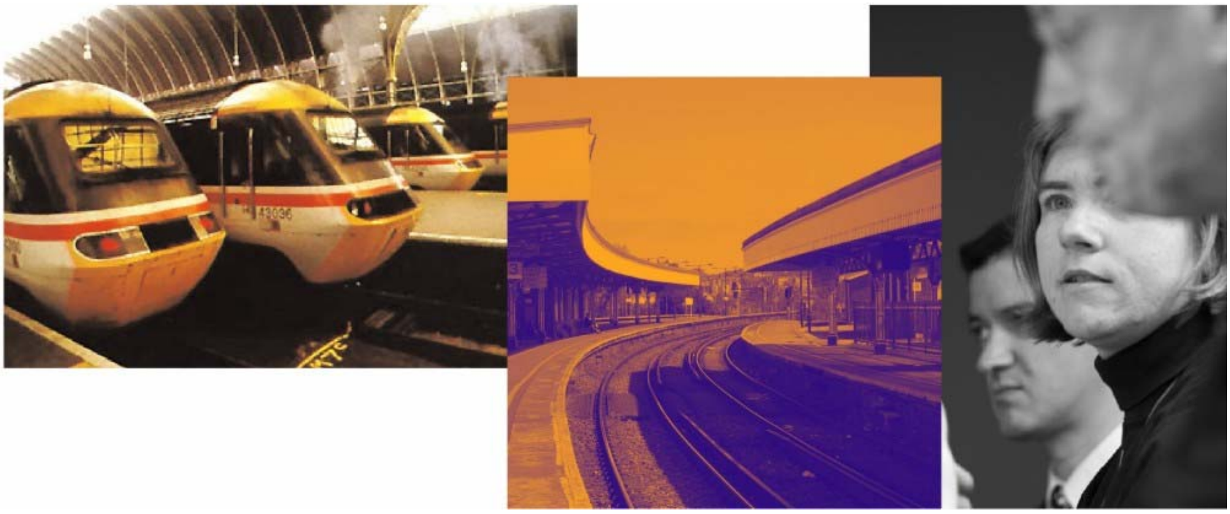
SEStran Regional Model

Public Transport Model Development Report

Report for SEStran / Transport Scotland

November 2010



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1 Introduction

1.1 Background

1.1.1 In March 2008 MVA Consultancy were commissioned by Transport Scotland to provide modelling support and advice for the Forth Replacement Crossing Team. As part of this project we developed a sub-area model of TMfS:07 centred on the Forth Crossing area. The sub-area model was developed in SATURN (Road model) and Cube Voyager (PT model and Demand model).

1.1.2 In August 2009, the model was further extended to encompass the whole of the South East Scotland Transport Partnership (SEStran) area, covering the Local Authorities of East Lothian, Midlothian and Scottish Borders.

1.2 Development of SEStran Model

1.2.1 This report describes the procedure undertaken to develop the Public Transport element of the SEStran Model and includes information on the following:

- model dimensions;
- development of the modelled public transport network;
- development of demand matrices;
- assignment procedures; and
- model validation.

1.3 Structure of this Report

1.3.1 Following this introductory Chapter, this Report includes the following chapters:

- Chapter 2 – is an overview of the model dimensions and user classes;
- Chapter 3 – describes how the public transport network was developed;
- Chapter 4 - explains the demand matrix development;
- Chapter 5 – describes the development of the public transport assignment model;
- Chapter 6 – summarises the validation process undertaken for the SEStran Public Transport Model; and
- Chapter 7 – includes our conclusions and recommendations.

2 Model Dimensions

2.1 Model Time Periods

2.1.1 The relevant week-day time periods are:

- AM peak hour - 08:00-09:00;
- AM peak period – 07:00-10:00;
- Inter-peak – average hour between 10:00 and 16:00;
- PM peak hour - 17:00-18:00; and
- PM peak period -16:00-19:00.

2.1.2 The public transport assignment model reflects conditions in the AM peak hour, average inter-peak hour and PM peak hour.

2.1.3 Peak hour demand data and observed count data has been derived from the three-hour peak period data through application of a peak period to peak hour factor. These factors have been obtained from analysis of the TMfS:07 bus occupancy count data and the National Rail Travel Survey (NRTS). The resulting factors were very similar for bus and rail and have therefore been combined into a single set of Public Transport peak hour factors. These factors are reported in Table 2.1.

Table 2.1 Peak Hour Factors

Time Period	Bus	NRTS	Average PT
Peak period to peak hour (AM)	0.44	0.45	0.45
Inter-peak (average of 10:00-16:00)	1/6	1/6	1/6
Peak period to peak hour (PM)	0.42	0.47	0.44

2.2 User Classes

2.2.1 There are three user classes in the model:

- 'In Work' (IW), eg trips on employers business;
- 'Non Work Commute ' (NWC), ie commuting trips to/from place of work; and
- 'Non Work Other' (NWO), ie all other journey purposes.

2.2.2 Demand matrices have been prepared for each user class, which are assigned separately to the public transport network in the model.

3 Public Transport Network

3.1 Network Development

3.1.1 The SEStran Model Public Transport network is based on the SATURN road network with the addition of the TMfS:07 rail network. This allows for simple and consistent transfer of changes in forecast road traffic delays. The modelled network includes the following elements:

- road network;
- heavy rail;
- road and rail zone connectors; and
- walking connections between rail stations and the road network.

3.1.2 The rail network and connectors in the SEStran Model have been adopted from TMfS:07. This approach allows direct consistency with TMfS:07 and avoids the need to edit rail lines files for the SEStran model. Those services that are outwith the SEStran modelled area will not be loaded in the model assignment as the rail network is only connected to the demand matrices in the relevant modelled area around the SEStran area.

3.2 Public Transport Lines Data

3.2.1 The development of the public transport lines file is dependent on the input of public transport system and line data. This includes the definition of System Information and the coding of PT lines.

3.2.2 System Information contains data relating to:

- available modes;
- operator definition;
- Wait Curves; and
- Crowding Curves.

3.2.3 The PT lines contain the data for the modelled public transport services including the route the line will take across the modelled transport network. Line data contains the following:

- mode;
- operating company;
- route type (circular/linear);
- service type (stopping/express);
- headway (by modelled time period);
- fares;
- short and long text descriptions; and
- sequence of nodes.

3.2.4 The lines files have been adapted from those used for TMfS:07. We have also included additional local bus services which were not included in the strategic national model.

3.2.5 All intra-urban and inter-urban bus lines have been coded to stop at every relevant node on the strategic transport network.

Modes

3.2.6 The MODE control statement defines the characteristics of the various modes used by the PT System. Six separate modes have been coded, namely:

- Intra-urban bus;
- Inter-urban bus;
- Rail;
- Underground;
- Ferry; and
- Tram (not used in base year but included within the model structure, in anticipation of future year coding).

3.2.7 It should be noted that there are currently no Underground, Ferry or Tram services in the SEStran modelled area but these modes have been retained for consistency with TMfS:07.

3.2.8 Intra-urban bus services have been defined as those that operate wholly within the Edinburgh conurbation shown in Figure 3.1. Services that extend outwith this area have been defined as inter urban bus.

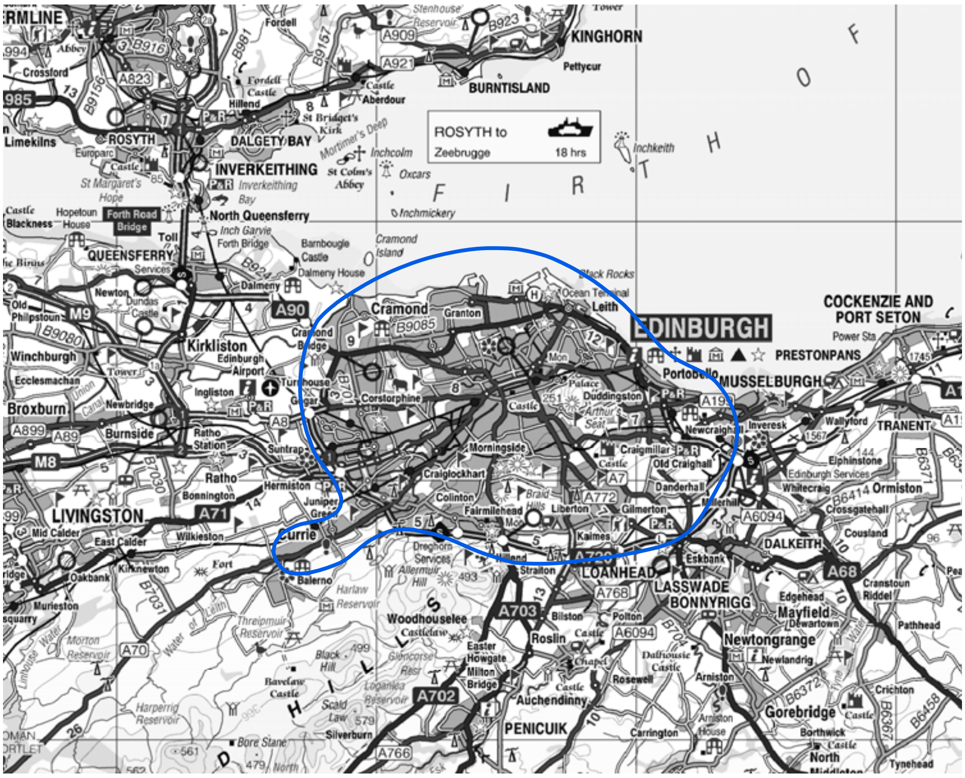

Figure 3.1 Extent of Intra-urban Bus Area – Edinburgh

3.2.9 Intra-urban buses have been coded on a corridor basis, with a single line coded in each direction that represents the average frequency along the corridor. This approach was adopted to minimise the number of lines coded and is considered to provide a robust representation of Intra-urban bus services. Appendix A contains further details of the specification of intra-urban bus services.

3.2.10 Inter-urban buses have been coded based on the relevant public timetables. Where the strategic modelled network does not include the actual road used by a service, the modelled service has been routed using the nearest equivalent road within the model.

3.2.11 Table 3.1 summarises the number of PT lines coded by mode and time period.

Table 3.1 PT Lines by Mode

Mode	AM Peak	Inter Peak	PM Peak
Intra Urban Bus	26	26	26
Inter Urban Bus	592	491	537
Rail	199	193	196
Total	**817**	**710**	**759**

Public Transport Operators

3.2.12 Twenty-three operating companies were coded, reflecting operators across all modes. Table 3.2 summarises the number of PT lines coded by operator and time period. The Operator Number matches that assigned to the Operator within the overarching TMfS:07 public transport model.

Table 3.2 Number of Services by Public Transport Company

Operator No.	Operator	AM Peak	Inter Peak	PM Peak
1	ScotRail - National	59	64	57
2	ScotRail - SPT	107	85	108
3	ScotRail - Highlands	9	8	6
4	ScotRail - Northern Highlands	6	7	6
5	East Coast Intercity Rail	10	16	11
6	West Coast Intercity Rail	8	13	8
15	First Glasgow	8	7	8
16	First Edinburgh	202	149	180
18	Scottish Citylink	35	31	33
21	Stagecoach Strathtay	10	9	7
22	Stagecoach Fife	192	160	169
32	Crieff Travel	1	1	0

Operator No.	Operator	AM Peak	Inter Peak	PM Peak
33	Docherty's Midland	5	6	5
34	Pegasus Travel	3	2	4
36	Bluebus	1	1	0
42	Lothian	61	48	62
43	D&G Various	3	5	4
44	First Borders	30	24	26
51	Edinburgh Urban Bus	26	26	26
54	Eve Coaches	9	18	7
55	Munros of Jedburgh	15	17	17
56	Perrymans	11	9	9
57	Don Prentice Coaches	4	2	4
100	Lothian Air	2	2	2
Total Services		**817**	**710**	**759**

3.2.13 It should be noted that all rail services included in TMfS:07 have been included within the SEStran Model. However, rail services outwith the SEStran modelled area will not be loaded with demand in the model assignment.

3.2.14 Public Transport lines have been coded for all services for which publicly available timetables could be found for the companies listed in Table 3.2. The base for all bus and rail services is Spring 2007.

4 Demand Matrix Development

4.1 Introduction

4.1.1 The SEStran PT model demand matrices have been developed based on the national TMfS:07 demand matrices. This chapter describes the matrix development procedures.

4.1.2 Demand matrices have been prepared for three modelled time periods and user classes which are consistent with those used in TMfS:07.

4.2 Zone System

4.2.1 The SEStran Model network has three types of 'internal' zone:

- 296 'simulation' zones outwith Edinburgh;
- 39 'buffer' zones in Edinburgh; and
- 99 park and ride zones where P&R trips are loaded onto the PT network.

4.2.2 Outwith this area there are 36 'external' zones, which were defined for each link at the edge of the study area, to represent the rail and road corridors at the edge of the model.

4.2.3 This type of zone structure makes it possible to model the areas which are key to the scheme being assessed in detail, while taking into account possible implications of public transport movements to and from the modelled area.

4.2.4 A key requirement for the SEStran internal zone system was to be consistent with the TMfS:07 zone system. The TMfS:07 zone boundaries were therefore used as the basis for the SEStran zone system.

4.2.5 Within the Simulation area additional detail was added to the zone system, by disaggregating the TMfS:07 zones into smaller zones. The level of disaggregation used was similar to the TMfS:05 model.

4.2.6 Within the Buffer area the SEStran zones are identical to the TMfS:07 zones.

4.3 Matrix Development

4.3.1 As indicated in Figure 4.1, three movement types have been identified that require to be extracted from TMfS:07 and this is described in more detail below.

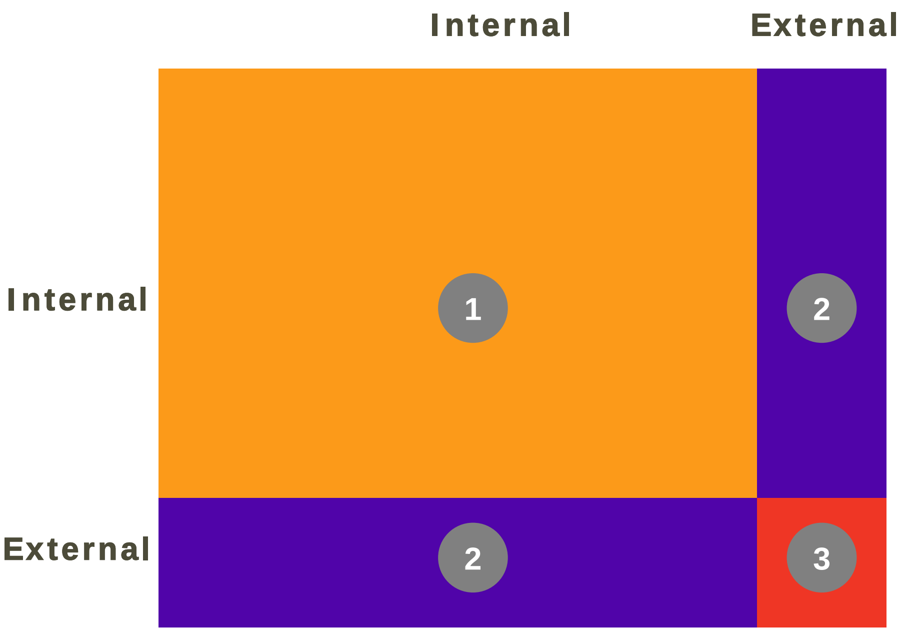

Figure 4.1 Zone Movements

(1) Internal to Internal Movements

4.3.2 Movements between internal zones are extracted using a direct zone equivalence. Park and Ride trips were identified based on observed car park occupancies and TMfS:07 data and moved to the appropriate SEStran model zones.

(2) Internal to/from External Movements

4.3.3 Movements between internal and external zones are based on a select link assignment in TMfS:07.

(3) External to External Movements

4.3.4 This movement has been derived through inspection of the TMfS:07 demand matrices at local authority level with movements through the Forth modelled area allocated to route zones. For example, journeys from Inverness and the Highlands to Berwick-Upon-Tweed enter through rail lines or the A9 at Perth and exit the model at the eastern edge of the Borders.

4.4 Creation of SEStran Public Transport Matrices

4.4.1 Assignment matrices have been prepared through summation of the three matrix elements, ie (1) + (2) + (3).

4.4.2 Table 4.1 shows the matrix totals by period and user class and includes totals.

Table 4.1 Matrix Totals

		Movement			
		Internal to Internal	Internal to/from External	External to External	**Total**
AM	IW	1296	1375	201	**2872**
	TW	25608	2448	73	**28129**
	NW	18179	3020	708	**21907**
	Total	**45082**	**6843**	**982**	**52907**
IP	IW	783	578	123	**1485**
	TW	4255	2217	35	**6507**
	NW	19615	509	379	**20503**
	Total	**24653**	**3304**	**537**	**28494**
PM	IW	868	1035	186	**2088**
	TW	21654	2509	104	**24266**
	NW	16335	2848	455	**19638**
	Total	**38856**	**6392**	**745**	**45993**

5 Assignment Model

5.1 Introduction

5.1.1 This Chapter describes the development of the public transport assignment model, including:

- the modelling of crowding;
- a review of assignment model parameters; and
- the fares model.

5.1.2 The assignment model procedure is consistent with TMfS:07. For ease of reference this assignment procedure is described below.

5.2 Assignment Model Inputs

5.2.1 The inputs to the Public Transport Assignment Model for each time period are:

- public transport road and rail network (described in Chapter 3);
- public transport lines file (described in Chapter 3); and
- hourly assignment matrices (described in Chapter 4).

5.3 Path Building and Loading

5.3.1 The path building and loading procedures have been developed using the CUBE Voyager public transport assignment model software, with the following models:

- Walk Choice Model;
- Service Frequency and Cost Model; and
- Alternative Alighting Model.

5.3.2 The model assignment is split into two stages as follows:

- **route enumeration**, which identifies a set of discrete routes between zone pairs along with the probability that passengers will use the routes to travel between the zones - routes that fail to meet certain criteria are discarded; and
- **route-evaluation**, which calculates the “probability of use” for each of the enumerated routes between zone pairs.

5.4 Crowding

5.4.1 Public transport crowding has been included in the SEStran PT assignment procedures for the morning and evening peak. Crowding is not considered to be a significant issue outwith the peak periods and, therefore, has not been included in the inter-peak period assignment. This also assists in reducing run times.

5.4.2 Note that the restrictions on demand created by car park capacity constraints at Park and Ride sites is dealt with by the Park and Ride model, which is described elsewhere.

5.4.3 PT crowding is an iterative process where the model calculates an initial set of crowding factors and passenger loadings. These are then fed back into the model and a revised set of crowding factors and passenger loadings are calculated. Convergence of the model is reached when the factors and loadings stop changing significantly between iterations.

5.4.4 The number of iterations is specified by the user and the objective is to minimise the number of iterations required, while achieving stable network conditions. A review of the model convergence has shown that five iterations of the PT crowding loop are appropriate for the TMfS assignment models using the load and crowd factor averaging procedures.

5.4.5 The PT crowding assignment requires the specification of the following data:

- PT crowding curves;
- PT line capacities; and
- passenger and vehicle arrival profiles.

5.4.6 Crowding curves are implemented as multiplicative curves in the CUBE Voyager public transport assignment procedures. For each level of utilisation the free link journey time is multiplied by the appropriate adjustment factor to represent the perceived journey time spent in crowded conditions.

5.4.7 The measure of utilisation in CUBE Voyager is approximately the same as the percentage of standing passengers as a proportion of the capacity for standing passengers. Utilisation is therefore zero until all seats are occupied and standing is necessary. Utilisation is 100% when the vehicle is at crush capacity, ie all standing room is taken.

5.4.8 The UK Rail standard curves included in the Passenger Demand Forecasting Handbook (PDFH) are multiplicative and are applicable to rail only. The PDFH Non-London Commuting Rail Crowding curve has been allocated to all rail lines in the SEStran Model in the morning and evening peak. The data points for this curve are shown in Table 5.1.

Table 5.1 PDFH Non-London Commuting Rail Crowding

Utilisation	Crowding Factor
0%	1.00
20%	1.09
40%	1.18
60%	1.26
80%	1.35
100%	1.44

5.4.9 No crowding modelling calculations were performed for the bus lines as it is assumed that operators would increase supply to match future demand wherever possible, and thus keep the average load factors broadly constant.

5.4.10 The model framework allows the user to include crowding effects to be modelled on future tram services, if required.

5.4.11 Capacities have been coded for all rail lines in the morning and evening peak periods based on rolling stock usage in 2006. The crush capacity was assumed to be 40% above the seated capacity. A review of the assigned ratios of loading to capacity for coded rail services is included in Chapter 6.

5.4.12 In the absence of any data, the passenger and vehicle arrival profiles have been assumed to be level throughout the modelled time periods. This is a potential weakness in the crowding procedures applied in that there is no allowance for varying demand on individual services within the modelled peak hour. This may result in an under-estimation of crowding on certain services, where the number of passengers is above the hourly average.

5.5 Assignment Model Parameters

5.5.1 A range of parameters are available to control the path building process, including:

- mode specific in-vehicle time weighting factors;
- mode specific waiting time weighting factors;
- walk time weighting factors;
- mode specific boarding penalties;
- mode to mode transfer penalties (Sub-Mode Choice Model only); and
- mode specific minimum and maximum wait times.

5.5.2 The assignment model parameters, common to peak and inter-peak assignments, are shown in Table 5.2.

Table 5.2 Public Transport Assignment Model Parameters

Model Parameter	Value / Factor
Parameter:	
In vehicle times - bus	1.05
- rail	1.0
Walk Time Factor	1.6
Minimum Wait Time	0 mins
Maximum Wait Time	60 mins
Boarding Penalty	5 mins
Transfer Penalty	
- rail to rail	5 mins
- bus to bus	10 mins
- bus to rail/underground and vice versa	10 mins
Value of time:	
- in work	21.58 £/hr
- non work	5.11 £/hr

5.5.3 All parameters were based on standard ranges used in other studies. The values in Table 5.2 are the values used in the final calibration.

5.5.4 Values of time were derived using the Transport Economic Note (TEN) methodology, with Values of Time taken from WebTAG 3.5.6 (June 2004). Using the average earnings data, a factor was derived and applied to the 2007 Value of time to produce the value used in TMfS:07 and the SEStran Model.

5.6 Wait Curves

5.6.1 Wait curves have been implemented for all PT lines in the SEStran Model and a single wait curve was used for all time periods. The route-enumeration process uses a simple estimate of wait time as half headway, weighted by WAITFACTOR. Therefore, in keeping with adjustments made to TMfS.07, wait curves were coded equal to half of the perceived wait time using a wait time factor of two. This allows a better representation of wait time in enumeration, also reducing run times, without affecting assigned wait times. Table 5.3 shows the wait curves used.

Table 5.3 Wait Times

Headway (minutes)	Perceived Wait Time (minutes)	Coded Wait Curve (Wait Time Factor = 2)
5	5	2.5
10	10	5
15	14	7
20	18	9
30	23	11.5
40	26	13
60	31	15.5
90	39	19.5
120	47	23.5
180	63	31.5

5.6.2 It should be noted that the minimum wait time has been set at 0 minutes and the maximum wait time has been set at 60 minutes for all modes in the route enumeration stage.

5.7 Fares Model

5.7.1 The Fares Model for the SEStran Model is based on a set of Fare Tables for different PT operators and is consistent with TMfS:07.

5.7.2 The Fare Tables consist of a set of distances and fares that define points on a curve. For distances between two fixed points in the table, the Fares Model will linearly interpolate to find the assumed fare. Fare tables have been defined based on scatter plots showing fare versus distance for each modelled PT operator. Average fare curves were then prepared.

5.7.3 For Lothian Buses, all fares in the table are set to a single 'flat' fare of £1.00 (2007 prices), to reflect the flat-fare across the Lothian Bus network in 2007.

5.7.4 Table 5.4 shows the rail fares as they are coded in the model.

Table 5.4 Rail Fares

Fare Table		AM/PM Peak		IP	
		Distance (km)	Fare (£)	Distance (km)	Fare (£)
1	ScotRail - National	0	0.7	0	0.7
		12	3.2	22	3.2
		140	14	120	8
		750	110	750	85
2	ScotRail - SPT	0	0.7	0	0.7
		15	3.1	25	2.8
		750	55	750	36
3	ScotRail - Highland	0	0.7	0	0.7
		12	3.2	22	3.2
		140	14	120	8
		260	24	225	15
		750	75	750	65
4	ScotRail - Nth Highland	0	2	0	2
		140	14	140	14
		750	22	750	22

5.7.5 Table 5.5 shows the bus fares as they are coded in the model.

Table 5.5 Bus Fares

Fare Table	Operator	Distance	Fare (pence)
15	First Glasgow	0	60
		8	140
		750	800
16	First Edinburgh	0	60
		750	5500
17	Citylink	0	100
		750	5500
18	Stagecoach Scotland	0	50
		750	5000
19	Stagecoach Fife	0	50
		750	9000
20	Rapsons	0	70
		20	280
		750	4500
21	McGills	0	100
		750	5500
22	Arriva	0	85
		750	6500
23	First Aberdeen	0	75
		7	180
		18	180
24	All services	0	100
		750	6000
25	Lothian Buses		Flat Fare – £1.00

6 Model Validation

6.1 Introduction

6.1.1 This Chapter describes the validation process undertaken for the assignment of the SEStran Model and matrices through detailed analysis of the following:

- observed bus and rail passenger count data; and
- comparison of timetabled and modelled bus journey times.

6.1.2 The validation of the SEStran PT assignment model has compared the modelled flows with equivalent observed data. This has focused on screenlines for which the modelled flow would typically be expected to be within 15% of observed, as indicated in Road Traffic and Public Assignment Modelling (WebTAG Unit 3.11.2). On individual links the modelled flow would typically be expected to be within 25% of counts, except where observed flows are particularly low (less than 150). There is no specific guidance on sub-mode count comparisons at screenline level, however, it is considered that at this disaggregate level that the 15% target may be too stringent. Therefore, for the cordons and screenlines the modelled flows within 25% has also been reported.

6.1.3 The analysis of the modelled flows also makes use of a summary statistic known as GEH, which is defined as:

$$GEH = ((observed-modelled)^2/(0.5*(observed+modelled)))^{0.5}$$

6.1.4 The GEH value is designed to be more tolerant of large percentage differences at lower flows. For example, one would not normally be concerned about a modelled flow which differed from a count by 40% if the count was only 100, but one would be if the count were 1000. The reason for introducing such a statistic is the inability of either the absolute difference or the relative difference to reflect differences over the wide range of flows contained in the model.

6.1.5 The GEH statistic is typically used for the validation of road assignment models. It is, however, also a useful indicator for PT assignment model though a greater level of tolerance would be expected due to the higher level of variation of public transport data. For a model of this complexity and size a GEH of 5 or less is considered to be excellent. Values between 5 and 10 are considered to be acceptable.

6.1.6 Comparisons have been made with by ScotRail count data and TMfS:07 bus occupancy surveys. It should be noted that the ScotRail count data is independent data separate from the data used in matrix development. Due to the high quality of the underlying travel demand information (from NRTS and the Census), there is no specific procedure undertaken to re-estimate the travel demand matrices to specifically match the independent counts. Therefore, there is a greater degree of scope for the counts versus modelled flows to differ.

6.1.7 It should be noted that the ScotRail data does not include passenger count information on rail services run by other operators, ie Virgin West Coast Mainline, National Express East Coast Mainline and Arriva Cross Country Services. This includes services that operate between Inverness/Aberdeen/Dundee and England via Edinburgh. For the purposes of the modelled versus observed count comparisons presented below the modelled passenger flows on non-ScotRail services have been excluded in order to present a direct comparison.

6.1.8 Tables 6.1 to 6.4 indicate the comparison of the observed passenger flows with the modelled assignments for selected screenlines and cordons across the road and rail network. Appendix B contains the individual count comparisons at the screenlines and cordons and at a selection of strategic locations.

Table 6.1 Inbound Edinburgh Cordon

Time	Mode	Observed	Modelled	Diff	% Diff	GEH
AM	Bus	4805	4900	95	2%	1
	Rail	5261	5337	76	1%	1
	Multi	10066	10237	171	2%	2
IP	Bus	965	1156	191	20%	6
	Rail	1837	1903	66	4%	2
	Multi	2802	3059	257	9%	5
PM	Bus	1510	1619	109	7%	3
	Rail	2816	2454	-362	-13%	7
	Multi	4326	4073	-253	-6%	4

Table 6.2 Outbound Edinburgh Cordon

Time	Mode	Observed	Modelled	Diff	% Diff	GEH
AM	Bus	1319	1334	15	1%	0
	Rail	2087	2171	84	4%	2
	Multi	3406	3505	99	3%	2
IP	Bus	909	1078	169	19%	5
	Rail	1896	1538	-358	-19%	9
	Multi	2805	2616	-189	-7%	4
PM	Bus	4432	4645	213	5%	3
	Rail	5684	5503	-181	-3%	2

	Multi	**10116**	**10148**	**32**	**0%**	**0**

Table 6.3 Lower Forth Crossing Northbound

Time	Mode	Observed	Modelled	Diff	% Diff	GEH
AM	Rail	271	372	101	37%	6
	Bus	90	106	16	18%	2
	Multi	361	478	**117**	**32%**	6
IP	Rail	229	357	128	56%	7
	Bus	143	68	-75	-52%	7
	Multi	372	425	**53**	**14%**	3
PM	Rail	1471	1506	35	2%	1
	Bus	366	281	-85	-23%	5
	Multi	1837	1787	**-50**	**-3%**	1

Table 6.4 Lower Forth Crossing Southbound

Time	Mode	Observed	Modelled	Diff	% Diff	GEH
AM	Rail	1505	1593	88	6%	2
	Bus	448	540	92	21%	4
	Multi	1953	2133	**180**	**9%**	4
IP	Rail	312	285	-27	-9%	2
	Bus	142	97	-45	-32%	4
	Multi	454	382	**-72**	**-16%**	4
PM	Rail	350	337	-13	-4%	1
	Bus	106	159	53	50%	5
	Multi	456	496	**40**	**9%**	2

6.1.9 Examination of the above tables and Appendix B indicates that the validation is acceptable and there is a reasonable correlation between the assigned model flows and the observed passenger flows.

6.1.10 Count comparisons show the Edinburgh cordon total is good, while individual count comparisons are also generally satisfactory.

6.1.11 The lower Forth Crossing total flow comparison is slightly high, but within an acceptable range - mode split is reasonable.

6.1.12 Overall, it is considered that the key strategic passenger movements are well represented in the SEStran Model.

6.2 Passenger Boarding / Alighting Comparisons

6.2.1 ScotRail data provides information on the volume of passengers boarding and alighting at each station for each time period. This has been compared with the equivalent modelled data and the comparisons can be found in Appendix C.

6.2.2 Table 5.5 provides a summary of the GEH statistics for all the stations in the SEStran Model. This indicates that the majority of the boarding and alighting comparisons have a GEH of less than 5 and nearly all have a GEH of less than 10. Therefore, the validation is considered to be within an acceptable range.

Table 6.5 Boarding / Alighting Summary

	AM		IP		PM	
GEH	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
less than 5	61%	64%	71%	66%	79%	60%
less than 7	88%	85%	83%	81%	91%	74%
less than 10	92%	96%	96%	91%	98%	94%

6.2.3 Further examination of the individual station boarding and alighting comparisons in Appendix C indicates a reasonable level correlation at the global level. As expected, there is a greater degree of variability at the individual station level.

6.3 Rail Capacities

6.3.1 As indicated in Chapter 4, the PT assignment model includes crowding on rail lines in the morning and evening peak periods.

6.3.2 The most crowded services in the core modelled network are:

- between Stirling / Dunblane and Edinburgh; and

- cross-Forth movements to and from Fife (including Dundee to and from Edinburgh).

6.3.3 Appendix D provides further details of the ratio of passenger flow to seated capacity on the modelled rail lines. Examination of the results in Appendix D indicates that the morning peak is slightly more crowded than the evening peak within the model.

6.4 Comparison of Timetabled and Modelled Bus Journey Times

6.4.1 As modelled bus journey times are based on assigned road speeds, checks have been made to ensure that modelled bus journey times are representative of timetabled bus journey times in 2007. In making any comparisons, however, it should be recognised that timetables are not necessarily a true reflection of actual bus journey times as they may include allowances for layover and turnaround time.

6.4.2 The analysis was undertaken on a sample of the coded services intended to give a representative geographical spread.

6.4.3 Appendix E contains three tables and 18 diagrams presenting the results of this analysis. A summary of the journey time validation can be seen in Table 6.6.

Table 6.6 Journey Time Validation

		AM		IP		PM	
Within 15% of PT Timetable (DMRB Criteria)	Yes	40	63%	40	68%	36	63%
	No	23	37%	19	32%	21	37%
Within 25% of PT Timetable	Yes	55	87%	51	86%	51	89%
	No	8	13%	8	14%	6	11%

6.4.4 The results show, in general, a reasonable match between modelled and timetabled bus journey times. Where there is a difference between modelled and timetabled the model is, in most cases, quicker. This is due to the strategic nature of the model, and the consequent under-representation of journey times through small towns, villages and hamlets, especially where the services make many stops and also make detours into residential areas that are not modelled. This is fairly typical for most PT models.

6.4.5 A small number of bus services have a modelled journey time that is higher than the equivalent timetable data. Further inspection of this has revealed that the underlying road JT validation is reasonable and it is considered that the operator timetables may be underestimating actual journey times.

7 Conclusion and Recommendations

7.1 Model Development

7.1.1 The SEStran Model Public Transport network has been based on the SATURN road network with the addition of the TMfS:07 rail network.

7.1.2 The modelled network includes the following elements:

- road network;
- heavy rail;
- road and rail zone connectors; and
- walking connections between rail stations and the road network.

7.1.3 Inter urban bus, intra urban bus and rail services have been coded to a base year of 2007.

7.1.4 TMfS:07 zone boundaries have been used as the basis for the SEStran zone system and include internal “simulation” and “buffer” zones and external zones. The demand matrix is based on TMfS:07. The assignment model procedures are also based on TMfS:07.

7.2 Validation

7.2.1 For passenger loading, validation has been carried out to observe passenger counts and the results have generally been satisfactory. The lower Edinburgh Cordon and Forth Crossing are within an acceptable range.

7.2.2 Boarding and alighting comparisons also indicate a reasonable level correlation at the global level, however, there is a greater degree of variability at the individual station level.

7.2.3 There is generally a reasonable match between modelled and timetabled bus journey times.

7.3 Conclusions and Recommendations

7.3.1 Our view is that the public transport element of the SEStran Model has been successfully developed and is fit for its intended purpose; to assess public transport travel movements in the SEStran area at a strategic level.

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