Land use And Transport Integration in Scotland (LATIS)

Reference number 102936 12

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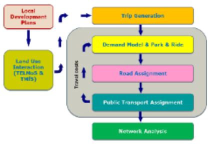
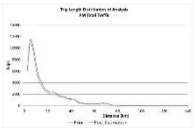
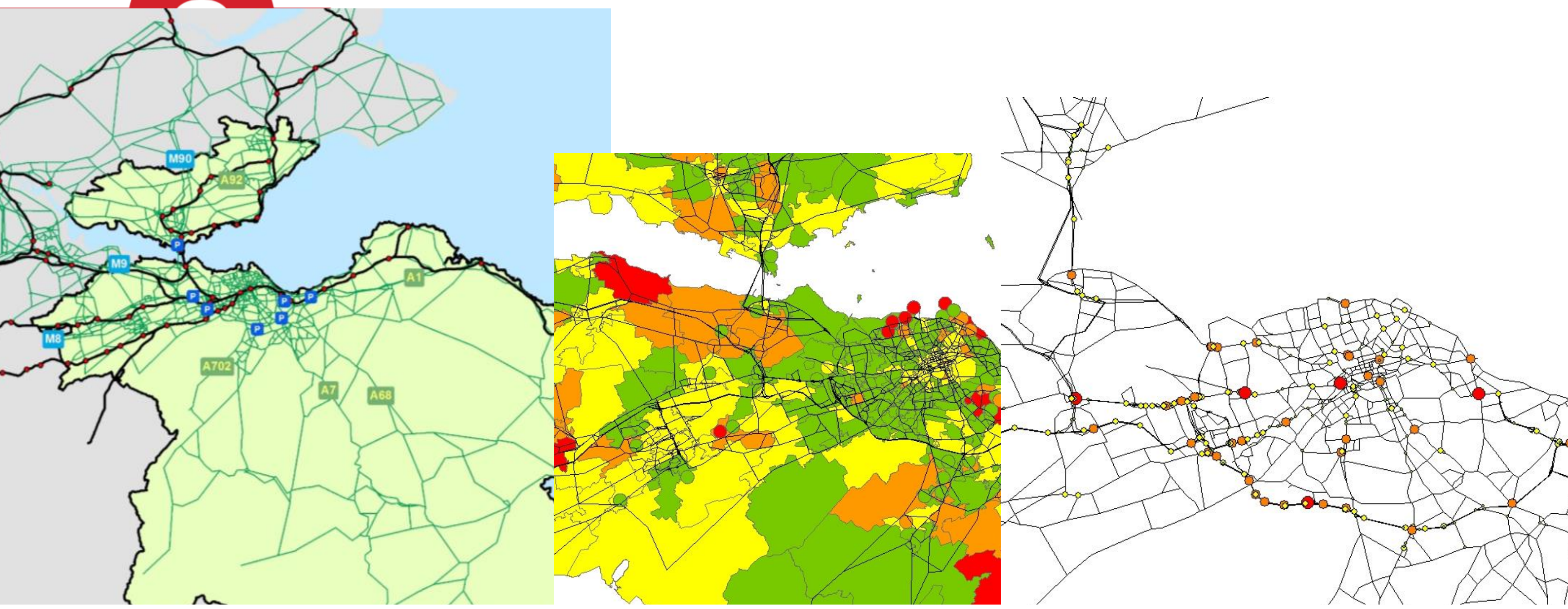




SESTRAN REGIONAL MODEL 2012 (SRM12) DEVELOPMENT REPORT



SYSTRA

LAND USE AND TRANSPORT INTEGRATION IN SCOTLAND (LATIS)

SESTRAN REGIONAL MODEL 2012 (SRM12) DEVELOPMENT REPORT

IDENTIFICATION TABLE	
Client	Transport Scotland
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APPROVAL

Version	Name		Position	Date	Modifications
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	Checked by	Jeff Davidson	Project Manager	21/12/2015	
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	Checked by	Malcolm Neil	Associate Director	26/07/2019	
	Approved by	Malcolm Neil	Associate Director	26/07/2019	

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1. INTRODUCTION

1.1 SEStran Regional Model

1.1.1 This report documents the development of the SEStran Regional Model 2012 (SRM12) - a new strategic multi-modal transport model covering the South East of Scotland, including the six Local Authorities within the Strategic Development Planning Authority for Edinburgh and South East Scotland (SESPlan) area.

1.1.2 The SRM12 represents the road and public transport network and service supply present during 2012, and is calibrated and validated to reflect 2012 observed traffic and travel conditions. It aligns the LATIS national model hierarchy 2012 base year and is informed through the TMfS / TELMoS 12 land use and transport interaction processes.

1.1.3 The SRM12 is capable of forecasting changes in travel demand and travel patterns over time, identifying potential impacts from new developments, and assessing the benefits associated with proposed transport investment and policies.

1.1.4 The SRM12 development builds on the previous SRM 2007 model version (SRM07), and also includes some specific features extracted from the Central Scotland Transport Model 2012 (CSTM12). The SRM07 Model Development documentation should be read in conjunction with this SRM12 report.

1.1.5 This Development Report is supplemented by a number of additional Excel Spreadsheets, which provide detailed descriptions of model calibration and validation data sets.

1.2 SESPlan Cross-Boundary Appraisal

1.2.1 SYSTRA was commissioned by Transport Scotland to develop the SRM12 for the specific purpose of informing the SESPlan cross-boundary transport and land use appraisal study. This study is considering the transport implications of proposed land use allocations in the SESPlan area and aims to generate a robust evidence base which would:

- Identify and quantify the predicted cumulative and cross-boundary transport impacts of the current and emerging development plans in the SESplan area;
- Identify potential transport interventions, including multi-modal options, required to mitigate the impacts; and
- Identify the likely form, scale and cost of these interventions.

1.2.2 The study will employ a methodology that will deliver a robust evidence base in accordance with DPMTAG for development plans. It will put forward a series of multi-modal transport interventions designed to support development and mitigate potential cumulative impacts (associated with both current and emerging development plans) and provide an indication of the apportionment of costs to new development locations.

1.2.3 The appraisal of development proposals requires a detailed examination of the South East Scotland transport system. The SRM12 would be used to compare current and future network operations based on the phasing and distribution of development, and subsequent traffic and travel generation.

1.2.4 The basis of the appraisal would include sets of 'committed' and 'non-committed' residential and business planning allocations provided by Local Authorities. These planning data sets would be input to the TMfS / TELMoS 12 processes to generate the required household, population and employment forecasts for the SRM12.

1.2.5 With proposed developments across the SESplan area distributed throughout the six constituent authorities, the appraisal geographical coverage area needs to be extensive to represent travel movements consistently. The evidence base needs to address 'core' areas or corridors which centre on known areas of transport congestion and provide the key infrastructure associated with cross-boundary travel.

1.2.6 With the requirement for multi-modal scheme / mitigation option appraisal, the evidence base needs to adequately represent both public and private transport based travel choices.

1.2.7 The objective of 'linking' development impacts to key transport infrastructure locations is a particularly detailed transport modelling output, and therefore an extensive calibration phase ensures modelled travel movements are appropriately represented and compare well with observed data sources.

1.2.8 Transparency of the modelling and appraisal approach and data input assumptions is key to ensure stakeholder endorsement of the evidence base extracted from these models.

1.3 SRM12 Development Scope

1.3.1 The model construction has been undertaken in-line with the 'SRM12 Development Approach Note V6.1b', which outlines the specific aspects of model development which were agreed to be undertaken as part of the SRM12 commission by Transport Scotland and SYSTRA. The development scope includes:

- Updating the SRM **Road**, **Public Transport** and **Park & Ride** models to reflect **2012** traffic and travel conditions;
- Updating the CUBE Voyager & Saturn modelling procedures to operate with the Windows 7 operating system. The SRM will also be updated to operate with CUBE Software version 6;
- Generating a more detailed **zone system**:
  - to reduce the level of traffic loading into a single network point;
  - compatible with TMfS/TELMoS12; and
  - with additional zones to isolate modelling of major new development areas.
- Updating the **road network** supply to incorporate:
  - enhancements made during separate projects undertaken for Midlothian and West Lothian Councils;
  - new transport schemes that were on the ground in 2012;
  - 'simulation' junction coverage across central Edinburgh;
  - network detail to coincide with the zoning system and model major junctions;
  - traffic signal settings for significant intersections where data is available; and
  - 'stopping nodes' Saturn coding to improve the representation of motorway merges.

- Updating the **public transport** supply to incorporate:
  - an updated PT network, that is consistent with the road network coverage;
  - a review and updating of bus lanes as required;
  - an identification of bus service gaps in and around new areas of development, with new bus services coded to provide an appropriate representation;
  - further limited updates to cross-boundary bus services where it has been identified services no longer exist or have significantly changed to that represented within the previous SRM07 model;
  - new rail infrastructure & associated service coding to reflect recent scheme delivery;
  - rail service supply representation which reflects 2012 timetabling (i.e. in-line with more recent CSTM12 updates).
  - cross border Scotland-England rail services adjustments to improve the 'average hour' representation for long distance services operating between time periods; and
  - representation of rail passenger crowding within the public transport model within the morning and evening modelled peak time periods.

- Updating the **Park & Ride** model to incorporate:
  - P&R site travel demand that were on the ground in 2012; and
  - compatibility with the new zoning system for site catchment areas.

- Collating **data sets** including:
  - traffic signal settings;
  - available Transport Scotland and Local Authority traffic count data and traffic signal data to identify data gaps;
  - commissioning a classified traffic count for Hermiston Gait;
  - an aligned GIS database of traffic counts for SRM12 calibration/validation;
  - interrogating GPS TomTom satellite navigation data to record observed road journey times for a number of journey time routes;
  - collating a set of bus patronage counts located around the periphery of Edinburgh; and
  - collating an additional set of observed bus patronage figures extracted from the Joint Revenue Committee (JRC) VISUM Edinburgh model development report.

- Building updated **travel demand matrices**:
  - with road demand predominantly based upon the original SRM07 calibrated assignment matrices, which will be disaggregated and altered to reflect the new zone system and 2012 activity levels, based on 2011 Census population & household data and (BRES) business surveys;
  - rationalising goods vehicles trip rates across the three modelled time periods applying a consistent HGV / pattern across the modelled time periods;
  - transferring rail movements (between the West of Scotland and the internal SRM12 area) from CSTM12 into the new SRM12 zone system;
  - using CSTM12 rail passenger counts to validate SRM12 rail patronage;
  - rationalising travel purpose proportions for specific zonal areas to reflect recently observed planning data; and

- rationalising the SRM12 AM Peak commuter matrix against 2011 Census Travel to Work movements to reflect Local Authority travel patterns.

- **Calibrating / validating** to a standard range of DMRB / WebTAG criteria, including:

Road Model

  - observed traffic volumes;
  - journey times (based on TomTom data); and
  - trip length distributions.

Public Transport Model

  - observed rail & bus passenger volumes;
  - bus journey times;
  - public transport distributions;
  - mode share statistics; and
  - Census travel pattern comparison at a more detailed sector level.

- Updating the **Demand** model:
  - zoning, parameters and inputs files to reflect the new model dimensions;
  - Saturn-to-CUBE travel demand / cost matrix conversion process;
  - re-calibrate the demand and park and ride models based on updated travel demand and calibrated network travel costs; and
  - undertake standard sensitivity testing an initial testing of example scheme.

- Developing a new **Trip End Generation** model to incorporate:
  - zoning, parameters and inputs files to reflect the new model dimensions;
  - a process for modelling specific development zones in isolation; and
  - processes for undertaking subsequent adjustments to external route zones and goods vehicle movements.

- Preparing a model development report to describe development tasks and calibration and validation statistics, with accompanying data Spreadsheets.

Road Modelling

1.3.2 A proportionate approach is used to develop the modelled road network, improving the areas of the model that are most critical to the SESPlan appraisal. This focuses within the core A720 Old Craighall to M9 Junction 1a corridor, with the major intersections and approaches to this corridor reviewed and coding refined as required.

1.3.3 Central Edinburgh is now coded as (Saturn) Simulation area, consistent with the rest of the SRM, with the main roads and junctions represented in the road and PT networks. However, the city centre remains relatively strategic in nature so as to avoid a full scale Edinburgh modelling exercise (i.e. detailed network arrangements are represented close to the core study area with more generic representation within central parts of Edinburgh and the city centre is calibrated to a set of aggregate screenlines and journey times, rather than individual points or junction locations).

Public Transport Modelling

1.3.4 The SRM07 did not include the modelling of individual 'intra-urban' bus services within Edinburgh. Urban buses are coded as a generic service frequency along the major urban corridors. This approach is consistent with TMfS, but is less appropriate when aiming to represent varying levels of local public transport accessibility.

1.3.5 The task of re-coding bus services to reflect individual routes and 2012 bus timetables is not part of the model development remit. Therefore, urban bus service coding continues to have a generic representation across the majority of Edinburgh. Similarly, many inter-urban services remain as coded to represent 2007 timetabling. However, the representation of bus services are now more detailed in places due to the improved network coverage and inclusion of simulation junctions within central Edinburgh.

Matrix Development

1.3.6 The 2011 Census Travel to Work detailed (intermediate zone) data sets were not available during the time of the SRM12 matrix development. Therefore, the underlying SRM12 matrices are predominately based on the existing SRM 2007 matrices (disaggregated into the new zone system and calibrated to reflect 2012 population / employment data).

1.3.7 Road travel demand matrices were calibrated through traffic count comparison and Matrix Estimation processes. However, the calibration and major adjustment of public transport matrices is not included within the model development remit. Therefore, the SRM12 bus passenger *travel pattern data* is now relatively dated, with underlying bus travel patterns representing (2007-based) inter-urban bus surveys, 2001 Census Travel-to-Work data and matrix synthesising processes.

2. MODEL STRUCTURE

2.1 Model Coverage

2.1.1 This Chapter discusses the underlying SRM12 technical structure and describes the relevant model dimensions in terms of geography, time periods, travel purposes and modes.

2.1.2 The SRM12 Base Year Model has been developed to represent 2012 traffic and travel conditions. The road and public transport network and demand model covers an area from the Firth of Tay to the Scottish border with England, and from the East Coast to Stirling and Bathgate in the West.

2.1.3 Comparing with the previous SRM07 model, the SRM12 now includes Saturn 'Simulated' junction coverage within central Edinburgh, and also represents recent transport investments such as the Dalkeith Northern Bypass and Airdrie Bathgate Railway re-opening.

2.1.4 Network and zonal development has focussed within cross-boundary locations between the SESPlan authorities (i.e. Edinburgh, Fife, Scottish Borders, and East Lothian, Midlothian and West Lothian). The SRM12 geographical coverage is illustrated in Figure 1.

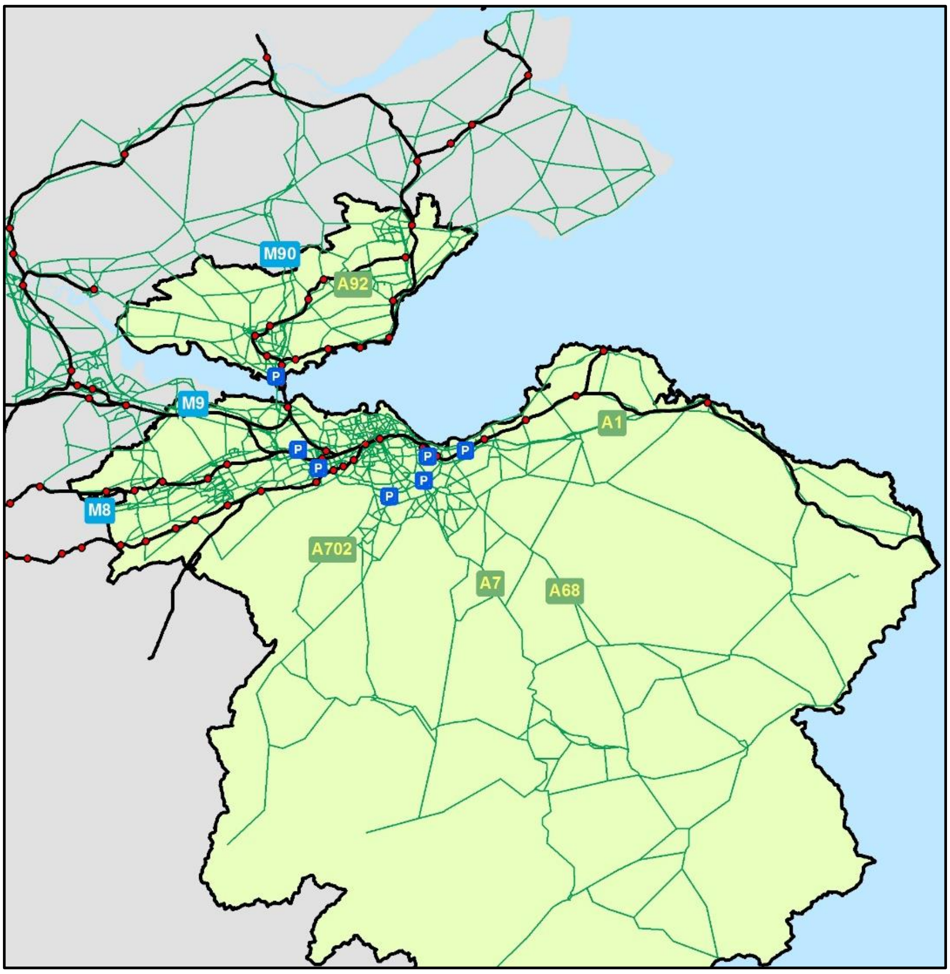

Figure 1. SRM12 Geographical Coverage

2.2 Zone System

2.2.1 The model zone system defines the extent of the area where road and PT trips access the modelled transport network. The system constitutes a large number of zonal areas and zone centroid connectors, or loading points. The SRM12 zoning contains 874 zones, including:

- 739 'internal' demand modelling zones (1-739);
  - with 97 of these internal zones set-aside for representing specific new development areas;
- 36 'external' zones (740-775) to represent route zones around the boundary of the demand model coverage area;
- 99 Park & Ride zones (776-874) which are 'point' zones representing road and public transport interchange points;
  - including an allocation of 'spare' zones which are available for future 'new' park and ride\rail station zones as required.

2.2.2 The existing SRM07 zone system was used as the starting point for SRM12 zonal development, with a review undertaken to identify areas where more disaggregated zoning would be beneficial. This focused on a number of aspects, including locations where development was known to have taken place between 2007 and 2012 and areas proposed for future development. The review also took account of the SRM12 road network coverage, to ensure adequate representation of travel demand along modelled routes.

2.2.3 During development, analysis of local population, households and employment levels was undertaken and cross referenced with approximate road trip rates to establish the level of traffic that would be associated with a potential zone. Zoning was developed to limit traffic loadings to under 500 vehicles per hour, to ensure that the road network was not affected by large zones, either by further disaggregation or incorporating additional centroid connectors.

2.2.4 The <500 trips target focussed on comparing households with an approximate trip rate of 0.3 trips per household, where an upper limit of 1,500 households per zone would limit trips to this threshold. The effective trip rates per zone are calculated by comparing the road trip matrices and zonal planning data. Zoning updates focussed on Edinburgh, where the number of zones was increased considerably through an iterative disaggregation process. In areas where there were both substantial housing and employment, zones were disaggregated. For other areas, further zone centroids were incorporated to assist zone loading.

2.2.5 Key features of the SRM12 zone system include:

- finer and more consistent zonal definition (compared to SRM07), in particular within the Edinburgh urban area;
- zones are amalgamations of 'Scottish Output Area' and 'Datazone' geographies;
- consistent and lie within a TELMoS 12 zone;
- consistent with Local Authority boundaries;
- train stations are associated with separate zonal areas, with separate zoning to distinguish train station and park and ride car park usage; and
- spare zones to isolate travel demand modelling of proposed development areas.

2.2.6 The coverage and level of detail contained within the SRM12 zone system is illustrated in Figure 2 and Figure 3 below.

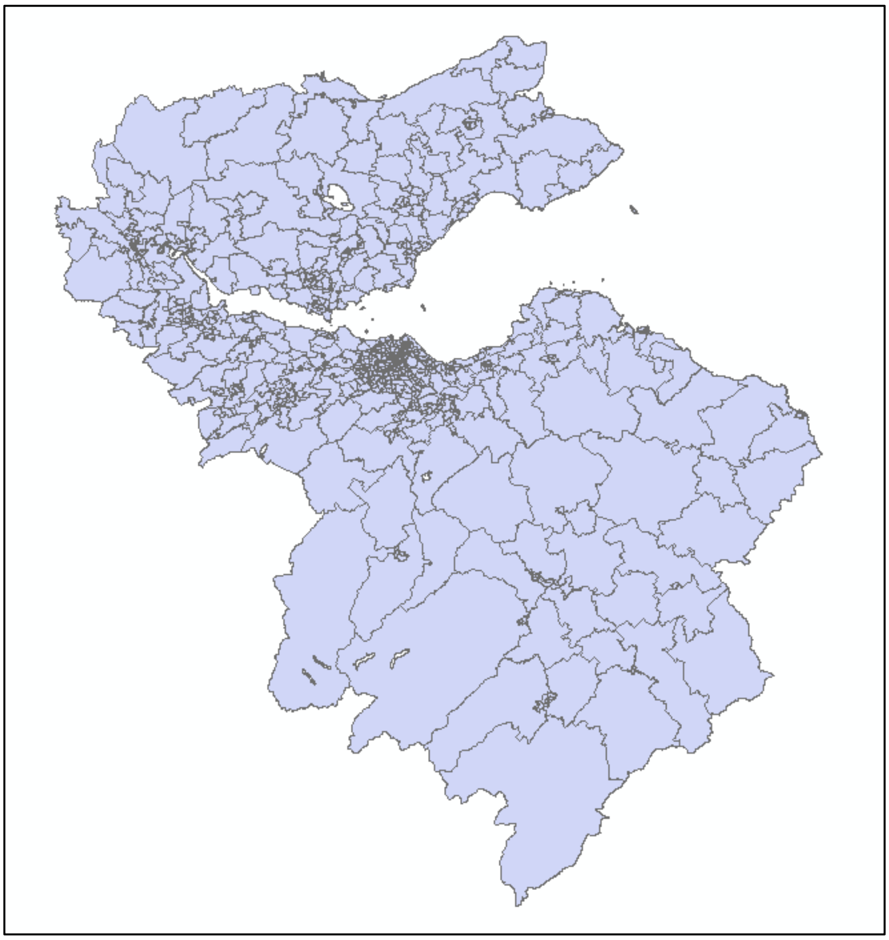

Figure 2. SRM12 Zone System

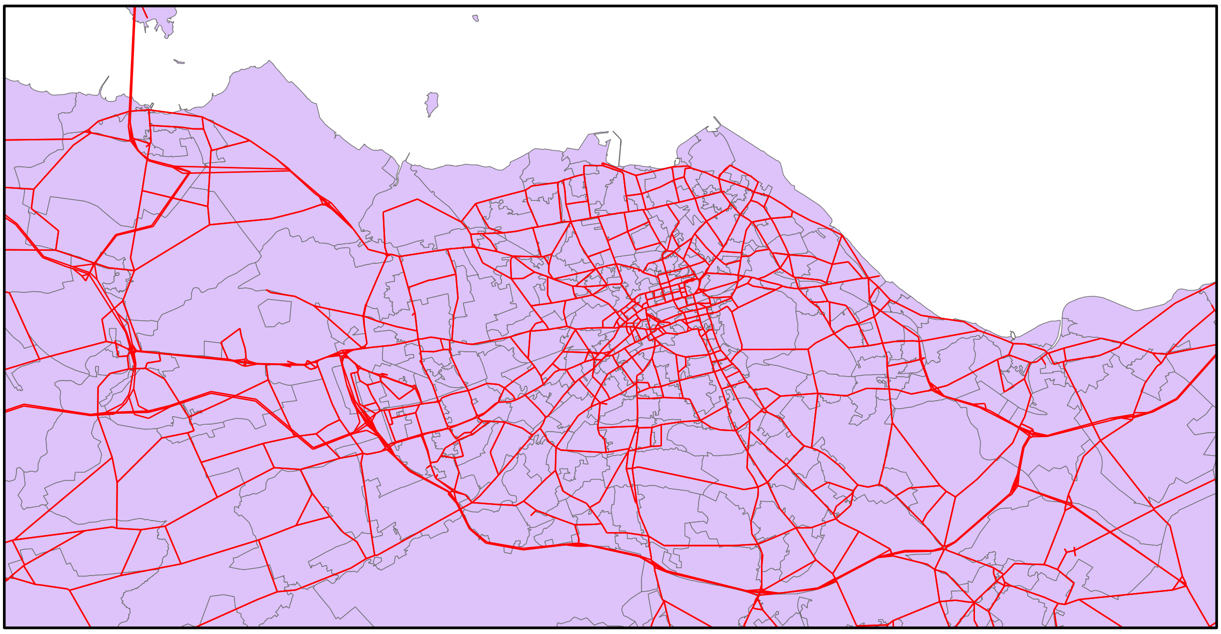

Figure 3. SRM12 Edinburgh Zoning

2.3 Structure & Components

2.3.1 The SRM12 is a 'four-stage' multi-modal demand model, with additional park and ride segmentation, and linkages to the TMfS/TELMoS12 national modelling hierarchy. The full modelling capability and components of the SRM12 are illustrated in Figure 4 and include:

- Linkages with TELMoS12 to provide land use planning forecasts;
- Linkages with TMfS12 to provide 'external' travel forecasts.
- **Trip Generation**;
- **Mode choice** (car, public transport and mixed mode Park & Ride);
- **Destination choice**;
- Park and ride site / station choice;
- To-home and non-home trip estimation; and
- Road and public transport **route choice assignment** network models;

The traditional elements of a four-stage model are denoted in bold.

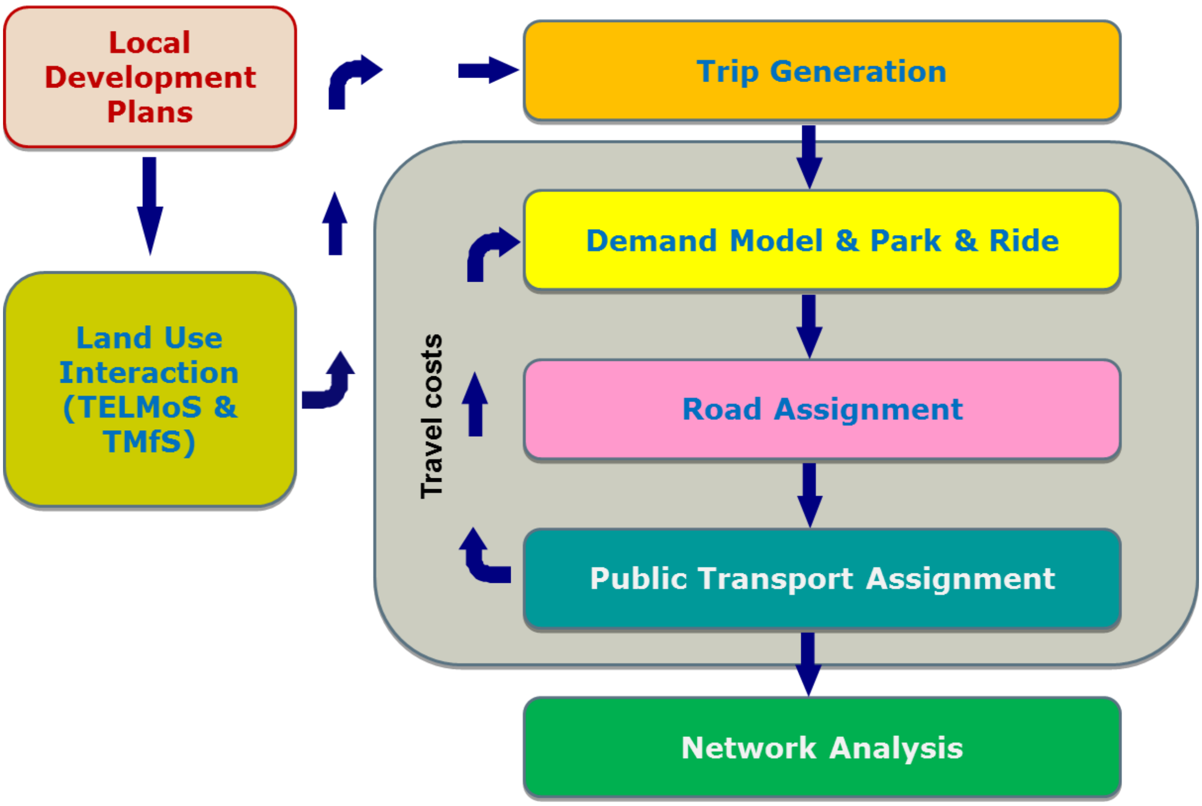

Figure 4. SRM12 Structure

Choice Models

2.3.2 The Road and Public Transport Assignment models consist of calibrated and validated assignment matrices and network models by time period. These models determine the potential routes and services used by motorists and PT passengers, and calculate the average travel time and costs experienced by travellers.

2.3.3 The Assignment models can be used for operational, economic, environmental and road traffic accident analysis, and they are also applied to generate base year generalised cost matrices to inform the Demand model.

2.3.4 In forecast mode, the SRM12 Trip Generation and Demand models calculate predicted changes in travel demand and patterns from base-year (2012) conditions. These calculations are undertaken in an incremental manner. The Demand model forecasts changes to the Road and Public Transport assignment matrices that arise through changes in forecast planning data (i.e. development / population changes) and/or changes in future transport costs (i.e. transport investments, policies and/or congestion).

2.4 Journey Purposes, User Classes, Travel Modes & Time Periods

2.4.1 The SRM12 Demand model contains six journey purposes as follows:

- **Home-Based Work (HBW)** – travelling 'From-Home' to work (and back again) – a typical commuting journey (note – this travel purpose does not take place in employer's time);
- **Home-Based Other (HBO)** – travelling 'From-Home' to a non-work-related location such as shopping or leisure (but excluding education);
- **Home-Based Employer's Business (HBEB)** – travelling 'From-Home' to a destination where you are in employer's time as soon as you leave the home;
- **Non-Home-Based Other (NHBO)** – travel between two Non-Home-Based locations (e.g. from work to shops);
- **Non-Home-Based Employer's Business (NHBEB)** – travelling during employer's time, such as travelling from your place of work to a business meeting, visiting customers etc.; and
- **Home-Based Education (HBS)** – travelling 'From-Home' to an education destination (e.g. school, college etc.). These are not part of the main Demand Model, but are considered separately after the mode and destination choice phases.

2.4.2 The Demand model operates with a dimension of four household types:

- C0 – zero car household (these travellers are considered to be captive to PT);
- C1/1 – 1 car, 1 adult household;
- C1/2+ – 1 car, 2+ adult household; and
- C2+ – 2+ car household.

Note: These household types serve as a proxy for car availability.

Road Model User Classes & Modes

2.4.3 Five user classes are included in the Road Assignment model as follows:

- Car – in work time (CIW);
- Car – in commute time (CNWC);
- Car – in other time (i.e. shopping, leisure etc) (CNWO);
- Light goods vehicles (LGV); and
- Heavy goods vehicles (HGV).

2.4.4 The Road Model travel demand matrices are stored in Passenger Car Unit (PCU) equivalent values for Car In Work, Car Commute, Car Other, Light Goods Vehicles (LGV's) and Heavy Goods Vehicles (HGV's). The HGV PCU to vehicle factor is 1.9.

Public Transport Model User Classes

2.4.5 There are three user classes in the Public Transport assignment model as follows:

- In Work (IW) – Business trips;
- To/from Work (NWC) - Commuting trips to/from place of work; and
- Non Work (NWO) – Other journey purposes (i.e. shopping, leisure, escort education).

2.4.6 Travel demand matrices are allocated for each user class, which are assigned separately in the PT assignment model.

2.4.7 Public Transport travel demand matrices are assigned in person trip for In-Work, Commute and Other PT passengers.

Public Transport Modes

2.4.8 Four distinct modes are specified in the public transport assignment model, as follows:

- Urban Bus;
- Inter-urban bus;
- Rail; and
- Tram.

The Tram mode is not used in the base year (2012), (as Edinburgh Tram opened in 2014), but is included to permit the modelling of Tram-related demand and costs in future year PT networks.

Modelled Time Periods

2.4.9 The road and PT assignment models reflect average conditions within the AM peak hour, Average Inter-peak hour and PM peak hour.

2.4.10 The SRM12 peak periods and peak hour time segments are defined as follows:

- AM peak period 0700 - 1000;
- AM peak hour (for assignment modelling) 0800 - 0900;
  - (Calculated as 0.38 of AM Peak Period Road Travel Demand)
- Inter peak period 1000 - 1600;
- Inter peak hour (for assignment modelling) 1/6 of 1000 - 1600;
- PM peak period 1600 - 1900; and
- PM peak hour (for assignment modelling) 1700 - 1800.
  - (Calculated as 0.36 of PM Peak Period Road Travel Demand)

2.4.11 These road time period factors are consistent with and follow through from the original SRM07 model development. These factors were originally based on analysis of the Scottish Roads Traffic Database (SRTDb).

2.4.12 Public Transport factors were obtained from analysis of the TMfS07 bus occupancy survey count data and the National Rail Travel Survey (NRTS) during the development of the existing SRM07. The resulting factors were very similar for bus and rail and were therefore combined into a single set of Public Transport Peak Hour factors. These factors are reported in Table 1.

Table 1. PT Period to Peak Hour Factors

TIME PERIOD	BUS	NRTS	AVERAGE PT
AM Peak period to peak hour	0.44	0.45	0.45
Inter-peak (average of 10:00-16:00)	1/6	1/6	1/6
PM Peak period to peak hour	0.42	0.47	0.44

2.5 Software

2.5.1 The SRM12 has been developed using CUBE Voyager and Saturn software. The Road model has been calibrated and validated using SATURN version 11.2.05. The Public Transport and Demand models have been developed using CUBE version 6.1.0. The model has been developed for use within the Windows 7 operating system.

2.5.2 The computers currently used to operate the SRM12 have the following specification:

- Windows 7 64-bit operating system;
- 8 GB RAM; and
- I7 processor (3.4 GHz).

2.5.3 This specification is not a minimal requirement but it should be noted that run times could increase significantly should these specifications not be met.

2.5.4 A full forecast year demand model run requires around 20 hours to complete.

3. ROAD NETWORK & ASSIGNMENT

3.1 Network Construction

3.1.1 The SRM12 road transport network has been developed using Saturn software and a combination of the following data sets:

- Existing SRM07 Saturn road network coding;
- ESRI ArcGIS networks;
- Transport scheme delivery information received from Local Authorities;
- Traffic signal settings data;
- SRM12 zone system; and
- Satellite mapping.

3.1.2 The SRM07 Saturn network formed the basis of the SRM12 network coding, with updates made to represent the 2012 road network situation and coverage. The additional schemes incorporated include:

- Clackmannanshire Bridge;
- M9 Spur;
- Dalkeith Northern Bypass; and
- Removal of tolls from the Forth Road Bridge.

3.1.3 Reference to satellite imagery and GIS mapping was used to code-up these specific schemes.

3.1.4 The SRM12 development also included updating the modelled road network to reflect a number of smaller schemes. These were identified by using a list of recently delivered schemes (provided by Local Authorities), previous SRM07 network updates, and local knowledge. For example, recent improvements along the A701 corridor, with new traffic signalling and access to the Supermarket at ASDA were coded into the SRM12.

3.1.5 Additional network detail was coded within Central Edinburgh and other network locations such as, Edinburgh Park, Musselburgh area, A701 Midlothian corridor, Dalkeith, and the Dunfermline and Kirkcaldy areas.

Road Link Coding

3.1.6 The central Edinburgh network and other road link updates were developed using GIS and reference to satellite mapping. These data formed the basis of road link coding, priority and roundabout modelling and representing the layout at signalised junctions.

3.1.7 Traffic flow-delay relationships were coded for all links greater than 250 metres in length. Attributes for these links (distances, speed flow curves, number of lanes/allocation and saturation flow) were inferred from satellite imagery and photography. The range of Speed Flow curves used within the SRM12 is described within Table 2.

3.1.8 These speed flow delay relationships are designed to give road link speeds due to traffic interactions on the links themselves. Therefore, overall delay is a combination of the link travel time and time taken to negotiate simulated junctions.

3.1.9 Modelled capacity / lane allocation was reduced for roads where bus lanes are in operation during the peak and inter peak periods. Traffic restrictions / bans were also coded where relevant (i.e. Princes Street general traffic ban, and turning restrictions). Bus lane coverage was extracted from the earlier SRM07 model and operate across all modelled time periods.

3.1.10 Roundabouts were mainly coded as a set of 'expanded links', with circulating sections represented by short one-way links and each roundabout approach coded as a priority junction. Smaller roundabout locations were coded with a Saturn Roundabout junction type.

3.1.11 A number of Saturn 'Dummy nodes' were coded into to the road model to improve the geographical representation / alignment of the network, particularly in and around grade separated intersections.

Junction Simulation Coding

3.1.12 Previously, the central area of Edinburgh was largely coded as 'buffer' network within SRM07 (i.e. excluding specific junction modelling). As part of the SRM12 development central Edinburgh was coded as a 'simulation' area, with junction capacity restraint modelling included across the city.

3.1.13 Note that the SRM12 contains a more generic representation within the Edinburgh city centre area. This approach reflects the model development remit, which in turn reflects the challenges of representing and calibrating the city centre which has seen ongoing change throughout the time period of the construction of the Edinburgh Tram project.

3.1.14 The SRM12 development also included a review of the road network and junction coding within the core study area – i.e. cross-boundary locations along the main Edinburgh bypass corridor and strategic road network. This involved reviewing the model coding for consistency and incorporating new junction attributes and/or updating signal timings.

3.1.15 A series of default saturation flows (described in Passenger Car Units per Hour (PCU's)) were established to represent new junction attributes depending on the scale and nature of the intersection & approaches:

- Traffic Signal: Left turn 1,500, Straight ahead 1,800, Right turn 1,500;
- Priority: Left turn 1,200, Straight ahead 1,800, Right turn 875; and
- Roundabout Approach: 1,000-1,800 per lane.

3.1.16 Note that modelled Saturation flows (per lane) were reduced were junction geometry appeared constrained due to the nature of the junction layout. For example elements such as lane widths and flare lengths at roundabout approaches.

3.1.17 These type of variations were made at several locations throughout the model where it was noted that on-street conditions would impact the maximum capacity of links/turns. One of the most prominent examples is the Morningside corridor, where standard coding values would overestimate the capacity of this corridor, due to significant level of parking, loading, pedestrian crossings and poor visibility from side arms. Professional judgement was used for any variation in the standard coding approach.

Traffic Signal Settings

3.1.18 During the early project stages, the development team sought to obtain the latest signal timing information for relevant simulation junctions. Although, many data sets were provided, signal settings were not available for many locations.

3.1.19 Where possible, traffic signal coding was developed based on information provided by LA's and Transport Scotland, or previous SRM07 data. For specific intersections, signal information was provided from the Edinburgh JRC model, which formed the basis of signal coding for these locations. Where traffic signal settings were unavailable, generic settings were coded into the model, informed from local knowledge. This process estimated the following parameters: cycle time, lost time per phase, phase timings and number of phases.

3.1.20 Signal timings were reviewed and updated as required as part of the road model calibration phase (for example where intersections did not provide an intuitive balance of flows / delays that reflected the nature / capacity of the route / intersection).

3.1.21 Several traffic signals were adjusted using professional judgement, local knowledge and through cross referencing with traffic volume data. Where signal data was unavailable, signals were created for these locations, with SRM07 signals used as a starting point. Less detailed template signal coding was used within Edinburgh City centre, which was coded in less detail, in-line with the specification.

3.1.22 During initial calibration, signals were adjusted where initial settings clearly did not balance appropriately when cross referencing with traffic volume data. Where larger than expected junction delays were identified (due to the lack of junction detail), green times were adjusted to improve representation, and for template signals, filters added where required. The majority of adjustments related to central Edinburgh (as these signals were based on estimates), along with locations where signal timings were not provided

3.1.23 Note that there are a number of coded signalised junctions where the straight ahead and right turn movements share a lane, and may lead to right turning traffic blocking the straight ahead movement. At some locations, there may be sufficient space for straight ahead traffic to squeeze past the right turners, albeit at a reduced capacity throughput.

Stopping Nodes

3.1.24 Saturn coding guidance refers to the use of specific coding at merge points. The SRM12 incorporates a number of these 'stopping nodes' to improve the representation of high speed merge locations along motorways and dual carriageways.

3.1.25 Stopping nodes were coded-up for each merge point between the A1 at Tranent (to the M8 west of Bathgate, to the M9 at Linlithgow and along the M90 to the A92. Default capacities coded at merge points include:

- 4,000: Forth Road Bridge;
- 4,000-4,400: Edinburgh City Bypass; and
- 4,400: M8 / M9 / M90;

Buffer Network Coding

3.1.26 Within the SRM12, the majority of the road network is represented by Simulation coding. However, sections of 'Buffer' coding exist to connect with 'external route' zones at the edge of the model area, and for small 'spigot' links connecting to zone centroid connectors.

Zone Centroid Connectors

3.1.27 The SRM12 zone system design aimed for less than 500 vehicles loading from a zonal location. Zone centroids were positioned to represent the approximate entry/egress points associated with local roads. More than one centroid was coded within central Edinburgh and for other locations, reflecting the local geography and access options available. Default centroid distances were coded as follows:

- Central Edinburgh: 100 metres;
- Suburban Edinburgh and other settlements: 200 metres; and
- External Route zones: 1,000 metres;

3.1.28 With detailed zoning used to model specific geographies and access arrangements, the SRM12 provides an improved representation of actual network access points.

3.1.29 The SRM12 road network covers the South East of Scotland and includes all Motorways and A-Roads along with the majority of B-Roads and a number of relevant minor roads. Route zone centroid connectors are used to represent the external areas at the edge of the core modelled area, including the key cross-border links to England.

Network & Junction Coverage Summary

3.1.30 Within the SRM12 coverage there are 874 zones, 25,000 simulation nodes, 1,200 buffer nodes and 6,000 intersections in total. The following number of junctions have been included:

- 4,000 Priority junctions;
- 375 Roundabouts; and
- 430 traffic signals.

3.1.31 Figure 5 provides an illustration of the SRM12 model network representation.

Figure 5. SRM12 Road Network Coverage

Table 2. Speed Flow Curve Relationships

LINK TYPE	SPEED FLOW CURVE				
	LINK INDEX	MAX KPH	MIN KPH	CAPACITY (PCU)	POWER INDEX
Urban Central	1	32	15	1600	1.73
Urban Non Central - Single	2	42	15	1800	1.48
Urban Non Central - Dual	3	51	25	3600	1.67
Small Town	4	44	20	1800	2.45
Suburban - Single	5	45	20	1800	1.55
Suburban - Dual	6	54	25	3600	1.40
Urban Motorway 70mph	7	99	45	4800	3.68
Urban Motorway <70mph	8	73	35	4800	3.29
Ramp at Grade Separation	9	96	45	1800	3.29
Rural Single Hills H Bends H	10	60	20	1600	2.00
Rural Single Hills H Bends M	11	74	45	1600	2.16
Rural Single Hills H Bends L	12	83	45	1600	2.16
Rural Single Narrow	13	55	45	1200	2.00
Rural Single Hills M Bends M	14	74	45	1600	2.16
Rural Single Hills M Bends L	15	83	45	1600	2.16
Rural Single Hills L Bends H	16	69	45	1600	2.16
Rural Single Hills L Bends M	17	75	45	1600	2.16
Rural Single Hills L Bends L	18	81	45	1600	2.16
Rural Dual Hills H Bends H	19	78	45	3600	3.68
Rural Dual Hills H Bends M	20	87	45	3600	3.68
Rural Dual Hills H Bends L	21	94	45	3600	3.68

LINK TYPE	SPEED FLOW CURVE				
	LINK INDEX	MAX KPH	MIN KPH	CAPACITY (PCU)	POWER INDEX
Rural Dual Hills M Bends H	22	80	45	3600	3.68
Rural Dual Hills M Bends M	23	90	45	3600	3.68
Rural Dual Hills M Bends L	24	96	45	3600	3.68
Rural Dual Hills L Bends H	25	83	45	3600	3.68
Rural Dual Hills L Bends M	26	93	45	3600	3.68
Rural Dual Hills L Bends L	27	100	45	3600	3.68
Motorway D2M Hills H Bends H	28	77	45	4800	3.85
Motorway D2M Hills H Bends M	29	84	45	4800	3.85
Motorway D2M Hills H Bends L	30	90	45	4800	3.85
Motorway D2M Hills M Bends H	31	80	45	4800	3.85
Motorway D2M Hills M Bends M	32	86	45	4800	3.85
Motorway D2M Hills M Bends L	33	92	45	4800	3.85
Motorway D2M Hills L Bends H	34	82	45	4800	3.85
Motorway D2M Hills L Bends M	35	89	45	4800	3.85
Motorway D2M Hills L Bends L	36	96	45	4800	3.85
Motorway D3M Hills H Bends H	37	83	45	7200	3.81
Motorway D3M Hills H Bends M	38	90	45	7200	3.81
Motorway D3M Hills H Bends L	39	96	45	7200	3.81
Motorway D3M Hills M Bends H	40	86	45	7200	3.81
Motorway D3M Hills M Bends M	41	92	45	7200	3.81
Motorway D3M Hills M Bends L	42	98	45	7200	3.81
Motorway D3M Hills L Bends H	43	88	45	7200	3.81

LINK TYPE	SPEED FLOW CURVE				
	LINK INDEX	MAX KPH	MIN KPH	CAPACITY (PCU)	POWER INDEX
Motorway D3M Hills L Bends M	44	95	45	7200	3.81
Motorway D3M Hills L Bends L	45	101	45	7200	3.81
Urban Non Central - Dual	46	60	25	1800	2.16
Urban Non Central - Single	47	42	25	3200	1.48
Urban Central	48	32	15	1600	1.73
Rural Dual Hills L Bends L Dev L	49	107	45	4000	3.00
Ramp at Grade Separation	50	80	45	1800	3.29
Motorway 2 Lanes Standard	51	107	45	4800	3.29
Small Town 20mph	52	32	15	1500	2.45
Small Town 30mph	53	44	15	1000	2.45
Rural Dual Dev L 40mph	54	73	45	3600	3.68
Rural Dual Dev H 40mph	55	65	30	3600	3.00
Rural Dual Grade Separated	56	107	45	4400	2.90
Rural Single 50mph	57	83	45	1800	2.16
Rural Dual 50mph	58	80	45	4400	3.29
Rural Single 50mph Grade	59	80	45	2200	3.29
Rural Dual Dev H 40mph Narrow	60	65	30	3000	3.00
Rural Dual Dev H 40mph Very	61	54	35	2500	1.40
Rural Single Dev H 40mph	62	54	25	1800	1.40
Rural Single 30mph	63	45	35	1600	1.55
Rural Dual Grade Separated Narrow	64	107	45	3400	3.00
Rural 3 lane 50mph	65	78	45	5400	3.00

LINK TYPE	SPEED FLOW CURVE				
	LINK INDEX	MAX KPH	MIN KPH	CAPACITY (PCU)	POWER INDEX
Rural 2 lane 50mph Wide	66	78	45	4000	3.00
Rural 2 lane 40mph Wide	67	65	45	3800	3.29
Heavy Weaving Section 2 lanes	68	96	45	4400	3.00
Heavy Weaving Section 3 lanes	69	96	45	6600	3.00
Heavy Weaving Section 2 lanes	70	78	35	4400	3.00
Lower capacity for Stopping Nodes	71	107	45	4000	3.00
Heavy Weaving Section 2 lanes	72	35	15	2800	1.73
New 4 Lane Section of M9	73	107	45	8000	3.00
New FRC Stopping Node 2 Lane	74	96	45	4000	3.29
New FRC Stopping Node 3 Lane	75	107	45	6000	3.29
Wide single lane Motorway Merge	76	96	45	2400	3.29

Edinburgh City Bypass Speed Flow Curve

3.1.32 During the calibration phase, when comparing modelled and observed journey times along the Edinburgh City Bypass it was found that the road model produced higher speeds than recorded by the TomTom journey time data sets. This suggested that motorists tended to travel more slowly along this route than generated by the standard 'rural dual carriageway' relationship – possibly reflecting the relatively high mix of Lothian distributor traffic which do not travel the full length of the bypass route (i.e. some motorists are more concerned at being in the inside lane to egress at the next junction, rather than use the over-taking lane to travel at a faster speed.

3.1.33 Journey time data also suggested a degree of slow moving traffic (rather than a stationary queue) along some Bypass sections during peak times (i.e. that was tailing back from a downstream location (e.g. Dreghorn)). These types of effects are difficult to represent using Saturn software.

3.1.34 To mitigate these issues, a specific Edinburgh Bypass Speed Flow curve was developed which was updated with a slightly lower maximum speed and slightly steeper curve (approximately 90% of the original Speed Flow curve value).

3.2 Road Assignment Procedures

3.2.1 The road assignment model procedure adopted for the SRM12 Saturn model is an Equilibrium Assignment. The Frank-Wolfe Algorithm is used to identify the equilibrium solution.

3.2.2 The Saturn model combines the assignment stage with a junction simulation stage. The traffic delay information from the simulation is passed back to the assignment stage where a new trip pattern is derived. The process is iterated until convergence is achieved.

3.2.3 The Assignment process input files include:

- Saturn road network '.Dat' file;
- Bus 'preloads';
- Road trip matrices;
- Generalised cost parameters; and
- Range of assignment procedures, including defining convergence.

Saturn Road Network Files

3.2.4 The assignment model contains Saturn road network coding (.Dat files) for each modelled time period. These files contain link and junction coding, Speed Flow curve definitions and model parameters.

Bus Preloads

3.2.5 Bus vehicle traffic within the Saturn network is modelled using fixed pre-load flows. The bus routes and frequencies were extracted from the SRM12 (Cube Voyager) Public Transport model and converted to Saturn format. These are then input as a set of link-based preloaded flows into the Saturn Road model.

3.2.6 All traffic within the Road model is expressed in Passenger Car Units (PCUs). For consistency bus flows are also converted into PCUs using a factor of 2.2 per vehicle.

Road Trip Matrices

3.2.7 The Road model assigns five main traffic user types, including:

- Car In-work (UC 1);
- Car Non-work Commute (UC 3);
- Car Non-work Other (UC 5);
- Light Goods Vehicles (UC 7); and
- Heavy Goods Vehicles (UC 8)

3.2.8 These are assigned to the network using a set of trip matrices, expressed in PCUs. The PCU factors for the Road Model are 1.0 for all light vehicles and 1.9 for heavy goods vehicles. Note that the model is designed to allow for future modelling high occupancy vehicles and therefore there are a total number of 8 User Classes, with User Classes 2, 4 and 6 currently blank.

Generalised Cost Parameters

3.2.9 The calculation of generalised cost parameters was based on WebTAG guidance issued in November 2014. The units of time parameters and the distance based parameter are 'Pence Per Minute' (PPM) and 'Pence Per Kilometre' (PPK) respectively, as required by Saturn. Table 3 describes the parameters calculated for each User Class along with their associated value of time coefficients. The Toll parameter was used to convert tolls from pence to generalised minutes for each user class.

Table 3. Road Assignment Coefficients for 2012 Base Year

MODE	PPM	PPK	TOLL	TIME	DISTANCE
Car In-Work	52.21	13.90	0.058 / 3.03	1.0	0.264
Car Commute	11.53	7.51	0.162 / 1.87	1.0	0.648
Car Other	15.36	7.51	0.162 / 2.49	1.0	0.486
LGV	21.00	17.04	0.026 / 0.54	1.0	0.809
HGV	36.41	45.98	0.026 / 0.94	1.0	1.251

All figures are in 2010 values

3.2.10 The road generalised cost function for assignment by user class is:

GC = *a x distance (km) + b x time (mins) + c x toll* (pence)

where a, b and c are the parameters and GC is in Generalised time

Convergence

3.2.11 Within Saturn the convergence of the assignment / simulation loops is controlled by the parameters 'PCNEAR', 'ISTOP' and 'NISTOP'. The loops stop automatically if ISTOP percent of link flows change by less than PCNEAR percent from one assignment to the next for a number of consecutive iterations (NISTOP). For the SRM12 these parameters were set as follows:

- ISTOP = 99, NISTOP = 4,
- PCNEAR = 2.00

3.2.12 The final convergence % GAP (% DELTA – actual costs less minimum costs) for the 2012 Base year models were:

- 0.183 % for the AM Peak model after 63 iterations ;
- 0.241 % for the Inter Peak model after 15 iterations; and
- 0.218 % for the PM Peak model after 70 iterations.

3.2.13 The final convergence percentage of links where flows change by less than 2% are as follows:

- 98.0 % of links for the AM Peak (95.3% of links under a 1% criteria);
- 98.1 % of links for the Inter Peak (96.3 of links under a 1% criteria);
- 96.9 % of links for the PM Peak (93.3 of links under a 1% criteria)

3.2.14 The final convergence percentage of links with cost change of less than 2% are as follows:

- 99.1% of links for the AM Peak (99.1% of links under a lower 1% criteria);
- 99.7 of links for the Inter Peak (99.7% of links under a lower 1% criteria);
- 98.8 of links for the PM Peak (98.7% of links under a lower 1% criteria).

3.2.15 Note that following updates to the model network undertaken for later model versions the % of links where flows change by less than 2% increased to over 99% for the PM Peak. The model user should review the level of convergence when using the model for scheme appraisal, particularly economic assessment

3.2.16 The SRM12 Saturn assignment model is operated through a CUBE Voyager interface. Multi-core operation is used which utilises additional processors to enable each road assignment time period to be run in parallel.

Road Assignment Outputs

3.2.17 The Road Model assignment produces several output files, including:

- Unassigned Network File (*.UFN): At the start of the assignment process, Saturn builds an unassigned network file based on the network coding data, which, together with the input Trip Matrix (*.UFM), creates the Assigned Network File;

- Assigned Network File (*.UFS): These files contain all the assigned network traffic volumes and loaded / congested network data for each time period. They can only be opened from the Saturn Software interface;

- Link/Route Costs File (*.UFC): These binary files contain information about the complete set of link travel "costs" used to construct minimum cost routes; and

- Various Print Files (*.LPD, LPP, LPX, LPT, LPL, LPN): These print files summarise various parameters, processes and information to facilitate analysis of the performance of the model.

4. PUBLIC TRANSPORT NETWORK, SERVICES & ASSIGNMENT

4.1 Public Transport Structure

4.1.1 This Chapter describes the development of the Public Transport (PT) morning, inter and evening peak assignment models, including the network and service supply definition, fares and capacity modelling, assignment procedures and model parameters.

4.1.2 The SRM12 public transport model has been developed using CUBE Voyager Software, and is predominantly based on the underlying SRM07 model, with additional enhancements that include:

- Updated road network to provide consistency with the SRM12 road model;
- Updated rail services to reflect 2012 timetabling and scheme delivery;
- Updated fares model to reflect 2012 fares;
- Updated rail fares modelling to reflect station-station fares matrices;
- Updated bus service routes to reflect known service changes from 2007 to 2012;
- Updated matrices to reflect introduction of rail schemes and changes in population and employment between 2007 and 2012; and
- Updated PT assignment parameters.

4.1.3 The PT assignment model covers three time periods reflecting average travel conditions during the AM peak, inter peak and PM peak hourly time periods, including:

- AM Peak hour: 0800-0900;
- Inter Peak: Average hour between 1000-1600; and
- PM Peak hour: 1700-1800

4.1.4 Demand matrices are prepared for three public transport user classes (travel purposes) which are assigned separately to the public transport network. These include:

- In Work (IW) - Business trips;
- Non Work Commute (NWC) - Commuting trips to/from place of work; and
- Non Work Other (NWO) - Other journey purposes (i.e. retail, leisure, escort education).

4.2 Public Transport Network

4.2.1 The SRM12 PT network is based on the SRM12 Saturn network with the addition of the CSTM12 rail network. This structure allows for simple and consistent transfer of changes in forecast road traffic delays. The modelled PT network includes the following elements:

- Road network;
- Rail network;
- Bus priority measures (bus lanes, bus only routes);
- Walk connections between zones and the road network and rail stations; and
- Walk connections between rail stations and park & ride sites and the road network.

Road Network

4.2.2 Congested traffic speeds are extracted from the Saturn model to form the underlying basis of bus network speeds. Bus vehicle speeds are adjusted by a range of factors to represent the slower average speeds of buses and the time required for passengers boarding and alighting. Bus speed factors were initially taken from the original SRM07 model, and adjusted during calibration to represent timetabled journey times where appropriate.

4.2.3 The relevant bus link speed adjustments are set as follows:

- Motorway: 90%
- Rural: 60%
- Urban: 60%
- Bus Lanes: 90%

4.2.4 A minimum congested speed of 5kph has been set for buses. This reflects the detailed nature of bus manoeuvres approaching heavily congested intersections within Edinburgh, where buses can tend to block traffic as passengers board / alight – reducing the traffic volume along the next section of the route, and potentially providing a higher speed and quicker journey time. Furthermore, although bus lanes are represented within the PT modelling, Saturn software will predominately allocate junction delays at the specific junction node, resulting in an over estimate in delays for buses (as the majority of bus lanes will stop just prior to the junction). In reality, only a proportion of this delay would be attributed to buses, and the allocation of a delay and a percentage reduction for boarding / alighting, and therefore the capping of low speeds limits this potential over estimate of congestion impacts.

New Rail Lines & Stations

4.2.5 Within the PT network, the following rail stations and associated rail lines and connectors have been incorporated into the SRM12:

- Alloa;
- Armadale; and
- Blackridge.

4.2.6 Each of these stations also have car park capacity allocation within the Park & Ride model.

4.2.7 Note that the SRM12 Western (M8 corridor) boundary is located at the western edge of West Lothian, therefore the recently opened station at Caldercruix sits just outwith the SRM12 coverage. Travel demand associated with Caldercruix and stations further west is represented by an external zone.

Bus Priority

4.2.8 As part of the network development the coverage of bus lanes and bus only links was reviewed and updated to reflect the more detailed layout link/node structure of the road network. Streets which include general traffic bans (such as Princes Street) are coded as bus-only links. These lanes are coded within the road model and carried through to the PT network. The PT model applies 90% of the relevant free-flow speed (rather than congested speed) for modelled links that are located along bus lanes and bus only links.

Walk Links

4.2.9 The walk speed within the PT model is set at 4.8kph. For links where there are no PT services, a motorised time is assumed for rural areas, reflecting the potential to travel by taxi, or local services. Maximum (unweighted) walk time is capped at 60 minutes for rail access legs, 40 minutes for accessing inter-urban bus, and 20 minutes for Urban Bus.

4.3 Public Transport Services

4.3.1 The development of the public transport services ('lines') file is dependent on the input of public transport system and service data. This includes the definition of System Information and the coding of PT services.

4.3.2 System Information contains data for:

- available PT modes;
- PT operator definition;
- wait curves; and
- crowding curves.

4.3.3 The PT lines contain the data for the modelled public transport services including the route the service will take across the modelled transport network. Public transport service data contains the following information:

- mode;
- operating company;
- route type (circular/linear);
- headway for each modelled time period;
- short and long text descriptions; and
- sequence of nodes along the route.

Bus Services

4.3.4 The SRM12 bus services are modelled for each time period and have been formed based on the underlying SRM07 urban and inter-urban bus service coding. Service routing has been updated as required to match the more detailed central Edinburgh road network.

4.3.5 Inter-urban bus services were originally coded (within SRM07) to represent specific bus routes and timetables. Where cross-boundary services were identified to have changed between 2007 and 2012, updates were made to the relevant services. These updates include addition/ removal of routes, frequency change and/or route change. Bus corridors were compared with online timetables, in particular for routes with no modelled services and where services were known to operate. A further 'cross-boundary' review was undertaken following the review of 2007/2014 Bus passenger data which highlighted recent service changes within Midlothian and East Lothian).

4.3.6 For example, in recent years, First Bus have removed a number of services – some of these have either been replaced by First Bus themselves (renumbered), or are now provided by another company. Some services have not been replaced at all.

4.3.7 The review looked at the routes taken by these services and the timetable that they follow in each time period. Online maps and timetables were used to determine the correct route and headway required for each service.

4.3.8 Urban bus services (within Edinburgh) were originally coded (within SRM07) as sets of generic 'corridor based' service frequencies across Edinburgh. Where new road network detail was incorporated into the SRM12, bus services along these routes were coded to reflect the specific service routes and frequencies.

4.3.9 Urban and inter-urban bus services are coded to stop at every node within the network.

4.3.10 Using the same approach as the national model, Intra Urban bus services have been defined as those that are wholly within Edinburgh. Services that extend outwith these areas have been defined as Inter Urban Bus.

4.3.11 Where the modelled network does not include the actual road (e.g. diversions to local settlements, used by a service), the modelled service has been routed using the nearest equivalent road.

Rail Services

4.3.12 Rail services within the SRM12 have been updated to be based on the CSTM12 2012 Base year AM, inter and PM peak models.

4.3.13 During the development of the CSTM12, rail services were completely re-coded based on the 2011 ATCO-CIF rail service database, which provides a complete record or all rail service in Scotland including cross-border services. Rail services were aggregated based on stopping patterns with average headways derived for each time period.

4.3.14 Note that the 2012 ATCO-CIF was not available during the development of CSTM12, however, using the slightly older 2011 data would have a limited impact on the modelled network due to the anticipated limited changes made to timetables during this time.

4.3.15 The following broad approach was undertaken when preparing the PT lines files:

- modelled headways are based on the number of services that operate in each time period (i.e. 0700–1000, 1000–1600 and 1600–1900) with the time period definition based on the timetable mid-point within the model network;
- some long distance services have been included in more than one time period, particularly those with an infrequent service pattern, to ensure connectivity throughout the model network; and
- A review of East Coast mainline service patterns was undertaken for the SRM12 to ensure that the general frequency of longer distance services were represented within the model;

Modes

4.3.16 The MODE control statement defines the type and characteristics of the various modes used by the PT system. Within the SRM12 these include:

- Intra-urban bus;
- Inter-urban bus;
- Rail; and
- Tram (unused in the base year but included for forecast year scenarios).

4.3.17 The SRM12 inter-urban and urban bus service coverage is illustrated within Figure 6 and Figure 7 respectively. Table 4 shows the number of PT lines coded by mode and time period.

Table 4. Number of Public Transport Services (Lines)

MODE	AM PEAK	INTER PEAK	PM PEAK
Inter Urban Bus	547	467	502
Intra Urban Bus	57	52	57
Rail	246	195	221
Total	**850**	**714**	**780**

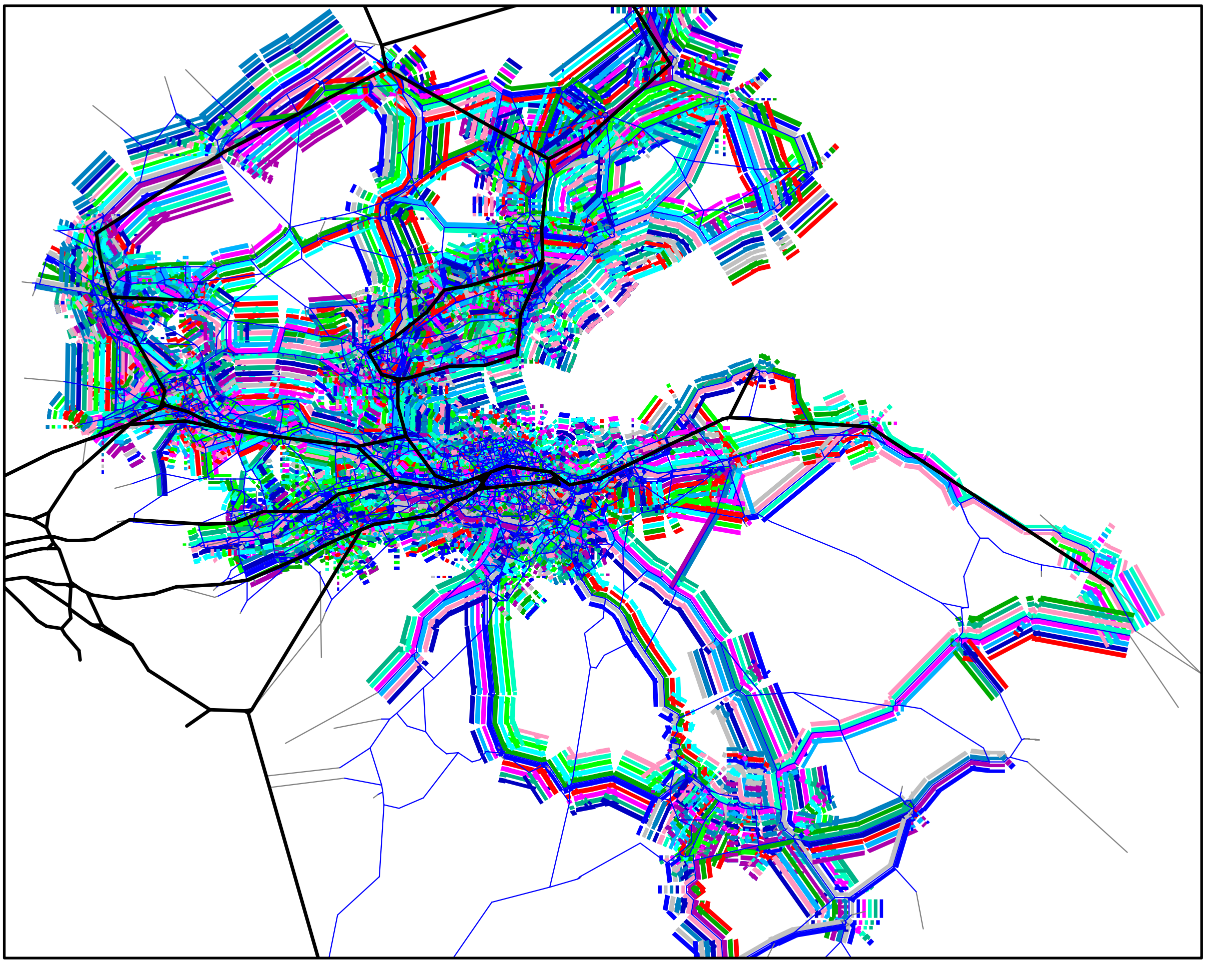

Figure 6. SRM12 Inter-Urban Bus Service Coverage

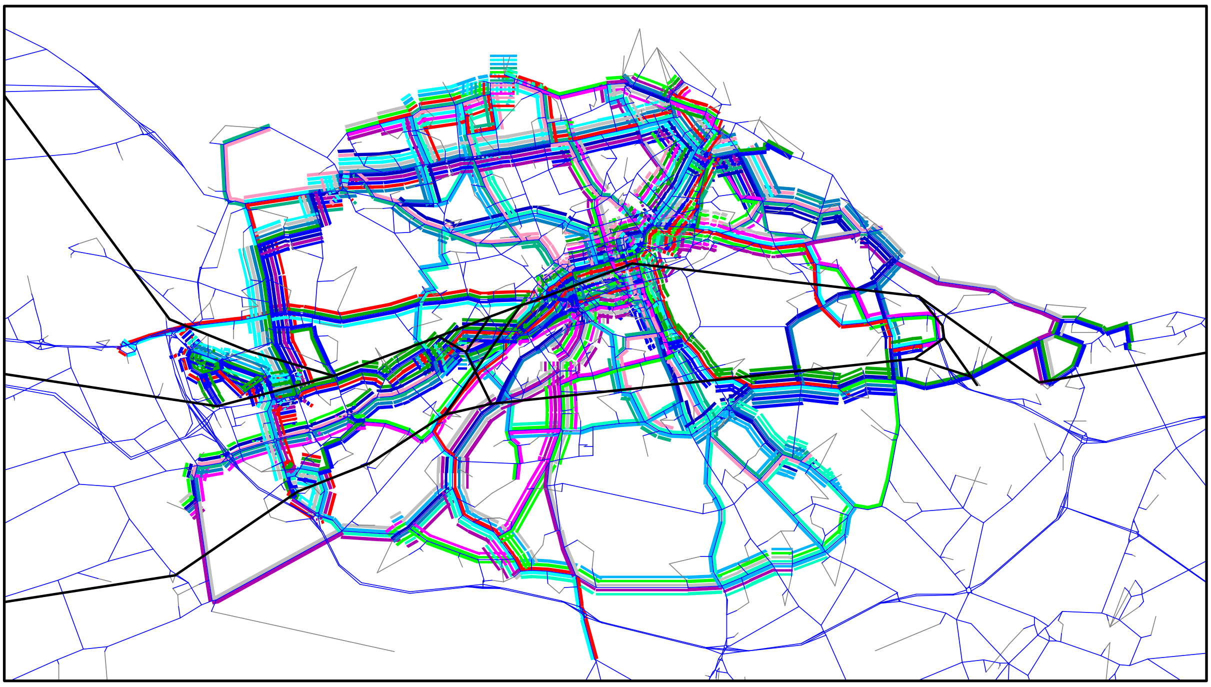

Figure 7. SRM12 Urban Bus Service Coverage

4.4 Public Transport Fares

4.4.1 The SRM12 public transport fares modelling incorporates a set of flat, distance-based fare tables to represent urban and inter-urban bus service fares, and station to station fare tables to represent rail fares. SRM12 PT fares are based on the underlying fares modelling developed for the CSTM12 2012 base model. The following steps have been taken to prepare the fare tables:

- all fare tables prepared in terms of the 2010 price index;
- rail fares are defined by station pair and prepared using consistent data sources as the CSTM12 demand matrix preparation as follows:
  - LENNON revenue and journeys data for 2009, 2010, 2011 and 2012 used to derive average fares with fare indices applied to represent all years equivalent to 2012 fares;
  - MOIRA revenue and journeys data used to derive 2012 average fares to/from England;
  - LENNON and MOIRA data combined to derive average fares by ticket type:
    - AM peak - combination of full and season tickets;
    - Inter peak - reduced tickets with SPT fare reductions applied for the concessionary travel user class; and
    - PM peak - combination of full, season and reduce tickets on station pairs entirely within SPT, combination of full and season tickets on all other journeys.

- for station pairs without LENNON or MOIRA data or with very low annual passenger volumes distance based fares were applied based on rail distances and average fare per kilometres taken from the ticket sales data, which was calculated on an area basis to reflect any regional variations;

- Lothian Buses published annual revenue and journeys data used to derived average passenger flat fare applied in all time periods, reflecting the range of tickets available;
- TMfS07 distance-based bus fare tables factored by Scottish Transport Statistics Bus Fare indices for 2007 to 2012. These were then factored by the Lothian Buses standard single fare to derived average fare ratio to reflect the range of tickets available and ensure consistency with other modes;
- Edinburgh airport bus and City Link Gold flat fares derived based on operator data with an assumed mix of fare types; and
- Fares are allocated to modelled service by operator;

4.4.2 Separate AM, Inter and PM peak fares are allocated to each of the relevant time period models.

4.5 Passenger Wait Curves

4.5.1 A wait curve is applied to reflect the perceived time waiting to board a public transport service. For the SRM12 a wait curve has been derived from the Passenger Demand Forecasting Handbook (PDFH) and has been implemented for all PT lines in SRM12 (described as 'Non London Inter-urban'). This is a consistent approach as applied within CSTM12.

4.5.2 The SRM12 wait curve is described in Table 5. The wait curve values have been halved and a wait time factor of two applied such that the route enumeration simplified wait times are also scaled appropriately.

4.5.3 The rise in wait time is decreased for waits of over 120 minutes – which also effects all waits longer than the maximum of 180 defined. The wait time will continue to increase at the same gradient as it does between the last two points (so every extra hour increase in headway will add an extra 2 minutes to the wait time).

Table 5. SRM12 Wait Curve Definition

HEADWAY (PT SERVICES PER HOUR)	PERCEIVED WAIT TIME (MINUTES)
5	5 (2.5)
10	10 (5)
15	14 (7)
20	18 (9)
30	23 (11.5)
40	26 (13)

HEADWAY (PT SERVICES PER HOUR)	PERCEIVED WAIT TIME (MINUTES)
60	31 (15.5)
90	39 (19.5)
120	47 (22)
180	63 (24)

4.6 Passenger Crowding

4.6.1 Public transport crowding is represented within the SRM12 PT assignment procedures for morning and evening peak rail services. The model framework allows the user to model crowding effects for tram services in forecast years, if required.

4.6.2 It is assumed that crowding is not currently considered to be a significant issue outside the peak periods and therefore has not been included in the Inter peak period assignment. This also assists in reducing model run times.

4.6.3 No crowding modelling calculations are performed for bus services, as it is assumed that operators will be likely to increase the vehicle capacity and/or service frequency on routes where demand regularly exceeds vehicle capacity, and thus the average load factors are likely to remain broadly constant over time.

4.6.4 Note that the impact that car park capacity constraints at rail stations and park and ride sites will have on mode and route choice is dealt with by the Park and Ride model.

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

- Rail service train set capacities;
- PT crowding curves; and
- passenger and vehicle arrival profiles.

4.6.6 The SRM12 crowding model is based on consistent processes as developed for the CSTM12 2012 base year crowding modelling.

Rail Service Capacity

4.6.7 Specific rail service capacities have been coded for all rail services in the SRM12 base year, based on the previous development of the CSTM12 2012 base Year model. These capacities are based on ScotRail rolling stock usage allocations. This provided an indication of the seated and crush capacity on all train services in December 2012, which is broadly representative of rolling stock allocation throughout the year. Capacities were aggregated on a service group basis by direction and time period and allocated to modelled rail lines.

4.6.8 Capacities on non-ScotRail services have been estimated based on available data on rolling stock and service provision.

Crowding Curves & Utilisation

4.6.9 Crowding curves are implemented as multiplicative curves in the CUBE Voyager public transport assignment procedures. For each level of utilisation, the free link journey time is multiplied by the appropriate adjustment factor to represent the perceived journey time spent in crowded conditions. It should be noted that all modelled occupants perceive the same crowding on a given section of the route, regardless of where they boarded.

4.6.10 The measure of utilisation is expressed as the percentage of standing passengers as a proportion of the standing capacity. Utilisation is therefore zero until all seats are occupied and standing is necessary. Utilisation is 100% when the vehicle is at crush capacity, i.e. all standing room is taken.

4.6.11 The PDFH recommends that the measure of crowding 'is taken to be the load factor up to 100% of seats being taken, and the standing passengers per m2 of standing space beyond that'. In the absence of available standing space figures for rail rolling stock in Scotland, the ScotRail rolling stock crush capacity figures have been used to allocate the PDFH Regional crowd curve. The ratio of seated versus crush capacity varies between train classes ranging from 1.27 to 1.56 suggesting the crush capacities do reflect variations in standing space. Therefore, in order to derive a crowding curve that can be applied across the entire network an assumed crush capacity equivalent to 140% of the seated capacity on average has been applied where it is assumed the crush capacity is equivalent to 5 passengers per m2. The data points for the resulting crowding curve are described in Table 6 (based on the 'Non-London Commuting Rail' Crowding definition).

Table 6. SRM12 Crowding Curve

% SEATED CAPACITY	UTILISATION	CROWDING FACTOR
100%	0%	1.00
108%	20%	1.26
116%	40%	1.53
124%	60%	1.80
132%	80%	2.07
140%	100%	2.35

Passenger & Vehicle Arrival profiles

4.6.12 The passenger and vehicle arrival profiles have been assumed to be constant throughout the modelled time periods. This is a potential weakness in the crowding procedures applied, since it makes no allowance for varying demand on individual services within the modelled peak hour. Given the non-linear nature of crowding costs, this assumption of constant hourly demand may result in an under-estimation of crowding on busy routes where demand varies significantly across the peak hour.

Crowding Calculations

4.6.13 Modelling PT crowding is an iterative process. The model calculates an initial set of crowding factors and passenger loadings, feeds these back into the model and produces a revised set of passenger loadings and corresponding perceived crowding costs. Model convergence is achieved when the public transports loadings (and hence the crowding costs) stop changing significantly between iterations.

4.6.14 The number of iterations is specified by the user. A review of the convergence of the Base Year model suggests that five iterations of the PT crowding loop will generally be sufficient for the SRM12 PT assignment procedures. Model users should consider reviewing the number of iterations depending on the interventions being tested.

4.7 Public Transport Assignment Parameters

Path Building and Loading

4.7.1 The SRM12 path building and loading procedures have been developed using the CUBE Voyager public transport assignment model software, with the following models:

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

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

Route Enumeration:

- This stage identifies a set of discrete routes between each zone pair, along with the probabilities that passengers will use each route. Routes that fail to meet certain criteria are discarded. The criteria are specified using the Spread Factor and Spread Constant parameters that define the range of routes that will be retained for each zone pair based on their generalised time relative to the minimum generalised time. Fares are not included explicitly at this stage but a mode specific run-time factor, exclusively used in route enumeration, is used to make a proxy of the impact of fare on generalised costs. Passenger crowding is not considered within this Route Enumeration stage.

Route Evaluation:

- This calculates the "probability of use" for each of the enumerated routes between zone pairs, including the impacts of crowding and fares.

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

- route enumeration fare run-time factors;
- spread factor and spread constant;
- mode specific in-vehicle time weighting factors;
- wait time weighting factors;

- walk time weighting factors;
- mode specific boarding penalties;
- mode to mode transfer penalties; and
- mode specific minimum and maximum wait times.

4.7.4 The assignment model parameters, common to peak and Inter peak assignments, are described in Table 7.

Table 7. Public Transport Assignment Model Parameters

MODEL PARAMETER		VALUE/FACTOR
Route Enumeration Fare In-vehicle Time Factors:	urban bus / inter-urban bus	0.85
	rail / tram	1.0
Spread Factor		1.25
Spread Constant		10 mins
In-vehicle Time Factors: AM + PM	urban bus	1.4
	inter-urban bus	1.2
	rail / tram	1.0
In-vehicle Time Factors: IP	urban bus	1.4
	inter-urban bus	1.2
	rail / tram	1.0
Walk Time Factor		1.6
Minimum Wait Time		0 mins
Maximum Wait Time (Route Enumeration Only)		60 mins
Boarding Penalty: AM, IP & PM		5 mins
Transfer Penalty:	to/from rail	0 mins
	To/from bus	5 mins
Value of time (2012 Base Year): 2010 prices / values	in work (business)	24.67 £/hr
	non work (commute & other)	5.94 £/hr

5. MATRIX DEVELOPMENT

5.1 Matrix Composition

5.1.1 The road and public transport assignment models require trip matrices containing origin-destination travel patterns to perform the road network and public transport service assignments. SRM12 matrices consist of individual tables describing travel movements between zonal areas associated with each modelled user class and hourly time period.

5.1.2 The user classes / travel purposes are assigned separately for business, commuter and other trips for car and PT modes, with additional and separate LGV and HGV user class movements within the road model.

SRM07 Travel Matrix Development

5.1.3 The underlying matrices used to form the basis of SRM12 development were the original SRM07 2007 calibrated matrices – which represent 2007 traffic and travel conditions. These SRM07 matrices were originally constructed based on the TMfS07 model version. The approach to the development of the previous SRM07 model included:

SRM07 Road Matrices

5.1.1 The SRM07 'prior' road matrices used to start the matrix calibration process were based on the corresponding sub-area cordons of the TMfS07 road model matrices. The sub area coverage reflected the external boundary of the SRM07 network and internal zone system.

5.1.2 'Final calibrated' matrices were produced by Matrix Estimation (ME) using the program SATME2. SATME2 essentially tries to improve the fit between modelled and observed flows by selectively factoring individual cells of the input trip matrix.

5.1.3 The five user class matrices were aggregated into one general matrix and this was estimated to reach total target counts. At the end of the estimation the global matrix was re-split into single matrices using cell by cell factors.

5.1.4 Sets of calibration input counts were combined into screenlines to form sets of aggregate constraints, such that SATME2 tries to satisfy the sum of all the individual flows. This provides a good method to constrain the estimation process and achieve a more reliable estimation. SRM07 Calibration count screenlines are illustrated within Figure 8.

5.1.5 The SRM07 ME procedure was able to achieve a good level of screenline calibration and the analysis of the Trip Length Distribution for each time period before and after the ME process showed that the distribution did not significantly change as a result of the estimation. Table 8 describes the matrix trip totals before and after matrix estimation. The SRM07 Road and Public Transport Model Development Reports provide more details regarding SRM07 calibration / validation.

Table 8. Previous SRM07 Road Matrix Estimation Adjustments (Total Trips per Hour)

SRM07 MATRIX	AM PEAK	INTER PEAK	PM PEAK
Prior	169,004	130,780	195,186
Final Calibrated	170,724	130,679	196,763

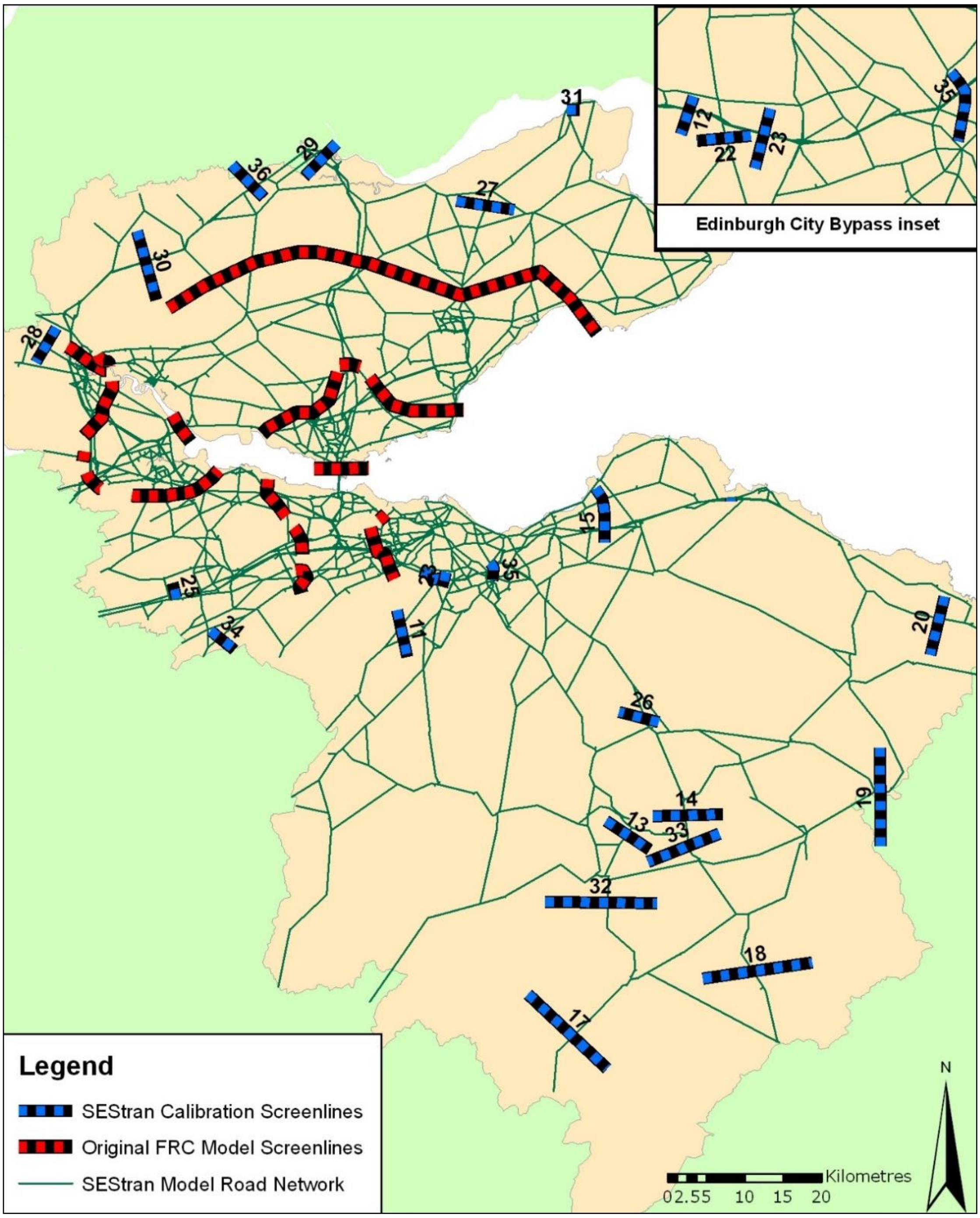

Figure 8. Previous SRM07 Calibration Screenline locations

SRM07 Public Transport matrices

5.1.6 The SEStran 2007 PT model demand matrices were developed based on the national TMfS07 demand matrices. PT demand matrices were prepared for three modelled time periods and user classes, which is consistent with those used in TMfS07.

5.1.7 Three movement types were identified that required to be extracted from TMfS07 as follows:

1. **Internal to Internal Movements**
   - Movements between internal zones were extracted using a direct zone equivalence. Park and Ride trips were identified based on observed car park occupancies and TMfS07 data and moved to the appropriate SEStran model zones.
2. **Internal to/from External Movements**
   - Movements between internal and external zones were based on a select link assignment using TMfS07.
3. **External to External Movements**
   - This movement was derived through inspection of the TMfS07 demand matrices at local authority level with movements through the Forth modelled area allocated to route zones. For example, journeys from Inverness and the Highlands to Berwick-Upon-Tweed enter through rail lines or the A9 at Perth and exit the model at the eastern edge of the Borders.

5.1.8 Assignment matrices were prepared through summation of the three matrix elements, i.e. (1) + (2) + (3). Table 9 shows the matrix totals by time period and user class.

Table 9. Previous SRM07 PT Matrix movements Totals (Total Passengers per Hour)

TIME PERIOD	INTERNAL TO INTERNAL	INTERNAL TO/FROM EXTERNAL	EXTERNAL TO EXTERNAL	TOTAL
AM Peak	45,893	6,276	982	53,151
Inter Peak	24,639	3,094	537	28,270
PM Peak	39,996	6,225	744	46,966

5.2 SRM12 Matrix Development

5.2.1 To develop the SRM12 matrices, a number of alterations and updates were made to the underlying SRM07 matrices to reflect changes in travel demand between 2007 and 2012, and create compatibility with the more disaggregate SRM12 zone system and network coverage.

5.2.2 The process used to create the SRM12 road and public transport hourly assignment matrices included the following steps:

- comparison of 2007 and 2012 demographic and employment data sets to assess suitability for use in updating 2007 matrices to 2012 levels;
- disaggregation of 2007 SRM matrix into SRM 2012 zone system;
- creation of 12-hour freight matrices and disaggregation to individual time periods;
- adjusting 2007 zonal trip ends to reflect 2012 levels;
- furnessing of 2007 matrix with 2012 trip ends;
- comparison of matrices, trip rates and network to identify and repair anomalies;
- comparison of SRM12 Commute matrices with 2011 Census Travel to Work LA-LA travel patterns and required adjustment; and
- Park and Ride movement updates.

Data Review & Database Development

5.2.3 To inform the matrix development process a data review was undertaken to compare changes in demographic and employment levels and characteristics between 2007 and 2012. This analysis was used to assess suitability for use in updating 2007 matrices to 2012 levels and to build a database to inform the matrix development process.

5.2.4 Data from a variety of sources was analysed and compared to assess its suitability for use in disaggregating the SRM07 matrices to the new zone system and adjusting to 2012 levels. The following data was considered:

- TELMoS national model planning data for 2007 and 2012;
- 2012 Business Register and Employment Survey BRES data;
- Local Authority Planning Data;
- 2011 Census Data; and
- 2011 and 2012 Mid-Year Population Estimates.

TELMoS Planning Data

5.2.5 Planning data was available for the 2007 (TELMoS07) and 2012 (TELMoS12) versions of TELMoS, providing modelled population, households and employment data for each TELMoS zone. As a modelled output, rather than observed or survey data, consideration was given to whether, at a zonal level, the data would reflect more recent trends, given the economic downturn between 2008 and 2011, and the build-out of developments from 2007 to 2012.

5.2.6 Analysis of the TELMoS data showed a large reduction in employment in some Local Authorities, in particular East Lothian, Stirling and Clackmannanshire. This was considered potentially unrealistic given changes in employment nationally, so other sources of employment data were also analysed.

Business Register & Employment Survey

5.2.7 BRES is a survey of businesses registered for VAT and/ or PAYE carried out each year, and captures the number of employees employed at each business. Employment data, based on this survey, is available at datazone level. BRES data was converted from datazone format into the SRM12 zone system to provide 2012 levels of employment for each SRM12 zone.

5.2.8 BRES data showed a reduction in employment of -4.5% across the total modelled area from 2008 (when the BRES data was first available) to 2012. This was considered a more realistic change in employment given the post-2010 economic recovery.

5.2.9 Within the BRES data set some issues were identified regarding the specific location of large employers which appeared incorrectly located (e.g. the Western General Infirmary) or had recently moved (e.g. Queen Margaret University). These issues were refined in the SRM12 employment data by transferring a proportion of jobs to the relevant location / zone.

Local Authority Planning Data

5.2.10 Local Authorities within the SESPlan area (Edinburgh, West Lothian, Midlothian, East Lothian, Fife and Scottish Borders) provided housing and employment data along with completions between 2007 and 2012. These included the number of housing units, employment type and floorspace, and coordinates so that the developments could be allocated to SRM12 zones.

5.2.11 Whilst the housing data provided was relatively detailed, employment data was less so. This data also only included data on completions, and not demolitions (or, in the case of employment, closures, which may be considerable in light of the economic downturn). Hence this data was used to check the TELMoS data to make sure it took into account known recent developments, but was not directly used to disaggregate the SRM07 matrices.

2011 Census Data

5.2.12 2011 Census Data was analysed to calculate the number of people and households in each SRM12 zone (by aggregating relevant small geographical area data). Some zones had very high levels of population compared to the number of households due to the University Halls of Residence. Hence 'household population' rather than total population was used, which excludes students living in halls of residence and other institutional populations.

5.2.13 The 2011 Census provided information on the number of people working in each Small Area (by household origin). This was converted to generate the number of workers by SRM12 zone.

Mid-Year Population Data

5.2.14 Census Mid-Year Population Estimates for 2011 and 2012 were also available at the datazone level. These are based on a survey of a sample of the population. These were converted to the SRM12 zone system and compared to the 2011 Census population. They were then used to adjust the 2011 Census population to 2012 levels.

5.2.15 The output of the review stage was a database of 2012 (household population, working population, households and employment (jobs)) for each SRM12 zone, relevant change between 2007 and 2012 and proportion split between SRM12 and TELMoS12 zonal areas.

5.2.16 SRM12 zonal population and household disaggregation data is predominately based on the 2011 Census, whilst employment / jobs data is based on the BRES data set. Each SRM12 zone lies within a TELMoS boundary, and the SRM12 population and household data sets were developed to enable the SRM12 to match TELMoS zonal household and population totals when aggregated. As SRM12 employment data was also developed using BRES, the SRM12 jobs data set does not match TELMoS totals when aggregated.

Disaggregation of SRM07 Matrices to SRM12 Zone System

5.2.17 Each SRM07 travel purpose matrix was disaggregated to the SRM12 zone system based on employment, total population, working population, or a combination of these, depending on the time period and travel purpose. These disaggregation factors are described in Table 10.

Table 10. SRM07 to SRM12 Disaggregation Factors

TIME PERIOD	TRAVEL PURPOSE	ORIGIN			DESTINATION		
		TOTAL POPULATION	WORKING POPULATION	JOBS	TOTAL POPULATION	WORKING POPULATION	JOBS
AM	In-Work		100%				100%
	Commute		100%				100%
	Other	100%			50%		50%
	LGV	25%		75%	25%		75%
	HGV			100%			100%
IP	In-Work		100%				100%
	Commute		50%	50%		50%	50%
	Other	50%		50%	50%		50%
	LGV	25%		75%	25%		75%
	HGV			100%			100%
PM	In-Work			100%			100%
	Commute			100%		50%	50%
	Other	25%		75%	50%		50%
	LGV	25%		75%	25%		75%
	HGV			100%			100%

5.2.18 'In-Work' and 'Commute' trips were disaggregated to the new zone system based on the assumption that these types of journeys will relate to the number of people travelling to work in the AM peak (i.e. workers travelling from their place of residence to their usual place of employment or another place of employment) and returning home during the PM peak. Within the inter-peak, it is assumed these are a mix of people travelling to and from work.

5.2.19 'Other' purpose trips were disaggregated based on the assumption that most morning peak other trip origins relate to population (i.e. starting a journey From-Home), with people travelling to both residential and non-residential locations. Factors were then adjusted to relate to the characteristics of the inter and evening peak time periods, with larger proportions of jobs included to account for non-home based education, retail, healthcare and leisure trip making.

5.2.20 LGV trips were disaggregated based mainly on jobs data, and also reflect a smaller percentage of population to reflect the home-based nature of some LGV trip making and the increasing levels of home deliveries.

5.2.21 HGV trips were disaggregated based on the employment (jobs) data set.

Creation of 12 Hour Freight Matrices

5.2.22 The majority of underlying freight travel movement data used to create the original SRM07 LGV and HGV matrices is more than 10 years old, and was undertaken at an individual time period level. Therefore, LGV and HGV patterns are dated and can be relatively coarse.

5.2.23 To mitigate this issue, LGV and HGV matrices for the individual time periods were combined to create a 12-hour pattern, and then factored back to the separate hourly time periods using a global factor. This process applies a consistent pattern across all time periods and improves the quality of freight trip distribution. The hour to period factors are described in Table 11. Factors are consistent with SRM07 and TMfS07 'hour-to-period' traffic factors, which were summed to create 12 hour demand.

Table 11. LGV & HGV 12 Hour Time Period Factors

TIME PERIOD	FACTOR
AM Peak Hour to 3hr Period	2.63 (where peak hour is 38% of the 3hr Period)
Inter Peak Hour to 6hr Period	6 (where peak hour is 1/6th of the 6hr Period)
PM Peak Hour to 3hr Period	2.63 (where peak hour is 38% of the 3hr Period)

Adjustment of 2007 Trip Ends to 2012 Level

5.2.24 Following the disaggregation of the SRM07 matrix to the SRM12 zone system, trip ends were adjusted based on the change in population/ working population/ jobs between 2007 and 2012, with individual factors for each purpose/ zone/ time period.

5.2.25 The overall changes in zonal trip ends were controlled to the global matrix change totals described within Table 12. These factors were applied consistently across time periods for all internal and external zones (with the exception of travel to/from Park and Ride sites).

Table 12. Trip End Adjustments from 2007-2012

TRAVEL PURPOSE	CHANGE 2007-2012
In-Work	-3.5%
Commute	-3.5%
Other	3.8%
LGV	-0.35%
HGV	-2.5%

5.2.26 The rationale for the use of each of these travel purpose changes is as follows:

- **In-Work**: Average percentage change in Working Adults 2007-2012 (TELMoS SEStran area (Origin End)) and Change in jobs 2008-2012 (BRES SEStran Area (Destination End)), i.e. average of -2.5% and -4.5%;
- **Commute**: Average percentage change in Working Adults 2007-2012 (TELMoS SEStran area (Origin End)) and Change in jobs 2008-2012 (BRES SEStran Area (Destination End)), i.e. average of -2.5% and -4.5%;
- **Other**: Percentage change in 2007-2012 total mid-year population estimates (Origin & Destination) for all SEStran LA's combined (i.e. +3.8%);
- **LGV**: Average percentage change in jobs 2008-2012 (BRES) (i.e. -4.5%) and Total Mid-Year Population Change (+3.8%) – potentially reflecting rise in home deliveries; and
- **HGV**: Average percentage change in total Scotland Local Authority Vehicle kilometres 2007-2012 (Scottish Transport Statistics Table 5.5 (Origin & Destination End)) (-2.5%).

Furnessing SRM07 Matrices with SRM12 Trip Ends

5.2.27 A Furnessing process was applied to ensure SRM12 matrix totals by user class matched the overall anticipated change in Trip ends described in Table 12.

5.2.28 Within the public transport matrix processing, a specific trip end adjustment was also undertaken to allow for the impact of the re-opening of the Airdrie to Bathgate railway to be represented within the 2012 base year movements.

5.2.29 This process used a CSTM12 2012 base year select link to identify trip movements using the Airdrie to Bathgate line, which were then incorporated into the external zone associated with this line. A similar adjustment was undertaken to other Edinburgh to Glasgow rail lines to account for the potential change to travel patterns along these lines following the delivery of the scheme.

Matrix, Trip Rate & Network Comparison & Adjustment

5.2.30 Following the production of initial SRM 2012 matrices, travel productions and attractions were cross checked against household and employment data to generate a set of trip rates. These trip rates were reviewed to identify and refine anomalies. The initial matrix was also assigned to the SRM12 network to identify areas for refinement.

5.2.31 In order to improve the accuracy of the matrices, the following adjustments were made:

- **Unreasonably high/low trip rates:** Zones which displayed unusually high or low trip rates in comparison with the level of residential, population or employment / retail activity etc were adjusted to fall within a general trip rate band. The trip rate band was prepared by comparing trips rates for zones which appeared to display reasonable trip rate characteristics;

- **Edinburgh Park / Gyle proportioning:** Planning data comparisons and local knowledge of the Edinburgh Park, Gyle & Hermiston Gait areas suggested that the number and type of trips using these zones (in certain time periods / directions) appeared counter intuitive. A new traffic count capturing movements to/from Hermiston Gait also suggested some refinement was required. Therefore, the number of origin and destination trips for each travel purpose in each specific time period was modified to better match the nature of activity associated with each zone. Zones were constrained with the exception of uplifting traffic volumes accessing Hermiston Gait to better match observed data collected at this location;

- **Royal Bank of Scotland (RBS):** Initially modelled traffic levels to/from the RBS site at the A8 were compared and found to fall outwith a reasonable tolerance indicated by observed data collected at the RBS access points. Therefore, travel movements to/from the RBS zone at the A8 were uplifted to better match these observations;

- **Recent development:** Matrices were adjusted to reflect the recent completion of developments or demolitions in specific zones. This included transferring the jobs and movements associated with Queen Margaret University (previously located at Corstorphine) to the A1 (where the University is now located) ;

- **Edinburgh airport freight trips:** Two zones are used to represent Edinburgh Airport within the SRM12: the main zone for accessing the passenger terminal building, and a zone further to the north east to represent delivery / freight access (whereas one general zone was used within the previous modelling). To improve the representation of airport freight traffic, it was assumed that 75% of freight trips (HGV's and LGV's) would use the delivery zone, along with a small proportion of business, commuter and other trips; and

- **Edinburgh Airport travel purpose proportions:** The proportion of some airport travel purpose movements (in some directions) appeared counter intuitive. Adjustments were made to the proportion of business, commute and other trips so that the proportions matched those established in CSTM12 (and to ensure the commuter proportions reflected the actual level of employment at the airport site (rather than a commuter travelling via the airport for business purposes). The total level of travel across all purposes remained fixed at SRM12 levels.

5.3 Census Travel to Work Comparison & Adjustment

5.3.1 At the time of matrix development, the 2011 Census Travel to Work pattern data was only available at Local Authority level. This data was used to compare with the initial SRM12 road and public transport morning peak hour matrices, to identify if any refinements would be beneficial at the Local Authority level.

5.3.2 The SRM12 AM Peak commuter matrices were sectored to convert them into Local Authority to Local Authority (LA-LA) matrices. Comparison with the equivalent LA-LA 2011 Census Travel to Work matrices indicated that the SRM12 contained a higher proportion of car trips traveling within each of the SESPlan Local Authorities, and a lower proportion of car commuters travelling between Local Authorities. The comparisons also revealed the SRM12 contained a higher proportion of public transport trips to/from Edinburgh. As a result of these comparisons, the SRM12 commuter matrices were adjusted to match the overall 2011 Census LA-LA travel proportions.

5.3.3 Census LA-LA proportions were calculated for car and public transport. For the AM time period, the 2011 Census proportions were applied. For the Inter-Peak, factors of 0.5 were applied to the Census Local Authority to Local Authority matrix and also to its transpose, and these matrices combined (to reflect the assumption that 50% of trips in the Inter-Peak were From-Home to work and 50% from work To-Home). For the PM peak, the transpose of the Census matrix was used.

5.3.4 The SRM12 matrices were then factored, with one factor for each LA-LA movement (by time period and mode) so that the proportion of Non-Work Commute trips between each Local Authority was consistent as indicated within the 2011 Census.

5.3.5 The Census commuter movement comparisons and adjustments are described within Tables 13 to 16 for car drivers and Tables 17 to 20 for public transport passengers. Census road patterns represent 'Car Drivers', including 'no-fixed' workplace respondents. Census public transport patterns represent rail and bus passengers, and also include 'no-fixed' workplace respondents.

Table 13. 2011 Census TTW Car Driver Proportions for SESPlan LA-LA Movements

LA	EDINBURGH	EAST LOTHIAN	MID LOTHIAN	WEST LOTHIAN	FIFE	BORDERS
Edinburgh	79.6%	3.9%	5.5%	6.8%	3.5%	0.7%
East Lothian	45.2%	43.4%	7.7%	1.9%	0.6%	1.2%
Mid Lothian	53.0%	5.7%	35.4%	3.4%	1.1%	1.5%
West Lothian	29.5%	0.6%	1.5%	66.1%	2.2%	0.1%
Fife	10.0%	0.2%	0.4%	2.1%	87.3%	0.0%
Borders	13.0%	2.8%	3.7%	0.7%	0.3%	79.5%

Table 14. SRM12 Initial Road Car Commuter Proportions for SESPlan LA-LA Movements

LA	EDINBURGH	EAST LOTHIAN	MID LOTHIAN	WEST LOTHIAN	FIFE	BORDERS
Edinburgh	85.2%	2.2%	4.4%	5.4%	1.9%	0.9%
East Lothian	40.8%	49.8%	6.4%	1.4%	0.3%	1.2%
Mid Lothian	48.0%	3.6%	42.2%	3.9%	0.7%	1.6%
West Lothian	28.2%	0.2%	1.3%	67.6%	2.5%	0.1%
Fife	6.1%	0.0%	0.4%	2.1%	91.3%	0.0%
Borders	10.3%	4.1%	2.7%	0.5%	0.3%	82.1%

Table 15. Change in SRM12 Initial Road Car Commuter Proportions Compared to 2011 Census

LA	EDINBURGH	EAST LOTHIAN	MID LOTHIAN	WEST LOTHIAN	FIFE	BORDERS
Edinburgh	5.6%	-1.7%	-1.1%	-1.4%	-1.6%	0.3%
East Lothian	-4.4%	6.4%	-1.3%	-0.5%	-0.3%	0.0%
Mid Lothian	-5.0%	-2.1%	6.9%	0.4%	-0.3%	0.1%
West Lothian	-1.4%	-0.3%	-0.2%	1.5%	0.3%	0.0%
Fife	-3.9%	-0.1%	0.0%	0.0%	4.0%	0.0%
Borders	-2.6%	1.3%	-1.1%	-0.2%	0.1%	2.5%

Table 16. Change in Car Commuter Proportions Compared to 2011 Census Post Adjustment

LA	EDINBURGH	EAST LOTHIAN	MID LOTHIAN	WEST LOTHIAN	FIFE	BORDERS
Edinburgh	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
East Lothian	0.0%	-0.9%	0.8%	0.0%	0.0%	0.0%
Mid Lothian	-0.4%	-0.3%	0.7%	0.0%	0.0%	0.0%
West Lothian	-0.6%	0.0%	0.0%	0.7%	-0.1%	0.0%
Fife	0.2%	0.0%	0.0%	-0.1%	-0.1%	0.0%
Borders	-0.8%	-0.4%	1.5%	0.0%	0.0%	-0.2%

Table 17. 2011 Census TTW PT Commuter Proportions for SESPlan LA-LA Movements

LA	EDINBURGH	EAST LOTHIAN	MID LOTHIAN	WEST LOTHIAN	FIFE	BORDERS
Edinburgh	94.9%	1.9%	1.6%	0.8%	0.6%	0.1%
East Lothian	78.0%	19.6%	1.9%	0.2%	0.2%	0.0%
Mid Lothian	77.8%	1.3%	20.5%	0.2%	0.1%	0.2%
West Lothian	54.6%	0.4%	0.2%	44.7%	0.1%	0.0%
Fife	37.1%	0.2%	0.1%	0.2%	62.4%	0.0%
Borders	25.3%	0.8%	2.5%	0.5%	0.2%	70.7%

Table 18. SRM12 Initial PT Commuter Proportions for SESPlan LA-LA Movements

LA	EDINBURGH	EAST LOTHIAN	MID LOTHIAN	WEST LOTHIAN	FIFE	BORDERS
Edinburgh	95.6%	0.5%	1.9%	1.3%	0.6%	0.1%
East Lothian	77.7%	17.9%	1.6%	1.4%	1.1%	0.2%
Mid Lothian	77.2%	1.4%	21.0%	0.2%	0.1%	0.2%
West Lothian	65.0%	0.2%	0.1%	34.3%	0.4%	0.0%
Fife	47.6%	0.0%	0.0%	0.3%	52.0%	0.0%
Borders	43.1%	0.5%	1.7%	0.4%	0.0%	54.3%

Table 19. Change in SRM12 Initial PT Commuter Proportions Compared to 2011 Census

LA	EDINBURGH	EAST LOTHIAN	MID LOTHIAN	WEST LOTHIAN	FIFE	BORDERS
Edinburgh	0.6%	-1.4%	0.3%	0.4%	0.0%	0.0%
East Lothian	-0.3%	-1.7%	-0.3%	1.2%	1.0%	0.1%
Mid Lothian	-0.6%	0.1%	0.5%	0.0%	0.0%	0.0%
West Lothian	10.4%	-0.1%	0.0%	-10.4%	0.2%	0.0%
Fife	10.5%	-0.2%	0.0%	0.2%	-10.4%	0.0%
Borders	17.9%	-0.3%	-0.9%	-0.1%	-0.2%	-16.3%

Table 20. Change in PT Commuter Proportions Compared to 2011 Census Post Adjustment

LA	EDINBURGH	EAST LOTHIAN	MID LOTHIAN	WEST LOTHIAN	FIFE	BORDERS
Edinburgh	0.3%	0.0%	0.0%	-0.4%	0.0%	0.0%
East Lothian	0.0%	0.2%	0.0%	-0.2%	-0.1%	0.0%
Mid Lothian	0.3%	0.0%	-0.3%	0.0%	0.0%	0.0%
West Lothian	-3.7%	0.0%	0.0%	3.6%	0.0%	0.0%
Fife	-1.4%	0.0%	0.0%	-0.1%	1.5%	0.0%
Borders	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

5.4 Park and Ride Trip Movements

5.4.1 A review of the Park and Ride sites currently included within the SRM07 base year and forecast year models and also CSTM12 was carried out to identify sites to be included in the SRM12 2012 base year model. The relevant rail and bus based Park & Ride sites are listed in Table 21.

Data

5.4.2 Park and Ride data for rail station car parks was originally extracted from the National Rail Travel Survey. The data was processed to generate site catchment areas, car park occupancies and origin-to-destination end-to-end trip movements for each Park and Ride site.

5.4.3 Bus based Park and Ride movements were generated from OD surveys undertaken at specific sites and recent data sets provided by Edinburgh City Council.

5.4.4 Car park capacities (number of spaces available), parking charges and many occupancies were extracted from CSTM12 (which was developed to represent 2012 based Park and Ride operations). These data sets were based on:

- ScotRail Website;
- ScotRail car park counts (2013);
- ScotRail car park audit (2012);
- SEStran parking strategy (2008);
- TMfS07 calibration (2007);
- NRTS; and
- City of Edinburgh Council (2011-2012)

5.4.5 Note that due to the (at times) contradictory nature of these counts, a certain amount of local knowledge was employed to choose the site usage that was most reflective of 2012 conditions. These sources also provided formal capacity (although not necessarily using the same source as that chosen for site usage).

5.4.6 The City of Edinburgh Council provided car park occupancy counts for three bus based Park and Ride sites, including Ingliston, Hermiston Gait and Straiton, along with data for the site at Sheriffhall operated by Midlothian Council.

5.4.7 The data represented the period from 2005 to 2014. Parking occupancy data for neutral months covering 2011 and 2012 (Mondays – Thursdays only) was used to calculate the average occupancy of these sites. Observed occupancy data for other park and ride sites were extracted from the CSTM12 Park and Ride calibration comparisons.

5.4.8 The City of Edinburgh Council also provided park and ride passenger origin and destination survey data representing August 2011 for the Hermiston, Ingliston and Straiton sites. This data was processed to generate site catchments and end-to-end OD trips for each site.

5.4.9 As passenger movement data was not available for Sheriffhall, trip movements for this site were synthesised based on the level of zonal population within the catchment area. A similar methodology was also applied to generate travel movement data for the recently opened site at Kinross. Occupancy data at Kinross was also unavailable, so this was estimated, with 50 cars assumed to park within the morning period.

Matrices

5.4.10 The Park and Ride matrices have been developed in two stages, firstly establishing a pattern for each site and then identifying the level of travel for each matrix.

5.4.11 Park and ride demands are initially prepared using full end to end OD trip movements. The demand model is then used to generate road movements to and PT movements from park & ride sites, based on catchment areas and travel costs, and are calibrated to reflect observed parking occupancy data.

5.4.12 In processing the data sources, only from-home trips have been considered for the Park and Ride process and were identified by purpose and time period where data was available. Where data was unavailable, assumptions based on global datasets were applied to segregate by travel purpose. These are applied to 11 sites where trips were distributed using a Gravity Model (Addiewell, Alloa, Armadale, Blackridge, Cardenden, Falkirk, Kincardine, Wester Hailes, Springkerse, Sheriffhall and Kinross) using the following purpose split factors:

- AM_HE = 0.039029, AM_HW = 0.808260, AM_HO = 0.152711
- IP_HE = 0.106217, IP_HW = 0.042319, IP_HO = 0.851464

5.4.13 As travel patterns were not available for these sites, matrices for these were developed using a gravity model (using public transport generalised costs) with trip ends provided by planning data and trip rates. Population and jobs based trip ends were masked to the origin/destination catchments of each P&R site, and then distributed using a gravity model, with site demand split into purposes via the process described above (i.e. global factors).

5.4.14 The origin/destinations for each site were scaled to match observed totals on an individual site basis and thus the full end to end matrix has been developed to match observed totals.

5.4.15 The SRM12 does not contain an Inter peak Park & Ride model. The PM peak park and ride model is essentially a reversal of the AM peak modelling.

Table 21. SRM12 Park and Ride Sites

BUS & RAIL BASED PARK AND RIDE SITES		
Aberdour	Edinburgh Waverley	Livingston South
Addiewell	Falkirk (Carmuirs)	Lochgelly
Alloa	Falkirk Grahamstown	Longniddry
Armadale	Falkirk High	Markinch
Bathgate	Fauldhouse	Musselburgh
Blackridge	Ferrytoll	Newcraighall
Breich	Gleneagles	North Berwick
Bridge of Allan	Glenrothes with Thornton	North Queensferry
Brunstane	Haymarket	Polmont
Burntisland	Hermiston	Prestonpans
Camelon	Ingliston	Rosyth
Cardenden	Inverkeithing	Sheriffhall
Cowdenbeath	Kincardine	Slateford
Cupar	Kinghorn	South Gyle
Curriehill	Kingsknowe	Springfield
Dalgety Bay	Kirkcaldy	Springkerse
Dalmeny	Kirknewton	Stirling
Drem	Ladybank	Straiton
Dunbar	Larbert	Uphall
Dunblane	Leuchars	Wallyford
Dunfermline Queen Margaret	Linlithgow	West Calder
Dunfermline Town	Livingston North	Wester Hailes
Edinburgh Park	Kinross	

5.5 Matrix Totals

5.5.1 The SRM12 2012 'prior' (to matrix estimation) matrix totals prepared for the road assignment model are described in Table 22. The final SRM12 2012 public transport assignment matrices are described in Table 23.

Table 22. Road Assignment 'Prior' Matrix totals (PCUs per hour)

USER CLASS	AM PEAK	INTER PEAK	PM PEAK
In-Work	10,021	6,776	9,872
Non-Work Commute	75,224	16,435	68,934
Non-Work Other	41,426	69,501	82,449
Light Goods	14,922	13,661	12,095
Heavy Goods	27,546	26,917	23,026
Total	**169,139**	**133,290**	**196,376**

Table 23. Public Transport Matrix totals (passengers per hour)

USER CLASS	AM PEAK	INTER PEAK	PM PEAK
In-Work	2,798	1,746	2,447
Non-Work Commute	28,681	5,717	25,649
Non-Work Other	22,723	23,275	20,625
Total	**54,202**	**30,738**	**48,721**

5.5.2 The public transport matrix remains consistent throughout the remainder of model development as no further calibration is undertaken in terms of public transport movements.

6. ROAD MODEL CALIBRATION

6.1 Approach

6.1.1 Calibration and Validation of the SRM12 Road model makes use of a variety of data to undergo a process of, firstly, attempting to achieve a 'best fit' against observed data and then, secondly, validating the robustness of the model against other independent observed data. The SRM12 road model calibration process included the following steps:

- Collation of traffic count data;
- Formation of traffic count screenlines;
- Matrix Estimation (based on the 'Prior matrices');
- Iterations of model refinement; and
- Calibration analysis.

6.1.2 The model calibration approach uses groups of traffic counts to form screenlines, which are used to compare modelled traffic volumes. Initial comparisons are based on the Prior road model matrices (described within Chapter 5), which are used as a starting point for matrix calibration. Using an iterative process, the screenline comparisons are then used to review and refine the model network and matrices, and subsequently undertake matrix estimation to adjust traffic movements to better match observed traffic volumes.

6.1.3 The calibration is compared in terms of overall matrix adjustments, trip distribution analysis and screenline flow comparisons.

6.1.4 These steps and resultant calibration analysis are described within the following sections.

6.2 Collation of Traffic Data

6.2.1 A variety of observed traffic count data sources were collated to inform the calibration and validation processes, including:

- The Scottish Roads Traffic Database (SRTDb) – year 2012, collated for neutral months excluding major holiday periods (i.e. including March, May, June, Sept, Oct and Nov) to form average weekday period data;

- Traffic counts collated by CH2M Hill – covering years 2012/2013/2014, average weekday period data (including counts at Newbridge, 03/12/2013). Covering mostly Spring (April) or November periods;

- Traffic counts collated by Jacobs – years 1998–2014, assumed neutral month, average weekday period data;

- Automatic Traffic Counter (ATC) data collected for Midlothian Council – year 2011, assumed neutral month, average weekday hourly data;

- Hermiston Gait traffic counts collected for Transport Scotland (these camera surveys were required as it is a key area of the model and no existing traffic counts were available) – undertaken from 23rd to 27th June 2014, 00:00-2400; and

- Other miscellaneous traffic data (including radar surveys) collected for various local authorities – years 2005-2014, assumed neutral month, average weekday period/hour data.

6.2.2 Average AM peak hour, Inter peak and PM peak hour traffic count data was derived from each of these data sources.

6.2.3 Note that it is not possible to determine the specific date for a number of surveys to understand the 'neutrality' of all data. Where data was processed specifically for SRM12 development, data for neutral months were used, which excluded holiday periods. For other data sets highlighted above, it is assumed that the counts were undertaken outwith the main holiday periods.

6.2.4 Due to the size and nature of a regional model, there can be a significant variation in availability and quality of data for use in the calibration and validation processes. In order to achieve a degree of consistency in the data available, a factoring process was undertaken to make the data representative of a common base year of 2012.

6.2.5 The factoring process was based on the year-to-year change in Scottish Vehicle Kilometres as recorded in the Scottish Transport Statistics 2013 (Total Veh Kms across 'All Roads'). Note that as this approach applies a generic change in traffic volumes across all data recorded, the 2012 common base data set may not reflect the impact of local changes in specific areas. All traffic counts recorded between 2012 and 2014 were assumed to reflect 2012 traffic levels.

6.2.6 No factoring was applied to account for seasonal variations, as the model design aims to represent average conditions across the neutral months where data is collated. The limited data confirming survey dates creates some uncertainty surrounding the consistency of traffic count comparison data across the modelled coverage. This and the use of 'global' factors to scale up older traffic data suggests that there is a general uncertainty surrounding traffic counts at the local level, but is unlikely to be significant across the model as a whole.

6.2.7 There are few instances of where major new roads have been delivered (by the 2012 model base year) which would significantly impact traffic routing. The Dalkeith Northern bypass was delivered between the previous model base of 2007 and the current base year (opening in 2008), but the traffic counts used in this area were collected during 2011-2012, so would be representative of current conditions. Therefore, uncertainty is likely to be mostly relating to the level of traffic volumes located close to areas of new development, where older traffic counts (combined with a general scaling factor) may not reflect the level of growth occurring within the local area.

6.3 Traffic Count Screenlines

6.3.1 The collated observed traffic counts are combined to form groups of Screenlines, (and also single data points where appropriate) to compare with modelled traffic volumes.

6.3.2 A total of 37 screenlines and an additional 29 single calibration points were developed to inform the calibration comparisons and undertake matrix estimation. These screenlines were chosen to represent the major movements across the key network corridors. The screenlines contains between two and nine traffic counts, depending on location and proximity to other screenlines. A total of 66 individual traffic count data points are used to form all screenlines.

6.3.3 A further set of screenlines were developed using data that was not used within the calibration analysis to inform the road model validation comparisons.

6.3.4 The individual traffic count locations used to generate the calibration screenlines are illustrated in Figure 9. Calibration screenlines and individual calibration points are illustrated in Figures 10 and 11. The location description and direction of travel for all screenlines are described in Table 24.

Table 24. Calibration Screenline Location Descriptions

SCREENLINE NAME AND NO.	LOCATION
1. West_Outer_EB 1. West_Outer_WB	M8 West of Hermiston Gait A8 West of Gogar A71 Riccarton A70 Juniper Green
2. South_Outer_NB 2. South_Outer_SB	B702 at Straiton A701 Straiton Rd A702 South of City Bypass
3. SEast_Outer_NB 3. SEast_Outer_SB	A68 South of Sheriffhall A68 Dalkeith Bypass North A7 North of Gilmerton Road A772 near A720 Lasswade Road near A720
4. East_Outer_WB 4. East_Outer_EB	Mall Ave Bridge Street A1 River Esk
5. East_Outer_WB 5. East_Outer_EB	A1 Gladsmuir to Haddington B1377 Longniddry A6093
6. SEast_External_IN 6. SEast_External_OUT	A6088 West of Carter Bar A68 Huntford
7. NW_External_IN 7. NW_External_OUT	A84 at Ochtertyre Road M9 South of Keir Roundabout B823 Cornton Road (South of A9)
8. M80_External_IN	A803 West of M80

SCREENLINE NAME AND NO.	LOCATION
8. M80_External_OUT	M80 West of J6a Castlecary B816 Castlecary Road
9. Midlothian_OUT 9. Midlothian_IN	A702 North of Silverburn A766 Calops Road A6094 at Leadburn A701 Springfield Farm
10. Midlothian_OUT 10. Midlothian_IN	A68 East of Fala Tunnel A7 North Middleton B6367 South of Tynehead
11. S of Galashiels _NB 11. S of Galashiels _SB	A7 Ashkirk A68 Harrietsfield North of B6400
12. NorthBerwick_SB 12. NorthBerwick_NB	A198 Dirleton Ave B1347 Haddington Rd
13. M8_Corridor_EB 13. M8_Corridor_WB	A89 East of Boghall Roundabout M8 East of J3a A779 East of Starlaw West Roundabout A71 at Polbeth B7015 North of Polbeth A705 at Seafield
14. M9_Corridor_EB 14. M9_Corridor_WB	A904 East of Old Philipstoun (M9 Jct 2) M9 East of J3 B9080 West of the B8046
15. Fife_Corridor_SB 15. Fife_Corridor_NB	M90 South of A912 at Glenfarg A92 North of Glenrothes A91 Burnside A915 West of Lundin Links A916 North of the B927 B996 South of Calford Brae B934 North of A823/ B934 Junction A823 North of A823/ B934 Junction A9 Blackford
16. Newbridge_Corridor_EB 16. Newbridge_Corridor_WB	A89 West of Newbridge M8 West of M9 Junction B7030 Southwest of Newbridge
17. Livingston_Corridor_EB	A899 East of Galloway Crescent

SCREENLINE NAME AND NO.	LOCATION
17. Livingston_Corridor_WB	A89 West of Station Road M8 West of Claylands A71 at Calder B7015 West of the B8046 B8046 Pumpherston Road (South of Millbrae)
18. Bypass_Loth_Stra_EB 18. Bypass_Loth_Stra_WB	B701 Frogston Road A720 East of Lothianburn
19. Bypass_Las-Gilm_EB 19. Bypass_Las-Gilm_WB	A720 West of Gilmerton A768 at Lasswade
20. West_Inner_EB 20. West_Inner_WB	A8 between Gogar and Maybury South Gyle Broadway at Shopping Centre Hermiston Gait Access A71 East of Calder Roundabout
21. South_Inner_NB 21. South_Inner_SB	A701 North of A720 Straiton Junction B701 North of A720 Dreghorn junction A702 North of A720 Lothianburn junction
22. SEast_Inner_NB 22. SEast_Inner_SB	Lasswade Road North of A720 Lasswade Junction A772 North of A720 Gilmerton Junction A7 at Sheriffhall P&R A6106 Millerhill Rd North of Sheriffhall
23. Edinburgh_West_EB 23. Edinburgh_West_WB	A90 East of Barnton Junction A8 West of Balgreen Road Stevenston Drive West of Balgreen Road A71 West of Stevenson Road / Hutchison Crossway A70 between Moat Terrace & Moat Street Colinton Road West of Polwarth Terrace
24. Edinburgh_East_WB 24. Edinburgh_East_EB	A6095 West of A6106 A1 West of A6106 Duddingston Road West of A6106
25. Edinburgh_South_NB 25. Edinburgh_South_SB	A702 South of Colinton Road Blackford Avenue at Mortonhall Road Mayfield Road West of West Mains Road A701 Craigmillar Park North of Lady Road A7 Dalkeith Road South of Holyrood Park Road
26. Edin_CityCentre_NB_IN	

SCREENLINE NAME AND NO.	LOCATION
26. Edin_CityCentre_SB_OUT	George IV Bridge between Victoria Street & Chambers Street St Marys Street South of Canongate A7 South Bridge Western Approach Road at Lothian Road A700 Lothian Road North of Morrison Street / Bread Street Shandwick Place West of Queensferry Street / Princes Street
27. Edin_CityCentre_SB_IN 27. Edin_CityCentre_NB_OUT	Queen Street West of North Charlotte Street A900 Leith Walk West of London Road East London Street West of Annandale Street Dundas Street North of Great King Street Kerr Street Southeast of Hamilton Place Bellevue North of London Street Waterloo Place West of Princes Street
28. Edinburgh_NWest_SB 28. Edinburgh_NWest_NB	Pilton Drive North Crewe Road North Pennywell Road B9085 Ferry Road West of Pennywell Rd A902 Telford Road West of Groathill Rd A90 Queensferry Road West of Craigleith Road Ravelston Dykes West
29. Edinburgh_NEest_WB 29. Edinburgh_NEest_EB	A903 Granton Road South of Wardie Crescent A901 Lower Granton Road West of Trinity Road Craighall Road South of Granton Road A902 Ferry Road West of Craighall Road B900 Broughton Road West of Newhaven Road / Pilrig Street A900 Leith Walk West of Pilrig Street
30. Bridges_NB 30. Bridges_SB	A876 East of Bowtrees Junction A90 Echline North - main carriageway A90 Echline North - on slip
31. West Dunfermline_WB 31. West Dunfermline_EB	A823 North of Dunfermline A907 West of Dunfermline A994 West of Dunfermline A985 West of Waggon Road
32. East Fife_EB 32. East Fife_WB	B981 East of Cowdenbeath B925 Auchtertool A909 South of Kelty

SCREENLINE NAME AND NO.	LOCATION
	A92 Cowdenbeath to Lochgelly B9157 East of A909 / B9157 Junction A921 South of Kirkcaldy
33. Midlothian_Additional_IN 33. Midlothian_Additional_OUT	A702 South of Hillend A701 South of A768 Polton Road South of Polton Polton Street at Moorfoot View B6392 East of Cockpen Road B703 Newbattle Road South of Eskbank
34. M9/A905_SB 34. M9/A905_NB	A905 Howkerse to A88 M9 South of Junction 7
35. South of Falkirk_WB 35. South of Falkirk_EB	M9 Between Junction 4 and 5 A803 Main Street East of Bo'ness Road B805 Redding Road South of Grange Place B8028 South of Falkirk Road B803 Southwest of Lionthorn Road
36. Edinburgh_East_EB 36. Edinburgh_East_WB	Salamander Street at Seafield Road Restalrig Road at Claremont Park Claremont Park at Restalrig Road Lochend Road North of Hawkhill Avenue London Road at Montrose Terrace Queen's Drive East of Horsewynd
37. M80/A872_SB 37. M80/A872_NB	M80 South of Stirling A872 between Dunipace and A872 / A91 Roundabout
38. Bypass_Dal-OldC_NB 38. Bypass_Dal-OldC_SB	A720 West of Old Craighall
39. A1_EastLinton_WB 39. A1_EastLinton_EB	A1 at River Tyne
40. M8_External_IN 40. M8_External_OUT	M8 between Harthill Services and Junction 4
41. B818_External_IN 41. B818_External_OUT	B818 between Darroch Drive and Kirkland Drive

SCREENLINE NAME AND NO.	LOCATION
42. A90_Outer_SB 42. A90_Outer_NB	A90 West of Barnton
43. A7_External_IN 43. A7_External_OUT	A7 South of Teviothead
44. A698_External_IN 44. A698_External_OUT	A698 at Coldstream
45. A1_External_IN 45. A1_External_OUT	A1 at Burnmouth
46. Perth_External_OUT 46. Perth_External_IN	M90 at Friarton Bridge
47. Dundee_External_IN 47. Dundee_External_OUT	A92 Tay Bridge approach
48. Bypass_Cal-Bab_EB 48. Bypass_Cal-Bab_WB	A720 West of Baberton Junction
49. Bypass_Bab-Dreg_EB 49. Bypass_Bab-Dreg_WB	A720 West of Dreghorn Junction
50. Bypass_Dreg-Loth_EB 50.Bypass_Dreg-Loth_WB	A720 West of Lothianburn Junction
51. Misc cal points	M9 Spur West of Scotstoun
52. Misc cal points	A904 West of A90
53. Misc cal points	B924 Boness Road
54. Misc cal points	A907 West of A977
55. Misc cal points	A68 at Lauder
56. Misc cal points	A92 Thornton Bypass

SCREENLINE NAME AND NO.	LOCATION
57. Misc cal points	M90 North of Junction 2
58. Misc cal points	A899 Livingston Road South of M9 Junction 3
59. Misc cal points	A823 South of A907
60. Misc cal points	A89 West of A800
61. Misc cal points	A921 East of M90 Junction 1
62. Misc cal points	M9 South of Junction 1
63. Misc cal points	B800 Between South Queensferry and Kirkliston
64. Misc cal points	Crewe Road South at Ferry Road
65. Misc cal points	A91 West of B908
66. Misc cal points	Eastfield Road

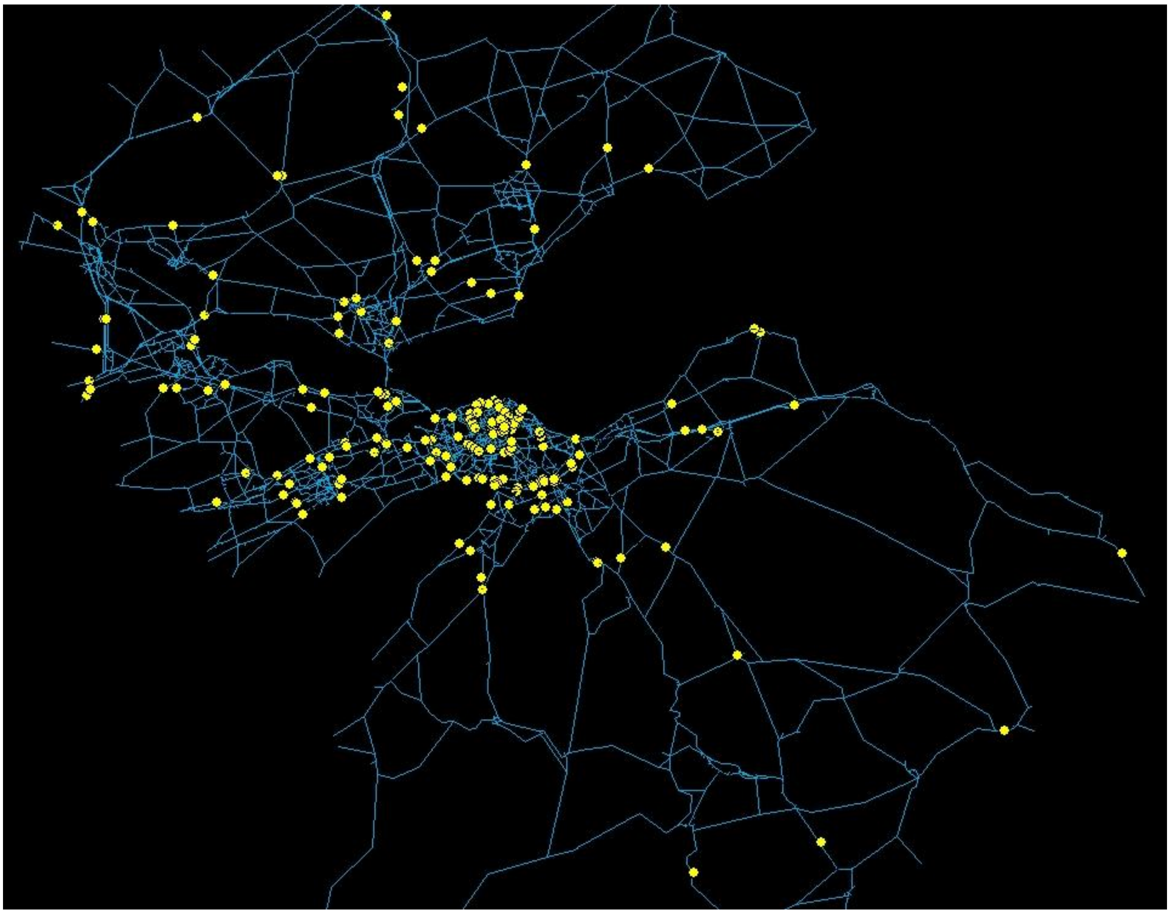

Figure 9. Individual Traffic Count Calibration Locations

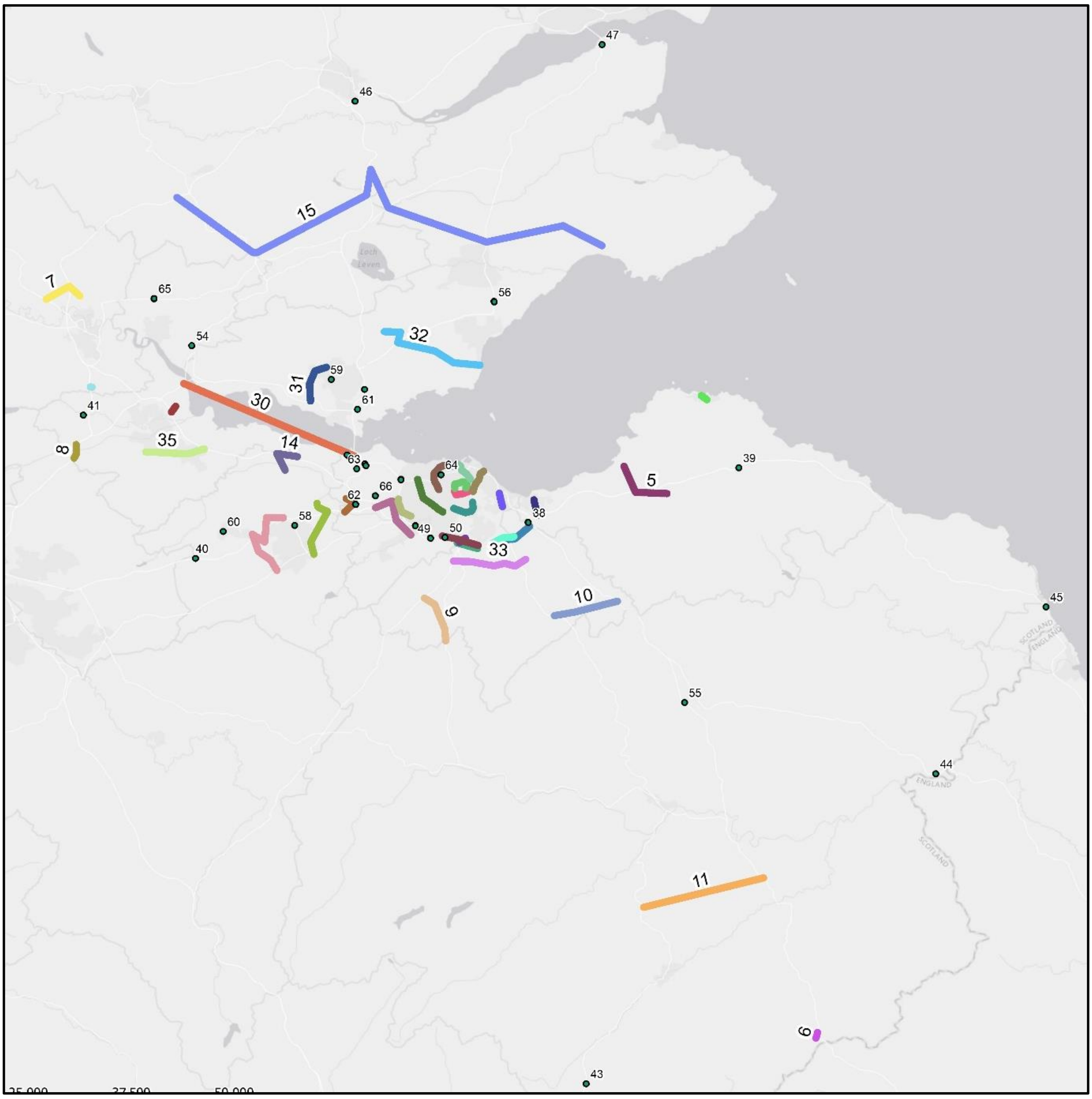

Figure 10. Road Model Calibration Screenline Locations: South East

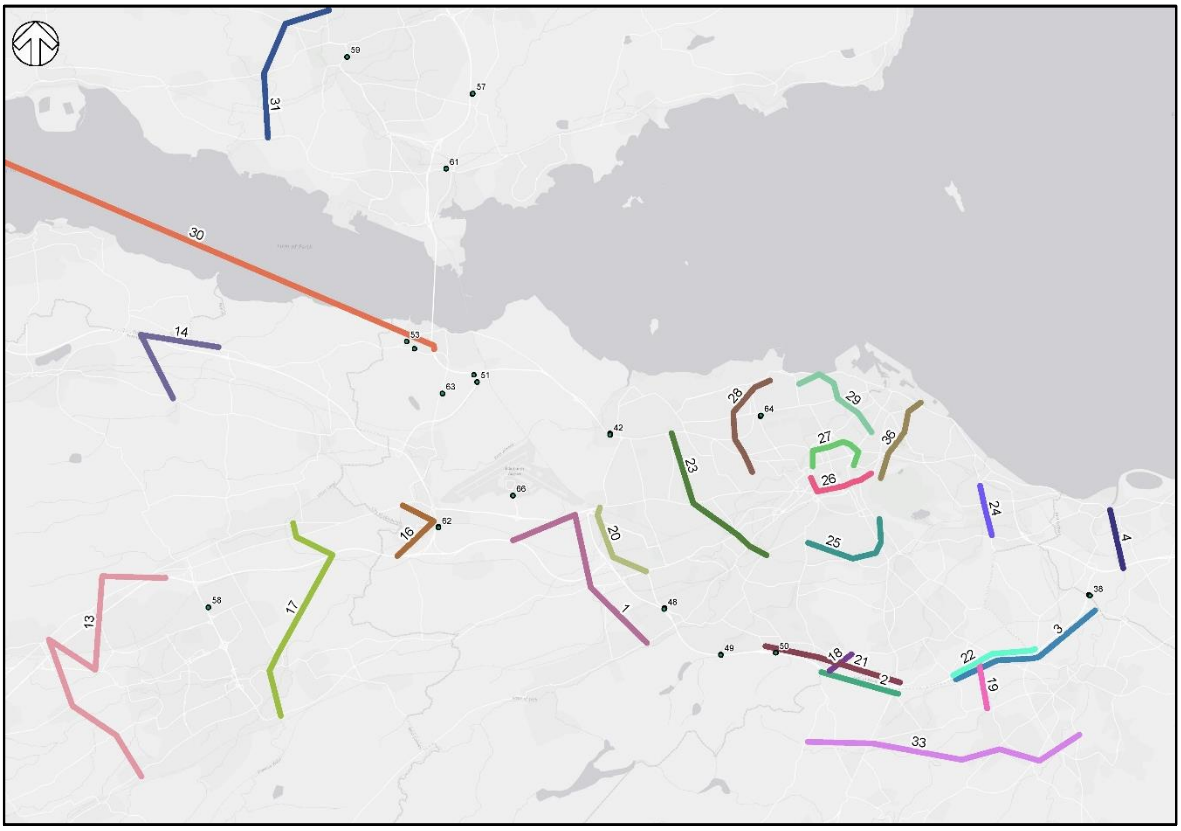

Figure 11. Road Model Calibration Screenline Locations: Edinburgh

6.4 Matrix Estimation

6.4.1 The matrix estimation process is a mechanism employed in the creation of the base year matrices. The goal of the process is to modify the Prior trip matrices to better match a range of observed data.

6.4.2 Matrix estimation procedures were undertaken using the Saturn SATME2 and SATPIJA processes. The inputs were AM, Inter and PM peak hourly Prior matrices, and traffic count screenlines, with data sets separated by user class (cars (combined), LGV's and HGV's). Trip movements between Park and Ride sites, were kept constant during matrix estimation as these are controlled by another development process.

6.4.3 A Saturn road assignment was carried out using the base year road network containing screenline locations and the Prior demand matrix. To reach a balance between accuracy and runtime required, the procedure was configured to loop through six Matrix Estimation iterations, producing intermediate files after each iteration, with a final set of matrices at the end of the procedure.

6.4.4 The above procedure was carried out for all three time periods, over a number of iterations, with investigation and refinement of the road modelling undertaken to improve the comparison in specific areas and for specific purposes. The process was judged to be successful when comparisons between model outputs were favourable when compared to observed data sets and calibration criteria.

6.4.5 An early adjustment was to review the matrix composition / trip ends for the specific areas listed in section 5.2.31. Several adjustments were also made to the network, to improve capacity representation where the road model was deemed to be deficient. For example, for locations / corridors where early coding representation would clearly not allow the capacity for vehicle throughput to be realised (as indicated by the count data), this led to updates and refinements for some coding to better reflect junction / capacity arrangements.

6.4.6 Tables 25 to 27 describe the number of road travel movements and change in movements between the SRM12 Prior and newly post estimated matrix.

Table 25. Road Assignment 'Prior' Matrix totals (PCUs per hour)

USER CLASS	AM PEAK	INTER PEAK	PM PEAK
In-Work	10,021	6,776	9,872
Non-Work Commute	75,224	16,435	68,934
Non-Work Other	41,426	69,501	82,449
Light Goods	14,922	13,661	12,095
Heavy Goods	27,546	26,917	23,026
Total	**169,139**	**133,290**	**196,376**

Table 26. Road Assignment 'Post' Matrix totals (PCUs per hour)

USER CLASS	AM PEAK	INTER PEAK	PM PEAK
In-Work	11,504	7,760	10,842
Non-Work Commute	84,681	19,525	74,608
Non-Work Other	46,980	79,793	91,150
Light Goods	15,381	13,308	11,631
Heavy Goods	22,132	20,682	16,290
Total	**180,678**	**141,068**	**204,521**

Table 27. Change (%) Between Prior & Post Estimation Road Assignment Matrices

USER CLASS	AM PEAK	INTER PEAK	PM PEAK
In-Work	15%	15%	10%
Non-Work Commute	13%	19%	8%
Non-Work Other	13%	15%	11%
Light Goods	3%	-3%	-4%
Heavy Goods	-20%	-23%	-29%
Total	**6.8%**	**5.8%**	**4.1%**

6.4.7 The rationale for the changes between the prior and estimated matrix are described below:

- The general increase in trip making reflects the more detailed road network and zone system incorporated within the SRM12, compared to the less detailed SRM07 model. The matrix estimation process has effectively infilled road movements using the new routes incorporated within the model; and

- The reduction in HGV movements and some LGV movements stem from the more detailed calibration process developed for the SRM12. Whereby the matrix estimation and screenline comparisons have been undertaken at a user class level, with specific calibration undertaken separately for cars, lights and heavies matrices (whereas the SRM07 model was calibrated to total PCU movements). Therefore, the estimation process has reduced freight movements where count data indicated this was required.

6.5 Calibration Comparisons

6.5.1 The level of road model calibration was compared using trip length distribution analysis and traffic count screenline comparisons. These analyses are discussed further below.

Trip Length Distribution Analysis

6.5.2 Trip length distribution is used in matrix estimation to understand the level of trips travelling at a range of distances across the modelled area. This analysis is used to ascertain whether the estimation process has had an effect on the overall distribution of trips and the distances travelled while attempting to match observed flows across the screenlines.

6.5.3 Figures 12-14 illustrate the Prior and Post estimation trip distributions for the AM , Inter and PM peak time periods respectively. The analysis shows a close match between the two sets of matrices, with the general increase in trips distributed over a range of trip distances. There is a general increase in relatively short distance trips, and also an increase in trips around the 20km distance within the PM Peak.

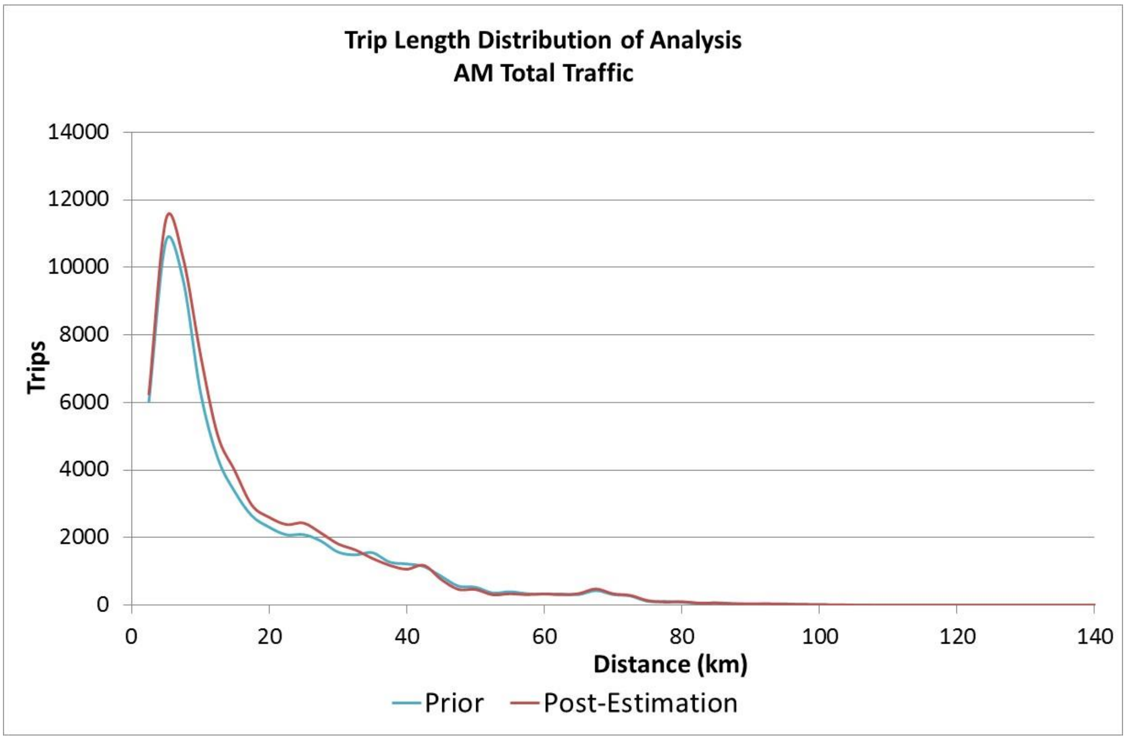

Figure 12. AM Trip Length Distribution for Prior and Post-Matrix Estimation

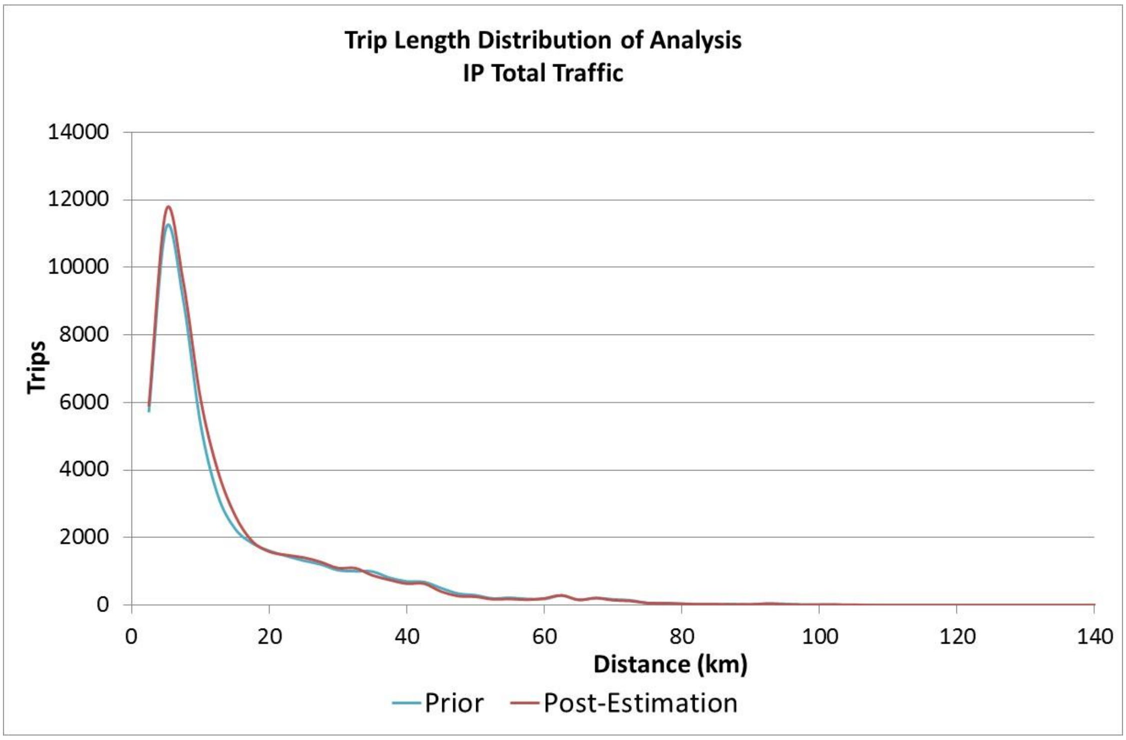

Figure 13. IP Trip Length Distribution for Prior and Post-Matrix Estimation

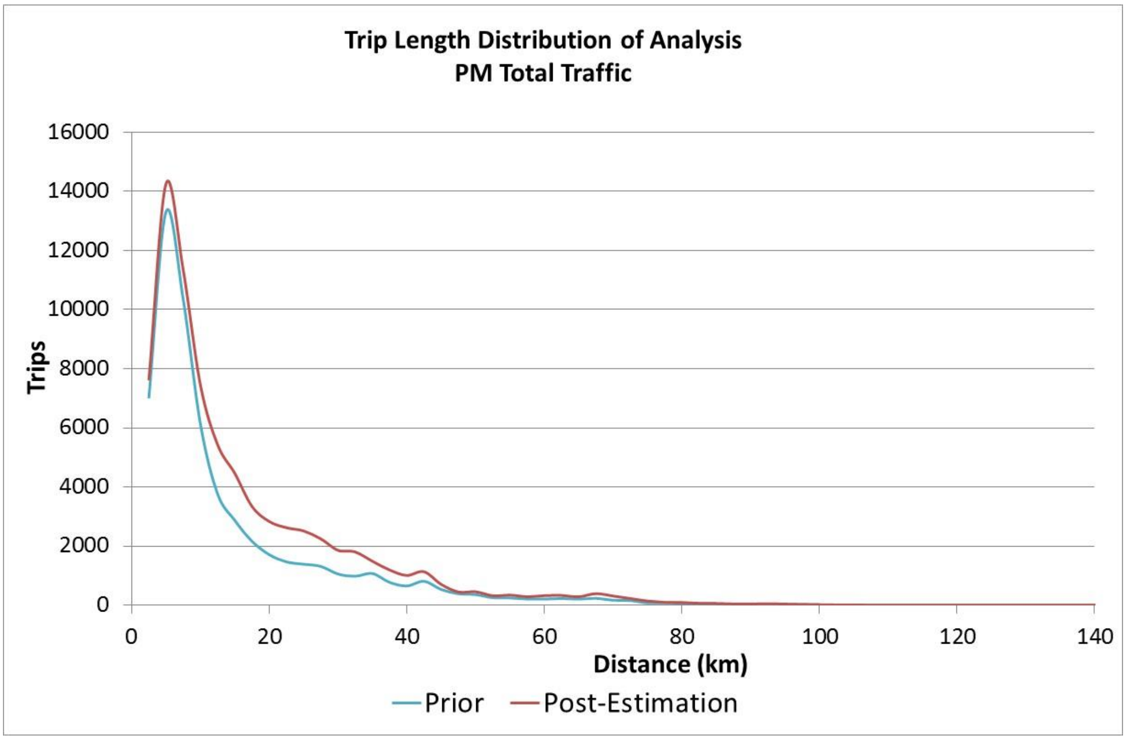

Figure 14. PM Trip Length Distribution for Prior and Post-Matrix Estimation

Traffic Count Screenline Analysis

6.5.4 Modelled traffic volumes for each time period were measured against 66 observed traffic count screenlines (including some single calibration points) and cross referenced using DMRB guidance. Two levels of screenline analysis were undertaken, the first comparing the total traffic flow across all screenlines, and the second comparing all individual data points included within the screenlines.

GEH Statistic

6.5.5 When comparing observed and modelled counts, focusing on either absolute differences or percentage differences alone can be misleading when there is a wide range of observed flows. For example, a difference of 50 vehicles is more significant on a link with an observed flow of 100 vehicles than on one with 1,000 vehicles, while a 10% discrepancy on an observed flow of 100 vehicles is less important than a 10% discrepancy on an observed flow of 1,000 vehicles.

6.5.6 To avoid these comparison difficulties, a standard summary statistic known as the GEH score is used. This statistic is designed to focus attention on significant absolute differences at low flows and significant percentage differences at high flows.

6.5.7 The GEH Statistic is defined as:

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

6.5.8 Where, *GEH* is the Statistic, *M* is the Modelled Flow and *C* is the Observed Count.

Total Screenline Calibration Criteria

6.5.9 DMRB guidance relating to total screenlines comparisons are as follows:

- Total screenline flows (normally > 5 links) to be within 5% for all (or nearly all) screenlines; and
- GEH Statistic: Screenline totals GEH < 4 for all (or nearly all) Screenlines.

6.5.10 Note that most DMRB guidance refers to comparisons based on vehicles, however, in the calibration and validation of the SRM12 model, PCUs are used for assignment and matrix estimation purposes. These flows have been converted to vehicles for comparison with DMRB criteria, and all traffic volumes are reported in vehicles for this section.

Screenline Total Traffic Flow Comparison

6.5.11 This section presents the results of the total screenline traffic flows based on the estimated matrix assignment, compared against total observed traffic counts. Table 28 provides a summary of the proportion of screenlines that fall within various percentage difference bands compared to the observed traffic count data for each time period. Table 29 describes the proportion of screenline comparisons that fall within the various GEH statistic bands.

Table 28. Summary of Total Screenline Traffic Flows Percentage Differences

% RANGES	AM PEAK TOTAL SCREENLINE	% OF TOTAL	INTER PEAK TOTAL SCREENLINE	% OF TOTAL	PM PEAK TOTAL SCREENLINE	% OF TOTAL
+/- 5%	63	85%	63	85%	60	81%
+/- 10%	72	97%	68	92%	66	89%
+/- 15%	74	100%	70	95%	72	97%
> +/-15 %	0	0%	4	5%	2	3%
Total	**74**	**100%**	**74**	**100%**	**74**	**100%**

Table 29. Summary of Total Screenline Traffic Flows GEH Statistic

GEH RANGES	AM PEAK TOTAL SCREENLINE	% OF TOTAL	INTER PEAK TOTAL SCREENLINE	% OF TOTAL	PM PEAK TOTAL SCREENLINE	% OF TOTAL
0 – 4	69	93%	67	91%	64	86%
4 – 7	4	6%	3	4%	6	9%
>7	1	1%	4	5%	4	5%
Total	**74**	**100%**	**74**	**100%**	**74**	**100%**

6.5.12 The total screenline percentage flow difference analysis demonstrates that 85% of total screenline comparisons fall within 5% of the total observed flow for the AM and Inter peak time periods, and 81% fall within 5% for the PM Peak time period.

6.5.13 The GEH statistical analysis indicates that over 86% of screenlines fall within a GEH of 4 across all time periods, rising to over 91% for the AM and inter peak time periods.

6.5.14 Overall, the total screenline traffic flow analysis demonstrates that the SRM12 road model provides an appropriate comparison with observed traffic data sets, with 'nearly all' screenlines falling within the relevant guidance ranges.

DMRB Individual Link Count Calibration

6.5.15 For individual link flow comparisons, DMRB criteria are as follows;

- Individual flows within 15% for flows 700 – 2,700 vph (>85% of cases);
- Individual flows within 100 vph for flows < 700 vph (>85% of all cases);
- Individual flows within 400 vph for flows > 2,700 vph (>85% of all cases); and
- Individual flows: GEH < 5 (>85% of all cases).

Screenline Individual Link Traffic Flow Comparison

6.5.16 Tables 30 and 31 summarise the individual link flow comparisons between the modelled and the observed flows, set against the individual link flow calibration criteria described above.

Table 30. Individual Link Flow Comparisons

FLOW RANGES	AM PEAK NO. OF LINKS	% WITHIN CRITERIA	INTER PEAK NO. LINKS	% WITHIN CRITERIA	PM PEAK NO. OF LINKS	% WITHIN CRITERIA
<700	234	93%	269	96%	216	90%
700 – 2,700	104	93%	93	99%	129	95%
>2,700	24	100%	0	NA	17	100%
Total	**362**		**362**		**362**	

Table 31. Summary of Individual Link Count GEH statistic

GEH RANGES	AM PEAK NO. OF LINKS	% OF TOTAL	INTER PEAK NO. LINKS	% OF TOTAL	PM PEAK NO. OF LINKS	% OF TOTAL
0 – 5	338	93%	347	96%	329	91%
5 – 7	9	3%	4	1%	12	3%
7 – 10	10	3%	3	1%	8	2%
10 – 15	1	<1%	4	1%	9	3%
15+	4	1%	4	1%	4	1%
Total	**362**	**100%**	**362**	**100%**	**362**	**100%**

6.5.17 Overall, the individual link flow calibration analysis demonstrates that the road model provides a close match to observed traffic levels, surpassing the 85% criteria within all modelled time periods.

6.5.18 The full list of traffic count calibration comparisons for individual sites is described within Appendix A.

Traffic Volume Calibration Anomalies

6.5.19 During the model audit three discrepancies were highlighted relating to traffic volumes comparisons. These were associated with individual link traffic counts/flows which show a poorer comparison and also impact total screenline flow calibration.

- **Screenline 3 South East Outer** – namely Lasswade Road, where modelled flows appear higher than observed counts (collected in 2011) during the AM and Inter peaks, and lower in the PM Peak.

6.5.20 Lasswade Road provides access to the Edinburgh City Bypass, and is anticipated to be a relatively busy route. An observed count of around 300 vehicles travelling northbound in the morning appears only slightly higher than the opposite southbound flow (180 vehicles). Within the inter peak, observed counts of 340 and 150 vehicles are recorded for the northbound and southbound directions respectively. Although the inter peak northbound flow appears reasonable, given the tidal nature of travel towards Edinburgh in the morning, it's possibly counter intuitive that the northbound flow in the AM peak would be lower than the inter peak, and therefore a modelled flow of around 500 vehicles travelling northbound in the morning appears more reasonable.

6.5.21 Observed traffic volumes of around 180 vehicles travelling southbound during the AM peak also appear lower than expected for a route providing access to the bypass and to/from Edinburgh. A modelled flow of around 300 vehicles does therefore not appear unreasonable.

6.5.22 The inter peak observed southbound count of 150 is significantly lower than the inter peak northbound count (340 vehicles). Therefore the slightly higher and consistent modelled flows of around 300-400 vehicles during the inter peak appears intuitive and does not cause any significant concern.

6.5.23 Within the PM peak an observed flow of 700 vehicles is recorded in the northbound direction. Although this count appears relatively high, it may suggest that flows for other time periods are on the low side. A model flow of 400 vph in the northbound direction appears consistent with other time periods. Only 280 vehicles are recorded in the southbound direction during the PM peak, and again this peak tidal flow outbound from Edinburgh is less than the equivalent southbound flow captured during the AM Peak. Therefore the southbound modelled flow of around 650 vehicles appears slightly high, but not unreasonable.

6.5.24 Although the actual modelling results appear reasonable and consistent, these potential issues generate some additional uncertainty relating to the level of calibration achieved for this location. Ideally, new traffic data would be collated/collected to confirm the level of observed traffic flows for studies associated with this area.

- **Screenline 17 Livingston Corridor**: M8 West of Claylands, where modelled flows appear higher than observed counts (collected in 2012) during the PM Peak.

6.5.25 The SRM contains a PM Peak flow of 3,500 vph on the M8 Westbound, compared to an observed count of around 2,700 vehicles. The observed count Eastbound/inbound to Edinburgh during the AM Peak is around 3,700 vehicles. It would be expected that traffic volumes at this location would be relatively tidal, and therefore the relatively consistent tidal nature of flows displayed in the road modelling appear reasonable. Collating more recent traffic data for this route would also be beneficial.

- **Screenline 33 Midlothian Additional**: Polton Street at Moorfoot View, where modelled flows appear lower than observed counts (collected in 2011) during all time periods.

6.5.26 Polton Street would be expected to be a relatively busy road in the centre of Bonnyrigg, and has observed traffic volumes of around 300 vehicles recorded across the time periods. However, the modelling is generally displaying lower flows of around 100-150 vehicles for this location.

6.5.27 The neighbouring zone for this area currently loads traffic to three centroid locations, including two priority spigots and a set of traffic signals to access the new Tesco supermarket. Further east, the traffic signal cross roads contains a relatively low green time for eastbound traffic, and a subsequent low capacity.

6.5.28 The combination of these local network characteristics result in no traffic loading directly onto Polton Street, causing the low flows recorded in the calibration comparisons. Although the overall level of demand appears reasonable, the immediate local traffic loading could be improved with greater detail.

6.5.29 Undertaking some minor updates to the priorities (allocating stop lines) and a review / allocating additional green time to the Eastbound traffic signal approach are likely to generate a more balanced loading of traffic. These local updates have been undertaken in the 2014 Baseline model update. Incorporating more significant changes, such as further zonal disaggregation could be considered during future model updates.

M8 Distance Road Link Coding Issue

6.5.30 During the model audit a discrepancy was found in the distance coded on the M8 between Junction 1 (Hermiston Gait) and 2 (Claylands), whereby the motorway carriageway section was around 500m too short. A further section between the M8 and M9 was found to be around 150m too short. These discrepancies were due to an error splitting longer links within the earlier SRM07 model.

6.5.31 To understand the potential impact of these issues, the additional distance required on the M8 and M9 were added to the SRM12 base year road network, and the road model was re-assigned. It was found that this produced no significant changes to the traffic calibration statistics, with some journey time routes comparing more favourably with TomTom data. With this section of the M8 and alternative A8 route section both generally congested and slow moving, the distance error therefore has a lower impact as journey time constitutes the larger influence on route choice.

6.5.32 These three distance discrepancies have been corrected within the latest SRM12 model version. This update also includes a series of minor amendments to junction coding as highlighted by the audit junction checks (Version SRM12 v2.1.1, Run scenario: 2014 ‘BL15’).

7. ROAD MODEL VALIDATION

7.1 Approach & Data Sets

7.1.1 This chapter analyses the level of validation of the SRM12 Road Model. This involves comparing how well the model compares to observed data that were set aside during the calibration process to provide an independent validation data set. Validation analysis includes comparisons with independent traffic count data, and road journey time analysis.

Validation Data

7.1.2 This validation process made use of the following data sources to determine the overall level of validation of the Road Model:

- SRTDb traffic data (2012);
- East Lothian traffic counts (2013);
- Midlothian traffic counts (2011-2012);
- Edinburgh Airport count data (2014);
- A8 corridor traffic survey (2012);
- TomTom satellite navigation journey time data (2012); and
- 2011 Census travel to work movement intermediate zone data.

7.2 Traffic Count Validation Comparison

7.2.1 Traffic count validation analysis compared total modelled traffic flows and individual heavy goods vehicle flows (described in vehicles) against observed traffic count data at individual locations. These comparisons were set against DMRB validation criteria.

DMRB Validation Criteria

7.2.2 Individual link criteria used for validation are consistent with the individual link criteria used in calibration, which are as follows:

- Individual flows within 15% for flows 700 – 2,700 vph (>85% of cases);
- Individual flows within 100 vph for flows < 700 vph (>85% of all cases);
- Individual flows within 400 vph for flows > 2,700 vph (>85% of all cases); and
- Individual flows: GEH < 5 (>85% of all cases).

7.2.3 As with the calibration count data, validation traffic count data were adjusted to a common 2012 base year level using a factoring process. The locations of the traffic count validation points are illustrated within Figure 15.

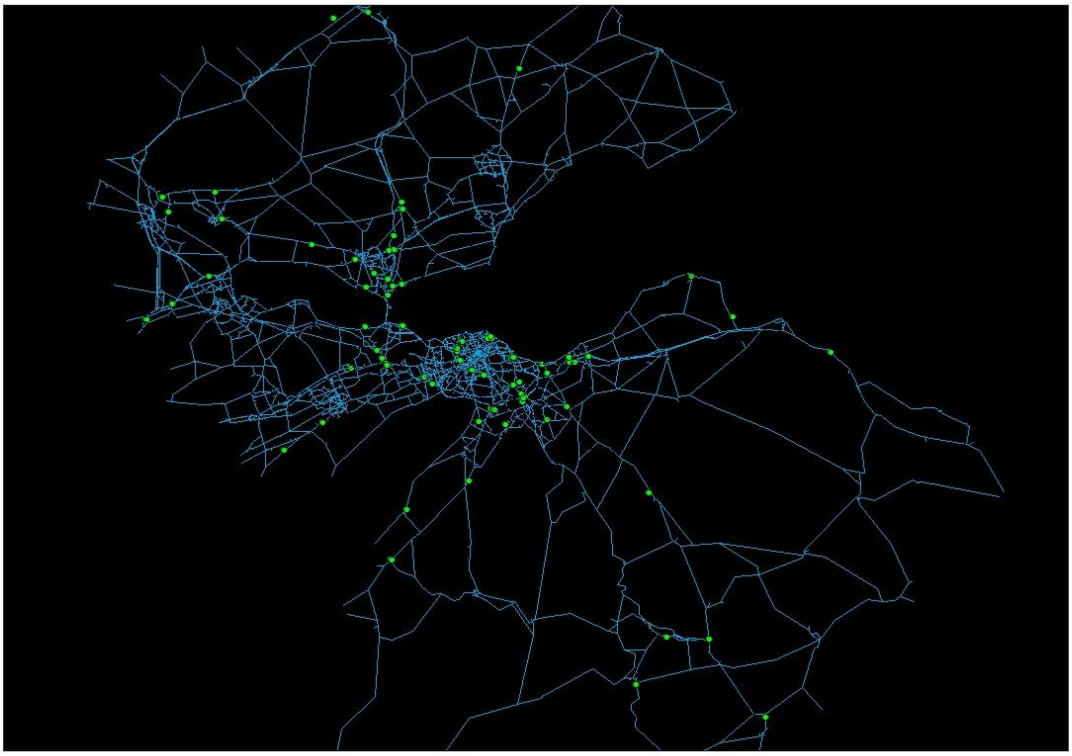

Figure 15. Individual Traffic Count Validation Locations

Individual Link Total Traffic Flow Comparison

7.2.4 Tables 32 and 33 summarise the individual link flow comparisons between the total modelled flows and the observed traffic data for each validation criteria. The full set of individual traffic count validation comparisons are described within Appendix B.

7.2.5 The validation analysis shows that the road model meets one of the relevant guidance thresholds within the inter peak period, and falls just under the thresholds within the other time periods. This is an appropriate level of validation given the scale and nature of this large regional model, and the differences in some of the age of the validation data sets.

Table 32. Individual Link Flow Validation

FLOW RANGES	AM PEAK NO. OF LINKS	% WITHIN CRITERIA	INTER PEAK NO. LINKS	% WITHIN CRITERIA	PM PEAK NO. OF LINKS	% WITHIN CRITERIA
<700	101	76%	112	89%	98	79%
700 – 2,700	50	70%	42	79%	53	68%
>2,700	5	100%	0	NA	5	100%
Total	**156**		**154***		**156**	

Table 33. Individual Link Validation GEH Criteria

GEH RANGES	AM NO. OF LINKS	% OF TOTAL	IP NO. LINKS	% OF TOTAL	PM NO. OF LINKS	% OF TOTAL
0 – 5	114	73%	116	75%	110	71%
5 – 7	12	8%	16	11%	20	12%
7 – 10	17	11%	14	9%	14	9%
10 – 15	11	7%	5	3%	9	6%
15+	2	1%	3	2%	3	2%
Total	**156**	**100**	**154***	**100**	**156**	**100**

**Flows at the RBS site on the A8 were not available for the IP, hence the total is lower for this time period*

HGV Validation

7.2.6 To determine the level of HGV validation cross the network, modelled HGV flows were compared against observed count data at the screenline locations. Due to a lack of HGV count data for some locations, we were restricted to those sites where an HGV flow has been derived from the data.

7.2.7 Table 34 provides a summary of the HGV validation GEH statistics.

Table 34. Summary of HGV Flow Validation

GEH RANGES	AM PEAK NO. OF LINKS	% OF TOTAL	INTER PEAK NO. LINKS	% OF TOTAL	PM PEAK NO. OF LINKS	% OF TOTAL
0 – 5	111	71%	116	75%	111	71%
5 – 7	19	12%	22	14%	25	16%
7 – 10	17	11%	10	6%	12	8%
10 – 15	8	5%	5	3%	7	4%
15+	1	1%	2	1%	1	1%
Total	**156**		**156**		**156**	

7.2.8 Given the relative detailed nature of these specific HGV comparisons, the analysis indicates that the modelled HGV flows display a reasonable comparison with observed data sets.

7.3 Journey Time Validation

7.3.1 The road journey time validation comprises comparing modelled traffic journey times for a selection of routes with observed data sets.

TomTom Satellite Navigation Data

7.3.2 Transport Scotland provided SYSTRA with TomTom data in December 2014. The data was supplied by Streetwise Services and covered a period representing mostly neutral months during 2012. The dataset consisted of all Tuesdays, Wednesdays and Thursdays between 1st February and 30th November 2012 excluding all July and August.

7.3.3 The TomTom (area based) link data was processed to format the journey times into routes, to compare with model output data on various key routes throughout the model.

7.3.4 The 'area based' data provides an average travel time along the length of a road section (or link) rather than a specific journey time for each left, right or straight ahead movement. Although for most routes this data format will appropriately represent general conditions, it may lead to the under or over estimation of journey times where large delays are only present for specific turning movements. This uncertainty is likely to be present for routes where major turns are included and turning movement capacity significantly varies. Junctions such as Barnton could be one location that may be impacted by this type of data limitation.

7.3.5 A total of 14 routes were developed for the SRM12 journey time comparisons. These routes are illustrated in Figure 16 and described below.

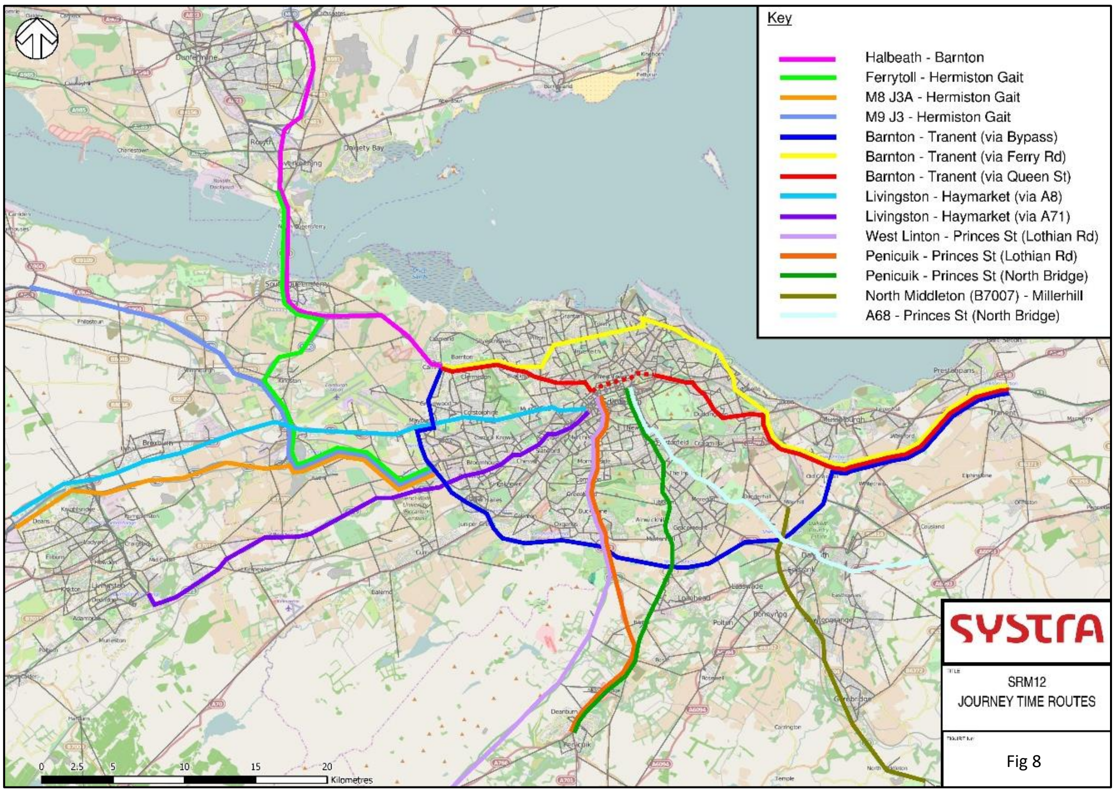

Figure 16. SRM12 Journey Time Routes

- Route 1: M9 J3 - Hermiston Gait
- Route 2: Ferrytoll - Hermiston Gait
- Route 3: M8 J3A - Hermiston Gait
- Route 4: Halbeath - Barnton
- Route 5: Barnton - Tranent (via Bypass)
- Route 6: Barnton - Tranent (via Ferry Rd)
- Route 7: Barnton - Tranent (via Queen St)
- Route 8: Livingston - Haymarket (via A8)
- Route 9: Livingston - Haymarket (via A71)
- Route 10: Penicuik (A702) - Princes St (Lothian Rd)
- Route 11: Penicuik (A703) - Princes St (Lothian Rd)
- Route 12: Penicuik (A701) - Princes St (North Bridge)
- Route 13: North Middleton (B7007) - Millerhill
- Route 14: A68 - Princes St (North Bridge)

7.3.6 The TomTom data was used to validate the model and was also used to feedback into the calibration process to allow refinements to be made to the road model. These predominately related to network coding along sections of corridors into Edinburgh (including the A702 and A7 corridors). The observed data suggested much lower speeds, and routes were adjusted in terms of detailed capacity, to better reflect the available capacity and speed data. Capacity and/or speed flow curves where generally lowered as the speed data indicated lower speeds in these corridor sections. Table 35 displays the journey time validation results by route.

Table 35. Summary of Journey Time Route Performance (mm:ss)

ROUTE	DIR	AM OBS	AM MOD	AM % DIFF	IP OBS	IP MOD	IP % DIFF	PM OBS	PM MOD	PM % DIFF
1	EB	16:35	14:58	-10%	13:21	11:39	-13%	14:26	13:00	-10%
	WB	12:28	11:59	-4%	12:34	11:47	-6%	15:08	15:13	1%
2	EB	23:30	21:27	-9%	15:49	13:16	-16%	18:35	16:27	-11%
	WB	16:06	15:33	-3%	15:17	13:29	-12%	21:00	18:27	-12%
3	EB	17:30	17:45	1%	11:30	11:23	-1%	12:33	13:07	5%
	WB	12:11	12:15	1%	12:39	11:41	-8%	16:19	16:27	1%
4	EB	23:04	22:52	-1%	12:24	13:54	12%	17:10	16:01	-7%
	WB	14:40	15:38	7%	11:37	13:09	13%	16:35	16:08	-3%
5	EB	32:06	30:38	-5%	26:38	25:38	-4%	36:07	33:09	-8%
	WB	39:50	34:34	-13%	25:44	24:54	-3%	37:07	31:20	-16%
6	EB	43:05	41:59	-3%	40:12	38:32	-4%	47:36	49:43	4%

ROUTE	DIR	AM OBS	AM MOD	AM % DIFF	IP OBS	IP MOD	IP % DIFF	PM OBS	PM MOD	PM % DIFF
	WB	47:04	49:47	6%	43:38	40:40	-7%	50:40	53:08	5%
7	EB	39:31	33:23	-16%	33:51	30:05	-11%	38:06	39:52	5%
	WB	36:53	39:38	7%	32:26	31:38	-2%	43:25	43:30	0%
8	EB	37:37	36:22	-3%	29:53	27:34	-8%	34:26	31:55	-7%
	WB	31:43	29:10	-8%	29:53	27:20	-9%	37:44	35:33	-6%
9	EB	36:16	33:56	-6%	28:50	27:19	-5%	33:18	32:26	-3%
	WB	30:00	28:38	-5%	30:56	26:28	-14%	37:29	32:01	-15%
10	NB	37:30	34:43	-7%	31:09	30:12	-3%	31:27	31:06	-1%
	SB	29:28	28:27	-3%	30:52	28:35	-7%	31:48	32:19	2%
11	NB	39:35	35:39	-10%	32:02	29:25	-8%	33:23	30:55	-7%
	SB	30:13	27:42	-8%	31:56	27:56	-13%	34:15	33:19	-3%
12	NB	36:09	33:37	-7%	32:39	29:50	-9%	33:31	30:09	-10%
	SB	33:30	28:47	-14%	34:54	29:56	-14%	38:41	33:59	-12%
13	NB	17:48	17:20	-3%	16:02	14:46	-8%	15:41	16:06	3%
	SB	15:55	15:39	-2%	15:58	14:58	-6%	20:18	18:43	-8%
14	WB	33:16	33:20	0%	31:39	29:26	-7%	30:54	31:18	1%
	EB	31:54	29:05	-9%	35:07	28:55	-18%	39:57	34:00	-15%

7.3.7 The TomTom data sets described here represent the mean journey time along a given (GIS) link or road segment. These links are combined to form journey time routes. The average TomTom times represent average travel speeds / times across the network during the AM, Inter and PM peak average hours, and are likely to include periods of disruption caused by roadworks and potentially accidents. These times of incidents are not captured within the base year model congested speeds, so the model will be unlikely to represent the full average recorded by TomTom.

7.3.8 From reviewing the data, it was felt that an appropriate level of journey time validation would be achieved if the road model provided journey times that fell just below the time recorded by the TomTom data.

7.3.9 Note that a specific adjustment was made to the observed journey times along the A90 to take account of the Forth Replacement Crossing roadworks that were in place when the observed data was collected. The model assumes 'normal' traffic conditions and so the speed limits on the affected sections of the A90 are higher in the model than those in place when the observed data was collected. The result was a decrease in the observed journey times on Routes 2 & 4 of 48 & 168 seconds, respectively, in each direction. These adjustments were derived through comparing with google maps times, with calculated travel times subtracted from the modelled travel time for the corresponding links.

7.3.10 Edinburgh Tram works were occurring during the TomTom data collection period. It is not possible to determine exactly how these works would impact each individual journey time route, but they would be generally anticipated to increase uncertainty within the journey time data sets for the city centre area. For example, a section of Queen St was missing data and was excluded from the validation comparisons. Motorists diverting due to road works may also lead to more heavily trafficked routes and higher journey times when compared to normal conditions. Only the Queen Street route compares road times 'through' the city centre. Six other routes start and end in the city centre, so only as small proportion of these routes would potentially be impacted by Tram works.

7.3.11 Further information on the use of the TomTom data is included within Appendix C.

DMRB Journey Time criteria

7.3.12 For journey time validation, the following DMRB criteria is advised:

- Modelled journey times to be within 15% (or 1 minute if higher) for greater than 85% of routes.

7.3.13 Table 36 summarises the overall operational performance of the road model against the observed journey times calculated.

Table 36. Summary of Overall Journey Time Performance

WITHIN DMRB	AM PEAK	% WITHIN 15%	INTER PEAK	% WITHIN 15%	PM PEAK	% WITHIN 15%
Yes	27	96%	26	93%	27	96%
No	1	4%	2	7%	1	4%

7.3.14 The validation analysis demonstrates that the road model meets the journey time validation criteria within all time periods.

7.3.15 For the key Edinburgh bypass route (route 5), the modelled journey times fall within the 15% threshold for the AM and Inter peak periods, and lies within 16% during the PM peak hour.

Additional Journey Time Comparisons

7.3.16 A supplementary data set was provided which represented the road section from the B6415 (at Ferguson Drive) to Old Craighall roundabout. Table 37 displays the performance of the model between the B6415 and Old Craighall.

Table 37. Summary of B6415 @ Old Craighall Journey Time Performance

ROUTE	AM OBS	AM MOD	AM % DIFF	IP OBS	IP MOD	IP % DIFF	PM OBS	PM MOD	PM % DIFF
B6415* - Old Craighall	01:16	01:40	32%	01:15	01:14	-1%	02:15	04:24	96%
Old Craighall – B6415*	01:08	00:58	-15%	01:08	00:59	-13%	01:09	01:00	-13%

** At Monktonhall Place*

7.3.17 The specific analysis at Old Craighall indicates a good match with observations in the outbound direction. The AM and PM peak also compare favourably for movements approaching Old Craighall. However, the analysis indicates that modelled journey times are higher within the PM peak than demonstrated within the TomTom data.

7.4 Census Commuter Movement Comparison

7.4.1 During the later stages of model development 2011 Census travel to work movements became available at the more detailed intermediate zone level. These data were grouped into a sub-Local Authority sector system and used to compare SRM12 commuter travel movements contained within the final post estimated road and PT matrices.

7.4.2 The detailed comparisons of sector to sector movements are described within Appendix D. Tables 38 to 41 summarise the post estimated road commuter matrices comparisons at the more aggregate Local Authority level for the AM Peak hour.

Table 38. 2011 Census TTW Car Driver Proportions for SESPlan LA-LA Movements

LA	EDINBURGH	EAST LOTHIAN	MID LOTHIAN	WEST LOTHIAN	FIFE	BORDERS
Edinburgh	79.6%	4.0%	5.5%	6.8%	3.5%	0.7%
East Lothian	45.2%	43.4%	7.7%	1.9%	0.6%	1.2%
Mid Lothian	53.0%	5.7%	35.4%	3.4%	1.1%	1.5%
West Lothian	29.5%	0.6%	1.5%	66.1%	2.2%	0.1%

LA	EDINBURGH	EAST LOTHIAN	MID LOTHIAN	WEST LOTHIAN	FIFE	BORDERS
Fife	9.9%	0.2%	0.4%	2.1%	87.3%	0.0%
Borders	12.9%	2.8%	3.7%	0.7%	0.3%	79.6%

Table 39. Post Estimated SRM12 Car Commuter Proportions for SESPlan LA-LA Movements

LA	EDINBURGH	EAST LOTHIAN	MID LOTHIAN	WEST LOTHIAN	FIFE	BORDERS
Edinburgh	80.6%	4.6%	4.5%	6.8%	3.1%	0.4%
East Lothian	46.6%	40.6%	8.6%	2.2%	0.8%	1.3%
Mid Lothian	49.9%	5.2%	37.8%	3.3%	1.0%	2.7%
West Lothian	28.0%	1.4%	1.6%	66.7%	2.2%	0.1%
Fife	8.1%	0.4%	0.6%	2.2%	88.7%	0.0%
Borders	10.9%	2.4%	6.5%	0.6%	0.3%	79.3%

Table 40. % Change in Post Estimated Car Commuter Proportions Compared to 2011 Census

LA	EDINBURGH	EAST LOTHIAN	MID LOTHIAN	WEST LOTHIAN	FIFE	BORDERS
Edinburgh	1.0%	0.7%	-1.0%	0.0%	-0.4%	-0.2%
East Lothian	1.4%	-2.7%	0.8%	0.3%	0.1%	0.1%
Mid Lothian	-3.0%	-0.5%	2.5%	-0.1%	-0.1%	1.3%
West Lothian	-1.6%	0.8%	0.1%	0.6%	0.0%	0.0%
Fife	-1.9%	0.2%	0.1%	0.1%	1.4%	0.0%
Borders	-2.0%	-0.5%	2.8%	-0.1%	0.0%	-0.3%

Table 41. Change in Post Estimated Car Commuters Compared to 2011 Census

LA	EDINBURGH	EAST LOTHIAN	MID LOTHIAN	WEST LOTHIAN	FIFE	BORDERS
Edinburgh	1853	199	-66	144	-3	-28
East Lothian	-51	-247	20	9	4	0

LA	EDINBURGH	EAST LOTHIAN	MID LOTHIAN	WEST LOTHIAN	FIFE	BORDERS
Mid Lothian	-12	-8	203	2	-1	64
West Lothian	-266	69	1	-239	-6	2
Fife	-401	33	20	3	-544	-2
Borders	-202	-45	117	-8	-2	-613

7.4.3 The LA comparisons suggest that the SRM12 car commuter matrix proportions are similar to the 2011 Census proportions, with all comparisons falling within +/- 3%.

7.4.4 As these matrices were very closely matched at the pre estimation stage, the analysis indicates that the matrix estimation process created additional (short distance) trips within Local Authorities and reduced the proportions of some LA-LA movements. This is a common outcome of the ME process.

7.4.5 Note that the absolute differences described here are based on an uncalibrated Census data set, so these comparisons should only be used for broad comparisons.

7.4.6 The more detailed SRM12 sector to sector comparisons (described in Appendix D) indicate a reasonable reflection of Census data, with travel proportions ranging between +13 to -10%. The analysis indicates that matrices generally overestimate commuter movements to central Edinburgh and underestimates Edinburgh southwest inner movements.

8. PUBLIC TRANSPORT MODEL VALIDATION

8.1 Approach

8.1.1 This chapter describes the validation process undertaken to review the SRM12 public transport assignment model and matrices.

8.1.2 The PT assignment matrices were originally extracted from the SRM07 model version, and adjusted to reflect changes in population and employment between 2007 and 2012. Although a formal PT matrix calibration process was not part of the SRM12 approach remit, some matrix calibration adjustments were undertaken to rationalise trip ends and trip rates, and undertake Census Travel to Work adjustments.

8.1.3 The PT validation process compared modelled bus and rail passenger demand with observed patronage levels and flows, and also included bus journey time comparisons. Validation was undertaken on an iterative basis, with the modelled network and services reviewed and updated as required as a result of the validation comparisons.

8.1.4 The validation process comparisons include:

- Bus passenger demand link flows;
- Rail passenger demand link flows;
- Bus journey times; and
- Census Commuter movement comparisons

8.2 Public Transport Validation Data

8.2.1 Passenger counts were available from CSTM12 and TMfS14 development and the Edinburgh Tram Joint Revenue Committee (JRC) Model applied for the appraisal of Edinburgh Trams. This data included:

- Edinburgh Tram JRC Model: 2005 bus patronage counts;
- CSTM12 / TMfS07: 2007 bus patronage roadside counts;
- CSTM12: 2012 rail patronage counts based on ticket sales; and
- TMfS14: 2014 bus patronage roadside counts;

8.2.2 Bus timetables available during 2014 and 2015 were interrogated to identify currently anticipated travel times and compare with modelled bus journey times.

8.2.3 Note that some considerable differences have been identified between the 2007 and 2014 observed bus patronage data. In general, the 2014 bus data indicates considerable less bus patronage than demonstrated by the 2007 data set. Some potential reasons for these differences include:

- Reduction in some inter-urban services, and subsequent fall in passenger levels;
- General reduction in bus passenger levels;
- Park & ride sites opened inside the patronage count cordon (potentially reducing the level of bus passengers at the specific point the survey was undertaken;
- Variances in survey outcomes, due to the relatively coarse nature of roadside bus passenger counts.

8.2.4 These variations should be borne in mind when comparing the validation comparisons.

Bus & Rail Passenger Volume Data Sets

- **2007 Bus Counts**: bus occupancy roadside surveys were undertaken around the periphery of Edinburgh as part of the TMfS07 development, and subsequently CSTM12. To reflect changes in patronage levels since 2007, bus counts were factored down slightly to reflect the drop in bus patronage between 2007 and 2012 as recorded in the Scottish Transport Statistics Bus and Coach data;

- **2014 Bus Counts**: bus occupancy roadside surveys were again undertaken around the periphery of Edinburgh as part of the development of TMfS14. No changes have been made to these data sets to reflect changes in patronage between 2012 and 2014;

- **Edinburgh Tram Joint Revenue Committee Report:** Bus patronage surveys were undertaken for the development of the Validation Screenlines as part of the Edinburgh Tram VISUM model. No changes have been made to these data sets to reflect changes in patronage between 2005 and 2012; and

- **2012 LENNON/MOIRA/ORR Assigned Demand:** During the development of CSTM12, LENNON and MOIRA ticket sales data and ORR station usage data was combined and assigned to a rail only network to derive estimated passenger loading volumes between stations. Time periods were assigned based on National Rail Travel Survey (NRTS) data allocated by station pairs. This data is directly comparable with the assigned model (link) passenger volumes and has been used for the SRM12 rail validation presented in this report.

8.3 Passenger Demand Link Flow Comparisons

8.3.1 Tables 42-53 describe SRM12 bus and rail passenger modelled link flows, compared to both 2007 and 2014 observations. The count locations are illustrated in Figure 17. Tables 54 to 59 provide a summary of validation statistics, compared against the 2007 and 2014 validation criteria.

Validation Criteria

8.3.2 The validation of the SRM12 PT assignment model has compared the modelled flows with equivalent observed data across screenlines with the following criteria considered:

- modelled public transport flow should ideally fall within 15% of observed flow across appropriate screenlines; and
- modelled public transport flow should ideally fall within 25% of observed flow, except where observed flows are particularly low (less than 150), on individual links.

Table 42. PT Validation – AM Peak Inbound Passenger Flows (per hour) (2007 Bus, 2012 Rail)

STATION/ROAD NAME	DIR	OBSERVED	MODELLED	DIFF	% DIFF	GEH
R1: South Gyle to Dalmeny	E	2,026	1,831	-195	-10%	4
R2: West of Edinburgh Park	E	2,635	2,973	+338	+13%	6
R3: Wester Hailes to Curriehill	E	559	731	+172	+31%	7
R4: Brunstane to Newcraighall	W	67	65	-2	-3%	0
R5: West of Musselburgh	W	1,807	1,836	+29	+2%	1
B1: A90 (Forth Road Bridge)	S	412	469	+57	+14%	3
B2: A8 (West of Airport)*	E	800	650	-150	-19%	6
B3: M9 (N of Newbridge)	S	147	67	-80	-54%	8
B4: M8 (W of Hermiston Gait)	E	148	170	+22	+15%	2
B5: A71 (W of Hermiston House Rd)	E	315	134	-181	-57%	12
B6: A70 Lanark Rd (E of Newmills Rd)	E	69	72	+3	+4%	0
B7: A702 Bigger Rd (South of Bypass)	N	74	71	-3	-4%	0
B8: A701 Straiton Rd (S of B702)	N	634	567	-67	-11%	3
B9: Lasswade Road (S of Bypass) *	N	204	257	+53	+26%	3
B10: A772 Gimerton Rd (S of Bypass)	W	452	564	+112	+25%	5
B11: A7/A68 (S of Newton Church Rd)	N	524	297	-227	-43%	11
B12: A1 (South of The Jewel) *	N	393	253	-140	-36%	8
B13: Newcraighall Road (E of Station)	W	147	69	-78	-53%	8
B14: A199 (East of B6415 Eastfield)*	W	818	1,128	+310	+38%	10
TOTAL – Rail Inbound		**7,094**	**7,436**	**+342**	**+5%**	**4**
TOTAL – Bus Inbound		**5,137**	**4,768**	**-369**	**-7%**	**5**
TOTAL - Inbound		**12,231**	**12,204**	**-27**	**-0%**	**0**

Table 43. AM Peak Outbound Passenger Flows (per hour) (2007 Bus, 2012 Rail)

STATION/ROAD NAME	DIR	OBSERVED	MODELLED	DIFF	% DIFF	GEH
R1: South Gyle to Dalmeny	E	518	381	-137	-26%	6
R2: West of Edinburgh Park	E	1,178	1,091	-87	-7%	3
R3: Wester Hailes to Curriehill	E	250	342	+92	+37%	5
R4: Brunstane to Newcraighall	W	5	29	+24	+480%	6
R5: West of Musselburgh	W	617	557	-60	-10%	2
B1: A90 (Forth Road Bridge)	S	83	147	+64	+77%	6
B2: A8 (West of Airport)*	E	390	275	-115	-29%	6
B3: M9 (N of Newbridge)	S	47	45	-2	-4%	0
B4: M8 (W of Hermiston Gait)	E	135	129	-6	-4%	1
B5: A71 (W of Hermiston House Rd)	E	129	46	-83	-64%	9
B6: A70 Lanark Rd (E of Newmills Rd)	E	41	23	-18	-44%	3
B7: A702 Bigger Rd (South of Bypass)	N	78	39	-39	-50%	5
B8: A701 Straiton Rd (S of B702)	N	224	137	-87	-39%	6
B9: Lasswade Road (S of Bypass) *	N	71	47	-24	-34%	3
B10: A772 Gilmerton Rd (S of Bypass)	W	233	161	-72	-31%	5
B11: A7/A68 (S of Newton Church Rd)	N	146	123	-23	-16%	2
B12: A1 (South of The Jewel) *	N	26	236	+210	+808%	18
B13: Newcraighall Road (E of Station)	W	199	133	-66	-33%	5
B14: A199 (East of B6415 Eastfield)*	W	343	388	+45	+13%	2
TOTAL – Rail Inbound		**2,568**	**2,400**	**-168**	**-7%**	**3**
TOTAL – Bus Inbound		**2,145**	**1,929**	**-216**	**-10%**	**5**
TOTAL - Inbound		**4,713**	**4,329**	**-384**	**-8%**	**6**

Table 44. PT Validation – Inter Peak Inbound Passenger Flows (per hour) (2007 Bus, 2012 Rail)

STATION/ROAD NAME	DIR	OBSERVED	MODELLED	DIFF	% DIFF	GEH
R1: South Gyle to Dalmeny	E	395	465	+70	+18%	3
R2: West of Edinburgh Park	E	754	879	+125	+17%	4
R3: Wester Hailes to Curriehill	E	184	226	+42	+23%	3
R4: Brunstane to Newcraighall	W	13	12	-1	-8%	0
R5: West of Musselburgh	W	478	425	-53	-11%	2
B1: A90 (Forth Road Bridge)	S	131	116	-15	-11%	1
B2: A8 (West of Airport)*	E	267	346	+79	+30%	5
B3: M9 (N of Newbridge)	S	23	42	+19	+83%	3
B4: M8 (W of Hermiston Gait)	E	98	128	+30	+31%	3
B5: A71 (W of Hermiston House Rd)	E	63	84	+21	+33%	2
B6: A70 Lanark Rd (E of Newmills Rd)	E	52	23	-29	-56%	5
B7: A702 Bigger Rd (South of Bypass)	N	59	50	-9	-15%	1
B8: A701 Straiton Rd (S of B702)	N	147	194	+47	+32%	4
B9: Lasswade Road (S of Bypass) *	N	52	81	+29	+56%	4
B10: A772 Gilmerton Rd (S of Bypass)	W	127	279	+152	+120%	11
B11: A7/A68 (S of Newton Church Rd)	N	170	132	-38	-22%	3
B12: A1 (South of The Jewel) *	N	72	171	+99	+138%	9
B13: Newcraighall Road (E of Station)	W	186	101	-85	-46%	7
B14: A199 (East of B6415 Eastfield)*	W	408	458	+50	+12%	2
TOTAL – Rail Inbound		**1,824**	**2,007**	**+183**	**+10%**	**4**
TOTAL – Bus Inbound		**1,855**	**2,205**	**+350**	**+19%**	**8**
TOTAL - Inbound		**3,679**	**4,212**	**+533**	**+14%**	**8**

Table 45. Inter Peak Outbound Passenger Flows (per hour) (2007 Bus, 2012 Rail)

STATION/ROAD NAME	DIR	OBSERVED	MODELLED	DIFF	% DIFF	GEH
R1: South Gyle to Dalmeny	E	433	568	+135	+31%	6
R2: West of Edinburgh Park	E	578	773	+195	+34%	8
R3: Wester Hailes to Curriehill	E	218	237	+19	+9%	1
R4: Brunstane to Newcraighall	W	16	15	-1	-6%	0
R5: West of Musselburgh	W	468	513	+45	+10%	2
B1: A90 (Forth Road Bridge)	S	131	137	+6	+5%	1
B2: A8 (West of Airport)*	E	234	299	+65	+28%	4
B3: M9 (N of Newbridge)	S	16	93	+77	+481%	10
B4: M8 (W of Hermiston Gait)	E	67	111	+44	+66%	5
B5: A71 (W of Hermiston House Rd)	E	108	70	-38	-35%	4
B6: A70 Lanark Rd (E of Newmills Rd)	E	41	26	-15	-37%	3
B7: A702 Bigger Rd (South of Bypass)	N	62	44	-18	-29%	2
B8: A701 Straiton Rd (S of B702)	N	176	140	-36	-20%	3
B9: Lasswade Road (S of Bypass)	N	60	93	+33	+55%	4
B10: A772 Gilmerton Rd (S of Bypass)	W	139	230	+91	+65%	7
B11: A7/A68 (S of Newton Church Rd)	N	177	181	+4	+2%	0
B12: A1 (South of The Jewel) *	N	82	198	+116	+141%	10
B13: Newcraighall Road (E of Station)	W	126	74	-52	-41%	5
B14: A199 (East of B6415 Eastfield)*	W	447	337	-110	-25%	6
TOTAL – Rail Inbound		**1,713**	**2,106**	**+393**	**+23%**	**9**
TOTAL – Bus Inbound		**1,866**	**2,033**	**+167**	**+9%**	**4**
TOTAL - Inbound		**3,579**	**4,139**	**+560**	**+16%**	**9**

Table 46. PT Validation – PM Peak Inbound Passenger Flows (per hour) (2007 Bus, 2012 Rail)

STATION/ROAD NAME	DIR	OBSERVED	MODELLED	DIFF	% DIFF	GEH
R1: South Gyle to Dalmeny	E	537	436	-101	-19%	5
R2: West of Edinburgh Park	E	1,494	1,368	-126	-8%	3
R3: Wester Hailes to Curriehill	E	113	343	+230	+204%	15
R4: Brunstane to Newcraighall	W	10	10	0	0%	0
R5: West of Musselburgh	W	510	404	-106	-21%	5
B1: A90 (Forth Road Bridge)	S	97	130	+33	+34%	3
B2: A8 (West of Airport)*	E	510	366	-144	-28%	7
B3: M9 (N of Newbridge)	S	35	71	+36	+103%	5
B4: M8 (W of Hermiston Gait)	E	93	158	+65	+70%	6
B5: A71 (W of Hermiston House Rd)	E	214	61	-153	-71%	13
B6: A70 Lanark Rd (E of Newmills Rd)	E	44	35	-9	-20%	1
B7: A702 Bigger Rd (South of Bypass)	N	36	20	-16	-44%	3
B8: A701 Straiton Rd (S of B702)	N	347	170	-177	-51%	11
B9: Lasswade Road (S of Bypass) *	N	68	26	-42	-62%	6
B10: A772 Gilmerton Rd (S of Bypass)	W	236	165	-71	-30%	5
B11: A7/A68 (S of Newton Church Rd)	N	179	119	-60	-34%	5
B12: A1 (South of The Jewel) *	N	111	186	+75	+68%	6
B13: Newcraighall Road (E of Station)	W	183	149	-34	-19%	3
B14: A199 (East of B6415 Eastfield)*	W	590	525	-65	-11%	3
TOTAL – Rail Inbound		**2,664**	**2,561**	**-103**	**-4%**	**2**
TOTAL – Bus Inbound		**2,743**	**2,181**	**-562**	**-20%**	**11**
TOTAL - Inbound		**5,407**	**4,742**	**-665**	**-12%**	**9**

Table 47. PM Peak Outbound Passenger Flows (per hour) (2007 Bus, 2012 Rail)

STATION/ROAD NAME	DIR	OBSERVED	MODELLED	DIFF	% DIFF	GEH
R1: South Gyle to Dalmeny	E	1,819	1,599	-220	-12%	5
R2: West of Edinburgh Park	E	2,768	2,846	+78	+3%	1
R3: Wester Hailes to Curriehill	E	780	720	-60	-8%	2
R4: Brunstane to Newcraighall	W	67	44	-23	-34%	3
R5: West of Musselburgh	W	1,846	1,670	-176	-10%	4
B1: A90 (Forth Road Bridge)	S	337	435	+98	+29%	5
B2: A8 (West of Airport)*	E	819	726	-93	-11%	3
B3: M9 (N of Newbridge)	S	21	126	+105	+500%	12
B4: M8 (W of Hermiston Gait)	E	79	152	+73	+92%	7
B5: A71 (W of Hermiston House Rd)	E	309	120	-189	-61%	13
B6: A70 Lanark Rd (E of Newmills Rd)	E	97	66	-31	-32%	3
B7: A702 Bigger Rd (South of Bypass)	N	91	99	+8	+9%	1
B8: A701 Straiton Rd (S of B702)	N	795	472	-323	-41%	13
B9: Lasswade Road (S of Bypass) *	N	232	226	-6	-3%	0
B10: A772 Gilmerton Rd (S of Bypass)	W	594	578	-16	-3%	1
B11: A7/A68 (S of Newton Church Rd)	N	641	179	-462	-72%	23
B12: A1 (South of The Jewel) *	N	390	321	-69	-18%	4
B13: Newcraighall Road (E of Station)	W	171	81	-90	-53%	8
B14: A199 (East of B6415 Eastfield)*	W	850	999	+149	+18%	5
TOTAL – Rail Inbound		**7,280**	**6,879**	**-401**	**-6%**	**5**
TOTAL – Bus Inbound		**5,426**	**4,580**	**-846**	**-16%**	**12**
TOTAL - Inbound		**12,706**	**11,459**	**-1,247**	**-10%**	**11**

Table 48. AM Peak Inbound Passenger Flows (per hour) (2014 Bus, 2012 Rail)

STATION/ROAD NAME	DIR	OBSERVED	MODELLED	DIFF	% DIFF	GEH
R1: South Gyle to Dalmeny	E	2,026	1,831	-195	-10%	4
R2: West of Edinburgh Park	E	2,635	2,973	+338	+13%	6
R3: Wester Hailes to Curriehill	E	559	731	+172	+31%	7
R4: Brunstane to Newcraighall	W	67	65	-2	-3%	0
R5: West of Musselburgh	W	1,807	1,836	+29	+2%	1
B1: A90 (Forth Road Bridge)	S	513	469	-44	-9%	2
B2: A8 (West of Airport) *	E	404	650	+246	+61%	11
B3: M9 (N of Newbridge)	S	147	67	-80	-54%	8
B4: M8 (W of Hermiston Gait)	E	148	170	+22	+15%	2
B5: A71 (W of Hermiston House Rd)	E	54	134	+80	+148%	8
B6: A70 Lanark Rd (E of Newmills Rd)	E	69	72	+3	+4%	0
B7: A702 (South of City Bypass)	N	10	71	+61	+610%	10
B8: A701 (South of B702)	N	397	567	+170	+43%	8
B9: Lasswade Road (East of A768) *	N	472	308	-164	-35%	8
B10: A772 Gilmerton Rd (S of Bypass)	W	425	564	+139	+33%	6
B11: A7/A68 (S of Newton Church Rd)	N	524	297	-227	-43%	11
B12: A1 (E of A720 at Slaters Road) *	N	239	135	-104	-44%	8
B13: Newcraighall Road (E of Station)	W	27	69	+42	+156%	6
B14: A199 (East of B6415 Eastfield) *	W	398	1,177	+779	+196%	28
TOTAL – Rail Inbound		**7,094**	**7,436**	**+342**	**+5%**	**4**
TOTAL – Bus Inbound		**3,827**	**4,750**	**+923**	**+24%**	**14**
TOTAL - Inbound		**4,713**	**4,318**	**-395**	**-8%**	**6**

Table 49. AM Peak Outbound Passenger Flows (per hour) (2014 Bus, 2012 Rail)

STATION/ROAD NAME	DIR	OBSERVED	MODELLED	DIFF	% DIFF	GEH
R1: South Gyle to Dalmeny	E	518	381	-137	-26%	6
R2: West of Edinburgh Park	E	1,178	1,091	-87	-7%	3
R3: Wester Hailes to Curriehill	E	250	342	+92	+37%	5
R4: Brunstane to Newcraighall	W	5	29	+24	+480%	6
R5: West of Musselburgh	W	617	557	-60	-10%	2
B1: A90 (Forth Road Bridge)	S	126	147	+21	+17%	2
B2: A8 (West of Airport) *	E	195	248	+53	+27%	4
B3: M9 (N of Newbridge)	S	47	45	-2	-4%	0
B4: M8 (W of Hermiston Gait)	E	135	129	-6	-4%	1
B5: A71 (W of Hermiston House Rd)	E	14	46	+32	+229%	6
B6: A70 Lanark Rd (E of Newmills Rd)	E	41	23	-18	-44%	3
B7: A702 (South of City Bypass)	N	36	39	+3	+8%	0
B8: A701 (South of B702)	N	159	137	-22	-14%	2
B9: Lasswade Road (East of A768) *	N	91	105	+14	+15%	1
B10: A772 Gilmerton Rd (S of Bypass)	W	112	162	+50	+45%	4
B11: A7/A68 (S of Newton Church Rd)	N	146	123	-23	-16%	2
B12: A1 (E of A720 at Slaters Road) *	N	40	44	+4	+10%	1
B13: Newcraighall Road (E of Station)	W	22	133	+111	+505%	13
B14: A199 (East of B6415 Eastfield) *	W	140	419	+279	+199%	17
TOTAL – Rail Outbound		**2,568**	**2,400**	**-168**	**-7%**	**3**
TOTAL – Bus Outbound		**1,304**	**1,800**	**+496**	**+38%**	**13**
TOTAL - Outbound		**3,872**	**4,200**	**+328**	**+8%**	**5**

Table 50. Inter Peak Inbound Passenger Flows (per hour) (2014 Bus, 2012 Rail)

STATION/ROAD NAME	DIR	OBSERVED	MODELLED	DIFF	% DIFF	GEH
R1: South Gyle to Dalmeny	E	395	465	+70	+18%	3
R2: West of Edinburgh Park	E	754	879	+125	+17%	4
R3: Wester Hailes to Curriehill	E	184	226	+42	+23%	3
R4: Brunstane to Newcraighall	W	13	12	-1	-8%	0
R5: West of Musselburgh	W	478	425	-53	-11%	2
B1: A90 (Forth Road Bridge)	S	150	116	-34	-23%	3
B2: A8 (West of Airport) *	E	160	346	+186	+116%	12
B3: M9 (N of Newbridge)	S	23	42	+19	+83%	3
B4: M8 (W of Hermiston Gait)	E	98	128	+30	+31%	3
B5: A71 (W of Hermiston House Rd)	E	8	84	+76	+950%	11
B6: A70 Lanark Rd (E of Newmills Rd)	E	52	23	-29	-56%	5
B7: A702 (South of City Bypass)	N	8	50	+42	+525%	8
B8: A701 (South of B702)	N	111	194	+83	+75%	7
B9: Lasswade Road (East of A768) *	N	162	130	-32	-20%	3
B10: A772 Gilmerton Rd (S of Bypass)	W	112	279	+167	+149%	12
B11: A7/A68 (S of Newton Church Rd)	N	170	132	-38	-22%	3
B12: A1 (E of A720 at Slaters Road) *	N	30	80	+50	+167%	7
B13: Newcraighall Road (E of Station)	W	18	74	+56	+311%	8
B14: A199 (East of B6415 Eastfield) *	W	260	479	+219	+84%	11
TOTAL – Rail Inbound		**1,824**	**2,007**	**+183**	**+10%**	**4**
TOTAL – Bus Inbound		**1,362**	**2,157**	**+795**	**+58%**	**19**
TOTAL - Inbound		**3,186**	**4,164**	**+978**	**+31%**	**16**

SYSTRA

Table 51. Inter Peak Outbound Passenger Flows (per hour) (2014 Bus, 2012 Rail)

STATION/ROAD NAME	DIR	OBSERVED	MODELLED	DIFF	% DIFF	GEH
R1: South Gyle to Dalmeny	E	433	568	+135	+31%	6
R2: West of Edinburgh Park	E	578	773	+195	+34%	8
R3: Wester Hailes to Curriehill	E	218	237	+19	+9%	1
R4: Brunstane to Newcraighall	W	16	15	-1	-6%	0
R5: West of Musselburgh	W	468	513	+45	+10%	2
B1: A90 (Forth Road Bridge)	S	100	137	+37	+37%	3
B2: A8 (West of Airport) *	E	255	300	+45	+18%	3
B3: M9 (N of Newbridge)	S	16	93	+77	+481%	10
B4: M8 (W of Hermiston Gait)	E	67	111	+44	+66%	5
B5: A71 (W of Hermiston House Rd)	E	14	69	+55	+393%	9
B6: A70 Lanark Rd (E of Newmills Rd)	E	41	26	-15	-37%	3
B7: A702 (South of City Bypass)	N	20	44	+24	+120%	4
B8: A701 (South of B702)	N	106	140	+34	+32%	3
B9: Lasswade Road (East of A768) *	N	95	126	+31	+33%	3
B10: A772 Gilmerton Rd (S of Bypass)	W	73	232	+159	+218%	13
B11: A7/A68 (S of Newton Church Rd)	N	177	181	+4	+2%	0
B12: A1 (E of A720 at Slaters Road) *	N	36	90	+54	+150%	7
B13: Newcraighall Road (E of Station)	W	29	101	+72	+248%	9
B14: A199 (East of B6415 Eastfield) *	W	161	380	+219	+136%	13
TOTAL – Rail Outbound		**1,713**	**2,106**	**+393**	**+23%**	**9**
TOTAL – Bus Outbound		**1,190**	**2,030**	**+840**	**+71%**	**21**
TOTAL - Outbound		**2,903**	**4,136**	**+1,233**	**+42%**	**21**

Table 52. PM Peak Inbound Passenger Flows (per hour) (2014 Bus, 2012 Rail)

STATION/ROAD NAME	DIR	OBSERVED	MODELLED	DIFF	% DIFF	GEH
R1: South Gyle to Dalmeny	E	537	436	-101	-19%	5
R2: West of Edinburgh Park	E	1,494	1,368	-126	-8%	3
R3: Wester Hailes to Curriehill	E	113	343	+230	+204%	15
R4: Brunstane to Newcraighall	W	10	10	0	0%	0
R5: West of Musselburgh	W	510	404	-106	-21%	5
B1: A90 (Forth Road Bridge)	S	117	130	+13	+11%	1
B2: A8 (West of Airport) *	E	188	366	+178	+95%	11
B3: M9 (N of Newbridge)	S	35	71	+36	+103%	5
B4: M8 (W of Hermiston Gait)	E	93	158	+65	+70%	6
B5: A71 (W of Hermiston House Rd)	E	23	61	+38	+165%	6
B6: A70 Lanark Rd (E of Newmills Rd)	E	44	35	-9	-20%	1
B7: A702 (South of City Bypass)	N	9	20	+11	+122%	3
B8: A701 (South of B702)	N	100	170	+70	+70%	6
B9: Lasswade Road (East of A768) *	N	172	75	-97	-56%	9
B10: A772 Gilmerton Rd (S of Bypass)	W	143	166	+23	+16%	2
B11: A7/A68 (S of Newton Church Rd)	N	179	119	-60	-34%	5
B12: A1 (E of A720 at Slaters Road) *	N	23	96	+73	+317%	9
B13: Newcraighall Road (E of Station)	W	57	81	+24	+42%	3
B14: A199 (East of B6415 Eastfield) *	W	332	568	+236	+71%	11
TOTAL – Rail Inbound		**2,664**	**2,561**	**-103**	**-4%**	**2**
TOTAL – Bus Inbound		**1,515**	**2,116**	**+601**	**+40%**	**14**
TOTAL - Inbound		**4,179**	**4,677**	**+498**	**+12%**	**7**

Table 53. PM Peak Outbound Passenger Flows (per hour) (2014 Bus, 2012 Rail)

STATION/ROAD NAME	DIR	OBSERVED	MODELLED	DIFF	% DIFF	GEH
R1: South Gyle to Dalmeny	E	1,819	1,599	-220	-12%	5
R2: West of Edinburgh Park	E	2,768	2,846	+78	+3%	1
R3: Wester Hailes to Curriehill	E	780	720	-60	-8%	2
R4: Brunstane to Newcraighall	W	67	44	-23	-34%	3
R5: West of Musselburgh	W	1,846	1,670	-176	-10%	4
B1: A90 (Forth Road Bridge)	S	345	435	+90	+26%	5
B2: A8 (West of Airport) *	E	554	657	+103	+19%	4
B3: M9 (N of Newbridge)	S	21	126	+105	+500%	12
B4: M8 (W of Hermiston Gait)	E	79	152	+73	+92%	7
B5: A71 (W of Hermiston House Rd)	E	90	120	+30	+33%	3
B6: A70 Lanark Rd (E of Newmills Rd)	E	97	66	-31	-32%	3
B7: A702 (South of City Bypass)	N	29	99	+70	+241%	9
B8: A701 (South of B702)	N	418	472	+54	+13%	3
B9: Lasswade Road (East of A768) *	N	491	270	-221	-45%	11
B10: A772 Gilmerton Rd (S of Bypass)	W	336	576	+240	+71%	11
B11: A7/A68 (S of Newton Church Rd)	N	641	179	-462	-72%	23
B12: A1 (E of A720 at Slaters Road) *	N	160	156	-4	-3%	0
B13: Newcraighall Road (E of Station)	W	41	149	+108	+263%	11
B14: A199 (East of B6415 Eastfield) *	W	544	1,054	+510	+94%	18
TOTAL – Rail Outbound		**7,280**	**6,879**	**-401**	**-6%**	**5**
TOTAL – Bus Outbound		**3,846**	**4,511**	**+665**	**+17%**	**10**
TOTAL - Outbound		**11,126**	**11,390**	**+264**	**+2%**	**2**

Note that some 2007 and 2014 observed counts were undertaken in a different location along the various corridors (*Denoted by red font). No count data was available for the M9, M8 West of Newbridge and the A70 Lanark Road within the 2007 data set, therefore 2014 data has been patched-in to provide a more consistent comparison.

2007 Based Data

Table 54. Summary of AM Peak Validation Across 38 Sites (10 rail, 28 bus) 2007 Data

MODE	WITHIN 25%	GEH <5	GEH <10
Rail	70%	50%	100%
Bus	46%	46%	89%
Rail & Bus	53%	47%	92%

Table 55. Summary of Inter Peak Validation Across 38 Sites (10 rail, 28 bus) 2007 Data

MODE	WITHIN 25%	GEH <5	GEH <10
Rail	80%	80%	100%
Bus	57%	71%	93%
Rail & Bus	63%	74%	95%

Table 56. Summary of PM Peak Validation Across 38 Sites (10 rail, 28 bus) 2007 Data

MODE	WITHIN 25%	GEH <5	GEH <10
Rail	90%	80%	90%
Bus	46%	54%	79%
Rail & Bus	58%	61%	82%

8.3.3 The 2007 based total screenline level analysis illustrates the rail passenger volumes compare favourably with observed data. However, the bus-based comparisons are considerably more varied and this impacts the overall level of public transport validation.

8.3.4 Generally, the model underestimates public transport passenger volumes when compared to 2007 based data, with some considerable variation for specific routes.

2014 Based Bus Data

Table 57. Summary of AM Peak Validation Across 38 Sites (10 rail, 28 bus) 2014 Data

MODE	WITHIN 25%	GEH <5	GEH <10
Rail	70%	50%	100%
Bus	46%	50%	82%
Rail & Bus	53%	50%	87%

Table 58. Summary of Inter Peak Validation Across 38 Sites (10 rail, 28 bus) 2014 Data

MODE	WITHIN 25%	GEH <5	GEH <10
Rail	80%	80%	100%
Bus	46%	50%	75%
Rail & Bus	55%	58%	82%

Table 59. Summary of PM Peak Validation Across 38 Sites (10 rail, 28 bus) 2014 Data

MODE	WITHIN 25%	GEH <5	GEH <10
Rail	90%	80%	90%
Bus	39%	46%	71%
Rail & Bus	53%	55%	76%

8.3.5 The (2014-based) total screenline level analysis suggests that the level of modelled bus passenger compares less favourably with this more recent observed data set.

8.3.6 Generally, the model underestimates public transport passenger volumes when compared to 2014 based data, with some considerable over-estimates for specific routes.

2005 Based Joint Revenue Committee (JRC) comparisons

8.3.7 Tables 60-63 describe SRM12 bus passenger volume comparisons with the older 2005 data sets collected as part of the Edinburgh JRC model. The count locations are illustrated in Figure 18. This alternative data set suggests that the SRM12 contains some considerable underestimates within central areas. It also suggests that model provides an underestimates across the Western Screenline – whereas the recent 2014 based bus count at the A8 suggested the model over estimates bus passenger volumes.

The variations in bus passenger volumes demonstrates the potential benefit for collecting a new set of Edinburgh bus patronage data to assist model calibration and validation.

Table 60. AM Peak Screenline Validation Across 56 Bus Sites (2005 JRC Data)

SCREENLINE	DIRECTION	OBS FLOW	DIFFERENCE	% DIFFERENCE
City Centre Screenline	Inbound	20,182	-7,314	-36%
	Outbound	6,475	1,096	17%
	Total Two Way	***26,657***	***-6,218***	**-23%**
Foreshore Screenline	Inbound	386	133	34%
	Outbound	283	6	2%
	Total Two Way	***669***	***139***	**21%**
Western Screenline	Inbound	2,136	-667	-31%
	Outbound	1,971	-404	-20%
	Total Two Way	***4,107***	***-1,071***	**-26%**
Inner Southeast Screenline	Inbound	3,335	-172	-5%
	Outbound	1,081	357	33%
	Total Two Way	***4,416***	***184***	**4%**
Outer Southeast Screenline	Inbound	1,776	741	42%
	Outbound	854	409	48%
	Total Two Way	***2,630***	***1,150***	**44%**
	Total	**38,479**	**-5,816**	**-15%**

Table 61. Inter Peak Screenline Validation Across 56 Individual Bus Sites (2005 JRC Data)

SCREENLINE	DIRECTION	OBS FLOW	DIFFERENCE	% DIFFERENCE
City Centre Screenline	Inbound	7,767	-2,667	-34%
	Outbound	6,157	-1,543	-25%
	Total Two Way	***13,924***	***-4,211***	**-30%**
Foreshore Screenline	Inbound	243	-41	-17%
	Outbound	283	-56	-20%
	Total Two Way	***526***	***-97***	**-18%**
Western Screenline	Inbound	869	65	7%
	Outbound	1,104	-287	-26%
	Total Two Way	***1,973***	***-223***	**-11%**
Inner Southeast Screenline	Inbound	1,312	-16	-1%
	Outbound	1,166	74	6%
	Total Two Way	***2,478***	***58***	**2%**
Outer Southeast Screenline	Inbound	792	402	51%
	Outbound	780	213	27%
	Total Two Way	***1,572***	***615***	**39%**
	Total	**20,473**	**-3,857**	**-19%**

Table 62. PM Peak Screenline Validation Across 56 Individual Bus Sites (2005 JRC Data)

SCREENLINE	DIRECTION	OBS FLOW	DIFFERENCE	% DIFFERENCE
City Centre Screenline	Inbound	8,599	-1,193	-14%
	Outbound	17,107	-5,341	-31%
	Total Two Way	***25,706***	***-6,534***	**-25%**
Foreshore Screenline	Inbound	416	-160	-38%
	Outbound	241	206	85%
	Total Two Way	***657***	***46***	**7%**
Western Screenline	Inbound	1,432	272	19%
	Outbound	2,669	-833	-31%
	Total Two Way	***4,101***	***-561***	**-14%**
Inner Southeast Screenline	Inbound	1,329	223	17%
	Outbound	2,797	86	3%
	Total Two Way	***4,126***	***309***	**7%**
Outer Southeast Screenline	Inbound	958	420	44%
	Outbound	2,209	-115	-5%
	Total Two Way	***3,167***	***305***	**10%**
	Total	**37,757**	**-6,435**	**-17%**

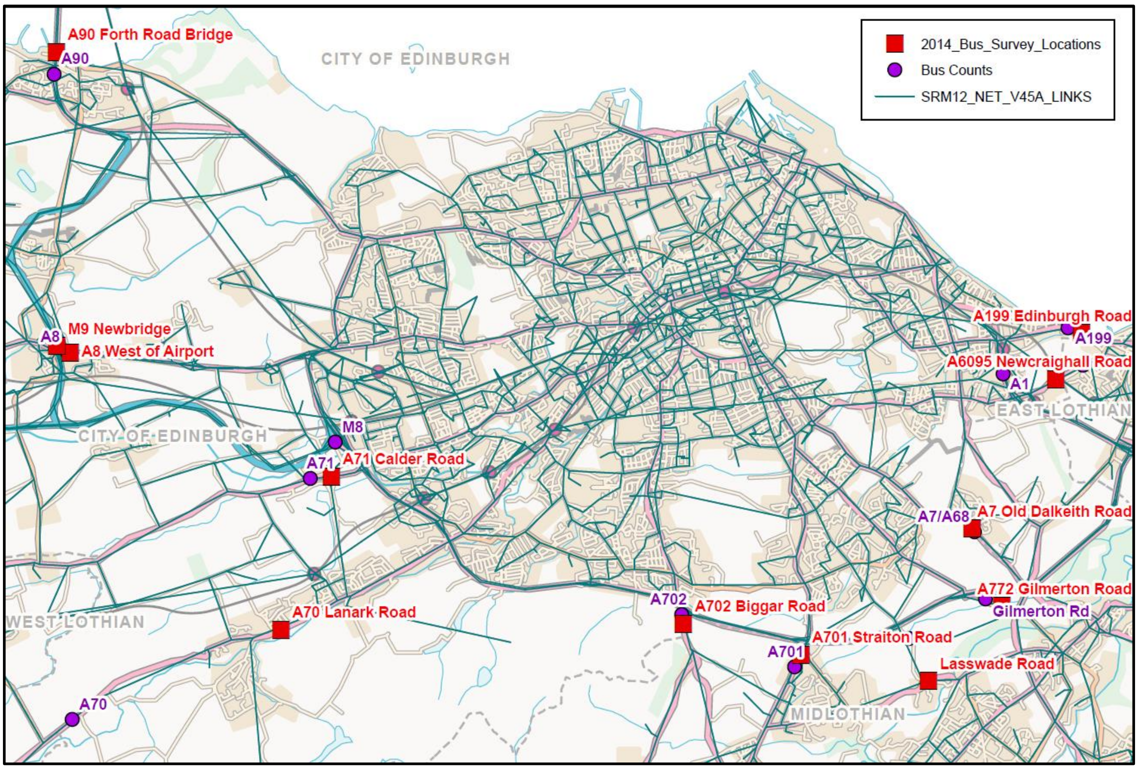

Figure 17. 2007 & 2014 Observed Patronage Count Screenlines

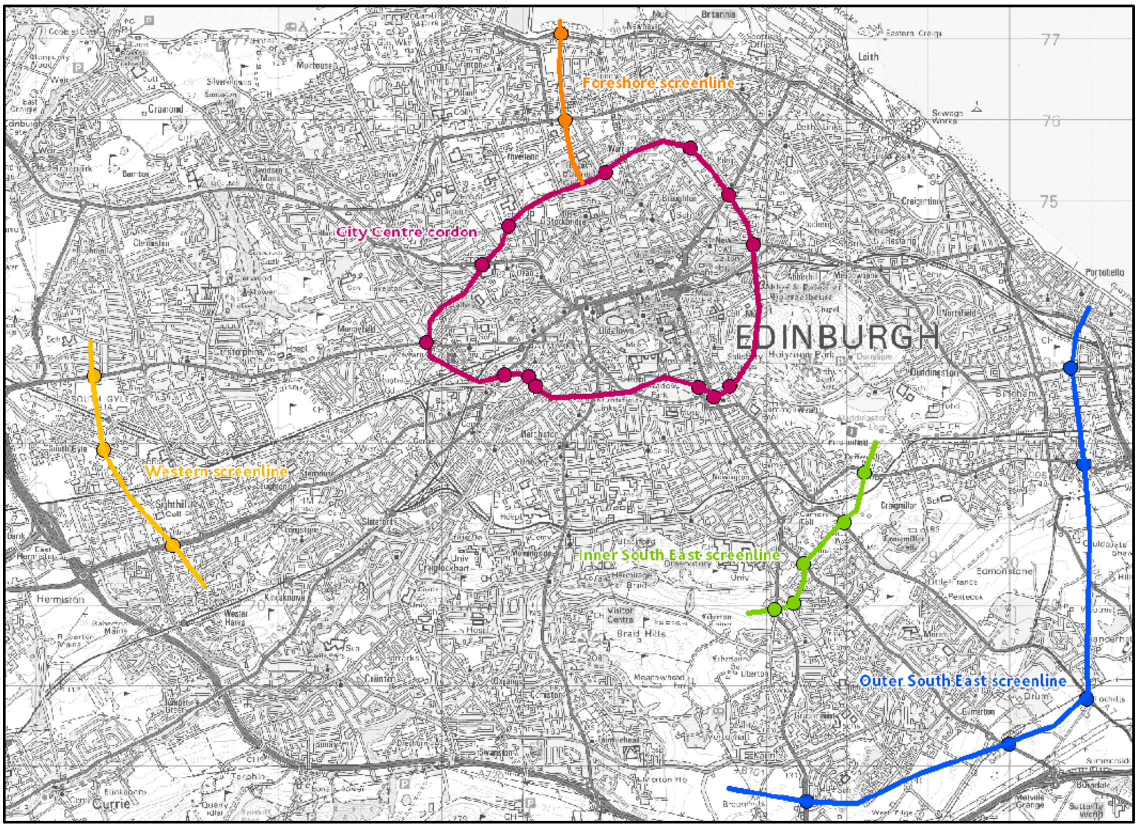

Figure 18. JRC Observed Patronage Count Screenlines

8.4 Bus Journey Time Validation

8.4.1 The SRM12 bus journey times are calculated on the basis of assigned road speeds, and also take account of bus network infrastructure, such as bus lanes, and allow for a generic representation of the time to board and alight services. This section compares the modelled bus journey times with timetabled (from 2015) bus journey times.

8.4.2 The journey time analysis was undertaken on a sample of the SRM12 coded services intended to give a representative geographical distribution. The journey time validation is described for each time period in Tables 63 to 65 and a description of each route is presented in Table 66.

Table 63. AM Peak Bus Journey Time Validation

OPERATOR	SERVICE	DIR.	TIMETABLE	SRM12 JT	DIFF	% DIFF
Stagecoach Fife	X58/X60	In	169	183	14	8%
		Out	177	182	5	3%
Stagecoach Fife	X24	In	132	144	12	9%
		Out	121	141	10	8%
First Borders	62	In	112	116	4	3%
		Out	115	120	5	4%
Airlink	100	In	30	35	5	17%
		Out	34	31	-3	-10%
Lothian	15A	In	60	57	-3	-4%
		Out	68	65	-3	-4%
Lothian	X48	In	74	78	4	6%
		Out	68	75	7	10%
Scottish CityLink	M91	In	105	102	-3	-3%
		Out	100	107	7	7%
First Edinburgh	38	In	148	136	-12	-8%
		Out	141	128	-14	-10%
First Edinburgh	124	In	99	107	8	8%
		Out	94	100	6	6%

OPERATOR	SERVICE	DIR.	TIMETABLE	SRM12 JT	DIFF	% DIFF
Lothian	44 44A	In	98	85	-13	-13%
		Out	95	84	-11	-11%
Scottish Citylink	900	In	52	63	11	21%
		Out	48	50	2	4%
Lothian	15	In	107	99	-8	-7%
		Out	113	102	-12	-10%
Lothian	26	In	97	80	-17	-17%
		Out	90	75	-15	-16%
Lothian	49	In	102	90	-12	-11%
		Out	102	87	-15	-14%
Lothian	47	In	78	67	-11	-14%
		Out	75	67	-8	-11%
Stagecoach Fife	55	In	80	74	-6	-8%
		Out	62	71	9	14%

Table 64. IP Peak Bus Journey Time Validation

OPERATOR	SERVICE	DIR.	TIMETABLE	SRM12 JT	DIFF	% DIFF
Stagecoach Fife	X58/X60	In	159	170	11	7%
		Out	162	176	14	9%
Stagecoach Fife	X24	In	127	138	11	8%
		Out	126	134	8	6%
First Borders		In	112	112	0	0%
		Out	115	120	5	4%
Airlink		In	28	29	1	3%
		Out	30	29	-1	-3%

OPERATOR	SERVICE	DIR.	TIMETABLE	SRM12 JT	DIFF	% DIFF
Lothian	15A	In	59	58	-1	-2%
		Out	62	57	-5	-7%
Lothian	X48	In	74	70	-3	-4%
		Out	73	70	-3	-4%
Scottish Citylink	M91	In	100	97	-3	-3%
		Out	100	96	-4	-4%
First Edinburgh	38	In	141	124	-17	-12%
		Out	141	124	-17	-12%
First Edinburgh	124	In	98	101	3	3%
		Out	94	100	6	6%
Lothian	44 44A	In	93	82	-11	-12%
		Out	97	80	-17	-17%
Scottish Citylink	900	In	46	49	3	6%
		Out	48	49	1	1%
Lothian	15	In	107	95	-12	-11%
		Out	108	94	-14	-13%
Lothian	26	In	94	73	-21	-22%
		Out	92	72	-20	-21%
Lothian	49	In	97	86	-11	-12%
		Out	101	83	-18	-18%
Lothian	47	In	74	64	-10	-14%
		Out	69	66	-3	-4%
Stagecoach Fife	55	In	62	62	0	0%
		Out	62	66	4	6%

Table 65. PM Peak Bus Journey Time Validation

OPERATOR	SERVICE	DIR.	TIMETABLE	SRM12 JT	DIFF	% DIFF
Stagecoach Fife	X58/X60	In	159	178	19	12%
		Out	162	194	32	20%
Stagecoach Fife	X24	In	137	146	9	6%
		Out	128	143	15	12%
First Borders	62	In	109	113	4	4%
		Out	128	126	-2	-2%
Airlink	100	In	31	31	0	0%
		Out	34	33	-1	-2%
Lothian	15A	In	67	65	-2	-3%
		Out	68	60	-8	-11%
Lothian	X48	In	74	77	3	4%
		Out	73	79	5	7%
Scottish CityLink	M91	In	108	113	5	5%
		Out	101	103	2	2%
First Edinburgh	38	In	134	130	-4	-3%
		Out	149	134	-15	-10%
First Edinburgh	124	In	98	103	5	5%
		Out	101	105	4	4%
Lothian	44 44A	In	96	89	-7	-8%
		Out	98	86	-12	-13%
Scottish Citylink	900	In	56	52	-5	-8%
		Out	53	59	6	11%
Lothian	15	In	116	100	-16	-14%

OPERATOR	SERVICE	DIR.	TIMETABLE	SRM12 JT	DIFF	% DIFF
		Out	118	101	-17	-14%
Lothian	26	In	94	78	-16	-17%
		Out	92	78	-14	-15%
Lothian	49	In	100	94	-6	-6%
		Out	104	91	-13	-13%
Lothian	47	In	70	65	-5	-6%
		Out	75	72	-3	-4%
Stagecoach Fife	55	In	62	69	7	11%
		Out	72	82	10	13%

Table 66. Bus Journey Time Validation – Route Descriptions

SERVICE	ROUTE DESCRIPTION
X58/X60	St Andrews - Anstruther - Leven - Kirkcaldy - Edinburgh
X24	St Andrews - Glenrothes - Dunfermline - Cumbernauld - Glasgow
62	Melrose - Galashiels - Innerleithen - Peebles - Penicuik - Edinburgh
100	Edinburgh - Corstorphine - Edinburgh Airport
15A	St. Andrew Square - Penicuik
X48	Ratho - Ingliston P&R - Haymarket - Sheriffhall P&R
M91	Edinburgh - Ferrytoll P+R - Dunfermline - Duloch Park - Perth
38	Stirling - Bannockburn - Falkirk - Linlithgow - Edinburgh
124	North Berwick - Edinburgh
44	Balerno - St. Andrews Square - Wallyford
44A	Wallyford - St. Andrews Square - Balerno High School - Balerno
900	Glasgow - Baillieston - Harthill - Ingliston - Edinburgh

SERVICE	ROUTE DESCRIPTION
15	Tranent - Musselburgh - St. Andrew Square - Auchendinny - Penicuik
26	Seton Sands - Musselburgh - St. Andrew Square - Clerwood
49	The Jewel - North Bridge - Sheriffhall P&R - Rosewell
47	Ladywood - Penicuik - North Bridge - Granton Square.
55	Dunfermline - Rosyth - Inverkeithing - Edinburgh

Table 67. Bus Journey Time Validation Summary (within 15% of Bus Timetable)

WITHIN 15% CRITERIA	AM PEAK BUS SERVICES / %		INTER PEAK BUS SERVICES / %		PM PEAK BUS SERVICES / %	
Yes	28	88%	28	88%	29	91%
No	4	13%	4	13%	3	9%

Table 68. Bus Journey Time Validation Summary (within 25% of Bus Timetable)

WITHIN 25% CRITERIA	AM PEAK BUS SERVICES / %		INTER PEAK BUS SERVICES / %		PM PEAK BUS SERVICES / %	
Yes	32	100%	32	100%	32	100%
No	0	0%	0	0%	0	0%

8.4.3 The bus journey time validation summary presented in Table 67 and Table 68 indicate that the public transport model provides a reasonable match with observed timetables with over 88% of services falling within 15% of the published journey time.

8.4.4 At the more detailed level, the SRM12 public transport model tends to overestimate journey times for longer distance services and underestimate some urban service journey times. This is likely to be a function of the rural bus speed weighting, and the difficulty of modelling some of the detailed congestion points along sections of bus routes within Edinburgh.

8.5 Census Commuter PT Movement Comparison

8.5.1 During the later stages of model development 2011 Census travel to work movements became available at the more detailed intermediate zone level. These data were grouped into a (Sub-Local Authority) sector system and used to compare SRM12 commuter travel movements contained within the final road and PT matrices.

8.5.2 The detailed comparisons of sector to sector movements are described within Appendix E. Tables 69 and 70 summarise the PT commuter matrices comparisons at the more aggregate Local Authority level for the AM Peak hour.

Table 69. % Difference in SRM12 PT Commuter Proportions Compared to 2011 Census

LA	EDINBURGH	EAST LOTHIAN	MID LOTHIAN	WEST LOTHIAN	FIFE	BORDERS
Edinburgh	0.3%	0.0%	0.0%	-0.4%	0.0%	0.0%
East Lothian	-0.1%	0.3%	0.0%	-0.2%	-0.1%	0.0%
Mid Lothian	0.3%	0.0%	-0.3%	0.0%	0.0%	0.0%
West Lothian	-3.6%	0.0%	0.0%	3.5%	0.0%	0.0%
Fife	-1.4%	0.0%	0.0%	-0.1%	1.4%	0.0%
Borders	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 70. Difference in SRM12 PT Commuters Compared to 2011 Census

LA	EDINBURGH	EAST LOTHIAN	MID LOTHIAN	WEST LOTHIAN	FIFE	BORDERS
Edinburgh	88	6	4	-50	2	0
East Lothian	5	6	1	-3	-1	0
Mid Lothian	45	0	6	0	0	0
West Lothian	-138	0	0	15	0	1
Fife	-44	0	0	-2	49	0
Borders	3	0	0	0	0	7

8.5.3 The Local Authority comparisons suggest that the SRM12 PT commuter matrix proportions are reasonably similar to the 2011 Census proportions, with all comparisons falling within +/-4%.

8.5.4 Note that the absolute differences described here are based on an uncalibrated Census data set, so these comparisons should only be used for broad comparisons.

8.5.5 The more detailed SRM12 sector to sector comparisons indicate a reasonable reflection of Census data, although travel proportions have a greater range between +15% to -22%. The analysis indicates that matrices generally overestimate commuter movements to central Edinburgh and underestimates to Edinburgh Southeast, Southwest inner, West and Southwest outer movements. There is also a general underestimate between West Lothian, East Lothian, Midlothian and Scottish Borders to some of the Edinburgh sectors.

8.6 Public Transport Conclusions & Recommendations

Conclusions

8.6.1 Using comparisons with observed data, the SRM12 displays a reasonable representation of observed public transport journey times and public transport passenger volumes. However, the differences in passenger levels recorded between the available observed data sets do tend to lower the confidence when making passenger comparisons.

8.6.2 The general view is that the comparisons indicate that the SRM12 modelled PT patronage tends to fall within these two (2007 and 2014-based) data sets. The model also records a reasonable reflection of the tidal nature of passenger flows to/from Edinburgh, and reasonable changes between time periods. Rail passenger comparisons also generally compare well.

8.6.3 The comparisons with the Joint Revenue Committee model data suggest a shortage of bus-based trips within central Edinburgh. This potentially reflects the lack of bus patronage data collection within the city centre area since the original model development, where only limited calibration is likely to be undertaken.

8.6.4 Whilst using the updated model to provide incremental comparisons will continue to be appropriate, the lack of definitive PT data should be borne in mind, if using the model to provide absolute changes in patronage levels. This limitation is more relevant within central Edinburgh, than when undertaking more strategic or cross-boundary comparisons.

Recommendations

8.6.5 A further and more extensive survey or bus patronage in and around Edinburgh would be beneficial to compare public transport flows. A new survey would also capture post Tram and Borders Railway passenger flows.

8.6.6 The detailed road and public transport movement data included within the underlying model, relies on some 2001 Census Travel to Work (TTW) movements. The inclusion of the 2011 TTW data would be advantageous, and significantly reduce one of the model limitations (age of underlying PT travel movements) and is also likely to improve the quality of central Edinburgh patronage levels.

9. PARK & RIDE SITE CHOICE DEVELOPMENT & CALIBRATION

9.1 Park & Ride Approach

9.1.1 The Park and Ride process is a distinct module which sits within the larger demand model structure. The module estimates the journeys which utilise each individual park and ride site (including rail station car parking) based on a range of parameters. These trips are then segmented to identify the individual 'legs' of the trip relevant to other modes i.e. the road trip From-Home to a site and the PT trip from a site to the ultimate destination.

Inputs

9.1.2 The inputs from the demand model to the park and ride process are origin-destination, from-home matrices which are outputs from the mode and destination choice within the demand model. Average generalised costs are also taken into account for the weighting mechanism applied within the park and ride process.

9.1.3 During calibration, a number of site specific parameters are used in tandem with global parameters to enable selection of trips between sites. These parameters are described in Tables 71 and 72.

Table 71. Global Park and Ride Parameters

PARAMETER	DESCRIPTION	DEFAULT VALUE
PnR Occupancy	Average occupancy of car using Park and Ride	1.2
PnR Lambda	Weighting parameter of the logit model	0.04
PnR Gamma	Road generalised cost weighting	1.7
PnR Alpha	PT generalised cost weighting	0.55
LParam	Parameter for adding on an imposition to sites with low capacity (effectively a proxy for search time)	40

Table 72. Site Specific Park and Ride Parameters

PARAMETER	DESCRIPTION	EXAMPLE VALUE
Site No.	Sequential number (beginning at 1) for each site	1
Site Name	Site name (enclosed by single quotes)	'Aberdour'
Zone	Actual Park and Ride zone (between (776-874))	777
Parking Charge	Parking Charge at site (in pence)	250
Attr	Attraction factor (minutes)	10

PARAMETER	DESCRIPTION	EXAMPLE VALUE
Bttr	Base attraction factor to rationalise over/under capacity sites within base year (minutes)	0
Near Cap	Formal capacity at the site (can take into account nearby non-station parking in some instances)	82
Far Cap	Formal 'far' capacity (0 is used for unlimited parking)	0
Origin Catchment	List of zones (enclosed by single quotes). Typically the local corridor and reflecting origin survey data.	'345-349'
Destination Catchment	List of zones (enclosed by single quotes). Typically all internal zones for rail or local urban centre for bus-based sites.	'1-739'

Note: site parking charges are converted to generalised minutes using a value of time. The base model currently applies a hard-coded VoT unchanged from the original TMfS07 modelling, and is therefore out of date. Although the forecasting models are treated consistently, this value should be updated in future base model updates, and ideally linked to the main values of time used within the demand modelling.

Processing

9.1.4 The generalised costs are calculated from the base road and public transport assignment model travel costs. A Park and Ride cost matrix is created, based on the minimum cost Park and Ride route available for each origin-destination movement.

9.1.5 Park and Ride trips, which have been calculated by the mode choice model, are then assigned to the best path Park and Ride site using the formula:

$$P_s = \frac{e^{-\lambda(\alpha HC_s + \gamma PC_s + A_s + Pk_s + LP/Near_s)}}{\sum_{s \in S} e^{-\lambda(\alpha HC_s + \gamma PC_s + A_s + Pk_s + LP/Near_s)}}$$

9.1.6 Where:

- P_s is the proportion of Park and Ride sites from a given origin using site *s*;
- λ is the spread parameter for the Park and Ride station choice;
- αHC_s is the weighted road generalised cost From-Home to site *s*;
- γPC_s is the weighted PT generalised cost from site s to destination;
- A_s is the attraction factor (which includes transfer time) for site *s*;
- Pk_s is the parking charge (if any) at sites; and
- *LP* is the search time parameter .

9.1.7 The Park and Ride module works separately for each travel purpose and calculates park and ride demand for Home-Based Work, Home-Based Employers Business and Home-Based Other simultaneously. The model generates car parking data by site for each travel purpose, and outputs from-home and to-home matrices by purpose and mode. These trips are then added to the road and PT matrices for route choice assignment.

9.1.8 External trips (i.e. those coming from North East England and the rest of Scotland) do not have the choice of using Park and Ride. These external trips can be adjusted during forecasting using factors to derive external forecasts.

9.1.9 The SRM12 applies the Park and Ride module within the AM and PM Peak periods only. A simple assumption is applied that all morning peak trips return in the evening peak time period (assuming the majority of travellers are commuters).

9.2 Overcapacity Feedback Mechanism

9.2.1 The Park and Ride process identifies sites which are overcapacity and therefore where motorists would need to park further away outside the main car park, or spend more time searching / waiting for a space. The model response increases the attraction factor by an increment for each additional car over capacity. This is to represent the increasing search and/or walk times associated with using the 'unofficial' car parking spaces.

9.2.2 The Park and Ride module has the ability to adjust the individual Attr factors at each site in the case that the site usage is greater than the formal Near capacity. It adjusts the factor based on the equation below.

$$Attr_{n+1} = Attr_n + Bttr + \frac{g(Dem - Near)\^2}{2Denom}$$

9.2.3 Where:

- *Attr* is the Attraction factor;
- *Bttr* is the Base Attraction factor which regulates sites which are overcapacity in the base year;
- *g* is the adjustment gradient;
- *Dem* is the site usage;
- *Denom* is the maximum of 1 and Dem; and
- *Near* is the near capacity of the site.

9.2.4 In addition, if the site exceeds the Far capacity then a significant adjustment is made to Attr defined by the parameter PnR_Penalty.

9.2.5 Since adjusting the Attr factors employs a looping mechanism there are three conditions which must be met to exit the loop (i.e. to reach convergence). There conditions include:

- The maximum absolute difference in demand at any site falls below the threshold a specified number of times in succession;
- The maximum absolute difference in Attr at any site falls below the threshold a specified number of times in succession; or
- The maximum number of loops are reached.

9.2.6 To allow user control over this mechanism, an additional set of catalog keys are employed in the model which are defined alongside default values. Table 73 describes the Park & Ride convergence parameters.

Table 73. Park and Ride Convergence Parameters

PARAMETER	DESCRIPTION	EXAMPLE VALUE
PnR_Penalty	Penalty for sites which exceed a stated (non-zero) far capacity	30
PnR_Grad	Gradient of the curve which adjusts sites exceeding near capacity	0.15
PnR_Threshold	The threshold for absolute changes in Attr to be considered converged	1
PnR_Dem_Threshold	The threshold for maximum absolute changes in Attr to be considered converged	1
PnR_Succ	The threshold for maximum absolute changes in demand to be considered converged	1
Max_PnR_Loop	The maximum number of Park and Ride loops allowed on a single demand model loop	20
Run PnR Model	Key which allows Park and Ride to be undertaken solely on first and last demand model loops, or on all loops.	All

9.3 Park & Ride Site Choice Calibration

Approach

9.3.1 The true origin destination Park and Ride matrices are input to the Park and Ride site choice module with no Attr adjustment (i.e. all sites with Attr = 0). This allows the global parameters to be evaluated in isolation with no bias inherited from the introduction of site specific attraction factors.

9.3.2 The focus of the global calibration related to the following parameters:

- PnR Lambda (λ);
- LParam; and
- PnR Alpha (α) (and conversely PnR gamma (γ) as discussed previously).

9.3.3 To establish the correlation of modelled and observed data, the number of sites which had a GEH < 5 (when comparing AM observed and modelled values) was considered as the primary gauge, although some larger sites were also considered in isolation.

9.3.4 Considering the λ parameter first, a range of values were tested between 0.01 and 0.5 and while little difference was seen in the total number of sites with GEH<5, a peak was observed at 0.02 which also showed a reasonable match between a number of larger sites.

9.3.5 The 'LParam' parameter was then considered using values between 0 and 60. Again, little difference was noticed at the global level but a peak was seen at LParam = 40 and this value was considered constant.

9.3.6 During examination of the NRTS dataset conclusions were drawn about the fitness for purpose of the WebTAG generalised cost parameters within the Park and Ride module. Analysis was undertaken on the largest true origin and destination cells to see which Park and Ride sites people tended to use. This was plotted alongside road, PT, and the combined generalised costs to plot a curve similar to a trip length distribution.

9.3.7 The results showed that, for the road leg motorists tended to use the closest park and ride site rather than sites farther away sites, which provided a relationship for increasing the road generalised cost component. The results also showed that there was weak correlation between the PT leg and combined generalised cost.

9.3.8 A weighting was therefore applied to both the road and PT costs to make the road cost more significant in the choice mechanism whilst reducing the public transport generalised cost, and continuing to retain an overall Park and Ride generalised cost that was of similar magnitude to the original combination.

9.3.9 While analysis of the NRTS dataset showed that increasing the road proportion of the overall generalised cost by 1.6 led to significantly better correlation on the cells in question, analysis of the parameter changes within the full Park and Ride model showed that $\alpha = 1.7$ and $\gamma = 0.55$ led to a stronger correspondence in the unweighted case.

Calibration of the Park and Ride Site Choice

9.3.10 Once global parameters for the Park and Ride module have been established, individual site usage is calibrated to reflect observed occupancy levels. This process includes altering the site attraction factors ('Attr') and refining catchment areas.

9.3.11 Table 74 describes the car park occupancy comparisons and associated capacity for a number of key Park and Ride sites.

9.3.12 It shows that there is a good match at the main bus-based Park and Ride sites around Edinburgh. However, the match is less good at the main rail-based sites. This is potentially caused by the model assigning demand to alternative nearby rail-based sites.

9.3.13 Table 75 describes at for each of the Local Authorities contained within the SRM12 coverage area.

9.3.14 It shows that at a Local Authority level there is a good match between the total capacity and the usage of the Park and Ride sites. The two Local Authorities that perform the worst are Perthshire & Kinross and Clackmannanshire which have two and one site in them respectively, making improved calibration more difficult.

9.3.15 Table 76 summarise the GEH statistics across all park and ride sites. Appendix F describes the calibration statistics for all 68 Park and Ride sites within the SRM12. It indicates that none of the sites have a GEH above 5, and the vast majority (84%) are under 3. This implies a high level of calibration.

Table 74. Park and Ride Key Sites Calibration Summary

SITE	OBSERVED OCCUPANCY	MODELLED OCCUPANCY	DIFFERENCE	% DIFFERENCE
Ferrytoll	452	457	5	1%
Hermiston Gait	368	371	3	1%
Ingliston	466	462	-3	-1%
Sheriffhall	300	314	14	5%
Straiton	113	134	21	19%
Inverkeithing	347	364	17	5%
Kirkcaldy	413	372	-41	-10%
Linlithgow	189	158	-32	-17%
Livingston North	210	183	-26	-13%
Livingston South	124	107	-18	-14%
Wallyford	194	159	-35	-18%

Table 75. Park and Ride Calibration Summary by Local Authority

SITE	OBSERVED OCCUPANCY	MODELLED OCCUPANCY	DIFFERENCE	% DIFFERENCE
East Lothian	548	483	-64	-12%
City of Edinburgh	1,897	1,953	56	3%
West Lothian	985	921	-65	-7%
Falkirk	794	795	1	0%
Stirling	615	612	-3	-1%
Fife	1,891	1,890	-2	0%
Perthshire & Kinross	62	44	-18	-29%
Clackmannanshire	44	35	-9	-21%

Table 76. Park and Ride Calibration Summary Statistics

GEH	NUMBER OF SITES	PROPORTION
<3	57	84%
3-5	11	16%
>5	0	0%
Total	**68**	**100%**

10. DEMAND MODEL

10.1 Approach

10.1.1 The SRM12 demand model is based on CSTM12, but excludes inter peak park and ride modelling. The SRM12 Demand Model Structure is illustrated in Appendix G.

10.1.2 The Demand Model consists of the following components;

- Mode Choice;
- Destination Choice;
- Park & Ride Choice (AM Only);
- Generation of PM demand from the IP; and
- Generation of To-Home and Non-Home based demand.

10.1.3 There are separate demand models for each time period (AM and Inter peak only). Each model (i.e. mode/destination choice) is for From-Home trips only. The To-Home trips and Non-Home based trip ends are derived from the outputs of the From-Home models.

10.1.4 From-Home Education demand is added into the model after the main Mode and Destination choice model and To-Home and Non-Home based trips are calculated using the process as for the main purposes.

10.1.5 HGV and LGV travel movements are calculated within the trip end model process and are not subject to the demand response mechanisms.

Inputs & Outputs

10.1.6 The inputs to the Demand Model are:

- trip productions and attractions;
- generalised costs of travel by road and public transport modes from the base year assignment models;
- Parking Charges;
- External Demand Add-in matrices;
- park and ride site files – details provided in previous chapter; and
- model parameters.

10.1.7 The outputs from the demand model are matrices by time period and travel purpose – and park and ride demand for the AM peak.

Trip Ends

10.1.8 Trip ends, which contain production and attraction information by purpose, represent the level of trip making to input to the Demand Model. The trip ends are required by mode, household type, time period and journey purpose.

10.1.9 Trip generation forecasting (discussed later in this report) is undertaken using a combination of trip rates and land use planning data. These are used to create growth factors which are then applied to the SRM12 base year trip ends.

Generalised Costs

10.1.10 The first iteration of the demand model uses generalised costs from the base model to develop initial assignment matrices. On subsequent loops generalised costs are taken from the forecast assignment model skims.

Parking Charges

10.1.11 Parking charges are introduced by adding representative costs to the controlled areas of Edinburgh and other large towns. SRM12 also includes representation of parking charges for leisure travellers using Edinburgh Airport.

10.1.12 Parking charges vary by journey purpose, which reflects different types of journey having different average lengths of stay. Parking charges are required as an input to the calculation of generalised cost for use in the Demand Model, with average cost per car used.

10.1.13 There are three types of parking charges within the SRM12, these are:

- **long stay parking:** Applied to home based commute trips. This assumes that 15% of total trips to the city centre for work are variations of 'kiss and ride' so no cost for parking is incurred, and also that 40% park in private non-residential car parks. It is therefore assumed that 45% of total trips will pay this cost.
- **short stay:** this is applied 'To-Home based other' and 'Non-Home based other' trips. It is assumed that 80% of total trips will pay this charge; and
- **no charge:** this is applied to employers business trips as it is perceived that even if they pay a parking charge they will not perceive the cost.

10.1.14 Table 77 describes the average charges for each controlled parking area alongside the zones where they are applied. These costs are in 2012 prices and reflect a parking space weighted average car park charge over all car park sites in the area.

Table 77. Parking Charge Average Costs

CITY	DESTINATION ZONES	SHORT STAY (HBO)	LONG STAY (HBW)
Edinburgh	1-13,24-29,31-33,35,37,40,41,46,49-51,54,59-61,63-66,77-80,82,83,201-202,241,243	£3.61	£9.14
Dunfermline	362	£1.26	£3.40
Stirling	720-725	£1.74	£2.53
Falkirk	281,284,287,301,309	£1.41	£1.61
Edinburgh Airport	219	£3.89	£0.00

10.1.15 In application these costs are added to the base year generalised cost skim matrices after first being multiplied by the tolling parameter of the generalised cost equation. Table 78 shows the calculated values for addition to the cost matrices. The values are also halved for input into the demand model (i.e. half of the cost is perceived in each direction).

Table 78. Parking Charge as Generalised Costs (Minutes)

CITY	DESTINATION ZONES	SHORT STAY (HBO)	LONG STAY(HBW)
Edinburgh	1-13,24-29,31-33,35,37,40,41,46,49-51,54,59-61,63-66,77-80,82,83,201-202,241,243	23.48	33.40
Dunfermline	362	8.16	12.42
Stirling	720-725	11.31	9.23
Falkirk	281,284,287,301,309	9.15	5.88
Edinburgh Airport	219	31.55	0.00

Demand Model Parameters

10.1.16 The demand model parameters control the modelled sensitivity of the various traveller choices and also, to some extent, the fit of the model to base-year data.

10.1.17 The base-year demand model parameters include distribution model sensitivity parameters, mode choice scaling factors and mode specific constants. The base model also contains Park and Ride model parameters.

10.1.18 The sensitivity parameter values are calculated using the SRM12 travel demand matrices. These parameters are then subjected to realism testing as defined by the Variable Demand Model (VADMA) guidance in WebTAG; the implied sensitivities of the model have then been compared to the standard published values.

10.2 Other Choice models

10.2.1 The underlying CSTM12 modelling (which SRM12 was based upon) made reference to three ‘other’ choice models, including:

- Peak spreading;
- Macro time of day; and
- High occupancy vehicle (HOV) choice.

10.2.2 The first two choice models are not included within the SRM12 model structure. The underlying structure of the HOV choice model is available within the SRM12 and could be updated and utilised should it be require in the future. Reinstating the first two choice models would require updating and calibration prior to use.

10.3 Forecasting Procedures

Base Year Demand Model

10.3.1 The function of the Base-year Demand Model is to:

- demonstrate and validate the model operation and procedures to base year travel conditions;
- test the sensitivity of model parameters; and
- establish the incremental adjustment matrices.

Demand Model Forecasting

10.3.2 The forecasting process is designed to provide forecast matrices using an incremental procedure. The Base-Year Demand Model structure is designed to operate in an iterative manner to deal with the supply/demand convergence issue.

10.3.3 The general application of the Demand Model for forecasting requires the following inputs:

- model parameters;
- trip ends;
- road and public transport cost matrices; and
- road and public transport networks.

10.3.4 For a given forecast year and land-use scenario, the trip end creation procedure is run to produce forecast trip productions and attractions. Analyses of the broad travel demand effects of the land-use planning and economic assumptions (excluding the impacts of travel costs) can be undertaken at this stage. The remaining sub-models operate in an iterative manner to produce final road traffic and public transport assignments.

10.3.5 There are two main iterative loops in the modelling approach:

- **Inner Loops:** iterating between the Mode Choice and Distribution Choice Models;

- **External Loops:** iterating between Assignment Models and the Mode and Destination Choice Models.

10.3.6 The Inner Loops are the primary iterative process to achieve a converged state between the two main travel choices within the Demand Model - mode and distribution choice. It is necessary to undertake the inner loops before initiating the external loop.

10.3.7 The Inner Loops should be run until a converged state is reached. This may vary with the forecast year and economic assumptions and between a Do-Minimum and Do Something test. Testing has shown that four inner loops are generally adequate.

10.3.8 The external loop provides the link between the Assignment Models and the Demand Model. Infrastructure, PT services, pricing and congestion changes in a future year will change travel costs within the Assignment Models. From the resultant converged state assigned travel costs are skimmed and supplied to the Demand Model. The sub models are then run with the revised costs to complete the external loop.

10.3.9 As standard, the Public Transport model is only run on the first and last external loops of the Demand Model (primarily due to model run time constraints). However, if crowding effects are considered sufficient to cause large changes, it may be run on every external loop. The Road Assignment Model is run for each external Loop.

10.3.10 External loops should be run until a converged state is reached. This could vary depending on future year assumptions and between a Do-Minimum and Do-Something tests. External loop assignment matrices can be inspected between successive loops to determine whether to select to undertake further external Loops. Tests have shown that eight external loops are sufficient for most applications (and as a result this is the default setting in the model).

10.3.11 On each external loop of the demand model a process of trip damping takes place, which combines 50% of the current matrix, with 50% of that from the previous loop. This is the same in effect as the fixed step approach included in DIADEM and recommended in WebTAG.

10.4 The Incremental Forecasting Approach

10.4.1 The forecasting procedure for SRM12 is designed to operate in an incremental manner. Mode choice and distribution models can require a large number of factors to ensure a close match with observed data. Applying these models to estimate incremental changes from a well-established base situation removes reliance on these factors in the forecasting process. The Base-year Matrices are accepted as the best representation of the travel patterns in that year.

10.4.2 The Demand Model is operated to produce matrices for the Base year and Forecast year. We define the Forecast Year matrices in the following way:

- F = B + Sf - Sb (1); or
- F = B * Sf / Sb (2).

Where:

- B = base observed trips;
- Sb = base modelled trips;
- Sf = future modelled trips; and
- F = future trips.

Then we define five cases:

10.4.3 Case (1-2) are used where B is zero or where we have high B and low Sb, defined as the case where B/Sb>2.

10.4.4 Case (3-5) are used in the following circumstances:

- low B, high Sb;
- low B low Sb; and
- high B high Sb.

10.4.5 The incremental matrices remain constant for all applications, and the synthesised road and PT assignment trip matrices produced by a forecast run of the Demand Model are adjusted by the incremental matrices before assignment.

10.5 Model Parameters

10.5.1 The need to calculate and input changes to some of the model parameters for a forecast run of the Demand Model is standardised. The 'user defined' parameters for which forecast values are required are:

- generalised cost coefficients for road assignment – these are recalculated in line with TAG Unit 3.5.6;
- occupancy factors to convert from person to vehicle matrices – these are calculated using growth factors from WebTAG databook December 2015;
- values of time and vehicle operating costs – default values are based on relevant WebTAG (3.5.6) guidance; and
- the mode specific constants calculated for the base year are specific to the base year distribution of single and multi-car owning households. They remain constant in forecast year as the trip ends change relative to the change in household types.

10.5.2 Other Demand-based forecast inputs, such as trip ends and external add-ins are produced as part of the Trip End Model.

11. FROM-HOME & TO-HOME TRIP MATRIX DERIVATION

11.1 From-Home Matrix Derivation

Previous Processing Procedures

11.1.1 During development of TMfS07 and SRM07 From-Home matrices were developed from a combination of data sources including:

- 2001 Census;
- Planning data, trip rates and matrix synthesising; and
- WebTAG guidance.

11.1.2 These allowed From-Home matrices to be developed independently and then subsequently passed through the reverse factoring portion of the demand model to create 'prior' matrices for the assignment models, as advised by WebTAG.

11.1.3 However, there was no mechanism employed to pass back any alterations that occurred during the assignment model calibration process. This lead to deviations from the demand model and the calibrated assignment matrices that were accounted for using an incremental adjustment.

SRM12 From-Home Matrix Derivation

11.1.4 As SRM12 has limited new travel pattern data specific to From-Home trips and relies heavily on point data (traffic counts etc.) for road and public transport assignment calibration an alternative approach was used to derive From-Home trips. This approach focusses on the assignment matrices as the starting point to derive From-Home matrices.

11.1.5 A starting point was derived from the From-Home proportion of the assignment matrices at a disaggregate level and applying the proportions to the assignment matrices. At the same time, car availability proportions were applied.

11.1.6 From these initial From-Home matrices, the reverse factoring process is undertaken and then comparisons were drawn between the summed From-Home, To-Home and Non-Home based and the demand level (persons per period) assignment matrices. A matrix of factors is derived to apply to the From-Home matrices to reconcile the outcome demand matrices with the assignment matrices (as the From-Home trips constitute the majority of the AM and Inter peak totals). This process is then repeat for 15 iterations, when the factors applied have converged towards one.

11.1.7 Having established a reasonable fit of From-Home to derive the assignment matrices, the trip rates were then rationalised against the planning data to prevent growth rates in forecasting becoming unstable.

11.2 Reverse and Non-Home-Based Trips

11.2.1 The demand works at for From-Home journey purposes for the AM peak and Inter peak periods only. Further factoring procedures are then run to calculate the PM From-Home trips, To-Home and Non-Home based trips.

Evening PM Peak Trips

11.2.2 For the evening peak, From-Home trips were generated by factoring the From-Home trips for the Inter peak time period.

We then have:

$$T_{ij}^{(pmpeak)\,pm} = \delta^{pm} * T_{ij}^{(\text{interpeak})\,pm}$$

where, $$\delta^{pm} = \frac{\sum_{T,P,M} V_{TPM}^{(pmpeak)\,pm}}{\sum_{T,P,M} V_{TPM}^{(\text{interpeak})\,pm}}$$

'To-Home' Trips

11.2.3 Some definitions need to be made so that the process for creating To-Home trips can be defined more precisely, including:

- *t* the time period of the From-Home trip;
- *p* the journey purpose of the From-Home trip;
- *m* the mode of the From-Home trip;
- *T* the time period of the To-Home trip;
- *P* the journey purpose of the To-Home trip; and
- *M* the mode of the To-Home trip.

11.2.4 For From-Home, we have three time periods – AM peak, Inter peak and PM peak, three home based purposes – work (HBW), employer's business (HBEB) and other (HBO), and two modes, each by four car availability segments.

11.2.5 The To-Home trips are derived from the From-Home trips as follows:

$$T_{ij(to)}^{TMP} = \sum_{t,p,m} \{\alpha_{TPM}^{tpm} * T_{ji(from)}^{tpm}\}$$

where:

$T_{ij(to)}^{TMP}$ = *To-Home person trips from origin i to destination j in time period **T** for home based purpose **P** by mode **M**;*

$T_{ji(from)}^{tpm}$ = *From-Home* person trips from origin *j* to destination *i* in time period **t** for *home based* purpose **p** by mode **m**; and

α_{TPM}^{tpm} = factors by *From-Home* time period **t**, *From-Home* purpose **p***, From-Home* mode **m***, To-Home* period **T**, *To-Home* purpose **P** and *To-Home* mode **M**.

Note that α_{TPM}^{tpm} = 0 for *From-Home* time periods later than the *To-Home* time period, i.e. *To-Home* trips in the AM peak for example, cannot be linked to *From-Home* trips in the Inter peak.

11.2.6 The parameters α_{TPM}^{tpm} were calculated from the results of the tabulations from the Scottish Household Survey. The details of return journeys for each *From-Home* trip made by the sampled adult were tabulated so that for each $T_{ij(from)}^{tpm}$ the return trips $T_{ji(to)}^{TPM}$ were included. The cell entries in the table can be called V_{TPM}^{tpm}. We then define:

$$\alpha_{TPM}^{tpm} = \frac{V_{TPM}^{tpm}}{\sum_{T,P,M} V_{TPM}^{tpm}}$$

Non-Home-Based Trips

11.2.7 For Non-Home based trips, the origins and destinations for the two Non-Home based purposes (In-Work and Non-Work) were calculated based on the destinations of From-Home trips and the origins of To-Home trips. The Non-Home based trip ends were calculated separately by time period.

11.2.8 For Non-Home based origins:

$$O_i^{tnm} = \sum_{p,t} \left(\beta_{I(from\text{home})}^{ntpm} * D_{i(from\text{home})}^{tpm} \right)$$

11.2.9 For *Non-Home based* destinations

11.2.10 $$D_j^{tnm} = \sum_{p,t} \left(\beta_{J(to\text{home})}^{ntpm} * O_{j(to\text{home})}^{tpm} \right)$$

where:

- n is the Non-Home based purpose i.e. work or Non-Work.
- Note that the factors β are zero for time periods later than the Non-Home based origins/destinations.

11.2.11 It is unlikely that the total origins will equal the total destinations when applying this process, so the totals will be constrained to an average of the two. Matrices of Non-Home based trips by mode and time period will be created by applying the trip ends to a distribution model using appropriate inter zonal costs.

11.2.12 The total trips by mode are calculated simply by adding the origin-destination matrices together for public transport, and weighting by vehicle occupancy for car trips.

12. DESTINATION AND MODE CHOICE CALIBRATION

12.1 Preliminary Data Inspection

12.1.1 Census (commuting) and SHS (Business/ Other) trip data used for the SRM12 shows a good relationship between the generalised cost of travel (in minutes) and journey distance. It also shows a decrease in public transport mode share at greater distances.

12.1.2 The distribution of trips by journey length shows, as expected, a distribution that is negatively skewed, with a peak volume between 0 and 5km and a long tail (illustrated in Appendix H). Section 5.3 illustrates observed commuter patterns, which show intuitive travel movements across the model coverage, with Edinburgh the primary focus of the main commuter flows.

12.1.3 This data exploration shows plausible patterns and trends in travel demand and travel costs and suggests that the data provides a good foundation on which to develop mode and destination choice models. Note that although the Census provides extensive data to compare relationships, the SHS records a much lower sample of business and other trips. Census data covers all commuting movements and it is not possible to distinguish travel frequency or weekday only travel to directly observe variations for specific movements.

12.2 Model Parameters

12.2.1 WebTAG median parameters were adopted and used to calibrate the mode and destination choice parameters, with manual alterations undertaken to better match observed trip length distribution by period, purpose, car availability and mode.

12.2.2 The mode and destination choice parameters are shown in tables 79 to 82. As the WebTAG parameters were used as a starting point the coefficients for the Ln(Cost) and Intra-zonal parameters are all zero.

12.2.3 A full set of trip length distributions, comparing the observed and modelled values are included within Appendix H.

Table 79. C1/1 Mode and Destination Choice Parameters

C1/1 PARAMETERS	SEGMENT	HBE	HBO	HBW
Home Based Mode Choice, θ	AM	0.45	0.53	0.68
	IP	0.45	0.53	0.68
Home Based C Params, β2	AM Car	-0.062	-0.055	-0.068
	IP Car	-0.067	-0.082	-0.069
	AM PT	-0.015	-0.021	-0.033
	IP PT	-0.018	-0.026	-0.023
	AM P&R	-0.051	-0.050	-0.045

Table 80. C1/2+ Mode and Destination Choice Parameters

C1/1 PARAMETERS	SEGMENT	HBE	HBO	HBW
Home Based Mode Choice, θ	AM	0.45	0.53	0.68
	IP	0.45	0.53	0.68
Home Based C Params, β2	AM Car	-0.065	-0.055	-0.065
	IP Car	-0.067	-0.082	-0.065
	AM PT	-0.012	-0.015	-0.033
	IP PT	-0.018	-0.021	-0.023
	AM P&R	-0.051	-0.050	-0.045

Table 81. C2+ Mode and Destination Choice Parameters

C1/1 PARAMETERS	SEGMENT	HBE	HBO	HBW
Home Based Mode Choice, θ	AM	0.45	0.53	0.68
	IP	0.45	0.53	0.68
Home Based C Params, β2	AM Car	-0.067	-0.055	-0.065
	IP Car	-0.067	-0.082	-0.065
	AM PT	-0.021	-0.019	-0.033
	IP PT	-0.026	-0.026	-0.023
	AM P&R	-0.051	-0.050	-0.045

Table 82. C0 Mode and Destination Choice Parameters

C1/1 PARAMETERS	SEGMENT	HBE	HBO	HBW
Home Based Mode Choice, θ	AM	0.45	0.53	0.68
	IP	0.45	0.53	0.68
Home Based C Params, β2	AM PT	-0.031	-0.015	-0.029
	IP PT	-0.036	-0.021	-0.033

12.3 Model Results: Mode Specific Constants

12.3.1 In order to ensure that the synthesised modal split is consistent with the mode split in the base-year trip ends, the mode specific constants have been calculated for each zone using the following formulae:

Kcar = (Up&r - UCar) + {(1/ θ) * log (PCar/Pp&r); and

Kpt = (Up&r – Upt) + {(1/ θ) * log (Ppt/Pp&r).

12.3.2 Where:

- Upt - composite utility for public transport;
- Up&r - composite utility for Park and Ride;
- UCar - composite utility for car;
- θ - mode choice scaling factor (see Table 5.2);
- PCar - proportion of car in base;
- Pp&r - proportion of Park and Ride in base; and
- Ppt - proportion of public transport in base.

12.3.3 These formulae have been derived from the mode split formulation and are carried out for each journey purpose.

12.4 Non-Home-Based Destination Choice

12.4.1 The destination choice sensitivity parameters are taken directly from WebTAG and are shown in Table 84. Note that, unlike TMfS07 there is no change in the factors for car availability (as there are no values available from WebTAG). Also, as WebTAG parameters were used the Ln(Cost) and Intra-Zonal parameters are all zero.

Table 83. Non-Home-Based Destination Choice Parameters

C1/1 PARAMETERS	SEGMENT	NON-HOME BASED EMPLOYERS BUSINESS	NON-HOME BASED OTHER
Non-Home Based C,β2	AM Car	-0.081	-0.077
	IP Car	-0.081	-0.077
	PM Car	-0.081	-0.077
	AM PT	-0.042	-0.033
	IP PT	-0.042	-0.033
	PM PT	-0.042	-0.033

13. MODEL REALISM TESTS

13.1 Model Response Validation Approach

13.1.1 As part of SRM12 development, the mode and destination choice calibration has been validated to ensure that an appropriate response is presented for a range of potential impacts. Model Realism Tests have been run according to the WebTAG (Variable Demand Modelling) guidance in WebTAG Unit M2 (Jan 2014).

13.1.2 The advice on Variable Demand Modelling (WebTAG) recommends carrying out realism tests to check the elasticity of demand with respect to:

- car journey time;
- car fuel price; and
- public transport fares.

13.1.3 The tests undertaken to test these responses within the demand model were as follows:

- 10% increase in generalised cost (as a proxy for journey times);
- 10% increase in fuel costs; and
- 10% increase in PT fares.

13.1.4 To analyse the outputs, the elasticities are calculated on the entire simulated modelled area (the 'internal demand model zones') with the following calculation:

$$e = (\ln(K') - \ln(K)) / (\ln(C') - \ln(C))$$

Where:

- C is the initial calibrated cost;
- C' is the respondent cost;
- K is the total base car kilometres; and
- K' is the respondent total car kilometres.

13.1.5 This method of calculating the elasticity ensures the same resulting elasticity, regardless of the direction of change and can be thought of as an approximation to a point elasticity at the mid-point of the data.

13.1.6 For the car realism tests, the elasticities were calculated by weighting the trips by distance to get vehicle kilometres; for PT, it is calculated using the trips weighted by fare.

13.1.7 It should be borne in mind that, SRM12 is a model that contains a very diverse range of travel patterns and purposes along with a mix of urban (with high density public transport provision) and rural (with lower levels of public transport provision) areas. While elasticities are created for 'the model as a whole', single model values mask the variation that will occur on a mode disaggregate (e.g. corridor basis). An example of this is a fares elasticity comparison where, for the many short distance journeys by PT (e.g. within Edinburgh), the actual fare will be a small component of overall perceived cost and therefore changes in fare will have less of an impact in journey behaviour. If this impacts a high number of movements, it would subsequently impact on the total elasticity.

13.2 Sensitivity Test Results: 2012 Base Year

13.2.1 The results for the three demand model sensitivity realism tests are presented in Table 84 to Table 86 for the 2012 Base Year Model. Table 84 shows the elasticities with respect to fuel cost implied in the model. The latest WEBTAG guidance recommends that elasticities should be in the range -0.25 to -0.35, and on the 'correct' side of -0.3 with all trips being with:

- Short trip lengths should be closer to zero than -0.3;
- High car driver mode share should be closer to zero than -0.3; and
- Employers business trips should be closer to zero than -0.3;

13.2.2 The model shows that commute and other trips are broadly within the suggested range or slightly oversensitive while business trips are much lower, at approximately -0.14.

13.2.3 Note that legacy versions of WebTAG have suggested a range of -0.1 to -0.4.

Table 84. Fuel Price Sensitivity Tests: Distance Weighted Trips

	AM PEAK			INTER PEAK		
Journey Purpose	**C1/1 Car**	**C1/2+ Car**	**C2 Car**	**C1/1 Car**	**C1/2+ Car**	**C2 Car**
In-Work	-0.136	-0.141	-0.141	-0.182	-0.194	-0.178
Non-Work Commute	-0.289	-0.316	-0.286	-0.335	-0.376	-0.325
Non-Work Other	-0.214	-0.224	-0.214	-0.291	-0.299	-0.290

13.2.4 Table 85 shows the Car Generalised Cost elasticities. These are directly related to the car journey times, as time makes up about 70%-80% of the overall Car Generalised Costs. The WEBTAG guidance gives no range for these, but suggests that they should be much greater than the fuel cost elasticities and no greater than -2.0. The modelled elasticities are around three to four times greater than the fuel elasticities, with Employers Business being more responsive.

Table 85. Car Generalised Cost Sensitivity Tests: Distance Weighted Trips

	AM PEAK			INTER PEAK		
Journey Purpose	**C1/1 Car**	**C1/2+ Car**	**C2 Car**	**C1/1 Car**	**C1/2+ Car**	**C2 Car**
In-Work	-0.843	-0.845	-0.862	-0.963	-0.972	-0.917
Non-Work Commute	-0.964	-0.966	-0.919	-0.991	-0.984	-0.943
Non-Work Other	-0.915	-0.910	-0.893	-1.063	-1.048	-1.049

13.2.5 Table 86 shows the elasticities with respect to public transport fares. The WEBTAG guidance suggests that PT fares elasticities generally lie in the range -0.2 to -0.9 for changes over a long period of time. While the model is at the lower end of the recommended level, and below in some cases, indicating less sensitivity. Therefore, care should be taken when testing interventions, schemes or policies that may impact public transport fares.

Table 86. Public Transport Fare Sensitivity Tests: Unweighted Trips

	AM PEAK			INTER PEAK		
Journey Purpose	**C1/1 Car**	**C1/2+ Car**	**C2 Car**	**C1/1 Car**	**C1/2+ Car**	**C2 Car**
In-Work	-0.048	-0.045	-0.083	-0.058	-0.043	-0.076
Non-Work Commute	-0.281	-0.188	-0.268	-0.208	-0.134	-0.196
Non-Work Other	-0.234	-0.185	-0.233	-0.261	-0.221	-0.266

13.3 Sensitivity Tests - 2014 Baseline

13.3.1 Section 15 describes updates to the SRM12 model undertaken following the completion of the standard 2012 base year model. This section describes the sensitivity test results undertaken using the 2014 Baseline (pivoting) model scenario.

13.3.2 These results include model-wide and sector/area based elasticity results for the three sensitivity tests; Fuel, Journey Time / Generalised Cost and PT fares.

13.3.3 Model results for an assignment based test are also described, which measured the response to vehicle kilometres travelled for the 10% increase in fuel price test.

2014 Baseline: Fuel Price

13.3.4 Table 87 describes the calculated fuel price elasticity for the AM and IP time periods for the updated 2014 Baseline model. The overall elasticity for the AM Peak for all purposes and car availability is -0.3, and -0.35 for the Inter Peak. These elasticity values are more sensitive than the original base year model, with the Inter Peak displaying on the higher side of the guidance thresholds. The response for business users is close to -0.1, as suggested by guidance.

13.3.5 The modelling continues to show a commuter elasticity higher than that shown for other trips. There is no specific reason identified for this (potentially counter intuitive relationship), particularly as the modelled travel patterns display a reasonable match with the observed data sets. Ideally, future model updates would aim to reduce the commuter sensitivity to provide an improved relationship. The availability of more extensive travel pattern data to understand the relationships for Non-Work Other trip movements would also be of value.

Table 87. Fuel Price Sensitivity Test: 2014 Baseline – Distance Weighted Trips

	AM PEAK			INTER PEAK		
Journey Purpose	**C1/1 Car**	**C1/2+ Car**	**C2 Car**	**C1/1 Car**	**C1/2+ Car**	**C2 Car**
In-Work	-0.12	-0.13	-0.13	-0.18	-0.19	-0.18
Non-Work Commute	-0.34	-0.36	-0.33	-0.40	-0.44	-0.39
Non-Work Other	-0.24	-0.26	-0.25	-0.35	-0.35	-0.34

2014 Baseline: Journey Time

13.3.6 Table 88 describes the elasticity of demand for the car journey time sensitivity test for the updated 2014 Baseline model. Note that this calculation is weighted by distance for consistency with the earlier model testing.

Table 88. Car Generalised Cost Sensitivity Tests: 2014 Baseline - Distance Weighted Trips

	AM PEAK			INTER PEAK		
Journey Purpose	**C1/1 Car**	**C1/2+ Car**	**C2 Car**	**C1/1 Car**	**C1/2+ Car**	**C2 Car**
In-Work	-0.92	-0.95	-0.93	-0.92	-0.98	-0.88
Non-Work Commute	-1.03	-1.14	-1.04	-1.04	-1.19	-1.03
Non-Work Other	-0.96	-1.02	-0.96	-1.09	-1.13	-1.08

13.3.7 Table 89 describes the elasticity for the car journey time test using unweighted trips only (in-line with guidance). The overall elasticity is calculated at -0.16 for the AM Peak and -0.12 for the Inter Peak. These responses are at the very lower end of the range suggested by guidance. The results for both journey time tests suggests that the demand modelling is responding by increasing the distance travelled rather than modal shift impacts.

Table 89. Car Generalised Cost Sensitivity Tests: 2014 Baseline – Unweighted Trips

	AM PEAK			INTER PEAK		
Journey Purpose	**C1/1 Car**	**C1/2+ Car**	**C2 Car**	**C1/1 Car**	**C1/2+ Car**	**C2 Car**
In-Work	-0.11	-0.13	-0.09	-0.08	-0.16	-0.08
Non-Work Commute	-0.15	-0.25	-0.16	-0.13	-0.30	-0.15
Non-Work Other	-0.08	-0.13	-0.10	-0.09	-0.14	-0.10

2014 Baseline: Public Transport Fare

13.3.8 Table 90 describes the elasticity of demand for the PT fares test for the updated 2014 model. The response shown is similar to the earlier model PT fare testing, with an overall elasticity of -0.19 calculated for both the AM Peak and Inter Peak time periods. This sensitivity response lies out with the guidance range, and therefore care should be taken when testing interventions, schemes or policies that may impact public transport fares.

Table 90. Public Transport Fare Sensitivity Tests: 2014 Baseline – Unweighted Trips

	AM PEAK			INTER PEAK		
Journey Purpose	**C1/1 Car**	**C1/2+ Car**	**C2 Car**	**C1/1 Car**	**C1/2+ Car**	**C2 Car**
In-Work	-0.05	-0.05	-0.09	-0.06	-0.04	-0.08
Non-Work Commute	-0.25	-0.16	-0.24	-0.20	-0.13	-0.19
Non-Work Other	-0.24	-0.19	-0.24	-0.27	-0.22	-0.27

2014 Baseline: Network Sensitivity – Fuel Price

13.3.9 WebTAG recommends further network-based analysis by comparing the vehicle distance travelled (vehicle kilometres (Vkms)) to support the demand choice validation. Table 91 describes the change in network Vkms for the 2014 Baseline and 10% increase in fuel price test scenarios. Note that these results are anticipated to represent the change in demand for the internal demand model area only, as an adjustment was made to exclude Vkms associated with external trips - where the demand choice model has no impact.

13.3.10 The level of external trip Vkms were estimated by calculating the proportion of external trip demand, and applying the average external trip length of 50km (where the model average is 15km) and removing these external Vkms from the total Vkms).

13.3.11 The network analysis shows that the response to fuel price across the network is at the higher end of the range suggested by guidance for the AM and PM Peaks, with the response for the IP higher than guidance (similar to the results of the demand-based fuel price test).

Table 91. Road Fuel Price Sensitivity Test: 2014 Baseline – Network Veh Kms per hour

SCENARIO	AM PEAK	INTER PEAK	PM PEAK
2014 Baseline	1,252,954	858,133	1,433,251
2014 Fuel Test	1,216,673	825,736	1,386,716
Change	-36,282	-32,397	-46,535
% Change	-2.9%	-3.8%	-3.2%
Elasticity	**-0.31**	**-0.40**	**-0.35**

13.4 Sector-Based Sensitivity Analysis

13.4.1 Appendix I contains detailed tables describing elasticity results on a sector-to-sector geographical basis for each sensitivity test compared to the 2014 Baseline. The results demonstrate that the model response varies considerably depending on travel movement, with responses associated with longer distance movements clearly more sensitive, and shorter distance movements (i.e. within central Edinburgh) less sensitive. These outcomes are generally consistent for each of the three sensitivity tests and for both the AM and Inter Peak time periods.

13.4.2 Note that some test results display a positive elasticity for some sector movements (within mostly urban areas). These areas are likely to have a lower percentage of car ownership and a larger proportion of short distance trips made. With these tests demonstrating changes in both mode and destination choice, this suggests that fewer travellers change their journey from these areas, and are off-set by the larger changes in demand moving from other sectors to travel to/from more urban areas. Although this trend is at first glance perhaps counter-intuitive, the calculations allow for this, particularly where there are some small numbers involved.

13.4.3 As the model response is considerably higher for longer distance trip movements, this suggests that the introduction of a cost damping procedure would benefit the SRM demand modelling.

Notes

13.4.4 Users should take note that the SRM demand model will contain an overly-sensitive response for longer distance movements during model application.

13.4.5 The model response will generally tend to respond to changes in travel costs with an increase/decrease in trip distances rather than a significant mode shift response.

13.4.6 Note that there is a separate exercise underway to investigate this resultant low mode shift sensitivity which has been found across other Scottish national and regional models.

14. TRIP END MODEL

14.1 Introduction

14.1.1 The SRM12 Trip End Model provides forecast trip ends and add-in matrices, using a combination of trip rates from the DfT National Trip End Model (NTEM), land use and commodity flows from TELMoS and a process for generating Greenfield demand in zones where the base year contained no demand.

14.2 National Trip End Model (NTEM)

14.2.1 The Trip End model is based on the DfT National Trip End Model (NTEM). This model (NTEM) is an integral part of the DfT's National Transport Model (NTM) for which it provides forecasts of demand growth. Trip rates are applied from TEMPRO.

14.2.2 NTEM has been integrated by DfT into a set of routines to produce trip end forecasts by mode and time period for UK Local Authority Districts. The NTEM model structure is disaggregate and works at the person level. It is therefore appropriate to apply the model at a relatively detailed zone system such as that of SRM12.

14.2.3 There are three main components to NTEM:

- household car ownership forecasting;
- a demographic model which allocates household and person type planning data to a system of 88 person type categories; and
- calculation of trip ends by applying trip rates to the numbers of persons in each of the 88 person type categories.

14.2.4 The NTEM person type categories are 11 person types and eight household types giving 88 categories in total. The person types are:

- Children (0 to 15);
- Males in full time employment (16 to 64);
- Males in part time employment (16 to 64);
- Male students (16 to 64);
- Male not employed/students (16 to 64) – unemployed plus other inactive;
- Male 65+;
- Females in full time employment (16 to 64);
- Females in part time employment (16 to 64);
- Female students (16 to 64);
- Female not employed/students (16 to 64) – unemployed plus other inactive; and
- Female 65+.

14.2.5 The household types are:

- 1 adult household with no Car;
- 1 adult household with one or more Cars;
- 2 adult households with no Car;
- 2 adult households with one Car;

- 2 adult households with two or more Cars;
- 3+ adult households with no Car;
- 3+ adult households with one Car; and
- 3+ adult households with two or more Cars.

14.2.6 These are combined into the following segments for input into the SRM12 demand model:

- persons from non-car owning households;
- persons from single car owning households with 1 adult;
- persons from single car owning households with 2+ adults; and
- persons from multi car owning households.

14.2.7 There are eight home based journey purposes of which work, employers business and education are used directly for SRM12. The remaining five purposes are combined to form home based other (HBO).

14.2.8 The AM peak, Inter peak and PM peak time periods in NTEM are directly compatible with the SRM12 time periods.

14.3 Model Inputs

14.3.1 The inputs to the Trip End model can be split into four main types. These are:

- Base Year files.
- Land Use files.
- Parameters/Factors.
- Greenfield file.

Base Year Files

14.3.2 These files include:

- Trip End files;
- Education demand; and
- Add-in matrices.

14.3.3 In addition the model requires generalised cost matrices which are used for the gravity models for Education and Goods demand respectively.

14.3.4 The Trip End model will generate forecast versions of these sets of Base Year files.

Land Use

14.3.5 Base and forecast year population, jobs and commodity flow data are provided from the TELMoS land use model. These are disaggregated to the SRM12 zoning system and are used to provide growthing factors for trip ends.

14.3.6 The TELMoS population data is split into nine person types, which correspond to the NTEM person types, with the exception of having the “Not Employed” and “Student” categories combined into a “Not Working” category. Prior to use in the Trip End model the “Not Working” category is split out using a global percentage of students.

Parameters / Factors

14.3.7 The Trip End model requires a number of parameters and factors. These are:

- **Trip Rates:** defined by person type, car availability class, time period, purpose and mode. Trip Rates are based on NTEM, alternative Trip Rates can also be defined;
- **Attraction Trip Rates:** used to weight the number of jobs to give an appropriate "attractiveness" to destination zones;
- **Student Factors:** used to split out the TELMoS "Not Working" category into the NTEM "Not Employed" and "Student"; and
- **External and Airport Growth:** factors used to change demand to and from external areas and associated with Edinburgh airport.

Greenfield Sites

14.3.8 The Greenfield process provides details on new development sites during forecasting, and defines the assumptions that control Greenfield 'growth' within a future year scenario (such as which 'Parent' zones to develop travel demand for the Greenfield development site).

14.4 Model Processes

14.4.1 The model is made up of four main components:

- Growthing of internal production and attraction trip ends;
- Growthing of Education demand matrices;
- Growthing of the Internal Goods demand matrices; and
- Growthing of External add-in matrices, including goods demand.

14.4.2 Each stage also contains processes for calculating Greenfield demand.

Internal Production & Attraction Trip Ends

14.4.3 For non-Greenfield zones the trip ends for the internal zones are growthed using the change in population provided in the TELMoS data. This process can be described as:

$$fTE(c,m,t,p) = bTE(c,m,t,p) * \{ (NTEM(c,m,t,p) * fPop(c,pt)) / (NTEM(c,m,t,p) * bPop(c,pt)) \}$$

Where:

- fTE(c,m,t,p) – forecast year person trip productions, by car availability c, mode m, time period t and journey purpose p;
- bTE(c,m,t,p) – base year person trip productions, by car availability c, mode m, time period t and journey purpose p;
- NTEM(c,m,t,p) – NTEM trip rates, by car availability c, mode m, time period t and journey purpose p;
- fPop(c,pt) – forecast year population, by car availability c and person type pt; and
- bPop(c,pt) – base year population, by car availability c and person type pt.

14.4.4 This NTEM-based process is only used for trip productions for the From-Home trip purposes, which are included in the demand model. To-Home trips and Non-Home based trip ends are created within a separate process. The reverse and Non-Home based trips derivation is discussed earlier in this report.

14.4.5 The trip attraction process is a parallel procedure in the trip end model to the trip production process. There are separate trip attractions for each journey purpose and time period, but they are combined by household segment and mode.

14.4.6 Attractions fall into two distinct categories:

- **i.** attractions for home based work, which is a doubly constrained purpose in the destination choice model; and
- **ii.** attraction factors for home based employer's business and home based other, which are singly constrained purposes in the destination choice model.

14.4.7 The Attractions in i) above represent actual Trip Attractions, since they act as constraints in the destination choice process. For ii) however, we have Attraction Factors, which are used along with generalised cost to distribute trips across destinations. In this case there are no constraints for the actual Trip Attractions to equal the Attraction Factors for each zone.

14.4.8 The process for growthing the Attraction trip ends is similar to that used for the Production end, but with jobs instead of population and attraction trip weights in place of trip rates.

14.4.9 For Greenfield sites the absolute number of trips is used. This process can be described as follows, using the same definitions as above:

For productions: fTE(c,m,t,p) = NTEM(c,m,t,p) * fPop(c,pt)

For attractions: fTE(c,m,t,p) = AttWeights(c,m,t,p) * fJobs(c,pt)

Education Trip Forecasting

14.4.10 The process to calculate the forecast year Education demand matrices has four stages;

- Furness forecast trip ends using Base Year Education demand for distribution;
- Distribute Greenfield trip ends using a gravity model;
- Combine both sets of demand; and
- Re-furness the combined trip ends to the combined demand distribution.

14.4.11 The process outputs trip length distributions for the Greenfield and non-Greenfield demand.

Internal Goods Demand

14.4.12 The process to calculate the forecast year Internal Goods demand matrices has seven stages;

- Output Base Year Goods demand to origin/destination trip ends;
- Growth base year trip ends using TELMoS commodity matrices;
- Furness to base year Goods demand distribution;
- Calculate Greenfield demand from Parent zones;
- Distribute the Greenfield trip ends using a gravity model;
- Combine both sets of trip ends and demand; and
- Re-furness the combined trip ends to the combined demand distribution.

14.4.13 The process outputs trip length distributions for the Greenfield and non-Greenfield demand.

External Demand

14.4.14 The process to calculate the forecast year External Add In demand matrices has four main stages;

- apply external growth factors to the Base Year add-in matrices. These growth factors are calculated from TMfS model runs;
- calculate the Greenfield demand. The process takes the distribution of trips to/from each Parent Zone and combines them to form the external demand to/from the Greenfield site;
- the non-Greenfield demand is factored down so that the combined non-Greenfield and Greenfield demand matches the forecast growth from TMfS; and
- Greenfield and Non-Greenfield demand is combined to create the output Add-in matrices. The Internal Goods demand is also added to the external demand.

15. MODEL APPLICATION UPDATES

15.1 Model Updates

15.1.1 Following the completion of the underlying 2012 base year model development, the SRM12 has been used to inform several transport studies. Feedback from the audit process has also been received. The following section details the main changes made to the modelling which support the use of the model going forward.

Baseline Scenario – 2014/15

15.1.2 A 'Baseline' Scenario was created which included the impact of the Edinburgh Trams and Borders Rail schemes. Note that the impact of these schemes are not calibrated against observed passenger data, and therefore represent a forecasting scenario containing schemes that are now delivered for comparison purposes with other forecast year scenarios.

Cross-Boundary Study Forecasting

15.1.3 Forecast year scenarios were developed to inform the Cross-Boundary Study (CBS), which forecast the impact of land use development proposals and analysed the benefits of a number of transport mitigation proposals. During the interrogation of traffic impacts, it was found that the impact of the slow moving traffic along the bypass route was being mainly represented at 'Q-nodes' situated at the slip road merge points (as expected), but the modelling was not able to extend the slow moving queue back further along the bypass. Although over the wider section, changes in forecast year journey times were intuitive, the main delays were focussed at specific points (merges) along the network.

Audit Amendments & Network Updates

15.1.4 A number of coding issues were identified during the audit process and during early model application. To resolve these issues, coding updates were undertaken during 2019 within the Baseline network and consistently across the forecast year scenarios. These updates include:

- Distance amendments along the M8 (Jnc 1-2), M9 Newbridge and M90 Ferrytoll;
- Junction turning movement lane allocations within Edinburgh, at the A68 / A720 intersection and for zone loading at Bonnyrigg; and
- Specific walk links to park & ride station car parks (for recently delivered stations).

TMfS & TELMoS 14 Linkages, Pivoting and Forecasting

15.1.5 The original SRM12 modelling was linked to the TMfS and TELMoS '12' modelling suite to inform external boundary movements and the underlying development, population and employment forecasting inputs. This model version was applied for the cross-boundary study (SRM12_v1.3.1).

15.1.6 During 2018 / 2019 an updated SRM12 model version was created to link to TMfS14 and TELMoS 14 – which has a 2014 base year and subsequent forecast years. A new SRM12 2014 Baseline scenario was created to generate a pivoting year from 2012-2014, and to apply forecasts to. The SRM12 was not re-calibrated, but provided an updated set of scenarios consistent with the TMfS14 and TELMoS national modelling forecasting.

15.1.7 The development of the 2014 pivoting year and subsequent forecast year scenarios are described in a separate report. This model version is referred to as SRM12_V2.1.1.

15.1.8 A separate Do Minimum note describes the network interventions included within the updated forecast year scenarios.

Forecasting Assumptions

15.1.9 SRM12 includes a number of forecast year parameters that require consideration during forecasting. These include parking charges within the City Centre. The method for updating parking charges, and other parameters, such as values of time, are described within the forecast development reporting in 2018 / 2019.

Running SRM12 in Forecasting Mode

15.1.10 The updated 2014 Baseline (pivoting) model has been run using 4 outer demand model loops for the 2014 year. The later forecast year models are run for 8 outer demand model loops. The Public Transport Assignment was run on the first and last demand model loops. The PT assignment can be run on every external loop to improve convergence, however this will impact model run times substantially. Four internal loops is run as standard.

15.1.11 The Demand Model GAP convergence statistics for the latest Baseline Model and forecast year scenarios are as follows:

- 2014: 0.067
- 2017: 0.063
- 2022: 0.066
- 2027: 0.061
- 2032: 0.066
- 2037: 0.070

15.1.12 The demand model can be run for further loops to reduce the GAP if the content of the forecast year scenarios produces an increase in the GAP convergence.

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