South Bristol Link
PTAM Validation Report

April 2013

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South Bristol Link

Public Transport Assignment Model Development Report

April 2013

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1. Introduction

Background

1.1 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.

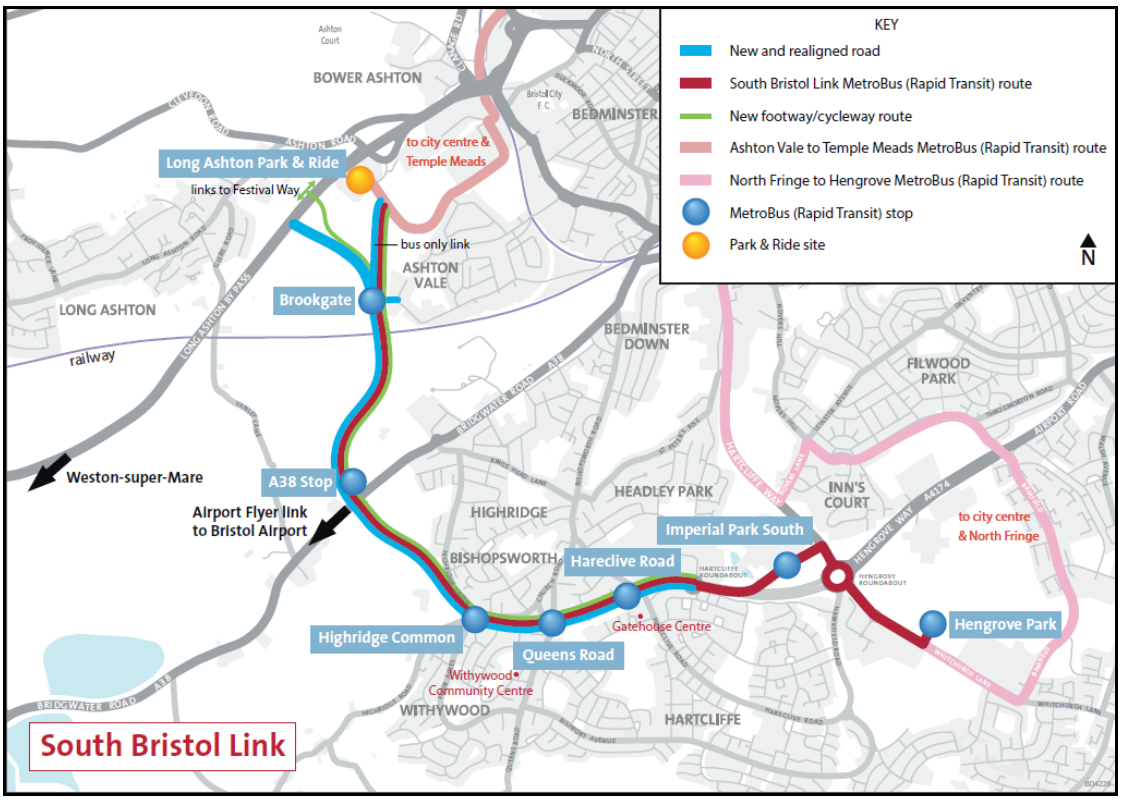
The Scheme

1.2 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.

1.3 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.

1.4 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.

Figure 1.1 – SBL Scheme



1.5 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.

1.6 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).

1.7 This report describes the development of the SBL Public Transport Assignment Model and its validation.

Scope of Report

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

- Section Two sets out the proposed uses of the model and describes the key model design considerations;
- Section Three presents the validation criteria and acceptability guidelines for the PTAM;

- Section Four gives an overview of the key features of the model;
- Section Five presents the calibration and validation data used in the development of the PTAM;
- Sections Six and Seven give details of the network and matrix development;
- Section Eight presents the calibration and validation results; and
- a summary of the model development is presented in Section Nine.

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

Interventions to be Tested

2.1 The SBL PTAM will be used specifically in the assessment of the South Bristol Link scheme. The previous version of the model (G-BATS3 PTAM v2.3) has already been used to support the Ashton Vale to City Centre Rapid Transit MSB, and another variant of the G-BATS3 PTAM has been developed to support a further MSB for the North Fringe to Hengrove Package[1].

Key Model Design Considerations

2.2 G-BATS3 covers the whole of the Bristol urban area in detail, and is suitable for testing a wide range of transport interventions. The PTAM covers bus, rail, Rapid Transit and park and ride modes (via a separate park and ride module).

2.3 The G-BATS3 zoning system was designed to be adequate for testing public transport interventions within the Bristol urban area. It is very detailed within Bristol, particularly in the city centre and other areas of high public transport usage, and hence provides a level of detail around alternative public transport stations and stops within the urban area. However, the SBL scheme is located on the edge of the urban area, where the G-BATS3 zoning is not sufficiently detailed to distinguish between alternative stops on the proposed SBL Rapid Transit route.

2.4 In view of the quality of the existing G-BATS3 model within the SBL area, the requirements for collection of new data, costs and time implications, the SBL methodology combines the strengths of the existing G-BATS3 demand model (updated to a 2009 base year) with new, more detailed assignment models for the SBL local area. The SBL PTAM and HAM use the finer SBL zoning system, and also have a more detailed network representation in the south Bristol area. Outside the SBL area, the assignment models are identical in geographical scope and detail to their G-BATS3 v2.3 equivalents.

2.5 For the SBL PTAM, the bus matrices were rebuilt using newly collected origin-destination survey data. The update incorporated data collected in the south Bristol area specifically for the SBL study as well as further data collected on the North Fringe to Hengrove corridor. Hengrove is at the eastern end of the SBL and the surveys were designed to improve the representation of orbital demand along the SBL route and radial demand into the city centre.

[1] The North Fringe to Hengrove variant of the model includes the updates to the bus demand matrices, but has been developed for a 2006 base year and does not use the enhanced zoning system within the SBL area.

3. Model Standards

Validation Criteria and Acceptability Guidelines

3.1 As indicated in the public transport calibration guidelines in TAG Unit 3.11.2, the PTAM validation includes:

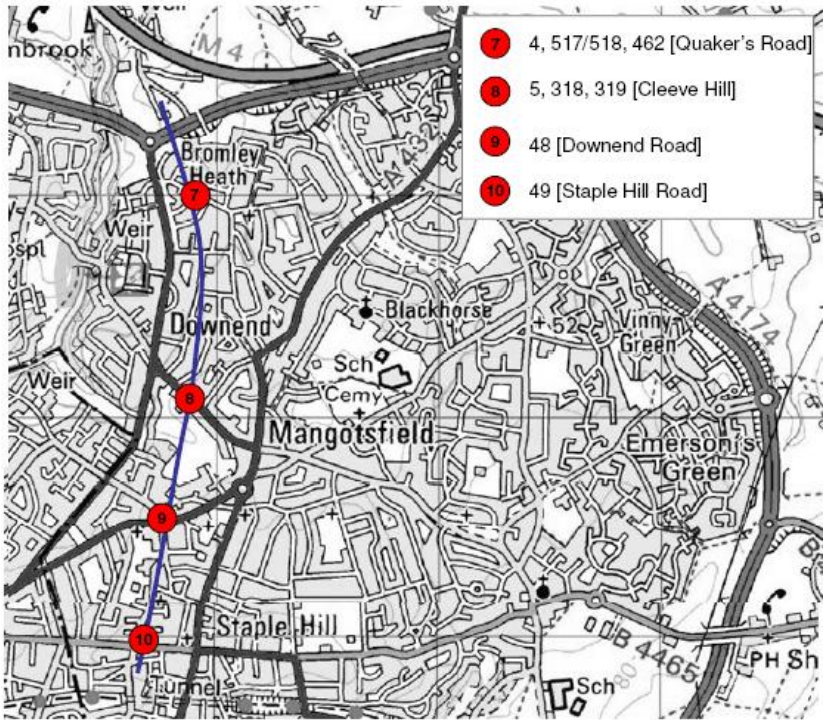
- validation of the trip matrix;
- network and service validation; and
- assignment validation

Trip Matrix Validation

3.2 WebTAG Unit 3.11.2, para 12.3.2 states that "Matrix level validation should involve comparisons of assigned and counted passengers across complete screenlines and cordons (as opposed to individual services). At this level of aggregation, the differences between assigned and counted flows should in 95% of the cases be less than 15%."

3.3 It was not possible to complete a full trip matrix validation for the PTAM as reliable screenline and cordon counts were not available in all parts of the fully modelled area. In particular, counts collected in the south Bristol area did not form a convenient screenline for trip matrix validation. The data collected in south Bristol were, however, used in the assignment validation (see Chapters 5 and 8 for more details).

Figure 3.1 – North Fringe Screenline



3.4 Some additional cordon and screenline bus count data were available, but this is derived from roadside counts, which TAG Unit 3.11.2 advises is not sufficiently accurate for the purposes of validation. No cordon or screenline counts were available for rail.

Network and Service Validation

3.5 The PTAM bus network is identical in structure to the validated highway network. Checks on the accuracy of the coded network geometry are covered in the HAM Development Report. The coding of bus services was verified by checking the modelled flows of buses by route against the roadside bus count data.

Assignment Validation

3.6 TAG Unit 3.11.2, para 10.1.6 states that "Across modelled screenlines, modelled flows should, in total, be within 15% of the observed values. On individual links in the network, modelled flows should be within 25% of the counts, except where the observed flows are particularly low (less than 150)."

3.7 A large number of the observed link counts that were collected have flows less than 150. In order to give some measure of the fit of the model to counts less than 150, we have calculated the GEH statistic, a definition of which is given below. A GEH of less than 5 indicates a good fit of the modelled link flow to the observed count.

3.8 Whilst WebTAG does not specify an overall objective for the calibration/validation, we have aimed to achieve 85% of links meeting the criteria.

GEH Statistic

3.9 As well as differences in flow, the GEH statistic has been included in the tables below as an indicator of 'goodness of fit', i.e. the extent to which the modelled flows match the corresponding observed flows.

$$GEH = \sqrt{\frac{(M-C)^2}{0.5 \times (M + C)}}$$ where M = modelled flow and C = observed flow

Bus Assignment Validation

3.10 For the bus assignment validation, new (single day) onboard bus occupancy counts were collected at four sites in the SBL area and at ten sites in the North Fringe to Hengrove (NFH) corridor. These are considered to be more reliable than previous passenger counts as they were collected on-bus rather than from the roadside. The counts are disaggregated by time period and bus service. Count comparisons were therefore made at both the overall link and bus service group level.

Rail Assignment Validation

3.11 For the rail assignment validation, (single day) boarding and alighting counts were available from the Avon Rail Census.

3.12 As with the link flow validation, we have adopted the criterion that modelled boardings and alightings should be within 25% of the counts, except where observed flows are less than 150. We have also reported the GEH statistic as a further guide to the degree of fit of the model to the data.

Journey Time Validation

3.13 Both the bus and rail assignments are based on timetabled journey times and hence journey time validation is not necessary. Note that in the case of bus services, this is a change from previous versions of the G-BATS3 model, which did not control bus journey times to timetabled times. Further details of the coding of bus journey times are given in para 6.13 and Appendix A.

4. Key Features of the Model

Fully Modelled Area and External Area

G-BATS3 Modelled Area

4.1 The G-BATS3 modelled area covers the greater Bristol urban area and its environs, extending approximately to the boundary of the former county of Avon. The main focus of the model is on Bristol City Centre and the surrounding urban area. This is bounded to the west by the M5, to the North by the M4 - with an extension along the A432 to Yate - to the east by the A4174 outer ring road - with an extension to include Keynsham and Cadbury Heath - and to 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. A detailed zoning system has been defined to represent this area. Outside the modelled area – termed the external area – a less detailed zone system has been defined. This covers the area immediately around the modelled area and also extends to cover the rest of the UK. Further details are given in the G-BATS3 v2.3 Public Transport Local Model Validation Report (Atkins, March 2009).

SBL Area of Detailed Modelling

4.2 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.

4.3 Within the FMA, the area of detailed modelling (ADM) was bounded by the:

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

4.4 The ADM, FMA and External Area were shown earlier in Figure 4.1 to Figure 4.3.

Figure 4.1 – SBL Area of Detailed Modelling

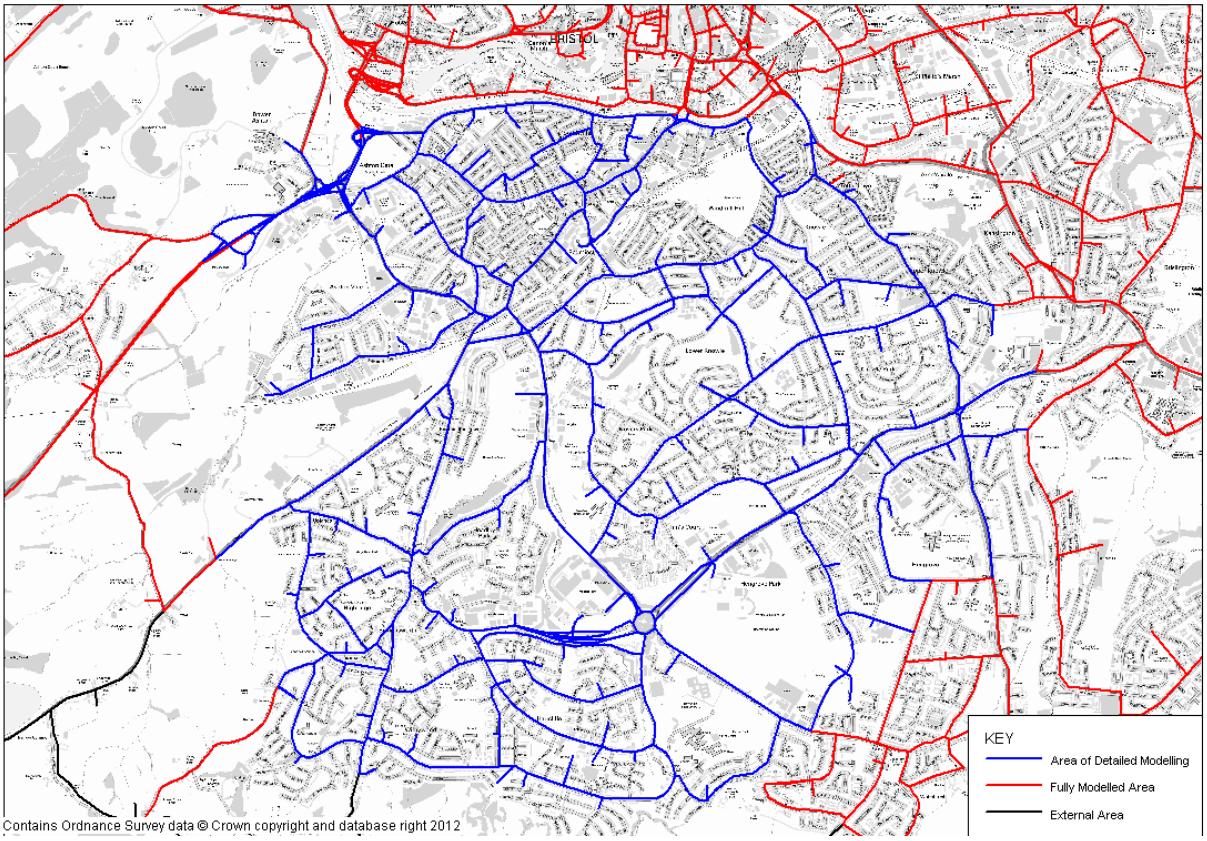


Figure 4.2 – SBL Fully Modelled Area

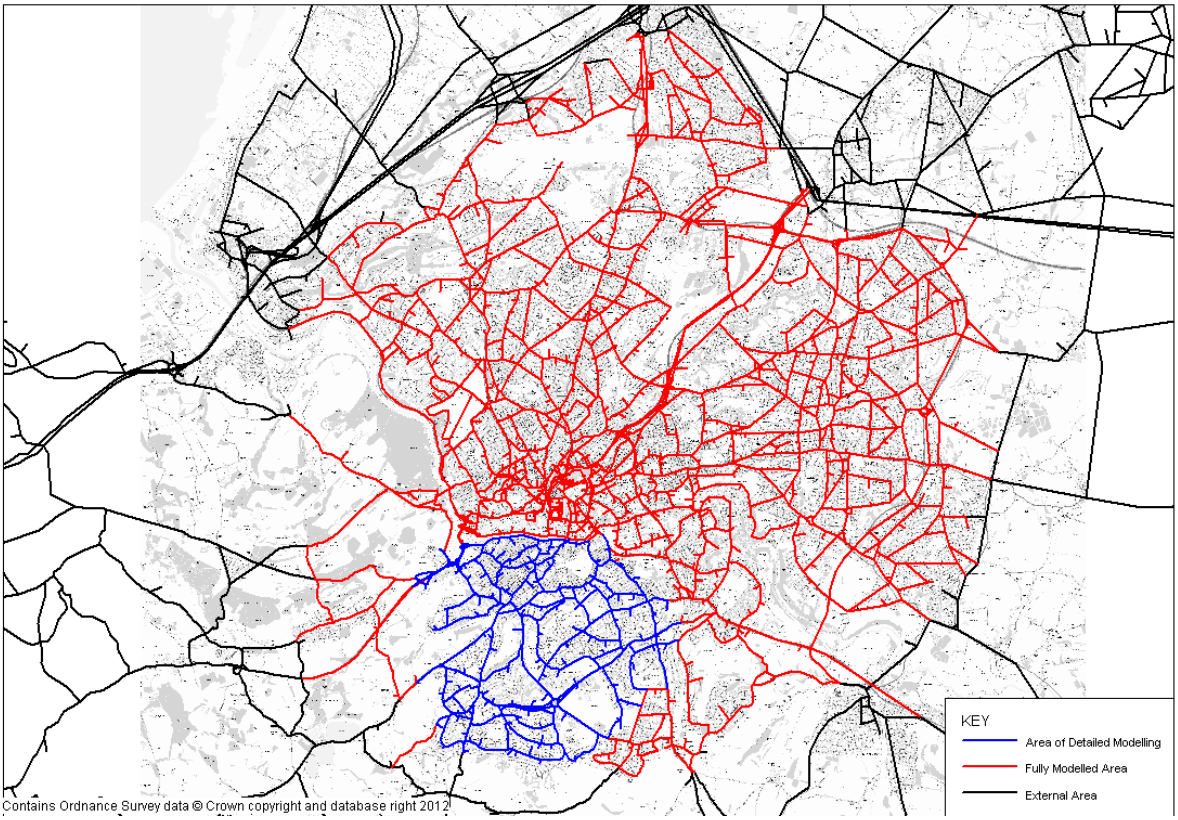
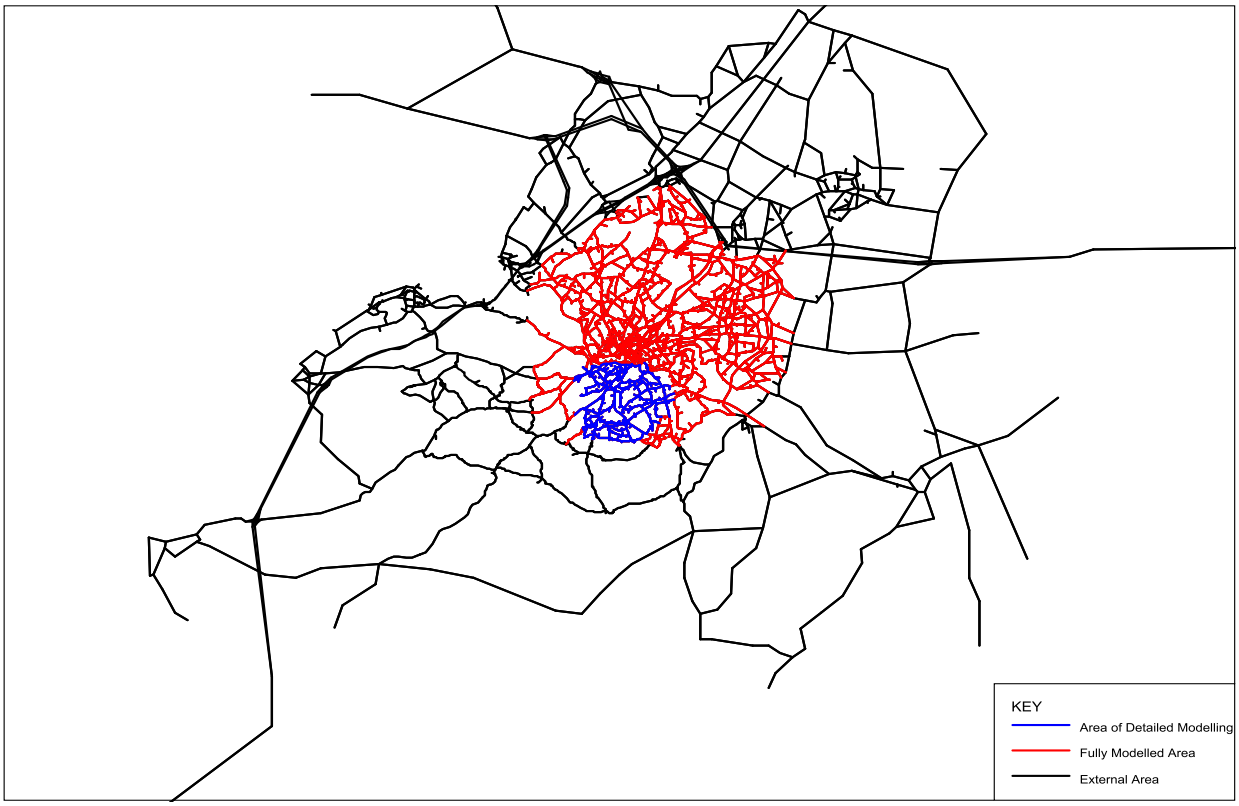


Figure 4.3 – SBL External Area

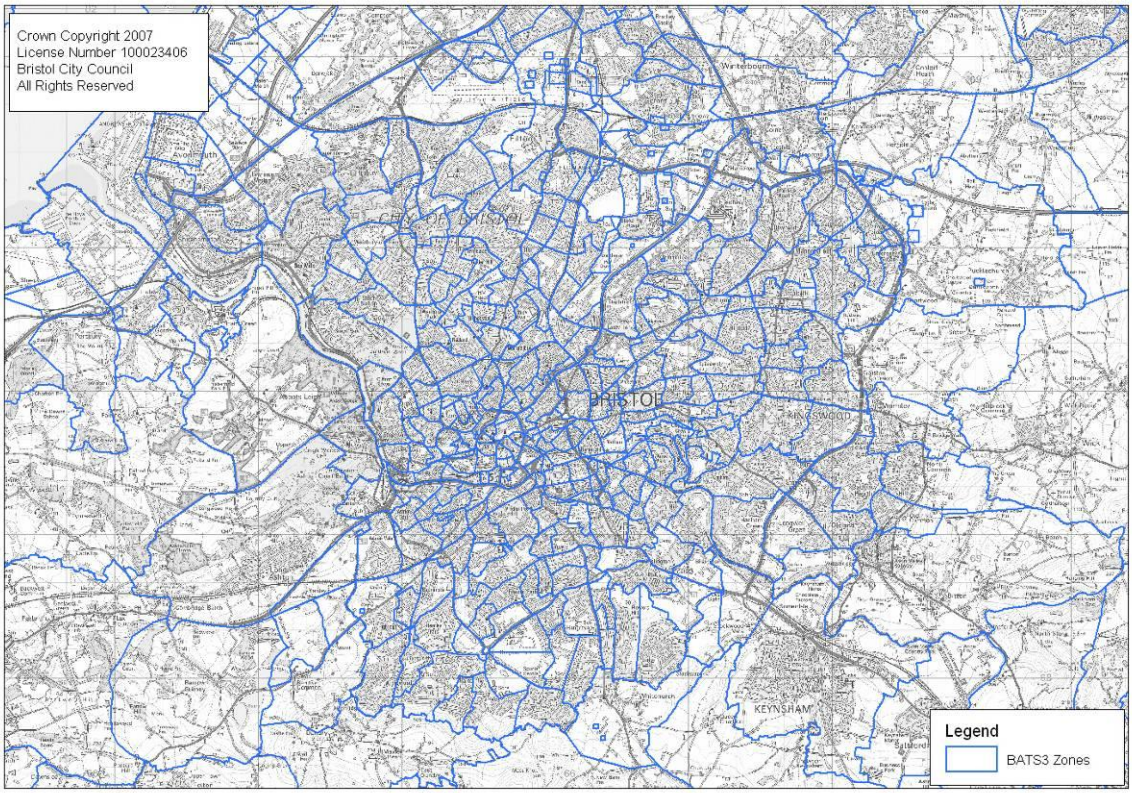


Zoning System

G-BATS3 Zoning System

4.5 The G-BATS3 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. The zoning system also includes 10 Park and Ride zones (of which three are already in operation and the other seven are proposed) as well as separate development zones. The G-BATS3 Zoning System is shown in Figure 4.4.

Figure 4.4 – G-BATS3 Zoning System



SBL Zoning System

4.6 The SBL zoning system is based on the G-BATS3 zoning system, but has been enhanced in the SBL area of detailed modelling, taking account of the SBL scheme alignment and the locations of new developments, increasing the total number of zones from 600 to 650. The new zones were formed by subdividing G-BATS3 zones to facilitate transfer of data between the two models. The PTAM zoning system is identical to that used in the HAM. The finer zoning in the SBL corridor gives a sufficient level of detail around SBL Rapid Transit stops and alternative bus stops in the SBL corridor.

Comparison of G-BATS3 and SBL Zoning Systems

4.7 The SBL and G-BATS3 zone systems are shown Figure 4.5 alongside the alignment of the SBL, with G-BATS3 zone boundaries shown in green and SBL zone boundaries in orange – note that the zoning is unchanged from that used for G-BATS3 outside of the SBL area of detailed modelling shown in the diagram.

4.8 Table 4.1 below summarises the number of zones within different geographical sub areas whilst Table 4.2 lists the three Park and Ride zones.

Table 4.1 - G-BATS3 and SBL Zoning Systems by Sub-Area

Area	SBL Zones	G-BATS3 Zones
Bristol	283	274
North Somerset	88	62
B&NES	37	36
South Gloucestershire	162	162
External	46	46
Unallocated zones	34	20
Totals	**650**	**600**

Table 4.2 - G-BATS3 and SBL Park & Ride Zones

Type	Description	Zone Number
Park & Ride	P&R A4 Portway (Avonmouth)	20190
Park & Ride	P&R Long Ashton	39390
Park & Ride	P&R Brislington	20890

Figure 4.5 – SBL Zone System

Network Structure

4.9 The base year PTAM has been developed to represent two public transport modes:

a) bus; and

b) rail.

4.10 In addition, the model also includes a bus-based park and ride mode and the performance of the park and ride sub-model is separately reported below.

4.11 Provision for future modes, such as LRT and BRT has been built into the model at this stage. Separate provision has been reserved for each new mode, and the assignment procedures allow the flexibility of integrating the new modes into the Demand Model.

4.12 The SBL PTAM inherits the network structure from the SBL HAM. This means that the SBL PTAM includes certain enhancements in the SBL area, principally a more detailed highway/ bus network representation in Long Ashton village and the B3130 / A370 interchange at Cambridge Batch.

Model Year

4.13 In Autumn 2012, to support the Planning Application, the SBL model was updated to a 2012 base year. It was considered prudent consider an update the rail and bus demand to take account of the growth between 2009 and 2012, but the PT services were left unchanged. The Bristol Annual Monitoring Report for 2011[2] shows an increase of 1% in bus demand between 2008/9 and 2011/12, so the bus demand and validation remained unchanged. The National Rail Portal Statistics for total franchised journeys[3] showed an increase of 31% between 2006 and 2012. The rail validation was updated by factoring the counts using the same growth factor.

Time Periods

4.14 Temporally, the model covers the AM Peak (08:00-09:00), Inter-peak (an average hour between 10:00-16:00) and PM peak (17:00-18:00).

User Classes

4.15 The public transport assignment uses a single user class.

Assignment Methodology

4.16 The Public Transport Assignment Model uses the standard transit assignment implemented in Emme, i.e. a multipath assignment, based on the computation of optimal strategies. Further details of the assignment methodology may be found in the Emme reference manual.

Generalized Cost Formulations and Parameter Values

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

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[22] Source: http://www.bristol.gov.uk/sites/default/files/documents/planning_and_building_regulations/planning_policy/local_development_framework/AMR2011_0.pdf

[3] http://dataportal.orr.gov.uk/displayreport/report/html/22c71959-3f97-405f-8342-e4981745d08b

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

where:

- V_{wk} is the weight applied to time spent walking (walk time weight);
- A is the total walking time to and from the services;
- V_{wt} is the weight applied to time spent waiting;
- W is the total waiting time for all services used on the journey;
- T is the total in-vehicle time; and
- B is the total boarding penalty applied for each service boarded on the journey

4.18 The public transport assignment model uses the parameters based on those provided in WebTAG Unit 3.11.2, which in turn are derived from work undertaken by Institute of Highways and Transportation to establish guidelines for urban transport strategies and further work commissioned by the DfT on the value of travel time savings. Further details, including the various references, may be found in the WebTAG Unit.

4.19 The parameter values for assignment are set out below in Table 4.3. In the Emme assignment, the modelled wait time is controlled by the 'wait time factor' of 0.5, indicating that the wait time is set at half the service headway.

Table 4.3 – Assignment Parameters

Parameter	Value
Wait time factor	0.5
Wait time weight	2.5
Walk time weight	2.0
Interchange penalty	5 to 20*

** Sourced from WebTAG and adjusted as part of the calibration process.*

Fares

4.20 The PT sub-mode choice (ie P&R v BRT v Bus v Rail) is undertaken within the Demand Model based on the standard WebTAG generalised cost formulation (which includes fares). The PTAM does not consider the impact of fares. The PTAM determines the route choice (within each mode) and whilst there will be some influence of fares, it is unlikely to be significant, because:

a) Bus Services were provided principally by First Avon with a single fare system, whilst rail fares are distance-based and the park and ride mode has a flat fare system;

b) The choice of route is sensitive to the difference in the total cost of the journey not the absolute cost and the influence of fare is small compared to the weights attached to In-Vehicle Time, Wait Time and Interchange penalties;

4.21 The fare differentials between realistic competing routes for the same O-D pair will be small.

Relationship with Highway Assignment Model and Demand Model

Links with Highway Assignment Model

4.22 The SBL PTAM is closely integrated with the SBL HAM. The two models use different software packages (Emme and Saturn respectively), but are identical in terms of road network structure, allowing for the automated transfer of link and turn time data from the highway network model to

the public transport network model. Further details of how the bus journey times are updated on the basis of changes in highway link and turn times are given in para 6.13 and Appendix A.

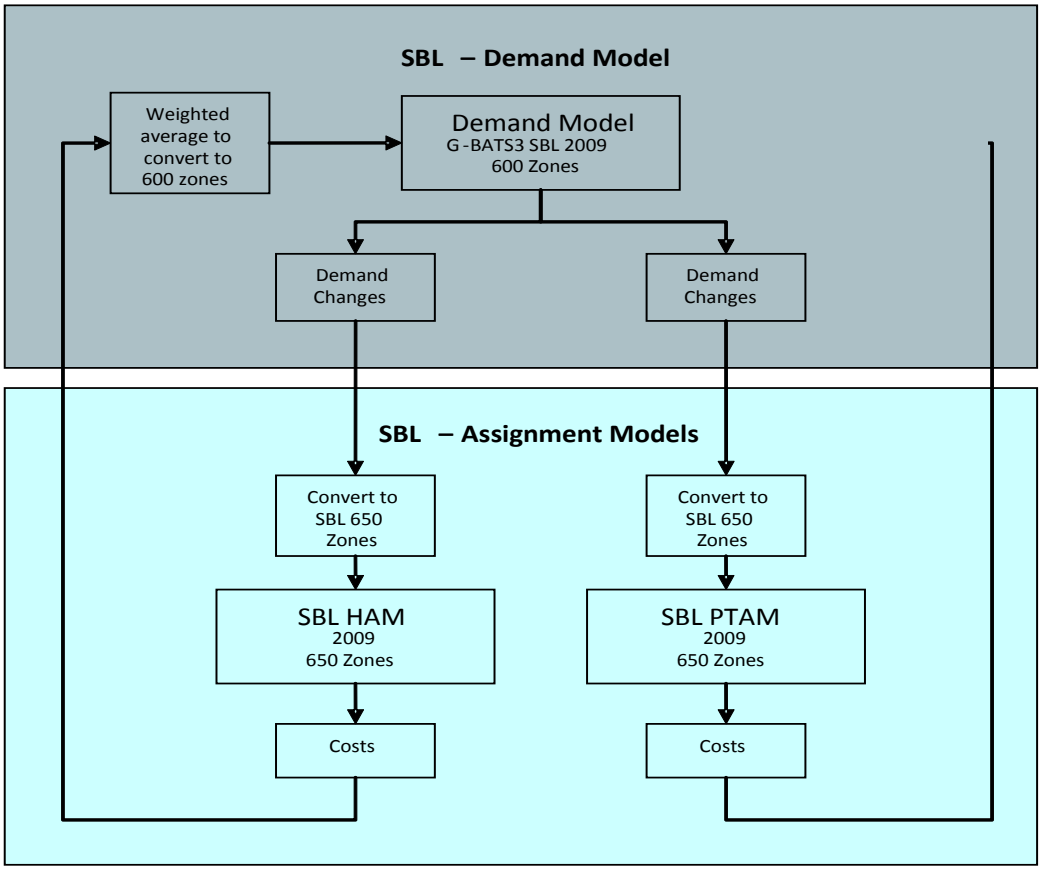
4.23 The bus routes and frequencies that are coded in the Emme public transport model are readily transferred into the bus route format required for the Saturn .dat file using an automated spreadsheet tool, ensuring that the impact of buses on other road traffic is also taken into account.

4.24 In addition to road links, the PTAM also includes the rail network, and associated interconnecting links. The centroid connectors are not necessarily the same in the PTAM and HAM, as in each case they have been optimised as part of the network validation.

Links with Demand model

4.25 The SBL PTAM is fully integrated within the G-BATS3 demand modelling system. The PTAM provides public transport costs to the Demand Model, which in turn provides trip matrices for the PT assignment. The relationship between the elements of the modelling system is shown in Figure 4.6.

Figure 4.6 – SBL Modelling System



4.26 The SBL Demand Model operates at the G-BATS3 600 zone level, while the HAM and PTAM operate at the SBL 650 zone level. Within the SBL area of detailed modelling, the finer SBL zones are subdivisions of G-BATS3 zones to facilitate transfer of data between the demand and assignment models. This involves additional steps to:

- convert demand matrices generated by the G-BATS3 Demand Model to SBL zoning ahead of assignment; and
- convert cost matrices derived from the assignment and skims back to G-BATS3 zoning,

4.27 Further details of the Demand Model are available in the SBL Demand Model Development Report.

Modelling Software

4.28 The SBL PTAM uses EMME software (EMME v3.0.30), to enable it to be closely linked to the Demand Model, which has also been developed using EMME. The HAM is implemented in SATURN.

5. Calibration and Validation Data

Bus Occupancy Counts

5.1 Previously, the calibration and validation of the G-BATS3 PTAM has relied on roadside counts collected by the local authorities. TAG Unit 3.11.2 advises that roadside counts are not sufficiently accurate for the purposes of validation, so new on-board surveys were commissioned, focusing on the SBL area of detailed modelling and the North Fringe to Hengrove Corridor.

5.2 Single day, 12-hour occupancy counts were collected at 4 sites in conjunction with the July 2009 SBL bus origin-destination surveys, and at a further 10 sites in conjunction with the November 2009 North Fringe to Hengrove bus origin-destination surveys. Counts were undertaken on-board, rather than from the roadside, ensuring a higher level of accuracy. The sites and services which were surveyed are shown in Table 5.2 and Table 5.1, and also in Figure 5.1. Services to and from south Bristol and North Somerset were surveyed at site 1 and sites 11-14.

Table 5.1 – November 2009 North Fringe to Hengrove Onboard Bus Counts

Site no.	Site	Bus Routes Surveyed
1	St Luke's Road	routes 20,21
2	Old Market	route 36
3	A38 Gloucester Road	routes 75, 309, 310
4	Filton Avenue	routes 70,71,72,73,U1,U2
5	UWE	routes 312, 318, 319, 517, 518, U4
6	Hatchet Road	routes X73, 73, 312, 318, 319, 517, 518
7	Quaker's Road	routes 4, 517, 518, 462
8	A4017 Cleeve Hill	routes 5, 318, 319
9	Downend Road	route 48
10	Staple Hill Road	route 49

Table 5.2 – July 2009 SBL Surveys

Site no.	Site	Bus Routes Surveyed
11	Anchor Road (by Cathedral)	routes 330, 351, 353, 354, 355, 357,358, 359, 362, 364, X1, X7
12	Bedminster Parade (A38)	routes 24, 25, 52, 75, 76, 90, 121,330, 331
13	Temple Meads (A4)	routes 51, 52, 54, 54A, 331, 376
14	Bedminster Down (A38)	routes 52, 75, 76, 330, 331

Figure 5.1 – Location of Count Sites

Rail Boarding and Alighting Counts

5.3 The updates to the PTAM for SBL did not include a major revision of the rail matrix, but both the rail matrix and the 2006 rail validation counts used for G-BATS3 v2.3 were uplifted to account for the increase in rail demand between 2006 and 2012.

5.4 Through the West of England Partnership, the four Local Authorities organise an Avon Rail survey on a single day in November each year for the majority of railway stations in Greater Bristol. Although the data are collected on a single day, the survey has been conducted on an annual basis for the last few years and provides a valuable resource for the cross-checking of data.

6. Network Development

Bus network

6.1 As noted above, the PTAM bus network is derived directly from the SBL HAM. Checks on the accuracy of the coded network geometry are covered in the HAM Development Report.

Bus Routes

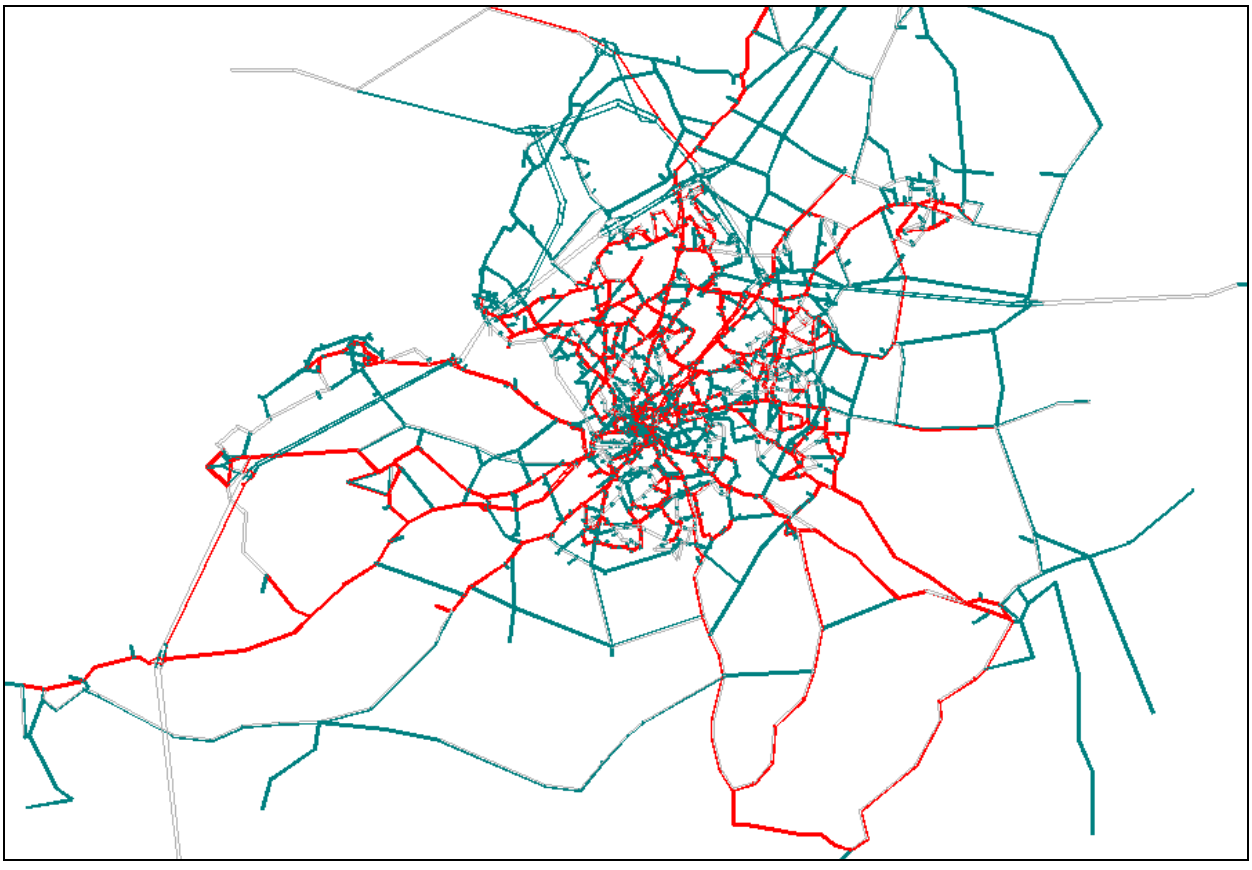
6.2 The SBL PTAM development included updating the routeing and frequencies of the G-BATS3 bus services to an Autumn 2009 base for routes passing through the area covered by the bus surveys (i.e. south Bristol, North Somerset, North Fringe and East Fringe areas). This review used published timetable information supplied by First Group, other bus companies and the local authorities. This information was cross-checked against observations at the patronage survey sites. There were a number of changes to routes serving the University of the West of England (UWE), with Ulink services replacing several routes that were run previously by First Group.

6.3 Park and ride services were calibrated separately from the bus services reflecting the different data sources available. The park and ride calibration is presented in Chapter 8 of the report.

6.4 The majority of bus services in the area are operated by First Group, but the model also includes a limited number of other services provided by Ulink, Abus, Wessex Connect, Bugler Coaches, Eurotaxis and Eagle Coaches.

6.5 The bus network is illustrated below in Figure 6.1. The links shown in red have bus services running along them.

Figure 6.1 – SBL Bus Network



6.6 Table 6.1 summarises the bus services included in the base year PTAM

Table 6.1 – Bus Services included in the PTAM

Service	Route	Operator
1	Broomhill - Cribbs Causeway/Henbury	First Bristol
4	Bristol - Downend	First Bristol
4	Wickwar – Bristol Cathedral School	Westward Travel
5	Iron Acton – Colston Girls School	Westward Travel
5a	Bristol - Downend	First Bristol
6	Bristol - Kingswood	First Bristol
6a	Bristol - Kingswood	First Bristol
7	Bristol - Staple Hill	First Bristol
8	Temple Meads Circular via Whiteleadies	First Bristol
9	Temple Meads Circular via Whiteleadies	First Bristol
21	Rookery Farm - Westbury	First Bristol
24	Ashton Vale - Lockleaze	First Bristol
36	Bristol - Withywood	First Bristol
36a	Bristol - Brislington	First Bristol
40	Cribbs - Broadmead	First Bristol
40a	Cribbs - Avonmouth - Broadmead	First Bristol
41	Cherry Gardens - Avonmouth	First Bristol
44	Bristol - Park Estate	First Bristol
48	Bristol - Emersons Green	First Bristol
49	Bristol - Emersons Green	First Bristol
51	Rookery Farm - Bristol	First Bristol
52	Hengrove - Inns Court	First Bristol
54	Stockwood - Cribbs	First Bristol
57	Stockwood - Bristol	First Bristol
70	Bristol - UWE	First Bristol
71	Bradley Stoke - Bristol	S Glos Bus & Coach
72	Bradley Stoke - Bristol	S Glos Bus & Coach
73	Bristol - Cribbs	First Bristol
74	Bristol - Bradley Stoke	First Bristol
75	Hartcliffe - Cribbs	First Bristol
75a	Whitchurch - Cribbs	First Bristol
76	Hartcliffe - Southmead	First Bristol
90	Bristol - Hengrove Leisure Park	First Bristol

Service	Route	Operator
121	Weston - Bristol	First S&A
178	Bath - Bristol	First S&A
179	Bath - Midsomer Norton	First S&A
309	Bristol - Dursley	First S&A
310	Bristol - Dursley	First S&A
312	Thornbury - UWE	S Glos Bus & Coach
318	Cribbs - Keynsham	First Bristol
319	Cribbs - Bath	First Bristol
328	Bristol - Yate	First S&A
330	Blackboy Hill - Airport	First S&A
331	Bristol - Airport	First S&A
332	Bath - Bristol	First S&A
337	Bath - Keynsham	First S&A
342	Bristol - Chipping Sodbury	First S&A
349	Keynsham - Bristol	First Bristol/First S&A/Abus
350	Bristol - Weston	First S&A
351	Bristol - Weston	First S&A
353	Bristol - Weston	First S&A
354	Bristol - Nailsea	First S&A
355	Bristol - Clevedon	First S&A
358	Portishead - Bristol	First S&A
359	Portishead - Bristol	First S&A
362	Bristol - Clevedon	First S&A
364	Bristol - Clevedon	First S&A
376	Yeovil - Bristol	First S&A
379	Radstock - Bristol	First S&A
462	Emerson's Green - Clifton	S Glos Bus & Coach
482	Chipping Sodbury - Cribbs	S Glos Bus & Coach
483	Chipping Sodbury - Cribbs	S Glos Bus & Coach
500	Baltic Wharf Loop	Bugler Coaches
503	Windmill Hill - Broadmead	S Glos Bus & Coach
510	Bedminster - Hotwells	S Glos Bus & Coach
511	Stockwood - Bedminster	S Glos Bus & Coach
517	Avonmouth - Emerson's Green	S Glos Bus & Coach / Eurotaxis
518	Shirehampton - Emerson's Green	S Glos Bus & Coach / Eurotaxis

Service	Route	Operator
558	Knowle - Brislington TESCO	S Glos Bus & Coach
559	Knowle - Brislington Village	S Glos Bus & Coach
581	Longwell Green - Chipping Sodbury	S Glos Bus & Coach
584	Kingswood - Sea Mills	Eurotaxis
585	Bristol - Sea Mills	Eurotaxis
586	Bristol - Hotwells	Eurotaxis
587	Kingswood - Hotwells	Eurotaxis
532	Keynsham - Mangotsfield	Bath Bus Company
533	Keynsham - Mangotsfield	Bath Bus Company
580	Cribbs - Parkway	S Glos Bus & Coach
581	Longwell Green - Chipping Sodbury	S Glos Bus & Coach
611	Severn Beach - Thornbury	S Glos Bus & Coach / Eurotaxis
622	Cribbs - Chipping Sodbury	S Glos Bus & Coach / Eurotaxis
624	Severn Beach - Bristol	S Glos Bus & Coach
626	Wotton - Bristol	S Glos Bus & Coach
634	Bristol - Tomarton	First S&A
635	Bristol - Chippenham	First S&A
636	Hartcliffe - Keynsham	Eagle Coaches
686	Wotton - Kingswood	S Glos Bus & Coach
689	Bristol - Yate	First S&A
U1	Bower Ashton Campus - Frenchay Campus	Ulink
U2	Bristol City Centre - Frenchay Campus	Ulink
U3	Redcliffe - Frenchay Campus	Ulink
U4	Redcliffe - Frenchay Campus via M32	Ulink
U5	Bristol City Centre - Frenchay Campus	Ulink
X1	Weston - Bristol	First S&A
X7	Bristol - Clevedon	First S&A
X10	Bristol - Magor	First S&A
X11	Bristol - Newport	Stagecoach South Wales
X14	Bristol - Newport	First S&A
X23	Weston - Clevedon	First S&A
X25	Weston - Cribbs	First S&A
X39	Bristol - Bath	First S&A
X27	Bristol - Brimsham Park	First S&A
X42	Bristol - Chipping Sodbury	First S&A

Service	Route	Operator
X73	Bradley Stoke – Bristol	First Bristol
Park & Ride Services		
902	A4 Portway P&R	First Bristol
903	A370 Long Ashton P&R	First Bristol
904	A4 Brislington P&R	First Bristol

Rail Network

6.7 The rail network is unchanged from the G-BATS3 v2.3 version as the proposed SBL scheme will only have a limited interaction with rail services and demand. All stations in the WoE are included, together with a series of indicative stations outside this area. Figure 6.2 shows the rail network graphically. Rail journey times were 'hard-coded' into the line descriptions, and are based on 2006/7 timetabled information.

Figure 6.2 – Rail Network

6.8 Table 6.2 shows the list of stations included within the model.

Table 6.2 – Railway Stations included in SBL PT Model

Node Number	Station
6001	Bristol Temple Meads
6002	Lawrence Hill
6003	Stapleton Road
6004	Montpelier
6005	Redland
6006	Clifton Down
6007	Sea Mills
6008	Shirehampton
6009	Avonmouth
6010	St Andrews Road
6011	Severn Beach
6012	Filton Abbey Wood
6013	Patchway
6014	Pilning
6017	Bristol Parkway
6018	Bedminster
6019	Parsons Street
6020	Nailsea
6021	Yatton
6022	Worle
6023	Weston Milton
6024	Weston-super-Mare
6025	Highbridge
6026	Severn Tunnel Junction
6027	Yate
6028	Bath
6029	Keynsham
6031	Swindon
6032	Newport

6.9 Services were coded according to Autumn 2006 timetable information. All rail services that call at stations in the WoE in the modelled time periods were included (i.e. 08:00-09:00, average hour between 10:00-16:00 and 17:00-18:00).

6.10 The main focus of the rail network was upon rail services that provide local movements within the WoE and from nearby external zones to/from Bristol. As Bristol is the focus of a great number of long-distance rail services this means that a significant number of rail services appear in the rail network model in only a generalised manner.

Centroid Connectors

6.11 Centroid connectors for the SBL PTAM were initially taken from the SBL HAM, but these were subsequently adjusted to improve routing in the public transport assignment model.

6.12 The rail network also includes a significant number of access/egress walk links to enable bus/rail connections to zones that do not have a direct link to railway stations. This was particularly important for the Bristol city centre zones, with Bristol Temple Meads station connected to the city centre by appropriate walk and (non-rail) public transport links.

Bus Travel Times

6.13 In the base year SBL PTAM, end-end bus travel times are controlled to end-to-end travel times in the current (2009) timetables. The travel times along each service are based, pro-rata, on the travel times on the corresponding highway network. Transfer of data from the highway network is facilitated by the fact that the highway and bus networks are identical in structure. First Group have recently amended their Bristol service timetables in line with data from the ACIS real time bus information system, so the timetabled times now provide a good approximation actual average bus journey times. It is considered that the timetabled journey times give a more consistent and robust dataset than the journey time survey data, which is based on a single day and (often) a limited number of observations of each service.

6.14 In forecasting mode, the base bus travel times are updated on the basis of changes in highway travel times between the base and forecast scenarios. If the bus route is new, or has changed since the base year, journey times are calculated solely on the basis of forecast highway travel times.

6.15 The impact on bus journey-times of new bus lanes and bus priority measures at junctions are also modelled, as is the impact of capacity reduction on general traffic and the effect this has on bus journey times.

6.16 The methodology may be summarised as follows.

Base Year

a) estimate journey time on each segment along the bus route on the basis of highway link and turn times, and the effect of any bus priority measures;

b) factor the time on each segment such that the total modelled journey time along the route matches the observed timetabled journey time

Forecast

a) in forecast mode, the base year journey times (controlled to the timetable) are adjusted up or down on the basis of changes in highway travel times and any changes in bus priority

b) if it is a new bus route with no base year equivalent, the estimated journey times are used directly

6.17 More details of the journey time calculations are given in Appendix A.

Boarding Penalties

6.18 A number of boarding penalties at specific nodes were applied to dissuade unrealistic interchanges. These penalties have been reviewed and updated for the revised model. The values have been calibrated specifically for the model, to ensure a realistic assignment of trips;

a) Line based penalties for specific services (ut2);

b) Node based at a maximum of 10 minutes for selected bus nodes (ui1); and

c) Node based at selected rail stations (ui1).

Fares

6.19 As noted in para 4.20, the PTAM does not include fares in the generalised cost formulation, but fares are used in the sub-mode choice between bus and rail which is carried out within the Demand Model.

6.20 The bus fare matrix, derived previously for G-BATS3 v2.3, was updated to a 2009 base year by the application of a factor to uplift the fares from 2006 values and prices to 2009 values and prices. Similarly, the distance-based rail fares were also uplifted by a global factor. The factors used to update the fares are given in Table 6.3.

Table 6.3 – Uplift Factors for PT Fares

Mode	2006 to 2009 Uplift Factor	Source
Bus	5%	Comparison of a selection of ticket prices within the WoE area
Rail	21%	Office of the Rail Regulator Rail Fares Index

6.21 Further details of the BATS3 bus fare matrix development are given in the G-BATS3 v2.3 Public Transport Local Model Validation Report (Atkins, March 2009).

7. Trip Matrix Development

Bus Trip Matrices

Overview of Methodology

7.1 For the SBL PTAM, the bus trip matrices were substantially rebuilt to incorporate newly collected origin-destination survey data. The surveys covered both the SBL area of detailed modelling and the North Fringe to Hengrove (NFH) corridor.

7.2 The trip matrix development methodology aims to make the best use of each of the available sources of origin-destination data, namely onboard origin-destination survey data, Wayfarer ticket data and the previous G-BATS3 bus matrices. A new sub-matrix was developed for trips within the surveyed area and trips between this area and the rest of Greater Bristol. The surveyed area consists of the area covered by the complete set of surveys carried out during 2008 and 2009, i.e. North Somerset, South Bristol, North Fringe and East Fringe areas. The sub-area matrix combined data from the observed origin-destination surveys with Wayfarer ticket data. This sub-area matrix was then "patched" into the G-BATS3 bus matrix, replacing the previous G-BATS3 data for corresponding movements to create the updated bus matrix.

7.3 A separate bus matrix was produced for each time period at the OD-level. The process is set out in Figure 7.1, and is described in detail in the sections below. Initially, the matrices were built at the all purpose level, but subsequently the matrices were disaggregated by trip purpose using proportions derived from the survey data on a sector-sector basis. Details of the purpose splits and demand totals by trip purpose are given in the Demand Model report.

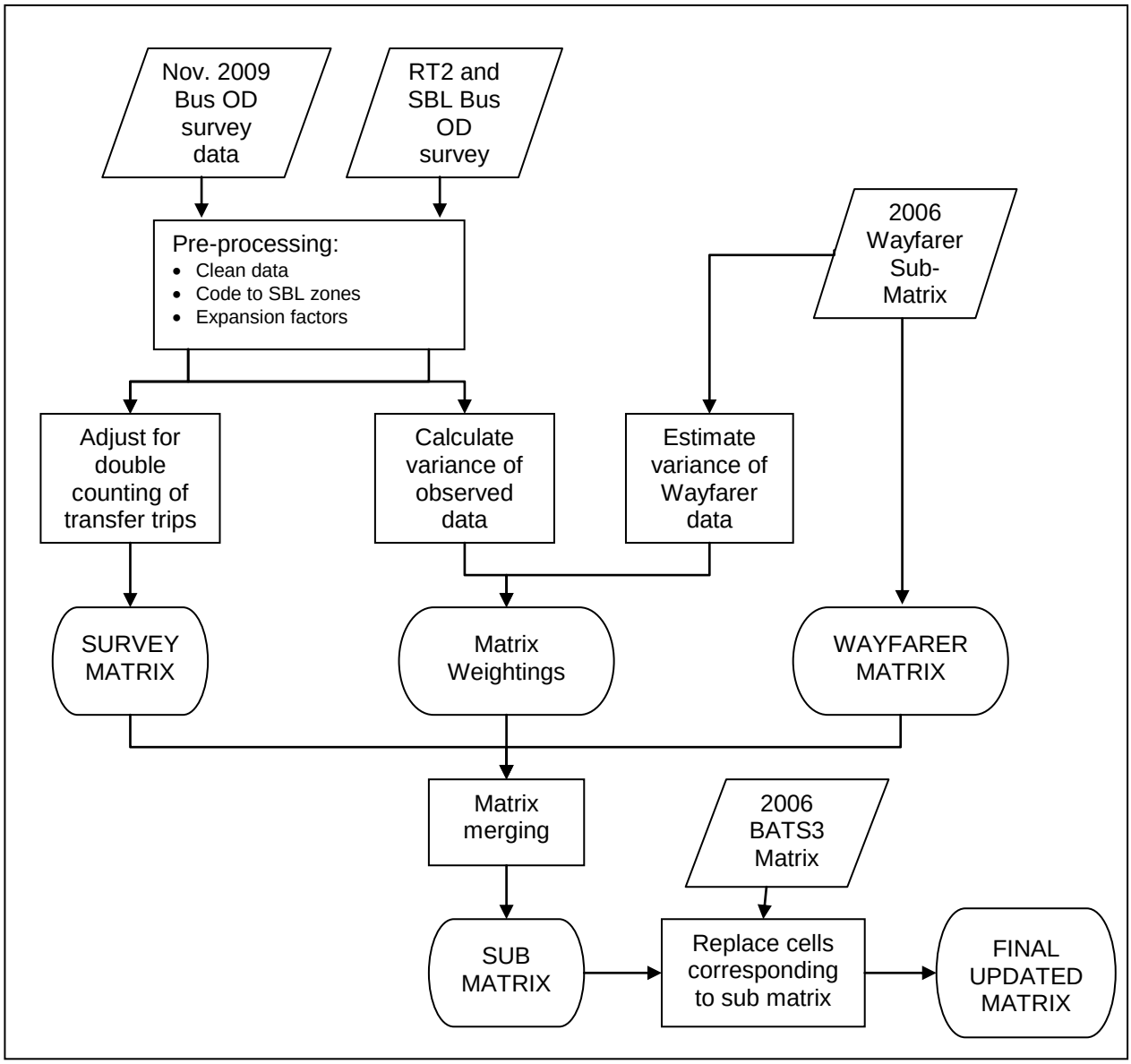
Bus Travel Demand Data

7.4 Bus origin-destination survey data were collected for services within the SBL area of detailed modelling and the NFH corridor in July and November 2009. Combining this new information with data from the bus origin-destination surveys along the A370 corridor carried out in 2008 for the 'Ashton Vale to Temple Meads' Rapid Transit Scheme (RT2) MSB provides good coverage of demand for the bus services in the main areas of interest for the SBL study.

Other sources of origin-destination data available for the matrix building process are:

- Wayfarer ticket data for most routes within the WoE (collected in 2006); and
- validated BATS3 bus matrices (2006, but updated to 2008 on A370 corridor).

Figure 7.1 – Public Transport Matrix Development Process



Onboard Bus Origin-Destination Surveys

7.5 A series of onboard bus occupancy and onboard origin-destination surveys were undertaken in July and November 2009 to supplement the RT2 surveys previously undertaken in November 2008. The bus services surveyed are summarised below in Table 7.1, Table 7.2 and Table 7.3 below.

Table 7.1 – November 2008 RT2 Surveys

Key Bus Route	Similar Routes	Number of Journeys
X1 (Weston-super-Mare – Bristol)	350, 351, 353	37
X7 (Clevedon – Bristol)	355, 362, 364	28
354 (Nailsea – Bristol)	-	26
902 (Portway P&R)	-	68
903 (Long Ashton P&R)	-	68
24 (Ashton Vale – City Centre)	25	72
500 (Harbour Link)	-	33

Table 7.2 – July 2009 SBL OD Surveys

Bus Corridor	Bus Routes (& Respective Frequencies for the AM Peak Hr)	Onboard OD Surveys
A37	51 (3), 52 (3), 54 (3), 54A (2), 376 (2), 379 (1)	51, 52, 54
A38	52 (3), 75 (6), 76 (6), 77 (4), 89 (3), 90 (4), 121 (1),	75,76, 90
A369	357 (1), 358 (1), 359 (1)	357, 358, 359
Bristol Airport (A38)	330 (2), 331 (2) – Airport Flyer services	330, 331 (limited stops)

Table 7.3 – November 2009 NFH OD Surveys

Day 1	Day 2	Day 3
20 – South of city	70	309 – South of Aztec West
21 – South of city	71 & 72	310 – South of Aztec West
36	73	312 – South of Aztec West
48	X73	318 – NW of Kingswood
49	U1	319 – NW of Kingswood
	U2	462
		517 & 518 – East of Westbury

Wayfarer Data

7.6 Wayfarer ticketing data were supplied by First Group (First Bristol and First Somerset & Avon) for all of their services in the Greater Bristol area, for the weekdays between Monday 1st October 2006 and Friday 14th October 2006, thus providing ten days of aggregated data in total. The data were grouped into three time periods:

- AM peak period (07:00 - 10:00);
- Inter-peak period (10:00 – 16:00); and
- PM peak period (16:00 – 19:00).

7.7 The Wayfarer ticket data had previously been processed and coded to G-BATS3 zones, and was available in matrix format. The Wayfarer matrices were converted to SBL zoning.

Partial Trip Matrices from Surveys

Processing Bus Survey Data

7.8 The new data from the 2009 onboard origin-destination surveys were processed by:

- a series of checks to correct transcription errors and remove any inconsistent records;
- coding trip origins and destinations to SBL zones;
- calculating expansion factors; and
- infilling reverse direction trips for certain PM peak period routes.

7.9 Data from the 2008 onboard origin-destination surveys were also reprocessed by:

- recalculating expansion factors on a consistent basis to that used for the 2009 data;
- infilling reverse direction trips; and
- uplifting the 2008 demand to 2009 levels.

7.10 The two datasets were then combined before the following steps were undertaken:

- dealing with multi-stage bus trips and bus-rail trips; and
- converting from 3/6 hour time periods to hourly demand.

Coding Origins and Destinations to Zones

7.11 The 2009 survey data were geocoded directly to SBL zones using the coordinates of the origin and destination postcodes. For airport journeys, only the surface leg to/from the airport was considered. The 2008 survey data had already been coded to G-BATS3 zones, and was converted to SBL zones.

Expansion Factors

7.12 Expansion factors were calculated for each surveyed bus service, taking account of:

- the proportion of timetabled bus services actually surveyed (by time period); and
- the proportion of passengers on each surveyed bus who completed the survey questionnaire

7.13 Expansion factors were also recalculated for the 2008 survey data to ensure consistency in the treatment of each dataset. The 2008 survey was carried out over a two-day period, allowing many services to be surveyed twice. This is reflected in the proportion of buses surveyed (which can be greater than 100%) and feeds through to the expansion factors. The 2009 survey obtained a less complete sample, and this is reflected in higher expansion factors. Table 7.4 shows the proportion of buses surveyed and the average overall expansion factors for each surveyed service by time period[4].

7.14 It is noted that the expansion factors are particularly high for certain services covered by the 2009 surveys. The impact of these trips on the final matrices is mitigated by the use of a variance weighting technique to combine the observed data with the Wayfarer ticket data, which gives less prominence to data points derived from large expansion factors – see para 7.28 for more details.

[4] The time periods referred to here are AM Peak Period (0700-1000), Interpeak Period (1000-1600) and PM Peak Period (1600-1900)

Table 7.4 – Expansion Factors by Service and Time period

Bus Route	Proportion of buses surveyed[5]			Average Expansion Factor		
	AM	IP	PM	AM	IP	PM
2008 Surveys (towards Bristol only)						
24	200%	178%	133%	1.90	1.65	2.19
25	200%	183%	143%	1.69	1.48	1.53
354	125%	175%	260%	0.68	0.61	0.47
355	200%	N/A	N/A	0.55	N/A	N/A
362	200%	N/A	200%	0.94	N/A	0.77
364	150%	183%	250%	0.81	0.70	0.47
X1	220%	192%	160%	0.72	0.80	0.93
X7	200%	200%	200%	0.69	0.72	0.51
350-353	200%	200%	160%	0.59	0.60	0.76
2009 Surveys (towards Bristol)						
51	21%	43%	25%	11.7	6.5	8.0
52	25%	39%	22%	8.7	6.0	9.2
54	29%	23%	46%	11.5	9.8	5.3
75	25%	40%	25%	12.8	8.6	5.7
76	31%	60%	56%	8.6	4.0	3.2
90	31%	40%	50%	12.8	7.5	2.2
357	50%	50%	33% [6]	5.7	4.5	2.6
358	133%	50%		1.8	4.0	N/A
359	67%	67%		3.4	3.1	2.1
330	33%	33%	17% [4]	3.1	2.8	N/A
331	17%	33%		7.5	3.0	4.4
309	33% [4]	42% [4]	14% [4]	N/A	2.40	N/A
310				3.94	3.13	12.38
462	43%	N/A	N/A	2.77	N/A	N/A
70	45%	47%	45%	4.44	3.46	3.32
71	11% [4]	50% [4]	67% [4]	9.00	2.00	2.25
72				N/A	2.49	N/A
73	8%	30%	21%	13.00	4.47	6.55
U1	100%	46%	50%	1.92	3.73	3.00
U2	67%	36%	20%	2.82	3.42	7.14
X73	75%	N/A	N/A	2.60	N/A	N/A
20	46% [4]	50% [4]	22% [4]	3.10	2.77	5.63
21				5.69	2.34	N/A
36	8%	22%	25%	17.14	8.01	4.94
48	52% [4]	32% [4]	41% [4]	2.83	4.10	3.68
49				3.69	4.47	3.08
2009 Surveys (out from Bristol)						

[5] The 2008 survey covered some services timed slightly before the start of the AM peak or after the end of the PM peak. To maximise the sample, these have been included in the AM peak/PM peak matrices, and hence in some cases this factor is greater than 200%. Although it was intended to include all services on both days of the survey, some were missed, resulting in factors less than 200%.

[6] Factor calculated across similar services.

Bus Route	Proportion of buses surveyed[5]			Average Expansion Factor		
	AM	IP	PM	AM	IP	PM
51	44%	38%	7%	11.1	6.2	10.7
52	14%	17%	13%	17.6	19.0	51.8
54	55%	30%	8%	2.6	6.1	40.2
75	46%	47%	11%	5.6	6.2	25.3
76	50%	36%	22%	4.7	4.7	6.8
90	36%	37%	36%	7.8	7.4	8.7
357	33%	67%	0%	5.3	3.5	N/A
358	150%	50%	0%	2.0	5.4	N/A
359	33%	83%	0%	3.8	3.0	N/A
330	43%	42%	0%	3.3	3.3	N/A
331	33%	25%	0%	3.2	4.7	N/A
309	33% [4]	42% [4]	20% [4]	N/A	2.40	5.88
310				4.38	3.91	N/A
462	N/A	N/A	60%	N/A	N/A	2.35
70	64%	53%	20%	2.86	3.40	7.05
71	67% [4]	45% [4]	22% [4]	1.59	2.64	5.99
72				N/A	2.46	N/A
73	31%	34%	N/A	4.83	5.05	N/A
U1	50%	50%	50%	4.07	2.62	2.80
U2	57%	45%	N/A	4.50	3.95	N/A
X73	N/A	N/A	50%	N/A	N/A	2.63
20	50% [4]	48% [4]	15% [4]	3.00	2.58	8.80
21				3.13	2.86	N/A
36	20%	25%	N/A	6.83	5.81	N/A
48	56%	34%	19%	2.44	3.69	11.48
49	50%	48%	15%	2.47	3.89	6.44
Towards Fishponds/Kingswood						
312	33%	67%	33%	3.60	2.25	3.75
318	33% [4]	75% [4]	40% [4]	4.50	2.21	5.45
319				3.86	2.08	3.54
Towards Aztec West/Cribbs Causeway						
312	50%	83%	60%	2.29	1.50	1.67
318	60% [4]	50% [4]	20% [4]	3.67	3.38	N/A
319				1.83	2.45	5.21
Towards Westbury-on-Trym						
517	18% [4]	33% [4]	17% [4]	N/A	5.47	N/A
518				5.89	4.25	10.77
Towards Emerson's Green						
517	0% [4]	25% [4]	15% [4]	N/A	6.74	15.17
518				N/A	4.93	9.75

Reverse Direction Trips

7.15 The 2008 survey was only conducted in the inbound direction towards Bristol city centre, whereas the 2009 surveys covered trips in both directions along the routes. Nevertheless, in the 2009 surveys, no services going out from Bristol were sampled in the PM peak on routes 330, 331, 357-359, 36, 73 or U2, and no AM peak services towards Emerson's Green were sampled on routes 517/518. Data were collected on whether the journey was the outbound or return leg of a return journey. The 2009 surveys also included a question on the timing of the later return or earlier outbound journey. This allowed for the calculation of a set of return factors by journey purpose (Appendix B).

7.16 An initial estimate of the reverse direction trips was made by:

- taking the trips that were reported as being one leg of a return journey and reversing the origin and destination; and
- allocating these trips to reverse time period using the return factors (i.e. multiplying the expansion factor by the reverse time period factor to get the reverse trip expansion factor for each time period)

7.17 The number of reverse trips was then adjusted so that the ratio of trips going out of Bristol to trips going towards Bristol city centre was in line with count data. Table 7.5 shows the ratios, which were calculated using the data from the onboard bus occupancy counts.

Table 7.5 – Ratio of Trips Going Out of Bristol : Trips Going Towards Bristol City Centre

Bus Route	Ratio of Trips		
	AM	IP	PM
24	0.37	1.13	2.27
25	0.76	1.30	3.62
51	0.35	1.25	3.83
52	0.30	1.03	1.60
54	0.09	0.90	3.55
75	0.54	1.37	2.89
76	0.28	1.25	2.33
90	0.32	1.14	1.48
351-364	0.27	0.73	2.89
376	0.07	0.94	0.70
X1	0.42	0.84	0.55
X7	0.00	0.97	1.59
36	0.21	1.25	3.35
73	1.14	1.08	0.34
U2	5.62	0.65	0.45
517*	0.47	1.2	1.49
518*	0.47	1.2	1.49

Source: 2009 Onboard Bus Occupancy Counts
** Ratio of trips going towards Emersons Green: trips going towards Shirehampton*

Uplifting to 2009 Demand Levels

7.18 Demand derived from the 2008 survey was uplifted to 2009 demand based on average changes in annual bus passenger journeys between financial years 2006/7 and 2008/9 (see Table 7.6). As most of the routes surveyed in 2008 originate in North Somerset, the North Somerset growth was applied (i.e. an increase of 3.62%).

Table 7.6 – Change in Bus Patronage (Bus Passenger Journeys Per Annum)

Area	2006/7	2007/8	2008/9	average % change per annum
West of England Total	**52,584**	**51,454**	**52,611**	**0.03%**
B&NES	11,716	11,563	11,753	0.16%
Bristol	27,772	27,101	27,451	-0.58%
North Somerset	4,766	4,890	5,118	3.62%
South Gloucestershire	8,330	7,900	8,290	-0.24%
Bristol and North Somerset	*32,538*	*31,991*	*32,569*	*0.05%*

Source: Monitoring Data for Bristol Annual Monitoring Report

Multi-stage Bus Trips and Bus-Rail Trips

7.19 Trips using rail as their mode of access to the bus stop or onwards mode to their final destination were separated out and stored in a separate matrix. Due to the hierarchical definition of public transport trips that has been adopted for GBMF, these journeys are included in the rail matrix and not the bus matrix. The matrix of multi-modal rail/bus trips was therefore merged into the G-BATS3 rail matrix – see para **Error! Reference source not found.** for more details.

7.20 While there were a number of trips using bus as their mode of access to the bus stop or onwards mode to their final destination, an analysis of origins and destinations indicated that only a very small proportion of them were likely to have transferred to or from another surveyed service, so the amount of possible double counting of bus trips was minimal, and therefore no action was taken to correct for this.

Converting to Hourly Demand

7.21 The period demands were converted to hourly values by dividing by the following factors:

- 2.5 for AM and PM peak period to peak hour; and
- 6 for Interpeak period to average Interpeak hour.

Wayfarer Ticket Record Data

7.22 Wayfarer ticket data from 2006 was collected for the majority of the bus routes in the WoE area. The subset of these routes covering the area covered by the bus surveys was selected. These routes used are summarised in Table 7.7 below, along with details of whether survey data were also available.

Table 7.7 – Wayfarer Routes

Route	Wayfarer available?	OD Survey Data Available?	Route	Wayfarer available?	OD Survey Data Available?
24	✓	✓	1	✓	×
25	✓	✓	4	✓	×
51	✓	✓	5	✓	×
52	✓	✓	5B	✓	×
54	✓	✓	22	✓	×
75	✓	✓	40, 40A	✓	×
76	✓	✓	50	✓	×
90	✓	✓	54A	✓	×
350-353	✓	✓	57	✓	×
354	✓	✓	75A	✓	×
355	✓	✓	77	✓	×
357-359	✓	✓	89	✓	×
362	✓	✓	99	✓	×
364	✓	✓	121	✓	×
376	✓	✓	375	✓	×
X1	✓	✓	376	✓	×
X7	✓	✓	W1	✓	×
330	×	✓	W3, W3A-C	✓	×
331	×	✓	W5A, W5C	✓	×
20-21	✓	✓	W7A	✓	×
36	✓	✓	W14	✓	×
309	✓	✓	W83, W83A	✓	×
310	✓	✓	W86	✓	×
462	×	✓	X21	✓	×
70	✓	✓	X22	✓	×
71	×	✓	X23	✓	×
72	×	✓	X24	✓	×
73	×	✓	X25	✓	×
U1	×	✓	X58	✓	×
U2	×	✓	X84	✓	×
X73	✓	✓			
48	✓	✓			
49	✓	✓			
312	×	✓			
318	✓	✓			
319	×	✓			
517	×	✓			
518	×	✓			

7.23 The Wayfarer data were processed into two matrices, representing those services for which survey data were also available, and services for which no survey data were available.

7.24 The annual bus patronage data for the years 2006/7 to 2008/9 shows very little change in bus passengers over this period for Bristol and North Somerset combined (the area covered by the Wayfarer data), see Table 7.6. It was therefore not considered necessary to apply any uplift to the 2006 Wayfarer data.

7.25 Wayfarer data were converted to hourly demand using the factors presented in para 7.21.

Merging Data from Surveys and Ticket Records

7.26 The observed onboard origin-destination survey and Wayfarer matrices were merged to produce the *sub-area matrix*. The sub-area matrix only covers the geographical area included in the bus origin-destination surveys. Each data source has its own particular strengths and weaknesses:

- the survey matrix gives the best indication of true origins and destinations, but relates to a single day, and is derived from a sample of trips such that each recorded trip is assumed to represent a number of actual trips (how many is governed by the expansion factor). This results in a "lumpy" matrix distribution whereby the demand is concentrated among an arbitrary subset of the true set of origins and destinations;
- the Wayfarer matrix is based on average trip making over a two week period and (in principle) includes all trips rather than just a sample. However, various approximations have been required to convert from fare stage to true origin-destination. In some respects, the Wayfarer matrix can be considered "synthetic" because the trips to/from each stage have been spread synthetically among appropriate origin and destination zones. This means that the Wayfarer matrix is "smooth", as opposed to the "lumpy" survey matrix.

7.27 The following steps were carried out to merge the survey and Wayfarer matrices:

- combine Wayfarer data for surveyed routes with the observed data using variance weighting techniques;
- control demand to observed totals at the sector-sector level; and
- add in Wayfarer demand for non-surveyed routes.

Variance Weighting

7.28 The two sources of demand data were combined using variance weighting to give an output matrix that makes use of the most reliable estimate of demand for each origin-destination pair.

7.29 The Wayfarer and observed matrices were combined on a cell by cell basis using a weighted average. Thus for cell i,j:

$$M_{ij} = \frac{I_{ij}^{O} W_{ij} + I_{ij}^{W} O_{ij}}{I_{ij}^{O} + I_{ij}^{W}} \qquad (1)$$

where: M_{ij} = Merged matrix

W_{ij} = Wayfarer matrix

O_{ij} = Observed matrix

I_{ij}^{W} = Index of dispersion matrix for Wayfarer data

I_{ij}^{O} = Index of dispersion matrix for Observed data

and the Index of dispersion I_{ij} is a function of the variance of the trip estimate:

$$I_{ij} = Var(T_{ij}) / T_{ij} \qquad (2)$$

Variance of Trip Estimate for Observed Data

7.30 For the observed data, the variance of the trip estimate may be calculated directly:

$$Var(T_{ij}) = \sum_{n} e_{ij}(e_{ij} - 1) \qquad (3)$$

where: e is the expansion factor for each recorded journey;

n is the number of recorded journeys from origin i to destination j; and

$T_{ij} = \sum_{n} e_{ij}$ is the total number of trips for cell ij.

7.31 Notes on the calculation of variances:

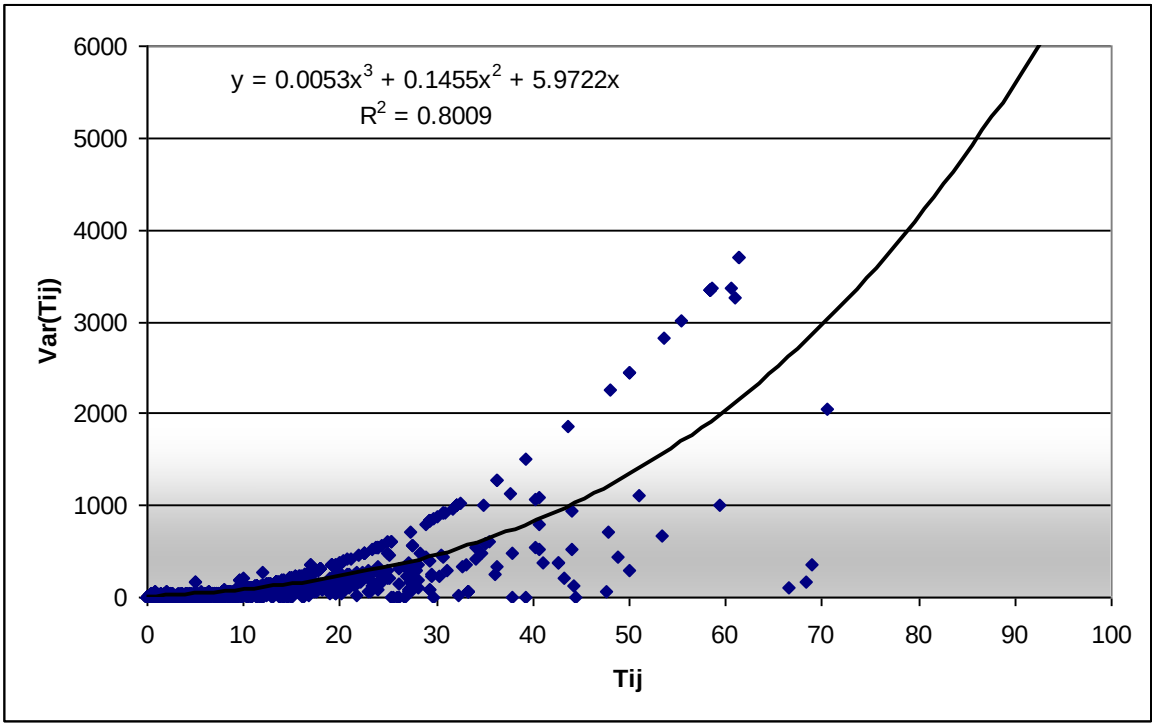
a) for some ij pairs served by routes covered by the 2008 survey, expansion factors were <1. In this case a negative value of e(e-1) was obtained, which was instead set to zero.

b) For infilled reverse trips, the value of e(e-1) obtained was doubled and capped at a minimum value of 2.0 to reflect the added uncertainty in the trip estimate.

Variance of Trip Estimate for the Wayfarer Data

7.32 For the Wayfarer data, the variance could not be calculated directly in the same way as for the observed data. The observed data were analysed to find a relationship between the demand estimate (T_{ij}) and the variance ($Var(T_{ij})$), as shown in Figure 7.2.

Figure 7.2 – Regression analysis of T_{ij} and $Var(T_{ij})$



7.33 The function $Var(T_{ij}) = 0.0053T_{ij}^3 + 0.1455T_{ij}^2 + 5.9722T_{ij}$ was then used to estimate variances for the Wayfarer data based on the Wayfarer demand for each ij pair, where T_{ij} is the all-day

Wayfarer demand. The Wayfarer variance was then multiplied by 2.0 to reflect added uncertainty in the synthetic process of allocating the Wayfarer demand to ij pairs.

Index of Dispersion Calculation

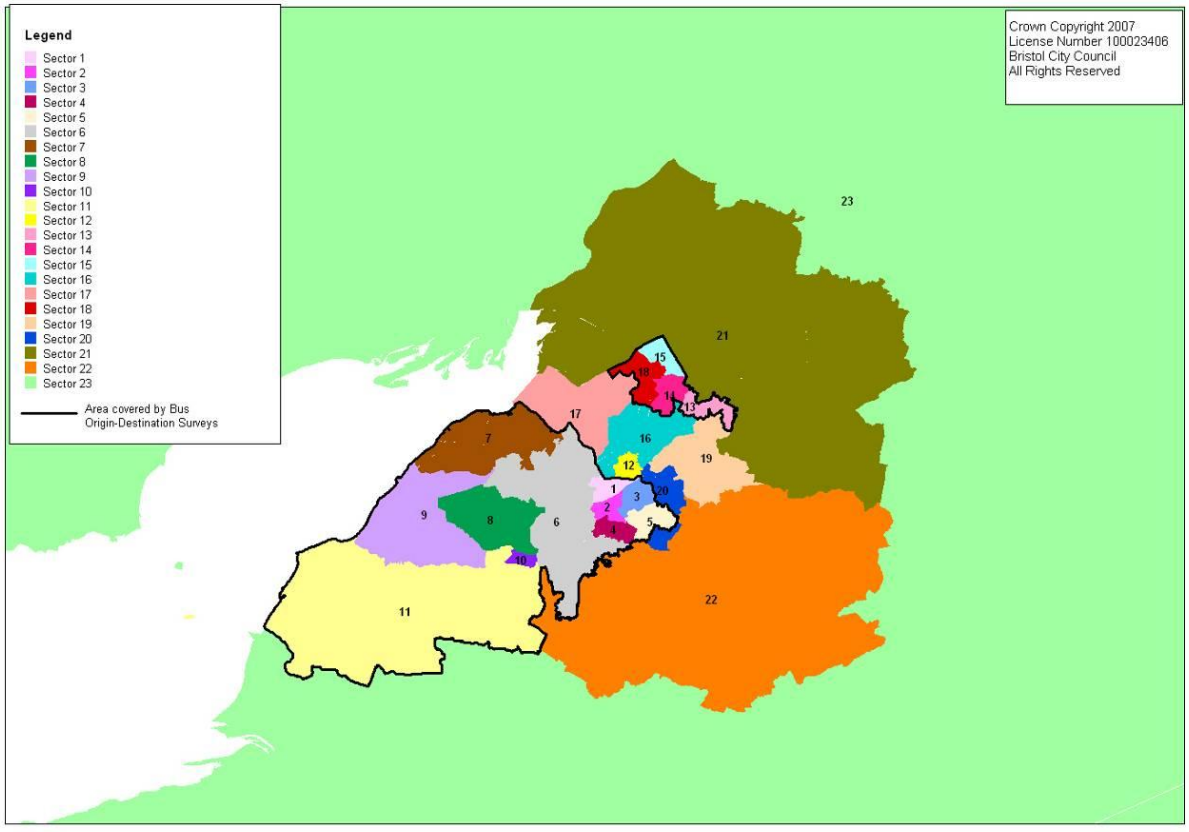
7.34 The index of dispersion was calculated for both observed and Wayfarer data using equation (2) above. The Wayfarer index of dispersion ranged between 11.9 and 248.9, whereas the observed matrix index of dispersion ranged between 0 and 2633, with the vast majority of the values being in the range 0 to 200.

7.35 Where there were no trips in the matrix (either Wayfarer or observed) the index of dispersion was set to 20.0.

Control Sector-Sector Movements

7.36 The merging process causes changes in the number of trips in the matrix. To deal with this, the matrix was factored to retain the observed demand estimates on a sector-sector basis[7]. The sectors used are shown in Figure 7.3.

Figure 7.3 – Sector System for BATS3 Bus Matrix Development



Comparison of Observed, Wayfarer and Merged Matrices

7.37 Figures 6.4 to 6.6 show trips to selected city centre zones in the AM peak observed, Wayfarer and merged matrices respectively. The figures illustrate how the merging process smoothes the observed demand over a greater range of origins and destinations than are found in the observed matrix, while still retaining the observed pattern of trips.

[7] Comparison of assigned flows with count data highlighted a lack of trips in the observed matrix between sectors 5 and 7 and central Bristol. These movements were therefore controlled to the Wayfarer totals rather than the observed totals.

Figure 7.4 – AM Peak Observed Trips to Selected City Centre Zones

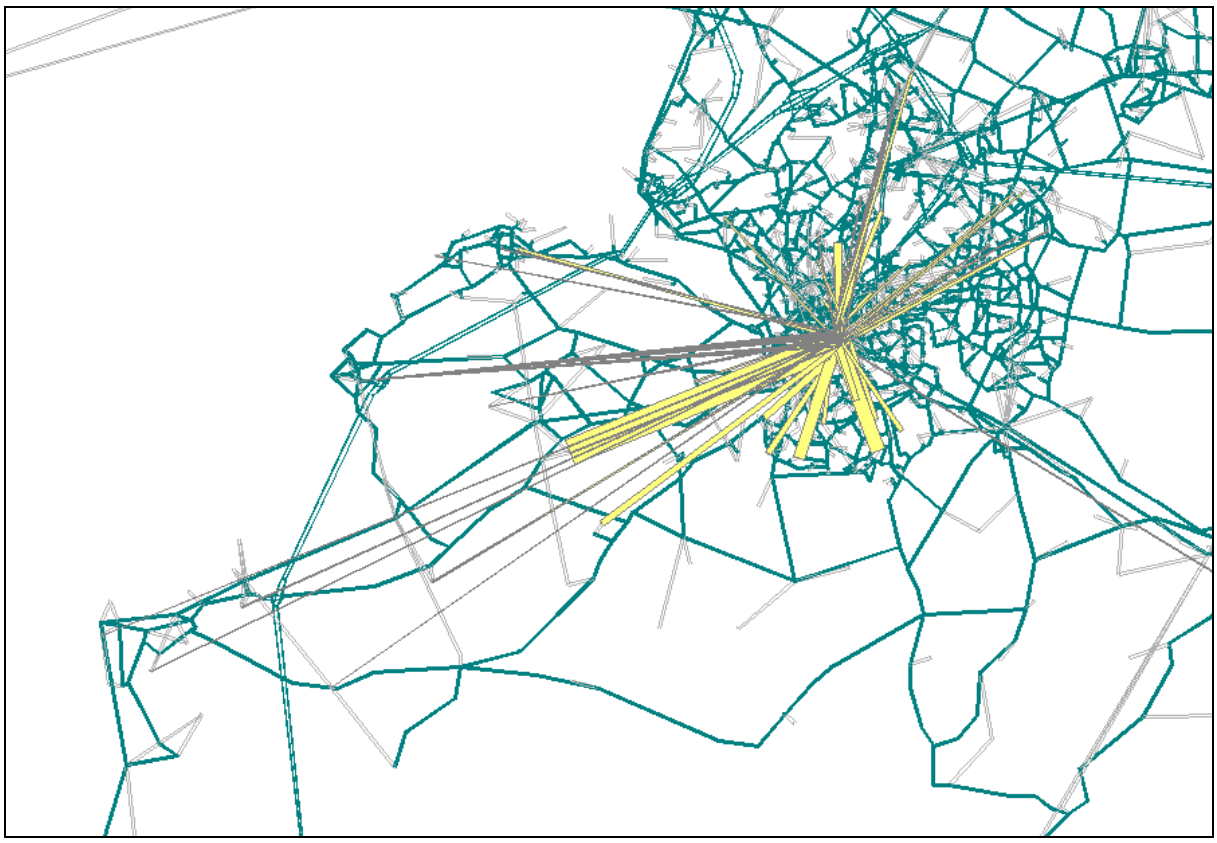


Figure 7.5 – AM Peak Wayfarer Trips to Selected City Centre Zones

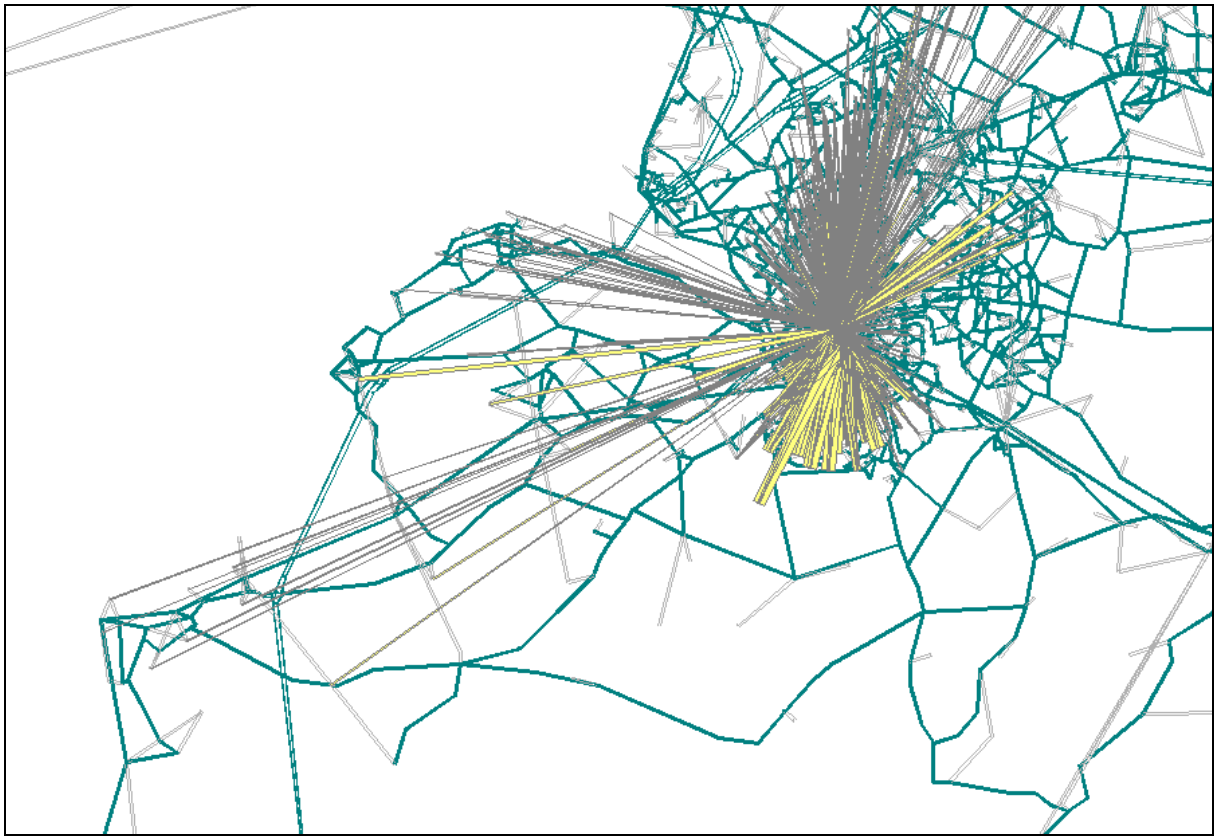
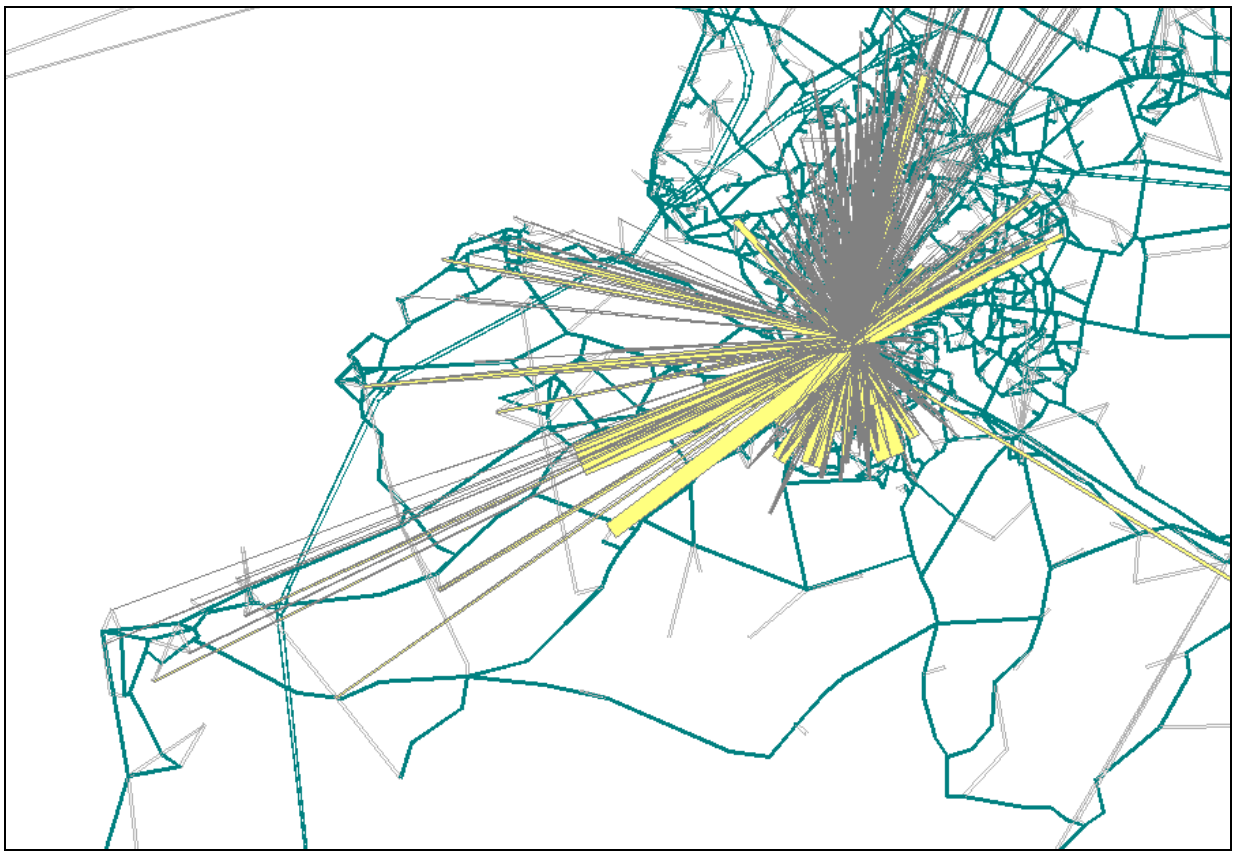


Figure 7.6 – AM Peak Merged Matrix Trips to Selected City Centre Zones



Adding Demand for Non-Surveyed Routes

7.38 Wayfarer data for routes passing through the surveyed area, but for which no observed data were available was added in to the merged matrix described above to complete the sub-area bus matrix.

Combining Sub-Area Matrix and G-BATS3 Matrix

7.39 In the final stage of the matrix building process, the bus sub-area matrix was incorporated into the previous G-BATS3 matrix. This involved substituting trips in the G-BATS3 matrix going to and from the surveyed area with the corresponding trip estimates from the sub-area bus matrix. The geographical area covered by the surveys and for which the substitution was carried out is shown in Figure 7.3.

7.40 Note that it was considered unnecessary to apply an uplift the 2006 G-BATS3 demand estimates because monitoring data suggests that bus demand across the West of England area has not increased significantly over the 2006-2009 period (see Table 7.6).

Initial Assignment and Matrix Adjustment

7.41 An initial assignment of the bus matrices to the SBL bus network was carried out and initial checks on routing and adjustments to boarding penalties made. This indicated that there were too few trips on certain routes, particularly the U4 service, which was not included in either the origin-destination surveys or the Wayfarer ticket dataset.

7.42 Select line analysis was carried out to identify the trips using the under-represented routes. These were then factored up in line with count data. This process was carried out on:

- U4 – all time periods; and

- U1 southbound and 310 northbound – AM peak only

7.43 Note that matrix adjustments were limited to trips using the services specified above, and no wholesale change to the matrices or matrix estimation was carried out.

Matrix Characteristics

7.44 Table 7.8 shows the matrix totals for each stage in the matrix building process.

Table 7.8 – Bus Matrix Totals

Matrix building stage	AM Peak Hour	Average Interpeak Hour	PM Peak Hour
Observed Demand	3109	2585	3313
Wayfarer Demand (Surveyed Routes)	3931	3510	3327
Merged Demand (Observed + Wayfarer)	4083	3490	4122
Complete Sub-matrix (Including Wayfarer for non-surveyed routes)	6503	5398	6188
Final Bus Demand Matrix	13364	9991	11507

7.45 Figure 7.7 to Figure 7.9 show the trip length distribution of the bus demand matrix at each stage in the process. It can be seen that the distribution of the sub-area matrix is slightly different to the rest of the G-BATS3 matrix, with more longer-distance journeys. This is partly due to the nature of the routes in the sub-area, which include a number of comparatively lengthy journeys from Weston-super-Mare and other towns in North Somerset to Bristol city centre.

7.46 The average journey lengths for each matrix are shown in Table 7.9. This indicates that the Wayfarer matrices for the surveyed routes have a shorter trip distribution than the observed data. This could be due to:

- the methodology adopted to allocate trips from fare stages to zones; and/ or
- a sampling bias whereby passengers on longer journeys are more likely to complete the survey questionnaire; and/or
- a bias in the Wayfarer data due to the exclusion of full destination information for season and other pre-paid tickets.

Table 7.9 – Average Journey Lengths

Matrix building stage	AM Peak Hour	Average Interpeak Hour	PM Peak Hour
Observed Demand	10.55	10.08	10.92
Wayfarer (surveyed routes)	7.03	7.37	7.44
Merged Demand (Observed + Wayfarer)	9.37	8.94	10.02
Complete Sub-matrix (Including Wayfarer for non-surveyed routes)	9.54	9.01	9.67
Final Bus Demand Matrix	8.86	9.05	8.49

Figure 7.7 – AM Peak Trip Length Distribution Comparison

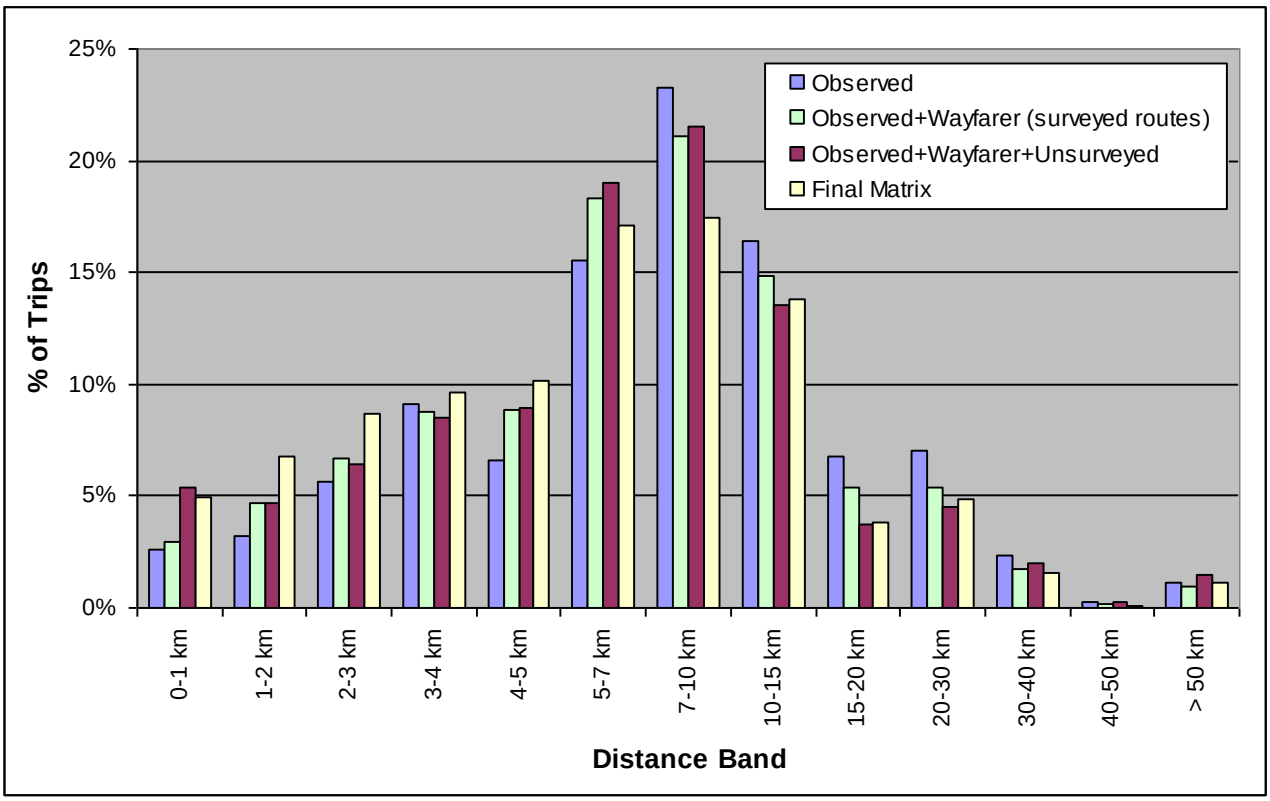


Figure 7.8 – Interpeak Trip Length Distribution Comparison

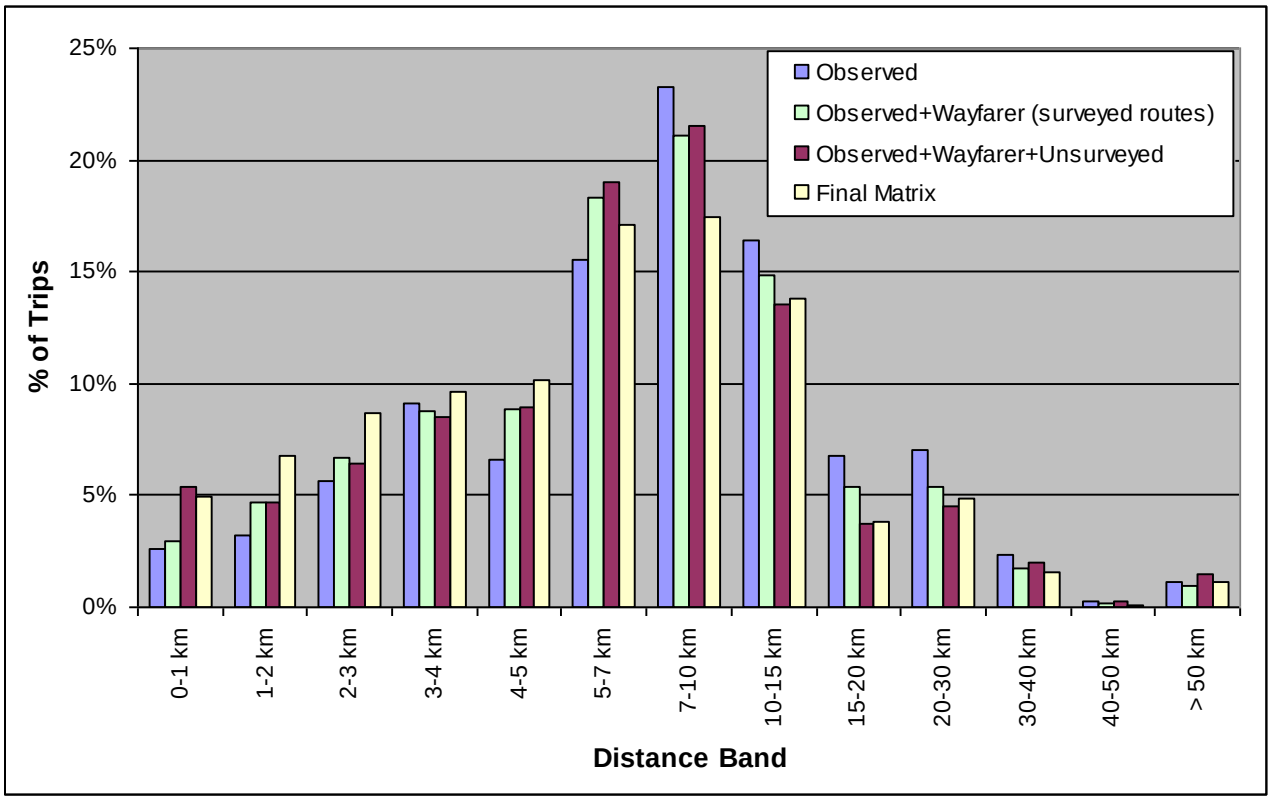
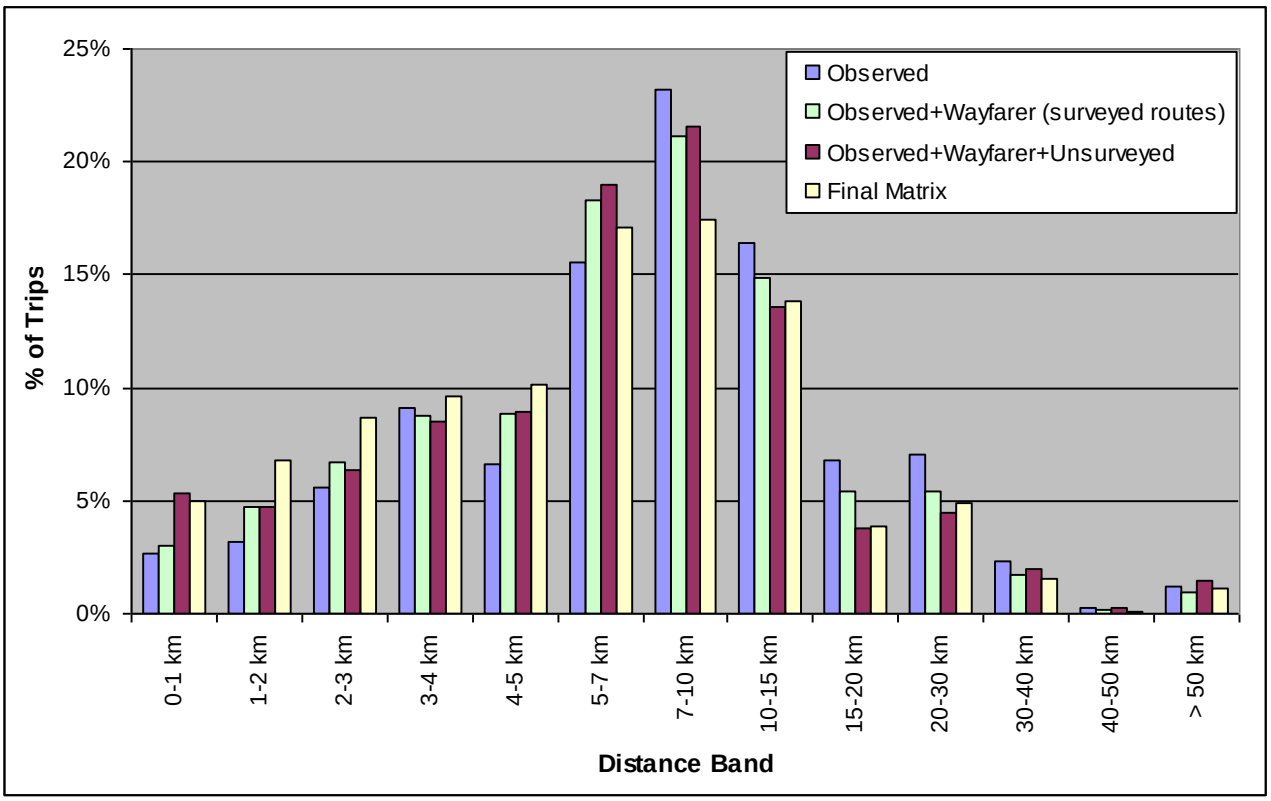


Figure 7.9 – PM Peak Trip Length Distribution Comparison



Park and Ride Matrix Development

7.47 The Park and Ride distribution was based on onboard origin destination Park and Ride passenger surveys collected by BCC in November 2008. Table 7.10 shows the matrix totals for the base year matrices inbound to the city centre for each time period. Note that it was assumed that the volume of inbound trips from the P&R sites to the city centre was insignificant in the evening peak. However, the model included trips returning to the P&R site in the evening.

Table 7.10 - Base Year P&R Matrix Totals (persons)

	AM Peak Hour	Average IP Hour	PM Peak Hour
P&R (Inbound) Totals	929	322	819

Base Year P&R Charges and Site Constants

7.48 The parking charge was set to zero and all charges are modelled as bus fares. These were set at a £1.52 daily charge (2009 prices) – though this can be varied on an individual site basis.

7.49 Site specific constants can also be defined. These influence the choice of park and ride site in the absolute site allocation logit model described in the Demand Model Report.

Rail Matrix Development

7.50 The SBL rail matrix is essentially based on the (2006) G-BATS3 v2.3 rail matrix, with the following modifications:

- inclusion of multi-modal bus-rail trips intercepted in the 2008 and 2009 bus origin-destination surveys; and

- uplift to 20012 demand by applying global growth factor.

Development of G-BATS3 v2.3 Rail Matrix

7.51 The G-BATS3 v2.3 rail matrix relies on three sources of data:

a) The 2006 Avon Rail Surveys;

b) 2006 LENNON ticketing data, and

c) PLANET Strategic Model.

7.52 The Avon Rail survey forms were handed out at all the Greater Bristol Area (GBA) stations to gather information about trips leaving GBA stations and travelling to other internal or external stations. However, no information about trips either arriving at the GBA stations from external stations or external to external trips was collected.

7.53 The Avon Rail survey data were cleaned and processed and a matrix of Internal to Internal (I-I) and Internal to External (I-E) trips was created from them. The PM peak period Internal-External trips were transposed to create the equivalent External to Internal trips for the AM Peak period. External to External (E-E) trips were distributed using information from the PLANET Strategic Model (PSM).

7.54 LENNON ticketing data were then used to furness the trips to get total demand for the AM, IP and PM periods. As the LENNON data does not differentiate by time period, to replicate the effects of tidality, the boarding and alighting counts from the Avon Rail Surveys were used to revise the row and column totals derived from the LENNON data where necessary, for the furnessing process by time period.

7.55 Based on the postcode information collected about the true origins and destinations from the Avon Rail Survey, the station-to-station matrices were disaggregated into the relevant G-BATS3 zones.

Inclusion of Bus-Rail Trips

7.56 As noted above, any passengers recorded in the bus origin-destination surveys as using rail as their access or egress mode were identified and processed as a separate matrix. The total number of such trips is given in **Error! Reference source not found.**. The majority of the bus-rail trips were recorded on the Airport flyer services 330 and 331.

Table 7.11 – Bus-Rail Trips (Persons/hr)

AM Peak Hour (08:00 – 09:00)	Inter-Peak Hour (Ave 10:00 – 16:00)	PM Peak Hour (17:00 – 18:00)
99	82	95

7.57 Bus-rail trips were incorporated into the rail matrix, but as the rail matrix had been controlled to LENNON trip totals, they were not simply added into the matrix. Other trips to and from the WoE area were factored down so that the total trips to and from the WoE area did not change.

Update to 2012 Demand Levels

7.58 Data from the National Rail Portal Statistics for total franchised journeys[8] were used to uplift the rail demand to 2012 levels (Table 7.12)

Table 7.12 – Rail Demand Uplift Factor 2006 – 2012

	2006	2012	Growth Factor
Rail passenger journeys (millions)	1121	1474	31%

Matrix Totals

7.59 The final matrix totals are shown in Table 7.13. Checks were undertaken on the resulting rail matrices for each time period by assigning them to the rail network and the resultant line and station flows were compared against available count data. These comparisons are described in Chapter 6.

Table 7.13 – Rail Matrix Totals (Persons/hr)

Model	AM Peak Hour (08:00 – 09:00)	Inter-Peak Hour (Ave 10:00 – 16:00)	PM Peak Hour (17:00 – 18:00)
G-BATS3 SBL (2012)	6,704	1,708	7,022

8. Calibration and Validation

Introduction

8.1 As previously stated, the SBL model has beenupdated to a 2012 base year. It was considered prudent consider an update the rail and bus demand to take account of the growth between 2009 and 2012, but the PT services were left unchanged. The Bristol Annual Monitoring Report for 2011[9] shows an increase of 1% in bus demand between 2008/9 and 2011/12, so the bus demand and validation remained unchanged. The National Rail Portal Statistics for total franchised journeys[10] showed an increase of 31% between 2006 and 2012. The rail validation was updated by factoring the counts using the same growth factor.

Bus Matrix Validation

8.2 As described in Chapter 3, the bus matrix validation involved the comparison of observed and modelled flows across two screenlines in the North and East Fringe areas (Figure 3.1 and

[99] Source: http://www.bristol.gov.uk/sites/default/files/documents/planning_and_building_regulations/planning_policy/local_development_framework/AMR2011_0.pdf

[10] http://dataportal.orr.gov.uk/displayreport/report/html/22c71959-3f97-405f-8342-e4981745d08b

). As noted above, no complete screenline in the south Bristol area was available for the matrix validation. The criteria[11] were met on both screenlines, in both directions, in all time periods (Table 8.1 and Table 8.2).

Table 8.1 – North Fringe Screenline Flow Comparison

Site no.	Location	Inbound (Southbound)			Outbound (Northbound)		
		Observed	Modelled	Diff Mod vs Obs	Observed	Modelled	Diff Mod vs Obs
AM Peak							
3	Gloucester Road	116	103		198	191	
4	Filton Avenue	167	131		283	286	
5	UWE	26	53		200	154	
	Total	**309**	**287**	***-7%***	**681**	**631**	***-7%***
Interpeak							
3	Gloucester Road	91	100		96	100	
4	Filton Avenue	175	161		136	146	
5	UWE	82	47		70	79	
	Total	**347**	**308**	***-11%***	**301**	**325**	***8%***
PM Peak							
3	Gloucester Road	156	153		116	122	
4	Filton Avenue	200	212		118	123	
5	UWE	152	113		31	52	
	Total	**508**	**478**	***-6%***	**265**	**297**	***12%***

Table 8.2 – East Fringe Screenline Flow Comparison

Site no.	Location	Inbound (Southbound)			Outbound (Northbound)		
		Observed	Modelled	Diff Mod vs Obs	Observed	Modelled	Diff Mod vs Obs
AM Peak							
7	Quaker's Road	131	103		14	11	
8	Cleeve Hill	66	57		10	11	
9	Downend Road	51	51		36	37	
10	Staple Hill Road	43	51		38	41	
	Total	**291**	**262**	***-10%***	**98**	**100**	***2%***
Interpeak							
7	Quaker's Road	11	21		21	24	
8	Cleeve Hill	32	20		31	18	
9	Downend Road	26	41		32	44	
10	Staple Hill Road	32	32		26	32	
	Total	**101**	**114**	***13%***	**110**	**118**	***8%***
PM Peak							
7	Quaker's Road	2	12		75	70	

[11] Modelled flows across screenlines should be within 15% of observed flows.

8	Cleeve Hill	13	7		75	23	
9	Downend Road	37	41		39	62	
10	Staple Hill Road	15	15		30	39	
	Total	**67**	**75**	***12%***	**219**	**194**	***-11%***

Bus Assignment Validation

8.3 The bus assignment validation made use of the newly collected on-board bus counts (Figure 5.1), which were collected on a single day. Comparisons between modelled and observed flows are presented below in Table 8.4 to Table 8.9. The counts were disaggregated by bus service, so the comparisons were also made for "service groups" (groups of bus routes serving similar destinations) at each site. The service group level comparisons are given in Appendix C.

8.4 The validation to link counts is very good, with over 85% of links with flows greater than 150 meeting the criterion of being within 25% of the observed count in each of the time periods. A summary of the validation achieved is given in Table 8.3 below. Looking at count sites in the south Bristol area only (shown in bold in Table 8.4 to Table 8.9) 100% validation was achieved in all three time periods.

8.5 For links with flows of less than 150, the GEH statistic has been calculated to give a measure of the degree of fit between the modelled flows and observed counts. The percentage of such links with a GEH of less than 5 is given in Table 8.3.

Table 8.3 – Bus Assignment Validation Summary

	Inbound	Outbound	Total
AM Peak			
% link counts meeting criteria			
- Links with flows > 150 (Criterion: flow difference < 25%)	**83%**	**100%**	**90%**
- Links with flows < 150 (Criterion: GEH <5)	100%	100%	100%
Interpeak			
% link counts meeting criteria			
- Links with flows > 150 (Criterion: flow difference < 25%)	**100%**	**100%**	**100%**
- Links with flows < 150 (Criterion: GEH <5)	100%	100%	100%
PM Peak			
% link counts meeting criteria			
- Links with flows > 150 (Criterion: flow difference < 25%)	**75%**	**100%**	**88%**

	Inbound	Outbound	Total
- Links with flows < 150 (Criterion: GEH <5)	100%	80%	90%

Table 8.4 – AM Peak Bus Link Flow Validation: Inbound (Towards Bristol City Centre)

Site	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Flow difference within 25%?
Anchor Road	**195.0**	**238.0**	**22%**	**2.9**	**Yes**	**Yes**
Bedminster Down	**282.0**	**286.0**	**1%**	**0.2**	**Yes**	**Yes**
Temple Gate	**356.0**	**299.0**	**-16%**	**3.1**	**Yes**	**Yes**
Bedminster Parade	**558.0**	**515.0**	**-8%**	**1.9**	**Yes**	**Yes**
St Luke's Rd	**135.0**	**153.0**	**13%**	**1.5**	**No**	
Old Market	99.0	97.0	-2%	0.2	No	
Gloucester Road	116.0	103.0	-11%	1.2	No	
Filton Avenue	167.0	131.0	-22%	2.9	Yes	Yes
UWE (Coldharbour Lane)	26.0	53.0	104%	4.3	No	
Hatchet Road	166.0	117.0	-30%	4.1	Yes	No
Quaker's Road	131.0	103.0	-21%	2.6	No	
Cleeve Hill	66.0	57.0	-14%	1.1	No	
Downend Road	51.0	51.0	0%	0.0	No	
Staple Hill Road	43.0	51.0	19%	1.2	No	

Source: Onboard single day bus counts (2008 and 2009)

Table 8.5 - AM Peak Bus Link Flow Validation: Outbound

Site	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Flow difference within 25%?
Anchor Road	**78.0**	**63.0**	**-19%**	**1.8**	**No**	
Bedminster Down	**109.0**	**79.0**	**-28%**	**3.1**	**No**	
Temple Gate	**60.0**	**89.0**	**48%**	**3.4**	**No**	
Bedminster Parade	**200.1**	**236.0**	**18%**	**2.4**	**Yes**	**Yes**
St Luke's Rd	**13.0**	**17.0**	**31%**	**1.0**	**No**	
Old Market	23.0	33.0	43%	1.9	No	
Gloucester Road	198.0	191.0	-4%	0.5	Yes	Yes
Filton Avenue	283.0	286.0	1%	0.2	Yes	Yes
UWE (Coldharbour Lane)	200.0	154.0	-23%	3.5	Yes	Yes

Site	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Flow difference within 25%?
Hatchet Road	88.0	60.0	-32%	3.3	No	
Quaker's Road	14.0	11.0	-21%	0.8	No	
Cleeve Hill	10.0	11.0	10%	0.3	No	
Downend Road	36.0	37.0	3%	0.2	No	
Staple Hill Road	38.0	41.0	8%	0.5	No	

Source: Onboard single day bus counts (2008 and 2009)

Table 8.6 – Interpeak Bus Link Flow Validation: Inbound (Towards Bristol City Centre)

Site	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Flow difference within 25%?
Anchor Road	**177.1**	**163.0**	**-8%**	**1.1**	**Yes**	**Yes**
Bedminster Down	**146.8**	**167.0**	**14%**	**1.6**	**No**	
Temple Gate	**200.1**	**152.0**	**-24%**	**3.6**	**Yes**	**Yes**
Bedminster Parade	**300.1**	**303.0**	**1%**	**0.2**	**Yes**	**Yes**
St Luke's Rd	**43.3**	**41.0**	**-5%**	**0.4**	**No**	
Old Market	32.5	45.0	38%	2.0	No	
Gloucester Road	90.8	100.0	10%	0.9	No	
Filton Avenue	174.5	161.0	-8%	1.0	Yes	Yes
UWE (Coldharbour Lane)	81.8	47.0	-43%	4.3	No	
Hatchet Road	78.8	47.0	-40%	4.0	No	
Quaker's Road	10.5	21.0	100%	2.6	No	
Cleeve Hill	32.2	20.0	-38%	2.4	No	
Downend Road	26.2	41.0	57%	2.6	No	
Staple Hill Road	32.3	32.0	-1%	0.1	No	

Source: Onboard single day bus counts (2008 and 2009)

Table 8.7 - Interpeak Bus Link Flow Validation: Outbound

Site	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	**Flow difference within 25%?**
Anchor Road	**174.9**	**152.0**	**-13%**	**1.8**	**Yes**	**Yes**
Bedminster Down	**207.8**	**180.0**	**-13%**	**2.0**	**Yes**	**Yes**
Temple Gate	**193.4**	**192.0**	**-1%**	**0.1**	**Yes**	**Yes**
Bedminster Parade	**346.0**	**354.0**	**2%**	**0.4**	**Yes**	**Yes**
St Luke's Rd	**50.3**	**23.0**	**-54%**	**4.5**	**No**	
Old Market	37.2	28.0	-25%	1.6	No	
Gloucester Road	95.8	100.0	4%	0.4	No	

Site	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Flow difference within 25%?
Filton Avenue	135.7	146.0	8%	0.9	No	
UWE (Coldharbour Lane)	69.5	79.0	14%	1.1	No	
Hatchet Road	97.5	71.0	-27%	2.9	No	
Quaker's Road	21.0	24.0	14%	0.6	No	
Cleeve Hill	31.0	18.0	-42%	2.6	No	
Downend Road	32.0	44.0	38%	1.9	No	
Staple Hill Road	25.7	32.0	25%	1.2	No	

Source: Onboard single day bus counts (2008 and 2009)

Table 8.8 – PM Peak Bus Link Flow Validation: Inbound (Towards Bristol City Centre)

Site	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Flow difference within 25%?
Anchor Road	**137.0**	**128.0**	**-7%**	**0.8**	**No**	
Bedminster Down	**124.0**	**107.0**	**-14%**	**1.6**	**No**	
Temple Gate	**122.0**	**82.0**	**-33%**	**4.0**	**No**	
Bedminster Parade	**262.0**	**275.0**	**5%**	**0.8**	**Yes**	**Yes**
St Luke's Rd	**18.0**	**18.0**	**0%**	**0.0**	**No**	
Old Market	28.0	28.0	0%	0.0	No	
Gloucester Road	156.0	153.0	-2%	0.2	Yes	Yes
Filton Avenue	200.0	212.0	6%	0.8	Yes	Yes
UWE (Coldharbour Lane)	152.0	113.0	-26%	3.4	Yes	No
Hatchet Road	58.0	57.0	-2%	0.1	No	
Quaker's Road	2.0	12.0	500%	3.8	No	
Cleeve Hill	13.0	7.0	-46%	1.9	No	
Downend Road	37.0	41.0	11%	0.6	No	
Staple Hill Road	15.0	15.0	0%	0.0	No	

Source: Onboard single day bus counts (2008 and 2009)

Table 8.9 – PM Peak Bus Link Flow Validation: Outbound

Site	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Flow difference within 25%?
Anchor Road	**274.5**	**289.0**	**5%**	**0.9**	**Yes**	**Yes**
Bedminster Down	**337.0**	**335.0**	**-1%**	**0.1**	**Yes**	**Yes**
Temple Gate	**325.0**	**346.0**	**6%**	**1.1**	**Yes**	**Yes**
Bedminster Parade	**544.4**	**565.0**	**4%**	**0.9**	**Yes**	**Yes**
St Luke's Rd	**77.0**	**106.0**	**38%**	**3.0**	**No**	

Site	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Flow difference within 25%?
Old Market	75.0	85.0	13%	1.1	No	
Gloucester Road	116.0	122.0	5%	0.6	No	
Filton Avenue	118.0	123.0	4%	0.5	No	
UWE (Coldharbour Lane)	31.0	52.0	68%	3.3	No	
Hatchet Road	142.0	72.0	-49%	6.8	No	
Quaker's Road	75.0	70.0	-7%	0.6	No	
Cleeve Hill	75.0	23.0	-69%	7.4	No	
Downend Road	39.0	62.0	59%	3.2	No	
Staple Hill Road	30.0	39.0	30%	1.5	No	

Source*: Onboard single day bus counts (2008 and 2009)*

Rail Assignment Validation

8.6 Passenger counts by station have previously been provided by BCC to validate the rail model. The data come from the 2006 Avon Rail Surveys where available, or derive a 2006 base from previous years' data otherwise. However, the validation counts are from a single day, and therefore, particularly for stations with a small number of users, the potential level of variability in recorded flows on a day-to-day basis should be noted. It should also be noted that no data were available for Bristol Temple Meads and some observed counts in the Bristol area (particularly at Filton Abbey Wood and Bristol Parkway) appeared to be incorrect. Modelled passenger boardings and alightings were obtained for the AM peak, Inter-peak and PM peak hours by assigning the rail matrices to the rail network.

8.7 As the boarding and alighting count data were from 2006, this was uplifted by applying the rail trip growth factor given in Table 7.12.

8.8 The comparisons provided between the observed counts and modelled flows follow the requirements for WebTAG 3.11.2 (para. 10.1.6) whereby flows on individual links should be within 25% of the counts except where the observed flows are particularly low (less than 150). Table 8.10 to Table 8.12 present a summary comparison between observed and modelled station boardings and alightings for the morning, inter-peak and evening peak models respectively. There are very few stations with boarding and/or alighting counts greater than 150, but of these 78% (7/9) of the modelled flows are within 25% of the counts in the AM peak, 75% (3/4) in the inter-peak and 67% (4/6) in the PM peak. Although these proportions are lower than the target of 85%, only one or two count comparisons failed to meet the criterion in each of the time periods, and some of these cases may be due to the inconsistencies in the count data noted above.

8.9 Overall, the tables show that the model provides a reasonable representation of boarding and alighting in each time period, with a GEH of less than 5 achieved for most of the boarding and alighting counts less than 150, although it is recognised that there has been some loss of accuracy in factoring the rail demand.

Table 8.10 - AM Peak Validation: Rail Boarding and Alighting

Station	Boarding					Alighting				
	Observed	Modelled	% Diff	GEH	Flow diff < 25% ?*	Observed	Modelled	% Diff	GEH	Flow diff < 25% ?*

Principal Stations										
Bristol Temple Meads	n/a	2117				n/a	2364			
Bristol Parkway	815	936	15%	4.10	Yes	326	801	146%	20.00	No
Weston-s-Mare	190	129	-32%	4.83	No	46	44	-4%	0.28	
Bath Spa	983	1016	3%	1.06	Yes	896	954	6%	1.91	Yes
Other Stations										
Lawrence Hill	54	13	-76%	7.05		47	8	-83%	7.46	
Stapleton Road	123	50	-59%	7.86		10	25	139%	3.45	
Montpelier	64	1	-98%	11.07		69	5	-93%	10.56	
Redland	68	25	-63%	6.32		31	14	-55%	3.66	
Clifton Down	41	5	-88%	7.46		85	26	-69%	7.93	
Sea Mills	24	15	-36%	1.95		3	0	-100%	2.29	
Shirehampton	14	20	39%	1.35		3	1	-62%	1.20	
Avonmouth	21	32	53%	2.15		21	21	0%	0.01	
St Andrews Road	0	0	-			3	0	-	2.29	
Severn Beach	16	24	53%	1.86		1	0	-100%	1.62	
Filton Abbey Wood	39	183	366%	13.63		402	314	-22%	4.66	Yes
Patchway	28	1	-96%	7.02		21	10	-52%	2.79	
Bedminster	29	14	-51%	3.20		20	33	68%	2.60	
Parson Street	12	1	-	4.27		9	12	31%	0.87	
Nailsea	176	202	15%	1.93	Yes	39	57	45%	2.55	
Yatton	160	168	5%	0.64	Yes	17	35	106%	3.52	
Worle	139	169	22%	2.43		18	30	64%	2.37	
Weston Milton	48	56	16%	1.04		3	23	778%	5.69	
Keynsham	131	143	9%	1.03		33	47	44%	2.26	
Oldfield Park	159	217	37%	4.27	Yes	25	108	334%	10.20	

***** *Boarding/alighting flows greater than 150 only*

Table 8.11 – Inter-Peak Validation: Rail Boarding and Alighting

Station	Boarding					Alighting				
	Observed	Modelled	% Diff	GEH	Flow diff < 25% ?*	Observed	Modelled	% Diff	GEH	Flow diff < 25% ?*
Principal Stations										

Bristol Temple Meads	n/a	607				n/a	484			
Bristol Parkway	296	336	13%	2.25	Yes	236	302	28%	4.04	No
Weston-s-Mare	63	54	-14%	1.16	Yes	58	46	-20%	1.62	
Bath Spa	153	184	20%	2.37	Yes	135	161	19%	2.14	
Other Stations										
Lawrence Hill	8	15	91%	2.11		10	5	-52%	1.97	10
Stapleton Road	9	18	96%	2.40		14	14	-3%	0.11	14
Montpelier	21	2	-90%	5.60		9	6	-35%	1.15	9
Redland	10	4	-62%	2.41		5	7	34%	0.71	5
Clifton Down	14	11	-24%	0.96		20	7	-64%	3.47	20
Sea Mills	13	8	-39%	1.57		5	3	-43%	1.10	5
Shirehampton	3	4	53%	0.76		12	15	27%	0.88	12
Avonmouth	8	12	53%	1.31		13	14	7%	0.24	13
St Andrews Road	0	0	-	0.00		0	0	-	0.00	0
Severn Beach	3	3	15%	0.23		3	2	-24%	0.41	3
Filton Abbey Wood	25	37	49%	2.18		9	23	151%	3.45	9
Patchway	3	1	-62%	1.20		4	2	-49%	1.12	4
Bedminster	3	3	15%	0.23		3	3	15%	0.23	3
Parson Street	0	1	-	1.41		1	1	-24%	0.29	1
Nailsea	18	25	36%	1.43		9	12	31%	0.87	9
Yatton	20	26	32%	1.33		21	22	5%	0.22	21
Worle	9	15	64%	1.68		9	13	42%	1.15	9
Weston Milton	1	12	816%	4.14		1	8	511%	3.10	1
Keynsham	10	15	43%	1.27		12	12	2%	0.06	
Oldfield Park	12	26	120%	3.27		21	23	8%	0.37	

***** *Boarding/alighting flows greater than 150 only*

Table 8.12 - PM Peak Validation: Rail Boarding and Alighting

Station	Boarding					Alighting				
	Observed	Modelled	% Diff	GEH	Flow diff < 25% ?*	Observed	Modelled	% Diff	GEH	Flow diff < 25% ?*
Principal Stations										

Bristol Temple Meads	n/a	2025				n/a	1464			
Bristol Parkway	549	624	14%	3.10	Yes	601	649	8%	1.91	Yes
Weston-s-Mare	31	23	-27%	1.62		134	105	-21%	2.62	Yes
Bath Spa	516	484	-6%	1.44	Yes	274	356	30%	4.63	No
Other Stations										
Lawrence Hill	20	64	226%	6.86		18	23	25%	1.02	
Stapleton Road	14	39	171%	4.76		55	47	-15%	1.12	
Montpelier	37	12	-67%	5.00		24	4	-83%	5.27	
Redland	12	25	112%	3.08		12	3	-75%	3.23	
Clifton Down	41	9	-78%	6.35		24	4	-83%	5.27	
Sea Mills	1	16	1121 %	4.99		5	14	167%	2.82	
Shirehampton	3	19	625%	4.98		8	14	78%	1.86	
Avonmouth	28	37	34%	1.67		14	28	94%	2.95	
St Andrews Road	1	0	-	1.62		0	0	-	0.00	
Severn Beach	1	10	663%	3.65		9	10	9%	0.27	
Filton Abbey Wood	402	559	39%	7.15	No	21	124	492%	12.10	
Patchway	13	36	175%	4.62		18	12	-35%	1.63	
Bedminster	16	13	-17%	0.72		17	6	-65%	3.25	
Parson Street	8	3	-62%	2.09		9	4	-56%	2.01	
Nailsea	25	57	129%	5.02		122	140	15%	1.59	
Yatton	9	41	347%	6.36		92	104	13%	1.24	
Worle	3	26	892%	6.18		100	109	9%	0.92	
Weston Milton	1	27	1961 %	6.83		43	62	43%	2.59	
Keynsham	33	33	1%	0.04		97	74	-24%	2.48	
Oldfield Park	22	51	129%	4.75		115	141	22%	2.27	

***** *Boarding/alighting flows greater than 150 only*

Park and Ride Calibration/Validation

8.10 Site specific factors have been defined so as to acceptably match the allocation of park and ride demand to each existing site based on independently observed AM peak hour entry flows. The constants and the resultant fit to the observed data are show in Table 8.13 below.

Table 8.13 - Bristol Base P&R Site Allocation Calibration (AM Peak Period)

Site	Site Constant (min)	Volumes (Period)		Proportions	
		Observed	Modelled	Observed	Modelled

A4 Portway (Avonmouth)	25	99	103	12%	13%
Brislington	0	426	376	50%	48%
Long Ashton	10	319	305	38%	39%
Total		**844**	**784**	**100%**	**100%**

Note: An informal Park & Rail is also available at Bristol Parkway Station but without any dedicated P&R facilities and any reliable survey data on passenger volumes. In this case, P&R is simply modelled as the cheapest mode (ie by bus or rail) versus car in terms of overall generalised cost.

9. Summary

Summary of Model Development

9.1 A suite of models termed the Greater Bristol Modelling Framework (GBMF) covers the WoE's main urban areas. The G-BATS3 model is the component of the GBMF that focuses on the main urban area of Bristol. G-BATS3 comprises Demand Model, Highway Assignment Model (HAM) and Public Transport Assignment Model (PTAM) elements.

9.2 The SBL model has been updated to a 2012 base year. It was considered prudent to update the rail and bus demand to take account of the growth between 2009 and 2012; services were left unchanged. The Bristol Annual Monitoring Report for 2011[12] shows an increase of 1% in bus demand between 2008/9 and 2011/12, so the bus demand and validation remained unchanged. The National Rail Portal Statistics for total franchised journeys[13] showed an increase of 31% between 2006 and 2012. The rail validation was updated by factoring the counts using the same growth factor. The PTAM element has been revised in light of this and the principal changes consist of:

- more detailed zoning in the SBL area;
- updating the movements in the existing bus demand matrix within the SBL area and North Fringe –Hengrove corridor to a 2009 base year, using new data collected for the study;
- updating coding of bus routes to the November 2009 timetable;
- controlling end-end bus journey times to match travel times in the November 2009 timetable;
- revalidating the bus network and matrices on the basis of newly collected on-board bus occupancy counts;
- upgrading rail demand to a 20012 forecast year; and
- updating bus and rail fares to 2009 values and prices.

Summary of Standards Achieved

9.3 The SBL PTAM has been updated to a 2012 base year, with the addition of bus origin-destination survey data covering the SBL area and North Fringe to Hengrove corridor, significantly enhancing the robustness of the representation of bus demand. The SBL PTAM has been validated to onboard bus counts, and a high standard of validation has been achieved, as detailed in Chapter 8. In particular, validation was achieved on 100% of the bus link counts within the south Bristol area in each of the three time periods.

Assessment of Fitness for Purpose

9.4 The SBL PTAM has been enhanced from previous versions of G-BATS3, specifically in the SBL area and the North Fringe to Hengrove corridor. It is considered that the model is fit for the purpose of assessing the South Bristol Link scheme, supplemented by sensitivity testing as appropriate.

[1212] Source: http://www.bristol.gov.uk/sites/default/files/documents/planning_and_building_regulations/planning_policy/local_development_framework/AMR2011_0.pdf

[13] http://dataportal.orr.gov.uk/displayreport/report/html/22c71959-3f97-405f-8342-e4981745d08b

Appendix A
Bus Segment Time Calculations

A.1 Bus Segment Time Calculations

Mechanisms

Step 1: First Estimate of Bus Travel Time using Highway Times

A.1.1 A **first estimate** of the total journey time for a bus service on each link segment along its route was calculated as:

$$BusLinkTime + BusTurnTime$$

A.1.2 The link and turn times were calculated using inputs from the SATURN HAM. Table A.1 shows the attributes in the SATURN model that were imported into the EMME model.

Table A.1 - SATURN and EMME Attributes

SATURN Code	Filename	EMME Attribute	Description
2033	*.blk	@bol	Bus Only Lane Marker
4023	*.clk	@clkp	Congested Link time
1633	*.ctu	@tup	Congested Turn Time
1803	*.flk	@flkp	Free flow link time

A.1.3 The congested link time was used when the bus mixes with general traffic. The free flow link time was used when the bus travels in a bus-only lane. The bus only lane-marker was used within EMME to differentiate which link time should be used. The turn time was added to the link time to provide the total journey-time.

A.1.4 However, there were some additional complexities that needed to be incorporated into the calculation to ensure an accurate representation of the journey time, namely:

a) where there were a large number of other users in the bus lane, such as taxis or high occupancy vehicles, the benefits are diluted. The magnitude of the effect depends upon which traffic is able to use the bus lanes, and the proportion of traffic this entails;

b) the additional priority at junctions resulting in the installation of SVD is not recognised within SATURN. Therefore a calculation of the likely effect of additional bus priority was necessary.

c) delays to bus run-time occurring through boarding and alighting. Typical boarding times were as follows[14]:

- 3 seconds (where majority of tickets are off-vehicle);
- 6 seconds (where a high proportion involve cash transactions);
- 9 seconds (where almost all ticketing involves cash transactions).

A.1.5 alighting times were typically 1 to 1.5 seconds per person[14]. Therefore alighting times may also have a bearing on journey-times, although not as dramatic an impact as boarding.

A.1.6 These impacts are reflected by the model through factoring bus-journey times accordingly.

A.1.7 Additional attributes within EMME were used to calculate bus journey times as shown in Table A.2.

[14] *The demand for Public Transport – TRL Report 593, 2004*

Table A.1 – Additional EMME Attributes

EMME Attribute	Description
@svd	Marker for SVD at Signalised Junction
@bsd	Bus Stop Density. Number of bus stops per km

@svd = 1 if there is selective vehicle detection for buses at a given node (signalised junction).

@bsd is derived from empirical data for a number of bus routes in Bristol: @bsd = 2.83 (Urban) & 1.70 (Rural).

Link Time Calculation

A.1.8 The following formula – derived from regression analysis - was used to calculate the bus journey time on links:

Bus Link time = 1.36*(Link time + Link length*BSD*delay)

where:

a) Link time = SATURN congested link time (if no bus lane)

b) Link time = SATURN free-flow link time (if a bus lane exists)

c) BSD = Bus Stop Density per km (2.83 (urban), 1.70 (rural) – based on SATURN link types – derived from actual bus stop intervals).

d) Delay = 20 seconds to allow for boarding / alighting

Turn Time Calculation

A.1.9 The following formula was used to calculate the bus delay at turns:

Bus turn time = SATURN turn time

A.1.10 However, there are a number of complications to this formula, depending on the presence of a bus lane that leads up to the stopline and if SVD exists. Little information exists as to the effects on turn times for buses at such facilities. The figures in Table A.3 are considered a best estimate.

Table A.1 - The Assumed Effect of Bus Priority on Turn Times

Bus priority measure		Factor on turn time
Bus Lane	SVD	
N	N	1
Y	Y	0.05
Y	N	0.15
N	Y	0.90

A.1.11 The factors used in this calculation were calibrated for BATS3 v2.3, such that there was a good agreement between modelled and observed journey times. Note that in v2.3, the PTAM relied solely on the calculation, and did not control end-end journey times to observed journey times.

Step 2: Controlling to end-end Observed Journey Times

A.1.12 In the **base** year model, there was a second step to control the total end-end bus journey time to the observed timetabled time. This was done by factoring each segment time:

$$segtime = segtime_{initial} \cdot linetime_{timetable} / linetime_{initial}$$

A.1.13 where segtime is the time on each transit line segment, linetime is the total journey time for the route and initial refers to the initial estimate as calculated in Step 1.

A.1.14 In **forecasting** mode, Step 1 is again undertaken to calculate an initial estimate of the bus journey time. If the bus route exists in both the base and forecast networks, the forecast travel time is calculated as follows:

$$segtime^{F} = segtime^{B} \cdot segtime^{F}_{initial} \Big/ segtime^{B}_{initial}$$

where:

$segtime^{F}$ is the final forecast segment time

$segtime^{B}$ is the final base segment time, controlled to the observed journey time

$segtime^{F}_{initial}$ is the initial forecast segment time

$segtime^{B}_{initial}$ is the initial base segment time

A.1.15 i.e. the base segment time is adjusted by the estimated change in travel time between base and forecast scenarios (with the estimate taking account of both changes in highway time and changes in bus time due to bus priority measures)

A.1.16 For new bus routes, no adjustment to control back to base year timetabled times is possible, so the estimated time is used directly.

Appendix B
Factors used in Bus Matrix Processing

B.1 Factors used to convert between G-BATS3 and SBL Zones

Table B.1 - Factors for Conversion from G-BATS3 to SBL Zones

BAT3 zone	SBL zone	FACTOR	BAT3 zone	SBL zone	FACTOR
19102	19102	0.5	32001	32001	0.8
19102	19103	0.5	32001	32003	0.1
20301	20301	0.5	32001	32004	0.1
20301	20306	0.5	39301	80001	0.167
20501	20501	0.3	39301	80005	0.167
20501	20507	0.4	39301	80006	0.167
20501	20508	0.3	39301	81001	0.167
20502	20502	0.99	39301	81005	0.167
20502	80010	0.005	39301	81006	0.167
20502	81010	0.005	39401	80000	0.25
22102	22102	0.45	39401	80004	0.25
22102	22105	0.55	39401	81000	0.25
22103	22103	0.1	39401	81004	0.25
22103	22106	0.45	39402	80003	0.125
22103	22108	0.45	39402	80007	0.125
22104	22104	0.5	39402	80008	0.125
22104	22107	0.5	39402	80009	0.125
24303	24303	0.5	39402	81003	0.125
24303	24305	0.5	39402	81007	0.125
24304	24304	0.6	39402	81008	0.125
24304	24306	0.4	39402	81009	0.125
30001	30001	0.2	39501	39501	0.5
30001	30003	0.2	39501	80002	0.05
30001	30004	0.2	39501	80009	0.125
30001	80011	0.2	39501	80010	0.075
30001	81011	0.2	39501	81002	0.05
31902	31902	0.55	39501	81009	0.125
31902	31903	0.45	39501	81010	0.075

B.2 Reverse Direction Trip Factors

Table B.2 - Reverse Direction Trips by Time Period Factors (SBL Surveys)

Surveyed Journey	Trip Purpose	Time Surveyed Journey	Time Reverse Journey	Proportion
Outbound	HBEB	AM	AM	0.13
Outbound	HBEB	AM	IP	0.13
Outbound	HBEB	AM	PM	0.75
Outbound	HBEB	IP	IP	0.50
Outbound	HBEB	IP	PM	0.50
Outbound	HBO	AM	AM	0.44

Surveyed Journey	Trip Purpose	Time Surveyed Journey	Time Reverse Journey	Proportion
Outbound	HBO	AM	IP	0.42
Outbound	HBO	AM	PM	0.14
Outbound	HBO	IP	IP	0.73
Outbound	HBO	IP	PM	0.27
Outbound	HBO	PM	PM	1.00
Outbound	HBW	AM	AM	0.25
Outbound	HBW	AM	IP	0.14
Outbound	HBW	AM	PM	0.61
Outbound	HBW	IP	IP	0.44
Outbound	HBW	IP	PM	0.56
Outbound	HBW	PM	PM	1.00
Outbound	NHBEB	AM	PM	1.00
Outbound	NHBEB	IP	IP	1.00
Outbound	NHBO	AM	AM	0.38
Outbound	NHBO	AM	IP	0.45
Outbound	NHBO	AM	PM	0.17
Outbound	NHBO	IP	IP	0.59
Outbound	NHBO	IP	PM	0.41
Outbound	NHBO	PM	PM	1.00
Return	HBEB	AM	AM	1.00
Return	HBO	AM	AM	1.00
Return	HBO	IP	AM	0.16
Return	HBO	IP	IP	0.84
Return	HBO	PM	AM	0.10
Return	HBO	PM	IP	0.35
Return	HBO	PM	PM	0.54
Return	HBW	AM	AM	1.00
Return	HBW	IP	AM	0.37
Return	HBW	IP	IP	0.63
Return	HBW	PM	AM	0.40
Return	HBW	PM	IP	0.09
Return	HBW	PM	PM	0.51
Return	NHBEB	IP	IP	1.00
Return	NHBO	AM	AM	1.00
Return	NHBO	IP	AM	0.24
Return	NHBO	IP	IP	0.76
Return	NHBO	PM	AM	0.43
Return	NHBO	PM	IP	0.14
Return	NHBO	PM	PM	0.43
Return	NHBO	PM	AM	0.43

Source: 2009 SBL Onboard Origin-Destination Surveys

Table B.3 - Reverse Direction Trips by Time Period Factors (NFH Surveys)

Surveyed Journey	Trip Purpose	Time Surveyed Journey	Time Reverse Journey	Proportion
Outbound	HBEB	AM	AM	0.47
Outbound	HBEB	AM	IP	0.13
Outbound	HBEB	AM	PM	0.40
Outbound	HBEB	IP	IP	0.71
Outbound	HBEB	IP	PM	0.29
Outbound	HBEB	PM	PM	1.00
Outbound	HBO	AM	AM	0.67
Outbound	HBO	AM	IP	0.24
Outbound	HBO	AM	PM	0.09
Outbound	HBO	IP	IP	0.79
Outbound	HBO	IP	PM	0.21
Outbound	HBO	PM	PM	1.00
Outbound	HBW	AM	AM	0.43
Outbound	HBW	AM	IP	0.13
Outbound	HBW	AM	PM	0.43
Outbound	HBW	IP	IP	0.67
Outbound	HBW	IP	PM	0.33
Outbound	HBW	PM	PM	1.00
Outbound	NHBO	AM	AM	0.41
Outbound	NHBO	AM	IP	0.28
Outbound	NHBO	AM	PM	0.30
Outbound	NHBO	IP	IP	0.55
Outbound	NHBO	IP	PM	0.45
Outbound	NHBO	PM	PM	1.00
Outbound	NHBEB	AM	AM	0.50
Outbound	NHBEB	AM	IP	0.25
Outbound	NHBEB	AM	PM	0.25
Outbound	NHBEB	IP	IP	0.33
Outbound	NHBEB	IP	PM	0.67
Return	HBEB	IP	AM	0.33
Return	HBEB	IP	IP	0.67
Return	HBEB	PM	AM	1.00
Return	HBO	AM	AM	1.00
Return	HBO	IP	AM	0.23
Return	HBO	IP	IP	0.77
Return	HBO	PM	AM	0.23
Return	HBO	PM	IP	0.50
Return	HBO	PM	PM	0.27
Return	HBW	AM	AM	1.00
Return	HBW	IP	AM	0.43
Return	HBW	IP	IP	0.57
Return	HBW	PM	AM	0.63
Return	HBW	PM	IP	0.18
Return	HBW	PM	PM	0.18

Surveyed Journey	Trip Purpose	Time Surveyed Journey	Time Reverse Journey	Proportion
Return	NHBO	AM	AM	1.00
Return	NHBO	IP	AM	0.29
Return	NHBO	IP	IP	0.71
Return	NHBO	PM	AM	0.19
Return	NHBO	PM	IP	0.56
Return	NHBO	PM	PM	0.25
Return	NHBEB	IP	IP	1.00

Source: 2009 NFH Onboard Origin-Destination Surveys

Appendix C
Bus Link Validation (Service Group Level)

C.1 Bus Link Validation (Service Group Level)

Table C.1 - AM Peak Bus Link Flow Validation: Inbound (Towards Bristol City Centre)

Site	Bus Service Group	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Validation?
Anchor Road	Weston	52.0	74.0	42%	2.8	No	Yes
Anchor Road	Portishead	52.5	68.0	30%	2.0	No	Yes
Anchor Road	Nailsea	46.5	41.0	-12%	0.8	No	Yes
Anchor Road	Clevedon	44.0	55.0	25%	1.6	No	Yes
Anchor Road	**Total**	**195.0**	**238.0**	**22%**	**2.9**	**Yes**	**Yes**
Bedminster Down	Hengrove	35.0	49.0	40%	2.2	No	Yes
Bedminster Down	Whitchurch	247.0	237.0	-4%	0.6	Yes	Yes
Bedminster Down	**Total**	**282.0**	**286.0**	**1%**	**0.2**	**Yes**	**Yes**
Temple Gate	Rookery Farm	86.0	75.0	-13%	1.2	No	Yes
Temple Gate	Hengrove	43.0	53.0	23%	1.4	No	Yes
Temple Gate	Stockwood	181.0	156.0	-14%	1.9	Yes	Yes
Temple Gate	Street	46.0	15.0	-67%	5.6	No	No
Temple Gate	**Total**	**356.0**	**299.0**	**-16%**	**3.1**	**Yes**	**Yes**
Bedminster Parade	Ashton Vale	109.0	41.0	-62%	7.9	No	No
Bedminster Parade	Hengrove	156.0	173.0	11%	1.3	Yes	Yes
Bedminster Parade	Whitchurch	293.0	301.0	3%	0.5	Yes	Yes
Bedminster Parade	**Total**	**558.0**	**515.0**	**-8%**	**1.9**	**Yes**	**Yes**
St Luke's Rd	Rookery Farm - Southmead	135.0	153.0	13%	1.5	No	Yes
St Luke's Rd	**Total**	**135.0**	**153.0**	**13%**	**1.5**	**No**	**Yes**

Site	Bus Service Group	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Validation?
Old Market	Withywood	99.0	97.0	-2%	0.2	No	Yes
Old Market	**Total**	**99.0**	**97.0**	**-2%**	**0.2**	**No**	**Yes**
Gloucester Road	Hartcliffe - Cribbs	75.0	67.0	-11%	0.9	No	Yes
Gloucester Road	Bristol-Thornbury	41.0	36.0	-12%	0.8	No	Yes
Gloucester Road	**Total**	**116.0**	**103.0**	**-11%**	**1.2**	**No**	**Yes**
Filton Avenue	UWE Services	69.0	53.0	-23%	2.0	No	Yes
Filton Avenue	Bradley Stoke - Bristol	38.0	15.0	-61%	4.5	No	Yes
Filton Avenue	Cribbs - Bristol	60.0	63.0	5%	0.4	No	Yes
Filton Avenue	**Total**	**167.0**	**131.0**	**-22%**	**2.9**	**Yes**	**Yes**
UWE (Coldharbour Lane)	Thornbury - Fishponds	3.0	17.0	467%	4.4	No	Yes
UWE (Coldharbour Lane)	Cribbs - Bath/Keynsham	9.0	3.0	-67%	2.4	No	Yes
UWE (Coldharbour Lane)	Emersons Green - Avonmouth/Shirehampton	13.0	33.0	154%	4.2	No	Yes
UWE (Coldharbour Lane)	UWE	1.0	0.0	-100%	1.4	No	Yes
UWE (Coldharbour Lane)	**Total**	**26.0**	**53.0**	**104%**	**4.3**	**No**	**Yes**
Hatchet Road	Cribbs - Bristol	54.0	42.0	-22%	1.7	No	Yes
Hatchet Road	Thornbury - Fishponds	10.0	10.0	0%	0.0	No	Yes
Hatchet Road	Cribbs - Bath/Keynsham	10.0	0.0	-100%	4.5	No	Yes
Hatchet Road	Emersons Green - Avonmouth/Shirehampton	48.0	43.0	-10%	0.7	No	Yes
Hatchet Road	Stoke Lodge - Bristol	44.0	22.0	-50%	3.8	No	Yes
Hatchet Road	**Total**	**166.0**	**117.0**	**-30%**	**4.1**	**Yes**	**No**
Quaker's Road	Downend - Bristol	12.0	30.0	150%	3.9	No	Yes

Site	Bus Service Group	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Validation?
Quaker's Road	Emersons Green - Temple Meads	59.0	33.0	-44%	3.8	No	Yes
Quaker's Road	Emersons Green - Avonmouth/Shirehampton	60.0	40.0	-33%	2.8	No	Yes
Quaker's Road	**Total**	**131.0**	**103.0**	**-21%**	**2.6**	**No**	**Yes**
Cleeve Hill	Downend - Bristol	0.0	31.0	100%	7.9	No	No
Cleeve Hill	Cribbs - Bath/Keynsham	66.0	26.0	-61%	5.9	No	No
Cleeve Hill	**Total**	**66.0**	**57.0**	**-14%**	**1.1**	**No**	**Yes**
Downend Road	Emersons Green - Bristol	51.0	51.0	0%	0.0	No	Yes
Downend Road	**Total**	**51.0**	**51.0**	**0%**	**0.0**	**No**	**Yes**
Staple Hill Road	Emersons Green - Bristol	43.0	51.0	19%	1.2	No	Yes
Staple Hill Road	**Total**	**43.0**	**51.0**	**19%**	**1.2**	**No**	**Yes**

Table C.2 - AM Peak Bus Link Flow Validation: Outbound

Site	Bus Service Group	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Validation?
Anchor Road	Weston	40.0	15.0	-63%	4.8	No	Yes
Anchor Road	Portishead	31.0	32.0	3%	0.2	No	Yes
Anchor Road	Nailsea	1.0	7.0	600%	3.0	No	Yes
Anchor Road	Clevedon	6.0	9.0	50%	1.1	No	Yes
Anchor Road	**Total**	**78.0**	**63.0**	**-19%**	**1.8**	**No**	**Yes**
Bedminster Down	Hengrove	18.0	19.0	6%	0.2	No	Yes
Bedminster Down	Whitchurch	91.0	60.0	-34%	3.6	No	Yes
Bedminster Down	**Total**	**109.0**	**79.0**	**-28%**	**3.1**	**No**	**Yes**

Site	Bus Service Group	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Validation?
Temple Gate	Rookery Farm	30.0	34.0	13%	0.7	No	Yes
Temple Gate	Hengrove	10.0	34.0	240%	5.1	No	No
Temple Gate	Stockwood	17.0	21.0	24%	0.9	No	Yes
Temple Gate	Street	3.0	0.0	-100%	2.4	No	Yes
Temple Gate	**Total**	**60.0**	**89.0**	**48%**	**3.4**	**No**	**Yes**
Bedminster Parade	Ashton Vale	53.0	54.0	2%	0.1	No	Yes
Bedminster Parade	Hengrove	42.7	112.0	163%	7.9	No	No
Bedminster Parade	Whitchurch	104.4	70.0	-33%	3.7	No	Yes
Bedminster Parade	**Total**	**200.1**	**236.0**	**18%**	**2.4**	**Yes**	**Yes**
St Luke's Rd	Rookery Farm - Southmead	13.0	17.0	31%	1.0	No	Yes
St Luke's Rd	**Total**	**13.0**	**17.0**	**31%**	**1.0**	**No**	**Yes**
Old Market	Withywood	23.0	33.0	43%	1.9	No	Yes
Old Market	**Total**	**23.0**	**33.0**	**43%**	**1.9**	**No**	**Yes**
Gloucester Road	Hartcliffe - Cribbs	104.0	110.0	6%	0.6	No	Yes
Gloucester Road	Bristol-Thornbury	94.0	81.0	-14%	1.4	No	Yes
Gloucester Road	**Total**	**198.0**	**191.0**	**-4%**	**0.5**	**Yes**	**Yes**
Filton Avenue	UWE Services	189.0	208.0	10%	1.3	Yes	Yes
Filton Avenue	Bradley Stoke - Bristol	3.0	5.0	67%	1.0	No	Yes
Filton Avenue	Cribbs - Bristol	91.0	73.0	-20%	2.0	No	Yes
Filton Avenue	**Total**	**283.0**	**286.0**	**1%**	**0.2**	**Yes**	**Yes**
UWE (Coldharbour Lane)	Thornbury - Fishponds	0.0	5.0	100%	3.2	No	Yes

Site	Bus Service Group	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Validation?
UWE (Coldharbour Lane)	Cribbs - Bath/Keynsham	18.0	22.0	22%	0.9	No	Yes
UWE (Coldharbour Lane)	Emersons Green - Avonmouth/Shirehampton	63.0	47.0	-25%	2.2	No	Yes
UWE (Coldharbour Lane)	UWE	119.0	80.0	-33%	3.9	No	Yes
UWE (Coldharbour Lane)	**Total**	**200.0**	**154.0**	**-23%**	**3.5**	**Yes**	**Yes**
Hatchet Road	Cribbs - Bristol	30.0	16.0	-47%	2.9	No	Yes
Hatchet Road	Thornbury - Fishponds	1.0	2.0	100%	0.8	No	Yes
Hatchet Road	Cribbs - Bath/Keynsham	15.0	7.0	-53%	2.4	No	Yes
Hatchet Road	Emersons Green - Avonmouth/Shirehampton	42.0	35.0	-17%	1.1	No	Yes
Hatchet Road	Stoke Lodge - Bristol	0.0	0.0	0%	0.0	No	Yes
Hatchet Road	**Total**	**88.0**	**60.0**	**-32%**	**3.3**	**No**	**Yes**
Quaker's Road	Downend - Bristol	1.0	6.0	500%	2.7	No	Yes
Quaker's Road	Emersons Green - Temple Meads	0.0	0.0	0%	0.0	No	Yes
Quaker's Road	Emersons Green - Avonmouth/Shirehampton	13.0	5.0	-62%	2.7	No	Yes
Quaker's Road	**Total**	**14.0**	**11.0**	**-21%**	**0.8**	**No**	**Yes**
Cleeve Hill	Downend - Bristol	1.0	10.0	900%	3.8	No	Yes
Cleeve Hill	Cribbs - Bath/Keynsham	9.0	1.0	-89%	3.6	No	Yes
Cleeve Hill	**Total**	**10.0**	**11.0**	**10%**	**0.3**	**No**	**Yes**
Downend Road	Emersons Green - Bristol	36.0	37.0	3%	0.2	No	Yes
Downend Road	**Total**	**36.0**	**37.0**	**3%**	**0.2**	**No**	**Yes**
Staple Hill Road	Emersons Green - Bristol	38.0	41.0	8%	0.5	No	Yes
Staple Hill Road	**Total**	**38.0**	**41.0**	**8%**	**0.5**	**No**	**Yes**

Table C.3 - Interpeak Bus Link Flow Validation: Inbound (Towards Bristol City Centre)

Site	Bus Service Group	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Validation?
Anchor Road	Weston	91.9	66.0	-28%	2.9	No	Yes
Anchor Road	Portishead	35.0	54.0	54%	2.8	No	Yes
Anchor Road	Nailsea	25.2	27.0	7%	0.4	No	Yes
Anchor Road	Clevedon	25.1	16.0	-36%	2.0	No	Yes
Anchor Road	**Total**	**177.1**	**163.0**	**-8%**	**1.1**	**Yes**	**Yes**
Bedminster Down	Hengrove	17.0	43.0	153%	4.7	No	Yes
Bedminster Down	Whitchurch	129.8	124.0	-4%	0.5	No	Yes
Bedminster Down	**Total**	**146.8**	**167.0**	**14%**	**1.6**	**No**	**Yes**
Temple Gate	Rookery Farm	48.2	51.0	6%	0.4	No	Yes
Temple Gate	Hengrove	31.0	35.0	13%	0.7	No	Yes
Temple Gate	Stockwood	86.9	56.0	-36%	3.7	No	Yes
Temple Gate	Street	34.0	10.0	-71%	5.1	No	No
Temple Gate	**Total**	**200.1**	**152.0**	**-24%**	**3.6**	**Yes**	**Yes**
Bedminster Parade	Ashton Vale	45.3	59.0	30%	1.9	No	Yes
Bedminster Parade	Hengrove	94.9	126.0	33%	3.0	No	Yes
Bedminster Parade	Whitchurch	159.9	118.0	-26%	3.6	Yes	No
Bedminster Parade	**Total**	**300.1**	**303.0**	**1%**	**0.2**	**Yes**	**Yes**
St Luke's Rd	Rookery Farm - Southmead	43.3	41.0	-5%	0.4	No	Yes
St Luke's Rd	**Total**	**43.3**	**41.0**	**-5%**	**0.4**	**No**	**Yes**
Old Market	Withywood	32.5	45.0	38%	2.0	No	Yes

Site	Bus Service Group	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Validation?
Old Market	**Total**	**32.5**	**45.0**	**38%**	**2.0**	**No**	**Yes**
Gloucester Road	Hartcliffe - Cribbs	70.2	68.0	-3%	0.3	No	Yes
Gloucester Road	Bristol-Thornbury	20.7	32.0	55%	2.2	No	Yes
Gloucester Road	**Total**	**90.8**	**100.0**	**10%**	**0.9**	**No**	**Yes**
Filton Avenue	UWE Services	117.7	115.0	-2%	0.2	No	Yes
Filton Avenue	Bradley Stoke - Bristol	10.3	4.0	-61%	2.4	No	Yes
Filton Avenue	Cribbs - Bristol	46.5	42.0	-10%	0.7	No	Yes
Filton Avenue	**Total**	**174.5**	**161.0**	**-8%**	**1.0**	**Yes**	**Yes**
UWE (Coldharbour Lane)	Thornbury - Fishponds	2.7	3.0	13%	0.2	No	Yes
UWE (Coldharbour Lane)	Cribbs - Bath/Keynsham	19.2	10.0	-48%	2.4	No	Yes
UWE (Coldharbour Lane)	Emersons Green - Avonmouth/Shirehampton	11.0	16.0	45%	1.4	No	Yes
UWE (Coldharbour Lane)	UWE	49.0	18.0	-63%	5.4	No	No
UWE (Coldharbour Lane)	**Total**	**81.8**	**47.0**	**-43%**	**4.3**	**No**	**Yes**
Hatchet Road	Cribbs - Bristol	41.2	22.0	-47%	3.4	No	Yes
Hatchet Road	Thornbury - Fishponds	4.5	3.0	-33%	0.8	No	Yes
Hatchet Road	Cribbs - Bath/Keynsham	15.7	6.0	-62%	2.9	No	Yes
Hatchet Road	Emersons Green - Avonmouth/Shirehampton	17.5	16.0	-9%	0.4	No	Yes
Hatchet Road	Stoke Lodge - Bristol	0.0	0.0	0%	0.0	No	Yes
Hatchet Road	**Total**	**78.8**	**47.0**	**-40%**	**4.0**	**No**	**Yes**
Quaker's Road	Downend - Bristol	5.3	7.0	31%	0.7	No	Yes
Quaker's Road	Emersons Green - Temple Meads	0.0	0.0	0%	0.0	No	Yes

Site	Bus Service Group	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Validation?
Quaker's Road	Emersons Green - Avonmouth/Shirehampton	5.2	14.0	171%	2.9	No	Yes
Quaker's Road	**Total**	**10.5**	**21.0**	**100%**	**2.6**	**No**	**Yes**
Cleeve Hill	Downend - Bristol	2.3	2.0	-14%	0.2	No	Yes
Cleeve Hill	Cribbs - Bath/Keynsham	29.8	18.0	-40%	2.4	No	Yes
Cleeve Hill	**Total**	**32.2**	**20.0**	**-38%**	**2.4**	**No**	**Yes**
Downend Road	Emersons Green - Bristol	26.2	41.0	57%	2.6	No	Yes
Downend Road	**Total**	**26.2**	**41.0**	**57%**	**2.6**	**No**	**Yes**
Staple Hill Road	Emersons Green - Bristol	32.3	32.0	-1%	0.1	No	Yes
Staple Hill Road	**Total**	**32.3**	**32.0**	**-1%**	**0.1**	**No**	**Yes**

Table C.4 - Interpeak Bus Link Flow Validation: Outbound

Site	Bus Service Group	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Validation?
Anchor Road	Weston	95.6	52.0	-46%	5.1	No	No
Anchor Road	Portishead	33.2	32.0	-4%	0.2	No	Yes
Anchor Road	Nailsea	22.4	52.0	132%	4.8	No	Yes
Anchor Road	Clevedon	23.7	16.0	-32%	1.7	No	Yes
Anchor Road	**Total**	**174.9**	**152.0**	**-13%**	**1.8**	**Yes**	**Yes**
Bedminster Down	Hengrove	25.9	35.0	35%	1.6	No	Yes
Bedminster Down	Whitchurch	181.9	145.0	-20%	2.9	Yes	Yes
Bedminster Down	**Total**	**207.8**	**180.0**	**-13%**	**2.0**	**Yes**	**Yes**
Temple Gate	Rookery Farm	60.2	59.0	-2%	0.2	No	Yes

Site	Bus Service Group	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Validation?
Temple Gate	Hengrove	22.8	50.0	119%	4.5	No	Yes
Temple Gate	Stockwood	78.6	83.0	6%	0.5	No	Yes
Temple Gate	Street	31.8	0.0	-100%	8.0	No	No
Temple Gate	**Total**	**193.4**	**192.0**	**-1%**	**0.1**	**Yes**	**Yes**
Bedminster Parade	Ashton Vale	54.1	44.0	-19%	1.4	No	Yes
Bedminster Parade	Hengrove	97.4	169.0	74%	6.2	No	No
Bedminster Parade	Whitchurch	194.5	141.0	-28%	4.1	Yes	No
Bedminster Parade	**Total**	**346.0**	**354.0**	**2%**	**0.4**	**Yes**	**Yes**
St Luke's Rd	Rookery Farm - Southmead	50.3	23.0	-54%	4.5	No	Yes
St Luke's Rd	**Total**	**50.3**	**23.0**	**-54%**	**4.5**	**No**	**Yes**
Old Market	Withywood	37.2	28.0	-25%	1.6	No	Yes
Old Market	**Total**	**37.2**	**28.0**	**-25%**	**1.6**	**No**	**Yes**
Gloucester Road	Hartcliffe - Cribbs	75.5	74.0	-2%	0.2	No	Yes
Gloucester Road	Bristol-Thornbury	20.3	26.0	28%	1.2	No	Yes
Gloucester Road	**Total**	**95.8**	**100.0**	**4%**	**0.4**	**No**	**Yes**
Filton Avenue	UWE Services	72.7	72.0	-1%	0.1	No	Yes
Filton Avenue	Bradley Stoke - Bristol	9.2	11.0	20%	0.6	No	Yes
Filton Avenue	Cribbs - Bristol	53.8	63.0	17%	1.2	No	Yes
Filton Avenue	**Total**	**135.7**	**146.0**	**8%**	**0.9**	**No**	**Yes**
UWE (Coldharbour Lane)	Thornbury - Fishponds	1.0	5.0	400%	2.3	No	Yes
UWE (Coldharbour Lane)	Cribbs - Bath/Keynsham	15.2	18.0	19%	0.7	No	Yes

Site	Bus Service Group	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Validation?
UWE (Coldharbour Lane)	Emersons Green - Avonmouth/Shirehampton	6.3	22.0	247%	4.2	No	Yes
UWE (Coldharbour Lane)	UWE	47.0	34.0	-28%	2.0	No	Yes
UWE (Coldharbour Lane)	**Total**	**69.5**	**79.0**	**14%**	**1.1**	**No**	**Yes**
Hatchet Road	Cribbs - Bristol	55.3	30.0	-46%	3.9	No	Yes
Hatchet Road	Thornbury - Fishponds	3.7	4.0	9%	0.2	No	Yes
Hatchet Road	Cribbs - Bath/Keynsham	25.2	15.0	-40%	2.3	No	Yes
Hatchet Road	Emersons Green - Avonmouth/Shirehampton	13.3	22.0	65%	2.1	No	Yes
Hatchet Road	Stoke Lodge - Bristol	0.0	0.0	0%	0.0	No	Yes
Hatchet Road	**Total**	**97.5**	**71.0**	**-27%**	**2.9**	**No**	**Yes**
Quaker's Road	Downend - Bristol	7.3	13.0	77%	1.8	No	Yes
Quaker's Road	Emersons Green - Temple Meads	6.3	0.0	-100%	3.6	No	Yes
Quaker's Road	Emersons Green - Avonmouth/Shirehampton	7.3	11.0	50%	1.2	No	Yes
Quaker's Road	**Total**	**21.0**	**24.0**	**14%**	**0.6**	**No**	**Yes**
Cleeve Hill	Downend - Bristol	3.5	2.0	-43%	0.9	No	Yes
Cleeve Hill	Cribbs - Bath/Keynsham	27.5	16.0	-42%	2.5	No	Yes
Cleeve Hill	**Total**	**31.0**	**18.0**	**-42%**	**2.6**	**No**	**Yes**
Downend Road	Emersons Green - Bristol	32.0	44.0	38%	1.9	No	Yes
Downend Road	**Total**	**32.0**	**44.0**	**38%**	**1.9**	**No**	**Yes**
Staple Hill Road	Emersons Green - Bristol	25.7	32.0	25%	1.2	No	Yes
Staple Hill Road	**Total**	**25.7**	**32.0**	**25%**	**1.2**	**No**	**Yes**

Table C.5 - PM Peak Bus Link Flow Validation: Inbound (Towards Bristol City Centre)

Site	Bus Service Group	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Validation?
Anchor Road	Weston	86.0	38.0	-56%	6.1	No	No
Anchor Road	Portishead	16.0	59.0	269%	7.0	No	No
Anchor Road	Nailsea	10.0	24.0	140%	3.4	No	Yes
Anchor Road	Clevedon	25.0	7.0	-72%	4.5	No	Yes
Anchor Road	**Total**	**137.0**	**128.0**	**-7%**	**0.8**	**No**	**Yes**
Bedminster Down	Hengrove	16.0	14.0	-13%	0.5	No	Yes
Bedminster Down	Whitchurch	108.0	93.0	-14%	1.5	No	Yes
Bedminster Down	**Total**	**124.0**	**107.0**	**-14%**	**1.6**	**No**	**Yes**
Temple Gate	Rookery Farm	30.0	25.0	-17%	1.0	No	Yes
Temple Gate	Hengrove	18.0	21.0	17%	0.7	No	Yes
Temple Gate	Stockwood	47.0	33.0	-30%	2.2	No	Yes
Temple Gate	Street	27.0	3.0	-89%	6.2	No	No
Temple Gate	**Total**	**122.0**	**82.0**	**-33%**	**4.0**	**No**	**Yes**
Bedminster Parade	Ashton Vale	35.0	22.0	-37%	2.4	No	Yes
Bedminster Parade	Hengrove	90.0	73.0	-19%	1.9	No	Yes
Bedminster Parade	Whitchurch	137.0	180.0	31%	3.4	No	Yes
Bedminster Parade	**Total**	**262.0**	**275.0**	**5%**	**0.8**	**Yes**	**Yes**
St Luke's Rd	Rookery Farm - Southmead	18.0	18.0	0%	0.0	No	Yes
St Luke's Rd	**Total**	**18.0**	**18.0**	**0%**	**0.0**	**No**	**Yes**
Old Market	Withywood	28.0	28.0	0%	0.0	No	Yes

Site	Bus Service Group	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Validation?
Old Market	**Total**	**28.0**	**28.0**	**0%**	**0.0**	**No**	**Yes**
Gloucester Road	Hartcliffe - Cribbs	124.0	128.0	3%	0.4	No	Yes
Gloucester Road	Bristol-Thornbury	32.0	25.0	-22%	1.3	No	Yes
Gloucester Road	**Total**	**156.0**	**153.0**	**-2%**	**0.2**	**Yes**	**Yes**
Filton Avenue	UWE Services	107.0	150.0	40%	3.8	No	Yes
Filton Avenue	Bradley Stoke - Bristol	2.0	12.0	500%	3.8	No	Yes
Filton Avenue	Cribbs - Bristol	91.0	50.0	-45%	4.9	No	Yes
Filton Avenue	**Total**	**200.0**	**212.0**	**6%**	**0.8**	**Yes**	**Yes**
UWE (Coldharbour Lane)	Thornbury - Fishponds	0.0	1.0	100%	1.4	No	Yes
UWE (Coldharbour Lane)	Cribbs - Bath/Keynsham	28.0	27.0	-4%	0.2	No	Yes
UWE (Coldharbour Lane)	Emersons Green - Avonmouth/Shirehampton	26.0	23.0	-12%	0.6	No	Yes
UWE (Coldharbour Lane)	UWE	98.0	62.0	-37%	4.0	No	Yes
UWE (Coldharbour Lane)	**Total**	**152.0**	**113.0**	**-26%**	**3.4**	**Yes**	**No**
Hatchet Road	Cribbs - Bristol	31.0	22.0	-29%	1.7	No	Yes
Hatchet Road	Thornbury - Fishponds	1.0	2.0	100%	0.8	No	Yes
Hatchet Road	Cribbs - Bath/Keynsham	13.0	13.0	0%	0.0	No	Yes
Hatchet Road	Emersons Green - Avonmouth/Shirehampton	13.0	20.0	54%	1.7	No	Yes
Hatchet Road	Stoke Lodge - Bristol	0.0	0.0	0%	0.0	No	Yes
Hatchet Road	**Total**	**58.0**	**57.0**	**-2%**	**0.1**	**No**	**Yes**
Quaker's Road	Downend - Bristol	2.0	4.0	100%	1.2	No	Yes
Quaker's Road	Emersons Green - Temple Meads	0.0	0.0	0%	0.0	No	Yes

Site	Bus Service Group	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Validation?
Quaker's Road	Emersons Green - Avonmouth/Shirehampton	0.0	8.0	100%	4.0	No	Yes
Quaker's Road	**Total**	**2.0**	**12.0**	**500%**	**3.8**	**No**	**Yes**
Cleeve Hill	Downend - Bristol	6.0	1.0	-83%	2.7	No	Yes
Cleeve Hill	Cribbs - Bath/Keynsham	7.0	6.0	-14%	0.4	No	Yes
Cleeve Hill	**Total**	**13.0**	**7.0**	**-46%**	**1.9**	**No**	**Yes**
Downend Road	Emersons Green - Bristol	37.0	41.0	11%	0.6	No	Yes
Downend Road	**Total**	**37.0**	**41.0**	**11%**	**0.6**	**No**	**Yes**
Staple Hill Road	Emersons Green - Bristol	15.0	15.0	0%	0.0	No	Yes
Staple Hill Road	**Total**	**15.0**	**15.0**	**0%**	**0.0**	**No**	**Yes**

Table C.6 - PM Peak Bus Link Flow Validation: Outbound

Site	Bus Service Group	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Validation?
Anchor Road	Weston	87.0	47.0	-46%	4.9	No	Yes
Anchor Road	Portishead	43.5	119.0	174%	8.4	No	No
Anchor Road	Nailsea	63.0	43.0	-32%	2.7	No	Yes
Anchor Road	Clevedon	81.0	80.0	-1%	0.1	No	Yes
Anchor Road	**Total**	**274.5**	**289.0**	**5%**	**0.9**	**Yes**	**Yes**
Bedminster Down	Hengrove	40.0	44.0	10%	0.6	No	Yes
Bedminster Down	Whitchurch	297.0	291.0	-2%	0.3	Yes	Yes
Bedminster Down	**Total**	**337.0**	**335.0**	**-1%**	**0.1**	**Yes**	**Yes**
Temple Gate	Rookery Farm	115.0	110.0	-4%	0.5	No	Yes

Site	Bus Service Group	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Validation?
Temple Gate	Hengrove	24.0	76.0	217%	7.4	No	No
Temple Gate	Stockwood	167.0	157.0	-6%	0.8	Yes	Yes
Temple Gate	Street	19.0	3.0	-84%	4.8	No	Yes
Temple Gate	**Total**	**325.0**	**346.0**	**6%**	**1.1**	**Yes**	**Yes**
Bedminster Parade	Ashton Vale	97.0	98.0	1%	0.1	No	Yes
Bedminster Parade	Hengrove	115.3	135.0	17%	1.8	No	Yes
Bedminster Parade	Whitchurch	332.1	332.0	0%	0.0	Yes	Yes
Bedminster Parade	**Total**	**544.4**	**565.0**	**4%**	**0.9**	**Yes**	**Yes**
St Luke's Rd	Rookery Farm - Southmead	77.0	106.0	38%	3.0	No	Yes
St Luke's Rd	**Total**	**77.0**	**106.0**	**38%**	**3.0**	**No**	**Yes**
Old Market	Withywood	75.0	85.0	13%	1.1	No	Yes
Old Market	**Total**	**75.0**	**85.0**	**13%**	**1.1**	**No**	**Yes**
Gloucester Road	Hartcliffe - Cribbs	84.0	102.0	21%	1.9	No	Yes
Gloucester Road	Bristol-Thornbury	32.0	20.0	-38%	2.4	No	Yes
Gloucester Road	**Total**	**116.0**	**122.0**	**5%**	**0.6**	**No**	**Yes**
Filton Avenue	UWE Services	65.0	41.0	-37%	3.3	No	Yes
Filton Avenue	Bradley Stoke - Bristol	22.0	17.0	-23%	1.1	No	Yes
Filton Avenue	Cribbs - Bristol	31.0	65.0	110%	4.9	No	Yes
Filton Avenue	**Total**	**118.0**	**123.0**	**4%**	**0.5**	**No**	**Yes**
UWE (Coldharbour Lane)	Thornbury - Fishponds	2.0	16.0	700%	4.7	No	Yes
UWE (Coldharbour Lane)	Cribbs - Bath/Keynsham	17.0	11.0	-35%	1.6	No	Yes

Site	Bus Service Group	Observed Flow	Modelled Flow	%Diff., (Modelled v observed)	GEH	Flow > 150?	Validation?
UWE (Coldharbour Lane)	Emersons Green - Avonmouth/Shirehampton	12.0	23.0	92%	2.6	No	Yes
UWE (Coldharbour Lane)	UWE	0.0	2.0	100%	2.0	No	Yes
UWE (Coldharbour Lane)	**Total**	**31.0**	**52.0**	**68%**	**3.3**	**No**	**Yes**
Hatchet Road	Cribbs - Bristol	59.0	37.0	-37%	3.2	No	Yes
Hatchet Road	Thornbury - Fishponds	9.0	4.0	-56%	2.0	No	Yes
Hatchet Road	Cribbs - Bath/Keynsham	10.0	6.0	-40%	1.4	No	Yes
Hatchet Road	Emersons Green - Avonmouth/Shirehampton	19.0	16.0	-16%	0.7	No	Yes
Hatchet Road	Stoke Lodge - Bristol	45.0	9.0	-80%	6.9	No	No
Hatchet Road	**Total**	**142.0**	**72.0**	**-49%**	**6.8**	**No**	**No**
Quaker's Road	Downend - Bristol	6.0	14.0	133%	2.5	No	Yes
Quaker's Road	Emersons Green - Temple Meads	46.0	39.0	-15%	1.1	No	Yes
Quaker's Road	Emersons Green - Avonmouth/Shirehampton	23.0	17.0	-26%	1.3	No	Yes
Quaker's Road	**Total**	**75.0**	**70.0**	**-7%**	**0.6**	**No**	**Yes**
Cleeve Hill	Downend - Bristol	0.0	5.0	100%	3.2	No	Yes
Cleeve Hill	Cribbs - Bath/Keynsham	75.0	18.0	-76%	8.4	No	No
Cleeve Hill	**Total**	**75.0**	**23.0**	**-69%**	**7.4**	**No**	**No**
Downend Road	Emersons Green - Bristol	39.0	62.0	59%	3.2	No	Yes
Downend Road	**Total**	**39.0**	**62.0**	**59%**	**3.2**	**No**	**Yes**
Staple Hill Road	Emersons Green - Bristol	30.0	39.0	30%	1.5	No	Yes
Staple Hill Road	**Total**	**30.0**	**39.0**	**30%**	**1.5**	**No**	**Yes**