Aberdeen Sub Area Model 14

Audit Report

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Aberdeen Sub Area Model 14 – Audit Report

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Table of Contents

1 Introduction 2
- 1.1 Purpose of the Report 2
- 1.2 Background 2
- 1.3 Audit Guidance 4
- 1.4 Relevant Guidance 4
- 1.5 Audit Approach 5
- 1.6 Fitness for Purpose Requirements 5
- 1.7 Structure of the Report 6
- 1.8 Acknowledgements 7

2 Model Scope and Structure 9
- 2.1 Introduction 9
- 2.2 Spatial Coverage and Representation 9
- 2.3 Demand Representation 13
- 2.4 Summary and Recommendations 13

3 Data Collection, Collation and Assimilation 16
- 3.1 Introduction 16
- 3.2 Traffic Flow Data 16
- 3.3 Roadside Interview Data 20
- 3.4 Journey Time Route Data 20
- 3.5 Public Transport Data 22
- 3.6 Summary and Recommendations 25

4 Roads Model Development 28
- 4.1 Introduction 28
- 4.2 Network Development 28
- 4.3 Road Model Time Period factors 32
- 4.4 Prior Matrix Development 32
- 4.5 Assignment Model Development 38
- 4.6 Summary and Recommendations 41

5 Roads Model Calibration and Validation 44
- 5.1 Introduction 44
- 5.2 Calibration 44
- 5.3 Validation 54
- 5.4 Summary and Recommendations 60

6 Public Transport Model Development 62
- 6.1 Introduction 62
- 6.2 Public Transport Network 62
- 6.3 Matrix Development 66
- 6.4 Assignment Model Procedures and Parameters 66
- 6.5 Summary and Recommendations 67

7 Public Transport Model Calibration and Validation 69
- 7.1 Introduction 69
- 7.2 Calibration 69
- 7.3 Validation 73
- 7.4 Summary and Recommendations 74

8 Demand Model 76
- 8.1 Introduction 76
- 8.2 Model Scope and Processes 76
- 8.3 Model Calibration 78
- 8.4 Model Validation 79

8.5 Summary and Recommendations 81

9 Performance against objectives 83

9.1 Introduction 83

9.2 Model Design 83

9.3 Model Performance/Data Quality 83

9.4 Recommended Uses of ASAM 84

List of Tables

Table 1-1 Implications of Model Objectives for Model Design and Quality 5
Table 3-1 peak period to peak hour factors – rail, Aberdeen to Dundee..25
Table 3-2 peak period to peak hour factors – rail, Aberdeen to Inverness..25
Table 4-1 ASAM14 Default Junction Saturation Flows 30
Table 4-2 Road Time period to Peak Hour Factors 32
Table 4-3 ASAM14 Base Year Road Assignment Coefficients 39
Table 4-4 Summary of Convergence Measures and Base Model Acceptable Values 40
Table 4-5: Model Convergence Results by Time Period..40
Table 5-1 WebTAG matrix estimation significance guidance 46
Table 5-2 Roads model pre- and post-matrix estimation zonal cell value results.............................46
Table 5-3 Roads model matrix estimation zonal trip end comparisons..47
Table 5-4 Roads model matrix estimation trip length distribution comparisons 47
Table 5-5 Highway matrix estimation sector movement comparisons 47
Table 5-6 Highway matrix estimation sector movement comparisons (> 500 vehicles) 48
Table 5-7 WebTAG screenline performance guideline 48
Table 5-8 Highway calibration screenline performance against webTAG criterion 49
Table 5-9 WebTAG link flow and turning movement validation criteria and acceptability guidelines .52
Table 5-10 Highway calibration individual count performance against webTAG criteria 53
Table 5-11 Highway validation individual count performance against webTAG criteria.....................56
Table 5-12 WebTAG journey time validation criterion and acceptability guideline 58
Table 5-13 Highway validation journey time route performance..59
Table 6-1 PT Time period to Peak Hour Factor...66
Table 7-1 Public transport matrix estimation zonal trip end comparisons 71
Table 7-2 Public transport matrix estimation trip length distribution comparisons.............................71
Table 7-3 Public transport matrix estimation sector movement comparisons 72
Table 7-4 Public transport matrix estimation sector movement comparisons (> 150 passengers) 72
Table 7-5 Public transport calibration screenline performance..72
Table 7-6 Public transport individual count calibration summary..73
Table 7-7 Public transport comparisons with bus timetables...74
Table 8-1 Cost Damping Parameters..78

List of Figures

Figure 2-1 Network Coverage...10
Figure 2-2 Extent of ASAM Zone System..11
Figure 3-1 Screenline Locations Aberdeen City Centre 17
Figure 3-2 ASAM14 Screenline Locations – Aberdeen City...18
Figure 3-3 ASAM14 Screenline Locations – Full network 19
Figure 3-4 Age of Calibration and Validation Counts 20
Figure 3-5 TomTom data coverage..21
Figure 3-6 2016 Inner Cordon Bus Passenger Survey Location 23
Figure 3-7 2014 Aberdeen "Outer Cordon" Bus Passenger Survey Locations 23
Figure 4-1 ASAM14 Network Coverage 29
Figure 4-2 Observed v Modelled Prior Sector Values, Total Road and Parking................................35
Figure 4-3 Observed v Modelled Prior Sector Values, Total Public Transport and Park and Ride 36
Figure 5-1: Count of Sites Used in Calibration Screenlines 45
Figure 5-2 Calibration screenline performance (total vehicles, all time periods) 50
Figure 5-3 AM screenline performance by location..51
Figure 5-4 IP screenline performance by location..51

Figure 5-5 PM screenline performance by location....52
Figure 5-6 Calibration individual count performance (total vehicles, all time periods)....54
Figure 5-7 Validation count locations (links)....55
Figure 5-8 Validation individual count performance (total vehicles, all time periods)....57
Figure 6-1 ASAM14 Wait Curve Definition....65
Figure 7-1 Public Transport calibration locations....70

List of Abbreviations

AQMA	Air Quality Management Area
ATC	Automatic Traffic Counter
BRES	Business Register Employment Survey
DMRB	Design Manual for Roads and Bridges
JTC	Junction Turning Count
PT	Public Transport
RSI	Roadside Interview
SHS	Scottish Household Survey
SRTDb	Scottish Road Traffic Database
STS	Scottish Transport Statistics
TELMoS	Transport Economic and Land-Use Model of Scotland
TMfS	Transport Model for Scotland
WebTAG	Web-based Transport Analysis Guidance

Introduction

01

1 Introduction

1.1 Purpose of the Report

AECOM was commissioned by Nestrans to undertake an audit of the model development work associated with the Aberdeen Sub Area Model (ASAM), intended to provide an updated 2014 base year model to develop future year forecasts (ASAM14). Audit services were defined in scope N14/6, dated 5 September 2016, as:

- *Undertake an audit to determine whether the model upgrade is proportionate and fit for the purposes defined in the Model Objectives.*
- *Make recommendations for model appliers on the use of the model as defined in the Model Objectives.*
- *Make recommendations on what aspects should be improved or enhanced in any future development of the model following completion of the AWPR.*

This report forms the first of two deliverables associated with the audit services. A separate technical note on future enhancements will also be submitted.

The audit has involved a review of the ASAM14 base model networks for the roads and public transport (PT) models and a review of the documentation produced by the model developers, Systra, along with additional documentation and analysis produced in response to queries.

1.2 Background

1.2.1 Model Summary

ASAM is a multi-modal transport model covering the North East of Scotland. The ASAM14 Development Inception Report[1] (henceforth referred to as the "inception report") states (§3.1.1) that:

> *The development of a new ASAM regional model ('ASAM14') provides the opportunity to update and advance the transport modelling across the North East of Scotland and interfaces with other higher and lower tier transport and land use models.*

The original inception of the ASAM model as a sub-area model of TMfS representing the area around the Aberdeen Western Peripheral Route took place in 2002. Previous versions of the model used CUBE Voyager for the demand model, TRIPS for the road and public transport models and ALOGITA for the calibration of the demand model. Several updates to the model took place over the years, the latest (ASAM4) in 2010 to update the model to a 2007 base year. A further update of the model to a 2014 base year has resulted in the current ASAM14.

ASAM14 represents 2014 transport supply, traffic and travel conditions and incorporates updates to align ASAM with TMfS14 and the TELMoS14 national transport model.

The inception report additionally identifies the importance of the ASAM14 in providing an evidence base that will benefit:

- *Outline and Strategic Business Case development – providing travel demand forecasts and cost benefits 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;*

[1] "Aberdeen Sub Area Model (ASAM) Upgrade, ASAM14 Model Development Inception Report", reference number 10381112, Systra, 20/9/2016

- *'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 (AQMAs).*

The ASAM14 presents an update to the previous version of the model incorporating the following enhancements:

- *Software platform to CUBE (Demand and PT) and SATURN (Highway);*
- *Use of Digital GIS data sets 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;*
- *Improved rail fares matrices;*
- *Application of SATURN PASSQ functionality to preload queuing from earlier time periods;*
- *Cost damping to improve response sensitivity; and*
- *Calibration / validation to match recently observed travel data sets.*

ASAM14 includes the following components:

- Trip generation model;
- Behavioural models covering:
    - Mode;
    - Destination; and
    - Parking choices;
- Road model; and
- Public Transport (PT) model.

ASAM14 uses SATURN version 11.3.12U for the road assignment model, and CUBE version 6.4 for the demand and PT elements. CUBE Cluster was used to speed-up run times.

1.2.2 Audit Sources

The audit drew on a number of key pieces of information including:

- ASAM14 Development Inception Report (ref 20160920 103811), Systra, September 2016 ("the inception note");
- ASAM14 Model Development report – Draft (ref 10381122), Systra, June 2018 ("the initial development report");
- ASAM14 Model Development report – Draft (ref 10381122), Systra, May 2019 ("the development report"); and
- Various pieces of bespoke analysis produced by Systra at the Auditor's request.

Where appropriate, additional sources are listed in detail at the start of each chapter.

1.2.3 LATIS Models

Other transport models within the LATIS service are referred to within this report, as they serve as a source of data, parameters, or other form of input. Relevant models are:

- Transport Model for Scotland ’12 (TMfS12): update to TMfS07, rebasing the model to 2012;
- SEStran Regional Model 12 (SRM12);
- Transport Model for Scotland ’14 (TMfS14): update to TMfS12, rebasing the model to 2014; and
- Transport and Economic Land-use Model of Scotland ’14 (TELMoS:14): a land use model which provides a view of future land use and a representation of the interaction between the pattern of land use and transport demand over time.[2]

1.3 Audit Guidance

It is assumed all users of ASAM14 have sufficient technical knowledge of the transport modelling concepts and software packages pertinent to the application of the model. ASAM14 is owned by Nestrans. Transport Scotland have agreed with Nestrans that applications for using the model will be managed in an identical manner to Transport Scotland’s suite of regional and national transport models. Where insufficient detail is available from the supporting model development documentation, or this Audit Report, users should, therefore, refer to the LATIS support team for advice. Contact details and the Terms of Use can be found on the LATIS website.

Applications of any part of the modelling component of the LATIS model, including the use of model data or outputs is subject to permission from Transport Scotland, which is obtainable through the completion and submission of a LATIS User Request Form. This includes the ASAM and its inputs and outputs.

In line with the Audit Specification Report, the audit process documented in this report has considered the development, calibration and validation of the ASAM14 base model. While the audit seeks to undertake a thorough review this has been balanced against the practicality of undertaking the audit within an appropriate timeframe and making best use of the resources invested by Nestrans in this process. By implication, topics not outlined or referenced in this Audit Report should be considered as not having been subject to the audit process.

It is assumed that any user of the model will undertake a thorough review of ASAM in their intended study area to establish fitness for purpose of the model in the context of the application. This review process should continue throughout the model application to ensure that appropriate amendments are included and to verify the robustness of any assumptions made, the model inputs, and its outputs in forecast mode. If in any doubt over this matter users should seek advice and clarification through the LATIS service. This will enable any issues to be resolved and if required, rectified for any future model releases.

1.4 Relevant Guidance

The development of transport models in Scotland is subject to best practice advice as outlined in the Transport Analysis Guidance released by the Department for Transport. The following units are relevant to this audit:

- TAG Unit M2 Variable Demand Modelling;
- TAG Unit M3-1 Highway Assignment Modelling;
- TAG Unit M3-2 Public Transport Assignment Modelling;
- TAG Unit M4 Forecasting and Uncertainty;
- TAG Unit M5-1 Modelling Parking and Park and Ride, and residual aspects of DMRB/TAM that relate to trip matrices.

References to relevant paragraphs in these documents have been in included in each section of the report.

[2] http://www.transport.gov.scot/latis/national-transport-and-land-use-models#telmos

1.5 Audit Approach

The model development was intended to be undertaken to an extremely challenging programme, and is an update intended for short term use prior to a major update, being undertaken with limited new data. The demand model structure was to be taken from other regional models within Scotland, which have already been audited.

Given the above constraints, AECOM proposed a proportionately high level audit, focusing on understanding the main risks in model application, rather than detailed commentary on the approaches to model development that are restricted by the model development programme. Specifically:

- Comment on limits to demand data sources and uncertainty;
- Review methods of development of supply side, but not provide detailed independent review of quality which should be provided in the development reporting prepared by the model developer;
- Upon receiving confirmation from Systra that the approach from another audited model is being used, the demand model and park and ride model structures would not require additional audit;
- Concentrate on the calibration and validation of the assignment models, and the realism testing, to allow commentary on the suitability of the model for the types of studies listed in the objectives.

1.6 Fitness for Purpose Requirements

The objectives listed in §1.2.1 have implications for both the design of the model and the level of validation against observed data that should be achieved in the model development. This is summarised in Table 1-1, with the quality of validation expressed in terms of the criteria detailed within WebTAG. .

Table 1-1 Implications of Model Objectives for Model Design and Quality

Objective	Design	Performance/Data Quality
Outline Business Case, major proposals	Coverage of highway and PT modes and travel demand behaviour across the area where proposals will have material impacts	WebTAG where the scheme will have material impacts
Strategic Business Case, major proposals		Lower than WebTAG accuracy tolerance can be acceptable, provided forecasting uncertainty is appropriately explained to inform decision makers about the reliability of information
Development plans, DPMTAG	Generally detailed local coverage, particularly for highway, in the vicinity of the development	WebTAG in area materially impacted
Cumulative Development Plans across North East and potential mitigation	Coverage of highway and public transport models and travel demand behaviour, across the area where proposals would have material impacts	Lower than WebTAG accuracy tolerance can be acceptable, provided forecasting uncertainty is appropriately explained to inform decision makers about the reliability of information
Changes in travel patterns caused by AWPR , locking in benefits	Coverage of highway travel demand across the Aberdeen area, with capability to forecast redistribution and route changes caused by the scheme	WebTAG across all major radials and routes within / near Aberdeen that could be impacted.
City centre SUMP, parking constraint and routeing strategies	Spatially detailed representation of city centre and radial routeing patterns, covering highway, public transport and probably active modes, together with capability of representing parking costs on route and destination choice behaviour	WebTAG across city centre and radials

Objective	Design	Performance/Data Quality
Regional Transport Projects	As for business case requirements	
Informing detailed microsimulation models of traffic demand change	Highway travel demand and routeing over area covered by microsimulation	WebTAG, but with added requirement on the quality of demand data, particularly HGVs
Traffic flows and composition in AQMAs	Highway travel demand and routeing	

A test of model adequacy for the model design can be summarised as:

1. There must be a fully modelled area covering the hinterland/North East adequate for the proposed range of schemes.
2. Within this area highway and public transport networks must be represented in reasonable detail. If the schemes are focused on new A roads then the network should include B and key minor roads (ie one 'grade' more detailed).
3. Across Aberdeen there must be a similar representation of radial / routeing and there should be evidence on the credibility of changes (routeing and redistribution) in response to land use change and AWPR.
4. Within the city centre there must be spatially detailed representation of the transport networks. It is unlikely that this can be limited to A/B roads. There must be some mechanism to represent parking costs / access time that affects demand modelling
5. Depending on the range of policies there may be a need for representation of active mode demand.

The test for model adequacy against objectives in regards to performance/data quality can be summarised as:

1. The demand matrices must be verified against observed origin destination information to represent completely broad travel patterns across the North East and to / from this area. There must be finer grain analysis / verification within Aberdeen City.
2. Highway and PT network performance must be tested against WebTAG accuracy requirements within and near Aberdeen City. Analysis of performance in respect of AWPR, city centre and AQMAs must demonstrate acceptable performance or explain limitations of use.
3. Analysis of performance standards and data quality across the North East should explain the model quality and extent to which the outputs can be used, eg for initial planning purposes, and where refinement would be necessary in preparing outline / full business cases.

1.7 Structure of the Report

This report contains a further nine chapters, the contents of which are summarised below:

- Chapter Two describes the model scope and structure;
- Chapter Three audits the processing of data for the model development;
- Chapter Four reviews the Road assignment model;
- Chapter Five presents an analysis of the calibration and validation of the Road assignment model;
- Chapter Six reviews the Public Transport (PT) assignment model;
- Chapter Seven audits the calibration and validation of the PT assignment model;
- Chapter Eight reviews the Demand model;
- Chapter Nine reports the audit of the Park and Ride Model; and
- Chapter Ten presents an overall Summary and Conclusions.

Audit recommendations are summed up at the end of each chapter.

1.8 Acknowledgements

AECOM wish to acknowledge the assistance and cooperation of Nestrans, Transport Scotland, and Systra in supplying the necessary information during the course of this audit.

Model Scope and Structure

02

2 Model Scope and Structure

Relevant guidance:

Tag Unit M2 Variable Demand Modelling, March 2017

Tag Unit M3.1 Highway Assignment Modelling, January 2014

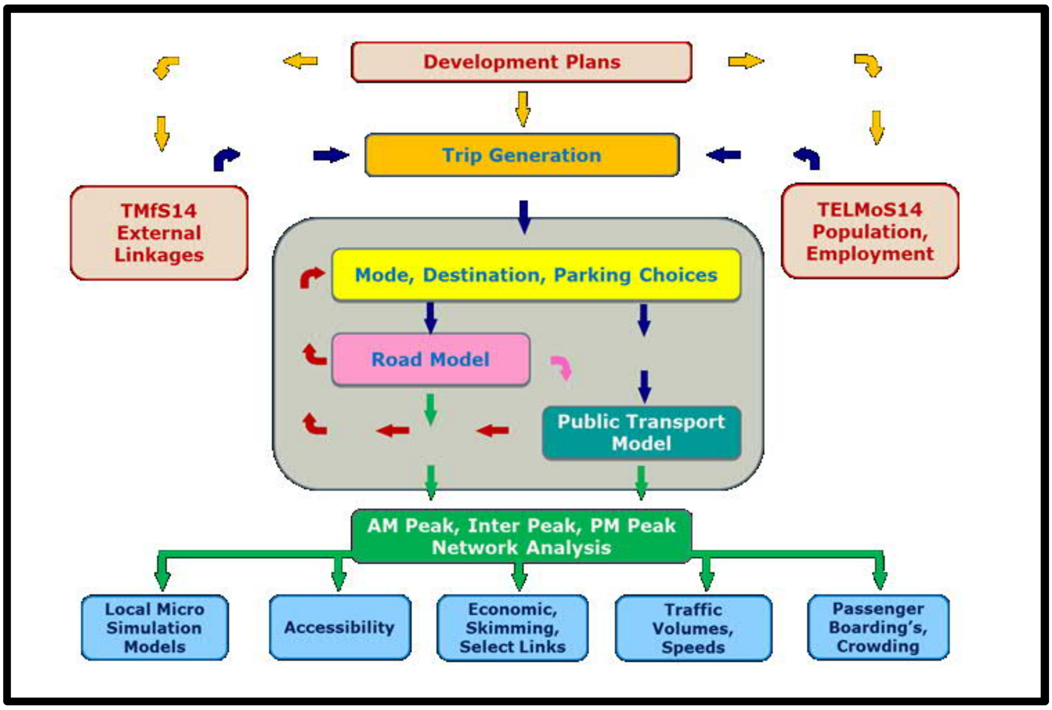
Tag Unit M3.2 Public Transport Assignment Modelling, January 2014

2.1 Introduction

This section considers the general structure of the model and covers the following:

- Model background;
- Spatial coverage and representation; and
- Demand representation.

The overall model structure of ASAM14 is as follows:



2.2 Spatial Coverage and Representation

2.2.1 Modelled Area

We note that the main body of ASAM14 covers an area from the north of Inverurie at its northernmost to south of Stonehaven in the south, and from east of Inverurie at its westernmost to the east coast of Scotland. An additional part of ASAM14 covers a further part of the East Coast Mainline towards Montrose in the south (Figure 2-1).

The development report (§2.24) also states that additional parts of Angus and Moray have been included to improve representation of the travel to work area for Aberdeen.

The auditor considers the modelled area to be suitable for the model objectives.

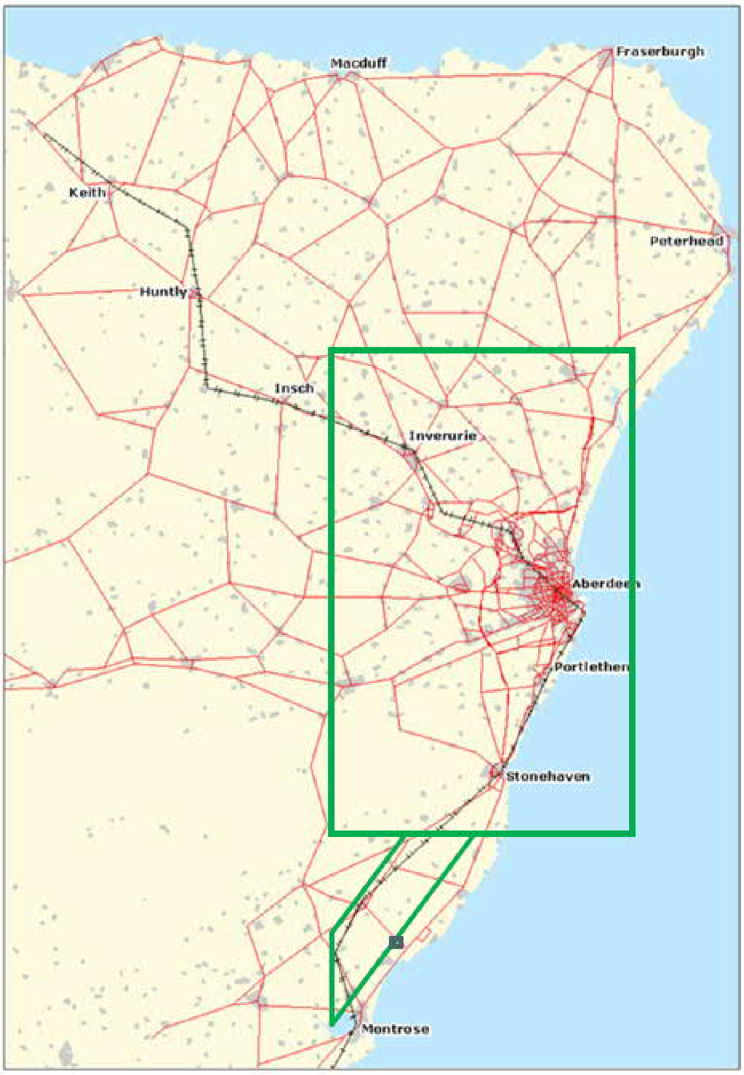


Figure 2-1 Network Coverage

2.2.2 Model Zoning

2011 Census boundaries have been applied to create the zoning system for TMfS14 and TELMoS. We note that, for consistency, ASAM14 zoning was updated to form dis-aggregations of TMfS14 zones.

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. The extent of the zone system is shown in Figure 2-2.

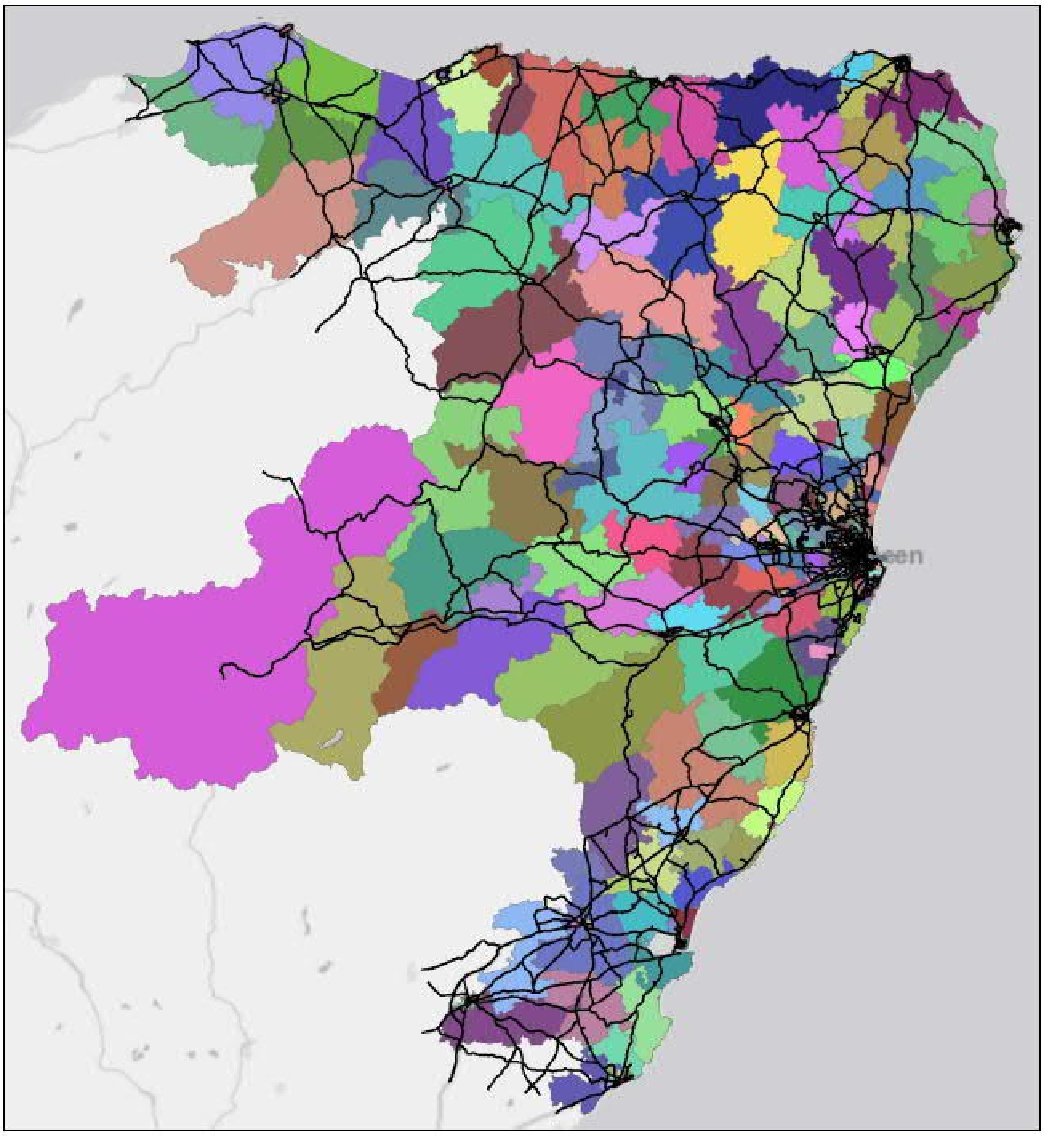


Figure 2-2 Extent of ASAM Zone System

As part of the present update, additional network and zonal detail was incorporated in the following areas:

- Aberdeen City Centre;
- Key towns and commuter corridors, including Stonehaven, Portlethen, Banchory, Westhill, Inverurie, Kintore, Ellon and Peterhead; and
- The Laurencekirk Montrose corridor.

Following the inclusion of more detailed zoning in these areas the zoning system comprises 574 zones, including:

- 507 internal demand modelling zones, including 21 spare zones;
- 29 parking capacity zones, including 5 spare zones;
- 25 Park and Ride zones, including 11 spare zones;
- 13 external route zones, representing the A90, A92, A96 and A93 etc and reflecting the boundary with TMfS14

The development report (§3.1.2) also states that provision was made for future updates through the inclusion of an additional 55 spare demand model zones.

The methodology followed in developing the zone system is described in §3.2.4 of the development report. The process appears appropriate. More specifically we comment as follows:

- The overall level of zonal details and the provision of additional detail in areas relevant to the purpose of the model are appropriate to the stated objectives and model requirements as outlined in §1.2 of this report.
- TAG Unit M3.1 recommends (§2.3.11) that "..the numbers of trips to and from each zone should be some relatively small number, such as 200 or 300 per hour...". Dis-aggregations based on zonal population and employment were applied to prevent large volumes of traffic loading into a single point. The development report states that a threshold of around 1,000 households was applied to limit the volume of traffic loading at any one point to under 500 vehicles per hour, based on a trip rate of around 0.3 per peak hour per household. A detailed review of the network loadings is outwith the scope of this audit. However, the thresholds stated should be sufficient to limit excessive zonal loadings. Similarly, where possible a threshold of a 1,000 jobs was applied to limit loadings associated with employment zones.
- The 2011 Census provided the key data on population and employment, supplemented with 2011-2014 Business Register Employment Survey (BRES) data and 2011-2014 mid-year population estimates from National Records of Scotland to account for growth between 2011 and 2014. New employment growth to 2014 at the Prime Four sites near Kingswells was also included in the base year model.
- The ASAM household and employment totals were constrained to TELMoS levels through a process which applying factors derived from the ASAM population and employment levels to disaggregate the TELMoS totals.

2.2.3 Zone Connectors

The process for zone connector coding is described in the development report §3.2.8 to §3.2.11. Zones were connected to the main network using spigots, i.e. less detailed links which do not represent capacity constraints.

The approach described is in line with WebTAG requirements to represent actual access and egress points and represent differences in access costs across the modelled area through applying larger connector distances in rural areas where there is less network detail. The default distances used are listed in the development report (§4.4.13):

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

TAG Unit M3.1 (§2.4.14) also advises that:

> *In general, centroid connectors should not be connected directly into modelled junctions unless a specific arm exists to accommodate that movement.*

Whilst this is not stated explicitly, we are content that based on a review of the maps provided in Figures 5 and 6 of the development report connectors have been coded in line with this requirement, at least in the central area of the model.

The development report (§3.2.10) states that

> *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.*

We are content that in general together with the thresholds limiting zone size described in the §2.2.2 this is likely to limit excessive volumes of traffic loading onto a single network point. **However, it is recommended that the level of zonal detail and connector loadings in the study area are reviewed in advance of specific model applications.**

2.3 Demand Representation

2.3.1 Modelled Time Periods

The modelling time periods used in ASAM14 are:

- Am Peak (0700-1000)
- Inter-peak (1000-1600)
- PM Peak (1600-1900)

The time periods for the roads and PT assignment models are:

- AM peak hour (0800 - 0900)
- Interpeak hour (1/6 of 1000 - 1600)
- PM peak hour (1700-1800).

The time periods are consistent with TMfS14 and are appropriate.

2.3.2 User Classes

Five user classes are used in the road assignment model, consistent with those used in TMfS14, which are as follows:

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

Travel purposes will be consistent with the TMfS14 structure, with the following three purposes represented:

- Car & PT In Work (business trips);
- Car & PT Non-Work Commute (commuter trips to/from place of work); and
- Car & PT Non-Work Other (including shopping, leisure, education, etc).

The PT model represents three distinct modes of transport, which are:

- Intra-urban Bus;
- Inter-urban bus; and
- Rail.

The development report (§5.1.6) states that the model represents school travel within Aberdeen through scheduled bus services but does not include public transport travel to and from schools in Aberdeenshire through specific school bus services.

2.4 Summary and Recommendations

This section summarises the comments arising from the audit for each section. Where audit recommendations have been offered, they are divided into “Advice for Nestrans on future model development”, “Requested analysis from model developers”, and “Advice for model users”.

2.4.1 Spatial Coverage and Representation

No substantial issues have been found with the model scope and structure, which is appropriate for a regional model of North East Scotland, and for the model objectives. The level of zonal detail has been extended substantially as part of the update and additional areas have been included in the demand model to more fully represent the travel to work area. This should provide improved representation in relation to the intended model applications stated in §1.2.1.

The following minor recommendations are made:

Advice for model users:

- The level of zonal detail and connector loadings in the study area should be reviewed in advance of specific model applications.

2.4.2 Demand Representation

No issues have been found with the definition of demand segments in the model. Time periods and user classes in the model are suitable.

Data Collection, Collation and Assimilation

03

3 Data Collection, Collation and Assimilation

Relevant guidance:

Tag Unit M2 Variable Demand Modelling, March 2017

3.1 Introduction

The use of statistically robust and up-to-date data is fundamental to the development of reliable and fit for purpose transport models. An assessment of data adequacy and the methods to address shortcomings lies at the heart of the balance between risk and timely delivery of model results. This section reviews key pieces of data used by Systra in the development of ASAM14.

3.2 Traffic Flow Data

3.2.1 Data Availability

The data sources for traffic count data used in the calibration and validation of the ASAM14 are listed in §7.2.1 of the development report:

- *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*

The auditor further recommends that processed data from previous models is only used where the processing is documented adequately. In the absence of such documentation, raw data should be obtained and the processing repeated.

It is stated in the development report (§7.2.2-§7.2.5) a factoring process was adopted to bring the various data sources to a common base year:

> *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.*

We infer from this that the lack of growth in the Scottish Transport Statistics did not compare well with analysis of long term ATCs, or tally with local knowledge of changes in the study area. The approach adopted is, therefore, reasonable.

Where no survey data was available, 15 modelled flows from ASAM4 were used. These were uplifted from 2007 to 2014 through the application of an uplift factor of 7%, which is within 0.22% of seven annual increases of 1%.

Though not ideal, it is accepted that the use of previous model data is, in some circumstances, better than an absence of any data. We note that the reporting of the screenline performance in Appendix E notes the year that the observed value was collected, and whether the value was derived from the previous model. This will help model users interpret the robustness of the model, and is to be welcomed.

Figure 3-1 Screenline Locations Aberdeen City Centre[3]

[3] ASAM14 Model Development Report, SYSTRA, June 2018, Figure 32

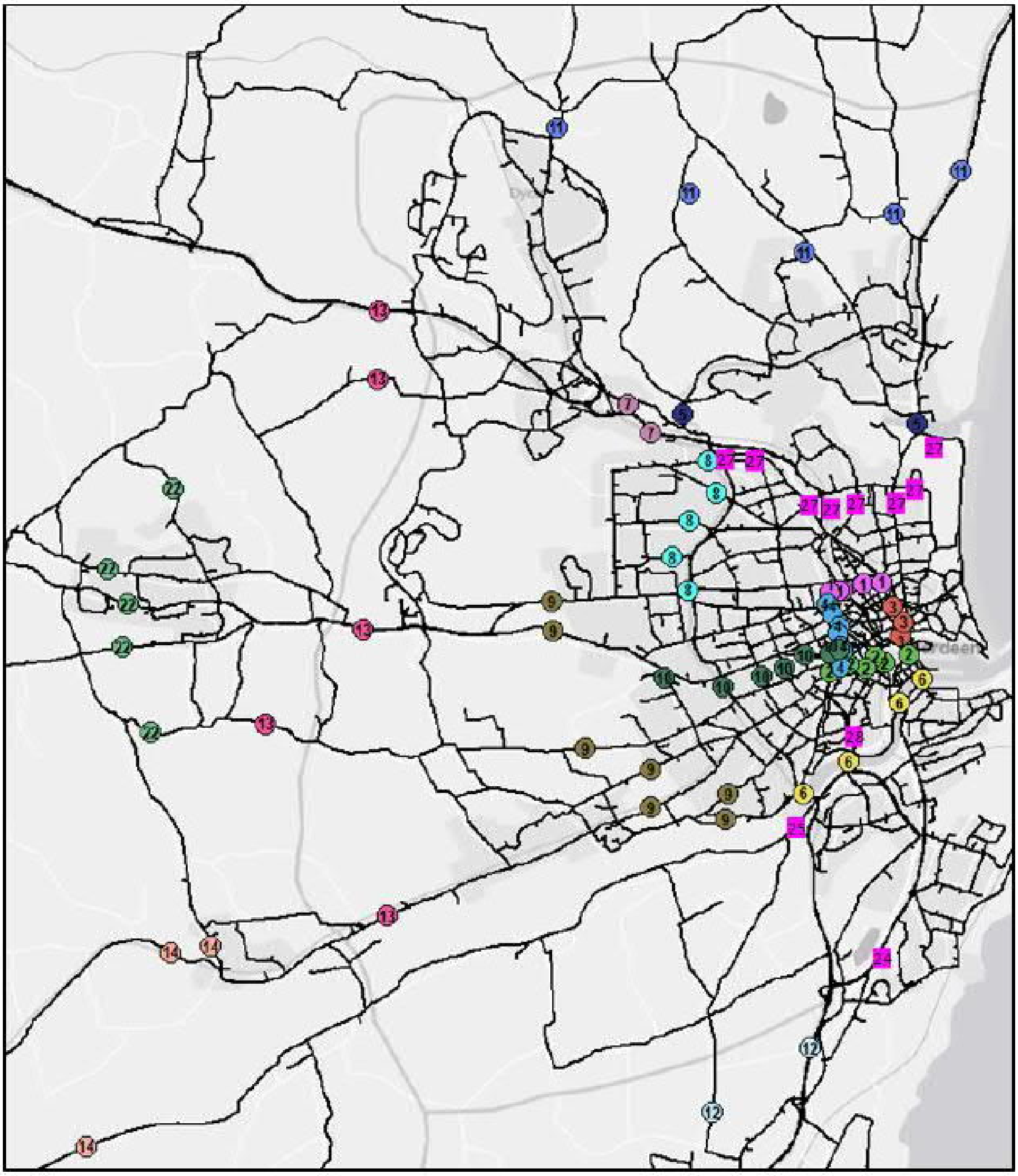


Figure 3-2 ASAM14 Screenline Locations – Aberdeen City[4]

[4] ASAM14 Model Development Report, SYSTRA, June 2018, Figure 33

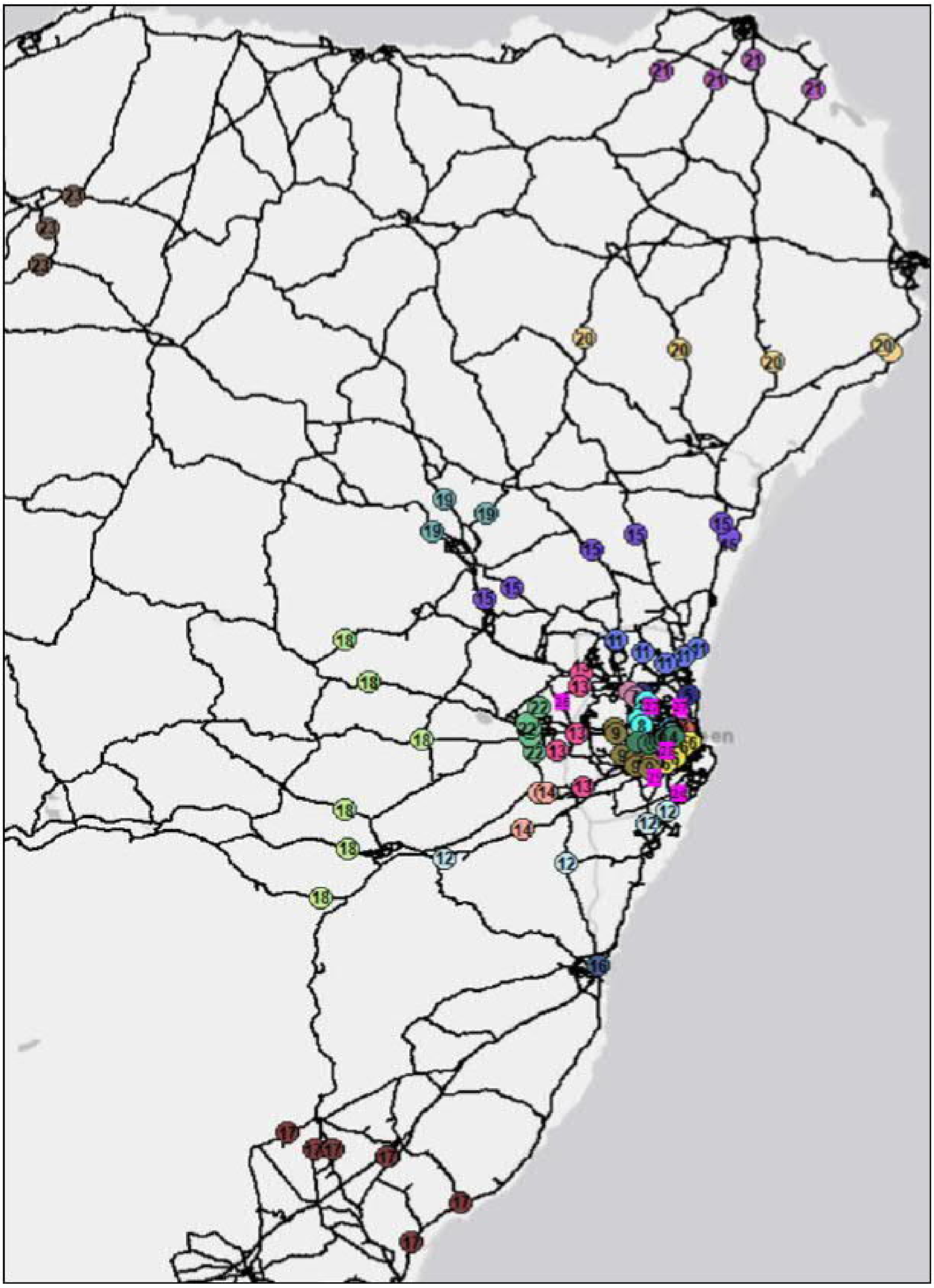


Figure 3-3 ASAM14 Screenline Locations – Full network[5]

The data availability appears reasonable for a model of this size and focus with an appropriate concentration on the key road corridors.

DMRB guidance with respect to the age of data (Volume 12, Section 1, Part 1, §2.2.31) recommends that:

> *Where a model is based mainly on data more than about 6 years old then the validation should be carried out on a "forecast" of the present day*

Both the Calibration and Validation count datasets feature data from 2007. Figure 3-4 shows the number of counts used from each year.

[5] ASAM14 Model Development Report, SYSTRA, June 2018, Figure 34

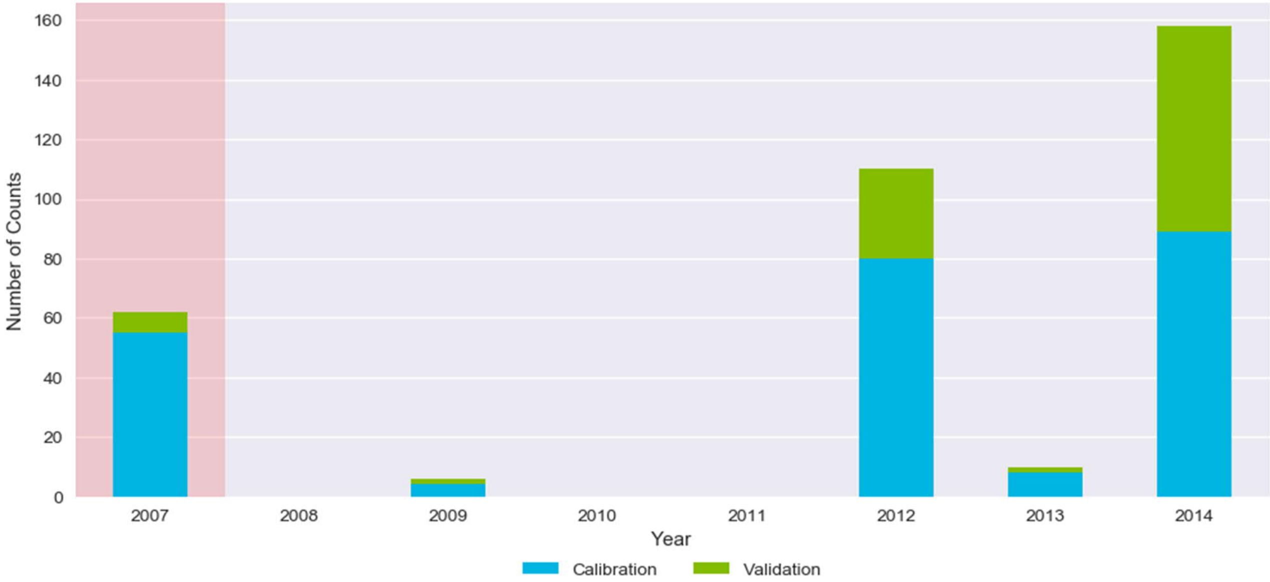


Figure 3-4 Age of Calibration and Validation Counts

23% of calibration and 6% of validation count data used in the model dates from years at least six years prior to 2014. **The auditor recommends the use of more recent Calibration and Validation counts in future versions of the model**.

3.2.2 Data Cleaning and Processing Methodology

The development report provides limited information regarding the methodology employed in the cleaning and processing of traffic count data. **The auditor recommends that a summary of steps taken to clean and process traffic counts is included in the report. This should include a clear definition of the months and weekdays considered neutral.**

Not all of the surveys listed are long term sites. **The report should also state any adjustments to make data from short term traffic surveys representative of neutral month averages, such as the application of seasonality factors.**

The report confirms that factoring was applied to make the traffic counts representative of the 2014 base year, using traffic growth factors based on vehicle kilometres as recoded in the Scottish Transport Statistics 2013. **The auditor notes that this includes data up to 2012 only and that traffic growth factors should include growth up to the base year of the model.** It is not clear from the reporting whether traffic growth factors were calculated from Scotland-wide data or from data reflecting Local Authorities in the modelled area. The use of the latter is recommended.

3.3 Roadside Interview Data

No new Roadside Interview Data was used in the development of the ASAM.

3.4 Journey Time Route Data

The journey time validation of the ASAM drew on TomTom Satellite navigation journey time data. The development report notes that this included data representing weekdays between 13th January and December 19th December 2014, suggesting that non-neutral months may be included. The auditor notes that all data used in model development should represent neutral periods as listed in WebTAG Unit M1.2 (§3.36), namely, Mondays to Thursdays in:

- *late March and April – excluding the weeks before and after Easter;*
- *May - excluding the Thursday before and all of the week of each Bank Holiday;*
- *June;*
- *September – excluding school holidays or return to school weeks;*

- *all of October; and*
- *all of November – provided adequate lighting is available.*

Clarity should be provided as to whether non-neutral periods were removed prior to use of the data for model validation. Model users should be aware of the possible incompatibility between the datasets used and the possible lack of neutrality in the journey time data. **For future model versions, the auditor recommends care is taken to ensure direct compatibility is maintained between all input data sets**.

TomTom “area-based “ product was provided for the area shown in Figure 3-5.

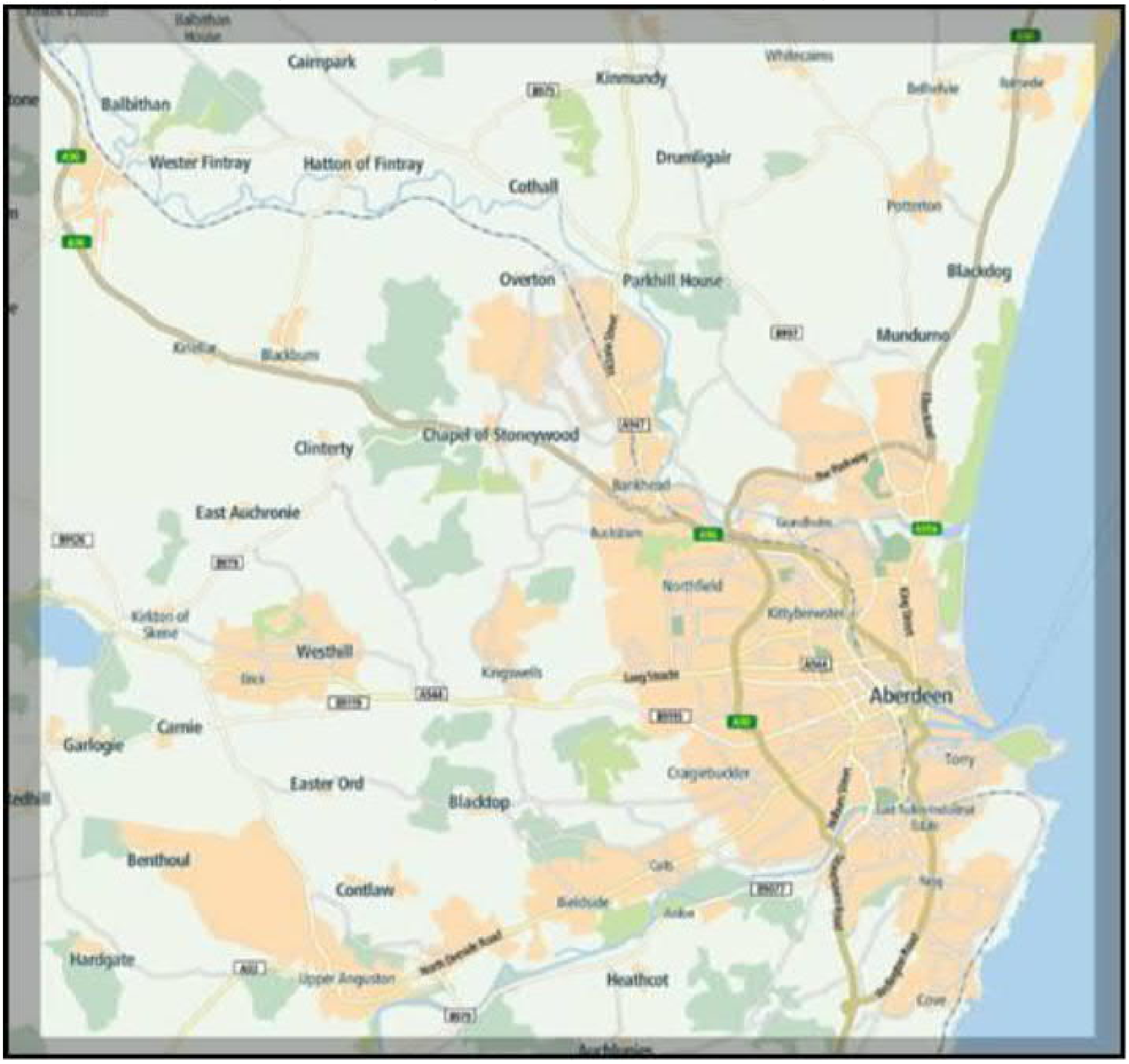


Figure 3-5 TomTom data coverage

Mean and median link travel times were provided. The link journey-times provided were accumulated to provide route journey times for the twelve journey time validation routes, as listed in §5.3.6.

Validation route journey times were processed to provide averages for the AM peak (0800-0900), Interpeak (average of 1000-1600) and PM peak (1700-1800) periods. This is consistent with the definition of the modelled time periods for the roads assignment model.

The report notes (§8.4.8) that

> *As TomTom data is collected over a long period, it is likely to include periods of disruption caused by roadworks and potentially accidents.*

This was addressed (§8.4.9) by

> *..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…*

Potential bias from roadworks and other incidences should ideally be dealt with by the supplier by seeking information on areas where major disruption occurred during the survey period and removing compromised periods prior to averaging. **It is recommended that clarity is gained from TomTom on the screening methodology (if any) that is applied to remove journey times affected by incidents, so that the errors and biases in the data derived are better understood.**

This issue was reflected in the processing of the journey times for validation by (§8.4.10)

> *…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.*

The choice of the 25:75 split is discussed:

> *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.*

A reasoned interpretation of input data is to be welcomed. However, for future model updates we **recommend working with the journey time data supplier in order to define the most appropriate averaging method for the supplied dataset.**

It should be noted that TomTom provides journey time averages over a specified period. **The report should confirm what if any adjustments were made to ensure that the time periods used in generating the averages were free from major road works, incidents or similar biases.**

It should also be noted that the values provided in the dataset are the average of all recorded vehicles using a given link, irrespective of the turning movement at the downstream intersection. When aggregating individual links into journey time routes for use into continuous routes, therefore, biases can potentially be introduced if significant flows with different average delays turn off the route. **For future models, the auditor recommends that a review of each journey time route is undertaken, to ensure that any such biases are identified and, where necessary, adjustments are made to compensate**.

WebTAG recommends that surveys are undertaken that measures mean travel times with 95% confidence to an accuracy of ±10%. **For future models, model developers should make efforts to establish the confidence that can be placed in the journey time data used by the model development.**

3.5 Public Transport Data

3.5.1 Data Availability

Data sources for the public transport data used in the development of the ASAM are described in §9.2 of the development report. This included:

- 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.

Further bus passenger data for the A90 North Ellon to Aberdeen corridor was provided by an operator.

Bus surveys

A map showing the locations covered by the bus occupancy surveys is shown in Figure 3-6 (Inner Cordon) and Figure 3-7 (Outer Cordon). Sites 8 and 9 in Figure 3-7 represent rail count locations.

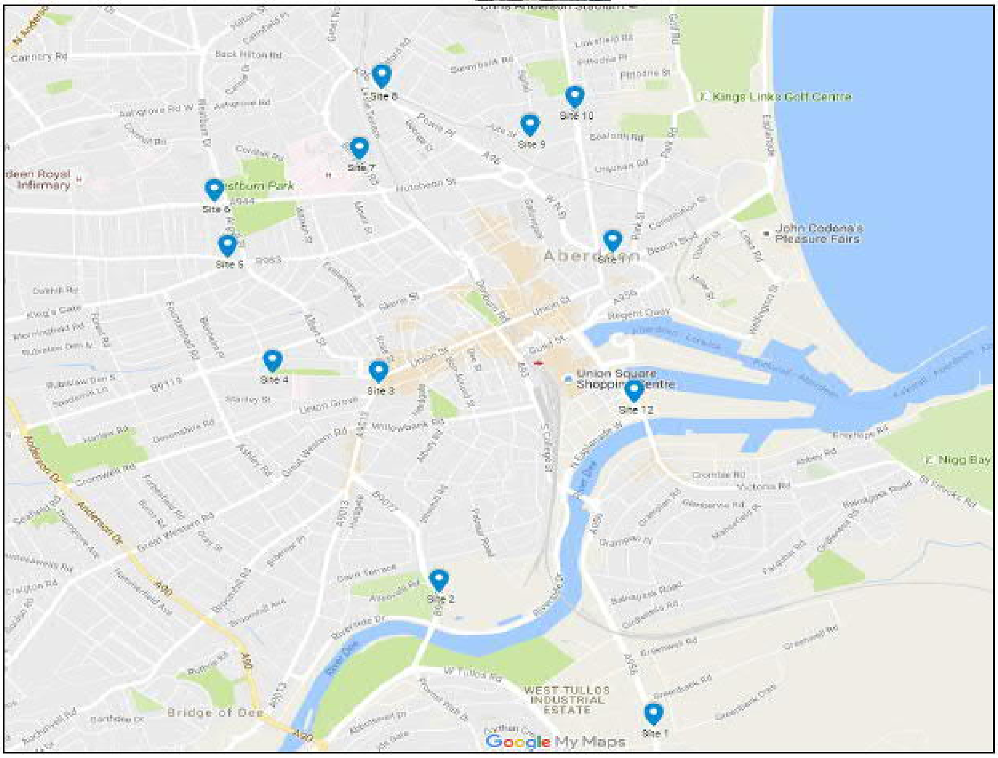


Figure 3-6 2016 Inner Cordon Bus Passenger Survey Location[6]

Figure 3-7 2014 Aberdeen "Outer Cordon" Bus Passenger Survey Locations[7]

This include existing surveys capturing strategic bus journeys crossing a cordon outside the A90, which were collected in June 2014 to inform the development of TMfS and bespoke surveys to capture movement across a cordon around the City Centre of Aberdeen undertaken in September 2016.

[6] Source: ASAM14 Model Development Report, SYSTRA, June 2018, Figure 45
[7] Source: ASAM14 Model Development Report, SYSTRA, June 2018, Figure 46

The Auditor has reviewed the cordon survey locations, and is content that the great majority of scheduled bus services would be included.

Data for the validation of bus journey times was extracted from 2016 timetables. It should be noted that these were accepted as 'true' representation of journey times for the purposes of model validation. **In any future model development, the validity of the bus timetable journey times should be investigated**.

Bus origin destination surveys were not progressed as part of ASAM14 development as discussions between the client group and model developer concluded that the coverage involved would provide relatively limited value in terms of validation.

Rail surveys

Data describing passenger flows on the Aberdeen to Dundee corridor was based on rail passenger surveys of boardings and alightings undertaken in May 2015. Data for any services not provided were filled based on 2012 data or data from the 2015 surveys which covered similar services.

Data describing the Aberdeen to inverness corridor was based on processed data from TMfS. This was based on rail passenger surveys undertaken in February 2013.

3.5.2 Data Cleaning and Processing Methodology

Bus surveys

The 2014 and 2016 counts were based on roadside observation. WebTAG Unit M1.2 provides (§3.4.7) the following advice on the preferred methodology for passenger counts

> *Estimates of the numbers of passengers on public transport vehicles made by observers standing at the roadside will not, generally, be sufficiently accurate for any of the purposes listed in §3.4.3 [expanding interview samples; use as constraints in matrix estimation; and validation of trip matrices and assignments].*

A brief note of the processing methodology for bus passenger surveys is provided in §9.2.5 to §9.2.7 of the development report. The standard capacity assumptions used in converting the estimated percentage occupancy recorded during the surveys to bus passenger counts are listed in Table 45 of the development report, and are inherited from TMfS14.

The development report (§9.2.7) pays cognisance to the approximate nature of the data and states the measures applied to sense-check the data:

> *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.*

Spot checks to validate the bus occupancy data were also undertaken based on operator data for southbound bus movements between Ellon and Aberdeen.

Whilst we recognise the efforts made to ensure data is sensible, **it is recommended that any future passenger counts are undertaken in line with the advice on survey methods in WebTAG Unit M1.2 §3.4.**

The development report goes on to mention (§9.3.3) that patching was undertaken to correct for identified errors. The sites are identified separately in the reporting (through brown shading) to enable the reader to better interpret results.

The development report (§9.2.6) also states that

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

This is reasonable.

Rail Surveys

Aberdeen to Dundee corridor

The processing of the rail passenger surveys is described in §9.2.11 to §9.2.14 of the development report. Peak period flows were extracted from the survey data and factored to peak hours using the factors shown in Table 3-1.

Table 3-1 peak period to peak hour factors – rail, Aberdeen to Dundee

Direction	Time period	Peak period to peak hour factor
Northbound	AM	0.532
Northbound	PM	0.525
Southbound	AM	0.680
Southbound	PM	0.522
Both directions	IP	1/6

Peak hour to peak period factors were derived by

calculating a factor for each station, and then an average across all stations for each direction

We infer from this that an unadjusted numeric mean of the factors was calculated. A flow weighted average would be a more robust solution.

Aberdeen to Inverness corridor

Data for the Aberdeen to Inverness corridor was processed as part of the development of TMfS14. A brief description of the methodology is provided in §9.2.15 to §9.2.21 of the development report.

The peak period to peak hour factors were based on the TMfS14 peak hour factors and are stated in Table 3-2.

Table 3-2 peak period to peak hour factors – rail, Aberdeen to Inverness

Time period	Peak period to peak hour factor
AM	0.45
IP	1/6
PM	0.44

The auditor notes that based on a comparison of the local factors for the Aberdeen to Dundee corridor (Table 3-1) the use of national factors may result in underrepresentation of peak-hour flows to and from Aberdeen.

Details of any seasonality and growth factors applied to ensure that the rail data is representative of 2014 average neutral month conditions should be provided in the development report.

3.6 Summary and Recommendations

3.6.1 Traffic Flow Data

Advice for Nestrans on future model development:

- Local adjustment factors should be used to modify older counts;
- More recent Calibration and Validation counts should be used;
- A summary of steps taken to clean and process traffic counts is included in the development report. This should include a clear definition of the months and weekdays considered neutral;
- The report should also state any adjustments to make data from short term traffic surveys representative of neutral month averages, such as the application of seasonality factors;

Requested analysis from model developer:

- Where processed data from other models is used, ensure processing has been adequately documented and is in line with WebTAG. In the absence of such documentation, raw data should be obtained and the processing repeated;
- Review the methodology for deriving traffic growth factors to ensure they include growth up to 2014.

3.6.2 Journey Time Route Data

Advice for Nestrans on future model development:

- In future updates, care should be taken to maintain direct compatibility between datasets in terms of neutral months and days of the week included;
- Seek confirmation from TomTom on the screening methodology that is applied to remove journey times affected by disruption from roadworks and incidents;
- Review journey time routes should be undertaken to ensure that any biases due to the inclusion of all vehicles in the journey time, regardless of the turn taken at the end of the link are immaterial or adjusted for;
- Model developers should make efforts to establish the confidence that can be placed in the journey time data used by the model development;
- Model developers should work with the journey time data supplier in order to define the most appropriate averaging method for the supplied dataset.

Requested analysis from model developer:

- Confirm what, if any, adjustments were made to ensure that the time periods used in generating the averages were free from major road works, incidents or similar biases.

3.6.3 Public Transport Data

Advice for Nestrans on future model development:

- The validity of the bus journey timetable journey times should be investigated;
- In future updates, undertake passenger counts are undertaken in line with the advice on survey methods in WebTAG Unit M1.2 §3.4.
- Review appropriateness of national peak period to peak hour factors applied on the Aberdeen to Dundee corridor to ensure they do not understate local peak hour flows.
- Local, rather than national, factors should be applied when adjusting observed values.

Requested analysis from model developer:

- Provide details of any adjustment factors used ensure data represents 2014 neutral period conditions.

Roads Model Development

04

4 Roads Model Development

Relevant guidance:

TAG Unit M3.1 Highway Assignment Modelling, DfT, January 2014

TAG data book, DfT, January 2016

4.1 Introduction

This section considers the following:

- Development of the road network in the model;
- Development of the road trip matrix; and
- Development of the assignment model.

In line with the proposed audit methodology, this chapter details a review of the supplied documentation only. No independent checks of the roads model network have been undertaken.

4.2 Network Development

The development of the modelled road network was reviewed. As a general note **it is recommended that a Network Coding Manual should be produced and used to ensure consistency of coding across the model area. This would also allow third party users of the model to ensure that the coding of future schemes uses the same assumptions and conventions as the base network development**.

Specific observations regarding the network construction, links and junction coding are discussed in the following sections.

4.2.1 Network Construction

The ASAM14 road network was developed using the following sources (development report §4.1.1):

- *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.*

The Buffer Network

The extent of the modelled network is shown in Figure 4-1.

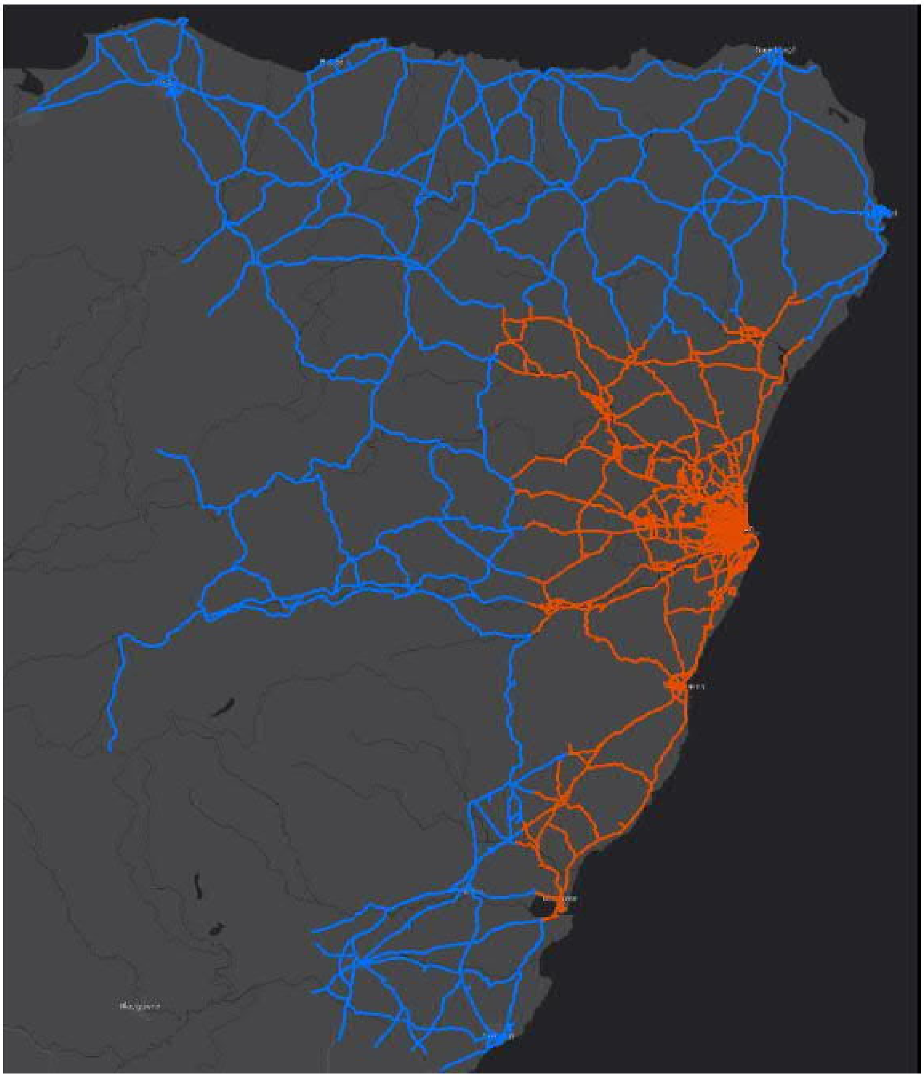


Figure 4-1 ASAM14 Network Coverage[8]

The simulation network includes Aberdeen City, areas of Aberdeenshire linking key commuter towns including Ellon, Inverurie, Westhill, Banchory and Stonehaven, the A90 south corridor to Laurencekirk and A92 to Montrose.

The road network to the north, east and south of the Fully Modelled Area (shown in red) has been represented by a buffer network (shown in blue), which was modelled as SATURN buffer coding. This includes link-based information such as distance, speed and capacity but no junction modelling. The buffer network includes the rural parts of Aberdeenshire, Moray and Angus and connections to inverness and the south of Scotland. For links outside of this area, there is no representation of the wider network as this is outside of the model's scope.

Trips entering and leaving the modelled area are obtained from TMfS14 via the trip end model processes and they are not adjusted by the demand modelling.

Geographic coverage

WebTAG Unit M3.1 (§2.2.1-§2.2.3) states that

The geographic coverage of highway assignment models generally needs to:

- *allow for the strategic re-routeing impacts of interventions;*
- *ensure that areas outside the main area of interest, which are potential alternative destinations, are properly represented; and*

[8] Source: ASAM14 Model Development Report, SYSTRA, June 2018

- *ensure that the full lengths of trips are represented for the purpose of deriving costs.*

It is important to establish at the outset the nature, scale and location of the interventions which are to be tested using the model.

The second and third requirements are particularly important where a highway assignment model will be linked to a demand modelling system.

The auditor has undertaken a high level review of the representation of the network and is content that it is appropriate for a regional model, and with a view of the proposed model uses as outlined in §1.2.1 of this report.

Network Construction

The ASAM road network was based on the 2016 ITN network. The methodology employed in constructing the network is described in the development report §4.2 and §4.3 and included key edits for:

- Remove links representing the new Diamond Bridge Crossing in order to ensure accurate representation of the 2014 network;
- Prevent mis-representing flyovers as junctions through concatenating the ITN node number with the gradient flag; and
- Identify one-way links based on links with parameter setting nature = Dual Carriageway.

An automatic Network Builder program was used to validate and format the network for SATURN input.

Link attributes were inferred from the attributes of the GIS network using an automatic set of rules. Where this was insufficient (e.g. setting of speed limits through towns), changes were made based on the TMfS road network and speed limit information extracted from TomTom. Recent changes to reflect new speed limits in the A944 corridor and delivery of 20mph zones in Aberdeen were included manually. Road attributes were reviewed using satellite images.

Traffic restrictions such as banned turns and limitation on HGV traffic were applied manually.

In line with advice in WebTAG M3.1 (§2.10), bus lanes and priority measures such as bus gates were coded into the network. Saturation flows and lane allocations were reduced accordingly. §4.4.9 of the development report also states that bus lanes were not modelled during the interpeak, in line with the operating times.

The increase of speeds for HGVs listed in the development report §4.5.20 in order to reduce HGV rat-running will introduce biases, which could reduce the responsiveness of the model forecasts, potentially increasing uncertainty around economic and environmental outputs.

4.2.2 Junction Coding

Junction coding was applied throughout the Fully Modelled Area as shown in Figure 4-1.

With the exception of mini-roundabouts, which were coded using SATURN's in-built roundabout type, roundabouts were coded as a set of one -way links representing the circulating sections together with priority junctions representing the approaches. This is appropriate.

The default junction saturation flows are listed in Table 4-1.

Table 4-1 ASAM14 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

In previous audits, after queries on the source of these standard saturation flows, Systra have cited previous model developments. The development report (§4.5.1) confirms that the values were taken from the SEStran Regional Model,

> ***…****with slightly lower straight ahead capacities and varied roundabout coding to match different road approach capacities.*

The development report does not state why such amendments were made. Similar to the conclusions of the SEStran Regional Model audit, the values adopted are considered reasonable starting, but we recommend that in **any update to ASAM14 a systematic review of generic junction capacity coding is undertaken.**

Traffic signals

Traffic signal settings were obtained from existing Paramics models covering the following areas:

- 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 Great Western Road (2010) / A93, Westburn Road and Kings Gate (2016).

Signal settings in areas where no data was available from previous models were obtained from Local Authorities. Any missing data was filled in using a template with adjustments applied as required during the calibration process.

We note that the models providing signal data for the south and west of Aberdeen are five and four years old, respectively. Model users focussed on these areas of the model should review signal coding prior to use. We further recommend that **in any update to the model, signal timings are taken from primary sources.**

Merges

Stopping nodes were used to improve representation of capacity constraints at merges on motorways and dual carriageways. Saturation flows in these locations were reduced to 3,600 representing 90% of the standard saturation flow based on link capacities.

4.2.3 Flow-delay relationships

Flow-delay relationships were coded for all modelled road links. The speed-flow curve parameters are listed in Table 2 in the development report. The modelled links are represented by 65 speed-flow curves, including 14 to represent HGV speeds. Speed flow –curves are extracted from the SRM12 and A96 corridor models.

We are satisfied that the range of flow-delay relationships used within ASAM14 provides sufficient flexibility to represent road characteristics in the modelled area. The development report provides some information on how the flow-delay relationships were applied (§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.*

In the absence of a coding manual, this provides guidance to model users on how to choose appropriate relationships for new coding. **Transparency would be also be aided by explicitly describing the derivation of the relationships, which we assume are ultimately derived from NESA/WebTAG.**

Additional curves were added to improve representation of links in the FMA. Adjustments were made to some speed-flow curves following a review of observed speeds on key corridors. This is in line with WebTAG M3.1 §2.9.14 which recommends that cruise speeds, rather than speed limits, are used as the free flow speed**. However, a record of these adjustments should be provided.**

The HGV speed-flow curves were included to represent lower HGV speed-limits on higher speed links. Some modification of lower HGV speed limits was required during the model calibration process in order to remove unrealistic rat-running. **A list of such manual edits, departing from the network coding standards should be provided.**

4.3 Road Model Time Period factors

Table 4-3 shows the time period to peak hour factors.

Table 4-2 Road Time period to Peak Hour Factors

Time period	Peak hour	Peak hour factor (road)
0700-1000	0800-0900	0.37
1000-1600	Average hour of 1000-1600	1/6
1600-1900	1700-1800	0.37

The development report (§2.3.18) states that the time period factors were updated based on analysis of traffic counts used in the calibration and validation of ASAM14.

4.4 Prior Matrix Development

The prior matrices for the Roads and PT models were developed through the application of the trip end model, demand model, and the application and comparison of several data sets. The methodology is described in §6 of the development report.

4.4.1 Demand Matrix Elements

In addition to the standard processes handling the five user classes as stated in §2.3.2, the assignment matrices contains procedures to develop the following more detailed demand elements:

- Education movements (excluding school bus services)- included within “Other”;
- Park and Ride movements – legs included within relevant car and PT user classes, excludes travel to education;
- External movements;
- Aberdeen Airport air passenger trips, including business and leisure passenger travel to and from the airport. Airport employee travel is handled by the standard processes for Commute trips; and
- Aberdeen Heliport air passenger trips, including commuter trips to offshore sites. Heliport employee travel is handled by the standard processes for Commute trips.

4.4.2 Standard trip purposes – data inputs

The development report (§6.2.2) lists the data inputs:

- *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.*

We note that adjustments were made to the 2011 Census population and employment data to account for changes between 2011 and 2014. The adjustments were based on 2011-2014 mid-year population estimates (for population data) and 2011-2014 BRES data (for employment data). This is appropriate.

4.4.3 Standard trip purposes – process

The development report (§6.2.5) describes the method adopted:

> *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.*

This process was applied iteratively, as the new prior matrices resulted in modified zonal travel costs.

Trip end calibration was undertaken through reasoned modifications to trip rates and planning data. The synthesised zonal person demand time period matrices by mode and purpose created by the demand model were then analysed as follows:

- Trip length distribution comparisons;
- 'Commuter' matrices compared with Census Travel To Work (TTW) at a 28 sector level;
- 'Other' movements compared with Scottish Household Survey (SHS) Travel Diary data converted to 28 sector level;

Observations on the process described in §6.2.6:

- Trip Generation and Attraction:
  - adjustments were made at an aggregate level to trip rates; there will, accordingly, be local variation in modal trip rates not reflected in the model assumptions;
  - Given that census data records 'usual' mode and 'main place of work' it is unclear how this can be used to interpret commuting frequency and inform trip rate adjustments;
- Mode and Destination Choice:
  - Calibration adjustments were made based on Census JTW, but it is unclear whether adjustments were made to reflect definitional differences and age of census data in respect of travel on a neutral weekday;
  - Calibration adjustments were made based on SHS. The sample size for SHS is most unlikely to be sufficient to use with any reasonable confidence at the 28 sector level of detail. Its use as stated is likely to distort rather than improve the trip matrices due to sampling error;

A series of K-factors were then applied to adjust some modelled sector to sector movements to better reflect the observed pattern. The development report includes some discussion on the values of K-factors adopted (§6.2.6):

> *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.*

While it is somewhat reassuring that the adjustments ranged around one, the scatter is large. A value of 0.1 means that the intra-sector trips are reduced by 90% by the k-factor. The distribution model used has been subject to quite limited calibration and the development report notes the need for, and application of, a number of adjustments to trip rates. While the explanation of the adjustments and their location is helpful, it also suggests weakness in the distribution model fit. Whilst k-factors will constrain the inter-sector totals to the data used for the constraint, the distribution model is also used to capture more local travel patterns between matrix cells within the inter-sector totals, for which the range of k-factors may be indicative of quite low confidence, and are subject to the confidence that can be placed on the observed data used to derive these constraints.

The development report presents the following analysis of the prior matrices:

- Appendix B presents a comparison of modelled and observed sector matrices for each travel purpose, by mode and time period;
- Appendix C presents trip cost distribution comparisons for each travel purpose, by mode and time period. A selection is presented in the main body of the development report, as Figures 17 to 22, and a summary of average travel costs is provided in Tables 8 to 10;
- Mode share proportions for each travel purpose, mode, and time period are supplied in Tables 11 to 13.

The difference between modelled and observed average generalised costs exceeded 10% in the following instances:

- Commute: AM Car (10%), PM Car (11%)
- Other: AM Car (12%), IP Car (13.9%)
- Business: AM Car (16%), IP Car (19%), PM Car (14%)

The comparison appears reasonable although the model slightly overestimates road trip lengths, particularly for Business trips. Observed differences between trip purposes are reproduced by the model.

The difference in mode share between model forecasts and observation exceeded 5% in the following instances:

- Other: PM Car (8%), PM PT (-8%)
- Business: IP Car (-6%)

In general the model tends to over-estimate car mode share by around 5% in comparison with Census and SHS data. The development report (§6.2.28) gives the following reason related to the methodology for generating the prior matrices

> *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*

The comparisons of sectored matrices presented in Appendix B shows a mixed picture, and will provide the model user a valuable resource for understanding the model's suitability for the specific intended use. Figure 4-2 and Figure 4-3 present a scatter plot comparison of observed and modelled values in Appendix B for 'total road and parking' and 'total PT and Park and Ride, respectively. They exclude trips between Sectors 19 to 28, in order to focus on trip to, from, through, and within Aberdeen.

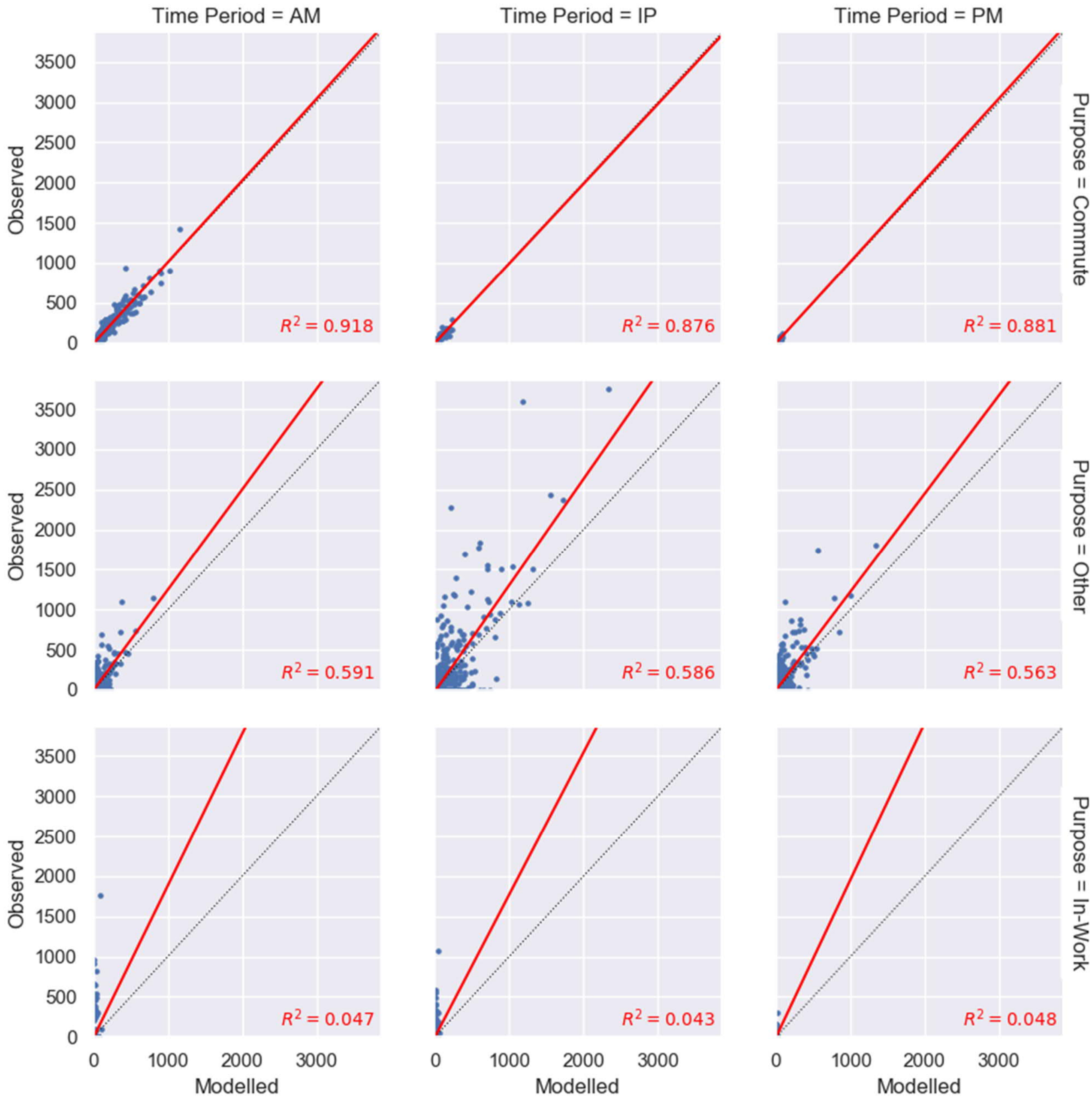


Figure 4-2 Observed v Modelled Prior Sector Values, Total Road and Parking

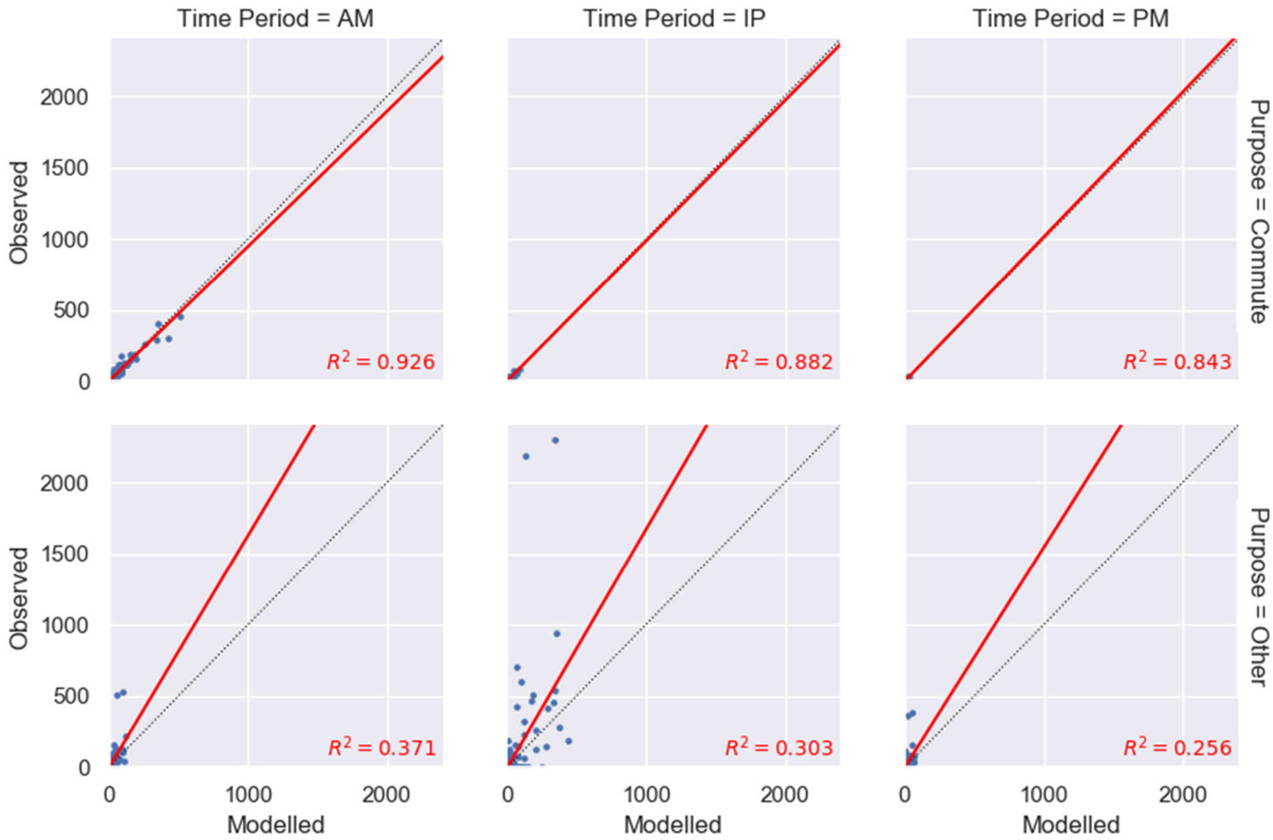


Figure 4-3 Observed v Modelled Prior Sector Values, Total Public Transport and Park and Ride

The R^2 statistics demonstrate that there is a much better fit for the commute purpose than for Other or In-Work. This would be expected, as commute is a doubly constrained purpose, being a function of both population and employment. However, it is likely that this is also due to the source of the 'observed' values. Census Travel To Work is a complete dataset, and, although some assumptions would have to be applied in order to derive time period origin-destination matrices to form the comparison, we can have a good level of confidence in the values presented. 'Other' and 'In-Work', in contrast, rely upon the Scottish Household Survey Travel Diary, which is based on a rolling sample. Though an excellent, robustly carried out survey, the sample size collected means that when attempting to generate a 28 sector matrix of trips, additionally segmented by travel purpose, sample sizes will be extremely small, leading to 'lumpiness' in the expanded matrices. This issue is such that no comparison is possible for In-Work Public Transport.

The fundamental issue is a lack of observed data. Indeed, if there was observed data available, it would have been used as the basis of the matrix construction. However, without reliable observed data to validate the resulting pattern, the only confidence that can be derived is through the reasonably strong performance of the commute comparison.

The decision taken in the scoping of the model to proceed with an approach that for non-commute purposes does not either use observed demand pattern information, or include any data for independent validation, will result in uncertainty in the demand matrices and consequential uncertainty in forecasts produced by the model.

4.4.4 Detailed Demand Elements - process

Trips are added for the more detailed demand elements described above.

Student Travel to Education

Travel to Education is established by a gravity model which uses trip end outputs from the Trip Generation Model. The location of education establishments were established based on TELMoS/ASAM14 planning data and a web search. Schools and Universities were treated separately to account for differences in trip length/distribution. The development report (§6.3.3) notes that in University zones schools were assumed to represent 10% and higher education for 90% of attractions. The source is not stated.

The text also notes that

> *Gravity model trip distribution parameters were developed for road and PT travel by comparing the output travel demands with observed data.*

For schools, this was based on the 2016 Pupil Census. In the absence of data describing the distribution of Higher Education trips, comparisons were based on data for commute trips. The 2011 Census Travel to Education data was not available at the time of development.

Higher Education mode shares were adjusted based on Travel Plan data for local universities.

Park & Ride and City Centre Parking Movements

Park & Ride and City Centre Parking trips are generated by the Park and Ride and Parking Model.

External Movements

External movements by road and PT were extracted from TMfS14 and disaggregated to the ASAM14 zoning system using planning data applying rules based on employment, total population and residential population as detailed in Table 16.

Airport and Heliport Passenger Modelling

Airport Passenger Travel was based on an Airport Access Model. The model was informed by data from 2013 CAA passenger surveys for Aberdeen Airport, which provided trip movement and mode share patters disaggregated by business and leisure.

The development report (§6.6.4) states that

> *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).*

Passenger trip distributions were derived from zonal demographic and land-use data, and did not vary by distance. This assumption was informed by analysis undertaken during the development of the Glasgow Airport Access Model used by the SRTM.

The Heliport Passenger Model used the following sources:

- 2011 Census data describing the origins of offshore workers;
- Census Commuter mode share proportions;
- Web-based data on flight departures and arrivals and helicopter capacities.

Together with assumptions on arrival times and time required to depart this allowed the calculation of trip ends.

A comparison of the total number of trips with CAA (rotary wing) passenger data for 2014 was undertaken.

Heliport trips were calculated by applying the productions and attractions to Census offshore trip patterns.

Goods Vehicles

In the absence of observed data on goods vehicle movements, goods vehicle demand was established by applying trip rates generated by the Trip Generation Model.

Inter-sector trip distribution patterns were based on a disaggregated version of the TMfS14 LGV and HGV matrices. Zonal disaggregation factors were based on a mix of jobs and employment data. A 10% contribution to longer distance trips patterns was taken from a disaggregated version of the TELMoS goods commodity matrices in order to correct for "lumps" resulting from patchy RSI data.

Intra-sector trips were derived disaggregating relevant TMfS and TELMoS goods vehicle movements and furnessing to match the ASAM14 trip ends.

The development report (§6.7.13) states that the representation of multiple drop-offs was improved by uplifting the proportion of intra-sector trips and reducing inter sector trips, whilst ensuring the ASAM14 distribution fell between the TMfS and TELMoS distributions.

4.4.5 Formation of the Prior Matrices

The final prior matrices were formed by combining the standard commuter, other and business travel demand with the Park and ride, airport, heliport and external movements. Education movements are incorporated in the Other matrix.

4.4.6 Prior Matrices - discussion

The development of the demand matrices for ASAM14 is, therefore, entirely synthetic. WebTAG M2 §2.5.6 reflects current UK practice, which is carefully to assemble observed evidence on travel demand patterns. The need to augment survey data with synthetic estimates to infill unobserved movements, reflecting limitations of data sources is discussed. Reflecting the importance of the distribution for the model forecasts, the recommendation is to adopt an incremental approach, preserving the detailed observed evidence on the distribution of travel demand. The importance of understanding travel patterns is reinforced in unit M3-1 §8 that sets out the need both to demonstrate the accuracy of prior highway assignment matrices against independent data and imposing strict limits on the extent to which matrix estimation methods should alter the matrices.

UK modelling practice has evolved over 60-70 years, currently with guidance on developing demand matrices set out in the now aged Transport Appraisal Manual (TAM). This focuses on the methods used to conduct and analyse surveys, together with the complementary use of synthetic methods. The UK Department for Transport has initiated work to update this guidance with a technical review ‘Provision of Technical Advice and Support for Matrix Building Guidance’ published in late 2017. This review document continues to place high importance to understanding travel demand patterns.

There has been no use of detailed local survey data to develop the SRTM trip matrices, in contrast with UK best practice. However, the model developer has made, and reported upon, significant efforts to compare the prior matrices with the observed data that is available, and has made reasoned adjustments in an iterative process in order to attempt to refine their definition. However, we would recommend that, **for any model update, in line with guidance and best practice, survey data on demand patterns are included as part of the model specification.**

An additional substantive concern is that the Census and SHS have been used to calibrate the synthetic model parameters. These constants, the model form, and parameters, force a fit. Some commentary has been provided on the k-factors adopted during the calibration, but the distribution model used has been subject to quite limited calibration and the documentation notes the need for and application of a number of adjustments to trip rates.

As it stands, the development report explains the limits of the calibration. There remain appreciable uncertainties in the accuracy of the prior matrices. **All model users should consider whether to defer model applications until the planned model update with new demand data is undertaken, or should consider how to explain the consequential uncertainty in the model forecasts, consulting Appendix B of the development report. These concerns equally apply to the public transport matrices.**

The lack of data available for the creation of credible, validated goods vehicle movements is of particular concern. Without such, **we would recommend in particular that ASAM should not be used for the testing of schemes that are sensitive to the impact of goods vehicles.**

4.5 Assignment Model Development

4.5.1 Assignment Procedures

The assignment procedures are described in §4.6 of the development report. The road assignment model is based on an equilibrium assignment, evaluated by a Frank-Wolfe Algorithm. SATURN procedures operate a loop consisting of an assignment stage combined with junction simulation, and a subsequent stage which uses the resulting delays to calculate new trip patterns. This loop is terminated when convergence criteria are met.

The auditor is content that the interface between junction delays and reassignment is appropriate to represent congestion in the modelled area.

In the AM and PM period, the network was pre-loaded to provide a realistic representation of initial conditions due to traffic present on network during the hour preceding the modelled period. The pre-load was applied using SATURN's PASSQ facility, and was based on a proportion of calibrated traffic demand the proportions were evaluated separately for three areas: trips solely within Aberdeen City, trips solely outside Aberdeen City and trips between Aberdeen City and the surrounding area, and were based on observed traffic count data. This is appropriate.

The development report states in §4.3.2 that the assignment parameters

> *were extracted from the SEStran Regional Model (SRM12) SATURN assignment model where appropriate.*

Some evidence of review undertaken to ensure they are appropriate for application in the modelled area should be provided.

4.5.2 Generalised Cost

The derivation of generalised cost parameters is described in §4.6.10 to §4.6.13. The calculation was based on the January 2016 version of WebTAG. The July 2016 version of WebTAG was current at the time of the project Inception. As well as updates only relevant to forecast generalised cost parameters, this contained updates to the OGV1 and OGV2 fuel consumption parameters when compared to the January 2016 version. This would affect the base HGV generalised cost parameters. As noted in §4.6.10, since 2016, fundamental updates to the values of time have been implemented. We agree that **any update to ASAM should take as its basis for parameter calculation the current version of WebTAG.**

The generalised cost coefficients used in the assignment are shown in Table 4-3.

Table 4-3 ASAM14 Base Year Road Assignment Coefficients[9]

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

The form of the generalised cost function is given by (§4.6.13)

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

In line with WebTAG, this is expressed in units of time.

The following recommendations are made with respect to the calculation and reporting of generalised costs:

- **The definition of the coefficients A, B and C in this equation should be provided, in order to confirm the equation is equivalent to the formulation in WebTAG Unit M3.1 §2.8.1.**
- **Confirmation should be provided of the methodology for converting vehicle operating costs to time units, including the values and source of vehicle occupancies used to convert values of time per person to vehicle based values. WebTAG Unit M3.1 §2.8.3 recommends that this is based on local data.**

4.5.3 PCU Factors

The model uses PCU factors of 1.0 for cars and 1.9 for heavy goods vehicles. These factors are consistent with TMfS, however, it was noted (Table 10) in the TMfS12 Audit that:

> *The continued use of the historic HGV PCU factor of 1.9 should be reviewed for future model updates*

[9] ASAM14 Model Development Report, SYSTRA, June 2018

The development report also states (§4.6.6) that a PCU factor of 3.2 is used for buses, which is an increase from the value of 2.2 used in TMfS and the SRM. The development report (§4.6.6) states:

> *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.*

Further, in §4.6.8:

> *…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.*

We infer from this that analysis was undertaken to support the proportionally large increase in the inherited factor, which would have been helpful to summarise in the text. **The auditor recommends that a review of the HGV and PSV PCU factors are undertaken, particularly for future versions of the model.**

4.5.4 Treatment of Buses

Bus routes and frequencies are extracted from the PT assignment model and applied to the road network as fixed bus preloads. This is appropriate.

4.5.5 Convergence

Information on performance against WebTAG standards for convergence (Unit M3.1, Table 4) as provided in the Development report is summarised in Table 4-4.

Table 4-4 Summary of Convergence Measures and Base Model Acceptable Values

Measure of convergence	Base Model acceptable values	AM	IP	PM
Delta and %GAP	Less than 0.1% or at least stable with convergence fully documented and all other criteria met	Yes	Yes	Yes
Percentage of links with flow change (P)<1%	Four consecutive iterations greater than 98%	N/A	N/A	N/A
Percentage of links with cost change (P2)<1%	Four consecutive iterations greater than 98%	N/A	N/A	N/A
Percentage change in total user costs (V)	Four consecutive iterations less than 0.1% (SUE only)	N/A	N/A	N/A

Further detail of the number of iterations required to achieve convergence and the value of the %GAP statistic are shown in Table 4-5.

Table 4-5: Model Convergence Results by Time Period

Time Period	%GAP	Number of Iterations
AM	0.0	20
IP	0.0	16
PM	0.0	20

Based on Table 4-5 WebTAG convergence criteria in terms of Delta and %GAP are met.

However, it should be noted that convergence is confirmed and the model run terminated when the percentage of link flows given by RSTOP changes by less than PCNEAR for a number of consecutive iterations (NISTOP). The ASAM14 values for RSTOP, PCNEAR, and NISTOP are 98, 2.0, and 4 respectively. The parameter values required to reflect WebTAG criteria are:

- ISTOP = 98 / RSTOP = 98.0;
- PCNEAR = 1; and

- NISTOP = 4.

In order to meet WebTAG standards for convergence, the parameter PCNEAR should be reduced from 2.0 to 1.0. **We recommend that the simulation parameters defining the stopping criteria are set to the above values in compliance with WebTAG requirements for convergence.**

4.6 Summary and Recommendations

4.6.1 Network Development

Advice for Nestrans on future model development:

- In future updates, produce a Network Coding Manual to ensure consistency of coding across the model area, and of scheme coding.
- A systematic review of generic junction capacity coding should be undertaken.
- In line with guidance and best practice, survey data on demand patterns should be included as part of the model specification of any update.
- Model development reports should explicitly describe the derivation of flow/delay relationships used.
- A list of manual edits that depart from the network coding standards should be supplied.
- Signal junction timings should be derived from primary data sources.

Advice for Model Users:

- Model users with a particular focus on south and west Aberdeen should review signal timings prior to use.

4.6.2 Assignment Model Development

Advice for Nestrans on future model development:

- In line with guidance and best practice, survey data on demand patterns must be included as part of the specification for any model update;
- Update any parameters used to the most up-to-date version of the webTAG databook;
- Review and update PCU factors;
- Define simulation parameters defining the stopping criteria in compliance with WebTAG requirements for convergence.

Requested analysis from model developer:

- In regard to the demand model parameters adopted to derive the prior matrices, additional commentary is required on whether the cost related parameters are intuitive and align with previous experience; on the size of k-factors required; etc;
- State what review was undertaken to ensure SRM12 assignment parameters are applicable;
- Report definition of the coefficients A, B and C in the Generalised Cost equation;
- State methodology for converting vehicle operating costs to time units, including the values and source of vehicle occupancies used to convert values of time per person to vehicle based values;
- Provide information on the derivation of the bus factor of 3.2.

Advice for Model Users:

- All model users should consider whether to defer model applications until the planned model update with new demand data is undertaken, or should consider how to explain the consequential uncertainty in the model forecasts, consulting Appendix B of the development report. These concerns equally apply to the public transport matrices;

- We recommend in particular that ASAM should not be used for the testing of schemes that are sensitive to the impact of goods vehicles.

Roads Model Calibration and Validation

05

5 Roads Model Calibration and Validation

Relevant guidance:

TAG Unit M3.1 Highway Assignment Modelling, DfT, January 2014

5.1 Introduction

This section considers the following:

- Calibration of the road assignment model, through matrix estimation and count data;
- Validation of the road assignment model, through count data and journey time routes.

5.2 Calibration

5.2.1 Calibration Data Inputs

Counts used in the calibration of the ASAM14 road assignment model have come from the following 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.

5.2.2 Calibration Locations

A total of 64 calibration screenlines (32 bi-directional locations) have been used in the development of the model matrices, including 8 screenlines consisting of a single count location. Some of these screenlines were revised following an initial set of comments from the auditor during development. Figure 5-1 shows the location of the screenlines, coloured according to the number of count locations used in the screenline.

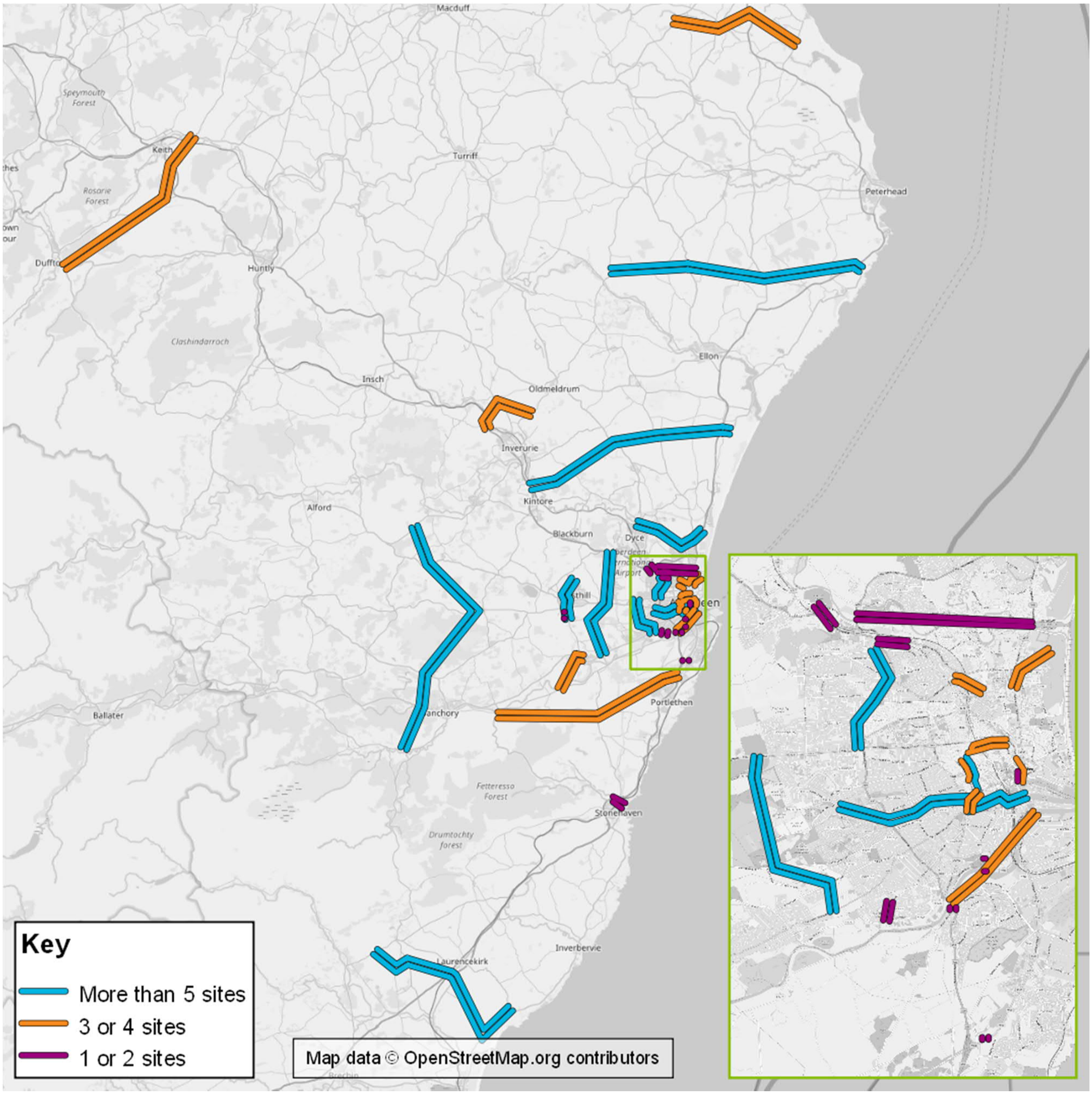


Figure 5-1: Count of Sites Used in Calibration Screenlines

WebTAG guidance states (Unit M3.1, §3.2.6) that:

> *…screenlines should normally be made up of 5 links or more*

Of the 64 directional screenlines used in ASAM14 calibration, 41 consist of fewer than 5 links with 19 of these consisting of only one or two locations. **The auditor recommends a review of screenlines to identify any which could be combined into larger screenlines**. The development report (§7.3.2) states that

> *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.*

This is acknowledged. However, some screenline locations would benefit from combination or extension in future updates.

Additionally, as noted above, 8 individual count locations were used in calibration. The use of single sites means that the matrix estimation process has a tendency to satisfy count constraints at a single site level by adjusting origin/destination patterns from immediately local zones and 'over encouraging' local short distance trips. The development report states that (§7.3.2):

> *…Some individual calibration points were used to improve calibration at locations which significantly under or overestimated traffic during initial calibration...*

The requirement to use single point screenlines in order to correct significant over or underestimation would suggest gross differences in the prior matrices, or errors in the route choice. Efforts to confirm the validity of these should be made, and documented, prior to resorting to the application of single point screenlines. **The auditor recommends that single count sites not be used in the calibration of model update, or, if the model developer considers them essential, separate evidence presented as to their impact**.

The overall coverage of the screenlines is considered reasonable, with the majority of movements in and out of the city covered reasonably well.

5.2.3 Calibration Procedures

Separate estimations of car, LGV, and HGV vehicle classes are undertaken for each time period. It is assumed that estimations for the three vehicle classes are carried out simultaneously.

WebTAG M3.1 recommends that before matrix estimation is undertaken a process of network and route choice calibration and validation is undertaken. These processes should be presented in the development report.

5.2.4 Impact of Matrix Estimation on Prior Matrix

WebTAG Unit M3.1 (Table 5) provides guidelines as to the scale of change that is deemed acceptable from the matrix estimation process, detailed in Table 5-1.

Table 5-1 WebTAG matrix estimation significance guidance

Measure	Significance Criteria
Matrix zonal cell values	Slope within 0.98 and 1.02 Intercept near zero R^2 in excess of 0.95
Matrix zonal trip ends	Slope within 0.99 and 1.01 Intercept near zero R^2 in excess of 0.98
Trip length distributions	Means within 5% Standard deviations within 5%
Sector to sector level matrices	Differences within 5%

The prior and estimated comparison statistics are presented in section §7.5 of the development report. The matrix zonal cell value comparisons are detailed in Table 5-2.

Table 5-2 Roads model pre- and post-matrix estimation zonal cell value results

Statistic	AM Peak	Inter Peak	PM Peak
Slope	0.97	0.93	0.98
Intercept	6.82	8.18	7.56
R^2	0.95	0.92	0.94

No time period manages to pass all of the criteria, with the AM and PM periods each matching a single criterion. In particular, the intercepts are quite high across the three time periods.

The trip end comparisons are detailed in Table 5-3.

Table 5-3 Roads model matrix estimation zonal trip end comparisons

Type	Statistic	AM Peak	Inter Peak	PM Peak
Origin	Slope	0.95	1.02	0.98
	Intercept	4.85	-0.28	-0.28
	R^2	0.98	0.98	0.98
Destination	Slope	0.97	1.03	0.97
	Intercept	2.65	-0.84	1.49
	R^2	0.98	0.97	0.98

Again no time period manages to pass all of the criteria, with the slope outwith webTAG recommendations for all time periods for both origins and destinations.

Trip length distribution comparisons are detailed in Table 5-4.

Table 5-4 Roads model matrix estimation trip length distribution comparisons

Time Period	Statistic	Pre Estimation	Post Estimation	% 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%

These results show values significantly larger than the restrictions placed by webTAG. The mean trip distance reduces for all time periods, suggesting that the estimation process is increasing the proportion of short-distance trips. The comparison of the average trip lengths of the prior matrices and observed data discussed in §4.4.3 showed that the prior matrices averages were approximately 10% higher than observed. It appears, therefore, that the matrix estimation is correcting for this, reflecting weaknesses in the prior matrices.

Finally, the main body of the development report does not provide detailed results for the sector movement comparisons. The values are provided, however, in Appendix D. A comparison of all of the results can be found in Table 5-5.

Table 5-5 Highway matrix estimation sector movement comparisons

Difference	AM		IP		PM	
	Count	Percentage	Count	Percentage	Count	Percentage
< 5%	121	14%	98	12%	107	13%
> 5%	720	86%	743	88%	734	87%

Table 5-5 shows a large number of sectors reporting trip changes greater than the 5% recommended threshold from webTAG. However, it should be noted that a large number of these changes apply to relatively small numbers of trips. Table 5-6 instead presents these comparisons restricted to sector pairs reporting over 500 vehicles in the prior matrix.

Table 5-6 Highway matrix estimation sector movement comparisons (> 500 vehicles)

Difference	AM		IP		PM	
	Count	Percentage	Count	Percentage	Count	Percentage
< 5%	18	86%	14	88%	18	86%
> 5%	3	14%	2	13%	3	14%

Table 5-6 shows that there are several sector pairs with reasonably high trip levels showing changes above the recommended level from webTAG. These values are all 10% or lower and generally located towards the periphery of the model, and as such are not a significant concern. However, in the AM peak there is a 10% increase in trips from sector 4 to sector 1. This relates to trips travelling across Aberdeen, and may require further attention.

5.2.5 Calibration Results: Screenline Counts

WebTAG Unit M3.1 provides (Table 1) provides the criterion for screenline performance:

Table 5-7 WebTAG screenline performance guideline

Criteria Acceptability	Acceptability Guideline
Differences between modelled flows and counts should be less than 5% of the counts	All of nearly all screenlines

WebTAG Unit M3.1 also states (§3.2.6):

With regard to screenline validation, the following should be noted:

- *[…]*
- *the comparisons should be presented by vehicle type (preferably cars, light goods vehicles and other goods vehicles)*

The development report currently only provides screenline comparisons for all vehicles – **future development reports should provide comparisons by vehicle type**.

The development report also currently uses DMRB guidance to assess screenline performance, adding in a further condition of GEH across the screenline being less than 4. **This is not contained within webTAG and should be removed from the report for consistency with other standards applied for the model**.

Screenline performance against the webTAG criterion is presented in Table 5-8.

Table 5-8 Highway calibration screenline performance against webTAG criterion

Classification	Result	AM		Inter Peak		PM	
		Number	%	Number	%	Number	%
Car	Pass	35	55%	43	67%	37	58%
	Fail	29	45%	21	33%	27	42%
LGV	Pass	34	53%	33	52%	29	45%
	Fail	30	47%	31	48%	35	55%
HGV	Pass	28	44%	28	44%	28	44%
	Fail	36	56%	36	56%	36	56%
All Vehicles	Pass	34	53%	39	61%	38	59%
	Fail	30	47%	25	39%	26	41%

The performance against this criterion is relatively poor, particularly in the AM period, with the pass rate generally being between 50% and 60%. Performance is worst for HGVs, though this is to be expected as a result of the relatively low flows associated with this vehicle type.

Figure 5-2 plots the modelled screenline totals against the observed values for all vehicles, with both the webTAG criterion and wider DMRB criterion shown.

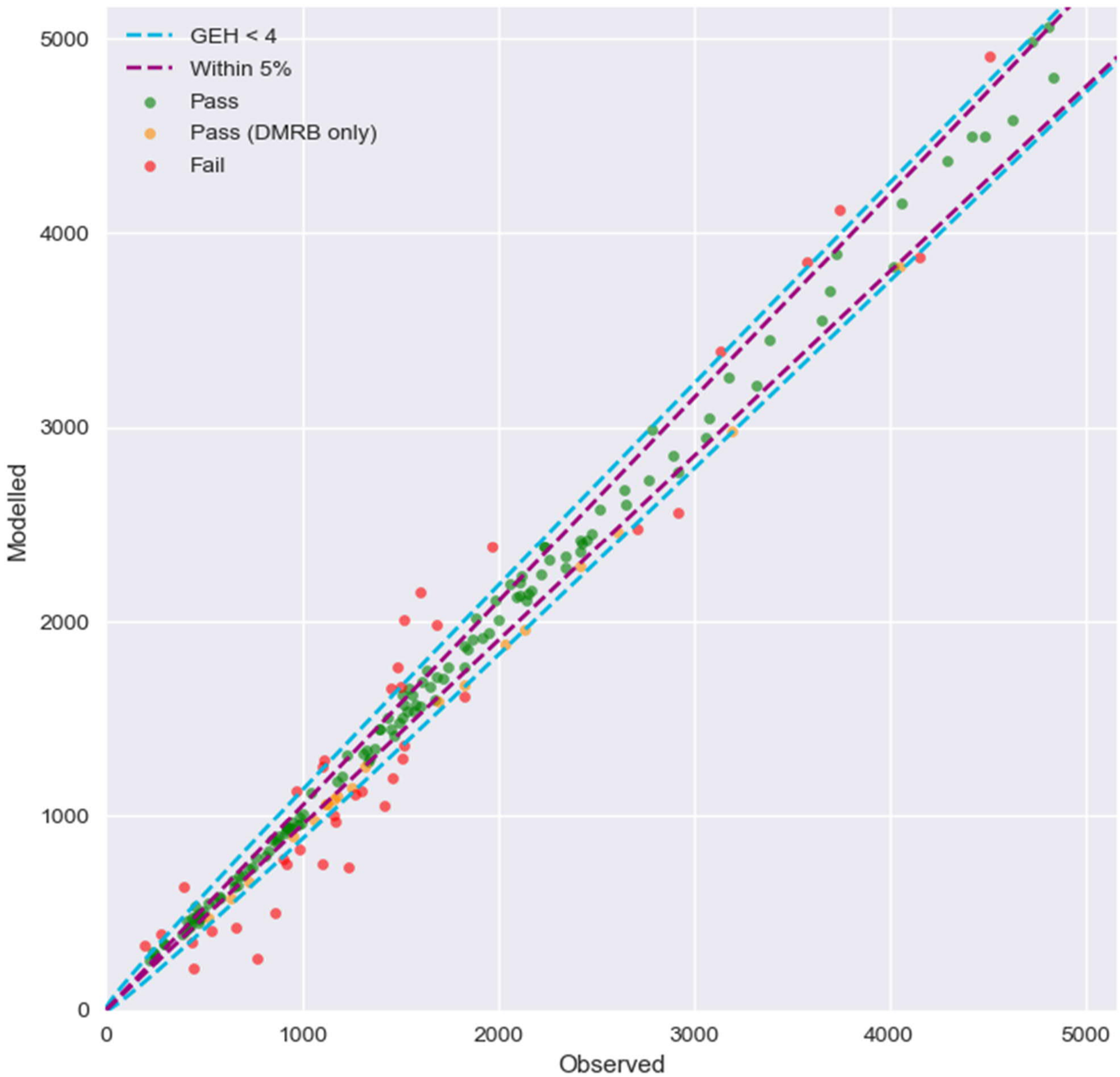


Figure 5-2 Calibration screenline performance (total vehicles, all time periods)

Figure 5-2 shows that while performance against screenlines does not match the criterion recommended by webTAG, there does not appear to be any systematic over- or under-estimation of flows.

Figure 5-3 to Figure 5-5 show the performance by location screenline location for the AM, IP and PM periods respectively.

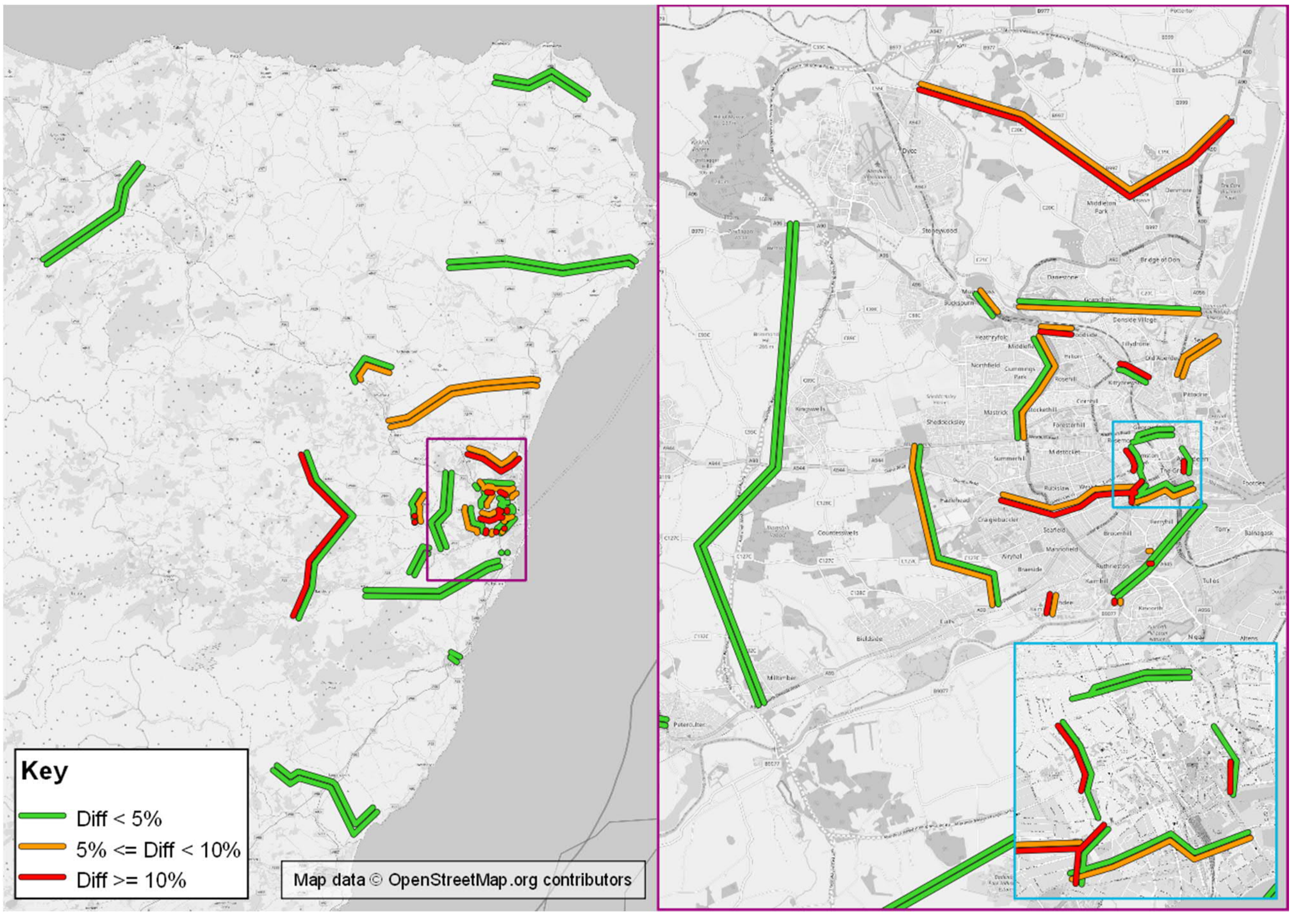


Figure 5-3 AM screenline performance by location

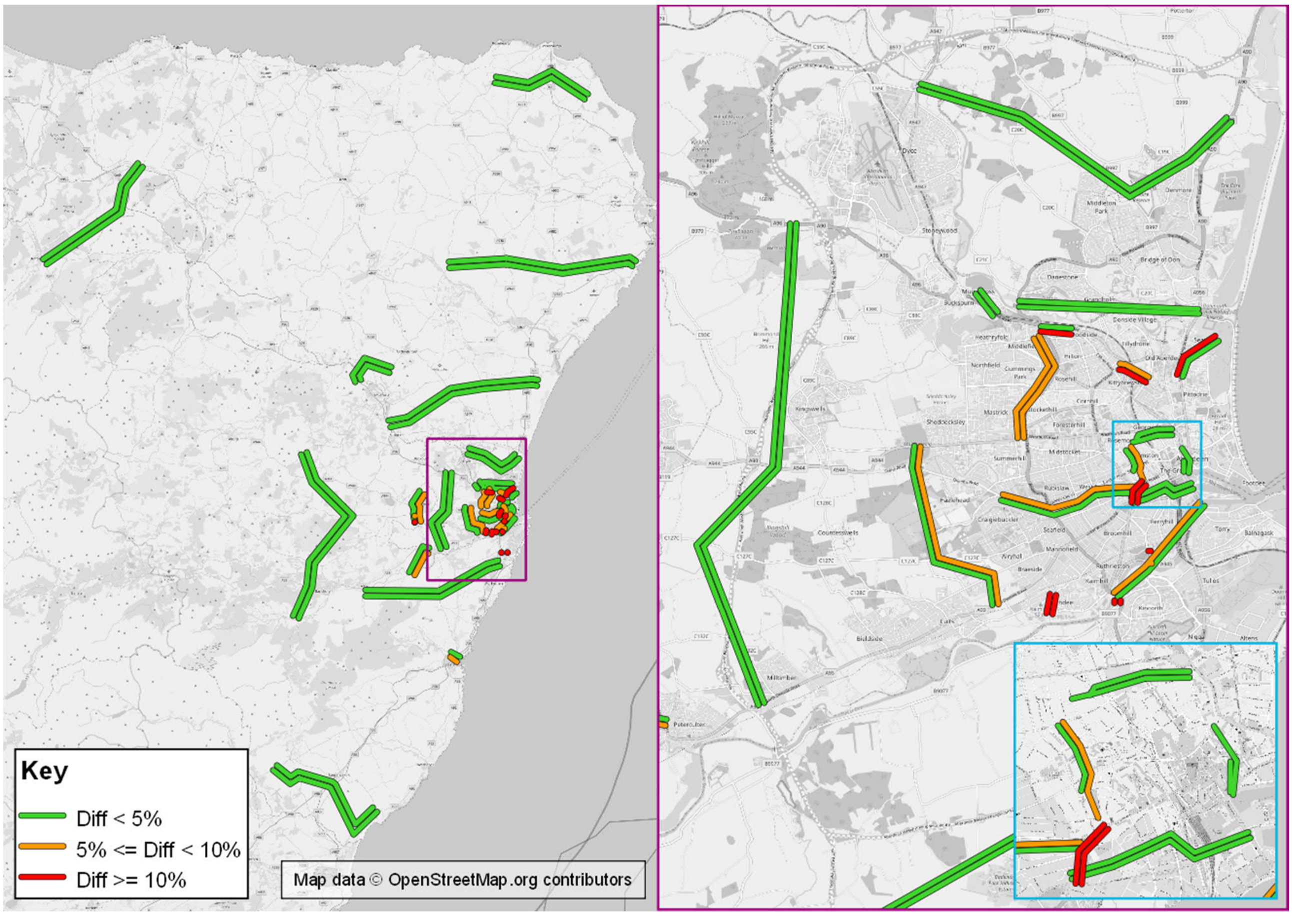


Figure 5-4 IP screenline performance by location

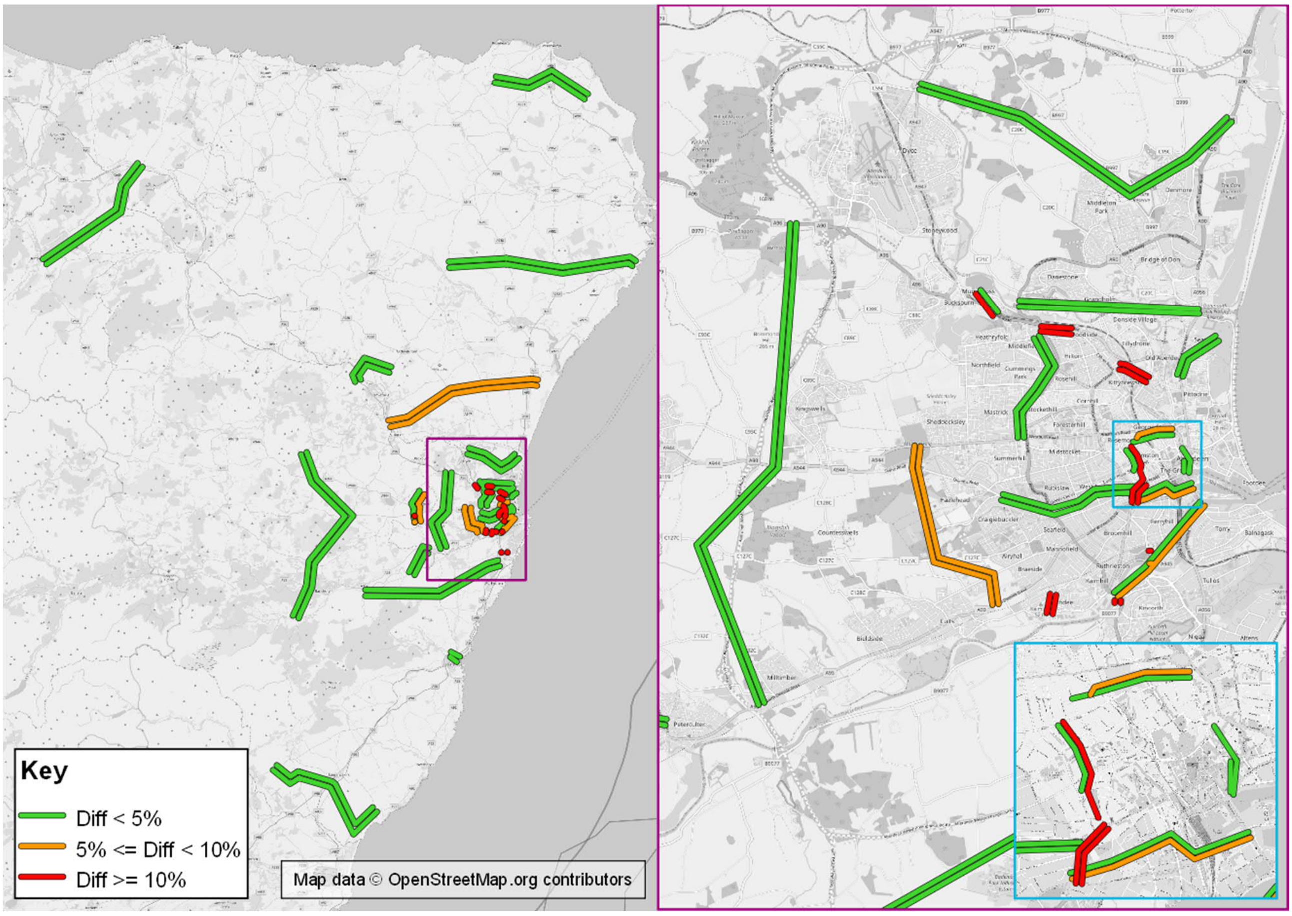


Figure 5-5 PM screenline performance by location

These figures show that there are some locations with poor performance consistently across the three modelled periods. The development report (§7.6.15) highlights these and provides reasoned discussion of the differences.

The auditor would recommend that users of the model consider the impact of the performance in these areas on any uses of the model. In particular, the performance around Aberdeen city centre should be considered with great care in the context of the use of the model for the City Centre Master Plan and Sustainable Urban Mobility Plan.

5.2.6 Calibration Results: Individual Counts

WebTAG Unit M3.1 (Table 2) provides additional guidance for assessing the performance of the model against individual link flows and turning movements, detailed in Table 5-9.

Table 5-9 WebTAG link flow and turning movement validation criteria and acceptability guidelines

Criteria	Description of Criteria	Acceptability Guideline
1	Individual flows within 100 veh/h of counts for flows less than 700 veh/h	>85% of cases
	Individual flows within 15% of counts for flows from 700 to 2,700 veh/h	>85% of cases
	Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h	>85% of cases
2	GEH < 5 for individual flows	>85% of cases

As mentioned in §5.2.1 of this report, previous model flows have been used in locations where no observed data is available. While this is not unreasonable at a screenline level, these values should not be included in performance summaries at an individual count level as they do not represent “real” observed data. As it is not possible to identify these locations, the rest of this section is inclusive of those locations however **the report should be updated to ensure that the individual count calibration results only include those locations with “real” observed data**.

Table 5-10 shows the overall performance of the individual counts against these criteria, where the modelled value is given a pass if either criteria is met, as recommended by webTAG.

Table 5-10 Highway calibration individual count performance against webTAG criteria

s	AM		Inter Peak		PM	
	Number	%	Number	%	Number	%
Pass	177	75%	177	75%	175	74%
Fail	59	25%	59	25%	61	26%

Table 5-10 shows that the model falls noticeably short of the webTAG criteria for all time periods, reaching a pass rate of around 75% rather than the recommended 85%.

Figure 5-6 compares modelled and observed values across all three time periods, with the limits of the two webTAG criteria shown on the graph.

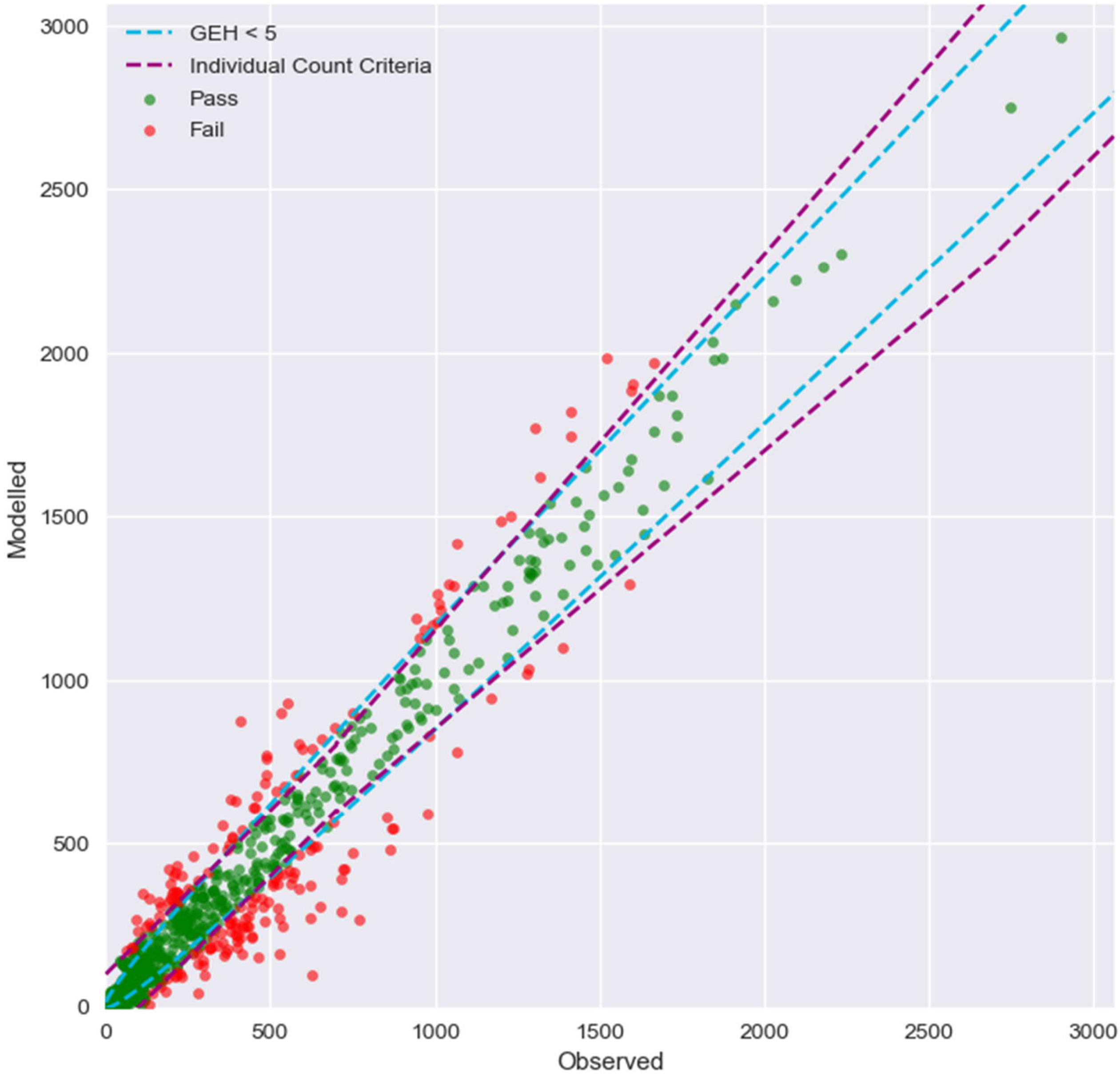


Figure 5-6 Calibration individual count performance (total vehicles, all time periods)

Again we see that while webTAG criteria are not met there seems to be no systematic over- or under-representation of flows. In particular it can be seen that the model performs reasonably at the counts of highest volume though these form only a relatively small proportion of counts.

5.3 Validation

5.3.1 Validation Data Inputs

Data used in the validation of ASAM14 has come from the following sources:

- 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).

As mentioned in §5.2.6 of this report, it is not recommended that previous model flows are used for performance summaries at an individual count level as they do not represent "real" observed data. As it is not possible to identify these locations, the rest of this section is inclusive of those locations however **the report should be updated to ensure that the individual count validation results only include those locations with "real" observed data**.

5.3.2 Count Validation Locations

A total of 56 count locations were used in model validation, with 54 of these representing two-way locations and 2 corresponding to one-way locations. This produces a total of 110 counts. The locations of these counts are shown in Figure 5-7, where each count is shown according to the link it has been associated with.

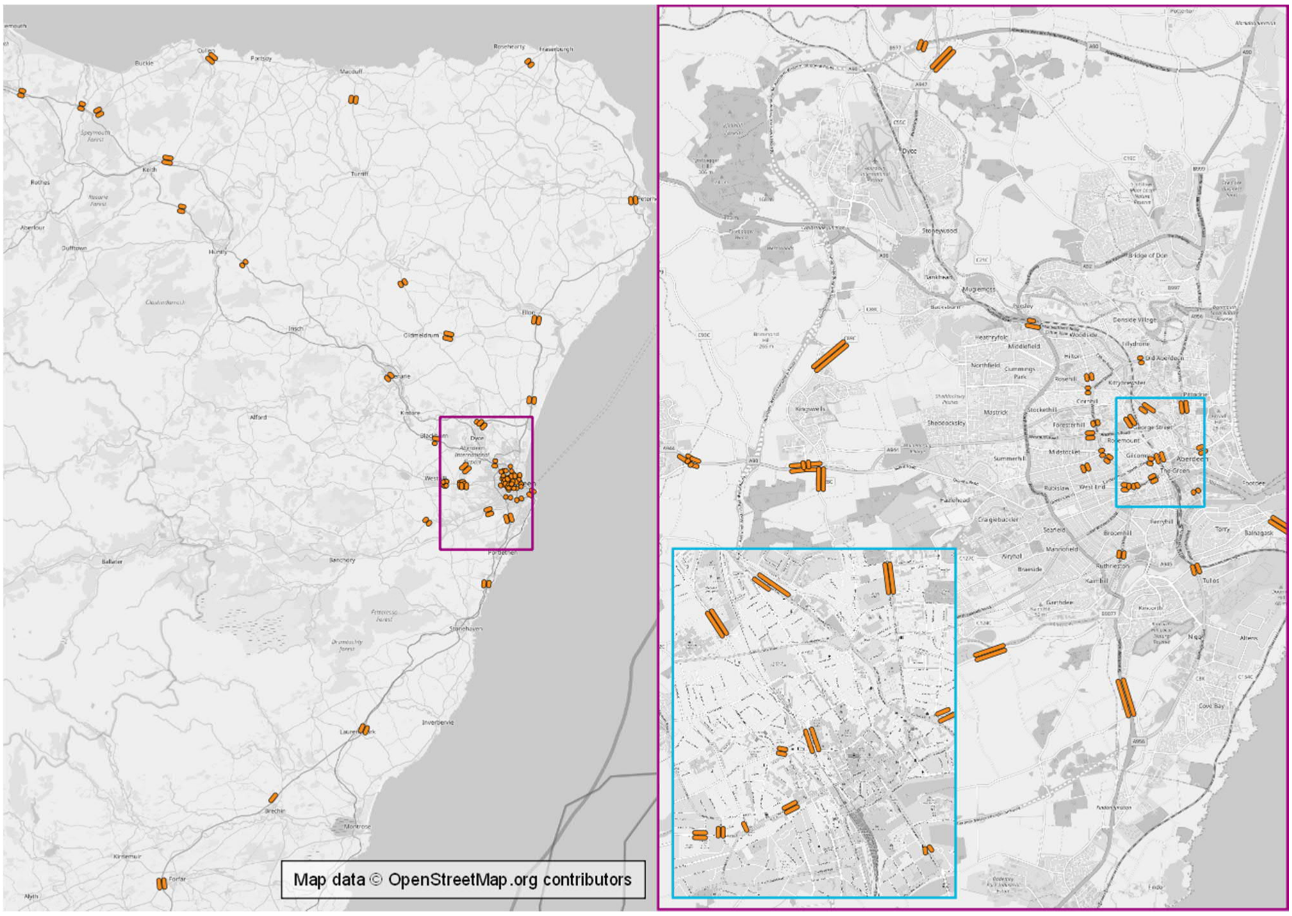


Figure 5-7 Validation count locations (links)

The development report states (§8.2.8) that:

> *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 [...]*

The auditor would recommend that a review of validation data is undertaken to ensure that all data used is reliable. In cases where a reliable count cannot be sourced, this count should either be removed from the comparisons or flagged as "unreliable" to provide a better understanding of the performance of the model.

A more general recommendation would be that **explicit consideration as to the confidence that can be given to survey data should be included in any model update, and that this be reported**.

Additionally it seems that one (bidirectional) validation count, located on St Machar Drive, features no Inter Peak counts. **The reasons for this should be documented in the development report**.

5.3.3 Journey Time Routes

The journey time validation routes used in the model are detailed in Appendix G of the development report. WebTAG Unit M3.1 (§4.4.4) recommends that:

> *The validation routes should be neither excessively long (greater than 15 km) nor excessively short (less than 3 km).*

At present, Appendix G does not provide any information as to the length of the journey time routes. **This should be updated to include this information**. A check was undertaken on Route 1 of the journey times, as this produces the longest journey times, which found its length to be approximately 30km, double the recommended maximum route length. Other routes similarly appear to be longer than recommended, and as such, **the auditor recommends that the journey time routes are reviewed and, where this recommendation is exceeded, split into smaller routes**. The coverage of the routes seems reasonable, covering the main routes into and through Aberdeen city centre.

5.3.4 Validation Results: Counts

The webTAG criteria for validation counts are the same as those for calibration counts, as shown in Table 5-9 of this report. The performance of the model against these criteria for the validation counts is shown in Table 5-11.

Table 5-11 Highway validation individual count performance against webTAG criteria

Result	AM		Inter Peak		PM	
	Number	%	Number	%	Number	%
Pass	61	55%	67	62%	68	62%
Fail	49	45%	41	38%	42	38%

Table 5-11 shows that the model does not meet the webTAG criteria for any time period, falling substantially short of the required 85% of counts passing.

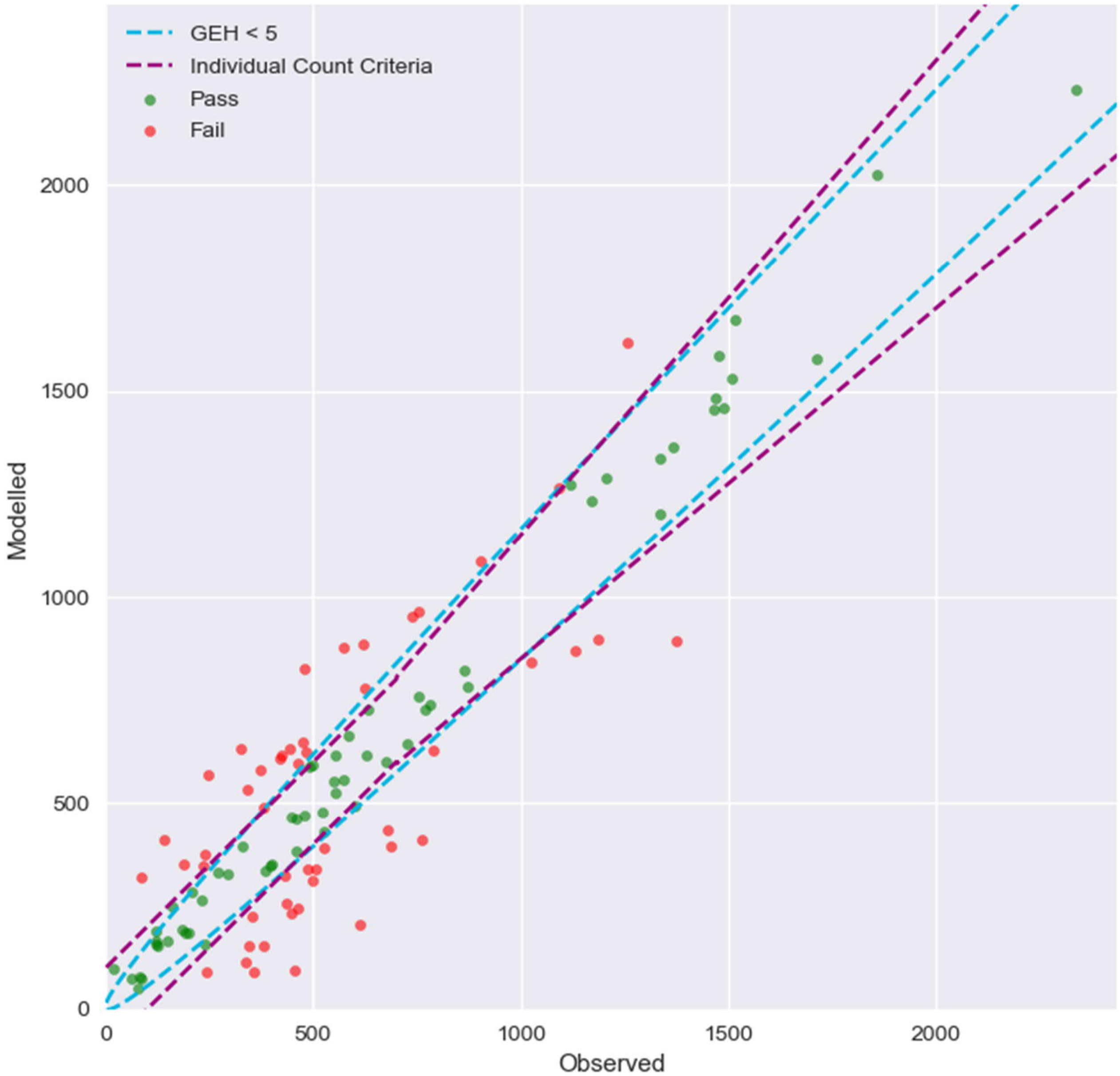


Figure 5-8 Validation individual count performance (total vehicles, all time periods)

Figure 5-8 shows the relatively poor performance of the model against the validation counts, with a number of locations outside the criteria, but again we see no systematic over- or under-representation of counts.

5.3.5 Validation Results: AQMA

Section §8.3 of the development report discusses the validation of count sites in three Air Quality Management Areas, focussing particularly on total vehicles and HGVs, the representation of which is particularly sensitive for air quality. The comparison is presented for three AQMAs:

- City Centre;
- Anderson Drive; and
- Wellington Road.

Appendix K presents the analysis by site, with tables 38 to 40 summarising the results for each area, by time period. Appendix K should be reviewed by potential model users considering the use of the model for AQMA assessment. Concentrating on the Inter Peak results, as these will tend to dominate the daily totals relevant for air quality assessment, for HGVs:

- The model shows a good fit on Wellington Road, though on only two sites;

- the Anderson Drive AQMA sites are affected by routing issues in regard to small HGVs violating the HGV ban on the Bridge of Dee; and
- there tends to be an underestimation on sites in the city centre AQMA, though it should be noted that the sites are not arranged in a cordon, so are not independent, which could adversely affect the analysis.

Model Users with an interest in employing the model for use in assessing AQMAs should review the provided information extremely carefully, taking into account observed errors in the base model, prior to undertaking any work.

5.3.6 Validation Results: Journey Times

WebTAG Unit M3.1 (Table 3) provides guidance for assessing the performance of the model against observed journey time routes, detailed in Table 5-12.

Table 5-12 WebTAG journey time validation criterion and acceptability guideline

Criteria	Acceptability Guideline
Modelled times along routes should be within 15% of surveyed times (or 1 minute, if higher than 15%)	>85% of routes

WebTAG Unit M3.1 (§4.4.5) also states that:

> *As described, it is standard practice to use journey time validation at the route level. However, increasingly there is a need to take a more detailed approach and check journey time validation at the link level or for segments of the route as well. This can be very important to assess noise and air quality impacts in the detail that they are required. Where these impacts may be material, the analyst should produce some assessment of the accuracy of speeds at a finer level.*

At present, journey time results are only presented for full routes. As one of the intended uses of the model is for AQMAs, **the auditor recommends that the journey time analysis is updated to include comparisons by link or section**.

The overall results by route and time period are presented in Table 5-13.

Table 5-13 Highway validation journey time route performance

Route	Description	Direction	Modelled compared to Observed		
			AM	IP	PM
1	A96 Kintore to A90 Portlethen	NB	-8%	-1%	-5%
		SB	-5%	-6%	-13%
2	A90 Balmedie to Portlethen	NB	4%	-4%	-1%
		SB	-4%	1%	10%
3	A93 Drumoak to Aberdeen	EB	13%	-4%	-2%
		WB	-3%	-10%	-4%
4	A944/Garlogie/Westhill to Aberdeen City Centre	EB	4%	-2%	-7%
		WB	-12%	-9%	-2%
5	B9077/Cults to Aberdeen City Centre	EB	-1%	-8%	-13%
		WB	0%	-2%	4%
6	A90 The Parkway to Aberdeen City Centre	NB	0%	-8%	12%
		SB	-11%	-7%	-4%
7	A947 Dyce to A96	NB	-13%	-1%	-12%
		SB	-9%	0%	0%
8	B977 to A93	NB	3%	-2%	11%
		SB	-4%	-1%	19%
9	B997 to Aberdeen City Centre	NB	2%	0%	-2%
		SB	6%	12%	9%
10	A944 to Aberdeen City Centre	EB	-3%	0%	-4%
		WB	-9%	-2%	3%
11	B979 Corridor	NB	-1%	-9%	-10%
		SB	-6%	-6%	0%
12	A90 (Hillside) to Aberdeen City Centre	NB	13%	6%	-6%
		SB	5%	12%	10%
Percentage of passing routes			**100%**	**100%**	**96%**

Table 5-13 shows that the model passes webTAG criteria for all time periods, though this should be considered in the context of the length of some of the routes as mentioned in §5.3.3 of this report. There is a single instance where the modelled journey times lie outside the recommended range from webTAG – this occurs in the PM period on Route 8 in a southbound direction. It should be noted that this route runs alongside the route for the AWPR, and as such will likely require further intention for the intended model use of “Locking in the Benefits” of the AWPR, as poor performance in this area may result in an overestimation of the potential benefits of the AWPR.

5.3.7 Validation Results: HGV routing

The development report §8.2.11-§8.2.15 contains a discussion of HGV routing in the base. **Model users should review this section when undertaking modelling in the urban area.**

5.4 Summary and Recommendations

5.4.1 Calibration

Advice for Nestrans on future model development:

- Update any parameters used to the most up-to-date version of the webTAG databook;
- A review of screenlines should be undertaken to identify any which could be combined into larger screenlines. This should be done at inception stage, as additional data collection may be required;
- Single count sites should not be used in the calibration of the model update, or, if the model developer considers them essential, separate evidence presented as to their impact;
- Model development tasks of network and route choice calibration and validation should be documented;
- Development reports should present screenline comparisons by vehicle type;
- Model development should follow WebTAG, rather than DMRB guidance, to assess screenline performance.

Requested analysis from model developer:

- The development report should be updated to remove reference to DMRB guidance in the assessment of screenline performance;
- The development report should be updated to remove individual site calibration comparisons for those sites using flows from previous models due to lack of survey data;

Advice for model users:

- Model users should consider the analysis of model performance presented in §5.2.5 of this report in light of their area of interest;

5.4.2 Validation

Advice for Nestrans on future model development:

- Explicit consideration as to the confidence that can be given to survey data should be included in any model update, and included in the model development report.

Requested analysis from model developer:

- The development report should be updated to remove individual site calibration comparisons for those sites using flows from previous models due to lack of survey data;
- The reasons for the lack of Inter Peak counts on St Machar Drive should be included in the development report;
- Appendix G should be updated to include information in journey time route lengths;
- Consideration should be given to reviewing the journey time routes, and to splitting them into lengths compatible with webTAG M3.1 §4.4.4. Further, analysis should be provided by link or section, in line with webTAG M3.1 §4.4.5.

Advice for model users:

- Model users should consider the analysis HGV route choice presented in §8.2.11 to §8.2.15 of the development report in light of their area of interest.
- Model Users with an interest in employing the model for use in assessing AQMAs should review the provided information (§8.3 and Appendix K) extremely carefully, taking into account observed errors in the base model, prior to undertaking any work.

Public Transport Model Development

06

6 Public Transport Model Development

Relevant guidance:

TAG Unit M3.2 Public Transport Assignment Modelling, DfT, January 2014

6.1 Introduction

This section considers the following:

- Development of the public transport network;
- Development of the public transport matrix; and
- Development of the assignment model.

The development report (§5.1.3) states that the PT model was based on the modelling approach followed in developing the SRM12/TMfS PT model with the following edits:

- *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.*

6.2 Public Transport Network

6.2.1 Network Construction

The ASAM14 PT network is discussed in the development report §5.2. The network is constructed from the network of the ASAM14 road model and relevant sections of the TMfS14 rail network, under addition of the following key elements:

- Bus priority measures;
- Walk connections between zones and the road and rail networks;
- Walk connections between rail stations and park and ride sites and the road network.

The rail network represents stations on the Aberdeen to Inverness Line and on the East Coast Mainline, between Montrose and Elgin. External connectors link to Carnoustie and Forres. Station car parks are represented within the park and ride model.

Rail service times are time-table based, whilst bus journey times are influenced by road network speeds and bus priority measures.

Bus priority measures were extracted from the previous ASAM model and updated through review of satellite imagery, local knowledge and client feedback. Congested speeds are transferred from the road model to form the basis of bus speeds. This ensures that change in road congestion over time is reflected in the performance of buses. Adjustment factors are applied by road type to reflect lower bus speeds and the impact of passengers boarding and alighting on journey times. The factor values are listed in the development report (§5.2.3):

75%: Rural Dual Carriageways 2 or 3 Lane A-Road;

60%: Rural Roads;

50%: Suburban / Urban >30mph;

60%: Suburban / Urban <30mph;

90%: Bus Lanes;

A minimum congested speed for buses of 5mph is applied, in order to prevent buses being disproportionately being affected by junction delays exported from the roads model. This appears reasonable. The source of the factors are described in the development report (§5.2.3):

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

We recommend that in future model updates **bus speed factors are derived from collected data.**

The walk speed is set to 4.8 kph. In rural areas, where no PT alternatives exist motorised speeds are applied to walk links. This is based on the assumption that access to PT services in these areas will be dominated by passengers being given a lift or taking a taxi. Maximum walk time assumptions are applied as follows:

- Rail: 60 minutes;
- Inter-urban bus: 40 minutes;
- Urban bus: 20 minutes.

6.2.2 Public Transport Services

Service time periods were defined based on the mid-point of the service time.

Bus Services

The coding of bus services was based on the 2016 version of the ATCO-CIF / TransXchange digital bus timetables. 2016 service information was used to ensure consistency with the 2016 bus passenger surveys and base on the assumption that the service levels provided did not substantially change between the base year (2014) and 2016. **The auditor would recommend that the appropriate base year transXchange / ATCO-Cif data is used in future model development. This recommendation also applies to rail services and capacities, discussed later**.

Bus stops located on sections of the local road network not represented in the ASAM network were “snapped” to the nearest modelled node. Bus journey times on such sections were determined automatically based on the shortest time path between stops. Spot checks were undertaken to ensure bus routes followed logical paths following the edits. This is appropriate.

Rail

Rail service coding was based on information extracted from TMfS14 and updated based on 2016 ATCO-CIF timetable data. Average headways were calculated for services that fell into each time period (0700-100, 1000-1600,1600-1900) based on the mid-point timetabled time. Adjustments were then made where connectivity was compromised due to the representation of infrequent long-distance services based on this approach. Where required such services were included in more than one time period. A review of service frequency for long distance services was subsequently undertaken in order to prevent unrealistic service frequencies as a result.

6.2.3 Public Transport Fares

The PT Fares Model is described in §5.4 of the Development report. All fares are in 2014 prices, unless stated otherwise.

Bus

Fares were calculated for each user class, improving the representation of travel cost by allocating preferred ticket types:

- Bus In-Work: Return fare divided by two;
- Bus Non-Work Other: As above with the application of a concessionary factor of 29% non-concessionary cardholders making non-work and commute trips based on on-board bus questionnaire surveys carried out in 2014. The fare for concessionary pass holders was set to zero;
- Bus Non-Work Commute: Price of a weekly season ticket divided by a seasons factor of ten.

These assumptions are considered appropriate.

Bus fares are based on distance based fare tables. Depending on the operator, the following approaches were used:

- Stagecoach and "Other Aberdeenshire operators": nine distance based fares;
- First: five distance based fares; and
- Citylink: three distance based fares.

The 2016 fares have been used to represent Citylink fares, without adjustment. **We recommend that all fares are adjusted to the common price base of 2014.**

Rail

The calculation of rail fares is described in §5.4.6 to §5.4.9 of the development report. Rail fares are evaluated based on station to station fares tables, by time period and travel purpose. The station to station fares matrix was developed based on 2014/5 LENNON data by ticket type.

As with the bus fares model, variability of fares by trip purpose was accounted for by allocating preferred ticket types. In addition, the impact of peak and off-peak fares on the cost of travel in different time periods was taken into consideration. Non-work other fares were adjusted to account for the use of advance tickets. Based on analysis of LENNON data on movements between Aberdeen and Dundee and Aberdeen and Inverness it was assumed that this accounted for 37% of movements. Concessionary factors (33%) were also applied to a proportion of travellers based on the number of rail cards issued at UK level/total UK population.

The assumptions made in deriving rail fares appear reasonable.

6.2.4 Passenger Wait Curves

Wait curves are based on the PDFH Non London Inter-urban curves for all PT lines, the shape of the wait time curve is shown in Figure 6-1. The actual wait time values represent approximately half of the headway where services arrive every 15 minutes or more frequently. For longer headways the gradient reduces gradually. Where the headway is longer than two hours the additional wait time is capped at two minutes per hour. A factor of 2 is applied to reflect people perceived wait time. This is in line with the range for the perceived wait time weighting given in WebTAG Unit M3.2 §3.1.5.

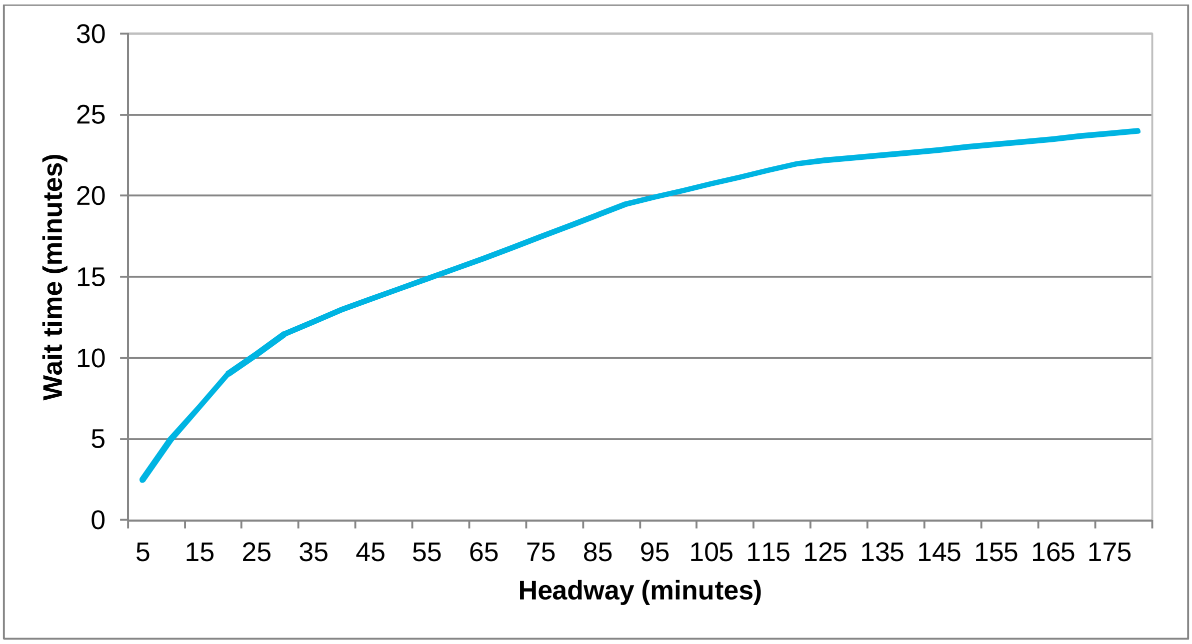


Figure 6-1 ASAM14 Wait Curve Definition[10]

6.2.5 Crowding

Crowding is considered in the modelling of AM and PM peak rail services only. Based on the assumption that operators will provide additional capacity to meet demand where required, bus crowding is not modelled. This is a reasonable approach.

The development report states (§5.6.7) that specific rail service capacities sourced from TMfS14 were allocated to the 2016 ATCO-CIF timetable data to establish overall capacity. Capacity on non-ScotRail services was estimated based on available data on rolling stock and service provision.

The methodology to represent crowding impacts is based on the SRM12 crowding model.

The “PDFH Non-London Commuting Rail” crowding curve is used with the following simplifying assumptions:

- Crush capacity is assumed to be 140% of seated capacity on all services (based on an average of crush capacities of train classes operating in the modelled area.
- In the absence of data describing availability of standing space, the ScotRail rolling stock crush capacity figures was used to allocate the PDFH Regional crowd curve. The version of PDFH used should be stated.

It should be noted that the SRM12 audit includes the following recommendation regarding the crowding model used:

> *Systra should clarify whether “PDFH Non-London Commuting Rail Crowding” is taken from the current version of PDFH, and whether the tables of seating and standing m2 included in PDFH is insufficient to allow the application of the quoted PDFH 5.1 approach.*

Furthermore a suggestion is made for any future updates to

> *[undertake a] review of the rolling stock in use in the modelled area, in order to derive individual, or, where sufficiently similar, average crowding curves. The crush capacity values should similarly be reviewed.*

The auditor would recommend that some commentary is included as to how these recommendations have been considered.

[10] Source: ASAM14 Model Development Report, SYSTRA, June 2018

Constant arrival profiles are used to model passenger and vehicle arrivals. SYSTRA acknowledges that this may underestimate crowding impacts during peak periods. At a strategic level the impact is not likely to be significant, however, **consideration should be given to enhancing the representation of arrivals as crowding impacts may be noticeably understated in some areas of the models as a result.**

The crowding model operates on a loop which calculates a set of crowding factors and passenger loadings and feeds these back into the assignment stage to produce new passenger loadings and crowding costs. The number of iterations is specified by the user (with a default of five) rather than automatically by a set of convergence criteria based on the change in PT loadings and crowding costs. This means that that the crowding model may be terminated before convergence is achieved. The development report (§5.6.14) places the onus on the model user to review the settings for each model application, though advice is offered on the settings in §16.2.7. **In future model updates, it may be worth considering setting convergence thresholds to terminate the crowding model should this be practical in terms of model run times.**

6.2.6 Public Transport Model Peak Hour Factors

The PT time period to peak hour factors for ASAM14 are shown in Table 6-1.

Table 6-1 PT Time period to Peak Hour Factor

Time period	Peak hour	Time period to peak hour factor
AM (0700-1000)	0800-0900	0.43
Interpeak (1000-1600)	1/6 of 1000-1600	1/6
PM (1600-1900)	1700-1800	0.43

The development report (§2.3.18) states that the factors were updated based on public transport passenger counts during the development of the ASAM14 model. We note that the factor values for the AM peak and PM peak are the same. This also applies to the factors used in the Roads Model. **The source of the passenger counts data used in establishing these factors should be stated and sufficient detail of the processing methodology provided to confirm that factors for the AM and PM periods have been considered separately.**

6.3 Matrix Development

The development of the prior matrices is described in §4.4 of this report.

6.4 Assignment Model Procedures and Parameters

A standard approach to path building and loading is adopted, incorporating a walk choice model, service frequency and cost model and alternative alighting model.

A series of parameters are defined to control the assignment, as follows:

- Walk, wait and in-vehicle time:
    - Walk times are factored by 1.6;
    - Wait times are modelled using the wait curve discussed above but capped at 60 minutes at the route enumeration stage only; and
    - In-vehicle times are factored according to mode: urban bus (1.4), inter-urban bus (1.4) and rail (1.0). These factors do not vary by time period.
- Penalties:
    - Boarding penalties of 5 minutes are applied in all time periods; and
    - A transfer penalty of 5 minutes is applied (to/from bus only).
- Route enumeration:
    - A route enumeration fare runtime factor of 0.85 is applied to bus only;

- A spread factor of 1.5 and a spread constant of 10 minutes are used.

The factors are considered appropriate. The route enumeration parameters will ensure that even relatively short urban routes will consider a reasonable set of multi-routing. A combined boarding and transfer penalty of 10 minutes is reasonable for an urban focussed model.

6.5 Summary and Recommendations

6.5.1 Public Transport Network

Advice for Nestrans on future model development:

- In future model development, ensure all inputs reflect base year supply and demand or that appropriate adjustments are made. Where change is considered negligible evidence should be provided to justify this assumption;
- In future model updates adjustment factors applied to road model speeds to reflect lower bus speeds and the impact of passengers boarding and alighting should be derived from observed data;
- In future model development consider enhancing the representation of passenger and vehicle arrivals;
- In future model updates, consider the use of convergence thresholds to terminate the crowding model should this be practical in terms of model run times.

Requested analysis from model developer:

- Ensure all fares are adjusted to the common price base (2014);
- Include commentary on how the SRM12 audit recommendations for the crowding model have been considered, to confirm that this is appropriate for use;
- State the source of the passenger counts data used in establishing the peak hour factors should be stated and provide detail of the processing methodology to confirm that factors for the AM and PM periods have been considered separately.

Public Transport Model Calibration and Validation

07

7 Public Transport Model Calibration and Validation

Relevant guidance:

TAG Unit M3.2 Public Transport Assignment Modelling, DfT, January 2014

7.1 Introduction

This section considers the validation of the public transport assignment model to observed flows and journey times.

7.2 Calibration

7.2.1 Calibration Data Inputs

Data used in the calibration of the ASAM14 public transport assignment model consists of the following:

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

7.2.2 Calibration Locations

Two screenlines have been used in the calibration of the public transport model – an inner screenline and an outer screenline, relative to Aberdeen city centre. The locations used in these screenlines are shown in Figure 7-1.

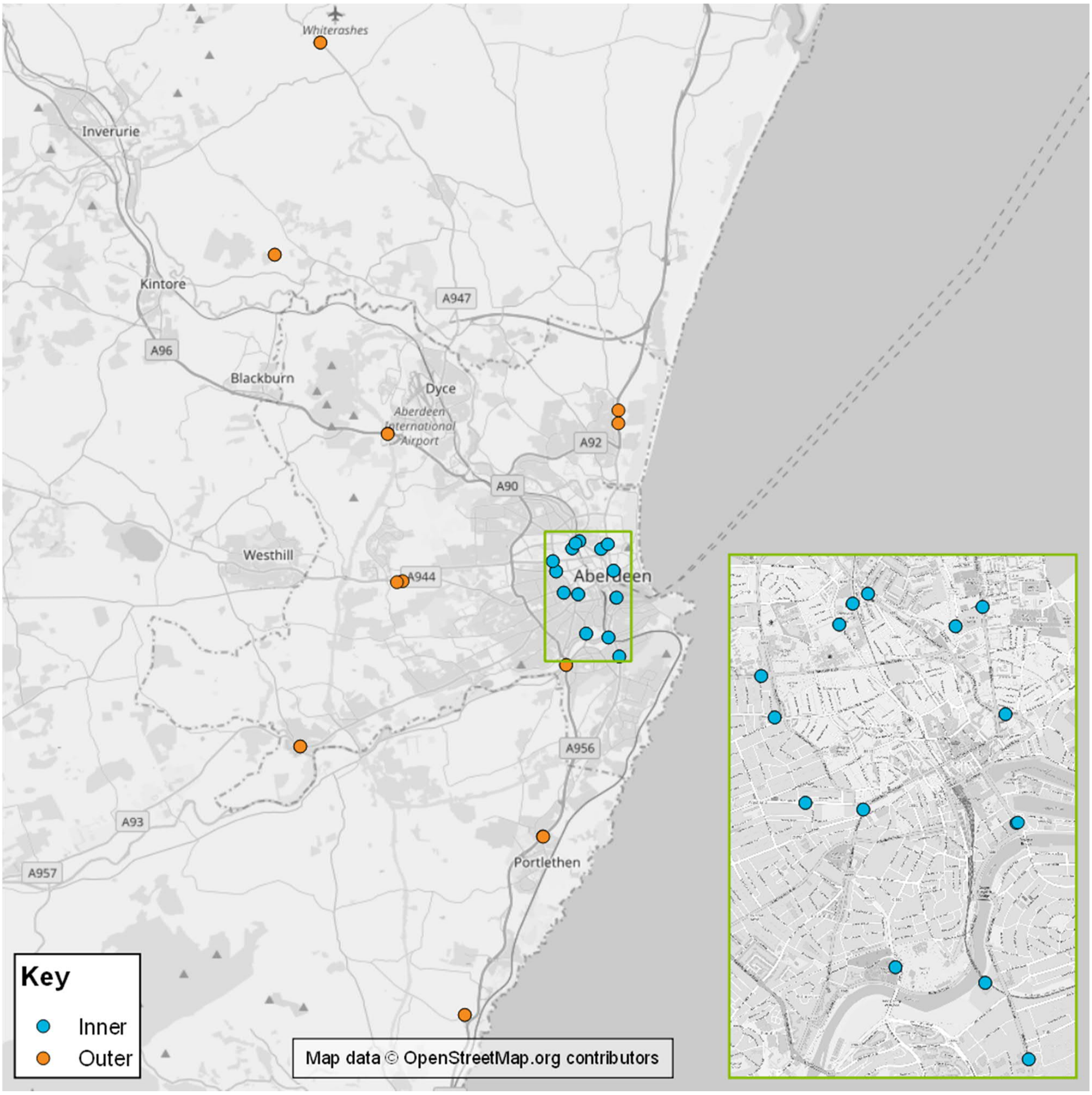


Figure 7-1 Public Transport calibration locations

A review of these cordon points against bus route maps by the auditor has confirmed that the screenlines cover the great majority of routes.

7.2.3 Calibration Procedures

The development report states (§9.3.2) that:

> *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.*

This is appropriate, given the use of the assignment model to apply sub mode split.

7.2.4 Impact of Matrix Estimation on Prior Matrix

The webTAG guidance for levels of impact of matrix estimation for public transport matrices is the same as that for highway matrices, detailed previously in §5.2.4 of this report. These criteria have been used to assess the impacts of matrix estimation on the public transport matrix, however **no comparison has been provided for matrix cell values. This comparison should be undertaken and added to the appropriate section of the report.**

The impact of calibration on trip ends is provided in Table 7-1.

Table 7-1 Public transport matrix estimation zonal trip end comparisons

Type	Statistic	AM Peak	Inter Peak	PM Peak
Origin	Slope	0.995	0.974	0.982
	Intercept	-0.156	-0.022	0.041
	R^2	0.997	0.997	0.998
Destination	Slope	0.994	1.001	0.984
	Intercept	-0.323	-0.358	0.055
	R^2	0.999	0.998	0.998

The performance against criteria is good, with only the slope falling marginally outside guidelines in a few instances.

Table 7-2 provides a comparison against webTAG guidance for trip length distribution changes.

Table 7-2 Public transport matrix estimation trip length distribution comparisons

Time Period	Statistic	Pre Estimation	Post Estimation	% 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%

As with the highway matrices, these results show values significantly larger changes than recommended by webTAG. The mean trip distance reduces for all time periods, again suggesting that the estimation process is increasing the proportion of short-distance trips. This combined with the reduction in standard deviation for all time periods suggests that the estimation process may be smoothing the matrix more than expected.

Finally, the main body of the report again does not provide detailed results for the sector movement comparisons. The values are provided, however, in Appendix H. A comparison of all of the results can be found in Table 7-3.

Table 7-3 Public transport matrix estimation sector movement comparisons

Difference	AM		IP		PM	
	Count	Percentage	Count	Percentage	Count	Percentage
< 5%	87	10%	116	14%	116	14%
> 5%	754	90%	725	86%	725	86%

Table 7-3 shows a large number of sectors reporting trip changes greater than the 5% recommended threshold from webTAG. As with the highway matrices comparison, it should be noted that a large number of these changes apply to relatively small numbers of trips. Table 7-4 instead presents these comparisons restricted to sector pairs reporting over 150 passenger trips in the prior matrix.

Table 7-4 Public transport matrix estimation sector movement comparisons (> 150 passengers)

Difference	AM		IP		PM	
	Count	Percentage	Count	Percentage	Count	Percentage
< 5%	6	38%	6	60%	7	50%
> 5%	10	63%	4	40%	7	50%

Table 7-4 shows that there are sector pairs in each time period with reasonably high trip levels showing changes above the recommended level from webTAG. These changes should be reviewed. The large change reported may indicate the low quality of the underlying prior matrices.

7.2.5 Calibration Results: Screenline Counts

The calibration of the PT model is discussed in chapter 9 of the model development report. The calibration criteria used are in line with WebTAG Unit M3.2, which states (§7.1.6):

> *…across modelled screenlines, modelled flows should, in total, be within 15% of the observed values.*

Table 7-5 presents comparisons according to this guidance.

Table 7-5 Public transport calibration screenline performance

SL	Direction	Type	AM Peak				Inter Peak				PM Peak			
			Obs	Mod	Diff	%Diff	Obs	Mod	Diff	%Diff	Obs	Mod	Diff	%Diff
Inner	Inbound	Bus	3748	3687	-61	-2%	2153	1944	-209	-10%	2957	2884	-73	-2%
		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%
	Outbound	Bus	2418	2385	-33	-1%	1916	1749	-167	-9%	3387	3426	39	1%
		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%
Outer	Inbound	Bus	603	663	60	10%	262	246	-16	-6%	429	423	-6	-1%
		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%
	Outbound	Bus	281	274	-7	-2%	248	270	22	9%	633	660	27	4%
		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%

Overall the comparison is good, with only the Inter Peak rail flows falling outside of webTAG guidelines.

7.2.6 Calibration Results: Individual Counts

The calibration criteria for individual counts are given in WebTAG Unit M3.2, which states (§7.1.6)

> *On individual links in the network, modelled flows should be within 25% of the counts, except where observed hourly flows are particularly low (less than 150 passengers per hour).*

The inclusion of GEH statistics in the development report is not compliant with guidance, and should not be included in future model development reports.

Table 7-6 provides a summary of the individual count performance against this guidance.

Table 7-6 Public transport individual count calibration summary

Number of Sites	Inner Cordon			Outer Cordon		
	AM	IP	PM	AM	IP	PM
Overall	30			20		
…of which > 150 passengers	18	10	21	5	1	4
…of which > 25% difference	0	0	1	0	0	0

Table 7-6 shows that there is only one instance of the modelled flows not meeting the webTAG criterion. This occurs on the A956 Market Street in the PM period, though it should also be noted that this site features "patched" data.

7.3 Validation

7.3.1 Validation Data Inputs

Data used in the validation of the ASAM14 public transport assignment model consists of the following:

- Office of Rail regulator (ORR) 2015 rail passenger boardings and alightings by station.

7.3.2 Trip Matrix Validation

No validation of the trip matrix has been undertaken as the development report explains (§9.1.5) 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*

7.3.3 Network and Service Validation

Network and service validation was undertaken by comparing modelled bus times against timetabled journey time. As discussed in §6.2.1, the modelled bus journey times are a function of two inputs:

- Road model journey times; and
- Adjustment factors to account for the lower speeds and more frequent stopping of buses when compared with general road traffic.

However, though timetabled times have been treated as 'observed' it is unclear how closely these timetables relate to actual bus journey times – in general, our experience is that though operators do attempt to ensure that timetables do reflect actual journey times, there can often be a time lag. Ideally, a check should be undertaken to see how much the timetabled times vary across the day – if the times do not change between peak and off peak times, this would suggest that the timetables may actually be significantly faster than "actual" in the peak periods. **In future model developments, efforts should be made to establish how representative of actual journey times the published timetables are if the intent is to use them as a source of bus journey time validation**.

Table 7-7 provides a summary of these comparisons.

Table 7-7 Public transport comparisons with bus timetables

Within 15% of timetable?	AM		IP		PM	
	Count	%	Count	%	Count	%
Yes	17	59%	16	55%	17	59%
No	12	41%	13	45%	12	41%

Overall, the comparison provided is poor, with around 60% of services falling within 15% of the published timetables. We also note that the majority of the routes which fall outside 15% of the published timetables are faster than the timetable, suggesting that the difference between modelled and observed may be even greater than it appears. However, conclusions are difficult without understanding how representative the data source is.

7.3.4 Assignment Validation

No comparisons of passenger flows have been undertaken in network validation for the reasons mentioned in §7.3.2 of this report, however, comparisons of boardings and alightings at rail stations have been undertaken.

These comparisons, shown in Table 57 of the development report, show that the model compares well with the data in some locations (particularly Dyce and Stonehaven) but performs poorly in other areas. In particular the comparisons at Arbroath and Montrose are poor; however the development report notes (§9.6.7) that:

> *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)*

This explanation is considered reasonable.

The comparisons at Aberdeen itself show the model is around 25% lower than observed for both boardings and alightings, however the PT calibration screenline performance (as seen in §7.2.5 of this report) suggested that the inner screenline around Aberdeen city centre performs fairly well for rail.

7.4 Summary and Recommendations

7.4.1 Calibration

Requested analysis from model developer:

- The development report section covering matrix estimation should be expanded to provide more detail;
- In line with webTAG, a comparison of matrix cell values pre and post estimation should be undertaken and reported upon;
- Assessment of link validation should be presented using WebTAG measures only.

7.4.2 Validation

Advice for Nestrans on future model development:

- In future model developments, efforts should be made to establish how representative of actual journey times the published timetables are if the intent is to use them as a source of bus journey time validation.

Demand Model

08

8 Demand Model

Relevant guidance:

WebTag Unit M2 Variable Demand Modelling, March 2017

8.1 Introduction

The ASAM14 demand model is based on the SRM12 demand model. Since the processes involved in this model have been audited for that model, in line with our proposed audit approach the discussion in this section is limited to a brief description of the methodology together with commentary on any departures from the SRM12 approach, and the reported realism testing. Users should consult the SRM12 Audit Report for detailed commentary on the modelled structures.

8.2 Model Scope and Processes

The demand model constitutes a multi-modal mode and destination choice model which has been executed in CUBE. The model incorporates park and ride site choice and to-home and non-home based trip estimation and uses a logit based choice mechanism and incorporates distance-based cost damping.

Changes in Goods Vehicle and external movements are handled by the Trip Ends Model.

The main inputs are listed in the model development report (§10.2.1):

- *trip productions and attractions [from the TRIP End Model];*
- *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.*

Generalised costs inputs for the first iteration of the model are obtained from the assignment models. Parking charges were developed based on a review of online parking data for 2016 and applying assumption on the length of stay.

8.2.1 Derivation of 'From Home' Matrices

From home trips are calculated for the three time periods, i.e. AM (-), Interpeak (-) and PM (-) and the three travel purposes, i.e. Business, Commute and Other.

From-Home Education trips are added after the main Mode and Destination choice models are run.

8.2.2 To-Home Trips

To-Home trips are derived from the From-Home trips using a reverse factoring process. This was informed by the process used for the SRTM and is described in the development report (§11.1.3 to §11.1.7)

A matrix of "return" factors for each origin-destination pair was derived from Scottish Household Survey data generate appropriate "return" factors for each "from home" O-D pair, by time period, journey purpose and mode.

The process of generating To Home trips is described in the development report (§11.1.2) as follows:

> *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.*

8.2.3 Non-Home Based Trips

Non-Home based trip ends were derived from the From-Home destinations and To-Home origins for In-Work and Non-Work using a factoring process. Non-Home based trip matrices were derived by applying the resulting trip ends to a distribution model. Constraints were applied to ensure origin and destination totals are equal.

8.2.4 Treatment of Parking

Park and ride and parking is incorporated in the mode and destination choice processes as a separate mode. Demand outputs are then allocated by a site choice procedure, which includes park and ride, rail station car parks and paid for city centre parking.

Private non-residential, residential and other paid for parking outside Aberdeen City is handled by the main mode and destination choice procedures.

For the purpose of calculating generalised Costs, parking charges for facilities not covered by the Park and Ride and Parking Model, and that are located in Aberdeen City and larger towns, are represented by average costs per zone. Charges vary by journey purpose.

Variations in ease of access due to constrained availability are reflected through parking constants, ranging from a minimum of 5 minutes in rural areas to 27 minutes in Aberdeen City Centre.

8.2.5 Treatment of Airport and Heliport Demand

Airport trips are handled through the inclusion of from-home airport passenger trips in the Business and Other matrices, subsequent to the main From–Home To-Home and non-Home based model processes. Airport Destination choice is made through a separate procedure which is responsive to future changes in cost.

Travel demand to the Heliport based on offshore travel to work movements from the 2011 Census is also included. A mode choice procedure which responds to future changes in Heliport travel costs is applied.

Trips for employees at Aberdeen Airport and heliport are included in the standard procedures generating the Commute matrices.

8.2.6 Structure and parameters

The structure is shown in Appendix J and includes the following departures from the structure of the SRM12 model:

- Inclusion of evening peak demand model;
- Inclusion in inter-peak Park & Ride modelling;
- Reflection of City centre car parking (as Park and Walk) in the Park and Ride module;
- Inclusion of airport model, reflecting Aberdeen City Airport and Heliport.

The following parameters are available to influence choice:

- Distribution model sensitivity parameters,
- Mode choice scaling factors;
- Mode specific constants; and
- Park and Ride parameters.

The model development report (§10.2.15) states that realism testing based on WebTAG guidance on Variable Demand Modelling is applied and that sensitivities were compared to guidance standards.

8.2.7 Mode Choice Mechanism

The mode choice mechanisms operates by calculating utilities based on the generalised costs for each mode by time of day.

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

Where $v_{i,j}$ denotes the utility to be used in the mode choice comparisons, $C_{i,j}$ the generalised cost, ASC_M the mode specific constant and α and λ are estimated parameters.

The proportion of car and public transport users is the calculated using a logit model of the form

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

Where P denotes the proportion of mode M for a given origin-destination pair i,j.

It should be noted that applying these proportions to overall travel demand results to matrices in terms of person trips. Car occupancy factors are applied to convert the road person demand to vehicle journeys.

8.2.8 Cost Damping

Distance based cost-damping is applied, in line with WebTAG (M2 §3.3.3). Damping was applied to the Generalised Costs calculation as follows:

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

Where G' denotes the damped Generalised Cost, G the Generalised Cost prior to damping and α and k are calibration parameters. The initial value for k was given by the mean trip length by mode.

The final cost-damping parameters are shown in Table 8-1.

Table 8-1 Cost Damping Parameters

Mode	Alpha	K
Car	0.37	25 km
Public Transport	0.15	3.5 km

8.3 Model Calibration

8.3.1 Data

The model development report (§12.1) briefly reports on a preliminary inspection of the data 2011 census travel to Work and 2014 Scottish Household Travel Diary movement data and concludes that they are suitable for use in the calibration process, showing a good relationship between generalised costs (in minutes) and journey distance, a sensible trip length distribution and plausible trends in mode share, travel demand and travel costs. In terms of sample size the report notes that there is a level of uncertainty around the trip patterns generated from the SHS data due to the small sample size particularly with respect to PT.

As discussed in §4.4.3, though an excellent, robustly carried out survey, the sample size collected for the SHS means that when attempting to generate a 28 sector matrix of trips, additionally segmented by travel purpose, sample sizes will be extremely small, leading to 'lumpiness' in the expanded matrices. This is evident in the matrices presented in Appendix B. **It would be beneficial if details of these data and checks were presented in the report to confirm that the calibration process starts from a sound basis.**

8.3.2 Processes

The initial settings for the mode choice parameters were based on the median parameter values stated in WebTAG. Manual adjustments were applied in order to improve agreement with the observed trip length distributions by period, purpose, car availability and mode. **Commentary should be included on the extent of adjustments made.**

The rationale for excluding trip frequency from the model responses should be included in the development report.

8.4 Model Validation

8.4.1 Realism Tests

A series of "realism tests" were undertaken, as prescribed by WebTAG, to demonstrate that the model responds in an appropriate manner to various changes in generalised costs. The realism tests covered fuel price elasticity; travel time elasticity and PT fare elasticity. These tests are described in §13 of the model development report.

There is an unacknowledged issue in calculating elasticities in ASAM. As ASAM only applies its choice models to internal to internal trips, it is not possible to assess the sensitivity of a complete range of trip lengths. Since the WebTAG targets are for a complete range of trip lengths, the model sensitivity is expected to be low. As the modelled area is relatively large this issue will probably not have a very large effect, **but in future model developments it should be considered and the scale of effect estimated in a spreadsheet if possible.**

The development report states that the realism tests have been undertaken in line with webTAG. Though details of the methods used are omitted, we therefore assume that, for example, the fuel price and PT fare elasticity tests have been iterated to convergence, whereas the journey time elasticity test was run for a single iteration. Elasticities are presented separately by time period as well as purpose, and total annualised values, which is very helpful. WebTAG Unit M2 requires (§6.4.13) that fuel cost elasticities be calculated at both a network and matrix level. The model development report presents only one set of values in Table 65 are at matrix level. **Fuel cost elasticity values calculated at matrix and network level should be presented in the report**.

8.4.2 Car Fuel Price Realism Test

WebTAG M2 §6.4 provides the following guidance for judging acceptability of performance:

> *Elasticities may also be regarded as more plausible if:*
>
> *• the pattern of annual average elasticities shows values for employers' business trips near to -0.1, for discretionary trips near to -0.4, and for commuting and education somewhere near the average; and*
>
> *• the pattern of all-purpose elasticities shows peak period elasticities which are lower than interpeak elasticities which are lower than off-peak elasticities.*

The results presented in Table 65 do exhibit this pattern, both between time periods and between purposes. The overall expectation of webTAG is that

> *• the annual average fuel cost elasticity should lie within the range -0.25 to -0.35 (overall, across all purposes); and*
>
> *• the annual average fuel cost elasticity should lie on the right side of -0.3, taking account of the levels of income and average trip lengths prevailing in the modelled area – see below for advice on what is the 'right' side of -0.3.*

The elasticity when annualised and summed across all car availability and travel purposes is -0.37. This is above the recommended levels. WebTAG M2 §6.4.15 states:

> *However, it is generally difficult to estimate the magnitude of the effects of these factors and therefore the extent to which the true elasticity for the area being modelled may vary from the figure of -0.3. It is for this reason that an acceptable range, from -0.25 to -0.35, is specified and analysts should not use models for scheme appraisal which have elasticities outside this range without providing a reasoned case for doing so and without the Department's approval.*

The development report contains a discussion of the results, and suggests a possible explanation of the overall elasticity falling slightly outside of the suggested range being longer than average trip lengths. **This statement should be backed by analysis of available data.**

The description contained in §13.2.2 misrepresents the guidance: WebTAG M2 does not state that "short trip lengths…closer to zero than -0.3" or "high car driver mode share…closer to zero than -0.3". When stating "closer to zero", WebTAG M2 §6.4.15 is indicating the 'right' side of -0.3 ie trip lengths that are shorter than average will tend to be between 0 and -0.3 (it does not use the intuitive word 'less', as less than a negative is awkward to express in these terms). **This should be revised.**

8.4.3 Generalised Cost Realism Test

The generalised cost realism test is undertaken as a proxy for the journey time elasticity test in webTAG. This is acceptable. WebTAG M2 §6.4 recommends that

> *The output elasticities should be checked to ensure that the model does not produce very high output elasticities (say stronger than -2.0)*

The results presented are in the range of -0.8 and -1.4, with a generally intuitive relationship between purposes and time periods. The annual value is -1.13.

8.4.4 Public Transport Fare Realism Test

WebTAG M2 §6.4 states that

> *Elasticities of public transport trips with respect to public transport fares have been found to lie typically in the range –0.2 to -0.9 for changes over a period longer than a year (TRL, 2004). Values close to -0.2 are unlikely for the whole public transport market unless this includes a high proportion of concessionary fare trips with a significant number made free of charge.*

and

> *The elasticities may also be regarded as more plausible if:*
>
> > *• the pattern of annual average public transport fare elasticities shows values for non-discretionary purposes which are lower than those for discretionary trips; and*
> >
> > *• the pattern of all-purpose public transport fare elasticities shows peak period elasticities which are lower than inter-peak elasticities which are lower than off-peak elasticities; and*
> >
> > *• the elasticities for car-available segments are greater than the non-car-available segments since the former have greater choice than the latter, although there are arguments to suggest that noncar-available fare elasticities may be higher where incomes are lower.*

and

> *Elasticities of bus trips with respect to bus fares for full fare paying passengers have been found to lie typically in the range –0.7 to -0.9 for changes over a period longer than 5 years (Dargay and Hanley). Unless analysts can provide a good reason otherwise, the Department's view is that the annual average bus fare elasticity from the base year model should lie within this range.*

The values presented in the model development report range from -0.09 to -0.23, and are therefore outside of the recommended range. The annual value is -0.14. It is also noticeable that the commute purpose is the most sensitive, which is contrary to expectations. The model developer notes that:

> *With the model displaying a response at the lower end of the recommended level, care should be taken when testing interventions, schemes or policies that may impact public transport fares.*

Our judgement is that the displayed responses are outside of the recommended range, and that the model should not be used when testing interventions, schemes, or policies that may impact public transport fares. Further, we note that this issue has recurred over several LATIS regional models, and recommend that **Transport Scotland commission an investigation of this issue prior to using an existing model with this problem as the basis of a further model development or update.**

8.5 Summary and Recommendations

8.5.1 Model Calibration

Requested analysis from model developer:

- It would be beneficial if details of the SHS data and checks were presented in the report to confirm that the calibration process starts from a sound basis;
- Commentary should be included on the extent of calibration adjustments made in the calibration process;
- The rationale for excluding Trip Frequency response should be included.

8.5.2 Model Validation

Advice for Nestrans on future model development:

- In future model developments, the possible scale of impact of excluding external trips on the expected elasticities should be estimated and presented;
- Fuel cost elasticities should be estimated on a network and matrix basis, as required by WebTAG;

Requested analysis from model developer:

- Discussion posits that a possible explanation of the annual fuel price sensitivity of -0.37 being outside of the range -0.25 to -0.35 is higher than average trip lengths. This assertion should be backed by analysis of data.
- The description in the development report §13.2.2 misrepresents the guidance. This should be revised.

Advice for Model Users:

- Our judgement is that the displayed responses for the public transport fare realism tests are outside of the recommended range, and that the model should not be used when testing interventions, schemes, or policies that may impact public transport fares;

Advice for Transport Scotland:

- Transport Scotland should commission an investigation of the low levels of sensitivity, and lack of intuitive relationship between the modelled purposes, in the public transport fare realism tests, as this issue has manifested in several LATIS regional models. This should be concluded prior to using an existing model with this problem as the basis of a further model development or update.

Performance against objectives

9 Performance against objectives

9.1 Introduction

As discussed in §1.6, the proposed objectives of the model development have implications for both the design of the model and the level of validation against observed data though should be achieved. This final chapter summarises the findings of the model audit against these criteria, and then provides recommendations as to the possible applications of the model. We note that the model development report does not discuss the performance against objectives of the model, though §1.4 does provide general advice on how to review model performance in a model applier's area of interest, information on model performance in the AQMAs are provided in the development report. **We recommend that for future model developments, the reporting should include the opinions of the model developer as to the suitability of the resulting model for the intended uses listed in the project brief in a concluding chapter, particularly concentrating on the limitations of use.**

As discussed in Chapter 4, there remain consequence appreciable uncertainties in the accuracy of the prior matrices. **All model users should therefore consider whether to defer model applications until the planned model update with new demand data is undertaken, or should consider how to explain the consequential uncertainty in the model forecasts, consulting Appendix B of the development report.**

9.2 Model Design

There must be a fully modelled area covering the hinterland/North East adequate for the proposed range of schemes.

The fully modelled area of ASAM is sufficient for the testing of schemes in the daily travel of work area of Aberdeen.

Within this area highway and public transport networks must be represented in reasonable detail. If the schemes are focused on new A roads then the network should include B and key minor roads (ie one 'grade' more detailed).

The model represents the roads hierarchy in sufficient detail, with A, B, and key minor roads represented.

Across Aberdeen there must be a similar representation of radial / routeing and there should be evidence on the credibility of changes (routeing and redistribution) in response to land use change and AWPR.

The Information Note "ASAM14 Forecasting Scenario Results and AWPR Impacts" presents a discussion of the model changes in response to the AWPR. As the AWPR has only, as of writing, recently opened, the note presents and discusses the modelled flow changes without undertaking a comparison with observed data. This is sensible, as trip patterns are likely to still be in a state of flux. **Model users should review the presented material and judge whether the described performance is intuitive and gives confidence.**

Within the city centre there must be spatially detailed representation of the transport networks. It is unlikely that this can be limited to A/B roads. There must be some mechanism to represent parking costs / access time that affects demand modelling.

The model is spatially detailed in the city centre, and represents parking costs in the demand model.

Depending on the range of policies there may be a need for representation of active mode demand.

Active modes are not represented. **The model user should consider the relevance of this to the intended application.**

9.3 Model Performance/Data Quality

The test for model adequacy against objectives in regards to performance/data quality can be summarised as:

The demand matrices must be verified against observed origin destination information to represent completely broad travel patterns across the North East and to / from this area. There must be finer grain analysis / verification within Aberdeen City.

Due to a lack of data, the model developer used a purely synthetic method of developing the prior matrices. Considerable effort was then expended in validating the pattern of the resulting matrices against what data was available, including finer grain analysis within Aberdeen City, with an iterative process of adjustment undertaken in order to refine the output. However, this is not compliant with UK practice, and the lack of any data even for validation is particularly concerning.

Highway and PT network performance must be tested against WebTAG accuracy requirements within and near Aberdeen City. Analysis of performance in respect of AWPR, city centre and AQMAs must demonstrate acceptable performance or explain limitations of use.

Model performance in respect of AWPR has been included in a supplementary forecasting note, which also includes discussion of the impacts following introduction of the city centre masterplan transport proposals. As noted above, as the AWPR has only, as of writing, recently opened, the note presents and discusses the modelled flow changes without undertaking a comparison with observed data. This is sensible, as trip patterns are likely to still be in a state of flux. Model users should review the presented material and judge whether the described performance is intuitive and gives confidence. **Once available, a 'present year validation' should be run against observed data collected post AWPR opening, with the results documented for review by model users.**

Analysis of performance standards and data quality across the North East should explain the model quality and extent to which the outputs can be used, eg for initial planning purposes, and where refinement would be necessary in preparing outline / full business cases.

In the absence of this discussion in the model development report, this audit will form the only source of recommendations on model use.

9.4 Recommended Uses of ASAM

As a general recommendation, due to the performance of ASAM in the public transport fare realism test, as noted in §8.4.4, ASAM should not be used when testing interventions, schemes, or policies that may impact public transport fares. Also, as discussed in §9.2, prior to the model's use in forecasting any model outputs, such evidence should be documented.

9.4.1 Outline Business Case, major proposals

Design Requirement	Performance/Data Quality Requirement
Coverage of highway and PT modes and travel demand behaviour across the area where proposals will have material impacts	WebTAG where the scheme will have material impacts

As with all regional models, the quality of model validation varies across the area. Prior to using ASAM to prepare an Outline Business Case, the model user must be satisfied that ASAM, as a minimum, satisfies webTAG recommended levels of validation across the area where the scheme will have material impacts. Given the variable performance of the model on screenlines in and around Aberdeen (see §5.2.5), in practical terms this will mean that for major proposals impacting Aberdeen itself ASAM is not suitable for use in the preparation of OBCs.

9.4.2 Strategic Business case, major proposals

Design Requirement	Performance/Data Quality Requirement
Coverage of highway and PT modes and travel demand behaviour across the area where proposals will have material impacts	Lower than WebTAG accuracy tolerance can be acceptable, provided forecasting uncertainty is appropriately explained to inform decision makers about the reliability of information

As with all regional models, the quality of model validation varies across the area. Prior to using ASAM to prepare an Strategic Business Case, the model user undertake an analysis of base model validation across the area where the scheme will have material impacts in order that resulting forecasting uncertainty can be understood, and communicated to decision makers as part of any SBC. After detailed review of the model performance for the intended purpose it should be recognised that the need for some enhancement may be identified.

9.4.3 Development plans, DPMTAG

Design Requirement	Performance/Data Quality Requirement
Generally detailed local coverage, particularly for highway, in the vicinity of the development	WebTAG in area materially impacted

See §9.4.1

9.4.4 Cumulative Development Plans across North East and potential mitigation

Design Requirement	Performance/Data Quality Requirement
Coverage of highway and public transport models and travel demand behaviour, across the area where proposals would have material impacts	Lower than WebTAG accuracy tolerance can be acceptable, provided forecasting uncertainty is appropriately explained to inform decision makers about the reliability of information

See 9.4.2.

9.4.5 Changes in travel patterns caused by AWPR, locking in benefits

Design Requirement	Performance/Data Quality Requirement
Coverage of highway travel demand across the Aberdeen area, with capability to forecast redistribution and route changes caused by the scheme	WebTAG across all major radials and routes within / near Aberdeen that could be impacted.

Model users should review the provided material on the responses of the model to the opening of the AWPR and be satisfied that the model performs intuitively. Once available, the present year validation should be reviewed in order to understand the strengths and weaknesses of the model forecasts.

9.4.6 City centre SUMP, parking constraint and routeing strategies

Design Requirement	Performance/Data Quality Requirement
Spatially detailed representation of city centre and radial routeing patterns, covering highway, public transport and probably active modes, together with capability of representing parking costs on route and destination choice behaviour	WebTAG across city centre and radials

Active modes are not represented. Given the variable performance of the model on screenlines in Aberdeen (see §5.2.5), ASAM is not suitable for use in city centre SUMP, parking constraint, and routeing strategies.

9.4.7 Regional Transport Projects

Design Requirement	Performance/Data Quality Requirement
As for business case requirements	As for business case requirements

See 9.4.1, or 9.4.2, depending on the stage of development of the project.

9.4.8 Informing detailed microsimulation models of traffic demand changes

Design Requirement	Performance/Data Quality Requirement
Highway travel demand and routeing over area covered by microsimulation	WebTAG, but with added requirement on the quality of demand data, particularly HGVs

The demand matrices underpinning ASAM were not developed using observed sources, in contravention of accepted UK practice. In particular, the demand matrices for goods vehicles did not draw on observed sources even for validation. We cannot, therefore, place any confidence in the pattern of the resulting HGV matrix in particular, and, hence, in the model's response to interventions. As the provision of information for detailed microsimulation models is particularly sensitive to the underlying pattern of demand in local areas, we do not recommend that ASAM is used for informing lower tier local microsimulation models.

9.4.9 Traffic flows and composition in AQMAs

Design Requirement	Performance/Data Quality Requirement
Highway travel demand and routeing	WebTAG, but with added requirement on the quality of demand data, particularly HGVs

Though information has shown that base HGV link flow validation in the three AQMAs is of reasonable quality, the demand matrices underpinning ASAM were not developed using observed sources, in contravention of accepted UK practice. In particular, the demand matrices for goods vehicles did not draw on observed sources even for validation. We cannot, therefore, place confidence in the pattern of the resulting HGV matrix in particular, and, hence, in the model's response to interventions. As air quality assessments are particularly sensitive to the underlying pattern of demand in local areas, we do not recommend that ASAM is used for informing air quality assessments.

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