REGIONAL MODELLING SYSTEM

RM Spec2 Road Model Specification Report

Údarás Náisiúnta Iompair
National Transport Authority

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Foreword

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

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

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

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

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

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

1 Introduction

1.1 Regional Modelling System

The NTA has developed a Regional Modelling System for the Republic of Ireland to assist in the appraisal of a wide range of potential future transport and land use options. The regional models 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 the NTA, SYSTRA and Jacobs Engineering Ireland.

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

Table 1.1 Regional Models and their Population Centres

Model Name	Code	Counties and population centres
West Regional Model	WRM	Galway, Mayo, Roscommon, Sligo, Leitrim, Donegal
Eastern 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, Tipperary South
South West Regional Model	SWRM	Cork and Kerry

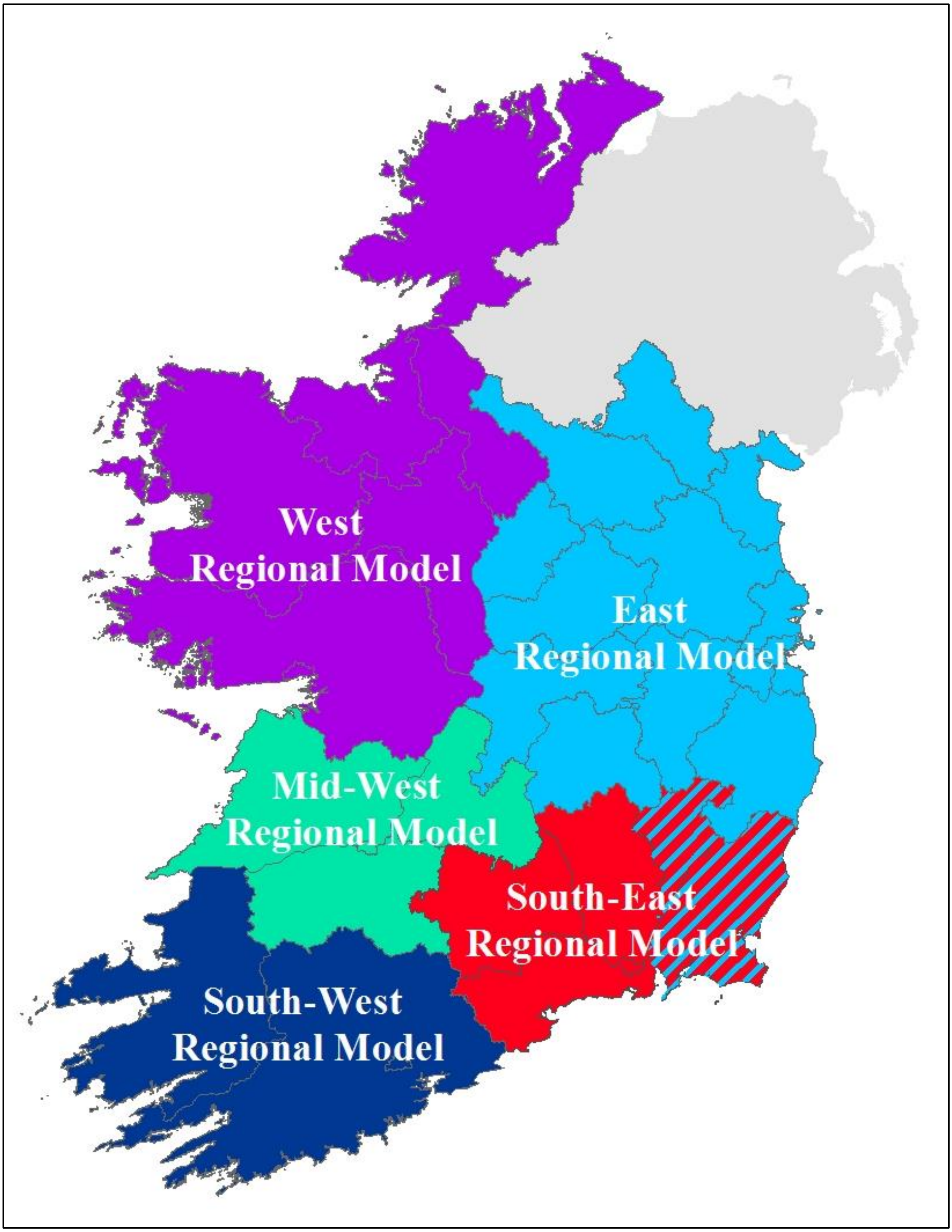

Figure 1.1 Regional Model Areas

1.2 Development of RMS Road Model Specification

The 5 regional transport models comprising the NTA's Regional Modelling System (RMS) all use a consistent approach to the development of the Road Model (RM). An important objective of the RMS RM Specification is that its principles can be applied to any regional model area to act as an overarching road model development guide prior to calibrating to local data.

Four technical notes were used as the basis for the specification of the update of the Regional Modelling System, which are as follows:

- RMS Scope 1 NTA Modelling Needs Review;
- RMS Scope 2 Greater Dublin Area Model Review;
- RMS Scope 3 Transport Modelling Best Practice Review; and
- RMS Scope 4 Modelling Data Review

These documents have informed the specification of the RM and its development, which is described throughout this Report.

Guidance on the RM specification has also been drawn from the UK Department for Transport's Transport Analysis Guidance (TAG). TAG provides a best practise guide and the guidance is kept up-to-date in light of new evidence and developments in modelling and appraisal methodologies in the UK.

TAG unit M3-1 provides guidance on highway (road) assignment modelling in transport appraisals, which can be found via the following web link. With no specific Irish equivalent, this document will be used as the primary point of guidance for the RMS RM specification and development in conjunction with the expertise and experience of NTA staff and the Consultants.

https://www.gov.uk/government/publications/webtag-tag-unit-m3-1-highway-assignment-modelling

A range of other documents have been reviewed for specific aspects of the RMS RM development, e.g. validation criteria, and these are documented where relevant throughout this report.

1.3 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 regional models is shown below in Figure 1.2. The main stages of the regional modelling system are described below.

1.3.1 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.

1.3.2 Regional Models

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.

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 Spec 2 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 Spec 3 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.

1.3.3 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

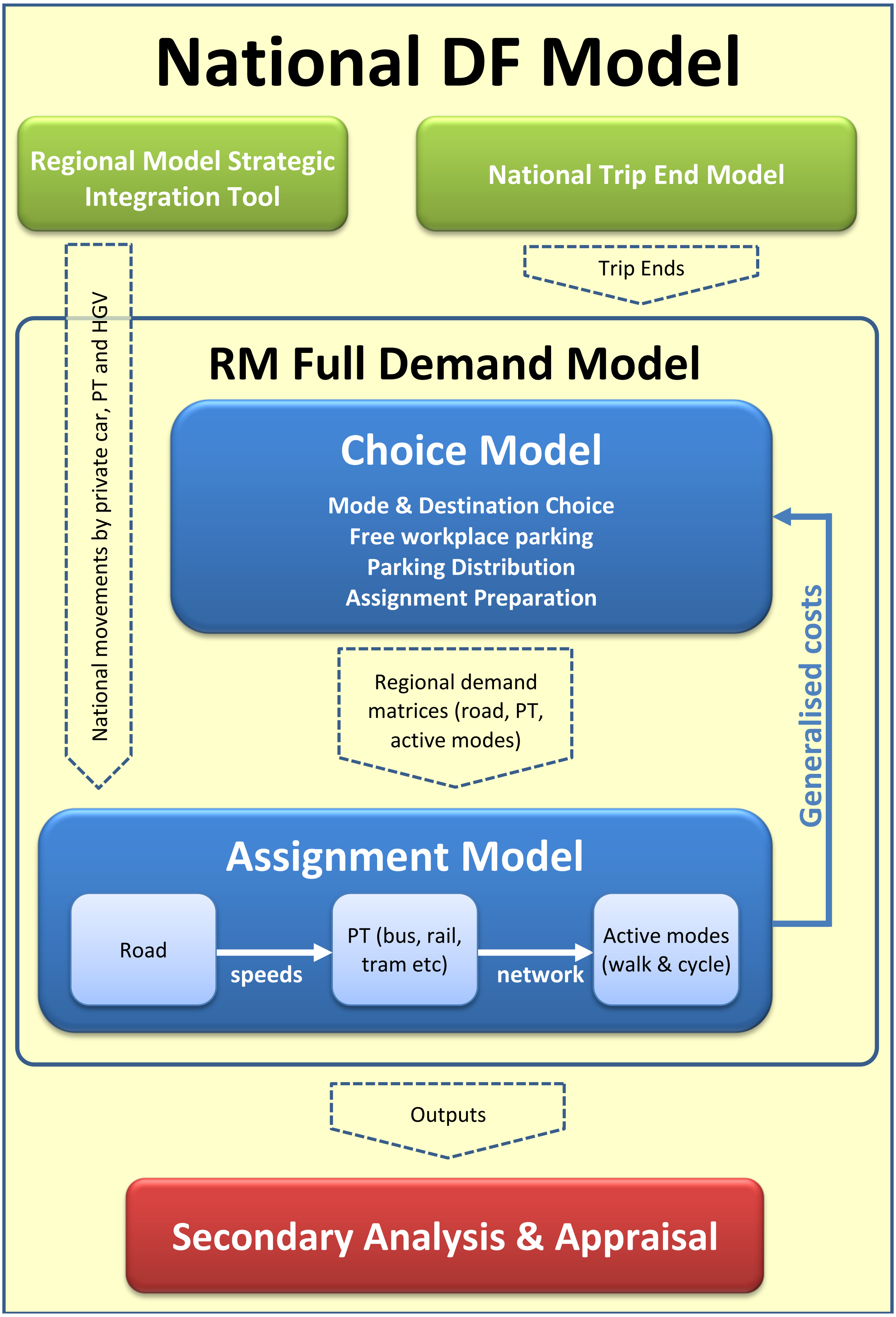

Figure 1.2 RMS Model Structure

1.4 Purpose of Report

The purpose of the RMS RM is to assign road users to a route or group of routes between their origin and destination zones. The cost of travel is then calculated by the RMS RM for input to the demand model and economic appraisal. Aspects of the RMS RM that require specification include:

- which **time periods** to represent;
- **demand segment definition** (e.g. by journey purpose and/or fare);
- approach to **road network development and coding**;
- **parameters** used within the assignment including SATURN variables and generalised cost; and
- **calibration and validation** of the model to ensure that it replicates observed road travel patterns and conditions adequately.

This report describes the specification of the RMS RM and considers all these aspects.

The Eastern Regional Model (ERM) was used as a 'test' case for the development of the RMS RM Specification.

2 RMS Road Model Structure & Dimensions

2.1 Introduction

Figure 2.1 provides an overview of the RMS 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.

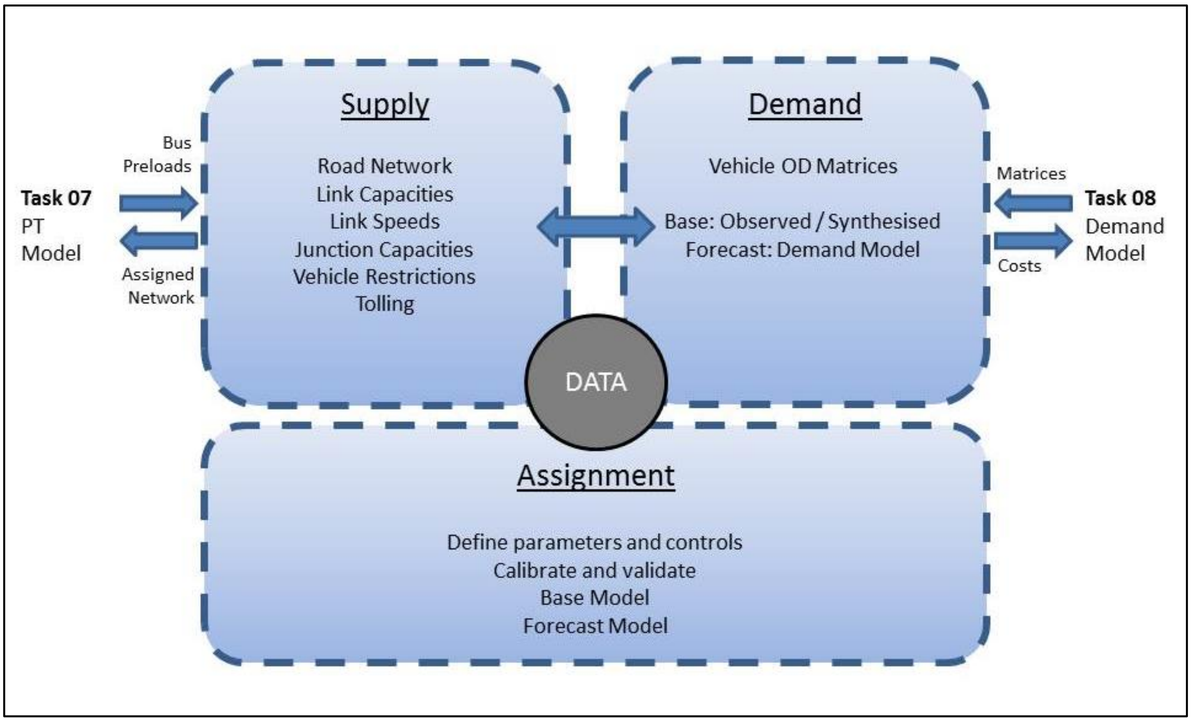

Figure 2.1 RMS RM Structure Overview

2.2 Overview of Data Sources

Data is an essential input for the development of the RMS RM for each regional modelled area. This is required to build the RM network for each area, to prepare demand matrices, derive parameter values and provide observed calibration & validation data. The data required for the RMS RM, includes:

- **Local authority information on traffic signals and traffic volumes (e.g. Dublin City Councils SCATS Database)** – traffic volumes and observed signal data;
- **HERE (formerly NavTeq) GIS Database;**
- **Census POWSCAR data**; and
- **National Household Travel Survey (NHTS).**

The application of the above data sources is described throughout this document in the relevant sections.

2.3 Model Dimensions

2.3.1 Definition of Model Simulation and Buffer Areas

The simulation area is the area within which interaction of traffic streams at junctions, and subsequent delays are modelled. For the ERM, this area was defined to cover the Greater Dublin Area for which detailed analyses of transport conditions is required (for the other regional model areas a similar approach will be required). Junction delay is not calculated in the buffer area where such delay is minimal in comparison with total travel times. The buffer area is included to ensure that appropriate levels of traffic enter the simulation area at the appropriate location, and that journey times are approximately correct. Figure 2.2 illustrates, for the ERM, the extents of the simulation and buffer areas.

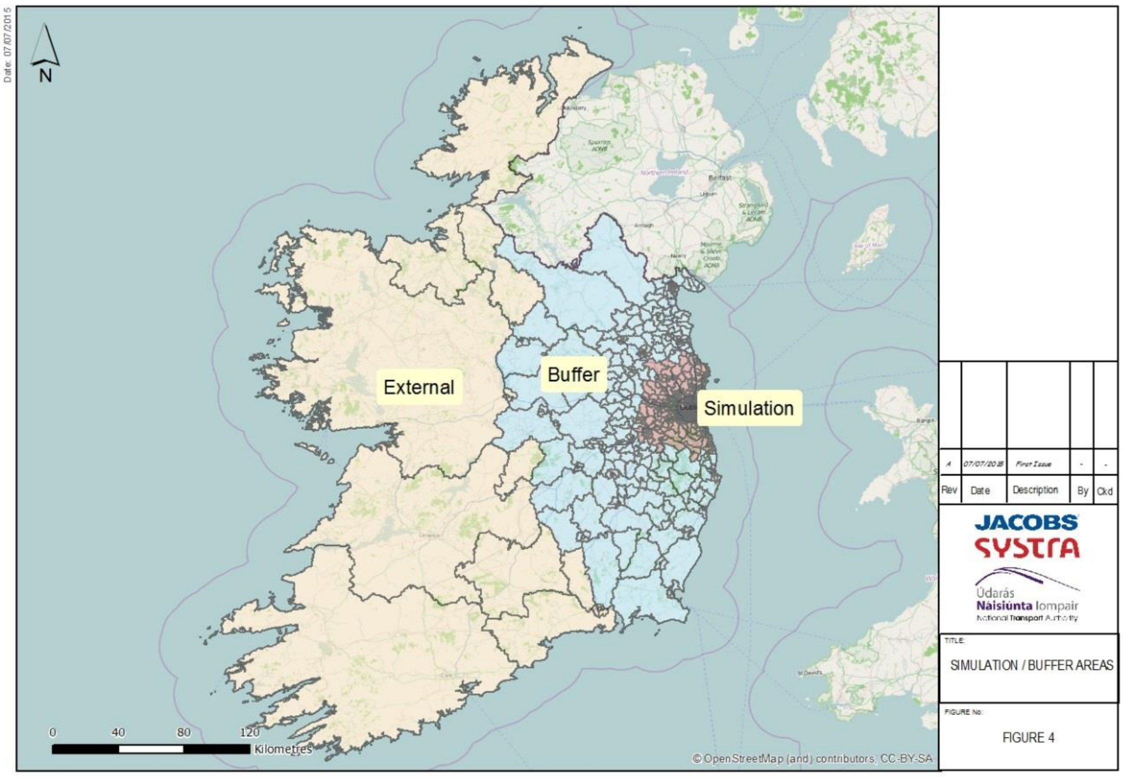

Figure 2.2 Example of Simulation and Buffer Areas (taken from ERM)

2.3.2 Definition of Zone System

The RMS RM zone system is consistent with the overall ERM model as described in the Zone Development task (TO3) report, “Zone Development Report (May 2014)” and shown in Figure 2.3.

Figure 2.3 Example of Zone System (taken from ERM)

2.3.3 Network Detail Definition

The level of network detail between the RMS RM and RMS PT Model is consistent to facilitate equivalent cost calculations between modes for each zone pair. In addition, consistent networks allow for efficient coding of bus services in both models and for speeds (or speed changes) calculated in the RMS RM to be transferred to the RMS PT model for each regional model area.

The criterion which determine the links that are represented in the road model network were defined under the Network Development task (TO2) and summarised in “MSF 002 Report 1 – Road Network Development Task Report”.

The density of the full network structure is illustrated in Figure 2.4, while Figure 2.5 illustrates the network density in Dublin City Centre.

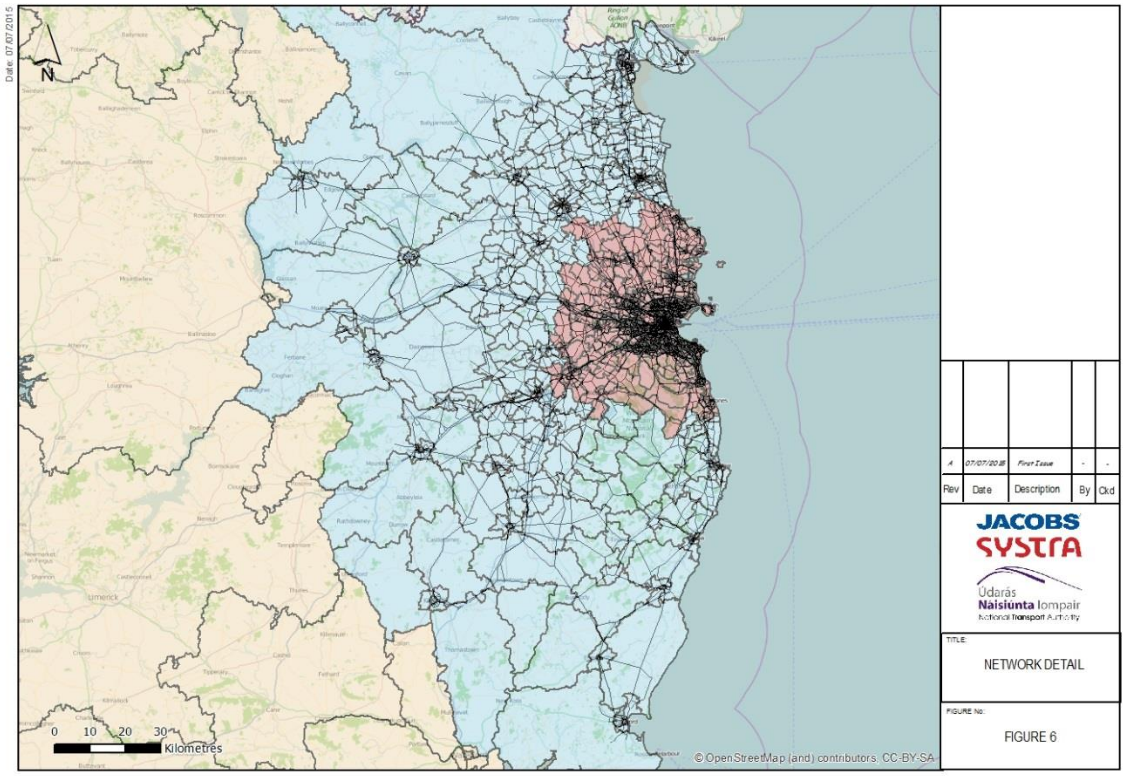

Figure 2.4 Example of RM Network Detail, Full Network (taken from ERM)

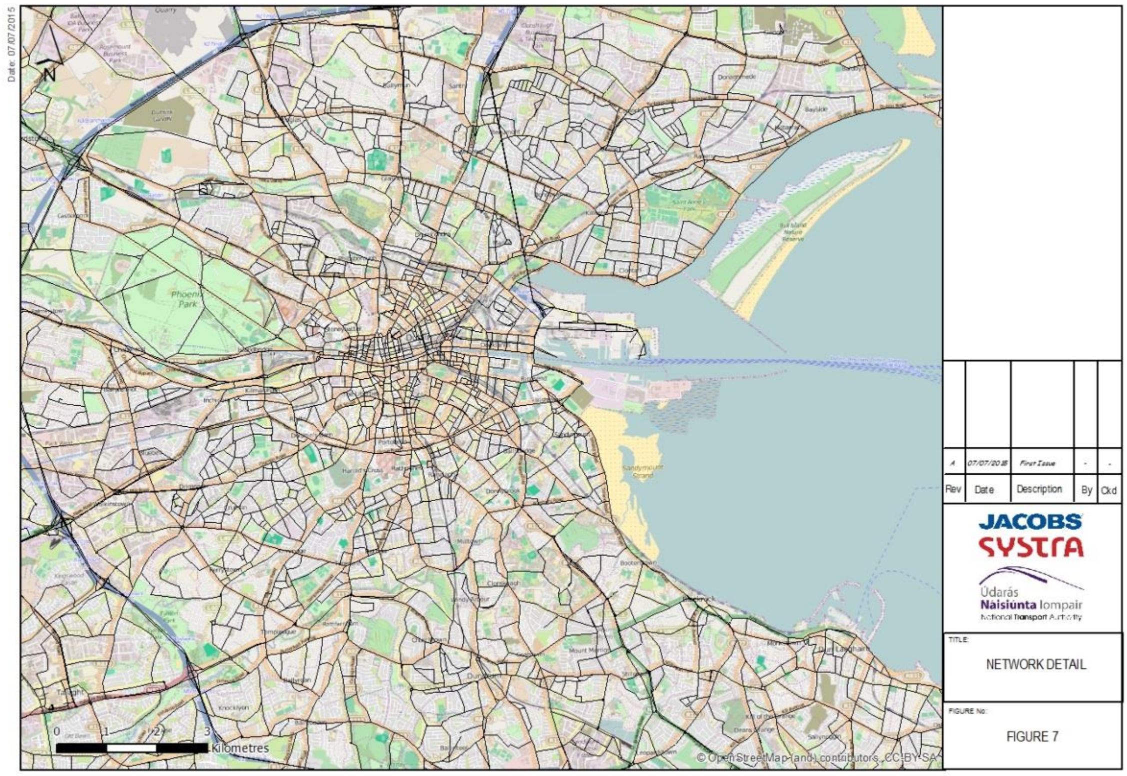

Figure 2.5 Example of RM Network Detail, Dublin City Centre (taken from ERM)

2.3.4 Base Year Definition

The base year of the model is 2012 with a nominal neutral month of November. This is largely driven by the time of POWSCAR and NHTS surveys, and not data for traffic flows in the RMS RM. It should be noted that the POWSCAR dates to 2011 but the travel patterns are assumed to be broadly the same in 2012 when the NHTS surveys were undertaken.

2.3.5 Time Period Definition

Table 2.1 provides detail of the three weekday periods that will be modelled in the RMS RM. The periods allow the relative differential in travel conditions and hence costs to be represented.

Table 2.1 RMS RM Time Periods

PERIOD	FULL PERIOD FOR DEMAND MODEL	ASSIGNMENT PERIOD
AM Peak	07:00-10:00	Peak hour (factored from period)
Inter Peak 1	10:00-13:00	Average hour from full period
Inter Peak 2	13:00-16:00	not assigned
PM Peak	16:00-19:00	Peak hour (factored from period)
Off Peak	19:00-07:00	not assigned

3 RMS Road Network Development Approach

3.1 Section Overview

The HERE Maps NAVSTREETS Streets Data GIS layer should be used as the primary source of network detail. This layer covers all of Ireland's roads, and contains details such as link class, speed class and an indication of the number of available lanes. As the NAVSTREETS layer includes every road in the Country, a Link Selection process is required to remove superfluous network detail from the NAVSTREETS layer that is not required from a strategic traffic perspective. The network generation exercise ensures that unnecessary links and nodes are removed from the initial SATURN road network, prior to the commencement of detailed SATURN coding.

The 'SATURN Conversion Process' Report prepared as part of GDA model development provides comprehensive details on the initial road network generation process; a summary of the steps is provided below.

3.2 NAVSTREETS Link Selection Process

The initial task in the Link Selection Process is to select the network extent to correspond to the agreed modelled area. This involves selecting all roads within the county boundaries to be included in the model area.

The next step is to select the type of links to be maintained in the network. By default, NAVSTREETS types 1 through 4 are retained as they represent major roads and residential collector roads. Link type 5 represents minor roads and accesses. Link type 5 should be subject to a manual review. Minor -"back roads" and lightly trafficked lanes should be removed at this stage. It must be ensured that roads required for bus routes are maintained at this stage. The General Transit Feed Specification (GTFS) public transport data source should be used as a reference to identify bus routes that are in the modelled area.

3.3 NAVSTREETS Node Dissolving Process

The NAVSTREETS shapefile is made up of a series of links with no defined nodes. Nodes are created in the network at the extremities of each NAVSTREETS link segment. This leads to an excessive number of nodes in the network and requires rationalisation before detailed SATURN coding can commence.

The node dissolving process aims to remove superfluous node detail, such as redundant shape nodes, redundant public transport nodes and redundant nodes retained to provide alternative zone access. All main junction nodes are to be retained. Some nodes still need to be kept in the network to connect zones to the network and to localise bus stops. They will be coded as 2-arm priority junctions. As they may slow model run times, only useful nodes need to be kept.

To avoid zones connecting to the network at junctions, links between zones and junctions should have an intermediate node, where it's necessary, to connect centroids. The node density in the network is related to the zoning density and as a general rule; for any given zone there should be approximately four nodes retained i.e. two to provide zone access, and two for local traffic movements and public transport access.

3.4 NAVSTREETS to SATURN Conversion Process

The final step in the process is to convert the dissolved network from an A-node B-node & attributes format to a SATURN readable format. This is undertaken using an Excel macro.

3.5 Final Network Review

It must be noted that although this process is a good starting point for building the SATURN road network, it will not create an error free road model and still requires a manual network checking and coding process, particularly in relation to priorities at junctions (where the NAVSTREETS layer does not detail which road has priority), roundabouts and traffic signals.

4 RMS Road Network Coding within SATURN

4.1 Section Overview

Manual coding of the SATURN road network can commence once the network generated by the NAVSTREETS conversion process is of a suitable standard. Automation techniques, such as taking information from NAVSTREETS and automatically generating error-free SATURN coding has been trialled with limited success. Therefore, it is recommended that all simulation nodes should be manually coded.

It is possible to automatically generate accurate buffer network coding using the NAVSTREETS to SATURN conversion process. Following creation of the buffer network, the relevant details must be coded into each junction according to the guidelines below.

- Buffer Link Coding
  The updated NAVSTREETS to SATURN conversion process provides a more accurate representation of buffer link speeds, based on the available information from NAVSTREETS mapping. It may be required to amend links in the buffer network to better reflect on the ground conditions that NAVSTREETS mapping cannot replicate.
- Simulation Junction / Link Coding
  All simulation junctions are to be manually coded in accordance with the information in the Junction Coding Strategy section below, which was developed during the construction of the Eastern Regional Model.

4.2 Junction Coding Strategy

This section details the approach to coding each junction type within the GDA SATURN road model.

4.3 Two Arm Junctions (SATURN Junction Type 1)

Two arm junctions are sometimes erroneously referred to as “dummy nodes” as they often do not represent a physical junction. They are often used to provide the network with some shape to resemble local mapping. They are also used to depict the location of speed limit change or road characteristic change, such as the beginning or end of a dedicated bus lane, while also representing pedestrian crossing or level crossing points. Unlike real “dummy nodes”, represented in SATURN using junction type 4, junction delay is modelled at a two arm junction, and blocking back can extend through the node.

A Geographic Information System (GIS) layer such as NAVSTREETS will include shape points that are not at recognised junctions. The conversion process will create two arm junction in the raw SATURN when it encounters any such node.

There are two possible ways to represent two arm junctions in SATURN;

- As a two arm priority junction; or
- As a two arm “dummy” node.

Both approaches have benefits, although Atkins, developers of the SATURN software, recommends the use of priority junctions due to the limitation of dummy nodes to retain queuing through the node.

A series of sensitivity tests were undertaken, the results of which are presented in the “RD TN06 Use of Dummy Notes”.

The recommended methodology for coding a two arm junction involves coding the node as a priority junction, junction type 1 in SATURN, as opposed to a dummy node (junction type 4 in SATURN).

Although this may have a negative impact on overall model run time, it is considered that allowing queues to block back through these nodes will reflect reality as accurately as possible, and may provide greater control over the model during calibration, validation and operation.

4.4 Roundabout Junctions (SATURN Junction Type 2)

The GIS layer and hence the raw model network conversion will split / explode roundabouts into a series of links and priority junctions in the raw SATURN base file generated by the NAVSTREETS GIS layer conversion process.

Traditionally in SATURN, roundabouts are represented by a single node, junction type 2 in SATURN (or junction type 5 if U-turns are to be modelled). Internally, SATURN treats the roundabout as a series of priority junctions during delay calculations; however as no exit capacities are defined in SATURN it does not permit queuing to pass through the roundabout node.

Typically, roundabouts of significant size, such as a gyratory, are split into a series of links and priority junctions, as it does not behave like a true roundabout, with traffic on opposite sides having very little impact on the decisions of merging traffic.

Similarly, it is common practice to represent signalised roundabouts as a series of links and signalised junctions. This allows for greater control over each arm and the interlinking properties of the junction as a whole, such as signal offsets.

A series of sensitivity tests were undertaken, the results of which are presented in the Technical Note “RD TN07 Roundabout Coding”.

The recommended methodology for coding roundabout junctions includes retaining the detail provided by the NAVSTREETS GIS layer conversion process and to code roundabouts as a series of linked priority or signalised junctions, if their size warrants such detail. Smaller roundabouts such as mini-roundabouts shall be coded as junction type 2 in SATURN.

Although this results in an increase in the number of nodes, which will in turn increase the model run times, retaining the link between the SATURN model and the parent NAVSTREETS GIS layer is highly desirable from a repeatable method perspective.

4.5 Signalised Junctions (SATURN Junction Type 3)

Signalised junctions are coded in SATURN using junction type 3. A cycle time, number of phases, offset and time slice length can be specified for each individual signalised junction. Each phase is then defined, with an associated green time and inter-green time for each set of permitted movements.

Standard signalised junction types, SATURN junction type 3, should be used in SATURN, and where data supports, an offset should be coded. Signal phase definitions are based on the signal diagrams extracted from the SCATS database, and should be reflected as accurately as the network structure will allow. A standard inter-green period for all signal phases should be assumed to be five seconds, unless data are available.

Signal offsets should be incorporated at each junction by extracting the time difference (in seconds) between the start of the model period (08:00, 14:00 or 17:00) and the calling of the first phase in the cycle plan; typically phase A. The first phase in the cycle plan should be coded as the first phase in the SATURN model.

4.6 Universally Applicable Guidance

Introduction

The following methodologies are applicable to all appropriate junctions. For example, flared approaches should not be incorporated at roundabout junctions (junction type 2).

Bus Lane Representation

In order to improve the representation of public transport, bus lanes should be coded in the regional models.

Where a bus lane operates for the entirety of a link, a bus lane should be added in SATURN using the “B” indicator in the number of lanes section of coding. Where a turn is bus-only, the turn should be coded in a standard manner with the applicable turn saturation capacity, and the turn should be added to the 44444 section of the data file. This is to allow taxis, if applicable to make the turn as well as buses. A “-1” should be coded in the 44444 section for each vehicle class that cannot make the turn, and a “0” should be coded in the 44444 section for each vehicle class that is permitted to make the turn. Please refer to SATURN Manual, section 6.7 for further information.

Where a bus lane entry or exit is significantly set back from an existing node, a new node should be inserted. Accurately reflecting the bus lane network is a key requirement of the National Transport Authority in key locations.

Flared Approaches

A recent advancement in SATURN is the inclusion of the FLAREF nearside flare identifier, and the FLAREX offside flare identifier.

These two parameters should be used in place of increasing the number of available lanes, and therefore the available capacity, on the approach to an appropriate junction. Please refer to SATURN Manual, section 6.4.9 for more information.

In the instance of a significant change in carriageway cross section, such as expanding from a single lane to three or four lanes, a two arm priority junction should be inserted at the point of flare development or contraction of carriageway width.

4.7 Junction Saturation Flow Coding Methodology

Saturation flows for movements through a junction refer to the maximum number of passenger car units (pcu) per hour, which could make a particular turning movement, provided there were no other vehicles on the road; no opposing traffic red lights etc. Thus the only restrictions to be taken into account when specifying the turn saturation flow are the physical characteristics of the junction, such as the number of lanes, their widths, turn radii, and presence of give way markings. The model then simulates the reduction to the turn capacities for all other effects such as opposing traffic and green time at signals. In order to set the saturation flow for each movement at each junction, a practical approach is to define ‘standard’ saturation flows for each movement, based on the number of lanes and whether the movement is straight ahead or a turn.

For signalised junctions the ‘standard’ saturation flows per lane can be derived from TRL report RR67 (January 1986), which provides calculations for lane capacities at signals based on lane width and turning radii. For priority junctions, the saturation flow capacity for signals can be adopted for unopposed movements such as the straight ahead movement from major arm to major arm. However, opposed movements such as right turns from the major to minor arm or movements emerging from the minor arm, need to be determined from priority junction capacity guidance, in order to take account of geometric delays from turns and visibility restrictions. Guidance from “TD42/95 – Geometric Design of Major/Minor Priority Junctions” may be applied. The formulae set out in this guidance, is applied in the PICADY priority junction modelling software. Finally, entry capacities for roundabouts should be defined using ARCADY roundabout modelling parameters.

It is not always practical to take specific road and lane width measurements, flare lengths and turning radii for each arm of each junction to be simulated in a model of this scale. Therefore it was agreed that for the GDA SATURN road model a set of ‘standard’ saturation flow values would be defined for initial model coding based on the type of junction and the number of lanes available for each movement. These are usually based on the guidance outlined above for each of the junction types and based on a ‘typical’ junction layout. Where the junction coded clearly differs from the ‘typical’ example used for reference, the saturation flow needs to be adjusted accordingly to take account of factors such as carriageway width, visibility and the presence of parked vehicles close to the junction. Typical values adopted from the existing GDA SATURN model are given below.

4.8 Signalised Junctions (SATURN Junction Type 3)

The following saturation flows have been widely used:

- The straight ahead movement: 1900 pcu per lane available for that movement;
- The left turn movement: 1300 pcu per lane available for that movement; and
- The right turn movement: 1600 pcu per lane available for that movement.

The values taken from the existing GDA model should be used as a starting point, adjusted based on model performance during calibration and validation should the situation arise.

4.9 Priority Junctions (SATURN Junction Type 1)

The following saturation flows have been widely used:

- The straight ahead movement: 1900 pcu per lane available for that movement;
- The unopposed turning movement: 1300 pcu per lane available for that movement;
- The right turn movement from major arm to minor arm opposed by straight through traffic on the opposite arm: 1200 pcu per lane available for that movement;
- Left turn from minor arm: 750 pcu per lane available for that movement;
- The straight ahead movement from minor arm: 650 pcu per lane available for that movement; and
- Right turn from minor arm: 650 pcu per lane available for that movement.

The values taken from the existing GDA model should be used as a starting point, adjusted based on model performance during calibration and validation should the situation arise.

4.10 Roundabouts (SATURN Junction Type 2 or 5)

In SATURN, the capacity of all lanes on each entry, are taken to be available for all movements from that entry. Each turn is therefore coded with the full capacity of each arm and the SATURN modelling process allocates available capacity in proportion to turning movement demand. As a reference point, saturation capacities at Roundabouts are often close to the values indicated below:

- One standard width lane with no flare on entry: 1100 pcu;
- One standard width lane on approach flaring to two lanes with at least 30 metres flare length: 1800 pcu;
- Two standard width lanes on approach with no flare on entry: 2200 pcu;
- Two standard width lanes on approach flaring to three lanes with at least 30 metres flare length: 2900 pcu; and
- Three standard width lanes on approach with no flare on entry: 3300 pcu.

In the existing GDA model a wide variety of saturation flows have been used, based on road type, speed limit and geometry. The typical values listed above should be used as an initial value, adjusted based on roundabout geometry.

4.11 "Exploded" Roundabout (SATURN Junction Type 1)

As the recommended methodology retains the exploded layout of roundabouts, as produced by NAVSTREETS, the proposed roundabout turn saturation capacities are not applicable to all locations.

The following turn saturation capacities were applied for the South West Regional Model (SWRM) and should subsequently be adopted for the development of future regional models.

Roundabouts / Gyratories with ICD > 30m

- 1100 pcu per lane at the give way line;
- 1600 pcu per lane for circulating carriageway; and
- 1800 pcu per lane for exiting lanes.

Roundabouts / Gyratories with ICD < 30m

- 750 pcu per lane at the give way line;
- 1300 pcu per lane for circulating carriageway; and
- 1300 pcu per lane for exiting lanes.

Roundabouts and gyratories whose inscribed circle diameter is less than 30 metres should be represented by a single node, coded as either SATURN Junction Type 2 or 5, unless the layout and operation of the junction warrants the retention of the "exploded" layout.

4.12 Mid-link Capacity Coding Methodology

Mid-link capacities in the simulation area are defined as part of the speed / flow relationship, and are normally employed in areas where there are fewer junctions to influence the flow of traffic through the network, such as rural or residential areas. Speed / flow relationships should be applied to selected links within the model if the link volume is approaching or at capacity, or is likely to be at or near capacity in the future, adding link delay to the junction delay experienced by traffic.

It is proposed that only links identified as being influenced by factors other than junction delay are assigned a speed / flow relationship. These links will typically be roads that are in rural / residential areas, motorway, national and regional roads, and roads where not every junction has been modelled in detail. The following speed / flow relationships are proposed for use in regional model development, and all subsequent models developed using this methodology.

Table 4.1 Speed/Flow Relationships Proposed for Use in Regional Model Development

Free Flow Sped (km/h)	Speed at Capacity (km/h)	Max. Capacity (pcus / link)	N	Index	Description
37	15	740	1.83	11	Urban Central 1 Lane
37	15	1480	1.83	12	Urban Central 2 Lanes
37	15	2220	1.83	13	Urban Central 3 Lanes
37	15	2960	1.83	14	Urban Central 4+ Lanes
54	25	980	1.67	21	Urban Non-Central 1 Lane
54	25	1960	1.67	22	Urban Non-Central 2 Lanes
54	25	2940	1.67	23	Urban Non-Central 3 Lanes
54	25	3920	1.67	24	Urban Non-Central 4+ Lanes
61	25	1270	2.32	31	Suburban Narrow Collector 1 Lane
61	25	2540	2.32	32	Suburban Narrow Collector 2 Lanes
61	25	3810	2.32	33	Suburban Narrow Collector 3 Lanes
78	35	1730	3.29	41	Suburban Distributor 1 Lane
78	35	3460	3.29	42	Suburban Distributor 2 Lanes
78	35	5190	3.29	43	Suburban Distributor 3 Lanes
68	25	1730	3.74	51	Suburban Narrow Distributor 1 Lane
68	25	3460	3.74	52	Suburban Narrow Distributor 2 Lanes
68	25	5190	3.74	53	Suburban Narrow Distributor 3 Lanes
78	45	1380	2.07	61	Rural Narrow Country Road 1 Lane
78	45	2760	2.07	62	Rural Narrow Country Road 2 Lanes
78	45	4140	2.07	63	Rural Narrow Country Road 3

Free Flow Sped (km/h)	Speed at Capacity (km/h)	Max. Capacity (pcus / link)	N	Index	Description
					Lanes
112	45	4860	3.85	71	Dual C'way – Motorway Standard 2 Lanes
112	45	7290	3.85	72	Dual C'way – Motorway Standard 3 Lanes
112	45	9720	3.85	73	Dual C'way – Motorway Standard 4+ Lanes
105	45	4360	3.68	81	Dual C'way – Near Motorway Standard 2 Lanes
105	45	6540	3.68	82	Dual C'way – Near Motorway Standard 3 Lanes
105	45	8720	3.68	83	Dual C'way – Near Motorway Standard 4+ Lanes
91	45	1860	2.20	91	Wide National 1 Lane
91	45	3720	2.20	92	Wide National 2 Lanes
91	45	5580	2.20	93	Wide National 3 Lanes
91	45	7440	2.20	94	Wide National 4+ Lanes
84	45	1660	2.20	101	National / Regional 1 Lane
84	45	3320	2.20	102	National / Regional 2 Lanes
84	45	4980	2.20	103	National / Regional 3 Lanes
84	45	6640	2.20	104	National / Regional 4+ Lanes
87	45	1640	2.20	111	Regional 1 Lane
87	45	3280	2.20	112	Regional 2 Lanes
87	45	4920	2.20	113	Regional 3 Lanes
78	45	1860	2.20	121	Slip Road / Interchange Link 1 Lane
78	45	3720	2.20	122	Slip Road / Interchange Link 2 Lanes

As speed / flow curves will not be used in the urban area within County Dublin, the following assumptions have been made with regard to fixed link speed, and should be applied to future regional model development.

- 50 km/h free flow speed assumed on wide roads with few side road / parking etc. with speed limit of 50 km/h;
- 40km/h default free flow speed derived from NAVSTREETS conversion process maintained in most cases;
- 30km/h free flow speed assumed when there is traffic management on the link i.e. speed humps or parking both sides resulting in traffic giving way;
- 20 km/h free flow speed assumed when link is narrow/highly residential and there is traffic management on the link i.e. speed humps;
- 10 km/h free flow speed assumed when link is very narrow or is a minor back street; and
- 15, 25 or 35 km/h assumed in places for variations of above based on local conditions.

4.13 Zone Connector Methodology

There are two commonly used methodologies used to connect zones to a simulation or buffer network. One methodology is to connect a zone along the length of a link. This has the effect of causing no delay to the traffic as it enters the simulated network. Concerns were raised regarding the impact that this may have on journey times and over-representing the available capacity of the road network. One commonly used alternative to loading traffic mid-link is to use stub connectors, typically representing network access points such as car park entrances or residential streets, to load the traffic on to a link just off the main network.

Technical Review

A review of existing SATURN models, and the SATURN manual was undertaken to determine the most appropriate methodology for connecting zones to the GDA model.

Each approach has merits, with a “stub” connector approach better representing a predefined access point, such as a residential street or car park. Connecting a zone along the length of a link would better represent an area of on-street parking, for example, or a small settlement where multiple access points are not included in the model detail. For further discussions regarding the Technical Review, please refer to the Technical Note “RD TN08 Zone Connectors”.

Recommended Methodology

After discussions with the NTA it was recommended that, at least initially, all zone connectors would be coded using the “stub” connector methodology, ensuring that only a single zone is connected to each stub in most cases. Where applicable, to reduce the number of additional nodes and links required, it may be possible to connect the zone along the length of the link. However, this is unlikely to be in areas central to the study area.

4.14 Quality Checking

Quality checking during and post network completion will help to minimise the time spent at the road model calibration and validation stage correcting errors in the road network. Detailed checking of each node should be completed during the network coding phase, and stress testing should be undertaken on the network during and post network completion.

Local Knowledge

It may be possible to utilise local knowledge during the road network coding phase. Local knowledge may identify unnecessary or missing links from the road network, and may provide insight into junction operation and model route choice.

Road Network Coding Checking

A checking strategy should be clearly defined before commencing the coding of the road network. A typical checking strategy would identify the key personnel involved in the coding of the road network, and their role. Each road network should be coded in accordance with the Road Network Coding Guide, Report 3, and each node checked for consistency with the suggested values set out in Report 3.

Stress Testing

- Low Traffic Volume Test
  Should a matrix be available, an initial stress test should be undertaken, assigning one per cent of the overall demand to the road network. This test will indicate areas of incorrect coding as there should be very little link and junction delay, except for the natural delay incurred at signalised junctions. This test can also be used to verify that traffic is taking the appropriate routes within the modelled area. If a matrix is not available, a scaled unit matrix should be created and assigned. That is, one in which all demands are a fraction of one passenger car unit.
- Full Assignment
  Periodically, the full demand matrix should be assigned to the road network to ensure the model reaches the specified convergence parameters. This test also acts as a secondary quality check to the SATURN coding, highlighting areas where there may be unexpected delay, queued traffic or irregular route choice. If available, a flow bandwidth plot can be compared to an existing model to verify route choice at a high level. A review of the following should be completed as part of this test:
  - Flow bandwidth plot;
  - Junction delay plot (overall delay);
  - Individual turn delays;
  - Queue at end of time period;
  - Crow-fly versus modelled distance;

    - Route choice via select link analysis; and
    - Model convergence.

- High Traffic Volume Test
  Another useful test is to assign, for example, 150 per cent of overall demand to the road network. This test may identify areas of incorrect coding that may be subject to low traffic volumes under normal operating conditions.

This test can also be useful in determining whether or not the current network is likely to cope with future year demand, and whether or not a future year network is likely to reach the current target convergence levels.

It may be necessary to constrain traffic growth in certain model areas as, for example, a City Centre may not be able to cope with an increase in overall demand of 50 per cent which could result in the test being futile.

5 RMS Definition of Demand Segments for Road Model

5.1 Overview

Demand segmentation is the practice of disaggregating the total travel demand into individual segments. Segments were chosen to reflect significant variations in the value of time, travel behaviour, availability of travel options or sensitivity of travel choices. Individual segments also represent a significant proportion of overall demand.

The RMS RM demand segments are aligned with the RMS Full Demand Model (FDM) segmentation. It is advantageous if the assignment segments are aggregations of the demand model segments so that forecast demand changes can be applied to assignment matrices. It is possible to split demand model segments for assignment if necessary using a set of user calculated factors, although the demand forecasts could not capture differences between the behavioural traits of each “sub-segment”.

A detailed analysis of options for segmentation of demand in the model system was reported in “FDM Scope2 Demand Segmentation” report. It was recommended that the demand model is segmented into 33 categories for personal (non-freight) travel based on purpose, car availability, employment status and educational level (for the education purposes). These 33 segments were aggregated for use in the RM where the ratio of value of time (VoT) and vehicle operating cost (VOC) is the main influence on route choice. Derivation of VoT and VOC is discussed in greater detail in ‘ERM Road Model Development Report’.

5.2 Definition of User Classes

5.2.1 Cars

The following aggregation is used to define matrices for the RMS RM:

- in work time (employer’s business);
- travel to work (commute);
- travel to education; and
- other non-work purposes (shopping, visiting friends, etc).

5.2.2 Taxis

A review of data sources for taxis has been documented in “RMS Scope 4 Modelling Data Review”. This review concluded that there was insufficient data available to validate a taxi matrix. However, for home-base work (commute) it was possible to derive taxi as a proportion of the total car matrix on a sector by sector basis as part of the Demand Modelling task (TO8). The remainder of the taxi demand is subject to mode choice, with the mode choice being determined through the use of a logit model. The traffic count dataset containing taxi as a separate vehicle type is not sufficiently large to allow the calibration and validation of taxi as a separate user class, and therefore the taxi matrix was calibrated and validated as part of a larger “car” vehicle type. However, where a robust dataset was available, such as the canal cordon count dataset, a review of taxi proportion was undertaken, with analysis provided to TO8.

5.2.3 Goods Vehicles

Goods vehicles are segmented to reflect differences in VoT, VOC and passenger car unit (PCU) values. Four categories of goods vehicles are represented as separate segments:

- LGV;
- OGV1;
- OGV2 – banned from central Dublin; and
- OGV2 – not banned from central Dublin (those with a city centre permit).

Many goods vehicle bans within Dublin, for example, are for vehicles with five or more axles, which is a subset of the OGV2 category. In Dublin, this ban is in operation between 7am and 7pm. There is insufficient data to robustly disaggregate OGV2 trips by number of axles and therefore these bans were applied to all OGV2. However, any vehicle which is delivering within the banned area in central Dublin (or the other regional cities) can apply for a permit to allow them to drive in the city centre between 7am and 7pm. It was possible to split the OGV2 category into "banned" or "not banned" depending on their origin or destination. This allowed a small number of OGV2 trips within the city centre to match counts, whilst banning through city centre movements.

In addition, there are numerous three tonne vehicle bans across the city, which effectively prohibit all OGV1 and OGV2 from certain routes, principally through residential areas.

5.2.4 Definition of User Classes

The final RMS assignment matrices contain nine user classes, these being:

- Taxi;
- Car Employer's Business
- Car Commute;
- Car Education;
- Car Other;
- LGV;
- OGV1;
- OGV2 Permit Holder; and
- OGV2.

The taxi user class contains all taxi trips, regardless of journey purpose.

5.2.5 Defining User Class Specific Parameters

Each user class has its own defined set of generalised cost parameters based on a price per kilometre and a price per minute. The final generalised costs are detailed in 'ERM Road Model Development Report'.

5.2.6 Combining User Classes

The nine assigned user classes were grouped in to three broader vehicle classes, based on the availability of disaggregated survey data. The three vehicle classes represented are:

- All Car;
- LGV; and
- All other Goods Vehicles.

Very few classified traffic surveys differentiated between a taxi and a regular car which meant that in order to accurately represent non-taxi travel the taxis and cars (user classes one to five) were combined, for matrix estimation and calibration purposes, in to a single vehicle class. Matrix estimation would therefore retain the percentage split between taxi and regular car, as well as retaining the percentage split of each car journey purpose.

Disaggregating goods vehicles is often subjective, and many manual counts simply have an “HGV” vehicle classification. For these reasons, OGV1 and OGV2 user classes (user classes seven to nine) were combined, for matrix estimation and calibration purposes, in to a single vehicle class. Matrix estimation would retain the percentage split between OGV1 and OGV2, where vehicle bans permit.

Light goods vehicles were not combined with any other user classes either during matrix estimation or calibration.

5.2.7 Defining Vehicle Factors

The latest UK guidance in WebTAG (January 2014) sets out in Unit M3-1, the following equivalent Passenger Car Unit (PCU) values.

- LGVs on all road types: 1.0;
- HGVs on motorways and all-purpose dual carriageways: 2.5; and
- HGVs on other road types: 2.0

For this purpose, HGVs consist of OGV1, OGV2 and PSV vehicle types.

The types and operational characteristics of goods vehicles in Ireland are similar to the UK and therefore the above guidance represents a solid starting point in deriving appropriate PCU values for the ERM. However, there are two points to note:

- Within SATURN a global PCU factor has to be applied across all trips and therefore it is not possible to distinguish between motorway and dual carriageway trips and trips on other road types. Many end to end journeys will involve driving on multiple road types.
- The above PCU values do not distinguish between different types of HGV (specifically OGV1 and OGV2), which will be modelled as separate user classes.

Reference to the now superseded WebTAG Unit 3.5.9, Annex B, Table B4, defined separate PCU factors for different types of vehicle as follows:

- Light Goods Vehicle: 1.0;
- Rigid Goods vehicle: 1.9;
- Articulated Goods Vehicle: 2.9; and
- Public Service Vehicle: 2.5.

The current WebTAG figures, at least in part, reflect the higher proportion of articulated goods vehicles on motorways and dual carriageways and a higher proportion of rigid goods vehicles on urban road networks. Since the ERM will represent OGV1 (primarily rigid vehicles) and OGV2 (primarily articulated vehicles) separately, these values are considered the more appropriate values for inclusion within the RMS and will be adopted for the calibration and validation of each of the regional models.

For the modelling of public service vehicles, a value of 3.0 has been selected for consistency with the public transport service development process, delivered under the Public Transport Model task (TO7).

5.2.8 Further Considerations

There are a number of pros and cons associated with the chosen user and vehicle classes, which can be summarised as follows:

Pros

- More accurate representation of OGV2 movements;
- Separate taxi user class provides future functionality;
- Faster estimation of matrices; and
- Cleaner data extraction.

Cons

- Aggregate changes during matrix estimation; and
- No consideration to journey purpose for taxi trips.

There is no noticeable impact in aggregating to vehicle types during assignment in SATURN, although it does provide additional flexibility during network interrogation, as both user class traffic volumes and vehicle class traffic volumes can be displayed.

5.3 Model Network

5.3.1 Network

There are several reports written under TO2 which detail the network development process. “MSF 002 Report 1 – Network Development Task Report” details the network development activities undertaken. The network was developed in accordance with the parameters outlined in SATURN Coding Guide.

5.4 Travel Demand Matrices

For the ERM, the initial RM travel demand matrix was based on the previous GDA Regional Model matrices, disaggregated to the ERM zone system. POWSCAR data, covering travel to work and travel to education journey purposes replaced these historic trip purposes in the previous matrices.

These matrices were prepared using POWSCAR data where applicable, with remaining journey purposes synthesised using the Trip End Model trip ends and a preliminary estimate of RM for the ERM generalised costs for distribution. Initial prior matrices for all user classes were developed in accordance with “FDM Scope12 Base Year Matrix Building”.

As part of the RM development for the ERM these matrices were adjusted using estimation techniques based on available traffic count data. Available data includes single day and multiple day traffic counts throughout the years of 2010, 2011, 2012 and 2013.

Matrix estimation was required as there are proportions of the prior matrices that were not based on a larger observed dataset. Only the travel to work and travel to education have a large observed dataset, with the other journey purposes having a partially observed dataset or a wholly synthetic dataset. Matrix estimation was required in order to better reflect traffic conditions for the less observed journey purposes and vehicle types.

5.5 Park & Ride Integration

At present there is no Park & Ride representation or integration within the current release version of the ERM base model (v2.0.17). This will not be the case in future versions of the Base model.

6 RMS Road Model Assignment Methodology

6.1 Defining the Assignment Procedure

As mentioned the ERM RM was used to test the development of the RMS RM specification. The ERM RM was developed in SATURN and the model was calibrated and validated using release versions 11.2.05 of the software. The model is designed for use within a Windows 7 or newer operating systems.

The SATURN application SATNET was used to build the various data files in to an assignable road network (UFN) file. Matrices were then assigned to the network using the multi-core version of the SATALL application, where it iterates through assignment and simulation loops until the user defined levels of convergence are reached (RSTOP and STPGAP), or the model reaches the user defined maximum number of assignment and simulation loops (MASL).

SATALL uses a converged equilibrium assignment method to assign the traffic to the road network over successive iterations, until user defined convergence criteria are achieved.

6.2 Defining Generalised Cost Parameters

Generalised cost formulae were developed for the Galway Interim Model and a similar approach was adopted for the ERM. The approach is derived from the values in the draft Common Appraisal Framework (CAF) 2015, including forecast values.

Furthermore, the derivation of the values for each user class incorporated a number of proportions derived from the NHTS, with occupancy levels for goods vehicles and journey purpose vehicle proportions being taken from the Project Appraisal Guidelines (PAG).

Table 6.1 details the source of all indicators used in the derivation of the generalised cost equations. It should be noted that there was insufficient observed data in the draft CAF 2015 dataset to reliably provide vehicle operating costs for OGV2 vehicles. OGV2 vehicle operating costs have been derived using the draft CAF 2015 OGV1 values and the relationship between OGV1 and OGV2 vehicle operating costs from the UK WebTAG guidance.

Table 6.1 Generalised Cost Equation Data Sources

Indicator	Source
Average tax on final consumption	CAF
Rate of Value Added Tax (VAT)	Irish Tax and Customs
Journey Purpose Final Consumption	CAF
Vehicle Occupancy (Car)	NHTS
Vehicle Occupancy (Goods)	PAG Unit 6.11 Table 27
Journey Purpose Vehicle Proportions (Car)	PAG Unit 6.11 Table 28
Journey Purpose Vehicle Proportions (Goods)	PAG Unit 6.11 Table 28
Future Values of Time (PPM)	CAF / WebTAG
Vehicle Operating Costs (PPK)	CAF
Average Network Speed	SATURN Base Model

The initial average network speed was taken from the output road network from TO2. This was updated periodically through TO6 with the current average network speed of the road model.

6.3 Defining SATURN Assignment Parameters

There are many other user defined variables within the SATURN data file that control and influence the assignment of traffic to the road network. The key variables, their impact and their value are defined in the Table 6.2.

Table 6.2 Generalised Cost Equation Data Sources

Variable	Description	Value
MASL	Maximum number of assignment / simulation loops.	100
NISTOP	Number of successive loops which must satisfy the RSTOP criteria for convergence	3
WRIGHT	If true, certain warnings are upgraded to semi-fatal errors	False
BUSPCU	Factor to convert bus flows to PCUs	0.3
NITS	Maximum number of simulation loops	30
NITS_M	Minimum number of simulation loops	18
GAP	Minimum gap (in seconds) accepted by a vehicle giving way at a priority or signalised junction	2.5
GAPM	Minimum gap (in seconds) accepted by a vehicle which merges	2.0
GAPR	Minimum gap (in seconds) accepted by a vehicle entering in to a roundabout	2.0
ALEX	Average length of a PCU (in metres)	5.95
NITA	Maximum number of assignment loops	20
NITA_M	Minimum number of assignment loops	6
NITA_S	Maximum number of assignment loops to be used during the SAVEIT assignment	50
STPGAP	Critical gap value (%) used to terminate assignment / simulation loops	0.2
PCNEAR	Percentage change in flows judged to be “near” in successive assignments	5

RSTOP	The assignment / simulation lops stops if RSTOP % of link flows change by less than PCNEAR % in successive assignments	96

7 RMS Road Model Calibration & Validation Process

7.1 Introduction

Chapter 7 sets out the specification and execution of the model calibration process. This includes the incorporation and application of matrix estimation.

7.2 Calibration 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 7.1 indicates the location of traffic count data that was collated under TO11.

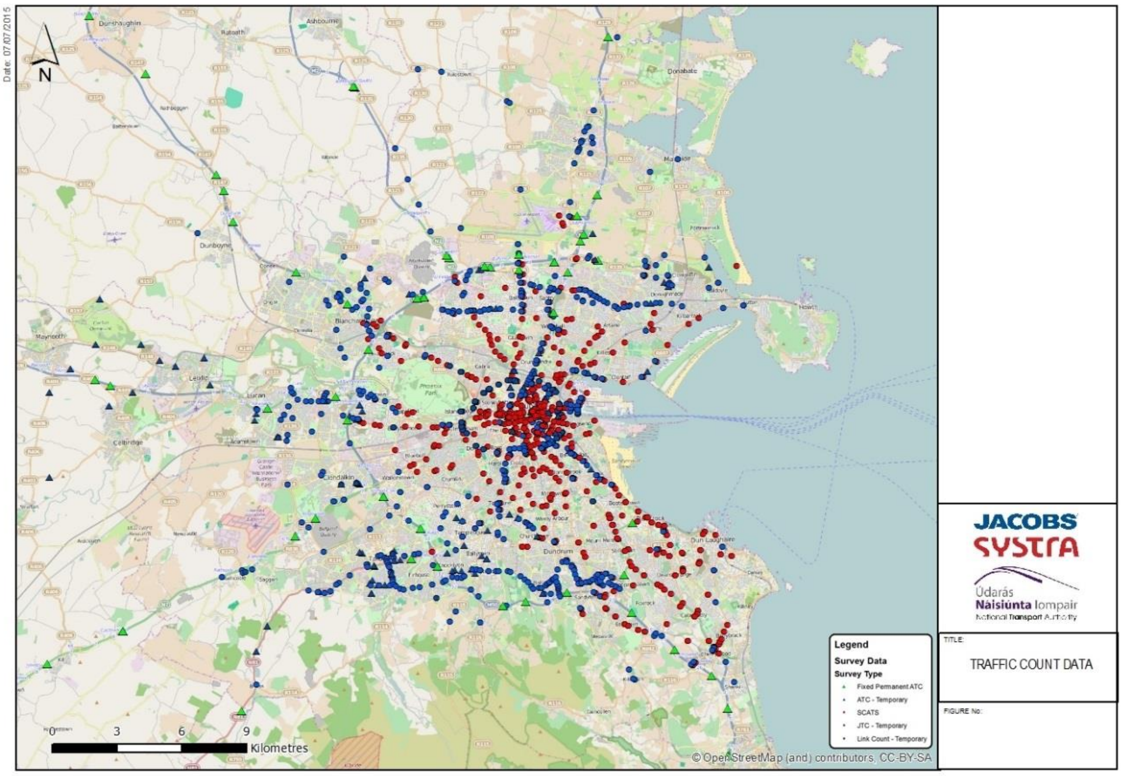

Figure 7.1 Location of Traffic Count Data

7.3 Journey Time and Queue Length Data

7.3.1 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.

7.3.2 GPS-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 20160505 V1 0” and “MSF 011 TomTom Data Extraction and Processing 20160112 V3 0”.

7.3.3 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.

7.4 Assignment Calibration Process

7.4.1 Overview

The assignment calibration process was undertaken for the assignment of the ERM RM and matrices through comparisons of the following:

- Traffic volumes (link counts); and
- Screen-line comparison.

7.4.2 Calibration

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

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

- Remedial action at specific junctions where data supports such as;
    - Increase or reduction in turn saturation capacity;
    - Adjustment to signal timings;
    - Adjustment to cruise speeds;
- 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 and network calibration. Matrix calibration ensures the correct total volume of traffic is bound for certain areas through the use of sector analysis, while network calibration ensures the correct traffic volumes on distinct links (roads) within the modelled area. Table 7.1 outlines the matrix estimation change calibration criteria, as specified in TAG Unit M3-1, Section 8.3, Table 5.

Table 7.1 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[1] summary statistic. This statistic is designed to be more tolerant of large percentage differences at lower flows. When comparing observed and modelled counts, focus on either absolute differences or percentage differences alone can be misleading when there is a wide range of observed flows. For example, a difference of 50 PCUs is more significant on a link with an observed flow of 100 PCUs than on one with and observed flow of 1,000 PCUs, while a 10 per cent discrepancy on an observed flow of 100 vehicles is less important than a 10 per cent mismatch on an observed flow of 1,000 PCUs.

The GEH Statistic is defined as:

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

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

Table 7.2 outlines the link calibration criteria as set out in TAG Unit M3-1, Section 3.2, Table 2.

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

Table 7.2 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

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 or validation 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

The typical criterion was also informed by the Calibration Summary Statistics provided to the NTA on a weekly basis.

Table 7.3 outlines the screenline calibration criteria as set out in TAG Unit M3-1, Section 3.2, Table 3.

Table 7.3 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

7.5 Initial Generalised Cost Parameters

The initial generalised cost parameters are set out in the following four tables. The generalised cost parameters have a base year of 2011 to remain consistent with the other model components and input values.

Table 7.4 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 7.5 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 7.6 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 7.7 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

7.6 Network Progression / Calibration

The follow aspects of a regional road model should be checked to ensure a good starting point for calibration.

7.6.1 Taxi Modelling

Taxis are a separate assigned user class, and bus-only turns are coded as a normal turn. This allows all vehicles to make the turn, then specific turns are added to the banned turn section (44444) of the network data file for all user classes except for taxi (UC1).

Taxis should be checked for correct assignment to the model network based on this technique. However they do not utilise bus lanes 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.

7.6.2 5-Axle Goods Vehicle Ban

An OGV2 user class is available for modelling 5-axle goods vehicles which have a permit to enter a restricted area for deliveries, based on trip origin and trip destination.

A SATURN key file is available splits the OGV2 user class in to two separate matrices, based on their origin and destination. If a trip in the prior matrix has an origin or destination within the boundary of the 5-axle ban, then the trip would be deemed to have a permit. This facilitates 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.

7.6.3 Wider Scale 3 Tonne Ban

Bans on any vehicle which exceed 3 tonnes may apply to a large proportion of residential areas. There isn't a single source available that lists the locations of all bans, so often bans have to be added as routes are inspected.

7.6.4 Link Speed Reduction

Initial link travel speeds can provide a more accurate initial link travel speed than using the speed limit. Speeds on several routes, particularly through traffic calmed residential areas may be 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.

7.6.5 Increase in Average PCU Length (SATURN Parameter ALEX)

Analysis by the NTA, including visual reviews of several aerial / satellite photographs suggests that the average PCU length is closer to 5.95m. The ALEX parameter should be set to 5.95 based on this recent research.

7.6.6 Junction Rationalisation

The initial conversion of GIS to SATURN networks may result in many “exploded” junctions, which can be simplified by removing unnecessary detail. This may allow for more accurate representation of traffic movements and delay experienced at the junction.

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

7.6.7 Junction Refinement

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

7.7 Assignment validation process

7.7.1 Overview

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

7.7.2 Validation Criteria

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

Table 7.8 outlines the screenline validation criteria as set out in TAG Unit M3-1, Section 3.2, Table 1.

Table 7.8 Road Assignment Model Screenline Validation Criteria

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

Table 7.9 outlines the journey time validation criteria as set out in TAG Unit M3-1, Section 3.2, Table 3.

Table 7.9 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

7.7.3 Trip length distribution

The trip length distribution of the prior and incremental assignments should be compared to ensure that they are not significantly distorted by matrix estimation and still compare well against the observed trip length distribution profile. Analysis of the change in mean trip length and the change in the standard deviation of the trip length should be included.

7.7.4 Journey times

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.

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