

# Land-Use and Transport Integration in Scotland (LATIS)

## TMfS:07 National Public Transport Model Development Report

Report for Transport Scotland

October 2009



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# Contents

<b>1</b>	<b>Introduction</b>	<b>i</b>
1.1	Overview	1.1
1.2	Structure of this Report	1.1
<b>2</b>	<b>Model Dimensions</b>	<b>2.1</b>
2.1	Model Dimensions	2.1
<b>3</b>	<b>Public Transport Network</b>	<b>3.1</b>
3.1	Introduction	3.1
3.2	Public Transport Network	3.1
3.3	Public Transport Lines Data	3.2
3.4	Lines Coding	3.3
<b>4</b>	<b>Matrix Development</b>	<b>4.1</b>
4.1	Introduction	4.1
4.2	Zone System	4.1
4.3	Data Sources	4.1
4.4	National Rail Travel Survey	4.1
4.5	TMfS:07 Inter Urban Bus Passenger Surveys	4.2
4.6	2001 Census Journey to Work Data	4.3
4.7	Synthesised Demand based on Planning Data	4.3
4.8	Matrix Development	4.4
<b>5</b>	<b>Conclusions</b>	<b>5.1</b>
5.1	Conclusions	5.1

## Tables

Table 2.1	Peak Hour Factors	2.1
Table 3.1	Public Transport Network Link Types	3.2
Table 3.2	Number of Public Transport Services By Mode	3.6
Table 3.3	Number of Services by Public Transport Company	3.6
Table 4.1	Matrix Totals by Source	4.5
Table 4.2	Matrix Totals by User Class	4.5

## Figures

Figure 1.1	Simplified TMfS Model Hierarchy – National PT Model Interaction	1.1
Figure 3.1	Extent of Urban Bus Area – Aberdeen	3.3
Figure 3.2	Extent of Urban Bus Area – Dundee	3.4
Figure 3.3	Extent of Urban Bus Area – Edinburgh	3.4
Figure 3.4	Extent of Urban Bus Area - Glasgow	3.5
Figure 4.1	Inter-Urban Bus Cordons	4.4

## Appendices

A	Urban Bus Specification
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## 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.

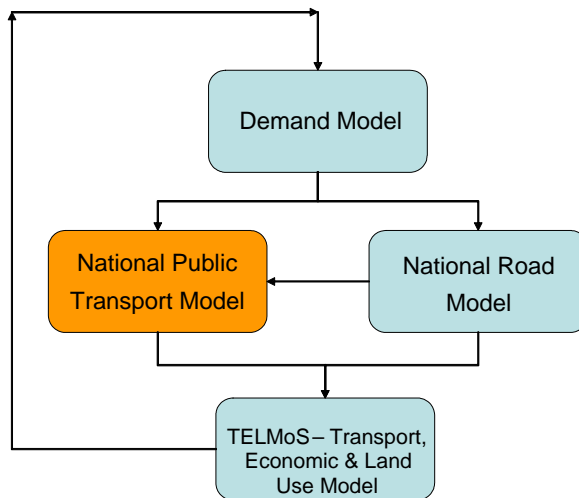
### TELMoS:07 National Land Use Model

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 (see diagram below). 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 Simplified 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 modelled time periods, user classes and modes;
- Chapter 3 provides information defining the operational characteristics of the public transport system;
- Chapter 4 describes the matrix development procedure and data sources used to create the Public Transport Assignment Matrices; and
- Chapter 5 summarises the conclusions & recommendations relating to the TMfS:07 Public Transport model.

## 2 Model Dimensions

### 2.1 Model Dimensions

2.1.1 The relevant week-day time periods are:

- AM peak hour - 08:00-09:00;
- AM peak-period – 07:00-10:00;
- Inter peak – average hour between 10:00 and 16:00;
- PM peak hour - 17:00-18:00; and
- PM peak period (16:00-19:00).

2.1.2 The public transport assignment model reflects conditions in the AM Peak Hour, Average Inter-peak Hour and PM Peak Hour.

2.1.3 Peak hour demand data and observed count data has been derived from the three-hour peak period data through application of a peak period to peak hour factor. These factors have been obtained from analysis of the TMfS:07 bus occupancy count data and the National Rail Travel Survey (NRTS). The resulting factors were very similar for bus and rail and have therefore been combined into a single set of Public Transport Peak Hour factors. These factors are reported in Table 2.1.

**Table 2.1 Peak Hour Factors**

Time Period	Bus	NRTS	Average PT
Peak Period to Peak Hour (AM)	0.44	0.45	0.45
Inter-peak (average of 10:00-16:00)	1/6	1/6	1/6
Peak Period to Peak Hour (PM)	0.42	0.47	0.44

#### User Classes

2.1.4 There are three user classes in the model:

- 'In work' (IW), eg trips on employers business;
- 'To/from work' (TW), ie commuting trips between home and work; and
- 'Non work' (NW), ie all other journey purposes.

2.1.5 Demand matrices have been prepared for each user class, which are assigned separately to the public transport network in the model.

### Modes

2.1.6 The MODE control statement defines the characteristics of the public transport modes used by the PT System. Six separate modes have been coded, namely:

- Urban Bus;
- Inter-urban bus;
- Rail;
- Underground;
- Ferry; and
- Tram (not used in the base year but included to permit the modelling of tram schemes in future year public transport networks).



## 3 Public Transport Network

### 3.1 Introduction

- 3.1.1 This Chapter describes the development of the network and public transport supply. The TMfS:07 National Model has been developed in Cube Voyager.

### 3.2 Public Transport Network

- 3.2.1 TMfS:07 includes a single modelled network that is used by both the Public Transport assignment model and Road assignment model. This allows for easy and consistent transfer of changes in forecast road traffic delays.
- 3.2.2 The modeled transport network has been developed using a Geographic Information System (GIS), with files being directly input to CUBE Voyager software. The network is based on ITN MasterMap data to give better representation of actual road network (geo-rectification), which is particularly useful for environmental analysis of model outputs.
- 3.2.3 The modelled network includes the following elements:
- strategic road network;
  - heavy rail/underground;
  - ferry links;
  - road, rail and ferry zone connectors; and
  - walk connections between rail/underground/ferry ports and stations, and the road network.
- 3.2.4 The *TMfS:07 National Road Model Development Report* provides a full description of the development and preparation of the TMfS:07 network. Table 3.1 provides a summary of the TMfS:07 link types relevant to the PT model.

**Table 3.1 Public Transport Network Link Types**

Link Type Value	Description
1 to 9	General Road Links
10	Bus Only Link
11	Rail Links
12	Subway Links
13	Tram/LRT/New Mode Links (for future year networks)
18	Rail to Road Connector
19	Zone Rail Connector
22	Zone-Road Connectors
22	Zone-Ferry Connectors
28	Ferry Routes – Banned for HGV
29	Ferry-Road Connectors
30	Ferry Routes – Car and HGV allowed
31	Ferry Routes – Banned for both Car and HGV, ie passenger ferry
32	Rail-Ferry Connector

### 3.3 Public Transport Lines Data

3.3.1 The development of the public transport lines file is dependent on the input of public transport system and service data. This includes the definition of System Information and the coding of PT services.

3.3.2 System Information contains data for:

- modes;
- operator definition;
- wait curves; and
- crowding curves.

3.3.3 The PT lines contain the data for the modelled public transport services including the route the service will take across the modelled transport network.

### 3 Public Transport Network

3.3.4 Public transport service data contains the following information:

- mode;
- operating company;
- route type (circular/linear);
- service type (stopping/express);
- headway for three modelled time periods;
- fare (generally expressed as a distance-based fare table);
- short and long text descriptions; and
- sequence of nodes along the route.

3.3.5 Urban and Inter urban bus lines have been coded to stop at every node on the transport network with the exception of shape nodes.

### 3.4 Lines Coding

#### Urban Bus

3.4.1 Urban bus services have been defined as those that are wholly within the contiguous Aberdeen, Dundee, Edinburgh or Glasgow conurbations as shown in Figures 3.1 to 3.4. Services that extend out with these areas have been defined as Inter Urban Bus.

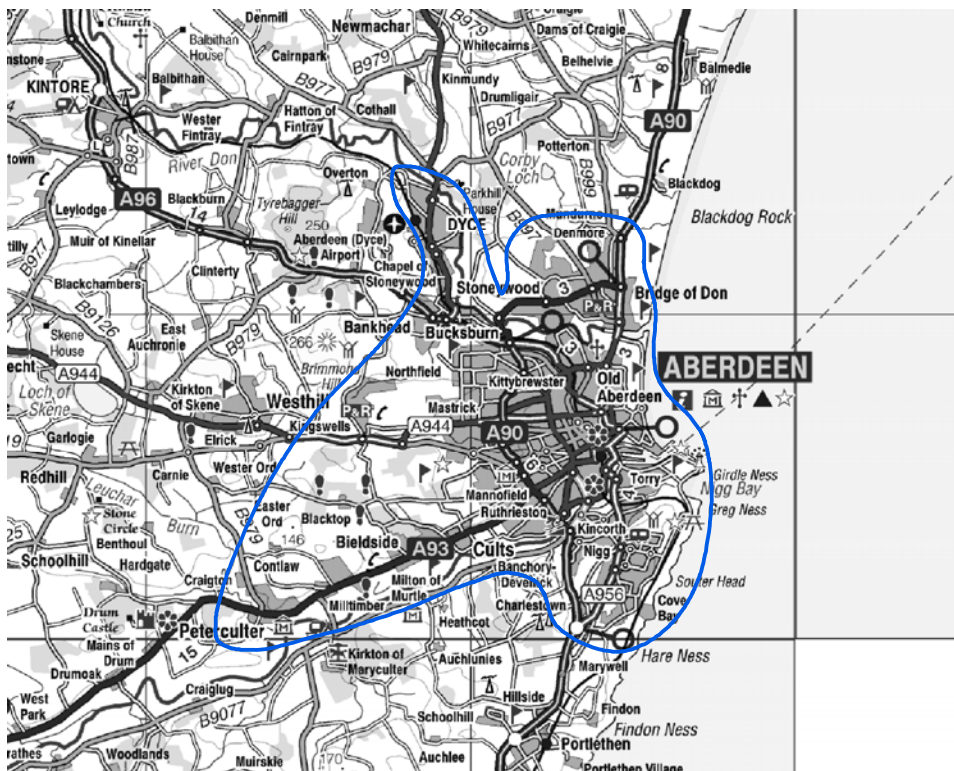


Figure 3.1 Extent of Urban Bus Area – Aberdeen

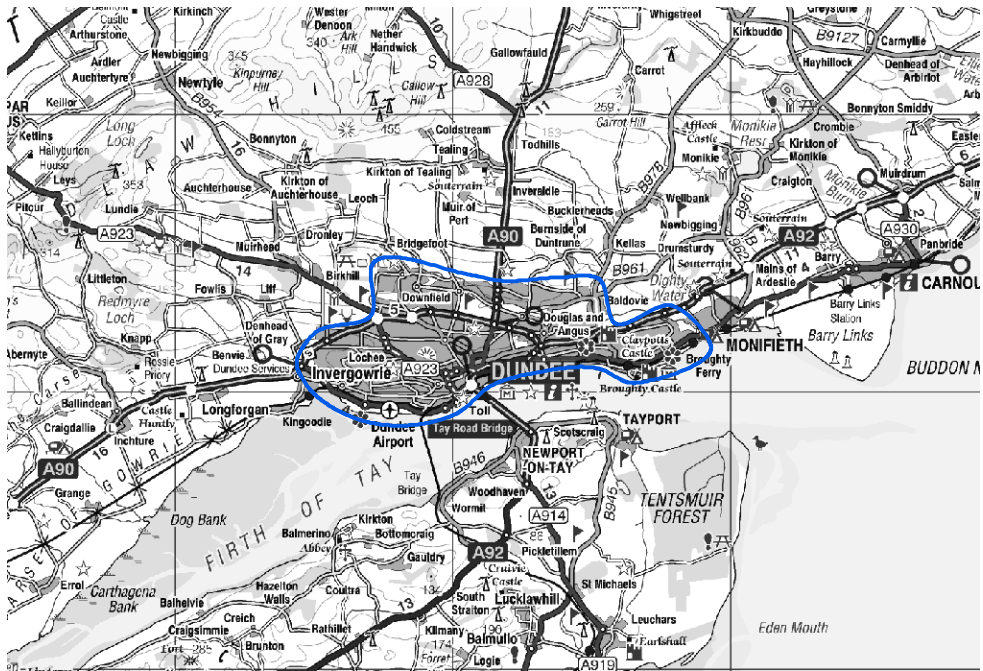


Figure 3.2 Extent of Urban Bus Area – Dundee



Figure 3.3 Extent of Urban Bus Area – Edinburgh





Figure 3.4 Extent of Urban Bus Area - Glasgow

- 3.4.2 Urban buses have been coded on a corridor basis with a single line coded in each direction that represents the average frequency along the corridor. This approach was adopted to reduce the need to code large numbers of urban bus routes, while still providing a reasonable representation of urban bus supply within this national strategic model. Appendix A contains further details of the specification of urban bus services.

#### Inter-urban Bus

- 3.4.3 Inter-urban buses have been coded based on the public timetables. Where the strategic modelled network does not include the actual road, eg diversions to local settlements, used by a service the modelled service has been routed using the nearest equivalent road.
- 3.4.4 Table 3.2 shows the number of PT lines coded by mode and time period.

**Table 3.2 Number of Public Transport Services By Mode**

Mode	AM Peak	Inter Peak	PM Peak
Urban Bus	100	100	100
Inter Urban Bus	826	668	759
Rail	203	195	198
Underground	2	2	2
Ferry	58	58	58
Total	1189	1023	1117

### Operator Companies

3.4.5 Fifty one operating companies were coded, reflecting operators across all modes. Table 3.3 shows the number of PT lines coded by operator and time period.

**Table 3.3 Number of Services by Public Transport Company**

Operator No.	Operator	AM Peak	Inter Peak	PM Peak
1	ScotRail - National	63	66	59
2	ScotRail - SPT	107	85	108
3	ScotRail - Highlands	9	8	6
4	ScotRail - Northern Highlands	6	7	6
5	East Coast Intercity Rail	10	16	11
6	West Coast Intercity Rail	8	13	8
11	SPT Subway	2	2	2
15	First Glasgow	98	66	88
16	First Edinburgh	141	99	128
17	National Express	4	6	5
18	Scottish Citylink	57	52	52
19	Stagecoach West	60	41	53
20	Stagecoach Inverness	40	31	25
21	Stagecoach Strathtay	64	56	64
22	Stagecoach Fife	77	53	69
23	Stagecoach Bluebird	65	68	69
24	Stagecoach Perth	10	10	10
25	Watermill Coaches	1	2	0
26	Strathtay Scottish	3	2	3
27	Travel Dundee	2	2	2

Operator No.	Operator	AM Peak	Inter Peak	PM Peak
28	Rapsons	10	12	7
29	Citylink/Rapsons	4	8	5
30	Scotbus	4	4	4
31	Westerbus	1	1	1
32	Crieff Travel	3	4	5
33	Dochertys Midland	5	6	5
34	Pegasus Travel	3	2	4
36	Bluebus	1	1	0
37	McGills	5	5	6
38	Arriva	23	16	19
39	SPT	1	2	3
40	McKindless	2	1	2
41	Irvines	3	3	3
42	Lothian	61	48	62
43	D&G Various	46	41	37
44	First Borders	30	24	26
45	Arriva Airport	2	2	2
51	Edinburgh Urban Bus	26	26	26
52	Glasgow Urban Bus	44	44	44
53	Aberdeen Urban Bus	16	16	16
54	Dundee Urban Bus	14	14	14
101	SPT Renfrew Ferry	2	2	2
102	Cal Mac Ferries	36	36	36
103	Highland Council	2	2	2
104	Western	2	2	2
105	JOG Ferries	2	2	2
106	Pentland	2	2	2
107	Northlink	8	8	8
108	SPT Kilcreggan Ferry	2	2	2
109	Cromarty Ferry	2	2	2
	Total Services	1189	1023	1117

3.4.6 Spring 2007 routes, frequencies and stopping patterns for all relevant inter-urban public transport services operated by the companies listed in Table 3.3 have been included in the model.

# 4 Matrix Development

## 4.1 Introduction

- 4.1.1 The PT model demand matrices have been developed based on several data sources. This Chapter describes the matrix development procedures.
- 4.1.2 Demand matrices have been prepared for three modelled hour periods and three user classes as described in Chapter Two.

## 4.2 Zone System

- 4.2.1 The TMfS:07 national model has the following 720 zones:
  - 708 internal zones;
  - four airport zones; and
  - eight external zones covering England and Wales.
- 4.2.2 The number of rail stations has generally been kept to at most one per zone. The exceptions to this rule (eg several large rural zones on the Kyle of Lochalsh and Mallaig lines, Tyndrum Lower & Upper, Sanquhar and Kirkconnel, Ardrossan Town and Ardrossan Harbour, Barry Links and Golf Street etc) are described in Appendix B of the *TMfS:07 Demand Model Development Report*.
- 4.2.3 The *TMfS:07 National Road Model Development Report* provides a full description of the TMfS:07 zone system.

## 4.3 Data Sources

- 4.3.1 The TMfS:07 National PT Model demand matrices have been prepared using the following sources of data:
  - National Rail Travel Survey (NRTS);
  - TMfS:07 Inter Urban Bus Passenger Surveys;
  - 2001 Census Journey to Work Data; and
  - Synthesised Demand based on Planning Data.
- 4.3.2 Each of these is described in more detail below.

## 4.4 National Rail Travel Survey

- 4.4.1 The National Rail Travel Survey (NRTS) is a survey of passenger trips on the National Rail system. It was designed to fill a gap in knowledge about who uses the rail network, where, when and for what purposes.



## 4 Matrix Development

- 4.4.2 All stations in Great Britain were surveyed on weekdays during school term-times during the period 2000-2005. Data was collected from passengers by self-completion questionnaire, and passenger counts are carried out at the same time to give details of the volume of people using each station. This enabled the survey responses to be weighted up to represent all rail passengers. About 430,000 questionnaires were collected in total. The return rate of questionnaires was typically 20% to 30% of questionnaires distributed to passengers.
- 4.4.3 The data collected was subject to extensive cleaning and analysis to allow for double counting the balancing of flows between stations. The final files of processed survey records were made available to Transport Scotland for use in the development of TMfS:07.
- 4.4.4 The following information is available:
- Rail stations used;
  - Time of travel;
  - Access and egress modes;
  - Origin and destination addresses;
  - Trip purposes;
  - Ticketing information; and
  - Demographic information plus car availability.
- 4.4.5 The NRTS origin-destination data was processed and demand matrices prepared suitable for incorporation in the national model.

### 4.5 TMfS:07 Inter Urban Bus Passenger Surveys

- 4.5.1 Traditionally, there has been a general lack of bus-based origin-destination data for TMfS and indeed for other transport models. As a result, the collection of such data for Aberdeen, Dundee, Edinburgh, Glasgow and Inverness was seen as important in improving the public transport element of the new national model. Given that these were inter-urban surveys, the data also provided valuable data for a range of other important towns including Stirling, Falkirk, Dunfermline, Livingston, Ayr, Kilmarnock and Cumbernauld.
- 4.5.2 An initial desk based review of timetables and routes was undertaken to identify where data collection was required and a cordon was defined around each city designed to capture all bus-based movements into and out of the urban area. Passenger interviews and accompanying occupancy survey were conducted between 7am and 7pm on a typical weekday. The collected origin-destination data was processed and demand matrices prepared suitable for incorporation in the national model.
- 4.5.3 *Public Transport Model Development Note 2 - Inter-Urban Bus Processing* describes the analysis of the survey data and the preparation of demand matrices.

### 4.6 2001 Census Journey to Work Data

- 4.6.1 The 2001 Population Census included a question relating to location of normal place of work and main mode used for travel to the workplace. This question was included on all questionnaires rather than the 10% sample which was included in the 1991 Census.
- 4.6.2 Standard output tables of the implied origin destination pattern for the journey to work are supplied at Census Output Area level. It can be noted that in all tables of census data published by ONS individual cells with small values (1 or 2) are randomly given the values 0 or 3 in order to preserve anonymity. When aggregated to traffic zone level the effect of this random allocation are minimised.
- 4.6.3 These tables represent home - workplace linkages and need further analysis before they can be treated as origin destination trip matrices suitable for use in transport modelling. Special software developed for the Department for Transport (DfT) is available for further processing of this data. This is called Census Matrix Tools and provides the following:
- 4.6.4 Aggregation to study area zone system;
- split by main mode;
  - split by household car availability;
  - selection of suitable time period, eg annual average weekday; and
  - allowance for work trips which do not occur every working day.
- 4.6.5 These additional features were developed by including the results of analyses of the National Travel Survey. Following an initial overview of the journey-to-work data, including comparisons with the National Rail Travel Survey data, this data was accepted as suitable for use in matrix development for TMfS:07.
- 4.6.6 The Census Matrix Tools data was processed and demand matrices prepared suitable for incorporation in the national model.

### 4.7 Synthesised Demand based on Planning Data

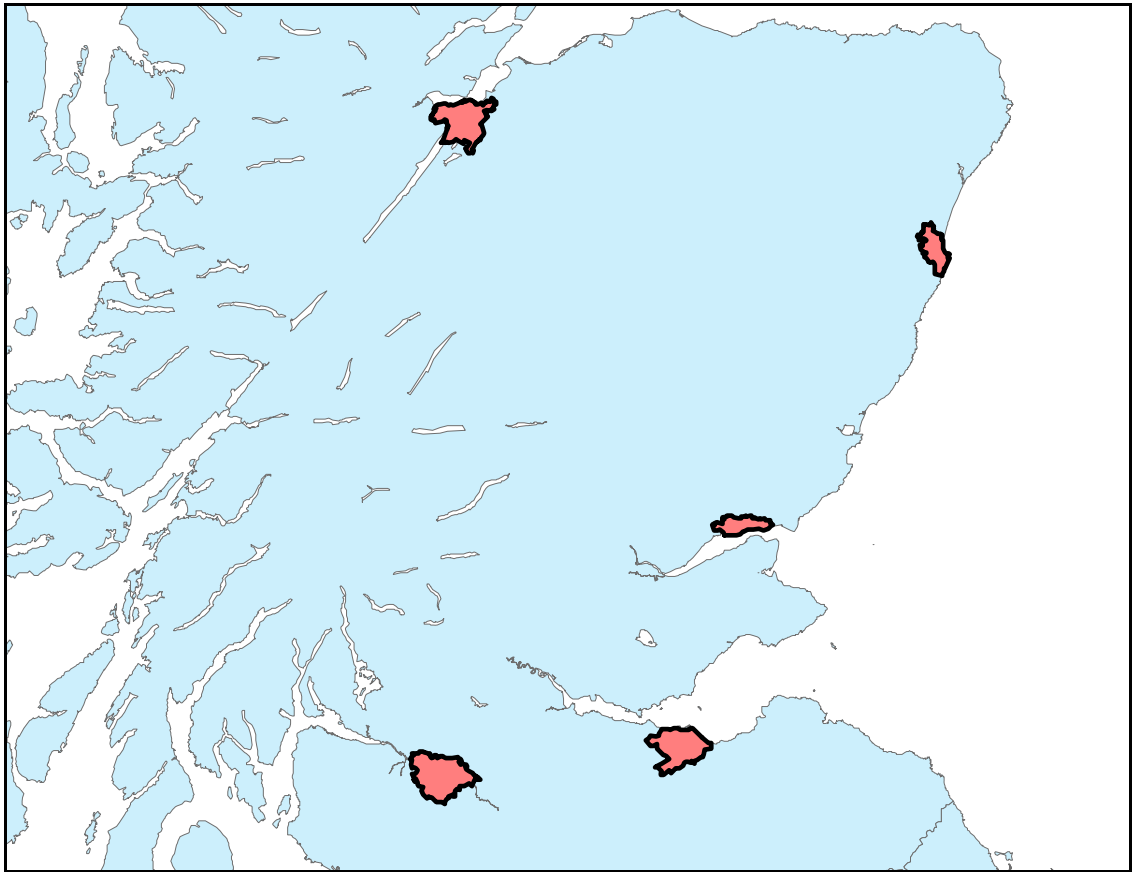
- 4.7.1 The combination of the NRTS, Inter-Urban Bus and Census Journey Work data forms a complete picture of PT demand in Scotland with the exception of bus travel for non-commuting purposes which do not cross any of the relevant urban boundaries.
- 4.7.2 For the missing data, person trip data was synthesised using 2007 planning data and TEMPRO trip rates. These trips were then distributed using a compressed TMfS:05A matrix and sensitivity parameters from TMfS:05A.
- 4.7.3 The data which has been used in the process has been brought up to 2007 levels using factors derived from TEMPRO data. Matrices were then built for fully observed From-Home movements. Factors were also derived from Scottish Household Surveys to factor out time period matrices from the Census journey to work data.

## 4 Matrix Development

- 4.7.4 Trip 'reversing' procedures were then applied to these From-Home matrices within the demand model (these are described in the *TMfS:07 Demand Model Development Report*) to produce the equivalent To-Home and Non-Home-Based person matrices. These matrices were then all combined to produce hourly person matrices to be used in the PT matrix development.

### 4.8 Matrix Development

- 4.8.1 The NRTS, Inter-Urban Bus, Census Journey Work Data and Synthesised Demand data was combined to form assignment matrices for each modelled time period and user class.
- 4.8.2 The NRTS provided an observed matrix of rail demand for the whole of the modelled area including trips to/from external zones in England. The Inter-Urban Bus survey cordons were used to identify matrix cells where fully observed bus survey data had been collected and Figure 4.1 shows the cordon areas.



**Figure 4.1 Inter-Urban Bus Cordons**

- 4.8.3 Where observed Inter-Urban Bus data was not available, the Census Journey Work Data (which can be classified as observed) and Synthesised Demand data was incorporated instead. Table 4.1 shows the TMfS:07 national PT model matrix totals by source data and Table 4.2 shows the matrix by user class.

Table 4.1 Matrix Totals by Source

	NRTS	Inter-Urban Bus	Census	Synthesised	Total
AM	26610	16966	35589	34865	114028
IP	8083	8410	8201	36585	61281
PM	26416	17944	32689	29357	106407

Table 4.2 Matrix Totals by User Class

	In work	To/from work	Non work	Total
AM	5046	61300	47682	114028
IP	2630	10565	48086	61281
PM	3616	59709	43082	106407

# 5 Conclusions

## 5.1 Conclusions

- 5.1.1 This report has presented the development of the TMfS:07 National Public Transport Model.
- 5.1.2 There are a number of 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, 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.

# Appendix A – Urban Bus Specification

**Aberdeen**

Corridor	Route Description	Comments	Combined Corridor Headway				Op.	Service	Headway			Op.	Service	Headway			Op.	Service	Headway		
			AM	IP	PM	AM			IP	PM	AM			IP	PM	AM			IP	PM	
1	Union Terrace Skene Sq Berryden Rd Clifton Rd Auchmill Rd Stoneywood Rd		5	5	5	First	17	10	10	10	First	21	10	10	10						
2	King Street Eilon Rd Balgownie Rd Scotstown Rd		6	6	6	First	1	12	12	12	First	2	12	12	12						
3	King Street Eilon Rd B999		10	10	10	First	5	15	15	15	First	13	30	30	30						
4	Market St North Esplanade West Wellington Rd		5	5	5	First	3	10	10	10	First	21	10	10	10						
5	Holburn St Great Southern Rd Bridge of Dee		8	8	8	First	9	15	15	15	First	17	10	10	10						
6	Holburn St Great Western Rd North Deeside Rd		15	15	15	First	19	15	15	15	First										
7	Waverley Place Carden Place Queens Rd Skene Rd A944		8	8	8	First	14	15	15	15	First	40	15	15	15						
8	Waverley Place Albert St Argyll Place Westburn Rd Lang Stracht		8	8	8	First	3	10	10	10	First	13	30	30	30						





**Edinburgh**

Corridor	Route Description	Comments	Combined Corridor Headway			Op.	Service	Headway			Op.	Service	Headway			Op.	Service	Headway		
			AM	IP	PM			AM	IP	PM			AM	IP	PM			AM	IP	PM
1	Broughton St Broughton Rd Gt Junction Rd Constitution St Commercial Rd Lower Granton Rd		5	5	5	Lothian	11	10	10	10	Lothian	16	10	10	10	Lothian	17	30	30	30
2	Regent Rd London Rd Portobello Rd Musselburgh Rd Bridge St High St	LB 15,26,44 inter-urban	0	0	0															
3	Regent Rd London Rd Willowbrae Rd Duddingston Rd West Niddrie Mains Rd Newcraighall Rd A1 Milton Link Rd	LB 44 inter-urban	7	7	7	Lothian	4	20	20	20	Lothian	5	15	15	15	Lothian	45	30	30	30
4	Bridges Dalkeith Rd Millerhill Rd	LB X48,49 inter-urban	10	10	10	Lothian	33	10	10	10										
5	Bridges Minto St Gilmerton Rd	LB 3,29 inter-urban	15	15	15	Lothian	8	15	15	15										
6	Bridges Minto St Liberton Rd Burdiehouse Rd	LB 37,47 inter-urban	15	15	15	Lothian	7	10	10	10										
7	Lothian Rd Bruntsfield Pl Morningside Rd Comiston Rd	LB 15 inter-urban	6	6	6	Lothian	4	20	20	20	Lothian	11	10	10	10	Lothian	17	30	30	30
8	Lothian Rd Bruntsfield Pl Colinton Rd		4	4	4	Lothian	10	10	10	10	Lothian	16	10	10	10	Lothian	27	10	10	10
9	Lothian Rd Fountainbridge Slateford Rd Lanark Rd	LB 35, 44 inter-urban	10	10	10	Lothian	34	15	15	15	Lothian	45	30	30	30					
10	Dalry Rd Gorgie Rd Calder Rd	LB 3,30,35 inter-urban	5	5	5	Lothian	25	10	10	10	Lothian	33	10	10	10					
11	Corstorphine Rd Glasgow Rd	LB 26,31,X48 inter-urban	8	8	8	Lothian	1	15	15	15	Lothian	12	15	15	15					
12	Queensferry Rd Hillhouse Rd Queensferry Rd		10	10	10	Lothian	24	30	30	30	Lothian	41	15	15	15					
13	Frederick St Raeburn Pl Crewe Road South Ferry Rd	LB 29,37 inter-urban	9	9	9	Lothian	19	15	15	15	Lothian	42	20	20	20					
14	Orbital	Combination of Lothian Bus services 18 & 21 to form circular service	30	30	30	Lothian	18	30	30	30	Lothian	21	30	30	30					



**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.**

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