Transport Model for Scotland 2005 Rebase : TMfS:05 Audit

Transport Scotland

Model Development Audit : Final Report

SIAS Limited in association with WSP

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TRANSPORT MODEL FOR SCOTLAND 2005 REBASE : TMFS:05 AUDIT

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Transport Model For Scotland 2005 Rebase : TMfS:05 Audit - Executive Summary

SIAS and WSP acting as the Traffic and Transport Advisor and Auditor (TTAA) to Transport Scotland were, requested to undertake an audit of the transport model development for the Transport Model for Scotland (TMfS). The latest development phase for TMfS involved a rebase from the original Base year of 2002 (TMfS:02) to a more up to date Base year of 2005 (TMfS:05).

The audit concentrated on examining the main components of the model that were altered during the rebase to 2005 namely the Highway and Public Transport (PT) networks, the Highway and PT model calibration/validation and the Demand Model calibration/validation. During the rebase some selected model enhancements were also incorporated into TMfS:05 and these were reviewed during the audit process. The process for examining the Transport/Economic/Land-Use Model of Scotland (TELMoS) was also instigated during the TMfS:05 audit, although the detailed findings of the TELMoS audit will be published at a later date.

The audit relied heavily on information supplied by MVA, which was generally in the form of the Draft Model Development, Calibration and Validation Reports for the Highway, PT and demand models. The TMfS:05 networks were also supplied along with other supporting information to enable a review by the TTAA. The audit largely concentrated on examining the differences between TMfS:02 and TMfS:05.

Highway Network Coding

The review of the Highway network generally demonstrated that it was appropriately coded. The TTAA examined the zoning system, node positioning, link lengths, link types, jurisdiction codes, capacity indicators and some junction coding. The updated zoning system included separate zones to represent Edinburgh, Prestwick and Dyce Airports and the Royal Bank of Scotland Headquarters at Gogar and is an improvement over the TMfS:02 zoning.

The review of the highway network coding did identify some errors, however, these would generally not have a significant impact on the TMfS operation as a whole. Nevertheless users of the model should bear these errors in mind when examining outputs in a local context. In particular the inclusion of the A9/M876 Glenbervie slip roads and the M8 Junction 21 Seaward Street motorway loop scheme in the TMfS:05 Base network should be noted as these schemes have not been constructed to date.

Highway Assignment Model Development, Calibration and Validation

In reviewing the Highway Assignment Model the trip matrix development, recalibration and revalidation were reviewed along with the assignment model parameters. This process generally demonstrated that the changes to the trip matrices between 2002 and 2005, whilst significant on some sectors, were explainable due to a combination of the changes in observed flows between 2002 and 2005 and the adopted methodology for producing the prior trip matrix. Overall, the TTAA is content that the changes in the trip matrices between 2002 and 2005 are acceptable.

The recalibration to traffic counts demonstrates that TMfS:05 achieves a similar level of global calibration to TMfS:02 with 60% or more GEH values less than 5 in all time periods. This does not conform to the DMRB guidelines which state that 85% or more GEH values should ideally be less than 5. Nevertheless, this level of calibration is not unusual for a model of the scale, nature and spatial variability of TMfS. Overall, whilst not ideal, this level of calibration is considered acceptable, particularly at a strategic level. However, users are advised to review the calibration in their local area of interest prior to any model application or use of TMfS outputs due to regional and local variability in the quality of calibration.

The revalidation to independent counts, journey times, trip length distribution and Census data were all considered acceptable for a model of this scale. The TTAA would recommend that improved reporting procedures could be adopted for future TMfS calibration/validation, particularly with respect to graphical presentation, calibration by local area and with respect to journey times.

Public Transport Network Coding

The PT network and services audit examined the coding of new rail schemes and stations, the extent of the network, the coding of selected services and the PT operators included. Generally, the coding of the new schemes and the overall network coverage was acceptable. Users should note the curtailment of the

rail network at the boundary of the internal model area. The service coding identified some potential minor errors in the coding of individual services, however, these are unlikely to significantly affect the operation of TMfS. The PT operators included are acceptable, however, there are some notable bus operator omissions including First Aberdeen, Strathtay Scottish and some Borders services due to reasons of lower network detail and lack of travel demand information in these areas.

Public Transport Assignment Model Development, Calibration and Validation

The PT Assignment Model development included new LENNON ticketing data, crowding for AM and PM peak rail services and an updated fares model. The model was recalibrated and validated to available data. The LENNON data was subject to a series of processes to incorporate this within the origin-destination matrices. These processes were reliant on various assumptions to enable the data to be converted to the appropriate form for use in TMfS. Overall, the TTAA is content that the assumptions made are logical and these were necessary to make the best use of the available data. It must be borne in mind, however, that sufficient data was not available to ascertain whether these assumptions hold true.

The crowding model was invoked for AM and PM peak rail services only, which is an enhancement over TMfS:02. In most cases this will be adequate, however, users should take care to ensure that the sub-mode share (between bus and rail) conforms to expectations in corridors where there is strong competition between rail and bus services. This comment applies equally to the Base and any future year model applications. The fares model was updated to reflect varying fares between the peak and off-peak and this is considered to be an enhancement in TMfS:05.

The rail model validation compared modelled flows with the LENNON data and generally demonstrated an acceptable match between the modelled and observed values. As expected, the level of validation is more variable on an individual link by link basis. Rail passenger boarding and alighting comparisons generally demonstrate a good match between modelled and observed values. It should be noted that the match is better at a city-wide level rather than individual station level within central Glasgow.

Bus validation to historic passenger flow data showed a significant degree of variability. This can be attributed to a number of factors including limited data availability for both trip matrix development (no new bus data in TMfS:05) and model validation and the variable quality of available observed data. The TTAA considers that this element of the TMfS development is one which would benefit significantly from additional data collection for future versions of the model.

Demand Model Development, Calibration and Validation

The TMfS:05 Demand Model remained largely the same as its 2002 predecessor with the exceptions that the Park and Ride adjustment process is now integrated rather than being a supplementary add-on and the effects of rail crowding are reflected in the demand modelling process. Overall, the TTAA is content that the TMfS:05 Demand Model structure, coefficients, and method of operation are acceptable. It should be noted that a detailed assessment of the demand model outputs in forecast mode was not undertaken during this audit process. The TTAA considers that some elements of the demand model could be considered for refinement and enhancement in future versions of TMfS and has commented on these in the main report.

Transport/Economic/Land-Use Model of Scotland (TELMoS)

An audit process for TELMoS was instigated during the audit of TMfS:05, the first time such a review has been undertaken. Due to the scale and complexity of TELMoS in its own right, the complete audit process cannot run entirely in tandem with that of TMfS:05. A higher level, superficial review of available documentation was therefore undertaken for TELMoS as part of the TMfS:05 audit.

This review indicated that the model structure of TELMoS is well designed, with sensible definition and segmentation of land use and economic activities, and linkages between the activities. The TTAA considers that the model design and structure are consistent with the good practice of land use activity and travel demand modelling.

The ongoing audit process, which will be reported at a later date, will seek to provide audit findings and further details on the empirical underpinnings of the model mechanisms, calibration strategy, sensitivity testing and general model validation.

Overall Summary

The TTAA considers that the TMfS:05 rebase has been undertaken with due skill and care and making best use of the available data sources. In view of this, TMfS:05 is considered to be suitable for its intended application although users should take cognisance of the findings and recommendations in this audit.

TRANSPORT MODEL FOR SCOTLAND 2005 REBASE : TMFS:05 AUDIT

CONTENTS :

TRANSPORT MODEL FOR SCOTLAND 2005 REBASE : TMFS:05 AUDIT

TABLES :

1 INTRODUCTION

1.1 Purpose of Report

1.1.1 SIAS and WSP were commissioned under the Traffic and Transport Advisor and Auditor term commission to undertake an audit of the model development work undertaken in rebasing the Transport Model for Scotland to a 2005 base year. This rebased model will be referred to as TMfS:05 throughout this audit and supersedes its 2002 base year predecessor (TMfS:02).

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 highway 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 and WSP, in their role as auditors, will be collectively 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 therefore 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 within 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 Report Structure

1.3.1 Following this brief introductory chapter the individual elements of the audit are presented as follows:

- Chapter 2 – Highway Network and Zoning System
- Chapter 3 – Highway Assignment Model
- Chapter 4 – Public Transport Network and Zoning System
- Chapter 5 – Public Transport Assignment Model
- Chapter 6 – Demand Model
- Chapter 7 – TELMoS

1.4 Acknowledgements

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

2 HIGHWAY NETWORK AND ZONING SYSTEM

2.1 Introduction

2.1.1 This chapter presents the TTAA's findings based on information supplied by MVA for the TMfS:05 model development audit and relates to Audit Task 1: Review updated network and zoning system.

2.1.2 Audit Task 1 concentrated on analysing both the changes in the updated TMfS network (TMfS:05), compared against the previously audited TMfS network (TMfS:02) and also the suitability of the updated TMfS:05 network in terms of the inclusion of new traffic schemes and any other coding changes.

2.1.3 All requested files were made available through the TMfS website www.tmfs.org.uk.

2.2 Zoning System

2.2.1 The updated TMfS:05 model retained the TMfS:02 zone structure with the exception of four new zones. All four new zones were created by splitting original zones which contained an airport and in one instance an airport and a new company headquarters. Three airports were to be represented: Edinburgh Airport, Glasgow Prestwick Airport and Aberdeen Airport. The purpose of this amendment was to allow for the separate modelling of airports, particularly with respect to their future development forecasts. The TMfS:02 zone (Zone 167) which contained Edinburgh airport was further split to model the Royal Bank of Scotland Headquarters on the A8 as a separate zone. The four new zones added were Zones 1097 (Glasgow Airport), 1098 (Edinburgh Airport), 1099 (Aberdeen Airport) and 1100 (Glasgow Prestwick Airport), bringing the total number of modelled zones to 1137 once external zones are included in the total.

2.2.2 The TTAA acknowledges that the new zoning system provides a number of advantages and is appropriate for TMfS:05. It should be noted that no further zone updates have been made, therefore comments from the previous TMfS:02 audit regarding the zoning system at Hermiston Gait are considered to remain valid. MVA has acknowledged these comments and will consider further zoning refinements in this area at the next major upgrade of TMfS.

2.3 TMfS:05 Highway Network Coding

2.3.1 MVA provided the TTAA with a copy of the TMfS:05 network in TRIPS format, which enabled an analysis of the skeletal detail of the network. Given that the general network description, in terms of overall coverage, for TMfS:02 was considered acceptable, the TTAA concentrated on the areas of the network where TMfS:05 differs from TMfS:02.

Scope of Skeletal Network Coding Audit

2.3.2 In reviewing the TMfS:05 network coverage, the areas where coding differences were evident between TMfS:02 and TMfS:05 have been outlined by the TTAA.

2.3.3 The TTAA undertook a series of checks on the logic and accuracy of the network coding within TMfS:05 taking cognisance of previous checks undertaken as part of the TMfS:02 audit and to ensure that the TMfS:05 network is representative of the current road network.

2.3.4 The elements of the skeletal coding that have been checked are:

- Node Positioning
- Link Type
- Jurisdiction Code
- Capacity Indicator
- Link Lengths

2.3.5 A review of newly coded schemes was also undertaken for the 18 schemes outlined in the *Highways Assignment Model – 2005 Rebase Calibration and Validation Report*. MVA supplied the TTAA with an

outline description of each of these schemes and generally, the coding was shown to reflect the descriptions. The TTAA has identified the following issues during the examination of the newly coded schemes:

- M876 Junction 2 slip roads – The east facing slips (eastbound on and westbound off) connecting the A9 with the M876 at Glenbervie have been included in the 2005 Base network. These slip roads have not yet been constructed and should therefore not be part of the 2005 Base network. Whilst the inclusion of these slip roads will not significantly affect the model operation as a whole, it will have a localised influence on the Base model routeing on the M9/A9/M876 in the Stirling/Plean/Falkirk area. Users of the Base model should bear this anomaly in mind whilst applying the model
- Ravenscraig link roads – The inclusion of this link road is appropriate, however, 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). It should also be noted that the road has been coded as link type 3 (Trunk – A Roads Non-Built Up) and it should be coded as link type 5 (Non-Trunk – A Roads Non-Built Up). This is unlikely to materially affect the model during application but should be addressed during the next major upgrade of TMfS
- M8 Junction 21 Improvements – The proposed new gyratory system with a direct, free-flow connection between the M8 and M77 at the Seaward Street Junction has been included in the 2005 Base network. This scheme has not yet been constructed and is not scheduled to be in place until summer 2007 at the earliest. Whilst the inclusion of this will not significantly affect the model operation as a whole, it will have a localised influence on the Base model routeing on the M77 between J1 and Plantation Interchange (M8 J22), on the M8 between J24 (Helen Street) and J21 (Seaward Street) and on the local surface streets in the Dumbreck area (e.g. Dumbreck Road, Mosspark Boulevard, Paisley Road West). This is likely to have an effect on movements between the M77 south of J1 and the M8 west of J24. Users of the Base model should bear this anomaly in mind whilst applying the model
- Glasgow Southern Orbital (GSO) – This is coded appropriately along its route. It should, however, 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 TMfS:05 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

Node positioning

2.3.6 When the TMfS:02 and TMfS:05 network node positions were compared it was noted that the coordinates for Dundee had shifted slightly northwards. It is understood this change is to reflect inaccuracies in the TMfS:02 node positioning in this area.

Periodic Differences

2.3.7 It was found that TMFS:05 AM and PM Peak Networks were identical. One difference in link capacity was found between the AM (and PM) and Off Peak TMFS:05 networks. This difference was found on the link between nodes 43097 and 42402 to the north of Aberdeen where a link capacity of 2200 is coded for the AM (and PM) period and 3200 in the Off-Peak period. MVA informed the TTAA that this was due to the coding of a bus lane in the AM and PM periods that was not in place in the Off-Peak and this detail was carried through from the Aberdeen Sub-Area Model (ASAM). The TTAA is content that this is appropriate.

2.3.8 It should be noted that there have been a number of Off-Peak capacity differences (compared with AM/PM peak) that have been dropped between TMfS:02 and TMfS:05. Consequently, the only link in the TMfS:05 network which reflects a capacity difference between peak and off-peak is the above mentioned link in Aberdeen. Therefore, issues such as peak/ off peak variation in loading/ parking restrictions are not generally reflected in TMfS:05.

Link Type

2.3.9 The link type coding within TMfS:05 was checked to ensure that the appropriate types were represented in the network. The TMfS:05 link types are listed in Table 2.1. It is acknowledged that the link types are consistent with the Scottish Transport Statistics Note 24, with the addition of two extra link types for Banned HGV links and Bus Only Links.

Table 2.1 : TMfS:05 Link Type Coding

TMfS:05 Link Type Number	Description	Examples in TMfS:05
1	Trunk - Motorway	M8 between Glasgow and Edinburgh
2	Trunk - Motorway Slip	Junction 6 of M74 at Hamilton
3	Trunk - A Roads Non-Built up	A92 betweeen Dundee and Dunfermline
4	Trunk - A Roads Built up	A82 at Inverness
5	Non-Trunk - A Roads Non-Built up	A713 between Castle Douglas and Ayr
6	Non-Trunk - A Roads - Built up	A70 in Edinburgh
7	Minor Roads Non-Built up	B818 between Killearn and Denny
8	Minor Roads Built up	Queen Street in Edinburgh
9	Banned HGV	Queens Drive, around Arthurs Seat, Edinburgh
10	Bus Only	Princes Street, Edinburgh

2.3.10 Table 2.2 details the link type differences (excluding any new TMfS:05 links) that were noted between the TMfS:02 and TMfS:05 networks.

Table 2.2 : TMfS:05 model link type differences from TMfS:02

Location	Link	TMfS:02 Link Type	TMfS:05 Link Type	Comments
M77 Extension	15110:20358	3	1	**Motorway should not extend as far south. MVA to correct in future TMfS upgrade**
	20358:20360	3	1	
	20360:15096	3	1	
	15096:15094	3	1	
	15094:20361	3	1	
	20361:15093	3	1	
	15090:15091	3	1	
	15091:15035	3	1	
	15092:15091	3	2	
	15095:15093	3	2	
	15035:15097	3	1	
	15097:15034	3	1	
	15034:15033	3	1	
	15033:15111	3	1	
A737/A761	2217:2219	2	3	Correctly changed due to TMfS:02 audit
	2219:2218	2	3	
	2218:2220	2	3	
	2220:2217	2	3	
Glasgow Centre	11152:11014	8	10	Correct changes on a number of links to Bus Only
	11014:11153	8	10	
	11370:16861	6	10	
	16861:11666	6	10	
	11666:11663	6	10	
	11663:11659	6	10	
A977 (Kincardine to Clackmannan)	8138:17038	5	6	**Link types incorrectly specified. MVA to correct in future upgrade of TMfS**
	17038:8138	5	6	
	8050:17652	3	6	
	17652:8050	3	6	
George Street, Edinburgh	1668:1721	10	8	Correct change to reflect CETM
Princes Street, Edinburgh	1651:1513	10	6	Correct changes to reflect CETM
	1513:1512	10	6	
	1651:1514	6	10	
	1514:1515	6	10	
	1515:1516	6	10	
	1516:1655	6	10	
	1655:1500	6	10	

2.3.11 Although some of the link type differences could be explained by new traffic schemes, the M77 motorway extension as far south as Kilmarnock and the link changes near Kincardine/Clackmannan were clearly erroneous. The TTAA also identified some other minor link type coding issues during the audit process. These issues and MVA's subsequent response (shown in *"italics"*) are as follows:

- Refer to above table. *"M77 Extension. This scheme has been extended too far south to the junction of the A71 and A76. MVA seek to amend this coding for future modelling. The links south of M77 Fenwick should be modelled as link type 3 and with amendments made to connecting roads"*
- Refer to above table. *"Kincardine/Clackmannan. The link types that have been changed during the rebase process have been done so incorrectly and should be classed as link type 5 (non trunk A road non-built up). MVA will strive to correct this during future enhancements"*
- An extra link at the western end of the M8. Link 14732:16113 should not be coded as Link Type 1 (Motorway) as the M8 stops at the junction at node 14732. *"M8 Junction 31. Link 14732 - 16113 classified as Motorway (M8) is incorrectly coded and should be given a link type classification of 3. MVA will amend this in the network during future enhancements"*

- Link 20497:20497 to the west of Inverness coded as Link type 3 when the rest of the A862 is coded as Link Type 5. *"A862 Inverness. Link 20497 – 20494 to the west of Inverness has been coded as link type 3 when it should be classified as link type 6, reflecting the built up nature of the location. This link was coded using this type in 2002 and was not updated, however, this will be amended by MVA in due course"*
- Telford Road in Edinburgh coded as Link Type 5 (non trunk A Road non built-up) but should be Link Type 6 (non trunk A Road built-up) from node 41203 to 41206. *"Telford Road, Edinburgh. Like the previous link, this link's type has not been updated and therefore remains the same as 2002. As correctly stated by the TTAA, this link should be coded as link type 6 and not 5. MVA will reclassify the route for future model versions"*
- HGV only links along Western Approach in Edinburgh not correctly coded, the ban extends too far east. This issue was raised in the previous audit (ref. Model Development Audit – Final Report, September 2005, Paragraph 3.3.3). *"Western Approach Road, Edinburgh. MVA undertaken a site visit and can confirm that the HGV ban begins immediately west of the Morrison Link Road. MVA will amend the network to reflect this"*
- Airbles Road in Motherwell coded as single lane when in fact it is Dual Carriageway for the full length of road between the A723 and A721. *"Airbles Road, Motherwell. This link (13257 to 13256) has been coded as single carriageway in TMfS:05, however evidence suggests that a dual carriageway would better reflect the road's characteristics. MVA will amend the capacity of the link to be consistent with the remainder of the road (2000 pcus/hr)"*
- The link outside Motherwell station coded as two-way when it is only one way, with traffic able to travel clockwise only. *"Motherwell Station. MVA accepts that this link has been coded as two-way when in reality it should be one way in the northbound direction. MVA will delete link 13250 to 13252"*
- The B754 between Motherwell and Wishaw coded as single lane when it is dual carriageway. *"B754 Motherwell/Wishaw. MVA accepts that the links (13185 to 16894 to 13186) have been coded as single carriageway in TMfS:05, however evidence suggests that a dual carriageway would better reflect the road's characteristics. MVA will amend the capacity of the links involved to be consistent with the remainder of the road (2000 pcus/hr)"*

2.3.12 Notwithstanding the issues identified above, overall the TTAA is satisfied that the link type coding within TMfS:05 is appropriate. Whilst the above issues should be corrected at the next major upgrade of TMfS they will generally not affect the assignment process or calibration/validation of TMfS:05. The one exception is the coding of the HGV banned links on the West Approach Road in Edinburgh which will have a localised effect on HGV routeing in the Haymarket/Morrison Street/Lothian Road/Shandwick Place quadrant and users should bear this in mind during model application. Potential users of TMfS:05 should also take cognizance of the above link type coding issues, particularly if undertaking any analysis of outputs by link type.

Jurisdiction Code

2.3.13 The jurisdiction codes for the TMfS:05 network were checked to ensure that they were appropriately coded. The TTAA audit of TMfS:02 identified errors with Jurisdiction code 5, for the Edinburgh area, that had included a significant number of zone connectors throughout the model area. A similar error occurred for jurisdiction code 6 which is for West Lothian and included links in Aberdeen. These issues have been corrected in the TMfS:05 network.

2.3.14 Table 2.3 shows changes in jurisdiction code between the TMfS:02 and TMfS:05 networks, excluding the large number of corrected zone connector links. The TTAA is satisfied that the changes made are generally appropriate.

Table 2.3 : TMfS:05 model Jurisdiction Code differences from TMfS:02

Location	Link	TMfS:02 Jurisdiction Code	TMfS:05 Jurisdiction Code	Comments
Aberdeen	42359:42526	25	26	Aberdeenshire to Aberdeen
	42426:42605	26	25	Aberdeen to Aberdeenshire
	42171:42566	25	26	Aberdeenshire to Aberdeen
	42268:42001	6	26	West Lothian to Aberdeen
A737/A761	14050:14053	12	16	Glasgow to Renfrewshire
	14053:14040	12	16	Glasgow to Renfrewshire
	14040:14042	12	16	Glasgow to Renfrewshire
	14042:14050	12	16	Glasgow to Renfrewshire
A8 Renfrew	17194:14203	16	12	Renfrewshire to Glasgow
	14203:17194	16	12	Renfrewshire to Glasgow
Forth Bridge	8973:2198	21	5	Fife to Edinburgh
	2009:9020	21	5	Fife to Edinburgh
A720 Edinburgh By-pass	17060:1774	4	3	Mid Lothian to East Lothian
A977 at Clackmannan	17038:8138	21	20	Fife to Clackmannanshire
	8138:17038	21	20	Fife to Clackmannanshire

2.3.15 The TMfS:02 audit found 5 out of the 21236 links in the TMfS:02 network with differing jurisdiction code for the two directions on the same link. This issue has been rectified in the TMfS:05 model.

2.3.16 TTAA is generally satisfied that the TMfS:05 links have been assigned the correct jurisdiction codes.

Capacity Indicator

2.3.17 The TTAA has undertaken selective checks to ensure that the appropriate forms of speed/flow curve have been applied across the network and is satisfied that this is the case. The TTAA also examined individual link capacity changes between the TMfS:05 and previous TMfS:02 networks. Of these changes, the majority were incorporated to reflect Quality Bus Corridors, PT priority and new infrastructure schemes or were included to better reflect the capacities and assist in model calibration. The TTAA is therefore generally content that the individual link capacity changes incorporated between TMfS:02 and TMfS:05 are appropriate.

2.3.18 Separate commentary is provided elsewhere in this document relating to the generic link capacity coding in TMfS:05.

Link Lengths

2.3.19 The TTAA performed a number of checks on link lengths in the TMfS:05 model network. These checks included comparisons with the TMfS:02 model network and logic checks on individual link lengths (by comparison with lengths independently calculated by the TTAA using the grid references in the TMfS:05 highway network). Further checks on the accuracy of coded cumulative link lengths for various routes within the network and logic checks on the maximum and minimum coded link lengths were also undertaken.

TMFS:05 VS TMFS:02 COMPA*RISON*

2.3.20 Link lengths were compared between the TMfS:05 network and TMfS:02 network. A total of 509 links were found to have changed length in the updated 2005 model (excluding newly coded links) and of these, 308 links showed a change in distance of more than 100m. MVA subsequently clarified that the majority of these changes were due to a review of the link lengths on junction approaches in TMfS:05 to better reflect

link speeds on the approaches. The TTAA is satisfied with this rationale for the changes.

CODED LINK LENGTHS VS HIGHWAY NETWORK NODE CO-ORDINATES FILE

2.3.21 The TTAA undertook a series of logic checks on the coding of individual link lengths. The individual coded link lengths were compared against link lengths which were calculated by the TTAA based on the grid references in the TMfS:05 highway network node coordinates file. The vast majority of coded and calculated link lengths compared reasonably well within acceptable error limits. However, there were a number of errors which were significant in terms of the discrepancy between coded, calculated values and true distance. The calculated lengths have been compared to the coded links lengths using the GEH statistic as well as a percentage difference check.

2.3.22 A specific check was made on newly coded links in the TMfS:05 network that were found to have a GEH >20 and a percentage difference greater than 50% between coded link distance and the coordinate link distance. The TTAA acknowledges the potential inaccuracy in calculating link lengths based on the node coordinates. Consequently, the criteria adopted to identify the "significant" differences (GEH>20 & >50% difference) were devised to identify the largest of potential errors.

2.3.23 MVA provided clarification regarding the identified discrepancies and in the majority of cases this was due to the inaccuracies in the location of the node coordinates as opposed to the coded link length. The following cases, however, demonstrated discrepancies in the coded link lengths:

- Link 2365:17528, the B8048 Cumbernauld – Coded length should be reduced from 0.3km to 0.2km
- Links 17652:3252, 3252:3251, 3251:17038, the A977 at Kincardine – Cumulative coded length should be increased from 3.21km to 3.44km
- Link 2449:2450, A96 Great Northern Rd in Aberdeen – Coded length should be reduced from 0.35km to 0.12km

2.3.24 The TTAA is content that the above discrepancies will have little impact on model operation and can be corrected at the next major upgrade of TMfS.

2.3.25 No links were found with differing link lengths for the two directions on the same link. Overall, the TTAA is content that the link length coding within TMfS:05 is acceptable.

CUMULATIVE ROUTE LINK LENGTH ANALYSIS

2.3.26 The TTAA also undertook a series of checks to ensure the accuracy of coded cumulative link lengths for various routes within the network. Overall, the TTAA was satisfied that the coded route lengths were within reasonable limits of accuracy for TMfS:05.

2.3.27 The cumulative link length along a series of routes was checked by comparing the coded link length and the true route distance using an OS map. Each route was checked in both directions. The ten key routes analysed were:

- Glasgow to Edinburgh
- Glasgow to Carlisle
- Glasgow to Inverness
- Glasgow to Dumfries
- Glasgow to Dundee
- Edinburgh to Carlisle
- Edinburgh to Dumfries
- Edinburgh to Aberdeen
- Aberdeen to Inverness

- Edinburgh to Newcastle

2.3.28 The results of the analysis are shown in Table 2.4.

Table 2.4 : Route Analysis Summary

		Forward Direction				Reverse Direction			
	Route	Actual Distance (km)	Coded Distance (km)	Absolute Distance (km)	% Distance change	Actual Distance (km)	Coded Distance (km)	Absolute Distance (km)	% Distance change
1	Glasgow to Edinburgh	74	74	0	0%	75	71	-4	6%
2	Glasgow to Carlisle	154	157	3	-2%	156	154	-2	1%
3	Glasgow to Inverness	272	266	-6	2%	272	266	-6	2%
4	Glasgow to Dumfries	122	125	3	-2%	124	121	-3	2%
5	Glasgow to Dundee	133	132	-1	1%	133	131	-2	2%
6	Edinburgh to Carlisle	148	148	0	0%	148	148	0	0%
7	Edinburgh to Dumfires	117	115	-2	2%	117	115	-2	2%
8	Edinburgh to Aberdeen	203	201	-2	1%	204	201	-3	1%
9	Aberdeen to Inverness	168	167	-1	1%	168	166	-2	1%
10	Edinburgh to Newcastle	170	167	-3	2%	170	167	-3	2%

2.3.29 The TTAA is satisfied that the comparison of the link length coding and the true distance measured from an OS map on these routes is within acceptable limits.

MINIMUM AND MAXIMUM LINK LENGTHS

2.3.30 The TTAA is satisfied that the minimum and maximum link lengths coded are within realistic limits.

Junction Coding

2.3.31 The TTAA undertook a series of checks on the junction coding within the TMfS:05 network. A selection of significant junctions/interchanges was chosen and audited. Care was taken to ensure that the selection was a sample of junctions across the network and not biased to a specific area. Some of the junctions chosen were those from the TMfS:02 model audit.

2.3.32 The aspects of the junctions that were interrogated are as follows:

- Number of approaching lanes
- Link capacities
- Turn Capacities

2.3.33 Table 2.5 shows the junctions that were checked and the results of the checks.

Table 2.5 : Junction Coding Observations

Junction	Comments
A723 Hamilton Road/Airbles Rd signalised junction (Motherwell)	Correct junction configuration
A90/A902 junction (Barnton, Edinburgh)	Correct junction configuration
M74 J5 (Raith Interchange)	All circulating links coded as 2 lanes but some should be coded as 3 lanes
Chapelhall Interchange	Correct junction configuration
Eurocentral Interchange	Correct junction configuration
M73/M74 Interchange	Correct junction configuration
M8/A720 Hermiston Gait Interchange	Hermiston Gait Approach (approach lane should be coded as 3 lanes)
M9/A8 Newbridge Roundabout	Correct junction configuration
M9(E) to M876	Coded with capacity of 3600 but should be 1800
M9/A9 Keir Roundabout	Correct junction configuration
M8/A737 St James Interchange	Correct junction configuration

2.3.34 Of the 2002 audit junction coding issues that were reconsidered, it was found that two sites had not been rectified. These junctions were the M8/A720 at Hermiston Gait and the M9/M876 interchange. The commentary provided on the Hermiston Gait coding during the TMfS:02 audit (ref. *Model Development Audit – Final Report, September 2005*, Paragraph 2.7.4) therefore remains valid. MVA stated that the free-flow link from Hermiston Gait to the A720/A71 was omitted due to *"…the geographical coverage of zone 102 from the census area. This zone straddles the rail line covering Edinburgh Park and Hermiston Gait. The inclusion of the free-flow lane would have given trips from Edinburgh Park an unrealistically easy route out of that area and was therefore omitted"*. The TTAA acknowledges the rationale for excluding the free-flow link, nevertheless, potential users of TMfS:05 should be aware of this issue when conducting analysis of the assigned flows in this area.

2.3.35 MVA has acknowledged the above identified coding anomalies and has agreed to address these issues at the next major upgrade of TMfS.

2.3.36 Notwithstanding the coding issues identified, the TTAA is generally satisfied that the junction coding is appropriate for TMfS:05. However, 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 cost robustly in future years.

3 TMFS:05 HIGHWAY ASSIGNMENT MODEL DEVELOPMENT & VALIDATION

3.1 Background and Chapter Structure

3.1.1 This chapter presents the TTAA's findings based on information supplied by MVA for the Transport Model for Scotland 2005 rebase (TMfS:05) development audit and relates to TMfS Audit Task 2 : Review Highway Assignment Model Development/Trip Matrix Development/Validation. The TTAA will use the acronym HAM to refer to the TMfS:05 Highway Assignment Model throughout this report.

3.1.2 MVA provided the "TMfS HAM Calibration and Validation – Draft Final Report, Issue 5, November 2006" along with other information made available through the TMfS website www.tmfs.org.uk.

3.1.3 The findings in this chapter are based on a review of the specific information supplied by MVA. The TTAA's comments regarding the TMfS HAM are listed in the following sections of this chapter. The section headings correspond with the chapter headings from MVA's HAM Calibration and Validation – Draft Final Report.

3.2 Introduction

3.2.1 The introductory chapter initially sets out the background and context of the HAM development and the key objectives of TMfS:05. The TTAA has no substantive comments on this aspect of the report. The TMfS modelled area is depicted in Figure 1.1 of MVA's report and appears consistent with the model area. More detailed comments on the TMfS highway network coverage and coding are provided elsewhere in this report.

3.3 Network Development

3.3.1 The various changes made to the TMfS:05 network to update this from the previous TMfS:02 network are outlined in this chapter. The TTAA's findings from the review of each process are outlined as follows.

Introduction

3.3.2 A total of 18 new development schemes have been incorporated into the TMfS:05 network. Issues regarding these schemes and their coding are outlined in Chapter 2 and the reader is referred there for more detailed commentary.

3.3.3 The 2005 Scottish Roads traffic Database (SRTDb) was also utilised during the model development process to update counts during the calibration or validation process.

Link Types

3.3.4 The link type specification is consistent with those of the Scottish Transport Statistics to enable more meaningful analytical outputs from TMfS. The TTAA acknowledges that the same link type specifications from TMfS:02 have been used in TMfS:05 and considers this acceptable and practical from an analytical point of view.

3.3.5 The TTAA undertook a detailed comparison of link types between TMfS:02 and TMfS:05 with commentary provided in Chapter 2.

3.3.6 The TTAA would recommend that any user of TMfS undertake an examination of the detail of the link type coding within their local study area prior to undertaking any assessments. This will ensure that detailed coding aspects such as HGV bans and Bus only links are appropriately reflected in their area of interest.

Link Capacities

3.3.7 Link capacities in TMfS:05 remain consistent with those used in TMfS:02. Table 3.1 lists the link types along with their description and capacity.

Table 3.1 : Link Type Capacities

TMfS:05 Link Type	Description	Capacity (PCUs/lane)
1	Trunk - Motorway	2400
2	Trunk - Motorway Slips	1800
3	Trunk - A Roads Non-Built up	1800
4	Trunk - A Roads Built-up	1800
5	Non Trunk - A Roads Non-Built up	1600
6	Non Trunk - A Roads Built up	1600
7	Minor Roads Non Built up	1000
8	Minor Roads Built up	800
9	Banned HGV	Misc
10	Bus Only	Misc
22	Zone Centroid Connector	N/A

3.3.8 It is acknowledged by the TTAA that some of the individual links were allocated a manually coded capacity based on observed flow data, which differed from the generic value. This is considered to be good practice, nevertheless, many of the changes implemented appear to result in relatively minor capacity increase (usually 200 PCUs/lane). The TTAA is of the opinion that the link capacities for link type 5 to 8 are below what is expected. The rationale for the link capacities adopted during the TMfS:02 development was stated by MVA as being predominantly taken from DMRB Volume 5 Section 1 Part 3 (TA 46/97 and TA 79/99).

3.3.9 The TTAA considers these appropriate references for deriving generic capacities, however, the values expressed in MVA's documentation refer to PCUs per lane per hour, whilst the values in DMRB refer to vehicles per hour. As an example, a link of type 5 with a capacity of 1600 PCUs/lane would have an overall capacity of approximately 1520 vehicles per lane, assuming an HGV percentage of 5%. The TTAA considers this to be lower than would be expected, particularly given some of the allocation of link types in some areas (e.g. A8, A90 etc.).

3.3.10 With regard to which links in the network have been allocated which link types, the TTAA is generally satisfied that the link types (particularly types 1 to 4) have been appropriately allocated in TMfS. Nevertheless, with this form of generic coding, some detail from the original donor models may have been diluted and/or link capacities altered to potentially unrealistic values. The TTAA is content that link types 1 to 4 and 22 are satisfactory but has the following comments on other link types:

Link Types 5 & 6 – Non-Trunk A roads Non-built up and Built up : Capacity = 1600 PCUs/lane

3.3.11 The following bulleted list gives examples of links coded as types 5 & 6 in TMfS:

- A8 Newbridge to Gogar
- A90 Barnton to Inverkeithing
- A705 Livingston to Whitburn
- A71 west of Edinburgh
- A8011 Central Way Cumbernauld
- A899 Livingston
- A724 between Cambuslang and Blantyre
- A814 Clydeside Expressway Glasgow

3.3.12 The TTAA considers that whilst the label of "Non-Trunk A road" is appropriate in most cases, the generic per lane capacity is not truly representative of the differing road types. It is particularly considered that the capacities coded for the A8, A90 and A814 are underestimating the capacity for these link types.

3.3.13 MVA has subsequently acknowledged that in some cases, particularly on the A90 and A914, the link capacity coding may be considered conservative and this will be reviewed at the next major upgrade of TMfS.

Link Type 7 – Minor roads Non-Built up: Capacity = 1000 PCUs/lane

3.3.14 This link type is coded mainly towards the edges of the main urban areas or in suburban and rural areas of the model. The application of the link type is considered to be representative in TMfS:05, however, the generic capacity of 1000 PCUs/lane is considered to be very conservative for links of this nature in some areas. For example, the B969 around Glenrothes is coded with this link type, as is the connection between Gogar Roundabout and Edinburgh Park/Gyle Centre as are many rural links in Ayrshire and the Borders. Again, it is considered that the generic per lane capacity is not truly representative of the differing road types.

Link Type 8 – Minor roads <40mph : Capacity = 800 PCUs/lane

3.3.15 This link type has been mainly applied in urban and suburban areas to represent connector, access or residential links. Again, the application of the "Minor road" label has been appropriately applied in most cases, however, the capacity of 800 PCUs/lane is considered very conservative in some areas. The following list provides examples of links coded as type 8:

- Stewartfield Way East Kilbride
- Cathcart Road Glasgow
- Various links in all major urban centres in the model
- Queen Street Edinburgh City Centre
- Hanover Street Edinburgh City Centre

3.3.16 It is clear that each of the above links performs a different function within its locality and that a uniform capacity is unlikely to be truly representative of the actual capacity in each case. Additionally, a value of 800 PCUs/lane is exceptionally low for some, if not all of these locations. It is also evident that where any local adjustments have been applied, these are generally conservative. For example, the link capacity of Queen Street (Edinburgh) westbound is coded as 1000 PCU/hr in some sections. Whilst the TTAA recognises there are a number of constraints (bus lanes, parking etc.) the capacity coded is considered prohibitively low.

3.3.17 The TTAA does acknowledge that in cases where junctions have been coded at the end of these links, then the coded junction capacity will be the governing factor in terms of overall capacity. Therefore, the impact of the conservative link capacity coding will be neutralised in many cases, particularly in the urban centres such as Glasgow and Edinburgh. There are, however, many instances in the urban centres where links of type 8 do not have junctions coded at the terminal node and in such circumstances the conservative capacity coding will have an influence. The TTAA considers that this issue should be reviewed during the next major upgrade of TMfS.

SUMMARY OF LINK CAPACITY CODING

3.3.18 Overall the TTAA acknowledges that the rationalisation of the link types to match the Scottish Transport Statistics link types was introduced as a means of providing comparable analytical outputs. However, the associated generic link type capacities applied are considered by the TTAA to be conservative and in some cases unrepresentative of actual conditions.

3.3.19 The TTAA considers that whilst the chosen generic capacities, and the minor adjustments applied may represent a reasonable strategic, global road hierarchy within TMfS for the base year, this may have an influence on the model operation in future years. The issue is unlikely to have materially affected the overall level of base year calibration/validation and may also be relatively minor in respect of large scale, wide area policy/intervention testing in TMfS:05. Nevertheless, users of the model can reasonably expect to require robust outputs within more localised areas of the model. Whilst the impact cannot be quantified in this audit, the TTAA considers the link capacity coding may influence the robustness and realism of predicted model flows within more localised areas of the model.

3.3.20 It is recognised that TMfS is primarily a tool to be applied in strategic transport assessments, nevertheless, it will often be the only readily available model for a particular application in a particular area. Consequently, potential users of TMfS:05 should be made aware of the extent to which the generic coding has influenced the coded link capacities in TMfS:05, particularly when considering an application of TMfS:05 which is likely to require analysis at a local level.

3.3.21 The TTAA would recommend a review of the generic link capacities coding at the next major upgrade of TMfS.

Speed/Flow Curve Definition

3.3.22 No changes have been made to the speed flow curve definitions for the updated TMfS:05 model from those used in TMfS:02. The TTAA analysed the capacity indices and speed/flow curve definition and is satisfied that these have been defined appropriately for TMfS:05.

Link Distance Checks

3.3.23 More detailed commentary on this matter is provided in Chapter 2. It is considered that the link distances are generally coded appropriately for TMfS:05.

3.3.24 A comparison of total modelled distance for motorways and trunk A roads only was undertaken for the TMfS:05 network against the values found in the Scottish Transport Statistics (STS) Note 24 and against the TMfS:02 network. The absolute and GEH values obtained for the differences were small and show no major changes in the TMfS:05 network.

Link Connectivity Checks

3.3.25 Network connectivity was updated in TMfS:05 by incorporating relevant details from sub-area models and their representative audits, such as the Dalkeith Sub-Area model (DALSAM). The TTAA has supplemented MVA's checks by examining the network in MapInfo GIS and considers the connectivity to be appropriate.

Updating Modelled Junctions

3.3.26 A number of changes were made in the TMfS:05 network update with regards to the approaches to roundabouts, priority and signalised junctions. Any links with a distance in excess of 500m were manually checked by MVA and if necessary recoded to have a distance of 500m. This change allowed vehicles approaching modelled junctions to maintain a greater speed for a longer distance than previously coded. In line with these changes, capacity indices which designate the speed on the approaches to junctions were also checked by MVA and amended where appropriate. The TTAA acknowledges the rationale for this change and that it will enhance the model's ability to appropriately model junction approaches.

3.3.27 A full, detailed review of junction coding within the TMfS:05 model area was not feasible within the scope of this model development/rebase audit. Nevertheless, a sample of major junctions was examined. More detailed comments on the TTAA's review of the TMfS junction coding and issues arising from this are provided in Chapter 2.

3.3.28 A diagrammatic representation of the extent of modelled junctions within TMfS:05 is presented in Appendix A of MVA's report. Whilst a detailed, network wide, junction by junction review has not been undertaken by the TTAA, it is considered that the overall extent of junction coding is appropriate for TMfS:05.

3.4 Trip Matrix Development

3.4.1 The various aspects of the highway trip matrix development are outlined in Chapter 3 of MVA's report. A number of processes were involved in the development of the TMfS:05 HAM trip matrices from the TMfS:02 matrices, including:

- Conversion to the new TMfS:05 zone structure

- Zonal trip rate amendments
- Park and ride amendments
- Matrix estimation

3.4.2 The TTAA's findings based on a review of the HAM trip matrix development information are provided here.

Change in Zoning System

3.4.3 The TMfS:02 development rationalised the zoning system to be consistent with the 2001 census output area boundaries. This had a number of advantages including simplifying the provision of planning data for the model and integration with the land use model. From the strategic model perspective this change was considered desirable and appropriate for TMfS:02.

3.4.4 The TMfS:05 zoning system retains this structure, although zones containing airports were split to allow for the separate modelling of airports. The new zones allow for direct airport growth predictions to be used in future years which can then be excluded from the trip end and demand models. One airport zone (Edinburgh airport) was then further split to allow for the modelling of the new RBS headquarters on the A8 at Gogar. The TTAA recognises the benefit of these changes to the zoning system.

Matrix Data

3.4.5 Matrices for TMfS:05 were built using forecast matrices from TMfS:02. Trip rates were adjusted using planning data from TELMoS where this was deemed appropriate. No new RSI data was collected specifically for TMfS:05.

Prior Matrix Development

3.4.6 The TMfS prior matrices were developed by a process involving various stages which can be broadly described as follows:

- TMfS:02 matrices were forecast to 2005
- TMfS:02 forecast matrices converted into the new TMfS:05 zoning system
- Amendments made to the assignment matrices based on the most up to date 2005 planning data available
- Resultant trips ends passed through to MVGRAM along with the demand matrix to produce a prior matrix which is compatible with the most up to date trip ends
- Base network assigned with these matrices to attain network costs
- Matrices and costs run through the Park and Ride process to produce Park and Ride demand matrices

3.4.7 Although details are provided on the changes in the trip matrices due to Park and Ride adjustments and the subsequent matrix estimation process, no detailed information was provided in the HAM report covering more precisely the changes that were made to the matrices due to the TELMoS data or the smoothing process before the matrix estimation process began. MVA therefore provided the TTAA independently with matrices showing the changes incorporated in including the latest planning data.

3.4.8 Having examined the matrices it is clear that the changes resulting from the planning data adjustments are generally small across the matrix as a whole and at a sector trip end level. Larger changes are evident on some individual sector to sector movements as would be expected with the addition of more up to date information. Whilst the TTAA's assessment of this process has been largely qualitative it can be concluded that the changes introduced due to the planning adjustments broadly conform with expectations.

3.4.9 The TTAA would recommend that detailed changes at all stages of the matrix development, including the development of the prior matrix, should be reported in the documentation during the next major upgrade of TMfS.

Matrix Estimation

3.4.10 A process of matrix refinement was applied using matrix estimation, by applying the CUBE program MVESTM, to attempt to improve the fit between the trip matrix/assignment and observations. The data used in this process was the prior matrix, trip end data, assignment paths and traffic counts. Confidence levels were applied to specific movements in the matrix estimation process to manipulate changes in areas where the expressed level of confidence is lower.

3.4.11 All OD pairs were given the same level of confidence in the prior matrices due to a high level of confidence in the TMfS:02 matrices.

3.4.12 The trip end data was given a higher confidence than that of the matrix as the confidence in the total zonal productions and attractions was considered to be high due to amendments made using the planning data. The TTAA is content that this seems intuitively correct.

3.4.13 The paths used in the matrix estimation procedure were created during successive iterations between the matrix estimation and the highway assignment.

3.4.14 The count information used in the estimation process was that collected for the RSIs, grouped into appropriate screenlines as depicted in Appendix B of MVA's report. In addition to this, a selection of 2005 SRTDb count sites was included. A higher level of confidence was given to the more recently collected count data and a lower confidence applied to count data used during the previous TMfS:02 calibration.

3.4.15 The confidence level for the prior matrix was consistent (60) for all cells whilst the trip end data was given a higher confidence (80) for all origins and destinations. The 2005 SRTDb traffic counts were given a higher confidence (100) than the corresponding older 2002 data (55). The TTAA is content that the logic of these confidence levels appears sound for the matrix estimation process. **The TTAA suggests that for future TMfS upgrades, consideration should be given to refining the confidence levels for the prior matrix on a sector basis to reflect the relative confidence in differing areas of the matrix (e.g. due to availability or otherwise of RSI observations)**.

3.4.16 The matrices are presented in a 14 sector format in Tables 3.3 to 3.9 of MVA's report for all periods for matrices prior to the park and ride process, before MVESTM and in their final form. The TTAA has examined these to establish the scale of any changes at these different stages and if any rationale for this is clear. In order to establish the major changes in the matrices at the various stages, criteria were devised, which when matched, indicated a 'significant' change was evident between matrix development stages. The criteria defined by the TTAA were:

- Change ≥ 15% and
- PCUs ≥ 200

3.4.17 Table 3.2 to Table 3.7 show the matrices for the AM, IP and PM respectively for the changes between the Prior to post Park and Ride, and post Park and Ride to post Matrix Estimation. The greyed out cells indicate no significant change and the white starred cells indicate sector to sector movements which meet the 'significant' change criteria outlined previously.

Table 3.2 : AM Prior to post Park and Ride matrix changes

Sector	OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Edinburgh	1														
Lothian	2														
Fife	3	***													
Central	4														
Glasgow	5														
Strathclyde	6														
Ayrshire	7														
Dumfries and Galloway	8														
Borders	9														
Perthshire	10														
Dundee	11														
North East	12														
External (North)	13														
External (South)	14														

Table 3.3 : AM post Park and Ride to post Matrix Estimation matrix changes

Sector	OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Edinburgh	1														
Lothian	2														
Fife	3														
Central	4														
Glasgow	5	***													
Strathclyde	6	***													
Ayrshire	7														
Dumfries and Galloway	8														
Borders	9									***					
Perthshire	10											***			
Dundee	11										***				
North East	12														
External (North)	13														
External (South)	14														

Table 3.4 : IP Prior to post Park and Ride matrix changes

Sector	OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Edinburgh	1														
Lothian	2														
Fife	3														
Central	4														
Glasgow	5														
Strathclyde	6														
Ayrshire	7														
Dumfries and Galloway	8														
Borders	9														
Perthshire	10														
Dundee	11														
North East	12														
External (North)	13														
External (South)	14														

Table 3.5 : IP post Park and Ride to post Matrix Estimation matrix changes

Sector	OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Edinburgh	1						***								
Lothian	2														
Fife	3														
Central	4														
Glasgow	5														
Strathclyde	6														
Ayrshire	7														
Dumfries and Galloway	8														
Borders	9									***					
Perthshire	10											***			
Dundee	11														
North East	12														
External (North)	13														
External (South)	14														

Table 3.6 : PM Prior to post Park and Ride matrix changes

Sector	OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Edinburgh	1			***											
Lothian	2														
Fife	3														
Central	4														
Glasgow	5														
Strathclyde	6														
Ayrshire	7														
Dumfries and Galloway	8														
Borders	9														
Perthshire	10														
Dundee	11														
North East	12														
External (North)	13														
External (South)	14														

Table 3.7 : PM post Park and Ride to post Matrix Estimation matrix changes

Sector	OD	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Edinburgh	1				***	***	***								
Lothian	2					***	***								
Fife	3						***								
Central	4					***									
Glasgow	5														
Strathclyde	6		***												
Ayrshire	7						***								
Dumfries and Galloway	8														
Borders	9									***					
Perthshire	10											***			
Dundee	11														
North East	12														
External (North)	13														
External (South)	14														

Prior Matrices to post Park and Ride adjustment matrix changes

3.4.18 The AM matrix shows a decrease of 22% for Fife to Edinburgh trips. The PM matrix shows a corresponding vice-versa 16% decrease for Edinburgh to Fife trips. Intra-Fife trips have also increased in both periods. This change is as expected due to the Park and Ride scheme in Inverkeithing which will divide such trips that pre Park and Ride in the AM period (i.e. one trip from Fife to Edinburgh) into the appropriate legs (i.e. one intra-Fife car trip and then a PT trip from Fife to Edinburgh). This reduces the Fife to Edinburgh car trips. A similar phenomenon occurs in the PM but for the reverse direction.

3.4.19 It is evident that other changes have occurred in the matrices as a result of the Park and Ride adjustments, however, these do not meet the 'significant' criteria defined above. Generally these are in

areas where Park and Ride facilities, whether official or unofficial, exist (e.g. Edinburgh, Fife, Lothians, Glasgow, Strathclyde and Tayside). Overall, the TTAA is generally satisfied that the 'significant' changes in trips between the Prior matrices to post Park and Ride matrices are intuitively correct.

3.4.20 MVA provided the TTAA independently with details of the Park and Ride sites included in the TMfS:05 Base model as these are not listed in either the HAM or Public Transport Model development reports. **The TTAA would recommend that a list of all Park and Ride sites should be included as a matter of course in future TMfS development reports**.

Post Park and Ride matrices to post Matrix Estimation matrix changes

3.4.21 The 14 sector matrix change analysis highlighted a number of 'significant' changes between the post park and Ride matrices and the post Matrix Estimation matrices (ref. Tables 3.3, 3.5 and 3.7).

3.4.22 Perth to Dundee and Dundee to Perth movements were found to be fully observed movements during the TMfS:02 model audit. However, in the analysis of the matrix changes during the matrix estimation process in TMfS:05, it becomes apparent that in all three periods there are substantial changes in the matrix values for both Perth to Dundee and Dundee to Perth movements, with the AM showing a 40% increase in Dundee to Perth movements and a 41% increase in Perth to Dundee movements. The PM matrices show a 21% increase in Dundee to Perth movements and a very large 67% increase in Perth to Dundee movements. Fife movements were also previously defined as fully observed. However, Fife to Strathclyde movements have decreased by 37% in the AM, 32% in the inter-peak, and by 41% in the PM. Fife to Glasgow movements have also decreased by 49% in the PM period.

3.4.23 Glasgow and Strathclyde to Edinburgh and to a lesser extent Glasgow to Lothian movements have reduced significantly in the AM post matrix estimation, with the reverse directions also reducing significantly in the PM. Intra-Borders movements have increased by 34% in the AM, 31% in the inter-peak and 25% in the PM. Furthermore, the AM post matrix estimation matrices see a very large increase of 73% in trips from the External (North) sector to Ayrshire, a 22% decrease in trips from Ayrshire to External (North) and a decrease in trips of 30% for the Central to North East sector. It should be noted that these movements were not previously defined as fully observed.

3.4.24 Some PM movements showed unexpected increases and decreases on movements that were previously deemed to be fully observed. These included a decrease in Edinburgh to Central movements of 17%, a decrease in North East to Central movements of 26% and an increase in Perthshire to Edinburgh sector movements of 31%. Other movements which altered significantly but were not deemed to be fully observed were, Edinburgh to Dumfries and Galloway movements which decrease of 27%, Lothian to Strathclyde movements which decreased by 25%, Central to Glasgow sector movements which decreased by 22%, Glasgow to Lothian and Strathclyde to Lothian movements which increased by 18% and 17% respectively, and Ayrshire to Strathclyde sector movements which increased by 15%.

3.4.25 MVA has subsequently confirmed that these changes are as a result of significant changes in the SRTDb counts between 2002 and 2005 which were not reflected in the forecast prior matrices. Consequently, when undertaking the matrix estimation process, the movements passing through these SRTDB counts, which were assigned a high confidence level, were factored to ensure a match between modelled and observed flows. The TTAA is content that this explains the significant changes to the fully observed movements.

3.4.26 The TTAA also undertook a comparison at the 14 sector level between the final TMfS:02 and TMfS:05 matrices (post matrix estimation) to establish the overall differences. This comparison is complicated by the fact that the TMfS:05 final matrices include an adjustment for Park and Ride trips which is not the case with TMfS:02. To provide as reliable a comparison as possible, the TTAA adjusted the TMfS:05 final matrices by removing the pre- to post-Park and Ride adjustment from these matrices before comparing them with the TMfS:02 final matrices (accepting that this does not provide a 100%, like for like comparison). It is reassuring to note that in this comparison, no changes between TMfS:02 and TMfS:05 matched the 'significant' change criteria outlined previously. Globally the matrices show an increase of approximately 5% in each time period in TMfS:05 which seems intuitively correct.

3.4.27 Overall, the TTAA is generally content that the changes on a 14 sector basis in the final TMfS:05 matrices, relative to those for TMfS:02, are of an acceptable order of magnitude.

3.4.28 The TTAA strongly recommends that at the next major upgrade of TMfS, details of the changes introduced at each stage of the matrix development process are reported using a finer sectoring system (e.g. 35 sector system, or finer). This would detail the changes introduced during all major stages of development including those due to planning data adjustments and matrix smoothing as well as other stages of development such as Park and Ride and matrix estimation.

3.5 Assignment Model Development

3.5.1 The assignment procedure for TMfS is a volume averaged capacity restraint assignment based on All or Nothing (AoN) paths at each iteration. This is similar to that adopted for TMfS:02 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.

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

Assignment Procedure

3.5.3 The assignment procedure, as per TMfS:02, 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.

3.5.4 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, and so the best paths on the first iteration will stay best throughout assignment"*. This point should be noted by users of TMfS for any assessment which involves examination of flows in rural areas.

3.5.5 The TTAA is content that the volume averaged capacity restraint assignment method adopted for TMfS:05 is appropriate.

Cost versus Time Assignment Method

3.5.6 This assignment methodology which was incorporated within TMfS:02 to enable tolling tests to be undertaken without the requirement to develop a separate tolling model and remains the approach in TMfS:05. 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.

3.5.7 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 therefore used for all applications whether concerned with tolling or not. The TTAA acknowledges the advantages of the adopted assignment methodology in this regard.

3.5.8 Overall, the TTAA is content that the CvT assignment technique is an appropriate one to use for TMfS:05. 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 TMfS:02 and TMfS:05.

Model Convergence

3.5.9 Post-calibration of the TMfS HAM, a convergence criteria was adopted which considered the toll parameter within the generalised cost formulation. Consequently, tolling costs were added to the time and distance network costs to obtain the total costs on an iteration by iteration basis. A normalised regression statistic was then calculated which relates the cost in the current iteration to the total network cost.

3.5.10 The HAM is considered to have converged when the regression statistic is less than or equal to 1% on 3

successive iterations. The resulting, post-calibration TMfS:05 HAM base year convergence using this methodology is shown in Table 3.8 along with the corresponding values for TMfS:02.

Table 3.8 : Iterations needed for Convergence

Period	Iterations needed for convergence	
	TMfS:02	TMfS:05
AM	75	77
IP	33	36
PM	74	68

3.5.11 Table 3.8 shows a small increase in the number of iterations needed for convergence in TMfS:05 compared to TMfS:02 for the AM and OP periods and a small decrease in the number of iterations needed for convergence in the PM. 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 within the model.

3.6 Highway Model Calibration

3.6.1 The HAM for TMfS:05 was subject to a wide area calibration process by comparing modelled and observed traffic flows at the RSI locations. 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 highway assignment validation acceptability guidelines (ref. Table 4.2 in above section of DMRB). These guidelines are ideal standards for comparing modelled to observed flows for assignment modelling. These guidelines are replicated in Table 3.9 below.

Table 3.9 : 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

3.6.2 Rather than adopting the DMRB guidelines, MVA adopted a series of calibration targets which they consider better reflected the model scale and intended purpose. 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

3.6.3 These targets are consistent with those adopted for TMfS:02 and are therefore considered appropriate for TMfS:05. The less stringent nature of the adopted calibration targets compared with DMRB guidelines should, however, be noted.

Key Strategic Screenline Flows

3.6.4 Three key strategic screenlines were defined in the TMfS:05 area:

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

3.6.5 Table 3.10 presents the observed versus modelled GEH values for all three strategic screenlines for all three time periods for both TMfS:05 and the corresponding values for TMfS:02.

Table 3.10 : Screenline GEH Comparison

			GEH	
Screenline	Direction	Period	TMfS:02	TMfS:05
Forth Estuary	Northbound	AM	2.2	0.6
		IP	2.0	0.2
		PM	2.9	5.2
	Southbound	AM	0.1	1.5
		IP	1.1	5.0
		PM	3.8	2.1
Clyde	Northbound	AM	5.3	2.3
		IP	0.3	3.2
		PM	2.3	2.1
	Southbound	AM	0.7	12.5
		IP	0.9	4.9
		PM	7.8	5.0
Tay	Northbound	AM	3.3	3.8
		IP	2.3	0.7
		PM	1.8	2.7
	Southbound	AM	1.8	4.3
		IP	3.4	0.2
		PM	3.5	4.1

3.6.6 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 0.2 and 5.2.

3.6.7 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 with five out of six (AM, IP and PM northbound and IP and PM southbound) GEH values of 5.0 or less. The AM peak southbound GEH is a high value of 12.5 largely due to a significant overestimate of flow (approx. +1000 PCUs) on the Kingston Bridge. This is also true of the Inter-peak period where the flow is overestimated by approx. +800 PCUs and the PM peak where the flow is overestimated by approx. 900 PCUs.

3.6.8 With respect to this issue, MVA has subsequently quoted that "As part of the TMfS:05 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".

3.6.9 The TTAA acknowledges 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 TMfS:05. 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.

3.6.10 It should also be noted that when considering the individual links which make up the screenline, in the northbound direction in the AM, even though an overall GEH of 2.3 is achieved, on an individual basis the GEH values on links are as high as 13.1. There is an overestimate of the flow at the M8 J23 by 800 PCUs with underestimates of the flow on Commerce Street by approximately 600 PCUs and through the Clyde Tunnel by approximately 500 PCUs. A similar issue occurs in the PM in the northbound direction with the flow on Commerce Street again being substantially underestimated. Therefore even though the overall screenline flow is acceptable, the routeing split of traffic is not accurate.

3.6.11 Regarding this issue, MVA has subsequently commented that "Regarding the M8 J23, TMfS:05 has improved the relationship between the observed count and modelled flow at this location. However, at locations such as Commerce Street, the modelled flow has reduced while the observed count remains that of 2002. This will result in an increased GEH value. The main reason for this variability is the use of some new count data (where possible) and the use of old, 2002 count data".

3.6.12 Again the TTAA acknowledges MVA's comments regarding data availability and the use of a mixture of old and new data on the screenline. **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 TMfS:05, 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**.

3.6.13 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 0.2 to 4.3.

3.6.14 Overall, the strategic screenline calibration comparisons, considering total screenline flows, demonstrate a good level of calibration in most cases with half of the screenlines values bettering their TMfS:02 value and only one screenline (Clyde AM Southbound) showing a significant worsening in GEH value from the corresponding TMfS:02 value.

Other Screenline Flows

3.6.15 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 TMfS:05 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 in Table 3.11 below.

Table 3.11 : Key Link Flow Calibration

Time Period	% of site with GEH value:									
	≤ 5		≤ 7		≤ 10		≤ 12		≤ 15	
Target	60%		80%		95%		100%		100%	
	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05
AM	60	**62**	75	**78**	90	**89**	95	**95**	99	**100**
IP	75	**79**	89	**90**	96	**96**	99	**99**	100	**100**
PM	62	**66**	78	**79**	92	**91**	97	**95**	99	**99**

3.6.16 The key link flow calibration table demonstrates that the targets are met in almost all cases for the inter-peak model. In the AM, the GEH ≤5 and GEH ≤ 15 targets are met with all other targets being narrowly missed. In the PM just the GEH ≤5 target is met with all other targets being 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 TMfS:05. In relation to the calibration of TMfS:02, the TMfS:05 results show a higher proportion of key link flows with a GEH of ≤5 and ≤7.

3.6.17 The multi-point screenline analysis summary is presented in Table 3.12. It is stated in §5.3.8 of MVA's report that 230 multi-point screenlines were used in the TMfS:05 calibration compared with only 48 in TMfS:02. MVA has subsequently confirmed that there were in fact 41 two-way multipoint screenlines used in the TMfS:05 calibration and this anomaly will be addressed in the final version of the report.

Table 3.12 : Multipoint Screenline Calibration

Time Period	% of site with GEH value:									
	≤ 5		≤ 7		≤ 10		≤ 12		≤ 15	
Target	60%		80%		95%		100%		100%	
	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05
AM	57	**62**	81	**77**	94	**91**	95	**97**	100	**100**
IP	78	**67**	88	**81**	95	**94**	98	**99**	100	**100**
PM	71	**62**	79	**75**	92	**90**	96	**96**	99	**99**

3.6.18 This demonstrates that the inter peak model meets or almost meets every target whilst the AM and PM model meets the ≤5 target, narrowly failing to meet all other targets with the exception of the AM ≤ 15 target which is met. At a global level, the TTAA considers this to be an acceptable level of calibration for TMfS:05. Compared with the corresponding TMfS:02 calibration values, the TMfS:05 values are the same or better than the TMfS:02 values in 7 of the 15 cases across all time periods with the remainder showing a slight worsening.

3.6.19 The global level of calibration for all of the counts used in the TMfS:05 HAM calibration is presented in Table 3.13 below, along with the corresponding level of calibration achieved for TMfS:02.

Table 3.13 : Global Link Flow Calibration

Time Period	% of site with GEH value:									
	≤ 5		≤ 7		≤ 10		≤ 12		≤ 15	
Target	60%		80%		95%		100%		100%	
	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05
AM	60	**60**	76	**74**	90	**88**	95	**94**	99	**99**
IP	72	**72**	85	**84**	94	**95**	97	**99**	99	**100**
PM	60	**62**	75	**76**	89	**89**	94	**93**	98	**98**

3.6.20 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 however only meet the calibration criteria for the ≤ 5 target. For the majority of the criteria over all three periods, the TMfS:05 calibration at a global level is better than that for TMfS:02. Overall, the TTAA considers that 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 Summary

3.6.21 The TTAA has undertaken an independent check of the TMfS calibration against the various DMRB assignment validation acceptability guidelines (ref. Table 3.9 above). The results of this comparison are presented in Table 3.14.

Table 3.14 : TMfS:05 Calibration Compared with DMRB Criteria

	Criteria	AM	IP	PM	Acceptability
1	Flows 700-2700vph within 15%	59%	72%	58%	>85%
2	Flows <700vph within 100vph	72%	79%	71%	>85%
3	Flows >2700vph within 400vph	65%	55%	53%	>85%
4	Total Screenline flows within 5%	18%	29%	24%	All or nearly all
5(i)	Individual Flows GEH < 5	61%	71%	62%	>85%
5(ii)	Screenline Totals GEH < 4 *	54%	68%	54%	All or nearly all

* Based on all local area screenlines combined

3.6.22 The TTAA recommends that all future model development and calibration reports for TMfS and any derivatives present a table similar to Table 3.14 above which demonstrates the model's level of calibration against all of the DMRB target guidelines. The TTAA recognises that the DMRB guidelines should not necessarily be considered as pass/fail criteria against which to assess a model, particularly one of the scale and nature of TMfS, nevertheless, they do provide a useful benchmark against which to appraise the level of calibration achieved for various criteria. In light of this, the table could also be expanded/duplicated to reflect alternative target levels which may be considered more appropriate for the model in question.

3.6.23 This independent check demonstrates that the model calibration is outwith the DMRB guideline targets in all cases although it is encouraging to note that the number of individual flows approaching the DMRB targets is generally quite high in all time periods (ref. criteria 1, 2, 3 & 5(i)). The model is furthest from meeting the DMRB criteria for screenline flows (ref. criteria 4 and 5(ii)). It should be noted, however, that the total screenline flows include the key link (single point) count sites, which were also used as part of the calibration process.

3.6.24 Overall, it is not considered surprising that the level of calibration for TMfS:05 is below the ideal DMRB target guidelines given the scale, nature and spatial variability in detail of the model and its data in relation to the stringent targets in DMRB. It is also encouraging that the individual link flow DMRB targets are met in a minimum of 53% of cases for all time periods. The generally lower level of calibration across screenlines should be noted by potential users of TMfS:05.

3.6.25 The calibration comparisons generally demonstrate that TMfS:05 has achieved an acceptable level of calibration to link flows and screenlines on a global basis across the model. The key link and strategic screenline analysis has also demonstrated a generally acceptable level of calibration, albeit at a level below the ideal DMRB target guidelines.

3.6.26 Given the geographical variation in the level of calibration achieved in TMfS:05 and the difficulties in readily identifying individual link flow comparisons from the tables and graphics presented in the reports, the TTAA considers that at the next major upgrade of TMfS, a graphical form of presentation of the calibration should be made available to prospective users of TMfS. This would enable users to more readily identify and understand the calibration at a local area and individual link level. The information presented should include, but not be restricted to, the following:

- **Observed and modelled flows at calibration sites**
- **Colour coded GEH comparisons (by target bin e.g. ≤5, ≤7 etc.) for all calibration link flows individually by time period**
- **As above, but separately for the strategic, key link flow and multi-point screenlines**

3.6.27 This could be made available either via enhanced documentation or (more likely) via the user group area of the TMfS website.

3.7 Validation

3.7.1 Independent validation of the TMfS:05 HAM has been undertaken by comparing modelled and observed journey times, modelled flows with independent traffic counts not used in the calibration and by examining the trip length distribution. A comparison of modelled to observed HGV flows across screenlines has also been undertaken. The various aspects of the independent validation are considered as follows.

Journey Times

3.7.2 Observed and modelled journey times were compared across 59 journey routes including two new routes along the M8. The 95% confidence interval calculation for assessing the acceptability of the modelled journey times has been calculated using the following formula:

$$X \pm ts$$

Where,

- X is the average of observed journey times along a route
- t is the students t –distribution used with the 95% confidence probability value of 0.025 for the 2-sided test
- s is the standard deviation of the observed journey times.

3.7.3 The TTAA believes the above formula to be incorrect and having discussed this matter with MVA it has been agreed that for future TMfS reporting, the following formula will be adopted for the calculation of 95% confidence intervals:

$$X \pm \frac{ts}{\sqrt{n}}$$

3.7.4 The implication of applying the formula adopted by MVA is that the validation of the journey times essentially becomes more likely as the calculated confidence interval range within which the modelled journey time could lie would be wider.

3.7.5 It should be noted that the observed journey times used for the TMfS:05 validation have in many cases not altered since the validation process undertaken in TMfS:02 was performed. As well as this, there have been some structural changes in the network which lie on some of the journey time routes. It is the TTAA's opinion that whilst it is worthwhile to re-validate the model to the available data, it is important to note the limitations of a validation based on out-of date data. **It is strongly recommended that for the next major upgrade of TMfS, it would be of high importance to collect more up-to-date journey time data for validation**.

3.7.6 A number of inconsistencies between the text in Section 6.2 and the information contained in Appendices H and I of MVA's Draft Report were identified during the audit process. MVA has stated the intention to address these inconsistencies in the Final Report in due course. For the purpose of the audit, the data in the appendices is assumed correct and the text in Section 6.2 is assumed to be incorrect or unclear.

3.7.7 The TTAA has summarised the journey time validation in Table 3.15 below showing how many routes fall within the 95% confidence intervals (as calculated by MVA) of the observed sample on an area by area basis. This demonstrates that, with the exception of the inter-urban routes in the PM peak, modelled journey times are within the 95% confidence interval of the observed sample for each area and in all time periods in at least 60% of cases. Overall, this appears to represent an acceptable level of validation to journey times.

Table 3.15 : Summary of Journey Time Validation (MVA Criteria)

Area	Total number of Routes	No. routes within 95% Confidence interval of observed AM Number of routes	AM % of routes	IP Number of routes	IP % of routes	PM Number of routes	PM % of routes
Edinburgh Urban	14	12	86%	12	86%	11	79%
Glasgow Urban	84	71	85%	61	73%	67	80%
Aberdeen Urban	4	4	100%	4	100%	4	100%
Inter-Urban	14	12	86%	9	64%	8	57%

3.7.8 No comparison between modelled and observed journey times in accordance with the DMRB assignment validation acceptability guidelines (ref. Table 2.9, criteria 6) was presented in MVA's Draft Report. This information was provided independently by MVA to the TTAA for average journey times and is reproduced in Table 3.16 below.

Table 3.16 : Summary of Journey Time Validation (DMRB Criteria)

Area	Total number of Routes	% of routes within 15% of observed (or 1 minute if higher)		
Edinburgh Urban	14	57%	86%	64%
Glasgow Urban	82	70%	80%	70%
Aberdeen Urban	4	75%	100%	75%
Inter-Urban	14	100%	86%	93%
Total	**114**	**72%**	**82%**	**72%**

3.7.9 This comparison against DMRB criteria demonstrates that the journey times across all routes meet the criteria in 72%, 82% and 72% of cases for the AM, inter and PM peaks respectively. The TTAA considers this an acceptable level of journey time validation for a model such as TMfS. The journey time validation is generally good on inter-urban routes in all time periods. The urban route validation is generally good in the inter peak with (as expected) lower validation levels in these areas in the AM and PM peaks, particularly in the Edinburgh area.

Flow Validation

3.7.10 Traffic count data not used in the calibration process has been used for the purpose of Validation. In total, 1,372 one-way counts were used for the validation of the TMfS:05 HAM. Table 3.17 presents the results of the independent highway validation of all sites achieved for TMfS:05 against the corresponding TMfS:02 values.

Table 3.17 : TMfS:05 versus TMfS:02 validation Summary

	≤ 5		≤ 7		≤ 10		≤ 12		≤ 15	
Target	*60%*		*80%*		*95%*		*100%*		*100%*	
Time Period	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05
AM	55	**48**	70	**65**	87	**84**	94	**92**	98	**98**
IP	62	**60**	76	**77**	90	**91**	96	**97**	100	**100**
PM	52	**50**	68	**65**	83	**84**	92	**93**	99	**99**

3.7.11 It can be seen that the TMfS:05 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 TMfS:05, and the fact that the overall level of validation has not significantly altered between TMfS:02 and

TMfS:05, the TTAA considers this to be an acceptable level of independent validation. It is noted that the validation summary statistics for each target are not significantly improved in TMfS:05 compared with those for TMfS:02 with nearly half of the values being lower in TMfS:05 than TMfS:02. The MVA report states that the TMfS:05 validation used a significant increase in the number of screenlines in the validation process and that many of the extra counts were in rural areas or at the periphery of the modelled area. These areas of the model can be affected by a lack of adequate travel pattern data and that this could be part of the reason for the poorer TMfS:05 screenline validation when compared against that for TMfS:02.

3.7.12 An independent comparison of the TMfS:05 validation against the various DMRB assignment validation acceptability guidelines (ref. Table 3.9) has been undertaken by the TTAA. The results of this comparison are presented in Table 3.18 below.

Table 3.18 : TMfS:05 Validation Compared with DMRB Criteria

	Criteria	AM	IP	PM	Acceptability
1	Flows 700-2700vph within 15%	55%	61%	56%	>85%
2	Flows <700vph within 100vph	59%	72%	58%	>85%
3	Flows >2700vph within 400vph	75%	77%	75%	>85%
4	Total Screenline flows within 5%	13%	15%	12%	All or nearly all
5(i)	Individual Flows GEH < 5	48%	60%	50%	>85%
5(ii)	Screenline Totals GEH < 4 *	42%	51%	43%	All or nearly all

* It should be noted that each individual flow is treated as a screenline

3.7.13 The analysis in Table 3.18 demonstrates that the level of independent validation achieved, in many cases, is slightly lower than the level of calibration achieved when both are compared with DMRB guidelines. However, the validation is not significantly worse than the calibration in any instances other than the GEH calculations (ref. Criteria 5(i) and 5(ii)).

3.7.14 Overall, the TTAA is content that, in light of the generally good level of calibration achieved, and given the scale, nature and spatial variation in detail of the model, the level of global independent validation achieved for TMfS:05 is acceptable.

3.7.15 Similar to the calibration, the TTAA considers that during the next major upgrade of TMfS, it would be of benefit to potential users for a graphical representation of the validation to be made available. This would enable prospective users of TMfS to more readily identify and understand the validation at a local area and individual link level. For future model development purposes, the TTAA recommends the information presented should include, but not be restricted to, the following:

- **Observed and modelled flows at validation sites**
- **Colour coded GEH comparisons (by target bin e.g. <5, <7 etc.) for all validation link flows individually by time period**
- **As above, but separately for the HGV, car in-work and car non-work screenlines**
- **Details of the journey time validation including comparisons with DMRB acceptability guidelines**

3.7.16 Again, this could be made available either via updated documentation or (more likely) via the user group area of the TMfS website.

Trip Length Distribution

3.7.17 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 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).

HGV Screenline Analysis

3.7.18 HGV screenline analysis was undertaken for the screenlines used in the validation for instances where suitably classified count data was available. Table 3.19 shows the HGV screenline analysis for TMfS:05 along with the corresponding TMfS:02 values. TMfS:05 values are either similar to or poorer than the corresponding TMfS:02 values. However, MVA suggests this is due to similar reasons as stated previously regarding the use of extra count data in the TMfS:05 validation, including areas at the model periphery where data is of a lower quality.

Table 3.19 : TMfS:05 versus TMfS:02 HGV Screenline Validation Screenline Analysis

Time Period	% of site with GEH value:									
	≤ 5		≤ 7		≤ 10		≤ 12		≤ 15	
Target	60%		80%		95%		100%		100%	
	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05
AM	62	**54**	77	**68**	88	**82**	92	**88**	96	**93**
IP	67	**57**	71	**70**	90	**85**	93	**91**	97	**96**
PM	67	**59**	80	**73**	90	**88**	95	**94**	97	**97**

Car In Work and Car Non Work Screenline Analysis

3.7.19 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.

Table 3.20 : TMfS:05 versus TMfS:02 Car in Work Screenline Validation Screenline Analysis

Time Period	% of site with GEH value:									
	≤ 5		≤ 7		≤ 10		≤ 12		≤ 15	
Target	60%		80%		95%		100%		100%	
	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05
AM	76	**74**	90	**86**	98	**93**	100	**97**	100	**100**
IP	84	**78**	97	**91**	99	**98**	99	**98**	100	**100**
PM	80	**80**	93	**88**	98	**95**	100	**98**	100	**99**

Table 3.21 : TMfS:05 versus TMfS:02 Car Non-Work Screenline Validation Screenline Analysis

Time Period	% of site with GEH value:									
	≤ 5		≤ 7		≤ 10		≤ 12		≤ 15	
Target	60%		80%		95%		100%		100%	
	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05
AM	56	**61**	73	**74**	89	**86**	95	**91**	98	**95**
IP	66	**67**	84	**81**	94	**95**	97	**97**	100	**98**
PM	57	**53**	71	**66**	87	**83**	95	**88**	99	**93**

3.7.20 Table 3.20 and Table 3.21 show little difference between TMfS:02 and TMfS:05 values and show a generally good degree of validation.

Census Travel to Work Data

3.7.21 Post Matrix Estimation, the AM peak hour matrix was validated against 'Census Travel to Work' data. TMfS:05 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 TMfS:05 percentages compare favourably with those of the Census data, the only exception being the heightened TMfS:05 productions and attractions to and from the City of Glasgow.

3.7.22 MVA has subsequently commented 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".

3.8 Summary of TMfS HAM Calibration/Validation

3.8.1 The TTAA has reviewed the development, calibration and validation of the TMfS:05 HAM. A summary of the main findings is as follows.

Network Development

3.8.2 Generally, the network development in terms of coverage, connectivity, link length coding and speed/flow curve definition is considered acceptable for TMfS. The TTAA does have some concerns, particularly for future year applications, regarding the apparently very low capacities coded for many link types within the TMfS:05 study area. This is unlikely to significantly affect strategic assessments, however, it is likely to have an influence when considering analysis of any outputs at a more local level. The TTAA recommends that this be reviewed at the next major upgrade of TMfS.

Trip Matrix Development

3.8.3 The TMfS trip matrix development has been undertaken using existing trip matrices from TMfS:02 supplemented with new TELMoS data to adjust trip rates where it was deemed appropriate. No new RSI data was used. The matrices were subject to Park and Ride adjustments to refinement through matrix estimation. The TTAA is generally content that the appropriate data and processes have been applied in creating the TMFS:05 HAM matrices. The TTAA is generally content that the changes on a 14 sector basis in the final TMfS:05 matrices, relative to those for TMfS:02, are of an acceptable order of magnitude.

Assignment Model Development

3.8.4 The TMfS:05 HAM has been developed along similar lines to that of TMfS:02. The TTAA is satisfied that these developments are appropriate for TMfS:05.

Model Calibration

3.8.5 The TMfS:05 HAM has been calibrated to traffic flows at the various RSI sites from which the observed trip matrices were developed. The calibration has considered key strategic screenlines, key link flows, multi-point screenlines as well as all link flow comparisons combined.

3.8.6 The calibration comparisons generally demonstrate that TMfS:05 has achieved an acceptable level of calibration to link flows and screenlines on a global basis across the model. The key link and strategic screenline analysis has also demonstrated a generally acceptable level of calibration, albeit at a level below the ideal DMRB target guidelines. Users should note the variable quality of the calibration across the Clyde Strategic Screenline and in particular, the poor southbound calibration over the Kingston Bridge.

Model Validation

3.8.7 The TMfS:05 HAM has been validated to journey time data, count data not used in the model calibration and the trip length distribution. The journey time validation is acceptable for a model of the scale and nature of TMfS. Discrepancies between the text in the main body of MVA's Draft Report and the journey time graphs provided in the appendices were identified and MVA has stated the intention to revise this for the Final Report. It should be noted that the journey time comparisons have been undertaken using largely historic data from TMfS:02 which clouds the comparisons made in this case.

3.8.8 The TTAA considers that the definition of the 95% confidence interval for the mean observed journey times

is incorrect in the Draft Report. Following discussion, MVA has agreed to change the formula used for future reporting purposes. Additionally, MVA will include a comparison of modelled to observed journey times against DMRB criteria in future reporting.

3.8.9 The validation to independent link flows has been presented for individual link flows and for screenlines, as well as supplementary validation of car in-work and non-work and HGV screenlines. Overall, the TTAA is content that, in light of the generally good level of calibration achieved, the level of global independent validation to traffic flows achieved for TMfS:05 is acceptable.

3.8.10 The trip length distribution analysis presented also demonstrates intuitively correct trends and that the distributions do not appear to have been significantly altered during the matrix estimation procedure.

4 PUBLIC TRANSPORT NETWORK AND SERVICES

4.1 Introduction

4.1.1 This chapter presents the TTAA's findings based on information supplied by MVA for the Transport Model for Scotland (TMfS:05) development audit and relates to TMfS Audit Task 3: Public Transport Network and Services.

4.1.2 All data files requested for the audit by the TTAA were made available through the TMfS website www.tmfs.org.uk.

4.2 Public Transport Network

4.2.1 MVA provided the TTAA with a copy of the TMfS:05 network in TRIPS format, which enabled an analysis of the network to be undertaken.

4.2.2 The public transport (PT) road network is consistent with the TMfS:05 highway network. The TTAA is satisfied with the PT network coding.

4.2.3 The TTAA acknowledges that the significant changes to the TMfS:05 public transport network (compared to TMfS:02) are:

- a new station at Edinburgh Park
- a new station at Gartcosh
- addition of a new Larkhall line including new stations at Chatelherault, Merryton and Larkhall
- a new station at Kelvindale

4.2.4 The extent and coverage of the skeletal PT (bus and rail) network is considered to be appropriately representative of the existing network within the main internal TMfS:05 study area. It should be noted, however, that the Aberdeen to Inverness rail line is curtailed one station short of Inverness at Nairn with external zone connectors providing connectivity to Inverness.

4.2.5 As stated in the TMfS:02 audit, it is worth noting that the Perth-Inverness (and further north) line is curtailed in Perthshire (around Dunkeld) rather than extending into the external model area. Similarly, Glasgow to Fort William (and onwards to Mallaig in the north) is curtailed at Crianlarich rather than extending into the external model area. The rail spur between Tyndrum and Oban has also been omitted from the PT model network, and unlike the TMfS:02 model, bus services do not extend to Oban. All main west coast ferry terminals within the main internal model area appear to be served by the relevant PT links (e.g. Gourock, Ardrossan, Stranraer etc.) with the exception of Oban, which has rail links omitted. Given Oban's proximity to the internal/external model boundary (the zone straddles the boundary), this is unlikely to be a significant issue for most applications of TMfS:05.

4.2.6 MVA has commented on this issue that "Regarding the curtailment of the Perth to Inverness and Glasgow to Fort William railway lines, the external zones link into these stations and therefore the network connectivity allows patrons to use the rail services from Crianlarich and Dunkeld. The external zones are connected by walk links to stations such as Crianlarich therefore the distance to be walked is minimal".

4.3 Public Transport Services

Mode Type

4.3.1 The TTAA received a list of all the bus, rail and ferry companies where services have been included in TMfS:05. In total there are 41 bus companies coded within TMfS. Table 4.1 shows the breakdown of the bus services by Mode type in TMfS:05 compared against those from TMfS:02.

Table 4.1 : TMfS:02 vs TMfS:05 Transport Services

Mode	AM Peak		Inter Peak		PM Peak	
	TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05
Urban Bus	470	478	462	471	466	472
Inter-Urban Bus	400	410	590	587	371	378
Rail	138	146	274	244	139	138
Underground	2	2	2	2	2	2
Ferry	2	2	2	2	2	2
Total	1012	1038	1330	1306	980	992

4.3.2 The total number of PT services has remained broadly the same between TMfS:02 and TMfS:05 in the all model periods with the biggest change the 11% reduction in rail services in the interpeak in TMfS:05.

4.3.3 The results showed that over all modes a total of 48 additional services had been included in the TMfS:05 model but also that 34 services from the TMfS:02 model had not been included in the TMfS:05 model, of which 30 of these related to the 11% decrease in rail services in the interpeak period. MVA has subsequently clarified that the differing number of services between TMfS:02 and TMfS:05 is due to a complete update of all First Scotrail, GNER and Virgin services to reflect the most up to date timetable information.

4.3.4 The TTAA is satisfied that the changes in the PT mode type definitions in rebasing from TMfS:02 to TMfS:05 conform with expectations.

Operator Provision

4.3.5 An analysis of the number of services that individual operators provide in both TMfS:02 and TMfS:05 was undertaken and Table 4.2 shows the results.

Table 4.2 : TMfS:02 vs TmfS:05 Company Service Provision Comparison

Company Line Number	Company	Number of Modelled Services					
		AM		Inter Peak		PM	
		TMfS:02	TMfS:05	TMfS:02	TMfS:05	TMfS:02	TMfS:05
1	HUTCHINSONS COACHES	17	15	19	19	19	19
2	WESTERN SCOTTISH	11	11	19	19	13	13
3	MCKINDLESS	16	16	15	15	15	15
4	SCOTTISH CITYLINK COACHES	21	27	55	46	25	25
5	HAD	13	13	13	13	15	15
6	FIFE SCOTTISH	3	3	9	9	2	2
7	STOKES COACHES	3	3	10	10	4	4
8	ANNS COACHES	1	3	2	2	2	2
9	STRATHCLYDE PASSENGER TRANSPORT	2	2	2	2	2	2
10	LOWLAND OMNIBUSES	15	15	1	1	0	0
11	SCOTRAIL	133	139	230	191	131	128
12	EAST COAST	0	1	15	18	2	2
13	CROSS COUNTRY	5	6	29	35	6	8
14	IRVINES COACHES	0	0	2	2	2	2
15	STUARTS COACHES	8	8	10	10	9	9
16	STAGECOACH	191	193	305	307	178	183
17	DOCHERTY'S MIDLAND COACHES	3	3	8	8	2	2
18	NATIONAL EXPRESS	1	1	11	13	4	4
19	FIRST GLASGOW	231	231	206	206	221	221
20	FIRST EDINBURGH	45	47	47	49	47	49
21	LOTHIAN BUSES	98	104	100	107	99	103
22	ARRIVA	55	55	54	54	58	58
23	WAVERLY TRAVEL	2	2	4	4	3	3
24	M8 MOTORVATOR	2	2	2	2	2	2
25	COLCHRI COACHES	2	2	2	2	2	2
26	GILLENS COACHES	2	2	2	2	2	2
27	GLASGOW CITYBUS	5	5	11	11	5	5
28	KEY COACHES	6	6	4	4	5	5
29	LIPPEN COACHES	3	3	3	3	3	3
30	PARKS OF HAMILTON	1	1	0	0	1	1
31	RIVERSIDE TRANSPORT	10	10	14	14	11	11
32	WILSON OF RHU	2	2	2	2	2	2
33	FIRST FALKIRK	50	50	54	54	41	41
34	DON PRENTICE	2	2	2	2	2	2
35	EM HORSBURGH	10	10	12	12	12	12
36	FIRST BORDERS	20	20	31	31	18	18
37	RENFREW FERRY	2	2	2	2	2	2
38	C GRAHAM	3	3	5	5	1	1
39	PERTH COUNCIL	2	2	2	2	2	2
40	WHITLAWS COACHES	14	14	14	14	9	9
41	STW	2	2	2	2	1	1
89	ADDITIONAL TMfS REF CASE SERVICES	0	2	0	2	0	2
99	ADDITIONAL TMfS REF CASE SERVICES	0	0	0	0	0	0

4.3.6 Analysis of the breakdown of services modelled by company provider indicated that the reduction in the interpeak in rail services was split as a modelled decrease in 39 Scotrail services and an increase of 3 and 6 services respectively for GNER and Virgin services.

4.3.7 The analysis also showed an increase in bus services for Stagecoach, First Edinburgh and Lothian Buses bus operators in all periods. Other bus operators had small changes (both increases and decreases) in services over the different time periods.

4.3.8 It was noticed during the audit of services by company that in the AM period, Hutchinson Coaches (Company 8) had been coded as Ann's Coaches (Company 1). This error was not detected in the Off-Peak or PM periods. Further checks showed that this coding error was also present in the 2002 network.

For the purpose of the above analysis, the TMfS:05 AM period files were changed to correctly analyse the provision of services by company. MVA has subsequently acknowledged this minor labelling error, which has no impact on model operation, and has agreed to rectify this during the next upgrade of TMfS.

Rail Services

4.3.9 As part of the 2005 TMfS rebase, the rail network was updated to include the following changes:

- a new station at Edinburgh Park
- a new station at Gartcosh
- addition of the Larkhall line including new stations at Chatelherault, Merryton and Larkhall
- a new station at Kelvindale

4.3.10 The TTAA reviewed the timetables and route coding of the following Railway services (for the AM, Off-Peak and PM periods) concentrating specifically on the stopping locations and the timetabled stopping times and ensuring that appropriate routes were chosen to encompass the newly coded stations:

- Glasgow - Edinburgh via Falkirk
- Edinburgh – Bathgate (incorporating Edinburgh Park Station)
- Glasgow – Cumbernauld/Falkirk Grahamston (incorporating Gartcosh Station)
- Dalmuir – Larkhall (incorporating Chatelherault, Merryton and Larkhall stations)
- Glasgow – Anniesland (incorporating Kelvindale station)
- Edinburgh – Aberdeen
- Aberdeen to Inverness
- Edinburgh To Carlisle

4.3.11 The TTAA is satisfied that the coding of the new stations on the appropriate routes is accurate.

4.3.12 Tables 4.3 to 4.5 highlight issues arising from the audit of the AM, inter and PM peak period rail route coding checks respectively.

Table 4.3 : Rail Services Coding Checks (AM period)

RAIL SERVICE	COMMENTS
Glasgow - Edinburgh via Falkirk	Correctly coded
Edinburgh – Bathgate (incorporating Edinburgh Park Station)	Correctly coded
Glasgow – Cumbernauld/Falkirk Grahamston (incorporating Gartcosh Station)	Correctly coded
Dalmuir – Larkhall (incorporating Chatelherault, Merryton and Larkhall stations)	Correctly coded
Glasgow – Anniesland (incorporating Kelvindale station)	Correctly coded
Edinburgh – Aberdeen	The coding suggests all services are provided by Virgin Trains but should be a Scotrail service. Service frequency coded with a headway of 6000, but website suggests a headway of 3000 would be more appropriate.
Aberdeen to Inverness	Service terminates one stop short of Inverness at Nairn.
Edinburgh To Carlisle	Correctly coded

Table 4.4 : Rail Services Coding Checks (Interpeak period)

RAIL SERVICE	COMMENTS
Glasgow - Edinburgh via Falkirk	Two services have been coded to run slightly too frequently (headway of 2571 rather than 3000 for both)
Edinburgh – Bathgate (incorporating Edinburgh Park Station)	Service has been coded to run slightly too frequently (headway of 2769 rather than 3000)
Glasgow – Cumbernauld/Falkirk Grahamston (incorporating Gartcosh Station)	Two services have been coded to run slightly too frequently (headway of 5143 rather than 6000 for both)
Dalmuir – Larkhall (incorporating Chatelherault, Merryton and Larkhall stations)	Service has been coded to run slightly too frequently (headway of 2571 rather than 3000)
Glasgow – Anniesland (incorporating Kelvindale station)	Service has been coded to run slightly too frequently (headway of 2769 rather than 3000)
Edinburgh – Aberdeen	Five services coded each running roughly once an hour (4 Scotrail services and 1 GNER service). Some services coded to stop at Springfield which is not the case in the interpeak according to the Scotrail website timetables. Service coded too frequently.
Aberdeen to Inverness	Service is curtailed at Nairn and does not reach Inverness.
Edinburgh To Carlisle	Two services both coded with a headway of 8000 but Virgin Trains website suggests service only runs once every hour in the interpeak i.e. service coded too frequently.

Table 4.5 : Rail Services Coding Checks (PM period)

RAIL SERVICE	COMMENTS
Glasgow - Edinburgh via Falkirk	Correctly coded
Edinburgh – Bathgate (incorporating Edinburgh Park Station)	Correctly coded
Glasgow – Cumbernauld/Falkirk Grahamston (incorporating Gartcosh Station)	Correctly coded
Dalmuir – Larkhall (incorporating Chatelherault, Merryton and Larkhall stations)	Service has been coded with a headway of 6000 but Scotrail website suggests service runs with a headway of 3000
Glasgow – Anniesland (incorporating Kelvindale station)	Correctly coded
Edinburgh – Aberdeen	Service coded as Edinburgh to Dyce but not all services travel that far and stop at Aberdeen.
Aberdeen to Inverness	Service is curtailed at Nairn and does not reach Inverness.
Edinburgh To Carlisle	Confusingly in the coding Edinburgh to Carlisle and Edinburgh to Carnoustie given same code "EDI->CAR". Apart from that correctly coded

4.3.13 MVA has confirmed that the issues identified above fall into various categories with explanations as follows:

- Frequency/headway coding – The identified discrepancies are either down to changes to the 2005 timetables used by MVA in coding and the present day timetables used by the TTAA in checking the coding. Alternatively, they are due to subtleties in the methodology for deriving headway whereby MVA assumed that this included all services arriving and departing within the peak period being considered. The TTAA is content that this satisfactorily explains the identified frequency/headway discrepancies
- Rail network curtailment – All Inverness services have a terminus at Nairn with connectivity to Inverness via zone centroid connectors. The TTAA has acknowledged this issue previously in this chapter

- Coding error – MVA acknowledges that all Edinburgh to Aberdeen inter-peak services should not stop at Springfield, as has been reflected in the coding. Line numbers 7026 and 7028 have both been coded to stop at Springfield whilst only line number 7026 should do so. This is unlikely to be a significant issue for general application but should be noted by users of TMfS:05. **The TTAA recommends that this be reviewed and revised if appropriate at the next significant upgrade of TMfS**
- Labelling – The Carlisle and Carnoustie services have been coded with the same three letter short code (CAR). This does not affect operation but could be a source of confusion to users who should take note of this issue. **Again, the TTAA would recommend that this be revised at the next upgrade of TMfS**

4.3.14 Notwithstanding the issues identified above, the TTAA is satisfied that the coding of the above services is acceptable for the purposes of modelling rail travel within TMfS:05.

Bus Services

4.3.15 The TTAA reviewed the timetables and route coding (for the AM, Off-Peak and PM periods) of the following Bus services:

- Glasgow – Edinburgh (Citylink, Service 900)
- Silverknowes – Hunter's Tryst (Service 27, Lothian Buses, Edinburgh)
- Garelochhead to Helensburgh (Service 316, Wilson's of Rhu, Argyll and Bute)
- Larkhall – Forgewood (Service 1, Hutchinson's Coaches, North Lanarkshire)
- Dunfermline – St Andrews (Stagecoach, Service X26)
- Glasgow – Perth (Citylink, Service M9)
- Dundee – Aberdeen (Citylink, Service M9)
- Glasgow - Harestanes (First Glasgow, Service 88)

4.3.16 Tables 4.6 to 4.8 highlight issues arising from the audit of the AM, inter and PM period bus route coding checks.

Table 4.6 : Bus Services Coding Checks (AM period)

BUS SERVICE	COMMENTS
Glasgow – Edinburgh (Citylink, Service 900)	Not all stops coded as per timetable on Citylink website. Stops missing at Gogar and on Princes Street in Edinburgh. Bus timetable should show bus stopping at Ballieston every 15 minutes in the AM period but only stops every half hour.
Silverknowes – Hunter's Tryst (Service 27, Lothian Buses, Edinburgh)	Coded to run every 12 minutes but Lothian Bus website suggests service runs every 10 minutes.
Garelochhead to Helensburgh (Service 316, Wilson's of Rhu, Argyll and Bute)	Correctly coded
Larkhall – Forgewood (Service 1, Hutchinson's Coaches, North Lanarkshire)	Only coded to run every hour but Hutchinson's Coaches website suggests service runs every half hour. Forgewood to Larkhall opposite direction uses the one way link in Motherwell in the wrong direction.
Dunfermline – St Andrews (Stagecoach, Service X26)	Correctly coded
Glasgow – Perth (Citylink, Service M9)	Correctly coded
Dundee – Aberdeen (Citylink, Service M9)	Correctly coded
Glasgow - Harestanes (First Glasgow, Service 88)	Correctly coded

Table 4.7 : Bus Services Coding Checks (Interpeak period)

BUS SERVICE	COMMENTS
Glasgow – Edinburgh (Citylink, Service 900)	Not all stops coded as per timetable on Citylink website. Stops missing at Gogar and on Princes Street in Edinburgh. One of the two services coded with headway of 2769 rather than 3000.
Silverknowes – Hunter's Tryst (Service 27, Lothian Buses, Edinburgh)	Coded to run every 12 minutes but Lothian Bus website suggests service runs every 10 minutes.
Garelochhead to Helensburgh (Service 316, Wilson's of Rhu, Argyll and Bute)	Correctly coded
Larkhall – Forgewood (Service 1, Hutchinson's Coaches, North Lanarkshire)	Headway of 2769, should be 3000 as service runs once every half hour.
Dunfermline – St Andrews (Stagecoach, Service X26)	Service coded to run with a headway of 2000 but Stagecoach website suggests a headway of 6000. Route coded to divert through Largoward but website suggests bus does not take this route.
Glasgow – Perth (Citylink, Service M9)	Service coded to run with a headway of 4000 but Citylink website suggests service runs every 30 minutes.
Dundee – Aberdeen (Citylink, Service M9)	Service coded to run with a headway of 4000 but Citylink website suggests service runs only every 60 minutes.
Glasgow - Harestanes (First Glasgow, Service 88)	Service coded to run with a headway of 878 but Citylink website suggests service runs only every 10 minutes.

Table 4.8 : : Bus Services Coding Checks (PM period)

BUS SERVICE	COMMENTS
Glasgow – Edinburgh (Citylink, Service 900)	Service coded with a headway of 857 when website suggests a headway of 10 minutes.
Silverknowes – Hunter's Tryst (Service 27, Lothian Buses, Edinburgh)	Headway coded as 1200 but Lothian Buses website suggests every ten minutes.
Garelochhead to Helensburgh (Service 316, Wilson's of Rhu, Argyll and Bute)	Correctly coded
Larkhall – Forgewood (Service 1, Hutchinson's Coaches, North Lanarkshire)	Correctly coded but Forgewood to Larkhall opposite direction uses the one way link in Motherwell in the wrong direction.
Dunfermline – St Andrews (Stagecoach, Service X26)	Correctly coded
Glasgow – Perth (Citylink, Service M9)	Correctly coded
Dundee – Aberdeen (Citylink, Service M9)	Correctly coded
Glasgow - Harestanes (First Glasgow, Service 88)	Correctly coded

4.3.17 MVA has confirmed that the issues identified above fall into various categories with explanations as follows:

- Frequency/headway coding – The identified discrepancies are either down to changes to the 2005 timetables used by MVA in coding and the present day timetables used by the TTAA in checking the coding. Alternatively, they are due to subtleties in the methodology for deriving headway whereby MVA assumed that this included all services arriving and departing within the peak period being considered. The TTAA is content that this satisfactorily explains the identified frequency/headway discrepancies

- Coding error – MVA acknowledges that the Glasgow to Edinburgh AM and inter-peak services should stop on Princes Street but this has not been reflected in the coding. MVA also identified that the Gogar stop is reflected on these services, although perhaps not at the optimum location (node 2168). These are unlikely to be significant issues for general application but should be noted by users of TMfS:05. **The TTAA recommends that this be reviewed and revised if appropriate at the next significant upgrade of TMfS**
- Representation – The M9 Glasgow to Perth and M9 Dundee to Aberdeen services are not explicitly coded as such in the inter-peak. These are reflected by the M9 Glasgow to Aberdeen service which encompasses both routes

4.3.18 Notwithstanding the issues identified above, the TTAA is satisfied that the coding of the above services is acceptable for the purposes of modelling bus travel within TMfS:05. It is anticipated that a full, detailed review of the bus and rail service coding will be undertaken at the next major upgrade of TMfS and will include the review and rectification, if necessary, of issues identified in this audit.

Bus Operators

4.3.19 The TTAA has reviewed the bus operators contained within TMfS:05.

4.3.20 As was noted during the TMfS:02 audit, and similarly within TMfS:05, a number of bus operators have not been included within the PT network. The exclusion of a number of operators may be due to their location or services provided, e.g. D and E Coaches which is based in the Inverness area (i.e. external model area) and West Coast Motors which provides a largely rural service in Argyll. However, a number of companies (some of which are considered significant) operating within the TMfS:05 modelled area have been omitted, as summarised below. It is the case for a number of these companies, such as Munros of Jedburgh, that their exclusion removes important public transport services from a given area, in this case the south east Borders region (and also links with the north of England). Equally, the First Aberdeen and Strathtay Scottish services cover a significant number of routes intra-Aberdeenshire and intra-Perth/Dundee/Angus respectively which will not be reflected in TMfS:05. . Table 4.9 lists the omitted services.

Table 4.9 : Bus Services Omitted from TMfS:05

Company	Area
Alex Wait and Son	East Borders
Bulldog Travel	West Lothian (Livingston, Bathgate etc.)
Earnside Coaches	Perth & Kinross
First Aberdeen	Aberdeen and surrounds
Henderson Travel	Glasgow conurbation
MacEwan Coaches	Edinburgh/Dumfries links, Lanarkshire
Megabus	City links
MacEwan's Coaches	Dumfries area, Edinburgh-Peebles/Dumfries)
Meffans Coaches	Angus and Perth & Kinross
Munro of Jedburgh	South East Borders, links to North England in the east
Perrymans	Berwick Upon Tweed, Eyemouth, Edinburgh
Rowe's Coaches	Ayrshire (Cumnock, Dalmellington etc.)
Shuttle Busses	Ayr, West Coast
Strathtay Scottish	Dundee and Angus
Swans Coaches	South East Borders, links to England in the east
Travel Dundee	Dundee and surrounds
Telford Coaches	Links Borders to England in the west
West Coast Motors	Argyll (Inveraray, Lochgilphead, Campbelltown etc.)

4.3.21 It should be noted that Fife Scottish and Western Scottish services are now run by Stagecoach but are still coded as separate companies within the network. MVA has acknowledged this issue but also suggests that there may be some analytical advantage in defining separate regional Stagecoach services.

4.3.22 During the TMfS:02 audit MVA confirmed that due to network (and zoning) detail in TMfS a number of the services were omitted as it would be difficult to provide a reasonable representation of the services in the

model. In particular, the intra-Aberdeen and Strathtay services were affected by the network detail issues and were consequently omitted. Stagecoach inter-urban services to areas outlying Aberdeen (e.g. Ballater, Inverurie etc.) were, however, included in TMfS. Strathtay inter-urban services such as Dundee to Perth via Errol have also been omitted due to network detail, however, Stagecoach and Citylink services have been coded to stop at zone centroids on the main A90, thereby enabling passengers to access inter-urban services on this corridor.

4.3.23 The TTAA acknowledges these reasons for omitting such services and considers them acceptable given the more strategic focus of TMfS. Nevertheless, the TTAA considers that this general lack of detail of bus service representation, particularly in the Tayside and Aberdeen areas should be borne in mind by potential users of TMfS.

4.4 Summary of Public Transport Coding Audit

4.4.1 The main points from the TTAA's review of the TMfS public transport coding are as follows:

- The general coverage of the public transport bus and rail network is acceptable for TMfS:05. It should be noted that the Glasgow to Fort William line has been curtailed at Tyndrum whilst the Tyndrum to Oban spur has been omitted. Equally, Inverness services have a terminus at Elgin with connection to Inverness itself by zone centroid connectors. These are unlikely to be significant for most TMfS:05 applications but their omission should be noted
- Notwithstanding the issues identified in Table 4.3 to Table 4.5, the TTAA is generally satisfied that from the sample of rail services checked, the coding is acceptable for TMfS:05
- Notwithstanding the issues identified in Table 4.6 to Table 4.8, the TTAA is generally satisfied that from the sample of bus services checked, the coding is acceptable for TMfS:05
- Users should note the bus services omitted from TMfS:05 (ref. Table 4.9) and should consider the potential implications of these prior to any model application

5 TMFS:05 PUBLIC TRANSPORT ASSIGNMENT MODEL

5.1 Background and Chapter Structure

5.1.1 This chapter presents the TTAA's findings based on information supplied by MVA for the Transport Model for Scotland (TMfS:05) development audit and relates to TMfS:05 Audit Task 4 : Review Public Transport Assignment Model. The TTAA will use the acronym PTM to refer to the TMfS:05 Public Transport Model throughout this report.

5.1.2 All requested Public Transport (PT) network files were made available through the TMfS website www.tmfs.org.uk. The findings in this chapter are based on a review of the specific information supplied during the audit process.

5.1.3 The TTAA's comments regarding the TMfS:05 PTM are listed in the following sections of this chapter. The section headings correspond with the chapter headings from MVA's Public Transport Model – Development and Validation Draft Report.

5.2 Introduction

5.2.1 The introductory chapter initially sets out the background and overview of the PTM development. The TTAA has no substantive comments on this aspect of the report.

5.3 Public Transport Network Development

5.3.1 The PT network description and coding are the subject of more detailed discussion in Chapter 4 of this document. The comments in this section relate specifically to the information in Chapter 2 of the TMfS:05 PT Model – Development and Validation Draft Report.

5.3.2 The TMfS:05 network has been updated from the TMfS:02 network to include new infrastructure. Selected public transport lines have also been updated to reflect changes to timetabling and routeing.

Network Update

5.3.3 The physical PT network is based on that for the Highway Assignment Model (HAM) with the addition of the appropriate heavy rail/underground links and walk connections between rail/underground stations and the highway network. The TTAA is satisfied that the link types described in the PTM for TMfS:05 are appropriate.

5.3.4 The extent and coverage of the skeletal PT (bus and rail) network is considered to be appropriately representative of the existing network within the main internal TMfS:05 study area. It should be noted, however, that the Aberdeen to Inverness rail line is curtailed one station short of Inverness at Nairn with external zone connectors providing connectivity to Inverness.

5.3.5 As stated in Chapter 4, it is also worth noting that the Perth-Inverness (and further north) line is curtailed in Perthshire (around Dunkeld) rather than extending into the external model area. Similarly, Glasgow to Fort William (and onwards to Mallaig in the north) is curtailed at Crianlarich rather than extending into the external model area. The rail spur between Tyndrum and Oban has also been omitted from the PT model network, and unlike the TMfS:02 model, bus services do not extend to Oban. All main west coast ferry terminals within the main internal model area appear to be served by the relevant PT links (e.g. Gourock, Ardrossan, Stranraer etc.) with the exception of Oban, which has rail links omitted. Given Oban's proximity to the internal/external model boundary (the zone straddles the boundary), this is unlikely to be a significant issue for most applications of TMfS:05.

5.3.6 The TMfS:05 rebase includes the following changes:

- A new station at Edinburgh Park
- A new station at Gartcosh
- The addition of the Larkhall line including new stations at Chatelherault, Merryton and Larkhall.

- A new station at Kelvindale

Public Transport Lines and Services

5.3.7 The details of the PT lines and service coding are examined further in Chapter 4 of this document. Some general details of updates to the PT services are provided in Chapter 2 of MVA's report and the TTAA's comments on these updates are provided below.

5.3.8 The total number of PT services has remained broadly the same between TMfS:02 and TMfS:05 in all periods with the biggest change the 11% reduction in rail services in the inter-peak in TMfS:05. Analysis of the breakdown of services modelled by company provider indicated that the reduction in the inter-peak in rail services was split as a modelled decrease in 39 Scotrail services and an increase of 3 and 6 services respectively for GNER and Virgin services. The TTAA has also provided more detailed commentary on the representation of bus operators and services in TMfS:05 in Chapter 4.

5.3.9 The 2005 rebase also included a review of the timetables for a number of public transport services where the PT files were updated where necessary. These included:

- All First ScotRail services
- All GNER and Virgin rail services that operate in Scotland
- All Citylink, Megabus and Motorvator inter-urban bus services
- Stagecoach Bluebird and Stagecoach Perth bus services
- Lothian Buses Park and Ride bus services

5.3.10 Details of checks comparing service coding with timetables are contained in Chapter 4.

5.4 PT Demand Matrix Update

5.4.1 Chapter 3 of the report presents the PT demand matrix development process and data sources.

5.4.2 The main update to the PT matrices was the inclusion of rail LENNON (Latest Earnings Networked Nationally Overnight) data. LENNON data provides more detailed rail demand data than was available from MOIRA data used in the TMfS:02 matrix build process.

5.4.3 Other than the use of LENNON data to update the rail information, no other data was used to update the TMfS:05 PT matrix.

5.4.4 The TTAA acknowledges that the LENNON data source is appropriate for the development of the TMfS:05 PT matrices. Further comments on the use of this data and the resulting matrices are provided throughout this section.

5.4.5 The process to update the demand model was split into 5 stages:

- Split 2002 matrices to isolate rail demand
- Process LENNON data to obtain station to station matrix for each time period
- Identification and removal of Park and Ride (station to station) trips
- Convert station to station matrices to true origin-destination TMfS:05 zone matrices
- Replace rail element of 2002 matrices with prepared LENNON rail demand matrices to form complete 2005 rebase PT matrices

5.4.6 Each of these processes is discussed below.

Matrix Split

5.4.7 TMfS:02 matrices were first split by mode type to isolate the rail demand by using in-vehicle time skims extracted from the PT assignment. This information provided the 'best path' for each OD pair. It is important to note that a 'best path' could be made up of a series of journey legs by different modes. Therefore to separate individual transport modes, a skim was made by mode type. This information was then used to determine the dominant mode for each OD pair, using time rather than distance as the factor on which make the dominant mode choice.

LENNON Data Processing

5.4.8 LENNON data used in the 2005 Rebase has been obtained by MVA from the Scottish Executive. Data relates to all rail trips originating or destinating in Scotland. The data is based on all tickets sold including ticket office, ticket machine, telephone and internet sales. Factors are applied within LENNON to convert tickets issues to actual trips so that tickets issued for return trips/season tickets are counted as more than a single trip.

5.4.9 LENNON data does not represent true origin-destination data but allocates journeys to the station of issue i.e. a return ticket from Glasgow to Croy would count as two journeys from Glasgow to Croy rather than one in each direction.

5.4.10 For this reason, MVA has devised a method by which to convert the LENNON data into more representative origin-destination data for the demand matrix.

Station Allocation

5.4.11 The station allocation process was split into two steps in order to allocate LENNON ODs to appropriate TMfS:05 stations:

- The definition of a station allocation table to allocate LENNON ODs to equivalent TMfS:05 stations where possible, with stations outwith the model allocated to stations at the network edge
- Where multiple stations were possible (e.g. Glasgow), dummy stations were allocated. Following allocation, dummy stations were manually assigned to the appropriate station by examination of the rail network and local knowledge.
- Conversion to Annual Station to Station Matrix

5.4.12 Three stages were undertaken to create the annual station to station matrix:

- Transposing the matrix
- Appending the origin matrix to the transposed matrix
- Averaging the journeys observed in both directions resulting in a station to station matrix

5.4.13 A number of assumptions were made in order to carry out these steps:

- A symmetrical matrix
- If trips were only made in one direction then the number of trips in each direction was made equal to half of the observed trips
- If trips were made in both directions then the number of trips in each direction will be the average of the two

Modelled Time Period Demands

5.4.14 As the LENNON data represents the total rail demand for a single year it was necessary to convert the data to AM, inter-peak and PM peak hour periods. A number of steps were necessary:

- Convert annual data to an average weekday (assuming 310 "average" weekdays annually)

- Apply ORCATS (Operational Research Allocation of Tickets to Services) demand profiles by defining major commuter stations

Park and Ride Assignment Model

5.4.15 The Park and Ride model is implemented separately following a complete TMfS:05 model run. However, calibration and validation of the PT assignment model is carried out post Park and Ride implementation so is an integral part of TMfS:05. The Park and Ride Assignment Model (PARAM) predicted demand change due to park and Ride is applied to the highway and PT matrices, which are manipulated to allow for transfer to Park and Ride.

5.4.16 The TMfS:05 rebase includes a number of additional stations in the PARAM. To avoid potential double counting of rail trips due to the use of LENNON data in the creation of the rail demand, it was necessary to identify which trips in the rail demand were Park and Ride and to remove these from the rail demand matrix.

Removal of Park and Ride Trips

5.4.17 A number of steps were undertaken in order to remove Park and Ride trips from the rail demand matrix:

- Trip distributions extracted from PARAM
- PARAM output matrices from TMfS:02 compared against input matrices to identify effect of PARAM on PT matrices
- Station-Zone allocation table defined
- Identified Park and Ride rail trips subtracted from the observed LENNON rail demand matrix

5.4.18 The Park and Ride trips were subsequently reinstated through the implementation of PARAM.

Development of True Origin-Destination Rail Matrices

Manipulation of the LENNON data

5.4.19 Due to the LENNON data not representing true origin-destination data, manipulation of the data was required in order to produce a more accurate rail trip distribution.

5.4.20 An allocation table was defined so that the station to station matrix could be converted to a TMfS:05 zone to zone matrix and was done by allocating each station to their nearest TMfS:05 zone and defining zones within a “reasonable” walking distance of each station zone. The proportion of trips allocated to each zone was calculated based on the following characteristics:

- Planning data
- Distance between rail station and TMfS:05 zone
- Settlement type of each station (Major Urban, Urban, Urban Local, Rural) which influenced the selection of planning data and distance weightings

Creation of the Public Transport Matrices

5.4.21 The TMfS:05 PT matrices are created by replacing the TMfS:02 rail demand with that of the newly created LENNON TMfS:05 zone to zone rail demand to create the pre-Park and Ride TMfS:05 PT matrices.

5.4.22 Table 5.1 Shows the TMfS:05 PT total trips matrix against the corresponding TMfS:02 values.

Table 5.1 : TMfS:05 versus TMfS:02 PT Matrix Trip Totals

Time Period	TMfS:02	TMfS:05	Absolute Difference	% Difference
AM	98998	99300	302	0%
IP	65744	61267	-4477	-7%
PM	101181	95246	-5935	-6%

5.4.23 Table 5.1 indicates that the AM PT demand remains unchanged in the newly created TMfS:05 matrices when compared against the previous TMfS:02 matrices. The inter-peak and PM matrices however show a significant decrease in rail travel in the TMfS:05 matrices. MVA states in §3.7.3 *that '…this is because the LENNON data indicates a lower rail demand than that extracted from the 2002 TMfS demand matrices'*. In further discussion on this matter with the TTAA, MVA has stated that *"We consider the LENNON data to provide a more robust and consistent source of travel demand data for TMfS than the sample surveys used previously and consider its use to offer a considerable enhancement to the model"*.

5.4.24 Overall, the TTAA is satisfied that the logic and assumptions underpinning the various steps in the methodology for creating the TMfS:05 rebase PT matrices seek to make the best use of the available data and are therefore acceptable for TMfS:05. Nevertheless, the LENNON data itself is initially subject to a factoring process to convert tickets issued to trips. Additionally, the processes adopted by MVA in the several steps undertaken to apply this factored LENNON data are based on a series of assumptions and these facts should be recognised when considering the robustness of the resulting matrix. The lack of any additional bus data in the matrix development process should also be noted.

5.4.25 The TTAA recommends that during the next major upgrade of TMfS, details should be provided in the supporting documentation of the changes to the PT matrices at the various stages of the development process (e.g. sector matrices at major stages).

5.5 Assignment Model

5.5.1 The TMfS:05 PT assignment is similar to that of TMfS:02 with the following aspects having been updated:

- Introduction of crowding
- Introduction of 'wait curves'
- Review of assignment model parameters
- Update of fares model

Assignment Model Inputs

5.5.2 The TTAA is satisfied with the model inputs as discussed in previous sections of this chapter.

Path Building and Loading

5.5.3 Path building and loading in TMfS:05 remains unchanged from TMfS:02 and is therefore considered acceptable.

Crowding

5.5.4 The effects of crowding were previously not considered within TMfS:02 for either bus or rail. Implementation of crowding curves, applied to the in-vehicle time component of generalised cost, is considered likely to improve the quality of the modelled forecasts for public transport passenger flows, particularly in corridors of significant competition, as well as for road traffic.

5.5.5 Due to the significant increase in model run time that results from the introduction of crowding, it has only been introduced in the AM and PM peak periods. Tests performed by MVA indicated that 5 model iterations were sufficient to minimise the number of iterations required whilst achieving stable network

conditions.

5.5.6 Crowding curves are implemented as multiplicative curves in the CUBE PT assignment procedures. For each level of utilisation the free link journey time by the appropriate adjustment factor which then represents the perceived journey time whilst spent in crowded conditions. The utilisation measure is calculated in CUBE as the percentage of standing passengers as a proportion of the capacity for standing passengers.

5.5.7 The UK rail standard Passenger Demand Forecasting Handbook (PDFH) Non-London Commuting Rail Crowding curve was allocated to all rail lines in TMfS:05 rail lines for the AM and PM peak periods. The 'crush capacity' was assumed to be 40% above the seated capacity. Passenger and vehicle arrival profiles have been assumed to be level throughout the modelled time periods leaving no allowance for varying demand on services within the peak hours leading to the potential underestimation of crowding on services where the number of passengers is above the hourly average.

5.5.8 No crowding factors were applied to bus lines due to the increased ability of bus operators to increase supply to match demand.

5.5.9 In general, the TTAA is satisfied that the above approach for the inclusion of crowding is appropriate for TMfS:05. However, users should note the fact that crowding has been applied on peak hour rail services only. In a model such as TMfS, where the PT sub-mode split is undertaken at the assignment stage, on corridors with high PT modal competition this could have implications for both the base year sub-mode split and more particularly, when applying the model in forecast mode. This is unlikely to affect applications other than those where competition between PT sub-modes is a significant issue and in such circumstances users should examine the TMfS:05 outputs in sufficient detail to ensure that the resultant sub-mode split on competing rail and bus services conforms with expectations.

Wait Curves

5.5.10 Wait curves were not previously considered within TMfS:02. Wait curves have however been included in TMffS:05 for inter-urban bus and rail lines. Two wait curves, derived from PDFH, have been applied to the AM and PM and inter-peak period respectively.

5.5.11 A default wait time calculation with a wait time factor of 1.8 was applied to urban bus and underground services, as was the case in TMfS:02. The TTAA is satisfied that the above approach is appropriate for TMfS:05.

Assignment Model Procedures

5.5.12 Due to the introduction of rail crowding and wait curves, assignment model parameters were reviewed as part of the 2005 rebase. Table 5.2 shows the Public Transport Assignment Model Parameters for 2005 along with the corresponding 2002 values.

Table 5.2 : Public Transport Assignment Model Parameters

Model Parameter		Value/Factor	
		TMfS:02	TMfS:05
Parameter:			
In vehicle times	Bus	1.2	**1.5**
	Rail/underground	1.0	**1.0**
Walk Time Factor		1.6	**1.6**
Wait Time Factor	Urban Bus/Underground/Ferry	1.8	**1.8**
Minimum Wait Time		0 mins	**0 mins**
Maximum Wait Time		15 mins	**60 mins**
Transfer Penalty	rail to rail or underground	5 mins	**5 mins**
	underground to rail or underground	5 mins	**5 mins**
	bus to bus	10 mins	**10 mins**
	bus to rail/underground and vice versa	10 mins	**10 mins**
Value of Time:			
	in work	1901.24 p/hr	**2016.17 p/hr**
	non-work	461.86 p/hr	**489.78 p/hr**

5.5.13 TMfS:05 model parameters differ from TMfS:02 values for the in-vehicle times for buses from 1.2 in TMfS:02 to 1.5 in TMfS:05. This was due to the increase in rail generalised cost as the result of rail crowding and hence the need to recalibrate. The maximum wait time has increased from 15 to 60 minutes. Whilst explanation has not been given in MVA's report for the parameter changes, the TTAA is generally content that the PT assignment model parameter values are appropriate for TMfS:05.

Fares Model

5.5.14 The fares model has been updated to reflect 2005 fares. The model is based on a boarding charge and a fares table for each PT operator. The following changes were made to the fares table as part of the 2005 rebase:

- Lothian Buses, Glasgow Underground and the Renfrew Foot Ferry have all been updated to reflect 2005 fares
- All other urban bus fares have been increased to 2005 prices using the Retail Price Index
- Inclusion of Lothian Buses Ingliston Park and Ride standard fare
- Inter-urban bus and rail fares have been recalculated to reflect 2005 fares
- A separate fares table has been defined for each time period in order to represent peak rail fares
- A separate rail fares table has been defined for the Strathclyde area where examination of the fares structure indicated a significant difference to the rest of Scotland

5.5.15 Table 5.3 and Table 5.4 show the TMfS:05 fares against the corresponding TMfS:02 values for the fares which remain constant during all time periods and those that vary between time periods respectively. It should be noted that in the TMfS:02 model there was no variation in fare prices between time periods.

5.5.16 All fare prices in the 2005 rebase have increased from their 2002 values with the exception of the off-peak (longer distance) fares for Scotrail which have decreased by approximately 4%. The TTAA assumes this decrease is due to the coding of varying prices depending on period in TMfS:05 whereas TMfS:02 used a standard fare over all time periods (distance dependent).

Table 5.3 : Fare table for operators with constant fares in all periods

Operator	Distance (km)	Fare (pence)	
		TMfS:02	**TMfS:05**
Lothian Buses	0.00	53	**80**
	1.60	60	**80**
	6.40	80	**80**
	7.20	100	**100**
	1000.00	100	**100**
Inter-Urban Bus	0.00	160	**160**
	500.00	2840	**3196**
	1000.00	6040	**6393**
Glasgow Underground	0.00	90	**100**
	1000.00	90	**100**
Other Rail	0.00	95	**95**
	1.91	110	**110**
	60.75	560	**560**
	80.51	800	**800**
	99.52	1270	**1270**
	152.36	2650	**2650**
	293.97	4950	**4950**
Renfrew Foot Ferry	0.00	90	**100**
	1000.00	90	**100**
Other Urban Bus	0.00	68	**72**
	10.00	117	**124**
	20.00	201	**213**
	30.00	223	**236**
	40.00	245	**259**
	50.00	263	**279**
	1000.00	263	**279**
Lothian Buses (Ingliston Park and Ride)	0.00	N/A	**100**
	1000.00	N/A	**100**

Table 5.4 : Fare table for operators with varying fares in different periods

Operator	Distance (km)	Fare (pence)					
		AM		IP		PM	
		TMfS:02	**TMfS:05**	TMfS:02	**TMfS:05**	TMfS:02	**TMfS:05**
Scotrail	0.00	60	**60**	60	**60**	60	**60**
	10.40	120	**201**	120	**158**	120	**201**
	46.80	380	**695**	380	**503**	380	**695**
	91.60	870	**1302**	870	**927**	870	**1302**
	183.20	1850	**2544**	1850	**1794**	1850	**2544**
	366.40	3810	**5028**	3810	**3529**	3810	**5028**
Strathclyde Trains	0.00	N/A	**60**	N/A	**60**	N/A	**60**
	10.40	N/A	**152**	N/A	**123**	N/A	**123**
	46.80	N/A	**476**	N/A	**345**	N/A	**345**
	91.60	N/A	**874**	N/A	**618**	N/A	**618**
	183.20	N/A	**1687**	N/A	**1177**	N/A	**1177**
	366.40	N/A	**3314**	N/A	**2294**	N/A	**2294**

5.5.17 Mode specific boarding fares are unchanged from their TMfS:02 values. Overall the TTAA is satisfied that the update of fares from the TMfS:02 values is appropriate and that the use of period specific fares is an enhancement in TMfS:05.

5.5.18 It should also be noted that Lothian Buses recently instigated a £1 flat fare irrespective of journey length. It is recommended that this change will be reflected in the next major upgrade of TMfS along with other appropriate changes.

5.6 Model Validation

5.6.1 The validation of the TMfS:05 PT matrices was undertaken through detailed analysis of the following:

- LENNON station to station electronic rail ticket data (as previously discussed)
- Historical bus and rail passenger survey data
- Comparison of timetabled and modelled bus journey times

5.6.2 Screenline were compared between modelled versus observed flows for modelled flows which would typically be expected to be within 15% of observed as indicated in the Major Scheme Appraisal in Local Transport Plans document.

5.6.3 The GEH statistic was used as the tool with which to assess the PT validation.

Validation to LENNON Data

5.6.4 LENNON station to station data was assigned to the modelled network using the CUBE program MVESTL.

Passenger Loading Comparisons

5.6.5 Four main screenlines are presented in the MVA report to analyse the assigned versus modelled values for passenger loadings:

- Central Scotland East West Rail Screenline
- Forth Estuary Rail Screenline
- Edinburgh Rail Cordon
- Glasgow Rail Cordon

5.6.6 Analysis of the full screenlines shows good validation for all except the AM inbound direction for the Glasgow cordon, which has a high GEH of 12. It should however be recognised that more in-depth analysis of the screenlines on an individual site basis (as presented in Appendix A of the MVA report) indicates that certain individual locations exhibit much higher GEH values than the screenline as a whole. For instance, the East-West screenline in the PM period has a GEH of 2 for the full screenline but the East of Camelon Station actually has a GEH of 15. The Forth Estuary screenline in the southbound direction has a GEH of 0 but within the screenline the North of Stirling Station has a GEH of 8.

5.6.7 The Glasgow Cordon with the GEH of 12 has three main locations where the observed versus modelled counts vary significantly. These three locations are at Carmyle, Burnside and Corkerhill with GEH values of 11, 15 and 18 respectively and all show lower modelled flows at these sites when compared against observed. It is encouraging to note, however, that these three locations generally exhibit the lowest observed flows on the screenline.

5.6.8 MVA states that the high GEH value of 12 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.

5.6.9 Modelled to observed rail flow comparisons are presented for a further 27 locations across the rail network in Appendix A of MVA's report. 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.

5.6.10 Generally the TTAA is content that the modelled to observed rail passenger flow comparisons demonstrate an acceptable level of calibration for TMfS:05 particularly on a screenline basis. Potential users of TMfS should, however, bear in mind the variability in the modelled to observed comparisons for individual rail links.

5.6.11 It is noted that some of the table headings in Appendix A of MVA's Draft Report are misleading. For instance, the Forth Bridge screenline has the title 'Central Scotland – East West Screenline'. **The TTAA recommends that, to avoid confusion, tables should be renamed with the appropriate headings in the final version of the report**.

5.6.12 It should be noted that no validation of Glasgow Underground passenger flows was presented in MVA's report. MVA has subsequently confirmed that this was due to a lack of available data.

Passenger Boarding/Alighting Comparisons

5.6.13 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. Table 5.5 shows the comparison.

Table 5.5 : Boarding/Alighting LENNON versus Observed

		GEH		
		≤ 5	≤ 7	≤ 10
AM	Boarding	71	82	93
	Alighting	78	89	96
IP	Boarding	93	97	98
	Alighting	93	97	98
PM	Boarding	83	93	95
	Alighting	75	86	95

5.6.14 At a global level this demonstrates a good match between modelled and observed boarding/alighting figures. It should be noted, however, 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, 20 and 36 for boarding for the AM, IP and PM periods respectively and 46, 20 and 22 for alighting for the AM, IP and PM periods respectively. The high AM values relate to Glasgow Central station where modelled values are lower than that observed, and Argyle Street station in the inter-peak and PM periods, where modelled values are much greater than that observed.

5.6.15 In general, the boarding and alighting comparisons for the 6 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. Throughout the remainder of the network the boarding/alighting comparisons are generally acceptable.

5.6.16 The TTAA is satisfied that the overall validation of individual station boarding and alighting figures is acceptable for TMfS:05. Potential users of TMfS:05 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.

5.6.17 MVA has subsequently commented further on this matter 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".

Edinburgh to Glasgow Flows

5.6.18 Specific analysis of the flow on the rail line between Edinburgh and Glasgow was undertaken using the CUBE PT assignment select link analysis feature. The matrix of trips that use both the rail lines to the north of Glasgow Queen Street and the west of Edinburgh Haymarket was extracted. From this the validation of trips between Edinburgh and Glasgow was analysed. Table 5.6 shows the validation.

Table 5.6 : Validation of Edinburgh to Glasgow and Glasgow to Edinburgh Rail Trips

	Edinburgh to Glasgow			Glasgow to Edinburgh		
	LENNON	Modelled	GEH	LENNON	Modelled	GEH
AM Peak Hour	768	779	0	768	863	3
IP Peak Hour	208	257	3	208	260	3
PM Peak Hour	724	603	5	724	699	1

5.6.19 The TTAA is satisfied that the validation of the Edinburgh to Glasgow and Glasgow to Edinburgh rail trips is acceptable for TMfS:05.

Validation to Historic Survey Data

5.6.20 Validation to historic count data used for the validation of TMfS:02 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 TMfS:02 was based on estimates of the percentage occupancy of each bus and the number of seats associated with each bus type. Therefore, whilst this methodology may provide reasonable estimates of the passenger occupancy numbers it is prone to discrepancies. MVA suggested during the TMfS:02 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.

5.6.21 MVA states in §5.3.2 of the report that *"These comparisons show broadly the same level of validation as the original version of TMfS with some individual variation"*. Whilst it is true that the comparisons show a similar level of validation as that obtained for TMfS:02, 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 63 in the PM peak with the worst GEH value for the Edinburgh Outer Cordon being 23 for the inbound inter-peak.

5.6.22 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 whilst the inter peak comparisons are good.

5.6.23 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.

5.6.24 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 23 for the Edinburgh cordon as a whole although percentage differences in the peaks are all within 25%. 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.

5.6.25 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.

5.6.26 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 good for the AM peak southbound and PM peak northbound 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, however, generally acceptable in both directions in all time periods

5.6.27 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 whilst 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 within the PT trip matrix development process for TMfS:05.

5.6.28 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

5.6.29 As the PT assignment now 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 (117%)
- Dundee to Edinburgh AM peak (2 service lines, 115% and 118%)
- Carlisle to Glasgow AM peak (113%)
- Dyce to Edinburgh PM peak (127%)
- Glasgow to Dunblane PM peak (111%)
- Glasgow to Kirkcaldy PM peak (107%)

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

- Between Edinburgh and Glasgow
- Services between the central belt and the north of Scotland
- Bathgate to Edinburgh in the AM peak and the reverse in the PM peak
- Services from Ayrshire to Glasgow in the AM peak and the reverse in the PM peak

5.6.31 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 TMfS.

Comparison of Timetabled and Modelled Bus Journey Times

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

5.6.33 Modelled to timetabled bus journey time comparisons were undertaken for 44, 46 and 45 services in the AM, inter-peak and PM peaks respectively, within the TMfS:05 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, 78% in the inter-peak and 76% in the PM) the TMfS:05 modelled journey times are quicker than the timetabled average journey time. This is often the case with models of this nature since 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 TMfS:05.

5.6.34 The graphs in Appendix E 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 11% 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 recognized by the TTAA that the variation in timetabled journey times, where available, was often relatively small.

5.6.35 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 highway based vehicles. That is that the modelled time should be within 15% (or 1 minute if higher) of the observed journey time. Applying these criteria shows that 45%, 48% and 47% of the journey times match within DMRB criteria for the AM, inter-peak and PM peaks respectively. The TTAA considers this to be a generally acceptable level of bus journey time validation for TMfS:05.

5.6.36 The TTAA would recommend that any users of TMfS:05 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

5.6.37 The validation of the PT matrix has focused mainly on the LENNON data and showed in general, acceptable validation for a model such as TMfS:05. 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 within 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 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 in §6.3.3 of their Draft Report.

5.6.38 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 TMfS:05. 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.

5.6.39 The role of TMfS:05 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 TMfS:05 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 TMfS:05 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.

5.6.40 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 TMfS:05. However, 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 11% falling in the range in the AM.

5.6.41 The TTAA would also recommend that a more graphical presentation of the PT matrix development and model validation should be provided at the next major upgrade of TMfS. This would greatly assist users in establishing the areas of the network where PT data is and is not available and where the available data has been used in the development process. Equally, a graphical presentation of the validation comparisons would assist users in identifying the level of validation in specific areas of the model.

5.7 Summary of TMfS PT Model Development and Validation

5.7.1 The TMfS:05 PTM has been developed to represent the PT network of bus, rail and underground services within the TMfS:05 model area. Some detailed comments are provided in the relevant section of this chapter, however, the TTAA is generally content that the PT network coverage and detail is appropriate for TMfS:05.

5.7.2 The PT demand matrices were developed using historic matrices from TMfS:02 augmented with more up to date rail LENNON data. Overall, the TTAA is satisfied that the logic and assumptions underpinning the various steps in the methodology for creating the TMfS:05 rebase PT matrices seek to make the best use of the available data and are therefore acceptable for TMfS:05. Nevertheless, the LENNON data itself is initially subject to a factoring process to convert tickets issued to trips. Additionally, the processes adopted by MVA in the several steps undertaken to apply this factored LENNON data are based on a series of assumptions and these facts should be recognised when considering the robustness of the resulting matrix. The lack of any additional bus data in the matrix development process should also be noted.

5.7.3 Crowding has been included for the rail mode of travel in the AM and PM periods. This was not added for bus travel due to the increased ability of bus service operators to increase supply to match demand. Users should note this issue given that the PT sub-mode split within TMfS is undertaken at the assignment stage.

5.7.4 Wait curves have been added for rail services and inter-urban bus services in the AM, inter-peak and PM periods. Fares have been updated to reflect 2005 prices and have been split to be period specific.

5.7.5 The validation of the PT matrix has focused mainly on the LENNON data and showed in general, acceptable validation for a model such as TMfS:05. 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 within the TMfS study area.

5.7.6 It is significant to note that the equivalent MVA report for TMfS:02 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 TMfS:05.

5.7.7 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.

5.7.8 The TTAA would recommend that any TMfS:05 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.

5.7.9 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**

6 TMFS DEMAND MODEL

6.1 Background and Chapter Structure

6.1.1 This chapter presents the TTAA's findings based on information supplied by MVA for the Transport Model for Scotland (TMfS) 2005 Rebase audit and relates to TMfS Audit Task 5 : Review Demand Model.

6.1.2 During 2005, MVA carried out further model enhancements to TMfS. The work included a rebase of TMfS to a 2005 Base Year (TMfS:05) using newly available data, and incorporating other procedural enhancements. MVA provided the TTAA with the TMfS "Demand Model Development – 2005 Rebase Draft Report", Issue 4, 29 November 2006 (TMfS:05 Report). The findings in this report are based on a review of the specific information supplied for the TMfS:05 Demand Model Development.

6.1.3 For clarity, the term TMfS is used in this chapter to refer to Transport Model for Scotland where there is no differentiation between TMfS:02 and TMfS:05.

6.1.4 The TTAA's comments regarding the TMfS:05 Demand Model are listed in the following sections of this chapter. The section headings generally correspond with the chapter headings from MVA's Demand Model Development – 2005 Rebase Draft Report.

6.2 Introduction

6.2.1 The report introduction sets out the background and context to the demand model development as well as defining the TMfS model objectives and illustrating the demand model structure. The TTAA has no substantive comments to make on the introductory chapter.

6.3 Demand Model Overview

6.3.1 This chapter deals with several aspects of the demand model, its structure, inputs, parameters and application. The TTAA's comments on each aspect are dealt with in turn below.

Demand Model Structure

6.3.2 The TMfS:05 demand model structure is broadly the same as that used for TMfS:02, however, two enhancements are included in the TMfS:05 demand model structure:

- Park and Ride (PnR) Amendments
- Crowding Model in the Public Transport Assignment

6.3.3 According to Figure 1.1 of the TMfS:05 Report, the step for the PnR amendment is introduced after the main demand model run and modification is made to the final highway and PT assignment matrices. Changes in travel costs due to PnR usage are therefore not fed back into the main Demand modelling process and are therefore only reflected in any subsequent analysis (e.g. economic, environmental etc.) and also in feedback to TELMoS. This process differs from TMfS:02 only by virtue of being undertaken automatically as part of a full demand model run. In TMfS:02 the procedure was an optional "add on" following the main supply/demand convergence to enable the testing of schemes or policies with a significant Park and Ride component. The TTAA is satisfied with this overall approach.

6.3.4 The Park and Ride modelling procedure itself remains unchanged from TMfS:02 other than by being recalibrated to include additional Park and Ride sites (both official and unofficial). **It should be noted that the updated calibration for the Park and Ride model for TMfS:05 has not been audited by the TTAA**.

6.3.5 The TMfS:05 PT assignment procedure includes new functionality to model the effect of crowding. In principal, the PT travel time is updated to include the potential additional travel time due to overcrowding on PT services and a time penalty for travelling in discomfort. In theory, the TTAA considers that the addition of PT crowding is an enhancement to the TMfS structure, however, as acknowledged by MVA, it will have a significant detrimental impact on model run times and this must be considered by potential users. Users should also be aware that crowding effects have only been implemented for AM and PM peak rail services in TMfS:05. More detailed comments on the PT crowding element are included in

Chapter 5 regarding the PT Assignment Model.

6.3.6 TMfS:05 maintains the same hierarchical demand model structure as TMfS:02 whereby mode choice precedes destination choice. Within the limitations of a rebase to 2005 conditions, significant changes to the TMfS model structure would not have been anticipated by the TTAA. Equally, this structure conforms with the Department for Transport's "expected" structure outlined in WebTAG Unit 2.9.1 and is therefore considered appropriate for TMfS:05. **The TTAA would, however, recommend that the TMfS demand model structure be subject to a review aimed at establishing the most appropriate hierarchical structure, during the next major upgrade of TMfS**.

6.3.7 The TMfS:05 demand model operation in forecast mode is, at a broad level, the same as for TMfS:02. That is, that the model is designed to synthesise travel demand and apply changes to the base year trip matrices in an incremental manner based on changes in forecast planning data and/or transport network costs. The TTAA is content that this is an appropriate method of operation of the TMfS demand model.

6.3.8 It should be noted due to the demand model's incremental forecasting technique, it is important to ensure that the planning data assumptions for the TMfS base year match closely with actual conditions (e.g. census data) on a zone by zone basis. This will help to ensure that the growth increment between base and future years does not significantly over or underestimate the absolute level of development indicated by the future year planning data. MVA has confirmed that no checks in this regard have been made for TMfS:05. **The TTAA strongly recommends that such checks are undertaken and reported at the next major upgrade of TMfS**. **In the meantime, users of TMfS:05 should take note of this issue and undertake logic checks to ensure that the incremental growth (in both percentage and absolute terms) in their study area conforms with expectations**.

6.3.9 The inputs and calibration process for the TMfS:05 demand model are consistent with those for TMfS:02. More detailed comments on these aspects are provided later in this document.

6.3.10 The data sources used in preparing the demand model parameters include the HAM and PTM assignment matrices, RSI and PT survey data, cost skims from the HAM and PTM, Scottish Household Survey data and planning data from TELMoS. The TTAA is content that these are appropriate data sources to utilise in the demand model development.

Zoning System

6.3.11 The zoning system for the TMfS demand model is entirely consistent with that for the HAM and the PTM. Additionally, the demand model is designed to operate on a zonal level rather than at a more aggregate district level, as was the case for TMfS:02.

6.3.12 For TMfS:05, four additional special generator zones are added to uniquely represent Edinburgh Airport, Aberdeen Airport, Prestwick Airport, and the Royal Bank of Scotland Headquarters at Gogar. The trips in these special generators are independently projected and do not fall within the general demand modelling framework. The TTAA is content that the zoning changes are appropriate for TMfS:05.

6.3.13 Demand model parameters have been devised for a more aggregate 3 sector system which demarcates Glasgow, Edinburgh and the rest of the modelled area from each other. This approach is consistent with TMfS:02 and is acceptable for TMfS:05. Users should be aware, however, that the "rest of the modelled area" covers a mix of urban, suburban and rural areas (e.g. Aberdeen, Dundee, Perth, the Borders, Dumfries & Galloway etc.) within which the travel characteristics are assumed to be consistent. Clearly the travel characteristics in and around towns and cities with distinct urban and suburban settings such as Aberdeen and Dundee will be different to towns and areas within a more rural setting. **Therefore, the TTAA would recommend that additional sectoring and corresponding calibrated parameters be considered at the next major upgrade of TMfS to better represent the differing travel characteristics in areas outwith Edinburgh and Glasgow**.

Journey Purposes and Time Periods

6.3.14 The demand model contains five journey purposes (HBW, HBO, HBEB, NHBO & NHBEB) and two person

types (non-car available & car available). The HAM is further disaggregated into four user classes in TMfS representing cars in-work and non-work separately and LGVs and HGVs separately. The TTAA considers these appropriate for TMfS.

6.3.15 The demand model for TMfS operates separately for each time period. Each periodic demand model operates for "from home" trips only with "to home" and "non home based" trips derived from the outputs of the "from home" models. The time periods for the demand model are:

- AM peak period : 0700-1000 (peak hour for assignment : 0800-0900);
- Inter-peak period : 1000-1600 (peak hour for assignment : $^{1}/_{6}^{th}$ of1000-1600); and
- PM peak period : 1600-1900 (peak hour for assignment : 1700-1800);

6.3.16 The time periods specified are consistent with TMfS:02 and are considered appropriate for TMfS:05.

Generalised Costs

6.3.17 The generalised cost-journey purpose equivalence is reported in Table 2.1 of MVA's report and appears to be consistent with the demand model specification for TMfS (i.e. represents "home based" trips only).

6.3.18 The corresponding TMfS:05 generalised cost coefficients, calculated in accordance with TAG Unit 3.5.6 are provided in Table 2.2. The TTAA notes the fuel consumption equation used in TMfS:05 is in the quadratic form ($a+bV+cV^2$). It is acknowledged that the development of TMfS:05 predates the release of the latest WebTAG guidance (October 2006), where the fuel consumption equation has been revised to take the cubic form ($a+bV+cV^2+dV^3$). It is assumed that the distance cost coefficients will be updated to take account of the latest WebTAG guidance at the next major upgrade of TMfS.

6.3.19 The TMfS:05 distance and toll cost coefficients have reduced in scale compared to those calculated for TMfS:02 to take account of price growth adjustments between 2002 and 2005 These are replicated below in Table 6.1.

Table 6.1 : TMfS Generalised Cost Coefficients – HAM Base Year

	Generalised Cost Coefficients		
Mode	**Time**	**Distance**	**Average Toll**
Cars in-work	1.0	0.2114	0.0530
Cars non-work	1.0	0.3161	0.1511
LGV	1.0	0.6694	0.0237
OGV	1.0	2.5253	0.0237

6.3.20 The TTAA notes from the calculations shown in Appendix C, that the distance parameters generally appear to have been correctly calculated in accordance with TAG Unit 3.5.6. However, there is a lack of clarity regarding the derivation of the 1.069 and 1.036 factors applied in the petrol and diesel price calculations respectively. MVA has subsequently clarified that these were based on the fuel growth rates in Table 14 of the pre-October 2006 version of WebTAG unit 3.5.6 and the TTAA is satisfied that this is the case. The value of time for the toll cost parameters for the car non-work and in-work appear to have been calculated in the same way as they were for the TMfS:02 using the methodology from the DfT paper "Advice on Modelling Congestion Charging or Tolling Options for Multi-Modal Studies". The TTAA is content that the calculations have been undertaken correctly, however, the information in Appendix C of MVA's draft report does not make this distinction clear and cannot therefore be followed logically to enable confirmation of the final reported toll parameters of 0.1511 and 0.0530 respectively.

6.3.21 It should also be noted that MVA has referenced WebTAG Unit 3.5.6 Table 14 as the source for the rate of change of fuel consumption for the car in-work calculations. This should in fact be Table 13 as is correctly referenced for the car non-work calculations. Overall, the TTAA is content that the TMfS:05 generalised cost parameters have been calculated using a methodology consistent with TMfS:02 and are of the

expected order of magnitude. MVA has acknowledged the reporting omissions and lack of clarity in the Draft of Appendix C and has agreed to update this information as appropriate in publishing the Final Report.

6.3.22 The PT assignment model coefficients for the base year are provided in Table 2.3 of MVA's report. Changes have been introduced to the TMfS:05 parameters over TMfS:02, (viz. bus in-vehicle times factor increased from 1.2 to 1.5, inter-urban service wait time factor decreased from 1.8 to 1.0, maximum wait time reduced from 60 minutes to 15 minutes). Values of time have accordingly been updated to take account of price growth between 2002 and 2005 with a resulting increase of approximately 6%.

6.3.23 It was assumed by the TTAA that the "rail to rail or underground" transfer penalty of 5 minutes implies "rail to rail or underground and vice versa". Hence, any rail to rail (whether overland or underground) transfer penalty is a consistent 5 minutes. MVA has subsequently confirmed this to be the case and has agreed to make this clear in the Final Report.

6.3.24 MVA has confirmed that the parameter values were changed due to the introduction of crowding in the PT model. The TTAA is generally content that the parameter values and values of time presented in Table 2.3 of MVA's report are appropriate for TMfS:05. **The TTAA recommends that in updating Appendix C for the Final Report, it would be prudent to present information regarding the derivation of the in-work value of time for the PT model, as is presented in Table 2.3 (in-work VoT = 2016.169p/hr)**.

Parking Charges

6.3.25 Parking charges in TMfS:05 remain unchanged to those used in TMfS:02 whereby they are applied by including charges in the central areas of Aberdeen, Glasgow, Edinburgh, Perth, Stirling, Dunfermline and Dundee. The areas covered by the parking charges in TMfS are generally appropriate. It should be noted that the parking coverage in Dundee only encompasses a very small area (3 zones) in the city centre, whilst in Glasgow only parking north of the River Clyde is included (although this represents the majority of significant parking areas for Glasgow).

6.3.26 Details of the parking charges and how these have been applied in TMfS are provided in Appendix D of MVA's report. The parking charges appear to be broadly of the correct order of magnitude for most areas, however, no details of the source of the parking charge information are provided.

6.3.27 It is assumed in TMfS that 45% of home based work trips to each city/town will pay for long stay parking with the remaining 55% (15% kiss and ride and 40% PNR) not paying. 80% of home based other and non-home based trips to each city/town centre are assumed to pay for short stay parking. These proportions were estimated based on data supplied by Aberdeen City Council as part of the ASAM development. Equivalent data for other cities was not available, therefore it should be noted that these assumptions have been applied uniformly for all areas where parking has been included (i.e. Glasgow, Aberdeen, Dunfermline etc. all share the same assumptions).

6.3.28 The parking charges are then allocated 50% each to outward and return journeys and added to the base year generalised cost skim matrices, following application of the non-work car tolling parameter. The parking charges are represented by an average cost per car, which is considered crude but acceptable for TMfS.

6.3.29 Overall, the methodology for applying the parking charges within TMfS follows a logical process which the TTAA considers appropriate for TMfS. Potential users should, however, note the limited coverage of parking charges and uniformity of parking assumptions within the TMfS network with respect to possible applications considering changes to parking charges and/or policies. It is likely that TMfS could only be used to give broad rather than detailed indications of the likely response to changes in parking charge and/or policy.

Highway and PT Assignment Models

6.3.30 The audit of the highway and PT assignment models are covered in Chapters 3 and 5 of this report respectively.

Trip Ends

6.3.31 The process used to derive the trip ends for input to the demand model is reviewed in the following section of this report.

Demand Model Parameters

6.3.32 Demand model parameters are discussed in more detail in later sections this chapter.

Sensitivity Testing

6.3.33 The sensitivity testing undertaken is discussed in more detail in a later section of this chapter.

Forecasting Procedures

6.3.34 The forecasting procedures are discussed in more detail in a later section of this chapter.

6.4 Trip and Cost Matrices

6.4.1 Various data sources were used in the calibration of the demand model as follows:

- Person trip matrices by journey purpose, mode and time period;
- Trip productions and attractions by journey purpose, mode and time period;
- Generalised cost of travel from the assignment model by journey purpose, mode and time period);
- RSI data;
- Vehicle occupancy and journey purpose breakdowns from TMfS:02 and forecast changes in vehicle occupancy from TAG;
- Scottish Household Survey data; and
- Planning data from TELMoS.

6.4.2 The use of these data sources is discussed in detail in the following sections.

Highway Matrix Development

6.4.3 The methodology adopted to develop the 24 hour person trip matrices from the final highway assignment model is similar to that adopted for TMfS:02, in that it is a mechanistic factoring process. The following points have been identified during the audit process:

- A coarse sectoring system has been utilised for the journey purpose information (Edinburgh, Glasgow and Everywhere else)
- The process inherently assumes that all zone to zone movements in each sector (Edinburgh, Glasgow and Everywhere else) will have the same journey purpose split. Similarly, all inter-sector zone to zone movements will have the same journey purpose split as all other zone to zone movements for the same sector pair. This simplistic assumption is likely to be far from reality for many zone to zone movements
- CSTM3A provided the journey purpose split information, which inherited the data from CSTM3, which itself inherited the data from SITM, JIF and CSTM2. This information is therefore at least 10 years old as it pre-dates CSTM3
- The car occupancy factors were derived from analysis of the TMfS RSI database. In TMfS:05, these factors change over time in line with the guidance in TAG unit 3.5.6

- The AM and PM period to hour factors (to create hourly matrices for assignment from the period matrices created in the demand model) were derived mainly from analysis of the TMfS RSI database with the exception of intra-Edinburgh and Edinburgh to/from Glasgow trips which were taken from CSTM3A. The inter-peak period to hour factor is 0.166667 for all movements
- In Table 3.1 of MVA's report, the TMfS:05 Period to Hour Factors for intra Glasgow, Glasgow to/from Everywhere else and Edinburgh to/from Everywhere else movements have slightly reduced from TMfS:02. This suggests a general trend of peak hour flows being less pronounced compared with the peak period (i.e. peak spreading). **At the next major upgrade of TMfS, in the absence of any new data, the TTAA recommends that consideration be given to introducing a generalised adjustment for other movements' period to hour factors, i.e. intra Edinburgh and Edinburgh to/from Glasgow, to reflect similar changes in the peak hour to period ratio of traffic**

6.4.4 Given the function and purpose of the TMfS demand model (to provide travel demand growth forecasts rather than absolute travel demand forecasts), these aspects of the matrix development process are considered acceptable within the context of TMfS.

Initial Zonal Trip Ends

6.4.5 The initial trip productions and attractions by journey purpose were developed using data from the TMfS RSI database along with zonal planning data which defined the level of employment and employed persons in each zone. The planning data used in this process was output planning data for 2005 for the TELMoS model.

6.4.6 As noted previously in Section 6.3, no checks have been made to verify the robustness and accuracy of the 2005 TELMoS output planning data at a zonal level. The TTAA considers that such checks would provide verification of the accuracy of the base planning data within TMfS, thereby providing confidence in the demand model's ability to robustly predict growth increments at a zonal level. **The TTAA would recommend that at the next major upgrade of TMfS, such checks be undertaken as a matter of course during the demand model development process**.

6.4.7 Notwithstanding the above, the TTAA considers that appropriate planning data source has been used in the creation of the initial zonal trip ends.

6.4.8 The planning data was used to classify individual zones by relating the number of employed persons to the amount of employment. Twelve such classification groups were defined and the productions (P) and attractions (A) from the RSI data were classified in these groups. Trip end parameters (for P&A by time period and journey purpose) were then defined by calculating these directly from the RSI data. Examples of the trip ends and parameters by zone group are provided for the AM and inter-peak periods in the report. The TTAA considers that these have been derived in accordance with the methodology outlined by MVA in the report.

Car Occupancy

6.4.9 In TMfS:05, car occupancy factors by travel purpose by the 3 sectors for the base year were derived from local RSI data, and change over time in line with the guidance in TAG unit 3.5.6. The TTAA considers this as an improvement over TMfS:02 where Intra Edinburgh and Edinburgh to/from Glasgow trip factors were taken from CSTM3 due to insufficient local information and where car occupancy factors remained constant over time.

Public Transport Matrix Development

6.4.10 The process for creating person trip matrices by journey purpose and time period for PT trips is similar to that for car trips, although without the need to consider vehicle occupancy. The following points have been identified during the audit process:

- It was mentioned in the TMfS:02 Report (ref. §3.4.1) that "*Initial PT journey purpose matrices were not created as no equivalent CSTM3A journey purpose factors for PT were available*." The statement in the TMfS:05 Report, however, was omitted without clarification. MVA has subsequently confirmed that the same process was used in TMfS:05

- Global period to hour factors (to create hourly matrices for assignment from the period matrices created in the demand model) of 0.498 (AM peak) and 0.166667 (inter-peak) have been applied for PT trips. These factors were inherited from CSTM3A
- Zonal trip end factors for non-home based PT trips are uniformly applied across the TMfS study area as insufficient PT interview data was available to calculate these by planning data group.

6.4.11 Similar to the highway matrix development, given the function and purpose of the TMfS demand model (to provide travel demand growth forecasts rather than absolute travel demand forecasts), these aspects of the PT matrix development process are considered acceptable within the context of TMfS.

6.4.12 The PT zonal trip end factors (P & A) for "from home" and "non-home based" trips are provided in Tables 3.19 to 3.21 of MVA's report. Unlike the corresponding factors for highway trips, the number of trips has not been reported. Consequently, the TTAA cannot confirm that the resulting parameters have been derived appropriately, therefore it is assumed by the TTAA that this is the case.

6.5 Destination Choice Model

6.5.1 The TMfS:05 destination choice model basically retains the same framework as that for TMfS:02. The 2005 rebase however has resulted in newly calibrated model parameters.

6.5.2 The adopted demand model structure for TMfS implies that destination choice is more sensitive than mode choice. Therefore, the destination choice sensitivity parameters and constants were calculated first as the mode choice calibration relies on outputs from the destination choice model.

6.5.3 Sensitivity parameters were calibrated for each of the five journey purposes, two time periods (AM and inter-peak) and three mode/car available segments (car available car users, car available PT users and non-car available PT users). Separate parameters were calibrated for 4 areas as follows:

- Intra-Edinburgh trips;
- Intra-Glasgow trips;
- Intra-"remainder of the study area" trips; and
- All inter-sector trips.

6.5.4 The destination choice model is a traditional gravity model using an exponential deterrence function. In forecast mode, the destination choice model will be singly constrained for "from home" to "employer's business" and "other" trip purposes, thereby enabling trips to change destination based on changes in accessibility. Home based to work trips will be run as doubly constrained to reflect the balance between workers and jobs and to retain consistency with the planning data. For the destination choice model calibration, all purposes were treated as doubly constrained.

6.5.5 The form and processes adopted for the TMfS:05 destination choice model are similar to those for TMfS:02 and are therefore considered appropriate.

6.5.6 The TTAA notes that the TMfS:05 destination choice sensitivity parameters for highway have reduced from TMfS:02 in the inter-peak for all intra-sector movements of all travel purposes with some small increases evident on inter-sector movements. The TMfS:05 destination choice sensitivity parameters have also reduced in most cases in the AM Peak (i.e. all purposes for intra-Edinburgh and Intra-"reminder of study area"), whilst increases in some travel purpose sensitivity parameters are noted for the Intra-Glasgow and All inter-sector trips.

6.5.7 For PT, the TMfS:05 sensitivity parameters are uniform across the model area as insufficient data was available to derive these on a sector basis. The TTAA also notes that, apart from HBW and HBO car available trips, all other AM peak PT destination choice parameters have reduced in sensitivity compared with TMfS:02. In the inter-peak, the majority of PT destination choice parameters have increased in TMfS:05 compared with TMfS:02, with all employers business and NHBO trips being the exceptions.

6.5.8 A series of destination choice constants (K factors) has also been derived for TMfS. These factors ensure that the destination choice model output trip matrices match the input matrices at a 3 sector (Edinburgh,

Glasgow and Elsewhere) level. The calibrated K factors are presented in Appendix E of the TMfS:05 Report. It is noted that sector comparison between input and output matrices previously included in the TMfS:02 Report was omitted in the TMfS:05 Draft Report. This information was independently supplied to the TTAA by MVA and will be incorporated in the Final Report in due course.

6.5.9 The sector comparison between input and output matrices demonstrates a good match whilst the K factors are broadly comparable with those from TMfS:02. The TTAA is therefore content that the distribution model parameters are appropriate for TMfS:05.

6.5.10 The TTAA also recommends that during the next major upgrade of TMfS, more detailed information be provided regarding the destination choice model development. This would include statistical significance of the destination choice model parameters and evidence that the model can readily reproduce the observed matrix (at a detailed rather than 3x3 sector level). It will be beneficial if details of the fit of the distribution model including a comparison of observed and modelled trip length distributions (by purpose) and scatter graphs illustrating observed and modelled matrix cells is included in the demand model documentation. MVA has noted that a change of software platform may be necessary to enable this information to be produced.

6.6 Mode Choice Model

6.6.1 The TMfS:05 mode choice model basically retains the same framework as that for TMfS:02. The 2005 rebase however has resulted in newly calibrated model parameters.

6.6.2 The mode choice model within TMfS:05 operates at a trip end level for car available trips only. The model has a logit structure using logsum composite utilities calculated using the inter-zonal costs used by the distribution model. As with TMfS:02 the mode choice model does not consider “non home based” trips, as these are factored from the “home based” trips. Overall, the TTAA is content that the adopted mode choice model structure is appropriate for TMfS.

6.6.3 Mode choice sensitivity parameters were derived for the 3 sector system (Edinburgh, Glasgow and Other areas) as insufficient data was available to reliably calculate these on a zonal basis. The TMfS:05 parameters derived for “home based” trips are presented in Table 5.2 of MVA’s report. The TTAA notes that TMfS:05 mode choice sensitivity parameters have mostly reduced in sensitivity compared with the TMfS:02 parameters, particularly for the Edinburgh and Glasgow sectors. These TMfS:05 parameters are replicated in Table 6.2.

Table 6.2 : TMfS Mode Choice Sensitivity Parameters

Mode		Edinburgh	Glasgow	Other
AM Peak				
	HBW	0.836	0.705	0.911
	HBO	0.450	0.641	1.000
	HBEB	0.648	0.419	0.644
Inter Peak				
	HBW	0.298	0.453	0.054
	HBO	0.238	0.284	0.035
	HBEB	0.390	0.055	0.098

6.6.4 The mode choice sensitivity parameters clearly demonstrate that mode choice is more sensitive during the AM peak (as the magnitude of the sensitivity parameters is consistently greater). This would generally be expected, however, it is worthy of note that the relative difference in magnitude of the sensitivity parameters between the AM and inter-peak periods is extremely significant in some cases. In particular, it is noted that the inter-peak mode choice sensitivity outwith Glasgow and Edinburgh is especially low for all trip purposes.

6.6.5 As in the TMfS:02 Report, little commentary is provided in the TMfS:05 Report regarding these

parameters, other than a statement that *"…mode choice is more sensitive in the AM peak…"*. MVA previously commented during the TMfS:02 audit process that *"The TMfS definition of car availability for a person is that the person comes from a car owning household. This definition was made because car ownership data is widely available in comparison with data on actual car availability for a specific trip. For the inter-peak period it is likely that there is actually less real car availability for a particular car ownership level than for the peak since the household vehicle(s) are more likely to be used for peak hour travel. We would expect therefore that there is less sensitivity to mode choice in the inter-peak period"*.

6.6.6 The TTAA acknowledges the logic of the above statement, nevertheless the relative difference in sensitivity between peak and inter-peak should be noted by potential users. **The TTAA considers that it would be an appropriate enhancement at the next major upgrade of TMfS to calibrate mode choice parameters separately for 1 and 2+ car owning households. Additionally, consideration should be given to introducing a more disaggregate sectoring system for the mode choice sensitivity parameter derivation**.

6.6.7 It is not possible within this model development audit to draw firm conclusions regarding the appropriateness of the derived mode choice sensitivity parameters. Such conclusions can only be drawn following comparison with expectations and previous experience when applying the model in predictive mode.

6.6.8 Mode specific constants (similar in function to the destination choice K factors) were also derived for the mode choice model. These constants are used to ensure that the observed base year mode split (at the trip end level) is replicated in the base year model. The process for deriving these constants is consistent with that adopted for TMfS:02 and is therefore considered acceptable for TMfS. The derived mode specific constants are not, however, presented in MVA's report, therefore the TTAA cannot provide any commentary regarding the appropriateness of the constants used.

6.6.9 As per TMfS:02, the mode specific constants are recalculated for forecast years in TMfS:05. This is intended to reflect the fact that car ownership will increase over time and the assumption that members of the 1+ car ownership segment will be less likely to use PT in the future (all other things remaining equal). Travel choice behaviour on 1+ car ownership segment changes between base and forecast years due to changes in 1 and 2+ car owning households. As a result, a recalculation of mode specific constants is undertaken.

6.6.10 It should be noted that the statistical significance of the mode choice model parameters has not been presented in MVA's report and has not been investigated in this audit. As with the destination choice parameters, MVA has noted that a change of software platform may be necessary to enable such information to be provided for the mode choice parameters during future model developments.

6.7 Reverse Trips and Non-Home Based Trips

6.7.1 The TMfS:05 demand model, as with TMfS:02 operates on an individual time period basis dealing only with "from home" trips separately for the AM, inter and PM peaks. Consequently, a process is required to derive the "to home" trips, by linking them to the "from home" trips. Furthermore, "non-home based" trips are also linked to "home based" trips in TMfS rather than treating them as a separate journey purpose. The different trip types are handled in the TMfS demand modelling process as follows.

To Home Trips

6.7.2 The "to home" trips for all time periods are derived by applying a series of factors to the "from home" trips. Separate factors by time period, mode and trip purpose were derived using data from the Scottish Household Survey.

Evening Peak Trips

6.7.3 The evening peak "from home" trips are derived by a factoring process applied to the "from home" trips from the inter-peak periods. Again, factors are derived separately by mode and trip purpose and applied to the corresponding inter-peak trips.

Non-Home Based Trips

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

6.7.5 Overall, the TTAA is content that the principles of the above approach appear to be logical and reasonable for a model such as TMfS, based on a review of the description provided in the documentation.

6.8 Trip End Model

6.8.1 The TMfS:05 Trip End Model is basically the same as that for TMfS:02. The trip end model for both car and public transport trips in TMfS is a growth factor model based on the DfT National Trip End Model (NTEM). NTEM can be used to produce trip end forecasts by mode and time period for Local Authority districts at a person trip level. TMfS also has an associated land use model (TELMOS) which can output planning data and car ownership data on a zonal basis for a given forecast year.

6.8.2 The TMfS trip end model therefore becomes a relatively simple method of calculating future year trip ends by multiplying vectors of trip rates by the planning data person type vectors for each zone. The trip ends for the forecast year are then divided by those for the base year to create growth factors. The base year trip productions are then multiplied by these factors to create future year trip productions by mode/car availability, time period and journey purpose.

6.8.3 The NTEM based process relates solely to trip productions for “from home” trips. The “to home” and “non-home based” trip ends are created in a separate process.

6.8.4 The trip attraction process involves applying attraction parameters to the number of jobs in each zone. The forecast trip attractions are then divided by the base year attractions to create growth factors to be applied to the base year trip attractions.

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

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

6.9 Time of Day Choice

6.9.1 The TMfS:05 Report provides background on the two elements of time of day choice considered:

- Macro Time of Day Choice (i.e. shifting from AM or PM peak period into the inter-peak or pre-AM peak/post-PM peak periods)
- Peak spreading (i.e. moving from peak to shoulder of the peak, but within the same peak period)

6.9.2 The latest development of the TMfS:05 demand model has implemented Macro Time of Day Choice (MTODC) to be less sensitive than mode and destination choice. However, model testing according to VADMA guidelines has led to the decision to exclude MTODC as part of the standard model. The TTAA is content that MTODC is excluded from the standard model as the current WebTAG guidance on the matter whilst not definitive, does suggest that MTODC will generally only be relevant for schemes where differential pricing or access restrictions between time periods exists.

6.9.3 The TTAA’s comments on the Peak Spreading Model are as follows.

Peak Spreading

6.9.4 The TMfS:05 Peak Spreading Model is basically the same as that for TMfS:02. The peak spreading model within TMfS has been designed to operate in the AM peak only at the individual matrix cell level. The form of the peak spreading model is an incremental logit model. The shoulder peak costs (not modelled in the HAM) have been estimated for input to the peak spreading model as the additional run time to create these through assignment was considered prohibitive. It is assumed in the peak spreading model that the overall level of demand within the peak period remains unchanged with the model simply altering the ratio of peak to shoulder trips.

6.9.5 The peak spreading model operates on the basis that for each outer loop of the demand model an approximation of the peak spreading supply/demand is established. This is undertaken by simplifying the supply and demand functions to linear approximations. The shoulder peak costs are estimated by reducing converged assignment flows by a percentage representing the average ratio of shoulder to peak flows. The link journey times are then reduced in line with the reduced flows and costs skimmed from the network. It should be noted that a uniform, rather than cell/area specific reduction factor is applied to the flows (as the shoulder peak assignments are not carried out). Nevertheless, this provides an acceptable means of estimating supply functions on a cell by cell basis.

6.9.6 An adjustment factor to the average change in costs (between peak and shoulder of peak) can be applied to improve the estimate on a cell by cell basis. A weighting can be applied taking account of the ratio of shoulder to peak flow for the specific cell being considered relative to the average ratio of shoulder to peak flow.

6.9.7 Overall, the TTAA is content that the specification of the peak spreading model is acceptable for TMfS. The TTAA would recommend that during the next major update of TMfS, an advisory paper is produced to demonstrate the scale and relative geographical sensitivity of peak spreading effects under various forecast scenarios.

6.10 Model Realism Tests

6.10.1 MVA undertook a series of tests to establish the broad realism of the TMfS:05 model outputs in forecast mode. These tests were undertaken in accordance with the DfT draft advice on Variable Demand Modelling (VADMA). The sensitivity tests were undertaken to examine the elasticity of demand with respect to:

- Car journey times (20% increase in car journey time tested);
- Car fuel price (20% increase in car fuel price tested); and
- PT fares (20% increase in PT fares tested).

6.10.2 The modelled elasticity in response to each of the above tests was derived on an average basis across the whole TMfS study area and the elasticities compared with the values in §27.7 and §27.8 of the draft VADMA guidance. Each of the sensitivity tests is discussed in turn in the following sections.

Car Fuel Price Elasticity

6.10.3 For this test, the generalised costs were recalculated based on a 20% increase in fuel price and a full demand model run was undertaken. The resulting car matrices were then weighted by a distance matrix to establish the car kilometres. The elasticity was then calculated by comparison with the base case and these are shown in Table 6.3.

Table 6.3 : Fuel Price Elasticities

Journey Purpose	Elasticity Guidance	AM Peak	Inter Peak
In-Work	-0.15 to -0.30	-0.1192	-0.1592
Non-Work	for all purposes	-0.1716	-0.2237

6.10.4 The AM and inter-peak non-work and inter-peak in-work elasticities are within the guideline range, whilst the AM peak in-work value is outwith the range. The in-work elasticities have increased and the non-work elasticities have decreased relative to TMfS:02. It is intuitively correct that non-work trips would demonstrate a greater sensitivity to changes in fuel price than in-work trips.

PT Fares Elasticity

6.10.5 The same methodology as per the fuel price test was applied in this test with the difference being that a 20% increase in PT fares replaced the 20% increase in fuel price. The resulting elasticities are shown in Table 6.4.

Table 6.4 : PT Fares Elasticities

Journey Purpose	Elasticity Guidance	AM Peak	Inter Peak
All	-0.20 to -0.40	-0.1458	-0.0421

6.10.6 The AM and inter-peak elasticities are demonstrated to fall outwith the guideline range. The demonstrated TMfS:05 PT fares elasticities are lower than the corresponding TMfS:02 values.

Car Journey Time Elasticity

6.10.7 This test involved skimming generalised costs from the highways network with a factor of 1.2 applied to the time weighting of the generalised cost formula. A single internal loop (no assignment/cost iteration) was run and the output car matrices were weighted by distance. The resulting elasticities are shown in Table 6.5.

Table 6.5 : Car Journey Time Elasticities

Journey Purpose	Elasticity Guidance	AM Peak	Inter Peak
In-Work	-0.15 to -0.70	-0.4510	-0.5099
Non-Work	for all purposes	-0.4291	-0.4738

6.10.8 The TMfS:05 car journey time elasticities fall in the middle of the guideline range for all time periods and purposes. These have unilaterally increased over those reported for the corresponding test with TMfS:02.

Summary of Sensitivity Tests

6.10.9 Overall, the TMfS:05 sensitivity tests generally demonstrate fuel price and car journey time elasticities to be within the range outlined in the draft VADMA guidance (with the exception of AM peak in-work fuel price elasticity which is lower than the guideline range). The PT Fare sensitivities for both the AM and inter-peaks fall outwith the recommended ranges, demonstrating a very low sensitivity to changes in PT fares. The inter-dependence between PM and AM (and to some extent inter-peak) trips in the TMfS demand model would imply a similar level of sensitivity in the PM peak compared with the AM.

6.10.10 It is recognised that the guidelines in VADMA attempt to cover a number of factors such as journey purpose, spatial differences and modal competition which may or may not reflect the specific conditions within TMfS as a whole. Furthermore, the demonstration of fuel price and car journey time sensitivity generally being within the guideline range is encouraging. The very low PT fare sensitivity should, however, be noted by users of TMfS particularly in assessing any scheme where changes in PT fares are likely to be a significant component.

6.10.11 It is noted that the elasticities have, in many cases, increased compared with the corresponding TMfS:02

values, particularly with respect to car journey times. This is despite the model parameters (e.g. generalised cost, mode/destination choice sensitivity parameters etc.) in the 2005 rebase recalibration generally decreasing in scale. In discussion of this matter MVA has subsequently commented that *"The explanation for this is that the elasticities depend on more than just sensitivity parameters, as full model runs are undertaken to get these elasticities. Other aspects of the model have been changed, for example generalised cost parameters and the introduction of crowding in the PT model, both of which could have impacts for the size of the elasticities*".

6.10.12 It is worthy of note that the sensitivity tests have been undertaken at a global level across the TMfS network. Furthermore, the sensitivities across the network as a whole tend to be at the low to mid-level of the VADMA guidance ranges. It follows therefore, that some areas of the model will have much lower sensitivities and other areas much higher. **The TTAA considers that during the next major upgrade of TMfS, additional (more localised and focused) sensitivity testing would be beneficial to provide potential users with guidance on the relative elasticity in different areas of the model with respect to issues such as fuel price, PT fare and car journey time changes. More specific measurable outcomes (e.g. mode shift on a sector basis) would assist in the interpretation of these tests**.

6.11 Forecasting Procedures

6.11.1 The general operation of the TMfS:05 demand model in forecast mode is the same as TMfS:02. That is that the model is designed to produce forecast matrices to be applied in an incremental manner to the base year matrices. The process relies on model parameters, trip ends and inputs from the highway and public transport assignment models. The differing aspects of the forecasting process are outlined as follows.

Overall Operation of Demand Model

6.11.2 The overall operation of the TMfS:05 demand model in forecast mode is essentially the same as TMfS:02. Trip ends are created for the relevant forecast year and economic growth scenario whilst the various sub-models operate in an iterative manner to create the relevant highway and PT assignment matrices. The TTAA is content that the procedures adopted are appropriate for TMfS.

Sequence of Tasks

6.11.3 The sequence of tasks for the demand model differs depending on whether the forecast is for a reference or variance case. The sequence outlined for TMfS:05 is consistent with that for TMfS:02 and is therefore considered appropriate by the TTAA.

The Incremental Forecasting Approach

6.11.4 The TMfS demand model operates in an incremental manner. The model therefore produces estimates of the ratio of forecast year to base year synthesised trip ends and applies these ratios to the base year "observed" trip ends to create the forecast trip ends and consequently the forecast assignment matrices. The TTAA considers this consistent with good working practice and is appropriate for TMfS.

Model Parameters

6.11.5 The mode specific constants, vehicle occupancy factors and the generalised cost coefficients for assignment are recalculated for forecast years in TMfS. The TTAA has commented on the mode specific constants elsewhere in this document.

6.11.6 Notwithstanding the above, the TTAA is content that the model parameter adjustments are acceptable for TMfS.

Trip Ends

6.11.7 Forecast trip ends in TMfS are created by applying trip rates (by mode, car availability, time period and journey purpose) from NTEM to planning data outputs from TELMOS. The TTAA considers the principle of this approach to be acceptable for TMfS.

6.11.8 It should be noted, however, that TELMOS, its inputs and the realism of its outputs have not at this stage been the subject of a detailed audit. The TTAA therefore cannot currently provide any commentary regarding the appropriateness of the TELMOS outputs for use in the TMfS forecasting process.

Highway and Public Transport Cost Matrices

6.11.9 The generalised cost matrices from the base year are used as the start point for the demand model process for a reference case. Although not stated in the Draft Report, MVA has confirmed that the reference case generalised cost matrices are used as the start point for a variance case in TMfS. The TTAA concurs with this approach.

Highway and Public Transport Networks

6.11.10 The user is required to code the relevant highway and public transport networks for all reference and variance cases using conventional coding methods for TRIPS models. Specification of the appropriate reference and variance case networks for highway and PT is the responsibility of the TMfS user.

Goods Vehicles

6.11.11 Goods vehicle forecasting is not undertaken as part of the standard demand modelling procedure in TMfS. Instead, forecast goods vehicle matrices are created by calculating growth on a cell by cell basis from TELMOS data and applying these to the TMfS base year goods vehicle matrices. External goods vehicle movements are subject to uniform NRTF growth rates. As was the case for TMfS:02, growth is applied on a factor basis and logic checks are applied on a zone to zone basis to ensure that total zonal growth is consistent with planning data.

6.11.12 The TTAA considers the principle of this methodology acceptable for TMfS and recognises the advantages of enabling differential goods vehicle growth on a zone by zone basis within the internal model area.

6.11.13 Again, it should be that TELMOS, its inputs and the realism of its outputs have not at this stage been the subject of a detailed audit. The TTAA therefore cannot currently provide any commentary regarding the appropriateness of the goods vehicle data within TELMOS for use in the TMfS forecasting process.

6.11.14 The TTAA considers that during the proposed TELMoS audit process a supplementary paper providing details of goods vehicle growth from TELMOS should be prepared. This should include details of the differential growth on an area by area basis.

External Trips

6.11.15 External trip growth is handled in the same way in TMfS:05 as with TMfS:02. That is that private car trips (in-work and non-work) are subject to uniform NRTF growth rates and PT trips are subject to a uniform growth rate derived from application of the trip end model in the internal model area. The one difference introduced in TMfS:05 is that for the airport zones (1197-1110) forecast year demand is obtained by applying airport growth predictions to the base airport travel demand. These predictions come from British Airports Authority for Edinburgh, Glasgow and (presumably) Aberdeen and from Infratil for Prestwick. It should be noted that in §10.10.3 of MVA's Draft Report it is stated that *"These predictions come from British Airways for Edinburgh, Glasgow and Edinburgh".* MVA has subsequently clarified that this should read *"These predictions come from British Airports Authority for Edinburgh, Glasgow and Aberdeen"* and that this will be corrected in the Final Report. Notwithstanding this typographical error, the TTAA is content that this methodology is appropriate for TMfS.

6.12 Summary of TMfS Demand model Audit

6.12.1 The main findings from the TTAA's review of the TMfS:05 demand model are outlined below.

Model Overview

6.12.2 The TMfS:05 demand model maintains broadly the same model structure as that developed for TMfS:02 with the addition of PT crowding effects and the incorporation of Park and Ride within the main demand

model process. The model operates as a four stage model and in an incremental manner in forecast mode. Consistent with TMfS:02, the TMfS:05 model structure adopted is one where mode choice precedes destination choice in the model hierarchy. Within the limitations of a rebase to 2005 conditions, significant changes to the TMfS model structure would not have been anticipated by the TTAA. Equally, this structure conforms with the Department for Transport's "expected" structure outlined in WebTAG Unit 2.9.1 and is therefore considered appropriate for TMfS:05. **The TTAA would, however, recommend that the TMfS demand model structure be subject to a review aimed at establishing the most appropriate hierarchical structure, during the next major upgrade of TMfS**.

6.12.3 As with TMfS:02, the TMfS:05 demand model operates at a zonal level consistent with the highway and PT models. Separate demand models are present for each model time period (with linkages between) whilst the trip end, mode and destination choice models are concerned only with "from home" trips. "To home" and "non-home based" trips are linked to "from home" trips by a factoring process. Peak spreading is also included in the main supply/demand convergence process and operates at the zonal level. It should be noted that Macro Time of Day Choice effects are not included as standard in TMfS:05.

6.12.4 Whilst content with the methodology and the parameters derived, the TTAA has identified some reporting inconsistencies and issues regarding the generalised cost derivation for the base year as reported in Appendix C of the Demand Model Development – 2005 Rebase Draft Report. MVA has indicated that these will be corrected in the final report.

6.12.5 Parking charges have also been included in TMfS for Aberdeen, Edinburgh, Glasgow, Perth, Stirling, Dunfermline and Dundee. These can be used to give broad indications of the likely response to changes in parking charge and/or policy.

Trip and Cost Matrices

6.12.6 These have been derived using various data sources. The TTAA is content that, given the function and purpose of the TMfS demand model (to provide travel demand growth forecasts rather than absolute travel demand forecasts), these aspects of the matrix development process are considered acceptable.

6.12.7 No checks have been made to verify the robustness and accuracy of the 2005 TELMoS output at a zonal level (e.g. with the 2001 census based data). The TTAA considers that such checks would have provided verification of the accuracy of the base planning data within TMfS, thereby providing confidence in the demand model's ability to robustly predict growth increments at a zonal level. **The TTAA would recommend that at the next major upgrade of TMfS, such checks be undertaken as a matter of course during the demand model development process**.

Mode and Destination Choice Model Calibration

6.12.8 The TMfS:05 mode choice and destination choice models basically retain the same framework as that for TMfS:02. The 2005 rebase however has resulted in newly calibrated model parameters for these models.

6.12.9 Overall, the TTAA is content that the mode choice and destination choice models have been developed and the relevant parameters calibrated in an appropriate manner for TMfS:05 . It is encouraging to note that sector comparisons between the input and output trip matrices from the destination choice model demonstrate a good match.

Reverse Trips and Non-Home Based Trips

6.12.10 Overall, the TTAA is content that the principles of the approach appear to be logical and reasonable for a model such as TMfS, based on a review of the description provided in the documentation.

Trip End Model

6.12.11 The TTAA is content that this aspect of the TMfS model development is appropriate.

Peak Spreading and Time of Day Choice

6.12.12 Overall, the TTAA is content that the specification of the peak spreading model and the application of this on a cell by cell basis, albeit with various assumptions in the process, are appropriate for TMfS. It is also appropriate that the peak spreading model is applied in the AM peak only.

6.12.13 A Macro Time of Day Choice (MTODC) was developed for the TMfS:05 demand model, however, this has excluded as part of the standard model after testing according to VADMA guidelines. The TTAA is content that MTODC is excluded from the standard model as the current WebTAG guidance on the matter whilst not definitive, does suggest that MTODC will generally only be relevant for schemes where differential pricing or access restrictions between time periods exists.

Model Realism Tests

6.12.14 Overall, the TMfS:05 sensitivity tests generally demonstrate fuel price and car journey time elasticities to be within the range outlined in the draft VADMA guidance and in most cases these show higher sensitivity compared with TMfS:02 The PT Fare sensitivities fall outwith the recommended ranges, demonstrating very low sensitivity in both AM and Inter-peak. This very low PT fare sensitivity should be noted by users of TMfS particularly in assessing any scheme where changes in PT fares are likely to be a significant component The inter-dependence between PM and AM (and to some extent inter-peak) trips in the TMfS demand model would imply a similar level of sensitivity in the PM peak compared with the AM.

6.12.15 It is noted that the elasticities have, in many cases, increased compared with the corresponding TMfS:02 values, particularly with respect to car journey times. This is despite the model parameters (e.g. generalised cost, mode/destination choice sensitivity parameters etc.) in the 2005 rebase recalibration generally decreasing in scale. MVA has commented that this is due to the combination of changes in sensitivity parameters, generalised cost parameters and the introduction of crowding in the PT model, all of which could have impacts for the size of the elasticities.

Forecasting Procedures

6.12.16 The forecasting procedures for the TMfS:05 demand model are essentially the same as those adopted for TMfS:02, in that an incremental forecasting methodology is applied to base year trip matrices. The main difference in the forecasting process is that the forecast year demand for zones containing airports is obtained by applying airport growth predictions to the base airport travel demand. These predictions come from British Airways for Edinburgh, Glasgow and (presumably) Aberdeen and from Infratil for Prestwick. The TTAA is satisfied that the principle of this approach is appropriate for TMfS:05.

7 TRANSPORT ECONOMIC LAND-USE MODEL OF SCOTLAND (TELMOS)

7.1 Introduction

7.1.1 This chapter presents the TTAA's findings based on information supplied by the David Simmonds Consultancy (DSC) for the Transport Model for Scotland (TMfS) 2005 Rebase audit and relates to TMfS Audit Task 8 : Review TELMoS.

7.1.2 TELMoS was incorporated as part of TMfS:02 and has been further developed in the rebase to TMfS:05. To date TELMoS has not been the subject of any formal audit process by the TTAA. Due to its scale and complexity, the overall audit of TELMoS has run with a different timescale to that of the general TMfS:05 model development audit work. The findings in this report are based on an initial, superficial review of the specific information supplied relating to TELMoS. Further findings will be published following a more detailed examination of TELMoS, its inputs, calibration and outputs.

7.1.3 DSC supplied the TTAA with a report entitled "Transport/Economic/Land-Use Model of Scotland (TELMoS) : Model Description" dated February 2007. The TTAA's comments following an initial review of this report are presented as follows.

7.2 Initial Audit Findings

7.2.1 The documentation provided by DSC provides details of the implementation of the land-use and economic components of TELMoS, and their interactions with the transport components of TMfS. This provides a clear description of the model definitions, the processing of the 2001 Census data, other data sources for setting up the Base Year model for 2001, the regional economic database, the structure and inputs of the urban and regional models, the DELTA/TMfS interface, and a brief outline of the scenario inputs.

7.2.2 It is clear that the model structure of TELMoS is well designed, with sensible definition and segmentation of land use and economic activities, and linkages between the activities. The TTAA considers that the model design and structure are consistent with the good practice of land use activity and travel demand modelling.

7.3 Ongoing Audit Process

7.3.1 As the audit process to date has been limited there is a requirement to continue the audit of TELMoS to examine the model in more detail. This process is currently ongoing and subsequent reporting will provide details and audit findings relating to the following aspects:

- further details on the empirical underpinnings of the model mechanisms
- calibration strategy
- sensitivity testing
- general model validation

7.3.2 To facilitate the audit process, the TTAA has requested further outline information on calibration and validation and details of model sensitivity tests that have already been carried out as part of previous project work. Additionally, the TTAA has requested a diagram showing the information exchanges between TELMoS and TMfS to complement the existing documented diagrams, which focus on each of the two models individually. The TTAA will also seek to identify whether there are any additional needs for sensitivity tests as part of the audit process.

7.3.3 The audit process will be progressed through exchange of technical information and discussions between Transport Scotland, MVA, DSC and the TTAA as appropriate.