REGIONAL MODELLING SYSTEM

Modelling Services Framework

South East Regional Model

Road Model Development Report

Údarás Náisiúnta Iompair
National Transport Authority

CONTENTS

TABLES

FIGURES

Foreword

The NTA has developed a Regional Modelling System (RMS) for Ireland that allows for the appraisal of a wide range of potential future transport and land use alternatives. The RMS was developed as part of the Modelling Services Framework (MSF) by the National Transport Authority (NTA), SYSTRA and Jacobs Engineering Ireland.

The National Transport Authority’s (NTA) Regional Modelling System comprises the National Demand Forecasting Model, five large-scale, technically complex, detailed and multi-modal regional transport models and a suite of Appraisal Modules covering the entire national transport network of Ireland. The five regional models are focussed on the travel-to-work areas of the major population centres in Ireland, i.e. Dublin, Cork, Galway, Limerick, and Waterford.

The development of the RMS followed a detailed scoping phase informed by NTA and wider stakeholder requirements. The rigorous consultation phase ensured a comprehensive understanding of available data sources and international best practice in regional transport model development.

The five discrete models within the RMS have been developed using a common framework, tied together with the National Demand Forecasting Model. This approach used repeatable methods; ensuring substantial efficiency gains; and, for the first time, delivering consistent model outputs across the five regions.

The RMS captures all day travel demand, thus enabling more accurate modelling of mode choice behaviour and increasingly complex travel patterns, especially in urban areas where traditional nine-to-five working is decreasing. Best practice, innovative approaches were applied to the RMS demand modelling modules including car ownership; parking constraint; demand pricing; and mode and destination choice. The RMS is therefore significantly more responsive to future changes in demographics, economic activity and planning interventions than traditional models.

The models are designed to be used in the assessment of transport policies and schemes that have a local, regional and national impact and they facilitate the assessment of proposed transport schemes at both macro and micro level and are a pre-requisite to creating effective transport strategies.

1 Introduction

1.1 Regional Modelling System

The NTA has developed a Regional Modelling System for the Republic of Ireland to assist in the appraisal of a wide range of potential future transport and land use options. The Regional Models (RM) are focused on the travel-to-work areas of the major population centres of Dublin, Cork, Galway, Limerick, and Waterford. The models were developed as part of the Modelling Services Framework by NTA, SYSTRA and Jacobs Engineering Ireland.

An overview of the 5 regional models is presented below in both Table 1.1 and Figure 1.1.

Table 1.1 Regional Models and their Population Centres

Model Name	Standard Abbreviation	Counties
West Regional Model	WRM	Galway, Mayo, Roscommon, Sligo, Leitrim, Donegal
East Regional Model	ERM	Dublin, Wicklow, Kildare, Meath, Louth, Wexford, Carlow, Laois, Offaly, Westmeath, Longford, Cavan, Monaghan
Mid-West Regional Model	MWRM	Limerick, Clare, Tipperary North
South East Regional Model	SERM	Waterford, Wexford, Carlow, Kilkenny, Tipperary South
South West Regional Model	SWRM	Cork and Kerry

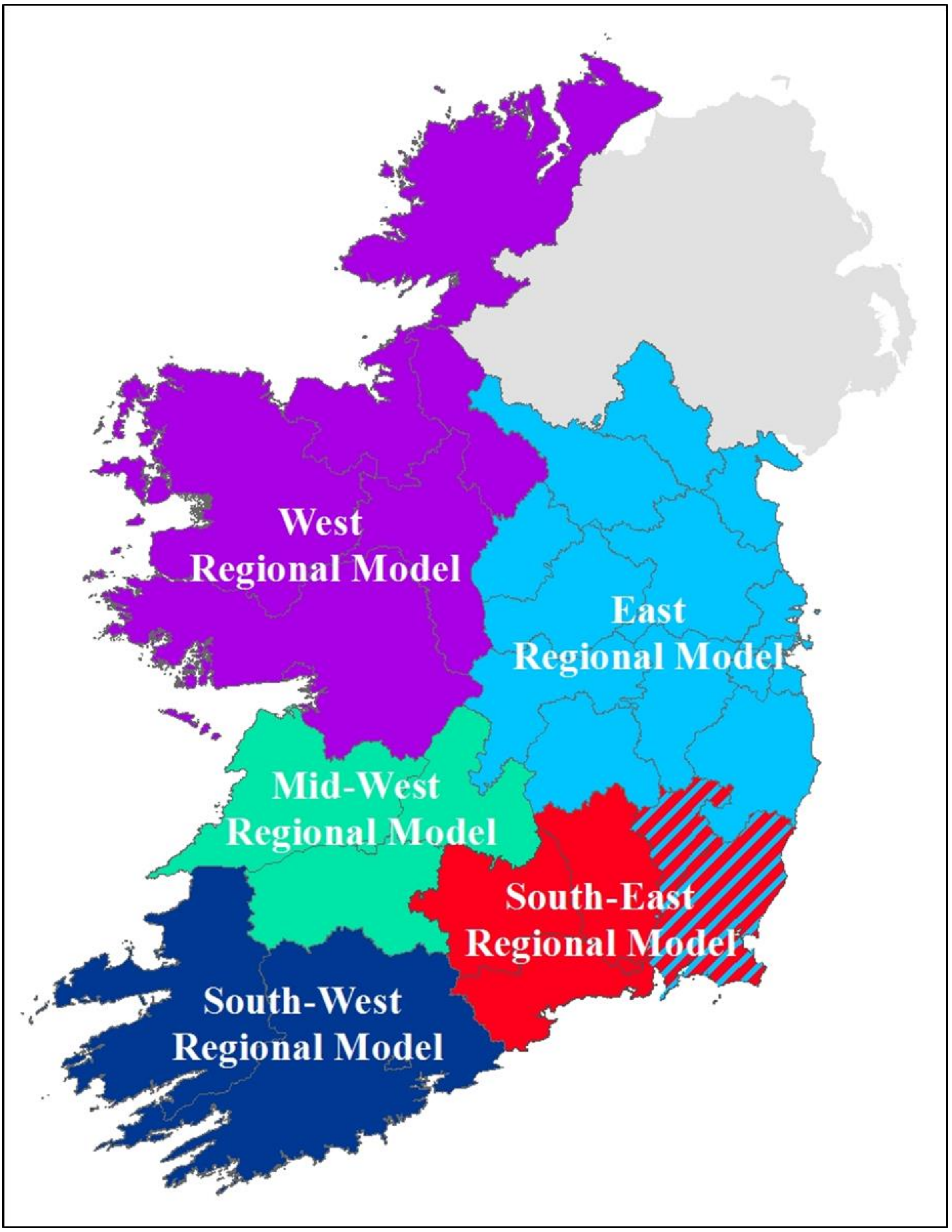

Figure 1.1 Regional Model Areas

1.2 Regional Modelling System Structure

The Regional Modelling System is comprised of three main components, namely:

- The National Demand Forecasting Model (NDFM);

- 5 Regional Models; and
- A suite of Appraisal Modules.

The modelling approach is consistent across each of the regional models. The general structure of the SWRM (and the other regional models) is shown below in Figure 1.2. The main stages of the regional modelling system are described below.

1.2.1 National Demand Forecasting Model (NDFM).

The NDFM is a single, national system that provides estimates of the total quantity of daily travel demand produced by and attracted to each of the 18,488 Census Small Areas. Trip generations and attractions are related to zonal attributes such as population, number of employees and other land-use data. See the NDFM Development Report for further information.

1.2.2 Regional Models (RM)

A regional model is comprised **of the following key elements:**

Trip End Integration

The Trip End Integration module converts the 24 hour trip ends output by the NDFM into the appropriate zone system and time period disaggregation for use in the Full Demand Model (FDM).

The Full Demand Model (FDM)

The FDM processes travel demand and outputs origin-destination travel matrices by mode and time period to the assignment models. The FDM and assignment models run iteratively until an equilibrium between travel demand and the cost of travel is achieved.

See the RMS Spec1 Full Demand Model Specification Report, RM Full Demand Model Development Report and SERM Full Demand Model Calibration Report for further information.

Assignment Models

The Road, Public Transport, and Active Modes assignment models receive the trip matrices produced by the FDM and assign them in their respective transport networks to determine route choice and the generalised cost for origin and destination pair.

The Road Model assigns FDM outputs (passenger cars) to the road network and includes capacity constraint, traffic signal delay and the impact of congestion. See the RM Spec2 Road Model Specification Report for further information.

The Public Transport Model assigns FDM outputs (person trips) to the PT network and includes the impact of capacity restraint, such as crowding on PT vehicles, on people’s perceived cost of travel. The model includes public transport networks and services for all PT sub-modes that operate within the modelled area. See the RM Spec3 Public Transport Model Specification Report for further information.

Secondary Analysis

The secondary analysis application can be used to extract and summarise model results from each of the regional models.

1.2.3 Appraisal Modules

The **Appraisal Modules** can be used on any of the regional models to assess the impacts of transport plans and schemes. The following impacts can be informed by model outputs (travel costs, demands and flows):

- Economy;
- Safety;
- Environmental;
- Health; and
- Accessibility and Social Inclusion.

Further information on each of the Appraisal Modules can be found in the following reports:

- Economic Module Development Report;
- Safety Module Development Report;
- Environmental Module Development Report;
- Health Module Development Report; and
- Accessibility and Social Inclusion Module Development Report.

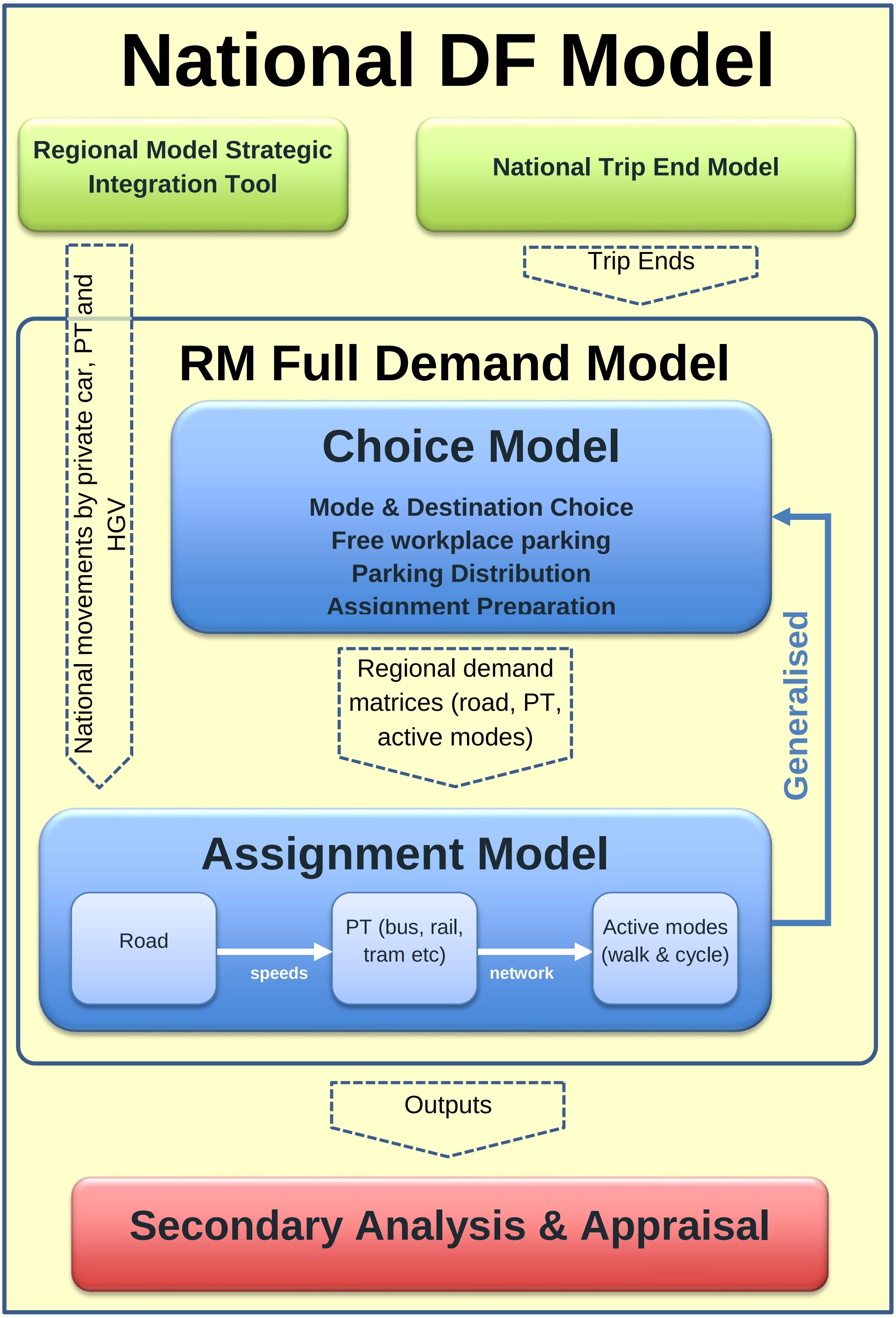

Figure 1.2 RMS Model Structure

1.3 SERM Road Model Overview

1.3.1 RMS Road Model Specification

The Regional Modelling System Road Model Specification Report (*RM Spec2 Road Model Specification Report*) was used as a guide for the development of the SERM Road Model. This specification report provides an overview with regard to:

- RMS Road Model Structure & Dimensions;
- RMS Road Network Development Approach;
- RMS Road Network Coding within SATURN;
- RMS Definition of Demand Segments for Road Model;
- RMS Road Model Assignment Methodology; and
- RMS Road Model Calibration & Validation Process.

1.3.2 Structure of RMS Road Model

Figure 1.3 provides an overview of the RMS Road Model (RM) structure. This shows the principal function of the RMS RM to represent the relationship between supply and demand through an assignment procedure and where data is an essential input to all elements of the model. This also shows the relationship with the RMS model components. The RM structure is the same for all five regional models.

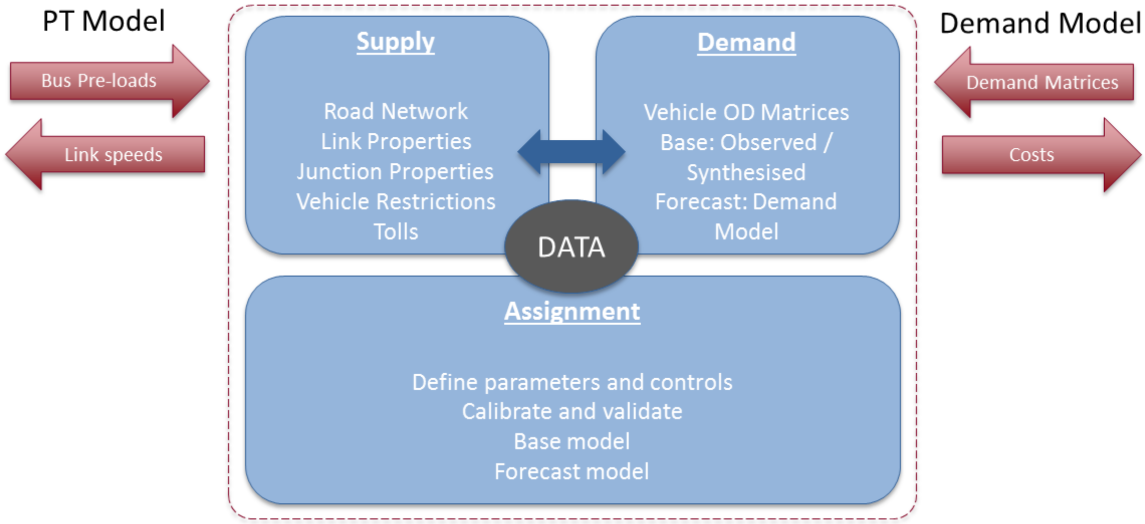

Figure 1.3 RMS RM Structure Overview

1.3.3 The Purpose of the Road Model

The purpose of the Road Model (RM) is to assign road users to routes between their origin and destination zones. The RM is sufficiently detailed to allow multiple routes between origins and destinations, and accurately model the restrictions of the available route choices.

Typical outputs from the RM that can be used directly for option development, design and appraisal include:

- Vehicle flows on links;
- Vehicle journey times along pre-defined routes; and
- Cost of travel for economic appraisal.

1.3.4 Linkages with Overall SERM

The development of the RM includes a number of inter-dependencies with other elements of the RMS. These linkages are discussed in later sections where relevant and can be summarised as follows.

- Inputs to the RM
  - Zone System, defining zonal boundaries for the RM;
  - Travel demand matrices provided by the FDM;
  - Pre-load bus volumes provided by the PT Model;
- Outputs from the RM
  - Provision of assigned RM network to PT Model; and
  - Provision of generalised cost skims to FDM.

1.3.5 SERM Zone System

The Road Model zone system is the same as the zoning system specified for the overall SERM as described in the “SERM Zone System Development Report”. The zone system has been designed to include 572 zones and is illustrated in Figure 1.4.

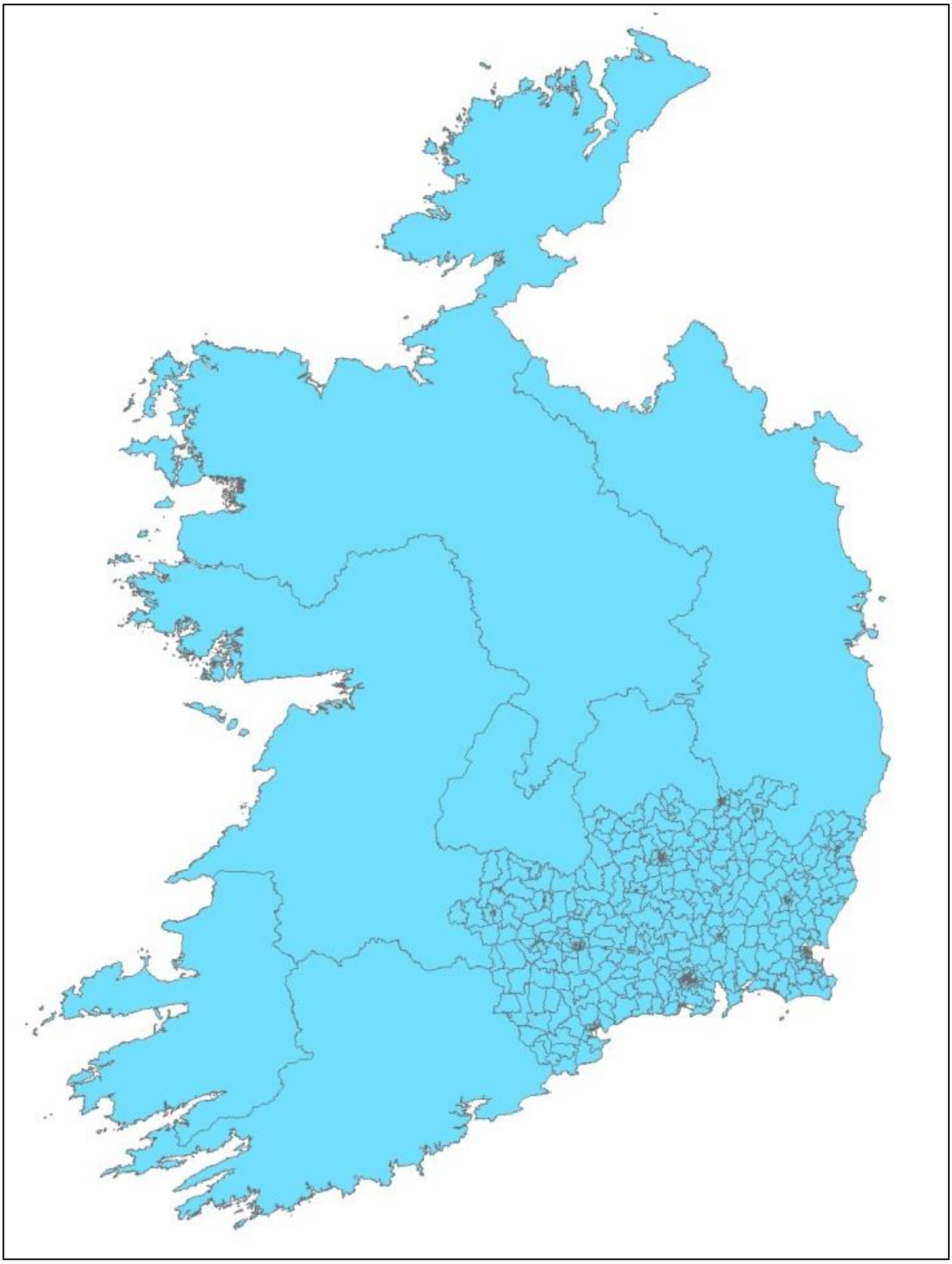

Figure 1.4 SERM Zone System

The key zone system statistics include:

- Total zones: 571;
    - Waterford City zones: 82;

- Waterford County zones: 70;
- Wexford County zones: 142;
- Kilkenny County zones: 118;
- South Tipperary County zones: 94;
- Carlow County zones: 57;
- External zones: 7; and
- Special Use Zones: 2.

This high level of zonal detail allows the road model to be modelled to a greater degree of accuracy. Increased zonal density in urban areas such as Waterford allows for the accurate representation of walk times for users wishing to access public transport. This allows the cost of travel by PT, and associated modal split, to be calculated with greater accuracy within the model.

1.3.6 Software

All demand and Public Transport model components are implemented in Cube Voyager version 6.4. SATURN version 11.2.05 is used for the Road Model Assignment. The main Cube application includes integration modules that are responsible for running SATURN assignments and performing the necessary extractions.

1.4 This Report

This report focuses on the Development, Calibration and Validation of the Road Model component of the South-East Regional Model (SERM). It includes the following chapters:

- **Section 2: Road Model Development:** This chapter provides information on the network dimensions, network development and initial assignment checks undertaken prior to calibration and validation;
- **Section 3: Matrix Development:** This chapter outlines the hierarchy of User Classes used in the SERM Road Model and describes the process of development of travel matrices for these User Classes prior to the model calibration process;
- **Section 4: Data Collation and Review:** This chapter outlines where the data used to calibrate and validate the SERM was sourced;
- **Section 5: Road Model Calibration:** This chapter details the process of calibration and assignment of the Road Model;
- **Section 6: Road model validation:** This chapter sets out the specification and execution of the Road Model validation process; and
- **Section 7: Conclusion and recommendations**: This chapter provides a summary of the development, calibration and validation of the Road Model. It also provides recommendations for future versions of the model.

2 Road Model Development

2.1 Introduction

Section 2 summarises the specification of the road model development process undertaken prior to calibration and validation.

2.2 SERM Road Network Development

2.2.1 Overview

The original SERM network was produced from HERE[1] using the methodology developed for the ERM, as outlined in "RD TN14 Network Development Task Report". The HERE GIS layer is provided in the "Irish National Grid" projection. Node and link data from the HERE GIS layer was also processed, taking the GIS information such as link speed, link length and number of connecting arms at junctions and converting this information into SATURN node coding. This skeleton network coding was then used as a foundation for the manual coding of each simulation junction in the highway model.

2.2.2 Node Coding Convention

Each node was manually coded in accordance with "SA TN11 Regional Model Coding Guide" to ensure consistency across the simulated model area, and consistency with the other regional models being developed. Node numbering followed the hierarchical node numbering system developed for the Regional Models, as described in "SA TN07 Regional Model Hierarchical Numbering System".

2.2.3 Zone Centroid Convention

Zone centroid connection points were defined and coded in accordance with "SA TN11 Regional Model Coding Guide". Centroid locations within the public transport model were identical to the road model.

2.2.4 Public Transport Service Files

The public transport lines files generated as part of the Public Transport Model Development task were converted into a SATURN pre-load file within Cube Voyager, which assigns a timetabled volume of buses to turns and links in the SATURN model. This file is referenced at the network build stage, and buses are pre-loaded on to the SATURN network before general traffic is assigned.

Where a bus lane exists, the buses will utilise the bus lane and not be affected by link congestion. If no bus lane is present buses will use regular road space at a

[1] HERE Maps (http://maps.here.com), originally Navigation Technologies Corporation (NavTeq) provides mapping, location businesses, satellite navigation and other services under one brand.

rate of one bus equals three passenger car units (PCU) and will be affected by link congestion. Other road users will subsequently be affected by the presence of the bus on the regular road space.

2.2.5 Vehicle Restrictions

Bus lanes adjacent to general traffic lanes are fully represented within the road model. Due to a limitation within SATURN in which taxis cannot use a bus lane, bus-only links have been coded as general traffic links in the road model, with a ban in place to all traffic with the exception of taxis.

In the rare instance where taxis are not permitted to use a bus-only link these links have been coded as traditional bus-only links in STAURN, designated with a negative saturation capacity.

Waterford City Council enforces a 3 Tonne weight limit on a number of roads in Waterford. These bans have been included in the model through the use of turning penalties for the affected user classes and include the following roads:

- Slevekeale Road;
- Lacken Road; and
- The Waterford Institute of Technology campus.

2.2.6 Tolling

There are several tolled roads within the SERM modelled area. These are:

- N25 Waterford City Bypass; and
- M7 / M8 Portlaois - Castletown / Portlaoise - Cullahill;

Tolling levels were taken from the Transport Infrastructure Ireland (TII) tolling information website[2].

The tolling levels are in 2012 prices, but are then factored to a cost base of 2011 to remain consistent with the calculated values of time.

2.2.7 Ferry Charges

There is a ferry charge between Passage East and Ballyhack. The ferry toll charge was also factored to a cost base of 2011 to remain consistent with the calculated values of time. The ferry crossing takes approximately 15 minutes and an additional boarding/departing penalty of five minutes was applied to the travel time of the link representing the ferry in the road model. The ferry charge value was obtained from Passage East Ferries.

2.2.8 Speed Flow Curves

Speed flow curves and mid-link capacities are specified in “SA TN11 Regional Model Coding Guide” and were implemented in the development of the supply

[2] http://www.tii.ie/roads-tolling/tolling-information/toll-locations-and-charges/

networks. Speed flow curves have only been applied in the area outside of Waterford City, including the buffer network.

During the network calibration and validation stage additional amendments to the speed flow relationships were made. These amendments include changing the capacity index of the curve applied on an individual link or making small changes to the shape (as defined by the power value), free-flow speed, speed at capacity or capacity per lane for a specific curve, which would be replicated across all links in the network with similar characteristics. Where a more significant change is deemed necessary, it is likely to be more appropriate to adopt an alternative speed flow relationship, for example after checking speed limit or road cross section.

In the SERM, speed flow curves have been applied to all buffer links and a number of radial routes outside the Waterford Outer Ring Road. Combining flow delay curves with simulated junction coding within congested urban areas can have the effect of double counting the delay experienced by traffic as they are delayed by the capacity of the link and the capacity of the junction. In an urban environment, delays are typically caused by junction capacity and not by link capacity. However, as there are very few junctions on the radial routes outside of the Waterford Outer Ring Road, it was considered appropriate to apply speed flow curves on these simulation links to more accurately reflect the relationship between traffic flows and journey times.

2.3 Assignment Model Preparation

2.3.1 Network Checking

A comprehensive set of network checks was undertaken before commencing calibration. These checks included:

- a range of semi-automated coding checks across the entire network, including saturation flows, free flow speeds, flares, etc;
- spot checking of junction coding;
- check that the right types of junctions are coded;
- check that all zones are connected;
- coded link distances versus crow-fly distance;
- observed traffic volumes versus coded and calculated capacity in SATURN; and
- Identification of largest delays;
- Route choice; and
- Traffic bandwidth plots.

2.3.2 Assignment Parameter Updating

The vehicle operating cost (Price Per Kilometre, PPK) and value of time (Price Per Minute, PPM) components were calculated based on model outputs using the methodology outlined in the Galway Interim Model Development report.

The calculated PPK, component takes the average simulated network speed as an input variable. Between model and matrix versions it is possible that the average network speed changes. Although changes in network speed will have a small impact on the calculated generalised cost components it is prudent to update the costs to reflect network performance on a regular basis during model development.

The calculated PPM component does not change with the average simulated network speed and is fixed for all assignments.

Although it is possible to adjust the PPK and PPM values to improve calibration of the road model, this is generally not undertaken as this may introduce an inconsistency with future year values of PPK and PPM which will have been calculated using the formulae used to calculate the base values.

3 Matrix Development

3.1 Overview

The unadjusted travel demand matrices derived from available data sources are referred to as prior matrices. Prior matrices were provided for the following user classes:

- User Class 1 - Taxi
- User Class 2 – Car Employer's Business
- User Class 3 – Car Commute
- User Class 4 – Car Education
- User Class 5 – Car Other
- User Class 6 – Light Goods Vehicles (LGV)
- User Class 7 – Other Goods Vehicle 1 (OGV1)
- User Class 8 – Other Goods Vehicle 2 (OGV2) Permit Holder
- User Class 9 – OGV2 Non Permit Holder

Prior matrices for all user classes were developed in accordance with "SERM Full Demand Model Calibration Report". These matrices are an essential input into the development of the Road Model.

3.2 Prior Matrix Factoring

The prior matrices (referred to in Section 3.1) represent travel demand over a three-hour period (e.g. 0700 – 1000). However, for assignment in the Road Model, SATURN requires a travel demand matrix that represents a single hour. Several methodologies are available to factor the three-hour travel demand matrix to a single hour, using a Period-to-Hour (PtH) factor.

Two common approaches to deriving this PtH factor are to divide the total matrix by the number of hours it represents in order to provide an average hourly travel demand matrix, or to factor the matrix to a specific hour, for example 0800 – 0900, using observed traffic count data.

A third methodology is to represent the "peak everywhere" by applying a single factor, derived from various data sources, with the aim of representing the worst traffic conditions at each point in the network simultaneously. ATC data was used to derive factors for the SERM in order to best represent the traffic conditions within Waterford, and is discussed further in the "FDM Scope3 Modelling Time of Travel" report. This factor represents the "flow" PtH factor, and the factors calculated from the ATC data are outlined in Table 3.1. These factors were applied to interim versions of the road model.

Table 3.1 SERM RM Initial Period to Assigned Hour Factors

Time Period	Period to Hour Factor
AM Peak (0700 – 1000)	0.409
Inter Peak 1 (1000 – 1300)	0.333
Inter Peak 2 (1300 – 1600)	0.333
PM Peak (1600 – 1900)	0.378
Off Peak (1900 – 0700)	0.083

The “demand” PtH factor is based on the Household Travel Diary and represents the proportion of all trips which take place within the peak hour. The “flow” PtH factors are generally lower than the “demand” factors as trips are travelling between a variety of origins and destinations and therefore pass the fixed observation points at different times. The result is that the flow profile is more evenly spread throughout the period compared to the demand profile.

The flow PtH factors were applied to all counts and, initially, to the assignment matrices. It was later recognised that, due to the way SATURN assigns trips to the network, the true PtH factor required to convert the 3-hour demand matrices into 1-hour assignment matrices is somewhere between the two factors. In practice there is no straightforward way to determine mathematically what the factor should be, prior to model calibration.

An iterative process was therefore required to vary the PtH factor within the upper and lower limits formed by the demand and flow PtH factors, until the overall level of demand matched the observed flows. The final PtH factors used in the SERM are outlined in Table 3.2.

Table 3.2 SERM RM Final Period to Assigned Hour Factors

Time Period	Period to Hour Factor
AM Peak (0700 – 1000)	0.443
Inter Peak 1 (1000 – 1300)	0.409
Inter Peak 2 (1300 – 1600)	0.441
PM Peak (1600 – 1900)	0.490
Off Peak (1900 – 0700)	0.083

3.3 Prior Matrix Checking

Comprehensive checks of the matrices were undertaken before commencing calibration. These checks included:

- Comparing matrix trip ends against NTEM outputs;
- Checking trip length distribution against observed data;
- Checking implied time period splits by sector-pair;
- Checking implied purpose splits by sector pair; and
- Comparing sectored matrices with total screen-line and cordon flows where possible.

These checks revealed no significant issues with the prior matrices. These matrices were then assigned to the current version of the road model at the time the matrices were produced.

4 Data Collation and Review

4.1 Supply Data

As described in the RMS RM Specification report, road link specification is based on the HERE GIS layer for the Republic of Ireland. The HERE data includes a number of data fields including: link lengths; road class; speed category; single / dual carriageway; and urban / rural characteristics.

This was used to create the initial network topology. The simulation area was then coded with reference to the agreed coding guide.

Based on guidelines established for ERM and described in "SA TN11 Regional Model Coding Guide", superfluous network detail was removed from the SERM road network (the development of the SERM road network pre-dated the finalisation of the ERM guidance).

Traffic signal stages and timing have been developed for Waterford City from:

- Observed signal time data, where available; and
- Proportional green time split based on observed traffic count if not available from SCATS.

4.2 Demand Data

4.2.1 Car Based Journeys

The Full Demand Model (FDM) processes the all-day travel demand from the National Trip End Model (NTEM) and outputs origin-destination travel matrices by mode and time period. These are then combined with matrices from the Regional Model Strategic Integration Tool (RMSIT) and passed to the appropriate assignment model to determine the route choice of the trips.

These matrices are calibrated against the POWSCAR[3] dataset and outputs of the NTEM. NTEM, which has been calibrated using the National Household Travel Survey 2012 (NHTS) travel diary data, provided origin and destination trip ends for each modelled time period for all other journey purposes and to corroborate with POWSCAR.

The sample sizes of the NHTS 2012 are too small to be used directly to calibrate matrices for individual zone to zone trip volumes. However, the NHTS can be used to estimate broader sector to sector totals, mode share, time of day profiles and time of day return factors.

[3] Place of Work, School, or College Census of Anonymised Records, part of the 2011 Census of Ireland

4.2.2 Goods Vehicles

Goods vehicles are comprised of the following classes of vehicles:

- Light Goods Vehicles (LGVs): up to 3.5 tonnes gross weight, for example transit vans.
- Other Goods Vehicles 1 (OGV1): rigid vehicles over 3.5 tonnes gross weight with two or three axles, for example tractors (without trailers) or box vans.
- Other Goods Vehicles 2 (OGV2): rigid vehicles with four or more axles, and all articulated vehicles.

For the purposes of the regional models, these three classes have been divided into two groupings with different trip characteristics, bulk goods and non-bulk goods.

Bulk Goods Trips are defined as trips between locations such as ports, airports, quarries, major industrial sites and distribution centres. These trips will be made regardless of the cost of travel. As with ERM, they have been assumed to be made mainly by OGV2, with a proportion of OGV1. Bulk Goods Trips have been derived from RMSIT, with the local distribution of trips to destinations other than ports, airports and similar locations based on NACE survey data relating to industrial activities. A 70/30 split was used to disaggregate the Bulk Goods matrices between OGV1 and OGV2

Non-Bulk Goods Trip Ends were estimated using linear regression based on factors estimated for ERM. These disaggregated between LGVs and OGV1 using an 84/16 split.

More detail on the goods vehicles matrices is given in FDM Scope12 Base Year Matrix Building”.

4.3 Count Data

There are between 6,000 and 7,000 road traffic survey data records nationwide, including manual classified counts, automatic traffic counts (ATC) and SCATS data, which were collated under the Data Collection task. The data was collated in 2014 and represents data from January 2009 to October 2013.

Figure 4.1 indicates the location of the traffic count data that was collated.

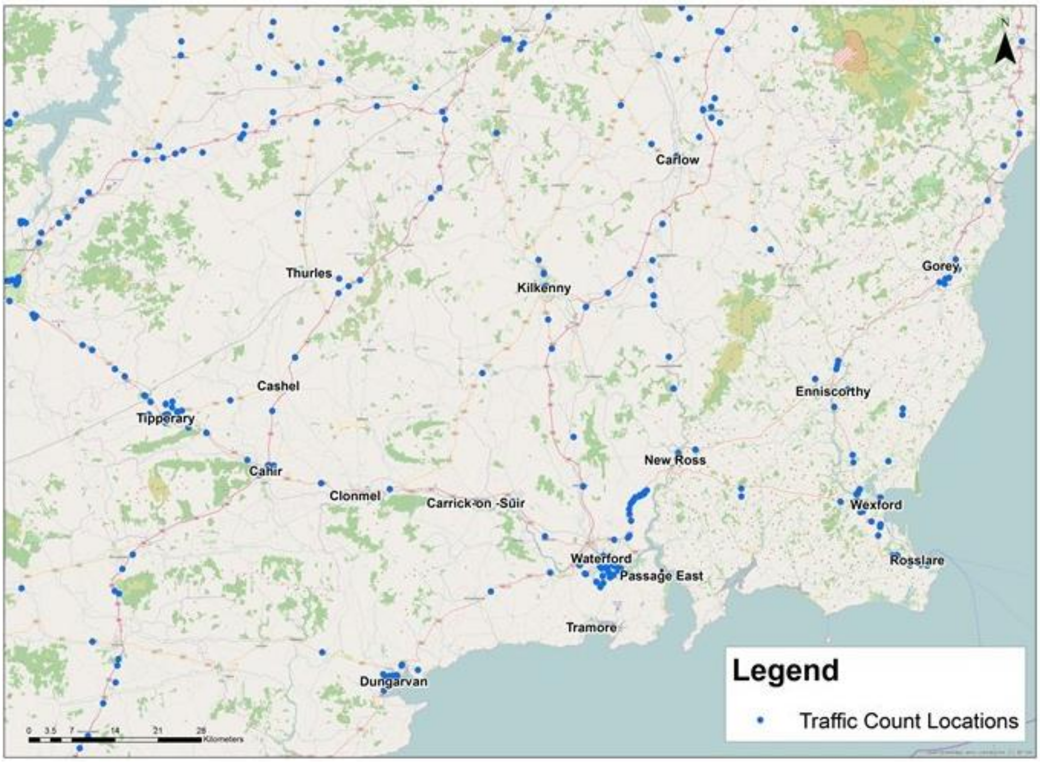

Figure 4.1 Location of Traffic Count Data

4.4 Journey Time and Queue Length Data

4.4.1 GPS-based Travel Time Data

The NTA purchased a license from TomTom[4] for their travel time product Custom Area Analysis (CAA). This product provides average travel time data on every road link within a given area over a specified time period. Details of the data acquisition and data processing are discussed in “MSF 011 TomTom Data Portal Guide” and “MSF 011 TomTom Data Extraction and Processing”.

The SERM uses 2012 TomTom journey time data on 11 routes inbound and outbound, totalling 22 journey times, to validate the model. There are three journey time categories that form a hierarchy of routes. Category 1 consists of the urban, national primary, motorway and arterial commuter. Category 2 comprises regional and secondary routes, while Category 3 includes inter urban routes between regional towns.

TomTom data is available in both directions in all time periods. Figure 4.2 and Table 4.1 indicate the routes and their description.

---

[4] http://trafficstats.tomtom.com

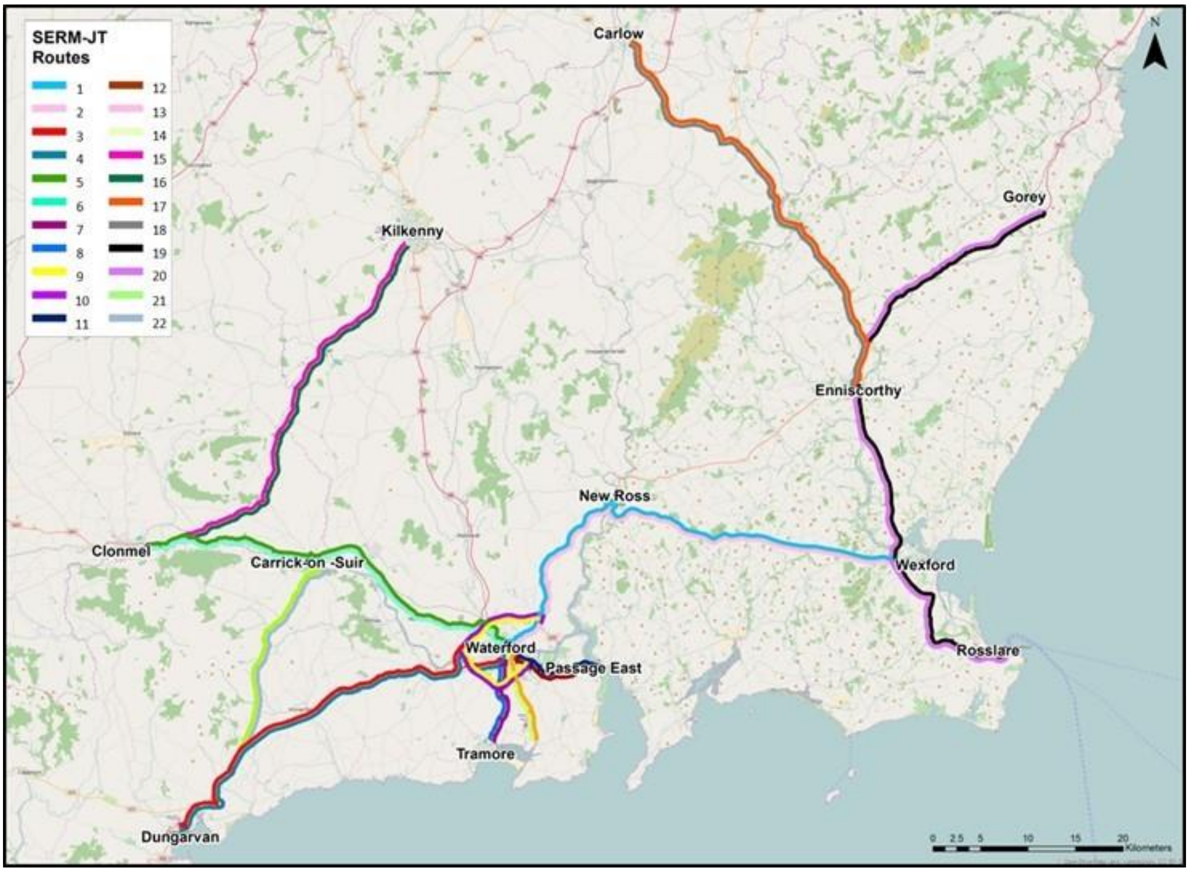

Figure 4.2 TomTom Journey Time Routes

Table 4.1 TomTom Journey Time Routes

Route	Description
1	Waterford to Wexford
2	Wexford to Waterford
3	Dungarvan to Waterford
4	Waterford to Dungarvan
5	Clonmel to Waterford
6	Waterford to Clonmel
7	Waterford to Tranmore
8	Tranmore to Waterford
9	Waterford Orbital Clockwise
10	Waterford Orbital Counter-Clockwise
11	Passage East to Waterford
12	Waterford to Passage East
13	Waterford to Kilmacleague
14	Kilmacleague to Waterford
15	Clonmel – Kilkenny
16	Kilkenny – Clonmel
17	Carlow to Enniscorthy
18	Enniscorthy to Carlow
19	Rosslare to Gorey
20	Gorey to Rosslare
21	Dungarvan to Carrick-on-Suir
22	Carrick-on-Suir to Dungarvan

Data is available at an hourly average level between 0700 and 1900, and at an average level for 1900 – 0700. The average travel times between 1900 and 0700 are split into two datasets, with a “quiet” off-peak covering 0100 – 0400 and the remainder of the off-peak (1900 – 0100 and 0400 – 0700) forming a second dataset.

Data was averaged over the neutral 2012 months of February, March, April, May, October and November, excluding weekends, public and school holidays within these months. This resulted in 112 days’ worth of observations which were averaged to form the TomTom travel time dataset. This number of observations is significantly in excess of what could normally be achieved through moving car observer type surveys, providing a more robust dataset.

The inbound and outbound direction for all routes is available and extracted in the AM (08:00 – 09:00), Inter-peak 1 (13:00 – 14:00), Inter-peak 2 (14:00 – 15:00) period, and PM peak period (17:00 – 18:00). A single hour of data was selected for the AM and PM peak periods after discussions with the NTA as this time period better represented the “peak” travel conditions across the network compared with alternative solutions, and aligned with the assignment model time periods and methods. An average time for Inter-peak 1 and Inter-peak 2 was also selected to align with the assignment model time periods and methods. This data was used to validate the final SERM road model.

4.4.2 Queue Length Data

Where available, queue length data was used to confirm that queuing occurs at the correct locations in the model network. However, owing to potential ambiguity regarding the definition of a queue in a survey and the definition of a queue within SATURN, no attempt was made to match the observed queue length in anything other than general terms.

5 Road Model Calibration

5.1 Introduction

This chapter sets out the specification and execution of the model calibration process. This includes the incorporation and application of matrix estimation.

5.2 Assignment Calibration Process

5.2.1 Overview

The assignment calibration process was undertaken for the assignment of the SERM RM and matrices through comparisons of model flows against observed traffic counts at:

- Individual links (i.e. link counts); and
- Across defined screen lines.

5.2.2 Calibration

Calibration is the process of adjusting the SERM RM to ensure it provides robust estimates of assignment and generalised cost before integrating it into the wider demand model. This is typically achieved in iteration with the validation of the model to independent data.

The UK's Department for Transport's Transport Analysis Guidance (TAG) unit M3-1 indicates that the assignment model may be recalibrated by one or more of the following means:

- Remedial action at specific junctions where data supports such as;
  - Increase or reduction in turn saturation capacity;
  - Adjustment to signal timings;
  - Adjustment to cruise speeds; and
- Adjustments to the matrix through matrix estimation as a last resort.

TAG indicates that the above suggestions are generally in the order in which they should be considered. However, this is not an exact order of priority but a broad hierarchy that should be followed. In all cases, any adjustments must remain plausible and should be based on a sound evidence base.

Calibration is broadly split into two components; matrix calibration and network calibration. Matrix calibration ensures the correct total volume of traffic is bound for certain areas through the use of sector analysis, while network calibration ensures the correct traffic volumes on distinct links (roads) within the modelled area. Table 5.1 outlines the matrix estimation change calibration criteria, as specified in TAG Unit M3-1, Section 8.3, Table 5.

Table 5.1 Significance of Matrix Estimation Changes

Measure	Significance Criteria
Matrix zonal cell value	Slope within 0.98 and 1.02; Intercept near zero; R^2 in excess of 0.95.
Matrix zonal trip ends	Slope within 0.99 and 1.01; Intercept near zero; R^2 in excess of 0.98.
Trip length distribution	Means within 5%; Standard Deviation within 5%.
Sector to sector level matrices	Differences within 5%

The comparison of the modelled vehicle flows also makes use of the GEH[5] summary statistic. This statistic is designed to be more tolerant of large percentage differences at lower flows. When comparing observed and modelled counts, focus on either absolute differences or percentage differences alone can be misleading when there is a wide range of observed flows. For example, a difference of 50 PCUs is more significant on a link with an observed flow of 100 PCUs than on one with and observed flow of 1,000 PCUs, while a 10 per cent discrepancy on an observed flow of 100 vehicles is less important than a 10 per cent mismatch on an observed flow of 1,000 PCUs.

The GEH Statistic is defined as:

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

Where, GEH is the Statistic, M is the Modelled Flow and C is the Observed Count.

Table 5.2 outlines the link calibration criteria as set out in TAG Unit M3-1, Section 3.2, Table 2.

[5] Developed by Geoffrey E. Havers (GEH)

Table 5.2 Road Assignment Model Calibration Guidance Source

Criteria	Acceptability Guideline
Individual flows within 100 veh/h of counts for flows less than 700 veh/h	> 85% of cases
Individual flows within 15% of counts for flows from 700 to 2,700 veh/h	> 85% of cases
Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h	> 85% of cases
GEH < 5 for individual flows	> 85% of cases

Table 5.3 outlines the screenline calibration criteria as set out in TAG Unit M3-1, Section 3.2, Table 3.

Table 5.3 Road Assignment Model Screenline Calibration Guidance Sources

Criteria	Acceptability Guideline
Differences between modelled flows and counts should be less than 5% of the counts	All or nearly all screenlines

5.3 Initial Generalised Cost Parameters

The Initial generalised cost parameters applied were taken from the ERM as a starting point. This formed the basis for the first steps of model development. The initial generalised cost parameters are set out in the following four tables. The generalised cost parameters have a base year of 2011 to remain consistent with the other model components and input values.

Table 5.4 Initial AM Generalised Cost Values

User Class	Cents Per Minute	Cents Per Kilometre
UC1 – Taxi	58.82	17.58
UC2 – Car Employers Business	58.82	17.58
UC3 – Car Commute	21.70	9.29
UC4 – Car Education	42.82	9.29
UC5 – Car Other	21.09	9.29
UC6 – LGV	43.34	12.74
UC7 – OGV1	46.08	28.33
UC8 – OGV2 Permit Holder	44.40	51.84
UC9 – OGV2 (Other)	44.40	51.84

Table 5.5 Initial IP1 Generalised Cost Values

User Class	Cents Per Minute	Cents Per Kilometre
UC1 – Taxi	58.82	17.58
UC2 – Car Employers Business	58.82	17.58
UC3 – Car Commute	21.70	9.29
UC4 – Car Education	42.82	9.29
UC5 – Car Other	21.09	9.29
UC6 – LGV	43.34	12.74
UC7 – OGV1	46.08	28.33
UC8 – OGV2 Permit Holder	44.40	51.84
UC9 – OGV2 (Other)	44.40	51.84

Table 5.6 Initial IP2 Generalised Cost Values

User Class	Cents Per Minute	Cents Per Kilometre
UC1 – Taxi	52.96	16.51
UC2 – Car Employers Business	52.96	16.51
UC3 – Car Commute	21.55	8.85
UC4 – Car Education	27.83	8.85
UC5 – Car Other	24.38	8.85
UC6 – LGV	45.91	13.20
UC7 – OGV1	46.08	28.33
UC8 – OGV2 Permit Holder	44.40	51.84
UC9 – OGV2 (Other)	44.40	51.84

Table 5.7 Initial PM Generalised Cost Values

User Class	Cents Per Minute	Cents Per Kilometre
UC1 – Taxi	60.02	16.36
UC2 – Car Employers Business	60.02	16.36
UC3 – Car Commute	21.42	8.67
UC4 – Car Education	43.76	8.67
UC5 – Car Other	27.49	8.67
UC6 – LGV	43.34	12.09
UC7 – OGV1	46.08	25.98
UC8 – OGV2 Permit Holder	44.40	47.54
UC9 – OGV2 (Other)	44.40	47.54

5.4 Road Model Network Progression

5.4.1 Overview

In total there were four iterations of the network data files used during the creation of the pre-assignment SATURN network (UFN). Each iteration consisted of an update to the network coding for the four assigned peak periods (AM, Inter-peak 1, Inter-peak 2 and PM) with the coding for Inter-peak 1 being replicated for the Off-peak networks.

The main checks undertaken and adjustments made during the network development stage are outlined in the following sections.

5.4.2 RMS Rationalisation

Several Regional Models were being developed in parallel, with the ERM informing many model alterations during the development cycle. Many of these changes were related to assignment parameters which did not materially affect the assigned traffic volumes or patterns, but did ensure a consistently converged solution. The two changes with the largest effect as a result of developments on other Regional Models were the changes to the average PCU length, controlled by the parameter ALEX in SATURN, and the changes to the generalised cost assignment parameters.

5.4.3 Increase in Average PCU Length (SATURN Parameter ALEX)

The average PCU length parameter in SATURN, ALEX, was set to the default value of 5.75m as used in the 2006 Base version of the GDA model, and remained consistent at this level during the network development tasks. Further analysis by the NTA, including visual reviews of several aerial / satellite photographs suggested that the average PCU length has increased in recent years and is closer to 5.95m in length. The ALEX parameter was subsequently revised to 5.95 based on this recent research.

The increase in the average PCU length within SATURN reduces the stacking capacity of links, which in turn will increase the length of any queue, potentially beyond the end of a link, and can affect the link speeds as a result. This change had the effect of slowing down the modelled journey times, which was consistent with comparisons between the observed and modelled journey times.

5.4.4 Revised Cost Base

The Common Appraisal Framework (CAF) provides the largest proportion of information used during the derivation of the generalised cost assignment parameters; value of time (VoT) and vehicle operating cost (VOC). At the commencement of the initial network development, the latest available information from the CAF provided costs with a base year of 2002. During the development of the road network, a draft version of the CAF was circulated which provided generalised cost parameters with a base cost year of 2011. A summary of all variables used during the development of the SERM and their sources is presented in the “FDM Scope18 Regional Transport Model Exogenous Variables” report.

5.4.5 Initial Network Checks

In parallel with setting up and running the FDM, a detailed review of the network was carried out using the Second-Pass prior matrix, as described in Section 5.5.3. This included:

- **Junction turning counts and capacity checks:**
  Checks were undertaken to identify the junctions with counts greater than the modelled capacity. The network coding for these junctions

was then reviewed to see how the capacity can be increased. For this purpose, flares and lane allocation were checked. The capacity was increased by adding flares or changing flares to extra lanes where necessary. For signalised junctions, signal timings and signals stages were reviewed. Where appropriate, green time adjustments were made. If this was not possible overall cycle time was increased. For some junctions, signal phases were rearranged. Overall, approximately 20 links were updated in this process.

- **Review of regional roads:**
  All the regional roads have been reviewed to check that the capacity and speed flow curves are consistent along each road.
- **Over capacity links in buffer area:**
  V/C and delay checks were carried out in the buffer area. No changes were made as a result of the checks.
- **Centroid connector review:**
  A review of centroid connectors was carried out to check that they are connected to the zones properly. Any unnecessary links were removed and the connectors were moved to appropriate links where required.
- **Exploded roundabout checks:**
  Exploded roundabouts in the simulation network were reviewed. Saturation flows were checked according to the inscribed circle diameter requirements set out in "SA TN11 Regional Model Coding Guide". Capacity, V/C and delay checks were also undertaken.
- **Bus lane checks:**
  Bus lane coding for the Waterford City area was reviewed. No changes were required for bus lane coding in the model.
- **Data checks:**
  A review of the observed data being used to calibrate and validate the model was undertaken to ensure that the data was processed and applied correctly. This exercise identified that the N25 / N9 count data had been processed incorrectly, and highlighted the fact that there was no data available for the N25 traffic flows at this location.
- **Stress test:**
  110% of the original matrix was assigned to the network and compared to the original network. Checks were made to identify any junctions that were now over capacity as a result of assigning the larger matrix.

5.4.6 Period-to-Hour Factor

As outlined in Section 3.2, the PtH factors were adjusted during the development of the final model. These factors had the impact of varying the overall travel demand (matrix size) in each time period prior to any adjustment. The factors tended to increase during development, which in turn highlighted additional areas of the model that were weak and required review.

5.4.7 Detailed Network Audit

A detailed network audit was completed after all major changes had been applied to the model. The headline statistics prior to the detailed audit are outlined in the following six tables.

Table 5.8 Pre-audit Significance of Matrix Estimation Changes, AM Peak

Measure	Significance Criteria	UC 1	UC 2	UC 3	UC 4	UC 5	UC 6	UC 7	UC 8	UC 9
Matrix zonal cell value	Slope within 0.98 and 1.02;	1.01	0.93	0.91	1.00	0.98	1.00	1.00	1.00	
	Intercept near zero;	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	R^2 in excess of 0.95.	0.71	0.64	0.67	0.74	0.75	1.00	1.00	1.00	
Matrix zonal trip ends	Slope within 0.99 and 1.01;	0.96	0.78	0.74	0.96	0.77	1.00	1.00	1.00	
	Intercept near zero;	0.08	1.24	8.73	0.22	15.68	0.00	0.00	0.00	
	R^2 in excess of 0.98.	0.86	0.67	0.82	0.80	0.73	1.00	1.00	1.00	
Trip Length Distribution	Means within 5%;	-11%	-16%	-17%	-8%	-20%	0%	0%	0%	
	Standard Deviation within 5%.	-7%	-11%	-9%	-7%	-15%	0%	0%	0%	

Table 5.9 Pre-audit Significance of Matrix Estimation Changes, Inter-peak 1

Measure	Significance Criteria	UC 1	UC 2	UC 3	UC 4	UC 5	UC 6	UC 7	UC 8	UC 9
Matrix zonal cell value	Slope within 0.98 and 1.02;	1.07	1.03	0.85	1.05	1.00	1.00	1.00	1.00	
	Intercept near zero;	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	R^2 in excess of 0.95.	0.58	0.55	0.86	0.70	0.69	1.00	1.00	1.00	
Matrix zonal trip ends	Slope within 0.99 and 1.01;	1.01	0.94	0.64	1.07	0.78	1.00	1.00	1.00	
	Intercept near zero;	0.08	0.47	3.50	0.01	15.07	0.00	0.00	0.00	
	R^2 in excess of 0.98.	0.79	0.66	0.94	0.86	0.66	1.00	1.00	1.00	
Trip Length Distribution	Means within 5%;	-13%	-21%	-23%	-8%	-24%	0%	0%	0%	
	Standard Deviation within 5%.	-7%	-14%	-3%	-4%	-17%	0%	0%	0%	

Table 5.10 Pre-audit Significance of Matrix Estimation Changes, Inter-peak 2

Measure	Significance Criteria	UC 1	UC 2	UC 3	UC 4	UC 5	UC 6	UC 7	UC 8	UC 9
Matrix zonal cell value	Slope within 0.98 and 1.02;	1.03	0.99	0.89	1.05	1.00	1.00	1.00	1.00	
	Intercept near zero;	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	R^2 in excess of 0.95.	0.66	0.57	0.80	0.69	0.68	1.00	1.00	1.00	
Matrix zonal trip ends	Slope within 0.99 and 1.01;	0.97	0.94	0.72	1.02	0.85	1.00	1.00	1.00	
	Intercept near zero;	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	R^2 in excess of 0.98.	0.85	0.84	0.92	0.90	0.72	1.00	1.00	1.00	
Trip Length Distribution	Means within 5%;	-13%	-21%	-24%	-10%	-21%	0%	0%	0%	
	Standard Deviation within 5%.	-7%	-14%	-8%	-5%	-16%	0%	0%	0%	

Table 5.11 Pre-audit Significance of Matrix Estimation Changes, PM Peak

Measure	Significance Criteria	UC 1	UC 2	UC 3	UC 4	UC 5	UC 6	UC 7	UC 8	UC 9
Matrix zonal cell value	Slope within 0.98 and 1.02;	1.08	0.99	0.97	1.00	1.02	1.00	1.00	1.00	
	Intercept near zero;	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	
	R^2 in excess of 0.95.	0.55	0.68	0.63	0.71	0.64	1.00	1.00	1.00	
Matrix zonal trip ends	Slope within 0.99 and 1.01;	1.03	0.81	0.87	1.02	0.85	1.00	1.00	1.00	
	Intercept near zero;	0.12	1.16	6.68	0.07	16.3	0.00	0.00	0.00	
	R^2 in excess of 0.98.	0.79	0.66	0.86	0.92	0.67	1.00	1.00	1.00	
Trip Length Distribution	Means within 5%;	-12%	-20%	-21%	-11%	-20%	0%	0%	0%	
	Standard Deviation within 5%.	-7%	-14%	-10%	-10%	-15%	0%	0%	0%	

It should be noted that there was no observed data available to derive the prior goods vehicles matrices. These were developed synthetically, and hence were unlikely to accurately represent the true patterns of travel of heavy goods vehicles. This fact makes the results summarised above look worse, with matrix estimation making particularly large changes to the LGV, OGV1 and OGV2 matrices across all time periods. However, even for the other user classes the differences between pre- and post-Matrix Estimation matrices generally exceed the significance criteria. At the zonal cell value, whilst the slope of the best-fit line through all data points for some user classes was between the range 0.98 to 1.02, none of the R^2 values achieved the threshold value of 0.95. The same scale of change is noted at the trip end level and the changes to the trip length distribution also fall outside of the 5 per cent significance criteria with some user classes being both longer and shorter. This indicates that the changes made during Matrix Estimation were larger than desired.

To address this, the XAMAX parameter in SATURN was reduced and trip end constraints were applied. The XAMAX parameter is discussed more fully in Section 5.8.1, but defines a maximum (or minimum) adjustment factor during Matrix Estimation. A lower value restricts the magnitude of the changes that can be made at a cell level during Matrix Estimation, while the trip end constraints were applied to further reduce the significance of the changes made during Matrix Estimation.

Table 5.12 Pre-audit Road Assignment Model Calibration

Measure	Significance Criteria	AM Peak	Inter-peak 1	Inter-peak 2	PM Peak
Individual flows within 100 veh/h of counts for flows less than 700 veh/h **within 15% of counts for flows from 700 to 2,700 veh/h** **within 400 veh/h of counts for flows more than 2,700 veh/h**	> 85% of cases	45%	50%	41%	42%
GEH < 5 for individual flows	> 85% of cases	38%	39%	34%	35%

Table 5.12 indicated the Road Assignment Model at the pre-audit stage falls short of the advised criteria for all four time periods.

Table 5.13 Pre-audit Road Assignment Model Screenline Calibration

Measure	Significance Criteria	AM Peak	Inter-peak 1	Inter-peak 2	PM Peak
Differences between modelled **flows and counts should be less than 5% of the counts**	> 85% of cases	17%	25%	17%	17%

Table 5.13 shows all time periods fail to reach advised criteria across the model screenlines.

In post-audit calibration the XAMAX value, as mentioned in Section 5.8.1, was reduced and trip end constraints applied. However, reducing the XAMAX parameter and applying trip end constraints during Matrix Estimation to reduce the significance of matrix changes, was anticipated to reduce the level of flow calibration achieved. The reason for this is that by restricting the matrix changes permitted during Matrix Estimation, the Matrix Estimation process may no longer make a significant enough change to the prior matrices to meet the flow calibration criteria at as many locations.

5.5 Road Model Matrix Progression

5.5.1 Overview

For the SERM five versions of the prior matrices were produced, and assigned in order to provide updated network costs for further refinement of the synthetic component of the prior matrix development process. The matrices are numbered one through five in Figure 5.1, which illustrates the process involved in developing the final road model matrices for the SERM. Note that not all of the steps that were undertaken are shown on this diagram for clarity.

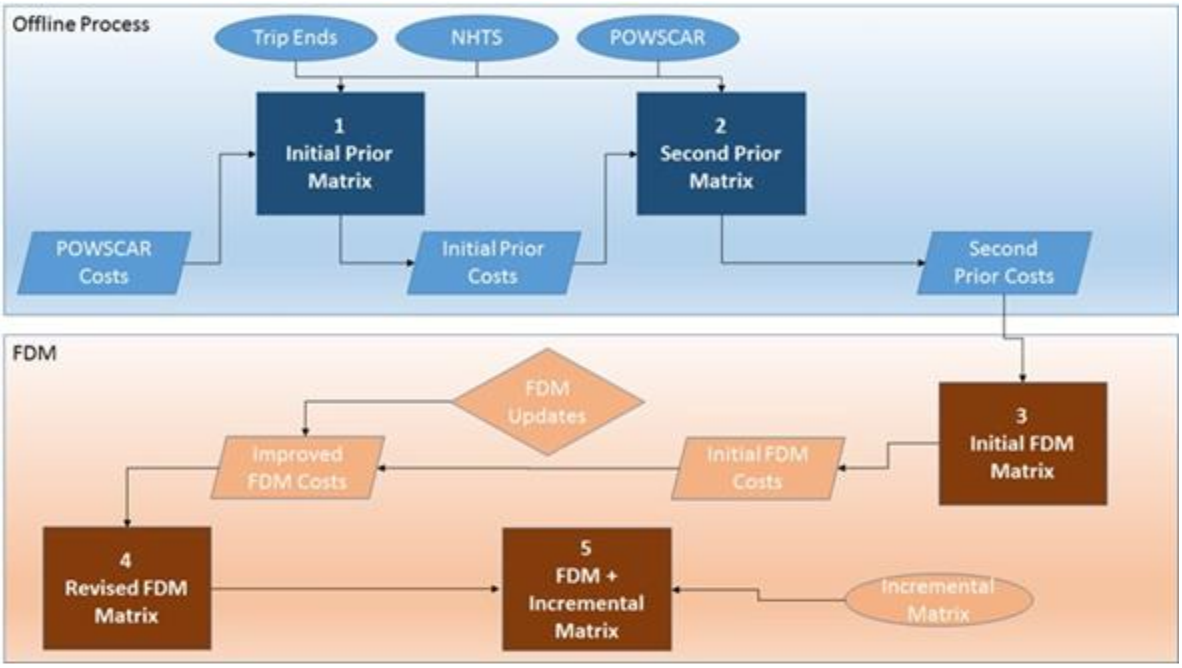

Figure 5.1 Road Model Matrix Development Process

5.5.2 1. Initial Prior Matrices

The initial prior matrices were developed following the priors development process developed for SERM using NHTS, POWSCAR, Trip Ends and cost skims from approximate POWSCAR matrices. A detailed description of this is given in "SERM FDM Calibration Report". These matrices were assigned and costs skimmed to give more accurate costs for input into the second iteration of the prior matrix development process. No updates to the network were made at this stage.

5.5.3 2. Second-Pass Prior Matrices

The second-pass prior matrices used costs skimmed from the initial prior matrices to improve the matrices. These were assigned and limited comparisons with observed flows on strategic corridors suggested they provided a good starting point to create costs for the FDM. Costs were skimmed from these assignments and used as costs for the first calibration of the FDM.

5.5.4 3. Initial FDM Matrices

The initial calibration of the FDM used the costs skimmed from the Second-Pass Prior Matrices. One loop of the FDM was run to create road matrices for all time periods, and these were assigned and costs skimmed. These costs were then used to recalibrate the FDM. Once this had been completed, one loop of the re-calibrated FDM was run to create road matrices, and these were assigned. A check of the assigned demand at the 24-hour level with observed data for each of the screenlines showed that the demand from the FDM was low compared to observed flows on the network.

5.5.5 4. Revised Demand Model Matrices

As part of the calibration of the FDM, a number of assumptions were reviewed and changes made. This resulted in improved road assignment matrices which were taken forward as the starting point from which an incremental matrix was calculated. A description of these steps is given in "SERM FDM Calibration Report".

5.5.6 Matrix Estimation

Matrix estimation was undertaken on the final prior matrices using SATME2. SATME2 uses observed traffic count data and assigned road model paths to adjust the matrix. A maximum (or minimum) adjustment factor is defined by the parameter XAMAX. Traffic passing a particular point in the network where a traffic count is located can be factored by any number that lies between XAMAX and 1 / XAMAX. XAMAX has been set to 2 for cars and taxis, and 1000 (essentially unlimited) for goods vehicles due to the low confidence in the prior goods matrices. In this case, cars and taxis can be adjusted by a factor between 0.5 and 2. Goods vehicles can be adjusted by a factor between 0.001 and 1000.

Further matrix estimation controls included applying a trip end constraint to the adjustments of + / - 10 per cent for all zone trip ends for cars (user classes 1 – 5).

SATME2 and the assignment module, SATALL, were run iteratively with the assigned paths and costs from the latest road assignment informing the next iteration of SATME2. The goods vehicle matrices were updated and retained between successive iterations, whereas the car input matrices remained constant throughout with the exception of the Taxi user class.

5.5.7 Incremental Matrix

The incremental matrix reflects those parts of the full travel behaviour pattern which are not estimated by the demand model. This would include factors like:

- The choice of a school which gets particularly good exam results over another local school;
- A trip made via an irrational route because the driver is showing the passenger some local landmarks; or,
- The choice of a journey by tram or train rather than bus which is made because the user can work more reliably on a tram or a train.

The incremental matrix includes all of these varied, hard to predict, behaviour patterns. In the base model it is used to adjust the matrices which are directly output from the demand model to match the calibrated base matrices and so produce a calibrated base network following assignment. In the future model it is intended to improve the predictive power of the model by adding in a contribution from the more unpredictable parts of the travel demand.

5.5.8 5. Final Incremental Matrices

Two types of incremental matrix are in use in the model:

- Additive incrementals, where the incremental matrices (whose values may be positive, negative, or a mix of the two) are added on to the matrices output by the demand model; and
- Multiplicative incrementals, where the incremental matrices are used to factor the matrices output by the demand model.

There is no reason in principal why each incremental could not be a mix of additive and multiplicative values but at present the model uses additive incrementals for the road and public transport matrices and multiplicative incrementals for the active modes. This is because the calibrated base matrices are considered to be much better defined in the road and public transport networks than is the case in the active modes model.

The additive incrementals are calculated by taking the best direct demand model output and finding the difference between this and the best calibrated base matrix on a cell by cell basis. The incremental matrix produced is added on to the best direct demand model output such that the final assignment output matches the calibrated base (in the base case).

As no detailed calibration of the active modes component was carried out the multiplicative incrementals used are calculated by working out the factor which will adjust the assignment matrices to give the best overall fit to the total observed flow on any observed screenline. For example if 100 trips were observed and the model with no incremental applied gave a value of 120 trips on that screenline then the incremental matrix would be set to a value of 100/120 in every cell such that once the incremental is applied the assignment model would mimic the 100 observed trips closely.

The final assignment matrices including the incremental adjustments are what the network calibration and validation assessments are based on. In relation to road travel, the incremental matrix only applies to car user classes; for goods vehicles the matrix estimated matrix was input directly as an updated version of the input internal goods matrix.

5.6 Final generalised cost parameters

The road assignment model was calibrated and subsequently validated using the generalised cost parameters set out in the following four tables.

Table 5.14 Final AM Generalised Cost Values

User Class	Cents Per Minute	Cents Per Kilometre
UC1 – Taxi	60.13	17.11
UC2 – Car Employers Business	60.13	17.11
UC3 – Car Commute	21.52	9.09
UC4 – Car Education	36.39	9.09
UC5 – Car Other	21.16	9.09
UC6 – LGV	43.34	12.55
UC7 – OGV1	46.08	27.56
UC8 – OGV2 Permit Holder	44.40	50.42
UC9 – OGV2 (Other)	44.40	50.42

Table 5.15 Final IP1 Generalised Cost Values

User Class	Cents Per Minute	Cents Per Kilometre
UC1 – Taxi	70.39	16.53
UC2 – Car Employers Business	70.39	16.53
UC3 – Car Commute	20.74	8.87
UC4 – Car Education	42.66	8.87
UC5 – Car Other	38.41	8.87
UC6 – LGV	45.91	13.23
UC7 – OGV1	47.87	27.72
UC8 – OGV2 Permit Holder	46.55	50.87
UC9 – OGV2 (Other)	46.55	50.87

Table 5.16 Final IP2 Generalised Cost Values

User Class	Cents Per Minute	Cents Per Kilometre
UC1 – Taxi	70.39	16.22
UC2 – Car Employers Business	70.39	16.22
UC3 – Car Commute	20.74	8.78
UC4 – Car Education	42.66	8.78
UC5 – Car Other	38.41	8.78
UC6 – LGV	45.91	13.22
UC7 – OGV1	47.87	27.34
UC8 – OGV2 Permit Holder	46.55	50.17
UC9 – OGV2 (Other)	46.55	50.17

Table 5.17 Final PM Generalised Cost Values

User Class	Cents Per Minute	Cents Per Kilometre
UC1 – Taxi	60.13	17.15
UC2 – Car Employers Business	60.13	17.15
UC3 – Car Commute	21.52	9.11
UC4 – Car Education	36.39	9.11
UC5 – Car Other	21.16	9.11
UC6 – LGV	43.34	12.56
UC7 – OGV1	46.08	27.61
UC8 – OGV2 Permit Holder	44.40	50.52
UC9 – OGV2 (Other)	44.40	50.52

5.7 Road Model Network Calibration

5.7.1 Overview

This section details the calibration process and the level of calibration for the road assignment model across the four assigned peak periods. In total, 522 observations have been used in the SATME2 procedure. A total of 73 observations form part of the strategic screenlines. For comparison, the statistics in this section can be compared to the calibration statistics presented in Section 5.4.7

Although TAG suggests that GEH values should be less than 5 for 85 per cent of cases, acceptable models, where it is common for larger GEH values to be accepted, typically achieve a reasonable level of calibration when considered in full with the intended model application and other performance indicators. An acceptable criterion is typically:

- GEH < 5 for 65 per cent of all sites;
- GEH < 7 for 75 per cent of all sites; and
- GEH < 10 for 95 per cent of all sites.

5.7.2 Traffic Count Locations

A detailed map showing the location of all traffic counts used during calibration is presented in Figure 5.2 and Figure 5.3.

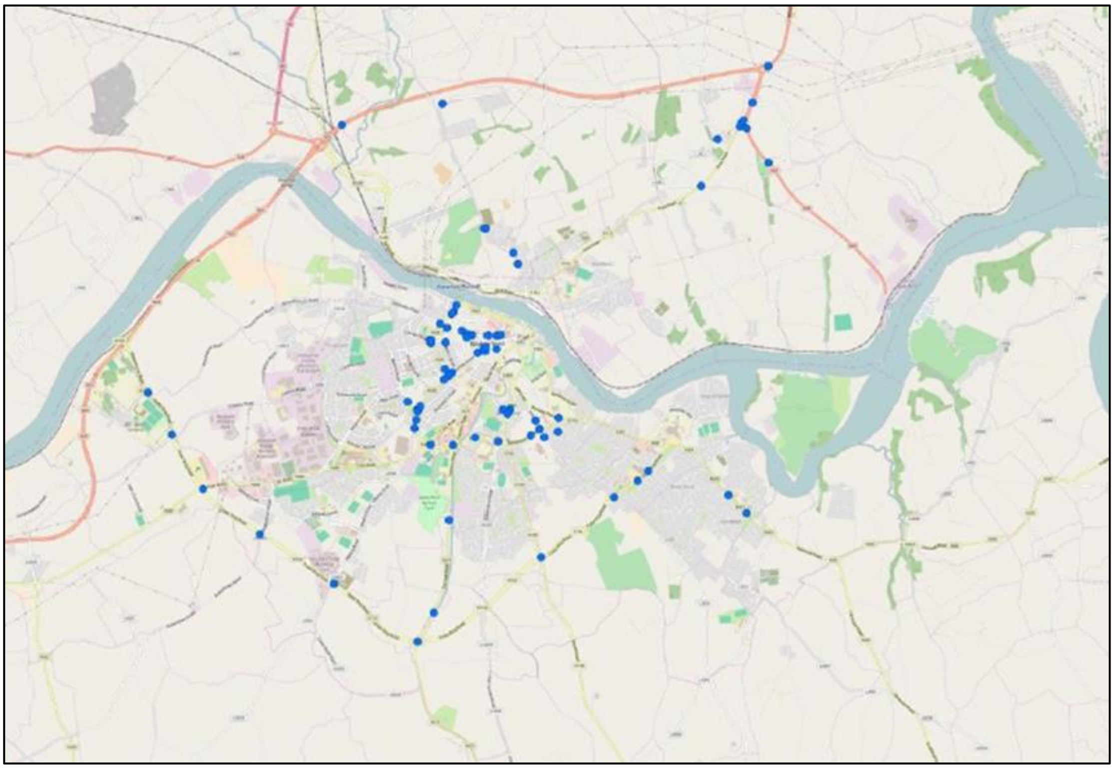

Figure 5.2 Link Calibration Target Locations – Waterford City and surrounds

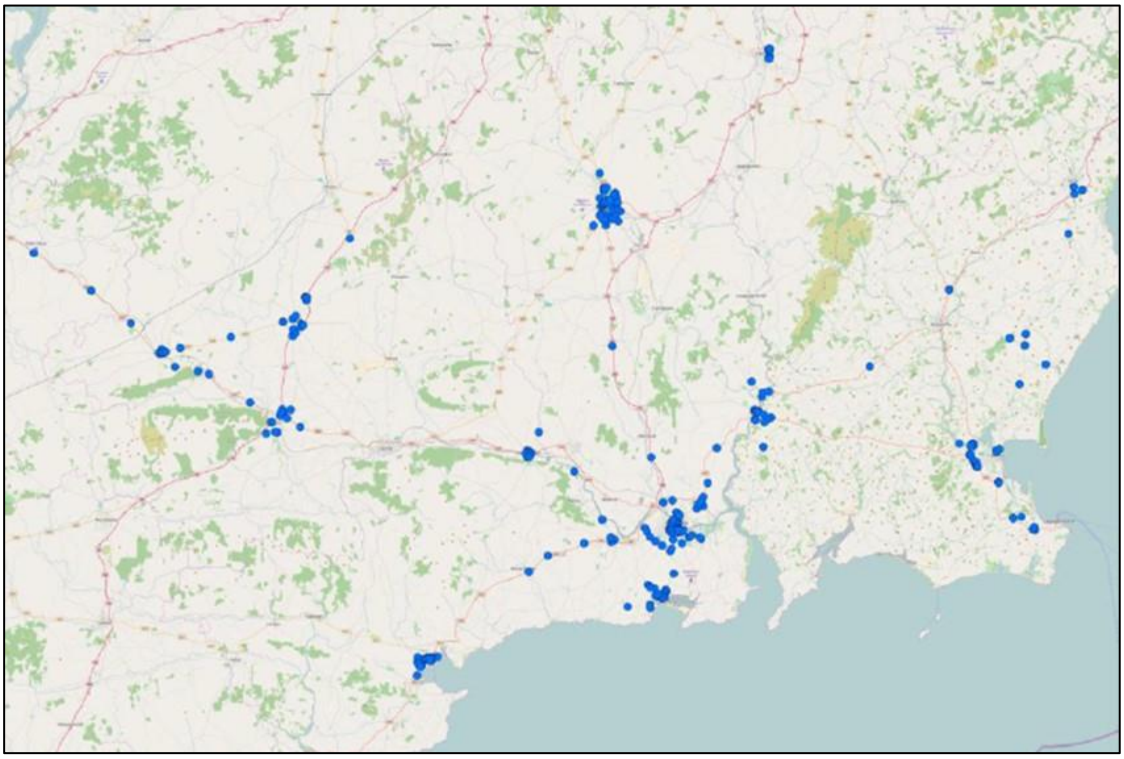

Figure 5.3 Link Calibration Target Locations – Wider Model Area

5.7.3 Individual link calibration criteria compliance – AM peak

There are a total of 489 individual link traffic counts used during the AM peak road model network calibration. Table 5.18 details the individual link count acceptability criteria.

Table 5.18 AM Link Flow Calibration

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	81% (396)
GEH < 5 for individual flows	> 65% of cases	76% (373)
GEH < 7 for individual flows	> 75% of cases	84% (409)
GEH < 10 for individual flows	> 95% of cases	91% (447)

The model statistics show that the individual link calibration for the AM peak road model does not meet the recommendations set out in TAG. However, in terms of GEH, it is close to passing all typical acceptability criteria, with only the number of links with a GEH less than 10 failing to meet the recommended criteria by four percentage points. In terms of Link Flow criteria, it is also close to passing, with the model failing to meet the recommended criteria by four percentage points.

Detailed calibration results, highlighting specific links that pass or fail the recommended calibration criteria are included in Appendix A. The maximum recorded GEH was 30.4. In this specific example, the GEH of 30.4 was recorded on Bridge Street in New Ross where the observed flow was 977 and the modelled flow is 229. All GEH values in excess of 15 have been reviewed, and in total there were 13 links with a GEH greater than 15 in the AM peak. This accounts for 3 per cent of the individual links used for calibration. Geographically, these links were not found to be located in one specific area, but instead are located throughout the South-East region. Six of these links are located within the Simulation area of Waterford City and its environs, the remainder are in Kilkenny (2), Dungarvan (3), Tramore (1) and New Ross (1).

For the locations within Waterford City Centre, the high GEH values were located on links in urban areas containing numerous competing parallel roads and with relatively aggregated zonal detail which resulted in model flows lower than the observed traffic data.

5.7.4 Screenline calibration criteria compliance – AM peak

A total of six individual screenlines (inbound and outbound) were compared as part of the network calibration exercise.

Table 5.19 details the number of SATURN links forming each screenline, and the difference between the total observed traffic volume across the screenline and the total modelled traffic volume across the screenline.

Table 5.19 AM Screenline Flow Calibration

Screenline	Number of Links	Modelled Difference
TAG Criteria		Within 5%
Waterford Urban (Inbound)	9	-8%
Waterford Urban (Outbound)	8	-17%
Outer Ring Road Outer Screenline (Inbound)	8	-6%
Outer Ring Road Outer Screenline (Outbound)	9	20%
Outer Ring Road Inner Screenline (Inbound)	8	-3%
Outer Ring Road Inner Screenline (Outbound)	9	0%
Tranmore Road (Inbound)	3	-6%
Tranmore Road (Outbound)	3	12%
River Suir (Inbound)	3	-6%
River Suir (Outbound)	3	-13%
Northern Outer (Inbound)	5	-10%
Northern Outer (Outbound)	5	-2%

25 per cent of the screenlines (3 out of 12) meet the recommended calibration criteria as set out in TAG Unit M3-1, and three other screenlines fail by only one percentage point. This does not meet the acceptability criteria of “all or nearly all” screenlines meeting the criteria.

5.7.5 Individual Link Calibration Criteria Compliance – Inter-peak 1

There are a total of 479 traffic counts used during the Inter-peak 1 road model network calibration. Table 5.20 details the individual link count acceptability criteria.

Table 5.20 Inter-peak 1 Link Flow Calibration

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	88% (421)
GEH < 5 for individual flows	> 65% of cases	79% (379)
GEH < 7 for individual flows	> 75% of cases	88% (421)
GEH < 10 for individual flows	> 95% of cases	94% (450)

The model statistics show that the individual link calibration for the Inter-peak 1 road model meets the recommendations set out in TAG, for link flows and GEH values.

Detailed calibration results, highlighting specific links that pass or fail the recommended calibration criteria are included in Appendix A. A review of GEH values in excess of 15 revealed that there is a total of 9 links with a GEH greater than 15, equating to 2 per cent of the individual links used for calibration. Of these, 4 are in Waterford City and Environs, 1 in Kilkenny, 3 in Dungarvan and 1 in New Ross. The Maximum recorded GEH was 19.8 in this time-period and occurs on Sexton Street eastbound in Dungarvan where the observed flow is 28 and the modelled flow is 269.

5.7.6 Screenline calibration criteria compliance – Inter-peak 1

A total of six individual screenlines were compared as part of the network calibration exercise.

Table 5.21 details the number of SATURN links forming each screenline, and the difference between the total observed traffic volume across the screenline and the total modelled traffic volume across the screenline.

Table 5.21 Inter-peak 1 Screenline Flow Calibration

Screenline TAG Criteria	Number of Links	Modelled Difference Within 5%
Waterford Urban (Inbound)	9	-10%
Waterford Urban (Outbound)	8	-11%
Outer Ring Road Outer Screenline (Inbound)	8	11%
Outer Ring Road Outer Screenline (Outbound)	9	14%
Outer Ring Road Inner Screenline (Inbound)	8	-4%
Outer Ring Road Inner Screenline (Outbound)	9	0%
Tranmore Road (Inbound)	3	3%
Tranmore Road (Outbound)	3	2%
River Suir (Inbound)	3	7%
River Suir (Outbound)	3	-8%
Northern Outer (Inbound)	5	1%
Northern Outer (Outbound)	5	6%

42 per cent of the screenlines (5 out of 12) meet the recommended calibration criteria as set out in TAG Unit M3-1, which is below the recommended acceptability criteria of “all or nearly all” screenlines meeting the criteria.

5.7.7 Individual Link Calibration Criteria Compliance – Inter-peak 2

There are a total of 478 traffic counts used during the Inter-peak 2 road model network calibration. Table 5.22 details the individual link count acceptability criteria.

Table 5.22 Inter-peak 2 Link Flow Calibration

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	84%(401)
GEH < 5 for individual flows	> 65% of cases	75%(360)
GEH < 7 for individual flows	> 75% of cases	86%(409)
GEH < 10 for individual flows	> 95% of cases	92%(442)

The model statistics show that the individual link calibration for the Inter-peak 2 road model does not meet the recommendations set out in TAG. However, in terms of GEH, it is close to passing all typical acceptability criteria, with only the number of links with a GEH less than 10 failing to meet the recommended criteria by three percentage points. In terms of Link Flow criteria, it is also close to passing, with the model failing to meet the recommended criteria by one percentage point.

Detailed calibration results, highlighting specific links that pass or fail the recommended calibration criteria are included in Appendix A. GEH values in excess of 15 were reviewed and it was found that there was a total of 13 links with a GEH greater than 15, equating to 3 per cent of the individual links used for calibration. Of these, 5 were located in Waterford City and Environs, 2 in Kilkenny, 3 in Dungarvan, 2 in Tramore and 1 in New Ross. The Maximum recorded GEH was 21.9 in the Inter-peak 2 period and occurs on Sexton Street eastbound in Dungarvan where the observed flow is 43 and the modelled flow is 351.

5.7.8 Screenline calibration criteria compliance – Inter-peak 2

A total of six individual screenlines were compared as part of the network calibration exercise.

Table 5.23 details the number of SATURN links forming each screenline, and the difference between the total observed traffic volume across the screenline and the total modelled traffic volume across the screenline.

Table 5.23 Inter-peak 2 Screenline Flow Calibration

Screenline TAG Criteria	Number of Links	Modelled Difference Within 5%
Waterford Urban (Inbound)	9	-6%
Waterford Urban (Outbound)	8	-8%
Outer Ring Road Outer Screenline (Inbound)	8	14%
Outer Ring Road Outer Screenline (Outbound)	9	12%
Outer Ring Road Inner Screenline (Inbound)	8	-3%
Outer Ring Road Inner Screenline (Outbound)	9	1%
Tranmore Road (Inbound)	3	4%
Tranmore Road (Outbound)	3	3%
River Suir (Inbound)	3	10%
River Suir (Outbound)	3	-8%
Northern Outer (Inbound)	5	3%
Northern Outer (Outbound)	5	11%

42 per cent of the screenlines (5 out of 12) meet the recommended calibration criteria as set out in TAG Unit M3-1, which is below the recommended acceptability criteria of “all or nearly all” screenlines meeting the criteria. A further screenline narrowly fails to meet the criteria (by less than one percentage point).

5.7.9 Individual Link Calibration Criteria Compliance – PM Peak

There are a total of 491 traffic counts used during the PM peak road model network calibration. Table 5.24 details the individual link count acceptability criteria.

Table 5.24 PM Link Flow Calibration

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	77%(379)
GEH < 5 for individual flows	> 65% of cases	73%(360)
GEH < 7 for individual flows	> 75% of cases	83%(406)
GEH < 10 for individual flows	> 95% of cases	91%(447)

The model statistics show that the individual link calibration for the PM peak road model does not meet the recommendations set out in TAG. However, in terms of GEH, it is close to passing all typical acceptability criteria, with only the number of links with a GEH less than 10 failing to meet the recommended criteria by four percentage points.

Detailed calibration results, highlighting specific links that pass or fail the recommended calibration criteria are included in Appendix A. Following a review of all GEH values in excess of 15 it was found that there was a total of 14 links with a GEH greater than 15 in the PM period. This equates to 3 percent of the individual links used for calibration. Of these, 7 are in Waterford City and Environs, 3 in Kilkenny, 1 in Dungarvan and 3 in Tramore. The Maximum recorded GEH was 28.9 in the PM peak period and occurs northbound on N25 to Glenmore Road, on the outskirts of Waterford City, where the observed flow is 2134 and the modelled flow is 991.

As is the case in all time periods, the high GEH values recorded within the simulation area of Waterford City were located on links in urban areas containing numerous competing parallel roads and with relatively aggregated zonal detail which resulted in model flows lower than the observed traffic data.

5.7.10 Screenline Calibration Criteria Compliance – PM Peak

A total of six individual screenlines were compared as part of the network calibration exercise.

Table 5.25 details the number of SATURN links forming each screenline, and the difference between the total observed traffic volume across the screenline and the total modelled traffic volume across the screenline.

Table 5.25 PM Screenline Flow Calibration

Screenline TAG Criteria	Number of Links	Modelled Difference Within 5%
Waterford Urban (Inbound)	9	-11%
Waterford Urban (Outbound)	8	-13%
Outer Ring Road Outer Screenline (Inbound)	8	23%
Outer Ring Road Outer Screenline (Outbound)	9	-2%
Outer Ring Road Inner Screenline (Inbound)	8	-5%
Outer Ring Road Inner Screenline (Outbound)	9	-9%
Tranmore Road (Inbound)	3	7%
Tranmore Road (Outbound)	3	-3%
River Suir (Inbound)	3	1%
River Suir (Outbound)	3	-14%
Northern Outer (Inbound)	5	-7%
Northern Outer (Outbound)	5	-1%

33 per cent of the screenlines (4 out of 12) meet the recommended calibration criteria as set out in TAG Unit M3-1, which is below the recommended acceptability criteria of "all or nearly all" screenlines meeting the criteria.

5.8 Road Model Matrix Calibration

5.8.1 Overview

Matrix estimation was undertaken on the final prior matrices, including constraints at a cellular and trip end level. These are discussed further in Section 5.5.6.

5.8.2 Calibration criteria compliance – AM Peak

Table 5.26 details the overall change in inter-zonal matrix size between the pre-estimation matrix and the post-estimation matrix. Intra-zonal matrix totals are not adjusted by matrix estimation and do not affect assignment in SATURN.

Table 5.26 SERM RM AM Peak Matrix Totals

User Class	Prior (PCU)	Post-Incremental (PCU)	Change (%)
TAG Criteria			Within 5%
Taxi	1,060	1,021	-4%
Car Employers Business	4,353	4,080	-6%
Car Commute	24,450	23,245	-5%
Car Education	1,265	1,266	0%
Car Other	42,424	40,462	-5%
LGV	4,351	4,418	2%
OGV1	5,287	5,345	1%
OGV2 Other	273	273	0%

A table of sectored matrix differences is presented in Appendix B.

The changes to all user classes are of an acceptable level with the exception of Car Employers Business. The overall change on the matrix total is 4 per cent.

GEH analysis was undertaken on the individual (non-zero) cells and their change between the pre-estimation and post-estimation values. 24 per cent of cells have a GEH value of less than 0.01, with 84 per cent of cells having a GEH value of less than 0.1. A graph illustrating the distribution of GEH values is shown in Figure 5.4 and Figure 5.5. Please note the change in scale for both axes in Figure 5.5.

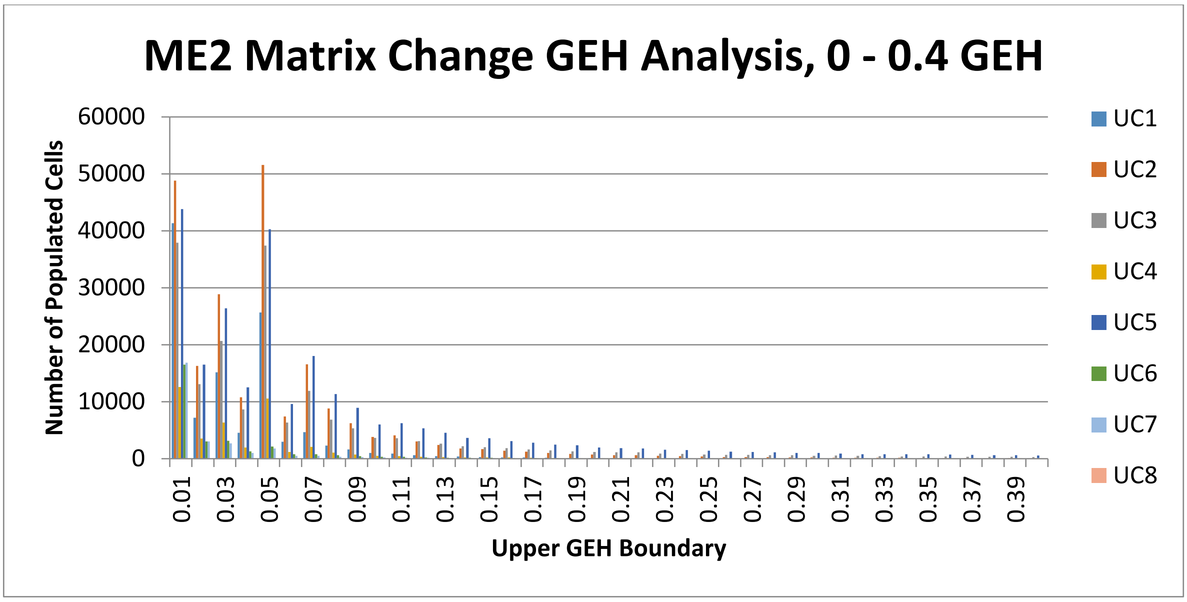

Figure 5.4 SATME2 AM Matrix Change GEH Analysis; 0 GEH to 0.4 GEH

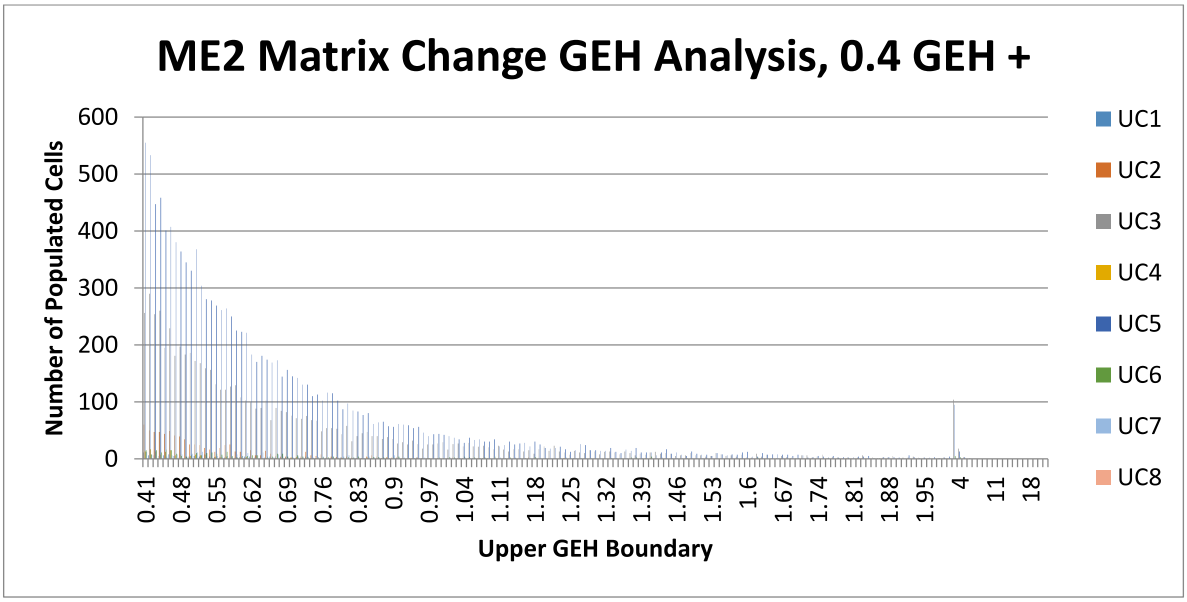

Figure 5.5 SATME2 AM Matrix Change GEH Analysis; 0.4 GEH Upwards

R^2 analysis was undertaken to further understand the matrix changes made by SATME2. Table 5.27 details the R^2 values for each individual user class. These are represented graphically in Appendix C.

Table 5.27 SATME2 AM Matrix Change R^2 Analysis

User Class	Cell R^2 Value	Cell Slope	Cell Y-Int
TAG Criteria	> 0.95	0.98 - 1.02	Near 0
Taxi	0.74	1.03	0.00
Car Employers Business	0.86	0.98	0.00
Car Commute	0.87	0.97	0.00
Car Education	0.92	0.99	0.00
Car Other	0.92	1.02	-0.01
LGV	0.96	1.00	0.00
OGV1	0.98	0.99	0.00
OGV2 Permit Holder	-	-	-
OGV2 Other	1.00	1.00	0.00

TAG Unit M3-1, Section 8, Table 5 indicates that an acceptable R^2 value for individual matrix zonal changes is in excess of 0.95. Three of the eight user classes pass the criteria for R^2 values.

Each user class passes the comparison of the intercept value, which should be zero or close to zero. All user classes except Taxi, Car Employers Business, and Car Other pass the comparison of the slope of the line, which should be between 0.98 and 1.02.

Trip End analysis was undertaken for each user class and summarised in Table 5.28.

Table 5.28 AM Trip End Matrix Change R^2 Analysis

User Class	Trip End R^2 Value	Trip End Slope	Trip End Y-Int
TAG Criteria	**> 0.98**	**0.99 - 1.01**	**Near 0**
Taxi	0.98	0.88	0.22
Car Employers Business	0.96	0.88	0.55
Car Commute	0.98	0.86	4.62
Car Education	0.99	0.96	0.14
Car Other	0.97	0.89	7.53
LGV	0.99	1.01	0.07
OGV1	1.00	1.00	0.07
OGV2 Permit Holder	-	-	-
OGV2 Other	1.00	1.00	0.00

Analysis was also undertaken on the trip ends at a combined matrix level. The R^2 value for the changes to the trip ends was 0.982, with a y-intercept value of 0.935 and a slope of 1.651. All values are close to the recommended calibration criteria of an R^2 in excess of 0.98, a y-intercept near zero and a slope value between 0.99 and 1.01.

Five of the user classes pass the R^2 value criteria while three pass the Slope Criteria. Two user classes fall short on the intercept criteria, Car Commute and Car Other.

The matrix was compared against six prominent screen lines to determine whether or not the matrix broadly contains the correct number of trips. Table 5.29 details the total traffic crossing the screenlines.

Table 5.29 SERM RM AM Screenline Check

User Class TAG Criteria	Observed (Veh)	Model (Veh)	Difference (%) Within 5%
Waterford Urban Inbound	4,035	3,698	-8%
Waterford Urban Outbound	3,476	2,885	-17%
Outer Ring Road Outer Screenline Inbound	3,126	2,936	-6%
Outer Ring Road Outer Screenline Outbound	1,408	1,683	20%
Outer Ring Road Inner Screenline Inbound	3,910	3,793	-3%
Outer Ring Road Inner Screenline Outbound	2,243	2,251	0%
Tramore Road Inbound	2,168	2,032	-6%
Tramore Road Outbound	1,662	1,861	12%
River Suir Inbound	4,108	3,862	-6%
River Suir Outbound	2,121	1,835	-13%
Northern Outer Inbound	1,676	1,515	-10%
Northern Outer Outbound	2,100	2,059	-2%

Traffic crossing the Outer Ring Road Inner and Northern Outer Outbound are all within acceptability criteria outlines in TAG unit M3-1, however the remaining screen lines are not. The Outer Ring Road Outer Outbound sees the greatest difference in flows between observed and modelled.

Trip length distribution was also assessed as part of the matrix calibration process. An overall reduction in longer distance trips, coupled with matrix estimation's tendency to in-fill shorter distance trips in order to meet calibration targets resulted in the mean trip length reducing by approximately 7 per cent averaged across User Classes, which is in excess of the recommended calibration criteria of 5 per cent.

Table 5.30 Trip Length Distribution Analysis - AM

User Class	Mean Percentage Change	Standard Deviation Change
TAG Criteria	**< 5%**	**< 5%**
Taxi	-16%	-23%
Car Employers Business	-10%	-7%
Car Commute	-10%	-5%
Car Education	-5%	-6%
Car Other	-12%	-9%
LGV	-1%	0%
OGV1	0%	0%
OGV2 Other	0%	0%

Graphical representation of the trip length distribution changes at a user class level are presented in Appendix D.

5.8.3 Calibration criteria compliance – Inter-peak 1

Table 5.31 details the overall change in inter-zonal matrix size between the pre-estimation matrix and the post-estimation matrix. Intra-zonal matrix totals are not adjusted by matrix estimation and do not affect assignment in SATURN.

Table 5.31 SERM RM Inter-peak 1 Matrix Totals

User Class	Prior (PCU)	Post-Incremental (PCU)	Change (%)
TAG Criteria			**Within 5%**
Taxi	1,054	1,007	-4%
Car Employers Business	4,518	4,173	-8%
Car Commute	7,125	6,472	-9%
Car Education	190	203	7%
Car Other	42,101	39,366	-6%
LGV	3,563	3,582	1%
OGV1	4,684	4,741	1%
OGV2 Other	217	217	0%

A table of sectored matrix differences is presented in Appendix B.

The changes to all user classes are of an acceptable level with the exception of Car Employers Business, Car Commute, Car Education and Car Other. The overall change on the matrix total is 6 per cent.

GEH analysis was undertaken on the individual (non-zero) cells and their change between the pre-estimation and post-estimation values. 24 per cent of cells have a GEH value of less than 0.01, with 83 per cent of cells having a GEH value of less than 0.1. A graph illustrating the distribution of GEH values is shown in Figure 5.6 and Figure 5.7. Note the change in scale for both axes in Figure 5.7.

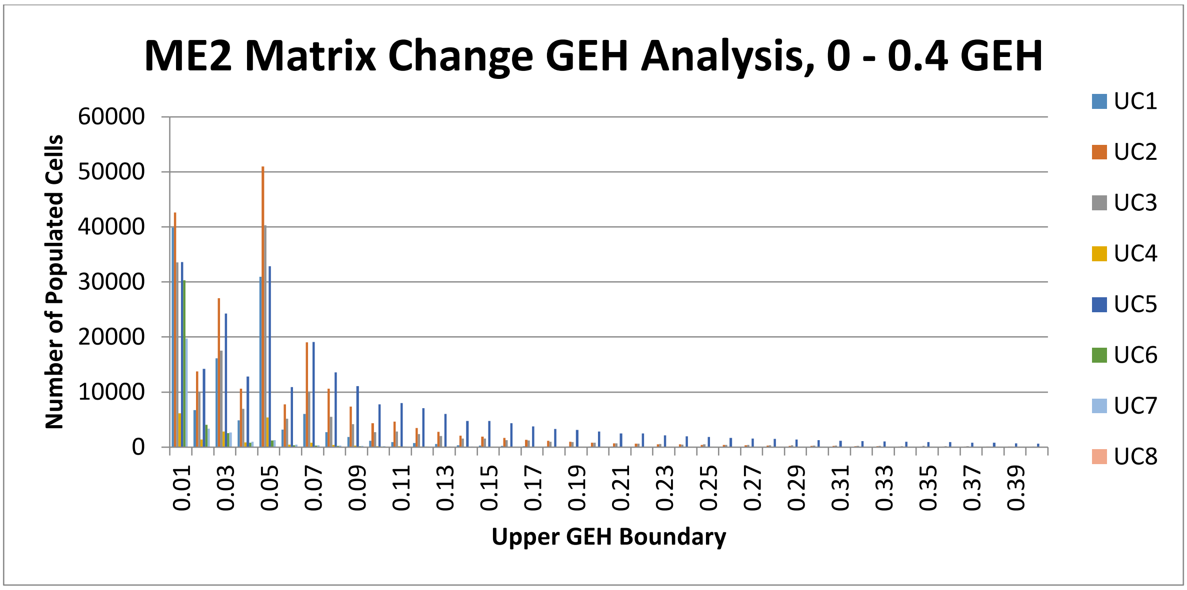

Figure 5.6 SATME2 IP1 Matrix Change GEH Analysis; 0 GEH to 0.4 GEH

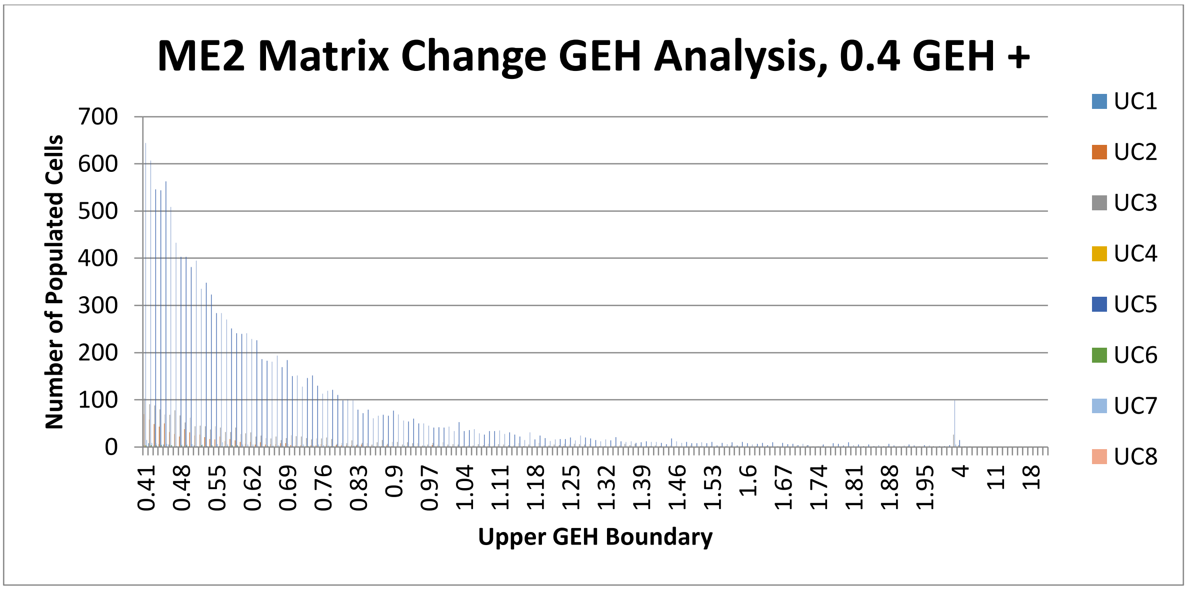

Figure 5.7 SATME2 IP1 Matrix Change GEH Analysis; 0.4 GEH Upwards

R^2 analysis was undertaken to further understand the matrix changes made by SATME2. Table 5.32 details the R^2 values for each individual user class. These are represented graphically in Appendix C.

Table 5.32 SATME2 IP1 Matrix Change R^2 Analysis

User Class	Cell R^2 Value	Cell Slope	Cell Y-Int
TAG Criteria	**> 0.95**	**0.98 - 1.02**	**Near 0**
Taxi	0.83	1.01	0.00
Car Employers Business	0.82	1.04	0.00
Car Commute	0.90	0.99	0.00
Car Education	0.87	1.06	0.00
Car Other	0.88	1.05	-0.02
LGV	0.99	1.02	0.00
OGV1	0.99	1.00	0.00
OGV2 Permit Holder	-	-	-
OGV2 Other	1.00	1.00	0.00

TAG Unit M3-1, Section 8, Table 5 indicates that an acceptable R^2 value for individual matrix zonal changes is in excess of 0.95. Three of the eight user classes pass this criterion.

Each user class passes the comparison of the intercept value, which should be zero or close to zero. All user classes except Car Employers Business, Car Education and Car Other pass the comparison of the slope of the line, which should be between 0.98 and 1.02.

Trip End analysis was undertaken for each user class and summarised in Table 5.33.

Table 5.33 IP1 Trip End Matrix Change R^2 Analysis

User Class	Trip End R^2 Value	Trip End Slope	Trip End Y-Int
TAG Criteria	**> 0.98**	**0.99 - 1.01**	**Near 0**
Taxi	0.98	0.98	0.00
Car Employers Business	0.96	0.93	0.11
Car Commute	0.98	0.80	1.54
Car Education	0.97	1.04	0.02
Car Other	0.97	0.91	4.41
LGV	1.00	1.01	-0.01
OGV1	1.00	1.00	0.09
OGV2 Other	1.00	1.00	0.00

Analysis was undertaken on the trip ends at a combined matrix level.

Five of the eight user classes pass the R^2 value criteria while three pass the Slope Criteria. Two user classes fall short on the intercept criteria, Car Commute and Car Other. This is the same as the AM with the intercept values closer to criteria.

The matrix was compared against six prominent screen lines to determine whether or not the matrix broadly contains the correct number of trips. Table 5.34 details the total traffic crossing the screenlines.

Table 5.34 SERM RM IP1 Screenline Check

User Class TAG Criteria	Observed (Veh)	Model (Veh)	Difference (%) Within 5%
Waterford Urban Inbound	3,311	2,965	-10%
Waterford Urban Outbound	3,270	2,909	-11%
Outer Ring Road Outer Screenline Inbound	1,617	1,795	11%
Outer Ring Road Outer Screenline Outbound	1,559	1,785	14%
Outer Ring Road Inner Screenline Inbound	2,302	2,203	-4%
Outer Ring Road Inner Screenline Outbound	2,241	2,231	0%
Tramore Road Inbound	1,425	1,473	3%
Tramore Road Outbound	1,524	1,556	2%
River Suir Inbound	2,211	2,359	7%
River Suir Outbound	1,888	1,736	-8%
Northern Outer Inbound	1,165	1,171	1%
Northern Outer Outbound	1,145	1,214	6%

42 per cent (five of twelve) total screen lines pass the criteria, with the Outer Ring Road Outer Screenline Outbound and Waterford Urban Outbound seeing the greatest differences in flows. The average over all screenlines falls within the criteria.

Table 5.35 Trip Length Distribution Analysis – Inter-peak 1

User Class	Mean Percentage Change	Standard Deviation Change
TAG Criteria	**< 5%**	**< 5%**
Taxi	-14%	-10%
Car Employers Business	-15%	-8%
Car Commute	-13%	-1%
Car Education	-5%	-3%
Car Other	-16%	-9%
LGV	0%	0%
OGV1	0%	0%
OGV2 Other	0%	0%

Graphical representation of the trip length distribution changes at a user class level are presented in Appendix D.

5.8.4 Calibration criteria compliance – Inter-peak 2

Table 5.36 details the overall change in inter-zonal matrix size between the pre-estimation matrix and the post-estimation matrix. Intra-zonal matrix totals are not adjusted by matrix estimation and do not affect assignment in SATURN.

Table 5.36 SERM RM Inter-peak 2 Matrix Totals

User Class	Prior (PCU)	Post-Incremental (PCU)	Change (%)
TAG Criteria			**Within 5%**
Taxi	1,371	1,314	-4%
Car Employers Business	4,043	3,675	-9%
Car Commute	10,930	9,980	-9%
Car Education	670	699	4%
Car Other	55,117	51,726	-6%
LGV	2,993	3,021	1%
OGV1	4,553	4,593	1%
OGV2 Other	256	256	0%

A table of sectored matrix differences is presented in Appendix B.

Five of the eight user classes pass the criteria while Car Employers Business, Car Commute and Car Other fall short. Car Other falls short by only 1 per cent while Car Employers Business and Car Commute fall short by 4 per cent. The overall change on the matrix total is 6 per cent.

GEH analysis was undertaken on the individual (non-zero) cells and their change between the pre-estimation and post-estimation values. 7 per cent of cells have a GEH value of less than 0.01, with 71 per cent of cells having a GEH value of less than 0.1. A graph illustrating the distribution of GEH values is shown in Figure 5.8 and Figure 5.9. Note the change in scale for Figure 5.9.

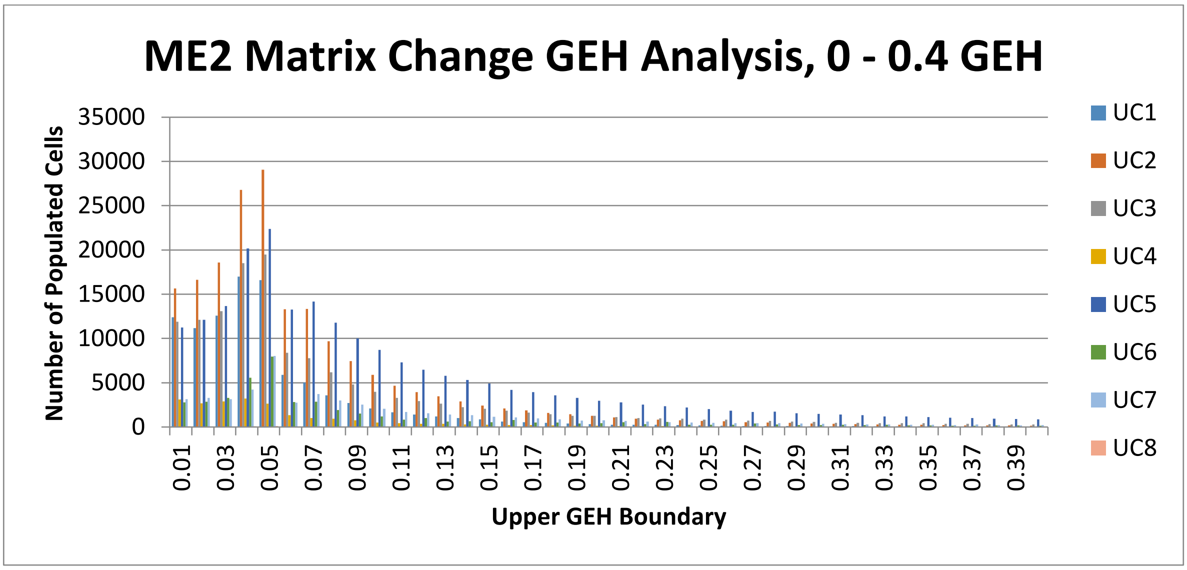

Figure 5.8 SATME2 IP2 Matrix Change GEH Analysis; 0 GEH to 0.4 GEH

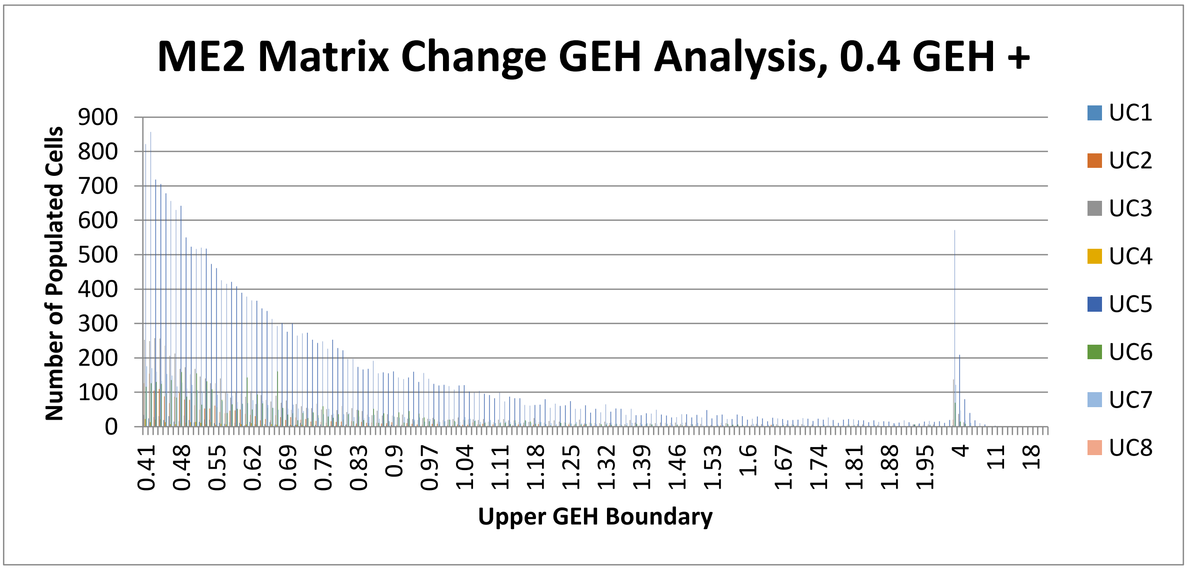

Figure 5.9 SATME2 IP2 Matrix Change GEH Analysis; 0.4 GEH Upwards

R^2 analysis was undertaken to further understand the matrix changes made by SATME2. Table 5.37 details the R^2 values for each individual user class. These are represented graphically in Appendix C.

Table 5.37 SATME2 IP2 Matrix Change R^2 Analysis

User Class	Cell R^2 Value	Cell Slope	Cell Y-Int
TAG Criteria	**> 0.95**	**0.98 - 1.02**	**Near 0**
Taxi	0.84	1.01	0.00
Car Employers Business	0.83	1.02	0.00
Car Commute	0.89	1.00	-0.01
Car Education	0.86	1.06	0.00
Car Other	0.88	1.04	-0.02
LGV	0.99	1.01	0.00
OGV1	1.00	1.00	0.00
OGV2 Permit Holder	-	-	-
OGV2 Other	1.00	1.00	0.00

Three of the eight user classes pass the R^2 criterion. Each user class passes the comparison of the intercept value, which should be zero or close to zero. All user classes except Car Employers Business, Car Education and Car Other pass the comparison of the slope of the line, which should be between 0.98 and 1.02.

Trip End analysis was undertaken for each user class and summarised in Table 5.38.

Table 5.38 IP2 Trip End Matrix Change R^2 Analysis

User Class	Trip End R^2 Value	Trip End Slope	Trip End Y-Int
TAG Criteria	**> 0.98**	**0.99 - 1.01**	**Near 0**
Taxi	0.98	0.97	0.03
Car Employers Business	0.96	0.89	0.27
Car Commute	0.98	0.81	2.39
Car Education	0.97	1.01	0.07
Car Other	0.97	0.90	6.29
LGV	1.00	1.01	0.00
OGV1	1.00	1.00	0.06
OGV2 Other	1.00	1.00	0.00

Five of eight user classes pass the criteria for R^2 and three pass criteria for slope, of these only three (LGV, OGV1 and OGV2) pass both. Six user classes pass the intercept criteria with Car Other falling the furthest from the criteria.

The matrix was compared against six prominent screenlines to determine whether or not the matrix broadly contains the correct number of trips. This check was undertaken around Waterford City. Table 5.39 details the total traffic crossing the screenlines.

Table 5.39 SERM RM IP2 Screenline Check

User Class TAG Criteria	Observed (Veh)	Model (Veh)	Difference (%) Within 5%
Waterford Urban Inbound	3,831	3,612	-6%
Waterford Urban Outbound	3,988	3,657	-8%
Outer Ring Road Outer Screenline Inbound	1,859	2,122	14%
Outer Ring Road Outer Screenline Outbound	2,194	2,457	12%
Outer Ring Road Inner Screenline Inbound	2,667	2,584	-3%
Outer Ring Road Inner Screenline Outbound	3,060	3,078	1%
Tramore Road Inbound	1,761	1,833	4%
Tramore Road Outbound	1,848	1,896	3%
River Suir Inbound	2,311	2,550	10%
River Suir Outbound	2,587	2,371	-8%
Northern Outer Inbound	1,407	1,449	3%
Northern Outer Outbound	1,288	1,433	11%

Traffic levels at five of the twelve locations measured are with acceptable boundaries of 5 per cent. Of those that fall short most are close with the exception of the Outer Ring Road Outer Screenline, River Suir Inbound and Northern Outer Outbound.

Table 5.40 Trip Length Distribution Analysis – IP2

User Class	Mean Percentage Change	Standard Deviation Change
TAG Criteria	< 5%	< 5%
Taxi	-13%	-10%
Car Employers Business	-15%	-7%
Car Commute	-14%	-2%
Car Education	-8%	-9%
Car Other	-16%	-9%
LGV	0%	0%
OGV1	0%	0%
OGV2 Other	0%	0%

Graphical representation of the trip length distribution changes at a user class level are presented in Appendix D.

5.8.5 Calibration criteria compliance – PM peak

Table 5.41 details the overall change in inter-zonal matrix size between the pre-estimation matrix and the post-estimation matrix. Intra-zonal matrix totals are not adjusted by matrix estimation and do not affect assignment in SATURN.

Table 5.41 SERM RM PM Peak Matrix Totals

User Class	Prior (PCU)	Post-Incremental (PCU)	Change (%)
TAG Criteria			Within 5%
Taxi	1,117	1,145	2%
Car Employers Business	2,699	2,650	-2%
Car Commute	26,021	25,370	-2%
Car Education	771	791	3%
Car Other	42,444	42,114	-1%
LGV	3,926	3,964	1%
OGV1	3,925	3,914	0%
OGV2 Other	332	332	0%

A table of sectored matrix differences is presented in Appendix B.

All user classes pass the criteria of less than 5 per cent change. The average change is 0 per cent when comparing modelled to observed levels. The overall change on the matrix total is 1 per cent.

GEH analysis was undertaken on the individual (non-zero) cells and their change between the pre-estimation and post-estimation values. 25 per cent of cells have a GEH value of less than 0.01, with 84 per cent of cells having a GEH value of less than 0.1. A graph illustrating the distribution of GEH values is shown in Figure 5.10 and Figure 5.11. Note the change in scale for both axes in Figure 5.11.

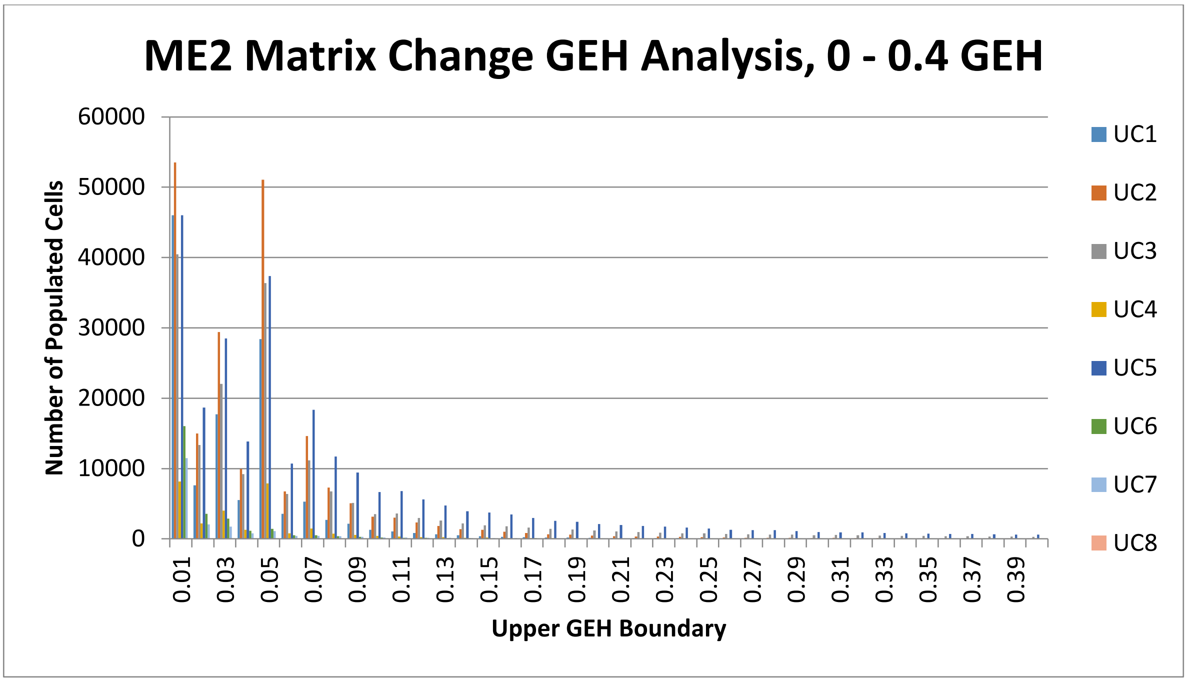

Figure 5.10 SATME2 PM Matrix Change GEH Analysis; 0 GEH to 0.4 GEH

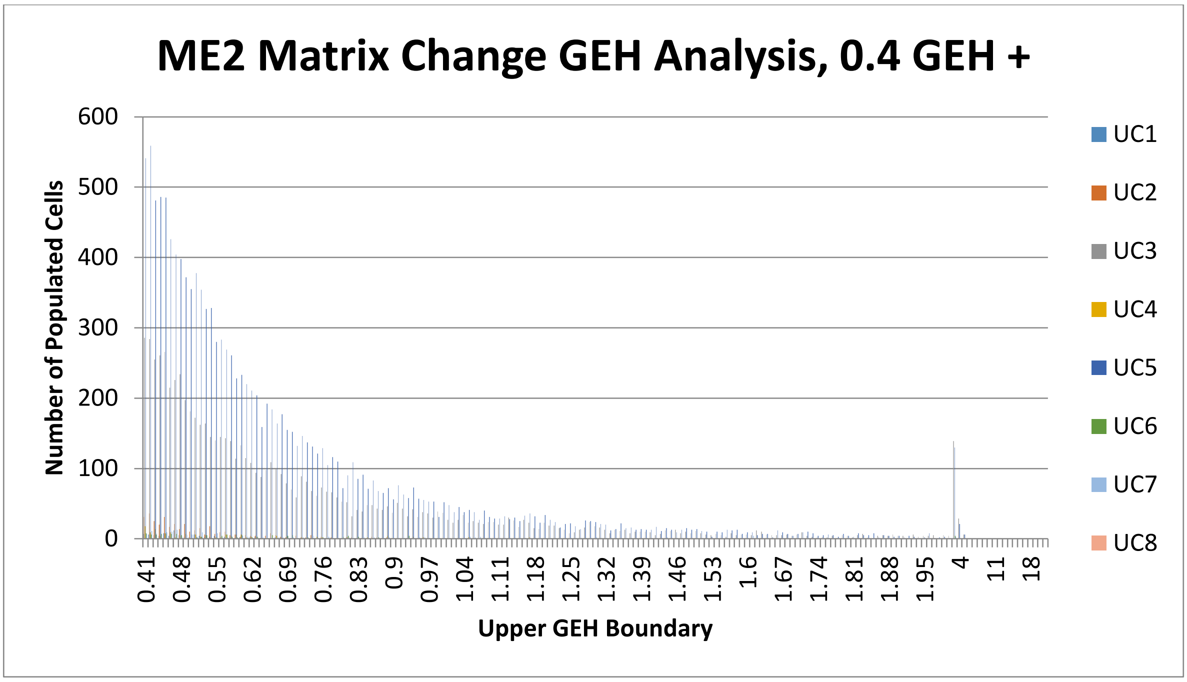

Figure 5.11 SATME2 PM Matrix Change GEH Analysis; 0.4 GEH Upwards

R^2 analysis was undertaken to further understand the matrix changes made by SATME2.

Table 5.42 details the R^2 values for each individual user class. These are represented graphically in Appendix C.

Table 5.42 SATME2 PM Matrix Change R^2 Analysis

User Class TAG Criteria	Cell R^2 Value > 0.95	Cell Slope 0.98 - 1.02	Cell Y-Int Near 0
Taxi	0.81	1.02	0.00
Car Employers Business	0.92	1.00	0.00
Car Commute	0.86	0.96	0.00
Car Education	0.83	0.98	0.00
Car Other	0.91	1.01	0.00
LGV	0.98	1.02	0.00
OGV1	0.99	0.99	0.00
OGV2 Permit Holder	-	-	-
OGV2 Other	1.00	1.00	0.00

Three user classes pass the R^2 criterion. Each user class passes the comparison of the intercept value, which should be zero or close to zero. Six user classes pass the comparison of the slope of the line, which should be between 0.98 and 1.02.

Trip End analysis was undertaken for each user class and summarised in Table 5.43.

Table 5.43 PM Trip End Matrix Change R^2 Analysis

User Class	Trip End R^2 Value	Trip End Slope	Trip End Y-Int
TAG Criteria	**> 0.98**	**0.99 - 1.01**	**Near 0**
Taxi	0.98	1.02	0.01
Car Employers Business	0.95	0.82	0.81
Car Commute	0.98	0.86	5.84
Car Education	0.97	0.99	0.06
Car Other	0.96	0.89	9.33
LGV	0.99	1.01	0.02
OGV1	1.00	1.01	-0.05
OGV2 Other	1.00	1.00	0.00

Three of the eight user classes pass the R^2 criteria and the slope criteria. As with previous time periods, Car Commute and Car Other fall short on the intercept.

The matrix was compared against six prominent screenlines to determine whether or not the matrix broadly contains the correct number of trips. Table 5.44 details the total traffic crossing the screenlines.

Table 5.44 SERM RM PM Screenline Check

Screenline TAG Criteria	Observed (Veh)	Model (Veh)	Difference (%) Within 5%
Waterford Urban Inbound	4,369	3,867	-11%
Waterford Urban Outbound	4,699	4,082	-13%
Outer Ring Road Outer Screenline Inbound	1,914	2,349	23%
Outer Ring Road Outer Screenline Outbound	3,310	3,244	-2%
Outer Ring Road Inner Screenline Inbound	2,756	2,607	-5%
Outer Ring Road Inner Screenline Outbound	4,187	3,819	-9%
Tramore Road Inbound	1,919	2,046	7%
Tramore Road Outbound	2,432	2,354	-3%
River Suir Inbound	2,888	2,903	1%
River Suir Outbound	3,926	3,383	-14%
Northern Outer Inbound	1,967	1,829	-7%
Northern Outer Outbound	1,788	1,768	-1%

Traffic levels across the screenlines pass the criteria for four of the twelve screenlines. The biggest difference is measured at the Outer Ring Road Outer Screenline Inbound. The average change across all the points is a reduction of 3 per cent between the observed and modelled.

Table 5.45 Trip Length Distribution Analysis – PM

User Class	Mean Percentage Change	Standard Deviation Change
TAG Criteria	< 5%	< 5%
Taxi	-6%	-7%
Car Employers Business	-12%	-9%
Car Commute	-12%	-6%
Car Education	-7%	-7%
Car Other	-12%	-10%
LGV	-1%	0%
OGV1	1%	0%
OGV2 Permit Holder	0%	0%

Graphical representation of the trip length distribution changes at a user class level are presented in Appendix D.

5.9 Calibration summary

5.9.1 Overview

Table 5.46 details the status of each component of the calibration process for each modelled period.

Table 5.46 Model Calibration Status

Component	AM Status	IP1 Status	IP2 Status	PM Status
Individual Link Flows	81%	88%	84%	77%
Individual Link GEH <5	76%	79%	75%	73%
Individual Link GEH <7	84%	88%	86%	83%
Individual Link GEH <10	91%	94%	92%	91%
Screenlines	25%	42%	42%	33%
Matrix Cell R^2 Analysis	38%	38%	38%	38%
Trip End Analysis	63%	63%	63%	38%
Matrix Trip Length Distribution	50%	50%	38%	38%

5.9.2 Traffic count observations

The highest GEH in the AM Peak (30.4) was located at Bridge Street/N quay/Quay St/ in New Ross in the eastbound direction. The traffic count at this location was nearly four times the modelled count. For all instances where the GEH is over 15 the majority have a lower modelled flow. One noted exception is the "New Rd/Castlecomer Rd/Newpark Dr East Westbound" in Kilkenny, which has an observed flow of 8 but a modelled flow of 226, an increase of 2808 per cent (GEH of 20.2).

The highest GEH in the Inter-peak 1 time period (19.8) was located on Sexton Street, in Dungarvan, where the modelled flow was 269 and the observed flow was 28.

The highest GEH in the Inter-peak 2 time period (21.9) was located on Sexton Street eastbound. The traffic count at this location is 43 and the modelled flow 351.

The highest GEH in the PM Peak (28.9) was located on the N25 on the southbound direction. The traffic count at this location is 2,134 and the observed flow is 991.

In general, throughout all time periods, instances of high GEH occur where modelled flows are lower than the observed traffic volumes at the same location. This tends to occur in areas where there is a lot of network detail (e.g. Anne Street in Waterford City Centre and Bridge Street in New Ross) but a relatively lower level of zonal detail. In these instances nearby roads which have slightly less congestion / higher speeds divert traffic away from these streets. This can result in very low modelled flows on some minor roads.

Further to this, any link which returned a modelled flow of zero, where the observed was greater than zero, were investigated and analysed. The majority of such links occurred on links with low observed flow.

Modelled traffic flows on the N25, between Waterford and New Ross, are consistently lower than observed traffic levels in all time periods. The change traffic volume is due to the changes in trip length distribution during the calibration process.

5.9.3 Matrix observations

In most time-periods, Car Employers Business sees the greatest change between prior and estimated matrices.

As would be expected, the user classes that are influenced more heavily by observed data, such as Car Commute, have relatively small changes between the prior matrices and the estimated matrices compared to the other user classes, though in some time periods, in particular Inter-peak 1 and Inter-peak 2, matrix estimation still results in some large changes in these user classes.

5.9.4 Trip Length Distribution Observations

Analysis of each modelled time period results in the same conclusion regarding the influence that matrix estimation is having on the prior matrices. As with many implementations of a matrix estimation solution, SATURN has generated shorter distance trips in order to meet the specified target traffic flows instead of generating longer distance trips. This has the effect of reducing the mean trip length distribution and the standard deviation of trips within the estimated matrices.

It should be noted that the increases in shorter distance trips are not of a significant level, but the trend is worth highlighting.

5.9.5 Calibration observation summary

Table 5.47 outlines the key calibration observations and indicates which modelled time periods the observation relates to.

Table 5.47 Model Calibration Identified Issues

Issue	**AM Peak**	**IP1**	**IP2**	**PM Peak**
Northbound flow on N25 is low	○	○	○	○
Southbound flow on N25 is low	○	○	○	○
Eastbound flow on Anne St is low	○	○	○	○
Bridge Street New Ross is Low	○	○	○	○

6 Road model validation

6.1 Introduction

This chapter sets out the specification and execution of the model validation process. This includes the source of validation criteria, application of these criteria, comparison of the model outputs with these criteria and commentary on this.

6.2 Assignment validation process

6.2.1 Overview

Model validation is the process of comparing the assigned traffic volumes against data that was kept independent of the calibration process, comparing modelled versus observed journey times and comparing trip length distribution of pre- and incremental matrices. Validation serves as an essential quality check on the calibrated road model. It is recommended that modelled flows and counts should be compared by vehicle type and time period if possible.

6.2.2 Validation Criteria

Table 6.1 outlines the screenline validation criteria as set out in TAG Unit M3-1, Section 3.2, Table 1.

Table 6.1 Road Assignment Model Screenline Validation Criteria

Criteria	Acceptability Guideline
Differences between modelled flows and counts should be less than 5% of the counts	All or nearly all screenlines

Table 6.2 outlines the journey time validation criteria as set out in TAG Unit M3-1, Section 3.2, Table 3.

Table 6.2 Road Assignment Model Journey Time Validation Criteria

Criteria	Acceptability Guideline
Modelled times along routes should be within 15% of surveyed times (or 1 minute, if higher than 15%)	> 85% of routes

6.2.3 Traffic volume comparison

The following data sources are available for the traffic volume comparisons:

- Permanent ATCs operated by the NRA; and
- Individual link and junction turning counts.

Individual link validation was undertaken against the same acceptability criteria as set out previously.

6.2.4 Journey times

Observed journey time data is available for a number of major roads within the SERM through the TomTom dataset. The routes previously defined for the moving car observer surveys were retained for the validation of the SERM. These routes constitute eight two-way radial routes, plus two two-way orbital routes.

AM Peak travel times were taken as being the average observed link times between 08.00 and 09.00. Inter-peak 1 travel times were taken as being the average observed link times between 10.00 and 13.00, with Inter-peak 2 travel times being the average observed link times between 13.00 and 16.00. PM Peak travel times were taken as being the average observed link times between 17.00 and 18.00

TAG Unit M3-1, Section 3.2.10 states that modelled journey times should be within 15 per cent of the observed end to end journey time, or within one minute if higher.

6.3 Traffic volume validation

6.3.1 Overview

Traffic Counts around Waterford City on key radial routes leading into the City were utilised for the traffic volume comparisons. From this data it is possible to validate the SATURN model against an all-vehicle total across 20 links.

6.3.2 Traffic count locations

A detailed map showing the location of all traffic counts used during validation is presented in Figure 6.1.

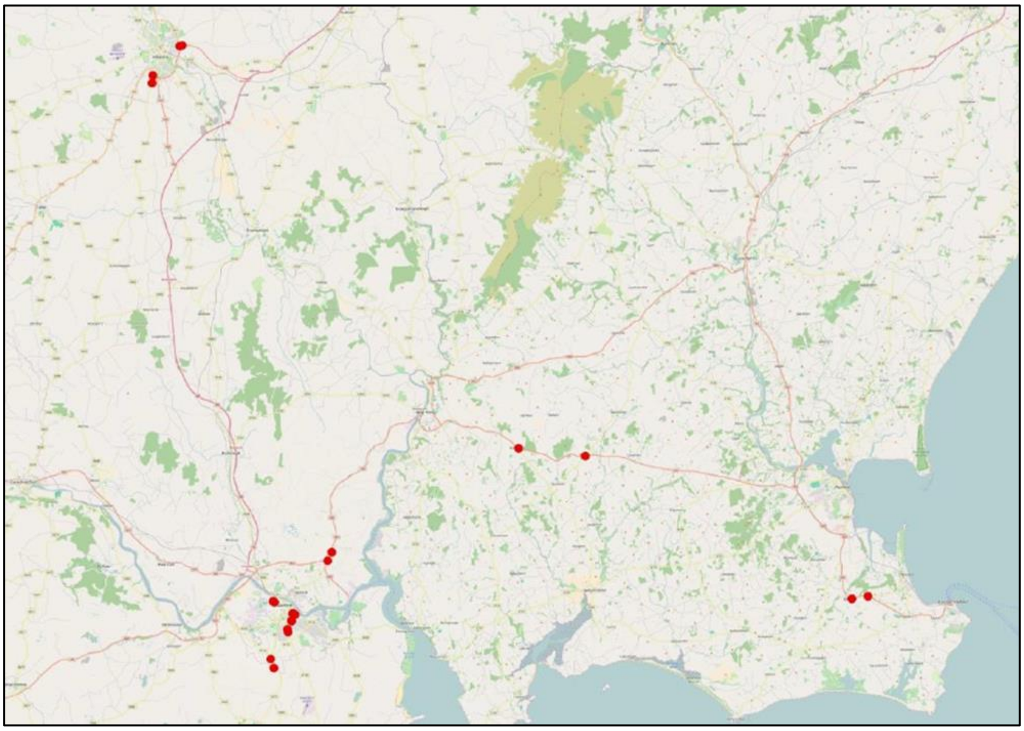

Figure 6.1 Link Validation Target Locations

6.3.3 Validation criteria compliance – AM peak

The validation statistics of the AM Peak model when compared against the individual link count validation criteria are outlined in Table 6.3.

Table 6.3 AM Peak Link Flow Validation

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	60% (12)
GEH < 5 for individual flows	> 65% of cases	60% (12)
GEH < 7 for individual flows	> 75% of cases	70% (14)
GEH < 10 for individual flows	> 95% of cases	70% (14)

Across the 20 count locations in the AM Peak, 60 per cent (12) pass the TAG flow validation criteria. 60 per cent of links have a GEH of less than 5. However, slackening the criteria to include GEH values of less than 10 yields a 70 per cent pass rate, which remains below the TAG recommendation of 85 per cent of links passing validation. The areas of poorest validation are generally north of Waterford with the Luffany Roundabout the closest location to the city centre. Validation points on the N25 between New Ross and Wexford also fail. Other locations that do not meet the criteria fall further north, around Kilkenny.

Detailed validation results, highlighting specific links that pass or fail the recommended validation criteria are included in Appendix E.

In general, modelled traffic volumes are lower than observed traffic volumes, specifically in urban areas. This is potentially attributed to average to poor R^2 and trip length calibration. There were specific traffic volume differences that warranted further investigation, and these are discussed in more detail in Section 6.5.

6.3.4 Validation criteria compliance – Inter-peak 1

The validation statistics of the Inter-peak 1 model when compared against the individual link count validation criteria are outlined in Table 6.4.

Table 6.4 Inter-peak 1 Link Flow Validation

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	71% (12)
GEH < 5 for individual flows	> 65% of cases	59% (10)
GEH < 7 for individual flows	> 75% of cases	71% (12)
GEH < 10 for individual flows	> 95% of cases	71% (12)

Across the 17 count locations on the Inter-peak 1, 71 per cent (12) pass the TAG flow validation criteria. 59 per cent of links have a GEH of less than 5. However, slackening the criteria to include GEH values of less than 10 yields a 71 per cent pass rate. This remains below the TAG recommendation of 85 per cent of links passing validation, and below the typical acceptability criteria of 95 per cent of links with a GEH value of less than 10.

As with the AM Peak the poorest performing locations are North of Waterford with the majority occurring near Kilkenny. The Luffany Roundabout fails validation as with the AM peak.

6.3.5 Validation criteria compliance – Inter-peak 2

The validation statistics of the Inter-peak 2 model when compared against the individual link count validation criteria are outlined in Table 6.5.

Table 6.5 Inter-peak 2 Link Flow Validation

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	71% (12)
GEH < 5 for individual flows	> 65% of cases	65% (11)
GEH < 7 for individual flows	> 75% of cases	71% (12)
GEH < 10 for individual flows	> 95% of cases	71% (12)

Across the 17 count locations in the Inter-peak 2, 71 per cent (12) pass the TAG flow validation criteria. 65 per cent of links have a GEH of less than 5. However, slackening the criteria to include GEH values of less than 10 yields a 71 per cent pass rate. This remains below the TAG recommendation of 85 per cent of links passing validation, and below the typical acceptability criteria of 95 per cent of links with a GEH value of less than 10.

The locations of the failing links remain the same as the AM and Inter-peak 1 time periods.

6.3.6 Validation criteria compliance – PM peak

The validation statistics of the PM Peak model when compared against the individual link count validation criteria are outlined in Table 6.6.

Table 6.6 PM Peak Link Flow Validation

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	67% (12)
GEH < 5 for individual flows	> 65% of cases	67% (12)
GEH < 7 for individual flows	> 75% of cases	72% (13)
GEH < 10 for individual flows	> 95% of cases	72% (13)

Across the 18 count locations in the PM Peak, 67 per cent (12) pass the TAG flow validation criteria. 67 per cent of links have a GEH of less than 5. However, slackening the criteria to include GEH values of less than 10 yields a 72 per cent pass rate, which remains below the TAG recommendation of 85 per cent of links passing validation. The areas of poorest validation are north of Waterford. The majority of the failing locations are near to Kilkenny in the buffer area. The other failing point is the Luffany Roundabout approach from the North.

6.4 Journey Time Validation

6.4.1 Overview

The NTA purchased historical journey time data from TomTom. The application of this data is a shift away from the traditional moving observer approach. The benefit of using TomTom data is that there is an abundance of journey time routes available with a larger sample of observations in order to determine the typical journey times on a particular link.

6.4.2 Journey Time Routes

Appropriate journey time routes were identified and agreed with the client. The journey time routes cover the main arterial routes into the city centre (Category 1) and origins and destinations from the main regional roads towards Waterford (Category 2). A detailed map of each journey time route is presented in Figure 4.2, in Section 4.4.1.

6.4.3 Validation Criteria Compliance – AM Peak

Of the 22 journey time routes, 86 per cent (19) pass TAG criteria, which exceeds the TAG recommendation of 85 per cent of routes passing the criteria. Figure 6.2 details the validation of each route. Route 18 is the poorest performing route in the AM Peak, with the modelled journey performing 36 per cent quicker than the observed time. This is due to a lack of junction-based delay on the modelled journey time route. Further details, including route profiles, are included in Appendix F, with detailed analysis of any significant issues discussed in Section 6.5.

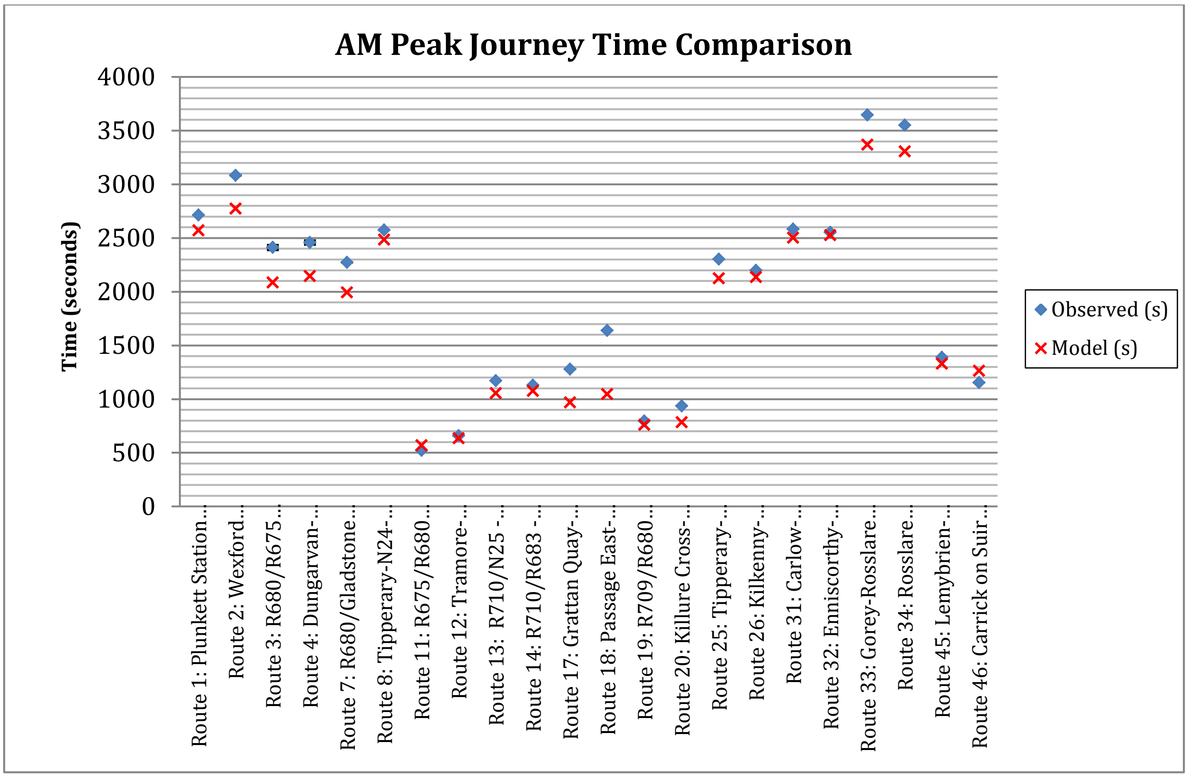

Figure 6.2 AM Peak Journey Time Comparison

6.4.4 Validation Criteria Compliance – Inter-peak 1

Of the 22 journey time routes, 100 per cent (22) pass the TAG criteria, which exceeds the TAG recommendation of 85 per cent of routes passing the criteria. Figure 6.3 details the validation of each route. Further details, including route profiles, are included in Appendix F, with detailed analysis of any significant issues discussed in Section 6.5.

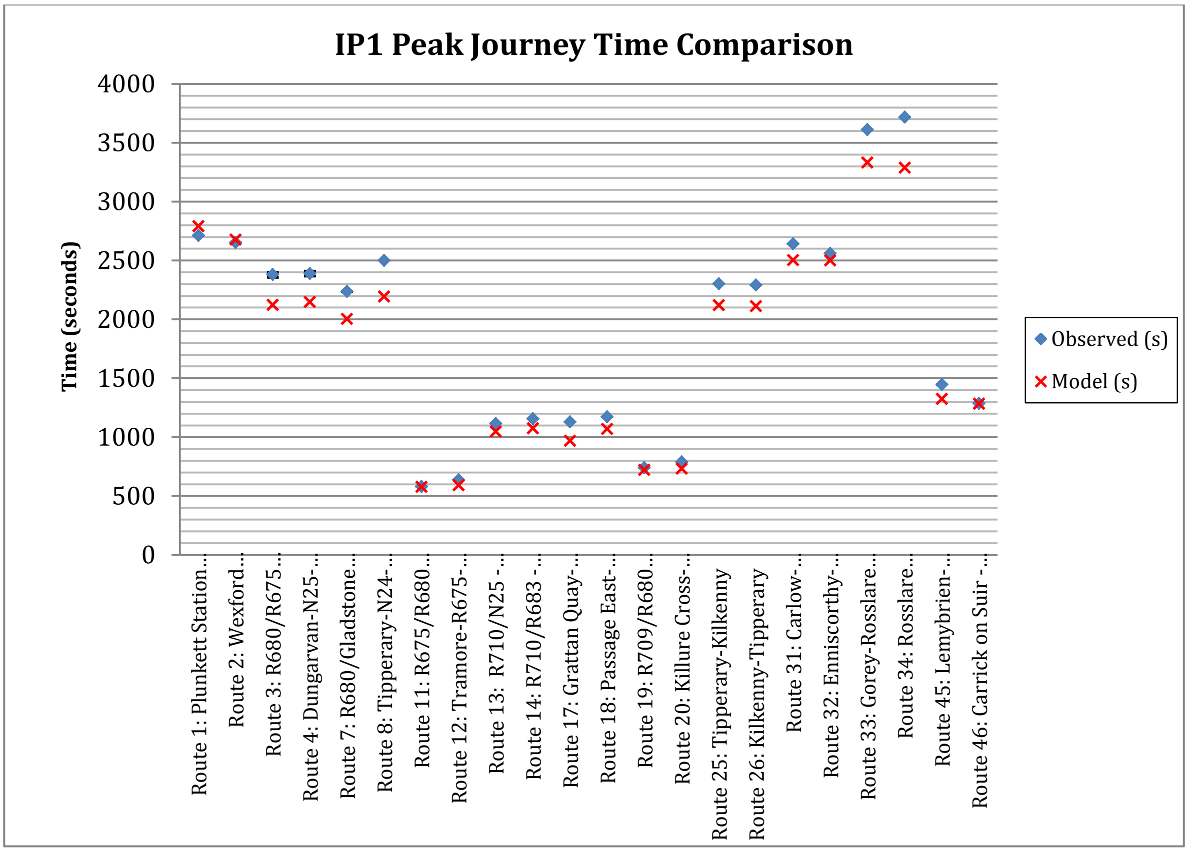

Figure 6.3 Inter-peak 1 Journey Time Comparison

6.4.5 Validation Criteria Compliance – Inter-peak 2

Of the 22 journey time routes, 91 per cent (20) pass the TAG criterion which exceeds the TAG recommendation of 85 per cent of routes passing the criteria. Figure 6.4 details the validation of each route. Routes 8 and 17 are the poorest performing routes in the Inter-peak 2, with the modelled journey performing fractionally above15 per cent quicker than the observed time.

Further details, including route profiles, are included in Appendix F, with detailed analysis of any significant issues discussed in Section 6.5.

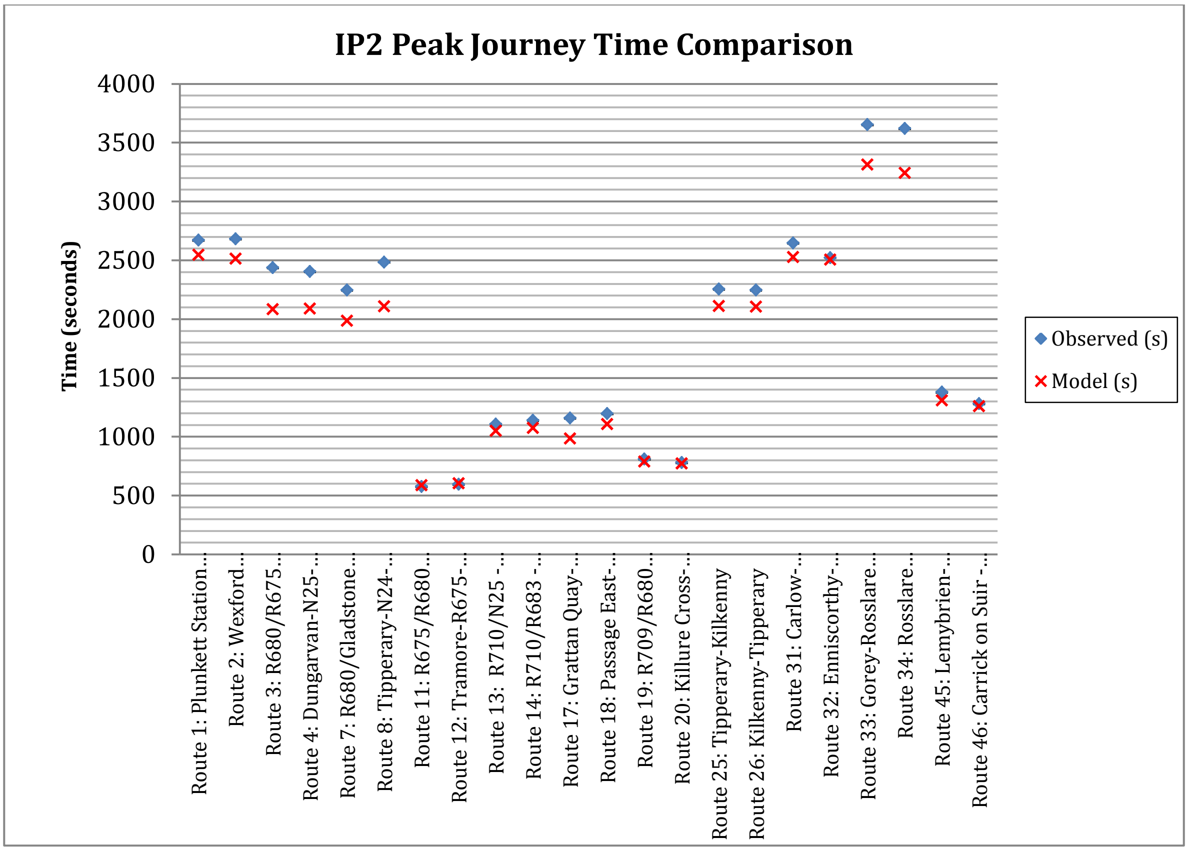

Figure 6.4 Inter Peak 2 Journey Time Comparison

6.4.6 Validation Criteria Compliance – PM Peak

Of the 22 journey time routes, 91 per cent (20) pass the TAG criteria, which exceeds the TAG recommendation of 85 per cent of routes passing the criteria. Figure 6.5 details the validation of each route. Route 17 is the poorest performing route in the PM peak, with the modelled journey performing 22 per cent quicker than the observed time due to a lack of junction-based delay on the modelled journey time route.

Further details, including route profiles, are included in Appendix F, with detailed analysis of any significant issues discussed in Section 6.5.

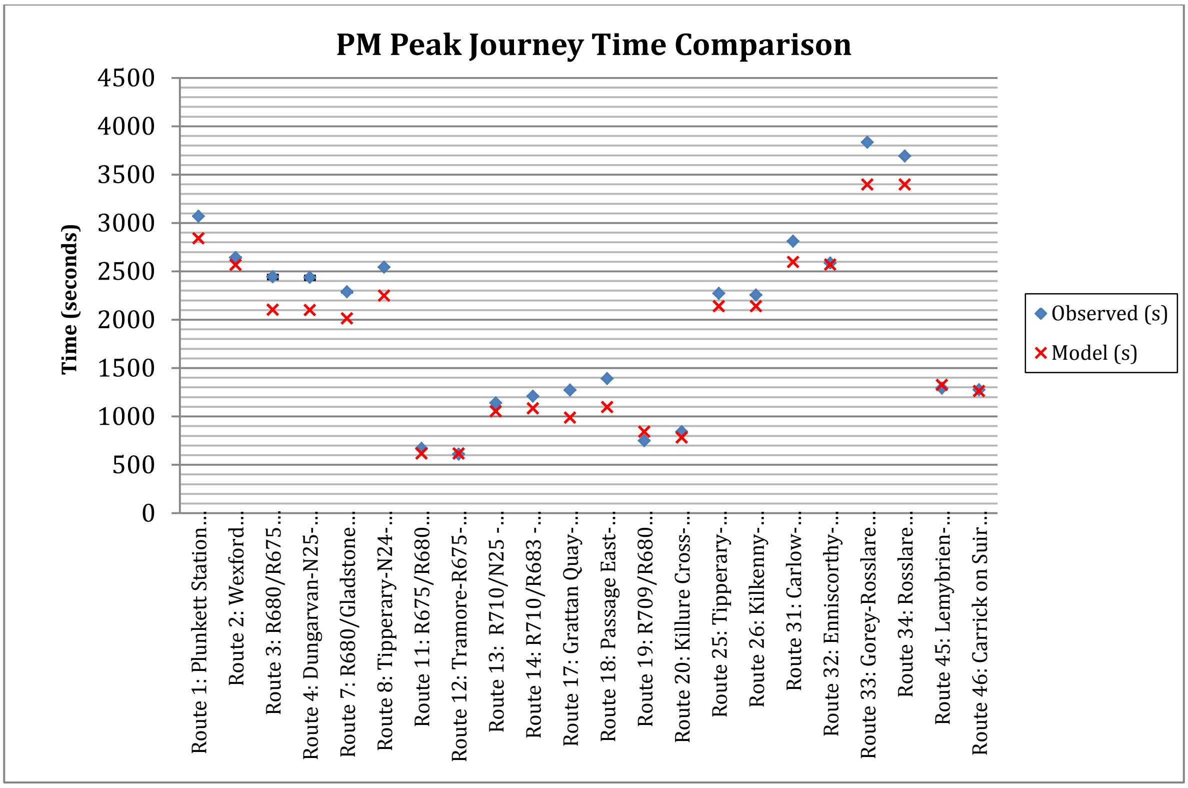

Figure 6.5 PM Peak Journey Time Comparison

6.5 Validation summary

6.5.1 Overview

Table 6.7 details the status of each component of the calibration process for each modelled period.

Table 6.7 Model Validation Status

Component	AM Status	IP1 Status	IP2 Status	PM Status
Individual Link Flows	60%	71%	65%	67%
Journey Times	86%	100%	91%	91%

6.5.2 Traffic count observations

The traffic count locations chosen for inclusion in the validation dataset were selected to provide a consistent coverage of observations into and through Waterford City centre. Despite this, as a regional model which covers a significant area outside of the Waterford urban area, the representation of final destinations may be an issue in some cases. However, without another comprehensive validation dataset (equivalent to the SCATS data used for ERM) this was considered the most appropriate dataset available at the time of the development of the model.

6.5.3 Journey Time Observations

Comparing the modelled journey times to the observed data in the AM Peak, there is high level of accuracy in the model with 19 of the 22 routes having a modelled journey time within 15 per cent of the observed times. Of the routes which fall outside the TAG criteria, route 20 (-16.3 per cent) is close to achieving the TAG requirements.

The Inter-peak 1 journey times compare excellently with observed data as 100 per cent of Journey Times meet TAG criteria. Generally, the majority of modelled journey times are quicker than the observed journey times.

The Inter-peak 2 period also performs very well in terms of journey times with 91 per cent of routes meeting TAG criteria. Both of the two routes which fall outside the TAG criteria (routes 8 and 17) are just marginally outside the required limits with modelled journey times 15.1 per cent quicker than observed journey times. In general, the majority of modelled journey times are quicker than the observed journey times.

The PM Peak period again compares very well with observed times with 91% of routes meeting TAG requirements.

In general, journey times in the model are slightly quicker than observed times. Two routes (Grattan Quay to Passage East and Clonmel to Waterford City) are consistently faster than the observed data in the majority of time periods. In the case of the Passage East route this appears to be caused by the model under representing delay at a small number of junctions on the outskirts of Waterford City.

6.5.4 Validation Observation Summary

Table 6.8 outlines the key validation observations and indicates which models the observation relates to.

Table 6.8 Model Validation Identified Issues

Issue	AM Peak	IP1	IP2	PM Peak
Consistently quick journey times on routes 17+18	○	○	○	○
Increase in short distance trips for Car User Classes	○	○	○	○
Low Waterford City Validation	○	○	○	○

7 Conclusion and recommendations

7.1 Summary

The South East Regional Model has been developed to assist the NTA with the assessment of current and future network performance, and the appraisal of local and strategic transport interventions. This report has presented the development of the road model element of the South East Regional Model.

7.2 Road Model Development

The road model network and the assignment parameters, as well as the demand model, have been significantly enhanced during all stages of the task. The model makes best use of the available information at the time of model inception through to this version of the model being completed. As part of the calibration and validation process the model network was adjusted to better reflect observed data. However, further improvements could be made for future model versions to improve model calibration and validation.

7.3 Road Model Calibration

The model calibrates reasonably well, given the significant scale of the model, coupled with the varied nature of the observed data, although each assigned user class does not meet all of the recommended guidelines set by the UK's TAG. These recommended criteria are summarised in Table 7.1, Table 7.2 and Table 7.3, representing a review of the change in demand and also a comparison of observed and modelled traffic levels.

Table 7.1 outlines the matrix estimation change calibration criteria, as specified in TAG Unit M3-1, Section 8.3, Table 5, and a summary of the range of results obtained across each of the nine user classes, from each peak period model.

Table 7.1 Significance of Matrix Estimation Changes

Measure	Significance Criteria	AM Peak	Inter-peak 1	Inter-peak 2	PM Peak
Matrix zonal cell value	Slope within 0.98 and 1.02; Intercept near zero; R^2 in excess of 0.95.	0.97 to 1.03 -0.01 to 0.00 0.74 to 1.00	0.99 to 1.06 -0.02 to 0.00 0.82 to 1.00	1.00 to 1.06 -0.02 to 0.00 0.83 to 1.00	0.96 to 1.02 0.00 to 0.00 0.81 to 1.00
Matrix zonal trip ends	Slope within 0.99 and 1.01; Intercept near zero; R^2 in excess of 0.98.	0.86 to 1.01 0.00 to 7.53 0.96 to 1.00	0.80 to 1.04 -0.01 to 4.41 0.96 to 1.00	0.81 to 1.01 0.00 to 6.29 0.96 to 1.00	0.82 to 1.02 -0.05 to 9.33 0.95 to 1.00
Trip length distribution	Means within 5%; Standard Deviation within 5%.	-16% to -0% -23% to -0%	-16% to 0% -10% to -0%	-16% to 0% -10% to 0%	-12% to 1% -10% to 0%
Sector to sector level matrices	Differences within 5%	35/169	17/169	18/169	35/169

In the AM Peak period the matrix zonal cell changes for the observed user classes (Car Education and Car Other) are close to the TAG recommended criteria, with R^2 values of 0.92. The slope for both Car Employers Business and Car Commute falls narrowly outside the TAG recommended range of 0.98 to 1.02, with values of 0.978 and 0.974 respectively, and the intercept for each of the observed user classes is within the TAG recommended ranges. The slope and intercept for both Car Education and Car Other also falls within the recommended ranges.

In the Inter-peak 1 period R^2 for Taxi, Car Employers Business, Car Commute, Car Education and Car Other fail to meet the TAG recommended criteria. The slope and intercept for Taxi and Car Commute met the criteria.

In the Inter-peak 2 period R^2 for LGV, OGV1 and OGV2 meet the TAG recommended criteria.

In the PM Peak period, R^2 for LGV, OGV1 and OGV2 meet the TAG recommended criteria. The slope and intercept for Car Employers Business, Car Education and Car Other also meet he TAG recommended criteria.

Table 7.2 outlines the link calibration criteria as set out in TAG Unit M3-1, Section 3.2, Table 2, and the level of calibration achieved in each specific period model

Table 7.2 Road Assignment Model Calibration Guidance Source

Criteria	Acceptability Guideline	AM Peak	Inter-peak 1	Inter-peak 2	PM Peak
Individual flows within 100 veh/h of counts for flows less than 700 veh/h ***within 15% of counts for flows from 700 to 2,700 veh/h*** ***within 400 veh/h of counts for flows more than 2,700 veh/h***	> 85% of cases	81% (396)	88% (421)	84% (401)	77% (379)
GEH < 5 for individual flows	> 85% of cases	76% (373)	79% (379)	75% (360)	73% (360)

The AM Peak period is close to the TAG recommended criteria for individual link flows at 81% and is also close to the GEH criteria for individual flows, with 76 per cent of links passing. Extending the analysis of the GEH to assess the number of links with GEH of 7 or less, and 10 or less results in 84 per cent and 91 per cent of links passing, respectively, which is satisfactory.

The Inter-peak 1 period meets the criteria set out in TAG for individual flows but narrowly fails in terms of GEH. Extending the analysis of GEH to assess the number of links with GEH of 7 or less, and 10 or less, results in a pass rate of 88 per cent and 94 per cent of links, respectively.

The Inter-peak 2 period is close to the TAG recommended criteria for individual flows at 84% and is close to the GEH criteria for individual flows, with 84 per cent of links passing. Extending the analysis of GEH to assess the number of links with a GEH value of 7 or less, and 10 or less, results in a pass rate of 86 per cent and 92 per cent of links, respectively.

In the PM peak period, 77 per cent of the links meet the individual link flow recommended criteria, and 73 per cent of links meet the GEH recommended criteria. Extending the analysis of GEH to assess the number of links with GEH of 7 or less and 10 or less, results in a pass rate of 8387 per cent and 91 per cent of links respectively, which is satisfactory.

Table 7.3 outlines the screenline calibration criteria as set out in TAG Unit M3-1, Section 3.2, Table 3, and the level of calibration achieved in each specific period model

Table 7.3 Road Assignment Model Screenline Calibration Guidance Sources

Criteria	Acceptability Guideline	AM Peak	Inter-peak 1	Inter-peak 2	PM Peak
Differences between modelled flows and counts should be less than 5% of the counts	All or nearly all screenlines	25%	42%	42%	33%

In the AM peak 25 per cent of screenlines are within 5 per cent of the observed traffic flows, and the remaining screenlines are within 20% per cent of the observed total traffic flows.

The Inter-peak 1 period has 42 per cent of screenlines within the TAG recommended criteria of total modelled screenline flows within 5 per cent of observed.

The Inter-peak 2 period has 42 per cent of screenlines within the TAG recommended criteria of total modelled screenline flows within 5 per cent of observed. The remaining screenlines are all within 14 per cent of observed flow.

The PM peak has 33 per cent of screenlines within 5 per cent of the observed traffic flows, and all but one of the screenlines are within 14 per cent of observed traffic flows.

Careful consideration was given to each criterion during the calibration and validation exercise such that the level of matrix change was balanced against the observed traffic volumes and observed journey times. Calibration of the car vehicle type is very strong across all time periods.

The more synthetic matrix elements (Taxi, Car Other, LGV and HGV) calibrate to a lesser extent, however this was anticipated owing to the synthetic nature of the input matrices, and the lack of disaggregated observed traffic data, particularly for Taxi.

Trip length distribution analysis and cellular GEH analysis of the matrix estimation changes indicates that the matrix estimation procedure has not excessively altered the observed user class data.

7.4 Road Model Validation

Traffic volume validation does not meeting TAG criteria in the AM Peak, where modelled traffic volumes are generally lower than observed traffic volumes. Journey times compare very well against TomTom data, with 86 per cent of routes meeting the TAG criteria of modelled journey times being within 15 per cent of observed journey times. Journey times therefore pass the recommended TAG criteria of 85% of all routes passing validation.

Traffic volumes in the Inter-peak 1 period fail against the recommended GEH criteria. However, Journey time validation for the Inter-peak 1 period meets the TAG criteria with 100 per cent of journey times being within 15 per cent of observed journey times.

Traffic volume validation in the Inter-peak 2 period fail the TAG recommendation of 85 per cent of links passing validation, and are below the typical acceptability criteria of 95 per cent of links with a GEH value of less than 10. In the Inter-peak 2 period, 91 per cent of the journey time routes meet the TAG criteria, and all routes are within 15.5 per cent of the observed journey times.

In the PM peak, traffic volume validation fails the TAG recommended criteria. Journey time validation for the PM peak passes TAG criteria, with 86 per cent of the journey time routes within 15 percent of observed journey times.

7.5 Recommendations

At present the values of time and the vehicle operating costs applied during the road model assignment are user defined within the SATURN data files prior to the final assignments. These are based on the best available model information at the time to inform the parameter calculations. The model information used is the average simulation network speed, which does not vary significantly between model versions of the same scenario. However, there are improvements to this process that could be applied to add further functionality.

A procedure could be written that takes the average network speed and re-calculates the vehicle operating cost between iterations / loops of the demand model. This would provide a more stable solution between model iterations should the network and information be refined or updated in the future. This would also ensure that the vehicle operating costs were updated in future year scenarios; a process which currently relies on user intervention.

Appendix A

Individual Link Calibration Results

Appendix B

Matrix Sector to Sector Differences

Appendix C

R^2 Analysis Graphs

Appendix D

Trip Length Distribution Analysis

Appendix E

Individual Link Validation Results

Appendix F

Journey Time Analysis

Údarás
Náisiúnta Iompair
National Transport Authority

National Transport Authority
Dún Scéine
Harcourt Lane
Dublin 2

Údarás Náisiúnta Iompair
Dún Scéine
Lána Fhearchair
Baile Átha Cliath 2

Tel: +353 1 879 8300
Fax: +353 1 879 8333

www.nationaltransport.ie