

STRATHCLYDE REGIONAL TRANSPORT MODEL (SRTM) DEVELOPMENT

SRTM PUBLIC TRANSPORT MODEL DEVELOPMENT REPORT

IDENTIFICATION TABLE

Client	Transport Scotland / Strathclyde Partnership for Transport
Project	Strathclyde Regional Transport Model (SRTM) Development
Title of Document	SRTM Public Transport Model Development Report
Type of Document	Final Report
Date	06/08/2019
Reference number	10365912/7_PT/2
Number of pages	112

TABLE OF CONTENTS

1.	PUBLIC TRANSPORT ASSIGNMENT MODEL	4
1.1	OVERVIEW	4
1.2	MODEL PROCESSES	5
1.3	MODEL INPUTS	9
1.4	MODEL OUTPUTS	10
2.	PUBLIC TRANSPORT NETWORK	11
2.1	ROAD NETWORK	11
2.2	RAIL / FERRY NETWORK	11
2.3	WALK NETWORK	11
2.4	ZONE CONNECTORS	12
2.5	NETWORK STATISTICS	13
3.	PUBLIC TRANSPORT SYSTEM CODING	14
3.1	MODES	14
3.2	OPERATORS	14
3.3	WAIT CURVES	15
3.4	CROWDING CURVE	18

3.5	OUTPUT RAIL MODE CROWDING CURVES	20
3.6	SRTM CROWDING CURVES	22
3.7	OTHER PARAMETERS	22
4.	BUS SERVICE CODING	27
4.1	OVERVIEW	27
4.2	DATA SOURCES	30
4.3	TIME PERIOD DEFINITION	30
4.4	METHODOLOGY	30
4.5	SERVICE TYPE SELECTION	31
4.6	OPERATOR CODES	32
4.7	HEADWAY CHECKS	33
4.8	BUILDING ROUTES FROM SHAPEFILE	35
4.9	CHECKING ROUTES	39
4.10	CONCLUSIONS	39
5.	NON BUS SERVICE CODING	40
5.1	SUBWAY SERVICES	40
5.2	FERRY SERVICES	40
5.3	RAIL SERVICES – SRTM / ATCOCIF CODING	40
6.	PUBLIC TRANSPORT FARES	43
6.1	CONTEXT	43
6.2	LOCAL BUS FARES	44
6.3	EXPRESS BUS FARES	64
6.4	RAIL FARES	66
6.5	SUBWAY FARES	69
6.6	FERRY FARES	70
6.7	SRTM INPUTS	71
7.	CALIBRATION OUTLINE	72
7.1	CONTEXT	72
7.2	AVAILABLE SURVEY DATA	72
7.3	BUS PASSENGER OCCUPANCY	75
7.4	RAIL PASSENGER COUNTS	76
7.5	RAIL LENNON DERIVED STATION TO STATION COUNTS	79
7.6	SUBWAY BOARDING AND ALIGHTING DATA	83

7.7	COUNT ADJUSTMENT TO COMMON YEAR	83
7.8	CALIBRATION APPROACH	84
8.	CALIBRATION RESULTS	87
8.1	BUS ROUTE DISTANCE CHECKS	87
8.2	BUS ROUTE JOURNEY TIME CHECKS	90
8.3	PUBLIC TRANSPORT FLOW RESULTS	96
8.4	CHANGES DUE TO MATRIX ESTIMATION	101
8.5	MATRIX SECTOR COMPARISON WITH CENSUS AND MOBILE PHONE DATA	106
8.6	AGGREGATED OUTPUTS	106
8.7	CONCLUSIONS	111

LIST OF APPENDICES

APPENDIX A – ENUMERATION CONTROLS

APPENDIX B – SCREENLINE SUMMARY ANALYSIS

APPENDIX C – LINK FLOW RESULTS



1. PUBLIC TRANSPORT ASSIGNMENT MODEL

1.1 Overview

1.1.1 The SRTM model structure is illustrated in the figure below.

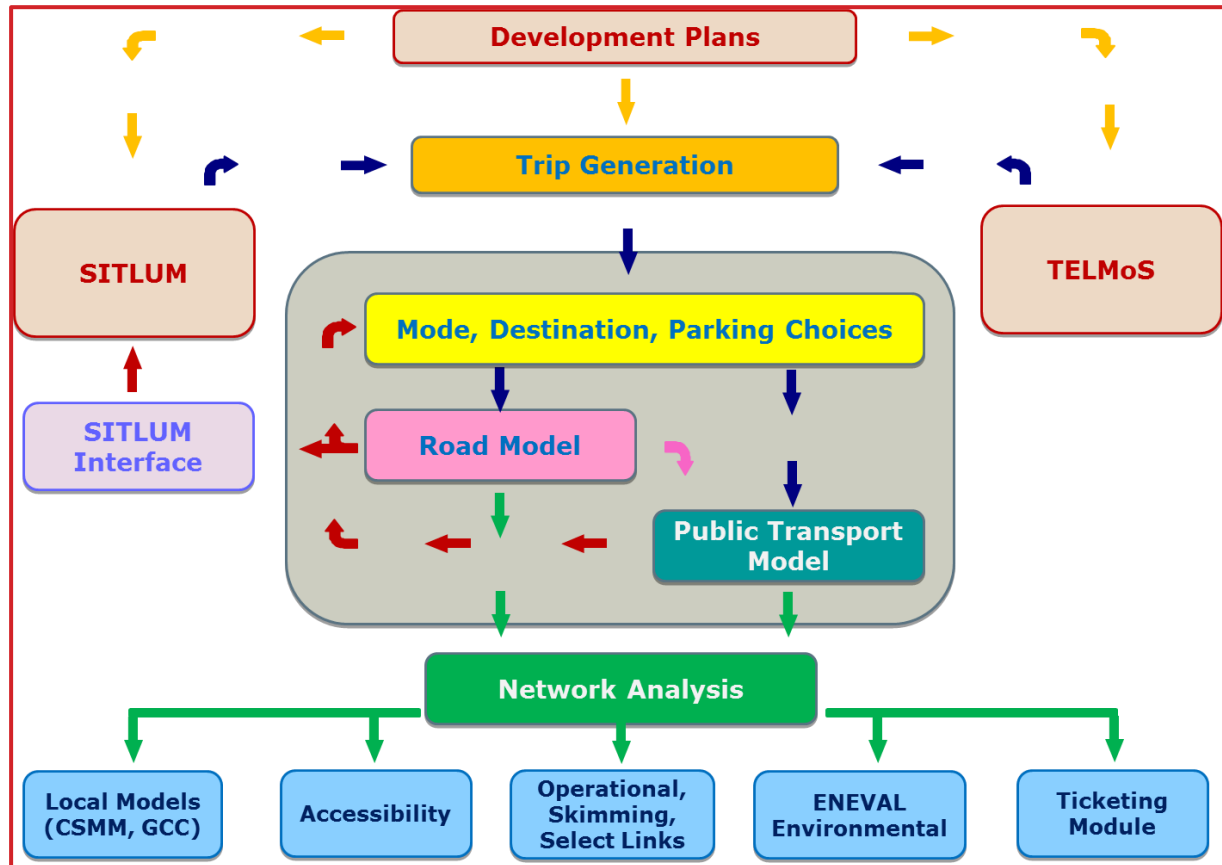


Figure 1 SRTM Model Structure

1.1.2 This note documents information related to the public transport model. The public transport model serves as the means by which public transport trips forecast from the demand model are loaded onto the public transport network. The process makes use of a number of subroutines detailed in this report.

1.1.3 The model operates over three time periods, those being:

- AM morning peak hour – 0800 to 0900;
- LT inter peak – average hour of 1000 to 1600; and
- PM morning peak hour – 1700 to 1800.

1.1.4 The choice of time period was to retain consistency with the higher level TMfS14 model, particularly important given the use of TMfS inputs for rail services, and to be consistent with the road model time period specification.

1.1.5 The model covers a variety of transport modes, with source data for busses from the SPT Corporate Database, for rail based modes from the higher level TMfS14 model and survey information from a variety of survey programmes undertaken by SPT and Transport Scotland over the last few years.

1.1.6 The peak period to peak hour factors are presented in Table 1.

Table 1. Road Peak Period to Peak Hour Factors

	AM	Lunchtime	PM
Peak Period to Peak Hour Factor	0.449	0.333	0.407

1.1.7 The remainder of this chapter documents the model processes.

1.2 Model Processes

1.2.1 An overview of the public transport assignment model processes is provided in the two figures overleaf.

1.2.2 The steps in the assignment model process are:

- Ticket Conversion module – stage to convert from demand model user classes into public transport model user classes;
- Build public transport network;
- Public Transport Assignment;
- Post Assignment Analysis; and
- Cost Conversion.

Ticket Conversion

1.2.3 This stage takes trip matrices segmented by demand model user class and factors to the public transport model user class based. These user classes and the relationship between them are listed in the table below.

Table 2. User Class to Ticket Conversion

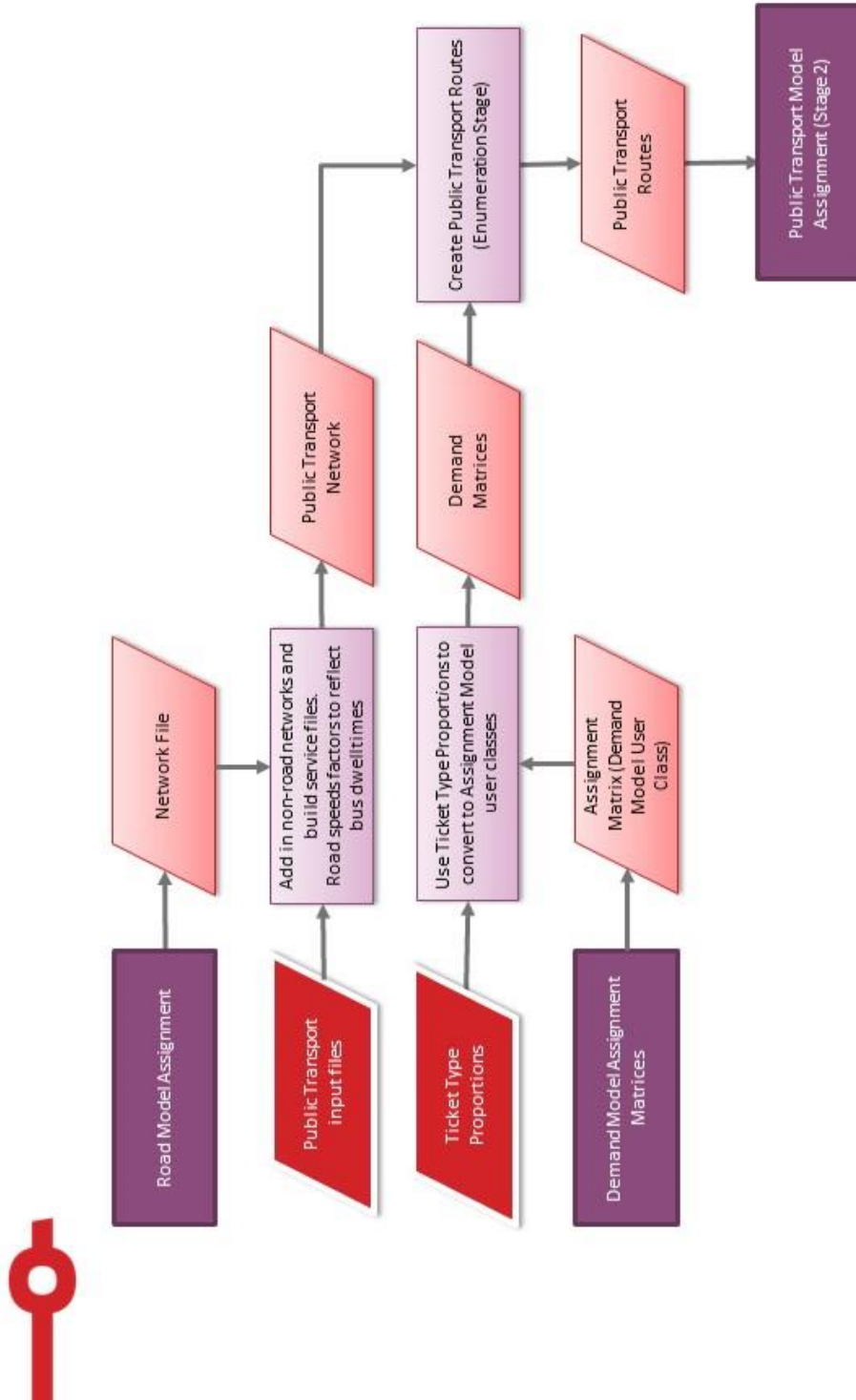
DEMAND MODEL USER CLASS	PT MODEL USER CLASS	LABEL	DESCRIPTION
EMP	Employers' Business	EBN	Employers' Business – Day Travel
COM	Commute	CMN	Commute – Day Travel
		CMS	Commute – Multi-Day Travel
OTH	Other	OTN	Others – Day Travel
		OTS	Others – Multi-Day Travel

DEMAND MODEL USER CLASS	PT MODEL USER CLASS	LABEL	DESCRIPTION
EDU	Education	EDS	Education – Multi-Day Travel
RET	Retired	RET	Retired

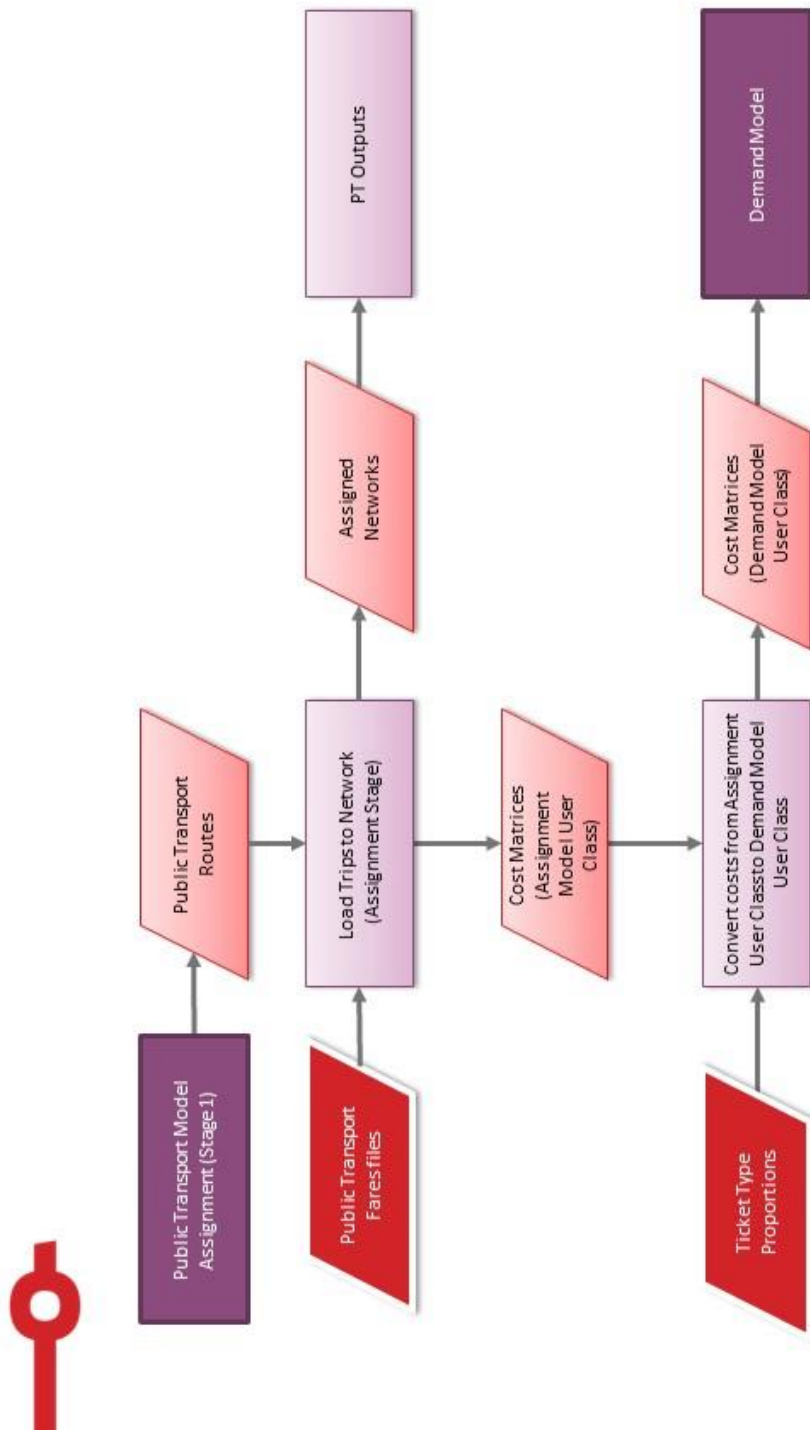
1.2.4 The process loads in the demand model trip matrices and applies factors to proportion the trips to the appropriate public transport model user class. Currently, these factors have been sourced from the rail industry’s Passenger Demand Forecasting Handbook (PDFH v5).



Public Transport Model Process (Stage 1)



Public Transport Model Process (Stage 2)



Build Public Transport Network

- 1.2.5 This stage takes the road network as output from the road assignment model and adds additional nodes and links to represent the railway, subway, ferry and walk network.
- 1.2.6 In addition, PT model user class specific factor files are generated with the appropriate value of time for the model run year.
- 1.2.7 The resulting network and factor files are then used in conjunction with the input public transport lines files to build a complete set of public transport inputs for the assignment model.

Public Transport Assignment

- 1.2.8 The public transport model takes the build network and service files and generates paths by PT model user class.
- 1.2.9 It does this through the two stage process of route enumeration followed by loading of the PT model user class matrices to the network.

Post Assignment Analysis

- 1.2.10 Following the loading of trips a variety of analysis routines are called using the output network and cost skims. The outputs from these represent the PT model outputs as documented in section 1.4.

Cost Conversion

- 1.2.11 The final stage of the public transport assignment model is to convert the costs for each demand model user class.
- 1.2.12 This is accomplished by weighting the travel costs from the assignment model by the ticket type factors used to proportion the trip matrices in the ticket conversion stage.

1.3 Model Inputs

- 1.3.1 The inputs to the public transport assignment model are either:

- Outputs from other model components; or
- Direct inputs from the user.

- 1.3.2 The inputs sourced from the other model components are:

- Public transport hourly trip matrices by demand model user class; and
- Time period specific road networks with post assignment road speeds.

- 1.3.3 The inputs from the user are listed below in Table 3, together with a reference to the subsequent section of this report where the input source information is discussed in detail.



Table 3. Public Transport Model Inputs

TYPE	SEGMENTED BY	CHAPTER
Ticket Conversion	for Commute and Others only	1
Factor Files	User Class	3
System File	N/A	3
Nodes files	Mode	2
Links files	Mode	2
Lines files	Mode	4/5
Fare System	N/A (used for other operators)	6
Fares Matrices	Operator Group, Time Period (used for First Group/McGills/Western Stagecoach)	6

1.4 Model Outputs

1.4.1 The public transport provides a range of output files, including:

- Cost skims for the SRTM demand model;
- Cost skims of various public transport trip components (walk time, wait time, etc);
- Cost skims of various public transport trip components by mode;
- Network file with volume loadings for each time period;
- Summaries of public transport loadings by line; and
- Rail boarding and alighting data via STOP2STOP analysis file.

1.4.2 The key outputs for operation of the model are the composite cost matrices for the next loop of the demand model.

1.4.3 All other outputs are broadly similar to those from the TMfS and other models. The difference is primarily due to differences in the number of time periods or user classes.



2. PUBLIC TRANSPORT NETWORK

2.1 Road Network

2.1.1 The road network has been sourced from a run through of the road assignment model using the final Phase 2 network.

2.1.2 A series of scripts are called that convert the road network into a format suitable for public transport.

2.1.3 These scripts accomplish the following tasks:

- Restrict the maximum speed on all road types to 56mph, this mainly effects motorway corridors; and
- Factoring the road speeds from the road model for rural roads (Capacity Index X), to reduce the speeds of bus services to match timetabled speeds. The factor values that were applied to achieve accurate bus journey times are provided below:
 - Motorway & Motorway Junctions 0.95
 - Rural Roads 0.6
 - Urban Roads 0.6
 - Simulation Roads 0.6
- Where a bus lane exists the low flow speed i.e. where speed/flow curves are not applied is used and multiplied by 0.9 to take account of reduced speed associated with bus stops on the bus lane.

2.1.4 The output network file is passed to the next stage that includes the rail and ferry links.

2.2 Rail / Ferry Network

2.2.1 The railway, subway and ferry only links from TMfS14 have been extracted and inserted into the appropriate SRTM network update files.

2.2.2 This has been done for consistency between the two models, especially for forecast year railway service coding.

2.3 Walk Network

2.3.1 The walk network represents the following types of links:

- Reverse direction walking on one way vehicular links;
- Ban Walking on Motorway Links;
- Pedestrianised streets, such as Buchanan Street;
- Routes to facilitate walk access to railway and subway stations;
- Routes to access ferries; and
- Connections at interchanges between platforms, such as Queen Street Low Level to High Level.

- 2.3.2 The reverse direction walking is obtained through scripts within the model. These scripts reformat the network available for walking (i.e. reverse direction non-Motorway links) as a dbf file. This dbf file is then reloaded within CUBE and links reversed and joined.
- 2.3.3 The pedestrianised streets have been sourced from the ITN layer and processed into records for the walk links and walk nodes files in a manner consistent with the road network build processes.
- 2.3.4 The routes to access railway and subway stations have been coded to include a single link to enable valuation of the boarding and alighting flows through link analysis.
- 2.3.5 Additional links have been manually added to reflect walk routes through parks such as Glasgow Green.
- 2.3.6 The walk link speeds have been set to 4.8kph for Glasgow City Centre (Sector 1) and 6.4kph for the remainder of the network.

2.4 Zone Connectors

- 2.4.1 The zone connectors are coded as per the road assignment model.
- 2.4.2 For external zones that represent railway links, additional zone centroids are coded through the walk links file. The road centroids for these zones are coded as link type 10, a link type that is excluded from the public transport generate script that connects zones to the network.
- 2.4.3 The external rail zone centroid is coded to the railway station nearest the external boundary.
- 2.4.4 Additional connector links have been coded for external zones that connect direct to the motorway, as walking is not permitted on motorway links
- 2.4.5 The connections from the zone centroids to the public transport network are specified through the NTL_Generate_Script – the non-transit leg generate script.
- 2.4.6 Walking connections are not allowed along motorways, railway tracks, subway tracks or ferry links.
- 2.4.7 This script establishes connections from each zone node to a public transport stopping node through a series of rules. These rules are as listed below:
 - If zone is in urban area of Glasgow (zones 1 to 377), set the maximum connection time for all modes to 15 minutes
 - If zone is not in urban area of Glasgow, set the maximum connection time for all modes to 30 minutes
 - Where a connector cannot be established extend the connector time in 15 minute increments to an hour;
 - Where a connector cannot be established extend the connector time in 30 or 60 minute increments to 3 hours;
- 2.4.8 Only two zones, zone 672 and 1221 required a three hour connection time, both were in rural areas remote to the public transport network.

2.5 Network Statistics

2.5.1 The additional network statistics are reported below in Table 4.

Table 4. Network Statistics

DESCRIPTION	TYPE	NUMBER	TOTAL LENGTH (KM)
Walk / Station to Road Links	25	636	96
Railway Links	11	1000	5,113
Subway Links	12	30	21
Ferry Links	30	10	93

2.5.2 As a check that the coding has been transferred correctly, the total rail network has been compared to the TMfS rail network. The TMfS rail network is 5,113 km, while the subway network is 21.3 km, which match the values in the above table.



3. PUBLIC TRANSPORT SYSTEM CODING

3.1 Modes

3.1.1 The modes contained within the SRTM are as outlined in the Inception report, though they have been reordered to match TMfS14 where possible.

3.1.2 The table below documents the seven transit modes and accompanying four non-transit modes

Table 5. Public Transport Assignment Model Modes

NUM	NAME	LONG NAME
1	LocalBus	Local Bus (Termed Urban Bus in TMfS14)
2	ExpBus	Express Bus (Termed Inter-Urban Bus in TMfS14)
3	Rail	Railway
4	Subway	Subway (Termed Underground in TMfS14)
5	Ferry	Ferry
6	Tram	Tram
7	Spare	Spare Mode
96	NTL_AE	NTL Access / Egress
97	NTL_AE	NTL Access / Egress (Park and Ride)
98	NTL_ZZZ	NTL Zone 2 Zone
99	NTL_Trans	NTL Transfer Legs

3.1.3 The rationale for the changed names for the two bus modes (LocalBus and ExpBus) is to retain as far as possible the naming conventions adopted within the SPT bus database.

3.2 Operators

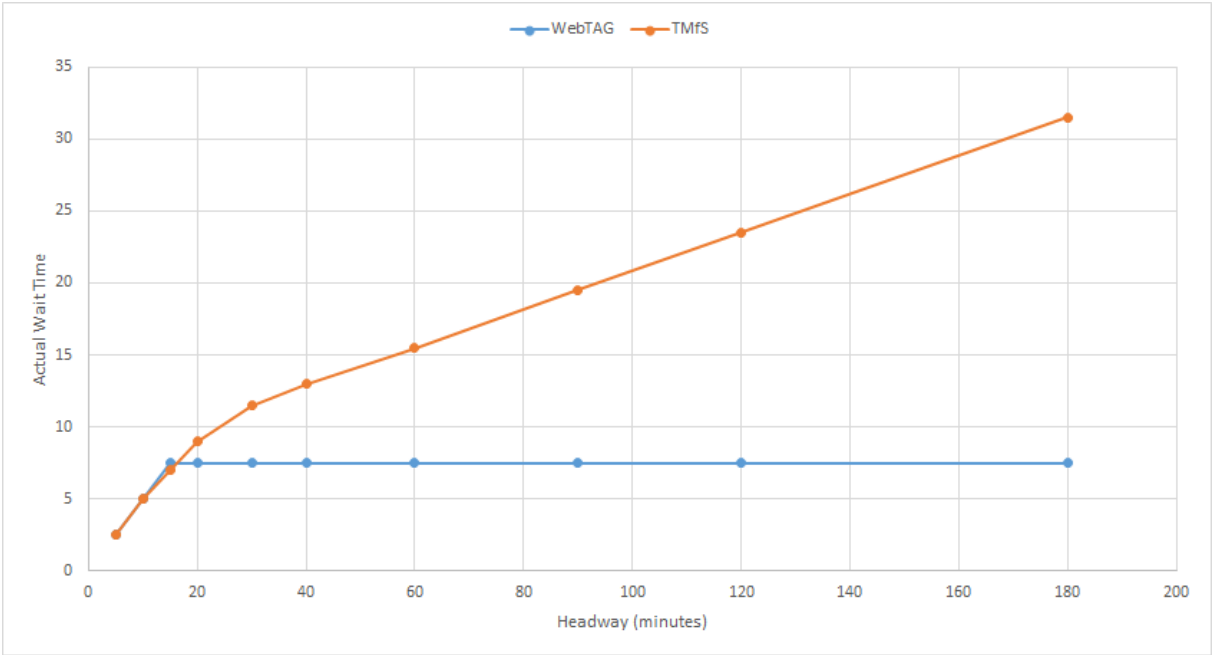
3.2.1 Each service within the public transport model are allocated to an operator. For bus services, the operator has been sourced from the SPT corporate database. The process for this is documented within Chapter 4.

3.2.2 Sources for the operators of other services is provided in Chapter 5.

3.3 Wait Curves

- 3.3.1 The calculation of average wait times will be done using wait curves. The figure below illustrates wait curves from WebTAG guidance (Unit M3.2, section 3.2) and the default TMfS wait curve that we will adopt in SRTM.
- 3.3.2 The graph below illustrates the “actual walk time”, this is the name of the Cube skim output and represents the unweighted waiting time within the model at a specific headway. The assignment model uses the “perceived wait time” defined as the actual wait time below multiplied by the wait time factor.

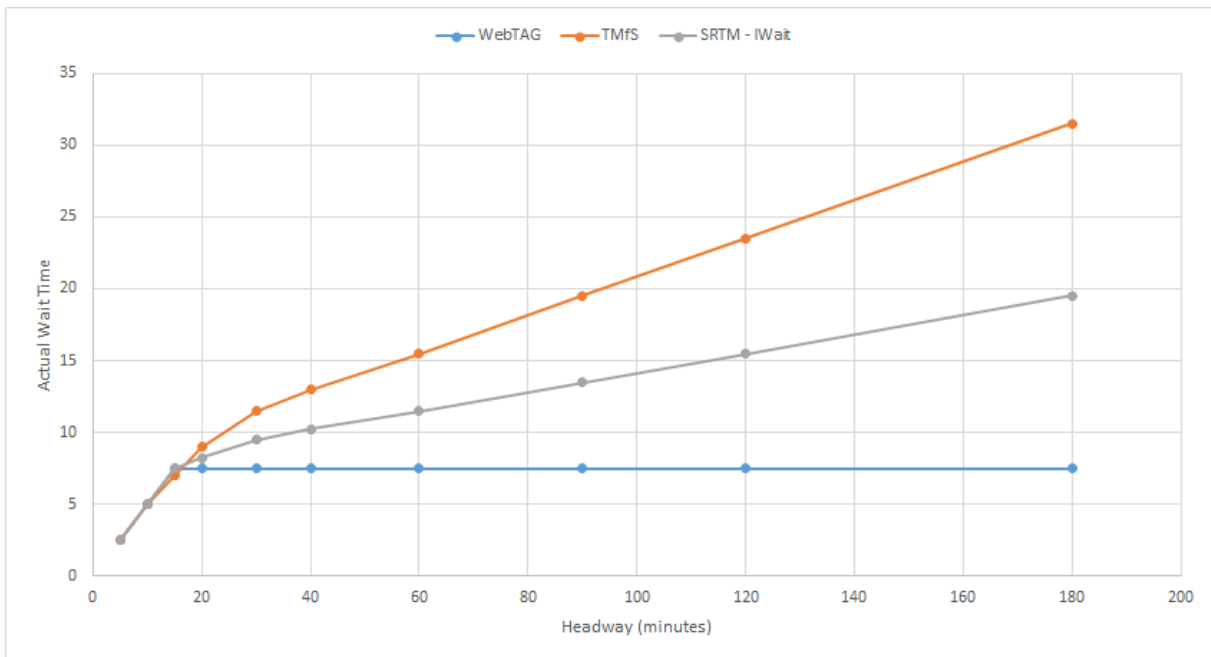
Figure 4. Wait Curves



- 3.3.3 As can be seen, the curves are comparable for frequent services, where the effective headway is lower than 20 minutes.
- 3.3.4 We have developed two wait curves, one for the Initial Wait and one for subsequent waits after interchange.
- 3.3.5 The initial wait curve has been defined as the mid-point of the TMfS / WebTAG curves. This has limited impact for the majority of services / service clusters where the effective headway will be below 20 minutes.
- 3.3.6 This curve is illustrated in the figure below.

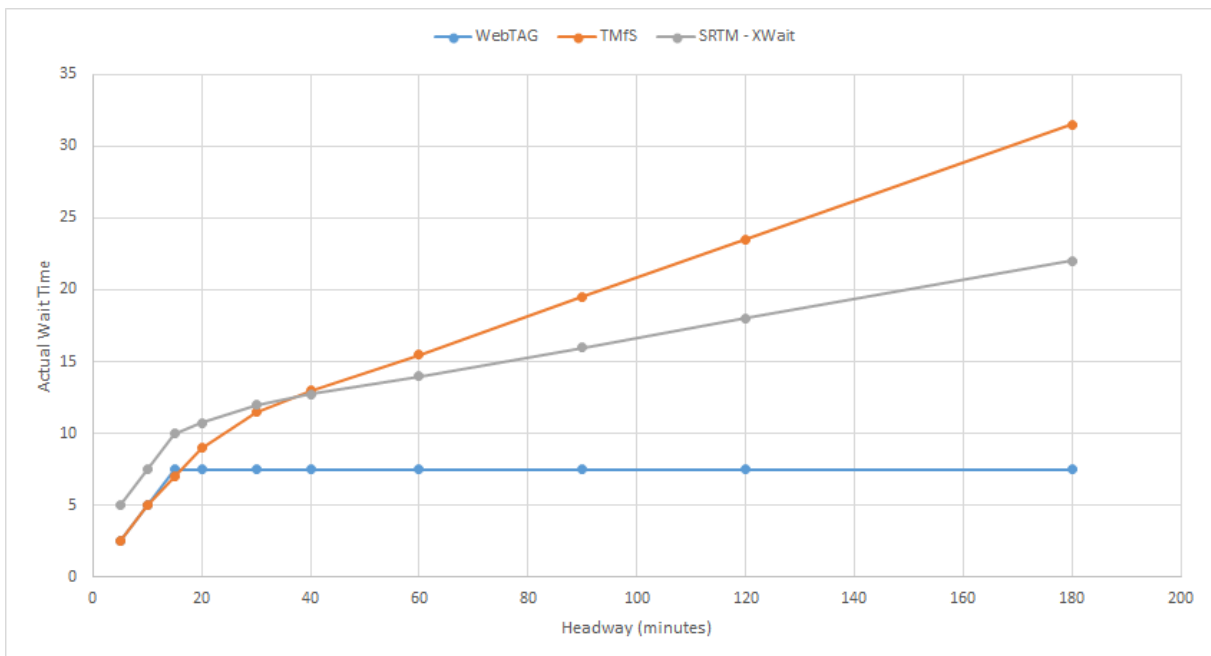


Figure 5. Initial Wait Curves



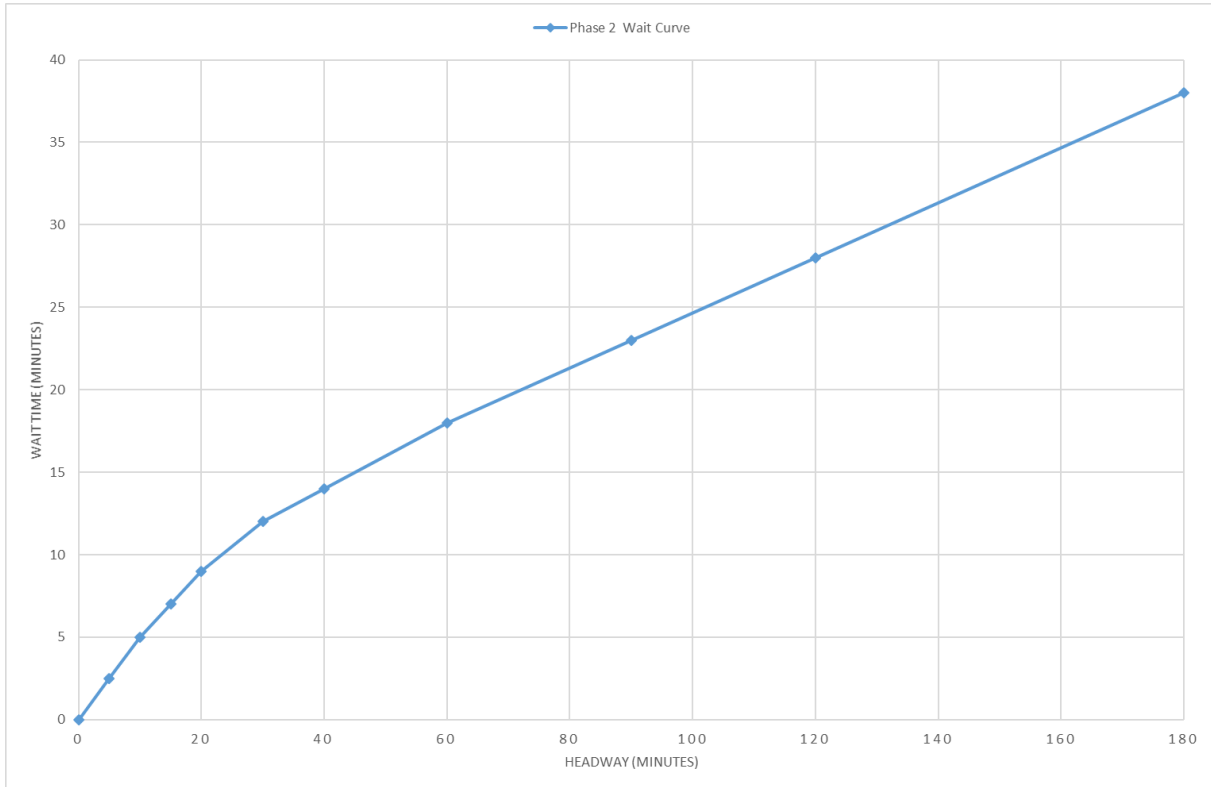
3.3.7 The wait curve for non-initial waits has been set to be the same curve as above, but with an additional five minutes of perceived time (2.5 minutes added to the wait curve) to reflect the uncertainty of connections. This curve is illustrated together with the TMfS and WebTAG curve in the following figure.

Figure 6. Transfer Wait Curves



3.3.8 Following a review of this approach in the Phase 1 model, and discussions with the auditor, it was decided to revert to a TMfS based wait curve for both the initial and transfer wait curve in Phase 2 of the model. Thus the final wait curve is as displayed in the figure below:

Figure 7. Phase 2 Wait Curves



3.4 Crowding Curve

3.4.1 The crowding curves, which are only applied to the Rail modes, have been updated from the versions used in TMfS14, making use of the guidance given in PDFH v5 Chapter B6.

3.4.2 Table B6.2 of this guidance represents the time multipliers to reflect the discomfort of crowding. This table has been reproduced below as Table 6.

Table 6. PDFH Table B6.2 – Recommended VoT multipliers

LOAD FACTOR	LONDON SOUTH EAST		REGIONAL		INTERCITY	
	SIT	STAND	SIT	STAND	SIT	STAND
60%	1.00	na	1.00	na	1.00	na
70%	1.00	na	1.00	na	1.02	na
80%	1.01	na	1.01	na	1.03	na
90%	1.03	na	1.04	na	1.05	na
PASS / M²						
0.0	1.06	1.52	1.08	1.45	1.07	1.89
0.5	1.11	1.59	1.21	1.60	1.13	2.01
1.0	1.16	1.65	1.34	1.74	1.19	2.11
1.5	1.21	1.73	1.47	1.89	1.25	2.23
2.0	1.25	1.79	1.6	2.03	1.32	2.34
2.5	1.30	1.87	1.73	2.18	1.38	2.46
3.0	1.35	1.93	1.86	2.33	1.43	2.57
3.5	1.40	2.00	1.99	2.48	1.50	2.70
4.0	1.44	2.07	2.12	2.62	1.56	2.80
4.5	1.49	2.14	2.25	2.78	1.63	2.93
5.0	1.54	2.20	2.38	2.92	1.68	3.05
6.0	1.63	2.34	2.64	3.21	1.81	3.31



- 3.4.3 For the railway network, we have made use of the Regional values above, while for the Subway crowding curve we have used LSE to reflect the more urban nature of the Subway service.
- 3.4.4 The TMfS14 rail service file was analysed by coded SEATCAP and CRUSHCAP values. In total 20 variations of SEATCAP and CRUSHCAP were identified within the service file, as indicated in the table below. The Group is named as SEATCAP_CRUSHCAP, thus the first group 136_190 represents 136 seats and crush capacity of 190.
- 3.4.5 These values were compared with data within PDFH v5 to identify an appropriate railway vehicle class and from this a standing space (in m2) was sourced.

Table 7. TMfS Services Grouped by Coded Capacities

GROUP	SERVICE COUNT	STANDING SPACE	CURVE	RATIONALE IF NO CURVE
136_190	27	32	Y	
145_203	49	30	Y	
183_256	17	32	Y	
192_269	186	32	Y	
212_297	12	56	Y	
218_305	2	68.8	Y	
219_307	14	68.8	Y	
230_322	32	65.1	Y	
230_360	1	65.1	Y	
252_353	9	75.9	Y	
272_381	8		N	Double version of 136_190
290_406	15		N	Double version of 145_203
366_512	34		N	Double version of 183_256
382_538	1		N	Double version of 192_269
384_538	21		N	Double version of 192_269
400_560	37		N	Intercity Services
408_571	2		N	Low sample

GROUP	SERVICE COUNT	STANDING SPACE	CURVE	RATIONALE IF NO CURVE
438_613	1		N	Low sample
458_640	15		N	Double version of 230_322
460_644	2		N	Double version of 230_322

3.4.6 Further investigation revealed that only the first 10 records were unique and included services within the SRTM modelled area. Of the remaining 10, 7 represented a double formation of an earlier record, another represented the capacity of InterCity / cross border railway services while the remaining two represented internal Scotland services that are locomotive hauled.

3.4.7 As the latter two represented only three services it was decided to process curves for the first ten records that (together with their two unit variants) represented 92% of all coded services.

3.4.8 The approach used took as input the seating capacity and crush capacity from the TMfS coding. Then, using PDFH Table B6.6, the rolling stock unit was identified and the standing space was identified.

3.4.9 From these three inputs, the following attributes were calculated for each 10th percentile of crush capacity:

- Number of passengers at x0% of crush loading;
- Calculate effective load factor (as a proportion of seats)
- From load factor, extract the Sit and Stand factor from Table 6; and
- Obtain the average factor, by weighting the sit factor by seated passengers, and the stand factor by standing passengers.

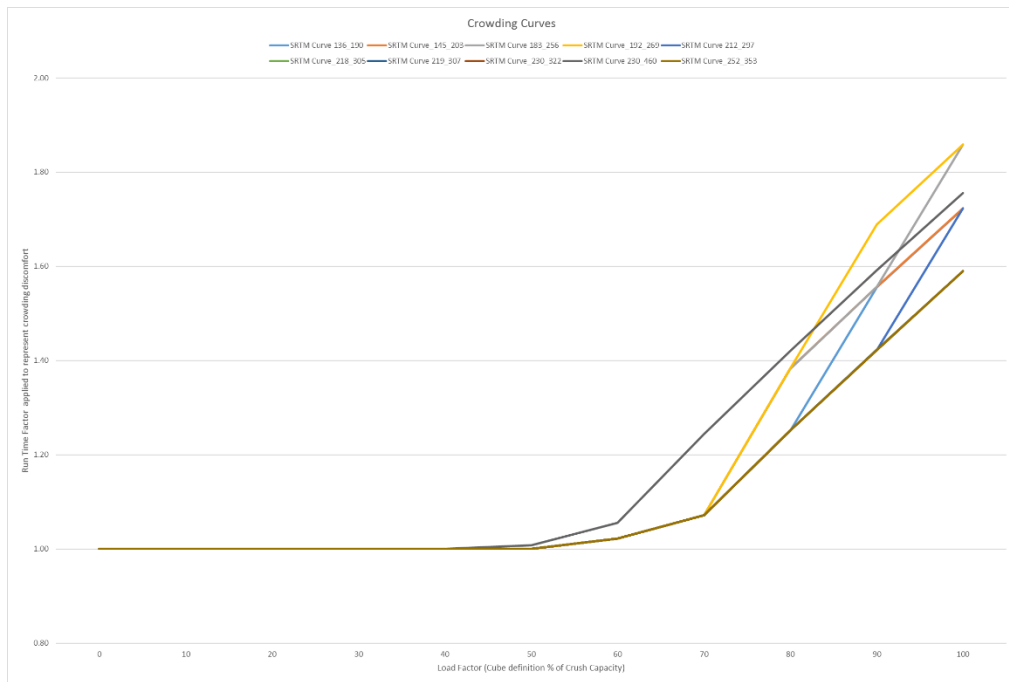
3.4.10 It should be noted that we have assumed that if a seat is available, it will be used.

3.5 Output Rail Mode Crowding Curves

3.5.1 The output crowding curves are documented in the table below by ten percentile of crush capacity, and through the chart below.

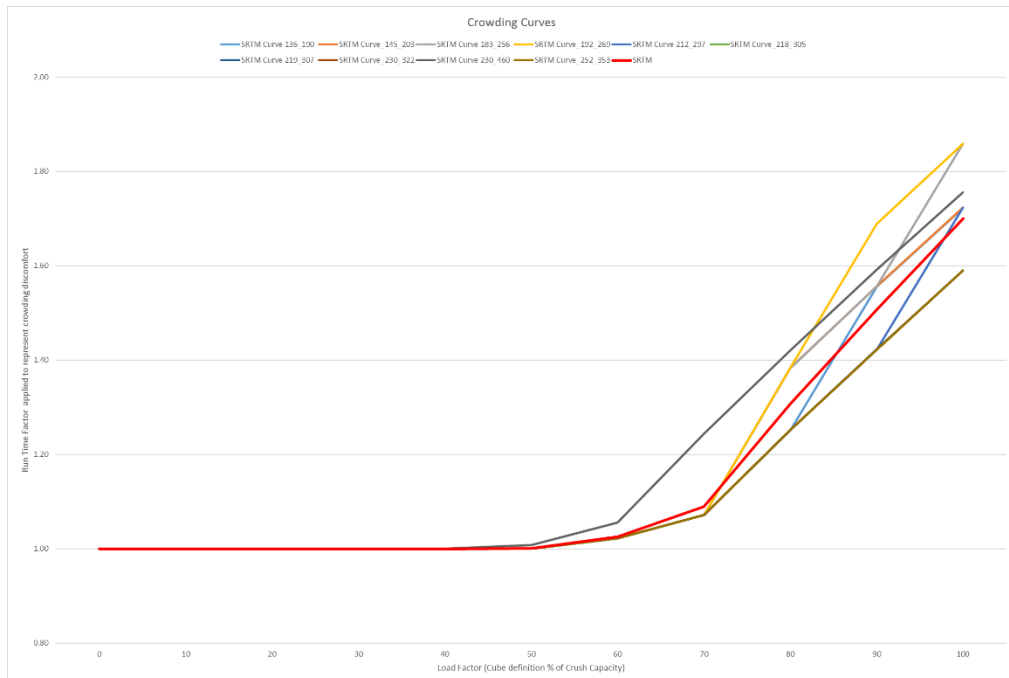


Figure 8. Service Group Crowding Curves



3.5.2 These represent a range of crowding curves on a rolling stock basis. These differ primarily due to a different ratio of seats to standing space by rolling stock. The final SRTM rail crowding curve has made use of the average value and is displayed as the thick red line in the following figure.

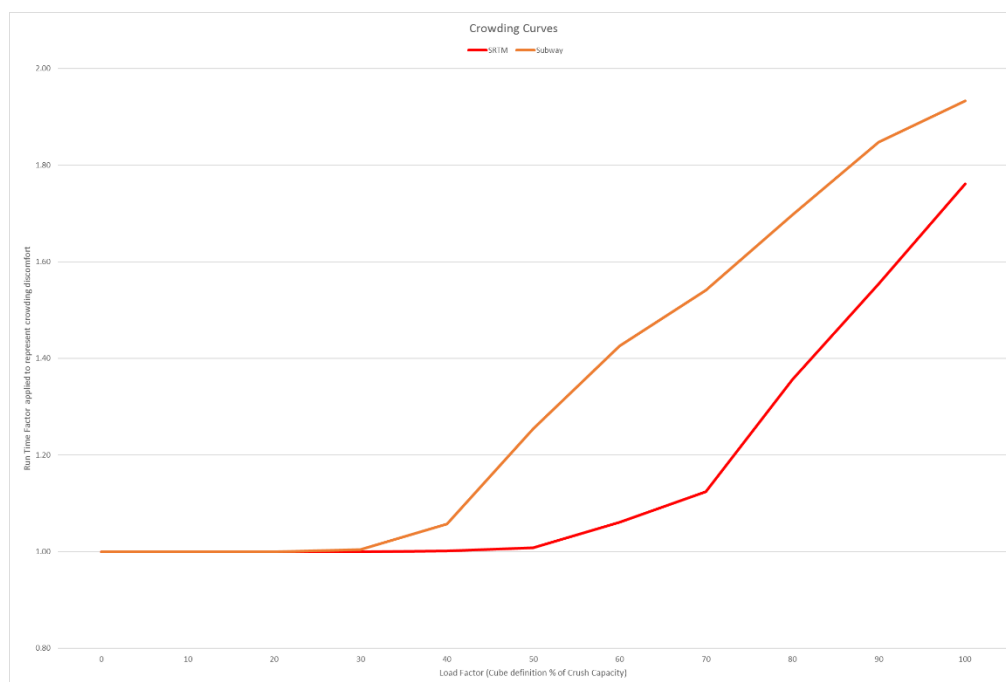
Figure 9. Service Group Crowding Curves with Average



3.6 SRTM Crowding Curves

- 3.6.1 Given that the key determinant of differences in crowding curve by rolling stock is the ratio of seating to standing space, it was decided to calculate a crowding curve for the Subway.
- 3.6.2 This has been based on the coded seating capacity of 112, a crush capacity of 277 and the standing space of 34 sq m. The capacity inputs were sourced from TMfS, with the space obtained for the new rolling stock from published specifications.
- 3.6.3 The resulting crowding curves for rail and subway are illustrated in the figure below.

Figure 10. Rail and Subway Crowding Curves



3.7 Other Parameters

- 3.7.1 The public transport assignment model requires a number of parameters to operate. Although these parameters are coded within user class specific factor files, the majority of the parameters will be constant across each user class.
- 3.7.2 The parameters that change are the values of time, supplied via an input database, and the fare system definition.
- 3.7.3 The constant parameters fall into seven categories:
- Generalised Cost
 - Enumeration Controls, that form the parameters for the path building algorithms;
 - In Vehicle Time factors;
 - Boarding Penalties;
 - Interchange Penalties;
 - Wait Time Parameters; and
 - Walk Time Parameters.

3.7.4 Each of the above controls is discussed in a subsequent section.

Generalised Cost

3.7.5 The Value of Time for the base year of 2014 (£/hr) is shown in table 8 below:

Table 8. SRTM Value of Time parameters

User Class	VoT £/hr
In- Work	16.958
Non - Work	6.621

Enumeration Controls

3.7.6 These parameters govern the path building process within the assignment model.

3.7.7 The initial values were sourced from the SRM12 model. They have been subject to change during the calibration process with the final values included in Appendix A to this note.

In Vehicle Time Factors

3.7.8 The in-vehicle time factor is a weighting applied to the travel time spent within the transit vehicle. This varies by mode, to represent the differing perceptions of each mode.

3.7.9 Our starting values are sourced from TMfS14, these being reproduced below in Table 9.

Table 9. TMfS In Vehicle Time Factors

VOT	TP	ZD	TMFS MODE					
			Local Bus	Express Bus	Rail	Subway	Ferry	Tram
IW	ALL	ALL	1.4	1.3	1.0	1.0	1.0	1.0
NW	ALL	ALL	1.4	1.2	1.0	1.0	1.0	1.0

Notes: VOT => Value of Time, either IW = In Work or NW = Non Work

TP=> Time Period, PK = Peak periods or IP = Inter Peak

ZD=> Zero Demand, Y = Yes or N = No

3.7.10 These parameters have been translated into the equivalent time period and user class specific SRTM values, as documented in the table below.



Table 10. SRTM Starting In Vehicle Time Factors

USER CLASS	TP	SRTM MODE						
		Local Bus	Express Bus	Rail	Subway	Ferry	Tram	Spare
Calibration Start	ALL	1.4	1.3	1.0	1.0	1.0	1.0	1.4
Final Calibration	ALL	1.1	1.0	1.0	1.0	1.0	1.0	1.0

Notes: User Classes=> As listed in Table 2

TP=> Time Period, either PK = Peak periods or IP = Inter Peak

3.7.11 These parameters were updated during model calibration, with the final values common across user classes and as reported in the table above.

Boarding Penalties

3.7.12 Boarding penalties are mode specific penalties that add the specified time penalty to each service boarded.

3.7.13 The default value will be 0, however a mode specific boarding penalty will be coded into the wait curves to enable the testing of softer measures at boarding points as discussed above.

3.7.14 These parameters are subject to change through model calibration.

Interchange Penalties

3.7.15 Interchange penalties are additional time coded into the model to represent the inconvenience of transferring between the modes of the public transport system.

3.7.16 The default interchange penalties are shown in the figure below:



Table 11. Default Interchange Penalties

MODE		1	2	3	4	5	6	7
1	LOCAL BUS	10	10	10	10	10	10	10
2	EXPRESS BUS	10	10	10	10	10	10	10
3	RAIL	10	10	5	5	10	10	10
4	SUBWAY	10	10	5	5	10	10	10
5	FERRY	10	10	10	10	10	10	10
6	TRAM	10	10	10	10	10	10	10
7	SCHOOL BUS	10	10	10	10	10	10	10

- 3.7.17 The default parameters adhere to WebTAG guidance (TAG Unit M3.2 – 3.1.5), with the lower time based on the facilities provided for interchange between the Subway and the national rail network.
- 3.7.18 Due to the way Cube Voyager operates, the minimum value of these penalties (5 minutes) is included within the boarding penalty. Thus, for the above default interchange penalties, the interchange value is thus coded as the time penalty in the above table reduced by 5 minutes.
- 3.7.19 This is because only boarding penalties are included within the route enumeration (path building) stage.
- 3.7.20 During model calibration, modification to the boarding penalties was applied to achieve a better sub-mode split in the model. This involved increasing the penalty for transfer from rail and subway to bus to increase walking for (primarily) city centre egress.
- 3.7.21 The final interchange penalties are shown in the figure below:



Table 12. Final Interchange Penalties

MODE		1	2	3	4	5	6	7
1	LOCAL BUS	10	10	10	10	10	10	10
2	EXPRESS BUS	10	10	10	10	10	10	10
3	RAIL	15	15	15	15	15	15	15
4	SUBWAY	15	15	15	15	15	15	15
5	FERRY	10	10	10	10	10	10	10
6	TRAM	10	10	10	10	10	10	10
7	SCHOOL BUS	10	10	10	10	10	10	10

Wait Time Factor

3.7.22 The wait time will be valued at 2 times the value of in-vehicle time, in line with the mid-point of WebTAG guidance (TAG Unit M3.2 – 3.1.5).

Walk Time Parameters

3.7.23 The walk time will be valued at 1.6 times the value if in-vehicle time, in line with the values used in TMfS14 and consistent with WebTAG guidance of using a value between 1.5 and 2.0 (TAG Unit M3.2 – 3.1.5).



4. BUS SERVICE CODING

4.1 Overview

- 4.1.1 The bus services have been coded through a semi-automatic process using data from the SPT corporate database.
- 4.1.2 The database contains all bus services registered to operate within the Strathclyde area. In summary, the approach forms a database of service information required for Voyager from the information supplied by the SPT database.
- 4.1.3 The database was supplied with a GIS shapefile providing a route map for each service. The shapefile is then processed in conjunction with the SRTM network to produce a template lines file containing route information only, using CUBE building tools.
- 4.1.4 The next stage will be a process that matches the output lines file to the Voyager database to incorporate all of the required data.
- 4.1.5 The final stage is a manual adjustment process using SYSTRA tools to update specific routes where the CUBE build routes from shapefile tool has departed from the shapefile route.
- 4.1.6 The steps to convert from the SPT corporate database information to SRTM bus lines coding is illustrated through Figure 11 and Figure 12.



SPT Database Process (Stage 1)

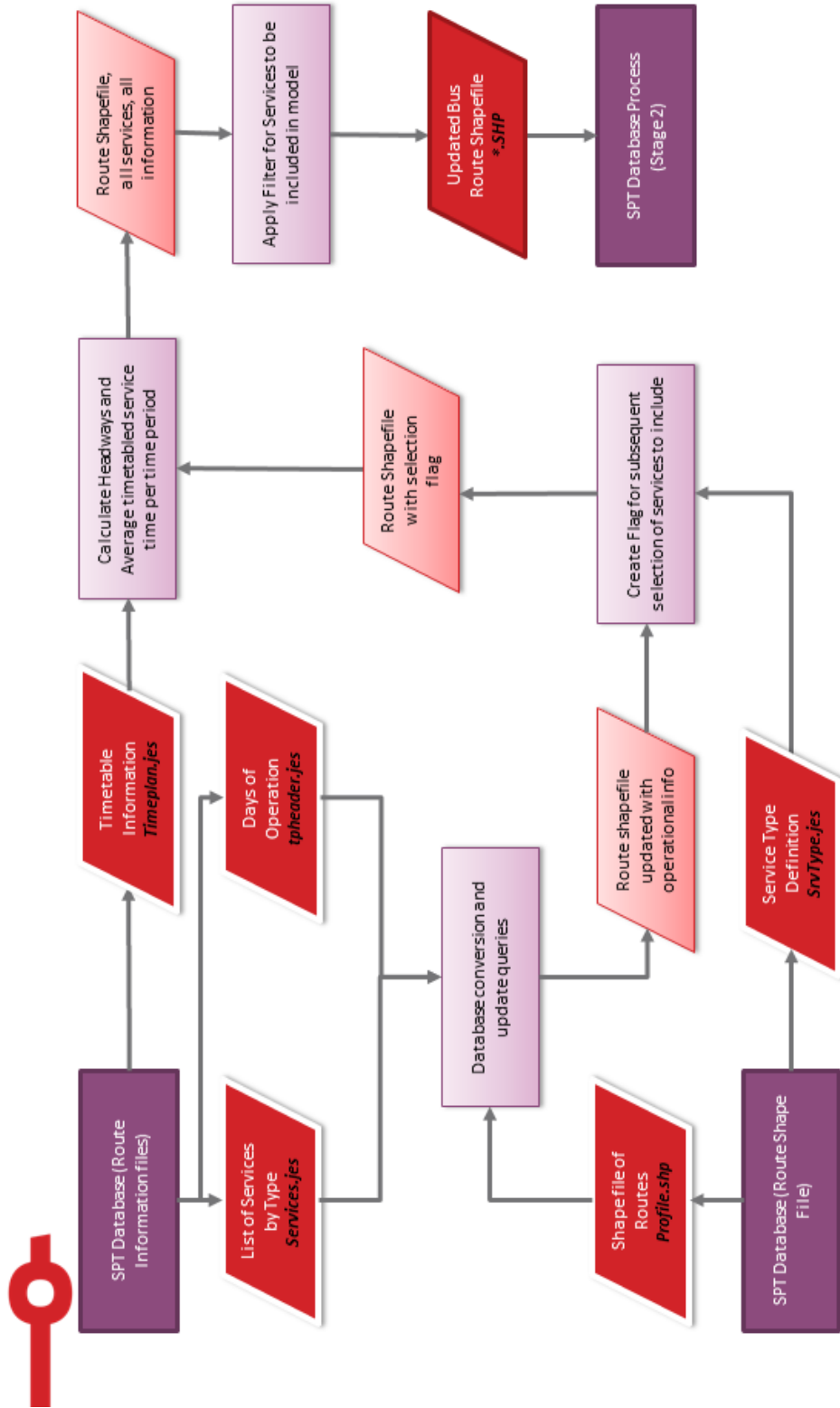


Figure 11. SPT Database Process – Stage 1

SPT Database Process (Stage 2)

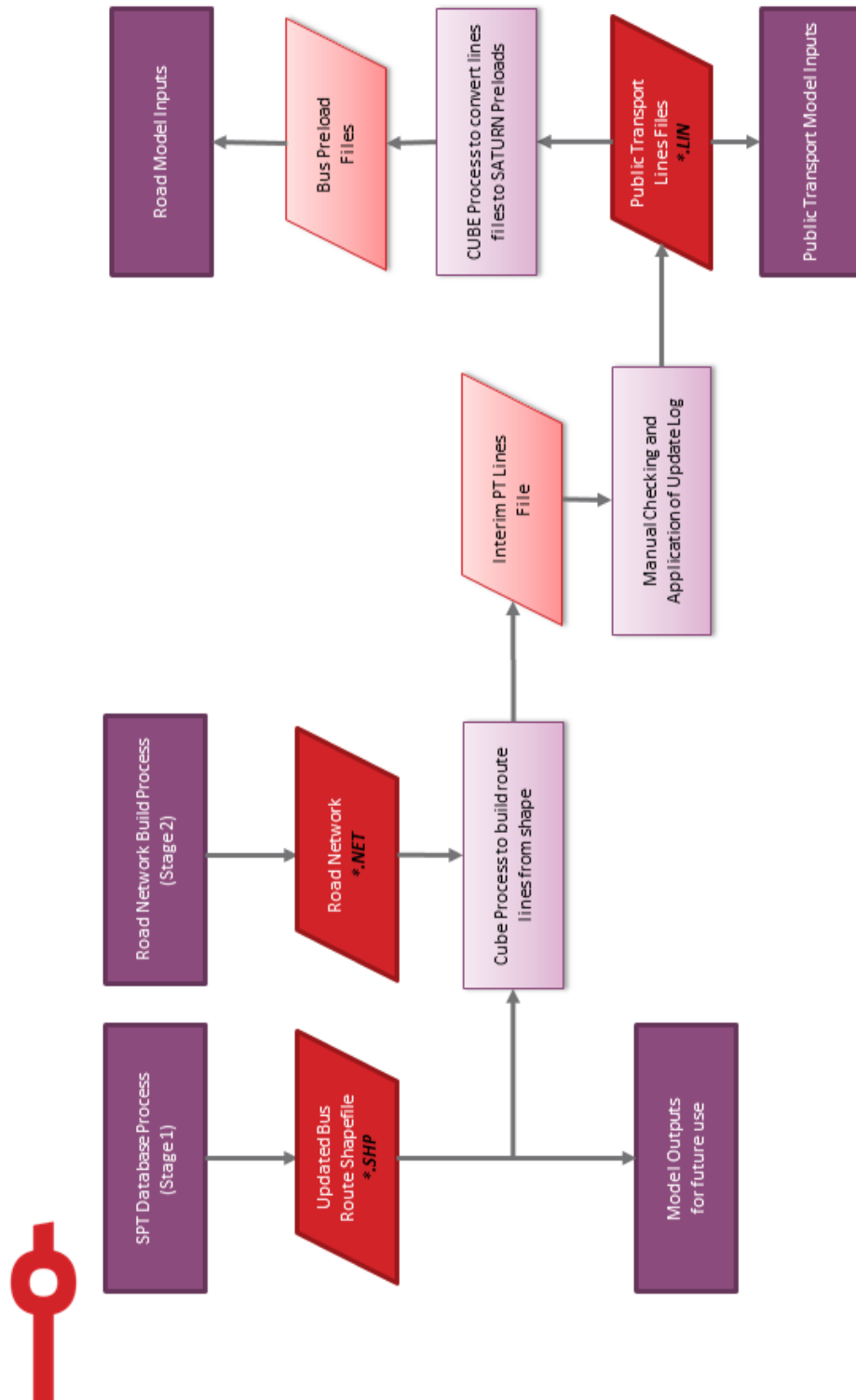


Figure 12. SPT Database Process – Stage 2

4.2 Data Sources

4.2.1 The data used in the construction of the SRTM bus route files was:

- SPT supplied Integrated Transport Network layer data (this is the standard Ordnance Survey ITN layer with additional links for SPT bus services);
- SPT supplied bus route shapefile (March 2016);
- SPT supplied bus route JES export files (March 2016);
- SPT supplied bus stop shapefile (March 2016);
- Google Maps / Earth; and
- Various background mapping layers to aid visualisation.

4.3 Time Period Definition

4.3.1 Table 13 below restates the specification of time periods for the SRTM model.

Table 13. Time Period Definitions

MODEL	DESCRIPTION	CODE	TIME DEFINITION
SRTM	Morning Peak	AM	0700 to 1000
	Lunch Time	LT	1000 to 1300
	<i>School Run</i>	SR	<i>1300 to 1600</i>
	Evening Peak	PM	1600 to 1900
	Off Peak	OP	1900 to 0700

4.4 Methodology

4.4.1 SPT provided March 2016 service details and shapefile on 6th April 2016. The analysis within this report is based on the March 2016 services.

4.4.2 SPT have also stated that although they retain service information records in their database, they do not retain shapefiles, thus this removes our ability to use this process to generate lines file for services concurrent with the 2014 survey programme.

4.4.3 Furthermore the shapefiles created prior to August 2015 made use of the OSCAR (road centreline) database rather than the OS ITN layer. Hence, even if the data were available, it would use a database of roads inconsistent with the SRTM road network.

4.4.4 Consequently, the bus services within SRTM will be present day services from the March 2016 timetable.

4.4.5 While there will have been changes since the various data collection programmes / model 2014 base year and the services operated in 2016, unfortunately there is no efficient way to check this. This is because although the service database exists, the route shapefile has not been retained.

4.4.6 The process has been undertaken within an Access database and related macros, with the stages undertaken listed below:

- Load the SPT supplied bus route JES export files into Access database – undertaken through a macro import of the files required by the process;
- The process then runs through six queries, these performing the following;
 - Load the timeplan data and calculate the start and end time, defined in minutes from midnight, for each service (defined as each ‘profile’ and ‘PT Seq #’ combination).
 - Calculate the duration of each journey from start and end times, together with the mid-time of the journey. From the mid-point time allocate to time period based on the definitions in Table 13.
 - For each service assign a daily factor for each weekday of 0.2 if the service runs on that day or 0 if it does not. School services are considered a special case, as due to school holidays they are defined in the database as running only on exceptional days, thus their weekday pattern is not defined. These services have thus been assumed to run on all weekdays.
 - Sum the daily factors to produce a weekly weight between 0 and 1 representing the average number of weekdays the service is operational. For example a service that only runs on Fridays will count as 0.2 services. This avoids double counting routes that have services recorded separately on different weekdays and disregards weekend-only services.
 - The next query is a reorder query to ease formatting later. Furthermore, at this stage all off-peak and weekend-only services are dropped and service counts are weighted by the weekly weight factor.
 - The next step calculates headways and average service durations for the SRTM time periods. The query also registers supplementary operator and service information from various JES tables for each route.
 - The next process is a stage to remove services on the Isle of Arran from the output, as the island is external to the STM modelled area. The Cluster table is queried according to stop description. This is then cross checked against a list of locations on the Isle of Arran and each service is given a binary variable for being on the island or not.
 - The final query removes any services that have any presence on the Isle of Arran.
- Update the database profile table with the values required for the bus lines file, such as operator code, mode number, headway and additional user specific parameters such as timetabled journey times to enable subsequent checking of model output;
- Update bus route shapefile with data from output database, using the route profile ID as the join field; and
- Use Cube in built “Build PT Lines from SHP” tool to create bus lines using prevailing road network file.

4.4.7 A subsequent stage will be the manual checking of routes and the repeating of the final stage of the above process upon finalisation of the road network.

4.5 Service Type Selection

4.5.1 The SPT Bus Databases contains 10 specific types of services, including Ferry and Subway

services.

4.5.2 The table below documents the types retained in SRTM, together with the SRTM mode, and where applicable the rationale for exclusion.

Table 14. Service Type Definitions

CODE	DESCRIPTION	MODE	INCLUDED	RATIONALE
EX	Express Service	2	Yes	
FE	Ferry Service		No	Ferries included by import of TMfS14 coding
FS	Football Special Service		No	Time of operation not included in SRTM assignment
HS	Hospital Service	1	Yes	
LO	Local Services	1	Yes	
NS	Night Services		No	Time period not included in SRTM assignment
PS	PostBus Services		No	Tourist focussed
SL	Schools / Local Services	7	Yes	
TO	Tour Services		No	Tourist focussed
UG	Underground Services		No	Subway included by import of TMfS14 coding

Source: SPT Bus Database – January 2016 Export files

4.6 Operator Codes

4.6.1 Operator codes have been define to maintain consistency with TMfS for the non-bus modes, with bus operators being defined from the SPT corporate database.

4.6.2 The table below illustrates the relationship between TMfS and SRTM operator codes.

Table 15. TMfS to SRTM Operator Relationship

SRTM CODE	LONG NAME	TMfS CODE
1	ScotRail – National	1
2	ScotRail – SPT	2
3	ScotRail – Highlands	3
4	ScotRail – Northern Highlands	4

SRTM CODE	LONG NAME	TMFS CODE
5	East Coast Intercity Rail	5
6	West Coast Intercity Rail	6
11	SPT Subway	11
12	SPT Renfrew Ferry	101
13	Cal Mac Ferries	102
14	Western	104
15	SPT Kilcreggan Ferry	108

4.6.3 We have set the CUBE NAME parameter for the non-bus operators to “TMfs” followed by the TMfS code number.

4.6.4 The bus operator codes are set from 101 onwards, with the CUBE NAME parameter set to the SPT corporate database operator code and the LONGNAME parameter set to the SPT operator name for cross checking purposes.

4.6.5 The version of the corporate database used has 59 district bus operators.

4.7 Headway Checks

4.7.1 We have undertaken a sample of spot checks on the coded headways, based on comparison to published timetables available on the web.

4.7.2 We have done these for a selection of First Group, McGills and Stagecoach Western services. These are summarised below:

Table 16. Bus Service Headway Checks

Operator	Service	Direction	TIMETABLED SERVICES			MODELLED SERVICES		
			AM	IP	PM	AM	IP	PM
First	10	Outbound	14	30	14	14	30	14
		Inbound	15	31	12	13	30	12
First	57	Outbound	16	30	11	15	30	13
		Inbound	15	30	15	15	28	12
First	57a	Outbound	17	30	11	17	30	12
		Inbound	15	30	13	13	30	13

			TIMETABLED SERVICES			MODELLED SERVICES		
First	19	Outbound	7	12	6	5	14	5
		Inbound	6	12	4	6	12	3
First	19a	Outbound	6	12	5	6	12	6
		Inbound	7	12	5	7	12	5
First	1	Outbound	9	12	4	8	12	5
		Inbound	8	14	5	6	12	6
First	1A	Outbound	7	12	5	7	12	6
		Inbound	8	12	5	8	12	5
First	1E	Outbound	2	0	0	3	0	0
		Inbound	0	0	3	0	0	3
First	38	Outbound	19	35	17	19	35	18
		Inbound	24	34	16	24	36	19
First	38B	Outbound	8	15	7	8	12	7
		Inbound	5	12	1	4	10	2
McGill's	54	Inbound	10	18	9	10	18	9
		Outbound	9	18	9	9	18	9
McGill's	14	Inbound	3	6	1	3	6	2
		Outbound	4	6	1	3	6	3
Stagecoach	X11	Inbound	1	6	1	1	6	2
		Outbound	1	5	2	1	6	2
Stagecoach	X77	Inbound	6	12	4	6	12	5
		Outbound	9	12	11	8	12	10

4.7.3 In the majority of cases, the coded headway matched the timetables, in the instance where this was not the case this was primarily high frequency services that were different by a single service.

4.7.4 This is likely to be caused by the time period definition, as this is based on the mid-point time within the database scripts, whereas the manual check was based directly on the service start time.

4.8 Building Routes from Shapefile

4.8.1 The shapefile supplied by SPT representing the routes of bus services was updated to include the following records from the database processing tool:

- Mode and Operator Code;
- Headway for each time period; and
- Vehicle Type and associated seating and crush capacity.

4.8.2 The resulting shapefile was then input into CUBE via a Graphics module and the Build PT Lines file from shape tool was used to convert the shapefile into bus lines.

4.8.3 While the tool successfully processed the shapefile, the following three main issues were identified:

1. Some routes were not within the SRTM area (for example services on the Isle of Arran) and thus the process failed to generate a node list;
2. The bus services performed loops in order to obtain a valid route; and
3. The bus services deviated off the shapefile route due to finding an incorrect node.

4.8.4 Issue one is straightforward, but the reasons behind issues two and three required further investigation, the outcomes of which are described below

Issue 2 – Bus Service Looping

4.8.5 The bus service looping issue is as a consequence of the SPT Corporate database, in places, seeing a one way link as a two way link.

4.8.6 The most frequently observed, and easiest to understand, example of this is a roundabout as shown in the figure below.

4.8.7 The figure on the left represents the ITN layer, as a series of one way links forming a roundabout. The SPT corporate database seeks to define a bus route around the roundabout. However, as the SPT process in this instance sees the links as two way links, its route around the roundabout is the direct anticlockwise route.

4.8.8 When the Cube process is operated using the network, it sees the links as one way links and produces the image to the right as a route.

4.8.9 The route, loops around the roundabout three times. It does this because to reach the first node it sees on the route (identified as 1st node), it has to make a loop of the roundabout.

4.8.10 Similarly, to reach the 2nd node from the 1st node, it has to make a second loop of the roundabout, and then finally a third loop to reach the exit of the roundabout.

4.8.11 The number within the Cube Node is the number of times the node is reported within the output Cube lines file.



Figure 13 Original Cube Based Coding

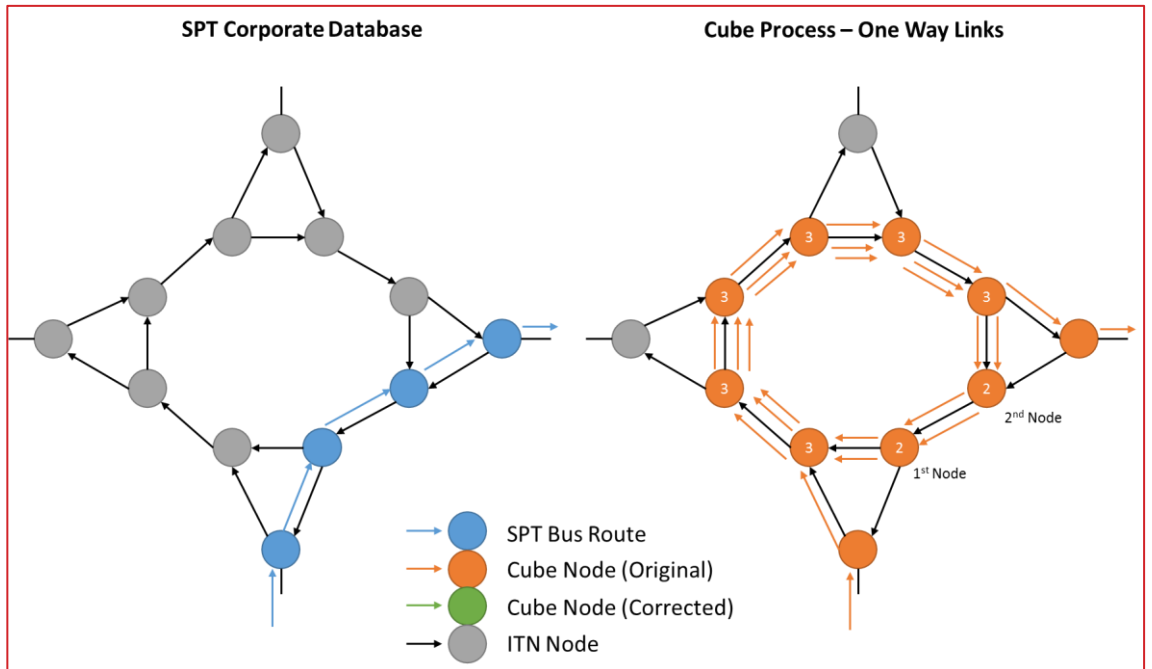
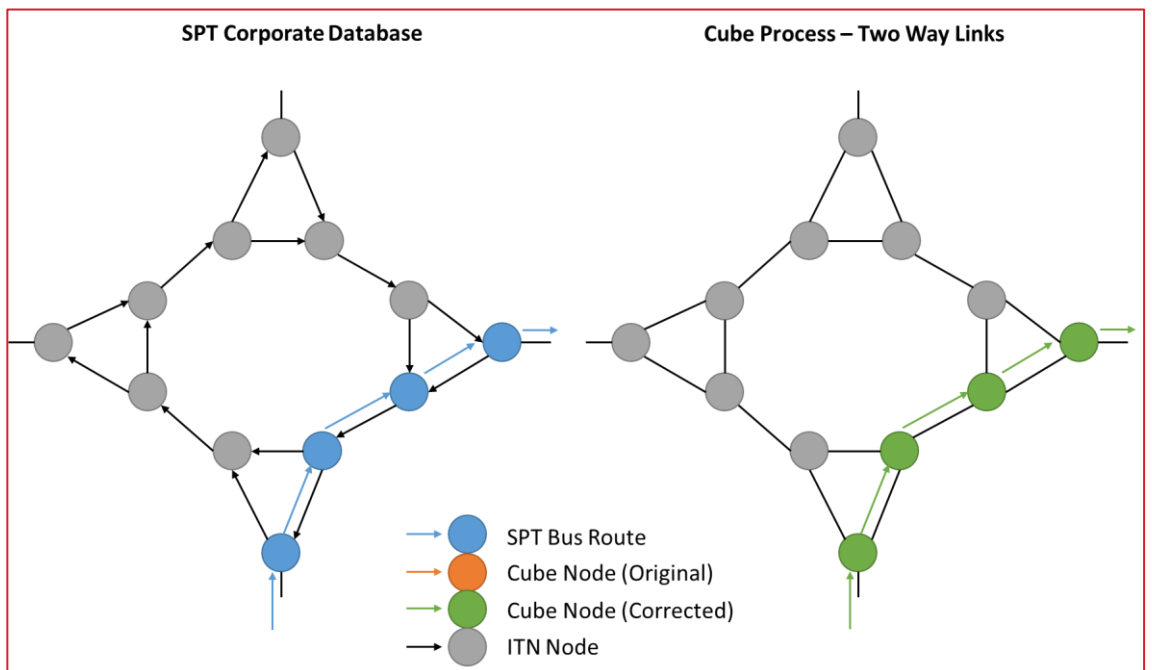


Figure 14 Corrected Cube Based Coding



4.8.12 Our methodology for 'correcting' the service is to enable two way running for bus services on all road links. The result of this is that the Cube process output a bus lines file that matches the SPT Corporate database route through the junction.



4.8.13 We have chosen this option for the following reasons:

- The coding will match the SPT corporate database as required by the brief;
- It represents the least disruptive correction, to reduce the impact on timescales; and
- It allows for the SRTM team and the SPT GIS team to discuss the issues identified with the aim of updating the SPT Corporate database.

4.8.14 To ensure that the coding best represents the public transport network a check on journey times will be performed based on the “corrected” route and the times that would be output by the model if the true route was used.

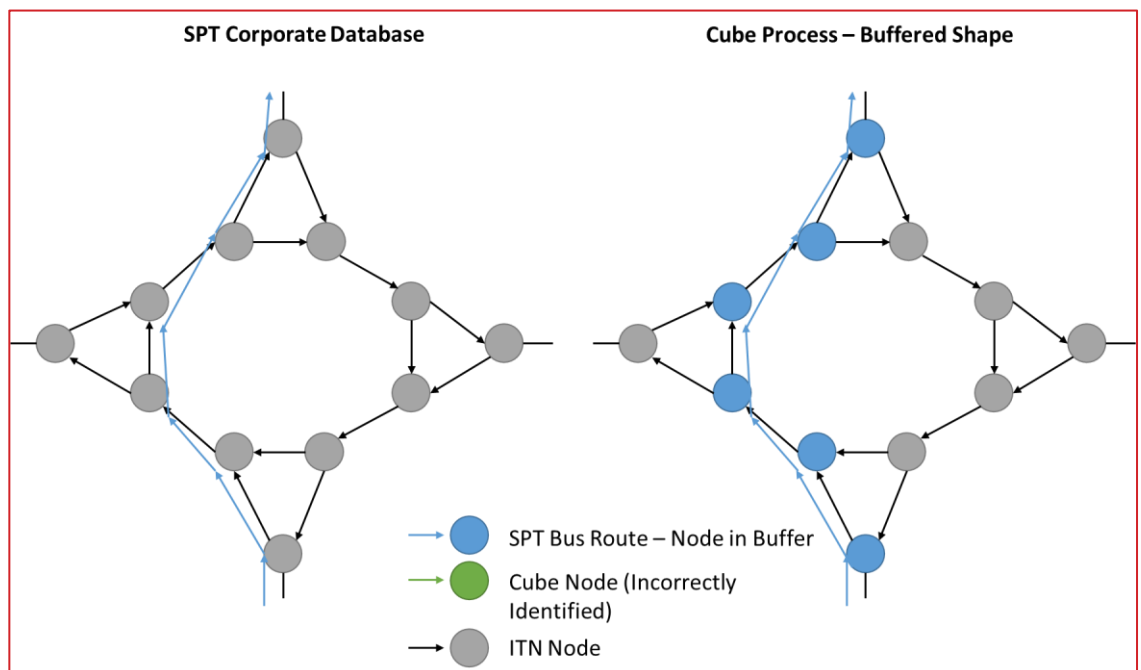
4.8.15 This will be done by manually correcting a random sample of the services with ‘bus service looping’ issues.

Issue 3 – Bus Service Deviation

4.8.16 The third issue that has been identified is that of Bus Service Deviation. To explain the issue, it is necessary to first outline how the Cube process establishes the route through the network.

4.8.17 The figure below illustrates the process. It begins by loading in the Cube network, represented here through the ITN node points and link shapes, together with the GIS format shapefile with a line representing each of the routes. This is shown on the left hand side of the image below.

Figure 15 Cube Coding Process

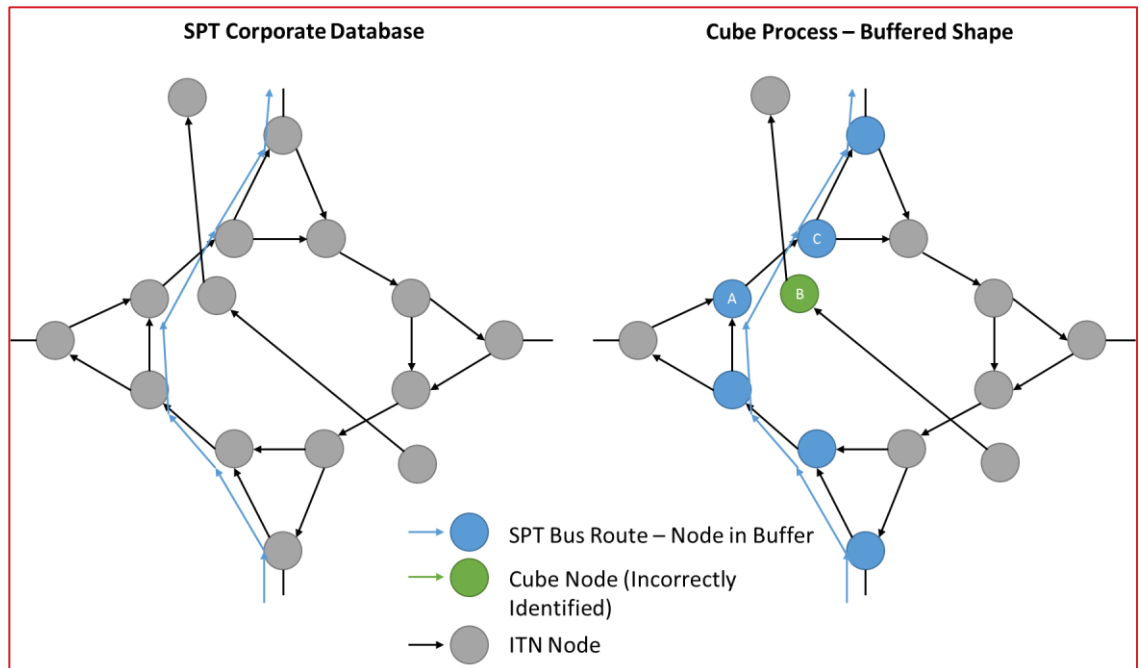


4.8.18 The process then essentially buffers the shapefile and lists each of the nodes, based on the direction of the shapefile that the coded bus route must traverse through.

4.8.19 In the example above, the blue nodes represent the nodes that the route must traverse.

4.8.20 The issue of deviation arises when an “incorrect” node is identified as being on the route. This would occur if the roundabout above had a grade separated route through like in the figure below.

Figure 16 Bus Service Deviations



4.8.21 In the figure, the bus route is identical, but the buffer catches one of the nodes of the grade separation, and thus the route through the roundabout is as before, except for between A and C, which is now to be routed via the grade separation point B.

4.8.22 The impact of the diversion tends to be quite severe, and thus easily identifiable, through a check of the coded distance. In the case above for example, the bus service would have to turn around after A and go back until it could be routed over the grade separation. It would then have to be routed back to the roundabout to reach node C.

4.8.23 The correction process for these is to identify the problems via the route distance check and to then manually identify the section of the coded route that needs to be replaced.

4.8.24 The following mitigations were performed to overcome the identified issues above:

1. Services that could not form routes, like those on the Isle of Arran, were flagged such as to not be included within the input shapefile. This was done through the profile number;
2. Setting up the network as two way links; and
3. Using our node string replacement programme to replace lists of nodes. In this way, the X node list that forms the deviation of the route can be removed. This is a manual correction process.



4.9 Checking Routes

4.9.1 A number of checks will be performed on the bus routes, as listed below:

- Distance check of coded distance versus the SPT corporate database;
- Journey time checks comparing the averaged timetabled journey time with that output by the times from the factored road assignment model; and
- A list of services that require correcting in the SPT corporate database, based on the services that report an error when an attempt is made to build to the “one-way” network.

4.9.2 These checks will be reported through the calibration process, as documented in Chapter 6.

4.10 Conclusions

4.10.1 This note presents the original methodology for the creation of a bus lines file and the revisions to it that have led to the construction of the current bus lines file.

4.10.2 The process is currently setup as a series of Access macros, a form based user interface will be included once the process is fully checked and validated.



5. NON BUS SERVICE CODING

5.1 Subway Services

5.1.1 The subway service coding from TMfS14 has been adopted in the SRTM model.

5.2 Ferry Services

5.2.1 The ferry services coding from TMfS14 has been adopted in the SRTM model, with appropriate manual changes where road node numbers differ in the SRTM model.

5.2.2 There are a total of 7 ferries coded into the SRTM model, these represent services from:

- Renfrew - Yoker
- Hunter's Quay - Gourock
- Gourock - Dunoon
- Rothsey - Wemyss Bay
- Ardossan - Brodick
- Cumbrae - Largs
- Gourock - Kilcreggan

5.2.3 The headway and journey times of the ferry services have been kept consistent with TMfS14.

5.3 Rail Services – SRTM / ATCOCIF coding

5.3.1 The rail services coding from TMfS14 has been adopted in the SRTM model, with appropriate changes where required and documented below.

5.3.2 This enables the use of the TMfS14 files directly (or as directly as possible) to aid the compatibility between models. This is particularly relevant considering the large changes due to the Edinburgh-Glasgow Improvement Program (EGIP) project that is currently being delivered.

5.3.3 We have compared the TMfS14 coding to the ScotRail supplied December 2015 rail services as a check of the validity of the TMfS14 coding. The following differences were noted:

Anniesland to Glasgow Queen Street

5.3.4 Services from Anniesland to Glasgow Queen Street are incorrectly labelled in the TMfS14 lines file as operating from Glasgow Queen Street to Anniesland, giving the appearance that the service frequency inbound to Glasgow is zero across all time periods, and the outbound frequency is doubled (i.e. one train every 15 minutes). This is just a labelling issue and the actual frequency is correct in the TMfS14 lines file.

Edinburgh to Glasgow Queen Street (via Falkirk High)

- 5.3.5 Some services from Edinburgh to Glasgow Queen Street (via Falkirk High) in the TMfS14 lines file have been coded as operating between Haymarket and Glasgow Queen Street. This gives the appearance that the headway on this line is 30 minutes taking into account only the services between Edinburgh and Glasgow Queen Street; including the services between Haymarket and Glasgow Queen Street gives the correct headway of 15 minutes. As both Edinburgh Waverley and Haymarket are outside of the SRTM area this will have no impact on SRTM.

Argyle and North Clyde Lines

- 5.3.6 As noted above, the electrification of the Whifflet line and the incorporation of these services into the Argyle Line, as well as the electrification of the line between Springburn and Cumbernauld has resulted in changes in the origin and destination of some services. This makes it difficult to do a direct comparison. Instead service levels at key stations were checked and this indicated that the coding is comparable between the December 2015 Train Plan and TMfS14 lines file, and hence, given the frequency with which services operate over the core of the route, that there is little change in service frequency between the main destinations.
- 5.3.7 Given that for future use of the model there are considerable benefits in keeping consistency between the final TMfS model and final SRTM model for railway service coding, and that there is no significant difference in the coding to the December 2015 train plan we propose to use the TMfS14 rail coding as the basis for the SRTM rail services.
- 5.3.8 It should be noted that due to the loading of external trips within SRTM the TMfS14 files could not be used directly, a change would be required to ensure that each service stops at the cordon point to ensure loading.
- 5.3.9 The locations of these changes are listed in the table below:



Table 17. External Station Loading Points

NODE	STATION NAME	SRTM ZONE
100255	Kirkconnel	1287
100287	Falkirk High	1293
100288	Larbert	1294
100292	Fauldhouse	1288
100304	Kirknewton	1291
100335	Stranraer	1289
100340	Lockerbie	1290
100386	Crianlarich	1292
100601	Armadale	1295

5.3.10 There are two other changes that are required to convert from TMfS rail service codings, these being:

- Replacement of Headway[3] for Headway[4] due to the differing naming convention of time periods between the models; and
- The replacement of the reference to the crowding curves (one per user class). TMfS has CROWDCURVE[1] through to CROWDCURVE[3], whereas SRTM has CROWDCURVE[1] through to CROWDCURVE[9].

5.3.11 These are accomplished through standard file editor “Find/Replace” tools.



6. PUBLIC TRANSPORT FARES

6.1 Context

6.1.1 As part of the public transport assignment model, the SRTM requires representations of fares for each of the services included in the model.

6.1.2 These fares vary by user class, with the table below providing the equivalence between user class and fare (or ticket) class.

Table 18. Ticket Class by User Class

USER CLASS	DESCRIPTION	TICKET CLASS (BUS)	TICKET CLASS (RAIL)
EBN	Employers' Business – Day Travel	Day Return	Day Return
CMN	Commute – Day Travel	Day Return	Day Return
OTN	Others – Day Travel	Day Return	Day Return
EDN	Education – Day Travel	Day Return (Child)	Day Return (Child)
EBS	Employers' Business – Multi-Day Travel	Weekly Ticket	Season
CMS	Commute – Multi-Day Travel	Weekly Ticket	Season
OTS	Others – Multi-Day Travel	Weekly Ticket	Season
EDS	Education – Multi-Day Travel	Weekly Ticket (Child)	Season (Child)
RET	Retired	Concessionary	Discounted Day Return
ZOD	Zero Demand	N / A	N / A

6.1.3 As can be seen from the above table, the fares fall into five classes, these being listed below:

- ADT STD – Adult Day Return based fares;
- ADT WKY – Adult Weekly / Season based fares;
- CHD STD – Child Day Return based fares;
- CHD WKY – Child Weekly / Season based fares; and
- CONCES – Concessionary travel based fares.

6.1.4 Fares have been sourced by mode for publicly available data sources, as identified in the following sections.

6.1.5 As there are a significant number of bus operators within the SRTM area, fares have been sourced by operator groups for the bus mode. For local buses the main three operators, First Group, McGills and Stagecoach Western have individual fares structures, while all remaining operators have a fares distance curve coded. Consequently, a fare system numbering convention has been adopted such that:

- First digit – Mode number;
- Second digit – Ticket class; and
- Third digit – Operator group / service.

6.1.6 Thus, fare system 111 represents a bus fare (mode 1), for adult daily (ticket class 1) for operator group 1. The use of this structure does limit the number of distinct fares by mode / ticket class to 10, which is sufficient for the base year fare representation. It will not be necessary for future users of the model to adopt this convention.

6.1.7 The remainder of this chapter discusses the sources and calculations performed to derive the different types of bus fares on a bus sub-mode basis.

6.2 Local Bus Fares

6.2.1 Fares are allocated by operator within the user class specific “Factor File” input into the Public Transport module.

6.2.2 In principle, each individual operator could be allocated a tailored fare table. This would require a significant amount of data collations of fares for each operator, while publicly available is only in practice available on request (i.e. when purchasing a ticket).

6.2.3 Consequently, we have allocated operators into a specific operator group and defined a fare system for each operator group. These groups are defined below:

Table 19. SRTM Operator Group

OP GROUP	DESCRIPTION	SERVICES IN TIME PERIOD			
		AM	IP	PM	ALL
1	First Group	475	203	406	701
2	McGills	286	168	276	407
3	Western (Stagecoach)	235	153	243	368
4	Others	302	239	308	450

6.2.4 For the three defined operators (Operator Group 1 to 3) a fares matrix approach has been used.

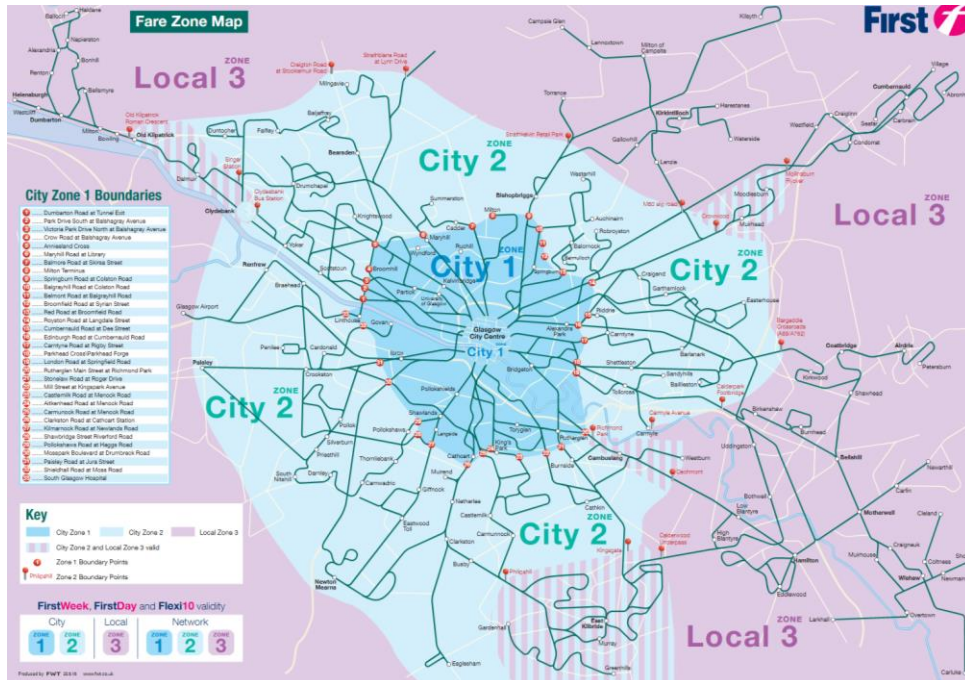
6.2.5 For the final operator group, a distance based fares curve has been derived from the fares of the other three operator groups.



First Group

- 6.2.6 The figure below, from the First Group website, illustrates the fare zones within the First Glasgow operating area.

Figure 17 First Group Fares Zones

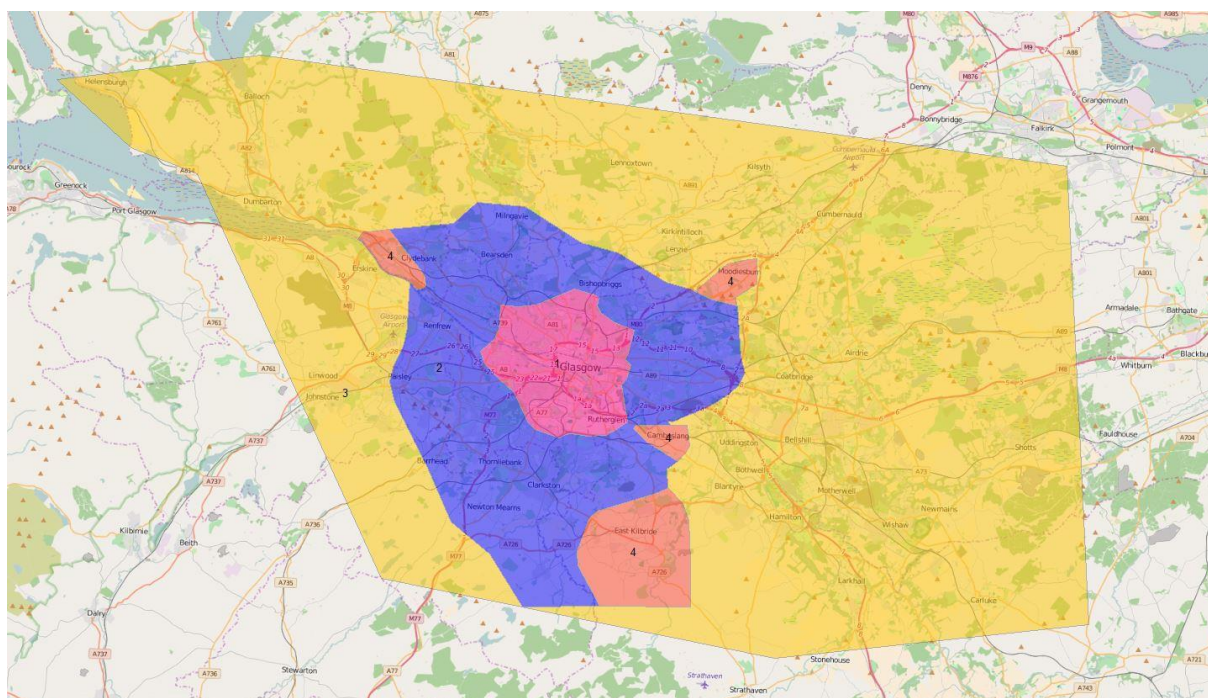


Source: <https://www.firstgroup.com/greater-glasgow/routes-and-maps/network-maps>

- 6.2.7 These cannot be directly represented in the Cube model as three areas, due to the overlaps in the East Kilbride, Dalmuir and Moodiesburn. Thus, a fare zone structure (defined as Cube Fares Area) has been defined that includes these common zones as an additional area.



Figure 18 First Group Cube Fares Areas



6.2.8 Fares have been sourced from First group website for each available ticket as shown in the table below, related to the First Group fare zone in Figure 7. These fares relate to the cost of travel within a zone.

Table 20. First Group Fare Structure

FIRST GROUP ZONE		DAILY FARES		WEEKLY FARES	
		ADULT	CHILD	ADULT	CHILD
1	Glasgow City	£4.50	£1.85	£15.50	£8.50
2	Local	£4.50	£1.85	£15.50	£8.50
3	Network	<i>£6.00</i>	<i>£2.20</i>	£20.00	£9.75

Note: Concessions receive free travel

6.2.9 The first step has been to estimate a daily fare for the “network” zone, the values italicised in the above table. The source website for the fares states that this is the same as the Glasgow City and Local fare but this would imply that the ticket per day is cheaper than the weekly ticket on a per trip basis (see Table 21).

6.2.10 Consequently, we have estimated a value based on factoring the ratio of Network and Local tickets and applying this to the Child Network to yield a local.

6.2.11 The fares are then factored from daily tickets (with an assumption of two trips) and weekly (with an assumption of ten trips) to yield a cost per trip. The resulting single trip fares are illustrated below in Table 21.

Table 21. First Group Fare Structure

FIRST GROUP ZONE		DAILY FARE – PER TRIP		WEEKLY FARE – PER TRIP	
		ADULT	CHILD	ADULT	CHILD
1	Glasgow City	£2.25	£0.93	£1.55	£0.85
2	Local	£2.25	£0.93	£1.55	£0.85
3	Network	£3.00	£1.10	£2.00	£0.98

6.2.12 The next stage was allocating a First Group Zone to each Cube fare area. This was achieved through manual inspection of the First Glasgow zoning map (Figure 17), with the allocation as below. Thus Cube area 1 to Cube area 1, requires a ticket for First group zone 1.

Table 22. First Group Cube Area to First Group Zone Definition

CUBE AREA	1	2	3	4
1	1	1	3	1
2	1	1	3	1
3	3	3	2	2
4	1	1	2	2

6.2.13 The resulting fare tables, by ticket class are provided in the following four tables.

Table 23. First Group Fare – Adult Daily per 1 way trip

CUBE ZONE	1	2	3	4
1	£2.25	£2.25	£3.00	£2.25
2	£2.25	£2.25	£3.00	£2.25
3	£3.00	£3.00	£2.25	£2.25
4	£2.25	£2.25	£2.25	£2.25



Table 24. First Group Fare – Adult Weekly per 1 way trip

CUBE ZONE	1	2	3	4
1	£1.55	£1.55	£2.00	£1.55
2	£1.55	£1.55	£2.00	£1.55
3	£2.00	£2.00	£1.55	£1.55
4	£1.55	£1.55	£1.55	£1.55

Table 25. First Group Fare – Child Daily per 1 way trip

CUBE ZONE	1	2	3	4
1	£0.93	£0.93	£1.10	£0.93
2	£0.93	£0.93	£1.10	£0.93
3	£1.10	£1.10	£0.93	£0.93
4	£0.93	£0.93	£0.93	£0.93

Table 26. First Group Fare – Child Weekly per 1 way trip

CUBE ZONE	1	2	3	4
1	£0.85	£0.85	£0.98	£0.85
2	£0.85	£0.85	£0.98	£0.85
3	£0.98	£0.98	£0.85	£0.85
4	£0.85	£0.85	£0.85	£0.85



6.2.14 These have been coded into Cube Voyager format for input into the model. Concessionary fares tables have been coded with a fare value of zero.

McGills Fares

6.2.15 The McGill's operations cover three distinct service groups, these being:

- Western area (8 Go Zones);
- Eastern (1 Go Zone); and
- Coach / Tour operations.

6.2.16 The west area covers Renfrewshire and Inverclyde and in fare terms is represented by 8 fare zones, named GoZone1 through to GoZone 7 (with a GoZone 1+ providing the eighth).

6.2.17 The extent of these Go Zones is illustrated in the seven figures below, Go Zone 1+ is as for Go Zone 1 with the inclusion of additional service 904 to Largs.

Figure 19 Go Zone 1

zone
1

go!
zones

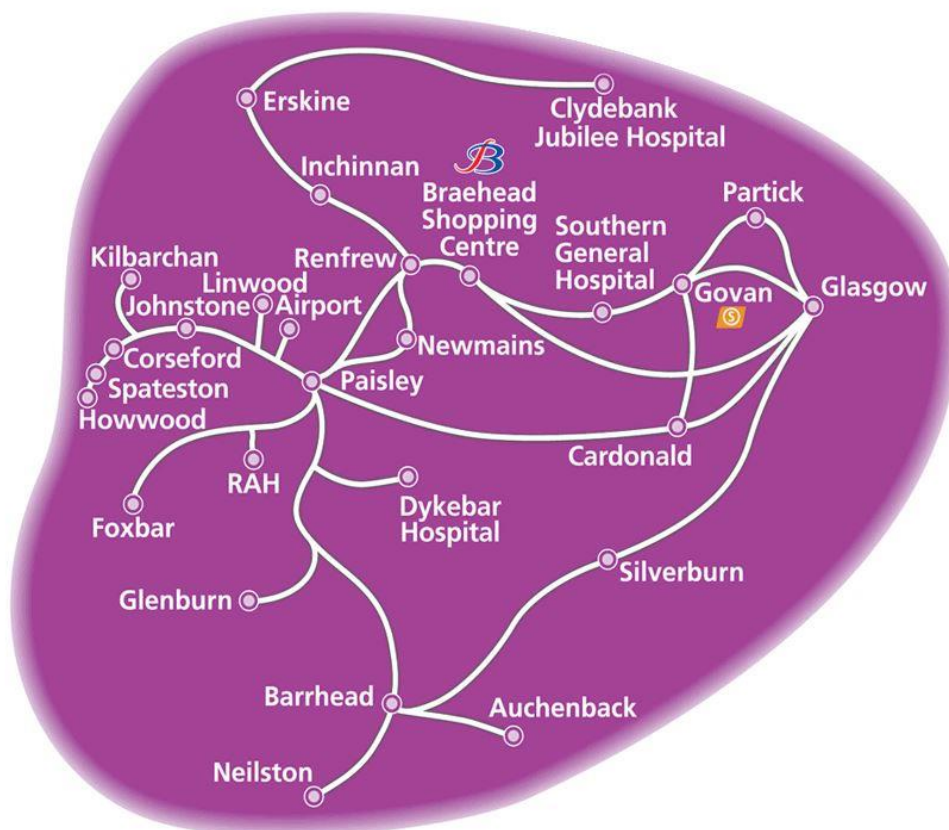


Figure 20 Go Zone 2

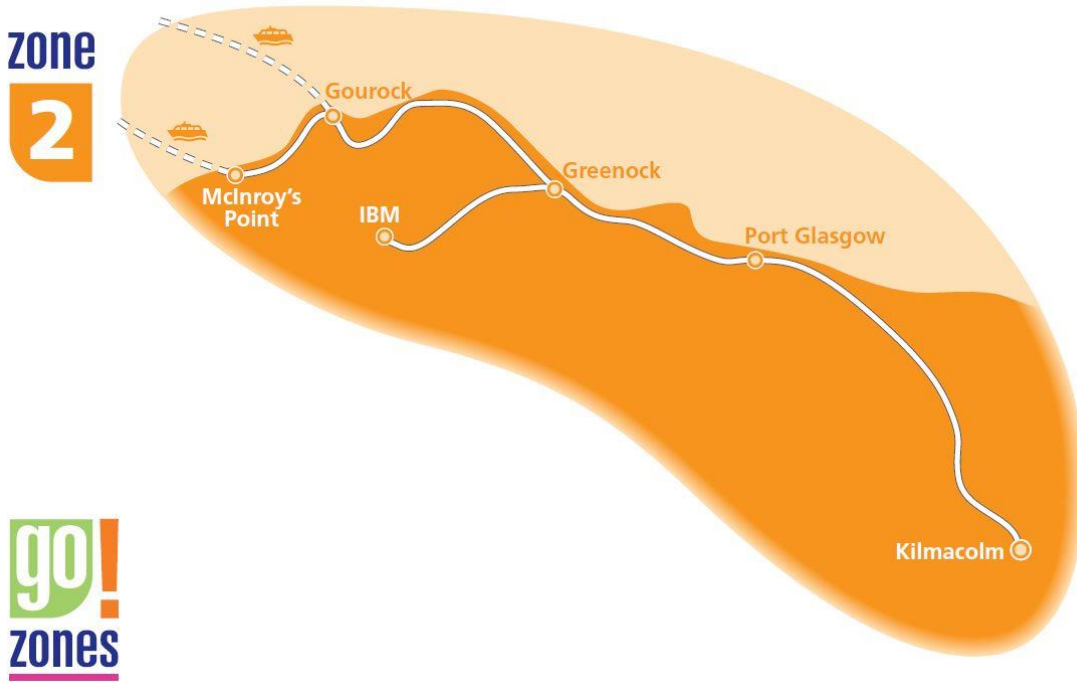


Figure 21 Go Zone 3

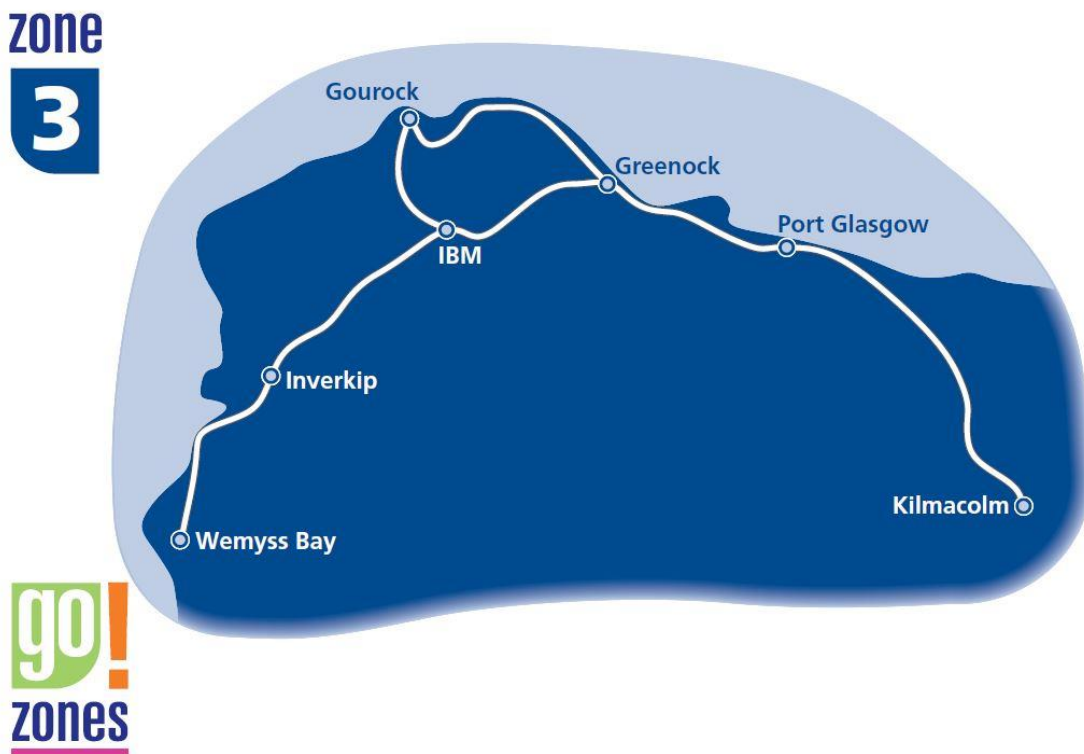


Figure 22 Go Zone 4

zone
4



Figure 23 Go Zone 5

zone
5

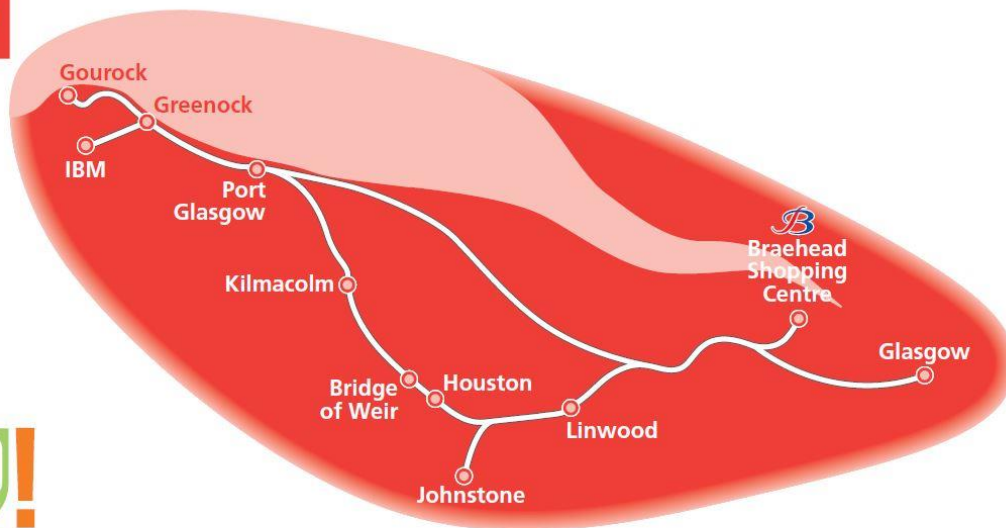


Figure 24 Go Zone 6

zone
6

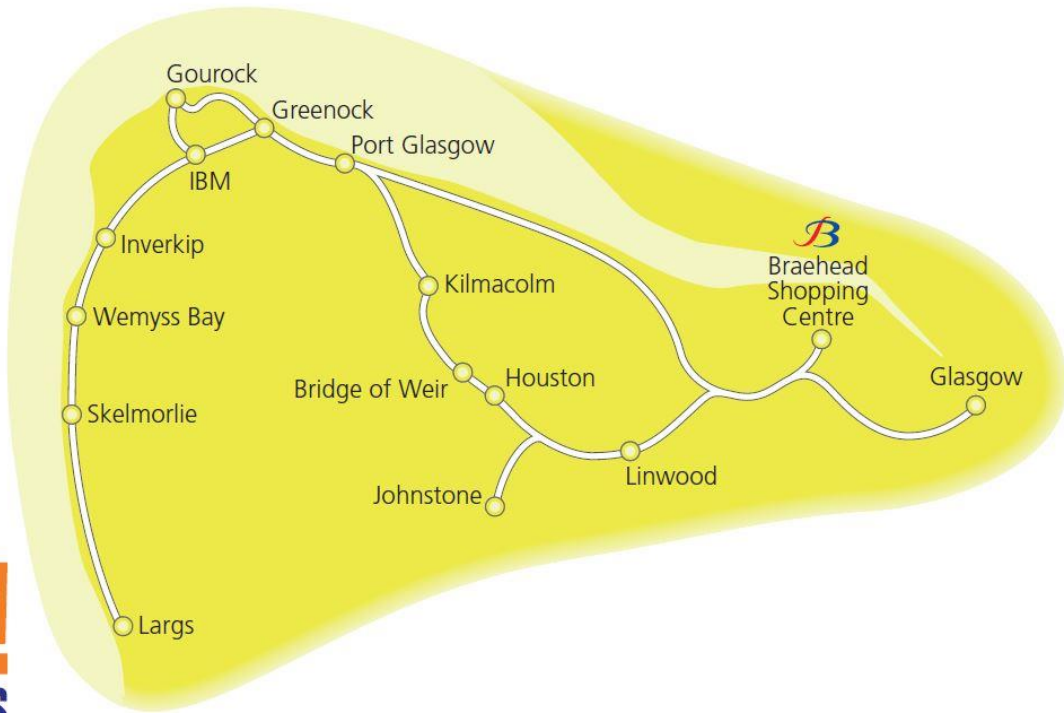
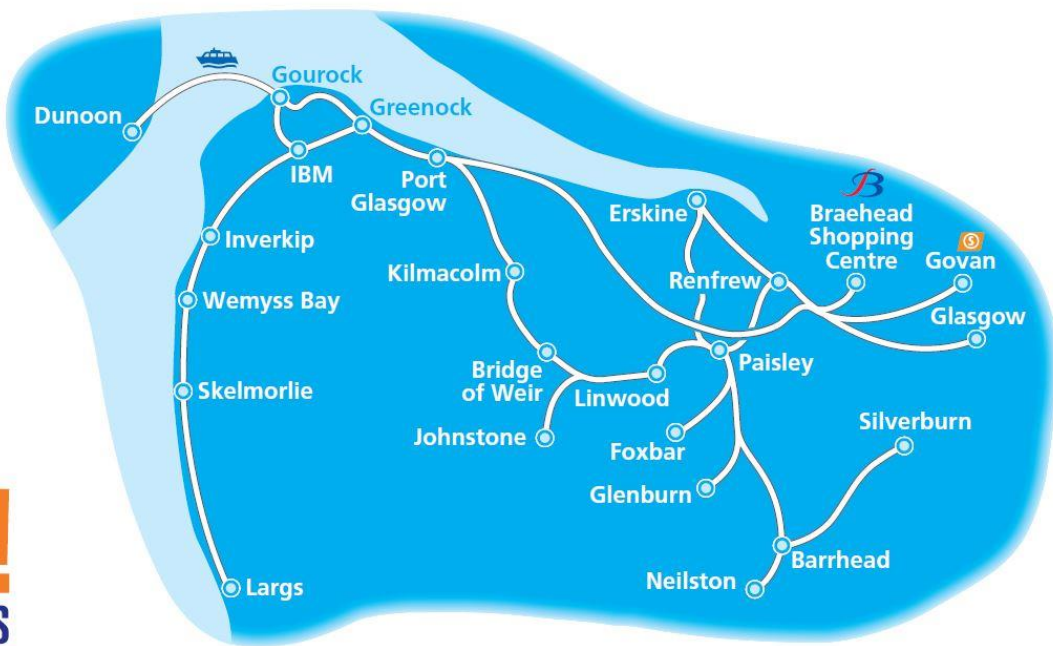


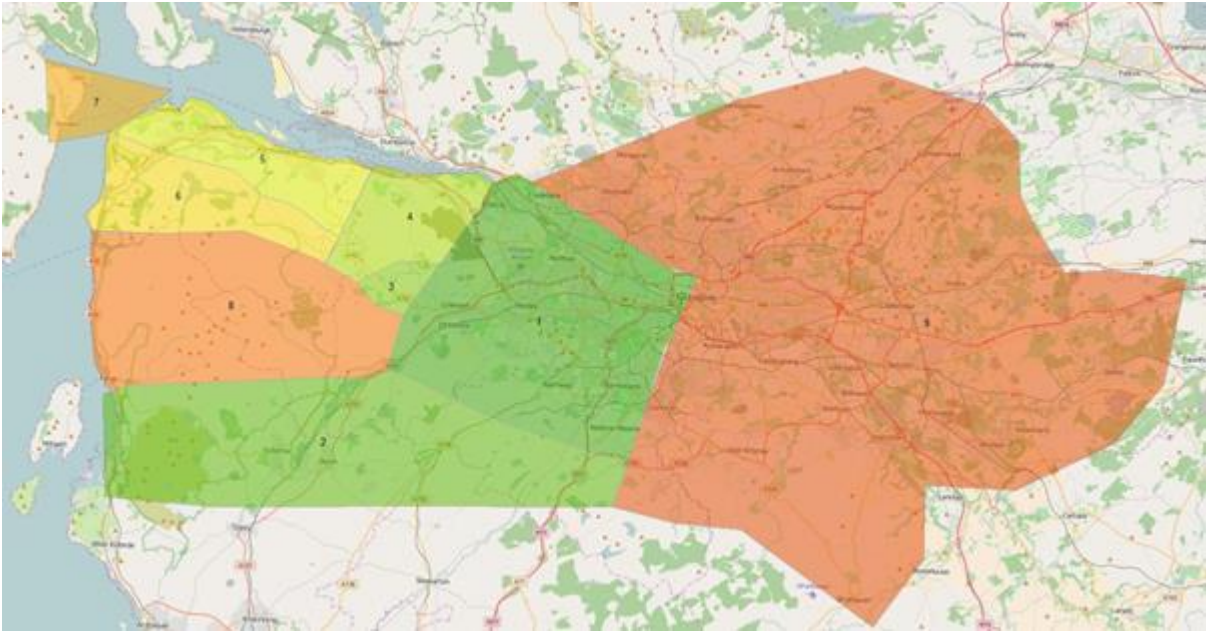
Figure 25 Go Zone 7

zone
7



- 6.2.18 The east area covers McGills operations in Lanarkshire and cross Glasgow operations. This forms a standalone fare zone (Go Zone 8, but no map is available via McGills website).
- 6.2.19 For simplicity, we have added the Go Zone 8 into the McGills fare zones and assumed that the fares are additive to use both networks. In other words, to go from Inverclyde to Motherwell (via Glasgow), the fare would be a fare from Inverclyde to Glasgow followed by a separate fare from Glasgow to Motherwell.
- 6.2.20 The final McGill’s operation is the coach / tour operations from Paisley to the Loch Lomond and Paisley to Greta. These are included within the SPT Corporate database and hence also within the SRTM, though at a low frequency.
- 6.2.21 In order to represent these fares within SRTM, we have defined 10 areas, as illustrated in the figure below.

Figure 26 McGills Cube Fare Areas



- 6.2.22 The first eight areas represent ‘building blocks’ of the western “Go Zones”. Area 9 represents the eastern McGills area (Go Zone 8), while area 10 represents the tour operations extend to the north and south of the Glasgow area.
- 6.2.23 The following table defines each of the western GoZones by the numbered area in Figure 14. A “Y” in the box indicates that the Go Fare zone includes the area. Thus, for example Go Zone 1 is represented by Area 1, whereas GoZone 1+ is the combination of Area 1 and 2.



Table 27. McGills West GoZone Definition per one-way trip

GO ZONE	AREA 1	AREA 2	AREA 3	AREA 4	AREA 5	AREA 6	AREA 7	AREA 8
1	Y							
1+	Y	Y						
2					Y			
3					Y	Y		
4	Y		Y					
5	Y		Y	Y	Y			
6	Y		Y	Y	Y	Y		Y
7	Y	Y	Y	Y	Y	Y	Y	Y

6.2.24 Fares have been sourced from McGills website for each zone to zone movement. These have been factored from daily tickets (with an assumption of two trips) and weekly (with an assumption of ten trips) to yield a cost per trip.

6.2.25 The resulting zone to zone fares for the ‘west’ operations are shown below in Table 28 for daily fares, and Table 29 for weekly fares.

6.2.26 The fares for within ‘Go Zone 8’ have been sourced from McGill’s website, as listed below:

- £1.90 for Adult Daily;
- £1.55 for Adult Weekly;
- £0.80 for Child Daily;
- £0.63 for Child Weekly; and
- £0.00 for concessionary.

6.2.27 For fares between an origin in Go Zones 1 to 7 and Go Zone 8, an assumption has been made that the fare is the cost to travel from origin to central Glasgow, followed by a central Glasgow to Go Zone 8 fare.

6.2.28 A similar approach has been adopted for fare zone number 10, representing the area covered by the tour operations. The cost from each other zone to zone 10 has been defined as the cost to Paisley (where the operations start) plus the cost of the day tour service, £6 per person per direction.

6.2.29 Fares within zone 10 have been set as the maximum of this number as the day tour service does not operate as a commercial local service in the area covered by zone 10. While this final assumption may not be robust, the frequency of the services, and the detour via Paisley, means that the number of trips on this service is likely to be negligible.



Table 28. McGills Fares Table (Adult Daily) per one-way trip

FARE ZONE	1	2	3	4	5	6	7	8	9	10
1	£1.90	£2.25	£2.45	£3.31	£3.31	£3.77	£4.68	£4.68	£3.80	£7.90
2	£2.25	£2.25	£4.68	£4.68	£4.68	£4.68	£4.68	£4.68	£4.15	£8.25
3	£2.45	£4.68	£2.45	£3.31	£3.31	£3.77	£4.68	£4.68	£4.35	£8.45
4	£3.31	£4.68	£3.31	£3.31	£3.31	£3.77	£4.68	£4.68	£5.21	£9.31
5	£3.31	£4.68	£3.31	£3.31	£2.05	£2.45	£4.68	£4.68	£5.21	£9.31
6	£3.77	£4.68	£3.77	£3.77	£2.45	£2.45	£4.68	£4.68	£5.67	£9.77
7	£4.68	£4.68	£4.68	£4.68	£4.68	£4.68	£4.68	£4.68	£6.58	£10.68
8	£4.68	£4.68	£4.68	£4.68	£4.68	£4.68	£4.68	£3.77	£6.58	£10.68
9	£3.80	£4.15	£4.35	£5.21	£5.21	£5.67	£6.58	£6.58	£1.90	£9.80
10	£7.90	£8.25	£8.45	£9.31	£9.31	£9.77	£10.68	£10.68	£9.80	£10.68

Table 29. McGills Fares Table (Adult Weekly) per one-way trip

FARE ZONE	1	2	3	4	5	6	7	8	9	10
1	£1.70	£2.05	£2.15	£2.90	£2.90	£3.30	£4.10	£4.10	£3.25	£7.70
2	£2.05	£2.05	£4.10	£4.10	£4.10	£4.10	£4.10	£4.10	£3.60	£8.05
3	£2.15	£4.10	£2.15	£2.90	£2.90	£3.30	£4.10	£4.10	£3.70	£8.15
4	£2.90	£4.10	£2.90	£2.90	£2.90	£3.30	£4.10	£4.10	£4.45	£8.90
5	£2.90	£4.10	£2.90	£2.90	£1.80	£2.15	£4.10	£4.10	£4.45	£8.90
6	£3.30	£4.10	£3.30	£3.30	£2.15	£2.15	£4.10	£4.10	£4.85	£9.30
7	£4.10	£4.10	£4.10	£4.10	£4.10	£4.10	£4.10	£4.10	£5.65	£10.10
8	£4.10	£4.10	£4.10	£4.10	£4.10	£4.10	£4.10	£3.30	£5.65	£10.10
9	£3.25	£3.60	£3.70	£4.45	£4.45	£4.85	£5.65	£5.65	£1.55	£9.25

FARE ZONE	1	2	3	4	5	6	7	8	9	10
10	£7.70	£8.05	£8.15	£8.90	£8.90	£9.30	£10.10	£10.10	£9.25	£10.10

Table 30. McGills Fares Table (Child Daily) per one-way trip

FARE ZONE	1	2	3	4	5	6	7	8	9	10
1	£0.80	£1.05	£0.96	£1.22	£1.22	£1.47	£1.82	£1.82	£1.60	£6.80
2	£1.05	£1.05	£1.82	£1.82	£1.82	£1.82	£1.82	£1.82	£1.85	£7.05
3	£0.96	£1.82	£0.96	£1.22	£1.22	£1.47	£1.82	£1.82	£1.76	£6.96
4	£1.22	£1.82	£1.22	£1.22	£1.22	£1.47	£1.82	£1.82	£2.02	£7.22
5	£1.22	£1.82	£1.22	£1.22	£0.80	£0.90	£1.82	£1.82	£2.02	£7.22
6	£1.47	£1.82	£1.47	£1.47	£0.90	£0.90	£1.82	£1.82	£2.27	£7.47
7	£1.82	£1.82	£1.82	£1.82	£1.82	£1.82	£1.82	£1.82	£2.62	£7.82
8	£1.82	£1.82	£1.82	£1.82	£1.82	£1.82	£1.82	£1.47	£2.62	£7.82
9	£1.60	£1.85	£1.76	£2.02	£2.02	£2.27	£2.62	£2.62	£0.80	£7.60
10	£6.80	£7.05	£6.96	£7.22	£7.22	£7.47	£7.82	£7.82	£7.60	£7.82

Table 31. McGills Fares Table (Child Weekly) per one-way trip

FARE ZONE	1	2	3	4	5	6	7	8	9	10
1	£0.63	£0.77	£0.75	£0.96	£0.96	£1.15	£1.43	£1.43	£1.26	£6.63
2	£0.77	£0.77	£1.43	£1.43	£1.43	£1.43	£1.43	£1.43	£1.40	£6.77
3	£0.75	£1.43	£0.75	£0.96	£0.96	£1.15	£1.43	£1.43	£1.38	£6.75
4	£0.96	£1.43	£0.96	£0.96	£0.96	£1.15	£1.43	£1.43	£1.59	£6.96
5	£0.96	£1.43	£0.96	£0.96	£0.63	£0.75	£1.43	£1.43	£1.59	£6.96
6	£1.15	£1.43	£1.15	£1.15	£0.75	£0.75	£1.43	£1.43	£1.78	£7.15

FARE ZONE	1	2	3	4	5	6	7	8	9	10
7	£1.43	£1.43	£1.43	£1.43	£1.43	£1.43	£1.43	£1.43	£2.06	£7.43
8	£1.43	£1.43	£1.43	£1.43	£1.43	£1.43	£1.43	£1.15	£2.06	£7.43
9	£1.26	£1.40	£1.38	£1.59	£1.59	£1.78	£2.06	£2.06	£0.63	£7.26
10	£6.63	£6.77	£6.75	£6.96	£6.96	£7.15	£7.43	£7.43	£7.26	£7.43

Western (Stagecoach) Fares

6.2.31 Fare zones for Western (Stagecoach) have similarly been mapped as illustrated in the figure below.

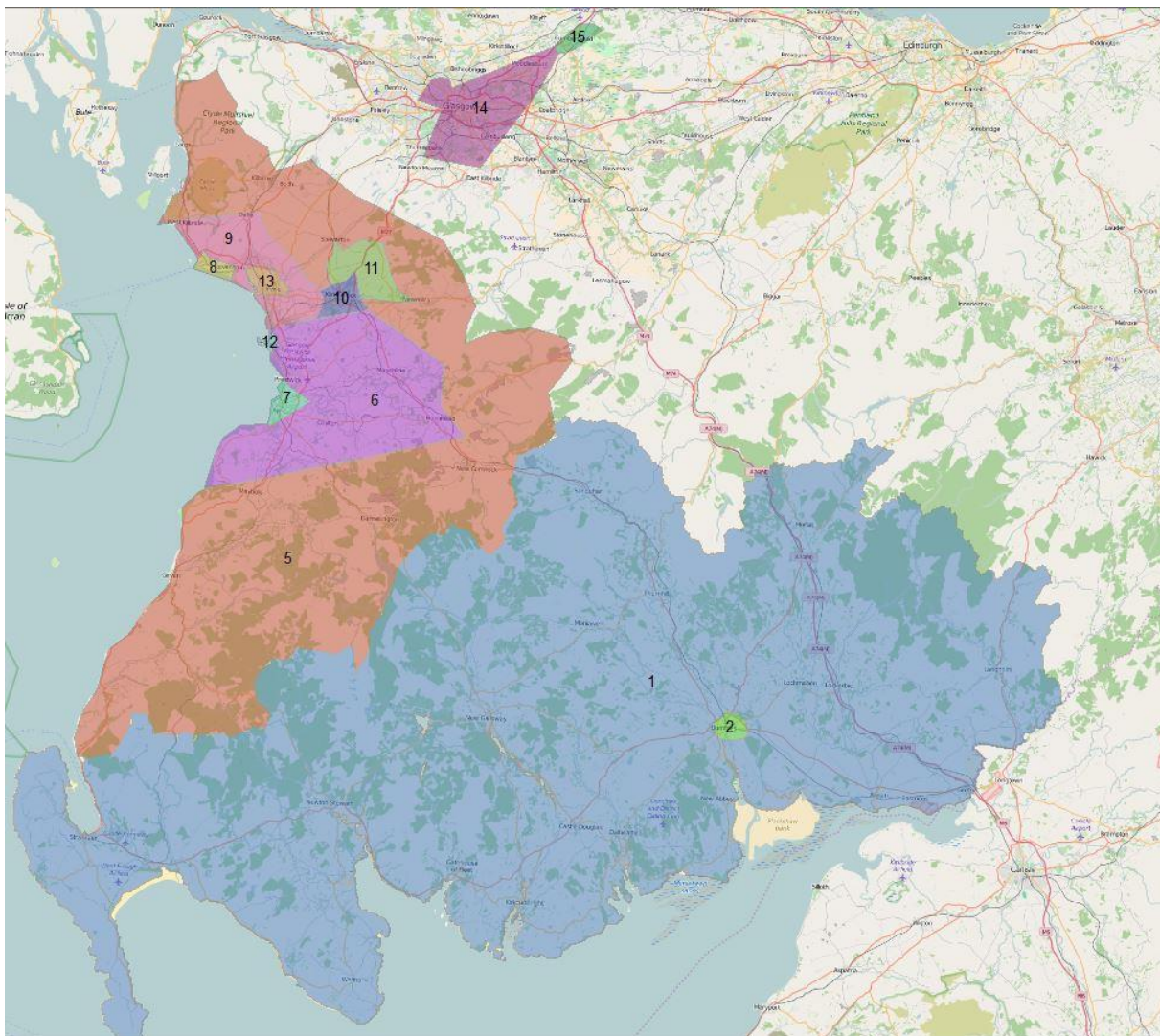


Figure 27 Western Fares Zones (Source: Stagecoach Website)



6.2.32 These have been coded via GIS for the CUBE model into the numbered spatial areas in the figure below.

Figure 28 Western (Stagecoach) Fares Area



- 6.2.33 The numbers in the image refer to the fare zone number within the SRTM model. For areas outside the image a fare zone number of 0 has been coded for each node. The Edinburgh and Biggar zones are not coded by area as they are external areas in the SRTM model. However, the external loading point that Western buses use to access the model has been coded as “Edinburgh” or zone 4.
- 6.2.34 Fares have been sourced from Stagecoach website for each zone to zone movement, in a manner consistent to the methodology for the McGills fares. These have been factored from daily tickets (with an assumption of two trips) and weekly (with an assumption of ten trips) to yield a cost per trip. As the extent of operations of Stagecoach Western extends outside of the SRTM modelled area, not all of the values in the fares table below are used within the model. As an example of this, trips from fare zone 3 to fare zone 4 is a journey from West Linton to Edinburgh, neither locations within the SRTM area.
- 6.2.35 The resulting zone to zone fares are shown below in the following four tables for daily fares, and for weekly fares.



Table 32. Western Fares Table (Adult Daily)

FARE ZONE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	£3.60	£3.60	£8.30	£8.30	£7.25	£7.25	£7.25	£7.25	£7.25	£7.25	£7.25	£7.25	£7.25	£4.40	£5.88
2	£3.60	£1.80	£8.30	£8.30	£7.25	£7.25	£7.25	£7.25	£7.25	£7.25	£7.25	£7.25	£7.25	£4.40	£5.88
3	£8.30	£8.30	£3.00	£4.10	£15.55	£15.55	£15.55	£15.55	£15.55	£15.55	£15.55	£15.55	£15.55	£12.70	£14.18
4	£8.30	£8.30	£4.10	£4.10	£15.55	£15.55	£15.55	£15.55	£15.55	£15.55	£15.55	£15.55	£15.55	£12.70	£14.18
5	£7.25	£7.25	£15.55	£15.55	£2.50	£2.50	£2.50	£2.50	£2.50	£2.50	£2.50	£2.50	£2.50	£5.60	£5.60
6	£7.25	£7.25	£15.55	£15.55	£2.50	£3.60	£3.60	£2.50	£2.50	£2.50	£2.50	£2.50	£2.50	£5.60	£5.60
7	£7.25	£7.25	£15.55	£15.55	£2.50	£3.60	£1.80	£2.50	£2.50	£2.50	£2.50	£2.50	£2.50	£5.60	£5.60
8	£7.25	£7.25	£15.55	£15.55	£2.50	£2.50	£2.50	£1.85	£2.50	£2.50	£2.50	£2.50	£2.50	£4.40	£4.40
9	£7.25	£7.25	£15.55	£15.55	£2.50	£2.50	£2.50	£2.50	£2.50	£2.50	£2.50	£2.50	£2.50	£4.40	£4.40
10	£7.25	£7.25	£15.55	£15.55	£2.50	£2.50	£2.50	£2.50	£2.50	£1.95	£1.95	£2.50	£2.50	£4.80	£4.80
11	£7.25	£7.25	£15.55	£15.55	£2.50	£2.50	£2.50	£2.50	£2.50	£1.95	£1.95	£2.50	£2.50	£4.80	£4.80
12	£7.25	£7.25	£15.55	£15.55	£2.50	£2.50	£2.50	£2.50	£2.50	£2.50	£2.50	£2.50	£2.50	£4.40	£4.40
13	£7.25	£7.25	£15.55	£15.55	£2.50	£2.50	£2.50	£2.50	£2.50	£2.50	£2.50	£2.50	£1.40	£4.40	£4.40
14	£4.40	£4.40	£12.70	£12.70	£5.60	£5.60	£5.60	£4.40	£4.40	£4.80	£4.80	£4.40	£4.40	£2.05	£2.35
15	£5.88	£5.88	£14.18	£14.18	£5.60	£5.60	£5.60	£4.40	£4.40	£4.80	£4.80	£4.40	£4.40	£2.35	£1.75

Table 33. Western Fares Table (Adult Weekly)

FARE ZONE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	£2.30	£2.30	£8.30	£8.30	£3.60	£3.60	£3.60	£3.60	£3.60	£3.60	£3.60	£3.60	£3.60	£4.40	£5.88
2	£2.30	£1.20	£8.30	£8.30	£3.60	£3.60	£3.60	£3.60	£3.60	£3.60	£3.60	£3.60	£3.60	£4.40	£5.88
3	£8.30	£8.30	£2.36	£3.18	£11.90	£11.90	£11.90	£11.90	£11.90	£11.90	£11.90	£11.90	£11.90	£12.70	£14.18
4	£8.30	£8.30	£3.18	£3.18	£11.90	£11.90	£11.90	£11.90	£11.90	£11.90	£11.90	£11.90	£11.90	£12.70	£14.18
5	£3.60	£3.60	£11.90	£11.90	£1.33	£1.33	£1.33	£1.33	£1.33	£1.33	£1.33	£1.33	£1.33	£3.90	£3.90
6	£3.60	£3.60	£11.90	£11.90	£1.33	£2.20	£2.20	£1.33	£1.33	£1.33	£1.33	£1.33	£1.33	£3.90	£3.90
7	£3.60	£3.60	£11.90	£11.90	£1.33	£2.20	£0.98	£1.33	£1.33	£1.33	£1.33	£1.33	£1.33	£3.90	£3.90
8	£3.60	£3.60	£11.90	£11.90	£1.33	£1.33	£1.33	£0.82	£1.33	£1.33	£1.33	£1.33	£1.33	£3.59	£3.59
9	£3.60	£3.60	£11.90	£11.90	£1.33	£1.33	£1.33	£1.33	£1.33	£1.33	£1.33	£1.33	£1.33	£3.59	£3.59
10	£3.60	£3.60	£11.90	£11.90	£1.33	£1.33	£1.33	£1.33	£1.33	£1.11	£1.11	£1.33	£1.33	£3.59	£3.59
11	£3.60	£3.60	£11.90	£11.90	£1.33	£1.33	£1.33	£1.33	£1.33	£1.11	£1.11	£1.33	£1.33	£3.59	£3.59
12	£3.60	£3.60	£11.90	£11.90	£1.33	£1.33	£1.33	£1.33	£1.33	£1.33	£1.33	£1.33	£1.33	£3.59	£3.59
13	£3.60	£3.60	£11.90	£11.90	£1.33	£1.33	£1.33	£1.33	£1.33	£1.33	£1.33	£1.33	£0.82	£3.59	£3.59
14	£4.40	£4.40	£12.70	£12.70	£3.90	£3.90	£3.90	£3.59	£3.59	£3.59	£3.59	£3.59	£3.59	£2.05	£2.35
15	£5.88	£5.88	£14.18	£14.18	£3.90	£3.90	£3.90	£3.59	£3.59	£3.59	£3.59	£3.59	£3.59	£2.35	£1.75

Table 34. Western Fares Table (Child Daily)

FARE ZONE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	£1.80	£1.80	£4.15	£4.15	£3.63	£3.63	£3.63	£3.63	£3.63	£3.63	£3.63	£3.63	£3.63	£2.20	£2.94
2	£1.80	£0.90	£4.15	£4.15	£3.63	£3.63	£3.63	£3.63	£3.63	£3.63	£3.63	£3.63	£3.63	£2.20	£2.94
3	£4.15	£4.15	£1.50	£2.05	£7.78	£7.78	£7.78	£7.78	£7.78	£7.78	£7.78	£7.78	£7.78	£6.35	£7.09
4	£4.15	£4.15	£2.05	£2.05	£7.78	£7.78	£7.78	£7.78	£7.78	£7.78	£7.78	£7.78	£7.78	£6.35	£7.09
5	£3.63	£3.63	£7.78	£7.78	£1.25	£1.25	£1.25	£1.25	£1.25	£1.25	£1.25	£1.25	£1.25	£2.80	£2.80
6	£3.63	£3.63	£7.78	£7.78	£1.25	£1.80	£1.80	£1.25	£1.25	£1.25	£1.25	£1.25	£1.25	£2.80	£2.80
7	£3.63	£3.63	£7.78	£7.78	£1.25	£1.80	£0.90	£1.25	£1.25	£1.25	£1.25	£1.25	£1.25	£2.80	£2.80
8	£3.63	£3.63	£7.78	£7.78	£1.25	£1.25	£1.25	£0.93	£1.25	£1.25	£1.25	£1.25	£1.25	£2.20	£2.20
9	£3.63	£3.63	£7.78	£7.78	£1.25	£1.25	£1.25	£1.25	£1.25	£1.25	£1.25	£1.25	£1.25	£2.20	£2.20
10	£3.63	£3.63	£7.78	£7.78	£1.25	£1.25	£1.25	£1.25	£1.25	£0.98	£0.98	£1.25	£1.25	£2.40	£2.40
11	£3.63	£3.63	£7.78	£7.78	£1.25	£1.25	£1.25	£1.25	£1.25	£0.98	£0.98	£1.25	£1.25	£2.40	£2.40
12	£3.63	£3.63	£7.78	£7.78	£1.25	£1.25	£1.25	£1.25	£1.25	£1.25	£1.25	£1.25	£1.25	£2.20	£2.20
13	£3.63	£3.63	£7.78	£7.78	£1.25	£1.25	£1.25	£1.25	£1.25	£1.25	£1.25	£1.25	£0.70	£2.20	£2.20
14	£2.20	£2.20	£6.35	£6.35	£2.80	£2.80	£2.80	£2.20	£2.20	£2.40	£2.40	£2.20	£2.20	£1.03	£1.18
15	£2.94	£2.94	£7.09	£7.09	£2.80	£2.80	£2.80	£2.20	£2.20	£2.40	£2.40	£2.20	£2.20	£1.18	£0.88

Table 35. Western Fares Table (Child Weekly)

FARE ZONE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	£1.15	£1.15	£4.15	£4.15	£1.80	£1.80	£1.80	£1.80	£1.80	£1.80	£1.80	£1.80	£1.80	£2.20	£2.94
2	£1.15	£0.60	£4.15	£4.15	£1.80	£1.80	£1.80	£1.80	£1.80	£1.80	£1.80	£1.80	£1.80	£2.20	£2.94
3	£4.15	£4.15	£1.18	£1.59	£5.95	£5.95	£5.95	£5.95	£5.95	£5.95	£5.95	£5.95	£5.95	£6.35	£7.09
4	£4.15	£4.15	£1.59	£1.59	£5.95	£5.95	£5.95	£5.95	£5.95	£5.95	£5.95	£5.95	£5.95	£6.35	£7.09
5	£1.80	£1.80	£5.95	£5.95	£0.67	£0.67	£0.67	£0.67	£0.67	£0.67	£0.67	£0.67	£0.67	£1.95	£1.95
6	£1.80	£1.80	£5.95	£5.95	£0.67	£1.10	£1.10	£0.67	£0.67	£0.67	£0.67	£0.67	£0.67	£1.95	£1.95
7	£1.80	£1.80	£5.95	£5.95	£0.67	£1.10	£0.49	£0.67	£0.67	£0.67	£0.67	£0.67	£0.67	£1.95	£1.95
8	£1.80	£1.80	£5.95	£5.95	£0.67	£0.67	£0.67	£0.41	£0.67	£0.67	£0.67	£0.67	£0.67	£1.80	£1.80
9	£1.80	£1.80	£5.95	£5.95	£0.67	£0.67	£0.67	£0.67	£0.67	£0.67	£0.67	£0.67	£0.67	£1.80	£1.80
10	£1.80	£1.80	£5.95	£5.95	£0.67	£0.67	£0.67	£0.67	£0.67	£0.56	£0.56	£0.67	£0.67	£1.80	£1.80
11	£1.80	£1.80	£5.95	£5.95	£0.67	£0.67	£0.67	£0.67	£0.67	£0.56	£0.56	£0.67	£0.67	£1.80	£1.80
12	£1.80	£1.80	£5.95	£5.95	£0.67	£0.67	£0.67	£0.67	£0.67	£0.67	£0.67	£0.67	£0.67	£1.80	£1.80
13	£1.80	£1.80	£5.95	£5.95	£0.67	£0.67	£0.67	£0.67	£0.67	£0.67	£0.67	£0.67	£0.41	£1.80	£1.80
14	£2.20	£2.20	£6.35	£6.35	£1.95	£1.95	£1.95	£1.80	£1.80	£1.80	£1.80	£1.80	£1.80	£1.03	£1.18
15	£2.94	£2.94	£7.09	£7.09	£1.95	£1.95	£1.95	£1.80	£1.80	£1.80	£1.80	£1.80	£1.80	£1.18	£0.88

SRTM Mode Files

- 6.2.36 These three sets of fare zones have been used to update the SRTM nodes database with the fare zone number by operator. This was done in GIS through point in polygon spatial update queries.
- 6.2.37 This value provides the fare zone number reference to enable CUBE to calculate the appropriate stop to stop fares through looking up each stop's fare zone number.
- 6.2.38 A separate fare matrix has been created by operator group in CUBE format using the data in the preceding sections.

Other Operator Fares

- 6.2.39 For all other operators of the local bus sub-mode a distance-based fares curve has been estimated by ticket class using skim matrices from a test assignment containing the three operator groups above and non-bus modes.
- 6.2.40 Skims by mode, essentially the skims from the three operator groups above have been extracted for transit distance, boardings and actual fare.
- 6.2.41 From these skims passenger kilometre and passenger revenue values have been calculated. Following this, an analysis has been performed to establish a fare curve to apply to other services in the SRTM area, (except concessionary as these have been assumed to be 0 fare).
- 6.2.42 Distance based fares curves have been coded into the model files using the above output.

6.3 Express Bus Fares

- 6.3.1 There are 8 operators within the SRTM that are defined as mode 2. Two of these, First Glasgow and Stagecoach / Western have fares defined as fare matrices through the local bus service fare definitions.
- 6.3.2 The remaining six operators are:
 - Citylink;
 - Stagecoach Fife;
 - National Express;
 - Marbill Coach Services;
 - Parks of Hamilton Coach Hire; and
 - Gillens Coaches.
- 6.3.3 The last three of these operators are coach hire operators that undertake specific and essentially rural operations. The remaining three operate wider area services, these being Citylink, Stagecoach Fife and National Express.
- 6.3.4 The underlying fares information for the above six operators has been sourced from three TMfS distance based fares curves. These three TMfS distance curves are labelled:
 - Citylink;
 - Stagecoach Fife; and
 - All_Bus.

6.3.5 The six operators have been allocated a distance based fares curve as illustrated in the table below:

Table 36. Express Bus TMfS Equivalence

SRTM OPERATOR	TMfS EQUIVALENT / GROUP	TMFS FARE SYSTEM #
Citylink	Citylink	17
National Express		
Stagecoach Fife	Stagecoach Fife	19
Marbill Coach Services	All_Bus	24
Parks of Hamilton Coach Hire		
Gillens Coaches.		

6.3.6 For Citylink and Stagecoach Fife, research from their respective websites has been used to establish factors to convert from adult day ticket to the other four ticket classes. The factors derived for Stagecoach Fife have been used to adjust the “local bus” fares table from TMfS.

6.3.7 These factors to reweight the TMfS fares curves are documented in the table below:

Table 37. Assumed Express Bus Fare Factors

GROUP	ADT STD	ADT WKY	CHD STD	CHD WKY	CONCES
Citylink	£11.40	£8.80	£7.98	£6.02	n/a
Factors->	100%	75%	70%	53%	0%
Stagecoach Fife	£14.50	£8.40	£7.30	£5.60	n/a
Factors->	100%	58%	50%	39%	0%
All_Bus	<i>Assumed as per Stagecoach</i>				
Factors->	100%	58%	50%	39%	0%

6.3.8 From a combination of the above information, fare system coding has been established for the three groups established in paragraph 6.3.4, with the factor files being coded to allocate as per Table 36



6.4 Rail Fares

- 6.4.1 A matrix of fares for station to station movements by ticket class has been generated for the SRTM using the Association of Train Operating Companies (ATOC) fares database.
- 6.4.2 Although the fare table is for use within the SRTM, we have made use of the station definition file from CSTM12 (to enable comparison) and consequently there are fare values for each station to station movement within Scotland.
- 6.4.3 The original database has been downloaded from (<http://data.atoc.org/fares-data>) for September 2015 and is in the form of a collection of fixed width text files. No adjustment was made to convert to 2014 prices.
- 6.4.4 These are initially reformatted in order to separate all the tables contained for SQL work and uploaded into a SQL database through Windows batch files and an SQL Server procedure.
- 6.4.5 The fare matrix creation process makes use of the following tables from the ATOC database:
- [Flow];
 - [Station clusters];
 - [Fare];
 - [Ticket types]; and
 - [Non derivable fares].
- 6.4.6 The structure of the database is described in detail through the documentation on the ATOC website - <http://data.atoc.org/sites/all/themes/atoc/files/SP0035.pdf>
- 6.4.7 The station clusters tables identifies the stations that are within clusters, such as “Central Glasgow Stations”, which contains Glasgow Queen Street and Glasgow Central. There are four station clusters relevant to the Scotland area, these are listed below:
- Central Glasgow stations – Glasgow Queen Street and Glasgow Central;
 - Falkirk stations – Falkirk High and Falkirk Grahamston;
 - Helensburgh stations – Upper Helensburgh and Helensburgh Central; and
 - Tyndrum stations – Upper Tyndrum and Tyndrum Lower.
- 6.4.8 The ticket type table lists all of the ticket types available on the railway. These include first class tickets and promotional / operator specific advance fares. We have not included these in our output given they are used predominately by longer distance rail travellers, rather than local SRTM trips.
- 6.4.9 In addition to the above ATOC tables, the process makes use of two further tables to enable linkages to the SRTM model:
- [Station ref]; and
 - [Node ref].
- 6.4.10 Together these relate the NLC (National Location Code) number to single stations and consequently station to nodes in the SRTM model.



- 6.4.11 The process consists of a single SQL query that brings together movements and fares from the fare tables and ticket information from the ticket types table, along with the reverse movements where applicable.
- 6.4.12 Fares associated with flows are generated by joining the [Flow] table with the [Fare] table. A field specifies whether the reverse fare applies.
- 6.4.13 These are further joined with [Station clusters] in order to separate the clustered stations into fares for individual stations.
- 6.4.14 Fares with no associated flow are found in the [Non-derivable fares] table. These are taken as recorded and transposed for the reverse movement.
- 6.4.15 Tickets marked as 'Promotion' are not recorded but these are predominately for long distance operators such as those operating on the West and East Coast Mainlines.
- 6.4.16 Movements are converted into inter node movements by joining with the pre-defined tables of station [station_ref] and nodes [node_ref] based on NLC numbers.
- 6.4.17 The output table of station to station movements is then exported into access to segment by ticket type, these types being:
 - Anytime Return;
 - Anytime Day Return;
 - Off Peak Return;
 - Off peak Day Return; and
 - Season.
- 6.4.18 For some movements, there is only either a "Return" or a "Day Return" available. Thus, to get a full database of movements, the next stage joined these outputs such that if the Day Return value was 0, it was replaced by the Return.
- 6.4.19 The results of this combination was that for Anytime data returns only 26 movements which were not covered out of the 121,452 station to station movements.
- 6.4.20 Eight of these represented station to station movements within a station cluster, for example Glasgow Queen Street to Glasgow Central fares, while others were specific movements, as listed in the table below (note, all bi-directional):

Table 38. Railway Fares manually processes

ORIG FZ	DEST FZ	ORIGIN STATION	DESTINATION STATION
40	230	Bathgate	Livingston South
65	140	Camelon	Falkirk High
73	238	Carntyne	Lockerbie
122	266	Dunbar	North Berwick
133	238	Easterhouse	Lockerbie



ORIG FZ	DEST FZ	ORIGIN STATION	DESTINATION STATION
149	238	Garrowhill	Lockerbie
229	230	Livingston North	Livingston South
301	238	Shettleston	Lockerbie
328	230	Uphall	Livingston South

Note: FZ = Fare Zone number

- 6.4.21 These movements were manually interrogated within the database, with values extracted. In some cases, as no return fare was available within the database, the single journey fare was doubled. In other cases, the fare from an adjacent station was used.
- 6.4.22 The matrices were then factored to create an average fare per journey, assuming weekly travel by season ticket (10) and 2 journeys per return ticket.
- 6.4.23 A point to note is that none of the above fares are within the SRTM modelled area, consequently these represent data for movements that will not be used within the model.
- 6.4.24 The Child matrices were based on half of the fares of the adult tickets in accordance with ScotRail fares policy (<https://www.scotrail.co.uk/tickets/leisure?accordion=off-peak>).
- 6.4.25 A transit distance skim was sourced from a TMfS based “rail only” model to obtain transit distances for each station to station movements. This enabled concessionary travel to be priced in accordance with the SPT concessionary travel scheme.
- 6.4.26 The fares (<http://www.spt.co.uk/travelcards/concessions/>) are £1.30 return for travel up to 10 miles on the network, and half the adult fares for trips longer than 10 miles. A further restriction is that these are stations within the SPT area, thus the concessionary tickets for movements outside of the SPT area have been set as those of an adult.
- 6.4.27 The output is a matrix file with 356 zones with eleven tables included, these being:
- AM Adult Daily;
 - IP Adult Daily;
 - PM Adult Daily;
 - AM Child Daily;
 - IP Child Daily;
 - PM Child Daily;
 - Adult Weekly (Season);
 - Child Weekly (Season);
 - AM Concessionary;
 - IP Concessionary;
 - PM Concessionary.
- 6.4.28 As a check, the fares output have been checked against fares from the ScotRail season ticket website (<https://www.scotrail.co.uk/tickets/commuter>). This webpage illustrates the savings available via a season ticket for six journeys.

6.4.29 The data from the website has been reproduced in the two tables below, for season tickets and standard tickets respectively together with the output from the SRTM database.

Table 39. ScotRail ticket check – per one way trip – Season Tickets

ROUTE	SCOTRAIL	SRTM	DIFF	% DIFF
East Kilbride to Glasgow Central	£2.32	£2.30	£0.02	1%
Wemyss Bay to Glasgow Central	£4.55	£4.50	£0.05	1%
Helensburgh Central to Queen Street	£3.73	£3.69	£0.04	1%
Neilston to Glasgow Central	£2.32	£2.30	£0.02	1%
Kirkcaldy to Edinburgh Waverley	£5.44	£5.39	£0.05	1%
North Berwick to Edinburgh Waverley	£4.27	£4.23	£0.04	1%

Table 40. ScotRail ticket check – per one way trip – Standard Tickets

ROUTE	SCOTRAIL	SRTM	DIFF	% DIFF
East Kilbride to Glasgow Central	£3.15	£3.10	£0.05	2%
Wemyss Bay to Glasgow Central	£5.90	£5.85	£0.05	1%
Helensburgh Central to Queen Street	£5.00	£4.95	£0.05	1%
Neilston to Glasgow Central	£3.15	£3.10	£0.05	2%
Kirkcaldy to Edinburgh Waverley	£7.00	£6.95	£0.05	1%
North Berwick to Edinburgh Waverley	£5.60	£5.55	£0.05	1%

6.4.30 As can be seen, the fares within the SRTM area consistent with those on the ScotRail website.

6.5 Subway Fares

6.5.1 The subway fares have been sourced from the SPT website, as shown below in Table 41.

Table 41. Subway Fares per one-way trip (by User Class)

USER CLASS	DESCRIPTION	FARESYSTEM	PRICE
EBN	Employers' Business – Day Travel	411	£1.50
CMN	Commuter – Day Travel	411	£1.50
OTN	Others – Day Travel	411	£1.50

USER CLASS	DESCRIPTION	FARESYSTEM	PRICE
EDN	Education – Day Travel	421	£0.67
EBS	Employers' Business – Multi-Day Travel	431	£1.30
CMS	Commute – Multi-Day Travel	431	£1.30
OTS	Others – Multi-Day Travel	431	£1.30
EDS	Education – Multi-Day Travel	441	£0.65
RET	Retired	451	£0.65

Note: Fares as sourced from SPT Website (2016 prices)

<http://www.spt.co.uk/subway/tickets/>

6.6 Ferry Fares

6.6.1 Ferry fares have been sourced from operator websites for nine ferries that are coded within the SRTM. These nine services require seven systems to represent the fare structures. The table below lists the ferry services and the respective ferry fare system.

6.6.2 A review of operator websites has provided the information on fares for individual passenger journeys on each operator. The multi-day travel has been represented by averaging the cost of 10 journey tickets.

Table 42. Ferry Fares – per one way trip

OPERATOR	FERRY FROM	FERRY TO	FARE SYSTEM
Clydelink	Renfrew	Yoker	5x1
SPT	Gourock	Kilcreggan	5x2
Calmac	Gourock	Dunoon	5x3
Western Ferries	Gourock	Hunter's Quay	5x4
Calmac	Weymess Bay	Rothesay	5x5
Calmac	Androssan	Arran	5x6
Calmac	Largs	Millport	5x7
Calmac	Androssan	Brodick	5x6
Calmac	Largs	Cumbrae	5x7

6.7 SRTM Inputs

6.7.1 The railway fares, and fares for operator groups 1 to 3 are stored in four files, with the railway matrices containing additional tables for time period specific fares (Anytime and Offpeak tickets).

6.7.2 These files are in {CATALOG_DIR}\Runs\{Model Year}\{Run ID}\Input\Additional_PT\ and are named:

- Rail_Fares;
- OpGrp1_Fares;
- OpGrp2_Fares; and
- OpGrp3_Fares.

6.7.3 The remaining fares systems are coded within the three time period specific files {CATALOG_DIR}\Runs\{Model Year}\{Run ID}\Input\Additional_PT\FARES_%TIME%.FAR



7. CALIBRATION OUTLINE

7.1 Context

7.1.1 This chapter documents our approach to the calibration of the SRTM public transport assignment model, including the methodologies and the source data used in the calibration and validation process.

7.2 Available Survey Data

7.2.1 The survey data available for the SRTM is as follows:

- 2014 Bus onboard Questionnaires for TMfS14;
- 2014 Bus passenger counts for TMfS14;
- 2015 SPT inner Glasgow bus cordon count;
- 2016 SRTM public transport survey programme;
- Subway boarding and alighting data (by stop and time);
- ScotRail rail counts;
- LENNON ticket data; and
- SPT Corporate Bus service data (timetabled bus times).

7.2.2 We have investigated data from the Bus Information and Signalling system (BIAS data), unfortunately the licenses are not currently in place to enable an extraction of data from the system.

7.2.3 We have also investigated the potential for boarding data from Transport Scotland's concessionary smartcard database. Unfortunately, the lack of geocoding in the database would make it impractical to use at this stage of model development.

7.2.4 The count data has been processed into screenlines as cordons as listed below, and shown in the following three figures:

- Glasgow Inner Cordon;
- Glasgow Outer Cordon;
- River Clyde Cordon; and
- Ayrshire Cordon.





Figure 29 Glasgow Inner Cordon

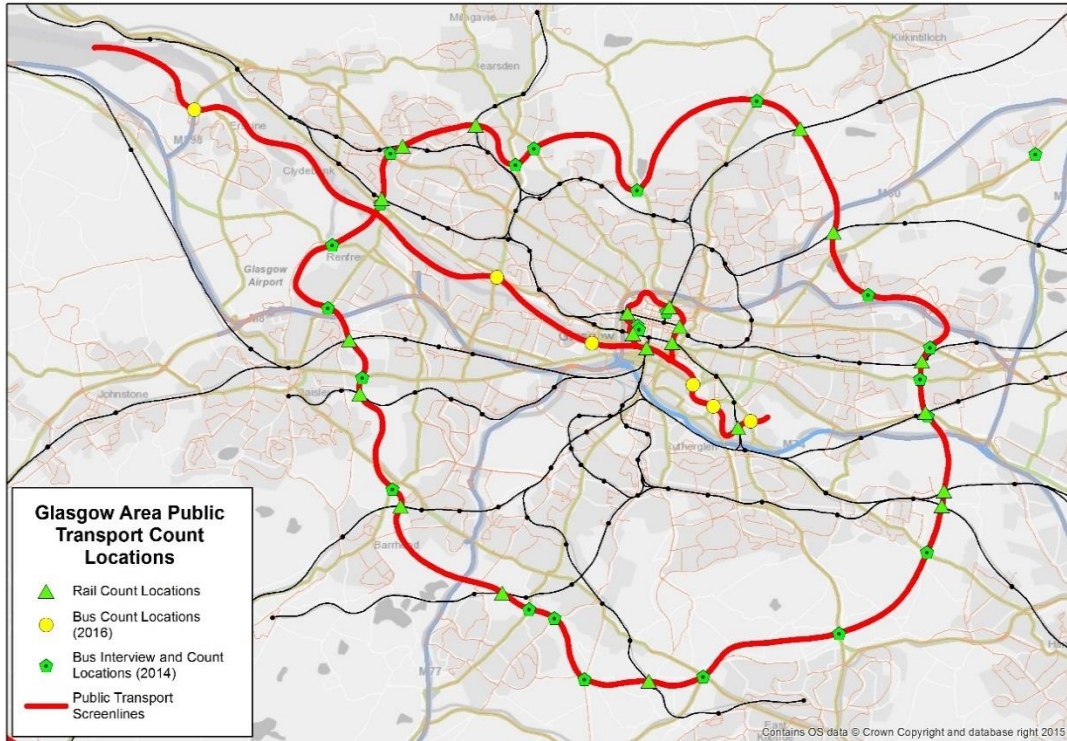


Figure 30 Glasgow Outer Cordon

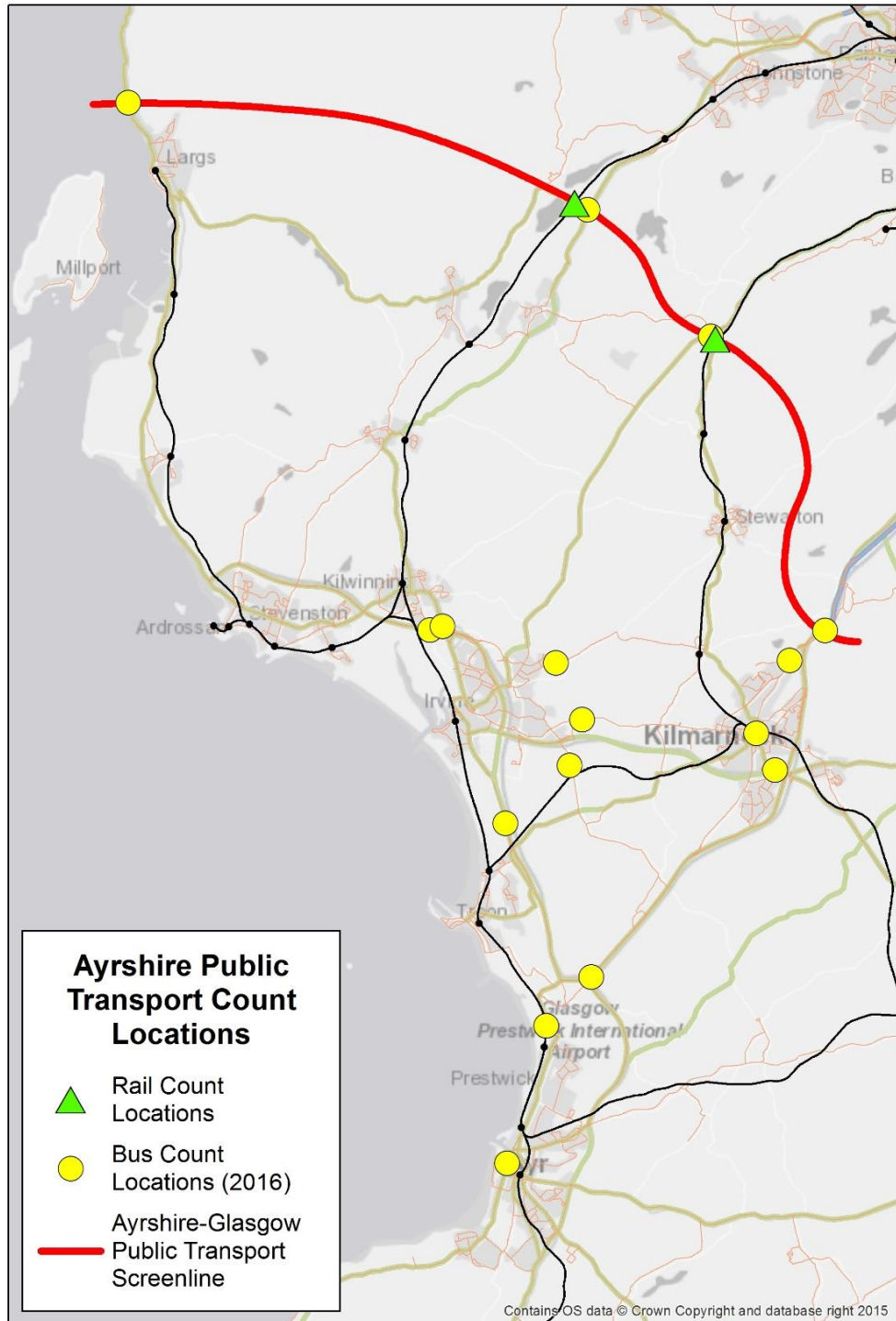


Figure 31 Ayrshire Cordon

7.2.5 The inner cordon, outer cordon and river cordon have been subdivided into sections for more localised analysis.

7.3 Bus Passenger Occupancy

7.3.1 The bus count data was processed by different methodologies according to data sources and the manner of the data collection.

7.3.2 The first set, those sites surveyed as part of the LATIS commission for TMfS14 were processed using the following methodology:

- Using the TMfS14 assumptions identify the seating capacity for each surveyed bus, these are as follows:
 - Midi / Minibus – 30 seats
 - Single decker – 40 seats
 - Double decker – 70 seats
 - Coach – 56 seats
- Factor the seating capacity by the surveyed percentage occupancy to yield the passengers per service;
- Identify the time period and modelled hour for each service;
- Use pivot tables to sum by direction and time period / modelled hour; and
- Multiply observed count values by rebasing factor to convert from 2016 to 2014 flows.

7.3.3 The second set of bus count sites were surveyed as part of the SPT central cordon surveys over a six week period in 2015, from middle of February to early April 2015. These were processed in the following manner:

- Combine into a single database;
- Add a time period and modelled hour flag based on the standard definition to each record;
- Use pivot tables to sum by direction and time period / modelled hour; and
- Multiply observed count values by rebasing factor to convert from 2016 to 2014 flows.

7.3.4 The count for site C04 was removed from the database due to the location being identified during the survey as a main route taken by buses to / from the depot while operating empty.

7.3.5 The third set of bus count sites were surveyed as part of the SRTM survey programme in 2016.

7.3.6 As these bus occupancy counts were based on identifying a bus type and approximating a percentage occupancy, these site were processed using the following methodology:

- Identify seating capacity for each bus type, this was set as to the values used in the processing of the TMfS data;
- Identify the reported percentage occupancy and multiply by the seating capacity;
- Apply filters for time period and peak hour to obtain observed count values; and

- Multiply observed count values by rebasing factor to convert from 2016 to 2014 flows.

7.3.7 A data type flag was linked to each count site to identify the type of data, this will be used to set confidence levels within matrix estimation.

7.3.8 As the surveys were sourced from different years, there is a requirement to rebase the counts to our 2014 base year.

7.3.9 The data published within Scottish Transport Statistics has been analysed to provide factors to rebase the count data based on the average growth rate of buses in South West Scotland in the last 5 years, this process is common to bus, rail and subway modes and is documented in section 7.5.2.

7.4 Rail Passenger Counts

7.4.1 Two tranches of surveys have been carried out:

- Tranche 1 between November 2015 and early February 2016; and
- Tranche 2 between late February 2016 and April 2016 .

7.4.2 The number of services surveyed by route for each tranche is summarised below:

Table 43. Rail Passenger Surveys

ROUTE NO	ROUTE DESCRIPTION	NUMBER OF TRAIN SERVICES SURVEYED
Tranche 1		
1	Glasgow Central - East Kilbride	207
2	Glasgow Queen St - Anniesland	161
3	Edinburgh - Tweedbank	158
4a	Glasgow Central - Cathcart (Circle)	63
4b	Glasgow Central - Neilston	210
4c	Glasgow Central - Newton	172
5	Glasgow Central - Paisley Canal	152
6	Glasgow - Girvan/Stranraer & Kilmarnock - Girvan/Stranraer	58
7&11	Glasgow Queen St/Edinburgh - Dundee, Aberdeen and Inverness. Aberdeen-Inverness	258
8	Glasgow Queen St - Falkirk Grahamston	77

ROUTE NO	ROUTE DESCRIPTION	NUMBER OF TRAIN SERVICES SURVEYED
9	Helensburgh/Balloch/Milngavie - Edinburgh via Airdrie/Bathgate	307
10	Glasgow/Edinburgh - Stirling/Alloa/Dunblane/Perth	378
12	Glasgow Queen St - Crianlarich/Oban/Fort William/Mallaig	42
13	Glasgow Central - Edinburgh	127
14a	Glasgow Central - Barrhead	96
14b	Glasgow Central - Kilmarnock	113
15	Inverness - Highlands	26
16	Glasgow Central - Gourrock	41
17	Edinburgh - Fife	235
18	Glasgow Queen St - Edinburgh via Falkirk	303
19	Lanarkshire and Dunbartonshire	170
20	Glasgow Central - Wemyss Bay	11
21	Edinburgh - North Berwick/Dunbar	13
Tranche 2		
1	Glasgow Central - East Kilbride	209
2	Glasgow Queen St - Anniesland	161
4a	Glasgow Central - Neilston	211
4b	Glasgow Central - Newton	202
4c	Glasgow Central - Cathcart (Circle)	69
5	Glasgow Central - Paisley Canal	152
7a	Glasgow Queen St - Dundee, Aberdeen and Inverness	126
8	Glasgow Queen St - Falkirk Grahamston	79

ROUTE NO	ROUTE DESCRIPTION	NUMBER OF TRAIN SERVICES SURVEYED
9	Helensburgh/Balloch/Milngavie - Edinburgh via Airdrie/Bathgate	363
10a	Glasgow - Stirling/Alloa/Dunblane/Perth	167
12	Glasgow Queen St - Crianlarich/Oban/Fort William/Mallaig	42
18	Glasgow Queen St - Edinburgh via Falkirk	310
19a	Lanarkshire	498
19b	Dunbartonshire	126
20	Glasgow Central - Wemyss Bay	6

7.4.3 For each train surveyed, the Train Id, date, time and number of passengers boarding and alighting at each station was recorded.

7.4.4 SPT provided the December 2015 Train Plan. This contained information on all of the services planned to be operated under the December 2015 timetable, including day of the week, origin and destination, origin time and destination time, and planned seats.

7.4.5 Any deviations to the planned service pattern, such as terminating short of the final destination, were also noted.

7.4.6 The survey data was processed through a four stage process:

- Factoring of counts to treat deviations to the train service;
- Calculation of cumulative service flow by section;
- Aggregation of services to link flow; and
- Adjustment of surveyed flows to common year.

Adjustments for Train Service Deviation

7.4.7 Surveyed train services were compared to the December 2015 Train Plan for each route, direction and time period (AM, IP, PM), and a factor calculated based on the ratio of services surveyed to total services planned to be operated. The counts were then factored to take account of any services that were not surveyed. If no services on a route were surveyed for a time period then TMfS14 flows were used instead.

Calculation of Cumulative Service Flow by Section

7.4.8 For each service, the midpoint time was identified to allocate the service to a model time period.



7.4.9 Then, each service was process to calculate the cumulative load on the service as it traversed the railway network by subtracting the alighting flow and adding the boarding flow at each stop.

Aggregation of Services to Link Flow

7.4.10 Each station to station section was identified and added as a field to the data. This enabled the summing of the service flows for each individual section by time period.

7.4.11 Then each station to station section was allocated to a link within the rail network.

Adjustment to Common Year

7.4.12 Since the surveys were from December 2015 to April 2016 and the base year of the model is 2014, surveyed counts were factored on a 2014 level. TMfS14 data is based on 2014, so no factor was required for this data. The process for this is documented in section 7.7.

7.4.13 Along with the link flows key stations, listed below, were identified as the busiest stations in the modelled area based on annual station usage for 2014/2015. This list comprised:

- Glasgow Central
- Glasgow Queen Street
- High Street
- Argyle Street
- Anderston
- Charing Cross
- Exhibition Centre
- Partick
- Paisley Gilmour Street
- Ayr

7.4.14 The final stage was combining the rail flows with the bus flows to form screenlines for model comparison.

7.5 Rail LENNON derived Station to Station Counts

7.5.1 The LENNON (Latest Earnings Networked Nationally Over Night) ticket sales database has been analysed to provide an annualised matrix of rail passenger movements by purchased ticket type for each station to station.

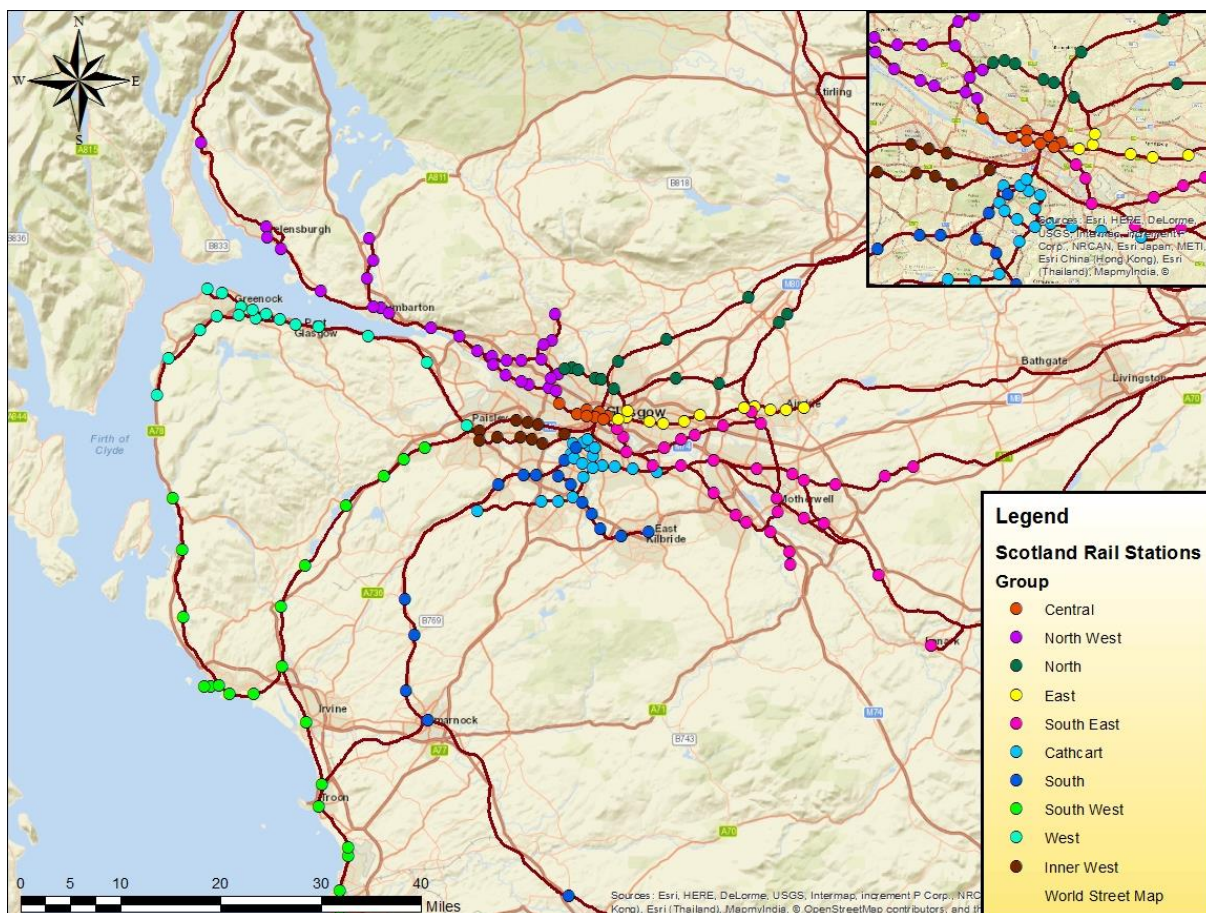
7.5.2 The database output annualised numbers by ticket class, we have made the following assumptions in addition to those incorporated within LENNON:

- Single ticket class trips have not been changed;
- Return ticket class trips are converted to two directional trips by halving the trips to represent the outbound, and halving and transposing to represent the inbound; and
- Season ticket class trips are converted to two directional trips using the same process as for return tickets.



7.5.3 To aid analysis the stations have been aggregated to formed 11 station groups, the first 10 being stations within the SRTM modelled area and group 11 representing external stations. These 10 groups represent the key rail corridors, as illustrated in the figure below.

Figure 32 Station Groupings



7.5.4 The resulting annualised rail movements are shown below in Table 44 and Table 45.

7.5.5 Time period station group to station group are output from SRTM using CUBE Voyager’s STOP2STOPO functionality. These outputs are then factored to annual values using current SHS derived annualisation factors) for the SPT rail area. These are:

- 630 AM hour assignments;
- 3663 IP hour assignments; and
- 508 PM hour assignments.

7.5.6 The resulting annual SRTM flows are then compared with the LENNON dataset, primarily in terms of the relative percentage flow for each movement.



Table 44. LENNON Annual Rail Flows – All Data

GROUP	GROUP NAME	1	2	3	4	5	6	7	8	9	10	11	TOT
1	Central Glasgow	923	2989	1560	1630	2895	1904	1660	1730	693	1022	4683	21690
2	North West	2870	1439	94	167	198	57	40	54	25	64	186	5195
3	North	1143	87	91	38	53	16	11	15	5	24	219	1702
4	East	1550	165	37	317	22	18	11	14	6	28	67	2235
5	South East	2797	197	52	21	666	78	32	51	21	81	277	4275
6	Cathcart Lines	1750	55	16	18	76	427	27	40	20	56	62	2547
7	South	1571	39	10	11	31	27	294	40	12	37	82	2155
8	South West	1677	54	15	14	52	41	40	1264	32	279	176	3644
9	West	675	26	5	6	21	20	12	33	288	213	45	1345
10	Inner West & Paisley Canal	988	65	24	28	82	59	39	298	221	100	53	1957
11	Externals	4561	188	246	67	278	61	82	177	45	53	23598	29356
TOT	All Stations	20505	5304	2151	2317	4376	2708	2249	3715	1368	1958	29447	76100

Source: LENNON Database, note values are in rounded 1000 trips per annum

Table 45. LENNON Annual Rail Flows – Glasgow Area data

GROUP	GROUP NAME	1	2	3	4	5	6	7	8	9	10	11	TOT
1	Central Glasgow	923	2989	1560	1630	2895	1904	1660	1730	693	1022		17006
2	North West	2870	1439	94	167	198	57	40	54	25	64		5008
3	North	1143	87	91	38	53	16	11	15	5	24		1483
4	East	1550	165	37	317	22	18	11	14	6	28		2168
5	South East	2797	197	52	21	666	78	32	51	21	81		3996
6	Cathcart Lines	1750	55	16	18	76	427	27	40	20	56		2485
7	South	1571	39	10	11	31	27	294	40	12	37		2072
8	South West	1677	54	15	14	52	41	40	1264	32	279		3468
9	West	675	26	5	6	21	20	12	33	288	213		1299
10	Inner West & Paisley Canal	988	65	24	28	82	59	39	298	221	100		1904
11	Externals												
TOT	All Stations	5116	1904	2250	4096	2647	2166	3539	1323	1904	5116		40889

Source: LENNON Database, note values are in rounded 1000 trips per annum

7.6 Subway Boarding and Alighting Data

- 7.6.1 Boarding and alighting data for the Subway was sourced from SPT.
- 7.6.2 This data was supplied via an EXCEL spreadsheet with a record each time a ticket barrier was activated, either for entry / boarding or for exit / alighting from the system. The data was collected over a two week period of 3 March to 20 March 2015.
- 7.6.3 The data was processed into time period and modelled hour counts by time of entry to the system for boarding or exit from the system for alighting. Following this the data from the 10 surveyed weekdays was averaged to create a daily value.
- 7.6.4 As the surveys were sourced from 2015, there is a requirement to rebase the counts to our 2014 base year. The data published within Scottish Transport Statistics has been analysed to provide factors to rebase the count data based. This process is documented below in section 7.7.
- 7.6.5 Additional data for the subway was extracted from the TMfS14 base year model run. These data provide link flows to complete cordons, such as the river screenline, where boarding and alighting data would not provide a direct equivalence.
- 7.6.6 Data from TMfS has not been adjusted to a common year as the modelled base year is 2014, and this data has been given a lower confidence in the calibration given it is sourced from a model.

7.7 Count Adjustment to Common Year

- 7.7.1 The data collated for the SRTM public transport model covers three modes and three years, those of 2014, 2015 and 2016.
- 7.7.2 As the base year of the model is 2014, to match the planning data inputs, a factoring process is required to rebase counts to the 2014 base year.
- 7.7.3 Data has been sourced for rail from the Office of Road and Rail Regulation, and from Scottish Transport Statistics for Bus and Subway.
- 7.7.4 These data represent annualised numbers of trips for 2015, with 2016 being estimated from trend analysis where direct data is not available. The analysis has resulted in the factors in the table below.

Table 46. Count Adjustment Factors

MODE	COUNT YEAR	FACTOR TO 2014
SUBWAY	2015	0.998
BUS	2016	1.084
BUS	2015	1.047
RAIL	2016	0.926
RAIL	2015	0.932

7.7.5 The buses factor is greater than 1 as there has been a noticeable decline in bus usage over the last few years. The rail and subway show values less than 1, reflecting the increase in patronage on rail-based modes over time.

7.8 Calibration Approach

7.8.1 Our approach to model calibration and validation will undertake the following checks:

- Network checks;
- Service checks;
- Network route checks;
- Validation of the trip matrix; and
- Matrix estimation.

7.8.2 The network checks will predominately be performed within the road model. Checks on the railway / subway and ferry networks have already been undertaken and reported previously in this note.

7.8.3 Checks on plausibility of the walk network, in terms of access to the public transport network and interchange links will be undertaken. We anticipate that there will be some zones where due to the public transport system this is not possible within 1km, particularly for rural and external zones, and hence the maximum connection distances will be increased until each zone can connect to the public transport network.

7.8.4 The checks on the railway, subway and ferry services have been performed. Further checks on the bus services will be done to ensure that the coded distance within the model is consistent with the equivalent coded ITN distance in the SPT corporate database.

7.8.5 Checks on the process to convert the SPT corporate database to Voyager lines files have been undertaken to ensure that the headways, and therefore number of buses per road, is sufficiently robust prior to the commencement of model development.

7.8.6 Checks on network routes will be undertaken during model calibration with networks from the road model that are potentially subject to revision. These checks will identify the models responsiveness to changes in the enumeration controls and seek to ensure that the generated routes are sensible.

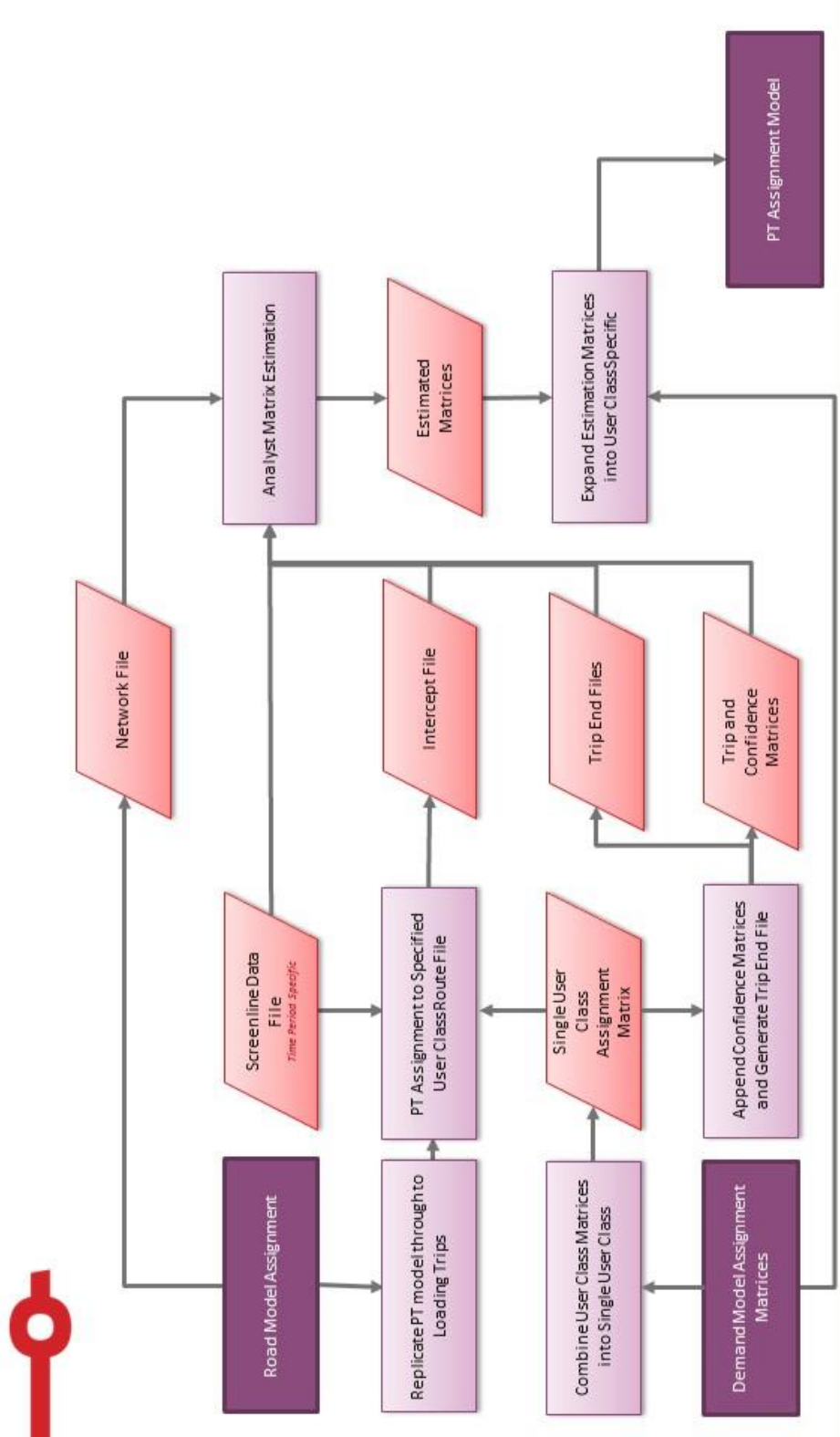
7.8.7 The validation of the trip matrix will be accomplished through comparison to the screenline flow comparison (illustrated through the figures in this chapter) and for the rail model the station group to station group flows. These will be reported both pre and post matrix estimation to aid the interpretation of the impact of matrix estimation.

7.8.8 It is likely that matrix estimation techniques will be required to finalise the calibration and validation of the public transport assignment model.

7.8.9 Our approach to matrix estimation will be as illustrated in the flowchart overleaf and is discussed in detail in the following paragraphs.



Public Transport Estimation Process



SYSTRA

Figure 33 Public Transport Matrix Estimation Process

- 7.8.10 The estimation process begins by replicating the public transport model through the route enumeration stage. Paths are constructed for all nine user classes.
- 7.8.11 The demand matrices are combined over user classes to form an all trip matrix by time period.
- 7.8.12 These are then assigned to a single path file, this path file will be the user class with the largest contributory matrix of trips.
- 7.8.13 This combination is required because the flows that are being estimated to are total passenger flows and have no segmentation by user class. The assignment model is run and an intercept file is produced.
- 7.8.14 This intercept file represents the routes that are used through each link with a calibration count.
- 7.8.15 These calibration counts and intercept files are then input together with the trip matrix and trip ends into the Cube analyst matrix estimation programme.
- 7.8.16 Cube analyst estimates the matrices to best fit the input data, primarily focused on the link and screenline count flows. The estimation takes as inputs the following data types:
- Screenline flows (e.g. the sum of movements across the Clyde);
 - Individual link flows;
 - Trip end totals; and
 - Individual trip movements.
- 7.8.17 Each of the data types in the list above is given a confidence weighting, with the list above being sorted by confidence level from high to low. The confidence of individual link flows will also be influenced by the age of the count.
- 7.8.18 Once a matrix has been estimated it is factored to user class matrices based on the proportions from the demand model output. These matrices are then reassigned through the standard public transport assignment model with link flows extracted for analysis within the calibration spreadsheet.



8. CALIBRATION RESULTS

8.1 Bus Route Distance Checks

- 8.1.1 The bus route distances as coded within the model were checked against the SPT corporate database journey distance record. This distance record was calculated by SPT from the aggregation of ITN link distances on the assigned route.
- 8.1.2 The results have grouped into SRTM operator group, essentially the three largest operators with all other operators grouped together.
- 8.1.3 The checks performed have been the number and percentage of individual services within a specified distance, the results given in the following two tables.

Table 47. Bus Route Distance Check

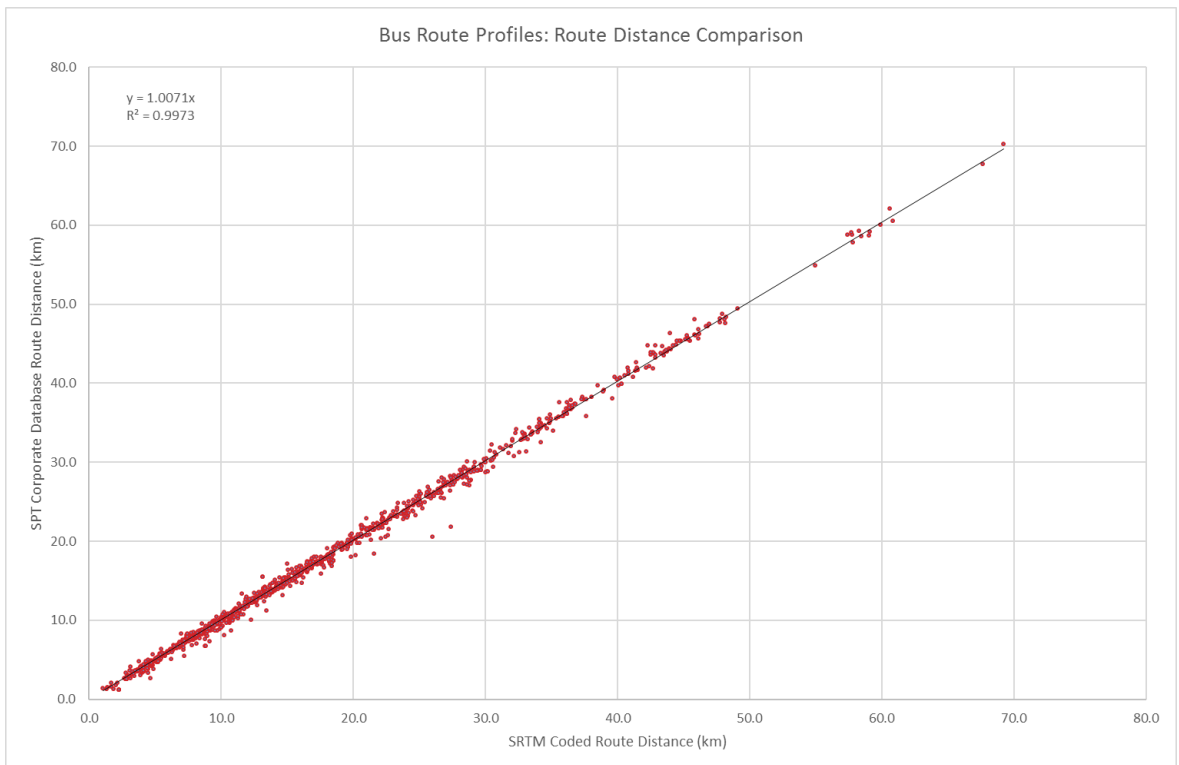
OPERATOR GROUP		DISTANCE RANGE (WITHIN 'X' KM)					TOTAL
		<1	1-2	2-3	3-4	4-5	
1	First Group	406	7	0	0	0	413
2	McGill's Bus	252	12	0	1	0	265
3	Western Bus	217	4	0	0	0	221
4	All Others	256	2	1	0	0	259

Table 48. Bus Route Distance Check – Percentage

OPERATOR GROUP		DISTANCE RANGE (WITHIN 'X' KM)					TOTAL
		<1	1-2	2-3	3-4	4-5	
1	First Group	98%	2%	0%	0%	0%	100%
2	McGill's Bus	95%	5%	0%	0%	0%	100%
3	Western Bus	98%	2%	0%	0%	0%	100%
4	All Others	99%	1%	0%	0%	0%	100%

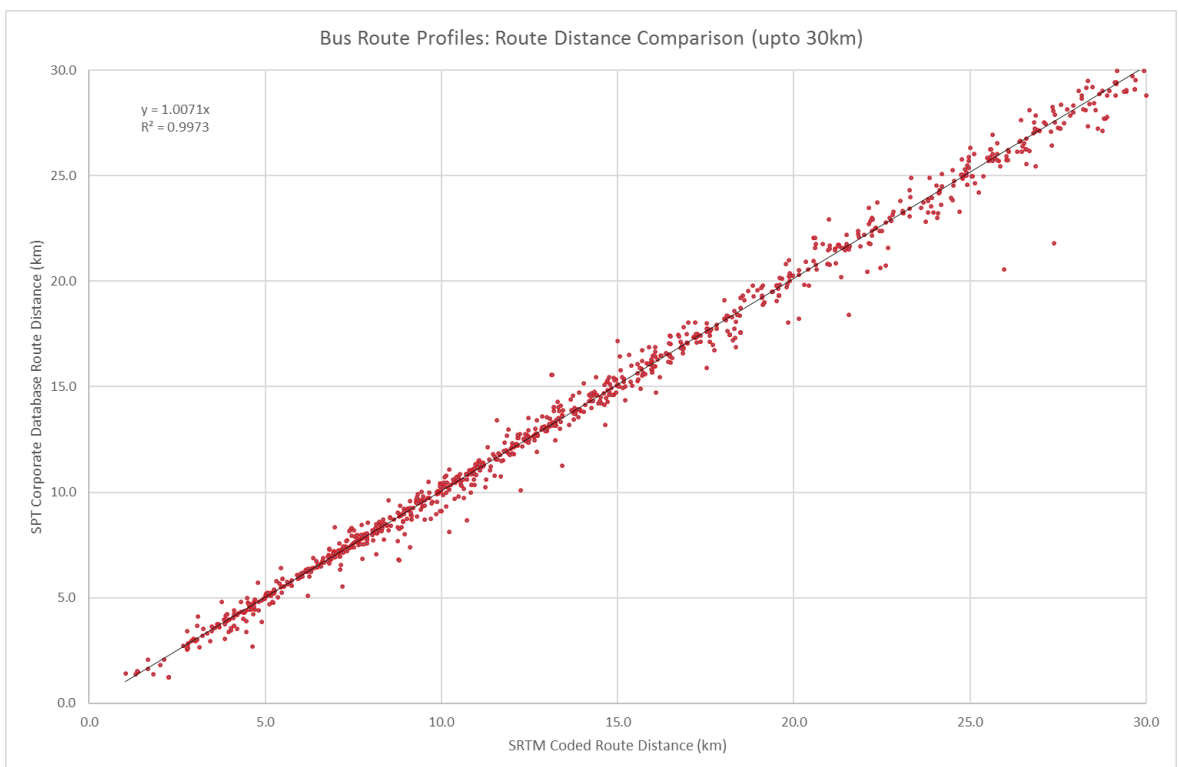
- 8.1.4 The figure below provides a plot of the bus distances of each service, comparing the SPT Corporate database distance with the SRTM coded distance.
- 8.1.5 As can be seen from the graph there is a strong correlation between the records, giving confidence in the coding of the services. In particular, the gradient of the line is very close to 1, providing evidence of little bias in the coding of routes.

Figure 34 Plot of Bus Route Distance Check



8.1.6 The figure below provides a similar plot for services up to 30km in route distance. As with the full dataset, there is a strong correlation between the data.

Figure 35 Plot of Bus Route Distance Check (up to 30km)



Similar graphs have been produced for services that have a section on the “reverse” link. As can be seen from the following two graphs the outputs are similar and the regression values are not substantially lower. This provides further confidence that the adoption of the reverse direction approach has not unduly affected the coding of these services.

Figure 36 Plot of Bus Route Distance Check – ‘Reverse Link Routes’

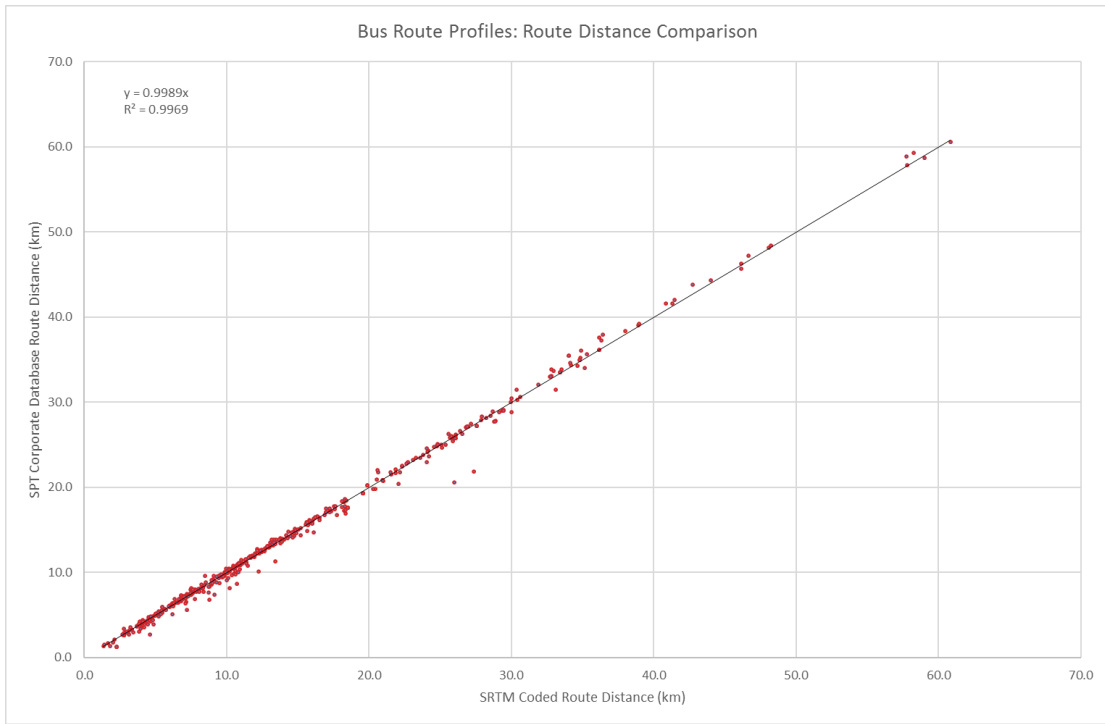
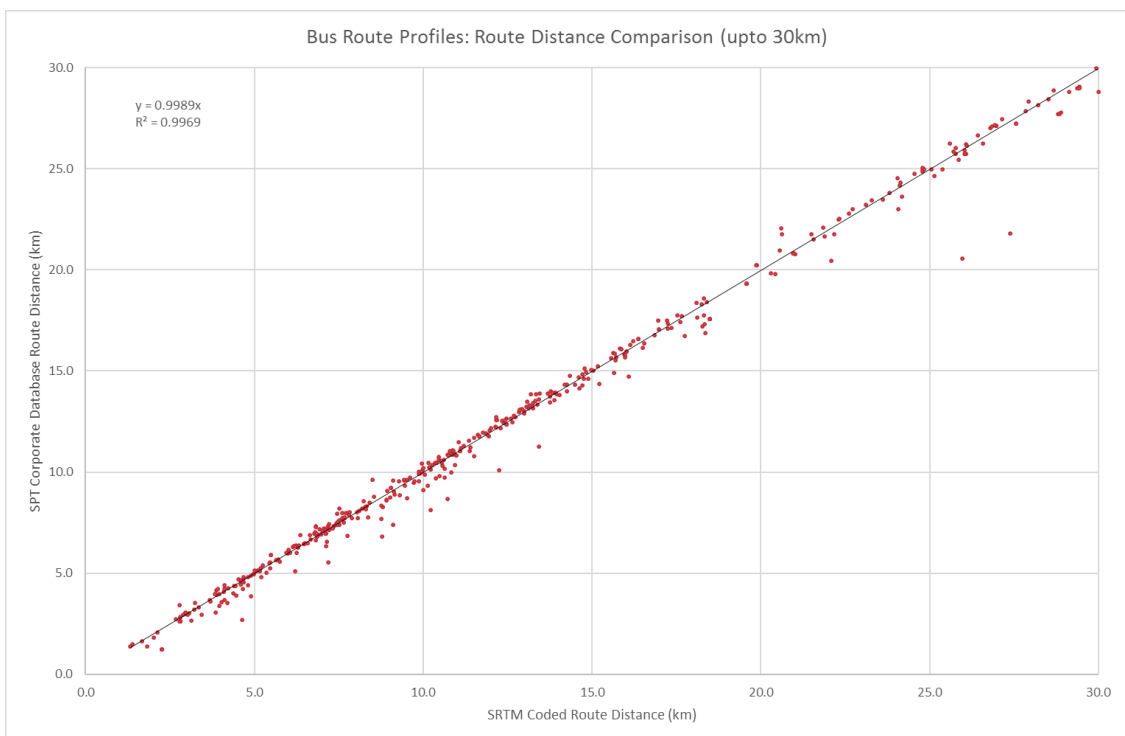


Figure 37 Plot of Bus Route Distance Check – ‘Reverse Link Routes’ (up to 30km)



8.2 Bus Route Journey Time Checks

- 8.2.1 The journey times for bus routes within the SRTM model are sourced from a combination of the link journey time and an assumed dwell time per stop on route.
- 8.2.2 The link journey times are sourced from the SATURN assignment through used of the congested speed (DA Code 4053). This speed represents the prevailing link speed and an average delay should there be simulated delays at the node at the end of the link.
- 8.2.3 Public transport speeds are calculated through the process outlined in section 2.1.
- 8.2.4 Following this, a dwell time was calculated for input into the model to best match journey times. This was input as a single dwell time of 12 seconds for all stops, given the lack of detailed journey time data for all routes.
- 8.2.5 The public transport assignment model was then run and a check of the output bus journey times against bus timetables performed. The table below provides a summary analysis by time period.

Table 49. Bus Route Journey Time Check

TIME PERIOD	WITHIN $\pm 15\%$ OF TIMETABLE		WITHIN $\pm 25\%$ OF TIMETABLE	
Morning Peak	429	67%	559	88%
IP Time Period	416	67%	547	88%
Evening Peak	716	62%	943	81%

- 8.2.6 As can be seen from the table above, the majority of bus journey times are within the 15% range as specified by WebTAG unit M3-2. There is a large number of additional services within the evening peak. This is reflected within the SPT corporate database, as there are a number of routes in the evening peak that have different routes.
- 8.2.7 The analysis above has been further subdivided into ten minute time band differences, as presented in the table below.

Table 50. Bus Route Journey Time Range Check

TIME PERIOD	<-40	[-40, -30]	[-30, -20]	[-20, -10]	[-10, 10]	[10,20]	[20,30]	[30,40]	>40
AM	0%	0%	0%	4%	89%	5%	1%	0%	0%
Lt	0%	0%	1%	9%	88%	2%	0%	0%	0%
PM	0%	0%	0%	4%	89%	6%	1%	0%	0%

- 8.2.8 Overall, the level of calibration is good, with over 88% of journeys within 10 minutes for all three time periods, and very few journeys have a difference of more than 20 minutes.



8.2.9 The journey times have also been compared by operator group, with the following three tables providing analysis for the morning, inter-peak and evening peaks respectively.

Table 51. Operator Group Journey Time Check - AM

OPERATOR GROUP		AM DIFFERENCE		
		<-10	[-10,10]	>10
1	First Group	6%	89%	5%
2	McGill's Bus	4%	90%	6%
3	Western Bus	4%	88%	8%
4	All Others	3%	90%	7%

Table 52. Operator Group Journey Time Check - LT

OPERATOR GROUP		LT DIFFERENCE		
		<-10	[-10,10]	>10
1	First Group	18%	82%	0%
2	McGill's Bus	8%	89%	3%
3	Western Bus	6%	87%	7%
4	All Others	4%	94%	3%

Table 53. Operator Group Journey Time Check - PM

OPERATOR GROUP		PM DIFFERENCE		
		<-10	[-10,10]	>10
1	First Group	8%	87%	5%
2	McGill's Bus	3%	92%	6%
3	Western Bus	6%	86%	9%
4	All Others	3%	90%	6%

8.2.10 The key observation from the operator group analysis is the lower level of calibration for First Group for the LT period. It should be noted that further checks indicate that 95% of services are within -15 to +15 minutes, implying that the majority of journey times that are more than 10 minutes quicker in the LT period, are still within 15 minutes of timetabled journey time.



8.2.11 An analysis of the SPT corporate database timetable revealed that 54% of services that exist in all three time periods have the same timetabled time. In practice, it is likely that the inter-peak services would be quicker and that the inter-peak timetable has in effect some additional time allowed in the timetable.

8.2.12 As for the analysis of bus route journey distances, an assessment of the journey times for those bus routes that contain a “reverse link” has been included. The following two tables, replicate the analysis of Table 54 and Table 55 for service that have a section on a “reverse” link.

Table 54. Bus Route Journey Time Check – “Reverse Link Routes”

TIME PERIOD	WITHIN <+/-15% OF TIMETABLE		WITHIN <+/-25% OF TIMETABLE	
Morning Peak	159	62%	220	85%
IP Time Period	155	61%	214	84%
Evening Peak	280	58%	372	77%

Table 55. Bus Route Journey Time Range Check – “Reverse Link Routes”

TIME PERIOD	<-40	[-40, -30]	[-30, -20]	[-20, -10]	[-10, 10]	[10,20]	[20,30]	[30,40]	>40
AM	0%	0%	0%	3%	94%	2%	1%	0%	0%
Lt	0%	0%	1%	4%	93%	2%	0%	0%	0%
PM	0%	0%	0%	4%	92%	3%	0%	0%	0%

8.2.13 The tables illustrate that while the level of fit is lower for routes that have a “reverse” link, they are not substantial differences,.

8.2.14 The full set of routes have also been graphed to illustrate the level of fit between journey times in SRTM and the timetabled journey duration within the SPT corporate database.

8.2.15 The following six graphs illustrate the comparison for all services and for services up to 60 minutes duration for each modelled time period.



Figure 38 Bus Journey Time Comparison – AM

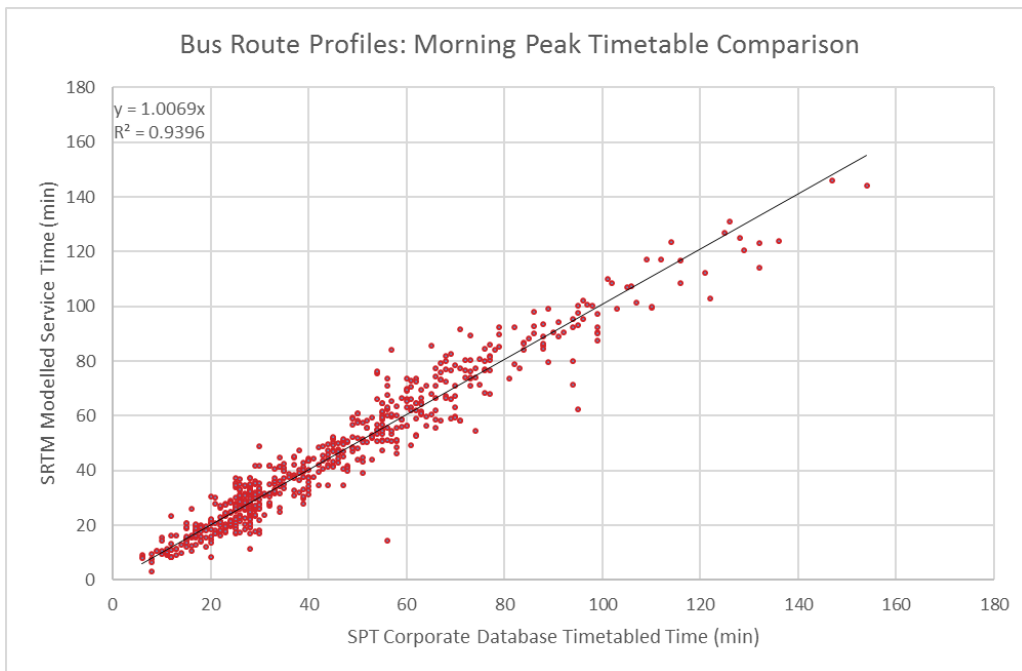
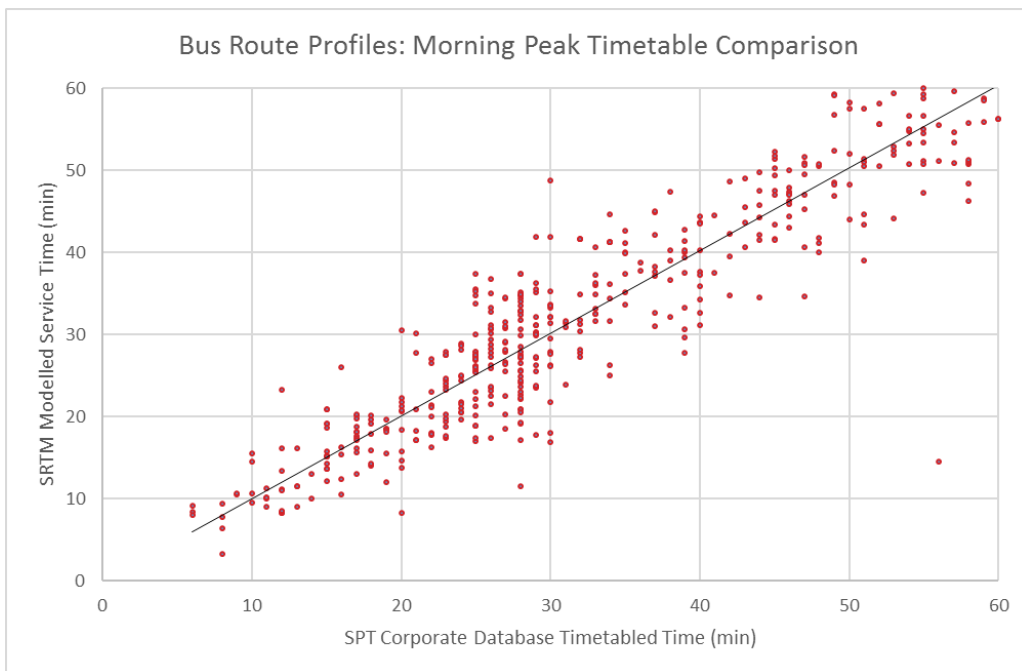


Figure 39 Bus Journey Time Comparison - AM – Up to 60 mins duration



8.2.16 As expected the data is quite dispersed in vertical rows as the SPT Corporate database is in minutes, whereas the model outputs in seconds. Overall though, the level of fit is good.

8.2.17 For services with a timetabled time lower than 60 minutes, a selection to draw out the urban buses, illustrates that the services are generally slower than timetable in the morning peak ($y=1.025x$, $R^2=0.8576$). This broadly fits with expectations that the timetables would be specified to provide some cushion for service performance.



Figure 40 Bus Journey Time Comparison - LT

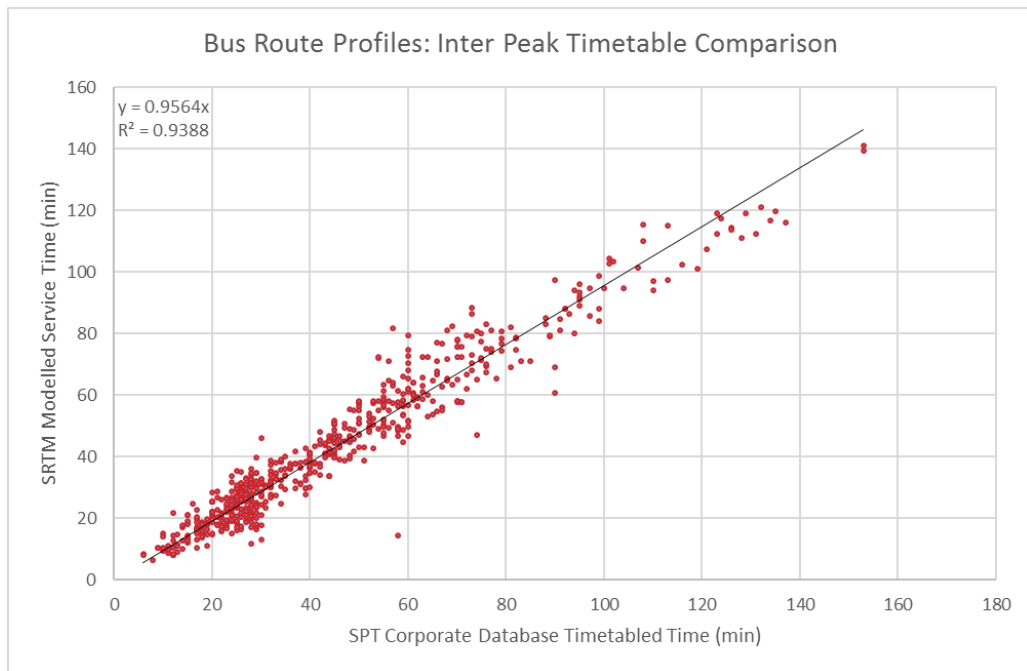
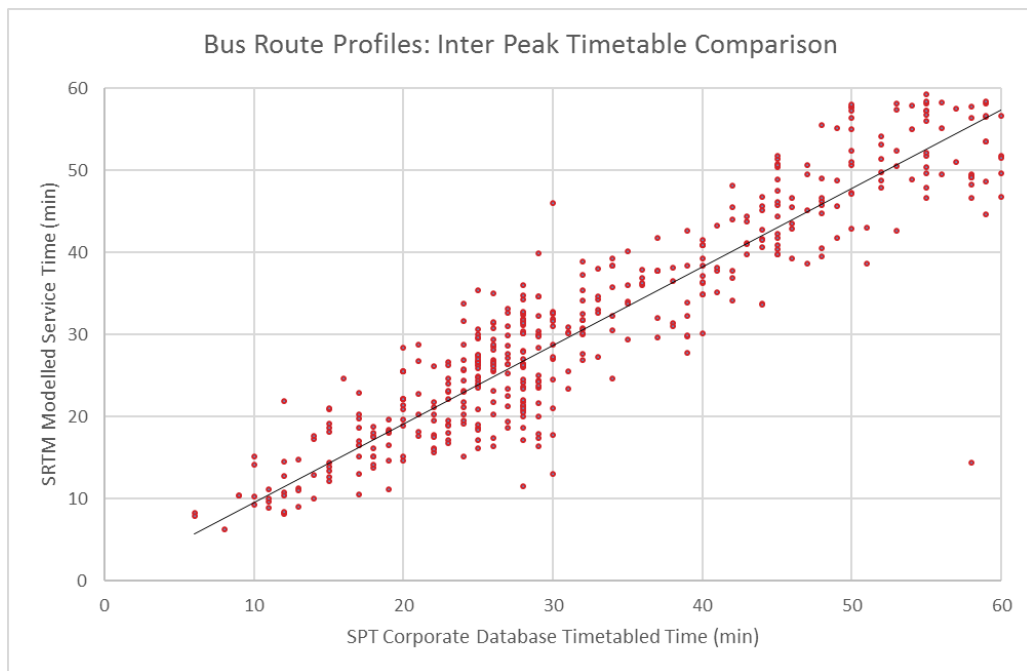


Figure 41 Bus Journey Time Comparison - LT – Up to 60 mins duration



8.2.18 For the inter-peak, the services generally run quicker than timetabled. As stated above, an analysis of the SPT corporate database timetable revealed that 54% of services that exist in all three time periods have the same timetabled time. Hence, given the lower levels of travel delays in the LT period, the gradient of the regression line will be lower than the other peak periods.

8.2.19 As for the morning peak, there is a lower R² value of 0.85 for services timetabled up to 60 minutes, with the equation of the line being $y=0.98x$.

Figure 42 Bus Journey Time Comparison – PM

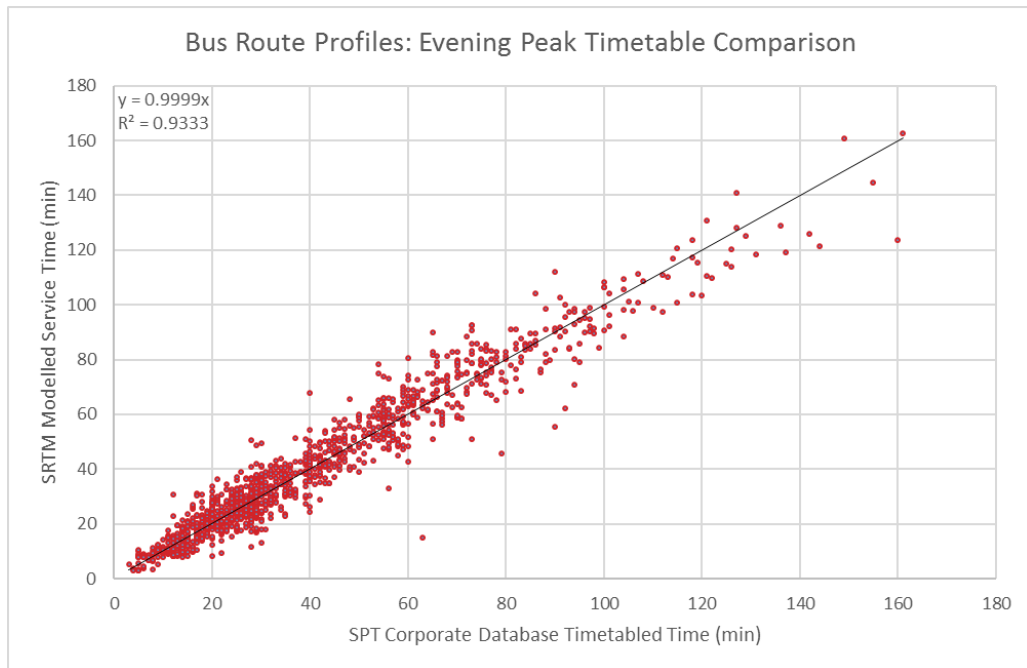
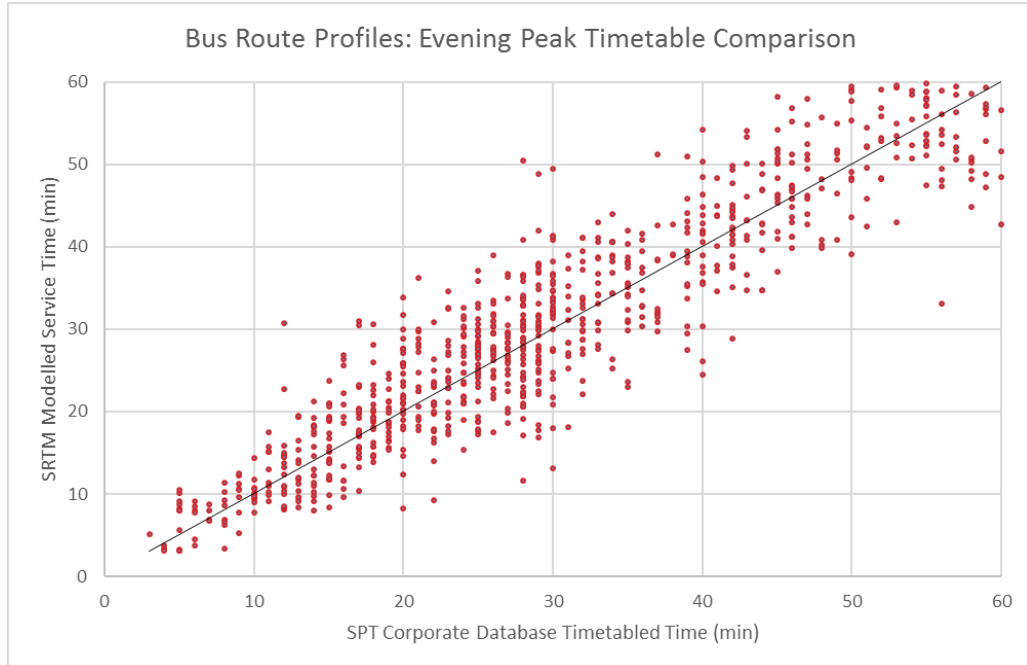


Figure 43 Bus Journey Time Comparison - PM – Up to 60 mins duration



8.2.20 The evening peak results mirror the morning peak results with a good level of fit and R-square regression value.



8.2.21 There is a lower R² value of 0.86 for services timetabled up to 60 minutes, with the equation of the line being y=1.03x.

8.3 Public Transport Flow Results

8.3.1 The following table provides summary screenline analysis for percentage difference in flow by time period and sub-divided by public transport sub-mode. The rows in bold represent the values at the WebTAG target of within 15% of screenline volumes.

8.3.2 As can be seen from the table below, the model calibrates well in the inter-peak and evening peak time periods but less so when segmented by mode.

Table 56. Summary Screenline Analysis (Rail includes Subway links)

% GAP	MORNING PEAK			INTER-PEAK			EVENING PEAK		
	BUS	RAIL	ALL	BUS	RAIL	ALL	BUS	RAIL	ALL
<5	29%	29%	21%	25%	29%	44%	36%	39%	50%
<15	61%	57%	68%	71%	61%	89%	68%	75%	82%
<25	71%	71%	86%	86%	82%	96%	86%	82%	96%
>=25	29%	29%	14%	14%	18%	4%	14%	18%	4%

8.3.3 In general there is an over-assignment to both buses and rail as documented below through the total link flow for all links.

Table 57. 'Total' Flow Analysis (Rail includes Subway links)

MEASURE	MORNING PEAK			INTER-PEAK			EVENING PEAK		
	BUS	RAIL	ALL	BUS	RAIL	ALL	BUS	RAIL	ALL
All Count	35,020	100,117	135,137	23,166	42,514	65,680	38,893	101,344	140,237
All Flow	38,025	104,723	142,748	24,629	43,183	67,812	39,052	108,524	147,576
% Diff	109%	105%	106%	106%	102%	103%	100%	107%	105%
Average Count	302	758	545	200	322	265	335	768	565
Average Flow	328	793	576	212	327	273	337	822	595

8.3.4 The table above indicates that the overall assignments are generally marginally higher, with a greater over-assignment in the peak period, particularly the morning peak.



- 8.3.5 For the morning peak the issue is a couple of locations that are significantly over-assigned, and as these contribute to multiple screenlines, there is a significant effect on the screenline summary analysis.
- 8.3.6 A key point is the A749 corridor from East Kilbride towards Glasgow where there is an over-assignment of approximately 500 on a count of around 200. This is due to this location count site not being included within the estimation as a consequence of the bus lines coding issue. It is the only substantial link that is effected by this but has had an influence on two screenlines directly (OUTER and OUTER SOUTH).
- 8.3.7 Another large difference flow is the section from Uddingston to Newton and vice versa. The issue here is that the link count is for ScotRail services only – thus does not include TransPennine, East Coast nor West Coast trains that approach Glasgow Central on this section. The difference is around 600 passengers for the AM peak. If (for example only) an assumption was made that the flow difference was solely due to these services, then the table below would be the resulting screenline summary.
- 8.3.8 As can be seen through comparison with Table 58 the results are improved for rail in the peak periods, with a slight decline in the inter-peak.

Table 58. Summary Screenline Analysis (Rail includes Subway links) – Adjusted for Long Distance Rail

% GAP	MORNING PEAK			INTER-PEAK			EVENING PEAK		
	BUS	RAIL	ALL	BUS	RAIL	ALL	BUS	RAIL	ALL
<5	29%	29%	25%	25%	32%	56%	36%	39%	50%
<15	61%	61%	75%	71%	57%	89%	68%	79%	86%
<25	71%	71%	86%	86%	82%	96%	86%	86%	100%
>=25	29%	29%	14%	14%	18%	4%	14%	14%	0%

- 8.3.9 We have investigated the sub-mode split further and attempted various changes to parameters to better match counts and increased estimation confidences on count data to improve the level of flow validation.
- 8.3.10 The results presented are the best that we have achieved given other constraints such as matching bus service times to timetable, restraining the impact of matrix estimation and the routing issues due to both bus service coding and the “global” or model wide nature of parameter changes.
- 8.3.11 Our investigations suggest that the main influence on the lower performance is passengers travelling through the city centre, as the largest relative over-assignments are on “counter-peak” movements such as the Inner Cordon Outbound in the morning peak. This replicates an issue observed in Phase 1 of the model and is as a consequence of the prior matrix build approach that could only be addressed through extensive matrix estimation.
- 8.3.12 Appendix B contains the summary analysis by screenline (see Chapter 7) for all, bus and rail modes.



8.3.13 The following series of images illustrate the calibration results on a link by link basis for each time period for bus and subway flows.

Figure 44 AM Time Period – GEH Plot for Bus Flows (BYP2F Estimated) – Wide Area



Figure 45 LT Time Period – GEH Plot for Bus Flows (BYP12F Estimated) – Wide Area



Figure 46 PM Time Period – GEH Plot for Bus Flows (BYP2F Estimated) – Wide Area



8.3.14 At the wide area level the model calibrates well to the outer cordon screenlines, with the only significant issue being routes to the north of East Kilbride.

Figure 47 AM Time Period – GEH Plot for Bus Flows (BYP2F Estimated) – Central Area

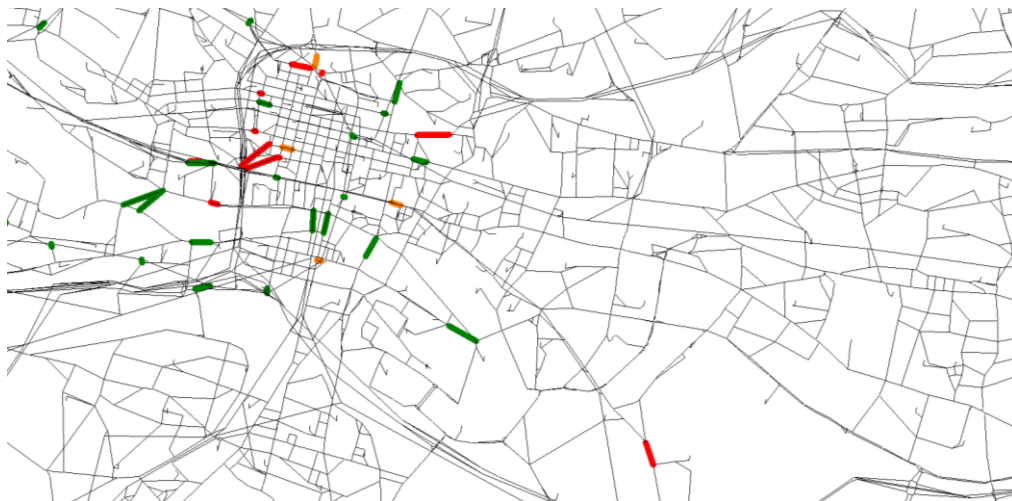


Figure 48 LT Time Period – GEH Plot for Bus Flows (BYP2F Estimated) – Central Area

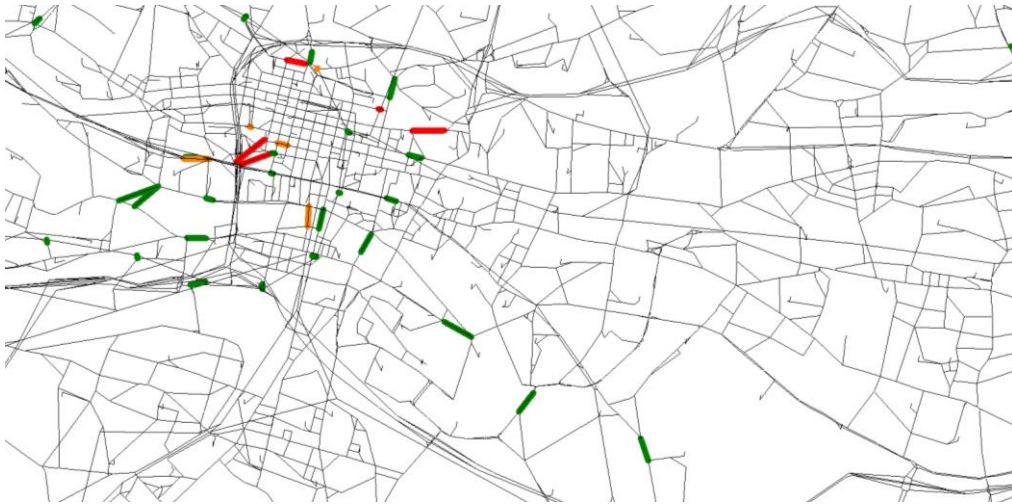
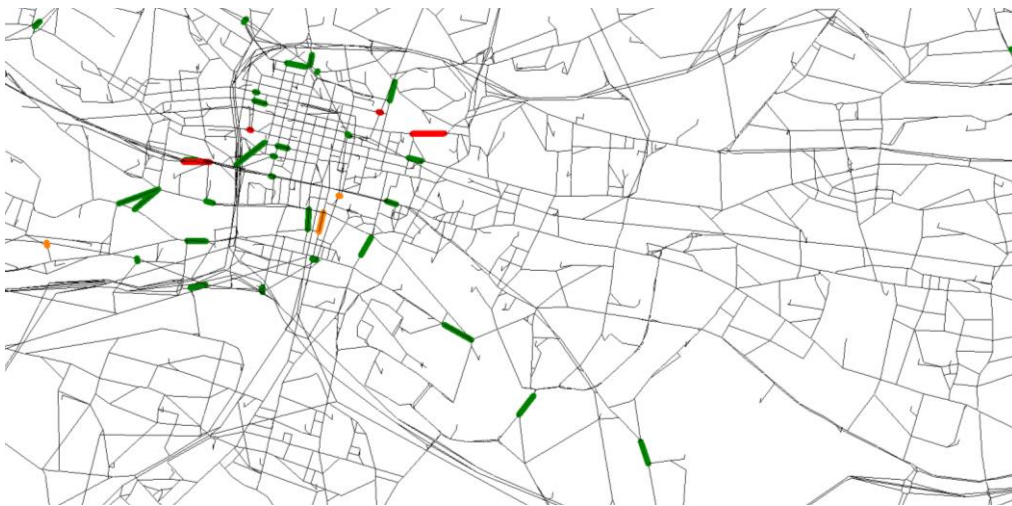


Figure 49 PM Time Period – GEH Plot for Bus Flows (BYP2F Estimated) – Central Area



- 8.3.15 For the central area, the level of performance when measured using the GEH statistic is more varied.
- 8.3.16 The results for the Subway are that is a general over-use of Cowcaddens station in all three time periods. For the morning and inter-peak, this is offset by an under use at Buchanan Street station, which being the adjacent station indicates an over-estimate of walking within the central area. Overall, for the Subway boardings and alightings are within 15% for all three time periods, and within 8% for the morning and inter-peak time period.
- 8.3.17 The table below illustrates the % of flows within a fixed percentage of the counts, where the count is greater than 150 passengers per hour (in line with WebTAG Unit M3.2, paragraph 7.1.6).



Table 59. Individual Link Flow Analysis

% GAP	MORNING PEAK				INTER-PEAK				EVENING PEAK			
	BUS	RAIL	SUB	ALL	BUS	RAIL	SUB	ALL	BUS	RAIL	SUB	ALL
<5	27%	29%	10%	22%	32%	22%	18%	24%	27%	18%	16%	21%
<15	59%	64%	47%	57%	59%	44%	41%	48%	56%	55%	41%	51%
<25	71%	76%	59%	69%	69%	56%	63%	63%	71%	62%	57%	64%
>=25	29%	24%	41%	31%	31%	44%	37%	37%	29%	38%	43%	36%

8.3.18 The table illustrates that the model does not meet the WebTAG expectations for flows greater than 150 passengers per hour. The performance is slightly worse than for the Phase 1 model though the balance between bus and rail has improved.

8.3.19 It should be noted that for the subway mode – the comparison is with TMfS link flows as the observed data for the subway is boarding and alighting counts.

8.3.20 Appendix C provides link flow analysis by count site.

8.4 Changes due to Matrix Estimation

8.4.1 The matrix estimation process has made use of Cube Analyst matrix estimation software. This estimation software package uses confidence levels to weight the estimation process towards specific inputs, usually counts.

8.4.2 The hierarchy of confidences (highest confidence to lowest) was as listed below:

- External trip ends;
- External trip movements;
- Observed Counts;
- Internal trip ends; and
- Internal trip movements.

8.4.3 In this way, the internal trip movements can be adjusted while retaining trip ends and external trip movements as close to the input values as possible.

8.4.4 The changes in trip ends are shown by the following six scatterplots, for trip origins by time period followed by trip destinations by time period.



Figure 50 Trip Origin Analysis - AM

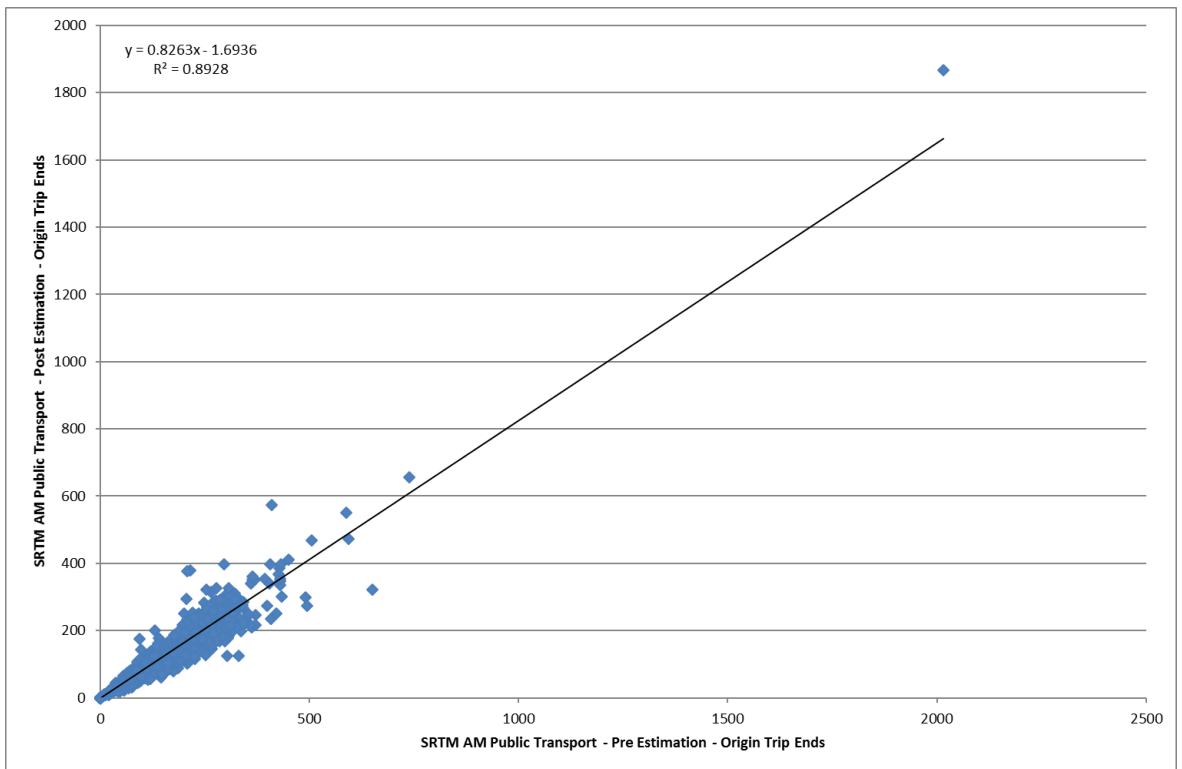


Figure 51 Trip Origin Analysis - LT

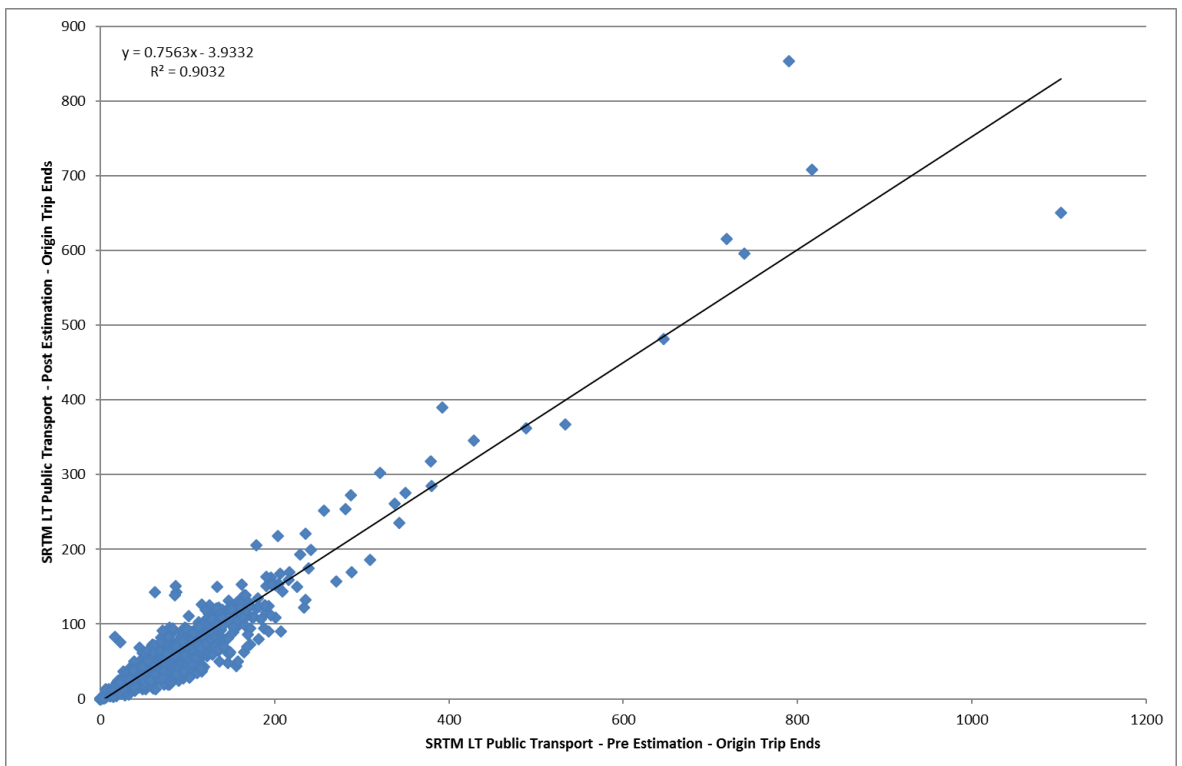
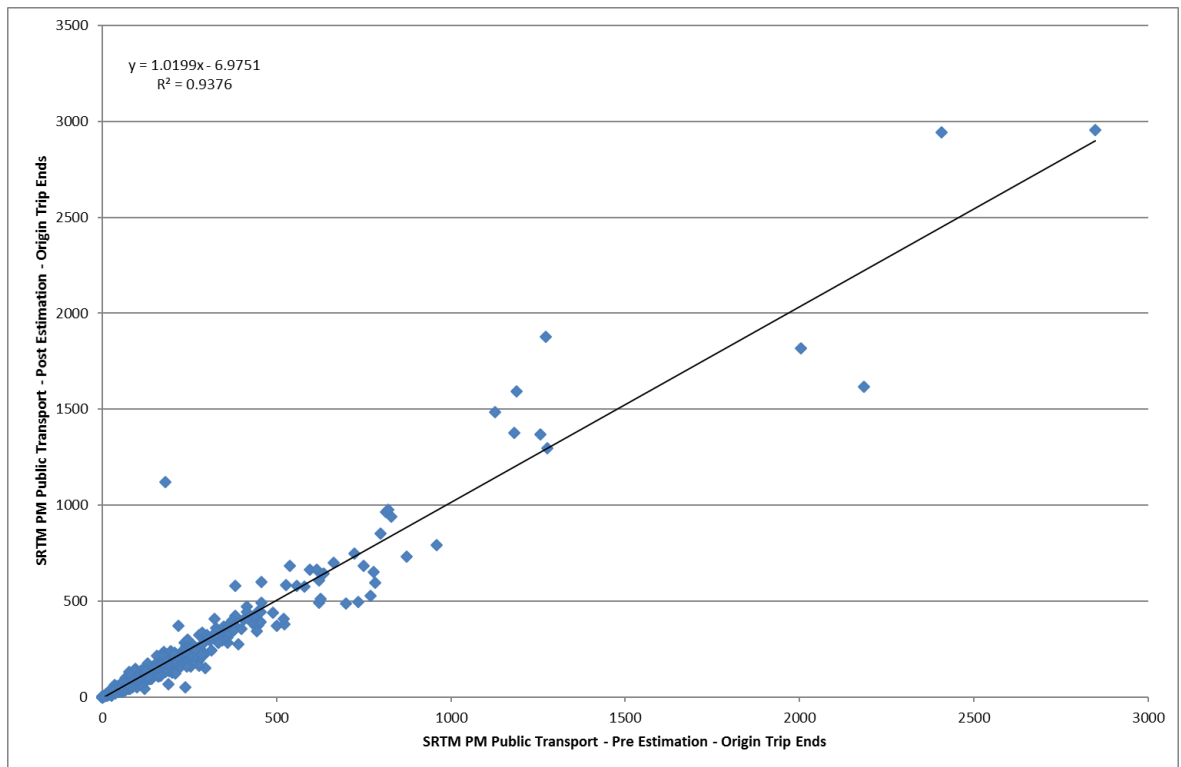


Figure 52 Trip Origin Analysis -PM



8.4.5 For trip origins the gradient of the trendline varies but the general trend is for a reduction in the size of the demand matrix, with R-square values between 0.89 and 0.94.

Figure 53 Trip Destination Analysis -AM

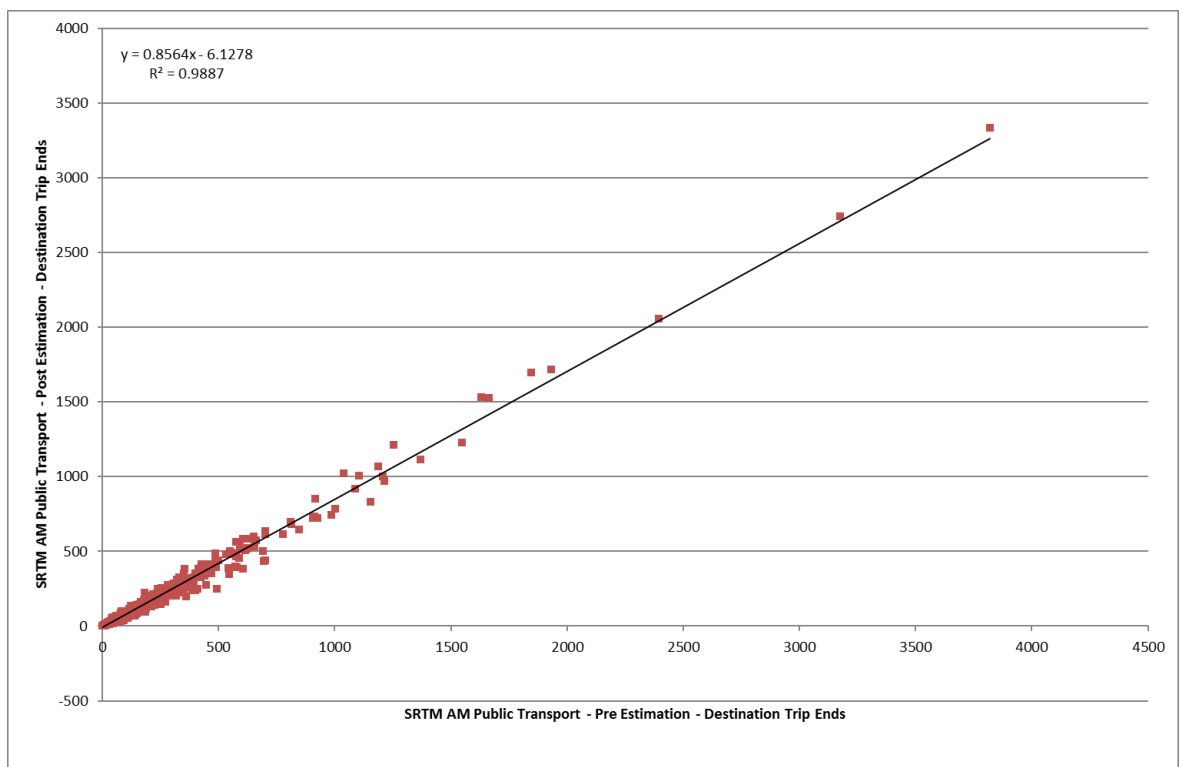


Figure 54 Trip Destination Analysis -LT

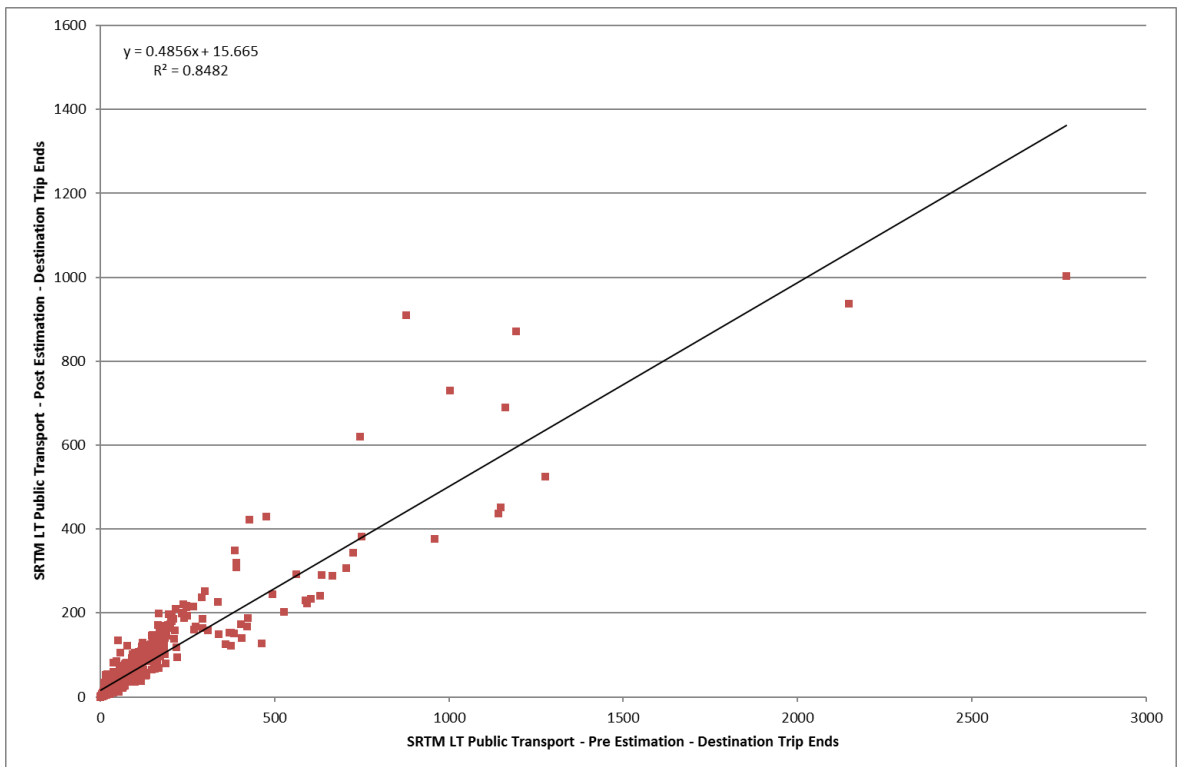
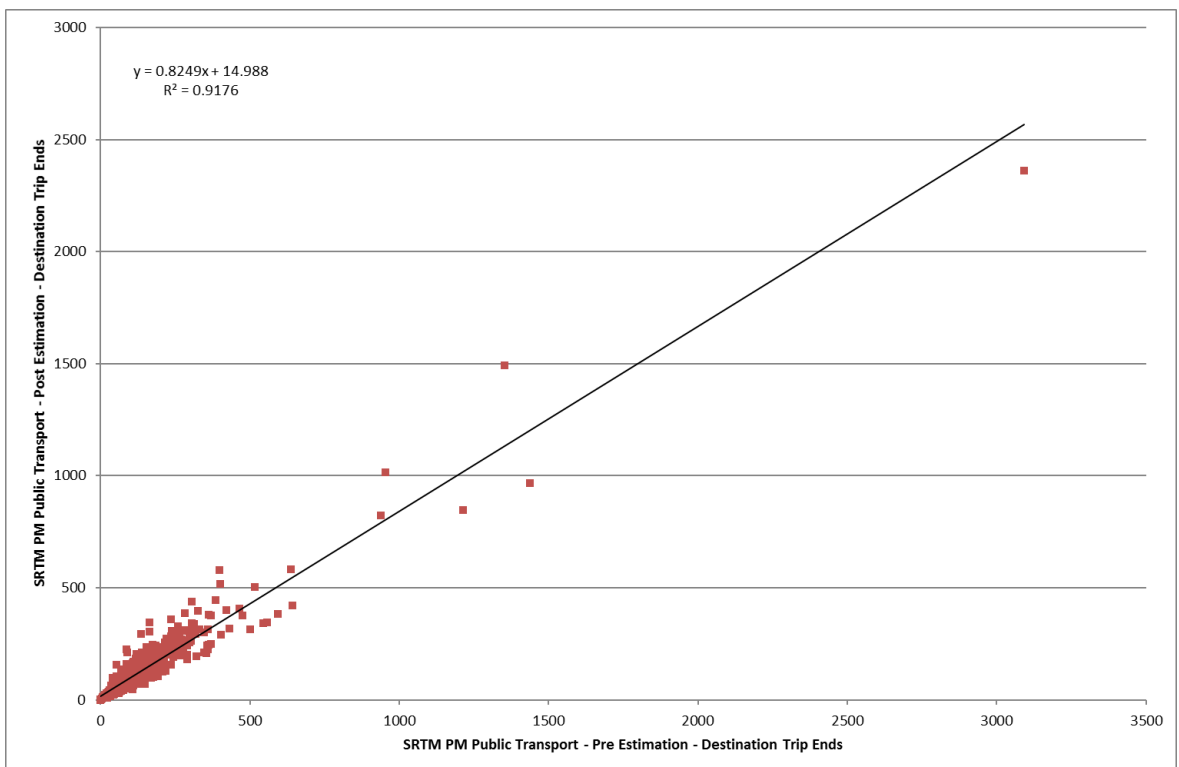


Figure 55 Trip Destination Analysis -PM



8.4.6 For trip destinations, the analysis produces a more favourable outcome for R-square statistics though the general pattern of trip volume reduction is the same.

8.4.7 The matrices have also been analysed on a sector basis – to illustrate the difference between the input matrices from the initial phase 2 demand model and the output estimated matrices. The sector analysis for the 4 sector system is presented in tables below.

Table 60. 4 Sector System Analysis - AM Time Period

SECTOR	1 - CENTRAL		2 - GLASGOW		3 – REST/AREA		4 - EXTERNAL	
	DEM	EST	DEM	EST	DEM	EST	DEM	EST
1 - Central	1592	1772	4487	1925	72	37	455	350
2 – Glasgow	32545	27095	118971	97792	547	400	3019	2547
3 – Rest of Area	1496	1352	2189	1351	20497	16206	335	267
4 - External	2007	2124	2022	1569	212	246	869	848

Table 61. 4 Sector System Analysis - LT Time Period

SECTOR	1 - CENTRAL		2 - GLASGOW		3 – REST/AREA		4 - EXTERNAL	
	DEM	EST	DEM	EST	DEM	EST	DEM	EST
1 - Central	1742	1490	6994	4846	223	282	670	533
2 – Glasgow	20649	7918	48501	38925	311	388	1634	1264
3 – Rest of Area	892	286	774	427	8043	6519	210	161
4 - External	659	495	1485	1248	174	187	1079	1046

Table 62. 4 Sector System Analysis - PM Time Period

SECTOR	1 – CENTRAL		2 - GLASGOW		3 – REST/AREA		4 - EXTERNAL	
	DEM	EST	DEM	EST	DEM	EST	DEM	EST
1 - Central	4655	4454	20735	22679	1050	1357	2198	1813
2 – Glasgow	7852	3963	83194	80767	1099	881	2851	2188
3 – Rest of Area	165	140	349	331	15985	16414	199	205
4 - External	481	279	3871	3135	323	273	1340	1316

- 8.4.8 The sector analysis reveals that the initial demand matrices have too many public transport trips when compared to counts at the assignment model level. While this was partially expected as a consequence of the lower level of calibration in the initial demand model, the level of change is greater than expected.

8.5 Matrix Sector Comparison with Census and Mobile Phone Data

- 8.5.1 A comparison between the modelled matrices and the census and Mobile Phone data has been undertaken at a 4 sector and a 33 sector level. Further details of this analysis is contained in the SRTM Demand Model Report, SYSTRA, August 2019.

8.6 Aggregated Outputs

- 8.6.1 The Stop2Stop movements from the estimated assignment have been analysed and compared with the LENNON observed data.
- 8.6.2 The percentage analysis reveals of Table 66 that the majority of difference is due to intra-sector trip making and for services from the South East to Central Glasgow and vice versa.
- 8.6.3 The intra-sector reflects that for short distance journeys along a specific rail corridor the railway has a better generalised cost than the adjacent bus service. This may not reflect how the service is used, especially for regular / bus network ticket holders where the travel opportunities afforded by the bus network would influence mode choices.



Table 63. LENNON Annual Rail Flows – Glasgow Area data

GROUP	GROUP NAME	1	2	3	4	5	6	7	8	9	10	11	TOT
1	Central Glasgow	923	2989	1560	1630	2895	1904	1660	1730	693	1022		17006
2	North West	2870	1439	94	167	198	57	40	54	25	64		5008
3	North	1143	87	91	38	53	16	11	15	5	24		1483
4	East	1550	165	37	317	22	18	11	14	6	28		2168
5	South East	2797	197	52	21	666	78	32	51	21	81		3996
6	Cathcart Lines	1750	55	16	18	76	427	27	40	20	56		2485
7	South	1571	39	10	11	31	27	294	40	12	37		2072
8	South West	1677	54	15	14	52	41	40	1264	32	279		3468
9	West	675	26	5	6	21	20	12	33	288	213		1299
10	Inner West & Paisley Canal	988	65	24	28	82	59	39	298	221	100		1904
11	Externals												
TOT	All Stations	15944	5116	1904	2250	4096	2647	2166	3539	1323	1904		40889

Source: LENNON Database, note values are in rounded 1000 trips per annum

Table 64. SRTM Stop 2 Stop Analysis – Glasgow Area data

GROUP	GROUP NAME	1	2	3	4	5	6	7	8	9	10	11	TOT
1	Central Glasgow	4832	3276	766	1953	1992	3603	2162	2363	1175	2009		24131
2	North West	4474	3255	141	304	41	48	22	36	25	40		8387
3	North	1166	263	524	60	189	6	2	1	1	4		2216
4	East	2283	302	111	1994	6	11	5	12	3	7		4733
5	South East	2339	38	134	8	5541	254	21	17	10	31		8393
6	Cathcart Lines	4168	28	6	15	282	3104	15	53	38	83		7793
7	South	2432	14	3	8	21	21	2276	77	19	41		4911
8	South West	2335	16	2	4	14	54	68	3058	112	1052		6713
9	West	1010	10	1	2	8	35	14	71	712	727		2588
10	Inner West & Paisley Canal	1971	20	3	7	24	73	30	680	653	675		4135
11	Externals												
TOT	All Stations	27011	7221	1689	4354	8117	7209	4615	6367	2747	4670		74000

Source: SRTM Estimation Assignment, note values are in rounded 1000 trips per annum

Table 65. LENNON Annual Rail Flows – Glasgow Area data - % of flows

GROUP	GROUP NAME	1	2	3	4	5	6	7	8	9	10	11	TOT
1	Central Glasgow	2%	7%	4%	4%	7%	5%	4%	4%	2%	2%		42%
2	North West	7%	4%	0%	0%	0%	0%	0%	0%	0%	0%		12%
3	North	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%		4%
4	East	4%	0%	0%	1%	0%	0%	0%	0%	0%	0%		5%
5	South East	7%	0%	0%	0%	2%	0%	0%	0%	0%	0%		10%
6	Cathcart Lines	4%	0%	0%	0%	0%	1%	0%	0%	0%	0%		6%
7	South	4%	0%	0%	0%	0%	0%	1%	0%	0%	0%		5%
8	South West	4%	0%	0%	0%	0%	0%	0%	3%	0%	1%		8%
9	West	2%	0%	0%	0%	0%	0%	0%	0%	1%	1%		3%
10	Inner West & Paisley Canal	2%	0%	0%	0%	0%	0%	0%	1%	1%	0%		5%
11	Externals												
TOT	All Stations	39%	13%	5%	6%	10%	6%	5%	9%	3%	5%		100%

Source: LENNON Database, note values are in rounded 1000 trips per annum

Table 66. SRTM Stop 2 Stop Analysis - % of flows

GROUP	GROUP NAME	1	2	3	4	5	6	7	8	9	10	11	TOT
1	Central Glasgow	7%	4%	1%	3%	3%	5%	3%	3%	2%	3%		33%
2	North West	6%	4%	0%	0%	0%	0%	0%	0%	0%	0%		11%
3	North	2%	0%	1%	0%	0%	0%	0%	0%	0%	0%		3%
4	East	3%	0%	0%	3%	0%	0%	0%	0%	0%	0%		6%
5	South East	3%	0%	0%	0%	7%	0%	0%	0%	0%	0%		11%
6	Cathcart Lines	6%	0%	0%	0%	0%	4%	0%	0%	0%	0%		11%
7	South	3%	0%	0%	0%	0%	0%	3%	0%	0%	0%		7%
8	South West	3%	0%	0%	0%	0%	0%	0%	4%	0%	1%		9%
9	West	1%	0%	0%	0%	0%	0%	0%	0%	1%	1%		3%
10	Inner West & Paisley Canal	3%	0%	0%	0%	0%	0%	0%	1%	1%	1%		6%
11	Externals												
TOT	All Stations	37%	10%	2%	6%	11%	10%	6%	9%	4%	6%	0%	100%

8.7 Conclusions

- 8.7.1 Overall, the model shows a good representation against public transport journey times and a reasonable representation against public transport flows.
- 8.7.2 The services have been coded to match the SPT Corporate Database, which has been identified as having a large minority of routes travelling the wrong way around roundabouts (essentially, the “reverse” direction is often on the same links as the “outbound”).
- 8.7.3 This does not affect the quality of the model, as the journey times and journey distances are comparable and within guidelines but it may result in link flow plots looking ‘odd’.
- 8.7.4 The main weaknesses are in the starting prior matrices of travel demand which have a tendency to overstate the level of cross city movements. The restrictions placed on matrix estimation, in place to reduce the level of changes to the pattern of travel, limits the calibration against link flows.

APPROVAL

Version	Name		Position	Date	Modifications
1	Author	Paul Gray	Associate Director	04/07/2016	Internal
	Checked by	Ian Burden	Projects Director	11/07/2016	
	Approved by				
	Author	Paul Gray	Associate Director	30/01/2017	Updated to reflect comments from auditor and (Phase 1) model calibration results
	Checked by	David Connolly	Project Director	01/02/2017	
	Approved by	Jeff Davidson	Project Manager	06/02/2017	
2	Author	Paul Gray	Associate Director	20/09/2017	Phase 2 Report – as sent to auditor 21/09/17
	Checked by	David Connolly	Projects Director	20/09/2017	
	Approved by	David Connolly	Projects Director	21/09/2017	
3.3	Author	Daniel Ruscoe	Senior Consultant	06/08/2019	Final draft addressing auditor queries
	Checked by	Malcolm Neil	Associate Director	06/08/2019	
	Approved by	Malcolm Neil	Associate Director	06/08/2019	

