Transport Model for Scotland – TMfS05A Audit

Transport Scotland

Model Development Audit – Final

TRANSPORT MODEL FOR SCOTLAND – TMFS05A AUDIT

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TRANSPORT MODEL FOR SCOTLAND – TMFS05A AUDIT

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1 INTRODUCTION

1.1 Purpose of Report

1.1.1 SIAS Limited (SIAS) was commissioned under the Traffic and Transport Advisor and Auditor term commission to undertake an audit of the model development work undertaken in updating the existing TMfS05 to create the latest general release version TMfS05A. The main focus of the TMfS05A development was to improve spatial detail and the representation of the supply side of the model in 'external' areas of the road traffic and public transport assignment models, mainly in the Highlands. Furthermore, new Roadside Interview (RSI) data was incorporated in Ayrshire and Dundee.

1.1.2 The audit has focused mainly on reviewing the documentation produced by MVA for the different elements of the model development and a review of the road traffic and public transport (PT) networks. Additionally, 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.

1.1.3 It should be noted that SIAS, in its 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 have sufficient technical knowledge of the transport modelling concepts and software packages pertinent to the application of TMfS. Where insufficient detail is available from the supporting TMfS model development documentation, or this Audit Report, it is further assumed that users will refer to the model development and support team for the necessary advice.

1.2.2 A procedure has been instigated whereby prospective model users must complete a TMfS User Request Form to be submitted to Transport Scotland prior to the application of the model. This has mutual benefits for both the model developers and potential users and the TTAA fully endorses this procedure. Prospective users of TMfS should bear this process in mind when embarking on any study using TMfS or its outputs. It is assumed by the TTAA that any hands-on user of the model will undertake a thorough, study specific review of TMfS 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 verify the robustness of the model outputs in forecast mode.

1.3 Acknowledgements

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

2 ROAD TRAFFIC ASSIGNMENT MODEL

2.1 Introduction

2.1.1 This chapter presents the TTAA's findings based on information supplied by MVA in relation to TMfS05A Audit Task 1: Review Road Traffic Assignment Model Updates.

2.1.2 The audit has concentrated on reviewing the documentation relating to the TMfS05A Road Traffic Assignment Model. The *Transport Model for Scotland 05A – Highways Calibration and Validation Report* (Draft version 3) was supplied to the TTAA in October 2007 for use in the audit process and much of the commentary in this chapter relates to that document. The networks were also supplied to the TTAA and, where appropriate, commentary has also been made relating to any checks undertaken on these networks.

2.1.3 The chapter follows the same structure as MVA's report and the following sections will deal with commentary relating to the network and matrix development, the assignment model, calibration and validation and the conclusions and recommendations.

2.2 Network Development

Introduction

2.2.1 Chapter 2 of MVA's report outlines the model development with the most significant developments being:

- Refinement of modelled road network following the Audit of TMfS05 and application of model to improve network representation
- Review and refinement of road links in the Highlands and Argyll and Bute areas based on journey time data collected as part of the Strategic Transport Projects Review commission
- Addition of ferry links and connecting roads infrastructure to represent the Scottish Islands including the Clyde estuary, Argyll and Bute, the western isles, Orkney and Shetland

2.2.2 The chapter then describes the various components of the network update. The TTAA's comments on each section are provided as follows:

Link Types

2.2.3 The link type definition was based on the *Scottish Transport Statistics Note 24* and is consistent with that adopted for TMfS05. The TTAA has examined the link type coding in TMfS05A by analysing the following:

- Link type differences between common links in TMfS05 and TMfS05A
- Link types for new links coded in TMfS05A

2.2.4 The common links where the link type coding has changed in TMfS05A represent only a very small number of links. These changes have generally been introduced to correct issues identified in the audit of TMfS05 (e.g. M77 south of Fenwick, M8 J31, etc.) or to more appropriately represent the link type for a given route (e.g. A199 Haddington to Dunbar).

2.2.5 The TTAA is content that the majority of link type coding issues from the TMfS05 audit have been addressed in TMfS05A (Ref. §2.3.11 of *TMfS05 Model Development Audit – Final Report*, TTAA Ref. 67633, April 2007). The two exceptions are the previous comments relating to Airbles Road and the B754 Motherwell to Wishaw. Neither of these comments is considered significant in the context of TMfS05A and can, therefore, be addressed in a future upgrade.

2.2.6 The link types for new links in the TMfS05A study area have been examined and are considered to be appropriately representative. The TTAA is content that the link type coding for TMfS05A is acceptable.

Link Capacities

2.2.7 The generic link capacities coded by link type remain consistent between TMfS05 and TMfS05A. The TTAA notes that the capacities have been adjusted on some individual links/routes. Some of these changes were to address points raised in the TMfS05 audit (Ref. A90 Barnton to Inverkeithing, A814 Clydeside Expressway, etc.), while others have been included to better reflect the characteristics of the route (e.g. A90 Perth to Dundee).

2.2.8 Overall, the TTAA is content that the link capacities coded are acceptable for TMfS05A. More detailed commentary was provided in the TMfS05 audit regarding link capacity coding and, while some of these issues have been addressed in TMfS05A, the TTAA would recommend that the issues raised previously are considered in the development of TMfS07.

Speed/Flow Curve Definition

2.2.9 The speed/flow curve definition for capacity indices 1 to 25 remains consistent between TMfS05 and TMfS05A. The vast majority of existing links have had the same curve definition applied in TMfS05A. The exceptions are on links where the coding has altered to address a previous audit issue (e.g. M77 south of Fenwick and A977 Kincardine to Clackmannan).

2.2.10 Additional speed/flow curves have been derived for TMfS05A and these are specifically intended to represent speeds on journey time routes surveyed as part of the Strategic Transport Projects Review (STPR). The new curves are based on capacity index 16 (rural routes), however, they maintain free flow speed up to 50% capacity, whereas the speed for capacity index 16 reduces above 0% capacity. The 15 additional curves are specified in 3mph steps ranging from free flow speeds of 26mph up to 68mph.

2.2.11 These new capacity indices (26 to 40) have been applied on rural routes in Argyll, the Highlands, Aberdeenshire and Perthshire, while capacity index 32 (44mph free flow speed) has also been applied to all zone connector links in the model. The TTAA requested clarification from MVA regarding the rationale for the change to the zone connector links in TMfS05A compared with TMfS05.

2.2.12 MVA has commented in response that:

> *"This change to the zone connectors was a result of the introduction of additional speed flow curves. The link times on zone connectors are relatively arbitrary values based on local geography and the slight change in speed will have a negligible impact. This will, however, be amended in the next release version of TMfS".*

The TTAA acknowledges that the change in zone connector methodology will have a negligible impact, nevertheless, continuing users of TMfS should note this subtle change between the two versions of the model.

2.2.13 The TTAA has reviewed the coding of these new indices on a geographical basis and is content that the capacity index coding in TMfS05A is appropriate.

Link Distance Checks

2.2.14 A series of checks on the link length coding in TMfS05A has been undertaken. This included comparison with TMfS05 and range and logic checks to ensure that no unusually long or short links were coded. Table 2.5 of MVA's report compares the total coded length of motorway and trunk A roads with the *Scottish Transport Statistics Note 24* and this shows a good correlation for TMfS05A.

2.2.15 The comparison with TMfS05 shows that the majority of common links have the same length coded. The majority of changes to link lengths are relatively small and occur generally in the Highlands, Islands and Argyll and Bute areas of the model. MVA has confirmed that these link length changes are as a result of the network refinements in these areas, in particular to enable the coding of new capacity indices based on the Strategic Transport Projects Review journey time routes. The benefit of these changes is that they enable greater disaggregation of the network to reflect varying characteristics along surveyed routes (e.g. localised "urban" areas).

2.2.16 Range and logic checks examined the location and extent of the following:

- Links with coded length > 100km
- Links with coded length > 50km and < 100km
- Links with coded length > 10km and < 50km
- Links with coded length < 1km

2.2.17 The links with lengths in excess of 100km occur only sparingly and cover external motorway links in England and ferry links to Orkney, Shetland and the Western Isles. Link lengths of greater than 50km are also relatively scarce and cover medium distance ferry services and rural links (e.g. A697 in the Borders) and external links in England. The links with lengths in excess of 10km cover shorter ferry services and the majority of rural and inter-urban links. The vast majority of links with length less than 1km are in urban areas, or on connecting links where the physical detail of junctions is represented (e.g. grade separated motorway junctions).

2.2.18 The TTAA is content that the link lengths coded in TMfS05A are acceptable. Given the close correlation between modelled and measured distances in TMfS05 and the relatively minor changes that have occurred between TMfS05 and TMfS05A, the TTAA has not re-examined the cumulative route lengths along specific corridors for TMfS05A.

Modelled Junction Data

2.2.19 The modelled junctions in TMfS05A remain largely the same as those of TMfS05 with only minor updates during network refinement and to address previous audit issues. Given the nature of these updates a full review of junction coding across the TMfS05A network has not been undertaken by the TTAA.

2.2.20 Previous audit comments regarding junction coding were checked (Ref. Table 2.5 and §2.3.34 of *TMfS05 Model Development Audit – Final Report*, TTAA Ref. 67633, April 2007). The TTAA notes that the comment regarding the coding of the circulating carriageway at Raith roundabout have been addressed in TMfS05A. No action has been taken in respect of comments regarding the M8/A720 Hermiston Gait Interchange or the M9/M876 Interchange.

2.2.21 It is noted that the coding of the Marketgait/Seagate/Blackscroft/Princes Street/King Street quadrant in Dundee city centre has been refined in TMfS05A compared with TMfS05 and better represents the physical network in this area. The TTAA has identified some minor coding errors in this area as follows:

- King St/Marketgait junction – The movements between King Street east and west across Marketgait are bus only in reality. These have been coded as permissible for all vehicles in TMfS05A.
- Seagate/Blackscroft junction – The left turn from Blackscroft southbound into Blackscroft/Broughty Ferry Rd eastbound is banned in reality but has been coded as permissible in TMfS05A.
- Seagate/Blackscroft junction – The right turn from Blackscroft westbound into Blackscroft/Princes St northbound is banned in reality but has been coded as permissible in TMfS05A.

2.2.22 These minor coding errors will have no impact on the operation of TMfS05A as a whole and are not considered significant by the TTAA. Nevertheless, users should note these localised discrepancies if examining model outputs in detail in these areas. **The TTAA would recommend that these coding discrepancies be rectified at the next major upgrade of TMfS**.

2.2.23 As was the case for TMfS05, notwithstanding the coding issues identified in the TMfS05A audit, the TTAA is generally satisfied that the junction coding is appropriate for TMfS05A. **During the next major update of TMfS, the junction coding, particularly on the strategic network, should be thoroughly reviewed prior to the widespread application of TMfS. This could be a relatively inexpensive task which would enhance the integrity of the network without significantly affecting the assignment in the base year. Furthermore, this would enhance the confidence in the network's ability to predict costs robustly in future years**. The TTAA acknowledges that the next major release of TMfS (TMfS07) will have a different structure with a high level, national model, possibly supported with more detailed local or regional models. The above recommendations would more likely be addressed in the local or regional models rather than the national model.

Representation of Ferry Fares

2.2.24 The representation of ferry fares is commented upon in Chapter 3 regarding the Public Transport Assignment Model.

Additional Checks by TTAA

2.2.25 The TTAA has undertaken a series of additional checks on the network coding to ensure consistency and robustness. Firstly, the consistency of the link coding characteristics was checked between time periods and this confirmed that all characteristics (link type, capacity index, length etc.) are consistent in the AM, inter and PM peaks. A check was also undertaken for two-way links to ensure that the link lengths were common in each direction, which was shown to be the case for TMfS05A.

2.2.26 Checks were also undertaken to ensure that other issues from the TMfS05 audit were addressed. Firstly, comments regarding the coding of new road schemes from the TMfS05 audit were checked (Ref. §2.3.5 of *TMfS05 Model Development Audit – Final Report*, TTAA Ref. 67633, April 2007). It is evident that the A9 Glenbervie slips connecting to the M876 and the M8 J21 Seaward Street scheme have both been removed in TMfS05A having been incorrectly included in TMfS05. The two following minor issues from the TMfS05 audit do remain:

- Ravenscraig link roads – The TTAA notes that the link type has correctly changed to Type 5 in TMfS05A having previously been Type 3. In terms of its capacity it has been coded as a single carriageway along its entire length. The northern section of the link road should be coded as a dual carriageway (between nodes 13378 and 13384).

- Glasgow Southern Orbital (GSO) – This is coded appropriately along its route. It should be noted that the eastbound on/off slips which connect Redwood Crescent with the A726 GSO (and the corresponding eastbound on-slip opposite) have not been included in the network. These slip roads are likely only to carry specific development traffic which will all gain access in TMfS05 via the all-ways grade separated junction which connects Redwood Drive with the GSO. The exclusion of these slips is unlikely to be a significant issue for most applications, however, users requiring detailed outputs in this area should bear this simplified coding in mind when analysing model outputs.

2.2.27 These issues are unlikely to materially affect TMfS05A during application, but should be considered for amendment amendments during the next major upgrade of TMfS.

2.2.28 Checks were also undertaken to ensure that links had been assigned the appropriate jurisdiction code. This was undertaken by visually inspecting the network using a GIS to group links together by jurisdiction code and to identify any physical outliers. Following this process the TTAA was content that the jurisdiction codes have been appropriately assigned in TMfS05A.

2.3 Matrix Development

Introduction

2.3.1 The TMfS05A matrices were enhanced by the following processes:

- Conversion to TMfS05A zoning system
- Incorporation of new RSI data for Dundee/TACTRAN and Ayrshire areas
- Matrix estimation

2.3.2 Within the timeframe for developing TMfS05A this methodology is considered appropriate. Readers of this audit should note that, while the network and zoning have been refined, the travel demands in the extended model area (Argyll and Bute, the Highlands and Islands) have not been refined with new RSI data in the development of TMfS05A.

Change in Zoning System

2.3.3 The zoning system in the Highlands, Argyll and Bute and Islands has been refined in TMfS05A to enable a better representation of travel costs nationally. The zones have been split consistent with census output areas based on a review of significant settlements within the existing TMfS05 zones. An additional 29 zones have been created expanding the zoning system for TMfS05A to contain 1,162 zones.

2.3.4 The expanded zoning system has been created by disaggregating zones in the Argyll and Bute and Highland regions on the mainland and by representing certain islands individually rather than collectively, as was the case with TMfS05. The TTAA has reviewed the expanded zoning system and is content that this appears to have been created appropriately. Potential users of TMfS05A in the extended area should note the following issues:

- The expanded zoning system in TMfS05A is appropriate for a national, strategic model of this scale and nature, however, the zoning system, as a consequence of the sparse population in many parts of Argyll, the Highlands and Islands remains relatively coarse.

- The most populous islands for which ferry services have been included in TMfS05A have been represented individually, however, some of the smaller islands, although physically represented in the zoning system, remain grouped with a larger neighbouring island. This is the case for islands such as Barra (grouped with South Uist), Coll, Tiree, Rhum, Eigg, Muck and Canna (grouped with Mull) and Colonsay (grouped with Jura). Similarly, the Orkney and Shetland archipelagos are represented as two collective groups (i.e. one zone for each). As neither ferry services nor travel demand data for the smaller islands are represented, this has no bearing on the operation of TMfS05A. Nevertheless, users should be aware of the detail of the TMfS05A zoning system when considering application or interpreting model outputs.

2.3.5 The travel demand matrices were converted to the updated zoning system by splitting the TMfS05 travel demand using population data. The underlying travel pattern was retained from TMfS05, however, the proportion of trips in each new TMfS05A zone was split using the ratio of the population total relative to the population in the original TMfS05 zone. The TTAA is content that this approach is appropriate.

RSI Data

2.3.6 RSI data from three sources was available for TMfS05A as follows:

- TACTRAN (Dundee and surrounds), 16 sites from March/April 2007
- Ayrshire (SITM4), 18 sites from April 2007
- Kilmarnock (East Ayrshire Council), 8 sites from October/November 2006 (AM & PM only)

2.3.7 Three additional sites from the TACTRAN dataset were not used in the matrix development. These sites being:

- A85 Riverside Avenue prior to Apollo Way Junction
- A90 Dundee Kingsway at Gourdy Croft
- A90 South of Forfar at Gallowfauld

2.3.8 At all these sites, recent RSI data had previously been incorporated in TMfS. Prior to excluding this data, select link analysis was undertaken at the site locations and was compared with the new RSI site data. This showed very similar travel patterns, therefore MVA considered that the new RSI data would not significantly benefit the TMfS05A matrix development. The classified count data for these sites was, however, used in the model calibration.

RSI Data Processing

2.3.9 The RSI data processing involved checking for illogical movements. A high volume of illogical records were identified for the TACTRAN and Kilmarnock sites with a lesser volume in the SITM4 Ayrshire dataset. Illogical movements were identified and these records removed prior to calculating expansion factors. The TTAA requested MVA to supply details of the extent of these illogical records and how much data was therefore discarded, particularly for the TACTRAN and Kilmarnock sites. This demonstrated that:

- Of the total of 19 TACTRAN sites, five sites had 6% or less illogical movements, a further five sites had between 9% and 15% illogical movements and the remaining nine sites had between 17% and 36% illogical movements. Overall approximately 13% of the total TACTRAN data was discarded.
- Of the total of 8 Kilmarnock sites, six sites had 8% or less illogical movements with the other two sites having 12% and 13% illogical movements respectively. Overall approximately 8% of the total Kilmarnock data was discarded.

- Of the total of 18 Ayrshire sites, 17 sites had 5% or less illogical movements (mainly <5%) while the remaining site had 9% illogical movements. Overall approximately 2% of the total Ayrshire data was discarded.

2.3.10 The RSI data was then processed to create matrices for each site as follows:

- Append TMfS05A origin zone and destination zone attributes to each RSI record
- Aggregate the RSI records to form interview direction record matrices for each time period and user class – AM includes records between 0700-1000 hours, IP 1000-1600 hours, PM 1600-1900 hours
- Transpose the interview direction record matrices to create reverse direction matrices - AM interview matrices transposed to represent the PM reverse, IP interview matrices transposed to represent the IP reverse, PM interview matrices transposed to represent the AM reverse
- Calculate matrix expansion factors for each time period and vehicle type based on the record matrix totals and the corresponding count data
- Expand each time period/user class/direction matrix to the observed count, using the calculated expansion

2.3.11 Two TACTRAN sites in central Dundee had no inter-peak count data and factors derived from neighbouring sites were applied to equivalent AM peak counts at the sites. The RSI site on the A78 (T) south of Pennyburn had missing data in the evening peak and, therefore, the inter-peak and evening records where combined before calculating the expansion factors. At a number of sites the expansion factors for heavy goods vehicles and to a lesser extent light goods vehicles were very high as few RSI records were available. In these instances data patching was undertaken and records from neighbouring sites were copied to obtain a better representation of the travel pattern. While, ideally, complete records would be available for all locations and time periods, this is often not the case and the remedial action taken to address these shortfalls is considered acceptable.

2.3.12 The TTAA is satisfied that the described RSI data processing methodology was appropriate for TMfS05A. Users should note the generally high level of discarded, illogical data from the TACTRAN and to a lesser extent Kilmarnock RSI datasets.

Prior Matrix Development

2.3.13 The prior matrix was created by incorporating the processed RSI data into the previous TMfS05 matrix. The TMfS05 matrices were firstly converted to the TMfS05A zoning system and the RSI data incorporated in a five stage process as follows:

- For the TACTRAN RSI sites on the A93 south of Blairgowrie and on the A94 north of Scone Airport, select link matrices were derived from TMfS05 and these trips were removed in the TMfS05 matrix and replaced with the RSI data.
- For the TACTRAN RSI site on the A90 North of Forfar, trips between Forfar and zones south of Aberdeen were selected for the RSI matrix and replaced the equivalent movements in the TMfS05 matrix. Based on the site location it was considered that only trips between Forfar and zones south of Aberdeen would be fully observed as other movements would possibly use alternative routes.
- The 13 RSI sites in Dundee formed a fully observed cordon, which replaced the equivalent movements in the TMfS05 matrix.

- The 18 RSI sites in Ayrshire were combined into five screenlines and fully observed movements were identified for each. The screenlines were then combined to form a complete observed Ayrshire RSI matrix and potential multiple observed movements were factored to obtain the average number of trips across the screenlines. The TMfS05 matrix was then replaced with the Ayrshire RSI matrix for fully observed movements.
- The eight RSI sites in Kilmarnock formed a fully observed cordon, which replaced the equivalent movements in the TMfS05 matrix.

2.3.14 Overall, the described methodology is considered appropriate.

Matrix Estimation

2.3.15 A matrix estimation procedure was undertaken in calibrating the assignment process. The input data sources and confidence levels applied were as follows:

- Prior matrix (with a confidence of 100 for TMfS05 movements and 75 for TMfS05A RSI movements)
- Trip end data (with a confidence of 40)
- Routeing paths
- Traffic counts (with an initial confidence of 100 for counts used to develop TMfS05 and 75 for new TMfS05A RSI counts)

2.3.16 MVA has clarified that:

> *"A higher confidence interval was applied to the older RSI and count data in order to retain as much of the existing travel pattern as possible in areas away from the new RSI sites. In addition the new count data is from 2006/2007 while the model base year is 2005".*

Generally, the TTAA is content these inputs are appropriate for undertaking a matrix estimation procedure.

2.3.17 The count data used in the matrix estimation was that used in the development of TMfS05 with the addition of the manual classified counts undertaken at the TMfS05A RSI locations. The resulting calibration is discussed later in this document.

Matrix Development Comparisons

2.3.18 Tables have been presented in MVA's report to demonstrate the matrix changes on a 14 sector basis, consistent with corresponding analysis for TMfS05. The comparisons represent the TMfS05, TMfS05A Prior Incorporating RSIs (Prior meaning before MVESTM) and Final Road Traffic matrix totals.

2.3.19 MVA made the following observations on the matrices:

- Inclusion of the RSI data in the prior matrix increases the volume of trips within Ayrshire in all three time periods with a reduction in trips to external sectors and a net increase overall
- Inclusion of the RSI data in the prior matrix increases the volume of trips to/from Dundee in the morning and inter peak periods with a reduction in the evening peak
- Overall, the change in the matrix from the prior matrices to the final post-MVESTM matrices in absolute terms is small

2.3.20 In addition, the TTAA notes that:

- The changes as a result of introducing the RSI data only affect movements to, from or between the Ayrshire, Dundee and Perthshire sectors as expected
- During matrix estimation, trips to and from Lothian in particular, but also Edinburgh, Fife and Central are all shown to decrease
- During matrix estimation, intra-Glasgow trips increase in all time periods
- During matrix estimation, intra-North East sector trips decrease in all time periods

2.3.21 The TTAA requested some commentary and clarification from MVA regarding the rationale for the changes in the above sector movements as a result of matrix estimation. Lothian, for example, is quite remote from the areas where any new RSI and/or count data has been introduced and would be expected to remain largely consistent between TMfS05 and TMfS05A. MVA commented that:

2.3.22 *"The matrix estimation process is controlled as far as possible to retain the existing travel pattern and volumes in areas where no new count data is added. The process will, however, continue to adjust the matrix to better match observed data in all areas, if only slightly. The changes to the matrix are not considered to be significant, and this is demonstrated when considering the calibration to count data".*

2.3.23 To examine this issue in further detail the TTAA undertook comparisons of the link flow calibration in Edinburgh and the Lothians between TMfS05 and TMfS05A. In most locations the link flow calibration is similar between the two versions of the model with a general, slight improvement in TMfS05A.

2.3.24 As an additional check the TTAA examined the changes between each stage of matrix development (i.e. pre to post RSI data inclusion then pre to post matrix estimation) to identify any changes in sector totals that could be considered "significant". A "significant" difference was classified as one where the absolute change in the intra or inter-sector trip total was $\geq$100PCUs and the percentage difference was $\geq$15%. It is encouraging to note that no movements were identified as having undergone a "significant" change either as a result of introducing the RSI data or following matrix estimation.

2.4 Assignment Model Development

Introduction

2.4.1 The assignment procedure for TMfS05A is a volume averaged capacity restraint assignment based on All or Nothing (AoN) paths at each iteration. This is the same as that adopted for TMfS05 and includes the assignment of the four user classes (Car in work, Car non-work, LGV and OGV) with the assignment itself adopting the 'Cost versus Time' (CvT) Davis method which allows for the modelling of tolls during the main assignment.

2.4.2 The TTAA's findings on the assignment model development are outlined as follows.

Assignment Procedure

2.4.3 The assignment procedure, as per TMfS05, operates in an iterative manner assigning trips to AoN paths for n iterations until a predetermined convergence level is achieved. The flows are averaged over all paths and iterations to produce a volume averaged assignment upon model convergence.

2.4.4 This procedure is most appropriate for congested urban situations where multi-routeing is evident based on changing travel costs due to congestion. It is rightly pointed out by MVA in §4.2.3 that:

> *"...an uncongested rural area will tend to give mono-routeing results because the low level of traffic compared with capacity and the reduced routeing choices. As a result, the optimum paths on the first iteration will remain optimum throughout the assignment".*

This point should be noted by users of TMfS for any assessment which involves examination of flows in rural areas.

2.4.5 The TTAA is content that the volume averaged capacity restraint assignment method adopted for TMfS05A is appropriate.

Cost versus Time Assignment Method

2.4.6 This assignment methodology which was incorporated within TMfS02 to enable tolling tests to be undertaken without the requirement to develop a separate tolling model and has remained the approach in TMfS05 and TMfS05A. The methodology adopted is based on the paper *Cost versus Time Equilibrium over a Network* by Fabien Leurent published in the European Journal of Operational Research. The principle of this method is that the willingness to pay tolls is varied between iterations by randomly sampling from a distribution that represents the whole population and is similar to a stochastic user equilibrium process.

2.4.7 The advantage of this method is that it negates the requirement to further disaggregate the assignment to represent differing willingness to pay bands. A single, consistent version of the model is used for all applications whether concerned with tolling or not. The TTAA acknowledges the advantages of the adopted assignment methodology in this regard.

2.4.8 Overall, the TTAA is content that the CvT assignment technique is an appropriate one to use for TMfS05A. The principles of the methodology outlined in Section 4.3 of MVA's report are considered to be reasonable. The distributions from which the willingness to pay for each user class are randomly sampled remain the same between TMfS05 and TMfS05A.

Model Convergence

2.4.9 The convergence methodology and criteria remain the same in TMfS05A as they were for TMfS05. The road traffic assignment model is therefore considered to have converged when the regression statistic is less than or equal to 1% on three successive iterations. The number of iterations needed for convergence in TMfS05A are:

- AM Peak 68 iterations (TMfS05 - 77 iterations)
- Inter-peak 30 iterations (TMfS05 -36 iterations)
- PM Peak 67 iterations (TMfS05 - 68 iterations)

2.4.10 This shows a generally small decrease in the number of iterations needed for convergence in TMfS05A compared to TMfS05 in all time periods. This is considered to be in the expected range for a model the scale of TMfS and with the level of user class disaggregation inherent in the model.

2.5 Model Calibration

Introduction

2.5.1 TMfS05A was subject to a wide area calibration process by comparing modelled and observed traffic flows at the RSI locations. A total of 739 sites were used in the calibration process in the AM and PM peaks and 723 in the inter-peak (as the Kilmarnock RSIs did not cover this period). Comparisons have been undertaken for individual link flows and screenline flows using the GEH statistic. *DMRB* Vol. 12, Section 2, Part 1 sets out the traffic assignment validation acceptability guidelines (Ref. Table 4.2 in the above section of *DMRB*). These guidelines are ideal standards for comparing modelled to observed flows for assignment modelling. These guidelines are replicated in Table 2.1.

Table 2.1 : DMRB Validation Criteria

Criteria and Measures	
Assigned Hourly Flows compared with observed flows	
1. Individual flows within 15% for flows 700-2,700vph	)
2. Individual flows within 100vph for flows < 700vph	) > 85% of cases
3. Individual flows within 400vph for flows > 2700vph	)
4. Total screenline flows (normally > 5 links) to be within 5%	All (or nearly all) screenlines
5. GEH Statistic	
i) individual flows: GEH < 5	>85% of cases
ii) screenline (+) totals: GEH < 4	All (or nearly all) screenlines
Modelled Journey Times compared with observed times	
6. Times within 15% (or 1 minute if higher)	> 85% of routes

2.5.2 As with TMfS02 and TMfS05, rather than strictly considering the *DMRB* guidelines as "pass" or "fail" criteria, MVA adopted a series of calibration targets which they consider better reflected the scale and intended purpose of TMfS05A. These targets for link flow and screenline comparisons are:

- GEH < 5 – 60% of all sites (*DMRB* guidance is 85%)
- GEH < 7 – 80% of all sites
- GEH < 10 – 95% of all sites
- GEH < 12 – 100% of all sites

2.5.3 These targets are consistent with those adopted for TMfS05 and the TTAA therefore considers them appropriate for TMfS05A. The less stringent nature of the adopted calibration targets compared with *DMRB* guidelines should, however, be noted.

Key Strategic Screenline Flows

2.5.4 Three key strategic screenlines were defined in the TMfS05A area:

- Forth Estuary (Forth Road Bridge, Kincardine Bridge and the Forth crossing at Stirling)
- River Clyde
- River Tay

2.5.5 Table 2.2 presents the observed versus modelled GEH values for all three strategic screenlines for all three time periods for both TMfS05 and the corresponding values for TMfS05A.

Table 2.2 : TMfS05 and TMfS05A Key Strategic Screenline Flow Comparisons

			GEH	
Screenline	Direction	Period	TMfS05	TMfS05A
Forth Estuary	Northbound	AM	0.6	0.3
		IP	0.2	0.1
		PM	5.2	4.4
	Southbound	AM	1.5	0.6
		IP	5.0	3.8
		PM	2.1	1.1
Clyde	Northbound	AM	2.3	3.8
		IP	3.2	2.3
		PM	2.1	3.0
	Southbound	AM	12.5	11.7
		IP	4.9	7.2
		PM	5.0	8.5
Tay	Northbound	AM	3.8	3.6
		IP	0.7	3.1
		PM	2.7	2.3
	Southbound	AM	4.3	5.3
		IP	0.2	1.6
		PM	4.1	1.8

2.5.6 The first point of note is that all three screenlines demonstrate a similar level of calibration in TMfS05A compared with TMfS05, as would be expected given the nature of the updates incorporated.

2.5.7 The Forth Estuary screenline (screenline 17 and 117 in MVA's report) covers the Forth Road Bridge, the Kincardine Bridge and the Forth crossing at Stirling. The model demonstrates good calibration across the screenline in both directions in all time periods with GEH values all lying in the range between 0.1 and 4.4.

2.5.8 The Clyde strategic screenline (screenline numbers 246 and 346) covers all river crossings from Albert Bridge in the east to the Erskine Bridge in the west. This screenline demonstrates a generally good level of calibration in the northbound direction with all GEH values 3.8 or less. Generally, the calibration in the southbound direction is poorer with GEH values ranging between 7.2 and 11.7. The AM peak southbound GEH has the highest value of 11.7, largely due to a significant overestimate of flow (approx. +800 PCUs) on the Kingston Bridge. This is also true of the Inter-peak period where the flow is overestimated by approx. +850 PCUs and the PM peak where the flow is overestimated by approx. 900 PCUs.

2.5.9 Similar issues were discussed during the TMfS05 audit, at which point MVA stated that:

> *"As part of the TMfS05 rebase new count data was used to enhance the existing model data. In this instance, the count is significantly lower than the forecast growth in flow. Part of the reason for this is due to the unavailability of 2005 count data in certain locations and therefore, 2002 data has been used which may underestimate the actual conditions. An additional point that must be noted is that due to the removal of restrictions in the Kingston Bridge area, the individual screenline locations have been updated".*

2.5.10 The TTAA continues to acknowledge MVA's comments regarding data availability and the use of the 2002 data on the Kingston Bridge. Nevertheless, given that the data used in this instance was presumably the most robust information available, the significant overestimate of southbound flow across the Kingston Bridge in all time periods should be noted by potential users of TMfS05A. **The TTAA would recommend that steps are taken at the next major upgrade of TMfS to attempt to address this apparent overestimate of flow on what is a key link in Scotland's trunk road network**.

2.5.11 As was the case with TMfS05, when considering the individual links which make up the Clyde screenline, in the northbound direction in the AM, even though an overall GEH of 3.8 is achieved, on an individual basis the GEH values on links are as high as 9.8. There has been an improvement in TMfS05A in the overall balance of northbound flows on individual links, particularly through the Clyde Tunnel. Similarly, there has been an overall improvement in the individual northbound link flows in the inter-peak with the exception of Gorbals Street. In the PM peak there has also been an overall improvement in the individual northbound link flows although there remains a significant underestimate of flow on Commerce Street, which is counter-balanced to some extent by an overestimate on Gorbals Street.

2.5.12 During the TMfS05 audit MVA stated that *"The main reason for this variability is the use of some new count data (where possible) and the use of old, 2002 count data"*.

2.5.13 Again the TTAA continues to acknowledge MVA's comments regarding data availability and the use of a mixture of old and new data on the screenline and also that general improvements have been made in TMfS05A compared with TMfS05. Nevertheless, given that the data used in this instance was presumably the most robust information available, the variability in the level of calibration on the individual links comprising the Clyde Strategic Screenline should be noted by potential users of TMfS05, particularly during the AM and PM peaks. **The TTAA would recommend that steps are taken at the next major upgrade of TMfS to obtain a consistent, robust observed dataset for calibration across this key screenline**.

2.5.14 The Tay strategic "screenline" (screenline 27 and 127) in fact covers only the Tay Bridge, however, the level of calibration is demonstrated to be good in both directions in all time periods with GEH values falling in the range 1.6 to 5.3.

2.5.15 Overall, the strategic screenline calibration comparisons, considering total screenline flows, demonstrate a good level of calibration in most cases in TMfS05A. More than half of the screenline values better their TMfS05 value and only two screenlines (Clyde IP & PM Southbound) show a significant worsening in GEH value from the corresponding TMfS05 value.

Other Screenline Flows

2.5.16 The other calibration comparisons undertaken have concentrated on what are termed as "key links" and "multi-point" screenlines. The key links cover the major key trunk and principal roads within the TMfS05A model area. The multi-point screenlines consider groups of individual link flows that have been combined to form screenlines. In some cases, the individual key link flows are included in these screenlines. The key link flow calibration is demonstrated for TMfS05A in Table 2.3, with the TMfS05 figures shown in brackets.

Table 2.3 : Key Link Flow Calibration

Time Period	% of site with GEH value:									
	≤ 5		≤ 7		≤ 10		≤ 12		≤ 15	
Target	60%		80%		95%		100%		100%	
	TMfS05A	**(05)**	**TMfS05A**	**(05)**	**TMfS05A**	**(05)**	**TMfS05A**	**(05)**	**TMfS05A**	**(05)**
AM	**68**	(62)	**81**	(78)	**93**	(89)	**97**	(95)	**100**	(100)
IP	**80**	(79)	**91**	(90)	**98**	(96)	**99**	(99)	**100**	(100)
PM	**66**	(66)	**83**	(79)	**94**	(91)	**100**	(95)	**100**	(99)

2.5.17 The key link flow calibration table demonstrates that the targets are met in almost all cases for all time periods. Only the GEH ≤10 (AM and PM) and GEH ≤12 (AM and IP) targets are narrowly missed. Globally across the network, this demonstrates an acceptable level of calibration to link flows for a model of the scale and nature of TMfS05A. In relation to the calibration of TMfS05, the TMfS05A results are the same as or better than TMfS05 in all categories with a general improvement in most categories.

2.5.18 The multi-point screenline analysis summary is presented in Table 2.4.

Table 2.4 : Multi-Point Screenline GEH Analysis

Time Period	% of site with GEH value:									
	≤ 5		≤ 7		≤ 10		≤ 12		≤ 15	
Target	60%		80%		95%		100%		100%	
	TMfS05A	**(05)**	**TMfS05A**	**(05)**	**TMfS05A**	**(05)**	**TMfS05A**	**(05)**	**TMfS05A**	**(05)**
AM	**60**	(62)	**74**	(77)	**87**	(91)	**93**	(97)	**97**	(100)
IP	**67**	(67)	**83**	(71)	**95**	(94)	**98**	(99)	**100**	(100)
PM	**60**	(62)	**75**	(75)	**88**	(90)	**94**	(96)	**97**	(99)

2.5.19 This demonstrates that the inter-peak model meets or almost meets every target while the AM and PM model meets the ≤5 target, narrowly failing to meet all other targets. At a global level, the TTAA considers this to be an acceptable level of calibration for TMfS05A. Compared with the corresponding TMfS05 calibration values, the TMfS05A values are the same or better than the TMfS05 values in five of the 15 cases across all time periods with the remainder showing a slight worsening.

2.5.20 The global level of calibration for all of the counts used in the TMfS05A road traffic assignment model calibration is presented in Table 2.5, along with the corresponding level of calibration achieved for TMfS05.

Table 2.5 : Global Link Flow Calibration GEH Analysis

Time Period	% of site with GEH value:									
	≤ 5		≤ 7		≤ 10		≤ 12		≤ 15	
Target	60%		80%		95%		100%		100%	
	TMfS05A	**(05)**	**TMfS05A**	**(05)**	**TMfS05A**	**(05)**	**TMfS05A**	**(05)**	**TMfS05A**	**(05)**
AM	**62**	(60)	**74**	(74)	**88**	(88)	**94**	(94)	**98**	(99)
IP	**73**	(72)	**86**	(84)	**96**	(95)	**98**	(99)	**100**	(100)
PM	**61**	(62)	**76**	(76)	**88**	(89)	**95**	(93)	**98**	(98)

2.5.21 Analysis of the global link flow calibration shows that the inter-peak period achieves the calibration targets on all but the ≤ 12 target. The AM and PM periods only meet the calibration criteria for the ≤ 5 target. For the majority of the criteria over all three periods, the TMfS05A calibration at a global level is very similar to that reported for TMfS05. Overall, the TTAA considers that for TMfS05A the inter peak model is well calibrated and that the AM and PM peak models are considered to be generally acceptable at a global level.

Calibration At New RSI Sites

2.5.22 The TTAA has undertaken an independent check by looking at the level of calibration achieved in the areas where the new RSI data has been incorporated for Kilmarnock, Ayrshire and Dundee & Perthshire. The TTAA has the following comments to make:

- The calibration across the Dundee city centre screenline as a whole (screenlines 601 & 701) is reasonable in the AM peak inbound and in the inter and PM peaks in both directions but is poorer in the AM peak outbound.
- The level of calibration achieved on the individual links comprising the Dundee city centre screenline is extremely variable in all time periods.
- The calibration across the Riverside Avenue/A90 Kingsway screenline as a whole (screenlines 602 & 702) is reasonable in the AM peak inbound and in the inter and PM peaks in the outbound direction. There is a general tendency for flows to be overestimated on this screenline with the one exception being the inbound Riverside Avenue AM peak flow which is underestimated.
- The calibration at the other A90, A93 and A94 sites in the TACTRAN area is generally good in all time periods.
- The level of calibration at the individual Ayrshire area RSI sites (screenlines 607 to 623 and 707 to 723) is variable in all directions and across all time periods. Between 1/3 and 2/3 of individual sites demonstrate a GEH of >5 considering each time period and direction.
- The calibration across the Kilmarnock screenline as a whole (screenline 624 & 724) is reasonable in the AM peak outbound but is poorer in the AM peak inbound and in the PM peak in both directions. Again, there is considerable variability on the individual links which comprise the screenline in both the AM and PM peaks in either direction.

2.5.23 Given that these sites all represent locations where recent RSI and classified count information was available for matrix development the reasons for the variability in the level of calibration achieved at these individual locations was unclear. The TTAA requested further commentary from MVA to explain the reasons behind the variable level of calibration that has been achieved at these new RSI locations. MVA commented that:

2.5.24 "*Agreed that the level of calibration achieved at the new RSI locations is variable. This is a result of the spatial detail in the model in these locations where the zone connectivity and network detail is relatively sparse. Overall the level of calibration achieved is considered acceptable*".

2.5.25 The TTAA acknowledges that the sparse network and zoning detail can lead to difficulties in achieving a high level of link flow calibration on individual links. The potential implications of this should therefore be considered prior to any specific application of TMfS05A and it is anticipated that this would be achieved through the user request process.

2.5.26 Additional, more detailed comments were made in the TMfS05 audit regarding the presentation of calibration statistics for TMfS. The TTAA considers that these should be taken into consideration at the next major upgrade of TMfS.

2.6 Validation

Introduction

2.6.1 Validation was undertaken by comparison with independent data sources and examining the trip patterns in more detail. The model validation concentrated on the following analysis:

- Journey time comparisons
- Independent traffic flow comparisons using data not used in calibration
- Trip length distribution analysis
- HGV screenline analysis

2.6.2 The TTAA's findings from the review of the validation chapter of the report are outlined in the following sections.

STPR Journey Time Survey Routes

2.6.3 Journey time surveys were undertaken on a series of routes in the Argyll and Bute, Highland and Perthshire areas as part of the STPR. A total of 20 routes were surveyed with observed times ranging from approximately 11minutes (Perth to Dunkeld) to over two hours (Tarbet to Campbeltown). The majority (18 out of 20) of the STPR journey time routes had observed times of approximately 30minutes or more with around 40% of the observed times being in excess of one hour. The routes represent significant lengths of inter-urban/rural roads with differing characteristics.

2.6.4 The modelled journey times were compared against the observed average and the match was shown to be good for all 20 routes in both directions with *DMRB* criteria being satisfied. This represents a good level of journey time validation in the extended model area (Argyll & Bute, Highlands and Perthshire) along the surveyed routes. It should be noted that a good match between modelled and observed times would be expected on these routes, as the journey time data was itself used in defining the more detailed capacity indices (speed/flow curves) introduced in TMfS05A specifically in the extended model area.

2.6.5 While the STPR journey time comparisons are not entirely independent they do reflect a very good match between modelled and observed data. No statistical analysis of the observed data is presented, so the sample sizes and the degree of variability of the STPR observations are unknown. Observations would generally be expected to show relatively lower variability in rural rather than urban areas.

Further Journey Time Validation

2.6.6 Additional journey time validation was undertaken by comparing the modelled values against the same 59 observed routes used in validating TMfS05. It is recognised by the TTAA that the majority of observed data was inherited from TMfS02 and that no factoring has been undertaken to convert this to a common 2005 base. Furthermore, changes have occurred along some of the journey time routes since they were surveyed which are incorporated in the model and this may affect the comparisons to a greater or lesser extent.

2.6.7 MVA has presented comparisons of the modelled journey times against the observed mean with 95% confidence intervals of both the sample as a whole and the mean of the sample and against *DMRB* criteria. At a global level, 70%, 81% and 71% of the journey times satisfy *DMRB* acceptability criteria in the AM, inter and PM peaks. This is very similar to TMfS05 and is considered an acceptable level of global journey time validation for a model such as TMfS05A.

2.6.8 A further breakdown of the results is presented in four groupings for Edinburgh Urban, Glasgow Urban, Aberdeen Urban and inter-urban classifications. The inter-peak journey time comparisons are good across all classifications of urban and inter-urban with a minimum of 75% of routes meeting *DMRB* criteria. The urban journey time comparisons tend to demonstrate a lower level of validation in the AM and PM peaks with between 50% (Edinburgh AM) and 75% (Aberdeen AM and PM) of routes matching *DMRB* criteria. The inter-urban comparisons are generally good in all time periods with a minimum of 93% of routes matching the *DMRB* criteria.

2.6.9 MVA has further disaggregated the longer, inter-urban comparisons by dividing each route into 3 segments. Generally, the comparisons are good on the segments and along the inter-urban routes as a whole.

2.6.10 Overall, the TTAA is satisfied that the level of journey time validation achieved is acceptable for TMfS05A. The comparisons on the STPR routes and the historical inter-urban routes are generally very good. While the *DMRB* recommended criteria are not satisfied in all cases, this is mainly in the urban areas in the AM and PM peaks as would be expected. There could be a number of reasons for this including the age and variability of the observations, network changes since the data was collected, factors not explicitly modelled and the level of calibration in some local urban areas.

Independent Flow Validation

2.6.11 A total of 1,372 one-way counts not used during calibration were instead used to provide an independent flow validation exercise for TMfS05A. The results of this comparison at a global level are presented in Table 2.6, along with the corresponding figures from TMfS05.

Table 2.6 : Independent Flow Validation Comparisons

Time Period	% of site with GEH value:									
	≤ 5		≤ 7		≤ 10		≤ 12		≤ 15	
Target	60%		80%		95%		100%		100%	
	TMfS05A	**(05)**	**TMfS05A**	**(05)**	**TMfS05A**	**(05)**	**TMfS05A**	**(05)**	**TMfS05A**	**(05)**
AM	**48**	(48)	**65**	(65)	**82**	(84)	**89**	(92)	**97**	(98)
IP	**60**	(60)	**75**	(77)	**90**	(91)	**95**	(97)	**99**	(100)
PM	**49**	(50)	**65**	(65)	**84**	(84)	**92**	(93)	**98**	(99)

2.6.12 Similar to TMfS05, it can be seen that the TMfS05A validation only meets the ≤5 target in the Inter Peak with the AM and PM values being low. None of the validation statistics meet the target of GEH ≤10. Given the nature of TMfS05A, and the fact that the overall level of validation has remained largely unaltered from TMfS05, the TTAA considers this to be an acceptable level of independent validation.

2.6.13 The TTAA made additional, more detailed comments regarding the presentation of calibration/validation information in the audit of TMfS05. It is not the intention to repeat these here but the TTAA would recommend that these be considered at the next major upgrade of TMfS.

Trip Length Distribution Analysis

2.6.14 The trip length (cost) distributions for each assignment user class and time period are presented in Appendix M of MVA's report. These demonstrate intuitively correct trends with goods vehicles generally having a greater spread of trip costs compared with car trips. It is also encouraging to note that the post-MVESTM trip length distributions for car non-work, LGV and OGV do not appear to have altered significantly from the pre-MVESTM distributions. This provides some validation that the matrix estimation procedure has not unduly altered the trip pattern in the matrices (e.g. by unduly satisfying target counts in the estimation procedure by factoring up a larger number of shorter distance trips) for these journey purposes.

2.6.15 It is noticeable that the most significant changes to the trip length distribution are for the car in-work trips in the AM and PM peaks while all other distributions remain virtually the same. MVA subsequently confirmed that:

> *"…the matrix estimation process is undertaken using the car non-work assignment paths and a combined matrix containing all vehicle classes. Following the estimation process the individual vehicle class matrices are created using the original matrix proportions. Therefore, it is possible that the car in-work matrix will see a more significant change to the trip length distribution".*

The graphs, as presented in Appendix M, may also exaggerate the apparent effect of this due to differing scales adopted on the Y-axis between graphs. The TTAA would therefore recommend that consistent scales be adopted, if possible, for future presentation of such information.

HGV Screenline Analysis

2.6.16 HGV screenline analysis was undertaken for the screenlines used in the validation for instances where suitably classified count data was available. Table 2.7 shows the HGV screenline analysis for TMfS05A along with the corresponding TMfS05 values.

Table 2.7 : HGV Screenline Analysis

Time Period	% of site with GEH value:									
	≤ 5		≤ 7		≤ 10		≤ 12		≤ 15	
Target	60%		80%		95%		100%		100%	
	TMfS05A	**(05)**	**TMfS05A**	**(05)**	**TMfS05A**	**(05)**	**TMfS05A**	**(05)**	**TMfS05A**	**(05)**
AM	**63**	(54)	**77**	(68)	**88**	(82)	**92**	(92)	**96**	(93)
IP	**66**	(57)	**79**	(70)	**90**	(85)	**93**	(91)	**96**	(96)
PM	**66**	(59)	**78**	(73)	**90**	(88)	**95**	(94)	**98**	(97)

2.6.17 The TMfS05A values are generally better that the corresponding TMfS05 values. The GEH<5 target is met in all time periods while the other targets, although not met, are generally missed by a small margin. Overall, the HGV screenline analysis is considered acceptable for TMfS05A. Readers should refer to MVA's model development report for further, specific commentary on the HGV screenline analysis.

Car In Work, Car Non Work Analysis

2.6.18 Screenline analysis was undertaken for the screenlines used in the validation for instances where count data was available which was split suitably by journey purpose. It should be noted that no data split by journey purpose was used in the calibration process. The car in-work and car non-work screenline analysis is presented in Tables 2.8 and 2.9.

Table 2.8 : Car In-Work Screenline Analysis

Time Period	% of site with GEH value:									
	≤ 5		≤ 7		≤ 10		≤ 12		≤ 15	
Target	60%		80%		95%		100%		100%	
	TMfS05A	**(05)**	**TMfS05A**	**(05)**	**TMfS05A**	**(05)**	**TMfS05A**	**(05)**	**TMfS05A**	**(05)**
AM	**72**	(74)	**83**	(86)	**93**	(93)	**97**	(97)	**98**	(100)
IP	**80**	(78)	**90**	(91)	**96**	(98)	**96**	(98)	**98**	(100)
PM	**74**	(80)	**86**	(88)	**94**	(95)	**97**	(98)	**98**	(99)

Table 2.9 : Car Non-Work Screenline Analysis

Time Period	% of site with GEH value:									
	≤ 5		≤ 7		≤ 10		≤ 12		≤ 15	
Target	60%		80%		95%		100%		100%	
	TMfS05A	**(05)**	**TMfS05A**	**(05)**	**TMfS05A**	**(05)**	**TMfS05A**	**(05)**	**TMfS05A**	**(05)**
AM	**63**	(61)	**78**	(74)	**89**	(86)	**93**	(91)	**96**	(95)
IP	**67**	(67)	**85**	(81)	**94**	(95)	**96**	(97)	**98**	(98)
PM	**63**	(53)	**77**	(66)	**91**	(83)	**95**	(88)	**96**	(93)

2.6.19 This demonstrates a similar level of validation compared with TMfS05 with the GEH<5 target met in all time periods and the GEH<7 target met in most cases. This is considered to represent a good level of validation to user class specific data.

Census Travel to Work Data

2.6.20 A comparison has been presented between the AM peak TMfS05A peak hour matrix and the census travel to work data.

2.6.21 Post Matrix Estimation, the AM peak hour matrix was validated against 'Census Travel to Work' data. As was previously the case for TMfS05, TMfS05A tends to have slightly high proportions in the urban area and small proportions in the more rural areas. MVA reports that this is due to the finer zoning system in the urban areas with a more coarse zoning system in rural areas. The TTAA is satisfied this is the case and that in general the TMfS05A percentages compare favourably with those of the Census data, the only exception being the heightened TMfS05A productions and attractions to and from the City of Glasgow.

2.6.22 It is also stated in MVA's report that:

> *"It should be noted that the commuter matrix was extracted from the Base Year Non Work assignment matrix using factors from the Scottish Household Survey. These factors are only at a three sector level and hence this analysis is very coarse. It should also be noted that the factors from the Scottish Household Survey tend to be higher in the Glasgow area".*

2.6.23 More detail is provided in the appendices of MVA's report where the TMfS05A and census travel to work data is presented in a Local Authority by Local Authority matrix. Generally, the TMfS05A figures compare well with the census data, with a few exceptions which tend to involve trips in areas on the periphery of the model. Overall, the TTAA is content that the comparison between TMfS05A and the census travel to work data represents an acceptable match.

2.7 Conclusions and Recommendations

Conclusions

2.7.1 It is concluded in MVA's report that TMfS05A:

> *"…is particularly well calibrated in the key areas (trunk roads/motorways), it validates well in the vast majority of the modelled area. While it is less well calibrated in some rural areas, due to the large zones on the periphery of the modelled area and absence of quality observed data, the model still meets good standards of calibration.*

2.7.2 > *"The model validates well in the key areas against journey times and against the very large number of counts not included in calibration. "…Our view is that the HAM has been successfully developed and is fit for its intended purpose. "…The TMfS05A Highway Assignment Model can be used for the assessment of major strategic Highway schemes and policy decisions as part of the TMfS modelling suite. It is also fit for use as a source of travel demand and network structure for more localised models*".

2.7.3 Notwithstanding the commentary and recommendations made throughout this document the TTAA generally endorses MVA's conclusions.

Recommendations

2.7.4 MVA further recommends that:

> *"For future development, it is recommended that the highway matrices are enhanced using new RSI data. In particular, the collection of RSI data within Edinburgh is particularly dated and the model would benefit from inclusion of updated information.*

2.7.5 > *"Each potential application of the model should be assessed in detail prior to ensure that the quality of the model is appropriate for the desired output as the quality of data input and consequently output differs across the entire modelled area".*

2.7.6 In addition to the recommendations made elsewhere in this document and those made during the audit of TMfS05, the TTAA concurs with MVA's recommendations.

3 PUBLIC TRANSPORT ASSIGNMENT MODEL

3.1 Introduction

3.1.1 This chapter presents the TTAA's findings based on information supplied by MVA for the Transport Model for Scotland version 05A (TMfS05A) development audit Task 2: Review Public Transport Assignment Model Updates.

3.1.2 This audit has concentrated on reviewing the documentation relating to the TMfS05A Public Transport (PT) Assignment Model. The *Transport Model for Scotland 05A – Public Transport Calibration and Validation Report* (Draft version 2) was supplied to the TTAA in October 2007 for use in the audit process and much of the commentary in this chapter relates to that document. The PT networks were also supplied to the TTAA and where appropriate, commentary has also been made relating to any checks undertaken on these networks.

3.1.3 This chapter generally follows the same structure as MVA's report and deals with commentary relating to the model development and model validation.

3.2 Model Development

Introduction

3.2.1 Chapter 2 of MVA's report outlines the model development and in particular, the update of the network, zoning, PT lines and fares information. The main changes included in the TMfS05A PT assignment model are:

- Refinement of modelled PT network following the Audit of TMfS05 and application of the model, to improve network representation
- Extension of PT network into the Highlands and Argyll and Bute areas
- Addition of ferry links connecting PT infrastructure to represent the Scottish Islands including the Clyde estuary, Argyll and Bute, the Western Isles, Orkney and Shetland

3.2.2 The TTAA comments on each element of the network development are outlined in the following sections. The TTAA generally refers to the area of TMfS05A comprising Argyll and Bute, the Highlands and Islands as the "extended area" throughout this chapter.

Network Update

3.2.3 The TMfS05A PT network now includes a full representation of the Scottish PT network, whereas previously in TMfS05 the roads network was removed from the PT representation in the Highlands and Islands and Argyll and Bute. The network also now includes ferry links to all the islands including passenger only services.

3.2.4 The TTAA has undertaken checks on the PT network representation and coding in the extended model area. Given that information is not available to represent the PT travel demand in detail in the extended area the most important aspect is to ensure that the appropriate PT links and services are represented to provide the relevant PT accessibility within the Highlands and Islands and Argyll and Bute.

Ferry Links

3.2.5 One of the main elements of the PT network extension is the inclusion of ferry links to the islands. The TTAA has checked that the relevant ferry links have been included in TMfS05A and it is clear that the majority of key ferry links have been included. This covers the main

vehicle and passenger ferry links in the Firth of Clyde and between the mainland and the larger islands such as Islay, Mull, Bute, Skye, the Outer Hebrides, Orkney and Shetland. Some of the key inter-island ferry services are also represented (e.g. Islay-Jura, North Uist-Harris, Orkney-Shetland etc.).

3.2.6 Checks have been undertaken to ensure that the coded ferry link lengths are appropriate for each service and the TTAA is satisfied that this is the case. The TTAA is content that the main ferry links have been adequately represented in TMfS05A.

3.2.7 It is worthy of note that some of the smaller islands and/or shorter inter-island ferry services have not been represented in TMfS05A. For example, smaller islands such as Cumbrae, Colonsay and Tiree are not represented. Additionally, inter-island services within the Orkney and Shetland archipelagos are not represented. The TTAA does not consider the exclusion of these services significant within the context of a national model such as TMfS, however, potential users should be aware of their absence.

3.2.8 During the audit process, the TTAA requested clarification from MVA regarding the following points which should be noted by potential users:

- Services 9949 & 9950 are labelled as "Abe-Ler", presumably referring to the service between Aberdeen and Lerwick in Shetland. The service shown in TMfS, however, travels between Aberdeen and Orkney. MVA has confirmed that this is simply a labelling error which will be rectified at the next update of the model.
- Services 9947 & 9948 are labelled as "Abe-Kir", presumably referring to the service between Aberdeen and Kirkwall in Orkney. The service shown in TMfS, however, travels between Aberdeen and Shetland. MVA has confirmed that this is simply a labelling error which will be rectified at the next update of the model.
- Services 9941 & 9942, labelled as "Gil-Ork", travel on a differing link type than other services. MVA has confirmed that these represent the ferry service between Gill's Bay and St Margarets Hope. This service does not carry heavy goods vehicles and hence a Link Type 9 (Banned HGV) was allocated to reflect this restriction.

Rail Services

3.2.9 One of the limitations in the rail coding within TMfS05 was that the services were terminated at the edge of the detailed model area and did not extend into the Highlands and Argyll and Bute. This has been addressed in TMfS05A by extending the rail network to include services to Oban, Fort William, Mallaig, Kyle of Lochalsh, Wick and Thurso. While the TTAA has not undertaken an exhaustive review of all services and timetables coded, the general representation of the services within the extended model area appears to reflect the rail service coverage adequately.

Bus Services

3.2.10 The extension to the bus service coding in TMfS05A included the addition of:

- Stagecoach services in Aberdeenshire, Moray and the Highlands
- Bus services operating in Argyll and Bute and the Highlands and Islands

3.2.11 Having reviewed the extent of the bus coding in the extended model area it is clear that service provision has now been incorporated for many locations not previously served in TMfS05. This includes services to Campbeltown, Inveraray, Oban, Skye, Thurso, Brora etc. Additionally, services are represented on the most populous islands including the Outer Hebrides, Orkney, Shetland, Mull and Islay.

3.2.12 Similar to the rail services, while the TTAA has not undertaken an exhaustive review of all bus services and timetables coded, the general representation of the services in the extended model area appears to reflect the main service coverage adequately.

Summary of PT Service Extension

3.2.13 It is understood that the intention behind the extension and refinement of the PT network in TMfS05A is to enable accessibility analysis to be undertaken on a consistent basis nationwide. Within this context the extended PT service provision is considered adequate by the TTAA. As indicated in MVA's report, the extension of the PT network reflects only the supply side and no additional information relating to PT travel demand has been reflected in the TMfS05A PT matrices (compared with TMfS05). This places obvious limitations on the bounds of applicability of the TMfS05A PT model within the extended area. **Potential users should therefore note that TMfS05A was not designed for and could not be reliably applied in the detailed assessment of any demand related responses to PT network/service changes in the extended area of the model**.

3.2.14 A detailed examination of all PT services and timetables coded in the extended model area has not been undertaken given the limited bounds of applicability of TMfS05A outlined above. It is clear that the main PT services have been represented serving the most significant destinations in the extended model area, however, not all services which operate have been represented. This is considered acceptable given the detail, scope and limited bounds of applicability of TMfS05A. With respect to the ongoing development of TMfS, MVA has commented that:

> *"PT provision in the next significant upgrade of TMfS will be determined in similar manner with additional PT services added when they are supported by corresponding network detail. The scope of the model will be determined based on the anticipated application".*

Change in Zoning System

3.2.15 The zoning system in the Highlands, Argyll and Bute and Islands has been refined in TMfS05A to enable a better representation of travel costs nationally. The zones have been split consistent with census output areas based on a review of significant settlements within the existing TMfS05 zones. An additional 29 zones have been created expanding the zoning system for TMfS05A to contain 1,162 zones.

3.2.16 The expanded zoning system has been created by disaggregating zones in the Argyll and Bute and Highland regions on the mainland and by representing certain islands individually rather than collectively as was the case with TMfS05. The TTAA has reviewed the expanded zoning system and is content that this appears to have been created appropriately. Potential users of TMfS05A in the extended area should note the following issues:

- The expanded zoning system in TMfS05A is appropriate for a national, strategic model of this scale and nature, however, the zoning system, as a consequence of the sparse population in many parts of Argyll, the Highlands and Islands remains relatively coarse.

- The most populous islands for which ferry services have been included in TMfS05A have been represented individually, however, some of the smaller islands, although physically represented in the zoning system, remain grouped with a larger neighbouring island. This is the case for islands such as Barra (grouped with South Uist), Coll, Tiree, Rhum, Eigg, Muck and Canna (grouped with Mull) and Colonsay (grouped with Jura). Similarly, the Orkney and Shetland archipelagos are represented as two collective groups (i.e. one zone for each). As neither ferry services nor travel demand data for the smaller islands are represented, this has no bearing on the operation of TMfS05A. Nevertheless, users should be aware of the detail of the TMfS05A zoning system when considering application or interpreting model outputs.

3.2.17 The PT travel demand matrices were converted to the updated zoning system by splitting the TMfS05 travel demand using population data. The underlying travel pattern was retained from TMfS05, however, the proportion of trips in each new TMfS05A zone was split using the ratio of the population total relative to the population in the original TMfS05 zone. The TTAA is content that this approach is appropriate.

Fares Model

3.2.18 The fares model was updated to reflect fares for the new services added to TMfS05A, while all existing fares tables remain the same as those adopted in TMfS05. The fares tables are based on a boarding charge and a distance based fare table for differing PT operator types. The mode specific boarding fares remain unchanged from TMfS05. Ferry fares were obtained from operators and, in the case of multiple ticket types, assumptions were derived from the *Origin and Destination of Passengers and Freight on Strategic Sea Crossings Report*, prepared for HITRANS, Shetland Transport Partnership and Strathclyde Partnership for Transport (March 2007).

3.2.19 The TTAA acknowledges the difficulty of representing the variation in rail and ferry fares and ticket type combinations across the range of services represented in TMfS05A, particularly in the extended area of the model. The approach adopted in TMfS05A has been to separate the Clyde and West from the Orkney and Shetland ferry fares and to separate rail fares for Thurso and Wick from those in the remainder of the highlands. The TTAA considers this a reasonable approach to adopt given the likely application of TMfS05A.

3.2.20 The fares coded in the extended model area provide a reasonable estimate of likely fares and relative differences between the differing service types. The TTAA is therefore content that the fares model adopted for TMfS05A is appropriate given its likely application.

3.2.21 **Should further detail in Argyll and Bute, the Highlands and Islands be incorporated during the next major upgrade of TMfS, the TTAA would recommend that a more detailed fares model be considered. This could, for example, split the longer distance western island ferry fares (e.g. for Mull, Islay, the Outer Hebrides) from those in the Firth of Clyde and possibly further disaggregate bus and rail fares in the extended area from those in more densely populated areas**.

Assignment Model Structure

3.2.22 Aside from the fares model changes highlighted above, the PT assignment model and parameters remain unchanged from TMfS05. The TTAA is satisfied with this approach. Details of the audit findings for TMfS05 can be found in the *Transport Model for Scotland 2005 Rebase: TMfS05 Audit – Final Report* (TTAA Ref. 67633, April 2007).

3.3 Model Validation

Introduction

3.3.1 The PT model validation for TMfS05A was undertaken using the same datasets as for TMfS05 with analysis of:

- LENNON station to station rail ticket data
- Historical bus and rail passenger survey data
- Comparison of timetabled and modelled bus journey times

3.3.2 The TTAA's views on the validation as presented in MVA's report are outline in the following sections.

Validation to LENNON Data

3.3.3 The validation to LENNON data has been presented for passenger loadings across critical cordons and screenlines, passenger boardings/alightings and for Edinburgh to Glasgow flows.

Passenger Loading Comparisons

3.3.4 As was the case with TMfS05, comparisons have been presented for two main rail screenlines (Central Scotland East West and Forth Estuary) and two main rail cordons (Edinburgh and Glasgow). Generally, considering total flows across the screenlines these show a very similar level of validation in TMfS05A to the previous validation for TMfS05.

3.3.5 Considering flows on individual links the Central Scotland East West screenline shows very similar validation in the AM and inter peaks in TMfS05A compared with TMfS05. It is encouraging to note that in the PM peak this screenline demonstrates a better level of validation in TMfS05A on individual links compared with TMfS05.

3.3.6 The Forth Estuary and Edinburgh screenlines also demonstrate very similar levels of validation between TMfS05 and TMfS05A when considering the individual links comprising the screenlines. It is encouraging to note that the comparison for the link North of Stirling Station on the Forth Estuary screenline has significantly improved in the PM peak outbound in TMfS05A.

3.3.7 When considering the Glasgow rail cordon, the level of validation, while similar, is generally slightly worse in TMfS05A compared with TMfS05. The modelled rail flows across this cordon are generally shown to be lower than observed, particularly in the AM peak inbound and in the PM peak both inbound and outbound.

3.3.8 As was the case in TMfS05 it must also be recognised that more in-depth analysis of the Glasgow Rail cordon on an individual site basis (as presented in Appendix A of the MVA report) indicates that certain individual locations exhibit much higher percentage difference and GEH values than the screenline as a whole. The AM peak inbound cordon comparison is the worst (GEH = 13) and this has particularly low link flows at Carmyle, Burnside, Muirend, Corkerhill and Cardonald.

3.3.9 Similar issues were identified during the audit of TMfS05 at which point MVA stated that the high GEH value for the Glasgow cordon is *"...because of strong competition between bus and rail services in the Glasgow conurbation area"*. This statement is significant and should be

recognised by potential users, particularly in view of the fact that crowding effects have been reflected on rail services only and that sub-mode choice is undertaken at the assignment stage.

3.3.10 Modelled to observed rail flow comparisons are presented for a further 27 locations across the rail network in Appendix A of MVA's report. Similar to TMfS05, these generally demonstrate a good match between modelled and observed values with the main exceptions to this being at a small number of locations around Glasgow and between Hamilton West and Central Stations.

3.3.11 As was the case for TMfS05, given the similarities in rail flows the TTAA is generally content that the modelled to observed rail passenger flow comparisons demonstrate an acceptable level of calibration for TMfS05A, particularly on a screenline basis. Potential users of TMfS05A should bear in mind the variability in the modelled to observed comparisons for individual rail links.

3.3.12 It should be noted that no validation of Glasgow Underground passenger flows was presented for either TMfS05 or TMfS05A. MVA commented during the TMfS05 audit that this was due to a lack of available data.

Edinburgh to Glasgow Flows

3.3.13 Specific analysis of the flow on the rail line between Edinburgh and Glasgow was undertaken by analysing the matrix of trips that use both the rail lines to the north of Glasgow Queen Street and the west of Edinburgh Haymarket (Ref. Table 3.6 of MVA's report). From this the validation of trips between Edinburgh and Glasgow was analysed.

3.3.14 The validation of these trips is shown to be very similar between TMfS and TMfS05A with GEH values of 4 or less in all time periods in both directions. The TTAA is therefore satisfied that the validation of the Edinburgh to Glasgow and Glasgow to Edinburgh rail trips is acceptable for TMfS05A.

Boarding/Alighting Summary

3.3.15 The volume of passengers boarding and alighting at each station based on LENNON data has been compared against modelled values and is shown in Appendix B of the MVA report. The TMfS05A comparisons are very similar to those for TMfS05 with around 70% or better of boarding or alighting comparisons demonstrating a GEH of less than five in all time periods. At a global level this demonstrates a good match between modelled and observed boarding/alighting figures.

3.3.16 It should be noted that within the global analysis of the comparisons between observed and modelled data, there were a number of GEH values which were very high, with maximum GEHs of 29, 21 and 31 for boarding for the AM, IP and PM periods and 45, 23 and 29 for alighting for the AM, IP and PM periods. The high AM and inter-peak values relate to Glasgow Central station where modelled values are lower than that observed. Argyle Street station and Lockerbie Station show the highest GEH values for boarding and alighting in the PM period, where modelled values are much greater than that observed.

3.3.17 In general, the boarding and alighting comparisons for the six Central Glasgow stations show significant variation with Queen Street station and particularly Glasgow Central station demonstrating lower boarding and alighting figures than those observed, especially during the AM and PM peaks. It is also worthy of note that Lockerbie Station demonstrates a consistent significant overestimate of both boardings and alightings with GEH values ranging between 19 and 29 across the three modelled time periods.

3.3.18 The TTAA requested some commentary regarding the Lockerbie issue from MVA who responded as follows:

> *"The Lockerbie issue is a problem with the MVPUBM assignment module, which the software vendors are currently looking into. Inspection of the boarding and alighting data indicates that passengers are disembarking at the station then re-boarding the same services. Given the remote location of the station and that the problem appears to be isolated, this is not considered to be a significant issue with minimal impact on model applications".*

Users should note this localised issue in TMfS05A.

3.3.19 Throughout the remainder of the network the boarding/alighting comparisons are generally acceptable. The TTAA is therefore satisfied that the overall validation of individual station boarding and alighting figures is acceptable for TMfS05A. Potential users of TMfS05A for more local studies involving detailed PT outputs should be aware of the significant variability in the comparisons for the Central Glasgow stations, in particular at Central and Queen Street stations in the AM and PM peaks.

3.3.20 This issue was also evident during the TMfS05 audit at which time MVA commented further on that:

> *"It should be noted that the stations in central Glasgow and Edinburgh have been grouped in order to show the total comparison for each city. This is because the LENNON data does not always give a good representation of where people board and alight in the city centre. For example, in some cases where people buy a ticket to a main station (e.g. Glasgow Central), they may alight at a different station. This is particularly the case on low level trains in Glasgow. It is considered the assignment of such trips within TMfS offers a good representation of boarding and alighting in the city centre".*

Validation to Historic Bus Survey Data

3.3.21 As no new information was available, validation to historic count data used for the validation of TMfS02 was also undertaken. This included data sources for Glasgow, Edinburgh and Kilmarnock Bus Occupancy data. It should be recognised that the bus occupancy data collected for TMfS02 was based on estimates of the percentage occupancy of each bus and the number of seats associated with each bus type. While this methodology may provide reasonable estimates of the passenger occupancy numbers it is prone to discrepancies. MVA suggested during the TMfS02 audit that a minimum error of 10% is applicable to the data with some instances where the error would be up to 20%. This should be borne in mind when interpreting the PT bus validation.

3.3.22 MVA states in §3.3.2 of the report that "*These comparisons show broadly the same level of validation as the original version of TMfS with some individual variation*". While it is true that the comparisons show a similar level of validation as that obtained for TMfS02, it should be noted that the validation is very poor in many instances. For example, the outbound Glasgow City Centre Cordon has a GEH of 60 in the PM peak with the worst GEH value for the Edinburgh Outer Cordon being 21 for the inbound inter-peak.

3.3.23 For the Glasgow Outer cordon the GEH values are generally acceptable in the inbound direction during the AM and PM peaks and in the outbound direction in the AM peak. The inter-peak (both directions) and PM peak outbound comparisons are poor. The modelled flows are higher than observed in all cases except the PM peak outbound. Comparisons for the Glasgow City Centre (inner) cordon are poor in both the AM and PM peaks with modelled flows significantly lower than observed while the inter-peak comparisons are good.

3.3.24 Combining the Glasgow Outer bus and rail cordon data demonstrates that overall the total PT calibration across the cordon is reasonable in both directions in the AM peak and inbound in the PM peak. The calibration is poor for the inter-peak (both directions) and for the PM peak outbound.

3.3.25 For the Edinburgh Outer Cordon, the modelled count is lower than the observed count in all instances except for the AM inbound and is especially low in the inter-peak. The GEH values range between 5 and 21 for the Edinburgh cordon as a whole although percentage differences in the peaks are all within 23%. When examining the individual comparisons it is evident that there is a considerable variation on a site by site basis. There is a general trend for overestimates of passenger volumes on the eastern half of the cordon with underestimates generally evident on the western half of the cordon for either direction.

3.3.26 Combining the Edinburgh Outer bus and rail cordon data demonstrates that overall the total PT calibration across the cordon is reasonable in the AM peak outbound and in the PM peak inbound. The calibration is generally poorer for the inter-peak (both directions), for the AM peak inbound and the PM peak outbound.

3.3.27 Other bus screenlines considered were:

- Clyde in Glasgow (North to South) which showed an over-estimate of passenger flows in the AM and inter-peak in both directions and in the PM in the southbound direction. The comparisons are best for the AM peak southbound but poor for all other time period/direction combinations.
- Glasgow (East to West) which showed an under-estimate of passenger flows for all periods in all directions except the inter-peak in the eastbound direction. The comparisons are good for the inter peak (both directions) and the AM peak westbound but poor for all other time period/direction combinations.
- Kilmarnock Cordon which showed an underestimate of passenger flows for all periods and directions except the outbound direction in the AM. The comparisons are generally acceptable in both directions in all time periods.

3.3.28 Given the historic nature and inherent limitations in the collection of the bus passenger occupancy data it is difficult to draw firm conclusions regarding this calibration exercise. Overall it can be concluded that the quality of the calibration to bus passenger occupancies is variable across the Edinburgh and Glasgow cordons. This is the case both across each cordon as a whole and at individual sites within the cordon. The calibration across the Kilmarnock cordon is generally acceptable while the Glasgow Clyde and East/West screenline calibration is extremely variable. This variable level of calibration is perhaps unsurprising given the lack of any recent bus specific data being included in the PT trip matrix development process for TMfS05 or TMfS05A.

3.3.29 Total PT screenline flows (combining bus and rail) are good for Glasgow inbound in the AM and PM peaks and for Edinburgh inbound in the PM peak. The comparisons are good for Edinburgh and Glasgow outbound in the AM.

Rail Capacities

3.3.30 As the TMfS05A PT assignment includes crowding on rail lines in the AM and PM peaks, information is provided in Appendix D of MVA's report on the ratio of passenger to seated capacity on the modelled lines. Analysis of Appendix D shows that services with a ratio of over 100% are:

- Edinburgh to Aberdeen AM peak (116%)

- Dundee to Edinburgh AM peak (2 service lines, 116% and 112%)
- Inverness to Aberdeen AM peak (116%)
- Bathgate to Newcraighall AM Peak (106%)
- Dyce to Edinburgh PM peak (129%)
- Glasgow to Dunblane PM peak (108%)

3.3.31 Other crowded (but not over capacity) services include:

- Between Edinburgh and Glasgow (AM and PM peaks)
- Aberdeen to Inverness in the AM peak
- Carlisle to Glasgow in the AM peak
- Glasgow to Dunblane and Stirling in the AM peak
- Perth to Edinburgh in the AM peak
- Berwick to Edinburgh in the AM peak
- Edinburgh to Dyce in the PM peak
- Dundee to Aberdeen in the PM peak
- Glasgow to Carlisle in the PM peak
- Newcraighall to Dunblane in the PM peak
- Edinburgh to Bathgate in the PM peak
- Glasgow to Ayr in the PM peak

3.3.32 The crowding comparisons are very similar between TMfS05 and TMfS05A and the TTAA is satisfied that the crowding on certain services seems intuitively correct., however, in the absence of any observations it is difficult to draw any firm conclusions regarding the accuracy, or otherwise, of the crowding on rail services in TMfS05A.

Comparison of Timetabled and Modelled Bus Journey Times

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

3.3.34 Modelled to timetabled bus journey time comparisons were undertaken for 44, 44 and 43 services in the AM, inter-peak and PM peaks, within the TMfS05A model area (note, not all services run in all three time periods hence, the differing number of comparisons). The modelled journey times were compared with the average, maximum and minimum timetabled journey times. For the vast majority of cases, (80% in the AM and 77% in the inter and PM peaks) the TMf05A 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. Equally, 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 TMfS05A.

3.3.35 The graphs in Appendix E of MVA's report showed the modelled journey time against the timetabled journey time, plotted to show the timetabled journey time with the maximum and minimum values where these existed. The results show that in the AM of the 17 bus routes that had a minimum and maximum recorded, only 18% of the modelled journey times fell within the

timetabled minimum and maximum. The inter-peak and PM had no modelled journey times fall within the minimum and maximum timetabled journey times where they were recorded. This suggested a very poor level of journey time validation in all three periods for bus journey times. However, it is recognised by the TTAA that the variation in timetabled journey times, where available, was often relatively small.

3.3.36 To provide a more meaningful comparison the TTAA examined the bus journey time validation using the *DMRB* criteria for comparing modelled to observed journey times for road traffic. That is that the modelled time should be within 15% (or one minute if higher) of the observed journey time. Applying these criteria shows that 45%, 45% and 42% of the journey times match within *DMRB* criteria for the AM, inter-peak and PM peaks. This demonstrates a very similar patter to that observed in TMfS05 and the TTAA considers this to be a generally acceptable level of bus journey time validation for TMfS05A.

3.3.37 **The TTAA would recommend that any users of TMfS05A for schemes likely to be sensitive to changes in bus journey times should examine the level of bus journey time validation within their area of interest prior to undertaking any assessments**.

Summary of PT Validation

3.3.38 The validation of the TMfS05A PT matrix has focused mainly on the LENNON data and showed in general, a similar level of validation with TMfS05 which is considered acceptable for a model such as TMfS05A. The validation for bus passenger flows focused mainly on the Edinburgh and Glasgow area, with an added screenline for Kilmarnock. The level of validation to this data was variable.

3.3.39 As no additional PT demand data was utilised in the TMfS05A development, the TTAA acknowledges that MVA has made use of the best available PT data in developing the PT matrix and validating the model. Nevertheless, during the audit of TMfS02 and TMfS05 it became clear that the availability of reliable PT data, particularly for buses, is limited in the TMfS study area. This is true of both OD based inputs for matrix development and passenger flow based observations for calibration/validation. **The TTAA reiterates that it strongly recommends that action is taken at the next major upgrade of TMfS to overhaul the PT matrix with all available reliable data sources**. This concurs with MVA's recommendation made in the report (Ref. §4.2.1 of *The Transport Model for Scotland 05A – Public Transport Calibration and Validation Report (Draft version 2)*).

3.3.40 Given the fact that TMfS adopts a single PT matrix with sub-mode split undertaken at the assignment stage and the fact that crowding effects are only reflected for peak rail services it is important, particularly for corridors with high PT modal competition, to ensure that overall PT demand (irrespective of mode) is reflected as robustly as possible. With the current disparity between the availability of reliable rail and bus data for matrix development it is difficult to see how this could have realistically been achieved (and verified) for TMfS05A. The current validation exercise demonstrates reasonable validation to LENNON based rail flows but much more variable validation to independent bus occupancy data. It is unknown to what extent the issues regarding PT data collection, the quality of the trip matrix, PT assignment model parameters or crowding effects on the PT sub-mode split in TMfS have affected the level of validation achieved on a sub-mode specific basis.

3.3.41 **The role of TMfS05A as a strategic model considering aggregate representations of movements between major sectors/areas of the transport network must be recognised by users, particularly with respect to the representation of PT movements. The TTAA would recommend that any TMfS05A user seeking to assess any scheme to which PT demand is**

likely to be sensitive should do so with caution, particularly within a local context. In particular, any users assessing schemes where detailed outputs regarding passenger loadings on PT sub-modes or services will be analysed, should take cognisance of the issues outlined in this audit. This is not to say that TMfS05A cannot be used in such circumstances but that prior to embarking on such testing, a detailed review of the quality of the PT travel demands and passenger loadings by PT sub-mode within the corridor(s) of interest, should be undertaken. Additionally, appropriate sensitivity testing should be undertaken to enable the effects of any scheme on PT to be fully understood.

3.3.42 The modelled to timetabled bus journey time comparisons undertaken demonstrate that the modelled values are generally faster than the timetables. This is expected for a model of this nature and applying *DMRB* journey time acceptability criteria demonstrates a reasonable match between modelled and timetabled values for TMfS05A. The further analysis, which considered the comparison of timetabled journey times to modelled journey times where a minimum and maximum timetabled journey time was available, shows a poor level of validation with the no modelled journey falling within the minimum to maximum range in the inter-peak and PM and only 18% falling in the range in the AM.

3.4 Overall Summary

3.4.1 The TMfS05A PTM has been developed to represent the PT network of bus, rail and underground services in the TMfS05A model area. In particular, the detail and coverage has been extended in Argyll and Bute, the Highlands and Islands in TMfS05A with the major bus, rail and ferry services represented in these areas. The PT travel demand has been inherited from TMfS05 with disaggregation to the refined TMfS05A zoning system. As PT travel demand was not reflected in detail in Argyll and Bute, the Highlands and Islands in TMfS05, this remains the case in TMfS05A. Given that the main focus of the refinement in the extended area was to feed accessibility analysis, the TTAA is generally content that the PT network coverage and detail is appropriate for TMfS05A. Some detailed comments are provided in the relevant section of this note relating to individual aspects of the TMfS05A PT model development.

3.4.2 The PT demand matrices were inherited from TMfS05 with the only update being the disaggregation to the refined TMfS05A zoning system. Similarly, with the exception of refinements to the PT fares tables, the PT assignment model remains unchanged in TMfS05A. The reader is referred to the TMfS05 audit for further details and findings relating to these processes. Users should note the limited bounds of applicability of the TMfS05A PT assignment model in the extended area (discussed elsewhere in this chapter) due to the lack of detailed demand data being reflected in that area.

3.4.3 The validation of the PT matrix has focused mainly on the LENNON data and showed in general, acceptable validation for a model such as TMfS05A. The validation for bus passenger flows focused mainly on the Edinburgh and Glasgow area, with an added screenline for Kilmarnock. The level of validation to this data was variable. The TTAA acknowledges that MVA has made use of the best available PT data in developing the PT matrix and validating the model. Nevertheless, it is clear that the availability of reliable PT data, particularly for buses is limited in the TMfS study area.

3.4.4 As was noted in the TMfS05 audit, it is significant to note that the equivalent MVA report for TMfS02 states in §6.2.6 of the PT validation report that:

> *"…the reliability of much of the count data is viewed as unsatisfactory. The bus validation flows were recorded at the kerbside on a single day and are based on estimates of the occupancy of buses passing various sites".*

Given this statement and the knowledge that no new data was used to update the bus information, little in the way of firm conclusions can be drawn regarding the level of validation of the PT model for buses in TMfS05A.

3.4.5 The TTAA (and MVA) strongly recommends that action is taken at the next major upgrade of TMfS to overhaul the PT matrix with all available reliable data sources.

3.4.6 The TTAA would recommend that any TMfS05A user seeking to assess any scheme to which PT demand is likely to be sensitive should do so with caution, particularly within a local context. In particular, any users assessing schemes where detailed outputs regarding passenger loadings on PT sub-modes or services will be analysed, should take cognisance of the issues outlined in this audit.

3.4.7 As was stated in the TMfS05 audit, the TTAA considers that during the next major upgrade of TMfS, a guidance paper should be prepared to advise potential users of the implications of the various issues discussed in this chapter when applying TMfS. This guidance note should include, but not be restricted to guidance regarding the robustness of the following:

- PT matrices on a sector by sector basis
- PT service coding/coverage on an area by area basis
- PT calibration/validation in TMfS on an area by area basis
- PT model forecasting abilities on a Strategic (inter-sector) and Local (intra-sector) basis
- Effects of PT crowding on sub-mode split

4 PARK & RIDE MODEL

4.1 Introduction

4.1.1 This chapter presents the TTAA's findings based on information supplied by MVA in relation to TMfS05A Audit Task 3: Review Park & Ride Model Updates.

4.1.2 This task concentrated on reviewing the documentation relating to the TMfS05A Park & Ride Model. The *Transport Model for Scotland 05A - Park & Ride Model Report* (Draft version 2) was supplied to the TTAA in October 2007 for use in the audit process and all comments in this chapter relate to that document.

4.1.3 The chapter generally follows the same structure as MVA's report and the following sections will deal with commentary relating to the model update, model calibration and the conclusions and recommendations.

4.2 Model Update

4.2.1 Chapter 2 of MVA's report outlines the model update and in particular, the update of the Park & Ride site information. It was stated in §2.2.1 of MVA's report that *"The Park and Ride Assignment Model (PARAM) includes 67 sites in the 2005 base year as detailed in Table 2.1"*. On inspection of Table 2.1 only 66 sites were listed, the TTAA therefore examined the list of sites previously supplied during the TMfS05 audit (Ref. Table 7 of *AN2-1 Audit Note Response – Full*, C Robinson, 25 February 2007). This previous list appeared to have 68 sites listed and a cross check shows that the two sites not included in the updated list relate to Greenfaulds and Williamwood.

4.2.2 Further comparison with Table 3.1 in the TMfS05A report showed that 71 sites were listed, however, four of these (Aberdour, Airdrie, Ayr and Bargeddie) appeared twice, suggesting that only 67 sites were indeed included. Finally, when examining the table in Appendix A, only 67 sites were listed, which tied up with the statement in §2.2.1 and (neglecting the four duplicates) with Table 3.1, but not with the data in Table 2.1.

4.2.3 MVA has subsequently clarified that Table 2.1 of the report was incorrect and should have contained a list of 67 sites. Furthermore, Table 3.1 was correct aside from the four duplicated sites. A subsequent 3rd draft of the report has been published by MVA which corrects this discrepancy.

4.2.4 Following examination of the corrected 3rd draft report, it is clear that the list of Park & Ride sites is similar to that provided for TMfS05, as would be expected. The TTAA does not have any significant concerns regarding the specification of Park & Ride sites in TMfS05A.

4.3 Model Calibration

4.3.1 The model calibration of the PARAM has been undertaken by comparing modelled and observed car park occupancies and by undertaking sanity checks to ensure that occupancies are within reasonable ranges where no data exists. This was undertaken using the cost matrices from the TMfS05A pre-Park & Ride model runs and setting global and site specific parameters as appropriate. The TMfS05 global parameters, which were consistent with TMfS02, were adopted as the start point for calibration and were updated accordingly following the adjustment of any site specific parameters.

4.3.2 It is stated in MVA's report that the LAMBDA and mode constant parameters were set with reference to the values used in the previous version of the PARAM. Initial runs indicated that the model showed lower than expected Park & Ride patronage and hence adjustments were made to improve this. The mode constants were both reduced by 5minutes to -25minutes for car (previously -20minutes in TMfS02 & TMfS05) and to 25minutes for PT (previously 30minutes in TMfS02 & TMfS05). The LAMBDA parameter has remained unchanged in TMfS02, TMfS05 and now TMfS05A.

4.3.3 The TTAA is content that these adjustments to the mode constant parameters are acceptable for TMfS05A.

4.3.4 Examining the modelled occupancies on a site by site basis, the sites can be split into two categories as follows:

- Sites for which observed data is available
- Sites where no observed data is available (hence modelled can be compared with capacity)

4.3.5 Firstly, considering sites for which observed data is available, there are 20 listed in Table 3.1 (and Appendix A). Of these 20 sites, 14 demonstrate a very good comparison between modelled and observed occupancy. The sites which demonstrate poorer comparisons all show an underestimate of Park & Ride occupancy with two showing moderately lower than observed occupancies (Inverkeithing and Linlithgow) and the remaining four showing significantly lower than observed occupancies (Dunbar, Falkirk Grahamston, Falkirk High and North Berwick).

4.3.6 Of the sites for which no data was available the only reliable comparison which could be made was with the carpark capacity. As capacity is not as reliable a comparator as observed occupancy it is difficult to draw firm conclusions regarding the realism of Park & Ride occupancies for these sites. It is encouraging to note that, in the majority of cases, the maximum modelled occupancy is generally similar to the available capacity.

4.3.7 The TTAA has identified the following sites as having modelled occupancies which are significantly lower than the available capacity:

- Ayr, Bathgate, Drem, Dunfermline Queen Margaret, Dunfermline Town, Ellon, Glengarnock, Montrose, Newton, Prestwick Town, Saltcoats, Stirling, Troon and Wemyss Bay. All show a modelled occupancy of less than 40% of the overall capacity
- Glenrothes with Thornton and Helensburgh Central. Both show a modelled occupancy of zero

4.3.8 The TTAA acknowledges that the majority of comparisons between modelled and observed (where available) occupancies and with parking capacity are good. Nevertheless, some commentary or additional explanation was requested from MVA regarding the reason for the poorer comparisons at the sites listed above, particularly those with modelled occupancies of zero.

4.3.9 Version 3 of MVA's report was updated to include such commentary and it stated that:

> *"Reasons for these potential under-estimates of P&R demand include:*
>
> - *over-estimate of the cost of using a specific P&R site, eg because the relevant Park and Ride facility is a significant distance from the centre of the relevant TMfS zone*
> - *over-estimate of the attractiveness of walk-in public transport demand*
> - *under-estimation of the costs of the competing car journey (congestion, shortage of town centre car parking etc)*

- *actual demand is much lower than the capacity (ie model is correctly predicting low car park occupancy – this could be confirmed by additional Park and Ride surveys*
- *observed values include users of local facilities and P&R users – again this could be confirmed by additional P&R surveys"*

4.3.10 Furthermore, the report goes on to state that *"It is strongly recommended that model users should consider the calibration and validation of Park and Ride sites in their study area before using this aspect of the TMfS model for a given application"*. Given the potential reasons for the poorer comparisons at some individual Park & Ride sites outlined by MVA, the TTAA concurs with this recommendation.

4.3.11 It is stated in §3.2.5 that *"In general, the TMfS:05A Park and Ride model displays a good level of calibration broadly similar to TMfS:05…"*. Version 2 of MVA's report did not contain a detailed comparison of this information to support this statement, however, this was subsequently provided in Appendix A of MVA's updated Version 3 of the report.

4.3.12 It is evident that the site specific transfer parameters have been applied consistently between TMfS05 and TMfS05A. Examination of the modelled occupancies and how these compare with observations (or capacities where observations are unavailable) also demonstrates a generally similar level of calibration in TMfS05A compared with its predecessor. Having reviewed the updated Version 3 of the report the TTAA generally concurs with MVA's statement and considers the overall calibration of the Park & Ride Model for TMfS05A to be acceptable.

4.4 Conclusions and Recommendations

4.4.1 MVA concludes in §4.1.1 that a generally good level of calibration has been displayed. It is further concluded in §4.1.2 that:

> *"…the model is fit for purpose as a strategic Park and Ride model, which will form an integral part of TMfS. The model database and processes can also be adopted, extended and calibrated for use in more localised assessment of Park and Ride schemes".*

4.4.2 MVA also makes recommendations in §4.2.1 that:

> *"It is recommended by MVA that this model is used as an initial appraisal of potential major Park and Ride sites or strategies. It is expected that during such appraisal, further more detailed work would be undertaken in the local transport corridor under evaluation"*

and in §4.2.2 that

> *"If the Park and Ride model is used as part of a more detailed appraisal, it is recommended that, where necessary, additional Park and Ride data collection is undertaken, which would then form part of the appraisal process".*

4.4.3 The TTAA concurs with these conclusions and recommendations.