Land-Use and Transport Integration in Scotland (LATIS)

TMfS:07 National Public Transport Model Calibration and Validation Report

Report for Transport Scotland

October 2009

Transport Model for Scotland

mvaconsultancy

Document Control

Project Title:	TMfS:07
MVA Project Number:	C3713602
Document Type:	Report
Directory & File Name:	H:\Contracts\Live\C3713600_Tmfs Update\Report\PT Reports\2 PT Calibration And Validation Report\V5 - Oct09\C37136_Tmfs07 National PT Model Cal Val Report V5.Doc

Document Approval

Primary Author:	Andrew Bagnall
Other Author(s):	Gordon Scott
Reviewer(s):	David Connolly, Jeff Davidson, Kevin Lumsden
Formatted by:	Nicola Milne

Distribution

Issue	Date	Distribution	Comments
1	26/01/09	David Connolly	Draft for Internal Review
2	30/01/09	Transport Scotland TTAA	First release version (for TS/TAA review/comment)
3	11/05/09	Transport Scotland TTAA	Second release version (for TS/TAA review/comment)
4	05/10/09	Transport Scotland TTAA	Draft Final Report
5	28/10/2009	General Release via LATIS Website	Final Report

Contents

Figures

Appendices

Background

LATIS Commission – Development of Modelling Framework

In August 2006 Transport Scotland commissioned MVA Consultancy to a Term Commission for the maintenance and enhancement of the Transport Model for Scotland (TMfS) and the accompanying Transport, Economic and Land-use Model of Scotland (TELMoS).

A central element of the Commission was to develop and deliver an enhanced 2007-based land-use and transport modelling system. MVA proposed a hierarchical modelling framework, with a single National Strategic Travel demand and Land Use Modelling framework as the upper tier, Regional Travel Demand Models as the mid-tier and detailed local models (eg microsimulation) as the lower tier. The National Modelling Framework has now been developed. It incorporates a number of technical enhancements and new and more robust data and will, in time, replace its predecessor, TMfS/TELMoS:05.

On 6 November 2008, the TMfS Term Commission changed its name to Land-Use and Transport Integration in Scotland (LATIS). The service is provided by Transport Scotland and their supporting consultants and offers a wide range of support and technical advice.

The LATIS service currently includes four distinct elements, as follows:

- a user engagement programme, consultations, discussions and advice on a range of transport and travel planning issues;
- the collection and provision of land-use planning data;
- the collection of transport data through the use of the Data Collection Contract; and
- a travel demand and land-use modelling suite.

The TMfS:07 and TELMoS:07 models are designed to deliver the fourth of these elements.

TMfS:07 & TELMoS:07 Model Reports

This report describes the development of the TMfS:07 National Road Model and is one of a series of eight documents describing the construction, calibration and validation of the TMfS:07 and TELMoS:07 models, as shown below:

TMfS:07 National Travel Demand Model

1. TMfS:07 Demand Model Development Report.

TMfS:07 National Road Model

2. TMfS:07 National Road Model Development Report; and
3. TMfS:07 National Road Model Calibration & Validation Report.

TMfS:07 National Public Transport Model

4. TMfS:07 National Public Transport Model Development Report; and
5. TMfS:07 National Public Transport Model Calibration and Validation Report.

TELMoS:07 National Land Use Model

6. TELMoS:07 Model Description Report;
7. TELMoS:07 Assembly of Planning Policy Inputs; and
8. TELMoS:07 Model Demonstration Report.

1 Introduction

1.1 Overview

1.1.1 The National Public Transport Model forms part of the overall 2007 TMfS model hierarchy (illustrated in Figure 1.1). It is a strategic model which has been prepared with a level of detail commensurate with appraising national policy and strategic land-use and transport interventions and providing a key source of transport supply and demand data.

1.1.2 TMfS:07 will also form the starting point for the development of Sub-Area and Regional models; providing assistance in preparation of model structure, input to base year development and providing a source of forecast year travel demand.

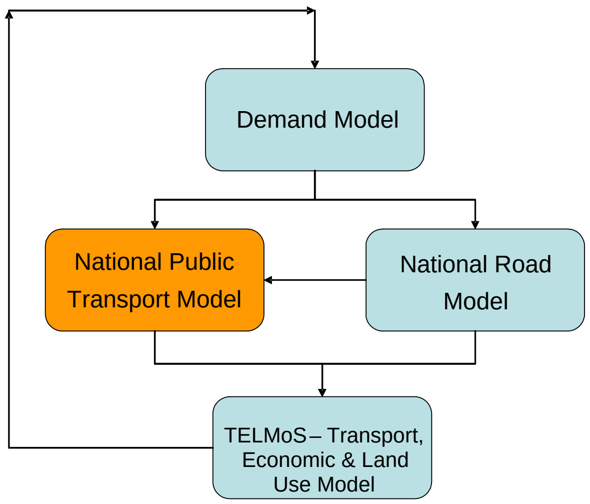

Figure 1.1 Overview of the TMfS Model Hierarchy – National PT Model Interaction

1.1.3 The National Public Transport Model has been developed using the GIS-based software package ArcGIS and Citilabs CUBE Voyager software.

1.2 Structure of this Report

1.2.1 The structure of the remainder of this report is as follows:

- Chapter 2 describes the model functions and procedures, reports the key assignment model parameters and provides details of the fares model;
- Chapter 3 provides detail of the model validation and presents comparisons of observed and modelled data; and
- Chapter 4 summarises the conclusions & recommendations relating to the TMfS:07 Public Transport model.

2 Assignment Model

2.1 Assignment Model Inputs

2.1.1 The inputs to the Public Transport Assignment Model for each time period are:

- the strategic transport network;
- a 'PT lines file' describing all relevant public transport services; and
- hourly public transport travel demand matrices (in person trips).

2.1.2 The *TMfS:07 National Public Transport Model Development Report* provides a description of the processes used to create of each of the above elements.

2.2 Path Building and Loading

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

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

2.2.2 The model assignment is split into two stages as follows.

Route Enumeration

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

Route Evaluation

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

2.2.3 Further details on the PT assignment processes can be found in the Cube Voyager software help documentation.

2.3 Crowding

2.3.1 Public transport crowding has been included in the TMfS:07 PT assignment procedures for the morning and evening peak. Crowding is not considered to be a significant issue out with the peak periods and, therefore, has not been included in the inter-peak period assignment. This also assists in reducing model run times.

2.3.2 Note that the impact that car park capacity constraints at Park and Ride sites will have on mode and route choice is dealt with by the Park and Ride model, which is described in the main Demand Model Development Report.

2.3.3 Modelling PT crowding is an iterative process. The model calculates an initial set of crowding factors and passenger loadings, feeds these back into the model and produces a revised set of passenger loadings and corresponding perceived crowding costs. Convergence of the model is achieved when the public transports loadings (and hence the crowding costs) stop changing significantly between iterations.

2.3.4 The number of iterations is specified by the user. A review of the convergence of the Base Year model suggests that five iterations of the PT crowding loop will generally be sufficient for the TMfS:07 PT assignment procedures. Model users should consider reviewing the number of iterations depending on the interventions being tested.

2.3.5 The PT crowding assignment requires the specification of the following data:

- PT crowding curves;
- PT line capacities; and
- passenger and vehicle arrival profiles.

2.3.6 Crowding curves are implemented as multiplicative curves in the CUBE Voyager public transport assignment procedures. For each level of utilisation, the free link journey time is multiplied by the appropriate adjustment factor to represent the perceived journey time spent in crowded conditions. It should be noted that all modelled occupants perceive the same crowding on a given section of the route, regardless of where they boarded.

2.3.7 The measure of utilisation is expressed as the percentage of standing passengers as a proportion of the standing capacity. Utilisation is therefore zero until all seats are occupied and standing is necessary. Utilisation is 100% when the vehicle is at crush capacity, ie all standing room is taken. The 'crush capacity' is assumed to be 40% above the seated capacity which corresponds to PDFH which indicates crowding penalties up to 140% load factor for Non-London Commuting, which is considered to be the maximum train loading

2.3.8 The Rail Passenger Demand Forecasting Handbook (PDFH) Non-London Commuting Rail Crowding curve has been allocated to all rail lines (including the Glasgow Subway) in the TMfS:07 Model in the morning and evening peak. The data points for this crowding curve are described in Table 2.1.

Table 2.1 PDFH Non-London Commuting Rail Crowding

% Seated Capacity	Utilisation	Crowding Factor
100%	0%	1.00
108%	20%	1.09
116%	40%	1.18
124%	60%	1.26
132%	80%	1.35
140%	100%	1.44

2.3.9 Capacities have been coded for all rail lines in the morning and evening peak periods based on rolling stock usage in 2006 derived from the ScotRail survey data. A review of the assigned ratios of loading to capacity for coded rail services is included in Chapter 3.

2.3.10 The model framework allows the user to model crowding effects on any new tram services, if required.

2.3.11 No crowding modelling calculations are performed for bus services, as it is assumed that operators will be likely to increase the vehicle capacity and/or service frequency on routes where demand regularly exceeds vehicle capacity, and thus the average load factors are likely to remain broadly constant over time.

2.3.12 The passenger and vehicle arrival profiles have been assumed to be constant throughout the modelled time periods. This is a potential weakness in the crowding procedures applied, since it makes no allowance for varying demand on individual services within the modelled peak hour. Given the non-linear nature of crowding costs, this assumption of constant hourly demand may result in an under-estimation of crowding on busy routes where demand varies significantly across the peak hour.

2.4 Bus Speed Factors

2.4.1 Modelled bus journey times in TMfS:07 are based on the assigned congested road speeds with a series of factors applied to adjust the bus link speeds by link class. These factors are common in all three time periods and are based on groupings of link classes, eg urban single carriageway. Bus lanes have also been coded in the PT modelled network and on these links the bus speed is related to the free flow road network. During the calibration process the bus link speed factors were adjusted to better match the timetable data where appropriate. The final bus speed factors are as follows:

- motorways - 95% of congested road speed;
- rural single - 85% of congested road speed;
- rural dual - 95% of congested road speed;
- urban single – 50% of congested road speed;
- urban dual - 75% of congested road speed; and
- bus lanes – 80% of freeflow speed.

2.4.2 Validation of the modelled bus journey times to timetable data is presented in Chapter 3.

2.5 Assignment Model Parameters

2.5.1 A range of parameters are available to control the path building process, including:

- route enumeration fare run-time factors;
- spread factor and spread constant;
- mode specific in-vehicle time weighting factors;
- mode specific wait time weighting factors;
- walk time weighting factors;
- mode specific boarding penalties;
- mode to mode transfer penalties; and
- mode specific minimum and maximum wait times.

2.5.2 The assignment model parameters, common to peak and inter-peak assignments, are shown in Table 2.2.

2.5.3 The spread parameters were defined based on achieving a reasonable range of enumerated routes for assignment, while maintaining practical model run-times. All other parameters were based on standard ranges used in other studies. The values in Table 2.2 reflect the values used in the final calibration.

2.5.4 Values of time were derived using the Transport Economic Note (TEN) methodology, with Values of Time taken from WebTAG 3.5.6 (June 2004). Using the average earnings data, a factor was derived and applied to the 2007 Value of time to produce the value used in the TMfS:07 Base Year Model.

Table 2.2 Public Transport Assignment Model Parameters

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

2.6 Wait Curves

2.6.1 A wait curve derived from PDFH has been implemented for all PT lines in the TMfS:07 model. It should be noted that the wait curve calculates the wait time in real time and, therefore, no additional wait time factor is applied to the resulting perceived wait-time. Table 2.3 shows the wait curve used.

2.6.2 It should be noted that, as noted in Table 2.2, the maximum perceived wait time will be capped at 60 minutes for all modes.

Table 2.3 Wait Times

Headway (minutes)	Perceived Wait Time (minutes)
5	5
10	10
15	14
20	18
30	23
40	26
60	31
90	39
120	47
180	63

2.7 Fares Model

2.7.1 The Fares Model for the TMfS:07 Model is based on a set of flat and distance-based Fare Tables for different PT operators.

2.7.2 The distance-based Fare Tables consist of a set of distances and fares that define points on a curve. For distances between two fixed points in the table, the Fares Model will linearly interpolate to determine the modelled fare. Fare tables for bus and rail have been defined based on analysis of scatter plots showing fare versus distance for each modelled PT operator. Average fare curves were then prepared. For subway and ferry services flat fare tables were derived based on operator data and in the case of ferries a weighted 'average' fare was derived using an estimated proportion of ticket sales. Further details are available on request.

2.7.3 Modelled rail fares are described in Table 2.4.

Table 2.4 Rail Fares (2007 prices)

Fare Table	Region	AM/PM Peak		IP	
		Distance (km)	Fare (£)	Distance (km)	Fare (£)
1	ScotRail - National	0	0.70	0	0.70
		12	3.20	22	3.20
		140	14.00	120	8.00
		750	110.00	750	85.00
2	ScotRail - SPT	0	0.70	0	0.70
		15	3.10	25	2.80
		750	55.00	750	36.00
3	ScotRail - Highland	0	0.70	0	0.70
		12	3.20	22	3.20
		140	14.00	120	8.00
		260	24.00	225	15.00
		750	75.00	750	65.00
4	ScotRail - Nth Highland	0	2.00	0	2.00
		140	14.00	140	14.00
		750	22.00	750	22.00
11	SPT - Subway	1.00 (flat fare)			

2.7.4 Table 2.5 shows the bus fares as they are coded in the model.

Table 2.5 Bus Fares (2007 prices)

Fare Table	Operator	Distance	Fare (£)
15	First Glasgow	0	0.60
		8	1.40
		30	3.00
		750	20.00
16	First Edinburgh	0	0.60
		750	55.00
17	Citylink	0	1.00
		750	55.00
18	Stagecoach Scotland	0	0.50
		750	50.00
19	Stagecoach Fife	0	0.50
		750	90.00
20	Rapsons	0	0.70
		20	2.80
		750	45.00
21	McGills	0	1.00
		750	55.00
22	Arriva	0	0.85
		750	65.00
23	First Aberdeen	0	0.75
		7	1.80
		18	1.80
24	All services	0	1.00
		750	60.00
25	Lothian Buses		Flat Fare – 1.00
26	Glasgow Airport Bus		Flat Fare – 3.65

2.7.5 Table 2.6 shows the ferry fares for foot passengers as they are coded in the public transport model.

Table 2.6 Ferry Fares (2007 prices)

Fare Table	Operator	Fare (£)
101	Renfrew Foot Ferry	1.00
1001	Rhubodach – Colintraive	1.10
1003	Ardgour – Corran	1.00
1005	Feolin – Port Askaig	1.10
1007	Lochaline – Fishnish	2.20
1009	Hunters Quay – Gourock	2.60
1011	Portavadie – Tarbet	2.80
1013	Gourock – Dunoon	2.70
1015	Mallaig – Armadale	3.00
1019	Rothesay – Wemyss Bay	3.30
1021	Berneray – Leverburgh	5.00
1023	Craignure – Oban	3.60
1025	Brodick – Ardrossan	4.50
1027	Uig – Tarbet (Harris)	8.90
1029	Uig – Lochmaddy	8.90
1031	Port Askaig – Kennacraig	7.50
1033	Port Ellen – Kennacraig	7.50
1035	Ullapool – Stornoway	13.70
1037	Lochboisdale – Oban	19.70
1039	John O'Groats – Burwick	12.20
1041	Gills Bay – St Mgrt Hope	10.80
1043	Scrabster – Stromness	13.60
1045	Kirkwall – Lerwick	67.80
1047	Kirkwall – Aberdeen	72.40
1049	Lerwick – Aberdeen	79.10
1051	Largs – Cumbrae	2.00
1053	Gourock – Kilcreggan	1.90
1055	Cromarty – Nigg	2.60
1057	Oban – Coll/Tiree	12.20

3 Model Validation

3.1 Introduction

3.1.1 In this chapter we describe the validation process undertaken for the assignment of the TMfS:07 PT model and matrices through detailed analysis of the following:

- observed bus and rail passenger count data; and
- comparison of timetabled and modelled bus journey times.

3.1.2 The validation of the TMfS:07 PT assignment model has compared the modelled flows with equivalent observed data across screenlines. As indicated in Appendix E of the *Major Scheme Appraisal in Local Transport Plans* document, the modelled public transport flow should ideally fall within 15% of observed flow across appropriate screenlines.

3.1.3 The analysis of the modelled flows also makes use of a summary statistic known as GEH, which is defined as:

$$GEH = ((observed-modelled)^2/(0.5*(observed+modelled)))^{0.5}$$

3.1.4 The GEH value is designed to be more tolerant of large percentage differences at lower flows. For example, one would not normally be concerned about a modelled flow which differed from a count by 40% if the count was only 100, but one would be if the count were 1000. The reason for introducing such a statistic is the inability of either the absolute difference or the relative difference to reflect differences over the wide range of flows contained in the model.

3.1.5 The GEH statistic is typically used for the validation of road assignment models. It is, however, also a useful indicator for PT assignment model though a greater level of tolerance would be expected due to the higher level of variation of public transport data. In the absence of official guidance it is considered that, for a model of this complexity and size, a GEH of five or less is considered to be excellent. Values between five and 10 are considered to be acceptable.

3.2 Passenger Loading Comparisons

3.2.1 Comparisons have been made with ScotRail count data and TMfS:07 bus occupancy surveys. It should be noted that the ScotRail count data is independent data separate from the data used in matrix development. Due to the high quality of the underlying travel demand information (from NRTS and the Census), there is no specific procedure undertaken to re-estimate the travel demand matrices to specifically match the independent counts. Therefore, there is a greater degree of scope for the counts versus modelled flows to differ.

3.2.2 It should be noted that the ScotRail data does not include passenger count information on rail services run by other operators, ie Virgin West Coast Mainline, National Express East Coast Mainline and Arriva Cross Country Services. This includes services that operate between Inverness/Aberdeen/Dundee and England via Edinburgh. For the purposes of the modelled versus observed count comparisons presented below the modelled passenger flows on non-ScotRail services have been excluded in order to present a direct comparison.

3.2.3 Appendix A contains a series of Figures that show the location of the public transport survey sites. Table 3.1 provides a summary of the cordon and screenline passenger flow comparisons and Table 3.2 of the individual site passenger flow comparisons for the PT model. Tables 3.3 to 3.12 show the comparison of the observed passenger flows with the modelled assignments for selected screenlines and cordons across the road and rail network.

Table 3.1 Summary of PT Cal Val – Cordons Screenlines

Mode	AM		IP		PM	
	No.	%	No.	%	No.	%
Bus within 15%	9	64%	7	50%	10	71%
Bus within 25%	11	79%	11	79%	11	79%
Rail within 15%	7	50%	7	50%	9	64%
Rail within 25%	9	64%	10	71%	12	86%
Multi within 15%	11	79%	10	71%	11	79%
Multi within 25%	13	93%	13	93%	14	100%

Note – Number of cordons and screenlines = 14

Table 3.2 Summary of PT Cal Val – Individual Sites

Mode	AM	IP	PM
Bus within 25%	44%	59%	49%
Rail within 25%	63%	72%	56%
Bus and Rail within 25%	54%	66%	52%

Table 3.3 Inbound Aberdeen Cordon

Time	Mode	Observed	Modelled	Diff	% Diff	GEH
AM	Rail	431	245	-186	-43%	10
	Bus	857	960	103	12%	3
	Total	**1288**	**1205**	**-83**	**-6%**	**2**
IP	Rail	167	164	-3	-2%	0
	Bus	313	453	140	45%	7
	Total	**480**	**617**	**137**	**29%**	**6**
PM	Rail	351	198	-153	-44%	9
	Bus	398	456	58	15%	3
	Total	**749**	**654**	**-95**	**-13%**	**4**

Table 3.4 Outbound Aberdeen Cordon

Time	Mode	Observed	Modelled	Diff	% Diff	GEH
AM	Rail	268	123	-145	-54%	10
	Bus	376	392	16	4%	1
	Total	**644**	**515**	**-129**	**-20%**	**5**
IP	Rail	190	129	-61	-32%	5
	Bus	358	376	18	5%	1
	Total	**548**	**505**	**-43**	**-8%**	**2**
PM	Rail	467	366	-101	-22%	5
	Bus	997	1097	100	10%	3
	Total	**1464**	**1463**	**-1**	**0%**	**0**

Table 3.5 Inbound Dundee Cordon

Time	Mode	Observed	Modelled	Diff	% Diff	GEH
AM	Rail	512	492	-20	-4%	1
	Bus	1170	1316	146	12%	4
	Total	**1682**	**1808**	**126**	**7%**	**3**
IP	Rail	317	379	62	20%	3
	Bus	586	715	129	22%	5
	Total	**903**	**1094**	**191**	**21%**	**6**
PM	Rail	495	446	-49	-10%	2
	Bus	406	662	256	63%	11
	Total	**901**	**1108**	**207**	**23%**	**7**

Table 3.6 Outbound Dundee Cordon

Time	Mode	Observed	Modelled	Diff	% Diff	GEH
AM	Rail	409	362	-47	-11%	2
	Bus	412	662	250	61%	11
	Total	**821**	**1024**	**203**	**25%**	**7**
IP	Rail	332	329	-3	-1%	0
	Bus	568	551	-17	-3%	1
	Total	**900**	**880**	**-20**	**-2%**	**1**
PM	Rail	588	550	-38	-6%	2
	Bus	1276	1242	-34	-3%	1
	Total	**1864**	**1792**	**-72**	**-4%**	**2**

Table 3.7 Inbound Edinburgh Cordon

Time	Mode	Observed	Modelled	Diff	% Diff	GEH
AM	Rail	4805	4636	-169	-4%	2
	Bus	5261	5362	101	2%	1
	Total	**10066**	**9998**	**-68**	**-1%**	**1**
IP	Rail	965	1090	125	13%	4
	Bus	1837	1749	-88	-5%	2
	Total	**2802**	**2839**	**37**	**1%**	**1**
PM	Rail	1510	1535	25	2%	1
	Bus	2816	2454	-362	-13%	7
	Total	**4326**	**3989**	**-337**	**-8%**	**5**

Table 3.8 Outbound Edinburgh Cordon

Time	Mode	Observed	Modelled	Diff	% Diff	GEH
AM	Rail	1319	1388	69	5%	2
	Bus	2087	1974	-113	-5%	3
	Total	**3406**	**3362**	**-44**	**-1%**	**1**
IP	Rail	909	1034	125	14%	4
	Bus	1896	1418	-478	-25%	12
	Total	**2805**	**2452**	**-353**	**-13%**	**7**
PM	Rail	4432	4677	245	6%	4
	Bus	5684	5410	-274	-5%	4
	Total	**10116**	**10087**	**-29**	**0%**	**0**

Table 3.9 Inbound Glasgow Cordon

Time	Mode	Observed	Modelled	Diff	% Diff	GEH
AM	Rail	11767	9330	-2437	-21%	24
	Bus	6549	8941	2392	37%	27
	Total	**18316**	**18271**	**-45**	**0%**	**0**
IP	Rail	2540	2871	331	13%	6
	Bus	3215	3040	-175	-5%	3
	Total	**5755**	**5911**	**156**	**3%**	**2**
PM	Rail	3494	4086	592	17%	10
	Bus	4071	3597	-474	-12%	8
	Total	**7565**	**7683**	**118**	**2%**	**1**

Table 3.10 Outbound Glasgow Cordon

Time	Mode	Observed	Modelled	Diff	% Diff	GEH
AM	Rail	2955	3528	573	19%	10
	Bus	3437	3822	385	11%	6
	Total	**6392**	**7350**	**958**	**15%**	**12**
IP	Rail	2134	2631	497	23%	10
	Bus	2955	2473	-482	-16%	9
	Total	**5089**	**5104**	**15**	**0%**	**0**
PM	Rail	9946	9604	-342	-3%	3
	Bus	6762	8208	1446	21%	17
	Total	**16708**	**17812**	**1104**	**7%**	**8**

Table 3.11 Inbound Inverness Cordon

Time	Mode	Observed	Modelled	Diff	% Diff	GEH
AM	Rail	171	59	-112	-65%	10
	Bus	832	885	53	6%	2
	Total	**1003**	**944**	**-59**	**-6%**	**2**
IP	Rail	61	61	0	0%	0
	Bus	401	430	29	7%	1
	Total	**462**	**491**	**29**	**6%**	**1**
PM	Rail	82	67	-15	-18%	2
	Bus	334	342	8	2%	0
	Total	**416**	**409**	**-7**	**-2%**	**0**

Table 3.12 Outbound Inverness Cordon

Time	Mode	Observed	Modelled	Diff	% Diff	GEH
AM	Rail	66	82	16	24%	2
	Bus	502	417	-85	-17%	4
	Total	**568**	**499**	**-69**	**-12%**	**3**
IP	Rail	90	43	-47	-52%	6
	Bus	428	422	-6	-1%	0
	Total	**518**	**465**	**-53**	**-10%**	**2**
PM	Rail	225	74	-151	-67%	12
	Bus	793	744	-49	-6%	2
	Total	**1018**	**818**	**-200**	**-20%**	**7**

3.2.4 Appendix B contains the individual count comparisons at the screenlines and cordons and at a selection of strategic locations.

3.2.5 Examination of the above tables and the additional analysis reported in Appendix B indicates that overall, the validation is considered acceptable for a model of this size and scope and there is a reasonable correlation between the assigned model flows and the observed passenger flows.

3.2.6 The multi-modal passenger count comparisons for the city cordon totals are generally acceptable. Individual count comparisons are generally satisfactory on the whole, although there are some less favourable variations at some specific validation locations.

3.2.7 In particular, the rail/bus sub-mode split in Glasgow is relatively poor in the AM inbound with more bus patronage being modelled, which goes against some of the other areas of model validation where Rail patronage is generally too high. This is a similar issue to that encountered previously in TMfS:05A where the observed Glasgow rail demand is historically high even though bus offers strong competition. The low levels of modelled road congestion in Glasgow combined with strategic representation of the city centre also make bus more attractive than in reality. In addition, the modelled distance based fares do not take account of the high uptake of zone cards and season tickets in the Glasgow area, which may increase actual rail patronage.

3.2.8 The multi-modal passenger count comparisons on the lower Forth Crossing and lower Tay Crossing screenline totals are satisfactory.

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

3.3 Rail Passenger Boarding / Alighting Comparisons

3.3.1 ScotRail data provides information on the volume of passengers boarding and alighting at each station for each time period. This has been compared with the equivalent modelled data and the comparisons can be found in Appendix C.

3.3.2 Table 3.11 provides a summary of the GEH statistics for all the stations in the TMfS:07 model. This indicates that the majority of the boarding and alighting comparisons have a GEH of less than five and nearly all have a GEH of less than 10. Therefore, the validation against these data is considered to be acceptable.

Table 3.13 Boarding/Alighting Summary

	AM		IP		PM	
GEH	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
less than 5	64%	65%	73%	71%	68%	66%
less than 7	81%	78%	84%	83%	81%	81%
less than 10	93%	89%	95%	95%	94%	91%

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

3.4 Rail Capacities

3.4.1 The PT assignment model includes crowding on rail lines in the morning and evening peak periods.

3.4.2 As previously stated, predictions of rail patronage within the model tend to be slightly too high. This, to a certain degree, may lead to the loading on some of the services exceeding capacity.

3.4.3 The most crowded services within the modelled network are:

- Fife Circle and through Fife;
- North Berwick; and
- Glasgow to Lanark and Larkhall.

3.4.4 Appendix D provides further details of the ratio of passenger flow to seated capacity on the modelled rail lines. Examination of the results in Appendix D indicates that the morning peak is slightly more crowded than the evening peak within the model.

3.5 Comparison of Timetabled and Modelled Bus Journey Times

3.5.1 As modelled bus journey times are based on assigned road speeds, checks have been made to ensure that modelled bus journey times are representative of timetabled bus journey times in 2007. In making any comparisons, however, it should be recognised that timetables are not necessarily a true reflection of actual bus journey times, since the former may include some 'slack' to enable the service to recover from higher-than-average delays. Conversely, there may be routes whose timetabled time does not fully reflect current network speeds.

3.5.2 The analysis was undertaken on a sample of the coded services intended to give a representative geographical spread.

3.5.3 Appendix E contains three tables and twelve diagrams presenting the results of this analysis. A summary of the journey time validation can be seen in Table 3.12 and Figure 3.1.

Table 3.14 Journey Time Validation

		AM		IP		PM	
Within 15% of PT Timetable (DMRB Criteria)	Yes	53	51%	55	52%	56	54%
	No	51	49%	51	48%	48	46%
Within 25% of PT Timetable	Yes	79	76%	81	76%	82	79%
	No	25	24%	25	24%	22	21%

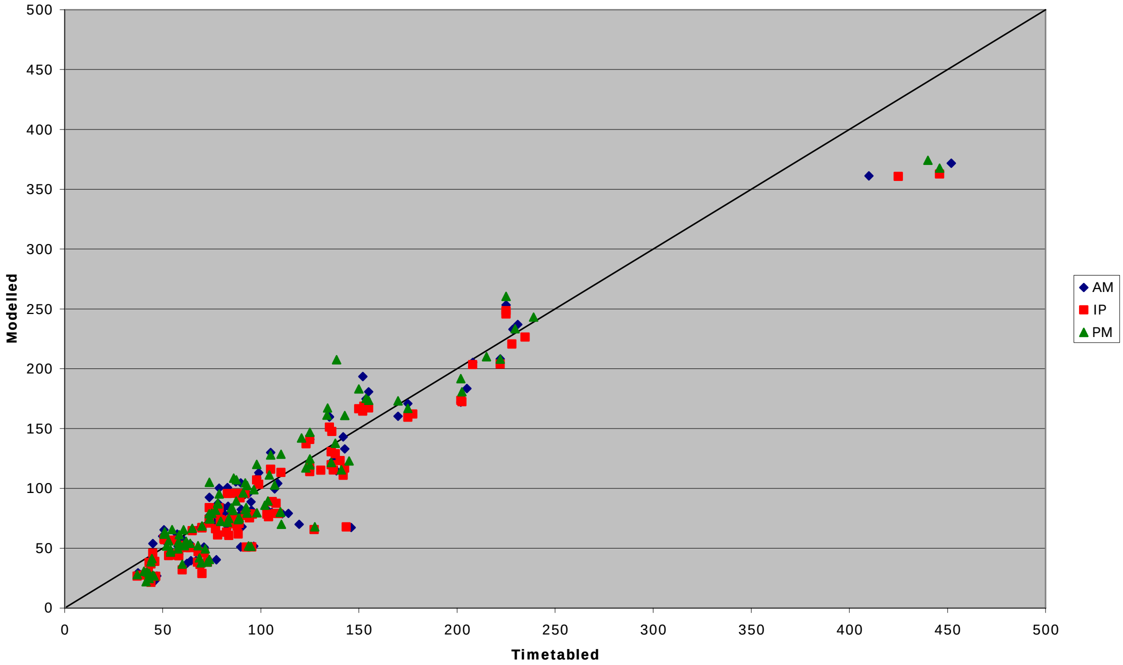

Figure 3.1 Timetable versus Modelled Bus Journey Times

3.5.4 The results show, in general, a reasonable match between modelled and timetabled bus journey times although there is some variation in the level of validation.

3.5.5 Where there is a difference between modelled and timetabled, the model is, in most cases quicker. This is due to the strategic nature of the model, and the consequent under-representation of journey times through small towns, villages and hamlets, especially where the services make many stops and also make detours into residential areas that are not modelled.

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

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

4 Conclusions and Recommendations

4.1 Summary

4.1.1 This report has presented the calibration and validation of the TMfS:07 National Public Transport Model.

4.1.2 There are several enhancements to the TMfS:07 National Public Transport Model over and above that of the previous versions, including:

- transition of modelling software to CUBE Voyager;
- the modelled transport network has been developed in GIS to give better representation of actual road network (geo-rectification);
- the inclusion of a range of data including; National Rail Travel Survey (NRTS), Inter-Urban Bus Survey and Census Journey to Work data in the demand matrices. This forms a significant improvement in the representation of travel demand compared to previous model versions;
- use of independent comprehensive ScotRail count data for validation; and
- demand matrices disaggregated by user class with multi-class assignment.

4.2 Validation

4.2.1 Throughout the validation, it is important to note that the travel demand matrix information is independent of the validation count information. Due to the high quality of the underlying travel demand information (from NRTS and the Census), there is no specific procedure undertaken to re-estimate the travel demand matrices to specifically match the independent counts. Therefore, there is a greater degree of scope for the counts versus modelled flows to differ.

4.2.2 For passenger loading, validation has been carried out to observed passenger counts and the results have generally been satisfactory. The city centre cordons are generally within an acceptable range, though there is some local variation. Overall the individual site count comparisons are also within an acceptable range, however, there are some sites that are less well validated.

4.2.3 Boarding and alighting comparisons also indicate a reasonable level correlation at the global level, however, there is a greater degree of variability at the individual station level.

4.2.4 Modelled bus journey times are generally quicker than the timetabled journey times, but this can be typical of PT models because of their strategic nature. Overall there is generally a reasonable match between modelled and timetabled bus journey times.

4.2.5 Overall the level of validation is considered within an appropriate range and is similar to the previous release version of TMfS (TMfS:05A). However, there is a higher degree of confidence in the underlying data that has been used to develop and validate the TMfS:07 model.

4.3 Recommendations

4.3.1 Our view is that the national public transport model has been successfully developed and is fit for its intended purpose which is to be used for the appraisal of major strategic public transport schemes and policy decisions as part of the national LATIS modelling system. It should be noted, however, that there is a degree of local variation in the validation of the model.

4.3.2 The model can also provide a good starting source of public transport supply and demand data for more-detailed sub-area/regional models, provided that relevant checks on the model's robustness in the relevant specific areas are carried out.

4.3.3 **All model applications should be preceded by an appropriate review of the robustness of the model validation in the area/corridor of interest.**

MVA Consultancy provides advice on transport and other policy areas, to central, regional and local government, agencies, developers, operators and financiers.

A diverse group of results-oriented people, we are part of a 500-strong team worldwide. Through client business planning, customer research and strategy development we create solutions that work for real people in the real world.

For more information visit www.mvaconsultancy.com

Abu Dhabi
Suite 118
The Avenue Business Centre, Emirates Tower
P.O. Box 33763, Abu Dhabi, UAE
T: +971 (0)2 412 4118

Birmingham
Second Floor, 37a Waterloo Street
Birmingham B2 5TJ United Kingdom
T: +44 (0)121 233 7680 F: +44 (0)121 233 7681

Dubai
Office 402, Building 49, Dubai Healthcare City
PO Box 123166, Dubai, UAE
T: +971 (0)4 433 0530 F: +971 (0)4 423 3613

Dublin
First Floor, 12/13 Exchange Place
Custom House Docks, IFSC, Dublin 1, Ireland
T: +353 (0)1 542 6000 F: +353 (0)1 542 6001

Edinburgh
Stewart House, Thistle Street, North West Lane
Edinburgh EH2 1BY United Kingdom
T: +44 (0)131 220 6966 F: +44 (0)131 220 6087

Glasgow
Seventh Floor, 78 St Vincent Street
Glasgow G2 5UB United Kingdom
T: +44 (0)141 225 4400 F: +44 (0)141 225 4401

London
Second Floor, 17 Hanover Square
London W1S 1HU United Kingdom
T: +44 (0)20 7529 6500 F: +44 (0)20 7529 6556

Lyon
11, rue de la République, 69001 Lyon, France
T: +33 (0)4 72 10 29 29 F: +33 (0)4 72 10 29 28

Manchester
25th Floor, City Tower, Piccadilly Plaza
Manchester M1 4BT United Kingdom
T: +44 (0)161 236 0282 F: +44 (0)161 236 0095

Marseille
76, rue de la République, 13002 Marseille, France
T: +33 (0)4 91 37 35 15 F: +33 (0)4 91 91 90 14

Paris
12-14, rue Jules César, 75012 Paris, France
T: +33 (0)1 53 17 36 00 F: +33 (0)1 53 17 36 01

Woking
Dukes Court, Duke Street, Woking
Surrey GU21 5BH United Kingdom
T: +44 (0)1483 728051 F: +44 (0)1483 755207

Email: info@mvaconsultancy.com

Offices also in
Bangkok, Beijing, Hong Kong, Shenzhen and Singapore

mvaconsultancy