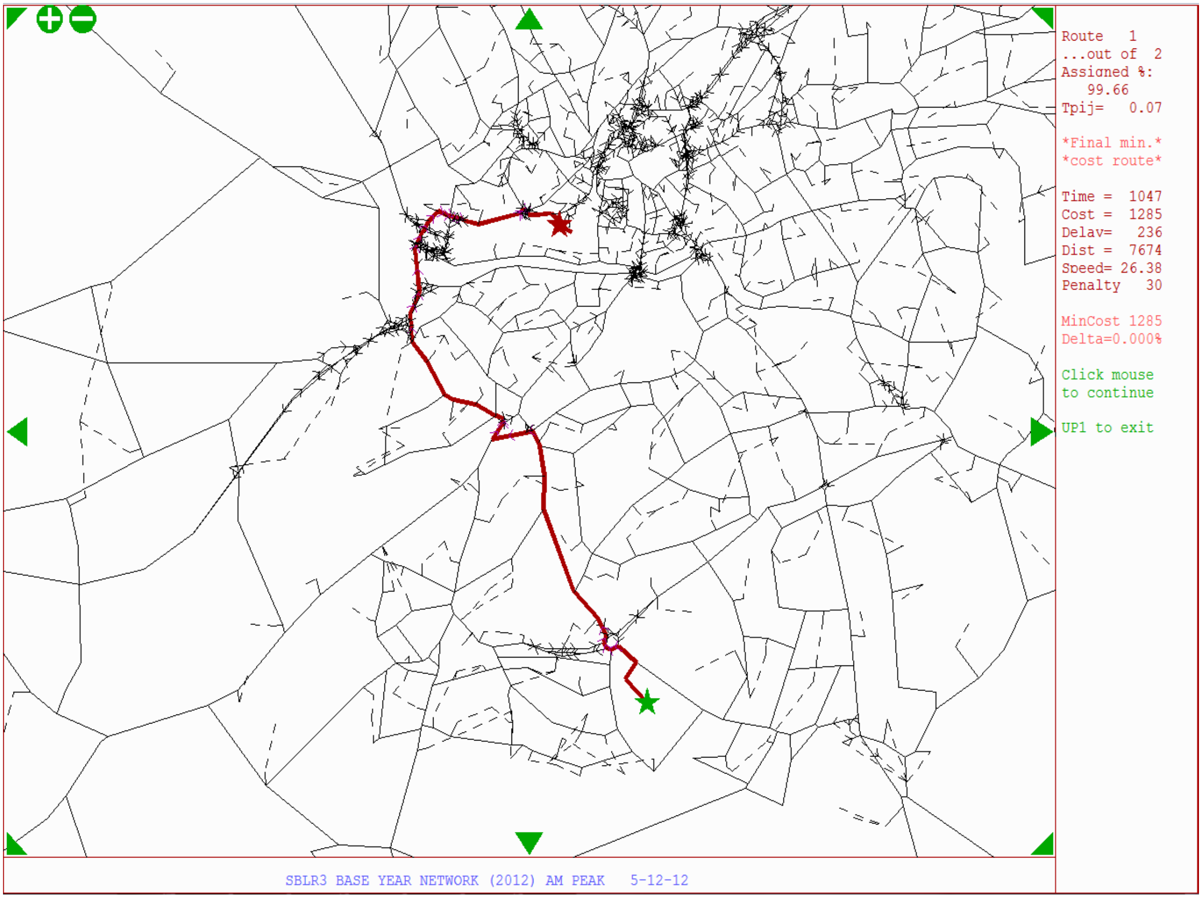


```
Route   1
...out of  1
Assigned %:
  100.00
Tpij=   0.14

*Final min.*
*cost route*

Time =   660
Cost =   821
Delay=   116
Dist =  5647
Speed= 30.80

MinCost  821
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

SBLR BASE YEAR NETWORK (2009) PM PEAK   5-12-12

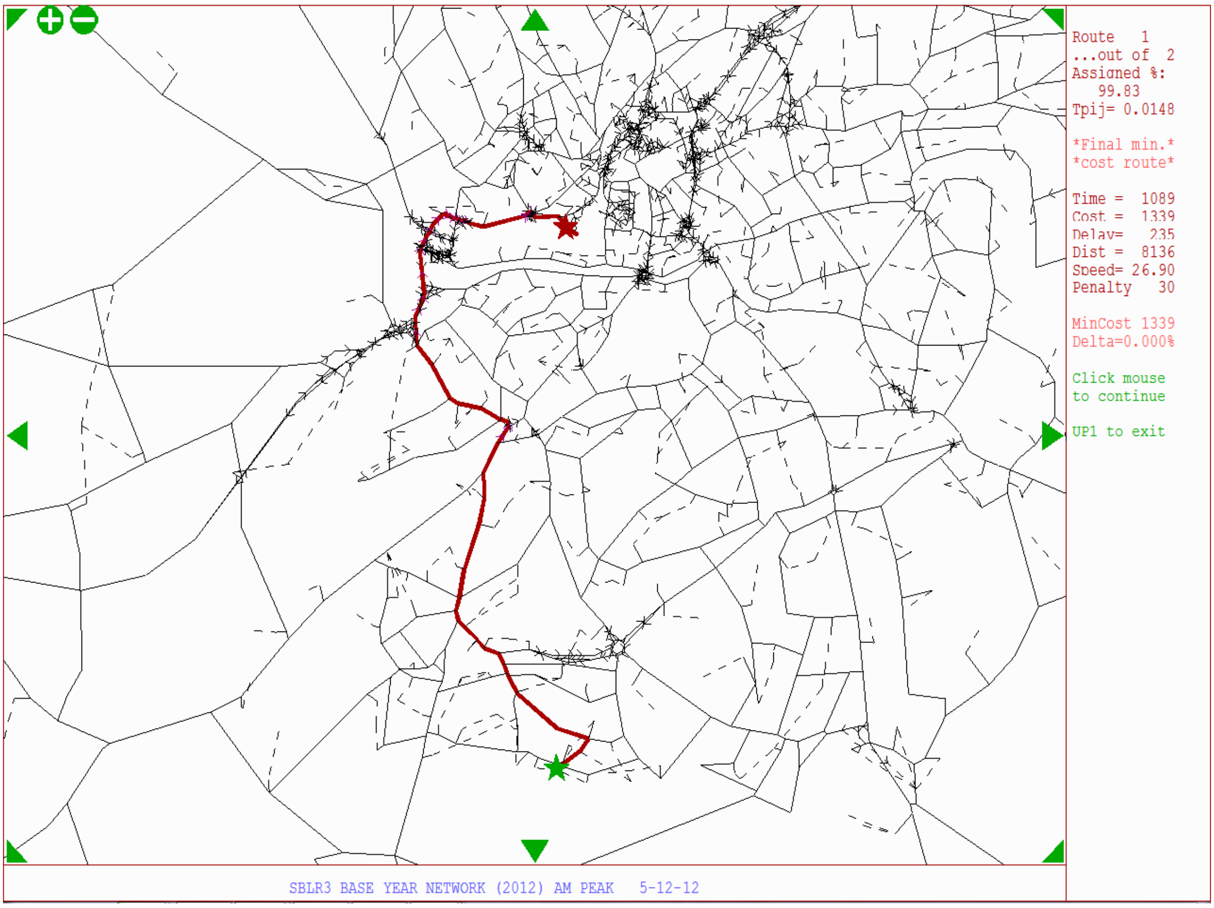
C.2. Post ME Assignment

C.2.1. Morning Peak



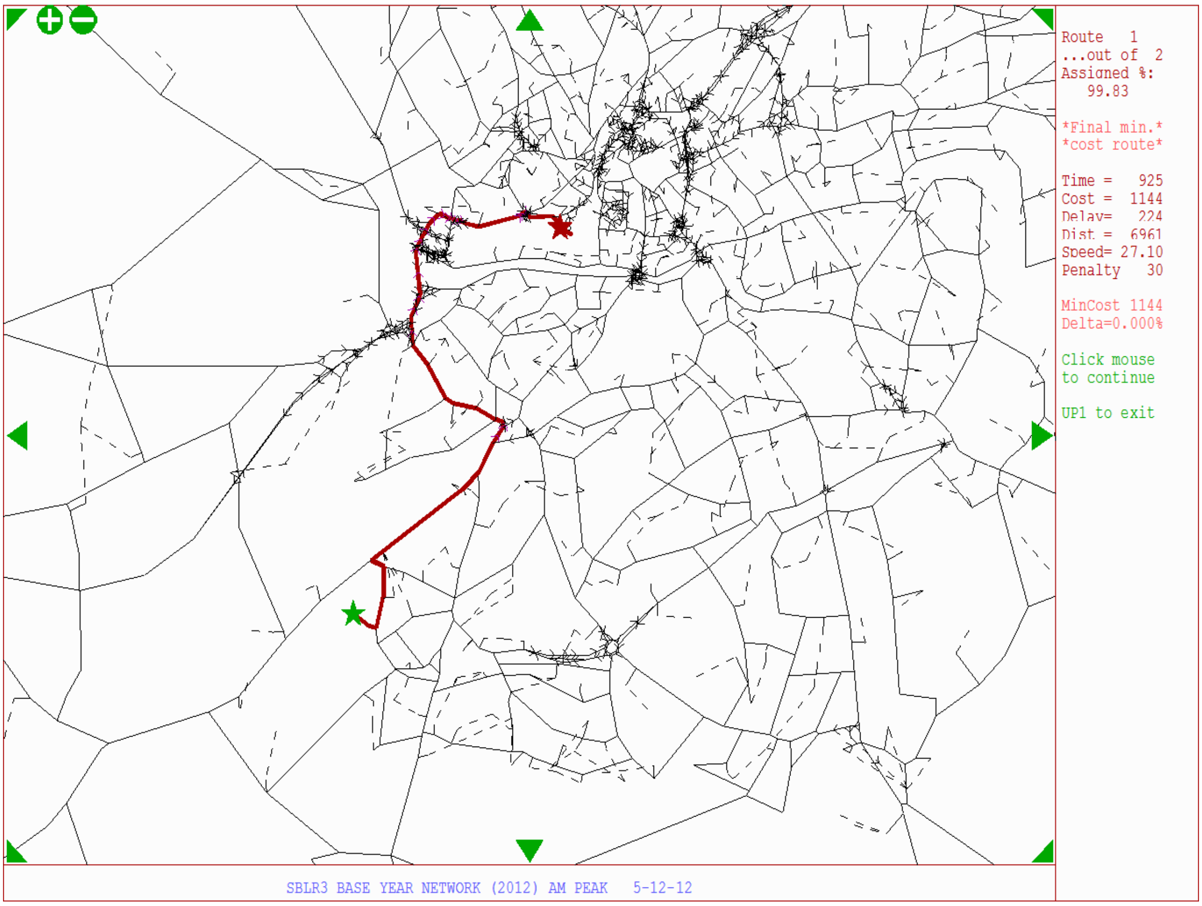
```
Route   1
...out of  2
Assigned %:
   99.66
Tpij=   0.07

*Final min.*
*cost route*

Time =  1047
Cost =  1285
Delay=   236
Dist =  7674
Speed= 26.38
Penalty   30

MinCost 1285
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

```
SBLR3 BASE YEAR NETWORK (2012) AM PEAK   5-12-12
```



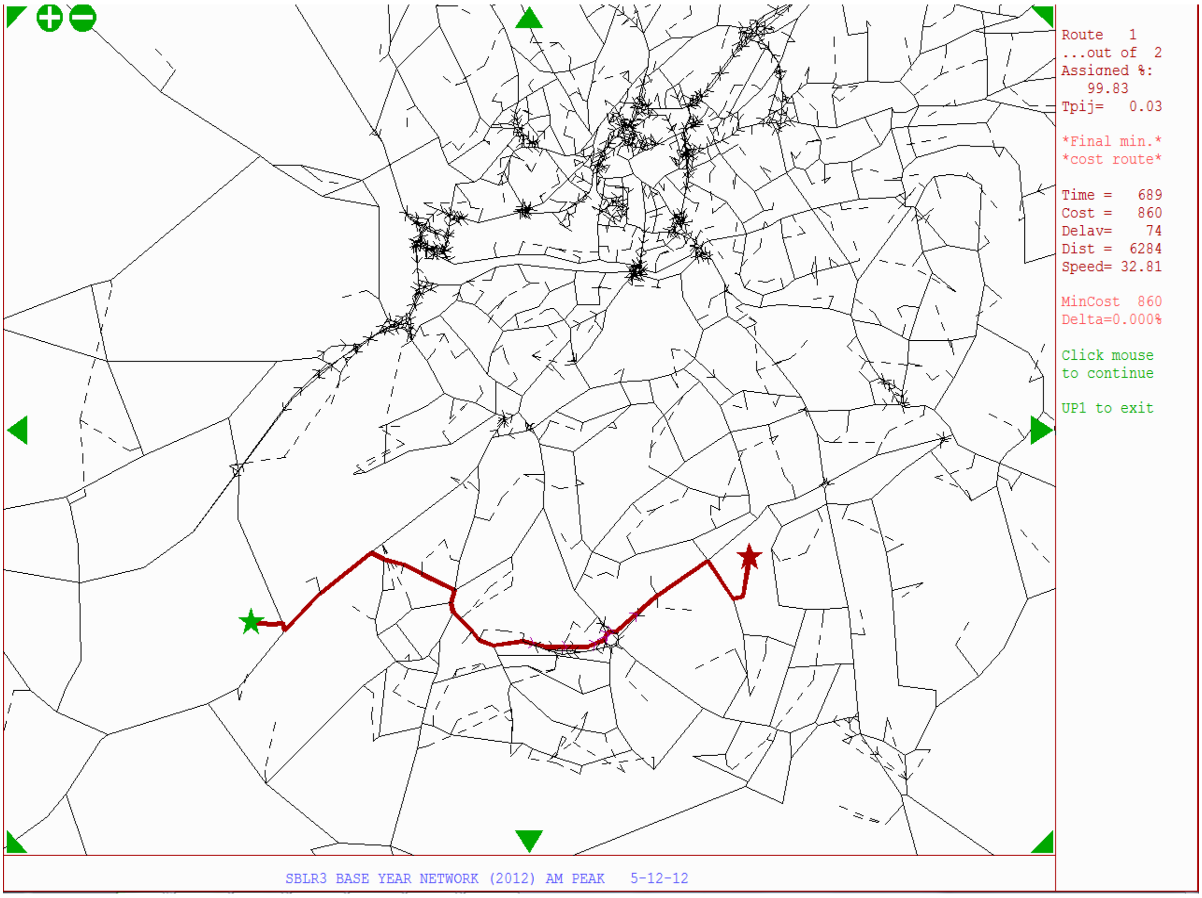
```
Route    1
...out of  2
Assigned %:
   99.83
Tpij= 0.0148

*Final min.*
*cost route*

Time =   1089
Cost =   1339
Delay=    235
Dist =   8136
Speed= 26.90
Penalty   30

MinCost 1339
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

```
SBLR3 BASE YEAR NETWORK (2012) AM PEAK   5-12-12
```



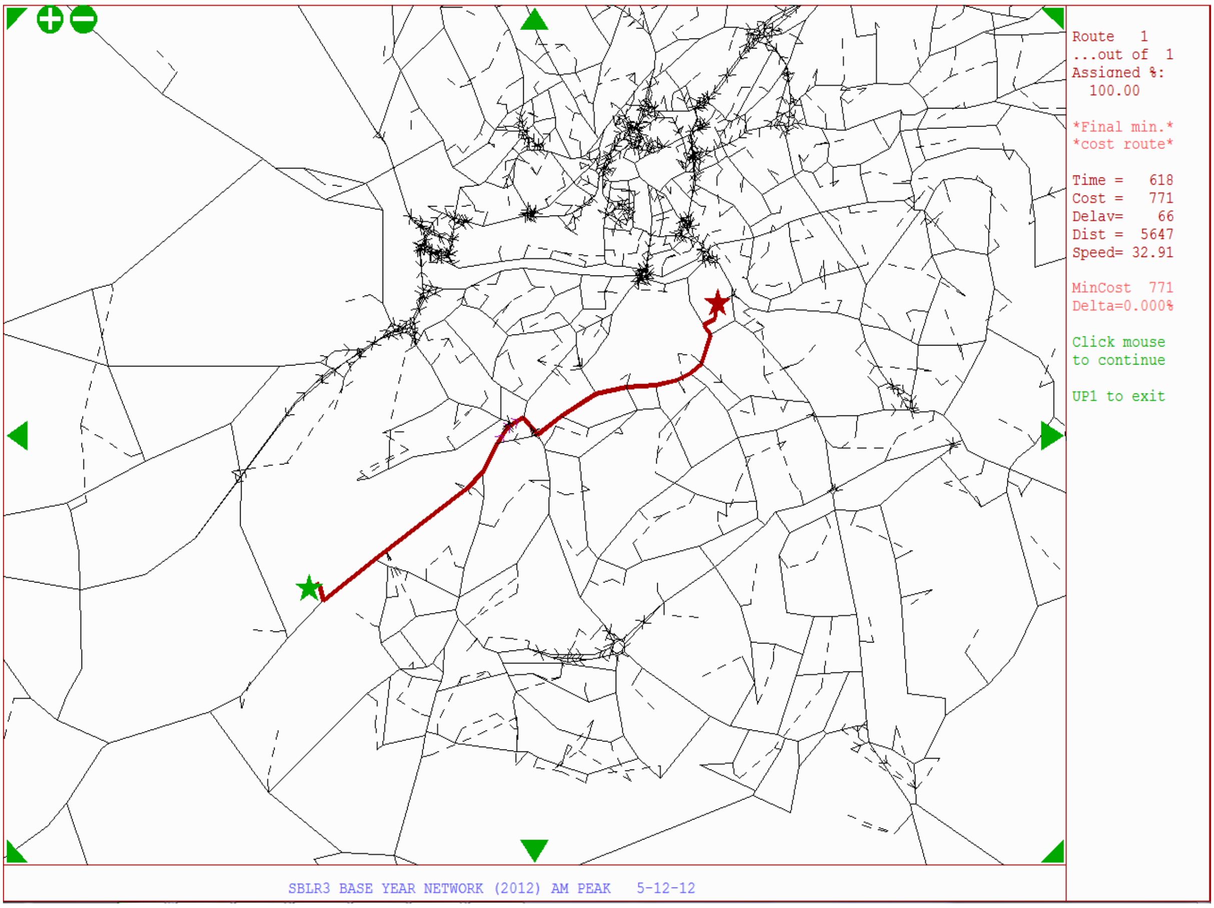
```
Route    1
...out of  2
Assigned %:
   99.83

*Final min.*
*cost route*

Time =    925
Cost =   1144
Delay=    224
Dist =   6961
Speed= 27.10
Penalty   30

MinCost 1144
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

```
SBLR3 BASE YEAR NETWORK (2012) AM PEAK   5-12-12
```



```
Route   1
...out of  2
Assigned %:
   99.83
Tpij=   0.03

*Final min.*
*cost route*

Time =   689
Cost =   860
Delav=    74
Dist =  6284
Speed= 32.81

MinCost  860
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

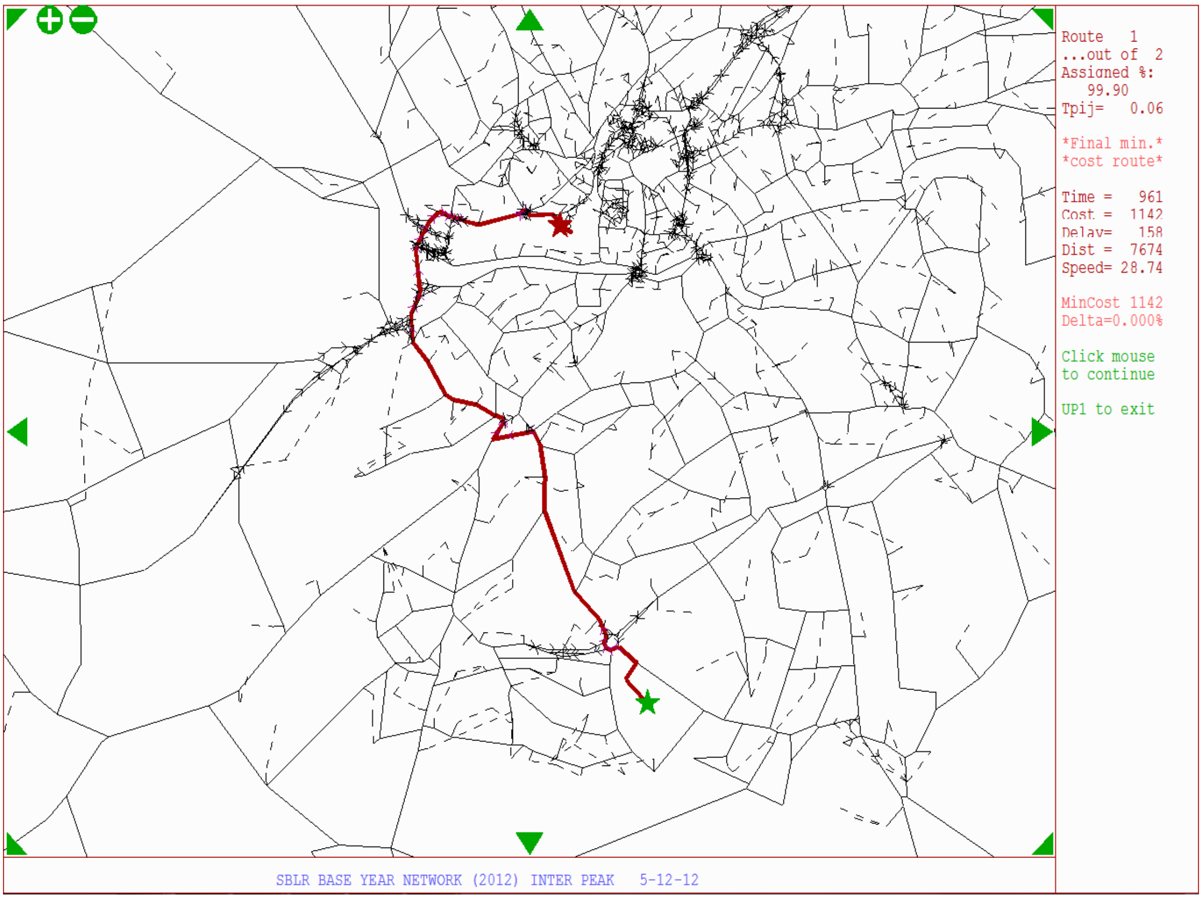
```
SBLR3 BASE YEAR NETWORK (2012) AM PEAK   5-12-12
```



```
Route    1
...out of  1
Assigned %:
  100.00

*Final min.*
*cost route*

Time =    618
Cost =    771
Delay=     66
Dist =  5647
Speed= 32.91

MinCost  771
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

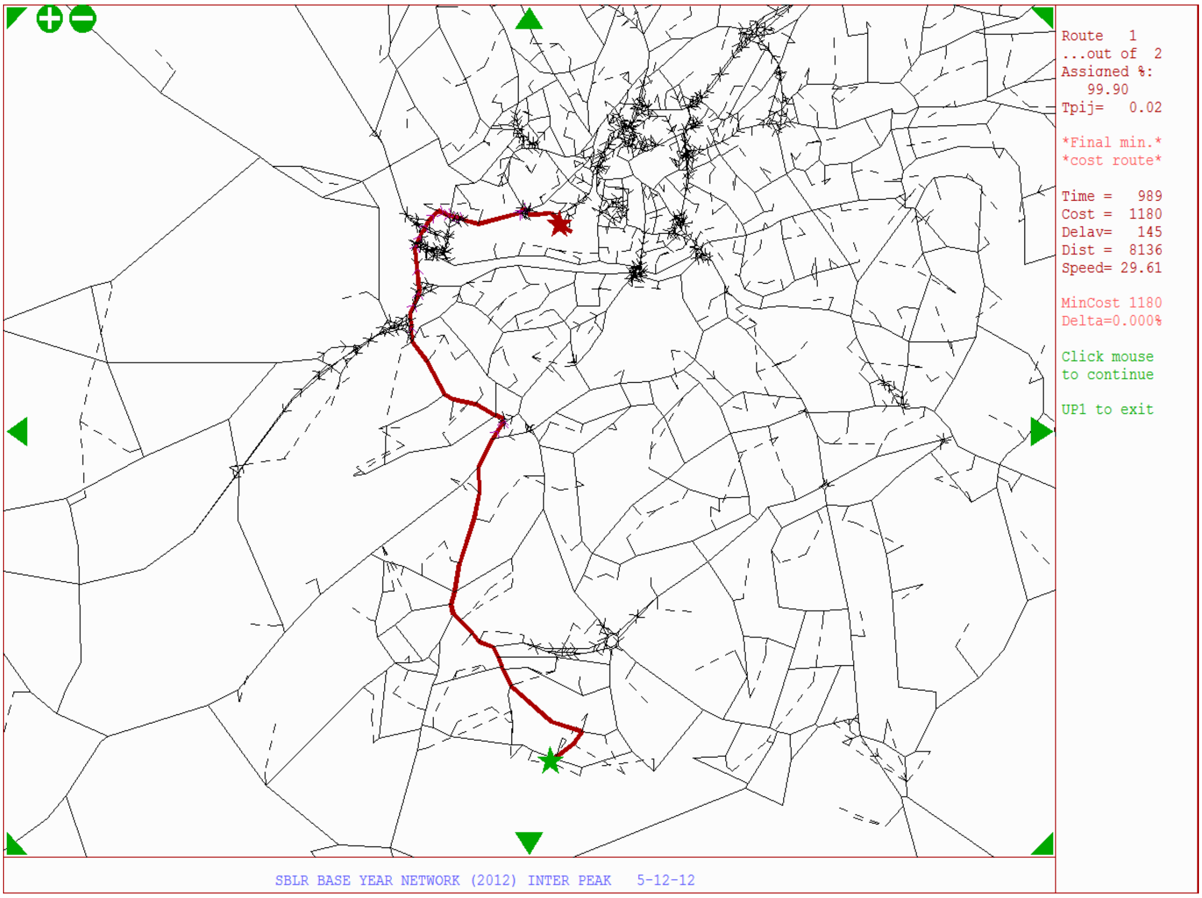
SBLR3 BASE YEAR NETWORK (2012) AM PEAK   5-12-12

C.2.2. Inter-Peak

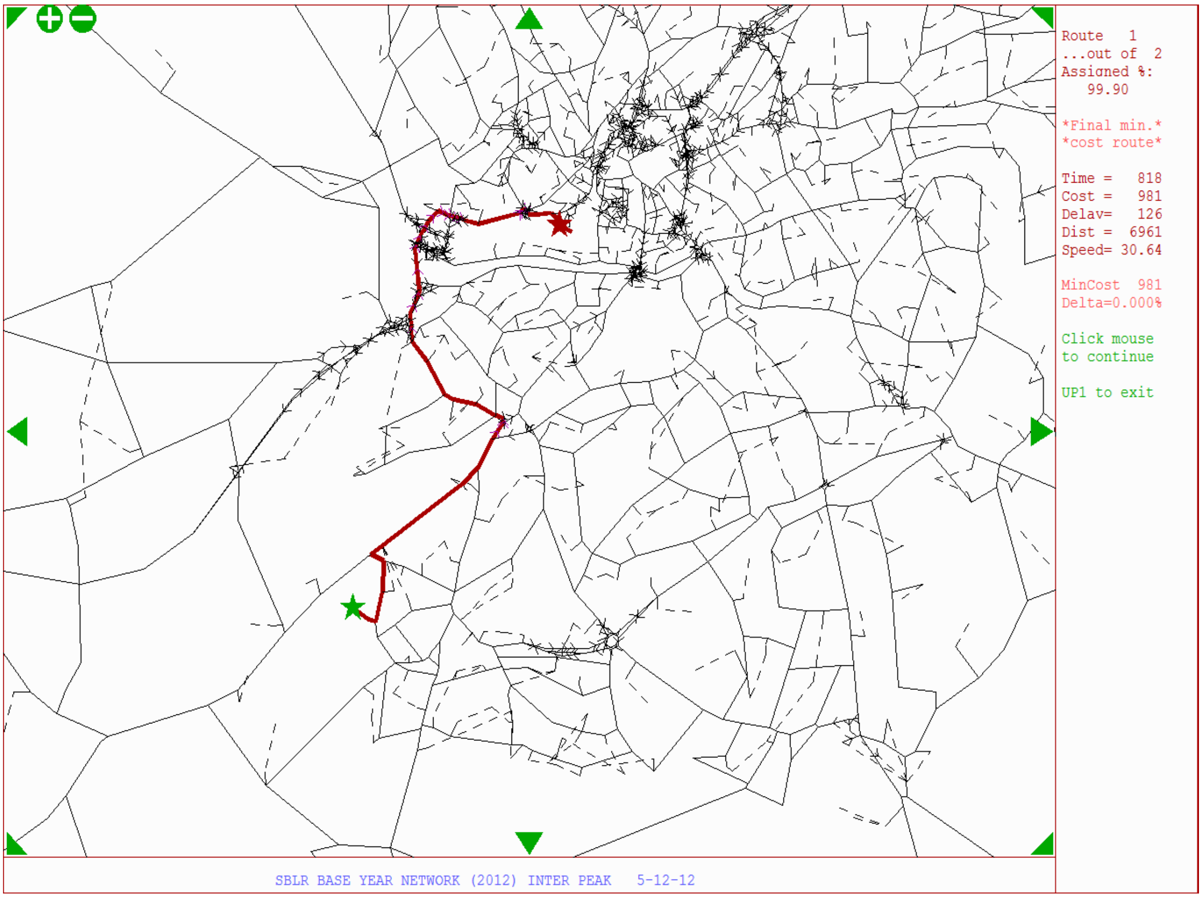


```
Route    1
...out of  2
Assigned %:
   99.90
Tpij=    0.06

*Final min.*
*cost route*

Time =    961
Cost =   1142
Delay=    158
Dist =   7674
Speed= 28.74

MinCost 1142
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

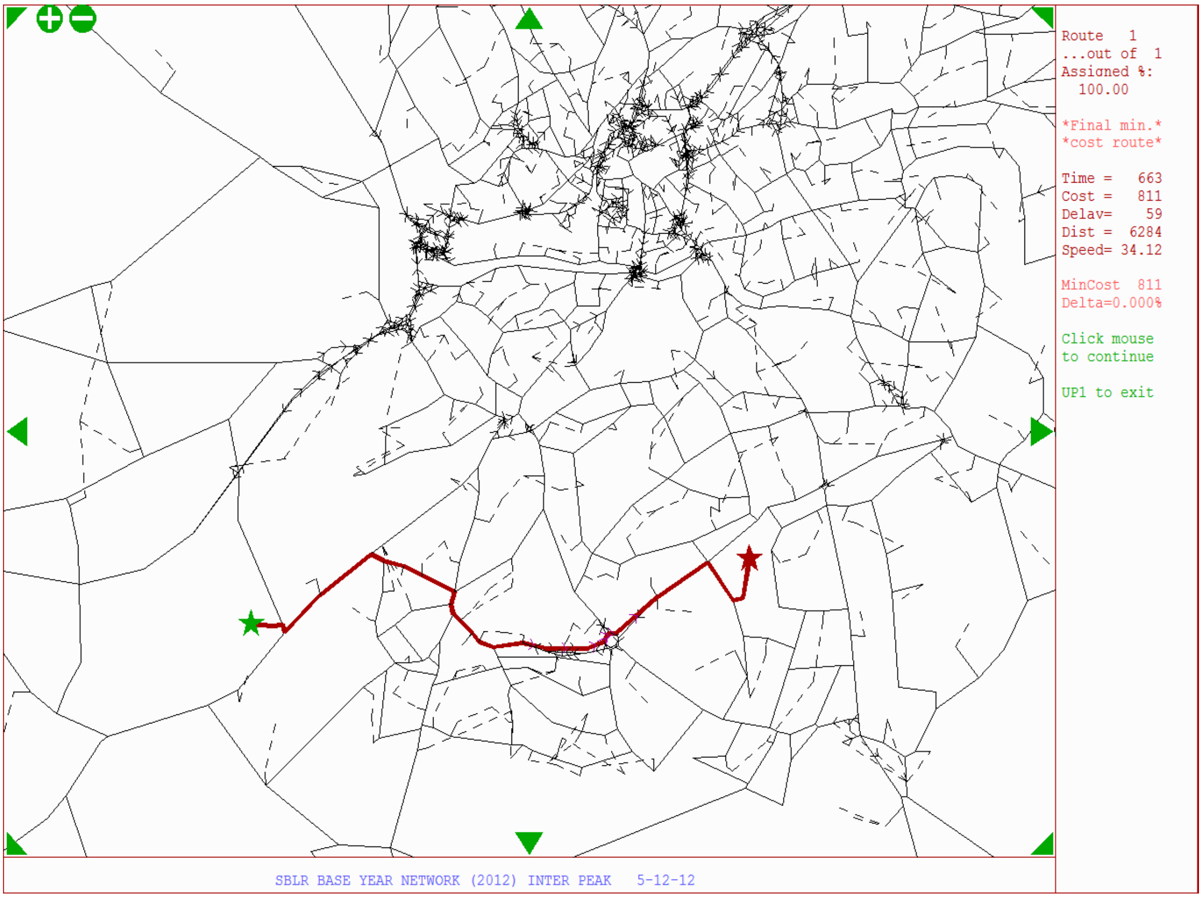
SBLR BASE YEAR NETWORK (2012) INTER PEAK   5-12-12



```
Route   1
...out of  2
Assigned %:
   99.90
Tpij=   0.02

*Final min.*
*cost route*

Time =   989
Cost =  1180
Delay=   145
Dist =  8136
Speed= 29.61

MinCost 1180
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

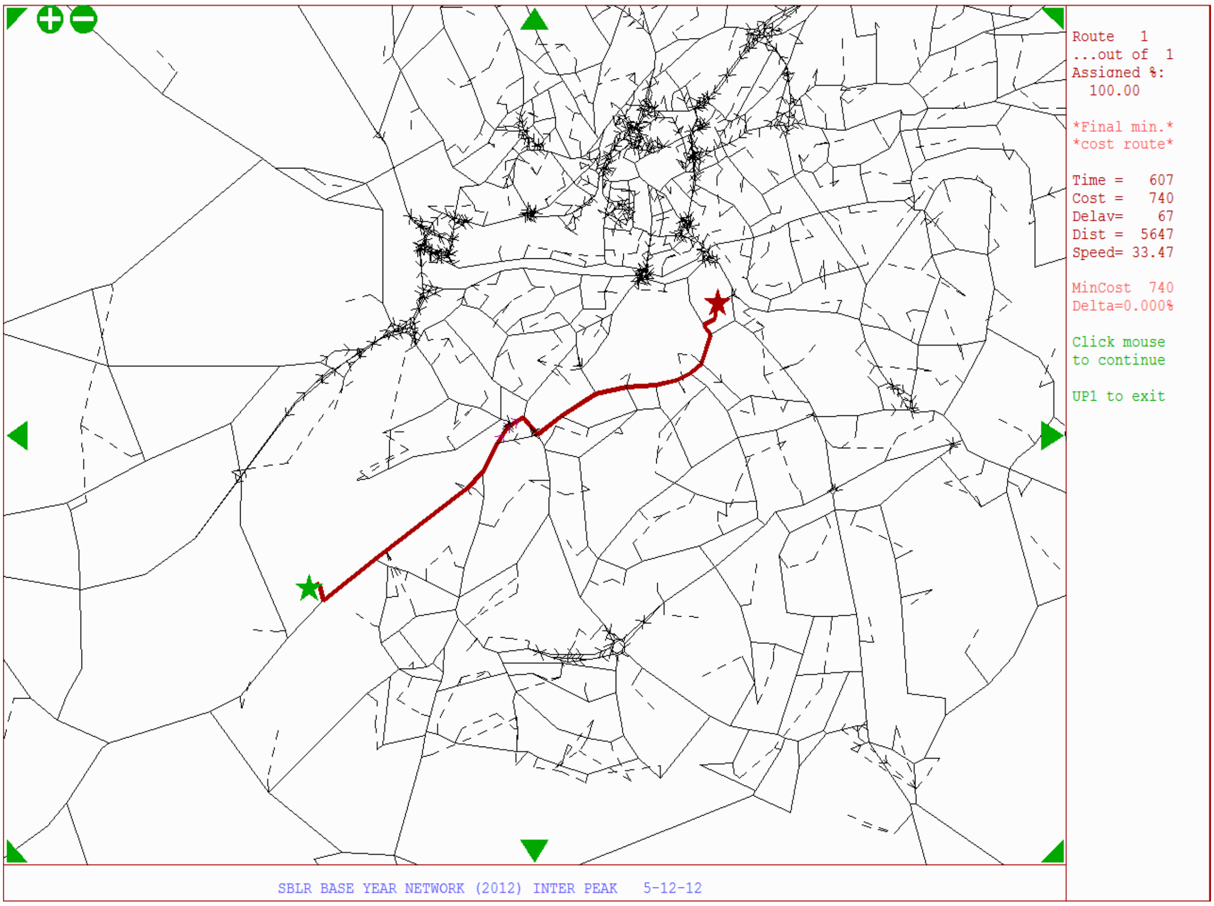


```
Route   1
...out of  2
Assigned %:
   99.90

*Final min.*
*cost route*

Time =   818
Cost =   981
Delay=   126
Dist =  6961
Speed= 30.64

MinCost  981
Delta=0.000%

Click mouse
to continue

UP1 to exit
```



```
Route   1
...out of  1
Assigned %:
  100.00

*Final min.*
*cost route*

Time =   663
Cost =   811
Delay=    59
Dist =  6284
Speed= 34.12

MinCost  811
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

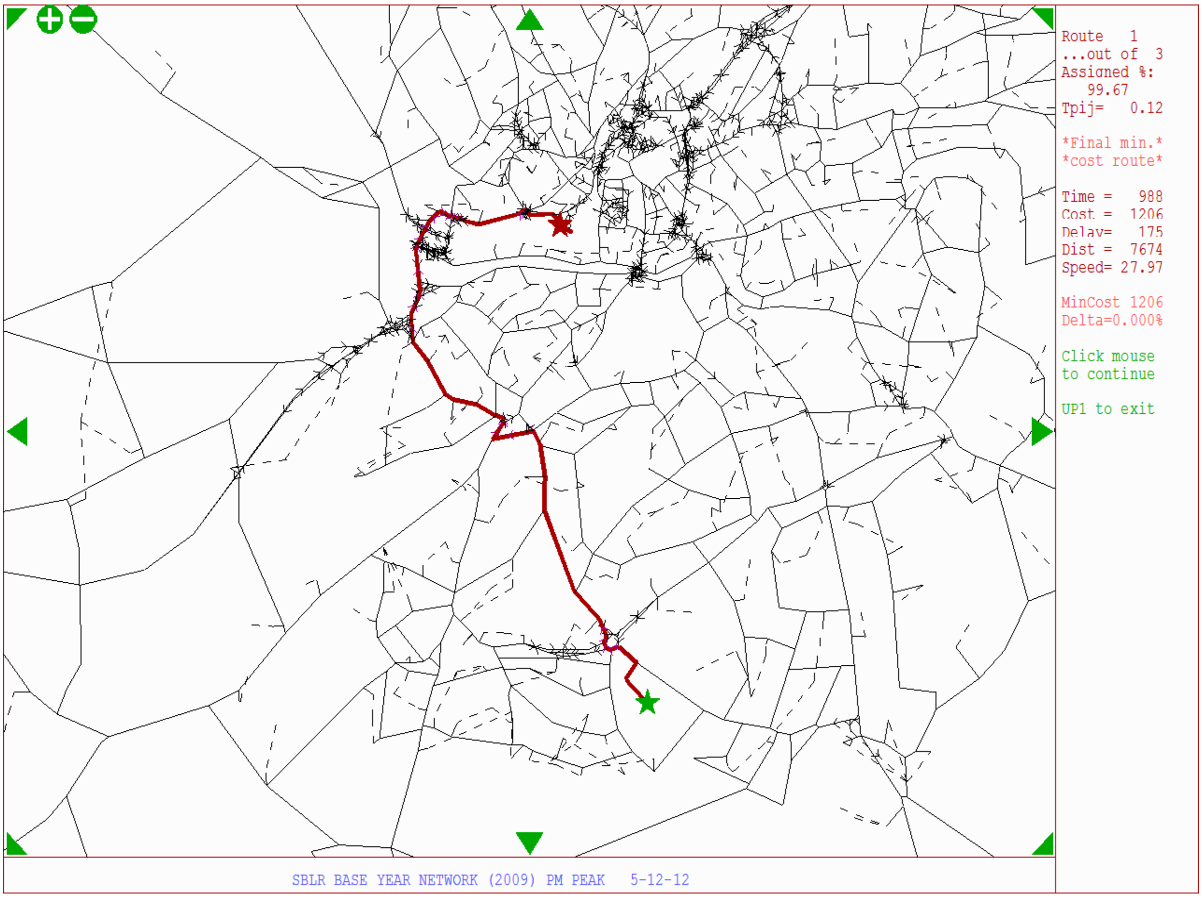
```
SBLR BASE YEAR NETWORK (2012) INTER PEAK   5-12-12
```



```
Route   1
...out of  1
Assigned %:
  100.00

*Final min.*
*cost route*

Time =   607
Cost =   740
Delay=    67
Dist =  5647
Speed= 33.47

MinCost  740
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

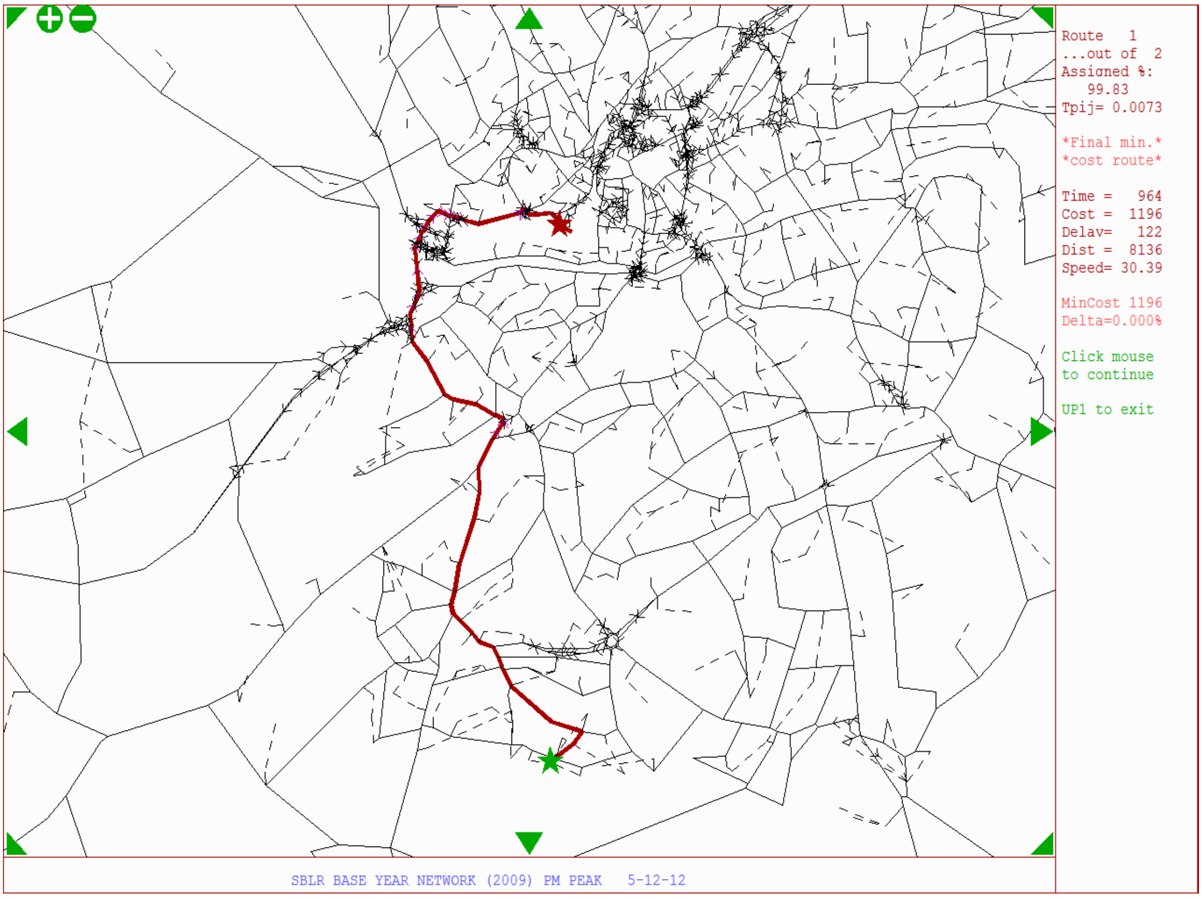
```
SBLR BASE YEAR NETWORK (2012) INTER PEAK   5-12-12
```

C.2.3. Evening Peak



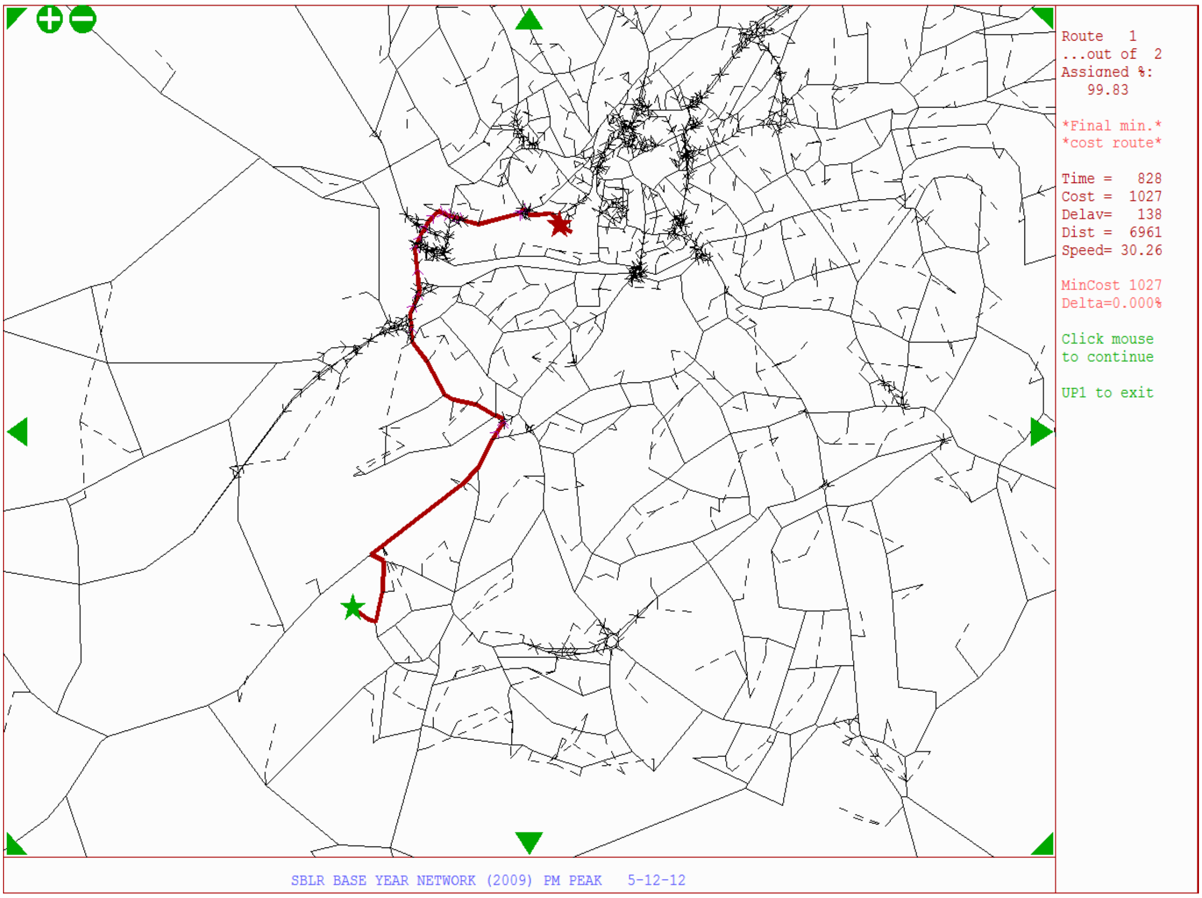
```
Route    1
...out of  3
Assigned %:
   99.67
Tpij=   0.12

*Final min.*
*cost route*

Time =    988
Cost =   1206
Delay=    175
Dist =   7674
Speed= 27.97

MinCost 1206
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

SBLR BASE YEAR NETWORK (2009) PM PEAK   5-12-12



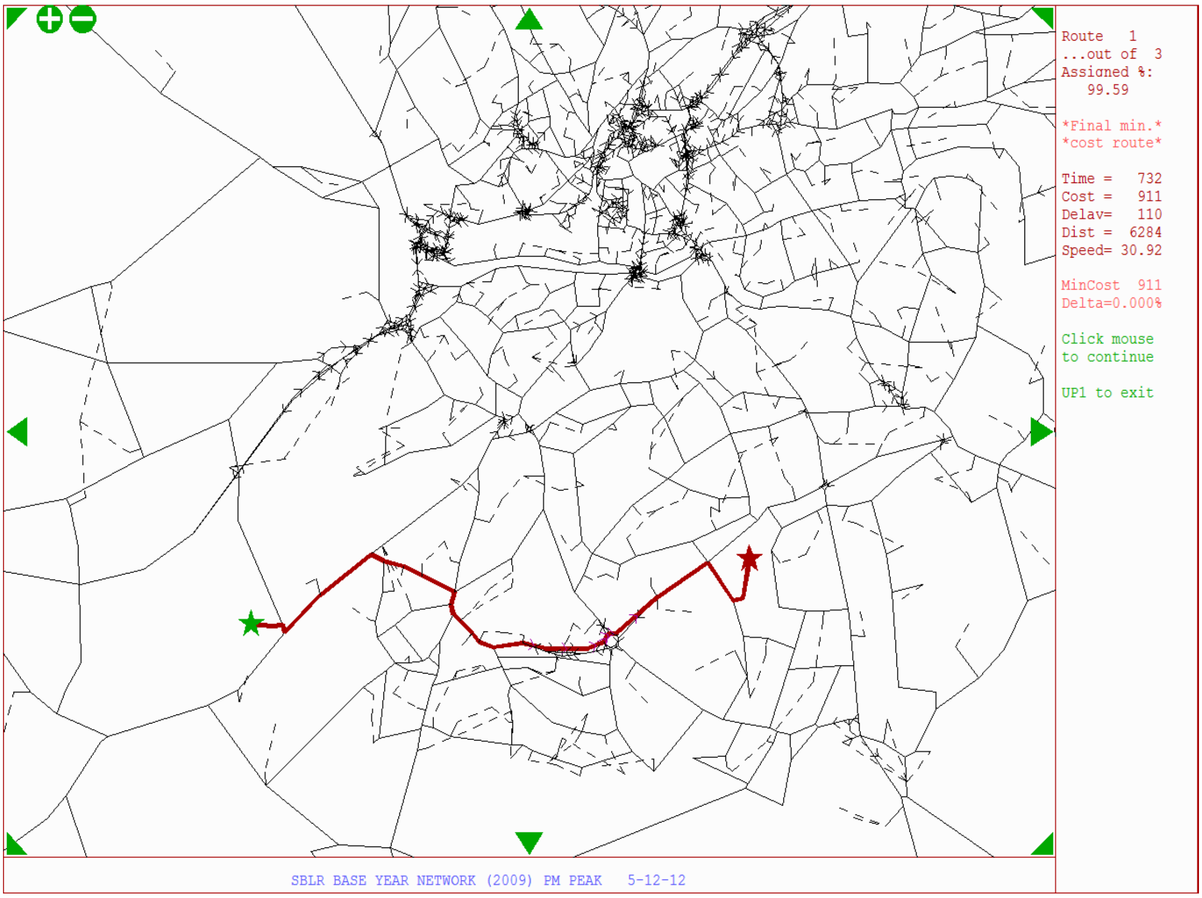
```
Route    1
...out of  2
Assigned %:
   99.83
Tpij= 0.0073

*Final min.*
*cost route*

Time =    964
Cost =   1196
Delay=    122
Dist =   8136
Speed= 30.39

MinCost 1196
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

SBLR BASE YEAR NETWORK (2009) PM PEAK   5-12-12



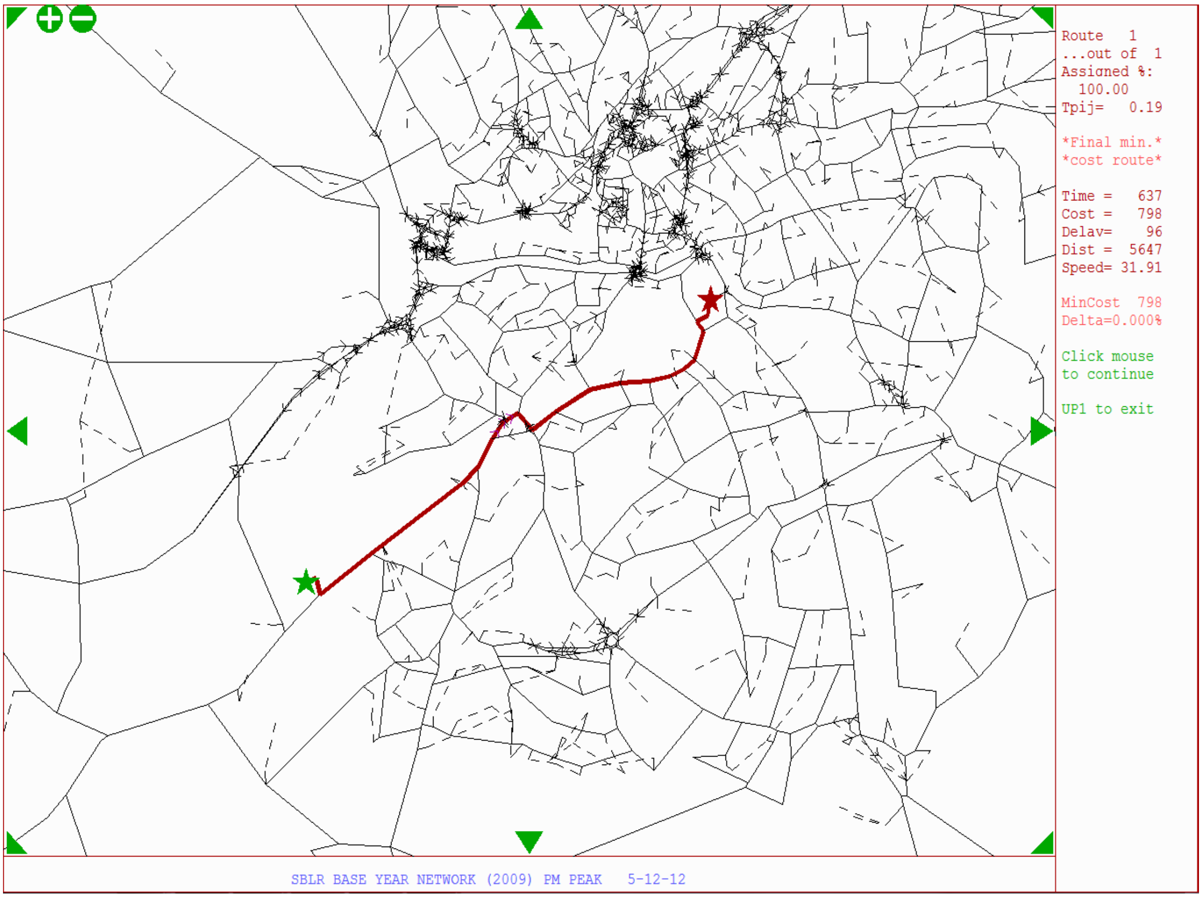
```
Route   1
...out of  2
Assigned %:
   99.83

*Final min.*
*cost route*

Time =   828
Cost =  1027
Delav=   138
Dist =  6961
Speed= 30.26

MinCost 1027
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

SBLR BASE YEAR NETWORK (2009) PM PEAK   5-12-12



```
Route   1
...out of  3
Assigned %:
   99.59

*Final min.*
*cost route*

Time =   732
Cost =   911
Delav=   110
Dist =  6284
Speed= 30.92

MinCost  911
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

SBLR BASE YEAR NETWORK (2009) PM PEAK   5-12-12



```
Route   1
...out of  1
Assigned %:
  100.00
Tpij=   0.19

*Final min.*
*cost route*

Time =   637
Cost =   798
Delay=    96
Dist =  5647
Speed= 31.91

MinCost  798
Delta=0.000%

Click mouse
to continue

UP1 to exit
```

```
SBLR BASE YEAR NETWORK (2009) PM PEAK   5-12-12
```

Appendix D. Matrix Estimation Changes

The impacts of matrix estimation at a sectored level are shown in the tables below. Trips with limited observed movements (because they do not cross an RSI cordon) are shaded and those movements where more than 1% of the matrix performs the movement are shown in bold.

Whilst movements from sectors 1 & 2 to sectors 3-8 were observed these form a small part of the matrix. So in the morning peak only movement 8-4 would be a significant change on a sector to sector movement that was partially observed and had >1% of the matrix. In all other cases the changes were to sectors with a small proportion of the matrix or cells that were not partially observed and it is in these locations that matrix estimation is required.

Table 56. AM Sector Changes

Cars	1	2	3	4	5	6	7	8
1	**12%**	21%	16%	-25%	-18%	38%	-27%	-30%
2	-15%	19%	45%	-18%	-17%	17%	-25%	4%
3	39%	-13%	**18%**	-27%	22%	22%	-19%	17%
4	-1%	-23%	31%	**0%**	33%	-18%	-3%	9%
5	8%	0%	21%	26%	5%	-13%	20%	0%
6	-12%	-33%	**1%**	8%	-24%	**-1%**	**2%**	**-5%**
7	1%	-32%	12%	**-1%**	14%	**-7%**	**0%**	**-2%**
8	-11%	-6%	8%	**12%**	-2%	**-8%**	**-1%**	**1%**
LGV								
1	25%	49%	17%	19%	26%	46%	7%	10%
2	6%	19%	22%	-27%	-22%	-24%	-30%	9%
3	85%	-22%	**30%**	9%	20%	27%	5%	20%
4	45%	-39%	7%	**-1%**	-5%	-18%	**-1%**	-20%
5	171%	28%	59%	-3%	**6%**	-7%	-12%	-20%
6	15%	-42%	**9%**	10%	12%	**-2%**	**0%**	**1%**
7	35%	-34%	26%	**1%**	-12%	**-4%**	**0%**	**-3%**
8	70%	3%	13%	20%	**-14%**	**-10%**	**0%**	**1%**
HGV								
1	-89%	-85%	-79%	-35%	-28%	25%	29%	-74%
2	-29%	-39%	43%	-29%	-91%	6%	-89%	-36%
3	-79%	-79%	-5%	1%	29%	12%	22%	-34%
4	-73%	-35%	-11%	**-4%**	-48%	-11%	**-8%**	8%
5	-42%	-23%	-24%	-27%	38%	16%	28%	17%
6	-70%	25%	-22%	10%	2%	**2%**	**1%**	**2%**
7	-18%	-98%	3%	**4%**	61%	**-1%**	**0%**	**-3%**
8	0%	0%	17%	-10%	-1%	**-1%**	**9%**	**6%**

Table 57. IP Sector Changes

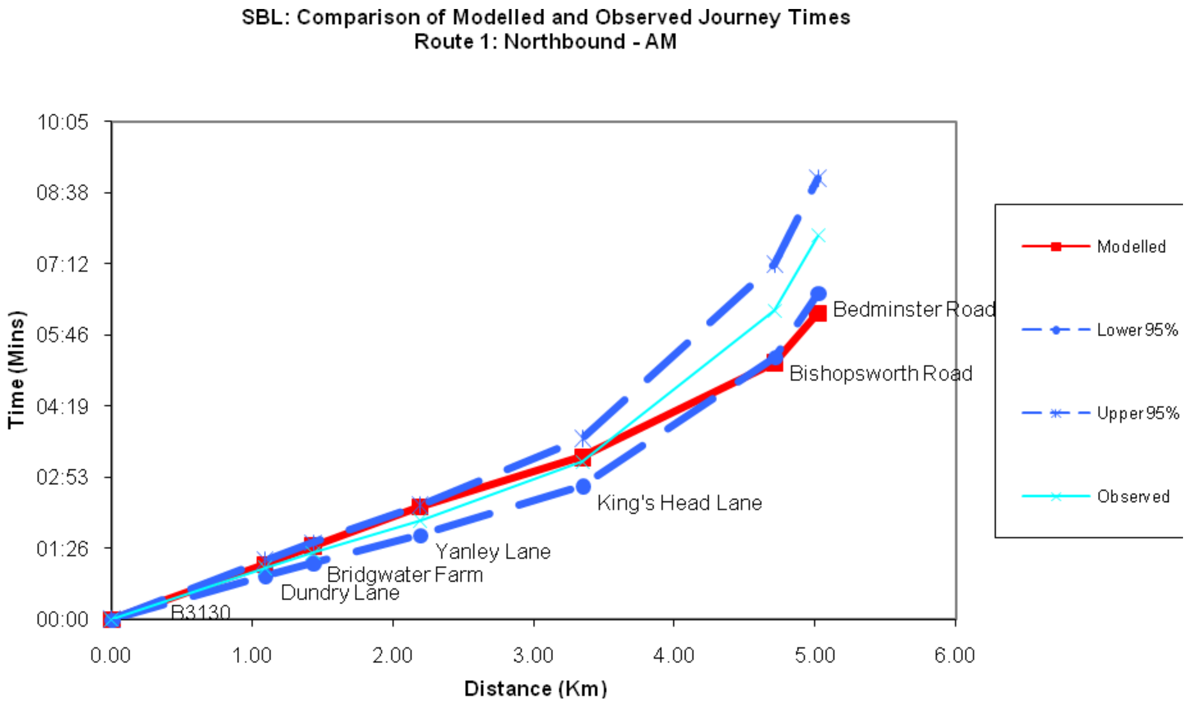
Cars	1	2	3	4	5	6	7	8
1	**22%**	15%	13%	0%	13%	22%	18%	-21%
2	19%	13%	3%	-23%	-14%	-7%	-9%	9%
3	19%	-6%	**6%**	-14%	12%	**4%**	-6%	9%
4	31%	6%	28%	**0%**	-2%	**-2%**	**-1%**	12%
5	36%	4%	28%	-12%	**10%**	1%	-5%	-4%
6	3%	-19%	**4%**	**-6%**	-10%	**-1%**	**1%**	**-4%**
7	2%	-15%	14%	**0%**	-3%	**-1%**	**0%**	**-1%**
8	15%	11%	19%	3%	-22%	**-4%**	**-2%**	**0%**
LGV								
1	**29%**	34%	1%	14%	32%	13%	34%	4%
2	36%	3%	-4%	-16%	-11%	-18%	0%	-2%
3	18%	-16%	**12%**	-1%	5%	37%	9%	-4%
4	21%	-18%	3%	**-1%**	-17%	-14%	**-5%**	-2%
5	124%	32%	9%	-9%	**2%**	11%	5%	3%
6	-13%	-26%	**16%**	-5%	-13%	**-1%**	**0%**	**-6%**
7	16%	-8%	13%	**4%**	-10%	**-2%**	**0%**	**-1%**
8	48%	19%	13%	-3%	-29%	**-2%**	**-2%**	**0%**
HGV								
1	-78%	-43%	-49%	-15%	-57%	-31%	-68%	-58%
2	-60%	-43%	40%	164%	-46%	-20%	-21%	0%
3	-2%	-80%	-10%	20%	9%	-28%	73%	-35%
4	-25%	13%	3%	**1%**	**-35%**	-13%	**3%**	-7%
5	-26%	-48%	76%	-56%	**-43%**	-71%	-45%	-2%
6	126%	-46%	-4%	2%	-8%	**-1%**	**0%**	**0%**
7	-13%	-26%	39%	**-3%**	-34%	**-2%**	**0%**	**9%**
8	-7%	69%	-5%	-36%	-27%	**3%**	**0%**	**1%**

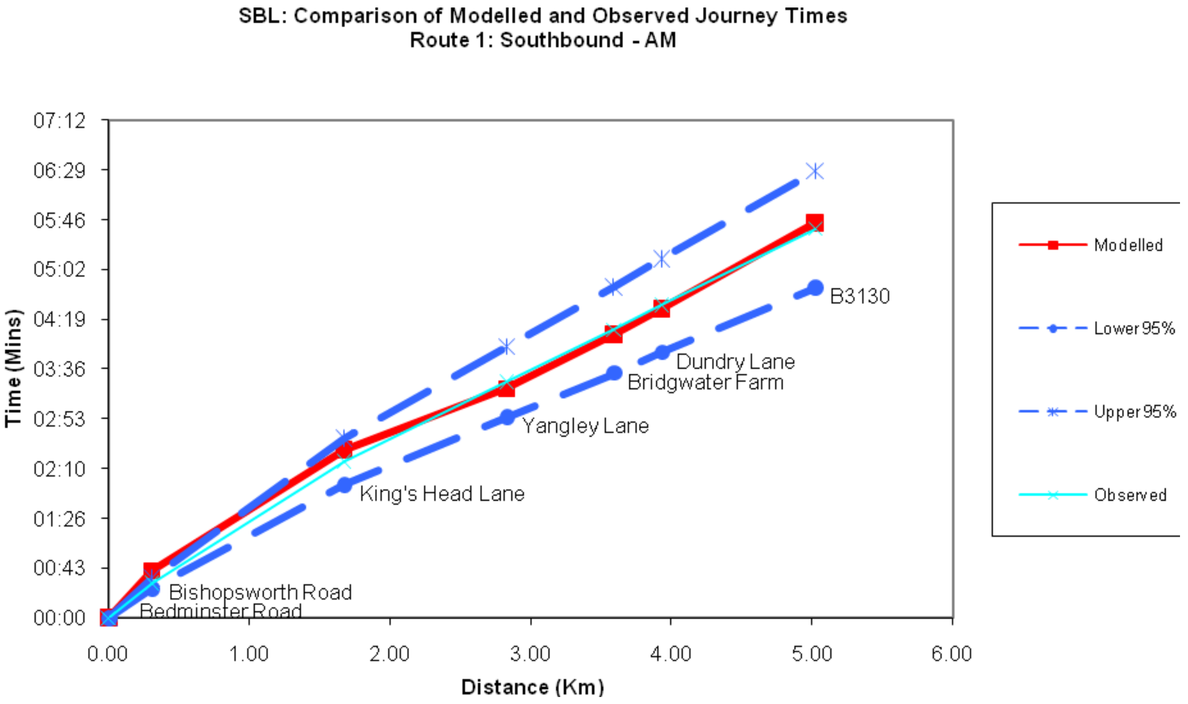
Table 58. PM Sector Changes

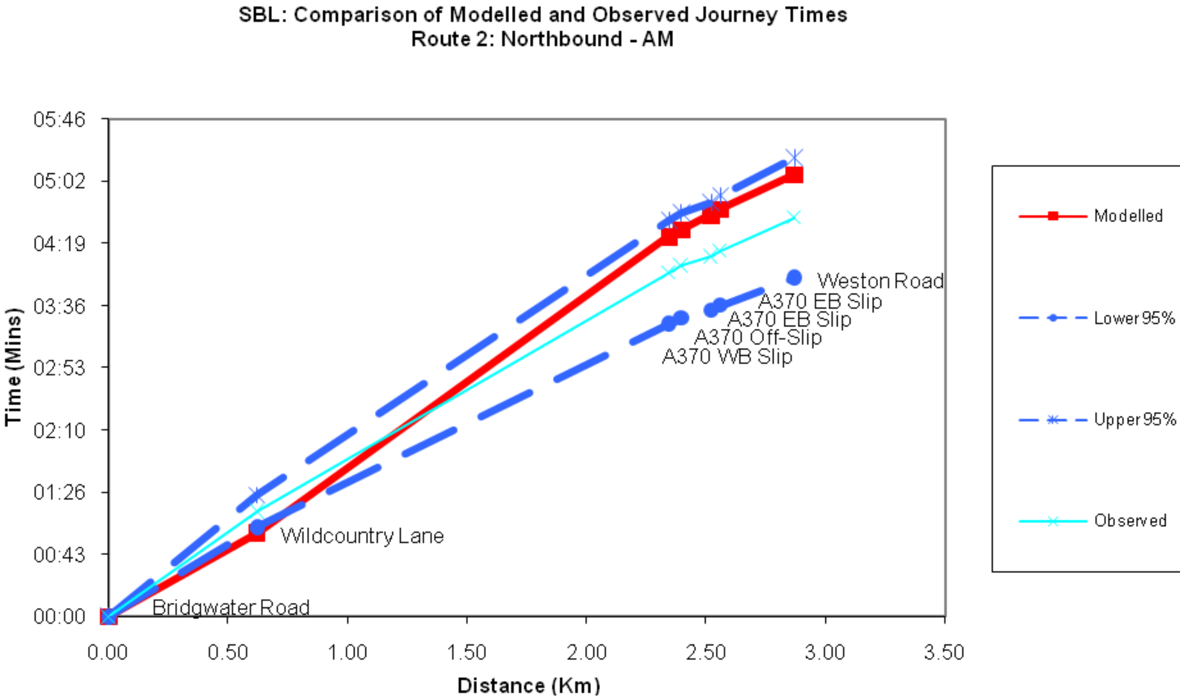
Cars	1	2	3	4	5	6	7	8
1	**12%**	113%	36%	-14%	7%	14%	-12%	9%
2	45%	56%	21%	-23%	-17%	6%	-29%	15%
3	34%	1%	**11%**	-16%	11%	-11%	-27%	-3%
4	44%	20%	42%	**2%**	43%	**3%**	**-2%**	**32%**
5	151%	44%	32%	4%	**4%**	17%	-2%	-15%
6	23%	-16%	14%	**2%**	-9%	**-2%**	**4%**	**-9%**
7	19%	-17%	15%	**-8%**	-7%	**6%**	**-1%**	**-1%**
8	-8%	29%	-6%	28%	-29%	**-3%**	**-2%**	**1%**
LGV								
1	42%	227%	43%	24%	13%	25%	46%	128%
2	46%	55%	7%	-31%	-43%	0%	-27%	-13%
3	66%	**-1%**	**26%**	3%	-6%	12%	18%	-17%
4	41%	-16%	15%	**2%**	-22%	-11%	**-3%**	**8%**
5	436%	89%	46%	0%	**12%**	79%	30%	2%
6	21%	-13%	15%	1%	-34%	**-2%**	**2%**	**-5%**
7	47%	-27%	**14%**	**13%**	-37%	**-2%**	**-1%**	**-1%**
8	11%	34%	-4%	24%	-46%	**1%**	**-2%**	**0%**
HGV								
1	-89%	-7%	-77%	-39%	-36%	-14%	30%	0%
2	-86%	-89%	-35%	-85%	-75%	-17%	-88%	0%
3	-85%	-88%	18%	13%	-17%	-19%	13%	131%
4	-86%	-92%	-3%	**0%**	-18%	-3%	**0%**	-11%
5	-68%	-91%	-10%	6%	-36%	-48%	-26%	-28%
6	9%	-60%	-14%	-16%	-9%	**-1%**	**0%**	**2%**
7	66%	80%	23%	**-3%**	-37%	**-1%**	**-1%**	**6%**
8	0%	0%	-26%	-14%	2%	**5%**	**2%**	**1%**

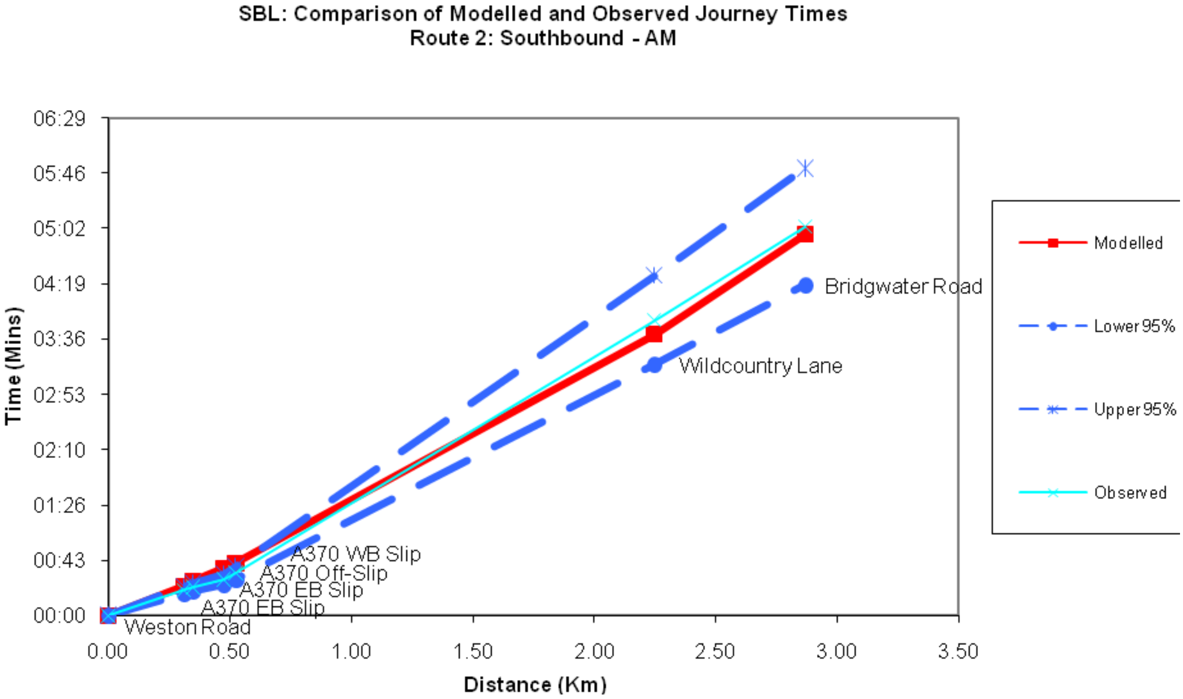
Appendix E. Journey Time Routes

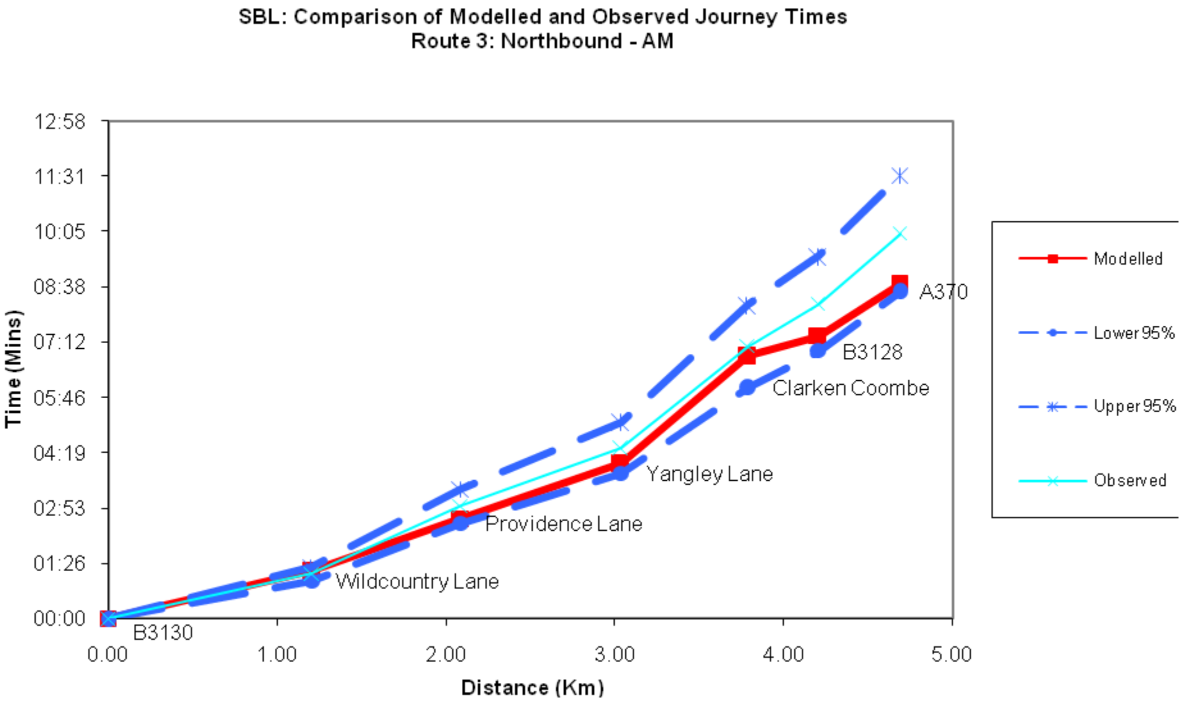
E.1. AM peak

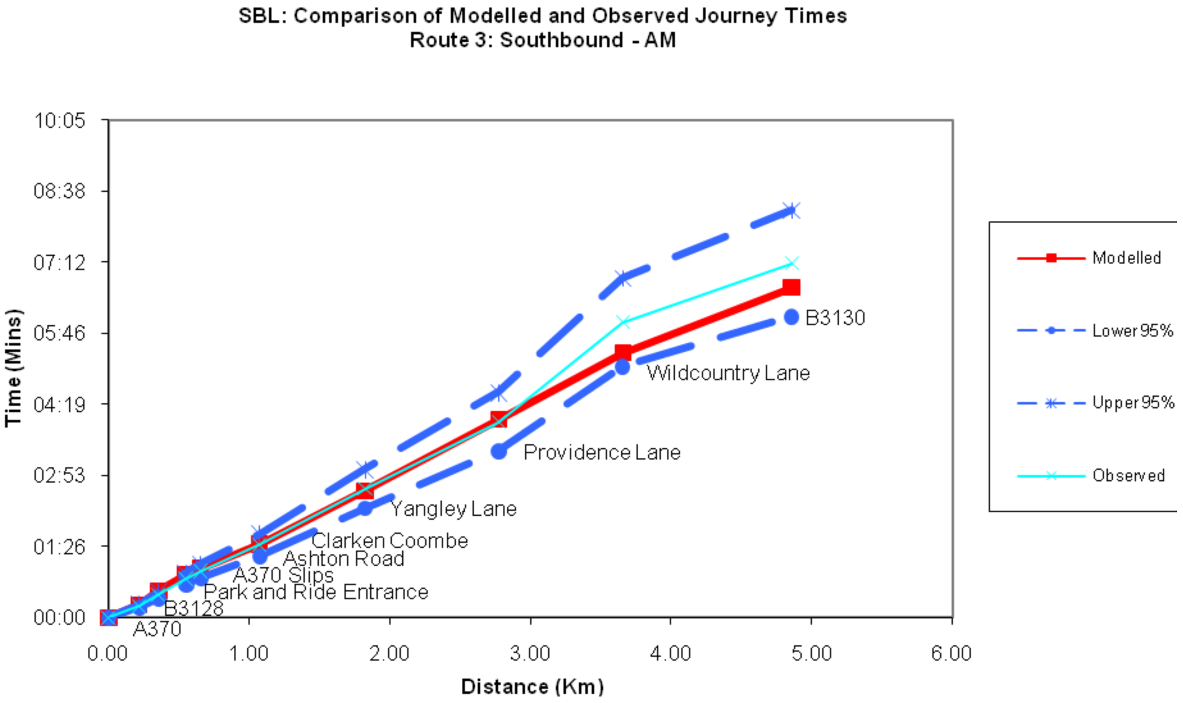


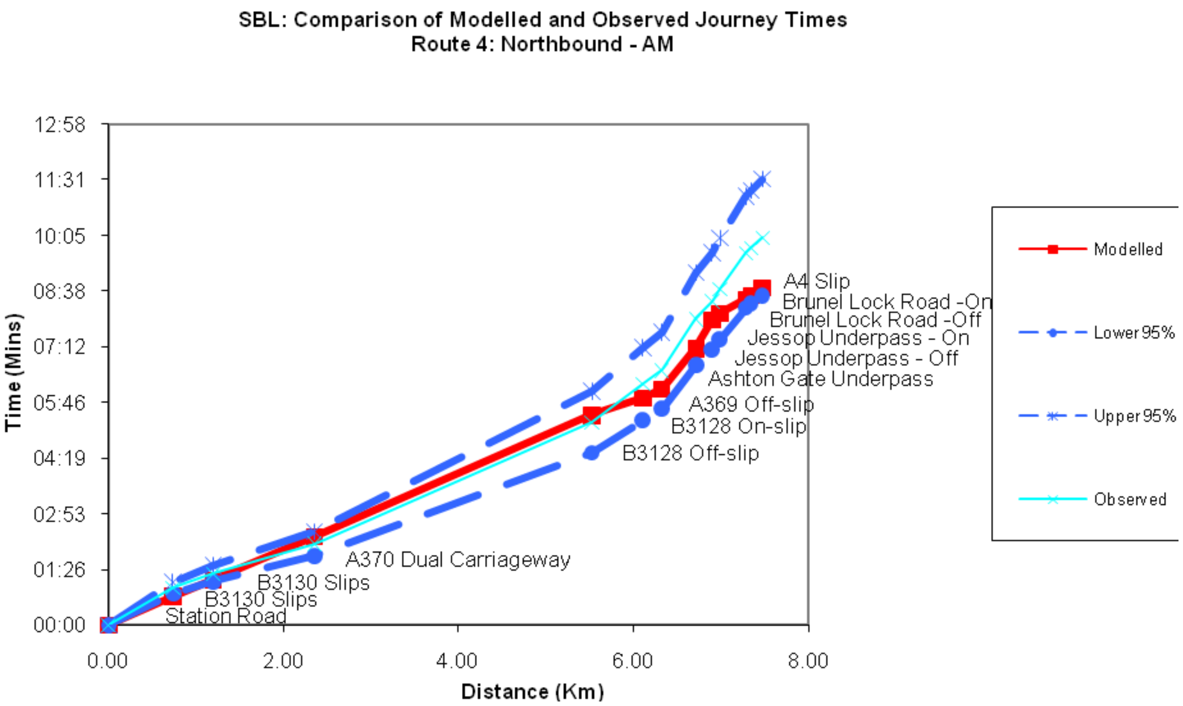


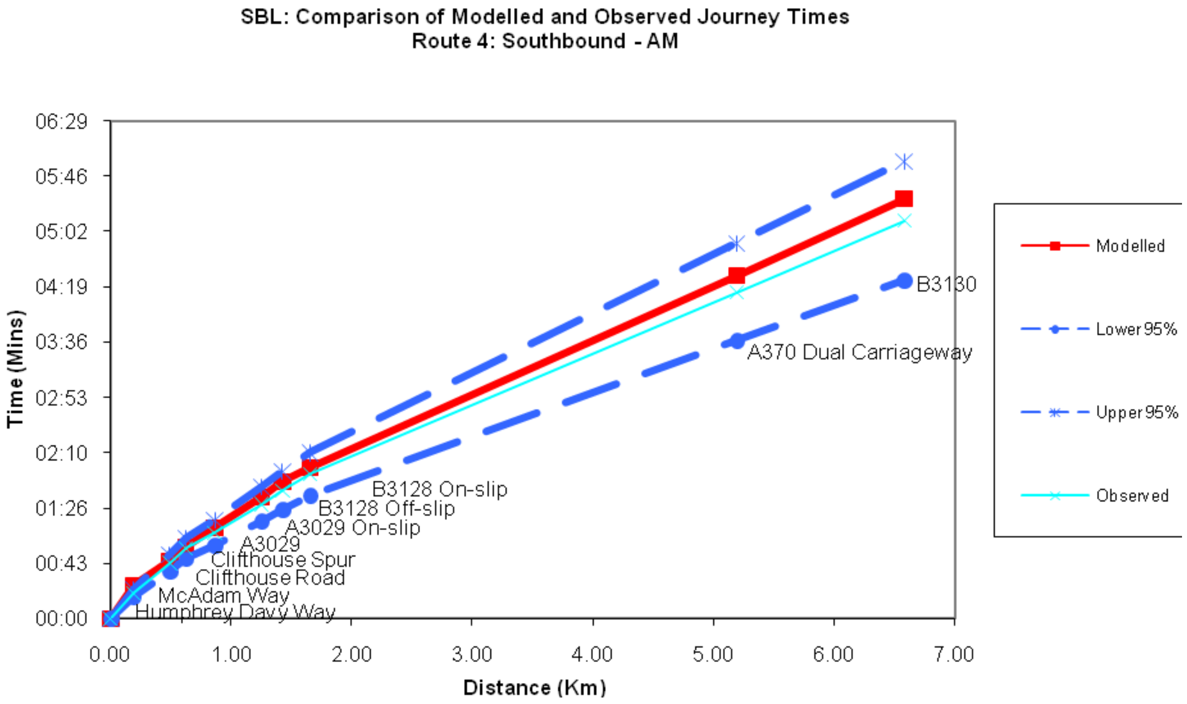

SBL: Comparison of Modelled and Observed Journey Times
Route 2: Northbound - AM
Time (Mins)
05:46
05:02
04:19
03:36
02:53
02:10
01:26
00:43
00:00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
Distance (Km)
Bridgwater Road
Wildcountry Lane
Weston Road
A370 EB Slip
A370 EB Slip
A370 Off-Slip
A370 WB Slip
Modelled
Lower 95%
Upper 95%
Observed

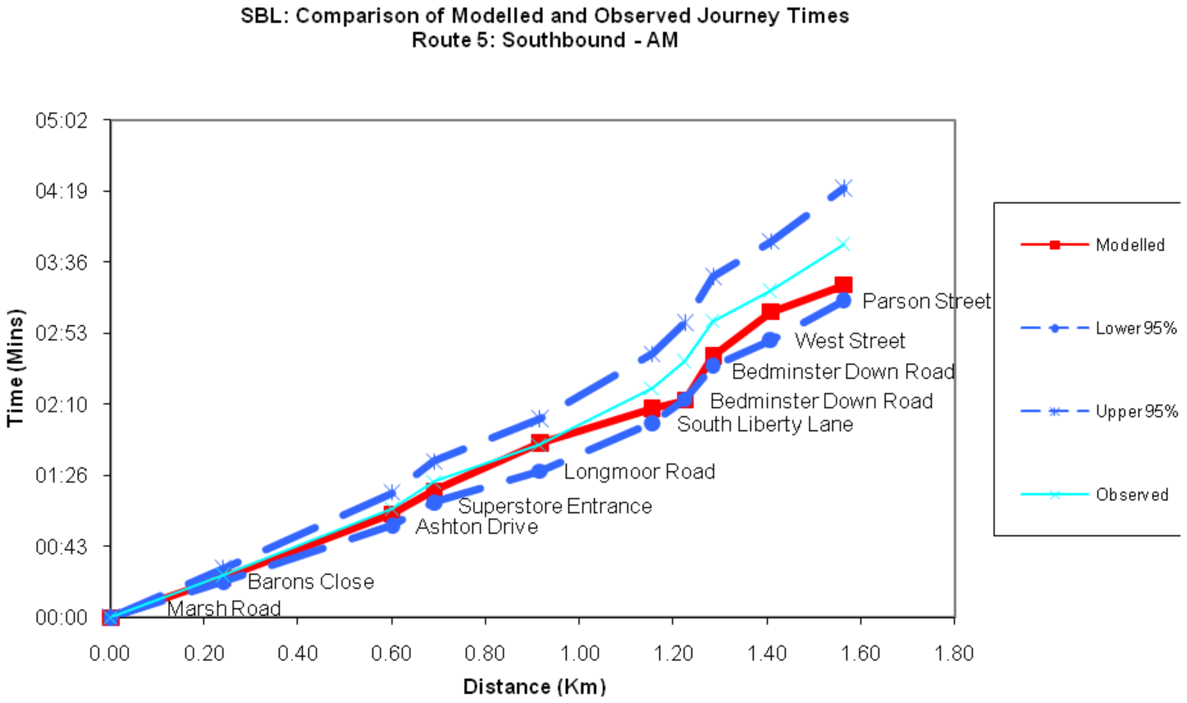

SBL: Comparison of Modelled and Observed Journey Times
Route 2: Southbound - AM
Time (Mins)
06:29
05:46
05:02
04:19
03:36
02:53
02:10
01:26
00:43
00:00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
Distance (Km)
Bridgwater Road
Wildcountry Lane
A370 WB Slip
A370 Off-Slip
A370 EB Slip
A370 EB Slip
Weston Road
Modelled
Lower 95%
Upper 95%
Observed

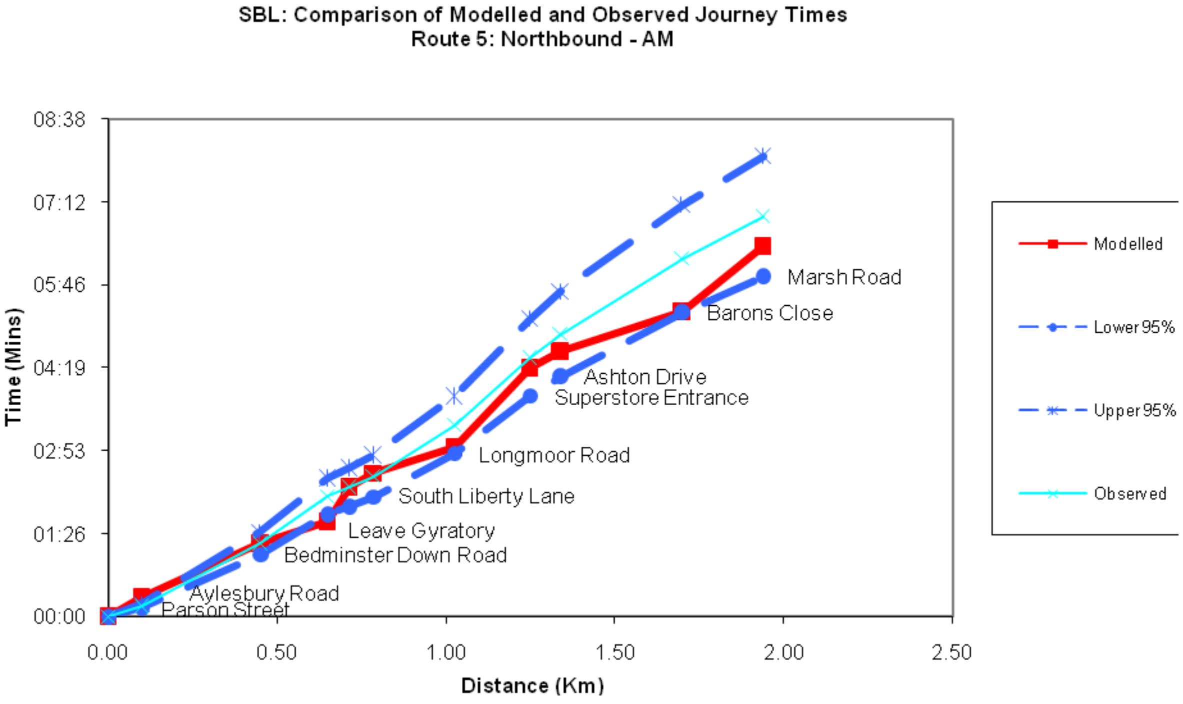

SBL: Comparison of Modelled and Observed Journey Times
Route 3: Northbound - AM
Time (Mins)
12:58
11:31
10:05
08:38
07:12
05:46
04:19
02:53
01:26
00:00
Distance (Km)
0.00
1.00
2.00
3.00
4.00
5.00
B3130
Wildcountry Lane
Providence Lane
Yangley Lane
Clarken Coombe
B3128
A370
Modelled
Lower 95%
Upper 95%
Observed

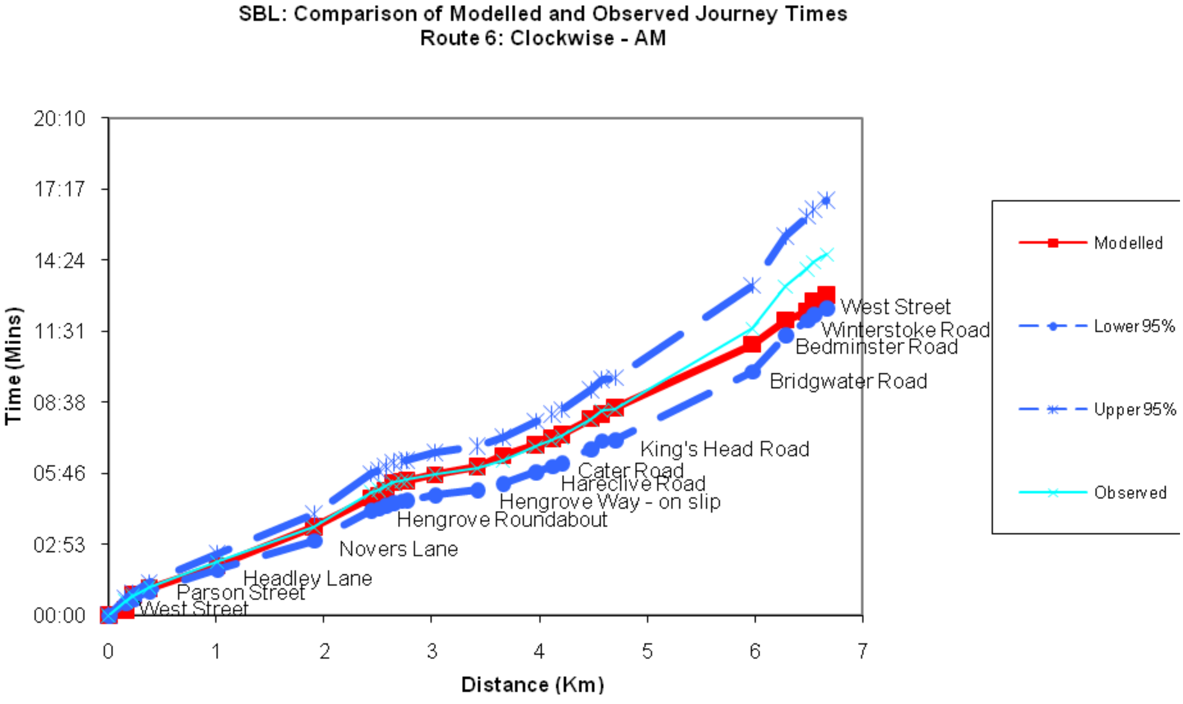

SBL: Comparison of Modelled and Observed Journey Times
Route 3: Southbound - AM
Time (Mins)
10:05
08:38
07:12
05:46
04:19
02:53
01:26
00:00
Distance (Km)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
A370
B3128
Park and Ride Entrance
A370 Slips
Ashton Road
Clarken Coombe
Yangley Lane
Providence Lane
Wildcountry Lane
B3130
Modelled
Lower 95%
Upper 95%
Observed

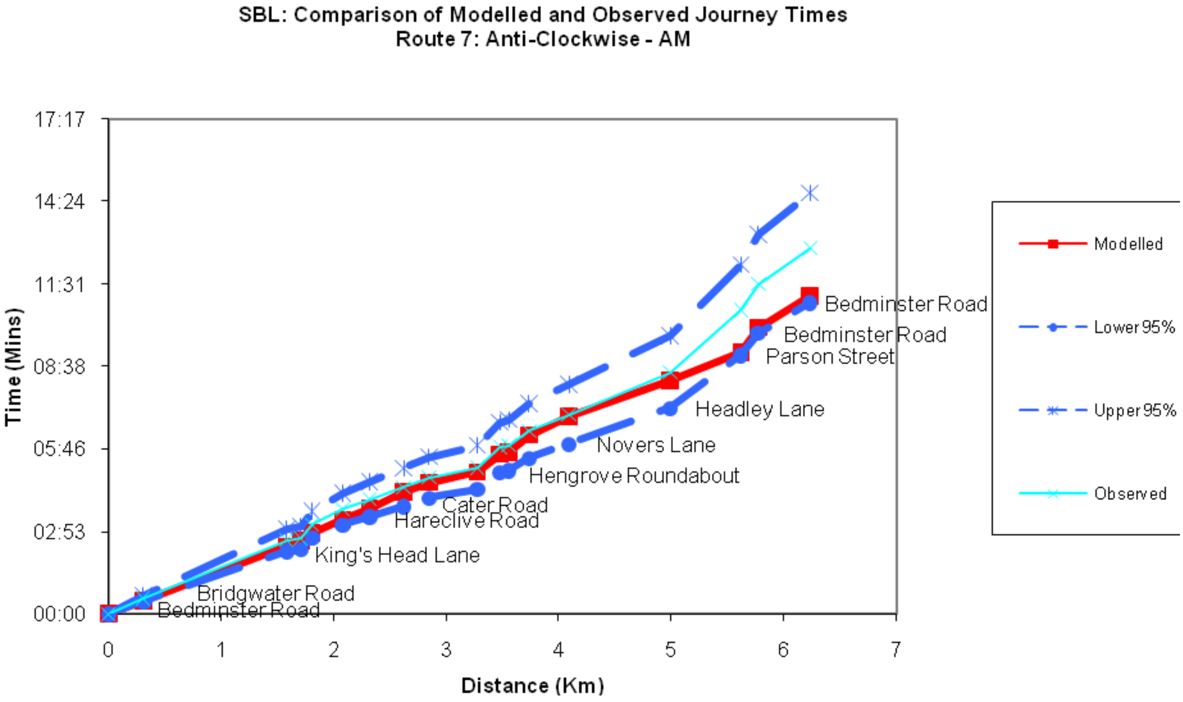

SBL: Comparison of Modelled and Observed Journey Times
Route 4: Northbound - AM
Time (Mins)
12:58
11:31
10:05
08:38
07:12
05:46
04:19
02:53
01:26
00:00
0.00
2.00
4.00
6.00
8.00
Distance (Km)
A4 Slip
Brunel Lock Road -On
Brunel Lock Road -Off
Jessop Underpass - On
Jessop Underpass - Off
Ashton Gate Underpass
A369 Off-slip
B3128 On-slip
B3128 Off-slip
A370 Dual Carriageway
B3130 Slips
B3130 Slips
Station Road
Modelled
Lower 95%
Upper 95%
Observed

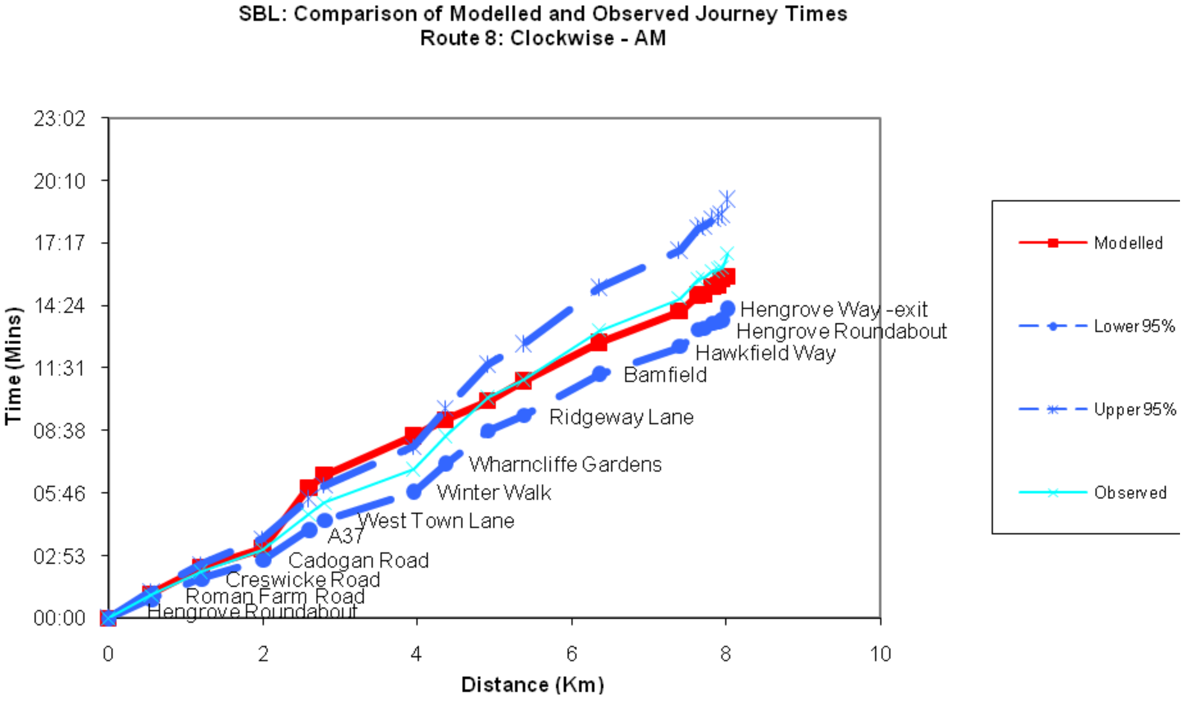

SBL: Comparison of Modelled and Observed Journey Times
Route 4: Southbound - AM
Time (Mins)
06:29
05:46
05:02
04:19
03:36
02:53
02:10
01:26
00:43
00:00
Distance (Km)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
B3130
A370 Dual Carriageway
B3128 On-slip
B3128 Off-slip
A3029 On-slip
A3029
Clifthouse Spur
Clifthouse Road
McAdam Way
Humphrey Davy Way
Modelled
Lower 95%
Upper 95%
Observed

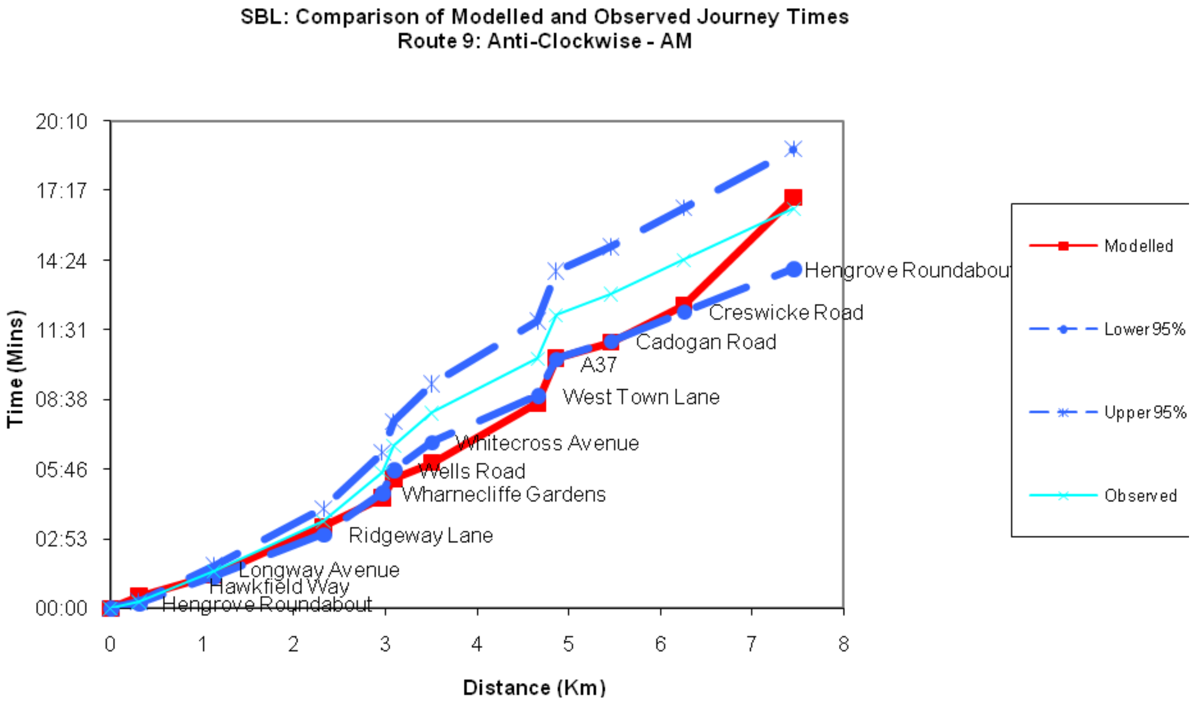

SBL: Comparison of Modelled and Observed Journey Times
Route 5: Southbound - AM
Time (Mins)
05:02
04:19
03:36
02:53
02:10
01:26
00:43
00:00
Distance (Km)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
Parson Street
West Street
Bedminster Down Road
Bedminster Down Road
South Liberty Lane
Longmoor Road
Superstore Entrance
Ashton Drive
Barons Close
Marsh Road
Modelled
Lower 95%
Upper 95%
Observed


SBL: Comparison of Modelled and Observed Journey Times
Route 5: Northbound - AM
Time (Mins)
08:38
07:12
05:46
04:19
02:53
01:26
00:00
0.00
0.50
1.00
1.50
2.00
2.50
Distance (Km)
Marsh Road
Barons Close
Ashton Drive
Superstore Entrance
Longmoor Road
South Liberty Lane
Leave Gyratory
Bedminster Down Road
Aylesbury Road
Parson Street
Modelled
Lower 95%
Upper 95%
Observed

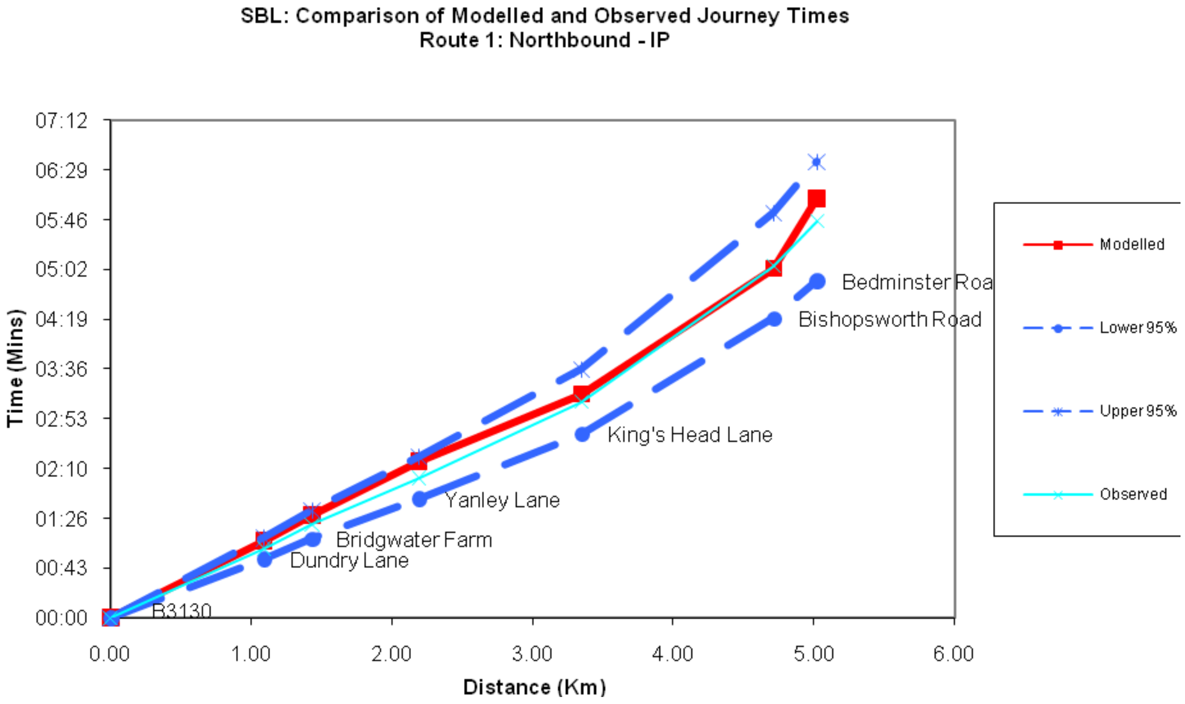

SBL: Comparison of Modelled and Observed Journey Times
Route 6: Clockwise - AM
Time (Mins)
20:10
17:17
14:24
11:31
08:38
05:46
02:53
00:00
0
1
2
3
4
5
6
7
Distance (Km)
West Street
Winterstoke Road
Bedminster Road
Bridgwater Road
King's Head Road
Cater Road
Hareclive Road
Hengrove Way - on slip
Hengrove Roundabout
Novers Lane
Headley Lane
Parson Street
West Street
Modelled
Lower 95%
Upper 95%
Observed

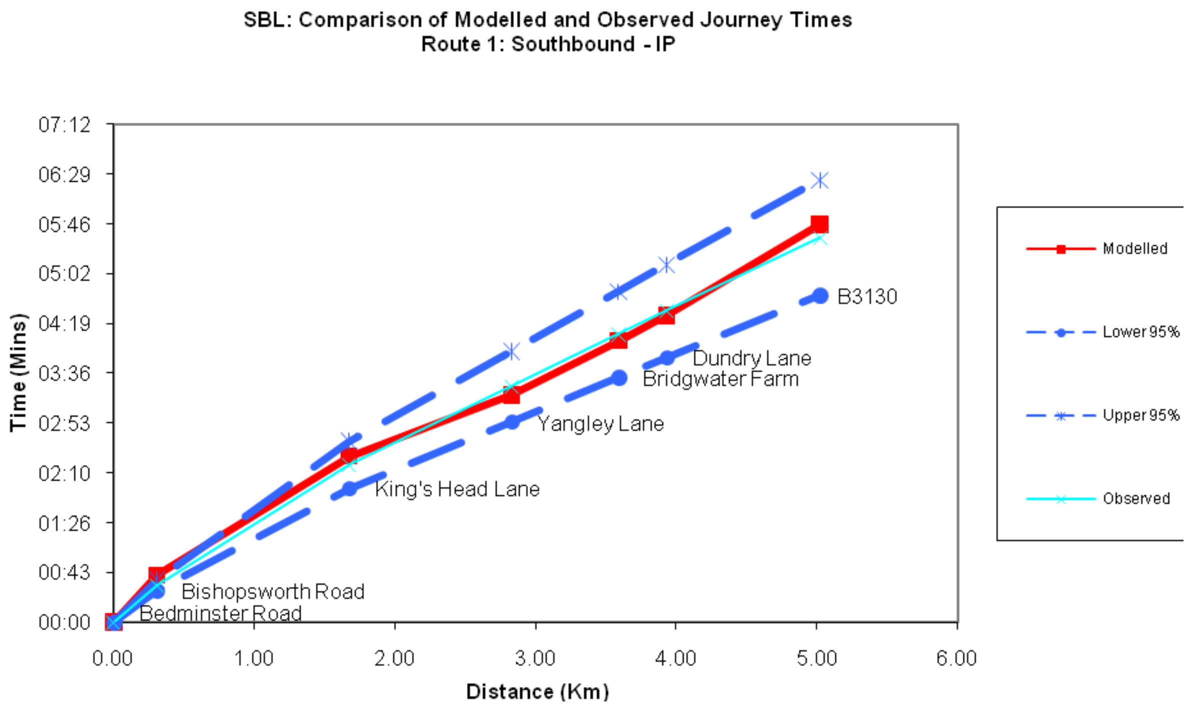

SBL: Comparison of Modelled and Observed Journey Times
Route 7: Anti-Clockwise - AM

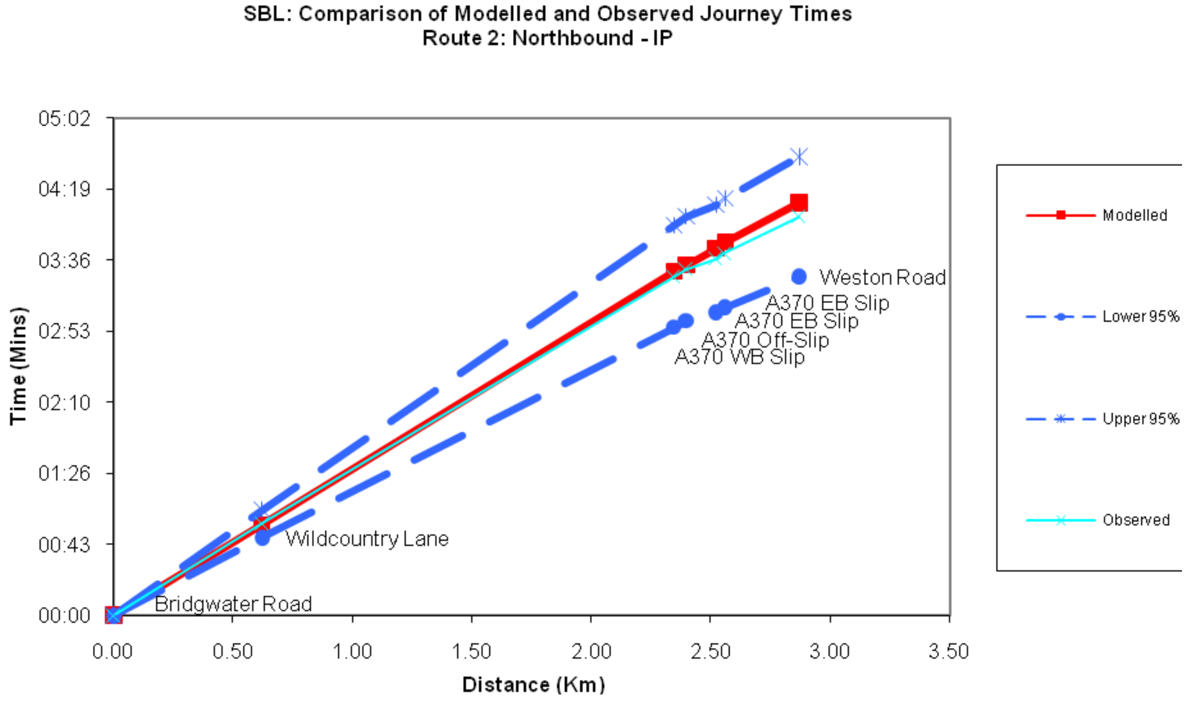

SBL: Comparison of Modelled and Observed Journey Times
Route 8: Clockwise - AM

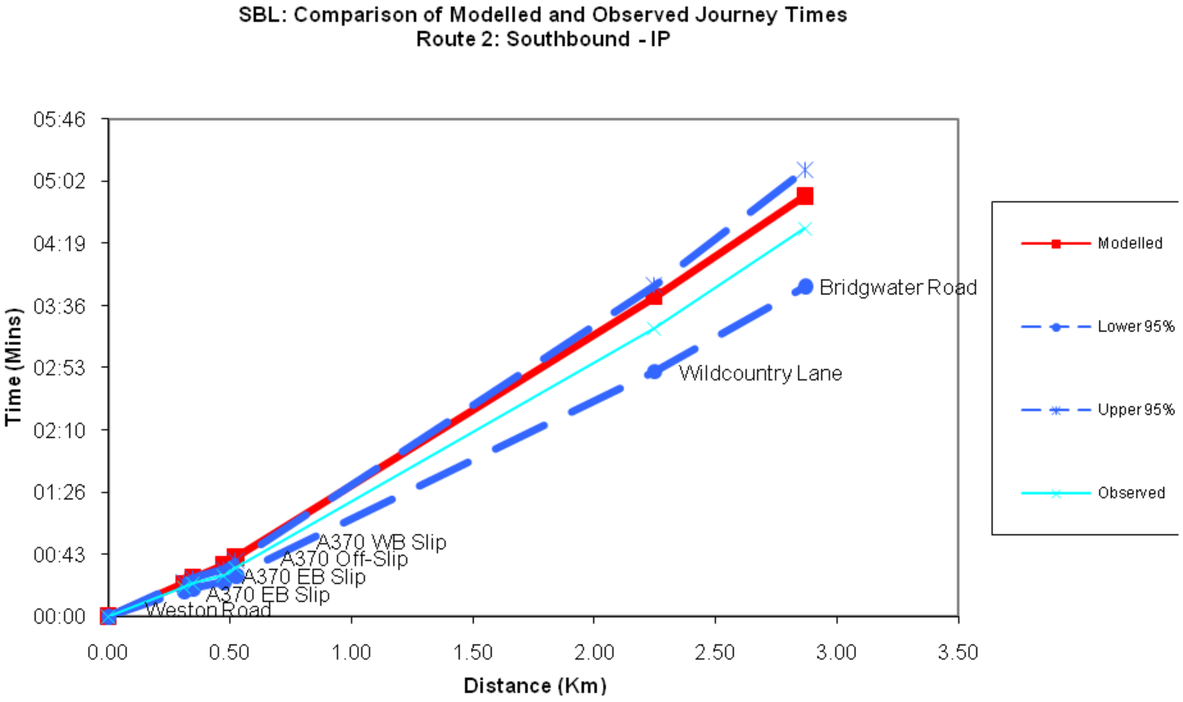


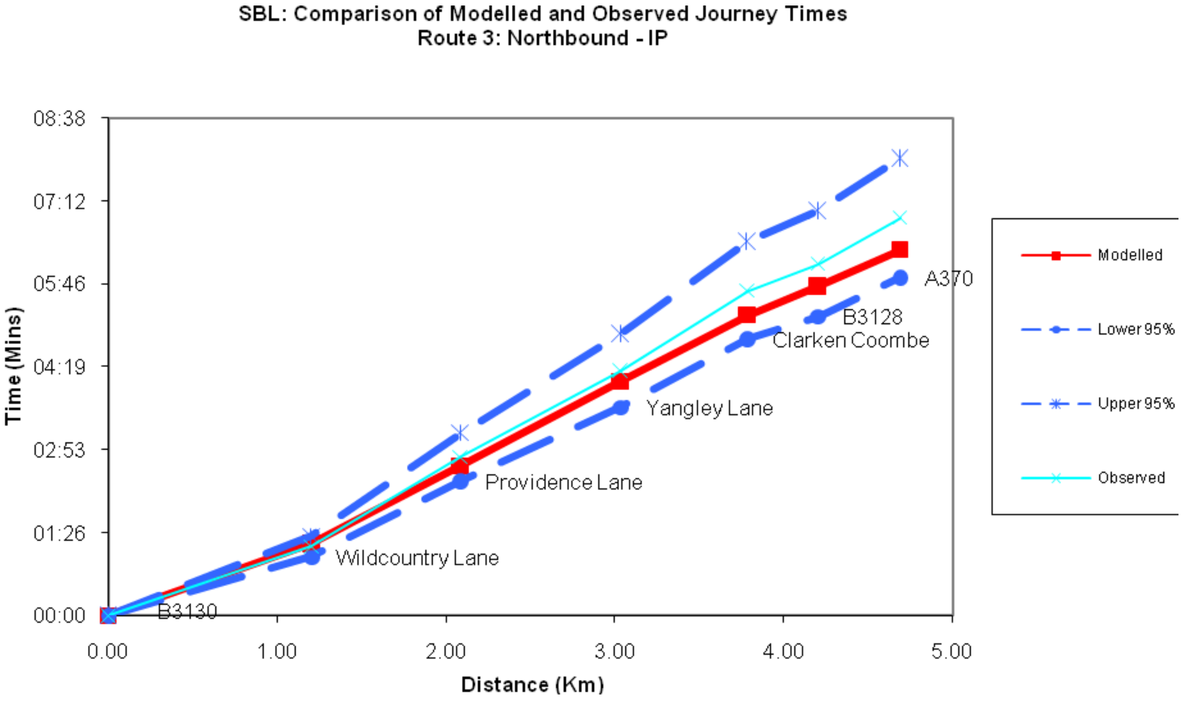
E.2. Inter peak

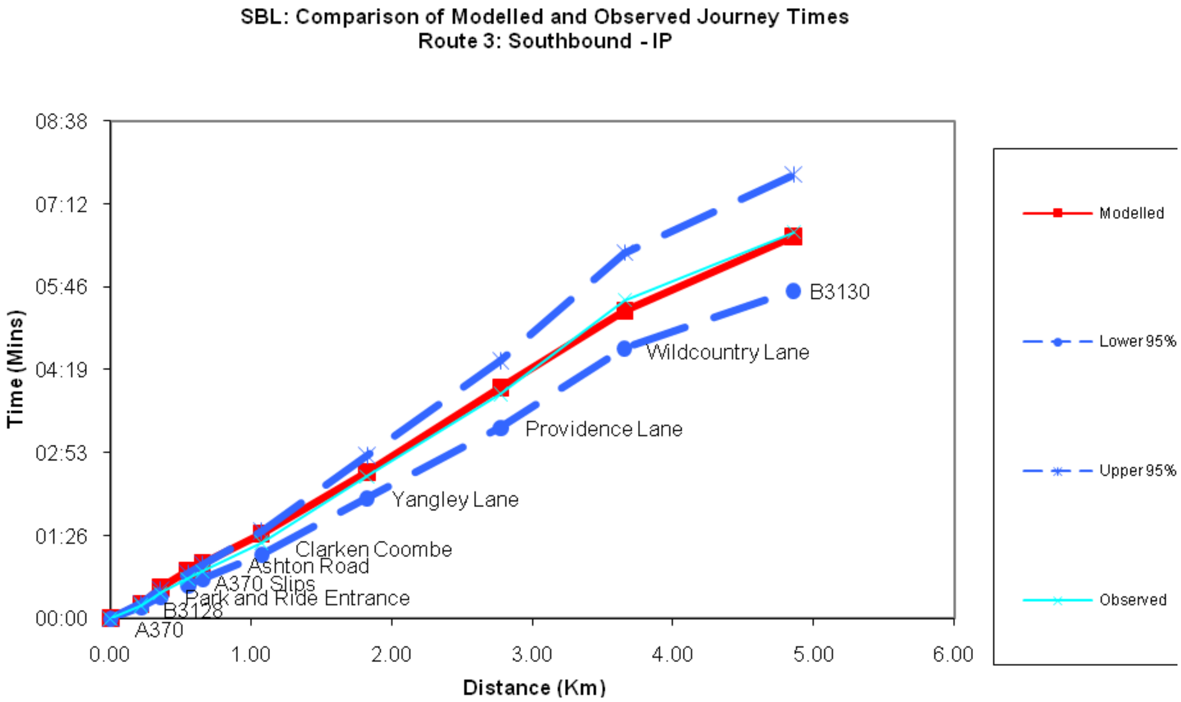


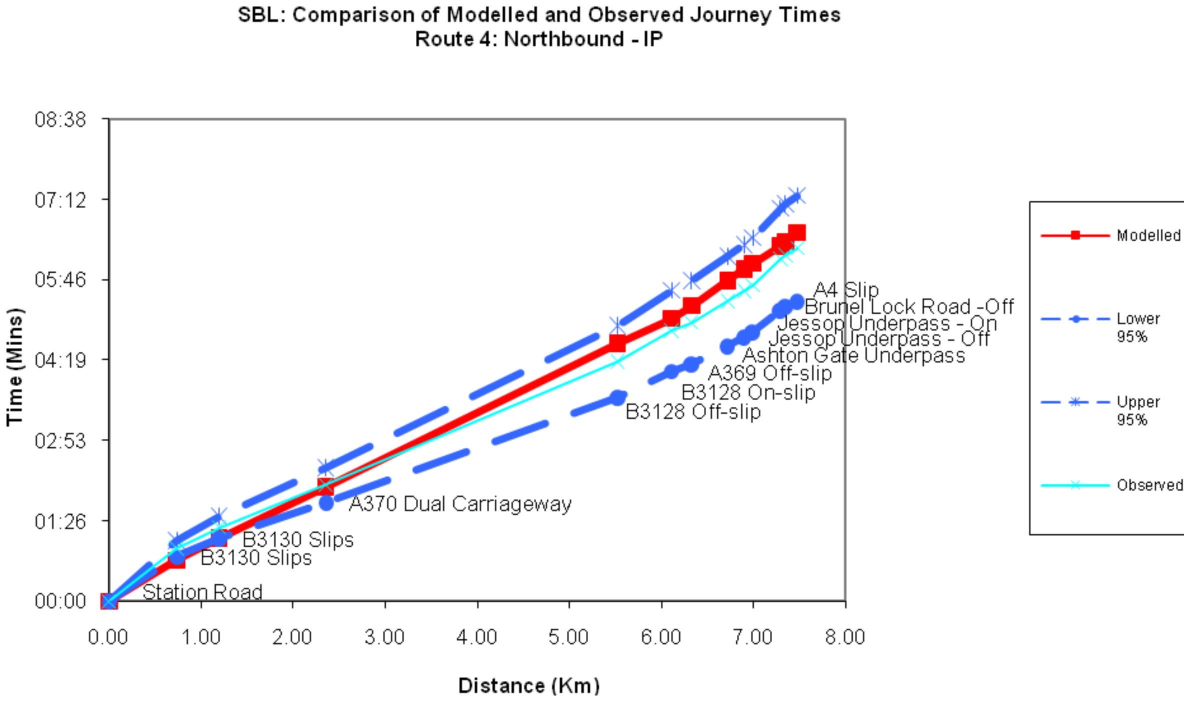

SBL: Comparison of Modelled and Observed Journey Times
Route 1: Southbound - IP
Time (Mins)
07:12
06:29
05:46
05:02
04:19
03:36
02:53
02:10
01:26
00:43
00:00
Distance (Km)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
B3130
Dundry Lane
Bridgwater Farm
Yangley Lane
King's Head Lane
Bishopsworth Road
Bedminster Road
Modelled
Lower 95%
Upper 95%
Observed

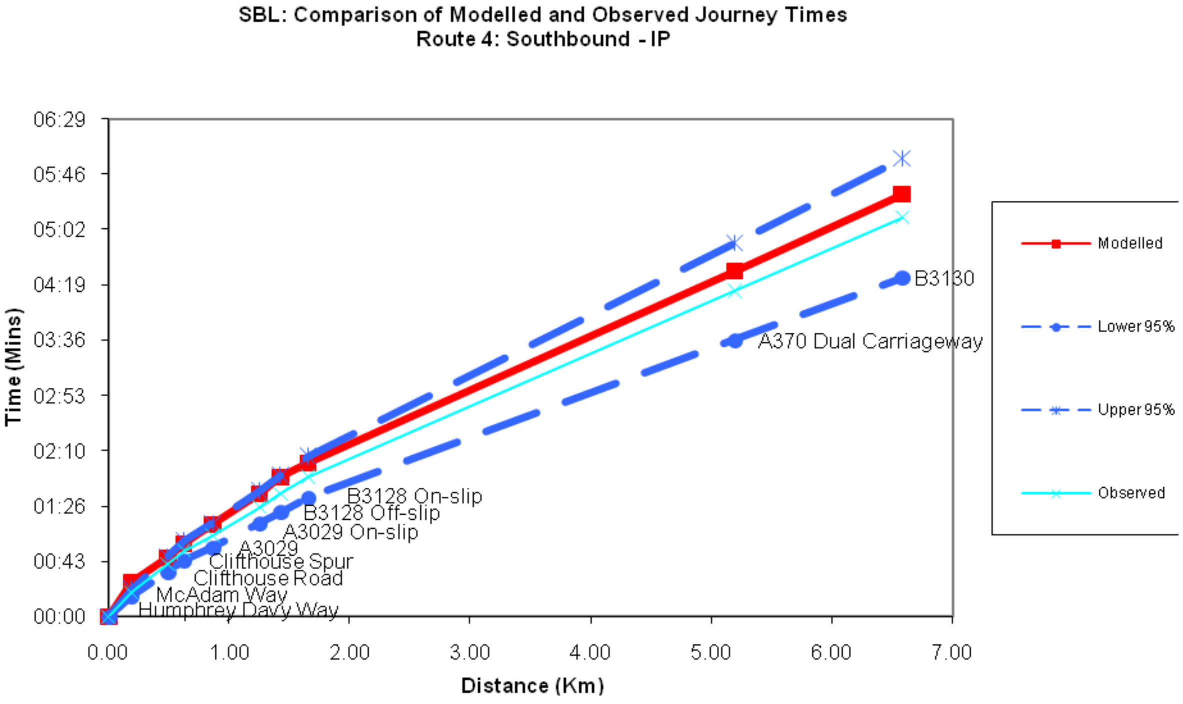

SBL: Comparison of Modelled and Observed Journey Times
Route 2: Northbound - IP
Time (Mins)
05:02
04:19
03:36
02:53
02:10
01:26
00:43
00:00
Distance (Km)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
Weston Road
A370 EB Slip
A370 EB Slip
A370 Off-Slip
A370 WB Slip
Wildcountry Lane
Bridgwater Road
Modelled
Lower 95%
Upper 95%
Observed

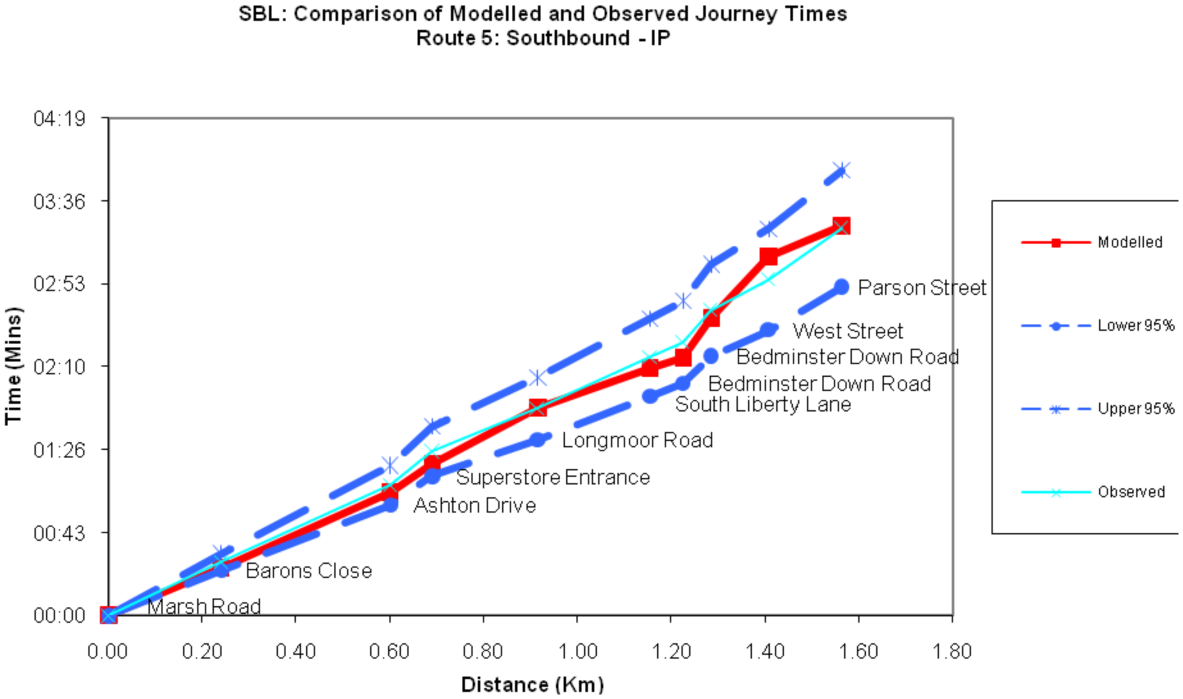

SBL: Comparison of Modelled and Observed Journey Times
Route 2: Southbound - IP
Time (Mins)
05:46
05:02
04:19
03:36
02:53
02:10
01:26
00:43
00:00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
Distance (Km)
Weston Road
A370 EB Slip
A370 EB Slip
A370 Off-Slip
A370 WB Slip
Wildcountry Lane
Bridgwater Road
Modelled
Lower 95%
Upper 95%
Observed

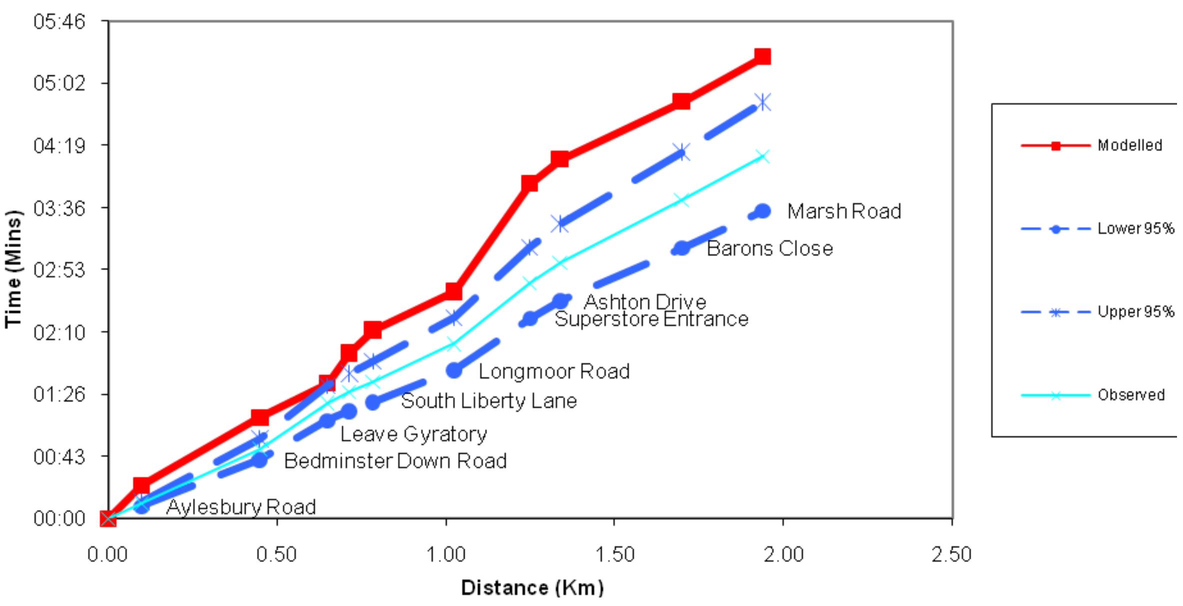

SBL: Comparison of Modelled and Observed Journey Times
Route 3: Northbound - IP
Time (Mins)
08:38
07:12
05:46
04:19
02:53
01:26
00:00
0.00
1.00
2.00
3.00
4.00
5.00
Distance (Km)
B3130
Wildcountry Lane
Providence Lane
Yangley Lane
Clarken Coombe
B3128
A370
Modelled
Lower 95%
Upper 95%
Observed


SBL: Comparison of Modelled and Observed Journey Times
Route 3: Southbound - IP
Time (Mins)
08:38
07:12
05:46
04:19
02:53
01:26
00:00
Distance (Km)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
B3130
Wildcountry Lane
Providence Lane
Yangley Lane
Clarken Coombe
Ashton Road
A370 Slips
Park and Ride Entrance
B3128
A370
Modelled
Lower 95%
Upper 95%
Observed

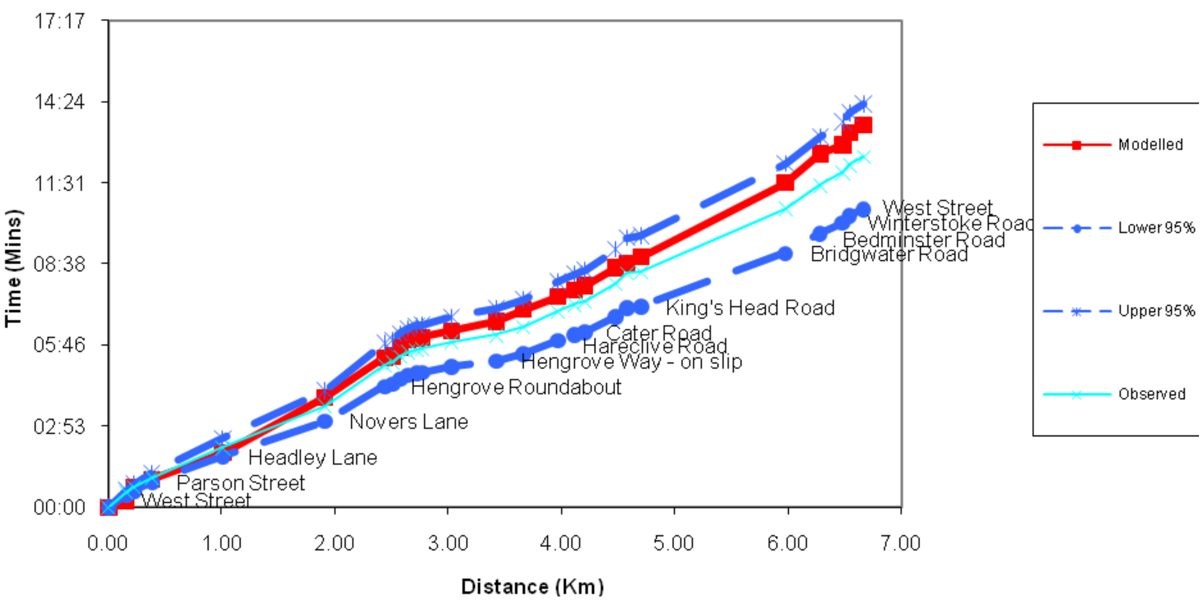

SBL: Comparison of Modelled and Observed Journey Times
Route 4: Northbound - IP
Time (Mins)
08:38
07:12
05:46
04:19
02:53
01:26
00:00
Distance (Km)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
A4 Slip
Brunel Lock Road -Off
Jessop Underpass - On
Jessop Underpass - Off
Ashton Gate Underpass
A369 Off-slip
B3128 On-slip
B3128 Off-slip
A370 Dual Carriageway
B3130 Slips
B3130 Slips
Station Road
Modelled
Lower 95%
Upper 95%
Observed


SBL: Comparison of Modelled and Observed Journey Times
Route 4: Southbound - IP
Time (Mins)
06:29
05:46
05:02
04:19
03:36
02:53
02:10
01:26
00:43
00:00
Distance (Km)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
B3130
A370 Dual Carriageway
B3128 On-slip
B3128 Off-slip
A3029 On-slip
A3029
Clifthouse Spur
Clifthouse Road
McAdam Way
Humphrey Davy Way
Modelled
Lower 95%
Upper 95%
Observed

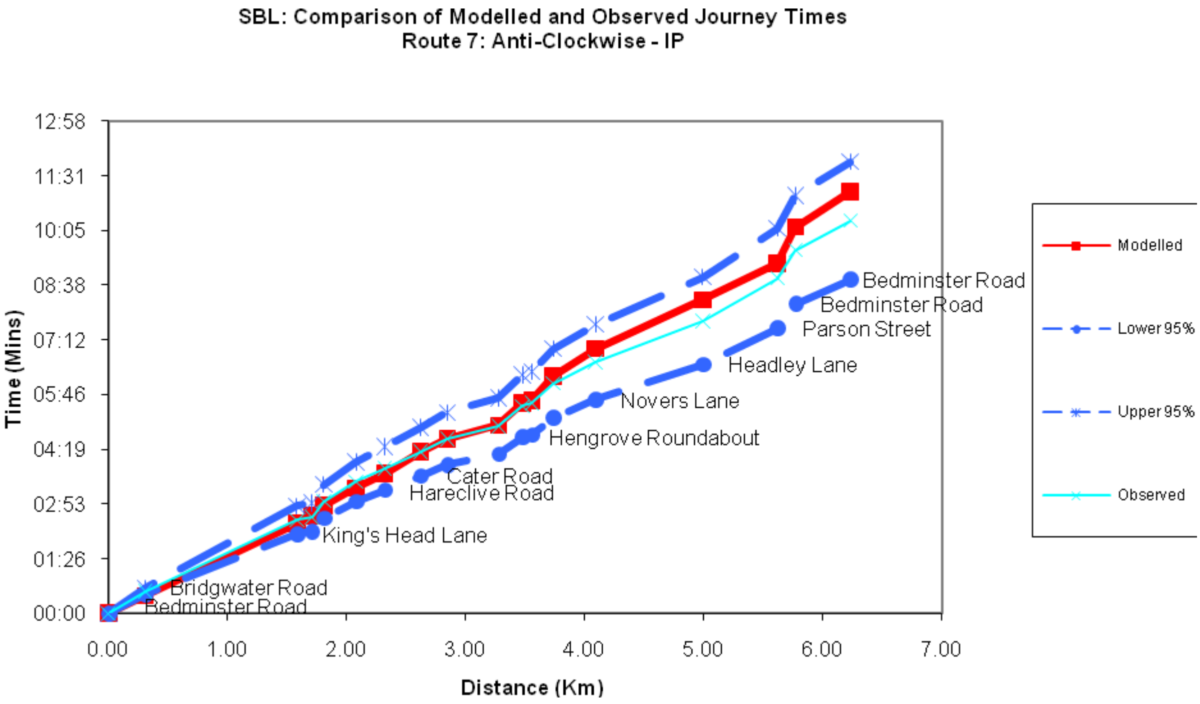

SBL: Comparison of Modelled and Observed Journey Times
Route 5: Southbound - IP
Time (Mins)
04:19
03:36
02:53
02:10
01:26
00:43
00:00
Distance (Km)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
Parson Street
West Street
Bedminster Down Road
Bedminster Down Road
South Liberty Lane
Longmoor Road
Superstore Entrance
Ashton Drive
Barons Close
Marsh Road
Modelled
Lower 95%
Upper 95%
Observed

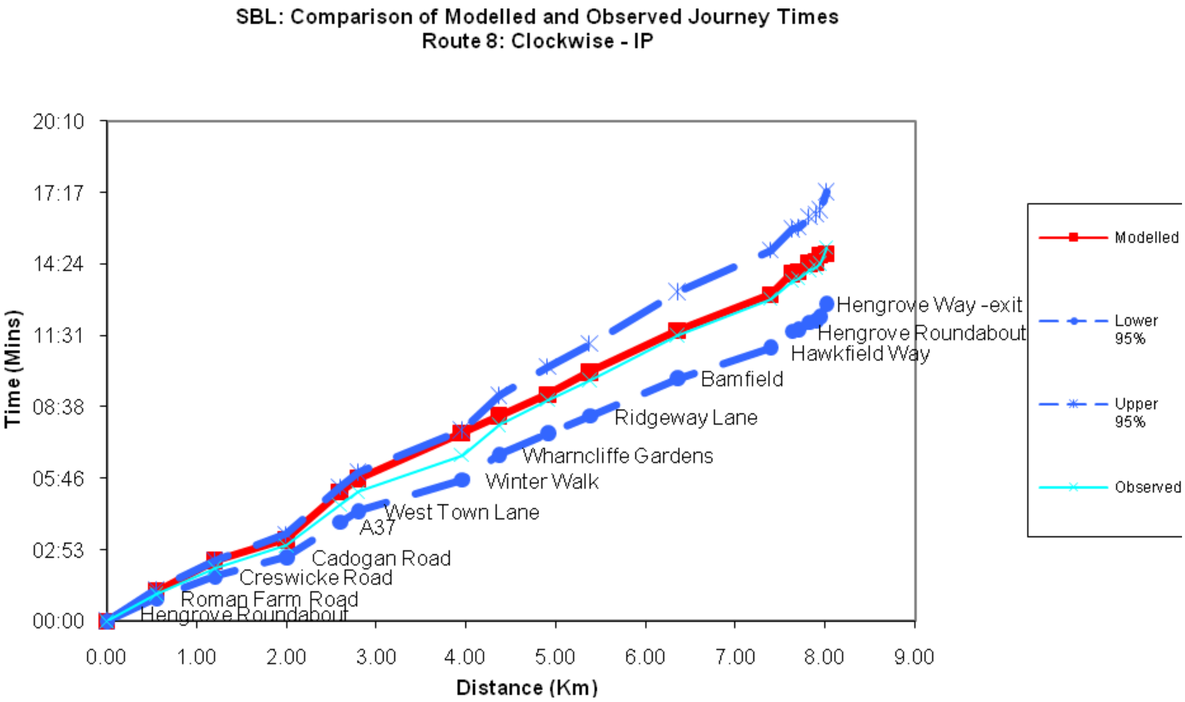


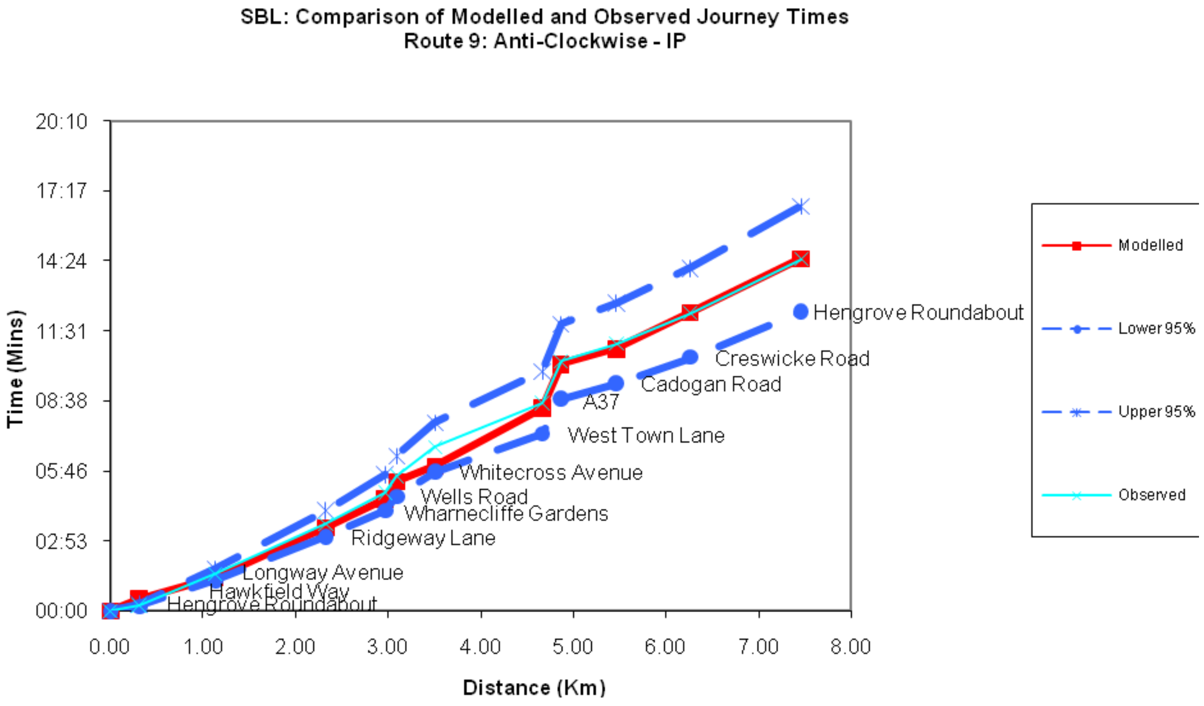
SBL: Comparison of Modelled and Observed Journey Times
Route 5: Northbound - IP



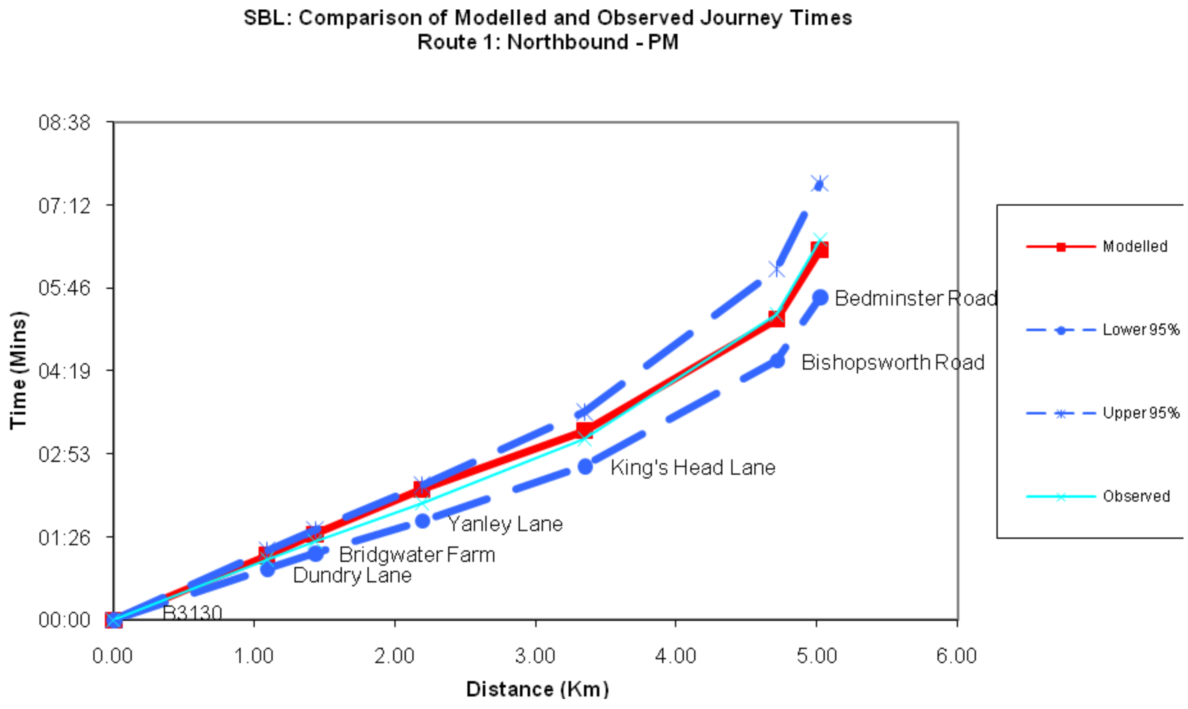
SBL: Comparison of Modelled and Observed Journey Times
Route 6: Clockwise - IP

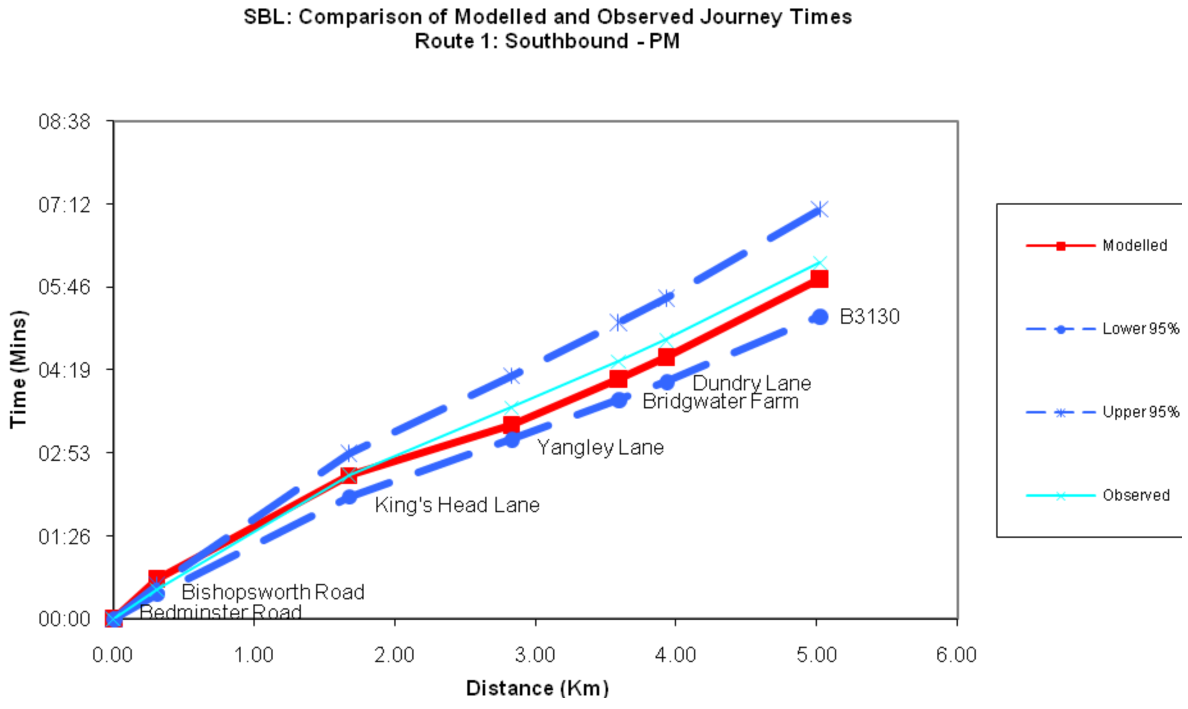

SBL: Comparison of Modelled and Observed Journey Times
Route 7: Anti-Clockwise - IP
Time (Mins)
12:58
11:31
10:05
08:38
07:12
05:46
04:19
02:53
01:26
00:00
Distance (Km)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Bedminster Road
Bedminster Road
Parson Street
Headley Lane
Novers Lane
Hengrove Roundabout
Cater Road
Hareclive Road
King's Head Lane
Bridgwater Road
Bedminster Road
Modelled
Lower 95%
Upper 95%
Observed

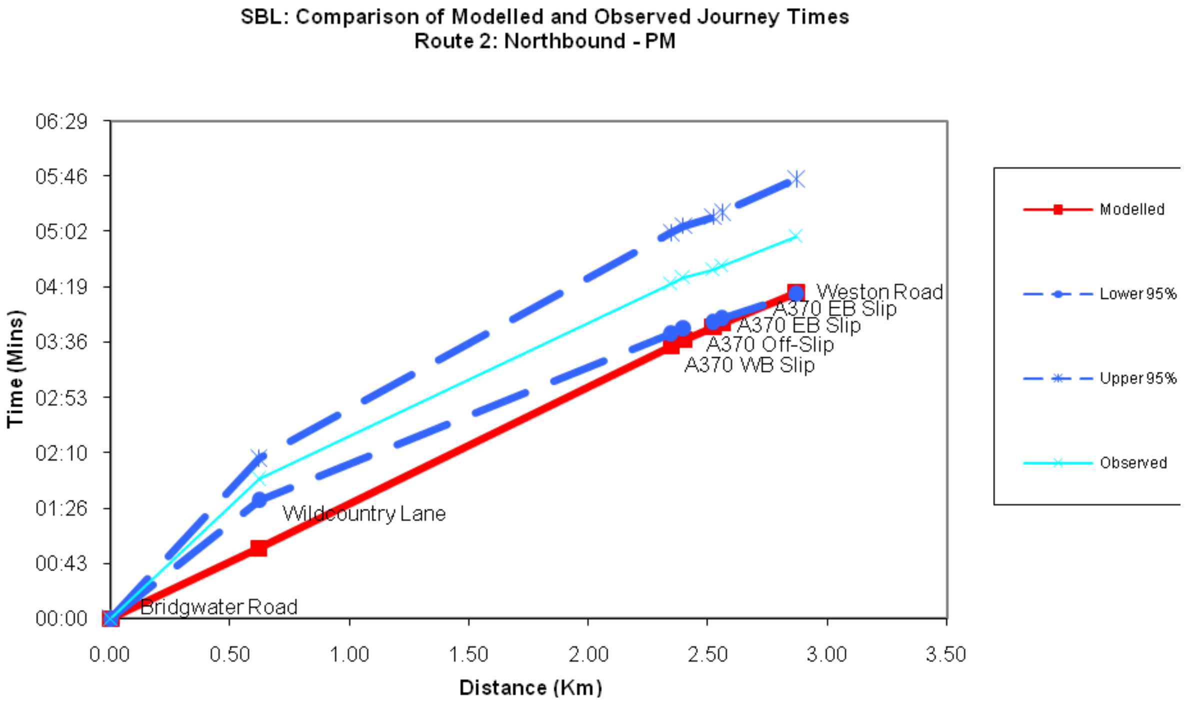

SBL: Comparison of Modelled and Observed Journey Times
Route 8: Clockwise - IP
Time (Mins)
20:10
17:17
14:24
11:31
08:38
05:46
02:53
00:00
Distance (Km)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
Hengrove Way -exit
Hengrove Roundabout
Hawkfield Way
Bamfield
Ridgeway Lane
Wharncliffe Gardens
Winter Walk
West Town Lane
A37
Cadogan Road
Creswicke Road
Roman Farm Road
Hengrove Roundabout
Modelled
Lower 95%
Upper 95%
Observed

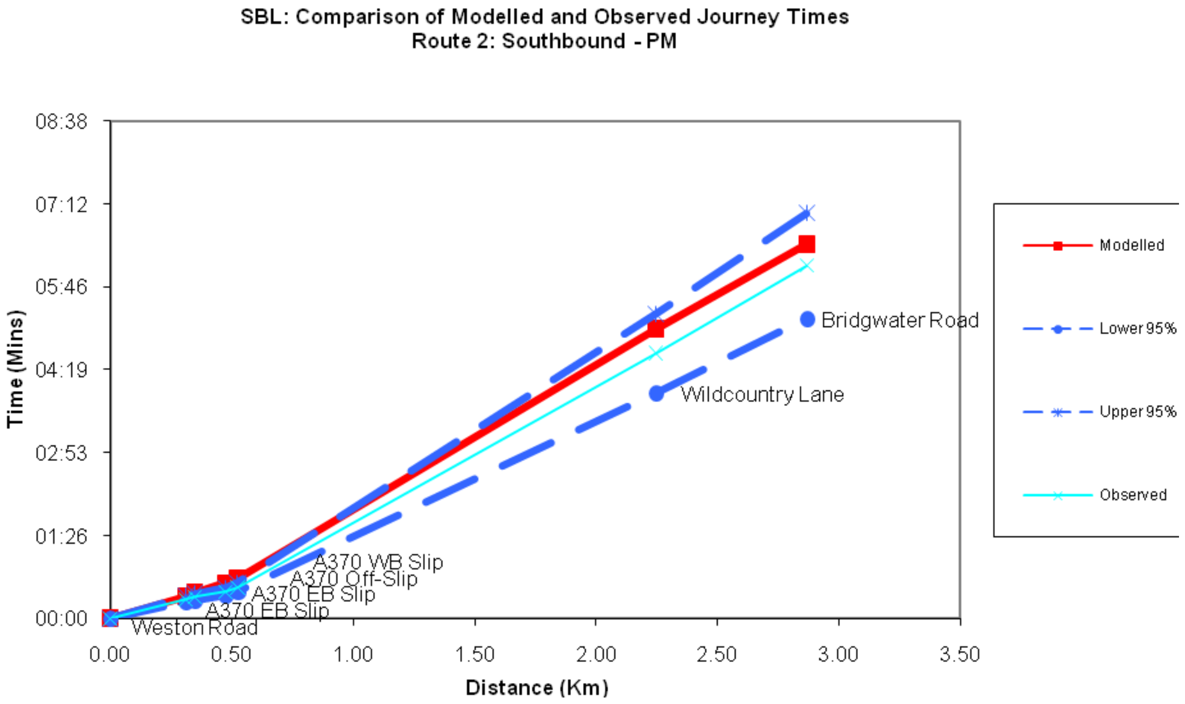

SBL: Comparison of Modelled and Observed Journey Times
Route 9: Anti-Clockwise - IP
Time (Mins)
20:10
17:17
14:24
11:31
08:38
05:46
02:53
00:00
Distance (Km)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Hengrove Roundabout
Creswicke Road
Cadogan Road
A37
West Town Lane
Whitecross Avenue
Wells Road
Wharncliffe Gardens
Ridgeway Lane
Longway Avenue
Hawkfield Way
Hengrove Roundabout
Modelled
Lower 95%
Upper 95%
Observed

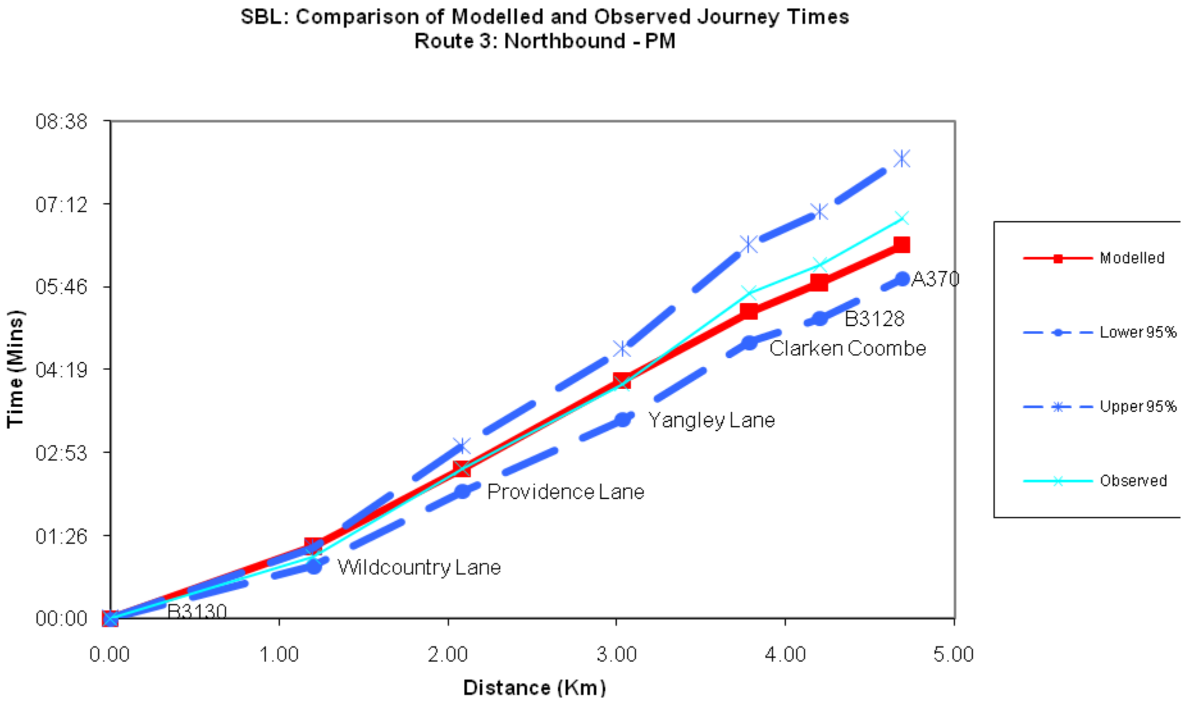
E.3. PM peak

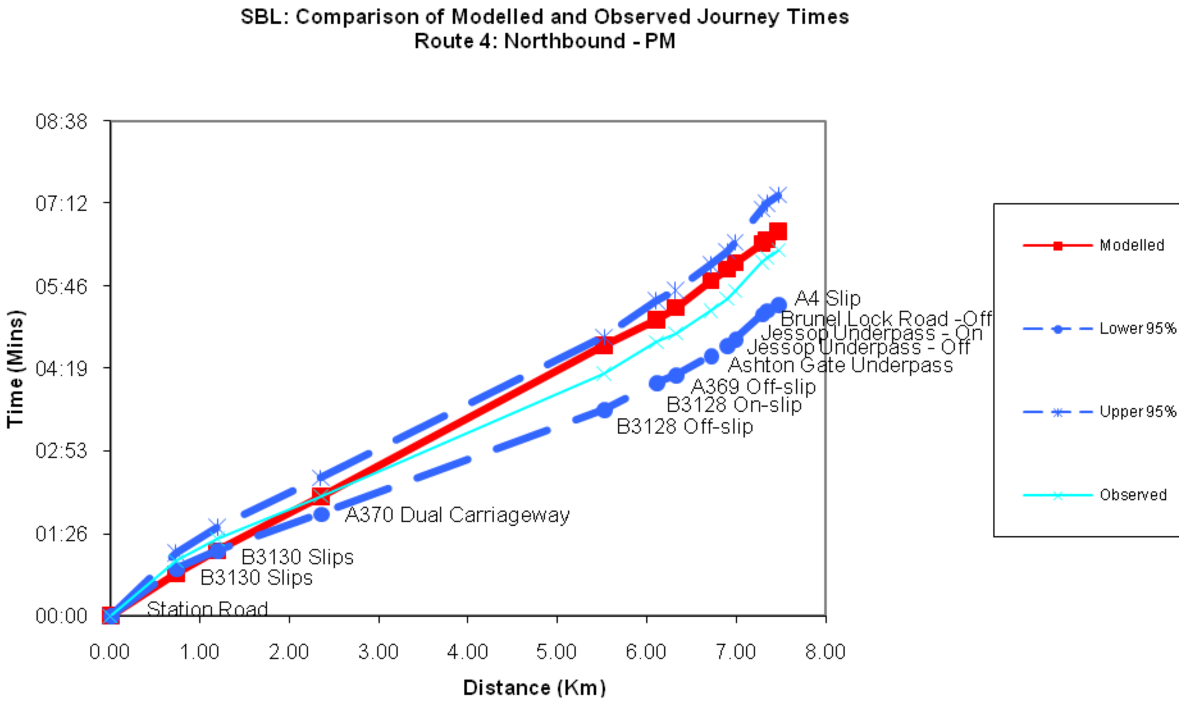

SBL: Comparison of Modelled and Observed Journey Times
Route 1: Northbound - PM
Time (Mins)
08:38
07:12
05:46
04:19
02:53
01:26
00:00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
Distance (Km)
B3130
Dundry Lane
Bridgwater Farm
Yanley Lane
King's Head Lane
Bishopsworth Road
Bedminster Road
Modelled
Lower 95%
Upper 95%
Observed

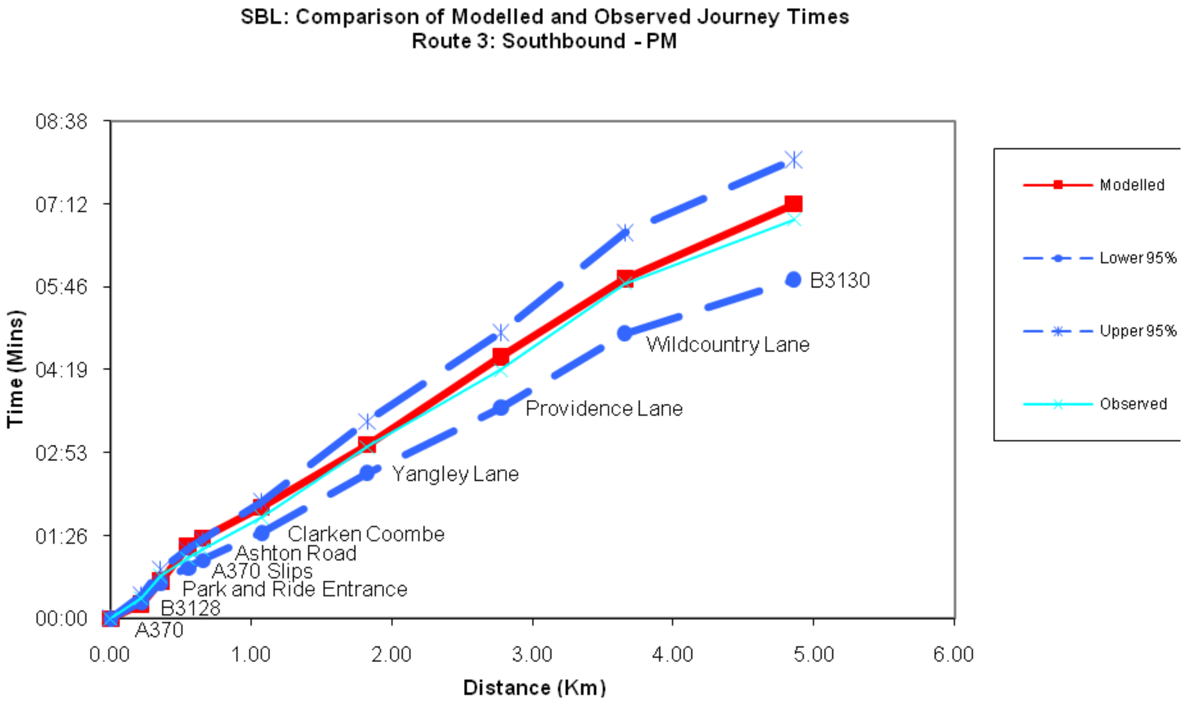

SBL: Comparison of Modelled and Observed Journey Times
Route 1: Southbound - PM
Time (Mins)
08:38
07:12
05:46
04:19
02:53
01:26
00:00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
Distance (Km)
Bedminster Road
Bishopsworth Road
King's Head Lane
Yangley Lane
Bridgwater Farm
Dundry Lane
B3130
Modelled
Lower 95%
Upper 95%
Observed

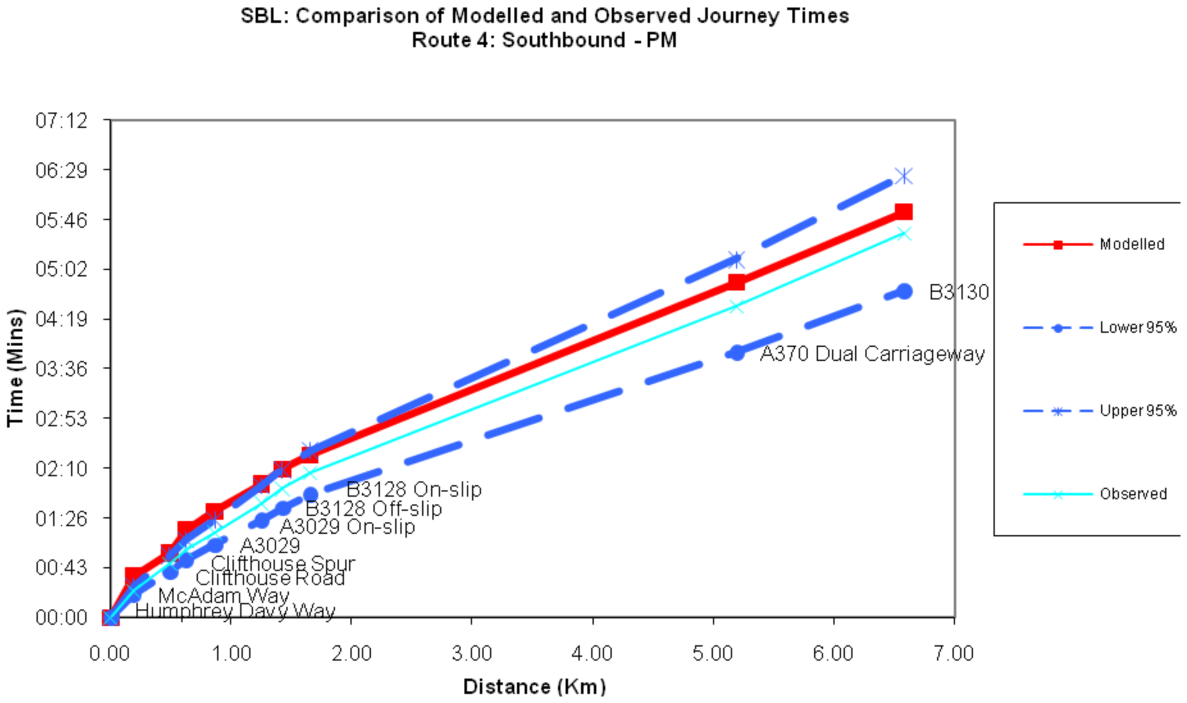

SBL: Comparison of Modelled and Observed Journey Times
Route 2: Northbound - PM
Time (Mins)
06:29
05:46
05:02
04:19
03:36
02:53
02:10
01:26
00:43
00:00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
Distance (Km)
Bridgwater Road
Wildcountry Lane
Weston Road
A370 EB Slip
A370 EB Slip
A370 Off-Slip
A370 WB Slip
Modelled
Lower 95%
Upper 95%
Observed

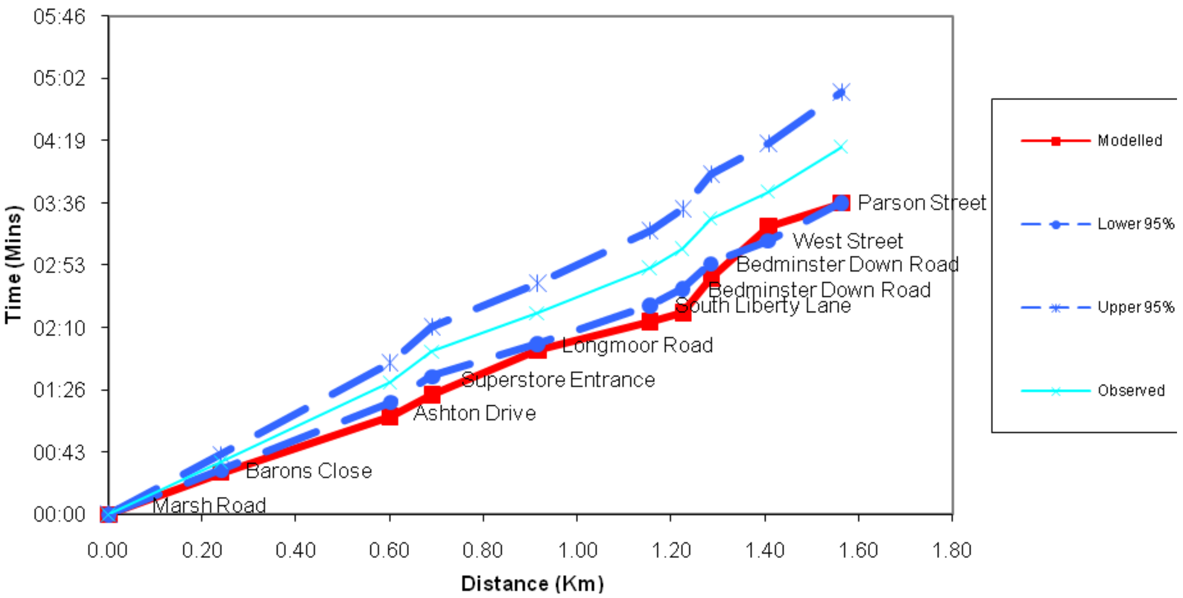

SBL: Comparison of Modelled and Observed Journey Times
Route 2: Southbound - PM
Time (Mins)
08:38
07:12
05:46
04:19
02:53
01:26
00:00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
Distance (Km)
Weston Road
A370 EB Slip
A370 EB Slip
A370 Off-Slip
A370 WB Slip
Wildcountry Lane
Bridgwater Road
Modelled
Lower 95%
Upper 95%
Observed


SBL: Comparison of Modelled and Observed Journey Times
Route 3: Northbound - PM

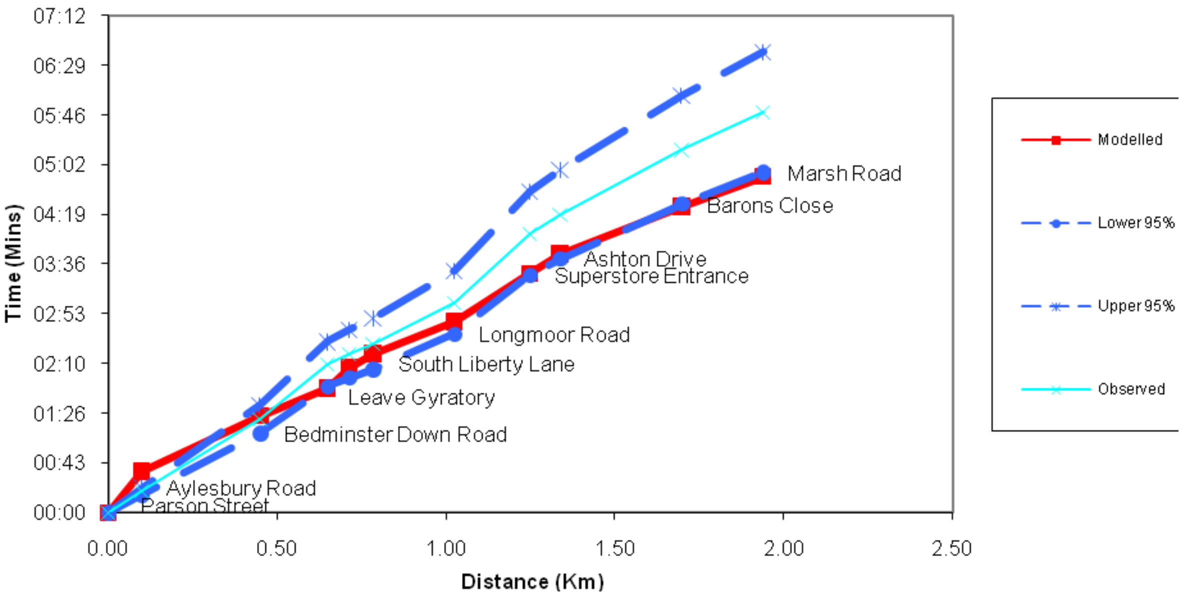

SBL: Comparison of Modelled and Observed Journey Times
Route 4: Northbound - PM


SBL: Comparison of Modelled and Observed Journey Times
Route 3: Southbound - PM
Time (Mins)
08:38
07:12
05:46
04:19
02:53
01:26
00:00
Distance (Km)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
B3130
Wildcountry Lane
Providence Lane
Yangley Lane
Clarken Coombe
Ashton Road
A370 Slips
Park and Ride Entrance
B3128
A370
Modelled
Lower 95%
Upper 95%
Observed

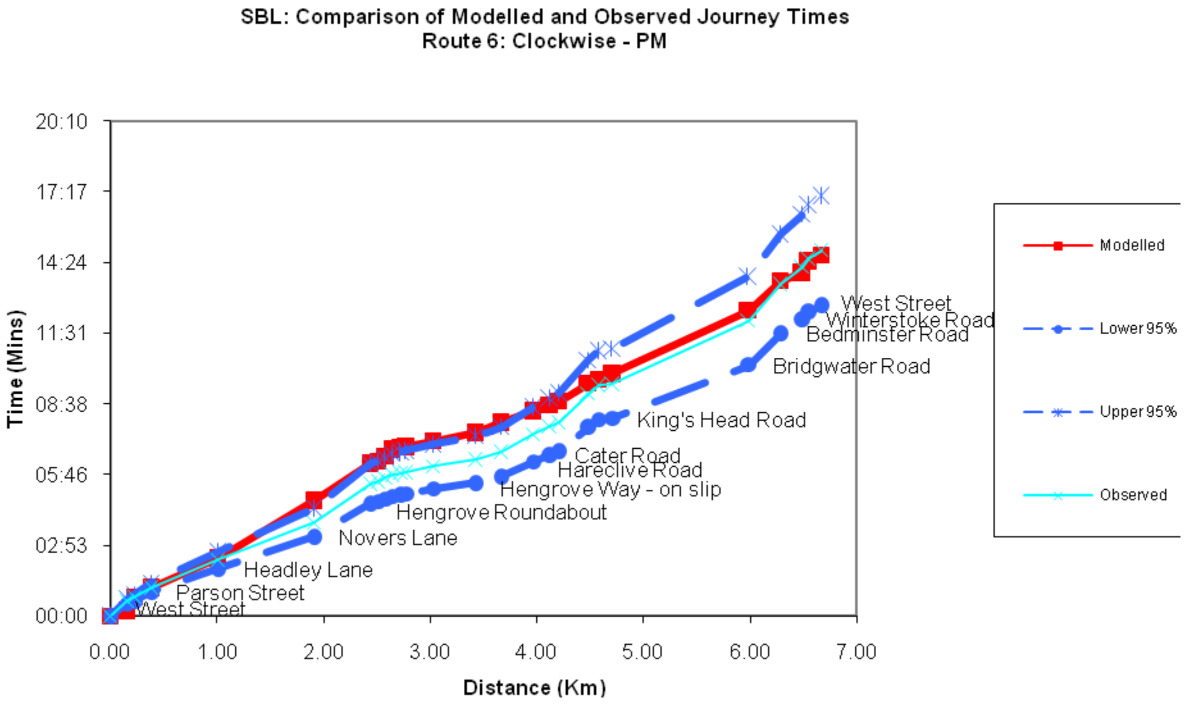

SBL: Comparison of Modelled and Observed Journey Times
Route 4: Southbound - PM
Time (Mins)
07:12
06:29
05:46
05:02
04:19
03:36
02:53
02:10
01:26
00:43
00:00
Distance (Km)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
B3130
A370 Dual Carriageway
B3128 On-slip
B3128 Off-slip
A3029 On-slip
A3029
Clifthouse Spur
Clifthouse Road
McAdam Way
Humphrey Davy Way
Modelled
Lower 95%
Upper 95%
Observed

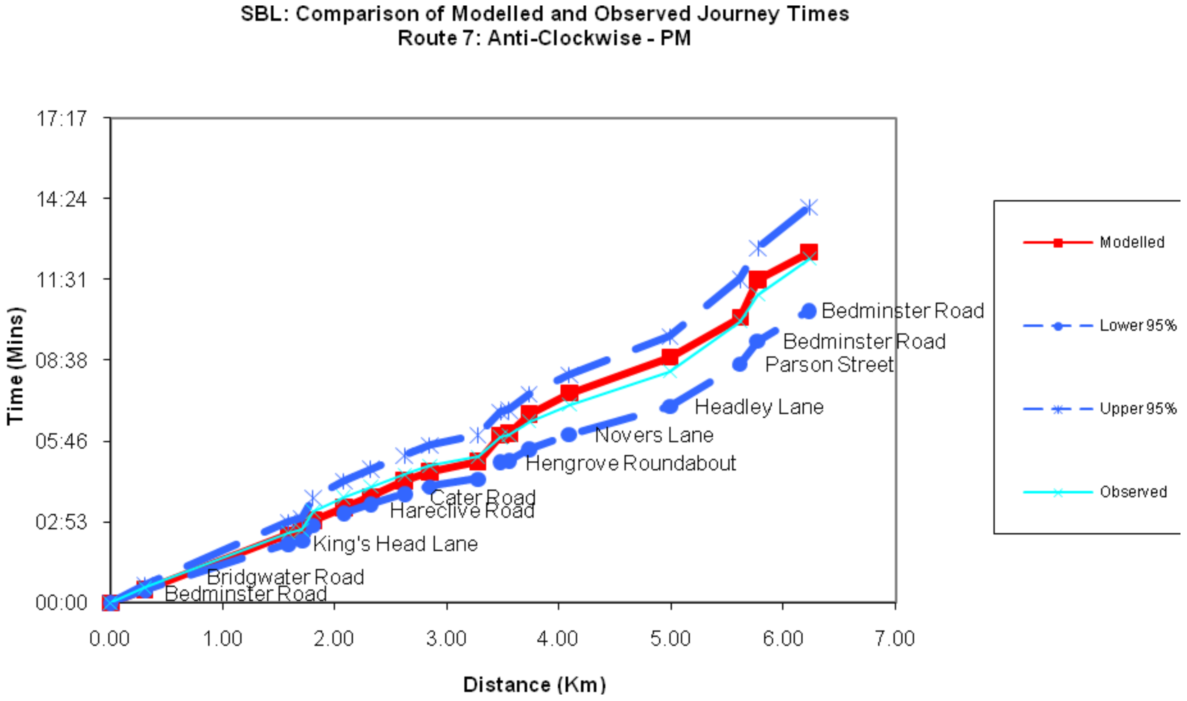


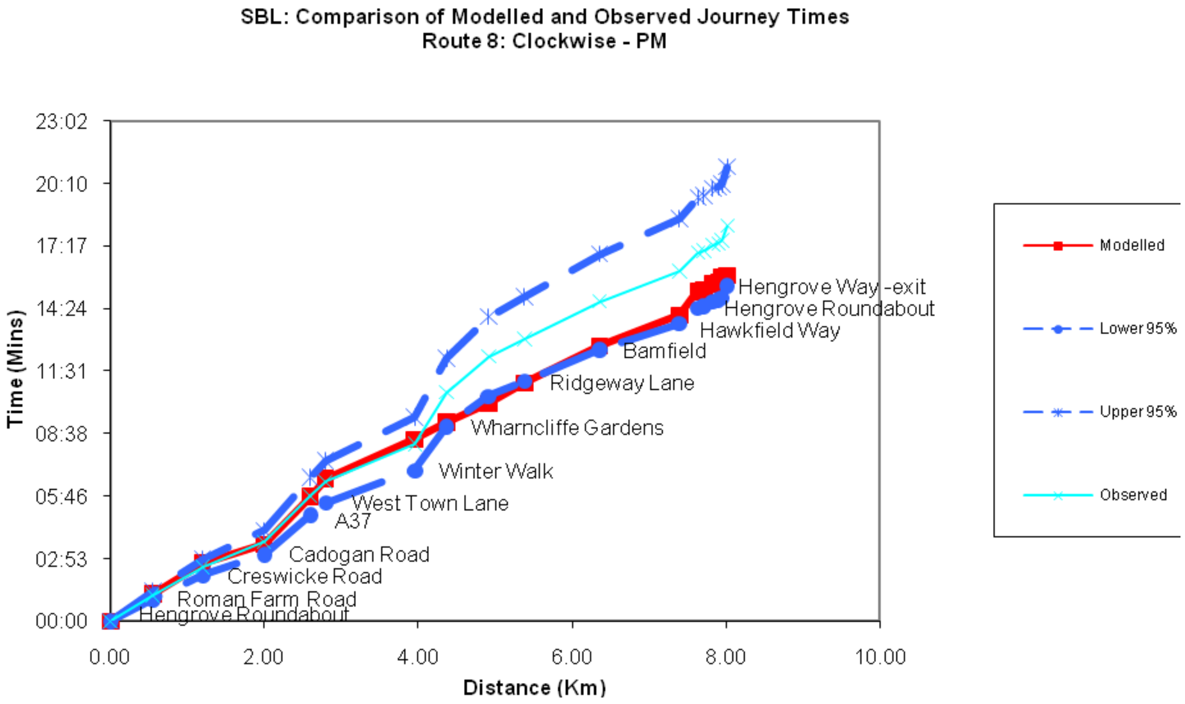
SBL: Comparison of Modelled and Observed Journey Times
Route 5: Southbound - PM

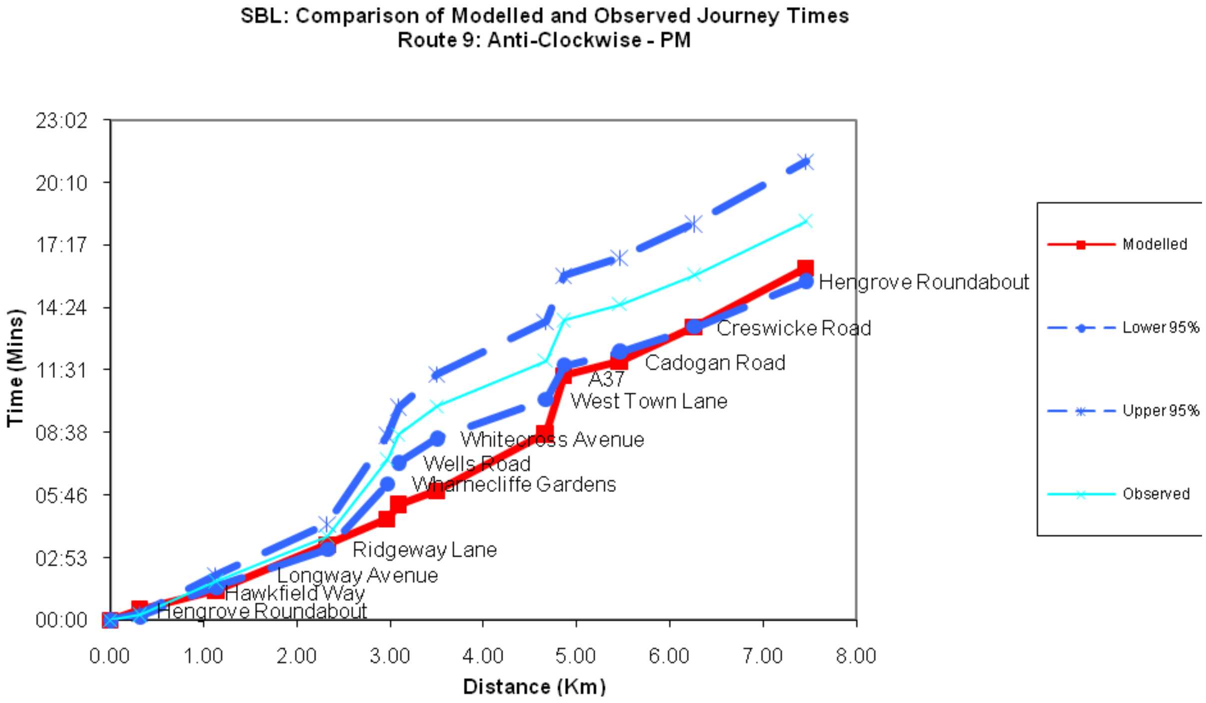


SBL: Comparison of Modelled and Observed Journey Times
Route 5: Northbound - PM


SBL: Comparison of Modelled and Observed Journey Times
Route 6: Clockwise - PM
Time (Mins)
20:10
17:17
14:24
11:31
08:38
05:46
02:53
00:00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Distance (Km)
West Street
Winterstoke Road
Bedminster Road
Bridgwater Road
King's Head Road
Cater Road
Hareclive Road
Hengrove Way - on slip
Hengrove Roundabout
Novers Lane
Headley Lane
Parson Street
West Street
Modelled
Lower 95%
Upper 95%
Observed


SBL: Comparison of Modelled and Observed Journey Times
Route 7: Anti-Clockwise - PM
Time (Mins)
17:17
14:24
11:31
08:38
05:46
02:53
00:00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Distance (Km)
Bedminster Road
Bedminster Road
Parson Street
Headley Lane
Novers Lane
Hengrove Roundabout
Cater Road
Hareclive Road
King's Head Lane
Bridgwater Road
Bedminster Road
Modelled
Lower 95%
Upper 95%
Observed


SBL: Comparison of Modelled and Observed Journey Times
Route 8: Clockwise - PM
Time (Mins)
23:02
20:10
17:17
14:24
11:31
08:38
05:46
02:53
00:00
0.00
2.00
4.00
6.00
8.00
10.00
Distance (Km)
Hengrove Way -exit
Hengrove Roundabout
Hawkfield Way
Bamfield
Ridgeway Lane
Wharncliffe Gardens
Winter Walk
West Town Lane
A37
Cadogan Road
Creswicke Road
Roman Farm Road
Hengrove Roundabout
Modelled
Lower 95%
Upper 95%
Observed


SBL: Comparison of Modelled and Observed Journey Times
Route 9: Anti-Clockwise - PM
Time (Mins)
23:02
20:10
17:17
14:24
11:31
08:38
05:46
02:53
00:00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Distance (Km)
Hengrove Roundabout
Creswicke Road
Cadogan Road
A37
West Town Lane
Whitecross Avenue
Wells Road
Wharnecliffe Gardens
Ridgeway Lane
Longway Avenue
Hawkfield Way
Hengrove Roundabout
Modelled
Lower 95%
Upper 95%
Observed

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