REGIONAL MODELLING SYSTEM

Eastern Regional Model

Road Model Development Report

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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 Background

The NTA has developed a Regional Modelling System (RMS) 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 List of Regional Models

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

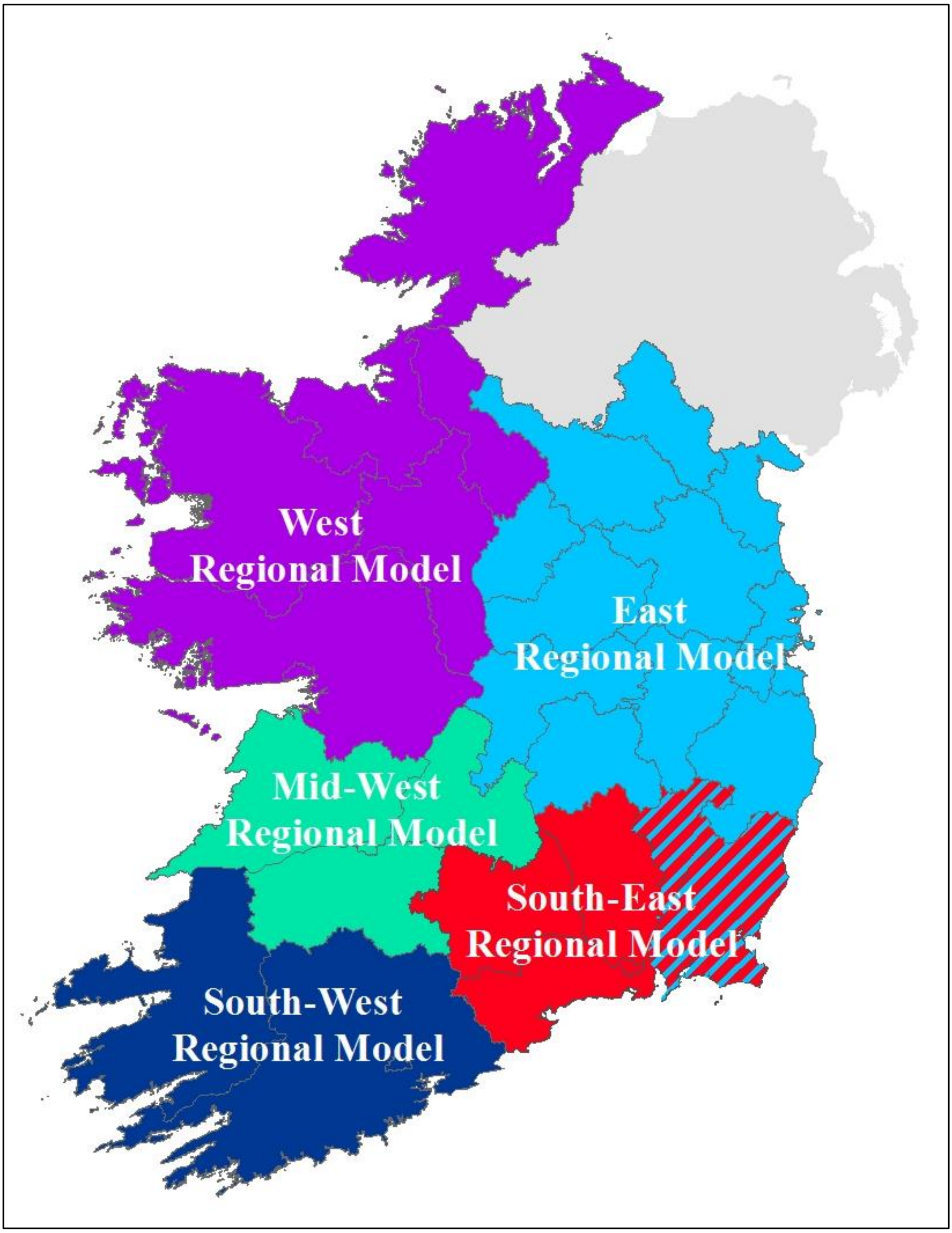

Figure 1.1 Regional Model Area

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 ERM (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 ERM 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.

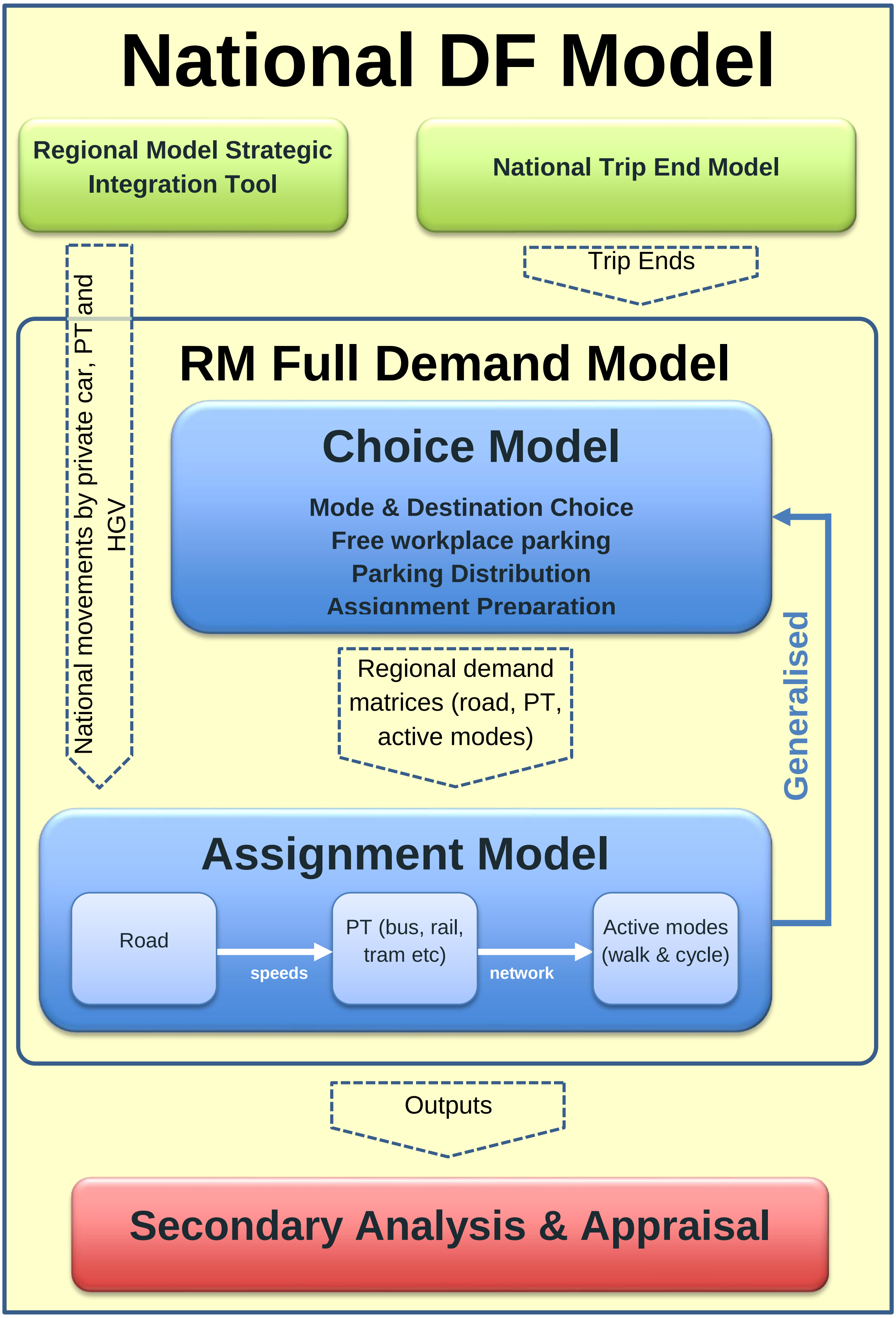

Figure 1.2 RMS Model Structure

1.3 ERM 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 ERM 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.

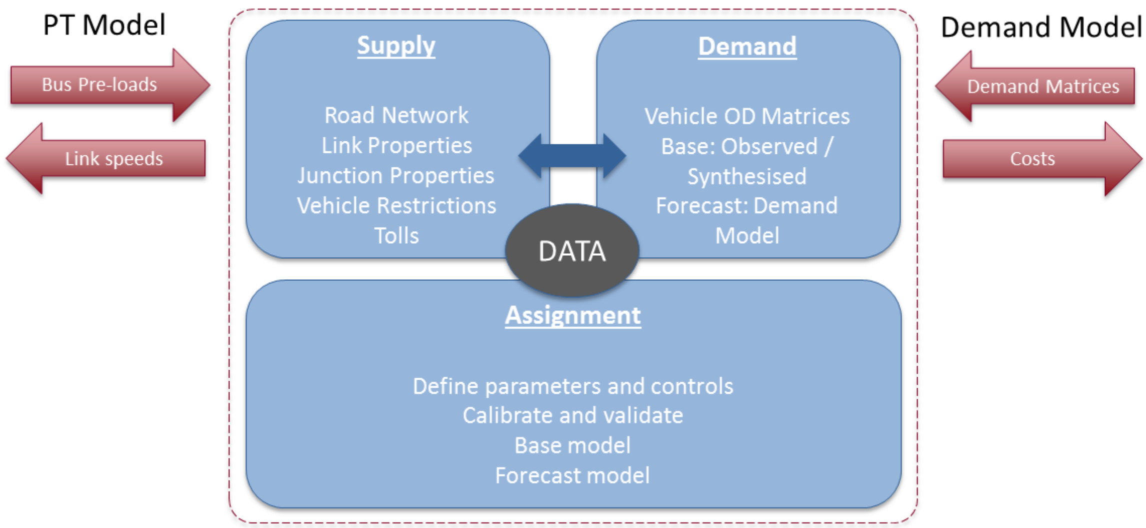

Figure 1.3 RMS RM Structure Overview

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 on 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 ERM Transport Model

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 Zone System

The Road Model zone system is the same as the zoning system specified for the overall ERM as described in the “ERM Zone System Development Report”. The zone system has been designed to include 1,854 zones and is shown in Figure 1.4.

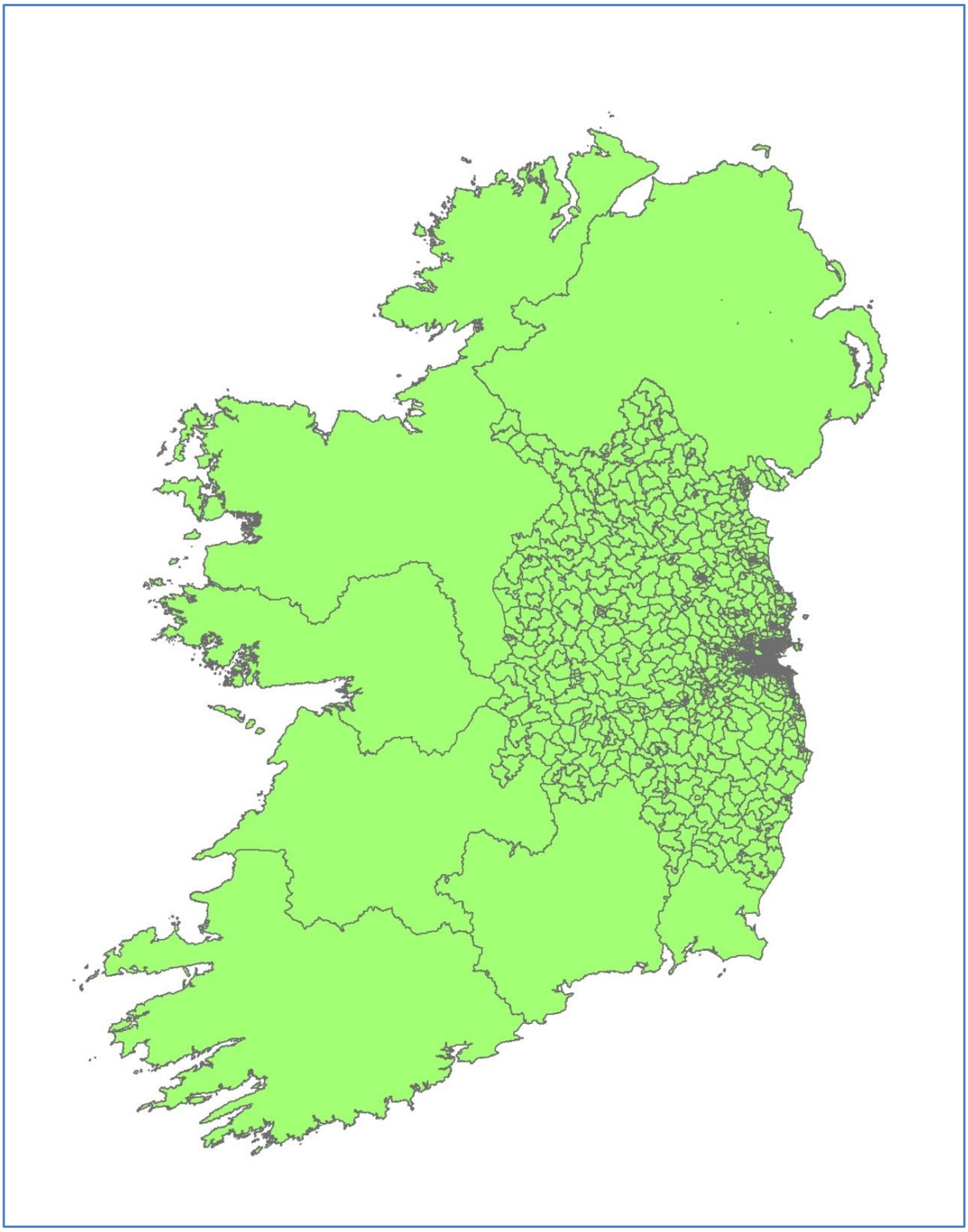

Figure 1.4 ERM Zone System

The key zone system statistics include:

- Total zones: 1,854;
  - Dublin zones: 1,315
  - Buffer zones: 529
  - External zones: 6
  - Special Use Zones: 3
  - Northern Ireland zones: 1

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 Dublin City 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 Eastern Regional Model (ERM). It includes the following sections:

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

2 Road Model Development

2.1 Introduction

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

2.2 Road Network Development

2.2.1 Overview

The base network was developed under the Road Network Development task (TO2), as set out in "RD TN14 Network Development Task Report". Node and link data from the HERE[1] geographic data GIS layer was processed under TO2, 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. The HERE GIS layer is provided in the "Irish National Grid" projection. This skeletal network coding was then used as a foundation for the manual coding of each simulation junction in the road model. The retention of coding from the existing GDA model is set out in "RD TN14 Network Development Task Report".

2.2.2 Node 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 under TO2, 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 under the Public Transport Model Development task (TO7), 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 road 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 rate of one bus equals three passenger car units (PCU) and will be affected by link congestion. Other

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

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 SATURN, designated with a negative saturation capacity.

Dublin City Council enforces a 5-axle ban broadly along the alignment of the canals. This ban has been included in the road model through the use of turn penalties for the affected user classes.

In addition to the 5-axle vehicle ban, Dublin City Council also bans vehicles whose gross weight exceeds three tonnes from many residential areas in the Greater Dublin Area. Inclusion of the three tonne vehicle ban has been included in the road model through the use of turn penalties for the affected user classes.

2.2.6 Tolling

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

- East Link Bridge;
- Dublin Port Tunnel;
- M50 West Link;
- M1 Gormanston – Monasterboice;
- M3 Clonee – Kells;
- M4 Kilcock – Enfield – Kinnegad; and
- M7 / M8 Portlaoise – 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 Speed Flow Curves

Initial speed flow curves and mid-link capacities have been specified under TO2 and these have been implemented in the development of the supply networks. Speed flow curves are only applied on the M50 motorway and in the rural area outside of the M50, including the buffer network. The speed flow curves are set out in “SA TN11 Regional Model Coding Guide”.

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

During the network calibration and validation stage some 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 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.

Speed flow curves are not currently applied in the simulation area within the M50. Combining speed flow 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.

Although speed flow curves are not currently applied in the simulation area within the M50, it may be necessary to apply speed flow curves on some corridors with fewer junctions in future iterations of the model development, where it is shown to be necessary to incorporate a speed flow curve to improve journey time validation.

2.3 Assignment Model Preparation

2.3.1 Network Checking

A comprehensive set of network checks were undertaken as part of TO2 and the previous Road Model Calibration and Validation task (TO6) before commencing calibration. These checks included:

- range of checks 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
- comparison of existing GDA model versus ERM model.

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. Whilst updating the model to newer versions of the network and assigning newer versions of the matrix 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 vehicle operating cost (PPK) was updated regularly during model development.

The calculated PPM component does not change with the average simulated network speed and was fixed for all assignments during model development.

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 method 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 road 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 Vehicles 1 (OGV1)
- User Class 8 – Other Goods Vehicles 2 (OGV2) Permit Holder
- User Class 9 – OGV2 Non Permit Holder

Prior matrices for all user classes were developed under the Demand Model Development task (TO8) in accordance with "ERM Full Demand Model Calibration Report". These matrices are an essential input to the development of the Road Model.

3.2 Prior Matrix Factoring

Prior matrices provided by TO8 represent travel demand over a three hour period, such as 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, undertaken 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 to derive the appropriate factor.

A third methodology is to represent the "peak everywhere" by
derived from various data sources, with the aim of representing the
at each point in the network simultaneously. Automatic traffic
used to derive factors for the ERM in order to best represent the
Dublin, and is discussed further in the "FDM Scope3 Modelling
This factor represents the "flow" PtH factor, and the factors
are outlined in

Table 3.1. These factors were applied to interim versions of the road model.

Table 3.1 RDAM Initial Period to Assigned Hour Factors

Time Period	Period to Hour Factor
AM Peak (0700 – 1000)	0.393
Inter Peak 1 (1000 – 1300)	0.333
Inter Peak 2 (1300 – 1600)	0.333
PM Peak (1600 – 1900)	0.358
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 without regard to journey purpose. 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 ERM are outlined in Table 3.2.

Table 3.2 RDAM Final Period to Assigned Hour Factors

Time Period	Period to Hour Factor
AM Peak (0700 – 1000)	0.479
Inter Peak 1 (1000 – 1300)	0.333
Inter Peak 2 (1300 – 1600)	0.380
PM Peak (1600 – 1900)	0.426
Off Peak (1900 – 0700)	0.083

3.3 Prior Matrix Checking

Comprehensive checks of the matrices were undertaken and documented as part of TO8 before commencing calibration. These checks included:

- comparing 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 latest version of the road model.

4 Data Collation and Review

4.1 Supply Data

As described in the "RM Spec2 Road Model 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 road network. The simulation area was then coded with reference to the agreed coding guide as part of TO2.

The NTA then oversaw a rationalisation of superfluous network detail, and a quality check of the road network in order for a base year assignment to converge.

Traffic signal stages and timing have been developed from:

- Sydney Co-ordinated Adaptive Traffic System (SCATS) database where available;
- the previous GDA model (if not available from SCATS); and
- proportional green time split based on observed traffic count if not available from SCATS or the previous model.

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 (there are approximately 20,000 records for the ERM). 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.

4.2.2 Goods Vehicles

Goods vehicles are comprised of the following classes of vehicles:

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

- 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, retail and distribution centres. These trips will be made regardless of the cost of travel. These have been assumed to be made primarily by OGV2, with a smaller proportion made by OGV1. Bulk Goods Trips were 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 30/70 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 estimated parameters. These were disaggregated between LGVs and OGV1 using a 84/16 split.

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

4.3 Count Data

There are between 6,000 and 7,000 survey data records nationwide, including manual classified counts, automatic traffic counts (ATC) and SCATS data, which were collated under the Data Collection task (TO11). The data was collated in 2014 and represents data from January 2009 to October 2013.

Figure 4.1 indicates the location of traffic count data that was collated under TO11.

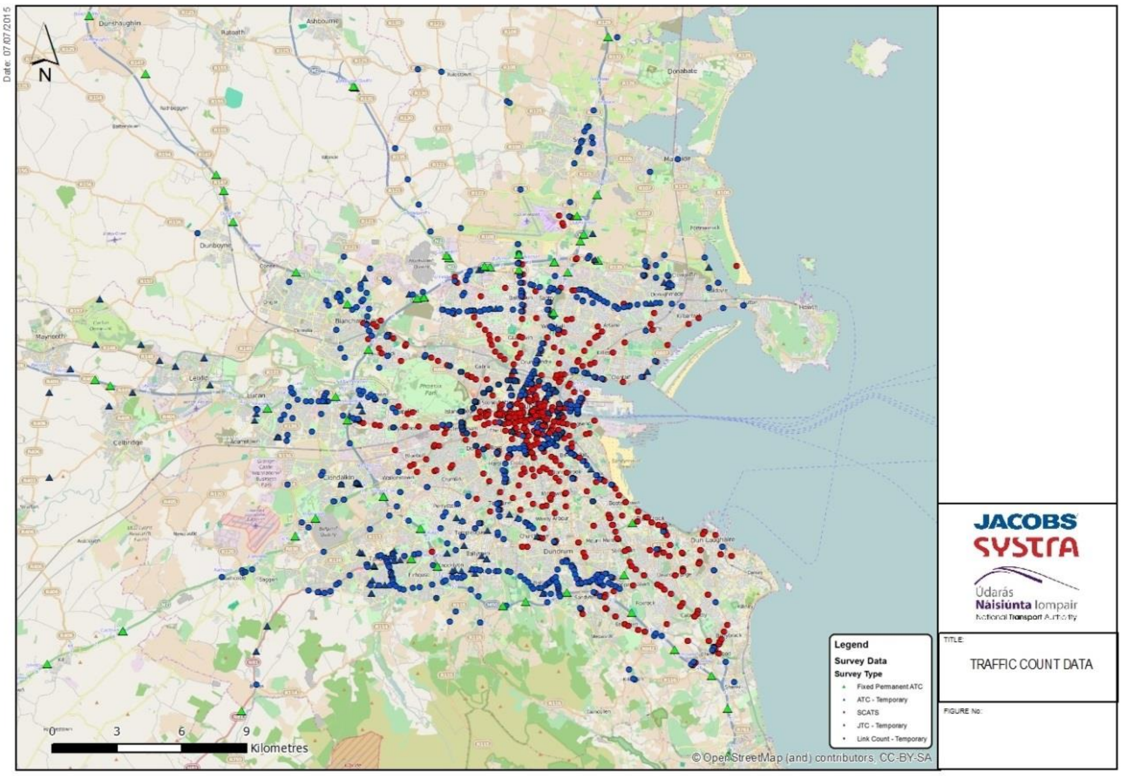

Figure 4.1 Location of Traffic Count Data

4.4 Journey Time and Queue Length Data

4.4.1 Moving Car Observer Data

The NTA commissioned moving-observer journey time surveys on 22 routes (16 Radial, 5 Orbital, and the Port Tunnel) to capture speed samples at peak and inter-peak times. Similar surveys were conducted each year from 2006 to 2009, and then again in 2012. Moving car observer data from 2012 was used during the validation of interim versions of the RM, supplemented by historic data if required.

The inbound direction for all arterial routes was surveyed in the AM (0800 – 0900) and Inter-peak (1400 – 1500) period, with the outbound direction of all arterial routes surveyed in the PM peak period (1700 – 1800). All radial routes were surveyed in both directions in all time periods and Figure 4.2 indicates the routes taken by the moving car observer surveys.

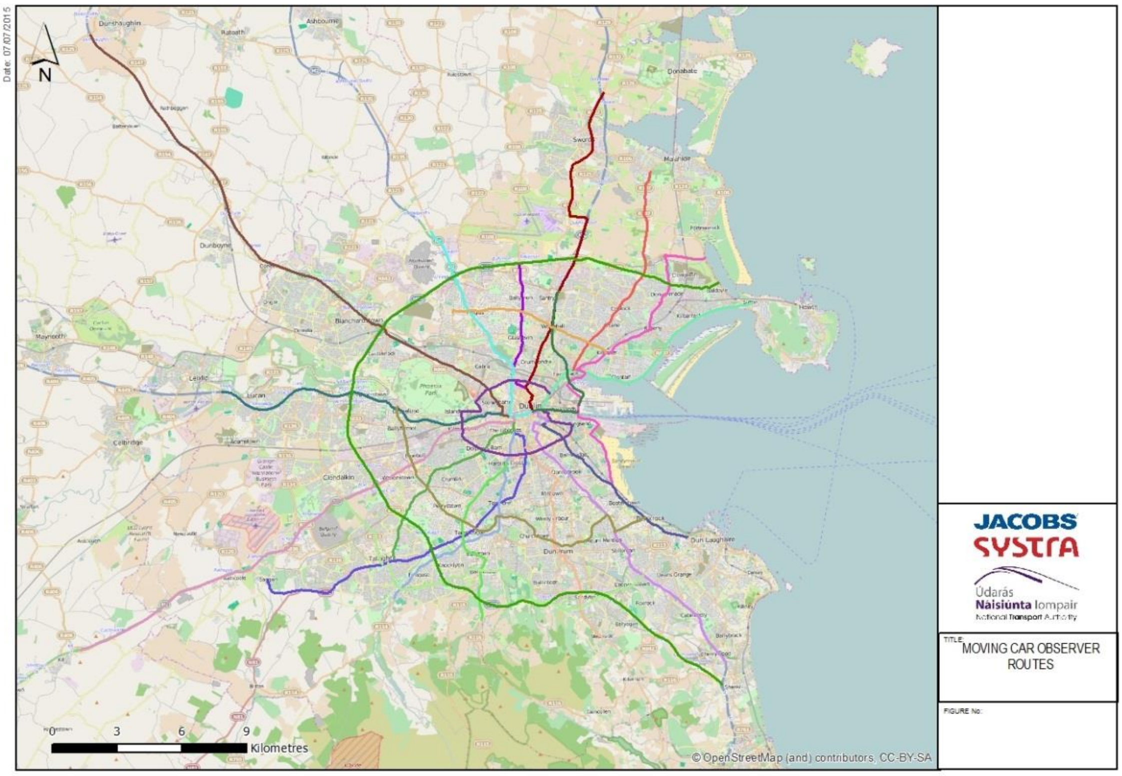

Figure 4.2 Moving Car Observer Routes

Journey time data is not available at a meaningful level for each of the vehicle types in the model (cars, LGV, and OGV) and therefore only car speed was considered for the journey time comparison. This is consistent with the method of obtaining the observed journey time data.

Individual car user classes were not considered given that they will all travel at the same speed in the model and therefore have the same journey times on consistent links.

4.4.2GPS-based Travel Time Data

The NTA purchased a license from TomTom for the 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 same travel time routes as indicated in Figure 4.2 were extracted from the dataset, with the exception of the following changes:

- Route 2 Inbound and Outbound truncated due to missing data on Balgriffin Park / Hole In The Wall Road between the R124 and the R139 / R809;
- Route 4 Inbound and Outbound truncated due to missing data on Temple Street / Hill Street between the N1 and the R803, Marlborough Street between the R803 and Cathal Burgha Street, and O'Connell Street (southbound);
- Route 5 Inbound and Outbound truncated due to missing data on Eccles Street between Berkley Road and the N1;
- Route 14 Inbound and Outbound truncated due to missing data on Sandyford Road (Dundrum) between Overend Avenue and Ballinteer Road;
- Route 17 Eastbound and Westbound excluded due to significant gaps in the dataset; and
- Route 19 Clockwise and Anti-clockwise truncated due to missing data on St. Lotts Road between the R815 and the R802.

Additional travel time routes were defined during the model calibration process in order to make best use of the TomTom data. These additional routes were:

- M1 between the M50 and M1 Junction 20 (near. Dromad), both directions;
- M4 (M6) between the M50 and M6 Junction 13 (west of Athlone), both directions;
- M7 between the M50 and M7 Junction 16 (near Portlaoise), both directions;
- M11 between the M50 and Ferrycarrig (near Wexford), both directions;
- N52 between Dundalk and Kells, both directions;
- N52 between Kells and Mullingar, both directions;
- N52 between Mullingar and Tullamore, both directions;
- N80 between Tullamore and Portlaoise, both directions;
- N80 between Portlaoise and Carlow, both directions; and
- N80 / N11 between Carlow and Arklow, both directions.

Data is available at an hourly average level between 0700 and 1900, and at an average period 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, with smaller variability and uncertainty.

The inbound and outbound direction for all routes was extracted in the AM (08:00 – 09:00), Inter-peak 1 (average of 10:00 – 13:00), Inter-peak 2 (average of 13:00 – 16:00), 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 ERM road model.

4.4.3 Queue Length Data

Where available, queue length data was used to confirm that queuing occurs at appropriate 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. TO11 included reviewing the availability of queue length data.

5 Road Model Calibration

5.1 Introduction

Section Five 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

5.2.1Overview

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

- Individual links (link counts); and
- Across defined screenlines.

5.2.2Calibration

Calibration is the process of adjusting the RM to ensure that it provides robust estimates of road traffic 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 advises 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;
- 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 in to two components; matrix calibration Matrix calibration ensures the correct total volume of traffic is bound through the use of sector analysis, while network calibration 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[4] 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 are 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.

4 Developed by Geoffrey E. Havers (GEH)

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

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

Initial generalised cost parameters, calculated using the output from the interim model used during the assessment of the Dublin Transport Strategy formed the basis for the first steps of model development. The initial generalised cost parameters are set out in the following four tables, with Inter-peak 2 mirroring the initial costs of Inter-peak 1 as there was no Inter-peak 2 assignment undertaken as part of TO6. 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	60.13	18.78
UC2 – Car Employers Business	60.13	18.78
UC3 – Car Commute	21.52	9.82
UC4 – Car Education	36.39	9.82
UC5 – Car Other	21.16	9.82
UC6 – LGV	43.34	13.38
UC7 – OGV1	46.08	30.52
UC8 – OGV2 Permit Holder	44.40	55.86
UC9 – OGV2 (Other)	44.40	55.86

Table 5.5 Initial IP1 Generalised Cost Values

User Class	Cents Per Minute	Cents Per Kilometre
UC1 – Taxi	70.39	17.80
UC2 – Car Employers Business	70.39	17.80
UC3 – Car Commute	20.74	9.38
UC4 – Car Education	42.66	9.38
UC5 – Car Other	38.41	9.38
UC6 – LGV	45.91	13.68
UC7 – OGV1	47.87	29.84
UC8 – OGV2 Permit Holder	46.55	54.79
UC9 – OGV2 (Other)	46.55	54.79

Table 5.6 Initial IP2 Generalised Cost Values

User Class	Cents Per Minute	Cents Per Kilometre
UC1 – Taxi	70.39	17.80
UC2 – Car Employers Business	70.39	17.80
UC3 – Car Commute	20.74	9.38
UC4 – Car Education	42.66	9.38
UC5 – Car Other	38.41	9.38
UC6 – LGV	45.91	13.68
UC7 – OGV1	47.87	29.84
UC8 – OGV2 Permit Holder	46.55	54.79
UC9 – OGV2 (Other)	46.55	54.79

Table 5.7 Initial PM Generalised Cost Values

User Class	Cents Per Minute	Cents Per Kilometre
UC1 – Taxi	60.13	18.40
UC2 – Car Employers Business	60.13	18.40
UC3 – Car Commute	21.52	9.65
UC4 – Car Education	36.39	9.65
UC5 – Car Other	21.16	9.65
UC6 – LGV	43.34	13.16
UC7 – OGV1	46.08	29.80
UC8 – OGV2 Permit Holder	44.40	54.55
UC9 – OGV2 (Other)	44.40	54.55

5.4 Interim Road Model Network Progression

5.4.1 Overview

In total there were 17 iterations of the network data files used during the creation of the pre-assignment SATURN network (UFN) used during the Dublin Strategy assessment. Each iteration consisted of an update to the network coding for the three assigned peak periods (AM, Inter-peak 1 and PM) with the coding for Inter-peak 1 being replicated for the Inter-peak 2 and Off-peak networks.

The major considerations during network development are outlined in the following sections.

5.4.2 Taxi Modelling

TO2 produced network version V0, on which all future network versions were based. Network version V1 was the first “major change” network which included taxis as a separate assigned user class.

In order to accommodate this change, bus-only turns, previously coded with a “-“ modifier in front of the turn saturation capacity were re-coded as a normal turn. This would allow all vehicles to make the turn. The specific turn was then added to the banned turn section (44444) of the network data file for all user classes except for taxi (UC1).

Taxis could now correctly be assigned to the model network. However they would not utilise a bus lane if there was a general traffic lane available. This is a limitation in SATURN. However, coding the bans in this way provides future model functionality should SATURN change the way in which user classes are assigned to the road network.

This change enabled taxis to route correctly through the model which improved model calibration by releasing some link and turn capacity currently incorrectly occupied by taxis. This change also allowed for separate estimation to be carried out on the taxi user class where observed taxi volumes were recorded. A separate inner taxi cordon was established around the canals, and individual link targets were placed around the network where a distinct taxi observation had been made.

It should be noted that taxi volumes are not always recorded by traffic surveys. However, a recommendation from this process, in conjunction with TO11, was to propose that all future counts undertaken in Ireland include taxi as a distinct vehicle type or user class.

5.4.35-Axle Goods Vehicle Ban

Initial discussions surrounding the inclusion of the 5-axle goods vehicle ban concluded that in order to accurately reflect the ban in effect around Dublin, the broader OGV2 user class would need to be separated into two user classes, based on trip origin and trip destination.

A SATURN key file was created that splits the OGV2 user class into two separate matrices, based on their origin and destination. It was agreed that if a trip in the prior matrix had an origin or destination within the boundary of the 5-axle ban then the trip would be deemed to have a permit. This facilitated the inclusion of two OGV2 user classes in the assignment.

As traffic counts are not disaggregated between OGV2s that have a permit and those that do not, the two OGV2 user classes can only be compared to, and estimated against a single OGV2 observation.

5.4.4Wider Scale 3 Tonne Ban

Dublin City Council enforces a ban on any vehicle which exceeds 3 tonnes on a large proportion of roads in residential areas. There isn’t a single source available that lists the locations of all bans, so often bans were added as routes were inspected. Some bans were missed from the initial sift, and locations were only identified after accurate matrices were assigned and irregular goods vehicle routing was identified.

5.4.5Link Speed Reduction

Initial link travel speeds inside the M50 were taken directly from the HERE output network which is based on in-vehicle GPS data. These are daily average speeds that are then placed into bands and often do not accurately reflect peak condition travel speeds. However, they can provide a more accurate initial link travel speed than using the speed limit. Speeds on several routes, particularly through traffic calmed residential areas were reduced.

It is proposed that link speeds are adjusted in future versions of the model, using average travel speed data from TomTom TrafficStats. The TomTom TrafficStats travel time data is derived from the TomTom database which collects data from compatible GPS devices. The database can be queried under license from TomTom through three commercial products; Speed Profiles, Custom Travel Times and Custom Area Analysis. This is likely to be constrained to routes being used during journey time validation and parallel routes to reduce illogical re-routing from the main routes.

5.4.6 Sector-based Node Numbering

There was no system or methodology applied to the initial numbering of nodes and zones in the road model network that was an output of TO2. A sector system was developed by the Zone Definition task (TO3) and all nodes and zones were then re-numbered to correspond with the sector to which they belong, allowing for easier assessment of model outputs.

5.4.7 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 in the 2006 Base version of the GDA model, and remained consistent at this level during TO2 and the initial TO6 network development tasks. Further analysis, 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 within SATURN was subsequently updated to 5.95m 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 required based on comparisons between the observed and modelled journey times.

5.4.8 Junction Rationalisation

The output network from TO2 retained several “exploded” junctions. Many of these junctions were rationalised or simplified during TO6. Removing unnecessary detail from the junctions allows for more accurate representation of traffic movements and delay experienced at the junction.

Junction rationalisation also improved the convergence of the assignment models by removing spurious route choice and unnecessary links and junctions from the model.

5.4.9 Junction Refinement

With a stable demand matrix assigned, the network was analysed for areas of high delay, queued traffic and unmet demand. Junction coding was adjusted where information indicated a change was required in order to meet the observed traffic volumes, journey time or queue length.

Limited samples of TomTom journey time data was used to validate journey times through individual junctions where the moving observer data was highly variable. TomTom data was also requested for seven key journey time routes. These routes were a mixture of radial and orbital routes, and a mixture of routes which had a relatively stable journey time profile across all observations and routes whose journey time profile was highly variable across the available observations.

5.4.10 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 TO2, the latest available information from the CAF provided costs with a base year of 2002.

During the development of the road network under TO6, a draft version of the CAF was circulated which provided generalised cost parameters with a base cost year of 2011. This was adopted by both TO6 and TO7.

A summary of all variables used during the development of the ERM and their sources is presented in the “FDM Scope18 Regional Transport Model Exogenous Variables” report.

5.4.11 Interim Calibration Statistics

The starting point for the road model network enhancements was the ERM model used during the assessment of the Dublin Transport Strategy. The headline calibration and validation statistics of this model are outlined in the following five tables, with detailed statistics included in Appendix A.

Table 5.8 Initial Significance of Matrix Estimation Changes, AM Peak

Measure	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	1.00	0.99	1.00	1.00	0.83	0.93	1.04	0.89
	Intercept near zero;	0.00	0.00	0.01	0.00	0.00	-0.00	0.00	0.00	0.00
	R^2 in excess of 0.95.	0.13	0.42	0.92	0.93	0.91	0.16	0.27	0.22	0.71
Matrix zonal trip ends	Slope within 0.99 and 1.01					0.97				
	Intercept near zero;					1.01				
	R^2 in excess of 0.98.					0.94				
Trip Length Distribution	Means within 5%;	-31%	-19%	-18%	-13%	-22%	-26%	-13%	0%	-3%
	Standard Deviation within 5%.	-18%	-12%	-18%	-13%	-18%	-17%	-7%	6%	0%
Sector to Sector Matrices	Differences within 5%					556 (of 11,664)				

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

Measure	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;	1.39	1.02	1.00	1.00	1.00	0.96	0.88	0.70	0.85
	Intercept near zero;	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	R^2 in excess of 0.95.	0.62	0.75	0.93	0.95	0.97	0.20	0.44	0.18	0.85
Matrix zonal trip ends	Slope within 0.99 and 1.01					0.93				
	Intercept near zero;					1.49				
	R^2 in excess of 0.98.					0.92				
Trip Length Distribution	Means within 5%;	-22%	-59%	-23%	18%	-31%	-37%	-16%	-10%	4%
	Standard Deviation within 5%.	-13%	-30%	-22%	11%	-17%	-26%	-1%	-16%	8%
Sector to Sector Matrices	Differences within 5%					573 (of 11,664)				

Table 5.10 Initial Significance of Matrix Estimation Changes, PM Peak

Measure	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;	0.87	0.89	0.99	1.00	1.00	0.88	0.86	0.58	0.86
	Intercept near zero;	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00
	R^2 in excess of 0.95.	0.54	0.23	0.69	0.66	0.70	0.24	0.38	0.23	0.47
Matrix zonal trip ends	Slope within 0.99 and 1.01					0.99				
	Intercept near zero;					1.76				
	R^2 in excess of 0.98.					0.85				
Trip Length Distribution	Means within 5%;	-19%	-47%	-14%	37%	-8%	-20%	-7%	-14%	-4%
	Standard Deviation within 5%.	-10%	-20%	-14%	18%	-8%	-15%	-5%	-11%	-2%
Sector to Sector Matrices	Differences within 5%					532 (of 11,664)				

Trip end calibration was undertaken at a matrix total level, and not assessed at an individual user class level. Overall, the interim matrix calibrates reasonable well, given the scale and complexity of the model. At a cellular level, the changes applied by matrix estimation were reasonable for the observed user classes of car commute and car education. Other user classes did not calibrate as well, owing to a lack of observed data used to construct the prior matrices.

The general trend of matrix estimation shortening the trip length is evident across all user classes, suggesting that matrix estimation was having to in-fill trips in order to meet the specific calibration link targets.

Table 5.11 Initial Road Assignment Model Calibration

Measure	Significance Criteria	AM Peak	Inter-peak 1	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	73% (266)	89% (324)	68% (249)
GEH < 5 for individual flows	> 85% of cases	69% (251)	86% (312)	66% (240)

Assigned traffic volume calibration for each peak period is acceptable, given the scale and complexity of the model with the Inter-peak period meeting TAG's recommended calibration criteria and outperforming both the AM and PM peak periods.

Table 5.12 Initial Road Assignment Model Screenline Calibration

Measure	Significance Criteria	AM Peak	Inter-peak 1	PM Peak
Differences between modelled flows and counts should be less than 5% of the counts	> 85% of cases	50%	75%	75%

The screenline calibration is reasonable across the key screenlines of the M50 and canal, although does not fully meet TAG's recommended criteria of 85 per cent of screenlines having a modelled flow within 5 per cent of observed levels.

5.5 Final Road Model Network Progression

5.5.1Network Improvements

Following the interim model, there were 21 iterations of the network data files used during the creation of the pre-assignment final SATURN network (UFN). Each iteration consisted of at minimum an update to the network coding for all four assigned peak periods, with the coding for Inter-peak 1 being replicated for the Off-peak network.

The major considerations during network development are outlined in the following sections.

5.5.2 Network Expansion

The number of zones in the model was increased from 1,680 to 1,854, with the network expanded to accommodate the additional zones. Prior to the expansion it was difficult to calibrate the demand model component properly due to the large variation in zone sizes. In particular, the interim zone system had no gradual increase in zone size as you move between the small urban zones and the large rural zones.

The supporting network for the additional zones was generated from the same GIS map base (HERE) as the interim network, and was attached to the extremities of the existing interim network. There was a slight increase in detail in the extremities of the interim model; therefore many external links were replaced during this process. No additional simulation network coding was added during the expansion.

5.5.3 TomTom Journey Time Data

The Moving Car Observer (MCO) dataset included five observations along each route in the interim model. This dataset highlighted that many journey time routes in the interim model were too quick when compared to observed data. From a limited review of a data sample provided by TomTom it was anticipated that average TomTom times would be quicker than the MCO dataset.

Upon receipt of the full TomTom dataset it was evident that the majority of routes were different to the MCO dataset, with some being quicker and some being slower. More confidence could be placed in this dataset as it included numerous observations over a sample in excess of 100 days.

Due to the disaggregated nature of the TomTom data, individual links, and not just sections between large junctions, could be adjusted in confidence based on the observed data.

5.5.4 Parking Distribution

Parking distribution was fully implemented as part of the final model development. This change altered the location of the car trips in the assignment model, to avoid locations of high demand and low parking availability. In the interim model there was parking constraint which would alter the mode share if demand exceeded the total number of available parking spaces, but there was no parking distribution.

Parking distribution changed the pattern of the assigned matrix, particularly in the City Centre and on the arterial routes, highlighting additional locations that required a more detailed review.

5.5.5 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 matrix size in the targeted time period prior to any adjustment. The factors tended to increase during development, which in turn highlighted additional areas of the model which were under stress and required review.

5.5.6Detailed Network Audit

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

Table 5.13 Pre-audit Significance of Matrix Estimation Changes, AM Peak

Measure	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;	0.81	0.99	1.00	1.00	0.98	0.92	1.07	2.65	1.24
	Intercept near zero;	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
	R^2 in excess of 0.95.	0.49	0.93	0.82	0.96	0.87	0.54	0.46	0.46	0.40
Matrix zonal trip ends	Slope within 0.99 and 1.01;	1.43	1.04	0.83	1.01	0.95	1.05	1.23	1.91	1.80
	Intercept near zero;	-0.88	1.03	4.28	0.25	12.36	0.38	0.49	0.00	0.02
	R^2 in excess of 0.98.	0.96	0.84	0.83	0.92	0.88	0.85	0.81	0.62	0.58
Trip Length Distribution	Means within 5%;	36%	0%	15%	0%	-6%	-9%	11%	5%	16%
	Standard Deviation within 5%.	25%	-12%	23%	0%	-8%	-4%	11%	9%	-1%

Table 5.14 Pre-audit Significance of Matrix Estimation Changes, Inter-peak 1

Measure	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;	0.86	0.98	0.84	1.00	0.98	0.91	1.09	1.23	1.09
	Intercept near zero;	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	R^2 in excess of 0.95.	0.91	0.85	0.65	0.94	0.97	0.87	0.71	0.45	0.81
Matrix zonal trip ends	Slope within 0.99 and 1.01;	0.97	0.95	0.84	1.07	0.91	0.96	1.28	1.35	1.42
	Intercept near zero;	0.23	0.96	3.31	0.00	12.22	0.48	0.06	0.00	0.01
	R^2 in excess of 0.98.	0.98	0.80	0.84	0.92	0.95	0.94	0.92	0.78	0.94
Trip Length Distribution	Means within 5%;	-6%	-17%	-16%	-6%	-19%	-4%	16%	2%	17%
	Standard Deviation within 5%.	-4%	-22%	-4%	-9%	-22%	-2%	17%	-2%	16%

Table 5.15 Pre-audit Significance of Matrix Estimation Changes, Inter-peak 2

Measure	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;	0.98	1.00	0.98	1.00	1.00	0.98	0.96	1.30	1.02
	Intercept near zero;	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	R^2 in excess of 0.95.	0.73	0.78	0.73	0.97	0.98	0.86	0.67	0.24	0.80
Matrix zonal trip ends	Slope within 0.99 and 1.01;	1.29	1.10	0.84	1.04	0.99	0.86	0.11	0.99	1.28
	Intercept near zero;	-0.28	0.51	2.27	0.12	8.81	1.21	0.24	0.00	0.01
	R^2 in excess of 0.98.	0.98	0.68	0.84	0.95	0.96	0.80	0.88	0.48	0.93
Trip Length Distribution	Means within 5%;	18%	-6%	5%	-1%	-6%	-14%	22%	10%	17%
	Standard Deviation within 5%.	16%	-12%	14%	0%	-8%	-6%	19%	10%	18%

Table 5.16 Pre-audit Significance of Matrix Estimation Changes, PM Peak

Measure	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;	1.02	0.97	1.00	1.02	1.00	0.91	0.91	1.94	0.97
	Intercept near zero;	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
	R^2 in excess of 0.95.	0.58	0.74	0.68	0.75	0.89	0.58	0.43	0.19	0.15
Matrix zonal trip ends	Slope within 0.99 and 1.01;	1.37	1.07	0.73	1.10	1.01	0.96	1.13	1.35	1.45
	Intercept near zero;	-0.37	1.40	5.51	0.10	9.28	0.62	0.27	0.00	0.02
	R^2 in excess of 0.98.	0.96	0.71	0.73	0.74	0.91	0.82	0.79	0.38	0.77
Trip Length Distribution	Means within 5%;	21%	0%	10%	21%	-2%	-6%	17%	21%	24%
	Standard Deviation within 5%.	12%	-13%	18%	39%	-4%	-3%	20%	8%	17%

Table 5.13 to

Table 5.16 indicates that the differences in the matrices pre- and post-matrix estimation generally exceed the Significance criteria. At the zonal cell value, whilst the intercept values were all near zero, the slope of the best-fit line through all data points was generally outside of the range of 0.98 to 1.02 with both higher and lower values recorded in all time periods. Whilst the R^2 values achieved the threshold value of 0.95 for some user classes in the AM and Inter-peak periods, lower values were achieved for some user classes in the PM period, with none of the user classes exceeding the desired threshold. A similar 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. This indicates that the changes made during matrix estimation were more 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 5.10.1, however 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 trip end constraints were applied to further reduce the significance of the changes made during Matrix Estimation.

Table 5.17 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	85% (311)	93% (338)	91% (331)	80% (292)
GEH < 5 for individual flows	> 85% of cases	82% (298)	92% (334)	88% (322)	79% (289)

Table 5.17 indicates that the road assignment model, pre-audit, generally meets the desired criteria in each time period, although flow calibration was a little low in the PM period. 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.

To address this, an audit of the road model network coding was undertaken, which considered whether the coding could be improved at specific locations to improve the level of calibration pre-matrix estimation. A review of the journey time validation, discussed in Section 6.4 indicated that on a number of journey time routes, the modelled journey times were less than observed. This was particularly true of the sections in the city centre area implying an over-representation of network capacity.

A number of changes were therefore made to the road network including amending coded signal times at a small number of locations to better represent pedestrian facilities. In general, the junctions that were amended were those where pedestrian movements are walk-with but there is either a late-start or early cut-off on one or more movements to allow pedestrians to cross one arm, although at some locations, a full pedestrian stage was added by extending the last inter-green period. It was also noted that at some locations, local rerouting was occurring, minimising delays at some junctions. These alternative routes were examined in more detail and a number of three tonne vehicle restrictions were noted that had not previously been coded in the model. In other instances, a small decrease was made to the coded speed on links where the alternative road was noted to be of a significantly lower standard that the main route and unlikely to carry the assigned flow at the coded speed. In other instances it was noted that a right turn ban was not represented.

The audit also noted that the modelled volume of traffic on the M50 was generally less than observed and that modelled journey times were also less than observed. The implication of this is that the modelled capacity of the parallel road network is potentially over-represented and that some of the traffic modelled on the local road network should potentially use the M50. A number of changes were therefore made to the local road network to reduce the network capacity in an attempt to force more traffic to use the M50 prior to undertaking Matrix Estimation. The changes made included the representation of several more three tonne vehicle restrictions on the local road network and the addition of Capacity Indices on a number of urban roads outside of the M50, particularly in the Tallaght and Clondalkin areas. Nearside flares were also coded on the M50 where a clear auxiliary lane is present in advance of a diverging slip road or lane drop, to remove a limited number of instances of queuing to exit the motorway, which is not attributable to queuing back from the at grade junction to which the slip road connects.

Table 5.18 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	75%	91%	83%	67%

Like Table 5.17, Table 5.18 demonstrates that the level of flow calibration across the model screen-lines pre-audit is generally acceptable in the inter-peak periods, but a little low in both the AM and PM peak models.

At a small number of locations, the modelled journey times were noted to be greater than observed and such instances were generally noted to be attributed to excessive modelled delays at one or more junctions on these routes. In these instances, changes included adding in a permitted filter movement to another stage at signalised junctions and in one instance a lane gain had been coded as a merge.

The impacts of the changes made as a result of the audit are presented in Sections 5.9 and 5.10.

5.6 Interim Road Model Matrix Progression

5.6.1 Overview

In total there were 17 distinct versions of the prior matrices produced by TO8, with nearly every version assigned in order to provide updated network costs to TO8 for further refinement of the synthetic component of the prior matrix development process. The first several iterations focused on the AM peak only, with later iterations providing the complete set of five time period matrices.

5.6.2 Initial Prior Matrices

The initial prior matrices, version 0, were derived using cost skims from the historic GDA model, disaggregated to the version 2.6 zoning system. The matrices only included “special” matrices (Airport, Dublin Port and Dún Laoghaire) and AM work and education components, with the remaining components being taken directly from the historic GDA matrices.

These prior matrices were to be assigned as early as possible in order to generate network costs that were specific to the ERM.

5.6.3 Inclusion of Bulk Goods

The matrices remained relatively consistent between version 0 and version 3, with only changes in trip ends, network costs and small changes to the process affecting the output matrices. Version 4 of the prior matrices included bulk goods vehicle matrices for the first time, allowing the goods vehicle component of the historic GDA matrices to be replaced. This did have the effect of underestimating the number of goods vehicles on the network as there was no way to disaggregate bulk and non-bulk goods vehicles from the historic matrices.

5.6.4 Trip end Revision

An error in the trip end process was discovered in version 6 of the prior matrices. Problems with trip ends persisted through to version 12 of the prior matrices, although intermediate versions of the matrices were useable for network calibration and validation.

5.6.5 Small Area to Zone Correspondence

The small area to zone correspondence was revised alongside the change to version V3.2 of the zone system. At the same time TO8 took the opportunity to revise the taxi mode split function based on feedback from earlier TO6 modelling work.

5.6.6 Inter-peak Scaling

The Inter-peak 1 (IP1) and Inter-peak 2 (IP2) time period matrices appeared to be unusually large when compared against known link volumes and matrix totals of the other peak periods. In order for SATURN to successfully assign the matrices the IP1 and IP2 time period matrices were globally halved in size. This was the case up to and including version 1 of the prior matrices.

5.6.7 Final Prior Matrices

The final prior matrices, version 17, included period matrices for all time periods (AM, IP1, IP2, PM and OP). The matrices did not require any additional factoring to bring them to a reasonable matrix total.

5.6.8 Matrix Masking

The final prior matrices produced by TO8 were masked to remove external to external traffic that would not pass through the model area. A list of the origin-destination pairs that were masked was provided to the NTA for discussion.

5.6.9 External Factoring

The final prior matrices produced by TO8 contained unusually high demand from the external zones to the west of the model area (Cork, Limerick, Galway etc). Demand from these zones to other external zones was factored down based on the observed traffic volumes extracted from the fixed ATC sites on the M6 and M8. Further detail regarding this issue is included within “ERM Demand Model Calibration Report”.

5.6.10 Special Zone Mode Split Calibration

The parameters that control the mode split for the Airport and Ports within the ERM were calibrated to match observed data.

5.6.11 Matrix Estimation

The adjustment of the final prior matrices was undertaken using SATURN’s matrix estimation module SATME2. There were various stages to the matrix estimation process, depending on the quality and reliability of the input data. The Taxi user class (user class 1) was estimated separately based on available Taxi count data in order for the Taxi matrix to be broadly of the correct size prior to full vehicle type estimation.

5.7 Final Road Model Matrix Progression

5.7.1 Overview

In total there have been 32 distinct versions of the Final Demand Model (FDM), with each producing a revised set of travel demand matrices. Nearly every version assigned in order to provide updated network costs to TO8 for further refinement of the synthetic component of the prior matrix development process. The following sections outline three of the more significant changes to the FDM that resulted in changes to the prior matrices.

5.7.2 Representation of Free Work Place Parking (FWPP)

In Version 2.0.9 a change to the way in which free workplace parking was implemented resulted in a different split of car and non-car trips to and from work. This resulted in changes to the car proportion of the prior matrix, especially in the City Centre of Dublin.

5.7.3 Long Distance Goods and Special Zone Processing

In Version 2.0.12 there was a major upgrade incorporating lessons learned from further testing of the parking distribution module in the ERM as well some issues identified in the other Regional Models and enhanced functionality relating to special zones.

Special zone processing was removed from the add-in stage and a new special zone processing stage was set up to follow parking constraint and to split input demand by mode on the basis of mode costs. As part of this process there were some changes to the definition of “other” trips at the add-in stage to be more consistent with that in use elsewhere and the option to factor up special zone demand in future years was added.

Factoring options for the RMSIT component, which provides the long distance goods vehicle trips, was also introduced in this version.

5.7.4 Parking Distribution Re-implementation

In version 2.0.14, testing indicated a new problem with the parking distribution. Essentially, zones with high levels of parking demand in the first FDM loop returned high search and walk times and demand collapsed to zero in the 2nd loop. This caused the model to flip between implausibly low and implausibly high demands for parking. To prevent this the costs output from the first loop were averaged with the initial input costs and those from the 2nd loop onwards used a method of successive averages, omitting the initial input costs, to progressively stabilise demand.

Further information on the demand model development can be found in “MSF Demand Model Development Report”.

5.7.5 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 5 for cars and taxis, and 15 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 0.2 and 5. Goods vehicles can be adjusted by a factor between 0.067 and 15.

Further matrix estimation controls included applying a trip end constraint to the adjustments of + / - 10 per cent for all zone trip ends.

The taxi user class (UC1) was estimated during a separate assignment. This is due to the limited number of traffic counts that include taxi as a separate vehicle type. The estimated taxi user class replaced the original taxi user class in the prior matrix before final estimation was undertaken on the car matrix components.

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 UC1.

5.7.6Incremental Matrix

The incremental matrix reflects those parts of the full travel behaviour pattern which have not been 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; 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.

5.7.7Final 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 there is no detailed calibration of the active modes component 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.

During the incremental process the ratio of the estimated “Taxi” user class to the estimated “Car Other” user class was calculated and applied to generate future “Taxi” matrices. Further details of the incremental process are presented in the “RM Spec1 Full Demand Model Specification Report”.

5.8 Final Generalised Cost Parameters

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

Table 5.19 Final AM Generalised Cost Values

User Class	Cents Per Minute	Cents Per Kilometre
UC1 – Taxi	60.13	18.80
UC2 – Car Employers Business	60.13	18.80
UC3 – Car Commute	21.52	9.83
UC4 – Car Education	36.39	9.83
UC5 – Car Other	21.16	9.83
UC6 – LGV	43.34	13.39
UC7 – OGV1	46.08	30.55
UC8 – OGV2 Permit Holder	44.40	55.92
UC9 – OGV2 (Other)	44.40	55.92

Table 5.20 Final IP1 Generalised Cost Values

User Class	Cents Per Minute	Cents Per Kilometre
UC1 – Taxi	70.39	17.17
UC2 – Car Employers Business	70.39	17.17
UC3 – Car Commute	20.74	9.11
UC4 – Car Education	42.66	9.11
UC5 – Car Other	38.41	9.11

UC6 – LGV	45.90	13.40
UC7 – OGV1	47.87	28.71
UC8 – OGV2 Permit Holder	46.55	52.72
UC9 – OGV2 (Other)	46.55	52.72

Table 5.21 Final IP2 Generalised Cost Values

User Class	Cents Per Minute	Cents Per Kilometre
UC1 – Taxi	70.39	17.30
UC2 – Car Employers Business	70.39	17.30
UC3 – Car Commute	20.74	9.16
UC4 – Car Education	42.66	9.16
UC5 – Car Other	38.41	9.16
UC6 – LGV	45.90	13.44
UC7 – OGV1	47.87	28.92
UC8 – OGV2 Permit Holder	46.55	53.10
UC9 – OGV2 (Other)	46.55	53.10

Table 5.22 Final PM Generalised Cost Values

User Class	Cents Per Minute	Cents Per Kilometre
UC1 – Taxi	60.13	18.13
UC2 – Car Employers Business	60.13	18.13
UC3 – Car Commute	21.52	9.52
UC4 – Car Education	36.39	9.52
UC5 – Car Other	21.16	9.52
UC6 – LGV	43.34	13.00
UC7 – OGV1	46.08	29.28
UC8 – OGV2 Permit Holder	44.40	53.60
UC9 – OGV2 (Other)	44.40	53.60

5.9 Road Model Network Calibration

5.9.1 Overview

This section details the calibration process and the level of calibration for the road assignment model across the four assigned peak periods. For comparison, the statistics in this section can be compared to the calibration statistics presented in Table 5.8 to Table 5.12 to compare the model against the interim model, or Table 5.13 to Table 5.18 to compare the model against the pre-audit model.

In total, 721 observations have been used in the SATME2 procedure. 147 of these observations also form part of the strategic screenlines.

Although TAG suggests that GEH values should be less than 5 for 85 per cent of cases, for a model of this size and complexity a range of standards suggest that it is common for larger GEH values to be accepted as showing a robust 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
- GEH < 10 for 95 per cent of all sites

5.9.2Traffic Count Locations

A detailed map showing the location of all traffic counts used during calibration is presented in Figure 5.1.

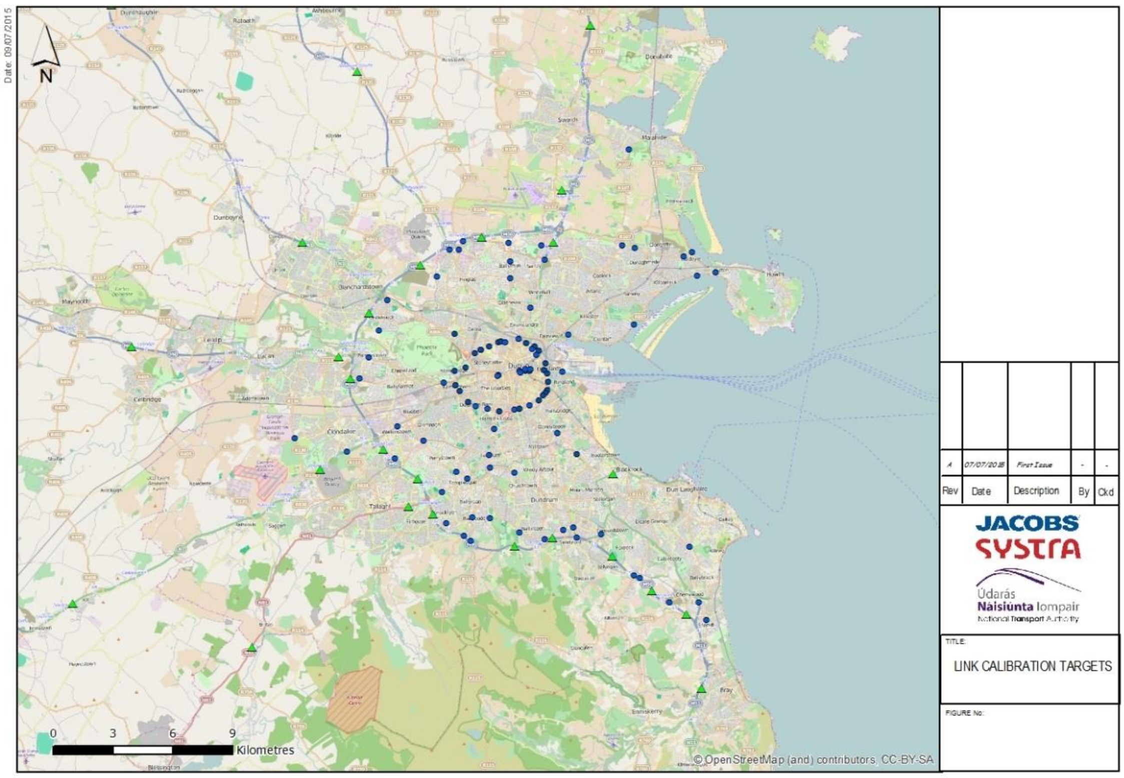

Figure 5.1 Link Calibration Target Locations

5.9.3Individual link calibration criteria compliance – AM peak

There are a total of 721 individual link traffic counts used during the network calibration.

Table 5.23 details the individual link count acceptability criteria.

Table 5.23 AM Link Flow Calibration

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	78% (564)
GEH < 5 for individual flows	> 65% of cases	75% (541)
GEH < 7 for individual flows	> 75% of cases	84% (603)
GEH < 10 for individual flows	> 95% of cases	90% (647)

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 set out in Section 5.9.1, with only the number of links with a GEH less than 10 failing to meet the recommended criteria by five per cent.

Detailed calibration results, highlighting specific links that pass or fail the recommended calibration criteria are included in Appendix B. The maximum recoded GEH was 30.7. All GEH values in excess of 15 were reviewed, and often these GEH values were recorded on links with small levels of observed traffic. In this specific example, the GEH of 30.7 was recorded on North Road (N2) which is part of the M50 (North) cordon. The observed flow at this location was 1,892 whereas the modelled flow was 773 (-59%). Further investigation indicated that the screenline as a whole is within 10 per cent, with the majority of screenline links marginally above observed levels, suggesting that traffic is re-routing to parallel routes. There is no significant queued traffic along the N2, and no evidence of traffic avoiding any particular junction or location with each other link forming this screenline passing both the TAG flow and GEH criterion.

Four per cent (29) of links in the AM peak have a GEH in excess of 15. Of the 29 links, 11 links (38 per cent) are classed as having a low observed traffic volume of less than 700 PCUs. The remaining 18 links are not centred on any particular area, and consist of a variety of road standards including arterial approaches to Dublin outside the M50, the M50, arterial approaches to Dublin inside the M50, local access roads and City Centre roads.

5.9.4 Screenline calibration criteria compliance – AM peak

A total of 12 individual screenlines were compared as part of the network calibration exercise.

Table 5.24 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 5.24 AM Screenline Flow Calibration

Screenline	Number of Links	Modelled Difference
TAG Criteria		Within 5%
M50 North (Inbound)	11	-10%
M50 North (Outbound)	11	0%
M50 West (Inbound)	7	-2%
M50 West (Outbound)	7	6%
M50 South (Inbound)	14	1%
M50 South (Outbound)	14	-5%
Canal North (Inbound)	17	-3%
Canal North (Outbound)	17	4%
Canal South (Inbound)	17	-13%
Canal South (Outbound)	17	-6%
River Liffey (Northbound)	7	2%
River Liffey (Southbound)	8	3%

75 per cent of the screenlines 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. It should be noted that both Canal South screenlines do not meet the recommended calibration criteria. Four of the six screenlines along the M50 and both screenlines along the River Liffey meet the recommended criteria.

5.9.5Individual Link Calibration Criteria Compliance – Inter-peak 1

There are a total of 721 traffic counts used during the Inter-peak 1 road model network calibration. Table 5.25 details the individual link count acceptability criteria.

Table 5.25 Inter-peak 1 Link Flow Calibration

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	89% (641)
GEH < 5 for individual flows	> 65% of cases	87% (627)
GEH < 7 for individual flows	> 75% of cases	92% (661)
GEH < 10 for individual flows	> 95% of cases	95% (684)

The model statistics show that the individual link calibration for the Inter-peak 1 road model meets the recommendations set out in TAG. In terms of GEH, it also passes all typical acceptability criteria set out in Section 5.9.1.

Detailed calibration results, highlighting specific links that pass or fail the recommended calibration criteria are included in Appendix B. The maximum recorded GEH was 28.8.

GEH values in excess of 15 were reviewed, and often these GEH values are recorded on links with small levels of observed traffic. In this specific example, the GEH of 28.8 was recorded on Ballyboden Way (WB) where the observed flow was 414 vehicles. The modelled flow was 0 as traffic chooses to use Scholarstown Road which has a lower route cost due to the uncongested network. Traffic summed across Ballyboden Way and Scholarstown Road is close to observed levels and calibrate well if summed together indicating localised re-routing.

In the Inter-peak 1 period, two per cent (11) of links have a GEH in excess of 15. Of these 11 links, nine have an observed traffic volume of less than 700 PCUs. The remaining two links are Inns Quay and North Road. These links are located in the northern quadrant of the model, although not in close proximity to one another. Inns Quay and North Road are light by approximately 600 PCUs. However, adjacent links do not suggest a transfer of traffic from the N2 to the M1.

5.9.6 Screenline calibration criteria compliance – Inter-peak 1

A total of 12 individual screenlines were compared as part of the network calibration exercise.

Table 5.26 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 5.26 Inter-peak 1 Screenline Flow Calibration

Screenline	Number of Links	Modelled Difference
TAG Criteria		Within 5%
M50 North (Inbound)	11	-5%
M50 North (Outbound)	11	0%
M50 West (Inbound)	7	2%
M50 West (Outbound)	7	1%
M50 South (Inbound)	14	1%
M50 South (Outbound)	14	0%
Canal North (Inbound)	17	4%
Canal North (Outbound)	17	7%
Canal South (Inbound)	17	-6%
Canal South (Outbound)	17	3%
River Liffey (Northbound)	7	2%
River Liffey (Southbound)	8	0%

83 per cent of the screenlines meet the recommended calibration criteria as set out in TAG Unit M3-1, which is close to satisfying the recommended acceptability criteria of “all or

nearly all" screenlines meeting the criteria. The screenlines along the Canal North (Outbound) and Canal South (Inbound) did not meet the recommended TAG criteria.

5.9.7 Individual Link Calibration Criteria Compliance – Inter-peak 2

There are a total of 721 traffic counts used during the Inter-peak 2 road model network calibration. Table 5.27 details the individual link count acceptability criteria.

Table 5.27 Inter-peak 2 Link Flow Calibration

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	86% (620)
GEH < 5 for individual flows	> 65% of cases	85% (610)
GEH < 7 for individual flows	> 75% of cases	90% (646)
GEH < 10 for individual flows	> 95% of cases	94% (675)

The model statistics show that the individual link calibration for the Inter-peak 2 road model meets the recommendations set out in TAG, for link flows. In terms of GEH, it passes all typical acceptability criteria set out in Section 5.9.1, with the exception of GEH values less than ten which it fails to meet by one per cent.

Detailed calibration results, highlighting specific links that pass or fail the recommended calibration criteria are included in Appendix B. The maximum recorded GEH was 33.4. GEH values in excess of 15 were reviewed, and often these GEH values are recorded on links with small levels of observed traffic. Similar to Inter-peak 1, the GEH of 33.4 was recorded on Ballyboden Way (WB) where the observed flow was 560 vehicles. The modelled flow was 0 as traffic chooses to use Scholarstown Road which has a lower route cost due to the uncongested network. Traffic summed across Ballyboden Way and Scholarstown Road is close to observed levels and calibrates well if summed together, indicating localised re-routing.

Two per cent of links (16) in the Inter-peak 2 time period have a GEH in excess of 15. 75 per cent of these links (12) are classified as carrying a low traffic volume (less than 700 PCUs per hour). The remaining four links are located on Inns Quay, the Airport Link Road, North Road and the R117 at Dundrum.

5.9.8 Screenline calibration criteria compliance – Inter-peak 2

A total of 12 individual screenlines were compared as part of the network calibration exercise.

Table 5.28 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 5.28 Inter-Peak 2 screenline flow calibration

Screenline	Number of Links	Modelled Difference
TAG Criteria		Within 5%
M50 North (Inbound)	11	-8%
M50 North (Outbound)	11	-3%
M50 West (Inbound)	7	0%
M50 West (Outbound)	7	7%
M50 South (Inbound)	14	-1%
M50 South (Outbound)	14	-1%
Canal North (Inbound)	17	2%
Canal North (Outbound)	17	5%
Canal South (Inbound)	17	-5%
Canal South (Outbound)	17	-1%
River Liffey (Northbound)	7	2%
River Liffey (Southbound)	8	-1%

75 per cent of the screenlines 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. The screenlines along the Canal North (Outbound) and Canal South (Inbound) narrowly failed to meet the recommended TAG criteria.

5.9.9Individual Link Calibration Criteria Compliance – PM Peak

There are a total of 721 traffic counts used during the PM peak road model network calibration. **Error! Reference source not found.**Table 5.29 details the individual link count acceptability criteria.

Table 5.29 PM Link Flow Calibration

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	75% (538)
GEH < 5 for individual flows	> 65% of cases	74% (532)
GEH < 7 for individual flows	> 75% of cases	82% (588)
GEH < 10 for individual flows	> 95% of cases	88% (631)

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 set out in Section 5.9.1, with only the number of links with a GEH less than 10 failing to meet the recommended criteria by seven per cent.

Detailed calibration results, highlighting specific links that pass or fail the recommended calibration criteria are included in Appendix B. The maximum recorded GEH was 34.6. All GEH values in excess of 15 were reviewed, and often these GEH values are recorded on links with small levels of observed traffic. In this specific example, the GEH of 34.6 was recorded on Naas Road (R110) westbound, where the observed flow is 705. The modelled flow at this location is 1,972 which is significantly higher than the observed level. Traffic levels downstream and upstream of this location are all close to observed levels, suggesting a localised route choice issue.

Six per cent (46) of links in the PM peak have a GEH in excess of 15. 50 per cent (23) of these are links whose observed flow is less than 700 PCUs per hour. The remaining 23 links are not concentrated in any particular area, and consist of a broad range of road types, from Motorway to central urban.

5.9.10 Screenline Calibration Criteria Compliance – PM Peak

A total of 12 individual screenlines were compared as part of the network calibration exercise.

Table 5.30 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 5.30 PM Screenline Flow Calibration

Screenline	Number of Links	Modelled Difference
TAG Criteria		Within 5%
M50 North (Inbound)	11	-12%
M50 North (Outbound)	11	-7%
M50 West (Inbound)	7	-4%
M50 West (Outbound)	7	8%
M50 South (Inbound)	14	-4%
M50 South (Outbound)	14	-4%
Canal North (Inbound)	17	2%
Canal North (Outbound)	17	6%
Canal South (Inbound)	17	-5%
Canal South (Outbound)	17	-7%
River Liffey (Northbound)	7	-1%
River Liffey (Southbound)	8	-13%

50 per cent of the screenlines 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. It should be noted that there is a net negative bias across

the screenlines, with all inbound screenlines with the exception of the Canal (North) exhibiting reduced traffic when compared with observed levels.

5.10 Road Model Matrix Calibration

5.10.1 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 5.7.5.

5.10.2 Calibration criteria compliance – AM peak

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 RDAM AM Peak Matrix Totals

User Class	Prior (PCU)	Post-Incremental (PCU)	Change (%)
TAG Criteria			**Within 5%**
Taxi	11,004	13,177	20%
Car Employers Business	18,480	19,149	4%
Car Commute	127,301	132,226	4%
Car Education	4,520	4,464	-1%
Car Other	184,443	180,305	-2%
LGV	20,446	21,242	4%
OGV1	16,493	16,714	1%
OGV2 Permit Holder	54	54	0%
Other OGV2	513	513	0%

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

The changes to all user classes are of an acceptable level with the exception of the “Taxi” user class. The large change in the taxi matrix was due to the lack of Taxi data in the original matrix building process. The Taxi matrix was based on a percentage of the Car Other matrix, then estimated to known taxi volumes.

GEH analysis was undertaken on the individual (non-zero) cells and their change between the pre-estimation and post-estimation values. Three per cent of cells have a GEH value of less than 0.01, with 79 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 5.2 and Figure 5.3 Note the change in scale for both axes in Figure 5.3

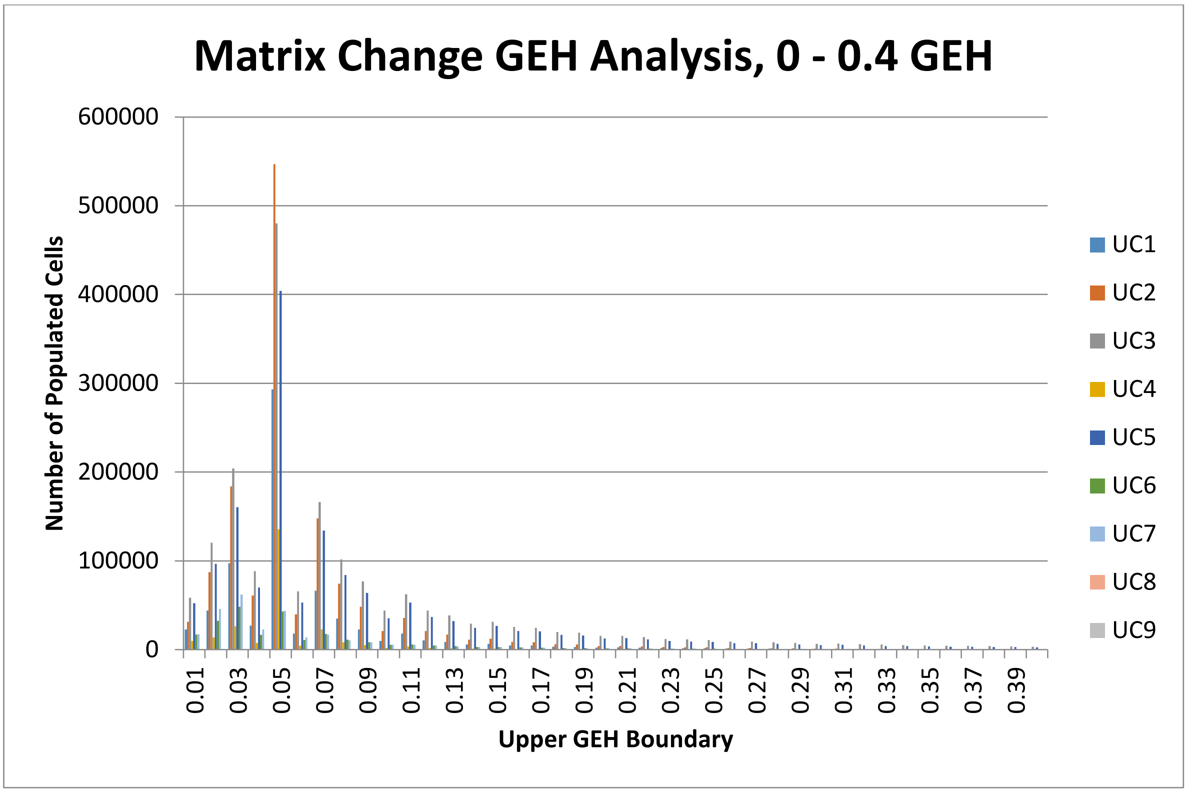

Figure 5.2 SATME2 AM Matrix Change GEH Analysis; 0 GEH to 0.4 GEH

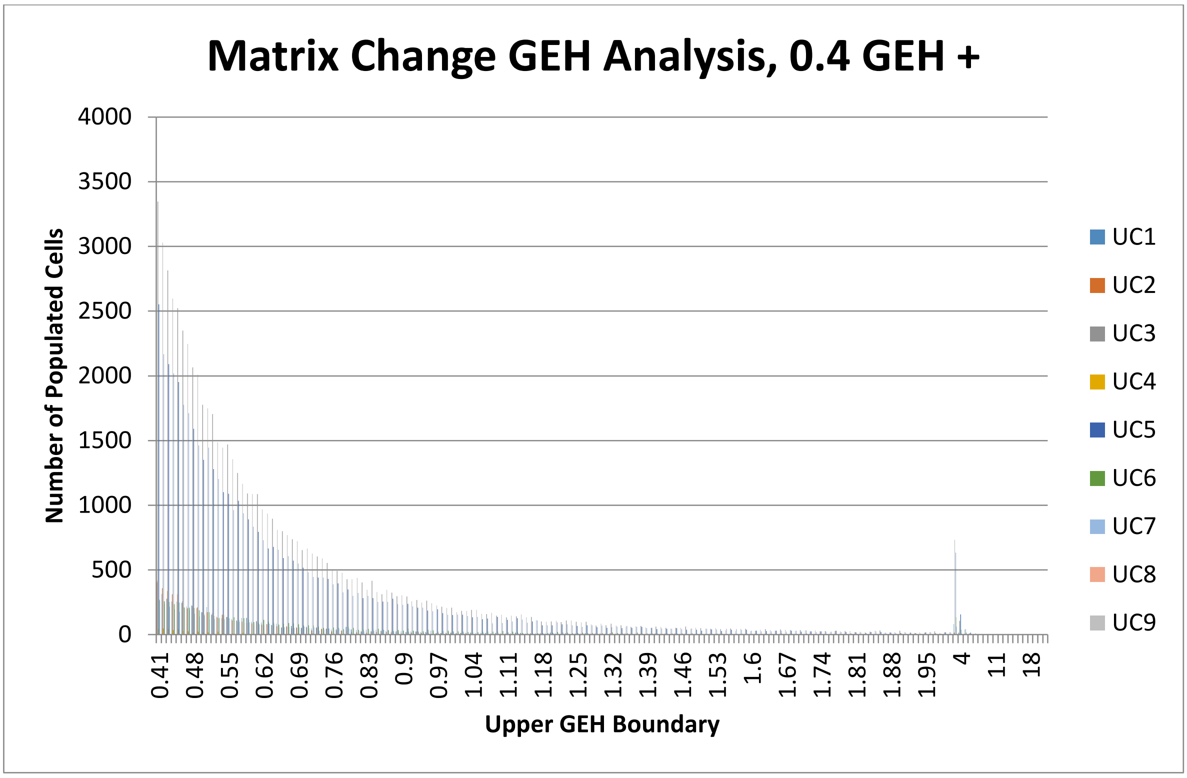

Figure 5.3 SATME2 AM Matrix Change GEH Analysis; 0.4 GEH Upwards

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

Table 5.32 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	0.64	0.65	0.00
Car Employers Business	0.93	0.93	0.00
Car Commute	0.92	0.93	0.00
Car Education	0.99	0.99	0.00
Car Other	0.94	0.98	0.00
LGV	0.80	0.79	0.00
OGV1	0.79	0.82	0.00
OGV2 Permit Holder	1.00	1.00	0.00
Other OGV2	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, with only “Car Education” meeting this criteria.

“Car Employers Business”, “Car Commute” and “Car Other” are close to passing the recommended criteria, with cell R^2 values of 0.93, 0.92 and 0.94 respectively.

Each user class passes the comparison of the intercept value, which should be zero or close to zero. Each car user class except “Car Education” does not meet the comparison of the slope of the line, with the recommended criteria being a slope between 0.98 and 1.02.

Trip End R^2 analysis was undertaken for each user class and summarised in Table 5.33.

Table 5.33 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	0.95	1.15	0.23
Car Employers Business	0.97	0.99	0.43
Car Commute	0.98	0.98	1.54
Car Education	0.99	0.98	0.03
Car Other	0.99	0.96	1.87
LGV	0.93	1.00	0.43
OGV1	0.92	0.98	0.29
OGV2 Permit Holder	1.00	1.00	0.00
Other OGV2	1.00	1.00	0.00

Analysis was undertaken on the trip ends for each matrix level. The R^2 value for the changes to the trip ends for all matrix levels was close to the recommended criteria of > 0.98. All user classes are also close to meeting the recommended criteria of a slope between 0.99 and 1.01. All y-intercept values are less than 1.87.

The matrix was compared against three prominent screenlines to the matrix broadly contains the correct number of trips. This check around the M50, around the canal and across the River Liffey.

Table 5.34 details the total traffic crossing the screenlines.

Table 5.34 RDAM AM Screenline Check

User Class	Observed (Veh)	Model (Veh)	Difference (%)
TAG Criteria			Within 5%
M50 Inbound	34,715	33,342	-4%
M50 Outbound	23,113	23,225	0%
Canal Inbound	23,850	21,913	-8%
Canal Outbound	12,981	12,778	-2%
River Liffey (Northbound)	5,837	5,950	2%
River Liffey (Southbound)	7,772	7,989	3%

Traffic levels across the M50, the Canal Outbound and the River Liffey are within the acceptability criteria outlined in TAG unit M3-1; however traffic crossing the Canal Inbound is not. The traffic crossing this screenline is within eight per cent which is considered reasonable for a model of this scale and complexity.

5.10.3 Calibration criteria compliance – Inter-peak 1

Table 5.35 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 5.35 RDAM Inter-peak 1 Matrix Totals

User Class	Prior (PCU)	Post-Incremental (PCU)	Change (%)
TAG Criteria			Within 5%
Taxi	9,918	11,240	13%
Car Employers Business	14,316	14,791	3%
Car Commute	21,547	21,737	1%
Car Education	394	414	5%
Car Other	169,426	168,795	0%
LGV	14,790	15,430	4%
OGV1	13,512	13,722	2%
OGV2 Permit Holder	80	80	0%
Other OGV2	759	759	0%

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

The changes to all user classes are of an acceptable level with the exception of the “Taxi” user class. Like the AM Peak, the large change in the taxi matrix was due to the lack of Taxi data in the original matrix building process. The Taxi matrix was initially based on a percentage of the “Car Other” matrix, derived at a sector level, and then estimated to known taxi volumes.

GEH analysis was undertaken on the individual (non-zero) cells and their change between the pre-estimation and post-estimation values. Four per cent of cells have a GEH value of less than 0.01, with 87 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 Note the change in scale for both axes in Figure 5.5

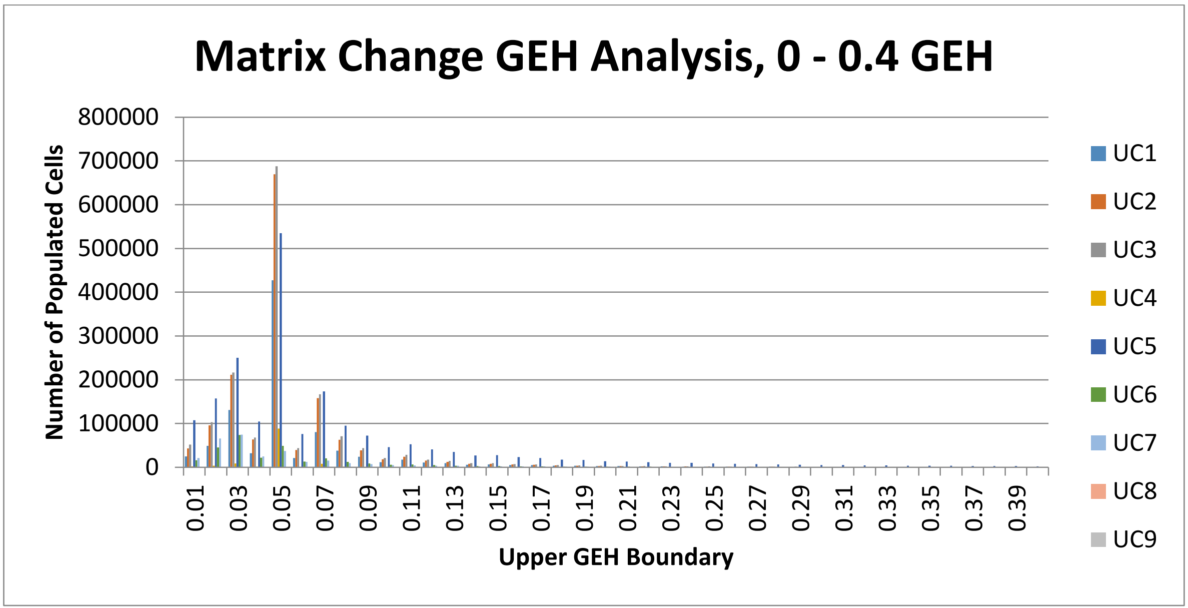

Figure 5.4 SATME2 IP1 Matrix Change GEH Analysis; 0 GEH to 0.4 GEH

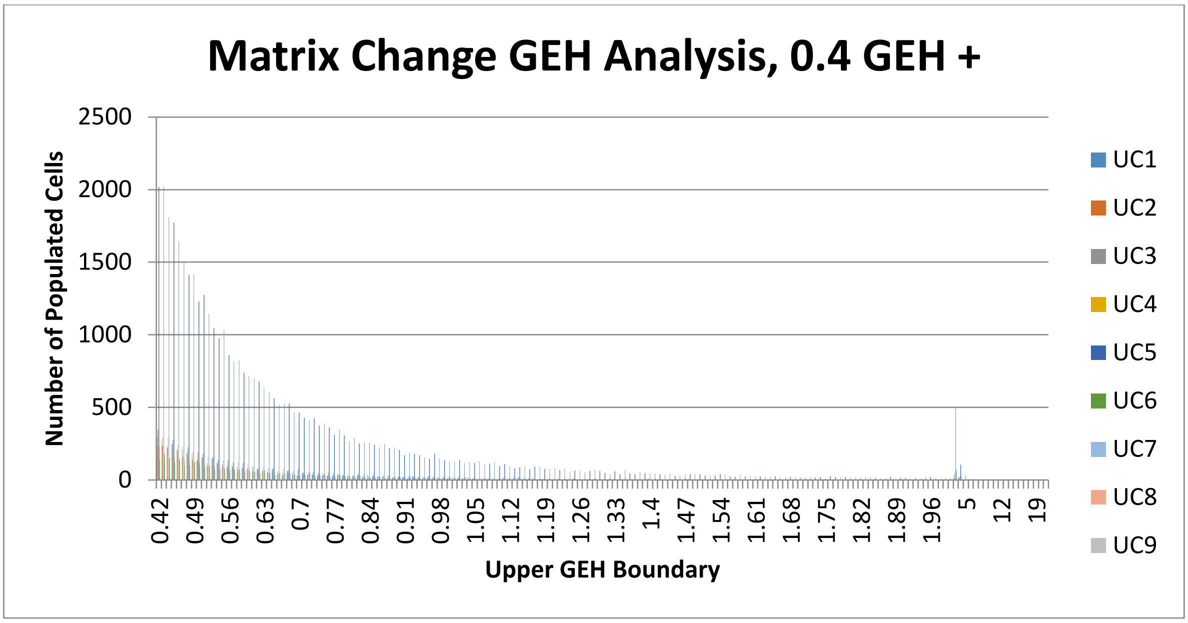

Figure 5.5 SATME2 IP1 Matrix Change GEH Analysis; 0.4 GEH Upwards

R^2 analysis was undertaken to further understand the matrix changes made by SATME2. Table 5.36 details the R^2 values for each individual user class. These are represented graphically in Appendix D.

Table 5.36 SATME2 IP1 Matrix Change R2 Analysis

User Class	Cell R^2 Value	Cell Slope	Cell Y-Int
TAG Criteria	> 0.95	0.98 - 1.02	Near 0
Taxi	0.61	0.77	0.00
Car Employers Business	0.81	0.93	0.00
Car Commute	0.78	0.80	0.00
Car Education	0.96	0.96	0.00
Car Other	0.94	0.97	0.00
LGV	0.85	0.89	0.00
OGV1	0.83	0.90	0.00
OGV2 Permit Holder	1.00	1.00	0.00
Other OGV2	1.00	1.00	0.00

Only the “Car Education” and the goods vehicle user classes (which are not subject to change) pass the cell R^2 criteria set out in TAG. Although each other user class fails the R^2 test, several are close to passing, including “Car Other”.

Each user class passes the comparison of the intercept value, which should be zero or close to zero. No user class meets the comparison of the slope of the line, which should be between 0.98 and 1.02. However, several including “Car Employer’s Business”, “Car Education” and “Car Other” are close or very close to meeting the recommended criteria.

Trip End R^2 analysis was undertaken for each user class and summarised in Table 5.37

Table 5.37 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	0.97	0.88	1.35
Car Employers Business	0.95	0.95	0.62
Car Commute	0.98	0.98	0.76
Car Education	0.97	0.99	0.01
Car Other	0.99	0.96	3.05
LGV	0.93	1.00	0.31
OGV1	0.96	0.97	0.35
OGV2 Permit Holder	1.00	1.00	0.00
Other OGV2	1.00	1.00	0.00

All trip end R^2 values are in excess of 0.93, with the recommended criteria being all values in excess of 0.98. Four of the nine user classes pass the recommended criteria for trip end slope, with the worst performing user class being “Taxi” with a slope value of 0.88. All y-intercept values are less than 3.05 which is considered to be near to the target value of 0.

The matrix was compared against three prominent screenlines to determine whether or not the matrix broadly contains the correct number of trips. This check was undertaken around the M50, around the canal and across the River Liffey. Table 5.38 details the total traffic crossing the screenlines.

Table 5.38 RDAM IP1 Screenline Check

User Class	Observed (Veh)	Model (Veh)	Difference (%)
TAG Criteria			**Within 5%**
M50 Inbound	21,001	20,815	-1%
M50 Outbound	18,791	18,864	0%
Canal Inbound	13,213	13,076	-1%
Canal Outbound	11,487	12,032	5%
River Liffey (Northbound)	5,371	5,465	2%
River Liffey (Southbound)	5,527	5,539	0%

Traffic levels across all cordons are within the acceptability criteria outlined in TAG unit M3-1.

5.10.4 Calibration criteria compliance – Inter-peak 2

Table 5.39 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 5.39 RDAM Inter-peak 2 Matrix Totals

User Class	Prior (PCU)	Post-Incremental (PCU)	Change (%)
TAG Criteria			**Within 5%**
Taxi	9,307	10,678	15%
Car Employers Business	13,380	13,929	4%
Car Commute	39,205	40,958	4%
Car Education	3,934	3,986	1%
Car Other	188,922	188,928	0%
LGV	15,294	15,867	4%
OGV1	11,988	12,061	1%
OGV2 Permit Holder	51	51	0%
Other OGV2	480	480	0%

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

All levels of the trip matrix, with the exception of “Taxi”, are within the TAG recommended criteria for matrix total changes.

GEH analysis was undertaken on the individual (non-zero) cells and their change between the pre-estimation and post-estimation values. Four per cent of cells have a GEH value of less than 0.01, with 86 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 Figure 5.7.

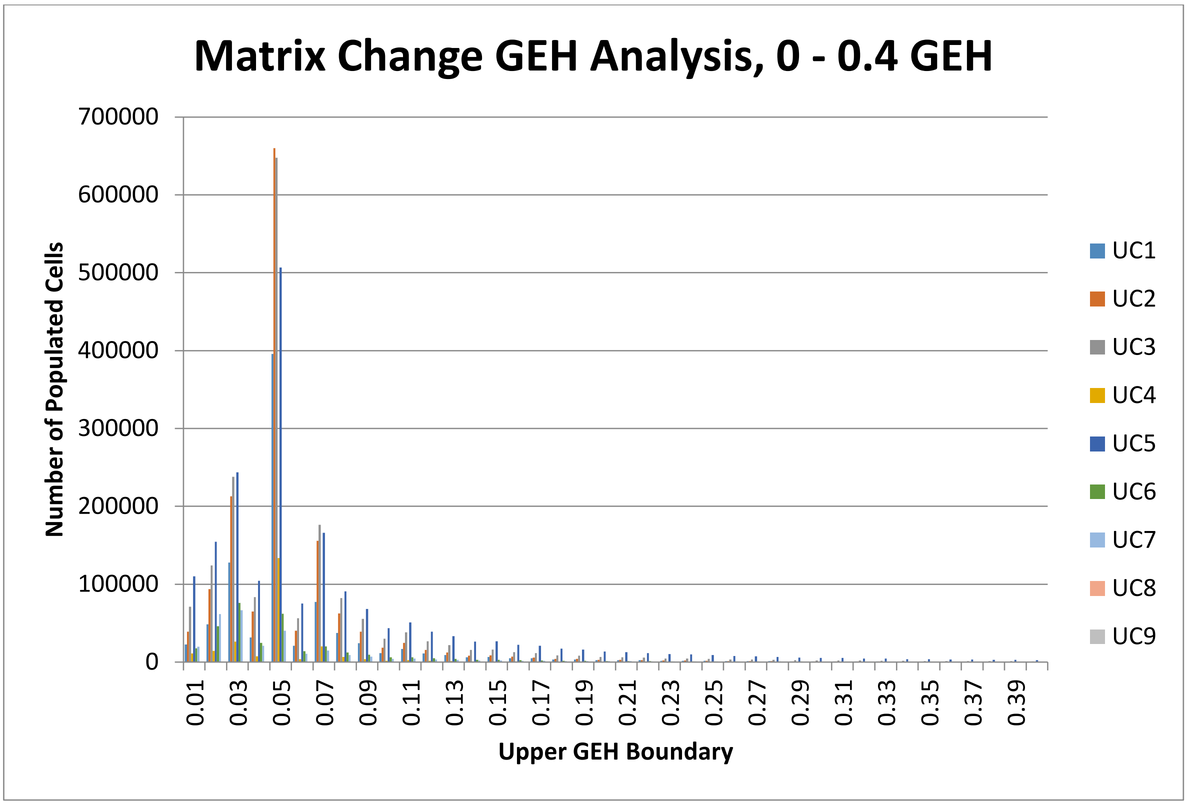

Figure 5.6 SATME2 IP2 Matrix Change GEH Analysis; 0 GEH to 0.4 GEH

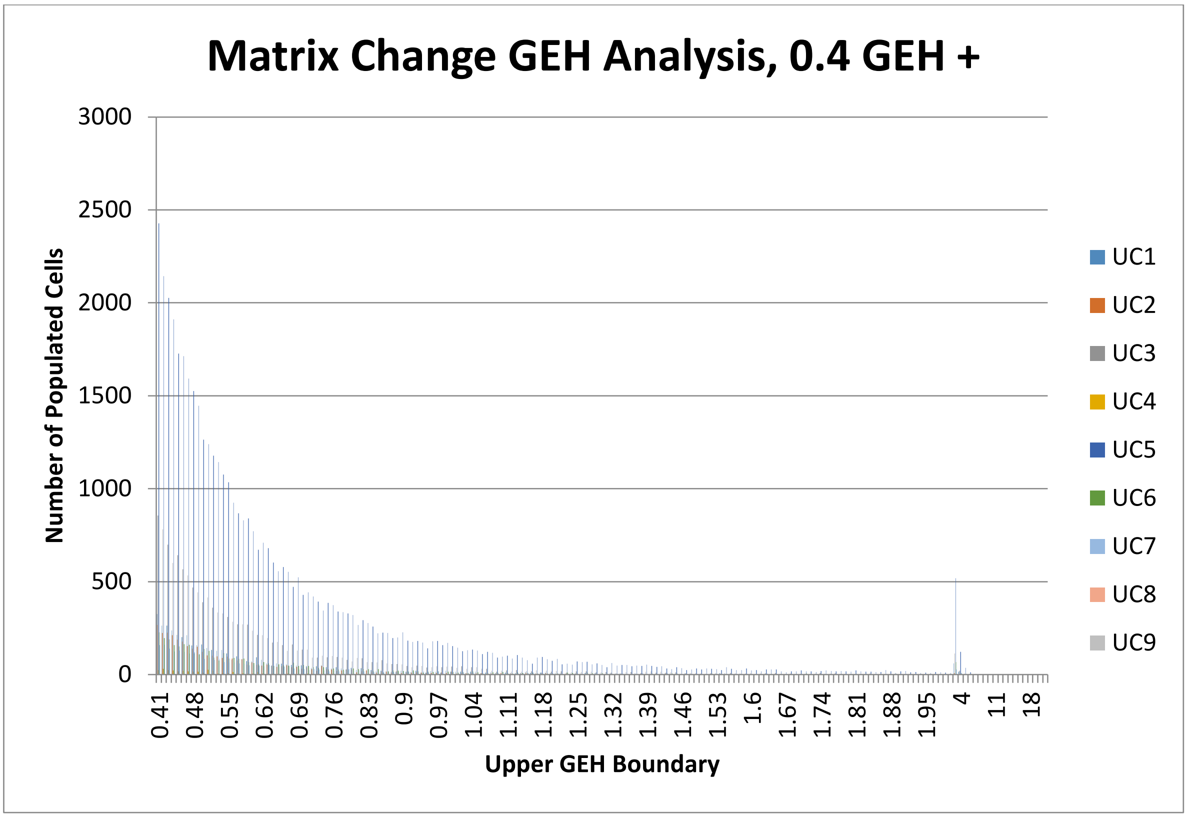

Figure 5.7 SATME2 IP2 Matrix Change GEH Analysis; 0.4 GEH Upwards

R^2 analysis was undertaken to further understand the matrix changes made by SATME2. Table 5.40 details the R^2 values for each individual user class. These are represented graphically in Appendix D.

Table 5.40 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	0.72	0.74	0.00
Car Employers Business	0.87	0.89	0.00
Car Commute	0.89	0.91	0.00
Car Education	0.98	0.99	0.00
Car Other	0.97	0.98	0.00
LGV	0.95	0.97	0.00
OGV1	0.80	0.86	0.00
OGV2 Permit Holder	1.00	1.00	0.00
Other OGV2	1.00	1.00	0.00

Despite relatively small changes in matrix totals, the cell R^2 analysis indicates that travel patterns are more significantly altered by matrix estimation than is initially evident. Five user classes meet the criteria set out in TAG Unit M3-1, Section 8, Table 5, with all user classes having an R^2 value in excess of 0.72.

Trip End R^2 analysis was undertaken for each user class and summarised in Table 5.41.

Table 5.41 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	0.97	0.92	1.15
Car Employers Business	0.97	0.97	0.49
Car Commute	0.97	0.97	0.96
Car Education	0.99	1.01	0.00
Car Other	0.99	0.98	1.88
LGV	0.96	1.01	0.21
OGV1	0.95	0.95	0.36
OGV2 Permit Holder	1.00	1.00	0.00
Other OGV2	1.00	1.00	0.00

All user classes have a trip end R^2 value that is in excess of 0.95. Four of the nine user classes meet the TAG criteria of an R^2 value in excess of 0.98, with another three narrowly failing. Four of the nine user classes meet the recommended TAG criteria of a Trip End Slope of between 0.99 and 1.01. The largest y-intercept value is 1.88 which is deemed to be close to 0, and thus all user classes meet the y-intercept criteria set out in TAG.

The matrix was compared against three prominent screenlines to determine whether or not the matrix broadly contains the correct number of trips. This check was undertaken around the M50, around the canal and across the River Liffey. Table 5.42 details the total traffic crossing the screenlines.

Table 5.42 RDAM IP2 Screenline Check

User Class	Observed (Veh)	Model (Veh)	Difference (%)
TAG Criteria			Within 5%
M50 Inbound	23,047	22,349	-3%
M50 Outbound	23,170	23,341	1%
Canal Inbound	12,567	12,360	-2%
Canal Outbound	14,184	14,441	2%
River Liffey (Northbound)	5,646	5,756	2%
River Liffey (Southbound)	5,523	5,469	-1%

Traffic crossing all screenlines is within the acceptability criteria outlined in TAG unit M3-1.

5.10.5 Calibration criteria compliance – PM peak

Table 5.43 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 5.43 RDAM PM Peak Matrix Totals

User Class	Prior (PCU)	Post-Incremental (PCU)	Change (%)
TAG Criteria			Within 5%
Taxi	9,642	11,391	18%
Car Employers Business	13,135	14,441	10%
Car Commute	107,874	112,983	5%
Car Education	1,513	1,552	3%
Car Other	169,201	168,766	0%
LGV	16,642	17,840	7%
OGV1	10,302	10,601	3%
OGV2 Permit Holder	69	69	0%
Other OGV2	655	655	0%

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

The percentage matrix adjustments meet the TAG recommended criteria, with the exception of “Taxi” and “Car Employer’s Business”. The taxi user class was anticipated to change by the largest percentage, given that the initial matrix is based on a percentage split from “Car Other”.

GEH analysis was undertaken on the individual (non-zero) cells and their change between the pre-estimation and post-estimation values. Three per cent of cells have a GEH value of less than 0.01, with 80 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 both axes in Figure 5.9

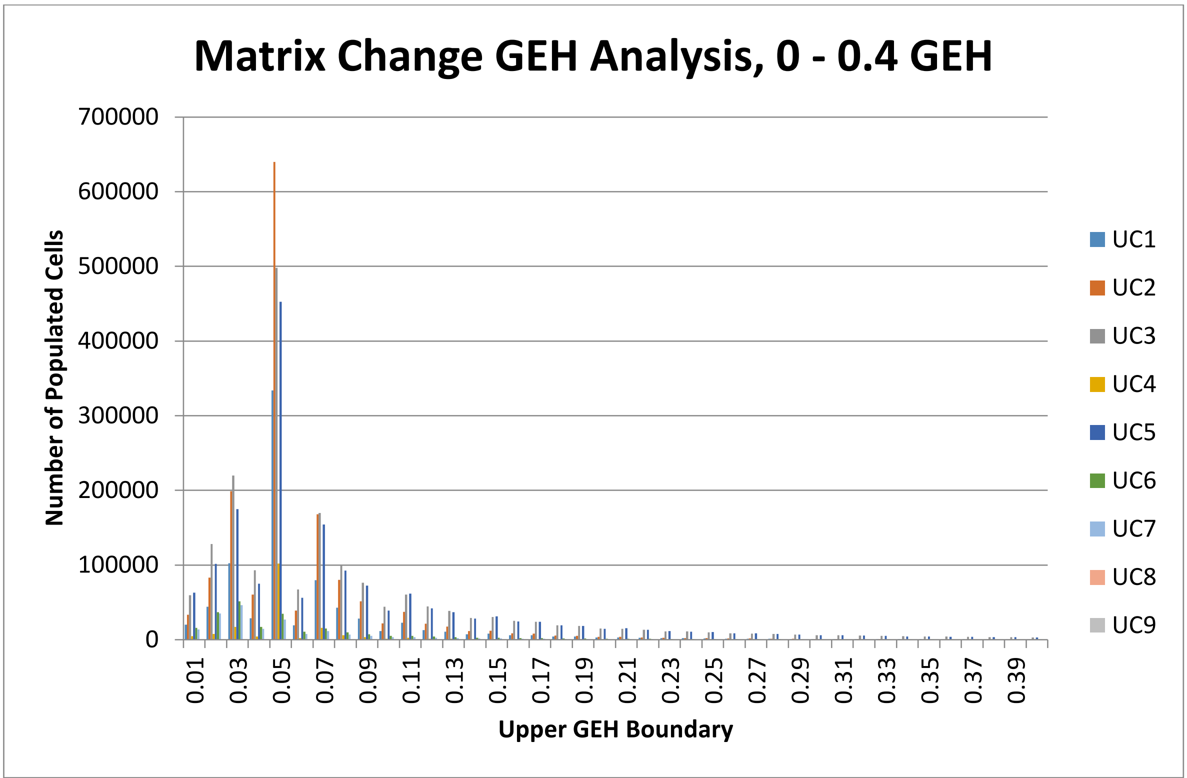

Figure 5.8 SATME2 PM Matrix Change GEH Analysis; 0 GEH to 0.4 GEH

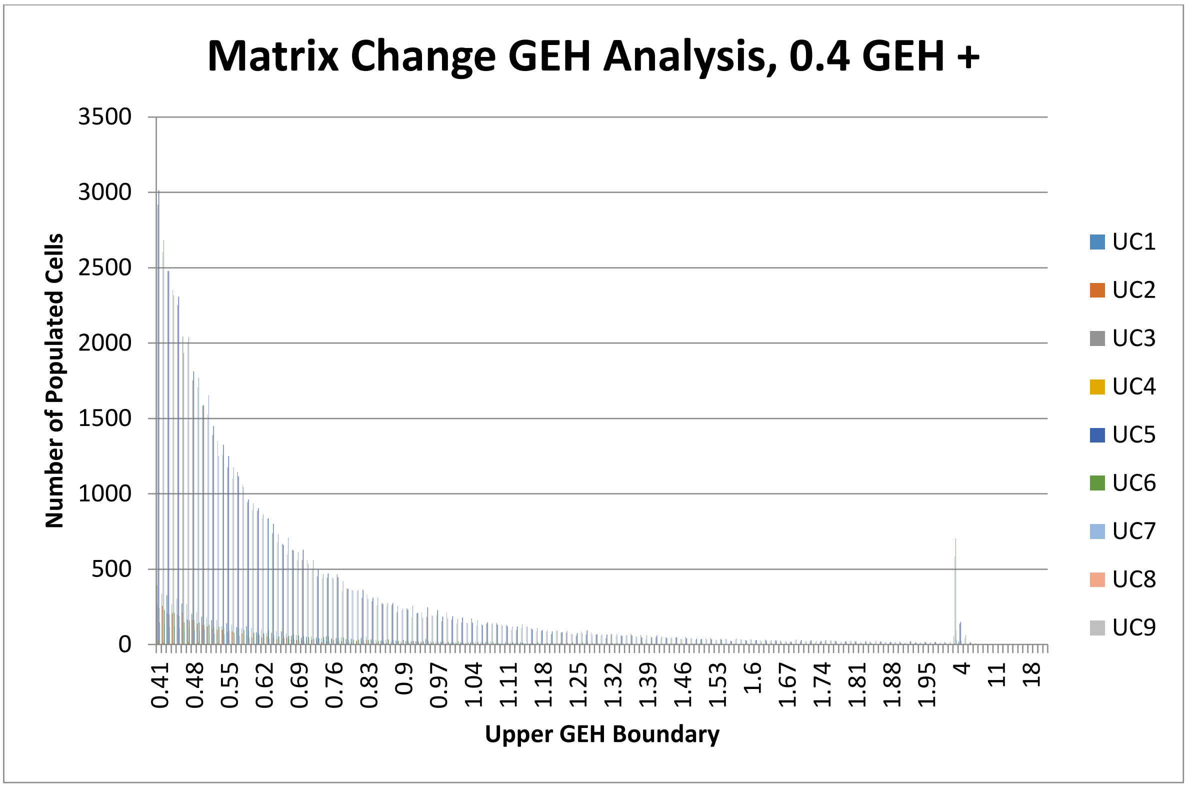

Figure 5.9 SATME2 PM Matrix Change GEH Analysis; 0.4 GEH Upwards

R^2 analysis was undertaken to further understand the matrix changes made by SATME2. Table 5.44 details the R^2 values for each individual user class. These are represented graphically in Appendix D.

Table 5.44 SATME2 PM 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	0.48	0.75	0.00
Car Employers Business	0.77	0.92	0.00
Car Commute	0.91	0.92	0.00
Car Education	0.95	0.96	0.00
Car Other	0.94	0.97	0.00
LGV	0.81	0.81	0.00
OGV1	0.71	0.68	0.00
OGV2 Permit Holder	1.00	1.00	0.00
Other OGV2	1.00	1.00	0.00

In the PM peak, three user classes meet the TAG recommended criteria with regards to R^2 values, with all R^2 values in excess of 0.71 when the “Taxi” user class is excluded.

The slope value is reasonable for each user class, with the exception of the "Taxi" user class which, as indicated in Table 5.43, experiences the largest overall matrix change during matrix estimation.

Trip End analysis was undertaken for each user class and summarised in Table 5.45

Table 5.45 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	0.93	0.95	1.19
Car Employers Business	0.96	1.00	0.70
Car Commute	0.98	0.98	0.99
Car Education	0.98	1.02	0.00
Car Other	0.99	0.98	1.31
LGV	0.93	1.05	0.19
OGV1	0.93	0.99	0.20
OGV2 Permit Holder	1.00	1.00	0.00
Other OGV2	1.00	1.00	0.00

The PM Peak trip end R^2 analysis is more favourable than the cellular analysis, with all R^2 values in excess of 0.93. All user classes are also close to passing the slope criteria, with all trip end slope values excluding "Taxi" and "LGV" within 0.01 of the recommended TAG criteria. The largest y-intercept value is 1.31 which is deemed to be close to 0, and thus all user classes meet the y-intercept criteria set out in TAG.

The matrix was compared against three prominent screenlines to determine whether or not the matrix broadly contains the correct number of trips. This check was undertaken around the M50, around the canal and across the River Liffey.

Table **5.46** details the total traffic crossing the screenlines.

Table 5.46 RDAM PM Screenline Check

Screenline	Observed (Veh)	Model (Veh)	Difference (%)
M50 Inbound	27,090	25,249	-7%
M50 Outbound	31,243	30,843	-1%
Canal Inbound	13,340	13,129	-2%
Canal Outbound	19,519	19,354	-1%
River Liffey (Northbound)	7,022	6,926	-1%
River Liffey (Southbound)	6,279	5,491	-13%

Traffic levels across the canal cordon, M50 Outbound and the River Liffey Northbound are within the acceptability criteria outlined in TAG unit M3-1, however traffic crossing the M50 Inbound and River Liffey Southbound are not. The traffic crossing this M50 Inbound is within seven per cent which is considered reasonable for a model of this scale and complexity.

5.11 Trip Length Distribution Analysis

5.11.1 Overview

An observed trip length distribution was used during the creation of the prior matrices under TO8. Once assigned, the trip length distribution of the SATURN assignment was compared against the observed distribution as part of TO8.

The trip length distribution of the prior and incremental assignments were compared to ensure that they were not significantly distorted by matrix estimation and still compared well against the observed trip length distribution profile. This included analysis of the change in mean trip length and the change in the standard deviation of the trip length. Changes in mean trip length and the standard deviation were compared to the guidance outlined in TAG, set out in Section 5 of this report.

The trip length distribution of the prior and incremental matrices was assessed by combining the network distance skims, which contains the travel distance between each origin and destination within the model, with the trip demand matrices from the pre- and post-estimation scenarios.

This comparison can identify areas of weakness in the prior matrices, such as an over-reliance on longer distance trips.

5.11.2 Trip Length Distribution Analysis

Graphical representation of the comparison for each modelled period and each user class is included in Appendix E. Overall, the matrix estimation impact on the trip length distribution does not seem significant from a profile perspective, despite the individual changes failing to meet the matrix calibration criteria.

TAG sets out the matrix changes acceptability criteria as being a change to the mean within 5 per cent, and a change to the standard deviation within 5 per cent. Table 5.47 sets out the mean change between the pre- and incremental matrices for each user class, while Table 5.48 sets out the standard deviation change between the pre-and post-estimation matrices for each user class.

Table 5.47 Percentage Change in Mean Trip Length

User Class	AM Peak	IP1	IP2	PM Peak
TAG Criteria	Mean Change < 5%			
Taxi (UC1)	5%	-10%	-9%	4%
Employers Business (UC2)	2%	-9%	-5%	4%
Commute (UC3)	8%	-8%	0%	7%
Education (UC4)	1%	-1%	1%	11%
Car Other (UC5)	-3%	-10%	-5%	0%
LGV (UC6)	-2%	-3%	-2%	-5%
OGV1 (UC7)	-1%	-4%	-3%	0%
OGV2 permit Holder (UC8)	0%	1%	1%	1%
OGV2 (UC9)	0%	0%	0%	0%

Table 5.48 Percentage Change in Standard Deviation of Trip Length

User Class	AM Peak	IP1	IP2	PM Peak
TAG Criteria	Standard Deviation Change < 5%			
Taxi (UC1)	7%	-10%	-9%	7%
Employers Business (UC2)	-7%	-14%	-10%	-7%
Commute (UC3)	15%	-3%	4%	12%
Education (UC4)	2%	-5%	2%	17%
Car Other (UC5)	-5%	-14%	-9%	-4%
LGV (UC6)	0%	-1%	-1%	-3%
OGV1 (UC7)	1%	0%	1%	5%
OGV2 permit Holder (UC8)	0%	0%	0%	1%
OGV2 (UC9)	0%	0%	0%	0%

In the AM Peak eight of the nine user classes pass the criteria of a change in the mean trip length of less than 5 per cent, and six pass the criteria of a change in the standard deviation of the trip length of less than 5 per cent. The largest changes are observed in the “Car Commute” user class. Although the overall mean trip length has changed, the distribution curve across each user class remains relatively consistent with the prior to estimation matrices.

For the Inter-peak 1 time period five of the nine user classes pass the criteria of a change in the mean trip length of less than 5 per cent, with five also passing the criteria of a change in the standard deviation of the trip length of less than 5 per cent. One of the largest changes is observed in the “Taxi” user class which is unsurprising as this user class was not subject to the matrix estimation constraints. “Car Employers Business”, Car

Commute” and “Car Other” also fail to meet the mean trip length change criteria. “Car Education” fails to meet the change in the standard deviation criteria through rounding only (greater than 5 per cent, but less than 5.5 per cent).

Eight of the nine user classes pass the criteria of a change in the mean trip length of less than 5 per cent in the Inter-peak 2 time period, with six also passing the criteria of a change in the standard deviation of the trip length of less than 5 per cent. The only user class to fail to meet both the mean and standard deviation criteria is “Taxi” which is not subject to the typical matrix estimation constraints.

In the PM Peak seven of the nine user classes pass the criteria of a change in the mean trip length of less than 5 per cent, and five pass the criteria of a change in the standard deviation of the trip length of less than 5 per cent. The largest changes are observed in the “Taxi” user class which is unsurprising as this user class was not subject to the matrix estimation constraints. “Car Commute” and “Car Education”, despite having reasonable R^2 results, have the most significant changes to mean change in trip length and standard deviation.

5.12 Calibration Summary

5.12.1 Overview

Table 5.49 details the status of each component of the calibration process for each modelled period. These results can be compared to the results summarised in Section 5.4 which cover the interim model statistics and Section 5.5 which cover the pre-audit model statistics.

Table 5.49 Model Calibration Status Summary

Component	AM	IP1	IP2	PM
Individual Link Flows	78%	89%	86%	75%
Individual Link GEH <5	75%	87%	85%	74%
Individual Link GEH <7	84%	92%	90%	82%
Individual Link GEH <10	90%	95%	94%	88%
Screenlines	75%	83%	75%	50%
Matrix Cell R^2 Analysis (Range)	0.64 – 1.00	0.61 – 1.00	0.72 – 1.00	0.48 – 1.00
Trip End R^2 Analysis (Range)	0.92 – 1.00	0.93 – 1.00	0.95 – 1.00	0.97 – 1.00

5.12.2 Traffic Count Observations

The highest GEH in the AM peak (30.7) was recorded on North Road (N2) which is part of the M50 (North) cordon. As stated in Section 5.9.3 the observed flow at this location was 1,892 whereas the modelled flow was 773 (-59 per cent). Further investigation indicated that the screenline as a whole is within 10 per cent, with the majority of screenline links marginally above observed levels, suggesting that traffic is re-routing to parallel routes.

There is no significant queued traffic along the N2, and no evidence of traffic avoiding any particular junction or location.

Extending the review further out from Dublin City Centre, there is a tendency for modelled traffic volumes to be higher than observed levels. This is evident on the M1 at Drogheda and the M9 at Kilkenny. The M2, M6, M7 and M11 all calibrate well at the extremities of the model in the AM Peak.

Within the City Centre across all peak periods there is an under representation of traffic volumes along each bank of the River Liffey. This may be exacerbated by the inclusion of parking constraint and parking distribution within the model, allocating trips to destinations outside the immediate City Centre and converting the final proportion of their journey into a walk trip. Traffic volumes entering the City Centre area in the AM peak, defined by the Canal Cordon are lower than observed by 8 per cent for inbound traffic and by 2 per cent for outbound traffic.

Goods vehicles do not calibrate as well as the car user class across all peak periods. In the AM peak modelled volumes across all but one screenline exceeding the observed levels for LGV, OGV1 and OGV2. This is unsurprising given the lack of observed data available when constructing the travel demand matrices prior to matrix estimation.

The highest GEH in both the Inter-peak 1 and Inter-peak 2 time periods is located on Ballyboden Way (westbound). This is due to traffic choosing to travel along the parallel Scholarstown Road due to a lack of congestion in the surrounding area. When both Ballyboden Way and Scholarstown Road are considered as a screenline the flows calibrate well against observed, suggesting a local routing issue.

Much like the AM peak, in the Inter-peak 1 period there is a tendency for modelled traffic volumes to be higher than observed levels at the extremities of the model. Where the higher volumes in the AM peak were mostly limited to the M1 and M9, larger than observed traffic volumes are also evident on the M1, M2, M6 and M7 in the Inter-peak 1 period. This leads to larger than observed traffic volumes along most sections of the M50.

The flows at the extremities of the Inter-peak 2 model are more in line with the AM peak, with only traffic volumes on the M1 and M9 larger than observed levels by any significant amount. The M50 still exhibits large than observed traffic volumes along most sections.

The highest GEH in the PM peak model (34.6) was recorded on Naas Road (R110) westbound, where the observed flow is 705. The modelled flow at this location is 1,972 which is significantly higher than the observed level. Traffic levels downstream and upstream of this location are all close to observed levels, suggesting a localised route choice issue. There is also a lack of traffic on the N11 northbound, just before the Bray junction, however downstream traffic on both the N11 and M50 are close to observed levels indicating a possible over reliance on the Bray zones as a traffic generator in the PM peak.

It should be noted that with the current implementation of matrix estimation SATURN does not have the ability to “seed” any trips between zone pairs. Therefore SATME2 cannot adjust parts of the matrix if no traffic is currently using a link as there are no origin-destination pairs to adjust, regardless of the XAMAX parameter.

5.12.3 Matrix Observations

Changes applied to all peak matrices via matrix estimation are generally acceptable at a matrix total and trip end level, excluding the “Taxi” user class. However, individual cells fail to meet the recommended criteria for most car-based user classes.

5.12.4 Trip Length Distribution Observations

In the AM and PM peak periods, the tendency of matrix estimation was to lengthen the mean trip length for all car user classes with the exception of “Taxi”. The changes are not of significant scale, again with the exception of the “Taxi” user class.

In the Inter-peak 1 time period matrix estimation has shortened the mean trip length, which is a more typical outcome from matrix estimation as it seeks to in-fill trips to match traffic counts, normally between the shortest origin-destination pair as to not impact the model as a whole.

The Inter-peak 2 time period is well balanced, with mean trip length distribution changes of less than 2 per cent for all user classes with the exception of “Taxi”. The balance between positive and negative changes indicates a well-calibrated Inter-peak 2 matrix prior to matrix estimation.

5.12.5 Calibration Observation Summary

Table 5.50 outlines the key calibration observations and indicates which modelled time periods the observation relates to.

Table 5.50 Model Calibration Identified Issues

Issue	AM Peak	IP1	IP2	PM Peak
Low traffic volumes along Quays	○	○	○	○
High traffic on M1 Southbound	○	○	○	
High traffic on M9 Eastbound	○	○	○	○
Large changes to Taxi User Class	○	○	○	○

6 Road model validation

6.1 Introduction

In Section Six we set out the specification and execution of the model validation process.

6.2 Assignment Validation Process

6.2.1 Overview

Model validation is the process of comparing the assigned traffic volumes against data that was independent of the calibration process and comparing modelled versus observed journey times. It is recommended that modelled flows and counts should be compared by vehicle type and time period if possible.

6.2.2 Validation Criteria

Traffic volume and trip length distribution criteria, set out in Section 5 were applied, in conjunction with recommended journey time validation criteria. Table 6.1 outlines the journey time validation criteria as set out in TAG Unit M3-1, Section 3.2, Table 3.

Table 6.1 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:

- SCATS;
- Permanent ATC's operated by Transport Infrastructure Ireland (TII); and
- Individual link and junction turning counts.

SCATS total vehicle count and individual link validation was undertaken against the same acceptability criteria as set out in Section 5.

6.2.4 Journey Times

Observed journey time data is available for the majority of major roads within Dublin through the TomTom dataset. The routes previously defined for the moving car observer surveys were retained for the validation of the ERM. These routes constitute 16 two-way radial routes, plus four two-way orbital routes. An additional six orbital and four arterial two-way routes were defined at a later date to maximise the benefit of using the TomTom travel time data. A fifth orbital route (Route 17) from the original moving car observer surveys was unavailable from the TomTom dataset, thus the moving car observer travel times have been used for this route during validation.

AM Peak travel times were taken as being the average observed link times between 0800 and 0900. Inter-peak 1 travel times were taken as being the average observed link times between 1000 and 1300, with Inter-peak 2 travel times being the average observed link times between 1300 and 1600. PM Peak travel times were taken as being the average observed link times between 1700 and 1800. These time periods were selected to align with the assignment model time periods and methods.

With regard to Route 17, the moving car observer observations for the AM Peak all commenced at 0800, with Inter-peak 1 commenting at 1400 and PM Peak commencing at 1700. The moving car observer time from 1400 was applied to both the Inter-peak 1 and Inter-peak 2 validation.

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

Dublin's SCATS database, maintained by Dublin City Council's Roads and Traffic Department, contains total volumetric data for each lane of the approaches to signalised junctions. From this dataset it is possible to validate the SATURN model against an all-vehicle total across 1,050 links; however, consideration must be given to motorcycles, pedal cycles and public service vehicles that are not assigned as part of the road model, but may be included in the SCATS total vehicle traffic count.

6.3.2 Traffic Count Locations

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

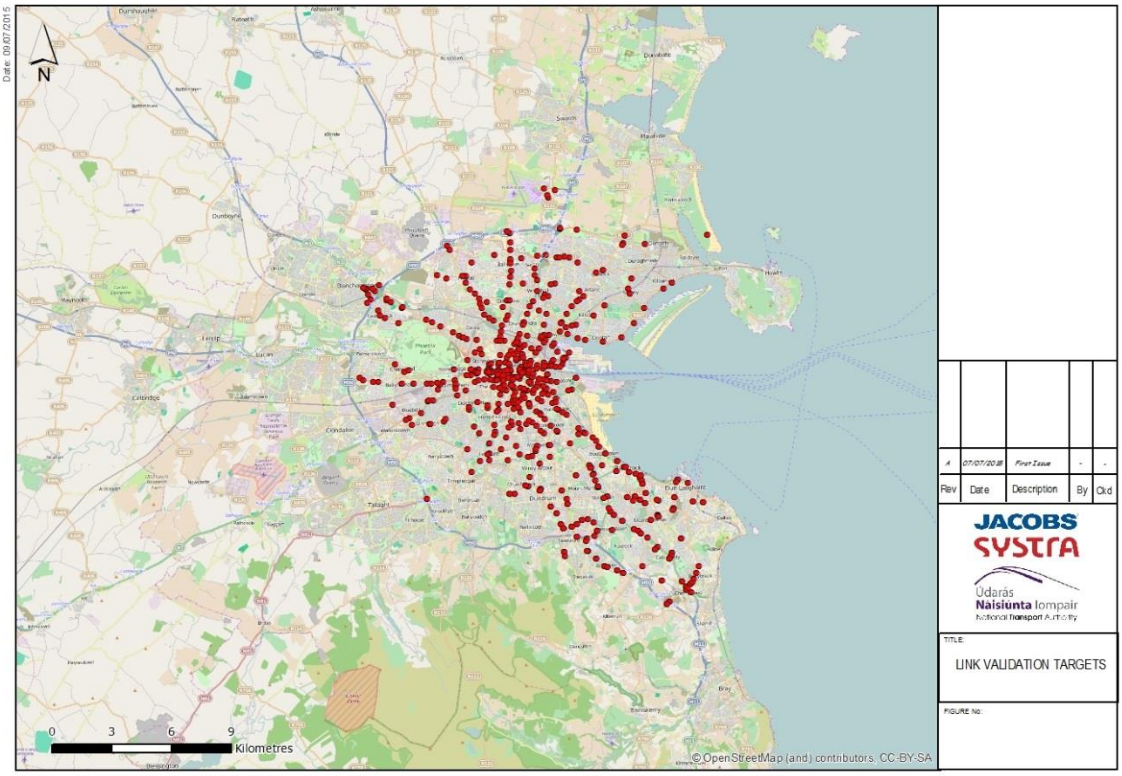

Figure 6.1 Link Validation Target Locations

6.3.3Validation 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 6.2.

Table 6.2 AM Link Flow Validation

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	46% (482)
GEH < 5 for individual flows	> 65% of cases	40% (422)
GEH < 7 for individual flows	> 75% of cases	52% (548)
GEH < 10 for individual flows	> 95% of cases	66% (691)

Across the 1,050 count locations in the AM Peak, 46 per cent (482) pass the TAG flow validation criteria. 40 per cent of links have a GEH of less than 5. However, relaxing the criteria to include GEH values of less than 10 yields a 66 per cent pass rate, which remains below the TAG recommendation of 85 per cent of links passing validation.

As the City Centre contains the highest density of signalised junctions it is unsurprising that there are a large number of links that do not meet the validation criteria levels. This is due to a number of factors, of which the primary factor is the composition of the traffic volumes presented by SCATS. As SCATS presents the total traffic volume for each detector, this volume may include motorcycles, pedal cycles and public service vehicles.

Public service vehicles are accounted for in the SATURN assigned flow to a certain extent using the pre-loaded bus volume from the public transport model, however this will not account for private coaches, mini buses or account for variations or delays to timetabled services.

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

In general, modelled traffic volumes are lower than observed traffic volumes. This trend was anticipated due to the reasons specified above relating to the composition of the SCATS dataset, and the potential impact that parking distribution will have on road-based trips.

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 6.3.

Table 6.3 IP1 Link Flow Validation

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	48% (509)
GEH < 5 for individual flows	> 65% of cases	41% (433)
GEH < 7 for individual flows	> 75% of cases	52% (551)
GEH < 10 for individual flows	> 95% of cases	68% (714)

Across the 1,050 count locations in the Inter-peak 1, 48 per cent (509) pass the TAG flow validation criteria. 41 per cent of links have a GEH of less than 5. However, relaxing the criteria to include GEH values of less than 10 yields a 68 per cent pass rate which is similar to the AM Peak. 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 model validation, the areas of the lowest level of validation are the City Centre area and areas where the model calibration is poorest, such as the N11 corridor.

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

In general, modelled traffic volumes are lower than observed traffic volumes. This trend was anticipated due to the reasons specified above relating to the composition of the SCATS dataset.

There were specific traffic volume differences that warranted further investigation, and these are discussed in more detail later in Section 6.5.

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 6.4.

Table 6.4 IP2 Link Flow Validation

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	48% (507)
GEH < 5 for individual flows	> 65% of cases	41% (435)
GEH < 7 for individual flows	> 75% of cases	52% (551)
GEH < 10 for individual flows	> 95% of cases	68% (713)

Across the 1,050 count locations in the Inter-peak 2, 48 per cent (507) pass the TAG flow validation criteria. 41 per cent of links have a GEH of less than 5. However, relaxing the criteria to include GEH values of less than 10 yields a 68 per cent pass rate which is similar to the AM Peak. 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 and Inter-peak 1 model validation, the areas of the lowest level of validation are the City Centre area, and areas where the model calibration is poorest, such as the N11 corridor.

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

In general, modelled traffic volumes are lower than observed traffic volumes. This trend was anticipated due to the reasons specified above relating to the composition of the SCATS dataset.

There were specific traffic volume differences that warranted further investigation, and these are discussed in more detail later in Section 6.5.

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 6.5.

Table 6.5 PM Link Flow Validation

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	43% (451)
GEH < 5 for individual flows	> 65% of cases	38% (399)
GEH < 7 for individual flows	> 75% of cases	50% (520)
GEH < 10 for individual flows	> 95% of cases	65% (684)

Across the 1,050 count locations in the PM Peak, 43 per cent (451) pass the TAG flow validation criteria. 38 per cent of links have a GEH of less than 5. However, relaxing the criteria to include GEH values of less than 10 yields a 65 per cent pass rate, which remains below the TAG recommendation of 85 per cent of links passing validation.

As with the AM Peak, Inter-peak 1 and Inter-peak 2 model validation, the areas of the lowest levels of validation are the City Centre area, and areas where the model calibration is poorest, such as the N11 corridor.

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

In general, modelled traffic volumes are lower than observed traffic volumes. This trend was anticipated due to the reasons specified previously relating to the composition of the SCATS dataset.

There were specific traffic volume differences that warranted further investigation, and these are discussed in more detail in Section 6.5.

6.4 Journey time validation

6.4.1 Overview

The NTA routinely collect moving car observer (MCO) journey time data for 16 arterial and 5 orbital routes. In addition, the NTA purchased access to the TomTom Custom Area Analysis (CAA) product, allowing the extraction of average travel times over user-defined time periods along each major road within the Greater Dublin Area.

6.4.2 Journey time routes

A detailed map showing each journey time validation route used during validation is presented in Figure 6.2.

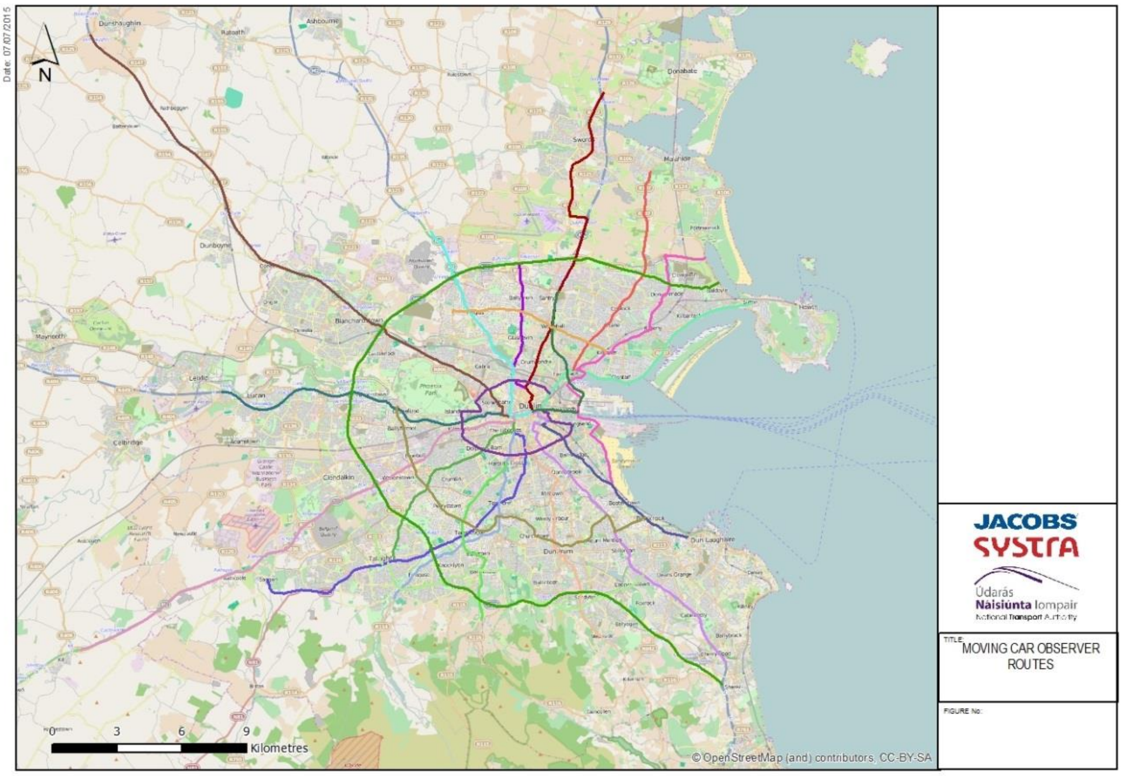

Figure 6.2 Journey Time Validation Routes

6.4.3Validation Criteria Compliance – AM peak

Of the 62 journey time routes, 73 per cent (45) pass TAG criteria of modelled journey times being within 15 per cent of observed journey times.

Figure 6.3 details the validation of each route.

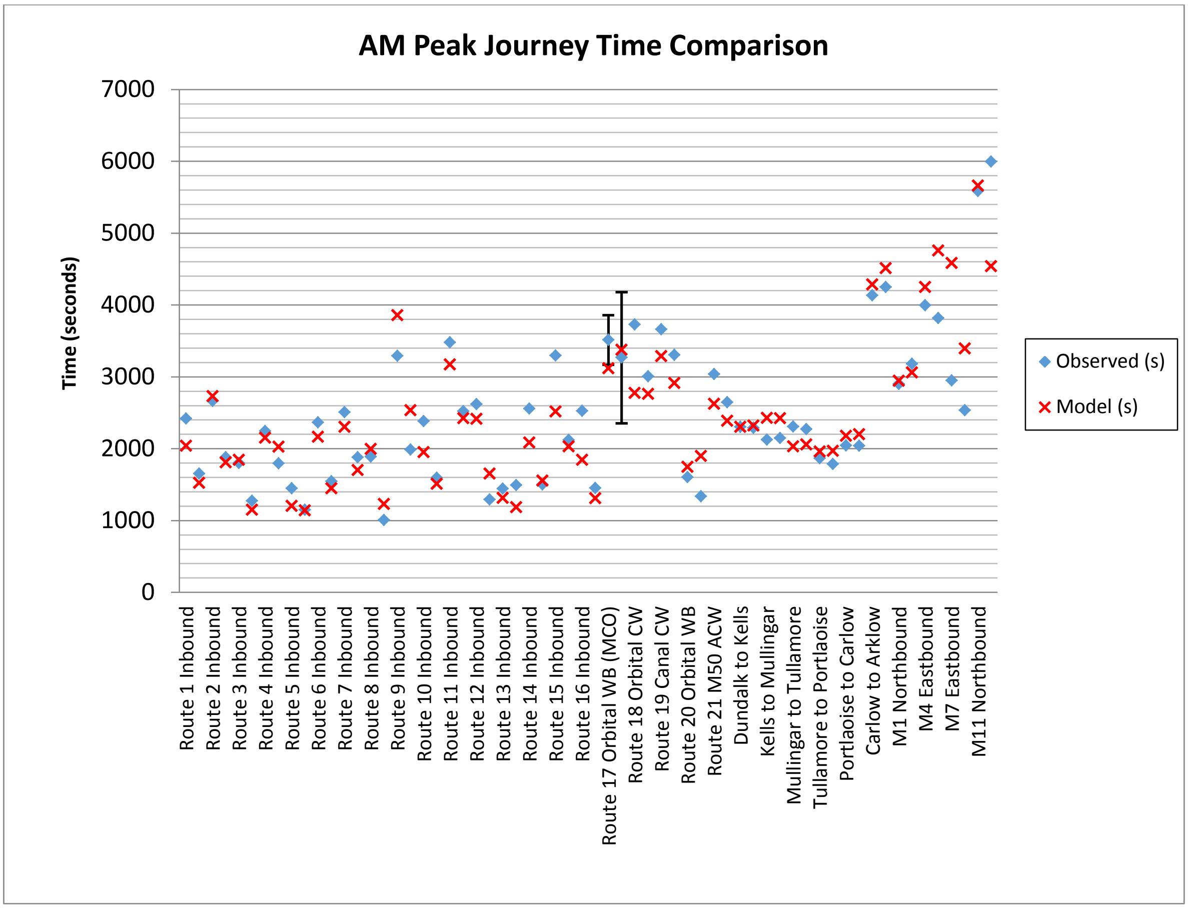

Figure 6.3 AM Peak Journey Time Comparison

Further details are included in Appendix G, with detailed analysis of any significant issues discussed in Section 6.5.

6.4.4 Validation Criteria Compliance – Inter-peak 1

Of the 62 journey time routes, 85 per cent (53) pass the TAG criteria of modelled journey times being within 15 per cent of observed journey times. Figure 6.4 details the validation of each route.

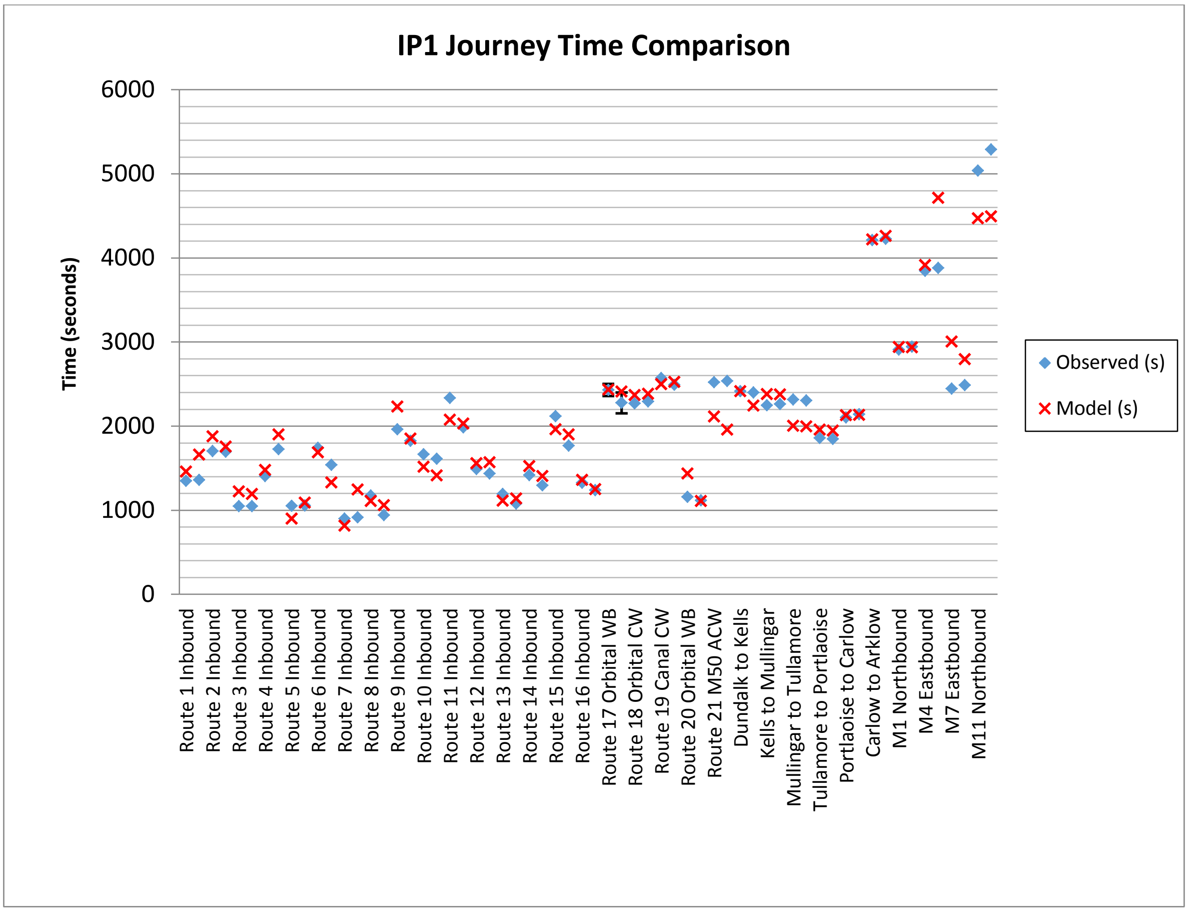

Figure 6.4 Inter Peak 1 Journey Time Comparison

Further details are included in Appendix G, with detailed analysis of any significant issues discussed in Section 6.5.

6.4.5Validation Criteria Compliance – Inter-peak 2

Of the 62 journey time routes, 76 per cent (47) pass the TAG criteria of modelled journey times being within 15 per cent of observed journey times. Figure 6.5 details the validation of each route.

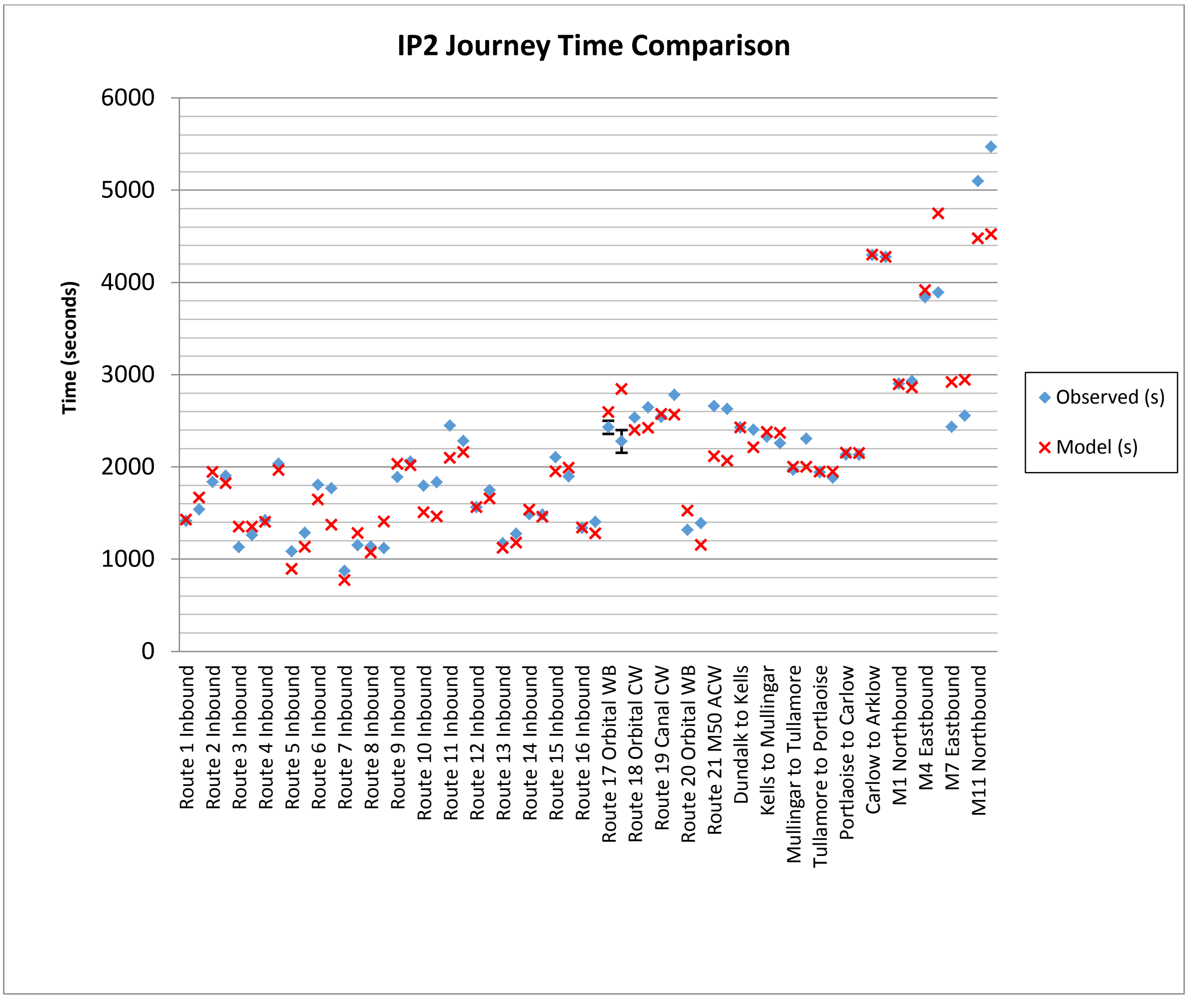

Figure 6.5 Inter Peak 2 Journey Time Comparison

Further details are included in Appendix G, with detailed analysis of any significant issues discussed in Section 6.5.

6.4.6Validation Criteria Compliance – PM Peak

Of the 62 journey time routes, 69 per cent (43) pass the TAG criteria of modelled journey times being within 15 per cent of observed journey times. Figure 6.6 details the validation of each route.

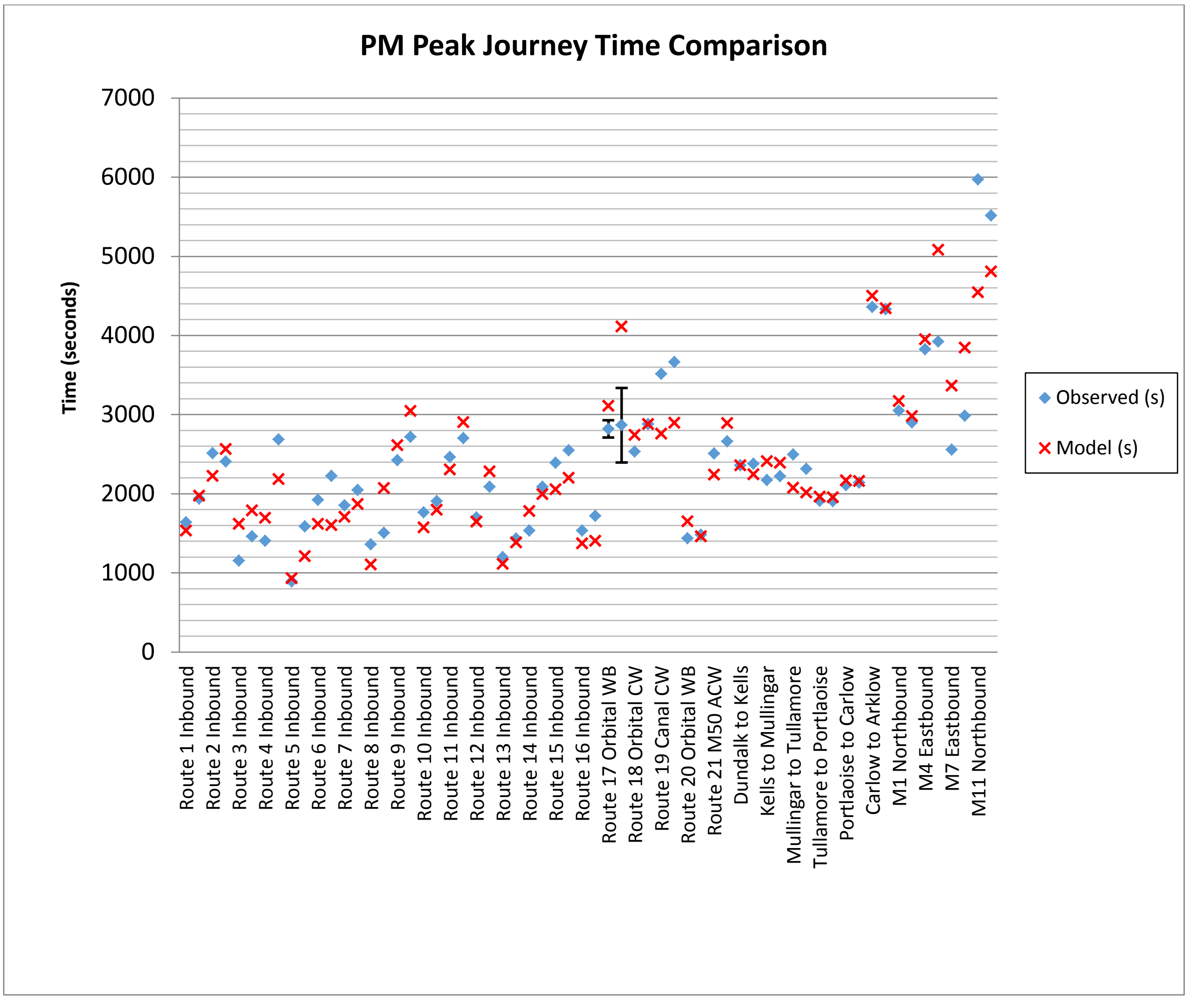

Figure 6.6 PM Peak Journey Time Comparison

Further details are included in Appendix G, with detailed analysis of any significant issues discussed in Section 6.5.

6.5 Validation Summary

6.5.1 Overview

Table 6.6 details the status of each component of the validation process for each modelled period.

Table 6.6 Model Validation Status

Component	AM Status	IP1 Status	IP2 Status	PM Status
Individual Link Flows	46%	48%	48%	43%
Journey Times	73%	85%	76%	69%

6.5.2 Traffic Count Observations

Validating traffic levels in Dublin City Centre, where the vast majority of the SCATS-controlled traffic signals are located, is challenging for a number of reasons. As discussed in previous sections, the all-vehicle nature of the SCATS count makes it difficult to validate against, as the all-vehicle count may contain pedal cycles, motor cycles and passenger service vehicles not accounted for in either the matrices or the bus pre-load files.

Another reason for the difficulty in achieving the recommended validation results is the impact that parking constraint and parking distribution within the FDM has on the road assignment model. Census data represents the true origin and true destination of a trip. For example, this could be a from-home trip to a place of work in a busy shopping street. The actual road model destination, such as a car park, may be located elsewhere due to parking restrictions and / or parking charges. The inability to accurately reflect the true road destination will impact on modelled traffic flows, particularly in the City Centre where SCATS data is more prevalent, impacting on the levels of validation achieved.

Furthermore, owing to the strategic nature of the current version of the ERM, there are fewer traffic counts within the City Centre area where the majority of the SCATS data covers. This data could not be used during model calibration due to its all-vehicle composition, and thus it was used as a high-level validation check. Therefore, many validation counts are isolated from calibration counts used to calibrate traffic levels along corridors.

6.5.3 Journey Time Observations

Comparing the modelled journey times to the observed data in the AM Peak, it is evident that as a whole there is a trend that end to end modelled journey times are quicker than observed journey times. Link speeds appear to be accurate when comparing the travel time between junctions, however it is clear that junction delay is underestimated at several locations. The M50 and Canal orbital routes both pass the recommended criteria.

Journey time route 4, 6, 7, 8, 9 and 15 represent the primary arterial approaches to Dublin. Of these routes, Routes 4, 6, 7 and 8 all meet the recommended criteria, with Routes 9 and 15 being 17 per cent too slow and 24 per cent too quick respectively. The longer-distance M7 journey time route fails to meet the criteria in both directions, while the longer-distance M11 route fails in a southbound direction due to the buffer network not accurately representing delays in Arklow.

After further investigation of the routes that fail, it is evident that it is normally a single location that does not replicate the observed travel delays. For example, journey time Route 1 does not replicate the observed delay on the approach to the Clontarf Road / Alfie Byrne Road junction. Modelled traffic volumes along Clontarf Road are very close to observed levels, and the queued traffic at this junction matches the observed level within a few vehicles. The junction is coded accurately in terms of lane definitions and capacities, with average 0800 – 0900 signal phasing and timings being taken directly from SCATS.

Journey times in the Inter-peak 1 period appear to be more accurate, suggesting that link speeds which are applied to all peak periods are correct for a less congested network. Although the model does not meet the desired level of 85 per cent of journey time routes within 15 per cent, there are three journey time routes that are within five per cent of passing, and would improve the overall percentage of routes passing to 85 per cent. The M50 in both directions fails to meet the recommended criteria, despite modelled flows being higher than observed levels. Journey times around the canal validate well in both directions.

Similar to the Inter-peak 1 period, Inter-peak 2 journey times appear to be more accurate overall, however still display a bias towards end to end journey times being quicker than observed. Although the model does not meet the desired level of 85 per cent of journey time routes within 15 per cent, there are eight journey time routes that are within five per cent of passing, and would improve the overall percentage of routes passing to 89 per cent. Routes that were too quick in Inter-peak 1 tend to be quick in Inter-peak 2, meaning the M50 does not meet the recommended criteria in both directions being 21 per cent too quick in both the anti-clockwise and clockwise directions. The canal validates well in both directions. The longer distance M7 route is too slow in either direction, with a large proportion of this route being in the buffer network.

The PM peak has the lowest level of journey time validation at 69 per cent. An additional six journey time routes are within 5 per cent of the recommended criteria. Under heavy traffic conditions the M50 passes the recommended criteria in both directions, as it did in the AM peak. The Canal, which passed in each of the other three assigned periods in both directions, fails to meet the recommended criteria in both directions by 21 per cent.

Table 6.7 outlines the key validation observations and indicates which models the observation relates to.

Table 6.7 Model Calibration Identified Issues

Issue	AM Peak	IP1	IP2	PM Peak
Quicker journey times, on average	○	○	○	○
Low City Centre validation	○	○	○	○

7 Conclusion and Recommendations

7.1 Summary

The ERM has been developed to assist the NTA with the assessment of current and future network performance, and the appraisal of local and strategic transport infrastructure projects and investments. This report has presented the development of the road model element of the ERM.

7.2 Model Development

The road model network has been thoroughly reviewed and enhanced considerably at all stages of development, starting with TO2 and TO6, progressing to the current TO8. The model makes best use of the available information at the time of model inception through to 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 Model Calibration

The model calibrates well, although each assigned user class does recommended guidelines set by the UK's TAG. The achieved level 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
		Range of Values			
Matrix zonal cell value	Slope within 0.98 and 1.02;	0.65 – 1.00	0.77 – 1.00	0.74 – 1.00	0.68 – 1.00
	Intercept near zero;	All 0.00	All 0.00	All 0.00	All 0.00
	R^2 in excess of 0.95.	0.64 – 1.00	0.61 – 1.00	0.72 – 1.00	0.48 – 1.00
Matrix zonal trip ends	Slope within 0.99 and 1.01;	0.96 – 1.15	0.88 – 1.00	0.92 – 1.01	0.95 – 1.00
	Intercept near zero;	0.00 – 1.87	0 – 3.05	0.00 – 1.88	0.00 – 1.31
	R^2 in excess of 0.98.	0.92 – 1.00	0.93 – 1.00	0.95 – 1.00	0.93 – 1.00
Trip Length Distribution	Means within 5%;	-3% – 8%	-10% – 1%	-9% – 1%	-5% – 11%
	Standard Deviation within 5%.	-7% – 15%	-14% – 0%	-10% – 4%	-7% – 17%
Sector to sector level matrices	Differences within 5%	61/529	64/529	71/529	52/529

In the AM peak period the matrix zonal cell changes for three out of nine user classes are close to the TAG recommended criteria. The slope values range from 0.93 to 1.00, with the exception of “Taxi”, “LGV” and “OGV1”. All Y-intercept values are 0. Changes at a trip end level, as well as changes to trip length distribution are close to passing the recommended criteria.

The Inter-peak 1 time period does not calibrate as well as the AM peak time period at a cellular level. Three out of the nine user classes pass or are close to passing the TAG recommended criteria for both R^2 and slope. All Y-intercept values are 0.

The Inter-peak 2 time period is similar to the AM peak in that with the exception of the “Taxi” user class all or nearly all user classes meet the recommended criteria outlined in TAG. All R^2 values are in excess of 0.72 at a cellular level, and above 0.95 at a trip end level. Slope values at a cell level are all in excess of 0.74, and for trip ends all slope values are in excess of 0.92.

The PM peak calibrates well against the recommended criteria. Three out of the nine cell R^2 values are in excess of 0.95. For trip ends, all R^2 values are in excess of 0.93 (including the "Taxi" user class). All slope and Y-intercept values either pass or are close to passing the recommended TAG 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 Model Calibration Status Summary

Component	Acceptability Guidelines	AM	IP1	IP2	PM
Individual Link Flows	> 85%	78%	89%	86%	75%
Individual Link GEH <5	> 85%	75%	87%	85%	74%

Although the AM peak period does not meet the TAG recommended criteria for either individual flows or GEH values it is close to the criteria for individual flows, with 77 per cent of links passing the flow criteria. Extending the analysis of the GEH value to assess the number of links with a GEH value of 7 or less, and 10 or less results in 83 per cent and 90 per cent of links respectively.

The Inter-peak 1 time period passes the recommended criteria for link flow calibration, and is two per cent lower than the recommended GEH criteria. Extending the analysis of the GEH value to assess the number of links with a GEH value of 7 or less, and 10 or less results in 88 per cent and 94 per cent of links respectively.

The Inter-peak 2 results are similar to the Inter-peak 1 results, with the model failing to meet the link flow criteria by one per cent, and the GEH criteria by two per cent. Extending the analysis of the GEH value to assess the number of links with a GEH value of 7 or less, and 10 or less results in 89 per cent and 94 per cent of links respectively.

The PM peak period is less well calibrated than the AM and Inter-peak periods, with 74 per cent of the links meeting the individual link flow recommended criteria, and 73 per cent of links meeting the GEH recommended criteria. Extending the analysis of the GEH value to assess the number of links with a GEH value of 7 or less and 10 or less results in 82 per cent and 88 per cent of links respectively.

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 Model Screenline Calibration Status Summary

Component	Acceptability Guidelines	AM	IP1	IP2	PM
Screenlines	All or nearly all screenlines within 5%	67%	83%	67%	50%

In the AM peak 67 per cent of screenlines are within 5 per cent of the observed traffic flows. Two additional screenlines are slightly higher than 5 per cent different (-5.8 per cent and 5.8 per cent), and all screenlines are within 13 per cent of the observed total traffic flows.

The Inter-peak 1 time period has 83 per cent of screenlines meeting the TAG recommended criteria of total modelled screenline flows within 5 per cent of observed. Two additional screenlines are marginally higher than 5 per cent different (-5.5 per cent and 7.0 per cent), and all screenlines are within seven per cent of the observed total traffic flows.

67 per cent of Inter-peak 2 screenlines meet the criteria set out in TAG. Four additional screenlines are close to passing the recommended criteria (-7.6 per cent, -5.1 per cent, 5.2 per cent and 7.4 per cent), and all screenlines are within eight per cent of observed total screenline flows.

Although only 50 per cent of PM peak screenlines are within 5 per cent of the observed traffic flows all screenlines are within 13 per cent of observed traffic flows, which is considered to be suitably representative of total screenline 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 non-observed matrix elements (Taxi, 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, R^2 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 Model Validation

The modelled traffic flows do not meet the recommended criteria as set out in TAG for any peak period. However journey time validation is close to passing the recommended criteria. Table 7.4 summarises the model validation statistics.

Table 7.4 Model Validation Status Summary

Component	Acceptability Guidelines	AM	IP1	IP2	PM
Individual Link Flows	> 85%	46%	48%	48%	43%
Individual Link GEH <5	> 85%	40%	41%	41%	38%
Journey Times within 15%	> 85%	73%	85%	76%	69%

Despite traffic volume validation not meeting TAG criteria in the AM Peak, the journey times compare reasonably well against the limited moving car observer dataset, with 73 per cent of routes meeting the TAG criteria of modelled journey times being within 15 per cent of observed journey times. 89 per cent of journey time routes are within 25 per cent of the observed journey times.

Journey time validation across the remaining peak periods is strong at 85 per cent for Inter-peak 1, 76 per cent for Inter-peak 2 and 69 per cent for PM Peak that meet the TAG criteria. In the Inter-peak 1 and Inter-peak 2 time periods 98 per cent of journey time routes are within 25 per cent of the observed journey time. 89 per cent of PM peak period journey time routes are within 25 per cent of the observed journey time.

In general, the traffic volumes are below observed levels and the journey times are faster than observed journey times. It is our view that this could mean that the benefits of potential public transport measures could be underestimated to a degree. In that as journeys by car could take longer, therefore any change in mode could also be marginally underestimated as the true travel time savings may be higher than modelled.

7.5 Sensitivity Testing

Sensitivity testing was undertaken as part of the FDM calibration process. Sensitivity Test results are available in “ERM Demand Model Calibration Report”.

7.6 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.

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