Aberdeen Sub Area Model (ASAM) Upgrade

07/01/2020

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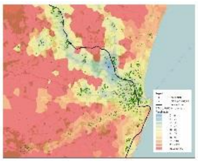

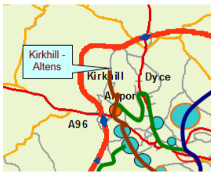

ASAM14 MODEL DEVELOPMENT

Model Development Final Report

ABERDEEN SUB AREA MODEL (ASAM) UPGRADE

ASAM14 MODEL DEVELOPMENT

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1. INTRODUCTION

1.1 Aberdeen Sub Area Model

1.1.1 SYSTRA Ltd was commissioned by Nestrans in July 2016 to upgrade the Aberdeen Sub Area Model (ASAM). ASAM is a multi-modal strategic transport model covering the North East of Scotland. The new strategic model is called 'ASAM14' and contains similar and also improved functionality compared to previous versions.

1.1.2 ASAM14 represents the road and public transport network and service supply present during 2014, 2014 levels of population and employment activity, and is calibrated and validated to reflect 2014 observed traffic and travel conditions. ASAM14 aligns with the Land use And Transport Integration in Scotland (LATIS) national model hierarchy 2014 base year and is informed through the TMfS14 / TELMoS14 land use and transport interaction and forecasting processes.

1.1.3 ASAM14 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 This report describes the work undertaken to develop ASAM14 and documents the calibration and validation to observed traffic and travel conditions.

1.1.5 This Report is supplemented by a number of Appendices providing detailed descriptions of model components and calibration and validation data sets.

1.2 Model Development Objectives

1.2.1 The project brief describes the model development requirements, and noted the issues and opportunities associated with the Aberdeen Western Peripheral Route (AWPR). The AWPR is due to be completed in late winter 2017 and will necessitate a significant data collection exercise to recalibrate the base model following a settling in period to reflect the change in traffic patterns. As this will be a number of years away, there is a requirement to update the existing regional model (ASAM) to provide a suitably robust model to undertake transport assessments in the interim period until an extensive upgrade is commissioned.

1.2.2 The current update to the regional model is required to:

- upgrade the software to a new supported platform;
- calibrate it to a new base year to improve representation of the current situation in the north east; and
- provide new forecast years based on latest understandings and predictions

1.2.3 Model development objectives and potential uses of ASAM14 are described below:

Objectives

- delivery of a 2014 based regional multi-modal model suitable for the development of outline and strategic business cases for major transport and land use interventions within the North East of Scotland;
- inclusion of 2011 Census travel to work travel data;
- inclusion of a parking capacity constraint demand response mechanism;
- inclusion of cost damping process;
- documented model development approach, calibration and validation in-line with WebTAG guidance;
- audited model development; and
- documented set of regional model forecasts aligning with the LATIS TMfS14 / TELMoS modelling suite with future year scenarios for 2017, 2022, 2027, 2032 and 2037.

1.2.4 The type of studies that would benefit from use of the ASAM14 model include:

- Outline and Strategic Business Case development – providing travel demand forecasts and cost benefit analysis for major proposals;
- Development Plans / DPMTAG – forecasting changes in traffic and travel patterns and the subsequent impact of development proposals;
- Cumulative Development Impact – capturing the combined impact of proposed development and transport investments across the North East and understanding the benefits of potential mitigation measures;
- 'Locking in the Benefits' of the AWPR – understanding the opportunities that changes in travel patterns bring to existing Aberdeen corridors;
- City Centre Master Plan & Sustainable Urban Mobility Plan (SUMP) – informing investment proposals, car parking constraint responses and alternative routing strategies within the City Centre;
- Regional Transport Projects – Appraising multi-modal transport projects and strategies;
- Strategic Growth Information – informing detailed micro simulation models of predicted changes in strategic traffic demand; and
- Air Quality – informing changes in travel patterns and composition within Air Quality Management Areas (AQMA's).

1.3 Data Collection

1.3.1 Two new key data sets were commissioned to inform the ASAM14 model development, and reduce significant data gaps, namely public transport bus occupancy surveys and satellite navigation road journey times. These data sets were used to inform the calibration and validation of the road and public transport assignment models.

1.3.2 Ideally, further information would be collected to inform the development of the base year travel demand matrices (i.e potentially mobile phone data, RSI's or wider coverage of bus and rail surveys). The ASAM14 development is regarded as a short term interim upgrade, to maintain the strategic modelling capability until a fuller upgrade is undertaken following the delivery of the Aberdeen Western Peripheral Route (AWPR). The ASAM update was undertaken during the construction of the AWPR, and therefore there is less value in commissioning these type of data which would quickly become dated once the AWPR is in place.

1.4 Model Application

1.4.1 The upgrade of the new ASAM regional model ('ASAM14') provided the opportunity to update and advance the transport modelling available across the North East of Scotland and interface with other higher and lower tier transport and land use models.

1.4.2 New data sources were utilised to record recent traffic and travel conditions and provide an updated calibrated 2014 base year model to form the basis of future year forecasting. New technical components tailored to potential model applications improve the model responses – maintaining and improving the evidence base for transport and land use appraisal within Aberdeen City and Aberdeenshire.

1.4.3 Prior to model application, users are recommended to review the model development and audit reports and relevant model coverage, components and calibration to understand how the model represents a particular study area or purpose. Users should consider some comparison of traffic and/or public transport volumes and journey times, **and** also some evaluation of travel demand movements.

1.4.4 These type of model reviews may result in identifying issues that need to be considered during appraisal, and/or updates to the modelling which would be beneficial to provide improved representation for the project. For example, minor coding updates may improve calibration within the relevant study corridor, which would be of key relevance if undertaking outline or strategic business case applications, or specific development appraisal.

1.4.5 Users may wish to commission separate local surveys to evaluate travel patterns within their relevant study area if deemed necessary for a particular model application.

1.4.6 For example Automatic Number Plate Recognition (ANPR) surveys would capture local travel patterns to evaluate specific modelled routing, travel movements and journey times. Mobile Phone Data (MPD) would provide a means of comparing the total level of travel movements between areas, particularly for longer distance movements. Lennon or Moira rail ticket data would provide a means of comparing specific rail travel movements between stations.

1.4.7 Some of these types of data sets may be analysed to inform the next Transport Model for Scotland development process and may become available to compare ASAM14 travel patterns. Further journey time data comparisons may also be available drawing on the TomTom data used for the ASAM14 road validation.

1.4.8 Monitoring is being undertaken for the AWPR, and these type of data sets would provide a valuable means of comparing modelled forecasts with post-AWPR traffic data. In addition, evidence demonstrating the predicted changes in traffic volumes with the AWPR in place are available within the ASAM14 forecasting report for comparison.

1.4.9 The forecasting report also provides evidence illustrating predicted changes in traffic within the city centre area following the introduction of bus priority and traffic management proposals.

1.4.10 The ASAM modelling can be used to provide traffic volume forecasts for various project applications. In areas where calibration and validation is deemed poorer, users are recommended to consider a wider coverage of traffic flows to compare changes in traffic volumes. For example, comparing screenlines of data, or flows at several locations along a corridor.

1.4.11 When preparing microsimulation modelling inputs (i.e. cordon matrices), comparisons of traffic volumes at external route zones would be beneficial, along with comparison of local traffic movements, particularly for HGV's. Combining ASAM14 forecasting with detailed microsimulation modelling provides a two-stage approach for assessing more detailed impacts, particularly operational performance and traffic routing within AQMA's.

2. MODELLING APPROACH & COVERAGE

2.1 Approach & Scope

2.1.1 The ASAM14 development approach utilises a variety of upgrades to maintain existing ASAM components, mitigate current limitations and provide additional functionality that would support potential applications.

2.1.2 The updated ASAM14 model represents 2014 traffic and travel conditions aligning the regional model with the TMfS and TELMoS national transport and land use model 2014 base year.

2.1.3 The new ASAM14 modelling structure enhances the:

- software platform to CUBE (Demand and PT) and SATURN (Highway);
- Digital GIS data sets used to build the road network and bus service lines;
- trip generation, demand and Park and Ride (P&R) models;
- P&R choice process to represent parking capacity within constrained areas;
- evening peak travel demand representation and responses;
- Aberdeen Airport and Heliport travel representation;
- rail passenger crowding;
- rail fares using a rail station matrix format;
- SATURN functionality preloading ‘PASSQ’ traffic queues from earlier time periods;
- Cost damping procedure to improve response sensitivity; and
- calibration / validation to match recently observed travel data sets.

2.1.4 The new model no longer utilises the ‘TRIPS’ Software for highway assignment. ‘Tours-based’ modelling, concessionary travel demand segmentation and active modes modelling are **not** implemented within ASAM14.

2.2 Coverage

2.2.1 The ASAM14 geographical coverage was extended slightly beyond the previous ASAM area. This includes some re-working of ‘external’ zones / processes to better coincide with the National Model hierarchy and improve representation within the study area.

2.2.2 Additional network and zonal detail has been incorporated within Aberdeen city centre and for the larger towns and commuter corridors within Aberdeenshire, including Stonehaven, Portlethen, Banchory, Westhill, Inverurie, Kintore, Ellon and Peterhead.

2.2.3 More detail has also been included within the Laurencekirk-Montrose corridor, which will benefit the representation of recent development and representing the proposed A90 intersection.

2.2.4 Further parts of Angus and Moray have been included within the demand model to represent the larger travel to work area and ensure more of the mode shift impacts can be captured within the regional model. The network representation within these parts of Moray and Angus is more aggregate than for the core area of the model (with the exception of Montrose).

2.2.5 The ASAM14 geographical coverage area is illustrated within Figure 1.

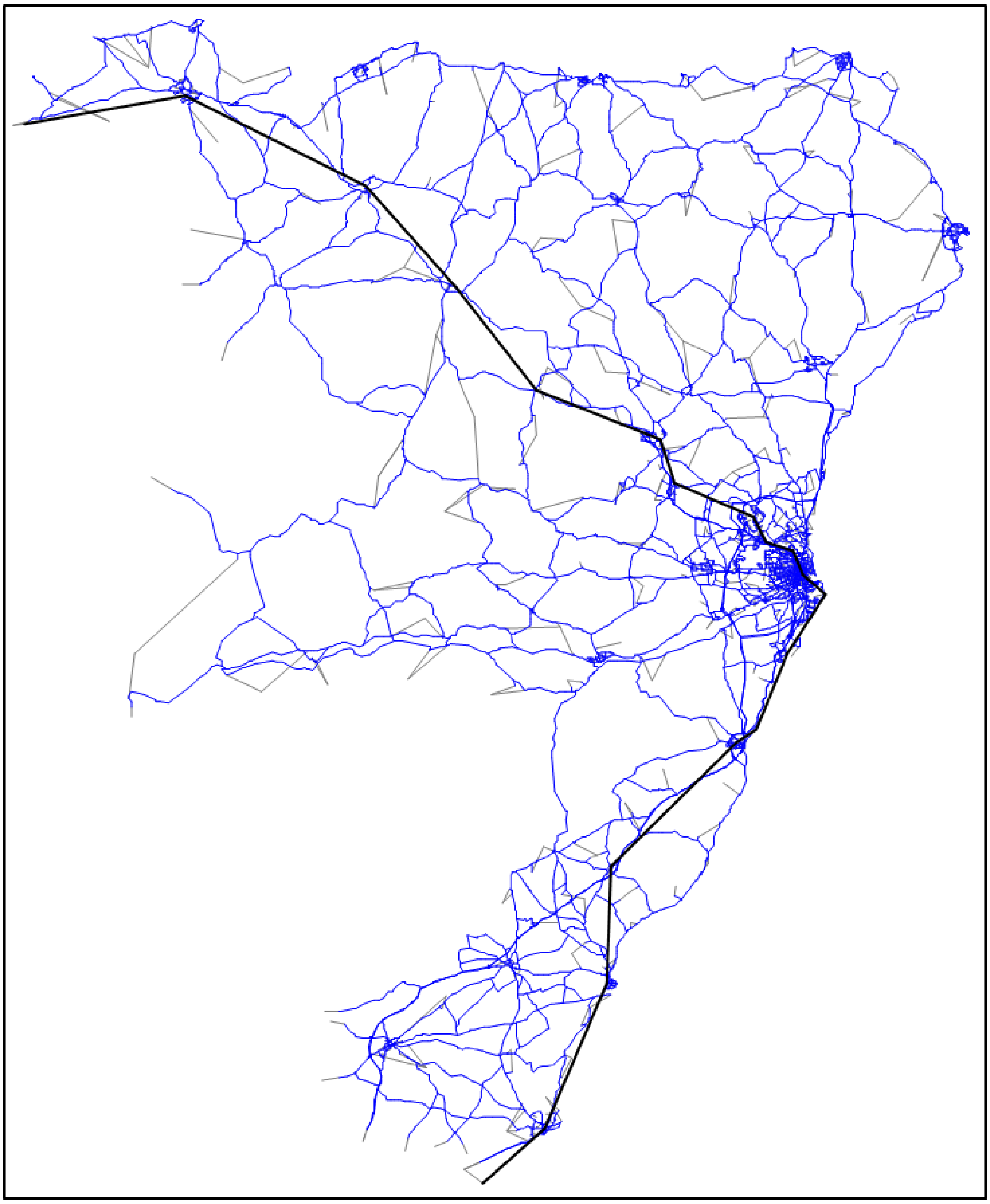

Figure 1. ASAM14 Geographical Model Coverage


2.3 Model Structure

2.3.1 ASAM14 provides all of the traditional 4-stage multi-modal modelling functionality across the North East of Scotland, including trip generation (with links to the TELMoS land use model), behavioural models covering mode, destination (and parking and park and ride) and road and public transport (PT) assignment models.

2.3.2 The ASAM14 model structure and capability is illustrated in Figure 2 and includes:

- Linkages with TELMoS14 to provide land use planning and goods vehicle forecasts;
- Linkages with TMfS14 to provide 'external' travel forecasts.
- **Trip Generation**;
- **Mode choice** (car, public transport and mixed mode Park & Ride and city centre car parking);
- **Destination choice**;
- Park and ride site / station, and city centre car park choice;
- To-home and non-home trip estimation; and
- Road and public transport **route choice assignment** network models and outputs.

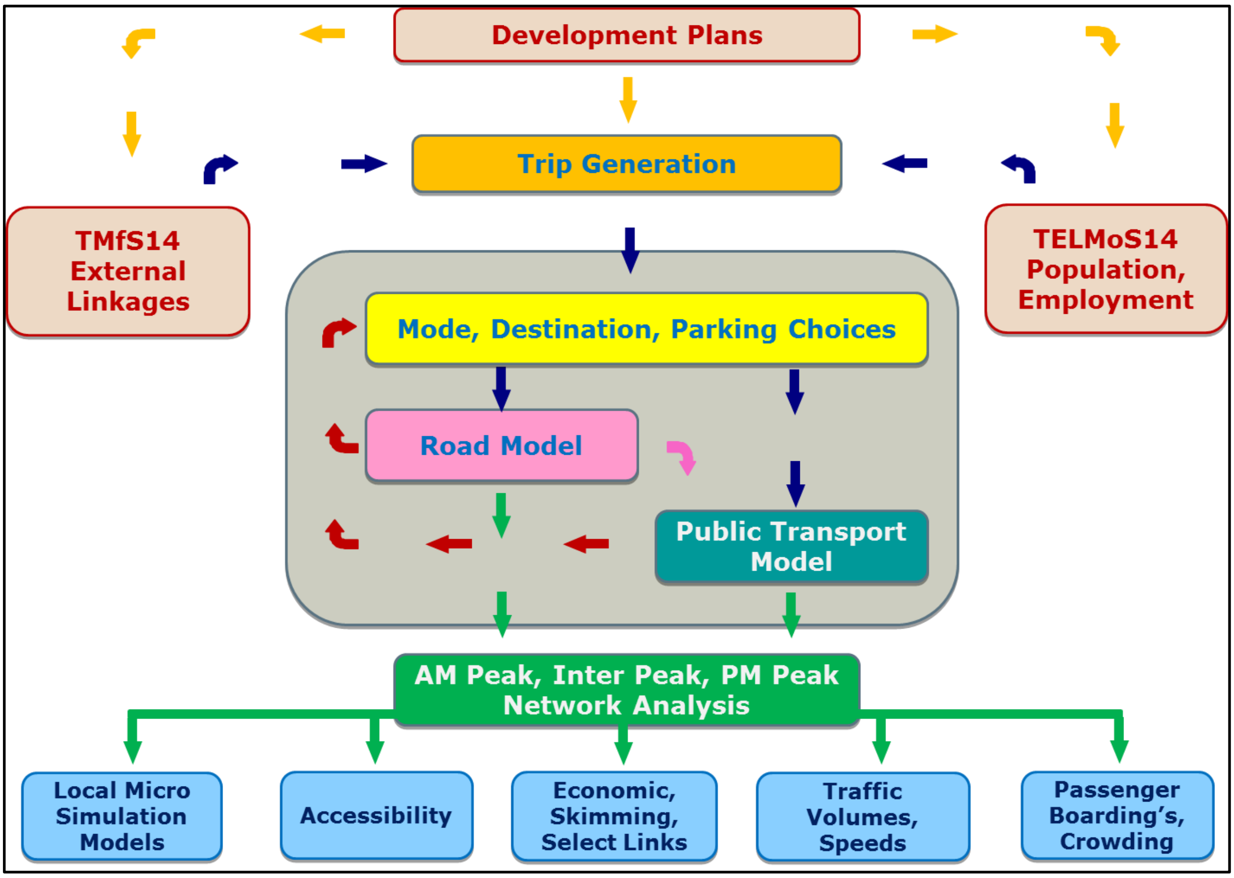

Figure 2. ASAM14 Model Structure

2.3.3 The enhanced ASAM14 structure generally follows the processes and scripting used within TMfS and subsequently SRM12 (SEStran Regional Model). The SRM12 was used as a starting point as it also used CUBE Voyager Demand and PT Software and SATURN Road Modelling Software. The main structural changes from SRM12 include:

- Evening Peak Demand modelling;
- Parking capacity modelling and Inter Peak Park & Ride modelling;
- Airport & Heliport modelling;
- Demand model cost damping procedure; and
- SATURN Road assignment, including PASSQ function.

Development Planning Data, Trip generation & Linkages

2.3.4 Trip generation is informed by a mixture of 2011 Census and TELMoS14 population and employment composition data, and Local Development Plans. TELMoS14 household, population and employment (jobs) data sets form the underlying basis of ASAM14 2014 Base Year levels of demographic activity – and the basis of future year forecasting.

2.3.5 External (longer distance) movements to/from areas located out with the model coverage area (particularly the A90 and A96 corridors and associated rail lines) are represented by and aligned with TMfS14 boundary movements.

Demand Choice Models

2.3.6 The Demand Model represents mode and destination choices with an incremental adjustment to reflect observed travel conditions. The demand model also includes a combined Park & Ride (Rail and Bus-based) and City Centre Car Park choice model, connecting through to a Park & Ride / Rail Station Site choice mechanism.

Travel Purposes

2.3.7 The ASAM14 Demand Model contains the following six car and public transport journey purposes during the AM, Inter and PM Peak time periods:

- **Home-Based Work (HBW):** travelling 'From-Home' to work (and back again) – a typical commuting journey (this 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, (ie travelling from work to a business meeting, visiting customers); and
- **Home-Based Education (HBS):** travelling 'From-Home' to a place of education (e.g. school, University). These are not part of the main Demand Model, and are considered separately after the mode and destination choice phases.

2.3.8 Heavy and Light Goods vehicle movements are also treated out with the demand model, within a separate forecasting procedure.

Car Availability

2.3.9 The Demand model operates with a dimension of four household types as described below. These household types serve as a proxy for car availability.

- 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.

Assignment Models

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

2.3.11 The road assignment model includes capacity restraint across the road network with specific junction modelling in Aberdeen and parts of Aberdeenshire. The Public Transport assignment reflect changes in bus speeds by connecting with the road assignment model while PT capacity restraint is represented for rail services only.

2.3.12 Park and ride and city centre parking car and PT passenger movements are reflected travelling to and from the relevant destination/origin car park.

Assignment User Classes

2.3.13 Five user classes are included in the ASAM14 AM, Inter & PM Peak Road Assignment models and assigned separately as follows:

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

2.3.14 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

2.3.15 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 Other (NWO): Other journey purposes (i.e. shopping, leisure, education etc).

2.3.16 Travel demand matrices are allocated for each user class, which are assigned separately in the PT assignment model. Public Transport travel demand matrices are assigned in person trips for In-Work, Commute and Other PT passengers.

Modelled Time Periods

2.3.17 The road and PT assignment models reflect average conditions within the AM peak hour, Average Inter-peak hour and PM peak hour. The ASAM14 peak periods and peak hour time segments are defined as follows:

- AM peak three hour period 0700 - 1000;
- AM peak hour (for assignment modelling) 0800 - 0900;
  - (Calculated as 0.37 of AM Peak Period Road travel demand
  - (Calculated as 0.43 of AM Peak Period PT travel demand
- AM pre-peak PASSQ road assignment 0700-0800;

- Inter peak period 1000 - 1600;
- Inter peak hour (for assignment modelling) 1/6 of 1000 - 1600;
  - (Calculated as 0.17 of the Inter Peak Period travel demand)

- PM peak period 1600 - 1900;
- PM peak hour (for assignment modelling) 1700 - 1800.
  - (Calculated as 0.37 of PM Peak Period Road travel demand
  - (Calculated as 0.43 of PM Peak Period PT travel demand
- PM pre-peak PASSQ road assignment 1600-1700;

2.3.18 These time periods factors were updated for ASAM14 based on the analysis of traffic and public transport passenger counts as used for the calibration and validation of the road and public transport assignment models.

Model Outputs & Analysis

2.3.19 Travel costs are extracted from the assignment models and applied to generate base year generalised cost matrices to inform the Demand model, and park and ride and parking modelling.

2.3.20 A variety of road and public transport outputs are available from the AM Peak, Inter Peak and PM Peak models, with the model capable of providing traffic outputs to inform operational, economic and environmental assessments and road traffic accident forecasting.

2.3.21 Public transport accessibility can also be informed using travel cost / time skims (ie zone-to-zone travel distances, times and costs).

Forecasting

2.3.22 In forecast mode, the ASAM14 Trip Generation and Demand models calculate predicted changes in travel demand and patterns from base-year (2014) conditions. The Trip Generation Model forecasts changes in student education travel and goods vehicle movements, along with the main commuter, business and other journey purpose trip ends.

2.3.23 The Demand model forecasts changes to the Road and Public Transport assignment matrices that arise through changes in forecast planning data (ie development / population changes) and/or changes in future transport costs (ie transport investments, policies and/or congestion). This process also represents changes associated with parking capacity and park and ride site / rail station accessibility.

2.3.24 In turn the road and PT assignment models inform the demand model of changes in travel costs, which iterates between mode, destination and parking choice responses to generate forecast year outputs.

2.4 Software

2.4.1 ASAM14 uses SATURN Software (version 11.3.12U) which is the UK standard for modelling congested urban networks and for capturing effects such as 'blocking back' from over-capacity junctions, downstream 'flow metering' and 'PASSQ' – preloading traffic queues from earlier time periods. The SATURN 'Multi-core' function is applied to improve model run times.

2.4.2 ASAM14 uses CUBE Software for demand and PT modelling (version 6.4). CUBE Cluster is used to run specific processes in parallel and speed-up model run times. ASAM14 no longer uses the older TRIPS Software.

2.4.3 The model has been developed for use within the Windows 7 operating system.

2.4.4 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), 4 cores.

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

2.4.6 A full forecast year demand model run requires around 24 hours to complete.


3. ZONE SYSTEM

3.1 Zone Types

3.1.1 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 ASAM14 base model zone system contains 574 zones in total (up from around 290 in ASAM4), including:

- 507 '**internal**' demand modelling zones (with relevant population / jobs data);
  - Aberdeen City = Zones 1-249 (232 used zones, +18 spare zones);
  - Aberdeenshire = Zones 250-434 (185 used zones, 0 spare zones);
  - Angus = Zones 435-477 (41 used zones, 2 spare zones);
  - Moray = Zones 478-507 (29 used zones, 1 spare zone);
- 29 **'Parking Capacity'** zones (11 off-street car parks, 13 on-street zonal areas and 5 spare parking zones);
- 25 **'Park & Ride'** bus and rail station zones (14 used and 11 spare P&R zones);
- 13 **External Route** Zones: representing A90, A92, A96, A93 etc and reflecting the boundary with TMfS14.

3.1.2 Note that an additional 55 demand model zones (from 575-630) were incorporated to an updated model version to increase the allowance of 'spare zones' available.

3.1.3 The ASAM14 zone system is illustrated in Figure 5 to Figure 8.

3.2 Zonal Data and Approach

Internal Demand Modelling Zones

3.2.1 The ASAM14 zone system geography was created using the 2011 Census boundaries at output area level. For consistency, ASAM14 zoning forms disaggregations of TMfS14 zones and does not overlap Census Data zones or Local Authority boundaries.

3.2.2 Zoning was developed to limit large volumes of traffic loading into a single point in the road network by splitting zones which have large trip generation / attraction. This was informed by comparing levels of zonal population and employment. As large employment areas are not fully disaggregated within Census geographical data sets, mapping and local knowledge was also used to review and split zones to represent large employment sites (i.e. for Kirkhill, Dyce, Altens and Westhill).

3.2.3 More detailed zoning is also provided within Aberdeen city centre, the Aberdeen harbour area, Aberdeenshire commuter towns, areas of recent development (ie Prime Four) and the Airport area.

3.2.4 The process for creating standard ASAM14 internal demand model zones was as follows:

- Use the 'Output Area2011_MHW' shape file (describing 2011 Census Household records) to identify output area household data to create zonal aggregations up to an approximate maximum of around 1,000 households per zone. This threshold was used to limit traffic loadings to under 500 vehicles per hour, to ensure the road network is not affected by large zone areas (assuming an approximate trip rate of around 0.3 trips per peak hour per household);

- Use 'SG_DataZone_Bdry_2011 shape file in conjunction with 'WF01BSC_DZ2011_Scotland' to illustrate and understand the location of 'Usual Residence and Place of Work'. Then separate out specific employment areas, and create zonal aggregations up to an approximate maximum of around 1,000 jobs per zone (noting that for some specific employment sites higher employment numbers were required).

  - Note that total employment figures were initially split on a geographical basis as the ASAM14 system often included disaggregations of data zones and (at this time) the Census employment data was not available at a lower spatial disaggregation (unlike household data).

- Cross reference household and employment zonal data to separate out areas which contained high numbers of both households and jobs;

- Split out large data zones which contain a high number of jobs, (ie Kirkhill, Dyce, Altens, Tullos, Westhill) based on satellite mapping and local knowledge;

  - At the end of this stage, generate a zone system with a total number of households and jobs per zone;

- Use National Records of Scotland 2011-2014 mid-year population estimates to incorporate population / household growth between the 2011 Census and 2014 base year model. These were analysed at 2011 data zone level and added to the relevant ASAM14 zone;

- Use 2011-2014 Business register Employment Survey (BRES) data to supplement 2011 Census jobs data and incorporate changes in jobs between 2011 and 2014. These data were available at **2001** data zone level and were incorporated into relevant ASAM14 zones. This included disaggregating total employment into the relevant BRES / TELMoS employment categories (ie retail, education, health) for each ASAM14 zone;

- The ASAM14 zone system was constrained to TELMoS 'Parent' zone population, household and employment levels (by employment category). Therefore, ASAM14 level household and employment data were used to create factors to disaggregate the TELMoS totals down to ASAM14 level.

- The zone system was reviewed to identify the main generators / attractors in terms of employment categories. Several discrepancies were found between the BRES job categories and the actual location of these type of employment sites. These discrepancies mostly appeared to relate to boundary issues, where for example education jobs may be located in or accessed through a neighbouring zone. This review focussed on areas with greater than 200 retail, education, or health related jobs, with some jobs data being transferred to the appropriate neighbouring zone;

- The majority of these job transfers were undertaken within the TELMoS parent zone, with the exception of Robert Gordon University Garthdee Campus, and education jobs at Hazelhead Academy. These jobs were first transferred between TELMoS zones, and therefore a consistent transfer is also required within forecast year TELMoS data sets;

- The end of this stage provided an ASAM14 zone system with a number of households, population by household car availability and employment by job category per zone. Zonal household, population and employment figures match TELMoS ‘parent’ zone totals when aggregated, and reflect more local locational and job category data when used at the ASAM14 zonal level.

3.2.5 Note that the new 2011 Census ‘employment workplace boundaries’ data set were not available at the time when the zone system was initially created.

3.2.6 The ASAM14 data captures recent employment (by 2014) at the new Prime Four site near Kingswells. The base model does not include jobs within the base year at the new ‘ABZ’, D2 and International Business Park at Dyce Drive – these sites would therefore be associated with forecasting, as would any further growth at Prime Four.

Spare zones

3.2.7 Separate zones are set aside within the modelling to facilitate the detailed modelling of future new development sites and/or car parks and park and ride sites. This approach provides flexibility during forecasting, enabling development data and site locations to be input to the model in isolation and forecasts / impacts to be understood in detail.

Zone Centroids

3.2.8 Zone centroids are used to load traffic and passengers to/from the road and public transport networks.

3.2.9 Centroids have been added to a number of ‘spigots’ (less detailed ‘approximate’ non-capacity restraint links) to join with the main network. These have been incorporated to reflect the geography of the network within or close to zonal areas, with traffic loading reflecting the layout and main access available (i.e. at the main residential sites).

3.2.10 For larger zones, multiple centroids have been used to reflect different access options, and to ensure a large number of trips are not inappropriately loading to a single network point.

3.2.11 Zone centroid distances reflect the local nature of the zone system and network coverage, with urban distances coded to represent a short journey from the main areas of activity to reflect the network access point, with slightly larger distances coded for rural zones where there is less network detail.

3.3 Parking Capacity Zones

City Centre Car Parks

3.3.1 There are 29 zones representing car parks in ASAM14 (including five spare), with 13 on-street zonal parking areas and 11 off-street car parks, as displayed below in Figure 3. Car park modelling is discussed further in Section 14.

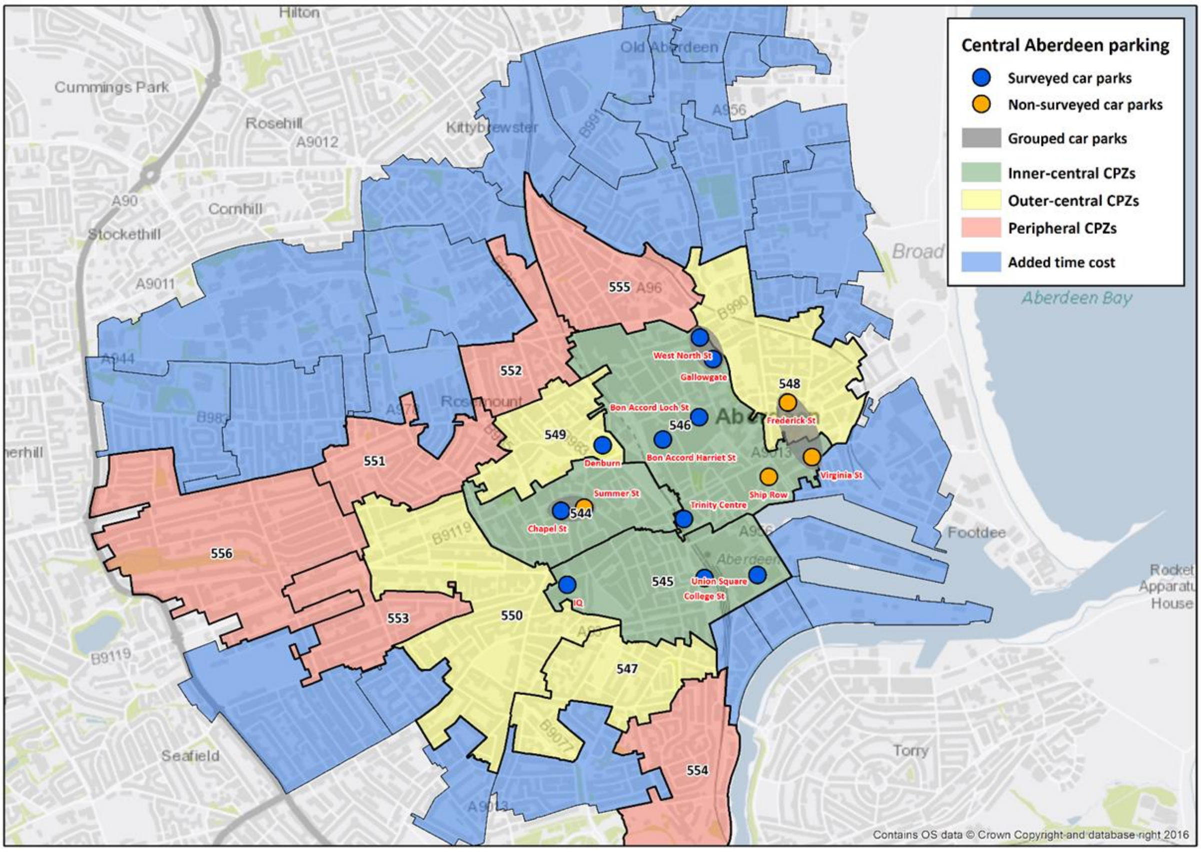

Figure 3. ASAM14 Parking Capacity Zones

Park & Ride Zones

3.3.2 Separate 'spot' zones are used to represent interchange at Park and Ride sites and rail stations (representing access at site car parks). These include:

Rail Station Car Parks

- Aberdeen Rail Station, Dyce;
- Inverurie, Insch, Huntly, Keith, Elgin;
- Portlethen, Stonehaven, Laurencekirk,
- Montrose, Arbroath;

Bus Based Park & Ride Car Parks

- Bridge of Don;
- Kingswells;
- Ellon;

3.4 Zone Coverage

3.4.1 The following figures display the coverage of the ASAM14 zone system.

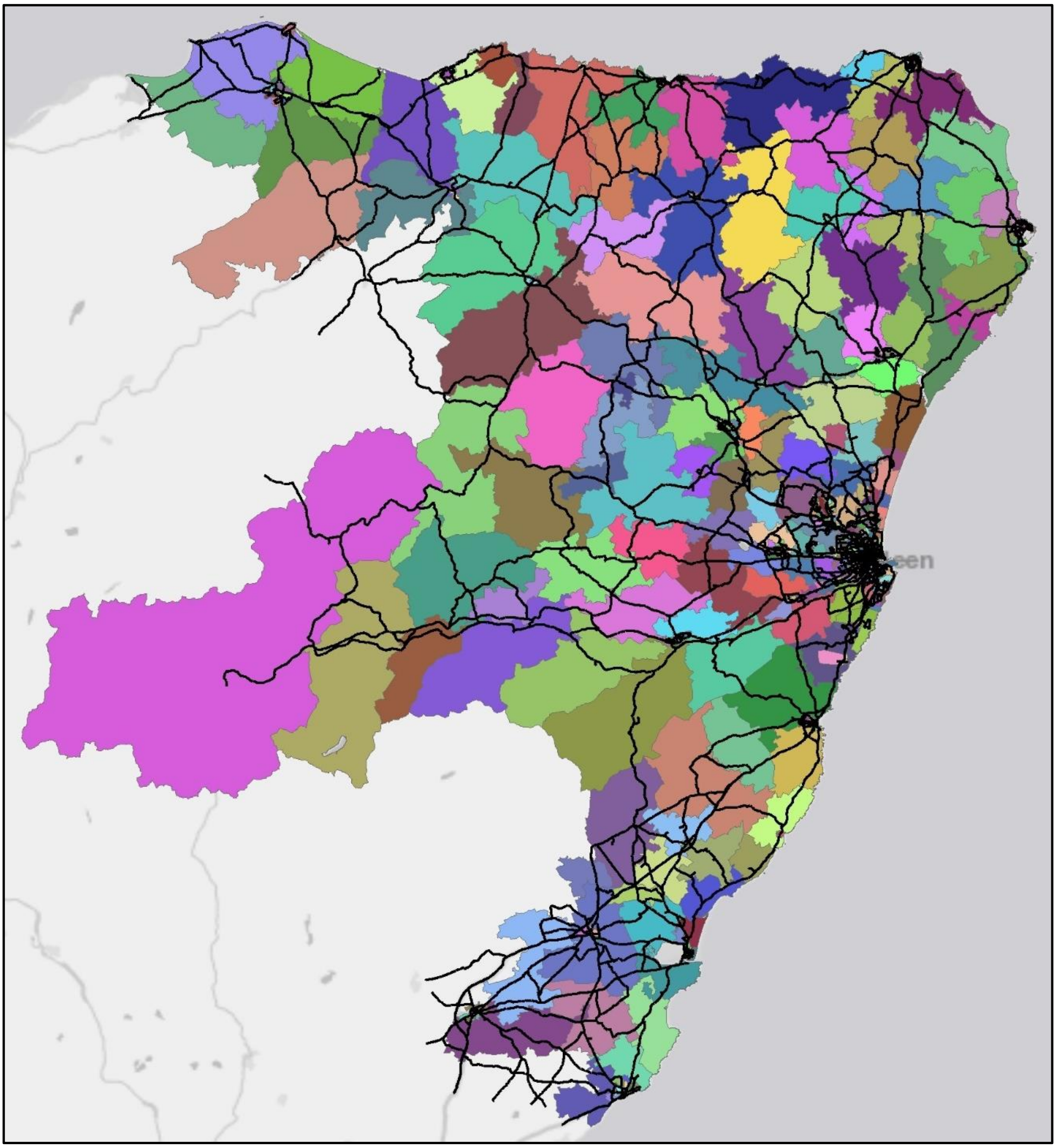

Figure 4. ASAM14 Model Internal Zone System

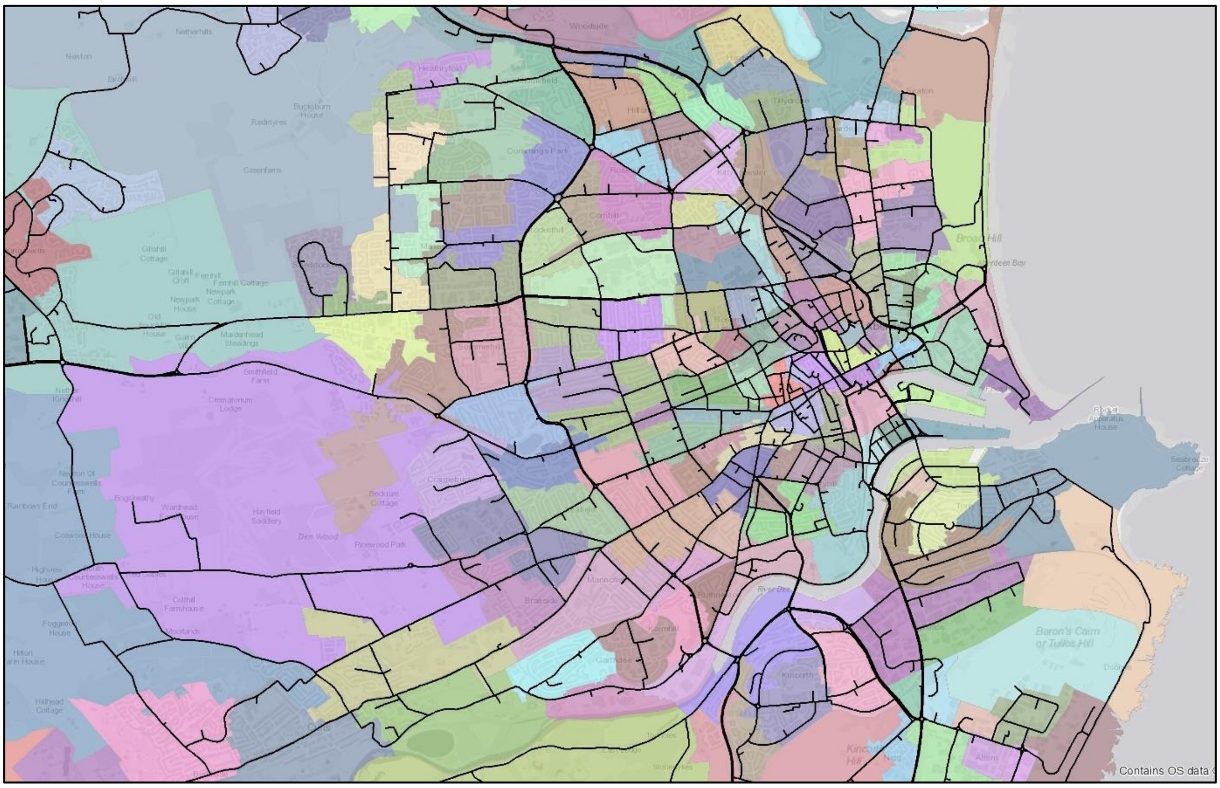

Figure 5. ASAM14 Model Zone System – Aberdeen City

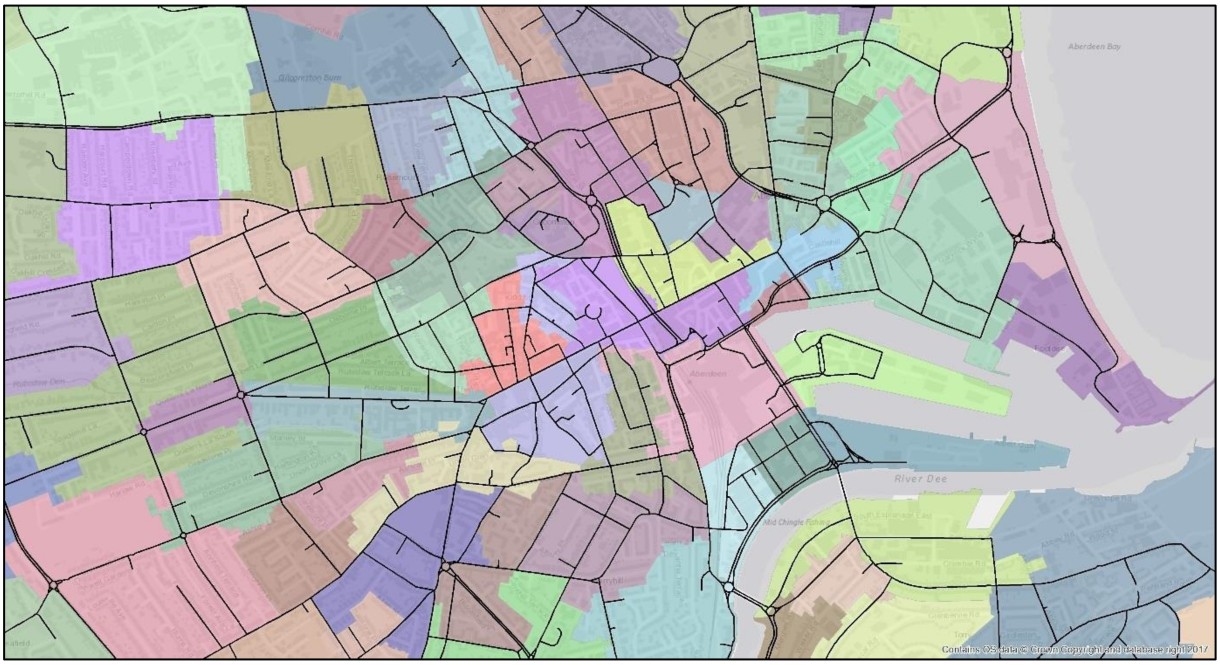

Figure 6. ASAM14 Model Zone System – Aberdeen City Centre

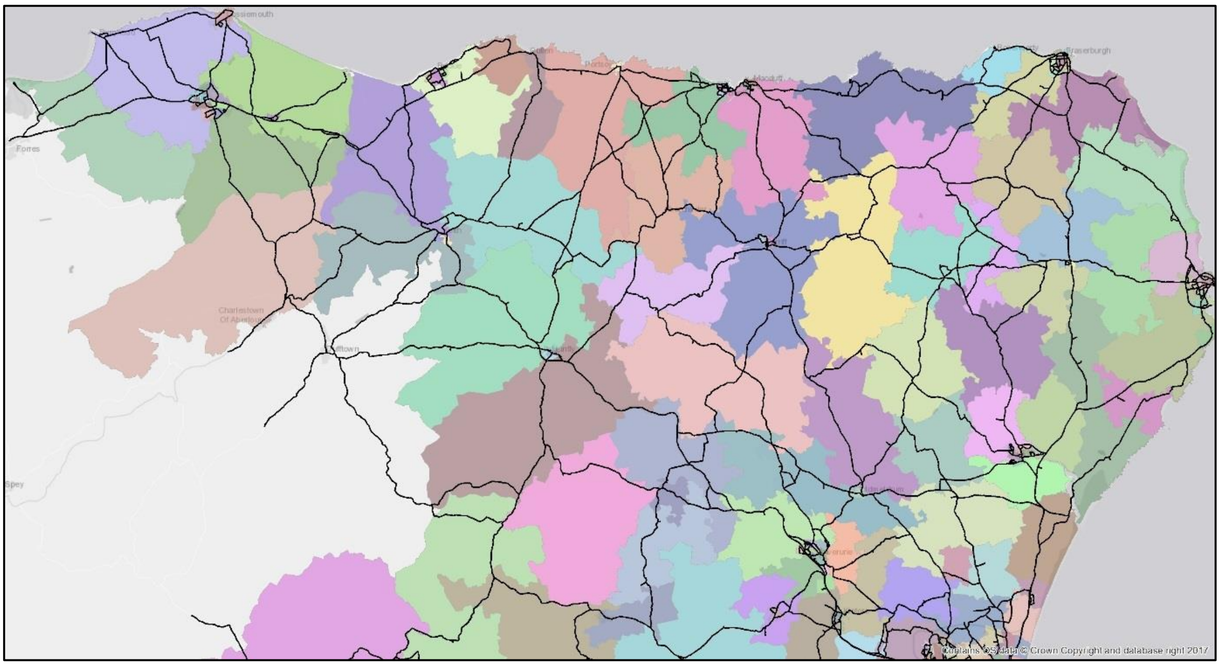

Figure 7. ASAM14 Model Zone System – North Aberdeenshire / Moray

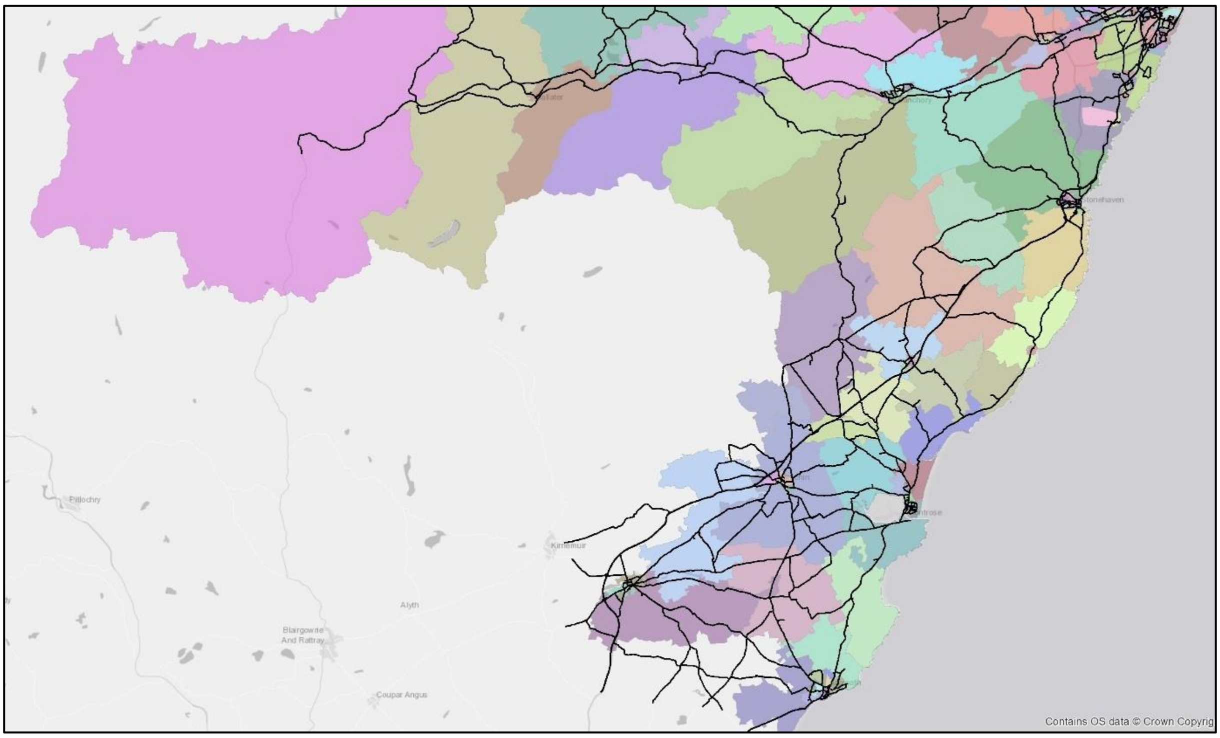

Figure 8. ASAM14 Model Zone System – South Aberdeenshire / Angus

4. ROAD NETWORK AND ASSIGNMENT

4.1 Network Construction Data

4.1.1 The following section describes how the road model network supply was constructed. The ASAM14 road network was developed using SATURN software and a combination of the following data sets:

- OS Mastermap Integrated Transport Network (ITN);
- TomTom speed/time data;
- Traffic signal settings data from Local Authorities and Paramics models;
- Transport scheme information received from Transport Scotland and Local Authorities;
- ASAM14 zone system;
- Existing ASAM4 version road network coding;
- Other existing SATURN model data sets; and
- Satellite mapping and Google Streetview;

4.2 Integrated Transport Network (ITN)

4.2.1 The ASAM14 road network was generated based on a detailed 2016 ITN GIS shapefile - which excluded the new Diamond Bridge Crossing, and therefore represented road accessibility during 2014. The ITN network includes attributes such as link distances, and this provides a robust database to convert the road network into SATURN format.

4.2.2 The first task in the road network development process was to decide on and flag the required links in the ITN shapefile layer (using ArcGIS) for inclusion to ASAM14. This includes flagging those links which were to form external links and zone loading points.

4.2.3 A key step was to concatenate the ITN node numbers with the gradient flag (“_0” or “_1”) in order to remove a potential problem where one road passes over another, otherwise SATURN would interpret this as a junction rather than a flyover.

4.2.4 The ITN data did not specify explicitly which links represented one-way and two-way links, and so this was inferred based on the road ‘Nature’ parameter, e.g. if Nature = Dual Carriageway then it was assumed this was a one-way link.

4.2.5 A significant amount of data was required to be added to the ITN layer before exporting to SATURN. A database containing the parameters used for the Capacity Indices (speed-flow curves) was developed and imported to MS Access, which were joined to the ITN ‘dbf’ file.

4.2.6 The ITN links flagged for removal were deleted from the ITN layer and this was exported as a shapefile. The ‘dbf’ file was used to create the buffer network by importing into an Excel file. A series of lookups converted this data into the correct format for SATURN buffer network coding.

4.3 SATURN Network Building & Coverage

4.3.1 The ASAM14 road assignment model was developed using SATURN software. This required coding road links and junction layouts across the modelled area.

4.3.2 Model assignment parameters for the ASAM14 SATURN model were extracted from the SEStran Regional Model (SRM12) SATURN assignment model where appropriate.

4.3.3 The SATURN model consists of two main road network areas: the buffer area and the simulation area. The coverage of the road network is illustrated in Figure 9. The orange links represent the simulation area and the blue links represent the buffer area.

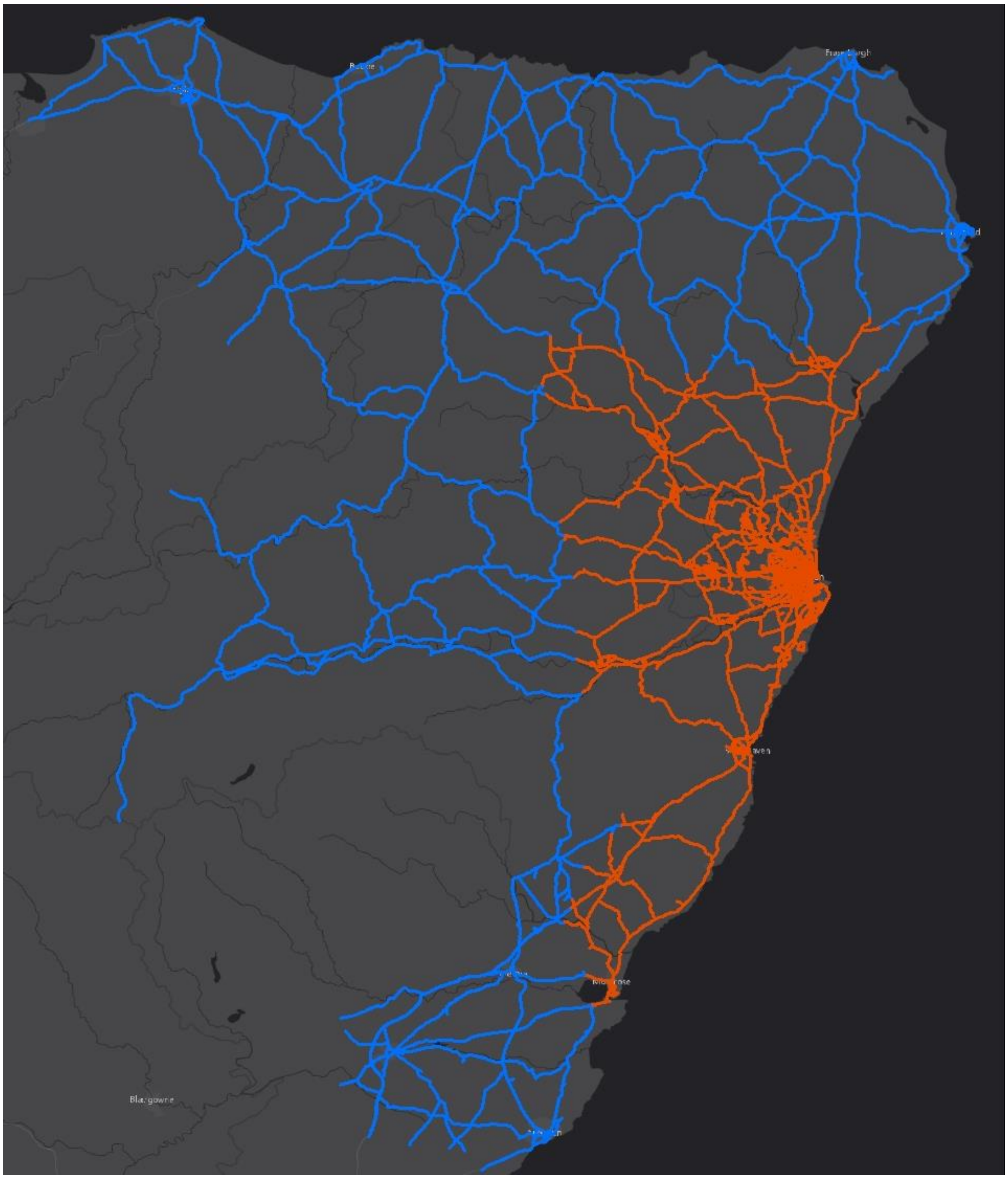

Figure 9. ASAM14 Network Coverage


Buffer Network

4.3.4 Less detailed 'buffer' links were used to represent more rural parts of Aberdeenshire, Moray, Angus and connections with external areas further south and towards Inverness. This represented a similar coverage to the existing ASAM model, with further detail around the key Aberdeenshire towns and to coincide with new zoning.

4.3.5 The buffer area contains no junction information. It contains link-based information, such as distance, link type, speed, etc.

4.3.6 The buffer network was created from the ITN shapefile layer, using Excel to convert the shapefile data into the correct buffer coding format to be read by SATURN.

Simulation Network

4.3.7 The SATURN simulation network, unlike the buffer area, includes detailed junction modelling to represent traffic signals, roundabouts and priority junctions. Simulation network covers the following areas and is illustrated in Figure 9:

- the whole of Aberdeen City;
- the area of Aberdeenshire between the main commuter towns (i.e. Ellon, Inverurie, Westhill, Banchory & Stonehaven) and Aberdeen; and
- the A90 South corridor to Laurencekirk & A92 to Montrose.

4.3.8 To create the SATURN simulation network, a 'Network Builder' executable program was used. This required further formatting of the ITN 'dbf' file using Excel, before passing through a macro-enabled spreadsheet to validate the data, exporting links and nodes data in a specific format for use in the Network Builder program.

4.4 Road Link Coding Approach

4.4.1 The road network was developed from the ITN GIS layer, reference to Satellite mapping and the Network Builder program. This data formed the basis of road link coding, priority and roundabout modelling and represented the layout at signalised junctions.

Road Attributes

4.4.2 Attributes for these links (distances, speed-flow curves, number of lanes/allocation and saturation flow) were inferred from the GIS network using a number of rules and default values to transfer the characteristics of road links into the relevant SATURN attribute format (ie Rural Dual Carriageway = 70mph, with two lane capacity).

4.4.3 Where no automatic distinction in road attributes could be made to isolate the characteristics between different road sections (ie separation of speeds for road sections through rural towns / villages, these were developed by comparing with the TMfS road network (which includes some rural town speed detail) and speed limits extracted from the TomTom data set covering Aberdeen). A number of manual changes were also made to reflect the delivery of 20mph areas within Aberdeen and recent changes to speed limits (i.e. A944 corridor). Satellite imagery and photography along with local knowledge was also used to review road attributes.

4.4.4 Roundabouts are primarily 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. This approach directly matches the ITN link structure. Mini-roundabouts have (usually) been coded using a SATURN Roundabout junction type.

4.4.5 A number of refinements were introduced to cater for different roundabout approach capacities/flares, linking to the road class attribute, and also to appropriately represent the circulating and diverge (off) movements at roundabouts.

4.4.6 Traffic flow-delay relationships were coded for all modelled road links. Speed-flow curves are described in Table 2. Speed-flow relationships are designed to provide road link speeds based on the traffic interactions on the links themselves (as opposed to at junctions). Therefore, the total delay is a combination of the link travel time and the time taken to travel through simulated junctions.

Traffic Restrictions

4.4.7 Traffic restrictions were added to the network, including a ban for Heavy Good Vehicles (HGVs) using the Bridge of Dee. The eastern section of Union Street, Esplanade, Victoria Street (Dyce), Cairn O'Mount and the coastal route at Dunnottar Castle also contain HGV restrictions. A number of banned turns are also incorporated into the junction modelling.

Representing Public Transport Connectivity

4.4.8 Additional public transport network and service information (bus lanes, bus gates) were added to the road network. Bus lanes are assumed to be operational within the AM and PM Peaks and excluded during the Inter Peak, in-line with the operating times displayed on traffic signage. The vast majority of roads used by public bus services are incorporated, especially within the simulation area. There are a number of more rural routes that are used by infrequent services that are not included in the network.

4.4.9 Modelled saturation flows and lane allocations were reduced on sections of road links where bus lanes are in operation (bus lanes are not modelled in the Inter Peak).

Zone Centroid Connectors

4.4.10 The ASAM14 zone system was developed with the aim of modelling fewer than 500 vehicles loading from a zonal location. Zone centroids were positioned to represent the approximate access/egress points associated with local roads.

4.4.11 Each zone was coded with between one and four zone loading points, depending on the zone location, land use mix, local geography and access options available.

4.4.12 Route zone centroid connectors are used to represent the external areas at the edge of the core modelled area.

4.4.13 The default centroid distances were coded as follows:

- Aberdeen City: 200 metres;
- Aberdeenshire, Moray and Angus: 350 metres; and
- External Route zones: 500 metres;

4.5 Junction Simulation Coding Approach

4.5.1 The Network Builder program provided the initial SATURN junction coding structure based on a series of default values. These were modified from values applied in previous Scottish regional model developments (i.e. SRM12)), with slightly lower straight ahead capacities and varied roundabout coding to match different road approach capacities.

4.5.2 The default saturation flows (described in passenger car units per hour (PCU)) for traffic signals and priority junctions are as follows (note the Network Builder does not model any junctions using SATURN's roundabout type):

Table 1. Default Junction Saturation Flows

MOVEMENT	TRAFFIC SIGNALS	PRIORITY JUNCTION
Left turn (major to minor)	1500	1500
Left turn (minor to major)	1500	1200
Straight ahead	1700	1700
Right turn (major to minor)	1250	1250
Right turn (minor to major)	1500	875

Modifications

4.5.3 A review of the outputs from the default network coding was undertaken and a series of modifications implemented to ensure appropriate network representation.

4.5.4 Small roundabouts were retrospectively converted to use SATURN's roundabout junction type, and were coded with saturation flows between 700-1,800 PCU per lane depending on the junction layout and constraints.

4.5.5 A number of saturation flow values were modified depending on the geometric properties of junctions and approaches. For example, some saturation flows were reduced where the junctions appeared to be constrained, have tight turns or poor visibility.

4.5.6 Additional elements such as flares and additional/reduced internal junction stacking capacities were added where appropriate.

4.5.7 Many junctions were consolidated into a single node (e.g. at dual-carriageway junctions) to accommodate signal timings or to more accurately model priority arrangements.

4.5.8 The coding output from the Network Builder process was imported into a series of bespoke spreadsheets to modify SATURN coding for specific junction characteristics and locations. This process included the following steps:

- 'Dummy' nodes changed to Priority type to enable blocking back impacts, with node turning saturation flows modified to match the saturation flow of link;

- Two-lane, non-priority movements changed from the default saturation flow of 3600 to the link's capacity (excluding nodes on roundabouts and zone connector nodes);
- Incorrect priority markers removed at locations where single-carriageway links are adjacent to dual-carriageway links, as well as turning saturation flows amended to match link saturation flows at these locations;
- Roundabout stop-line nodes changed to two lanes with 3,000 circulating saturation flow and 1,700 saturation flow for roundabout exit (if applicable). Turning saturation flow at approach to roundabout set equal to 95% of link capacity;
- An offside flare of five PCU's added to links with an opposed turning movement and a Capacity Index of 3 (for very good quality A-roads); and
- Specific location refinement. For example, large roundabouts (such as Haudagain Roundabout and those on the Anderson Drive corridor) required additional coding modifications to represent detailed characteristics appropriately.

Traffic Signal Settings

4.5.9 Existing Paramics models were used as the primary source of traffic signal information. These provided signal phasing and timings for the following areas and earlier years:

- Aberdeen City Centre (2012); Northern (2012) & Southern Aberdeen (2009) and Dyce / Airport (2014);
- Westhill (2014), Portlethen (2014), Stonehaven (2014), Ellon (2009), Inverurie (2012) and Kintore (2012); and
- Aberdeen A93 Great Western Road (2010), Westburn Road and Kings Gate (2016).

4.5.10 Where required, additional signal data was obtained from the relevant Local Authorities. This data covered signals in Banchory and around 12 locations across Aberdeen, including the A93 Deeside corridor and A944 Lang Stracht corridor (including Kingswells Roundabout and Prime Four access) and the Beach Boulevard. These locations were not covered by microsimulation models.

4.5.11 Where signal data was not available, template signals were used based on estimated signal timings. These were refined during the calibration process to ensure junction delays matched those suggested by observed data (i.e. TomTom data).

4.5.12 Signal timings were reviewed and updated where necessary 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).

Stopping Nodes

4.5.13 Stopping nodes represent specific coding at merge points in the road network. These improve the representation of traffic behaviour at junction merges on dual-carriageways and motorways.

4.5.14 Stopping nodes were coded at merge locations on the A96 and A90, with a default saturation flow at these locations of 3,600 PCUs per hour. This represented a 10% reduction in the standard link saturation flows used on these corridors (4,020 PCUs).


Network Coverage Summary

4.5.15 Within the ASAM14 road network there are approximately 9,000 simulation nodes, 8,500 buffer nodes and 150 signalised junctions. The network contains 630 zones within the updated model version. The first 507 zones and zones 575-630 are internal to the demand model. Zones 508-574 represent park and ride and parking sites, and external zones. The initial model contained 574 zones, excluding zones from 575-630.

Speed-Flow Curves

4.5.16 The initial speed-flow curves used in ASAM14 were extracted from the existing SRM12 model and A96 Corridor Study model, which included some coverage within the ASAM14 area. Some additional curves were added to isolate and better represent flow-delay characteristics for some modelled roads.

4.5.17 Speed flow curves were allocated based on a series of rules (as described in section 4.4), for example, regarding road hierarchy, number of lanes and speed limit, and also more subjective characteristics, such as the nature of the section of route (built/ non-built up) with more/less interactions within the road space available, such as pedestrian crossings, parked cars and general activeness of the road. Where identified lower capacities and/or free flow speeds were generally assigned to these more active areas.

4.5.18 Separate HGV maximum speeds were included for a number of speed-flow curves to represent the speed limit restrictions for these vehicles on higher speed routes. For example, on 70mph limit road, HGVs are restricted to 60mph.

4.5.19 It was found on review of the journey time data (TomTom) that the maximum speed coded on some speed-flow curves was too high, indicating that traffic was travelling on some routes below the speed limit of the link. Some modifications were made to a number of speed-flow curves following a review of observed speeds on key corridors in the modelled area.

4.5.20 When reviewing the HGV routing during the calibration process, it was found that many HGVs used inappropriate 'rat runs' that did not occur in the observed data, and therefore the speed on the links on the signposted route was increased for HGVs to encourage these vehicles to reassign to the correct route. This exercise related to the Anderson Drive corridor, and neighbouring routes. Specific updates to coding were also made to represent observed general traffic rat-running at the Bridge of Dee through Kincorth.

4.5.21 Table 2 displays the full list of speed-slow curves used in the ASAM14 road network.


Table 2. Speed-Flow Curve Relationships

LINK TYPE	SPEED FLOW CURVE				
	CI	Max kph	min kph	capacity (PCU)	power Index
Rural 3 lane A-Road / B-Road	1	109	65	6030	2.75
As above for HGV	1	92			
Rural 2 lane A-Road / B-Road	2	104	58	4020	2.70
As above for HGV	2	92			
Rural S10 Very Good A-Road / B-Road	3	93	45	1730	2.50
As above for HGV	3	78			
Rural S7.3 Good A-Road / B-Road	4	84	45	1640	2.35
As above for HGV	4	70			
Rural S7.0 Typical A-Road / B-Road	5	76	45	1640	2.25
As above for HGV	5	64			
Rural S6.5 Bad (B-Road Only)	6	64	30	1640	2.10
Unclassified Roads	7	44	18	800	2.05
A-Road / B-Road Slip-Roads	8	72	72	1700	0.00
As above for HGV	8	64			
A-Road / B-Road Gyratory	9	56	56	1700	0.00
Suburban 4-lane A-Road / B-Road Typical Development	10	59	30	6800	1.50
Suburban 3-lane A-Road / B-Road Typical Development	11	59	27	5100	1.50
Suburban 2-lane A-Road / B-Road Typical Development	12	59	26	3400	1.50
Suburban 1-lane A-Road / B-Road Typical Development	13	59	26	1700	1.50
Suburban 4-lane A-Road / B-Road (30mph limit)	14	44	19	6800	1.50
Suburban 3-lane A-Road / B-Road (30mph limit)	15	44	19	5100	1.50
Suburban 2-lane A-Road / B-Road (30mph limit)	16	44	19	3400	1.50
Suburban 1-lane A-Road / B-Road (30mph limit)	17	44	19	1700	1.50
Rural S7.3 Good A-Road / B-Road (2 lanes)	18	85	50	3260	2.35
As above for HGV	18	64			

LINK TYPE	SPEED FLOW CURVE				
	CI	Max kph	min kph	capacity (PCU)	power Index
Rural 3 lane A-Road / B-Road (50mph limit)	19	72	54	5190	2.25
As above for HGV	19	62			
Rural 2 lane A-Road / B-Road (50mph limit)	20	72	54	3460	2.25
As above for HGV	20	62			
Rural S10 Very Good A-Road / B-Road (50mph limit)	21	75	45	1730	2.50
As above for HGV	21	61			
Rural S7.3 Good A-Road / B-Road (50mph limit)	22	72	44	1640	2.35
As above for HGV	22	61			
Urban 40mph Fixed Speed	23	59	54	1700	1.25
Urban 30mph Fixed Speed (30mph, no impedances)	24	44	40	1700	1.25
Urban 25mph Fixed Speed (30mph, limited impedances)	25	40	35	1700	1.25
Urban 20mph Fixed Speed (30mph limit significant impedances, or 20mph no impedances)	26	29	26	1700	1.25
Urban 15mph Fixed Speed (20mph, limited impedances)	27	24	21	1700	1.25
Rural Roundabout	28	24	21	3000	1.25
Urban Roundabout	29	24	21	3000	1.25
2-lane Motorway	30	109	72	4380	3.80
As above for HGV	30	94			
Rural 20mph limit	31	28	16	1640	1.25
Urban 20mph limit	32	28	16	1600	1.25
CONNECTOR	33	40	40	2000	0.00
3-lane Urban Roundabout	34	24	15	4500	1.25
Urban 2-lane 40mph Fixed Speed	35	59	44	3400	1.25
Urban 2-lane 30mph Fixed Speed (30mph, no impedances)	36	44	30	3400	1.25
Urban 2-lane 25mph Fixed Speed (30mph, limited impedances)	37	40	25	3400	1.25

LINK TYPE	SPEED FLOW CURVE				
	CI	Max kph	min kph	capacity (PCU)	power Index
Urban 2-lane 20mph Fixed Speed (30mph limit significant impedances, or 20mph no impedances)	38	32	22	3400	1.25
Urban 2-lane 15mph Fixed Speed (20mph limit limited impedances)	39	24	15	3400	1.25
Urban 3-lane A-Road / B-Road (40mph limit)	40	59	50	5100	1.25
Urban 3-lane A-Road / B-Road (30mph limit)	41	44	40	5100	1.25
Urban 4-lane A-Road / B-Road (40mph limit)	42	59	44	6800	1.25
Urban Local Street 20mph (or 30mph with impedances)	43	29	10	1000	1.25
Urban Minor Road 30mph (some impedance)	44	40	13	1600	1.25
Very narrow, very slow road (or to simulate effect of chicane)	45	20	5	400	1.10
Urban 30mph / Rural National speed limit road (narrow and/or significant impedance)	46	40	12	750	1.25
National speed limit road (narrow or some impedance)	47	47	15	1200	1.75
National speed limit road (very narrow or some impedance)	48	38	11	600	1.65
Dual-carriageway with at-grade accesses (slower than National Speed Limit)	49	98	40	3400	2.70
As above for HGV	49	78			
Reduced approached speeds to roundabouts on 70mph roads	50	80	35	4020	2.50
As above for HGV	50	70			
Suburban 1-lane A-Road / B-Road Typical Development, (narrow and/or some impedance)	51	54	24	1700	1.40

4.6 Road Assignment Procedures

4.6.1 The road assignment model procedure adopted for the ASAM14 road model is an Equilibrium Assignment. The Frank-Wolfe Algorithm is used to identify the equilibrium solution.

4.6.2 The SATURN model combines the assignment stage with a junction simulation stage. The traffic delay data 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.

4.6.3 The Assignment process input files include:

- SATURN road network 'dat' file and subsequent top-up files;
- Bus 'preloads';
- Road trip matrices;
- Generalised cost parameters; and
- Range of assignment procedures, including defining convergence.

SATURN Road Network Files

4.6.4 The assignment model contains SATURN road network coding (.dat files) for each modelled time period. These files contain link and junction coding, zonal data, speed-flow curve definitions and model parameters (generalised costs parameters).

Bus Preloads

4.6.5 Bus vehicle traffic within the SATURN network is modelled using fixed preload flows. The bus routes and frequencies were extracted from the ASAM14 (Cube Voyager) Public Transport model and converted to SATURN format. These were then added as a set of link-based preloaded flows into the SATURN road model.

4.6.6 Bus flows are converted into PCUs using a factor of 3.2 per vehicle. This value was set higher than the earlier SRM12 model (set at 2.2) to better represent the impact bus service vehicles have on road network capacity.

Road Trip Matrices

4.6.7 The road model assigns five main traffic user types:

- Car Business (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)

4.6.8 These user classes 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 cars and light vehicles and 1.9 for heavy goods vehicles. These factors are consistent with earlier TMfS and ASAM modelling inputs. There would be some merit in reviewing the HGV and Bus PCU factors. Using a higher factor may provide a better representation of the impact of large vehicles travelling through constrained areas of the network where such local data supports this approach.

4.6.9 Note that the model is designed to allow for future modelling high occupancy vehicles and therefore there are a total number of eight User Classes, with User Classes 2, 4 and 6 currently empty.

Generalised Cost Parameters

4.6.10 The calculation of generalised cost parameters was based on WebTAG guidance issued in January 2016. Note that WebTAG guidance has changed since 2016 and updates to ASAM14 should consider use of the latest guidance for parameter calculations.

4.6.11 The units of time parameters and the distance based parameters are 'Pence Per Minute' (PPM) and 'Pence Per Kilometre' (PPK) respectively, as required by SATURN.

4.6.12 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 2014 Base Year

MODE	PPM	PPK	TOLL	TIME	DISTANCE
Car Business	44.60	12.88	2.51	1.00	0.289
Car Non-work Commute	12.95	6.65	2.05	1.00	0.513
Car Non-work Other	17.06	6.65	2.70	1.00	0.390
LGV	20.97	15.39	0.53	1.00	0.734
HGV	42.38	43.20	1.07	1.00	1.019

All figures are in 2010 values

4.6.13 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

4.6.14 Within SATURN the convergence of the assignment / simulation loops is controlled by the parameters 'PCNEAR', 'RSTOP' and NISTOP. The loops terminate automatically if RSTOP percent of the link flows change by less than PCNEAR percent from one assignment to the next for a number of consecutive iterations (NISTOP). For ASAM14 these parameters were set as follows:

- RSTOP = 98
- PCNEAR = 2.00
- NISTOP = 4

4.6.15 The final convergence % GAP (% DELTA – actual costs minus minimum costs) for the 2014 Base year models were:

- 0.074% for the AM Peak model after 20 iterations;
- 0.0086% for the Inter Peak model after 16 iterations; and
- 0.046% for the PM Peak model after 20 iterations.

4.6.16 The ASAM14 SATURN assignment model is operated through a CUBE Voyager interface. Multicore operation is used which utilises additional processors to run each road assignment.

4.6.17 Note that latest WebTAG guidance suggests a PCNEAR value of 1, and therefore there is some merit in updating this assignment value if producing a new set of model run scenarios.

Road Assignment Outputs

4.6.18 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 (*.LPT, LPN): These print files summarise various parameters, processes and information to facilitate analysis of the performance of the model.

4.7 PASSQ Assignment

4.7.1 The SATURN PASSQ function was applied during the model assignment process. This involved modelling a proportion of the calibrated traffic demand within an earlier hour to preload queues into the main modelled hourly time period.

4.7.2 The proportion of calibrated traffic used within the earlier hour was based on observed traffic count survey data. These proportions were:

- Intra-Aberdeen City zones: AM = 0.815, PM = 0.904
- Intra-Non Aberdeen City zones: AM = 0.863, PM = 0.961
- Aberdeen City to Non Aberdeen City (& vice-versa): AM = 0.839, PM =*0.933

** Average of AM or PM values*

5. PUBLIC TRANSPORT NETWORK, SERVICES & ASSIGNMENT

5.1 Public Transport Structure

5.1.1 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.

5.1.2 The main objective for the PT model was to bring ASAM up to date to reflect 2014 network and service representation and calibrate to represent 2014 travel conditions.

5.1.3 The ASAM14 public transport model has been developed using CUBE Voyager Software, and is predominantly based on the previous SRM12/TMfS public transport modelling approach, with re-working to include updated:

- road network to provide consistency with the ASAM14 road model;
- rail services to reflect 2014 timetabling and recent scheme delivery;
- bus fares model to reflect local 2014 bus fares for each travel purpose;
- rail fares model to reflect station-station fares matrices for each travel purpose;
- bus service routes to reflect 2016 digital bus timetables;
- travel demand matrices to reflect PT activity observed in 2014, recent delivery of PT schemes/services and changes in population and employment; and
- Updated PT assignment parameters, such as values of time.

Time Periods

5.1.4 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

Travel Purposes

5.1.5 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 (ie retail, leisure, escort education).

5.1.6 Note that public transport travel to/from schools within Aberdeenshire is **not** included within ASAM14 – ie the modelling does not represent specific school bus service transport. The modelling does generally reflect school travel within Aberdeen, through the use of scheduled bus services.


5.2 Public Transport Network

Road Network

5.2.1 The ASAM14 PT network is based on the ASAM14 SATURN road network with the addition of the TMfS14 rail network. This structure allows for simple and consistent transfer of changes in forecast road traffic speeds and delays. The modelled PT network includes the following elements:

- Road network;
- Rail network between Carnoustie and Forres, including all intermediate stations;
- 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.

Bus Speeds

5.2.2 Congested traffic speeds are extracted from the road 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.

5.2.3 The relevant bus link speed adjustments are described below. The initial (60%) rural and urban values were extracted from SRM12, with some additional disaggregation to distinguish between the higher speed (and more limited stop nature of dual carriageway routes), and a slightly lower speed for some suburban routes. These changes were based on judgement through reviewing the bus journey time validation:

- 75%: Rural Dual Carriageways 2 or 3 Lane A-Road
- 60%: Rural Roads
- 50%: Suburban / Urban >30mph
- 60%: Suburban / Urban <30mph
- 90%: Bus Lanes

5.2.4 A minimum congested speed of 5kph has been set for bus services. This reflects the detailed nature of bus manoeuvres approaching heavily congested intersections within Aberdeen, 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.

5.2.5 Bus journey times are therefore dependent on the road network speeds and interaction with bus priority measures.

5.2.6 Rail journey times are represented and dictated by timetabled service coding.

Rail Lines & Stations

5.2.7 The ASAM14 rail network represents the East Coast Mainline and Aberdeen to Inverness rail line, within the model boundary. The following rail stations and associated rail lines and connectors have been incorporated into ASAM14:

- **Aberdeen:** Aberdeen Station and Dyce,
- **Aberdeenshire:** Laurencekirk, Stonehaven, Portlethen, Inverurie, Insch, Huntly;
- **Angus:** Arbroath & Montrose;
- **Moray:** Keith & Elgin
- **External connectors:** at Carnoustie and Forres representing points of onwards travel to/from the South and North;

5.2.8 Where applicable, each of these stations also has a car parking capacity allocation within the Park & Ride model.

Bus Priority

5.2.9 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 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.

5.2.10 Bus priority information was derived from previous ASAM bus network coding, review of satellite imagery, local knowledge and client feedback. The new bus gates at Bedford Road and Dubford are **not** included within the base year modelling – but are included in the forecasting scenarios.

Walk Links

5.2.11 The walk link network included the reverse direction of links where the road network is one-way, together with links to represent facilities such as footpaths, footbridges and pedestrianised shopping streets as required.

5.2.12 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 potentially be dropped off at a bus stop/station. 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.

5.3 Public Transport Services

5.3.1 PT services were developed to represent the East Coast Mainline and Aberdeen to Inverness rail line, along with all scheduled public bus services within the modelled area.

5.3.2 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.

5.3.3 System Information contains data for:

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

5.3.4 The PT lines contain data for each modelled public transport service, including the route the service will take across the modelled transport network. Within ASAM14, 'Intra-urban' bus services reflect long distances coaches travelling on the A90 to/from the South. 'Urban' bus services cover buses operating within Aberdeen (ie First Group) and City-Shire services (ie Stagecoach). Public transport services contain the following data:

- 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.

5.3.5 Service time periods were identified by the mid-point of the service time, with the timetable used to calculate a headway for each route in the database. Rail service coding is timetabled within the PT modelling whilst bus journey times are dependent on the road network speeds and interaction with bus priority measures.

Bus Services

5.3.6 ASAM14 bus services are modelled for each time period and have been formed based on the relevant 2016 ATCO-CIF / TransXchange digital bus timetable files for services operating within the modelled area. This includes services crossing the model boundary.

5.3.7 Note that this 2016 database provides a more recent service representation than would traditionally inform a '2014' base year model. It was felt that these 2016 services would provide a generally similar service representation to that experienced in 2014, and would also provide consistency with the period where new bus passenger counts were being undertaken (late 2016). Using this data also reduces the number of timetable changes required in the forecast year scenarios.

5.3.8 TransXchange digital timetables record the bus stops relevant to each bus service, and these were cross referenced with the ITN GIS network TOIDs which are used to prepare the nodes for the road and bus networks. Where some route coverage was not available within ASAM14 (ie for some minor rural or urban routes, particularly in rural towns) bus stops where 'snapped' to be located at the nearest available network node.

5.3.9 Sequences of bus stopping nodes were used to highlight the approximate route of each service. Using GIS algorithms, bus node sequences were infilled with an estimate of the route used between each bus stop. This estimate was based on a calculation of the shortest time-path between each stop.

5.3.10 Urban and inter-urban bus services are coded to stop only at defined bus stops. 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. However, the vast majority of bus stops are reflected in ASAM14.

5.3.11 A number of spot checks were undertaken to check that services followed logical routes between bus stops, with some manual changes implemented as required.

Rail Services

5.3.12 Rail service coding was extracted from the TMfS14 PT model and timetables updated to be based on 2016 ATCO-CIF timetable data.

5.3.13 Where relevant, rail services were aggregated based on stopping patterns with average headways derived for each time period.

5.3.14 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 to ensure that the general frequency of longer distance services was appropriately represented.

5.3.15 The MODE control statement defines the type and characteristics of the various modes used by the PT system. The number of services is listed in Table 4:

- Intra-urban bus within and to/from the City and Shire;
- Inter-urban bus: long distance A90 coach services to/from the south; and
- Rail services;

Table 4. ASAM14 Public Transport Services

MODE	AM PEAK	INTER PEAK	PM PEAK
Intra Urban Bus	303	292	258
Inter Urban Bus	2	4	4
Rail	7	5	7
Total	**312**	**302**	**269**

5.3.16 Public Transport service coverage is illustrated in Figure 10 to Figure 14.

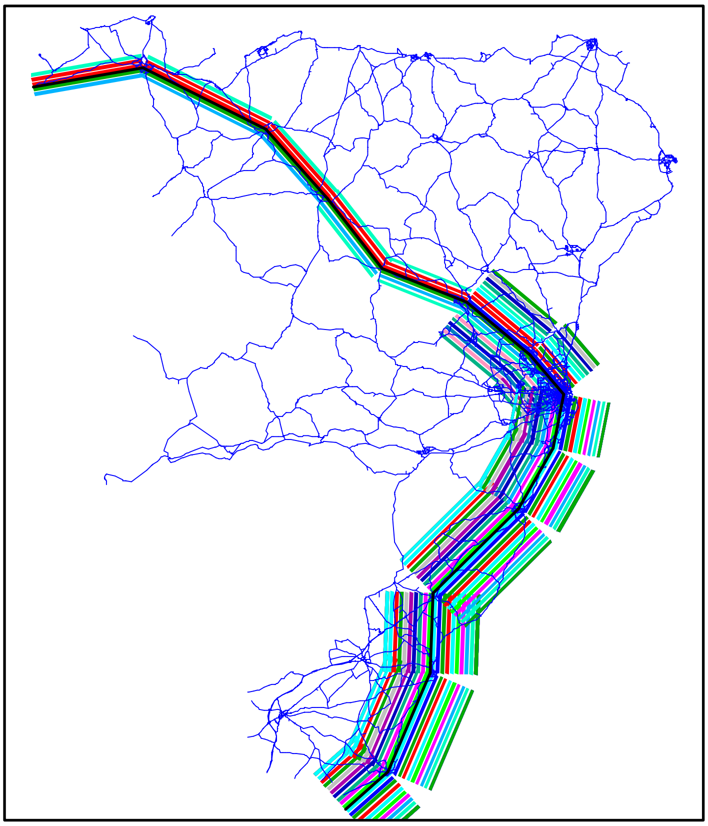

Figure 10. Rail Services

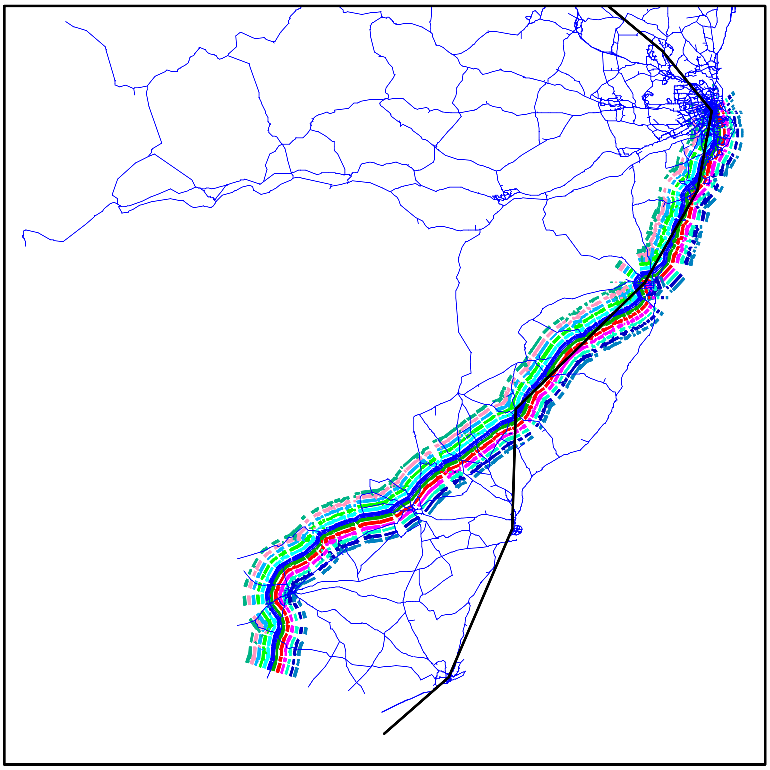

Figure 11. Inter Urban Coach Services

SYSTRA

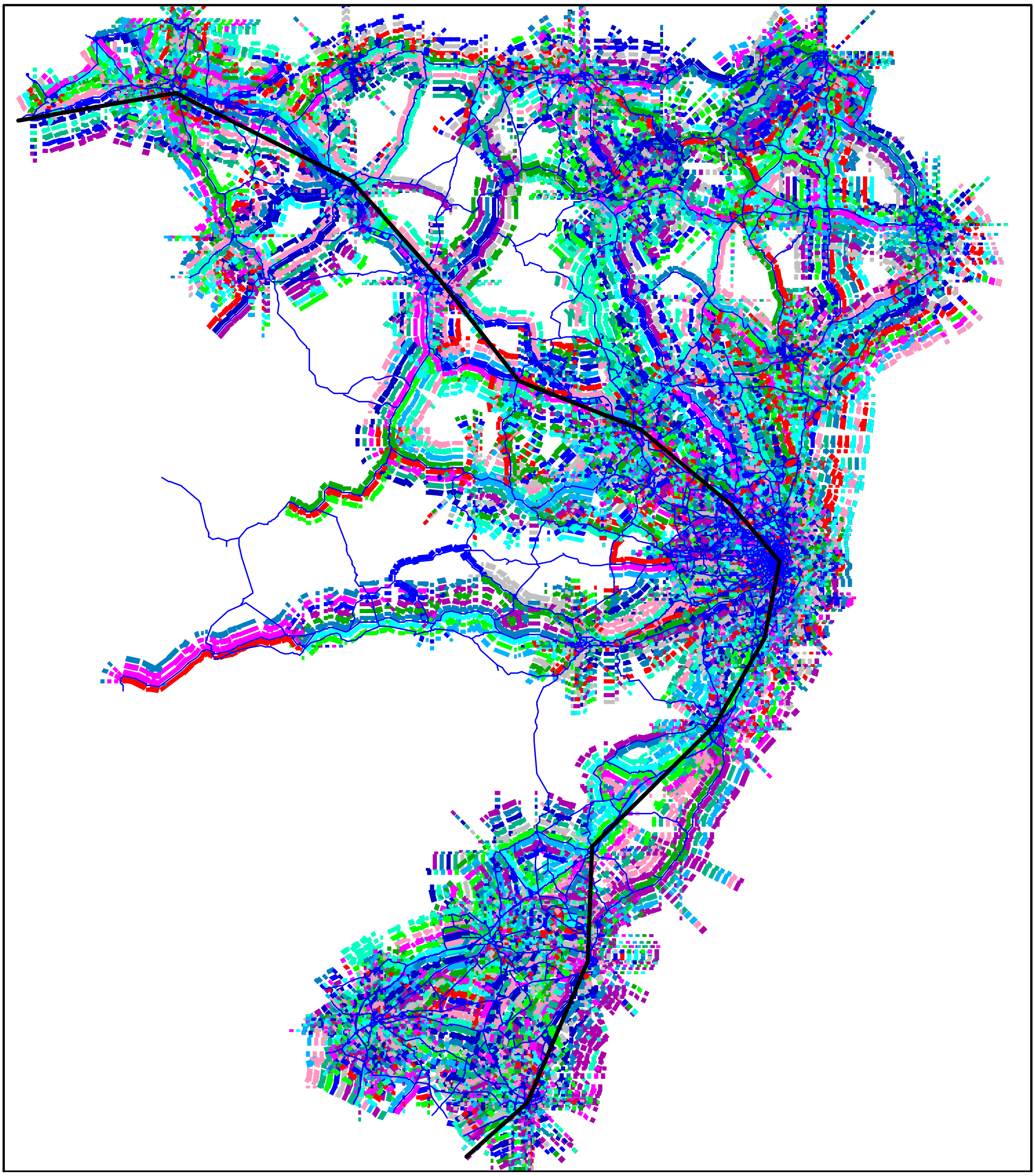

Figure 12. Intra Urban Bus Services

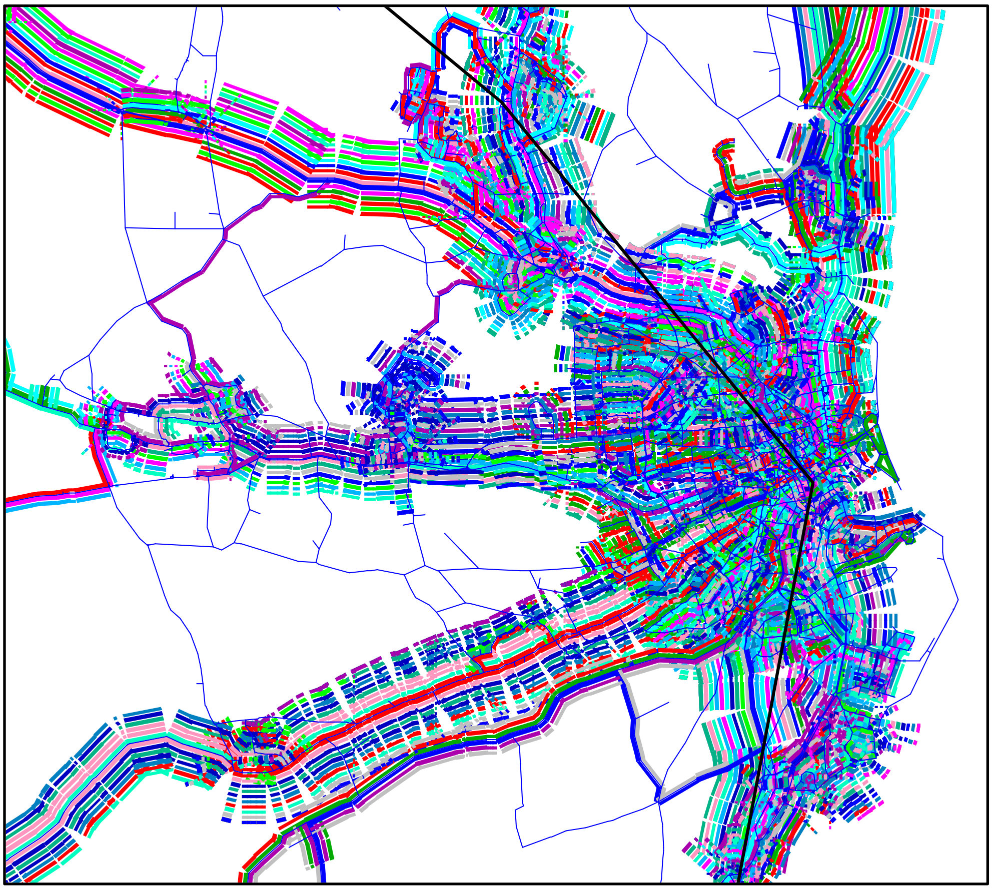

Figure 13. Intra Urban Bus Services - Aberdeen

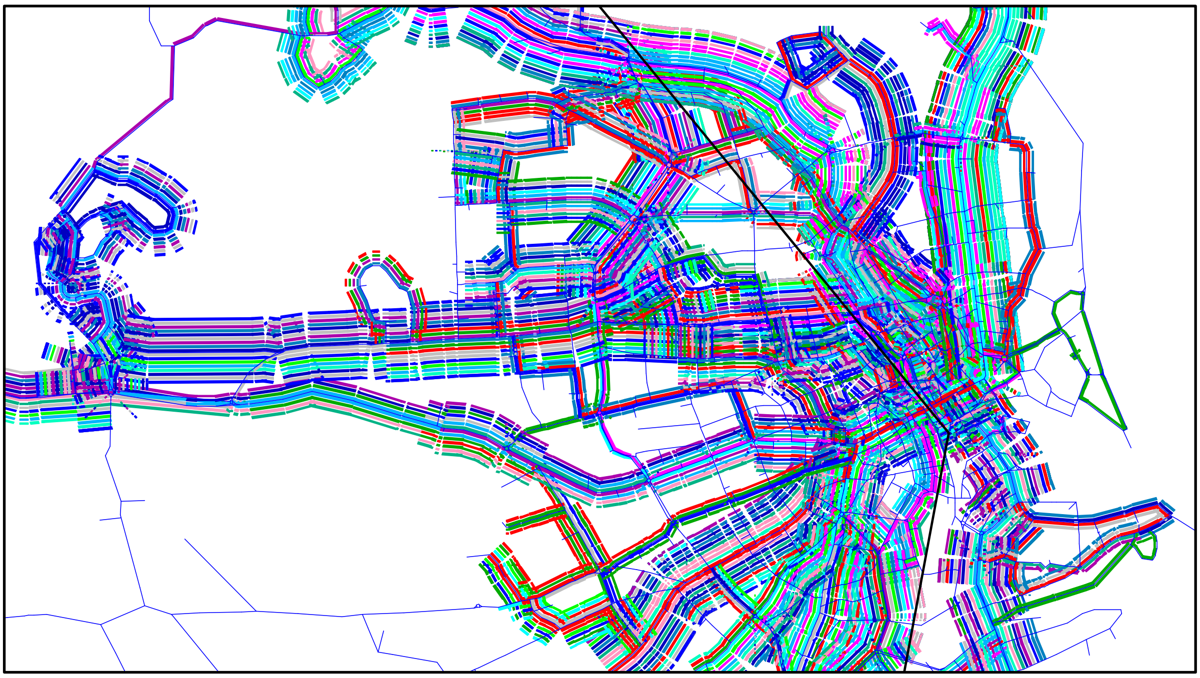

Figure 14. Intra Urban Bus Services – Central Aberdeen

5.4 Fares Model Development

5.4.1 The Fares Model for ASAM14 is based on a set of distance-based bus fares and station to station rail fare tables. Fare tables are allocated to modelled operators by user class (travel purpose) and time period and are in 2014 prices unless otherwise stated.

5.4.2 Allocating fares by travel purpose improves the representation of the average fare paid by commuters that have season tickets, other concessionary travellers, and the full prices paid by more irregular business travellers.

5.4.3 Bus fares are assigned within the PT model across the following bus operator groupings.

- First Aberdeen (covering all First services);
- Stagecoach Aberdeen (covering all Stagecoach services);
- Other intra-urban services operating within Aberdeen City
- Other services operating across Aberdeenshire – other rural services
- Citylink / Megabus Longer distance services.

Bus fares

5.4.4 ASAM14 Bus fares are distance based and were determined using analysis of a sample of fares for Stagecoach, First and Citylink services. This identified an average distance for each Stagecoach, First and Citylink fare stage. This fare was then adjusted for each user class based on the following assumptions:

- Bus In-Work:
  - Return fare divided by two
- Bus Non-Work Other:
  - Return fare divided by two with concession factor applied. The results from an onboard bus questionnaire carried out in Aberdeen in 2014 were used to calculate the concessionary fare factor. The concession factor of 19% is the proportion of non-concessionary cardholders making non-work or commute trips (sample size = 334).
  - A zero bus fare was assumed for concessionary pass holders.
- Bus Non-Work Commute:
  - Weekly season ticket for the relevant zone (based on distance) divided by the seasons factor. The seasons factor is 10, assuming 10 trips per week using the weekly pass.
- Stagecoach has nine distance based fares. The Stagecoach distance based fares have also been applied to 'Other_Aberdeenshire' operator fares.
- First has five distanced based fares. First distance based fares are also applied to 'Other_Aberdeen' fares. Until April 2016 First Aberdeen offered a return fare, calculated to be 1.8 times the 2014 single fare (to represent a 10% saving).
- Citylink has three distance based fares. 2016 fares have been used for Citylink with no adjustment applied.

5.4.5 Figure 15 compares Stagecoach and First AM Peak fares for each user class.

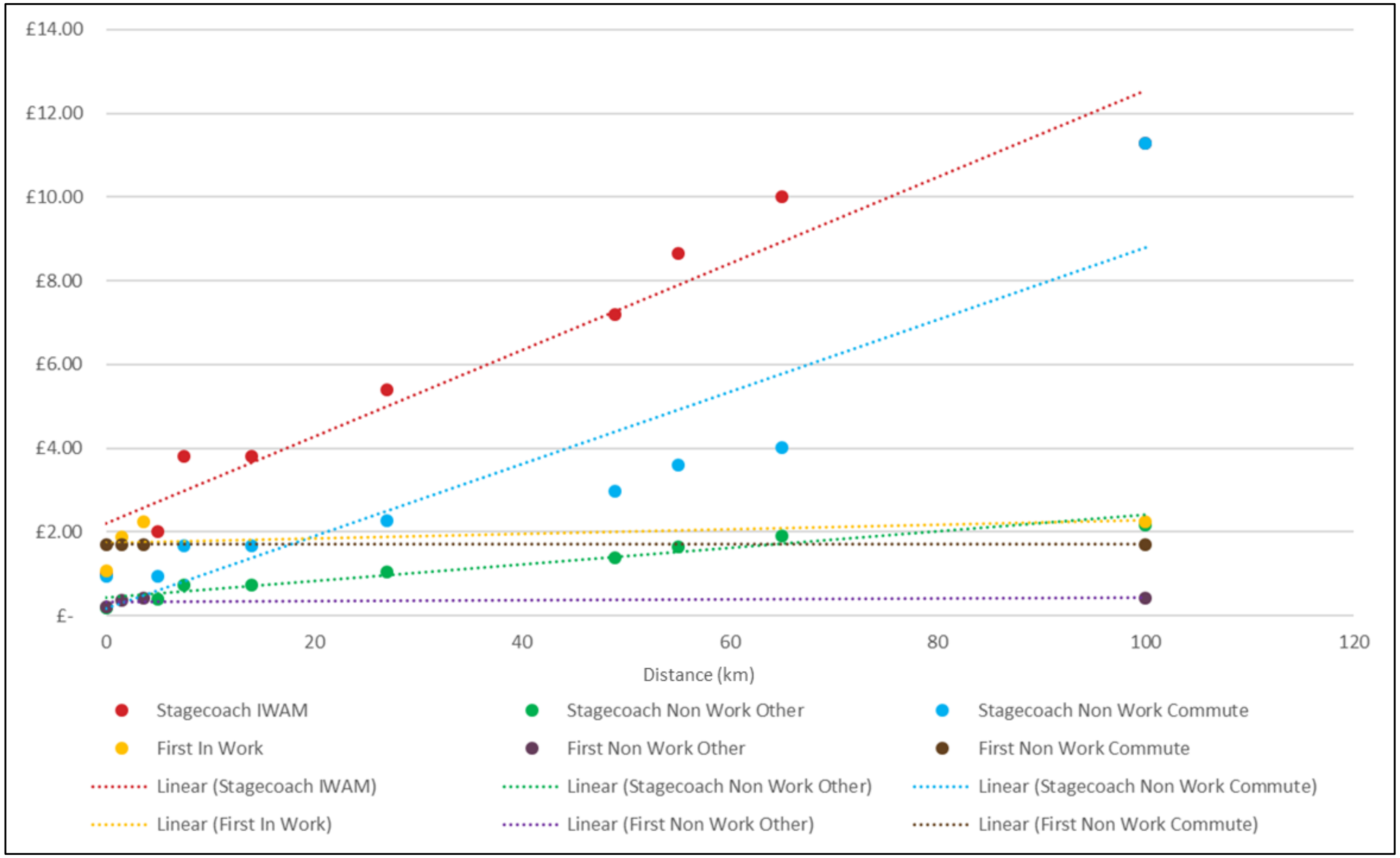

Figure 15. AM Peak Fare Comparisons – Stagecoach and First (Fare (£) vs Distance (km)

Rail fares

5.4.6 Rail fares are assigned consistently between stations for all rail operators using Fares matrices by time period and by travel purpose

5.4.7 To develop the ASAM14 rail fares, 2014/15 LENNON data was processed to create a station to station fare matrix. All ticket types sold for each station to station movement are included within the LENNON data. The following ticket types were identified for each movement and used, where available, to develop an In-Work, Non-Work Commute and Non-Work Other fare matrix:

- Off Peak Day Return
- Anytime Day Return
- Seven Day Standard
- Anytime Day Single
- Off Peak Return
- Anytime Return
- Advance
- Off Peak Day Single
- Off Peak Single
- Anytime Single

5.4.8 Varying fares and factors were applied to determine the station to station fare available for each user class and time period. The process applied to represent each user class and time period is as follows:

- Rail In Work - Business
  - AM and PM - Anytime Day Return/2
  - IP – Off Peak Return/2
- Rail Non Work Other - leisure, retail etc
  - AM and PM – Anytime Day Return/2 x Concessionary factor divided by two
  - IP – Off Peak Return/2
  - For Non-Work Other external movements it was assumed that there would be a quantity of Advanced ticket sales. The LENNON ticket types were mapped to Advanced, Seasons, Anytime, Reduced to identify the proportion of Advanced tickets on Aberdeen-Dundee and Aberdeen-Inverness movements (37%). The Advance fare was applied to the Advanced ticket proportion and Anytime or Off Peak (depending on time period) fare applied to the remaining proportion.
  - Concessionary factor is based on the number of railcards issued in the UK/total population and the assumption of a 33% discount on fares. Two Together and Family & Friends railcards were excluded from this calculation. The Concessionary factor is 98%, resulting in a discount of 2%.
- Rail Non Work Commute
  - AM, IP and PM – Seven Day Standard/Seasons Factor (10)

5.4.9 For movements where a Seven Day Standard fare was not recorded the Anytime Single fare was used with a Seasons factor applied. The Seasons factor is based on analysis of Seven Day Standard fares and Single fares on the ScotRail website for a sample of station to station movements within the modelled area. The Seasons factor is 75%

5.5 Passenger Wait Curves

5.5.1 A wait curve is applied to reflect the perceived time waiting to board a public transport service. For ASAM14 the wait curve was based on the existing SRM12 model, which was derived from the Passenger Demand Forecasting Handbook (PDFH) and has been implemented for all PT lines in ASAM14 (described as 'Non London Inter-urban').

5.5.2 The ASAM14 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.

5.5.3 The rise in wait time is decreased for waits of over 120 minutes – which also affects 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. ASAM14 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)
60	31 (15.5)
90	39 (19.5)
120	47 (22)
180	63 (24)

5.6 Passenger Crowding

5.6.1 Public transport crowding is represented within the ASAM14 PT assignment procedures for morning and evening peak rail services only.

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

5.6.3 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.

5.6.4 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.

5.6.5 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.

5.6.6 The ASAM14 crowding model is based on consistent processes as developed for the SRM12 base year crowding modelling.

Rail Service Capacity

5.6.7 Specific rail service capacities have been coded for all rail services in the ASAM14 base year, based on the previous development of the TMfS14 2014 base Year model. Capacities were allocated to each updated train timetable contained within the 2016 ATCO-CIF timetable data. This provided an indication of the seated and crush capacity on all train services in 2016, which is broadly representative of rolling stock allocations.

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

Crowding Curves & Utilisation

5.6.9 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. The ASAM14 approach is consistent with that used in SRM12.

5.6.10 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.


5.6.11 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. ASAM14 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

5.6.12 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

5.6.13 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 transport loadings (and hence the crowding costs) stop changing significantly between iterations.

5.6.14 The number of iterations is specified by the user, with five iterations applied for the ASAM14 PT crowding loop as standard (consistent with SRM12). Model users should consider reviewing the number of iterations depending on the travel demand and interventions being tested.

5.7 Public Transport Assignment Parameters

Path Building and Loading

5.7.1 The ASAM14 path building and loading procedures have been developed using the CUBE Voyager public transport assignment model software, with the following models:

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

5.7.2 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 stage calculates the “probability of use” for each of the enumerated routes between zone pairs, including the impacts of crowding and fares.

5.7.3 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.

5.7.4 The PT 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	1.0
Spread Factor		1.5
Spread Constant		10 mins
LAMBDAA		0.5
LAMBDAW		0.5
In-vehicle Time Factors: AM, Inter & PM Peaks	urban bus	1.4
	inter-urban bus	1.4
	rail	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 (2014 Base Year): 2010 prices / values (weighted rail and bus). Calculated from Generalised Cost working sheet, based on WebTAG January 2016	in work (business)	16.77 £/hr
	non work (commute & other)	6.62 £/hr

6. PRIOR MATRIX DEVELOPMENT

6.1 Travel Demand Matrix Elements

6.1.1 ASAM14 represents specific travel demand movements using a set of 2014 base year travel assignment matrices for relevant travel purposes. These purposes cover road and public transport travel and include the following user classes for AM, Inter and PM Peak hourly network assignments:

- Business trips (In-work – 'IW');
- Commuter trips (Non-work commute – ('NWC');
- Other trips (including retail, health, leisure trips etc and education) – 'NWO');
- Light Goods Vehicles (LGV); and
- Heavy Goods Vehicles (HGV).

6.1.2 The assignment matrices also contain the following more detailed travel demand movement elements:

- **Education movements:** student travel to school and university and colleges (noting that Aberdeenshire school PT trips are not included – as the model supply does not include school buses). These trips are included within the 'other' assignment matrix user class;

- **Park & Ride movements:** separate road and PT trip legs to / from specific Park & Ride and city centre car parks to zonal origins and destination. These business, commute and other road and PT trips are included within the relevant assignment user class. Note that education movements are not included within Park & Ride and the initial/final walk trip to/from a city centre car park to/from the origin/final trip destination is not included within the model assignment;

- **External Movements:** All travel user class movements to /from geographical areas external to the ASAM14 model coverage area;

- **Aberdeen Airport Air Passenger Trips:** Business and Leisure passenger trips using (flying to/from) Aberdeen Airport (to/from residential, business & Hospitality areas) are developed and included specifically for ASAM14 (in zone 210 representing Aberdeen airport). These trips are included in the relevant assignment matrix user class. Airport employee travel is also represented in zone 210, but with these demand movements created and accounted for within the standard commuter travel development processes; and

- **Aberdeen Heliport Air Passenger Trips:** Heliport passenger trips (offshore workers) are assumed to represent **commuter** travel patterns to/from the Heliport to/from residential areas. These trips are specifically developed and included within ASAM14 (in zone 209 representing Aberdeen Heliport). Heliport employee commuter travel is also represented in zone 209, but with these demand movements created and accounted for within the standard commuter travel development processes.

6.1.3 The creation of each of these different types of travel movements involved various processes and data sets. The following sections describe the development of each travel movement element which form the development of the Road and PT Prior assignment matrices for the AM, Inter and PM Peak hours.

6.2 'Standard' Demand Model Travel Purpose Trips

6.2.1 ASAM14 business, commuter and other road and PT travel movements were developed through the use of the trip end model, demand model processes, and the application and comparison of several data sets.

6.2.2 The main observed data inputs were:

- 2011 Census population inputs: at output area level, combined to ASAM14 zoning;
- 2011-2014 mid-year population estimates: at small area level used to growth 2011 census population to 2014 levels;
- 2011 Census employment (jobs) data: combined to ASAM14 zoning;
- 2011-2014 Business Register Survey (BRES) jobs data: at previous 2011 Census outputs area level to growth jobs to 2014 levels;
- 2011 Census Travel to work car and PT patterns: combined to ASAM14 zoning and used to compare synthesised road and PT commuter demand distributions;
- 2012-2016 Scottish Household Survey (SHS) Travel Diary travel patterns: combined to ASAM14 zoning and used to compare business and other trip purpose movements.

6.2.3 The approach for creating commuter, business and other trips to/from standard 'demand model' zones applied the ASAM14 Trip Generation model to create a set of zonal trip ends for each travel purpose based on detailed population and employment data. These were input to the demand model to synthesise person travel movements to match observed travel distributions.

6.2.4 Once all other elements of travel demand (described within section 6.1) were also incorporated, this produced a set of AM, Inter and PM Peak 'prior' assignment matrices, to be input to the matrix estimation phase for calibration against further observed data.

6.2.5 This Prior Matrix process therefore applies trip end data to generate the overall level of zonal travel demand, and combined these with zonal travel costs to create synthesised travel demand. Trip End data is calibrated to match the overall level of travel observed within traffic and PT passenger counts. The synthesised travel demand is calibrated (using mode/distribution parameters) to match observed Census and SHS travel patterns.

6.2.6 The matrix development involved several iterations of working through the required processes, updating travel costs and comparing outputs, and included the following key steps:

Trip Generation & Attraction

- The planning database detailing the level of population and jobs in 2014 was input to the trip end model using area-based person trip rates (ie urban, rural, rail corridor etc – as described in Section 15) to generate the level of road and PT trip productions for each modelled zone – creating **'Trip Ends'**. This included:

  - Adjustments to some geographical area trip rates were undertaken to better match the overall level of observed traffic volumes and public transport patronage across the modelled area (ie comparing with the road traffic Screenlines and PT passenger cordons described in Sections 7 and 9) – reflecting overall North East travel activity. Trip Rate adjustments are described in Appendix A.

  - Adjustments were also made to the number of jobs present in key employment estates – to increase the level of commuter trips attractions to these areas (as illustrated by the 2011 Census Travel to Work area) – reflecting Specific North East commuter travel movements.

    Note that the formation of the ASAM14 zonal jobs data was undertaken prior to the release of the new 2011 Census employment 'area' database (which aggregates area geography based on employment data rather than housing / population figures). The previous 'Population'-area based database included some large area zones for industrial estates (where there is little housing, which creates some uncertainty for disaggregation.

    BRES, TELMoS and Census employment data provide inconsistent estimates in terms of the overall level of jobs identified in and around Dyce and Kirkhill. There is also the additional uncertainty generated by some commuters that may both work offshore or in the office from time-to-time. Hence the approach to adjust underlying jobs data to provide a greater attractiveness and better match Census commuter movements.

  - A reduction in retail jobs in Aberdeen city centre (of -10%) was undertaken to reflect the potential for a larger proportion of jobs in the area to be part-time or weekend-related. This also reflected the balance of trip making between geographical areas suggested by the Census travel data comparisons (ie that typical 'nine-to-five' industrial estate / business park trips were being underestimated and city centre 'weekend' trips were being overestimated - with ASAM14 calibrated to represent a standard weekday).

  - A reduction to the number of jobs at Aberdeen Royal Infirmary was made to reflect the number of jobs associated or stationed at this location, but that may not involve typical weekday travel to/from this site (ie higher proportion of shift / weekend work).

- This process generated a set of AM, Inter and PM zonal **'Trip Ends'** - productions and attractions for business, commuter and Other trips (and education – see later).

Mode & Destination Choice

- Road and PT Trip End productions and attractions by travel purpose were input to the ASAM14 demand model and cross referenced with generalised travel costs for each purpose and mode.

  - The first set of initial Generalised costs was created by assigning a 2011 Census Travel to work matrix. Cost matrices were updated as demand matrices were prepared and supply network / services were refined. This involved several iterations of updating the assignments/matrices through the matrix development process;
  - A cost damping procedure was incorporated into the demand model used to produce travel movements. This varied underlying travel costs by zonal distance travelled for road and PT modes.

- The demand model then created sets of zonal person demand matrices by mode and travel purpose – based on the underlying Generalised travel costs and demand model mode and distribution choice parameters – Creating AM, Inter and PM Peak **'Period Matrices'.**

  - Trip distribution charts were prepared to compare modelled and observed trip lengths, with adjustments made to demand model parameters to better reflect observed travel distributions.

  - Commuter matrices were compared against Census travel to work mode and destination movements at a 28 Sector/Area level to understand differences in specific modelled and observed travel patterns.

  - 'Other' movements were compared against Scottish Household Survey (SHS) Travel Diary data which was also converted to 28 sector level. Calibration adjustments were undertaken to match the relevant trip length distributions implied by SHS travel diary for the North East (Note that travel diary data did not produce a sample for business trips and PT data was more limited).

  - A series of 'K-factors' were applied to adjust some modelled sector-sector movements to reflect the observed pattern. These factors change the attractiveness of a movement to increase/decrease the level of trip making between sectors.
    K-factors were intuitively applied to sectors and ranged from around 0.1 to 2.5 in magnitude for road movements, and from around 0.1 to 1.9 for public transport movements, with average values of around 0.85 for road and 0.95 for PT. The main focus of the high/low outlier values was to reduce movements within some sectors where data suggested trip making was lower than demand model estimates. For example, reducing trips within the city centre, where, once parked, motorists would tend to walk within this area. PT factors were aimed at increasing movements from some Aberdeenshire towns to better reflect the commuting nature of these areas to/from Aberdeen.

- Park and Ride and Parking origin to destination end-to-end trip patterns are also produced at this stage. These are based on taking a proportion of the road and PT trip productions, with the overall number of trips set to match the overall number of park and ride and parking trips / vehicles recorded parking in site / station car parks (this data is discussed further within the Park and Ride Chapter).

- Note that the Census does not isolate responses of PT users for Park and Ride, so it is assumed respondents would answer that they use PT travel (as opposed to car if using park & ride) – and therefore modelled PT and Park and Ride movements are combined to compare with Census movements.

- Similarly, it is assumed that Aberdeen City centre parking trips are comparable with Census road movements and should be combined prior to Census comparisons. Note that these issues create some difficulty in providing a consistent Census movement comparison, however the combination of data sets is thought to provide the most appropriate method available for comparing modelled outputs.

6.2.7 The 28 sector system used to compare travel movements is illustrated in Figure 16.

6.2.8 Sectors cover the following areas:

- Sector 1: Aberdeen City Centre;
- Sectors 2-7: Central Aberdeen;
- Sectors 8-13: Aberdeen Periphery;
- Sectors 14-18: Aberdeenshire Commuter Towns;
- Sectors 19-24: Aberdeenshire Rural;
- Sectors 25-26: Moray (East); and
- Sectors 27-28: Angus (North).

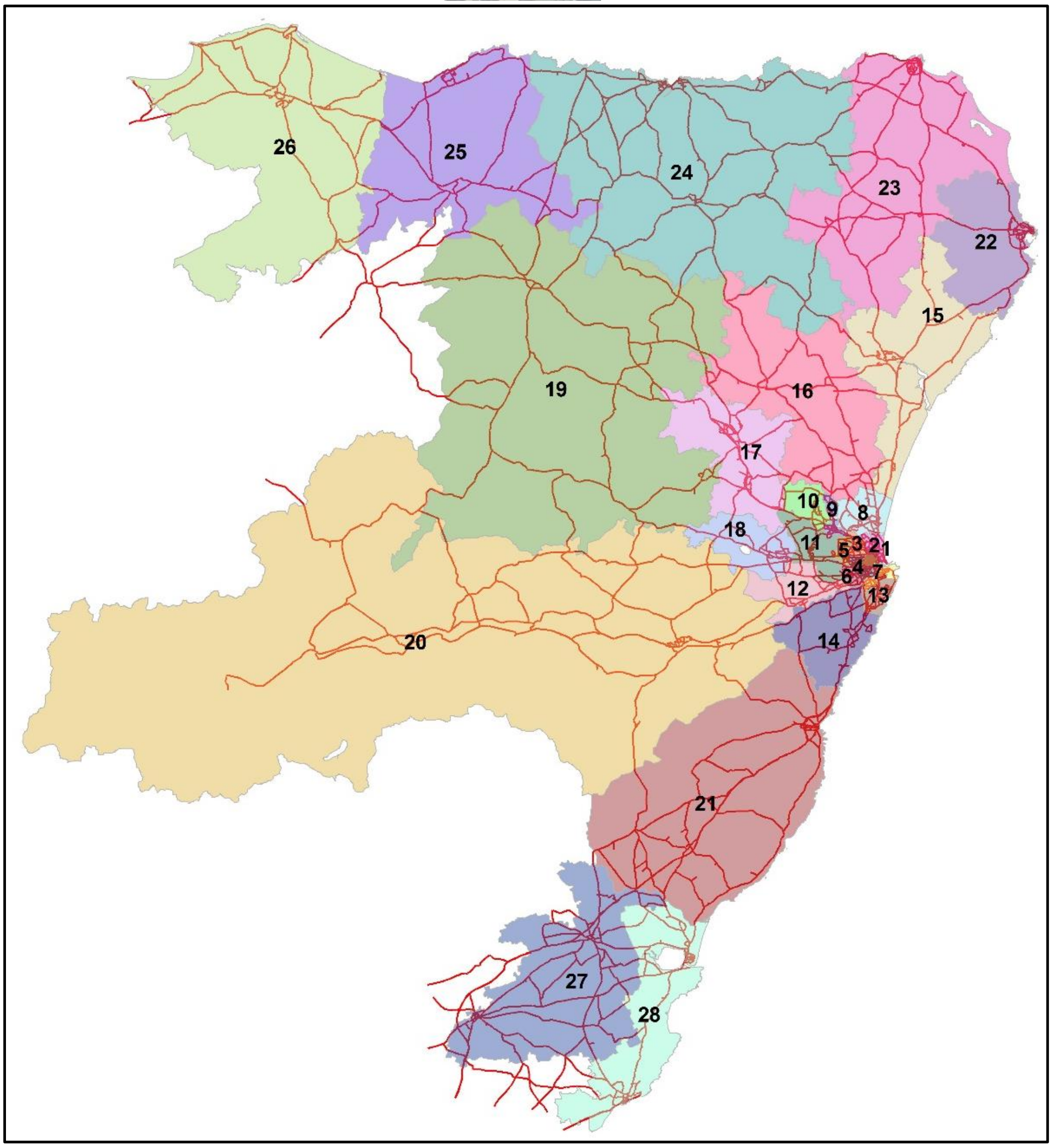

Figure 16. 28 Sector System

6.2.9 The following section discusses how the standard commute, other and business trip prior matrices compare with observed travel demand, including:

- Trip Distribution: illustrating travel cost / trip lengths;
- Mode Share: Road & PT travel demand proportions; and
- Travel Patterns: Illustrating how trips disperse between sectors.

6.2.10 Appendix B describes the modelled and observed sector-to-sector movements for each travel purpose. These show modelled 'From-home' trip movements compared to the Census travel to work data, with the Census comparison matrix scaled down to match the total level of modelled trips for each time period and mode.


6.2.11 The trip distribution comparison charts for each time period and travel purpose are described in Appendix C. The major travel movements by time period - AM Peak commute, and Inter Peak Other and Business, and PM Peak Other movements are shown in Figure 17 to Figure 22. These show the observed and modelled cumulative frequency (total travel cost distribution as costs change) and relative frequency (absolute number of trips for each cost level) of trips compared to generalised cost.

6.2.12 A summary of average trip generalised cost distribution are described in Table 8 to Table 10 for each, travel purpose, mode and time period. Generalised costs exclude parking charges and cost damping. PT costs reflect perceived costs and include PT fares.

6.2.13 Mode share proportions for each travel purpose, mode and time period are described in Table 11 to Table 13. Mode share comparisons contain a proportion of city centre parking trips included within the road demand (78% - based on car park occupancy data) and park and ride trips included within the PT demand (22%).

6.2.14 Note that the Census (daily) mode share data provides a consistent observed value for each time period. There is some potential that commuter (from home) travel could be more dispersed out with the morning peak, and that commuters that need to return home later in the evening (where PT services are less frequent), could tend to increase car use and result in a lower PT mode share as the day goes on.

6.2.15 Note that the SHS data set did not provide any responses for business travel by public transport. Therefore, there is no direct comparison for the modelled mode share values. The lack of responses tends to indicates a lower mode share for business trips compared to the other modes.


Table 8. Average Generalised Cost Distribution Comparison (Generalised Minutes)- Commute

PERIOD / MODE	OBSERVED TRAVEL AVERAGE COST	MODEL TRAVEL AVERAGE COST	DIFF.	% DIFF
AM Car	28.8	31.6	2.8	10%
AM PT	120.4	123.6	3.2	3%
IP Car	25.8	28.3	2.4	9%
IP PT	119.9	125.7	5.8	5%
PM Car	28.1	31.1	3.0	11%
PM PT	123.5	130.5	7.0	6%

Table 9. Average Generalised Cost Distribution Comparison (Generalised Minutes)- Other

PERIOD / MODE	OBSERVED TRAVEL AVERAGE COST	MODEL TRAVEL AVERAGE COST	DIFF.	% DIFF
AM Car	18.8	21.0	2.2	12%
AM PT	83.3	90.2	6.9	8%
IP Car	17.1	19.4	2.4	13.9%
IP PT	81.7	84.4	2.7	3.3%
PM Car	18.7	19.8	1.2	6.3%
PM PT	83.2	85.3	2.1	2.5%

Table 10. Average Generalised Cost Distribution Comparison (Generalised Minutes)– Business

PERIOD / MODE	OBSERVED TRAVEL AVERAGE COST	MODEL TRAVEL AVERAGE COST	DIFF.	% DIFF
AM Car	29.2	33.9	4.7	16%
AM PT	NA	121.7	NA	NA
IP Car	26.8	32.0	5.1	19%
IP PT	NA	114.1	NA	NA
PM Car	30.6	34.9	4.3	14%
PM PT	NA	117.8	NA	NA

Table 11. Mode Share Comparison - Commute

PERIOD / MODE	OBSERVED MODE SHARE	MODEL MODE SHARE	DIFF.
AM Car	86.4%	90.5%	4%
AM PT	13.6%	9.5%	-4%
IP Car	86.4%	91.5%	5%
IP PT	13.6%	8.5%	-5%
PM Car	86.4%	91.0%	5%
PM PT	13.6%	9.0%	-5%

Table 12. Mode Share Comparison - Other

PERIOD / MODE	OBSERVED MODE SHARE	MODEL MODE SHARE	DIFF.
AM Car	88.1%	92.3%	4%
AM PT	11.9%	7.7%	-4%
IP Car	88.1%	90.1%	2%
IP PT	11.9%	9.9%	-2%
PM Car	88.1%	96.4%	8%
PM PT	11.9%	3.6%	-8%

Table 13. Mode Share Comparison - Business

PERIOD / MODE	OBSERVED MODE SHARE	MODEL MODE SHARE	DIFF.
AM Car	100%	95.1%	-5%
AM PT	NA	4.9%	NA
IP Car	100%	94.4%	-6%
IP PT	NA	5.6%	NA
PM Car	100%	97.1%	-3%
PM PT	NA	2.9%	NA

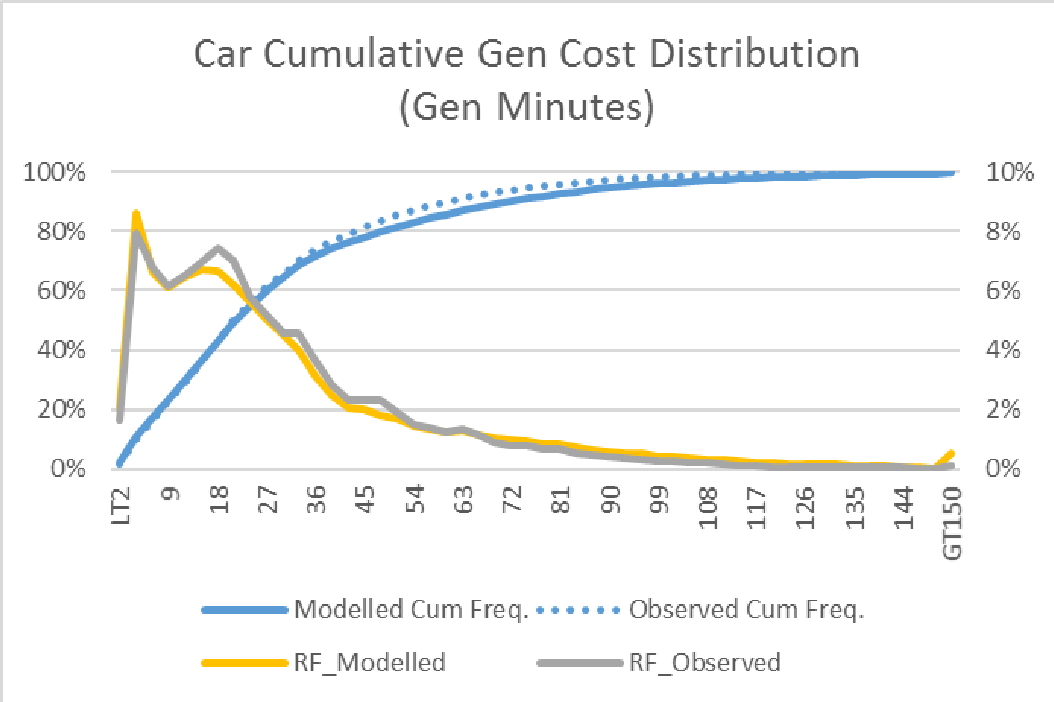

Figure 17. AM Peak Commuter Movement Cost Distribution Comparison (Census) – Car

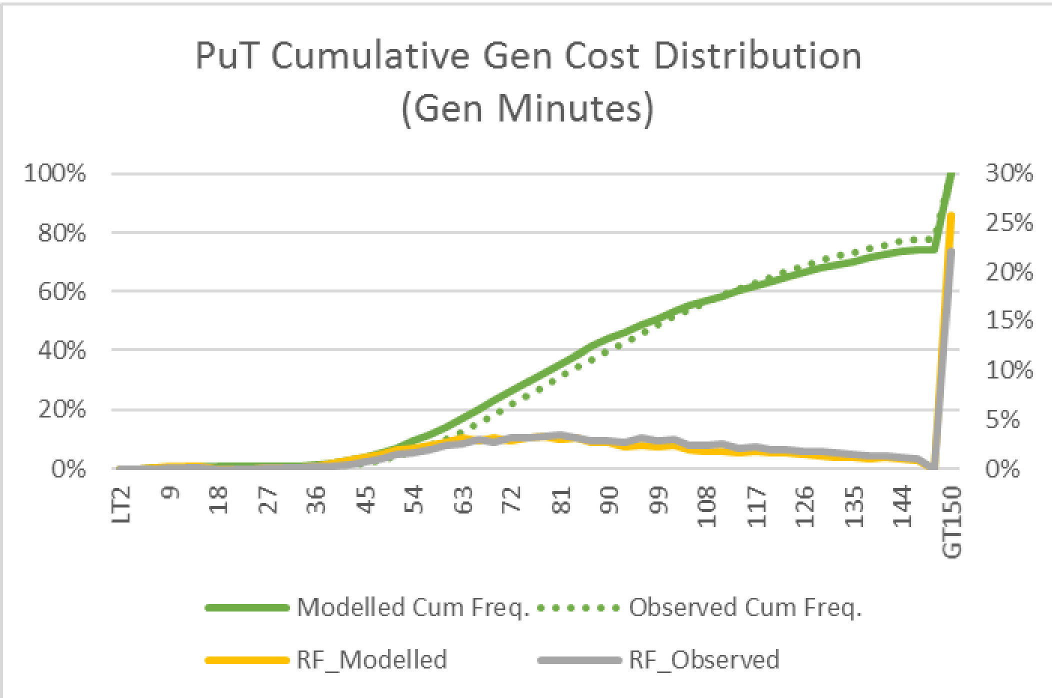

Figure 18. AM Peak Commuter Movement Cost Distribution Comparison (Census) - PT

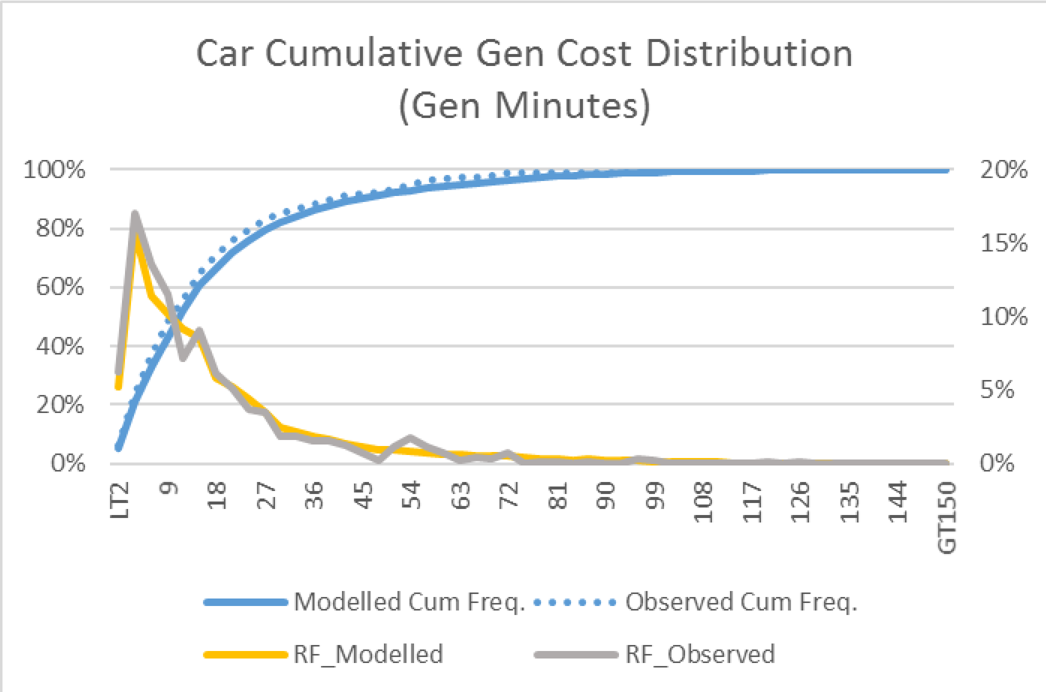

Figure 19. IP Peak Other Movement Cost Distribution Comparison (Census) – Car

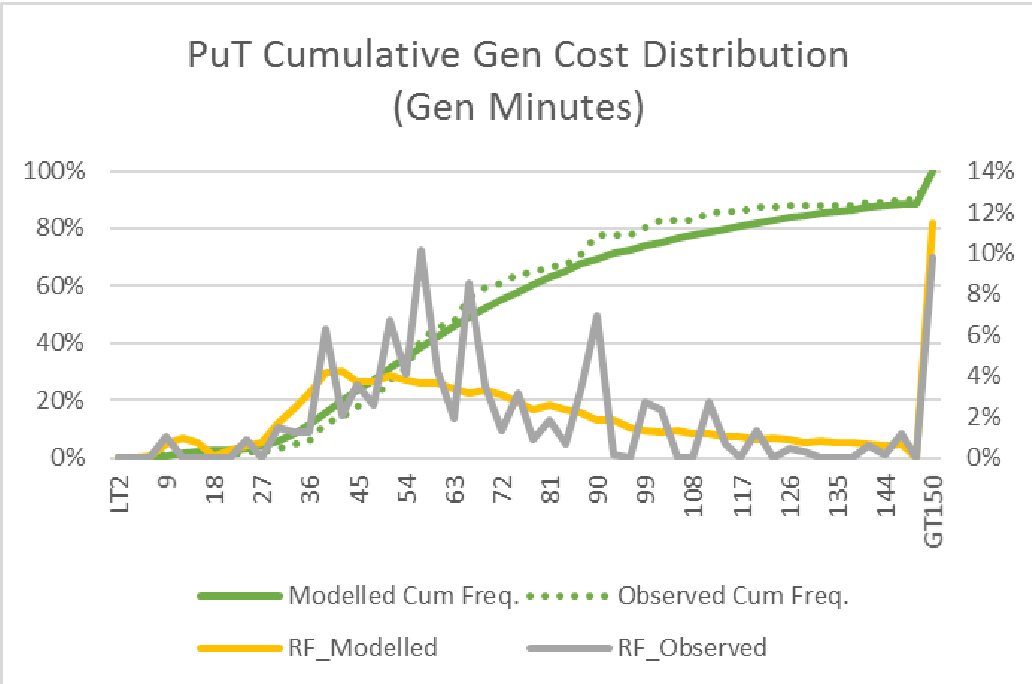

Figure 20. IP Peak Other Movement Cost Distribution Comparison (Census) - PT



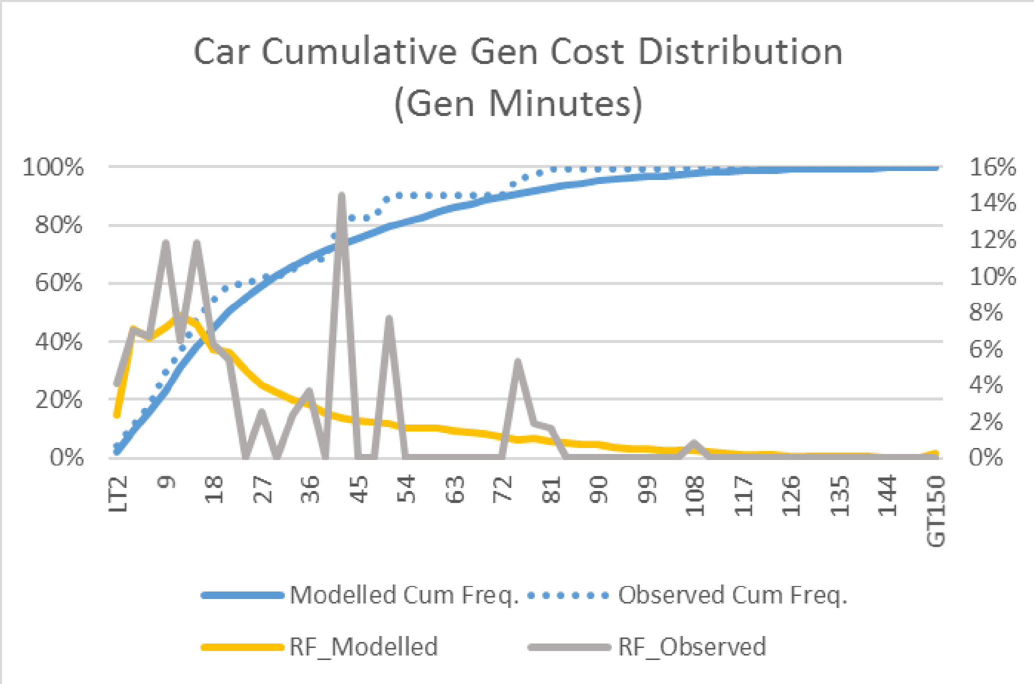

Figure 21. IP Peak Business Movement Cost Distribution Comparison (Census) – Car

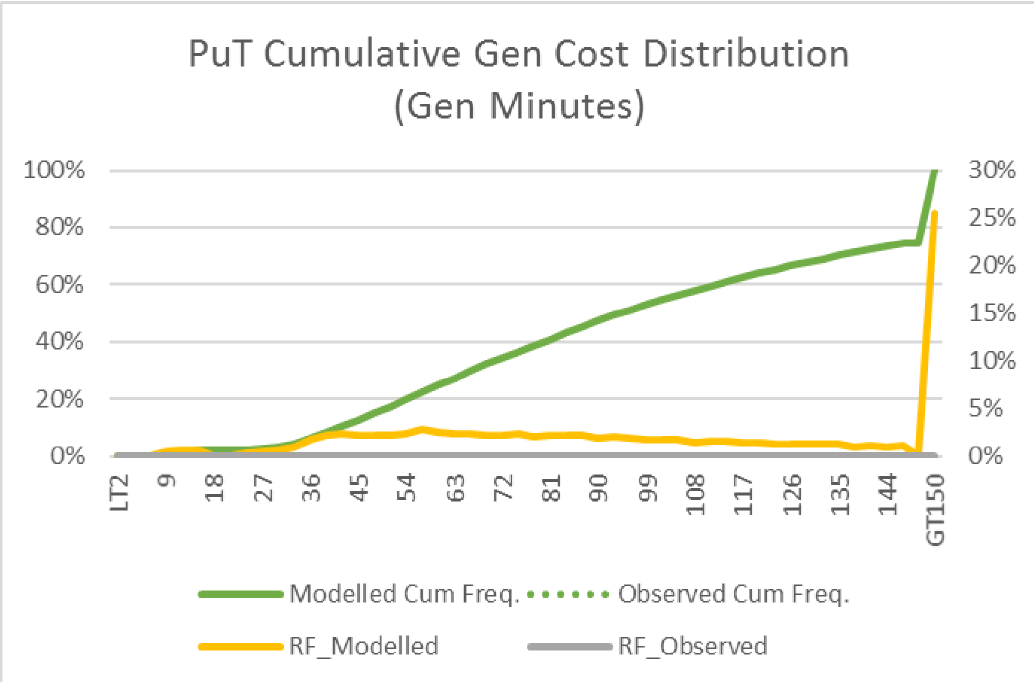

Figure 22. IP Peak Business Movement Cost Distribution Comparison (Census) - PT

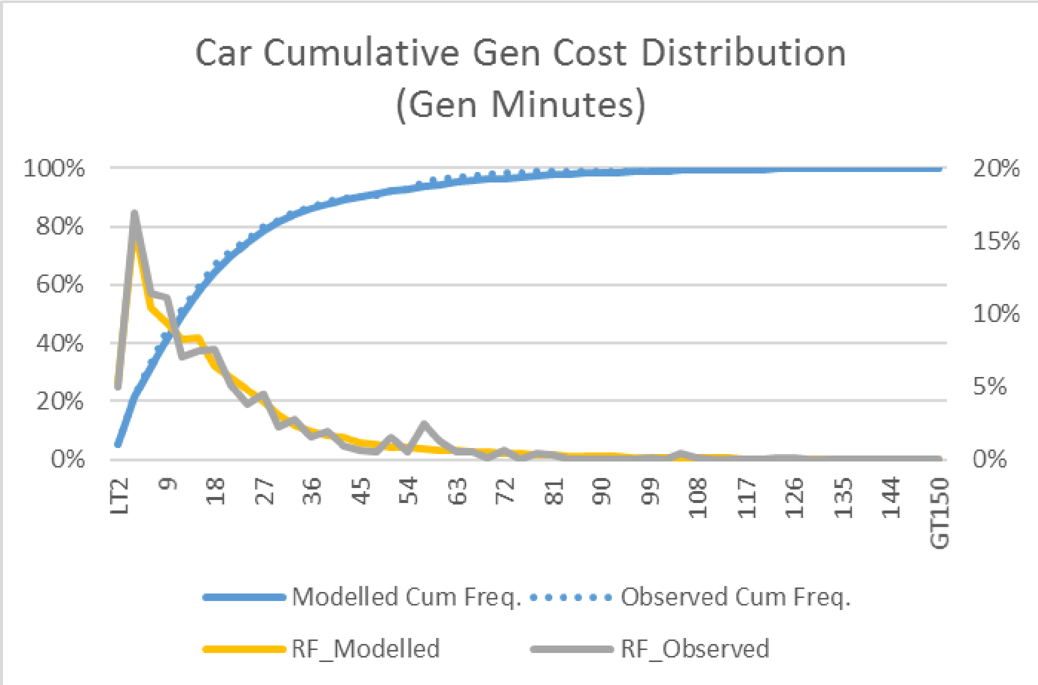

Figure 23. PM Peak Other Movement Cost Distribution Comparison (Census) – Car

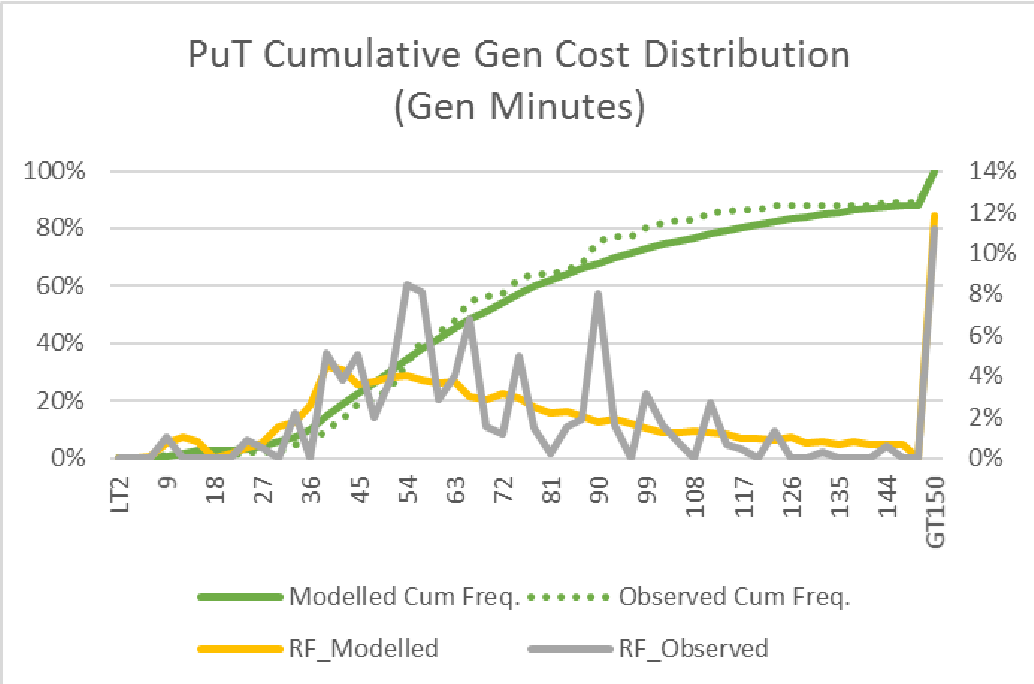

Figure 24. PM Peak Other Movement Cost Distribution Comparison (Census) – PT

Trip Distribution Comparisons

6.2.16 Table 8 indicates that ASAM14 generates an average generalised cost (trip length) of around 30 minutes for AM and PM Peak commuting trips, and a slightly lower average cost (of around 28 minutes) during the inter peak. Modelled commuter trip lengths are around 10% higher for car trips and around 5% higher for PT trips compared to Census travel to work data.

6.2.17 Tables 9 and 10 demonstrate similar trends for Other and business trips, where the model slightly overestimate the road trip lengths by around 10% and PT trip lengths by around 5% (noting that there is no comparison data available for PT business trips).

6.2.18 Comparing travel purposes and time periods, modelled trip lengths are highest for business travel, then for commuters and with the lowest average cost by other movements. These trends are consistent for both road and PT modes, and follow the anticipated characteristics associated with these different travel purposes.

6.2.19 Charts 17 and 18 demonstrate how closely the modelled road and PT commuter patterns match Census data, with only some very short and long distance/cost road trips slightly over estimated. The model tends to marginally over estimate shorter trips and provide a slight over estimate of longer trips.

6.2.20 Charts 19 and 20 illustrate cost distributions for other road and PT movements during the Inter Peak. These show a slight over estimate of both road and PT trips. Although the PT comparisons are based on a more limited number of observed responses, similar distribution trends are demonstrated.

6.2.21 Charts 21 and 22 illustrate cost distributions for business travel during the inter peak. Again the observed data for road trips is more limited, (and no observed data is available for PT), but the modelling shows a broadly similar trend to the available data.

6.2.22 Charts 23 and 24 illustrate cost distributions for other trips during the PM Peak. These distributions demonstrate a close match with the observed data.

6.2.23 With only relatively small variations between average modelled and observed trip cost distributions, the matrices demonstrate a good match with the available data sets.

6.2.24 The slightly over estimated nature of the travel distribution costs should be borne in mind when applying the model. Although users should also note that the matrix estimation stage (discussed later) tends to reduce down average trip costs/lengths, which would bring the final assignment matrices closer towards those observed.

6.2.25 The limited amount of observed business trip information should also be noted.

Mode Share Comparisons

6.2.26 Tables 11-13 compare the total modelled mode share for each time period and travel purpose. The modelling generally displays a car mode share of around 90% and a PT share of around 10%. Modelled commuting trips display the highest PT mode share, followed by other, and then business trips. This trend is generally in-line with the characteristics associated with these types of travel purposes (ie commuters regularly using PT, more dispersed nature of other travellers make it more difficult to use PT, and business trips less likely to use PT).

6.2.27 The comparison shows that the model consistently overestimates road mode share by around 5 percentage points, and therefore underestimates PT mode share. These diverging mode shares are partly as a result of the trip rate adjustments made following comparisons with observed passenger count data. These adjustments reduced PT trip rates, and subsequently the PT demand generated to enable a closer match to final assignment passenger flows observed around the inner and outer Aberdeen public transport cordons.

6.2.28 Therefore, the modelled trip rates, overall level of travel demand and subsequent mode shares are calibrated to match the final passenger assignment observed flows, rather than the mode shares indicated by Census and SHS data comparisons.

6.2.29 Note that there is clearly some uncertainty when comparing the mode shares generated by the different data sets. This uncertainty may suggest that the model could potentially underestimate PT trips, as indicated by the Census, and if so, are more likely to be associated with areas located away from the observed bus and rail passenger count cordons where PT data was available. This uncertainty regarding PT mode share should be borne in mind during model application, particularly when appraising public transport orientated schemes or policy.

Sector Movement Comparisons

6.2.30 Appendix B describes modelled trip movement Census and SHS comparisons for road and PT modes, with the road movements containing a proportion of city centre parking trips, and PT movements containing a proportion of Park and Ride movements.

6.2.31 Note that the observed comparison data sets are shown ‘unadjusted’, with no corresponding factoring of commuter movements to reflect adjustments made to specific employment levels (as discussed earlier). For example Census movements will still reflect shift work at the ARI and weekend retail orientated working in the city centre, whereas the modelling aims to reduce these movements. The modelled demand includes recent employment sites now occupied at Prime Four (Sector 11) since the Census was undertaken in 2011, and therefore we would anticipate the model to show an over estimate for travel to this sector.

6.2.32 The travel analysis indicates a broadly similar travel pattern between modelled and observed commuter movements. There are though some apparent underestimates (around -10%) of road demand to the Dyce (S9), Kirkhill (S10) and Altens (S13) industrial estates. Conversely, the modelling indicates an over estimate of commuting to sectors 15 (Ellon), 16 (Oldmeldrum) and 18 Westhill). There is potential that recent (post 2011) employment growth at Ellon and Westhill is not recorded by the Census, however, an explanation for differences associated with the Oldmeldrum area are more unknown.

6.2.33 In general, the road demand tends to overestimate demand for some rural movements and underestimate more city-bound travel. More local, intra-sector road travel within Angus and Moray is also underestimated.

6.2.34 The model displays a good representation of the main PT passenger movements into Aberdeen city centre, and lower levels of PT demand to other areas (with the exception of Sector 2 (the area just to the North of the city centre) where Aberdeen University is located.

6.2.35 Similar to car travel, PT passengers travelling to the main industrial estates is also underestimated, but broadly in-line with the Census pattern and proportional to the level of road demand (with a slightly higher PT mode share to Dyce which has higher PT accessibility with the local rail station).

6.2.36 There are a number of relatively high percentage differences when comparing PT travel, but many of these relate to quite small absolute values.

6.2.37 The apparent differences in travel movements when comparing Other and business travel is more challenging to detect due to the more limited SHS data sets. The number of responses does not record observed travel patterns for all sector movements (particularly for rural travel).

6.2.38 Modelled other and business road trips are more dispersed compared to the commuter pattern, but continue to display a reasonable high demand towards the city centre (Sector 1) – especially for PT passengers. There are also higher demands to Sector 3 (were the ARI is located) for other movements which appear intuitive.

Input to Final Prior Matrices

6.2.39 These three hour (AM and PM) and six hour period (inter peak) travel purpose matrices are then subjected to a number of calculations and factoring to produce proportions of to-home trips, non-home based trips, with all demand then scaled to reflect the relevant hourly level assignment.

  

6.3 Student Travel to Education

6.3.1 This section covers the development of road and public transport student movements to education establishments, including Schools, colleges, and Aberdeen University and Robert Gordons University.

6.3.2 Education student movements are **not** part of the core demand model or park and ride modelling. Education movements do form part of the Trip Generation modelling and are added into the 'Other' Assignment matrix purpose for each modelled time period.

6.3.3 ASAM14 Base Year Education trips were developed using the following steps:

- Identifying ASAM14 zones where education jobs are based (indicating an education establishment) and separating out areas of primary and secondary education from higher education – providing a set of 'school' and 'University' zonal activities.

  - A Web search was undertaken to understand the locations of the major colleges and designating ASAM14 zones, with the TELMoS/ASAM14 planning data used as a data base of education jobs / establishments;

  - Assumptions were used to isolate / proportion university/ school jobs within zones where both types of establishments were present (ie assuming a certain level of relevant job proportions). This resulted in a handful of model zones containing a relatively high level of higher education jobs / activities, and a more numerous set of zones which included levels of employment associated with the larger number of primary and secondary schools.

- General education road and PT trip productions and attractions were produced by running the trip end model (using area-based trip rates and attractions). Additional trip end files were generated to create separate trip ends for primary/secondary (school) and higher education (University).

  - Trip production proportioning calculations were based on the proportions of children and students, as described in TELMoS/ ASAM14 zonal population data, with education productions split into school education and higher education productions.

  - For trip attractions, in non-university zones higher education attractions are set to 0. In university zones, school attractions are set to 10% of all education attractions, while higher education attractions are set at 90%.

- School and University trip ends are then input separately to an education gravity modelling process to distribute trips based on travel costs and the relevant School/University trip attractions. Gravity model trip distribution parameters were developed for road and PT travel by comparing the output travel demands with observed data. These parameters are described in Table 14. These parameters tended to produce short distance school trips and longer dispersed movements for higher education.

- Primary and secondary school travel distributions were compared against the Pupil Census recorded in 2016 (which included survey responses for several schools within Aberdeen City and Shire). Model parameters were adjusted until a reasonably close matching modelled school trip distribution length was represented. Figure 25 and Figure 26 compare the observed and modelled road and PT school trip distributions with road and PT travel costs.

- No significant Higher Education travel distribution data was available. Therefore, student trip cost distributions were compared against average commuter trip cost data - with model parameters adjusted until a reasonably close modelled average trip distribution was represented. The University and school average trip distribution comparisons are described in Table 15.

- Following an inspection of Aberdeen University and RGU travel plans, mode share adjustments were made to the University Trip production and attraction rates to account for the balance of mode share associated with the University campuses. For example, the large walk-in catchment associated with Halls of Residence at Aberdeen University.

- Note that School education trip movements within Aberdeenshire were removed as the modelling supply side does not represent school buses.

Table 14. Education Gravity Model Distribution Parameters

MODE	HIGHER EDUCATION	SCHOOL
Car	0.1835	0.662
PT	0.0139	0.415

Table 15. Education Travel Average Trip Length Comparison (Generalised Minutes)

MODE	HIGHER EDUCATION		SCHOOL EDUCATION	
	Observed	Model	Observed	Model
AM Car	28.8	35.4	8.9	12.3
IP Car	25.8	23.6	8.9	11.5
PM Car	28.1	34.9	8.9	11.1
AM PT	120.4	114.1	35.0	34.0
IP PT	119.9	84.2	35.0	30.8
PM PT	123.5	117.1	35.0	41.8

* Higher Education modelled values are compared against 'commuter average trip distribution values'

6.3.4 Note that the 2011 Census Travel to Education data set would provide wider and more comprehensive data, but this was not available during the ASAM14 model development.

Input to Final Prior Matrices

6.3.5 These time period level university and school education matrices are then combined, with reverse trips added using the standard demand model factoring process to allocate reverse trips to relevant time periods. Matrices are then scaled down to the hourly level and available to be included within the 'other' assignment matrix user class during the demand model stage.

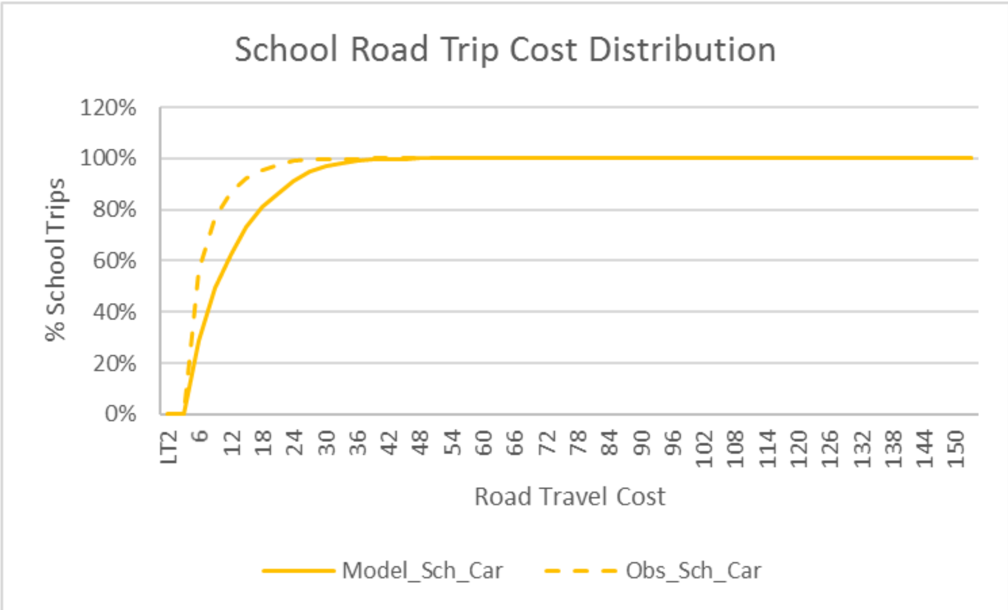

Figure 25. AM Peak School Road Movement Cost Distribution

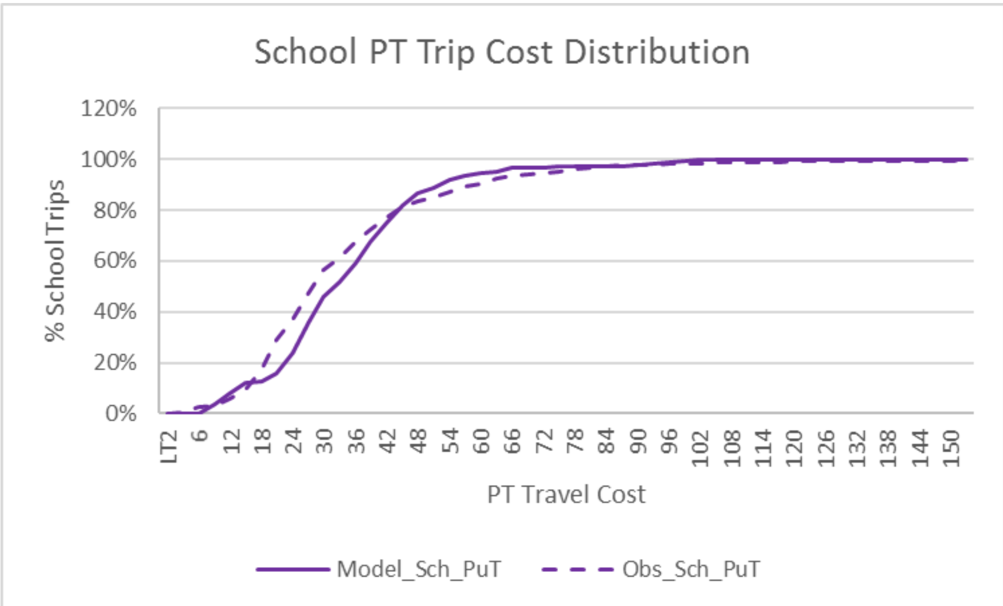

Figure 26. AM Peak School PT Movement Cost Distribution

6.4 Park & Ride & City Centre Parking Movements

6.4.1 The ASAM14 park and ride modelling follows a similar approach to that used within the SRM12, with ASAM14 containing the additional inter peak elements and city centre parking modelling.

6.4.2 This ‘interchange’ or ‘mixed mode’ modelling identifies the relevant number of park and ride and city centre parking trips within the standard demand model business, commute and other end-to-end origin to destination from home period matrices, and separate individual road and PT trip legs to/from specific P&R / rail station sites and city centre car parks. This allows the Demand, road and PT modelling to separately identify and model the response of mixed mode trips to changes in travel costs.

6.4.3 Non Park and Ride or city centre parking trips therefore represent road trips that do not pay for parking (ie residential, private non-residential car parking or drop off), and PT trips that make the full origin-destination travel movement by walk and PT modes (ie no car interchange).

6.4.4 ASAM14 park and ride or parking modelling does not cover education trips or external movements.

City Centre Parking Modelling

6.4.5 The inclusion of a parking capacity model significantly improves the representation of the full range of travel costs / issues impacting the choices for travel to central Aberdeen.

6.4.6 The current representation of car parking charges has been maintained, with charges updated to reflect 2014 parking costs and the city centre controlled area.

6.4.7 Parking capacity constraint within the mode and destination choices was implemented by extending the P&R modelling to represent parking capacity in controlled / constrained areas (Aberdeen City Centre). This models the location and mode choice of motorists as car parking becomes constrained – with changes in costs being passed to the demand model.

6.4.8 City centre parking surveys (undertaken in 2012) were used to inform the travel purpose splits and ultimate destination of car park users.

6.4.9 Standard assumptions for representing private non-residential (PNR) parking have been reviewed, with non-paid for parking now represented using a simplified constraint approach (i.e. using a 20 minute search time ‘inconvenience’ factor – which could be increased in future years depending on supply of PNR spaces).

6.4.10 Therefore, the park and ride and city centre parking movements balance the cost of travel to and the parking charge in the controlled area against a set of inconvenience parking costs which reduce further away from the controlled area.

6.4.11 The process for developing the Park & Ride and Parking costs and trip (segment) matrices are described in detail within the Park and Ride chapter.


Input to Final Prior Matrices

6.4.12 Using the Park & Ride and Parking model, the relevant number of motorists using park and ride sites and city centre car parks are isolated within the Park & Ride mode (ie a proportion of car-available motorists are extracted from the road and PT period matrices by purpose). Motorists are distributed across the sites based on observed parking data and the level of population observed within each site 'catchment area'.

6.4.13 Full Park and Ride end-to-end person movements are segmented into the separate road and public transport 'trip legs', and added to the relevant origin zone to parking site to final destination zonal movements. Park and Ride and Parking movements are calibrated using the P&R and Parking site choice model.

6.4.14 Park and ride segment person trips are converted to car vehicle and PT passenger trips and factored to be incorporated into the hourly road and PT time period matrices. This includes the reverse trip leg travelling away from the car park during the inter peak and PM peak periods.

6.4.15 Note that the final/start walking leg of city centre parking movements is not added into the Public Transport model (unlike a park and ride trip), as it is not a PT trip. The park and ride and parking modelling does not represent motorists going to car parks in the evening peak.

6.5 External Movements

6.5.1 External movements for all travel user classes to/from geographical areas located out with the ASAM14 coverage area are sourced from TMfS14 base year model runs and disaggregated into the ASAM14 zoning.

6.5.2 A sub area cordon procedure was undertaken using the TMfS14 Road and PT models, to extract Cordons for the AM, Inter, and PM peak time periods. Matrices were generated and disaggregated to the ASAM14 zone system using planning data.

Disaggregation of TMfS14 Matrices to ASAM14 Zone System

6.5.3 Each TMfS14 travel purpose demand assignment matrix (which is consistent with the assignment purposes applied in ASAM14) was disaggregated to the ASAM14 zone system based on employment, total population, working population, or a combination of these, depending on the time period and travel purpose. Disaggregation assumptions are consistent with those used previously within SRM12 and are described in Table 16.

6.5.4 '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.

6.5.5 '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.

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

6.5.7 Externals movements are processed at the hourly level and incorporated directly into the relevant Prior matrix external zones.

Table 16. TMfS14 to ASAM14 Travel Purpose 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%

6.6 Airport & Heliport Passenger Modelling

6.6.1 ASAM14 improves the representation of Airport/Heliport travel patterns by separate modelling of offshore (commuter) working patterns to/from Aberdeen Heliport, and business and leisure passengers to Aberdeen Airport (out with the main demand model which continues to represent actual commuters working at these locations).

Aberdeen Airport Passengers

6.6.2 A CAA airport passenger survey was undertaken during 2013 for Aberdeen airport and was interrogated and converted to the ASAM14 zone system to understand trip movement mode share patterns to this key travel generator – enabling separation of business and leisure travel by surface access mode.

6.6.3 This passenger data was used to develop a similar type of simplified Airport Surface Access model which was previously developed to model Glasgow and Prestwick airports, as part of the Strathclyde Regional Transport Model (SRTM) development.

6.6.4 The airport patronage data, travel costs from the road and PT models and assumptions about the resident/visitor and leisure/business splits were applied to adjust the car vs PT mode choice parameters by trip purpose, to reproduce the 'observed' number of cars & public transport trips to & from the airport (as recorded within the CAA data).

6.6.5 Glasgow Airport modelling assumptions were also applied for ASAM14, including:

- Mode splits of trips from the airport are generally assumed to match the mode splits of trips to the airport (as represented in the airport surface access data). Taxi drop off / pick up are simply included within the car demand;

- Passenger distributions were based on parameters obtained from the Glasgow Airport Model calibration, which showed that (for each zone) the number of airport trips produced was mostly determined by the land use / demography of each zone. The Glasgow model interrogation showed that distance (within a regional context) was a negligible factor, and therefore was omitted.

6.6.6 This data was applied to produce the relationship between planning data (jobs and population), to produce a plausible all-mode Aberdeen airport row and column pattern for (to/from home) business and leisure trips by car and PT.

6.6.7 The Airport model therefore picks up changes in the relevant zonal land-use and changes in the relative cost of car vs PT (for example additional bus services, shorter walk between the station and the airport, the impact of the AWPR etc) through a mode choice mechanism which reproduces observed surface access data.

Figure 27 and Figure 28 illustrate the modelled pattern of travel to Aberdeen Airport during the AM Peak for business and Leisure passengers using road and PT modes.

6.6.8 Airport passenger growth assumptions are required for forecasting passenger demand, along with zonal population data to forecast changes at travel origins.

Input of Airport Passengers to Prior Matrix

6.6.9 Aberdeen Airport business and leisure air passenger trips to/from (residential, business, hospitality) areas are developed and included specifically in ASAM14 zone 210. These trips are included to the business and other assignment matrix user class for each time period. Airport employee travel is also represented in zone 210, but accounted for within the standard commuter travel development processes.

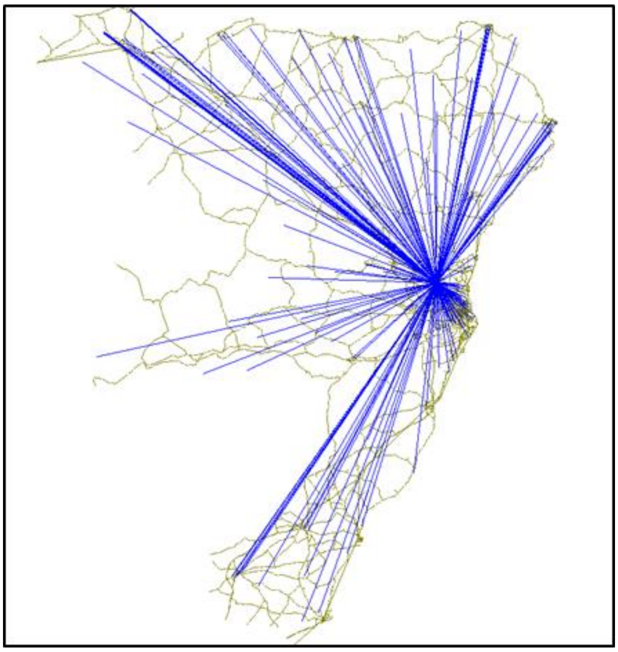

Figure 27. Road Movement Distribution to Aberdeen Airport (AM Peak)

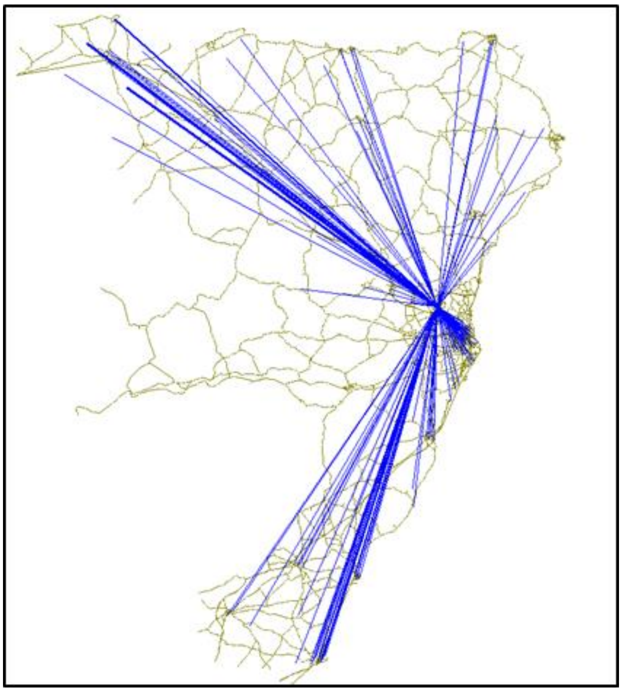

Figure 28. PT Movement Distribution to Aberdeen Airport (AM Peak)

Aberdeen Heliport Passengers (Offshore Workers)

6.6.10 The 2011 Census records the origins of commuters working at offshore installations. These road and PT travel patterns were interrogated and input to the ASAM14 zone system to identify offshore worker origins located within the ASAM geographical coverage area. These trips were assumed to form the main pattern of flight passengers to Aberdeen Heliport (the main access point for offshore working in the North East). The Census commuter mode share proportions were assumed to represent the relative proportions of road and PT passenger travel to the Heliport.

6.6.11 Web-based research was undertaken to understand the frequency of offshore helicopter flight departures and arrivals per day, how the schedule varied during the AM, Inter and PM peak time periods, and the average passenger capacity of helicopters (undertaken using the flight schedule available in 2017). An arrival time assumption (of 1.5 hours) was used to represent the lag between heliport passenger arriving at the Heliport and flight departure, and 30 minutes for the time required to depart. This data was combined and used with the Census distribution to calculate trip productions and attractions for the AM, Inter and PM peak hourly time periods for road and PT modes.

6.6.12 CAA (rotary wing) passenger (2014-based) data was used to control the total number of annual trips to/from Aberdeen Heliport. This annual passenger figure was scaled down to a weekday level, and then factored to reflect the helicopter flights / seats available during each modelled time period.

6.6.13 The road and PT Census offshore trip movements were factored by the resultant trip production and attraction data to produce row and column patterns to represent heliport trips.

6.6.14 Table 17 describes the total trip production and attractions to/from Aberdeen Heliport. Figure 29 illustrates the movement of road and PT trips to the Heliport for the AM Peak to/from areas within the ASAM demand model coverage area (ie excluding external trips).

6.6.15 Note that the pattern will remain consistent for each time period, but level of passenger demand will vary. The low number of heliport trips during the PM is due to the flight departure times.

6.6.16 Heliport passenger growth assumptions are required to forecast future year passenger demand, along with zonal population data to forecast changes for travel origins.

Input of Heliport Passengers to Prior Matrix

6.6.17 Aberdeen Heliport Air Passenger trips (offshore workers) are assumed to represent **commuter** travel patterns to/from the Heliport to/from residential areas. These trips are specifically included within ASAM14 zone 209. Heliport employee commuter travel is also represented in zone 209, but is accounted for within the standard commuter travel development processes.

Table 17. ASAM14 Aberdeen Heliport Travel Demand (Period)

TIME PERIOD	TOTAL CAR & PT ORIGIN	TOTAL CAR & PT DESTINATION
AM Commute 0700-1000	265	225
IP Commute 1000-1600	578	402
PM Commute 1600-1900	49	176

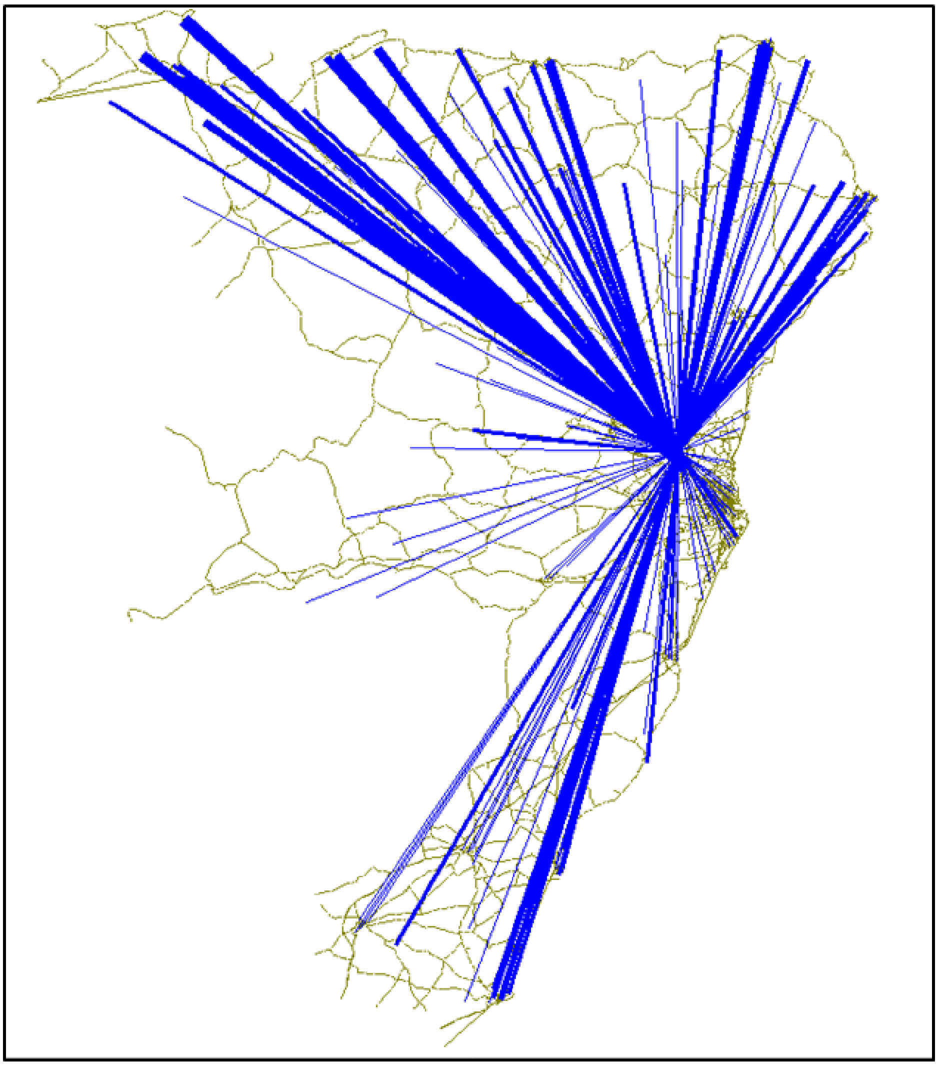

Figure 29. Travel Movement Distribution to Aberdeen Heliport

6.7 Light & Heavy Goods Vehicles Movements

6.7.1 There is limited observed data available that records detailed goods vehicle patterns across the North East. Existing Roadside Interview (RSI) data is relatively dated, and also is likely to provide an inconsistent coverage. Undertaking new RSI's is expensive and provides less value with the lower levels of HGV and LGV movements that actually tend to be recorded. 'Big data', such as Mobile Phone Data (MPD), is also costly and it is uncertain how well these data can isolate specific goods vehicle movements.

6.7.2 Therefore, a more proportionate approach was undertaken for ASAM14, making best use of available (modelled) goods pattern data, and cross referencing these with the more detailed ASAM14 zone system and local production and attraction activities.

LGV / HGV Trip Generation

6.7.3 ASAM14 LGV and HGV movements were based on a combination of data sets. Firstly, LGV and HGV Trip Generations for each modelled zone were calculated based on planning data (ie households and jobs) and trip rates extracted from the TRICs database. The underlying goods vehicle trip rates applied are described in Table 18.

6.7.4 Household trip rates are simply multiplied by the corresponding residential trip rate. The application of employment trip rates is more complex, as the zonal jobs database only provides combined figures for some employment types and can't be simply cross referenced with equivalent trip rates. Therefore, each zonal area was allocated an overall employment type, with varying proportions of each trip rate based on the general employment characteristics of the area (on a scale of 1-5). For example, a new business park was given a 'general office' classification, whilst specific harbour zones were given the highest classification.

6.7.5 As figures for some job types are provided separately within the database, retail jobs could be allocated directly to the retail trip rate. Financial, hospitality and education jobs were allocated to the lowest employment trip rate set (1), whilst agriculture and health jobs were classified as more industrial (with higher goods vehicle flows per job).

6.7.6 The employment classification types and corresponding proportion of each allocation of trip rate are shown in Table 19.

6.7.7 This Trip Generation process created LGV and HGV trip productions and attractions for each modelled zone. These were then disaggregated down to each of the modelled hourly assignment time periods using a series of proportional factors (previously used in the application of ASAM to produce daily flows). This resulted in around 8%-9% of the daily HGV / LGV demand being allocated to each hourly time period.

Table 18. LGV & HGV Trip Rates (Daily Weekday)

ACTIVITY TYPE	LGV IN	LGV OUT	HGV IN	HGV OUT
Residential (Per Dwelling)	0.21	0.18	0.02	0.02
Business Park / Office (per job)	0.26	0.26	0.02	0.02
Industrial Estate	0.75	0.77	0.18	0.18
Parcel Distribution	2.37	3.00	0.22	0.24
Retail (average of food & non-food)	0.49	0.48	0.05	0.05

Table 19. LGV & HGV Employment Type Proportions

EMPLOYMENT CATEGORY	% OFFICE TRIP RATE	% INDUSTRIAL TRIP RATE	% DISTRIBUTION TRIP RATE
1: General office	75%	25%	
2: Office / Industrial	50%	50%	
3: Industrial	25%	75%	
4: Industrial / Distribution	15%	75%	10%
5: Harbours		50%	50%

LGV / HGV Trip Distribution

6.7.8 The underlying LGV and HGV pattern was generated for longer-distance inter-sector movements and shorter distance ‘Intra-sector’ movements (using the 28 sector system shown in Figure 16).

6.7.9 Inter sector movements were created by extracting 90% of the TMfS14 LGV and HGV matrices and disaggregating these down to ASAM14 zonal level using a mixture of population and jobs data to split movements for each zone (using the LGV and HGV zonal proportions described in Table 16). These longer distance movements between sectors were based on TMfS AM, Inter and PM Peak matrices combined to 12 hour level for undertaking calculations, then proportioned down to hourly time periods to create the final prior matrices

6.7.10 The TELMoS LGV and HGV goods commodity matrices were also disaggregated to the ASAM14 zones, and scaled down to TMfS14 level (ie matching the LGV and HGV matrix total). 10% of the TELMoS matrix was used to inform the longer distance pattern – the aim of this was to reduce the potential for matrix 'lumps' recognising that during past development the TMfS14 matrix was likely built from, sometimes patchy RSI data.

6.7.11 Intra sector goods movements were developed by firstly extracting the relevant demand movements from the TMfS and TELMoS matrices and converting to ASAM14 zonal level. Intra-zonal movements were dispersed throughout the relevant ASAM14 zones covering each TMfS zone. A furnessing procedure was used to combine the TMfS and TELMoS travel patterns to match the ASAM14 trip generation figures described earlier.

6.7.12 For shorter distance Intra-sector trips, the aim was to better represent the 'multiple-leg' nature of many goods vehicle movements, which may have a number of delivery 'drops' between leaving the depot and returning.

6.7.13 This representation was undertaken by uplifting the proportion of intra sector (short distance) trips, and reducing inter sector (longer distance) trips. A comparison between TMfS14, TELMoS and ASAM14 LGV and HGV trip distributions was undertaken, with adjustments made to ensure the ASAM14 goods distributions fell approximately between the two parent model trip distribution patterns. .

6.7.14 Figure 30 and Figure 31 illustrate the comparison of ASAM movements with TMfS14 and TELMoS LGV and HGV travel cost distributions. This highlights a reasonably consistent comparison between the three models, with the ASAM14 pattern falling between the two models. With ASAM14 therefore containing a mixture of the longer distance movements commonly associated with some goods vehicles and also shorter distance multiple-drop delivery type movements – and disaggregated down to the more detailed ASAM14 zoning and reflecting local levels of residential and population activity.

6.7.15 During traffic count calibration LGV and HGV matrices were compared to overall LGV and HGV traffic Screenlines and percentage adjustments calculated to scale goods matrices to better reflect overall observed levels of demand. This amounted to adjustments of between -25% to +25% made to LGV and HGV movements in the AM, Inter and PM Peak time periods.

6.7.16 A specific reduction of -90% was made to the A93 - Strathdon external movement (zones 570-571), as LGV and HGV appeared significantly over represented at this location (falling through from the TMfS14 external matrix flows).

Input to Final Prior Matrices

6.7.17 The AM, Inter and PM peak LGV and HGV movements described, were combined with the LGV and HGV external movements to form the goods vehicles hourly matrices for input to matrix estimation.

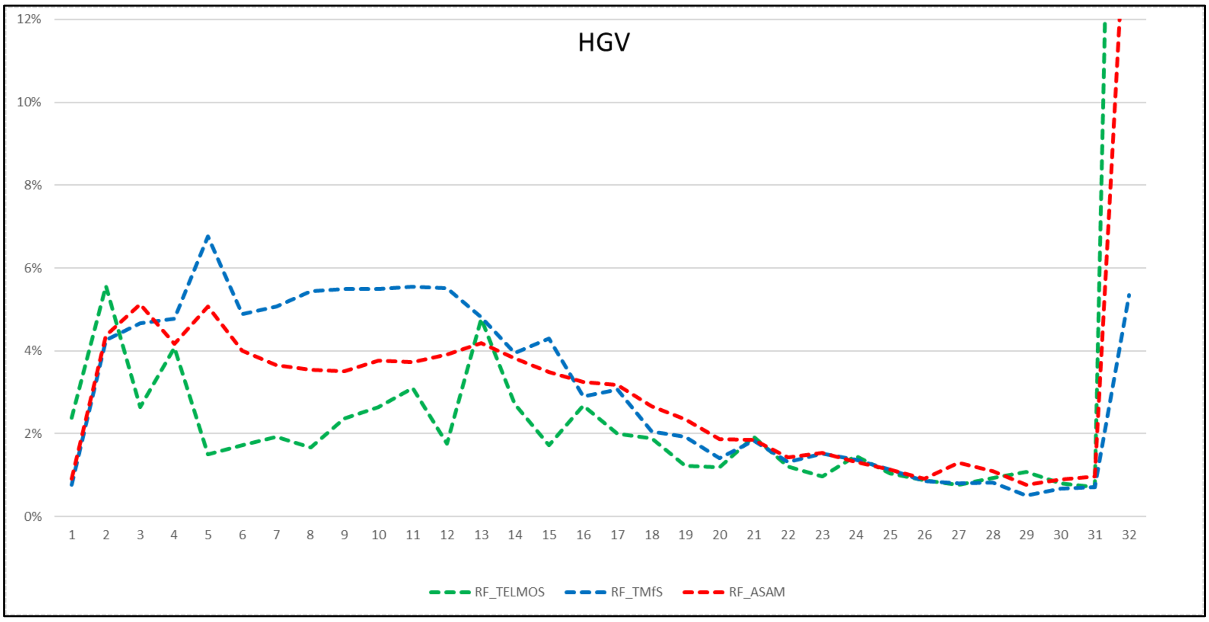

Figure 30. HGV Travel Cost Distribution Cost Distribution Comparison (Daily Weekday)

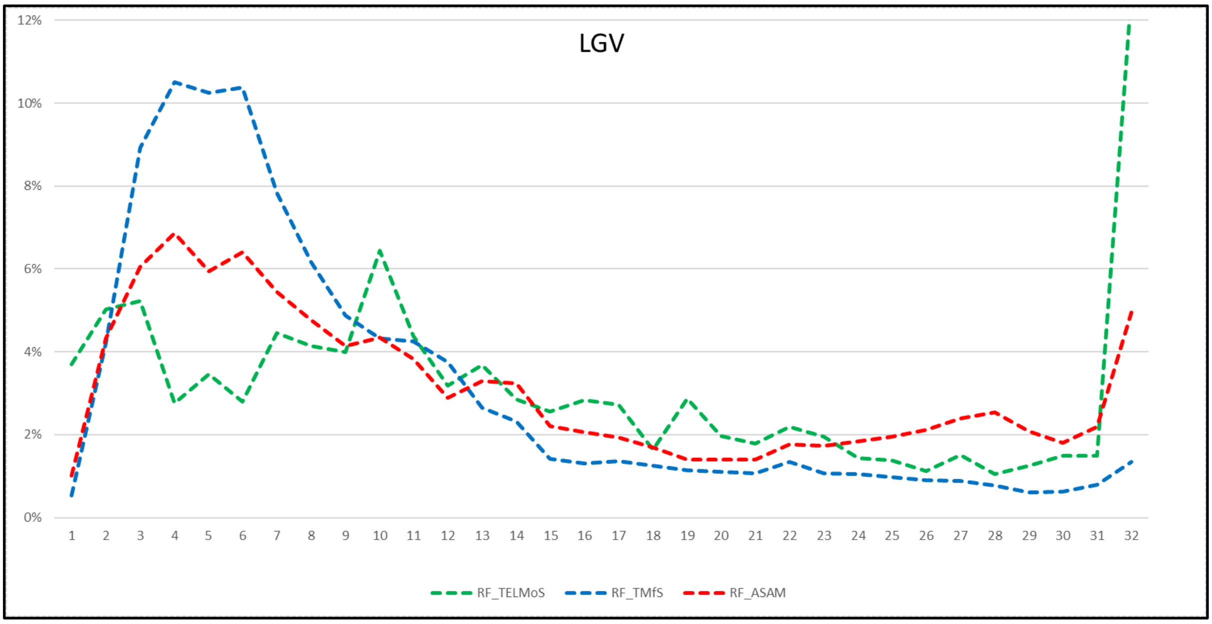

Figure 31. LGV Travel Cost Distribution Cost Distribution Comparison (Daily Weekday)

6.8 Formation of Priors

6.8.1 To collate the final prior matrices, the standard commuter, other and business travel demand is combined with Park and Ride movements and airport and heliport movements for each relevant travel purpose. Education movements are incorporated into the other demand segment. HGV and LGV movements are included within separate matrix tables (with HGV's forming 1.9 PCUs per vehicle). External movements for each user class are incorporated for the relevant zone-to-zone movements.

6.8.2 This provides Road and PT AM, Inter and PM Peak hourly Prior assignment matrices by user class for input to the matrix estimation process.

6.8.3 Following matrix estimation and final Road and PT model calibration and validation, the demand model based elements of the prior matrices (standard commuter, other, business and park and ride) are re-calculated using the final estimated travel costs, to enable the final demand model forecasting and incremental adjustment process to apply compatible travel costs which included adjustments made during the calibration phases.

6.9 Travel Demand Matrix Comparisons

6.9.1 The formation of the prior assignment matrices are undertaken on a synthetic basis, and there is therefore some uncertainty regarding the underlying travel patterns. Prior matrices are compared with available data to demonstrate how modelled movements compare with observed travel movements, with modelled patterns adjusted through calibration to better represent observed data.

6.9.2 The majority of matrix calibration focuses on commuter travel movements using observations from the 2011 Census travel to work data sets. With subsequent parameter and travel pattern adjustment following through to the 'other' and 'business' travel purposes where less observed data is available. Although the modelling demonstrates a relatively good comparison for the commuter travel purpose, the lack of data and patching of adjustments tends to create more uncertainty for business, retail and leisure travel movements.

6.9.3 With commuter movements making-up a larger proportion of travel during the peak time periods, this uncertainty will be greater for the inter peak period, which tends to contain larger proportions of business and leisure travel. Scaling up the modelling as an approximation for daily, weekly or annual patterns would also increase uncertainty.

6.9.4 The comparisons contained within Appendix B can be used to understand how calibrated travel movements compare with observed travel patterns at a sector area level. Further, more detailed comparisons are also possible by interrogating travel patterns using the zone system and associated planning data (which lays out activity data (i.e. residential, retail, education and total jobs) at a detailed geographical level). Major activity centres / destinations, such as the Airport, Hospital and Universities are also distinguishable within the matrices to compare specific travel patterns.

6.9.5 In-line with matrix development guidance, travel pattern adjustments have been incorporated into the demand modelling, ensuring that forecast travel patterns reflect the underlying calibrated travel patterns contained within the finalised prior matrices. The Trip Generation modelling, (the step preceding the distribution of travel patterns) is also calibrated to the overall level of trip making observed across the road and public transport networks.

6.9.6 The overall level of travel within the finalised calibrated assignment matrices is adjusted through matrix estimation to reflect observed traffic volumes and public transport passenger flows at a detailed link-by-link / screenline level, including specific calibration of light and heavy goods vehicles.

6.9.7 The combination of these calibration processes generally sought to reduce the risk of limited travel pattern data significantly impacting model application. The detailed nature of comparisons available provide the means for users to understand uncertainties and consider if further data collection is required for specific applications.

7. ROAD MODEL CALIBRATION

7.1 Approach

7.1.1 Road model calibration is the process of attempting to match the modelled output data with observed data as closely as possible, using a variety of data sources. The robustness of the model is then assessed using further, independent data sources during the validation process.

7.1.2 The calibration process for the ASAM14 road model makes use of several data sources, and includes 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.

7.1.3 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 initial ('Prior') matrices, which are used as a starting point for matrix calibration.

7.1.4 Using an iterative process, the screenline comparisons are used to review and refine the model network and matrices. Subsequently, a matrix estimation process has been undertaken to adjust traffic movements to better match observed traffic volumes.

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

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

7.2 Collation of Traffic Data

7.2.1 A variety of observed traffic count data sources were collated to inform the calibration process. Average AM peak hour, Inter peak and PM peak hour traffic count data was derived from each of these data sources:

- The Scottish Roads Traffic Database (SRTDb) – year 2014, neutral month, average weekday period data;
- Automatic Traffic Counter (ATC) data collected for Aberdeen City Council – November 2014, average weekday peak period data;
- Junction Turning Count (JTC) data collected for Aberdeen City Council – September 2013, average weekday peak period data;
- ATC data collected for Aberdeenshire Council – May 2014, average weekday peak period data;
- Survey data collected for Angus Council – year 2014, neutral month, average weekday peak hour data;
- Survey data collected for Moray Council – year 2014, neutral month, average weekday peak hour data;

- JTC data collected for the Laurencekirk junction improvement study – year 2014, neutral month, average weekday peak hour data;
- Survey data collected for the A96 Corridor Road Access Model (CRAM) – year 2013, neutral month, average weekday peak hour data;
- Survey data collected for the Prime Four (Westhill) development – October 2014, average weekday peak hour data;
- Survey data used for the development of several local Paramics models in Aberdeen City – year 2009-2014, neutral month, average weekday peak hour data; and
- Previous ASAM model versions count data, year 2007.

7.2.2 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 2014.

7.2.3 The factoring process was initially based on the year-on-year change in Scottish Vehicle Kilometres as recorded within the Scottish Transport Statistics (Total Vehicle Kilometres across all roads). However the statistics for Aberdeen City and Shire did not show any considerable increase in traffic during this period. The lack of an observed upward trend appeared counter-intuitive when compared to the significant growth associated with the North East of Scotland during this period of high oil prices. Therefore, a simple 1% uplift per annum was applied to earlier traffic data to provide a more consistent estimate of traffic volumes and widen the use of available data.

7.2.4 Where no appropriate survey data was available, use was made (where possible) of 15 modelled flows from the ASAM4 model to provide a best estimate of traffic flows. These flows were therefore increased by 7% (i.e. per annum) to adjust to a 2014 base year.

7.2.5 Note that as this approach applies a generic change in traffic volumes, elements of the 2014 common base may not reflect the impact of local changes in over time. The age of traffic data is described for each observed count in Appendices E and F.

7.3 Traffic Count Screenlines

7.3.1 The collated observed traffic counts were combined to form groups of screenlines to compare with modelled traffic volumes. A total of 64 screenlines (32 bi-directional locations) were developed to inform the calibration comparisons and undertake matrix estimation. These locations include 56 screenlines consisting of multiple road links, and eight individual calibration points / routes.

7.3.2 The screenlines were chosen to represent the major movements across the key network corridors. The screenlines contain between two and eight traffic counts, depending on location and proximity to other screenlines. Note that for some areas the geography of the network made it less logical for Screenlines to consist of at least 5 locations as suggested by guidance. For example at Bridge crossings in Aberdeen, and for the A90 at Stonehaven. Some individual calibration points were used to improve calibration at locations which significantly under or overestimated traffic during initial calibration. The layout and number of points included in screenlines was deemed most appropriate to make use of available data and compare and calibrate the major corridor traffic patterns.

7.3.3 A total of 122 (244 one way) individual traffic count data points are used to form all screenlines and single points. Screenline nine (at Aberdeen Deeside) consists of north (9a) and south (9b) segments. Screenline 27 (north central Aberdeen) consists of three segments.

7.3.4 The individual traffic count locations used to generate the calibration screenlines are illustrated in Figure 32 to Figure 34. The location description and direction of travel for all Screenlines are described in Table 20.

Table 20. Calibration Screenline Locations

ID	LOCATION/DESCRIPTION
1	Skene Square
	George Street
	Gallowgate
	Forbes Street
	Mount Street
2	Market Street
	College Street
	Crown Street
	Bon-Accord Street
	Hardgate
	Holburn Street
3	Virginia Street
	Union Street
	Littlejohn Street
4a	Rosemount Place
	Leadside Road
	Skene Street
	Huntly Street
	Thistle Street
4b	Union Street
	Justice Mill Lane

ID	LOCATION/DESCRIPTION
	Willowbank Road
5	King Street
	A90
6	Victoria Bridge
	A956
	Great Southern Road
	Stonehaven Road
7	Mugiemoss Road
	Auchmill Road
8	Manor Avenue
	Provost Rust Drive
	Provost Fraser Drive
	Mastrick Road
	Lang Stracht
9a	Lang Stracht
	Queen's Road
	Countesswells Road
	Craigton Road
	North Deeside Road
9b	Auchinyell Road
	Garthdee Road
10	Springfield Rd
	Anderson Drive
	Forest Avenue
	St Swithin Street
	Albyn Grove

ID	LOCATION/DESCRIPTION
	Holburn St S of Union St
11	A90
	B999
	B997
	Whitestripes Road
	A947
12	A90
	Unclassified (Portlethen)
	B979
	A957
13	A96
	A944 - Kingwells
	Unclassified (Craibstone)
	Countesswells Road
	A93 North Deeside Road - Milltimber
14	B9077
	A93 W of B979
	B979
15	A975
	A90
	B999
	A947
	Unclassified (Kintore)
	A96
16	A90
	B979

ID	LOCATION/DESCRIPTION
17	A937 S of Laurencekirk
	B966 SW of Fettercairn
	Unclassified (Laurencekirk)
	B974 W of Laurencekirk
	B9120
	A90 S of Laurencekirk
	A92 N of B9120
18	B976 W of Strachan
	A93 W of Banchory
	A980
	A944
	B993
	B9119 W of Echt
19	A96 W of Inverurie
	Inverurie Link (unnamed)
	B9001 S of Lochter
	B9170
20	B9170
	A975
	A90 Cruden Bay
	A952
	A948 N of Ellon
21	A90 S of Fraserburgh
	A981 S of Memsie
	B9033
	A98 Tyrie

ID	LOCATION/DESCRIPTION
22	Unclassified (Easter Ord)
	B9119
	A944 - Westhill
	Old Skene Road
	Westhill Drive
23	A95 E of Keith
	A96 NW of Huntly
	B9115 S of Keith
	A941 SW of Dufftown
24	A956 East of Charleston
25	B9007 Leggart Terrace
26	B979 Wester Ord
27a	A90 N Anderson Dr South of Haudagain Rdbt
	Anderson Rd S of A96
27b	A978 Leslie Rd S of A96
	A96 Great Northern Rd S of St Machar Dr
	Bedford Rd S of Hermitage Ave
27c	A956 King St S of Regent Walk
	School Rd E of King St
	Esplanade E of King St
28	B9077 Great Southern Road (North of Riverside Drive)

7.3.5 The screenline locations within the ASAM14 road network are displayed in Figure 32 (Aberdeen City Centre), Figure 33 (Aberdeen) and Figure 34 (Full Network).

Figure 32. ASAM14 Screenline Locations – Aberdeen City Centre

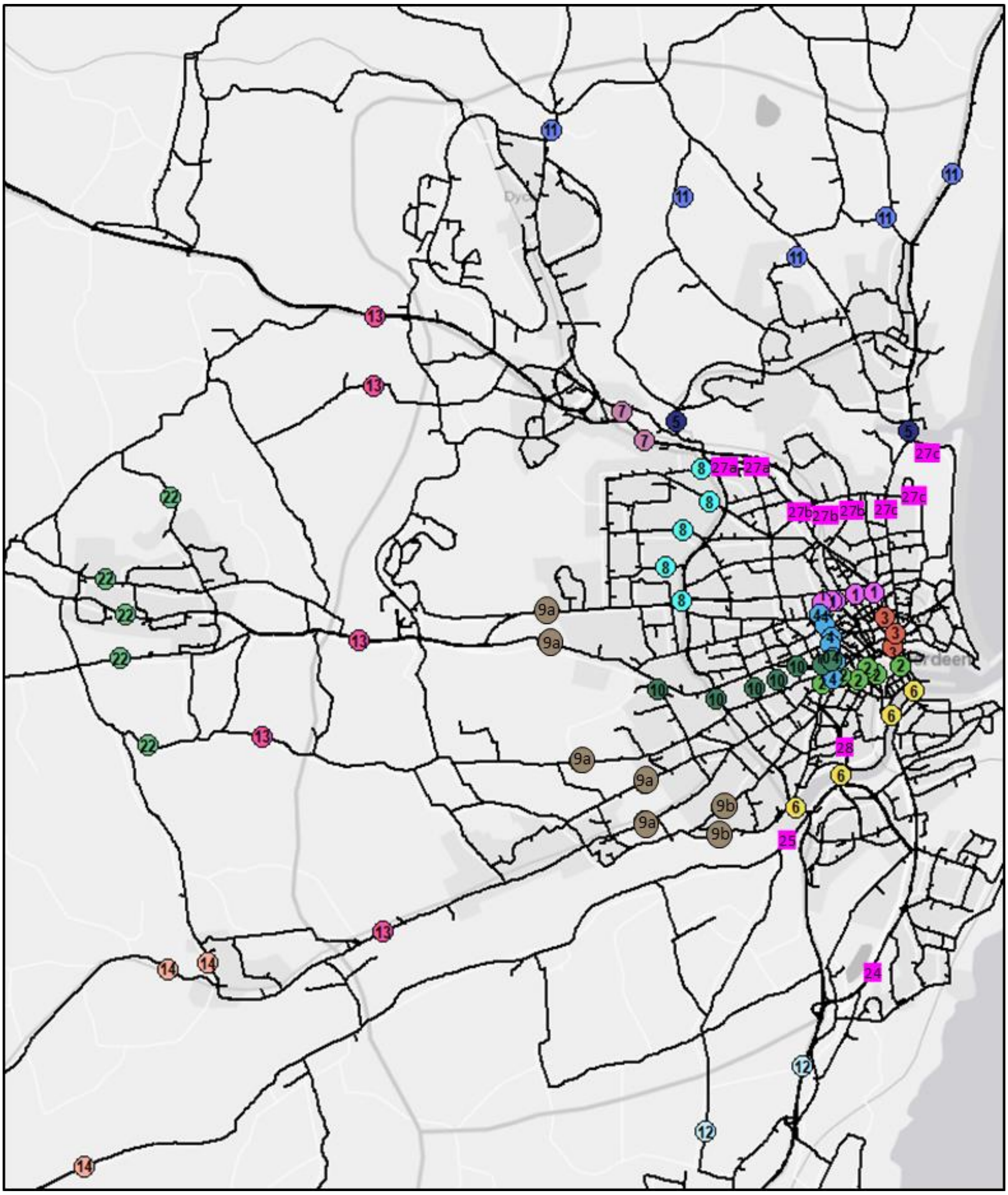

Figure 33. ASAM14 Screenline Locations – Aberdeen City

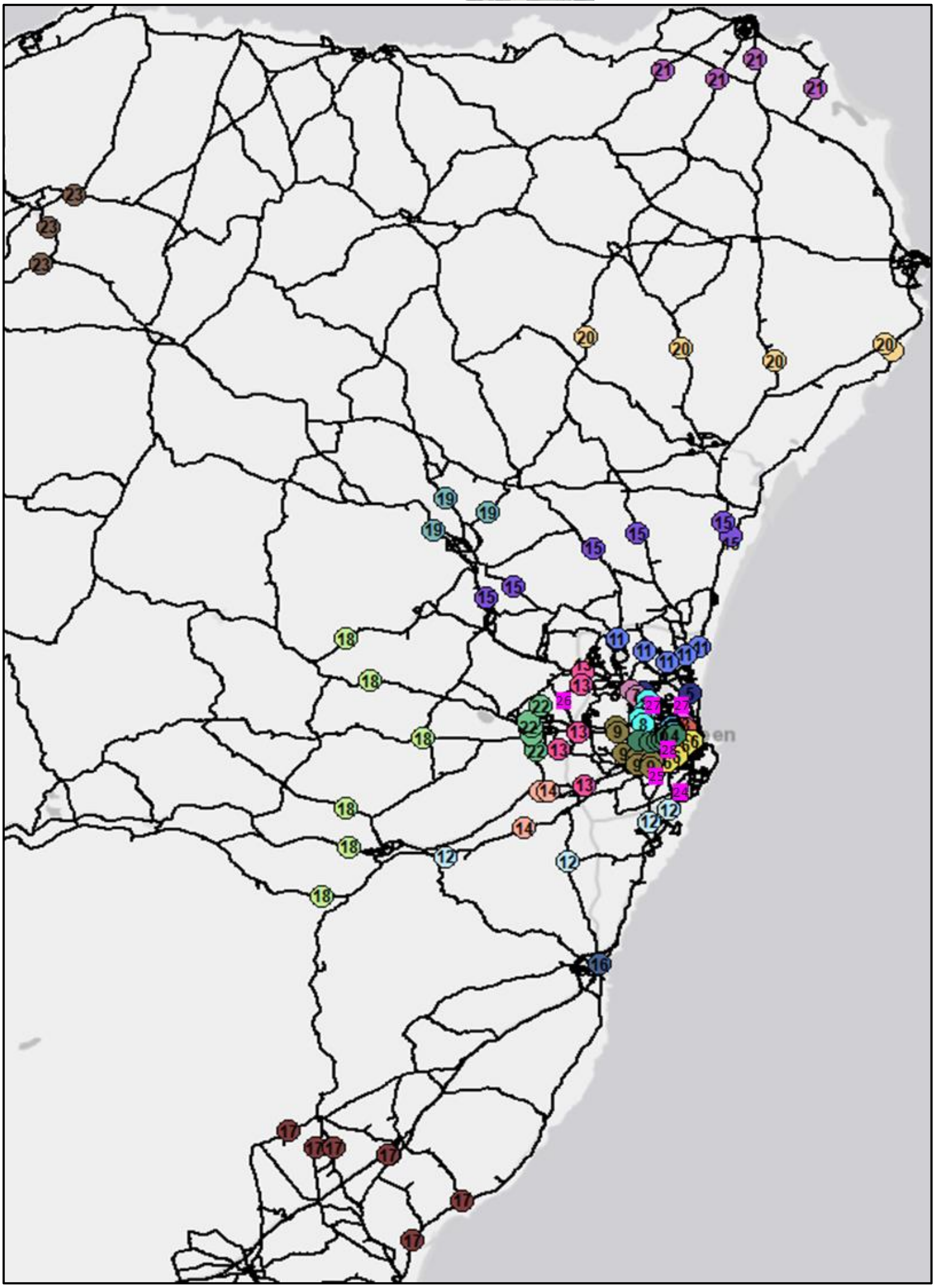

Figure 34. ASAM14 Screenline Locations – Full Network

7.4 Matrix Estimation Procedure

7.4.1 The Matrix Estimation (ME) 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.

7.4.2 A set of script files was developed to run the ME procedure; this was undertaken using SATURN's SATME2 and SATPIJA processes.

7.4.3 The ME inputs were for the AM, Inter and PM peak, as follows:

- SATURN road network data files;
- Prior matrices;
- Zonal origin and destination constraints; and
- Traffic count screenline links

7.4.4 The datasets were separated by user class (cars (combined), LGVs and HGVs). Trip movements between Park and Ride sites, were kept constant during matrix estimation, as these are controlled by another development process.

7.4.5 The zonal origin constraints inform the procedure of the minimum and maximum number of trips permitted to be in the final matrix produced at the end of the ME process. A constraint of +/- 17.5% was applied to the trip end origins and destinations.

7.4.6 To reach a balance between accuracy and runtime required, the procedure was configured to loop through three ME iterations, producing intermediate files after each iteration, with a final set of matrices produced at the end of the procedure.

7.4.7 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.

7.4.8 Table 21 to Table 23 display the total level of road movements in the ASAM14 Prior and post estimated matrices along with changes in movements through matrix estimation.

7.4.9 The comparisons show that the total matrix size (for all user classes) changes only very marginally following the application of matrix estimation for the AM and PM Peak Hours (<1%). There is a slightly higher change in overall trip making within the inter peak hour (of 3%), which mostly stems from an increase in goods vehicle flows to match specific count data. The PM Peak also displays an increase in goods vehicles following matrix estimation, with a corresponding reduction in car trips.

7.4.10 In general, changes in car trips are relatively small, whereas trip changes for LGV and HGV are slightly more considerable, as the estimation procedure aims to better match traffic volume data for these user classes. This indicates that generally the 'correct' overall level of traffic movements are contained within the prior (and post) estimation matrices, with an appropriate level of overall adjustment, and within the different user classes to help meet individual user class observed traffic count data.

Table 21. Road Assignment 'Prior' Matrix totals (PCUs per hour)

USER CLASS	AM PEAK	INTER PEAK	PM PEAK
Car Business	5,328	3,809	5,537
Car Non-work Commute	39,518	9,621	36,982
Car Non-work Other	25,016	36,617	40,977
LGV	11,366	7,947	10,013
HGV	4,364	2,992	3,588
Total	**85,593**	**60,986**	**97,097**

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

USER CLASS	AM PEAK	INTER PEAK	PM PEAK
Car Business	5,174	3,770	5,221
Car Non-work Commute	38,966	10,050	36,451
Car Non-work Other	25,016	37,138	40,761
LGV	11,755	8,647	10,583
HGV	4,371	3,402	3,825
Total	**85,283**	**63,007**	**96,841**

Table 23. Change (%) Between Prior & Post Estimation Road Assignment Matrices

USER CLASS	AM PEAK	INTER PEAK	PM PEAK
Car Business	-2.9%	-1.0%	-5.7%
Car Non-work Commute	-1.4%	4.5%	-1.4%
Car Non-work Other	0.0%	1.4%	-0.5%
LGV	3.4%	8.8%	5.7%
HGV	0.2%	13.7%	6.6%
Total	**-0.4%**	**3.3%**	**-0.3%**

7.5 Prior and Estimated Matrix Comparison Statistics

7.5.1 The following section describes the analysis undertaken to understand changes made to the prior road matrix trip movements during matrix estimation, comparing:

- Matrix Cell Values and Zonal Trip Ends: Slope, Intersect and R-Squared statistics
- Trip End Origin & Destination Plots;
- Trip Length Distributions; and
- Sector Movement Comparisons;

7.5.2 WebTAG guidance indicates that changes between prior and post estimated matrices should meet the following criteria described in Table 24:

Table 24. WebTAG Matrix Estimation Comparison Criteria

MEASURE	CRITERIA
Matrix zonal cell values	Slope within 0.98 and 1.02 Intercept near zero R2 in excess of 0.95
Matrix zonal trip ends	Slope within 0.99 and 1.01 Intercept near zero R2 in excess of 0.98
Trip length distributions	Means within 5% Standard deviations within 5%
Sector to sector level matrices	Differences within 5%

Matrix Cell Zonal Values

7.5.3 Table 25 describes the statistical comparison for the matrix zonal cell values for the car matrices (Change to total). This indicates that the model comparisons fall just within or just outwith the recommended range for the slope and R-squared statistics, for the AM and PM peaks and slightly further outwith the desired range for the Inter Peak.

7.5.4 The intercept values fall further away from zero for all time periods, which may reflect a general reduction in rural movements and increase in urban movements to match observed traffic count data.

Table 25. Car Matrix Estimation Comparison: Zonal Cell Values

STATISTIC	AM PEAK	INTER PEAK	PM PEAK
SLOPE	0.97	0.93	0.98
INTERCEPT	6.82	8.18	7.56
R-SQUARED	0.95	0.92	0.94

Trip End Statistics

7.5.5 Table 26 describes the changes between the prior and estimated matrix trip ends using a number of statistical techniques.

7.5.6 This shows that that the changes made to trip ends fall just within or just out with the recommended criteria for the Slope and R-Squared statistics across all time periods and for both matrix origins and destinations.

7.5.7 The intercept values for the inter peak and PM peak are close to zero, however the intercept value for the AM Peak Hour falls further away from zero.

Table 26. Car Matrix Estimation Comparison: Trip End Statistics

	STATISTIC	AM PEAK	INTER PEAK	PM PEAK
Origin	SLOPE	0.95	1.02	0.98
	INTERCEPT	4.85	-0.28	-0.28
	R-SQUARED	0.98	0.98	0.98
Destination	SLOPE	0.97	1.03	0.97
	INTERCEPT	2.65	-0.84	1.49
	R-SQUARED	0.98	0.97	0.98

Trip End Scatter Plots

7.5.8 Figure 35 contains Scatter Plots illustrating the modelled pattern by trip end origin and destination zones.

7.5.9 The Scatter Plots indicate a reasonably consistent pattern between the pre and post matrix estimation. Only the Inter peak destination data set records a variation lower than suggested by guidance.

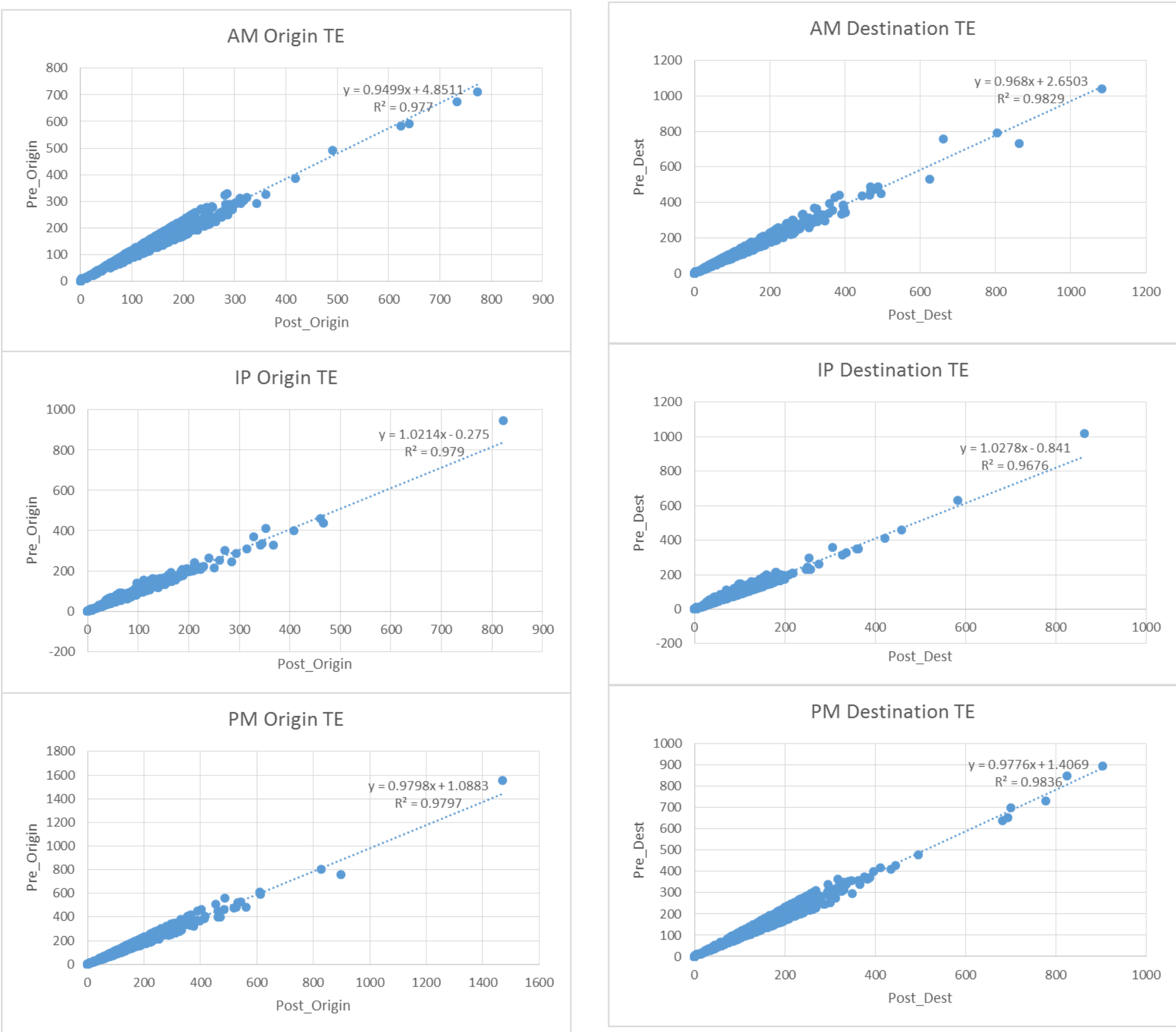

Figure 35. Road Matrix Estimation Comparison: Scatter Plots

Trip Length Distribution

7.5.10 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 ME process has had an effect on the overall distribution of trips and the distances travelled while attempting to match observed flows.

7.5.11 Figure 36 illustrates trip length distribution analysis for the road model prior and post estimation matrices. Table 27 summarises the change in the mean and standard deviation of distances for each time period during estimation.

7.5.12 The analysis demonstrates a reducing trip length during the ME process (of around -12% across all time periods) factoring down some longer distances movements with observed traffic counts highlighting too many trips to/from rural areas.


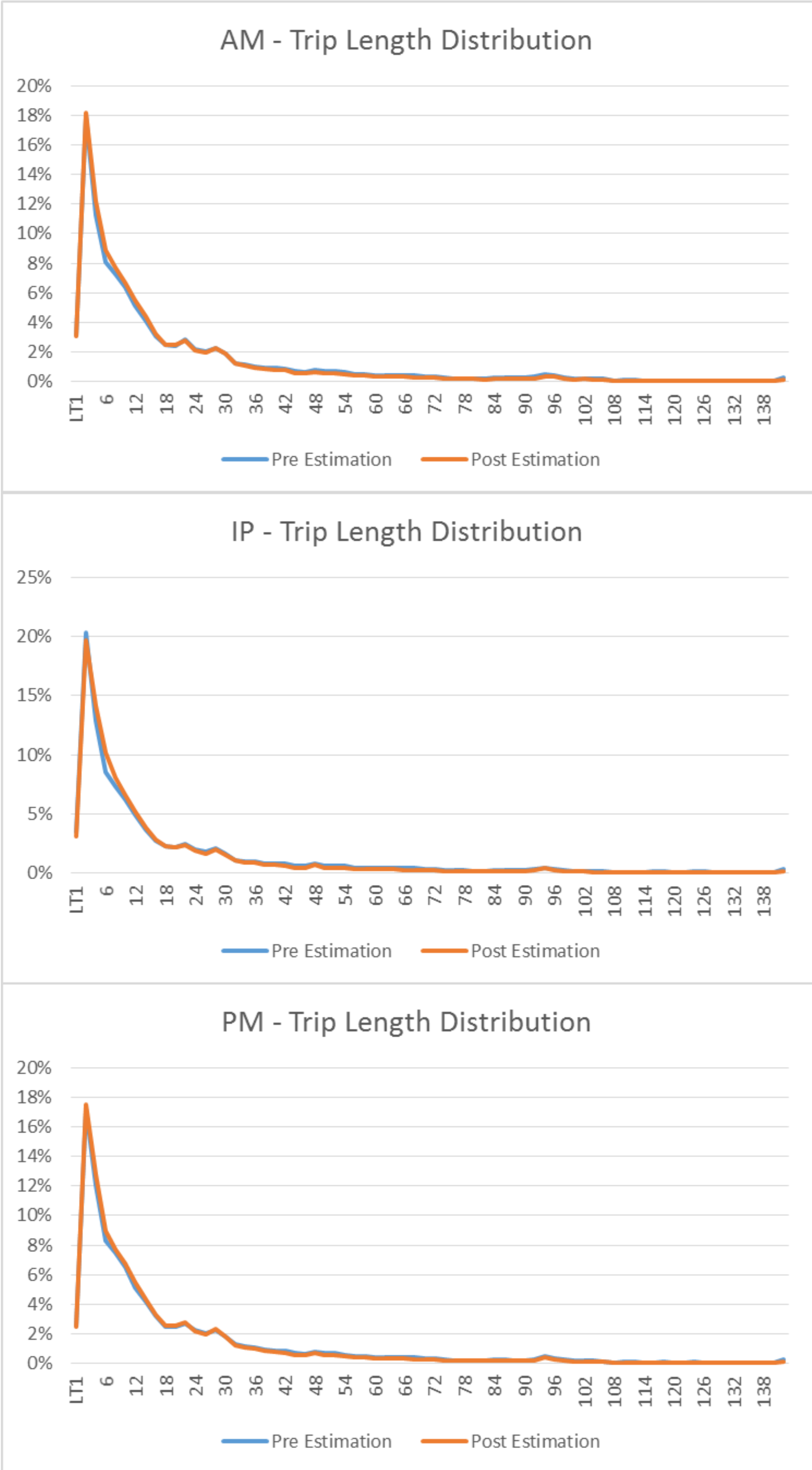

Figure 36. AM, IP & PM Trip Length Distribution for Prior & Post Road Matrix Estimation

Table 27. Road Matrix Estimation Comparison: Trip Length Distribution

TIME PERIOD	STATISTIC	PRE. EST.	POST EST.	% CHANGE
AM Peak	Mean	19	17	-13%
	Standard Deviation	24	21	-14%
Inter Peak	Mean	18	15	-14%
	Standard Deviation	24	21	-15%
PM Peak	Mean	19	17	-12%
	Standard Deviation	24	21	-13%

Sector Movements Comparisons

7.5.13 Appendix D describes the changes in Road traffic movements pre and post estimation using a 29 sector system. This analysis generally shows more rural area movements being reduced to coincide with observed counts. Many sector to sector changes in movements exceed the 5% criteria indicated by guidance, however, many of these changes relate to a relatively small number of traffic movements, using a relatively detailed comparison 29 sector system.

7.5.14 The overall number of Road trips included within the AM, Inter and PM Peak matrices changed by between -1 to -2% (around +/- 1,000 trips) during matrix estimation.

7.5.15 The major trip changes reflect movements to/from Aberdeen city centre, where short distance trips are increased, and more longer distanced orientated trips are reduced. This trend also explains some of the changes in trip length highlighted earlier.

7.6 Road Traffic Volume Calibration

Traffic Count Screenline Analysis

7.6.1 Modelled traffic volumes for each time period were measured against 28 observed traffic count screenlines (including some single calibration points) and cross-referenced using DMRB guidance.

7.6.2 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

7.6.3 Both absolute difference and percentage difference comparisons can be misleading when there is a wide range of observed flows when comparing observed and modelled counts. For example, a difference of 20 vehicles is more significant on a link with an observed flow of 50 vehicles than on one with 500 vehicles, while a 15% discrepancy on an observed flow of 50 vehicles is less important than a 15% discrepancy on an observed flow of 500 vehicles.

7.6.4 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.

7.6.5 The GEH Statistic is defined as:

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

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

Total Screenline Calibration Criteria

7.6.6 DMRB guidance relating to total screenlines comparisons is 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. Note that this statistic is not part of WebTAG guidance, but is useful for comparative purposes.

7.6.7 Note that most DMRB guidance refers to comparisons based on vehicles, however, in the calibration and validation of the ASAM14 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

7.6.8 This section presents the results of the total screenline traffic flows based on the estimated matrix assignment, compared against total observed traffic counts.

7.6.9 Table 28 describes the proportion of screenlines that fall within various percentage difference bands compared to observed traffic count data for each time period.

Table 28. Summary of Total Screenline Traffic Flows Percentage Differences

% RANGE	AM PEAK TOTAL SCREENLINE	AM PEAK % OF TOTAL	INTER PEAK TOTAL SCREENLINE	INTER PEAK % OF TOTAL	PM PEAK TOTAL SCREENLINE	PM PEAK % OF TOTAL
+/- 5%	34	53%	39	61%	38	59%
+/- 10%	49	77%	51	80%	48	75%
+/- 15%	56	88%	55	86%	53	83%
> +/- 15%	8	13%	9	14%	11	17%
Total	**64**		**64**		**64**	

7.6.10 The total screenline percentage flow difference analysis demonstrates that the proportion of screenline comparisons that fall within 5% of the total observed flow is around 53% in the AM peak, 61% in the Inter peak, and 59% in the PM peak. This is less than suggested by the relevant guidance criteria, however a much greater proportion of Screenlines (around 80%) fall within the (less onerous) 10% threshold. Only around 10% of Screenlines lie more than +/- 15% from the relevant screenline traffic count.

7.6.11 Table 29 describes the proportion of screenline comparisons that fall within the various GEH statistic bands.

Table 29. Summary of Total Screenline Traffic Flows GEH Statistic

GEH RANGE	AM PEAK TOTAL SCREENLINE	AM PEAK % OF TOTAL	INTER PEAK TOTAL SCREENLINE	INTER PEAK % OF TOTAL	PM PEAK TOTAL SCREENLINE	PM PEAK % OF TOTAL
0-4	39	78%	43	86%	37	73%
<7	46	92%	48	97%	45	89%
<10	48	95%	48	97%	46	92%
Total	**50**		**50**		**50**	

7.6.12 The GEH statistical analysis indicates the proportion of screenlines that fall within a GEH of 4 is 78% for the AM peak, 86% for the Inter peak and 73% for the PM peak.

7.6.13 Overall, the total screenline traffic flow analysis demonstrates that the ASAM14 road model provides a reasonable comparison with observed traffic data sets, with a high proportion of screenlines falling within the tolerance of ‘less than 4’, and ‘nearly all’ screenlines (>90%) falling within a GEH of 7.

7.6.14 Note that almost all screenlines used during development relate to ‘mini-screenlines’, rather than individual points – making it more challenging to match counts to the guidance criteria – particularly for a model of this size. The application of mini-screenlines better ensures that detailed travel patterns are not inappropriately distorted to match individual traffic counts during matrix estimation.

7.6.15 Some notable poorer areas of traffic volume calibration relate to Screenlines:

- 4b Westbound from the city centre – with lower modelled traffic levels than observed data suggests. This underestimate is partially accounted for due to the local model zones loading to neighbouring streets. Volumes in this area are also controlled by Holburn Street, which are shown to be overestimated, and Albyn Place (which are underestimated). The underestimate is therefore associated with the Union St to Albyn place movement;

- 9b Westbound towards the A93 Deeside corridor – with lower modelled traffic levels than observed data suggests. This underestimate is likely to relate to the modelling being less representative of the higher levels of activity associated with the Robert Gordon Campus and retail centres at Garthdee;

- 24 Southbound along A956 Wellington Road towards Charleston – with lower modelled traffic levels than observed data suggests. Note that the model tends to overestimate Southbound traffic (during the AM and Inter peak) along Great Southern Road. Some further network adjustments across these routes would provide a more balanced Southbound flow towards the A90 Charleston;

- 25 Leggart Terrace / South Deeside Rd – with higher modelled traffic volumes than observed data suggests (noting also that the traffic data was collected in 2009, so is relativity dated). South Deeside Road provides a rural alternative to the more urban routes North of the Dee, where an underestimate is traffic is noted. Some further changes to network speeds would provide a rebalance of the assignment. Note that the Leggart Terrace route is impacted by delays at the Bridge of Dee, which will also have some bearing on this route choice; and

- 27a North Anderson Drive – with higher modelled traffic volumes than observed data suggests. The overestimate is related to both the Auchmill Road and Persley Bridge movements through Haudagain Roundabout onto Anderson Drive. With significant delays associated with Haudagain, less peak hour traffic may actually travel through this location than that modelled. The A96 further into central Aberdeen is also showing an underestimate of traffic volumes, so some network adjustments would provide some re-balancing along these routes.

DMRB Individual Link Count Calibration

7.6.16 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

7.6.17 The following tables summarise the individual link flow comparisons between the modelled and the observed flows, set against the individual link flow calibration criteria described above.

7.6.18 Table 30 shows that around 75% of 'lower' flows fall within 100 vehicles of the traffic count, criteria (not quite matching the 85%). Around 70% of higher flows match the 'within 15% of the observed traffic flow guidance.

7.6.19 Table 31 indicates that around 60% of individual locations fall within a GEH <5, compared to the 85% criteria suggested by guidance. However, 85% of model comparisons do fall within this for GEH lower than 10, and with around 75% of locations displaying a GEH of less than 7. Only around 10%-15% of flows display a GEH of >10.

Table 30. Individual Link Flow Comparisons

FLOW RANGE	AM PEAK TOTAL LINKS	AM PEAK % WITHIN CRITERIA	INTER PEAK TOTAL LINKS	INTER PEAK % WITHIN CRITERIA	PM PEAK TOTAL LINKS	PM PEAK % WITHIN CRITERIA
<700	186	75%	199	74%	177	74%
700-2,700	49	67%	37	73%	58	67%
>2,700	1	100%	0		1	100%
Total	**236**		**236**		**236**	

Table 31. Summary of Individual Link Count GEH statistic

GEH RANGE	AM PEAK TOTAL LINKS	AM PEAK % OF TOTAL	INTER PEAK TOTAL LINKS	INTER PEAK % OF TOTAL	PM PEAK TOTAL LINKS	PM PEAK % OF TOTAL
0-5 (<5)	144	61%	139	59%	141	60%
5-7 (<7)	34	75%	32	72%	39	76%
7-10 (<10)	39	92%	42	90%	24	86%
>10	19	8%	23	10%	32	14%
Total	**236**		**236**		**236**	

7.6.20 Overall, the individual link flow calibration analysis demonstrates that the road model provides a reasonable match to observed traffic levels, within all modelled time periods for a model of this scale and nature.

7.6.21 Note also that the development process purposely incorporated additional screenlines in areas of poorer validation, and although the calibration has improved these locations, the overall statistics are impacted by these additional comparisons.

7.6.22 Some notable areas of poorer traffic volume calibration for individual roads include:

- Union Street – with underestimated modelled traffic volumes;
- B999 North of Aberdeen – with overestimated traffic volumes. ;
- Auchinyell Road – with underestimated traffic volumes;
- Garthdee Road - with underestimated traffic volumes;
- A956 East of Charleston - with underestimated traffic volumes;
- A96 Great Northern Rd S of St Machar Dr - with underestimated traffic volumes;

HGV & LGV Calibration Statistics

7.6.23 Table 32 and Table 33 describe the calibration statistics for HGV and LGV user classes – GEH for individual links.

Table 32. Summary of HGV Flow Calibration – Individual Links

GEH RANGE	AM PEAK TOTAL LINKS	AM % OF TOTAL	INTER PEAK TOTAL LINKS	IP % OF TOTAL	PM PEAK TOTAL LINKS	PM % OF TOTAL
0-5 (<5)	192	81%	144	82%	211	89%
5-7 (<7)	25	92%	34	96%	17	97%
7-10 (<10)	13	97%	39	98%	6	99%
>10	6	3%	19	2%	2	1%
Total	**236**		**236**		**236**	

Table 33. Summary of LGV Flow Calibration – Individual Links

GEH RANGE	AM PEAK TOTAL LINKS	AM % OF TOTAL	INTER PEAK TOTAL LINKS	IP % OF TOTAL	PM PEAK TOTAL LINKS	PM % OF TOTAL
0-5 (<5)	210	89%	218	92%	199	84%
5-7 (<7)	22	98%	13	98%	28	96%
7-10 (<10)	3	100%	4	100%	8	100%
>10	1	0%	1	0%	1	0%
Total	**236**		**236**		**236**	

7.6.24 The analysis indicates that 80%-90% of HGV and LGV calibration locations fall within a GEH of 5, approximately meeting the suggested 85% guidance threshold and demonstrates that the modelled HGV and LGV flows display a reasonable comparison with observed data.

7.6.25 A notable poorer are of HGV calibration is at the A956 East of Charleston.

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

7.7 Road Calibration Conclusions and Recommendations

7.7.1 The ASAM14 road calibration uses sets of classified traffic count data to calibrate traffic movements to observed hourly traffic flows by applying a matrix estimation process.

7.7.2 A variety of count data are used to represent 2014 traffic conditions, with some counts undertaken in earlier years, and scaled up to reflect 2014 levels. Some counts are also averaged over a number of days / months, and others can be one-day counts. These variations in count data characteristics can produce some uncertainty, which should be borne in mind when interpreting the calibration results.

7.7.3 Traffic count data form screenlines, located on individual road locations across the model coverage area. There is a high density of screenlines in Aberdeen, which then reduces out towards the Aberdeenshire commuter towns, with much sparser coverage towards and within Moray and Angus. The calibration and matrix estimation process will mainly adjust traffic levels where screenlines are present, so calibration will be more uncertain outwith the screenline locations.

7.7.4 The model traffic volume and observed traffic count data compare both the total screenline traffic flow and flows at each individual road location. These statistical results demonstrate that the model calibration falls short of the relevant guidance thresholds, but does provide a reasonable level of calibration when a higher threshold is compared. Calibration is similar across each of the modelled time periods. This level of calibration is not uncommon when calibrating a strategic model of this scale and nature, and should be borne in mind during model application.

7.7.5 The analysis also shows how the matrix estimation process alters the underlying matrix travel patterns. There is no significant difference in the overall size of each time period matrix, which demonstrates that the model contains an appropriate level of underlying traffic movements. When comparing the prior and post estimated matrices, the statistics show that matrix differences mainly fall outwith the guidance thresholds, which is mainly due to the process adjusting down rural flows and scaling up urban flows to improve the match with traffic observations.

7.7.6 Trip distribution comparisons indicate that the matrix estimation process resulted in a reduction of the average trip distribution length by between 10%-15%, which although not uncommon during estimation, is outwith the guidance thresholds. These reductions appear consistent across the model, and are considered reasonable.

7.7.7 The calibration data is provided at a detailed level, including by each user class / vehicle type and at a sector basis. Users can review these comparisons to form a more detailed view of the level of calibration in respective study areas. Further traffic count data maybe required in some areas to confirm traffic levels, depending on the coverage and characteristics of calibration data.


8. ROAD MODEL VALIDATION

8.1 Approach & Data Sets

8.1.1 This chapter analyses the level of validation of the ASAM14 road model. This involves determining how well the model compares to observed data that were not used during the calibration process, providing an independent validation data set.

8.1.2 Validation analysis includes comparisons with independent traffic count data and road journey time analysis.

Validation Data

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

- SRTDb traffic data (2014);
- Aberdeen City traffic counts (2014);
- Aberdeenshire Council traffic counts (2014);
- Angus Council traffic counts (2014);
- Moray Council traffic counts (2014);
- Prime Four (Westhill) development counts not used in calibration (2014);
- Aberdeen City Local Paramics model counts not used in calibration (2014);
- ASAM4 modelled flows not used in calibration (2007); and
- TomTom satellite navigation journey time data (2014);

8.2 Traffic Count Validation Comparison

8.2.1 Traffic count validation analysis was undertaken to compare the total modelled traffic flows and also individual heavy goods and light 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

8.2.2 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).

8.2.3 As with the calibration count data, validation traffic count data were extracted for the AM, IP and PM time periods and adjusted to a common 2014 base year level using a factoring process. The locations of the traffic count validation points are illustrated within Figure 39.

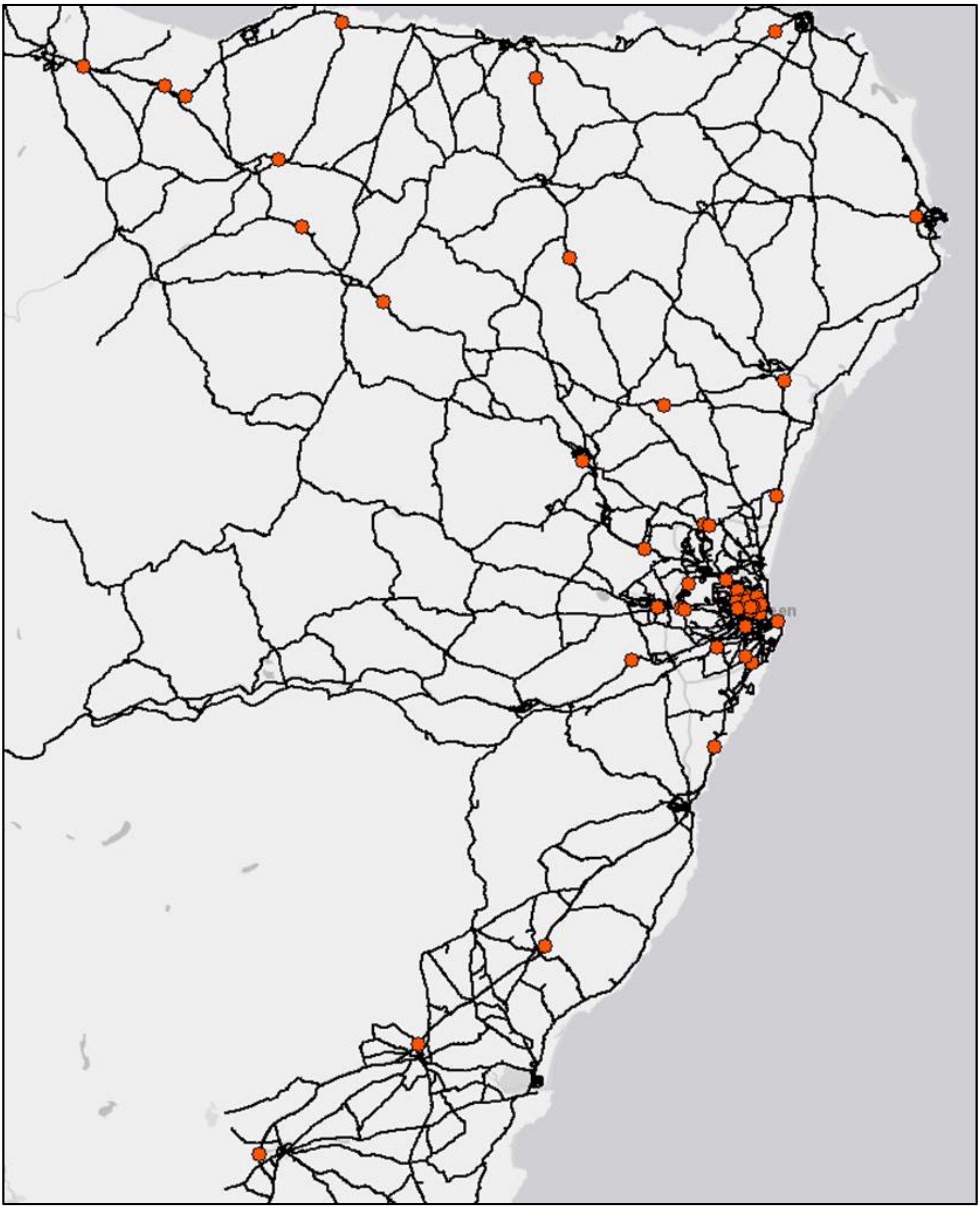

Figure 39. Individual Traffic Count Validation Locations

Individual Link Total Traffic Flow Comparison

8.2.4 The following tables 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 F.

Table 34. Individual Link Traffic Flow Validation

FLOW RANGE	AM PEAK TOTAL LINKS	AM PEAK % WITHIN CRITERIA	IP TOTAL LINKS	IP % WITHIN CRITERIA	PM PEAK TOTAL LINKS	PM PEAK % WITHIN CRITERIA
<700	78	50%	88	67%	76	54%
700-2,700	32	66%	20	35%	34	68%
>2,700	0		0		0	
Total	**110**		**108**		**110**	

Table 35. Individual Link Traffic Flow Validation GEH Criteria

GEH RANGE	AM PEAK TOTAL LINKS	AM % OF TOTAL	INTER PEAK TOTAL LINKS	IP % OF TOTAL	PM PEAK TOTAL LINKS	PM % OF TOTAL
0-5 (<5)	57	52%	61	55%	67	61%
5-7 (<7)	14	65%	17	71%	11	71%
7-10 (<10)	18	81%	12	82%	12	82%
>10	21	19%	18	18%	20	18%
Total	**110**		**108**		**110**	

8.2.5 The validation traffic analysis shows that the road model does not meet the relevant validation guidance thresholds for each modelled time period – with only around 50%-60% of links meeting the relevant criteria (compared to 85%). Validation comparisons are also poorer within the Inter peak model for links with larger traffic flows.

8.2.6 The GEH analysis shows improved comparisons, with around 65%-70% of links falling within a GEH of 7, although these statistics remain outwith the guidance thresholds.

8.2.7 Although not uncommon for a model of this scale and nature, with the generally low level of validation shown here, users should take care during model application when using absolute traffic volumes and also consider any further available data to review the suitability of modelled flows within areas of interest.

8.2.8 Note also that with the scale of data comparisons there could also be instances within the data sets where some observed data sets are less reliable, and therefore the modelled values are generally appropriate.

HGV & LGV Flow Validation

8.2.9 To determine the level of goods vehicle validation across the network, modelled HGV and LGV flows were compared against classified count data at validation locations. Table 36 and Table 37 provide summaries of the HGV and LGV validation GEH statistics.

Table 36. Summary of HGV Flow GEH Statistics Validation

GEH RANGE	AM PEAK TOTAL LINKS	AM % OF TOTAL	INTER PEAK TOTAL LINKS	IP % OF TOTAL	PM PEAK TOTAL LINKS	PM % OF TOTAL
0-5 (<5)	74	67%	71	65%	83	75%
5-7 (<7)	13	79%	18	81%	16	90%
7-10 (<10)	20	97%	13	93%	11	100%
>10	3	3%	6	7%	0	0%
Total	**110**		**108**		**110**	

Table 37. Summary of LGV Flow GEH Statistics Validation

GEH RANGE	AM PEAK TOTAL LINKS	AM % OF TOTAL	INTER PEAK TOTAL LINKS	IP % OF TOTAL	PM PEAK TOTAL LINKS	PM % OF TOTAL
0-5 (<5)	79	72%	83	75%	78	71%
5-7 (<7)	18	88%	20	94%	17	86%
7-10 (<10)	9	96%	3	96%	11	96%
>10	4	4%	2	4%	4	4%
Total	**110**		**108**		**110**	

8.2.10 The goods vehicle analysis shows that around 70% of HGV / LGV location comparisons fall within a GEH of 5 and around 80%-90% fall within a GEH of 7. Only a handful of locations have a GEH of greater than 10. These scale of comparisons are considered acceptable for this type of strategic model.

HGV Routing

8.2.11 To travel across central Aberdeen, two main routes are commonly used by HGV's. These include the 'Wellington Road to City Centre to King Street Corridor', and 'A90 to Bridge of Dee to Anderson Drive corridor'. As HGV's are restricted from using the Bridge of Dee (due to a width restriction), the local alternative is to travel a longer distance via King George VI Bridge and along Riverside Drive onto Holburn Street and South Anderson Drive. The length/time of the detour may result in drivers choosing an alternative, more direct, but potentially less suitable route.

8.2.12 Figure 40 to Figure 42 illustrate how the ASAM14 base year modelling assigns HGV's to routes within central Aberdeen for the AM, Inter and PM Peak time periods. This shows HGV demand flows using red bandwidths.

8.2.13 The figures generally demonstrate that the modelling assigns HGV's along the two major routes with larger HGV volumes at Wellington Road and King Street and approaching the Bridge of Dee and North Anderson Drive. The Market Street and Denburn corridors within the city centre are also shown to be more heavily trafficked with HGV's.

8.2.14 The analysis also shows a relatively low volume of HGV's at South Anderson Drive, with HGV's tending to travel via alternative routes within the Anderson Drive corridor. This alternative routing suggests the model is less likely to capture HGV's on the diversionary route around the Bridge of Dee, due to the shorter distance nature of HGV routing.

8.2.15 Users should bear this issue in mind when analysing changes in HGV flows, with a wider screenline of data potentially required to evaluate HGV traffic impacts.

Figure 40. HGV Routing within Central Aberdeen - AM Peak

Figure 41. HGV Routing within Central Aberdeen - Inter Peak

Figure 42. HGV Routing within Central Aberdeen - PM Peak

8.3 Road Validation in Air Quality Management Areas

8.3.1 This section discusses the level of model validation achieved in the three Air Quality Management Areas (AQMA's) located within Aberdeen. Table 38 to Table 40 describe the average level of observed traffic travelling via each count location along with a comparison with modelled traffic volumes. Data for total vehicles and HGV flows (two-way) are described, with data for individual count sites contained in Appendix K.

8.3.2 Note that to widen the available data used within the comparisons for these specific areas, both calibration and validation count data sets were used within this analysis.

Table 38. Traffic Volumes in City Centre AQMA (Hourly Vehicles)

TIME PERIOD	AVERAGE OBSERVED TRAFFIC		CHANGE IN MODEL TRAFFIC		% CHANGE IN MODEL TRAFFIC	
	HGV	Total	HGV	Total	HGV	Total
AM	96	1,229	3	-61	3%	-5%
IP	100	1,004	-18	-112	-18%	-11%
PM	56	1,266	-3	1	-6%	0%

Table 39. Traffic Volumes in Anderson Drive AQMA (Hourly Vehicles)

TIME PERIOD	AVERAGE OBSERVED TRAFFIC		CHANGE IN MODEL TRAFFIC		% CHANGE IN MODEL TRAFFIC	
	HGV	Total	HGV	Total	HGV	Total
AM	85	3,018	-13	118	-15%	4%
IP	57	2,680	9	309	16%	12%
PM	48	2,982	7	272	14%	9%

Table 40. Traffic Volumes in Wellington Road AQMA (Hourly Vehicles)

TIME PERIOD	AVERAGE OBSERVED TRAFFIC		CHANGE IN MODEL TRAFFIC		% CHANGE IN MODEL TRAFFIC	
	HGV	Total	HGV	Total	HGV	Total
AM	220	2,367	20	-348	9%	-15%
IP	158	1,753	-9	-287	-6%	-16%
PM	151	2,152	-13	400	-9%	19%

8.3.3 The comparisons indicate that both total modelled traffic volumes and specific HGV flows fall within 20% of observed flows for each AQMA and for all time periods, with the majority of comparisons falling within 15%. The comparison vary between AQMA and by time period. The comparisons show that on average, the model tends to underestimate total traffic volumes within the City Centre AQMA, (by around 5-10%). Whereas, the analysis suggests traffic volumes are generally over estimated along the Anderson Drive AQMA by around 10%.

8.3.4 Data for the Wellington Road AQMA generates a more varied pattern, with underestimates within the AM and inter peak time periods, which, to some extent, are off-set by an overestimate within the evening peak.

8.3.5 Differences in HGV volumes also vary by AQMA and time period, but with no significant bias identified.

Individual Location Comparisons

8.3.6 The following observations are noted when examining the more detailed comparisons for individual locations contained in Appendix K, and initial model application:

- ASAM14 contains an HGV ban at the Market Street section of Union Street, reflecting current restrictions, but traffic observations show some traffic travelling via this section. The zone system around Union Street tends to load traffic to the side roads rather than the main route, and these characteristics tend to explain the underestimate of both total traffic flow and HGV's along Union Street;
- The modelling appears to overestimate HGV's travelling along the Market Street – Virginia Street to King Street Corridor within the AM Peak, but not during the inter or PM peak periods;
- The Bridge of Dee is banned to HGV within ASAM14, reflecting the width restriction in place, but a small number of HGV's continue to use this route;
- The modelling tends to overestimate traffic volumes along the more northern sections of the Anderson Drive corridor;
- Riverside Drive (along Duthie Park) is open to HGV's within ASAM14, but this route has a height restriction in place. Separate observed data (available to Nestrans) does though suggest that HGV's do use this route.

8.3.7 Users can use the AQMA comparison data to understand how representative the modelling is when considering undertaking air quality and emissions assessments.

8.3.8 Note that the data here provides comparisons with observed data to understand the representation contained within ASAM14. However, when using the model to inform more detailed microsimulation modelling (i.e. through cordoning traffic demand), traffic validation within AQMA's would likely be finalised through the detailed routing and zoning determined within the microsimulation modelling. For example, the Aberdeen city centre Paramics model coverage is far wider than the immediate AQMA, and therefore the local city centre validation within ASAM14 would have less impact on the quality of city centre microsimulation modelling calibration. Traffic comparisons at locations at microsimulation model external route zones would also have some bearing.

8.4 Journey Time Validation

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

TomTom Satellite Navigation Data

8.4.2 SYSTRA was provided with TomTom data in October 2016. The data was supplied by Streetwise Services and covered a period representing weekdays (various time periods between 0700-1900) from January 13 to December 19 during 2014.

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

8.4.4 The data was provided in the form of both 'mean' and 'median' travel times across each TomTom link, based on the counts collected in the dataset. The TomTom counts were not used for any validation of modelled flow.

8.4.5 A total of 12 routes were developed for the ASAM14 journey time comparisons. The approximate coverage of TomTom data is illustrated in Figure 43, with routes illustrated in Appendix G, and described below.

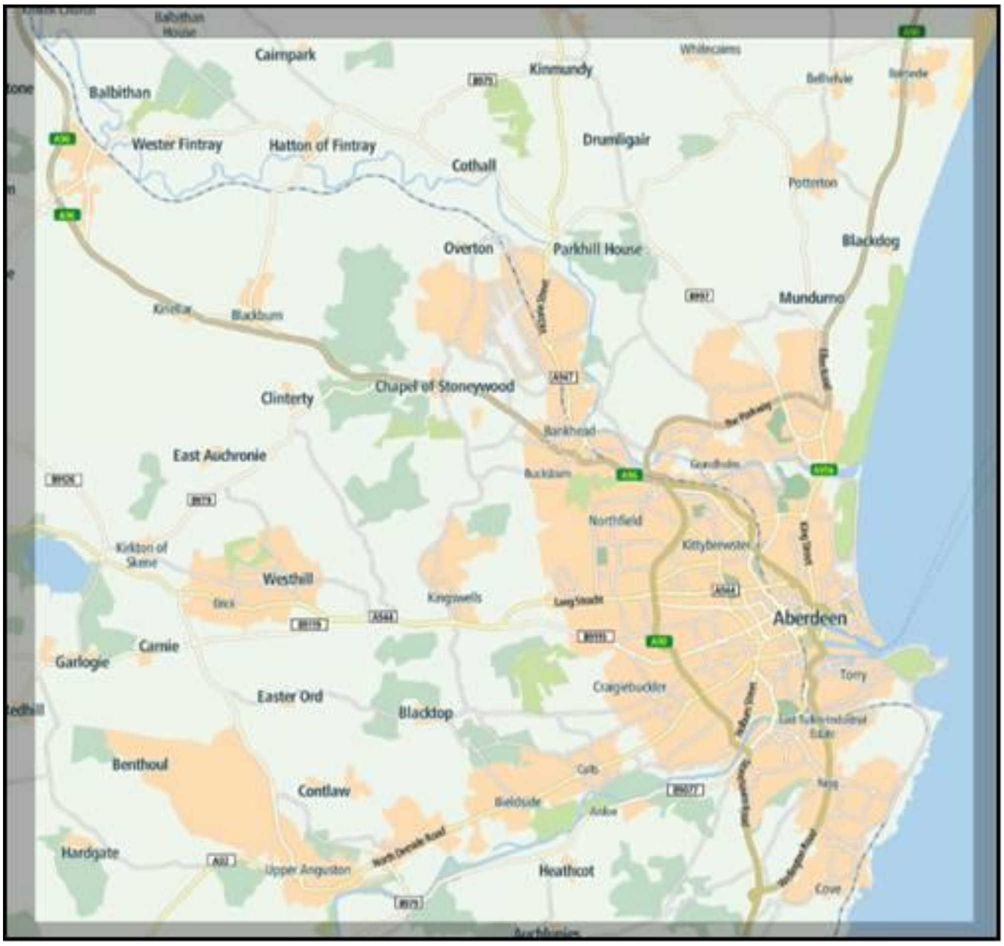

Figure 43. TomTom Speed Data Coverage

Road Journey Time Routes

- Route 1: A96 Kintore to A90 Portlethen
- Route 2: A90 Balmedie to Portlethen
- Route 3: A93 Drumoak to Aberdeen
- Route 4: A944/Garlogie/Westhill to Aberdeen City Centre
- Route 5: B9077/Cults to Aberdeen City Centre
- Route 6: A90 The Parkway to Aberdeen City Centre
- Route 7: A947 Dyce to A96
- Route 8: B977 to A93
- Route 9: B997 to Aberdeen City Centre
- Route 10: A944 to Aberdeen City Centre
- Route 11: B979 Corridor
- Route 12: A90 (Hillside) to Aberdeen City Centre

8.4.6 The TomTom journey time data was used to validate the road model and was also used to feedback into the calibration process to make refinements to the model network.

8.4.7 The datasets described here represent journey times along a given (GIS) link or road segment. These links are combined to form journey time routes. The 0800-0900, average 1000-1600, and 1700-1800 time/speed data was used to represent the AM, Inter and PM Peak time periods respectively.

Mean & Median Road Speeds

8.4.8 As TomTom data is collected over a long period, it is likely to include periods of disruption caused by roadworks and potentially accidents. These types of incidents are not captured within the base year model congested speeds, so cognisance of this should be taken when comparing the modelled data against that recorded by TomTom.

8.4.9 Following a review of mean and median travel times across the TomTom network, it was felt that the median time would likely underestimate congestion impacts, as some of the most severe congestion would potentially be under represented. Whereas the mean times would potentially over estimate congestion as they would also reflect network disruption, such as roadworks and accidents (where the modelling is required to compare against 'average' journey times with no network disruption).

8.4.10 Therefore, taking a weighted average of the two measures would provide a more balanced and appropriate set of journey times to compare against the modelled data. The observed times used in the ASAM14 road model are based on a weighted average of 25% median and 75% mean observed times. This bias in weighting towards the mean was felt to be more representative than a simple 50/50 split, as the mean times would capture more congestion impacts, (the main focus of calibration), whilst incorporating a proportion of the median would help off-set the impact of specific network disruption, which would tend to overestimate journey times within the recorded mean.

8.4.11 Table 41 displays the journey time validation results by route number and Table 42 describes the 'average' journey times across all routes.

8.4.12 Further information comparing modelled journey times with the TomTom data, (including route maps), is included within Appendix G.


Table 41. Journey Time Route Performance – Modelled vs Observed (mm:ss)

ROUTE	DIR	AM OBS	AM MOD	AM % DIFF	IP OBS	IP MOD	IP % DIFF	PM OBS	PM MOD	PM % DIFF
1	NB	43:30	39:57	-8%	33:46	33:32	-1%	42:16	39:59	-5%
	SB	39:54	37:55	-5%	35:58	33:39	-6%	49:33	43:08	-13%
2	NB	35:56	37:25	4%	32:04	30:42	-4%	42:01	41:29	-1%
	SB	39:27	38:00	-4%	32:01	32:29	1%	35:43	39:11	10%
3	EB	34:59	39:24	13%	30:49	29:44	-4%	34:00	33:13	-2%
	WB	30:02	29:00	-3%	30:58	27:49	-10%	36:23	35:05	-4%
4	EB	33:36	35:02	4%	28:13	27:32	-2%	33:42	31:28	-7%
	WB	31:26	27:36	-12%	29:00	26:22	-9%	34:03	33:12	-2%
5	EB	29:19	28:56	-1%	27:25	25:12	-8%	33:43	29:26	-13%
	WB	29:48	29:40	0%	27:39	27:07	-2%	31:55	33:12	4%
6	NB	17:17	17:16	0%	18:04	16:40	-8%	20:51	23:21	12%
	SB	23:21	20:47	-11%	17:50	16:35	-7%	19:05	18:21	-4%
7	NB	14:18	12:25	-13%	11:39	11:29	-1%	19:43	17:26	-12%
	SB	14:18	12:59	-9%	11:36	11:37	0%	15:08	15:04	0%
8	NB	31:07	31:58	3%	27:11	26:45	-2%	38:11	42:13	11%
	SB	32:32	31:11	-4%	27:33	27:24	-1%	36:33	43:29	19%
9	NB	15:45	16:06	2%	15:23	15:25	0%	19:52	19:24	-2%
	SB	18:49	19:58	6%	15:08	16:55	12%	16:30	18:04	9%
10	EB	17:00	16:26	-3%	13:53	13:57	0%	16:57	16:21	-4%
	WB	15:55	14:32	-9%	14:16	13:56	-2%	17:06	17:32	3%
11	NB	18:11	18:00	-1%	16:53	15:26	-9%	19:25	17:25	-10%
	SB	17:19	16:18	-6%	16:28	15:27	-6%	18:55	18:58	0%
12	NB	19:00	21:32	13%	18:41	19:48	6%	24:53	23:25	-6%

ROUTE	DIR	AM OBS	AM MOD	AM % DIFF	IP OBS	IP MOD	IP % DIFF	PM OBS	PM MOD	PM % DIFF
	SB	19:06	20:08	**5%**	17:15	19:18	**12%**	19:00	20:58	**10%**

Table 42. Average Journey Time Route Across All Routes (mm:ss)

ROUTE	DIR	AM OBS	AM MOD	AM % DIFF	IP OBS	IP MOD	IP % DIFF	PM OBS	PM MOD	PM % DIFF
12 Route Average	Two way	25:55	25:31	-1.5%	22:54	22:17	-2.7%	28:09	27:59	-0.6%

DMRB Journey Time criteria

8.4.13 For journey time validation, the DMRB criteria is advises that modelled journey times should be within 15% (or 1 minute if higher) for greater than 85% of routes.

8.4.14 Table 43 summarises the overall operational performance of the road model against the observed journey times calculated.

Table 43. Summary of Overall Journey Time Performance

WITHIN DMRB	AM PEAK TOTAL ROUTES	AM PEAK % WITHIN 15%	INTER PEAK TOTAL ROUTES	INTER PEAK % WITHIN 15%	PM PEAK TOTAL ROUTES	PM PEAK % WITHIN 15%
Yes	12	100%	12	100%	11	96%
No	0	0%	0	0%	1	4%

8.4.15 The validation analysis demonstrates that the road model meets the journey time validation criteria within all time periods, with only one route (R8 Southbound) falling out with the criteria, with too high a modelled journey time recorded during the PM Peak.

8.4.16 The average comparison of journey times across all routes suggests that the road model network is slightly faster than that observed during all AM, Inter and PM peak time periods.

8.5 Road Network Delays

8.5.1 To demonstrate where the road model represents congestion at the more detailed level, a series of traffic delay maps where produced to illustrate modelled network pinchpoints. These are shown in Figure 44 to Figure 47 for the AM and PM Peaks. These data plots represent average SATURN road network junction delays for all approaches to an intersection.

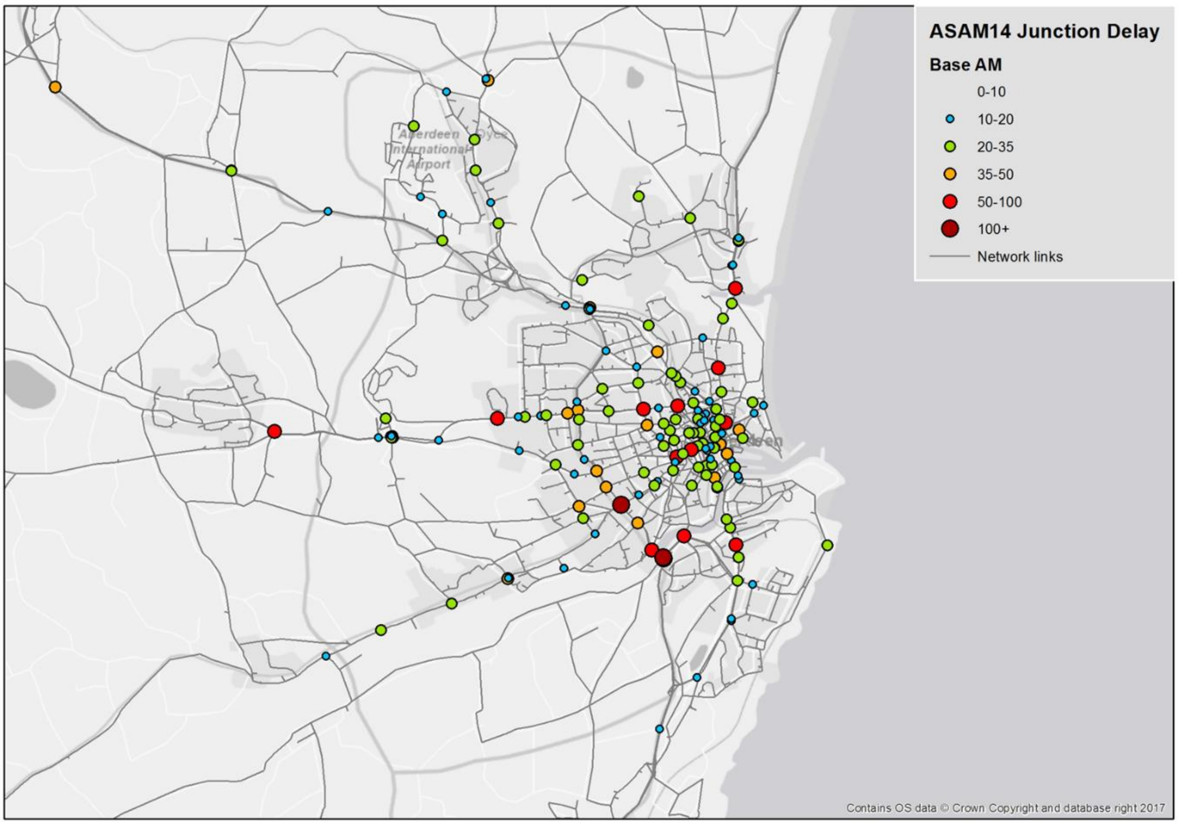

Figure 44. 2014 Base Year Modelled Road Network Delays (seconds): Aberdeen- AM Peak

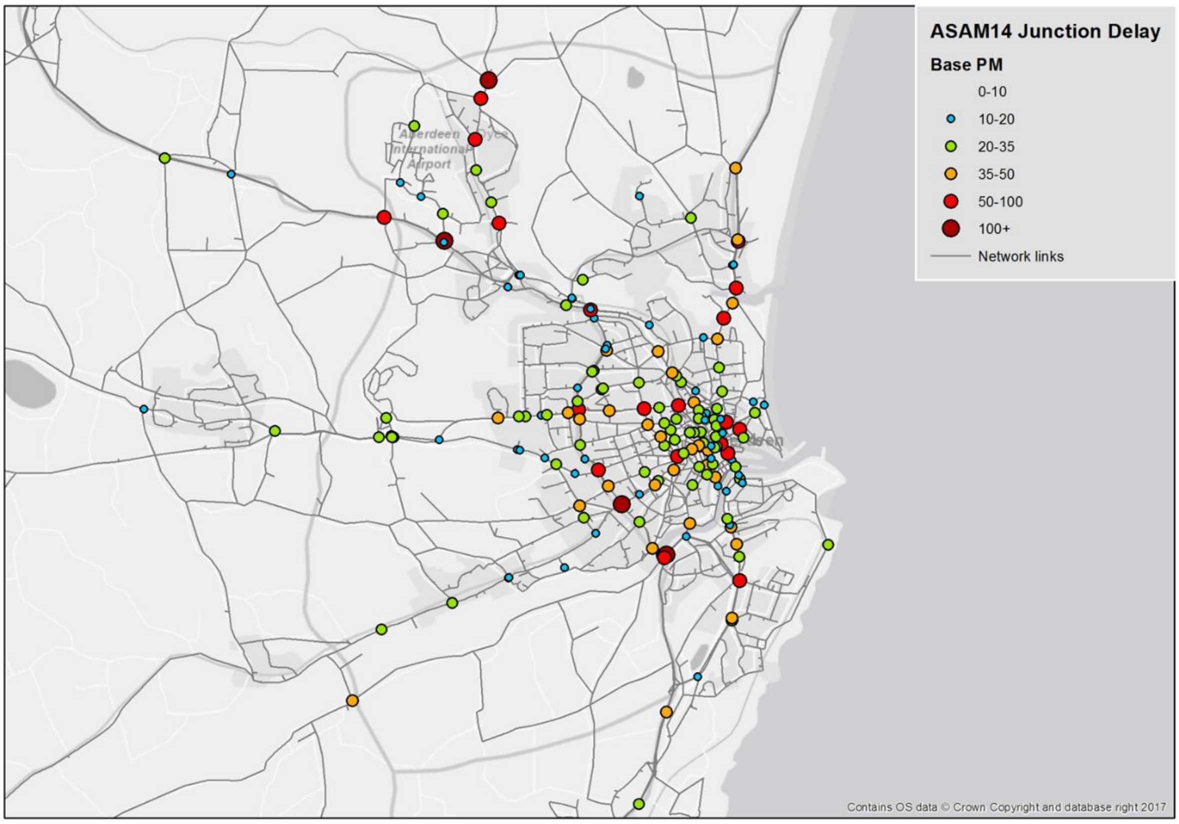

Figure 45. 2014 Base Year Modelled Road Network Delays Seconds): Aberdeen- PM Peak

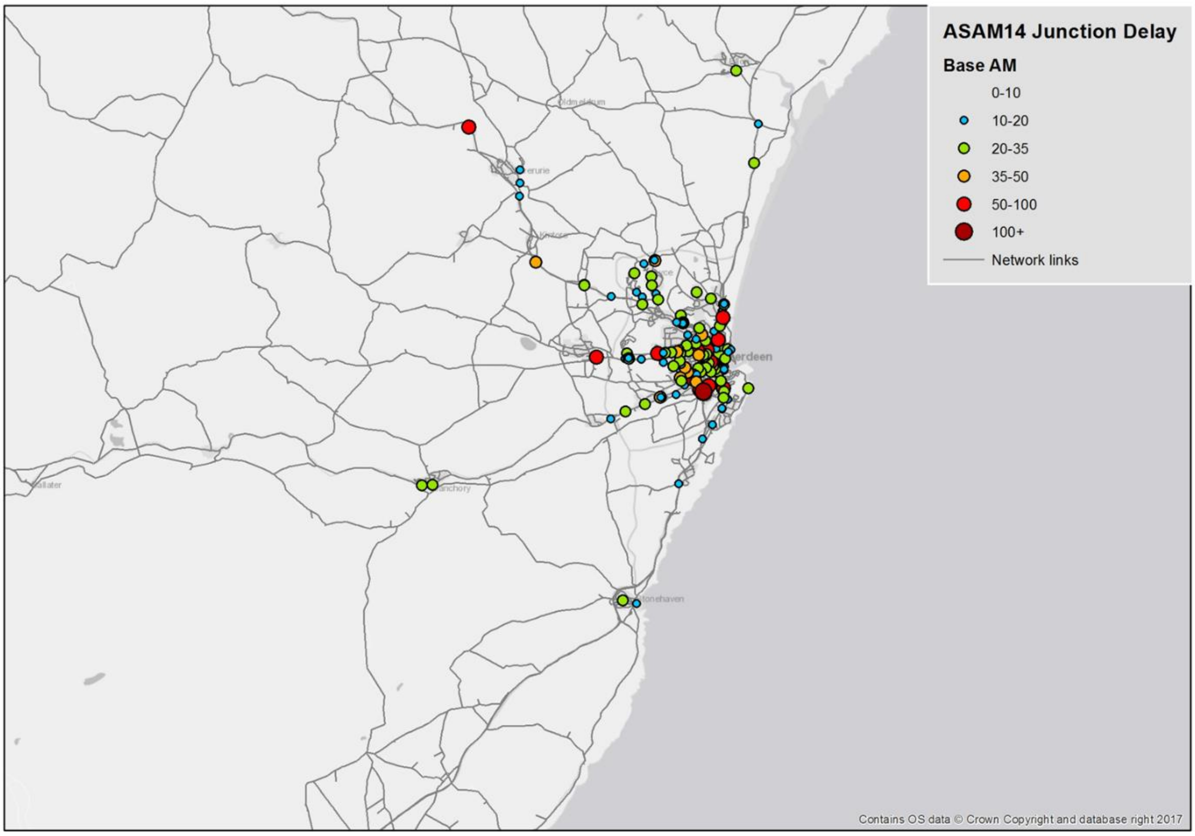

Figure 46. 2014 Base Year Modelled Road Network Delays Seconds): Aberdeenshire- AM Peak

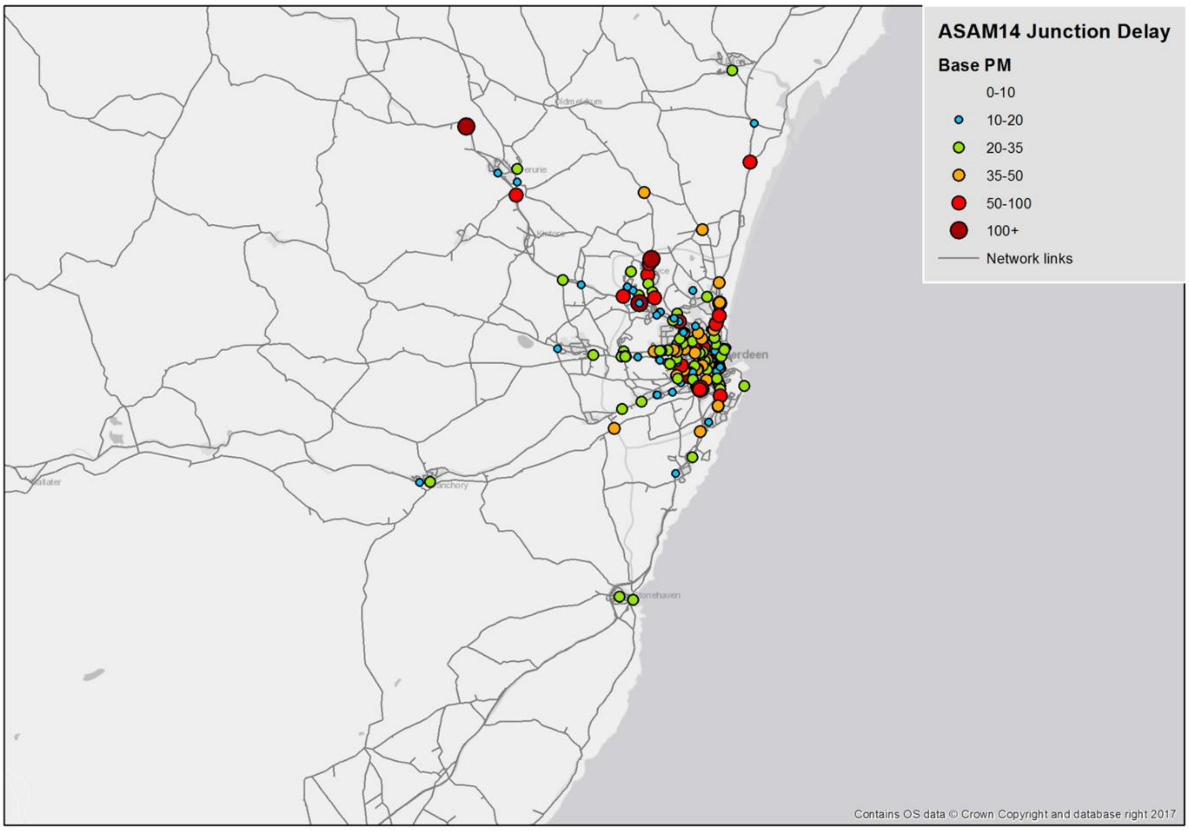

Figure 47. 2014 Base Year Modelled Road Network Delays Seconds): Aberdeenshire- PM Peak

8.6 Convergence

8.6.1 Table 44 describes the level of convergence achieved by the road assignment model alongside the recommended level of convergence within relevant guidance.

Table 44. Summary of Road Assignment Model Convergence

MEASURE	GUIDANCE	AM	IP	PM
No of Iterations	NA	20	16	20
Delta & %GAP	<0.1% or at least stable with convergence	Yes	Yes	Yes
% of links with flow change (P)<2%	Four consecutive iterations greater than 98%	Yes	Yes	Yes
% of links with cost change (P2)<2%	Four consecutive iterations greater than 98%	Yes	Yes	Yes
% change in total user costs (V)	Four consecutive iterations less than 0.1% (SUE only)	N/A	N/A	N/A

8.6.2 Note that ASAM14 sets the 'PCNEAR' convergence parameter to 2 and therefore these comparisons are undertaken with a <2% threshold rather than a <1% threshold.

8.6.3 The statistics show that the all three modelled time periods achieve the desired level of convergence.

8.7 Road Validation Conclusions and Recommendations

8.7.1 ASAM14 road validation uses traffic count data independent from the calibration data sets to understand how other areas of the model network compare to observed data. It also compares modelled and actual journey times to demonstrate traffic speed and time validation.

8.7.2 The road traffic volume comparisons indicate a generally low level of validation, with the level of variation falling outwith the guidance thresholds. Although not uncommon for a model of this scale and nature, users should take care during model application when using absolute traffic volumes and also consider the use of further available data to review the suitability of modelled flows within areas of interest.

8.7.3 The road journey times comparisons demonstrate a very good level of validation with observed travel time and speed data. Only one journey time route (out of 12) within the PM Peak time period falls outwith the 15% guidance threshold. The modelled average journey time is also close to the average observed journey time, falling within 3%.



9. PUBLIC TRANSPORT MODEL CALIBRATION & VALIDATION

9.1 Approach

9.1.1 This chapter describes the calibration and validation process undertaken for the ASAM14 public transport (PT) assignment model and demand matrices, comparing:

- final calibration of total PT road/PT link passenger demand crossing an observed inner Aberdeen and outer Aberdeen cordons of bus and rail passenger counts;
- final calibration of individual PT passenger flows travelling via roads/rail lines crossing the cordons;
- comparison of changes between 'prior' and 'estimated' PT demand matrices;
- validation of modelled bus journey times;
- validation of rail passenger boarding's.

9.1.2 Section 5 describes the development of the PT network and services, whilst section 6 describes the formulation of the PT Assignment 'Prior' matrices.

Calibration

9.1.3 The ASAM14 PT calibration process assigned the Prior matrices against the modelled networks and services and compared output bus and rail passenger flows with observed passenger counts. Network / service and matrix adjustments were undertaken through an iterative process until a satisfactory level of calibration was achieved. PT calibration was undertaken following the Road model calibration with final congested road speeds used to inform the PT bus modelling.

9.1.4 The outputs from the calibration process included a set of hourly PT assignment matrices (including all bus and rail movements) and assigned PT networks.

Validation

9.1.5 The PT validation process mainly included comparing modelled bus journey times with published timetables. Note that all relevant link-based passenger volume data were used within the calibration process, and there was insufficient additional data available for independent PT validation. However, modelled and observed rail station boarding and alighting data were used to validate passenger access levels at rail stations.

9.1.6 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. Updates to overall bus speed factors were introduced to balance bus and rail movements – by comparing passenger flows on competing routes.

9.2 Public Transport Data

9.2.1 There are five main data sources used to inform the PT calibration and validation. Each of these local data sets, (with the exception of ORR data) were collected at a 'neutral' time out with the main holiday periods:

- September 2016 Roadside Bus Occupancy Surveys (Inner Cordon);

- June 2014 Bus Occupancy Surveys (Outer Cordon) - as used in TMfS14;
- May 2015 Dundee to Aberdeen rail passenger surveys - collected as part of the LATIS commission;
- February 2013 Aberdeen to Inverness rail passenger surveys - as used in TMfS14 validation; and
- Office of Rail regulator (ORR) 2015 rail passenger boarding's and alighting's by station.

9.2.2 A 'spot-check' of bus occupancy data was also undertaken by comparing modelled and roadside counts with specific bus passenger data provided by an operator for the A90 North Ellon to Aberdeen corridor. Each data source is discussed in more detail below:

2016 Bus Occupancy Surveys

9.2.3 Given the age and coverage of existing PT data within the modelled area, particularly within Aberdeen city centre, the collection of bus occupancy data was deemed relatively essential for public transport model development. An 'Inner Cordon' of roadside bus occupancy counts were commissioned and carried out in September 2016, with the aim of informing the bus passenger calibration process.

9.2.4 Bus occupancy counts were undertaken along routes which are likely to be most-affected by the delivery of proposed schemes such as the city centre masterplan. The 12 sites surveyed are described below and illustrated in Figure 48.

1: A956 Wellington Rd, 2: B9077 Great Southern Rd, 3: A9013 Holburn St,

4: Albyn Place, 5: Mid Stocket Rd, 6: A944 Westburn Rd, 7: B986 Berryden Rd,

8: A96 Powis Terrace, 9: King's Crescent, 10: A956 King St, 11: A956 East North St,

12: A956 Market Street

9.2.5 At each site surveyors estimated the percentage occupancy of each service. Passenger estimates were then obtained using the following assumptions for bus capacity. These assumptions were kept consistent with those applied during the earlier TMfS14 survey processing:

Table 45. Bus Vehicle Type Passenger Capacity Assumptions

BUS VEHICLE TYPE	CAPACITY (PASSENGERS)
Mini Bus	30
Single Decker	40
Double Decker	70
Coach	56
Articulated Coach	117

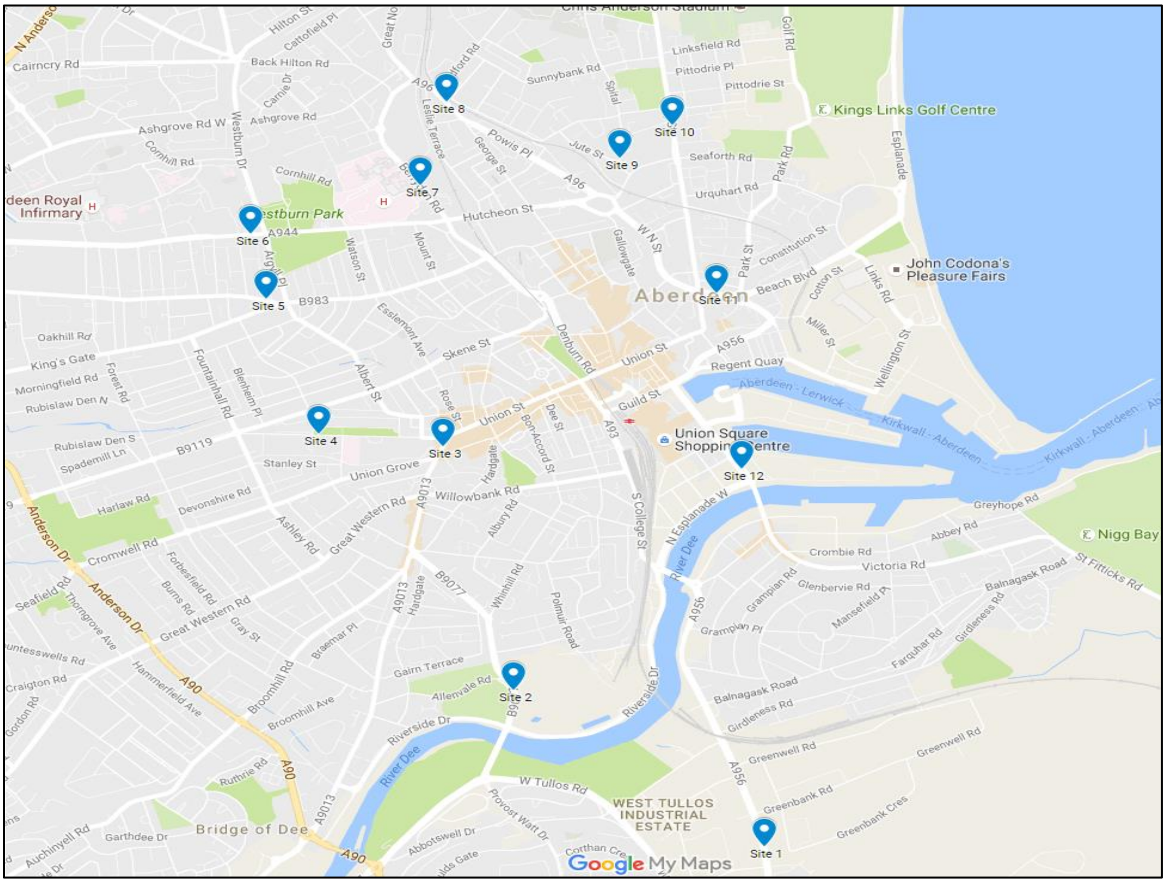

Figure 48. 2016 Aberdeen 'Inner Cordon' Bus Passenger Survey Locations

Limitations

9.2.6 Given the relative coarseness and potential variability associated with roadside bus occupancy counts, no attempt was made to factor 2016 data to 2014 levels.

9.2.7 Due to the relatively coarse nature of roadside bus passenger counts, and the use of darkened/tinted windows for some services, common sense checks were undertaken and estimates used to infill passenger numbers. Bus operators (Stagecoach / Megabus) were contacted to obtain approximate estimates to confirm that the level of occupancy assumed was reasonable. These limitations should be borne in mind when interpreting the validation comparisons. Estimates were also discussed with the client group.

2014 Roadside Bus Occupancy Surveys

9.2.8 The PT calibration also made use of roadside bus occupancy surveys which were undertaken around the periphery of Aberdeen as part of the development of TMfS14 during June 2014. The 2014 analysis applied consistent capacity assumptions as described above to calculate overall passenger levels. The corridor locations of the Outer Cordon surveys are illustrated in Figure 49 and include.

1: A90 Hillside South, 2: B9007 Leggart Place, 3: A93 Peterculter, 4: A944 / B9119 Fairley Rd, 5: A96 Chapel of Stoneywood, 6: A947 Hattoncrook, 7: A90 North Ellon Rd,

9.2.9 Locations 9 and 10 relate to the outer **rail** cordon points between Inverurie and Dyce, and Stonehaven and Portlethen, which are discussed further below.

Figure 49. 2014 Aberdeen 'Outer Cordon' Bus Passenger Survey Locations

Bus Data Spot-Check

9.2.10 The client group provided some specific data covering morning Peak Southbound bus movements between Ellon and Aberdeen. These were used to compare with the relevant 2014 roadside occupancy survey, and also the modelled flow. This confirmed that figures (from the 2014 survey) of around 200 passengers per hour provided a reasonable estimate of hourly volumes in the southbound direction (Outer Cordon location 7).

May 2015 Dundee to Aberdeen rail passenger surveys

9.2.11 The inner and outer cordon rail flows were derived from passenger surveys undertaken in May 2015 which provided boarding and alighting information for services running between Dundee and Aberdeen. The surveyed trains were checked against timetables to identify any missing service gaps and where missing services existed, the data was infilled using June 2012 survey data or in some cases, using similar services in the 2015 dataset which had similar stopping sequences in the same time period.

9.2.12 To identify flows between each station, the boarding and alighting data was analysed for each direction, within the AM, IP and PM periods which produced peak period passenger flows.

9.2.13 To convert the Peak period flows to peak hour, factors were established by calculating a factor for each station, and then an average across all the stations for each direction. The factors used for this dataset were:

- Northbound AM – 0.532
- Northbound PM – 0.525
- Southbound AM – 0.680
- Southbound PM – 0.522

9.2.14 The IP peak period flows were divided by 6 to calculate the IP peak hour flows

February 2013 Aberdeen to Inverness rail passenger surveys - as used in TMfS14 validation

9.2.15 To generate ASAM14 passenger estimates between stations on the Aberdeen to Inverness rail corridor, processes for the TMfS14 development were utilised. Below is the extract from the *TMfS14 Public Transport Development Report, SIAS, August 2017*.

9.2.16 The data used in TMfS14 Matrix Development are as follows:

- Public Transport Interview data between Perth and Inverness (6/7 February 2013);
- Public Transport Interview data between Inverness and Aberdeen (6/7 February 2013); and
- ScotRail 2012 Boarding and Alighting Surveys.

9.2.17 Each Public Transport interview dataset was 'cleaned' at source to remove or correct records whose origins and destinations appeared illogical. Interview records were mapped by origin and destination using the coordinates for each recorded postcode. Records with an illogical origin or illogical destination were rejected from the datasets.

9.2.18 The resulting records were then used to derive individual sample rates for the site, by journey type (Bus & Rail), by comparing with the surveyed data with the boarding and alighting data collected for each station on the two corridors. Factors were then generated to expand the sampled data for each corridor to meet the observed station boarding and alighting flows.

9.2.19 For the public transport records, the "Purpose" data provided for origin and destination (home, work, etc.) was then used to define the trip purpose for each record. The trip purposes are consistent with TMfS12, namely:

- In-Work (IW);
- Non-Work Commute (NWC);
- Non-Work Other (NWO).

9.2.20 The resulting observed Public Transport data was assigned and the boarding/alighting and loadings were compared to the observed data.

9.2.21 The observed flows in each peak period were multiplied by the TMfS14 Peak Hour factor, detailed below:

- AM -0.45
- IP -1/6
- PM -0.44

2015 rail passenger boarding's and alighting's by station

9.2.22 Observed Rail station boarding and alighting data from Office of Rail Regulator (ORR) 2015-2016 station boarding's (total entries, exits including Full, Reduced Season Tickets) were interrogated to provide patronage data to compare boarding's and alighting's for each ASAM14 rail station.

9.2.23 A number of assumptions were required to provide a more consistent comparison of the observed annual data set with the hourly flows output from ASAM14. Total observed station Boarding's & Alighting were divided by two to create individual boarding's and alighting's, and total modelled AM, IP, and PM rail patronage across all relevant stations were 'annualised' to match the total annual observed figures across all stations.

9.2.24 Note also that ASAM14 generally reflects 2014 passenger demand, whereas observed Rail station data reflects the 2015-2016 period. 'External' observed rail flows were set as consistent values as provided by the TMfS14 Model - as no data available for these lines, rather than stations.

Data Not Progressed

9.2.25 Note that an additional set of Bus Origin Destination surveys was proposed at key bus boarding points for specific corridors to inform the public transport model validation (including locations at Aberdeen Royal Infirmary and Garthdee Retail Park). Following discussions with the client group it was confirmed that these type of bus origin destination surveys would **not** be progressed as the coverage involved provides relatively limited value in terms of validation.

9.3 Passenger Demand Cordon Link Flow Calibration

9.3.1 Table 46 to Table 49 demonstrate the calibration of public transport passengers comparing modelled link flows with bus and rail observed data at specific locations for the AM, Inter and PM Peak hourly time periods.

9.3.2 These locations were included within the PT matrix estimation (ME) procedure, with the ME process altering travel patterns to better match these observed inputs. The ME process was run for each time period separately, using combined total passenger flows across all travel purposes. Bus and rail calibration points were used within the cordons and applied the combined rail and bus passenger PT travel demand matrices.

9.3.3 The brown shaded cells within the tables highlight where observed data was 'patched' or adjusted to deal with zero values or where observed data was counter intuitive (i.e. where tidal flows were inconsistent, and would impact the quality of matrix estimation). The eleven data patches amended a specific anomaly with a similar magnitude of passenger count from another time period by reversing the direction of travel.

9.3.4 The tables in this section describe ASAM14 bus and rail passenger modelled link flows, compared to 2014 observations for the bus outer cordon and 2016 observations for the bus inner cordon. Observed rail data reflects periods between 2013 and 2015.

9.3.5 A summary of calibration statistics is also provided, compared against the relevant calibration criteria.

Calibration Criteria

9.3.6 The calibration of the ASAM14 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 (< 150), on individual links.

Table 46. PT Passenger Flow Comparison (per hour) – Inner Cordon Inbound

Inner Cordon		AM	AM Peak Hour			IP	Inter Peak Hour			PM	PM Peak Hour		
INBOUND		OBS	MODELLED			OBS	MODELLED			OBS	MODELLED		
Station/Road Name	ID	Hour	Hour	Diff	% Diff	Hour	Hour	Diff	% Diff	Hour	Hour	Diff	% Diff
A956 Wellington Road	1	168	155	-13	-8%	76	78	+2	+3%	152	158	+6	+4%
B9077 Great Southern Road	2	341	344	+3	+1%	135	130	-5	-4%	223	254	+31	+14%
A9013 Holburn Street	3	887	840	-47	-5%	617	529	-88	-14%	828	763	-65	-8%
Albyn Place	4	195	207	+12	+6%	143	121	-22	-15%	176	204	+28	+16%
Mid Stocket Road	5	184	182	-2	-1%	139	120	-19	-14%	181	154	-27	-15%
A944 Westburn Road	6	121	138	+17	+14%	75	98	+23	+31%	89	132	+43	+48%
B986 Berryden Road	7	320	256	-64	-20%	121	88	-33	-27%	88	79	-9	-10%
A96 Powis Terrace	8	438	482	+44	+10%	283	290	+7	+2%	347	353	+6	+2%
King's Crescent	9	16	14	-2	-13%	12	10	-2	-17%	50	14	-36	-72%
A956 King Street	10	739	738	-1	-0%	312	280	-32	-10%	548	508	-40	-7%
A956 East North Street	11	64	21	-43	-67%	60	18	-42	-70%	50	20	-30	-60%
A956 Market Street	12	275	310	+35	+13%	180	182	+2	+1%	225	245	+20	+9%
Portlethen to Aberdeen	13	462	469	+7	+2%	140	166	+26	+19%	321	328	+7	+2%
Dyce to Aberdeen	14	383	375	-8	-2%	78	89	+11	+14%	323	285	-38	-12%
TOTAL - Bus		3748	3687	-61	-2%	2153	1944	-209	-10%	2957	2884	-73	-2%
TOTAL - Rail		845	844	-1	-0%	218	255	+37	+17%	644	613	-31	-5%
TOTAL		4593	4531	-62	-1%	2371	2199	-172	-7%	3601	3497	-104	-3%

Table 47. PT Passenger Flow Comparison (per hour) – Inner Cordon Outbound

Inner Cordon		AM	AM Peak Hour			IP	Inter Peak Hour			PM	PM Peak Hour		
OUTBOUND		OBS	MODELLED			OBS	MODELLED			OBS	MODELLED		
Station/Road Name	ID	Hour	Hour	Diff	% Diff	Hour	Hour	Diff	% Diff	Hour	Hour	Diff	% Diff
A956 Wellington Road	1	117	141	+24	+21%	59	61	+2	+3%	174	175	+1	+1%
B9077 Great Southern Road	2	345	297	-48	-14%	165	154	-11	-7%	300	298	-2	-1%
A9013 Holburn Street	3	739	637	-102	-14%	425	348	-77	-18%	750	682	-68	-9%
Albyn Place	4	150	165	+15	+10%	134	139	+5	+4%	204	222	+18	+9%
Mid Stocket Road	5	92	97	+5	+5%	114	108	-6	-5%	158	163	+5	+3%
A944 Westburn Road	6	49	72	+23	+47%	111	114	+3	+3%	135	150	+15	+11%
B986 Berryden Road	7	80	70	-10	-13%	115	92	-23	-20%	256	233	-23	-9%
A96 Powis Terrace	8	279	291	+12	+4%	247	244	-3	-1%	384	432	+48	+13%
King's Crescent	9	9	2	-7	-78%	12	5	-7	-58%	46	21	-25	-54%
A956 King Street	10	411	416	+5	+1%	300	287	-13	-4%	650	671	+21	+3%
A956 East North Street	11	44	20	-24	-55%	84	33	-51	-61%	80	42	-38	-48%
A956 Market Street	12	103	177	+74	+72%	150	164	+14	+9%	250	337	+87	+35%
Aberdeen to Portlethen	13	193	212	+19	+10%	177	188	+11	+6%	578	570	-8	-1%
Aberdeen to Dyce	14	210	199	-11	-5%	71	82	+11	+15%	340	354	+14	+4%
TOTAL - Bus		2418	2385	-33	-1%	1916	1749	-167	-9%	3387	3426	+39	+1%
TOTAL - Rail		403	411	+8	+2%	248	270	+22	+9%	918	924	+6	+1%
TOTAL		2821	2796	-25	-1%	2164	2019	-145	-7%	4305	4350	+45	+1%

9.3.7 The total passenger flow crossing the Inner Central Aberdeen Screenline cordon falls within a few percent of the total observed flow crossing the cordon inbound and outbound – at the total level and for total rail and bus flows. Only the Inter Peak inbound rail flow comparison falls outwith the 15% guidance threshold (at +17%).

9.3.8 In general, the public transport passenger flows are marginally lower than suggested by observed data, with some specific percentage fluctuations for some specific routes (although many of the absolute differences between modelled and observed represent relatively low passenger volumes.

9.3.9 Modelled rail passenger flows provide a good comparison with observed data.

Table 48. PT Passenger Flow Comparison (per hour) – Outer Cordon Inbound

Outer Cordon		AM	AM Peak Hour			IP	Inter Peak Hour			PM	PM Peak Hour		
INBOUND		OBS	MODELLED			OBS	MODELLED			OBS	MODELLED		
Station/Road Name	ID	Hour	Hour	Diff	% Diff	Hour	Hour	Diff	% Diff	Hour	Hour	Diff	% Diff
A90 Hillside South	1	185	179	-6	-3%	65	53	-12	-18%	147	137	-10	-7%
B9077 Leggart Place	2	4	6	+2	+50%	0	0	0		0	0	0	
A93 Peterculter	3	43	42	-1	-2%	38	30	-8	-21%	55	45	-10	-18%
A944/B9199 Fairley Road	4	52	65	+13	+25%	34	39	+5	+15%	77	76	-1	-1%
A96 Chapel Of Stoneywood Road	5	102	124	+22	+22%	69	68	-1	-1%	109	109	0	0%
A947 Hattoncrook/Dittrichie View	6	18	22	+4	+22%	9	7	-2	-22%	11	15	+4	+36%
A90 North Bound Ellon Road	7	199	225	+26	+13%	47	49	+2	+4%	30	41	+11	+37%
Inverurie to Dyce	8	363	342	-21	-6%	67	68	+1	+1%	99	101	+2	+2%
Stonehaven to Portlethen	9	434	431	-3	-1%	139	162	+23	+17%	321	329	+8	+2%
TOTAL - Bus		603	663	+60	+10%	262	246	-16	-6%	429	423	-6	-1%
TOTAL - Rail		797	773	-24	-3%	206	230	+24	+12%	420	430	+10	+2%
TOTAL		1400	1436	+36	+3%	468	476	+8	+2%	849	853	+4	+0%

Table 49. PT Passenger Flow Comparison (per hour) – Outer Cordon Outbound

Outer Cordon		AM	AM Peak Hour			IP	Inter Peak Hour			PM	PM Peak Hour		
OUTBOUND		OBS	MODELLED			OBS	MODELLED			OBS	MODELLED		
Station/Road Name	ID	Hour	Hour	Diff	% Diff	Hour	Hour	Diff	% Diff	Hour	Hour	Diff	% Diff
A90 Hillside South	1	51	60	+9	+18%	70	64	-6	-9%	205	193	-12	-6%
B9077 Leggart Place	2	0	0	0		0	2	+2		0	15	+15	
A93 Peterculter	3	46	34	-12	-26%	50	39	-11	-22%	134	98	-36	-27%
A944/B9199 Fairley Road	4	35	39	+4	+11%	25	32	+7	+28%	40	56	+16	+40%
A96 Chapel Of Stoneywood Road	5	77	67	-10	-13%	46	56	+10	+22%	108	118	+10	+9%
A947 Hattoncrook/Dittrichie View	6	11	13	+2	+18%	8	8	0	0%	21	23	+2	+10%
A90 North Bound Ellon Road	7	61	61	0	0%	49	69	+20	+41%	125	157	+32	+26%
Dyce to Inverurie	8	43	50	+7	+16%	75	73	-2	-3%	318	301	-17	-5%
Portlethen to Stonehaven	9	193	206	+13	+7%	184	185	+1	+1%	534	529	-5	-1%
TOTAL - Bus		281	274	-7	-2%	248	270	+22	+9%	633	660	+27	+4%
TOTAL - Rail		236	256	+20	+8%	259	258	-1	-0%	852	830	-22	-3%
TOTAL		517	530	+13	+3%	507	528	+21	+4%	1485	1490	+5	+0%

9.3.10 The total passenger flow crossing the Outer Aberdeen Screenline cordon also falls within a few percent of the total observed flow crossing the cordon inbound and outbound – at the total level and for total rail and bus flows. Comparisons for individual locations do vary in percentage terms, but reflect relatively small number of passengers.

9.3.11 Again, rail passenger volumes compare well, along with the main AM and PM Peak tidal flows using the competing A90 South and A96 bus routes.


Calibration Statistics

9.3.12 Table 50 to Table 52 describe the relevant comparison of calibration statistics for the AM, Inter and PM Peak time periods.

9.3.13 The statistics show that passenger demand travelling via all rail and bus link locations fall within a GEH of 10, with over 90% of bus locations and 100% of rail locations falling within a GEH of 5. All rail locations are within 25% of the observed passenger demand. Within the AM and Inter peaks, 82% of locations fall within 25% of the observed flow, and falling to 71% within the PM Peak.

9.3.14 Overall, the statistics demonstrate a good level of comparison with observed PT passenger demand.

Table 50. Summary of AM Peak Validation Across 23 Sites (4 rail, 19 bus)

MODE	WITHIN 25%	GEH <5	GEH <10
Rail	100%	100%	100%
Bus	82%	97%	100%
Rail & Bus	85%	96%	100%

Table 51. Summary of Inter Peak Validation Across 23 Sites (4 rail, 19 bus)

MODE	WITHIN 25%	GEH <5	GEH <10
Rail	100%	100%	100%
Bus	82%	97%	100%
Rail & Bus	85%	96%	100%

Table 52. Summary of PM Peak Validation Across 23 Sites (4 rail, 19 bus)

MODE	WITHIN 25%	GEH <5	GEH <10
Rail	100%	100%	100%
Bus	71%	92%	100%
Rail & Bus	76%	91%	100%

Notes:

9.3.15 Users should note the potential variability associated with roadside bus passenger counts, the method used to collect bus data for ASAM14 PT model development.

9.3.16 The passenger demands at these calibration locations are used to control the overall level of bus demand passing these points and the impact of these bus counts generally work to lower the PT demand generated within the prior matrices – which was originally controlled to Census travel to work mode share proportions.

9.3.17 With the contrasting levels of overall PT demand indicated within these two data sets, there is potential for the model to underestimate PT demand if the bus passenger count data is unreliable and the Census data is more viable. As the count data controls the overall PT demand for the main PT corridors, this uncertainty has the potential for underestimating modelled passenger demand.

9.3.18 The uncertainty associated with observed bus passenger counts should be borne in mind during model application.

9.4 Prior and Estimated Matrix Comparison Statistics

9.4.1 The following section describes the analysis undertaken to understand changes made to the prior PT matrix during matrix estimation, comparing:

- Matrix Trip Ends Slope, Intersect and R-Squared statistics;
- Trip End Plots;
- Trip Length Distributions; and
- Sector Movement Comparisons;

9.4.2 Guidance suggests that changes between two should fall within the following criteria as described in Table 53:

Table 53. WebTAG Matrix Estimation Comparison Criteria

MEASURE	CRITERIA
Matrix zonal trip ends	Slope within 0.99 and 1.01 Intercept near zero R2 in excess of 0.98
Trip length distributions	Means within 5% Standard deviations within 5%
Sector to sector level matrices	Differences within 5%

Trip End Statistics

9.4.3 Table 54 describes the changes between the prior and estimated matrix trip ends using a number of statistical techniques, whilst Figure 50 shows Trip End Scatter Plots.

Table 54. PT Matrix Estimation Comparison: Trip End Statistics

	STATISTIC	AM PEAK	INTER PEAK	PM PEAK
Origin	SLOPE	0.995	0.974	0.982
	INTERCEPT	-0.156	-0.022	0.041
	R-SQUARED	0.997	0.997	0.998
Destination	SLOPE	0.994	1.001	0.984
	INTERCEPT	-0.323	-0.358	0.055
	R-SQUARED	0.999	0.998	0.998

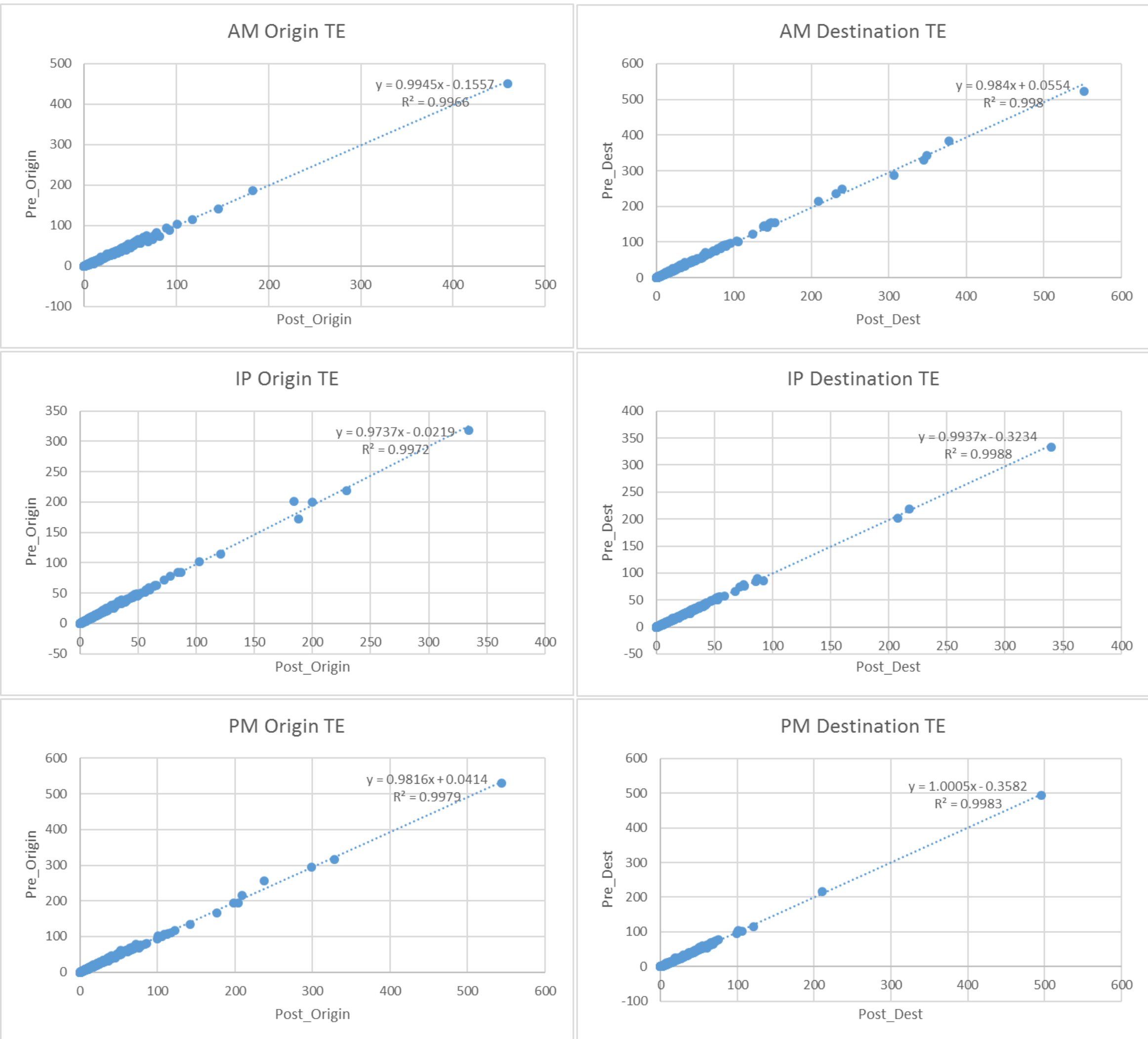

Figure 50. PT Matrix Estimation Comparison: Scatter Plots

9.4.4 This analysis shows that the majority of PT matrix changes during estimation fall within the recommended ranges, with a few statistical comparisons which lie marginally outside the desired range.

9.4.5 Figure 50 illustrates the Trip End Scatter Plots which show that the PT matrix estimation procedure does not significantly alter the matrix distribution.

Trip Length Distributions

9.4.6 Figure 51 illustrates trip length distribution changes between prior and post estimated PT matrices, whilst Table 55 provides a summary of the mean and standard deviation changes in Trip Length.

9.4.7 The analysis shows a reducing trip length within the matrices (of around -8 to -18%), with the ME process factoring down some longer distances movements to match observed counts – counts highlighting too many trips to/from rural areas. This trend can also be seen from the sector analysis.

Table 55. PT Matrix Estimation Comparison: Trip Length Distribution

TIME PERIOD	STATISTIC	PRE. EST.	POST EST.	% CHANGE
AM Peak	Mean	44	36	-18%
	Standard Deviation	65	56	-13%
Inter Peak	Mean	35	29	-18%
	Standard Deviation	58	49	-15%
PM Peak	Mean	43	39	-11%
	Standard Deviation	64	59	-8%

Sector Movements Comparisons

9.4.8 Appendix H describes the changes in PT movements pre and post estimation using a 29 sector system. This generally shows more rural areas being reduced to coincide with counts – although relatively small number of passengers within each sector. The overall number of PT trips included within the AM, Inter and PM Peak matrices reduced by between -1% to -3% (around 200 trips).

9.4.9 The major changes reflects movements to/from Aberdeen city centre, where short distance trips are increased, and longer distanced trips reduced. This explains some of the changes in trip length highlighted earlier.

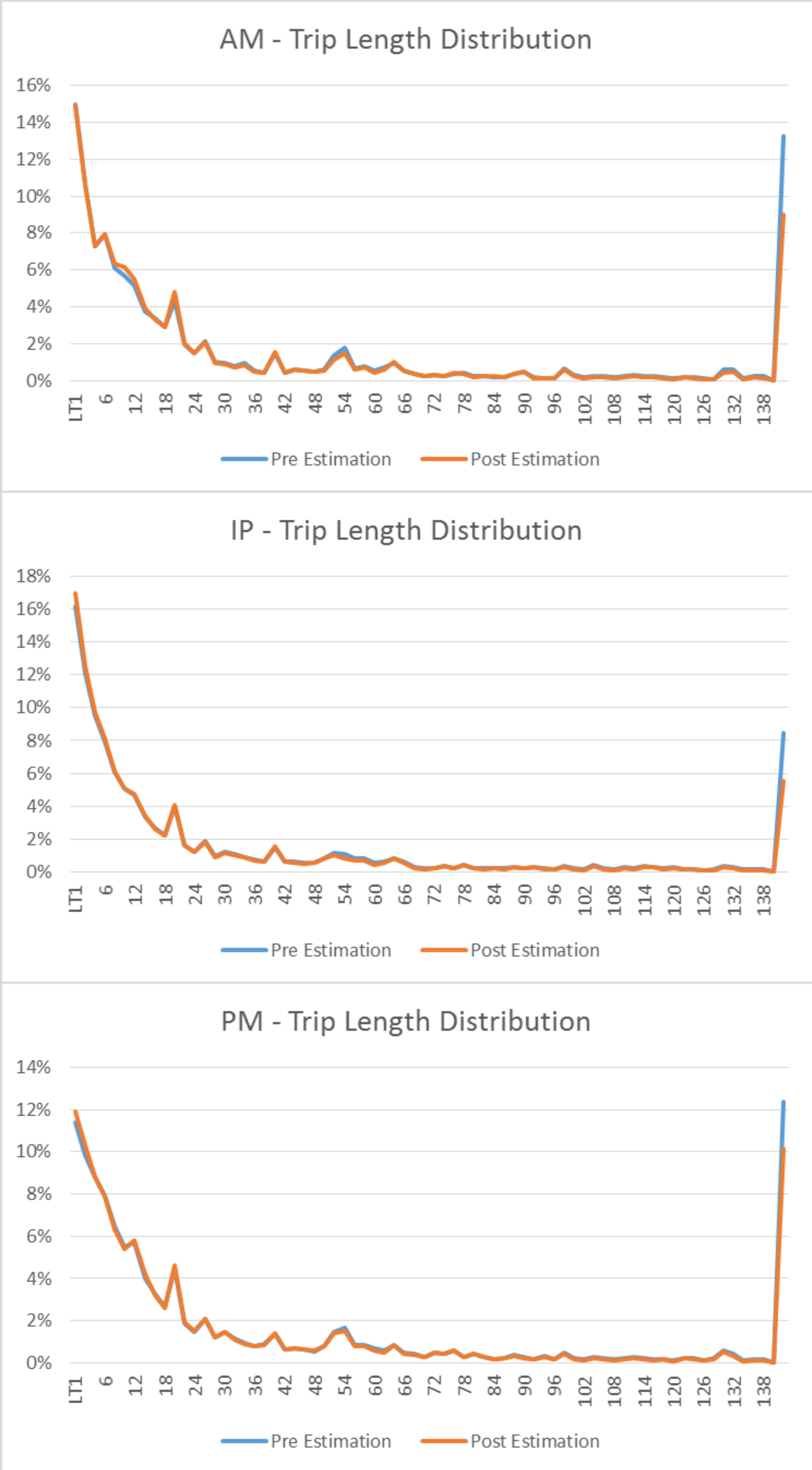

Figure 51. PT Matrix Estimation Comparison: Trip Length Distribution

9.5 Bus Journey Time Validation

9.5.1 The ASAM14 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 bus journey times (from 2016).

9.5.2 The journey time analysis was undertaken on a sample of the ASAM14 coded services intended to give a representative geographical distribution. The journey time validation is described for each time period in Table 56, with validation summary statistics provided in Table 57 and Table 58.

9.5.3 A description of the bus routes used for comparison is also provided.

Table 56. AM, IP & PM Peak Bus Journey Time Validation (Minutes)

		AM Peak				Inter Peak				PM Peak			
JT	**Service**	**Obs.**	**Model**	**Diff.**	**% Diff.**	**Obs.**	**Model**	**Diff.**	**% Diff.**	**Obs.**	**Model**	**Diff.**	**% Diff.**
1	63	48	49	1	2%	48	39	-9	-18%	48	37	-11	-23%
2	63	33	36	3	9%	33	38	5	16%	33	48	15	45%
3	291	69	71	2	3%	69	68	-1	-1%	75	79	4	5%
4	291	60	70	10	16%	69	81	12	18%	69	89	20	28%
5	35	222	215	-7	-3%	222	206	-16	-7%	222	212	-10	-5%
6	35	247	220	-27	-11%	247	218	-30	-12%	247	232	-15	-6%
7	37	95	92	-3	-3%	95	85	-10	-10%	95	87	-8	-8%
8	37	78	73	-5	-6%	78	72	-6	-8%	78	82	4	5%
9	X17	52	49	-3	-6%	52	47	-5	-9%	57	53	-4	-6%
10	X17	45	54	9	21%	45	53	8	18%	45	56	11	25%
11	201	81	80	-1	-2%	81	75	-6	-8%	81	76	-5	-7%
12	202	61	75	14	23%	61	74	13	21%	61	79	18	30%
13	19	129	130	1	1%	129	125	-4	-3%	129	131	2	2%
14	X7	132	138	6	5%	132	129	-3	-2%	132	130	-2	-1%
15	X7	137	133	-4	-3%	137	134	-3	-2%	137	147	10	8%
16	20*	17	19	2	10%	17	20	3	20%	17	21	4	21%
17	20*	17	23	6	33%	17	21	4	22%	17	21	4	23%
18	13	108	89	-19	-17%	108	89	-19	-18%	108	91	-17	-15%
19	17	58	55	-3	-6%	62	56	-6	-9%	58	55	-3	-5%
20	17	70	57	-13	-19%	62	60	-2	-3%	70	60	-10	-14%
21	2	115	96	-19	-16%	115	98	-17	-15%	115	99	-16	-14%
22	15	88	71	-17	-19%	88	72	-16	-19%	88	73	-15	-17%
23	23*	118	124	6	5%	118	125	7	6%	118	126	8	7%
24	11*	54	42	-12	-23%	54	43	-11	-20%	54	45	-9	-17%
25	11*	58	44	-14	-24%	58	43	-15	-27%	58	43	-15	-27%
26	12	87	85	-2	-3%	87	81	-6	-7%	87	85	-2	-3%
27	19	129	130	1	1%	129	125	-4	-3%	129	131	2	2%
28	5	95	80	-15	-16%	95	78	-17	-18%	95	82	-13	-13%
29	3	134	112	-22	-17%	134	105	-29	-21%	134	113	-21	-15%
Average		**91**	**87**	**-4**	**-5%**	**91**	**85**	**-6**	**-7%**	**92**	**89**	**-3**	**-3%**

9.5.4 The bus journey time validation indicates that the public transport model provides a reasonable match with observed timetables, with around 60% of services falling within 15% of the published timetables, and around 85% of modelled times falling within 25%.

9.5.5 Overall, modelled bus journey times are slightly quicker than observed, (which is likely to stem through from the slightly quicker modelled road times), and should be borne in mind during model application.

9.5.6 Differences may also relate to the enforcement of service levels, where 95% of buses should not exceed a time limit of 5 minutes later than timetable rule set by the traffic commissioner, which may potentially result in extensions of timetabled journey time.

9.5.7 Readers should also note that published bus timetables often do not vary between time periods, whereas different levels of congestion (and subsequently journey times) would likely be higher in the peaks than the inter peak for some service segments. These characteristics should also be borne in mind when interpreting these comparisons.

9.5.8 The PT model does intuitively demonstrate slightly higher bus journey times within the morning and evening peaks, compared to the inter peak.

Table 57. 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	17	59%	16	55%	17	59%
No	12	41%	13	45%	12	41%

Table 58. 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	28	97%	28	97%	24	83%
No	1	3%	1	3%	5	17%

9.6 ORR Station Usage Comparison

9.6.1 To supplement PT validation, comparisons of rail station boarding and alighting data was undertaken. This involved extracting rail station boarding and alighting for each modelled station, and comparing with Office of Rail Regulator (ORR) 'observed' ticket sales.

9.6.2 Note that this analysis does not directly provide a like-for-like comparison, as modelled and observed time periods differ, with factoring used to draw data sets closer together. Nevertheless, these comparisons provide some reasonable indications for interpreting model outputs.

9.6.3 Table 59 describes modelled rail station boarding's and alighting's for each time period. These highlight relatively intuitive calibrated outputs, with the main commuter stations demonstrating high boarding's in the morning and alighting during the evenings.

9.6.4 The majority of station usage appears in line with the size of settlements, with demands at Arbroath and Montrose potentially appearing high compared to other town stations.

Table 59. Hourly Modelled Rail Passenger Boarding's & Alighting's

	AM Peak Hour			Inter Peak Hour			PM Peak Hour		
Rail Station	Boarding	Alighting	Total	Boarding	Alighting	Total	Boarding	Alighting	Total
Forres: Inverness Line External	85	84	**170**	47	68	**116**	51	80	**131**
Elgin	139	55	**194**	50	41	**91**	77	88	**165**
Keith	41	12	**53**	9	9	**18**	12	39	**51**
Huntly	52	6	**58**	13	11	**24**	14	38	**52**
Insch	34	4	**38**	9	8	**18**	9	34	**43**
Inverurie	144	41	**184**	35	33	**67**	60	144	**204**
Dyce	88	204	**293**	51	39	**89**	241	110	**351**
Carnoustie: East Coast Line External	369	456	**825**	263	264	**526**	444	423	**867**
Arbroath	250	174	**424**	135	144	**279**	179	237	**416**
Montrose	177	56	**233**	61	60	**121**	61	136	**197**
Laurencekirk	33	14	**47**	11	12	**23**	23	41	**63**
Stonehaven	146	48	**194**	44	56	**100**	62	131	**193**
Portlethen	50	19	**69**	8	8	**17**	12	53	**65**
Aberdeen	313	746	**1,059**	241	225	**466**	830	519	**1,348**
Total	**1,920**	**1,920**	**3,840**	**977**	**977**	**1,955**	**2,073**	**2,073**	**4,147**

9.6.5 Table 60 describes the annual ORR observed boarding's data compared to annual modelled data (with modelled data factored at the regional level to match observed ticket sales).

Table 60. Annual Rail Passenger Boarding's & Alighting's Comparison with ORR (000's)

	Observed			Modelled			Difference			% Difference		
Rail Station	Boarding	Alighting	Total	Boarding	Alighting	Total	Boarding	Alighting	Total	Boarding	Alighting	Total
Forres: Inverness Line External	189	255	**444**	189	255	**444**	0	0	**0**	0%	0%	**0%**
Elgin	172	172	**345**	236	176	**413**	+64	+4	**+68**	+37%	+2%	**+20%**
Keith	48	48	**95**	51	48	**98**	+3	+0	**+3**	+6%	+0%	**+3%**
Huntly	54	54	**107**	68	49	**117**	+14	-5	**+10**	+26%	-9%	**+9%**
Insch	57	57	**114**	45	41	**86**	-12	-16	**-28**	-21%	-28%	**-25%**
Inverurie	267	267	**533**	192	177	**368**	-75	-90	**-165**	-28%	-34%	**-31%**
Dyce	268	268	**536**	296	259	**555**	+28	-9	**+19**	+10%	-3%	**+4%**
Carnoustie: East Coast Line External	1,076	1,112	**2,187**	1,076	1,112	**2,187**	0	0	**0**	0%	0%	**0%**
Arbroath	187	187	**373**	558	572	**1,130**	+371	+386	**+757**	+199%	+206%	**+203%**
Montrose	187	187	**374**	276	248	**523**	+88	+61	**+149**	+47%	+32%	**+40%**
Laurencekirk	48	48	**97**	55	59	**114**	+7	+11	**+17**	+14%	+22%	**+18%**
Stonehaven	268	268	**537**	216	232	**448**	-52	-36	**-88**	-19%	-13%	**-16%**
Portlethen	28	28	**56**	53	58	**111**	+25	+30	**+56**	+91%	+109%	**+100%**
Aberdeen	1,599	1,599	**3,199**	1,190	1,214	**2,404**	-409	-385	**-794**	-26%	-24%	**-25%**
Total	**4,448**	**4,550**	**8,997**	**4,500**	**4,500**	**9,000**	**+53**	**-50**	**+3**	**+1%**	**-1%**	**+0%**

9.6.6 The following observations are drawn from these boarding and alighting comparisons:

- Elgin and Huntly boarding's appear slightly high;
- Inverurie boarding's & alighting's appear slightly low;
- Arbroath boarding's & alighting's appear very high;
- Montrose boarding's & alighting's appear high;
- Laurencekirk data appears slightly high, whilst Stonehaven appears slightly low;
- Portlethen figures appear high – although with much fewer Portlethen rail services, using consistent annualisation factors may be less appropriate.
- Aberdeen figures appears low - although the model validation comparisons indicate that the model matches rail link counts north and south of Aberdeen Station in all time periods;

9.6.7 In particular, the comparisons above indicate that modelled passenger demand at Arbroath and to some extent Montrose appear high. The earlier rail passenger volume (link) calibration demonstrates that the modelled flows (further North on the East Coast Mainline between Portlethen & Aberdeen) provide a good match with observed passenger counts for each modelled time period. Therefore suggesting that any potential over-estimate of rail passenger flows are associated with more 'southern travel' movements (ie between Arbroath and Montrose and areas further South, rather than the main internal modelled area to the North towards Aberdeen).

9.7 Rail Service Capacity & Crowding Comparison

9.7.1 Capacity restraint for rail service usage is included within the ASAM14 PT modelling, with additional generalised costs incorporated for passenger movements where journey segments are crowded within the AM and PM Peaks.

9.7.2 Table 61 describes the modelled passenger crowding for the East Coast and Inverness rail lines (showing the main tidal directions, AM Inbound to Aberdeen and PM Outbound from Aberdeen. This shows the number of passengers travelling on all services compared to the average seated capacity per hour for the relevant rail line segment.

Table 61. Rail Passenger Occupancy & Crowding

LINE	DIRECTION	SEATS	PASSENGERS	% SEATED CAPACITY
East Coast: Portlethen-Aberdeen	Inbound: AM	619	469	76%
	Outbound: PM	693	571	82%
Inverness: Dyce-Aberdeen	Inbound: AM	557	375	67%
	Outbound: PM	595	354	60%

9.7.3 The analysis demonstrates that the East Coast line is the busiest in terms of % seats occupied within both the AM and PM peak models (at around 80% of seats occupied). Whereas the Inverness line is modelled at 60%-70% occupied.

9.7.4 Note that the modelled seated capacity/crowding is likely to underestimate some of the most crowded individual services, as the seating occupancy is calculated for an average hour (over a three hour period), rather than for individual services.

9.7.5 The PT modelling calculations represent all timetabled rail services and assumes all services are operational. With the relatively limited level of North East rail services, one cancelled train could potentially create a large influx of passengers on the next service creating additional crowding impacts.

9.7.6 Therefore, for these reasons, the modelled level of rail crowding is anticipated to fall towards the lower end of rail passenger perceptions.


9.8 Public Transport Conclusions & Recommendations

Conclusions

9.8.1 Using comparisons with observed data, ASAM14 displays a good representation of observed public transport passenger volumes, particularly rail passenger volumes.

9.8.2 The use of and uncertainty associated with roadside bus occupancy surveys to help calibrate bus passenger volumes tends to lower confidence levels when making bus passenger comparisons. However, a spot check of one bus service found a similar level of passengers when comparing with specific ticket sales.

9.8.3 Changes to some PT travel patterns made during matrix estimation are higher than that suggested by guidance. These changes are highlighted within detailed sector analysis comparisons and enable modelled flows to better match observed passenger volumes.

9.8.4 Bus journey times compare reasonably with bus timetable data, indicating that modelled PT speeds are in-line with day-to-day service operations.

9.8.5 Modelled rail station boarding's and alighting's within the model coverage also appear intuitive and broadly in line with observed ticket data, with the potential exception of Arbroath.

9.8.6 Rail capacity and passenger crowding levels are also intuitive, with average levels of crowding which are busy, but not fully over capacity.

9.8.7 The ASAM14 PT modelling will appropriately provide forecasting functionality to undertake incremental comparisons against a reliable 2014 base year model, that generally reflects observed travel conditions.

Recommendations

9.8.8 The more limited coverage of North East PT data, differences in overall level of mode share compared to the 2011 Census, and general uncertainty associated with roadside bus occupancy counts should be borne in mind when applying ASAM14, particularly if using the model to provide absolute changes in PT patronage levels.

9.8.9 Further (on-board or ticket based) bus patronage surveys in and around Aberdeen would be beneficial to provide a fuller understanding of public transport passenger volumes.

10. DEMAND MODEL

10.1 Approach & Functionality

SEStran Regional Model

10.1.1 The ASAM14 demand model is based on the SEStran Regional Model (SRM12), constructed in 2014 to represent the South East of Scotland transport network with a base year of 2012. The SRM12 demand model is a multi-modal Cube Software-based Mode-Destination choice model, and is also similar to the Transport Model for Scotland (TMfS) demand model. The detailed model structure is described in Appendix J.

10.1.2 The underlying demand modelling structure is connected to a trip generation model, and road and public transport assignment models. Trip End model planning data inputs are in a consistent format as provided for the TELMoS land use model.

ASAM14 Enhancements

10.1.3 ASAM14 has built on the SRM12 structure, enhancing it to include evening peak demand modelling and inter peak park & ride modelling. The Park and Ride module has been enhanced to also represent city centre car parking (as a Park and Walk) within the same site choice mechanism.

10.1.4 An Airport model representing trips to/from the main Aberdeen City airport and Heliport was also included within this demand model.

10.1.5 The ASAM14 demand model utilises the cost of making a trip from an origin to a destination by mode through applying a logit based choice mechanism. It consists of the following components:

- Mode Choice;
- Destination Choice;
- Park & Ride and Aberdeen City Centre Park & Walk Choice (AM & IP Only);
- Generation of To-Home and Non-Home based demand;
- Aberdeen Airport and Heliport Modelling; and
- Cost Damping process.

Mode & Destination Choice

10.1.6 There are separate demand models for each time period (AM, IP and PM) covering the main Business, Commuter and 'Other' travel purposes (ie leisure, retail etc). Each model (i.e. mode/destination choice) calculates From-Home trips only.

10.1.7 The To-Home trips and Non-Home based trip ends are derived from the outputs of the From-Home models. A reverse factoring process is used to transform From Home trips.

10.1.8 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 a similar process as for the main travel purposes.

Park & Ride & City Centre Parking

10.1.9 Park and Ride and Parking modelling is incorporated as a separate mode within the main mode and destination choice process. The allocated travel demand is then input to a separate site choice procedure – with sites covering park and ride sites, rail station car parks and city centre (paid for) car parking.

10.1.10 Private non-residential parking, residential parking and any other paid for parking out with Aberdeen city centre are represented within the main mode / destination choice processes.

Aberdeen Airport

10.1.11 From-Home Aberdeen Airport passenger demand for each time period and the relevant Business and Leisure travel purposes are added after the main From-Home model, To-Home process and Non-Home based trips process. Commuter trips for employees working at the Airport follow the same mechanisms as for the standard non home based work commuting trips.

10.1.12 A further 'Airport Destination' only mode choice is applied, which responds to future modelled travel costs. Overall changes in Airport demand over time are set by the user, with trip origins disaggregated and able to vary based on input population planning data.

Aberdeen Heliport

10.1.13 A separate process is also incorporated to represent Offshore travel to/from Aberdeen Heliport. Travel demand to the Heliport reflects Census 2011 offshore travel to work movements, scaled down to represent hourly time period helicopter traffic movements. Mode choice is represented through future changes in Heliport travel costs.

10.1.14 Offshore trips are incorporated to the matrices as a commuter trip, but note that commuter trips for employees working at the Airport follow the same mechanisms as for the standard non home based work commuting trips.

Cost Damping

10.1.15 A cost damping feature has been added to the variable demand model in order to improve the model choice response of longer distance trips. This process applies a further set of parameters that controls the generalised cost derivation within the model by a function of distance.

High Occupancy Vehicle Modelling

10.1.16 The underlying SRM12 modelling (which ASAM14 was based upon) made reference to a High occupancy vehicle (HOV) choice model, but was unused. Although the underlying structure of the HOV choice model is available within the ASAM14, it is also unused, but could be updated and utilised should it be require in the future.

10.2 Inputs & Outputs

10.2.1 The inputs to the Demand Model are:

- trip productions and attractions;
- TELMoS population planning data;
- generalised costs of travel by road and public transport modes, and park and ride and city centre parking 'mixed-modes' from the base year assignment models;
- Parking Charges and parking time constants;
- External Demand and HGV / LGV Demand 'add-in' matrices (see Trip End section);
- park & ride and car park site files, detailing car park capacity, parking charges and catchment areas (see Park & Ride Section); and
- model parameters.

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

Trip Ends

10.2.3 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.

10.2.4 Trip generation forecasting 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 ASAM14 base year trip ends to create future year trips for each forecast year.

TELMoS Population Planning Data

10.2.5 Zonal population data for each ASAM14 zone is used within the Trip End model and this is also required to inform parts of the demand model. The population data is used to ascertain future changes in productions for the Heliport model.

Generalised Costs

10.2.6 The first iteration of the demand model uses generalised costs from the base assignment models, coupled with parking costs to develop initial assignment matrices during demand model Loop 1. On subsequent loops new generalised costs are prepared from the forecast assignment model skims.

Parking Charges & Constants

10.2.7 Parking charges are introduced by adding representative average parking costs to zones within the controlled areas of Aberdeen City and Aberdeenshire larger towns - in addition to the parking charge costs for the controlled area modelled as part of Park & Walk and at Park and Ride car parks.

10.2.8 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.


10.2.9 Parking charges are present in the Park and Ride file to represent the charges by zone within the modelled parking area. These vary by purpose, with consistent charges for both the AM and Inter Peak periods.

10.2.10 Parking charges were developed by sifting through website off street and on-street parking data during 2016 and applying assumptions regarding length of stay for business and retail/leisure travellers and commuters (that did not have access to PNR parking).

10.2.11 Further information regarding the development of the parking modelling is contained in the Park and ride and Parking chapter.

10.2.12 Parking constants are applied to reflect differences in the perception of the ease of accessing private non-residential parking. These constants range from 5 minutes in rural areas to 27 generalised minutes in the city centre, reflecting the availability of free commuter or retail/leisure parking space within the periphery of Aberdeen (ie Altens/Dyce, Westhill) compared to the constrained nature of free parking availability within the city centre. Commuter and Other travel purpose values are as follows:

- Commuter: City Centre area 27 minutes, central Aberdeen 17 minutes, elsewhere 5 minutes; and
- Other: City Centre 17 minutes, central Aberdeen 13min, periphery of Aberdeen 7 minutes, elsewhere 5 min;

HGV / LGV and Externals

10.2.13 Changes in HGV and LGV travel movements are calculated using a separate process and are not subject to the demand model response mechanisms. These movements are discussed further within the trip end modelling section.

External Movements

10.2.14 Changes in Travel movements for all user classes to/from external areas out with the main demand model (ie South of Forfar, North West of Elgin, and West of Braemar and Strathdon) are calculated within a separate process. These movements are discussed further within the trip end modelling section.

Demand Model Parameters

10.2.15 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. The base-year demand model parameters include:

- distribution model sensitivity parameters,
- mode choice scaling factors;
- mode specific constants; and
- Park and Ride parameters.

10.2.16 The sensitivity parameter values are calculated using the ASAM14 travel demand matrices using an iterative procedure. 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.


10.3 Cost Damping

10.3.1 A cost damping feature was incorporated to the variable demand model to improve the model choice response of longer distance trips. This process applies parameters that control the generalised cost derivation within the model by a function of distance.

10.3.2 WebTAG section 3.3.3 states that 'cost damping is part of our current best understanding of travel behaviour and would be expected to be incorporated into models'. This is due to strong empirical evidence suggesting that the sensitivity of travel demand behaviour to changes in generalised costs decreases with an increasing trip length. For example, it seems unreasonable that a cost change of 3 minutes should have the same impact on demand for both a 16km journey and 100km journey. Cost damping was thus, introduced as part of the model calibration process.

10.3.3 Recommended forms of cost damping mechanism are set out in TAG Unit M2 3.3 as follows:

- Varying value of time with distance;
- Damping generalised cost by a function of distance or a power function; and
- The use of a log-cost plus linear cost in the generalised cost function.

10.3.4 The cost damping mechanism chosen was damping the generalised cost by a function of distance. The damped generalised costs take the form of:

$$G' = \left(\frac{d}{k}\right)^{-\alpha} G$$

Equation 1: Cost Damping Equation

where:

- G^' is the damped generalised cost;
- G is the generalised cost (combining trip time and monetary costs);
- α and k are calibration parameters.

10.3.5 As recommended α is positive and less than one, determined by experimentation through a number of iterations. Further, k is also positive, and can be set to the mean trip length for the modelled area.

10.3.6 The 'K' values were initially set at the mean modelled area trip length for each mode, and although the road distance continues to be close to the mean value, a much lower value for public transport trips was found to provide a better calibration for these movements – with a distance that started weighting PT costs out with a typical urban Aberdeen bus trip.

10.3.7 Note that demand model realism tests were initially run without any cost damping applied, with results indicating that cost damping would be beneficial.

Cost Damping Calibration

10.3.8 The calibrating parameters which best addresses the high elasticities found in the longer distance trips when cost damping is not employed were derived through a series of tests over several iterations. These tests generated travel demand movements for each travel purpose which reasonably matched overall observed trip length distributions and also produced sensitivity test results (at a sector level which improved the model response overall and for longer distance trips). Table 62 describes the final calibrated coefficients applied within the demand model.

Table 62. Cost Damping Parameters

MODE	ALPHA	K
Car	0.37	25 km
Public Transport	0.15	3.5 km

10.3.9 The cost damping mechanism chosen reduced the elasticities of the longer distance trips whilst allowing shorter distance trips to remain relatively elastic. All further realism tests were conducted with the implementation of cost damping.

10.4 Aberdeen Airport & Heliport Modelling

10.4.1 The travel pattern for non-commuting trips to and from the main airport in Aberdeen is taken into consideration in the main demand model. It is incorporated at the assignment preparation stage where the trips are added prior to the road and public transport assignments.

10.4.2 A similar process using similar procedures was adopted to calculate the Oil sector 'commuting' trips that are made to North Sea offshore locations via the heliport.

10.4.3 Aberdeen Airport Trips are calibrated to reflect Aberdeen Airport Passenger Survey movement data, whilst the Heliport trips are extracted from the 2011 Census Travel to Work movement data. Each data set is scaled to match hourly passenger demand to/from the Airport/Heliport.

10.4.4 A main input of the Airport model was the trip end planning data, consisting of demographic/employment information by zone for the ASAM14 modelled area. A set of trip rates which defines the trips to/from the airport was then applied to generate a set of trip distributions. The airport model does not implicitly include a destination choice, though it uses this type of methodology to determine origins and destinations.

10.4.5 During forecasting, this process is applied in conjunction with (set) airport / Heliport growth forecasts to provide the total number of trips to/from the airport for each year.

10.4.6 Airport / Heliport trip origins are determined and adjusted by the changes in zonal planning data.

Mode Choice Mechanism

10.4.7 A mode choice model then considers public transport and road costs as obtained from the main base year generalised costs to evaluate which mode a traveller might use at a particular time of the day.


10.4.8 The purpose of the mode choice component is to replicate the choices that a traveller might make when undertaking a journey to/ from the Airport / Heliport at a particular time of day.

10.4.9 The mode choice mechanism is based on calculating the expected utility from the generalised costs of each mode for a given time of day.

10.4.10 The mathematical framework and methodology used is presented below.

$$U_{ij} = -\lambda(\alpha C_{ij} + ASC_M)$$
$$V_{ij} = e^{U_{ij}}$$

Equation 2: Utility Calculation

Where

- V_{ij} is the utility to be used in the mode choice comparison;
- C_{ij} = is the generalised cost;
- ASC_M is the estimated mode specific constant and
- α,λ are estimated parameters.

10.4.11 The calculated utilities are then used in a logit model to calculate the proportion of car and public transport users.

$$P_{ij}^M = \frac{V_{ij}^M}{\sum V^M}$$

Equation 3: Logit Calculation

Where

- P_{ij}^M is proportion of mode M for a given origin (i) and destination (j).

10.4.12 Car occupancy factors are used to convert road person demand to vehicles for assignment. These are consistent with the parameters used in the main demand model.

10.4.13 Note that the ASAM14 Airport and Heliport modelling is not anticipated to represent all surface access options and traveller choices (ie taxis are not implicitly represented). The main objective here is to isolate these specific types of non-standard travel demand to enable separate understanding and forecasting for these movements.

10.5 Forecasting Procedures

Base Year Demand Model

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

- Generate 2014 base year travel demand using trip end productions, attractions, travel costs and parameters;
- demonstrate and validate the model demand, operation and procedures to base year travel conditions;

- test the sensitivity of model parameters; and
- establish the incremental adjustment matrices.

Demand Model Forecasting

10.5.2 The forecasting process is designed to provide forecast year matrices using an absolute choice procedure with incremental adjustment. The Base-Year Demand Model structure is designed to operate in an iterative manner to achieve supply/demand convergence.

10.5.3 The 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.

Model Parameters

10.5.4 A forecast demand model run requires various inputs / calculations to some of the model parameters. The 'user defined' parameters required include:

- values of time and vehicle operating costs – default values are based on relevant TAG Unit A1.3;

- generalised cost coefficients for road assignment – these are recalculated in line with TAG Unit A1.3;

- occupancy factors to convert from person to vehicle matrices – these are calculated using growth factors from WebTAG Annual Parameters; and

- mode specific constants calculated for the base year are specific to the base year distribution of single and multi-car owning households. They will vary during forecasting as the trip ends change relative to the change in household types; and

- Airport & Heliport passenger demand growth rates;

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

Trip End Model

10.5.6 For each forecast year and land-use scenario, the trip end procedure is run to produce forecast trip productions and attractions. The trip end model also creates future year HGV, LGV, external and education travel matrices. 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, prior to input to the demand model.

Demand Model

10.5.7 Thereafter the Demand model sub-models operate in an iterative manner to produce final road traffic and public transport assignments.

10.5.8 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.

10.5.9 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.

10.5.10 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 as part of the earlier SRM12 model indicates that four inner loops are generally adequate.

10.5.11 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.

10.5.12 As standard, the Public Transport model is only run on the first two and last two 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, as is the Park & Ride model.

10.5.13 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 indicate that six external loops are sufficient for most applications (which is the default setting in the model). However, if undertaking economic assessment or a finer level of converge is required, seven or eight loops could be required.

Trip Damping

10.5.14 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.

10.6 Incremental Forecasting Approach

10.6.1 The forecasting procedure for ASAM14 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.

10.6.2 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 (final Road & PT assignment models estimated matrices);
- Sb = base modelled trips (as output from the demand model processes);
- Sf = future modelled trips; and
- F = future trips.

Then we define five cases:

10.6.3 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.

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

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

10.6.5 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.

10.6.6 Two types of incremental adjustments are undertaken:

- Absolute adjustments for where trip movements are relatively large; and
- Percentage adjustments where trips are relatively small.

11. TO-HOME TRIP MATRIX DERIVATION

11.1 Reverse and Non-Home-Based Trips

11.1.1 From-Home matrix derivation were used to derive the To-Home and Non-Home Based trips. This process followed the reverse factoring process which was previously undertaken for the SRM12, which drew comparisons between the summed From-Home, To-Home and Non-Home based and the demand level (persons per period) assignment matrices.

11.1.2 During the SRM12 development a matrix of factors was 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, PM and Inter peak totals). This process was then repeated for 15 iterations, when the factors applied have converged towards one. This produced a reasonable fit of From-Home trips to derive the assignment matrices.

'To-Home' Trips

11.1.3 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.

11.1.4 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.

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

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

Equation 4: To-Home Trips Equation

where:

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

$T^{tpm}_{ji(from)}$ = *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 $\alpha_{TPM}^{tpm} = 0$ 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.

11.1.6 The parameters α_{TPM}^{tpm} were calculated from the results of the tabulations from the Scottish Household Survey. The details of return j

11.1.7 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

11.1.8 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.

For Non-Home based origins:

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

Equation 5: Non Home Based Origin

For Non-Home based destinations

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

Equation 6: Non Home Based Destination

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.

11.1.9 It is unlikely that the total origins will equal the total destinations when applying this process, so the totals are 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.

11.1.10 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 The 2011 Census Travel to Work movement data and 2014 Scottish Household Travel Diary movement data used to compare with ASAM14 outputs shows a good relationship between the generalised cost of travel (in minutes) and journey distance. It also shows a decrease in the public transport mode share at greater distances.

12.1.2 It should be noted that although the Census provides extensive commuter travel pattern and mode share data for comparison, the SHS movement data is more patchy, with much lower samples, especially for PT movements – so there is less certainty surrounding business movement and other movement comparisons.

12.1.3 The distribution of trips by journey length/cost shows, as expected, a distribution that is negatively skewed, with a peak volume over shorter distances / costs and a long tail.

12.1.4 This exploration of observed data shows plausible patterns and trends in travel demand and travel costs, with local variations relating to major activity centres such as Universities, retail centres and the ARI. The analysis suggests that the data provides a good foundation on which to develop mode and destination choice models.

12.1.5 The ASAM14 demand model was calibrated with the aim of appropriately representing these travel characteristics. Observed trip patterns and distributions are illustrated in Appendix B and Appendix C.

12.2 Calibration of Model Parameters

12.2.1 To calibrate the underlying demand model travel patterns and associated mode and destination choice response, Road, PT and Park and Ride (period) travel matrices were developed from trip ends and generalised costs, through an iterative process. This included the inclusion of cost damping, and the outputs and resultant generalised cost changes from the (iterative) calibration of Park and Ride site choice procedure.

12.2.2 Initially, the WebTAG medium 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.

12.2.3 Parameters were further adjusted following the introduction of cost damping and to satisfy the realism tests discussed in the next section. As the cost damping parameters were changed to improve the sensitivity response of long distance trips, the overall destination choice parameters needed to be altered such that the average distribution matched the observed data.

12.2.4 The final mode and destination choice parameters are shown in Table 63 to Table 66. As the WebTAG parameters were used as a starting point the coefficients for the Ln(Cost) and Intra-zonal parameters are all zero. Trip length distributions, comparing the observed and modelled values are displayed in Appendix C.

Table 63. C1/1 Mode and Destination Choice Parameters

C1/1 PARAMETERS	SEGMENT	HBE	HBO	HBW
Home Based Mode Choice, θ	AM	0.36	0.43	0.50
	IP	0.36	0.43	0.40
	PM	0.36	0.43	0.40
Home Based C Params, β2	AM Car	-0.056	-0.081	-0.050
	IP Car	-0.059	-0.086	-0.056
	PM Car	-0.056	-0.085	-0.052
	AM PT	-0.030	-0.036	-0.026
	IP PT	-0.036	-0.041	-0.024
	PM PT	-0.030	-0.043	-0.022
	AM P&R	-0.026	-0.028	-0.040
	IP P&R	-0.033	-0.045	-0.037

Table 64. C1/2+ Mode and Destination Choice Parameters

C1/2 PARAMETERS	SEGMENT	HBE	HBO	HBW
Home Based Mode Choice, θ	AM	0.36	0.43	0.50
	IP	0.36	0.43	0.40
	PM	0.36	0.43	0.40
Home Based C Params, β2	AM Car	-0.056	-0.081	-0.050
	IP Car	-0.059	-0.086	-0.056
	PM Car	-0.056	-0.085	-0.052
	AM PT	-0.030	-0.036	-0.026
	IP PT	-0.036	-0.041	-0.024
	PM PT	-0.030	-0.043	-0.022
	AM P&R	-0.026	-0.028	-0.040
	IP P&R	-0.033	-0.045	-0.037

Table 65. C2+ Mode and Destination Choice Parameters

C2 PARAMETERS	SEGMENT	HBE	HBO	HBW
Home Based Mode Choice, θ	AM	0.36	0.43	0.50
	IP	0.36	0.43	0.40
	PM	0.36	0.43	0.40
Home Based C Params, β2	AM Car	-0.056	-0.081	-0.050
	IP Car	-0.059	-0.086	-0.057
	PM Car	-0.056	-0.085	-0.056
	AM PT	-0.030	-0.036	-0.026
	IP PT	-0.036	-0.041	-0.024
	PM PT	-0.030	-0.043	-0.022
	AM P&R	-0.026	-0.028	-0.040
	IP P&R	-0.033	-0.045	-0.037

Table 66. C0 Mode and Destination Choice Parameters

C0 PARAMETERS	SEGMENT	HBE	HBO	HBW
Home Based Mode Choice, θ	AM	0.36	0.43	0.50
	IP	0.36	0.43	0.40
	PM	0.36	0.43	0.40
Home Based C Params, β2	AM PT	-0.030	-0.038	-0.026
	IP PT	-0.036	-0.045	-0.029
	PM PT	-0.030	-0.046	-0.024

12.3 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:

$$Kcar = (Up\&r - UCar) + \{(1/\theta) * \log(PCar/Pp\&r); \text{ and}$$

$$Kpt = (Up\&r - Upt) + \{(1/\theta) * \log(Ppt/Pp\&r).$$

Equation 7: Mode Specific Constants Derivation

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 the table below. This followed the same principle of the SRM12 model which this version of ASAM is based on.

Table 67. 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 ASAM14 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 2016).

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

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

- 20% increase in fuel costs;
- 20% increase in PT fares; and
- 20% increase in generalised cost (as a proxy for journey times).

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

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

Equation 8: Elasticities

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 unweighted trips.

13.1.7 Note that ASAM14 covers an area with a diverse range of travel patterns and purposes along with a mix of urban (high density public transport provision with typically short distance trips) and rural (lower levels of public transport provision with typical longer distance trips) areas.

13.1.8 The sensitivity analysis undertaken as part of model development also evaluated the sensitivity at a sector level such that the model's sensitivity range could be inspected.


13.1.9 The cost damping aspect of the demand should better represent and influence these geographical responses to an extent. However as many model parameters / factors are set at a 'global' level, (lack of data to apply more disaggregate) sensitivity fluctuations between area types are to be expected.

13.2 Sensitivity Test Results

13.2.1 The results for the three demand model sensitivity realism tests are presented in the tables below – covering 'Fuel price', Public Transport Fares and Road Journey Times.

Fuel Price

13.2.2 Table 68 shows the elasticities with respect to fuel cost implied in the model. The latest WEBTAG guidance (M2 6.4) recommends that annual fuel price elasticities should be in the range -0.25 to -0.35 (overall across all purposes and time periods), and on the right side of -0.3, with peak period elasticities lower than inter peak elasticities, and with:

- Short trip lengths closer to zero than -0.3;
- High car driver mode share closer to zero than -0.3; and
- Employers business trips near -0.1, and discretionary trips near -0.4;

Table 68. Fuel Price Sensitivity Tests

	AM PEAK			INTER PEAK			PM PEAK		
Journey Purpose	**C1/1 Car**	**C1/2+ Car**	**C2 Car**	**C1/1 Car**	**C1/2+ Car**	**C2 Car**	**C1/1 Car**	**C1/2+ Car**	**C2 Car**
In-Work	-0.09	-0.09	-0.08	-0.11	-0.12	-0.10	-0.08	-0.08	-0.07
Non-Work Commute	-0.32	-0.35	-0.29	-0.39	-0.43	-0.37	-0.35	-0.38	-0.34
Non-Work Other	-0.44	-0.46	-0.41	-0.46	-0.48	-0.42	-0.42	-0.44	-0.39
Annual	**-0.37**								

13.2.3 The calculations demonstrate that the overall model-wide sensitivity related to business trips falls in-line with the relevant guidance, with the In-Work response relatively close to -0.1 (at around -0.07 to -0.12 between time period and car availability segments).

13.2.4 The commuter response is broadly in-line with the guidance range for most segments in the peak periods, but slightly higher than the recommended response range for the inter peak (ranging between 0.39-0.43 throughout).

13.2.5 The analysis indicates that the response for 'other (discretionary) trips' is higher than that suggested by guidance, with the modelled response ranging from 0.39-0.48.

13.2.6 The overall, annual response for the fuel price test is -0.37, which lies slightly out with the recommended range. This (higher) result mostly relates to the inter peak period response, which constitutes a larger proportion when factoring the modelling up to generate annual values. The sensitivity results across travel purposes and time periods do though reflect the intuitive pattern of response expected by guidance.

13.2.7 Guidance notes it is generally difficult to determine the magnitude of effects of different factors on the true elasticity of an area. However, does suggests that an element associated with low elasticity is shorter trip lengths. As the North East is known to exhibit higher than average trip lengths, this may explain some of the higher responses.

13.2.8 Users should bear these higher sensitivities in mind when applying the model, particularly the higher response associated with the inter peak, and other trip purpose.

Public Transport Fares

13.2.9 Table 69 shows the elasticities with respect to public transport fares. WebTAG suggests that PT fares elasticities generally lie in the range -0.2 to -0.9 for changes over a long period of time.

Table 69. Public Transport Fare Sensitivity Tests

	AM PEAK			INTER PEAK			PM PEAK		
Journey Purpose	**C1/1 Car**	**C1/2+ Car**	**C2 Car**	**C1/1 Car**	**C1/2+ Car**	**C2 Car**	**C1/1 Car**	**C1/2+ Car**	**C2 Car**
In-Work	-0.13	-0.13	-0.14	-0.14	-0.14	-0.15	-0.12	-0.13	-0.14
Non-Work Commute	-0.22	-0.21	-0.23	-0.19	-0.18	-0.193	-0.18	-0.17	-0.17
Non-Work Other	-0.10	-0.09	-0.11	-0.11	-0.10	-0.12	-0.11	-0.10	-0.12
Annual	**-0.14**								

13.2.10 The analysis indicates that the model response for changes in PT fares is generally lower than that suggested by guidance. For business trips, the modelled values are around the 0.13, which although low, are consistent with the lower reaction of business users to changes in fares.

13.2.11 The overall commuter response falls around a sensitivity of 0.2, with Inter peak and PM peak values marginally lower.

13.2.12 Non-work other values are much lower than suggested by guidance. These lower values could reflect the method of how fares are calculated for the other traveller purpose – with average values calculated taking into account concessionary (zero) fares for a proportion of passengers. These would generally bring fares down to making up a lower proportion of the overall generalised cost and therefore less of a (20%) change is implemented during this test.

13.2.13 The annual elasticity to changes in PT fares is -0.14. With the model displaying an overall response lower than the recommended level, care should be taken when testing interventions, schemes or policies that may impact public transport fares.

Journey Time / Generalised Cost

13.2.14 Table 70 shows the Car Generalised Cost elasticities. These are directly related to the car journey times, as travel time makes up about 80%-90% of the overall Car Generalised Costs. The WEBTAG guidance gives no specific range for these, but suggests that they should be much greater than the fuel cost elasticities and no greater than -2.0.

13.2.15 The analysis shows that these sensitivities fall within the suggested guidance with all values being less than -2, and an overall response of -1.13. The modelled elasticities are around three times greater than the fuel price elasticities, with Other travellers being more responsive.

Table 70. Car Generalised Cost Sensitivity Tests

	AM PEAK			INTER PEAK			PM PEAK		
Journey Purpose	**C1/1 Car**	**C1/2+ Car**	**C2 Car**	**C1/1 Car**	**C1/2+ Car**	**C2 Car**	**C1/1 Car**	**C1/2+ Car**	**C2 Car**
In-Work	-0.9	-1.0	-0.8	-0.9	-1.0	-0.8	-0.9	-1.0	-0.8
Non-Work Commute	-0.9	-0.9	-0.8	-1.0	-1.1	-0.9	-1.0	-1.1	-1.0
Non-Work Other	-1.4	-1.4	-1.3	-1.4	-1.4	-1.3	-1.4	-1.4	-1.3
Annual	**-1.13**								

Geographical Response

13.2.16 In order to gauge the variation in elasticities across the modelled area, sectored sensitivity analysis was undertaken for all purposes, time period and car availability segments. The segments that dominate the majority of the trips in the model, AM Commute and IP Other are described below.

13.2.17 Note that WEBTAG provides guidance regarding the overall (global) model behaviour and omits any specific distance or area type based information within a modelled area.

13.2.18 The ASAM14 507 internal zones were aggregated to 6 sectors to evaluate the sensitivity of the main movements, with sector coverage shown below.

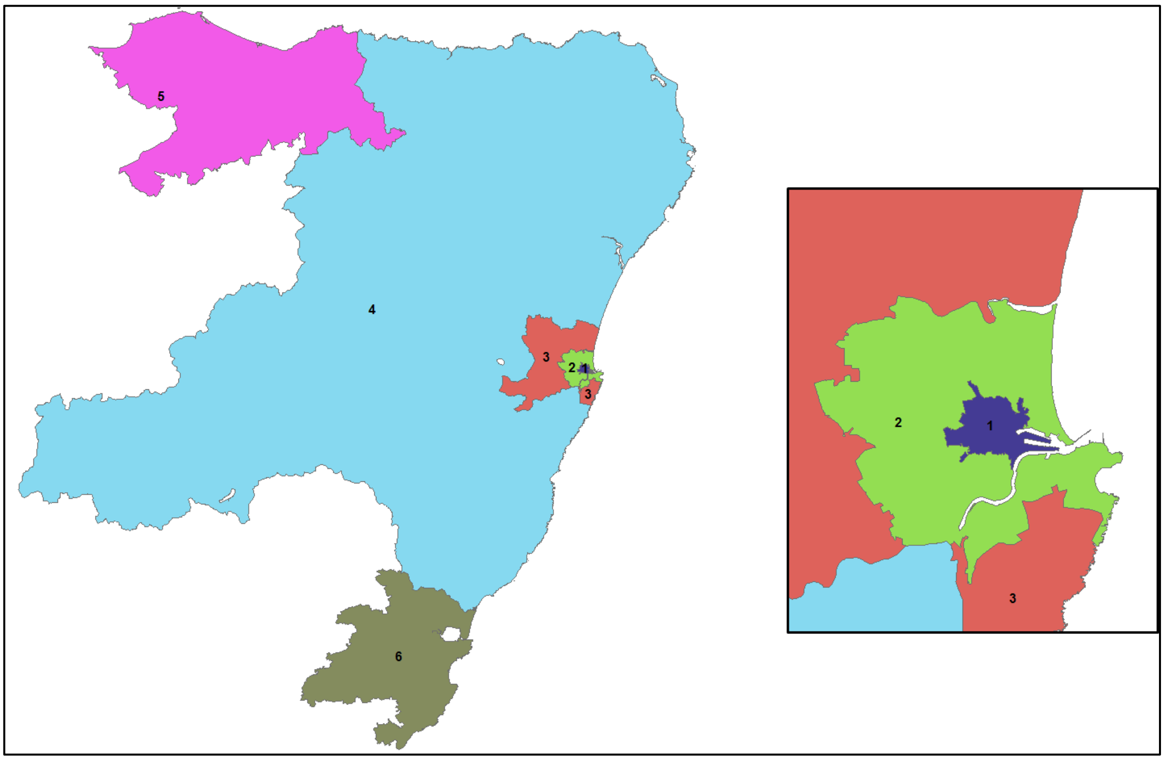

Figure 52. Sensitivity Testing Sector Coverage

13.2.19 Sectors cover:

- 1. Aberdeen City Centre;
- 2. Central Aberdeen (within Anderson Drive corridor);
- 3. Periphery of Aberdeen;
- 4. Aberdeenshire;
- 5. Moray; and
- 6. Angus.

13.2.20 Table 71 to Table 73 describe the response for AM peak commute elasticities by sector for each sensitivity test.

13.2.21 Table 74 to Table 76 describe the response for Inter peak other elasticities by sector for each sensitivity test.

13.2.22 The tables show that there is a wide range of variation between geographical sectors. As expected, there are larger elasticity amongst the longer distance trips to/from more rural sectors (which the cost damping aspect of the model addresses). Lower sensitivities are generated within the urban areas of Aberdeen.

13.2.23 Note that the fuel and generalised cost test elasticities have a positive elasticity for some sector 1-3 movements (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.

13.2.24 Although this trend is at first glance perhaps counter-intuitive, the calculations allow for this, particularly where there are some small numbers in play.

13.2.25 Fare elasticities suggest a similar pattern where longer distance trips exhibit a bigger elasticity as the shorter one. The fares test does not contain the similar trend of positive short distance elasticities as this test is undertaken using passenger levels only, rather than passenger distance.

13.2.26 The analysis for inter peak other journey purpose also suggests a similar pattern to the AM commute with regards to the three sensitivity tests which were evaluated.


Table 71. Fuel Sensitivity Sectors - AM Commute

FUEL: AM COMMUTE	1	2	3	4	5	6
1	0.169	0.126	0.063	-0.476	-1.573	-1.198
2	0.091	0.086	0.040	-0.499	-1.583	-1.219
3	0.028	0.037	0.040	-0.470	-1.518	-1.164
4	-0.193	-0.217	-0.170	-0.209	-0.971	-0.905
5	-0.852	-0.838	-0.782	-0.728	-0.013	-1.531
6	-0.725	-0.728	-0.718	-0.731	-1.970	-0.096

Table 72. Fare Sensitivity Sectors - AM Commute

FARE: AM COMMUTE	1	2	3	4	5	6
1	-0.040	-0.122	-0.107	-0.300	-0.986	-1.440
2	-0.122	-0.137	-0.134	-0.346	-1.034	-1.466
3	-0.123	-0.129	-0.156	-0.376	-1.129	-1.608
4	-0.234	-0.280	-0.318	-0.126	-0.436	-0.751
5	-0.918	-0.957	-0.964	-0.524	0.017	-1.776
6	-0.955	-0.947	-1.131	-0.650	-1.599	0.053

Table 73. Generalised Costs Sensitivity Sectors - AM Commute

GEN COST: AM COMMUTE	1	2	3	4	5	6
1	0.934	0.536	-0.023	-1.539	-4.010	-2.802
2	0.431	0.309	-0.066	-1.584	-4.017	-2.872
3	-0.002	-0.007	0.039	-1.331	-3.622	-2.783
4	-0.716	-0.798	-0.511	-0.517	-2.043	-2.218
5	-2.417	-2.391	-2.042	-1.861	-0.046	-3.964
6	-1.899	-1.939	-1.970	-2.035	-4.867	-0.228

Table 74. Fuel Sensitivity Sectors – IP Other

FUEL: IP OTHER	1	2	3	4	5	6
1	0.124	0.061	-0.104	-0.812	-1.953	-1.532
2	0.042	0.036	-0.110	-0.808	-1.946	-1.533
3	0.005	0.014	-0.010	-0.668	-1.776	-1.401
4	-0.418	-0.414	-0.407	-0.296	-1.012	-0.750
5	-1.468	-1.449	-1.419	-0.999	-0.007	-2.251
6	-1.288	-1.289	-1.310	-1.211	-2.469	-0.157

Table 75. Generalised costs Sensitivity Sectors – IP Other

GEN COST: IP OTHER	1	2	3	4	5	6
1	0.544	0.128	-0.712	-2.460	-5.414	-3.918
2	-0.049	0.011	-0.664	-2.355	-5.333	-3.873
3	-0.474	-0.232	-0.052	-1.617	-4.523	-3.485
4	-1.878	-1.704	-1.463	-0.736	-2.692	-1.941
5	-4.803	-4.590	-4.322	-2.714	-0.097	-6.765
6	-4.039	-3.971	-4.083	-3.519	-7.358	-0.475

Table 76. Fare Sensitivity Sectors – IP Other

FARE: IP OTHER	1	2	3	4	5	6
1	0.019	-0.036	-0.087	-0.371	-1.578	-1.944
2	-0.046	-0.044	-0.078	-0.347	-1.239	-1.625
3	-0.070	-0.066	-0.024	-0.300	-1.201	-1.550
4	-0.285	-0.239	-0.240	-0.034	-0.207	-0.219
5	-1.596	-0.929	-1.208	-0.315	-0.024	-3.156
6	-1.693	-1.310	-1.337	-0.600	-3.448	0.073

14. PARKING AND PARK & RIDE CHOICE

14.1 Approach

14.1.1 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.

14.1.2 The parking approach adopts a generally consistent approach to park and ride, where journeys which utilises an individual city centre car park (or on street parking zone) are estimated. The process is identified as a Park & Walk process.

14.1.3 These underlying processes are constructed based on those applied in the SRM12 (and other TMfS type models), with the addition of city centre parking, which includes 'site' competition between the city centre parking and park & ride sites. Here after both aspects are referred to as park and ride, with further distinction during calibration.

14.1.4 The parking modelling is applied within the AM Peak and Inter Peak models, with some reverse factoring applied to represent return trips within the PM Peak model.

14.2 Inputs & Data

Occupancy Data

14.2.1 The park and ride model is calibrated to match observed levels of occupancy at each park and ride site, station and city centre car park. Observed occupancy data was extracted from the following surveys:

- Park & Ride site car park occupancy survey at Bridge of Don, Kingswells and Ellon (2015) and rail stations (data patched from 2016 if unavailable for 2015); and
- City centre Off Street car park survey (2012); and
- On Street Car Park (limited) survey.

Park & Ride Occupancy

14.2.2 Car park occupancy for the AM period was calculated at 1000, and Inter peak car park occupancy was calculated at 1300. The occupancy surveys were undertaken at around midday, so were used to represent the inter peak occupancy. The modelling assumed that (an additional) 25% of the level of AM Peak motorists used park and ride sites during the inter peak.

14.2.3 No occupancy surveys were available for Aberdeen, Keith, Montrose and Arbroath stations. Feedback from the client group suggested that all the main station car parks were usually at full capacity by the end of the morning peak period, and this assumption was applied to fill the data gaps.

Off Street Parking Occupancy

14.2.4 Preparation for the parking model aggregates data for on-street and off-street parking in the centre of Aberdeen. These data relate to car park capacity, occupancy and prices, as well as proportions of trips observed using city centre car parks.

14.2.5 Data for off-street parking is based on a survey carried out in 2012 by Aberdeen City Council at ten car parks in the city centre. A total of 2,862 responses provide information on the origin location and purpose of the respondent's trip to the car park. The locations were assigned to model zones with recorded journey purposes assigned to the relevant model trip purposes.

14.2.6 SQL coding is used to produce a matrix of zone-to-car park sets of trips by journey purpose (Business, Commute and Other). These matrices are adjusted to reflect observed occupancy figures at 10:00 and 13:00 on a regular weekday derived from turning counts from the 2012 Central Aberdeen traffic survey. Purpose matrices are produced for the AM and Inter peak time periods.

14.2.7 Four other large off street car parks are accounted for, although they were not present in the 2012 survey. Trip origins and purposes assigned to these sites are calculated using the average values of surveyed car parks. Relevant city centre car parks are illustrated in Figure 53.

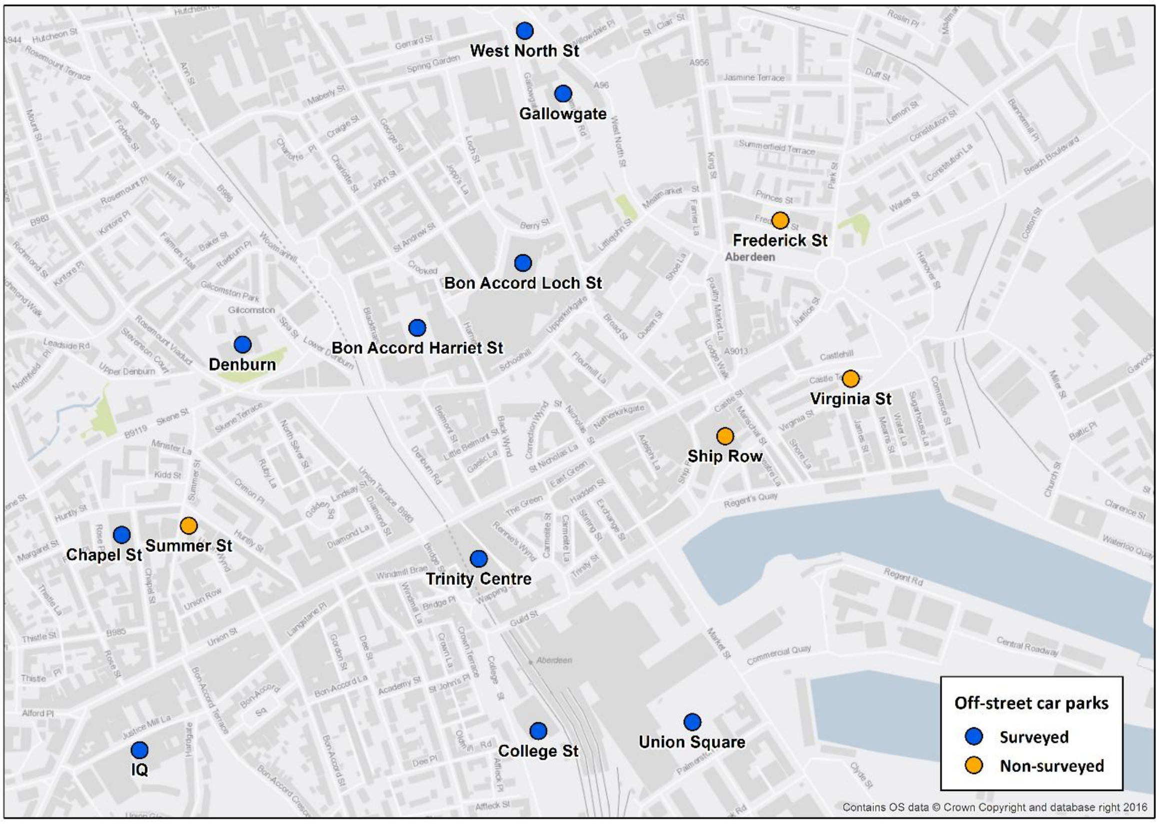

Figure 53. Aberdeen City Centre Off Street Car Parks



14.2.8 Car park occupancies are computed based on turning counts from the 2012 Aberdeen traffic survey (accessing car parks by time period).

14.2.9 Overall, there is a capacity of 5,257 off-street car park spaces recorded, with around 2,600 spaces occupied by the end of the AM Peak period and around 3,600 occupied during the Inter Peak (weekday). Off Street Car park occupancy by time period are shown in Table 77.

Table 77. Off Street Car Parking Spaces and Occupancy

CAR PARK	SPACES	OCC. 10:00 (AM)	OCC. 13:00 (IP)
Chapel Street Car park	500	66%	69%
Denburn Car Park	326	39%	37%
Bon Accord (Loch Street)	770	47%	75%
Bon Accord (Harriet Street)	400	50%	68%
College Street Car Park	500	94%	106%
Gallowgate	138	81%	89%
West North Street	160	76%	83%
Trinity Centre	400	54%	87%
Union Square	1,200	25%	60%
IQ Car park	260	56%	52%
Ship row	365	37%	36%
Frederick Street	150	57%	69%
Summer Street	42	57%	69%
Virginia Street	46	57%	69%
Total	**5,257**	**50%**	**68%**

14.2.10 The 10 surveyed and 4 non-surveyed off street car parks are assigned to 11 specific parking model zones. Three car parks (Summer Street, West North Street and Virginia Street) are sufficiently small and nearby to other car parks serving a similar area and are therefore combined into a single zone with the neighbouring car park.



Off Street Parking Prices

14.2.11 Charges for using the car parks were identified by sifting through City Council and private operator websites (in 2016), and noting parking process by length of stay. Where a zone aggregates two car parks a weighted average of the charges (with available spaces as weights) was used to compute the charge for the zone. Travel purpose specific parking charges are derived by assigning an expected length of stay to each purpose as follows:

- 3 hours stay for Business and 'Other' Trip purposes; and
- 8 hours for Commuters.

14.2.12 The calculated Parking Charges for each City Centre Car Park (or combined parking sites) are described in Table 78.

Table 78. Off-street Car Parking Charges (Pence)

ZONE	CAR PARK	SPACES	BUSINESS	OTHER	COMMUTER
533	Chapel St + Summer St	542	161	104	847
534	Denburn	326	159	103	847
535	Bon Accord Loch St	770	202	136	1271
536	Bon Accord Harriet St	400	202	136	1271
537	College St	500	202	136	508
538	Gallowgate + West North St	298	171	112	847
539	Trinity Centre	400	219	150	1144
540	Union Sq	1,200	202	136	1356
541	IQ	260	288	204	847
542	Ship Row	365	319	542	1356
543	Frederick St + Virginia St	196	178	118	847

On Street Car Parking Occupancy

14.2.13 Central Aberdeen has a number of controlled parking zones (CPZs) where parking is restricted to pay-and-display sites where paying a charge is required for use, except for holders of residential or business permits. To represent these areas within ASAM14, CPZs are categorized in three bands: inner central, outer central and peripheral. The CPZ coverage area are aggregated into 13 larger areas with a specific model zone assigned to each. These zonal areas are shown in Figure 54.

14.2.14 On-street parking capacity for the CPZs, along with numbers of business and residential issued permits, were provided by the city council. These figures were used to produce an effective capacity for each on-street (pay and display) parking zone (ie spaces available for business, commuter and other travellers and excluding residential-only spaces).

14.2.15 On Street parking occupancy data is more limited, with the only survey available reflecting an on street parking beat survey undertaken along Queens Terrace and Rubislaw terrace during 2011 at 0930 (inner central locations) (Parking Strategy Support Final Report, 08,08,2011). The survey indicated that 122 spaces were occupied out of a total of 176 spaces, recording a 69% occupancy.

14.2.16 This 69% occupancy figure was used as the basis for the On Street parking occupancy assumptions as follows:

- Inner Central: 85% AM Peak, 95% Inter Peak;
- Outer central: 70% AM Peak, 80% Inter Peak; and
- Peripheral: 50% AM Peak, 60% Inter Peak.

14.2.17 These assumptions amounted to a total On-Street occupancy of 57% during the AM Peak and 70% during the Inter Peak.

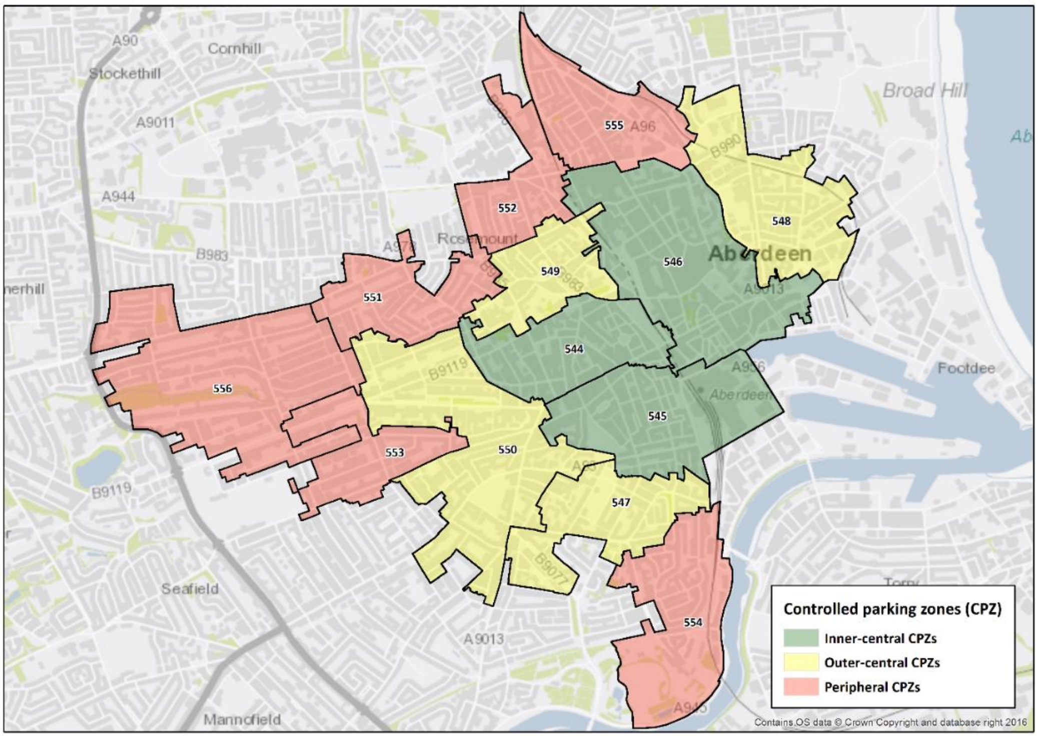

Figure 54. Aberdeen City Centre On-Street Car Parking Zones

On Street Parking Prices

14.2.18 The charges for parking in on-street spaces are derived by assigning durations of stay to travel purposes (3 hours for business and other, and 8 hours for commute), and using the



publicly available pay-and-display prices. A further adjustment reflects a set percentage of users holding a permit, and using the ratio of permits to number of days of validity as the daily charge for these users. The calculated On-Street parking charges for model zones are described in Table 79 along with the effective capacity.

Table 79. Effective Capacity & Charges for On-street Parking Zones (Pence)

ZONE	CAR PARKING AREA	SPACES	BUSINESS	OTHER	COMMUTER
544	A_+_C	99	231	508	1569
545	B_+_E	233	231	508	1569
546	F_+_G	58	231	508	1569
547	H	282	188	373	1060
548	J	403	188	373	1060
549	K	43	188	373	1060
550	P_+_N	373	188	373	1060
551	L	270	102	103	679
552	M	185	102	103	679
553	T	112	102	103	679
554	V	168	102	103	679
555	W	119	102	103	679
556	X	472	102	103	679

External Movements

14.2.19 The Park & Ride modelling does not represent external park and ride trips, which would though be included within some observed occupancy data. For bus-based P&R it is assumed all observed trips / occupancy are internal. For rail P&R a proportion of P&R trips that origin/destination the model area is calculated for each site.

14.2.20 The LENNON database provides numbers of rail trips recorded between stations in Britain over the course of a fiscal year. LENNON 2014-2015 was used to derive the number of trips originating at each station within the modelled area, heading towards other stations within the coverage area and those heading outside the model coverage. These calculations provide a proportion of external trips and these proportions are applied to P&R travellers using those stations. Table 80 describes the external Park & Ride trip proportions.

Catchment Areas

14.2.21 Park & Ride and Parking 'catchment' areas are used to define the likely origin and destination modelled zones of travellers using a specific site / city centre car park. For Park and Ride sites, these zonal catchments are based on relevant corridors of travel into Aberdeen. There is some overlap for some sites. All rail park & ride sites have a destination catchment covering the entire model area, while bus sites have defined destination catchments. Maps of all catchments areas are illustrated in Appendix I.

14.2.22 Parking catchments are identified using a four sector system to apply a proportion of road trips from each zone that are designated as parking trips. These sectors are illustrated in Figure 55 and cover the following areas:

- Aberdeen (out with the city centre controlled area);
- North Aberdeenshire;
- South Aberdeenshire; and
- Angus and Moray.

Figure 55. Parking Sectors Zones to Represent Trip Origins

Demand Model Person Trip Movements

14.2.23 Demand model inputs to the P&R and Parking processes are origin-destination, from-home matrices output from the mode and destination choice stage. These matrices represent total (person) car park usage across all sites. Average generalised costs are also used for the site weighting mechanism applied within the park & ride process.

14.2.24 Car-only productions are obtained by time period from the trip end model. Total productions are calculated as a sum of all zonal productions for a P&R site's origin catchment area. Ratios are then calculated by dividing trips into the car parks (scaled up by 20% for car occupancy (at 1.2 occupants per vehicle) and scaled down to eliminate external trips) by the total catchment area productions. This provides a demand proportion for each site, which is assigned to zones in the site's origin catchment area.

14.2.25 Where catchment areas overlap, i.e. a zone is part of more than one catchment area, all proportions for that zone, from each site that has it in its origin catchment, are added up to yield the final proportion associated with the zone.

Table 80. Proportions of P&R PT productions & External Occupancy Proportions

SITE	AM	IP	EXTERNAL %
Aberdeen	2.2%	0.7%	68%
Dyce	22.0%	6.9%	15%
Huntly	7.6%	2.5%	14%
Insch	39.9%	14.9%	7%
Inverurie	27.4%	8.7%	12%
Montrose	6.7%	1.9%	54%
Portlethen	9.5%	2.4%	7%
Stonehaven	29.6%	10.0%	21%
Keith	34.1%	8.1%	28%
Laurencekirk	31.4%	12.0%	19%
Arbroath	1.8%	0.5%	80%
Elgin	9.2%	2.5%	28%
Bridge of Don	48.0%	18.1%	0%
Ellon	28.4%	7.9%	0%
Kingswells	24.4%	7.1%	0%

Parking Demand

14.2.26 Proportions of trips generated by the trip end model are introduced into the parking model. The proportions are zonal with levels of demand derived from the aforementioned surveys undertaken at city centre car parks in central Aberdeen.

14.2.27 The use of the larger four sector system reduces the issue of small-size or non-existent samples, with all model zones outside of CPZs aggregated into four 'sectors'. Therefore, a proportion of travellers from all zones out with the CPZs will have some parking demand.

14.2.28 During processing all destination car parks are aggregated into a single city centre destination to again reduce the issue of relatively small samples. By aggregating all zone-to-off-street-car-park trips into a sector-to-city-centre trips, a full matrix of trips from each sector /zone are obtained to reflect car park occupancy counts.

14.2.29 Journey purpose proportions calculated from the parking survey are used to distribute these trips between purposes. Journey purpose proportions recorded at off street car parks are applied to on-street parking demand.

14.2.30 Table 81 describes the resultant total on and off street parking demand by origin sector.

Table 81. Car Parking Origin Sector Demand to City Centre Car Parks (vehicles)

SECTOR	TOTAL AM	TOTAL IP	EMP AM	EMP IP	COM AM	COM IP	OTH AM	OTH IP
Rest of Aberdeen	1,515	2,408	182	226	325	392	1,009	1,790
North Aberdeenshire	903	1,473	87	108	149	173	667	1,192
South Aberdeenshire	465	668	54	69	85	100	327	499
Angus & Moray	122	170	9	9	7	9	106	152
Total	3,005	4,719	332	412	565	673	2,108	3,633

14.2.31 Car-only productions by time period and purpose are obtained from the trip end model and aggregated to the 4 sectors. These figures provide the basis for the total number of trips of which trips to the car parks are proportioned.

14.2.32 The proportional figures described in Table 82 are used to generate a rate for each sector, which informs the proportion of trips that are fed into the parking model. This divides the number of parking trips for each car park by the number of productions (scaled up by 58% to account for on-street parking, and again by 20% for car occupancy). A sector's proportion is assigned to each zone within the sector.

Table 82. Car Parking Origin Sector Demand Proportions to City Centre Car Parks (%)

SECTOR	TOTAL AM	TOTAL IP	EMP AM	EMP IP	COM AM	COM IP	OTH AM	OTH IP
Rest of Aberdeen	5.8%	8.9%	9.0%	17.0%	1.8%	9.5%	16.2%	8.3%
North Aberdeenshire	3.1%	5.6%	3.8%	7.9%	0.7%	4.5%	10.0%	5.7%
South Aberdeenshire	4.4%	6.8%	6.2%	13.1%	1.2%	6.9%	13.0%	6.3%
Angus & Moray	0.8%	1.1%	0.8%	1.4%	0.1%	0.4%	2.7%	1.2%

14.2.33 The outcome from these data sets are a set of (proportional) PT car available trip productions and Car productions for input to the park and ride site choice model. The level of demand at each zone is proportional to the overall level of zonal demand, both at residential (from home) origin and car park destination, reflecting the observed data.

Parameters

14.2.34 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 the tables below.

Table 83. 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	PT generalised cost weighting	0.75
PnR Alpha	Road generalised cost weighting	1.4
LParam	Parameter for adding on an imposition to sites with low capacity (effectively a proxy for search time)	40


Table 84. 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)	'Inverurie'
Zone	Actual Park and Ride zone (between (508-556))	777
Employers Business Parking Charge	Parking Charge at site (in pence)	150
Other Parking Charge	Parking Charge at site (in pence)	250
Commute Parking Charge	Parking Charge at site (in pence)	1050
In Work Bttr	Base attraction factor to rationalise over/under capacity sites within base year (minutes)	10
Non Work Commute Bttr	Base attraction factor to rationalise over/under capacity sites within base year (minutes)	10
Non Work Other Bttr	Base attraction factor to rationalise over/under capacity sites within base year (minutes)	10
In Work Attr	Attraction factor (minutes)	10
Non Work Commute Attr	Attraction factor (minutes)	10
Non Work Other Attr	Attraction factor (minutes)	10
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.	'345-359'
Destination Catchment	List of zones (enclosed by single quotes). Typically all internal zones for rail or local urban centre for bus-based sites.	'1-507'

14.3 Processing

14.3.1 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.

14.3.2 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:

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

14.3.3 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 .

14.3.4 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.

14.3.5 External trips (i.e. those coming from Dundee and Inverness) do not have the choice of using Park and Ride. External trips can be adjusted during forecasting using factors to derive external forecasts and adjust car park capacity. Education trips also do not have the choice of using Park & Ride.

14.3.6 ASAM14 applies the Park and Ride module within the AM and Inter 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).

14.4 Site Overcapacity Feedback Mechanism

14.4.1 The Park and Ride process identifies site car parks 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 represents the increasing search and/or walk times associated with using the ‘unofficial’ car parking spaces.

14.4.2 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.

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

14.4.3 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.

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

14.4.5 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.

14.4.6 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 85 describes the Park & Ride convergence parameters.

Table 85. Park and Ride Convergence Parameters

PARAMETER	DESCRIPTION	VALUE
PnR Penalty	Penalty for sites which exceed a stated (non-zero) far capacity	30
PnR Grad	Gradient of the curve to adjust sites exceeding near capacity	0.15
PnR Threshold	Threshold for absolute change in Attr to be considered converged	1
PnR Dem Threshold	Threshold for maximum absolute change in Attr to be considered converged	1
PnR Succ	Threshold for maximum absolute change in demand to be considered converged	1

Max PnR Loop	Maximum number of Park & 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

14.5 Park & Ride Site Choice Calibration

Approach

14.5.1 The true origin-destination end-to-end Park and Ride matrices are initially 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.

14.5.2 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).

14.5.3 To establish the correlation of modelled and observed data, the number of sites which displayed large absolute differences in site occupancy (comparing AM observed and modelled values) was considered as the primary gauge. Note that the AM Peak is used as more representative gauge as the level of confidence in the observed data is higher.

14.5.4 Considering the λ parameter and 'LParam', these were analysed as part of the SRM12 model where firstly for λ, a range of values were tested between 0.01 and 0.5 and a value of 0.04 was chosen which showed a good spread of trips amongst the short and long distance trips. Secondly '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.

14.5.5 The Generalised Cost weighting parameter was also set with the previous modelling values used as a starting point. Earlier analysis of National Rail Travel Survey (NRTS) data showed that, for the road leg, motorists tended to use the closest park and ride site rather than sites farther away, 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.

14.5.6 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. The earlier SRM12 modelling showed that with α = 1.7 and γ = 0.55 led to a stronger correspondence in the unweighted case.

14.5.7 The final ASAM14 values were altered due to the introduction of Park & Walk at city centre car parks, which constitute a large number of road trips, and would attract some motorists past P&R sites to use city centre parking. In order to represent this, the car cost weight was reduced to 1.4 and the PT weight increased to 0.75.

Calibration of the Park and Ride Site Choice

14.5.8 Once global parameters for the Park and Ride module were established, the general balance between all park and ride sites, and city car park occupancy was calibrated. Subsequently, the balance between off-street and on-street city centre car parking was then calibrated. Finally, individual site usage was calibrated to reflect observed occupancy levels. This process includes altering the site attraction factors ('Attr') and refining catchment areas.

14.5.9 Table 86 to Table 91 describe the car park occupancy comparisons and associated capacity for each Park and Ride site and car park, along with an overall AM and Inter Peak summary.

14.5.10 As the modelling does not include external trips, an estimate of external demand is added to each site to allow consistent comparisons between site capacity and occupancy level.

14.5.11 Note that the car park at Laurencekirk station actually has 70 spaces available. This anomaly has been updated within an updated 'Base+' and forecast year scenarios.

14.5.12 The Park & Ride site specific data demonstrates that the modelled occupancy closely reflects observed data with most sites falling within a few vehicles of observed occupancy. The largest absolute differences are at Ellon and Keith stations.

14.5.13 The parking analysis shows that the modelled occupancy for most car parks lies reasonably close to the observed data values, with the majority of occupancies falling within around 30 vehicles of observations in the AM Peak. The largest (absolute) outliers appear at College Street and the Trinity Centre car parks. There appears a slight imbalance between the outer on-street parking zone (x), where occupancy is underestimated, and the other on street zones, where occupancy is overestimated. This is likely due to representing the benefit of the knowledge that spaces are more freely available in this outer zone, but the longer time required to walk to the city centre.

14.5.14 The summary data shows that the overall number of bus and rail park and ride users and off street car park users fall within +/-3% of observed occupancy. It also shows that on street parking is slightly over estimated within the modelling at +10%.

14.5.15 Note that there is some uncertainty regarding the level of additional parking out with the formal rail station car parks, which is not represented within the model. This could potentially lead to an underestimate of parking pressures during forecasting.

Table 86. Park and Ride Sites Occupancy – AM Peak Vehicles

SITE	CAP.	AM OBS.	AM MODEL	DIFF.	% DIFF.
Aberdeen	188	188	186	-2	-1%
Bridge of Don	650	175	188	13	7%
Dyce	100	100	103	3	3%
Huntly	27	27	34	7	27%
Insch	44	44	34	-10	-22%
Ellon	250	140	111	-29	-21%
Kingswells	900	110	118	8	7%
Inverurie	104	104	112	8	8%
Montrose	50	50	61	11	22%
Portlethen	28	28	33	5	19%
Stonehaven	47	47	65	18	39%
Keith	88	88	60	-28	-32%
Laurencekirk	15	15	21	6	43%
Arbroath	18	18	22	4	20%
Elgin	54	54	53	-1	-2%
Total	**2,563**	**1,188**	**1,202**	**14**	**1.2%**


Table 87. City Centre Car Park Occupancy – AM Peak Vehicles

CAR PARK	CAP.	AM OBS	AM MOD	DIFF.	% DIFF.
Chapel St + Summer St	542	354	336	-18	-5%
Denburn	326	127	153	26	20%
Bon Accord Loch St	770	362	363	1	0%
Bon Accord Harriet St	400	200	196	-4	-2%
College St	500	470	387	-83	-18%
Gallowgate + West North St	298	233	230	-3	-1%
Trinity Centre	400	216	273	57	27%
Union Sq	1200	300	269	-31	-10%
IQ	260	146	146	0	0%
Ship Row	365	135	142	7	5%
Frederick St + Virginia St	196	112	128	17	15%
A + C	99	54	54	0	-1%
B + E	233	128	136	8	6%
F + G	58	32	54	22	69%
H	282	155	206	51	33%
J	403	222	255	33	15%
K	43	24	46	23	96%
P + N	373	205	206	1	0%
L	270	149	167	18	12%
M	185	102	121	19	19%
T	112	62	83	21	34%
V	168	92	123	31	33%
W	119	65	77	11	18%
X	472	260	173	-87	-33%
Total	**4,325**	**4,204**	**4,325**	**121**	**2.9%**



Table 88. Park and Ride Sites Occupancy – Inter Peak Vehicles

SITE	CAP.	IP OBS.	IP MODEL	DIFF.	% DIFF.
Aberdeen	188	203	202	-1	0%
Bridge of Don	650	219	230	11	5%
Dyce	100	121	124	3	3%
Huntly	27	33	38	5	17%
Insch	44	54	48	-6	-12%
Ellon	250	175	157	-18	-11%
Kingswells	900	138	145	7	5%
Inverurie	104	127	134	7	6%
Montrose	50	56	64	8	14%
Portlethen	28	35	39	4	12%
Stonehaven	47	56	70	13	24%
Keith	88	104	85	-19	-18%
Laurencekirk	15	18	23	5	26%
Arbroath	18	19	21	3	13%
Elgin	54	64	63	0	-1%
Total	**2,563**	**203**	**202**	**-1**	**0%**

Table 89. City Centre Car Park Occupancy – Inter Peak - Vehicles

CAR PARK	CAP.	IP OBS	IP MOD	DIFF.	% DIFF.
Chapel St + Summer St	542	374	403	29	8%
Denburn	326	121	161	41	34%
Bon Accord Loch St	770	578	514	-63	-11%
Bon Accord Harriet St	400	272	260	-12	-4%
College St	500	530	510	-20	-4%
Gallowgate + West North St	298	256	276	21	8%
Trinity Centre	400	348	348	0	0%
Union Sq	1200	720	512	-208	-29%
IQ	260	135	163	28	20%
Ship Row	365	131	159	27	21%
Frederick St + Virginia St	196	135	151	16	11%
A + C	99	69	69	0	0%
B + E	233	163	168	5	3%
F + G	58	41	56	15	38%
H	282	197	233	36	18%
J	403	282	305	23	8%
K	43	30	46	16	53%
P + N	373	261	262	1	0%
L	270	189	202	13	7%
M	185	130	143	14	10%
T	112	78	93	15	19%
V	168	118	139	22	18%
W	119	83	91	8	10%
X	472	330	270	-61	-18%
Total	**4,325**	**5,571**	**5,534**	**-37**	**-0.7%**

Table 90. Park & Ride & Parking Occupancy at 1000 – AM Peak Summary (Vehicles)

P&R TYPE	CAP.	AM OBS	AM MODEL	DIFF.	% DIFF.	% OCC.
Bus P&R	1,800	425	417	-8	-1.9%	23%
Rail P&R	763	763	785	22	2.9%	103%
Off Street	5,257	2,655	2,624	-31	-1.2%	50%
On Street	2,817	1,549	1,701	151	9.8%	60%
Total P&R	2,563	1,188	1,202	14	1.2%	47%
Total Parking	8,074	4,204	4,325	121	2.9%	54%
Total	**10,637**	**5,392**	**5,527**	**135**	**2.5%**	52%

Table 91. Park & Ride & Parking Occupancy at 1300 – Inter Peak Summary (Vehicles)

P&R TYPE	CAP.	IP OBS	IPMODEL	DIFF.	% DIFF.	% OCC.
Bus P&R	1,800	531	531	0	-0.1%	29%
Rail P&R	763	889	911	22	2.5%	119%
Off Street	5,257	3,600	3,457	-143	-4.0%	66%
On Street	2,817	1,972	2,078	106	5.4%	74%
Total P&R	2,563	1,421	1,442	22	1.5%	56%
Total Parking	8,074	5,571	5,534	-37	-0.7%	69%
Total	**10,637**	**6,992**	**6,977**	**-15**	**-0.2%**	66%


15. TRIP END MODEL

15.1 Introduction

15.1.1 The ASAM14 trip end model (TEM) is derived from the trip end model built for SRM12. The TEM 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, traffic / passenger volumes from TMfS14, and a process for generating Greenfield demand in zones where the base year contained no demand.

15.1.2 The TEM generates trip productions and attractions for each modelled zone based on demographic and economic/employment data output from TELMoS. The TEM 'growths' calibrated base year trip ends based on the relative change in population and employment between the 2014 base and forecast test years. These trip ends are then input to the main demand model.

15.1.3 The TEM applies TELMoS commodity / goods vehicle forecasts to forecast changes in light and heavy goods vehicles over time. TMfS14 traffic and passenger flow data is used to forecast changes in external trip levels over time.

15.1.4 These 'add-in' matrices are then incorporated into the demand model matrices as fixed movements for each forecast year.

15.1.5 To enhance the current Trip Generation model, the underlying SRM12 Trip Generation model was transferred into the ASAM14 zone format.

15.1.6 Each of the TELMoS and TMfS14 data sets are disaggregated down to ASAM14 zonal level for processing.

15.1.7 The TEM enhances the underlying SRM12 approach in the following aspects:

- used to create road and PT productions and attractions to inform the ASAM14 Base year matrix development process;
- applied for three time periods (now including the PM Peak to inform the new PM Peak Demand Model) and as such, trips ends are generated for AM, IP and PM, for all four TEM purposes (Business, Commute, Other and Education;
- separation of school-based and university/college travel forecasting; and
- geographically specific trip rates that vary across modelled zones are applied.

15.2 National Trip End Model (NTEM)

15.2.1 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.

15.2.2 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 ASAM14.


15.2.3 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.

15.2.4 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+.

15.2.5 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.

15.2.6 These are combined into the following segments for input to the ASAM14 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.

15.2.7 There are eight home based journey purposes of which work, employers business and education are used directly for ASAM14. The remaining five purposes are combined to form home based other (HBO).

15.2.8 Education trip ends are created to represent school and university / college trips separately during greenfield site forecasting.

15.2.9 The AM peak, Inter peak and PM peak time periods in NTEM are directly compatible with the ASAM14 time periods.


15.3 Model Inputs

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

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

Base Year Files

15.3.2 These files include:

- Trip End files;
- Education demand; and
- Add-in LGV, HGV, and Road and PT external matrices.

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

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

Land Use

15.3.5 Base and forecast year population, jobs and commodity flow data are provided from the TELMoS land use model. These are disaggregated to the ASAM14 zoning system (based on base year planning data zonal proportioning (ie comparing population and jobs data for TELMoS and ASAM14 zones) and are used to provide growth factors for trip ends.

15.3.6 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

15.3.7 The Trip End model requires a number of parameters and factors. These include:

- **Trip Rates:** defined by person type, car availability class, time period, purpose, mode and geographical area type. 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.

Trip Rates

15.3.8 Production trip rates in ASAM14 are applied to population data to generate productions. They are now defined in a more complex way with trip rates now varying by different geographical areas.

15.3.9 Trip rates used within TMfS14 were disaggregated with a range of urban, semi-rural and rural values and this provides greater flexibility for choosing zonal trip rates with varying accessibility across the model geography. These TMfS14 geographical trip rates were used as the initial inputs to the ASAM14 TEM.

15.3.10 Area types reflect variation in trip rates across different urban and rural geographic areas which have different levels of accessibility. Each ASAM14 zone is assigned to one of eight area types, based on access to public transport. Types 1-3 are reserved for London-specific and type 3 for metropolitan trip rates and are not used in this model.

15.3.11 ASAM14 trip rate area types are described in Table 92 and illustrated in Figure 56.

Table 92. Production Trip Rate Area Types

AREA TYPE	NTEM DESCRIPTION	ASAM DESCRIPTION
1	Inner London	*- not used -*
2	Outer London	*- not used -*
3	Metropolitan areas	Aberdeen City Centre
4	Urban big (> 250k)	Central Aberdeen
5	Urban large (100k to 250k)	Peripheral Aberdeen
6	Urban medium (25k to 100k)	Railway access and Aberdeen suburbs
7	Urban small	Good bus or coach access in towns
8	Rural	Rural

15.3.12 The base year modelling examined the overall level of road and PT travel demand generated by the underlying trip rates and compared these to traffic and PT passenger counts. It was found that the underlying matrices over / underestimated some trip movements to/from some areas. Adjustments were made to trip rates to provide an improved match with observed levels of travel. The most significant change to trip rates related to rural PT movements where observed bus passenger data suggested much lower flows than that generated. Final ASAM14 Trip Rates and relevant adjustments are described in Appendix A.

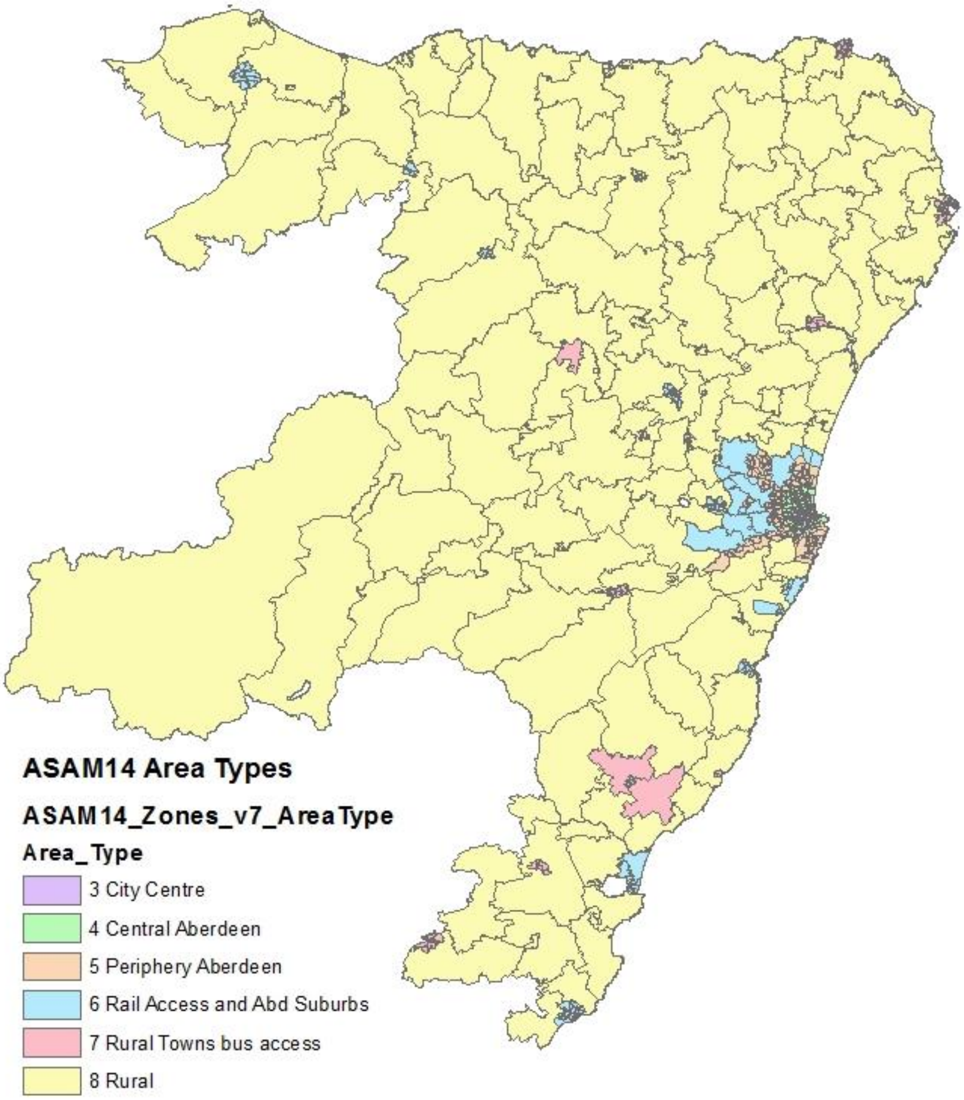

Figure 56. Production Trip Rates Area Type Coverage

External Movement Proportions

15.3.13 As the TEM is applied to create internal demand model productions and attractions, and adjustment was made to remove a proportion of trips associated with externals. Internal demand proportions were developed on a zonal basis to account for the proximity of zones to the external model boundary.

15.3.14 TMfS14 origin-destination assignment matrices were interrogated to generate the proportions of trip ends that produce internal ASAM14 trips. These were applied to the trip ends, which are thus scaled down by an average of 7.6% overall. Proportions are identified on a zonal basis by time period and by the classifications described below. Figure 57 to Figure 59 illustrate the change in internal proportions across the model.

- Car productions;
- PT productions;
- Attractions.

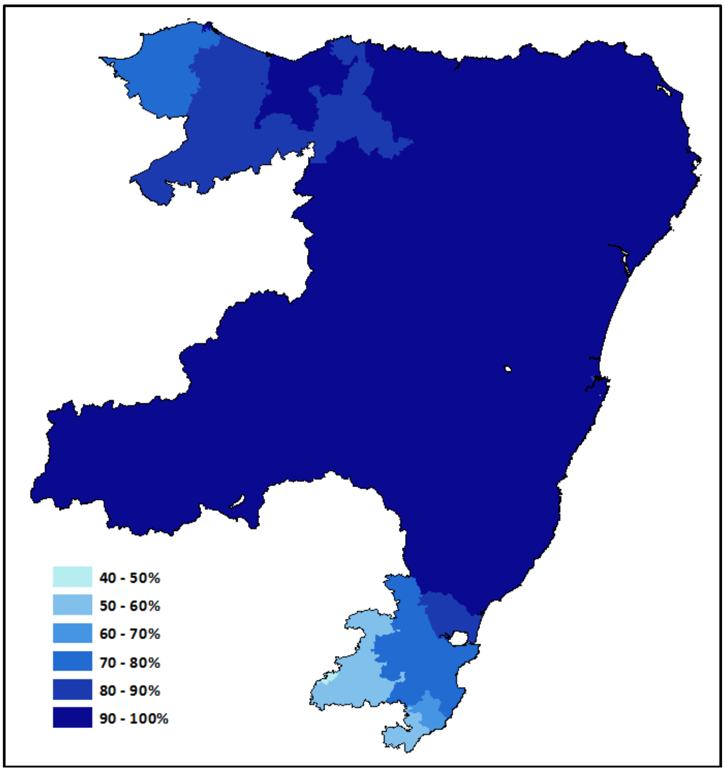

Figure 57. Internal proportions: car productions (average of AM, IP, PM)

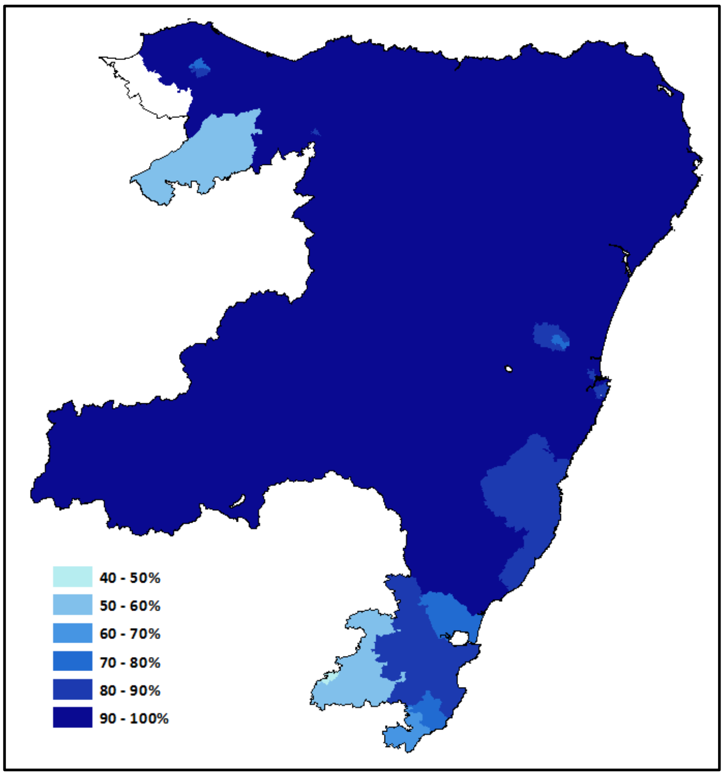

Figure 58. Internal proportions: PT productions (average of AM, IP, PM)

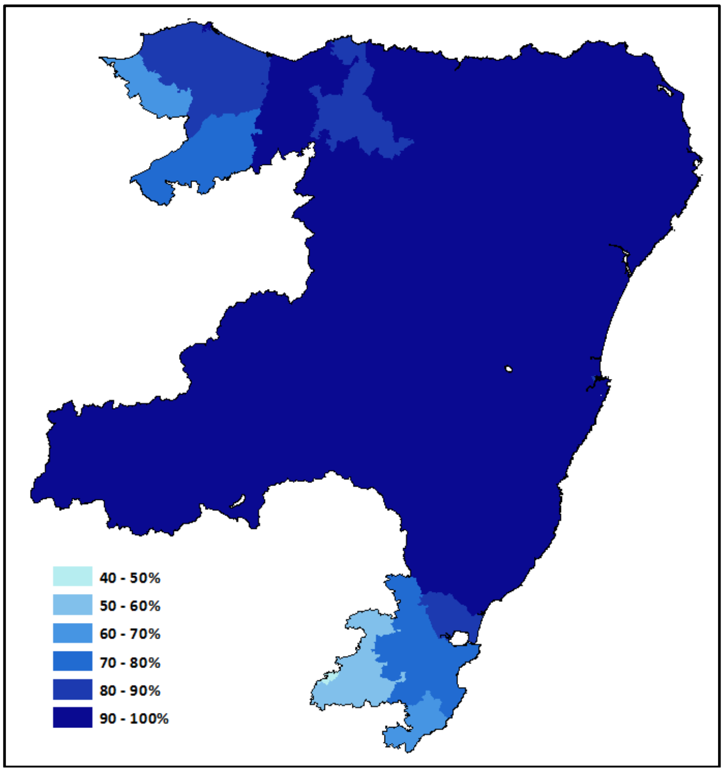

Figure 59. Internal proportions: attractions (average of AM, IP, PM)

Greenfield Sites

15.3.15 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).

15.3.16 Population and employment data associated with new development sites are added to the ASAM14 level ‘TAV’ and ‘TMfS’ planning data files in the trip end model.

15.3.17 A greenfield site file is used to link and describe the proportional level of travel activity for external movements and LGV’s and HGV’s compared to a neighbouring ASAM14 parent zone.

15.3.18 The greenfield process applies a relevant level magnitude and similar pattern of travel to estimate external trips. A gravity model, using forecast year travel costs, is applied to estimate trip patterns for internal LGV, HGV and education trips. This allows trip forecasting between greenfield and existing ASAM14 zones, along with greenfield to greenfield movements.

15.3.19 Greenfield education trip movements are estimated separately for school and university / college trips, an then combined with non-greenfield trips for input to the assignment matrices.

15.4 Model Processes

15.4.1 The Trip End 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.

15.4.2 Each stage also contains processes for calculating Greenfield demand. The main enhancement in ASAM14 is the inclusion of trip productions for the PM Peak period.

Internal Production & Attraction Trip Ends

15.4.3 For non-Greenfield zones the trip ends for the internal zones are growthed using the change in population provided in the (disaggregated) TELMoS planning 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.

15.4.4 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 within the demand model chapter.

15.4.5 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.

15.4.6 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.

15.4.7 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.

15.4.8 The process for growthing 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.

15.4.9 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)

15.4.10 Within the ASAM14 Greenfield processing, trip rate attraction weights (which are not time period specific) are adjusted to reflect the varying levels of travel demand across the AM, Inter Peak and PM periods – providing a set of relevant individual attraction factors for each modelled time period. These values are included within trip rate set 'two' within the attraction file.

Education Trip Forecasting

15.4.11 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 'school' and 'university / college' education trip ends separately using gravity models, with forecast year travel costs which include zone and network details for greenfield sites;
- Combine both greenfield and non-greenfield sets of demand; and
- Re-furness the combined trip ends to the combined demand distribution.

15.4.12 The process outputs trip length distributions for the Greenfield and non-Greenfield demand. Note that Aberdeenshire public transport education movements are excluded from the final matrices as the supply model does not include school bus transport.

Internal Goods Demand

15.4.13 The process to calculate the forecast year Internal LGV and HGV Goods demand matrices has eight stages;

- Convert TELMoS base and forecast commodity matrices to ASAM14 zone level and calculate growth at trip end level;
- Output Base Year Goods demand to origin/destination trip ends and apply growth to ASAM14 base year trip ends to trip ends using TELMoS commodity matrices;
- Furness forecast year level of demand to reflect ASAM14 base year Goods demand distribution;
- Calculate Greenfield demand from relevant proportions of Parent zones;
- Distribute the Greenfield trip ends using a gravity model and forecast year travel costs which include zone and network details for greenfield sites;
- Adjust non-greenfield TELMoS growth to exclude proportion of demand now accounted for within Greenfield sites;
- Combine both sets of trip ends and demand; and
- Re-furness the combined trip ends to the combined demand distribution.

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

External Demand

15.4.15 The process to calculate the forecast year External Add In demand matrices has three main stages;

- apply external growth factors to the Base Year add-in matrices. These growth factors are calculated from examining the relevant ASAM14 external crossing points within TMfS14 base and forecast year model run networks (ie A90 south of Forfar and A96 at Forres);
- calculate the Greenfield demand. The process takes the distribution of trips to/from each ASAM14 Parent Zone and combines them to form the external demand to/from the Greenfield site; and
- the non-Greenfield demand is factored down so that the combined non-Greenfield and Greenfield demand matches the forecast growth from TMfS;

15.4.16 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 to create the final add-in matrices to the AM, Inter and PM Peak assignment matrices. Note that education trips are not separately included within the external processes.

16. FORECASTING & UPDATES

16.1 Model Versions

Initial Base Year Modelling

16.1.1 The model calibration and validation results described within the development report relate to the ASAM14 2014 Base Year:

- Trip End Model version: v0.5
- Demand Model version: v0.3
- Base Year Network: v79
- Base Year Demand: BY01

16.1.2 These models produced a set of initial forecasting results for a standard TELMoS / TMfS14 set of forecasting scenarios from 2017-2037. These scenarios are based on standard ASAM14 base year disaggregation of the TELMoS forecasting planning data, with **no** use of specific greenfield site zones to represent new residential and business development sites. The model structure is set-up with a 574 zone system.

Updated 'Base +' Model Version

16.1.3 An updated model version was created with further Greenfield zoning to represent detailed planning data for significant new residential and business development sites. This relates to the ASAM14 2014 Base Year:

- Trip End Model version: v0.6
- Demand Model version: v0.5
- Base Year Network: BA02
- Base Year Demand: BY01

16.1.4 This model structure is set up with a 630 zone system, with the forecasting process operational to represent Greenfield development sites.

16.1.5 The underlying Base Year road and PT modelling results for this updated version are consistent with those output from the earlier model, with the potential exception of some marginal / decimal differences.

16.1.6 These updated models produced a set of detailed forecasting results - using consistent overall regional / TMfS14 zonal level planning data **and** with specific disaggregation of planning data to separate greenfield zoning for forecasting scenarios from 2017-2037.

16.1.7 The updated model therefore includes changes in matrix dimensions, trip end and demand model forecasting and some minor amendments to network coding where anomalies were identified during initial forecasting (applied consistently through the base and forecast year modelling).


16.2 Forecasting

16.2.1 The ASAM14 model structure is designed to apply planning data forecasts from TELMoS to control 'internal travel growth', and road and public transport road link flows to control 'external travel growth' to/from the North East of Scotland.

16.2.2 The updated forecasts represent internal and external transport movements to/from major development sites with unique zones. Disaggregated using Local Development Plan proposals provided by Aberdeen City and Aberdeenshire councils.

16.2.3 Separate assumptions are used to control:

- Value of Time;
- Public Transport Fares;
- Parking capacity / charges;
- Car occupancy;
- Varying trip rates; and
- Aberdeen Airport and Aberdeen Heliport Passenger Growth.

16.2.4 ASAM14 Do Minimum forecasting scenarios, inputs and assumptions are described within a separate note. A further note describes the changes in traffic and travel impacts associated with the forecast year scenarios. This includes information associated with the AWPR and city centre Masterplan Schemes, describing how these schemes are predicted to change travel patterns over time.

16.2.5 When running the model in forecasting mode, six external demand model loops have been used to run the model towards convergence. Due to the large development growth and number of Do Minimum schemes included within the forecast modelling, users should consider running the model for eight external loops to achieve a higher level of convergence during forecasting.

16.2.6 There is also merit in reviewing the latest WebTAG guidance and potentially consider updating the Value of Time Parameters to the latest information. This type of update would need to be undertaken consistently across the scenarios.

16.2.7 Additional rail services and seating capacity are included as part of the Do Minimum schemes, which is likely to reduce crowding impacts within the rail modelling. These capacity changes may allow users to consider reducing the number of crowding iterations (currently set at five) to reduce model run times during additional forecasting runs.

16.3 User Manual

16.3.1 A separate User Manual document describes the technical use of the ASAM14 model.

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