Transport Model for Scotland – TMfS07 National Model Audit

Transport Scotland

Model Development Audit

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TRANSPORT MODEL FOR SCOTLAND – TMFS07 NATIONAL MODEL AUDIT

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1 INTRODUCTION

1.1 Purpose of Report

1.1.1 SIAS Limited (SIAS) and WSP were commissioned under the Traffic and Transport Advisor and Auditor term commission to undertake an audit of the model development work associated with developing the National Model component of the Transport Model for Scotland 07 (TMfS07) hierarchy. The National Model is a more aggregate and strategic model than previous versions and it forms the higher tier of the transport modelling hierarchy with links to both the Transport, Economic and Land-Use Model of Scotland (TELMoS) and any lower tier regional or sub-area traffic/transport models. TMfS07 forms the key transport modelling tool within the Land Use and Transport Integration in Scotland (LATIS) toolkit (Ref. www.latis.org.uk).

1.1.2 The audit has involved a review of the TMfS07 base model networks for the roads and public transport (PT) models and a review of the documentation produced by MVA for the roads, PT and demand models. Furthermore, a review of the TELMoS technical specification, its inputs and outputs and some sensitivity testing has also been undertaken, although this is documented independently of this Report.

1.1.3 An iterative process of queries and responses between the auditor and auditee was adopted before audit findings were published. The audit was divided into a number of discrete sections relevant to the different aspects of model development. In each case, this ultimately led to audit findings being published in a series of documents termed Audit Notes (ANs). This Report presents the findings relating to all aspects which have been audited and effectively distils the findings from each of the ANs into a single document.

1.1.4 It should be noted that SIAS and WSP, in their combined role as auditor, will be referred to as the TTAA throughout the remainder of this document.

1.2 Audit Guidance

1.2.1 It should be borne in mind when reading this document that the TTAA assumes that all users of TMfS/TELMoS have sufficient technical knowledge of the transport modelling concepts and software packages pertinent to the application of TMfS/TELMoS. Where insufficient detail is available from the supporting TMfS/TELMoS model development documentation, or this Audit Report, it is further assumed that users will refer to the model development documentation and LATIS support team for the necessary advice. Contact details and the Terms of Use can be found on the LATIS website, www.latis.org.uk.

1.2.2 Prospective model users of the LATIS service must complete a LATIS User Request Form to be submitted to Transport Scotland prior to the use of data, the application of any of the modelling components or the use of model outputs. This has mutual benefits for both the model developers and potential users and the TTAA fully endorses this procedure. Prospective users of TMfS/TELMoS should bear this process in mind when embarking on any study using TMfS/TELMoS or its inputs and outputs.

1.2.3 The audit process documented in this report has considered the development, calibration and validation of the TMfS07 base model only. At the time of writing the TTAA has not reviewed the associated development work, inputs to or outputs from any future Reference Case, Do-Minimum or Variance Case situation. Furthermore, while the audit seeks to undertake a thorough review of the base model development this has been balanced against the practicality of undertaking the audit within an appropriate timeframe and making best use of the resources invested by Transport Scotland in this process. The audit offers a thorough review of the base model, but the detail of which is necessarily limited by this practicality. By implication, issues not outlined or referenced in this Audit Report should be considered as not having been subject to the TTAA's audit process.

1.2.4 It should be borne in mind that audit recommendations made in this document have the aim of constantly improving the TMfS07 national model over time. The TTAA recognises that certain recommendations may be considered idealistic and/or may have resource related or technical implications that are not easily resolved. The TTAA considers that making such recommendations is in line with the aim of constant improvement, however, it is also recognised that Transport Scotland's decision regarding whether to implement specific audit recommendations will necessarily involve an assessment of the resource and technical implications of doing so balanced against the consequences of not doing so.

1.2.5 The observed data sources used in the TMfS07 development, calibration and validation process are generally more comprehensive than in previous versions of TMfS resulting in a greater depth and variety of observed data types, however, it must also be recognised that the data collection is subject to resource and practicality limitations which mean that the collection of the ideal data, in terms of both coverage and sample size, for all calibration and validation comparisons is extremely challenging. Consequently, when interpreting the calibration, validation and findings in this Audit Report, it is important to bear in mind possible variability in the observations and to contrast individual, local comparisons against the wider context of comparing the modelled outputs across the full range of datasets used in the calibration and validation.

1.2.6 It is assumed by the TTAA that any hands-on user of the model will undertake a thorough, study specific review of TMfS/TELMoS in their intended study area to establish its localised strengths and weaknesses and overall fitness for purpose prior to application. This review process should also continue throughout the model application to ensure that amendments are included as appropriate 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.

1.3 Acknowledgements

1.3.1 The TTAA wishes to acknowledge the assistance and cooperation of Transport Scotland, MVA and David Simmonds Consultancy in supplying the necessary information during the course of this audit.

2 TMFS07 AUDIT: ROADS MODEL DEVELOPMENT

2.1 Background

2.1.1 The TMfS07 National Roads Model was developed in Cube Voyager and forms the road traffic assignment component of the overall TMfS07 National Model system. The initial audit findings relating to the roads model were presented by the TTAA in Audit Note *AN-TMfS07-2: Roads Model Development (TTAA Ref. 71139, 1 April 2009).* A subsequent response to *AN-TMfS07-2* was received from MVA and has been used in compiling the findings in this Audit Report.

2.1.2 The TTAA received the following information from MVA relating to the TMfS07 National Roads Model for use in the audit process:

- *TMfS07 National Road Model Development Report (Issue 3, 30 January 2009)*
- Base year (2007) loaded roads network and trip matrices (AM, Inter and PM peaks)
- Zoning system in GIS format
- *Information Note – TMfS07 Zone System (September 2007)*
- *Audit Response Note to AN-TMfS07-2 (MVA Ref. C37135/11, 24 April 2009)*

2.1.3 This section relates to the audit of the roads model development and generally follows the format of MVA's *National Roads Model Development Report*.

2.2 Introduction to Roads Model Development

Overview

2.2.1 The National Roads Model for TMfS07 forms the road assignment element of the overall 2007 TMfS model hierarchy. This model differs from its predecessors in that it is truly a 'national' model operating at a very high, strategic level with a level of network and zoning detail commensurate with this purpose. The main purposes of the National Model are to:

- Act as a key source of transport supply and demand data
- Appraise national policy measures
- Appraise strategic land-use and transport interventions

2.2.2 The National Model networks and outputs can also be used as the starting point for the development of sub-area and regional models as appropriate. The National Roads Model has linkages with the National Public Transport (PT) model, the Demand model and with the Transport Economics and Land-Use Model (TELMoS).

2.3 Network Development

Introduction

2.3.1 The road network for TMfS07 was developed from the Ordnance Survey MasterMap Integrated Transport Network (ITN) layer. This provides a significantly more geographically and geometrically accurate representation of the road network than was present in previous versions of TMfS and is considered by the TTAA to be a useful enhancement.

2.3.2 The detail of the roads network has also been reviewed for TMfS07 to ensure that it is commensurate with that of a strategic, National Model. The roads network includes all Scottish motorways and A-class roads, some strategically important Scottish B-class roads and a skeletal representation of the England and Wales road network.

2.3.3 The TTAA has reviewed the representation of the network and is content that it is appropriate for a strategic, national model.

Zone System

2.3.4 A key principle adopted in developing the TMfS07 zoning system was to ensure consistency with data zones. Data zones are the Scottish Government's defined small area boundaries for neighbourhood statistics and are themselves built up from census output area boundaries. The rationale for adopting consistency with data zones is considered sensible by the TTAA.

2.3.5 There are 6,505 data zones representing Scotland and aggregation of these into a coarser zoning system, more appropriate for a National Model such as TMfS07, was necessary. Three basic objectives were identified by MVA in developing the TMfS07 zoning system:

- To reduce the number of zones from TMfS05 to reflect the more strategic nature of the model
- To not cross Local Authority boundaries
- To include (where possible) only one train station per zone

2.3.6 The resulting zoning system contains 720 zones, compared with a 1,137 zone system for TMfS05. This represents a reduction of 417 zones (37%) and is consistent with the objective of developing a coarser, more strategic, National Model. The most significant reduction in zoning detail is in the major cities (Glasgow, Edinburgh, Dundee and Aberdeen), which reduce by 53% overall. This would be expected given their previously detailed zoning systems in TMfS05, particularly in Edinburgh and Glasgow.

2.3.7 This change is consistent with the move towards a more aggregate, strategic National Model for the higher tier. The TTAA considers it essential that potential users understand the change in nature of the National Model and its implications with respect to model application and scheme assessment. Given the more towards a more strategic model, it is less likely that TMfS07 would be appropriate for scheme assessment than TMfS05. In each case of application, a thorough review of the model capabilities and representation should be undertaken before considering if the National Model is appropriate for use. Should regional or sub-area models exist in the locale of the scheme in question, it may be more appropriate that use of these, or a combination of National and Regional\Sub models are utilised. **Potential users of TMfS07 should note the changing role of the National Model compared with previous versions of TMfS. In particular, this has implications for the development and application of regional models which need to be understood by potential users from the outset**.

2.3.8 The third objective in attempting to limit the number of rail stations to one per zone, has been achieved in most areas of the network. MVA's *Information Note - TMfS07 Zone System (September 2007)* identifies that this was achieved with the exception of North-West Scotland (including parts of Argyll and Bute, Perth and Kinross and Stirling) and the following zones:

- Zone 7 Dumfries and Galloway - Sanquhar and Kirkconnel
- Zone 220 North Ayrshire – Ardrossan Town and Ardrossan Harbour stations in the same data zone

- Zone 294 City of Glasgow – Ashfield and Possilpark & Parkhouse stations included in the same zone
- Zone 572 Angus – Barry Links and Golf Street stations included in the same zone

2.3.9 Having examined the spreadsheet that accompanies the *Information Note*, the TTAA notes that the zones in North-West Scotland (including parts of Argyll and Bute, Perth and Kinross and Stirling) to which this also applies are:

- Zone 653 Stations: 2, Connel Ferry and Taynult
- Zone 657 Stations: 2, Arrochar and Tarbet, Ardlui
- Zone 695 Stations: 2, Golspie, Dunrobin Castle
- Zone 458 Stations: 3, Crianlarich, Upper Tyndrum and Lower Tyndrum
- Zone 682 Stations: 3, Kingussie, Newtonmore, Dalwhinnie
- Zone 701 Stations: 3, Helmsdale, Kinbrace, Kildonan
- Zone 704 Stations: 3, Scotscalder, Georgemas Junction, Altnabreac
- Zone 656 Stations: 4, Dalmally, Loch Awe, Falls of Cruachan, Bridge of Orchy
- Zone 667 Stations: 4, Mallaig, Moror, Arisaig, Beasdale
- Zone 672 Stations: 4, Spean Bridge, Roy Bridge, Tulloch, Corrour
- Zone 673 Stations: 4, Achnasheen, Achanalt, Garve,Lochluichart
- Zone 677 Stations: 4, Culrain, Ardgay, Lairg, Invershin
- Zone 668 Stations: 6, Banavie, Corpach, Loch Eil, Locheilside, Glenfinnan, Lochailort
- Zone 669 Stations: 8, Kyle of Lochalsh, Durinish, Plockton, Duncraig, Stromeferry, Attadale, Strathcarron, Achnashellach

2.3.10 While not specifically outlined in the *TMfS07 National Road Model Development Report*, this information is contained in Appendix B of the *TMfS07 National Demand Model Development Report (Issue 2, January 2009).*

2.3.11 The ratio of data zones per TMfS07 zone is fairly consistent across the model area and there are generally between seven and ten data zones per TMfS07 zone. The only exception to this is on the Scottish islands and this is due to the relatively larger number of data zones that comprise certain islands, which have been represented as single zones (e.g. Lewis & Harris, Orkney, Shetland, etc.).

2.3.12 In some cases where the data zones were either strange shapes or contained development areas to be represented individually, these have been split. This applies to:

- Barry and Carnoustie Zones 572 and 573
- Tranent and Wallyford Zones 39 and 41
- Millerhill and Bonnyrigg Zones 54 and 56
- Bishopton, Langbank and Erskine Zones 407, 411 and 417
- West Kilbride and Fairlie Zones 218 and 217

• Westhill West and Westhill East	Zones 594 and 598
• Cullen and Buckie	Zones 644 and 645;
• Burntisland and Dalgety Bay East/Aberdour	Zones 493 and 497
• Tayport and Newport on Tay	Zones 520 and 523
• Auchinleck and Cumnock	Zones 195 and 197
• Whitburn East and Addiewell/Stoneyburn	Zones 124 and 126;
• Briech and West Calder	Zones 125 and 134
• Oakley & Saline and Dunfermline North East	Zones 479 and 483

2.3.13 The general principle of this is considered good working practice by the TTAA. It is understood that the zones were split according to:

- Potential future development sites (in the case of Millerhill and Bishopton)
- The shape of the datazones (in most cases)
- Data on development areas supplied by David Simmonds Consultancy (unknown which zones this applies to)

2.3.14 The TTAA requested MVA to supply further information relating to the treatment of strategic development sites throughout Scotland in the zoning system. In particular, whether significant development sites were specifically identified in consultation with local authority and central government planners in defining the zoning system and/or whether such developments could be considered differently within the national and regional/sub-area models. MVA responded with the following statement:

> *There was no direct consultation with local authority or central government planners in developing the zone system. However, key strategic development sites as defined by short, medium and long term planning data submissions made by local authorities, as well as an awareness of developments such as Millerhill, Heartlands and Ravenscraig were used to assist in the definition of zones in the base year model. Other development sites such as Leith already had an appropriate level of zone detail and remained untouched.*

2.3.15 With this in mind the TTAA would recommend that prior to applying the model all users of TMfS07 and any associated sub-area/regional models should seek advice from MVA/Transport Scotland regarding the details of the planning assumptions included in future year forecasts in the localities relevant to their particular application. This would be best instigated via a LATIS User Request Form and would ensure that the appropriate local developments are adequately reflected for the intended application or that recommendations for localised network and/or planning data adjustments can be made in advance of applying the model.

2.3.16 The four main airports in Scotland have been treated as individual zones in their own right, namely:

• Edinburgh Airport	Zone 709
• Prestwick Airport	Zone 710
• Glasgow Airport	Zone 711
• Aberdeen Airport	Zone 712

2.3.17 These airport zones are simply a small, arbitrary shape cut out from the surrounding zone to differentiate them. The attributes of the data zone that they were cut from are allocated to the surrounding TMfS07 zone and not to the airport zone. The boundary of the surrounding zone is not entirely consistent with data zone boundaries.

2.3.18 The remaining airports in Scotland are not differentiated in any way from their surrounding zones and do not receive any specific treatment in TMfS07. This general approach is consistent with that adopted for TMfS05 and is considered appropriate by the TTAA.

Geographical Coverage

2.3.19 The TMfS07 geographical coverage has been extended to include all motorway, A-class and strategically significant B-class roads in mainland Scotland and the Isle of Skye. The National Model also includes ferry links to other main islands including Mull, Islay, the Outer Hebrides, Orkney and Shetland. Users of TMfS07 should note that road links are not represented on the Scottish islands with the exception of Skye. Overall, the TTAA is content that the geographical coverage of the TMfS07 National Model road network is appropriate.

Node Convention

2.3.20 A node convention has been applied to classify differing node types in a given numerical range. Differing ranges are specified for zone (1 – 720), road (1,000 – 99,999), rail (100,000 – 149,999), subway (150,000 – 199,999), ferry (200,000 – 299,999) and airport (300,000 – 399,999) nodes. The nodes were built up from the *RoadNode_Point MasterMap* information where the nodes coincided with points to be included in the TMfS07 network and are geographically more accurately positioned than in previous versions of TMfS.

Attributes for Road Nodes and Network

2.3.21 Various attributes were allocated to each node and link in the network describing characteristics and properties pertinent to the roads assignment model. The volume of information has increased from previous versions of TMfS to include additional general information, such as node heights/gradients, whether the node represents a bridge, road names, etc. and to include additional parameters required by the assignment model (hilliness, bendiness, etc.).

2.3.22 In general terms the TTAA considers the link attributes appropriate and endorses the provision of additional information. Details of specific network checks undertaken by the TTAA are outlined in this section.

2.3.23 On initial inspection of the road network, it is clear that much of the central urban detail has been rationalised in Edinburgh and Glasgow and, in general terms, the network is more in line with that of a strategic national model than was previously the case, however, it is also evident that infrastructure associated with certain key development sites has been omitted from the TMfS07 network. Particular examples of this are at Strathclyde Business Park and at Eurocentral in North Lanarkshire (Note: These sites were selected purely on the basis of the TTAA's local knowledge and are simply to illustrate the point, there is no specific significance to be attached to the TTAA highlighting these sites).

2.3.24 In both cases, the grade separated interchanges from which these developments are accessed (on the A725 south of and the A8 west of Shawhead) have been omitted, while the zoning detail in these areas is also considerably too aggregate to enable specific development related growth to be reflected in detail. In these examples, this would result in more emphasis being placed on a regional model for any scheme assessment or detailed analysis in these areas (Note: There is currently no regional model of this area). The TTAA sought clarification from MVA on the general approach adopted to reflecting major development sites in the National Model and the implications this has with respect to regional models and, in particular, future year forecasting at both a national and regional level. MVA responded as follows:

> *Any user of the national model, or potential regional models would be required to review the level of detail for their own requirements prior to undertaking application. This guidance is in accordance with the LATIS license agreement.*
>
> *Where any potential omissions or alterations would be required to the model (be that national or regional) for their specific requirements, it would be anticipated that the LATIS team would be informed to comment on.*
>
> *Depending on the nature of the application, geographical location and level of detail desired by the user, it is possible that some links will not be included.*
>
> *Issues relating to regional models should be more of a feature as and when the requirement, nature and specification of regional models are defined.*

2.3.25 **The TTAA considers that this clearly emphasises the importance for each user of undertaking a review of the TMfS07 National Model and any sub-area or regional models in the areas of specific interest to their intended applications prior to using the model(s).**

Road Link Types and Capacity

2.3.26 The link types used in the TMfS07 National Roads Model are consistent with those outlined in *Scottish Transport Statistics Note 24 (August 2005)* to enable correspondence of output statistics with observations. The road link types and capacities adopted for inter-urban and urban links are outlined in Tables 2.1 and 2.2 of MVA's Report. These are reproduced as Tables 2.1 and 2.2.

Table 2.1 : TMfS07 Road Link Types and Capacities – Inter-Urban Links

Link Type	Description	Capacity Per Lane (PCUs)
1	Trunk - motorway	2,400
2	Trunk - motorway slips	1,800
3	Trunk A-roads Non-built up	1,800
5	Non Trunk A-roads Non-built up	1,600
9	Banned for Heavy Goods Vehicles	Dependent on road type
10	Bus only	Dependent on road type
22	Zone-Road Connectors	Unconstrained
22	Zone-Ferry Connectors	Unconstrained
28	Ferry Routes - Banned for HGV	Dependent on ferry size
29	Ferry-Road Connectors	1,000
30	Ferry Routes - Car & HGV Allowed	Dependent on ferry size
31	Ferry Routes - Banned for both Car & HGV	Dependent on ferry size

Table 2.2 : TMfS07 Road Link Types and Total Capacities – Urban/Built Up Links

Link Type	Description	Total Capacity (PCUs)
4	Trunk A-Roads Built up	2,500
6	Non Trunk A-Roads Built up	2,000
7	Minor Roads - Non-built up	1,000
8	Minor Roads - Built up	1,500

2.3.27 The generic capacities adopted seem reasonable and representative for each link type. The TTAA undertook a detailed check of the entire network to ensure that the generic capacities had been coded appropriately and that variations from the generic capacities were acceptable. This generally showed that the capacity coding across the network was acceptable. More detail of the specific network checks undertaken by the TTAA is provided in a later section of this Report.

Capacity on Approach to Rural Roundabouts

2.3.28 No junctions are modelled in the TMfS07 National Roads Model with all links using a flow-delay relationship to reflect the effects of congestion. In urban areas, which are not represented in detail in the TMfS07 National Model, these standard flow-delay relationships enable the general delays across urban routes to be adequately reflected.

2.3.29 For inter-urban routes, where there may be long stretches of relatively free-flowing road that terminate at a junction it is important to reflect the localised delays caused by vehicles traversing these junctions. This has been done in the TMfS07 National Model by reducing the capacity on the road links on the direct approach to these junctions. The capacities adopted are:

- Single carriageway 1,400 PCUs per hour
- Dual carriageway 2,100 PCUs per hour

2.3.30 These capacities have been adopted based on making various assumptions with respect to the geometry and capacity of roundabout entry arms, on the assumption that all such junctions on inter-urban routes will in fact be roundabouts. The methodology adopted for reflecting these localised capacity reductions is relatively simple, however, the TTAA is content that it is appropriate for the TMfS07 National Model given its strategic nature. **This methodology would not, however, be recommended for regional or sub-area modelling**.

2.3.31 Further commentary relating to the specific checks undertaken by the TTAA relating to the coding of rural roundabout capacities is provided later in this section.

Road Link Distance Checks

2.3.32 A comparison of the modelled road lengths by road type with the values published in the *Scottish Transport Statistics Note 24* was undertaken. This was presented in Table 2.3 of MVA's Report and demonstrated that:

- TMfS07 motorways excluding slip roads match to within 0.9% of STS figures
- TMfS07 motorways including slip roads match to within -6.6% of STS figures
- TMfS07 trunk A-roads match to within +5.4% of STS figures

2.3.33 This demonstrates that there is generally a reasonable correlation between TMfS07 and the STS figures, however, in the case of Motorway links, including slip roads and trunk A-roads the differences are more distinct. The reasons for the differences were not immediately obvious and the TTAA requested clarification on this matter from MVA who responded as follows:

> *Errors contained within the OS ITN data and the methods of relating the 'nature of the road' to model links has caused the discrepancy in modelled distances of motorways (including slips) and trunk A roads when compared with STS figures.*
>
> *OS have used two different methods of applying 'nature of road' to the ITN road link data (nature of road being motorway slip, trunk A road etc)*
>
> *1. One layer contains TOID and nature of road attributes; and*
>
> *2. One layer contains TOID and respective road names.*
>
> *These two layers were joined to create a table from which to derive the nature of the road for each road name. Some of these road links, however, had road names missing. In order to obtain these, and therefore create a link to 'nature of road', polygon shape files containing road names were used. As this method involved the use of a spatial join, non-trunk A roads intersecting the main trunk A-roads would also be attributed the name of the trunk A-road and hence the increase in modelled trunk A-road distance.*
>
> *In terms of modelled motorways (including slips) the Road models representation is based on the OS ITN data, ie what they have defined as a motorway slip. Any errors within this data will filter through and could be a possible reason for the discrepancy.*
>
> *A manual sweep of the network was undertaken to uncover such links and change their 'nature of road' status to reflect their true nature but it is possible this manual step did not catch all links.*
>
> *In addition to the above, it should also be noted that there can be inherent errors in the STS data. The tables inclusion in the road report is merely to demonstrated, as highlighted by the TTAA, that there is correlation between independent data sources.*

Road Network Enhancements Compared With Previous TMfS Road Models

2.3.34 A summary of the enhancements included in TMfS07 compared with previous versions of TMfS is provided in Table 2.4 of MVA's Report. This covers issues relating to the model hierarchy, the software platform, the zone system and the road model. The TTAA has no substantive comments on this summary but would advise potential users to familiarise themselves with the content of Table 2.4 of MVA's Report.

2.4 Demand Matrix Development

Introduction

2.4.1 The development of the prior (i.e. pre-matrix estimation) and final calibrated matrices is outlined in Section 3 of MVA's Report. This provides details of the overview of matrix development, data sources used, demand model matrices and the enhancements compared with previous versions of TMfS.

Matrix Development Overview

2.4.2 The trip matrix development process for TMfS07 differed slightly from previous versions of TMfS as the matrices for the demand and assignment models were developed separately, albeit from the same data sources. Previous versions of TMfS used the assignment matrices as the building block for the demand model matrices which were derived using a factoring process.

This change in approach was made possible by the availability of additional data sources for the TMfS07 model development, namely:

- 2001 Census Journey to Work data
- National Rail Travel Survey data
- Origin-destination surveys for inter-urban bus travel

2.4.3 Car travel for purposes other than journey to work and trips for all "to-home" and "non-home based" movements were derived by a synthetic process, while roadside interview (RSI) data was used in developing the heavy goods vehicle demand.

2.4.4 The assignment model matrices were created using the demand model process and are therefore wholly consistent with the demand model matrices in terms of "from home" trips. Further desire line analysis was undertaken to ensure that the travel pattern from the census travel to work data had been retained in the assignment matrices. The TTAA is generally content that the process of developing the assignment and demand model matrices independently from the same datasets is appropriate.

Data Sources

2.4.5 The various data sources used in matrix development are discussed in Section 3.3 of MVA's Report.

2001 Census Journey to Work Data

2.4.6 The 2001 Census provided an excellent source of information relating to the location and main mode of travel to people's "normal place of work". This information was collected as standard on all forms in the 2001 Census and enabled the origin-destination pattern for commuting trips to be established at the Census Output Area level. The TMfS07 zoning system was built up from data zones, which themselves are aggregations of Census Output Areas, enabling the straightforward translation of this data into a TMfS07 compatible trip matrix.

2.4.7 The Department for Transport's Census Matrix Tools software was used to process the Census data, enabling the outputs to be:

- Aggregated to the TMfS07 zone system
- Split by main mode choice
- Split by household car availability
- Isolated for the appropriate time period
- Adjusted to account for working trips that do not occur every weekday

2.4.8 The 2001 Census in Scotland also had the added advantage over the rest of the UK that journey to education information was also collected. Consequently, this enabled demand matrices for education trips to be established for TMfS07.

2.4.9 Overall, the TTAA is content that the 2001 Census provides a robust and valuable dataset to use in developing the TMfS07 trip matrices for commuting trips (work and education trips by mode). Furthermore, the use of the Census Matrix Tools for interrogation of this information is considered appropriate.

2.4.10 The TTAA notes that the level of information provided in the *Model Development Report* regarding the assumptions and settings used in interrogating the Census data is very limited. Some additional matrix development detail is provided in the documentation relating to the Demand Model, however, this remains at a relatively high level and it is difficult to comment in detail and draw conclusions regarding the robustness or otherwise of the data processing undertaken. **The TTAA would recommend that future documentation of the use of census data in matrix development include additional detail such as:**

- **A summary of the Census output data (e.g. by main mode and household car availability)**
- **The factors used to convert from the full Census dataset to the assignment model time periods**
- **Other adjustment factors (e.g. from 2001 to 2007, factors for trips not occurring each day, etc.)**

Roadside Interview Data

2.4.11 RSI data was used in developing the HGV demand matrices for TMfS07. This involved growthing the existing TMfS05A HGV matrices to 2007 levels by linearly interpolating between the 2005 TMfS05A base year and a future year 2012 forecast produced using the Reference Case model from the *Strategic Transport Projects Review*. RSI data for 69 sites was then used to replace relevant HGV movements in these matrices.

2.4.12 MVA provided the TTAA independently with additional information relating to the RSI data that was not included in the model development report. This showed that in most cases the HGV sample sizes were reasonable and MVA has confirmed that in cases where the sample size was low, this was expanded by using a combination of LGV and HGV records. The AM peak interview direction records were reversed to estimate the PM peak non-interview direction matrices and vice versa while the Inter-peak interview direction matrices were reversed to create the Inter-peak non-interview direction matrices. The TTAA is satisfied that this is an appropriate approach to adopt.

2.4.13 The RSI data was arranged into twelve cordons covering different areas, details of which were supplied to the TTAA. Additionally, a summary of the observed HGV matrices was supplied for the audit process showing the interview direction movements using a 16 sector system. In most cases this demonstrated that the observed movements are evident in the expected sectors based on the location of the RSI sites. The TTAA is generally satisfied that the processing of the RSI data appears to have been undertaken appropriately.

2.4.14 The TTAA does, however, note that there are some movements not represented in the observed HGV matrices that would perhaps be anticipated given the location of various RSI sites, these include:

- No trips evident originating in Lothian and travelling to Edinburgh, Borders or Fife (would have been captured in the West Lothian cordon)
- No trips on movements from either Edinburgh, Lothian, Borders or England to the Fife, Perth & Kinross, Dundee, Aberdeen or North East sectors except a small movement between England and the North East in the PM peak (would have been captured in the Forth Bridge northbound RSI)
- No trips destinating in Dumfries and Galloway and no trips from Dumfries and Galloway to anywhere other than Ayrshire in all periods and to Lothian in the Inter-peak only (would have been captures in the Dumfries RSI surveys)

Some data for these movements does exist in the HGV matrices, however, as the base year matrices are based on TMfS05A as described in 2.4.11.

2.4.15 MVA has subsequently confirmed that although RSI data was available for Dumfries and the Forth Road Bridge it was not used in the TMfS07 HGV matrix development process. **The TTAA considers this an unfortunate oversight and would recommend that all suitable RSI data be used in refining and further developing the HGV matrices during any future update of TMfS07**.

The National Rail Travel Survey

2.4.16 Commentary is provided in a separate section relating to the TMfS07 National PT Model Development.

Origin-Destination Surveys of Inter-Urban Bus Travel

2.4.17 Commentary is provided in a separate section relating to the TMfS07 National PT Model Development.

Demand Model Matrices

2.4.18 The matrices for the demand model were prepared in advance of the road model matrices thereby enabling the use of the "to home" and "non home-based" matrix generation processes in completing the road model matrices. The demand model matrices are in person trips for the AM and Inter-peaks and relate only to "from home" trips. Other time period and trip purpose combinations in the demand model are derived by a factoring process.

2.4.19 A summary of the data sources for the road matrices is provided in Table 3.1 of MVA's Report, this is reproduced as Table 2.3.

Table 2.3 : AM and Inter-peak Road Demand Matrix Data Sources

Journey Purpose	Mode	Source
From Home to Work	Car Driver/Passenger	Census Journey to Work Data
From Home to Employer's Business	Car Driver/Passenger	Synthesised
From Home to Other	Car Driver/Passenger	Synthesised

2.4.20 The TTAA concurs that the most substantial element, particularly of the AM peak demand matrices would constitute the "home to work" trips and the 2001 Census data is an appropriate source for this information. The "home to employer's business" and "home to other" purposes are simply listed as "synthesised" in MVA's Report, with no further description of how these trips have been synthesised. The Demand Model documentation does, however, provide a description of the synthesis process and the TTAA is satisfied that the process used was appropriate.

2.4.21 From the information in MVA's report and other information supplied independently to the TTAA, it has been possible to derive the proportion of the final assignment matrices which comprise observed and synthesised data by user class. These are summarised in Table 2.4.

Table 2.4 : Matrix Composition by User Class

User Class	Observed or synthesised?	% of total matrix
Car in-work	Synthesised	AM: 6%, IP: 5%, PM: 5%
Car non-work commute	Observed (census)	AM: 48%, IP: 13%, PM: 36%
Car non-work other	Synthesised	AM: 25%, IP: 56%, PM: 45%
LGV	Observed (RSI)	AM: 9%, IP: 11%, PM: 6%
HGV	Observed (RSI)	AM: 11%, IP: 15%, PM: 7%

2.4.22 This demonstrates that in the AM and PM peaks there is a higher level of observed data in the matrices due to the predominance of commuting trips which were observed from the census data. In the Inter-peak, the proportion of observed car trips reduces due to the significant amount of non-work other trips (e.g. shopping, leisure, etc.) that exist. The proportions outlined above demonstrate an intuitively correct trend. **The TTAA would recommend that consideration be given at the next upgrade as to what measures could be taken to further increase the overall percentage of observed data in the matrix**.

2.4.23 The TTAA notes that the documentation of the matrix development process is split over both the Roads Model and Demand Model development reports, which makes understanding and interpreting the process more difficult for the reader. **The TTAA would recommend that future documentation relating to TMfS matrix development either be included in a single report or at least include comprehensive references to the relevant other reports where appropriate to make the documentation more reader friendly. Furthermore, it is considered that it would be useful to supplement the information relating to the synthesis of trips in the matrix development process by including summary statistics showing the proportion of the matrix that is made up of observed and synthesised trips by user class**.

2.4.24 The TTAA also undertook a detailed examination of the assignment matrices supplied with the TMfS07 model network, in particular to examine the magnitude of the values in individual cells of the matrices. This process identified that:

- of all cell values >0 approximately 80% are <1
- of the approx. 80% <1, typically 60% or more of these are in the range 0 to 0.1

2.4.25 Approximately 50% or more of all values in the trip matrices lie in the range 0 to 0.1. With this in mind, the TTAA requested some commentary from MVA regarding the origin of these cell values, the possible implications for model application and the checks/measures that could be considered for future matrix development. MVA responded as follows:

> *The synthetic process, in the way we have done it will create very small values in certain cells (particularly where there are rows/columns with small numbers of trip ends). Since there are costs for every cell in the matrices, trips will be placed in all (internal) cells, most of which will be small values. The synthetic process was undertaken at the period level, so when these matrices are turned into the hourly assignment matrices these values will be even smaller. Similarly from the Census Travel to Work there are some very small values which when converted to hourly matrices become even smaller, however in this data there are some cells which are genuinely observed as zero. It should also be noted that that the assignment matrices will have long distance trips in them, this will account for a lot of the small values too. This is not an issue in the TMfS:05A matrices as they are created from surveys and not from census or synthetic data. In the TMfS:05A there are a lot more zero cells, but they may not be zero in reality, we may just have not picked up any movements in our survey data*

These small values should not be a problem for model application as the forecasting is done at the trip end level then the trips are spread using a gravity model similar to that used for the synthetic matrix creation. In fact it should be an improvement for forecasting, because it will allow the growth factoring processes to work better. Historically there have always been problems where there are lots of zero cells

In the commute matrix there are some cells which are observed as zero from a 100% sample. This is fine. In the other matrix I think it is fair to say that it we do not want to minimise these trips, as there are surely trips from every zone to every other zone at some point in time (for other and employers purposes) they may not be daily or even yearly, but they do occur

2.4.26 The TTAA acknowledges MVA's rationale for the existence of the small cell values and the comments regarding the forecasting process. Nevertheless, the TTAA considers that the predominance of very small values in the matrix would merit some formal additional checking procedures being adopted during the matrix development process to ensure that such values only occur in locations where it is appropriate and/or unavoidable. In particular, it would be anticipated that the observed elements of the matrix should contain a lower number of very small cell values compared with the synthesised elements. **The TTAA recommends that such checks are instigated and reported during the next upgrade of TMfS07**.

Matrix Enhancements Compared with Previous TMfS Road Models

2.4.27 A summary of the road model demand matrix enhancements included in TMfS07 compared with previous versions of TMfS is provided in Table 3.2 of MVA's Report. This covers issues relating to the data sources and the matrices themselves. The TTAA has no substantive comments on this summary, but would advise potential users to familiarise themselves with the content of Table 3.2 of MVA's Report.

2.5 Assignment Model Development

Introduction

2.5.1 The road traffic assignment component of TMfS07 is undertaken using the Citilabs CUBE Voyager software, which is controlled by a script file that specifies the relevant input files, parameters and output files.

2.5.2 The assignment process implements the Time versus Cost methodology, which applies a distribution of the value of time for converting monetary items in the generalised cost formula into equivalent time units. This enables road user charging and tolling to be implemented in the main assignment without the need for a standalone "Tolling" version of the model. The assignment procedure adopts a volume averaging, equilibrium method and is effectively the same as that adopted for previous versions of TMfS. The main difference with TMfS07 is that junctions are not explicitly modelled.

2.5.3 There are five user classes assigned:

- Car In-Work
- Car Non-Work Commute
- Car Non-Work Other
- Light Goods Vehicles
- Heavy Goods Vehicles

2.5.4 Overall, the TTAA is satisfied that the assignment procedure as described is appropriate for TMfS07.

Assignment Procedure

2.5.5 Generalised cost parameters for distance and toll values were calculated using the WebTAG guidance current in December 2008 (Ref. WebTAG Unit 3.5.6) and these were presented in Appendix D of MVA's Report for the base year and each user class. On initial inspection the values shown were broadly comparable with the values of time in WebTAG unit 3.5.6 and their relative scale and magnitude appeared to be consistent with previous versions of TMfS. In response to a request from the TTAA, MVA provided the spreadsheets showing the calculation of the generalised cost coefficients. The TTAA's review of this demonstrated that the calculations followed the expected methodology and used the appropriate values from WebTAG and are considered appropriate for TMfS07.

Road Model Convergence

2.5.6 A normalised regression statistic is calculated which relates the cost in the current iteration to the total network cost. The TMfS07 roads model assignment is considered to have converged when the regression statistic is less than or equal to 0.01% on 3 successive iterations. This results in 50, 19 and 63 iterations being required to reach convergence for the AM, Inter and PM peaks.

2.5.7 This demonstrates that convergence is reached after fewer iterations in TMfS07 compared with its predecessor, most likely due to the removal of junction modelling within TMfS07. The TTAA is satisfied that the roads model convergence parameters and number of iterations required to reach convergence are of the expected order of magnitude.

Flow Delay Relationships

2.5.8 Flow delay relationships have been used in TMfS07 to model the travel speeds in both congested and uncongested conditions. These are similar to speed-flow curves and reflect the increase in delay relative to an increase in flow. Unlike the linear speed-flow curves specified in *Design Manual for Roads and Bridges* (*DMRB*) *(Highways Agency)*, these adopt a power based form for flows up to capacity. The forms of flow-delay relationship adopted in TMfS07 are:

For $V \leq C$

- $TC = T_0 * (1 + TCCOEFF * (V/C)^{\wedge}TCEXP)$

For $V > C$

- $TC = T_0 * (1 + TCCOEFF)$ if no junction at end of link
- $TC = T_0 * (1 + TCCOEFF) + A*((V/C)-1)$ if link is a junction approach

Where:

- TC = Time (delay)
- T_0 = Free-flow time
- TCCOEFF & TCEXP = coefficients that vary by link class
- A = the gradient of the delay slope for junction delay when V > C (set at 7.5 in accordance with DfT Advice Note 1A)
- V = traffic volume

- C = Link capacity

2.5.9 The general form of the flow-delay relationships for motorway and trunk A-class roads is presented in Appendix E of MVA's Report, while the values of the TCEXP and TCCOEFF coefficients and the free-flow speeds for the link classes 1 to 22 are outlined in Appendix F. The TTAA requested details of the source of the parameter values to which MVA responded:

> *The flow delay curves are based on the speed flow curves used in previous versions of TMfS. The parameter values of the flow delay curves were calculated based on a methodology described in the user manual for SATURN, which uses the same functional specification for flow delay curves as VOYAGER. In addition there is differentiation made by road type, hilliness and bendiness*

2.5.10 The general form of the flow delay relationships and the descriptions and free-flow speeds listed for link classes 1 to 22 appear to have been defined appropriately.

Tolling Model

2.5.11 Tolling is included in TMfS07 using the Time versus Cost assignment method which represents differing willingness to pay tolls by randomly sampling from a distribution of values during each iteration of the assignment. This enables a single, consistent version of TMfS07 to be applied to both tolling and non-tolling tests. This methodology has been in place since the development of TMfS02 and the TTAA is content that it is appropriate for TMfS07.

Heavy Good Vehicle Speed Cap

2.5.12 The TMfS07 National Roads Model contains an enhancement over previous versions with the inclusion of a free-flow speed cap by link type for HGVs. The free-flow speed caps by link type are shown in Table 2.5.

Table 2.5 : HGV Free-Flow Speed Cap by Link Type

Link Type	Description	Free-Flow Speed kph		Free-Flow Speed mph	
1	Trunk – Motorway	96		60	
2	Trunk – Motorway slips	96		60	
3	Trunk A-Roads Non-built up	64	(80 if dual)	40	(50 if dual)
4	Trunk A-Roads Built up	48		30	
5	Non Trunk A-Roads Non-built up	64		40	
6	Non Trunk A-Roads Built up	48		30	
7	Minor Roads – Non built up	48		30	
8	Minor Roads – Built up	48		30	

2.5.13 These speed caps ensure that HGVs cannot travel faster than the legal limits in free-flow conditions. The HGVs speeds in congested conditions are derived in accordance with the relevant flow-delay curves. The TTAA considers that the adopted HGV speed caps provide an improvement with respect to representing HGV speeds and travel costs which will be reflected in the operational outputs from the model and in any ancillary processes in which these outputs are used (e.g. economic and environmental assessments, feedback to the land-use model, etc.).

Road Model Output Files

2.5.14 A total of six output files can be produced by the TMfS07 National Roads Model. By default the following three outputs are produced:

- Output Control File (*.prn)
  A text file with details of the input files and parameters for the assignment run and global assignment statistics, such as average assigned vehicle distance (km)
- Output Road Model Network File (*.net)
  A binary with information such as road link traffic flows, congested road speeds and travel times
- Convergence Report File (*.prn)
  A text file which summarises the global road network cost for each iteration and convergence level achieved

2.5.15 If selected by the user, the following additional outputs can also be produced:

- Output Path File (*.pth)
  A binary file containing traffic routeing information for all non-zero origin destination movements for each iteration
- Output Generalised Cost Skims (*.mat)
  Matrix file that contains generalised cost information for each of the five user classes and is fed into the demand model
- Output Time, Distance, Toll and Generalised Cost Skims (*.mat)
  Matrix file that contains Time, Distance, Toll and Generalised Cost skims for each of the five user classes combined over ALL iterations

2.5.16 The TTAA is satisfied that the described TMfS07 output files are appropriate for a model of this nature and to enable the relevant ancillary analyses and procedures to be undertaken.

Assignment Model Enhancements Compared with Previous TMfS Road Models

2.5.17 A summary of the roads assignment model enhancements included in TMfS07 compared with previous versions of TMfS is provided in Table 4.3 of MVA's Report. The TTAA has no substantive comments on this summary, but would advise potential users to familiarise themselves with the content of Table 4.3 of MVA's Report.

2.6 Roads Model Development Conclusions

Conclusions

2.6.1 In conclusion, MVA states in Section 5.1.1 of the Report that:

> *The TMfS:07 National Road Model has been developed to appraise national transport and planning policy and strategic land-use and transport interventions. It provides a source of current and forecast national/strategic travel demand and associated demographic information.*

2.6.2 The TTAA acknowledges that this provides an accurate description of the bounds of applicability of the TMfS07 National Model. Potential users should note that due to its more strategic nature than previous versions of TMfS, the TMfS07 National Model will not be the appropriate tool to apply in all cases. **Advice should be sought from Transport Scotland on a case by case basis regarding the applicability of the TMfS07 National Model**.

2.7 TTAA Network checks

Introduction

2.7.1 The TTAA undertook a series of detailed network checks to establish the robustness and appropriateness of the network coding. The checks generally showed that the network was appropriately coded and is acceptable for a strategic, national model. The following aspects of the network coding were examined in detail by the TTAA:

- Link types (capacity checks)
- Bus lanes/corridors
- Link class
- Tolls
- Rural roundabout approaches
- Urban/built-up links
- HGV lanes
- Miscellaneous additional checks
- Hilliness and Bendiness
- Route length checks

2.7.2 Some errors were identified in this process but these were generally minor in nature and unlikely to have a significant impact on the operation of the model in a strategic context. The majority of issues identified relate to slight coding discrepancies in terms of capacities or link speeds. In addition, a number of sections of bus lane have been identified as being missing from the TMfS07 network. A spreadsheet showing the checks undertaken and both the TTAA and MVA's comments on these matters accompanies this Report *(Ref. 72007 TMfS07 Network Checks.XLS)*. The TTAA is content that the identified coding errors will have a negligible impact on the strategic operation of TMfS07 and can be accepted for generic application of the model. **Nevertheless, the TTAA would recommend that potential users take note of the minor errors identified in this spreadsheet and furthermore, that any identified errors be addressed at the next upgrade of TMfS07**.

3 TMFS07 AUDIT: ROADS MODEL CALIBRATION & VALIDATION

3.1 Introduction

3.1.1 The TMfS07 National Model Roads Calibration and Validation was documented separately from the model development by MVA. The initial audit findings relating to the roads model calibration and validation were presented by the TTAA in Audit Note *AN-TMfS07-3: TMfS07 Roads Model Calibration & Validation (TTAA Ref. 71552, 30 June 2009).* A subsequent response to *AN-TMfS07-3* was received from MVA and has been used in compiling the findings in this Audit Report.

3.1.2 The TTAA received the following information from MVA for use in the audit process:

- *TMfS07 National Road Model Calibration & Validation Report (Issue 4, 22 May 2009)*
- Base year (2007) loaded roads network and trip matrices (AM, Inter and PM peaks)
- *Audit Response Note to AN-TMfS07-3 (MVA Ref. C37895/01, 6 September 2009)*

3.1.3 This section relates to audit of the roads model calibration and validation and generally follows the format of MVA's *National Roads Model Calibration & Validation Report.*

3.2 Introduction to Roads Model Calibration & Validation

Overview

3.2.1 The National Road model was developed as part of the overall TMfS07 hierarchy and forms a strategic model whose detail is commensurate with:

- Appraising national policy interventions
- Strategic land-use interventions
- Providing a key source of transport supply and demand data

3.2.2 The TMfS07 National Model can also provide a start point for the development of sub-area and/or regional models and provides a source of travel demand forecasts. The base model was developed to represent a "typical" 2007 weekday with the assignment covering average AM, Inter and PM peak hours.

3.2.3 The TTAA is content that an average peak hour assignment has been adopted given the strategic nature of the TMfS07 National Model. **Users of the model should, however, note this assumption when applying the model and interpreting its outputs**.

3.2.4 Five user classes are assigned to represent cars (in-work, non-work commuters and non-work other), LGVs and HGVs while bus flows are assigned as fixed pre-loads from the TMfS07 National Public Transport model.

3.2.5 Various elements of the calibration and validation process as well as the conclusions and recommendations are outlined in MVA's Report. This section contains the TTAA's comments following a review of this document.

Calibration and Validation of the National Roads Model

3.2.6 The calibration and validation processes and the data sources used are discussed in MVA's Report. MVA notes that the data sources vary in terms of the type, coverage and quality of data in differing areas of the model. While steps have been taken to ensure that all data is consistent for the common base year of 2007, there are inevitable inconsistencies across such a wide ranging dataset.

3.2.7 MVA also makes reference to the *Design Manual for Roads and Bridges (DMRB) (Highways Agency)* guidance used in assessing the model's calibration and validation. In particular, it is noted that the *DMRB* guidance:

- Is not considered to be directly appropriate and is considered too stringent for a model of the size and strategic nature of the TMfS07 National Road model
- Is written with a focus generally on smaller, road assignment only models developed with a specific scheme appraisal application in mind
- Is the only appropriate guidance available

3.2.8 The TTAA acknowledges that in models of the scale and nature of the TMfS07 National Model, the current *DMRB* assignment model validation acceptability criteria can be difficult to achieve. With that in mind, the *DMRB* targets have not been interpreted by the TTAA as simple pass or fail thresholds. Nevertheless, in the absence of more appropriate guidance the TTAA considers that these are the best available guidelines to follow. While the model may not achieve some of the idealistic calibration/validation targets, it is still considered appropriate to present the model's calibration and validation level relative to the current *DMRB* guidelines.

3.3 Calibration of the National Road Model

Introduction

3.3.1 The Road model calibration was undertaken using a matrix estimation (ME) process that attempts to refine an initial estimate of the trip matrices (prior matrices) using routeing and traffic count information. For the TMfS07 National Model, the site specific traffic count information was aggregated into 43 screenlines and the screenline total was used as the target to match in the ME process. In the vast majority of cases (33 out of 43) the screenlines cover multiple links, while 10 of the screenlines consist only of a single link.

3.3.2 The TTAA notes that the screenlines have a relatively sparse, high level definition due to the strategic nature of the TMfS07 National Model. This aggregate approach to defining the target values for the ME process, while likely to be robust in terms of representing sector to sector flows, by definition does not account for more detailed route or corridor specific targets in the cases where the screenlines cover multiple links. The implications of this on the more detailed link flow comparisons in key corridors will be examined later in this section. **The TTAA would recommend that for the next upgrade of TMfS, consideration is given to defining both additional screenline locations and less aggregate screenlines as this is likely to enable a better match between modelled and observed flows on more key links and corridors**.

3.3.3 MVA has indicated general agreement with this recommendation, but has further commented that:

> *…it must also be borne in mind when defining less aggregate and individual data point screenlines, matrix estimation may introduce short distance trips in order to match the count and thus reduce robustness of prior trip matrix patterns and average trip length. This would only be exacerbated when the model is in forecasting mode.*
>
> *Focus should be centred on checking network link characteristics, connectivity and zone centroid locations before adding in single data points to the matrix estimation process*

3.3.4 The TTAA fully agrees with these additional comments.

3.3.5 The 43 screenlines defined for the calibration process made use of data from 137 individual count sites for the AM and PM peaks and 134 sites for the Inter-peak as 3 sites in Clackmannanshire did not have data for the Inter-peak period. The locations (3 sites x2 directions) for which the Inter-peak data is missing are:

- A908 Alloa Road
- A91 West Stirling Road
- A907 Clackmannan Road

3.3.6 Notwithstanding the missing Inter-peak data, the defined screenlines generally cover the main, strategic links in the network and are considered acceptable in their own right.

3.3.7 MVA notes in Section 2.1.6 that while the observed values have excluded motorbikes, taxis and buses the modelled values include the bus pre-load figures. The TTAA acknowledges that this will likely have a very small impact in terms of making reliable comparisons between the modelled and observed flows. **Given that it is a known inconsistency and the removal of bus pre-loads from the modelled flows should be a relatively straightforward process the TTAA would recommend that future calibration exercises for TMfS should seek to address this inconsistency**.

Matrix Estimation

3.3.8 The ME process was undertaken using the ANALYST software in the CUBE Voyager suite. This process was undertaken to attempt to improve the fit between modelled and observed flows while maintaining the integrity of the input prior matrices.

Matrix Estimation Data Sources

3.3.9 The matrix estimation process used various data sources which require confidence level to be specified. These were specified as follows:

- Calibration Screenline Aggregate Observed Traffic Counts – 100%
- Trip End Data – 30% internal zones; 20% external zones
- Prior Matrix – 80% travel pattern

3.3.10 The above inputs are used alongside traveller path (routeing) information to provide the complete set of data required for the ME process.

Calibration Screenline Aggregate Observed Traffic Counts

3.3.11 The calibration screenlines comprise data from a variety of sources, from which the observations corresponding with the modelled hours were extracted. The data sources used were:

- The Scottish Roads Traffic Database (SRTDb) – 2007 neutral month, average weekday peak hour data
- Counts conducted during Road Side Interviews (RSI) – the majority were carried out during 2007, though some date back to 2005
- 2005 based traffic counts (used in the construction of the TMfS05A model)
- A small number of "gap-plugging" traffic counts carried out during October 2008

3.3.12 The TTAA is satisfied that the appropriate data sources have been used in compiling the screenline. **The TTAA would recommend that an additional "data" report be produced for future TMfS07 model development exercises which should include additional detail relating to the data (e.g. the year and source of the observed data) and the data cleaning and factoring processes**.

3.3.13 Count data used in the TMfS05A development was factored to 2007 levels using factors derived from analysis of SRTDb data in the local area of the counts. The counts undertaken at RSI sites were factored using year on year vehicle kilometre growth for the relevant Local Authority area from the Scottish Transport Statistics Bulletin. Any count data from 2008 was not factored down to 2007 conditions.

3.3.14 The TTAA is generally content with the described process for factoring observed count data to a common 2007 base.

Trip End Data

3.3.15 The total volume of trips originating or destinating at each zone was allocated a 30% confidence level for all internal zones and a 20% confidence level for external route zones.

Prior Trip Matrix

3.3.16 The prior matrix is described in the *TMfS07 Demand Model Development and Calibration Report (Issue 2, 22 May 2009)*. This was assigned an 80% confidence level for the ME process reflecting the quality of the input data used in developing the prior matrix.

Traveller Paths

3.3.17 Traveller paths were derived from the Roads model and used as input to the ME process. For the AM and PM peaks, Car Non-Work Commute traveller paths were used; while the Inter peak used Car Non-Work Other paths. These were chosen to reflect the predominant travel purposes in the relevant time periods and the TTAA is satisfied that this approach was appropriate.

Matrix Estimation Procedure

3.3.18 The ME procedure used the base year road network and the original prior matrices to create an initial routeing file. The process is then run and a new matrix is estimated using the various inputs previously described. The routeing file is then updated based on the latest estimated matrix and the process is repeated until a satisfactory estimated matrix is achieved.

3.3.19 In Section 2.4.3 and 2.4.3 of MVA's Report it is stated that:

The trip end data (with its associated confidence level), prior matrix travel pattern confidence and screenline files remained 'fixed' throughout the procedure; the only variables being the estimated matrix and the ICP file.

The traveller paths used in the estimation process were representative of the best traveller paths available after a run of the Road Model with the previous estimated matrix. ANALYST and the Road Model were run iteratively with successively improving paths being fed into the ANALYST program until a satisfactory estimated matrix was achieved.

3.3.20 This description is outlined graphically in Figure 2.2 and the TTAA is satisfied that the appropriate methodology has been adopted.

3.3.21 MVA has confirmed that checks were undertaken to compare the prior and post ME matrices, the robustness of which were further examined during the model validation process.

Demand Matrix Comparisons

3.3.22 MVA has presented a comparison of the prior and final matrix totals for each time period in Appendix C of the Report. This analysis has been presented with the TMfS study area disaggregated into a 16 sector system as follows:

- Argyll & Bute
- Ayrshire
- Central
- City of Aberdeen
- City of Dundee
- City of Edinburgh
- City of Glasgow
- Dumfries & Galloway
- England & Wales
- Fife
- Highland
- Lothians
- North East
- Perthshire & Kinross
- Strathclyde
- The Borders

3.3.23 The TTAA reviewed this analysis to investigate the impact of the ME process on the trip matrices at a sector level. The main focus of this was to identify sectors where a significant change had resulted from the ME process, where "significant" was defined as any change between the prior and estimated matrix that was both >200PCUs and >15%.

3.3.24 It is encouraging to note that the vast majority of the sectors demonstrate changes that are below the TTAA's defined significance threshold. The exceptions to this are outlined in Table 3.1.

Table 3.1 : "Significant" Sector Trip Changes Resulting from Matrix Estimation

Time Period	Origin Sector	Destination Sector	Absolute Difference	% Difference
AM	2) Ayrshire	7) City of Glasgow	-349	-18%
AM	10) Fife	5) City of Dundee	394	41%
AM	All) All	9) England & Wales	418	39%
IP	7) City of Glasgow	2) Ayrshire	-398	-29%
IP	15) Strathclyde	2) Ayrshire	-467	-18%
PM	3) Central	10) Fife	-235	-18%
PM	5) City of Dundee	10) Fife	229	23%
PM	6) City of Edinburgh	10) Fife	273	15%
PM	7) City of Glasgow	2) Ayrshire	-553	-24%
PM	9) England & Wales	All) All	277	15%

3.3.25 The TTAA requested additional commentary/clarification from MVA regarding the reasons behind the more significant changes evident on this small number of sector to sector movements. MVA confirmed that these changes were simply due to the prior matrix totals for these sector to sector movements being either higher or lower than the observations and the resulting ME procedure therefore factored these accordingly. MVA considers the changes to be generally in line with expectations. Given the relatively small number of "significant" changes identified and the information supplied by MVA, the TTAA is satisfied that these changes are acceptable.

3.3.26 MVA notes in Section 2.5.2 of the Report that the key points of interest from comparing the prior and estimated matrices are:

the change in the overall matrix totals for all three time period specific matrices from the Prior matrices (before matrix estimation) to the Final matrices (after matrix estimation) is relatively small

the matrix estimation procedure has provided an overall improvement in the match of modelled total PCU flows to total PCU count at an aggregate level within the vast majority of the 16 sectors

the largest increase in total PCUs is for movements within Ayrshire in the AM and PM peaks and Fife in the inter-peak. This is in line with matrix estimation targets for these sectors

in the AM Peak hour the largest decrease in total PCUs is for movements within the City of Aberdeen; in the Inter Peak hour the largest decrease in total PCUs is for Strathclyde to City of Glasgow movements; the largest decrease in total PCUs in the PM Peak hour sees the reverse of this movement. Once again, this is in line with matrix estimation targets

3.3.27 The TTAA generally concurs with the points noted by MVA.

3.3.28 A comparison of the modelled versus observed counts by geographical area is also presented in Appendix D of the Report. Again, MVA summarised the main points to note from this analysis as:

aggregations of screenlines in City of Glasgow (3%-9%), Borders (2%-11%) and City of Aberdeen (5%-15%) have the largest positive percentage differences between the observed and modelled totals (ie over-estimation in the model) in all time periods

The Argyll & Bute screenline has the largest negative percentage difference between modelled and observed screenline totals (under-estimation in the model) in all time periods (12%-23%). The aggregate screenline totals for the England & Wales area also show an underestimate (12%-16%), as is the case for the Perth & Kinross area (6%-10%)

3.3.29 MVA notes that while these differences still exist between modelled and observed flows, in general, the ME process has improved the fit in each of these geographical areas.

Trip Length Distribution Analysis

3.3.30 Graphs showing the pre and post ME trip length distribution are presented in Appendix E of MVA's Report. These show the trip length distribution for all trips between 0 - 100km, which represents more than 80% of the trips in all time periods. The graphs demonstrate that the trip length distribution has not significantly altered as a result of the ME process providing some reassurance that the underlying, observed travel demand pattern has been preserved. The TTAA is satisfied that this is acceptable for the TMfS07 National Roads Model.

GEH Statistic

3.3.31 MVA outlines the use of the GEH statistic for comparison between modelled and observed traffic flows. The TTAA is satisfied that this is appropriate for the calibration and validation exercise.

DMRB Total Screenline Criteria

3.3.32 MVA outlines the acceptability criteria to be adopted based on those outlined in *DMRB*, as follows:

- Total screenline flows: Model to be within 5% of observed in all, or nearly all, cases
- GEH Statistic: Screenline totals to have a GEH < 4 in all, or nearly all, cases

3.3.33 The TTAA concurs that these are the appropriate criteria to adopt as outlined in Table 4.2 of *DMRB*, Vol. 12, Section 2, Part 1, Chapter 4.

3.3.34 It is further noted in MVA's Report that the GEH statistic is typically applied to vehicle flow comparisons but in this case has been applied to PCU flows, which has the effect of making the criteria harder to meet. While the TTAA acknowledges that this is factually correct, it is likely only to have a minor impact on the resultant GEH statistic in the vast majority of cases. Only in cases where there is a very high percentage of HGV traffic would this matter potentially have a significant impact and in most cases the impact will simply be on the first digit after the decimal point.

Strategic Screenline Flows

3.3.35 The Strategic Screenline flow comparisons are presented in Tables 2.1 to 2.3 of MVA's Report, colour coded to highlight those comparisons with GEH values of <4, <7 and >7. A summary of this is as follows:

- 49%, 55% and 44% of screenlines meet the <5% criteria for the AM, IP & PM
- 78%, 78% and 69% of screenlines meet the GEH<4 criteria for AM, IP & PM
- 93%, 93% and 87% of screenlines have a GEH<7 for AM, IP & PM

- The poorest comparisons (GEH>10) are on screenlines: 1nb & 16wb (AM); 16eb & wb, 19eb (IP); 11eb, 15nb & sb, 16eb & wb, 19eb & wb (PM)

3.3.36 While all of the *DMRB* criteria are not met, in general the TMfS07 National Model demonstrates a reasonable, global level of calibration in terms of strategic screenline flows.

3.3.37 MVA provides some explanation for the poorer screenline comparisons in the Report. A summary of these is as follows:

- Screenline 1 (Aberdeen area)
  MVA suggests that the AM peak count may be questionable as the observed flows are shown to be higher in both the Inter and PM peaks. MVA subsequently confirmed to the TTAA that a review of the Aberdeen Sub-Area Model was undertaken in this area but no independent check of the count itself was carried out.

- Screenline 15 (Glasgow area)
  MVA suggests that the zoning system provides direct access onto Maryhill Road which lies on the screenline and this may be behind the overestimation of trips, particularly since Maryhill Road is the most dominant link showing an overestimate across all time periods. The TTAA acknowledges this commentary, although it should be noted that there is also generally an overestimate evident across most of the screenline links, albeit that these are generally smaller in magnitude.

- Screenline 16 (west Glasgow)
  MVA suggests that the coarse zoning around this area may influence the quality of the comparisons. This is plausible in an urban area and it is reassuring to note that the parallel screenline 34 which covers this route further west demonstrates a better match.

- Screenline 19 (Glasgow area)
  MVA suggests that the zoning detail may again be the likely cause of the poorer comparison. The TTAA notes, however, that the comparisons are good (if slightly high) in the AM but poorer and very high in the Inter and PM peaks. This suggests that the Inter and PM peak matrix/routeing may well be behind the poorer comparisons rather than zoning as a good comparison is achieved in the AM peak. MVA has subsequently acknowledged agreement with the TTAA's comments.

- Screenline 11 (Edinburgh area)
  MVA suggests that the strategic detail of TMfS07 means that all local route choice is not included and this may influence the quality of comparisons on this screenline.

DMRB Individual Link Count Calibration/Validation Criteria

3.3.38 MVA outlines the *DMRB* criteria to be adopted in assessing the individual link flow calibration/validation and references these to *DMRB* Vol. 12, Section 2, Part 2, Chapter 4, §4.4.43. The TTAA considers that these are the appropriate criteria to adopt in assessing the model validation.

Individual Calibration Points

3.3.39 The screenline flow calibration comparisons have been further examined in more detail by looking at the individual links that comprise each screenline. Appendix G of MVA's Report provides the breakdown of the screenline comparisons on a link by link basis while summaries of this analysis are presented in Tables 2.6 to 2.9.

3.3.40 The overall summary of individual link flow GEH comparisons demonstrates that:

- Between 62% and 69% of links demonstrate a GEH <5
- Between 79% and 86% of links demonstrate a GEH <7
- Between 91% and 94% of links demonstrate a GEH <10

3.3.41 The ideal *DMRB* standard suggests that 85% of links should demonstrate a GEH<5. It is evident that the TMfS07 National Model comes reasonably close to matching this standard.

3.3.42 If this analysis is further broken down to consider the level of calibration by road type this demonstrates that:

- Between 79% and 82% of Trunk A-Roads demonstrate a GEH <5
- Between 55% and 62% of Non-Trunk A-Roads demonstrate a GEH <5
- Between 43% and 59% of B-Roads demonstrate a GEH <5

3.3.43 The calibration is therefore shown to be best on the Trunk A-Roads which would be expected to form the main focus of the model and its applications. The calibration is less good on the Non-Trunk A-Roads and is poorest on the B-Roads. It is also encouraging to note that a relatively small number of links on all road types demonstrate poor GEH values of ≥10 with these mainly being evident on the Non-Trunk and B-Roads.

3.3.44 At a global level, while the TMfS07 National Roads Model does not meet the ideal *DMRB* standard of 85% of GEH values being less than 5, it does come reasonably close to meeting this standard. Given the aggregate zoning and network structure, the scale and strategic nature of the model, this level of calibration is not unusual. The TTAA is generally satisfied that the level of individual link flow calibration achieved at a global level is acceptable for TMfS07.

3.3.45 Table 3.2 provides a list of the links for which poorer comparisons (GEH>10) have been recorded. Those which are motorway links have been highlighted in red with A-class roads (outwith central Glasgow) highlighted in orange. The A-class roads in central Glasgow have been highlighted in green.

3.3.46 The level of calibration at these individual locations should be borne in mind when applying the model or interpreting its outputs.

Table 3.2 : Individual Calibration Points with GEH > 10

AM S'line	AM Location	IP S'line	IP Location	PM S'line	PM Location
1	A947	9	B702	1	B999
2	B9119	901	B702	101	A947
201	A93	15	A81 Maryhill Rd	2	B9119
9	B702	16	Argyle St	201	B9119
901	B702	16	A82	801	M8
1001	B1348	16	A814	9	B702
1501	A81 Maryhill Rd	1601	A82	901	B702
16	Argyle St	1601	A814	1001	B1348
16	A82	18	B765	15	A81 Maryhill Rd
16	A814	21	A761	1501	A81 Maryhill Rd
1601	A82	22	A77	16	Argyle St
17	A80	22	A8	16	A82
18	A89	42	B7080	16	A814
18	B765	43	Kilmarnock Site 8	1601	Argyle St
21	A761	4301	Kilmarnock Site 8	1601	A82
22	A77			1601	A814
22	A8			18	A89
22	A8			18	B765
41	A71 Livingston			19	M74
42	B7080			22	A77 n. of B7038
4201	B7080			22	A8
43	A77 n. of B7038			22	A8
4301	B7081			2201	A8
4301	B7038			2701	A85
				42	Irvine Site 7A
				4201	A71

Total PCU Traffic Level on Screenlines by Geographical Area

3.3.47 The screenline analysis is further disaggregated by geographical area in Tables 2.10 to 2.12 of MVA's Report. The seven geographical areas are defined as: Aberdeen, Central & Tayside, Edinburgh, Glasgow, Highland, South and West. In general terms this showed that for the majority of areas, the modelled and observed screenline totals compared well, with differences of 5% or less. The only exceptions to this, where modelled screenline flows differ from observed by greater than 5% are:

- AM Peak Aberdeen +7%, West -6%
- Inter-peak Highland +7%, West -6%
- PM Peak Glasgow +8%, West -9%

3.3.48 MVA concludes in Section 2.12.2 and 2.12.3 of its Report that:

> *The Tables indicate that Central & Tayside, South and West areas exhibit marginal underestimations in total PCU traffic in all three time periods. Conversely, Highland, Aberdeen, Edinburgh and Glasgow areas exhibit marginal over-estimations in total PCU traffic in all three time periods.*

Considering all calibration screenline areas, the net effect is a slight over-estimation (1%-3%) in total PCU traffic crossing the calibration screenlines. This analysis suggests that the TMfS:07 Road Model displays an appropriate level of calibration at the aggregate regional level.

3.3.49 The TTAA would generally agree with these conclusions. **Users of the model should, however, take note of the calibration level in their specific areas of interest prior to applying the model**.

Modelled Flow Observed Count Correlation Analysis

3.3.50 A linear regression analysis has been undertaken to present the goodness of fit between the modelled and observed count data and this is presented in Appendix F of MVA's Report. MVA has adopted the acceptability criteria outlined in *DMRB* (Ref. Vol 12, Section 2, Part 1, Chapter 4, §4.4.42) that the correlation coefficient (R) should be >0.95 and the slope of the best fit regression line should lie between 0.9 and 1.1. Appraising against these criteria demonstrates that:

- The correlation coefficient R=0.98 for all time periods
- The slope is 0.99 in the AM and Inter-peaks and 1.03 in the PM peak

3.3.51 There is a slight tendency towards underestimating flows in the AM and Inter-peaks and a slight tendency towards overestimation in the PM peak, however, on the whole these regression statistics demonstrate an acceptable level of fit at the global level.

3.3.52 Potential users should, however, note that these statistics are based on a global analysis across the whole TMfS07 network. The regressions statistics are likely to vary by geographical area and this should be borne in mind prior to application. **It may be necessary to undertake a localised regression analysis for a given geographical area relevant to the sphere of influence of a scheme or schemes prior to applying the TMfS07 National Model**.

Road Model Calibration Conclusions

3.3.53 MVA provides a summary of the main conclusions from the calibration process in Section 2.14 of the Report, the salient points of which are that:

- The matrix estimation procedure has not significantly altered the travel pattern and trip length distribution of trips inherent in the prior matrix
- The calibration to aggregate screenline flows, while not meeting the ideal *DMRB* target, achieves an acceptable level of calibration for a model of the scale, spatial aggregation and nature of TMfS07
- The calibration to individual count locations, again does not meet the ideal *DMRB* standard but achieves an acceptable level of calibration for a model of the scale, spatial aggregation and nature of TMfS07
- The screenline analysis by geographical area shows no particular trend towards significantly over or underestimating aggregate screenline flows
- The linear regression analysis shows a good fit between modelled and observed flows in all time periods with slight underestimates in the AM and Inter-peaks and a slight overestimate in the PM peak

3.3.54 MVA concludes in Section 2.14.7 of the Report that:

> *Overall, the calibration of the Road Model is considered reasonable and appropriate for a model of this scale and nature*

3.3.55 Notwithstanding any comments, clarifications or recommendations outlined elsewhere in this section the TTAA generally agrees with this conclusion relating to the calibration to link flows. The TTAA does note, however, that the calibration has been undertaken using a high level definition of screenlines comprising a relatively small number of datapoints overall. This should be borne in mind when interpreting the model calibration analysis. **The TTAA would recommend that future calibration exercises seek to increase the coverage and detail of the screenlines and individual datapoints used**.

3.3.56 MVA has subsequently commented in relation to this recommendation:

> *Agreed. However, it must also be borne in mind when defining less aggregate and individual data point screenlines, matrix estimation may introduce short distance trips just to match the count and thus destroying prior trip matrix patterns. This would only be exacerbated when the model is in forecasting mode.*
>
> *Focus should be centred on checking network link characteristics, connectivity and zone centroid locations before adding in single data points to the matrix estimation process.*
>
> *It should be borne in mind that, while increasing sceenlines and individual points will add detail, this is likely to significantly increase model development time. Should a highly detailed national model be required, there could potentially be greater concerns over consistency of observed data and consequent higher model run times. A balance needs to be struck based on data, hardware, software and resources and perhaps a heavier reliance on detail at the regional tier of modelling.*

3.3.57 The TTAA acknowledges this commentary and considers that these factors should be borne in mind when addressing the above recommendation.

3.4 Validation

Introduction

3.4.1 A series of independent validation checks was undertaken to compare the TMfS07 National Model against data not used in the calibration process. These included more detailed link flow comparisons, journey time comparisons, comparisons with Roadside Interview (RSI) data and comparisons with planning and census data. The TTAA's comments on the various validation comparisons are provided in the following sections.

DMRB Validation Link Count Criteria

3.4.2 MVA outlines the *DMRB* criteria to be adopted in assessing the link flow validation for individual link flows and references these to *DMRB* Vol. 12, Section 2, Part 2, Chapter 4, §4.4.43. The TTAA considers that these are the appropriate criteria to adopt in assessing the model validation.

Total PCU Link Count Validation

3.4.3 The comparison of the modelled outputs on individual links against independent observed data is covered in Section 3.3 of MVA's Report. This has been presented in Tables 3.1 to 3.10 summarised by geographical areas representing motorways as well as the trunk roads in south-east, south-west, north-east and north-west Scotland. The individual link statistics are presented in Appendix H and a diagrammatic representation is provided in Appendix I. It should be noted that this analysis is presented for the AM and PM peaks only and not the Inter-peak.

3.4.4 MVA points out that the information presented in Tables 3.1 to 3.10 in virtually all cases represents an average flow along each route and this has been derived by summing the individual flows on each road and dividing by the number of locations for which flow data is available. It is worthy of note that this is a simple method of representing the flows along a given route and tends to mask the variation in the quality of both count and modelled flows at individual locations along the route, so while acceptable as a broad indicator of the modelled to observed flow comparisons along a route it cannot be considered as providing a reliable measure of the general level of quality at individual locations along the route.

3.4.5 For example, considering the M8 eastbound, the AM and PM values in Tables 3.1 and 3.2 show an average overestimate of 4% and 10%, however, in examining the information in Appendix H it is clear that the individual comparisons at the 10 sites along the M8 are generally poorer with 7 of the locations showing a GEH of ≥7 in the AM and 6 of the sites showing a GEH of ≥10 in the PM, so while the average difference between modelled and observed is relatively low this average is clearly masking a series of significantly greater over and underestimates at the individual locations along the M8 route. Rather than providing a detailed commentary on the average information in Tables 3.1 to 3.10 the TTAA has summarised MVA's conclusions on the flow comparisons for each route and based on a review of the mode detailed information in Appendix H has provided a comment as to the validity or otherwise of each conclusion. MVA's paraphrased conclusions are shown in *italics* while the TTAA's comments are in **bold**.

3.4.6 Motorways

- M8: *Reasonable match AM & PM.*
  While the average comparisons are reasonable the individual comparisons are generally poor for the AM and PM.
- M80: *Reasonable match AM & PM.*
  Agreed, although there are overestimates of 19% northbound in the AM and 24% southbound in the PM.
- M73: *Model has lower levels of traffic AM & PM.*
  PM generally reasonable but the AM comparisons are generally very poor.
- M77: *No comment provided AM, varied comparison PM.*
  Significant variation in the individual comparisons with only 1 of 10 directional comparisons showing a GEH<5 in both the AM and the PM.
- M90: *Model has higher levels of AM traffic with doubt cast on validity of AM southbound count, no comment PM.*
  AM comment seems reasonable. The TTAA notes that all counts are listed as southbound with no corresponding northbound data. MVA has subsequently confirmed that there is a general lack of M90 count data with only two southbound counts PM comparison is good.
- M74: *Reasonable match AM, varied comparison PM.*
  Individual comparisons show the reverse of this with more variable comparisons AM and generally good comparisons PM.
- A74 (M): *Reasonable match AM & PM.*
  Agreed.

- M9: *Model has lower levels of traffic AM, varied comparison PM.*
  Agreed, flows are low in the AM and generally very low in the PM.
- *Overall, almost all Motorway validation locations record a % difference of less than +/- 20% in both the AM and PM Peak hours, with the majority of locations demonstrating a % difference of less than 10%.*
  While this holds true for the average comparisons are the individual comparisons are generally extremely variable for individual sections in the AM and PM, particularly on the M8, M77 and M73.

3.4.7 South East Trunk Roads

- A720: *Model tends to overestimate in the AM and PM particularly in the westbound direction.*
  Agreed, comparisons are varied in both periods and very poor in many cases.
- A702: *Routeing variations between the A702, A68, A6901 and the A7. Fluctuations minor on this route.*
  Agreed.
- A68: *Routeing variations between the A702, A68, A6901 and the A7. Fluctuations minor on this route.*
  Agreed.
- A6091: *Routeing variations between the A702, A68, A6901 and the A7. Fluctuations minor on this route.*
  Agreed.
- A7: *Routeing variations between the A702, A68, A6901 and the A7. Fluctuations more significant on this route. The traffic counts on the A7 are located to the North of Hawick, and the zone used to represent this town also covers a wide surrounding area. The traffic associated with this zone is loaded at one point, close to the count location and therefore the model will tend to over estimate traffic flows at this specific location*.
  Comment seems reasonable. The TTAA would recommend that consideration be given to disaggregation of the zoning or other refinements for future model development to improve this
- A1: No comment provided.
  MVA has confirmed that no observed data for this section of the A1 exists. It is impossible to draw any meaningful conclusions from the A1 validation analysis, however, it is reassuring to note that the calibration comparisons on the A1 are generally good.

3.4.8 South West Trunk Roads

- A75: *Reasonable reflection of observed traffic in the AM and PM peaks.*
  Agreed, although there is a wide variation along the route, albeit that most flows are relatively low.
- A77: *Road model overestimating traffic but the observed values are relatively low.*
  Southbound comparisons are generally reasonable although do exhibit local variation. Northbound comparisons are generally poorer.
- A76: *Reasonable reflection of observed traffic in the AM and PM peaks.*
  Agreed, although the AM comparisons are generally more variable than the PM.

- A8: *Reasonable reflection of observed traffic in the AM and PM peaks.*
  The individual comparisons show a tendency to underestimate A8 flows in both peaks with generally poorer comparisons west of Newhouse and east of Baillieston.
- A726: *Road model underestimating traffic but only 1 observed count available.*
  Agreed.

3.4.9 North East Trunk Roads

- A90: *Reasonable reflection of North East traffic levels using trunk roads.*
  Individual comparisons are generally extremely variable for individual sections, particularly in the PM peak.
- A96: *Reasonable reflection of North East traffic levels using trunk roads.*
  Agreed, albeit that there are various over and underestimates along the route.
- A95: *Reasonable reflection of traffic. Slight overestimation but used by a relatively low volume.*
  Agreed, albeit that there are various over and underestimates along the route . Note, the model actually underestimates traffic on the A95.
- A985: *Reasonable reflection of traffic. Slight overestimation westbound but used by a relatively low volume.*
  Agreed.

3.4.10 North West Trunk Roads

- A835, A87, A85, A83, A84, A82, A9 Caithness to Inverness, A9 Perth to Inverness & A9 Perth to Stirling: *Varied validation comparison. Although there are some fairly substantial % differences in some areas, most of these routes are used by a relatively low level of traffic. On more heavily used sections, (of the A9 for example) the model provides a more reasonable validation. Generally, the model underestimates the level of traffic using the majority of these lower-use routes. Given the relative coarseness of the model zone system, this trend would be expected, as the traffic not included in the model would constitute a higher proportion of the total traffic in these areas.*
  Agreed. Note: the "traffic not included in the model" referred to is intra-zonal traffic

3.4.11 Following this review of the link flow validation comparisons the TTAA considers that many of MVA's comments on the comparisons are fair and reasonable, however, it is felt that the average link flow comparisons used and some of the generic comments mask a significant amount of variation along many routes, in particular those on the motorway and on other key trunk roads. This can only be picked up by analysing the contents of Appendix H in detail and the TTAA considers that the main Report currently provides an overly positive impression of the independent validation comparisons than is actually the case.

3.4.12 While it is recognised by the TTAA that the TMfS07 National Model is an aggregate, strategic model, it is considered that the overly strategic definition of calibration counts and screenlines may have resulted in poorer flow validation comparisons being evident on some key, strategic links. **The TTAA would recommend that users should take care when applying the model and interpreting its outputs, particularly where the focus of the application is in areas where the level of validation is shown to be variable**.

3.4.13 **Furthermore, the TTAA would recommend that in the short to medium term an upgrade of the model be undertaken which includes a greater amount of data in the calibration process, particularly on key links in the motorway and trunk road network. While this would remove some data from the independent validation process it is considered that it would improve the fit of the model with observations at some key locations on the network**. MVA has commented in relation to this recommendation that:

> *The TMfS:07 National Road model has been developed, calibrated and validated to a sufficient level for the key objective of providing road transport costs as part of an integral process in the National Land Use and Transport Modelling Framework for the purpose of appraising major strategic transport schemes and policy decisions.*
>
> *MVA disagree with this specific recommendation for this purpose, but accept that, through application of the model for specific purposes there may be considerations of model improvement which will add to levels of detail. It would be considered at the time if those levels of additional detail and\or model improvements should become part of the standard national model.*

Heavy Goods Vehicle Flow Validation

3.4.14 The modelled HGV flows were compared against observations from SRTDb data at a series of key points on the trunk road network. This analysis is presented in Appendix J of MVA's Report and is summarised in Table 3.11. The salient points from this information are:

- 46%, 41% and 57% of GEH values are <5 in the AM, Inter and PM peaks
- 64%, 61% and 72% of GEH values are <7 in the AM, Inter and PM peaks
- Using the *DMRB* criteria for flows <700vph, 82%, 82% and 90% of comparisons are within 100vph of the observed in the AM, Inter and PM peaks

3.4.15 In general terms this level of validation to HGV counts is not atypical for a model of the scale and nature of TMfS07. MVA has subsequently confirmed to the TTAA that the matrix estimation process was undertaken for all user classes combined. **The TTAA would recommend that, if sufficient robust and consistent data were available, consideration should be given to undertaking matrix estimation separately for light and heavy vehicles in future developments/upgrades of TMfS07**.

3.4.16 MVA notes that the poorest HGV validation comparisons are on the M8 eastbound in the AM, M8 westbound in the Inter-peak and on the A8 westbound in the PM peak. These and the other locations where poorer comparisons are identified in Appendix J should be borne in mind by potential users of TMfS07.

Traffic Flow on Scotland's Key Road Bridges

3.4.17 As a means of assessing the level of validation in a more focused manner a comparison of the modelled and observed flows across the key road bridges was undertaken. These comparisons focused on the Kessock, Tay, Friarton, Kincardine, Forth Road, Kingston and Erskine bridges.

3.4.18 In general terms the comparisons across most bridges are good in all time periods, particularly on the Kessock, Kincardine, Forth Road and Erskine bridges. With respect to the other bridges:

- There is a slight tendency to overestimate flows on the Tay Bridge and underestimate flows on the Friarton Bridge.
- The GEH values on the Tay Bridge range from 5.0-5.5 in the AM, 2.5-6.0 in the Inter-peak and 3.5 to 4.2 in the PM and are generally acceptable.

- The GEH values for the Friarton Bridge range from 5.1-7.6 in the AM, 4.4-7.8 in the Inter-peak and 4.2-5.2 in the PM peak. The comparisons are generally acceptable although the AM peak northbound and Inter-peak southbound comparisons are the poorest.
- The Kingston Bridge comparisons are generally good with the exception of the AM peak southbound which shows a GEH of 7.9, and to a lesser extent the PM peak southbound with a GEH of 5.6.

3.4.19 Regarding the Friarton and Tay Bridges MVA has provided commentary which suggests that the issue may be due to the HGV speed cap and generalised cost parameters which were invoked post the model calibration stage. This may have resulted in more goods vehicles choosing the shorter route via the A92 and Tay Bridge, as opposed to the A90/M90 and Friarton Bridge.

3.4.20 With respect to the Kingston Bridge, MVA considers that the relative lack of zoning and network detail in Glasgow City Centre is likely to be contributing to the poorer matches in the southbound direction.

3.4.21 MVA recommends in §3.5.9 of its Report that:

> *These two issues should be borne in mind when appraising road schemes directly affected or influenced by these traffic corridors*

3.4.22 Given that the majority of GEH values on the key road bridges are <5 and those which exceed this threshold generally do so by a relatively small margin, the TTAA is content to concur with MVA's recommendation. **Nevertheless, given that these are known issues outlined in the base model development the TTAA would recommend that measures are taken to address these matters at the next upgrade of TMfS07**.

DMRB Journey Time Validation Criteria

3.4.23 MVA outlines that the *DMRB* journey time acceptability criteria, that modelled journey times should be within 15% of observed (or 1 minute if higher) for 85% of routes, have been adopted for the TMfS07 validation exercise. The TTAA endorses the use of these acceptability criteria.

Journey Time Validation

3.4.24 A total of 49 routes were defined for journey time validation across the TMfS07 model area. The data comes from two main sources, namely:

- ITIS (29 routes)
- STPR Highland Model journey time surveys (20 routes)

3.4.25 The ITIS data uses GPS type technology to collect speed and position information about probe vehicles which is then aggregated to provide an average speed along given sections of the road network with significant coverage across Great Britain. The ITIS data used in the validation only represents a single, average speed for each road section so no more detailed statistical analysis (max, min, 95% confidence intervals etc.) could be undertaken. MVA notes in §3.7.6 that:

> *the ITIS dataset is expected to provide a reasonable estimate of mean journey times against which to validate the model for routes where no directly-observed journey time surveys have been carried out*

3.4.26 The 29 ITIS routes provide coverage on the majority of the main inter-urban routes throughout the TMfS07 network. Given this widespread coverage of the dataset the TTAA considers this a valuable resource, in particular as it assists in minimising data collection costs in an exercise of this scale, however, it should also be recognised that the ITIS dataset, while comprehensive in coverage, is limited by a lack of statistical detail. Given the nature and focus of the TMfS07 National Model the TTAA considers that the use of the ITIS data to provide broad estimates of average journey times along route sections is acceptable. The TTAA would, however, suggest the use of ITIS data for journey time validation may not be appropriate in all cases for the development of more detailed sub-area or regional models in the overall TMfS07 hierarchy. **The LATIS support team should be consulted prior to the use of ITIS data for model validation purposes on a case by case basis**. MVA has further commented that:

> *We agree with this recommendation.*
>
> *While ITIS (and indeed Trafficmaster) data provides a valuable resource at a national level, the present quality of the data may be less robust for more detailed (regional and local) modelling. While ITIS should be considered for use in model development as it is a readily available data source and may avoid the requirement for specific journey time surveys, it should be considered on a case by case basis.*
>
> *It should also be borne in mind that the quality of ITIS data is improving as the database and experience of its use grows.*

3.4.27 The TTAA requested MVA to provide information regarding what year and time periods the ITIS data represents and how any gaps in the ITIS data were addressed. MVA confirmed that the ITIS data represents:

- Aggregated, average weekday vehicle speed data based on all available data for every Tuesday, Wednesday and Thursday in an eight month period
- The eight "neutral" months represented were February, March, May, September and November 2007, and February, March and May 2008
- The time periods were AM (08:00 – 09:00), IP (average of 10:00 – 16:00) and PM (17:00 – 18:00)

3.4.28 The TTAA is satisfied that the selected months and time periods for the ITIS data are appropriate.

3.4.29 Any gaps in the ITIS data were filled by using "Speed Plus with NAVTEQ streets" data to estimate speeds on the relevant links. This provided speed information for average AM (07:00 – 09:00), Inter (09:00 – 16:00) and PM (16:00 – 19:00) peak periods. It should be noted, however, that this data does not distinguish speed by direction of travel and the AM and PM peaks are combined into a single peak.

3.4.30 Overall, for the purpose of the Strategic National Model, the TTAA is satisfied that the small number of gaps in the ITIS data have been filled in an acceptable fashion. **However, given this relatively simple process for patching what is already a relatively coarse dataset, consideration would have to be given as to whether this data would subsequently be appropriate for the purpose of any more detailed regional or sub-area modelling within the overall TMfS07 hierarchy**.

3.4.31 The STPR Highland model journey time routes were surveyed in May 2007. These provide some duplicate coverage of the ITIS routes (A9, A96 etc.) while also covering additional routes within the Highland and Argyll & Bute areas. Overall the TTAA is satisfied that the journey time routes used for validation represent the majority of inter-urban routes across the model area and therefore provide acceptable coverage.

3.4.32 Comparison of the modelled journey times against the ITIS data in each peak period showed that the following number of routes met the *DMRB* acceptability criteria:

- AM Peak 84% (49 out of 58 routes)
- Inter-peak 90% (52 out of 58 routes)
- PM Peak 86% (50 out of 58 routes)

3.4.33 MVA has some commentary providing reasons for possible discrepancies between modelled and observed ITIS journey times on certain routes as follows:

> *The observed journey time for the Dunfermline to Edinburgh route appears unrealistic, ie illustrating a slower journey time (around 11 minutes) travelling northbound than southbound (around 14 minutes) in the AM Peak hour. The model suggests the reverse of this trend and with a journey time of around 20 minutes on the Dunfermline to Edinburgh route, this appears to be a more appropriate reflection for this route*

3.4.34 The TTAA would agree with MVA's view that the modelled trend appears more intuitively correct than the observed in the case of the Dunfermline to Edinburgh journeys.

> *The modelled Edinburgh Bypass westbound route illustrates an increase of 9 minutes when compared to the observed journey time data. The underlying congested network speeds highlight an intuitive trend of congestion build-up from Sheriffhall roundabout to the M8 Junction 1 (resulting from traffic feeding onto the Edinburgh Bypass at Sheriffhall, Straiton and Lothianburn from strategic routes north and south of the Bypass). This increase in journey time equates to an overall modelled journey time of around 30 minutes, which is deemed realistic and appropriate for this route*

3.4.35 In the absence of independent observations it is difficult to conclude whether the modelled time on the A720 westbound route is realistic or not, however, the TTAA does note that the link flow validation along the A720 is generally poor, particularly in the westbound direction. It is not entirely unexpected that the journey time validation along that route would fail to meet the *DMRB* standards. **The TTAA would recommend that users take particular care when applying the model and interpreting outputs in this area of the model. Furthermore, the TTAA would recommend action is taken to improve the link flow and journey time validation for the A720 at the next upgrade of TMfS07**.

> *there is a good representation of journey times in the modelled Inter Peak period, with only a handful of routes failing to meet the DMRB criteria (within 15% or 1 minute). These outliers represent fairly short distance routes and, as such, modelled times differ by only two to three minutes. The only exception, relates to the Stranraer to Ayr route, where the model shows a decrease of around 12 minutes for both directions over this 79km route. Generally, the model tends to illustrate a slight under estimation of journey times within the Inter Peak period*

3.4.36 The TTAA generally endorses this view of the Inter-peak journey time validation to ITIS data.

> *Table 3.17 illustrates PM Peak hour modelled journey times against the ITIS data. Once again, the model exhibits a good representation of journey times across Scotland's strategic road network. The majority of modelled journey times fall within the DMRB 15% criteria*

3.4.37 In broad terms the TTAA would agree, however, it is worthy of note that:

- The PM peak ITIS observations for the Edinburgh-Dunfermline route show that southbound journey times are longer than northbound while the model shows the reverse of this. The TTAA considers that the model represents a more intuitively correct trend and, similar to the AM peak on this route, the ITIS data must be considered as potentially questionable.
- The majority of other routes which fail the *DMRB* check generally show either a relatively small difference on a short route or are on very long routes with the majority showing an underestimation of times in the model.
- The A720 journey times are the main exception with the model overestimating these in both directions. Again, the TTAA considers this is likely to be related to the overestimate of link flows on this route and users should take note of the TTAA's earlier recommendations on this matter.

3.4.38 Comparison of the modelled journey times against the Highland journey time data in each peak period showed that the following number of routes met the *DMRB* acceptability criteria:

- AM Peak: 88% (30 out of 34 routes)
- Inter-peak: 82% (31 out of 38 routes)
- PM Peak: 77% (10 out of 13 routes)

3.4.39 The comparisons show that the main strategic, more heavily trafficked routes in the Highland area (e.g. A9, A96 etc.) tend to satisfy the *DMRB* criteria in all time periods. The routes which fail to meet the criteria all demonstrate an underestimate of journey time in the models and these are all on medium to longer distance routes. Overall, this is an acceptable level of validation to the Highland journey time data. The TTAA would recommend that users take care in applying the model in areas where the journey time validation has been demonstrated to be poorer. It should also be noted that in the Highland area, there is much less PM peak journey time data available than in the corresponding AM and Inter-peak periods.

3.4.40 Combining the ITIS and Highland datasets, at least 85% of routes are shown to meet the *DMRB* criteria in all time periods. The majority of routes (between 63% and 81%) tend to slightly underestimate journey times, which s often the case with transport models, particularly of a strategic nature. Notwithstanding the comments provided in relation to the journey time data and the comparisons achieved on specific routes, the TTAA is content that the overall journey time validation achieved for the TMfS07 National Model is acceptable.

RSI Journey Length Analysis

3.4.41 A series of comparisons were undertaken between the modelled and observed journey lengths at 14 RSI site locations. This comparison considered car non-work commuter and car non-work other user classes with commuters compared for the AM and PM peaks and other purposes in the Inter-peak. The matrices for these specific user classes were developed without reference to RSI data and this therefore provides an independent validation check of the matrices and network. This analysis is provided in Appendix N of MVA's Report and a summary of the key points from the analysis was provided by MVA as follows:

> *The modelled trip length at the A90 Forth Road Bridge, A899 Livingston, A780 Dumfries and A90 south of Aberdeen at Portlethen show a good match to observed RSI data across all three time periods*

In the AM Peak hour, observed data suggests all trips (100%) travel within the 0km-50km band for the A907 Clackmannan site; the model suggests 86% within this distance band and the remaining in the 50km-75km band

The key bridge RSI sites (Tay, Kessock, Forth and Erskine (on the A82)) show a very good comparison in trip length for all three time periods

As expected, for RSI sites close to urban areas (eg A90 south of Aberdeen at Portlethen, Livingston A899), the majority of car non-work commuter trips travel within the 0km-50km distance band

As expected, for RSI sites in more rural areas, car non-work commuter trips show a greater spread across the distance bands

3.4.42 In most cases the TTAA would concur with this summary, however, the TTAA would add the following comments:

- The Kessock Bridge trip length distribution is poorer than suggested by MVA. There is a definite tendency to underestimate short and overestimate long commuting trips in the AM and PM peaks and a slight tendency towards this for Inter-peak other trips.
- The distribution on the A96 at Elgin is extremely variable and is particularly poor in the AM peak with short commuter trips significantly underestimated, counter-balanced by longer trips. The Inter-peak other and PM peak commuter trips both show a tendency towards underestimating longer and overestimating shorter trips.
- The Tomatin, Crianlarich and SITM4 A71 sites all demonstrate variability in the quality of comparisons in both the Inter and PM peaks.

3.4.43 Overall, the majority of sites demonstrate a reasonable comparison between modelled and observed trip lengths and it is encouraging to note that the ones on the most heavily trafficked routes are generally the better comparisons. Nevertheless, there are some key locations where the comparisons are poorer, albeit that these are generally in more rural and/or less heavily trafficked parts of the network. **The TTAA would recommend that care is taken when applying the model and interpreting the outputs at locations where these comparisons are shown to be poorer. Furthermore, the TTAA would recommend that ideally, consideration would be given to what measures could be taken to address the poorer comparisons at the next upgrade of TMfS07**.

RSI Trip Distribution Analysis

3.4.44 Additional analysis was also undertaken to compare the trip distribution on a sector to sector basis at the same 14 RSI locations. A 16 sector system was used to analyse the distribution of trips across the model area. The salient points from this analysis are outlined in MVA's Report as follows:

All the largest observed and modelled sector-to-sector movements match across all three time periods with the exceptions of A82 Crianlarich (all time periods), SITM4 A71 (AM Peak hour only) and A82 Erskine (PM Peak hour only)

There is a reasonable match for all other sector-to-sector movements which make up the remaining distribution proportion (eg out-with the largest sector-to-sector movement, the A90 Forth Road Bridge RSI site in the AM Peak hour sees an observed 16% of Car Non-Work commuter trips from the Lothians to Fife, the model records 17% from the Lothians to Fife, and an observed 1% from Central to Fife compared to a modelled 3%

Of the three outliers, it is the neighbouring sectors which make up the largest movements, eg A82 Crianlarich AM Peak hour – the largest observed movement using this site is within the Central sector; the largest modelled movement using this site is from Strathclyde to Argyll & Bute, hence neighbouring sectors

RSI trip distributions generally fall in line with RSI journey lengths described in the previous section.

3.4.45 The TTAA generally agrees with this summary of the analysis, however, it should also be noted that:

- The A82 Erskine largest sector movement does not match in both the Inter and PM peaks, not just in the PM peak as reported.
- There is no observed data for the Clackmannan A907 eastbound site in the Inter-peak or the Erskine A82 eastbound site for the AM peak. It is unknown how well the modelled distribution matches observations at these locations for those time periods.
- The model generally demonstrates an intuitively correct trip distribution northbound over the Forth Road Bridge, however, the Observed data for the A90 Forth Road Bridge northbound suggests that 1% each of Inter-peak trips destinate in Edinburgh and England & Wales. In the PM peak the observed data suggests that 8% of trips destinate in Edinburgh with 1% each destinating in England & Wales and Lothians. MVA has subsequently confirmed that these are illogical movements in the northbound direction over the Forth Road Bridge that should have been removed from the observed data
- While the discrepancies between the modelled and observed are often evident on adjacent sectors, the discrepancies are significant in some cases (e.g. Elgin A96 wb AM Peak, Crianlarich A82 northbound all periods, Erskine A82 eastbound Inter-peak and SITM4 A77 westbound Inter-peak, etc.).

3.4.46 Similar to the trip length analysis. many of the sites demonstrate a reasonable comparison between modelled and observed trip distribution particularly on the most heavily trafficked routes, however, again there are some locations where the comparisons are poorer, albeit that these are generally in more rural and/or less heavily trafficked parts of the network. **The TTAA would recommend that care is taken before applying the model and in interpreting the outputs at locations where the trip distribution comparisons are shown to be poorer. Furthermore, the TTAA would recommend that action is taken to address the poorer comparisons at the next upgrade of TMfS07**.

RSI Car In-Work, Car Non-Work Analysis

3.4.47 A comparison between the modelled and observed journey purpose split for Car In-Work and Car Non-Work trips was undertaken using data from RSI sites where such information was recorded. This analysis covers 66 RSI sites across the model area and in the majority of cases a good comparison is evident between the modelled and observed split. In a small number of cases, there is a >10% difference between the modelled and observed split, as follows:

- AM Peak: A862 Beauly (+13% CIW), A816 Soroba Road (+11% CIW)
- Inter-peak: A90 Forth Rd Bridge (+14% CIW), A82 Crianlarich (+21% CIW), A737 S. of Dalry (-13% CIW), B780, N. of Ardrossan Bypass (-11% CIW), A737 Beith Bypass (-12% CIW)
- PM Peak: A735 Queen St (-12% CIW)

3.4.48 There is a general tendency in the AM and PM peaks for the model to slightly overestimate the Car In-Work proportion while there is generally an underestimate of this in the Inter-peak. Overall, the comparisons between the modelled and observed Car In-Work and Car Non-Work proportions are generally good. Nevertheless, users should note the points made above in relation to more detailed analysis of the TMfS07 National Model outputs.

Demand Matrix Trip Ends & Planning Data Analysis

3.4.49 The final base year demand matrices were compared with base year planning data. This comparison was undertaken to ensure that the planning data based trip ends had not been significantly altered during the matrix development process. The comparison was undertaken by grouping the population and employment planning data by Local Authority area and ranking these in order of magnitude. The relative rank of the modelled and observed data was then compared for each Local Authority area.

3.4.50 The analysis is presented in Appendix Q of MVA's Report and this shows that in most Local Authority areas a similar planning data ranking is achieved between the modelled and observed datasets. The most significant employment ranking differences are shown in Inverclyde where the modelled ranking is between 5 and 7 points lower than the observed in each time period. The largest population ranking differences are shown in Stirling, where the modelled ranking is between 9 and 10 points greater than the observed in all time periods.

3.4.51 MVA concluded in §3.11.4 of its Report that:

> *This analysis suggests the level of trip making within each local authority is generally acceptable, with a couple of outliers as described above. Given the more simplistic nature of this analysis, users should be mindful that the comparison has only considered some of the main drivers of demand. Other planning data assumptions, such as retail floorspace, which influence the level of trip making within a given local authority, have not been included*

3.4.52 This clearly demonstrates that this comparison is not a straightforward one and relies on a degree of interpretation and more detailed understanding. The value of this comparison other than as a very high level check is limited, however, it does generally demonstrate a reasonable correlation between the relative magnitude of modelled and observed trip ends by Local Authority area. MVA has also further commented subsequently that:

> *This is indeed a very high level of analysis and as such the analysis provides a very broad indication of the level of trip making in relation to the land-use information.*
>
> *The reasons for the larger discrepancies, particularly in the Inverclyde and Stirling local authorities may be (ie hypothetical) directed towards the limited land-use information as not all drivers of demand have been considered, just the key drivers.*

3.4.53 **Given the high level nature of this analysis the TTAA would recommend that for future TMfS07 model development reporting such analysis could be broadened by undertaking a conventional analysis of trip rates using a less aggregate sector system in order to provide quantification of the level of trip making in relation to land use information. The trip rate analysis should provide some additional assurance that trips have been distributed to locations with appropriate levels of land use.**

Census Travel to Work & Car Non-Work Commuter Traffic Analysis

3.4.54 The AM peak Car Non-Work commuter trip matrix was compared against the census travel to work data on a Local Authority area basis to provide an additional measure of validation. It should be noted that for the purpose of this analysis an assumption was made that a vehicle occupancy of 1.2 would apply across the model area to convert the census data from person trips to vehicles for comparison with the trip matrices. The analysis is presented in Appendix R of MVA's Report.

3.4.55 The analysis shows that the individual sector to sector movements, as a percentage of all movements show a close correspondence between the modelled and observed values, as would be expected. The modelled values show an approximately 9% higher volume of commuter traffic than the census data across the model area. On individual trip end and sector to sector movements the variation is more significant between the census data and the matrix in some cases. The TTAA has undertaken a check to ensure that there are no extremely significant differences and can confirm that there are no differences which are greater than both 25% and 300 vehicles. Given the relative simplicity of the comparison, the differences between the modelled and observed commuting patterns appear acceptable for the TMfS07 National Model.

Road Model Validation Conclusions

3.4.56 MVA has provided a brief set of conclusions relating to each aspect of the model validation in Section 3.13 of its Report. The TTAA will not comment on these conclusions as the issues outlined in this section provide the TTAA's views on each matter individually.

3.5 Conclusions & Recommendations

Conclusions

3.5.1 The conclusions section provides a list of the various aspects of the calibration and validation processes along with a series of conclusions as follows:

- The trip length distribution has not changed significantly during matrix estimation.
- The Road Model is considered by MVA to be reasonably calibrated at the aggregate screenline level and although not meeting the *DMRB* acceptability criteria most screenlines are close to meeting these criteria.
- The more detailed calibration is also considered by MVA to be reasonable as approximately 80% of link comparisons have a GEH<7.
- The main roads in the model demonstrate the highest level of calibration.
- The representation of HGV flows on motorway and A-Roads is considered reasonable with approximately 50% of GEH values less than 7.
- The traffic flows on Scotland's key road bridges are well represented in the majority of cases.
- The journey time validation is good with the *DMRB* criteria effectively being met in all time periods
- Car Non-Work commuter and census travel to work comparisons are considered by MVA to have a close pattern in terms of the distribution, albeit with variation on some sector to sector movements. There is 9% greater modelled Car Non-Work commuter traffic than observed.
- The car in-work and car non-work traffic at the RSI sites across the model area are considered to be well represented.

3.5.2 While the TTAA is generally in agreement with most of the above conclusions, it is difficult to fully summarise the calibration and validation with such brief conclusions. The TTAA considers that while the general level of the more detailed link flow calibration and the trip distribution validation is reasonable, there are significant variations on individual comparisons on some key routes and movements. **The specific locations are identified in the preceding sections and the TTAA would recommend that care is taken in applying the model and interpreting the outputs in these areas of the model**.

Recommendations

3.5.3 MVA's recommendations for the TMfS07 National Roads Model are:

> *Our view is that the National Road Transport Model has been successfully developed and is fit for its intended purpose which is to provide road transport costs as part of an integral process in the National Land Use and Transport Modelling Framework for the purpose of appraising of major strategic transport schemes and policy decisions*
>
> *It should be noted, however, that, due to the size, nature and data used in the model, there is some local variation in the calibration and validation of the model that is discussed within this report. Therefore, and as is recommended for any and every application of LATIS modelling tools, model applications should be preceded by an appropriate review of the robustness of the model validation in the area/corridor of interest*
>
> *The model can be used to provide robust estimates of road-based costs for use in the mode and destination sub-models and the over-arching TELMoS land-use model*
>
> *The model can also provide a good starting source of transport supply and demand data for more-detailed sub-area/regional models, provided that relevant checks on the model's robustness in the relevant specific areas are carried out*

3.5.4 In general terms, but notwithstanding the findings and recommendations made elsewhere in this document, the TTAA would agree with these recommendations.

3.5.5 In addition, MVA has made the following comment on some of the TTAA's recurring recommendations throughout the audit report as follows:

> *Where general recommendations of addressing poorer comparisons are made (throughout the audit comments), it should be noted that, to ensure more robust comparisons can be made, it is not only the modelling, but the collection and processing of widespread, consistent data that may also be required to achieve this. A degree of pragmatism needs to be applied in this throughout.*
>
> *The National model should benefit from the development and use of models around Scotland where specific scheme\policy application is undertaken (eg at the regional\local level) as it is likely that more locally observed data (count, journey time, travel pattern etc) would be collected for these. Both the data and model results may be able to be fed back up to the National Model. It is likely that through such applications a greater degree of 'detail' within the National model would be achieved, but less of a strain on the resources for the national model to consider this as part of a generic national model development programme.*

3.5.6 The TTAA acknowledges and supports these additional comments from MVA.

4 TMFS07 AUDIT: PUBLIC TRANSPORT MODEL DEVELOPMENT

4.1 Background

4.1.1 The TMfS07 National PT Model was also developed in Cube Voyager and forms the PT assignment component of the overall TMfS07 National Model system. The initial audit findings relating to the PT model were presented by the TTAA in Audit Note *AN-TMfS07-4: Public Transport Model* Development (TTAA Ref. 71200, 9 April 2009). A subsequent response to *AN-TMfS07-4* was received from MVA and has been used in compiling the findings in this Audit Report.

4.1.2 The TTAA received the following information from MVA for use in the audit process:

- *TMfS07 National Public Transport Model Development Report (Issue 3, 30 January 2009)*
- Base year (2007) loaded public transport network, lines files and trip matrices (AM, Inter and PM peaks)
- *Public Transport Model Development Note 2 – Inter-Urban Bus Processing (Version 2, 6 January 2009)*
- *Information Note IN014 : Relevant Files for Audit of TMfS07 (version 2, 16 January 2009)*
- Bus Effective Headways Note
- Fare Tables file (*TMfS07_FARES_AM.FAR, TMfS07_FARES_IP.FAR, TMfS07_FARES_PM.FAR*)
- System File (*TMfS07_SYSTEM _FILE.PTS*)
- Ferry coding spreadsheet
- Rail capacities spreadsheet
- Modelled services spreadsheet
- *Audit Response Note to AN-TMfS07-4 (MVA Ref. C37135/11, 24 April 2009)*

4.1.3 This section relates to audit of the PT model development and generally follows the format of MVA's *National PT Model Development Report*.

4.2 Introduction to National PT Model

Overview

4.2.1 The introductory section provides a brief overview of the PT model development and sets out the report structure. The TTAA has no comments on this aspect of the Report.

4.3 Model Dimensions

Model Dimensions

4.3.1 The TMfS07 National PT Model was developed to represent a 2007 base year with the following time periods:

- AM Peak hour 08:00 – 09:00 (within 07:00 – 10:00 peak period)
- Inter-peak average hour between 10:00 – 16:00

- PM Peak hour 17:00 – 18:00 (within 16:00 – 19:00 peak period)

4.3.2 The AM and PM peak hour factors have been derived from analysis of the three hour peak period bus occupancy count data and National Rail Travel Survey used in the development of the TMfS07. The Inter-peak hour factor is taken as an average one sixth of the time between 10:00 – 16:00. MVA's analysis has revealed that the peak hour factors for bus and rail to be similar and combined into a single set, as follows, for application in the PT model.

- AM Peak hour 0.45
- Inter-peak hour 0.167
- PM Peak Hour 0.44

4.3.3 The TTAA is satisfied that the adopted peak hour factors have been derived from an appropriate dataset and are acceptable for the TMfS07 National PT Model.

4.3.4 The TTAA requested MVA to clarify a number of the background assumptions associated with the coding of PT services in TMfS07 and the following response was received:

> *We can confirm that the TMfS07 National PT model represents a typical weekday.*
>
> *Ferry services were coded using the 2007 March-October timetables with accompanying bus services where appropriate. In general, seasonal special services have not been included in the model as these do not operate the majority of the year. As noted by the TTAA, the representation of ferry services may require to be amended or enhanced depending on the requirements of specific model applications.*
>
> *Where a service varies by school/non-school day then the non-school day service has been modelled, although the difference between services is generally negligible in the context of the national PT model.*
>
> *In rural areas where services may not run every day these have been included in the model in order that the PT journey is possible in the model.*

4.3.5 The TTAA considers these assumptions acceptable within the context of a National, strategic model such as TMfS07. Potential users should note these assumptions when using the model or interpreting its outputs.

User Classes

4.3.6 The user classes represented in the model are as follows:

- In work (IW)
- To/from work (TW)
- Non work (NW)

4.3.7 PT demand matrices were prepared to represent each of the above user classes and these are assigned individually in the PT model. The TTAA considers the user class disaggregation appropriate.

Modes

4.3.8 Six separate modes have been included in the TMfS07 National PT Model, namely:

- Intra-urban bus

- Inter-urban bus
- Rail
- Underground
- Ferry
- Tram

4.3.9 The on-street network in Scotland currently contains no tram services and this mode is not used in the base year, however, this has been included in anticipation of the Edinburgh Tram scheme opening and its requirement to be included in future year networks. The TTAA is satisfied with this approach to coding.

4.3.10 With respect to the inclusion of Ferry services, these cover the majority of services between the Scottish mainland and the larger/most populated islands, however, it should be noted that not all ferry services are represented. Examples of ferry services not represented in the TMfS07 National PT Model include:

- Port Askaig-Feolin linking Jura and Islay as both islands are modelled as a single, combined zone with ferry services only represented to/from Islay
- Services to Eigg, Muck, Rum and Canna
- Intra-island ferries within the Orkney and Shetland archipelagos

4.3.11 In the context of a national, strategic model, such as TMfS07, then the omission of these ferry services is unlikely to represent a significant issue in the vast majority of model applications and can be considered acceptable. The TMfS07 National Model has appropriate, but limited, ferry service representation commensurate with its intended application. **The TTAA does note that for specific policy or scheme assessments where services currently not represented are relevant and/or where sensitivity to travel cost by ferry is high then it may be necessary to update and refine the ferry representation within the TMfS07 National Model or to develop a more detailed local model for the specific circumstances being considered**.

4.4 Public Transport Network

Introduction

4.4.1 The TMfS07 National Model was developed using the Cube Voyager software for the roads, PT and demand models. The TTAA is satisfied that this is an appropriate approach and recognises the potential benefit of adopting a single software platform. Notwithstanding this, some comments regarding more detailed aspects of the Cube Voyager software are made in Section 5 relating to the PT Model Calibration and Validation.

Public Transport Network

4.4.2 The TMfS07 National PT Model contains a single modelled network, including road and PT links, which eases the transfer of forecast traffic delays to the PT network. The network was developed using GIS and is based on the OS MasterMap Integrated Transport Network (ITN) layer providing a geo-rectified and significantly more geometrically accurate representation of the network than was the case with previous versions of TMfS. The geo-rectification also brings advantages with respect to undertaking ancillary analysis, such as environmental assessments.

4.4.3 The network includes links representing the strategic road network, heavy rail/underground, ferry links, road/rail/ferry zone connectors and inter-modal connectors used to represent walk connections between stations/ports and the road network. The TTAA is satisfied with the general description of the network outlined in the Report. A more detailed inspection of the network coding has also been undertaken and will be commented on later in this section.

4.4.4 The TMfS07 National PT network includes representation of all significant inter-urban PT services on mainland Scotland and the Isle of Skye, some intra-urban services and ferry links to the larger/most populated islands. This development has occurred through both TMfS05A and TMfS07 and assists in removing some of the boundary issues between the "internal" and "external" areas of the model highlighted in previous TMfS audits.

4.5 Public Transport Lines Data

4.5.1 PT system information is contained in the TMfS07_SYSTEM_FILE.PTS and includes the modes, operators, wait curves and crowding curves. The PT lines files, one for each mode, contain PT service data, including:

- Mode
- Operating company
- Route type (circular/linear)
- Service type (express/stopping)
- Headway (for each period)
- Fare (reference to fares tables for each time period)
- Text descriptions
- Nodes comprising the route

4.5.2 The urban and inter-urban lines have been coded to stop at every relevant node on the strategic transport network, excluding shape nodes. Rail lines are coded to pass through relevant nodes on the rail network (negative node reference numbers), but only to stop at nodes representing stations (designated positive node reference numbers).

4.5.3 For more detailed PT line files checking, the TTAA undertook a comprehensive check of selected urban and inter-urban bus services as well as rail and ferry services in the model. These checks included service coverage, headways, routeing and stopping locations and are reported in a separate section of this document.

4.6 Lines Coding

4.6.1 Urban buses have been specified as those that operate entirely within areas broadly representing the conurbations of Aberdeen, Dundee, Edinburgh and Glasgow. The urban areas are outlined in Figures 3.1 to 3.4 of MVA's Report and are shown to encompass the city centre and a significant amount of the surrounding hinterland in each case. The areas are considered appropriate by the TTAA.

4.6.2 Urban buses have not been coded to represent all individual services within the urban areas, but rather, these have been coded as a single line in each direction on a corridor basis with an average frequency representative of all services that operate along the corridor. This enabled the urban bus coding to be minimised while still adequately reflecting the supply on the key urban corridors. This offers advantages in terms of coding time and scope for errors, but reduces the sensitivity of the model to more detailed issues such as:

- Frequent services on urban corridors with irregular vehicle arrival times
- Frequent services on urban corridors with unreliable journey times due to congested road conditions
- Highly variable boarding/alighting profiles (applicable in-vehicle time factors and delay)

4.6.3 Given the strategic focus of the TMfS07 National PT Model, the TTAA is satisfied that this approach to urban bus coding is acceptable. **Users of the model should, however, note this relatively simple approach to urban bus coding when using or interpreting outputs from the TMfS07 National Model. It should also be noted that this approach to urban bus representation may require reconsideration in the development of any sub-area or regional models which operate within the overall TMfS07 hierarchy**.

4.6.4 Inter-urban buses have been coded based on publicly available timetable information. In some cases the modelled network does not include sufficient local detail for the scheduled route to be exactly replicated. In such cases the services have been re-routed locally to use the nearest available equivalent road. MVA has further clarified that in these cases:

- Where a pre-existing node (not a shape node) represents the point of diversion off-network and the service later rejoins the same modelled road route, the service is coded to continue on the modelled road route. Where a node does not exist to represent the point of diversion off-network, a node is added. The inter-urban bus line coding does not, however, include either distance or time (including any stopping time) spent off-network.
- Where an inter-urban bus service ends off-network, the service is ended on-network at the point closest to the point of diversion off-network. Where necessary, a node was added.

4.6.5 **The TTAA is generally content with this approach to inter-urban bus coding, however, potential users should take note of this simplification in the coding of inter-urban buses**.

4.6.6 Commentary on the detailed checks of the coding of urban and inter-urban bus services undertaken by the TTAA is reported in a separate section of this document.

4.6.7 The number of public transport services by mode included in the TMfS07 National PT Model is outlined in Table 3.1 of MVA's Report. This shows that there has been a significant reduction in the number of urban buses represented compared with TMfS05, as would be expected. Conversely, the volume of inter-urban buses has been shown to significantly increase compared with TMfS05. Again, this would be expected to some extent due to the re-classification of some previously urban services as inter-urban. The overall number of bus services coded in the AM and PM peaks has increased between TMfS05 and TMfS07 which again, to some extent, would be anticipated due to the greater network coverage in TMfS07 (i.e. including the Highlands & Islands and Argyll & Bute) which may counter-balance the thinning out of urban service coding. Additional clarification on this matter was requested from MVA who responded:

> *We can confirm that the change in the number of modelled bus lines compared with TMfS:05A is largely due to the redefinition of the intra-urban bus services in TMfS:07. It should also be noted that the PT service coding in TMfS:07 was derived from new service timetable data with no coding brought forward from TMfS:05A, which was*

relatively historic. Therefore, a change in the number of bus lines is inevitable arising from actual service changes as well reselection of which services should be included in the national model.

4.6.8 The number of underground services represented in TMfS07 has not changed and there is a large increase in the number of ferry services represented, as would be expected. The number of rail services represented has increased slightly in the AM and PM peaks and reduced slightly in the Inter-peak in TMfS07 compared with TMfS05. Again, clarification on the reasons for this was requested, to which MVA responded as follows:

As noted above, the PT service coding in TMfS07 was derived from new service timetable data with no coding brought forward from TMfS:05A. The number of rail lines has increased in the AM and PM peaks as three-hour time periods are considered when defining modelled services in TMfS07 compared with a single hour in TMfS:05A. This leads to a greater number of service and stopping patterns being modelled in the morning and evening peak. In the interpeak the same time six-hour time period is considered in TMfS:07 as TMfS:05A. However, operator timetable changes and rationalisation of duplicate modelled services (ie, services with same stopping pattern) lead to a reduction in the number of modelled rail lines.

4.6.9 The number of services coded for each time period is broken down by individual operator company in Table 3.2. of MVA's Report. This shows that some additional services have been included to represent companies in areas not previously covered by TMfS05 (e.g. in Highlands & Islands and Argyll & Bute). Furthermore, some services identified as being omitted in the TMfS05 audit have been represented (e.g. Strathtay Scottish). The TTAA is generally content with the services represented, however, comments on the more detailed PT lines coding are provided in a later section of this document.

4.6.10 The PT services were coded using the routes, frequencies and stopping patterns that were current in Spring 2007 and the TTAA is satisfied that this approach to service coding is appropriate.

4.7 Matrix Development

Introduction

4.7.1 The PT matrices by user class and time period were developed using a range of data sources. Commentary on specific aspects of the PT matrix development is provided in this section.

Zone System

4.7.2 The TMfS07 zoning system was commented on in detail in the section relating to the Roads Model Development and for brevity this discussion is not repeated here. The TTAA is, however, satisfied that the zoning system adopted for the PT model is appropriate for a strategic, national model.

Data Sources

4.7.3 Four data sources were used in preparing the TMfS07 National PT Model matrices as follows:

- National Rail Travel Survey (NRTS)
- TMfS07 Inter-Urban Bus Passenger Surveys
- 2001 Census Journey to Work Data
- Synthesised Demand based on Planning Data

4.7.4 Each data source is discussed in more detail in the following sections. In accordance with recommendations made in previous audits the matrix preparation process makes use of significant sources of PT data that were either not available or not used in the development of previous versions of TMfS.

National Rail Travel Survey

4.7.5 The National Rail Travel Survey (NRTS) was undertaken at all rail stations in Great Britain on weekdays during school term-time between 2000 and 2005. The surveys involved the distribution of self-completion passenger questionnaires supplemented by passenger counts with a resulting sample of between 20% and 30% achieved for the survey as a whole. The cleaned data was made available to Transport Scotland for use in the TMfS07 development and provides details of:

- Rail stations used
- Time of travel
- Access and egress modes
- Origin and destination addresses
- Trip purposes
- Ticketing information
- Demographic information plus car availability

4.7.6 MVA states in §4.4.5 of the *TMfS:07 National Public Transport Model Development Report* that:

> *The NRTS origin-destination data was processed and demand matrices prepared suitable for incorporation in the national model*

4.7.7 The level of information documented regarding the assumptions used in interrogating and factoring the NRTS data is very limited. For example, a quantitative summary of the NRTS data and the process and factors used to convert from the full NRTS dataset to the assignment model time periods and base year are not reported. While the TTAA is content that the high level description of the data and its intended use is appropriate, the TTAA requested additional information regarding the data processing from MVA who responded that:

> *The NRTS is provided as a 'complete' database and, therefore, aside from checking the credibility of the data compared with other sources and undertaking logic checks, limited processing was required. The NRTS data is provided with time of day information which enabled conversion to assignment model time period matrices. This included extraction of data for the P&R matrix development including access/egress journey legs at rail stations.*
>
> *The NRTS data does not include fare data and the ticketing splits where not used when deriving the distance-based fares tables, which were all based on return ticket types depending on time of day*

4.7.8 This provides a clearer description of the data processing and the TTAA is satisfied that this is appropriate for TMfS07. **The TTAA would recommend that future model development reports include additional detail relating to the processing, cleaning, logic checking and factoring of all data sources used in matrix development, including summary statistics where appropriate. This will enable conclusions to be drawn regarding the quality of data and the robustness of the processing undertaken**.

TMfS07 Inter-Urban Bus Passenger Surveys

4.7.9 Passenger interviews and occupancy surveys were undertaken between 07:00 – 19:00 on typical weekdays at selected sites along cordons established around the cities of Edinburgh, Glasgow, Dundee, Aberdeen and Inverness. The surveys were undertaken in both directions to capture all bus based movements into and out of these urban areas as well as providing data on travel to and from other important towns in the TMfS07 area.

4.7.10 In §4.5.3 of MVA's TMfS:07 National Public Transport Model Development Report, a separate Note, entitled *Public Transport Model Development Note 2 – Inter-Urban Bus Processing (PTN2)* is referenced. That Note provides details of the analysis of the survey data and preparation of the demand matrices.

4.7.11 Following an initial pilot survey on the A803 between Bishopbriggs and Glasgow a complete cordon was defined for survey around each of the five cities. The pilot study was considered largely successful and MVA has confirmed that any issues identified during the pilot study were extremely minor and where necessary were rectified before rolling out the full survey programme.

4.7.12 The cordons are shown in Figures 2.1 to 2.9 of PTN2 and these cover virtually all significant arterial routes leading to/from the five cities. The only obvious exceptions where surveys do not appear to have been undertaken are at:

- M8 west of Glasgow
- M77 south of Glasgow
- M74 south east of Glasgow

4.7.13 MVA has subsequently confirmed that:

> *Services on the M8 west of Glasgow and M77 south of Glasgow were captured at the Waterloo Street and Bothwell Street sites in Glasgow city centre.*
>
> *Services on the M74 south east of Glasgow were captured at the Motherwell and Hamilton sites.*

4.7.14 The occupancy of each service by direction was estimated based on observing the approximate percentage occupancy and applying assumed capacities for varying bus types. The occupancies were then summed for each route, hour and direction. While a relatively simple methodology, the TTAA considers this appropriate for estimating TMfS07 inter-urban bus occupancies.

4.7.15 The origin-destination surveys (OD) were undertaken between 07:00 – 14:30 with the assumption that tidality of PT flows would enable the data to be reversed to estimate the PM peak movements. The TTAA requested MVA to provide further information regarding whether the survey times within the overall time period and/or the selected services were randomised in any way. MVA responded with the following statement:

> *Prior to the Origin-Destination survey programme, the Data Collection Consultants carried out occupancy surveys at all of the defined cordon points. This data was used to understand the frequency of each service number and their patronage. This provided a baseline against which 'priority' bus services could be established.*
>
> *We identified a 'minimum' and 'ideal' number of buses to be surveyed for each service number on each route and in each period. Our initial 'minimum' and 'ideal' requirements were deemed to be too costly and were thus scaled back – in most cases, the minimum requirement was to survey one bus for each service number in each time period and in*

each direction. On busier routes, such as for the Citylink service between Edinburgh – Glasgow, we specified a higher minimum service level.

The enumerators were tasked with achieving at least the minimum number of surveys on each bus and then working towards the 'ideal' number of surveys. In attempting to attain the ideal number, service numbers were prioritised based on their frequency and patronage.

The times of the services boarded were, for the best part, random. Where possible, enumerators were asked to be on the first post 7am service of the day. Thereafter, they worked towards attaining the minimum and ideal level of surveys based on the priority of the services identified. However, there were no set buses which they had to board – they essentially boarded the first bus that came for the service number they required.

4.7.16 The records were processed to allocate TMfS07 origin and destination zones, time periods and journey purposes to the trips. The records were then factored for the AM, Inter and PM peaks using the relevant observed occupancies. The records were then adjusted to remove any illogical (i.e. intra-cordon) movements and to address double counting by halving trips which crossed more than one cordon. Again, while the methodology is relatively simple and based on certain assumptions, the TTAA considers that the description provided suggests that good use has been made of the available data in a manner that is appropriate for the estimating of TMfS07 inter-urban bus travel patterns.

4.7.17 Further detail on the factoring and processing of the occupancy and OD survey data is provided in *Model Development Note 2*. This shows that a substantial number of occupancy survey records had to be discarded due to invalid or unknown service numbers as well as zero occupancy recordings. Similarly, some OD records were rejected due to invalid times, locations, journey purposes or postcodes.

4.7.18 The TTAA examined the resulting expansion factors used in deriving the inter-urban bus movements for the trip matrix development and for the most part these are in the expected and acceptable range (i.e. <20). In some cases the factors adopted are higher and the TTAA has checked to ensure that the number of records rejected has not had a significant impact on the factors adopted. In most cases where the factor is high, this is simply due to a small number of OD records being available in the first place. The TTAA is therefore satisfied that the rejection of the survey data for the reasons outlined was appropriate and has not had a significant impact on the resulting expansion factors used.

4.7.19 **The TTAA would, however, recommend that any users wishing to test PT measures or policies using TMfS07 should familiarise themselves with the contents of Model Development Note 2 relating to the Inter-Urban Bus Surveys**.

2001 Census Journey to Work Data

4.7.20 Detailed commentary relating to the Census Journey to Work Data is provided in Section 2 relating to the TMfS07 Roads Model Development and for brevity is not repeated here.

Synthesised Demand Based on Planning Data

4.7.21 Non-observed elements of the matrices were infilled via a synthetic process to derive inter-urban bus trips for non-commuting purposes. This process used 2007 planning data and TEMPRO trip rates to derive trips that were then distributed using a compressed matrix and sensitivity parameters from TMfS05A. Where necessary, the data was factored to a common 2007 base using factors derived from TEMPRO.

4.7.22 Fully observed matrices were developed for "from home" trips and in the case of the census data factors were derived from Scottish Household Surveys to derive the relevant time period matrices. For "to home" and "non-home based" trips, the matrices were derived using the reverse and non-home based trip creation process used in the demand model. These matrices were then combined to produce hourly person trip matrices for use in the PT matrix development process.

4.7.23 Overall, the TTAA is generally content that the high level description of this process seems reasonable.

Matrix Development

4.7.24 The matrices from each of the four described data sources were combined to create PT assignment matrices by user class and time periods. In the case of the inter-urban bus data, this was incorporated instead of the census or synthesised data in cells identified as "fully observed". The matrix totals by data source are outlined in Table 4.1. of MVA's Report and this was supplemented with additional information supplied to the TTAA showing the breakdown of the matrices by data source. Table 4.1 shows the basic breakdown of the TMfS07 PT matrices by each data source.

Table 4.1 : TMfS07 PT Matrix Composition by Data Source

Data Source	% of total matrix
NRTS	AM: 23%, IP: 13%, PM: 25%
Inter-Urban Bus	AM: 15%, IP: 14%, PM: 17%
Census	AM: 31%, IP: 13%, PM: 31%
Synthesised	AM: 31%, IP: 60%, PM: 28%

4.7.25 This shows that matrices comprise approximately 70% observed data in the AM and PM peaks, although that this drops to 40% in the Inter-peak. The basic proportion of each dataset that makes up the matrices conforms with expectations, given the surveys undertaken and the other data sources used.

4.7.26 The matrix totals are also broken down by journey purpose in Table 4.2 of MVA's Report. This also demonstrates an intuitively correct trend with "in-work" trips forming only a small proportion of overall (3%-4%) PT trips. To/from work trips predominate in the AM and PM peaks while the "non-work" trips are shown to be predominant in the Inter-peak. The breakdown by journey purpose is also very similar in the AM and PM peaks reflecting to some extent the tidal nature of commuting trips.

4.7.27 Based on a review of the documentation and additional data supplied, the TTAA is satisfied that the described process for creating the demand matrices appears logical and appropriate.

4.7.28 As with the roads model the TTAA undertook a detailed examination of the PT assignment matrices supplied with the TMfS07 model network, in particular to examine the magnitude of the values in individual cells of the matrices. This process identified that:

- of all cell values >0 approximately 80% are <1
- of the approx. 80% <1, typically 55-60% are in the range 0 to 0.1

4.7.29 Similar to the roads model the TTAA acknowledges MVA's rationale for the existence of the small cell values and the comments regarding the forecasting process. Nevertheless, the TTAA considers that the predominance of very small values in the matrix would merit some formal additional checking procedures being adopted during the matrix development process to ensure that such values only occur in locations where it is appropriate and/or unavoidable. In particular, it would be anticipated that the observed elements of the matrix should contain a lower number of very small cell values compared with the synthesised elements. **The TTAA recommends that such checks are instigated and reported during the next upgrade of TMfS07**.

4.8 PT Model Development Conclusions

Conclusions

4.8.1 MVA's Report concludes that various enhancements have been incorporated in the TMfS07 National PT Model. These include the use of the CUBE Voyager software, geo-rectification of the network, the incorporation of significant new datasets not previously used and the disaggregation of the matrices by user class.

4.8.2 Notwithstanding the comments and clarifications requested elsewhere in this document the TTAA is generally in agreement with the conclusions. More detailed commentary relating to the CUBE Voyager software PT assignment capabilities will be provided in *AN-TMfS07-05: PT Model Calibration and Validation* to be published in due course.

4.9 TTAA PT Network Checks

Introduction

4.9.1 The TTAA undertook a series of detailed network checks to establish the robustness and appropriateness of the PT network coding. In the vast majority of cases this demonstrated that the coding was appropriate, and overall the PT service coding was considered to be acceptable for TMfS07.

4.9.2 The checking process did identify some minor possible errors and issues that required further explanation or clarification from MVA have been identified. A brief summary of the issues identified and MVA's subsequent response (*in italics*) is provided as follows:

- Inter-urban buses:
  Overall, services included generally OK. A number of issues identified regarding the irregularity of service frequency by AM/PM peak period, apparent discrepancies between modelled and timetabled frequencies and some services are coded, but have a zero frequency in all periods.

- Intra-urban buses:
  Services included generally OK. Most coded frequencies are adequate, although some possible discrepancies have been identified between modelled and timetabled frequencies, particularly in Edinburgh.

  It is noted that a small number of rail and bus services have a modelled headway of zero in all time periods. These services were retained in model lines files in case services patterns were to be amended in future year networks
  Miscellaneous:
  A small number of bus services have been identified as exclusions from TMfS07

  The Arriva service to Glasgow Airport is included in the Inter-urban Bus.LIN file in lines 972 and 973. First Glasgow 747 Airport services is not modelled as it not considered a strategically significant service, in addition it should be noted that the route has changed several times since 2007. First Glasgow 757 Airport service is not modelled as it did not run in 2007
  Rail services:
  Services included generally OK. Some possible discrepancies between modelled and timetabled frequencies identified

- Ferries:
  Services included generally OK. Ferry headways are coded as double the expected boarding and alighting time for each service. In some cases this results in a reasonable proxy for the timetabled headway, however, these have been applied uniformly across all three time periods and hence, ferries which, say only occur in one time period in reality, are reflected in all time periods in the TMfS07 National Model. The TTAA requests clarification from MVA regarding the implications of this with respect to the roads and PT assignment in the base and future years

  The impact of ferry headways on the PT assignment is largely irrelevant and services have been coded identically in all three time periods in order to provide the necessary network connectivity. Users should bear this in mind when considering testing of ferry schemes, where a long distance model with a broader time period would be more appropriate. As noted by the TTAA, the representation of ferry services may require to be amended or enhanced depending of the requirements of specific model applications

4.9.3 Based on the responses provided the TTAA is content that any discrepancies that exist between the modelled and timetabled information are either very minor or explainable (e.g. difference between MVA/TTAA interpretation, due to timetable changes since 2007, etc.). **Nevertheless, the TTAA would recommend that the issues raised in the spreadsheet accompanying *Audit Note AN-TMfS07-4 (TTAA Ref. 71200, 9 April 2009)* be reviewed during the next upgrade of TMfS07 to ensure that any minor outstanding coding issues are addressed at that stage**.

5 TMFS07 AUDIT: PUBLIC TRANSPORT MODEL CALIBRATION & VALIDATION

5.1 Introduction

5.1.1 The TMfS07 National Model PT Calibration and Validation was documented separately from the model development by MVA. The initial audit findings relating to the PT model calibration and validation were presented by the TTAA in Audit Note *AN-TMfS07-5: TMfS07 Public Transport Model Calibration & Validation (TTAA Ref. 71746, 21 August 2009)*. A subsequent response to *AN-TMfS07-5* was received from MVA and has been used in compiling the findings in this Audit Report.

5.1.2 The TTAA received the following information from MVA for use in the audit process:

- *TMfS07 National PT Model Calibration & Validation Report (Issue 3, 11 May 2009)*
- Base year (2007) loaded PT network, lines files and trip matrices (AM, Inter and PM peaks)
- Bus and rail fare scatter plots
- *Technical Note Public Transport Base Model Calibration and Validation Adjustment (Version 1b, 22 July 2009)* and associated appendices
- *Audit Response Note to AN-TMfS07-5 (MVA Ref. C37135/11, 28 August 2009)*

5.1.3 This section relates to audit of the public transport (PT) model calibration and validation and generally follows the format of MVA's *National PT Model Calibration & Validation Report* with references to other documents as appropriate.

5.2 Introduction to National PT Model Calibration & Validation

5.2.1 The introductory section provides a brief overview of the PT model and sets out the report structure. The TTAA has no comments on this aspect of the Report.

5.3 Assignment Model

Assignment Model Inputs

5.3.1 The model inputs encompass the strategic (roads and PT) network, PT lines file and hourly assignment matrices which are discussed separately in Section 4 relating to the PT Model Development. The TTAA is satisfied that these are the appropriate inputs.

Path Building and Loading

5.3.2 The path building and loading procedure includes the modelling of:

- Walk choice
- Service Frequency and Cost
- Alternative Alighting

5.3.3 The PT assignment is split into a Route Enumeration and a Route Evaluation stage which are described in §2.2.2 of MVA's Report as:

Route Enumeration

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

Route Evaluation

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

5.3.4 In addition to the previous description the Route Enumeration spread factor and spread constant parameters are quoted in Table 2.2 of MVA's Report, however, further detail such as the algorithms themselves and the process for calculating the probability of use in the Route Evaluation stage is not described. **The reader is referred to the Cube Voyager software help documentation for further detail on the route enumeration and route evaluation processes**.

5.3.5 Furthermore, it is significant to note that the Route Enumeration does not explicitly take cognisance of either crowding or fares. While it is understood that this is a current limitation of the CUBE Voyager software, this could potentially have implications in terms of erroneously including or excluding potential PT routes/modes in the assignment. This is most likely to be an issue affecting sub-mode assignment between competing bus and rail services where such factors may be important considerations. **All users of the TMfS07 National PT Model should note this when interpreting the model's outputs or considering its potential application**.

Crowding

5.3.6 The TMfS07 National PT Model assignment procedure includes the effect of crowding in the AM and PM peaks for rail services only. No crowding factors were applied to bus lines due to the assumed ability of bus operators to increase supply to match demand. The model framework also allows users to include crowding effects to be modelled on future tram services. The TTAA is generally satisfied that the effects of crowding have been modelled in the PT assignment procedure for the AM and PM peaks, but not the Inter-peak. Implementation of crowding curves, applied to the in-vehicle time component of generalised cost, is considered likely to improve the quality of the modelled forecasts for public transport passenger flows, particularly in corridors of significant inter-modal competition.

5.3.7 Users should note that the PT crowding loop has been set to run for five iterations in the base year. **While this may be appropriate to ensure satisfactory convergence of the base model, users may need to review and adjust the number of iterations for particular option or policy tests being undertaken**.

5.3.8 The UK rail standard Passenger Demand Forecasting Handbook (PDFH) Non-London Commuting Rail Crowding curve was allocated to rail only for the AM and PM peak periods. The "crush capacity" was assumed to be 40% above the seated capacity which MVA has clarified as:

The 'crush capacity' figure corresponds to PDFH which indicates crowding penalties up to 140% load factor for Non-London Commuting, which is considered to be the maximum train loading. PT service capacities were derived from the ScotRail survey data, which included information on rolling stock and seated capacities

5.3.9 The TTAA is satisfied that this is a reasonable approach to adopt.

5.3.10 MVA points out in §2.3.12 of the report that passenger and vehicle arrival profiles have been assumed to be level throughout the modelled time periods leaving no allowance for varying demand on services within the peak hours, leading to the potential underestimation of crowding on services where the number of passengers is above the hourly average. Users should also note the fact that crowding has been applied on peak hour rail services only. In the PT assignment procedure, where the PT sub-mode split is undertaken at the assignment stage, on corridors with high PT modal competition this could have implications for both the base year sub-mode split and more particularly, when applying the model in forecast mode. **While these are unlikely to be significant issues for the majority of applications of the TMfS07 National Model, users should note these when interpreting the model outputs or considering its application**. In some cases it may be prudent to examine the outputs in sufficient detail to ensure that the resultant loadings on services conform with expectations.

Bus Speed Factors

5.3.11 The modelled bus speeds in the TMfS07 National PT Model have been reflected by a series of factors which are applied to the congested road speed by differing link type. The factors are uniform across the three time periods and were adjusted during the calibration process to better match timetable data. The various factor adopted are:

- Motorway 0.95
- Rural single carriageway 0.85
- Rural dual carriageway 0.95
- Urban single carriageway 0.50
- Urban dual carriageway 0.75
- Bus lanes 0.80

5.3.12 It should be noted that the bus lane factor of 0.8 relates to an assumed reduction in free-flow bus speeds (and not congested speeds) reflecting the time associated with buses stopping. The TTAA is generally satisfied that the bus speed factors adopted follow a logical sequence and these are considered appropriate for the TMfS07 National PT Model

Assignment Model Parameters

5.3.13 The Public Transport Assignment Model Parameters for the TMfS07 National PT Model were determined during the model calibration stage. The initial parameters adopted were common to the peak and Inter-peak assignments. The assignment spread parameters were determined during calibration and set such that there was a balance between ensuring that a reasonable number of routes were enumerated in the assignment and the model run times.

5.3.14 The other assignment parameters were also defined during the calibration process by examining the assigned sub-mode split between bus and rail and these are based on standard ranges used in previous studies. **In principle, this is a reasonable approach to adopt for TMfS07. The TTAA does, however, note that the assignment factors and parameters are applied globally and in some cases this may require to be refined and reviewed for a future upgrade of TMfS07**.

5.3.15 The values of time were derived using the Transport Economics Note methodology using values of time taken from WebTAG Unit 3.5.6. The TTAA has reviewed the spreadsheets used to undertake these calculations and is content that they have been undertaken appropriately.

5.3.16 Some refinements to the assignment model parameters were introduced following the publication of the *TMfS07 National PT Model Calibration & Validation Report (Issue 3, 11 May 2009)*. These refinements and the resulting final assignment model parameters are discussed later in this section.

Wait Curves

5.3.17 A single wait curve was implemented for all PT lines in the TMfS07 National PT Model which does not vary between peak and Inter-peak. The curve is based on perceived values in the PDFH and represents the perceived wait time for a given headway/service frequency with a maximum wait time cut-off of 60 minutes. The curve adopts similar values to that used in previous versions of TMfS and is considered appropriate by the TTAA. **It would be appropriate to consider differentiating the wait curves by peak and Inter-peak in a future upgrade of the model**.

Fares Model

5.3.18 The fare tables for rail and bus consist of an initial boarding fare and a set of distances and fares that define points on a curve with the exception of flat fares that are represented for Lothian Buses (£1), the Glasgow Underground (£1) and the Glasgow Airport Bus (£3.65). Modelled fares (in 2007 prices) are calculated based on linear interpolation according to the distance travelled. The fare tables are sub-divided to represent differing operators and, hence, fare structures that exist in various regions of Scotland.

5.3.19 The fares tables were derived based on scatter plot analysis of the distance based "standard return" fares for various bus and rail operators. A line of best fit was then drawn through the scatter plots to define the linear, distance based fare tables for each operator. The TTAA has reviewed the scatter plot analysis and is satisfied that the fare tables adequately represent the actual fares for both rail and bus services. Users should note that the data in the fares model does not represent actual fare paid and does not reflect the effect of travel cards and other discounted fares. **This is unlikely to be a significant issue for most applications of TMfS07 but users should consider this before applying the model and seek advice from Transport Scotland/MVA as appropriate**.

5.3.20 The TTAA notes that in the case of the bus fares there are three potential minor anomalies in the fares data used in the scatter plots. These all relate to situations where the fare increases with distance as expected but at a given point along the route the distance based fare reduces without an obvious reason for this to occur. The three routes for which this has been identified are:

- Stagecoach P36 – Anomaly around Friarton/Craigend
- Rapsons 17A – Anomaly around Lewiston Cross/Drumnadrochit P.O
- First Edinburgh X13 – Anomaly around Elphinstone/Carlaverock Farm Road End

5.3.21 MVA has confirmed that these anomalies relate to the original data provided by the bus operators to Transport Scotland. The TTAA is satisfied that these minor anomalies will not have materially affected the average fares calculated for the fares model. **Nevertheless, it is recommended that this matter be addressed at the next upgrade of the model**.

5.3.22 In the case of ferry fares, the foot passenger fares are outlined in Table 2.6 of the *TMfS07 National PT Model Calibration & Validation Report (Issue 3, 30 January 2009)* and these appear to be reasonably representative of actual fares. The vehicle fares are coded separately for light and heavy vehicles as appropriate as a fixed fare in the roads network. These have been derived based on a weighted average fare using the estimated proportion of ticket sales.

The TTAA has reviewed the vehicle fare calculations and is content that in the majority of cases the coded fares appear reasonably representative. Given the variation in ticket types the TTAA acknowledges that it is difficult to establish a single representative figure for each ferry route and is satisfied that the adopted approach is acceptable for the TMfS07 National Model.

5.4 Post-Validation Changes

Background

5.4.1 Following the publication of the *TMfS07 National PT Model Calibration & Validation Report* (Issue 3, 11 May 2009), MVA undertook some additional changes to the model parameters and structure in an attempt to refine the model calibration further. The various changes and their impacts are discussed in this section.

Introduce Wait Time Factor

5.4.2 One of the measures adopted included halving of the wait curve values and applying a wait time factor of 2 which improves the efficiency of the route enumeration process in terms of run-times. The TTAA is satisfied that this is an acceptable change to introduce for TMfS07.

Amend Model Structure

5.4.3 MVA has investigated the possibility of amending the model structure to reduce the overall run-time. In particular, a large amount of run-time is caused by evaluating routes for OD pairs with zero demand and this process can be streamlined with a change to the model structure which enables the evaluation of zero ODs using separate paths with a lower level of spread. MVA recommends that additional testing is undertaken to determine the appropriate spread parameters to be adopted for the zero cell values. **The TTAA considers that improvements to run-time would be beneficial and concurs that this additional testing should be undertaken in due course**.

5.4.4 In the meantime the change to the model structure was adopted by MVA to take advantage of the improved run-times. The TTAA is satisfied that this is an acceptable change to the model structure.

Increase Route Enumeration Spread

5.4.5 The improved run-time enabled MVA to increase the route enumeration spread factor to allow more routes, particularly bus routes, to be considered in the PT assignment process. In testing, a spread factor of 1.25 (compared with the original 1.15) was found to improve the general split between bus and rail and slightly improved the flow comparisons. Increasing the factor beyond 1.25 was not shown to improve the validation and was ruled out. This change also resulted in the need to adjust the in-vehicle run time factor for urban bus to 1.1 (from 1.0). The TTAA is satisfied that these changes are acceptable given their general positive impact on the sub-mode split.

5.4.6 It should be noted that this change exacerbated the existing bus bias in some locations, particularly on the Glasgow cordon with even more trips choosing to use the bus. It is clear that the poor bus/rail split in the Glasgow area is related to factors other than (or at least not so heavily influenced by) the spread parameter. **The TTAA recommends that steps are taken to refine this during the next upgrade of TMfS07**.

Route Enumeration Fare In-Vehicle Time Factors

5.4.7 Examination of variations in the route enumeration fare in-vehicle time factors was undertaken to see if this improved the sub-mode split. This demonstrated that the factor has less impact following the introduction of a higher spread factor and consequently a value of 0.85 (previously 0.8) was adopted for both inter and intra-urban buses. The TTAA is content that this change is acceptable.

Increase Sensitivity of Choice Models

5.4.8 Tests were undertaken to establish the effect of varying the scaling parameters of the walk choice and alternative-alighting node models which affect the proportion of trips using each walk choice or alighting node. The tests indicated that reducing the parameters to 0.2 (from the previous value of 0.5) increased the sensitivity to the change in cost while improving the flow comparisons and spreading the passenger loadings over more routes. In principle the TTAA considers that these changes are acceptable, given that they positively impact on the validation. It should be noted that there is little information on either the walk choice or alternative alighting models in the PT model documentation. **The reader is referred to the Cube Voyager software help documentation for further detail on these choice models**.

Increase Boarding Penalty

5.4.9 Tests were also undertaken examining the impact of higher boarding penalties to ensure that direct routes were being chosen in favour of those with transfer where appropriate. Increasing the boarding penalty from 5min to 10min, along with reducing the transfer penalties to bus from 10min to 5min improved the flow comparisons in the AM and PM peaks and reduced the number of modelled transfers. In the Inter-peak there was little effect and the boarding penalty was left at its original value of 5min. On the basis of the apparent improvement in flow comparisons and the reduction in transfers the TTAA is satisfied that these changes are acceptable.

Increase Number of Walk Links

5.4.10 Inspection of the evaluated routes for key OD pairs showed that in some cases short PT journeys were being made which would be more likely made by walking. This was due to insufficient walk links being available from zones, particularly in the Edinburgh and Glasgow urban areas. Additional transit links from zones were therefore added along with walk connections between stops to allow for more walk transfer and this had a positive impact on the flow comparisons and assisted in reducing the modelled PT to PT transfers. Again, the TTAA considers this an acceptable change to adopt.

Amend Fares Structure

5.4.11 Some additional changes were made to the fare structure to:

- Enable the Citylink inter-urban bus fare table to better reflect fares for certain journeys (as fares were overestimated by the original fares model)
- Increase the fares on First Glasgow services to address a bias towards bus

5.4.12 These changes improved the fare representation on some services but worsened it on others, however, the changes were considered by MVA to improve the flow comparisons in all periods and were adopted. The TTAA considers these changes to the fare structure to be acceptable.

5.4.13 **The TTAA would recommend that consideration be given to having a more disaggregate fare table, better reflecting the localised variations by mode, distance, etc. at the next upgrade of TMfS07**.

Final PT Assignment Model Parameters

5.4.14 The post-validation changes made to the PT assignment model resulted in final parameters as outlined in Table 5.1.

Table 5.1 : Final PT Assignment Model Parameters

Model Parameter		Value/factor
Route Enumeration Fare In-vehicle Time Factors:		
	- urban bus/inter-urban bus	0.85
	- rail/subway/ferry	1.0
Spread Factor		1.25
Spread Constant		5 mins
In-vehicle Time Factors (AM & PM):		
	- urban bus	1.2
	- inter-urban bus	1.1
	- rail	1.0
In-vehicle Time Factors (IP):		
	- urban bus	1.2
	- inter-urban bus	1.0
	- rail	1.0
Walk time factor		1.6
Minimum wait time		0 mins
Maximum wait time		60 mins
Boarding penalty (AM & PM)		10 mins
Boarding penalty (IP)		5 mins
Transfer penalty:		
	- rail to rail	5 mins
	- bus to bus	5 mins
	- rail/underground/tram to/from bus	5 mins
Values of time (2007 Base Year):		
	- in work	£21.58 £/hr
	- non work	£5.11 £/hr

5.4.15 The TTAA considers these parameters acceptable given the calibration work and additional sensitivity testing undertaken.

5.5 Model Validation

Introduction

5.5.1 The validation of the TMfS07 National PT Model and matrices was undertaken through detailed analysis of the following:

- Observed bus and rail passenger count data
- Comparison of timetabled and modelled bus journey times

5.5.2 Comparisons between modelled and observed screenline flows were typically expected to be within 15% as indicated in Appendix E of the Major Scheme Appraisal in Local Transport Plans document. The GEH analysis was also used to assess the flow comparisons. A GEH of 5 and less is considered to be good and GEH between 5 and 10 is considered to be acceptable. The TTAA is satisfied with the adopted approach and criteria for the PT model validation.

Passenger Loading Comparisons

5.5.3 Comparisons between modelled and observed passenger loadings were undertaken using the TMfS07 bus occupancy survey data and independent Scotrail data that was not used in the model development. These comparisons were undertaken for cordons around Aberdeen, Dundee, Edinburgh, Glasgow and Inverness. A summary of the findings of the analysis presented by MVA is as follows:

- Aberdeen inbound cordon:
  The comparisons show a general underestimate on rail in the AM and PM peaks and a general tendency to slightly overestimate bus flows. The cordon totals are good in the AM and PM peaks and acceptable in the Inter-peak. Rail comparisons are at the limits of acceptability in the AM and PM peaks (GEHs of 10 and 9 respectively). Bus comparisons are generally better with the maximum GEH value of 6 in the Inter-peak.
- Aberdeen outbound cordon:
  The comparisons for rail are good in the Inter and PM peaks but on the limit of acceptability in the AM (GEH=10). Rail flows are underestimated in all time periods. Bus comparisons are good in all time periods, albeit with a very slight tendency towards overestimation. Total PT cordon flows are good in all time periods.
- Dundee inbound cordon:
- The rail flow comparisons are good in all time periods. Bus flows are good in the AM and Inter-peaks, but poor (GEH=11) in the PM peak. Overall cordon totals are good in the AM and acceptable in the Inter and PM peaks, albeit with a tendency towards overestimating total PT flows.
- Dundee outbound cordon:
  The rail flow comparisons are good in all time periods. Bus flows are good in the Inter and PM peaks but poor in the AM (GEH=11). Total cordon flows are acceptable in the AM and good in the Inter and PM peaks.
- Edinburgh inbound cordon:
  Bus flow comparisons are good in the AM and Inter-peak and acceptable (GEH=7) in the PM peak. Rail comparisons are good in all time periods as are the cordon totals.

- Edinburgh outbound cordon:
  Bus flow comparisons are good in the AM and PM peaks, but poor (GEH=12) in the Inter-peak. Bus flows are, however, underestimated in all periods. Rail flow comparisons are good in all time periods. Total cordon flows are good in the AM and PM peaks and acceptable in the Inter-peak, although there is a general tendency for overestimates in rail flows to counter-balance underestimates in bus flows which improves the cordon totals.

- Glasgow inbound cordon:
  Rail flow comparisons are poor in the AM and PM peaks (GEH=24 & GEH=10) and acceptable in the Inter-peak (GEH=10). Bus flow comparisons are poor in the AM peak (GEH=27), good in the Inter-peak and acceptable in the PM peak. Although there are many poor comparisons the overall cordon totals are good in all time periods, however, this is due to overestimates on rail being offset by underestimates on bus or vice versa in all cases.

- Glasgow outbound cordon:
  Rail comparisons on the borderline of acceptability in the AM and Inter-peaks (GEH=10) but good in the PM peak. Bus flows are acceptable in the AM and Inter-peak but poor in the PM (GEH-17). Cordon totals are poor in the AM peak with both bus and rail overestimated. Cordon totals are good in the Inter-peak and acceptable in the PM peak although with underestimates on one sub-mode counter-balancing overestimates on the other in both cases.

- Inverness inbound cordon:
  Rail flows are approaching the limit of acceptability in the AM (GEH=10) but are good in the Inter and PM peaks. Bus flows and overall cordon totals are good in all periods.

- Inverness outbound cordon:
  Rail flows are good in the AM peak, acceptable in the Inter-peak, but poor in the PM (GEH=12). Bus flows are good in all time periods while overall cordon totals are good in the AM and Inter-peaks and acceptable in the PM peak.

5.5.4 It is clear that the majority of the urban cordons compare reasonably well at the total PT flow level with all GEH values in the good or acceptable range, with the exception of the Glasgow outbound cordon in the AM peak. When examining the cordon totals by PT sub-mode it is clear that there are local variations in the quality of the comparisons across all cordons. With the exceptions of Aberdeen and Dundee, which generally show a bias towards bus use, there is no specific, clear pattern evident with the bias towards either bus or rail generally varying by cordon, direction and time period.

5.5.5 The individual link flow comparisons on the urban cordons are presented in the report appendices. As expected, there is some variability in the individual link comparisons and while some links show poor comparisons the majority of comparisons on the Aberdeen, Dundee and Inverness cordons are acceptable. In the case of the Edinburgh and Glasgow cordons the comparisons are much more variable. The Edinburgh AM inbound and PM outbound cordons show a number of poorer comparisons with GEH values of up to 15 and 16. The Glasgow inbound cordon demonstrates a number of poorer comparisons, particularly in the AM and PM peaks with GEH values up to 32. The Glasgow outbound cordon also shows variation, particularly in the PM peak with GEH values up to 28.

5.5.6 While the validation is acceptable in a number of cases it is important to note the variability and poorer comparisons evident across the Edinburgh and Glasgow cordons in the key directions in the AM and PM peaks. **With this is mind the TTAA would recommend that users of**

TMfS07 take particular care when interpreting PT sub-mode specific outputs from the Model, especially in the urban areas.

5.5.7 The post-validation assignment changes have been shown to have a positive impact in some cases with respect to the flow comparisons and they have addressed the issue of a bias towards rail in some cases. Nevertheless, it remains evident that there are local variations in the PT sub-mode split. This has been recognised by MVA who outline a series of possible further enhancements in Section 6 of technical note *Public Transport Base Model Calibration and Validation Adjustment (Version 1b, 22 July 2009).* **The TTAA would recommend that at the next upgrade of TMfS07, these possible enhancements should be considered and steps taken to address this matter to ensure a better level of PT sub-mode split at a regional level**.

5.5.8 Rail flows across the Forth Bridge are in the good to acceptable range in all time periods with a maximum northbound GEH value of 6 (Inter-peak) and a maximum southbound GEH value of 3. Bus flows across the Forth Road Bridge in many cases are also good to acceptable, however, it is notable that the PM peak northbound and AM peak southbound (i.e. the key direction in these peaks) show significant underestimates of bus flows and GEH values of 14 and 10 respectively. This further suggests that improvements to the PT sub-mode split should be investigated in any future upgrade of the model. **Users should note this when interpreting cross Forth PT sub-mode flows**.

5.5.9 Tay Bridge rail flows are in the good or acceptable range in all time periods while bus flows across the Tay Road Bridge are good in all time periods. Total PT flows across the Tay Bridges are therefore good in all periods.

5.5.10 A series of rail validation checks was also undertaken by comparing modelled and observed flows on 33 key links across the network as well as across an east-west and a Forth screenline. This analysis demonstrated that:

- On the 33 key links, 79% or more demonstrate an acceptable GEH (<10) in all time periods
- The east-west screenline has good or acceptable comparisons on all links in all time periods with the exception of the AM peak westbound east of Shotts
  [Note: This comparison is only presented in the *TMfS07 National PT Model Calibration & Validation Report (Issue 3, 11 May 2009)*]
- The Forth screenline shows good or acceptable comparisons in all time periods
  [Note: This comparison is only presented in the *TMfS07 National PT Model Calibration & Validation Report (Issue 3, 11 May 2009)*]

5.5.11 MVA concludes in §3.2.11 of the *TMfS07 National PT Model Calibration & Validation Report (Issue 3, 11 May 2009)* that:

> *Overall, it is considered that the key strategic passenger movements are represented appropriately in the TMfS:07 Model*

5.5.12 When considering total PT flows the TTAA would broadly agree with that conclusion, however, it is clear that the PT sub-mode split is not so well represented, including at some key locations. Similarly, the individual PT link flow comparisons are more variable, particularly in Edinburgh and Glasgow in the key directions in the peak periods. **With that in mind, users are urged to take cognisance of the comments and recommendations in this audit document when using TMfS07 and interpreting its PT outputs**.

Rail Passenger Boarding/Alighting Comparisons

5.5.13 Scotrail data was used to undertake a comparison between the modelled and observed boarding and alighting volumes at each rail station. At a global level the comparison is shown to be reasonably good with at least 65% of stations demonstrating a GEH of less than 5 and at least 78% of stations less than 7. As expected the individual station by station comparisons show more variability and it should be noted that some key rail stations show a poor comparison (e.g. Glasgow Queen Street and Glasgow Central, Haymarket, Hamilton/Motherwell, Croy, etc.). On balance, however, the boarding and alighting comparisons are considered acceptable for a national model of the nature of TMfS07.

5.5.14 MVA notes in §3.3.3 of the *TMfS07 National PT Model Calibration & Validation Report (Issue 4, 5 October 2009)* that:

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

5.5.15 Overall the TTAA is satisfied that the modelling of individual station boarding and alighting is acceptable at a global level across the model. **Potential users of the TMfS National PT Model should take note of the variability of the individual station boarding and alighting flows, particularly in major urban areas**.

Rail Capacities

5.5.16 The PT assignment includes crowding on rail lines in the AM and PM peaks. The information is provided in Appendix D of MVA's Report on the ratio of passenger loading to seated capacity on the modelled lines.

5.5.17 Analysis of Appendix D shows that there are some services with very high ratios, e.g. commuter services to/from Edinburgh and Glasgow, etc. The TTAA notes that the loading ratios are generally higher than those previously modelled in TMf05. The TTAA acknowledges that in the absence of any observations it is difficult to draw any firm conclusions regarding the accuracy of the information presented. The TTAA is, however, content that the effect of crowding is modelled and is shown to occur on services that are expected to be crowded such as those travelling into Edinburgh/Glasgow in the AM and outwards in the PM.

Comparison of Timetabled and Modelled Bus Journey Times

5.5.18 As part of the validation process, checks have been made to ensure that modelled bus journey times are representative of timetabled bus journey times.

5.5.19 Modelled to timetabled bus journey time comparisons, as shown in Appendix E of the report, were undertaken on a sample of services that intends to give a representative geographical spread in the model area. A summary of the journey time validation is presented in Table 3.12 of the Report which showed that 51% or more of services have journey times within 15% of PT timetables throughout the AM, IP and PM periods, and 76% or more of services have journey time within 25% of PT timetable throughout the modelled periods.

5.5.20 From the analysis undertaken in Appendix E, the TTAA notes that the majority of the strategic bus routes have journey times within 15% of PT timetables in all the peak periods. For the vast majority of the remaining cases the modelled journey times are quicker than the timetabled average journey time. This is often the case with models of this nature as the timetabled information does not provide a true reflection of actual travelled times. Furthermore, the TTAA acknowledges that the strategic nature of the model means that network journey times are likely to be under represented through small villages where services make multiple stops and where local detours into residential areas are not represented in the model.

5.5.21 MVA has highlighted in Appendix E the modelled journey times along with the timetabled time +/- 15%. This helps highlight those services whose modelled times are significantly different to the timetables. Some notable examples include:

- St Andrews-Edinburgh (slow AM), Dundee to/from Glasgow (slow AM)
- Glasgow to/from Bargeddie (fast all periods), Perth to/from Dundee (fast all periods)
- Edinburgh-Dumfries (slow PM), Edinburgh-St Andrews (slow PM)

5.5.22 MVA notes in §3.5.6 that:

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

5.5.23 The TTAA acknowledges that in many cases this will satisfactorily explain the reason for the differences between modelled and timetabled times, however, it was particularly noted that in the case of St Andrews to/from Edinburgh journeys the modelled journey time is generally around 3hr or more in all time periods and this is consistently higher than the timetabled value which, at approximately 2.5hr for a journey of around 50 miles does not appear to be unrepresentative or underestimated. MVA subsequently commented that:

> *Modelled congestion on the A90 near Barnton is increasing bus journey times including the St Andrews to Edinburgh southbound service in the morning peak and the reverse service in the evening peak*

5.5.24 **This issue should be borne in mind by users when applying the model or interpreting its outputs, particularly on the A90 corridor**.

5.5.25 **With this in mind, the TTAA would also recommend that consideration be given to reviewing the roads and PT calibration/validation on the A90 corridor during the next upgrade of TMfS07**.

5.5.26 A linear regression analysis is presented in Figure 3.1 of MVA's report and this suggests that in general terms the modelled values are lower than observed with a smaller number of cases where journey times are overestimated. This would be an expected trend particularly in a model of a more strategic nature such as TMfS07.

5.5.27 In consideration of the large variability of bus schedule timetables and constraints of the model, the TTAA is generally satisfied that the modelled bus journey times are appropriately represented, however, MVA states in §3.5.7 of its Report that:

> *Depending on the policies being tested, model users should review the bus journey time validation in their area of interest prior to undertaking model tests*

5.5.28 The TTAA is in general agreement with this recommendation.

5.6 Conclusions and Recommendations

Summary

5.6.1 The summary presented in MVA's Report outlines the various enhancements included within the TMfS07 National PT Model. These relate to the software adopted, the datasets used in development and validation and the disaggregation of the trip matrices. The TTAA has commented on these matters in previous sections of this document.

Validation

5.6.2 Validations of modelled passenger flows crossings the Aberdeen, Dundee, Edinburgh, Glasgow and Inverness Cordons and modelled rail passenger boarding and alighting against observed data have been undertaken. These are generally within an acceptable level at an aggregated analysis level (i.e. considering total PT flows) for Aberdeen, Edinburgh, Dundee and Inverness but are poorer for Glasgow in the outbound direction. With respect to the sub-mode split between rail and bus this is significantly more variable with a bias towards either bus or rail evident on virtually all cordons. There is no obvious pattern one way or the other with the bias towards bus or rail generally varying by cordon, direction and time period.

5.6.3 PT flows are good across the Tay crossings and in many cases good across the Forth Crossings. It is, however, significant to note that the AM peak southbound and PM peak northbound bus flows across the Forth Road Bridge are significantly underestimated.

5.6.4 Testing has been undertaken to attempt to improve the level of PT flow validation and this has led to MVA proposing a series of possible enhancements. **The TTAA would recommend that consideration is given to taking on board these enhancements during a future upgrade of TMfS07**.

5.6.5 Modelled bus journey times are in general quicker than the timetabled journey times. The TTAA is content that the majority of strategic bus routes have journey times within 15% of PT timetables in all the peak periods. In consideration of the large variability of bus schedule timetables and constraints of the model, the TTAA is generally satisfied that the modelled bus journey times are appropriately represented. MVA does, however, recommend that model users review the bus journey time validation in their area of interest prior to undertaking model tests.

5.6.6 MVA concludes in §4.3.1 that:

> *Our view is that the national public transport model has been successfully developed and is fit for its intended purpose which is to be used for the appraisal of major strategic public transport schemes and policy decisions as part of the TMfS modelling system. It should be noted, however, that there is some local variation in the validation of the model. Therefore, all model applications should be preceded by an appropriate review of the robustness of the model validation in the area/corridor of interest.*

5.6.7 The TTAA would broadly agree that as a strategic, high level assessment tool the TMfS07 PT model has achieved a level of validation that is acceptable, however, given the regional variation in the level of validation and the general variation in the quality of the sub-mode split comparisons the TTAA considers that particular care should be taken when applying TMfS07 in any PT scheme assessments. **The TTAA concurs with MVA's recommendation and considers that, in line with every application of TMfS, it essential that a review of robustness of the PT validation should be undertaken prior to proceeding with any application where PT is sensitive**.

6 TMFS07 AUDIT: DEMAND MODEL DEVELOPMENT

6.1 Introduction

6.1.1 The Demand Model provides the forecasting mechanism for TMfS07 and similar to previous versions of TMfS, this operates in an incremental manner. The TTAA's initial audit findings were published in Audit Note *AN-TMfS07-7: Demand Model Development (TTAA Ref. 71097, 24 March 2009).* MVA responded to *AN-TMfS07-7* in due course and this has been used in compiling the findings in this Audit Report.

6.1.2 The TTAA received the following information from MVA relating to the TMfS07 National Roads Model for use in the audit process:

- TMfS07 Demand Model Development Report (Issue 2, 29 January 2009)
- Zoning system in GIS format
- Information Note – TMfS07 Zone System (September 2007)
- Audit Response Note to AN-TMfS07-7 (MVA Ref. C37895 01, 17 April 2009)

6.1.3 This section relates to audit of the demand model development and generally follows the format of MVA's *Demand Model Development Report*.

6.2 Introduction to Demand Model development

Background

6.2.1 The background to the model development is set out in the Report and this highlights the fact that the new National Model has a base year of 2007 and is more strategic in nature than previous versions of TMfS. The intended hierarchical operation of the overall TMfS07 modelling system is also noted.

6.2.2 The TTAA has no substantive comments on this aspect of the Report.

6.3 Demand Model Overview

Model Structure

6.3.1 TMfS07 contains an extended four-stage demand model with the choice structure as follows:

- **Trip generation**
- Trip frequency
- **Mode choice**
- **Destination choice**
- Park & Ride station choice
- High occupancy vehicle choice
- Peak spreading
- **Route choice**

6.3.2 The TTAA is generally satisfied with the choices incorporated in the demand model. More detailed commentary on individual aspects of the model is provided later in this section.

6.3.3 The demand model operates in an incremental manner calculating changes to the base year road and PT assignment matrices arising through changes in planning data and/or transport costs. Again, the TTAA concurs with the adopted approach.

6.3.4 The inputs to the demand model in forecast mode are:

- Trip productions and attractions
- Generalised costs of travel by highway and public transport modes from the assignment models
- Park & Ride site files
- Calibrated model parameters

6.3.5 The data sources used in developing the demand model include:

- Census travel-to-work data
- Roadside interview survey data
- Public transport survey data
- Generalised costs of travel from the highway and public transport assignment models
- Scottish Household Survey data
- Planning data from TELMoS
- Trip rates from TEMPRO

6.3.6 The TTAA is content that both the inputs to the demand model in forecast mode and the data sources used in development are appropriate.

Zone System

6.3.7 The TMfS07 zoning system is commented on in detail in Section 2 relating to the Roads Model Development and for brevity this discussion is not repeated here. The TTAA is, however, satisfied that the zoning system adopted for the demand model is appropriate for a strategic, national model.

Journey Purposes and Time Periods

6.3.8 The six journey purposes contained in the demand model are described in MVA's Report as follows:

- Home-Based Work (HBW) – travelling "from home" to work (and back again) – a typical commuting journey (note – this travel purpose does not take place in employer's time).
- Home-Based Other (HBO) – travelling "from home" to a non work-related location such as shopping or leisure.
- Home-Based Employer's Business (HBEB) – travelling "from home" to a destination where you are in employer's time as soon as you leave the home.
- Non Home-Based Other (NHBO) – travelling from a non home-based origin to a destination (e.g. from work to shops).

- Non Home-Based Employer's Business (NHBEB) – travelling during employer's time, such as travelling from your place of work to a business meeting, visiting customers, etc.
- Home-Based Education (HBS) – travelling "from home" to an education destination (e.g. school, college etc). These are not part of the main Demand Model, but are added in separately after the mode and destination choice phases.

6.3.9 Additionally, there are four household types represented in the model which act as a proxy for car availability:

- C0 – zero car household (everyone from these is considered to be captive to PT)
- C11 – 1 car, 1 adult household
- C12 – 1 car, 2+ adult household
- C2+ – 2+ car household

6.3.10 The five user classes are consistent with the roads assignment model:

- Car – in work time
- Car – in commute time
- Car – in other time (e.g. shopping, leisure, etc.)
- Light goods vehicles
- Heavy good vehicles

6.3.11 A separate demand model operates for each peak period for "from home" trips only. The "to home" and "non-home based" trips are derived by applying factors to the "from home" trips. The time periods of operation are as follows:

- AM peak period 07:00 – 10:00
- AM peak hour (for assignment modelling) 08:00 – 09:00
(calculated as 0.38 of AM Peak Period Demand)
- Inter-peak period 10:00 – 16:00
- Inter-peak hour (for assignment modelling) 1/6 of 10:00 – 16:00
- PM peak period 16:00 – 19:00
- PM peak hour (for assignment modelling) 17:00 – 18;00
(calculated as 0.38 of PM Peak Period Demand)

6.3.12 In general terms the TTAA is content with the journey purpose, household type, user class and time period specifications adopted.

Generalised Costs

6.3.13 The generalised cost coefficients for the base year roads and PT assignment models were derived using the appropriate values contained in the version of TAG Unit 3.5.6 current in December 2008. The base year coefficients for the roads and PT assignment models are shown in Table 6.1.

Table 6.1 : Base Year Roads & PT Assignment Model Generalised Cost Coefficients

Mode		Time	Distance	Toll
Cars In-Work		1.0	0.2329	0.0503
Card Commute		1.0	0.5299	0.1448
Cars Other		1.0	0.3885	0.1448
LGV		1.0	0.6805	0.0225
OGV		1.0	2.1876	0.0225
PT VoT In-Work	£	21.58	£/hr	
PT VoT Non-Work	£	5.11	£/hr	

6.3.14 On initial inspection the values shown were broadly comparable with the values of time in WebTAG unit 3.5.6 and their relative scale and magnitude appeared to be consistent with previous versions of TMfS. In response to a request from the TTAA, MVA provided the spreadsheets showing the calculation of the generalised cost coefficients. The TTAA's review of this demonstrated that the calculations followed the expected methodology and used the appropriate values from WebTAG and are considered appropriate for TMfS07.

Parking Charges

6.3.15 Parking charges have been introduced by adding costs to the zones in the central areas of Aberdeen, Dundee, Dunfermline, Edinburgh, Glasgow, Inverness, Perth and Stirling. The costs vary by journey purpose to reflect the differing average length of stay by purpose. The costs have been applied using the methodology typically adopted in TMfS which assumes that:

- Long stay parking – 45% of commuting trips will pay this charge
- Short stay parking – 80% of home based other and non home based trips will pay this charge
- Employers business trips pay no parking charge as the cost is deemed not to be perceived
- Average short term and long term parking charges are assumed to apply across all parking sites
- The costs are added to the base year generalised cost skims after applying the appropriate tolling parameter
- The values are applied 50% each to outward and return journeys in the demand model

6.3.16 Overall the TTAA is content that the approach to reflecting parking charges in the National Model is appropriate. **Users should, however, note the limited application of parking charges in the model area and the various assumptions adopted. This is unlikely to be significant for most applications, however, for specific applications of the model considering parking measures and policies in more detail it may be appropriate to consider revising the methodology for applying parking charges to reflect charges in other areas of the model and/or differing assumptions with respect to the proportion of each trip purpose paying parking charges**. It is most likely that the methodology for reflecting parking charges will be more applicable to review for the purpose of regional and\or sub area models.

6.3.17 In relation to these recommendations MVA has subsequently commented that:

> *MVA agrees with these recommendations. In addition, we would note that the model currently does not contain the functionality necessary to predict the impacts that significant changes to car parking capacity may have on destination or mode choice.*

Roads and Public Transport Assignment Models

6.3.18 The roads and PT assignment models provide trip and cost matrices in OD format for input to the demand model. The roads model matrices are in PCUs with factors of 1.0 for light vehicles (cars and LGVs), 1.9 for heavy goods vehicles and 2.2 for buses. The roads and PT assignment models are commented upon separately in this document.

Trip Ends

6.3.19 The trip end outputs are by production and attraction, mode, household type, time period and journey purpose. The forecast trip ends are created by using TEMPRO trip rates and planning data from TELMoS07 to create growth factors which are applied to the TMfS07 base year trip ends. Further commentary on the forecasting process will be provided in a later section of this document.

Demand Model Parameters

6.3.20 The demand model parameters are calibrated to control the sensitivity of the various choice processes and to ensure an acceptable fit to the base year data. The base year parameters include distribution model sensitivity parameters, mode choice scaling factors and mode specific constants and Park & Ride model parameters. The sensitivity parameters were derived using local data. The parameters have also been subject to realism testing in accordance with the WebTAG guidance and compared with standard values. Again, further commentary on the derivation and sensitivity testing of the parameters will be provided in later sections of this document.

Software

6.3.21 The TMfS07 demand model operates using the CUBE Voyager software with the mode and destination choice calibration parameters being derived using ALOGIT.

6.4 Matrix Development

Overview

6.4.1 The data sources used in developing and calibrating the demand model included:

- Census journey-to-work data (CJTW)
- Planning data from TELMoS
- TEMPRO trip rates
- Generalised costs of travel from the assignment models, journey purpose, mode and time period
- Roadside interview data
- Public transport survey data
- National Rail Travel Survey data (NRTS)

- Park & Ride Site Survey data

6.4.2 The TTAA concurs that these data sources are appropriate for the demand model development.

Data

6.4.3 Three of the data sources were completely new to the base matrix development, namely the CJTW, NRTS and inter-urban bus survey data (Autumn 2007). The matrices were infilled via a synthetic process to derive road based and inter-urban bus trips for non-commuting purposes. This process used 2007 planning data and TEMPRO trip rates to derive trips that were then distributed using a compressed matrix and sensitivity parameters from TMfS05A.

6.4.4 Where necessary, the data was factored to a common 2007 base using factors derived from TEMPRO. Fully observed matrices were developed for "from home" trips and in the case of the CJTW data factors were derived from Scottish Household Surveys to derive the relevant time period matrices.

6.4.5 For "to home" and "non-home based" trips, the matrices were derived using the reverse and non-home based trip creation process used in the demand model. Further commentary on this process is provided in a later section of this document. All of the matrices were then combined with vehicle and person trip matrices being created for the roads and PT assignment models respectively.

6.4.6 In general terms the TTAA is satisfied that the described process for creating the demand matrices appears logical and appropriate.

6.5 Destination and Mode Choice Calibration

Overview

6.5.1 The TMfS07 National Demand Model has been defined with a hierarchy in which destination choice is more sensitive than mode choice (i.e. destination choice is lower down the four-stage hierarchy than mode choice). The ALOGIT software was used both to calibrate the mode and destination choice parameters and to test different model structures.

6.5.2 During the audit of the Forth Region Model, information was provided to the TTAA relating to the initial mode choice parameter estimation for AM peak home based work trips using the adopted model structure and an alternative model structure (with mode and destination choice models the other way round). This demonstrated that with the adopted model structure produced a parameter estimate within the correct range while the alternative did not, thereby supporting the adopted structure, which also conformed with the default structure recommended in WebTAG. This analysis was common to the TMfS07 National and Forth Region demand models. Overall, the TTAA considers this approach appropriate for TMfS07.

6.5.3 **The TTAA would recommend that future demand model development documentation, should include a detailed summary of the process followed and analysis undertaken in determining the demand model structure**.

Data

6.5.4 The demand model operates solely on the 712 internal zones, for which data exists on the volume, distance and generalised cost of car, PT and Park & Ride trips. This information is used as the input to the ALOGIT software used in calibrating the demand model.

Preliminary Data Inspection

6.5.5 It is stated in Section 4.3 of MVA's Report that:

> *The data used in the model shows a strong positive relationship between the generalised cost of travel (in minutes) and journey distance. It also shows a decrease in the PT mode share at greater distances.*
>
> *The distribution of trips by journey length shows, as expected, a distribution that is negatively skewed, with a peak volume between 0 and 5km and a long tail.*
>
> *This exploration of the data shows plausible patterns and trends in travel demand and travel costs. The analysis suggests that the data provides a good foundation on which to develop mode and destination choice models.*

6.5.6 The TTAA was independently provided with a summary of this data which relates to the full TMfS study area (*TMfS Model Development Report, Section 8.2, August 2008*) from which these conclusions were drawn. Having reviewed the summary the TTAA concurs with the statements and the conclusion that the data shows plausible patterns and appears to be a sound basis for developing the demand model.

Modelling Estimation

6.5.7 In the model estimation process the utility of each alternative is specified as a function of the generalised cost of travel, a dummy variable to account for intrazonal trips and a full set of alternative specific constants (ASCs). To expedite the process of estimating ASCs a process of "contraction mapping" was used which uses an iterative approach to gradually refine the ASC estimates until convergence is reached. This is undertaken for each time period, purpose and household segment. The TTAA is satisfied with the adopted approach.

Model Results

6.5.8 The calculated mode choice parameters are demonstrated in Tables 4.1 to 4.4 of MVA's Report. These are all between 0 and 1 and are of the expected nature and order of magnitude and are generally in line with the illustrative parameter values outlined in WebTAG Unit 3.10.3.

6.5.9 The destination choice parameters are also outlined in Tables 4.1 to 4.4 for the log of the generalised cost and for the generalised cost term. These parameters are all of the correct sign and an initial inspection of the values in Table 4.3 shows that they are generally of a similar scale to the corresponding parameters published for previous TMfS demand model developments. The intra-zonal K factors are also outlined in Tables 4.1 to 4.4 of MVA's Report.

6.5.10 While it is difficult to comment in detail on the absolute values of the estimated mode and destination choice model parameters the intuitively correct nature and magnitude of the estimated values, and a general similarity with previous TMfS models, provides some reassurance that they have been appropriately derived.

Mode Specific Constants

6.5.11 Mode specific constants have been calculated on a zonal basis to ensure that the synthesised mode split corresponds with that reflected in the base year trip ends. This uses a similar process and formula to that adopted previously in TMfS demand model developments and the TTAA is content with this approach.

6.6 Park & Ride Station Choice Calibration

Overview

6.6.1 The National Model includes Park & Ride choice in the main mode choice model, unlike previous versions of TMfS which included this as an add-on step prior to the final assignment. The Park & Ride module is applied to "from home" trips in the AM peak only with all corresponding return trips assumed to take place in the PM peak. Again, this differs slightly from previous versions of TMfS which enabled an element of Inter-peak Park & Ride activity. Given the relatively small Park & Ride demand during the Inter-peak period this is unlikely to be a significant issue for the TMfS07 National Model.

6.6.2 The Park & Ride module is specific to demand segments/household types which have a car available.

Methodology

6.6.3 The Park & Ride station choice was calibrated using the generalised cost of Park & Ride along with site specific inputs to define the catchment area, cost and parking capacity for each site. Possible destinations for bus based Park & Ride sites are restricted to the locations which the buses serve. For bus and rail Park & Ride sites, all zones in the model are possible origins, while for rail sites all destination zones are also possible.

6.6.4 The overall process for reflecting the Park & Ride costs, parking capacities and transfer penalties is very similar to that adopted for previous versions of TMfS. The main difference is its integration in the mode choice module, rather than acting as an ancillary adjustment process prior to the final assignment. The module operates separately by trip purpose and outputs "from home" and "to home" matrices by purpose and mode which are added into the roads and PT assignment matrices.

6.6.5 Overall the TTAA is content with the specified methodology for reflecting Park & Ride in the National Model.

Site Choice Calibration

6.6.6 The data for rail based Park & Ride sites comes from the recent National Rail Travel Survey, while the bus based Park & Ride data comes from separate surveys and the TTAA concurs that these are appropriate data sources. **The TTAA would, however, recommend that future documentation of the Park & Ride model would benefit from some more detail regarding the Park & Ride data being included (e.g. locations, data collected, sample sizes, etc.)**.

6.6.7 The comparison of modelled and observed Park & Ride trips by Local Authority area is provided in Table 5.1 of MVA's Report, while a more detailed breakdown is provided in Appendix H. The modelled total was calculated for the period person trips using a vehicle occupancy factor of 1.2. Clarification on the source of the occupancy factor was requested from MVA who confirmed that:

> *The average occupancy factor of 1.2 for Park and Ride is a 'guesstimate' based on previous Park and Ride data collection and modelling. It should be noted that this parameter is used only in the calculation of Park and Ride car park utilisation – the adjustments made to public transport demand use person trips, while the [road] traffic model converts the person trips to vehicles using appropriate vehicle occupancies for each journey purpose.*

6.6.8 The local authority based calibration demonstrates a good overall match between modelled and observed values, with 20 of the 29 local authorities demonstrating a GEH value less than 5. In 6 cases the GEH is slightly greater than 5 and in only 3 cases is the GEH value greater than 7, namely for Aberdeenshire (13.89), Angus (8.74) and South Ayrshire (13.14).

6.6.9 The site by site breakdown in Appendix H, while showing greater variability in the comparisons, still demonstrates a generally good match across the individual sites in the TMfS07 area. The majority of the 188 sites (79%) demonstrate a GEH of less than 5 with 94% of sites having a GEH of less than 7. The 12 sites which demonstrate GEH values of >7 are as follows:

- Stonehaven (GEH = 11.6)
- Montrose (GEH = 9.11)
- Aberdeen (GEH = 9.61)
- Waverley (GEH = 9.68)
- Thornliebank (GEH = 7.07)
- Perth (GEH = 7.75)
- Ayr (GEH = 12.7)
- Cambuslang (GEH = 7.72)
- Croftfoot (GEH = 7.28)
- Lanark (GEH = 9.65)
- Dumbarton Central (GEH = 8.24)
- Singer (GEH = 8.62)

6.6.10 The local authority based analysis is also further broken down by trip purpose in Appendix H and this shows no particular bias for any given trip purpose relative to the others.

6.6.11 The TTAA is generally content that the level of calibration achieved for Park & Ride sites in the TMfS07 National Model is acceptable. While the base level of calibration is acceptable at a global level within the context of a National Model, for particular applications of the model, it may be necessary to examine in more detail and/or refine the Park & Ride site calibration at those locations that exhibit poorer comparisons. For example, applications of the model where Park & Ride forms a significant element of the policies or interventions being tested and/or where the Park & Ride demand is expected to be sensitive to the policies or interventions, the localised calibration may need to be refined at certain locations. **Users should consider this prior to applying the TMfS07 National Model and seek advice from Transport Scotland/MVA prior to undertaking such applications**.

6.7 Reverse and Non-Home-Based Trips

Overview

6.7.1 The demand model operates for the “from home” journey purposes during the AM and Inter peak periods only. The calculation of the PM “from home” and the “to home” and “non home based” trips requires a series of factoring processes which are consistent with the TMfS07 National Model

Evening Peak Trips

6.7.2 The evening peak “from home” trips are derived by a factoring process applied to the “from home” trips from the Inter-peak period. The factors are derived separately by mode and trip purpose and applied to the corresponding Inter-peak trips.

6.7.3 This process is the same as that adopted in all previous versions of TMfS and the TTAA considers this appropriate.

To Home Trips

6.7.4 The “to home” trips for all time periods are derived by applying a series of factors to the “from home” trips. Separate factors by time period, mode and trip purpose were derived using data from the Scottish Household Survey. This is again the same process as included in previous versions of TMfS, however, it has been expanded to accommodate the greater household car availability segmentation in the TMfS07 National Model. The TTAA is content that the described process is appropriate.

Non Home Based Trips

6.7.5 Separate factors are derived for “non-home based” trips by time period, trip purpose and mode for both in-work and non-work trips. These factors are then applied to the destinations of the “from home” trips and the origins of the “to home” trips to establish the “non-home based” origins and destinations. The totals are constrained to the average of the total origins and destinations as origins and destinations are unlikely to match in this process.

6.7.6 Matrices of “non home-based” trips by mode and time period are created by applying a distribution model to the trip ends using appropriate inter-zonal costs. The calibrated parameters for these distribution models are described in the next section. The total trips by mode are calculated by adding the origin-destination matrices together for Public Transport and weighting by vehicle occupancy for car trips.

6.7.7 Again, this process is the same as that adopted in all versions of TMfS and the TTAA considers this appropriate.

Non Home Based Destination Choice

6.7.8 The sensitivity parameters for the “non-home based” destination choice were calibrated using the ALOGIT software. The destination choice parameters are outlined in Tables 6.1 to 6.4 for the log of the generalised cost and for the generalised cost term along with the intra-zonal K factors. The sensitivity parameters are all of the correct sign, however, there is little to comment other than to note that the values are generally very small, reflecting a relative insensitivity to destination choice for “non-home based trips”, particularly in the Inter-peak.

6.7.9 Overall the TTAA is content with the adopted approach for reflecting the “non-home based” destination choice is appropriate for the TMfS07 National Model.

6.8 Other Choice Models

Overview

6.8.1 In addition to the mode and destination choice models the TMfS07 National Demand Model also contains models for macro time of day choice, trip frequency and high occupancy vehicle modelling. MVA states in §7.1.1 of the *Demand Model Report* that:

Each of these modules is optional within the model structure and can all be turned off or turned on in any combination that suits the purpose of the model run. It should be noted that as standard forecast year Do-Minima and Reference Case test runs are run with Trip Frequency turned on, but the other choice models turned off

6.8.2 The inclusion of trip frequency effects in the hierarchy is in accordance with Variable Demand Modelling Advice (VaDMA) guidance (TAG Unit 3.10.3), where slow modes (walking, cycling, etc.) are not reflected in the main mode choice and the TTAA considers this an acceptable approach to adopt for the TMfS07 National Model.

6.8.3 **Hands-on users should take care to ensure that the appropriate optional choice mechanisms have been invoked for each application of the model**.

6.8.4 **Users should also note that peak spreading effects are not included within the TMfS07 National Model and, as such, would require to be accounted for in the relevant regional or sub-area model as appropriate**.

Trip Frequency Model

6.8.5 The trip frequency module is a simple logit model of the same form typically adopted in previous versions of TMfS. The adopted parameters have also been inherited from previous versions of TMfS and assume a given level of sensitivity to travel cost by trip purpose and are:

- Home-based employers business 1
- Home-based other 0.5
- Home-based work 0

6.8.6 There is no specific guidance in WebTAG regarding appropriate sensitivity parameters for trip frequency, so it is difficult to comment in detail on the appropriateness or otherwise of these parameters. It can be said that it is reasonable to assume that the frequency of "home based work" (i.e. commuter) trips would be less likely to be sensitive to changes in cost than "home based other" and "home based employers business" trips and in that regard the parameters adopted follow a logical sequence.

Macro Time of Day Choice Model

6.8.7 A Macro Time of Day Choice (MTODC) mechanism has been included in the TMfS07 National Demand Model. This particular choice mechanism is less established in variable demand modelling terms and has been included as an optional module that is not invoked by default. The TTAA concurs with this approach.

6.8.8 The MTODC module has been included before the main mode choice in the model hierarchy, which corresponds with the relevant guidance on the subject (WebTAG Unit 3.10.3, §1.11.17). The model is the same as that adopted in previous versions of TMfS and is applied by journey purpose at the person trip level on the principle that some of the "from home" trips in the AM peak will move to the pre-AM peak or Inter-peak period. The outputs from the process are "from home" matrices for the pre-AM peak that also have associated "to home" and "non-home based" trips in the other time periods which are derived from the AM peak factors for this.

6.8.9 Overall, the TTAA is satisfied that the defined methodology for dealing with MTODC appears to be logical and conforms with the available guidance on the subject, however, the TTAA notes that during a previous audit of the MTODC module for TMfS05 (Final Audit Note *FAN-6a-*

2005, TTAA Ref. 69913, 17 July 2008), MVA had identified some issues with respect to the results output from the module. MVA has subsequently commented further that:

> *Further investigation is ongoing, under the TMfS:07 Model audit and sensitivity test program. The initial results of this appear to suggest that the current implementation produces more intuitive results than previous versions. An information note with results of these findings will be provided to the TTAA in the near future.*

High Occupancy Vehicle Choice

6.8.10 An optional mechanism, which is not invoked as a default, has been included in the TMfS07 National Demand Model to enable trips to move between single and multiple occupancy vehicles. The module operates after the destination choice and before the assignment stage and enables car available "home based" trips to choose between single and multiple occupancy cars. The mechanism involves a logit model that uses differing generalised costs for single and multiple occupancy vehicles. The outputs from the module are "from home" matrices by purpose and car availability segment separately for single and multiple occupant cars, which are then subject to the standard factoring processes to create the "to home", "non home based" and PM peak trips.

6.8.11 The assignment process then takes place as standard, but with the greater disaggregation to reflect the single and multiple occupancy vehicle types. High occupancy vehicle lanes need to be reflected in the assignment model, as separate link types to enable the single and multiple occupancy costs to be skimmed separately for feedback to the demand model.

6.8.12 The adopted process is again similar to that included in TMfS05, with some updates to include sensitivity parameters for the logit model based on recent Stated Preference survey work. The TTAA is content that the adopted methodology for including high occupancy vehicle choice is acceptable for the TMfS07 National Model. It must be borne in mind, however, that such modelling practices remain in their infancy and little reliable guidance and practical experience exists in this regard. **The TTAA would recommend that the HOV module be used only in appropriate circumstances where a specific high occupancy vehicle policy measure requires testing. Furthermore, any application should be subject to appropriate sensitivity testing to verify the robustness and realism of the outputs and potential users should take account of the findings in previous audit notes on the matter *(AN-FRC-1, TTAA Ref. 70440, 24 October 2008* and Final Audit Note *FAN-7, Ref. 67846, 23 May 2007*)**.

6.9 Model Realism Tests

Overview

6.9.1 Realism testing was undertaken for the TMfS07 National Demand Model to ensure that the responses were in line with expectations and to compare the modelled elasticities with standard published values. This followed the VADMA guidance outlined in WebTAG Unit 3.10.4.

Introduction

6.9.2 In accordance with the VADMA guidance, realism tests were undertaken to establish the modelled elasticity of demand with respect to car journey time, car fuel price and public transport fares. The realism tests undertaken were:

- 20% increase in generalised cost (as a proxy for journey times)
- 20% increase in fuel costs
- 20% increase in PT fares

6.9.3 These tests are consistent with those typically undertaken during the development of the TMfS demand model and are considered appropriate by the TTAA.

Results

6.9.4 The modelled elasticities with respect to fuel cost are shown to lie in the range between -0.26 to -0.42 for "non work" purposes, with the majority lying within the VADMA recommended range (-0.1 to -0.4). The VADMA guidance recommends that "employers business" trips would be expected to have an elasticity value of nearer -0.1, however, the elasticity for "car in work" trips in the TMfS07 National Model is shown to range between -0.38 and -0.46.

6.9.5 With respect to the elasticity to changes in travel time the VADMA guidance suggests that the values should typically be much greater than for fuel cost and no more than -2.0 without giving definitive guidance on exact values. The modelled values obtained from the realism test all lie within the range between -0.68 and -0.95 and are predominantly -0.8 or more. None of the values exceed the recommended maximum value; while typically being approximately 3 times greater than the corresponding fuel price elasticity values.

6.9.6 The VADMA guidance for PT fare elasticities suggests that values should generally lie in the range -0.2 to -0.4, but in some cases can be as high as -0.9. The TMfS07 values are generally shown to lie within that range. MVA commented in §8.3.4 of the Report that:

> *the home-based employer's business elasticities are generally low and the AM home based-other trips are generally high…*

Summary

6.9.7 MVA summarises in §8.4.1 of the Report that:

> *The elasticities shown above demonstrate that the model has an acceptable level of sensitivity to changes in the modelled costs. The majority of the elasticities within the model fall within the VADMA guidelines*

6.9.8 The TTAA generally concurs with this as the majority of elasticities have been demonstrated to fall within the recommended ranges. It should be noted, however, that the fuel price tests demonstrate a higher-than-expected sensitivity for "employers business" trips and the PT fare tests show home-based employer's business elasticities that are generally low with the AM home based-other sensitivities being generally high. **Users should take note of these facts when interpreting the outputs of policy tests, particularly if they relate to fuel price or PT fares**.

6.10 Trip End Model

Car and Public Transport Trip Productions

6.10.1 The TMfS07 Trip End Model is basically the same as that for previous versions of TMfS. The trip end model for both car and public transport trips in TMfS is a growth factor model based on the DfT National Trip End Model (NTEM). NTEM can be used to produce trip end forecasts by mode and time period for Local Authority districts at a person trip level. TMfS also has an associated land use model (TELMOS), which can output planning data and car ownership data on a zonal basis for a given forecast year.

6.10.2 The TMfS trip end model becomes a relatively simple method of calculating future year trip ends by multiplying vectors of trip rates by the planning data person type vectors for each zone. The trip ends for the forecast year are then divided by those for the base year to create growth factors. The base year trip productions are then multiplied by these factors to create future year trip productions by mode/car availability, time period and journey purpose. The NTEM based process relates solely to trip productions for "from home" trips. The "to home" and "non-home based" trip ends are created in a separate process.

6.10.3 The TTAA is content that these aspects of the TMfS model development are appropriate.

Trip Attractions and Attraction Factors

6.10.4 The trip attraction process involves applying attraction parameters to the number of jobs in each zone. The trip attractions are separate for each journey purpose and time period but are combined by household segment and mode. The forecast trip attractions are then divided by the base year attractions to create growth factors to be applied to the base year trip attractions.

6.10.5 The base year trip attractions for "home based work" represent actual trip ends as they are used as a constraint in the destination choice process. Attraction factors are derived for "home based other" and "non-home based" purposes by successively adjusting the attraction factors and applying the singly constrained model until the trip attractions match those for the base matrices used in the destination choice model calibration.

6.10.6 Again, the TTAA is generally content that the described process is similar to previous versions of TMfS and appears logical and appropriate for TMfS07.

Base Year Trip Ends

6.10.7 MVA states in §9.3.1 of the Report that:

> *In TMfS:07 there is a good level of correlation between the base levels of demand and the base-year planning data. This is a result of using planning data and census matrix tools data to create the initial base-year demand matrices.*

6.10.8 The TTAA considers that a good correlation between the base year demand and planning data is advantageous given the incremental forecasting method adopted for TMfS. MVA provided the TTAA with details of the base year planning data, trip ends and implied trip rates on a zonal basis. This demonstrated that there is generally a reasonable level of consistency in the trip rates across the model area with only a small number of zones showing higher than expected trip rates. The TTAA is satisfied that the correlation between the trip ends and the input planning data for the base year is acceptable for TMfS07. **The TTAA would recommend that any user of TMfS07 should undertake an examination of the base year trip ends/rates in their area of interest prior to applying the model. This checking process should continue throughout the model application to ensure that appropriate trip rates are being applied in any future year forecasts**.

6.11 Forecasting Procedures

Introduction

6.11.1 The introduction provides a brief description of the purpose of the base year Demand Model and the general application in forecast mode. The TTAA has no comments on this section of the Report.

Overall Operation of the Demand Model

6.11.2 The overall operation of the demand model in forecast mode is essentially the same as previous versions of TMfS. Trip ends are created for the relevant forecast year and economic growth scenario, while the various sub-models operate in an iterative manner to create the relevant highway and PT assignment matrices.

6.11.3 There is an iterative inner loop to ensure convergence between the mode and destination choice processes. By default, four inner loops are run before the outer iterative loop between the assignment and demand models is run. The external loop enables changes in costs in a future year to be fed back from the assignment models to the demand model which then runs through the various sub-models. The PT costs are fixed after a single external loop of the demand model and by default five external loops are run.

6.11.4 The TTAA is content that the procedures adopted are appropriate for the TMfS07 National Model. **Users should, however, note the default number of iterations for the inner and outer loops and the fixing of PT costs after a single external demand model loop. While the defaults will be acceptable for general application, changes to these may be required in specific circumstances and this can be readily achieved if necessary**.

The Incremental Forecasting Approach

6.11.5 The TMfS07 National Demand Model operates in an incremental manner and produces estimates of the forecast year and base year synthesised trip matrices. Depending on scale of and the difference between the "observed" and synthesised base year matrix cell values, the growth is applied to the base year "observed" matrices either as a factor or as an incremental difference (between the synthesised base and future year trips). This attempts to prevent spurious over or underestimates of growth occurring in the future year assignment matrices.

6.11.6 The TTAA considers this approach to be appropriate for the TMfS07 National Model.

Model Parameters

6.11.7 The following model parameters are recalculated for forecast model runs:

- Generalised cost coefficients for assignment (Ref. WebTAG Unit 3.5.6)
- Occupancy factors to convert from person to vehicle matrices (using WebTAG factors)
- Values of time and vehicle operating costs (ref WebTAG Unit 3.5.6)

6.11.8 Unlike in previous versions of TMfS the mode specific constants do not need to be recalculated as the household car availability segregation has been improved in the TMfS07 National Model.

6.11.9 Overall the TTAA is content with the suggested parameter changes through time for the TMfS07 National Model.

Highway and Public Transport Cost Matrices

6.11.10 The generalised cost matrices from the base year are used by standard as the start point for the demand model process for a Reference Case, although the user can opt to replace these with future cost matrices if necessary. Similarly, Base or Reference Case generalised cost matrices can be used as the start point for a Variance Case in the TMfS07 National Model.

6.11.11 The base year cost matrices by mode are also required for the calculation of Reference Case mode specific constants. The TTAA concurs with this approach.

Highway and Public Transport Networks

6.11.12 The user is required to code the relevant roads and PT networks for all Reference and Variance Cases using conventional coding methods. Specification of the appropriate Reference and Variance Case networks for roads and PT is the responsibility of the TMfS user, who should undertake appropriate checks to ensure consistency between the roads and PT networks.

Education Trips

6.11.13 Education trips are included as add-in matrices post the inner loop of a demand model run. The base year matrices were built using the CJTW data and growth is calculated using TELMoS planning data. Trip ends are forecast as per other trip purposes and a simple gravity model is used to distribute these with sanity checks undertaken on all trips for all purposes. The TTAA is content that this approach is appropriate for TMfS07.

Goods Vehicles

6.11.14 Goods vehicle forecasting is not undertaken as part of the standard demand modelling procedure in TMfS. Instead, forecast light and heavy goods vehicle matrices are created by calculating growth on a cell by cell basis from TELMoS data and applying these to the TMfS base year good vehicle matrices for internal trips. External goods vehicle movements are subject to uniform NRTF growth rates with sanity checks undertaken as appropriate. The TTAA is content that this approach is appropriate for TMfS07.

Long Distance Vehicle Matrices

6.11.15 Long distance (employer's business and other) trips which are greater than 100km but internal to Scotland are treated separately from the main demand model in forecast mode. These trips are added into the assignment matrices at the same stage as the goods vehicle matrices. The forecast procedure uses an elasticity model using assumed levels of GDP growth through time. The forecasts are undertaken at the 12hr (07:00 – 19:00) level and split to time periods using the the base year time period splits. MVA has also confirmed that such trips are not treated differently in the year matrix development, only during forecasting.

6.11.16 Although this is a relatively simplistic process, the TTAA is satisfied that the adopted approach is acceptable for TMfS07.

External Trips

6.11.17 External trips from England and Wales are subject to NRTF growth factors by default, although the user can choose to override these factors if required.

6.11.18 It should also be noted that, as was the case for TMfS05, the external trip forecasting for PT trips and airport zones in TMfS07 applies as follows:

- PT trips are subject to a uniform growth rate derived from application of the trip end model in the internal model area
- Growth predictions for airport zones are based on data supplied directly from the relevant airport operator

6.12 Conclusions and Recommendations

Conclusions

6.12.1 MVA concludes in Section 11.1 that the TMfS07 National Demand Model has been implemented for the base year and that realism tests demonstrate acceptable elasticities, particularly for the main commuting travel purpose. It is further commented by MVA that:

> *We conclude that the Demand Model is therefore 'fit for purpose', ie predicting strategic travel responses to changes in future transport provision throughout Scotland.*
>
> *While this report discusses how the model will be applied in forecast mode, it does not include consideration of actual applications of the model in forecast mode. Further experience of these applications gained over time will assist in understanding the sensitivity and performance of the Model.*
>
> *Testing of the sensitivity of the High Occupancy Vehicle module, Macro Time of Day Choice and Trip Frequency modules have also not been discussed in detail in this report. These therefore also require further testing via live applications of the full model.*

6.12.2 Therefore, while realism tests have been undertaken, additional, more detailed sensitivity tests (e.g. to examine the impact of model parameters on the outcome from a scheme assessment) have not been undertaken at the model development stage. In relation to this matter MVA has further commented that:

> *However, early use of the model may provide evidence regarding the sensitivity of the model to a range of input assumptions.*

6.12.3 MVA's comments are acknowledged and supported by the TTAA. **However, the TTAA would recommend that, ideally, users applying the TMfS07 National Model and/or any sub-area or regional models within the overall TMfS07 hierarchy for scheme appraisals should undertake appropriate sensitivity tests to establish the robustness of the forecasts and resulting conclusions of such appraisals against the uncertainty of the input parameters (Ref. WebTAG Unit 3.10.4)**.

6.12.4 Notwithstanding the comments and recommendations elsewhere in this document, the TTAA generally concurs with MVA's conclusions and in particular the need to gain a better understanding of the model through its application and to undertake sensitivity testing as appropriate when applying the model. **Potential users of the model are advised to familiarise themselves with these conclusions prior to considering applying the TMfS07 National Model**.