Canterbury VISUM Transportation Model

Local Model Validation Report

Jun 2012

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1 Introduction

1.1 Study Background

Jacobs UK Ltd were appointed in May 2008 by Kent County Council in association with Canterbury City Council to develop a VISUM transport model of Canterbury City and its satellite towns to support the Local Development Framework (LDF) process. It is a 4-stage multimodal transport model developed to assess demand from car travel, commercial road vehicles, park & ride, bus and rail services. The model reflects total demand for travel across the City including the slow modes (walking and cycling) however the slow modes demand are not assigned to the network and cannot be used to directly appraise walking and cycling schemes. Slow modes can be fully incorporated in the model at a later date if required but were not in the original scope of work. The model has been set up to be compliant with the latest DfT WebTAG guidelines.

The demand in the model starts from person trips and the passenger demand side of the model will be able to switch between private and public transport, through a mode choice model. The model will be used to assess and optimise transport proposals for the City of Canterbury. It will provide the evidence base for the statutory Local Development Framework which sets out a development framework for the City and the model will provide a common standard for assessing forecast transport demand and impacts from developer led schemes.

1.2 Report Outline

This report summarises the work done to develop the **base model** and demonstrate its validity. It does not describe every detailed step but describes the key stages and assumptions used in the model development. Further detailed information about the model can be provided on request. Further information on Canterbury City and the scope of the modelling can be found in The Jacobs Scoping Report titled *Canterbury LDF VISUM Transportation Study, Scoping Report, dated July 2008.*

Following on from this introductory chapter, **Chapter 2** summarises key details about the structure and set up of the model. **Chapter 3** summarises the key data sources used to develop and validate the models. **Chapter 4** provides details about the network side of the model whilst **Chapter 5** describes the demand side of the model. **Chapter 6** describes the development of the variable demand model. **Chapter 7** outlines the assignment stage of the model. **Chapters 8** and **9** describe the calibration and validation of the model respectively against observed data. Finally **Chapter 10** offers a Summary and Conclusions around the validity and use of the model.

2 Model Description / Specification

2.1 The VISUM Software

The Canterbury Model is developed within the VISUM modelling software, which is a commercial software developed by PTV AG of Germany. It is a computer program for transport planning and forecasting and serves to analyse and plan a transportation system. It has two key components in modelling a transport system; supply as represented by the transport network and demand for using the transport system as represented by the demand matrices. It is able to do the key four stages that make up a travel demand model which are trip generation, trip distribution, mode choice and assignment.

Canterbury already have a 2004 SATURN Model also developed by Jacobs, however this model is a single mode highway model and is now out of date and not able to assess transport schemes in line with the latest DfT modelling advice encapsulated within the WebTAG guidelines. For this reason it was decided and commissioned in May 2008 that a new generation model was needed for the City of Canterbury based on the VISUM platform that would be multi-modal in capability. This model would be used to assess the transport impacts of future developments in the City and help in the planning and assessment of transport infrastructure and policies.

2.2 Study Area

The core study area of the model is the City of Canterbury in East Kent, which has the world famous Canterbury Cathedral, a major tourist attraction and a world heritage site. The City is also well known for its Universities and has a large student population along with its many tourist visitors. Within the Canterbury District also lie the satellite sea towns of Whitstable and Herne Bay which are also included in the study area of the model but to a lower level of detail. The A2 is the main strategic trunk road connecting Canterbury with Medway and London to the west and Dover to the south east. The other important strategic road link is the A28 which forms part of the inner ring road around the City. The A28 connects Canterbury with Ashford to the south and Margate to the north east.

In terms of railway connections the North Kent rail line splits at Faversham with the northern half serving Herne Bay and Whitstable to Margate whilst the southern half serves Canterbury East and Dover. The other Maidstone-Ashford rail network connects to Canterbury West and on to Thanet. It should be noted that Canterbury is not directly connected by rail to Whitstable and Herne Bay. Canterbury is also now served by a new High Speed rail service (HST1) into St Pancras running on the pre-existing rail network around Canterbury however this service was introduced in late 2009 and is not part of the Base Year VISUM model. Canterbury also has an extensive bus service serving various parts of the City and there is a Park & Ride service from three external locations with buses feeding the city centre.

Canterbury traffic is a combination of many journey purposes including commuter, shopping, education and tourist journeys. It is closely linked with the satellite towns of Herne Bay and Whitstable which were also included in the study area but were modelled with lesser network detail. It was decided to have a Canterbury City focussed model but include the two satellites towns to reflect radial traffic into Canterbury. The model will need to be able to assess how Canterbury is affected by possible development at places such as the Bridge, Little Barton Farm and other locations.

The model area was broken into a fully modelled area and the area that lies within a zone of influence. A more detailed description on the areas modelled is as follows:

- The City of Canterbury where all the classified roads and the more important local roads were modelled along with all the public transport services. The zoning was specified to a fine level of detail
- The satellite towns of Herne Bay and Whitstable where the key radial routes into Canterbury were modelled and the main road that connects the two towns. The zoning was at a more coarse level than in Canterbury City.
- The key neighbouring towns in Kent which have a link with Canterbury like Margate, Ashford and Dover along with London. Only the key roads were modelled to these areas, along with the rail links. The zoning system for these outlying towns was large, sufficient to capture the traffic coming into Canterbury on the relevant routes.

The study area is shown in **Figure 2-1**.

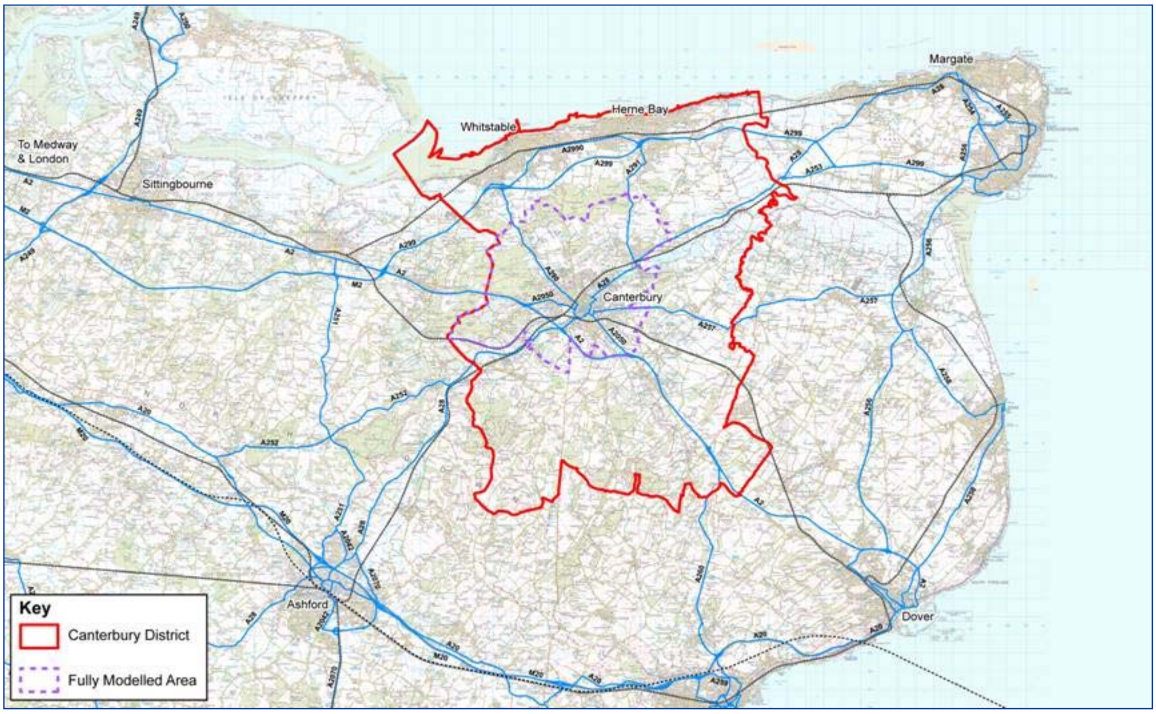

Figure 2-1 Study Area Model Specifications

The Canterbury VISUM Model is based on a 4-stage demand model structure consisting of a trip generation model, trip distribution model, mode choice model and a highway and public transport assignment model. In the base, the model was developed separately for road, public transport and Park & Ride travel demand. In forecasting, these models will be integrated through mode choice and distribution models.

The key characteristics and specification of the Canterbury VISUM model are summarised in **Table 2-A** below.

Model Development	Specification
Model Type	A 4 stage multi-modal transport demand model with trip generation, trip distribution, mode choice and assignment
Base Model Year	2008
Zoning System	221 zones comprising 140 inner zones (Canterbury City Urban Area), 62 outer zones including Whitstable and Herne Bay, and 19 zones representing the rest of Kent, Sussex and the UK.
Time Periods	*Highway Assignment Model:* AM Peak hour (0800-0900) and PM Peak hour (1700-1800) *PT Assignment Model:* AM Period (0700 – 1000) and PM Period (1600 – 1900)
Model Area	The detailed model area covers the City of Canterbury with slightly less detail for Whitstable and Herne Bay. The wider area of Kent and beyond is also covered at a very coarse level.
Demand Matrices	The trip demand is subdivided into 7 demand segments including 5 car journey purposes and 2 commercial vehicle classes as follows: • Home Based Work (HBW) • Home Based Other (HBO) • Home Based Education (HBED) • Non Home Based Other (NHBO) • Employers Business (EB) • Light Goods Vehicle (LGV) • Heavy Goods Vehicle (HGV) There is also a background demand for external through movements.
Modelling Package	VISUM 11.5
Calibration / Validation	In compliance with DMRB and WebTag standards

Table 2-A Key Features of the VISUM Model

2.3 Structure of Model

The Canterbury VISUM Model is a multi-modal travel demand model. A travel demand model aims at predicting the amount of travel which would take place under a given set of assumptions and in this process assesses network performance. Assumptions that drive the model can be separated into two components consisting on one side the population, employment and socio-activities and on the other side transport characteristics (network speed, travel costs, fare service, availability, etc.). From this definition, what is required is a model that is responsive to cost which will then be used to predict travel demand from a given set of transport policies.

There will be two models developed for Canterbury working in tandem: a base year model and a forecasting model. The purpose of the base year model is to replicate existing transport conditions, derive model parameters and validate them against observed data. The forecasting model will be the key engine model as it will be an incremental model with reference to the base year. The forecasting model will be used to test future year scenarios and various transport policies. The forecast model has not yet been commissioned and developed.

The base year model was based on the year 2008. It reflects 2008 transport conditions in the City of Canterbury. The base year model includes such components as trip generation, trip distribution, traffic assignment and a Park and

Ride model, whilst the forecasting model will encapsulate the same components accompanied by a trip re-distribution and mode choice process.

The demand is in person trips, segmented by journey purpose and mode, and built by car availability person type. The demand modelling (trip generation, distribution and mode choice stages) will reflect the peak periods 0700 – 1000 and 1600 – 1900 whilst the assignment stage for highways will be for the average peak hour 0800 – 0900 and 1700 – 1800. The assignment for the public transport models will be the same as the 3-hour demand models as some journeys particularly by rail are long distance trips which start earlier than the 0800 – 0900 peak hour and cause the rail peak time period to occur before 0800 – 0900. Note the peak periods for modelling were assessed in the Jacobs Scoping Report titled *Canterbury LDF VISUM Transportation Study, Final Scoping Report,* and dated July 2008.

Figure 2-2 shows the outline of the Canterbury VISUM Model structure for the Base Model. The model is designed as a person-trip production/attraction (PA) based model developed in accordance with the DfT's WebTAG advice on demand models. The demand in the model is generated for each zone from household, land-use and socio-economic data. The trips generated are then distributed with a gravity based trip distribution model to create demand matrices. These demand matrices are then converted from production/attraction to origin/destination (O-D) demand for assignment models. After assignment the generalised travel costs calculated are fed back to the demand model iteratively until convergence is achieved. In the Base Model demand was observed through surveys, this data was used directly to develop the base demand. Only those elements of demand that were not observed were synthetically derived with trip generation and distribution models.

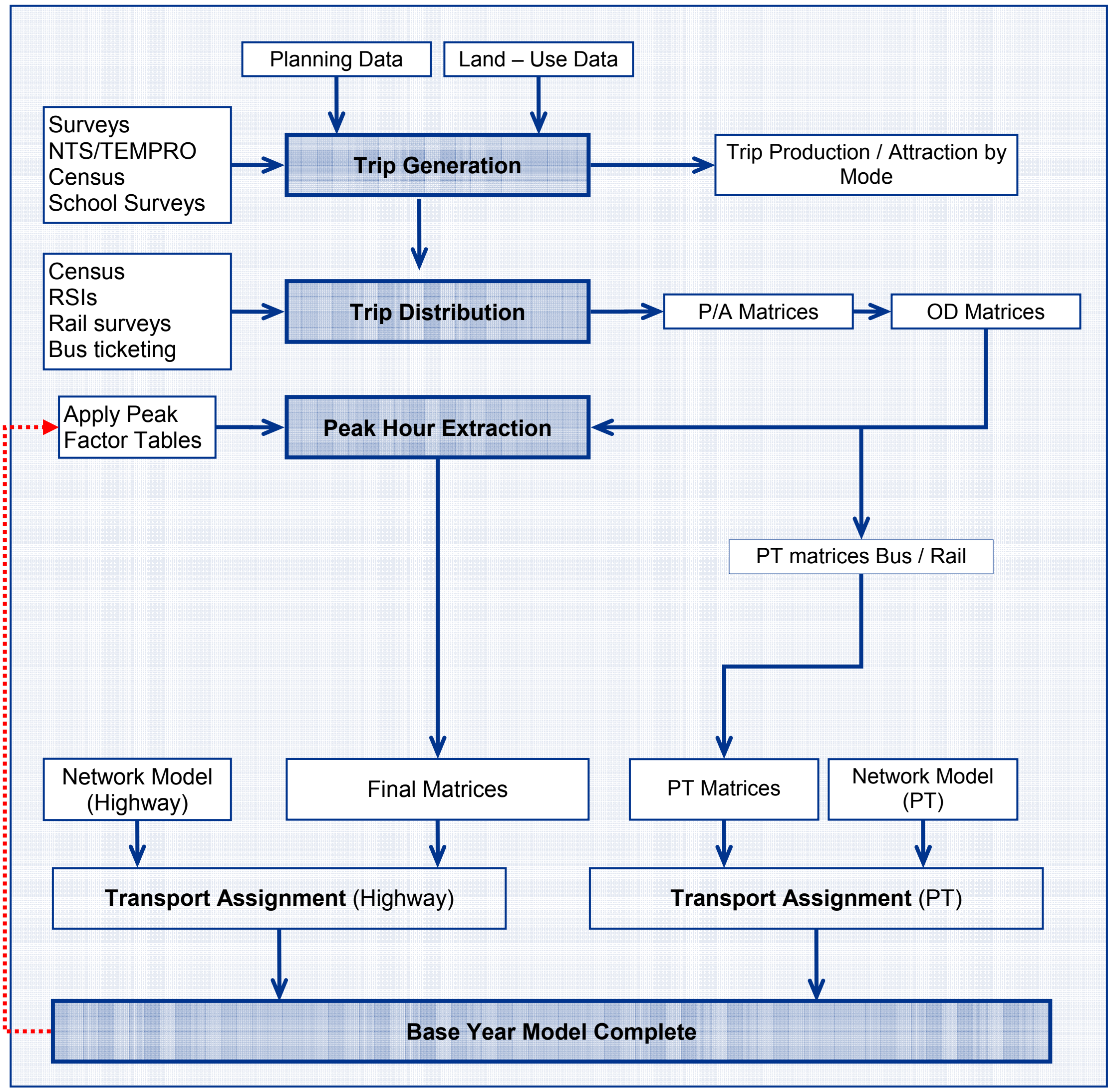

Figure 2-2 Canterbury Base VISUM Model Structure

The key components that make up the Base Year Model will now be described in the following chapters along with the evidence to demonstrate the validity of the model.

3 Data Summary

3.1 Model Data Sources

The Canterbury VISUM Model has been developed from a range of data sources including:

- Manual Classified Counts (MCC)
- Automatic Traffic Counts (ATC)
- Roadside Interview Surveys (RSI)
- Journey time surveys
- PLASC Schools data
- Travel Plan data
- Bus surveys
- Bus patronage data
- Rail surveys
- Census data
- Land Use data
- Traffic signals data
- Bus and rail timetable data
- Bus and rail fares data
- Car park data
- Post code data
- Other planning data

The information was collated from a number of sources including:

- Kent County Council (KCC)
- Canterbury City Council (CCC)
- Jacobs surveys
- Valuation Office
- Southeastern Rail
- Stagecoach
- Office of National Statistics (ONS)
- National Databases i.e. the census
- NaPTAN

3.2 Highway Data

The historical highway data available for the model development was explored and discussed at length in the Jacobs Scoping Study report already referenced, and will not be repeated here except for a brief summary. On the highways side two main surveys were conducted by Jacobs for this study, one related to journey time surveys to assess and measure the level of congestion in the network. The second were new roadside interview surveys carried out in two locations of the City. A selected number of '2008 traffic counts' conducted by Jacobs survey team which were mainly located around the Ring Road were selected to help calibrate the highway model. Note some of the key junctions around Canterbury Ring Road are too big for conventional turning count surveys and needed video surveillance type surveys to trace the turning movement. On grounds of cost and affordability it was not possible to do any extensive turning count surveys for this study around the Ring Road but there is available a good sample of link counts in this area. All other highway data was extracted either from third party sources or from previous Jacobs surveys.

The key data used to develop and validate the highway model is shown in **Table 3-A**.

Data Type	Details
Manual Classified Counts (MCC)	16 Link counts and 21 turning counts Count no from model
Automatic Traffic Counts (ATC)	30 ATC link counts
Roadside Interview Surveys	Three 2004 RSI surveys and two 2009 RSI surveys. Used to create observed demand for car journey purpose and commercial vehicle segments.
Journey Time Surveys	12 routes both inbound and outbound were surveyed in 2008.
Land Use data	Detailed information on Gross Floor Area (GFA) of existing land use in Canterbury acquired from the Valuation Office Agency (VOA); and Kent County Council had a GIS shapefile of residential properties.
Census data	2001 socio economic data which assisted the trip generation, and Home-to-work data for commuting journeys
PLASC Schools and Travel Plan data	Used to develop demand for education trips
Traffic signals data	Collected from Kent Highway Services for coding network
Car park data	Collected from Canterbury City Council for the Demand Model
TRICS data	Used to calibrate the trip generation rates from the model
TEMPRO	Used to assist with developing the car demand

Table 3-A Highway Traffic Data Summary

3.3 Public Transport Data

Unlike the highways data the majority of public transport data had to be collected afresh specific to this study as there was very little historical data available within Jacobs. Note the previous model for Canterbury was a highway only SATURN based model and therefore little data was assembled on the public transport side.

The key data used to develop and validate the Public Transport model is shown in **Table 3-B**.

Data Type	Details

Rail Station surveys	Conducted at 3 stations by Jacobs in 2008 to develop demand trip matrices
Bus surveys	Conducted on selected bus routes around Canterbury by Jacobs in 2009 to develop bus demand trip matrices
Park & Ride surveys	Park & Ride data supplied by Canterbury City Council to develop P+R demand trip matrices
Bus Patronage data	Supplied to us by the Principal Bus Operator (Stagecoach) for a two-week period in a typical month (May/June 2008) used to validate the bus demand.
PLASC Schools and University data	Supplied by Kent County Council to help develop school trips
Census data	Census data used to develop part of the bus demand
Timetable data	Acquired online for bus and rail services to develop the network model
Bus and rail fares	Extracted from service operators and used to develop a fare model for the supply model
TEMPRO	Used to assist with the development of the bus demand matrices

Table 3-B Public Transport Data Summary

3.4 Count data

The count data used to develop the model is shown in **Figure 3-1.** It should be noted as reported in the Jacobs Scoping Report there were more counts available than those used to develop the model. The counts were harmonised and rationalised.

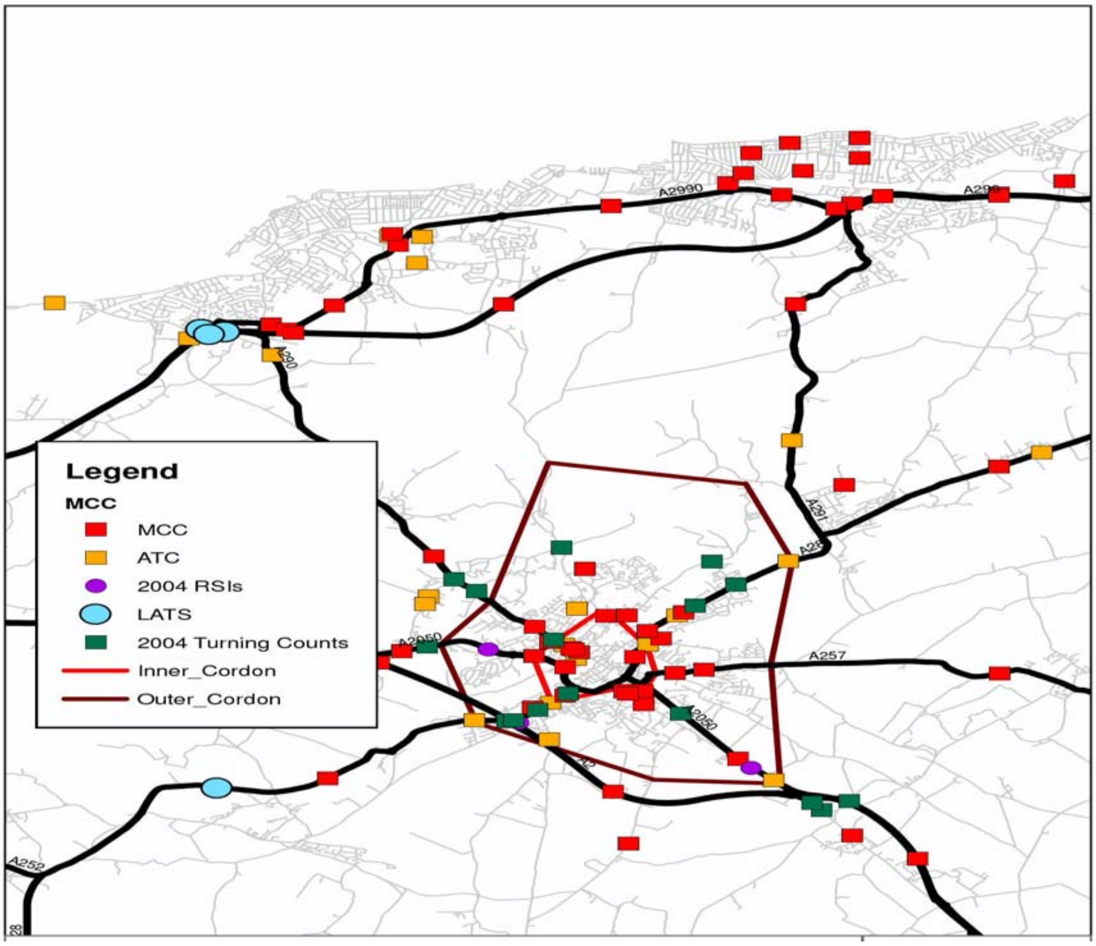

Figure 3-1 Count Locations

3.5 Journey times

Data was collected for 12 journey time routes for the validation of the Canterbury Model. All main routes into and out of Canterbury City were covered as shown **Figure 3-2**.

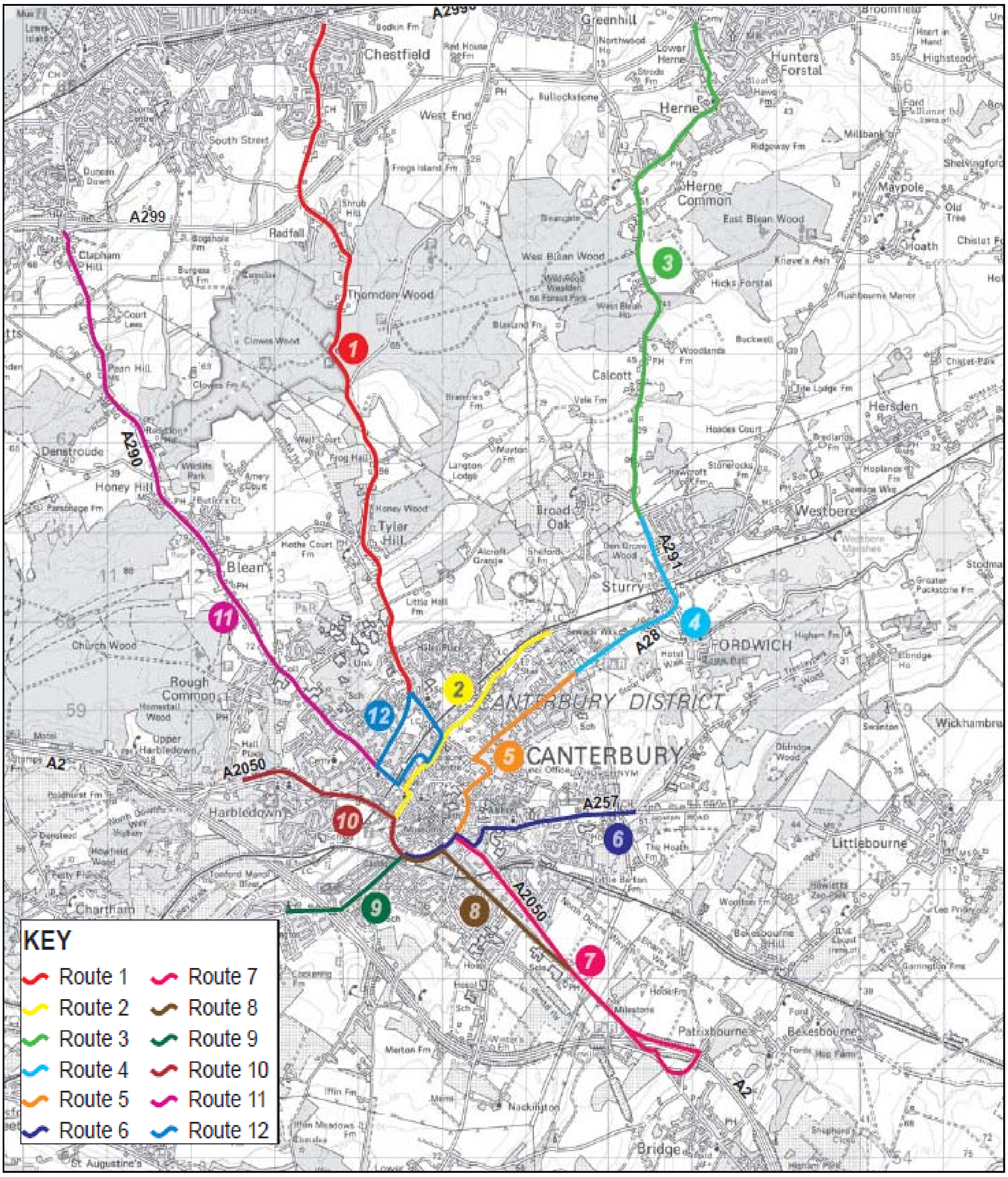

Figure 3-2 June 2008 Journey Time Survey Routes

3.6 Land-use data

Valuation Office Agency data was available for commercial land-use. This was geo-coded into zones, and could be disaggregated into square metres of offices, retail and industrial land-use as shown in **Table 3-C**. In addition a GIS shapefile allowed the number of residential properties in each zone to be calculated.

	Offices	Retail	Industrial	Other commercial	Residential (number)

	(sqm)	(sqm)	(sqm)	(sqm)	
Canterbury	76,802	186,365	108,636	186,522	19,024
Canterbury (rural)	8,631	3,270	131,087	46,451	8,725
Sturry	1,036	1,235	1,302	2,873	2,160
Whitstable	22,415	43,269	100,257	40,134	14,102
Herne Bay	6,423	46,711	44,498	48,440	15,502

Table 3-C Land-use

3.7 NTS / TEMPRO data

The National Statistics census data provides origin-destination movements for home to work journeys and gives a good basis for commuter trips (The Home Based Work demand segments). For the other demand segments the TEMPRO database, as based on the National Travel Survey, quantifies the level of trip-making.

3.8 Car Park data

The car parks in Canterbury are listed in **Table 3-D**.

Car Park	Long / Short Stay	Max Stay	No of Bays	Disabled Bays	Motorcycle Bays
Castle Row	Short Stay	12 Hrs	87	2	YES
Castle Street Multi Storey	Short Stay	12 Hrs	460	8	YES
Dover Street	Short Stay	24 Hrs	32	0	YES
Holmans Meadow	Long Stay	24 Hrs	172	4	YES
Longport	Short Stay	24 Hrs	105	2	YES
Millers Field	Short Stay	12 Hrs	46	0	NO
North Lane	Short Stay	12 Hrs	77	5	NO
Northgate	Short Stay	12 Hrs	70	5	YES
Pound Lane	Short Stay	12 Hrs	148	3	YES
Queningate	Short Stay	12 Hrs	102	6	YES
Rosemary Lane	Long Stay	12 Hrs	103	0	NO
St Johns Nursery	Long Stay	Unknown	212	Unknown	NO
St Radiguns	Short Stay	12 Hrs	304	0	YES
Station Road West	Long Stay	24 Hrs	135	0	NO
Watling Street	Short Stay	12 Hrs	150	4	YES
Whitefriars	Short Stay	5 Hrs	530	Unknown	NO

Table 3-D Canterbury Car Parks

3.9 Park and Ride data

The Canterbury Park and Ride sites are listed in **Table 3-E**.

Park & Ride Site	No of Bays	Disabled Bays
New Dover Road	645	20
Sturry Road	600	10
Wincheap	600	10

Table 3-E Park and Ride sites

4 Network Model Development

4.1 Highway Network

The highway network in the base model was derived from various sources available to represent the network elements with the best possible accuracy. The VISUM highway network was firstly developed in GIS using the ITN (Integrated Transport network) networks. VISUM provides a direct interface with GIS based datasets and this was useful in the development of the network model with accurate grid coordinates and basic information already available, such as network distances between junctions, from which to build.

The network established by this process was then refined using map backgrounds and aerial photographs. The resulting network model covers the detailed road network classified by link type into Motorways, Trunk Roads, A-Roads, B-Roads and Local Roads.

The extent of the wider modelled network is shown on **Figure 4-1** and the detailed modelled network in **Figure 4-2**.

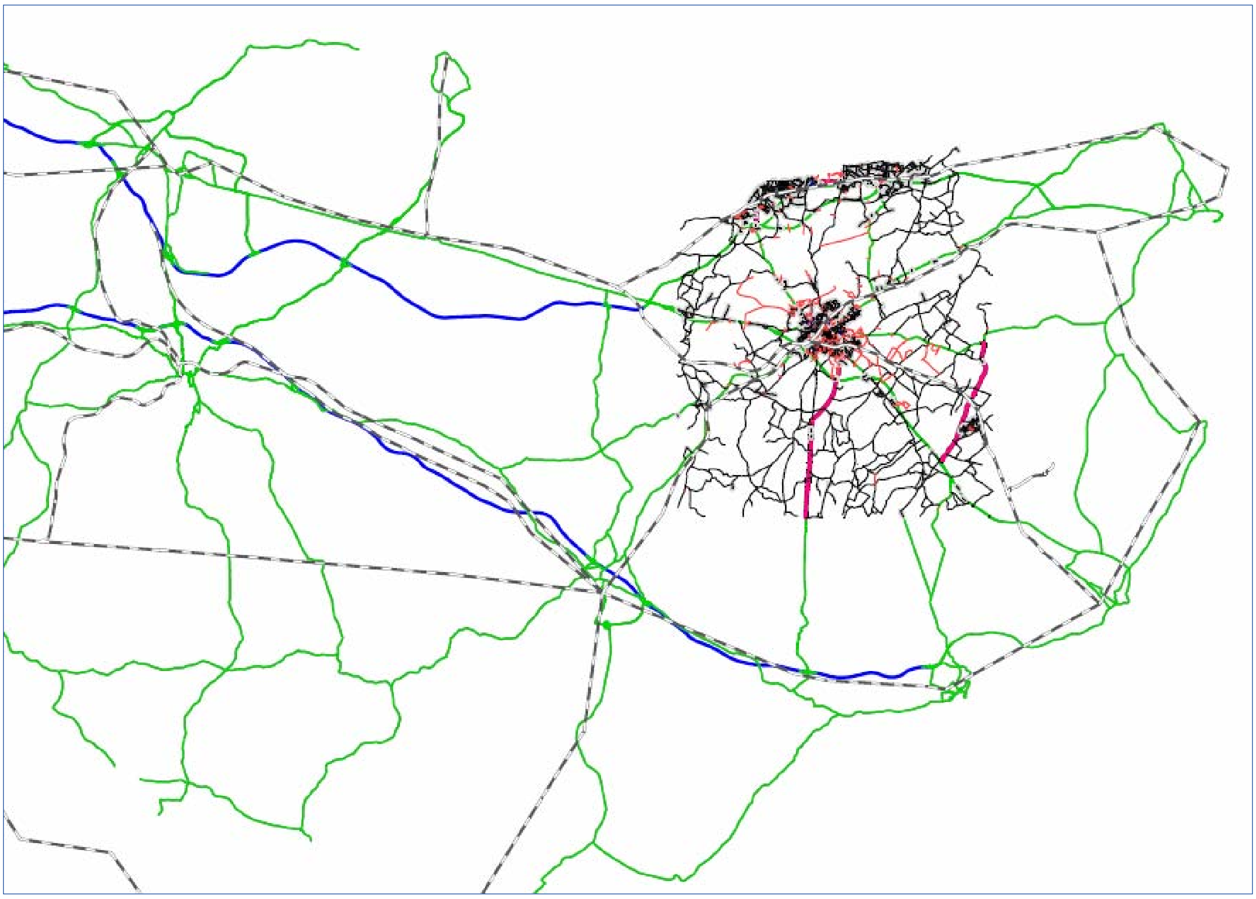

Figure 4-1 VISUM wider network

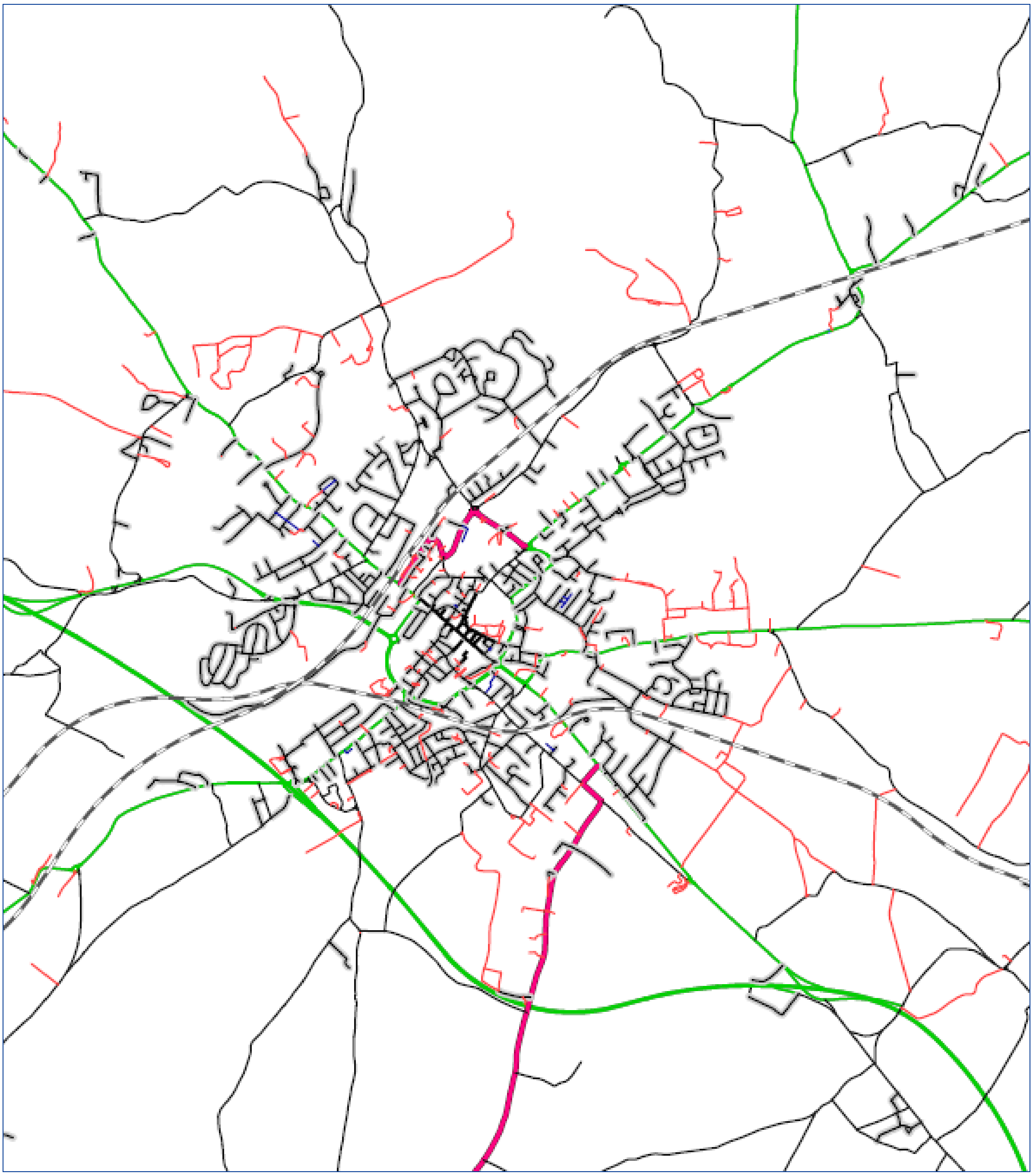

Figure 4-2 VISUM detailed network

4.1.1 Link Type

The link types defined within the VISUM model are based on road classification, link character and number of lanes.

Link capacities in the model are consistent with those recommended in the Highways Agencies Design Manual for Roads and Bridges (DMRB) manual, volume 5, Section 1. **Table 4-A**, **Table 4-B**, **Table 4-C** and **Table 4-D** below indicate the link capacities applied throughout the network.

Road Type	Urban Motorway	Urban All Purpose			
Classification	UM	UAP1	UAP2	UAP3	UAP4
Description	Through route with grade separated junctions, hard shoulders or hard strips and motorway restrictions.	High standard single/dual carriageway road carrying predominately through traffic with limited access.	Good standard single/dual carriageway road with frontage access and more than two side roads per km.	Variable standard road carrying mixed traffic with frontage access, side roads, bus stops and at-grade pedestrian crossings	Busy high street carrying predominately local traffic with frontage activity including loading and unloading.

Table 4-A Road Definitions for Link Capacities

		Two Way Single Carriageway – Busiest Direction Flow (Assumes a 60/40 directional split)									Dual Carriageway			
		Total Number Of Lanes									Number of Lanes in each direction			
		2				2-3	3	3-4	4	4+	2		3	4
Carriageway Width		6.1m	6.75m	7.3m	9.0m	10.0m	12.3m	13.5m	14.6m	18.0m	6.75m	7.3m	11.0m	14.6m
Road Type	UM	**Not Applicable**										4000	5600	7200
	UAP1	1020	1320	1590	1860	2010	2550	2800	3050	3300	3350	3600	5200	*
	UAP2	1020	1260	1470	1550	1650	1700	1900	2100	2700	2950	3200	4800	*
	UAP3	900	1100	1300	1530	1620	*	*	*	*	2300	2600	3300	*
	UAP4	750	900	1140	1320	1410	*	*	*	*	*	*	*	*

Table 4-B Capacities for Urban Roads (One Way Hourly Flows per Direction)

Notes

1. Capacities are in vehicles per hour.
2. HGV ≤ 15%
3. (*) Capacities are excluded where the road width is not appropriate for the road type and where there are too few examples to give reliable figures.

Carriageway Width		6.1m	6.75m	7.3m	9.0m	10.0m	11.0m
		2 Lanes			2-3 Lanes		3 Lanes
Road Type	UAP1		2950	3250	3950	4450	4800
	UAP2	1800	2000	2200	2850	3250	3550

Table 4-C Capacities for One Way Urban Roads (Hourly Flows)

Notes

1. Capacities are in vehicles per hour.
2. Capacities for one way road types UAP1 at 6.1m width, UAP3 and UAP4 are not shown as there are too few examples to give reliable capacities.
3. Capacities for one-way roads (e.g. UAP2 at 7.3m and 11.0m carriageway widths) are generally less than capacities of dual carriageways in one direction shown in **Table 4-B**. The reason is that one-way roads are often of short lengths and form part of a gyratory system between junctions, necessitating high proportion of vehicle weaving and stopping, thereby decreasing the capacities.

Heavy Vehicle Content	Total Reduction In Flow Level (vehs/hr)		
	UM and UAP Dual Carriageway Road	Single Carriageway UAP road having width of 10m or wider	Single Carriageway UAP road having width less than 10m
	Per Lane	Per Carriageway	Per Carriageway
15-20%	100	100	150
20-25%	150	150	225

Table 4-D Reduction in Flow Due to Heavy Vehicle Content

4.1.2 Speed Flow Relationship

Speed flow curves are based on those used in the DfT COBA program, and have been incorporated in the VISUM model. The COBA speed flow relationships allow for differential speed flow curves for cars and heavy goods vehicles as well as for different road types.

Speed flow curves were determined for cars / LGVs and HGVs for each of the following road types:

- *Urban central*
- *Urban non central*
- *Suburban single*
- *Suburban dual*
- *Rural single*
- *Rural dual*

4.1.3 Junction modelling

The base year highway network includes detailed junction coding which enables junction assessment at a strategic level. Junction modelling is carried out with the Intersection Capacity Analysis (ICA) module which is part of the VISUM package. ICA uses Highway Capacity Manual (HCM) formulae for junction modelling except roundabouts where it uses Transport Research Laboratory (TRL) formulae. Roundabout junctions are coded as a combination of priority and uncontrolled junctions. Details of signal plans for the signalised junctions were provided by the Kent Highway Service Urban Traffic Management Centre (UTMC) co-located with Jacobs office in Maidstone. Additional information was acquired online using aerial photographs (Google Earth) to assist with the junction geometry and lane definition.

Figure 4-3 Example of detailed photograph used for junction modelling. Source: Google Maps ©2010Google

4.1.4 Car parks

The car park data coding was undertaken with the support of aerial photographs which helped in locating car parks for the model and appending their details. Car parks were not modelled as dedicated demand zones but were grouped in with City centre zones. However the relevant car park charges were taken into account for demand modelling. Details of the car parking data were provided in **Chapter 3.**

Each of the car parks was allocated to a VISUM zone and the parking charges were extracted and averaged. The short stay car parks were averaged separately from long stay car parks.

4.1.5 Rail Level Crossings

There are four rail level crossings which impact on the highway network in the study area. When trains approach the level crossings, the rail barriers are triggered and highway traffic is stopped and this creates extra queuing and delay in the highway network. These crossings are located at:

- A290 St Dunstan’s Street
- St Stephens Road
- Broadoak Crossing
- A28 Mill Road

The level crossings were modelled as signalised junctions in VISUM. A sample of timings was recorded on site at St Dunstan's Street. The timing delays were then estimated for the various level crossings by reviewing the train timetables for the peak periods to assess the frequency of train movements.

4.2 Public Transport Network

The public transport network model includes a bus and rail model operating to, from and within the study area. The public transport network, rail in particular extends to the wider area of Kent and London. The bus and rail services incorporated in the model reflect the 2008 timetables. Note the base rail network model excludes the High Speed Rail service into St Pancras which started in late 2009.

4.2.1 Bus Network

The principal bus operator in Canterbury is Stagecoach. Main bus services were modelled including school services. A total of 34 public bus services were selected to be modelled plus school services (900 series). Timetable information and bus route details were extracted from the operator's database. The key bus routes modelled are shown in **Figure 4-4**.

VISUM requires the capacity of the bus to be coded and a standard single deck bus was assumed to have a seating capacity of 35 and total capacity of 53. The total seating capacity of a double deck bus was assumed to be 63 with a total capacity of 85.

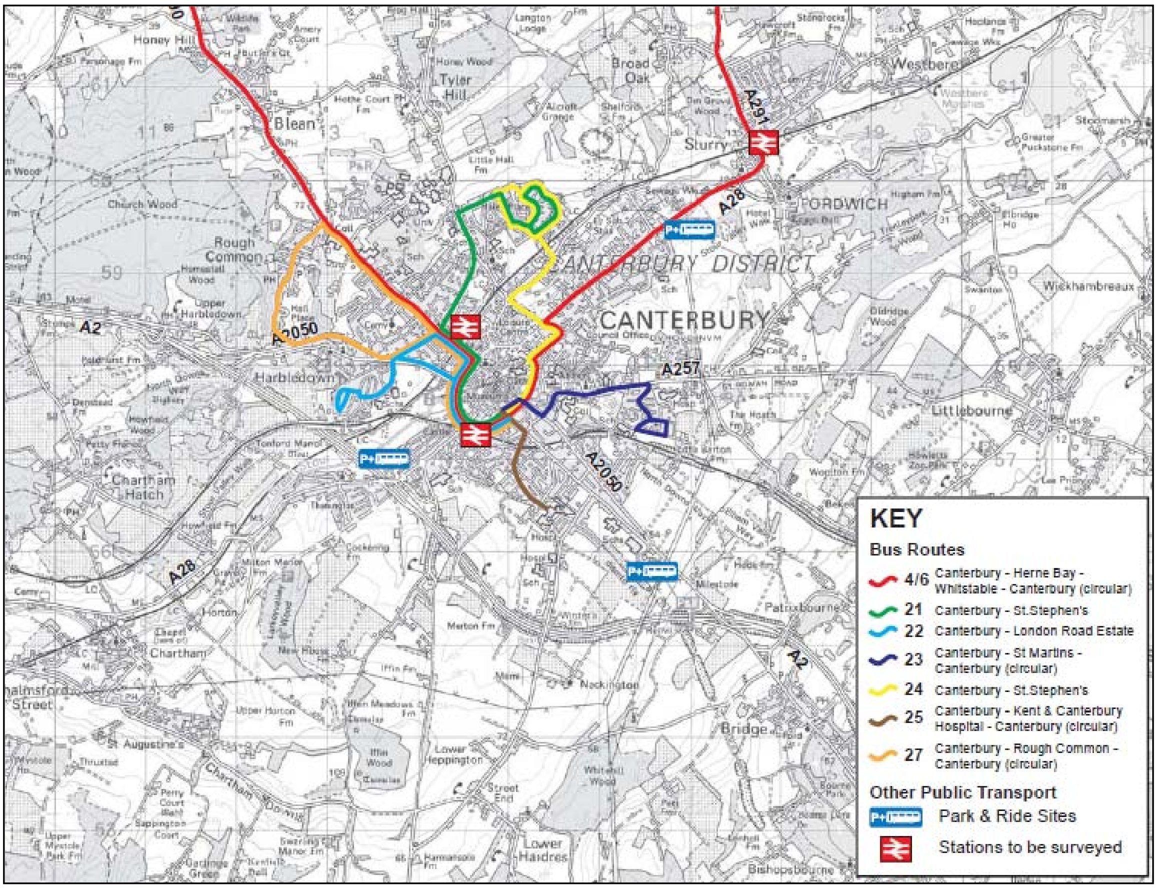

Figure 4-4 PT Bus Network

4.2.2 Bus Fares

The fare structure provided by the principal bus operator was used to develop a fare model. Due to the complexity of the fare structure for the Canterbury area, a fare stage model structure was adopted as illustrated in **Figure 4-5** and **Figure 4-6** below.

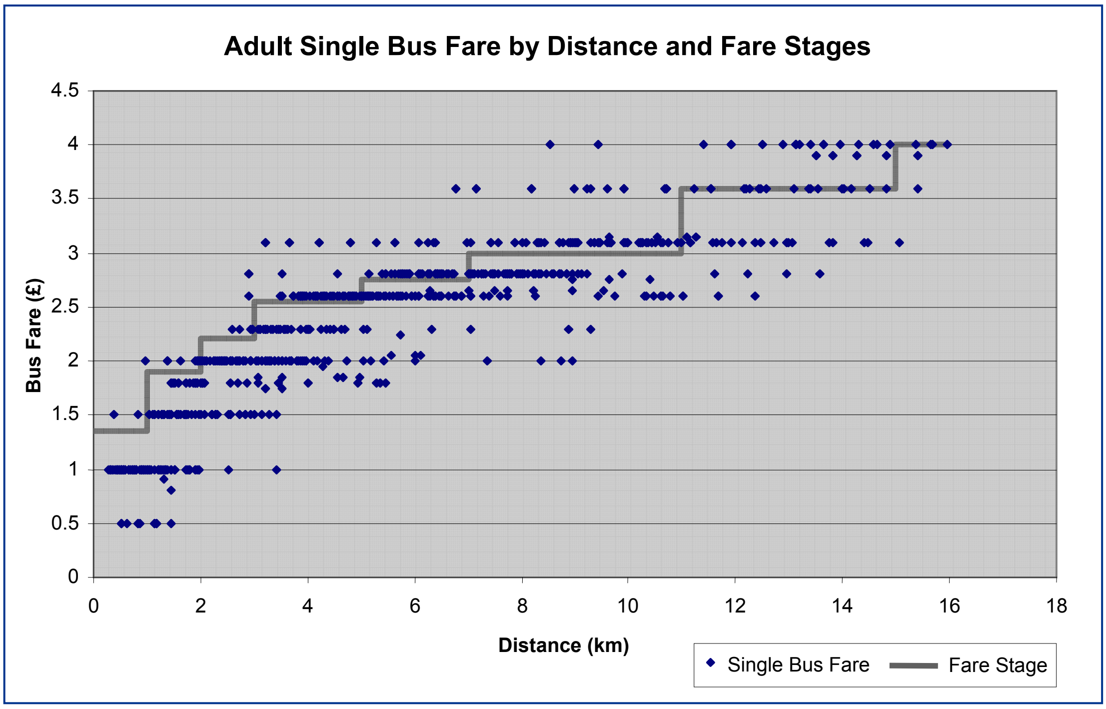

Figure 4-5 Adult Single Bus Fares & Fare Stages

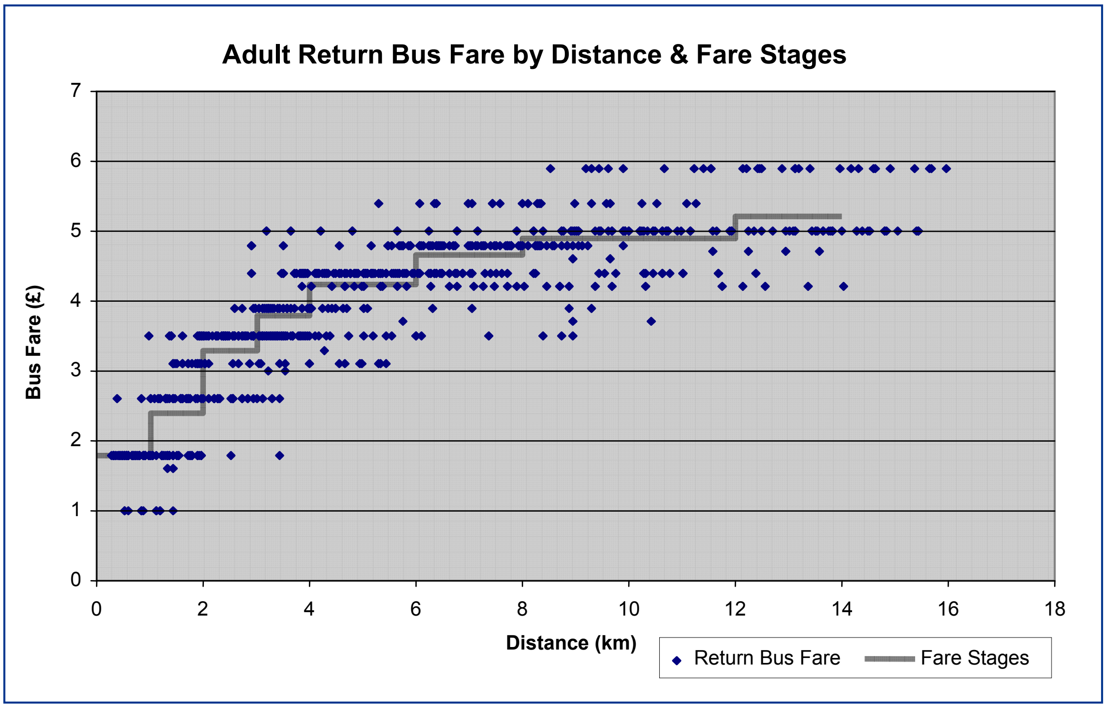

Figure 4-6 Adult Return Bus Fares & Fare Stages

The fare model includes single, return, child and concessionary fares as summarised in the following **Table 4-E**.

Bus Fare Stage	Adult Single (£)	Adult Return (£)	Child Single (£)	Child Return (£)	Season (£)	Concession	Average (£)
0 - 1	1.00	1.80	0.50	0.90	1.9	0	0.67
1 - 2	1.35	2.40	0.68	1.20	1.9	0	0.80
2 - 3	1.90	3.30	0.95	1.65	1.9	0	0.99
3 - 4	2.20	3.80	1.10	1.90	1.9	0	1.10
4 - 5	2.55	4.25	1.28	2.13	1.9	0	1.21
5 - 6	2.55	4.25	1.28	2.13	1.9	0	1.21
6 - 7	2.75	4.65	1.38	2.33	1.9	0	1.29
7 - 8	2.75	4.65	1.38	2.33	1.9	0	1.29
8 - 9	3.00	4.90	1.50	2.45	1.9	0	1.36
9 - 10	3.00	4.90	1.50	2.45	1.9	0	1.36
10 - 11	3.00	4.90	1.50	2.45	1.9	0	1.36
11 - 12	3.00	4.90	1.50	2.45	1.9	0	1.36
12 - 13	3.60	5.20	1.80	2.60	1.9	0	1.50
13 - 14	3.60	5.20	1.80	2.60	1.9	0	1.50
14 - 15	3.60	5.20	1.80	2.60	1.9	0	1.50
15 - 16	3.60	5.20	1.80	2.60	1.9	0	1.50
Assumed Proportions	16%	11%	2%	0%	16%	55%	100%

Table 4-E Bus Fare Stages and Fares

4.2.3 Rail Network

The rail network extends beyond the study area to enable realistic route choice and travel costs for travellers in the Canterbury area. The website of the main Kent rail operator (Southeastern) was used to identify the train services arriving and departing from the 3 stations within the study area that have been modelled.

For the non-high speed services in the Canterbury area, it was more important to reflect the eastern end of the North Kent Line and the Maidstone-Ashford network. Both provide connections between London and East Kent. The North Kent rail line splits at Faversham with the northern half serving Herne Bay and Whitstable to Margate whilst the southern half serves Canterbury East and Dover. The Maidstone-Ashford Network connects to Canterbury West and onto Thanet. It should be noted that the City of Canterbury is not directly connected by rail to Whitstable and Herne Bay.

There are eight stations to consider within the wider study area including the two main Canterbury stations as well as Sturry, Herne Bay and Whitstable stations. There are also three minor stations within the study area but these have relatively insignificant demand and are outside the urban area. It was decided with the agreement of the Local Authority that the three main Canterbury railway stations; Canterbury East, Canterbury West and Sturry would be the focus of rail demand and validation, and they were surveyed for this study.

4.2.4 Rail Fares

A linear model was developed for rail fares based on a boarding charge and a cost per kilometre travelled. This was developed for single and return journeys for adults and concessions. **Figure 4-7** and **Figure 4-8** illustrate the linear relationship used between rail fare and distance travelled for single and return journeys.

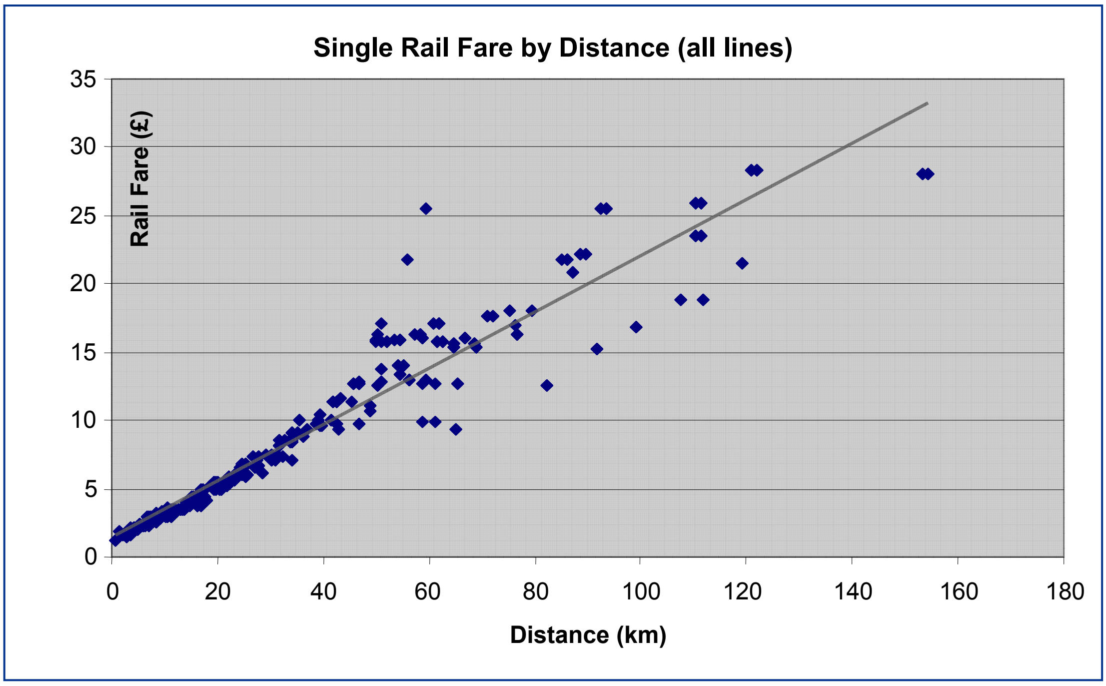

Figure 4-7 Single Rail Fares

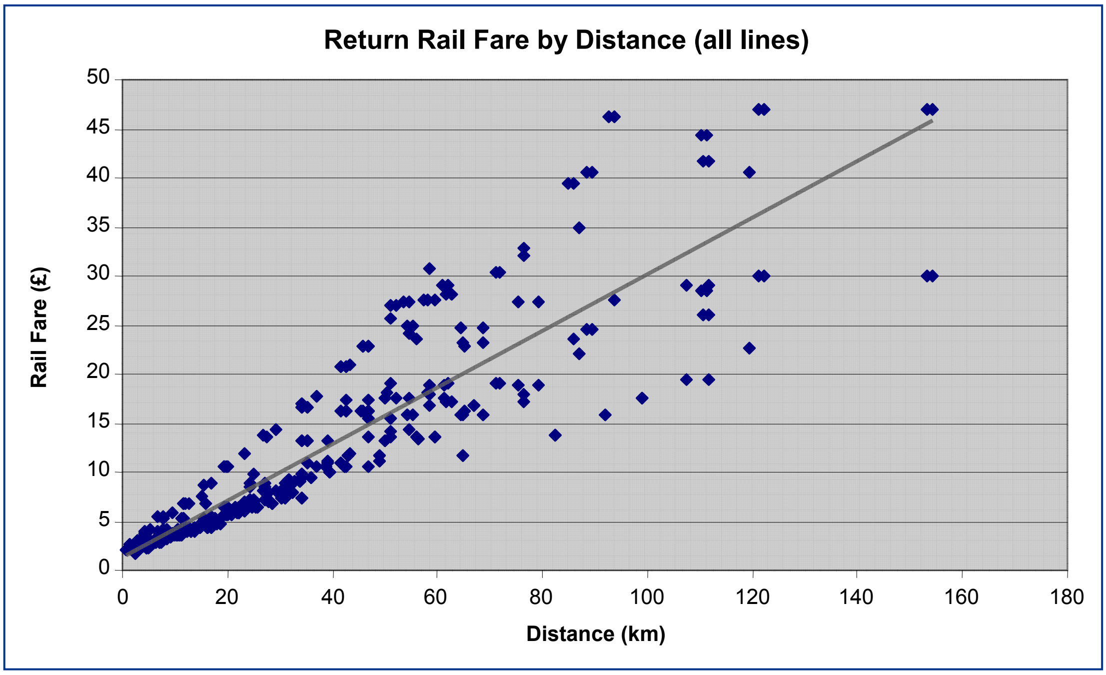

Figure 4-8 Return Rail Fares

4.3 Park & Ride Network

There are 3 Park & Ride sites serving Canterbury City centre at the following locations:

- Sturry Road (P1)
- Wincheap (P2)
- New Dover Road (P3)

The Park & Ride network allows car drivers' and their passengers to park outside the congested city centre, the objective being to reduce the total volume of traffic in central areas. The second leg of the journey is subsequently made by bus into the city centre. There is a flat fee of £2.50 for using the car parks and once the ticket is validated it allows travel on the Park & Ride bus. The car stage of the journey uses the VISUM highway network already described to access the Park & Ride site. The bus service timetables for the three routes were coded for the bus stage of the Park and Ride route.

4.4 Zoning System

The zoning system on which the demand matrices are based was developed in the first instance on political ward boundaries for the core study area. In the study area the zoning system was then refined as necessary to take into account a number of factors including census output areas, natural barriers, areas of consistent land use and local access to the model transport network.

The model has a total of 221 zones which are grouped as follows:

- *Inner Study Area* — *140 zones*
- *Outer Study Area* — *62 zones*
- *External Area covering Kent and the rest of the UK* — *19 zones*

Figure 4-9, **Figure 4-10** and **Figure 4-11** show the VISUM zones for the different geographical areas.

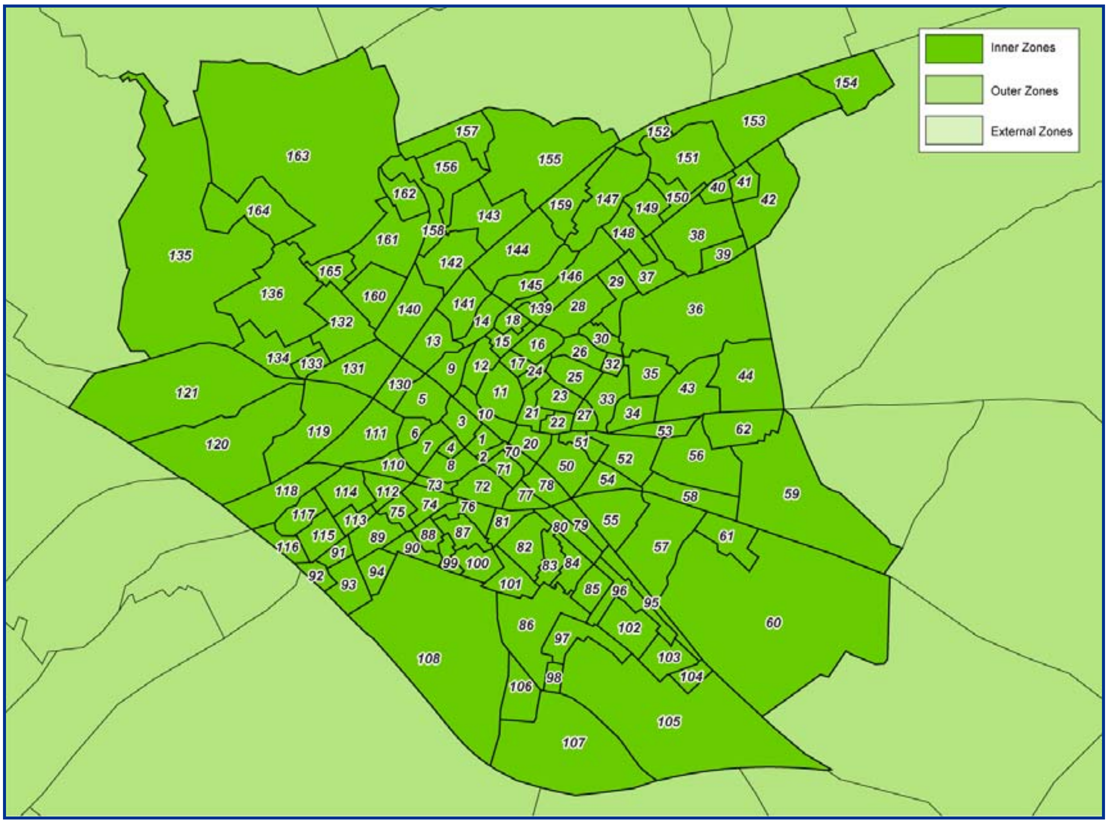

Figure 4-9 VISUM Inner zones

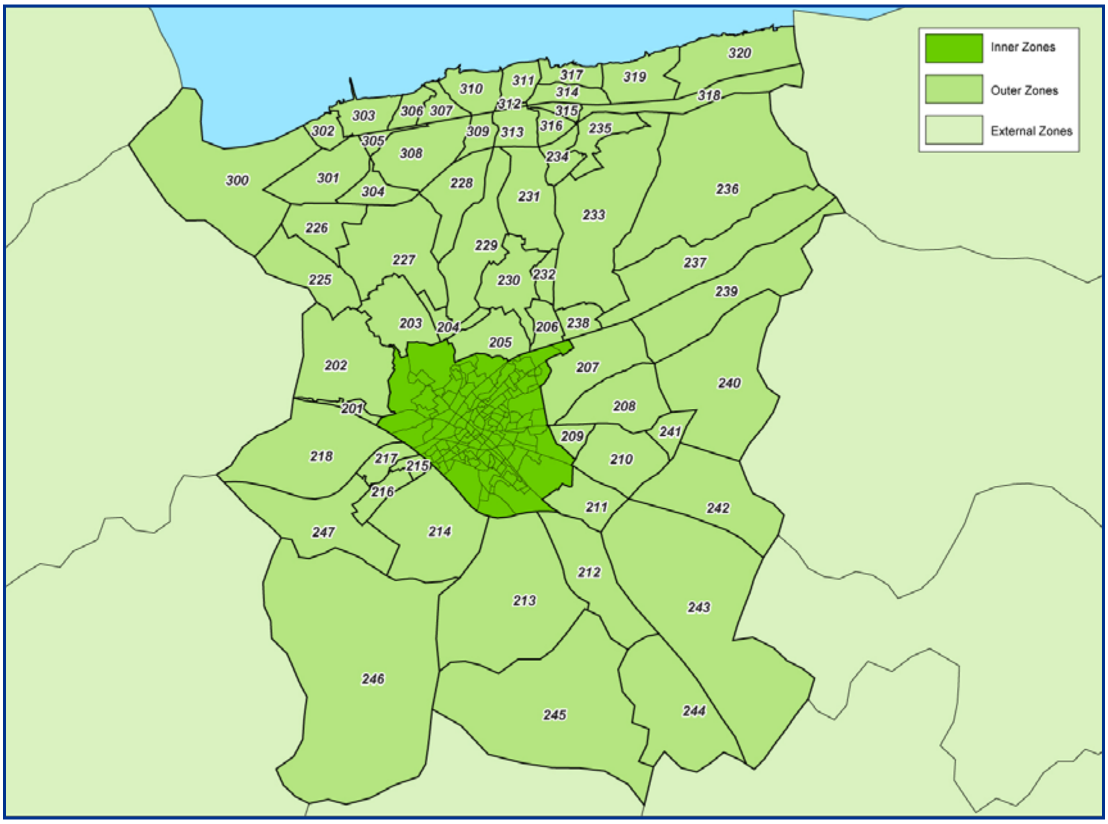

Figure 4-10 VISUM Outer zones

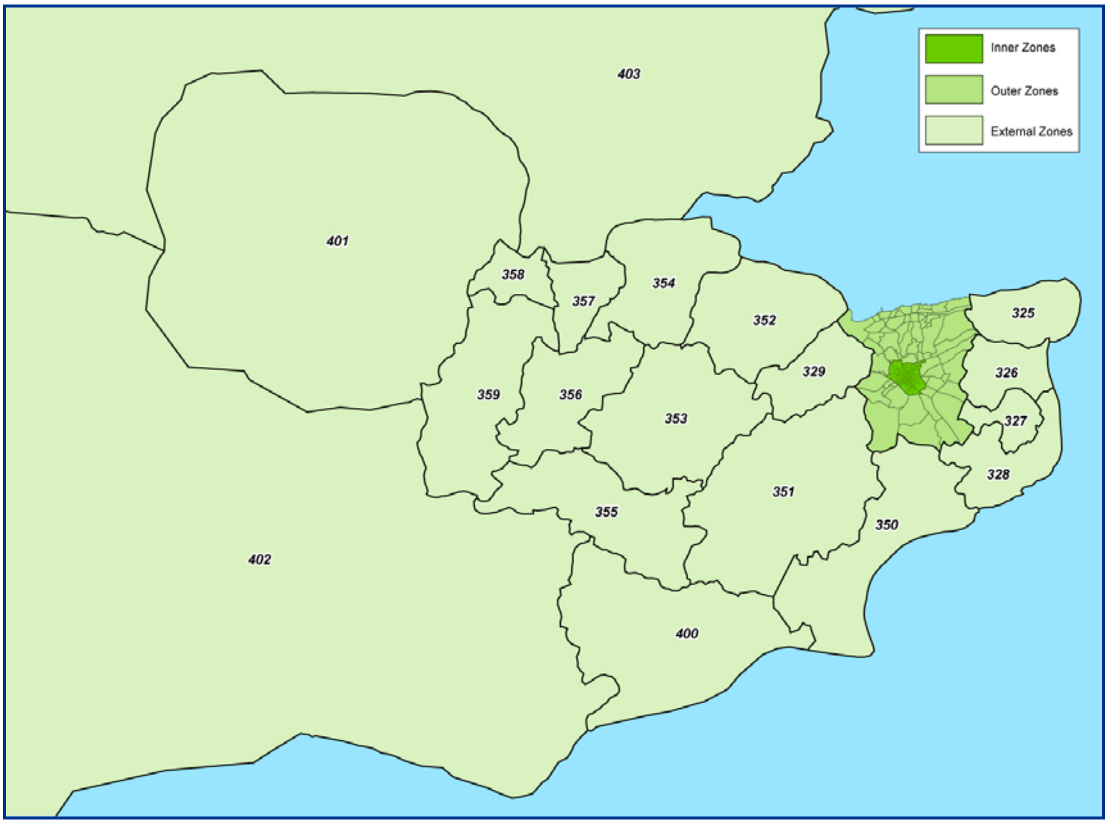

Figure 4-11 VISUM External zones

4.5 Heavy Goods Vehicles

Heavy Goods Vehicles (HGVs) are modelled as a separate vehicle class with additional restrictions in the network. Restrictions on HGVs routes and speeds are part of the highway network model. This information was extracted from a vehicle restriction database held by Kent Highway Services.

5 Model Development – Demand Matrices

5.1 Introduction

The Canterbury VISUM model is a 4-stage demand model based on car and non-car travel modes. Commercial vehicle demand is also reflected in the model. For the base model the demand is partly based on observed data from surveys and other data sources. Where demand data was not surveyed or collected it was synthetically derived with the assistance of trip generation and distribution models.

Demand matrices were built for the whole day from which peak period matrices were extracted. This also provides the potential to model other periods of the day if required at a later date.

This Chapter summarises the data sources and the processes used in the development of the demand model matrices for the AM and PM peak periods.

5.2 Data Sources

The key data sources for the development of the demand matrices are:

- *Roadside Interview data (RSI)*
- *2001 census – socio and economic data*
- *Land use data provided by the Valuation Office (VOA),*
- *2001 to 2008 development data provided by Canterbury City Council*
- *PLASC data for schools*
- *Stagecoach bus patronage data*
- *Rail station surveys*
- *Parking survey data*
- *TRICS*
- *National Travel Survey*

5.2.1 Development Data 2001 to 2008

The trip generation is developed around the 2001 census data. However it is clear that there have been changes to the land use since that time and that these should be taken into account within the model. New development since 2001, together with 'change of use' sites within the study area, have been identified, located and quantified as far as possible.

5.3 Demand Segmentation

The highway demand segmentation adopted for the model was based on journey purpose and vehicle category. Car traffic was split into 5 journey purposes. Commercial road vehicles were split into light and heavy goods vehicles. In addition there is a further demand segment for external-external trips. Highway segmentation is summarised in **Table 5-A**. For public transport and Park & Ride modes, demand is split into Home-based Work, Home-based Education and Home-based other. This assumes that both non-home-based and employer's business are negligible for public transport. Public transport segmentation is given in **Table 5-B**.

Highway Demand Segmentation	Mode	Matrix

Home Based Work (HBW)	Car	HBWC
Home Based Other (HBO)	Car	HBOC
Home Based Education (HBED)	Car	HBEDC
Non Home Based Other (NHBO)	Car	NHBOC
Employers business (EB)	Car	EBC
Light goods vehicles	LGV	LGV
Heavy goods vehicles	HGV	HGV
External	Car, LGV and HGV	EXTC

Table 5-A Demand Segmentation – Highway

Public Transport Demand Segmentation	Mode	Matrix
Home Based Work (HBW)	Bus	HBWB
Home Based Other (HBO)	Bus	HBOB
Home Based Education (HBED)	Bus	HBEDB
Home Based Work (HBW)	Rail	HBWR
Home Based Other (HBO)	Rail	HBOR
Home Based Education (HBED)	Rail	HBEDR
Home Based Work (HBW)	Park & Ride	HBWPR
Home Based Other (HBO)	Park & Ride	HBOPR
Home Based Education (HBED)	Park & Ride	HBEDPR

Table 5-B Demand Segmentation – Public Transport and P+R

The overall composition of the highway travel demand in the AM and PM peak models are indicated in **Table 5-C**.

Average Peak Hour	AM Peak	PM Peak
Home Based Work	20426	19591
Home Based Other	2705	2817
Non Home Based Other	642	845
Employers business	1068	957
Heavy goods vehicles	374	450
Light goods vehicles	1536	1615

Table 5-C Highway - Journey Purpose Split in Vehicles

5.3.1 Car Vehicles

Three roadside interview surveys (RSI) were conducted in 2003 for the 2004 Canterbury SATURN Model at the following locations:

- A2050 Harbledown By-Pass / Rheims Way
- A2050 New Dover Road
- A2 Eastbound On-Slip at Wincheap

There were also 2001 roadside interview surveys done for the London Area Transportation Study (LATS) in and around Canterbury District. These roadside interviews however lacked coverage on the north and east side of the City. Note there were also RSI surveys carried out around Canterbury in the 1990's but they were judged to be too old and it was decided additional surveys were needed. Two additional RSI surveys were therefore conducted in 2009 by Jacobs to reflect demand from the north and east side of the City at the following locations:

- A290 Whitstable Road around St Thomas Hill
- A28 Sturry Road

5.3.2 Commercial Goods Vehicles

Observed movements from the RSI surveys described above were also used to develop initial matrices for light and heavy goods vehicles. The remaining unobserved movements were in-filled using a calibrated gravity model with trip generation derived from a land use and TRICS database. The matrices were calibrated and validated against land use and socio-demographic data. The light and heavy goods vehicle demand matrices are not part of the mode choice modelling so were not broken down into journey purpose matrices.

5.4 Synthetic Highway Demand - Trip Generation

Synthetic demand was used to estimate car demand for those areas which were not observed in the roadside interview surveys. The locations where roadside interviews were used are described above and movements not intercepted by the surveys were synthetically derived.

The synthetic demand matrices are based on socio-economic, home-to-work data, and planning data. This data was derived largely from the 2001 census and information on land-use characteristics supplied by Canterbury City Council and the Valuation Office Agency.

Development and planning data was used to update the 2001 census data to the 2008 Base Year of the model and TEMPRO car ownership factors were applied to account for the increase in car ownership over time.

Education based trip matrices by mode of travel were developed using the Pupil Level Annual School Census (PLASC) surveys within the study area. The data was also used to estimate vehicle occupancy and trip chains, where for example car trips from home to school may be followed by a return to home or an onward trip to work.

In order to generate trip levels the land use details for each internal zone of the study area were established based on a combination of GIS data, Valuation Office (VOA) data, new development data and aerial photography. The land use details were used to determine economic attributes for each zone. The 2001 census data together with zone economic attributes were used to derive trip demand by journey purpose segment.

5.4.1 Vehicle Occupancy

On completion of the trip generation process, the number of trips in and out of each zone was established. The person trips generated in the demand model are converted into vehicles and the vehicle occupancy rates assumed are listed in **Table 5-D** below. These occupancy rates were determined from the RSI data.

	HBW	HBO	HBED	EB	NHBO
AM	1.17	1.45	1.54	1.17	1.52
PM	1.13	1.67	1.61	1.00	1.56

Table 5-D Average Vehicle Occupancy Rates by Journey Purposes AM & PM

5.4.2 External Movements

Some external to external movements through the study area were not accounted for using the census and survey data available, for example through traffic along the A2 section contained within the study area of the model. These movements were in-filled by adapting information available from other sources, including the TRADS counts.

5.4.3 Peak Demands

For the highway model assignment the average peak period (average of 3-hours) were then converted to a peak hour with peak hour factors. These factors were all derived from traffic counts in the study area. For the public transport assignment the 3-hour peak period was maintained. **Table 5-E** below shows the peak factors used in the model.

Period	Peak Factor
AM Peak	1.14
PM Peak	1.14

Table 5-E Average Peak Factors

5.5 Synthetic Highway Demand - Trip Distribution

5.5.1 Gravity Model

A gravity model was used to convert the synthetic highway demand from trip production and attraction, at the trip generation stage, to origin and destination matrices for the trip distribution stage.

The highway trip distribution for the synthetic demand within the Canterbury VISUM model is based on gravity models developed for each journey purpose. The impedance function within VISUM was used to develop the generalised costs used, based on travel distance.

The gravity model parameters were calibrated from the RSI data. The trip end data from the trip generation stage was input to the model to generate an initial distribution.

The gravity model function has the form:z

$$T_{ij} = a_i b_j O_i D_j f(U_{ij})$$

Where,
T_{ij} is the number of trip in cell ij;
$a_i b_j$ are balancing factors calculated iteratively and their value depends on trip constraints;
O_i is the total trip ends from an origin zone (i);
D_j is the total trip ends to a destination (j); and
$f(U_{ij})$ is the utility function.

When doubly-constrained T_{ij} is calculated as follows;

$$T_{ij} = \frac{O_i b_j D_j f(U_{ij})}{\sum b_k D_k f(U_{ik})}$$

Where the **bj**'s are calculated iteratively to satisfy the destination constraint

$$\sum_i T_{ij} = D_j .$$

The utility function is:

$$f(U_{ij}) = aU_{ij}^{b} e^{(cU_{ij})}$$

With:

a, b, c the gravity model parameters.

5.6 Combining matrices

External to external movements were then added to the highway origin and destination matrices.

The observed and synthetic matrices developed by journey purpose were combined together with HGV and LGV matrices within the model. Vehicle matrices were converted to passenger car units (PCU) and assigned to the network model.

PCU factors were derived based on DfT guidelines and supported by local data, and are as follows:

- *Cars and Light Goods Vehicles* *1.00*
- *Heavy Goods Vehicles* *1.75*

5.7 Matrix Calibration Process

The demand matrices were calibrated in two stages. In the first stage, the 3hr trip demand matrices (assigned as an average hour demand) were calibrated against average hour traffic count flows without using any matrix estimation. This process was to ensure that the right amount of trips were entering and leaving the inner and outer cordon points. Average journey times were used to calibrate link and junction delays and to ensure that the network model was good enough. The second stage of the calibration corresponded to developing and calibrating the peak hour demand models (08:00-09:00 for AM and 17:00-18:00 for PM). The demand matrices were converted to average peak hour demands. These matrices were then assigned to the network and calibrated against peak traffic count data.

5.8 Public Transport Matrix Development

5.8.1 Bus Matrices

Bus data was available in the form of bus patronage information from the principal operator Stagecoach. The patronage data was however not sufficiently detailed to develop bus matrices. The alighting information was not always accurate in the data. Therefore the patronage data was instead used to validate the bus demand. A bus survey was commissioned for this study in 2009 after the patronage data was reviewed. The bus survey data was constrained by best practice limitations with regards to interviewing school pupils. Also only major and representative routes were surveyed. These included 3, 4, 6, 8, 9, 16, 17 and 89. Origin and destination data was collected along with journey purpose and return time information.

The bus survey data was then used in conjunction with other data sources to construct the bus trip demand. The **Table 5-F** below shows the data sources used to derive the various bus journey purpose matrices for the model.

Demand Segmentation	AM matrices	PM matrices
HBW	Census data National Travel Survey	AM transposed National Travel Survey
HBO	Survey data TEMPRO Gravity model	Survey data TEMPRO Gravity model
HBED	School and University data	School and University data

Table 5-F Bus Matrices – Data Sources

Note travellers on Employers Business as a journey purpose were initially estimated but were negligible using public transport and were not incorporated. The Base matrix trip totals by journey purpose are as shown in **Table 5-G, Table 5-H, Table 5-I, Table 5-J** and **Table 5-K** below.

AM Bus Matrices	Matrices	% Proportion
Home Based Work	1712	20
Home Based Other	1734	21
Home Based Education	4911	59
Total	**8357**	**100%**

Table 5-G AM Bus Matrix Totals

PM Bus Matrices	Matrices	% Proportion
Home Based Work	2855	48
Home Based Other	822	14
Home Based Education	2321	38
Total	**5998**	**100%**

Table 5-H PM Bus Matrix Totals

5.8.2 Rail Matrices

Rail demand matrices were entirely built from detailed origin-destination survey data collected at the 3 major railway stations by Jacobs in Canterbury in 2008. The data includes details on origin-destination, journey purpose, return time and station access mode. The following railway stations were surveyed:

- *Canterbury East*
- *Canterbury West*
- *Sturry*

Passenger counts were carried out at the same time and used to expand the data as appropriate to develop the rail demand matrices. The rail census 'home to work' matrices were used to validate the rail demand matrices and also to derive the peak period factors for demand modelling. The matrix trip totals by journey purpose are as shown in **Table 5-I** and **Table 5-J** below.

AM Rail Matrices	Matrices	% Proportion
Work	944	42%
Other	615	28%
Education	659	30%
Total	**2218**	**100%**

Table 5-I AM Rail Matrix Totals

PM Rail Matrices	Matrices	% Proportion
Work	844	35%
Other	820	34%
Education	747	31%
Total	**2411**	**100%**

Table 5-J PM Rail Matrix Totals

5.8.3 Park & Ride Matrices

Park & Ride was treated as a separate mode of travel in VISUM. Park & Ride demand matrices were developed from car parking surveys conducted by the local authority at the three Canterbury Park & Ride sites in 2007. The matrix trip totals and journey purpose proportions are shown in **Table 5-K** below.

AM Park & Ride Matrices	Matrices	% Proportion
Work	357	43%
Other	176	22%
Education	294	35%
Total	**827**	**100%**

PM Park & Ride Matrices	Matrices	% Proportion
Work	686	78%
Other	72	8%
Education	121	14%
Total	**879**	**100%**

Table 5-K AM & PM Park & Ride Journey Purpose Proportions

6 Variable Demand Model Development

The modelling methodology is based on an incremental, PA (Production-Attraction) based, hierarchical, variable demand modelling approach as set out in the latest WebTAG advice. The approach is designed to meet appropriateness of the modelling requirements and data availability for this project.

6.1 Model Specification

Within the Tunbridge Wells and Tonbridge VISUM transport model, an incremental hierarchical logit choice model has been developed in order to model:

- *Four choice mechanisms: trip frequency, mode choice, time of day choice and destination choice (trip distribution);*
- *Three modes (car, bus and rail);*
- *Five journey purposes (HBW, HBO, HBEd, NHBO, EB)*
- *221 zones covering the study area*

The choice model operates in conjunction with supply models of the highway network and public transport network used to assign the appropriate trips onto the networks (over the validated AM peak and validated PM peak periods) and skims travel costs to be passed to the (demand) choice model.

6.2 Choice Model Structure

According to the DfT guidance (TAG unit 3.10.3, paragraph 1.9), the order of decision making within the hierarchy is:

- *trip frequency (**F**)*
- *mode choice (**M**)*
- *time of day choice (**T**)*
- *trip distribution (**D**).*

At each level the decision is taken on the basis of the composite cost of the possible choices at the lower level. Thus the order of constructing composite costs is the inverse to the order of decision making e.g. **D** → **T** → **M** → **F**. The proposed structure for the demand model is illustrated in **Figure 6-1**.

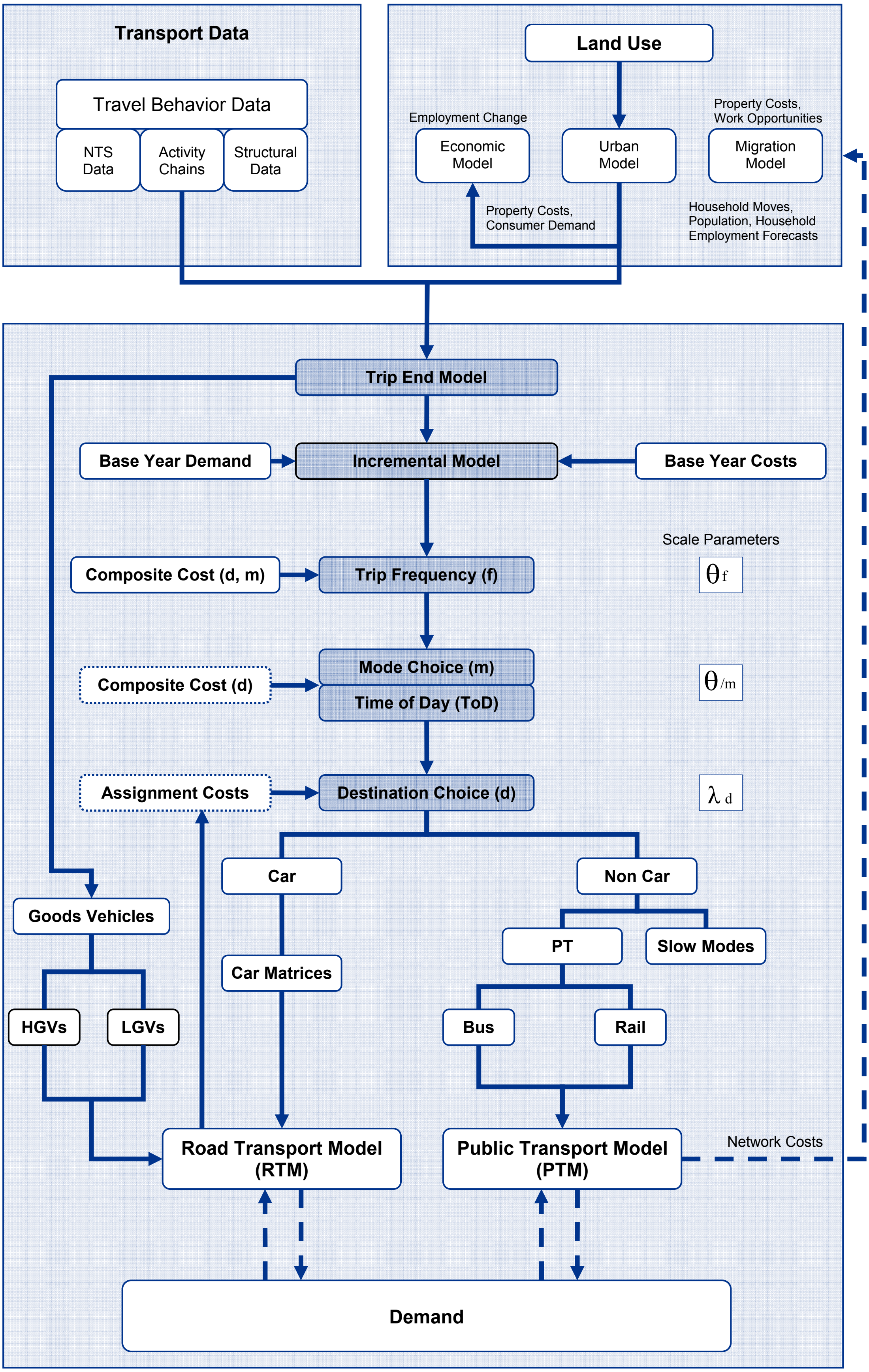

Figure 6-1 Incremental Hierarchical Logit Model Structure

In notational terms, the subscripts **i**, **j** and **m** label origin, destination and mode respectively. $\mathbf{B_{ijm}}$ is the future year 'reference case' demand matrix and $\mathbf{C_{ijm}}$ – $\mathbf{C^0_{ijm}}$ is the cost matrix difference that we require separately for each demand segment. The **p** terms are used for the proportions of travel demand calculated in each step of the choice model. The above matrices, together with the **λ** parameters which define the sensitivity of the responses are used to forecast the new trip matrix $\mathbf{T_{ijm}}$.

Choices made higher in the hierarchy act as constraints on those made later and therefore the sensitivity of the choice (as defined by the absolute values of **λ**) must not decrease down the sequence (paragraph 1.3.9, TAG Unit 3.10.3). In the above case of a hierarchy with structure **FMTD**, it must be the case that: $\boldsymbol{\lambda}^{\mathbf{F}} \le \boldsymbol{\lambda}^{\mathbf{M}} \le \boldsymbol{\lambda}^{\mathbf{T}} \le \boldsymbol{\lambda}^{\mathbf{D}}$.

The cost difference matrices are derived from the cost directly provided from the supply networks when the "base costs" are subtracted. They are passed up the structure of the hierarchical choice model by the 'composite costs' (also termed logsums), so that the choices made higher up reflect the choices below. The sequence of the calculations requires that the composite cost be calculated for each level starting from the bottom of the hierarchy and working its way up. The formula used for the calculation of the composite cost for incremental models is set out in **section 6.3**.

The choice model currently operates on five segments according to journey purpose and car availability. The underlying reason for this (as discussed in WebTAG) is that the sensitivity of the model is likely to be different for various trip purposes. Consequently, the logit sensitivity parameter is likely to be numerically larger when there is more freedom to choose. The choice model is undertaken at the 12 hour level using the 221 zone matrices. The journey purposes modelled are:

- *Home-based work;*
- *Home-based education;*
- *Home-based other;*
- *Non-home-based other;*
- *Employer business.*

6.3 Cost Difference Methodology

For each journey purpose / user class (p) a cost difference matrix is created, defined as follows:

$$\Delta C_{ijm}{}^{p} = C^{1}{}_{ijm}{}^{p} - C^{0}{}_{ijm}{}^{p}$$

where;

C^1 is the proposed policy test cost

C^0 is the reference test cost.

The cost is a 12-hour average cost from the three modelled time periods and generated by the supply model. The 12-hour average cost is calculated by summing cost across the time periods weighted according to the proportion of trips of each journey purpose in each period (paragraph 1.9.8 TAG unit 3.10.2).

$$C_{ijm}{}^{p} = \sum C_{ijm}{}^{p} \psi_{ijm}{}^{p}$$

where;

C_{ijm} p is the cost matrix specific to the time period and journey purpose / user class and ψ,

Ψ_{ijm} p is the factor specific to the time period and journey purpose / user class. It is calculated as the proportion of $T^{0}{}_{ijm}{}^{p}$ (demand matrix for a given time period and journey purpose / user class) and the $T^{0}{}_{ijm*}{}^{p}$ (AM and PM peak demand matrix for the given journey purpose / user class) times the length of period as shown in equation 8.3.3.

$$\Psi_{ijm}{}^{p} = [\, L_t T^{0}{}_{ijm}{}^{p} / T^{0}{}_{ijm*}{}^{p} \,]$$

Where;

L_t is the length of each time period (AM peak and PM peak) within 12 hours, for the Highway Model, which is a one hour assignment model;

$L_{tAM} = 3$

$L_{tPM} = 3$

and for the PT model, which is three hour assignment model;

$L_{tAM} = 1$

$L_{tPM} = 1$

$$T^{0}{}_{ijm*}{}^{p} = [T^{0}{}_{ijm}{}^{p}\ L_{tAM}] + [T^{0}{}_{ijm}{}^{p}\ L_{tPM}]$$

6.4 The Mathematical Specification

The model structure, as discussed above, have three modes (Car, Bus, Rail), 2 times of day (TOD) (AM and PM), and 221 zones. The model has two demand categories, car available and no-car available.

Below is the mathematical formulation of the model where post trip frequency estimation is carried out first followed by mode choice, then time of day choice and finally destination choice.

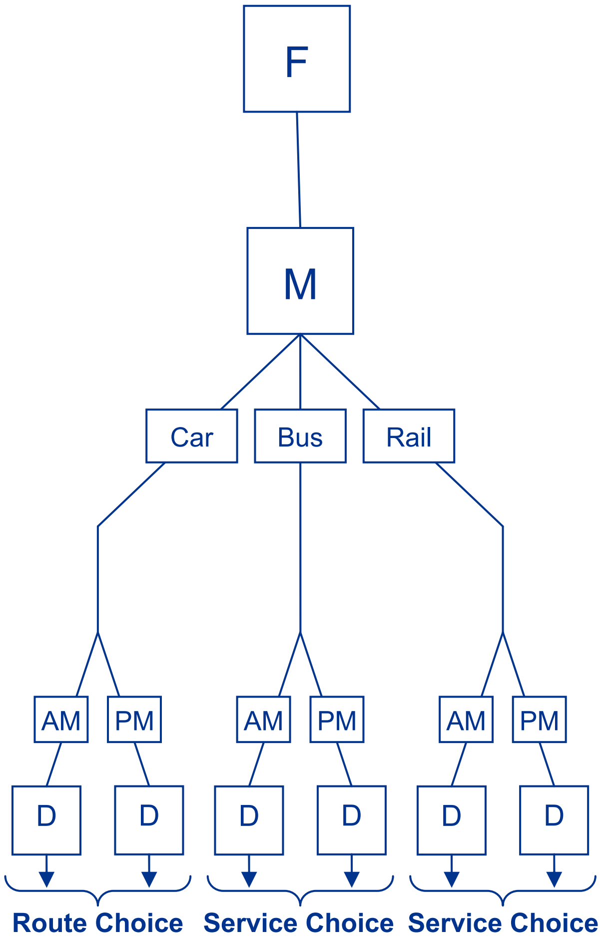

Figure 6-2 Model Structure

Above is the structure on which the mathematical calculation operates. Various levels in the above **Figure 6-2** are described below.

Level	Type	Choice Set
1	F for Frequency	{Motorised}
2	M for Mode Choice	{Car, Bus, Rail}
3	D for Destination Choice/Distribution	All zones

M node (**Figure 6-2**) takes base year or scenario demand in the form of vectors and produce demand per alternative transport mode.

In the case of the no-car demand category, level M has only Bus and Rail as alternatives. Logsums are carried upward along the tree. Two types of incremental models have been applied with D as singly- or doubly-constrained. In the singly-constrained case logsums are calculated based on the following equation:

Model Types	M, T	D
Singly Constrained	$\log \sum_k p_k^0 e^{\Delta U_k}$	$\log \sum_k p_k^0 e^{\Delta U_k}$
Doubly Constrained	$\log \sum_k p_k^0 e^{\Delta U_k}$	$\log \sum_k p_k^0 B_k e^{\Delta U_k}$

Table 6-A Logsum Equations

where;

k ranges over alternatives of the choice node,

U_k is the utility of alternative k,

ΔU_k the utility difference from the base or reference scenario,

A_k are the attractions of zone k,

p_k^0 is the prior share of alternative k.

B_k is the balancing factor for the k-th zone on the destination side.

The incremental model form takes base demand matrices $T^0_{ijm}T^0_{ijmz}$ at each leaf node which are propagated upward along the model structure and converted into the shares p_k^0 which appear in the logsum formula above. Then new shares p_k are calculated top-down and at the leaf level new matrices are computed from new shares and base demand. The data flow through the calculations is shown below:

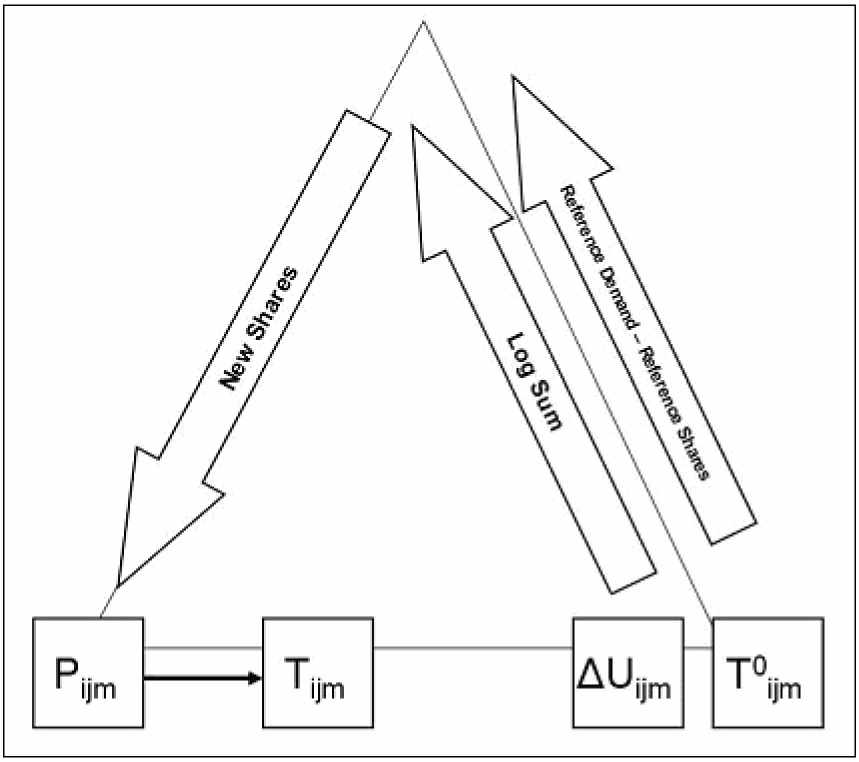

Figure 6-3 Calculation Flow

In the computation process, all choices happen at the level of round trips (Production-Attraction). In the model, the outward and return legs happen in different Times of Day, e.g. (home-to-work in AM, work-to-home in PM). Therefore the choices set for the T nodes contain pairs that the return leg happens later or within the same time period AM-IP and IP_PM trips are estimated using factors as defined in the DIADEM manual and approved by DfT NTS dataset. The leaf utility U_{ijmtu} is calculated based on the following equation:

$$U_{ijm} = U_{ijm} + U^{T}_{ijm}$$

6.5 Supply and Demand Convergence

In addition to the demand choice model functions, a mechanism is required to aid the convergence of the demand and supply (Highway, Bus and Rail) models to a stable solution. The methodology adopted is considered an improvement to the Method of Successive Averages (MSA) which has been used in other transport models.

6.5.1 Method of Successive Averages

The MSA requires that in each iteration, a new "target" estimate is made which is then weighted / combined with the existing estimate from the previous iteration by an increasingly small fraction. This is generally appropriate for traffic assignment (supply) convergence but it is much less appropriate for supply-demand convergence, where the new "target" demand matrix is likely to be a better estimate than the previous estimate. In this context, the methodology proposed is also a dampening mechanism that uses the average value of the demand estimates between various iterations as in MSA but with a different parameter.

Suppose that at iteration (*n-1*) of the "outer" loop (i.e. the adjustment between supply and demand), the estimate of the demand matrix is ^{T}n. By loading this on to the network, we obtain revised costs which, when input to the hierarchical demand mode, produce a new matrix $^{S}n+1$. Rather than treating this as the new demand estimate $^{T}n+1$, we average it with the previous estimate as:

n+1 nn+1

T = (1 −λ)T +λS

where $\lambda = 1/2$

This stabilises the convergence process and reduces required model run times. The testing of convergence occurs at the user class level following the creation of assignment matrices. This is to enable checking of convergence using compatible trip and cost matrices.

6.5.2 Supply / Demand Gap Measures

According to DfT guidance (WebTAG Unit 3.10.4), the recommended criterion for measuring convergence between demand and supply models is the demand/supply % gap defined by:

$$\frac{\sum_{ijcm} C(Xijcm)\,|\,D(C(Xijcm)) - Xijcm\,|}{\sum_{ijcm} C(Xijcm)Xijcm} * 100$$

where:

X $_{ijm}$ is the current flow vector or matrix from the model

C(X $_{ijm}$***)*** *is the generalised cost vector or matrix obtained by assigning that matrix*

D(C(X $_{ijm}$***))*** *is the flow vector or matrix output by the demand model, using the costs*

C(X $_{ijm}$***)*** *as input*

ijm represents origin *i*, destination *j* and mode *m.*

The demand/supply gap measure specified by the equation above was incorporated within the deck of the Canterbury transport model and convergence is assumed to be achieved when gap measure is less than 0.1% at the end of an iteration.

6.6 Variable Demand Model Calibration

Following the development of the demand model, a series of tests were undertaken in order to ensure that the model functions realistically. These tests involve changing the component costs of travel (e.g. fare and fuel prices, and journey times) and monitoring the overall demand responses. Model parameter (lambda) values have been defined to ensure that the changes in demand are in line with general observed experience.

To assess the realistic behaviour of the choice model and calibrate the chosen lambda values, tests were carried out by changing the components of travel costs and times in accordance with DfT guidance. (WebTAG unit 3.10.4). The initial calibration tests involved a 20% increase of the fuel cost, which was then re-run through the choice model to derive new estimates of demand as vehicle-kilometres, this is explained further in **paragraph 6.7** below. The guidance suggests that a number of studies in this country using time-series data on car travel, and fuel prices and costs have shown an elasticity of car use with respect to fuel cost of around -0.3 and this value is in line with a review of European research on this topic. These values were used as elasticity targets in the process of the choice model calibration.

6.6.1 Selection of Lambda Parameters

On the presumption that destination choice will follow the time of day choice and mode choice in the model hierarchy, the WebTAG guidance provides a suggested range of parameter values based on previous studies (WebTAG unit 3.10.3 paragraph 1.11).

It is important to note that according to the DfT guidance the ranges presented are not targets within which the parameter values must lie, but simply the minimum, median and maximum values from the sample of available values (WebTAG unit 3.10.3 paragraph 1.11.14).

In the first step of the calibration process the lower and higher values of the proposed range were tested in the model and the demand responses were checked for car use and public transport. The inferred demand elasticity values from these modelled responses were compared against the benchmark observed demand elasticity.

The final scaling parameters used are set out in the tables below.

Trip Purpose	Scaling Parameter (θ)
Home-based work	0.09
Home-based other	0.113
Home-based Education	0.113

Table 6-B   Destination Choice Scaling Parameter (λ^D)

Trip Purpose	Scaling Parameter (λ^D)
Home-based work	0.043
Home-based other	0.033
Home-based Education	0.033

Table 6-C   Public Transport - Destination Choice Scaling Parameter (λ^D)

Trip Purpose	Scaling Parameter (θ)
Home-based work	0.50
Home-based other	0.27
Home-based Education	0.27

Table 6-D   Mode Choice Scaling Parameter (θ)

6.7 Variable Demand Model Realism Tests

Guidance provided by the DfT Draft WebTAG Unit 3.10.4 recommends realism tests to check the elasticity of demand with respect to fuel cost, car journey time and bus fares.

Based on a number of studies in this country, the suggested acceptable values for annual average fuel cost elasticity, overall and by trip purpose, are as follows:

- *annual average fuel cost elasticity - between -0.25 and -0.35*
- *employers business trips fuel cost elasticity - near to -0.1*
- *discretionary trips fuel cost elasticity - near to -0.4*
- *commuting trips fuel cost elasticity - near to -0.3*
- *education trips fuel cost elasticity - near to -0.3*

Elasticity values car trips, with respect to car journey time, and for bus trips, with respect to bus fares for full fare paying passengers, are as follows:

- *journey time elasticity – no stronger than -2.0*
- *bus trip elasticity – in the range -0.7 to -0.9*

In order to assess the performance of the model realism tests were carried out for Home-based work (HBW) and Home-based other (HBO) journey purposes. These tests were based on a 20% increase in fuel cost and car journey time and the resulting elasticity of demand derived in each case is shown in **Table 6-E** and **Table 6-F** below.

Journey Purpose	Test Value	Recommended elasticity value
Home-based work	-0.31	near to -0.3
Home-based other	-0.30	near to -0.4

Table 6-E Realism Test – 20% Increase in Fuel Cost

Journey Purpose	Test Value	Recommended elasticity value
Home-based work	-0.22	no stronger than -2.0
Home-based other	-0.22	no stronger than -2.0

Table 6-F Realism Test – 20% Increase in Car Journey Time

The elasticity values resulting from the fuel cost and car journey time realism tests meet the recommended criteria.

A further test around a 20% increase in bus fares for full fare paying passengers resulted in the elasticity values shown in the table below.

Journey Purpose	Test Value	Recommended elasticity value
Home-based work	-0.5	No stronger than -0.9
Home-based other	-0.3	No stronger than -0.9

Table 6-G Realism Test – 20% Increase in Bus Fares

The results of the realism tests indicate that the model responds appropriately to changes in fuel cost, value of time and bus fares.

7 Model Assignment

7.1 Introduction

The Canterbury VISUM Model is a 4 stage modelling set up where the last stage corresponds to model assignment. The highway model assignment was based on Lohse equilibrium and the public transport (rail & bus) models were based on frequency assignments.

Lohse equilibrium is multi-procedure assignment based on the drivers learning process of the road network. The Lohse equilibrium has advantages over the more traditional multi-user equilibrium as it takes into account the drivers' previous experience of the network and model routes changing behaviour in congested multi-route network systems. Therefore the model does not assign traffic to the "quickest routes" but it assigns traffic over a set of possible quickest routes known to the driver. This results in a sturdier assignment modelling which is needed for modelling a city like Canterbury and its ring road. The frequency based public transport assignment model is estimated from the timetables coded in VISUM for the rail and buses.

In the base model the assignment stage is primarily used to benchmark network performance and measure it against observed data to validate the model. In the forecast model it will also assist in deriving the generalised costs to inform the demand modelling process (mode choice, distribution etc).

For highways the key parameter for the assignment is the in-vehicle travel time for each origin and destination. Vehicle travel times are derived from the model network distances and speeds coded in the network and from the simulation of delays. The demand model also requires vehicle operating costs, the product of the vehicle operating cost per kilometre and the distance travelled. To convert the vehicle operating time costs into equivalent monetary costs for the model, values of time are needed for the various journey purposes and vehicle classes and the values used based on the DfT WebTAG advice are shown in **Table 7-A**.

Value of time

Demand Segment	Value of time (AM)Pence per hour	Value of time (PM) Pence per hour
HBW	706	699
HBO	890	926
HBED	890	926

Table 7-A Value of Time

Fuel and non-fuel costs

Fuel and non-fuel costs were calculated separately and added together. The fuel costs were determined by using DfT formula for fuel consumption (*L*) and fuel costs as follows:

$L = a + b.v + c.v^2 + d.v^3$ (from WebTAG 3.5.6 April 2009)

Where
L = consumption expressed in litres per kilometre
v = average speed in kilometres per hour; and
a, b, c and d are parameters defined for every vehicle category.

The fuel parameters used are:

Fuel Parameters	a	b	c	d
Average Car	0.178	-0.004	0.000046	-.1E-07
Average LGV	0.196	-0.003	0.000016	6E-08
HGV	0.768	-0.022	0.003	-1E-06

Table 7-B Fuel efficiency Parameters (from WebTAG 3.5.6 April 2009)

The non-fuel costs were calculated as follows:

$C = a1 + b1/v$

Where
C = cost in pence per kilometre travelled,
V = average link speed in kilometres per hour.
a1 is a parameter for distance related defined for each vehicle category,
And b1 is a parameter for vehicle saving defined for each vehicle category. The parameters used are shown in **Table 7-C** below:

Non-Fuel Costs Parameters	a1	b1
Car (Petrol & Diesel)	3.308	19.048
LGV(Petrol & Diesel)	5.910	33.970
HGV	5.501	316.464

Table 7-C Non-Fuel Costs Parameters

The average fuel and non-fuel costs are summarised in **Table 7-D** below:

Vehicle Operating Costs	Pence per km
Car - HBW	10.80
Car - HBO	10.80
Car - HBED	10.80

Table 7-D Vehicle Operating Costs

For public transport the key parameters for the assignment are the in vehicle travel time, waiting and transfer time (with appropriate weights applied) and the fare paid. The PT fare structure used in the model is described earlier in Chapter 4 and the value of time used to convert the monetary fare into equivalent time value for the PT assignment is described in **Table 7-A**.

7.1.1 Highway Assignment Method

Equilibrium Lohse was developed by Professor Lohse and described in "*Foundations of Traffic Engineering and Transportation Planning"*, Shnabel, W and Lohse, D 1997. The procedure, models the learning process of drivers in the road network. Starting from an "all or nothing "assignment, drivers make use of information gained in their previous trips for the choice of their new route. Several shortest paths are searched interactively in which the route search impedance is deduced from the impedance of the current volume and the previously estimated impedance.

During the first iteration only the free flow network impedances are considered and this corresponds to a 100% best-route assignment. The calculation of the impedance, in subsequent iterations, is carried out using the current mean impedances calculated so far, and the impedances resulting from the current volume. The assignment of the OD matrix to the network corresponds to how many times the route was found ("kept in mind" by the model). The procedure only terminates when the estimated times underlying the route choice and the travel times resulting from these routes coincide to sufficient degree. It is shown that this stable state of traffic network corresponds to the drivers' route choice behaviour.

The Lohse assignment model used is summarised in **Table 7-E** below:

Steps	Description
Input	Upper and lower threshold of delta: $\Delta upper$ and $\Delta lower$ for the f(TT) function: V1, V2,V3 Termination conditions: maximum number of iterations ($N_{\max}$); E1, E2, E3 the max. deviation E of the impedance
Route search	Determination of shortest route R_n for all OD pairs on impedance If route R_n is new route, $Count_r = 1$ If route R_n already exists as route$_r$: $Count_r = Count_r + 1$
Route volumes	Determine volumes for all routes for any i-j pair as follows: Route volume $Vol_r = (F_{ij}/n) \cdot Count_r$
Impedance determination	$\text{Im}\, p_n$ = impedance at current volume n $\text{Im}\, p^*_{n-1}$ = previously estimated impedance $TT_n = \left\lvert \text{Im}\, p_n - \text{Im}\, p^*_{n-1} \right\rvert / \text{Im}\, p^*_{n-1}$ $f(TT_n) = V1/(1 + e^{V2 - V3\, x\, TT_n})$ $\Delta_n = \Delta lower + \dfrac{\Delta upper - \Delta lower}{(1 + TT_n)^{f(TT_n)}}$ $\text{Im}\, p^*_n = \text{Im}\, p^*_{n-1} + \Delta_n \cdot (\text{Im}\, p_n - \text{Im}\, p^*_{n-1})$
Assignment Evaluation	n = $N_{\max}$ or for every link the following condition is achieved: $\left\lvert \text{Im}\, p_n - \text{Im}\, p^*_{n-1} \right\rvert < E = E1 \cdot \text{Im}\, p_{n-1}^{E2/E3}$

Table 7-E Lohse Highway Assignment Method

For Canterbury, the assignment model parameters were:

V1 = 2.5
V2 = 4.0
V3 = 0.002
$f(TT_n) = 2.5/(1 + e^{4 - 0.002\, x\, TT_n})$
$\Delta upper$ = 0.5,
$\Delta lower$ = 0.15, and
$N_{\max}$ = 30.

With the Lohse assignment, the distribution of flows onto alternative routes is good and this produces realistic and stable results.

7.1.2 Highway Convergence Criteria

In the VISUM model the detailed evaluation of junction performance is enabled by Intersection Capacity Analysis (ICA) which includes procedures from the Highway Capacity Manual (HCM). This is similar to the junction capacity relationship in the Transport Research Laboratory (TRL) research.

VISUM highway model convergence is based on the following four pre-defined criteria that result in the termination of the loop:

- The turn volumes from the last assignment are close to those from the previous assignment;
- The turn volumes of the last assignment match closely the last smoothed volumes (weighted average) which is the input for ICA at each iteration;
- The final delays of the assignment and those obtained from the ICA are close, i.e. ICA produces delays that are consistent with the assignment result;
- The last assignment must have converged.

The indicators listed in **Table 7-F** below are used to assess the overall performance of the model assignment.

Type of Indicator	Indicator Definition	Criteria
Global Stability	Difference in total travel time, travel distance, travel cost or average travel cost or average speed between successive iterations	None specified
Disaggregate Stability	An average absolute difference in link flows between successive iterations **AAD** = $1/N \sum [V_a^{n} - V_a^{n-1}]$ for a = 1 to N where: N = number of links V_a^{n} = flow on link a in iteration n	< 1 vehicle per hour
	Relative average absolute difference in link flows between successive iterations: **RAAD** = $1/N \sum\{ [V_a^{n} - V_a^{n-1}] / V_a^{n-1} \}$ for a = 1 to N	< 1%
	% Flow, the proportion of links in the overall network with flows changing less than 5% from the previous iteration.	>95%
Proximity (only for equilibrium models and their deterministic extensions)	The most appropriate indicator is the duality gap, 5, which is defined as the percentage difference between the total network cost estimates as determined by the current flow pattern, and the costs on the minimum cost routes as calculated for the next all or nothing assignment. **δ** $= \sum Ca(V_a^{n})(V_a^{n} - F_a^{n+1}) / \sum F_a^{n+1} Ca(V_a^{n})$ for all 'a'. where: $Ca(V_a^{n})$ = costs of link 'a' based on current flow estimates V_a^{n}. F_a^{n+1} = all or nothing flow based on $Ca(V_a^{n})$	< 1%

Table 7-F Convergence Criteria

The results of the final iteration, by demand segment, are summarised in **Table 7-G** and **Table 7-H** below for the AM and PM peak models respectively. In both cases the model assignments satisfy the convergence criteria.

Criteria		HBWC	HBOC	NHBOC	EBC	HBED	LGV	HGV
MEAN ABSOLUTE VOLUME DIFFERENCE	<1vph	0.00000001	0	0	0	0	0	0
SHARE VOLUME DIFFERENCE LESS 5%	>0.95	1	1	1	1	1	1	1

Table 7-G AM Highway Assignment – Final Iteration

Criteria		HBWC	HBOC	NHBOC	EBC	HBED	LGV	HGV
MEAN ABSOLUTE VOLUME DIFFERENCE	<1vph	0.00000018	0.00000004	0.00000001	0.00000001	0.00000003	0.00000002	0
SHARE VOLUME DIFFERENCE LESS 5%	>0.95	1	1	1	1	1	1	1

Table 7-H PM Highway Assignment – Final Iteration

7.2 Public Transport Assignment

The Public Transport Model (PuT) is based on a frequency based assignment within the VISUM package, which is derived from the timetables coded in the model.

Two types of impedances are derived from generalised costs for the public transport assignment; the search impedance (***SearchImp***) and the connection impedance (***Imp***). The search impedance differs from the impedance used in the connection choice procedure.

The search impedance is used to determine the possible connections available in the PT network. The connection impedance is used for the distribution of the demand over possible connections found in the connection search process. The search uses impedance which takes into account journey time plus the number of transfers and fares.

7.2.1 Public Transport Model Attributes

The performance of the converged PT model is summarised using the performance indicators listed in **Table 7-I** below.

AM PT Model Attribute	Description	Converged Model Summary
MEANTRANSFERWAITTIMEPUT	Transfer-wait time (h:m:s)	1min 10s
MEANORIGINWAITTIMEPUT	Origin wait time (h:m:s)	19min 20s
MEANWALKTIMEPUT	Walk time (h:m:s)	22min 24s
MEANACCESSTIMEPUT	Access time (h:m:s)	7min 44s

MEANEGRESSTIMEPUT	Egress time (h:m:s)	2min 9s
MEANPERCEIVEDJOURNEYTIMEPUT	Perceived journey time (h:m:s)	1h 23min 7s
MEANJOURNEYDISTPUT	Journey distance (kms)	14.944
MEANRIDEDISTPUT	Ride distance (kms)	11.69
MEANDIRECTDISTPUT	Direct distance (kms)	9.174
MEANJOURNEYSPEEDPUT	Journey speed (kph)	12
MEANINVEHSPEEDPUT	In vehicle speed (kph)	29
MEANDIRECTDISTSPEEDPUT	Direct distance speed (kph)	7
MEANNUMTRANSFERSPUT	Number of transfers	0.1
TOTALJOURNEYTIMEPUT	Total journey time (h:m:s)	7460h 18min 59s
TOTALRIDETIMEPUT	Total ride time (h:m:s)	4634h 35min 52s
TOTALINVEHTIMEPUT	Total in vehicle time (h:m:s)	2356h 23min 8s
TOTALTRANSFERWAITTIMEPUT	Total transfer time (h:m:s)	112h 12min 52s
TOTALORIGINWAITTIMEPUT	Total origin wait time (h:m:s)	1870h 58s
TOTALWALKTIMEPUT	Total walk time (h:m:s)	2165h 59min 52s
TOTALACCESSTIMEPUT	Total access time (h:m:s)	747h 42min 20s
TOTALEGRESSTIMEPUT	Total egress time (h:m:s)	207h 59min 49s
TOTALPERCEIVEDJOURNEYTIMEPUT	Total perceived journey time (h:m:s)	8038h 11min 44s
TOTALJOURNEYDISTPUT	Total journey distance (kms)	86705.482
TOTALRIDEDISTPUT	Total ride distance (kms)	67826.129
TOTALDIRECTDISTPUT	Total direct distance (kms)	53231.077
TOTALNUMTRANSFERSPUT	Total number of transfers	827
PTRIPSUNLINKEDPUT	PT linked trips	6629
PTRIPSLINKEDTOT	Total PT passenger trips	5802

PM PT Model Attribute	Description	Converged Model Summary
MEANTRANSFERWAITTIMEPUT	Transfer-wait time (h:m:s)	35s
MEANORIGINWAITTIMEPUT	Origin wait time (h:m:s)	17min 22s
MEANWALKTIMEPUT	Walk time (h:m:s)	19min 9s
MEANACCESSTIMEPUT	Access time (h:m:s)	5min 7s
MEANEGRESSTIMEPUT	Egress time (h:m:s)	3min 35s
MEANPERCEIVEDJOURNEYTIMEPUT	Perceived journey time (h:m:s)	1h 9min 33s
MEANJOURNEYDISTPUT	Journey distance (kms)	13.362
MEANRIDEDISTPUT	Ride distance (kms)	10.423
MEANDIRECTDISTPUT	Direct distance (kms)	8.073
MEANJOURNEYSPEEDPUT	Journey speed (kph)	12
MEANINVEHSPEEDPUT	In vehicle speed (kph)	30
MEANDIRECTDISTSPEEDPUT	Direct distance speed (kph)	7

MEANNUMTRANSFERSPUT	Number of transfers	0.1
TOTALJOURNEYTIMEPUT	Total journey time (h:m:s)	11315h 16min 27s
TOTALRIDETIMEPUT	Total ride time (h:m:s)	6882h 3min 34s
TOTALINVEHTIMEPUT	Total in vehicle time (h:m:s)	3527h 12min 37s
TOTALTRANSFERWAITTIMEPUT	Total transfer time (h:m:s)	98h 4min
TOTALORIGINWAITTIMEPUT	Total origin wait time (h:m:s)	2953h 43min 46s
TOTALWALKTIMEPUT	Total walk time (h:m:s)	3256h 46min 56s
TOTALACCESSTIMEPUT	Total access time (h:m:s)	869h 52min 29s
TOTALEGRESSTIMEPUT	Total egress time (h:m:s)	609h 36min 37s
TOTALPERCEIVEDJOURNEYTIMEPUT	Total perceived journey time (h:m:s)	11830h 39min 11s
TOTALJOURNEYDISTPUT	Total journey distance (kms)	136373.916
TOTALRIDEDISTPUT	Total ride distance (kms)	106378.698
TOTALDIRECTDISTPUT	Total direct distance (kms)	82392.782
TOTALNUMTRANSFERSPUT	Total number of transfers	784
PTRIPSUNLINKEDPUT	PT linked trips	10990
PTRIPSLINKEDTOT	Total PT passenger trips	5770

Table 7-I AM and PM Public Transport Model Performance Indicators

7.3 Park & Ride Assignment

Park & Ride was modelled as a separate mode of travel. Park and Ride is a combination of car and bus modes travelling to the city centre from the external zones. The car leg of the journey to the Park & Ride site is modelled within the highway assignment model and the bus leg is processed within the bus model. Both car and public transport assignments were described earlier. A subroutine within VISUM was developed by Jacobs to transfer demand from the car to Park & Ride buses travelling to their final destination and to aggregate the journey costs. The choice for travelling by Park and Ride versus driving and parking in the city centre are dealt with within the mode choice model as is the choice of Park and Ride site.

8 Model Calibration

8.1 Network Checks

The network structure and integrity were confirmed using the inbuilt network checking facility within VISUM.

A sense check of the modelled network was also carried out based on a number of representative routes through the study area. The travel time and distance for a number of modelled paths between selected zones were compared with the output of an independent web based route finder program.

8.2 Highway Link Flow Calibration

In order to ensure that the model accurately reflects the current travel situation within the study area, 2008 cordon traffic count data were used to refine the matrices. Refer to **paragraph 5.7** for further details.

The Department for Transport sets various criteria to be met before a transport model can be said to be representing base year conditions to an acceptable standard. These criteria for highway traffic are set out in the Highway Agency's Design Manual for Roads and Bridges (DMRB).

For the highway traffic flow calibration to be acceptable, the guidelines suggest that the model outputs should meet the following statistical values.

- Over 85% of modelled flows are required to have a GEH value of less than 5.0 for individual flows and
- Over 85% of modelled flows are required to have a GEH value of 4.0 or less for screenline totals.

The GEH value is a form of the CHI-squared statistic and shows the goodness of fit between modelled and observed data. It is defined as:

$$GEH = \sqrt{\frac{(M-C)^2}{0.5(M+C)}}$$

Where M is the modelled flow and C is the observed flow.

In addition DMRB suggest at least 85% of modelled flows should also meet the requirements set out below:

- Individual flows within 15% for flows of 700-2700 vehicles per hour.
- Individual flows within 100 vehicles per hour for flows <700 vehicles per hour.
- Individual flows within 400 vehicles per hour for flows >2700 vehicles per hour.

The modelled flows were compared to observed data recorded at 18 sites forming inner and outer cordons for Canterbury.

The cordons shown in **Figure 8-1** are based on the annual monitoring sites and form screenlines around the inner and outer sectors of the City and provide a comprehensive measure of the performance of the model. The screenlines used are as follows:

- S1 Canterbury Inner Cordon
- S2 Canterbury Outer Cordon

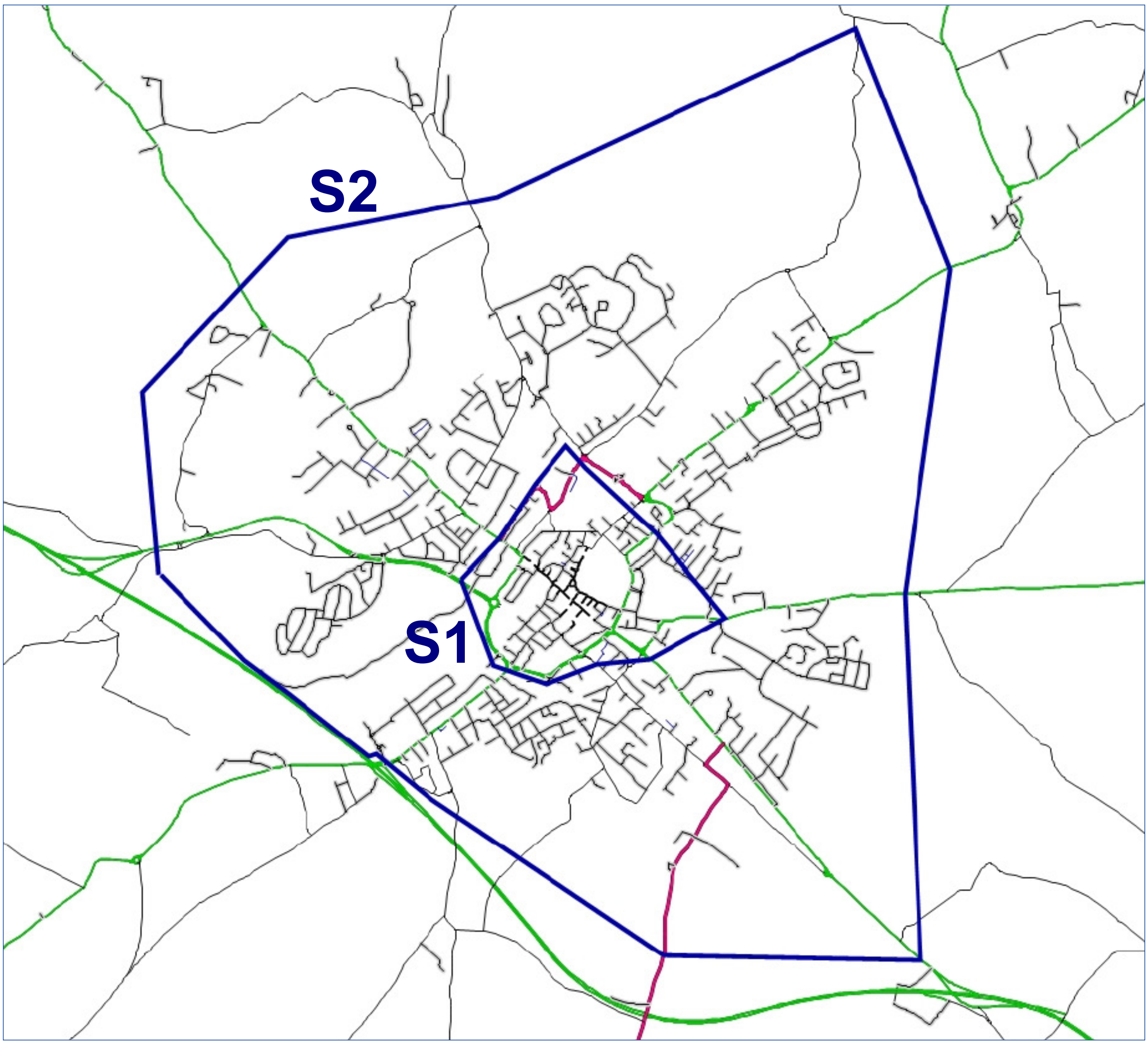

Figure 8-1 Highway calibration cordons

DMRB guidance also recommends that all or nearly all screenlines used should have total modelled flows within 5% of the observed flow as well as a GEH value of less than 4 as already mentioned above.

The screenline calibration for the AM and PM models is summarised in **Table 8-A** and in **Table 8-B** below. The model matches the counts for both peaks to a high standard and passes the DMRB criteria.

						DMRB Criteria	
Screenline	Direction	Observed Flow	Modelled Flow	% Diff	GEH	Flows	GEH<4
S1	Inbound	7087	7197	2%	1	Pass	Pass
Canterbury Inner Cordon	Outbound	5711	5638	-1%	1	Pass	Pass
S2	Inbound	8758	9043	3%	3	Pass	Pass
Canterbury Outer Cordon	Outbound	4184	4320	3%	2	Pass	Pass

Table 8-A Screenline Summary - AM Peak

						DMRB Criteria	
Screenline	Direction	Observed Flow	Modelled Flow	% Diff	GEH	Flows	GEH<4
S1	Inbound	5621	5945	6%	4	Fail	Pass
Canterbury Inner Cordon	Outbound	6743	6736	0%	0	Pass	Pass
S2	Inbound	8758	9043	3%	3	Pass	Pass
Canterbury Outer Cordon	Outbound	4184	4320	3%	2	Pass	Pass

Table 8-B Screenline Summary - PM Peak

Details of each modelled and observed flow by individual link location are given in **Appendix A -** .

8.3 Public Transport and Park & Ride Calibration

The public transport models including Park & Ride were developed directly from survey origin and destination data and did not use synthetic data. The exception was buses which were partly derived from synthetic data and more logic checks were therefore undertaken for this mode.

In order to test the validity of the public transport and Park and Ride models assigned flows must be compared with observed counts. Even where rail and Park & Ride demand is directly built from origin and destination surveys the demand in the model is free to choose which service or station to use from the assignment. Comparing the model flows at each location with observed counts the model validity can be assessed. This is described in **Chapter 9**.

9 Model Validation

9.1 Highway Model Validation

Following the development of the highway network and matrices the traffic assignment was assessed against an independent set of observed traffic flow and journey time data. In this chapter the DMRB criteria for journey time validation will be described.

9.1.1 Link Flows

Besides the key inner and outer Canterbury cordon screenline link flow calibration already discussed in **Chapter 8**, modelled flows were also compared with an independent set of traffic counts around the study area. **Table 9-A** and **Table 9-B** show the validation of the model for the AM and PM peak respectively along the strategic links around Canterbury namely the A2 and the A299 Thanet Way. In addition 29 random sites spread around the City where count information was available were also used for independent validation of the model (**Table 9-C**). The independent validation sites for the AM and PM peaks met the validation criteria. This is summarised in **Appendix B -** . All the various count locations across the study area were shown in **Figure 3-1**.

The results in the tables below generally show a good standard of independent flow validation of the highway model with a few exceptions. Note it is not expected for a model to have 100% of the flows passing the DMRB criteria for it to be an acceptable validated model as already discussed in Chapter 7.

						DMRB Criteria	
Location	Direction	ObservedFlow	ModelledFlow	% Diff	GEH	GEH<5	Flows
A2, Harbledown By-Pass	London-bound	1543	1649	7%	3	Pass	Pass
	Coast-bound	2546	2552	6	0	Pass	Pass
A2, A2050 – A28 Section	London-bound	967	830	-137	5	Pass	Pass
	Coast-bound	736	762	26	1	Pass	Pass
A2, Canterbury Bypass (A28 - B2068)	London-bound	1325	1230	-95	3	Pass	Pass
	Coast-bound	1359	1203	-156	4	Pass	Pass
A2, Bridge (A2050 - B2065)	London-bound	1869	1788	-81	2	Pass	Pass
	Coast-bound	1308	1315	7	0	Pass	Pass
Foxes Cross	London-bound	2103	2001	-102	2	Pass	Pass
	Coast-bound	1639	1651	12	0	Pass	Pass
A299 Thanet Way	London-bound	1809	1811	2	0	Pass	Pass
	Coast-bound	971	975	4	0	Pass	Pass

Table 9-A Strategic Link Flow Validation Sites – AM Peak

						DMRB Criteria	
Location	Direction	ObservedFlow	ModelledFlow	% Diff	GEH	GEH<5	Flows
A2, Harbledown By-Pass	London-bound	1961	2137	9%	4	Pass	Pass
	Coast-bound	1735	1922	11%	0	Pass	Pass
A2, A2050 – A28 Section	London-bound	782	750	-4%	1	Pass	Pass
	Coast-bound	822	782	-5%	0	Pass	Pass
A2, Canterbury Bypass (A28 - B2068)	London-bound	1162	1299	12%	4	Pass	Pass
	Coast-bound	1300	1547	19%	0	Fail	Fail
A2, Bridge (A2050 - B2065)	London-bound	1202	1220	2%	1	Pass	Pass
	Coast-bound	1899	2005	6%	0	Pass	Pass
Foxes Cross	London-bound	1492	1663	11%	4	Pass	Pass
	Coast-bound	2490	2749	10%	0	Fail	Pass
A299 Thanet Way	London-bound	1105	1154	4%	1	Pass	Pass
	Coast-bound	1897	1821	-4%	0	Pass	Pass

Table 9-B Strategic Link Flow Validation Sites – PM Peak

	No of Validation Sites	GEH<5	Flows
AM	29	100%	96.60%
PM	29	89.70%	93.10%

Table 9-C Independent Validation Sites – AM and PM peaks

9.1.2 Journey Time Validation

The journey time validation was based on the DMRB criteria which requires the modelled to be within 15% of the observed journey times (or 1 minute if more than 15%) for at least 85% of routes tested.

AM and PM peak modelled journey times have been compared with observed journey times for a total of 12 surveyed routes which extend across the highway network within the study area.

The journey time validation results for the AM and PM peak models are summarised in **Table 9-D** and **Table 9-E** respectively below. The tables show the results by direction for each of the 12 routes. The tables show the model matches the observed journey times to a high standard.

Routes 4 and 12 had rail level crossings as part of the journey route which can significantly affect journey times and even with the level crossing delays the model journey times validated quite well in these locations. For the AM peak 96% and PM peak 100% of the modelled journey times met the DMRB criteria. The DMRB target is 85% or more of the routes should be within the validation criteria and the results show that the model achieves this.

Route No.	Route Name	Direction	Observed (m:s)	Modelled (m:s)	Diff. (secs)	% Diff.	Observed Lower Limit (-15% or 1 min)	Observed Higher Limit (+15% or 1 min)	DMRB Criteria
1	Tyler Hill Route	SB	**10:56**	**10:03**	-53	-8%	12:34	08:33	OK
		NB	**11:30**	**11:28**	-2	0%	13:13	09:45	OK
2	Broad Oak Road	SWB	**11:52**	**12:08**	16	2%	13:38	10:19	OK
		NEB	**06:00**	**06:20**	20	6%	06:53	05:23	OK
3	A291	SB	**07:45**	**07:43**	-2	-1%	08:55	06:34	OK
		NB	**07:34**	**07:21**	-13	-3%	08:43	06:15	OK
4	Sturry Level Crossing	SB	**07:23**	**07:35**	12	3%	08:30	06:27	OK
		NB	**03:45**	**04:01**	16	7%	04:18	03:25	OK
5	A28 (Sturry Road)	SWB	**11:42**	**10:29**	-73	-10%	13:27	08:55	OK
		NEB	**06:26**	**05:36**	-50	-13%	07:24	04:46	OK
6	A251	WB	**08:10**	**09:28**	78	16%	09:24	08:03	Fail
		EB	**08:15**	**08:28**	13	3%	09:30	07:12	OK
7	A2050 (New Dover Road)	NWB	**07:54**	**07:36**	-18	-4%	09:05	06:28	OK
		SEB	**05:35**	**05:04**	-31	-9%	06:26	04:18	OK
8	Old Dover Road	NWB	**06:52**	**06:08**	-44	-11%	07:54	05:13	OK
		SEB	**07:09**	**08:00**	51	12%	08:13	06:48	OK
9	A28 (Wincheap)	NEB	**10:31**	**09:18**	-73	-12%	12:06	07:54	OK
		SWB	**04:51**	**04:55**	4	1%	05:34	04:11	OK
10	A2050 (Harbledown)	EB	**06:32**	**06:42**	10	3%	07:31	05:42	OK
		WB	**03:17**	**02:51**	-26	-13%	03:46	02:25	OK
11	A290	SB	**10:18**	**09:04**	-74	-12%	11:51	07:42	OK
		NB	**09:34**	**08:30**	-64	-11%	11:00	07:13	OK
12	St Dunstans and St Stephens Level Crossings	CW	**07:24**	**07:34**	10	2%	08:30	06:26	OK
		ACW	**06:04**	**06:39**	35	10%	06:58	05:39	OK
Percentage of routes meeting DMRB Criteria									**96%**

Table 9-D AM Peak Journey Time Validation

Route No.	Route Name	Direction	Observed (m:s)	Modelled (m:s)	Diff. (secs)	% Diff.	Observed Lower Limit (-15% or 1 min)	Observed Higher Limit (+15% or 1 min)	DMRB Criteria
1	Tyler Hill Route	SB	**10:12**	**09:54**	-18	-3%	11:44	08:25	OK
		NB	**10:20**	**11:05**	45	7%	11:53	09:25	OK
2	Broad Oak Road	SWB	**05:37**	**06:20**	43	13%	06:28	05:23	OK
		NEB	**04:56**	**04:49**	-7	-2%	05:40	04:06	OK
3	A291	SB	**07:25**	**07:41**	16	4%	08:32	06:32	OK
		NB	**08:49**	**09:05**	16	3%	10:09	07:43	OK
4	Sturry Level Crossing	SB	**03:58**	**04:34**	36	15%	04:34	03:53	OK
		NB	**06:08**	**05:18**	-50	-14%	07:03	04:30	OK
5	A28 (Sturry Road)	SWB	**05:40**	**05:43**	3	1%	06:32	04:52	OK
		NEB	**06:19**	**07:18**	59	16%	07:15	06:12	OK
6	A251	WB	**10:40**	**09:09**	-91	-14%	12:16	07:47	OK
		EB	**07:37**	**07:30**	-7	-2%	08:45	06:22	OK
7	A2050 (New Dover Road)	NWB	**06:25**	**05:36**	-49	-13%	07:23	04:46	OK
		SEB	**05:55**	**06:46**	51	14%	06:49	05:45	OK
8	Old Dover Road	NWB	**07:41**	**07:56**	15	3%	08:50	06:45	OK
		SEB	**05:05**	**05:51**	46	15%	05:51	04:58	OK
9	A28 (Wincheap)	NEB	**10:16**	**09:19**	-57	-9%	11:48	07:55	OK
		SWB	**05:37**	**06:33**	56	17%	06:27	05:34	OK
10	A2050 (Harbledown)	EB	**03:12**	**02:53**	-19	-10%	03:41	02:27	OK
		WB	**03:03**	**03:53**	50	27%	03:31	03:18	OK
11	A290	SB	**09:05**	**09:39**	34	6%	10:27	08:12	OK
		NB	**08:43**	**09:40**	57	11%	10:01	08:13	OK
12	St Dunstans and St Stephens Level Crossings	CW	**07:03**	**07:05**	2	1%	08:06	06:01	OK
		ACW	**06:38**	**05:43**	-55	-14%	07:38	04:52	OK
Percentage of routes meeting DMRB Criteria									**100%**

Table 9-E PM Peak Journey Time Validation

9.2 Public Transport Model

9.2.1 Bus Model Validation

Modelled bus patronage was compared with observed data available and is given as **Table 9-F**.

Bus Service	Observed patronage	Modelled patronage	Difference	% Diff	GEH
AM	7419	7485	-66	-1%	0.8
PM	5946	5770	413	7%	2.3

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Table 9-F Bus Patronage validation

These results show that the bus model is validated to an acceptable standard.

9.2.2 Rail Model Validation

The VISUM rail model will not be used for the detailed planning of rail services in East Kent, as this function is fulfilled by DfT / Network Rail with their own rail models. Therefore it is not essential that all the rail passengers in the East Kent area will be reflected in the model. Only rail passengers boarding or alighting at the Canterbury stations are present in the rail model which captures the full potential rail travel demand associated with the City.

Modelled rail passenger numbers using each of the three Canterbury stations have been compared with observed station alighting and boarding count passenger data. The modelled passenger numbers boarding and alighting at the key stations serving Canterbury East, Canterbury West and Sturry are mainly within 15% of the observed numbers with a maximum GEH value of 3.8. **Table 9-G** and **Table 9-H** show the AM and PM comparison respectively between modelled and observed for boarders and alighters at the three stations. The results demonstrate that the rail model is validated to an acceptable level for the key stations serving the City of Canterbury.

	Observed		Modelled		Difference		% Difference		GEH	
Station	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
Canterbury East	245	981	249	987	4	6	2%	1%	0.3	0.2
Canterbury West	328	552	263	539	-65	-13	-20%	-2%	3.8	0.6
Sturry	64	30	52	33	-12	3	-19%	10%	1.6	0.5
Total	637	1563	564	1559	-73	-4	-11%	0%	3.0	0.1

Table 9-G AM Peak Rail Passenger Validation

Station	Observed		Modelled		Difference		% Difference		GEH	
	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
Canterbury East	850	463	885	427	35	-36	4%	-8%	1.2	1.7
Canterbury West	547	467	518	405	-29	-62	-5%	-13%	1.3	3.0
Sturry	38	53	49	50	11	-3	29%	-6%	1.7	0.4
Total	1435	983	1452	882	17	-101	1%	-10%	0.4	3.3

Table 9-H PM Peak Rail Passenger Validation

9.2.3 Park & Ride Validation

Park & Ride is treated as a separate mode of travel in VISUM although in reality it is a combination of two standard modes being the private car and the bus.

There are three key Park & Ride stations in the City as follows:

- Wincheap
- Sturry Road
- New Dover Road

The Local Authority conducted car park surveys at the 3 Park & Ride sites in 2007 and counted the vehicles entering and leaving the Park & Ride sites. This data has been used to validate the Park & Ride mode and are shown in **Table 9-I** and **Table 9-J** for AM and PM peak respectively. The tables demonstrate that the Park & Ride model is able to replicate the observed counts using the Park & Ride sites to a high standard.

Park & Ride Site	Observed		Modelled		Difference		% Difference		GEH	
	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound
Wincheap	215	1	227	0	12	-1	6%	-100%	0.8	1.4
Sturry Road	267	1	266	0	-1	-1	0%	-100%	0.1	1.4
New Dover Road	345	1	328	0	-17	-1	-5%	-100%	0.9	1.4
Total	826	3	821	0	-5	-3	-1%	-100%	0.2	2.4

Table 9-I AM Peak Park & Ride Flow Validation

Park & Ride Site	Observed		Modelled		Difference		% Difference		GEH	
	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound
Wincheap	9	218	0	238	-9	20	-100%	9%	4.2	1.3
Sturry Road	9	292	0	285	-9	-7	-100%	-2%	4.2	0.4
New Dover Road	23	383	0	364	-23	-19	-100%	-5%	6.8	1.0
Total	41	893	0	887	-41	-6	-100%	-1%	9.1	0.2

Table 9-J PM Peak Park & Ride Flow Validation

10 Summary and Conclusions

A 2008 Base Year multi-modal VISUM travel demand model has been developed for the City of Canterbury and its environs. The model reflects a typical weekday peak period for the morning and evening peak conditions. A separate scoping study set out the rationale for the time periods modelled, with supporting data analysis, area coverage and the architecture of the model and should be read in conjunction with this report. The model study area also covers the satellite towns of Herne Bay and Whitstable although in less detail than Canterbury City. The model core study area also has links to other parts of Kent and beyond but in much less detail to reflect long distance travel. The model reflects total travel demand across the City and all modes of travel are modelled including highways (cars, LGV and HGV), bus, rail, and Park & Ride. The slow modes for walking and cycling are also taken into account in the demand modelling although this demand is not assigned to a network as this was not part of the model specification. The model however is set up that slow modes can be integrated and modelled in detail as with the other travel modes if the Local Authority wishes to incorporate this feature at a later date.

Travel demand has been segregated into 5 key journey purposes for the demand model to reflect different travel characteristics and is as follows:

- Home Base Work (HBW) – People travelling from home to work
- Home Base Other (HBO) – People travelling from home to destinations other than work mainly shopping, leisure etc.
- Home Base Education (HBED) - People travelling from home to education
- Non-Home Base Other (NHBO) - People travelling from non-home locations to destinations other than work mainly shopping, leisure and education
- Employers Business (EB) – People travelling to destinations on their employer's business. This latter option was not significant for users of public transport.

The supply side of the model is reflected by a highway and public transport network. The core characteristics of the network such as distances, speeds, junction layout and capacity, timetables etc were derived from various databases and from data held by the relevant transport authority. A considerable amount of the highway data was already held by Jacobs who are part of the Kent Highway Alliance, the Highway Authority for the study area. Some of the data like the rail timetables etc is publicly available on the internet.

The demand side of the model was developed from a variety of sources including surveys and various databases. As part of the study Jacobs conducted highway, rail and bus surveys to develop the demand but also used third party databases including the 2001 Census and Land Use data supplied by the Valuation Office. For the highways where demand was not observed it was derived synthetically with trip generation and distribution models. For buses the demand was developed from a combination of databases and surveys for the different journey purposes and included the 2001 Census, TEMPRO, School PLASC data, the National Travel Survey and Jacobs's bus surveys. Part of the bus demand was also synthetically derived with a calibrated gravity model. For rail and Park & Ride modes the demand was developed directly from surveys either carried out directly by Jacobs or from a Canterbury City Council car park survey in the case of the Park & Ride sites.

The highway model was calibrated and validated against traffic counts and journey times and the demand matrices were monitored and tightly controlled where matrix estimation was employed to ensure the demand changes were modest. For the public transport modes the model was validated against passenger count data at key locations for bus and rail whilst for the 3 Park & Ride sites vehicle count data at the entrance and exits to the car parks were validated. The model was measured against validation standards set by the DfT and was demonstrated to meet or exceed the minimum validation criteria set as evidence that the model is validated.

The model has been validated to a high standard and is now ready for model forecasting.

Appendix A - Highway Cordon Link Flow Validation Tables

AM inner cordon

SCREEN LINE 1 **Canterbury Visum**

Inbound

No	Site Id	Location	Observed	Modelled	Difference	% Difference	GEH	Criteria GEH<5	Flows
1	1a	Old Dover Road	629	726	97	15%	4	Pass	Pass
2	2a	A2050 New Dover Road	791	792	1	0%	0	Pass	Pass
3	3a	A257 Longport	705	779	74	10%	3	Pass	Pass
4	4a	A28 Military Rd	1068	1137	69	6%	2	Pass	Pass
5	45a	Kingsmead / Broadoak Rbt	635	649	15	2%	1	Pass	Pass
6	47a	St Dunstans St/Station Rd West Site 2	609	596	-13	-2%	1	Pass	Pass
7	8a	A2050 Rheims Way	1609	1617	8	0%	0	Pass	Pass
8	41a	Wincheap	1042	901	-141	-14%	5	Pass	Pass
		Inbound Total	**7087**	**7197**	**110**	**2%**	**1**	**Pass**	**Pass**

Outbound

No	Site Id	Location	Observed	Modelled	Difference	% Difference	GEH	Criteria GEH<5	Flows
9	1b	Old Dover Road	539	671	132	24%	5	Pass	Fail
10	2b	A2050 New Dover Road	646	584	-62	-10%	3	Pass	Pass
11	3b	A257 Longport	450	568	118	26%	5	Pass	Fail
12	4b	A28 Military Rd	950	822	-128	-13%	4	Pass	Pass
13	45b	Kingsmead / Broadoak Rbt	658	701	43	6%	2	Pass	Pass
14	47b	St Dunstans St/Station Rd West Site 2	373	372	-1	0%	0	Pass	Pass
15	8b	A2050 Rheims Way	1055	1020	-35	-3%	1	Pass	Pass
16	41b	Wincheap	1040	900	-140	-13%	5	Pass	Pass
		Outbound Total	**5711**	**5638**	**-73**	**-1%**	**1**	**Pass**	**Pass**

AM outer cordon

SCREEN LINE 2 Canterbury Visum

Inbound

No	Site Id	Location	Observed	Modelled	Difference	% Difference	GEH	Criteria GEH<5	Flows
17	11a	Shalloak Road Broad Oak	766	860	94	12%	3	Pass	Pass
18	12a	A28 Sturry Road	727	684	-43	-6%	2	Pass	Pass
19	13a	A257 Littlebourne Road	977	1063	86	9%	3	Pass	Pass
20	14a	A2050 New Dover Road -outer	1340	1299	-41	-3%	1	Pass	Pass
21	15a	Nackington Road	653	562	-91	-14%	4	Pass	Pass
22	62a	Hollow Lane	150	228	78	52%	6	Fail	Pass
23	23a	Wincheap - cityside of ten perch rd	860	865	5	1%	0	Pass	Pass
24	53a	A2050 (A2(T) spur and Knight Avenue roundabout, Canterbury	1599	1837	238	15%	6	Fail	Pass
25	27a	Rough Comm	677	725	48	7%	2	Pass	Pass
26	31a	St Stephen / Tyler Hill	1009	920	-89	-9%	3	Pass	Pass
		Inbound Total	**8758**	**9043**	**285**	**3%**	**3**	**Pass**	**Pass**

Outbound

No	Site Id	Location	Observed	Modelled	Difference	% Difference	GEH	Criteria GEH<5	Flows
27	11b	Shalloak Road Broad Oak	170	173	3	2%	0	Pass	Pass
28	12b	A28 Sturry Road	578	582	4	1%	0	Pass	Pass
29	13b	A257 Littlebourne Road	417	477	60	14%	3	Pass	Pass
30	14b	A2050 New Dover Road -outer	487	450	-37	-8%	2	Pass	Pass
31	15b	Nackington Road	289	330	41	14%	2	Pass	Pass
32	62b	Hollow Lane	127	123	-4	-3%	0	Pass	Pass
33	23b	Wincheap - cityside of ten perch rd	705	607	-98	-14%	4	Pass	Pass
34	53b	A2050 (A2(T) spur and Knight Avenue roundabout, Canterbury	700	877	177	25%	6	Fail	Pass
35	27b	Rough Comm	469	468	-1	0%	0	Pass	Pass
36	31b	St Stephen / Tyler Hill	242	233	-9	-4%	1	Pass	Pass
		Outbound Total	**4184**	**4320**	**136**	**3%**	**2**	**Pass**	**Pass**

PM inner cordon

SCREEN LINE 1 **Canterbury Visum**

Inbound

No	Site Id	Location	Observed	Modelled	Difference	% Difference	GEH	Criteria GEH<5	Flows
1	1a	Old Dover Road	357	427	70	19%	4	Pass	Pass
2	2a	A2050 New Dover Road	591	874	283	48%	10	Fail	Fail
3	3a	A257 Longport	436	550	114	26%	5	Fail	Fail
4	4a	A28 Military Rd	964	874	-90	-9%	3	Pass	Pass
5	45a	Kingsmead / Broadoak Rbt	740	709	-31	-4%	1	Pass	Pass
6	47a	St Dunstans St/Station Rd West Site 2	554	581	27	5%	1	Pass	Pass
7	8a	A2050 Rheims Way	967	972	5	1%	0	Pass	Pass
8	41a	Wincheap	1012	958	-54	-5%	2	Pass	Pass
		Inbound TOTAL	**5621**	**5945**	**324**	**6%**	**4**	**Pass**	**Pass**

Outbound

No	Site Id	Location	Observed	Modelled	Difference	% Difference	GEH	Criteria GEH<5	Flows
9	1b	Old Dover Road	552	591	39	7%	2	Pass	Pass
10	2b	A2050 New Dover Road	711	706	-5	-1%	0	Pass	Pass
11	3b	A257 Longport	689	592	-97	-14%	4	Pass	Pass
12	4b	A28 Military Rd	1142	1195	53	5%	2	Pass	Pass
13	45b	Kingsmead / Broadoak Rbt	720	637	-83	-12%	3	Pass	Pass
14	47b	St Dunstans St/Station Rd West Site 2	541	556	15	3%	1	Pass	Pass
15	8b	A2050 Rheims Way	1305	1458	153	12%	4	Pass	Pass
16	41b	Wincheap	1083	1001	-82	-8%	3	Pass	Pass
		Outbound TOTAL	**6743**	**6736**	**-7**	**0%**	**0**	**Pass**	**Pass**

PM outer cordon

SCREEN LINE 2 Canterbury Visum

Inbound

No	Site Id	Location	Observed	Modelled	Difference	% Difference	GEH	Criteria GEH<5	Flows
17	11a	Shalloak Road Broad Oak	220	179	-41	-19%	3	Pass	Pass
18	12a	A28 Sturry Road	585	660	75	13%	3	Pass	Pass
19	13a	A257 Littlebourne Road	364	433	69	19%	3	Pass	Pass
20	14a	A2050 New Dover Road -outer	483	358	-125	-26%	6	**Fail**	**Fail**
21	15a	Nackington Road	220	223	3	1%	0	Pass	Pass
22	62a	Hollow Lane	133	114	-19	-14%	2	Pass	Pass
23	23a	Wincheap - cityside of ten perch rd	648	799	151	23%	6	**Fail**	**Fail**
24	53a	A2050 (A2(T) spur and Knight Avenue roundabout, Canterbury	814	903	90	11%	3	Pass	Pass
25	27a	Rough Comm	393	303	-90	-23%	5	Pass	Pass
26	31a	St Stephen / Tyler Hill	286	274	-12	-4%	1	Pass	Pass
		Inbound TOTAL	**4146**	**4246**	**100**	**2%**	**2**	**Pass**	**Pass**

Outbound

No	Site Id	Location	Observed	Modelled	Difference	% Difference	GEH	Criteria GEH<5	Flows
27	11b	Shalloak Road Broad Oak	538	560	22	4%	1	Pass	Pass
28	12b	A28 Sturry Road	780	863	83	11%	3	Pass	Pass
29	13b	A257 Littlebourne Road	707	641	-66	-9%	3	Pass	Pass
30	14b	A2050 New Dover Road -outer	1144	1198	54	5%	2	Pass	Pass
31	15b	Nackington Road	456	554	98	22%	4	Pass	Pass
32	62b	Hollow Lane	164	130	-34	-21%	3	Pass	Pass
33	23b	Wincheap - cityside of ten perch rd	999	1075	76	8%	2	Pass	Pass
34	53b	A2050 (A2(T) spur and Knight Avenue roundabout, Canterbury	1155	1203	48	4%	1	Pass	Pass
35	27b	Rough Comm	622	661	40	6%	2	Pass	Pass
36	31b	St Stephen / Tyler Hill	739	636	-103	-14%	4	Pass	Pass
		Outbound TOTAL	**7303**	**7521**	**218**	**3%**	**3**	**Pass**	**Pass**

Appendix B - Other Highway Validation Sites

AM

Unique ID	Site Ref.	Data Ref.	Site Name	Observed Flow	Modelled Flow	Diff (Mod - Obs)	% Diff (Diff / Obs)	GEH	Criteria GEH<5	Criteria Flows
10	10a	Outer Cordon	C192 Tyler Hill	941	861	-80	-9	3	Pass	Pass
16	16a	Outer Cordon	A28 Thanington Road	889	995	106	12	3	Pass	Pass
65	65a	KCC ATC	Rough Common	446	501	56	12	3	Pass	Pass
43	43a	STUDY	Hackington Road	509	505	-4	-1	0	Pass	Pass
44	44a	STUDY	Thornden Wood Rd	326	358	32	10%	2	Pass	Pass
63	63a	PERM	Clapham Hill	739	717	-22	-3	1	Pass	Pass
17	17a	Outer Cordon	A2050 Harbledown	1562	1686	124	8	3	Pass	Pass
35	35a	STUDY	St Peters Place	632	689	57	9	2	Pass	Pass
36	36a	STUDY	Rheims Way (ringroad)	1939	2117	178	9	4	Pass	Pass
37	37a	STUDY	Pin Hill	1370	1534	164	12	4	Pass	Pass
38	38a	STUDY	Upper Bridge St	771	728	-43	-6	2	Pass	Pass
39	39a	STUDY	Broad St	832	727	-105	-13	4	Pass	Pass
57	57a	TRADS	WB, A2, Main Carriageway after Offslip	943	860	-83	-9	3	Pass	Pass
5	5b	Inner Cordon	Broad Oak Road	437	404	-33	-8	2	Pass	Pass
6	6b	Inner Cordon	St. Stephen's Road	323	373	50	15	3	Pass	Pass
10	10b	Outer Cordon	C192 Tyler Hill	267	201	-66	-25	4	Pass	Pass
16	16b	Outer Cordon	A28 Thanington Road	580	498	-82	-14	4	Pass	Pass
59	59b	DFT	A28 (A291 and A253	469	451	-18	-4	1	Pass	Pass
65	65b	KCC ATC	Rough Common	520	627	107	21%	4	Pass	Fail
43	43b	STUDY	Hackington Road	178	135	-43	-24	3	Pass	Pass
35	35b	STUDY	St Peters Place	768	800	33	4	1	Pass	Pass
36	36b	STUDY	Rheims Way (ringroad)	1541	1630	90	6	2	Pass	Pass
37	37b	STUDY	Pin Hill	1266	1322	56	4	2	Pass	Pass
38	38b	STUDY	Upper Bridge St	1113	1050	-63	-6	2	Pass	Pass
39	39b	STUDY	Broad St	1141	1197	57	5	2	Pass	Pass
40	40b	STUDY	Castle St	354	342	-12	-3	1	Pass	Pass
42	42b	STUDY	St Georges Place	837	919	82	10	3	Pass	Pass
49	49b	KCC MCC cordon	Military Rd (not A28)	410	424	15	4	1	Pass	Pass
50	50b	KCC MCC cordon	A28 Sturry Rd Canterbury	618	544	-74	-12	3	Pass	Pass

PM

					Node	Node		Flow	Flow	(Mod - Obs)	(Diff / Obs)		GEH<5	
5	5a	Inner Cordon	Broad Oak Road	ib	4224	4182	4224 4182	576	614	38	6.597222222	1.6	Pass	Pass
16	16a	Outer Cordon	A28 Thanington Road	ib	2475	8933	2475 8933	626	513	-113	-18	5	Pass	Fail
59	59a	DFT	A28 (A291 and A253	ib	7423	7403	7423 7403	518	440	-78	-15	4	Pass	Pass
43	43a	STUDY	Hackington Road	to Canterbury	2971	3012	2971 3012	241	162	-79	-33	6	Fail	Pass
44	44a	STUDY	Thornden Wood Rd	to Canterbury	3565	3125	3565 3125	64	158	94	147	9	Fail	Pass
63	63a	PERM	Clapham Hill	to Canterbury	1110	1114	1110 1114	412	357	-55	-1325%	3	Pass	Pass
66	66a	KCC ATC	A291	to Canterbury	5828	5824	5828 5824	396	454	58	15	3	Pass	Pass
18	18a	Outer Cordon	A290 Whitstable Road	ib	2605	2668	2605 2668	314	261	-53	-17	3	Pass	Pass
36	36a	STUDY	Rheims Way (ringroad)	acw	3619	3700	3619 3700	1389	1385	-4	-0	0	Pass	Pass
37	37a	STUDY	Pin Hill	acw	3776	3940	3776 3940	1027	1092	65	6	2	Pass	Pass
38	38a	STUDY	Upper Bridge St	acw	4136	8935	4136 8935	861	984	124	14	4	Pass	Pass
39	39a	STUDY	Broad St	acw	8889	4408	8889 4408	1093	1105	13	1	0	Pass	Pass
40	40a	STUDY	Castle St	sb	3743	3717	3743 3717	241	168	-73	-30	5	Fail	Pass
58	58a	TRADS	WB, A2, Offslip WB A2050	off	6138	5935	6138 5935	328	269	-59	-18	3	Pass	Pass
6	6b	Inner Cordon	St. Stephen's Road	ob	4003	3899	4003 3899	500	437	-63	-13	3	Pass	Pass
9	9b	Inner Cordon	A28 Wincheap	ob	3559	3446	3559 3446	698	712	14	2	1	Pass	Pass
16	16b	Outer Cordon	A28 Thanington Road	ob	8933	2475	8933 2475	754	788	34	4	1	Pass	Pass
59	59b	DFT	A28 (A291 and A253	ob	7403	7423	7403 7423	587	590	3	0	0	Pass	Pass
64	64b	KCC ATC	Beaconsfield Rd	nb	3667	3741	3667 3741	333	253	-80	-24	5	Pass	Pass
43	43b	STUDY	Hackington Road	to Whit/Herne Bay	3012	2971	3012 2971	427	388	-39	-908%	2	Pass	Pass
44	44b	STUDY	Thornden Wood Rd	to Whit/Herne Bay	3125	3565	3125 3565	248	191	-57	-23	4	Pass	Pass
36	36b	STUDY	Rheims Way (ringroad)	cw	3634	3595	3634 3595	1752	1649	-103	-6	2	Pass	Pass
37	37b	STUDY	Pin Hill	cw	3917	240009289	3917 240009289	1168	1166	-2	-0	0	Pass	Pass
38	38b	STUDY	Upper Bridge St	cw	4260	8931	4260 8931	878	745	-133	-15	5	Pass	Fail
39	39b	STUDY	Broad St	cw	4408	8889	4408 8889	1010	964	-46	-5	1	Pass	Pass
40	40b	STUDY	Castle St	nb	3717	3743	3717 3743	120	122	2	2	0	Pass	Pass
42	42b	STUDY	St Georges Place	eb	4301	4409	4301 4409	875	954	80	9	3	Pass	Pass
49	49b	KCC MCC cordon	Military Rd (not A28)	ob	4712	4757	4712 4757	160	129	-31	-20	3	Pass	Pass
50	50b	KCC MCC cordon	A28 Sturry Rd Canterbury	ob	4533	8904	4533 8904	778	743	-35	-4	1	Pass	Pass
7	7b	Inner Cordon	St. Dunstan's Street	ob	3689	3669	3689 3669	302	346	44	15	2	Pass	Pass