Appendix A.2.1

Traffic Modelling Report

A.2.1

Galway County Council

N6 Galway City Transport Project

Phase 3 Traffic Modelling Report

Issue 4 | 28/03/2018

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 223985-00

Ove Arup & Partners Ireland Ltd

Arup
15 Oliver Plunkett Street
Cork
Ireland
www.arup.com

Document Verification

ARUP

Job title	N6 Galway City Transport Project			**Job number** 223985-00	
Document title	Phase 3 Traffic Modelling Report			**File reference**	
Document ref					
Revision	**Date**	**Filename**			
	24-02-17	**Description**	Issue 2		
			Prepared by	Checked by	Approved by
		Name	David Conlon	Andrew Archer	Eileen McCarthy
		Signature			
	22-02-2018	**Filename**			
		Description	Issues 3 – Appendices Added		
			Prepared by	Checked by	Approved by
		Name	David Conlon	Andrew Archer	Eileen McCarthy
		Signature			
	28-03-2018	**Filename**			
		Description	Issues 4 – Route Maps Updated		
			Prepared by	Checked by	Approved by
		Name	David Conlon	Andrew Archer	Eileen McCarthy
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			

Issue Document Verification with Document ✓

Contents

Appendices

1 Introduction

1.1 Introduction

The purpose of this Traffic Modelling Report (TMR) is to describe the traffic forecasting that has been undertaken for Phase 3, Design, for the N6 Galway City Ring Road (GCRR). It outlines the development of the base year transport model, the methodology for forecasting future year travel demands and the testing of the scheme.

1.2 Background

Galway County Council and Galway City Council are fully committed to providing a transportation solution to the existing transportation issues in both Galway City and its environs.

The Galway City Outer Bypass, an earlier scheme, was previously developed and submitted to An Bord Pleanála (ABP) in 2006 for approval. However the scheme was ultimately quashed by the Supreme Court based on an interpretation of the Habitats Directive delivered by the Court of Justice of the European Union (CJEU) in April 2013. The process of developing a transportation solution for Galway city and environs therefore recommenced at Phase 1, feasibility and concept stage.

Arup have been appointed to provide multi-disciplinary engineering consultancy services for delivery of Phases 1, 2, 3 and 4 in compliance with NRA Project Management Guidelines (NRA PMG) for the N6 Galway City Transport Project (GCTP). Arup have appointed SYSTRA Ltd to undertake the transport modelling elements of the project.

Phase 1 and 2 are now complete. The conclusion of Phase 1 is that there is a strong justification for advancing a scheme which includes construction works to provide infrastructure to deliver a solution to the transportation issues in Galway. The conclusion of Phase 2 was to adopt the preferred route corridor (shown in the figure below) for the N6 Galway City Transport Project as the road component of the overall solution, as analysis showed an additional crossing of River Corrib was required. However, it was noted that this would be reviewed in conjunction with the wider integrated management transport programme for Galway, which is known as the Galway Transport Strategy (GTS).

The Galway Transport Strategy has concluded in parallel that a strategic relief road or orbital route is required in order to implement the level of service requirements for each mode of transport, including walking, cycling, public transport and private vehicle i.e. to deliver an integrated transport solution. This Strategy has identified an inner city centre access network and identified the preferred route corridor of the N6 Galway City Ring Road as the orbital route. The need and function of this route is defined in the Strategy, and therefore, it is appropriate to move ahead to the next phase of design of this road infrastructure.

Figure 1.2.1: Preferred Route Corridor

Phase 3 Design and Phase 4 EIA/EAR & The Statutory Processes are currently underway for this orbital road which has been identified as a necessary component of an overall transport solution. The title of the road component of the N6 Galway City Transport Project was selected to reflect the function of the road and its spatial location. Therefore, the road project is known as **N6 Galway City Ring Road (N6 GCRR)**.

The objective of Phase 3 is to develop the design of the N6 Galway City Ring Road to a stage where sufficient levels of detail exist to establish land-take requirement and to progress the scheme through the statutory processes which is the matter of Phase 4.

Traffic modelling undertaken at this stage will be a key input to the design of the scheme, as well as providing base data for the economic and environmental appraisals.

1.3 Proposed Road Development Description

1.3.1 Overview

The latest design of the proposed N6 GCRR is illustrated in Figure 1.3.1 below. The proposed road development is approximately 16.4 km in length and will link the R336 west of Bearna with the M6 near Coolagh to the east of Galway City.

Figure 1.3.1: Phase 3 Proposed Scheme Design

The proposed N6 GCRR ties into the existing R336 Coast Road in An Baile Nua with an at-grade roundabout junction approximately 2km to the west of Bearna Village and then proceeds north and east as a single carriageway to the north of Bearna Village and onwards towards Letteragh. An at-grade roundabout is proposed at the Bearna to Moycullen Road L1321, and at-grade signalised junctions are proposed at Cappagh Road and Ballymoneen Road.

To the east of the Ballymoneen Road junction the proposed N6 GCRR is a dual carriageway and continues east to the grade separated N59 Letteragh Junction. The junction connects to the N59 Moycullen Road via the proposed N59 Link Road North, and to the Letteragh Road and Rahoon Road via the proposed N59 Link Road South. The proposed road development continues eastwards to cross the existing N59 Moycullen Road at Dangan and travels on a viaduct over the NUIG Recreational Facilities before crossing the River Corrib on a bridge structure.

To the east of the River Corrib the proposed road development continues east on embankment toward the Menlough Viaduct. It crosses over Bóthar Nua and Sean Bóthar in the townland of Menlough, adjacent to Menlough Viaduct before entering a section of cut preceding Lackagh Tunnel immediately west of Lackagh Quarry and exits the tunnel in the quarry. The proposed road development continues east with a grade separated junction located at the N84 Headford Road Junction at Ballinfoyle and continues east through the townland of Castlegar to the grade separated junction at N83 Tuam Road. This junction provides access to both the N83 Tuam Road and the proposed Parkmore Link Road between the Ballybrit Business Park and the Parkmore Industrial Estate via the proposed City North Business Park Link road to provide full connectivity at this location.

The proposed road development then continues eastwards entering the Galway Racecourse Tunnel at Ballybrit to the north of the racetrack. On emerging from the tunnel the proposed road development continues south, crossing over R339 Monivea Road on embankment and continuing south to enter a cutting as it reaches its junction with the existing N6 at Coolagh Junction. The proposed Coolagh Junction will be a fully grade separated junction with partial free flow on the major movements.

1.3.2 Proposed Road Type and Cross Section

From the R336 to Ballymoneen the mainline carriageway of the proposed N6 GCRR is a Type 1 Single Carriageway in accordance with TII DMRB DN-GEO-03036 (Cross Sections and Headroom). The design speed of the mainline carriageway over this area is 85km/h, and the cross section is as follows:

Offside Verge Width (minimum): 3.0m

Offside Hard Shoulder: 2.5m

Carriageway Width: 7.3m (2 x 3.65m lanes)

Nearside Hard Shoulder: 2.5m

Nearside Verge Width (minimum): 3.0m

Total Width (minimum): 18.3m

Total Length: 5,610m

From Ballymoneen Road to the eastern tie in with the existing N6 at Coolagh, the mainline carriageway of the proposed road development is a Standard Dual Carriageway Urban Motorway (D2UM) in accordance with TII DMRB DN-GEO-03036. The design speed of the mainline over this area is 100km/h and cross section is as follows:

Offside Verge Width (minimum): 3.0m

Offside Hard Shoulder Width (minimum): 2.5m

Offside Carriageway Width: 7.0m (2 x 3.5m lanes)

Central Reserve Width (minimum): 2.6m (including 2 x 0.5m offside hardstrip)

Nearside Carriageway Width: 7.0m (2 x 3.5m lanes)

Nearside Hard Shoulder Width (minimum): 2.5m

Nearside Verge Width (minimum): 3.0m

Total Width (minimum): 27.6m

Total Length: 10,840m

The cross sections at the River Corrib Bridge and Menlough Viaduct consists of the same as described above with the exception of the hard shoulder width which is reduced to 0.6m (excluding widening requirements for visibility). The River Corrib Bridge connects to a viaduct and its total length will be 650m with a span of 150m.

The cross sections of the Lackagh Tunnel and the Galway Racecourse Tunnel differ from that required for a Standard Dual Carriageway Urban Motorway in accordance with TII DMRB DN-GEO-03036. The cross sections of these tunnels is dictated by national and international best practice with respect to tunnel layouts, geometric parameters such as stopping sight distance, the provision of space for operational equipment and the provision of safe access and egress in cases of emergency.

Cross sections of both tunnels consist of 2 x 3.75m lanes in both directions, minimum nearside and offside 0.5m hard strip (excluding widening requirements for visibility) and 1.2m walkways nearside and offside. The Lackagh Tunnel will be 270m in length and the Racecourse Tunnel will be approximately 240 m long.

The section of the GCRR between the N83 and N84 junctions will be a 3 lane dual carriageway. The total length of this section is approximately 1,850m.

1.3.3 GCRR Mainline Junctions

In total there will be 15 junctions along the length of the N6 GCRR these are summaried in the table below.

Table 1.3.1: GCRR Mainline Junction Summary

Junction Type	Number
Roundabout	2
Signalised	9
Grade Separated	4

1.4 Existing Conditions

1.4.1 Existing Road Network

The N6 is a National Primary route which connects the M6 / N6 on the east side of Galway at Ardaun to the N59 and the R338 on the north-west side of Galway at Newcastle, a total distance of 7.3km approximately. The existing N6 is a four lane carriageway from the N6 at-grade roundabout junction to the at-grade roundabout junction with the N59 at the western end.

The N6 terminates at the R338 at the at-grade roundabout junction with the N59/R338. The R338 then continues as a two lane single carriageway of varying width, including bus lanes on certain sections, to the R336, the coast road, thus completing a circumferential route around Galway City to the north of the city. See Figure 1.4.1 for a general layout of the existing road network. Areas which have been designated of high environmental importance are overlain on this graphic also.

There are eight at-grade junctions on the N6 between the M6 and the N59 at the intersections with the M6, R339, R865, N83, N84 and N59. Some of these are roundabouts and others are recently upgraded signalised junctions. There are various forms of at-grade junctions including roundabouts, signals and priority junctions on the R338 from its junction with the N59 to the R336.

1.4.2 Existing Natural Constraints

Galway City is physically constrained as it is divided by the River Corrib and a sea inlet known as Lough Atalia and it is bounded along the entire southern boundary by Galway Bay, all of which are natural barriers to free movement and development. There are currently four bridges crossing the river, which in 2012 cumulatively carried approximately 80,000 vehicles per day.

Three of the four bridges are in very close proximity to the city centre, thus drawing traffic into the city for the sole purpose of crossing the river.

Galway County and Connemara as far west as Clifden and onto Letterfrack are equally dependent on this narrow funnel for access as access to this area is restricted by the extents of Lough Corrib heading north, the Twelve Bens mountains, the Maamturk mountains and the many smaller lakes. Figure 1.4.2 highlights that access to this area is via the bridges across the River Corrib in Galway City due to the physical natural constraints. This is further compounded by the fact that a significant portion of this area is designated of environmental importance and therefore the options to provide multiple other access points are not readily available.

Figure 1.4.1: Existing Road Network

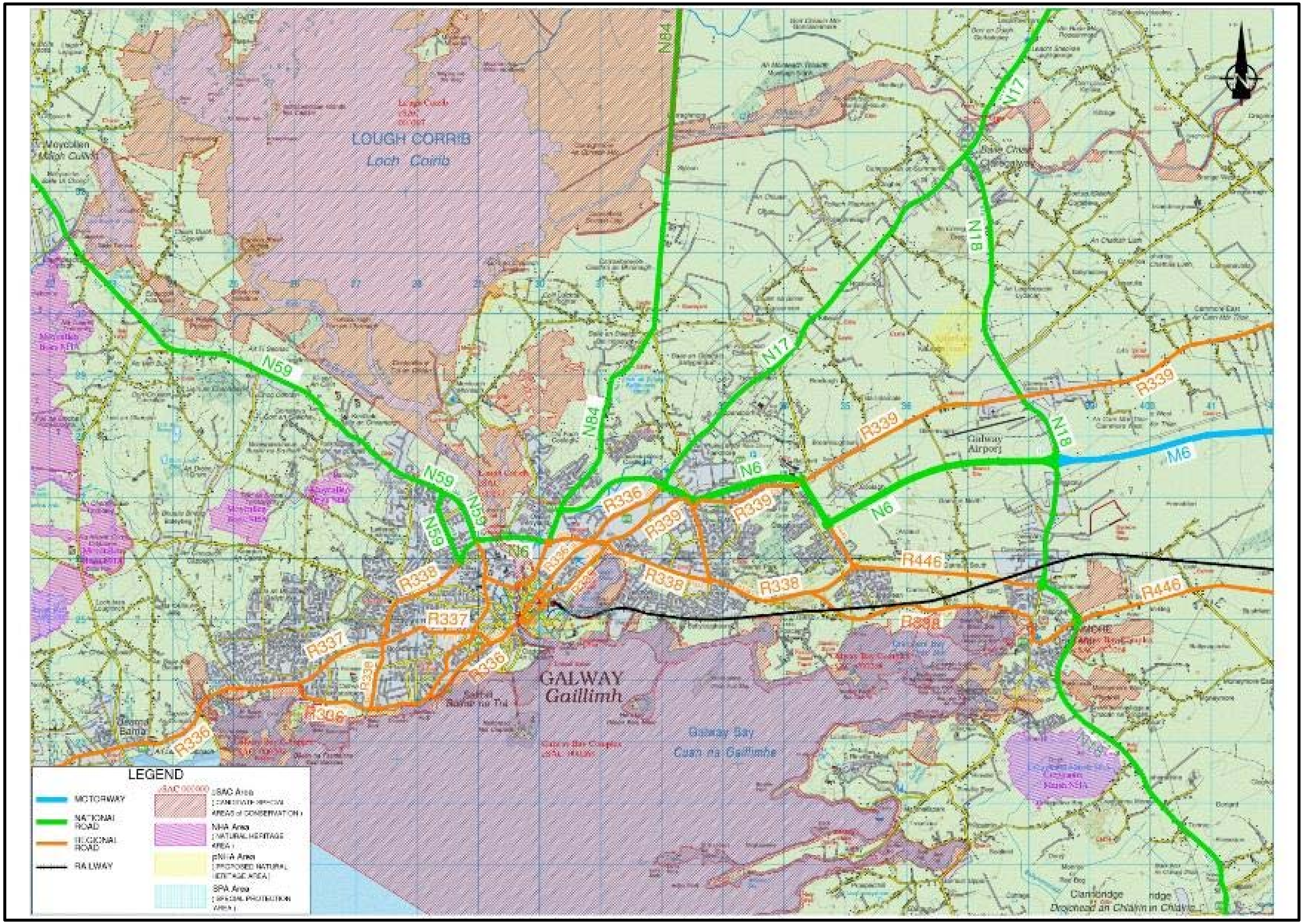
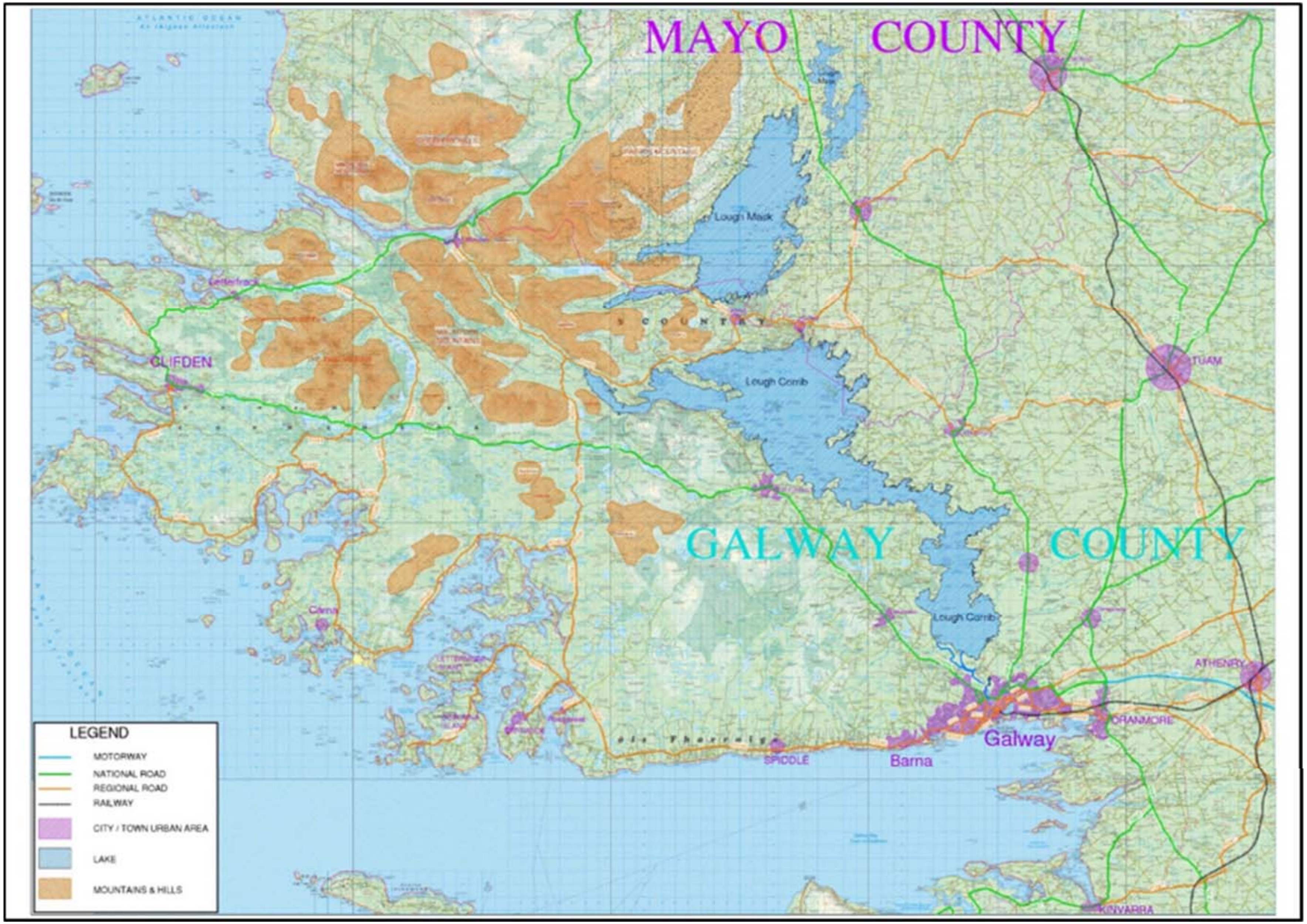


Figure 1.4.2: Existing Natural Constraints



1.4.3 Existing Road Capacity

Table 6/1 of TII standard DN-GEO-03031 (formerly National Roads Authority (NRA) TD9/12) 'Road Link Design' indicates that the Annual Average Daily Traffic (AADT) flow of a Type 2 Dual operating at Level of Service D would not exceed 20,000 AADT. The TII Project Appraisal Guidelines (PAG Unit 4: Consideration of Alternatives and Options) suggests that the AADT flow outlined in TII standard DN-GEO-03031 should only be treated as a guideline and not as a definitive means in the selection of carriageway type.

Notwithstanding this, the following AADT flows were estimated based on traffic counts undertaken by Galway City Council November 2012 and 2013 along the existing N6:

- N6 between Coolagh Roundabout and Monivea Road – 21,400 AADT;
- N6 at Galway Racecourse – 19,900 AADT;
- N6 between Tuam Road and Kirwan Roundabout – 22,400 AADT; and
- N6 River Corrib Crossing – 34,600 AADT.

At present, 24hr weekday flows on a number of sections of the N6 exceed the suggested AADT value of 20,000 for LOS D.

1.4.4 P-Factor

TII PAG Unit 16.1: Expansion of Short Period Traffic Counts, discusses the daily profile of traffic and the concept of 'peaky' or 'flat' profiles. The unit states that 'In order to represent the 'Peakiness' of a traffic flow profile over a particular day, the concept of a 'p-factor' has been derived. The p-factor simply describes the scale of the reduction in flow between the AM Peak and the quietest period of the afternoon (the Inter-Peak), and from the Inter-Peak back up to the PM Peak'. It is defined as follows:

$$p = a + b - 2c$$

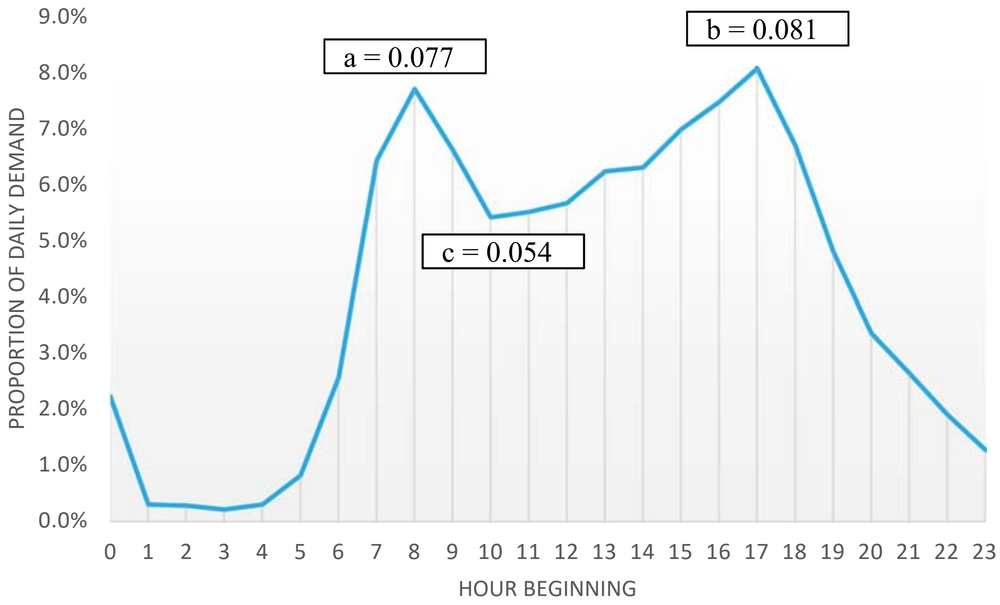
Where:

- p = the peakiness index
- a = the maximum hourly proportion of traffic between 00:00 and 12:00 on a weekday
- b = the maximum hourly proportion of traffic between 12:00 and 24:00 on a weekday
- c = the minimum hourly proportion of traffic between 08:00 and 18:00 on a weekday

The 'p-factor' has been calculated as 0.050 for the N6 based on the daily traffic profile illustrated in Figure 1.4.3. PAG Unit 16.1 states that "the maximum p-factor is 1.0, in which case all traffic flow would occur during two individual peak hours of the day, separated by a cessation of all traffic during the afternoon.

The national mean p-factor taken from the TII Permanent counters located throughout the country was found to be 0.062. The p-factor for the N6 is well below the mean p-factor nationally which would indicate high inter peak traffic levels.

Figure 1.4.3: N6 Traffic Profile



1.4.5 Peak Hour Flows

TA 79/99 of the UK DMRB is used to determine the capacity of urban roads. This standard is not formally implemented in Ireland but is considered as background reading which indicates good practice. Within this standard, classifications such as Urban Motorways or Urban All Purpose roads are used, with further sub-classification of Urban All Purpose Roads as UAP1 to UAP4. The N6 in Galway can be defined as a UAP2 which refers to a "good standard single/dual carriageway road with frontage access and two side roads per km"

The N6 Bóthar na dTreabh is generally a four lane single carriageway from the R338 Seamus Quirke Road to the R339 Monivea Road junction. The N6 then becomes a dual carriageway between the Monivea Road and the Coolagh Roundabout. From TA 79/99, a 2 lane UAP2 road has a capacity of approximately 1,470 vehicles per hour for a 7.3m wide 2 lane single carriageway. This capacity increases to 3,200 vehicles per hour for a 7.3m wide 2 lane dual carriageway

Average weekday peak hour traffic flows on the N6, within the Galway urban area have been derived from the November 2012 traffic surveys and are presented in Table 1.4.1.

Table 1.4.1: N6 Peak Hour Traffic Volumes (November 2012)

Road	Location	C'way	Direction	AM Peak (08:00-09:00)	PM Peak (17:00-18:00)
N6	Quincentenary Bridge	Single	Eastbound	1,614	1,357
			Westbound	1,466	1,520
N6	North of Bodkin Roundabout	Single	Northbound	1,315	1,132
			Southbound	1,286	1,052
N6	Terrysland	Single	Eastbound	925	885
			Westbound	1,000	1,000
N6	Galway Race Course	Dual	Eastbound	881	1,178
			Westbound	905	1,357
N6	Coolagh	Dual	Northbound	1,274	731
			Southbound	490	1,201
N6	Ardaun	Dual	Eastbound	601	1,183
			Westbound	930	603

The single carriageway section of the N6 between the Quincentenary Bridge and Terryland carries the highest volumes of traffic in the peak hour. These are frequently at or above the capacity threshold defined in TA 79/99, which results in congestion on the route. Lower traffic volumes are carried on the dualled eastern section of the N6 Bóthar na dTreabh, however congestion is still experienced along this section, due to capacity restrictions at junctions.

1.4.6 Journey Time Reliability Assessment

Peak hour congestion on the road network in Galway, predominantly caused by junction capacity issues outlined above, results in increased journey times in peak periods in Galway. This leads to a reduction in journey time reliability in the city during these periods.

An analysis of observed journey times on three key routes around Galway and environs was carried out to show the variance in journey times between the peak and off-peak periods in the base year. The difference between the peak and off-peak journey times is a measure of the level of congestion during the peak, and increasing congestion results in worsening journey time reliability.

Observed travel times in 2012 Base Year on each of the routes in the inbound direction in the morning peak period versus the off-peak period are tabulated in Table 1.4.2 below.

This assessment of journey time shows that the travel times on these three key routes in the morning peak hour are on average more than double the off-peak travel times.

Table 1.4.2: Journey Time Reliability

		2012 Observed Journey Times (minutes)			
		Off-peak average hour	Morning peak hour	Difference	%Difference
Inbound	Route 1 IN	14	28	14	100%
	Roue 2 IN	14	25	11	79%
	Route 3 IN	8	19	11	138%
	Average	**12**	**24**	**12**	**105%**

Figure 1.4.4: Journey Time Reliability Routes

1.4.7 Desire Lines

An analysis of desire lines for travel in Galway has been undertaken to gain an understanding of travel patterns in the study area. This has been developed using the extensive information on trip origins and destinations incorporated into the base year Transport Models.

The model is divided up into approximately 300 zones, which have been aggregated to 16 sectors for the purposes of establishing the desire lines or demand between the sectors. Figure 1.4.5 below shows the desire lines between all the sectors in the vicinity of Galway and environs. Figure 1.4.6 is zoomed into and highlights the city area.

The following should be noted when interpreting Figures 1.4.5 and 1.4.6:

- Sectors are delineated by solid grey lines;
- Journeys from one sector to another sector are aggregated together and shown as a single line. The thickness of the line highlights the level of demand and includes both directions of travel;
- The aggregated journeys are shown from the centre of one sector to the centre of the destination sector(s);
- Journeys undertaken and completed internally within sectors are not shown;
- Desire lines shown are not road based;
- Green lines denote journeys which commence and end without crossing the River Corrib;
- Red lines denote journeys which include crossing the River Corrib, and
- Aggregate journeys which total less than 250 passenger car units per hour (PCU.h) have been omitted from Figure 2.8 for clarity.

Figure 1.4.5 shows the demand towards the city, with a strong demand coming from all over the county to the city. It also shows many red desire lines which commence from sectors outside the city and terminate in sectors outside the city on the opposite side of the river, demonstrating the trips that are forced through the city to cross the river as part of their longer journey beyond the city.

Figure 1.4.6 shows a zoom closer into the city. As expected, there are strong desire lines matching the radial routes into the city. However, there also are strong desire lines crossing the city as demonstrated by the red lines, with 25% of all trips crossing the river. This demonstrates a significant cross-city travel pattern.

Figure 1.4.5: Desire Lines (All Sectors)

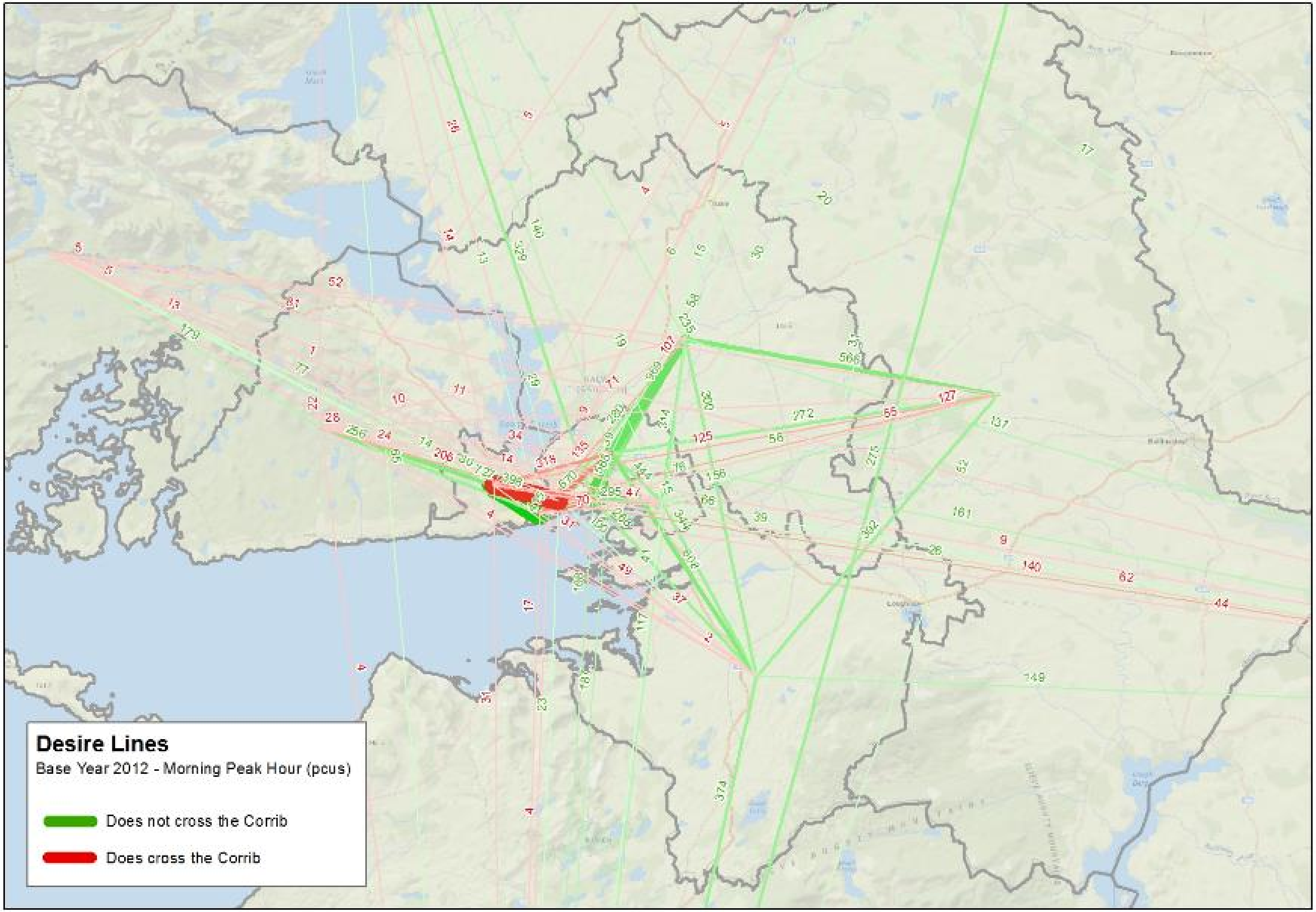
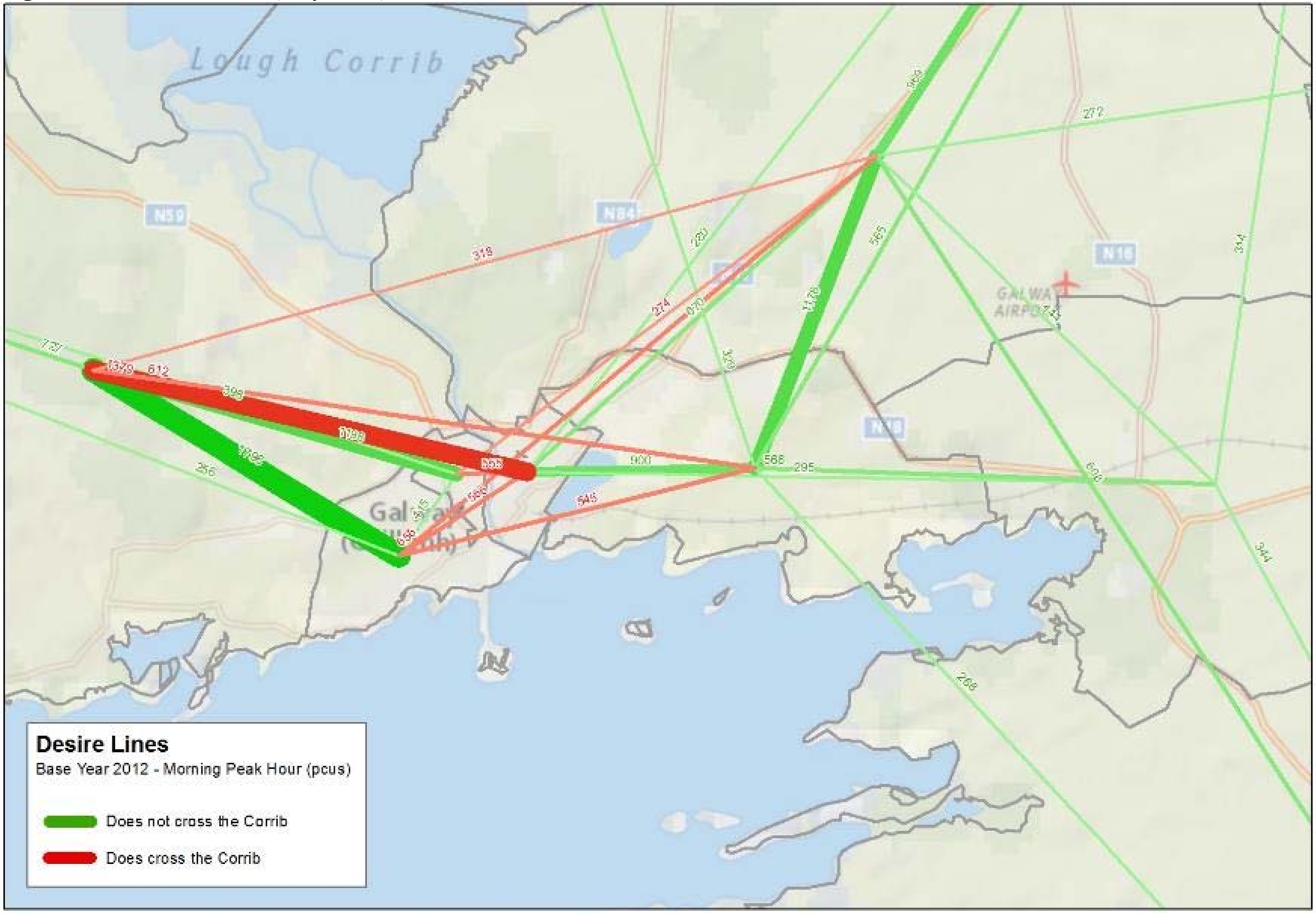


Figure 1.4.6: Desire Lines (City Area)

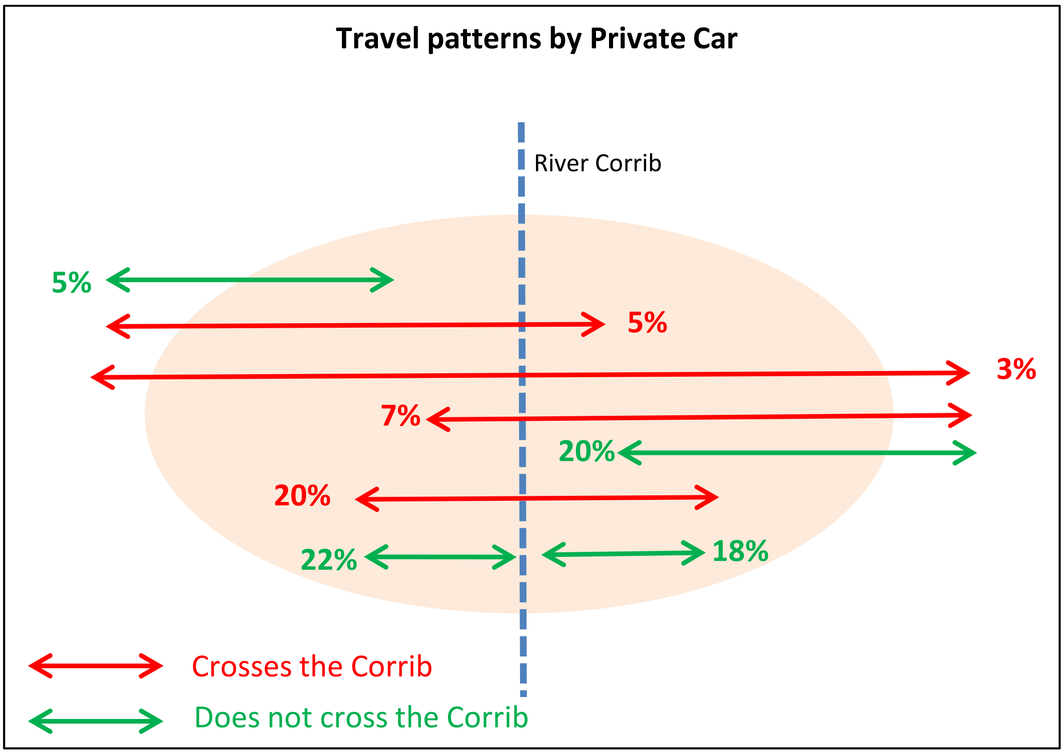


1.4.8 Strategic Travel Patterns

The desire line analysis can be further aggregated into a broad representation of strategic travel patterns in Galway focusing on trips that cross the River Corrib and that either travel into Galway City or travel through the city.

Figure 1.4.7 is a schematic diagram to illustrate the travel patterns for private car trips to, from or through Galway City in the 2012 Base year morning peak hour (extracted from the travel demand matrices). Red arrows show movements that cross the River Corrib and green arrows show movements that do not cross the River Corrib.

Figure 1.4.7: Travel Patterns 2012 Base Year Morning Peak Hour



In total 35% of total car trips into and around Galway City cross the River Corrib. Of this total number of cross-river trips, approximately 9% are bypass traffic. Some 40% of all trips remain in the city on the same side of the city as where they started.

The strongest movements are from the west side of Galway City to the east side of Galway City and vice versa which represents 20% of all trips.

1.5 Modelling Overview

1.5.1 Phase 2 Modelling – Galway Interim Model (GIM)

Modelling for Phase 2 of the project was undertaken using the Galway Interim Model (GIM). The GIM is a multi-modal transport model and was developed by consultants SYSTRA and Jacobs on behalf of the National Transport Authority (NTA) during 2013.

The GIM is capable of providing future year forecasts of travel demand, traffic flows and journey times for road and public transport schemes, and is a robust tool for assessing the traffic impacts and economic benefits.

The GIM comprises three main parts: a highway assignment model in SATURN software, a public transport assignment model in CUBE Voyager software, and a demand model in DIADEM software. These three parts work together as a modelling system to produce forecasts of travel demand and travel costs.

The assignment models were calibrated and validated against observed data for a 2012 Base Year for the morning peak hour (AM: 0800-0900) and average inter-peak hour (IP: average hour 1000-1600).

It was agreed with TII and the NTA that AM peak and Inter-peak models would be sufficient for the appraisal requirements for Phase 2 Route Selection. For the economic analysis of the scheme, PM benefits were estimated from the AM model and adjusted based on factors developed from the traffic flow profile.

It was also agreed that, for the Phase 3 Design and onwards, it would be necessary to incorporate a PM peak model into the detailed appraisal of the preferred scheme.

1.5.2 Phase 3 Modelling

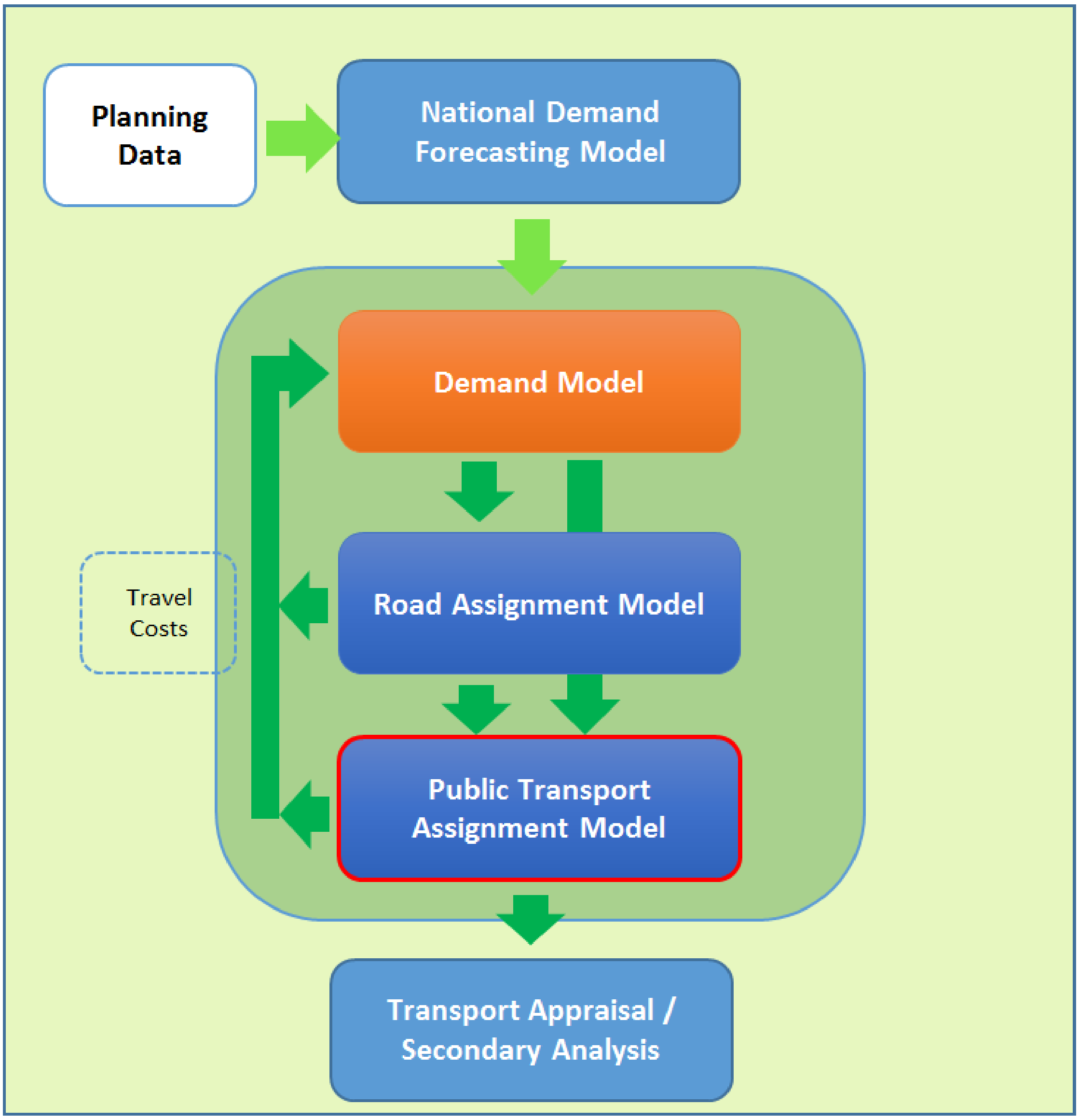
Western Regional Model (WRM)

The West Regional Model is a strategic transport multi-modal model for the counties Galway, Mayo, Roscommon, Sligo, Leitrim and Donegal, with a focus on the city of Galway. It is part of a hierarchical multi-modal transport modelling system for Ireland (Known as the 'Regional Modelling System' RMS) that allows the appraisal of a wide range of potential future transport and land use options. The regional models are focussed on the travel-to-work areas of major population centres (e.g. Dublin, Cork, Galway, Limerick, and Waterford). The models are being developed under the Modelling Services Framework (MSF) by the NTA, SYSTRA and Jacobs Engineering Ireland.

Structure

All of the regional models, including WRM, can be described as three core modelling processes which receive inputs from the National Demand Forecast Model (NDFM), as shown at the centre of the figure below.

Figure 1.5.1: WRM Structure



The **NDFM** is a separate modelling system that estimates the total quantity of travel demand generated by and attracted to every Census Small Area zone on a daily basis. The level of demand from, and to, each zone (referred to as trip-ends) is related to characteristics such as population, number of employees and land-use data. The trip ends form a consistent basis for modelling travel demand across Ireland and therefore allow consistent forecasts to be produced across all of the regional models. The NDFM provides forecasts for input to the regional model and into the demand model.

The **Demand Model** is implemented in Cube Voyager and models travel behaviour. The demand model processes all-day travel demand data from the NDFM through several choice models to represent combined mode, time of day, destination and parking decision making. The outputs of the demand model are assigned to the Road and Public Transport models to determine the route-choice of trips.

The **Road Assignment Model** is implemented in SATURN and includes capacity restraint whereby travel times are recalculated in response to changes in assigned flows.

The **Public Transport Assignment Model (PTAM)** is implemented in Voyager to allocate public transport (PT) users to services between their origin and destination zones. The model is representative of the public transport services (the transport network) for each represented PT sub-mode throughout the modelled area.

The **Secondary Analysis Utilities** efficiently and consistently use outputs from the model to calculate indicators of the impacts of transport and transport related interventions. The following impacts can be informed by model outputs (travel costs, demands and flows):

- social, economic and financial appraisal;
- road safety and accidents;
- environmental impacts: noise, local air quality and carbon;
- fitness benefits of more use of active travel modes; and,
- change in fare revenue for PSO services and tax revenue from fuel oil.

Road Model Time Periods

The West Regional Model is an all-day model with the following time periods represented in the Road and Public Transport Assignment Models;

Table 1.5.1: WRM assigned Time Periods

Period	Demand Model Full Period
AM Peak	07:00–10:00
Morning Inter Peak (IP1)	10:00-13:00
Afternoon Inter Peak (IP2)	13:00-16:00
PM Peak	16:00-19:00

The off peak period (19:00-07:00) is also represented in the Demand Model but is not assigned.

Road Model Calibration / Validation

This section provides a brief outline of some of the key calibration and validation statistics of the WRM. The WRM Road Model development report which is provided in Appendix A provides a much greater level of detail of the Calibration and Validation of the WRM.

Calibration/Validation Acceptability Criteria – Traffic Flows

The TII Project Appraisal Guidelines (PAG) Unit 5.1 provides guidance on the level of calibration and validation that should be achieved.

A standard measure used in model calibration and validation is called the GEH statistic, which is defined as:

$$\text{GEH} = \sqrt{\frac{(\text{observed flow} - \text{modelled flow})^2}{0.5.(\text{observed flow} + \text{modelled flow})}}$$

The GEH statistic is a measure that looks at both the difference between count and modelled flows, and at the size of each observation. Thus, where flows are high a low value of GEH can only be achieved where the percentage difference between observed and modelled flows are small. However, where flows are very low even quite sizeable percentage discrepancies are considered acceptable.

Summary statistics from the WRM Highway model traffic flow calibration, as well as the PAG Model development criteria, are presented in the tables below.

Table 1.5.2: WRM AM Traffic Flow Calibration

Criteria	TII PAG Criteria	Model Statistics
Link Flow	> 85% of cases	87%
GEH < 5 for individual flows	> 85% of cases	80%
GEH < 7 for individual flows	N/A	88%
GEH < 10 for individual flows	N/A	95%

Table 1.5.3: WRM IP1 Traffic Flow Calibration

Criteria	TII PAG Criteria	Model Statistics
Link Flow	> 85% of cases	93%
GEH < 5 for individual flows	> 85% of cases	86%
GEH < 7 for individual flows	N/A	92%
GEH < 10 for individual flows	N/A	98%

Table 1.5.4: WRM IP2 Traffic Flow Calibration

Criteria	TII PAG Criteria	Model Statistics
Link Flow	> 85% of cases	92%
GEH < 5 for individual flows	> 85% of cases	86%
GEH < 7 for individual flows	N/A	90%
GEH < 10 for individual flows	N/A	95%

Table 1.5.5: WRM PM Traffic Flow Calibration

Criteria	TII PAG Criteria	Model Statistics
Link Flow	> 85% of cases	88%
GEH < 5 for individual flows	> 85% of cases	81%
GEH < 7 for individual flows	N/A	88%
GEH < 10 for individual flows	N/A	94%

Journey Time Validation

Journey time data was purchased from TomTom providing observed flow weighted travel time of vehicles traversing each link in the city, to be used in the model validation process . Appropriate journey time routes were identified and average travel times extracted from the TomTom database. These journey time routes cover the main arterial routes into the city centre and origin and destinations from the main Regional roads towards Galway.

The table below provides a summary of the WRM Highway model Journey Time Validation for each of the assigned time-periods along side the, TII, PAG Model development criteria.

Table 1.5.6: WRM Journey Time Validation

Criteria	TII PAG Criteria	Model Statistics
AM	> 85%	60% (15)
IP 1	> 85%	88% (22)
IP 2	> 85%	88% (22)
PM	> 85%	60% (15)

1.5.3 Phase 3 Modeling Requirements

As per the TII Project Appraisal Guidelines (PAG), modelling for Phase 3 (scheme design) will require the following:

- AM, PM and at least one Inter-Peak (IP) model;
- All models to be used should meet the acceptability criteria set out in Unit 5.1 of the Project Appraisal Guidelines.

G.I.M vs Requirements

The GIM does not include a PM model and, therefore, does not meet the requirements by itself.

WRM vs Requirements

The traffic flow calibration summary tables, presented above, illustrate that the WRM has achieved an excellent level of calibration considering the complexity involved with incorporating a sophisticated demand model and multi-modal components in a strategic model such as this.

The individual link calibration for all of the peak road models meets the link flow recommendations set out in the TII PAG Unit 5.1. However, the AM and PM peak periods fall slightly short of meeting the GEH recommended criteria of 85% of links with a GEH value of less than 5.

Comparing the modelled journey times to the observed data in the AM peak it is evident that a proportion of routes, when comparing the end to end journey time, are faster in the WRM than compared with observed data. Link speeds appear to be accurate when comparing the travel time between junctions, however it is clear that junction delay is underestimated at a number of locations.

Journey times in the Inter peak 1 and Inter Peak 2 (IP 1 & IP2) periods appear to be very accurate, suggesting that link speeds, which are applied to all peak periods, are correct for a less congested network.

The PM Peak is more similar to the AM peak in that the journey times validate well in some areas, but could be improved at a number of locations.

1.5.4 Galway City Ring Road Model

In order to progress the modelling for Phase 3 of the N6 GCTP it was necessary to improve aspects of the WRM model so that the road model meets the required TII PAG model criteria listed above.

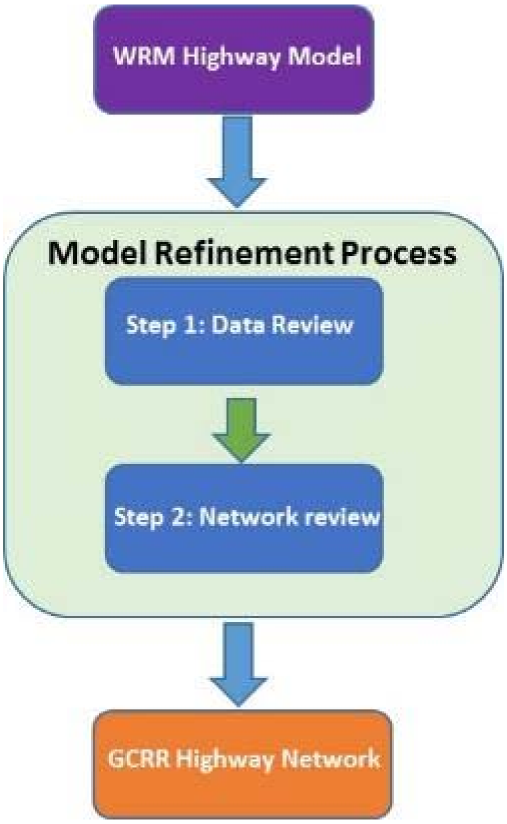
To achieve this, the WRM highway models for each time period (AM, IP1, IP2 & PM) were refined in the area of influence of the N6 Galway City Ring Road to provide the base models for the N6 GCRR assessment. This refinement process is described in more detail in the sections below.

Refining the WRM Highway model to meet all of the TII criteria involved following steps:

- **Step 1:** Data review of all count and Journey time data used in the WRM calibration**;** and
- **Step 2:** Network review to help improve Journey Time calibration.

The flow chart below provides a graphical description of the refinement process.

Figure 1.5.2: GCRR Refinement Process



Step 1 - data review

Remove Irrelevant Counts

In order to help meet the TII criteria, and to ensure the Phase 3 model focuses on the area of influence of the scheme, all counts used in the WRM calibration / validation process which lie outside of the area of influence of the scheme were removed as these counts are not relevant to the scheme.

Addition of Count Data at Key Locations

A large amount of traffic data has been used in the development of the WRM. However, not all of these observed traffic counts have been included in the calculation of the summary traffic flow calibration statistics. Additional observed traffic count data, from key locations in the network, were included in the calculation of summary calibration statistics of the WRM Road Model.

Sense Check Count Data

The traffic counts to be used for scheme model calibration / validation were checked for consistency and accuracy to ensure full confidence in the calibration count set.

Check Journey Time Data

Journey time data was reviewed for accuracy and consistency. Any spurious observations were removed.

Task 2 - Network review

WRM modelled journey times are extremely close to the observed journey times in the inter-peak periods (88% of routes meet criteria for IP1 and 88% for IP2). The AM and PM journey time comparison is less well matched however – 60% meet the acceptability criteria in the AM peak and 60% in the PM peak. For most of the routes, the model error can be traced to just one or two junctions that do not represent the observed delays.

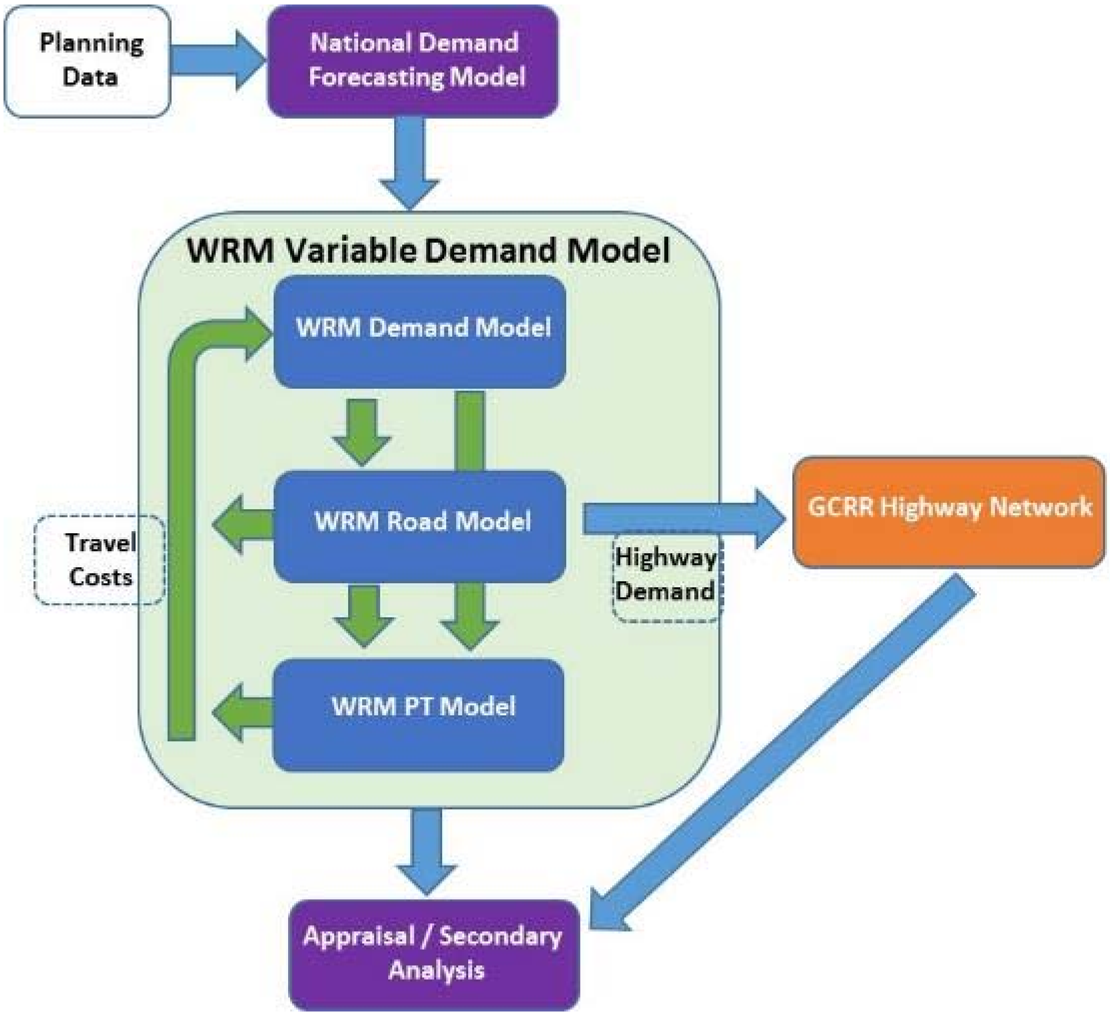
In some instances it was possible to improve the level of journey time calibration (through adjustments to the coding) at these critical junctions by checking and correcting if necessary:

- Modelled demand is equal to observed demand at the junction;
- Signal timings are close to observed timings (if available);
- Pedestrian phases are included in signals where appropriate; and
- Appropriate saturation flows are used.

1.5.5 Phase 3 Modelling Summary

The completion of steps 1 & 2, above, resulted in AM, IP1, IP2 and PM highway models of the area of influence of the scheme which meet the TII PAG criteria for model development. These Highway Models will be referred to as **The Galway N6 City Ring Road (GCRR) Model.** The demand for these models is derived from the WRM FDM and has been used to test the various scenarios required for Phase 3 of the proposed road development. The model structure is illustrated in the figure below.

Figure 1.5.3: GCRR Refinement Process



2 Data Collection

2.1 Introduction

The N6 GCRR Highway Model was developed using a comprehensive set of traffic data from a variety of sources. The types of data used in the highway model development include:

- Count data;
- Signalised data; and
- Journey time data;

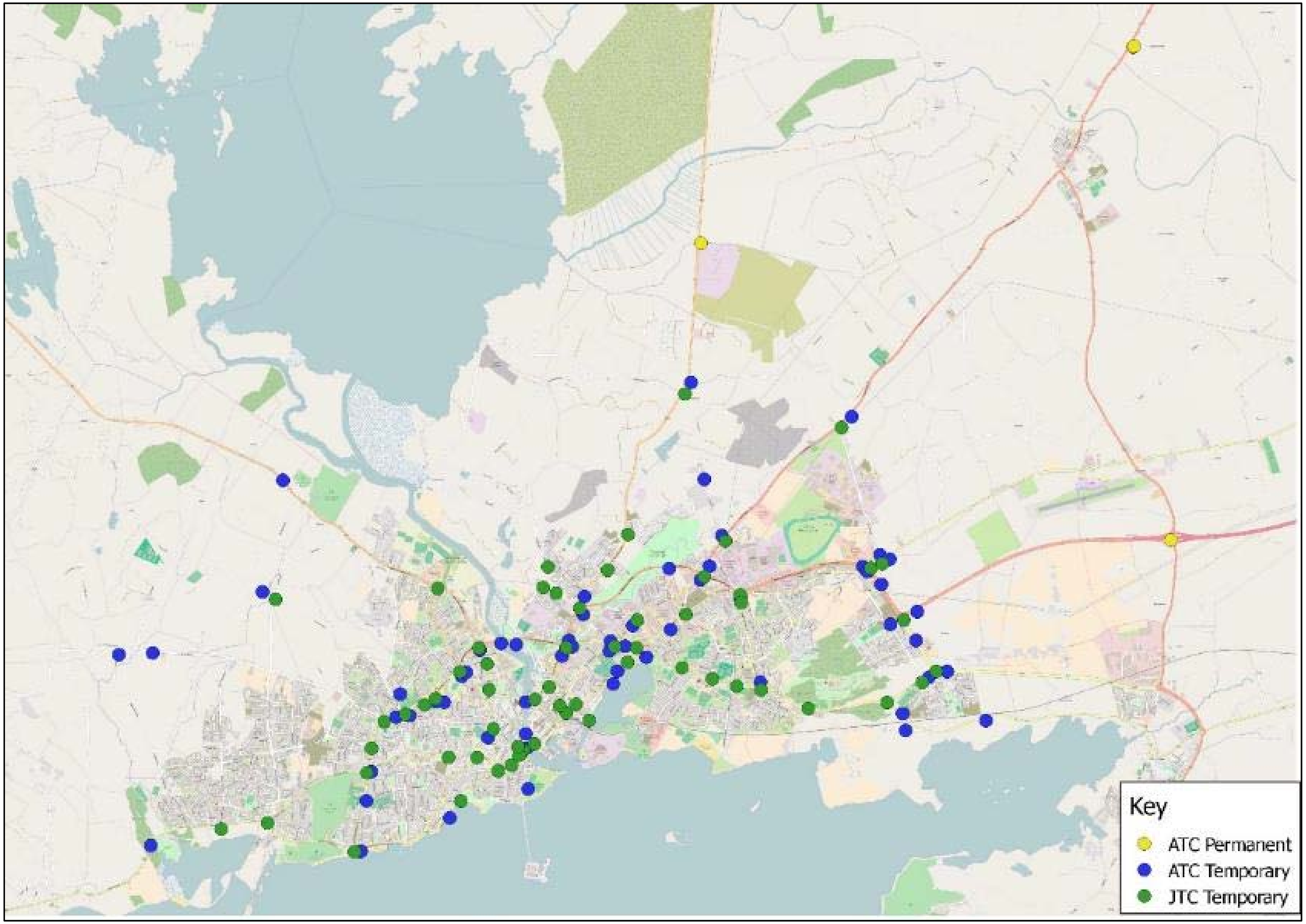
2.2 Traffic Count Surveys

There are between 6,000 and 7,000 survey data records nationwide, including manual classified counts, automatic traffic counts (ATC) and SCATS data, The data was collated in 2014 and represents data from January 2009 to October 2013. An NTA traffic count database is under construction which allows for integrated, user-friendly database for traffic count data to be centrally stored in a common format to allow seamless supply and sharing of data between authorities and agencies. WRM traffic count data was extracted from this database and applied to the calibration and validation of the model. Existing traffic count locations for the WRM area were examined and a gap analysis identified that additional traffic count locations were required to calibrate and validate the model. Up to 42 additional traffic count locations were identified during the gap analysis and these sites were processed into the traffic database. Due to the large amount of data available from the development of the Galway Interim Model (GIM), it was not necessary to supplement any of the existing 2012 count data for Galway City and County with additional 2014 counts and therefore none of the data from the additional 42 sites mentioned has been used in the calibration and validation of the GCRR.

The creation of this database allowed for easy extraction of traffic data. In addition, observed traffic data was expanded to include manual classified counts undertaken within the Galway area. These had previously been excluded due to a lack of proper classification of traffic. Observed LGV proportions were taken from accompanying ATCs and applied globally to the MCCs that did not have LGV as a separate vehicle type.

The figure below indicates the location of traffic count data within the study area.

Figure 2.2.1: Location of Traffic Counts



2.3 Traffic Signal Data

Traffic signal data was obtained from Galway City Council. Traffic signal stages and timing have been developed from:

- Split Cycle Offset Optimization Technique (SCOOT) database where available;
- Microprocessor Optimised Vehicle Actuation (MOVA); and
- Proportional green time split based on observed traffic count if not available from SCOOTS or MOVA.

The SCOOT data formed part of the majority of signal data in Galway city centre with MOVA data providing for signalised locations outside Galway city centre. Data was only provided for the AM and Inter-peak periods, with the PM taking an initial value from the AM peak network.

2.4 Journey Time Surveys

Traditionally, journey time data was collected using moving car observer data. In recent times a number of alternative data sources have come to light that provide a larger, more robust dataset on journey times. These allow the journey time data to be classed as statistically valid through the provision of increased observations. This has the advantage of reducing variability in the data. TomTom is a provider of such data and currently are in the unique position of being able to provide historic data for all routes in Ireland. The NTA purchased TomTom data, more specifically the Custom Area Analysis (CAA) data, which covers every link within a given boundary of the Western Regional Model.

Validating journey times on defined routes is a very common task in the development of transport models. Doing so using TomTom data does not differ significantly from using journey time surveys or other data sources. The first task is to define routes to be appraised based on local knowledge and to cover main desire lines through the simulation network. These routes then have to be matched to the modelled network and to the TomTom network. Modelled travel times on all the links that are part of the route are summed and compared to the sum of the observed travel times on TomTom network links.

The NTA uses 2012 TomTom journey time data on 12 routes in both the inbound and outbound directions. Due to a large unobserved gap in TomTom data, Route 4b outbound was split into two sections so there is a total of 25 individual journey routes reported. The inbound and outbound journey times for all routes are available and extracted in the AM period (0800 – 0900), Lunch Time period (1000 – 1300), School Run period (1300 – 1600), PM peak period (1700 – 1800). TomTom data is available in both directions in all time periods and the figure below indicates the routes.

Journey time data is not available separated by 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.

Figure 2.4.1: Journey time routes

3 Model Development

3.1 Road Network Development

The road network structure for both the WRM and GCRR is identical and was created from HERE mapping and converted into SATURN node and link format, the nodes being the junctions and the links being the lengths of road that connect them. The SATURN network is divided into three areas of decreasing detail: simulation, buffer and external, as shown below. The Galway Model Extent (GME) comprises the simulation and buffer areas: this is the area within which the proposed schemes are likely to affect travel patterns.

Simulation Area

The simulation area covers Galway City and is coded in full simulation detail, where all junctions' details are coded and the delays are calculated by SATURN based on the interaction of traffic at each junction. This form of delay calculation is recommended in urban areas, where much of the delay on the network is due to junction capacity issues.

Buffer Area

The buffer area covers the rest of Galway County and Counties Roscommon, Mayo, Leitrim, Sligo and Donegal. In the buffer area junction details are not coded, instead delays on the road network are calculated by SATURN based on flow-delay curves coded on every link.

External Area

Travel Demand from the rest of Ireland is represented by the External Area. Trips from or to the external area are loaded at the extremities of the model network. Within the external area delays on the road network are not included in the model

Figure 3.1.1: Galway Model Extent

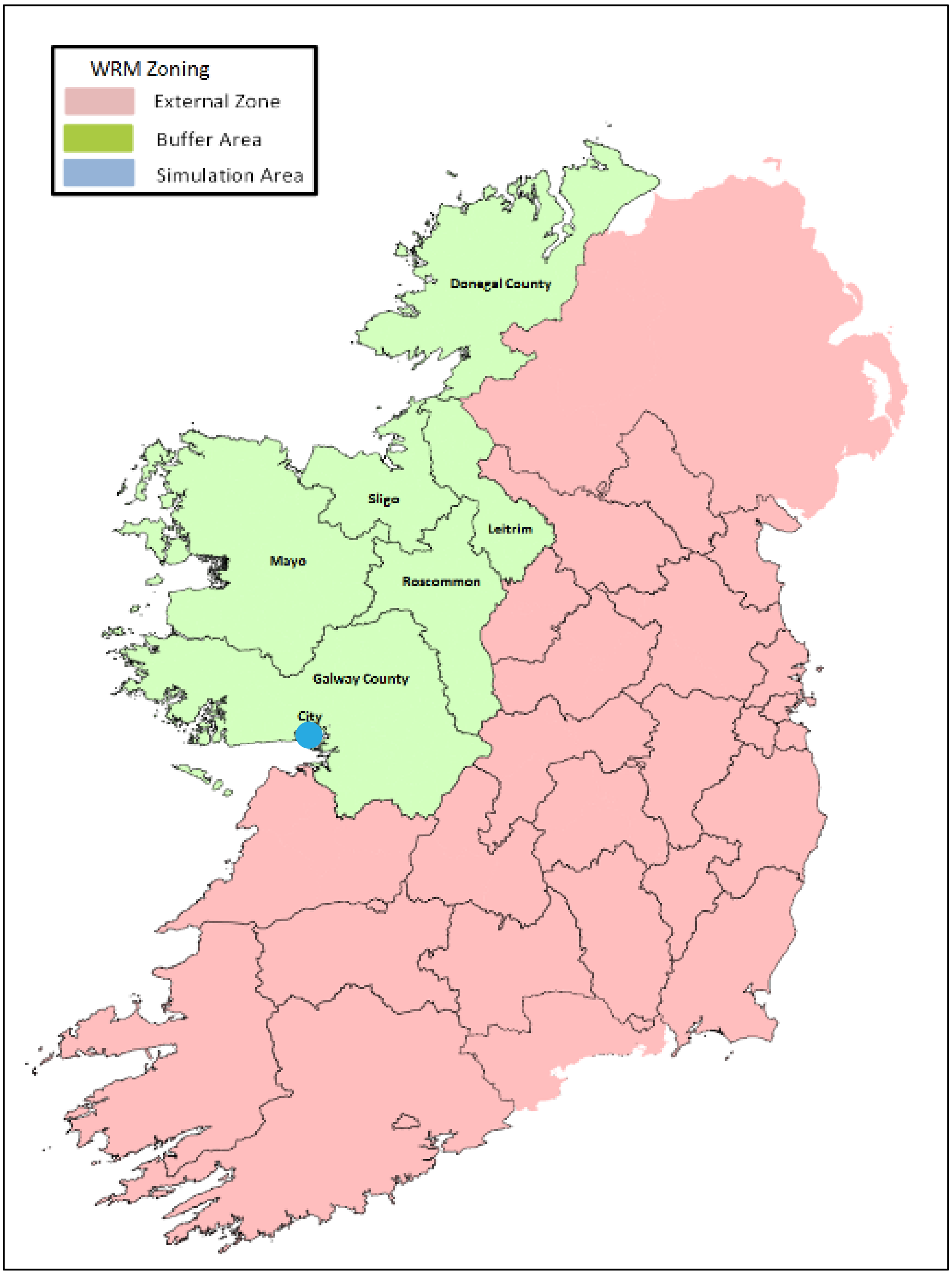
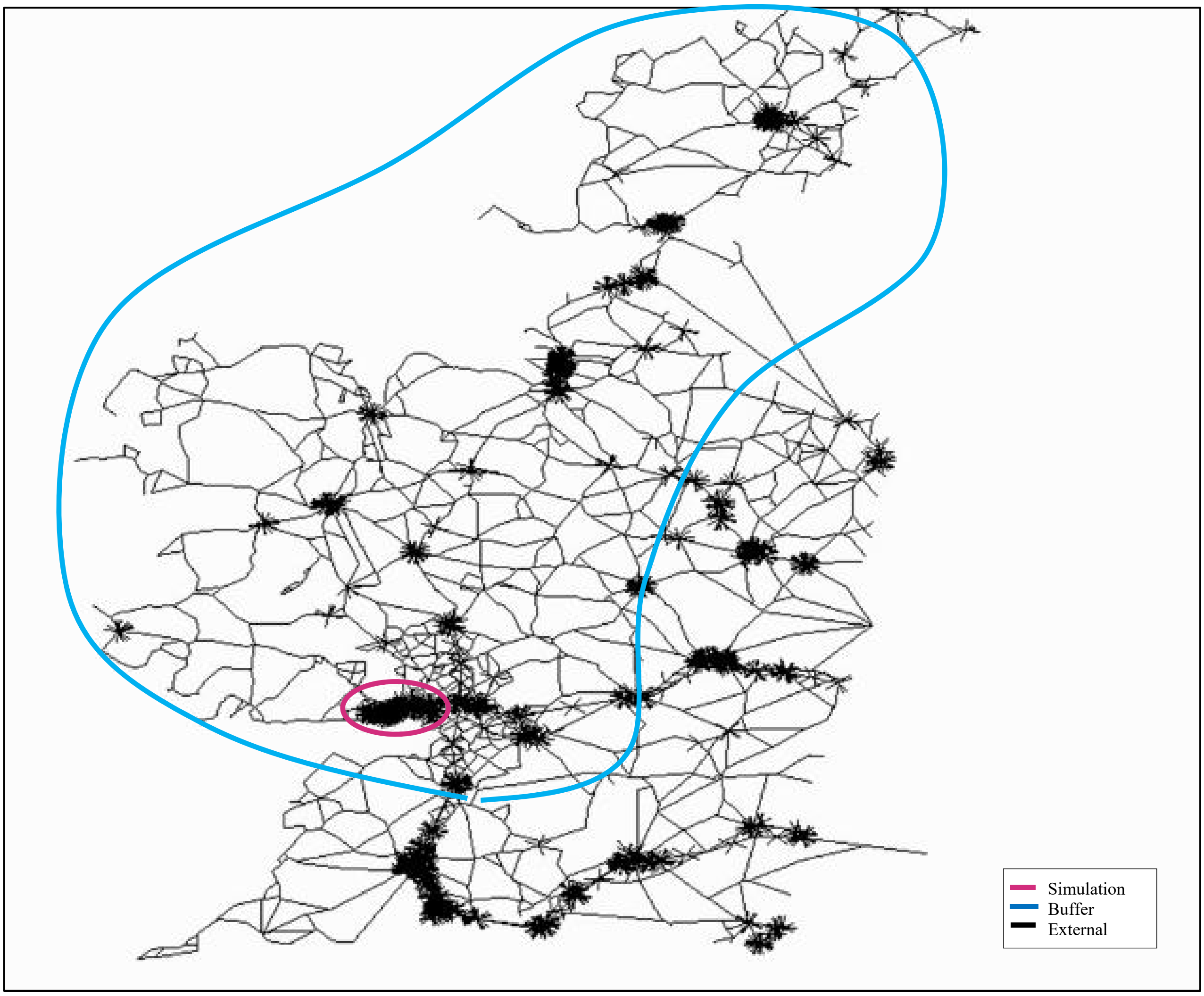


Figure 3.1.2: Galway Model Extent – SATURN Network



3.2 Public Transport Network Development

The public transport (PT) network was created from the highway network, which ensures that the highway and PT network structures are identical. This approach enables the PT link speeds to be updated from congested highway link speeds.

Additional links to represent rail lines were then added and railway stations were added and connected to the road network for access to and from zones.

All bus and rail services to, from, through and within the Galway Model Extent (GME) were coded using data from the National Journey Planner in April 2013.

3.3 Model Zone System

The model zones have been defined by aggregating Small Areas (SAs) such that the activity levels of each zone fall within a certain range, where activity levels are measured from the 2011 POWSCAR[1]. Other criteria taken into account in determining the zone size and shapes include:

- Electoral District (ED) boundaries;
- Large individual attractors;
- Physical barriers and connectivity to the network; and
- Land use.

In some cases it was necessary to split a SA into one or more zones in order to respect the above criteria, in particular to ensure accurate loading of trips from the zones onto the road network.

The WRM is made up of 693 model zones broken down as follows:

- Galway City: 138
- Galway County: 206
- Donegal County: 109
- Leitrim County: 28
- Sligo County: 43
- Roscommon County: 44
- Mayo County: 123
- Special Zones (Airport and Port of Galway): 2

The same model zone system is used for the road, PT and demand model.

The WRM model zone system development is presented in Appendix B.

[1] POWSCAR (Place of Work, School or College – Census Anonymised Records) is produced by the Central Statistics Office based on the 2011 Census and contains geo-coded data on the place of work or education for all workers and students in Ireland.

3.4 Matrix Development

Travel demand matrices are an essential part of the modelling system. They represent the demand for travel between every pair of model zones and therefore represent the trips that people make by car and public transport.

The process of building the travel demand matrices for the 2012 Base Year can be summarised as follows:

- Calculate 24 hour Production Attraction (PA) trip ends by purpose at the model zone level using a version of the National Trip End Model (NTEM) that has been developed specifically for the Regional Model Suite (the NTEM has been calibrated against data in the 2012 National Household Travel Survey (NHTS) and 2011 POWSCAR);
- Split the trip ends by travel mode and car availability, based on data from POWSCAR and NHTS;
- For home based commute and education, create PA travel demand matrices from POWSCAR and control to the trip ends calculated from the NTEM using a row and column balancing procedure;
- For the other purposes, create matrices as follows:
  - using a gravity model for trips within the WRM;
  - using distributions extracted from POWSCAR for trips to or from Galway with one end at an external zone; and
- Apply daily time profiles, return home probabilities and occupancy rates derived from NHTS to convert from 24-hour PA person trip matrices to peak hour Origin Destination (OD) vehicle trip matrices.

The National Trip End Model (NTEM) is a component of the NTA National Demand Forecasting Model (NDFM). The NDFM is a set of models and tools that are used to derive levels of trip making nationally from planning data, for input into each of the NTA Regional Models. The NTEM component converts planning data into person trips for a typical weekday. The main inputs into NTEM include zonal demographic and economic data such as population levels, employment, students and retail floor area.

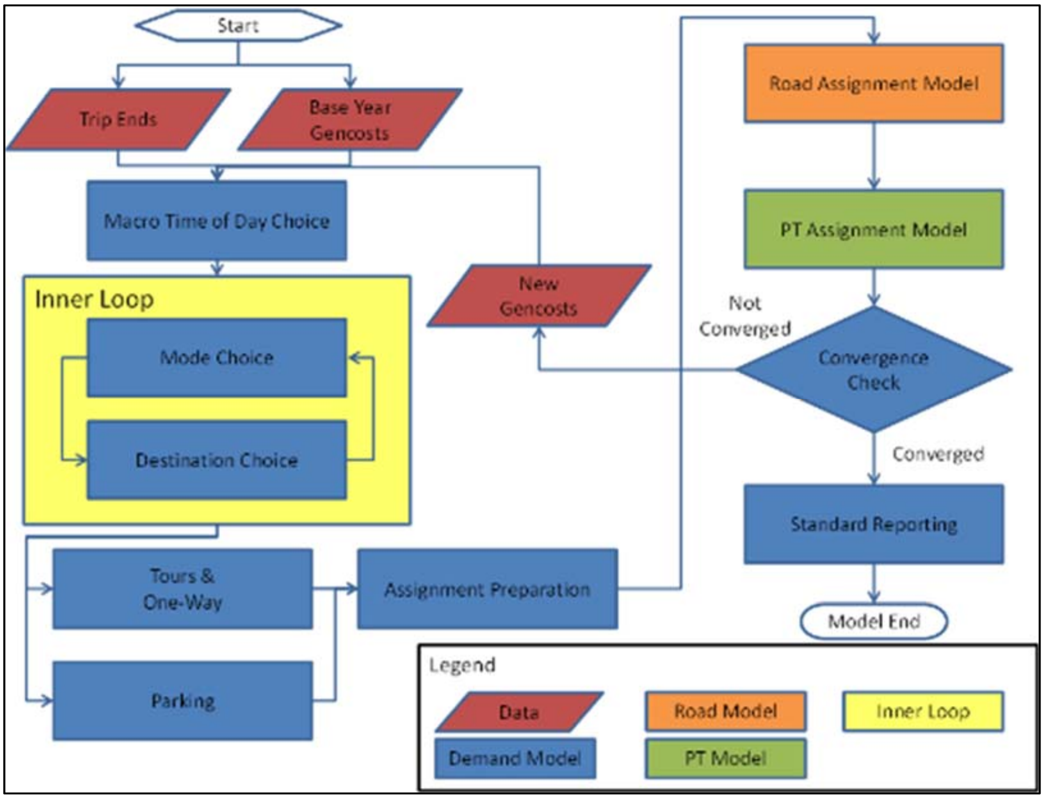
The outputs of the NTEM include two-way PA trip ends and one way OD matrices, segregated by journey purpose. For further detail of the operation of the NDFM and NTEM, please see Appendix C.

3.5 Demand Model Form

The WRM, as well as the other regional transport models comprising the NTA's Regional Modelling System (RMS), all use a consistent, identical Full Demand Model (FDM). During model development, the FDM was continually refined and updated based on feedback from the 5 regional models, including the WRM, until the demand models for each area were calibration to the satisfaction of the NTA. Further details on the WRM demand model calibration are contained within Appendix C.

The purpose of the FDM is to take input trip ends (at the 24-hour level) and costs (from the road, PT and active modes assignment models) and to allocate these trips to different time periods, modes and destinations so that they can be assigned using the peak-hour road, PT and active modes assignment models. The Figure below shows a simplified overview of the different modules of the FDM.

Figure 3.5.1: FDM Components



3.6 Assignment Method

The standard Wardrop Equilibrium using the Frank-Wolfe algorithm have been adopted as the assignment procedures for the highway model, to be consistent with the Greater Dublin Area model and other regional models.

Tight highway assignment convergence is important in order to provide a robust appraisal. A highway assignment convergence with a %GAP<0.03% was achieved in the GCRR, which considerably exceeds WebTAG guidance (%GAP<0.1%).

3.7 Generalised Cost Parameters

The SATURN assignment procedure builds paths through the network based on the generalised cost formulation. Generalised cost is a linear combination of time and distance, using values of pence per minute (PPM) and pence per kilometre (PPK) to convert distance into generalised minutes. It takes the following form:

Generalised Cost (minutes) = time + distance*PPK/PPM

The values of PPM and PPK within the GIM are based on the guidance on parameter values issued by the Department for Transport (DoT) and set out in the Common Appraisal Framework (CAF), which is consistent with NRA PAG Unit 6.11. The table below shows the PPM and PPK used in the GIM 2012 base year. Note that PPM for commute is lower than education and other because the commute vehicle occupancy is lower, and PPM and PPK are expressed in units *per vehicle.*

Table 3.7.1: PPM and PPK – AM

User Class	Cents Per Minute	Cents Per Kilometr
UC1 – Taxi	60.13	18.8
UC2 – Car Employers Business	60.13	18.8
UC3 – Car Commute	21.52	9.8
UC4 – Car Education	36.39	9.8
UC5 – Car Other	21.16	9.8
UC6 – LGV	43.34	13.3
UC7 – OGV1	46.08	30.5
UC8 – OGV2 Permit Holder	44.40	55.9
UC9 – OGV2 (Other)	44.40	55.9

Table 3.7.2: PPM and PPK - IP1

User Class	Cents Per Minute	Cents Per Kilometr
UC1 – Taxi	70.39	17.1
UC2 – Car Employers Business	70.39	17.1
UC3 – Car Commute	20.74	9.1
UC4 – Car Education	42.66	9.1
UC5 – Car Other	38.41	9.1
UC6 – LGV	45.90	13.4
UC7 – OGV1	47.87	28.7
UC8 – OGV2 Permit Holder	46.55	52.7
UC9 – OGV2 (Other)	46.55	52.7

Table 3.7.3: PPM and PPK - IP2

User Class	Cents Per Minute	Cents Per Kilometr
UC1 – Taxi	70.39	17.3
UC2 – Car Employers Business	70.39	17.3
UC3 – Car Commute	20.74	9.1
UC4 – Car Education	42.66	9.1
UC5 – Car Other	38.41	9.1
UC6 – LGV	45.90	13.4
UC7 – OGV1	47.87	28.9
UC8 – OGV2 Permit Holder	46.55	53.1
UC9 – OGV2 (Other)	46.55	53.1

Table 3.7.4: PPM and PPK - PM

User Class	Cents Per Minute	Cents Per Kilometr
UC1 – Taxi	60.13	18.1
UC2 – Car Employers Business	60.13	18.1
UC3 – Car Commute	21.52	9.5
UC4 – Car Education	36.39	9.5
UC5 – Car Other	21.16	9.5
UC6 – LGV	43.34	13.0
UC7 – OGV1	46.08	29.2
UC8 – OGV2 Permit Holder	44.40	53.6
UC9 – OGV2 (Other)	44.40	53.6

4 Model Calibration & Validation

4.1 Overview of the Calibration and Validation Process

Calibration is the process of adjusting the model to improve the fit to observed data, such as traffic counts or passenger flows, journey times, delays and route choice. Validation is a comparison of the final model flows and journey times against observed data. Two sets of validation statistics are reported: one with the set of counts used during calibration; and the other with a set of independent counts not used during calibration.

4.2 Highway Assignment Model Calibration Results

4.2.1 Overview

The N6 GCRR highway and public transport assignment models have been calibrated and validated to a 2012 base year. The calibration and validation process followed the guidelines in the TII Project Appraisal Guidelines (PAG), and where appropriate the DfT's WebTAG.The results of the base model calibration and validation are presented in the following order:

- Trip matrix calibration
- Link and turn flow calibration
- Journey time validation
- Validation against independent counts
- Impact of matrix estimation on trip length distribution

4.2.2 Summary of the Count Data used in Calibration & Validation

The table below provides a summary of the counts used in the various stages of calibration and validation. The number of counts in the table includes both directions, e.g. screenline 1 is made up of five 2-way counts. Refer to Figure 2.2.1 (presented earlier in this note) for the traffic count locations.

Table 4.2.1: Summary of Count Sets used in Calibration & Validation

Calibration / Validation Stage	No. Of Counts Used	Screen Lines (ATCs)					Used as individual counts or Screenlines
		1	2	3	4	5	
No. Of Counts Available	-	10	12	18	14	16	-
Matrix Estimation	260	✓	✓	✓	✓	✓	Screenlines
Trip Matrix Calibration	60	✓	✓	✓	✓	✓	Screenlines
Link Flow Calibration	130	✓	✓	✓	✓	✓	Individual counts
Turn Flow Calibration	72						Individual counts
Validation Against Independent Counts	20						Individual counts

4.2.3 Calibration/Validation Acceptability Criteria

TII Project Appraisal Guidelines (PAG) Unit 5.1 provides guidance on the level of calibration and validation that should be achieved.

A standard measure used in model calibration and validation is called the GEH statistic, which is defined as:

$$\text{GEH} = \sqrt{\frac{(\textbf{observed flow} - \textbf{modelled flow})^2}{0.5.(\textbf{observed flow} + \textbf{modelled flow})}}$$

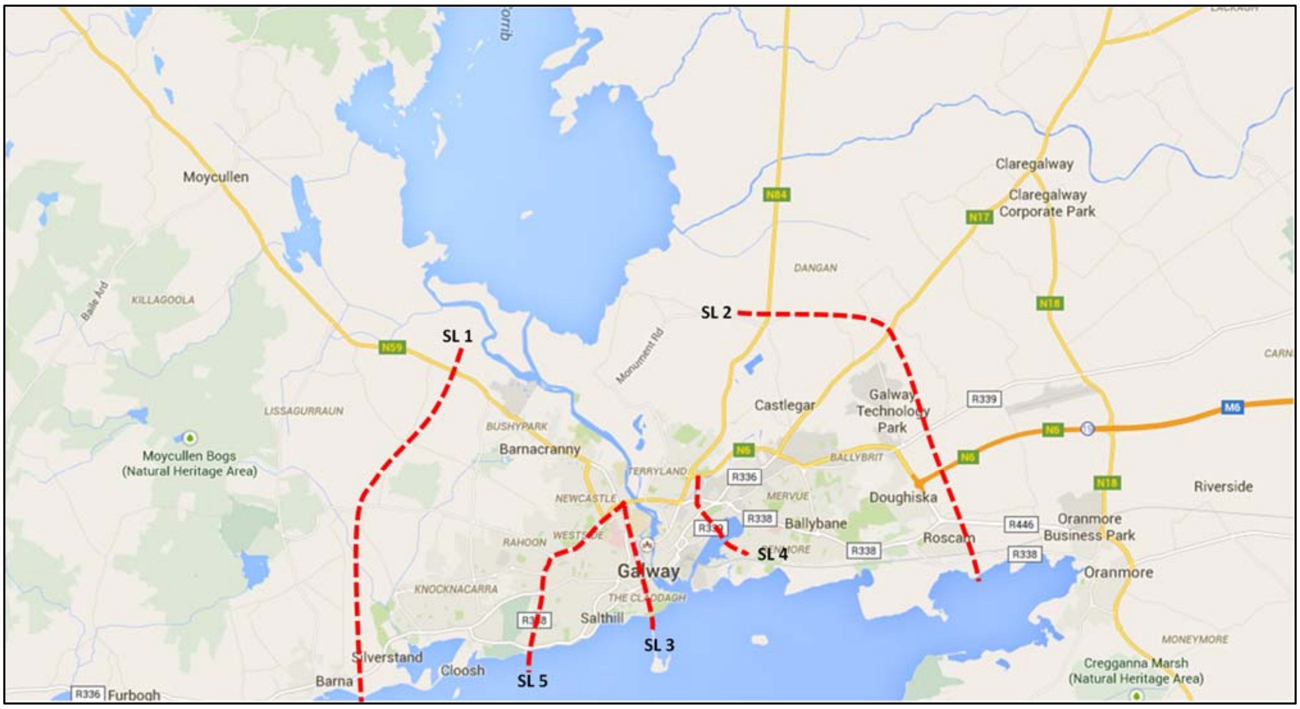
The GEH statistic is a measure that looks at both the difference between count and modelled flows, and at the size of each observation. Thus, where flows are high a low value of GEH can only be achieved where the percentage difference between observed and modelled flows are small. However, where flows are very low even quite sizeable percentage discrepancies are considered acceptable.

4.3 Trip Matrix Calibration

PAG (Unit 5.1 Table 5.1.4) says that total screenline flows should be within 5% or GEH<4 in more than 85% of cases.

The counts used for trip matrix calibration are the ATCs that form screenlines 1 to 5, illustrated in the Fugure below.

Figure 4.3.1: Traffic Count Screen Lines



Tables 4.3.1 to 4.3.4 show the percentage difference between model flows and observed counts for each of the screenlines used in matrix estimation. In all peaks 90%, or more, of screen lines satisfy the GEH Critera. All time periods bar the Inter-peak 1 period meet the percentage difference criteria. For Inter-peak 1, in the instances where the percentage difference exceeds the 5% guideline, the GEH value of the same screenline is however below 5 and therefore these differences are considered acceptable.

Table 4.3.1: Trip Matrix Calibration for Screenlines used in Matrix Estimation – Morning Peak Hour

Screen Line	Total Flows			
	Obs	Modelled	Diff	GEH
1 in	1846	1835	-1%	0
1 out	731	743	2%	0
2 in	2020	1807	-11%	5
2 out	715	737	3%	1
3 in	3633	3612	-1%	0
3 out	3012	3019	0%	0
4 in	2481	2464	-1%	0
4 out	2647	2578	-3%	1
5 in	2018	2022	0%	0
5 out	6044	5864	3%	2
Total Flow within 5%	**90%**			
Total GEH < 4	**90%**			

Table 4.3.2: Trip Matrix Calibration for Screenlines used in Matrix Estimation – Inter-peak 1 Average Hour

Screen Line	Total Flows			
	Obs	Modelled	Diff	GEH
1 in	871	868	0%	0
1 out	691	693	0%	0
2 in	974	849	-13%	4
2 out	793	757	-5%	1
3 in	2592	2462	-5%	3
3 out	2383	2352	-1%	1
4 in	2236	2239	0%	0
4 out	2584	2328	-10%	5
5 in	2012	2118	9%	4
5 out	2421	2619	8%	4
Total Flow within 5%	**60%**			
Total GEH < 4	**90%**			

Table 4.3.3: Trip Matrix Calibration for Screenlines used in Matrix Estimation – Inter-peak 2 Average Hour

Screen Line	Total Flows			
	Obs	Modelled	Diff	GEH
1 in	934	890	-5%	1
1 out	1029	1004	-2%	1
2 in	1134	1103	-3%	1
2 out	1243	1185	-5%	2
3 in	2723	2708	-1%	0
3 out	2515	2632	5%	2
4 in	2632	2570	-2%	1
4 out	2502	2387	-5%	2
5 in	3017	3104	3%	2
5 out	2444	2633	8%	4
Total Flow within 5%	**90%**			
Total GEH < 4	**100%**			

Table 4.3.4: Trip Matrix Calibration for Screenlines used in Matrix Estimation – Evening Peak Hour

Screen Line	Total Flows			
	Obs	Modelled	Diff	GEH
1 in	978	968	-1%	0
1 out	1614	1601	-1%	0
2 in	1045	987	-6%	2
2 out	1852	1752	-5%	2
3 in	2967	2930	-1%	1
3 out	3331	3263	-2%	1
4 in	3295	3323	1%	0
4 out	2807	2669	-5%	3
5 in	4983	5105	2%	2
5 out	2399	2394	0%	0
Total Flow within 5%	**90%**			
Total GEH < 4	**100%**			

4.4 Link and Turn Flow Calibration

PAG (Unit 5.1 Table 5.1.3) says that at least one of the following two criteria should be met in 85% of cases:

- Criteria 1: links should have a GEH value of less than 5;
- Criteria 2:
  - where modelled flows are less than 700, the model flow should be within 100 vehicles of the count;
  - where modelled flows are between 700 and 2700 the modelled flows should be within 15% of observed flows; and
  - where modelled flows are greater than 2700 the modelled flows should be within 400 vehicles of the observed flows.

Tables 4.4.1 – 4.4.4 present the summary statistics for the GCRR Highway Model Calibration for each modelled time period. The results demonstrate that the model is calibrated as per the requirements of PAG for link and turn flows. The tables in Appendix D present the calibration results for each link.

Table 4.4.1: AM Traffic Flow Calibration

Criteria	TII PAG Criteria	Model Statistics
Link Flow	> 85% of cases	85%
GEH < 5 for individual flows	> 85% of cases	85%
GEH < 7 for individual flows	N/A	91%
GEH < 10 for individual flows	N/A	98%

Table 4.4.2: IP 1 Traffic Flow Calibration

Criteria	TII PAG Criteria	Model Statistics
Link Flow	> 85% of cases	90%
GEH < 5 for individual flows	> 85% of cases	87%
GEH < 7 for individual flows	N/A	94%
GEH < 10 for individual flows	N/A	97%

Table 4.4.3: IP 2 Traffic Flow Calibration

Criteria	TII PAG Criteria	Model Statistics
Link Flow	> 85% of cases	92%
GEH < 5 for individual flows	> 85% of cases	89%
GEH < 7 for individual flows	N/A	93%
GEH < 10 for individual flows	N/A	96%

Table 4.4.4: PM Traffic Flow Calibration

Criteria	TII PAG Criteria	Model Statistics
Link Flow	> 85% of cases	88%
GEH < 5 for individual flows	> 85% of cases	86%
GEH < 7 for individual flows	N/A	92%
GEH < 10 for individual flows	N/A	97%

Figures 4.4.1 to 4.4.4 illustrate the Calibration results graphically.

It is noted that in the AM peak there is one link count and 2 turning counts which have a GEH of greater than 10. Of these, 2 are close to the proposed scheme:

1. the R339, eastbound, at Briarhill has an observed flow of 277 vehicles versus a model flow of 501 vehicles; and
2. The right turning movement from the N6 into the Ballybrit industrial estate has an observed flow of 472 and a modelled flow of 180;

In the IP 1 period there are 4 link counts and 1 turning count which have a GEH of greater than 10. Of these 2 are close to the proposed scheme:

1. the N6 westbound, at Briarhill Business Park has an observed flow of 507 vehicles versus a model flow of 762 vehicles; and
2. The right turn from the Ballybrit industrial estate onto the N6 has an observed flow of 74 and a modelled flow of 7;

In the IP 2 period there are 5 link counts and 1 turning counts which have a GEH of greater than 10. Of these 2 are close to the proposed scheme:

1. the right turn from the N6 onto the R339 at Briarhill Business Park has an observed flow of 170 vehicles versus a model flow of 40 vehicles; and
2. Traffic travelling northbound on the N83 at the N6 / N83 junction has an observed flow of 773 and a modelled flow of 490;

In the PM peak there are 5 link counts and 1 turning counts which have a GEH of greater than 10. Of these 2 are close to the proposed scheme:

1. the right turn from the R865 onto the N6 at Ballybrit has an observed flow of 407 vehicles versus a model flow of 104 vehicles; and
2. Traffic travelling eastbound on the R338 approaching cemetary cross has an observed flow of 561 and a modelled flow of 840;

In each of the above cases the coding of the network and alternative traffic data sources, such as traffic counts and journey time information, have been reviewed to identify the potential reasons for the variation between observed and modelled counts, and to ensure network coding, etc, is correct.

In overall terms, comparison of model counts to observed flows at the various screen lines leading into, and out of, Galway City shows an excellent level of calibration in all time periods and indicates that the level of modelled demand throughout the network matches observed demand. The model meets PAG model development criteria for both traffic counts and journey times within Galway City and the N6 corridor.

Given the level of flows observed and the variation in traffic between sites, from day to day, these GEH values are not deemed to be significant.

Figure 4.4.1: AM Peak Calibration

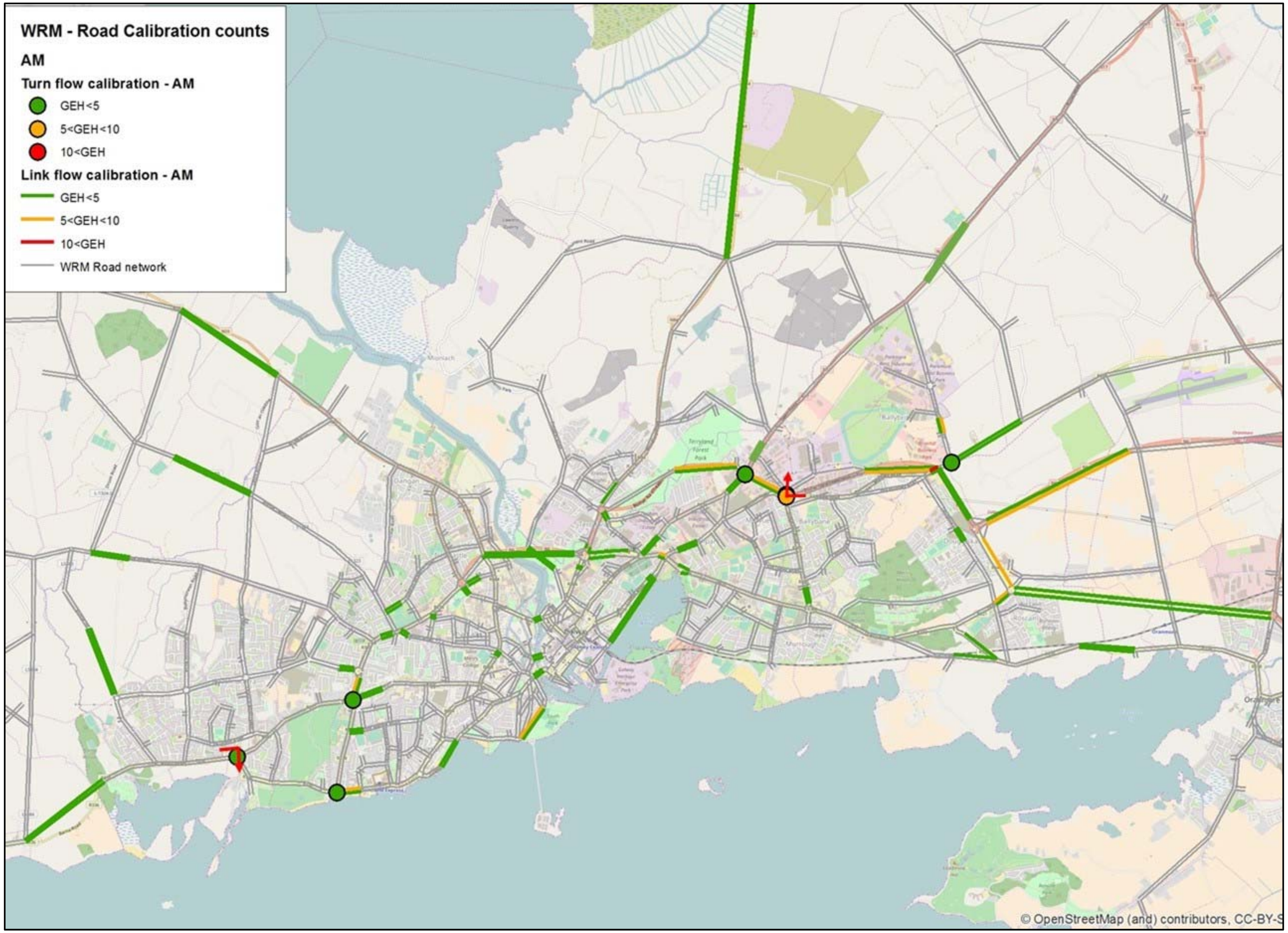


Figure 4.4.2: IP 1 Calibration

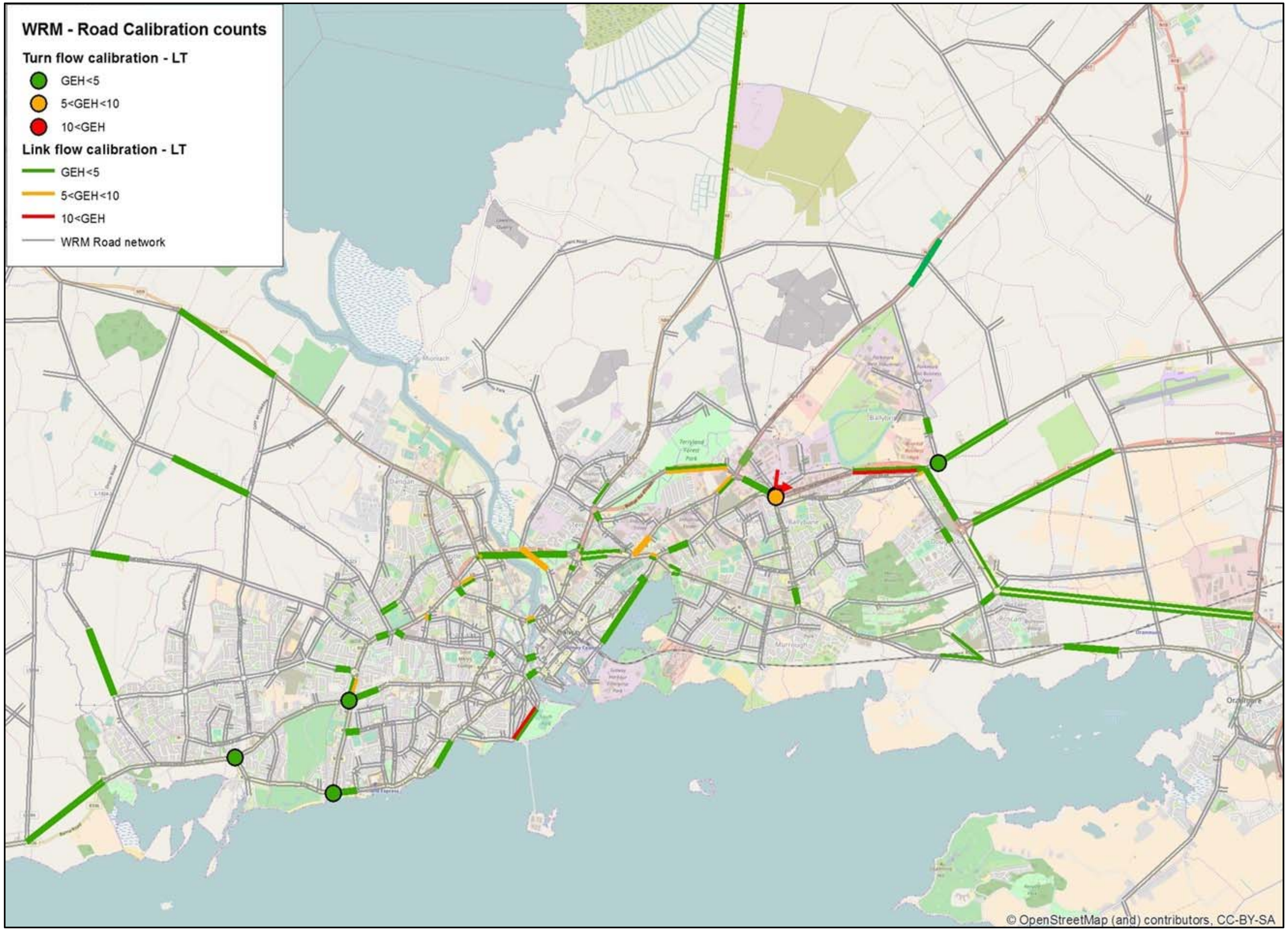


Figure 4.4.3: IP 2 Calibration

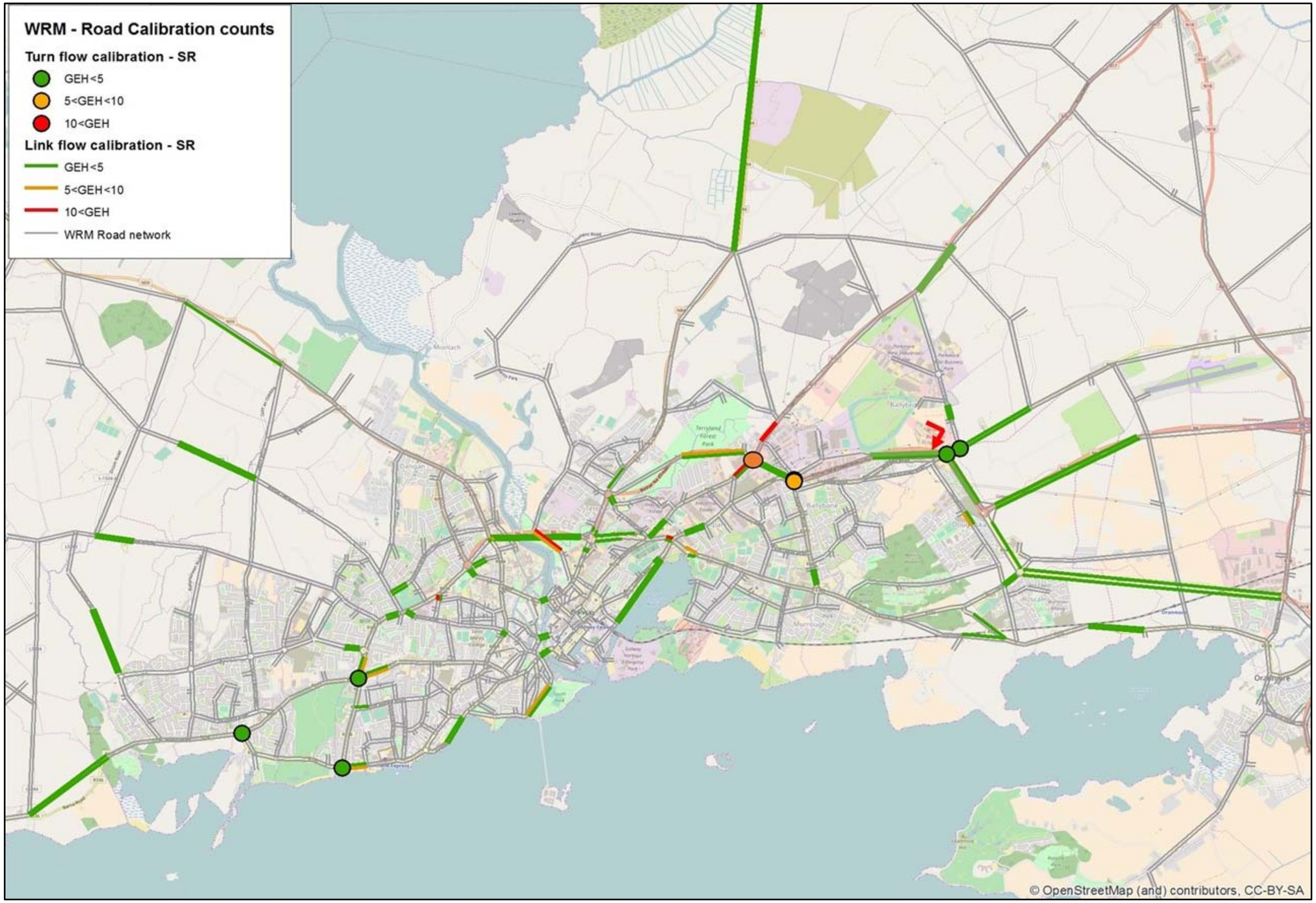
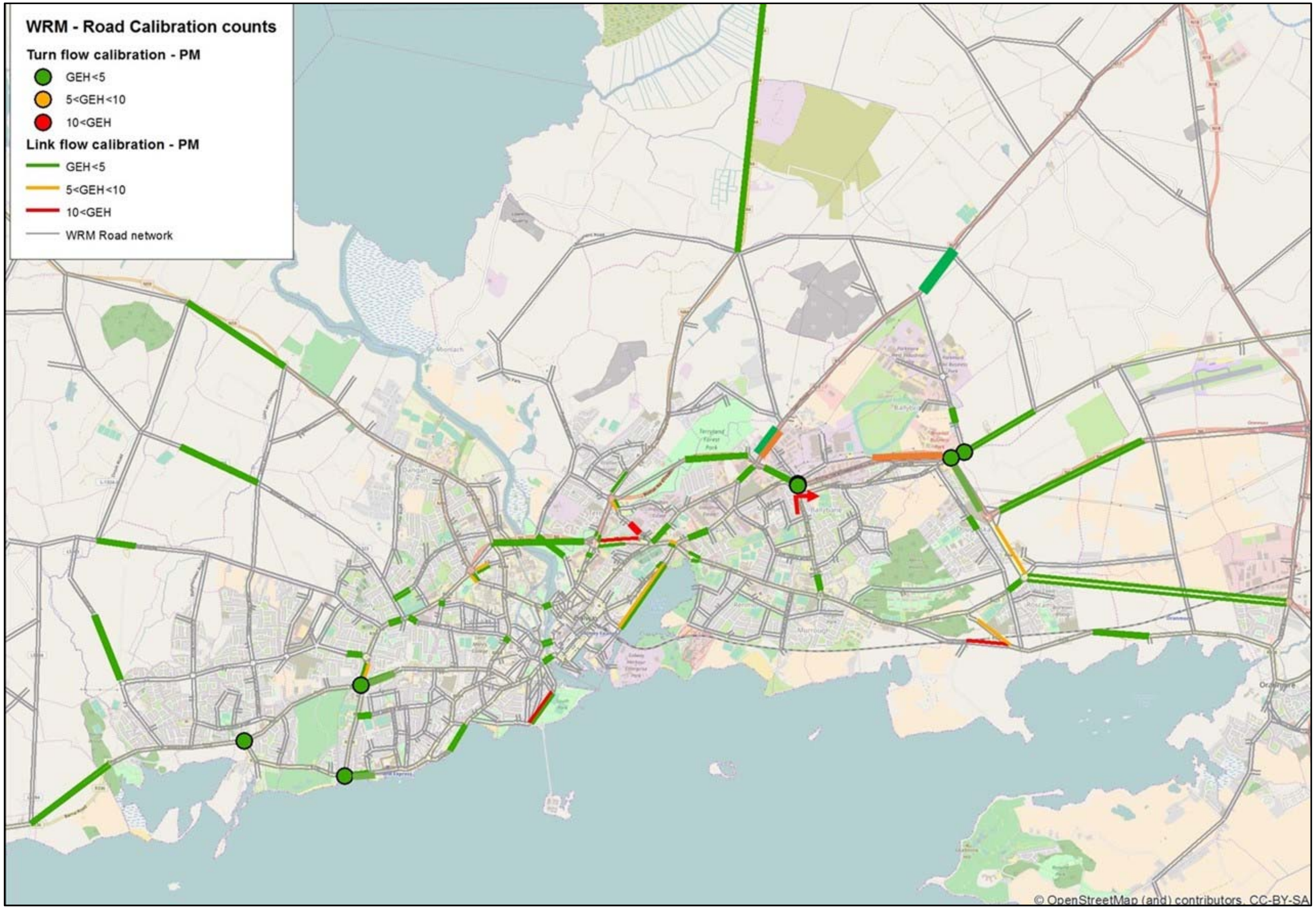


Figure 4.4.4: PM Calibration



4.5 Journey Time Validation

PAG (Unit 5.1 Table 5.1.3) says that modelled times along routes should be within 15% of surveyed times (or 1 minute if higher) for more than 85% of routes.

The journey time routes are shown in Figure 4.5.1. Tables 4.5.1 to 4.5.5 show the journey time validation for each route as a whole. In the morning peak 86% of routes satisfy the validation criteria, 86% and 91% meet the criteria in the inter-peak periods with 86% passing the criteria in the PM peak period.

The overall journey time in all peaks is within acceptable thresholds with some periods showing slightly faster overall journey times and some showing slightly slower overall journey times, which demonstrates that the model is not systematically biased towards being too fast or slow. The slightly lower journey times in the more congested morning and evening peaks are logical, as it can be difficult to replicate large observed delays in SATURN due to the assignment procedure's tendency to re-route traffic away from junctions with large delays.

Figure 4.5.1 shows the journey time routes used in the assessment. Data sample size for certain journey time routes (Routes 2 & 6 outbound and route 9 inbound) from the TomTom database was insufficient to provide full confidence in the observed results. Therefore, journey time comparisons were not undertaken on these routes. An additional check was carried out to validate the model distance against the TomTom distance for each route. The model distance was found to be within a few percent of the TomTom distance on all routes, which gives a high level of confidence in the model network and also demonstrates consistency between the model and observed data.

Figure 4.5.1: Journey Time Routes

Table 4.5.1: Journey Time Validation Summary

Criteria	TII PAG Criteria	Model Statistics
AM	> 85%	86%
IP 1	> 85%	86%
IP 2	> 85%	91%
PM	> 85%	86%

Table 4.5.2: Journey Time Validation AM Peak

Route	Observed (s)	Model (s)	Diff (s)	% Diff	Pass
Route 1 - Inbound	1058	981	-77	-7%	Y
Route 1 - Outbound	721	670	-51	-7%	Y
Route 2 - Inbound	1626	1288	-338	-21%	N
Route 3 - Inbound	502	263	-239	-48%	N
Route 3 - Outbound	230	258	28	12%	Y
Route 4a - Inbound	787	745	-42	-5%	Y
Route 4a - Outbound	820	724	-96	-12%	Y
Route 4b - Inbound	736	806	70	10%	Y
Route 4b - Outbound - Part 1	88	114	26	30%	Y
Route 5 - Inbound	1108	1012	-96	-9%	Y
Route 5 - Outbound	1100	971	-129	-12%	Y
Route 6 - Inbound	1024	901	-123	-12%	Y
Route 7 - Inbound	1438	1421	-17	-1%	Y
Route 7 - Outbound	1036	1038	2	0%	Y
Route 8 - Inbound	1167	1216	49	4%	Y
Route 8 - Outbound	591	557	-34	-6%	Y
Route 9 - Outbound	222	258	36	16%	Y
Route 10 - Inbound	595	640	45	8%	Y
Route 10 - Outbound	657	742	85	13%	Y
Route 11 - Inbound	1338	1152	-186	-14%	Y
Route 11 - Outbound	815	795	-20	-2%	Y
Route 4b - Outbound - Part 2	328	444	116	35%	N

Table 4.5.3: Journey Time Validation IP 1

Route	Observed (s)	Model (s)	Diff (s)	% Diff	Pass
Route 1 - Inbound	623	645	22	4%	Y
Route 1 - Outbound	616	643	27	4%	Y
Route 2 - Inbound	1157	1038	-119	-10%	Y
Route 3 - Inbound	211	254	43	20%	Y
Route 3 - Outbound	230	258	28	12%	Y
Route 4a - Inbound	564	617	53	9%	Y
Route 4a - Outbound	584	635	51	9%	Y
Route 4b - Inbound	475	518	43	9%	Y
Route 4b - Outbound - Part 1	90	113	23	26%	Y
Route 5 - Inbound	890	899	9	1%	Y
Route 5 - Outbound	907	946	39	4%	Y
Route 6 - Inbound	568	657	89	16%	N
Route 7 - Inbound	1154	1001	-153	-13%	Y
Route 7 - Outbound	993	1024	31	3%	Y
Route 8 - Inbound	793	633	-160	-20%	N
Route 8 - Outbound	636	557	-79	-12%	Y
Route 9 - Outbound	326	357	31	10%	Y
Route 10 - Inbound	355	415	60	17%	Y
Route 10 - Outbound	345	441	96	28%	N
Route 11 - Inbound	770	770	0	0%	Y
Route 11 - Outbound	707	792	85	12%	Y
Route 4b - Outbound - Part 2	344	404	60	17%	Y

Table 4.5.4: Journey Time Validation IP 2

Route	Observed (s)	Model (s)	Diff (s)	% Diff	Pass
Route 1 - Inbound	636	650	14	2%	Y
Route 1 - Outbound	738	650	-88	-12%	Y
Route 2 - Inbound	1219	1050	-169	-14%	Y
Route 3 - Inbound	227	254	27	12%	Y
Route 3 - Outbound	228	258	30	13%	Y
Route 4a - Inbound	678	613	-65	-10%	Y
Route 4a - Outbound	757	652	-105	-14%	Y
Route 4b - Inbound	487	508	21	4%	Y
Route 4b - Outbound - Part 1	104	188	84	81%	N
Route 5 - Inbound	995	897	-98	-10%	Y
Route 5 - Outbound	1054	991	-63	-6%	Y
Route 6 - Inbound	862	919	57	7%	Y
Route 7 - Inbound	1224	1260	36	3%	Y
Route 7 - Outbound	1228	1145	-83	-7%	Y
Route 8 - Inbound	910	677	-233	-26%	N
Route 8 - Outbound	749	642	-107	-14%	Y
Route 9 - Outbound	218.15	258	39.85	18%	Y
Route 10 - Inbound	403	425	22	5%	Y
Route 10 - Outbound	407	458	51	13%	Y
Route 11 - Inbound	802	756	-46	-6%	Y
Route 11 - Outbound	900	889	-11	-1%	Y
Route 4b - Outbound - Part 2	364	408	44	12%	Y

Table 4.5.5: Journey Time Validation PM

Route I.D.	Description	Observed (s)	Model (s)	Diff (s)	% Diff	Pass?
1	Route 1 - Inbound	649	659	10	2%	Y
2	Route 1 - Outbound	755	689	-66	-9%	Y
3	Route 2 - Inbound	1330	1161	-169	-13%	Y
5	Route 3 - Inbound	233	254	21	9%	Y
6	Route 3 - Outbound	231	259	28	12%	Y
7	Route 4a - Inbound	812	695	-117	-14%	Y
8	Route 4a - Outbound	999	771	-228	-23%	N
9	Route 4b - Inbound	513	542	29	6%	Y
10	Route 4b - Outbound - Part 1	71.57	90	18.43	26%	Y
11	Route 5 - Inbound	1240	1090	-150	-12%	Y
12	Route 5 - Outbound	1217	1071	-146	-12%	Y
13	Route 6 - Inbound	980	920	-60	-6%	Y
15	Route 7 - Inbound	1220	1212	-8	-1%	Y
16	Route 7 - Outbound	1148	1185	37	3%	Y
17	Route 8 - Inbound	1085	606	-479	-44%	N
18	Route 8 - Outbound	1148	772	-376	-33%	N
20	Route 9 - Outbound	321	358	37	12%	Y
21	Route 10 - Inbound	440	416	-24	-5%	Y
22	Route 10 - Outbound	472	461	-11	-2%	Y
23	Route 11 - Inbound	852	793	-59	-7%	Y
24	Route 11 - Outbound	1230	1041	-189	-15%	Y
25	Route 4b - Outbound - Part 2	496	442	-54	-11%	Y

4.6 Validation against Independent Counts

A set of counts were excluded from the counts used in matrix estimation so they could be used to carry out an independent check on the model to see how well the model flows match the observed counts.

Table 4.6.1 to 4.6.4 show the link count validation for the independent counts excluded from matrix estimation for each modelled time period. These tables show an excellent level of validation for all modelled time periods. Figures 4.6.1 to 4.6.4 represent the validation graphically.

Table 4.6.1: AM Traffic Flow Validation

Criteria	TII PAG Criteria	Model Statistics
Link Flow	> 85% of cases	90%
GEH < 5 for individual flows	> 85% of cases	85%
GEH < 7 for individual flows	N/A	90%
GEH < 10 for individual flows	N/A	100%

Table 4.6.2: IP 1 Traffic Flow Validation

Criteria	TII PAG Criteria	Model Statistics
Link Flow	> 85% of cases	80%
GEH < 5 for individual flows	> 85% of cases	90%
GEH < 7 for individual flows	N/A	95%
GEH < 10 for individual flows	N/A	100%

Table 4.6.3: IP 2 Traffic Flow Validation

Criteria	TII PAG Criteria	Model Statistics
Link Flow	> 85% of cases	90%
GEH < 5 for individual flows	> 85% of cases	90%
GEH < 7 for individual flows	N/A	100%
GEH < 10 for individual flows	N/A	100%

Table 4.6.4: PM Traffic Flow Validation

Criteria	TII PAG Criteria	Model Statistics
Link Flow	> 85% of cases	85%
GEH < 5 for individual flows	> 85% of cases	90%
GEH < 7 for individual flows	N/A	95%
GEH < 10 for individual flows	N/A	100%

Figure 4.6.1: AM Traffic Flow Validation

Figure 4.6.2: IP1 Traffic Flow Validation

Figure 4.6.3: IP2 Traffic Flow Validation

Figure 4.6.4: PM Traffic Flow Validation

4.7 Model Convergence

In assignment models, the assignment of demand onto a network alters the condition of the network (the level of congestion and hence the journey time). Therefore, the network state is recalculated after each assignment and the assignment is repeated until a stable condition is reached. The final assignment is defined as the point when the difference between subsequent assignments is below a specific threshold (convergence).

Tight highway assignment convergence is important in order to provide a robust appraisal. TII guidleines (Section 4.6 of PAG Unit 5.1) state that a base model should achieve a % Gap of <0.1%, where the % GAP is defined as:

"The difference between the costs along the chosen routes and those along the minimum cost routes, summed across the whole network, and expressed as a percentage of the minimum costs".

The convergence achieved in each of the GCRR **highway assignment** time periods is shown in the table below. This table indicates the level of convergence achieved considerably exceeds the recommended guidelines.

Table 4.7.1: Highway Assignment Convergence

Time Period	TII PAG Criteria	Model Convergence
AM	% Gap of <0.1%	0.03
IP1	% Gap of <0.1%	0.004
IP2	% Gap of <0.1%	0.01
PM	% Gap of <0.1%	0.01

4.8 Impact of Matrix Estimation on Trip Length Distribution

It is important to monitor the changes that matrix estimation makes to the prior matrix (pre matrix estimation matrices), in particular PAG recommends monitoring the changes to trip length distribution.

The tables below present the change in trip length distribution for all user classes, for each of the assigned model periods, as a result of matrix estimation. The tables show that the trip length distribution after matrix estimation matches the trip length distribution before matrix estimation excellently in both the AM and PM peak periods. a number of the user classes are seen to fall outside the 5% guidelines in the IP1 and IP2 periods. This is not considered significant and is a reasonable impact of the estimation process.

Table 4.8.1: Trip Length Distribution Analysis – AM

User Class (TAG Criteria)	Mean Percentage Change (< 5%)	Standard Deviation Change (< 5%)
Taxi	-2%	-2%
Car Employers Business	1%	2%
Car Commute	1%	4%
Car Education	2%	4%
Car Other	0%	1%
LGV	0%	0%
OGV1	0%	0%
OGV2 Permit Holder		
Other OGV2	0%	0%

Table 4.8.2: Trip Length Distribution Analysis – IP 1

User Class (TAG Criteria)	Mean Percentage Change (< 5%)	Standard Deviation Change (< 5%)
Taxi	-3%	-3%
Car Employers Business	-8%	-10%
Car Commute	-9%	-6%
Car Education	6%	6%
Car Other	-8%	-12%
LGV	0%	0%
OGV1	0%	0%
OGV2 Permit Holder		
Other OGV2	0%	0%

Table 4.8.3: Trip Length Distribution Analysis – IP 2

User Class (TAG Criteria)	Mean Percentage Change (< 5%)	Standard Deviation Change (< 5%)
Taxi	-3%	-3%
Car Employers Business	-6%	-5%
Car Commute	-3%	-2%
Car Education	-1%	-1%
Car Other	-4%	-6%
LGV	0%	0%
OGV1	0%	0%
OGV2 Permit Holder		
Other OGV2	0%	0%

Table 4.8.4: Trip Length Distribution Analysis – PM

User Class (TAG Criteria)	Mean Percentage Change (< 5%)	Standard Deviation Change (< 5%)
Taxi	-2%	-2%
Car Employers Business	-0%	2%
Car Commute	-0%	4%
Car Education	-3%	-3%
Car Other	0%	1%
LGV	0%	0%
OGV1	0%	0%
OGV2 Permit Holder		
Other OGV2	0%	0%

5 Future Year Model Development

5.1 Introduction

This section sets out the development of the future year WRM & GCRR models for the scheme opening year (2024) and design year (2039). These forecast years will be used for assessing the performance of the Scheme and for input into the design process.

5.2 Future Year Network Development

5.2.1 Core Tests

The future year 'Do-Minimum' network includes the 2012 base network plus all of the schemes (highway and PT) that are already built, or are committed, or likely to be built by 2024 and 2039. The list of schemes to be included was developed in coordination with Galway City Council, Galway County Council, TII and NTA and is included in Appendix E.

The future year 'Do-Something' networks include the Do-Minimum schemes plus the N6 GCRR. In addition to the validated 2012 base year network, the future year networks developed are:

- 2024 Opening Year Do-Minimum;
- 2024 Opening Year Do-Something;
- 2039 Design Year Do-Minimum; and
- 2039 Design Year Do-Something;

5.2.2 Galway Transport Strategy Sensitivity Test

In 2016 the National Transport Authority (NTA), in association with Galway City Council and Galway County Council, prepared the Galway Transport Strategy (GTS). The GTS sets down a framework for how Galway's transport network can be redefined to address existing transport issues as well as catering for the future development of the city.

In line with the aims and objectives of previous studies, the principal aim for the GTS is to seek to;

"Examine potential options to improve Galway's transport network and identify a package of measures whithin an agreed programme of infrastructural development which will enable the transport network of Galway City to serve travel demand in the most efficient, effective and sustainable manner"

The GTS outlines a host of proposed measures for active travel, public transport and general traffic in galway, to be implemented over a 20 year period. Some of the key proposals included in the Strategy are listed below:

- A Public Transport Corridor Through the City Centre with Public Transport Only allowed on the Salmon Weir Bridge, Eglington Street, College Road and Eyre Square;

- Localised City Centre Traffic Management proposals;
- An outer orbital route (N6 GCRR) to enhance resilience of the GTS;
- Rationalise Bus Route network and increase service frequencies;
- Provision for Park and Ride;
- Improved cycle network.

A full list of the proposals is contained within the GTS report in Appendix F.

In addition to the Core Scenarios tested (listed above) a further sensitivity test has also been carried out to assess the performance of the proposed N6 GCRR in conjunction with all of the active travel, public transport and highway infrastructure proposals included in the Galway Transport Strategy. As the GTS is a 20 year strategy, this sensitivity test has only been carried out in 2039, design year.

5.3 Future Year Matrix Development

5.3.1 Population and Employment Forecasts

During the inception of the N6 GCTP, it was agreed that a detailed approach to forecasting travel demand would be required, in order to capture the planned growth in population and employment at a local level in Galway. This approach required input from key stakeholders of the NTA, Galway County Council and Galway City Council.

The following forecast scenarios were agreed for use on this project:

- **Low:** NTA Reference Case- These are based on M2F2 Traditional (Scenario 1). The traditional scenario follows the Central Statistics Office (CSO) moderate path of seeing a return towards the 1996 patterns of inter-regional migration (specifically). The population in the West increases at a moderate pace of natural growth in line with the measured outflow of migrants (net) elsewhere.
- **Medium**: TII National Model Medium Growth Scenario; and
- **High:** TII National Model High Growth Scenario.

For the medium and high growth scenarios, TII population forecasts were taken at an ED level (smallest available) and distributed among the Census Small Areas and model zones based on a combination of the existing distribution and NTAs forecast distributions.

In the case of the Low Growth Scenario, the NTA applied a top-down approach to distribute the population forecasts across the census small areas (CSAs) within the WRM.

An assumption was made that the overall growth in employment would be in line with the population growth. This methodology is consistent with the approach adopted in the demographic forecasts for the NRA National Transport Model outlined in the NRA National Transport Model documentation, ‘Volume 3 – Demographic and Economic Forecasting Report’.

Regional Planning Guideline (RPG) values for future populations are targets rather than modelled projections and these targets are linked to implementation of regional and national policy. It was considered that their suitability for future extrapolation beyond 2022 as a 'High Scenario' presents many problems, not least of which would be the unqualified assumption that particular cornerstone policies will remain in effect at the same levels as were projected from 2009. It was concluded that the RPG forecasts were incompatible as an input for population projections for this study.

The tables below shows the population forecasts developed for this study for each of the growth scenarios.

Table 5.3.1: Population Forecasts – 2024

	NTA REF	TII Central	TII High
Galway City	78,939	76,762	77,081
Galway County	178,113	194,972	199,047
Total	**257,052**	**271,734**	**276,128**

Table 5.3.2: Population Forecasts – 2039

	NTA REF	TII Central	TII High
Galway City	83,339	77,666	78,304
Galway County	180,014	213,165	225,220
Total	**263,353**	**290,831**	**303,524**

5.3.2 Overview of Method to Develop Future Year Matrices

The process to develop future year matrices based on the demographic forecasts can be summarised as follows:

- Generate future year trip ends using the version of the National Trip End Model (NTEM) developed specifically for Regional Modelling Suite;
- Person Trip Ends are run through the WRM Demand Model to determine destination and mode choice;
- Future Year trips by mode are output from the WRM Demand Model.

5.4 Future Year Matrix Totals

A comparison of the morning peak hour trip matrix totals for the Base Year, 2024 Opening Year Do Minimum and 2039 Design Year, Do Something, scenarios are outlined in the tables below.

Table 5.4.1: Matrix Totals 2024 Opening Year

Morning Peak Hour Trips		
Scenario	**Trips**	**Growth**
Matrix Total - Base: 2012	**145,607**	**-**
Matrix Total - 2024 Low	153,014	5.1%
Matrix Total - 2024 Medium	157,351	8.1%
Matrix Total - 2024 High	157,985	8.5%

Table 5.4.2: Matrix Totals 2039 Design Year

Morning Peak Hour Trips		
Scenario	**Trips**	**Growth**
Matrix Total - Base: 2012	**145,607**	**-**
Matrix Total - 2039 Low	159,944	9.8%
Matrix Total - 2039 Medium	167,839	15.3%
Matrix Total - 2039 High	169,400	16.3%
Matrix Total - GTS 2039	167,248	14.9%

5.5 Future Year Matrix Analysis

The PAG requires a quantitative assessment of the impact of the traffic forecasting process to be undertaken upon the following criteria:

- Trip Length Distribution;
- Trip End Growth; and
- Zone to Zone Growth.

5.5.1 Trip Length Distribution

The graph below shows the change in trip length distribution between the 2012 Base and 2039 (Medium Growth) Do-Minimum, Design Year for car trips in the modelled time periods. The 2012 trip length distribution closely matches the 2039 Do-Minimum trip length distribution, however there has been a slight increase in the proportion of longer distance trips across the entire model area.

Figure 5.5.1: Change in Trip Length Distribution – Morning Peak Hour

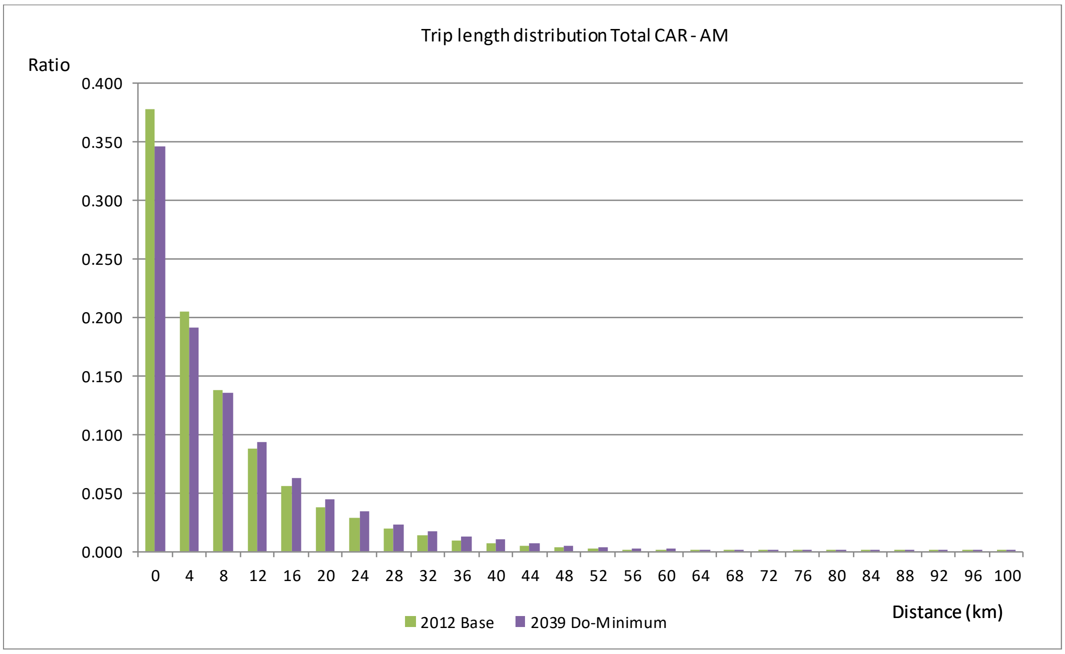


Figure 5.5.2: Change in Trip Length Distribution – IP 1

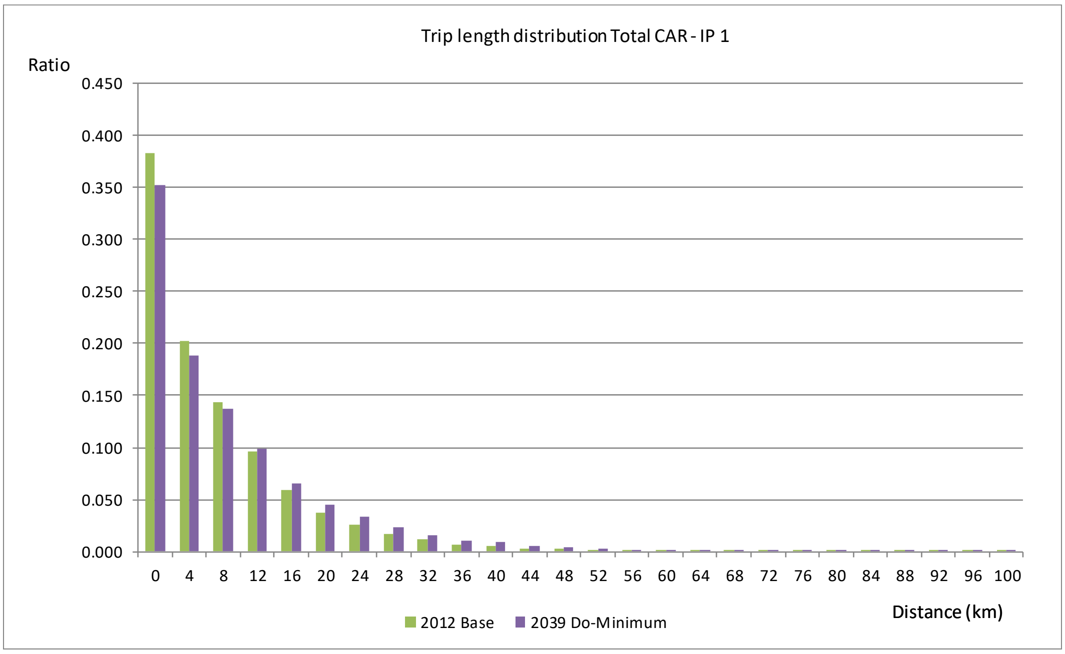


Figure 5.5.3: Change in Trip Length Distribution – IP 2

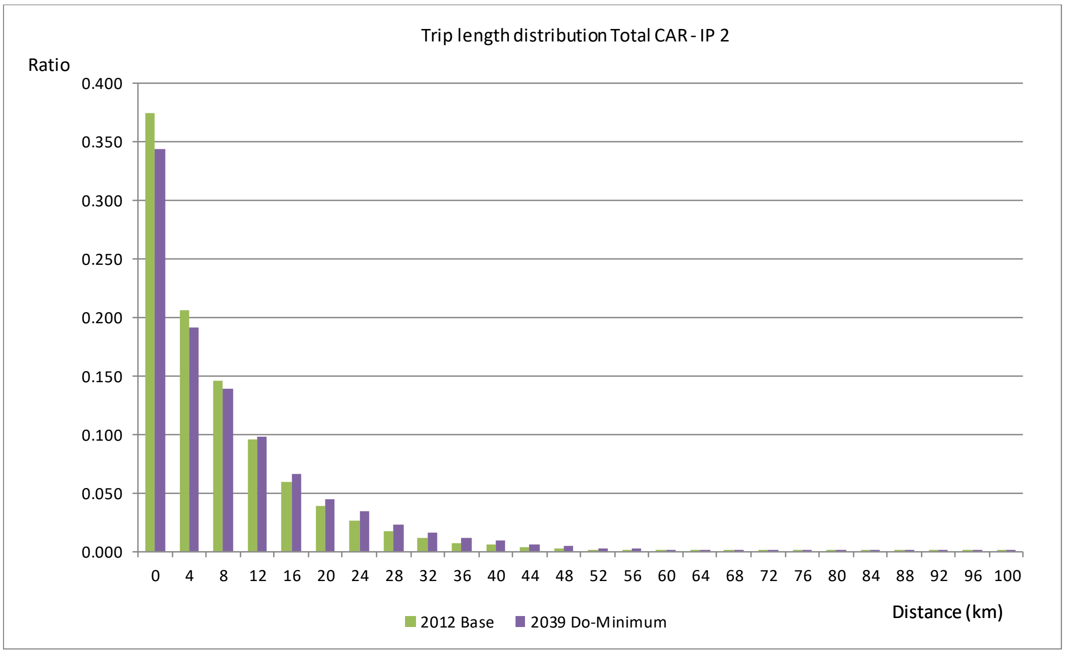
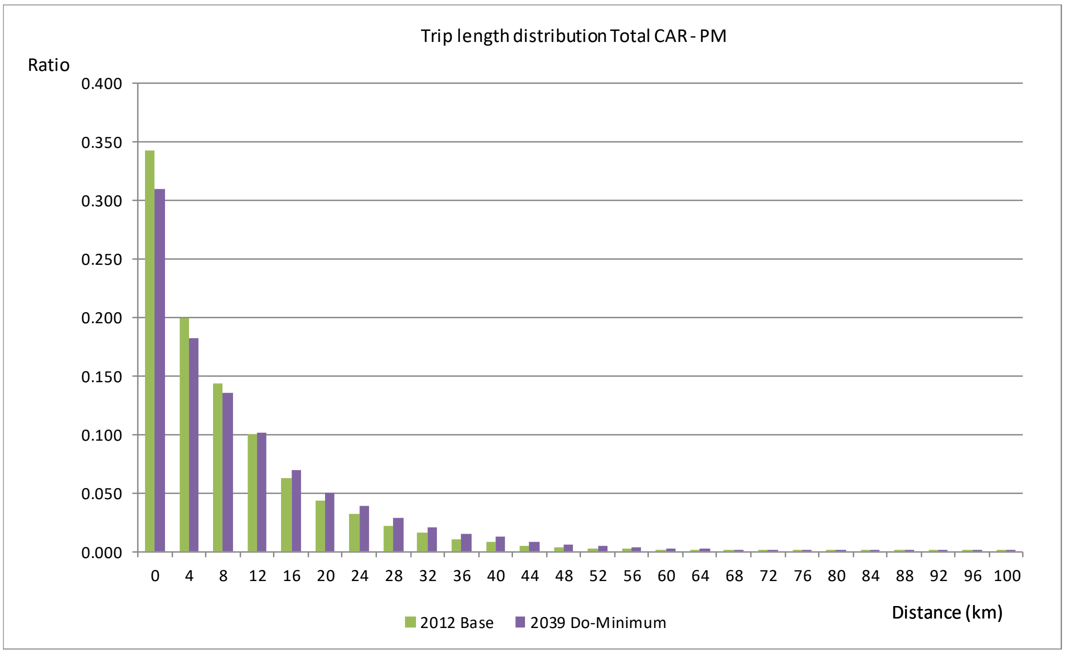


Figure 5.5.4: Change in Trip Length Distribution – PM



5.5.2 Trip End Growth

An assessment of the Trip End Growth (TEG) between the Base and Design Year demand in the Peak Hours was undertaken to assess if there were any significant changes in demand at trip end level when compared to the overall growth between the Base and Design Year demand.

The assessment indicated that the percentage increase between several trip ends in the Base and Design Year demand was significant but that the actual increase in the number of trips was only minor. In order to assess the true magnitude of TEG, the GEH statistic was applied to the Base and Design Year trip ends in order to take account of not only the difference between the Base and Design Year demand, but also the magnitude of the difference.

The Figures below illustrate the GEH between the Base and Design Year demand (Medium Growth) in the modelled time periods. The PAG guidance on the GEH statistic indicates that any GEH statistic above 10 warrants further investigation. The figures show that there are no zones with a GEH statistic above 10 in any of the time periods.

Figure 5.5.5: AM Trip End Growth (2012 to 2039)

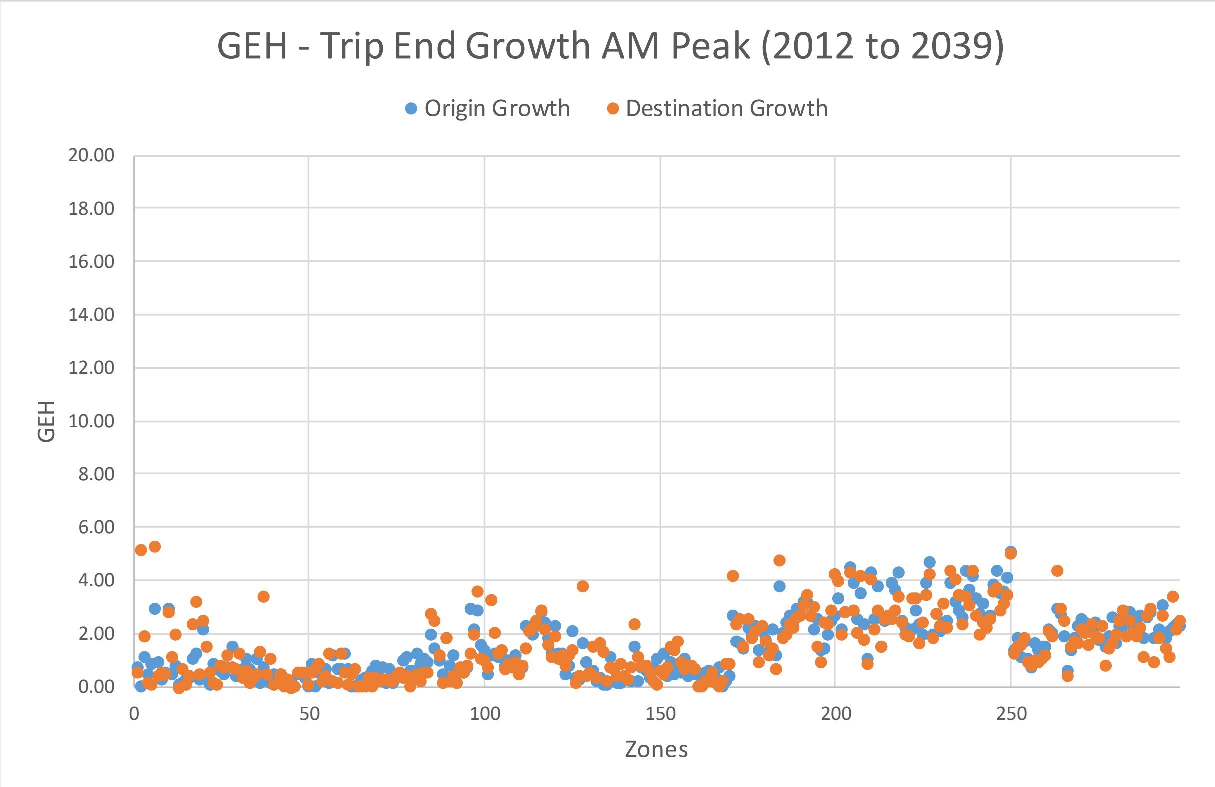


Figure 5.5.6: IP1 Trip End Growth (2012 to 2039)

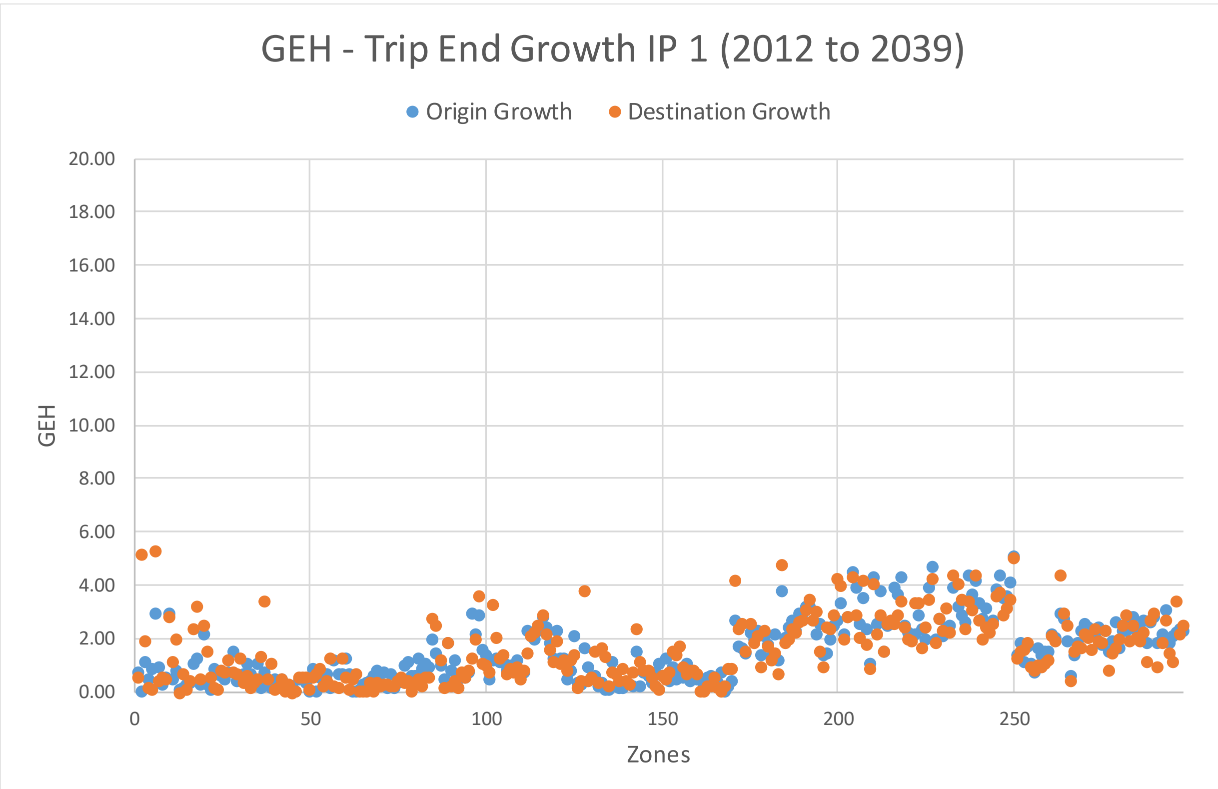


Figure 5.5.7: IP2 Trip End Growth (2012 to 2039)

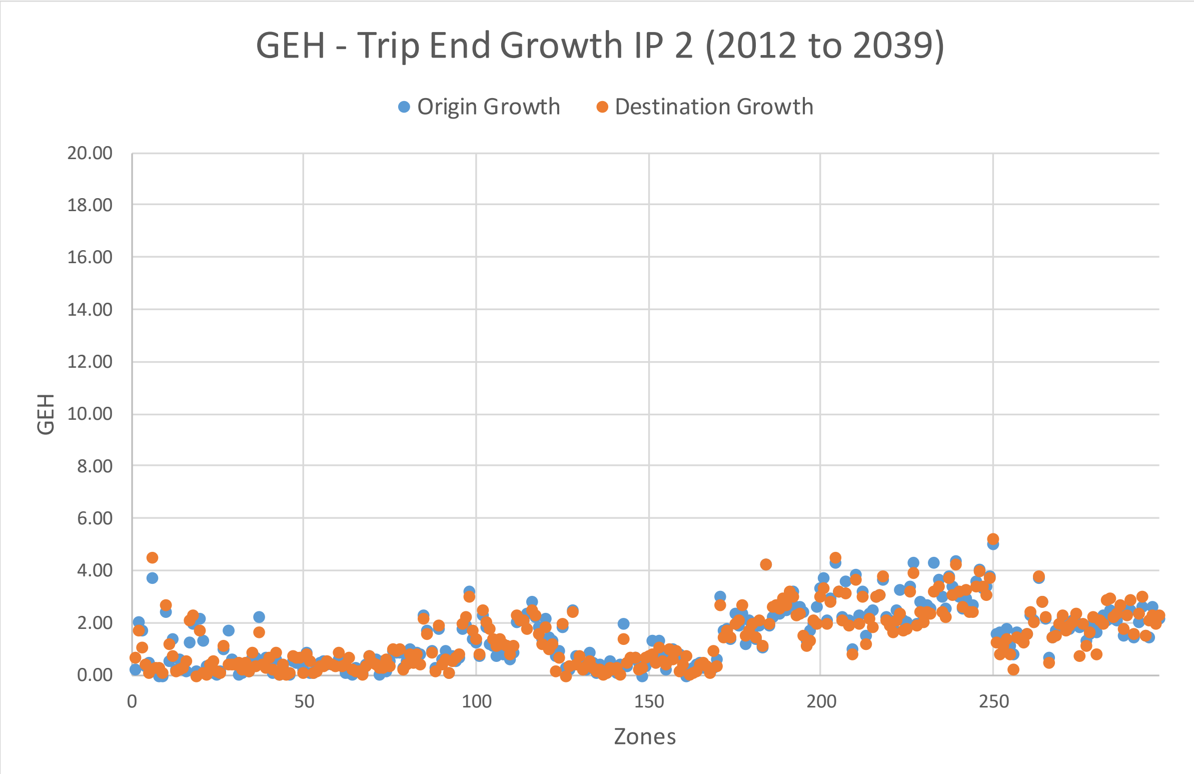
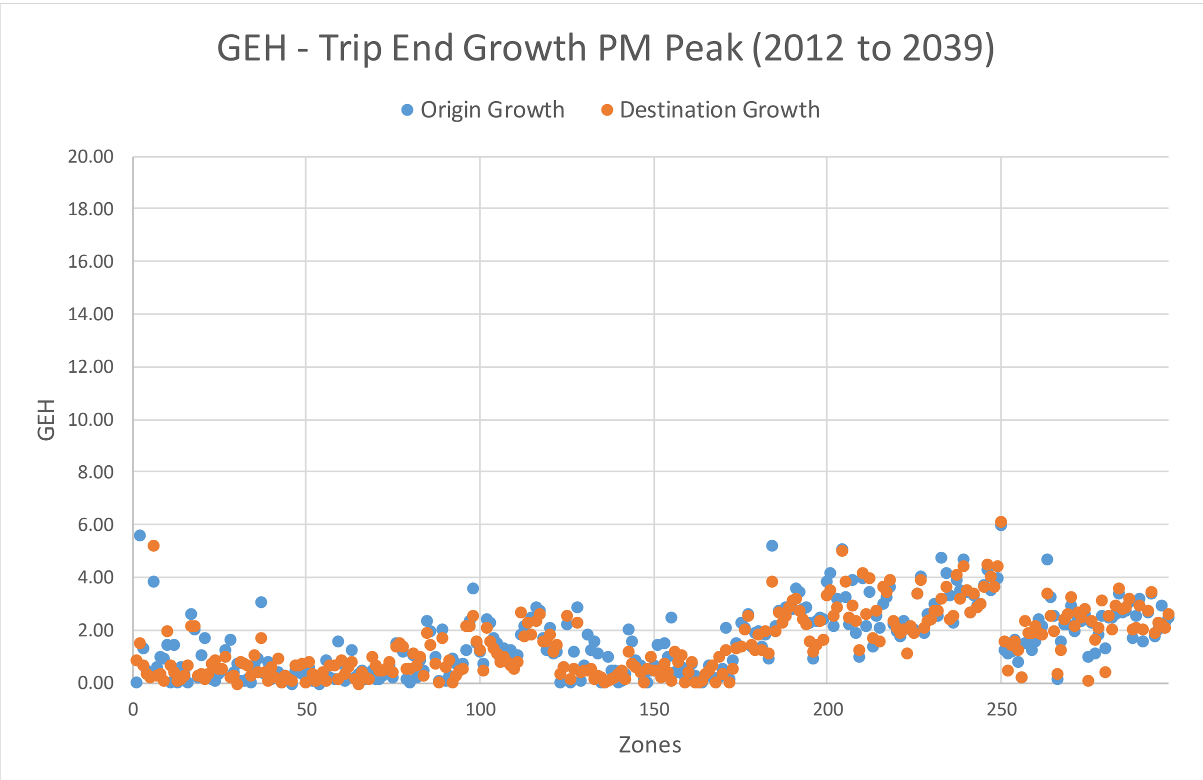


Figure 5.5.8: PM Trip End Growth (2012 to 2039)



5.5.3 Zone to Zone Growth

The same procedure for TEG was also undertaken for zone to zone growth. The GEH statistic for each origin-destination pair was assessed to show any significant outliers or issues in the modelled time periods.

The GEH statistic on a zone to zone basis for each period is shown in the Figures below.The graphs show that there are no GEH values greater than 10 in either Peak.

Figure 5.5.9: AM Zone to Zone Growth (2012 to 2039)

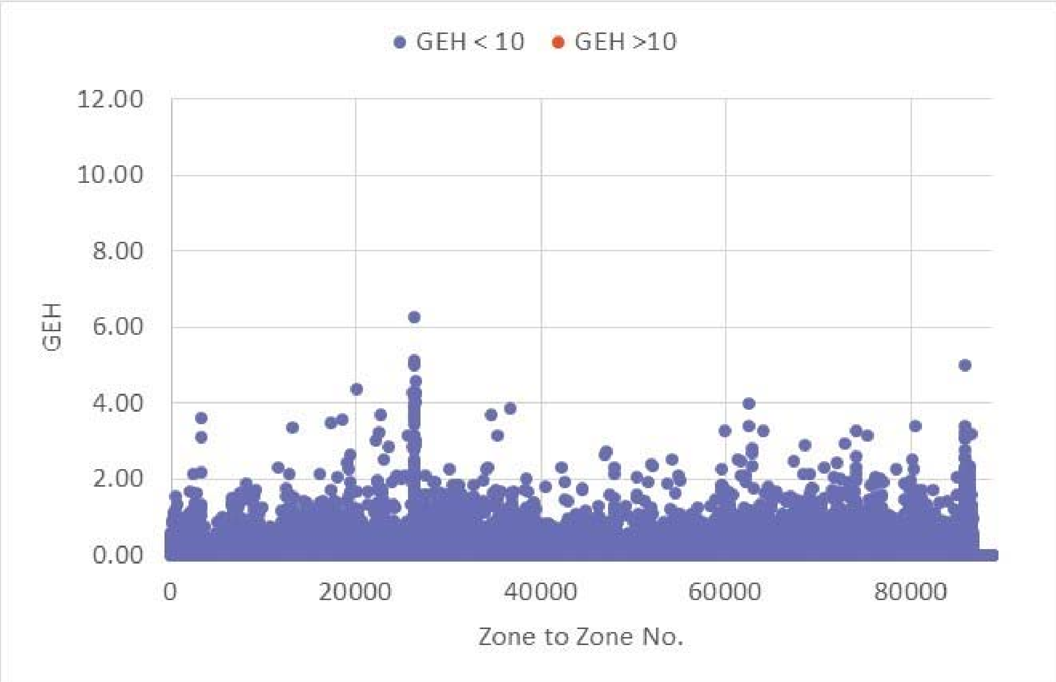


Figure 5.5.10: IP 1 Zone to Zone Growth (2012 to 2039)

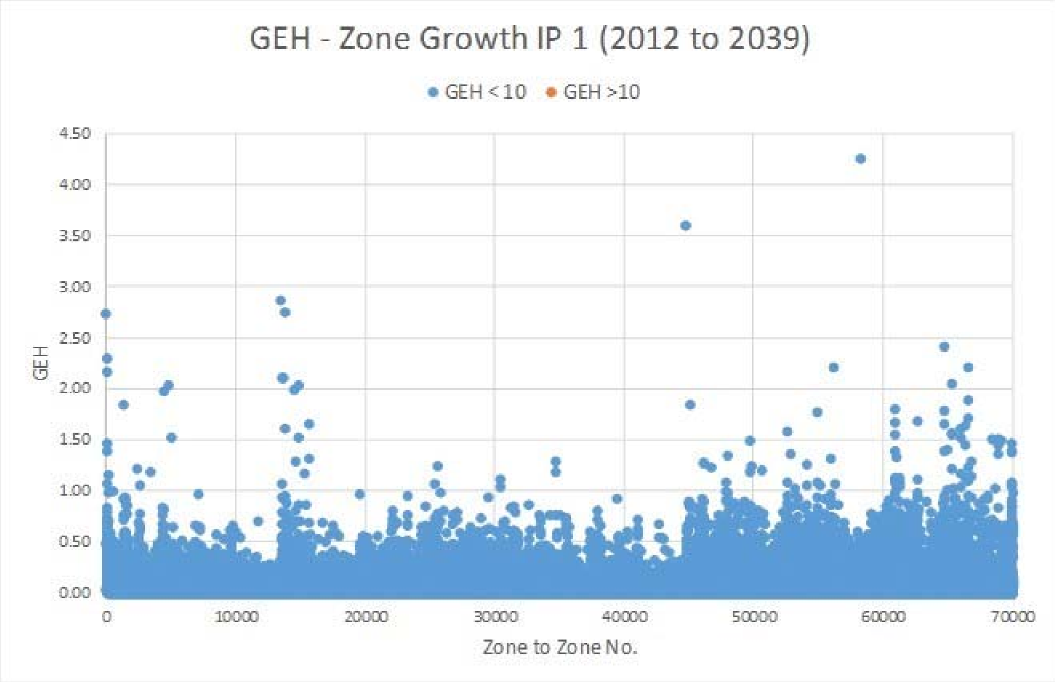


Figure 5.5.11: IP 2 Zone to Zone Growth (2012 to 2039)

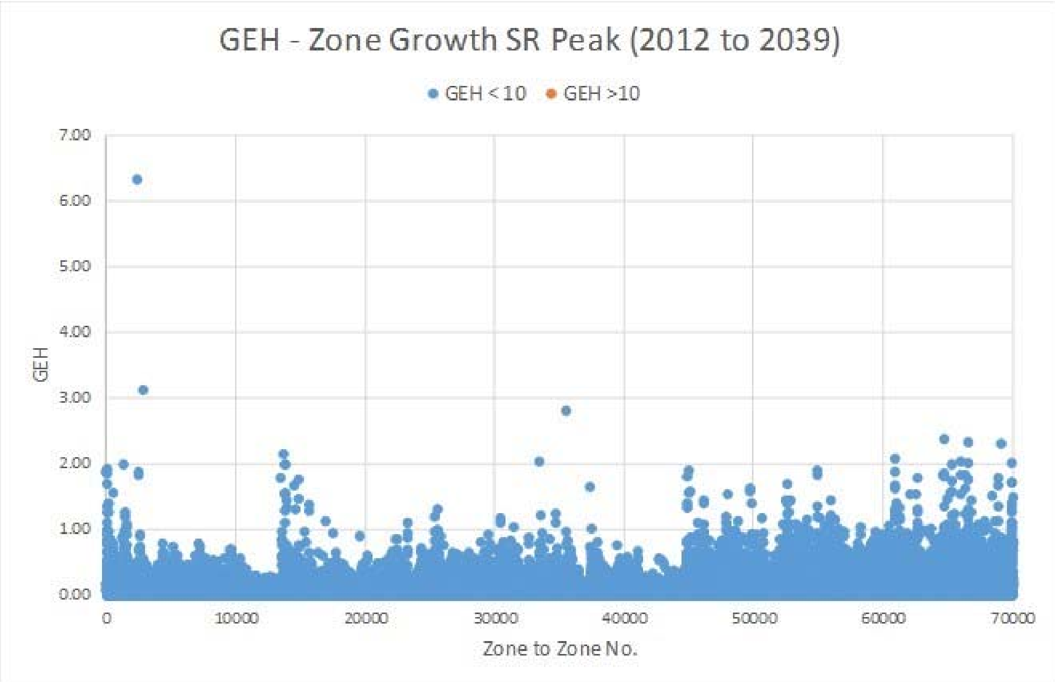
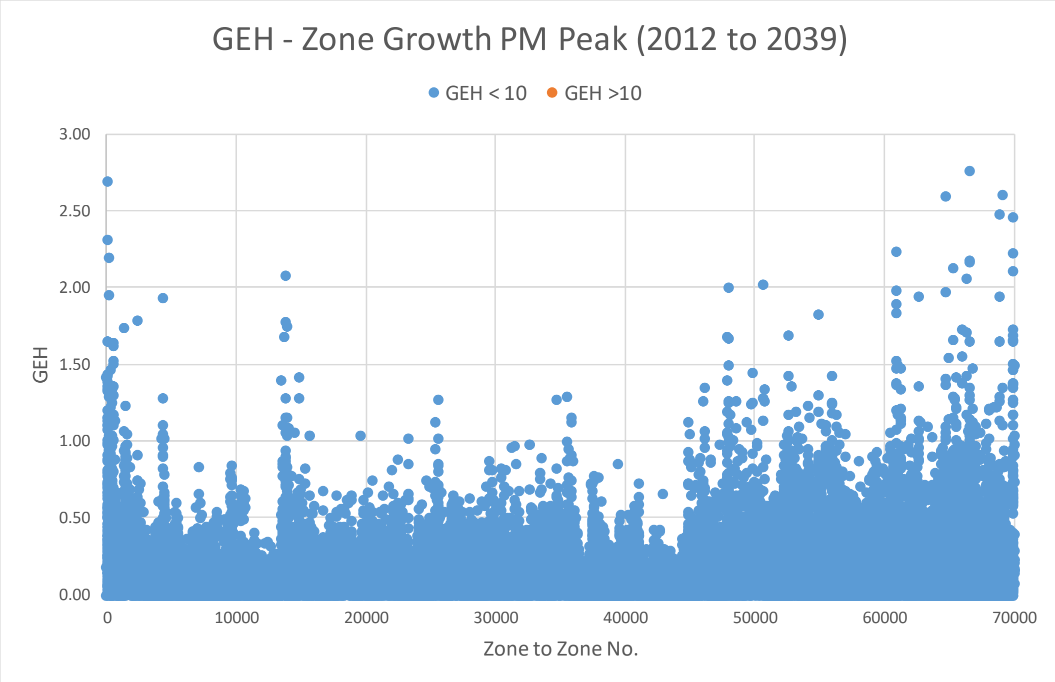


Figure 5.5.12: PM Zone to Zone Growth (2012 to 2039)



6 Analysis

6.1 Introduction

This section provides a summary of the performance of the preferred route option, based on the following analysis:

- Network Performance Indicators
- Journey Times
- V/C at major junctions
- Mode Share

The analysis presented in this section has been run through the demand model to take account of changes in transport costs, such as vehicle operating costs, values of time, congestion levels and the impact of Do-Minimum or Do-Something schemes.

Results presented in this chapter refer to the Central Case (Medium Growth Forecasts) only. Results for the Low and High Growth Sensititvity tests are included in Appendix H of this report.

6.2 Network Performance Indicators

Network performance indicators for the 2024 (Opening Year) and 2039 (Design Year) are outlined in the tables below, extracted from each of the model assignments.

6.2.1 Core Scenarios

The tables below demonstrate that the Do-Something (with N6 GCRR) Option reduces the network delay significantly relative to the Do-Minimum, and provides a faster average speed in all time periods in both the Opening and Design Year.

6.2.2 GTS Sensitivity Test

The full implementation of the Galway Transport Strategy (GTS) results in increased delay and slightly lower average speeds when compared to the "Do-Something" scenario of the same year. This increase in vehicular delay is caused by the implementation of a number of proposed active mode and public transport priority measures contained within the GTS (e.g. converting the Salmon Weir Bridge to Public Transport Only) which result in decreased highway capacity for general vehicular traffic in Galway City centre. However, the level of delay observed in this scenario is significantly lower than in the Do-Minimum Scenario of the same year. As with the Core Scenarios this is a result of the N6 GCRR relieving congestion in the city centre.

Table 6.2.1: Network Performance Indicators – Morning Peak Hour

Scenario	Total Vehicle Distance (pcu. Kms)	Total Network Travel Time (pcu. Hrs)	Total Network Delay (pcu. Hrs)	Average Vehicle Speed (kph)
2024 Do-Min	223,666	7,576	2,274	29.5
2024 Do-Something	258,719	6,798	1,505	38.1
2039 Do-Min	247,788	8,619	2,812	28.7
2039 Do-Something	294,178	7,611	1,738	38.7
2039 Galway Strategy	294,497	7,756	1,810	38

Table 6.2.2: Network Performance Indicators – IP 1

Scenario	Total Vehicle Distance (pcu. Kms)	Total Network Travel Time (pcu. Hrs)	Total Network Delay (pcu. Hrs)	Average Vehicle Speed (kph)
2024 Do-Min	148,147	4,321	920	34.3
2024 Do-Something	163,308	4,144	767	39.4
2039 Do-Min	171,081	5,039	1,171	33.9
2039 Do-Something	190,786	4,750	916	40.2
2039 Galway Strategy	192,388	4,932	1,009	39

Table 6.2.3: Network Performance Indicators – IP 2

Scenario	Total Vehicle Distance (pcu. Kms)	Total Network Travel Time (pcu. Hrs)	Total Network Delay (pcu. Hrs)	Average Vehicle Speed (kph)
2024 Do-Min	173,045	5,164	1,124	33.5
2024 Do-Something	192,752	5,023	980	38.4
2039 Do-Min	196,764	5,929	1,403	33.2
2039 Do-Something	223,715	5,731	1,189	39
2039 Galway Strategy	224,131	5,910	1,292	37.9

Table 6.2.4: Network Performance Indicators – Evening peak Hour

Scenario	Total Vehicle Distance (pcu. Kms)	Total Network Travel Time (pcu. Hrs)	Total Network Delay (pcu. Hrs)	Average Vehicle Speed (kph)
2024 Do-Min	206,659	6,669	1,824	31
2024 Do-Something	233,756	6,135	1,318	38.1
2039 Do-Min	230,010	7,774	2,453	29.6
2039 Do-Something	264,746	6,919	1,593	38.3
2039 Galway Strategy	266,632	7,128	1,720	37.4

6.3 Journey Times

To develop an understanding of the potential impact of the proposed N6 GCRR on key routes serving Galway, the projected change in vehicular journey times were assessed. Journey times represent a good basis for strategic traffic impact assessment as they provide a mechanism to quantify the traffic impact along a full route. This KPI will be based on a comparison between the 'Do Minimum' journey times (i.e. without the N6 GCRR) and the 'Do Something' journey times (i.e. with the N6 GCRR). Both the percentage change and absolute change in journey times (seconds) is considered in order to determine the impact, as shown in Table 6.3.1 below.

The journey time routes used for the assessment of impact are shown in Figure 6.3.1. This KPI, therefore, assesses the strategic traffic impact of the proposed Galway City Ring Road.

The impact scale used for journey times has been developed using the 2011 Census travel statistics for Galway and locally based traffic survey information. These CSO Census 2011 statistics state that the majority of journeys to work (62%) in Galway County took under 30 minutes and only 15% of workers faced a commuting time in excess of 45 minutes.

Table 6.3.1: Impact on Vehicle Journey Times

		Absolute Difference (seconds)			
		<60	60-120	120-240	>240
% Change	<5%	Negligible	Negligible	Minor	Moderate
	5-10%	Negligible	Minor	Moderate	Moderate
	10-20%	Minor	Minor	Moderate	Major
	>20%	Minor	Moderate	Major	Major

Green Box indicates a positive impact between the Do-Minimum and Do-Something Scenario

Figure 6.3.1: Jourey Time Routes

Table 6.3.1 can be interpreted as follows - the impact will be considered "Major" if the change in journey time, when comparing the 'Do Minimum' and 'Do Something' scenarios, is greater than 240 seconds and the percentage change is greater than 10% or the time increase is between 120 – 240 seconds and percentage change greater than 20%.

In situations where the journey times decrease, i.e. the change in journeys time when comparing the 'Do Minimum' to the 'Do Something' scenarios is negative; the impact will be described as 'Positive'.

Journey times on key routes have been considered in order to determine the traffic impacts on the strategic road network.

The impacts of the Galway City Ring Road, both at the strategic and at local levels, are rated as negligible, minor, moderate or major, as appropriate and these categories are described as follows:

- **Negligible:** effects that are of such low importance that they are not material to decision-making
- **Minor Significance:** effects that are of low importance in the decision-making process
- **Moderate Significance:** effects of the redevelopment that may be judged to be important at a local scale (i.e. in the planning context) only
- **Major Significance:** effects of the redevelopment which are of greater than local scale importance (i.e. strategic significance)

6.3.1 Core Scenarios

The tables below detail the results of the journey time comparison as extracted from the 2024 and 2039 traffic models for the medium growth test scenarios.

Table 6.3.2: 2024 AM Peak Journey Time Results

Route Description	2024 DM Seconds	2024 DM - Minutes	2024 DS Seconds	2024 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	1050	17.5	778	13.0	-272	-25.9%
Route 1 - Outbound	684	11.4	680	11.3	-4	-0.6%
Route 2 - Inbound	1334	22.2	1183	19.7	-151	-11.3%
Route 2 - Outbound	1196	19.9	1222	20.4	26	0
Route 3 - Inbound	433	7.2	305	5.1	-128	-29.6%
Route 3 - Outbound	259	4.3	266	4.4	7	2.7%
Route 4a - Inbound	725	12.1	669	11.2	-56	-7.7%
Route 4a - Outbound	804	13.4	678	11.3	-126	-15.7%
Route 4b - Inbound	1070	17.8	684	11.4	-386	-36.1%
Route 4b - Outbound	1065	17.8	704	11.7	-361	-33.9%
Route 5 - Inbound	1118	18.6	967	16.1	-151	-13.5%
Route 5 - Outbound	1159	19.3	1008	16.8	-151	-13.0%
Route 6 - Inbound	1077	18.0	1177	19.6	100	9.3%
Route 6 - Outbound	944	15.7	959	16.0	15	1.6%
Route 7 - Inbound	1358	22.6	1220	20.3	-138	-10.2%
Route 7 - Outbound	1264	21.1	1214	20.2	-50	-4.0%
Route 8 - Inbound	820	13.7	801	13.4	-19	-2.3%
Route 8 - Outbound	603	10.1	605	10.1	2	0.3%
Route 9 - Inbound	360	6.0	359	6.0	-1	-0.3%
Route 9 - Outbound	360	6.0	358	6.0	-2	-0.6%
Route 10 - Inbound	571	9.5	470	7.8	-101	-17.7%
Route 10 - Outbound	666	11.1	505	8.4	-161	-24.2%
Route 11 - Inbound	1292	21.5	972	16.2	-320	-24.8%
Route 11 - Outbound	1048	17.5	858	14.3	-190	-18.1%

Table 6.3.3: 2024 IP 1 Journey Time Results

Route Description	2024 DM Seconds	2024 DM - Minutes	2024 DS Seconds	2024 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	695	11.6	674	11.2	-21	-3.0%
Route 1 - Outbound	662	11.0	655	10.9	-7	-1.1%
Route 2 - Inbound	1047	17.5	1122	18.7	75	7.2%
Route 2 - Outbound	1106	18.4	1139	19.0	33	3.0%
Route 3 - Inbound	288	4.8	292	4.9	4	1.4%
Route 3 - Outbound	258	4.3	266	4.4	8	3.1%
Route 4a - Inbound	644	10.7	607	10.1	-37	-5.7%
Route 4a - Outbound	687	11.5	650	10.8	-37	-5.4%
Route 4b - Inbound	597	10.0	610	10.2	13	2.2%
Route 4b - Outbound	840	14.0	552	9.2	-288	-34.3%
Route 5 - Inbound	924	15.4	892	14.9	-32	-3.5%
Route 5 - Outbound	1088	18.1	959	16.0	-129	-11.9%
Route 6 - Inbound	960	16.0	980	16.3	20	0
Route 6 - Outbound	924	15.4	947	15.8	23	2.5%
Route 7 - Inbound	1053	17.6	1026	17.1	-27	-2.6%
Route 7 - Outbound	1245	20.8	1152	19.2	-93	-7.5%
Route 8 - Inbound	629	10.5	664	11.1	35	5.6%
Route 8 - Outbound	603	10.1	630	10.5	27	4.5%
Route 9 - Inbound	358	6.0	358	6.0	0	0.0%
Route 9 - Outbound	359	6.0	358	6.0	-1	-0.3%
Route 10 - Inbound	415	6.9	433	7.2	18	4.3%
Route 10 - Outbound	437	7.3	439	7.3	2	0.5%
Route 11 - Inbound	821	13.7	741	12.4	-80	-9.7%
Route 11 - Outbound	951	15.9	844	14.1	-107	-11.3%

Table 6.3.4: 2024 IP 2 Journey Time Results

Route Description	2024 DM Seconds	2024 DM - Minutes	2024 DS Seconds	2024 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	730	12.2	680	11.3	-50	-6.8%
Route 1 - Outbound	683	11.4	659	11.0	-24	-3.5%
Route 2 - Inbound	1076	17.9	1145	19.1	69	6.4%
Route 2 - Outbound	1139	19.0	1154	19.2	15	1.3%
Route 3 - Inbound	290	4.8	294	4.9	4	1.4%
Route 3 - Outbound	259	4.3	267	4.5	8	3.1%
Route 4a - Inbound	661	11.0	610	10.2	-51	-7.7%
Route 4a - Outbound	712	11.9	651	10.9	-61	-8.6%
Route 4b - Inbound	638	10.6	604	10.1	-34	-5.3%
Route 4b - Outbound	1078	18.0	569	9.5	-509	-47.2%
Route 5 - Inbound	963	16.1	893	14.9	-70	-7.3%
Route 5 - Outbound	1183	19.7	991	16.5	-192	-16.2%
Route 6 - Inbound	1047	17.5	1009	16.8	-38	-3.6%
Route 6 - Outbound	969	16.2	981	16.4	12	1.2%
Route 7 - Inbound	1101	18.4	1030	17.2	-71	-6.4%
Route 7 - Outbound	1421	23.7	1226	20.4	-195	-13.7%
Route 8 - Inbound	628	10.5	651	10.9	23	3.7%
Route 8 - Outbound	662	11.0	679	11.3	17	2.6%
Route 9 - Inbound	358	6.0	358	6.0	0	0.0%
Route 9 - Outbound	360	6.0	358	6.0	-2	-0.6%
Route 10 - Inbound	424	7.1	476	7.9	52	12.3%
Route 10 - Outbound	463	7.7	445	7.4	-18	-3.9%
Route 11 - Inbound	828	13.8	736	12.3	-92	-11.1%
Route 11 - Outbound	1183	19.7	932	15.5	-251	-21.2%

Table 6.3.5: 2024 PM Journey Time Results

Route Description	2024 DM Seconds	2024 DM - Minutes	2024 DS Seconds	2024 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	715	11.9	688	11.5	-27	-3.8%
Route 1 - Outbound	717	12.0	673	11.2	-44	-6.1%
Route 2 - Inbound	1137	19.0	1222	20.4	85	7.5%
Route 2 - Outbound	1163	19.4	1179	19.7	16	1.4%
Route 3 - Inbound	290	4.8	294	4.9	4	1.4%
Route 3 - Outbound	259	4.3	267	4.5	8	3.1%
Route 4a - Inbound	754	12.6	648	10.8	-106	-14.1%
Route 4a - Outbound	789	13.2	685	11.4	-104	-13.2%
Route 4b - Inbound	716	11.9	627	10.5	-89	-12.4%
Route 4b - Outbound	1154	19.2	644	10.7	-510	-44.2%
Route 5 - Inbound	1128	18.8	1004	16.7	-124	-11.0%
Route 5 - Outbound	1160	19.3	1040	17.3	-120	-10.3%
Route 6 - Inbound	1093	18.2	1020	17.0	-73	-6.7%
Route 6 - Outbound	1006	16.8	1030	17.2	24	2.4%
Route 7 - Inbound	1141	19.0	1061	17.7	-80	-7.0%
Route 7 - Outbound	1495	24.9	1313	21.9	-182	-12.2%
Route 8 - Inbound	619	10.3	633	10.6	14	2.3%
Route 8 - Outbound	797	13.3	838	14.0	41	5.1%
Route 9 - Inbound	359	6.0	359	6.0	0	0.0%
Route 9 - Outbound	360	6.0	359	6.0	-1	-0.3%
Route 10 - Inbound	510	8.5	424	7.1	-86	-16.9%
Route 10 - Outbound	491	8.2	476	7.9	-15	-3.1%
Route 11 - Inbound	851	14.2	736	12.3	-115	-13.5%
Route 11 - Outbound	1325	22.1	1023	17.1	-302	-22.8%

The 2024 AM Peak results show that, in general, the opening of the N6 Galway City Ring Road has a significantly positive impact on the majority of Journey Time routes analysed.

A number of routes (2, 3, 6) show negligible impacts, with increases in journey times of less than 60 seconds across the entire route. Route 6 Inbound experiences a minor impact, where the journey time has increased by 100 seconds across the entire route. These increases are caused by the addition of signalised junctions, for example the N59 Link Road Junctions, which require traffic to slow down where previously it was not necessary.

In this regard it should be noted that the impact of the N6 GCRR is hugely beneficial for reducing traffic congestion in Galway City in the AM Peak and for reducing journey times.

The 2024 PM Peak results show that, similar to the AM peak, the opening of the N6 Galway City Ring Road has a significantly positive impact on the majority of Journey Time routes analysed.

As with the AM peak number of routes show negligible or minor impacts, with relatively small (less than 2 minute) increases across the entire route. These increases are as a result of new signalised junctions, related to the N6 GCRR, requiring traffic to slow down where previously it was not necessary.

The introduction of the N6 GCRR significantly reduces traffic congestion and average journey times in Galway City in the PM Peak.

Journey time results for the inter peak periods demonstrate the same pattern as the AM and PM peaks, with positive impacts seen across the majority of routes analysed. Any increases in journey times are negligible in nature.

Table 6.3.6: 2039 AM Peak Journey Time Results

Route Description	2039 DM Seconds	2039 DM - Minutes	2039 DS Seconds	2039 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	1107	18.6	841	13.2	-266	-24.0%
Route 1 - Outbound	688	11.6	680	11.4	-8	-1.2%
Route 2 - Inbound	1376	23.0	1209	20.3	-167	-12.1%
Route 2 - Outbound	1221	20.5	1255	21.7	34	0
Route 3 - Inbound	465	8.0	315	5.3	-150	-32.3%
Route 3 - Outbound	259	4.3	267	4.5	8	3.1%
Route 4a - Inbound	729	12.2	680	11.5	-49	-6.7%
Route 4a - Outbound	827	15.9	683	11.4	-144	-17.4%
Route 4b - Inbound	1212	21.1	770	13.8	-442	-36.5%
Route 4b - Outbound	1105	20.0	707	11.9	-398	-36.0%
Route 5 - Inbound	1268	23.3	1016	17.9	-252	-19.9%
Route 5 - Outbound	1182	22.1	1029	18.4	-153	-12.9%
Route 6 - Inbound	1089	18.1	1110	18.8	21	1.9%
Route 6 - Outbound	956	15.9	978	16.4	22	2.3%
Route 7 - Inbound	1502	27.3	1270	22.5	-232	-15.4%
Route 7 - Outbound	1321	24.2	1257	20.9	-64	-4.8%
Route 8 - Inbound	952	18.7	846	16.7	-106	-11.1%
Route 8 - Outbound	609	10.9	611	9.9	2	0.3%
Route 9 - Inbound	361	6.0	359	6.0	-2	-0.6%
Route 9 - Outbound	360	6.0	358	6.0	-2	-0.6%
Route 10 - Inbound	593	11.1	487	7.6	-106	-17.9%
Route 10 - Outbound	667	11.9	511	16.9	-156	-23.4%
Route 11 - Inbound	1495	27.1	1061	18.5	-434	-29.0%
Route 11 - Outbound	1109	20.9	895	15.8	-214	-19.3%

Table 6.3.7: 2039 IP 1 Journey Time Results

Route Description	2039 DM Seconds	2039 DM - Minutes	2039 DS Seconds	2039 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	712	11.9	679	11.3	-33	-4.6%
Route 1 - Outbound	667	11.1	657	11.0	-10	-1.5%
Route 2 - Inbound	1056	17.6	1129	18.8	73	6.9%
Route 2 - Outbound	1114	18.6	1146	19.1	32	2.9%
Route 3 - Inbound	289	4.8	293	4.9	4	1.4%
Route 3 - Outbound	258	4.3	266	4.4	8	3.1%
Route 4a - Inbound	664	11.1	613	10.2	-51	-7.7%
Route 4a - Outbound	700	11.7	653	10.9	-47	-6.7%
Route 4b - Inbound	639	10.7	617	10.3	-22	-3.4%
Route 4b - Outbound	958	16.0	571	9.5	-387	-40.4%
Route 5 - Inbound	968	16.1	902	15.0	-66	-6.8%
Route 5 - Outbound	1162	19.4	988	16.5	-174	-15.0%
Route 6 - Inbound	964	16.1	989	16.5	25	2.6%
Route 6 - Outbound	930	15.5	962	16.0	32	3.4%
Route 7 - Inbound	1073	17.9	1046	17.4	-27	-2.5%
Route 7 - Outbound	1456	24.3	1207	20.1	-249	-17.1%
Route 8 - Inbound	638	10.6	690	11.5	52	8.2%
Route 8 - Outbound	618	10.3	657	11.0	39	6.3%
Route 9 - Inbound	358	6.0	358	6.0	0	0.0%
Route 9 - Outbound	360	6.0	358	6.0	-2	-0.6%
Route 10 - Inbound	415	6.9	435	7.3	20	4.8%
Route 10 - Outbound	439	7.3	438	7.3	-1	-0.2%
Route 11 - Inbound	880	14.7	800	13.3	-80	-9.1%
Route 11 - Outbound	1064	17.7	900	15.0	-164	-15.4%

Table 6.3.8: 2039 IP 2 Journey Time Results

Route Description	2039 DM Seconds	2039 DM - Minutes	2039 DS Seconds	2039 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	730	12.2	686	11.4	-44	-6.0%
Route 1 - Outbound	683	11.4	661	11.0	-22	-3.2%
Route 2 - Inbound	1076	17.9	1165	19.4	89	8.3%
Route 2 - Outbound	1139	19.0	1161	19.4	22	1.9%
Route 3 - Inbound	290	4.8	295	4.9	5	1.7%
Route 3 - Outbound	259	4.3	267	4.5	8	3.1%
Route 4a - Inbound	661	11.0	615	10.3	-46	-7.0%
Route 4a - Outbound	712	11.9	655	10.9	-57	-8.0%
Route 4b - Inbound	638	10.6	619	10.3	-19	-3.0%
Route 4b - Outbound	1078	18.0	594	9.9	-484	-44.9%
Route 5 - Inbound	963	16.1	903	15.1	-60	-6.2%
Route 5 - Outbound	1183	19.7	1028	17.1	-155	-13.1%
Route 6 - Inbound	1047	17.5	1024	17.1	-23	-2.2%
Route 6 - Outbound	969	16.2	1016	16.9	47	4.9%
Route 7 - Inbound	1101	18.4	1048	17.5	-53	-4.8%
Route 7 - Outbound	1421	23.7	1261	21.0	-160	-11.3%
Route 8 - Inbound	628	10.5	672	11.2	44	7.0%
Route 8 - Outbound	662	11.0	694	11.6	32	4.8%
Route 9 - Inbound	358	6.0	358	6.0	0	0.0%
Route 9 - Outbound	360	6.0	359	6.0	-1	-0.3%
Route 10 - Inbound	424	7.1	469	7.8	45	10.6%
Route 10 - Outbound	463	7.7	444	7.4	-19	-4.1%
Route 11 - Inbound	828	13.8	786	13.1	-42	-5.1%
Route 11 - Outbound	1183	19.7	998	16.6	-185	-15.6%

Table 6.3.9: 2039 PM Peak Journey Time Results

Route Description	2039 DM Seconds	2039 DM - Minutes	2039 DS Seconds	2039 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	731	12.2	691	11.5	-40	-5.5%
Route 1 - Outbound	738	12.3	677	11.3	-61	-8.3%
Route 2 - Inbound	1189	19.8	1308	21.8	119	10.0%
Route 2 - Outbound	1190	19.8	1183	19.7	-7	-0.6%
Route 3 - Inbound	291	4.9	295	4.9	4	1.4%
Route 3 - Outbound	259	4.3	268	4.5	9	3.5%
Route 4a - Inbound	790	13.2	685	11.4	-105	-13.3%
Route 4a - Outbound	1557	26.0	689	11.5	-868	-55.7%
Route 4b - Inbound	772	12.9	633	10.6	-139	-18.0%
Route 4b - Outbound	779	13.0	688	11.5	-91	-11.7%
Route 5 - Inbound	1189	19.8	1020	17.0	-169	-14.2%
Route 5 - Outbound	1271	21.2	1070	17.8	-201	-15.8%
Route 6 - Inbound	1097	18.3	1040	17.3	-57	-5.2%
Route 6 - Outbound	1027	17.1	1080	18.0	53	5.2%
Route 7 - Inbound	1169	19.5	1063	17.7	-106	-9.1%
Route 7 - Outbound	1663	27.7	1440	24.0	-223	-13.4%
Route 8 - Inbound	624	10.4	638	10.6	14	2.2%
Route 8 - Outbound	899	15.0	918	15.3	19	2.1%
Route 9 - Inbound	359	6.0	359	6.0	0	0.0%
Route 9 - Outbound	361	6.0	360	6.0	-1	-0.3%
Route 10 - Inbound	598	10.0	424	7.1	-174	-29.1%
Route 10 - Outbound	534	8.9	489	8.2	-45	-8.4%
Route 11 - Inbound	946	15.8	761	12.7	-185	-19.6%
Route 11 - Outbound	1620	27.0	1124	18.7	-496	-30.6%

The 2039 results show a similar pattern to the 2024 results discussed previously. In general, the opening of the N6 Galway City Ring Road has a significantly positive impact on the majority of Journey Time routes analysed in all 2039 modelled periods.

A small number of routes show negligible or minor impacts, with increases in journey times of less than 120 seconds across the entire route. These increases are caused by the addition of new signalised junctions, requiring traffic to slow down where previously it was not necessary.

6.3.2 GTS Sensitivity Test

The tables below outline the results of the journey time comparison as extracted from the traffic model for the 2039 Galway Transport Strategy Sensitivity Test.

These results show a similar pattern to the Core Tests discussed above. In general, the opening of the N6 Galway City Ring Road, in conjunction with the other measures propsed in the GTS, has a positive impact on the majority of Journey Time routes analysed, particularly in the AM and PM peak periods.

The results below show more negative impacts on journey times than the DS Core tests. The reason for this is that the GTS contains a number of proposals which limit capacity on the city centre network, as a result of increased active mode and public transport priority measures in the city centre, and therefore adds delay to certain sections of the network. Also, traffic management arrangements proposed in the GTS result in the lengthening of some journey time routes which in turn adds to the total journey times.

Table 6.3.10: 2039 GTS AM Peak Journey Time Results

Route Description	2039 DM Seconds	2039 DM - Minutes	2039 GTS Seconds	2039 GTS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	1107	18.6	900	15.0	-207	-18.7%
Route 1 - Outbound	688	11.6	685	11.4	-3	-0.4%
Route 2 - Inbound	1376	23.0	1245	20.8	-131	-9.5%
Route 2 - Outbound	1221	20.5	1421	23.7	200	16.4%
Route 3 - Inbound	465	8.0	411	6.9	-54	-11.6%
Route 3 - Outbound	259	4.3	427	7.1	168	64.9%
Route 4a - Inbound	729	12.2	682	11.4	-47	-6.4%
Route 4a - Outbound	827	15.9	724	12.1	-103	-12.5%
Route 4b - Inbound	1212	21.1	767	12.8	-445	-36.7%
Route 4b - Outbound	1105	20.0	662	11.0	-443	-40.1%
Route 5 - Inbound	1268	23.3	1063	17.7	-205	-16.2%
Route 5 - Outbound	1182	22.1	1176	19.6	-6	-0.5%
Route 6 - Inbound	1089	18.1	1066	17.8	-23	0
Route 6 - Outbound	956	15.9	1009	16.8	53	5.5%
Route 7 - Inbound	1502	27.3	1237	20.6	-265	-17.6%
Route 7 - Outbound	1321	24.2	1270	21.2	-51	-3.9%
Route 8 - Inbound	952	18.7	935	15.6	-17	-1.8%
Route 8 - Outbound	609	10.9	635	10.6	26	4.3%
Route 9 - Inbound	361	6.0	359	6.0	-2	-0.6%
Route 9 - Outbound	360	6.0	358	6.0	-2	-0.6%
Route 10 - Inbound	593	11.1	481	8.0	-112	-18.9%
Route 10 - Outbound	667	11.9	715	11.9	48	7.2%
Route 11 - Inbound	1495	27.1	1008	16.8	-487	-32.6%
Route 11 - Outbound	1109	20.9	903	15.1	-206	-18.6%

Table 6.3.11: 2039 GTS IP 1 Journey Time Results

Route Description	2039 DM Seconds	2039 DM - Minutes	2039 GTS Seconds	2039 GTS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	712	11.9	702	11.7	-10	-1.4%
Route 1 - Outbound	667	11.1	676	11.3	9	1.3%
Route 2 - Inbound	1056	17.6	1216	20.3	160	15.2%
Route 2 - Outbound	1114	18.6	1260	21.0	146	13.1%
Route 3 - Inbound	289	4.8	403	6.7	114	39.4%
Route 3 - Outbound	258	4.3	427	7.1	169	65.5%
Route 4a - Inbound	664	11.1	635	10.6	-29	-4.4%
Route 4a - Outbound	700	11.7	687	11.5	-13	-1.9%
Route 4b - Inbound	639	10.7	602	10.0	-37	-5.8%
Route 4b - Outbound	958	16.0	628	10.5	-330	-34.4%
Route 5 - Inbound	968	16.1	1018	17.0	50	5.2%
Route 5 - Outbound	1162	19.4	1187	19.8	25	2.2%
Route 6 - Inbound	964	16.1	1009	16.8	45	4.7%
Route 6 - Outbound	930	15.5	1028	17.1	98	10.5%
Route 7 - Inbound	1073	17.9	1038	17.3	-35	-3.3%
Route 7 - Outbound	1456	24.3	1257	21.0	-199	-13.7%
Route 8 - Inbound	638	10.6	688	11.5	50	7.8%
Route 8 - Outbound	618	10.3	702	11.7	84	13.6%
Route 9 - Inbound	358	6.0	358	6.0	0	0.0%
Route 9 - Outbound	360	6.0	358	6.0	-2	-0.6%
Route 10 - Inbound	415	6.9	417	7.0	2	0.5%
Route 10 - Outbound	439	7.3	448	7.5	9	2.1%
Route 11 - Inbound	880	14.7	854	14.2	-26	-3.0%
Route 11 - Outbound	1064	17.7	885	14.8	-179	-16.8%

Table 6.3.12: 2039 GTS IP 2 Journey Time Results

Route Description	2039 DM Seconds	2039 DM - Minutes	2039 GTS Seconds	2039 GTS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	730	12.2	721	12.0	-9	-1.2%
Route 1 - Outbound	683	11.4	696	11.6	13	1.9%
Route 2 - Inbound	1076	17.9	1251	20.9	175	16.3%
Route 2 - Outbound	1139	19.0	1276	21.3	137	12.0%
Route 3 - Inbound	290	4.8	406	6.8	116	40.0%
Route 3 - Outbound	259	4.3	427	7.1	168	64.9%
Route 4a - Inbound	661	11.0	636	10.6	-25	-3.8%
Route 4a - Outbound	712	11.9	687	11.5	-25	-3.5%
Route 4b - Inbound	638	10.6	607	10.1	-31	-4.9%
Route 4b - Outbound	1078	18.0	633	10.6	-445	-41.3%
Route 5 - Inbound	963	16.1	1028	17.1	65	6.7%
Route 5 - Outbound	1183	19.7	1228	20.5	45	3.8%
Route 6 - Inbound	1047	17.5	1049	17.5	2	0.2%
Route 6 - Outbound	969	16.2	1076	17.9	107	11.0%
Route 7 - Inbound	1101	18.4	1047	17.5	-54	-4.9%
Route 7 - Outbound	1421	23.7	1372	22.9	-49	-3.4%
Route 8 - Inbound	628	10.5	681	11.4	53	8.4%
Route 8 - Outbound	662	11.0	756	12.6	94	14.2%
Route 9 - Inbound	358	6.0	358	6.0	0	0.0%
Route 9 - Outbound	360	6.0	358	6.0	-2	-0.6%
Route 10 - Inbound	424	7.1	418	7.0	-6	-1.4%
Route 10 - Outbound	463	7.7	453	7.6	-10	-2.2%
Route 11 - Inbound	828	13.8	917	15.3	89	10.7%
Route 11 - Outbound	1183	19.7	978	16.3	-205	-17.3%

Table 6.3.13: 2039 GTS PM Peak Journey Time Results

Route Description	2039 DM Seconds	2039 DM - Minutes	2039 GTS Seconds	2039 GTS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	731	12.2	711	11.9	-20	-2.7%
Route 1 - Outbound	738	12.3	707	11.8	-31	-4.2%
Route 2 - Inbound	1189	19.8	1388	23.1	199	16.7%
Route 2 - Outbound	1190	19.8	1354	22.6	164	13.8%
Route 3 - Inbound	291	4.9	407	6.8	116	39.9%
Route 3 - Outbound	259	4.3	429	7.2	170	65.6%
Route 4a - Inbound	790	13.2	713	11.9	-77	-9.7%
Route 4a - Outbound	1557	26.0	728	12.1	-829	-53.2%
Route 4b - Inbound	772	12.9	607	10.1	-165	-21.4%
Route 4b - Outbound	779	13.0	699	11.7	-80	-10.3%
Route 5 - Inbound	1189	19.8	1063	17.7	-126	-10.6%
Route 5 - Outbound	1271	21.2	1325	22.1	54	4.2%
Route 6 - Inbound	1097	18.3	1015	16.9	-82	-7.5%
Route 6 - Outbound	1027	17.1	1168	19.5	141	13.7%
Route 7 - Inbound	1169	19.5	1050	17.5	-119	-10.2%
Route 7 - Outbound	1663	27.7	1629	27.2	-34	-2.0%
Route 8 - Inbound	624	10.4	669	11.2	45	7.2%
Route 8 - Outbound	899	15.0	873	14.6	-26	-2.9%
Route 9 - Inbound	359	6.0	359	6.0	0	0.0%
Route 9 - Outbound	361	6.0	359	6.0	-2	-0.6%
Route 10 - Inbound	598	10.0	509	8.5	-89	-14.9%
Route 10 - Outbound	534	8.9	557	9.3	23	4.3%
Route 11 - Inbound	946	15.8	859	14.3	-87	-9.2%
Route 11 - Outbound	1620	27.0	1070	17.8	-550	-34.0%

6.4 Ratio of Flow to Capacity

6.4.1 Strategic modelling results

To further understand the potential impact on junction operations of the proposed scheme, the ratio of flow (of traffic) over capacity (RFC) at key junctions along the N6 corridor have been analysed and compared across scenarios.

RFC is a standard reference for measuring traffic congestion at a junction. It is standard practice to consider that a junction is congested when traffic flows are at 85% of the estimated capacity of a priority junction, or 90% of a signalised junction. At traffic flows above 90% of capacity the delays at a junction become erratic and are difficult to control. A value of 100% means that demand and capacity are equal and no further traffic is able to progress through the junction without experiencing significant delays.

A Ratio of Flow to Capacity analysis has been undertaken using information from the N6 GCRR Highway Model for each modelling scenario and is presented below. This analysis considered the number of links at Key Junctions along the N6 /R338 corridor with an RFC over 90% and also the number of links in the entire City area with an RFC over 90%. Figure 6.4.1, below, illustrates the location of the Key Junctions on the N6 / R338 Corridor.

Figure 6.4.1: N6 / R338 Key Junctions

6.4.2 Core Scenarios

The Tables below summarise these junction evaluations for the 2024 and 2039-Medium Growth –Core Scenarios.

Table 6.4.1: Number of Links at or over capacity- AM Peak

		2024			2039		
		DM	**DS**	**Impact**	**DM**	**DS**	**Impact**
Key Junctions (N6 / R338)	RFC > 90%	15	9	Positive	18	12	Positive
Entire Network	RFC > 90%	151	78	Positive	200	115	Positive

Table 6.4.2: Number of Links at or over capacity- IP 1

		2024			2039		
		DM	**DS**	**Impact**	**DM**	**DS**	**Impact**
Key Junctions (N6 / R338)	RFC > 90%	6	2	Positive	9	5	Positive
Entire Network	RFC > 90%	28	12	Positive	60	26	Positive

Table 6.4.3: Number of Links at or over capacity- IP 2

		2024			2039		
		DM	**DS**	**Impact**	**DM**	**DS**	**Impact**
Key Junctions (N6 / R338)	RFC > 90%	8	4	Positive	11	5	Positive
Entire Network	RFC > 90%	53	29	Positive	81	49	Positive

Table 6.4.4: Number of Links at or over capacity- PM Peak

		2024			2039		
		DM	**DS**	**Impact**	**DM**	**DS**	**Impact**
Key Junctions (N6 / R338)	RFC > 90%	17	4	Positive	20	6	Positive
Entire Network	RFC > 90%	139	62	Positive	193	100	Positive

The above tables show that, with the introduction of the N6 GCRR, there is a significant decrease in the number of links in the network which have an RFC of over 90%. This is particularly evident in the PM peak period where the number of over-capacity links, at key junctions along the N6/ R338 Corridor, reduces by over 70% in both 2024 and 2039. Similarly, the number of over-capacity links on the entire city network is reduced by 55% and 48% in 2024 and 2039, respectively, as a result of the introduction of the N6 Galway City Ring Road.

6.4.3 GTS Sensitivity Test

The Tables below summarises the junction evaluations for the 2039- Medium Growth – Core Scenario (DS) and 2039 Galway Transport Strategy (GTS).

Table 6.4.5: Number of Links at or over capacity- AM Peak

		2024			2039		
		DM	GTS	Impact	DM	DS	Impact
Key Junctions (N6 / R338)	RFC > 90%	N/A	N/A	Positive	18	8	Positive
Entire Network	RFC > 90%	N/A	N/A	Positive	200	131	Positive

Table 6.4.6: Number of Links at or over capacity- IP 1

		2024			2039		
		DM	GTS	Impact	DM	DS	Impact
Key Junctions (N6 / R338)	RFC > 90%	N/A	N/A	Positive	9	2	Positive
Entire Network	RFC > 90%	N/A	N/A	Positive	60	32	Positive

Table 6.4.7: Number of Links at or over capacity- IP 2

		2024			2039		
		DM	GTS	Impact	DM	DS	Impact
Key Junctions (N6 / R338)	RFC > 90%	N/A	N/A	Positive	11	3	Positive
Entire Network	RFC > 90%	N/A	N/A	Positive	81	52	Positive

Table 6.4.8: Number of Links at or over capacity- PM Peak

		2024			2039		
		DM	GTS	Impact	DM	DS	Impact
Key Junctions (N6 / R338)	RFC > 90%	N/A	N/A	Positive	20	6	Positive
Entire Network	RFC > 90%	N/A	N/A	Positive	193	123	Positive

The above tables show that, as with the Core Scenarios, the introduction of the Galway Transport Strategy proposals results in a significant decrease in number of over capacity junctions within the entire city area and also along the N6 / R338 corridor when compared with the Do Minimum.

6.4.4 Micro-Simulation modelling results

In addition to the analysis carried out above, a further microsimulation analysis of the busiest junctions along the alignment of the N6 GCRR was carried out. Linsig[2] analysis software was used for analysing these signalised junctions in order to ensure that each of the junctions would operate within capacity in the opening and design years. The results of this analysis (available in the Phase 3 Junction Strategy Report included in Appendix G) show that all junctions along the N6 GCRR will operate within capacity in both the opening year and design year.

6.5 Mode Share

The tables below present the mode share between private vehicle, public transport, walking and cycling for the 2012 Base, 2024 Opening Year and 2039 Design Year, extracted from the model for the 24 hour period.

The mode share analysis shows that there is a low public transport mode share of just 4% in the Base Year. As can be seen below, the impact of the Do-Something

[2] Linsig is a modelling package for traffic signal junctions either individually or in a network of several junctions. http://www.jctconsultancy.co.uk/Software/software.php

options on mode share is minimal, with Car Mode share increasing by circa 1% in both 2024 and 2039 as a result of the opening of the N6 GCRR.

The GTS Sensitivity test increases PT mode share to 5.0%, which is a 16% increase in PT trips relative to the Do-Minimum.

Table 6.5.1: Mode Share Percentages

Option	% Car	% PT	% Walk	% Cycle
2012 Base Year	66.7%	3.9%	26.3%	3.1%
2024 Do-Min	67.4%	4.2%	25.4%	3.0%
2024 Do-Something	68.4%	4.0%	24.9%	2.7%
2039 Do-Min	67.4%	4.3%	25.2%	3.1%
2039 Do-Something	68.6%	4.1%	24.5%	2.8%
2039 Galway Transport Strategy	67.3%	5.0%	24.9%	2.8%

7 Annual Average Daily Traffic (AADT)

7.1 Introduction

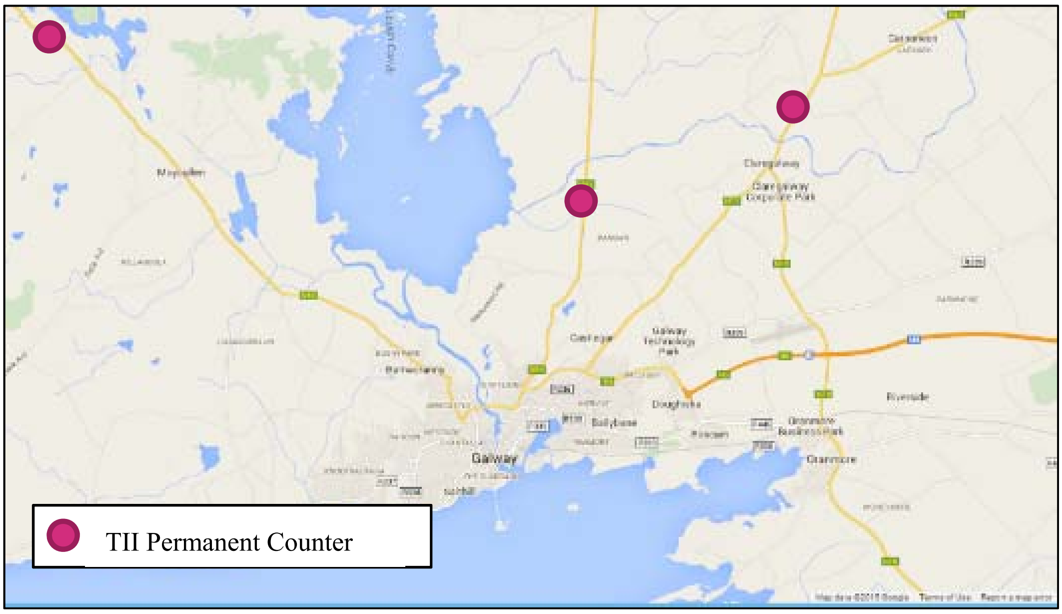
The information in this Chapter presents the methodology adopted to estimate AADT values from the modelled flows and also illustrates the estimated AADT values on key sections of the Galway Highway Network, with and without the scheme in place. This methodology has been based on the TII Project Appraisal guidelines. Unit 16.0: Estimating AADT on National Roads.

7.2 AADT Estimation Methodology

7.2.1 Permanent Counter Method

According to the PAG, the preferable method of estimating AADT is the **Permanent counter method**. Currently in Galway there are only 3 TII Permanent Counters near Galway and they are located a considerable distance from the city, as illustrated in Figure 7.2.1 below. As the purpose of this exercise is to estimate AADTs across a broad geographical area in Galway City and surrounds it is felt that the permanent counter method in not appropriate in this instance.

Figure 7.2.1: TII Permanent Counter Locations



7.2.2 Localised Period Counter Method

The Localised Period Counter Method utilises local traffic counts to estimate Period Expansion Factors, so that short period model flows (i.e. AM, IP1, IP2 and PM) can be expanded to estimate all day (24 hours flows). These 24 hour flows can subsequently be extrapolated to AADT using a selection of permanent TII traffic counters in the region.

The Localised Period Counter method has been adopted in this instance in order to estimate AADT (Annual Average Daily Traffic) values for Galway. The steps involved in estimating the AADTs are outlined in the remaining sections of this chapter.

7.3 AADT Estimation Process

Step 1 - 12hour Mid-Week Flow Calculation

The first step in the AADT estimation process is to apply peak hour factors to each of the model time periods to estimate 12 hour (07:00 – 19:00) weekday flows. The peak hour factors were calculated during model development to determine the relationship between the modelled peak hour (e.g. 08:00-09:00) and the entire, three hour, peak period (e.g. 07:00-10:00).

These peak hour factors were calculated using local traffic data which was collected from different sites around Galway City during the month of November (precisely from 12th of November to 18th) in 2012. Based on the PAG unit 16.0 methodology for multiple counts, a linear regression has been performed based on the ATCs in order to estimate these peak hour factors. These factors can then be used to calculate the peak period flows as follows:

- AM Peak assigned flows * peak hour factor = 07:00 – 10:00 flows;
- IP 1 assigned flows * peak hour factor = 10:00 – 13:00 flows;
- IP2 assigned flows * peak hour factor = 13:00 – 16:00 flows; and
- PM Peak assigned flows * peak hour factor = 16:00 – 19:00 flows.

Utilising the above factors therefore allows us to estimate 12 hour (07:00 – 19:00) weekday flows from the four, peak hour, model assignments.

Step 2 – WADT Calculation

The second step in the process requires expanding the 12 hour weekday counts, estimated above, to 24 hour Monday to Sunday flows (Weekly Average Daily Traffic, WADT). This is done by calculating an expansion factor based on the existing relationship between 12 hour Monday – Friday flows and 24 hour Monday – Sunday Flows. The formula for this factor is:

$$F1 = \frac{Average\ 24h\ Monday - Sunday}{Average\ 07{:}00 - 19{:}00\ Monday - Friday}$$

Based on the PAG unit 16.0 methodology for multiple counts, a linear regression has been performed based on all 72 ATCs in order to estimate this WADT factor. As different vehicle types display different mid-week and weekend travel patterns, separate factors were calculated for cars, light good vehicles (LGVs) and heavy goods vehicles (HGVs). These calculations resulted in the following WADT factors:

$$WADT_{Nov2012} = 1.21 \times 12hr_{WD}\ for\ cars$$
$$WADT_{Nov2012} = 1.07 \times 12hr_{WD}\ for\ LGVs$$
$$WADT_{Nov2012} = 1.08 \times 12hr_{WD}\ for\ HGVs$$

Where:
$WADT_{Nov2012}$ is the weekly average daily traffic for the 3rd week of November 2012,
$12hr_{WD}$ is the average 07:00-19:00 weekday (Monday-Friday) traffic for the 3rd week of November 2012.

Step 3 – AADT Calculation

The Final step in the process is to convert the WADT figures calculated above into Annual Average Daily Traffic (AADT) figures. This is done in order to take into account the seasonality of traffic flows. To do so, the period when the ATC counts have been performed has been compared with the rest of the year.

In this case, there is no available data for the 3 closest TII Permanent Counters for November 2012. Indeed between the summer 2012 and March 2013 a number of TII Permanent counters seem to have been relocated.

Therefore, in order to estimate how the 3rd week of November relates to the rest of the year in terms of traffic, available data of the 3 closest permanent counters from 2011 and 2013 has been considered. This is not ideal considering the fact that it won't capture any specific event that happened in November 2012 (e.g. weather[3], special event). Yet, apart from those special cases, one can assume that from year to year, the annual flow profile won't differ significantly.

A linear regression has been performed based on 4 annual counts to estimate the seasonal expansion factor (F2). The Permanent counters and the periods taken into account are:

TII PC Name	Location	Period start	Period end
Claregalway	N83-N63	01/01/2011	31/12/2011
PC1841	N84	01/03/2013	28/02/2014
PC20172	N83	15/03/2013	14/03/2014
PC1591	N59	24/03/2013	23/03/2014

[3] Met.ie in its "MONTHLY WEATHER BULLETIN" reports rainfall and temperature below average in November 2012 but not dramatically different from previous year. http://www.met.ie/climate/MonthlyWeather/clim-2012-Nov.pdf

This extrapolation factor, F2, is calculated using the formula below:

$$F2 = \frac{WADT_{Nov}}{AADT}$$

Where:
$WADT_{Nov2012}$ is the weekly average daily traffic for the 3rd week of November of the considered year and $AADT$ is the annual average daily traffic for the considered year. The seasonality factors calculated for each vehicle type are:

$$AADT = 1.03 \times WADT_{Nov} \; for\ cars$$
$$AADT = 0.96 \times WADT_{Nov} \; for\ LGVs$$
$$AADT = 0.97 \times WADT_{Nov} \; for\ HGVs$$

7.4 2039 AADT Estimates

The forecast AADT flows on the road network extracted from the models for both the Low, Meiudm and High Growth Scenario, as well as the 2039 GTS sensitivity test, are presented in the tables below.

Figure 7.4.1: Preferred Route AADT Locations

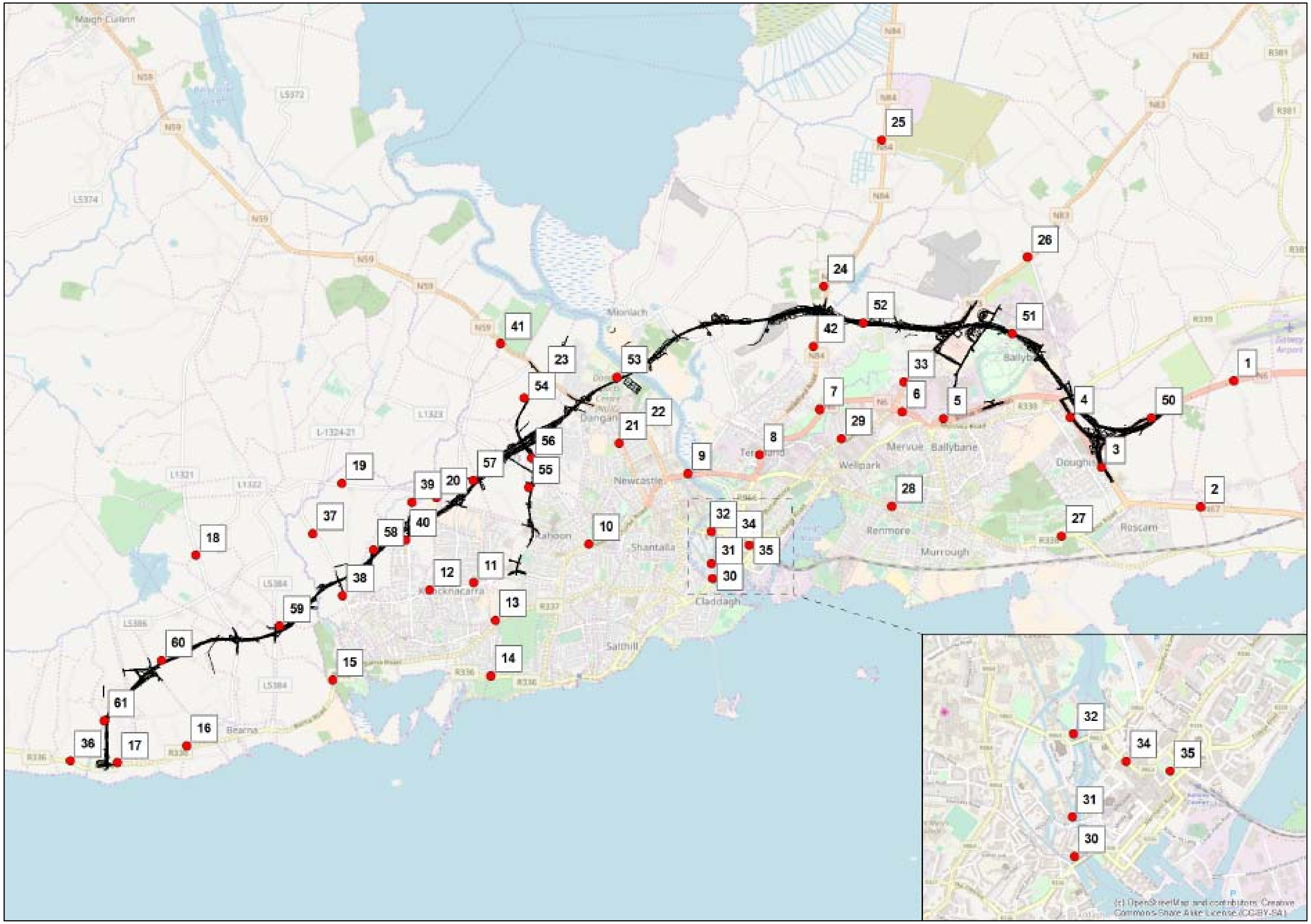


Table 7.4.1: N6 GCRR AADT 2024 Opening Year – Low Growth

	AADT Point	Location	AADT	% HGV	AADT	% HGV
DM links	1	N6 South of Galway Airport	19,659	7%	27,391	5%
	2	R446 West of Oranmore Business Park	21,995	8%	25,325	7%
	3	R446 South of N6 Roundabout	19,470	5%	28,951	4%
	4	N6 South of Briarhill	28,385	6%	16,797	5%
	5	N6 Near Ballybrit Business park	24,859	6%	14,106	4%
	6	N6 between N83 and R865	25,639	4%	17,200	3%
	7	N6 Between N84 and N83	20,306	4%	10,236	3%
	8	N6 East of Quincentenary Bridge	23,719	4%	22,872	4%
	9	N6 - On Quincentenary Bridge	33,256	5%	23,385	4%
	10	R338 at Westside Playing fields	13,867	3%	6,948	1%
	11	Western Distributor Rd between Clybaun Rd and R338	11,578	1%	7,379	1%
	12	Western Distributor Rd between Clybaun Rd and Ballymoneen Rd	8,212	1%	6,341	0%
	13	R337 Kingston Road. Kingston	10,882	3%	6,539	0%
	14	R336. Salthill Road Upper. Galway Golf Course.	10,750	2%	8,877	2%
	15	R336. Barna Road. Barna Woods	14,110	2%	3,747	0%
	16	R336. Barna Road. Barna. Creagan bus stop	10,810	2%	2,602	0%
	17	R336. Barna Road. West of Barna. Garrynagry	9,201	3%	11,100	2%
	18	L1321. At Loughinch. South East of Bearna Golf Club	630	0%	2,028	0%
	19	Boleybeg Road. Between Cappagh Road and Ballymoneen Road	1,818	0%	586	1%
	20	Rahoon Road. Between Clybaun Rd and Bothar Stiofain	4,158	0%	3,714	0%
	21	N59. Thomas Hynes road. Between Hazel Park and Cherry Park	6,134	2%	4,544	0%
	22	N59. Upper Newcastle Road. Between R338 and Corrib Village	12,080	2%	10,169	0%
	23	N59. Barnacranny. Between chesnut Ln and Circular Rd	16,190	2%	13,213	0%
	24	N84. South of Ballindooly. Ballindooly Lough	12,583	4%	16,805	3%
	25	N84. North of Ballindooly	14,299	2%	16,531	2%
	26	N83. Tuam Road. NorthEast of Parkmore Road	16,709	5%	18,260	6%
	27	R338. Dublin Road. West of Junction with Coast Road.	18,720	7%	17,430	5%
	28	R338. Dublin road. Between Renmore Rd and M. Collins road	17,722	5%	16,743	4%
	29	R336. Tuam Road. Mervue Business Park	16,407	6%	12,569	5%
	30	Wolfe Tone Bridge	18,151	3%	14,870	3%
	31	O'Briens Bridge	9,441	3%	8,720	2%
	32	Salmon Weir Bridge	16,878	1%	14,275	1%
	33	N83. Tuam Road. NorthEast of School Road	17,174	4%	17,458	3%
	34	Eglington Street	5,400	3%	4,829	1%
	35	R336 South of Eyre Square	13,637	4%	13,635	4%
	36	R336 West of N6	9,201	3%	11,101	2%
	37	Cappagh Road - North of GCRR	448	0%	207	0%
	38	Cappagh Road - South of GCRR	448	0%	5,777	1%
	39	Ballymoneen Rd - North of GCRR	1,537	0%	3,930	1%
	40	Ballymoneen Rd - South of GCRR	1,537	0%	5,767	2%
	41	N59 - North of GCRR Link Road	15,885	2%	16,627	2%
	42	N84 South of GCRR	12,584	4%	19,114	3%
DS links	50	GCRR - Briarhill Junction	-		27,391	5%
	51	GCRR - Parkmore	-		32,601	4%
	52	GCRR - Between N83 and N84	-		45,292	4%
	53	GCRR - New Corrib Crossing	-		31,626	4%
	54	GCRR - N59 Link Road	-		10,126	3%
	55	GCRR - Rahoon Link Road	-		6,108	3%
	56	GCRR - Letteragh Link Road	-		12,362	3%
	57	GCRR - Between Ballymoneen and N59 Interchange	-		18,979	3%
	58	GCRR - Between Ballymoneen and Cappagh Road	-		14,880	2%
	59	GCRR - Between Moycullen Rd and Cappagh Road	-		15,726	2%
	60	GCRR - at Turskey West	-		9,360	3%
	61	GCRR - North of R336 Junction	-		9,360	3%

Table 7.4.2: N6 GCRR AADT 2039 Design Year – Low Growth

Galway City Ring Road. Detailed Design. Forecast 2039.			2039 DM		2039 GCRR	
	AADT Point	Location	AADT	% HGV	AADT	% HGV
DM links	1	N6 South of Galway Airport	23,402	8%	36,484	6%
	2	R446 West of Oranmore Business Park	22,413	10%	24,606	9%
	3	R446 South of N6 Roundabout	19,831	7%	29,042	6%
	4	N6 South of Briarhill	31,500	7%	19,471	6%
	5	N6 Near Ballybrit Business park	26,513	7%	16,388	4%
	6	N6 between N83 and R865	27,096	5%	19,073	3%
	7	N6 Between N84 and N83	21,101	5%	11,886	4%
	8	N6 East of Quincentenary Bridge	24,321	6%	23,318	5%
	9	N6 - On Quincentenary Bridge	34,808	7%	24,614	5%
	10	R338 at Westside Playing fields	14,504	4%	7,812	1%
	11	Western Distributor Rd between Clybaun Rd and R338	12,124	2%	8,380	1%
	12	Western Distributor Rd between Clybaun Rd and Ballymoneen Rd	9,151	1%	7,099	0%
	13	R337 Kingston Road. Kingston	11,704	4%	6,973	0%
	14	R336. Salthill Road Upper. Galway Golf Course.	11,514	2%	9,618	2%
	15	R336. Barna Road. Barna Woods	15,648	2%	4,117	0%
	16	R336. Barna Road. Barna. Creagan bus stop	12,102	3%	2,732	0%
	17	R336. Barna Road. West of Barna. Garrynagry	10,466	3%	12,608	3%
	18	L1321. At Loughinch. South East of Bearna Golf Club	665	0%	2,115	0%
	19	Boleybeg Road. Between Cappagh Road and Ballymoneen Road	1,856	1%	665	1%
	20	Rahoon Road. Between Clybaun Rd and Bothar Stiofain	4,289	0%	4,342	0%
	21	N59. Thomas Hynes road. Between Hazel Park and Cherry Park	6,212	2%	4,901	0%
	22	N59. Upper Newcastle Road. Between R338 and Corrib Village	12,843	2%	10,978	0%
	23	N59. Barnacranny. Between chesnut Ln and Circular Rd	17,484	2%	14,125	0%
	24	N84. South of Ballindooly. Ballindooly Lough	13,724	5%	17,768	3%
	25	N84. North of Ballindooly	14,980	3%	17,528	3%
	26	N83. Tuam Road. NorthEast of Parkmore Road	16,941	5%	18,166	7%
	27	R338. Dublin Road. West of Junction with Coast Road.	18,723	8%	17,728	7%
	28	R338. Dublin road. Between Renmore Rd and M. Collins road	17,530	7%	17,078	5%
	29	R336. Tuam Road. Mervue Business Park	17,140	7%	13,340	6%
	30	Wolfe Tone Bridge	18,849	4%	15,875	3%
	31	O'Briens Bridge	9,990	4%	9,125	3%
	32	Salmon Weir Bridge	18,564	2%	15,072	2%
	33	N83. Tuam Road. NorthEast of School Road	17,437	6%	18,504	4%
	34	Eglington Street	5,826	3%	5,050	1%
	35	R336 South of Eyre Square	14,292	5%	14,481	6%
	36	R336 West of N6	10,466	3%	12,608	3%
	37	Cappagh Road - North of GCRR	479	0%	212	0%
	38	Cappagh Road - South of GCRR	479	0%	6,452	2%
	39	Ballymoneen Rd - North of GCRR	1,607	0%	4,736	2%
	40	Ballymoneen Rd - South of GCRR	1,607	0%	6,326	2%
	41	N59 - North of GCRR Link Road	17,174	2%	17,700	2%
	42	N84 South of GCRR	13,724	5%	19,784	5%
DS links	50	GCRR - Briarhill Junction	-		36,484	6%
	51	GCRR - Parkmore	-		38,143	5%
	52	GCRR - Between N83 and N84	-		50,421	5%
	53	GCRR - New Corrib Crossing	-		36,255	4%
	54	GCRR - N59 Link Road	-		11,074	4%
	55	GCRR - Rahoon Link Road	-		6,377	3%
	56	GCRR - Letteragh Link Road	-		13,761	3%
	57	GCRR - Between Ballymoneen and N59 Interchange	-		21,164	3%
	58	GCRR - Between Ballymoneen and Cappagh Road	-		16,421	3%
	59	GCRR - Between Moycullen Rd and Cappagh Road	-		17,436	2%
	60	GCRR - at Turskey West	-		10,747	3%
	61	GCRR - North of R336 Junction	-		10,747	3%

Table 7.4.2: N6 GCRR AADT 2024 Opening Year – Medium Growth

	AADT Point	Location	AADT	% HGV	AADT	% HGV
DM links	1	N6 South of Galway Airport	20,254	8%	27,024	5%
	2	R446 West of Oranmore Business Park	22,341	8%	25,700	7%
	3	R446 South of N6 Roundabout	19,050	5%	28,392	4%
	4	N6 South of Briarhill	28,935	6%	15,952	5%
	5	N6 Near Ballybrit Business park	24,305	6%	13,098	4%
	6	N6 between N83 and R865	25,695	5%	17,036	3%
	7	N6 Between N84 and N83	20,021	4%	9,959	3%
	8	N6 East of Quincentenary Bridge	24,083	5%	22,775	4%
	9	N6 - On Quincentenary Bridge	33,834	5%	23,497	4%
	10	R338 at Westside Playing fields	13,994	4%	6,926	1%
	11	Western Distributor Rd between Clybaun Rd and R338	11,361	1%	7,218	1%
	12	Western Distributor Rd between Clybaun Rd and Ballymoneen Rd	8,229	1%	6,307	0%
	13	R337 Kingston Road. Kingston	11,481	3%	6,746	0%
	14	R336. Salthill Road Upper. Galway Golf Course.	11,117	2%	9,003	2%
	15	R336. Barna Road. Barna Woods	14,947	2%	3,901	0%
	16	R336. Barna Road. Barna. Creagan bus stop	11,495	2%	2,714	0%
	17	R336. Barna Road. West of Barna. Garrynagry	9,759	3%	11,285	2%
	18	L1321. At Loughinch. South East of Bearna Golf Club	746	0%	2,147	0%
	19	Boleybeg Road. Between Cappagh Road and Ballymoneen Road	1,886	0%	605	1%
	20	Rahoon Road. Between Clybaun Rd and Bothar Stiofain	4,054	0%	3,581	0%
	21	N59. Thomas Hynes road. Between Hazel Park and Cherry Park	6,385	2%	4,718	0%
	22	N59. Upper Newcastle Road. Between R338 and Corrib Village	12,420	2%	9,914	0%
	23	N59. Barnacranny. Between chesnut Ln and Circular Rd	16,940	2%	13,346	0%
	24	N84. South of Ballindooly. Ballindooly Lough	13,254	4%	16,564	3%
	25	N84. North of Ballindooly	14,266	3%	16,297	2%
	26	N83. Tuam Road. NorthEast of Parkmore Road	16,214	5%	18,128	6%
	27	R338. Dublin Road. West of Junction with Coast Road.	18,994	7%	16,874	6%
	28	R338. Dublin road. Between Renmore Rd and M. Collins road	17,793	6%	16,539	4%
	29	R336. Tuam Road. Mervue Business Park	16,799	6%	12,385	5%
	30	Wolfe Tone Bridge	17,808	4%	14,204	3%
	31	O'Briens Bridge	9,426	3%	8,639	2%
	32	Salmon Weir Bridge	16,918	1%	14,100	1%
	33	N83. Tuam Road. NorthEast of School Road	17,548	4%	17,428	3%
	34	Eglington Street	5,255	3%	4,550	1%
	35	R336 South of Eyre Square	12,782	5%	12,383	5%
	36	R336 West of N6	9,759	3%	11,285	2%
	37	Cappagh Road - North of GCRR	512	0%	233	0%
	38	Cappagh Road - South of GCRR	512	0%	5,983	1%
	39	Ballymoneen Rd - North of GCRR	1,253	0%	3,774	1%
	40	Ballymoneen Rd - South of GCRR	1,253	0%	5,271	2%
	41	N59 - North of GCRR Link Road	16,635	2%	17,069	2%
	42	N84 South of GCRR	13,254	4%	19,028	3%
DS links	50	GCRR - Briarhill Junction	-		27,024	5%
	51	GCRR - Parkmore	-		32,686	4%
	52	GCRR - Between N83 and N84	-		44,520	4%
	53	GCRR - New Corrib Crossing	-		31,409	4%
	54	GCRR - N59 Link Road	-		10,163	3%
	55	GCRR - Rahoon Link Road	-		5,888	3%
	56	GCRR - Letteragh Link Road	-		12,280	3%
	57	GCRR - Between Ballymoneen and N59 Interchange	-		18,704	3%
	58	GCRR - Between Ballymoneen and Cappagh Road	-		15,150	2%
	59	GCRR - Between Moycullen Rd and Cappagh Road	-		16,133	2%
	60	GCRR - at Turskey West	-		9,504	3%
	61	GCRR - North of R336 Junction	-		9,504	3%

Table 7.4.4: N6 GCRR AADT 2039 Design Year – Medium Growth

Galway City Ring Road. Detailed Design. Forecast 2039.			2039 DM		2039 GCRR	
	AADT Point	Location	AADT	% HGV	AADT	% HGV
DM links	1	N6 South of Galway Airport	23,382	8%	36,008	6%
	2	R446 West of Oranmore Business Park	22,588	10%	26,107	8%
	3	R446 South of N6 Roundabout	18,807	7%	29,040	6%
	4	N6 South of Briarhill	31,459	7%	18,862	6%
	5	N6 Near Ballybrit Business park	25,974	7%	15,553	5%
	6	N6 between N83 and R865	26,749	6%	18,766	3%
	7	N6 Between N84 and N83	20,691	5%	11,307	4%
	8	N6 East of Quincentenary Bridge	24,315	6%	23,215	5%
	9	N6 - On Quincentenary Bridge	34,546	7%	24,442	5%
	10	R338 at Westside Playing fields	14,061	5%	7,556	1%
	11	Western Distributor Rd between Clybaun Rd and R338	11,657	2%	7,964	1%
	12	Western Distributor Rd between Clybaun Rd and Ballymoneen Rd	8,959	1%	7,134	0%
	13	R337 Kingston Road. Kingston	11,955	4%	7,148	0%
	14	R336. Salthill Road Upper. Galway Golf Course.	11,677	2%	9,638	2%
	15	R336. Barna Road. Barna Woods	16,273	2%	4,313	0%
	16	R336. Barna Road. Barna. Creagan bus stop	12,666	3%	2,934	0%
	17	R336. Barna Road. West of Barna. Garrynagry	10,875	3%	13,093	3%
	18	L1321. At Loughinch. South East of Bearna Golf Club	824	0%	2,315	0%
	19	Boleybeg Road. Between Cappagh Road and Ballymoneen Road	1,937	1%	713	1%
	20	Rahoon Road. Between Clybaun Rd and Bothar Stiofain	4,269	0%	4,232	0%
	21	N59. Thomas Hynes road. Between Hazel Park and Cherry Park	6,642	2%	5,137	0%
	22	N59. Upper Newcastle Road. Between R338 and Corrib Village	12,920	2%	10,803	0%
	23	N59. Barnacranny. Between chesnut Ln and Circular Rd	18,050	2%	14,705	0%
	24	N84. South of Ballindooly. Ballindooly Lough	14,298	6%	17,798	3%
	25	N84. North of Ballindooly	14,636	3%	17,371	3%
	26	N83. Tuam Road. NorthEast of Parkmore Road	16,170	5%	18,405	7%
	27	R338. Dublin Road. West of Junction with Coast Road.	18,606	8%	17,715	7%
	28	R338. Dublin road. Between Renmore Rd and M. Collins road	17,742	7%	16,905	5%
	29	R336. Tuam Road. Mervue Business Park	16,980	7%	13,183	6%
	30	Wolfe Tone Bridge	18,074	4%	14,606	4%
	31	O'Briens Bridge	9,725	4%	9,037	3%
	32	Salmon Weir Bridge	17,910	1%	14,613	2%
	33	N83. Tuam Road. NorthEast of School Road	17,907	5%	18,583	4%
	34	Eglington Street	5,420	3%	4,712	2%
	35	R336 South of Eyre Square	13,418	6%	13,113	6%
	36	R336 West of N6	10,875	3%	13,093	3%
	37	Cappagh Road - North of GCRR	548	0%	257	0%
	38	Cappagh Road - South of GCRR	548	0%	6,654	2%
	39	Ballymoneen Rd - North of GCRR	1,305	0%	4,441	2%
	40	Ballymoneen Rd - South of GCRR	1,305	0%	6,007	2%
	41	N59 - North of GCRR Link Road	17,749	2%	18,582	2%
	42	N84 South of GCRR	14,298	6%	19,788	5%
DS links	50	GCRR - Briarhill Junction	-		36,008	6%
	51	GCRR - Parkmore	-		38,705	5%
	52	GCRR - Between N83 and N84	-		49,876	5%
	53	GCRR - New Corrib Crossing	-		36,353	4%
	54	GCRR - N59 Link Road	-		11,530	4%
	55	GCRR - Rahoon Link Road	-		6,172	3%
	56	GCRR - Letteragh Link Road	-		13,709	3%
	57	GCRR - Between Ballymoneen and N59 Interchange	-		20,920	3%
	58	GCRR - Between Ballymoneen and Cappagh Road	-		16,953	3%
	59	GCRR - Between Moycullen Rd and Cappagh Road	-		18,306	2%
	60	GCRR - at Turskey West	-		11,155	3%
	61	GCRR - North of R336 Junction	-		11,155	3%

Table 7.4.5: N6 GCRR AADT 2024 Opening Year – High Growth

Galway City Ring Road. Detailed Design. Forecast 2024.			2024 DM		2024 GCRR	
	AADT Point	Location	AADT	% HGV	AADT	% HGV
DM links	1	N6 South of Galway Airport	19,223	7%	27,425	5%
	2	R446 West of Oranmore Business Park	22,186	8%	25,851	7%
	3	R446 South of N6 Roundabout	18,913	5%	28,514	4%
	4	N6 South of Briarhill	27,985	6%	16,101	5%
	5	N6 Near Ballybrit Business park	24,446	6%	13,269	4%
	6	N6 between N83 and R865	25,721	4%	17,127	3%
	7	N6 Between N84 and N83	20,019	4%	10,027	3%
	8	N6 East of Quincentenary Bridge	23,793	4%	22,789	4%
	9	N6 - On Quincentenary Bridge	33,491	5%	23,601	4%
	10	R338 at Westside Playing fields	13,789	3%	6,942	1%
	11	Western Distributor Rd between Clybaun Rd and R338	11,184	1%	7,231	1%
	12	Western Distributor Rd between Clybaun Rd and Ballymoneen Rd	8,040	1%	6,333	0%
	13	R337 Kingston Road. Kingston	11,278	3%	6,802	0%
	14	R336. Salthill Road Upper. Galway Golf Course.	10,898	2%	9,034	2%
	15	R336. Barna Road. Barna Woods	14,550	2%	3,942	0%
	16	R336. Barna Road. Barna. Creagan bus stop	11,156	2%	2,752	0%
	17	R336. Barna Road. West of Barna. Garrynagry	9,437	2%	11,365	2%
	18	L1321. At Loughinch. South East of Bearna Golf Club	733	0%	2,167	0%
	19	Boleybeg Road. Between Cappagh Road and Ballymoneen Road	1,863	0%	612	1%
	20	Rahoon Road. Between Clybaun Rd and Bothar Stiofain	4,038	0%	3,624	0%
	21	N59. Thomas Hynes road. Between Hazel Park and Cherry Park	6,343	2%	4,759	0%
	22	N59. Upper Newcastle Road. Between R338 and Corrib Village	12,117	2%	9,993	0%
	23	N59. Barnacranny. Between chesnut Ln and Circular Rd	16,596	2%	13,491	0%
	24	N84. South of Ballindooly. Ballindooly Lough	12,819	4%	16,571	3%
	25	N84. North of Ballindooly	13,969	2%	16,303	2%
	26	N83. Tuam Road. NorthEast of Parkmore Road	16,212	5%	18,245	6%
	27	R338. Dublin Road. West of Junction with Coast Road.	18,605	7%	17,018	6%
	28	R338. Dublin road. Between Renmore Rd and M. Collins road	17,696	5%	16,673	4%
	29	R336. Tuam Road. Mervue Business Park	16,473	6%	12,429	5%
	30	Wolfe Tone Bridge	17,638	3%	14,195	3%
	31	O'Briens Bridge	9,348	3%	8,653	2%
	32	Salmon Weir Bridge	16,673	1%	14,119	1%
	33	N83. Tuam Road. NorthEast of School Road	17,250	4%	17,495	3%
	34	Eglington Street	5,149	3%	4,540	1%
	35	R336 South of Eyre Square	12,609	5%	12,369	5%
	36	R336 West of N6	9,437	2%	11,366	2%
	37	Cappagh Road - North of GCRR	494	0%	235	0%
	38	Cappagh Road - South of GCRR	494	0%	6,007	1%
	39	Ballymoneen Rd - North of GCRR	1,256	0%	3,787	1%
	40	Ballymoneen Rd - South of GCRR	1,256	0%	5,285	2%
	41	N59 - North of GCRR Link Road	16,288	2%	17,205	2%
	42	N84 South of GCRR	12,819	4%	19,133	3%
DS links	50	GCRR - Briarhill Junction	-		27,425	5%
	51	GCRR - Parkmore	-		32,947	4%
	52	GCRR - Between N83 and N84	-		44,811	4%
	53	GCRR - New Corrib Crossing	-		31,608	4%
	54	GCRR - N59 Link Road	-		10,214	3%
	55	GCRR - Rahoon Link Road	-		5,898	3%
	56	GCRR - Letteragh Link Road	-		12,341	3%
	57	GCRR - Between Ballymoneen and N59 Interchange	-		18,796	3%
	58	GCRR - Between Ballymoneen and Cappagh Road	-		15,236	2%
	59	GCRR - Between Moycullen Rd and Cappagh Road	-		16,236	2%
	60	GCRR - at Turskey West	-		9,558	3%
	61	GCRR - North of R336 Junction	-		9,558	3%

Table 7.4.6: N6 GCRR AADT 2039 Design Year – High Growth

Galway City Ring Road. Detailed Design. Forecast 2039.			2039 DM		2039 GCRR	
	AADT Point	Location	AADT	% HGV	AADT	% HGV
DM links	1	N6 South of Galway Airport	24,144	8%	37,412	6%
	2	R446 West of Oranmore Business Park	22,948	10%	26,291	8%
	3	R446 South of N6 Roundabout	18,672	7%	29,799	5%
	4	N6 South of Briarhill	32,293	7%	19,514	6%
	5	N6 Near Ballybrit Business park	26,663	7%	16,220	5%
	6	N6 between N83 and R865	27,287	5%	19,126	3%
	7	N6 Between N84 and N83	20,925	5%	11,577	4%
	8	N6 East of Quincentenary Bridge	24,622	6%	23,340	5%
	9	N6 - On Quincentenary Bridge	35,044	6%	24,653	5%
	10	R338 at Westside Playing fields	14,170	5%	7,669	1%
	11	Western Distributor Rd between Clybaun Rd and R338	11,742	2%	8,089	1%
	12	Western Distributor Rd between Clybaun Rd and Ballymoneen Rd	9,152	1%	7,286	0%
	13	R337 Kingston Road. Kingston	12,019	3%	7,261	0%
	14	R336. Salthill Road Upper. Galway Golf Course.	11,847	2%	9,746	2%
	15	R336. Barna Road. Barna Woods	16,509	2%	4,387	0%
	16	R336. Barna Road. Barna. Creagan bus stop	12,883	2%	3,007	0%
	17	R336. Barna Road. West of Barna. Garrynagry	11,038	3%	13,280	2%
	18	L1321. At Loughinch. South East of Bearna Golf Club	855	0%	2,360	0%
	19	Boleybeg Road. Between Cappagh Road and Ballymoneen Road	1,996	1%	744	1%
	20	Rahoon Road. Between Clybaun Rd and Bothar Stiofain	4,376	0%	4,371	0%
	21	N59. Thomas Hynes road. Between Hazel Park and Cherry Park	6,606	2%	5,198	0%
	22	N59. Upper Newcastle Road. Between R338 and Corrib Village	13,201	2%	10,980	0%
	23	N59. Barnacranny. Between chesnut Ln and Circular Rd	18,393	2%	14,870	0%
	24	N84. South of Ballindooly. Ballindooly Lough	14,590	6%	17,813	3%
	25	N84. North of Ballindooly	14,740	3%	17,387	3%
	26	N83. Tuam Road. NorthEast of Parkmore Road	16,297	5%	18,656	6%
	27	R338. Dublin Road. West of Junction with Coast Road.	18,820	8%	17,866	7%
	28	R338. Dublin road. Between Renmore Rd and M. Collins road	17,780	6%	16,936	5%
	29	R336. Tuam Road. Mervue Business Park	17,540	7%	13,271	6%
	30	Wolfe Tone Bridge	18,124	4%	14,557	4%
	31	O'Briens Bridge	9,787	4%	9,059	3%
	32	Salmon Weir Bridge	18,171	1%	14,703	1%
	33	N83. Tuam Road. NorthEast of School Road	18,137	5%	18,780	4%
	34	Eglington Street	5,538	4%	4,704	1%
	35	R336 South of Eyre Square	13,591	6%	13,236	6%
	36	R336 West of N6	11,038	3%	13,280	2%
	37	Cappagh Road - North of GCRR	561	0%	263	0%
	38	Cappagh Road - South of GCRR	561	0%	6,729	2%
	39	Ballymoneen Rd - North of GCRR	1,320	0%	4,567	2%
	40	Ballymoneen Rd - South of GCRR	1,320	0%	6,159	2%
	41	N59 - North of GCRR Link Road	18,092	2%	18,867	2%
	42	N84 South of GCRR	14,590	6%	20,024	5%
DS links	50	GCRR - Briarhill Junction	-		37,412	6%
	51	GCRR - Parkmore	-		39,820	4%
	52	GCRR - Between N83 and N84	-		50,887	5%
	53	GCRR - New Corrib Crossing	-		37,190	4%
	54	GCRR - N59 Link Road	-		11,728	4%
	55	GCRR - Rahoon Link Road	-		6,267	3%
	56	GCRR - Letteragh Link Road	-		13,965	3%
	57	GCRR - Between Ballymoneen and N59 Interchange	-		21,370	3%
	58	GCRR - Between Ballymoneen and Cappagh Road	-		17,278	3%
	59	GCRR - Between Moycullen Rd and Cappagh Road	-		18,663	2%
	60	GCRR - at Turskey West	-		11,299	3%
	61	GCRR - North of R336 Junction	-		11,299	3%

Table 7.4.7: N6 GCRR AADT 2039 Design Year – Galway Trasnport Strategy - Medium Growth

Galway City Ring Road. Detailed Design. Forecast 2039.			2039 DM		2039 GTS	
	AADT Point	Location	AADT	% HGV	AADT	% HGV
DM links	1	N6 South of Galway Airport	23,382	8%	35,906	6%
	2	R446 West of Oranmore Business Park	22,588	10%	25,861	9%
	3	R446 South of N6 Roundabout	18,807	7%	29,747	6%
	4	N6 South of Briarhill	31,459	7%	17,225	6%
	5	N6 Near Ballybrit Business park	25,974	7%	15,158	5%
	6	N6 between N83 and R865	26,749	6%	20,663	3%
	7	N6 Between N84 and N83	20,691	5%	8,536	7%
	8	N6 East of Quincentenary Bridge	24,315	6%	21,668	5%
	9	N6 - On Quincentenary Bridge	34,546	7%	34,950	4%
	10	R338 at Westside Playing fields	14,061	5%	7,681	1%
	11	Western Distributor Rd between Clybaun Rd and R338	11,657	2%	3,062	0%
	12	Western Distributor Rd between Clybaun Rd and Ballymoneen Rd	8,959	1%	2,565	0%
	13	R337 Kingston Road. Kingston	11,955	4%	9,888	1%
	14	R336. Salthill Road Upper. Galway Golf Course.	11,677	2%	9,274	2%
	15	R336. Barna Road. Barna Woods	16,273	2%	4,815	0%
	16	R336. Barna Road. Barna. Creagan bus stop	12,666	3%	3,448	0%
	17	R336. Barna Road. West of Barna. Garrynagry	10,875	3%	13,013	3%
	18	L1321. At Loughinch. South East of Bearna Golf Club	824	0%	2,304	0%
	19	Boleybeg Road. Between Cappagh Road and Ballymoneen Road	1,937	1%	777	1%
	20	Rahoon Road. Between Clybaun Rd and Bothar Stiofain	4,269	0%	6,202	0%
	21	N59. Thomas Hynes road. Between Hazel Park and Cherry Park	6,642	2%	5,322	0%
	22	N59. Upper Newcastle Road. Between R338 and Corrib Village	12,920	2%	10,544	0%
	23	N59. Barnacranny. Between chesnut Ln and Circular Rd	18,050	2%	14,439	0%
	24	N84. South of Ballindooly. Ballindooly Lough	14,298	6%	17,028	3%
	25	N84. North of Ballindooly	14,636	3%	17,058	3%
	26	N83. Tuam Road. NorthEast of Parkmore Road	16,170	5%	18,991	6%
	27	R338. Dublin Road. West of Junction with Coast Road.	18,606	8%	17,545	8%
	28	R338. Dublin road. Between Renmore Rd and M. Collins road	17,742	7%	17,616	6%
	29	R336. Tuam Road. Mervue Business Park	16,980	7%	15,993	4%
	30	Wolfe Tone Bridge	18,074	4%	13,568	4%
	31	O'Briens Bridge	9,725	4%	7,155	1%
	32	Salmon Weir Bridge	17,910	1%	-	
	33	N83. Tuam Road. NorthEast of School Road	17,907	5%	18,791	4%
	34	Eglington Street	5,420	3%	2,103	1%
	35	R336 South of Eyre Square	13,418	6%	-	
	36	R336 West of N6	10,875	3%	13,013	3%
	37	Cappagh Road - North of GCRR	548	0%	257	0%
	38	Cappagh Road - South of GCRR	548	0%	6,354	3%
	39	Ballymoneen Rd - North of GCRR	1,305	0%	6,154	2%
	40	Ballymoneen Rd - South of GCRR	1,305	0%	5,311	1%
	41	N59 - North of GCRR Link Road	17,749	2%	17,749	2%
	42	N84 South of GCRR	14,298	6%	20,171	4%
DS links	50	GCRR - Briarhill Junction	-		35,906	6%
	51	GCRR - Parkmore	-		38,783	5%
	52	GCRR - Between N83 and N84	-		49,104	5%
	53	GCRR - New Corrib Crossing	-		37,986	4%
	54	GCRR - N59 Link Road	-		11,862	4%
	55	GCRR - Rahoon Link Road	-		5,300	3%
	56	GCRR - Letteragh Link Road	-		14,584	3%
	57	GCRR - Between Ballymoneen and N59 Interchange	-		22,111	3%
	58	GCRR - Between Ballymoneen and Cappagh Road	-		19,015	3%
	59	GCRR - Between Moycullen Rd and Cappagh Road	-		17,595	2%
	60	GCRR - at Turskey West	-		10,566	3%
	61	GCRR - North of R336 Junction	-		10,566	3%

7.5 Cross-section Assessment

7.5.1 Capacity of Rural Road Network

TA46/97 of the UK Design Manual for Roads and Bridges is used to determine the capacity of new build rural roads. This standard is not formally implemented in Ireland but is considered as background reading which indicates good practice. Within this standard, classifications from single carriageway to motorway are used. The variable used in the determination of a suitable new build rural cross-section is the anticipated or opening year Annual Average Daily Traffic (AADT) volume.

The information provided within TA46/97 is similar to the guidance provided within TD9/12: Road Link Design of the National Roads Authority Design Manual for Roads and Bridges (NRA DMRB). Table 6/1 of NRA TD9/12 recommends edge treatments, access treatments and junction types that would be suitable in broad terms for each type of road as well as corresponding vehicle flow capacities (Annual Average Daily Traffic).

Table 7.5.1 below is extracted from NRA TD9/12 and details recommended rural road layouts and vehicle flow capacities.

It should be noted that AADT values are to be used as a starting point only in the assessment of options as they do not provide a guaranteed ultimate capacity a rural road can carry and therefore, should be used flexibly – this ultimate capacity depends on many other factors also. Therefore, vehicle flow capacities cannot be used in isolation for the selection and assessment of improvement or widening schemes.

Table 7.5.1: Recommended Rural Road Layouts

Type of Road [1.]	Capacity[2] (AADT) for Level of Service D	Edge Treatment	Access Treatment	Junction Treatment at Minor Road	Junction Treatment at Major Road
Type 3 Single (6.0m) Carriageway (S2)	5,000	0.5m hard strip. Footways/Cycle Tracks where required,	Minimise number of accesses to avoid standing vehicles and concentrate turning movements.	Simple Priority Junctions	Priority junctions, with ghost islands where necessary.
Type 2 Single (7.0m) Carriageway (S2)	8,600	0.5m hard strips. Footways/Cycle Tracks where required	Minimise number of accesses to avoid standing vehicles and concentrate turning movements.	Priority junctions, with ghost islands where necessary.	Ghost islands
Type 1 Single (7.3m) Carriageway (S2)	11,600	2.5m hard shoulders Footways/Cycle Tracks where required	Minimise number of accesses to avoid standing vehicles and concentrate turning movements.	Priority junctions, with ghost islands where necessary.	Ghost islands or roundabouts [3.]
Type 3 Dual [4.] (7.0m + 3.5m) Divided 2+1 lanes Primarily for retro fit projects	14,000	0.5m hard strips.	Minimise the number of accesses to avoid standing vehicles and concentrate turning movements.	Restricted number of left in/left out or ghost priority junctions.	Priority junctions or at-grade roundabouts.
Type 2 Dual [4.] Divided 2 +2 Lanes (2x7.0m) Carriageways. ()	20,000	0.5m hard strips	No gaps in the central reserve. Left in / Left out	No gaps in the central reserve. Left in / Left out	At-grade roundabouts and compact grade separation
Type 1 Dual Divided 2+2 Lanes (2x7.0m) Carriageways ()	42,000	2.5m hard shoulders	No gaps in the central reserve. Left in / Left out	No gaps in the central reserve. Left in / Left out	At-grade roundabouts and full-or compact grade separation.
Standard Motorway Divided 2 +2 Lane (2X7.0m) (D2M)	52,000	2.5m hard shoulders	Motorway Regulations	No gaps in the central reserve.	Motorway standards Full-grade separation.
Wide Motorway Divided 2+2 Lane (2X7.5m) (D2M)	55,500	3m hard shoulders	Motorway Regulations	No gaps in the central reserve	Motorway standards Full-grade separation.

Notes:
1. For details of the standard road cross-sections, see NRA TD 27, NRA TD 10 'Type 2 and Type 3 Dual Carriageways' and Road Construction Details Series 000.
2. Capacity figures are indicative for general guidance. The appropriate cross section shall be selected in accordance with the NRA Project Appraisal Guidelines
3. Single lane dualling may be appropriate in some situations, but would be a Relaxation (see NRA TD 41-42).
4. See NRA TD 10 'Type 2 and Type 3 Dual Carriageways'
5. Refer to TA 79 for Urban Road capacities.

Table 6/1: Recommended Rural Road Layouts

7.5.2 Capacity of Urban Road Network

TA79/99 of the UK DMRB is used to determine the capacity of urban roads. This standard is not formally implemented in Ireland but is considered as background reading which indicates good practice. Within this standard, classifications such as Urban Motorways or Urban All Purpose roads are used, with further sub-classification of Urban All Purpose Roads as UAP1 to UAP4.

Table 7.5.2 and Table 7.5.3 below are extracted from TA79/99 and detail the types of urban roads and the features that distinguish them and the capacities of Urban Roads One-way hourly flows in each direction respectively.

Table 7.5.2: Types of Urban roads and the features that distinguish them

Feature	**ROAD TYPE**				
	Urban Motorway	**Urban All-purpose**			
	UM	**UAP1**	**UAP2**	**UAP3**	**UAP4**
General Description	Through route with grade separated junctions, hardshoulders or hardstrips, and motorway restrictions.	High standard single/dual carriageway road carrying predominantly through traffic with limited access.	Good standard single/dual carriageway road with frontage access and more than two side roads per km.	Variable standard road carrying mixed traffic with frontage access, side roads, bus stops and at-grade pedestrian crossings.	Busy high street carrying predominantly local traffic with frontage activity including loading and unloading.
Speed Limit	60mph or less	40 to 60 mph for dual, & generally 40mph for single carriageway	Generally 40 mph	30 mph to 40 mph	30mph
Side Roads	None	0 to 2 per km	more than 2 per km	more than 2 per km	more than 2 per km
Access to roadside development	None. Grade separated for major only.	limited access	access to residential properties	frontage access	unlimited access to houses, shops & businesses
Parking and loading	none	restricted	restricted	unrestricted	unrestricted
Pedestrian crossings	grade separated	mostly grade separated	some at-grade	some at-grade	frequent at-grade
Bus stops	none	in lay-bys	at kerbside	at kerbside	at kerbside

Table 1 Types of Urban roads and the features that distinguish them

Table 7.5.3: Capacities of Urban Roads One-way hourly flows in each direction

		Two-way Single Carriageway- Busiest direction flow (Assumes a 60/40 directional split)									**Dual Carriageway**			
		Total number of Lanes									Number of Lanes in each direction			
		2				2-3	3	3-4	4	4+	2		3	4
Carriageway width		6.1m	6.75m	7.3m	9.0m	10.0m	12.3m	13.5m	14.6m	18.0m	6.75m	7.3m	11.0m	14.6m
Road type	**UM**	**Not applicable**										4000	5600	7200
	UAP1	1020	1320	1590	1860	2010	2550	2800	3050	3300	3350	3600	5200	*
	UAP2	1020	1260	1470	1550	1650	1700	1900	2100	2700	2950	3200	4800	*
	UAP3	900	1110	1300	1530	1620	*	*	*	*	2300	2600	3300	*
	UAP4	750	900	1140	1320	1410	*	*	*	*	*	*	*	*

Table 2 Capacities of Urban Roads
One-way hourly flows in each direction

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

The capacities given in the tables above and within TA79/99 provide a guide for the assessment of an appropriate carriageway width and standard. They may be applied to both the design of new urban roads and to the improvement of existing roads. The capacities are intended to help designers make a judgement as to which carriageway standard is likely to provide an acceptable level of service within an urban context when operating close to capacity. The capacities apply to links and take no account of the effects of junctions.

As noted, the capacities apply to links and take no account of the effects of junctions. The potential capacity of a link will not be reached if either the capacity of junctions along the link or the capacity of the adjoining network is lower than the link in question. The flow on an urban road may be affected by turning movements restricting the mainline capacity. For this reason the assessment of the suitability of cross-section is as dependent, if not more dependent on junction capacity as link capacity.

7.5.3 N6 GCRR Cross-section Assessment

As part of Phase 3 modelling analysis, a cross-section capacity assessment for the N6 GCRR alignment was undertaken using the guidelines detailed above and as outlined below.

- In rural areas AADT values as per NRA TD9/12 were used in assessing proposed cross-sections.
- In suburban / urban the procedure as per UK DMRB TA79/99 were used in assessing proposed cross-sections.

The reference points identified and utilised for the assessment of cross-sections are illustrated in the figure below and are as follows:

- Bearna Area,
- Knocknacarra Area,
- River Corrib Crossing,
- N84 – N13;
- N83 to Coolagh Interchange.

The cross-section assessments for each of these sections are outlined in table below.

Figure 7.5.1: Cross Section Reference Points

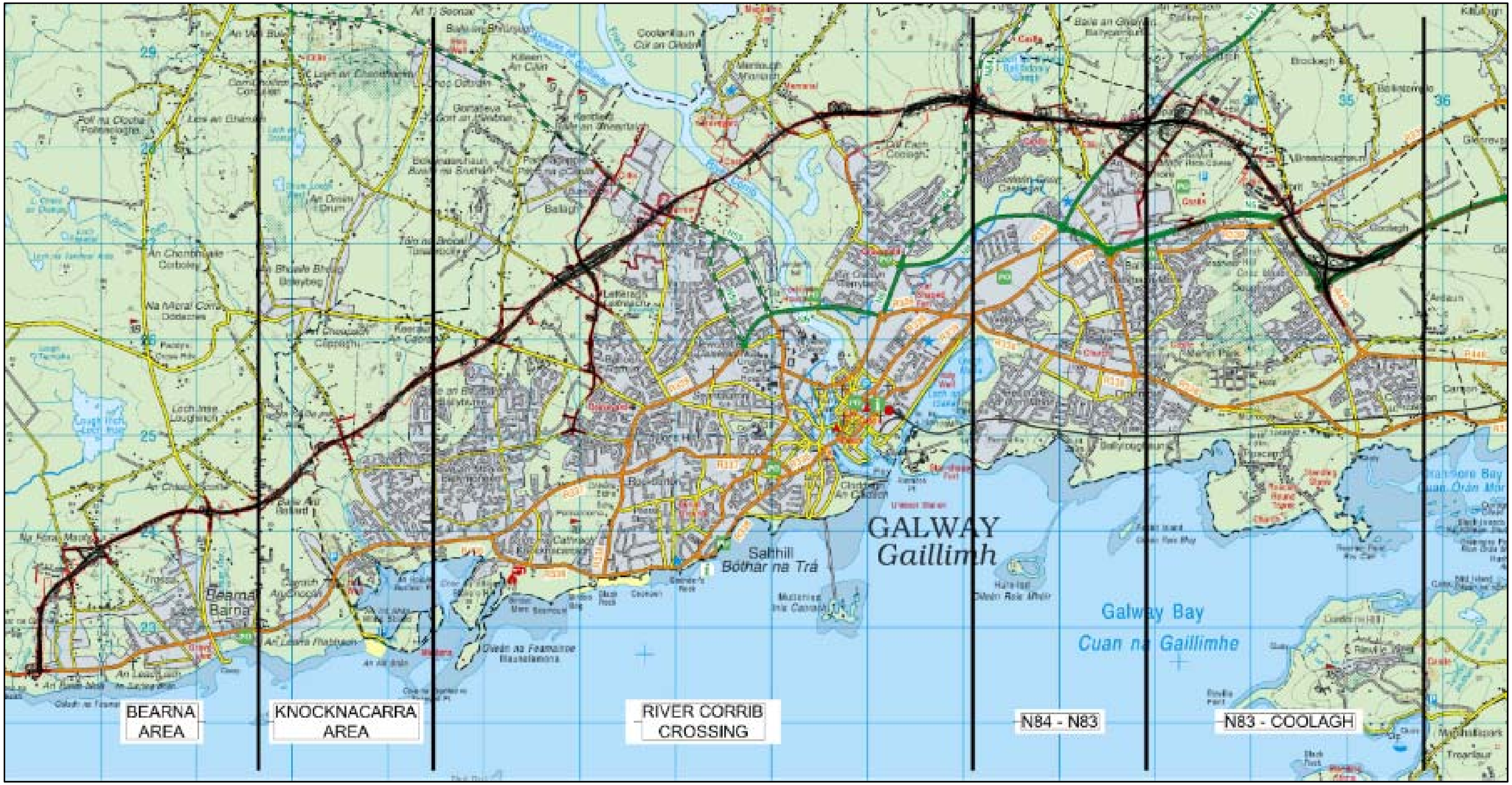


Table 7.4.3: Cross-section analysis

Cross-Section Analysis								
Section	Setting	AADT I.D.	Anticipated AADT [1]	LOS D – Capacity Threshold	TII TD9/12	Hourly Flows [2]	UK DMRB TA79	N6 GCRR Cross-section
Bearna Section	Rural	60	11,000	<11,600	Type 1 Single	N/A	N/A	Type 1 Single
Knocknacarra Section	Suburban/ Urban	57	N/A	N/A	N/A	<1110	UAP2 Single	Type 1 Single
River Corrib Crossing	Urban	53	N/A	N/A	N/A	<2300	UAP 3 (Dual 2 Lane)	Type 2 Dual
N84 to N83	Urban	52	N/A	N/A	N/A	<2950	UAP 2 (Dual 2 Lane)	Type 2 Dual (3 Lane)
N83 to Coolagh Interchange	Urban	51	N/A	N/A	N/A	<2950	UAP 2 (Dual 2 Lane)	Type 2 Dual

Notes:

1. Annual Average Daily Traffic.
2. Hourly Flows Each Direction for Peak Periods.

The table above show that each of the cross-sections assessed are line with TII and DMRB guidelines.

As noted in section 7.5.2, for suburban and urban areas, such as this, junction capacity is a significant consideration and should be considered along with AADTs and peak hourly traffic flow. The importance of junction capacity is highlighted by the fact that the capacity of a link will not be reached if either the capacity of junctions along the link or the capacity of the adjoining network is lower than the link in question. Analaysis of the junction performance on each of the main junctions along the entire N6 GCRR is contained within the junction strategy report and indicated that all junctions are predicted to operate well within capacity in the 2039 design year.

7.6 Changes in Traffic Patterns

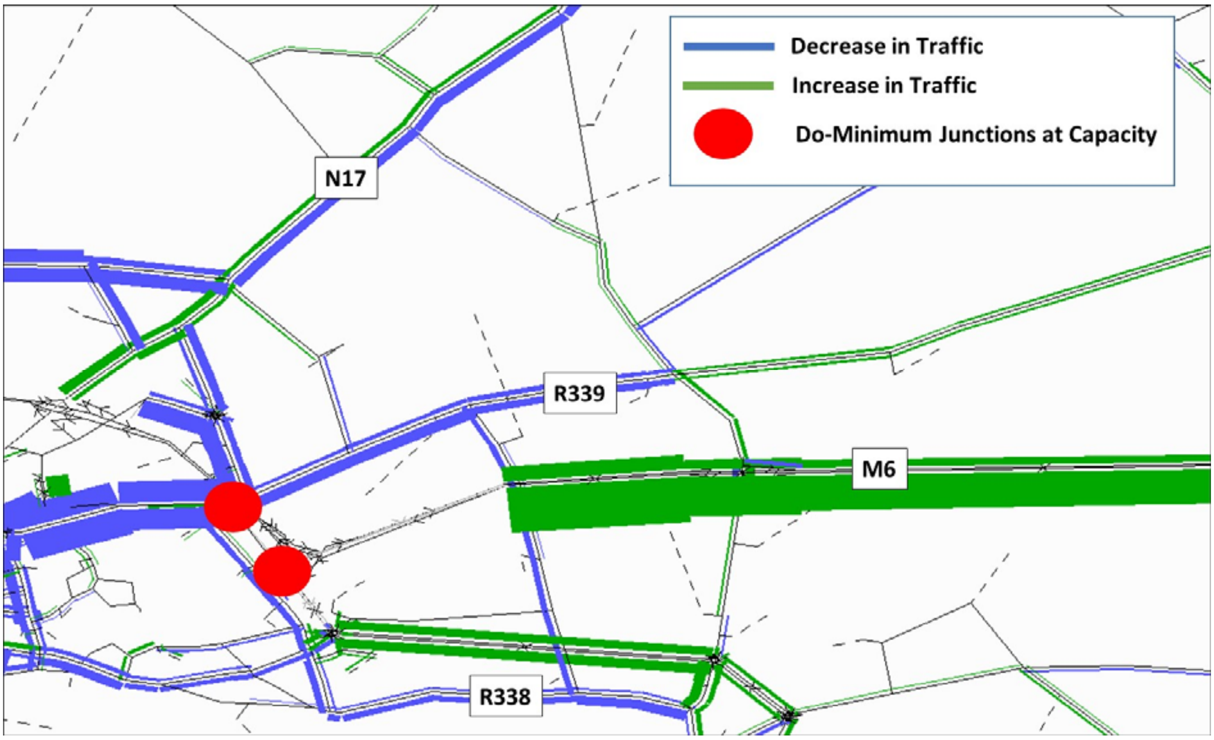
Analysis of the AADT tables presented in section 7.4 shows that, as would be expected, the introduction of the N6 GCRR leads to a significant decrease in traffic flows on the existing N6 and other city centre sites such as the 3 bridge crossings in the city centre.

These tables also indicate an increase in predicted traffic flows along the radial routes into the city from the east, most notably on the M6, N6 and R446 (AADT points 1,2 &3). Analysis of the GCRR Models indicates that these increases in predicted traffic flows are largely related to re-routing of traffic as a result of relieved congestion at critical junctions on the existing N6, specifically the Briarhill Interchange and Coolagh Roundabout.

Figure 7.6.1 below illustrates that, with the introduction of the N6 GCRR, traffic which accessed the city using roads such as the N83, R339 and R338 switch to the M6 and R446. This is because, in the do minimum scenario, the junctions of Briarhill and Coolagh have reached capacity limiting the amount of additional traffic that can proceed past these bottlenecks in the peak periods. The introduction of the N6 GCRR and associated Coolagh Interchange relieves the congestion at these junctions and also provides an alternative means of accessing the city from the east.

Furthermore, the removal of these bottlenecks result in Galway becoming more accessible from the east which in turn results in additional trips to Galway City, along the M6, from nearby towns such as Athenry and Loughrea. A comparison of the total trip matrices for the AM peak period, indicates that the introduction of the N6 GCRR results in approximately a 0.5% increase in car trips across the entire model area.

Figure 7.6.1: Do-Something Traffic Re-routing



Appendix A

WRM Highway Model
Development Report

REGIONAL MODELLING SYSTEM

Western Regional Model

Road Model Development Report

Údarás Náisiúnta Iompair
National Transport Authority

CONTENTS

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 (RMS) for 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 major population centres such as, Dublin, Cork, Galway, Limerick, and Waterford. The models were developed as part of the Modelling Services Framework (MSF) by the NTA, SYSTRA and Jacobs Engineering Ireland. Table 1.1 presents the five regional models which have been developed while Figure 1.1 illustrates the location and scale of each regional model area.

Table 1.1 Regional Models and their Population Centres

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

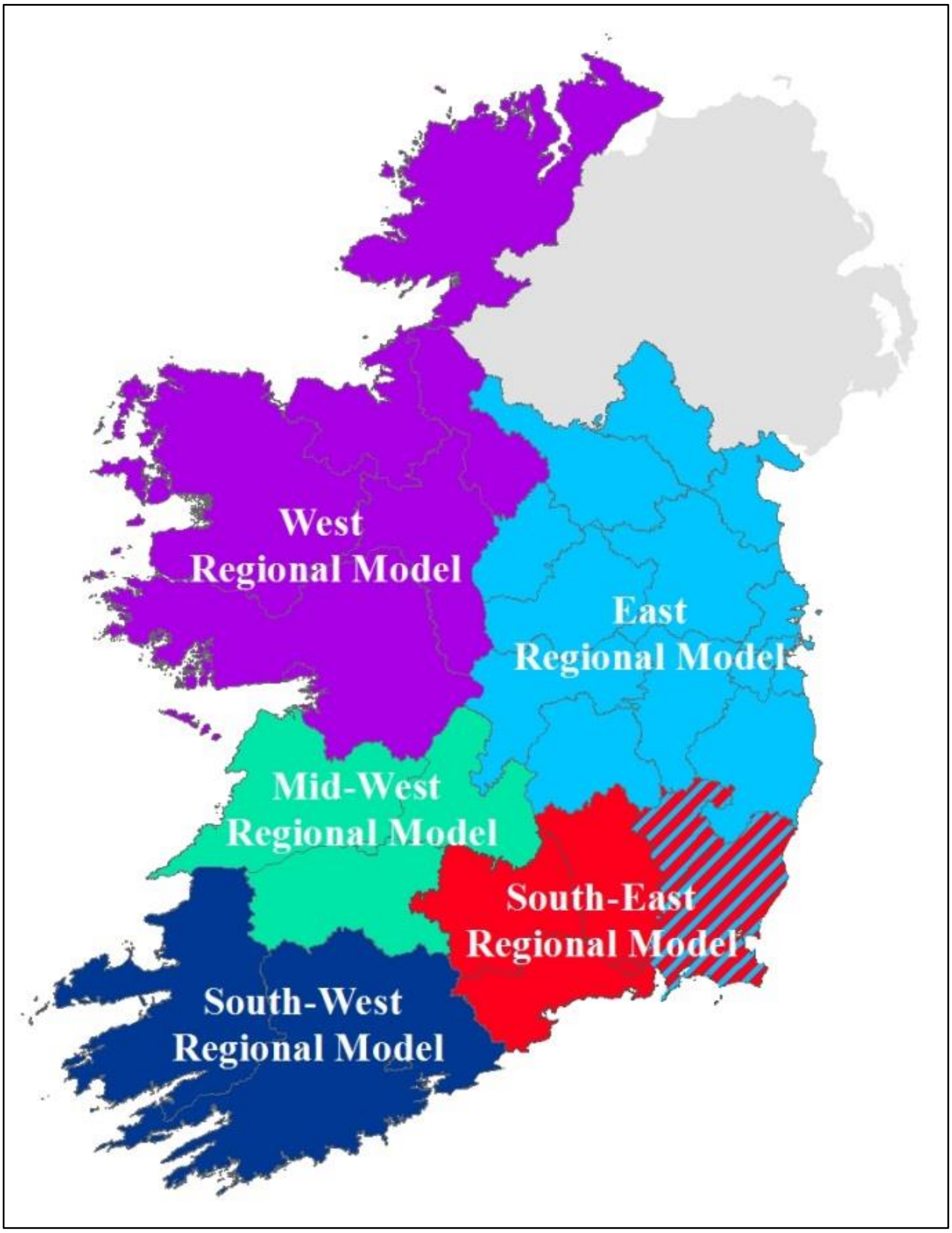


Figure 1.1 Regional Model Coverage

1.2 Regional Modelling System Structure

Each regional model uses a consistent and standardised “four stage” transport modelling approach, in which trip demand is generated by a demand model and assigned to the appropriate transport network using network assignment models. The general structure of the WRM and the other four regional models is shown in Figure 1.2 below.

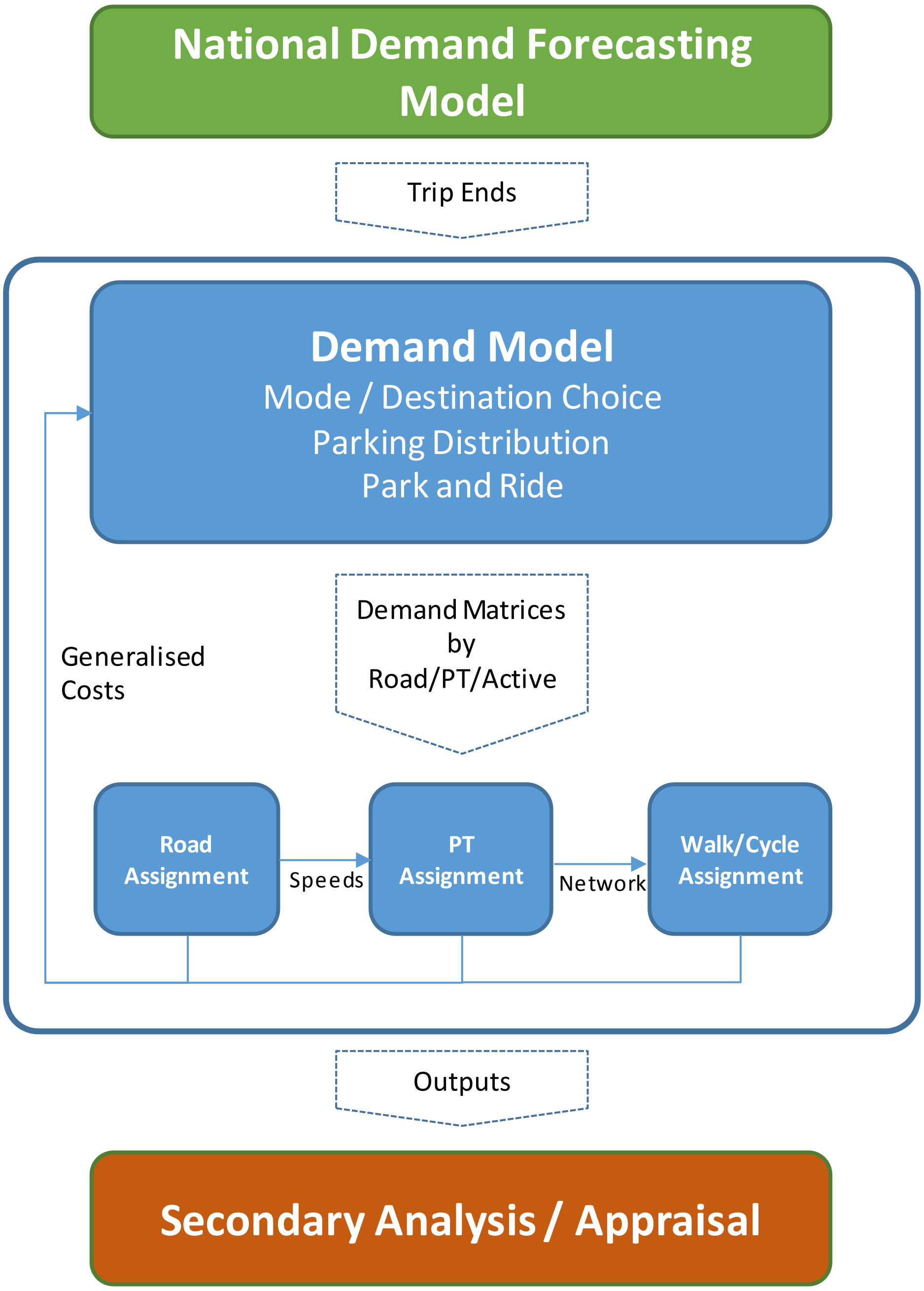


Figure 1.2 RMS Model Structure

Trip Generation is created nationally by the **National Demand Forecasting Model (NDFM).** The function of the NDFM is to estimate the total quantity of travel demand generated by and attracted to each model zone on a daily basis (known as trip ends). Daily trip generations and attractions are related to zonal attributes such as population, number of employees and other land-use data. See the report MSF04.04 NDFM Development Report v2 1 20160331 for further information.

The ***Demand Model*** is integral to the WRM and the other four regional models. The demand model processes all-day travel demand from the NDFM and outputs origin-destination travel matrices by mode and time period using information for each of the five modelled areas. The Road and PT Models then assign these travel matrices to determine the route-choice of trips in their respective transport networks. See the reports RMS Full Demand Model (FDM) Specification Report v4 and WRM Demand Model Calibration Report.

The **Road Model** (RM) assigns trips by private vehicles to the road network. It includes capacity restraint and the impact of congestion, whereby travel times are recalculated in response to changes in assigned flows. See report MSF 006 ERM Road Model Specification Report v4 May 16.

The **PT Model** assigns trips by public transport to the appropriate PT network. It also includes the impact of capacity restraint, such as, crowding on PT vehicles, impacting on people's perceived cost of travel. See report WRM v1 Public Transport Model Development Report.

As illustrated in Figure 1.3, the demand and assignment models are executed iteratively until a balance is achieved between travel demand and the costs of travel – at which stage the model is deemed to have converged.

The **Secondary Analysis / Appraisal** component of the regional model uses model outputs to assess the impacts of transport plans and schemes. The following impacts can be informed by model outputs (travel costs, demands and flows):

- Social, economic and financial appraisal;
- Road safety and accidents;
- Environmental impacts: noise, local air quality and carbon;
- Fitness benefits of increased use of active travel modes; and
- Change in fare revenue for PSO services and tax revenue from fuel oil.

1.3 WRM Road Model Overview

1.3.1 RMS Road Model Specification

The Regional Modelling System Road Model Specification Report was used as a guide for the development of the WRM 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.

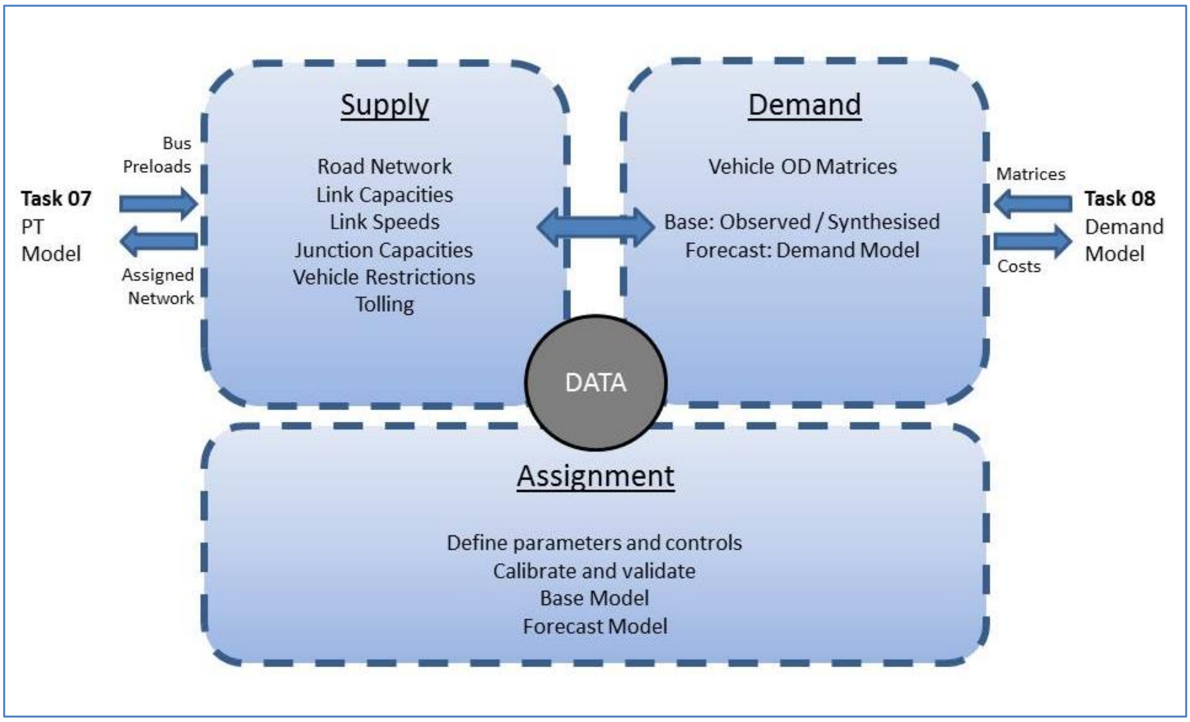


Figure 1.3 RMS RM Structure Overview

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 WRM Transport Model

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

- Definition of Zone System
  - definition of zonal boundaries for RM.
- System Architecture
  - consideration of model procedures and their impact on run-times;
  - coordination with overall RMS;
  - standardisation with overall RMS (e.g. scripts, procedures, units); and,
  - calculation of annualisation factors.

In addition, there are a number of inter-dependencies with other elements of WRM:

- Public Transport Model
  - Interchange of key data, notably network details including bus stops, retained access points and bus service volumes as pre-loaded traffic in the road model.
- Demand Model
  - the development of synthetic public transport assignment matrices;
  - the park & ride methodology and, if relevant, the subsequent interchange of input generalised costs and output trip matrices;
  - methodology for modelling peak periods – either as an average period hour or a peak hour; and
  - the definition of generalised cost parameters and specifically the value of time of public transport users.

1.3.5 WRM Zone System

The Road Model zone system is consistent with the zoning system specified for the overall WRM as described in the WRM Zone System Development Report. The final WRM zone system includes 693 zones and is illustrated in Figure 1.4.

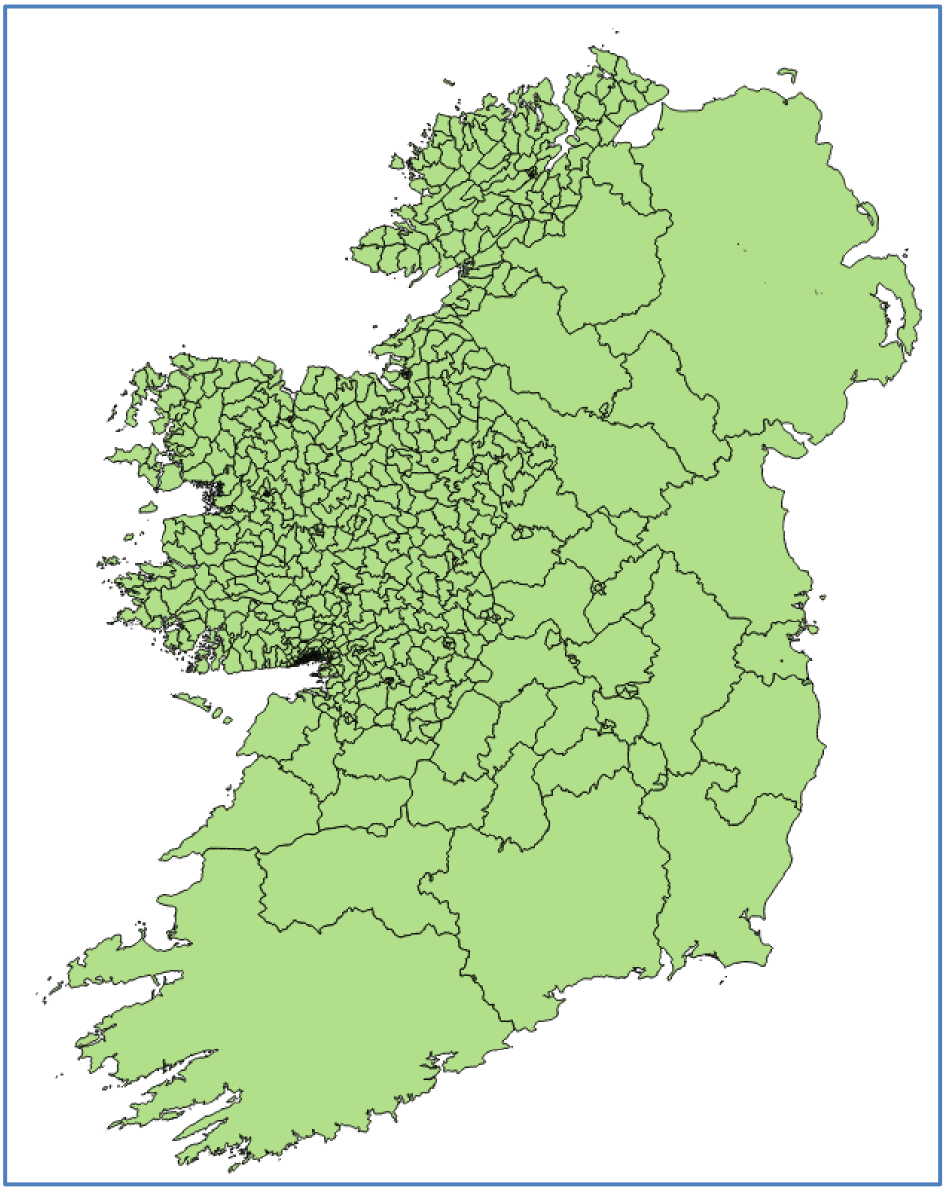


Figure 1.4 Zone System

The key zone system statistics include:

- Total zones: 749;
    - Galway City: 138
    - Galway County: 201
    - Donegal County: 108
    - Leitrim County: 27
    - Sligo County: 46
    - Roscommon County: 48
    - Mayo County: 123
    - Special Zones: 2
    - External Zones: 56

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 Galway 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 West Regional Model (WRM). It includes the following chapters:

- **Section 2: WRM Road Model Development:** Provides information on the network dimensions, network development and initial assignment checks undertaken prior to calibration and validation;
- **Section 3: WRM Road Model Matrix Development:** Outlines the hierarchy of User Classes used in the WRM Road Model and describes the process of development of travel matrices for these User Classes prior to the model calibration process;
- **Section 4: WRM Data Collection and Review:** Outlines where the data used to calibrate and validate the WRM was sourced;
- **Section 5: WRM Road Model Calibration:** Details the process of calibration and assignment of the Road Model;
- **Section 6: WRM 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 and validation of the Road Model. It also provides recommendations for future versions of the model.

2 WRM 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 WRM Road Network Development

2.2.1 Overview

The development of WRM road network differed from the other regional models due to the availability of the Galway Interim Model (GIM). The GIM was developed to cover the city of Galway and its environs and was used to assess the proposed Galway City Outer Bypass prior to the availability of the WRM.

The WRM model makes extensive use of the GIM, with the coding of the simulation area retained and reviewed to ensure consistency with other regions. The network has also been extended to cover the wider modelled area required for the WRM. Further details on the development of the WRM road network utilising the existing GIM is described in the following sections of this chapter.

For more information on the development of the GIM, the reader is referred to the following documents:

- MSF 016 GIM IN04 Highway Network Build (dated 07/03/2014);
- MSF 016 GIM IN05 Coding Guide (dated 07/03/2014);
- MSF 016 GIM IN07 Highway Model Checking Strategy (dated 07/03/2014); and
- MSF 040 TN1 Zone Specification Note (dated 07/03/2014).

2.2.2 Expansion of Galway Interim Model (GIM)

The road network developed for the Galway Interim Model (GIM) was the starting point for the development of the WRM. This model was fully calibrated, and utilised many of the practices implemented by the RMS process, including the derivation of generalised cost. The models share a base year of 2012, with the matrices developed from the same data sources with the exception of goods vehicles.

The network was expanded to cater for the increase in the number of zones from 288 to 749, and to fully align with the RMS architecture. This network was version V0 and was the foundation on which all future network versions were based.

The GIM model's time periods differed to those specified for the RMS. While the AM Peak definitions were consistent, an average Inter-peak hour, representing the period from 1000 to 1600 was used and no PM Peak time period was specified.

The introduction of the PM Peak required additional coding, principally for traffic signals within the simulation model. An assumption was made that the signal times for the PM Peak could be adequately represented by the existing AM Peak coding, at least initially. Changes were made to the coded cycle and phase definitions during model calibration.

With the disaggregation of the Inter-peak period into two distinct assignment periods, 1000 – 1300 and 1300 – 1600, it was assumed that the current Inter-peak traffic signal coding would be suitable for both the Inter-peak 1 and Inter-peak 2 time periods.

The user classes within the WRM assignment model have been updated for consistency with the ERM model.**Error! Reference source not found.Error! Reference source not found.Error! Reference source not found.Error! Reference source not found.Error! Reference source not found.Error! Reference source not found.** Table 2.1 below lists the updated WRM user classes and their links to the original six GIM model user classes:

Table 2.1 WRM User Classes

WRM User Class	WRM UC Description	GIM User Class	GIM UC Description
1	Taxi	3	NA[1]
2	Employers Business (EMP B)	3	EMPLOYERS BUSINESS
3	Commuting (COM)	1	WORK
4	Education (EDU)	2	EDUCATION
5	Others	4	OTHERS
6	Light Goods Vehicles	5	LGV
7	OGV1	6	OGV
8	OGV2 Permitted	6	OGV
9	OGV2 Not Permitted	6	OGV

The revised user class specification required an updating of the generalised cost equations which were derived for the GIM. The corresponding generalised costs from the GIM were applied to the revised user classes within the WRM. Further details are provided in Section 5.3 later in this report.

2.2.3 Simulation Area Coding

The WRM model network was built to utilise the maximum amount of information from the GIM. The GIM network development followed the same processes as subsequently used for the other regional models. Thus, the approach was to retain

[1] Taxi demand was not modelled as a separate user class in the GIM. Counts used in the GIM road model calibration would have included taxis and, as such, there demand was accounted for in this way.

and review the simulation area coding, while replacing the buffer area coding to enable its extension to connect all zones within the defined zoning system.

The review of the simulation modelling identified a few minor issues in coding, which were subsequently addressed prior to progressing with network calibration. These changes are detailed below:

- Bus lane added on both approaches to Node 50622 as per Google Maps (2010);
- Bus lane added to Node 53383 from approach 50930 as per Google Maps (2010);
- Node 50528 re-coded so arms were in correct order and with correct turn saturations;
- Node 50413 was signalised as per Google Maps (2011);
- Extended the flared approach at node 50862 from 6pcu to 8pcu;
- Removed second lane from Node 52842, and replaced it with a 2pcu flare;
- The nodes making up the R336 / R864 roundabout (50652, 50651, 52814, 52813, 52812 and 52940) recoded to match coding guide;
- Node 50650 was signalised to represent the pedestrian crossing;
- Node 50649 was deleted and Nodes 53059 and 50648 recoded accordingly;
- Added an AM-specific ban to link 50731 – 50734 as traffic appears to be banned until 11am (was previously just an HGV ban);
- Added second lane at Node 50721 from approach 50722 as per Google Maps (2014);
- Added second lane at Node 53386 from approach 50725 as per Google Maps (2014);
- Removed Zone 137 connection to 53271, and reconnected to 52233 instead; and
- Added turn saturation capacity at multiple external nodes (not all external nodes have a capacity).

2.2.4 Buffer Area Coding

The buffer network was derived from the HERE[2] maps data using a dissolving process developed for the ERM model and documented as a repeatable method.

The method required the identification of a subset of HERE links and the points at the end of a link to be retained as a SATURN node representing either a junction, bus stop, zone connector or shape node. Bus stop nodes were extracted from the

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

GTFS database and overlaid in GIS to ensure that there was sufficient network coverage.

The subset of links was derived through a three stage process:

- By taking links which are function classes 1- 4 which fall within a polygon representing the area to be modelled. ArcMap was used to facilitate this stage;
- Using the bus stops shapefile, identify manually any additional links required to ensure sufficient network coverage for the public transport network; and
- Using the zone centroid location, identify manually any additional links required to ensure sufficient network coverage to limit non-external zone centroid length to a maximum of 3km.

The nodes which were retained were identified by three stages:

- Excel was used to process the selected links to identify the meeting of 3 or more links and the end points where the route stopped at the end of route or the boundary of the modelled area;
- The nodes in the GIM were mapped to the end of link reference ID 'Nodes' in the HERE data set and these were selected; and
- The provisional zoning system was interrogated to create a set of points representing each of the zones. This was used to identify the nearest 'Node' and these nodes were included in the list nodes fed into the dissolving process.

The dissolving process takes the selected HERE links and the set of nodes identified through the above process. These are then processed using the dissolver to provide a set of links with a number of parameters including length. The dissolving process was developed for an earlier model and forms part of the repeatable methods process. A further spreadsheet was used to derive SATURN coding based on the data saved into the 'newLinks' tab.

The resulting Saturn coding provided a buffer network for the study area. This was then manually stitched to the existing SATURN simulation area from the reviewed GIM model. The stitching process is specific to the WRM to facilitate the coding recently prepared for the Galway Interim Model as this will reduce the time required during the calibration stage.

The stitching process was carried out to join the two data sets together this involved matching nodes from the data sets and coding a link to ensure continuity over the network. This process ensured that there were no overlapping or duplicate links.

2.2.5 Coding of Zone Centroids

The zone centroid locations were plotted in ArcMap and centroid connectors were assigned to the nearest buffer nodes using ArcMap. This procedure was appropriate for zones in the zone range 268 to 691, which represent the bulk of the buffer zones in the extended demand model area. Zones prior to zone 268 retained their GIM model coding, while the remaining two demand model zones represent the Port of Galway and Galway Airport. These were manually coded as additional zones within the simulation area.

The external zones, ranging from zone 694 to 745, were coded in a consistent manner to the other buffer area zones, with the maximum distance constraint relaxed. The exception to these rules were the zones representing Northern Ireland (746 to 749) that have multiple zone centroids connected.

2.2.6 Public Transport Service Files

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

Where a bus lane exists, the buses will utilise the bus lane and not be affected by link congestion. If no bus lane is present, buses will use regular road space at a rate of one-bus equals' three passenger car units (PCU) and will be impacted by link congestion. Other road users will subsequently be impacted by the presence of the bus on the regular road space.

2.2.7 Vehicle Restrictions

Bus lanes are fully represented within the road model. Bus-only links have been coded as general traffic links, but with all assigned user classes banned with the exception of taxis. Where taxis are not permitted to use a bus only link, these links have been coded as a bus-only link in SATURN.

Galway City Council bans vehicles whose length exceeds twelve metres from many residential areas in the WRM area. Inclusion of the vehicle ban has been included in the road model with the use of turn penalties for the affected user classes.

2.2.8 Tolling

There is only one tolled road within the WRM modelled area as of 2012. This is:

- Toll Plazas on the M6 / N6 between Galway and Ballinasloe;

Tolling levels were extracted from the Transport Infrastructure Ireland (TII) tolling information website[3].

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.

2.2.9 Speed Flow Curves

Initial speed flow curves and mid-link capacities were specified in "MSF 002 Report 3 – SATURN Highway Network Coding Guide" and implemented in the development of the supply networks. Speed flow curves are applied to all the buffer links in the WRM modelled area.

During the network calibration and validation stage, some amendments to the speed flow relationships were made. These amendments included 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 Galway City Centre. 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 Galway City Centre, it may be necessary to add speed flow curves on some corridors with few 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 was undertaken before commencing calibration. These included:

- range of checks including saturation flows, free flow speeds, flares, etc;
- spot checking of junction coding;

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

- check that the right types of junctions are coded;
- check that all zones are connected;
- coded link distances versus crow-fly distance; and
- observed traffic volumes versus coded and calculated capacity in SATURN.

2.3.2 Assignment Parameter Updating

The calculated vehicle operating cost (Price Per Kilometre, PPK) component takes the average simulated network speed as an input variable. Whilst updating the model to newer versions of the network and 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 value of time (Price Per Minute, PPM) component does not change with the average simulated network speed and will be fixed for all assignments.

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

3 WRM Road Model Matrix Development

3.1 Overview

Similar to the road network development outlined previously, the development of the prior WRM road model matrices benefited from the availability of GIM. The GIM was calibrated and validated in line with TII guidelines and, therefore, provided a good starting position for the WRM. The following sections of this chapter provide an overview of the process used to expand the calibrated GIM road matrices in line with the new WRM zone system (outlined in Figure 1.4 previously).

3.2 GIM Expansion

3.2.1 Introduction

The matrix expansion process undertook the following procedures:

- Source 24-hour production-attraction (PA) matrices and final estimated assignment model matrices from GIM archives;
- Factor 24-hour PA matrices to hourly time period OD matrices by mode and journey purpose using GIM parameters;
- Factor the AM and IP assignment matrices from GIM to proportion out to the additional user classes required for the WRM;
- Combine the factored PA matrices from 2 to obtain WRM user class matrices for the IP2 and PM time periods;
- Expand from the 288 to 749 zoning system through a matrix expansion file described subsequently in section 3.2.2; and
- Compress GIM and WRM matrices for comparison purposes.

3.2.2 Data Sources for Expansion Files

A matrix expansion file is a list of zone equivalences between two zoning systems used to either compress a large matrix, or expand a smaller matrix, to the required zoning system. The zone equivalence list was created in GIS using ‘point in polygon’ queries to establish which ‘small’ WRM zones are within the ‘larger’ GIM zones.

For expansion, additional information is required to enable the factoring of cells as, unlike compression, the process is not a simple sum. Expansion factors were calculated by comparing a summation of POWSCAR data for the final WRM zone system and the GIM zone system.

3.2.3 Matrix Comparison

A sector system was developed for the analysis of the GIM expansion process, with equivalence lists compiled for both the GIM and WRM zoning systems. This allows for a direct matrix comparison between the GIM matrices and the expanded WRM matrices. For brevity this was performed for all vehicle trips and all public transport trips for the AM Peak and Inter-peak periods.

The 4-sector system employed is based on the simulation, buffer, inner-external and outer-external areas of the zoning system, as shown in Figure 3.1, overleaf.

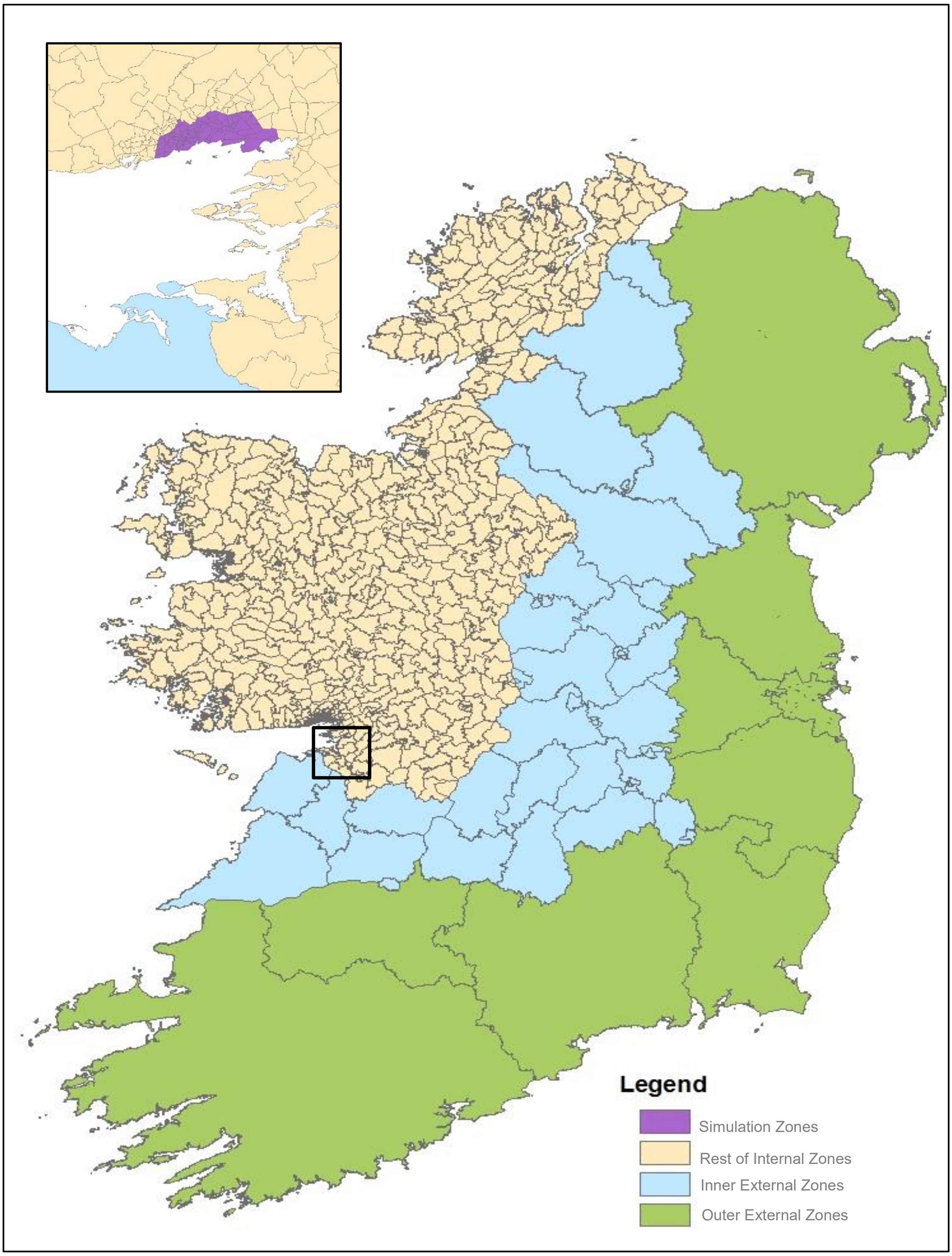


Figure 3.1 West Regional Model Zoning

The following two tables provide a comparison between the AM Peak road trip matrices for the GIM and expanded WRM models. As can be seen, the matrices are nearly identical when compressed to a common sector system. The differences can be explained by the rounding of expansion factors within the process. The differences are insignificant given that the expanded matrices are being used solely to generate initial costs for subsequent demand model calibration.

Table 3.1 AM Peak – Road Trip Matrices – GIM Model

Area	Galway Simulation Area	Rest of Internal Zones	Inner External	Outer External	Total
Galway Simulation Area	2,909	2,605	38	66	5,617
Rest of Internal Zones	8,106	10,676	443	567	19,792
Inner External	79	249	20	0	349
Outer External	157	238	0	0	395
Total	11,250	13,768	501	632	26,152

3.2.4 Inclusion of RMSIT trips

The next stage of the process was to infill trip demand in the zones outside the GIM demand model area (where trip data is available) based on RMSIT[4] data. This approach was required to enable preliminary assignments using the estimated trip data and hence provide initial costs for subsequent model development purposes.

The RMSIT process was used to obtain external and goods vehicle trips by modelled time period in OD format. These trips replaced those in the expanded WRM matrices, again ensuring that trips internal to the GIM demand model area were not changed.

The changes to the matrices are shown in the tables below for all road trips for the AM Peak. As can be seen, only the external trips are changed indicating that only the RMSIT matrices have been included. Furthermore, the RMSIT trips are exclusively from Inner External zones, reflecting the location of the RMSIT route zones and consequent loading points within the WRM.

[4] Regional Model System Integration Tool, which provides estimates of inter-regional trip demand – see MSF 5.3 IN01 RMS-IT Development Report v2 5 20151116 for further details.

Table 3.2 AM Peak – Road Trip Matrices – Expanded WRM Matrices

Area	Galway Simulation Area	Rest of Internal Zones	Inner External	Outer External	Total
Galway Simulation Area	2,921	2,602	40	64	5626
Rest of Internal Zones	8,132	10,641	449	560	19,782
Inner External	89	256	20	0	365
Outer External	148	231	0	0	378
Total	11,289	13,729	509	624	26,152

Table 3.3 AM Peak – Road Trip Matrices –WRM Matrices to generate Costs

Area	Galway Simulation Area	Rest of Internal Zones	Inner External	Outer External	Total
Galway Simulation Area	2921	2602	301	0	5824
Rest of Internal Zones	8132	10641	1548	0	20320
Inner External	301	1548	168	0	2017
Outer External	0	0	0	0	0
Total	11354	14790	2017	0	28160

3.2.5 Internal Goods Vehicle Trips

The final stage of the process involved using the Prior Matrix process to calculate matrices of goods vehicles for LGV, OGV1 and OGV2 for the “Rest of Internal zones” to “Rest of Internal zones” part of the matrix as illustrated below in Table 3.4**Error! Reference source not found.**.

The prior matrix process is documented in “MSF_GDA_TO8 2 1 Base Year Matrix Building Scoping v6 3 20150824.docx”. This process can be applied to any model area with appropriate updating of zoning systems and road travel costs from the initial GIM expanded matrix assignment.

It was preferable to use the Prior Matrix process for goods vehicles, rather than the GIM expanded matrices, because the latter were derived from a small number of movements (the process entails expanding a small number of zones to a large number of zones based on population proportions), and are hence less reliable.

Table 3.4 Use of Prior Matrix Process

Area	Galway Simulation Area	Rest of Internal Zones	Inner External	Outer External
Galway Simulation Area	GIM	**PRIORS**	RMSIT	RMSIT
Rest of Internal Zones	**PRIORS**	**PRIORS**	RMSIT	RMSIT
Inner External	RMSIT	RMSIT	RMSIT	RMSIT
Outer External	RMSIT	RMSIT	RMSIT	RMSIT

3.3 Final WRM Initial Trip Matrices

Upon completion of the goods vehicle processing stage, the matrices were compiled and assigned to the road network to provide initial costs for use in the demand model calibration. Section 5.6 provides a detailed overview of the development of the WRM Road matrices through calibration and improvement of the Full Demand Model (FDM).

3.4 Prior Matrix Factoring

The prior matrices (referred to in 3.2 above) 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, using a Period-to-Hour (PtH) factor.

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

A third methodology is to represent the “peak everywhere” by applying a single factor, derived from various data sources, with the aim of representing the worst traffic conditions at each point in the network simultaneously. Automatic Traffic Count (ATC) data was used to derive factors for the WRM in order to best represent the traffic conditions within Galway. The method used for this is consistent with the method used for ERM, which is discussed further in the “MSF 008 – Time Periods” report. This factor represents the “flow” PtH factor, and the factors calculated from the ATC data are outlined in Table 3.5. These factors were applied to interim versions of the road model.

Table 3.5 WRM RM Initial Period to Assigned Hour Factors

Time Period	Period to Hour Factor
AM Peak (0700 – 1000)	0.389
Inter-peak 1 (1000 – 1300)	0.333
Inter-peak 2 (1300 – 1600)	0.333
PM Peak (1600 – 1900)	0.363
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 spread more evenly 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 “demand” PtH factors used in the WRM are outlined in Table 3.6.

Table 3.6 WRM RM Final “demand” Period to Assigned Hour Factors

Time Period	Period to Hour Factor
AM Peak (0700 – 1000)	0.47
Inter-peak 1 (1000 – 1300)	0.35
Inter-peak 2 (1300 – 1600)	0.45
PM Peak (1600 – 1900)	0.48
Off Peak (1900 – 0700)	0.08

3.5 Prior Matrix Checking

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

- comparing matrix trip ends against NTEM outputs;
- checking trip length distribution against observed data;

- checking implied time period splits by sector-pair;
- checking implied purpose splits by sector pair; and
- comparing sectored matrices with total screen-line and cordon flows where possible.

These checks revealed no significant issues with the prior matrices. These matrices were then assigned to the latest version of the road model.

4 WRM Data Collation and Review

4.1 Supply Data

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

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

Based on guidelines established for ERM and described in MSF02.03 SATURN Road Model Coding Guide, superfluous network detail was removed from the WRM road network (the development of the WRM road network pre-dated the finalisation of the ERM guidance).

Traffic signal stages and timings were developed for Galway City from:

- Split Cycle Offset Optimization Technique (SCOOT) database where available;
- Microprocessor Optimised Vehicle Actuation (MOVA);
- Proportional green time split based on observed traffic count if not available from SCOOTS or MOVA; and
- Estimated if no other information was available.

4.2 Demand Data

4.2.1 Commute and Education Matrices

The POWSCAR[5] dataset provides a comprehensive set of production-attraction[6] matrices for commute and education purposes. POWSCAR does not include data on how frequently (e.g. how many times a week) a journey is made.

Outputs of the National Trip End Model (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.

4.2.2 Other Purposes

The sample sizes of the NHTS 2012 are too small to be used directly to construct matrices for individual zone to zone trip volumes (there are approximately 9,000 records for WRM). However, the NHTS can be used to estimate broader sector to

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

[6] Based on Census Small Area spatial disaggregation

sector totals, mode share, time of day profiles and time of day return factors. Trip ends were obtained from NTEM, as described in MSF04.04 NDFM Development Report v2 1 20160331. Mode choice and distribution models were calibrated to match the NHTS 2012 data. These models were applied to create the base year prior matrices for the WRM for purposes other than commute and education.

4.2.3 Goods Vehicles

Goods vehicles are comprised of the following classes of vehicles:

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

For the purposes of the regional models, these three classes were 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, supermarkets and distribution centres. These trips will be made regardless of the cost of travel. As with ERM, they have been assumed to be made mainly by OGV2, with a proportion of OGV1. Bulk Goods Trips have been derived from RMSIT, with the local distribution of trips to destinations other than ports, airports and similar locations with a single corresponding RMSIT centroid based on NACE survey data relating to industrial activities. A 70/30 split was used to disaggregate the Bulk Goods matrices between OGV1 and OGV2.

More information on the goods vehicle matrices and their derivation is available in the demand report.

Non-Bulk Goods Trip Ends were estimated using linear regression based on factors estimated for ERM. The same synthetic process as for the ‘Other Purposes’ (Section 4.2.2) was used to create a non-bulk goods matrix, which was disaggregated between LGVs and OGV1 using a 84/16 split.

More detail on the goods vehicles matrices is given in WRM TO9 TN01 Base Year Matrix Building.

4.3 Count Data

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

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

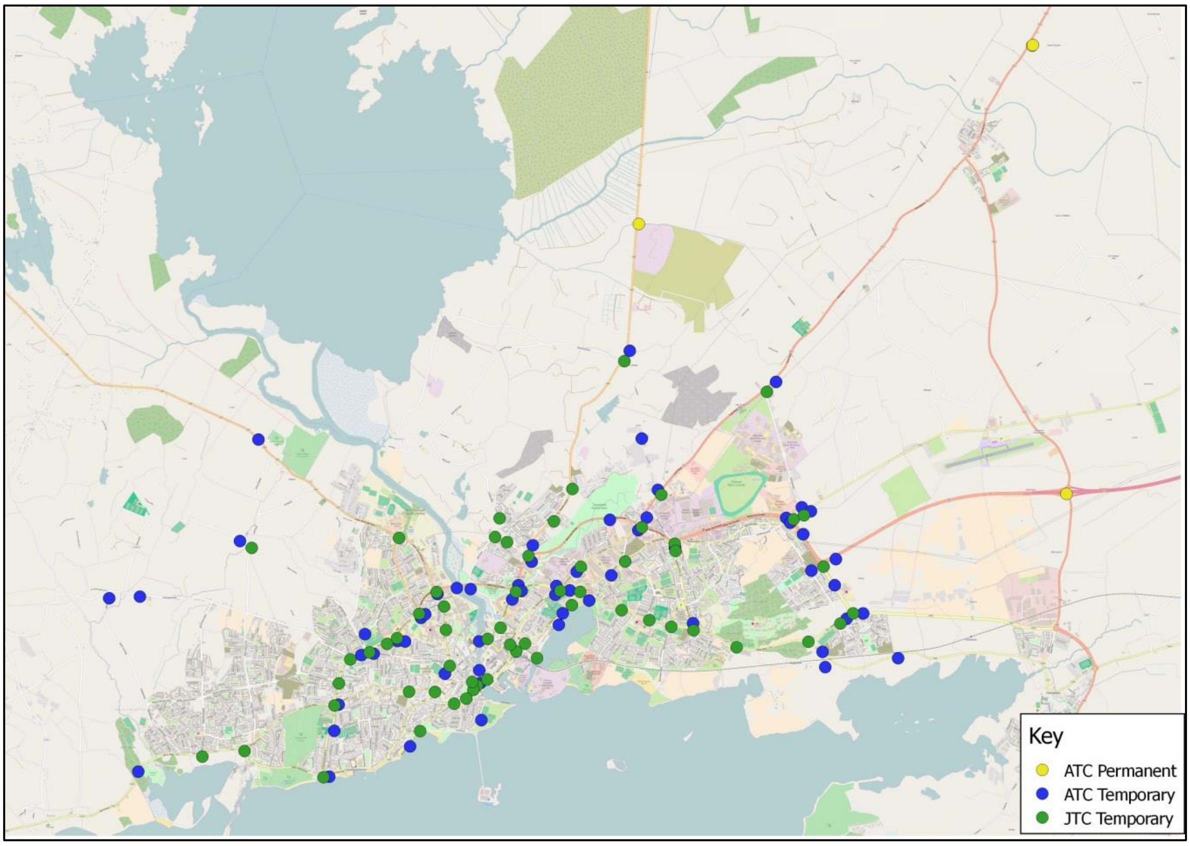


Figure 4.1 Location of Traffic Count Data

4.4 Journey Time and Queue Length Data

4.4.1 GPS-based Travel Time Data

The NTA purchased a license from TomTom[7] for their travel time product Custom Area Analysis (CAA). This product provides average travel time data on every road link within a given area over a specified time period. Details of the data acquisition and data processing are discussed in "MSF 011 TomTom Data Portal Guide 20160505 V1 0" and "MSF 011 TomTom Data Extraction and Processing 20160112 V3 0".

In total, 12 routes in both the inbound and outbound directions were specified for comparison, and these are detailed in

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

Figure 4.2 and Table 4.1, overleaf. Due to a large unobserved gap in TomTom data, Route 4b outbound was split into two sections resulting in a total of 25 individual journey routes reported.

The inbound and outbound direction for all routes is available and extracted in the AM (08:00 – 09:00), Lunch Time (13:00 – 14:00), School Run (14:00 – 15:00) period, PM peak period (17:00 – 18:00).

Figure 4.2 TomTom Journey Time Routes

Table 4.1 TomTom Journey Time Routes

Route	Description
1	Silverstrand to Galway
2	N59 to Galway
3	Western Distributor Road
4a	R338 to N6
4b	N6 to City Centre
5	R339 to City Centre
6	Letteragh to Salthill
7	N17 / R336 to City Centre
8	N84 to City Centre
9	Coolough Road to City Centre
10	Galway Airport to Ballybane
11	Thornpark to City Centre

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

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 is significantly in excess of what could normally be achieved through moving car observer type surveys. This data was used to validate the final WRM road model.

4.4.2 Queue Length Data

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

5 Road Model Calibration

5.1 Introduction

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

5.2 Assignment Calibration Process

5.2.1 Overview

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

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

5.2.2 Calibration

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

Table 5.1 Significance of Matrix Estimation Changes

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

The comparison of the modelled vehicle flows also makes use of the GEH[8] summary statistic. This statistic is 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 observe d flow of 1,000 PCUs.

The GEH Statistic is defined as:

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

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

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

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	> 85% of cases

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

flows more than 2,700 veh/h	
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 3.1.

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 applied were taken from the initial generalised cost parameters applied to the Galway Interim Model (see Section 2.2.2 previously). The initial generalised cost parameters are set out in the following four tables, with IP2 mirroring the initial costs of IP1 as there was no IP2 assignment undertaken at this stage. 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 Initial Road Model Network Progression

5.4.1 Overview

As noted previously in Section 2.2, the GIM was used as the basis for development of the WRM road network. Throughout the network development process, a number checks and alterations were made to provide a better representation of road costs and improve the overall road calibration.

Initially, the developed WRM network was reviewed and refined including updates to signal timings, junction capacities, observed count data, parameter values etc., and these are described in the following sections. Also presented, is a review of the interim GIM calibration and validation highlighting its appropriateness for use in developing the WRM road network.

5.4.2 Network Refinement

Network version V1 was the first “major change” network, which included model changes to accommodate all model issues identified by a high level review of the preliminary assignments.

Junction turning counts and capacity checks were undertaken to identify the junctions with counts lower than the modelled capacity. The network coding for these junctions was reviewed and it was discovered that several junctions had unwarranted flares at priority or signalised junctions that were artificially inflating the available capacity. For this purpose, flares and lane allocation were checked and the capacity was reduced by removing or changing flares on lanes where necessary.

A review of all signalised junctions led to the signal times at many junctions being altered. During the GIM, only AM and IP1 signal times were obtained from Galway Council, and thus the PM signals were a copy of the AM signals. PM signals were reviewed where SATURN indicated potential issues (delays, queues, route choice). For all signalised junctions in all peaks, signal timings and signals stages were reviewed. Where appropriate, green time adjustments were undertaken. If this was not possible overall cycle time was increased. For some junctions, signal phases were rearranged. In addition, several pedestrian crossing points with dedicated traffic signals were included to better match observed travel times, and to improve traffic route choice.

A review of all regional roads was also undertaken to check that the capacity, geometry and speed flow curves are consistent throughout the model.

Volume to capacity (V/C) and delay checks were carried out against the link capacity in the buffer area and turn saturation capacity was added at multiple external nodes as not all external nodes have a capacity. A review of centroid connectors was also carried out to check they are connected to the zones correctly and in an appropriate location. This was carried out in order to facilitate the proposed Galway City Centre traffic restrictions, and partly to better reflect the true major access from a zone. Exploded roundabout checks were undertaken in order to match the coding guide and bus lane coding for the Galway City area was reviewed.

A review of the observed data was undertaken to ensure that the count data was processed correctly and it was paired to the relevant nodes by direction and time period. A screenline at Bundoran was removed as it only contained two counts and was considered to provide no significant information on model performance. The removed counts were included as part of the individual count data. During calibration a number of manual classified counts, which were undertaken within Galway City, were included in the matrix estimation process. These had previously been excluded due to a lack of detailed classification of traffic. To overcome this issue, observed Car, LGV and HGV ratios were taken from accompanying ATCs and applied globally to the MCCs.

Finally, a stress test was undertaken where 110% of the original matrix was assigned to the network and compared to the original network. Checks to identify any junctions that were now over capacity as a result of assigning the larger matrix were undertaken. Based on the outcome of these checks, all junctions along the N6 were reviewed and coding amended where necessary.

5.4.3 Increase in Average PCU Length (SATURN Parameter ALEX)

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

5.4.4 Revised Cost Base

The Common Appraisal Framework (CAF) provides the largest proportion of information used during the derivation of the generalised cost assignment parameters; value of time (VoT) and vehicle operating cost (VOC). At the commencement of the initial network development, the latest available information from the CAF provided costs with a base year of 2002. During the development of the road network, a draft version of the CAF was circulated which provided generalised cost parameters with a base cost year of 2011. A summary of all variables used during the development of the WRM and their sources is presented in the “MSF 008 Exogenous Variables” report.

5.4.5 Period-to-Hour Factor

As outlined in Section 3.4, the PtH factors were adjusted during the development of the final model. These factors had the impact of varying the overall travel demand (matrix size) of the targeted time period prior to any adjustment. The factors tended to increase during development, which in turn highlighted additional areas of the model that required review.

5.4.6 Interim Calibration Statistics

This section provides a brief calibration summary of the Galway Interim Model. Further information on the performance of the Galway Interim Model (GIM) is located in the "MSF 016 GIM TN06 Base Model Assignment Calibration Validation".

The report states that 82 per cent of link flows and 83 per cent of turn flows satisfy the calibration criteria in the AM peak. Of the journey times in the AM peak, 79 per cent of routes satisfy the validation criteria, with 88 per cent in the Inter-peak. Of the remaining routes, all are within 31 per cent of the observed time.

Three alternative highway matrix estimation runs were undertaken, with differing parameters to establish whether a different balance could be found between reducing the impact of matrix estimation on the prior matrix and calibrating and validating well against the counts. Although the alternatives improved the model in some ways, it was often to the detriment of other areas of the model such that, on balance, no overall improvement was found.

The summary and conclusions within the report indicate that the road model has shown to calibrate and validate well against observed data, which demonstrates that there are no serious issues with the model. The GIM was used to assess the Galway City Outer Bypass and public transport alternatives to the Bypass.

5.5 Final Road Model Network Progression

5.5.1 Network Improvements

Following the use of the WRM for the Galway Integrated Transport Strategy, a number of updates were identified for the final SATURN road network. The major considerations during network development and detailed audit are outlined in the following sections.

5.5.2 Zone Connection Review

Several of the proposed transport interventions being considered as part of the Galway Integrated Transport Strategy included revisions to City Centre access arrangements. A complete review of City Centre zone centroid connectors was undertaken to ensure that access would not be affected by the proposed changes. The access point for three zones were changed as part of this review.

5.5.3 Detailed Network Audit

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

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

Measure	Significance Criteria	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9
Matrix zonal cell value	Slope within 0.98 and 1.02;	0.99	0.99	0.94	0.98	0.98	0.82	1.01	1.17	0.00
	Intercept near zero;	0.00	0.00	0.00	0.00	-0.01	0.00	0.01	0.01	0.00
	R^2 in excess of 0.95.	0.97	0.98	0.93	0.99	0.98	0.44	0.32	0.43	1.00
Matrix zonal trip ends	Slope within 0.99 and 1.01;	0.96	0.84	0.86	0.89	0.91	0.61	1.23	1.37	0.00
	Intercept near zero;	0.06	0.50	3.08	0.04	4.83	0.58	0.21	0.13	0.00
	R^2 in excess of 0.98.	0.92	0.85	0.90	0.93	0.93	0.64	0.78	0.76	1.00
Trip Length Distribution	Means within 5%;	-5%	-6%	-3%	-8%	-2%	-45%	-22%	-29%	-
	Standard Deviation within 5%.	-4%	0%	2%	-8%	1%	-37%	6%	7%	-

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

Measure	Significance Criteria	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9
Matrix zonal cell value	Slope within 0.98 and 1.02;	1.00	0.99	0.57	0.97	0.81	0.39	0.95	1.03	0.00
	Intercept near zero;	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00
	R^2 in excess of 0.95.	0.95	0.89	0.53	0.91	0.80	0.17	0.65	0.75	1.00
Matrix zonal trip ends	Slope within 0.99 and 1.01;	1.03	0.94	0.10	0.89	0.74	0.57	0.98	1.03	0.00
	Intercept near zero;	0.11	0.34	6.66	0.01	5.46	0.76	0.19	0.15	0.00
	R^2 in excess of 0.98.	0.93	0.70	0.05	0.80	0.56	0.63	0.89	0.91	1.00
Trip Length Distribution	Means within 5%;	-7%	-8%	-28%	-38%	-23%	-31%	-11%	-18%	-
	Standard Deviation within 5%.	-6%	-1%	-13%	-24%	-28%	-27%	11%	17%	-

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

Measure	Significance Criteria	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9
Matrix zonal cell value	Slope within 0.98 and 1.02;	1.00	1.00	0.98	0.99	0.99	0.31	0.90	0.89	0.00
	Intercept near zero;	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00
	R^2 in excess of 0.95.	0.96	0.87	0.93	0.99	0.98	0.15	0.70	0.63	1.00
Matrix zonal trip ends	Slope within 0.99 and 1.01;	1.05	1.28	0.99	0.89	0.95	0.48	0.94	0.89	0.00
	Intercept near zero;	0.12	-0.77	0.58	0.17	7.07	0.89	0.04	0.06	0.00
	R^2 in excess of 0.98.	0.91	0.68	0.92	0.88	0.93	0.59	0.91	0.84	1.00
Trip Length Distribution	Means within 5%;	-5%	-6%	-4%	-4%	-3%	-24%	-2%	-7%	-
	Standard Deviation within 5%.	-5%	-3%	0%	-5%	-1%	-23%	5%	7%	-

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

Measure	Significance Criteria	UC1	UC2	UC3	UC4	UC5	UC6	UC7	UC8	UC9
Matrix zonal cell value	Slope within 0.98 and 1.02;	1.00	1.00	0.96	0.95	0.99	0.63	0.84	0.91	0.00
	Intercept near zero;	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00
	R^2 in excess of 0.95.	0.97	0.77	0.92	0.88	0.98	0.33	0.35	0.38	1.00
Matrix zonal trip ends	Slope within 0.99 and 1.01;	1.02	1.40	0.90	0.68	0.93	0.56	1.08	1.21	0.00
	Intercept near zero;	0.11	-1.83	4.03	0.23	6.44	0.60	0.11	0.05	0.00
	R^2 in excess of 0.98.	0.93	0.38	0.93	0.74	0.93	0.60	0.83	0.83	1.00
Trip Length Distribution	Means within 5%;	-4%	-5%	-4%	-9%	-3%	-41%	-13%	-20%	-
	Standard Deviation within 5%.	-3%	-3%	0%	-7%	-1%	-36%	5%	3%	-

It should be noted that there was no observed data available to derive the prior goods vehicle matrices. These were developed synthetically, and hence were unlikely to accurately represent the true patterns of travel of heavy goods vehicles. As a result of this, matrix estimation was required to make large changes to the LGV, OGV1 and OGV2 matrices across all time periods.

For the remaining user classes the differences between pre- and post-matrix estimation matrices either exceeded or was close to exceeding the recommended criteria, with several exceptions. In the AM Peak and Inter-peak 2 periods, both the slope and R^2 values either exceed or are close to exceeding close to the recommended criteria. In the Inter-peak 1 period, Car Commute (UC3) and Car Other (UC5) fail to meet the recommended criteria by a significant margin. In the Pm Peak, although the slope values are near the recommended criteria, the R2 values are further away, especially for Car Employers Business (UC2) and Car Education (UC4). Overall, this indicates that the changes made during matrix estimation were larger than desired.

To address this, the XAMAX parameter in SATURN was reduced and trip end constraints were applied. The XAMAX parameter is discussed more fully in Section 5.9.1, however in summary it defines a maximum (or minimum) adjustment factor during Matrix Estimation. A lower value restricts the magnitude of the changes that can be made at a cell level during Matrix Estimation, while the trip end constraints were applied to further reduce the significance of the changes made during Matrix Estimation.

Table 5.12 Pre-Audit Road Assignment Model Calibration

Measure	Significance Criteria	AM Peak	Inter-peak 1	Inter-peak 2	PM Peak
Individual flows within 100 veh/h of counts for flows less than 700 veh/h within 15% of counts for flows from 700 to 2,700 veh/h within 400 veh/h of counts for flows more than 2,700 veh/h	> 85% of cases	94% (213)	94% (214)	94% (213)	94% (214)
GEH < 5 for individual flows	> 85% of cases	91% (206)	89% (203)	92% (208)	90% (205)

Table 5.13 Pre-Audit Road Assignment Model Screenline Calibration

Measure	Significance Criteria	AM Peak	Inter-peak 1	Inter-peak 2	PM Peak
Differences between modelled flows and counts should be less than 5% of the counts	> 85% of cases	72 %	72%	72%	72%

Table 5.13 indicates that the road assignment model, pre-audit, generally falls short of the recommended criteria in each time period, although it does meet the more relaxed criteria typically used for models of this size outlined in Section 5.2.2.

Table 5.10 shows a similar pattern across the model screenlines, with the pre-audit stage model falling short of the criteria in each time 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 adjustments 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 number of changes were made to the road network, including amending coded signal times at a small number of locations to more accurately reflect 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. Several dedicated pedestrian crossings were also added to the road model in order to more accurately reflect the delay along some routes. It was also noted that at some locations, local rerouting was occurring, minimising delays at some junctions. This was corrected where possible through the adjustment of junction coding, and a small decrease was applied to the coded free flow speed on links where the alternative road was noted to be of a significantly lower standard than the main route and unlikely to carry the assigned flow at the coded speed.

The audit also noted that the junction turning count dataset had not been fully utilised during matrix estimation as the traffic counts were not fully classified. Observed vehicle splits were calculated from neighbouring ATC data, and additional traffic count data was included in the matrix estimation dataset in order to adjust the traffic volumes at key locations.

5.6 Road Model Matrix Progression

5.6.1 Overview

For the WRM, four distinct versions of the prior matrices were produced, and each of these were assigned in order to provide updated network costs for further refinement of the Full Demand Model (FDM). The four versions of the matrices are numbered in Figure 5.1 below, which illustrates the process involved in developing the final road model matrices for the WRM. Note that not all of the steps that were undertaken are shown on this diagram.

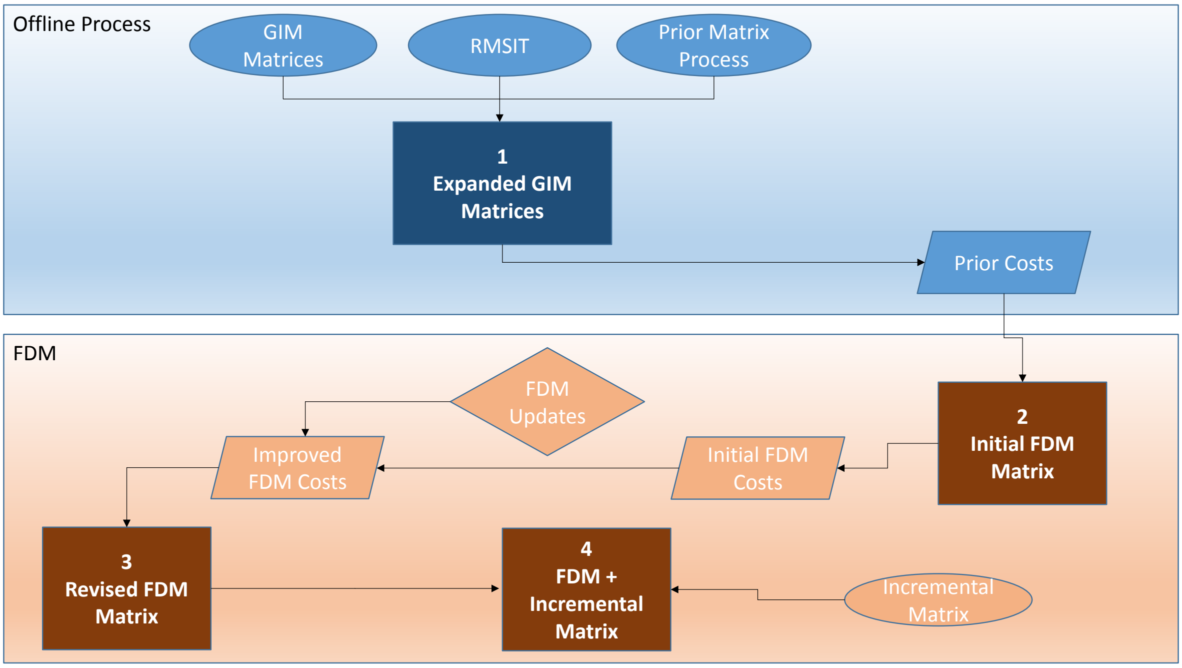


Figure 5.1 Road Model Matrix Development Process

5.6.2 Expanded GIM Matrices

As noted in Chapter 3 previously, the initial WRM matrices were developed through an expansion of the GIM matrices with information on external demand provided by RMSIT. The prior matrix development process, developed for the ERM, was utilised to generate initial goods vehicle matrices. These matrices were assigned to the road network and cost skims were extracted for input into the FDM.

5.6.3 Initial FDM Matrices

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

5.6.4 Revised FDM Matrices

The WRM FDM has been developed through a series of iterations where a number of alterations have been made including parameter estimation, scripting updates, assumption reviews etc. Further information on the WRM FDM development and calibration is provided in the WRM Demand Model Calibration Report and the MSF Demand Model Development Report, which should be read in conjunction with this report.

The revised FDM matrices have been created from the final calibrated WRM FDM, and have been taken forward for matrix estimation and development of the final incremental matrices.

5.6.5 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 SATURN parameter XAMAX. Traffic passing a particular point in the network where a traffic count is located can be factored by any number that lies between XAMAX and 1 / XAMAX. XAMAX has been set to 2 for cars, and 1000 (essentially unlimited) for goods vehicles due to the low confidence in the prior goods matrices. In this case, cars can be adjusted by a factor between 0.5 and 2. Goods vehicles can be adjusted by a factor between 0.001 and 1000.

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

SATME2 and the assignment module, SATALL, were run iteratively with the assigned paths and costs from the latest road assignment informing the next iteration of SATME2. The input prior matrices do not change between successive iterations.

5.6.6 Incremental Matrix Calculation

Once the final version of the prior matrix had been created and matrix estimation applied, an incremental matrix was calculated as the combination of the prior matrix plus the difference between the pre and post-matrix estimation assignments. The incremental adjustments have been calculated based on the estimated assignment matrices, where a 'mask' is produced to align demand model outputs with the estimated assignment matrices.

This approach involved either one of two types of increment being created, specifically:

- Where the factor $0.5 < M = \frac{C}{P} < 2$, the multiplicative factor $M = \frac{C}{P}$ will be applied such that $O = MP$;
- Where the factor $0.5 > M = \frac{C}{P} > 2$, an additive adjustment $A = C - P$ will be applied such that $O = \max(0, P + A)$.

Where

C is the calibrated assignment matrix,

P is the output assignment matrix from the demand model prior to the adjustment,

O is the output assignment matrix from the demand model,

M is the multiplicative incremental adjustment, and

A is the additive incremental adjustment.

The incremental matrix only applies to user classes in the FDM; for goods vehicles the estimated matrix was used directly as an updated version of the internal good matrix.

5.6.7 Final Incremental Matrices

The incremental matrices were developed by calculating the difference between the pre- and post-ME2 matrices. This incremental difference was then added to the original prior matrices in order to produce the incremental matrix. The final incremental matrix is what the calibration criteria will be measured against.

5.7 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 5.14 Final AM Generalised Cost Values

User Class	Cents Per Minute	Cents Per Kilometre
UC1 – Taxi	60.13	19.71
UC2 – Car Employers Business	60.13	19.71
UC3 – Car Commute	21.52	10.26
UC4 – Car Education	36.39	10.26
UC5 – Car Other	21.16	10.26
UC6 – LGV	43.34	13.97
UC7 – OGV1	46.08	32.27
UC8 – OGV2 Permit Holder	44.40	59.08
UC9 – OGV2 (Other)	44.40	59.08

Table 5.15 Final IP1 Generalised Cost Values

User Class	Cents Per Minute	Cents Per Kilometre
UC1 – Taxi	70.39	18.82
UC2 – Car Employers Business	70.39	18.82
UC3 – Car Commute	20.74	9.84
UC4 – Car Education	42.66	9.84
UC5 – Car Other	38.41	9.84
UC6 – LGV	45.91	14.26
UC7 – OGV1	47.87	31.82
UC8 – OGV2 Permit Holder	46.55	58.44
UC9 – OGV2 (Other)	46.55	58.44

Table 5.16 Final IP2 Generalised Cost Values

User Class	Cents Per Minute	Cents Per Kilometre
UC1 – Taxi	70.39	19.19
UC2 – Car Employers Business	70.39	19.19
UC3 – Car Commute	20.74	10.01
UC4 – Car Education	42.66	10.01
UC5 – Car Other	38.41	10.01
UC6 – LGV	45.91	14.48
UC7 – OGV1	47.87	32.53
UC8 – OGV2 Permit Holder	46.55	59.74
UC9 – OGV2 (Other)	46.55	59.74

Table 5.17 Final PM Generalised Cost Values

User Class	Cents Per Minute	Cents Per Kilometre
UC1 – Taxi	60.13	19.51
UC2 – Car Employers Business	60.13	19.51
UC3 – Car Commute	21.52	10.16
UC4 – Car Education	36.39	10.16
UC5 – Car Other	21.16	10.16
UC6 – LGV	43.34	13.84
UC7 – OGV1	46.08	31.89
UC8 – OGV2 Permit Holder	44.40	58.36
UC9 – OGV2 (Other)	44.40	58.36

5.8 Road Model Network Calibration

5.8.1 Overview

This section details the calibration process and the level of calibration for the road assignment model across the four assigned peak periods. In total, 272 observations have been used in the SATME2 procedure and a total of 82 observations 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. Acceptable models typically achieve criterion in the following ranges:

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

5.8.2 Traffic Count Locations

Detailed maps showing the location of all traffic counts used during calibration are illustrated in Figure 5.2 and Figure 5.3, overleaf.

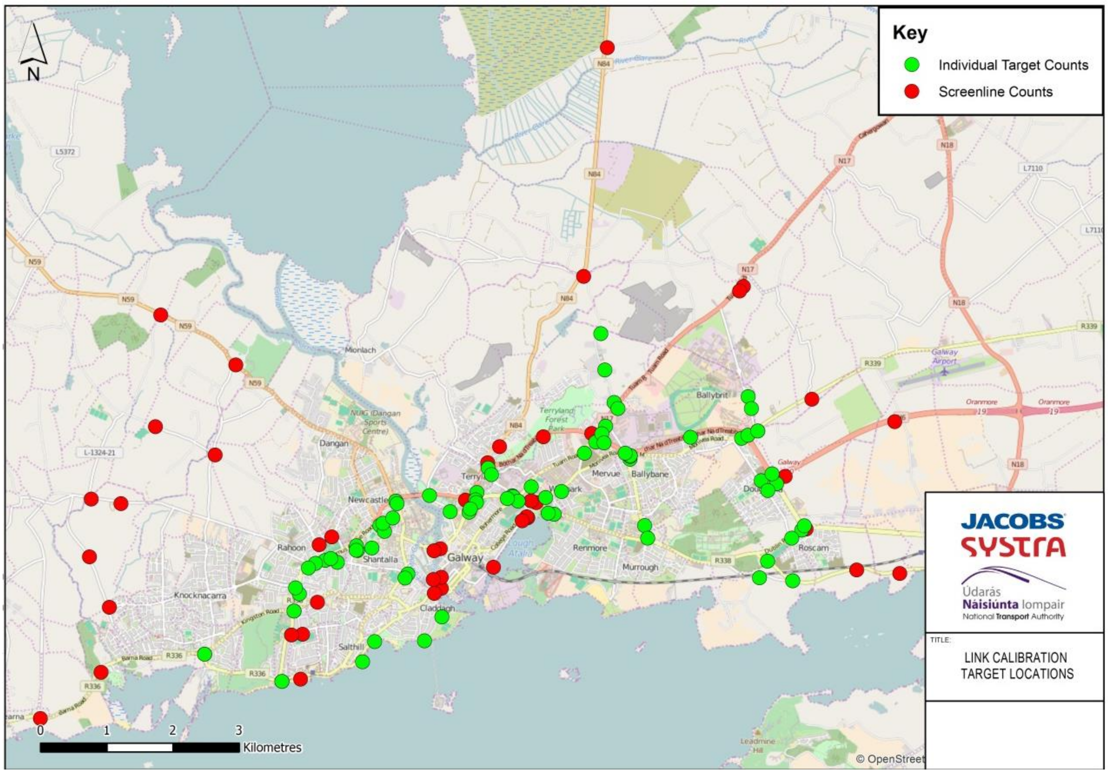


Figure 5.2 Link Calibration Target Locations

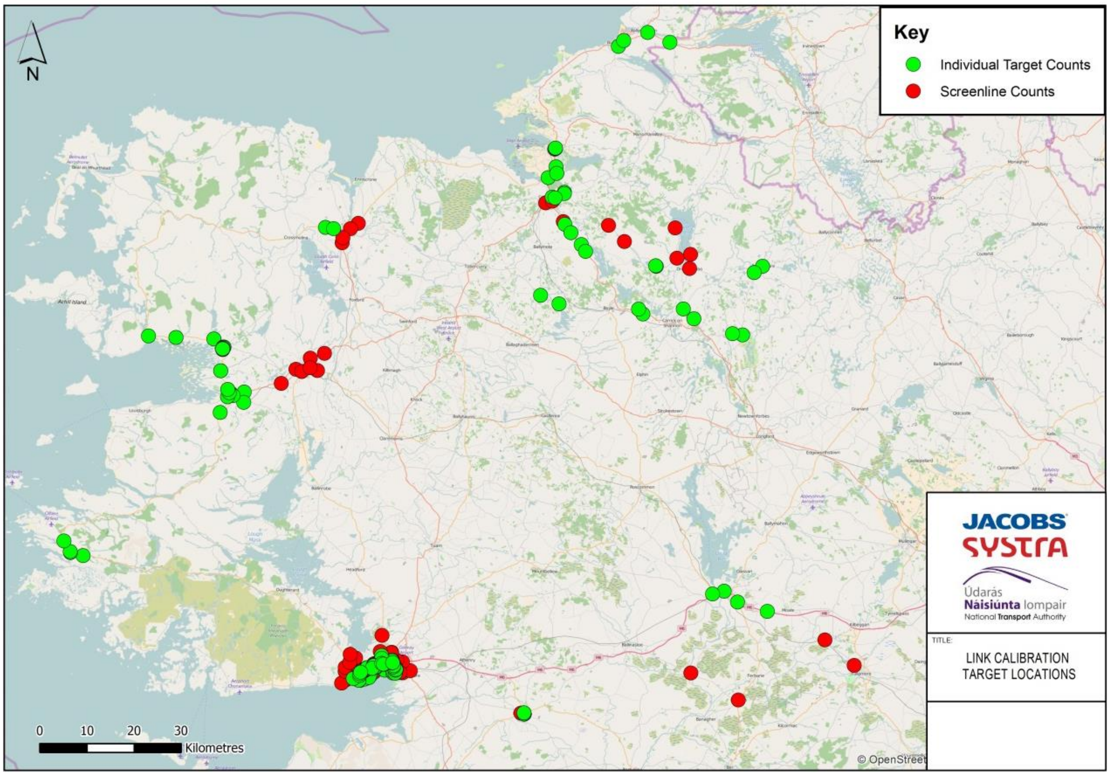


Figure 5.3 Link Calibration Target Locations – County Galway and Wider Region

5.8.3 Individual link calibration criteria compliance – AM Peak

There are a total of 272 individual link traffic counts used during the AM peak road model network calibration. Table 5.18 details the individual link count acceptability criteria.

Table 5.18 AM Link Flow Calibration

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	87% (236)
GEH < 5 for individual flows	> 65% of cases	80% (217)
GEH < 7 for individual flows	> 75% of cases	88% (238)
GEH < 10 for individual flows	> 95% of cases	95% (259)

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

Detailed calibration results, highlighting specific links that pass or fail the recommended calibration criteria are included in Appendix A. The maximum recoded GEH was 25.6. 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 17.3 was recorded on the N84 Headford Road westbound. This is part of the Ballinfoyle inbound screenline in the north of Galway City. The observed traffic flow is 748 vehicles per hour while the modelled flow is 345 vehicles per hour. In this instance, traffic was re-routing via parallel routes to avoid excessive delays at the N84 / N6 roundabout. The delays however were required in order to better match observed journey times.

5.8.4 Screenline calibration criteria compliance – AM Peak

A total of nine two-way screenlines (inbound and outbound) were compared as part of the network calibration exercise.

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

Table 5.19 AM Screenline Flow Calibration

Screenline	Number of Links	Modelled Difference
West Screenline (Inbound)	5	-1%
West Screenline (Outbound)	5	2%
R338 Screenline (Inbound)	4	-11%
R338 Screenline (Outbound)	4	3%
River Corrib Screenline (Eastbound)	4	-1%
River Corrib Screenline (Westbound)	4	0%
Ballinfoyle Screenline (Outbound)	5	2%
Ballinfoyle Screenline (Inbound)	5	-12%
East Screenline (Outbound)	6	-1%
East Screenline (Inbound)	6	-3%
Castlebar Screenline (Inbound)	4	4%
Castlebar Screenline (Outbound)	4	9%
Loughrea Screenline (Outbound)	4	6%
Loughrea Screenline (Inbound)	4	-2%
Outer West Screenline (Inbound)	4	0%
Outer West Screenline (Outbound)	4	1%
Outer East Screenline (Outbound)	5	0%
Outer East Screenline (Inbound)	5	1%

78 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, though the remaining four screenlines fail by less than seven percentage points.

5.8.5 Individual Link Calibration Criteria Compliance – Inter-peak 1

There are a total of 272 traffic counts used during the Inter-peak 1 road model network calibration. Table 5.20 details the individual link count acceptability criteria.

Table 5.20 Inter-peak 1 Link Flow Calibration

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	93% (254)
GEH < 5 for individual flows	> 65% of cases	86% (234)
GEH < 7 for individual flows	> 75% of cases	92% (251)
GEH < 10 for individual flows	> 95% of cases	98% (266)

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

Detailed calibration results, highlighting specific links that pass or fail the recommended calibration criteria are included in Appendix A. The recorded maximum GEH was 15.4. 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 15.4 was recorded on the minor road connecting Castlegar Village to the N17 in the northeast of Galway City. The observed traffic flow is 128 vehicles per hour while the modelled flow is 3 vehicles per hour. Given the location and density of the zones, it is often difficult to calibrate links with low levels of observed traffic given the strategic nature of the WRM.

5.8.6 Screenline calibration criteria compliance – Inter-peak 1

A total of nine two-way screenlines were compared as part of the network calibration exercise.

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

Table 5.21 Inter-peak 1 Screenline Flow Calibration

Screenline	Number of Links	Modelled Difference
West Screenline (Inbound)	5	-1%
West Screenline (Outbound)	5	0%
R338 Screenline (Inbound)	4	-13%
R338 Screenline (Outbound)	4	-5%

River Corrib Screenline (Eastbound)	4	-5%
River Corrib Screenline (Westbound)	4	-1%
Ballinfoyle Screenline (Outbound)	5	2%
Ballinfoyle Screenline (Inbound)	5	-11%
East Screenline (Outbound)	6	6%
East Screenline (Inbound)	6	6%
Castlebar Screenline (Inbound)	4	5%
Castlebar Screenline (Outbound)	4	3%
Loughrea Screenline (Outbound)	4	-5%
Loughrea Screenline (Inbound)	4	-5%
Outer West Screenline (Inbound)	4	0%
Outer West Screenline (Outbound)	4	0%
Outer East Screenline (Outbound)	5	4%
Outer East Screenline (Inbound)	5	1%

67 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. However, a further four screenlines fail by less than one percentage point.

5.8.7 Individual Link Calibration Criteria Compliance – Inter-peak 2

There are a total of 272 traffic counts used during the Inter-peak 2 road model network calibration. Table 5.22 details the individual link count acceptability criteria.

Table 5.22 Inter-peak 2 Link Flow Calibration

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	92% (249)
GEH < 5 for individual flows	> 65% of cases	86% (234)
GEH < 7 for individual flows	> 75% of cases	90% (245)
GEH < 10 for individual flows	> 95% of cases	95% (259)

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 and GEH values.

Detailed calibration results, highlighting specific links that pass or fail the recommended calibration criteria are included in Appendix A. The recorded maximum GEH was 17.6. GEH values in excess of 15 were reviewed, and often these GEH values are recorded on links with small levels of observed traffic. As with the Inter-peak 1 period, this GEH of 17.6 was recorded on the minor road connecting Castlegar Village to the N17 in the northeast of Galway City. The observed traffic flow is 156 vehicles per hour while the modelled flow is 1 vehicle per hour. This issue is consistent with the Inter-peak 1 assignment.

5.8.8 Screenline calibration criteria compliance – Inter-peak 2

A total of nine two-way screenlines were compared as part of the network calibration exercise.

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

Table 5.23 Inter-peak 2 Screenline Flow Calibration

Screenline	Number of Links	Modelled Difference
West Screenline (Inbound)	5	-5%
West Screenline (Outbound)	5	-3%
R338 Screenline (Inbound)	4	-3%
R338 Screenline (Outbound)	4	-5%
River Corrib Screenline (Eastbound)	4	0%
River Corrib Screenline (Westbound)	4	0%
Ballinfoyle Screenline (Outbound)	5	-3%
Ballinfoyle Screenline (Inbound)	5	-5%
East Screenline (Outbound)	6	1%
East Screenline (Inbound)	6	6%
Castlebar Screenline (Inbound)	4	4%
Castlebar Screenline (Outbound)	4	4%
Loughrea Screenline (Outbound)	4	-4%
Loughrea Screenline (Inbound)	4	-10%
Outer West Screenline (Inbound)	4	0%
Outer West Screenline (Outbound)	4	0%
Outer East Screenline (Outbound)	5	2%
Outer East Screenline (Inbound)	5	3%

78 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. A further screenline narrowly fails to meet the criteria.

5.8.9 Individual Link Calibration Criteria Compliance – PM Peak

There are a total of 272 traffic counts used during the PM peak road model network calibration. Table 5.24 details the individual link count acceptability criteria.

Table 5.24 PM Link Flow Calibration

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	88% (240)
GEH < 5 for individual flows	> 65% of cases	81% (220)
GEH < 7 for individual flows	> 75% of cases	88% (238)
GEH < 10 for individual flows	> 95% of cases	94% (257)

The model statistics show that the individual link calibration for the PM peak road model meets the recommendations set out in TAG, for link flows and for GEH values less than 5, and the typically acceptable criteria for GEH values less than 7. The GEH value less than 10 narrowly fails the typically acceptable criteria by one percentage point.

Detailed calibration results, highlighting specific links that pass or fail the recommended calibration criteria are included in Appendix A. The recorded maximum GEH was 16.8. GEH values in excess of 15 were reviewed, and often these GEH values are recorded on links with small levels of observed traffic. As with the Inter-peak 1 and Inter-peak 2 periods, this GEH of 16.8 was recorded on the minor road connecting Castlegar Village to the N17 in the northeast of Galway City. The observed traffic flow is 141 vehicles per hour while the modelled flow does not record any vehicles on this minor link. This issue is consistent with observations noted for the Inter-peak 1 and Inter-peak 2 assignments.

5.8.10 Screenline Calibration Criteria Compliance – PM Peak

A total of nine two-way screenlines were compared as part of the network calibration exercise.

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

Table 5.25 PM Screenline Flow Calibration

Screenline	Number of	Modelled

	Links	Difference
West Screenline (Inbound)	5	-1%
West Screenline (Outbound)	5	-1%
R338 Screenline (Inbound)	4	-6%
R338 Screenline (Outbound)	4	-12%
River Corrib Screenline (Eastbound)	4	0%
River Corrib Screenline (Westbound)	4	-1%
Ballinfoyle Screenline (Outbound)	5	-2%
Ballinfoyle Screenline (Inbound)	5	-4%
East Screenline (Outbound)	6	-5%
East Screenline (Inbound)	6	3%
Castlebar Screenline (Inbound)	4	16%
Castlebar Screenline (Outbound)	4	9%
Loughrea Screenline (Outbound)	4	-11%
Loughrea Screenline (Inbound)	4	-14%
Outer West Screenline (Inbound)	4	4%
Outer West Screenline (Outbound)	4	0%
Outer East Screenline (Outbound)	5	-1%
Outer East Screenline (Inbound)	5	2%

61 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. However, a further three screenlines fail by less than four percentage point.

5.9 Road Model Matrix Calibration

5.9.1 Overview

Matrix estimation was undertaken on the final prior matrices, including constraints at a cellular and trip end level.

5.9.2 Calibration criteria compliance – AM Peak

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

Table 5.26 WRM RM AM Peak Matrix Totals

User Class	Prior (PCU)	Post-Incremental (PCU)	Change (%)
Taxi	2,281	2,322	2%
Car Employers Business	4,361	4,361	0%
Car Commute	37,722	36,833	-2%
Car Education	1,409	1,389	-1%
Car Other	68,204	67,652	-1%
LGV	2,879	2,879	0%
OGV1	2,020	2,020	0%
OGV2 Permit Holder			
Other OGV2	7	7	0%

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

The changes to all user classes are of an acceptable level.

GEH analysis was undertaken on the individual (non-zero) cells and their change between the pre-estimation and post-estimation values. 43 per cent of cells have a GEH value of less than 0.01, with 90 per cent of cells having a GEH value of less than 0.1. A graph illustrating the distribution of GEH values is shown in Figure 5.4 and Figure 5.5. Please note the change in scale for both axes in Figure 5.5.

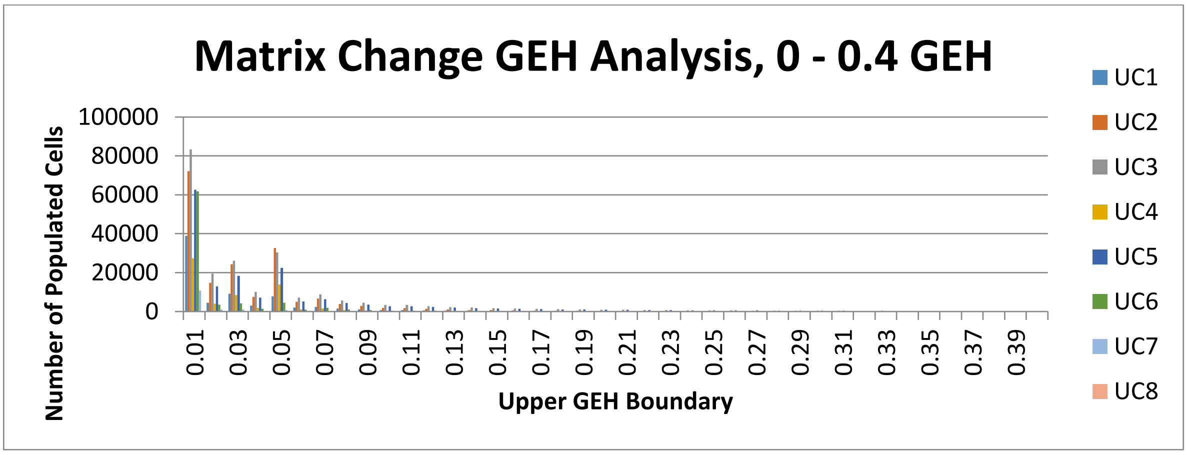


Figure 5.4 SATME2 AM Matrix Change GEH Analysis; 0 GEH to 0.4 GEH

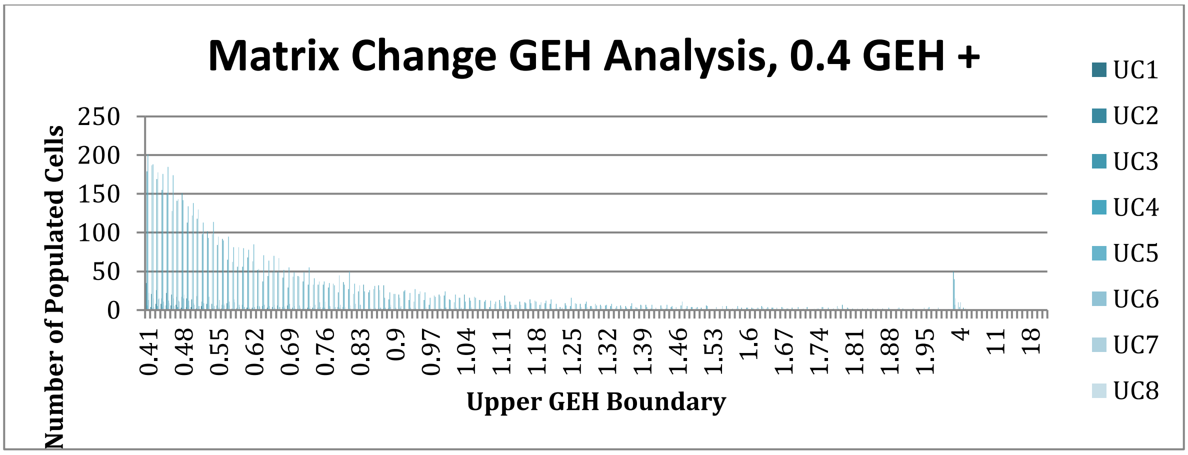


Figure 5.5 SATME2 AM Matrix Change GEH Analysis; 0.4 GEH Upwards

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

Table 5.27 SATME2 AM Matrix Change R^2 Analysis

User Class	Cell R^2 Value	Cell Slope	Cell Y-Int
TAG Criteria	> 0.95	0.98 - 1.02	Near 0
Taxi	0.98	0.99	0.00
Car Employers Business	0.94	0.96	0.00
Car Commute	0.95	0.97	0.00
Car Education	0.98	0.98	0.00
Car Other	0.99	0.99	0.00
LGV	0.86	0.94	0.00
OGV1	0.86	1.07	0.00
OGV2 Permit Holder			
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. Five of the user classes pass the R^2 test, and the one user class that did not pass, has a R^2 value of 0.94. Four of the user classes pass the recommended criteria for Slope values between 0.98 – 1.02. Two values of 0.96 – 0.97 narrowly fail to meet the TAG criteria. All Y-Intercept values are 0.00 and so are in accordance with the “Near 0” TAG criteria.

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

Table 5.28 AM Trip End Matrix Change R^2 Analysis

User Class	Trip End R^2 Value	Trip End Slope	Trip End Y-Int
TAG Criteria	> 0.98	0.99 - 1.01	Near 0
Taxi	0.99	1.00	0.00
Car Employers Business	0.99	0.98	0.14
Car Commute	0.99	0.97	0.85
Car Education	0.99	0.99	0.00
Car Other	1.00	0.98	1.40
LGV	0.94	0.98	0.11
OGV1	0.95	1.08	-0.05
OGV2 Permit Holder			
Other OGV2	1.00	1.00	0.00

The R^2 value for the trip ends is greater than 0.98 for all user classes with the exception of "LGV and OGV1". The trip end slope passes the TAG criteria for three user classes, with four narrowly failing to meet the TAG criteria. Values for the y-intercept are between -0.05 and 1.40.

Table 5.29 WRM RM AM Screenline Check

User Class	Observed (Veh)	Model (Veh)	Difference (%)
TAG Criteria			**Within 5%**
West Screenline (Inbound)	1846	1834	-1%
West Screenline (Outbound)	731	743	2%
River Corrib Screenline (Eastbound)	3633	3609	-1%
River Corrib Screenline (Westbound)	3012	3016	0%
East Screenline (Outbound)	2018	1996	-1%
East Screenline (Inbound)	6044	5848	-3%

Traffic levels across the West, River Corrib and East Screenlines are within the acceptability criteria outlined in TAG unit M3-1. However, the other screenlines do not meet the recommended criteria of total screenline flows being within 5 per cent.

Trip length distribution was also assessed as part of the matrix calibration process post-estimation. All of the user classes pass the criteria of a change in the mean trip length of less than 5 per cent, and in the criteria of a change in the standard deviation of the trip length of less than 5 per cent.

Table 5.30 Trip Length Distribution Analysis – AM

User Class	Mean Percentage	Standard Deviation

(TAG Criteria)	Change (< 5%)	Change (< 5%)
Taxi	-1%	-1%
Car Employers Business	0%	2%
Car Commute	2%	3%
Car Education	0%	2%
Car Other	1%	2%
LGV	-1%	0%
OGV1	-1%	0%
OGV2 Permit Holder		
Other OGV2	0%	0%

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

5.9.3 Calibration criteria compliance – Inter-peak 1

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

Table 5.31 WRM RM Inter-peak 1 Matrix Totals

User Class	Pre-Estimation (PCU)	Incremental (PCU)	Change (%)
Taxi	2,007	2,077	3%
Car Employers Business	4,369	4,490	3%
Car Commute	7,042	6,621	-6%
Car Education	63	70	11%
Car Other	60,657	60,391	0%
LGV	2,355	2,355	0%
OGV1	1,721	1,721	0%
OGV2 Permit Holder			
Other OGV2	12	12	0%

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

Car Commute and Car Education both fail to meet the recommended TAG criteria. However, Car Education changed by seven PCUs, therefore the level of change is considered acceptable. Car Commute failed to meet the recommended criteria by one per cent.

GEH analysis was undertaken on the individual (non-zero) cells and their change between the pre-estimation and post-estimation values. 43 per cent of cells have a GEH value of less than 0.01, with 92 per cent of cells having a GEH value of less than 0.1. 99.9 per cent of cells have a GEH value of less than 1.0. A graph illustrating the distribution of GEH values is shown in Figure 5.6 and Figure 5.7. Please note the change in scale for both axes in Figure 5.7.

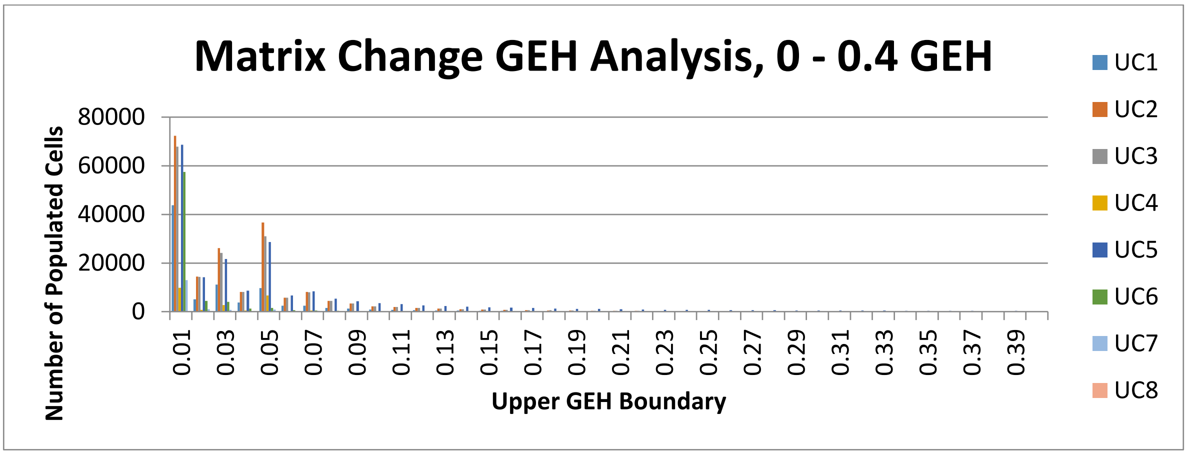


Figure 5.6 SATME2 IP1 Matrix Change GEH Analysis; 0 GEH to 0.4 GEH

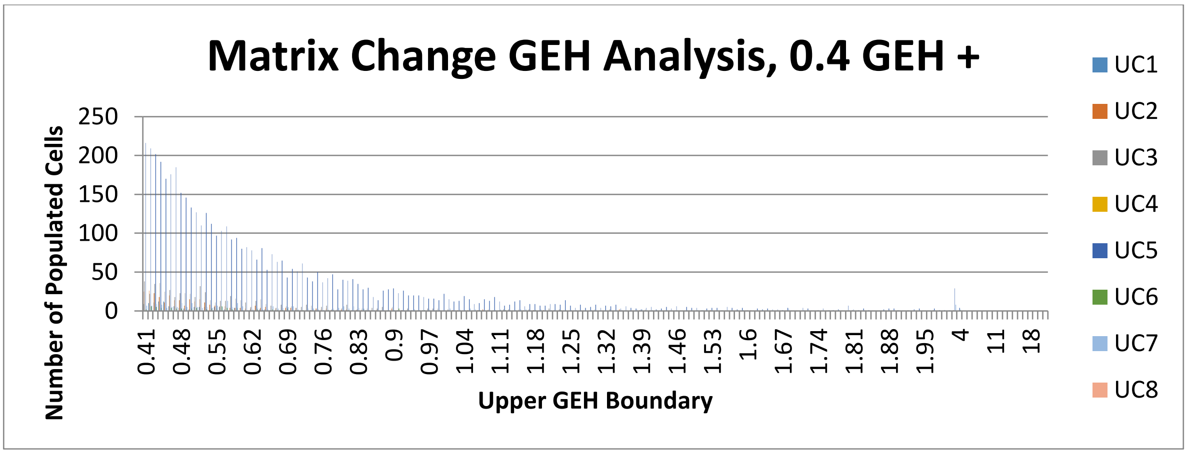


Figure 5.7 SATME2 IP1 Matrix Change GEH Analysis; 0.4 GEH Upwards

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

Table 5.32 SATME2 IP1 Matrix Change R^2 Analysis

User Class	Cell R^2 Value	Cell Slope	Cell Y-Int

TAG Criteria	> 0.95	0.98 - 1.02	Near 0
Taxi	0.97	1.00	0.00
Car Employers Business	0.93	0.98	0.00
Car Commute	0.95	0.97	0.00
Car Education	0.93	1.02	0.00
Car Other	0.99	0.99	0.00
LGV	0.96	1.02	0.00
OGV1	0.93	0.93	0.02
OGV2 Permit Holder			
Other OGV2	1.00	1.00	0.00

Four of the user classes pass the R^2 test, with the four that did not pass having R^2 values of 0.93 – 0.95. Five user classes pass the TAG criteria for Slopes, with the values between 0.98 – 1.02. The three remaining user classes have a Slope value of 0.93 – 1.02, which narrowly fails to meet the TAG criteria. Seven of the Y-Intercept values are 0.00, with one at 0.02 and so are in accordance with the “Near 0” TAG criteria.

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

Table 5.33 IP1 Trip End Matrix Change R^2 Analysis

User Class	Trip End R^2 Value	Trip End Slope	Trip End Y-Int
TAG Criteria	> 0.98	0.99 - 1.01	Near 0
Taxi	0.99	1.04	-0.06
Car Employers Business	0.99	0.99	0.13
Car Commute	0.98	0.90	0.48
Car Education	0.98	1.07	-0.01
Car Other	0.99	0.98	1.44
LGV	0.99	1.01	-0.03
OGV1	0.98	1.03	0.00
OGV2 Permit Holder			
Other OGV2	1.00	1.00	0.00

The R^2 value passes the recommended TAG criteria for seven user classes, with the remaining user class only narrowly failing the recommended criteria. Three of the user classes pass the TAG criteria for trip end slope, with a further one only narrowly failing. Values for the y-intercept near zero are between -0.06 and 1.44.

Table 5.34 details the total traffic crossing the screenlines.

Table 5.34 WRM RM IP1 Screenline Check

User Class	Observed	Model (Veh)	Difference (%)

	(Veh)		
TAG Criteria			Within 5%
West Screenline (Inbound)	871	866	-1%
West Screenline (Outbound)	691	690	0%
River Corrib Screenline (Eastbound)	2592	2460	-5%
River Corrib Screenline (Westbound)	2383	2349	-1%
East Screenline (Outbound)	2012	2139	6%
East Screenline (Inbound)	2421	2576	6%

Traffic levels across the West and River Corrib Screenlines are within the acceptability criteria outlined in TAG unit M3-1. The East Screenline narrowly fails with a 6 per cent difference in either direction.

Trip length distribution was also assessed as part of the matrix calibration process. Five of the eight user classes pass the criteria of a change in the mean trip length of less than 5 per cent, and four of the user classes pass the criteria of a change in the standard deviation of the trip length of less than 5 per cent.

Table 5.35 Trip Length Distribution Analysis – IP1

User Class	Mean Percentage Change	Standard Deviation Change
(TAG Criteria)	(< 5%)	(< 5%)
Taxi	-4%	-7%
Car Employers Business	-8%	-10%
Car Commute	-9%	-7%
Car Education	-1%	0%
Car Other	-8%	-13%
LGV	0%	0%
OGV1	0%	0%
OGV2 Permit Holder		
Other OGV2	0%	0%

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

5.9.4 Calibration criteria compliance – Inter-peak 2

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

Table 5.36 WRM RM Inter-peak 2 Matrix Totals

User Class	Pre-Estimation (PCU)	Incremental (PCU)	Change (%)
Taxi	2,298	2,333	2%
Car Employers Business	3,747	3,743	0%
Car Commute	14,836	14,493	-2%
Car Education	1,337	1,313	-2%
Car Other	75,934	75,163	-1%
LGV	2,270	2,270	0%
OGV1	1,894	1,894	0%
OGV2 Permit Holder			
Other OGV2	7	7	0%

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

The changes to all user classes are of an acceptable level.

GEH analysis was undertaken on the individual (non-zero) cells and their change between the pre-estimation and post-estimation values. 42 per cent of cells have a GEH value of less than 0.01, with 91 per cent of cells having a GEH value of less than 0.1 and 99.9 per cent of cells having a GEH value of less than 1.0. A graph illustrating the distribution of GEH values is shown in Figure 5.8 and Figure 5.9. Please note the change in scale for Figure 5.9.

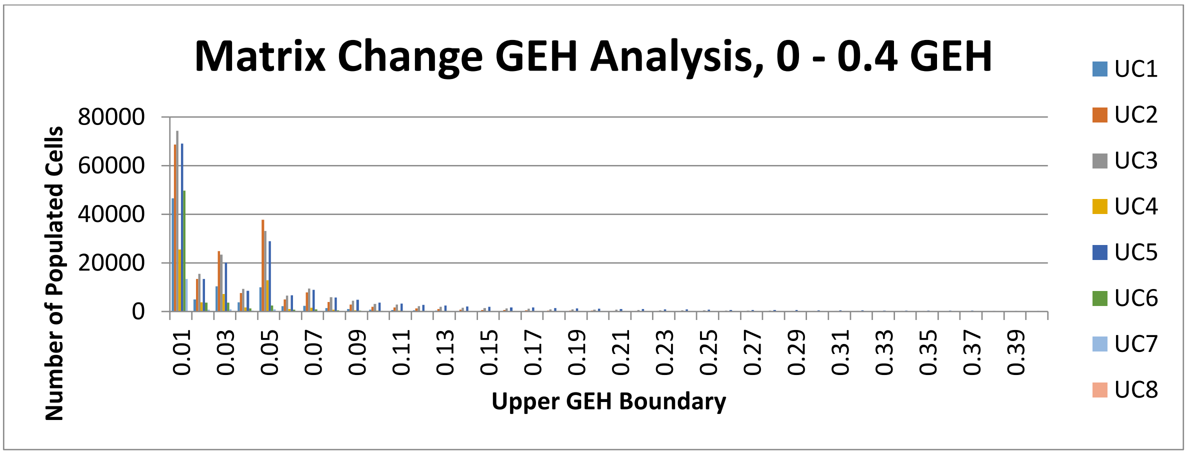


Figure 5.8 SATME2 IP2 Matrix Change GEH Analysis; 0 GEH to 0.4 GEH

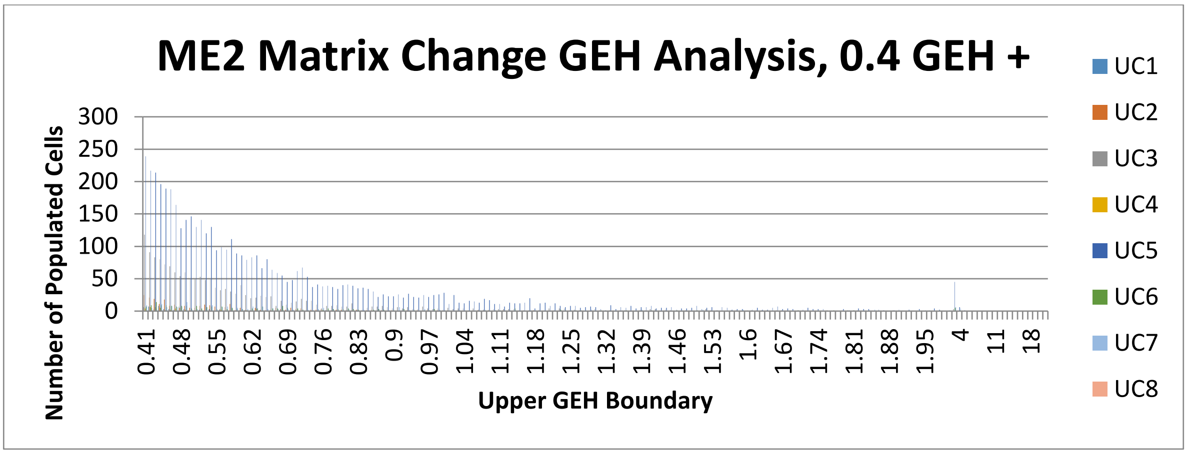


Figure 5.9 SATME2 IP2 Matrix Change GEH Analysis; 0.4 GEH Upwards

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

Table 5.37 SATME2 IP2 Matrix Change R^2 Analysis

User Class	Cell R^2 Value	Cell Slope	Cell Y-Int
TAG Criteria	> 0.95	0.98 - 1.02	Near 0
Taxi	0.98	0.99	0.00
Car Employers Business	0.93	0.98	0.00
Car Commute	0.95	0.99	0.00
Car Education	0.98	0.98	0.00
Car Other	0.99	0.99	0.00
LGV	0.92	1.02	0.00
OGV1	0.88	1.00	0.01
OGV2 Permit Holder			
Other OGV2	1.00	1.00	0.00

Four of the user classes pass the R^2 test, and the four that did not pass, have R^2 values of between 0.88 – 0.95. All of the Slopes pass the TAG criteria with the values between 0.98 – 1.02. All Y-Intercept values are 0.00 apart from OGV1 which is -0.01 and so are in accordance with the “Near 0” TAG criteria.

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

Table 5.38 IP2 Trip End Matrix Change R^2 Analysis

User Class	Trip End R^2 Value	Trip End Slope	Trip End Y-Int

TAG Criteria	> 0.98	0.99 - 1.01	Near 0
Taxi	0.99	1.02	-0.02
Car Employers Business	0.99	0.98	0.09
Car Commute	0.97	0.98	0.09
Car Education	0.99	0.96	0.09
Car Other	0.99	0.98	1.58
LGV	0.97	1.01	0.01
OGV1	0.98	1.05	-0.01
OGV2 Permit Holder			
Other OGV2	1.00	1.00	0.00

The R^2 value passes the TAG criteria for six of the user classes with the remaining two values narrowly failing at 0.97. The trip end slope passes for two of the eight user classes with the remaining values between 0.96 – 1.05. Values for the y-intercept near zero are between -0.02 and 1.58.

Table 5.39 details the total traffic crossing the screenlines.

Table 5.39 WRM RM IP2 Screenline Check

User Class	Observed (Veh)	Model (Veh)	Difference (%)
TAG Criteria			Within 5%
West Screenline (Inbound)	934	888	-5%
West Screenline (Outbound)	1029	1000	-3%
River Corrib Screenline (Eastbound)	2708	2707	0%
River Corrib Screenline (Westbound)	2631	2631	0%
East Screenline (Outbound)	3017	3061	1%
East Screenline (Inbound)	2444	2591	6%

Traffic levels across the East (Outbound), West and River Corrib Screenlines are within the acceptability criteria outlined in TAG unit M3-1. The East (Inbound) Screenline narrowly fails with a 6 per cent difference.

Trip length distribution was also assessed as part of the matrix calibration process. Seven of the eight user classes pass the criteria of a change in the mean trip length of less than 5 per cent, with the eighth failing by less than one percentage point. Once again, all apart from one pass the criteria of a change in the standard deviation of the trip length of less than 5 per cent.

Table 5.40 Trip Length Distribution Analysis – IP2

User Class	Mean Percentage	Standard Deviation

	Change	Change
(TAG Criteria)	(< 5%)	(< 5%)
Taxi	-5%	-8%
Car Employers Business	-6%	-4%
Car Commute	-2%	-1%
Car Education	-3%	-3%
Car Other	-3%	-5%
LGV	0%	1%
OGV1	0%	0%
OGV2 Permit Holder		
Other OGV2	0%	0%

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

5.9.5 Calibration criteria compliance – PM peak

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

Table 5.41 WRM RM PM Peak Matrix Totals

User Class	Pre-Estimation (PCU)	Incremental (PCU)	Change (%)
Taxi	2,122	2,146	1%
Car Employers Business	4,380	4,336	-1%
Car Commute	34,961	33,712	-4%
Car Education	684	663	-3%
Car Other	69,015	69,732	0%
LGV	2,241	2,241	0%
OGV1	1,516	1,516	0%
OGV2 Permit Holder			
Other OGV2	7	7	0%

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

The changes to all user classes are of an acceptable level.

GEH analysis was undertaken on the individual (non-zero) cells and their change between the pre-estimation and incremental values. 42 per cent of cells have a GEH value of less than 0.01, with 90 per cent of cells having a GEH value of less than 0.1. 99.9 per cent of cells have a GEH value less than 1.0. A graph illustrating the distribution of GEH values is shown in Figure 5.10 and Figure 5.11. Please note the change in scale for both axes in Figure 5.11.

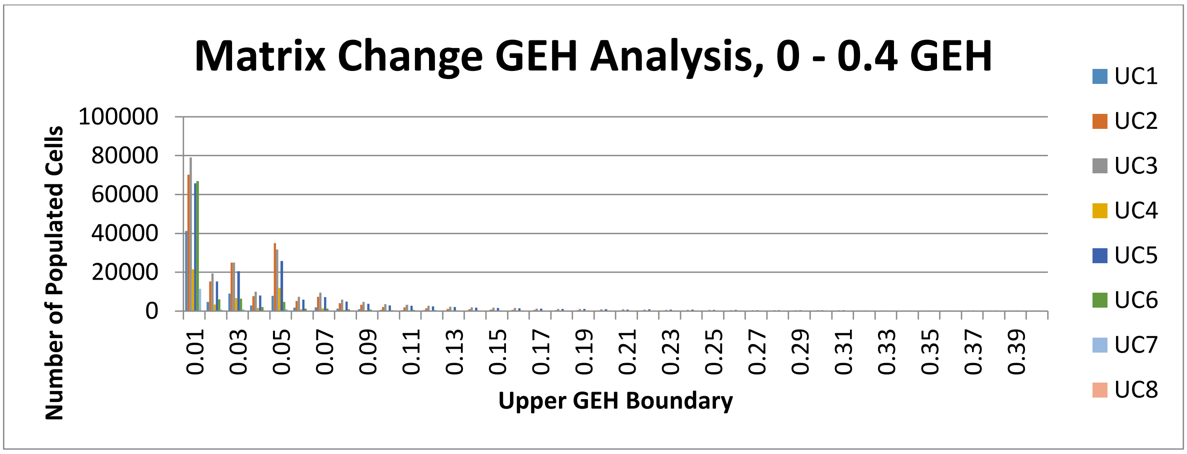


Figure 5.10 SATME2 PM Matrix Change GEH Analysis; 0 GEH to 0.4 GEH

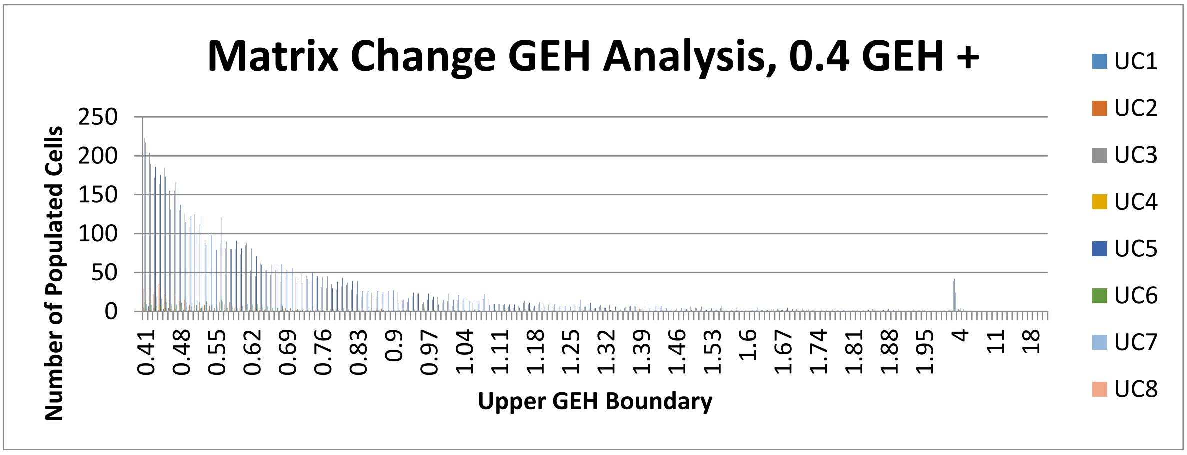


Figure 5.11 SATME2 PM Matrix Change GEH Analysis; 0.4 GEH Upwards

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

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

Table 5.42 SATME2 PM Matrix Change R^2 Analysis

User Class	Cell R^2 Value	Cell Slope	Cell Y-Int
TAG Criteria	> 0.95	0.98 - 1.02	Near 0
Taxi	0.98	1.00	0.00
Car Employers Business	0.93	0.97	0.00
Car Commute	0.96	0.98	0.00
Car Education	0.96	0.97	0.00
Car Other	0.99	0.99	0.00
LGV	0.87	0.98	0.00
OGV1	0.86	0.74	0.03
OGV2 Permit Holder			
Other OGV2	1.00	1.00	0.00

Five of the user classes pass the R^2 test, and the three that did not pass, had a R^2 value of 0.86 - 0.93. Five of the Slopes pass the TAG criteria with the values between 0.98 – 1.02. Two of the three remaining Slopes, with values of 0.97, narrowly fail to meet the TAG criteria. All Y-Intercept values are 0.00, apart from OGV1 which is 0.03 and so are in accordance with the “Near 0” TAG criteria.

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

Table 5.43 PM Trip End Matrix Change R^2 Analysis

User Class	Trip End R^2 Value	Trip End Slope	Trip End Y-Int
TAG Criteria	> 0.98	0.99 - 1.01	Near 0
Taxi	0.99	1.00	0.01
Car Employers Business	0.98	0.98	0.19
Car Commute	0.98	0.96	1.37
Car Education	0.98	0.89	0.12
Car Other	1.00	0.98	1.47
LGV	0.97	1.00	0.06
OGV1	0.93	0.83	0.54
OGV2 Permit Holder			
Other OGV2	1.00	1.00	0.00

Six of the user classes pass the R^2 criteria for trip ends with the other two narrowly failing. Three user classes pass the TAG criteria for trip end slope, with the three of the remaining five narrowly failing. Values for the y-intercept near zero are between 0.00 and 1.47.

Table 5.44 details the total traffic crossing the screenlines.

Table 5.44 WRM RM PM Screenline Check

User Class	Observed (Veh)	Model (Veh)	Difference (%)
TAG Criteria			Within 5%
West Screenline (Inbound)	978	970	-1%
West Screenline (Outbound)	1614	1600	-1%
River Corrib Screenline (Eastbound)	2967	2957	0%
River Corrib Screenline (Westbound)	3331	3300	-1%
East Screenline (Outbound)	4983	4726	-5%
East Screenline (Inbound)	2399	2469	3%

Traffic levels across the West, River Corrib and East Screenlines are all within the acceptability criteria outlined in TAG unit M3-1.

Trip length distribution was also assessed as part of the matrix calibration process. All of the user classes pass the criteria of a change in the mean trip length of less than 5 per cent, and in the criteria of a change in the standard deviation of the trip length of less than 5 per cent.

Table 5.45 Trip Length Distribution Analysis – PM

User Class	Mean Percentage Change	Standard Deviation Change
(TAG Criteria)	(< 5%)	(< 5%)
Taxi	-2%	-4%
Car Employers Business	-1%	1%
Car Commute	0%	3%
Car Education	-5%	-5%
Car Other	1%	2%
LGV	0%	1%
OGV1	-2%	2%
OGV2 Permit Holder		
Other OGV2	0%	0%

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

5.10 Calibration summary

5.10.1 Overview

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

Table 5.46 Model Calibration Status

Component	AM Status	IP1 Status	IP2 Status	PM Status
Individual Link Flows	Pass	Pass	Pass	Pass
Individual Link GEH <5 (TAG)	Fail	Pass	Pass	Fail
Individual Link GEH <5 (65%)	Pass	Pass	Pass	Pass
Individual Link GEH <7 (75%)	Pass	Pass	Pass	Pass
Individual Link GEH <10 (95%)	Pass	Pass	Pass	Fail
Screenlines	Pass	Fail	Pass	Fail
Matrix Cell R^2 Analysis	Fail	Fail	Fail	Fail
Trip End Analysis	Fail	Pass	Fail	Fail
Matrix Trip Length Distribution	Pass	Fail	Pass	Pass

5.10.2 Traffic count observations

Prior to matrix estimation, the modelled volume of LGVs is slightly higher than the observed volume and the volume of HGVs is slightly lower than the observed volume. Constraints applied to matrix estimation for these user classes were relaxed to allow greater changes to the prior matrix; further improvements to the prior goods matrices could allow stricter constraints to be used in future versions.

In three of the four time periods, the highest GEH is located on the same minor road connecting Castlegar Village to the N17 in the northeast of Galway City. As noted above, it is often difficult to calibrate links with low levels of observed traffic given the strategic nature of the WRM. However, in this instance, the nearest zone is also quite far north from the minor road. It is therefore likely that the traffic to and from this zone is using other more major links in the vicinity and avoiding the minor link, causing the minor link to register a limited flow.

Links displaying a modelled flow of zero where a flow of greater than zero was observed were investigated. The screenline and individual target counts in the AM and IP2 peak periods demonstrated no links with a modelled flow of zero where an observed flow was greater than zero. Isolated incidents on links were observed during the IP1 and PM peak periods where the modelled flow was zero and the observed flow was greater than zero. All instances were investigated with the main cause relating to low observed flows on the link.

5.10.3 Matrix observations

As would be expected, the two fully observed user classes validated against POWSCAR, Car Commute and Car Education, have relatively small changes between the prior matrices and the estimated matrices compared to the other non-fully observed user classes.

Larger changes in the goods vehicle matrices were anticipated due to the lack of observed input data. The goods vehicle matrices were matrix-estimated with lesser constraints to bring them in line with observed traffic volumes.

6 Road model validation

6.1 Introduction

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

6.2 Assignment validation process

6.2.1 Overview

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

6.2.2 Validation Criteria

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

Table 6.1 Road Assignment Model Screenline Validation Criteria

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

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

Table 6.2 Road Assignment Model Journey Time Validation Criteria

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

6.2.3 Traffic volume comparison

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

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

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

6.2.4 Trip length distribution

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

The trip length distributions 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.

6.2.5 Journey times

Observed journey time data is available for a number of major roads within the WRM through the TomTom dataset.

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

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

6.3 Traffic volume validation

6.3.1 Overview

Permanent ATC's operated by the NRA and Individual link and junction turning counts were utilised as an independent dataset to validate the model. From this data it is possible to validate the SATURN model against an all-vehicle total across 39 links.

6.3.2 Traffic count locations

A detailed map showing the location of the three screenlines used during validation is presented in Figure 6.1.

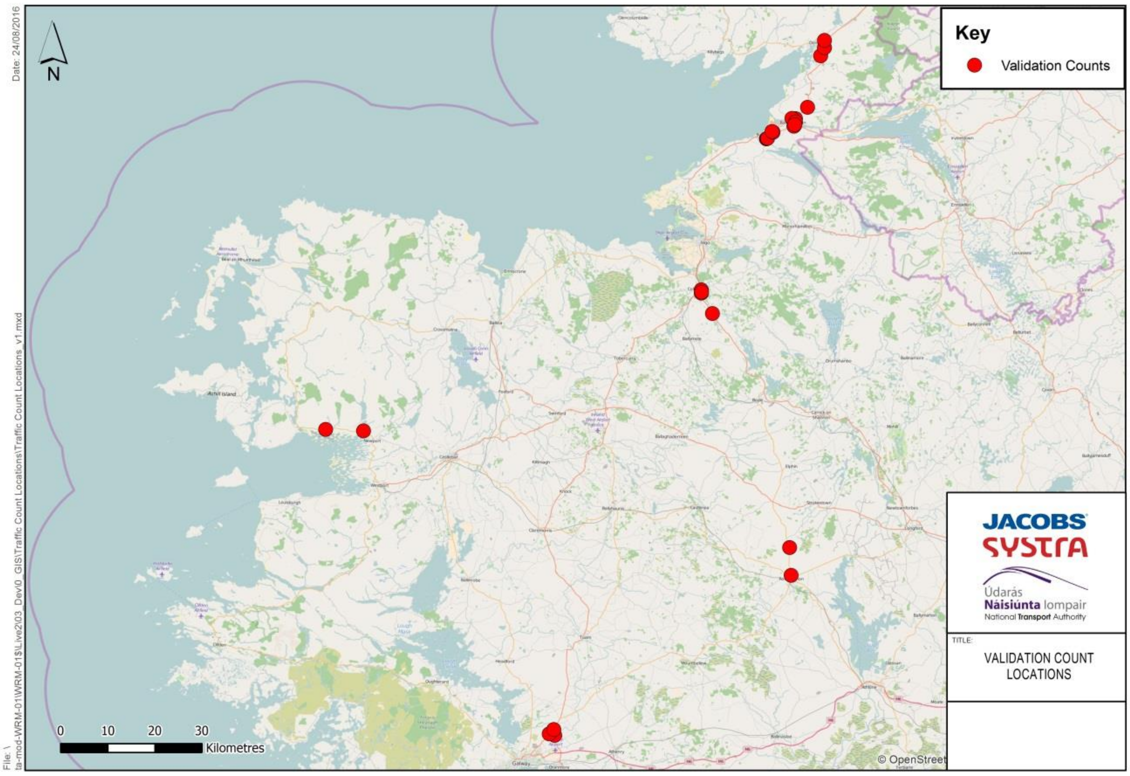


Figure 6.1 Link Validation Target Locations

6.3.3 Validation criteria compliance – AM peak

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

Table 6.3 AM Link Flow Validation

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	77% (30)
GEH < 5 for individual flows	> 65% of cases	59% (23)
GEH < 7 for individual flows	> 75% of cases	74% (29)
GEH < 10 for individual flows	> 95% of cases	87% (34)

Across the 39 count locations in the AM Peak, 77 per cent (30) pass the TAG flow validation criteria. 59 per cent of links have a GEH of less than 5. However, slackening the criteria to include GEH values of less than 10 yields an 87 per cent pass rate. The area of poorest validation is in Bundoran at the R280 / N15 interchange. The observed two way flows on this link are quite low at 15 and 39 vehicles while the modelled two way flows are 160 and 224 vehicles. Due to the strategic nature of the WRM it is very difficult to validate links with low observed traffic flow.

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

In general, modelled traffic volumes are lower than observed traffic volumes. There were specific traffic volume differences that warranted further investigation, and these are discussed in more detail in Section 6.6.

6.3.4 Validation criteria compliance – Inter-peak 1

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

Table 6.4 IP1 Link Flow Validation

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	85% (33)
GEH < 5 for individual flows	> 65% of cases	82% (32)
GEH < 7 for individual flows	> 75% of cases	85% (33)
GEH < 10 for individual flows	> 95% of cases	95% (37)

Across the 39 count locations on the Inter-peak 1, 85 per cent (33) pass the TAG flow validation criteria. 82 per cent of links have a GEH of less than 5. However, slackening the criteria to include GEH values of less than 10 yields a 95 per cent pass rate. Again the area of poorest validation is in Bundoran at the R280 / N15 interchange. The observed two way flows on this link are quite low at 8 and 26 vehicles while the modelled two way flows are 127 and 141 vehicles.

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

There were specific traffic volume differences that warranted further investigation, and these are discussed in more detail later in Section 6.6.

6.3.5 Validation criteria compliance – Inter-peak 2

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

Table 6.5 IP2 Link Flow Validation

Criteria	Acceptability Guideline	Model Statistics

Link Flow	> 85% of cases	79% (31)
GEH < 5 for individual flows	> 65% of cases	74% (29)
GEH < 7 for individual flows	> 75% of cases	85% (33)
GEH < 10 for individual flows	> 95% of cases	90% (35)

Across the 39 count locations in the Inter-peak 1, 79 per cent (31) pass the TAG flow validation criteria. 74 per cent of links have a GEH of less than 5. However, slackening the criteria to include GEH values of less than 10 yields a 90 per cent pass rate. This remains below the TAG recommendation of 85 per cent of links passing validation, and below the typical acceptability criteria of 95 per cent of links with a GEH value of less than 10. Once again, the area of poorest validation is in Bundoran at the R280 / N15 interchange. The observed two way flows on this link are quite low at 10 and 32 vehicles while the modelled two way flows are 135 and 163 vehicles.

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

There were specific traffic volume differences that warranted further investigation, and these are discussed in more detail later in Section 6.6.

6.3.6 Validation criteria compliance – PM peak

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

Table 6.6 PM Link Flow Validation

Criteria	Acceptability Guideline	Model Statistics
Link Flow	> 85% of cases	77% (30)
GEH < 5 for individual flows	> 65% of cases	69% (27)
GEH < 7 for individual flows	> 75% of cases	82% (32)
GEH < 10 for individual flows	> 95% of cases	87% (34)

Across the 39 count locations in the PM Peak, 77 per cent (30) pass the TAG flow validation criteria. 69 per cent of links have a GEH of less than 5. However, slackening the criteria to include GEH values of less than 10 yields a 87 per cent pass rate. The area of poorest validation is in Bundoran at the R280 / N15 interchange. The observed two way flows on this link are quite low at 13 and 51 vehicles while the modelled two way flows are 175 and 220 vehicles.

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

There were specific traffic volume differences that warranted further investigation, and these are discussed in more detail in Section 6.6.

6.4 Trip length distribution analysis

6.4.1 Overview

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.

6.4.2 Trip length distribution analysis

Graphical representation of the comparison for each modelled period and each user class is included in Appendix D. 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 6.7 sets out the mean change between the pre- and incremental matrices for each user class, while Table 6.8 sets out the standard deviation change between the pre-and post-estimation matrices for each user class.

Table 6.7 Percentage Change in Average Trip Length

User Class	AM Peak	IP1	IP2	PM Peak
Taxi (UC1)	-1%	-4%	-5%	-2%
Employers Business (UC2)	0%	-8%	-6%	-1%
Commute (UC3)	2%	-9%	-2%	0%
Education (UC4)	0%	-1%	-3%	-5%
Car Other (UC5)	1%	-8%	-3%	1%
LGV (UC6)	-1%	0%	0%	0%
OGV1 (UC7)	-1%	0%	0%	-2%
OGV2 permit Holder (UC8)	N/A	N/A	N/A	N/A
OGV2 (UC9)	0%	0%	0%	0%

Table 6.8 Percentage Change in Standard Deviation of Trip Length

User Class	AM Peak	IP1	IP2	PM Peak
Taxi (UC1)	-1%	-7%	-8%	-4%
Employers Business (UC2)	2%	-10%	-4%	1%
Commute (UC3)	3%	-7%	-1%	3%
Education (UC4)	2%	0%	-3%	-5%
Car Other (UC5)	2%	-13%	-5%	2%
LGV (UC6)	0%	0%	1%	1%
OGV1 (UC7)	0%	-1%	0%	2%
OGV2 permit Holder (UC8)	N/A	N/A	N/A	N/A
OGV2 (UC9)	0%	0%	0%	0%

6.5 Journey time validation

6.5.1 Overview

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

6.5.2 Journey Time Routes

Appropriate journey time routes were identified from TomTom Data and agreed with the NRA during the development of the GIM. The journey time routes cover the main arterial and through routes into Galway city centre and are described in further detail in Section 4.4 previously.

Further TomTom Journey time data and analysis is included in Appendix F.

6.5.3 Validation Criteria Compliance – AM Peak

Of the 25 journey time routes, 60 per cent (15) pass TAG criteria, which falls short of the TAG recommendation of 85 per cent of routes passing the criteria. Figure 6.2 details the validation of each route.

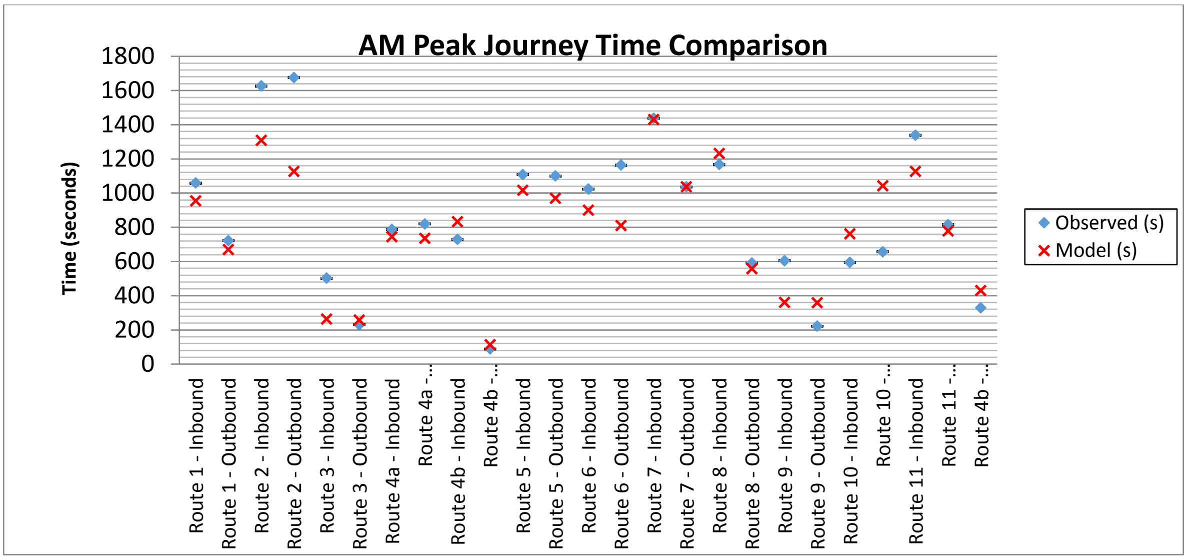


Figure 6.2 AM Peak Journey Time Comparison

In the AM Peak sixteen of the modelled routes are faster than the observed journey times, eight are slower and one is a close match. Further details are included in Appendix F, with detailed analysis of any significant issues discussed in Section 6.6.

6.5.4 Validation Criteria Compliance – Inter-peak 1

Of the 25 journey time routes, 88 per cent (22) pass the TAG criteria, which meet the TAG recommendation of 85 per cent of routes passing the criteria. Figure 6.3 details the validation of each route.

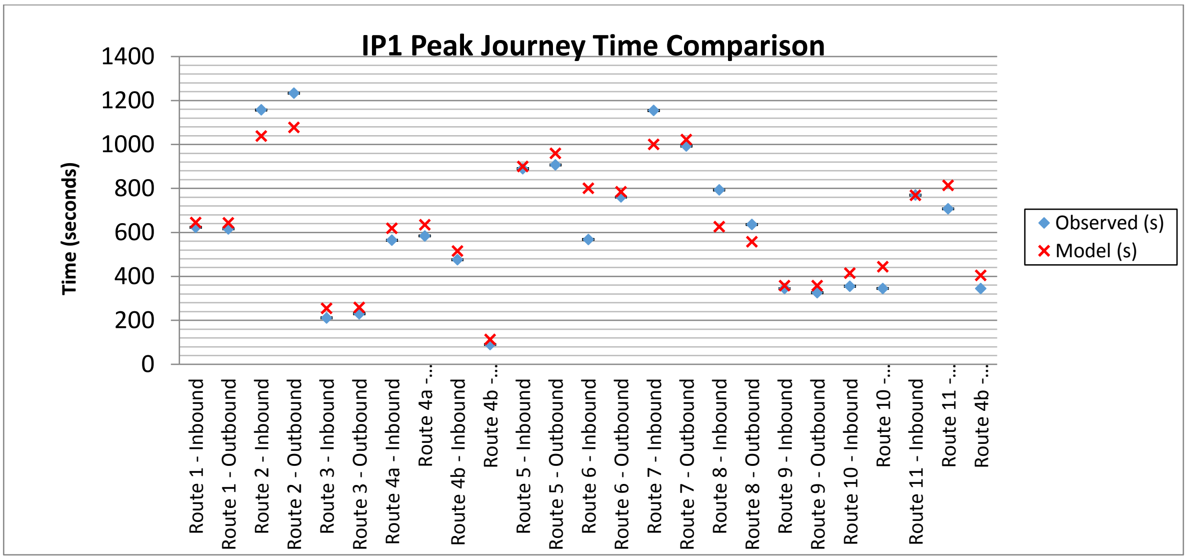


Figure 6.3 Inter-peak 1 Journey Time Comparison

Further details are included in Appendix F, with detailed analysis of any significant issues discussed in Section 6.6.

6.5.5 Validation Criteria Compliance – Inter-peak 2

Of the 25 journey time routes, 88 per cent (22) pass the TAG criteria, which meet the TAG recommendation of 85 per cent of routes passing the criteria. Figure 6.4 details the validation of each route.

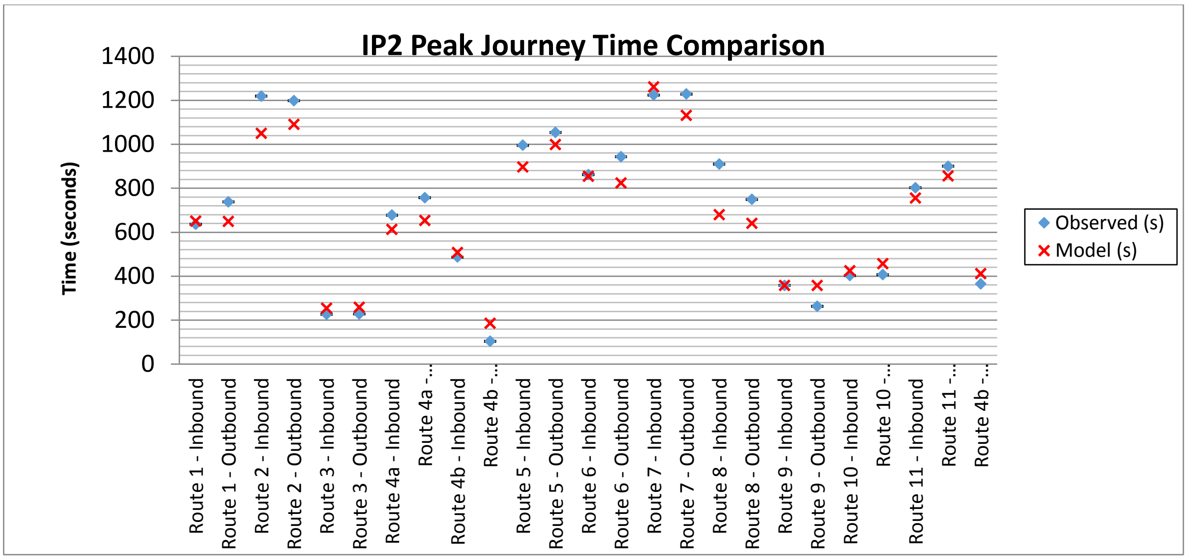


Figure 6.4 Inter-peak 2 Journey Time Comparison

Further details are included in Appendix F, with detailed analysis of any significant issues discussed in Section 6.6.

6.5.6 Validation Criteria Compliance – PM Peak

Of the 25 journey time routes, 60 per cent (15) pass the TAG criteria, which fall short of the TAG recommendation of 85 per cent of routes passing the criteria. Figure 6.5 details the validation of each route.

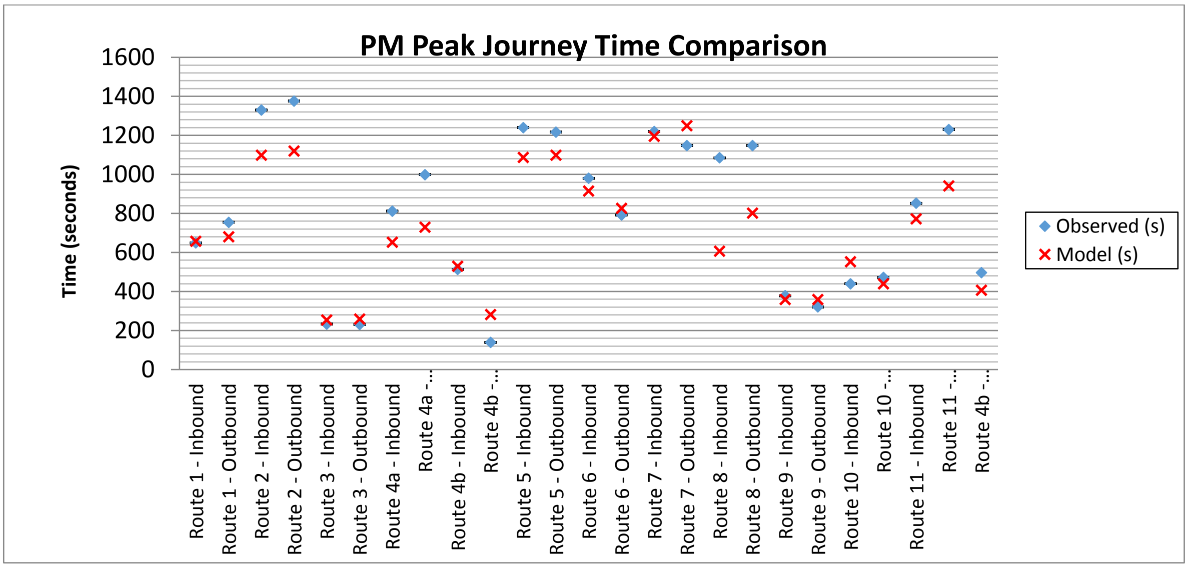


Figure 6.5 PM Peak Journey Time Comparison

In the PM peak sixteen of the modelled routes are faster than the observed journey times and nine are slower. Further details are included in Appendix F, with detailed analysis of any significant issues discussed in Section 6.6.

6.6 Validation summary

6.6.1 Overview

Table 6.9 details the status of each component of the validation process for each modelled period.

Table 6.9 Model Validation Status

Component	AM Status	IP1 Status	IP2 Status	PM Status
Individual Link Flows	Fail (77%)	Pass (85%)	Fail (79%)	Fail (77%)
Journey Times	Fail (60%)	Pass (88%)	Pass (88%)	Fail (60%)
Mean Matrix Change	8/8	5/8	7/8	7/8
Standard Deviation Change	8/8	4/8	7/8	7/8

6.6.2 Traffic count observations

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

Two of the validation counts were in the Bundoran area, and produced consistently high GEH levels across the four peak periods. It is possible that insufficient detail has been modelled at this location, given its location within the buffer network, and that this data should be reviewed during future iterations of the model development.

6.6.3 Trip Length Distribution Observations

As with many implementations of a matrix estimation solution, SATURN has generated shorter distance trips in order to meet the specified target traffic flows instead of generating longer distance trips. This has the effect of reducing the mean trip length distribution and the standard deviation of trips within the estimated matrices. This is evident in the Inter-peak 1, Inter-peak 2 and PM Peak periods.

In the AM Peak, the trip length distribution has lengthened, suggesting a lack of traffic further from Galway, where the zones are larger and have a larger travel distance between neighbouring zones.

6.6.4 Journey Time Observations

Comparing the modelled journey times to the observed data in the AM Peak, it is evident that on the majority of routes, modelled end-to-end journey times are too fast compared with observed data. Following further investigation of the routes that fail to meet the criteria, it is evident that it is normally a single location / junction that does not replicate the observed travel delays. For example, journey time route 4b does not replicate the observed delay on the N4 Bothar na dThreabh / R339 Monivea Road junction which encounters very large delays in the observed data. Large delays such as this are very difficult to replicate in a strategic demand model such as the WRM without affecting the traffic flow (GEH) criteria at the same location and therefore it is necessary to make a compromise between traffic flow and journey time validation.

Modelled journey times in the Inter-peak 1 and Inter-peak 2 periods appear to be very accurate, suggesting that uncongested link speeds, which are applied, to all peak periods are correct for a less congested network. The PM peak is more similar to the AM peak in that the journey times validate well in some areas but can be improved at a number of other locations.

It should also be noted that the TomTom journey times for the AM and PM peak have been taken for the time periods 8-9am and 5-6pm respectively, whereas the road assignment matrices output from the FDM and the traffic counts are created by factoring a 3-hour peak period to a 1-hour peak, rather than modelling a specific hour. In the two inter-peak time periods, the TomTom journey times, road assignment matrices and traffic counts are calculated consistently as the average of the 3-hour period.

6.6.5 Validation Observation Summary

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

Table 6.10 Model Validation Identified Issues

Issue	AM Peak	IP1	IP2	PM Peak
Consistently quick journey times	○			○
Low City Centre validation	○			○
Increase in short distance trips	○	○	○	○

7 Conclusion and recommendations

7.1 Summary

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

7.2 Road Model Development

The model network was in a strong position prior calibration and validation commencing due to previous work undertaken. The network and the assignment parameters, as well as the demand model, have been enhanced considerably during the task. The model makes best use of the available information at the time of model inception through to this version of the model being completed. As part of the calibration and validation process the model network was adjusted to better reflect observed data. However, further improvements could be made for future model versions to improve model calibration and validation.

7.3 Road Model Calibration

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

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

Table 7.1 Significance of Matrix Estimation Changes

Measure	Significance Criteria	AM Peak	Inter-peak 1	Inter-peak 2	PM Peak
Matrix zonal cell value	Slope within 0.98 and 1.02;	0.96 to 1.07	0.93 to 1.02	0.98 to 1.02	0.74 to 1
	Intercept near zero;	0 to 0	0 to 0.02	0 to 0.01	0 to 0.03
	R^2 in excess of 0.95.	0.86 to 1	0.93 to 1	0.88 to 1	0.86 to 1
Matrix zonal trip ends	Slope within 0.99 and 1.01;	0.97 to 1.08	0.90 to 1.07	0.96 to 1.05	0.83 to 1
	Intercept near zero;	-0.05 to 1.40	-0.06 to 1.95	-0.02 to 1.58	1.47 to 3.76

	R^2 in excess of 0.98.	0.94 to 1	0.98 to 1	0.97 to 1	0.93 to 1
Trip length distribution	Means within 5%;	-1.45% to 1.65%	-8.50% to 0%	-5.50% to 0.05%	-5.32% to 0.91%
	Standard Deviation within 5%.	-1.43% to 3.41%	-12.96% to 0.21%	-7.53% to 1.24%	-5.38% to 2.99%
Sector to sector level matrices	Differences within 5%	36/169	36/169	25/169	35/169

In the AM peak period the matrix zonal cell changes for the observed user classes (Car Commute and Car Education) are close to the WebTAG recommended criteria, with R^2 values of 0.95 and 0.98 respectively. The slope for both of these user classes falls narrowly outside the WebTAG recommended range of 0.98 to 1.02, with values of 0.972 and 0.977 respectively, and the intercept for each of the observed user classes is within the WebTAG recommended ranges. The slope and intercept for both Taxi and Car Other also falls within the recommended ranges.

In the Inter-peak 1 period R^2 for Car Other is 0.99, which meets the WebTAG recommended criteria. The slope and intercept for Taxi, Car Employers' Business and Car Other met the criteria.

In the Inter-peak 2 period R^2 for Education and Car Other meet the WebTAG recommended criteria.

In the PM peak period R^2 for Taxi, Commute, Education and Car Other meets the WebTAG recommended criteria. The slope and intercept for Taxi and Car Other also meet he WebTAG recommended criteria.

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

Table 7.2 Road Assignment Model Calibration Guidance Source

Criteria	Acceptability Guideline	AM Peak	Inter-peak 1	Inter-peak 2	PM Peak
Individual flows within 100 veh/h of counts for flows less than 700 veh/h	> 85% of cases	87% (236)	93% (254)	92% (249)	88% (240)
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					
GEH < 5 for individual flows	> 85% of cases	80% (217)	86% (234)	86% (234)	81% (220)

The AM peak period meets the criteria set out in WebTAG for individual flows, but narrowly fails to meet the criteria for GEH, with 80 per cent of links meeting the GEH criteria. Extending the analysis of GEH to assess the number of links with GEH value of 7 or less, and 10 or less, results in 88 per cent and 95 per cent of links, respectively, which is considered sufficiently robust.

The Inter-peak 1 period meets the criteria set out in WebTAG for both individual flows and GEH. Extending the analysis of GEH to assess the number of links with GEH value of 7 or less, and 10 or less, results in 92 per cent and 98 per cent of links meeting the criteria, respectively.

Similar to the Inter-peak 1 results, the Inter-peak 2 period meets the criteria set out in WebTAG for both individual flows and GEH. When the analysis of GEH is extended to assess the number of links with GEH value of 7 or less, and 10 or less, 90 per cent and 95 per cent of links meet each criterion, respectively.

In the PM peak period, 88 per cent of the links meet the individual link flow recommended criteria, however 81 per cent of links meet the GEH recommended criteria, narrowly failing to meet the criteria. Extending the analysis of GEH to assess the number of links with GEH value of 7 or less, and 10 or less, results in 88 per cent and 94 per cent of links, respectively, which is considered to be sufficient.

Table 7.3**Error! Reference source not found.** outlines the screenline calibration criteria as set out in TAG Unit M3-1, Section 3.2, Table 3, and the level of calibration achieved in each specific period model

Table 7.3 Road Assignment Model Screenline Calibration Guidance Sources

Criteria	Acceptability Guideline	AM Peak	Inter-peak 1	Inter-peak 2	PM Peak
Differences between modelled flows and counts should be less than 5% of the counts	All or nearly all screenlines	78%	67%	78%	61%

In the AM peak 78 per cent of screenlines are within 5 per cent of the observed traffic flows, and the remaining screenlines are within 12 per cent of the observed total traffic flows.

The Inter-peak 1 period has 67 per cent of screenlines meeting the WebTAG recommended criteria of total modelled screenline flows within 5 per cent of observed. Four additional screenlines are marginally outside the 5 per cent criteria.

The Inter-peak 2 period has 78 per cent of screenlines meeting the WebTAG recommended criteria of total modelled screenline flows within 5 per cent of observed. Three additional screenlines are marginally outside the 5 per cent criteria.

In the PM peak 61 per cent of screenlines are within 5 per cent of the observed traffic flows, and the remaining screenlines are within 16 per cent of observed traffic flows.

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

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

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

7.4 Road Model Validation

In the AM peak, 60 per cent of the journey time routes meet the WebTAG criteria, and 64 per cent are within 25 per cent of the observed journey times.

In the IP1 period, 88 per cent of the journey times meet the WebTAG criteria of 85 per cent of journey times being within 15 per cent of observed journey times, and 92 per cent are within 25 per cent of the observed journey times.

In the IP2 period, 88 per cent of the journey times meet the WebTAG criteria of 85 per cent of journey times being within 15 per cent of observed journey times, and 92 per cent are within 25 per cent of the observed journey times.

In the PM peak, 60 per cent of the journey time routes meet the WebTAG criteria, and 84 per cent are within 25 per cent of the observed journey times.

7.5 Recommendations

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

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

Appendix A

Individual Link Calibration Results

Appendix B

Sectored Matrix Differences

Appendix C

R squared analysis graphs

Appendix D

Trip Length distribution Analysis

Appendix E

Individual Link Validation results

Appendix F

TOM TOM Journey Time data and analysis

Údarás
Náisiúnta Iompair
National Transport Authority

National Transport Authority
Dún Scéine
Harcourt Lane
Dublin 2

Údarás Náisúnta Iompair
Dún Scéine
Lána Fhearchair
Baile Átha Cliath 2

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

www.nationaltransport.ie

No. XXXXXXXX 22-12-2016

Appendix B

WRM Zone System
Development Report

R E G I O N A L

M O D E L L I N G

S Y S T E M

Modelling Services Framework

West Regional Model

Zone System Development Report

Údarás Náisiúnta Iompair
National Transport Authority

CONTENTS

Tables

Figures

Foreword

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

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

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

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

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

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

1 Introduction

1.1 Regional Modelling System

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

An overview of the 5 regional models is presented below in 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, Tipperary South
South West Regional Model	SWRM	Cork and Kerry

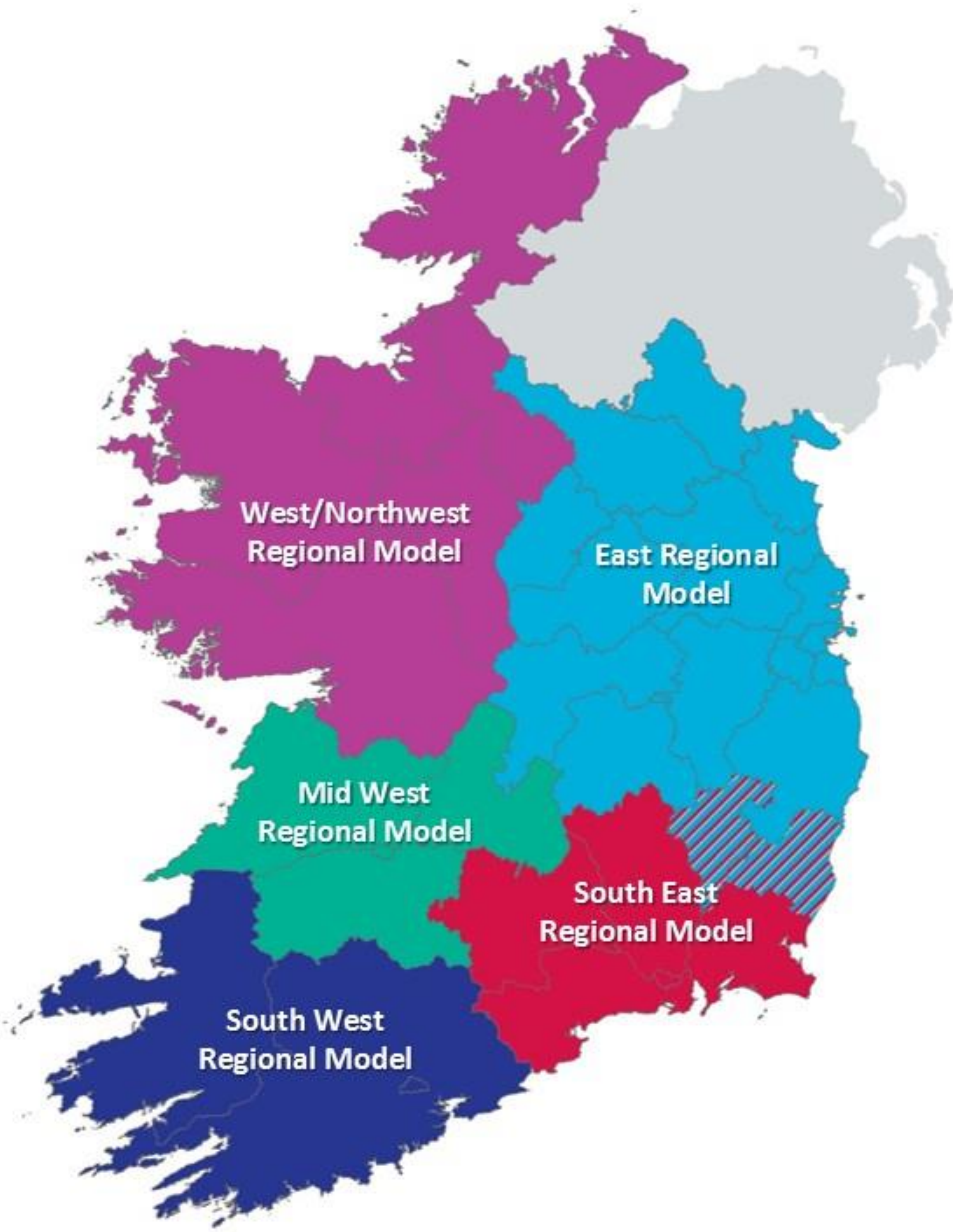


Figure 1.1 Regional Model Areas

1.2 Regional Modelling System Structure

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

- The National Demand Forecasting Model (NDFM)
- 5 regional models; and
- A suite of Appraisal Modules

The modelling approach is consistent across each of the regional models. The general structure of the SERM (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

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 Spec Full Demand Model Specification Report, RM Full Demand Model Development Report and SERM Full Demand Model Calibration Report for further information.

Assignment Models

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

The Road Model assigns FDM outputs (passenger cars) to the road network and includes capacity constraint, traffic signal delay and the impact of congestion. See the RM Spec 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 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 Specification Report;
- Safety Module Specification Report;
- Environmental Module Specification Report;
- Health Module Specification Report; and
- Accessibility and Social Inclusion Module Specification Report.

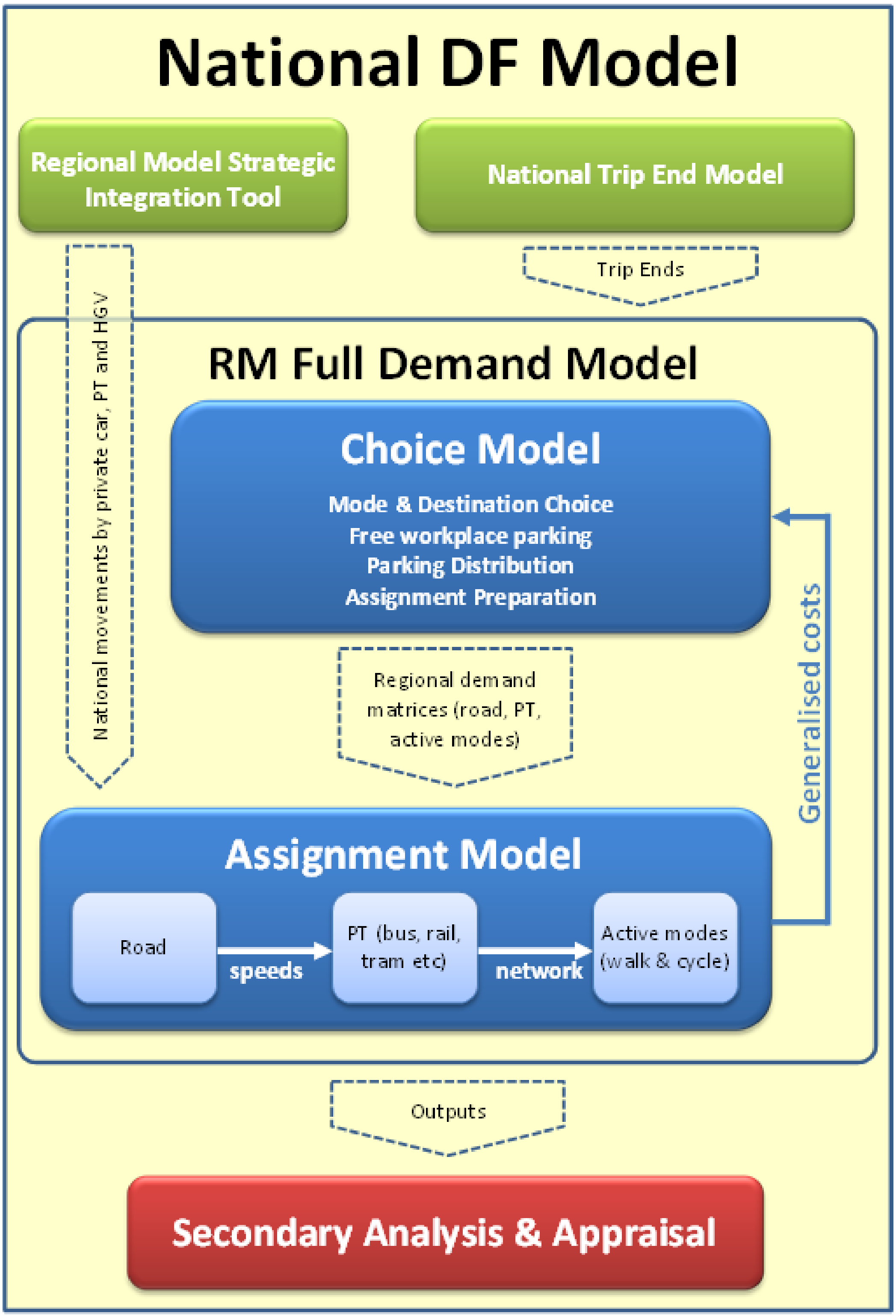


Figure 1.2 National and Regional Model Structure

1.3 Approach

The development of the WRM has followed a ‘Repeatable Methods’ approach (developed for the ERM), which provides the methodology, guidance and techniques to develop the Regional Modelling System. The methods used for both road network and zone system development are based on earlier development work and emerging guidance undertaken for the ERM. For the majority of aspects to date, the zoning development has adopted the methodology as outlined in “ZN TN05 Guidance for Zoning Delineation Process”. The document has been reviewed as part of the WRM development programme with updates provided where gaps were identified or further detail was required.

1.4 This Report

This report focuses on the development of an appropriate Zone System for the West Regional Model (WRM) and includes the following chapters:

- **Chapter 2:** WRM Zone System Development: provides information on the specification of the WRM Zone System and an overview of its development;
- **Chapter 3:** WRM Zone Development Review Process: details the review process carried out on the WRM Zone System;
- **Chapter 4: WRM Zone Area Review:** describes the specific review of zone areas;
- **Chapter 5: WRM Sectoring and numbering system:** Outlines the sectoring and hierarchical zone numbering system for the WRM; and
- **Chapter 6: WRM Final Zoning System:** presents the final zoning system.

2 WRM Zone System Development

2.1 Introduction

The zone system is used to segregate the modelled area into a number of disaggregate areas, enabling travel patterns to be separated and described in detail for each relevant origin-destination (OD) movement. The resultant travel demand associated with each zone is loaded onto or assigned to the modelled network using a series of zone centroid connectors.

The regional model zone delineation process aims to create a zone system which allows accurate modelling in the area concerned. The process, which has been established for all regional models, involves taking Census Small Areas, (the smallest spatial level at which data for building demand is available) and manipulating zone boundaries to create zones that take account of physical boundaries (motorways, rivers, etc.), and representative homogenous land use types and activity. This chapter outlines the process undertaken to develop the initial WRM zone system.

2.2 WRM Regional Zoning System Overview

The WRM zone system was produced using established NTA Regional Modelling approaches for developing a zoning system. However, in order to reduce development time, the WRM reused as much of the existing Galway Interim Model (GIM) zone system as could be allowed within the established methodology. Outside the usable area of the GIM system, the same methodology to the one used for the other Regional Models, as described in the “ZN TN05 Guidance for Zoning Delineation Process”, has been applied.

2.3 GIM Zoning System

The starting point for the development of the WRM zoning system is the GIM zoning system, shown in Figure 2.1 and Figure 2.2 below. The detailed central area (shaded in yellow) will be retained for the WRM and, therefore, the pre-existing simulation zones, as defined by the GIM model, were not altered and are consistent between the two models. Simulation coding within the SATURN road assignment model is confined to within this area. The GIM model area is represented by the shaded areas (yellow-simulation; blue-buffer) shown in the figures.

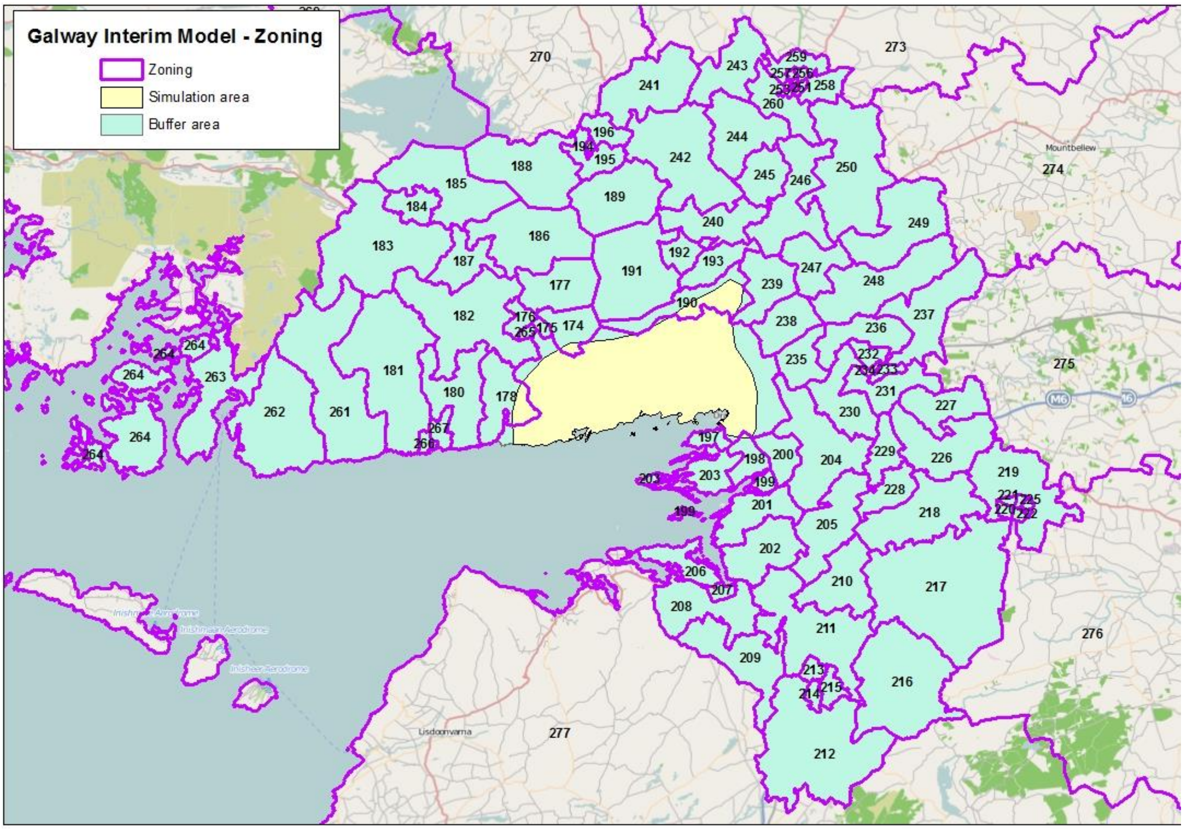


Figure 2.1 Galway Interim Model Zoning (Buffer Area)

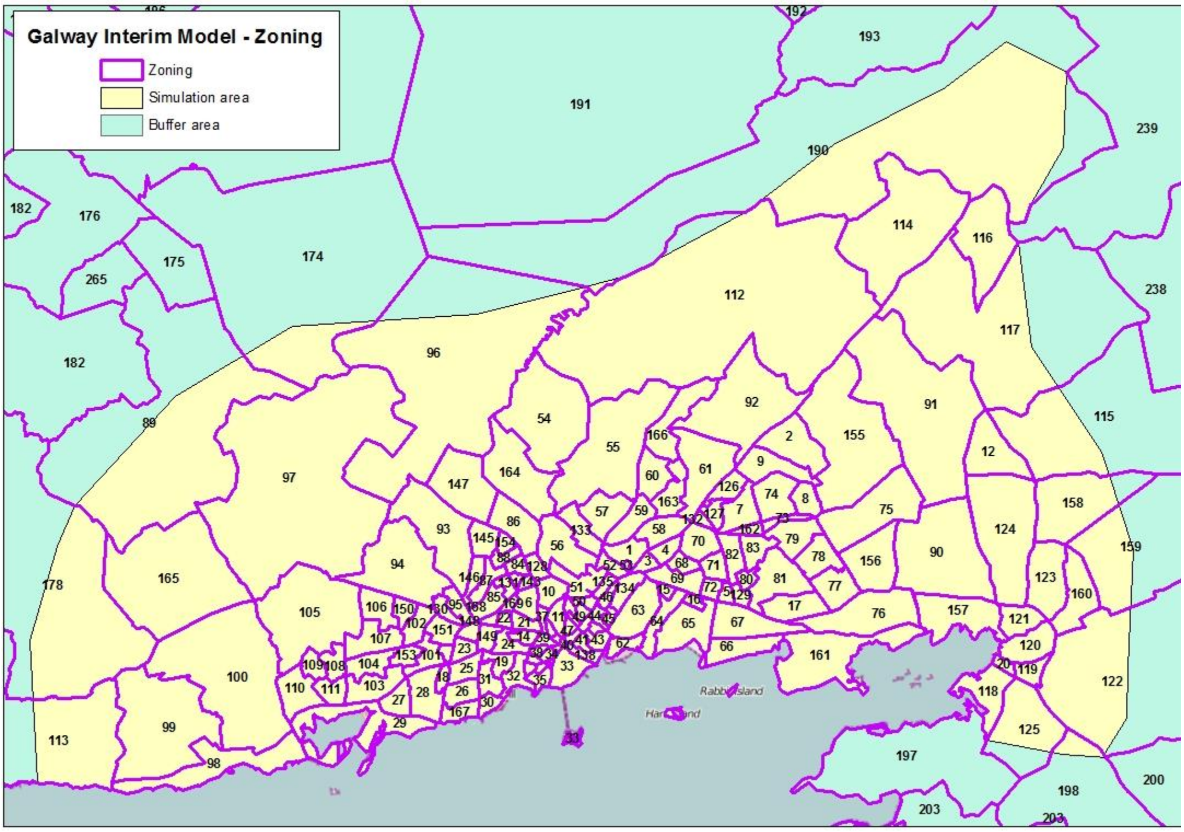


Figure 2.2 Galway Interim Model Zoning (Simulation Area)

The required coverage of the WRM zoning system is shown in

Figure 2.3 below and is significantly larger than the existing GIM model. As mentioned above, the WRM zone system for the geographic area not covered by the GIM zone system was produced using established NTA Regional Modelling approaches and is discussed in more detail in the following sections of this Report.

Figure 2.3 WRM Area

2.4 WRM Zone System Development

The remaining areas of the WRM model area (outside the pre-existing GIM simulation area) were defined according to the guidelines set out by the regional modelling programme and followed the steps described in the "ZN TN05 Guidance for Zoning Delineation Process", with some updates being applied where appropriate.

This process has been split into two main steps: Preparation Work and Zone Delineation. Within these steps the process is broken down into further sequences of sub-tasks. Figure 2.4 sets out the zone delineation process with arrows representing the chronological order of tasks. The process is iterative in order to achieve an acceptable balance between the various zone delineation conditions.

Preparation Work

Preparation Work comprises the following sub-tasks:

- **Data Review**
    - Collation and review of existing data sources.
- **Model Area Definition**
    - Review of the zonal detail included within previous regional models, the proposed level of model network detail and the potential applications of the completed model.
- **Define Zones Criteria**
    - Definition of criteria used to aggregate/ disaggregate zones.

Zone Delineation

Zone Delineation comprises the following sub-tasks:

- **Small Area Disaggregation**
    - Applying the disaggregation criteria to further disaggregate Small Areas if necessary;
- **Aggregation in Zones**
    - Applying the aggregation criteria to combine Small Areas into zones; and
- **Review Against Criteria**
    - Review of proposed zone system against criteria to check it meets the requirements.

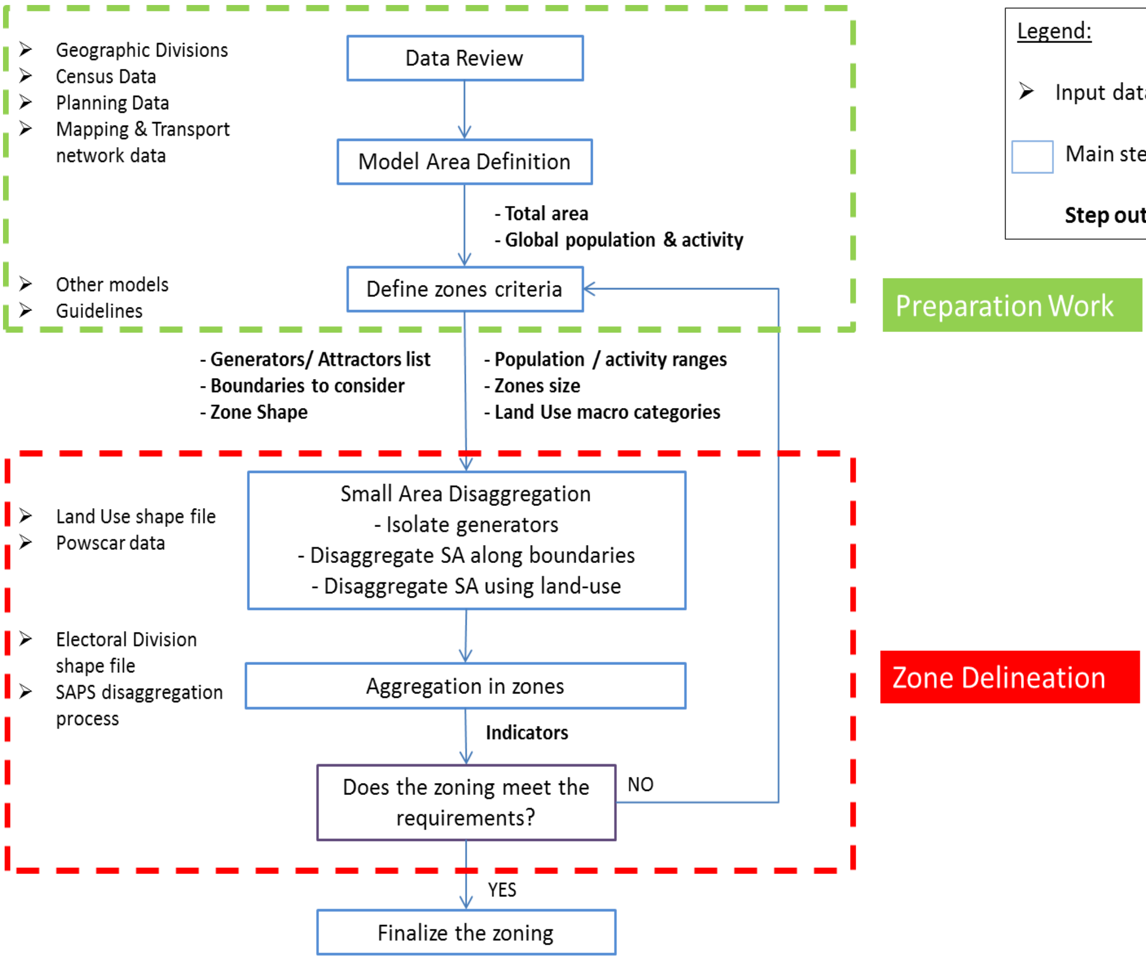


Figure 2.4 Overview of Zone Delineation Process

2.5 Preparation Work

2.5.1 Data Review

The Zone Delineation Guide identifies a number of zone characteristics, such as population and employment, which are correlated with travel activity levels. To understand the level of travel activity across the modelled area, the Small Area Population Statistics (SAPS) database, that contains the population and administration data from the 2011 Census, was interrogated. This GIS shapefile was cross-referenced with the Place of Work, School or College Census of Anonymised Records (POWSCAR) travel data (both data sets based on the 2011 Census). This level of geocoded detail allows for each CSA to be assigned the following data:

- total population;
- number of trips (Work and Education) from the Small Area in the AM peak; and
- number of trips (Work and Education) to the Small Area in the AM peak.

This data was used to build a database of population and trip generation across the modelled area to compare activity levels. A map of the Small Areas is shown below in Figure 2.5.

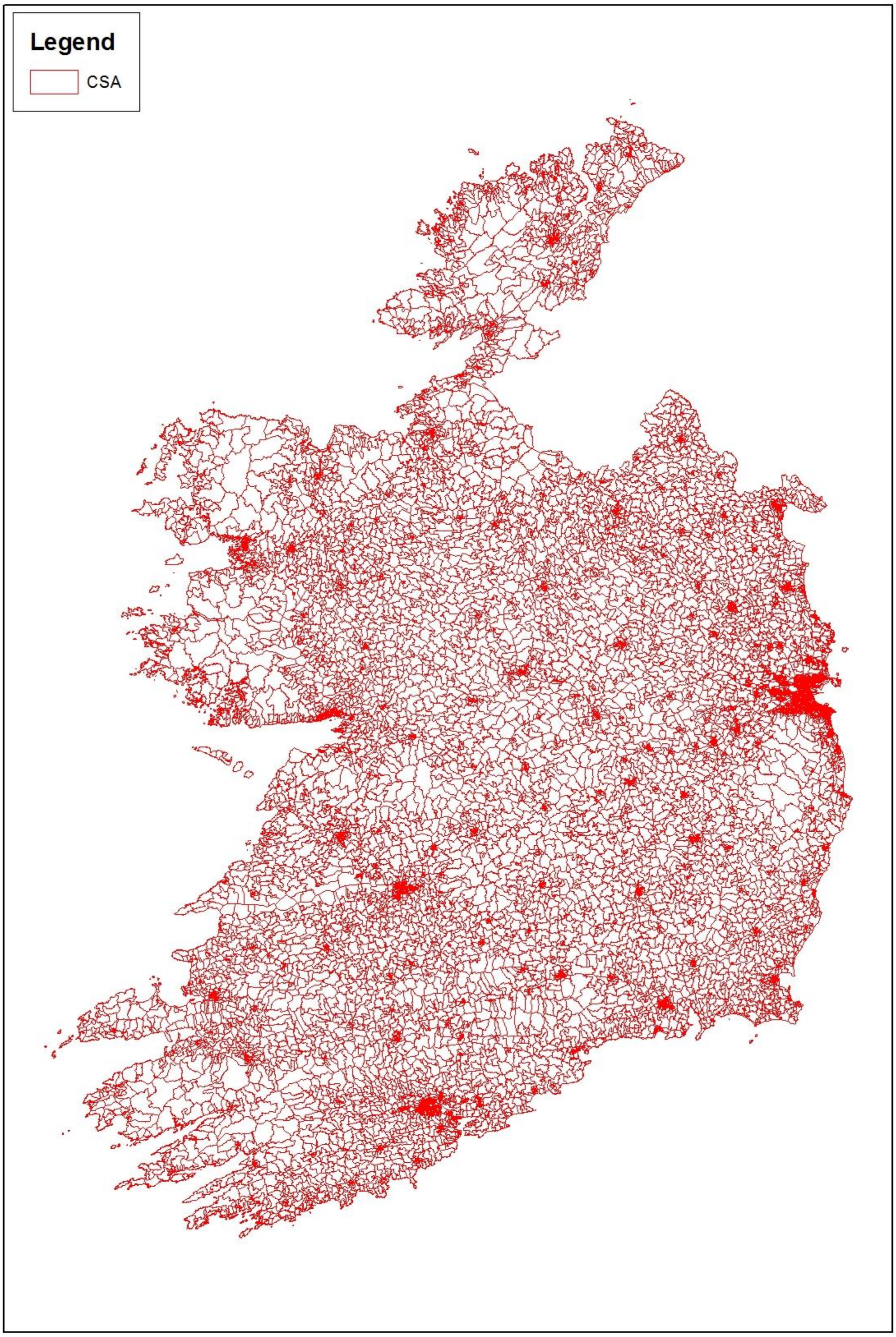


Figure 2.5 Map of Small Areas

Additionally, in accordance with the Zone Delineation Guide, data from a number of other sources was extracted and assigned to the relevant CSA. This included:

- MyPlan data: MyPlan is a database containing data relating to existing land use types in urban areas;
- Geo Directory data: Geo Directory is a database of addresses with geographic coordinates, each of which is categorised as either residential or commercial, with different addresses in the same building included;
- Electoral Divisions; and
- Road and rail networks.

2.5.2 Model Area Definition

The model boundary was defined as part of the Modelling Services Framework Model Scoping Task, as shown previously in Figure 2.3. The WRM zoning system includes Galway City, Counties Galway, Donegal, Leitrim, Sligo, Roscommon and Mayo. Following on from the Data Review, the next step in developing the zone system was Model Area Definition.

The WRM will be used to forecast changes in traffic levels and congestion on existing routes, appraise the benefits of proposed transport interventions and policies and predict the impact associated with land use development plans. These types of model application require a relatively detailed zone system and network to capture evidence relating to a wide range of potential impacts.

The WRM model network is composed of a simulation area, which includes modelling of individual junction layouts, and a buffer network which contains less detailed junction coding. As the zones tend to be of similar level of activity, the zoning is more detailed in city/town centres than in rural areas. Figure 2.6 illustrates the simulation and buffer areas of the WRM.

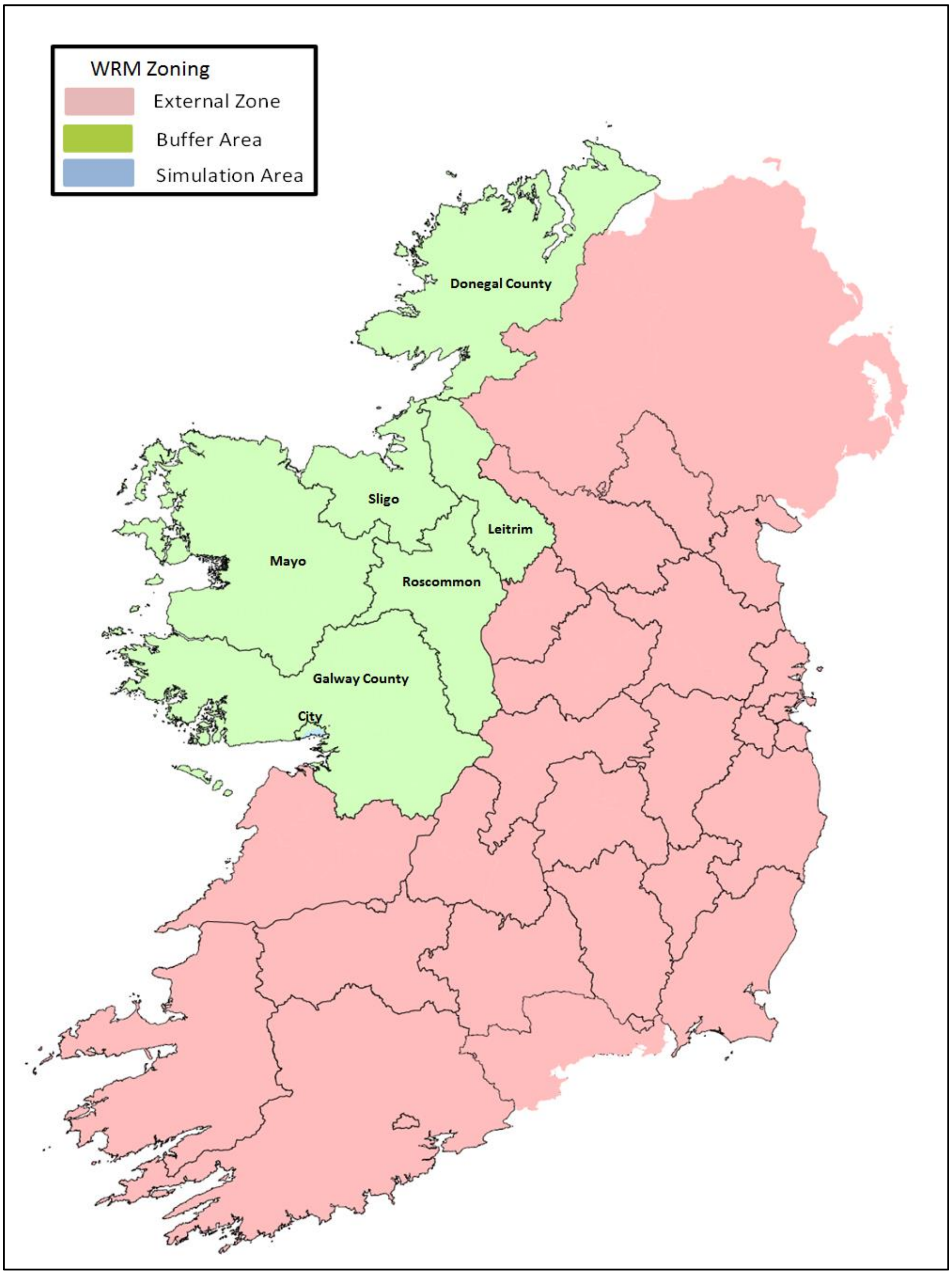


Figure 2.6 Map of WRM Area

2.5.3 Zone Criteria

The Zone Delineation Guide describes the range of conditions and thresholds to be taken into account when compiling a regional model zone system. This involves combining or segregating the individual CSAs into relevant zones. These conditions include:

- **Trip Generators / Attractors**:
  - Areas with an identified purpose and associated with a considerable level of travel activity/ trip movement (for example airports, universities, hospitals and shopping centres) should be isolated into separate zones representing specific travel patterns.

- **Geographical Boundaries**:
    - CSAs which intersected physical boundaries such as motorways, rivers and railways should be identified and disaggregated.
- **Land use**:
    - Areas with similar land use characteristics should be consolidated where appropriate to aggregate similar travel purposes.
- **Level of travel activity**:
    - Zones should lie within and not intersect a District Electoral Division (DED)
    - Zone activity should be in the 500-2,000 range (total trip generation/ attractions during the morning period)
    - A zone should not contain more than two incompatible land-use categories (only categories over 15% of the zone area are considered for this)
    - Zone population should be below 3,000 people.

2.6 Zone Delineation

2.6.1 Small Area Disaggregation

Three criteria were used to identify CSAs to be disaggregated:

- Significant trip attractors;
- Geographical boundaries; and
- Incompatible land-uses.

Significant Trip Attractors

Areas with an identified purpose and associated with a considerable level of travel activity / trip movement (for example airports, universities, hospitals, shopping centres) were isolated into separate zones representing specific travel patterns. Places considered as an attractor were identified using POWSCAR to select CSAs which attracted more than 2,000 trips over a three hour morning period.

The following high demand areas have been identified:

- NUIG (10,000 Education trips);
- Ballybrit Industrial Estate (8,000 work trips);
- University Hospital Galway (3,600 work trips & education trips);
- G.M.I.T (3,500 Education and Work trips); and
- Mervue Business Park (3,000 work & Education trips).

Geographical Boundaries

CSAs which intersected physical boundaries such as motorways, rivers and railways were identified and disaggregated. For the WRM zoning, the following boundaries have been considered:

- River Shannon

- M7 motorway
- Waterford – Limerick, Limerick – Galway & Cork - Dublin railway lines.

Land Use

Areas with similar land use characteristics were consolidated where appropriate to aggregate similar travel purposes. Using the MyPlan land-use database, macro-categories of land-use were defined, with incompatible categories identified (e.g. industry and residential) and isolated within separate zones.

The Geodirectory database (which provides locational data for residential & commercial buildings) was used to determine the appropriate split within zones where CSAs were required to be disaggregated.

2.6.2 Zone Aggregation

Following the disaggregation of the CSAs, the remaining CSAs were aggregated based on the criteria outlined previously to a logical and detailed zoning system, with an optimal level of travel activity within each zone. This process followed the approach and criteria developed for the ERM, which included:

- Zones should lie within and not intersect a District Electoral Division;
- Zone activity should be in the 500-2,000 range (total trip generation / attractions during the morning period (0630-0930, Time of Departure, source POWSCAR);
- A zone shouldn't contain more than two incompatible land-use categories. Only categories over 15% of the zone area are considered for this; and
- Zone population should be below 3,000 people.

The application of the criteria was treated as a hierarchy on occasions when not all conditions could be met. On occasions when conditions were not met, specific zones have been highlighted for potential review during the travel demand modelling development phase. The uncertainty surrounding these zones mostly relates to the potential level of travel activity, which will be confirmed during matrix development phase, at which point there may be an opportunity to further aggregate or disaggregate zones.

An example of zone aggregation in Tuam is illustrated in Figure 2.7. The first map shows the CSAs and the number of trip activity in each (in red). The five CSAs highlighted have a total trip attraction of 1,392, which is below the acceptable limit. Therefore, these five CSAs were combined to make one zone (zone 260).

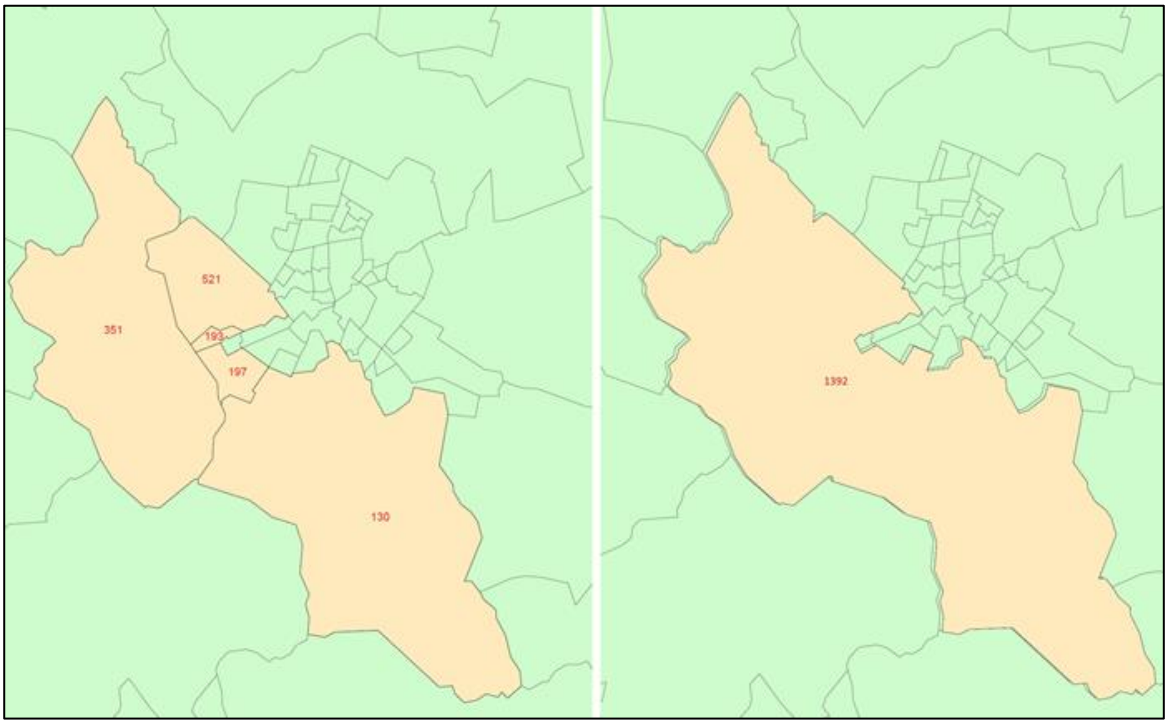


Figure 2.7 Zone Aggregation Example

2.7 External Zone Refinement

Based on emerging guidance from the ERM, the external zones were reviewed and refined. Specifically, Northern Ireland was disaggregated from one zone into four separate zones in order to allow more detailed modelling of trips taking place between the Western Region and Northern Ireland.

2.8 First Pass Zone System

The application of all of the process outlined above resulted in the First Pass WRM zone system (Version 1.0). This zone system had 693 zones in total:

- Galway City: 138
- Galway County: 206
- Donegal County: 109
- Leitrim County: 28
- Sligo County: 43
- Roscommon County: 44
- Mayo County: 123
- Special Zones (Airport and Port of Galway): 2

This zone system was then passed to the NTA and the Local Authorities in the WRM area for review.

3 WRM Zone Development Review Process

3.1 Overview

A first version of the zoning, following the zone delineation process, was sent to the Road Network Development team, the NTA and the relevant Local Authorities for review. The purpose of this step is to improve the initial zone system with respect to network and land use configuration whilst taking into account each of the previously discussed zone criteria.

3.2 Road Network Development Team Review

The WRM road network, which was developed separately and in parallel with the zoning system, is linked to the zone system via zone centroids and their connectors. Zone centroids can be defined in the road network, once a first version of the zoning is available. Centroids can be defined as geographical centres of a zone boundary. Zone centroid access (e.g. connectors) was defined using the road development method, which is detailed in WRM Road Model Development Report. That task (and preliminary assignment tests) raised issues that indicated some changes were required in the initial zoning system. Table 3.1 below contains examples of the type of issues that were identified and how they were addressed:

Table 3.1 WRM Road Network Access Review

Issue	Solution
Several actual accesses to a large zone	Zone disaggregated further to represent each main access point
Network locally overloaded due to link capacity limitation where a zone is connected	Zone disaggregated further if activity level allows it, modification to the access point if not
No road network coded within the zone (externals)	External zones have been redefined to represent “corridor access” to the simulation area

3.3 NTA and Local Authority Final Review

The NTA planning team reviewed the WRM zoning system to check against relevant local plans and to ensure the zoning system is consistent with the other regional model systems. Following this review no modifications were required.

No comments were received from the relevant Local Authorities.

3.4 External Zones

The model zoning system covers all of Ireland, with a fine level of detail within the Demand Model area (i.e., all of the 'Internal Zones'), a coarser level of zones surround these followed by large Outer External zones. The long border between the modelled area and the rest of Ireland requires detailed external zoning system (see Figure 3.1) to represent accurately interactions between these two areas.

56 external zones are represented in the WRM (52 in the Republic of Ireland and 4 in Northern Ireland). The external demand loads onto this network using centroid connectors with representative distances and speeds. External zones are connected to an appropriate motorway or national road node at the edge of the model road network.

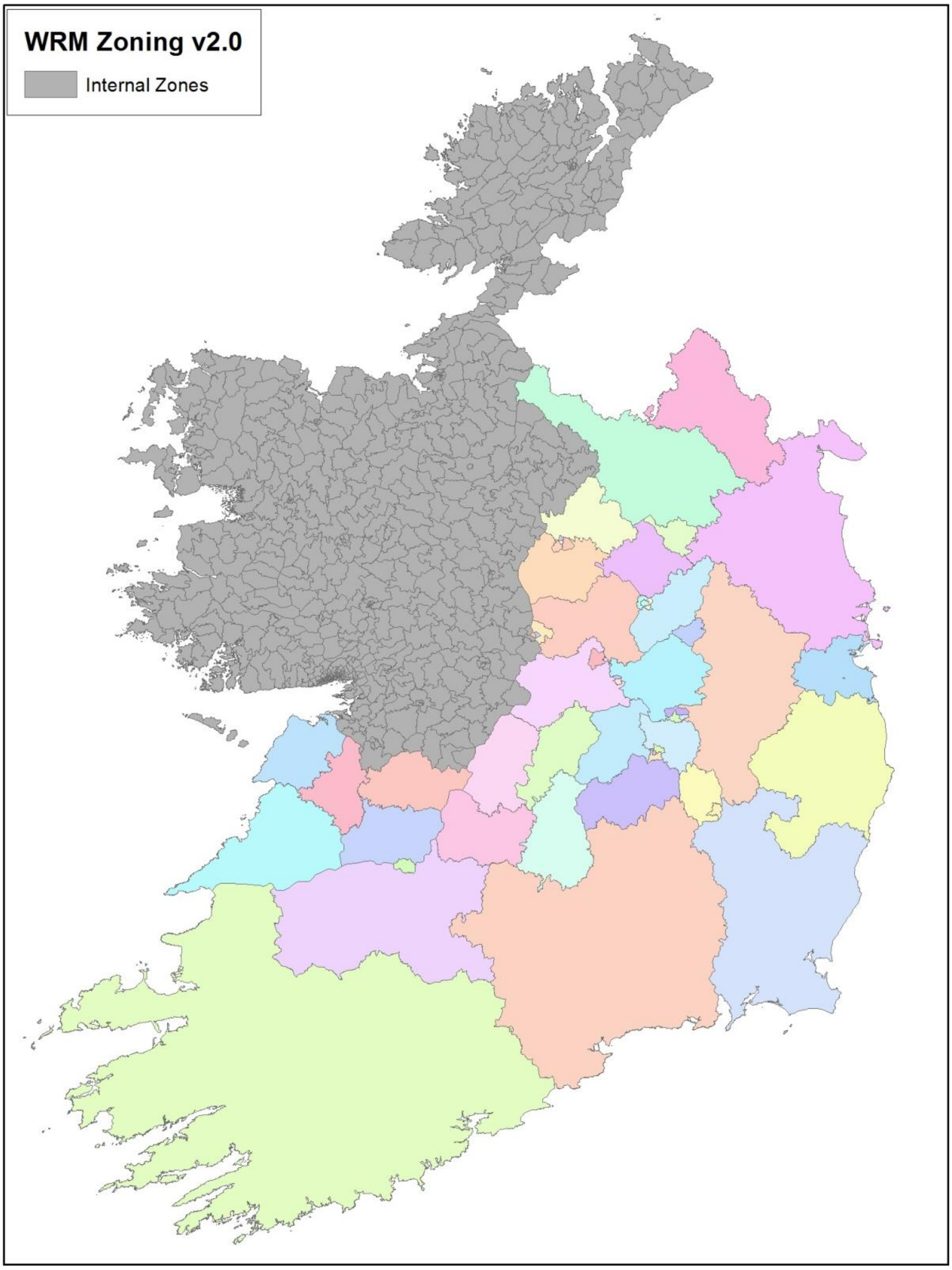


Figure 3.1 WRM External Zones

4 WRM Zone Area Review

4.1 Introduction

Emerging guidance from the development of ERM and tests carried out on the SWRM identified an issue relating to the area of some of the zones and the representation of active modes in the Regional Models. Application of the aggregation criteria outlined above resulted in some large zones in rural areas (where there were low levels of activity).

In the initial PT assignment of these models, the length of the public transport walk connector was taken to be proportional to the area of the zone (it was taken to be 2/3 of the radius of the zone, with the assumption that each zone was a perfect circle). This resulted in long walk connectors, and hence a high PT access cost, for some zones, which impacted on the calibration of the FDM. It also led to the over estimation of intra-zonal walking and cycling trips, with the error in the proportion of these trips proportional to the length of the centroid connector.

In order to avoid this issue arising in the WRM, large zones were reviewed and disaggregated if necessary. This process is described in more detail in the following sections.

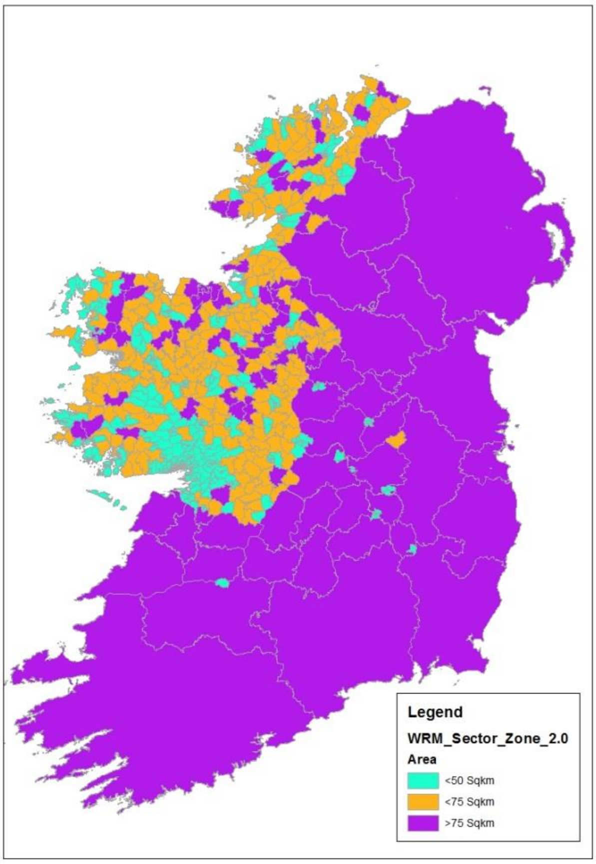


Figure 4.1 WRM Zone Area

4.2 Zone Disaggregation Criteria

If a zone had a walk connector longer than 3km then it was flagged for review, with zones being disaggregated to create a system with the majority of zones aiming for the following target attributes where possible:

- Zone activity target of 2,000;
- Zone population max target of 5,000; and
- Zone size below $70km^2$.

The application of the targets was on a case-by-case basis, so that some zones' attributes remain above the thresholds, but the overall system is much more disaggregate.

4.3 Zone Area Analysis

The following graph illustrates the distribution of zone sizes in sq km. As can be seen 81% of the zones are smaller than the target 70 sq km, with only 19 % above. Of these, approximately half (10%) have been kept this size, as to reduce further would require splitting of a CSO small area. The remaining 9% lie just above the 70 sq km threshold (under 75 sq km). The distribution of zone areas is shown in Figure 4.2 below.

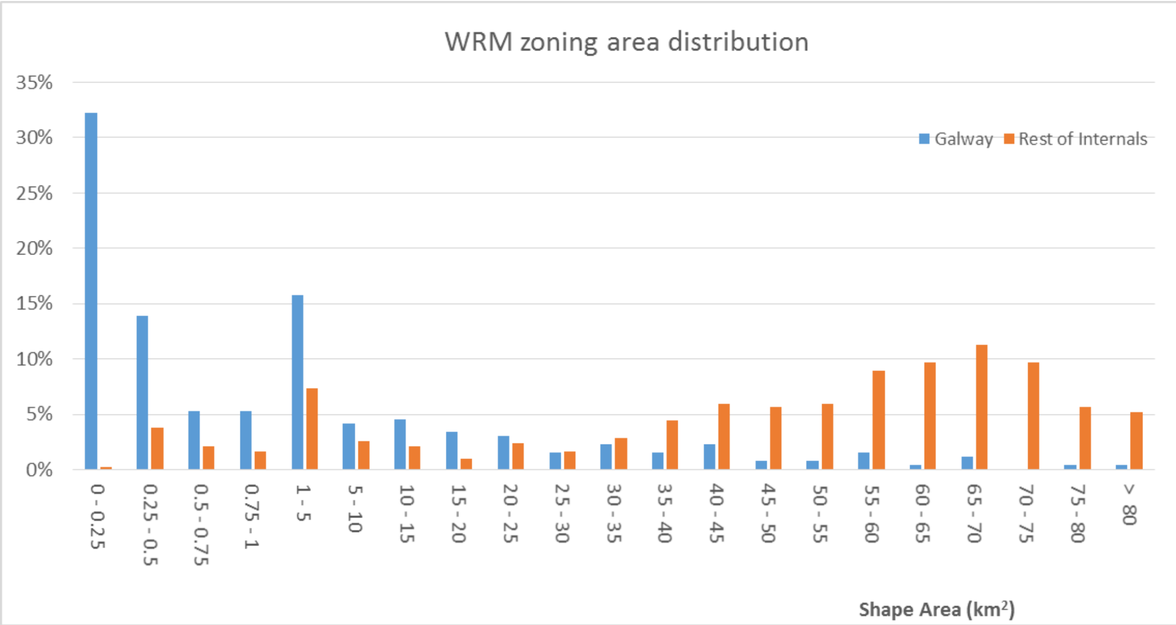


Figure 4.2 Zone Area Analysis

4.4 Network Changes

In addition to the zone disaggregation, weighted zone centroids were also introduced, based on the highest concentration of population and jobs in a zone. This more accurately reflects the generalised cost of trips to/ from zones where there was a small town or village in a large rural zone. More detail on the methodology employed for this and the impact is given in WRM Public Transport Development Report. The length of centroid connectors was also capped at 500m. Both of these measures further improved the representation of PT and active modes trips.

5 WRM Sectoring system & Special zones

5.1 ERM Guidance

As set out in the ERM Guidance “ZN TN07 GDA Sectoring System Information Note”, a sector system has been developed for the WRM. This sector system is presented below, and is used to define a hierarchical zone and node numbering system. It also facilitates the analysis of the demand and travel patterns at a more aggregated level.

5.2 Sectoring System

A number of resources have been used in the development of the sectoring system, including:

- the finalised zone boundaries of the WRM;
- key geographical features, notably motorways, rail lines and rivers;
- county boundaries; and
- a 19-settlement type classification system provided by the NTA.

In total, fifteen sectors have been developed for the WRM. These are listed in the table below, and are also shown on the following map.

Table 5.1 WRM Sectors

SECTOR	NAME
1	Galway City Centre - East
2	East of Galway Centre
3	North of Galway Centre
4	Galway City Centre West
5	West of Galway Centre
6	Northern Ireland
7	South East of Ireland
8	South West of Ireland
9	East of Ireland
10	South East Connacht
11	South West Connacht
12	North West Connacht
13	North Connacht
14	North East Connacht
15	Donegal

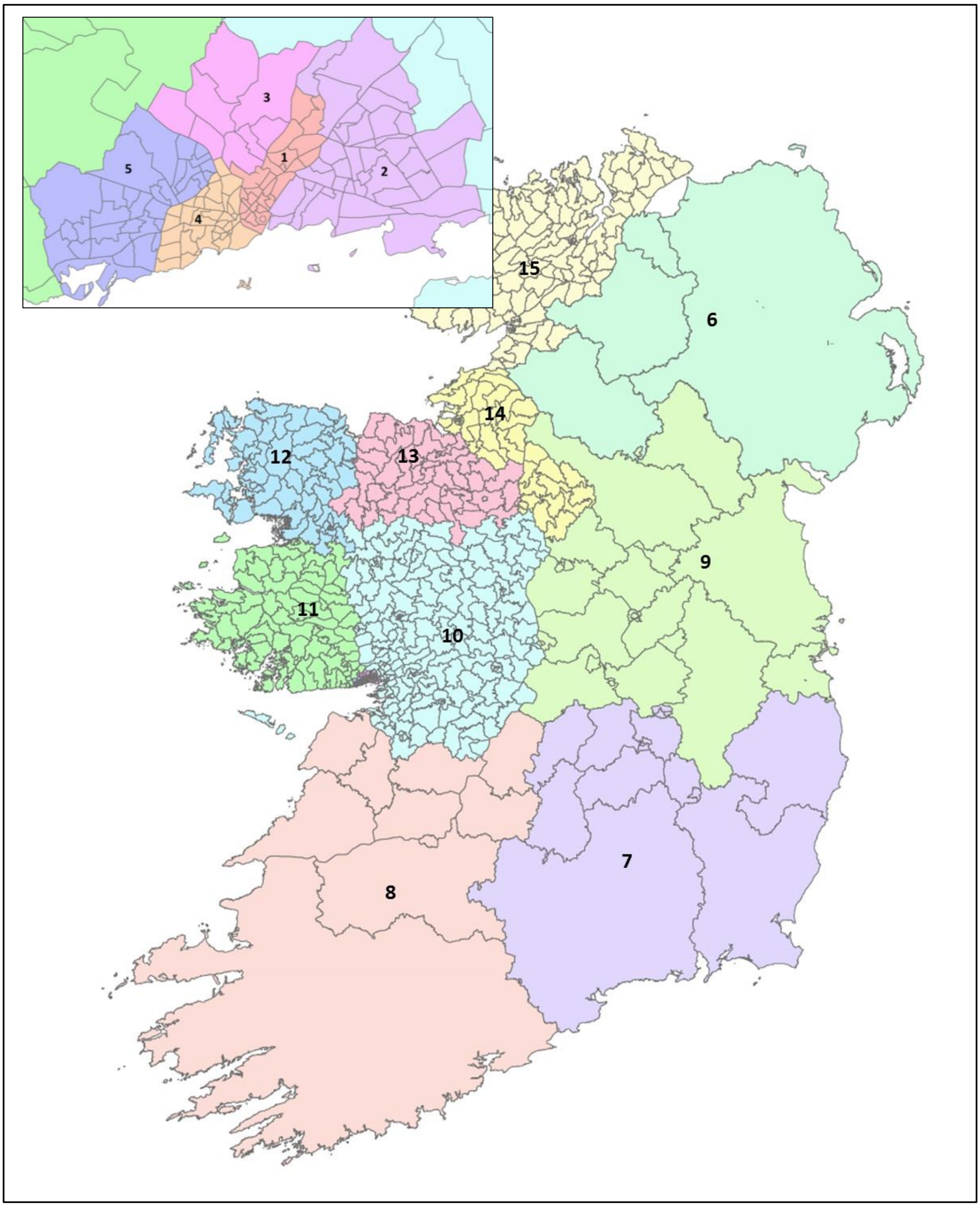


Figure 5.1 WRM Sectoring system

5.3 Special zones

Transport infrastructures where passengers travel from/to foreign destinations (such as airports or ports) can generate and attract a large number of trips. People that are working at these places are considered in the "regular" demand model as both origins and destinations are within the model area. Trips made by the travellers have a part of their journey outside the model area and a part made within the model area. These trips have then to be considered separately in the model and transport demand for these hubs is modelled differently from the rest of the zones.

In the WRM, two special zones are considered:

- Knock airport; and
- Galway Port

6 WRM Final Zone System

6.1 Overall Figures

The final WRM zone system (v2.0) is shown in Figure 6.1. It has 693 zones as follows:

- **Total Internal Zones: 693**
- Galway City: 138
- Galway County: 201
- Donegal County: 108
- Leitrim County: 27
- Sligo County: 46
- Roscommon County: 48
- Mayo County: 123
- Special Zones: 2

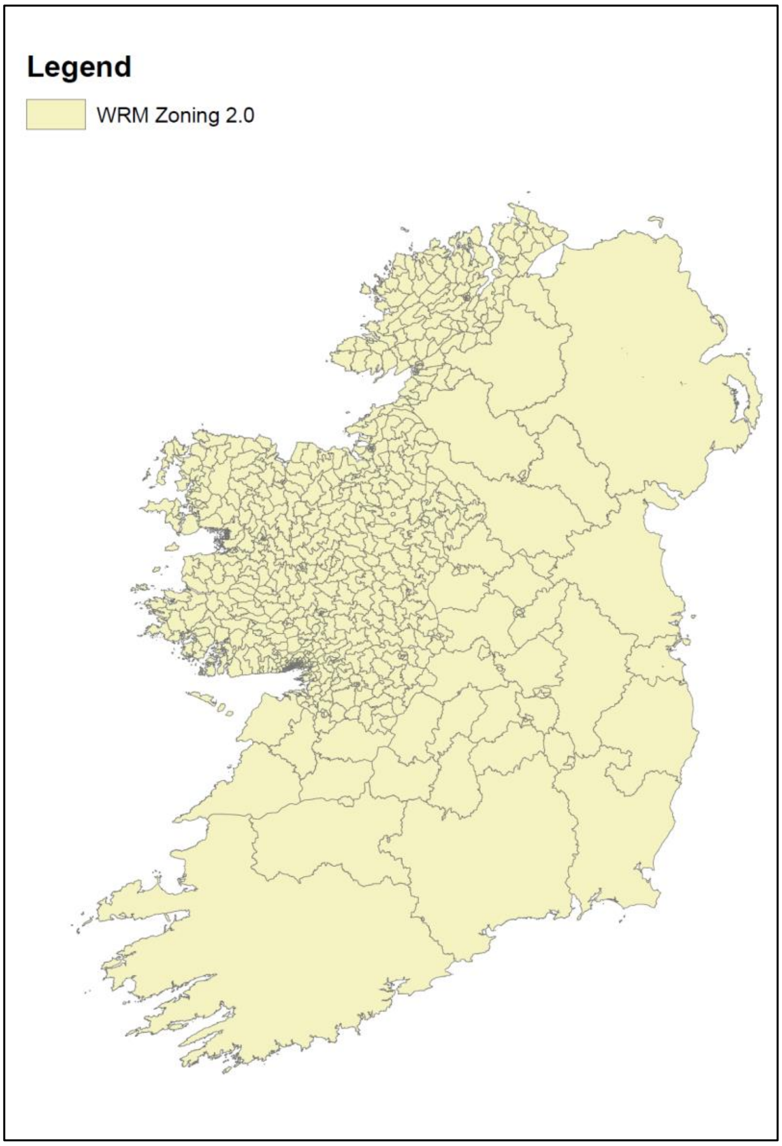


Figure 6.1 WRM Zone system v2.0

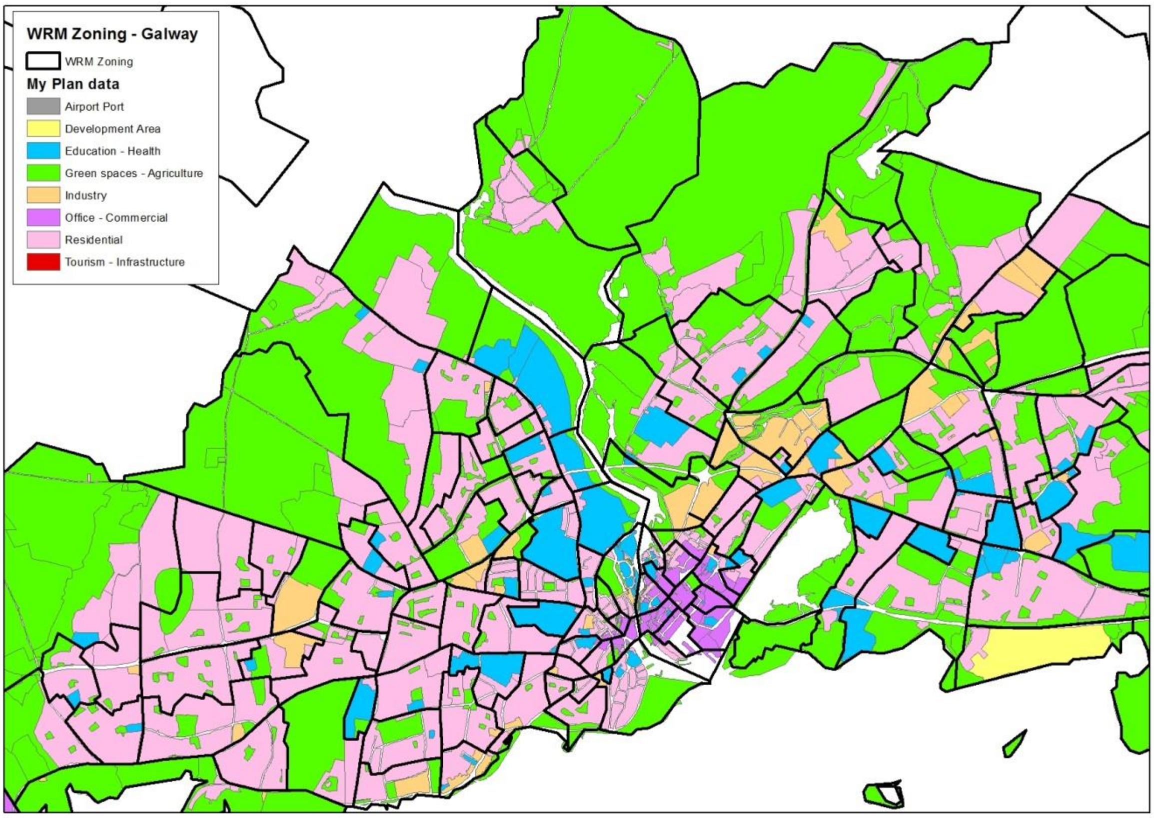


Figure 6.2 WRM Zoning V2.0 & My Plan data – Galway City

6.2 Zoning analysis

Along with the GIS shapefiles of the zone system, an analysis spreadsheet is produced to check that the zoning is acceptable and meets the criteria defined in the repeatable method process.

The following criteria have been applied across the final zone system to appraise its quality, and to compare it with the other Regional Model zone systems:

- **Population** below 3,000;
- **Activity** between 500 and 2,000 trips;
- Less than 2 different **land use categories**; and
- **Intrazonal trip ratio** below 5%.

6.2.1 Population

The population distribution for the WRM zone system is illustrated in Figure 6.3, overleaf, and is calculated using the Census Small Area data. In the WRM, there are nine zones (except externals) which have a population that exceed the 3,000 threshold criteria.

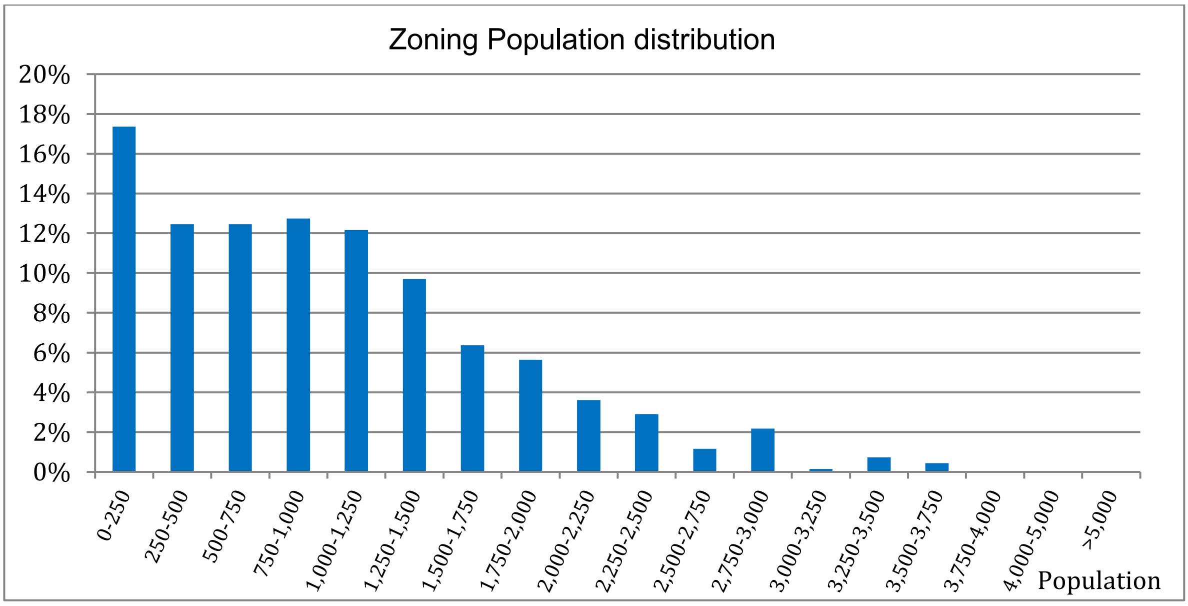


Figure 6.3 Final WRM Zoning – Population distribution

6.2.2 Activity

Activity is defined at the zonal level as the sum of trip productions and attractions. It is calculated at the zoning development stage and is derived from the POWSCAR 2011 database, for all modes and all time periods. This indicator provides a useful mechanism to compare zones of different types, i.e. residential zones (which are mostly trip producers in the POWSCAR database) and employment zones (which are mostly trip attractors).

The target activity range, defined by the repeatable method process, is 500 to 2,000 trips. The activity distribution for the final WRM zone system is shown in Figure 6.4, overleaf. Approximately 25% of the zones within the WRM have an activity level below the specified minimum threshold of 500 trips. This is acceptable due to the fact that these zones are mostly located in rural areas, and aggregating them to meet this criterion would have led to very large zones.

12% of the WRM zones have an activity level above the maximum threshold of 2,000 trips, and these represent large attractors (e.g. industrial estates, education and commercial areas).

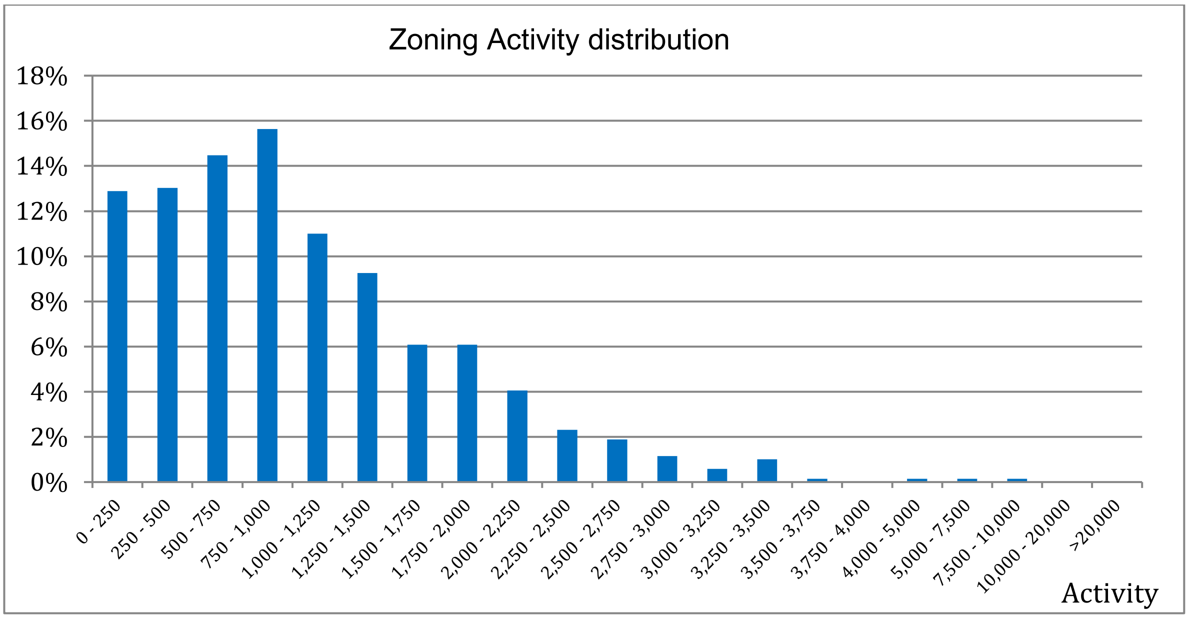


Figure 6.4 Final WRM Zoning – Activity distribution

6.2.3 Land Use Categories

Having homogeneous zones from a land use point of view is important as these areas will then exhibit similar travel purposes. As detailed earlier in this report, MyPlan data has been used to separate (where possible) areas with different land use. Figure 6.5 provides an overview of the number of different land use categories within zones in the WRM. It should be noted that MyPlan data was unavailable for more than 50% of the zones within the WRM. The results in Figure 6.5 indicate that only 16% of WRM zones contain more than a single land use category.

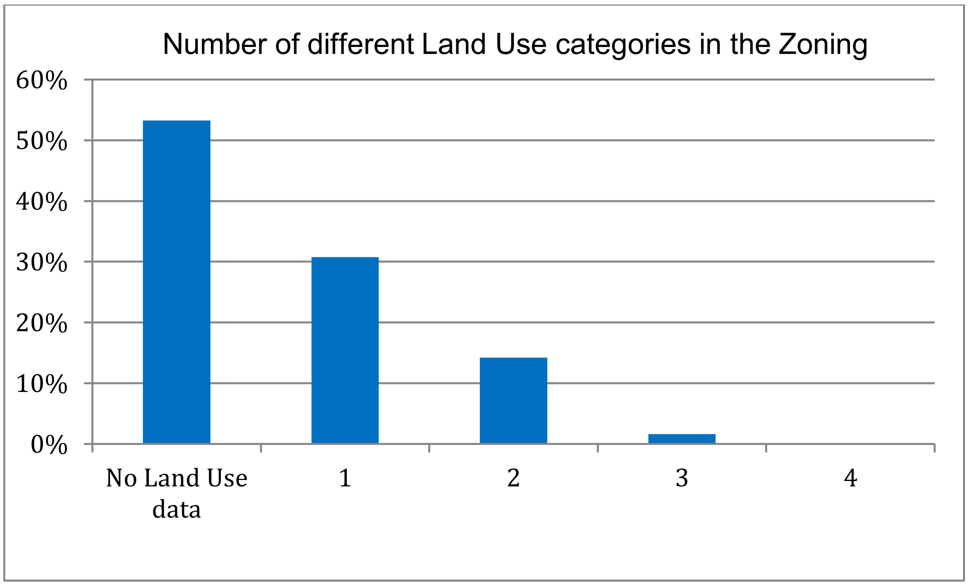


Figure 6.5 Final WRM Zoning – Different Land Use categories

6.2.4 Intrazonal Trip Ratio

The Intrazonal Trip Ratio is calculated as the ratio of trips that remain within a zone (intrazonal trips) over the sum of trips arriving and leaving the zone. This has been calculated for all zones within the WRM and measures the level of detail of the zone system. A high intrazonal trip ratio means that a large number of trips are not loaded on to the modelled network as they are made within the zone.

In the WRM zone system, 45% of zones have an intrazonal trip ratio below the threshold criteria of 5%. Zones with higher intrazonal trip ratios are mostly large in size with low activity levels. Further disaggregation of these zones to meet the intrazonal trip ratio criteria would have a negative impact on the minimum activity threshold of 500 trips outlined previously.

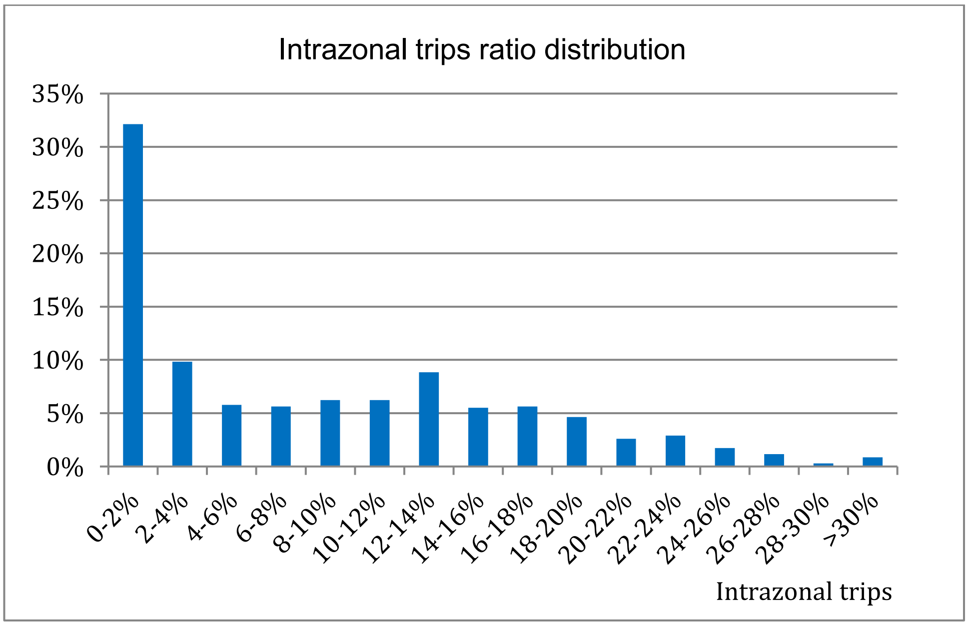


Figure 6.6 Final WRM Zoning – Intrazonal trip ratio distribution

6.2.5 Summary

The previous sections of this chapter outline the criteria utilised to appraise the quality of the WRM zone system. Figure 6.7, overleaf, illustrates the proportion of WRM zones which meet each of these criteria thresholds. The analysis indicates that:

- 24% of zones meet all the criteria;
- 58% of the zones fail one criterion;
- 17% fail two criteria; and
- 1% fail three criteria; and
- No zone fails more than three criteria.

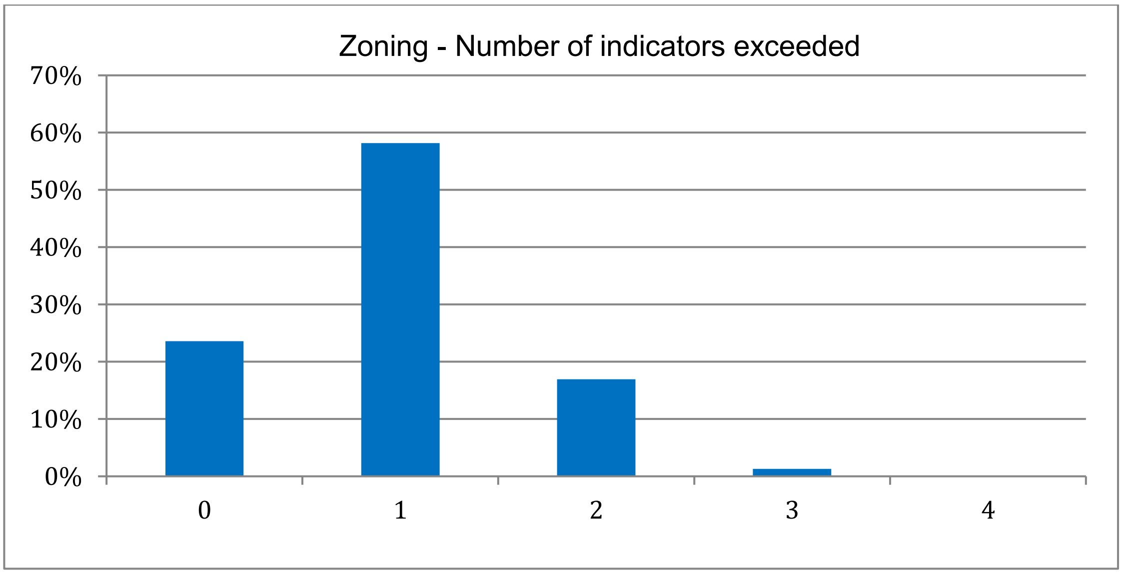


Figure 6.7 Final WRM Zoning – Number of indicators exceeded

Údarás
Náisiúnta Iompair
National **Transport** Authority

National Transport Authority
Dún Scéine
Harcourt Lane
Dublin 2

Údarás Náisúnta Iompair
Dún Scéine
Lána Fhearchair
Baile Átha Cliath 2

Tel: +353 1 879 8300
Fax: +353 1 879 8333
No. XXXXXXXX 22-12-2016
www.nationaltransport.ie

Appendix C

NTA NDFM Development Report

REGIONAL MODELLING SYSTEM

Modelling Services Framework

West Regional Model

Full Demand Model Calibration Report

Údarás Náisiúnta Iompair
National Transport Authority

CONTENTS

TABLES

FIGURES

Foreword

The National Transport Authority (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 NTA, SYSTRA and Jacobs Engineering Ireland.

The Regional Modelling System comprises the National Demand Forecasting Model (NDFM), 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 the 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 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	Code	Counties and population centres
Western 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

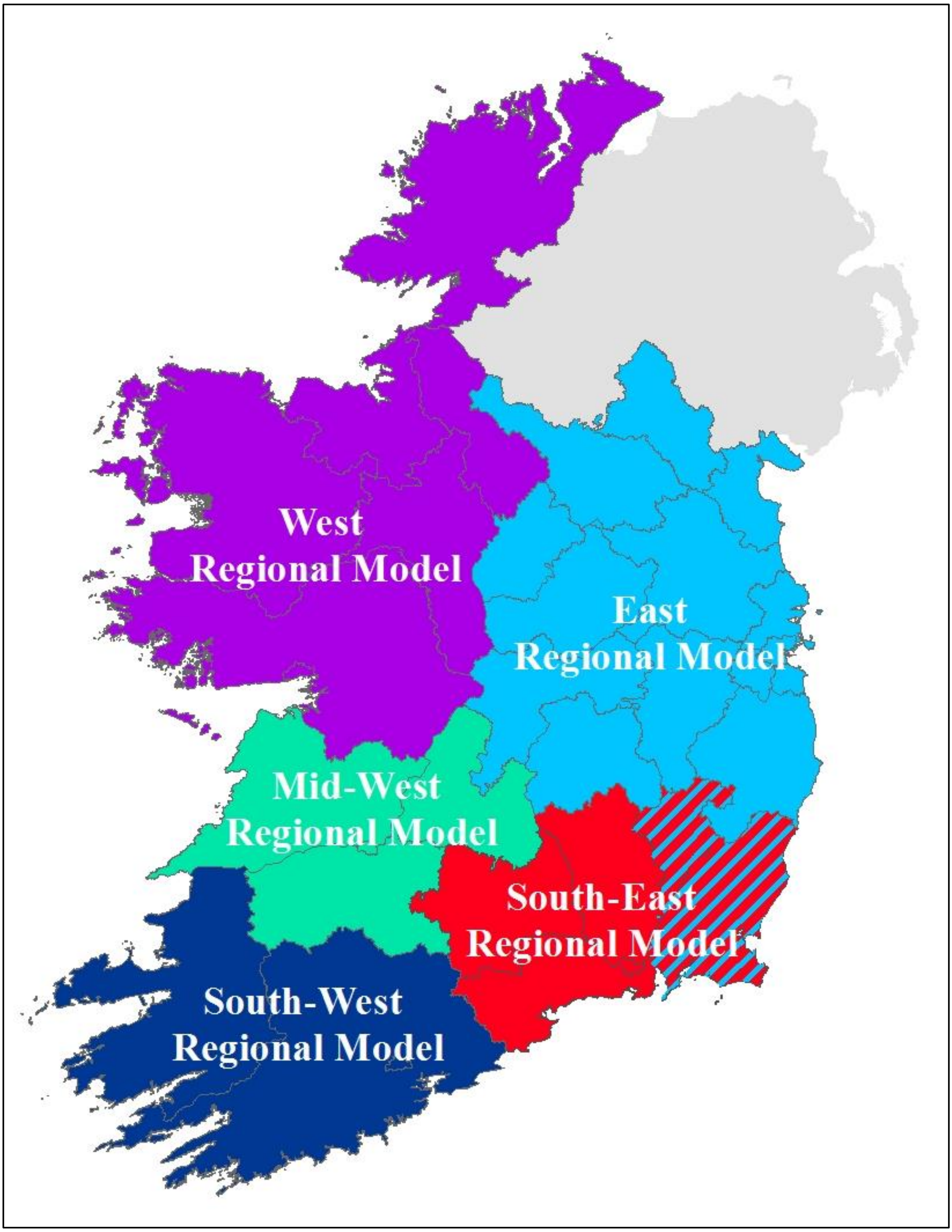


Figure 1.1 Regional Model Areas (the ERM and SERM overlap in the hashed area)

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 WRM (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

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

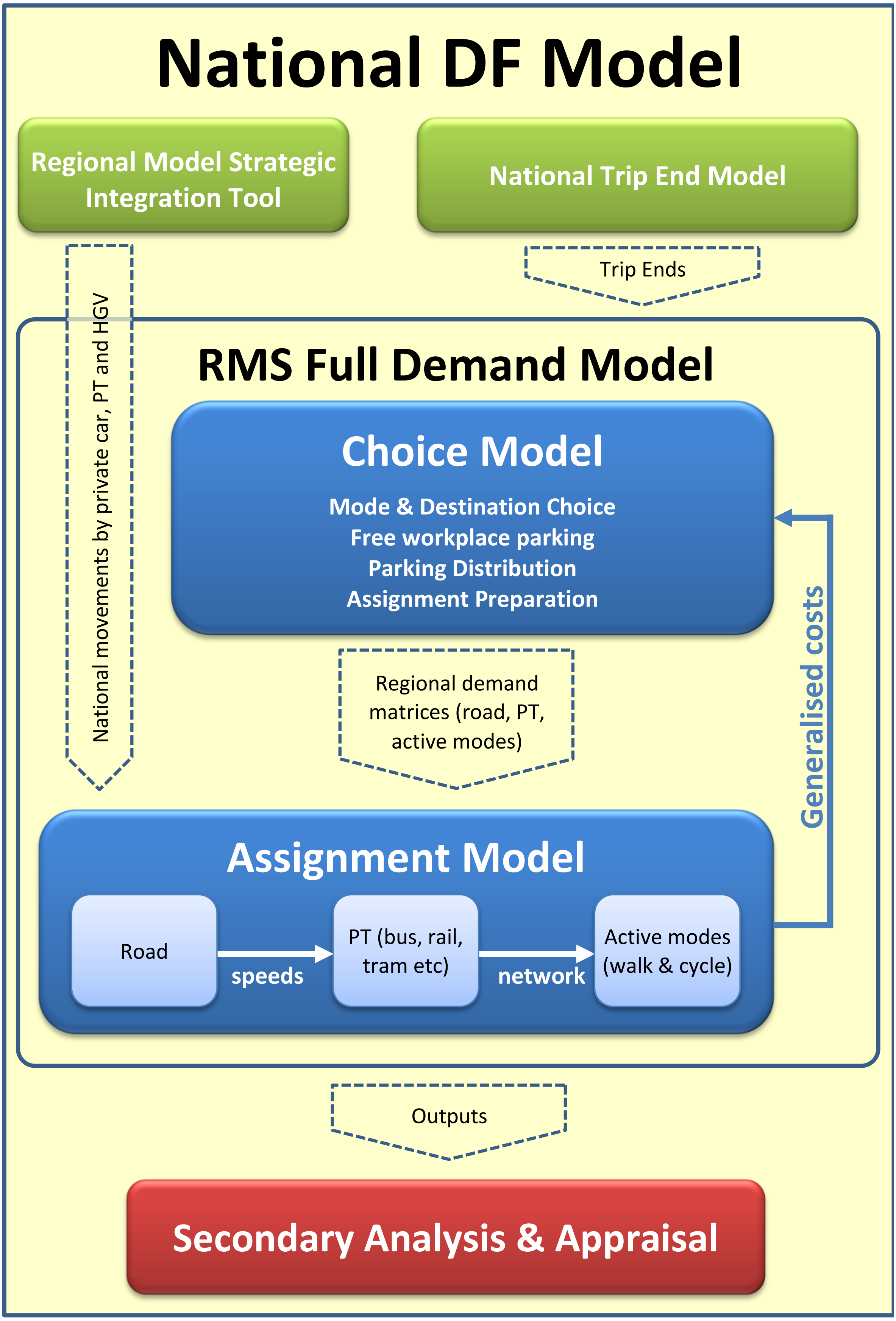


Figure 1.2 National and Regional Model Structure

1.3 Full Demand model (FDM)

The full demand model is common across all five regions of the RMS. Its form is of the 'absolute' type, so trip matrices for each forecast year are calculated directly from input trip ends and costs. Figure 1.3 on Page 9 shows an overview of the different modules of the FDM, including those which have yet to be fully implemented (in green). The purpose of the FDM is to take input trip ends (at the 24-hour level) and costs (from the road, PT and active modes assignment models) and then to allocate trips to different time periods, modes and destinations for input to the peak-hour road, PT and active modes assignment models.

The FDM consists of the following modules:

- **Trip End Integration:** Converts the 24 hour trip ends output by the National Trip End Model (NTEM) into the appropriate zone system and time period disaggregation for the RMS;
- **Add-in Preparation:** Takes the output of the Regional Model Strategic Integration Tool (RMSIT), factors it if necessary, and converts it into the zone system and time period disaggregation required by the RMS. In addition, it also reads in internal goods movements, and can apply a growth factor to them, and subtracts the long distance movements from the trip ends passed on to the later stages of the model;
- **Initialisation:** Converts the trip ends into tours and the costs into the required formats;
- **Tour Mode & Destination Choice:** Calculates where each production trip end will match with an attraction trip end, and by what mode the trip will be made, given the time when the trip will take place;
- **Free Workplace Parking:** For the journey purposes which have free workplace parking the initial mode & destination choice does not include parking charges. This module takes the initial car demand and decides whether it can be accommodated in the available free workplace parking spaces. For the proportion of the car matrix which cannot be accommodated, and for the corresponding proportions of the other mode matrices, it undertakes a secondary mode split including parking charges;
- **One Way Mode & Destination Choice:** Similar to the main mode & destination choice stages except that it works on the one way trip inputs;
- **Special Zone Mode Choice:** Models mode choice for zones such as ports and airports which are forecast differently than the regular population. Demand must be input for the peak hour in each time period;
- **User Class Aggregation:** Aggregates the initial 33 trip purposes into five user classes for further processing;
- **Park & Ride:** This module takes the trips assigned to Park & Ride by the mode & destination choice stage, works out which Park & Ride site each will use, and outputs the car and PT legs of each trip as well as information to be used in the calculation of the generalised costs;

- **Parking Distribution:** This allows car trips to park remotely from their destination, which is critical where parking capacity is limited or cheaper parking is available nearby. It only applies to certain areas in each of the regional models. The module gives car trips the choice to park in a number of alternative zones, based on the total trip cost and adds a penalty to over-capacity zones. It outputs the car and walk legs of each trip, as well as information to be used in the calculation of the generalised costs;
- **Parking Constraint:** For models where the details of parking distribution are not of interest this module can be used to apply a basic limit on car demand.
- **Tour to Trip Conversion:** Takes the tour based information, including that using free workplace parking, and converts it into the outbound and return legs needed by the assignment;
- **Assignment Preparation:** Combines the tour based and one way trips, special zone movements and Add-ins and applies vehicle occupancy and period to peak hour factors as appropriate. It also applies incremental adjustments, calculates taxi matrices and allows for greenfield development input;
- **Road Assignment Model:** Uses SATURN to assign traffic to the road network and generate costs;
- **PT Assignment Model:** Assigns public transport demand and generates costs;
- **Active Modes Assignment Model:** Assigns walk and cycle demand and generates costs;
- **Generalised cost calculations:** Takes the road, PT and active modes costs and processes them to generalised costs. It also calculates costs and cost adjustments for Park & Ride and Parking Distribution affected trips;
- **Convergence Check:** Undertakes a comparison of costs and demand from each successive loop to identify if the model has converged within acceptable criteria.

The following module is not yet fully implemented or tested:

- **Macro Time of Day Choice:** This module has not yet been implemented due to a lack of data on time choice behaviour. If implemented, it will allow trips to shift between macro time periods (e.g. from 7-10am to 10am-1pm).

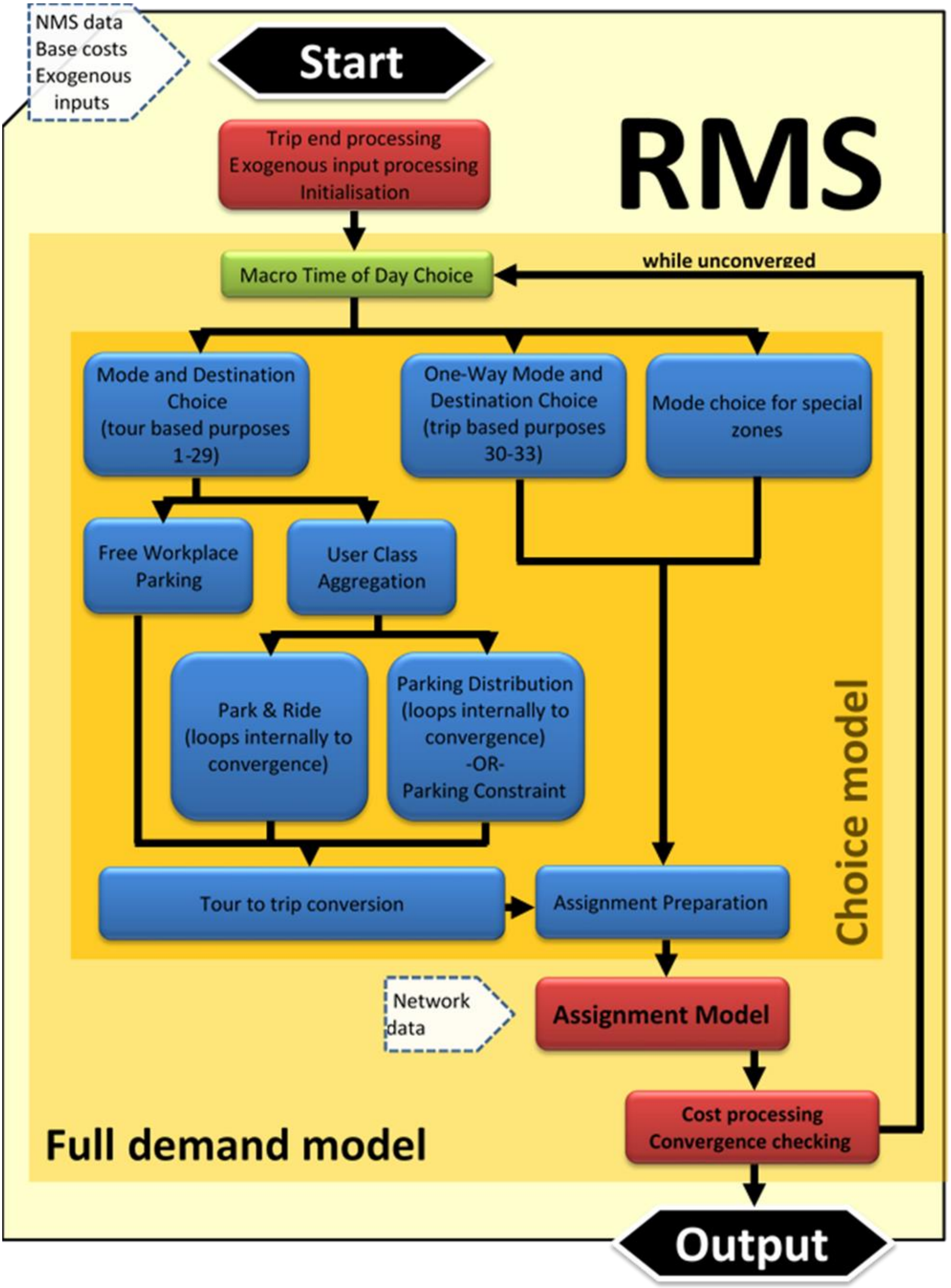


Figure 1.3 RMS Model Structure Overview

1.4 Report Library

This report is one document in a library of reports which describe various aspects of the scoping, building, development, calibration and validation of the NDFM and the five regional models.

The NDFM is covered in detail in the report:

- NDFM Development Report

The scoping of the RMS FDM is covered in a number of reports:

- FDM Scope1 Demand Modelling Workshop Recommendations
- FDM Scope2 Demand Segmentation
- FDM Scope3 Modelling Time of Travel
- FDM Scope4 Trips, Tours and Triangles
- FDM Scope5 Car Ownership Scoping Report
- FDM Scope6 Active Modes
- FDM Scope7 Parking Model Specification
- FDM Scope8 Goods Vehicle Model Specification
- FDM Scope9 Taxi Model Specification
- FDM Scope10 Airport and Other Special Zones
- FDM Scope11 External Zones
- FDM Scope12 Base Year Matrix Building
- FDM Scope13 Incorporation of Road Assignment
- FDM Scope14 Public Transport Assignment
- FDM Scope15 Choice Model Specification
- FDM Scope16 Trip End Integration
- FDM Scope17 Modelling of Greenfield Developments
- FDM Scope18 Regional Transport Model Exogenous Variables

The full, and finalised FDM specification is reported in:

- RM Spec Full Demand Model Specification Report

The detailed development and testing of the FDM is covered in:

- RM Full Demand Model Development Report

This report deals with the calibration and validation of one of the five RMS models, the Western Regional Model.

The following reports deal with FDM calibration and validation for the other RMS regions.

- ERM Full Demand Model Calibration Report
- SWRM Full Demand Model Calibration Report
- MWRM Full Demand Model Calibration Report
- SERM Full Demand Model Calibration Report

Three additional reports give detailed information on the development, calibration and validation of the WRM assignment models:

- WRM Road Model Development Report
- WRM Public Transport Model Development Report
- WRM Active Modes Model Development Report

1.5 This report: Calibration and Validation of the RMS for the West Region (WRM)

This report focuses on the calibration and validation of the RMS in the Western Region, otherwise known as the West Regional Model or WRM, including a description of the underlying theoretical process and the individual test runs conducted in the process of refining the model output. The report chapters include:

- Chapter 2: RMS Full Model Calibration Methodology: gives an overview of the theoretical process of calibrating and validating the FDM in general terms.
- Chapter 3: Full Demand Model calibration test history: in this chapter there is a detailed history of the various test runs undertaken in the process of calibrating the FDM.
- Chapter 4: Final calibration / validation results: presents the detailed calibration and validation results.
- Chapter 5: Realism Testing: the model's response to sensitivity or realism tests is outlined.
- Chapter 6: Conclusion: provides a summary of the process of model calibration and validation and makes recommendations for further work.

1.6 A note on terminology

There are five time periods in the model, one for the off-peak (OP), one for each of the morning and evening peaks (AM and PM) and two for the interpeak. The interpeak time periods were initially labelled 'lunchtime' referring to the period between 10:00 and 13:00 (LT) and 'school run' referring to the period between 13:00 and 16:00 (SR). These were later re-labelled as IP1 and IP2. However, as IP1 and IP2 are three letter codes whereas all of the original codes were two letter codes there were technical reasons why it was easier to retain the LT and SR labels in a number of places. The terms LT and IP1 are therefore used interchangeably, as are SR and IP2.

2 RMS Full Model Calibration Methodology

2.1 Introduction

Calibration involves the adjustment of the parameters which control the road, public transport and demand models, so that model predictions of flow and demand are as close to the observations as possible. Each NTA regional model is calibrated using the same process, which can be divided into distinct stages as shown below in Figure 2.1.

The calibration of the overall model requires the improvement of road and PT network assignment models so as to improve the costs being input to the FDM. It also requires calibration of the FDM so that the output assignment matrices match observed data (trip distributions and mode shares). As both requirements depend on each other, the calibration process is iterative. When the assignment models are calibrated to counts and journey times, and the demand model is responding appropriately to the input costs by outputting matrices that replicate observed data, the overall model is considered to be calibrated.

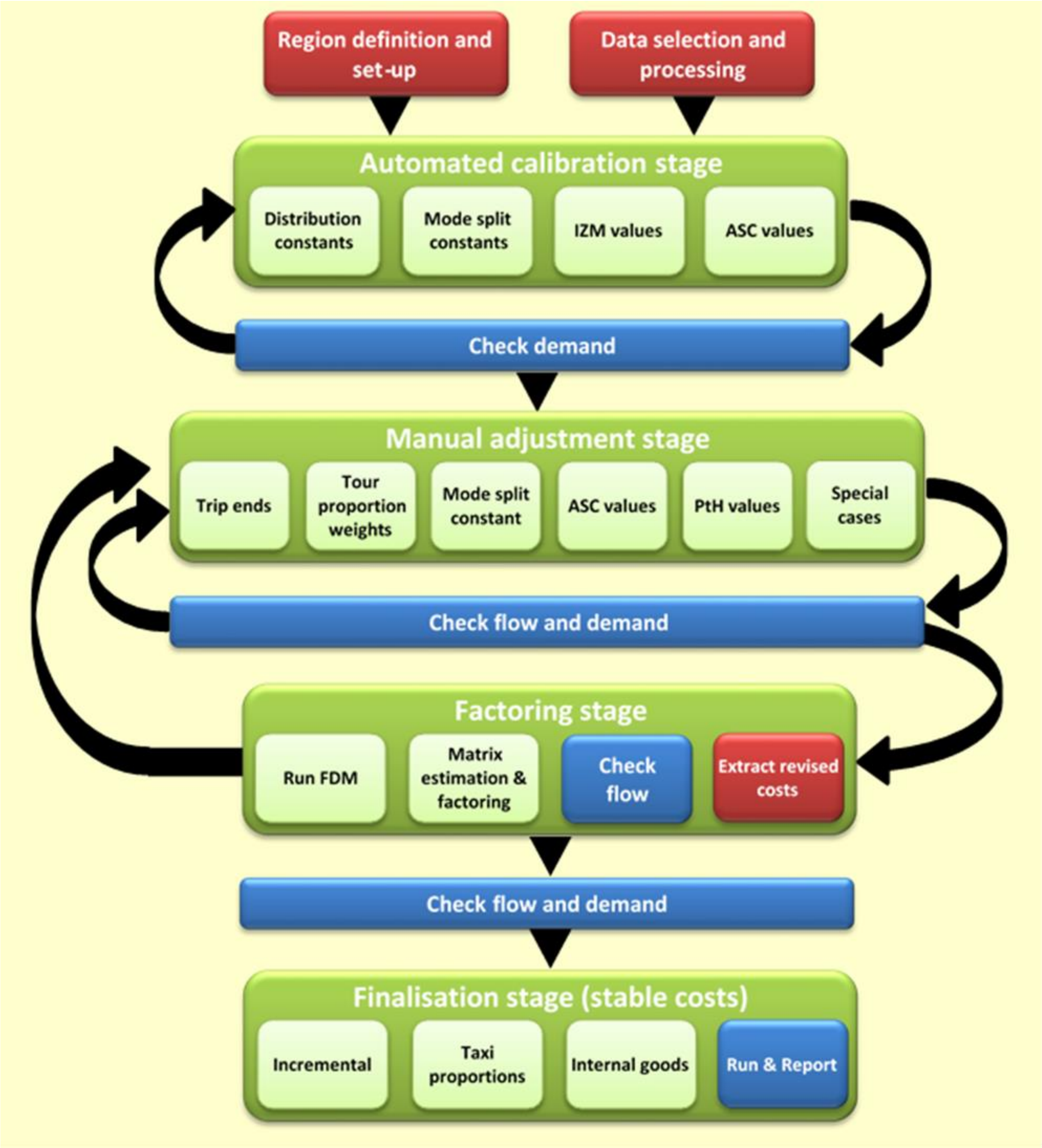


Figure 2.1 FDM calibration process

2.2 Region definition and set-up

The FDM implementation is identical across the regional models. A regional model is composed of the FDM plus the specific inputs required by that region, for example, input matrices expressed in the region's zoning system, or the region's particular road network. There are around 250 input files per regional model. These are listed in full in Annex 1 and they fall broadly into the following categories:

Table 2.1 Model inputs

Type of Input	Notes / Description
NDFM outputs	RMSIT matrices and NTEM trip ends.
Base cost matrices	From the best current estimation of the behaviour of the base network.
Preliminary test files	Dummy matrices and files for the assignment test stage.
Zone information files	Sequential to hierarchical numbering conversions, area, zone to small area correspondences and similar.
Mode and destination choice parameter matrices	Alpha, beta, lambda, ASC and IZM.
Parking information	Capacities, charges and parking parameters.
Greenfield inputs	Any input information for greenfield sites.
Road networks	All road network information files for all five modelled time periods.
PT network files	All PT information including networks, services, fares, values of time, annualisation factors and factor files for the four assigned time periods.
Active modes network files	Additional links and speed information.
Finalisation files	Incrementals, taxi proportions, car user to car driver factors and period to hour factors.

These files are found in the following locations within each model directory:

- {CATALOG_DIR}\Params (for those which are region specific but not run specific)
- {CATALOG_DIR}\Runs\{Year}\Demand (for those which are region and year specific)
- {CATALOG_DIR}\Runs\{Year}\{Growth}\Input (for those which are region, year and scenario specific)

As part of a model's calibration, all input files should be checked to ensure the region, year, and scenario are correct. A smoother calibration can be expected if this checking process is carried out in full.

2.3 Data selection and processing

2.3.1 Observed Demand Data

The WRM demand calibration data, which was also used at the automatic calibration stage, came from:

- "Census 2011 Place of Work, School or College - Census of Anonymised Records (POWSCAR)" which was processed and used to calibrate the mode splits and trip length distributions for the COM and EDU user classes; and
- 2012 National Household Travel Survey (NHTS) which was processed and used to calibrate the mode splits and trip length distributions for the EMP, OTH and RET.

Mode shares, trip distance, and journey time distributions were produced from these data for calibration. Demand matrices were produced from the observations and assigned to the road/PT models to derive the target trip cost distributions for each of the 33 journey purpose groupings.

The NHTS was used to extract mode shares based on the internal area of the WRM when possible. If the observed sample was too small for a particular purpose (less than 100 records), all the Non-Dublin NHTS trips were used in order to set the target mode share.

The observed trip length, journey time and generalised cost distributions were extracted from POWSCAR in the internal area of the WRM for COM and EDU purposes. The other segments were calibrated to either WRM or all non-Dublin NHTS subsets depending on the available sample size.

2.3.2 Observed Road Data

There was a large volume of data available for road calibration in the WRM. The data relates to two main types of traffic observation, i.e., volumes and journey times. In total, for all the regional models, there were between 6,000 and 7,000 road traffic survey records, including manual classified counts, automatic traffic counts (ATC) and Urban Traffic Control data, which were collated under the Data Collection task. Of these, approximately 272 link flow observations, illustrated in Figure 2.2 and Figure 2.3 below, were utilised as part of the WRM road model calibration.

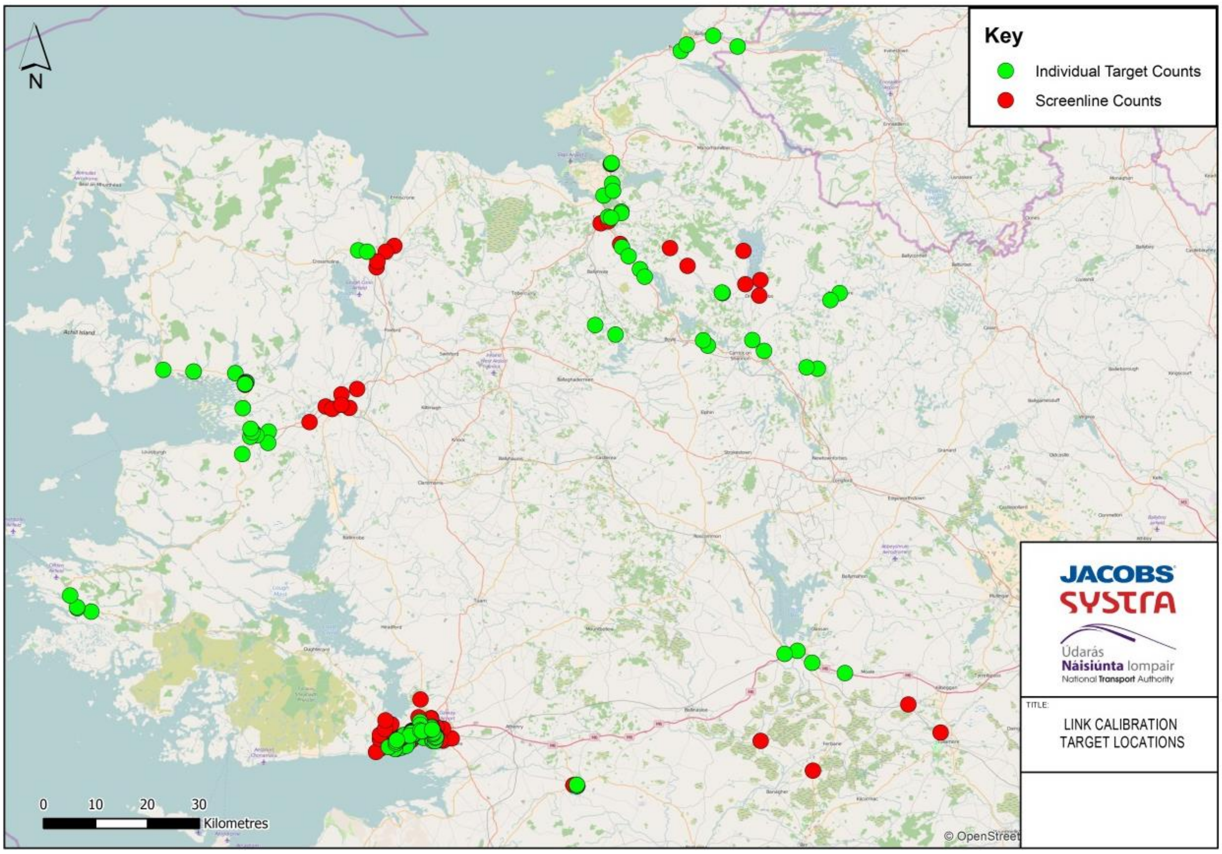


Figure 2.2 Link Calibration Target Locations (wider region)

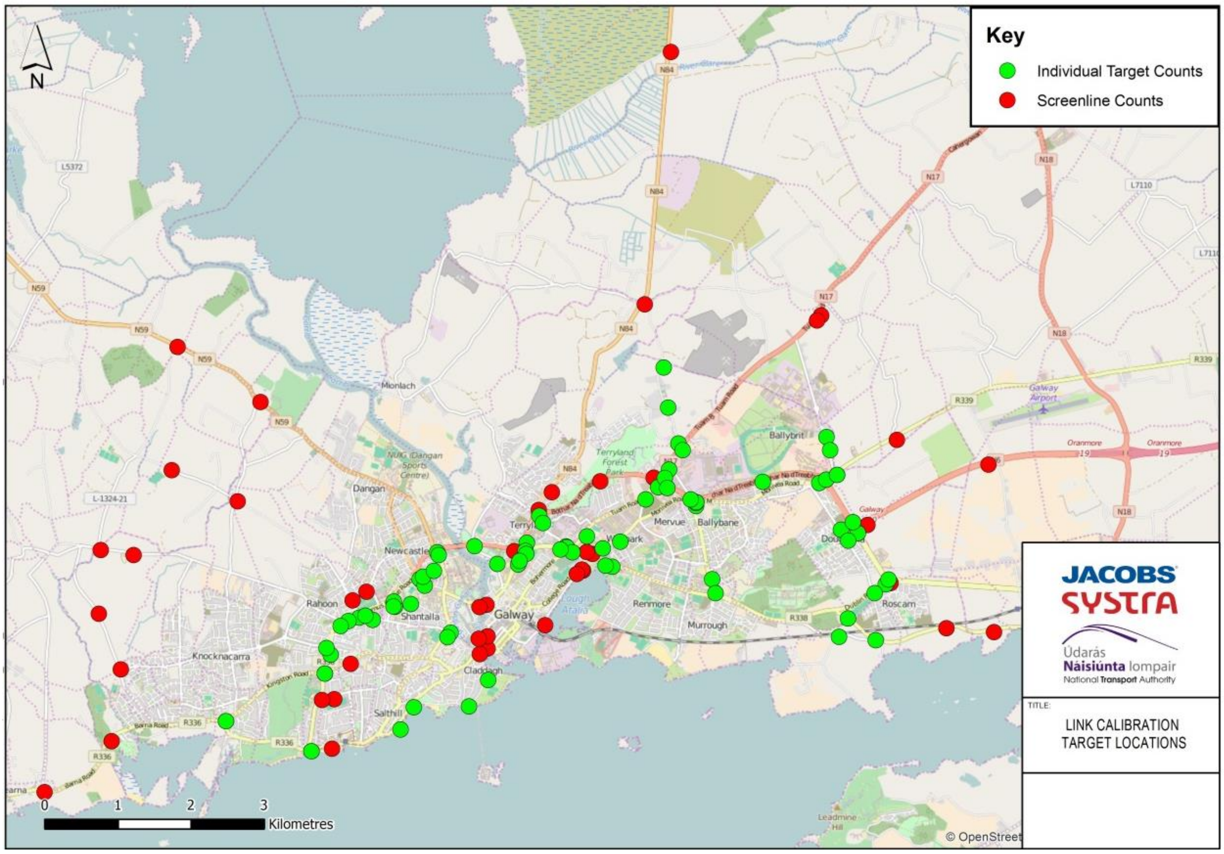


Figure 2.3 Link Calibration Target Locations (Galway)

In addition to this, there was also journey time validation data for 12 routes (inbound and outbound), illustrated in Figure 2.4, taken from TomTom data acquired by the NTA. Further information on observed road data is provided in the WRM Road Model Development Report.

Figure 2.4 TomTom Journey Time Routes

2.3.3 Observed Public Transport Data

Observed PT data for the WRM was collected and processed to build a single database of observed flows for use in the model validation. The following data sources were used:

- Rail: Irish Rail 2013 survey: provides boarding and alighting figures for all rail lines by station; and
- Bus: Nationwide Data Collection (2013 Survey): This database includes:
  - Boarding and alighting survey;
  - Bus Occupancy Surveys; and
  - Bus OD Surveys (not used)

Table 2.2 outlines the various surveys undertaken for different bus services operating in the WRM.

Table 2.2 Bus observed flow data sources

Group	B&A Survey	Occupancy Survey	Locations
BÉ Galway City Services	-	Yes	5 locations
City Direct	-	Yes	5 locations
BÉ Regional Services	Yes	-	Galway Train Station
Private Bus Operators	Yes	-	Galway Coach Station

Boarding and alighting (B&A) surveys were undertaken from 7:00 to 19:00 at two locations in Galway city: Galway Train Station and Galway Coach Station.

Bus Occupancy surveys were undertaken between 07:00 and 19:00 at five different locations and information about service, direction, time, and occupancy was recorded. Figure 2.5 illustrates the locations at which the various PT surveys were undertaken in the WRM. Further information on available PT observed data is presented in the WRM PT Model Development Report.

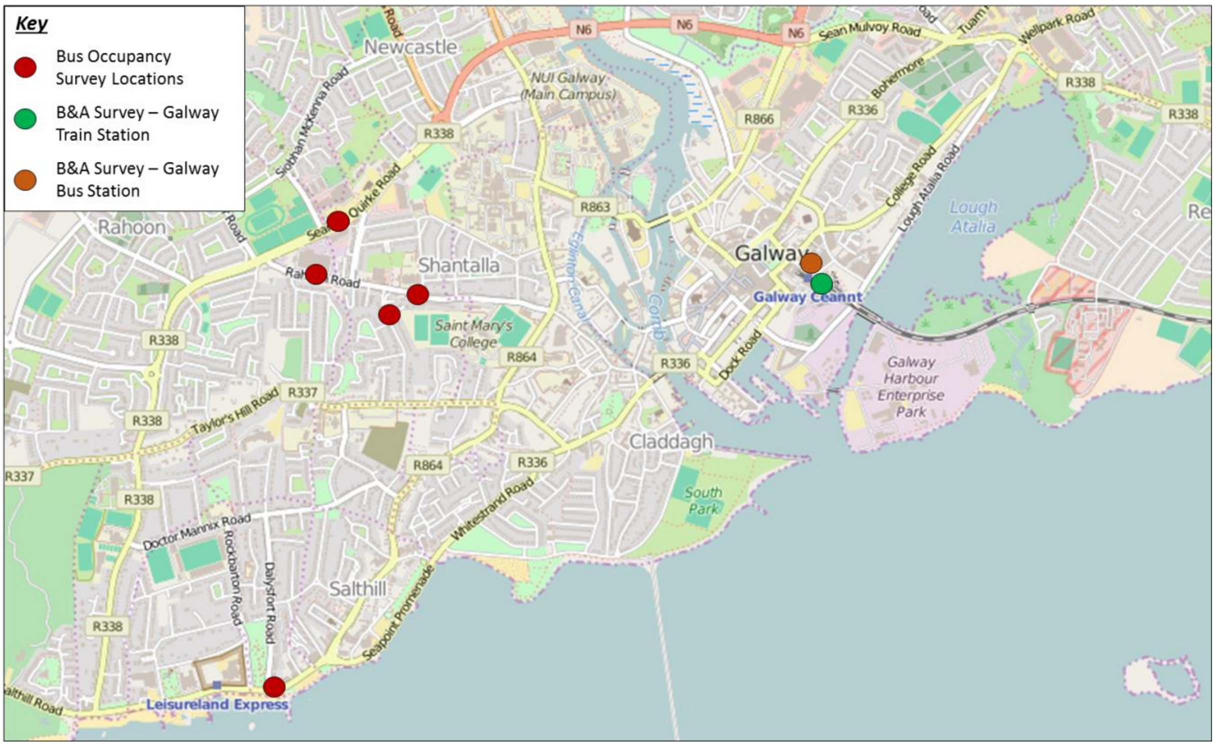


Figure 2.5 Galway City Bus Survey Locations

2.3.4 Observed Active Modes Data

There was no suitable active modes data available for the calibration of the WRM.

2.4 Automated calibration stage

2.4.1 Automated calibration

The automated calibration stage is used to provide an initial, approximate calibration of the demand model. The mode and destination choice loop is iterated while automatically varying selected calibration parameters to try and match key observations, such as the average journey lengths and mode shares.

Mathematically the probability of making a choice is:

$$P_n = \frac{e^{\lambda U_n}}{\sum_{n \in N} e^{\lambda U_n}}$$

Where: λ <0 is the relevant spread parameter;
U_n is the utility (or composite utility) of choice n; and
N is the subset of choices considered.

The utility value, which is required by both the mode and destination choice models, is calculated using the following formula:

$$U_{ij}^{mode} = \alpha^{mode} \times GC_{ij}^{mode} + \beta^{mode} \times \ln\left(GC_{ij}^{mode}\right) + ASC^{mode} + IZM^{mode}$$

The objective of the automated calibration stage is to adjust the lambda values and the utility by mode to match the observed cost distribution, mode share, and level of intrazonals (by mode), for each of the 33 journey purposes.

In the current version of the model the parameters which can be varied by the automated process are:

- Alpha (α): which controls the calculation of trip utilities at the distribution and mode split stages.
- Mode split lambda (λ): which controls the mode split.
- Intrazonal cost adjustments (IZM): which adjust the overall trip length by controlling the level of intrazonal demand.
- Alternative Specific Constants (ASC): which cover the unquantifiable costs perceived by travellers and not otherwise calculated.

Values of the parameters are initially set to 'neutral' values (IZM = 0, ASC = 0, $\alpha = 1$, $\beta = 0$). The main purpose of the lambda is to control sensitivity to costs in the calculation of choice probabilities based on the above utility; the higher it is, the higher the chances of a change in mode or destination when costs change. For mode choice there are separate main mode and active mode lambda values and these values are used in both the mode split and composite cost calculations. The lambda value used in the distribution is set according to WebTag guidance and further adjustments to the distribution calibration result from changes to the other parameters.

Beta values are not used in the current version of the model, and so they are set to zero everywhere. If included, the Beta values could be used to adjust the calculation of trip utilities at the distribution and mode split stages. Similarly, the distribution lambda could also be varied during calibration, instead of remaining fixed, but that is not allowed for in the approach adopted for this version of the model.

The calibrated base assignment models provide the generalised cost inputs to the automated calibration process. This is a fixed input. Alternatively, if a less approximate calibration was required, the generalised costs output from the most recent FDM run could be used as the input.

2.4.2 Check demand calibration

After running the automated calibration stage, the next step is comparing the outputs with the cost, trip length and mode split information in the data. There is a suite of spreadsheets able to do this efficiently and the outputs allow a decision to be made as to whether to proceed to the manual adjustment stage or to refine and repeat the automatic adjustment stage.

2.5 Manual adjustment stage

2.5.1 Manual calibration

Once a reasonable result was achieved using the automated process, manual adjustment could begin.

In some early iterations of the model this stage involved adjustments to trip ends and tour proportion weightings. In some cases, these improved the overall operation of the NDFM and these modifications were retained. In other cases, they tended to complicate a process of output factoring which could be better achieved by other means. For this reason, later iterations of the process did not include adjusted trip ends (with the exception of those which are now incorporated into the NDFM) or, for the most part, tour proportion weightings. Most adjustments in later versions of this stage are to ASC values and period to hour factors.

This stage may also include:

- The calibration of the mode split for the demand in some special zones, such as airports.
- The calibration of the Park & Ride module.

2.5.2 Check flow and demand calibration

Once suitable adjustments were made, and the FDM was run through, the standard output dashboards could be used to examine the levels of calibration in the demand, road, PT and active modes models and to decide if further adjustments were required. If further adjustments were required then they could be made, otherwise the process could proceed to the assignment adjustment stage, as described below.

It is important to note that the process is fluid and will switch from FDM calibration to assignment adjustment or vice versa, depending on the course of action suggested by the available results at the time.

2.6 Assignment Adjustment Stage

2.6.1 Matrix estimation, PT factoring and active modes adjustments

At this stage the matrices produced by the demand model may be adjusted to improve the fit of observed to modelled flow in the assignment models, using either matrix estimation (for road), PT factoring (for PT) or simple factoring (for active modes).

2.6.2 Check flows

The results of the adjustments with respect to assignment calibration are then checked to decide if further estimation / factoring is required, or if the pre-estimation matrices could be improved by further FDM calibration.

2.6.3 Cost extraction

The FDM may be improved further at this stage (in terms of distribution and mode split across the region) if the costs used are obtained from the latest assignments.

In later iterations, it may also help to update the (non FDM) processes that create internal goods matrices and taxi proportions with the latest assignment results. This is discussed in more detail below.

2.7 Finalisation

2.7.1 Exit criterion

The above process is repeated until it is observed that new demand model outputs do not produce noticeably different assignments as the previous loop of the process before estimation.

2.7.2 Finalisation

Once a stable solution is achieved the model can be finalised. At this stage three processes are required:

1) Internal goods matrices must be taken from the matrix estimated networks and provided as an input to the FDM.
2) The proportion of OTH[1] trips in each sector which are made by taxi must be extracted from the estimated road networks and provided as an input to the FDM.
3) The difference between the matrices output by the demand model and the matrices output by the estimation / factoring processes must be calculated. These are the incremental matrices and must be provided as in input to the FDM.

2.7.3 Reporting

With these three updated sets of inputs and a stable set of cost matrices, the final output from the FDM should match the final estimated / factored output and final demand, and flow dashboards can be populated.

---

[1] OTH refers to the ‘other’ user class. The remaining user classes are employer’s business (EMP), commuting (COM), education (EDU) and retired (RET)

3 Full Demand Model Calibration Test History

3.1 Region definition and set-up

The process of calibrating the WRM began in December 2015 in version ‘2.0.0: Save 1’ of the RMS FDM.

Input files were fully checked to ensure that they matched the latest input formats, were for the correct region and had been upgraded to be the best match to the actual networks on the ground, based upon the lessons learned from Model Version 1 of the ERM and the four other regional models.

3.2 Calibration / Validation Phases

The calibration and validation process can be broadly split into three phases. Phase 1 involved adjustments to trip ends, tour proportions, mode split lambda values and ASC values. Park and Ride (PnR), Free Workplace Parking (FWPP) and Parking Distribution (PDist) were switched off for Phase 1.

Phase 2 incorporated fixes and updates to the FDM and NDFM (which affected all of the regional models). Due to the updates in the NDFM, the trip end and tour proportion adjustments were not required and were removed during Phase 2.

Following the updating and enhancement of the model, calibration was completed in Phase 3.

Overall Phase 1 was undertaken from December 2015 to late February 2016 and Phase 2 from March to May 2016. Phase 3 began in early June 2016 and ended in late June 2016.

The remainder of this chapter describes the calibration of the FDM by phase, detailing the particular tests that were undertaken as part of each phase in turn.

3.3 Phase 1 Test 1

3.3.1 Run details

Model Version: *2.0.0, Save 4*
Date: *02/12/15*

The purpose of Test 1 was to confirm that the core parts of the model were functioning correctly, to check the initial road and PT networks, and to commence the calibration process. Initial costs were those provided from the assignment of the expanded Galway Interim Model matrices to the pre-calibration road network.

3.3.2 Results / outputs

This test run did not complete successfully due to errors in the scripts within the road assignment and connectivity issues identified in the public transport assignment.

The inputs and parameters were checked and corrected, thus allowing the first series of calibration iterations. The resulting comparison of modelled to observed mode share can be seen in Figure 3.1 below. The match was reasonable but there was too little walking and PT use, which coincided with too much cycling (further information is provided in the Phase 1 Test 1\2 Demand Folder).

Total Mode Share – Observed | **Total Mode Share - Modelled**

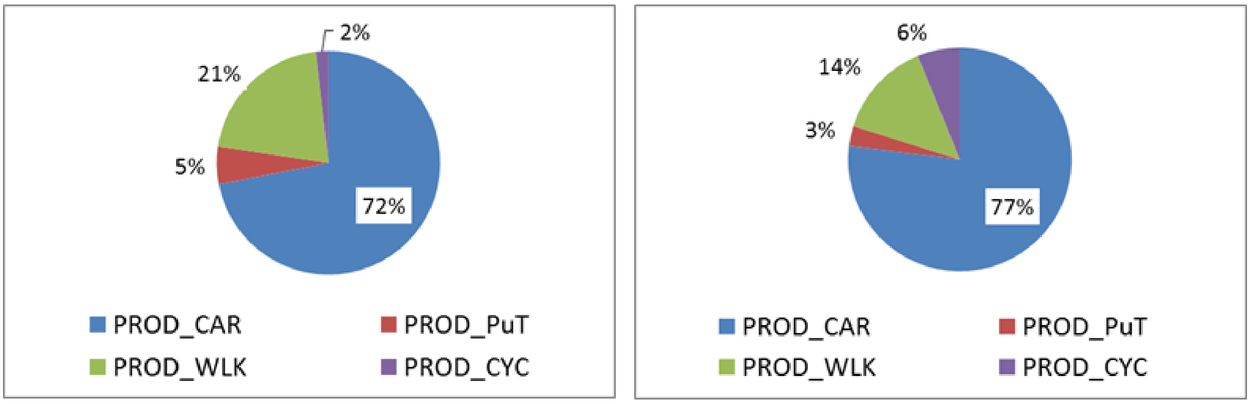


Figure 3.1 First calibration run total mode share

3.4 Phase 1 Test 2

3.4.1 Run details

Model Version: *2.0.0, Save 6 revised*[2]
Date: *11/12/16*

Following Test 1 it was felt that a good solution could not be achieved without improvements to the networks and assignment parameters, particularly the public transport assignment model.

The WRM PT network was checked to ensure full connectivity between zone centroids and coded public transport services. Improvements were made to the scripts used to generate connectors for the public transport model, and ensured that each zone could connect to the public transport model.

[2] Saves 2 to 5 fell between these two test runs. Additionally, as the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 6 strictly refers to the model at a point in its development slightly earlier than that used in this test.

3.4.2 Results / outputs

Following the above network improvements, three iterations of automatic calibration were run. This mainly provided an opportunity to check that the calibration application and data extraction processes were operating properly.

An evaluation of the mode share, intrazonal, and generalised costs for each demand segment was performed as part of this calibration run (full details of calibration results for all 33 model purposes are provided in the Phase 1 Test 2\1 Automatic Calibration folder).

Figure 3.2 below indicates that there was an improvement in the mode share calibration. Intrazonal proportions exhibited large variances to observed data, however, and were flagged for refinement in the next pass.

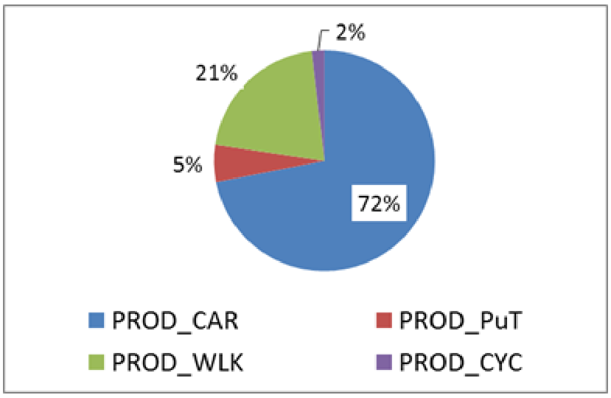
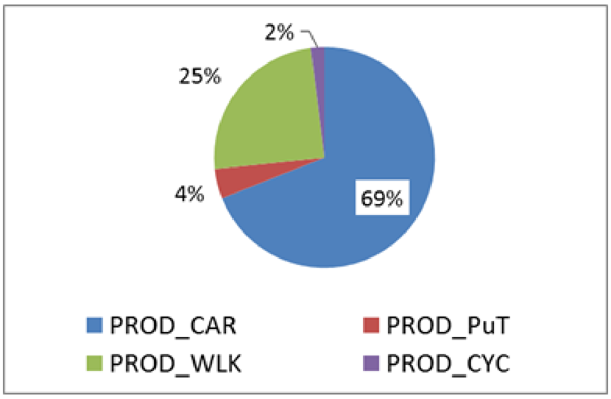
Total Mode Share – Observed	**Total Mode Share - Modelled**
	

Figure 3.2 Second calibration run total mode share

3.5 Phase 1 Test 3

3.5.1 Run details

Model Version: *2.0.0, Save 8 revised*[3]
Date: 11/01/16

Test 3 involved updating the add-ins, specifically the goods vehicle matrices for external trips from RMSIT, integrating road and PT network changes made as a result of investigations under Test 2, and updating the FDM version as well as incorporating the newly updated ASC, alpha and IZM parameters from Tests 1 & 2.

[3] Save 7 fell between these two tests. Additionally, as the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 8 strictly refers to the model at a point in its development slightly earlier than that used in this test.

3.5.2 Results / outputs

This model run was the first with both a reasonably stable model version and a full set of inputs, particularly those from RMSIT, and was the first for which outputs could be examined in detail.

As part of this examination, the demand dashboard was updated to include data from POWSCAR as it was more detailed than the NHTS data for commute and education. An issue with the processing of the NHTS data for time period proportions was identified and addressed, improving the calibration targets. Additionally, there were issues identified with unrealistically long walk trips within the observed data, especially for education trips, which were caused by students recording their college or university's main office rather than the campus that the students attended. As a result, long walk trips (in excess of 90 minutes), were removed from the observed data.

The calibration process was run again following correction of the above data issues. This revealed two issues with the modelling; first that the levels of demand were low generally and second that there appeared to be problems with the calculation of the intrazonal costs (for further information, the full demand dashboards are provided in the Phase 1 Test 3/2 Demand Folder).

Once conclusions from this test had been reached, the bus preloads were added into the road model and the road assignment was re-run to obtain updated costs.

3.6 Phase 1 Test 4

3.6.1 Run details

Model Version: *2.0.0, Save 10*[4]
Date: *27/01/16*

This run incorporated the new costs from Test 3 and included bus preloads in the road model inputs. In addition, there was a range of tests on the effects of capping the PT intrazonal costs at 30 minutes, 60 minutes, and uncapped costs. This was done by modifying the intrazonal costs and re-running the automatic calibration process through 10 loops.

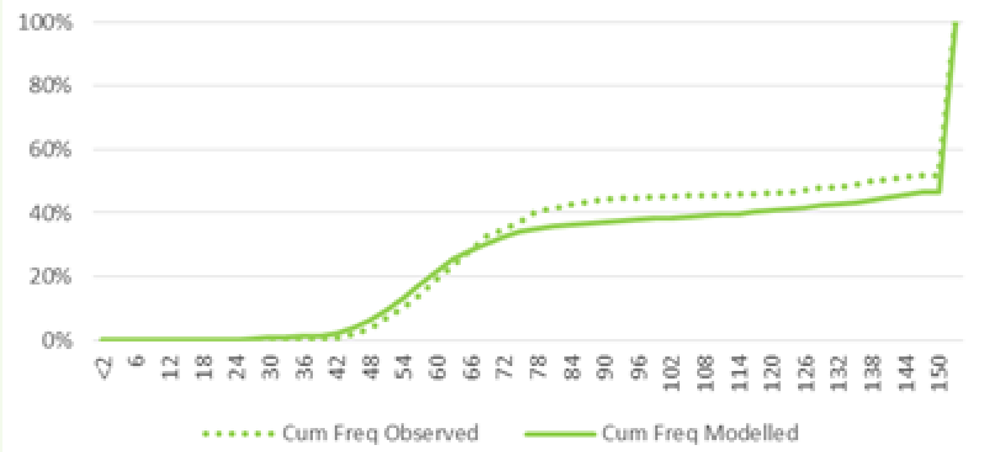
3.6.2 Results / outputs

Table 3.1 and Figure 3.3 below show the effects of capping intrazonal costs at the different levels. An unrestricted cost cap results in a match between the observed and modelled generalised cost distributions (Figure 3.3 - top). A 60 minute cap also results in a reasonable match (the observed cost distribution changes as the cost assigned to each observed trip is derived from the model) but a 30 minute cap on the intrazonal costs is too

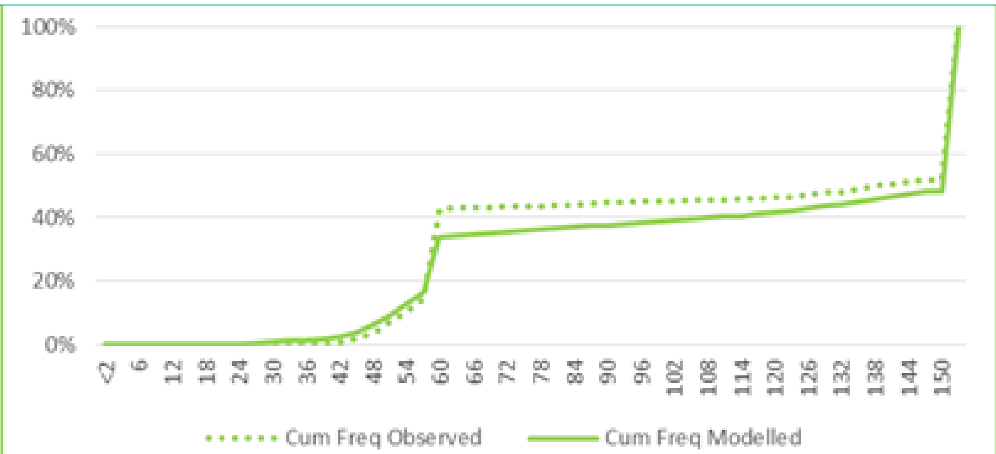
[4] Save 9 fell between these two tests.

restrictive, affects a large number of zones (Table 3.1) and results in a poor match (Figure 3.3 - bottom). The 60 minute cap was taken forward.

PT Gen Cost Curve – uncapped



PT Gen Cost Curve – 60 minute Cap



PT Gen Cost Curve – 30 minute Cap

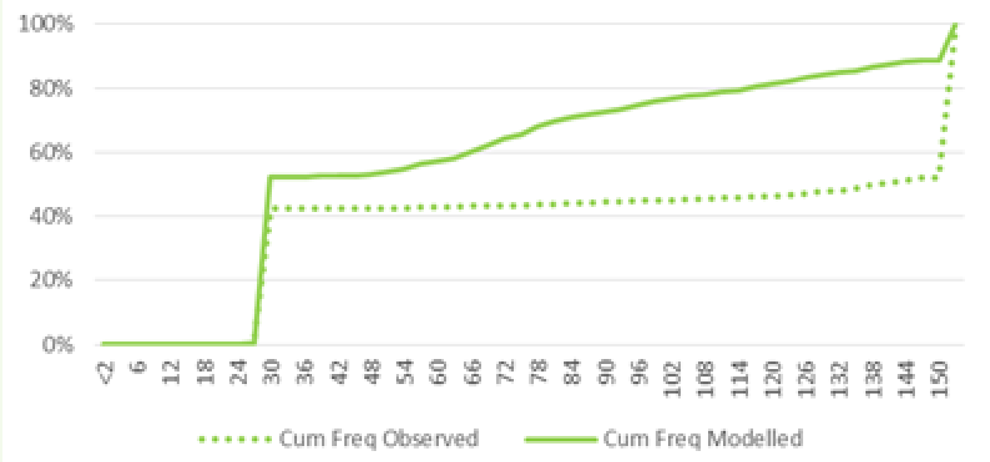


Figure 3.3 Cumulative generalised cost distributions (P05)

Table 3.1 Percentage of intrazonals affected by capping

Check	30 minute	60 minute	Uncapped
% of internal zones affected	77%	39%	n/a
% of all zones affected	77%	38%	n/a
Cap reduces cost by >10 minutes	69%	20%	n/a

3.7 Phase 1 Test 4b

3.7.1 Run details

Model Version: *2.0.1, Save 12*[5]

Date: *03/02/16*

In Test 4b the preferred cost cap was incorporated into the model and the costs were re-skimmed from the assignment models. Additionally, rail fare representation was changed from a fare matrix to a fare curve. Further automated calibration was carried out to improve the match to the generalised costs curves. The demand matrix output format was also changed at this stage.

3.7.2 Results / outputs

Improved calibration results were achieved within the limits of the data examination possible in the automatic calibration stage. The figure below outlines the total modelled mode share in comparison with the total observed mode share.

[5] Save 11 fell between these two tests.

Total Mode Share – Observed Vs Modelled

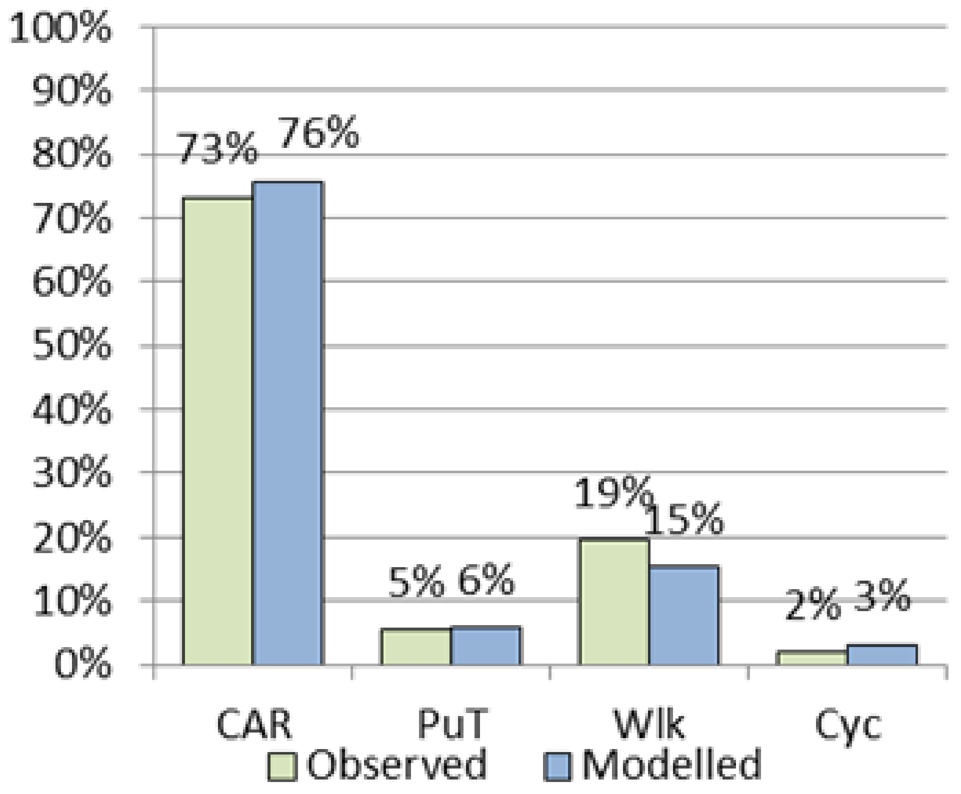


Figure 3.4 Test 4b Total mode share

Mode share results were improved, but the issue of overall low demand identified in Test 2 was still present (for detailed results see the Phase 1 Test 4\2 Demand and Phase 1 Test 4\3 Road folders).

3.8 Phase 1 Test 5

3.8.1 Run details

Model Version: *2.0.1, Save 12 revised*[6]
Date: *11/02/16*

Revised input trip ends were used in this test. These resulted from a change to the way in which the trip ends were created and increased the overall number of trip ends by 9%. Additionally, road and public transport networks were updated such that zone centroids were capped at 500m length in buffer areas and new costs were supplied.

[6] As the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 12 strictly refers to the model at a point in its development slightly earlier than that used in this test.

3.8.2 Results / outputs

Following these changes this test showed that there was an increase in demand, but initial checks on the road and public transport assignments showed there was still a significant difference between the modelled and observed flows. Figure 3.5 shows 24 hour PT flows and indicates that there are too few modelled trips overall (further information is provided in the Phase 1 Test 5\3 Road and Phase 1 Test 5\4 PT folders).

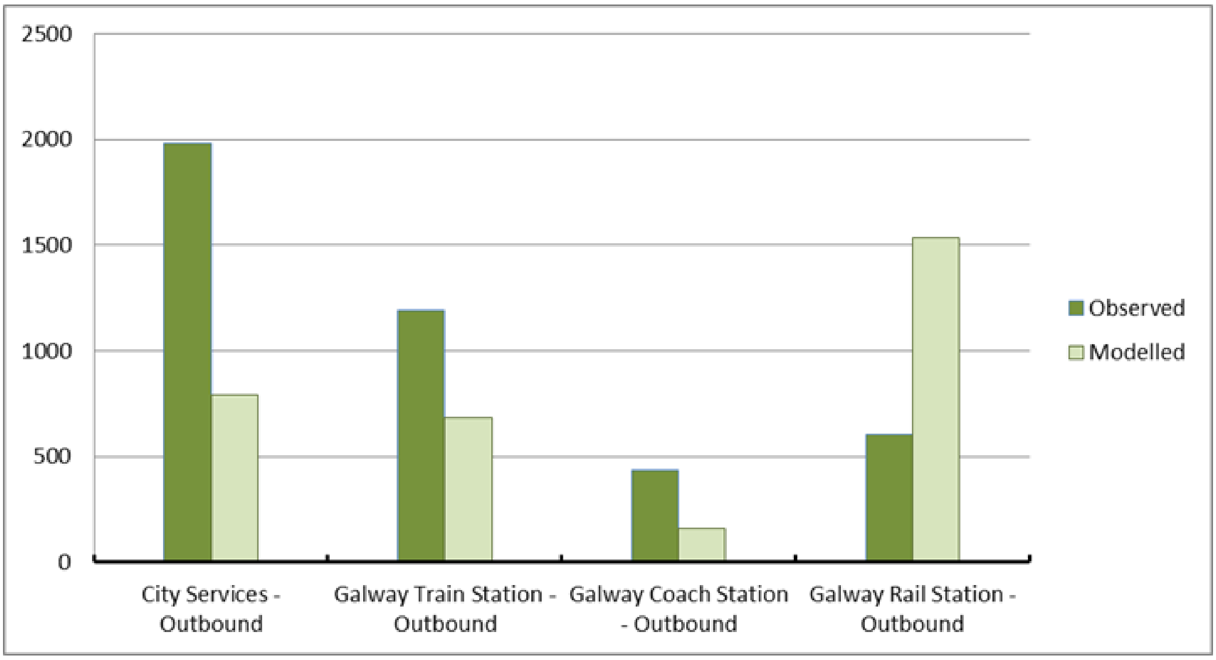


Figure 3.5 24-hour modelled versus observed PT flows – inbound[7]

3.9 Phase 1 Test 6

3.9.1 Run details

Model Version: *2.0.1, Save 12 revised*[8]
Date: *09/02/16*

In Test 6 an additional regional uplift of 34% was applied to the trip ends.

3.9.2 Results / outputs

This test provided the required uplift. For example, evaluating the total trips observed and modelled for Purpose 1.

- Prior to this uplift the observed to modelled ratio was 73,864 to 49,293; and
- Post the uplift the observed to modelled ratio was 73,864 to 65,921.

---

[7] Galway Train Station refers to bus services observed at Galway Rail Station

[8] As the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 12 strictly refers to the model at a point in its development slightly earlier than that used in this test.

This pattern was observed across the 33 purposes. Further, the mode share and generalised cost curves were better in terms of replicating the base year observed data (mode share and cost curves for all purposes are provided in the Phase 1 Test 6\01 Automatic Calibration folder).

3.10 Phase 1 Test 7

3.10.1 Run details

Model Version: *2.0.1, Save 12 revised*[9]
Date: *22/02/16*

In Test 7 there were some adjustments to the tour proportions based on the outputs of Test 6.

3.10.2 Results / outputs

Examples are shown in Table 3.2, Table 3.3 and Table 3.4 which compare the observed NHTS data to the modelled data before and after the correction. The match improves in some places (green figures), worsens in others (red figures) and is unchanged elsewhere. However, the largest change is for the morning peak and, following the adjustment, no figure is more than 2% out. These results can be examined in more detail in the demand dashboards.

Table 3.2 Mode shares in NHTS Observed Data

	Car	PT	Walk	Cycle	TOT
AM	19%	2%	4%	0%	**26%**
LT	12%	1%	4%	0%	**17%**
SR	15%	1%	5%	0%	**21%**
PM	17%	1%	4%	1%	**22%**
OP	10%	0%	2%	0%	**13%**
TOT	**73%**	**5%**	**20%**	**2%**	**100%**

Table 3.3 Modelled mode shares before tour proportion adjustment

	CAR	PT	Walk	Cycle	TOT
AM	22%	3%	5%	1%	**31%**
LT	12%	0%	3%	1%	**15%**
SR	16%	2%	3%	1%	**21%**
PM	16%	1%	3%	1%	**21%**
OP	10%	0%	1%	0%	**12%**
TOT	**76%**	**6%**	**15%**	**3%**	**100%**

[9] As the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 12 strictly refers to the model at a point in its development slightly earlier than that used in this test.

Table 3.4 Modelled mode shares after tour proportion adjustment

	CAR	PT	Walk	Cycle	TOT
AM	21%	3%	4%	1%	**28%**
LT	13%	0%	3%	0%	**16%**
SR	18%	2%	3%	1%	**23%**
PM	18%	1%	3%	1%	**22%**
OP	9%	0%	1%	0%	**11%**
TOT	**78%**	**6%**	**13%**	**3%**	**100%**

Matrix estimation and PT factoring was carried out following this test.

3.11 Phase 1 Test 8

3.11.1 Run details

Model Version: *2.0.1, Save 12 revised*[10]

Date: *26/02/16*

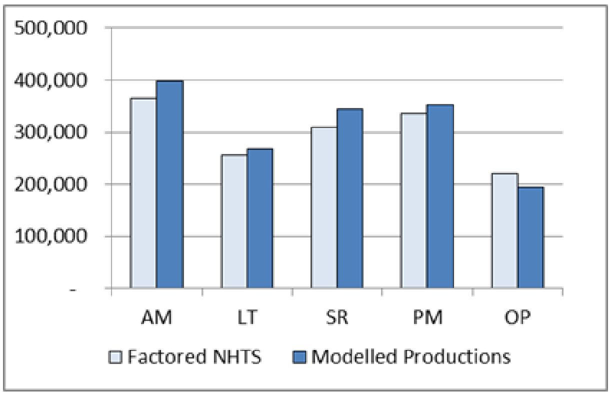
Test 8 was the final model run in Phase 1 and involved adding an updated road network to Test 7, as well as updating the input costs. Further to these changes, the ASC and alpha parameters were also refined as part of the automatic/ manual calibration process.

3.11.2 Results / outputs

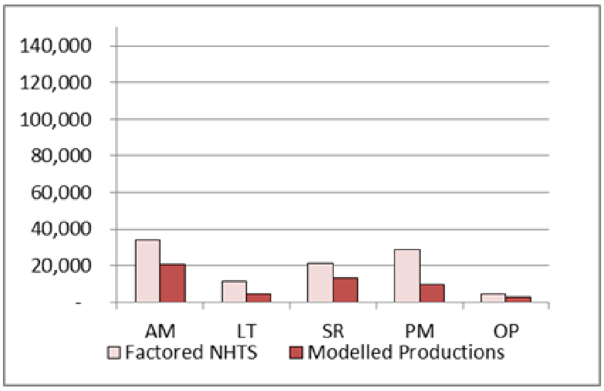
This test provided a closer calibration of the modelled values and parameters to the observed data, both in terms of the number of trips generated and their distribution.

The figures below show the total trips generated by mode and time period and the overall mode split achieved at the end of the Phase 1 calibration process.

Car Trips



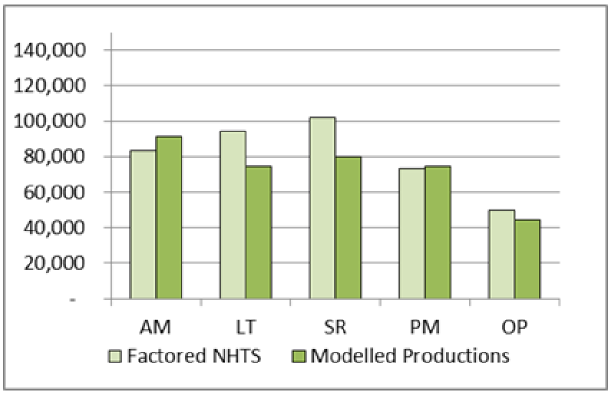
PT Trips



Walk Trips

Cycle Trips

[10] As the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 12 strictly refers to the model at a point in its development slightly earlier than that used in this test.



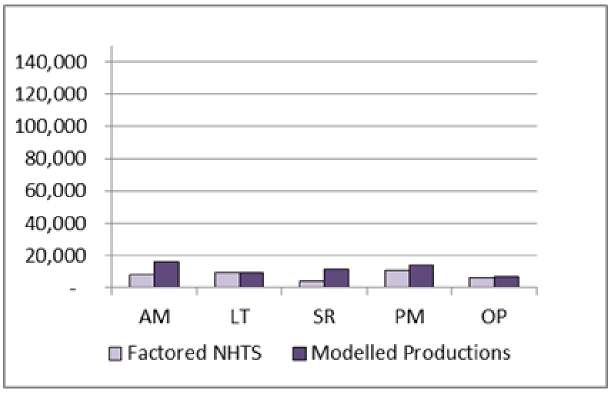


Figure 3.6 Total trips by time period and mode

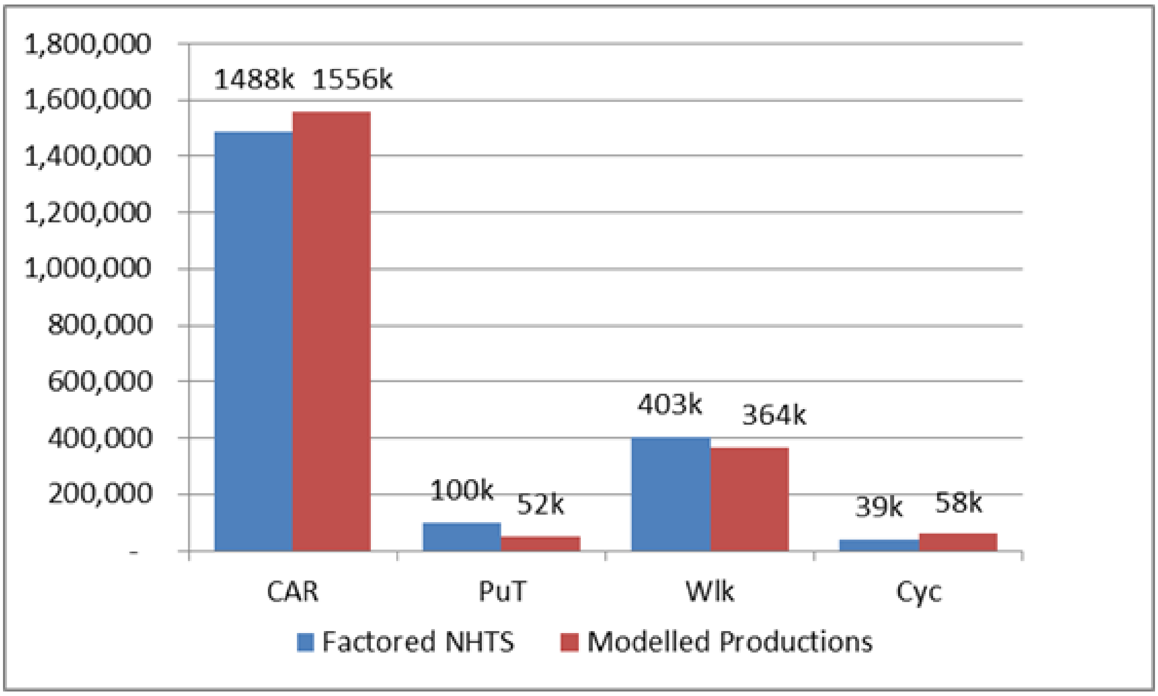


Figure 3.7 Total mode share (24hr)

Road flow calibration / validation (ratio of total flow to flow passing WebTag criteria) was at:

- AM 94% / 79%;
- IP1 94% / 88%;
- IP2 91% / 83%; and
- PM 92% / 83%.

Full demand, road and PT dashboards are provided in the following folders in the accompanying electronic information package:

- Phase 1 Test 8\2 Demand;
- Phase 1 Test 8\3 Road; and
- Phase 1 Test 8\4 PT

3.12 Post Phase 1 Calibration and Validation Process Review

At this stage, there was a review of the calibration and validation of the WRM and the other regional models and a decision was made to revise some elements of the calibration process. The factoring of trip ends and tour proportions was excluded from calibration in the absence of a sound theoretical basis for these adjustments. Some of the modifications to trip ends made during Phase 1 were considered justified and these were incorporated into NTEM. A new demand forecast, A9, was produced and used in subsequent tests.

From Phase 2 onwards the process of calibration / validation only included adjustments to mode split lambda, ASC, and period to hour factors.

The model was handed over to the core RMS development team who debugged some processes, resulting in a new version of the model. As a result, it was necessary to restart the calibration process (termed Phase 2).

3.13 Phase 2 Test 1 & 2

3.13.1 Run details

Model Version: *2.0.1, Save 12 revised*[11]
Date: *26/02/16*

Tests 1 & 2 were very simple runs to establish a new baseline following the change of team. Up to date trip ends and other inputs were included but there were no other modifications. The tour proportions were reset to the original values.

3.13.2 Results / outputs

Only basic matrix totals were checked at this stage to ensure that the demand model had run through without error.

3.14 Phase 2 Test 3-7

3.14.1 Run details

Model Version: *2.0.1, Save 12 revised*[12]
Date: *08/03/16*

---

[11] As the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 12 strictly refers to the model at a point in its development slightly earlier than that used in this test.

[12] As the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 12 strictly refers to the model at a point in its development slightly earlier than that used in this test.

Tests 3 to 7 were progressive adjustments to car period to hour factors used to get a feel for relationship between the input and the response. The starting and ending factors, as well as the changes, are shown in Table 3.5.

Table 3.5 Changes in period to hour factors for cars from Phase 2 Tests 3-7

Mode / time period	Starting factor	Ending factor	Change
Car AM	0.42	0.44	+0.02
Car IP1	0.33	0.43	+0.10
Car IP2	0.33	0.51	+0.18
Car PM	0.36	0.49	+0.13
Car OP	0.08	0.08	0.00

3.14.2 Results / outputs

Because these were preliminary tests only matrix totals and road flows were examined in detail. Following Test 3 the road calibration / validation (on percentage difference) was:

- AM 66% / 21%;
- IP1 61% / 25%;
- IP2 48% / 25%; and
- PM 53% / 25% (see the Phase 2 Test 3\3 Road folder for more details).

Following Test 7 this had improved to:

- AM 67% / 21%;
- IP1 55% / 21%;
- IP2 58% / 21 %; and
- PM 59% / 25% (see the Phase 2 Test 7\3 Road folder for more details).

This was an improvement, particularly in the poorly matched IP2 and PM time periods and it also gave a better overall match to the total flows. Following Test 7 matrix estimation was carried out, but the results were not considered suitable for the extraction of new costs.

3.15 Phase 2 Test 8

3.15.1 Run details

Model Version: *2.0.4, Save 14*[13]
Date: *09/03/16*

Phase 2 Test 8 used the latest model version, which included:

- Corrected cluster structure at the Add-in stage;
- Improved factoring of attraction trip ends in production free zones;

[13] Save 13 was not used.

- Revised PT cost capping

3.15.2 Results / outputs

Matrix estimation was carried out at this stage and pre and post ME road dashboards were prepared. However, the costs were not considered an improvement on those available previously and were not carried forward to Test 9. PT flows were also examined and an example of the fit across the IP1 screenline is shown in Figure 3.8 (for more information see the Phase 2 Test 8\4 PT folder).

The overall road calibration / validation (on percentage difference) was:

- AM 67% / 21% (before ME) improving to 85% / 92% (after ME);
- IP1 58% / 21% (before ME) improving to 88% / 83% (after ME);
- IP2 62% / 21 % (before ME) improving to 85% /83 % (after ME); and
- PM 60% / 25% (before ME) improving to 86 % / 92% (after ME) (see the Phase 2 Test 8\3 Road folder for more details).

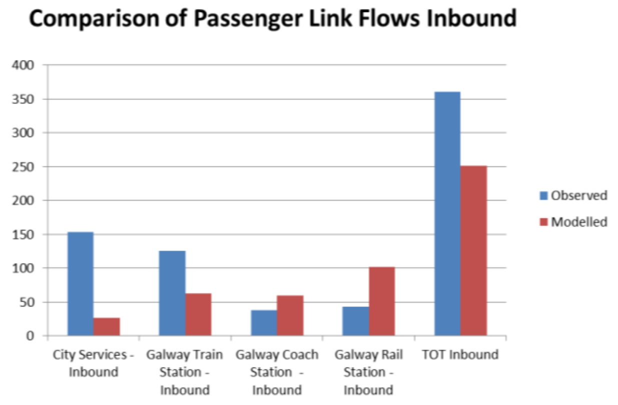
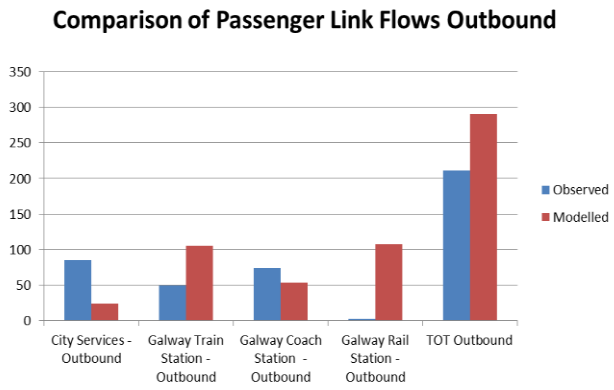
IP1 inbound	IP1 outbound
	

Figure 3.8 Phase 2 Test 8 PT flow calibration levels

3.16 Phase 2 Tests 9 & 10

3.16.1 Run details

Model Version: *2.0.2, Save 14*
Date: *10/03/16*

Test 9 involved adjustments to ASC values as shown in Table 3.6. Test 10 incorporated a newly estimated internal goods matrix and updated costs.

Table 3.6 Changes in ASC values in Test 10 vs Test 8

Trip purpose	Change in car ASC value	Change in PuT ASC value	Change in PnR ASC value	Change in walk ASC value	Change in cycle ASC value
P01-P29	0	+5	0	0	0
P30-P33	-3	+6	0	-3	-3

3.16.2 Results / outputs

Only PT flows were checked at the end of Test 9 (for details see the Phase 2 Test 9\4 PT folder). They were not much improved on previous passes but due to an issue with the PT crowding which was identified at this stage it was considered likely that the new costs would help. Following Test 10 road and PT dashboards were prepared. The PT screenlines were better, within about 30% in all cases but the proportion of trips using rail rather than bus was still high (for details see the Phase 2 Test 10\4 PT folder).

Road calibration (on percentage difference) stood at:

- AM 68% / 83%;
- IP1 59% / 83%;
- IP2 57% / 83 %; and
- PM 61% / 92% (see the Phase 2 Test 10\3 Road folder for more details).

3.17 Phase 2 Test 11

3.17.1 Run details

Model Version: *2.0.2, Save 14 revised*[14]
Date: *24/03/16*

For Test 11 free workplace parking and parking distribution were activated, and updated costs were taken from the preferred road and PT assignments (Test 10). There were a number of subtests using dummy inputs intended to check that these two modules functioned as they were supposed to.

3.17.2 Results / outputs

Visual comparisons of the outputs were made but no formal results were extracted. This was because revised parking data became available and a revised test was run including this. The outcome of this test was confirmation of the correct functioning of the parking processes.

3.18 Phase 2 Test 12

3.18.1 Run details

Model Version: *2.0.2, Save 14 revised*[15]
Date: *24/03/16*

Test 12 used estimated parking data inputs (rather than dummy values) and ran the model through in full.

[14] As the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 14 strictly refers to the model at a point in its development slightly earlier than that used in this test.

[15] As the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 14 strictly refers to the model at a point in its development slightly earlier than that used in this test.

3.18.2 Results / outputs

Only PT and road flow results were extracted at this stage. PT flows worsened, with screenline differences increasing to 50% in some places (for more information see the Phase 2 Test 12\4 PT folder). Road calibration, (on percentage difference), however, remained good at:

- AM 70% / 83%;
- IP1 59% / 83%;
- IP2 57% / 83 %; and
- PM 61% / 92% (see the Phase 2 Test 12\3 Road folder for more details).

Matrix estimation and PT factoring were undertaken following this test.

3.19 Post Phase 2 Test 12 (Parking Distribution review)

As a result of the preliminary work which took place to create the base parking data it became clear that there was a problem with the implementation of the parking distribution module. This was verified by a separate team using the WRM to test strategy options.

However, because the number of parking spaces was greater than total car demand, there was no impact on model results and testing could continue in the existing version, pending the release of a new implementation of the Parking Distribution module.

3.20 Phase 2 Test 14

3.20.1 Run details

Model Version: *2.0.2, Save 14 revised*[16]
Date: *24/03/16*

Test 14 used updated internal goods inputs, incrementals and taxi proportions based on the estimated / factored matrices produced following Test 12.

---

[16] As the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 14 strictly refers to the model at a point in its development slightly earlier than that used in this test.

3.20.2 Results / outputs

Although this was a run including incrementals, full pre and post dashboards were not produced. Flows were checked though and road calibration, (on percentage difference), improved to:

- AM 83% / 88%;
- IP1 86% / 96%;
- IP2 83% / 92 %; and
- PM 80% / 88% (see the Phase 2 Test 14\3 Road folder for more details).

PT flow calibration also improved, with screenline flows generally falling within 30% of observed values (for more information see the Phase 2 Test 14\4 PT folder). This was worse than was expected based on the outputs of the PT factoring and our investigations showed that the PT factoring had been run without crowding. This should not have caused any problems in the uncrowded WRM PT network, but it emerged that the issue was compounded due to the crowding not being modelled correctly, which caused delays to appear where none were expected, and this needed to be addressed.

3.21 Phase 2 Test 15_Pre & Test 15_Post

3.21.1 Run details

Model Version: *2.0.2, Save 14 revised*[17]
Date: *31/03/16*

A revised PT network was supplied by the PT development team. The incremental values previously added in Test 14 were removed (hence the outputs of this are termed 'Pre' test took place, e.g. before matrix estimation / factoring). The 'Post' test included the resulting new incrementals, taxi proportions and internal goods matrices. This 'Post' test produced outputs which mimicked the matrix estimated / factored solutions.

3.21.2 Results / outputs

Full road dashboards were created and indicated that the overall road calibration / validation (on percentage difference) was:

- AM 70% / 88% (before ME) improving to 84% / 88% (after ME);
- IP1 65% / 83% (before ME) improving to 90% / 96% (after ME);
- IP2 62% / 92 % (before ME) improving to 87% /92 % (after ME); and
- PM 63% / 92% (before ME) improving to 82 % / 88% (after ME) (see the Phase 2 Test 15 \3 Road folder for more details).

---

[17] Version 2.0.3 which had a corrected parking distribution module was available by this date. However, the model was not ported into the new version for this test because:
- Testing of the new version was ongoing
- The parking distribution input for this run was set such that it did nothing
- The primary objective of this test was to confirm that the revised PT network functioned correctly

Journey time calibrations were also reasonable with 56% to 84% of routes passing the defined criteria, depending on the peak in question.

Before PT factoring, some screenlines were as much as 59% out. After factoring this was improved to 37% (for more information see the Phase 2 Test 15\4 PT folder).

3.22 Phase 2 Test 17_Pre[18]

3.22.1 Run details

Model Version: *2.0.6*
Date: *20/04/16*

Test 17_Pre applied further ASC adjustments with an additional 5 added to all of the PT values in an attempt to reduce the excess PT flows being generated by the model. Additionally, the parking distribution and free workplace parking capacities were adjusted and parking charges were updated so that the model would continue to assign all COM and EDU trips to free spaces and there would only be minimal redistribution of the trips using other parking. Updated costs based on the outputs from Test 15_Post were also added.

3.22.2 Results / outputs

Road and PT flows were checked for Test 17_Pre. Road calibration, (on percentage difference), improved slightly to:

- AM 72% / 88%;
- IP1 68% / 83%;
- IP2 63% / 75 %; and
- PM 64% / 79% (see the Phase 2 Test 14\3 Road folder for more details).

PT screenline matches improved in most locations though they did worsen in others (for more information see the Phase 2 Test 17_Pre\4 PT folder). The outputs from Test 17_Pre were matrix estimated / factored, but only for the purposes of providing updated costs.

3.23 Phase 2 Test 18_Pre & Test 18_Post

3.23.1 Run details

Model Version: *2.0.6*
Date: *27/04/16*

[18] Test 16 was used for FDM development tests and did not form part of the WRM Calibration / Validation process

Test 18_Pre took the updated costs from the matrix estimated / factored matrices produced from Test 17_Pre and included updated internal goods matrices. In addition, PT ASC values were adjusted by an additional 5 for P01 to P29 and an additional 3 for the one way purposes, P30 to P33. Matrix estimation / factoring was carried out on the outputs from the 'Pre' test. Test 18_Post was the same as Test 18_Pre but with incrementals and taxi proportions calculated and included.

3.23.2 Results / outputs

Road calibration, (on percentage difference), was good at:

- AM 68% / 88% (before ME) improving to 83% / 88% (after ME);
- IP1 69% / 83% (before ME) improving to 91% / 92% (after ME);
- IP2 60% / 67 % (before ME) improving to 88% /88% (after ME); and
- PM 64% / 79% (before ME) improving to 87% / 92% (after ME) (see the Phase 2 Test 18 \3 Road\1 Pre and Phase 2 Test 18 \3 Road\2 Post folders for more details).

PT screenline matches tended to improve with a maximum difference in the 'Pre' of 46%. In the 'Post' there was a maximum difference of around 20% in all time periods except the IP1 which still tended to be more mismatched (for more information see the Phase 2 Test 18\4 PT folder\1 Pre and Phase 2 Test 18\4 PT folder\2 Post folders).

3.24 Phase 2 Test 19_Pre & Test 19_Post

3.24.1 Run details

Model Version: *2.0.6*

Date: *08/05/16*

This run took the updated costs and internal goods matrices from the result of the matrix estimation / factoring of Test 18_Pre. In addition, the IP1 and PM PT period to hour factors were increased slightly to address output flow shortfalls in these peaks. Matrix estimation / factoring was carried out on the outputs from the 'Pre' test, and Test 19_Post was the same as Test 19_Pre but with incrementals and taxi proportions calculated and included.

3.24.2 Results / outputs

Road calibration, (on percentage difference), was similar to in previous runs and good at:

- AM 69% / 88% (before ME) improving to 84% / 88% (after ME);
- IP1 68% / 83% (before ME) improving to 91% / 92% (after ME);
- IP2 61% / 67 % (before ME) improving to 88% /88% (after ME); and
- PM 62% / 79% (before ME) improving to 86% / 92% (after ME) (see the Phase 2 Test 19\3 Road\1 Pre and Phase 2 Test 19\3 Road\2 Post folders for more details).

PT calibrations were similar with a maximum mismatch, in IP1, of 46% before factoring and 44% after (for more information see the Phase 2 Test 19\4 PT folder\1 Pre and Phase 2 Test 19\4 PT folder\2 Post folders).

3.25 Post Phase 2 Calibration and Validation Process Review

At this stage the model was handed back to the original WRM team who continued with the calibration process, with a particular view to improving the calibration of PT flows.

3.26 Phase 3 Test 1

3.26.1 Run details

Model Version: *2.0.8b*
Date: *07/06/16*

In this test:

- Parking distribution was turned on;
- Free Workplace Parking (FWPP) was turned on; and
- Parking Constraint turned off.

The model version V2.0.8 included minor upgrades in the parking distribution module and the reimplementation of the parking constraint module. Further information on development of model V2.0.8 is provided in the MSF Demand Model Development Report.

At this stage, the WRM was the first model to implement the Parking Distribution module. Several iterations of the demand model were required in order to calibrate the FWPP and the Parking Distribution module.

Free Workplace Parking

In the absence of data detailing the number of car spaces by zone, FWPP capacities were first set to 10% above the base commute and education car demand.

In this case, all commute and education trips were automatically given a workplace parking space with no associated parking charge. In addition to this, due to the lack of detailed information on the availability and charge associated with paid parking in the model area (on-street/off-street), it was agreed to set the parking charge in the entire model to zero for calibration.

Parking constraint

The parking constraint module intends to restrict the number of car destinations in certain areas such a city centres. However, the lack of accurate data about the actual number of car spaces in Galway city centre makes it difficult to model. Also, it was assumed that the limitation of car spaces is not as crucial as other parameters such as travel time/cost in terms of mode and destination choice in Galway. Therefore, the Parking Constraint module was not turned on in this iteration of the model.

Parking distribution

The parking distribution module (PDist) facilitates the redistribution of trips to nearby zones when the level of demand entering their intended zone reaches the capacity of available parking spaces, or where there are cheaper parking alternatives in nearby zones. It is intended to replicate the fact that there are limited parking spaces available within the city centre, and that people often have to park away from their intended destination in order to find an available space. Further information on parking distribution is provided in the RMS Full Demand Model (FDM) Specification Report.

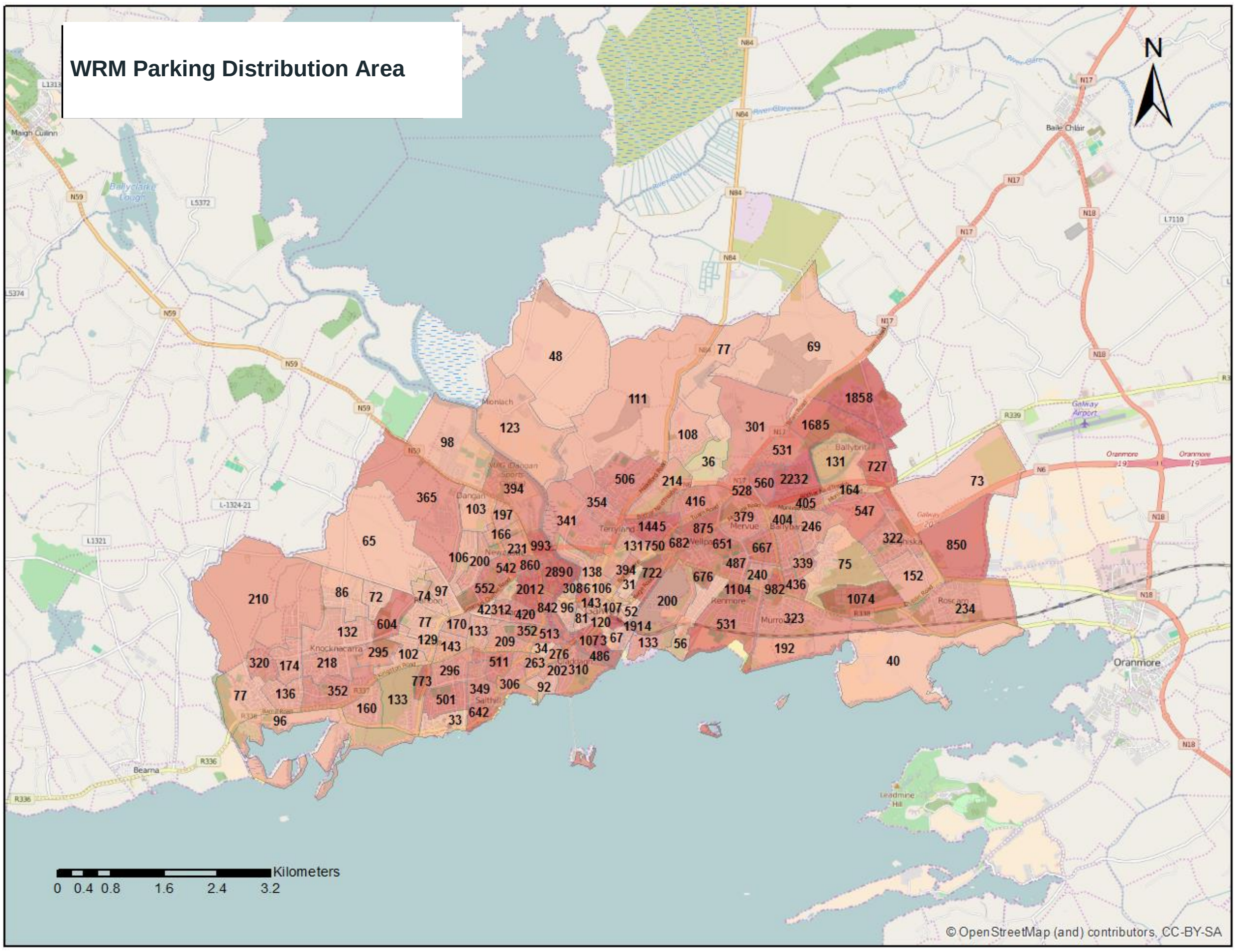


Figure 3.9 WRM Parking Distribution area and capacities[19]

Parking distribution in Galway city was defined using a similar methodology to the other regional models. With no information in terms of the number of car spaces actually

---

[19] OpenStreetMap data is available under the Open Database Licence www.openstreetmap.org/copyright or www.opendatacommons.org/licenses/odbl

available, it was decided to set the capacity of all zones within the parking distribution area to 90% of the car demand in the base year. The red shaded zones in Figure 3.9 were set as the PDist area. This included 141 zones and covered most of the built-up area in the city. Seventeen city centre zones were identified as having paid on-street parking and a parking charge was coded, based on the values used for MWRM. The purpose of this is to deter car trips from distributing into those specific zones.

A few iterations of the demand model were needed in order to calibrate the base year capacities and search times for every zone.

At this stage, the additional costs incurred in the Parking Distribution module were not being fed back to the demand model. This was to be included in future versions of the model.

Another impact of turning on the Parking Distribution is the addition of extra costs for the walk leg between the redistributed destination (car park) and the final destination. These walk trips are assigned as part of the active modes assignment matrix. The analysis of all travel matrices and assignment matrices for trip length or mode share purposes should take this feature into account, as the walk legs of car trips should not be analysed as if they are walk trips

3.26.2 Results / outputs

The inclusion of the Parking Distribution module resulted in 146,826 car trips being redistributed in Galway City centre over 24 hours which represented about 10% of total car demand. Given the progressive increase of search time as demand approaches capacity, trips will start to be redistributed to other zones even before capacity is reached.

No dashboards were created before the next run as the special zones demand still had not been added in and the FWPP capacities would need to be changed.

3.27 Phase 3 Test 2

3.27.1 Run details

Model Version: *2.0.8b*
Date: *10/06/16*

In this test, special zones (ports and airports) were added for the WRM. This included the Galway Harbour HGV demand, and the air passenger demand at Knock airport. For this version of the model, the mode share for passengers going from/to the airport is fixed and will not evolve in the future. An additional functionality enabling a mode choice for such trips is to be implemented in future versions of the model (see the MSF Demand Model Development Report for further information).

Galway airport closed in 2011 for commercial flights and only opened temporarily in 2015. The base scenario for all the Regional Models is representing the year 2012, therefore Galway airport will not be represented by a special zone. However, Knock Airport, the 4th largest airport in Ireland in terms of passengers (approximately 700,000/year) is located in the WRM area, and therefore, has its own special zone.

The special zone demand for Knock Airport and Galway Harbour was estimated based on a methodology developed for the MWRM. Further information on this methodology is provided in Annex 2 of this report and in the MWRM Development Report and Specification Note: Airports and Special Zones.

The road and PT networks were amended in order to ensure correct connectivity for those special zones.

For this test, it was agreed to set the FWPP capacities to 9,999 so that all commute and education trips could choose free workplace parking and were not subject to further mode choice.

In parallel, adjustments were made to the input road traffic signal files in order to improve journey time validation on certain routes.

3.27.2 Results / outputs

Road calibration, (on percentage difference), was similar to in previous runs and good at:

- AM 65% / 88% (before ME) improving to 83% / 88% (after ME);
- IP1 67% / 83% (before ME) improving to 92% / 92% (after ME);
- IP2 64% / 63 % (before ME) improving to 87% /88% (after ME); and
- PM 63% / 79% (before ME) improving to 85% / 92% (after ME).

The number of redistributed trips remained equal to the previous run.

On the PT side, the percentage of links within 25% of observed flows for Rail and Bus are:

- AM 50% / 17% (before PT factoring) improving to 100% / 50% (after PT factoring);
- LT 0% / 33% (before PT factoring) improving to 50% / 67% (after PT factoring);
- SR 0% / 50% (before PT factoring) improving to 50% / 67% (after PT factoring); and
- PM 50% / 33% (before PT factoring) improving to 50% / 83% (after PT factoring).

The change of FWPP capacities up to extreme values highlighted an inconsistency in the way the capacities were being processed in the model. An alteration in scripts was required which led to version 2.0.8d being used for the next set of tests.

The level of demand in the special zones is small (61 trips in the AM to Knock Airport, 52 HGV movements to Galway Harbour) and had no impact on the overall level of model calibration.

The analysis of Matrix Estimation showed that the R-square values outside the AM time period could possibly be improved. It was decided to carry out another iteration of Matrix Estimation and PT factoring. Further information on road and PT results are provided in the Phase 3 Test 2\3 Road and Phase 3 Test 2\4 PT folders.

Table 3.7 Matrix estimation analysis

ME R^2	AM	LT	SR	PM
Taxi	0.97	0.94	0.98	0.98
Emp. Bus.	0.93	0.90	0.90	0.90
Commute	0.96	0.92	0.93	0.93
Education	0.97	0.84	0.95	0.95
Car Other	0.99	0.98	0.98	0.98

3.28 Phase 3 Test 3

3.28.1 Run details

Model Version: *2.0.8d*

Date: *17/06/16*

The FWPP module included a minor update mentioned above (phase 3 Test 2), and input FWPP capacities were set to zero. In this case, no commute or education trips are automatically given a free workplace parking space, and as a result, these trips will be considered equally to other purposes in terms of parking charge.

Parking distribution capacities and search times were updated to match a level of 90% occupancy for all distributed zones, and to run a single PDist loop.

3.28.2 Results / outputs

The FWPP had no impact on results as having a 0 capacity for all zones is equal to not having the FWPP module turned on. Costs from this run were passed to the next phase of calibration.

Further information on road and PT results are provided in the Phase 3 Test 3\3 Road and Phase 3 Test 3\4 PT folders.

3.29 Phase 3 Test 4

3.29.1 Run details

Model Version: *2.0.8d*
Date: *20/06/16*

This run took the updated costs and internal goods matrices from the result of the matrix estimation and PT factoring undertaken for Phase 3 Test 3.

3.29.2 Results / outputs

The outcome of this run was seen as satisfactory. This run was therefore the last one to be undertaken at this stage.

3.30 Version upgrade and looping to convergence

3.30.1 Model version

Testing in the WRM continued on an older model version as the newer model versions included the Park & Ride functionality and this required separate calibration. However, once testing of the finalised model version (2.0.23) had been completed using the ERM, the remaining regions were upgraded to that version and recalibrated. In the WRM this process was undertaken in early February, 2017.

3.30.2 Inputs

Aside from the addition of the Park & Ride inputs there were no other changes to the model inputs made at this stage aside from the adjustments made to the parameters for the purposes of calibrating the model which are described below.

3.30.3 Recalibration

The first step in the recalibration process was to compare the modelled mode shares to observed data, segmented by user class and time period, in order to see how much recalibration was required. Following this, the ASC values for the 33 journey purposes were modified to adjust the relative cost of each mode so give a better match to the observed data. This was an iterative process which took seven passes to reach an acceptable level of calibration for the mode shares. An 8-loop full model run was done each time adjustments were made to the ASCs.

The results of the recalibration are shown in charts below. Using the same ASCs in v2.0.23 as in v2.0.8 generates fewer car trips and more walk and cycle trips than observed (see chart on the left-hand side). Post-calibration modelled mode shares (chart on the right-hand side) are close to observed data.

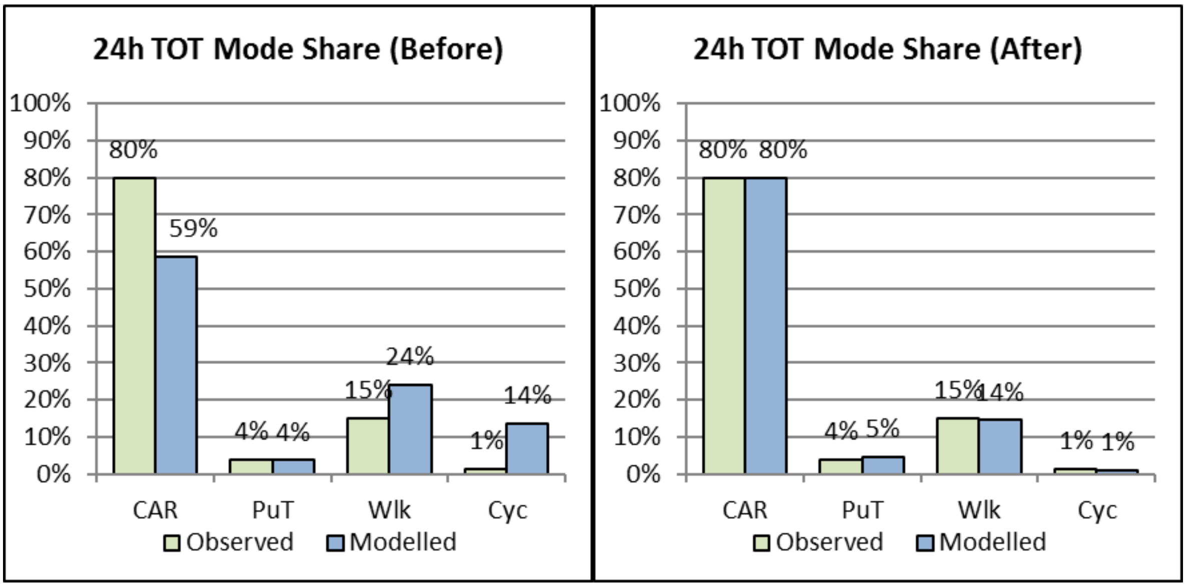


Figure 3.10 24h Total Mode Share before (left) and after (right) recalibration

Following this step, both the road and PT models were recalibrated, using same process as for v2.0.8. A new set of incremental matrices was generated and applied.

3.30.4 Park and Ride calibration

The Park and Ride mode share is calibrated as part of the main model calibration process. For more information on the development of the Park and Ride model and the site selection calibration process, please see Annex 4.

4 Final calibration / validation results

4.1 Introduction

The finalised parameters used in the demand model are given in Annex 3 and this chapter gives details of the final calibration and validation, across a whole range of model outputs, including the direct demand model indicators (modal split, generalised cost and trip length distributions, intrazonal trip numbers, and time period distributions). It then considers less direct indicators such as the change in the matrices required to match flows on the ground and the size of the incremental matrices needed to correct the directly output demand matrices to their equivalent estimated / factored partners, as well as the output road and PT movements.

Active modes have not been considered in detail due to a lack of data but information on the development of the WRM Active Modes model can be found in the Active Modes Model Development Report.

4.2 Full results in electronic format

This chapter gives a detailed summary of the contents of the final demand, road and PT dashboards. However, where more information is desired the full dashboards are contained in the following folders in the accompanying electronic information package:

- Demand: Final\2 Demand;
- Road: Final\3 Road; and
- PT: Final\4 PT.

4.3 Demand calibration

4.3.1 Modal Split

Figure 4.1 shows the observed and modelled mode shares for the full 24 hour period for the five user classes and for all trips combined. Overall, the match is good although the car and PT mode shares are slightly low, while the walk and cycle mode shares are slightly high. In the EMP, OTH and RET (CON) groups the match is excellent but the COM and EDU groups tend to have too little car and too many walking trips.

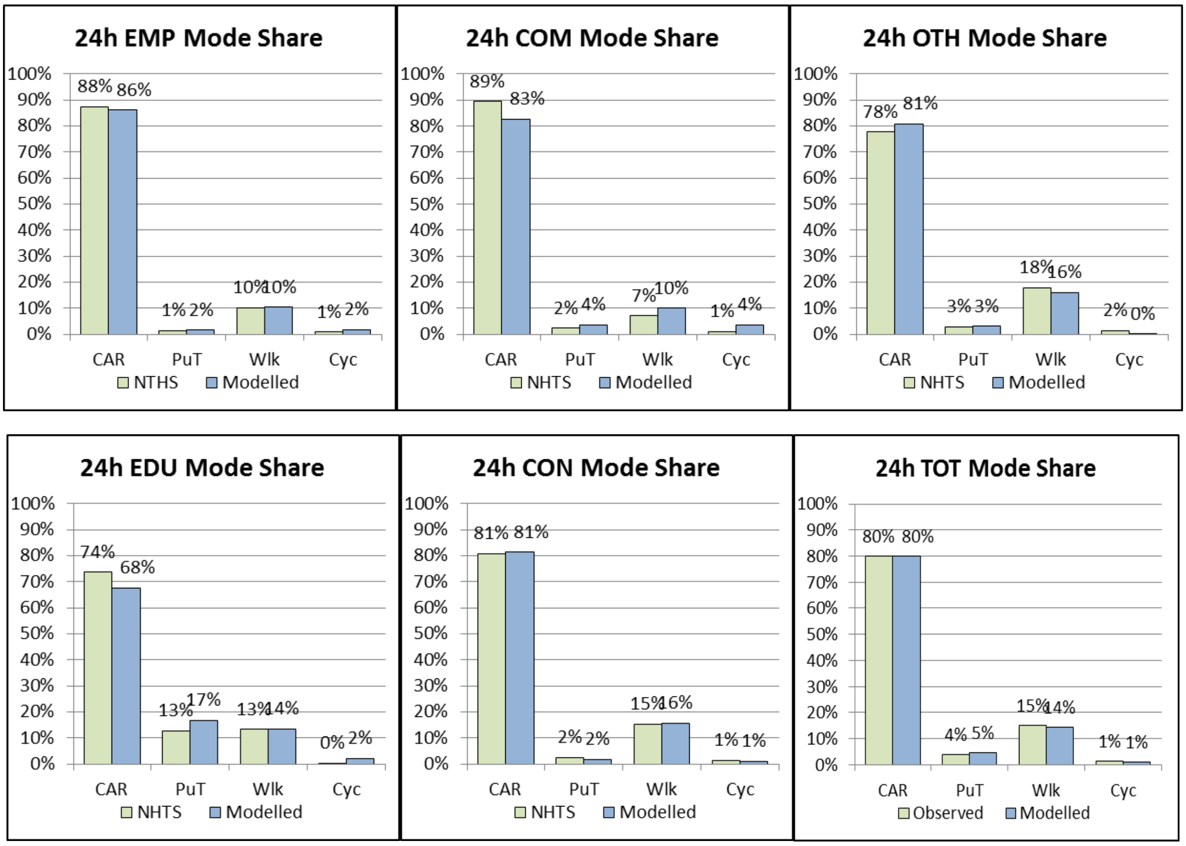


Figure 4.1 Total Mode Share (24hr)

4.3.2 Generalised cost distributions

Figure 4.2 and Figure 4.3 show the generalised costs curves for five user classes across the four daytime time periods. In general there is a good match between the generalised cost data and the modelled outputs, particularly for car, walk and cycle trips. PT trips are less well matched, particularly for the EMP user class.

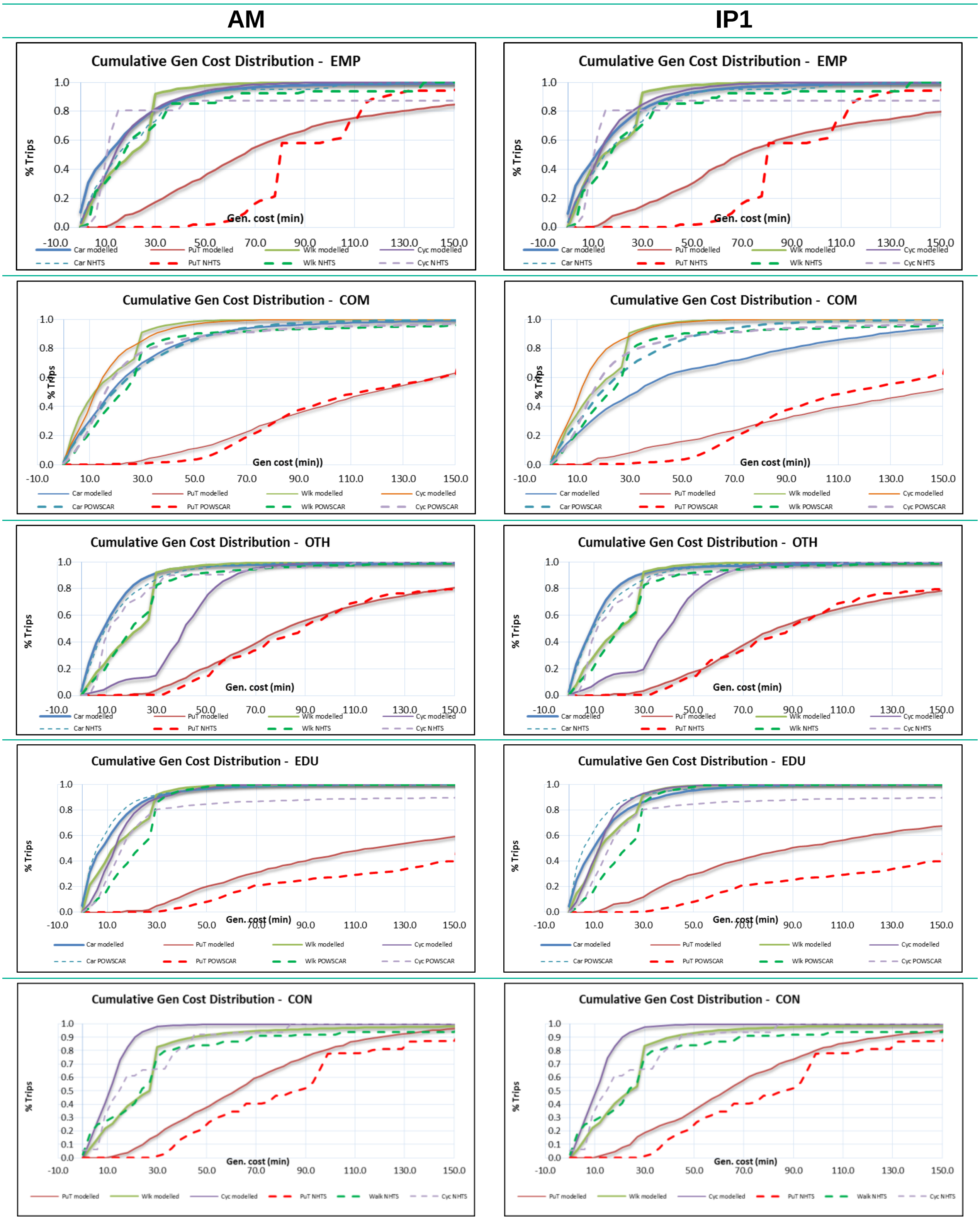


Figure 4.2 Cumulative trip length distributions (AM and IP1)

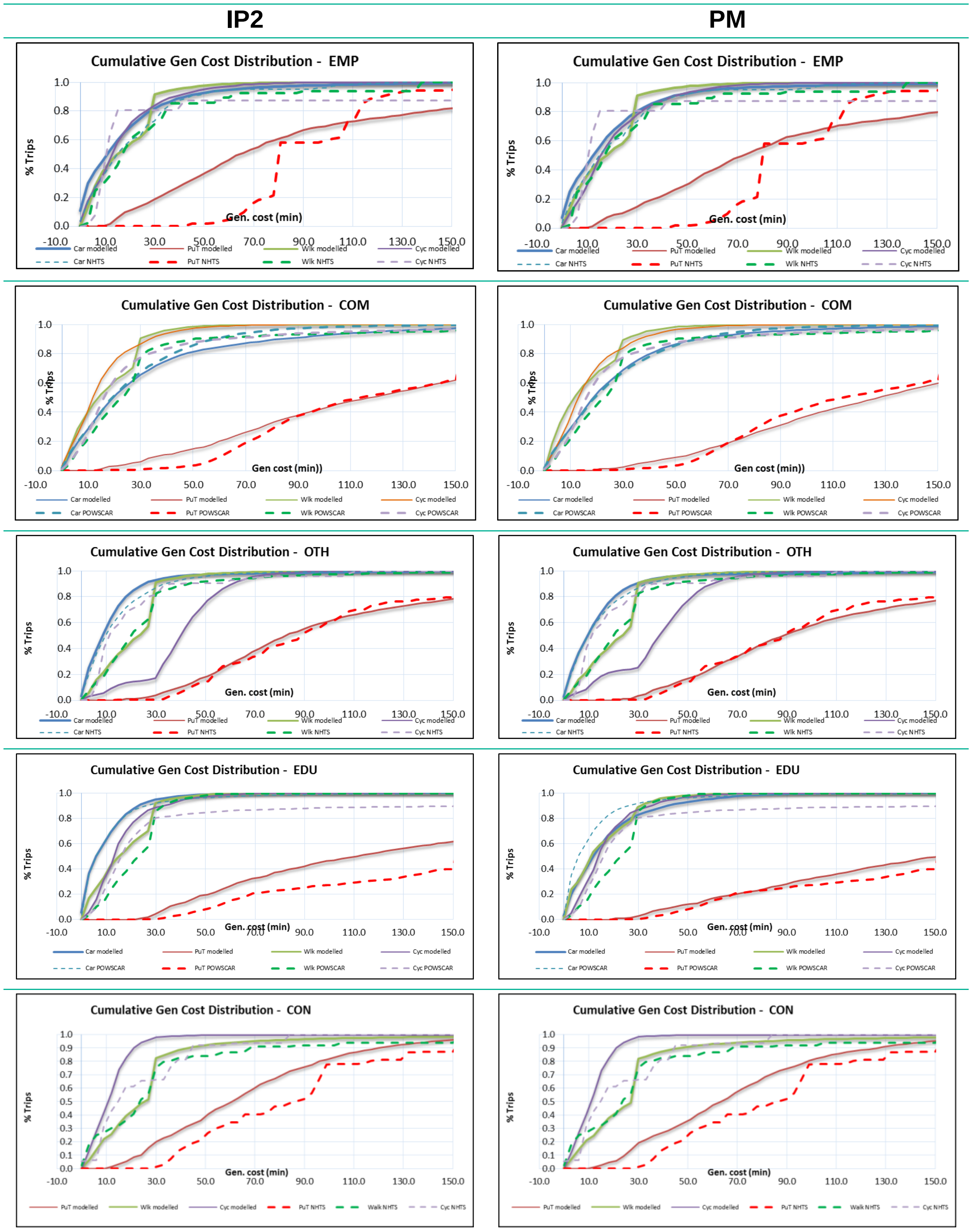


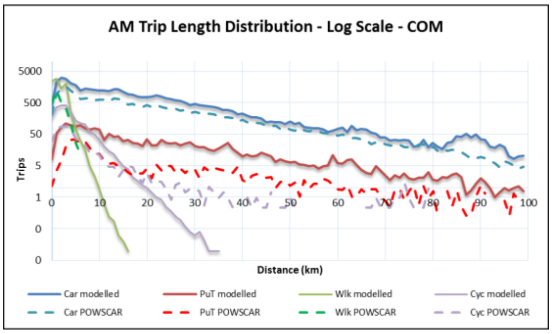
Figure 4.3 Cumulative trip length distributions (IP2 and PM)

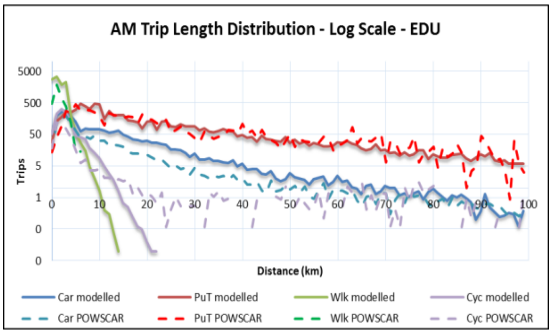
4.3.3 Trip length distribution

Figure 4.4 shows a comparison between the observed and modelled trip lengths for the COM and EDU user classes (data is unavailable for the other classes). Where there are enough trips for the goodness of fit to be important (greater than one, say) the matches are generally good.

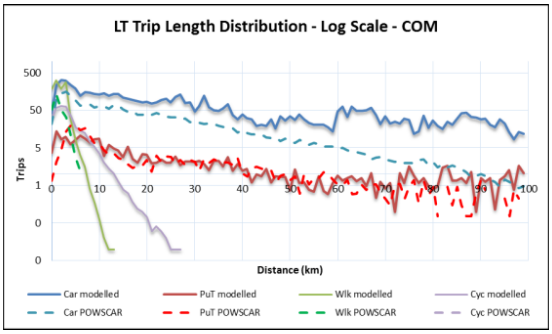
TP | **COM** | **EDU**

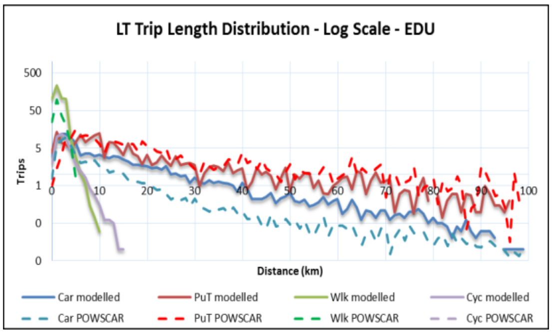
AM



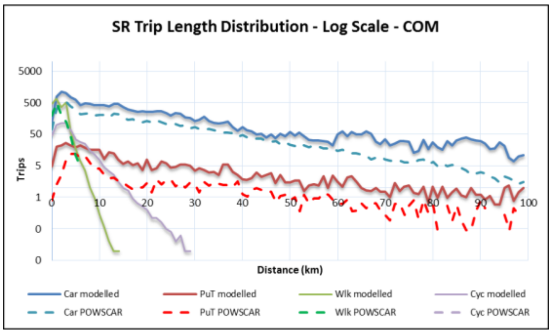


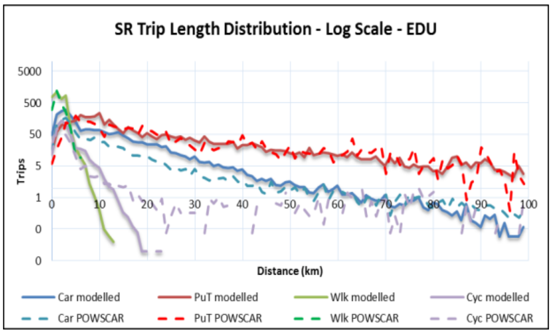
IP1



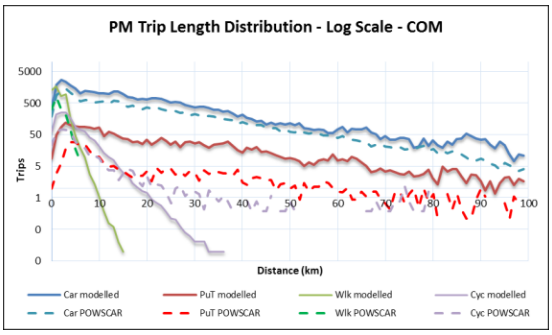


IP2





PM



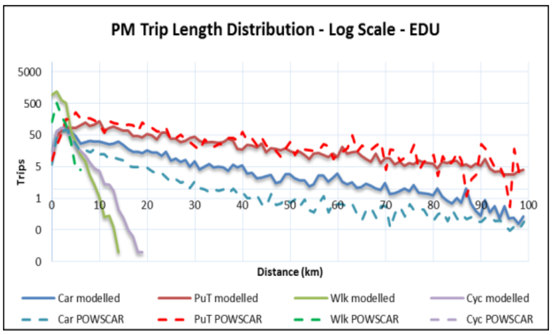


Figure 4.4 Trip lengths for COM and EDU

4.3.4 Intrazonal Trips

Intrazonal costs are calculated by the model and IZM adjustments are applied to the costs in order to match observed and modelled intrazonal trip rates.

Intrazonal demands (as a proportion of total demand) for each time period are shown in Figure 4.5 to Figure 4.8. These show an acceptable level of correspondence between the modelled and observed proportions of intrazonals. The largest disparities are between the modelled and observed proportions of PT and cycle trips and these disparities occur in all of the four time periods illustrated.

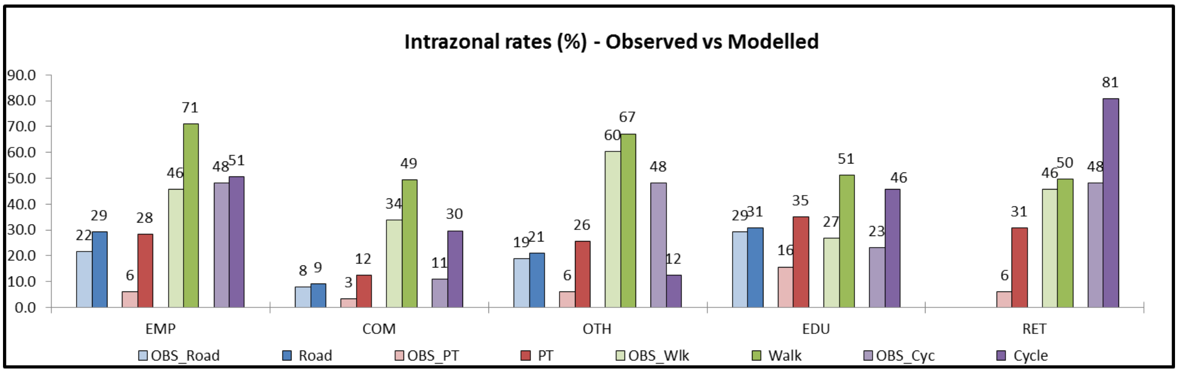


Figure 4.5 AM Intrazonal Trip Rate Proportion

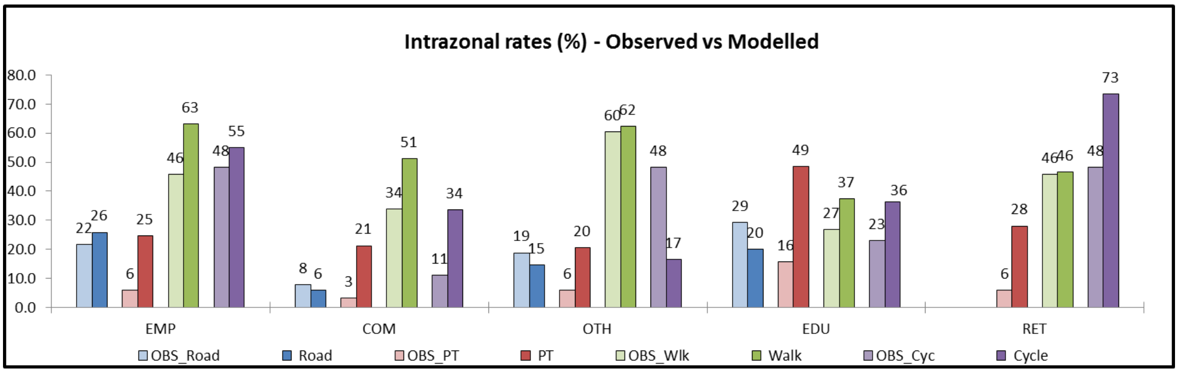


Figure 4.6 IP1 Intrazonal Trip Rate Proportion

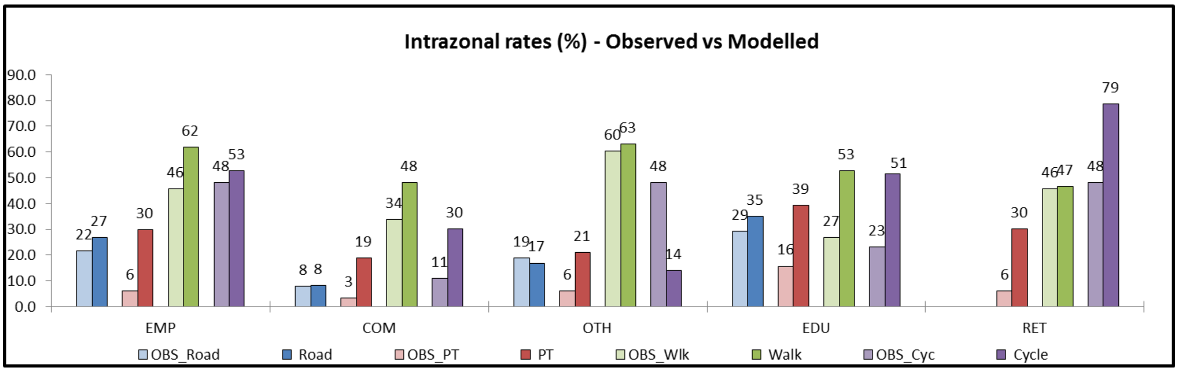


Figure 4.7 IP2 Intrazonal Trip Rate Proportion

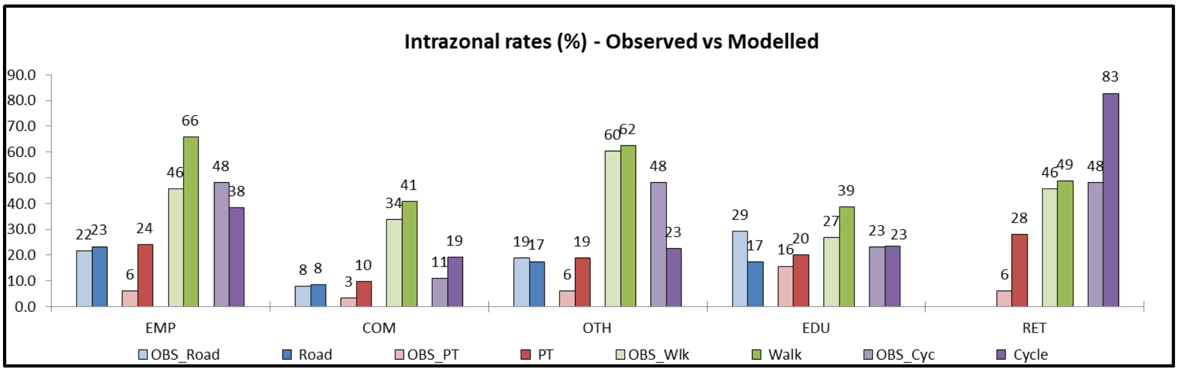


Figure 4.8 PM Intrazonal Trip Rate Proportion

4.3.5 Time period distribution

Figure 4.9 shows a comparison of the number of modelled trips in each time period with the number observed in the NHTS data. The total number of modelled trips in each time period compares well with the observed number of trips, with differences of less than 5% in each daytime time period, and less than 10% in the OP.

The number of observed and modelled trips by each mode in each time period (Figure 4.10) also compares well.

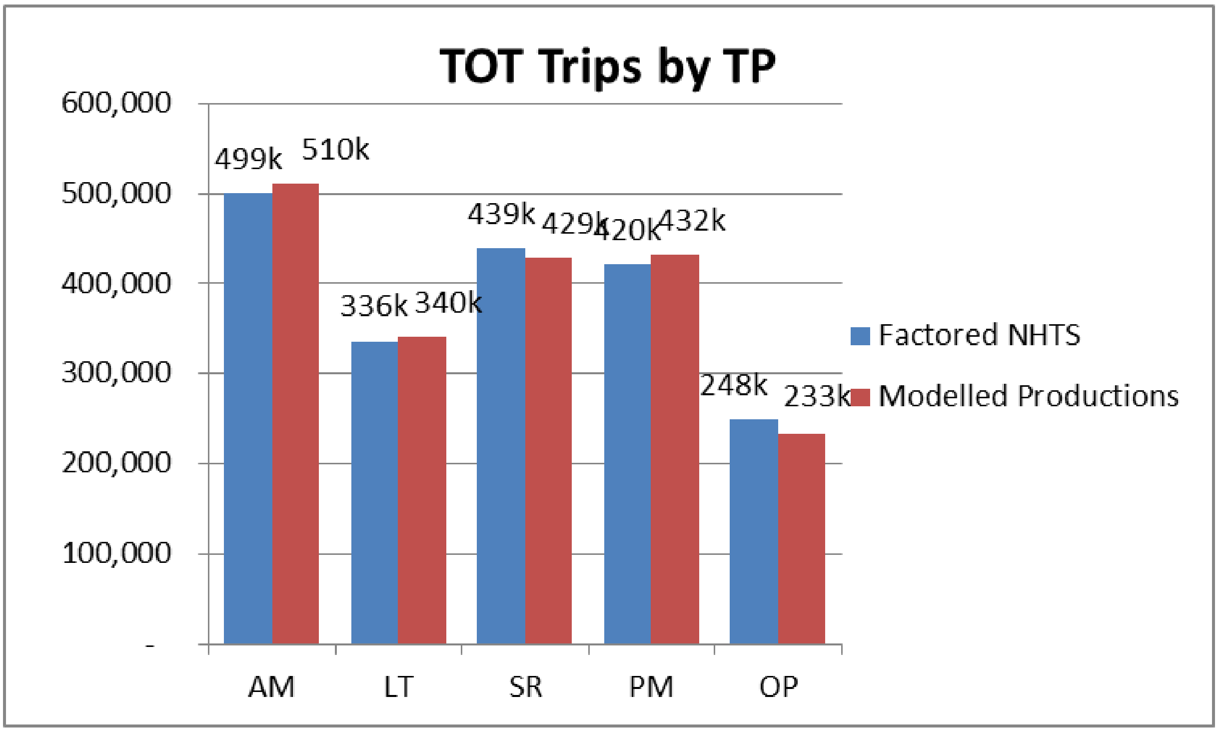


Figure 4.9 Total Trips by Time Period

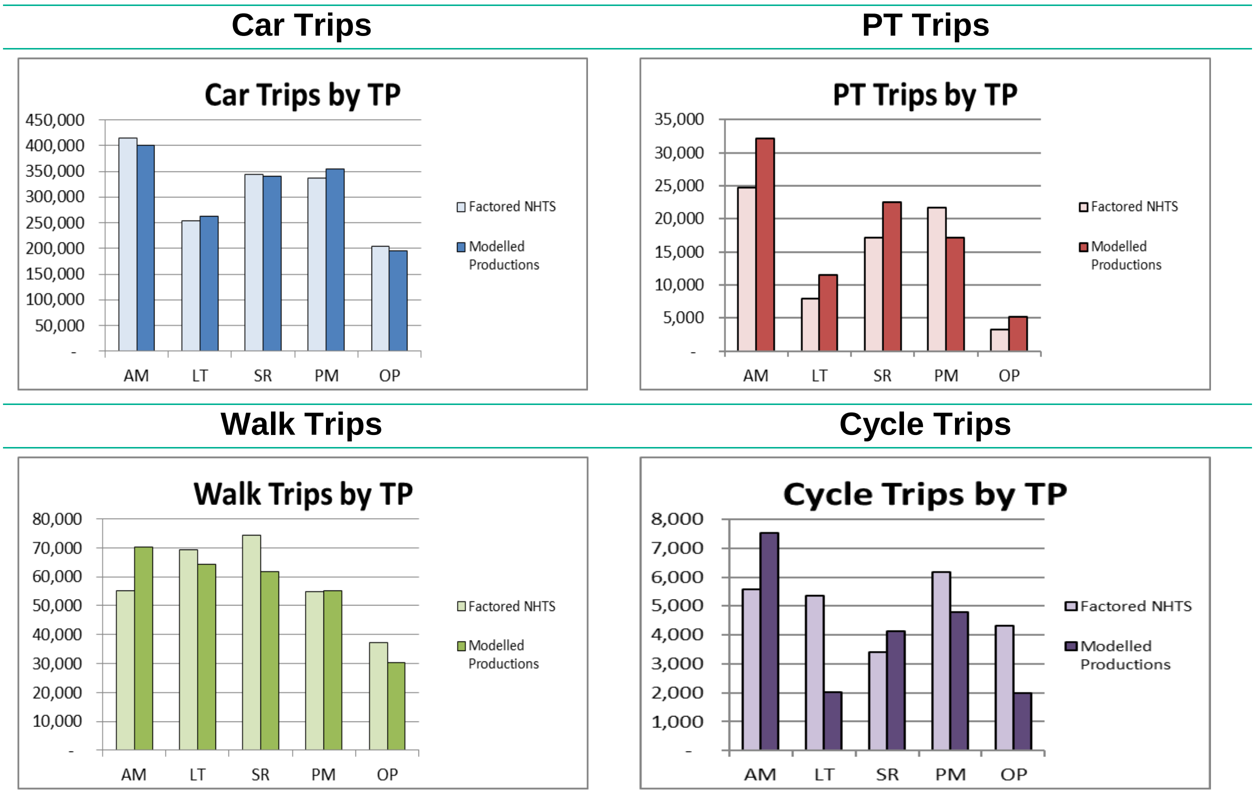


Figure 4.10 Total Trips by Time Period and Mode

4.4 Correcting calibrated demand to match observed movements on the ground

4.4.1 Limitations of demand model calibration

Experience and the intended purpose of the modelling system are factors in deciding whether or not the demand model outputs should be further adjusted in order to attain the guideline link flow comparison. In some cases, a correction process such as matrix estimation can be introduced into the model to ‘correct’ the demand model outputs and produce the desired assignments. While this does distort the calibrated demand model outputs, it helps to achieve the guideline targets for network calibration. The calibration of assignment matrices should limit divergence between the demand model outputs and the road assignment matrices (post-estimation). Once this is held to within tolerable levels, then calibrated trip length distribution and mode share data from the demand model, among others, should still be respected by road and public transport assignment.

Guidelines on such matrix adjustments require that the trip length distributions of the matrices are held to within small tolerances of the output demand model matrices, as this is the key observed data to which the demand model matrices are calibrated. This restriction is intended to avoid invalidating the underlying demand patterns and mode share calibration whilst allowing limited adjustment to demand model outputs in order to improve modelled flows.

The extent to which matrix adjustment can be applied in order to achieve network model specific targets has to be carefully considered. A balance must be reached that maximizes the quality of demand model outputs with respect to the assignments produced, and minimizes the need for further adjustment. The optimal overall model calibration (according to balanced consideration of all model calibration indicators spanning demand and assignment models) may require acceptance of a lower level of link flow calibration in order to maintain more fundamental aspects of the demand calibration, such as mode share and trip length. The level of compromise accepted is a function of the quality of the full range of observed data across all inputs to the overall calibration process and of the intended use of the model.

4.4.2 Sector to sector movements

In the ideal case the amount of change between the directly output demand matrices and the estimated / factored matrices would be small. A comparison of sector to sector movements before and after matrix estimation / factoring is shown in Figure 4.11 (for road) and Figure 4.12 (for PT). While there are some larger differences in individual cells the overall changes in the trip ends are smaller, almost all 5% or below in the road case.

Differences - Sector to sector matrix															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Tot
-5%	10%	-11%	10%	10%	-24%	-26%	-21%	-6%	5%	7%	-1%	1%	0%	0%	2%
10%	8%	15%	19%	25%	-29%	-15%	-20%	-7%	-13%	8%	0%	-1%	0%	0%	2%
1%	-4%	-12%	36%	8%	-57%	-45%	-33%	-27%	-16%	0%	0%	1%	0%	0%	2%
11%	24%	30%	-6%	9%	-34%	-22%	-12%	-6%	6%	6%	1%	1%	0%	0%	5%
25%	10%	-10%	15%	-6%	-51%	-35%	-29%	-21%	-16%	-8%	0%	1%	0%	0%	4%
-24%	-26%	-30%	-8%	-5%	7%	-2%	-14%	-14%	-37%	-29%	-32%	-29%	-7%	2%	-3%
-24%	-9%	-5%	-32%	-34%	-2%	20%	2%	3%	23%	-37%	2%	23%	4%	-37%	-6%
-16%	-10%	-16%	-22%	-21%	-7%	-2%	0%	21%	-1%	-13%	-34%	1%	-11%	-49%	-3%
-17%	1%	-11%	-18%	-24%	-15%	2%	18%	0%	12%	-19%	3%	4%	-5%	-16%	1%
3%	-4%	1%	26%	11%	-33%	25%	0%	14%	0%	-3%	-22%	0%	-3%	-22%	0%
30%	3%	-13%	18%	-11%	-35%	-31%	-14%	-11%	-3%	-2%	-15%	-1%	2%	0%	-2%
-1%	0%	0%	0%	0%	-11%	4%	-15%	14%	-17%	-18%	-1%	7%	1%	0%	-2%
1%	-1%	1%	12%	5%	-25%	34%	5%	4%	0%	-7%	6%	0%	-6%	-7%	0%
0%	0%	0%	1%	0%	-8%	11%	-15%	-7%	-4%	0%	0%	-9%	-3%	-14%	-4%
0%	0%	0%	0%	0%	3%	-43%	-52%	-15%	-22%	0%	0%	-8%	-12%	0%	0%
5%	5%	0%	7%	2%	-3%	-5%	-3%	2%	-1%	-3%	-2%	-1%	-3%	0%	-1%

Figure 4.11 24 hour road matrix sector changes with matrix estimation / factoring

Differences - Sector to sector matrix															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTAL
105%	57%	58%	103%	63%	22%	-51%	-38%	-31%	-9%	25%	19%	23%	18%	14%	21%
113%	40%	42%	95%	42%	24%	-19%	7%	-15%	13%	15%	16%	21%	22%	24%	40%
107%	37%	10%	93%	37%	34%	-15%	-13%	-28%	-1%	16%	12%	26%	14%	21%	44%
107%	60%	66%	92%	61%	24%	-25%	-32%	-33%	-20%	29%	19%	19%	16%	25%	22%
104%	31%	35%	91%	33%	18%	12%	-14%	-23%	-9%	23%	19%	18%	17%	19%	49%
37%	38%	16%	40%	16%	45%	-10%	-1%	-46%	2%	11%	10%	-23%	-9%	11%	5%
-35%	-5%	0%	-7%	21%	-11%	33%	-21%	-17%	-10%	-10%	-7%	-7%	3%	-16%	-14%
-29%	-6%	-21%	-32%	-23%	-21%	-25%	1%	-31%	-11%	0%	3%	2%	14%	16%	-12%
-14%	-1%	-15%	-15%	-7%	-43%	-25%	-34%	-18%	-29%	-16%	-28%	-26%	-26%	-12%	-20%
-16%	-7%	-9%	-33%	-17%	7%	-16%	-12%	-34%	-5%	1%	-23%	-4%	2%	19%	-10%
0%	-11%	-1%	-21%	-5%	11%	-8%	0%	-17%	-5%	7%	4%	5%	17%	19%	-1%
-15%	-17%	-10%	-28%	-22%	7%	-7%	3%	-27%	-25%	10%	7%	5%	13%	14%	2%
-23%	-22%	-8%	-23%	-25%	-19%	-2%	5%	-30%	-5%	3%	7%	1%	-5%	12%	-2%
-23%	-19%	-33%	-22%	-22%	-11%	4%	11%	-36%	-5%	8%	14%	-12%	3%	11%	-3%
-34%	-24%	-25%	-32%	-35%	11%	-14%	8%	-20%	9%	8%	12%	13%	14%	9%	9%
31%	19%	27%	15%	31%	4%	-21%	-12%	-28%	-7%	10%	2%	-2%	0%	9%	3%

Figure 4.12 24 hour PT matrix sector changes with matrix estimation / factoring

4.4.3 R-squared Analysis

The R-squared (R^2) statistic was utilised throughout calibration as a measure to check the changes to road model matrices during estimation. Table 4.1 outlines the matrix estimation change calibration criteria, as specified in TAG Unit M3-1, Section 8.3, Table 5.

Table 4.1 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.

The following sections provide an overview of the r-squared results for each model time period. Further details are provided in the WRM Road Model Development Report.

AM

Table 4.2 details the R^2 values for each individual user class for the AM peak Period.

Table 4.2 AM Matrix Change R^2 Analysis

User Class	EMP	COM	EDU	OTH
Cell R-Squared	0.94	0.95	0.98	0.99
Cell Slope	0.96	0.97	0.98	0.99
Cell Y-Intercept	0.00	0.00	0.00	0.00
Trip End R-Squared	0.99	0.99	0.99	1.00
Trip End Slope	0.98	0.97	0.99	0.98
Trip End Y-Intercept	0.14	0.85	0.00	1.40

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, which is exceeded by all user classes with the exception of Employers Business which falls just outside the range. Two of the user classes pass the recommended criteria for zonal slope values between 0.98 – 1.00. The remaining two values of 0.96 – 0.97 for EMP and COM narrowly fail to meet the TAG criteria. The COM, EMP and OTH user classes also narrowly fails the tighter criterion for trip end slope. All other criteria are met in the AM

LT

Table 4.3 details the R^2 values for each individual user class the LT period.

Table 4.3 IP1 Matrix Change R^2 Analysis

User Class	EMP	COM	EDU	OTH
Cell R-Squared	0.93	0.95	0.93	0.99
Cell Slope	0.98	0.97	1.02	0.99
Cell Y-Intercept	0.00	0.00	0.00	0.00
Trip End R-Squared	0.99	0.98	0.98	0.99
Trip End Slope	0.99	0.90	1.07	0.98
Trip End Y-Intercept	0.13	0.48	-0.01	1.44

Two of the four user classes are just outside the acceptable range for the individual cell R^2, with the COM class also falling outside the slope criterion. With regard to the trip end criteria, all of the user classes are within the R^2 criterion, but only one user class fully meets the slope criterion.

SR

Table 4.4 details the R^2 values for each individual user class for the SR time period.

Table 4.4 IP2 Matrix Change R^2 Analysis

User Class	EMP	COM	EDU	OTH
Cell R-Squared	0.93	0.95	0.98	0.99
Cell Slope	0.98	0.99	0.98	0.99
Cell Y-Intercept	0.00	0.00	0.00	0.00
Trip End R-Squared	0.99	0.97	0.99	0.99
Trip End Slope	0.98	0.98	0.96	0.98
Trip End Y-Intercept	0.09	0.09	0.09	1.58

Three of the user classes pass the individual cell R^2 test, with the remaining one falling just outside the range. All of the user classes meet the cell slope and three of the four meet the trip-end R^2 criteria. For the trip-end slope criterion, all of the user classes narrowly fail the criterion.

PM

Table 4.5 details the R^2 values for each individual user class for the PM peak period.

Table 4.5 PM Matrix Change R^2 Analysis

User Class	EMP	COM	EDU	OTH
Cell R-Squared	0.93	0.96	0.96	0.99
Cell Slope	0.97	0.98	0.97	0.99
Cell Y-Intercept	0.00	0.00	0.00	0.00
Trip End R-Squared	0.98	0.98	0.98	1.00
Trip End Slope	0.98	0.96	0.89	0.98
Trip End Y-Intercept	0.19	1.37	0.12	1.47

Three out of the four user classes pass the individual cell R^2 test, and the one that did not has an R^2 value of 0.93. All four user classes pass the trip end R^2 test. However, for the cell slope test, only the COM and OTH user classes pass, though the other fail narrowly. None of the user classes pass for the trip end slope, though the EMP and OTH classes are close.

4.4.4 Application of estimation / factoring information to the demand model

The information gained from matrix estimation / PT factoring is input into the demand model through the medium of incremental matrices. These give the difference between the directly calculated demand and the estimated / factored demand and so, in the base case, these effectively reproduce the estimated / factored matrices. Once this has taken place, the levels of calibration in the road and PT networks can be meaningfully considered.

Table 4.6 Scale of incremental matrices (incremental total as % assigned total)

Mode	AM	LT	SR	PM
Taxi	0%	0%	0%	0%
Car	-1%	-1%	-1%	-1%
PT	-8%	+2%	+12%	+11%
Walk	0%	0%	0%	0%
Cycle	0%	0%	0%	0%

The incremental values should only form a small part of the assignment matrix and their scale is indicated in Table 4.6.

4.5 Road calibration and validation

The development, calibration, and validation of the road model is described in detail in the WRM Road Model Development Report but the level of flow and journey time calibration / validation reported by the road dashboards is also a key consideration in the assessment of the demand model calibration and so the results are summarised here.

Road calibration (on percentage difference) was good with overall values for all links falling out at:

- AM 87% / 77%;
- IP1 93% / 85%;
- IP2 92% / 79 %; and
- PM 88% / 77%.

Journey time validation was reasonable with 60% of routes meeting the pass criteria in the AM and PM peaks and 88% in IP1 and IP2.

4.6 Public transport calibration and validation

The development, calibration, and validation of the public transport model is described in detail in the WRM PT Model Development Report but the level of passenger movement and journey time calibration / validation reported by the PT dashboards is also a key consideration in the assessment of the demand model calibration and so the results are summarised here.

Figure 4.13 and Figure 4.14 show the modelled versus observed flows at the locations where data is available, and Figure 4.15 and Figure 4.16 show rail boardings by time period. In general, the match to flows is reasonable though it tends to be worse in the inbound IP1 (LT) time period and for the outbound AM. Rail boardings tend to be high overall but the overall pattern is quite good.

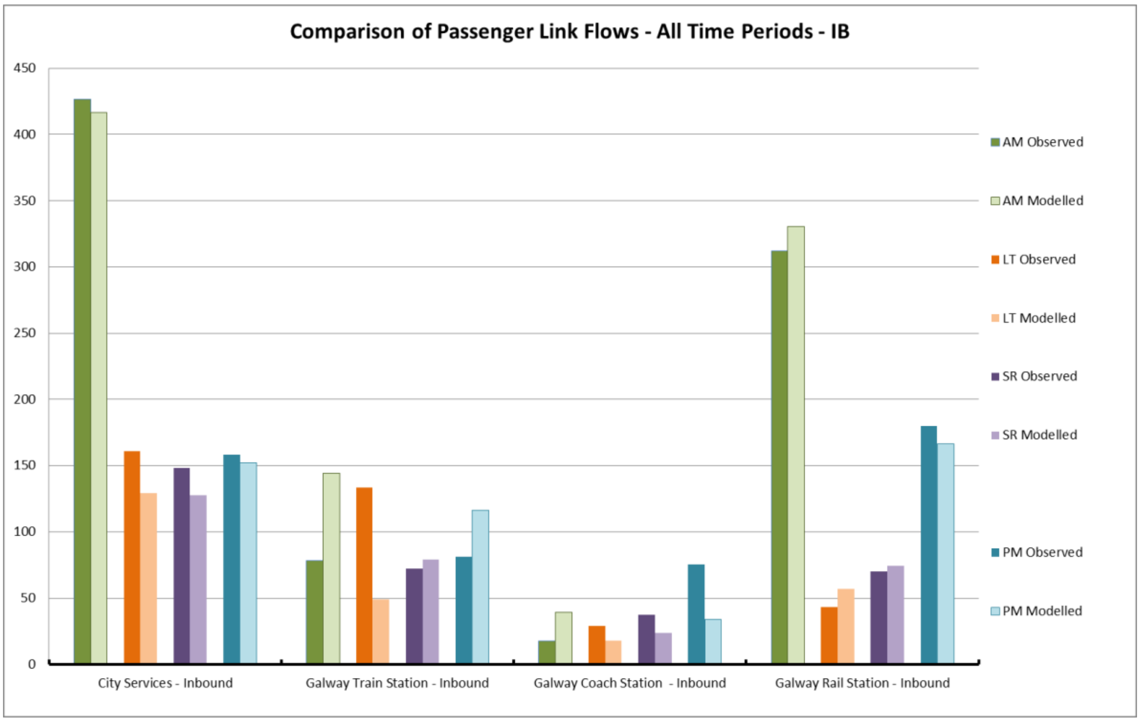


Figure 4.13 Inbound PT passenger flows[20]

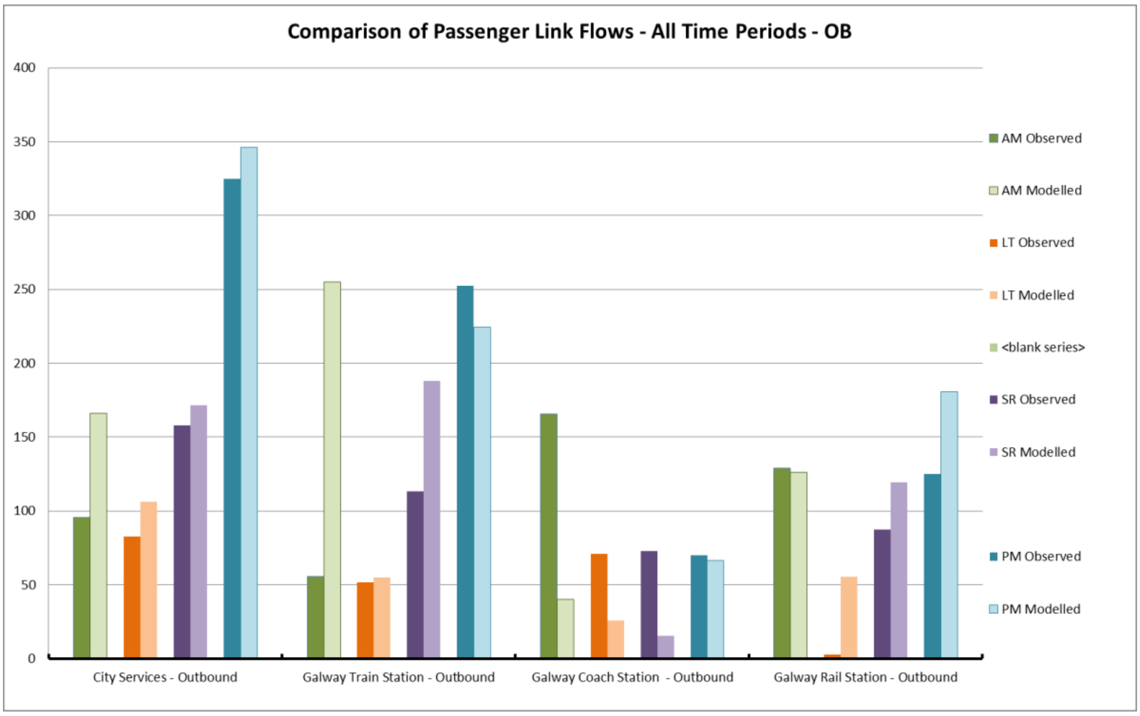


Figure 4.14 Outbound PT passenger flows[21]

[20] Galway Train Station refers to bus services observed at Galway Rail Station

[21] Galway Train Station refers to bus services observed at Galway Rail Station

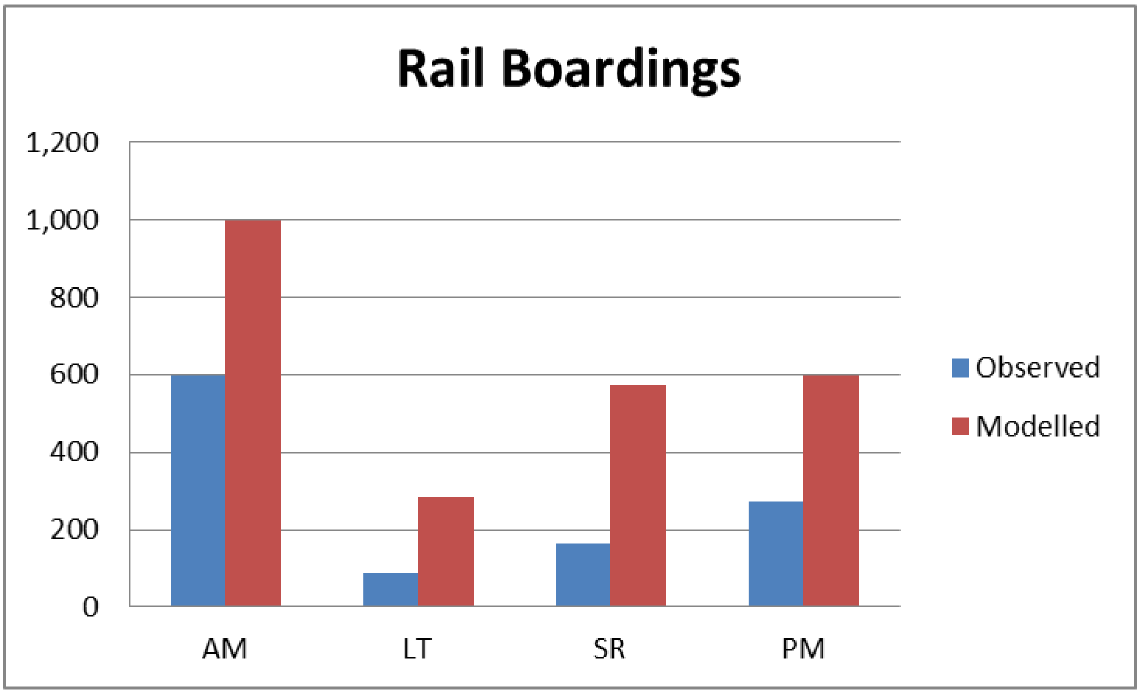


Figure 4.15 Rail boardings by time period

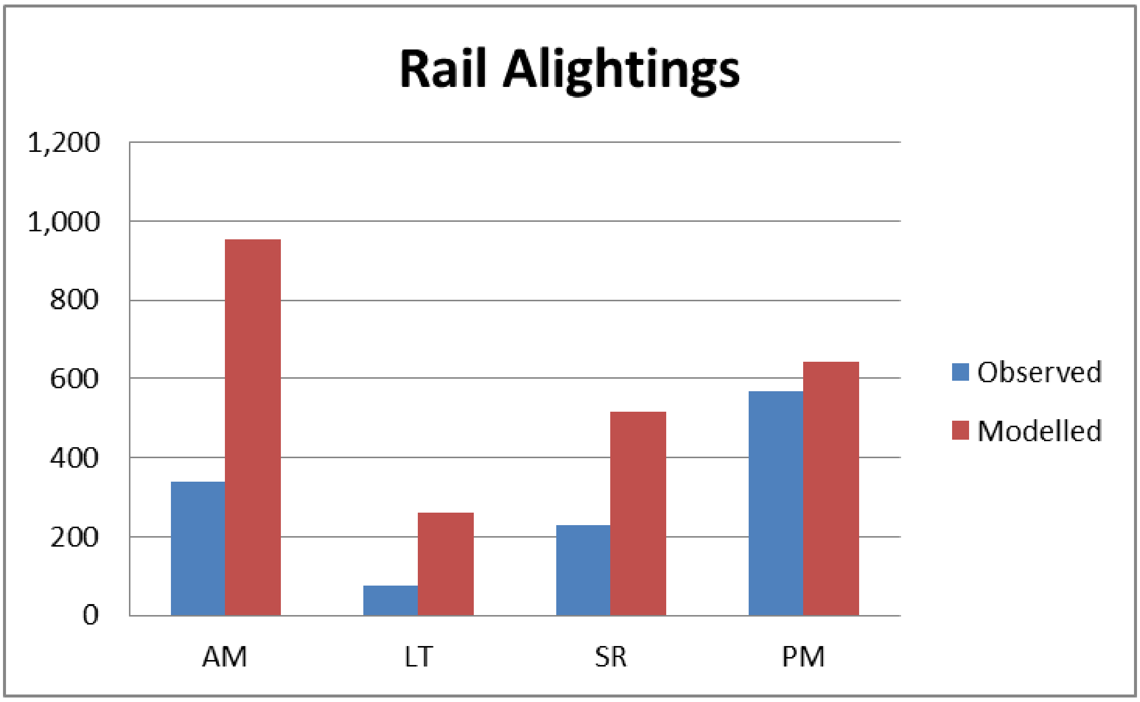


Figure 4.16 Rail alightings by time period

4.7 Overview

Though there is still room for improvement, overall:

- Mode splits are considered robust, as are generalised cost distributions, trip lengths, intrazonal trip numbers, and time period distributions.
- The amount of matrix estimation / factoring required to convert base output demand matrices to matrices which match behaviour on the ground is reasonable.
- Incrementals form only a small proportion of the overall assignment matrices.
- Road calibration / validation is good.
- PT calibration / validation is reasonable, particularly in view of limited data availability.

5 Realism Testing

5.1 Overview

The preceding chapters discuss how the base year scenario of the model was calibrated and validated which reflects its ability to reproduce current conditions. In order to estimate how accurately the model will be able to predict future conditions, it is important to run realism tests before undertaking true forecast year runs. WebTAG recommends a series of three standard realism tests[22], namely:

- Car fuel cost elasticity;
- PT fare elasticity; and
- Car journey time elasticity.

Elasticities are a measure of the size of changes to demand which result from a given change in generalised cost and are defined as:

$$e = \frac{\ln(T_1) - \ln(T_0)}{\ln(C_1) - \ln(C_0)}$$

Where:

T_0 is the demand of the initial condition (calibrated base);
T_1 is the demand with the change in place;
C_0 is the generalised cost of the initial condition (calibrated base); and,
C_1 is the generalised cost with the change in place.

Elasticities are derived based on a global summation of relevant costs and demands across the entire simulated area, as the overall demand is tied to the trip ends and hence cannot change. Consequently, the car fuel and car journey time tests will consider car costs and demands and the PT fare tests will consider PT costs and demands.

The values which models need to produce to be acceptable under WebTAG guidance are shown in Table 5.1.

Table 5.1 Realism Test Acceptability Criteria

Test	Valid Range	Notes
Fuel	-0.25 to -0.35	Should vary by purpose and certain individual purposes may be outside the range. Discretionary travel should be more elastic and employers' business should be less elastic.
Fare	-0.20 to -0.90	Can be as elastic as -2.0 for some long-term models[23]
Time	0.00 to -0.20	

[22] Chapter 6.4, *TAG Unit M2 – Variable Demand Modelling*, January 2014, Retrieved 1st October 2014 from https://www.gov.uk/government/publications/webtag-tag-unit-m2-variable-demand-modelling

[23] Long-term models represent a steady-state condition where all changes are in place and the initial shock of their introduction has stabilised. The FDM reflects long-term conditions.

5.2 Running the realism tests

5.2.1 Car fuel cost elasticity

The car fuel cost is input to the model via the Value of Distance parameter in the SATURN networks. This parameter was multiplied by 1.1 and the road assignment was re-run and re-skimmed in order to provide new base cost inputs. The model was then re-run through a single FDM loop in order to examine its response.

5.2.2 PT fare elasticity

The PT fares enter the model through a fares matrix and a number of fare tables. The costs in these were scaled by a factor of 1.1 and then a standalone PT assignment was undertaken (with the initial base year road assignment as the underlying network). New costs were skimmed from this run and input to the model as revised base costs. The model was then run through a single FDM loop and the outputs examined.

5.2.3 Car journey time elasticity

As the majority of the generalised cost of car travel is made up of the time component (due to the comparative magnitude of the generalised cost equation parameters), a good approximation to the change required by this test can be obtained by multiplying the input base cost matrices for cars by 1.1 and then running the model through a single FDM loop.

5.3 Results

5.3.1 Car fuel cost elasticity

At the 24 hour level (last column) and the all-purposes level (last row) the elasticities are inside the WebTAG range, with the exception of that for EMP across the whole day (Table 5.2). However, WebTAG does not make specific reference to trips on Employers Business and it seems reasonable that EMP trips would be less sensitive to changes in fuel cost than is usual, as the cost of staff time is generally much higher than the direct cost of business travel. It is therefore plausible that EMP trips should show a low level of sensitivity to car fuel cost, and these low values are replicated across all the individual time periods as well.

Table 5.2 Car fuel cost elasticities

User class	AM	LT	SR	PM	OP*	24 Hour
EMP	-0.178	-0.154	-0.172	-0.169	-0.143	**-0.161**
COM	-0.321	-0.389	-0.293	-0.308	-0.339	**-0.318**
OTH	-0.385	-0.243	-0.256	-0.337	-0.231	**-0.288**
EDU	-0.305	-0.321	-0.295	-0.293	-0.265	**-0.298**
RET**	-0.217	-0.286	-0.311	-0.384	-0.297	**-0.297**
Total	**-0.325**	**-0.251**	**-0.269**	**-0.320**	**-0.250**	**-0.290**

* LT distance skim used for OP
** OTH distance skim used for RET

Other low values can be found for OTH trips in the LT and OP. These values are only fractionally outside the desired range and the mismatches only occur in these individual peaks and so this is not considered to be problematic.

A low value is also given for RET trips in the morning peak. Users in this group are entitled to free bus and rail travel and so if they have chosen to make their trip by car it is probably because there are complicating factors which make the car more than usually attractive. Therefore, it makes some sense that they would be less cost sensitive than other user classes.

High values are found for COM trips in the LT, OTH trips in the AM and RET trips in the PM. Again, these values are only just outside the expected range and at the all-purposes and 24 hour levels these groups respond appropriately.

Overall, despite small localised deviations from the expected range the model is considered to respond appropriately to changes in fuel costs.

5.3.2 PT fare elasticity

At the all-purposes level (last row) and for the COM, OTH and EDU groups all of the values lie within the preferred range, but the EMP and RET groups are less cost sensitive than expected (Table 5.3). RET trips are subject to concessionary travel and do not pay fares regardless of the changes in them. Therefore, the actual expected elasticity in the RET group should be zero, or very near. The values returned are therefore wholly appropriate even though they do not fall inside WebTAG's preferred range. Similarly, to the pattern seen in the car fuel cost case the cost of staff time for EMP trips is generally much higher than the direct costs of staff travel and so it is not surprising that these trips are less sensitive to PT fare changes than is suggested by WebTAG.

Table 5.3 PT fare elasticities

User class	AM	LT	SR	PM	OP*	24 Hour
EMP	-0.164	-0.171	-0.130	-0.164	-0.178	**-0.159**
COM	-0.540	-0.546	-0.521	-0.553	-0.552	**-0.544**
OTH	-0.448	-0.428	-0.461	-0.450	-0.480	**-0.448**
EDU	-0.229	-0.255	-0.209	-0.270	-0.273	**-0.232**
RET*	-0.001	-0.001	-0.002	-0.001	0.000	**-0.001**
Total	**-0.286**	**-0.352**	**-0.266**	**-0.361**	**-0.391**	**-0.307**

* Concessionary travel

Overall the model is considered to respond predictably and sensibly to changes in PT fares.

5.3.3 Car journey time elasticity

Table 5.4 shows the response of the model to car journey time changes. In this case all the values except those for EDU lie within WebTAG's preferred range and there is no reason to expect unpredictable responses to changes in journey times.

Table 5.4 Car journey time elasticities

User class	AM	LT	SR	PM	OP*	24 Hour
EMP	-0.089	-0.073	-0.079	-0.094	-0.069	**-0.080**
COM	-0.184	-0.188	-0.167	-0.182	-0.166	**-0.179**
OTH	-0.118	-0.107	-0.100	-0.121	-0.108	**-0.111**
EDU	-0.252	-0.324	-0.202	-0.400	-0.381	**-0.259**
RET	-0.081	-0.091	-0.070	-0.086	-0.067	**-0.080**
Total	**-0.151**	**-0.108**	**-0.116**	**-0.144**	**-0.115**	**-0.130**

6 Conclusion and recommendations

6.1 Introduction

This report has described the calibration and validation of the FDM component of the West Regional Model. This section summarises the strengths and weakness of the model revealed by this process and gives a set of recommendations for further enhancements.

6.2 Calibration methodology – key points

The key points relating to the calibration of the WRM are:

- The WRM FDM initially used the standard FDM release version 2.0.8 (with some minor modifications) in combination with region specific inputs and appropriate road, PT, and active modes networks. At the final stage it was converted to 2.0.23.
- All modules are in use and turned on except macro time of day choice.
- The process of FDM calibration for the WRM has followed a repeatable method developed for all of the regional models.
- Calibration / validation outputs are presented in a common, dashboard format.

6.3 Calibration and validation outcomes – key points

The model was calibrated to local conditions using data derived from the 2011 POWSCAR and 2012 NHTS data sets.

- **Modal Split:** 24-hour mode share was calibrated to POWSCAR and NHTS data and is good overall, lying within 6% of the observed data, though the COM and EDU user classes are less well matched.
- **Generalised Cost Distribution:** Generalised cost curves were calibrated to POWSCAR and NHTS data and are well matched for car, walk and cycle trips. PT trips are less well matched, but primarily at high costs where there are comparatively fewer trips.
- **Trip Length Distribution:** Trip length distributions for COM and EDU were compared to observed (POWSCAR) trip length distributions. The match is reasonable, particularly in those areas of the curves where the majority of trips occur.
- **Intrazonal Trips:** The proportion of intrazonal trips was calibrated to observed data for each mode, time period and purpose and the modelled pattern is a good match to the observed pattern, though PT and cycle intrazonals tend to be high.
- **Time Period Distribution:** Total trips by time period, and trips by time period and mode, were calibrated to observed data and the overall match is excellent.

- **Matrix correction and incremental values:** Pre and post correction sector to sector comparisons indicate that the degree of correction required by the assignment matrices is reasonable and incremental values are acceptable in size.
- **Road calibration and validation:** Flow calibration (compared to counts) is excellent with calibrations above 87% and validations above 77% in all cases. Journey time validation is reasonable at 60-88%. The development, calibration, and validation of the road model is covered in more detail in the WRM Road Model Development Report.
- **PT calibration and validation:** Given the limited data availability the level of PT calibration is reasonable. The development, calibration, and validation of the PT model is covered in more detail in the WRM PT Model Development Report.
- **Active modes calibration and validation:** As there is no data available, the calibration and validation of the active modes model has not been covered here. However, the development of the active modes model is covered in more detail in the WRM Active Modes Model Development Report.
- **Realism tests:** Despite some localised variations, overall, the model responds appropriately to change in fuel cost, PT fares and car journey times.

6.4 Recommendations for further development

It is considered that the model in its current state is sufficiently calibrated to be fit for purpose. However, no model is ever ‘finished’ in the sense that no further improvements can be made. Accordingly, this section sets out some suggested recommendations for future enhancements of the model.

- Continue to refine the model to improve its functionality, flexibility and calibration.
- Continue to refine the base generalised cost inputs to improve stability in early model loops.

Annex 1 Full list of required input files

Group	Input file
NDFM outputs and tour proportions	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Dem_Zone_Zone_HGV.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Dem_Zone_Zone_M1.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Dem_Zone_Zone_M2.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Dem_Zone_Zone_M3.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Work_Zone_Zone_M1.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Work_Zone_Zone_M2.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Work_Zone_Zone_M3.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Prods_CA.CSV
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Blue_White_Collar.CSV
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Emp_Split.CSV
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\One_Way_NonRetired.CSV
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\One_Way_Retired.CSV
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Two_Way_Attractions_NonRetired.CSV
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Two_Way_Attractions_Retired.CSV
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Two_Way_Productions_NonRetired.CSV
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Two_Way_Productions_Retired.CSV
	{CATALOG_DIR}\Params\Trip_End_Parameters\Base_Prod_Tour_Proportions.MAT
	{CATALOG_DIR}\Params\Trip_End_Parameters\Base_Attr_Tour_Proportions.MAT
Special demands	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Internal_Goods.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\AM_SpecialZones.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\LT_SpecialZones.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\OP_SpecialZones.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\PM_SpecialZones.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\SR_SpecialZones.MAT
	{CATALOG_DIR}\Runs\{Model Year}\{Run ID}\Input\Special_Zones\SZ_data.csv
Base cost matrices	{CATALOG_DIR}\Params\BaseGenCosts\AM_ALL_D0.GCM
	{CATALOG_DIR}\Params\BaseGenCosts\LT_ALL_D0.GCM
	{CATALOG_DIR}\Params\BaseGenCosts\SR_ALL_D0.GCM
	{CATALOG_DIR}\Params\BaseGenCosts\PM_ALL_D0.GCM
	{CATALOG_DIR}\Params\BaseGenCosts\OP_ALL_D0.GCM
	{CATALOG_DIR}\Params\BaseGenCosts\EMP_M3.AGC
	{CATALOG_DIR}\Params\BaseGenCosts\COM_M3.AGC
	{CATALOG_DIR}\Params\BaseGenCosts\OTH_M3.AGC
	{CATALOG_DIR}\Params\BaseGenCosts\EDU_M3.AGC
	{CATALOG_DIR}\Params\BaseGenCosts\RET_M3.AGC
Zone information files	{CATALOG_DIR}\Params\Zone_Conversion\Seq_2_Hier.exe
	{CATALOG_DIR}\PARAMS\SYNTHESIS_SECTOR_V1_1.TXT
	{CATALOG_DIR}\Params\Trip_End_Parameters\SECTOR_LIST.DBF
	{CATALOG_DIR}\Params\Trip_End_Parameters\ZONE_LIST.DBF
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\Zone_Areas.DBF
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\Zone_Lookup.csv
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\SA_Zones_Sector.DBF

Group	Input file
Mode and destination choice parameters MDC for 01-29 One Way for 30-33	{CATALOG_DIR}\Params\MDC_Params\P??_ALPHA.MAT
	{CATALOG_DIR}\Params\MDC_Params\P??_BETA.MAT
	{CATALOG_DIR}\Params\MDC_Params\P??_LAMBDA.MAT
	{CATALOG_DIR}\Params\MDC_Params\P??_ASC.MAT
	{CATALOG_DIR}\Params\MDC_Params\P??_IZM.MAT
	{CATALOG_DIR}\Params\OneWay_Params\P??_ALPHA.MAT"
	{CATALOG_DIR}\Params\OneWay_Params\P??_BETA.MAT"
	{CATALOG_DIR}\Params\OneWay_Params\P??_LAMBDA.MAT"
	{CATALOG_DIR}\Params\OneWay_Params\P??_ASC.MAT"
	{CATALOG_DIR}\Params\OneWay_Params\P??_IZM.MAT"
Parking information	{CATALOG_DIR}\Params\GenCost_Params\Parking_VoT.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{Run ID}\Input\FWPP_{Run ID}{Model Year}.CSV
	{CATALOG_DIR}\Runs\{Model Year}\{Run ID}\Input\PCharge_{Run ID}{Model Year}.CSV
	{CATALOG_DIR}\Runs\{Model Year}\{Run ID}\Input\PDist_{Run ID}{Model Year}.CSV
	{CATALOG_DIR}\Runs\{Model Year}\{Run ID}\Input\PDistParams_{Run ID}{Model Year}.DAT
	{CATALOG_DIR}\Runs\{Model Year}\{Run ID}\Input\PnRSites_{Run ID}{Model Year}.CSV
Greenfield inputs	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Greenfield_Allocation.txt
	{CATALOG_DIR}\Params\Greenfield\Generic_Greenfield_Zone_File.MAT
	{CATALOG_DIR}\Runs\{Year}\2 Demand\{Growth}\GField\GField_Zone_?.csv
Road networks (AM, LT/IP1, SR/IP2, PM or OP)	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\Saturn.dat
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\DefaultOptions.dat
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\DefaultParams.dat
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\SATURN.BUS
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\saturn.111
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_Signals.111
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\saturn.222
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\saturn.333
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\saturn_??.444
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_9UC_Tolls_2011.444
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\saturn.555
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_NRA_JT_2014.666 *(except OP)*
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\JT20{Model Year}_??.666
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_additional.777
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_Bridges.777
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_Inner.777
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_M50.777
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_M50_ATC.777
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_Outer.777 *(AM only)*
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_PreLd.PLD *(except OP)*

Group	Input file
PT network files (factor files for EMP, COM, OTH, EDU, RET and ZOD)	{CATALOG_DIR}\Params\4 PT \4 PT_VOT_Table.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\FARES.MAT
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\FARES_AM.FAR
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\FARES_LT.FAR
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\FARES_PM.FAR
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\FARES_SR.FAR
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\NTL_GENERATE_SCRIPT.txt
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\4 PT_Dump_Links.csv
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\SELECT_LINK_SPEC.TXT
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\SYSTEM_FILE.PTS
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Factor_Files\???_NO_VOT_AM.FAC
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Factor_Files\???_NO_VOT_LT.FAC
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Factor_Files\???_NO_VOT_PM.FAC
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Factor_Files\???_NO_VOT_SR.FAC
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Lines\Bus_{RunID}_{Model Year}.LIN
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Lines\New_Mode_{RunID}_{Model Year}.LIN
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Lines\Rail_{RunID}_{Model Year}.LIN
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\BRT_FareZones.DBF
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\DBus_FareZones.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Luas_Links.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Luas_Nodes.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Metro_Links.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Metro_Nodes.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Rail_Links.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Rail_Nodes.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Walk_Links.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Walk_Nodes.dbf
Active modes	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\AMM\CYCLE_DATA.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\AMM\PED_ONLY.DBF
Finalisation files	{CATALOG_DIR}\Params\AssPrep\CarUserToCarDriver.PRM
	{CATALOG_DIR}\Params\AssPrep\PeriodToHour.PRM
	{CATALOG_DIR}\Params\AssPrep\AM_Incrementals.INC
	{CATALOG_DIR}\Params\AssPrep\LT_Incrementals.INC
	{CATALOG_DIR}\Params\AssPrep\SR_Incrementals.INC
	{CATALOG_DIR}\Params\AssPrep\PM_Incrementals.INC
	{CATALOG_DIR}\Params\AssPrep\OP_Incrementals.INC
	{CATALOG_DIR}\Params\AssPrep\TaxiProps.MAT
	{CATALOG_DIR}\Params\AssPrep\Taxi_Incrementals.INC
Preliminary test / dummy files	{CATALOG_DIR}\Params\Active_Assignment \Dummy_Active_Assign.AAM
	{CATALOG_DIR}\Params\Empty.prn
	{CATALOG_DIR}\Params\FWPP\Dummy_FWPP.MAT
	{CATALOG_DIR}\Params\PnR\PnR_Blank_Costs.AGC
	{CATALOG_DIR}\Params\PnR\PnR_Start_File.CSV
	{CATALOG_DIR}\Params\4 PT \4 PT_Assignment_Test.PTM
	{CATALOG_DIR}\Params\3 Road\Dummy_Demand.UFM
	{CATALOG_DIR}\Params\3 Road\Matrix_LowFlow.UFM
	{CATALOG_DIR}\Params\3 Road\SATALL_KR_1ITER.DAT

Annex 2 Special Zones Demand (Airports & Ports)

A2.1 Introduction

This technical note set out the methodology of how the productions and attractions are determined for special airports and zones, and how the matrices are developed for these special zones. This approach, originally developed for the MWRM, was adopted for special zones in other regional models where no further data was available.

A2.2 Knock Airport

Knock Airport is the 4th largest airport in Ireland in terms of passengers (approximately 700,000/year) and is located in the WRM area, and therefore has its own special zone. This section discusses how the highway and PT Attractions and Productions are generated.

A2.2.1 Demand

Terminal traffic – that is passengers who started or ended their journey at Knock Airport was 677,400 in 2012 (Source: DAA). DAA data provided by the NTA was used to break down the annual passenger numbers down to represent a typical weekday in November.

- 677,400 – Annual passenger numbers;
- 40,350 – Monthly passengers in November;
- 7,450 – Typical weekday (5day) passenger numbers; and
- 1,490 – Typical passenger numbers in November on a single day.

This approach to breaking down the annual passenger numbers considers the seasonality of high passenger trips in the summer and ensures that a typical weekday is considered.

A2.2.2 Flows by time period

The next consideration was to break down the daily passenger flow by time period. Flight arrival and departure data was obtained from the Knock Airport website. A profile was developed for trips (attractions and productions) from arrivals and departures information. Access to the airport up to an hour and a half before the flight departure was factored into the time period profile build. Table A2.1 presents the time period profile for trips to and from the airport.

Table A2.1 Passenger Trips Profile by time period

Time Periods	Time	Arrivals %	Departures %
AM	0700 - 1000	0%	24%
LT	1000 - 1300	41%	48%
SR	1300 - 1600	36%	19%
PM	1600 - 1900	14%	10%

OP	1900 - 0700	9%	0%
Total		100%	100%

CSO Aviation Statistics for all Irish airports including Knock Airport show that passenger numbers are split 50:50 between arrivals and departures. Therefore, if 677,400 passengers use Knock Airport it will be assumed that the split between arrivals and departures is 338,700 passengers each.

DAA surveys contained information on mode share for Dublin and a number of UK Airports. Figure A2.1 shows a summary of this data.

U.K Airport	**% Public Transport Mode Share for passengers**
Stansted	47%
Heathrow	40%
Gatwick	38%
* Dublin	33%
Edinburgh	27%
Glasgow	11%
Newcastle	13%
Manchester	13%

* *Figure for Dublin is from the 2011 NTA survey,*

U.K. figures relate to 2009 and 2010 data

Figure A2.1 PT Mode Share comparison of Dublin with other UK airports

Knock is not a large airport and, in the absence of specific observed mode share data, it was assumed that 10% of all trips to Knock Airport are by public transport.

A2.3 Car trips per passenger

There were two final factors to consider before the number of car movements generated by Knock Airport could be finalised. These were car occupancies and the proportion of drop off / pick up activity (Kiss & Fly).

Available case studies from other airports show that typical car occupancy is a value of 2. Taxis and Kiss & Fly trips generate four vehicle trips per return air trip as the cars make the return journey without the air passenger(s). This is in contrast to two trips when passengers park at the Airport. Evidence from other airport studies show car drop-off and pick-up represents 30% - 40% of total trips.

- Cork Airport – drop off / pick up approx. 30%[24]
- Leeds Bradford Airport – drop off / pick up approx. 34%[25]
- Glasgow Airport – drop off / pick up approx. 32.3%[26]

Therefore car drop off / pick up was be assumed to be 30%.

A2.4 Output production / attractions

Combining all of the data above gives the overall PT and HW attractions and productions in Table A2.2.

Table A2.2 PT & HW Attractions and Productions

Time Periods	Time	PT Attr	PT Prod	HW Attr	HW Prod
AM	0700 - 1000	18	0	104	0
LT	1000 - 1300	35	30	208	178
SR	1300 - 1600	14	27	83	158
PM	1600 - 1900	7	10	42	59
OP	1900 - 0700	0	7	0	40
		75	75	436	436

A2.4.1 Period to Peak Hour Factor

The period to peak hour factor was assumed to be 0.50 in order to get trips from the three hour time periods to the peak hour period. The factor may appear high but due to the actual distribution of passenger trips to the airport being difficult to quantify due to the absence of observed data, the 0.50 factor is considered reasonable.

A2.4.2 Split of Inbound and outbound trips by destination type

Due to the minimal demand for internal flights Irish travellers are assumed to derive from homes and businesses, overseas leisure travellers from homes and hotels and overseas business visitors from homes and hotels. In the regional models these splits are based on the NACE codes giving the distributions of hotels, employment and housing and assumptions about the likely directionality of trips at different times of day. The finalised split is shown in Table A2.3.

[24] http://www.corkcoco.ie/co/pdf/359024904.pdf

[25] http://www.leedsbradfordairport.co.uk/media/2175/route-to-2030-surface-access-strategy.pdf

[26] http://www.glasgowairport.com/media/37881/glasgow-surface-access-2009.pdf

Table A2.3 Split of Inbound and outbound trips by destination type

Time Period	Trips to airport			Trips from airport		
	Hotels	Businesses	Homes	Hotels	Businesses	Homes
07:00-10:00	13%	7%	80%	53%	27%	20%
10:00-13:00	40%	10%	50%	40%	10%	50%
13:00-16:00	40%	10%	50%	40%	10%	50%
16:00-19:00	80%	0%	20%	20%	0%	80%
19:00-07:00	80%	0%	20%	20%	0%	80%

A2.4.3 Distribution

In the absence of an Origin-Destination Survey, trip ends were distributed based on a gravity model and attraction factors by type of trips.

Home Trips

The matrix build for home trips was developed based on population data which was used to determine how trips would be distributed using a gravity model with costs based on distance.

The sensitivity to distance was derived from the Dublin Airport trip distribution where an accurate survey was undertaken with origin-destination surveys. All "Other" trip ends of the special zone of Dublin Airport extracted from the ERM model were used at the 24h level. This gave a lambda value of 0.03 (km^{-1}).

$$T_{i\rightarrow Airport} = Attr_{airport} \times \frac{Pop_i \times \exp(-\lambda . Dist_{i\rightarrow Airport})}{\sum_{j\in Zones}[Pop_j \times \exp(-\lambda . Dist_{j\rightarrow Airport})]}$$

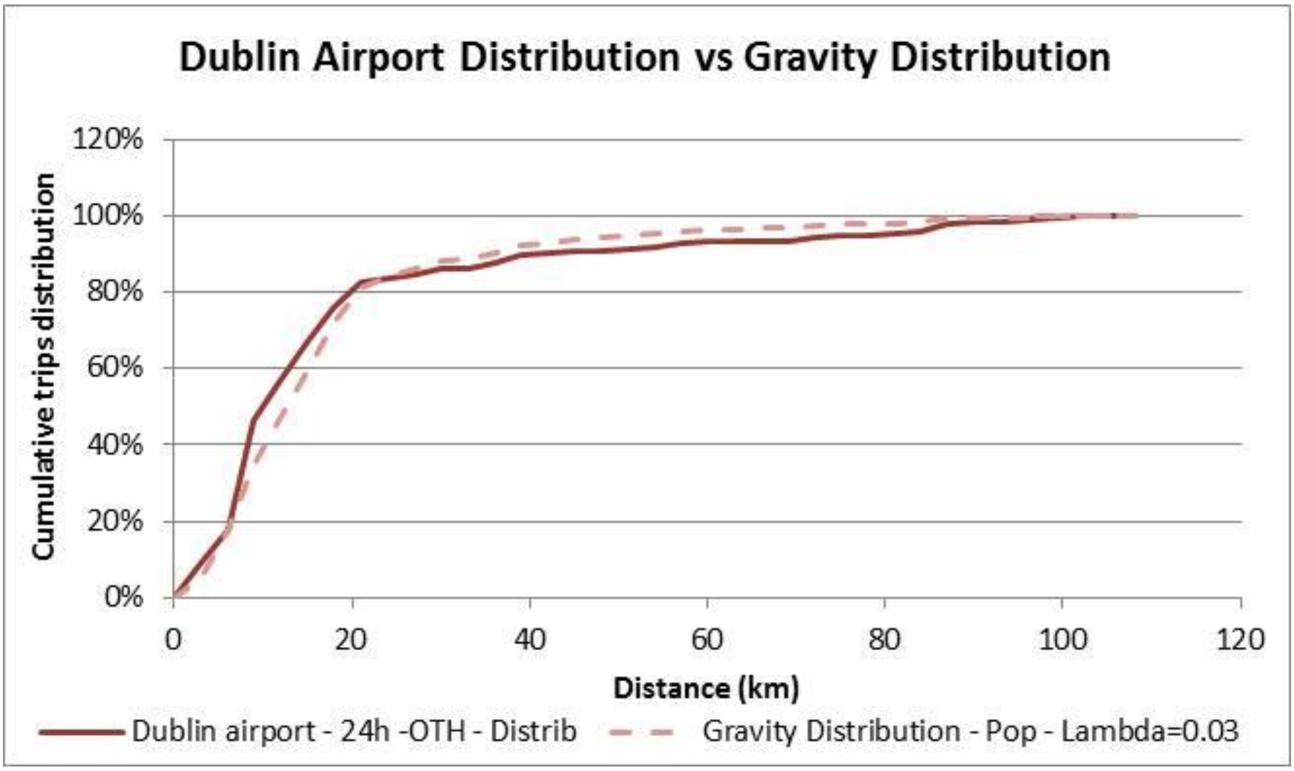


Figure A2.2 Dublin Airport – Distribution vs Gravity Distribution

The exponential gravity model with the estimated sensitivity of 0.03 has therefore been applied to all WRM zones (internal + externals). The obtained distribution is shown Figure A2.3 and suggests that 64% of trips heading to Knock airport are coming from internal zones and 36% of trips are from external zones.

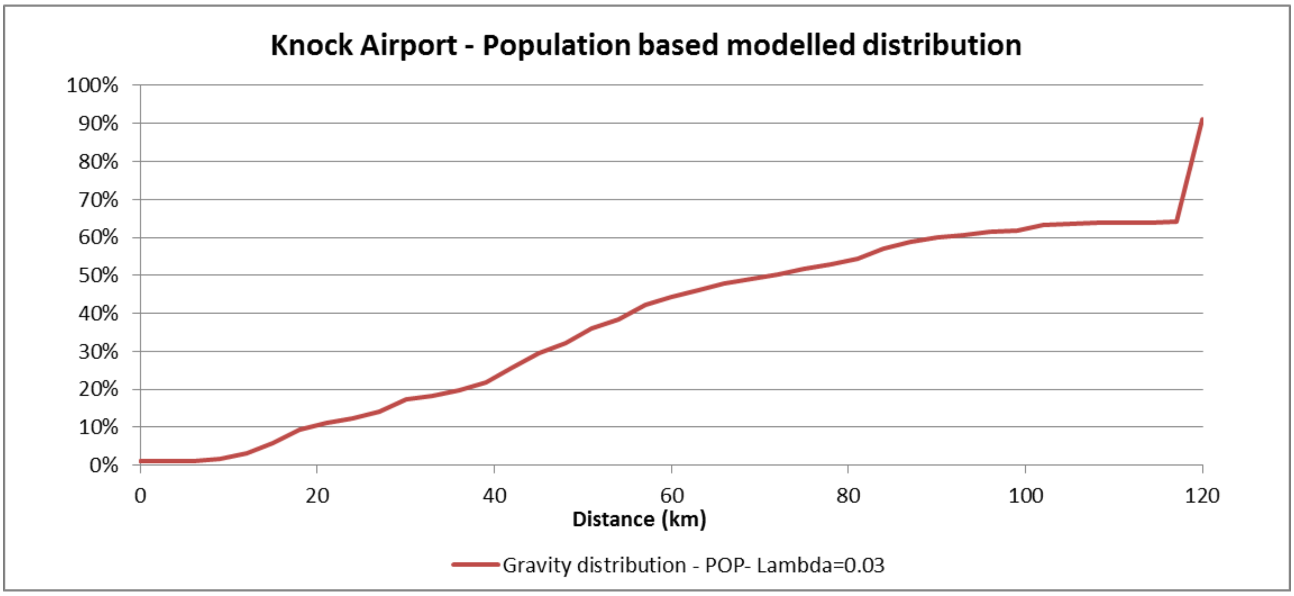


Figure A2.3 Knock Airport – Pop based modelled distribution

Leisure Trips

The NACE Building Codes dataset was used to determine the distribution of leisure trips. Hotel activity was cross referenced with the WRM zone plan and the trip distribution was weighted towards urban areas in order to determine the overall distribution of leisure trips.

Business Trips

The distribution of business trips was based on 'white collar' commuting attractions from the FDM.

A2.5 Galway Port

Galway Port generates a large number of HGV trips onto the network. Its activities include warehousing, logistics and cargo handling. The creation of this special zone ensured that port related HGV movements were considered in the model.

A2.5.1 Demand

Evidence from the CSO statistics (2012) indicates that 461,000 tons of freight went through Galway Port in the last trimester of that year. Based on this figure, the generation of 230 HGV movements was estimated per working day.

A2.5.2 Flows by time period

In order to assign the 230 HGV daily movements to the network it was necessary to determine the percentage of HGV trips by time period.

As no traffic count data was available for the road network around Galway Port, data from Transport Infrastructure Ireland near Foynes Port on the N69 were used. The HGV profile from this site was used to determine the percentage of HGV trips by time period.

A2.5.3 Output productions / attractions

Combining these two sets of factors gives the figures shown in Table A2.4.

Table A2.4 HGV attractions and productions

Time Periods	% HGV Trips by TP	HGV Prod	HGV Attr
AM	24%	27	27
LT	27%	31	31
SR	26%	30	30
PM	13%	15	15
OP	10%	11	11
Total	100%	115	115

A2.6 Distribution

Having established the expected numbers of trips NACE data was used to distribute them. NACE is a Statistical Classification of Economic Activities and is used as the CSO Standard Classification of Industrial Activity. In this case the NACE Building Codes Database version 1.55 was used to determine the port related trips and the proportion of the activity deriving from each relevant zone. Port related activity was assumed to derive from forestry and logging, mining and quarrying, land transport and transport via pipelines, warehousing, and support activities for transportation.

Annex 3 Final demand model parameter values

The data included is as follows:

- Table A3.5 Production tour proportions by purpose
- Table A3.6 Attraction tour proportions by purpose
- Table A3.7 Finalised distribution and mode split parameters
- Table A3.8 Finalised period to hour factors
- Table A3.9 Finalised parking distribution calibration parameters
- Table A3.10 Finalised special zone calibration parameters

Table A3.5 Production tour proportions by purpose

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25
P01	0.02252	0.02928	0.13964	0.46396	0.08108	0.00000	0.01351	0.01126	0.02703	0.00676	0.00000	0.00000	0.00225	0.07207	0.02478	0.00000	0.00000	0.00000	0.01577	0.02928	0.00901	0.00000	0.00901	0.02252	0.02027
P02	0.02252	0.02928	0.13964	0.46396	0.08108	0.00000	0.01351	0.01126	0.02703	0.00676	0.00000	0.00000	0.00225	0.07207	0.02478	0.00000	0.00000	0.00000	0.01577	0.02928	0.00901	0.00000	0.00901	0.02252	0.02027
P03	0.10526	0.04211	0.13684	0.32632	0.03158	0.00000	0.02105	0.03158	0.02105	0.06316	0.00000	0.00000	0.03158	0.06316	0.03158	0.00000	0.00000	0.00000	0.00000	0.06316	0.00000	0.00000	0.01053	0.02105	0.00000
P04	0.10526	0.04211	0.13684	0.32632	0.03158	0.00000	0.02105	0.03158	0.02105	0.06316	0.00000	0.00000	0.03158	0.06316	0.03158	0.00000	0.00000	0.00000	0.00000	0.06316	0.00000	0.00000	0.01053	0.02105	0.00000
P05	0.02581	0.02581	0.84516	0.07097	0.01290	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00645	0.00645	0.00000	0.00000	0.00000	0.00000	0.00645	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
P06	0.03261	0.04348	0.43478	0.36957	0.05435	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01087	0.00000	0.00000	0.00000	0.00000	0.01087	0.02174	0.00000	0.00000	0.00000	0.00000	0.02174
P07	0.01724	0.03448	0.20690	0.41379	0.05172	0.00000	0.00000	0.05172	0.03448	0.00000	0.00000	0.00000	0.01724	0.05172	0.00000	0.00000	0.00000	0.00000	0.00000	0.08621	0.00000	0.00000	0.00000	0.00000	0.03448
P08	0.02581	0.02581	0.84516	0.07097	0.01290	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00645	0.00645	0.00000	0.00000	0.00000	0.00000	0.00645	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
P09	0.03261	0.04348	0.43478	0.36957	0.05435	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01087	0.00000	0.00000	0.00000	0.00000	0.01087	0.02174	0.00000	0.00000	0.00000	0.00000	0.02174
P10	0.01724	0.03448	0.20690	0.41379	0.05172	0.00000	0.00000	0.05172	0.03448	0.00000	0.00000	0.00000	0.01724	0.05172	0.00000	0.00000	0.00000	0.00000	0.00000	0.08621	0.00000	0.00000	0.00000	0.00000	0.03448
P11	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P12	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P13	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P14	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P15	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P16	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P17	0.03902	0.08293	0.02439	0.00976	0.00976	0.00000	0.19024	0.13171	0.01951	0.01463	0.00000	0.00000	0.07317	0.09756	0.00976	0.00000	0.00000	0.00000	0.15122	0.07805	0.00000	0.00000	0.00000	0.00000	0.06829
P18	0.05543	0.05322	0.02217	0.01996	0.00222	0.00000	0.12860	0.07761	0.01996	0.00665	0.00000	0.00000	0.05543	0.10421	0.00665	0.00000	0.00000	0.00000	0.12639	0.13304	0.00000	0.00000	0.00000	0.00000	0.18847
P19	0.00000	0.06818	0.02273	0.04546	0.04546	0.00000	0.22727	0.11364	0.09091	0.02273	0.00000	0.00000	0.06818	0.02273	0.00000	0.00000	0.00000	0.00000	0.11364	0.06818	0.00000	0.00000	0.00000	0.00000	0.09091
P20	0.00000	0.18421	0.00000	0.07895	0.00000	0.00000	0.15790	0.05263	0.07895	0.00000	0.00000	0.00000	0.02632	0.07895	0.00000	0.00000	0.00000	0.00000	0.13158	0.02632	0.00000	0.00000	0.00000	0.00000	0.18421
P21	0.12069	0.05172	0.01724	0.00000	0.00000	0.00000	0.20690	0.10345	0.01724	0.03448	0.00000	0.00000	0.17241	0.10345	0.00000	0.00000	0.00000	0.00000	0.08621	0.01724	0.00000	0.00000	0.00000	0.00000	0.06897
P22	0.02941	0.07353	0.00000	0.00735	0.01471	0.00000	0.30147	0.10294	0.01471	0.00000	0.00000	0.00000	0.20588	0.02941	0.00735	0.00000	0.00000	0.00000	0.06618	0.05882	0.00000	0.00000	0.00000	0.00000	0.08824
P23	0.06329	0.07595	0.00000	0.00000	0.00000	0.00000	0.35443	0.07595	0.00000	0.00000	0.00000	0.00000	0.17722	0.05063	0.00000	0.00000	0.00000	0.00000	0.12658	0.01266	0.00000	0.00000	0.00000	0.00000	0.06329
P24	0.04082	0.04082	0.06122	0.04082	0.00000	0.00000	0.06122	0.12245	0.00000	0.00000	0.00000	0.00000	0.00000	0.22449	0.00000	0.00000	0.00000	0.00000	0.08163	0.20408	0.00000	0.00000	0.00000	0.00000	0.12245
P25	0.01587	0.07937	0.01587	0.03175	0.01587	0.00000	0.04762	0.06349	0.00000	0.01587	0.00000	0.00000	0.03175	0.12698	0.04762	0.00000	0.00000	0.00000	0.14286	0.15873	0.00000	0.00000	0.00000	0.00000	0.20635
P26	0.02439	0.04878	0.00000	0.04878	0.00000	0.00000	0.09756	0.14634	0.02439	0.02439	0.00000	0.00000	0.17073	0.17073	0.00000	0.00000	0.00000	0.00000	0.09756	0.12195	0.00000	0.00000	0.00000	0.00000	0.02439
P27	0.05063	0.06329	0.08861	0.11392	0.01266	0.00000	0.10127	0.10127	0.01266	0.06329	0.00000	0.00000	0.01266	0.03798	0.02532	0.00000	0.00000	0.00000	0.06329	0.08861	0.00000	0.00000	0.00000	0.00000	0.16456
P28	0.10355	0.05030	0.14497	0.09172	0.00296	0.00000	0.12722	0.04734	0.00592	0.00592	0.00000	0.00000	0.11539	0.08284	0.00000	0.00000	0.00000	0.00000	0.07396	0.08580	0.00000	0.00000	0.00000	0.00000	0.06213
P29	0.02564	0.02564	0.23077	0.20513	0.00000	0.00000	0.17949	0.12821	0.00000	0.05128	0.00000	0.00000	0.05128	0.05128	0.00000	0.00000	0.00000	0.00000	0.02564	0.02564	0.00000	0.00000	0.00000	0.00000	0.00000
P30	0.23316	0.00000	0.00000	0.00000	0.00000	0.00000	0.33679	0.00000	0.00000	0.00000	0.00000	0.00000	0.25907	0.00000	0.00000	0.00000	0.00000	0.00000	0.09845	0.00000	0.00000	0.00000	0.00000	0.00000	0.07254
P31	0.23316	0.00000	0.00000	0.00000	0.00000	0.00000	0.33679	0.00000	0.00000	0.00000	0.00000	0.00000	0.25907	0.00000	0.00000	0.00000	0.00000	0.00000	0.09845	0.00000	0.00000	0.00000	0.00000	0.00000	0.07254
P32	0.17865	0.00000	0.00000	0.00000	0.00000	0.00000	0.22382	0.00000	0.00000	0.00000	0.00000	0.00000	0.28131	0.00000	0.00000	0.00000	0.00000	0.00000	0.21561	0.00000	0.00000	0.00000	0.00000	0.00000	0.10062
P33	0.27273	0.00000	0.00000	0.00000	0.00000	0.00000	0.22727	0.00000	0.00000	0.00000	0.00000	0.00000	0.21212	0.00000	0.00000	0.00000	0.00000	0.00000	0.25758	0.00000	0.00000	0.00000	0.00000	0.00000	0.03030

Table A3.6 Attraction tour proportions by purpose

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25
P01	0.02252	0.02928	0.13964	0.46396	0.08108	0.00000	0.01351	0.01126	0.02703	0.00676	0.00000	0.00000	0.00225	0.07207	0.02478	0.00000	0.00000	0.00000	0.01577	0.02928	0.00901	0.00000	0.00901	0.02252	0.02027
P02	0.02252	0.02928	0.13964	0.46396	0.08108	0.00000	0.01351	0.01126	0.02703	0.00676	0.00000	0.00000	0.00225	0.07207	0.02478	0.00000	0.00000	0.00000	0.01577	0.02928	0.00901	0.00000	0.00901	0.02252	0.02027
P03	0.10526	0.04211	0.13684	0.32632	0.03158	0.00000	0.02105	0.03158	0.02105	0.06316	0.00000	0.00000	0.03158	0.06316	0.03158	0.00000	0.00000	0.00000	0.00000	0.06316	0.00000	0.00000	0.01053	0.02105	0.00000
P04	0.10526	0.04211	0.13684	0.32632	0.03158	0.00000	0.02105	0.03158	0.02105	0.06316	0.00000	0.00000	0.03158	0.06316	0.03158	0.00000	0.00000	0.00000	0.00000	0.06316	0.00000	0.00000	0.01053	0.02105	0.00000
P05	0.02581	0.02581	0.84516	0.07097	0.01290	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00645	0.00645	0.00000	0.00000	0.00000	0.00000	0.00645	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
P06	0.03261	0.04348	0.43478	0.36957	0.05435	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01087	0.00000	0.00000	0.00000	0.00000	0.01087	0.02174	0.00000	0.00000	0.00000	0.00000	0.02174
P07	0.01724	0.03448	0.20690	0.41379	0.05172	0.00000	0.00000	0.05172	0.03448	0.00000	0.00000	0.00000	0.01724	0.05172	0.00000	0.00000	0.00000	0.00000	0.00000	0.08621	0.00000	0.00000	0.00000	0.00000	0.03448
P08	0.02581	0.02581	0.84516	0.07097	0.01290	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00645	0.00645	0.00000	0.00000	0.00000	0.00000	0.00645	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
P09	0.03261	0.04348	0.43478	0.36957	0.05435	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01087	0.00000	0.00000	0.00000	0.00000	0.01087	0.02174	0.00000	0.00000	0.00000	0.00000	0.02174
P10	0.01724	0.03448	0.20690	0.41379	0.05172	0.00000	0.00000	0.05172	0.03448	0.00000	0.00000	0.00000	0.01724	0.05172	0.00000	0.00000	0.00000	0.00000	0.00000	0.08621	0.00000	0.00000	0.00000	0.00000	0.03448
P11	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P12	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P13	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P14	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P15	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P16	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P17	0.03902	0.08293	0.02439	0.00976	0.00976	0.00000	0.19024	0.13171	0.01951	0.01463	0.00000	0.00000	0.07317	0.09756	0.00976	0.00000	0.00000	0.00000	0.15122	0.07805	0.00000	0.00000	0.00000	0.00000	0.06829
P18	0.05543	0.05322	0.02217	0.01996	0.00222	0.00000	0.12860	0.07761	0.01996	0.00665	0.00000	0.00000	0.05543	0.10421	0.00665	0.00000	0.00000	0.00000	0.12639	0.13304	0.00000	0.00000	0.00000	0.00000	0.18847
P19	0.00000	0.06818	0.02273	0.04546	0.04546	0.00000	0.22727	0.11364	0.09091	0.02273	0.00000	0.00000	0.06818	0.02273	0.00000	0.00000	0.00000	0.00000	0.11364	0.06818	0.00000	0.00000	0.00000	0.00000	0.09091
P20	0.00000	0.18421	0.00000	0.07895	0.00000	0.00000	0.15790	0.05263	0.07895	0.00000	0.00000	0.00000	0.02632	0.07895	0.00000	0.00000	0.00000	0.00000	0.13158	0.02632	0.00000	0.00000	0.00000	0.00000	0.18421
P21	0.12069	0.05172	0.01724	0.00000	0.00000	0.00000	0.20690	0.10345	0.01724	0.03448	0.00000	0.00000	0.17241	0.10345	0.00000	0.00000	0.00000	0.00000	0.08621	0.01724	0.00000	0.00000	0.00000	0.00000	0.06897
P22	0.02941	0.07353	0.00000	0.00735	0.01471	0.00000	0.30147	0.10294	0.01471	0.00000	0.00000	0.00000	0.20588	0.02941	0.00735	0.00000	0.00000	0.00000	0.06618	0.05882	0.00000	0.00000	0.00000	0.00000	0.08824
P23	0.06329	0.07595	0.00000	0.00000	0.00000	0.00000	0.35443	0.07595	0.00000	0.00000	0.00000	0.00000	0.17722	0.05063	0.00000	0.00000	0.00000	0.00000	0.12658	0.01266	0.00000	0.00000	0.00000	0.00000	0.06329
P24	0.04082	0.04082	0.06122	0.04082	0.00000	0.00000	0.06122	0.12245	0.00000	0.00000	0.00000	0.00000	0.00000	0.22449	0.00000	0.00000	0.00000	0.00000	0.08163	0.20408	0.00000	0.00000	0.00000	0.00000	0.12245
P25	0.01587	0.07937	0.01587	0.03175	0.01587	0.00000	0.04762	0.06349	0.00000	0.01587	0.00000	0.00000	0.03175	0.12698	0.04762	0.00000	0.00000	0.00000	0.14286	0.15873	0.00000	0.00000	0.00000	0.00000	0.20635
P26	0.02439	0.04878	0.00000	0.04878	0.00000	0.00000	0.09756	0.14634	0.02439	0.02439	0.00000	0.00000	0.17073	0.17073	0.00000	0.00000	0.00000	0.00000	0.09756	0.12195	0.00000	0.00000	0.00000	0.00000	0.02439
P27	0.05063	0.06329	0.08861	0.11392	0.01266	0.00000	0.10127	0.10127	0.01266	0.06329	0.00000	0.00000	0.01266	0.03798	0.02532	0.00000	0.00000	0.00000	0.06329	0.08861	0.00000	0.00000	0.00000	0.00000	0.16456
P28	0.10355	0.05030	0.14497	0.09172	0.00296	0.00000	0.12722	0.04734	0.00592	0.00592	0.00000	0.00000	0.11539	0.08284	0.00000	0.00000	0.00000	0.00000	0.07396	0.08580	0.00000	0.00000	0.00000	0.00000	0.06213
P29	0.02564	0.02564	0.23077	0.20513	0.00000	0.00000	0.17949	0.12821	0.00000	0.05128	0.00000	0.00000	0.05128	0.05128	0.00000	0.00000	0.00000	0.00000	0.02564	0.02564	0.00000	0.00000	0.00000	0.00000	0.00000
P30	0.23316	0.00000	0.00000	0.00000	0.00000	0.00000	0.33679	0.00000	0.00000	0.00000	0.00000	0.00000	0.25907	0.00000	0.00000	0.00000	0.00000	0.00000	0.09845	0.00000	0.00000	0.00000	0.00000	0.00000	0.07254
P31	0.23316	0.00000	0.00000	0.00000	0.00000	0.00000	0.33679	0.00000	0.00000	0.00000	0.00000	0.00000	0.25907	0.00000	0.00000	0.00000	0.00000	0.00000	0.09845	0.00000	0.00000	0.00000	0.00000	0.00000	0.07254
P32	0.17865	0.00000	0.00000	0.00000	0.00000	0.00000	0.22382	0.00000	0.00000	0.00000	0.00000	0.00000	0.28131	0.00000	0.00000	0.00000	0.00000	0.00000	0.21561	0.00000	0.00000	0.00000	0.00000	0.00000	0.10062
P33	0.27273	0.00000	0.00000	0.00000	0.00000	0.00000	0.22727	0.00000	0.00000	0.00000	0.00000	0.00000	0.21212	0.00000	0.00000	0.00000	0.00000	0.00000	0.25758	0.00000	0.00000	0.00000	0.00000	0.00000	0.03030

Table A3.7 Finalised distribution and mode split parameters

Purp	Alpha					Beta	Lambda			ASC values					Intrazonals				
	Car	PT	PnR	Walk	Cyc	All mds	Dest	Md Ch	Act Ch	Car	PT	PnR	Walk	Cyc	Car	PT	PnR	Walk	Cyc
1	0.866	0.280	2.320	0.501	0.418	N/A	-0.266	-0.133	-0.110	-8.000	16.000	-12.00	20.000	50.000	4.690	21.850	10.000	0.830	5.935
2	1.685	0.490	2.320	1.233	1.557	N/A	-0.043	-0.052	-0.104	-8.000	34.000	-12.00	20.000	50.000	4.525	30.000	10.000	14.250	18.180
3	0.001	0.750	1.000	1.047	2.186	N/A	-0.146	-0.230	-0.230	-3.000	48.750	-12.00	0.000	5.000	10.000	-30.00	10.000	-13.70	-14.00
4	0.001	0.714	1.000	1.938	3.151	N/A	-0.043	-0.052	-0.104	-3.000	72.990	-12.00	-5.000	20.000	10.000	23.610	10.000	19.250	17.720
5	1.017	0.130	2.320	0.551	0.857	N/A	-0.154	-0.154	-0.308	-15.00	15.000	-12.00	10.000	25.000	-6.780	-7.110	10.000	-1.380	-11.70
6	1.149	0.152	2.320	0.722	1.103	N/A	-0.129	-0.129	-0.259	-5.000	20.000	-12.00	10.000	20.000	-4.230	3.675	10.000	2.780	1.725
7	0.637	0.147	2.320	1.246	1.985	N/A	-0.120	-0.120	-0.240	0.000	44.940	-12.00	-20.00	0.000	1.520	7.180	10.000	30.000	29.670
8	0.001	0.296	1.000	1.256	1.564	N/A	-0.062	-0.062	-0.124	-10.00	25.000	-12.00	5.000	35.000	10.000	-30.00	10.000	-21.10	-30.00
9	0.001	0.306	1.000	1.228	1.752	N/A	-0.062	-0.062	-0.124	-10.00	20.000	-12.00	10.000	30.000	10.000	9.980	10.000	-0.420	-1.530
10	0.001	0.402	1.000	1.748	2.971	N/A	-0.062	-0.062	-0.124	-10.00	111.53	-12.00	-10.00	15.000	10.000	-6.380	10.000	30.000	30.000
11	1.542	0.440	2.080	0.606	0.579	N/A	-0.160	-0.160	-0.319	-20.00	10.000	-12.00	10.000	80.000	5.600	30.000	10.000	12.490	-15.30
12	2.236	0.745	2.080	0.683	1.103	N/A	-0.160	-0.160	-0.319	-10.00	10.000	-12.00	15.000	70.000	-30.00	3.875	10.000	-30.00	-30.00
13	1.863	0.605	2.080	0.559	0.639	N/A	-0.160	-0.160	-0.319	-20.00	10.000	-12.00	10.000	70.000	-30.00	-3.060	10.000	-30.00	-30.00
14	1.000	0.747	1.000	1.933	2.277	N/A	-0.062	-0.062	-0.124	0.000	40.000	-12.00	-20.00	90.000	-30.00	30.000	10.000	30.000	0.655
15	1.000	0.775	1.000	1.120	1.383	N/A	-0.062	-0.062	-0.124	0.000	10.000	-12.00	0.000	80.000	-30.00	30.000	10.000	-19.80	-30.00
16	1.000	0.751	1.000	1.103	1.254	N/A	-0.062	-0.062	-0.124	0.000	10.000	-12.00	0.000	80.000	-30.00	30.000	10.000	-10.40	-26.30
17	1.485	0.565	2.080	0.483	0.503	N/A	-0.157	-0.157	-0.313	-20.00	5.000	-12.00	20.000	70.000	11.680	30.000	10.000	4.855	-18.40
18	1.325	0.458	2.080	0.437	0.598	N/A	-0.157	-0.157	-0.314	-15.00	5.000	-12.00	15.000	70.000	11.350	30.000	10.000	8.820	-14.60
19	1.000	0.825	1.000	1.572	2.699	N/A	-0.062	-0.062	-0.124	0.000	35.000	-12.00	-10.00	80.000	-30.00	26.700	10.000	14.320	-8.210
20	1.000	0.815	1.000	1.565	2.815	N/A	-0.062	-0.062	-0.124	0.000	35.000	-12.00	-10.00	80.000	-30.00	6.110	10.000	-8.720	-25.20
21	1.309	0.775	2.080	0.377	0.376	N/A	-0.320	-0.160	-0.160	-15.00	10.000	-12.00	10.000	70.000	3.340	30.000	10.000	-0.850	-5.950
22	2.195	0.630	2.080	0.636	0.878	N/A	-0.159	-0.159	-0.318	-15.00	5.000	-12.00	10.000	80.000	4.600	20.900	10.000	-12.30	-0.540
23	1.000	0.865	1.000	2.766	5.194	N/A	-0.062	-0.062	-0.124	0.000	100.00	-12.00	-30.00	70.000	-30.00	-30.00	10.000	-20.90	-30.00
24	0.535	0.191	2.080	0.376	0.292	N/A	-0.159	-0.159	-0.318	-15.00	10.000	-12.00	10.000	70.000	0.360	19.600	10.000	-10.90	3.660
25	0.720	0.230	2.080	0.417	3.052	N/A	-0.158	-0.158	-0.315	0.000	10.000	-12.00	10.000	50.000	6.270	25.420	10.000	5.610	24.760
26	1.000	0.431	1.000	0.859	1.107	N/A	-0.062	-0.062	-0.124	0.000	5.000	-12.00	0.000	80.000	-30.00	30.000	10.000	-10.30	-23.60
27	1.075	0.424	2.080	0.426	0.629	N/A	-0.100	-0.153	-0.306	-9.000	10.900	-12.00	10.000	20.000	-13.90	13.850	10.000	-15.00	-13.10
28	1.117	0.376	2.080	0.132	0.591	N/A	-0.158	-0.158	-0.315	-25.00	10.000	-12.00	20.000	30.000	4.995	26.560	10.000	-3.380	-16.30
29	1.000	0.775	1.000	1.061	2.131	N/A	-0.062	-0.062	-0.124	-5.000	20.000	-12.00	0.000	30.000	-30.00	30.000	10.000	11.030	3.470
30	0.573	0.212	2.080	0.222	0.404	N/A	-0.106	-0.146	-0.291	-12.00	2.140	-12.00	20.000	25.000	-20.30	6.595	10.000	-7.420	-30.00
31	1.000	0.491	1.000	1.092	1.413	N/A	-0.045	-0.062	-0.123	0.000	-2.000	-12.00	0.000	35.000	-30.00	5.115	10.000	-30.00	-30.00
32	1.190	0.383	2.080	0.390	0.392	N/A	-0.103	-0.183	-0.325	-20.00	0.000	-12.00	15.000	70.000	6.140	23.500	10.000	-0.970	-15.30
33	1.000	0.566	1.000	1.681	1.521	N/A	-0.062	-0.152	-0.304	0.000	0.000	-12.00	0.000	80.000	-30.00	30.000	10.000	27.500	5.285

Table A3.8 Finalised period to hour factors

Time Period	Car	PT	Walk	Cycle
AM	0.46864	0.47000	0.54000	0.52000
IP1	0.35267	0.33000	0.33000	0.33000
IP2	0.45467	0.33000	0.33000	0.33000
PM	0.48318	0.60000	0.40000	0.42000
OP	0.08000	0.08000	0.08000	0.08000

Table A3.9 Finalised parking distribution calibration parameters

Title	Value
Car occupancy	1.18
Minimum search time	0.9 minutes
Maximum search time	15 minutes
Search time scaling parameter	1.46
Value of Time	11.57
Lambda	-0.3
Weight on walk time	2

Table A3.10 Finalised special zone calibration parameters

	Airport EMP	Airport OTH
Charge (parking or taxi fare)	40	30
Lambda	-0.5	-0.5
Alpha car	1.28	1.26
Beta car	0	0
ASC car	0	0
Alpha PT	0.32	0.33
Beta PT	0	0
ASC PT	75	98
Prop car = taxi	0.42	0.42
Prop car = Kiss & Fly/Sail	0.51	0.51

Annex 4 Park and Ride Calibration

A4.1 Introduction

This chapter sets out the Park and Ride model development and calibration methodology for the WRM.

To undertake this, several steps are required:

- Identify park and ride sites;
- Collate site characteristics such as capacity and charges;
- Identify observed data for calibration;
- Define Park and Ride site catchments;
- Create site files; and,
- Calibrate.

A4.2 Model development

A4.2.1 Sites

23 park and ride sites were identified in the WRM, all of which are rail based and are outlined in Table A4.11.

Table A4.11 WRM Park and Ride sites

Site	Capacity	Charge (€)	Observed usage
Sligo	42	4	33
Collooney	57	4	20
Ballymote	30	0	43
Boyle	60	4	23
Carrick-on-Shannon	20	0	26
Dromod	30	0	38
Ballina	22	0	16
Foxford	25	0	5
Castlebar	43	4	31
Westport	51	4	31
Claremorris	30	0	20
Ballyhaunis	20	0	12
Castlerea	34	0	15
Roscommon	25	0	16
Ballinasloe	47	4	28
Woodlawn	60	0	20
Attymon	8	0	6
Athenry	70	4	49
Oranmore	140	0	50
Galway	60	4	51
Craughwell	120	0	12
Ardrahan	53	0	5
Gort	120	0	12

The Irish Rail website was consulted to gather pertinent information about each site such as capacity and any associated parking charges.

A4.2.2 Observed usage

Unfortunately, during the data collection programme, no data was collected for Park and Ride sites within the WRM region. As such, it was decided that the only feasible alternative method for determining site usage was via Google Maps imagery, further supported by BING Maps imagery. While this data is not wholly robust as the date or time of the day when the image was captured is not known it is the only data source available.

From this exercise it was determined that there is a supply of 1,167 parking spaces across the 23 sites, with an estimated demand of 562 spaces (48%).

A4.2.3 Site Catchments

Defining site origin catchments involves identifying all zones which could use each specific site as part of their journey. This process was undertaken manually within ArcGIS. Firstly, both rail stations and the railway line within the WRM were plotted. Zone centroids were then added to the map. Using a logical approach, by looking at site locations, road corridors and main destination zones, zones which would likely use a park and ride site were recorded and added to the origin catchment column within the site file. This approach assists in constraining the likely number of people who would use a park and ride site and eliminate illogical movements being made.

For destination zone catchments for each site, everywhere within the WRM was added as a destination to allow for park and ride movements as part of an overall journey.

A4.3 Site file generation

The site file lists each site and pertinent characteristics for use in calculating demand, including:

- Capacity;
- Charges;
- Attraction Factors;
- Site origin catchments; and
- Site destination catchments.

These attraction factors represent additional costs of using Park and Ride at a particular site and can be either increased or decreased on a site by site basis. These values are set independently for each site for each of the modelled time periods. Adjusting these factors helps manage demand at each site during the calibration process. Initially these factors were set to a default value of 1.1 before further refinement during calibration.

A4.4 Park and Ride Calibration

Two main elements influence the park and ride calibration process:

- Expected demand (target persons); and
- Mode share.

A4.4.1 Expected Demand

With no observed data to use in the calculation of the expected demand for each site in each time period, an alternative method was created to distribute the “observed” capacities recorded from Google Maps imagery. This exercise was completed utilising the boardings file output by the main Public Transport model.

The boardings files were available for each modelled time period (with the exception of OP) and listed the total boardings within that time period at each station. From this data the boardings for each of the 23 stations and sites within the WRM was extracted and proportions calculated for each time period based on the total boardings at the station, for example, for Sligo, it was calculated that 29% of daily boardings took place in the AM period, 13% in IP1, 22% in IP2 and 36% in the PM period.

These proportions were used to disaggregate the “observed” demand figures by time period to provide car park usage numbers which were then multiplied by the assumed Park and Ride user car occupancy figure of 1.44 to provide the target number of people using each site in each time period. These target figures are shown in Table A4.12

Table A4.12 Derived calibration data

Station	Boardings				Occupied Spaces				Users			
	AM	IP1	IP2	PM	AM	IP1	IP2	PM	AM	IP1	IP2	PM
Sligo	29%	13%	22%	36%	10	4	7	12	14	6	11	17
Collooney	23%	35%	20%	22%	5	7	4	4	7	10	6	6
Ballymote	38%	8%	15%	39%	16	4	7	17	23	5	9	24
Boyle	34%	9%	19%	37%	8	2	4	9	11	3	6	12
Carrick-on-Shannon	8%	11%	25%	56%	2	3	6	15	3	4	9	21
Dromod	17%	25%	23%	35%	7	10	9	13	10	14	12	19
Ballina	54%	0%	22%	24%	9	0	3	4	13	0	5	6
Foxford	48%	5%	20%	27%	2	0	1	1	3	0	1	2
Castlebar	65%	10%	20%	6%	20	3	6	2	29	4	9	3
Westport	62%	12%	26%	0%	19	4	8	0	28	5	12	0
Claremorris	27%	11%	27%	36%	5	2	5	7	8	3	8	10
Ballyhaunis	47%	14%	22%	17%	6	2	3	2	8	2	4	3
Castlerea	44%	9%	21%	26%	7	1	3	4	9	2	5	6
Roscommon	40%	11%	25%	24%	6	2	4	4	9	2	6	5
Ballinasloe	62%	7%	12%	19%	17	2	3	5	25	3	5	8
Woodlawn	47%	2%	20%	32%	9	0	4	6	14	0	6	9
Attymon	0%	0%	0%	0%	0	0	0	0	0	0	0	0
Athenry	44%	7%	19%	31%	22	3	9	15	31	5	13	22
Oranmore	55%	3%	14%	28%	28	1	7	14	40	2	10	20
Galway	24%	10%	28%	37%	12	5	14	19	18	7	21	28
Craughwell	64%	9%	17%	10%	8	1	2	1	11	2	3	2
Ardrahan	57%	12%	25%	6%	3	1	1	0	4	1	2	0
Gort	55%	8%	20%	17%	7	1	2	2	10	1	3	3

A4.4.2 Mode Share

As previous versions of the model were established with Park and Ride switched off, the first step was to re-run the model with Park and Ride switched on, so as to create some demand.

The model generates standard Park and Ride output files which are read automatically into a macro-enabled spreadsheet. These files are:

- PNR_OUTPUT_Site_Usage_By_Tour.csv – which provides demand in persons per site per time period;
- *_PnR_TP_Out.mat – which contains car and PT based trips per purpose type by time period using park and ride; and
- *_MDC_Params – which includes other costs of using each mode.

Once these have been read into the spreadsheet it calculates the mode share and the modelled demand for each of the individual sites.

Park and Ride ASC values were then adjusted and the model re-run until a plausible level of overall Park and Ride usage was obtained.

For the WRM a target usage of Park and Ride was estimated as 801 people. The ASC values were continually reduced but the model did not generate any Park & Ride demand.

A4.5 Site calibration

As there was no Park and Ride usage, Park and Ride site calibration was not undertaken.

A4.6 Recommendations

Several elements should be investigated in future to improve Park and Ride calibration in the WRM. Firstly, other costs within the model for all modes should be investigated. In order to calibrate other elements of the model, costs have been adjusted which has had a negative impact on the Park and Ride module.

Secondly, it would be recommended that observed data is collated at each rail station within the model region in order to produce robust and accurate target levels of site usage. These numbers can then be used to refine the distribution levels of Park and Ride site users in the model and produce a higher level of calibration.

Finally, network coding within the model could be looked at to address accessibility to Park and Ride sites along centroid connectors. Refining this coding could reduce the number of people who currently walk long distances to use rail stations and weight these movements more towards using Park and Ride. This process could also be carried out in conjunction with a review of public transport costs within the model to improve overall calibration levels.

Údarás
Náisiúnta Iompair
National Transport Authority

National Transport Authority
Dún Scéine
Harcourt Lane
Dublin 2

Údarás Náisúnta Iompair
Dún Scéine
Lána Fhearchair
Baile Átha Cliath 2

Tel: +353 1 879 8300
Fax: +353 1 879 8333
No. XXXXXXXX 22-12-2016

www.nationaltransport.ie

Appendix D

Highway Link and Turn Count Calibration

AM Link and Turn Counts

West Screenline - Inbound

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
50129	51417		R336 Barna Road	710	714	4	1%	0.2
51324	50844		Cappagh Road	25	19	-5	-22%	1.2
51428	51427		Rahoon Road	137	129	-8	-6%	0.7
51410	51413		Letteragh Road	47	43	-4	-9%	0.6
51403	50910		N59 Clifden Road	927	930	2	0%	0.1
Screenline Total				1846	1835	-11	-1%	0.3

West Screenline - Outbound

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
51417	50129		R336 Barna Road	430	430	1	0%	0.0
50844	51324		Cappagh Road	24	23	-1	-3%	0.1
51427	51428		Rahoon Road	43	43	0	0%	0.0
51413	51410		Letteragh Road	10	13	3	31%	0.9
50910	51403		N59 Clifden Road	225	234	9	4%	0.6
Screenline Total				731	743	12	2%	0.4

R338 Screenline - Inbound

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
50642	50654		R336 Salthill Road	827	664	-163	0	6
50549	52253		Dr Mannix Road	345	319	-26	-7%	1.4
50632	50664		Taylor's Hill Road	444	422	-21	-5%	1.0
50542	52319		Inishannagh Park	404	401	-3	-1%	0.2
Screenline Total				2020	1807	-213	-11%	4.9

R338 Screenline - Outbound

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
50654	50642		R336 Salthill Road	367	373	7	2%	0.3
52253	50549		Dr Mannix Road	126	139	13	11%	1.2
50664	50632		Taylor's Hill Road	137	139	3	2%	0.2
52319	50542		Inishannagh Park	85	85	0	-1%	0.0
Screenline Total				715	737	22	3%	0.8

River Corrib Screenline - Eastbound

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
52246	50925		Wolfe Tone Bridge	1015	1021	6	1%	0.2
50805	52310		William O'Brien Bridge	459	457	-2	0%	0.1
50918	50798		Salmon Weir Bridge	474	455	-19	0	1
50942	50486		Quincentenary Bridge Upper	1685	1680	-5	0%	0.1
Screenline Total				3633	3612	-20	-1%	0.3

River Corrib Screenline - Westbound

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
50925	52246		Wolfe Tone Bridge	594	604	10	2%	0.4
52310	50805		William O'Brien Bridge	132	141	10	7%	0.8
50798	50918		Salmon Weir Bridge	724	736	12	2%	0.4
50486	50942		Quincentenary Bridge Upper	1562	1537	-25	-2%	0.6

Screenline Total				3012	3019	7	0%	0.1

Ballinfoyle Screenline - outbound

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
50681	50741		Lough Atalia Road	421	398	-23	-5%	1.1
50738	50498		R339 College Road	161	174	12	8%	1.0
50752	52332		R338 Moneenageisha Road	685	495	-191	-28%	7.8
52630	53403		N6 Bothar na dTreabh	945	1127	182	19%	5.7
50766	70008		N84 Headford Road	268	270	2	1%	0.1
Screenline Total				2481	2464	-17	-1%	0.3

Ballinfoyle Screenline - Inbound

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
50741	50681		Lough Atalia Road	768	841	73	9%	2.6
50498	50738		R339 College Road	233	269	36	16%	2.3
52332	50752		R338 Moneenageisha Road	594	490	-103	-17%	4.4
53403	52630		N6 Bothar na dTreabh	1052	977	-75	-7%	2.3
Screenline Total				2647	2578	-69	-3%	1.8

East Screenline - outbound

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
51352	53096		R338 Coast Road	213	195	-18	-9%	1.3
52766	50049		R446 (Cartron)	586	593	7	1%	0.3
52392	52694		N6 (Coolagh)	408	468	60	15%	2.9
50860	51378		R339 (Briarhill)	240	186	-54	-22%	3.7
51389	51390		N83 Tuam Road	332	339	7	2%	0.4
50137	51065		N84 Headford Road	239	241	2	1%	0.1
Screenline Total				2018	2022	4	0%	0.1

East Screenline - inbound

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
53096	51352		R338 Coast Road	676	626	-50	-7%	1.9
50043	51372		R446 (Cartron)	1201	1215	15	1%	0.4
52964	53012		N6 (Coolagh)	1054	893	-161	-15%	5.2
51378	50860		R339 (Briarhill)	793	836	43	5%	1.5
51390	51389		N83 Tuam Road	1230	1199	-31	-3%	0.9
51065	50137		N84 Headford Road	1090	1094	4	0%	0.1
Screenline Total				6044	5864	-180	-3%	2.3

Individual Target Counts - AM

				Observed Flow (VEH)		Modelled Flow (VEH)	Difference (num)	Difference (%)	
A Node	B Node	C Node	Road Name	Total		Total	Total	Total	GEH
50648	50546		Site 57 - B24 Northbound	585	1	574	-11	-2%	0.5
50546	50648		Site 57 - B24 Southbound	305	1	294	-11	-4%	0.6
50539	52285		Site 46 - B24 Northbound	452	1	441	-11	-2%	0.5
52285	50539		Site 46 - B24 Southbound	224	1	227	3	1%	0.2
52685	52367		Site 12 - B24 Northbound	38	1	38	0	1%	0.0
52367	52685		Site 12 - B24 Southbound	387	1	429	42	11%	2.1
50487	52667		Site 14 - B24 Northbound	1373	1	1394	21	2%	0.6
53003	52803		Site 14 - B24 Southbound	1418	1	1281	-137	-10%	3.7
50966	50750		Site 40 - B24 Northbound	170	1	172	2	1%	0.2

53011	50930		Site 35 - B24 Eastbound	774	1	762	-13	-2%	0.5
50930	52583		Site 35 - B24 Westbound	1061	1	1052	-9	-1%	0.3
52561	50577		Site 38 - B24 Northbound	373	1	357	-15	-4%	0.8
50577	52561		Site 38 - B24 Southbound	653	1	640	-13	-2%	0.5
52248	52707		Site 20 - B24 Northbound	573	1	460	-113	-20%	5.0
52707	52248		Site 20 - B24 Southbound	933	1	987	55	6%	1.8
52703	52698		Site 22 - B24 Southbound	709	1	783	74	11%	2.7
52698	52703		Site 22 - B24 Northbound	614	1	656	42	7%	1.7
50629	50588		Site 56 - B24 Northbound	694	1	710	17	2%	0.6
50588	50629		Site 56 - B24 Southbound	484	1	485	1	0%	0.1
51364	50896		Site 33 - B24 Eastbound	25	1	23	-1	-5%	0.3
52613	50896		Site 34 - B24 Southbound	121	1	118	-3	-2%	0.3
51363	52614		Site 30 - B24 Northbound	566	1	439	-127	-22%	5.7
52614	51363		Site 30 - B24 Southbound	642	1	657	15	2%	0.6
52959	50111		Site 28 - B24 Southbound	787	1	647	-140	-18%	5.2
52536	50150		Site 31 - B24 Northbound	507	1	406	-101	-20%	4.7
50150	52536		Site 31 - B24 Southbound	186	1	169	-17	-9%	1.3
53013	52695		Site 25 - B24 Northbound	1485	1	1332	-153	-10%	4.1
52695	53013		Site 25 - B24 Southbound	846	1	783	-64	-8%	2.2
53390	52695		Site 26 - B24 Eastbound	277	1	501	224	81%	11.4
52695	53390		Site 26 - B24 Westbound	425	1	361	-64	-15%	3.3
52623	52695		Site 23 - B24 Eastbound	930	1	921	-9	-1%	0.3
52695	52623		Site 23 - B24 Westbound	1722	1	1465	-257	-15%	6.4
51376	51377		Site 24 - B24 Northbound	890	1	909	19	2%	0.6
51377	51376		Site 24 - B24 Southbound	529	1	417	-112	-21%	5.2
50753	52771		Site 41 - B24 Southbound	531	1	646	115	22%	4.8
52771	50753		Site 41 - B24 Northbound	544	1	440	-104	-19%	4.7
50906	55004		Site 4 - B24 Eastbound	1040	1	1045	5	0%	0.1
50551	50513		Site 5 - B24 Eastbound	276	1	290	15	5%	0.9
55004	50906		Site 4 - B24 Westbound	627	1	617	-10	-2%	0.4
50513	50551		Site 5 - B24 Westbound	143	1	144	1	0%	0.0
50707	50711		Site 58 - B24 Northbound	194	1	325	131	68%	8.1
50711	50707		Site 58 - B24 Southbound	185	1	205	19	10%	1.4
52318	50515		Site 7 - B24 Northbound	292	1	288	-4	-1%	0.2
50515	52318		Site 7 - B24 Southbound	191	1	187	-3	-2%	0.2
52032	50943		Site 8 - B24 Northbound	172	1	149	-24	-14%	1.9
50943	52032		Site 8 - B24 Southbound	656	1	616	-40	-6%	1.6
50773	52827		Site 9 - B24 Westbound	169	1	170	1	0%	0.1
52827	50773		Site 9 - B24 Eastbound	247	1	248	1	0%	0.1
52235	50942		Site 10 - B24 Northbound	216	1	189	-27	-12%	1.9
50942	52235		Site 10 - B24 Southbound	511	1	487	-24	-5%	1.1
52686	52820		Site 15 - B24 Westbound	695	1	798	103	15%	3.8
52821	52664		Site 15 - B24 Eastbound	692	1	678	-15	-2%	0.6
50754	52631		Site 18 - B24 Northbound	268	1	292	24	9%	1.4
52631	50754		Site 18 - B24 Southbound	614	1	556	-58	-9%	2.4
50960	50962		Site 16 - B24 Southbound	543	1	528	-15	-3%	0.6
50962	50960		Site 16 - B24 Northbound	425	1	466	41	10%	2.0
52260	50642	50654		126	1	57	-69	-55%	7.2
53057	50642	52260		148	1	126	-22	-15%	1.9
53057	50642	50654		716	1	647	-69	-10%	2.6
50654	50642	53057		299	1	298	0	0%	0.0
50654	50642	52260		78	1	75	-3	-4%	0.4
50643	50632	50664		195	1	190	-5	-3%	0.4
50643	50632	50550		340	1	362	22	6%	1.2
50643	50632	50634		140	1	138	-2	-2%	0.2
50634	50632	50643		206	1	114	-92	-45%	7.3
50634	50632	50664		282	1	217	-65	-23%	4.1

50634	50632	50550	43	1	77	34	78%	4.4
50550	50632	50634	44	1	47	3	7%	0.5
50550	50632	50643	158	1	151	-7	-4%	0.5
50550	50632	50664	10	1	32	22	220%	4.8
50664	50632	50550	22	1	23	1	2%	0.1
50664	50632	50634	90	1	91	0	0%	0.0
50664	50632	50643	30	1	26	-3	-11%	0.6
50841	50818	52255	378	1	170	-208	-55%	12.6
50841	50818	50819	446	1	423	-23	-5%	1.1
50819	50818	50841	211	1	212	1	1%	0.1
50819	50818	52255	10	1	27	17	162%	3.9
52255	50818	50819	45	1	46	1	2%	0.2
52255	50818	50841	212	1	185	-26	-12%	1.9
52701	52697	53014	49	1	17	-32	-66%	5.6
52701	52697	52698	126	1	179	53	42%	4.3
52701	52697	52700	63	1	136	73	115%	7.3
52700	52697	52701	223	1	204	-19	-8%	1.3
52700	52697	53014	820	1	609	-212	-26%	7.9
52700	52697	52698	239	1	183	-56	-24%	3.9
52703	52698	52700	215	1	332	117	55%	7.1
52698	52697	52701	192	1	184	-7	-4%	0.5
52698	52697	53014	276	1	266	-9	-3%	0.6
53014	52697	52698	433	1	296	-137	-32%	7.2
53014	52697	52700	1132	1	989	-143	-13%	4.4
53014	52697	52701	472	1	180	-291	-62%	16.1
50632	50643		395	1	283	-112	-28%	6.1
50643	50632		675	1	690	14	2%	0.5
50671	50680		684	1	801	117	17%	4.3
50680	50671		288	1	280	-7	-3%	0.4
52700	52706		1407	1	1457	50	4%	1.3
52706	52700		1281	1	995	-286	-22%	8.5
51378	50860	50859	217	1	277	60	28%	3.8
51378	50860	50857	577	1	559	-17	-3%	0.7
50857	50860	50859	787	1	775	-12	-2%	0.4
50857	50860	51378	190	1	137	-53	-28%	4.1
50859	50860	51378	50	1	49	-1	-2%	0.1
50859	50860	50857	502	1	365	-137	-27%	6.6
52704	52705	52706	49		1	-48	-98%	9.6
52704	52705	52707	444		359	-85	-19%	4.2
52704	52705	53403	232		198	-34	-15%	2.3
53403	52705	52704	270		271	1	0%	0.0
53403	52705	52706	870		841	-29	-3%	1.0
53403	52705	52707	37		64	27	74%	3.8
52707	52705	53403	18		29	11	63%	2.3
52707	52705	52704	303		277	-26	-8%	1.5
52707	52705	52706	285		153	-132	-46%	8.9
52706	52707		505		597	92	18%	3.9
52706	52705	53403	740		765	25	3%	0.9
52706	52705	52704	105		94	-11	-10%	1.1

GALWAY VALIDATION COUNTS - AM

			Observed Flow (VEH)		Modelled Flow (VEH)	Difference (num)	Difference (%)	
A Node	B Node		Total		Total	Total	Car	GEH
50716	50717		106		27	-79	-75%	9.7
50717	50716		129		94	-35	-27%	3.3
50552	50631		660		571	-89	-14%	3.6

50631	50552				646		873	227	35%	8.2
50630	50631				1023		1045	22	2%	0.7
50631	50630				658		653	-5	-1%	0.2
52942	50737				805		797	-8	-1%	0.3
50740	50737				216		272	56	26%	3.6
50737	50740				254		221	-33	-13%	2.2
50736	50737				122		183	61	50%	4.9
50737	50736				152		144	-8	-5%	0.6
50737	52941				723		888	165	23%	5.8
50741	50681				760		841	81	11%	2.9
50681	50741				375		398	23	6%	1.2
50795	52284				419		357	-62	-15%	3.2
52284	50795				498		585	87	18%	3.8
50551	50665				533		572	39	7%	1.7
50665	50551				992		871	-121	-12%	4.0
55001	50636				683		602	-81	-12%	3.2
50636	55001				426		448	22	5%	1.1

LT Link and Turn Counts

West Screenline

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
50129	51417		R336 Barna Road	415	415	0	0%	0.0
51324	50844		Cappagh Road	12	9	-3	-28%	1.0
51428	51427		Rahoon Road	40	39	-1	-2%	0.1
51410	51413		Letteragh Road	13	11	-2	-12%	0.4
51403	50910		N59 Clifden Road	391	394	3	1%	0.1
Screenline Total				871	868	-3	0%	0.1

West Screenline

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
51417	50129		R336 Barna Road	351	353	2	1%	0.1
50844	51324		Cappagh Road	11	10	-1	-9%	0.3
51427	51428		Rahoon Road	37	37	0	0%	0.0
51413	51410		Letteragh Road	14	12	-2	-15%	0.6
50910	51403		N59 Clifden Road	278	281	3	1%	0.2
Screenline Total				691	693	2	0%	0.1

R338 Screenline

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
50642	50654		R336 Salthill Road	466	382	-84	-18%	4.1
50549	52253		Dr Mannix Road	102	102	0	0%	0.0
50632	50664		Taylor's Hill Road	276	232	-44	-16%	2.7
50542	52319		Inishannagh Park	130	133	3	2%	0.3
Screenline Total				974	849	-125	-13%	4.1

R338 Screenline

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
50654	50642		R336 Salthill Road	409	376	-33	-8%	1.7
52253	50549		Dr Mannix Road	106	105	-1	-1%	0.1
50664	50632		Taylor's Hill Road	163	155	-8	-5%	0.6
52319	50542		Inishannagh Park	115	120	5	5%	0.5
Screenline Total				793	757	-36	-5%	1.3

River Corrib Screenline

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
52246	50925		Wolfe Tone Bridge	690	690	0	0%	0.0
50805	52310		William O'Brien Bridge	335	340	5	1%	0.3
50918	50798		Salmon Weir Bridge	509	373	-136	-27%	6.5
50942	50486		Quincentenary Bridge Upper	1058	1059	1	0%	0.0

Screenline Total				2592	2462	-130	-5%	2.6

River Corrib Screenline

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
50925	52246		Wolfe Tone Bridge	543	526	-17	-3%	0.8
52310	50805		William O'Brien Bridge	128	118	-10	-7%	0.9
50798	50918		Salmon Weir Bridge	619	603	-16	-3%	0.6
50486	50942		Quincentenary Bridge Upper	1093	1105	12	1%	0.4
Screenline Total				2383	2352	-31	-1%	0.6

Ballinfoyle Screenline

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
50681	50741		Lough Atalia Road	370	380	10	3%	0.5
50738	50498		R339 College Road	181	189	8	5%	0.6
50752	52332		R338 Moneenageisha Road	555	423	-132	-24%	6.0
52630	53403		N6 Bothar na dTreabh	733	846	113	15%	4.0
50766	70008		N84 Headford Road	397	400	3	1%	0.2
Screenline Total				2236	2239	3	0%	0.1

Ballinfoyle Screenline

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
50741	50681		Lough Atalia Road	604	598	-6	-1%	0.2
50498	50738		R339 College Road	176	172	-4	-2%	0.3
52332	50752		R338 Moneenageisha Road	529	448	-81	-15%	3.7
53403	52630		N6 Bothar na dTreabh	704	539	-165	-23%	6.6
70008	50766		N84 Headford Road	571	572	1	0%	0.0
Screenline Total				2584	2328	-256	-10%	7.1

East Screenline

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
51352	53096		R338 Coast Road	197	158	-39	-20%	2.9
52766	50049		R446 (Cartron)	538	627	89	17%	3.7
52392	52694		N6 (Coolagh)	369	417	48	13%	2.4
50860	51378		R339 (Briarhill)	219	210	-9	-4%	0.6
51389	51390		N83 Tuam Road	407	481	74	18%	3.5
50137	51065		N84 Headford Road	282	296	14	5%	0.8
Screenline Total				2012	2188	176	9%	3.8

East Screenline

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
53096	51352		R338 Coast Road	231	206	-25	-11%	1.7
50043	51372		R446 (Cartron)	651	757	106	16%	4.0
52964	53012		N6 (Coolagh)	430	445	15	3%	0.7

51378	50860		R339 (Briarhill)	183	194	11	6%	0.8
51390	51389		N83 Tuam Road	521	604	83	16%	3.5
51065	50137		N84 Headford Road	405	414	9	2%	0.4
Screenline Total				2421	2619	198	8%	3.9

Individual Target Counts - LT

				Observed Flow (VEH)		Modelled Flow (VEH)	Difference (num)	Difference (%)	
A Node	**B Node**	**C Node**	**Road Name**	**Total**		**Total**	**Total**	**Total**	**GEH**
50648	50546		Site 57 - B24 Northbound	304	1	305	1	0%	0.0
50546	50648		Site 57 - B24 Southbound	283	1	285	2	1%	0.1
50539	52285		Site 46 - B24 Northbound	299	1	300	1	0%	0.0
52285	50539		Site 46 - B24 Southbound	266	1	266	0	0%	0.0
52685	52367		Site 12 - B24 Northbound	90	1	33	-57	-63%	7.2
52367	52685		Site 12 - B24 Southbound	130	1	38	-92	-71%	10.0
50487	52667		Site 14 - B24 Northbound	1122	1	1185	63	6%	1.8
53003	52803		Site 14 - B24 Southbound	1053	1	996	-57	-5%	1.8
50966	50750		Site 40 - B24 Northbound	193	1	171	-22	-11%	1.6
53011	50930		Site 35 - B24 Eastbound	731	1	701	-30	-4%	1.1
50930	52583		Site 35 - B24 Westbound	845	1	844	-1	0%	0.0
52561	50577		Site 38 - B24 Northbound	367	1	381	14	4%	0.7
50577	52561		Site 38 - B24 Southbound	439	1	443	4	1%	0.2
52248	52707		Site 20 - B24 Northbound	618	1	420	-198	-32%	8.7
52707	52248		Site 20 - B24 Southbound	752	1	778	26	3%	0.9
52704	52683		Site 21 - B24 Northbound	586	1	494	-92	-16%	4.0
52683	52704		Site 21 - B24 Southbound	746	1	624	-122	-16%	4.7
52703	52698		Site 22 - B24 Southbound	518	1	520	2	0%	0.1
52698	52703		Site 22 - B24 Northbound	506	1	457	-49	-10%	2.3
50629	50588		Site 56 - B24 Northbound	395	1	385	-10	-3%	0.5
50588	50629		Site 56 - B24 Southbound	383	1	402	19	5%	1.0
51364	50896		Site 33 - B24 Eastbound	23	1	14	-9	-38%	2.0
50896	51364		Site 33 - B24 Westbound	31	1	10	-21	-67%	4.6
50896	52613		Site 34 - B24 Northbound	181	1	180	-1	-1%	0.1
52613	50896		Site 34 - B24 Southbound	143	1	131	-12	-9%	1.0
51363	52614		Site 30 - B24 Northbound	434	1	412	-22	-5%	1.1
52614	51363		Site 30 - B24 Southbound	473	1	474	1	0%	0.0
50110	52427		Site 28 - B24 Northbound	531	1	539	8	1%	0.3
52959	50111		Site 28 - B24 Southbound	522	1	524	2	0%	0.1
52536	50150		Site 31 - B24 Northbound	189	1	132	-57	-30%	4.5
50150	52536		Site 31 - B24 Southbound	181	1	152	-29	-16%	2.3
53013	52695		Site 25 - B24 Northbound	746	1	790	44	6%	1.6
52695	53013		Site 25 - B24 Southbound	672	1	748	76	11%	2.8
53390	52695		Site 26 - B24 Eastbound	269	1	289	20	7%	1.2
52695	53390		Site 26 - B24 Westbound	408	1	301	-107	-26%	5.7
52623	52695		Site 23 - B24 Eastbound	768	1	786	18	2%	0.7
52695	52623		Site 23 - B24 Westbound	507	1	762	255	50%	10.1
51376	51377		Site 24 - B24 Northbound	326	1	363	37	11%	2.0

51377	51376		Site 24 - B24 Southbound	394	1	322	-72	-18%	3.8
50753	52771		Site 41 - B24 Southbound	461	1	580	119	26%	5.2
52771	50753		Site 41 - B24 Northbound	576	1	428	-148	-26%	6.6
50906	55004		Site 4 - B24 Eastbound	752	1	753	1	0%	0.0
50551	50513		Site 5 - B24 Eastbound	142	1	165	23	16%	1.9
55004	50906		Site 4 - B24 Westbound	679	1	683	4	1%	0.2
50513	50551		Site 5 - B24 Westbound	120	1	161	41	34%	3.5
51332	50969		Site 13 - B24 Northbound	81	1	2	-79	-98%	12.3
50969	51332		Site 13 - B24 Southbound	92	1	0	-92	-100%	13.6
50707	50711		Site 58 - B24 Northbound	86	1	250	164	191%	12.7
50711	50707		Site 58 - B24 Southbound	177	1	207	30	17%	2.2
52318	50515		Site 7 - B24 Northbound	288	1	168	-120	-42%	7.9
50515	52318		Site 7 - B24 Southbound	257	1	240	-17	-7%	1.1
52032	50943		Site 8 - B24 Northbound	192	1	152	-40	-21%	3.0
50943	52032		Site 8 - B24 Southbound	222	1	220	-2	-1%	0.1
50773	52827		Site 9 - B24 Westbound	223	1	216	-7	-3%	0.5
52827	50773		Site 9 - B24 Eastbound	231	1	149	-82	-35%	5.9
52235	50942		Site 10 - B24 Northbound	228	1	226	-2	-1%	0.1
50942	52235		Site 10 - B24 Southbound	382	1	266	-116	-30%	6.4
52686	52820		Site 15 - B24 Westbound	666	1	778	112	17%	4.2
52821	52664		Site 15 - B24 Eastbound	542	1	494	-48	-9%	2.1
50754	52631		Site 18 - B24 Northbound	416	1	367	-49	-12%	2.5
52631	50754		Site 18 - B24 Southbound	450	1	411	-39	-9%	1.9
50960	50962		Site 16 - B24 Southbound	692	1	678	-14	-2%	0.5
50962	50960		Site 16 - B24 Northbound	708	1	662	-46	-7%	1.8
52260	50642	50654		93	1	54	-39	-42%	4.6
52260	50642	53057		41	1	24	-17	-41%	3.0
53057	50642	52260		46	1	33	-13	-27%	2.0
53057	50642	50654		327	1	328	1	0%	0.0
50654	50642	53057		347	1	318	-28	-8%	1.6
50654	50642	52260		71	1	58	-13	-19%	1.7
50643	50632	50664		66	1	35	-31	-47%	4.4
50643	50632	50550		148	1	156	8	6%	0.7
50643	50632	50634		163	1	177	14	9%	1.1
50634	50632	50643		173	1	183	10	6%	0.8
50634	50632	50664		180	1	187	7	4%	0.5
50634	50632	50550		23	1	32	9	38%	1.7
50550	50632	50634		40	1	38	-2	-5%	0.3
50550	50632	50643		124	1	127	3	2%	0.3
50550	50632	50664		10	1	10	0	5%	0.1
50664	50632	50550		15	1	16	1	4%	0.1
50664	50632	50634		95	1	112	17	18%	1.7
50664	50632	50643		42	1	28	-14	-32%	2.3
50841	50818	52255		264	1	256	-8	-3%	0.5
50841	50818	50819		185	1	191	7	4%	0.5
50819	50818	50841		194	1	206	12	6%	0.8
50819	50818	52255		23	1	29	6	28%	1.3
52255	50818	50819		22	1	25	3	15%	0.7

52255	50818	50841		190	1	192		2		1%		0.1
52701	52697	53014		74	1	7		-67		-90%		10.5
52701	52697	52698		122	1	66		-56		-46%		5.8
52701	52697	52700		68	1	48		-20		-30%		2.7
52700	52697	52701		45	1	54		8		18%		1.2
52700	52697	53014		663	1	624		-38		-6%		1.5
52700	52697	52698		198	1	244		45		23%		3.1
52703	52698	52700		207	1	301		94		46%		5.9
52698	52697	52701		94	1	84		-10		-11%		1.1
52698	52697	53014		200	1	135		-65		-33%		5.0
53014	52697	52698		168	1	147		-21		-12%		1.7
53014	52697	52700		661	1	526		-135		-20%		5.5
53014	52697	52701		123	1	88		-35		-28%		3.4
50632	50643			337	1	338		1		0%		0.0
50643	50632			377	1	368		-9		-2%		0.5
50671	50680			313	1	305		-7		-2%		0.4
50680	50671			302	1	287		-15		-5%		0.9
52700	52706			936	1	875		-61		-6%		2.0
52706	52700			906	1	921		15		2%		0.5
51378	50860	50859		46	1	49		3		6%		0.4
51378	50860	50857		136	1	145		9		6%		0.7
50857	50860	50859		351	1	369		18		5%		1.0
50857	50860	51378		184	1	177		-7		-4%		0.5
50859	50860	51378		36	1	33		-3		-8%		0.5
50859	50860	50857		385	1	346		-38		-10%		2.0

GALWAY VALIDATION COUNTS - LT

				Observed Flow (VEH)		Modelled Flow (VEH)		Difference (num)		Difference (%)		
A Node	B Node			Total		Total		Total		Car		GEH
50716	50717			93		30		-63		-67%		8.0
50717	50716			78		47		-31		-40%		3.9
50552	50631			665		514		-151		-23%		6.2
50631	50552			607		660		53		9%		2.1
50630	50631			753		693		-60		-8%		2.2
50631	50630			666		581		-85		-13%		3.4
52942	50737			730		611		-119		-16%		4.6
50740	50737			153		124		-29		-19%		2.5
50737	50740			188		167		-21		-11%		1.6
50736	50737			126		166		40		32%		3.3
50737	50736			157		108		-49		-31%		4.2
50737	52941			679		626		-53		-8%		2.1
50741	50681			569		598		29		5%		1.2
50681	50741			392		380		-12		-3%		0.6
50795	52284			495		522		27		6%		1.2
52284	50795			486		397		-89		-18%		4.2
50551	50665			721		605		-116		-16%		4.5
50665	50551			706		675		-31		-4%		1.2

55001	50636			588		518		-70		-12%		3.0
50636	55001			562		452		-110		-20%		4.9

SR Link and Turn Counts

West Screenline

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
50129	51417		R336 Barna Road	438	428	-10	-2%	0.5
51324	50844		Cappagh Road	30	14	-16	-53%	3.4
51428	51427		Rahoon Road	58	52	-6	-10%	0.8
51410	51413		Letteragh Road	30	17	-13	-42%	2.6
51403	50910		N59 Clifden Road	378	378	0	0%	0.0
Screenline Total				934	890	-44	-5%	1.5

West Screenline

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
51417	50129		R336 Barna Road	488	487	-1	0%	0.0
50844	51324		Cappagh Road	33	21	-12	-36%	2.3
51427	51428		Rahoon Road	64	57	-7	-11%	0.9
51413	51410		Letteragh Road	25	17	-8	-33%	1.8
50910	51403		N59 Clifden Road	419	421	2	0%	0.1
Screenline Total				1029	1004	-25	-2%	0.8

R338 Screenline

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
50642	50654		R336 Salthill Road	502	460	-42	-8%	1.9
50549	52253		Dr Mannix Road	184	183	-1	-1%	0.1
50632	50664		Taylor's Hill Road	283	275	-8	-3%	0.5
50542	52319		Inishannagh Park	165	185	20	12%	1.5
Screenline Total				1134	1103	-31	-3%	0.9

R338 Screenline

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
50654	50642		R336 Salthill Road	598	549	-49	-8%	2.0
52253	50549		Dr Mannix Road	204	204	0	0%	0.0
50664	50632		Taylor's Hill Road	220	227	7	3%	0.4
52319	50542		Inishannagh Park	221	205	-16	-7%	1.1
Screenline Total				1243	1185	-58	-5%	1.7

River Corrib Screenline

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
52246	50925		Wolfe Tone Bridge	700	714	14	2%	0.5
50805	52310		William O'Brien Bridge	364	375	11	3%	0.6
50918	50798		Salmon Weir Bridge	557	471	-86	-15%	3.8
50942	50486		Quincentenary Bridge Upper	1102	1148	46	4%	1.4

Screenline Total				2723	2708	-15	-1%	0.3

River Corrib Screenline

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
50925	52246		Wolfe Tone Bridge	632	629	-3	-1%	0.1
52310	50805		William O'Brien Bridge	127	106	-21	-16%	1.9
50798	50918		Salmon Weir Bridge	575	695	120	21%	4.8
50486	50942		Quincentenary Bridge Upper	1181	1203	22	2%	0.6
Screenline Total				2515	2632	117	5%	2.3

Ballinfoyle Screenline

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
50681	50741		Lough Atalia Road	376	375	-1	0%	0.0
50738	50498		R339 College Road	228	263	35	15%	2.2
50752	52332		R338 Moneenageisha Road	621	325	-296	-48%	13.6
52630	53403		N6 Bothar na dTreabh	799	1005	206	26%	6.9
50766	70008		N84 Headford Road	608	602	-6	-1%	0.2
Screenline Total				2632	2570	-62	-2%	1.2

Ballinfoyle Screenline

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
50741	50681		Lough Atalia Road	547	573	26	5%	1.1
50498	50738		R339 College Road	146	134	-12	-8%	1.0
52332	50752		R338 Moneenageisha Road	577	487	-90	-16%	3.9
53403	52630		N6 Bothar na dTreabh	706	637	-69	-10%	2.7
70008	50766		N84 Headford Road	526	557	31	6%	1.3
Screenline Total				2502	2387	-115	-5%	4.5

East Screenline

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
51352	53096		R338 Coast Road	322	269	-53	-16%	3.1
52766	50049		R446 (Cartron)	710	761	51	7%	1.9
52392	52694		N6 (Coolagh)	538	569	31	6%	1.3
50860	51378		R339 (Briarhill)	374	371	-3	-1%	0.1
51389	51390		N83 Tuam Road	610	659	49	8%	2.0
50137	51065		N84 Headford Road	463	475	12	3%	0.6
Screenline Total				3017	3104	87	3%	1.6

East Screenline

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
53096	51352		R338 Coast Road	234	232	-2	-1%	0.1
50043	51372		R446 (Cartron)	639	732	93	15%	3.6
52964	53012		N6 (Coolagh)	427	461	34	8%	1.6

51378	50860		R339 (Briarhill)	321	335	14	4%	0.8
51390	51389		N83 Tuam Road	470	513	43	9%	1.9
51065	50137		N84 Headford Road	353	361	8	2%	0.4
Screenline Total				2444	2633	189	8%	3.8

Individual Target Counts - SR

				Observed Flow (VEH)		Modelled Flow (VEH)	Difference (num)	Difference (%)	
A Node	**B Node**	**C Node**	**Road Name**	**Total**		**Total**	**Total**	**Total**	**GEH**
50648	50546		Site 57 - B24 Northbound	328	1	321	-7	-2%	0.4
50546	50648		Site 57 - B24 Southbound	410	1	407	-3	-1%	0.1
50539	52285		Site 46 - B24 Northbound	358	1	363	5	1%	0.2
52285	50539		Site 46 - B24 Southbound	361	1	361	0	0%	0.0
52685	52367		Site 12 - B24 Northbound	187	1	84	-103	-55%	8.9
52367	52685		Site 12 - B24 Southbound	143	1	40	-103	-72%	10.7
50487	52667		Site 14 - B24 Northbound	1204	1	1171	-33	-3%	1.0
53003	52803		Site 14 - B24 Southbound	952	1	924	-28	-3%	0.9
50966	50750		Site 40 - B24 Northbound	234	1	252	18	8%	1.2
53011	50930		Site 35 - B24 Eastbound	846	1	680	-166	-20%	6.0
50930	52583		Site 35 - B24 Westbound	824	1	834	10	1%	0.3
52561	50577		Site 38 - B24 Northbound	460	1	440	-20	-4%	0.9
50577	52561		Site 38 - B24 Southbound	432	1	468	36	8%	1.7
52248	52707		Site 20 - B24 Northbound	643	1	384	-259	-40%	11.5
52707	52248		Site 20 - B24 Southbound	651	1	667	16	3%	0.6
52704	52683		Site 21 - B24 Northbound	773	1	490	-283	-37%	11.3
52683	52704		Site 21 - B24 Southbound	716	1	450	-266	-37%	11.0
52703	52698		Site 22 - B24 Southbound	542	1	606	64	12%	2.7
52698	52703		Site 22 - B24 Northbound	647	1	565	-82	-13%	3.3
50629	50588		Site 56 - B24 Northbound	496	1	475	-21	-4%	1.0
50588	50629		Site 56 - B24 Southbound	526	1	500	-26	-5%	1.2
51364	50896		Site 33 - B24 Eastbound	49	1	20	-29	-59%	4.9
50896	51364		Site 33 - B24 Westbound	37	1	15	-22	-61%	4.4
50896	52613		Site 34 - B24 Northbound	174	1	185	11	7%	0.8
52613	50896		Site 34 - B24 Southbound	219	1	233	14	7%	1.0
51363	52614		Site 30 - B24 Northbound	496	1	527	31	6%	1.4
52614	51363		Site 30 - B24 Southbound	476	1	493	17	4%	0.8
50110	52427		Site 28 - B24 Northbound	623	1	656	33	5%	1.3
52959	50111		Site 28 - B24 Southbound	665	1	684	19	3%	0.7
52536	50150		Site 31 - B24 Northbound	244	1	146	-98	-40%	7.0
50150	52536		Site 31 - B24 Southbound	297	1	234	-63	-21%	3.9
53013	52695		Site 25 - B24 Northbound	772	1	834	62	8%	2.2
52695	53013		Site 25 - B24 Southbound	857	1	969	112	13%	3.7
53390	52695		Site 26 - B24 Eastbound	352	1	365	13	4%	0.7
52695	53390		Site 26 - B24 Westbound	515	1	410	-105	-20%	4.9
52623	52695		Site 23 - B24 Eastbound	961	1	1018	57	6%	1.8
52695	52623		Site 23 - B24 Westbound	947	1	858	-89	-9%	3.0
51376	51377		Site 24 - B24 Northbound	445	1	494	49	11%	2.3

51377	51376		Site 24 - B24 Southbound	487	1	536	49	10%	2.2
50753	52771		Site 41 - B24 Southbound	538	1	559	21	4%	0.9
52771	50753		Site 41 - B24 Northbound	651	1	596	-55	-9%	2.2
50906	55004		Site 4 - B24 Eastbound	755	1	766	11	1%	0.4
50551	50513		Site 5 - B24 Eastbound	183	1	183	0	0%	0.0
55004	50906		Site 4 - B24 Westbound	867	1	859	-8	-1%	0.3
50513	50551		Site 5 - B24 Westbound	204	1	258	54	27%	3.6
50707	50711		Site 58 - B24 Northbound	101	1	209	108	107%	8.7
50711	50707		Site 58 - B24 Southbound	245	1	247	2	1%	0.1
52318	50515		Site 7 - B24 Northbound	362	1	193	-169	-47%	10.2
50515	52318		Site 7 - B24 Southbound	314	1	307	-7	-2%	0.4
52032	50943		Site 8 - B24 Northbound	277	1	210	-67	-24%	4.3
50943	52032		Site 8 - B24 Southbound	239	1	231	-8	-3%	0.5
50773	52827		Site 9 - B24 Westbound	270	1	271	1	0%	0.0
52827	50773		Site 9 - B24 Eastbound	216	1	196	-20	-9%	1.4
52235	50942		Site 10 - B24 Northbound	265	1	280	15	6%	0.9
50942	52235		Site 10 - B24 Southbound	388	1	263	-125	-32%	7.0
52686	52820		Site 15 - B24 Westbound	689	1	776	87	13%	3.2
52821	52664		Site 15 - B24 Eastbound	555	1	638	83	15%	3.4
50754	52631		Site 18 - B24 Northbound	452	1	504	52	11%	2.4
52631	50754		Site 18 - B24 Southbound	440	1	363	-77	-17%	3.8
50960	50962		Site 16 - B24 Southbound	625	1	598	-27	-4%	1.1
50962	50960		Site 16 - B24 Northbound	743	1	775	32	4%	1.2
52260	50642	50654		120	1	78	-42	-35%	4.2
53057	50642	52260		81	1	50	-31	-38%	3.8
53057	50642	50654		374	1	383	9	2%	0.5
50654	50642	53057		493	1	479	-14	-3%	0.6
50654	50642	52260		109	1	71	-38	-35%	4.1
50643	50632	50664		95	1	63	-33	-34%	3.7
50643	50632	50550		240	1	235	-5	-2%	0.3
50643	50632	50634		193	1	210	17	9%	1.2
50634	50632	50643		158	1	172	14	9%	1.1
50634	50632	50664		177	1	198	21	12%	1.5
50634	50632	50550		32	1	52	20	64%	3.1
50550	50632	50634		66	1	77	11	16%	1.3
50550	50632	50643		165	1	190	25	15%	1.9
50550	50632	50664		15	1	15	-1	-4%	0.2
50664	50632	50550		19	1	20	1	3%	0.1
50664	50632	50634		130	1	172	42	32%	3.4
50664	50632	50643		52	1	35	-17	-32%	2.5
50841	50818	52255		255	1	257	2	1%	0.1
50841	50818	50819		227	1	229	1	1%	0.1
50819	50818	50841		306	1	320	14	4%	0.8
50819	50818	52255		27	1	48	21	79%	3.5
52255	50818	50819		20	1	33	12	60%	2.4
52255	50818	50841		274	1	280	6	2%	0.4
52701	52697	53014		74	1	22	-52	-70%	7.5
52701	52697	52698		139	1	150	11	8%	0.9

52701	52697	52700		118	1	105		-13		-11%		1.2
52700	52697	52701		56	1	50		-6		-10%		0.8
52700	52697	53014		744	1	740		-3		0%		0.1
52700	52697	52698		241	1	204		-37		-15%		2.5
52703	52698	52700		248	1	345		97		39%		5.6
52698	52697	52701		146	1	64		-82		-56%		8.0
52698	52697	53014		264	1	197		-67		-25%		4.4
53014	52697	52698		170	1	211		41		24%		3.0
53014	52697	52700		595	1	516		-79		-13%		3.4
53014	52697	52701		182	1	131		-51		-28%		4.1
50632	50643			406	1	397		-9		-2%		0.4
50643	50632			530	1	508		-22		-4%		1.0
50671	50680			416	1	407		-8		-2%		0.4
50680	50671			399	1	393		-5		-1%		0.3
52700	52706			962	1	967		5		1%		0.2
52706	52700			1040	1	994		-46		-4%		1.4
51378	50860	50859		53	1	57		4		8%		0.6
51378	50860	50857		268	1	278		10		4%		0.6
50857	50860	50859		508	1	490		-18		-3%		0.8
50857	50860	51378		294	1	297		3		1%		0.2
50859	50860	51378		80	1	74		-6		-7%		0.7
50859	50860	50857		491	1	529		37		8%		1.6
52623	52695	50857		340	1	305		-35		-10%		1.9
52623	52695	53013		600	1	673		73		12%		2.9
52623	52695	53390		170	1	40		-130		-76%		12.6
53390	52695	52623		152	1	114		-38		-25%		3.3
53390	52695	50857		264	1	183		-81		-31%		5.4
53390	52695	53013		107	1	67		-40		-37%		4.2
53013	52695	53390		93	1	93		0		0%		0.0
53013	52695	52623		525	1	442		-83		-16%		3.8
53013	52695	50857		197	1	299		102		52%		6.5
50857	52695	53013		239	1	229		-10		-4%		0.6
50857	52695	53390		252	1	276		24		10%		1.5
50857	52695	52623		270	1	301		31		12%		1.9

GALWAY VALIDATION COUNTS - SR

				Observed Flow (VEH)		Modelled Flow (VEH)		Difference (num)		Difference (%)		
A Node	B Node			Total		Total		Total		Car		GEH
50716	50717			108	1	46		-62		-57%		7.0
50717	50716			52	1	55		3		5%		0.4
50552	50631			781	1	624		-157		-20%		5.9
50631	50552			663	1	650		-13		-2%		0.5
50630	50631			777	1	699		-78		-10%		2.9
50631	50630			808	1	739		-69		-8%		2.5
52942	50737			690	1	637		-53		-8%		2.1
50740	50737			135	1	116		-19		-14%		1.7
50737	50740			194	1	245		51		26%		3.5

50736	50737			111	1	160		49		44%		4.2
50737	50736			136	1	102		-34		-25%		3.1
50737	52941			595	1	566		-29		-5%		1.2
50741	50681			629	1	573		-56		-9%		2.3
50681	50741			423	1	375		-48		-11%		2.4
50795	52284			603	1	705		102		17%		4.0
52284	50795			452	1	356		-96		-21%		4.8
50551	50665			877	1	827		-50		-6%		1.7
50665	50551			792	1	707		-85		-11%		3.1
55001	50636			633	1	542		-91		-14%		3.7
50636	55001			677	1	588		-89		-13%		3.5

PM Link and Turn Counts

West Screenline - Inbound

A Node	B Node	C Node	Road Name	Observed Flow (VEH)	Modelled Flow (VEH)	Difference (num)	Difference (%)	GEH
50129	51417		R336 Barna Road	531	528	-3	-1%	0.1
51324	50844		Cappagh Road	16	14	-2	-10%	0.4
51428	51427		Rahoon Road	62	60	-2	-3%	0.3
51410	51413		Letteragh Road	19	16	-3	-14%	0.6
51403	50910		N59 Clifden Road	350	349	-1	0%	0.0
Screenline Total				978	968	-10	-1%	0.3

West Screenline - Outbound

A Node	B Node	C Node	Road Name	Obs	Mod	Total	Total	GEH
51417	50129		R336 Barna Road	678	674	-4	-1%	0.2
50844	51324		Cappagh Road	28	24	-4	-16%	0.9
51427	51428		Rahoon Road	99	99	0	0%	0.0
51413	51410		Letteragh Road	34	37	3	9%	0.5
50910	51403		N59 Clifden Road	775	768	-7	-1%	0.3
Screenline Total				1614	1601	-13	-1%	0.3

R338 Screenline - Inbound

A Node	B Node	C Node	Road Name	Obs	Mod	Total	Total	GEH
50642	50654		R336 Salthill Road	444	413	-31	-7%	1.5
50549	52253		Dr Mannix Road	181	143	-38	-21%	3.0
50632	50664		Taylor's Hill Road	259	277	18	7%	1.1
50542	52319		Inishannagh Park	161	155	-6	-4%	0.5
Screenline Total				1045	987	-58	-6%	1.8

R338 Screenline - Outbound

A Node	B Node	C Node	Road Name	Obs	Mod	Total	Total	GEH
50654	50642		R336 Salthill Road	853	742	-111	-13%	3.9
52253	50549		Dr Mannix Road	350	356	6	2%	0.3
50664	50632		Taylor's Hill Road	274	343	69	25%	4.0
52319	50542		Inishannagh Park	375	311	-64	-17%	3.5
Screenline Total				1852	1752	-100	-5%	2.4

River Corrib Screenline - Eastbound

A Node	B Node	C Node	Road Name	Obs	Mod	Total	Total	GEH
52246	50925		Wolfe Tone Bridge	612	600	-12	-2%	0.5
50805	52310		William O'Brien Bridge	383	390	7	2%	0.3
50918	50798		Salmon Weir Bridge	579	552	-27	-5%	1.1
50942	50486		Quincentenary Bridge Upper	1393	1388	-5	0%	0.1

Screenline Total				2967	2930	-37	-1%	0.7

River Corrib Screenline - Westbound

A Node	B Node	C Node	Road Name	Obs	Mod	Total	Total	GEH
50925	52246		Wolfe Tone Bridge	863	811	-52	-6%	1.8
52310	50805		William O'Brien Bridge	152	142	-10	-6%	0.8
50798	50918		Salmon Weir Bridge	769	755	-14	-2%	0.5
50486	50942		Quincentenary Bridge Upper	1547	1555	8	1%	0.2
Screenline Total				3331	3263	-68	-2%	1.2

Ballinfoyle Screenline - outbound

A Node	B Node	C Node	Road Name	Obs	Mod	Total	Total	GEH
50681	50741		Lough Atalia Road	396	434	38	10%	1.9
50738	50498		R339 College Road	288	337	49	17%	2.8
50752	52332		R338 Moneenageisha Road	682	552	-130	-19%	5.2
52630	53403		N6 Bothar na dTreabh	922	1011	89	10%	2.9
50766	70008		N84 Headford Road	1007	989	-18	-2%	0.6
Screenline Total				3295	3323	28	1%	0.5

Ballinfoyle Screenline - Inbound

A Node	B Node	C Node	Road Name	Obs	Mod	Total	Total	GEH
50741	50681		Lough Atalia Road	564	534	-30	-5%	1.3
50498	50738		R339 College Road	135	88	-47	-35%	4.5
52332	50752		R338 Moneenageisha Road	594	496	-98	-16%	4.2
53403	52630		N6 Bothar na dTreabh	954	904	-50	-5%	1.6
70008	50766		N84 Headford Road	560	647	87	15%	3.5
Screenline Total				2807	2669	-138	-5%	3.1

East Screenline - outbound

A Node	B Node	C Node	Road Name	Obs	Mod	Total	Total	GEH
51352	53096		R338 Coast Road	520	460	-60	-12%	2.7
52766	50049		R446 (Cartron)	1149	1129	-20	-2%	0.6
52392	52694		N6 (Coolagh)	849	898	49	6%	1.7
50860	51378		R339 (Briarhill)	724	682	-42	-6%	1.6
51389	51390		N83 Tuam Road	863	1054	191	22%	6.2
50137	51065		N84 Headford Road	878	883	5	1%	0.2
Screenline Total				4983	5105	122	2%	1.7

East Screenline - inbound

A Node	B Node	C Node	Road Name	Obs	Mod	Total	Total	GEH
53096	51352		R338 Coast Road	235	216	-19	-8%	1.3
50043	51372		R446 (Cartron)	659	660	1	0%	0.1
52964	53012		N6 (Coolagh)	481	548	67	14%	2.9

51378	50860		R339 (Briarhill)	240		251		11		5%		0.7
51390	51389		N83 Tuam Road	448		368		-80		-18%		3.9
51065	50137		N84 Headford Road	336		350		14		4%		0.7
Screenline Total				2399		2394		-5		0%		0.1

Individual Target Counts - PM

				Observed Flow (VEH)		Modelled Flow (VEH)		Difference (num)		Difference (%)		
A Node	**B Node**	**C Node**	**Road Name**	**Total**		**Total**		**Total**		**Total**		**GEH**
50648	50546		Site 57 - B24 Northbound	282	1	285		3		1%		0.2
50546	50648		Site 57 - B24 Southbound	564	1	536		-28		-5%		1.2
50539	52285		Site 46 - B24 Northbound	325	1	315		-10		-3%		0.6
52285	50539		Site 46 - B24 Southbound	475	1	488		13		3%		0.6
52685	52367		Site 12 - B24 Northbound	438	1	394		-44		-10%		2.2
52367	52685		Site 12 - B24 Southbound	168	1	124		-44		-26%		3.6
50487	52667		Site 14 - B24 Northbound	1274	1	1265		-9		-1%		0.3
53003	52803		Site 14 - B24 Southbound	1104	1	1178		74		7%		2.2
50966	50750		Site 40 - B24 Northbound	221	1	204		-17		-8%		1.2
50750	50966		Site 40 - B24 Southbound	175	1	56		-119		-68%		11.0
53011	50930		Site 35 - B24 Eastbound	933	1	874		-59		-6%		2.0
50930	52583		Site 35 - B24 Westbound	821	1	832		11		1%		0.4
52561	50577		Site 38 - B24 Northbound	599	1	508		-91		-15%		3.8
50577	52561		Site 38 - B24 Southbound	379	1	307		-72		-19%		3.9
52248	52707		Site 20 - B24 Northbound	715	1	712		-3		0%		0.1
52707	52248		Site 20 - B24 Southbound	638	1	606		-32		-5%		1.3
52704	52683		Site 21 - B24 Northbound	831	1	762		-69		-8%		2.5
52683	52704		Site 21 - B24 Southbound	812	1	572		-240		-30%		9.1
52703	52698		Site 22 - B24 Southbound	625	1	467		-158		-25%		6.8
52698	52703		Site 22 - B24 Northbound	718	1	659		-59		-8%		2.3
50629	50588		Site 56 - B24 Northbound	459	1	470		11		2%		0.5
50588	50629		Site 56 - B24 Southbound	612	1	601		-11		-2%		0.4
51364	50896		Site 33 - B24 Eastbound	74	1	275		201		272%		15.2
50896	51364		Site 33 - B24 Westbound	31	1	30		-1		-4%		0.2
50896	52613		Site 34 - B24 Northbound	164	1	176		12		7%		0.9
52613	50896		Site 34 - B24 Southbound	371	1	235		-136		-37%		7.8
51363	52614		Site 30 - B24 Northbound	705	1	664		-41		-6%		1.6
52614	51363		Site 30 - B24 Southbound	633	1	648		15		2%		0.6
50110	52427		Site 28 - B24 Northbound	602	1	511		-91		-15%		3.8
52959	50111		Site 28 - B24 Southbound	671	1	818		147		22%		5.4
52536	50150		Site 31 - B24 Northbound	256	1	225		-31		-12%		2.0
50150	52536		Site 31 - B24 Southbound	477	1	380		-97		-20%		4.7
51376	51377		Site 24 - B24 Northbound	315	1	326		11		4%		0.6
51377	51376		Site 24 - B24 Southbound	838	1	758		-80		-10%		2.8
50753	52771		Site 41 - B24 Southbound	625	1	669		44		7%		1.7
52771	50753		Site 41 - B24 Northbound	644	1	541		-103		-16%		4.2
50906	55004		Site 4 - B24 Eastbound	780	1	782		2		0%		0.1
50551	50513		Site 5 - B24 Eastbound	140	1	175		35		25%		2.8

55004	50906		Site 4 - B24 Westbound	1119	1	1040	-79	-7%	2.4
50513	50551		Site 5 - B24 Westbound	220	1	264	44	20%	2.9
50707	50711		Site 58 - B24 Northbound	85	1	244	159	187%	12.4
50711	50707		Site 58 - B24 Southbound	374	1	428	54	14%	2.7
52318	50515		Site 7 - B24 Northbound	351	1	335	-16	-5%	0.9
50515	52318		Site 7 - B24 Southbound	276	1	344	68	24%	3.8
52032	50943		Site 8 - B24 Northbound	257	1	161	-96	-37%	6.7
50943	52032		Site 8 - B24 Southbound	123	1	125	2	1%	0.2
50773	52827		Site 9 - B24 Westbound	315	1	319	4	1%	0.2
52827	50773		Site 9 - B24 Eastbound	183	1	104	-79	-43%	6.6
52235	50942		Site 10 - B24 Northbound	374	1	360	-14	-4%	0.7
50942	52235		Site 10 - B24 Southbound	411	1	318	-93	-23%	4.9
52686	52820		Site 15 - B24 Westbound	797	1	773	-24	-3%	0.9
52821	52664		Site 15 - B24 Eastbound	561	1	840	279	50%	10.5
50754	52631		Site 18 - B24 Northbound	465	1	584	119	26%	5.2
52631	50754		Site 18 - B24 Southbound	309	1	313	4	1%	0.2
50960	50962		Site 16 - B24 Southbound	514	1	527	13	3%	0.6
50962	50960		Site 16 - B24 Northbound	633	1	719	86	14%	3.3
52260	50642	50654		104	1	85	-19	-18%	2.0
52260	50642	53057		158	1	140	-18	-11%	1.5
53057	50642	52260		77	1	72	-5	-6%	0.5
53057	50642	50654		314	1	328	14	4%	0.8
50654	50642	53057		733	1	696	-37	-5%	1.4
50654	50642	52260		115	1	46	-69	-60%	7.7
50643	50632	50664		99	1	80	-19	-19%	2.0
50643	50632	50550		226	1	227	1	1%	0.1
50643	50632	50634		246	1	192	-53	-22%	3.6
50634	50632	50643		172	1	206	35	20%	2.5
50634	50632	50664		162	1	179	17	10%	1.3
50634	50632	50550		35	1	27	-8	-22%	1.4
50550	50632	50634		109	1	102	-7	-7%	0.7
50550	50632	50643		259	1	267	8	3%	0.5
50550	50632	50664		15	1	18	3	21%	0.8
50664	50632	50550		20	1	9	-11	-54%	2.8
50664	50632	50634		196	1	302	106	54%	6.7
50664	50632	50643		63	1	32	-31	-49%	4.5
50841	50818	52255		282	1	278	-4	-1%	0.3
50841	50818	50819		209	1	212	3	1%	0.2
50819	50818	50841		472	1	469	-3	-1%	0.1
50819	50818	52255		26	1	37	11	41%	1.9
52255	50818	50819		25	1	28	4	15%	0.7
52255	50818	50841		334	1	344	10	3%	0.5
52701	52697	53014		64	1	5	-59	-92%	10.0
52701	52697	52698		176	1	178	2	1%	0.2
52701	52697	52700		216	1	108	-107	-50%	8.4
52700	52697	52701		24	1	33	8	34%	1.5
52700	52697	53014		926	1	799	-127	-14%	4.3
52700	52697	52698		257	1	317	60	23%	3.5

52703	52698	52700		305	1	304		-1		0%		0.1
52698	52697	52701		87	1	59		-28		-32%		3.3
52698	52697	53014		407	1	104		-303		-74%		19.0
53014	52697	52698		206	1	163		-43		-21%		3.1
53014	52697	52700		610	1	694		84		14%		3.3
53014	52697	52701		75	1	73		-2		-2%		0.2
50632	50643			493	1	506		13		3%		0.6
50643	50632			570	1	500		-70		-12%		3.0
50671	50680			423	1	416		-7		-2%		0.3
50680	50671			580	1	592		12		2%		0.5
52700	52706			1131	1	1107		-24		-2%		0.7
52706	52700			1208	1	1149		-59		-5%		1.7
51378	50860	50859		34	1	30		-4		-11%		0.6
51378	50860	50857		206	1	221		15		7%		1.0
50857	50860	50859		320	1	327		6		2%		0.4
50857	50860	51378		558	1	579		21		4%		0.9
50859	50860	51378		166	1	104		-62		-37%		5.3
50859	50860	50857		791	1	801		10		1%		0.3
52623	52695	50857		297	1	404		107		36%		5.7
52623	52695	53013		641	1	759		118		18%		4.5
52623	52695	53390		127	1	93		-34		-26%		3.2
53390	52695	52623		90	1	72		-18		-20%		2.0
53390	52695	50857		213	1	357		144		68%		8.5
53390	52695	53013		144	1	269		125		87%		8.7
53013	52695	53390		110	1	98		-12		-11%		1.2
53013	52695	52623		429	1	479		50		12%		2.3
53013	52695	50857		121	1	152		31		26%		2.7
50857	52695	53013		330	1	373		43		13%		2.3
50857	52695	53390		263	1	269		6		2%		0.3
50857	52695	52623		240	1	380		140		58%		8.0

GALWAY VALIDATION COUNTS - PM

				Observed Flow (VEH)		Modelled Flow (VEH)		Difference (num)		Difference (%)		
A Node	B Node			Total		Total		Total		Car		GEH
50716	50717			64		62		-2		-3%		0.2
50717	50716			59		54		-5		-9%		0.7
50552	50631			881		972		91		10%		3.0
50631	50552			665		670		5		1%		0.2
50630	50631			802		729		-73		-9%		2.6
50631	50630			882		1146		264		30%		8.3
52942	50737			763		737		-26		-3%		1.0
50740	50737			130		139		9		7%		0.8
50737	50740			290		326		36		12%		2.0
50736	50737			204		244		40		19%		2.7
50737	50736			137		129		-8		-6%		0.7
50737	52941			670		665		-5		-1%		0.2
50741	50681			560		534		-26		-5%		1.1

50681	50741			340		434		94		28%		4.8
50795	52284			582		744		162		28%		6.3
52284	50795			422		420		-2		-1%		0.1
50551	50665			869		1005		136		16%		4.4
50665	50551			576		666		90		16%		3.6
55001	50636			483		513		30		6%		1.4
50636	55001			670		763		93		14%		3.5

Appendix E

List of Future Year Do-Minimum

N6 Galway City Outer Bypass
Review of City Schemes (Doc Ref. GCOB-4.03-2.1-001)
Committed Projects

Ref.	NTA Ref.	Scheme Name	Scheme Description
001		Fairgreen Road Cycleway / Pedestrian Facilities Scheme	The project will involve the introduction of cycling facilities and the upgrading of pedestrian facilities along approximately 300 metres of Fairgreen Road, between Lough Atalia Road and Forster Street. This section of roadway forms the final section of the Dublin to Galway National Cycle Route and links to Ceannt Station for bus and rail services and with the Galway City Coach Station for other bus services.
002	016	Merlin Park Hospital Bus Access (NTA Plan 16)	Planning and design work: Completion of design development work on this project and the preparation of a statutory planning process application. This project will deliver a new junction and access road with on-road cycleway, approximately 350 metres long commencing at Dublin Road / Galway Crystal junction and finishing at Merlin Park Hospital, providing safer access / egress to Merlin Park Hospital for all road users It will also connect directly to the existing Dublin Road bus lane and, through linking with the UTMC system, will reduce delays for buses exiting Merlin Park.
008	026	Threadneedle Road Cycleway (NTA Plan 26)	This scheme will link the Western Distributor Road and Seamus Quirke Road Cycleways to the Salthill area and two secondary schools. Comprising two sections of cycleway,the first section is a northbound cyclelane,approximately 350 metres long. commencing at ThreadneedleRoad/SalthillRoad junction and finishing at ThreadneedleRoad/KingstonRoadjunction.The secondsection,approximately 200 metres long, commences at BishopO'DonnellRoad/KingstonRoad junction and finishes at BishopO'DonnellRoad/Western Distributor Road junction.Construction to be completed during 2014.
009		Tuam Road /Joyce Road Junction Improvement and Bus Prioritisation Scheme	Upgrade of junction of Tuam Road (R336)/Joyce's Road from a priority junction to a signalised junction, to provide bus prioritisation. Project will include widening on approaches, right turn lanes, improved pedestrian and cyclist facilities and linkage to Urban Traffic Management Centre. The junction upgrade will serve all bus operators accessing/egressing Galway via the Tuam Road (R336) and is anticipated to reduce bus journey times by 7-15 minutes during evening peak hours. To be completed in 2014.
012	025	Old Seamus Quirke/Newcastle Roads Bus/Cycle Corridor (NTA Plan 25)	Design and planning in 2013: Development of inbound Bus/Cycle Lane, approximately 950 metres long, commencing at Old Seamus Quirke Road/N6 junction and finishing at Newcastle Road/University Road junction. The Bus/Cycle lane is linked to the Seamus Quirke Road bus lane at the Old Seamus Quirke Road/N6 junction and serves to extend that bus lane towards the city centre via NUI Galway and Galway University Hospital. The bus lane will serve Bus Éireann routes 402, 404 & 405 and Galway City Direct route 412. Anticipated savings of 5-10 minutes in the AM & PM peaks.
015	027	Tuam Road Bus Corridor Project (NTA Plan 27)	Design and planning in 2014: Design of an inbound bus lane, approximately 2,750 metres long, along the N83 Tuam Road, commencing at the Parkmore Road junction and finishing at the junction with the N6. The bus lane will serve all bus operators entering Galway via the N83. It is anticipated that 7-15 minutes would be saved on bus journeys during the AM peak, following implementation of the project.
018		N59 Dangan Upgrade	Upgrade of the N59 Junction at Dangan.
019		Reconfiguration of Threadneedle Road Junction	Right turning movements will be prohibited/removed.
020		Alteration of the Clybaun Junction on the Western Distributor Road	Upgrade of this junction to a continental style roundabout.
021	040	Kirwin Roundabout Upgrade (NTA Plan 40)	Proposal to replace the Kirwan Roundabout (N6/N84 junction) with a signalised junction. This is one of three remaining roundabouts on the N6 in the city and is a major congestion point for bus services.

Ref.	NTA Ref.	Scheme Name	Scheme Description
022		Terryland Right turn lane on the N6	Provision of a right turning lane on the N6 at Terryland.
025	039	Browne Roundabout Upgrade (NTA Plan 39)	Proposal to replace the Browne Roundabout (N6/N59 junction) with a signalised junction. This is one of three remaining roundabouts on the N6 in the city and is a major congestion point for bus services. It is also a major access point for University Hospital Galway for ambulances and patients.
027	001	Ballybaan Road Cycleway (NTA Plan 1)	On-Road Cycleway, approximately 1,250 metres long. Running on both sides of the road from the Ballybaan Road/N6 junction to the Ballybaan Road/Dublin Road junction.
028	003	Canal Greenway (NTA Plan 3)	Mixed Greenway, approximately 800 metres long. Running from the University Road/Canal Road junction to the Raven Terrace/Wolfe Tone Bridge junction.
029	004	Castlepark Road Cycleway (NTA Plan 4)	Cycle Lanes, approximately 1,250 metres long. Running from the Ballybaan Road/Castlepark Road junction to the Castlepark Road/Monivea Road junction.
030	005	Clybaun Road Cycleway (NTA Plan 5)	Cycle Lanes, approximately 850 metres long. Commencing at Clybaun Road/Kingston Road junction and finishing at Clybaun Road/Western Distributor Road junction.
031	006	College Road Corridor (NTA Plan 6)	Bus Gate, Situated between City Hall and Sports Ground. The Bus Gate will convert College Road into two Cul-de-sacs, permitting only buses and cyclists to travel from its junction with Lough Atalia to its junction with Bothar Uí hEithir and vice-versa. The project will include Cycle Lanes, approximately 1,100 metres long. Commencing at College Road/Lough Atalia junction and finishing at College Road/Bóthar Uí hEithir Road junction.
032	007	Cross-Middle St Pedestrianisation (NTA Plan 7)	This will extend the existing Pedestrian Zone southwards to Galway Docks. It will enable the revitalisation of the historic centre of the city.
033	008	Dangan Greenway (NTA Plan 8)	Phase 1 – Off-Road Greenway, approximately 300 metres long. Commencing at University Road and finishing at NUI Galway Car-park (Orbsen Building). Phase 2 – Off-Road Greenway, approximately 750 metres long. Commencing at NUI Galway Car-park (Orbsen Building) and finishing at south of N6 Underpass. Phase 3 – Off-Road Greenway, approximately 2,400 metres long. Commencing at north of N6 Underpass and finishing at Dangan Playing Fields, with link along existing access road to N59. Phase 4 – Off-Road Greenway, approximately 10,000 metres long. Commencing at Dangan Playing Fields and finishing at Moycullen.
034	009	Dock Road Corridor (NTA Plan 9)	Bus Lane and Cycleway, approximately 500 metres long. Commencing at Victoria Place and finishing at Dock Road/Dock Street junction.
035	010	Doughiska Road Cycleway (NTA Plan 10)	Phase 1 – On-Road Greenway, approximately 200 metres long. Commencing at Doughiska Road/Brierhill Road junction and finishing at Brierhill Road/Monivea Road junction. Phase 2 – On-Road Greenway, approximately 1,000 metres long. Commencing at Doughiska Road/Merlin Park Lane junction and finishing at Doughiska Road/Coast Road junction.
036	011	Dr Mannix Road Cycleway (NTA Plan 11)	On-Road Greenway, approximately 1,600 metres long. Commencing at Dr. Mannix Road Road/Threadneedle Road junction and finishing at Ocean Wave/Whitestrand Road junction.

Ref.	NTA Ref.	Scheme Name	Scheme Description
037	012	Dublin Road Bus Lane (NTA Plan 12)	Inbound Bus Lane, approximately 300 metres long. Commencing South-east of the Coast Road/Dublin Road junction and finishing at the junction.
038	013	Eglinton Street Shared Space (NTA Plan 13)	Phase 1 - A Shared Space, approximately 200 metres long. Commencing at Eglinton Street/Mary street junction and finishing at Williamsgate Street/Eyre Square junction. Phase2 - A Shared Space, approximately 200 metres long. Commencing at Eyre Square/Williamsgate Street junction and finishing at Eyre Square/Bohermore Road junction.
039	014	Fr Griffin Road Corridor (NTA Plan 14)	Phase 1 – Inbound Bus/Cycle Lane, approximately 400 metres long. Commencing at Fr. Griffin Road/Whitestrand Road junction and finishing at Fr. Griffin Road/Fairhill junction. Phase 2 – Inbound & Outbound Bus/Cycle Lanes, approximately 200 metres long. Commencing at Fr. Griffin Road/Fr. Burke Road junction and finishing at Wolfe Tone Bridge.
040	015	Headford Road Cycleway (NTA Plan 15)	Phase 1 – Cycle Lanes, approximately 700 metres long. Commencing at Headford Road/Wood Quay junction and finishing at Headford Road/Sean Mulvoy Road junction. Phase 2 – Cycle Lanes, approximately 1,200 metres long. Commencing at Headford Road/Coolagh Road junction and finishing at Headford Road/Bóthar na Coiste junction. Phase 3 – Cycle Lanes, approximately 2,250 metres long. Commencing at Headford Road/ Bóthar na Coiste junction and finishing at Ballindooley Cross.
041	017	Monivea Road Corridor (NTA Plan 17)	Phase 1 – Outbound Bus/Cycle Lane, approximately 200 metres of Bus/Cycle Lane and a further 500 metres of Cycle lane . The Bus/Cycle lane commences at Mervue Industrial Estate and finishes at Monivea Road/Connolly Avenue junction. The additional 500 metres of cycle lane commences at Moneenageisha Cross and links into the Bus/Cycle lane. Phase 2 – Inbound Bus/Cycle Lane, approximately 700 metres long. Commencing at Monivea Park and finishing at Monivea Road/Connolly Avenue junction. Phase 3 – Cycle Lanes, approximately 1,750 metres long. Commencing at Monivea Road/Ballybaan Road junction and finishing at Monivea Road/Brierhill Road junction. Phase 4 – Cycle Lanes, approximately 3,750 metres long. Commencing at Monivea Road/Parkmore Road junction and finishing at Monivea Road/N18 junction.
042	018	Newtownsmith Cycleway (NTA Plan 18)	In-Bound Cycle Lane, approximately 550 metres long. Commencing at Newtownsmith/Salmon Weir Bridge junction and finishing at Nicholas Street/Dock Road junction.

Ref.	NTA Ref.	Scheme Name	Scheme Description
043	019	Oran Mor Greenway (NTA Plan 19)	Phase 1 – On-Road Greenway, approximately 5,500 metres long. Commencing at Órán Mór and finishing at Dublin Road/Ballybaan Road junction. Phase 2 – On-Road Greenway, approximately 1,750 metres long. Commencing at Dublin Road/Ballybaan Road junction and finishing at Moneenageisha Cross.
044	020	Parkmore Road Cycleway (NTA Plan 20)	Cycle Lanes, approximately 900 metres long. Commencing at Parkmore Road/Monivea Road junction and finishing at Parkmore Roundabout.
045	021	Race Course Cycleway (NTA Plan 21)	Off-Road Greenway, approximately 2,750 metres long. Running from the Ballybaan Road/N6 junction to the Racecourse Avenue/Parkmore Road junction.
046	022	Rahoon Road Bus Lane (NTA Plan 22)	Inbound Bus Lane, approximately 400 metres long. Commencing at Rahoon Cemetery and finishing at Rahoon Road/Bishop O'Donnell Road junction. Outbound Cycle Lane, approximately 550 metres long. Commencing at Rahoon Road/Bishop O'Donnell Road junction and finishing at Rahoon Road/Millers Lane junction.
047	023	Renmore Cycleway (NTA Plan 23)	Mixed Greenway, approximately 3,500 metres long. Commencing at Dublin Road/Ballyloughan Road junction and finishing at Galway Harbour.
048	024	Siobhan McKenna Road Cycleway (NTA Plan 24)	Phase 1 - Siobhan McKenna Road – Cycle Lanes, approximately 1,000 metres long. Commencing at Circular Road/Siobhan McKenna Road junction and finishing at Siobhan McKenna Road/Thomas Hynes Road junction. Phase 2 - Thomas Hynes Road – Cycle Lanes, approximately 1,200 metres long. Commencing at Seamus Quirke Road/Thomas Hynes Road junction and finishing at Thomas Hynes Road/Newcastle Road junction. Phase 3 - Circular Road – Cycle Lanes, approximately 700 metres long. Commencing at Seamus Quirke Road/Circular Road junction and finishing at Circular Road/Cnoic an Oir junction.

Ref.	NTA Ref.	Scheme Name	Scheme Description
049	028	University Road Corridor (NTA Plan 28)	Inbound Bus/Cycle Lane, approximately 400 metres long. Commencing at Newcastle Road/University Road junction and finishing at the Salmon Weir Bridge.
050	029	Western Distributor Road Corridor (NTA Plan 29)	Phase 1 – Inbound Bus Lane, approximately 600 metres long. Commencing at Gort na Bro/Western Distributor Road junction and finishing at Western Distributor Road/Bishop O'Donnell Road junction. Phase 2 – Inbound Bus Lane, approximately 2,400 metres long. Commencing at Western Distributor Road/Cappagh Road junction and finishing at Gort na Bro/Western Distributor Road junction.
051	030	City Centre 30kph Zone (NTA Plan 30)	Proposal to establish a 30kph zone in the City Centre. Initial Study to determine extent of zone and possible one way traffic flows & turning prohibitions. The second phase will include the production of Tender Documents, any assessments required for planning and the implementation of the zone.
053	033	UTMC Expansion (NTA Plan 33)	Continued expansion of the Urban Traffic Management & Control System in Galway City and to incorporate Traffic Signals in Galway County, to include the towns of Maigh Cuillínn, Órán Mór, Tuam, Ballinasloe, Loughrea and Baile Chlair.
057	037	Skerrit Roundabout (NTA Plan 37)	Replacement of the Skerrit Roundabout (Dublin Road/Ballybaan Road junction) with a signalised junction. This is the only remaining un-signalised major junction on the Dublin Road Corridor.
058	038	Cemetery Cross (NTA Plan 38)	Replacement of the Cemetery Cross Roundabout (Tuam Road/Bohermore Road junction) with a signalised junction. This is one of the three most critical junctions in the city and is a major congestion point for bus services.
061	043	Cathedral Parking (NTA Plan 43)	Study to examine options for the improvement of coach & car parking at Galway Cathedral and cycling & pedestrian movements at this location. The area is a major hub for tour coaches and also for student and commuter bus services.

Review of City Schemes (Doc Ref. GCOB-4.03-2.1-001)
Committed Projects

Ref.	NTA Ref.	Scheme Name	Scheme Description
063	046	Miller's Lane (NTA Plan 46)	Off-Road Pedestrian way, approximately 1km long. Commencing at Kingston Road and finishing at Rahoon Road. The scheme will involve the upgrading of an existing pedestrian route.
064	047	Galway Bike Scheme (NTA Plan 47)	-
068		Wellpark Road/Connolly Avenue Junction Improvements (Allocations 2012)	Proposal to upgrade the Wellpark Road/Connolly Avenue junction in advance of bus lane works being carried out on Wellpark Road (see 15 below) to include widening the approaches to the junction to provide right turning lanes, upgrading of signals, provision of pedestrian facilities and provision of vehicle detection incorporating a link to the Urban Traffic Management Centre. Vehicle detection and link to UTMC will allow priority to be given to buses at the junction.
070		Footpath Widening at Bridge Street (Allocations 2012)	Proposal to widen the southern footpath on Bridge Street between the Cross Street junction and the Dominick Street Lower junction. The footpath is restricted in width at present whilst catering for significant numbers of pedestrians. Includes works to O'Brien's Bridge.
071		Improvements to Bus Routes (Allocations 2012)	Realignment of the junction between the Headford Road and Tirellan Heights to allow access for Route No. 7 bus which currently cannot negotiate the turn from Headford Road in to Tirellan Heights, resulting in inbound buses not being able to appropriately serve the Tirellan Heights area. In addition, it is proposed to upgrade a number of bus stops with Kassel Kerbs and upgraded shelters.
072		Variable Message and Parking Guidance Signs (Allocations 2012)	Phase 2 of the provision of Variable Message Signs (VMS) and Parking Guidance Signs in city centre and on approaches to the city centre on non-national routes. The signs will link into the urban traffic management and control system currently under construction (See 2 above). The signs will allow the dissemination of information to drivers on availability of car parking, traffic incidents, journey times and other information.
073		NUI Galway to Fisheries Field Greenway (Allocations 2012)	Continuation of construction of the Greenway from the Clifden Road (N59) entrance to the NUI Galway Playing Fields to Galway Cathedral on University Road. Forms part of the Galway to Clifden Cycle Route. The route in its entirety passes through NUI Galway grounds. At the southern end it would link to Fisheries Field Bridge (currently under construction) and the previously constructed Fisheries Field Greenway which links to Galway City Centre.
075		CCTV Cameras at Junctions (Allocations 2012)	Provision of CCTV cameras at various locations in Galway City to facilitate better traffic management through improved monitoring. The works will include the installation of poles, or extensions to existing poles, ducting if required, cabling and communications back to the Urban Traffic Management Centre (UTMC).
076		Rahoon Road Bus Lane (Allocations 2012)	Provision of an eastbound bus lane on Rahoon Road between the junctions with Cruachan Park and Bishop O'Donnell Road. In conjunction with this, a cycle lane will be provided in the westbound direction. The total length of the scheme is approximately 350m and will provide approximately 320m of bus lane. The scheme received Part 8 approval in November 2011, and is due to commence construction in June 2012. The scheme will primarily be used by City Direct bus routes 33, 34 and 35.
077		Merlin Transport Corridor (Allocations 2012)	Proposed bus only link incorporating pedestrian and cycling facilities (Greenway) between the Dublin Road and the N6 Coolagh Roundabout Junction. Funding in the current year is for the commissioning of a study to access the potential of alternative routes using existing infrastructure.
079		Junction Upgrades Galway City	Upgrade of Junctions at Briarhill, Ballybaan, N83 Tuam Road and Terryland
080		Galway Transportation Unit	Include for all upgrades and improvements which have resulted from the establishment of the Galway Transportation Unit.

Review of City Schemes (Doc Ref. GCOB-4.03-2.1-001)
Committed Projects

Ref.	NTA Ref.	Scheme Name	Scheme Description
081		M17M18 Motorway	Account for the construction of the M17M18 and the effects it is likely to have on the way traffic approaches Galway City. The effects that are anticipated at villages along the existing N18 needs to be considered (Clarinbridge, Ardrahan and Oranmore etc.).
085		Fr Griffin road / Raven Terrace	Ban right-turn from Fr Griffin Rd to Raven Terrace and modify Fairhill Rd / Fr Griffin Rd junction
086		Rail - Ennis to Athenry	Hourly rail service between Athenry & Ennis
087		Rail - Athenry to Galway	Half Hourly rail service between Athenry & Galway
092		New Junction - Distillary Road Neigh.	Revised primary junction into NUIG with the downgrade of Distillary Road.
093		Bearna Road / Ballymoneen Road Junction	Signalisation Works.
094		Traffic Calming Grattan Road / Claddagh Quay	Installation of traffic calming measures.
096		Oranmore rail services	

Appendix F

Galway Transport Strategy Report

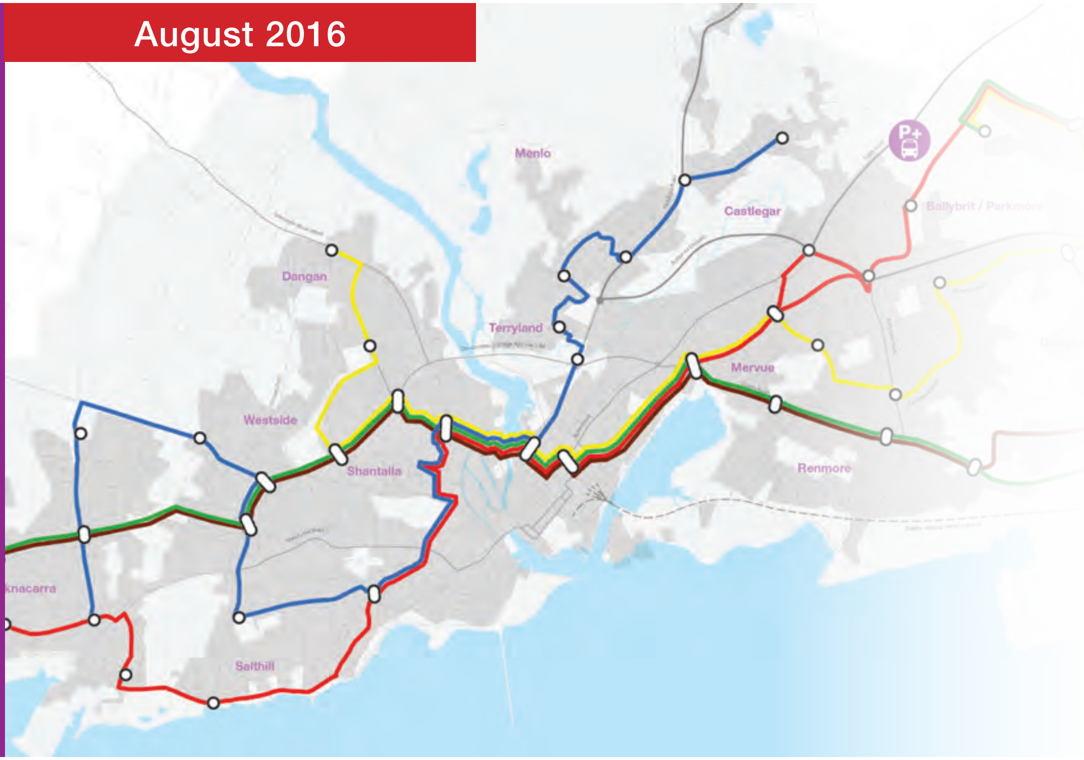
Straitéis Iompair na Gaillimhe
Galway Transport Strategy

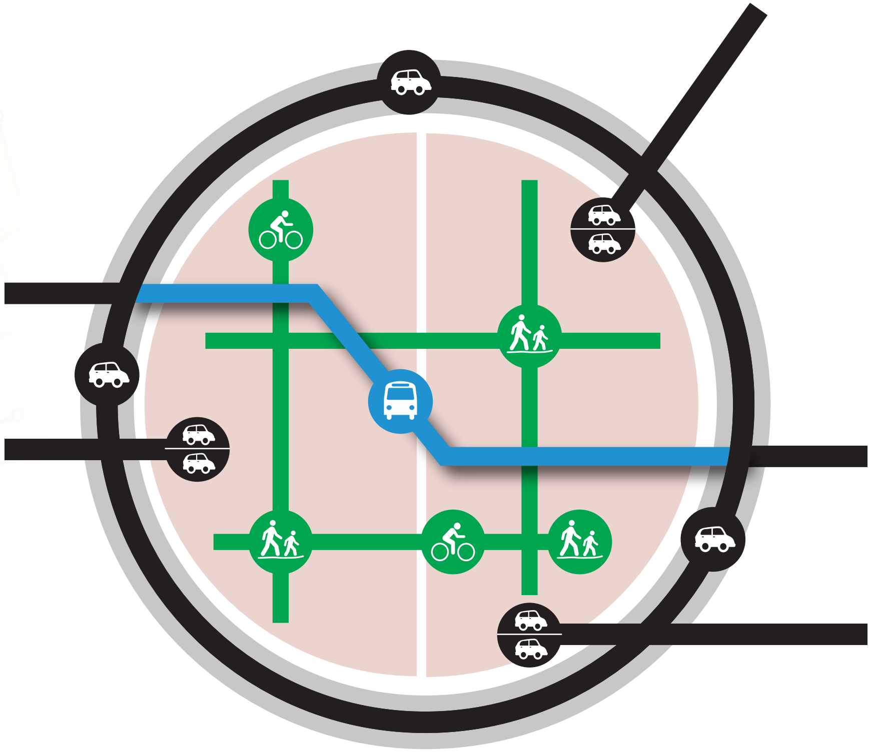
Comhairle Cathrach na Gaillimhe
Galway City Council

Comhairle Chontae na Gaillimhe
Galway County Council

An Integrated Transport Management Programme for Galway City and environs

August 2016





Údarás Náisiúnta Iompair
National Transport Authority

Aonad Iompair na Gaillimhe
Galway Transport Unit

SYSTRA

ARUP

This Transport Strategy will facilitate Galway with an opportunity to grow both physically and economically, offering better transport choices, and creating a public realm to be enjoyed by residents and visitors alike. This in turn will underpin the objectives of the existing and future City and County Development Plans.

Contents

“a connected city region driven by smarter mobility”

1 Introduction

1.1 Introduction

As Galway City and its environs continues to grow, it is crucial to safeguard the future development of the city as the principal economic centre in the West of Ireland and to ensure that its development is sustainable. There is a strong need to address the transportation issues facing the city and surrounding areas at present, and to underpin future growth by establishing a long-term strategy for transport to, within and around the city.

In many respects, Galway is a city of contrasts in terms of its physical development and transport requirements. While Galway has a compact walkable core, outside of the city centre the suburbs have developed as a succession of low density residential and employment areas, leading to a predominance of private car usage as a means of travel.

The transport problems currently experienced across the city, particularly during peak hours, are having a significant effect on the quality of life of residents, and are now impacting on the economic capability of the city. These effects extend to the wider county and region, due to the large number of people commuting daily for work or education to the city from the surrounding towns, villages and rural areas.

To address these issues, Galway City Council and Galway County Council, in partnership with the National Transport Authority, have developed this Galway Transport Strategy (GTS), which aims to address the current and future transport requirements of the study area, which encompasses the city and surrounding towns and villages, including Bearna, Oranmore, Maigh Cuilinn and Baile Chláir.

The Galway Transport Strategy builds on previous transport studies carried out for the Galway Region, and sets out an overview of the proposed actions and measures for implementation, covering infrastructural, operational and policy elements (an 'Integrated Transport Management Programme', or 'ITMP'). These consolidated proposals will provide Galway City and its environs with a clear implementation framework for the next 20 years and will be used to secure funding to deliver projects in a phased manner based on priority needs.

Ultimately, the strategy will underpin the objectives of the current and future Galway City and Galway County Development Plans.

The strategy development, analysis and proposed underpinning measures are presented in this summary report. This document is in turn supported by an accompanying technical GTS Report and a number of appendices.

Next steps

Secure Funding for Proposed Measures

Planning and Design of Proposed Measures

Implementation of Measures

Introduction

1.2 Current Issues

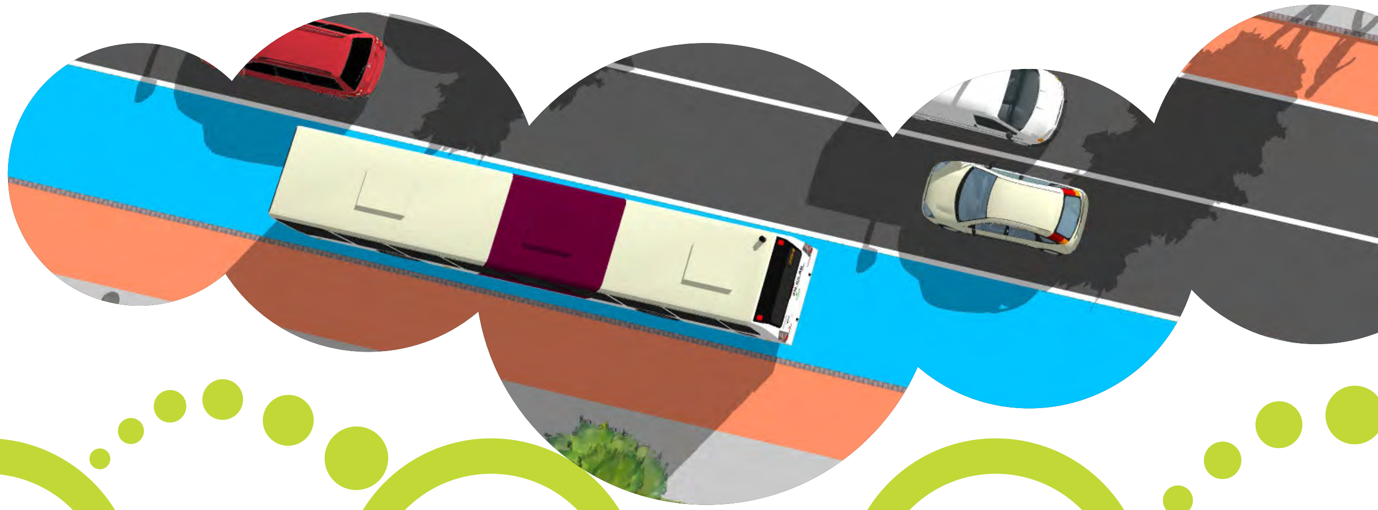
Galway experiences peak hour congestion and journey time unreliability for all motorised transport.

A number of specific characteristics of Galway City and its environs result in significant problems and inefficiencies with respect to the movement of people and goods, including:

- An over-reliance on private cars;
- Peak hour congestion and journey time unreliability for all motorised transport;
- Safety concerns as a result of traffic congestion;
- Many key junctions within the city operating at or over capacity;
- Connectivity issues on the National and Regional road network resulting in significant volumes of cross-county and strategic travel demand between east and west Galway being concentrated and funnelled through the city area in order to cross the River Corrib;
- The pattern of residential development in the area, along with the location of employment destinations, generating a large amount of cross-city as well as city-bound travel demand;
- Large amounts of residential development located proximate to major employment and education destinations city-wide, but not readily accessible by walking, cycling or public transport, thereby encouraging travel by private car;
- The short distance between Lough Corrib and Galway Bay, two significant physical natural constraints impacting upon the city;
- A natural barrier to cross-city and cross-county travel formed by Lough Corrib, the River Corrib and Galway Bay, with the three principal river crossings experiencing heavy traffic flows, leading to congestion and delay;
- The position of Galway City as a major regional centre for employment and education for a large geographical area, leading to large numbers of long-distance commuters for whom public transport is not currently a viable option, which leads to greater numbers of cars entering the city;
- The impact of traffic congestion on the City's reputation, particularly with regard to inward development;
- The suburban nature of much of the residential areas, and the wide distribution of jobs across a number of central and non-central locations, which lead to a situation where travel by public transport is not a viable option at this point for many journeys;
- Long journey times and delays on the current bus network, due in part to the limited available road space in the city centre for introducing bus priority, which both reduces its attractiveness to passengers and increases costs of operating; and
- Limited roadspace on most of the principal roads, which reduces opportunities for safe and comfortable cycling.

1.3 Vision and Principles

To address the current and future transport needs of the city, a shift is needed towards sustainable travel, reducing the dependence on the private car and taking action to make Galway more accessible and connected, improving the public realm and generally enhancing quality of life for all.



To achieve this vision the guiding principles underpinning the development of the Transport Strategy are:

Principle 1

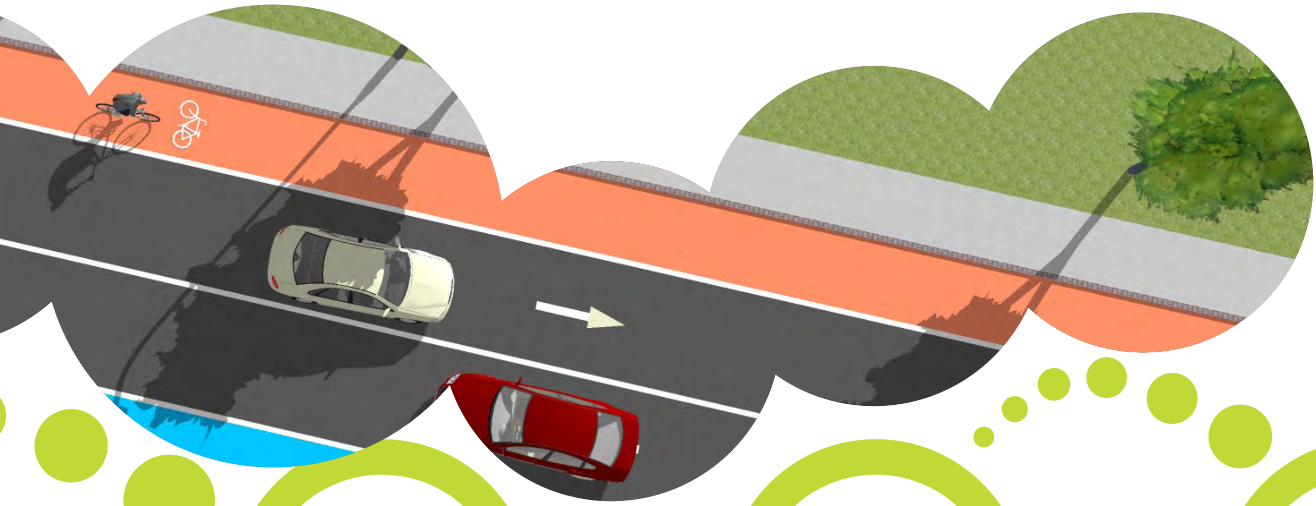
To promote and encourage sustainable transport, and in particular to make it convenient and attractive to walk, cycle or use public transport.

Principle 2

To improve accessibility and permeability to, and within the city centre for pedestrians, cyclists and public transport users, while also maintaining an appropriate level of access for vehicular traffic for commercial and retail purposes.

Principle 3

To maximise the safety and security of pedestrians, cyclists and other transport users, particularly within the core city centre.



1.4 Planning Framework

It is intended that the Galway Transport Strategy, once finalised, will be consistent with and supporitve of the new Galway City Development Plan (2017-2023), and the Galway County Development Plan (2015-2021).

As set out earlier, the strategy will extend beyond the timescale of both the current and new City Development Plans and the County Development Plan and is set out in terms of what needs to be delivered over a 20-year period.

Principle 4

To manage and increase transport capacity (where necessary), for the efficient movement of people and goods into and within the city.

Principle 5

To provide opportunities to enhance the city centre public realm through traffic management and transport interventions.

Principle 6

To maintain and develop transport infrastructure and services to a high degree of quality and resilience.

Principle 7

To adopt a ‘smarter technology’ approach to all transport interventions, whereby transport infrastructure and services are future-proofed.

The vision of Galway City Council and Galway County Council for transport for Galway is to create

“a connected city region driven by smarter mobility”.

1.5 Strategic Environmental Assessment, Appropriate Assessment and Strategic Flood Risk Assessment

The preparation of the Galway Transport Strategy was subject to Strategic Environmental Assessment (SEA). Article 1 of SEA Directive (2001/42/EC) states that the 'objective of this Directive is to provide for a high level of protection of the environment and to contribute to the integration of environmental considerations into the preparation and adoption of plans and programmes with a view to promoting sustainable development, by ensuring that, in accordance with this Directive, an environmental assessment is carried out of certain plans and programmes which are likely to have significant effects on the environment.'

The Galway Transport Strategy was subject to the formal, systematic environmental assessment of the likely significant effects of implementing the strategy to ensure that environmental implications have been taken into account in decision-making prior to the finalisation of the strategy. Therefore, the provisions of the strategy have been assessed for potential environmental effects and measures arising from the SEA have been integrated into the final strategy.

An Appropriate Assessment (AA) of the strategy is also being undertaken as part of the preparation of the GTS. The purpose of the AA is to provide a focused and detailed impact assessment of the implications of the strategy, alone and in combination with other strategic actions and projects, on the integrity of Natura 2000 sites in view of their conservation objectives.

A Natura Impact Statement (NIS) accompanies the GTS Technical Report (included in Appendix J) and presents an assessment of whether the GTS could affect the integrity of the European Sites within its Zone of Influence. The assessment process has informed the preparation of the GTS and includes a mitigation strategy (which has also been incorporated into the GTS) to ensure the adverse effects on the integrity of any European Sites will not occur as a result of implementing the GTS.

The GTS has also been subjected to a Strategic Flood Risk Assessment (SFRA), which addresses the issues of assessment and management of flood risk in plans and land-use plans. The findings of the NIS and the SFRA have informed the SEA process and any necessary measures arising from the recommendations of the NIS and SFRA have been incorporated into the strategy in order to ensure that potential adverse effects are mitigated and are documented in the Environmental Report for the SEA.

The AA Process will be completed by the relevant Competent Authority prior to adoption of the GTS into the Galway City and County Development Plans, and associated Local Area Plans.

It is important that the Galway Transport Strategy reflects the needs and aspiration of the public and key transport stakeholders across the city and county.

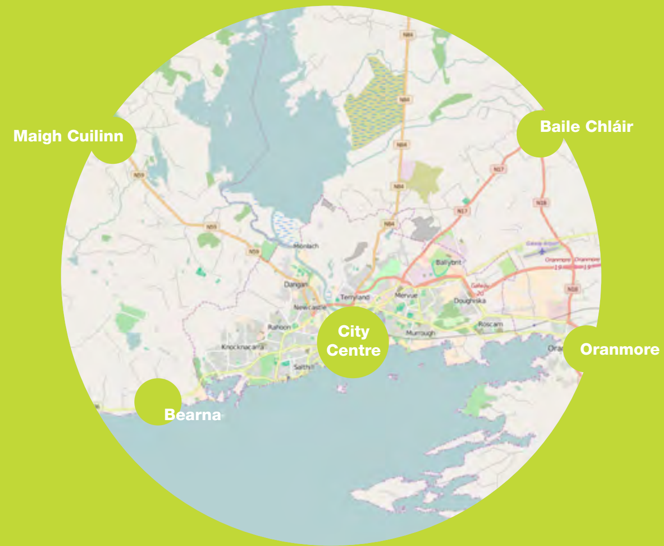
1.6 Consultation

An initial public information event was held in May 2015, at which feedback from the public on the key transport issues was received. A second consultation process was also undertaken on the final draft GTS and its sub-components in June 2016. The consultation material was made available online and at City Hall, and further responses from the public were received during the periods of open consultation which followed. The main themes and issues arising from the submissions were:

- Public transport in the city needs improvement generally;
- Cycle lanes should be improved generally;
- A light rail or improved heavy rail system should be considered;
- The bus lane network should be extended;
- A bypass of Galway City is not necessary;
- Public transport needs to incorporate school transport;
- Park & Ride sites should be introduced;
- Private car dependency should be reduced;
- Pedestrian/mobility impaired facilities should be improved;
- The use of Quincentenary Bridge for bus services should be considered;
- A new road traffic bridge should be provided adjacent to Salmon Weir Bridge (which should be pedestrianised);
- The city UTMC system should be expanded to improve traffic flow around city; and
- The environmental impacts of the GTS should be considered.

This feedback has been considered by Galway City Council and Galway County Council and has informed the development of this Galway Transport Strategy.

Figure 2.1 Study Area



2.1 Study Area & Existing Land-Use Context

The study area for the Galway Transport Strategy comprises the Galway City Council administrative area and the surrounding hinterland within the Galway County Council administrative area, including consideration of connectivity to the settlements of Bearna, Oranmore, Maigh Cuilinn and Baile Chláir. The city municipal area is illustrated in Figure 2.1.

Within the study area, the city centre has been defined for the purposes of this strategy. This is made up of the area bounded by the city's canal network to the west, and the Fairgreen/Bóthar Bhreandáin Uí hEithir/Bóthar na mBan road cordon to the east. This area is highlighted in Figure 2.1.

2.2 Land-Use Context

The existing land-use profile of the study area outlined above is characterised by significant residential development in the west and east of the city, and in other locations close to major employment and retail areas within the city centre area and in the east of the city. To the north of the city there are several small towns and villages on either side of Lough Corrib, with dispersed residential development throughout the rural areas.

In addition, there are also large residential developments in close proximity to major employment and educational facilities, but which are not easily accessible by walking, cycling or public transport. These settlement patterns have given rise to an increased need to travel, both to the city centre and across the city centre, from the suburban areas and from the wider region.

It is anticipated that the existing land uses will remain largely unchanged over the time period of this strategy, however it is necessary to consider the location and impact of new development both within the city centre and within the wider suburban areas as set out in City and County Development Plans and Local Area Plans, to ensure that these areas are considered in the development of the transport proposals.

A number of brownfield areas are identified as key development opportunities within the city centre, including Ceannt Station and Galway Harbour. The development and expansion of Galway Port is also expected to occur in the coming years. The Headford Road area to the north, where there is existing retail development, is also likely to be redeveloped with a wider mix of uses.

To the east of the city, significant residential development is envisaged at Ardaun, as well as complementary local employment and services. It is also important to note that opportunities for redevelopment of Galway Airport, purchased in 2014 by Galway City and Galway County Council, remain possible over the lifetime of this strategy.

Other existing suburban areas, including Knocknacarra, Castlegar and Doughiska are envisaged to grow, albeit at a more constrained rate. District centres and lower-order neighbourhood centres are identified by the Draft City Development Plan 2017 - 2023 for these suburban areas, and in other locations including Westside, Salthill, Ballinfoyle, Renmore and Ballyburke, which will increased levels of employment.

In the wider county, the settlements at Baile Chláir, Maigh Cuilinn, Bearna and Oranmore themselves see large numbers of daily commuters to and from Galway City. Approximately 50% of Galway City's daytime working population commute from outside the city boundary.

In the preparation of this strategy, appraisals of existing land-uses, planned growth areas in the City and County Development Plans and Local Area Plans, and the function of the city centre were undertaken to inform the development and design of the transport proposals.

2.3 Current Transport Supply

Local & Regional Bus Networks

Parts of the study area are served by the existing city bus service, which is facilitated by a limited range of bus-specific infrastructural elements of varying extent and quality, but which are not continuous over any significant portion of the network. The city bus network is very much discontinuous, with priority measures only provided along sections of key corridors.

As such the city bus network is subject to delay, impacting the attractiveness of the bus as a mode of choice. Indeed, the 2011 Census recorded a mode share of 8% for travel within the city area to work or education, which is a relatively low bus mode share for urban areas. Of the current city bus services, only one (the 409 Parkmore service) has a target frequency of one bus in each direction every 12 minutes at peak times (as of April 2016).

Improvements to the city bus service in recent years have included the re-organisation of routes and schedules, newer fleet and the roll-out of the Leap card, in addition to a number of significant bus infrastructure schemes and junction upgrades across the city. These measures have contributed to an increase in patronage of over 30% from 2012-2015, albeit from a previously low base.

A number of regional bus service providers operate to and from the city. Regional and intercity coach services are subject to delays due to infrastructural deficiencies approaching and within the city centre, where the principal destinations are located at Ceannt Station, Fairgreen Coach Station, Eyre Square/Merchants Road and Galway Cathedral. These delays, along with centralised destinations in the city centre and a lack of integration with the city bus routes and ticketing systems, discourage use of regional bus services for commuters from surrounding towns and villages which are served directly by regional buses.

National coach services benefit from high-quality road connectivity from the east and south, increasingly of motorway standard with the relatively recent construction of the M6 and the current development of the M17/M18, which will also improve connectivity to the north-east. Similar to regional services, there are numerous operators providing intercity services to and from the city, with a resultant high number of daily arrivals and departures. These services are also subject to delays due to infrastructural deficiencies approaching and within the city centre.

Rail Network

The study area is served by the existing single-track heavy rail line from the east, terminating in the city centre at Ceannt Station. The rail line extends east to Athenry, with a stop at Oranmore/Garraun. From Athenry, rail lines continue towards Dublin and to Limerick.

2.3 Current Transport Supply

Cycle Network
Although the city's generally flat topography is conducive to cycling, the current mode share of 5% is relatively low. Similar to the bus network, the existing network of cycle infrastructure is limited and discontinuous. The volume of vehicular traffic on the tight city centre streets also contributes to an environment that is neither appealing nor perceived as safe for cycling.

While there have been numerous cycle network improvements in recent years, not least the roll-out of the Bike Share Scheme, the cycling environment remains limited. This is particularly true in areas outside the city, despite the fact that many towns and villages are within cycling distance of the city and each other, such as Bearna, Oranmore, Maigh Cuilinn and Baile Chláir.

Pedestrian Network
Within the city centre, there are pedestrian-only streets which are a key asset to the local economy, in particular the tourism/shopping thoroughfare of Shop Street/Quay Street. Other pedestrian facilities of note include the city canal network and the promenade at Salthill. There have also been major junction improvement schemes in recent years which have considerably improved pedestrian facilities across the city.

However, there are numerous locations within the study area where the quality of the pedestrian facilities are poor. There are locations within the city centre where the mix of vehicular traffic impacts on the safety and comfort of pedestrians. There are streets throughout the city with substandard or missing footpaths, limited or no crossing facilities, and permeability issues resulting from the manner in which residential areas have been developed. The absence of permeability within housing areas often leads to excessively circuitous trips for pedestrians to walk relatively short distances.

Road Network
The geography of Galway City is physically constrained; it is divided by the River Corrib and Lough Atalia and it is bounded to the south by Galway Bay and to the north by Lough Corrib, natural barriers to free movement and development and constraints to the road network. There are currently four bridges crossing the river, of which three are in very close proximity to the city centre, thus drawing traffic into the city for the sole purpose of crossing the river. However, given the land-use characteristics of the city, there is significant cross-city and city-bound travel demand, particularly during peak hours.

Vehicular traffic crossing the city however is heavily constrained by the limited number of road crossings of the River Corrib. At present, Quincentenary Bridge is the sole option for traffic wishing to avoid the city centre area. Heavy congestion and delay on the approaches to Quincentenary Bridge often leads to traffic re-routing towards Salmon Weir Bridge, Wolfe Tone Bridge and O'Brien's Bridge, which in turn creates congestion across the city. Galway County and the Connemara region, as far west as Clifden and on to Letterfrack, are equally dependent on this narrow funnel for access as this area is restricted by the extents of Lough Corrib heading north, the Twelve Bens mountains, the Maamturk mountains and many smaller lakes. Access to this area is via the bridges across the River Corrib in Galway City due to the physical natural constraints. Therefore, cross-county traffic, and more strategic traffic to and from the west coast of the country is channelled towards Galway City in order to cross the River Corrib, in turn further exacerbating traffic congestion and delay.

The M/N6 is a highly important national road, and is identified as part of the TEN-T Comprehensive Network. The M/N6 is also identified as a Strategic Radial Corridor in the National Spatial Strategy (NSS) and is an important inter-urban transport corridor linking the Galway Gateway with the Greater Dublin Area via the Midlands Linked Gateway and gives access to regional and international markets, including through strategic airport and port locations as well as linking with other strategic national roads. Equally the N17 (NSS Strategic Linking Corridor) and the N59 and N84 (national roads) are important regional links to and from the city.

While a key challenge of this strategy is to provide sustainable and reliable alternatives to travel by private car, the management of the road network will remain critical.

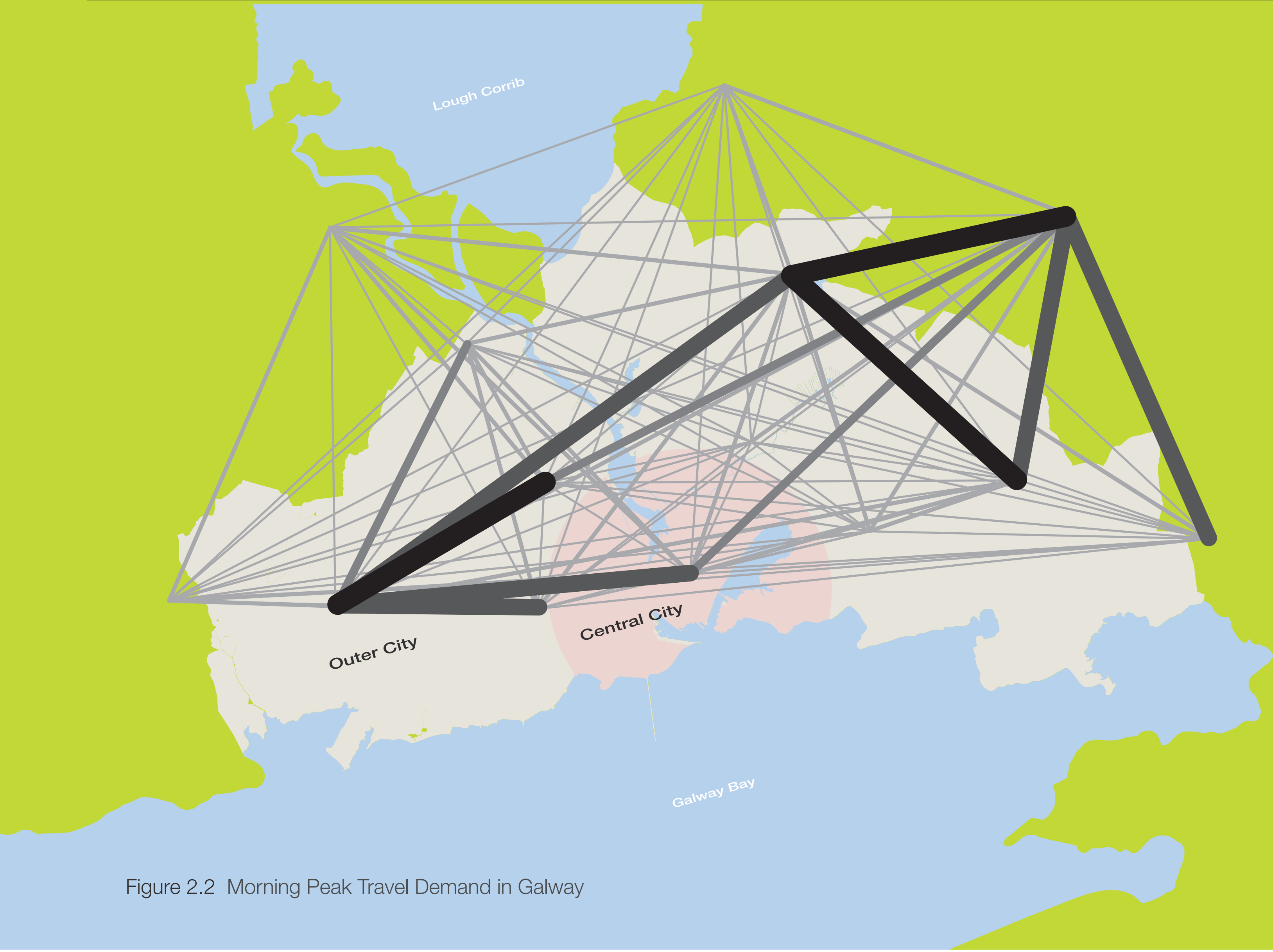


Figure 2.2 Morning Peak Travel Demand in Galway

Analysing Travel Demand in Galway

Figure 2.2 shows in summarised form the current typical movements between sectors of Galway in the AM period (7am – 10am) by motorised transport (car, van or bus). The movement 'desire lines' consist of a large number of movements, which have been grouped together for illustrative purposes.

Vehicular Trips - AM Peak (7:00 -10:00)

- 0 - 500
- 501 - 1,000
- 1,001 - 1,500
- 1,501 - 2,000
- > 2,000

23%
of City population travel on foot

5%
of City population travel by bicycle

8%
of City population travel by Bus/ Coach

<1%
of City population travel by Train

60%
of City population are driving in a car/ van

Source:
This data is from Census 2011

2.4 Movement Context

The highest concentration of trips in Galway occurs between 8am and 9am. ‘Home-to-work’ trips comprise the largest concentration of trips during this peak hour, making up 40% of the total. ‘Home to education’ is similarly high at 35%. Other trip purposes account for the remaining 25%.

Travel volumes reduce considerably mid-morning, with hourly trip volumes between 11am and 2pm being approximately half of the peak hour demand. The number of trips between 2pm and 3pm is 69% of the peak hour and correlates to the end of the school day. Whilst traffic congestion in Galway in the PM peak is perceived to be comparable to the AM peak, total trip demand between 5pm and 6pm is 75% of the AM peak hour volume.

Mode Share
Car is the dominant mode, accounting for approximately 60% of all trips in the city. Walking provides for a high proportion of trips, amounting to nearly 23% overall mode share, whilst bus caters for 8% of trips within Galway City. The mode share for walking and cycling in Galway City is higher than the national average, reflecting the relatively compact nature of the core city centre and the high proportion of the large student population living in close proximity to third level institutions.

Trip Origins and Destinations
As part of the 2011 Census, travel information was processed for Work, School or College trips (POWSCAR) in order to identify the major origin and destination of trips in Galway City.

Just over 45,000 total trips are recorded within POWSCAR for the Galway City and environs area. The origins and destinations with the highest trip volumes (work and education, including internal) are shown below in Figure 2.3.

Figure 2.3 The origins and destinations with the highest trip volumes

2.5 Planning and Policy

The Galway Transport Strategy has not been developed in isolation; it builds upon the on-going work of Galway City and County Councils and intentionally links directly with the principles, concepts and objectives outlined in the City and County Development Plans. In addition, the strategy has taken into account national and regional plans and policies. Figure 2.4 illustrates where the Galway Transport Strategy sits in terms of national, regional and local policy and planning. The strategy also complements other local initiatives such as the Health Cities and Age Friendly Initiatives.

Figure 2.4 Planning Context

Planning & Policy Level	Policy Documents	Guidance Documents
National Level	National Spatial Strategy Climate Action Policy Smarter Travel	DMURS National Cycle Policy Framework Permeability Best Practice Guide
Regional Level	Regional Planning Guidelines for the West Region	
Local Level	Galway City Development Plan Galway County Development Plan	Galway Metropolitan Area Smarter Travel Plan Galway City and Environs Walking and Cycling Strategy Galway Metropolitan Area Bus & Cycle Plan Galway Public Transport Feasibility Study Galway City Local Economic and Community Plan
	Galway Transport Strategy	

2.6 Key Challenges to be addressed in this Transport Strategy

As the economy continues to grow, and the role of Galway City as a regional gateway develops, it is critical that the transport network can evolve to meet future travel demand.

It is clear that the existing transport network and its component parts, as set out above, are experiencing difficulties meeting the current transport demands, with delays and congestion, particularly for vehicular traffic and public transport becoming increasingly prevalent. As the economy continues to grow, and the role of Galway City as a regional gateway develops, it is critical that the transport network can evolve to meet future travel demand. In this regard, a number of key challenges must be addressed by the Galway Transport Strategy. These include:

- The need to transform Galway City Centre from a location typically characterised by heavy congestion and significant traffic volumes to a destination of choice for residents, workers and visitors alike;
- The need to reduce the reliance on travel by private car;
- The need to deliver a public transport network that can offer journey time reliability and frequencies sufficient to maximise the attractiveness of the service and to meet demand;
- The need to supplement the public transport network with complementary facilities such as Park & Ride for the benefit of people accessing the city from the surrounding rural areas;
- The need to facilitate city-bound, cross-city, cross-county and strategic east-west travel on the National and Regional road network without impacting on the functionality of the city;
- The need to improve accessibility to and through residential areas for sustainable travel modes in order to improve the appeal of alternatives to the private car;
- The need to maximise connectivity by walking, cycling and public transport to major employment and education facilities;
- The need to minimise non-essential traffic flow through the city centre;
- The need to minimise the impact of traffic congestion on Galway City Centre, in order to allow the city to grow in a sustainable manner; and
- The need to achieve efficiency and resilience on Galway's transport network, across all modes.

3.1 Approach and Methodology

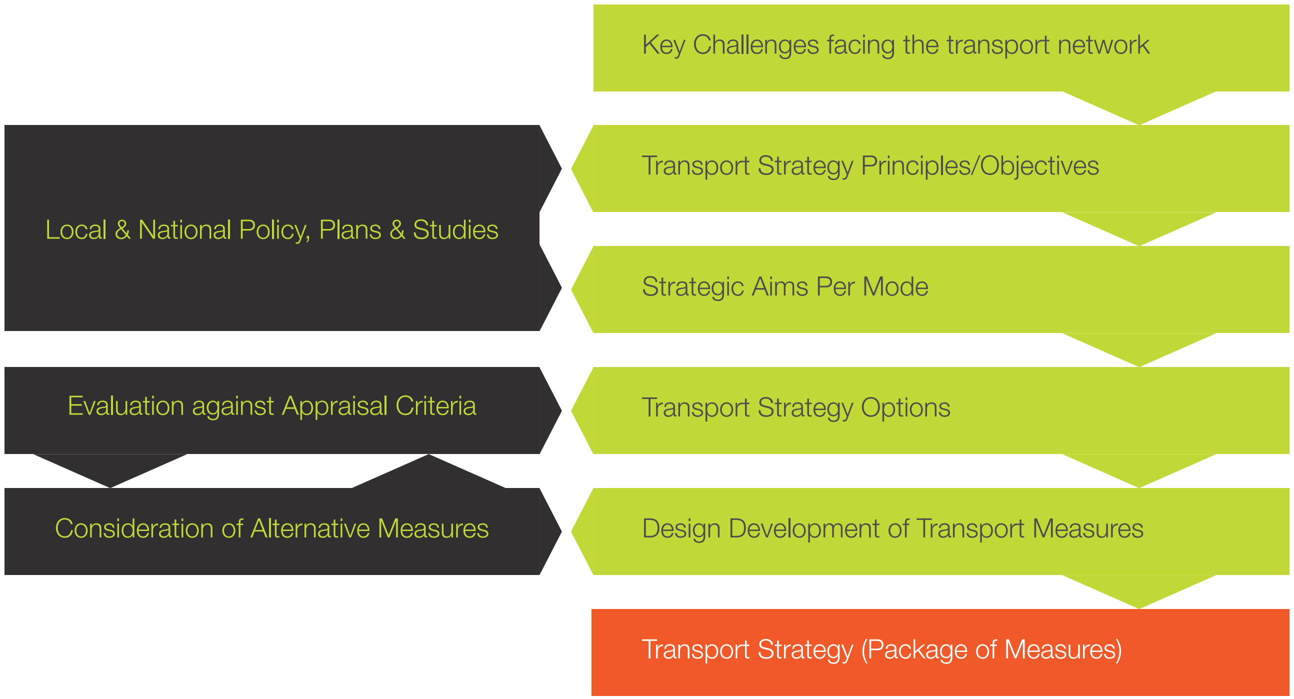
The approach adopted to formulating and testing this Transport Strategy and its constituent measures was:

- to initially **establish strategic objectives**;
- to **develop and test strategy options**; and
- to **develop specific proposals** which are brought together under the overall draft strategy.

The strategy development process is illustrated in Figure 3.1. The principles set out in Section 1.3 provide a basis for developing aims and proposals for mode-specific solutions (as described later in Sections 4-8) – in order to achieve the strategic objectives of the Transport Strategy.

Strategic Objectives: The development of the Galway Transport Strategy must be in accordance with the broader national economic, social and environmental objectives (as set out in the 'Department of Transport Guidelines on a Common Appraisal Framework (CAF) for Transport Projects and Programmes'). Strategic objectives have been formulated based on an analysis of the key objectives from the City and County Development Plans, and from previous transport studies.

Figure 3.1 Transport Strategy Development Process



The CAF appraisal categories and associated strategic objectives are as follows:

- Economic – to give **value for money**, and support Galway's function as a **regional centre;**
- Safety – to achieve a **safer** environment for all transport modes, and facilitate a **healthier lifestyle;**
- Environment – to encourage better **integration between transport and urban form**, thereby minimising harmful **transport emissions;**
- Integration – to provide for **integration of transport modes and land-use planning and policies;** and
- Accessibility and Social Inclusion – to improve **multi-modal accessibility**, and provide for a **socially-inclusive** transport network.

The transport network options developed have been evaluated in line with these, and an emerging strategy identified for each travel mode – which in turn has guided the development of specific proposals for each component of the overall Transport Strategy (public transport, walking, cycling and complementary measures, and road).

3.2 Examining Journey Types

In order to achieve a connected city and environs, the Transport Strategy seeks to deliver an integrated network of 'links' (routes) and 'nodes' (stops and interchange locations) along which people can travel seamlessly, changing corridors and modes as necessary to make their journey. In this context, the most suitable travel modes to address the travel demand for each type of journey have therefore been examined. Figure 3.2 presents the range of journeys undertaken in Galway together with the most appropriate modes of travel for each type of journey. For example, radial journeys into the centre are most suitable for bus travel, whereas journeys from rural areas into non-central areas of Galway may often be most suitable for car travel or combined with Park & Ride.

It is also relevant to note that the strategic movement of goods (for example to Galway Port) will continue to be predominantly road-based – and cannot be facilitated by walking, cycling or public transport. Also, long-distance traffic with origins and destinations outside of the city (for example from Dublin to Connemara), generally has no option but to travel through the city. This by-passing traffic is currently added to local traffic which increases congestion and decreases the accessibility of the western region.

Figure 3.2 Trips to, within and across Galway

A. Within the City - Example - Eyre Square to Dominick Street
These type of journeys should generally be made on foot or by bicycle. Journeys across the centre by car should be discouraged and drivers should be encouraged to either use public transport or park their car before travelling across the central area.

B. Outer City <<>> City Centre - Example - Knocknacarra to Eyre Square
Journeys on radial corridors should be possible by bus (or other forms of public transport) - provided that the service is of a high frequency. Safe bicycle lanes are also essential to encourage cyclists.

C. Outer City <<>> External Areas (not crossing River Corrib) - Example - Ballybrit to Tuam
These journeys are difficult to cater for by public transport, and are often not practical on foot or by bicycle. Use of Park & Ride bus services could however be attractive if the service is of a high quality and frequency.

D. City Centre<<>> External Areas - Example - Eyre Square to Loughrea
These journeys are difficult to attract in large numbers to public transport, as travellers have a wide range of origins outside the city which cannot all be served by frequent public transport. Provision of Park & Ride bus services could however be attractive if the service is of a high quality and frequency.

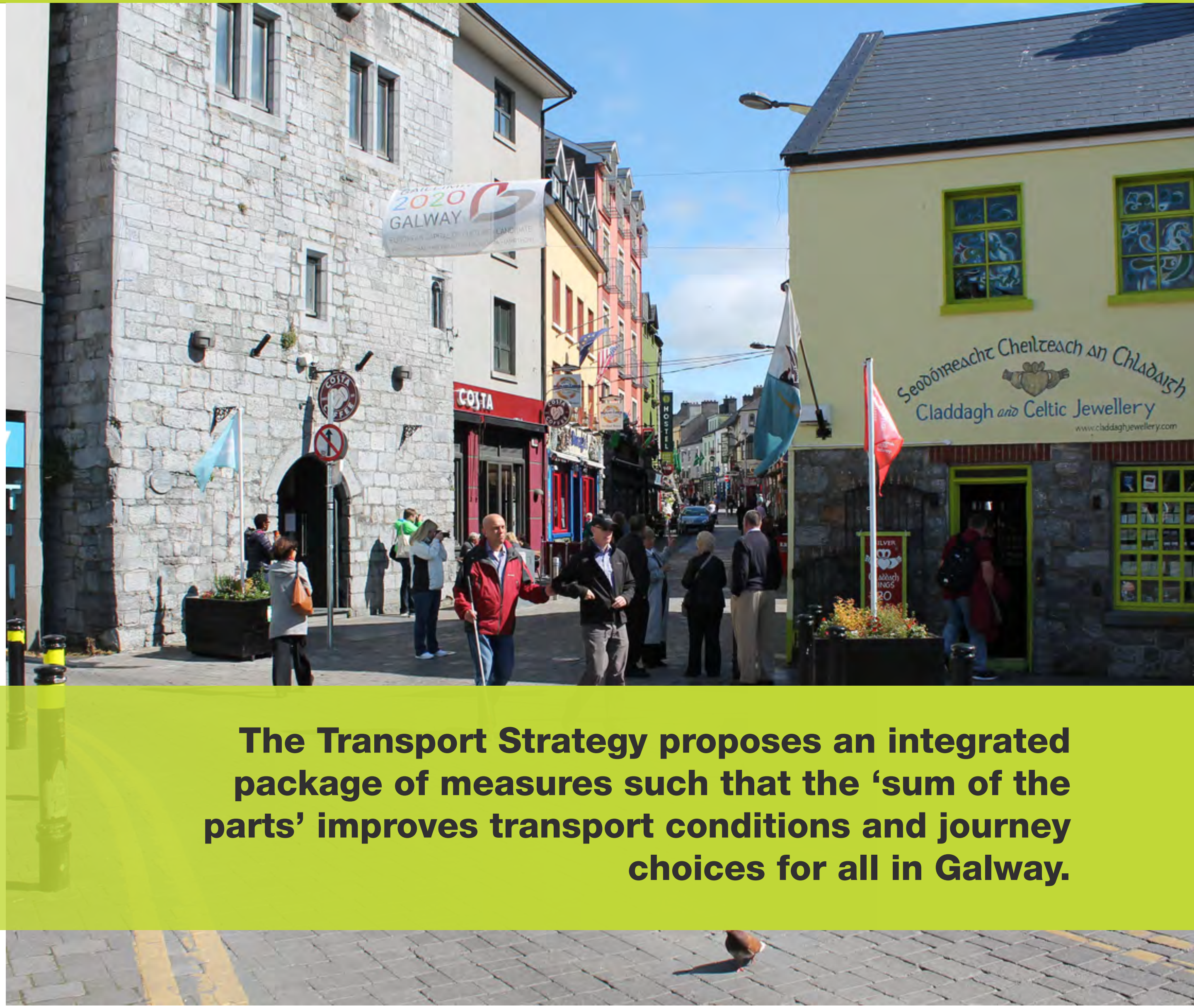
E. Outer City <<>> Outer City (crossing River Corrib and via the City Centre) - Example - Salthill to GMIT
At present, these journeys are generally made by car. However, safe and direct dedicated cycle routes would encourage cycling for this type and length of journey, and if a reliable public transport service was provided operated via the city centre some drivers would consider these options to be a reasonable alternative. Frequent and reliable bus services on a few radial corridors would allow passengers to transfer between services with a short wait.

F. External <<>> Outer City (crossing River Corrib, but not via City Centre) - Example - Maigh Cuilinn to Parkmore
These journeys are difficult to attract to public transport, as travellers have a wide range of origins outside the city which cannot all be served by frequent public transport. An alternative to travel by car could be Park & Ride bus services if the service is of a high quality and frequency.

G. Outer City <<>> Outer City (crossing River Corrib but not via City Centre) - Example - Westside to Mervue
Journeys between peripheral areas can be difficult to serve by public transport, as orbital public transport is generally not financially viable, and public transport via the centre can often be much slower than travel by car if not on connecting public transport routes. Some travellers will however use public transport via the centre if it is of sufficient frequency and reliability. In addition, the provision of safe dedicated cycle routes could facilitate cycling for this type of journey.

H. External Area <<>> External Area (crossing River Corrib, but not via City Centre) - Example - An Spidéal to Headford
These journeys are the most difficult to attract to public transport, as travellers have a wide range of origins and destinations outside the city which cannot all be served by frequent public transport. Travel by car is often the only practical mode.

I. Short travel in Outer City Areas - Example - Renmore to Merlin Park
These type of journeys can often be made on foot or by bicycle, and are generally difficult to make by public transport unless the journey is on a main radial bus corridor.



3.3 Transport Strategy by Travel Mode

Catering for the range of different journey types in Galway requires interventions to be made for each travel mode in order to develop an integrated package of measures such that the 'sum of the parts' improves transport conditions and journey choices for all in Galway.

The Transport Strategy proposes an integrated package of measures such that the 'sum of the parts' improves transport conditions and journey choices for all in Galway.

Transport Strategy - Traffic Networks

Traffic Management

Traffic within the city's central area needs to be managed to provide a more comfortable environment for pedestrians and cyclists, and to ensure that public transport travelling through the city is reliable throughout the day. This is essential to achieve a travel mode shift in favour of public transport. Key aims are therefore to reduce vehicular movement through the city centre, reduce vehicle speeds in the core city centre area, and to prioritise active modes (walking and cycling) and public transport in the city centre. The strategy therefore includes for routing of traffic which currently passes through the centre (to reach edge-of-centre locations) to more suitable orbital routes around the core city centre area.

Road and Street Network

It is recognised that some journeys across the city are not always convenient by non-car modes such as cycling or public transport (for example, most 'through' journeys on National or Regional roads across the city, journeys with an origin or destination outside the city in rural areas, journeys late at night, etc.). Hence it is considered necessary to provide a resilient/reliable cross-city route for travel by road. An orbital route (identified as part of the N6 Galway City Ring Road project), is considered to be an important element of providing this resilience. Providing additional orbital traffic capacity will increase the opportunities for re-allocation of existing roadspace for use by pedestrians, buses and cyclists, identified as a key traffic management objective of this strategy.

Parking

As part of a plan to manage traffic in the central area, it is envisaged that the availability of on-street parking will be reduced, and access routes to off-street parking facilities will be rationalised and managed to minimise car circulation within the city centre. Within this area, there will be greater emphasis on the management of, and accessibility to off-street parking locations (including wayfinding and parking guidance). Parking measures will also need to aspire towards reducing and managing on-street parking on public transport routes outside the core city centre area.

There will also be a need to adopt a parking pricing structure which seeks to set the cost of city centre parking at a level that does not undermine travel by public transport as a financially-realistic alternative to car travel.

HGV management

The central area of Galway is unsuitable for heavy goods traffic, and should be restricted to only those vehicles of a suitable size with destinations (or origins) in the city centre. In combination with this, there is a need to manage the arrangements for routing and timing of deliveries to the core city centre area. Articulated vehicles will be restricted to accessing and egressing Galway Port via Lough Atalia Road. While a planned redevelopment of Galway Port is currently in the planning process, it is not a project that forms part of the GTS. Although it may influence local freight movements if implemented, the GTS approach to HGV management will remain the same irrespective of this.

Transport Strategy - Local Public Transport Measures

Local Public Transport

For Galway to flourish as an attractive city in which to live and work, a modern high-quality public transport system is needed which allows people to conveniently reach key destinations within a reasonable time. This will, over time create opportunities for lifestyle choices with less reliance on private car use. Maximising the attractiveness of public transport can best be achieved by focusing on provision of a network of high-frequency cross-city services, with reliable journey times. This will require public transport priority measures to be implemented.

As it is not practical for all parts of the city to be covered by high-frequency public transport services, there also will be a requirement to provide less-frequent, subsidiary type services. These will facilitate public transport accessibility, including interchange with the principal public transport network, from other parts of the city, and transport services from the wider hinterland.

Public Transport Interchange and Transfer

The usage of public transport systems is maximised by 'building in' convenient interchange between public transport services. Simple end-to-end services will not attract passengers in sufficiently large numbers. The next generation of public transport in Galway will therefore need to recognise the principle of 'transfer' in the way people use services, as ultimately this will provide a much larger range of destinations accessible for the travelling public.

Taxis

Taxis provide an essential service for people for whom other forms of public transport are not always convenient. It is important that waiting areas are safe and attractive, and are conveniently located, but without detrimental impact on the local environment. Where appropriate, taxis will be able to use bus priority infrastructure.

Transport Strategy - Regional Public Transport

Regional/Inter-city/Commuter Bus & Coach Network

For regional and longer-distance bus and coach services, journey speed and reliability are crucial (compared to frequency). It is therefore important that coaches are able to access bus priority routes, and are provided with sufficent access to and from bus/coach termini in the city centre. The attractiveness of these services can also be enhanced by providing interchange between regional and local public transport at key locations on radial routes outside as well as within the city centre.

Rail

Rail provides regional and national connectivity, complementing the bus system. The improvement of this mode will involve more frequent services. Locally it is desirable to maximise opportunities for transfer between rail and local public transport at Ceannt Station, Oranmore/Garraun and Athenry. The strategy therefore includes for an improved transport hub at Ceannt Station/Fairgreen Coach Station in the heart of the city centre, providing enhanced interchange between rail and local and regional bus services.

Park & Ride

Galway has a high proportion of travel with one end of the journey outside the city. Many of these journeys have destinations throughout the city and hence it is particularly challenging to attract such journeys onto a Park & Ride system. A traditional bespoke Park & Ride bus service into the city centre would not provide accessibility to a sufficient range of destinations to make it attractive. It is therefore preferable to base Park & Ride provision on the proposed city-wide public transport network – such that a range of destinations can be reached.

This approach is also more financially sustainable and the service provision to users would be integrated within the public transport fare structure. In parallel with providing Park & Ride services, it will be important to manage the availability and price of parking in the city centre – such that Park & Ride will clearly offer a cost saving to commuters.

Tourist Coach Management

Tourist/visitor coaches will need to be provided with suitable drop-off/pick-up locations in the city centre, with layover spaces provided in a limited number of managed locations outside the core city centre area. Routing for coaches can also be planned such that use is made of proposed priority bus lanes where appropriate.

Transport Strategy - Walking and Cycling

Walking
Within the city centre, there needs to be an emphasis on improving and prioritising the pedestrian network and environment, encouraging and accommodating movement between places and to cater for mobility impaired persons. This will include reducing traffic in the core city centre area. Outside of the core city centre area, emphasis will be placed on increasing permeability within suburban residential and employment areas, improving the pedestrian network where necessary, increasing pedestrian safety and maximising pedestrian accessibility to the public transport network.

Cycling
For cycling to provide a means of 'mass' movement in the city, it will be necessary to provide a 'core' network combining good segregation from traffic where practical, and traffic management elsewhere. Feeder networks will also need to be defined to fill the gaps between core corridors. Convenient cycle parking at major destinations across the city is also essential. To establish a 'cycling city', the further roll-out of the city Bike Share Scheme is desirable – as this assists in normalising cycle travel in the central areas in particular.

Public Realm
The pedestrian environment serves all users, including residents, commuters, tourists and shoppers. The reallocation of road space to public transport in the city centre will be accompanied by an associated improvement in the public realm – in other words, an essential aspect of attracting passengers onto public transport is improve the quality of the receiving environment for passengers' onward journeys on foot. Improvement of the quality of the public space on transport corridors is therefore a key element of this strategy.

Transport Strategy - Supporting Transport Measures

Smarter Mobility
Intelligent Transport Systems (ITS) and technologies allow transport modes to communicate with each other and the wider environment, providing integrated transport solutions and enhanced experiences for transport customers.

Smarter Mobility and ITS will be incorporated into Transport Strategy measures to support infrastructure proposals and to further improve the transport network by maximising efficiency and capacity. Expansion of the existing City Urban Traffic Control (UTC) network is critical, as well as using ITS to manage parking efficiently, improve wayfinding around the city, upgrade street lighting, improve and upgrade junctions and to allow the city to leverage future developments in Smarter Mobility.

Travel to Places of Education
It is important to develop a public transport and cycling network that is conducive to school-related travel. However, there is no unique solution to this travel demand. Instead it is key to promote behavioural change in tandem with infrastructure improvements to encourage students to use sustainable modes. Promotion of school travel plans across the city will continue, while infrastructure and permeability improvements will seek to improve the appeal of sustainable modes. Galway City Council will liaise with the Department of Education regarding the implications of school admission policies on the travel patterns of students. Furthermore, increased use of the Leap card by school students will offer flexibility for public transport services.

Land-Use Integration
Integrating land-use with transport demand is a fundamental requirement for creating a sustainable city. It is vital to align settlements and major developments with transport interventions and services to reduce travel demand by the private car and to foster and promote sustainable transport modes. Major developments will need to be focussed on core corridors where they can be well-served by public transport and cycling and subject to design principles which promote walking. A co-ordinated approach to mobility management and improvements to permeability will also increase the appeal of sustainable modes.

Behavioural Change
Promotion of alternatives to the private car, for the workforce and for students alike is intended to raise awareness of the travel choices available and to underpin a shift to sustainable modes of transport. It is intended to continue the development of mobility management plans at major employment and educational institutions and to continue the roll-out of the Green Schools Travel Programme across Galway.

Demand Management
In order to shift the focus within the city centre to walking, cycling and public transport, demand management measures are needed to enhance the function of the city for these users. This may include measures such as managing and controlling the availability and cost of parking, restricting traffic flow from certain streets, reducing speed limits, providing additional pedestrian crossings at key locations and a reduced emphasis on facilitating through-traffic.

3.4 Strategy Appraisal

The strategy components set out in Section 3.3 have been subject to an assessment of how they address the strategic objectives of the Transport Strategy, as set out in Table 3.1. Transport network options have been modelled using the Western Regional Model to ascertain the impacts on travel conditions, mode share and delay.

Modelling has been undertaken for options with different combinations of measures (e.g. with and without major road interventions, with demand management, etc.) and the results quantified to provide guidance in identifying the preferred strategy. The key outcomes of the appraisal of strategy options are set out in Sections 3.5 and 3.6.

The transport model used in this case is the Western Regional Model (WRM) – a strategic multi-modal, network-based transport model developed in 2016 to help the National Transport Authority support its transport planning remit and deliver on its planning and appraisal needs. The model covers the five counties of Connacht and Donegal County with a focus on Galway City. It has demand matrices for five separate weekday periods modelled; AM Peak (07:00-10:00), Morning Inter-Peak (10:00-13:00), Afternoon Inter-Peak (13:00-16:00), PM Peak (16:00-19:00) and Off-Peak (19:00-07:00).

The model covers all surface access modes for personal travel and goods vehicles including private vehicles (taxis and cars), public transport (e.g. bus, rail), active modes (walking and cycling) and goods vehicles (light goods vehicles and heavy goods vehicles).

Table 3.1 Appraisal Criteria

Category	Assessment Criteria	Key Performance Indicators
Economic	Ensure **value for money** in the implementation of proposals	Utilisation of existing infrastructure and extent of new infrastructure requirements
	Support Galway City's function as a regional centre for employment, education, retail, leisure and tourism by providing **access for all** through an **efficient and reliable transport network**	Peak hour journey times by mode Capacity versus demand Congestion
Safety	Develop a **safer** city centre for all transport modes and users	Consider safety implication of all interventions Traffic management measures
	Exploit transport's role in facilitating a **healthier lifestyle**	Measures which support walking and cycling
Environment	Provide opportunities for better **integration between transport and urban form**	Reduced traffic volumes in sensitive areas
	Minimise harmful **transport emissions**	Reduced transport emissions
Integration	Support integration between **sustainable transport and land-use planning and policies**	Compatibility of transport measures with local, regional and national spatial planning and transport policy
	Provide for better **transport integration**	Park & Ride facilities Public transport interchange opportunities
Accessibility and Social Inclusion	Improve **multi-modal accessibility** within residential, employment and retail centres	Accessibility by walking and cycling, public transport, car and HGV
	Provide a **socially-inclusive** transport network	Coverage and quality of service of public transport network

3.5 Public Transport Choices

What Public Transport Network Configuration Best Suits Galway?
The transport model has been utilised to test the potential passenger use of high frequency public transport services along the busiest corridors in Galway – looking at bus-based or light rail-based options on these corridors (with buses on other corridors). The results provide a basis for identifying the most appropriate public transport system for Galway. Modelling of future conditions indicates that with high-frequency services in place, the maximum single-directional passenger demand is approximately 1,100 over a 1-hour period (in the AM Peak). As indicated in Figure 3.3, this broadly equates to 80-90% of the passenger capacity of a frequent bus service, and less than 25% of the capacity of a frequent light rail service.

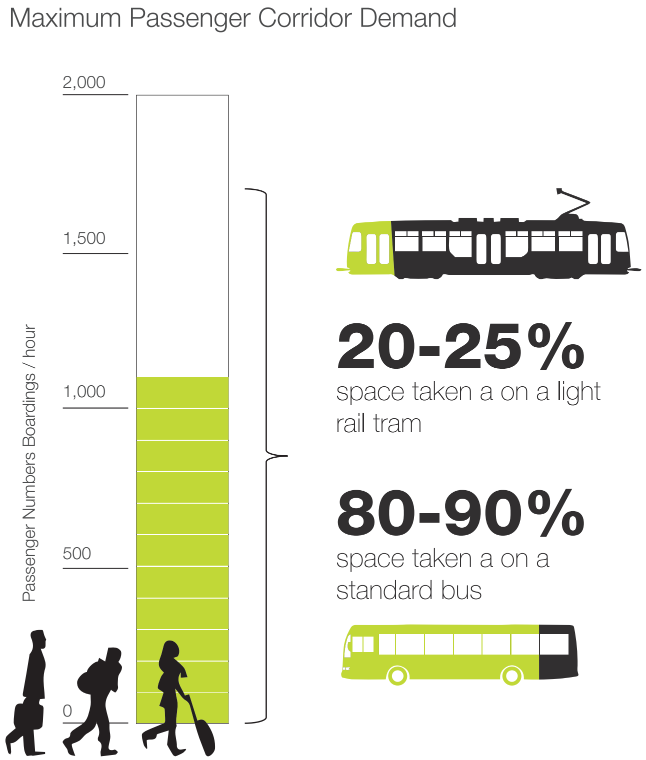
This indicates that a light rail service would provide capacity far in excess of what is practically required. Hence, when considering the greater cost of building and operating light rail services at the same frequency as bus services, it is clear that bus-based public transport represents the most appropriate system for Galway over the period considered in this Transport Strategy.

The public transport network and type of system (or mode) is also dependent on a number of further considerations:

Street Network: Galway is an historic city and its layout and road network reflect a city that has developed over many years with some roads and streets, especially in the city centre, being very narrow, resulting in difficult turning movements for some modern public transport vehicles. As is often the case, the limited available roadspace must provide for many competing demands such as pedestrian and cyclist movements, vehicular access and parking, loading and deliveries as well as public transport. An adaptable bus-based public transport mode, which can integrate with other modes when needed, is therefore considered to best suit the city.

Network or Corridor: The most successful public transport networks and services are generally those that offer a consistently high frequency throughout the day on a network of services, and hence can attract a broad variety of trip purposes such as commuter trips, trips to education and trips for retail and leisure activities. In addition, land-use in Galway is spread throughout a number of corridors, with a wide distribution of origins and destinations. Consequently, trips do not all converge to create high demand corridors, and as such, an integrated network of bus services is considered more appropriate for maximising mode-share and revenue (to pay for services) than linear corridor 'mass transit' services.

Figure 3.3 Estimated Maximum Occupancy of Public Transport System Options



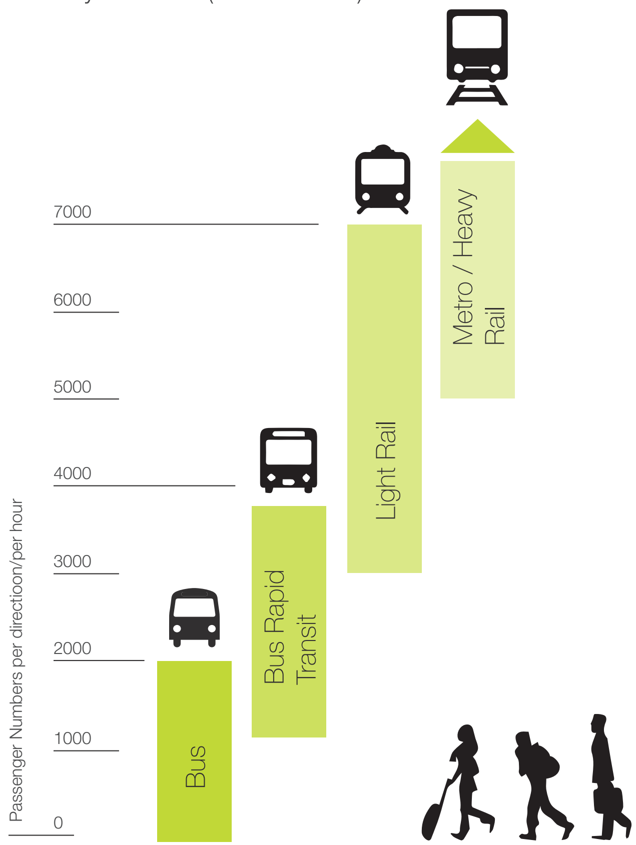
Best Practice Guidance on Mode vs Demand: Guidance in respect of the types of public transport systems most suitable relative to the levels of passenger demand (per direction per hour) is shown in Figure 3.4 (greater capacities can be reached through larger vehicles and/or dualling lanes/tracks). In terms of operating urban public transport systems, high-capacity rail-based systems are generally employed where the 'demand' (i.e. flows past a point) is over 3,000 per hour per direction. Modelling of future conditions indicate that, with a high-frequency service in place, the maximum single directional passenger demand on radial corridors in Galway is only 1,100 in the peak hour, and hence it would be necessary to reduce the frequency of a light rail service to match this lower demand.

This, in turn would be less attractive to passengers than a higher frequency bus-based service. Hence, when considering the typical capacity of public transport systems, it is clear that a bus-based system is the appropriate solution in Galway.

Therefore, it is concluded that a high-quality bus-based public transport service will cater for the forecasted passenger demand and will provide significant flexibility in terms of network options and the ability to integrate with other modes.

In particular, a bus-based public transport network can cater for high volumes of demand along combined corridor sections (for example through the city centre) whilst diverging out to efficiently provide greater direct catchment within less-dense suburban areas of Galway.

Figure 3.4 Public Transport Mode Capacities (source: UITP Paper 'Public Transport: making the right mobility choices' (Vienna 2009)




ZONE
Bank
AIB
BUS STOP
DIVERTED TRAFFIC
www.citydirect.ie
City Direct
TAXIS
LEFT LUGGAGE

Orbital services versus radial (with interchange) through the city centre
Surveys of existing transport and the transport model have confirmed that strong demand will remain for radial movements into the city centre and also east-west movements across the city. Providing for this cross-city movement by dedicated orbital services is not considered to be the best option as there is insufficient variety in trip purposes to support high-frequency services throughout the day. Furthermore, a lesser-frequency service, with limited hours of operation would not provide for good flexibility from the passenger's perspective, and would have an insignificant impact on overall modal splits in terms of transfer from private car usage to public transport.

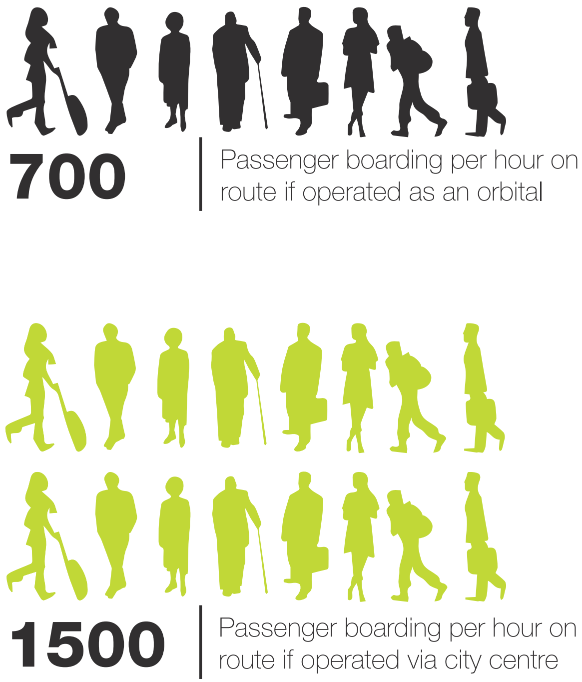
However, in order to quantify the potential impact of orbital bus services (via Quincentenary Bridge), the model has been utilised to test cross-city bus services travelling via the city centre against an orbital service.

The results are summarised in Figure 3.5, which shows that hourly boardings for an orbital service are approximately 50% of the boardings for an equivalent service routed via the city centre. This outcome clearly indicates that cross-city bus services via the city centre will be both more attractive to passengers and more financially viable than orbital services. Further key benefits of routing services through the city centre are:

- Service frequencies are maximised along the central portion of radial corridors, which will be likely to attract high passenger use due to low waiting times; and
- Co-routing of cross-city services along the same corridor through the city centre will, importantly, provide passengers with opportunities to transfer between services to reach a much wider range of destinations. An orbital bus service would tend to carry only those passengers with final destinations close to the route – with little opportunity for passengers to take advantage of interchange to other services.

Cross-city services will require significant bus priority measures (to ensure reliable journey times), and providing roadspace for buses simultaneously on city centre corridors and on the Quincentenary Bridge corridor is unlikely to be practical in respect of managing traffic capacity. Only one cross-city bus corridor is therefore proposed, with bus priority measures through the city centre (where most services are routed) considered to be much more beneficial than provision of bus priority just on Quincentenary Bridge, the N6 National Primary route.

Figure 3.5 Modelled Boardings Comparison for Radial and Orbital cross-city services (AM Peak boardings in both directions)



3.6 Road Network Choices

What Road Network Configuration Best Suits Galway?
The major traffic routes through Galway City are over capacity and congested at peak times, resulting in unreliable journey times for both general traffic and the existing bus network, particularly for cross-city journeys. Traffic delays have a negative impact on nearly all the strategic objectives identified for the Transport Strategy including:

- **Economy** – journey time costs for access to work and education. Delays in the network have cost implications for the movement of freight and goods;
- **Safety and active lifestyles** – traffic congestion has a range of direct and indirect impacts including impacts on quality of life, stress and safety of all road users, as well as impacts on adjacent residents and occupiers of road frontage properties;
- **Environment** – the rate of fuel consumption and the resulting traffic emissions increase significantly at lower speeds; and
- **Accessibility and Social Inclusion** – traffic congestion increases the time taken to travel and therefore reduces the accessibility of areas affected. In a mixed road user environment, as is largely the case in Galway, traffic congestion creates barriers for pedestrians, cyclists and public transport movements.

A key aspect of addressing current traffic issues is to support and facilitate a shift to more sustainable transport modes, where practical to do so. Increasing the rates of travel by sustainable modes in Galway City will require a significant improvement in the quality of the public transport, pedestrian and cycling networks. This will benefit from targeted reallocation of road space from general traffic to sustainable modes.

For example, to deliver cross-city journeys by public transport, major priority measures, such as bus lanes and traffic restrictions are required through the city centre. Whilst this will support travel mode shift, it will also reduce the capacity of the overall transport network. Therefore without accompanying road network and traffic management interventions, traffic congestion issues will persist.

Overall therefore, whilst a range of public transport, walking and cycling measures are intended to bring about a shift away from car travel, a significant level of traffic congestion will remain in the city. It is relevant that the provision of a high frequency bus network in Galway (with improved priority through the city centre) in the future would result in both increased public transport usage in the city, but also increased congestion on the major river crossings due to trip displacement.

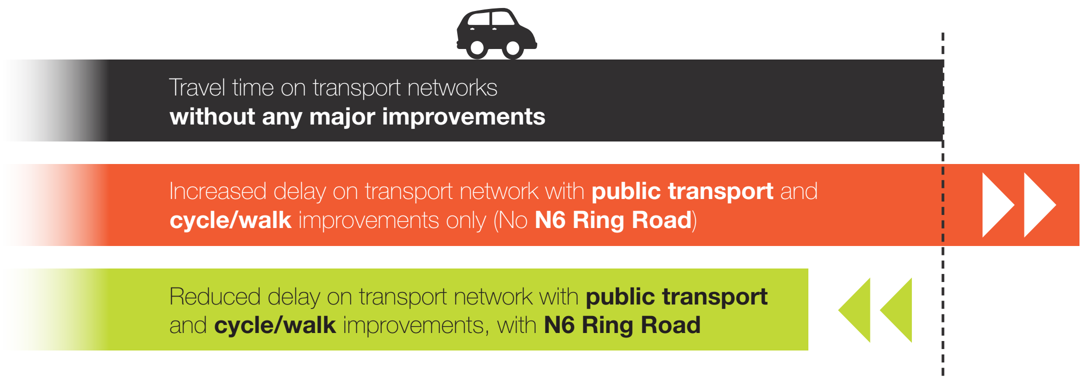


Figure 3.6 Travel Time comparison with and without N6 Galway City Ring Road

The diagram in Figure 3.6 illustrates the modelled comparison of overall travel times (for all modes) for the present day network, and for two scenarios with improved public transport and walking and cycling improvements; that is, with and without a new orbital traffic route. The comparison shows that reducing travel congestion requires both improvement to public transport, walking and cycling networks *and* the provision of a new orbital route.

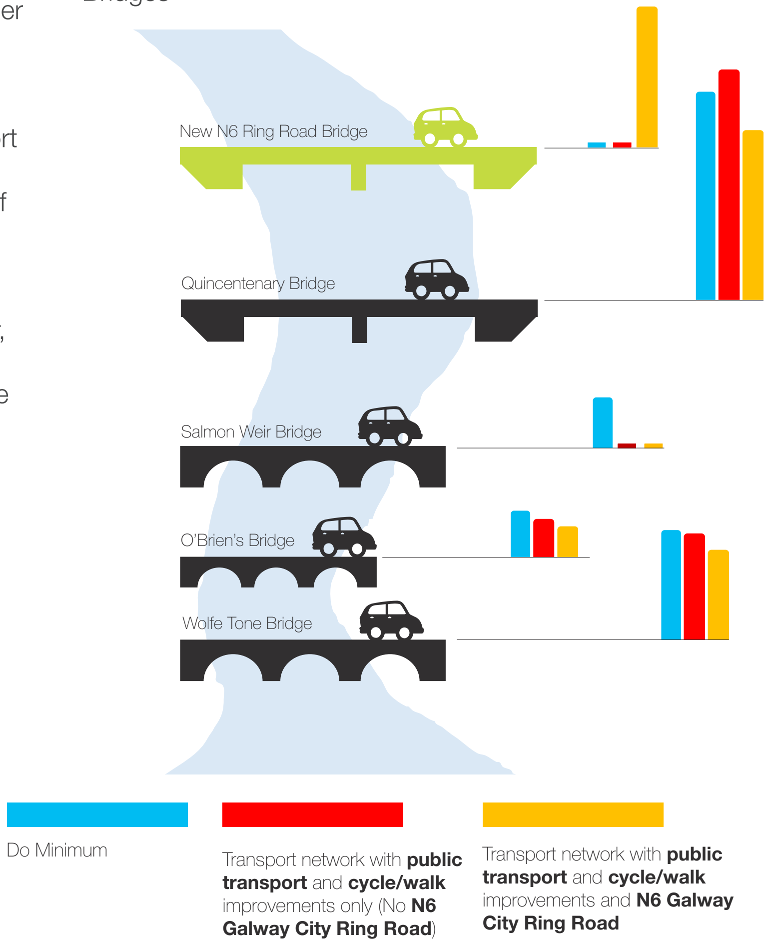
Given the strong negative impact of congestion on achieving the objectives of this strategy, unless additional capacity is provided for traffic, the overall objectives for the Transport Strategy will not be met. Furthermore, this additional road capacity should not be in conflict with the enhanced sustainable transport network, rather it should focus on supporting trips that cannot be facilitated by the proposed measures (i.e. outer-city movements and external-to-external trips). A new road link to the north of the city is therefore proposed as part of this Transport Strategy to deliver the necessary capacity and support the delivery of sustainable transport measures.

Traffic Flows on Galway's Bridges
Various options for the extent of the additional road capacity and connectivity have been tested together with the sustainable transport network measures. The results of the assessment shows that the inclusion of a new road link to the north of the city, in tandem with the active travel and public transport measures, results in a reduction in traffic volumes on Quincentenary Bridge and Wolfe Tone Bridge of approximately 20% in both cases.

This in turn improves journey time reliability within the city centre for all transport modes. In particular, public transport journey times will reduce and become much more reliable through the city centre with the inclusion of the new road link.

Figure 3.7 illustrates the change in traffic flows on the four River Corrib crossings as a result of providing public transport, walking and cycling improvements only, and with the N6 Galway City Ring Road project in place.

Figure 3.7 Peak Hour Vehicle Flows across Corrib Bridges

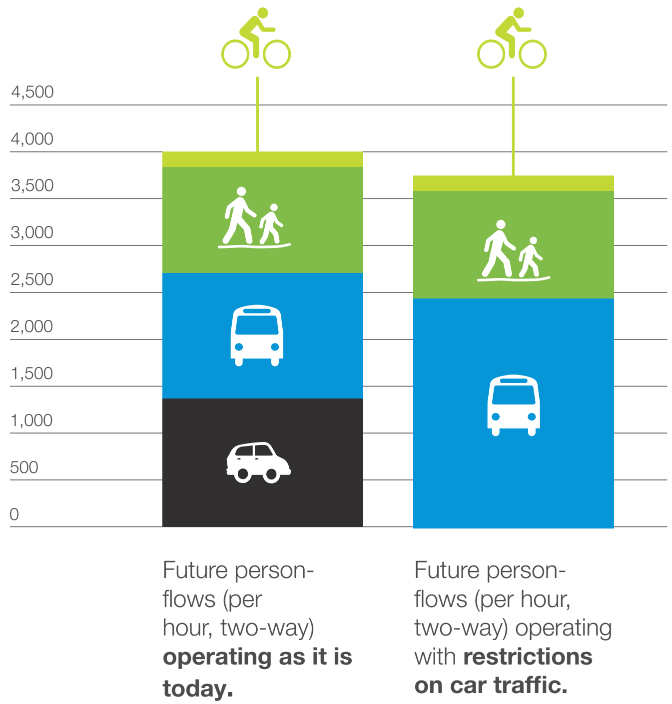


At Salmon Weir Bridge, it is proposed to remove all through-traffic such that the bridge is used only by buses, taxis and cyclists (with a new pedestrian bridge alongside). Modelling forecasts of journeys over the bridge indicate that the introduction of bus priority represents a change to the mode of travel rather than a change in the number of trips.

A major benefit of this change is the potential to significantly enhance the adjacent public realm and local environment as a result of the removal of through-traffic movements.

Figure 3.8 illustrates that passenger trips across Salmon Weir Bridge in the peak periods with the bridge designated as a public transport-only river crossing remain almost unchanged, compared with the bridge remaining open to all traffic.

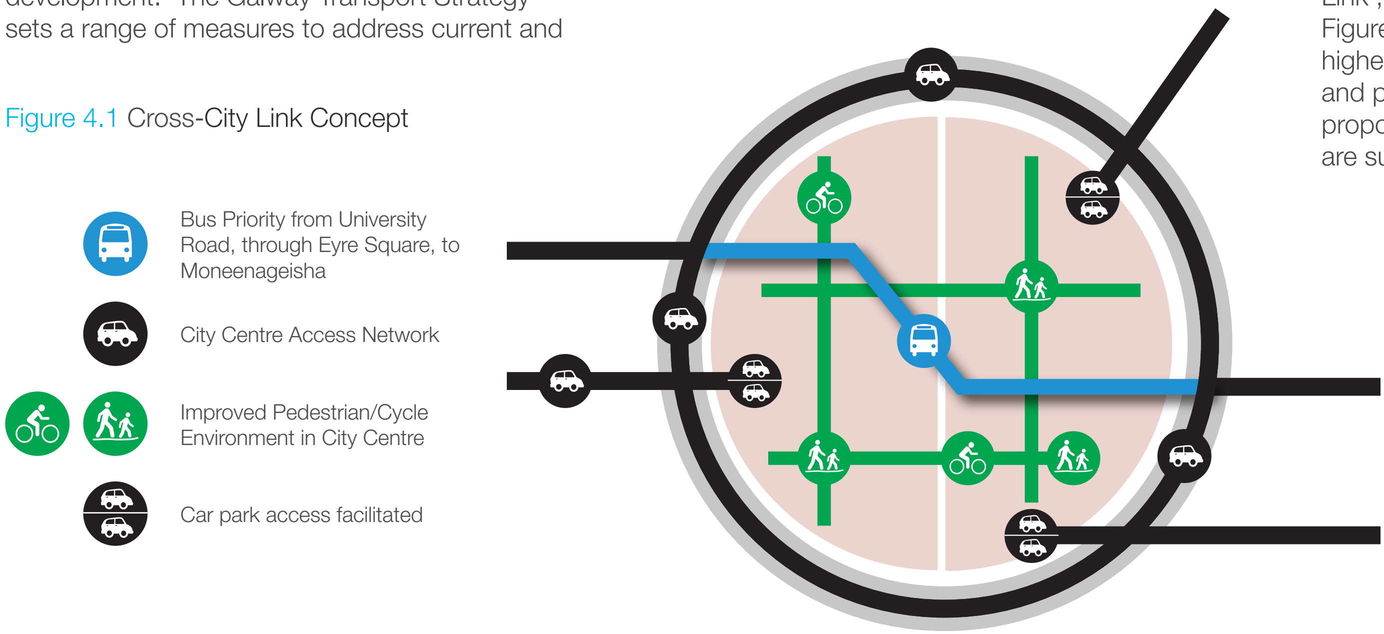
Figure 3.8 Peak Hour Person Flows across Salmon Weir Bridge



Introduction

As discussed in Section 1, the road network in Galway carries different users (cars, lorries, cyclists, buses, coaches, taxis, school transport, emergency services) as well as catering for varied journeys within the city, such as into the centre, across the city, short local trips, trips which start or end outside the city, through-trips, etc. Without intervention, present-day congestion will continue to worsen over time as the city grows and hence it is essential that the resilience of the road-based transport network is improved to support Galway's development. The Galway Transport Strategy sets a range of measures to address current and future congestion, and includes traffic management (especially in the city centre to prioritise walking, cycling and bus movement), new and improved road and highway links, management of parking activity, and controlling and managing heavy goods vehicle movement and deliveries. The routes through and around the city have been classified on different levels in order to separate journeys by type and assign the most suitable journey types to each road network or alternative mode.

Figure 4.1 Cross-City Link Concept



4.1 City Centre Traffic Management

The strategy set out in Section 3 provides a framework for the Traffic Management measures that have been developed.

The strategy aims to remove non-essential motorised traffic from the core city centre area (i.e. traffic travelling through the city centre whose origin and destination lie outside the city centre). This will be done using a combination of routes around the city centre, and will prioritise other modes within the core city centre area via the 'Cross-City Link', a proposed corridor (shown schematically in Figure 4.1) through the core city centre area with higher levels of priority allocated to walking, cycling and public transport over private car traffic. The proposed city centre traffic management measures are summarised in Table 4.1.

Table 4.1 City Centre Traffic Management

Strategic Aims	Proposed Measures	Design Development and Consideration of Alternatives
Reduce through-car movement and traffic speeds in the city centre.	It is proposed to organise the city centre road network such that there is a 'city centre access network' (made up of sections of road circumventing the core city centre area of Galway, rather than a continuous road) along sections of the following roads: • Lough Atalia Road; • Dock Road/Merchants Road; • Wolfe Tone Bridge; • Father Griffin Road; • The Crescent; • St. Mary's Road; • Lower Newcastle Road; • Quincentenary Bridge; • Sean Mulvoy Road; and • Moneenageisha Road. The city centre access network will provide access to the city centre and a through route for local journeys. A secondary network of road access routes will also provide access to car parks (including Fairgreen Road, Bóthar Na mBan and Headford Road).	Lough Atalia Road is designated as part of the city centre access network in preference to College Road (which is more suitable as a bus route), as it provides a route to car parks on the south side of the city centre and to the docks area, and it also forms a direct connection to Dock Road, Wolfe Tone Bridge and to Galway Port. The city centre access network has two orbital river crossings, at Wolfe Tone Bridge and Quincentenary Bridge, with the latter also serving as a key route for intra-city through-traffic.
Prioritise Public Transport movements in the city centre.	A public transport route, the 'Cross-City Link', is to be implemented through the core city centre area (with restrictions on other traffic). The Cross-City Link is routed along University Road, across Salmon Weir Bridge, along Eglinton Street, around Eyre Square and along Forster Street and College Road.	Salmon Weir Bridge was identified as the preferred bus-only route on the west side of the city centre. Alternatives were also considered at: • Wolfe Tone Bridge, which has a poor connection with the bus lane corridor on Seamus Quirke Road; and • Quincentenary Bridge which was found not to align as well with passenger desire lines (particularly into the city centre). On the east side of the city centre, establishing a bus priority route along College Road is identified as the most appropriate and feasible means of ensuring that buses and coaches can travel directly to and from the city centre via both the Old Dublin Road and Wellpark Road.

4.2 City Centre Access Network

It is clear that the future increase in travel demand cannot be catered for by private vehicle trips alone. In order to ensure that the overall transport system can facilitate this demand, some road space will need to be dedicated to active modes and public transport.

However, given the catchment of Galway City, some journeys by private car will still be necessary, and HGVs will continue to need access to the city and the port. A clearly defined 'city centre access network' is proposed to enable traffic to access and move around the core city centre area. This will facilitate access to car parks, allow traffic to access the city centre at the most appropriate entry points for its ultimate destination and allow for reduced cross-city traffic along specified corridors.

The city centre access network shown in Figure 4.2 illustrates the optimum routes to key destinations in central Galway. Vehicular traffic will travel in both directions on Lough Atalia Road, will use the current one-way system around Dock Road and Merchants Road, and will travel in both directions across Wolfe Tone Bridge, continuing west towards Salthill Promenade along Whitestrand Road (R336). The use of Lough Atalia Road as a part of the City Centre Access Network maintains access and egress from Galway Port (with or without expansion).

It will be possible to access the Lower Salthill and Taylor's Hill areas by continuing on Father Griffin Road, but traffic access in this area will be subject to junction revisions that will enable continuous bus priority from Salthill Road Lower (Devon Park junction) to St. Mary's Road and Newcastle Road. Access to Shantalla will be possible from the Salthill and Fr. Griffin Road areas, but traffic management measures will make it more favourable to access Shantalla from the R338 Seamus Quirke Road-Bishop O'Donnell Road corridor.

Access to Salthill, Rahoon, Westside, Newcastle, University Hospital Galway, and NUIG will generally be provided from that corridor. The city centre access network will have its primary junctions at the Bodkin junction (for access to Headford Road shopping area and Wood Quay), Sean Mulvoy Road (for access to Bohermore), and Moneenageisha Road (in order to connect with Lough Atalia Road).

In conjunction with these revisions, a two-way inner city access route comprising Bóthar na mBan, Bóthar Bhreandáin Uí hÉithir and Fairgreen Road will provide an additional inner link from the Headford Road to Lough Atalia Road. In effect, private motorised traffic will be able to access the city centre from all directions, and to exit on the same side. In order to circulate within the city however, cars will have to use the orbital River Corrib crossings on the city centre access network.

Key Changes: Under these proposals, Bóthar Bhreandáin Uí hÉithir and a section of Fairgreen Road will experience some change in movements, becoming two-way routes for traffic.

Figure 4.2 Galway City Centre Access Network

Junction numbers

City Centre Access Network

Inner City Access Route

Bus Interchange

Bus Priority / Bus Only Route (with local delivery/access at specified times)

Train Station **Bus Station** **Port**

Junctions Index

1. Lough Atalia Road/Fairgreen Road
2. Lough Atalia Road/Dock Road
3. Dock Road/Queen Street
4. Father Griffin Road/Flood Street
5. Father Griffin Road/Claddagh Quay
6. Father Griffin Road/The Crescent
7. The Crescent/St. Mary's Road
8. Shantalla Road/Newcastle Road
9. Newcastle Road/University Road
10. Newcastle Road/Old Seamus Quirke Road
11. Newcastle Road/N6
12. N6/Headford Road/Sean Mulvoy Road
13. Bohermore/Tuam Road/Sean Mulvoy Road
14. Moneenageisha Rd/Old Dublin Rd/College Rd/Wellpark Rd
15. College Road/Lough Atalia Road
16. Headford Road/Bóthar Na mBan
17. Bóthar Na mBan/Prospect Hill/Bohermore
18. Prospect Hill/Bohermore/Bóthar Uí hEithir
19. Bóthar Uí hEithir/Forster Street/Fairgreen Road

4.3 The Cross-City Link

The 'Cross-City Link', as illustrated schematically in Figure 4.1 consists of a central corridor traversing the core city centre area, which will be restricted to use by public transport vehicles, pedestrians, cyclists and local residential motorised access only. It will enable efficient and reliable public transport access to and through the city centre from University Road, across Salmon Weir Bridge, along Eglinton Street, around Eyre Square and along Forster Street and College Road. This forms a central route for public transport, cyclists and pedestrians accessing key areas such as University Hospital Galway, NUIG, the retail and recreational centre of the city and public transport hubs at the train and bus stations. Public realm improvements are proposed along the Cross-City Link to provide an enhanced environment for cycling and walking, and overall this will create more pleasant surroundings for journeys to and through the city centre. Further details of these proposals are presented in Section 7.

The image to the right shows a conceptual representation of the urban character at Galway Courthouse in the vicinity of Salmon Weir Bridge as a result of the Cross-City Link, and the associated reduction in motorised traffic flows.

The Cross-City Link concept - Galway Courthouse & environs

The Cross-City Link

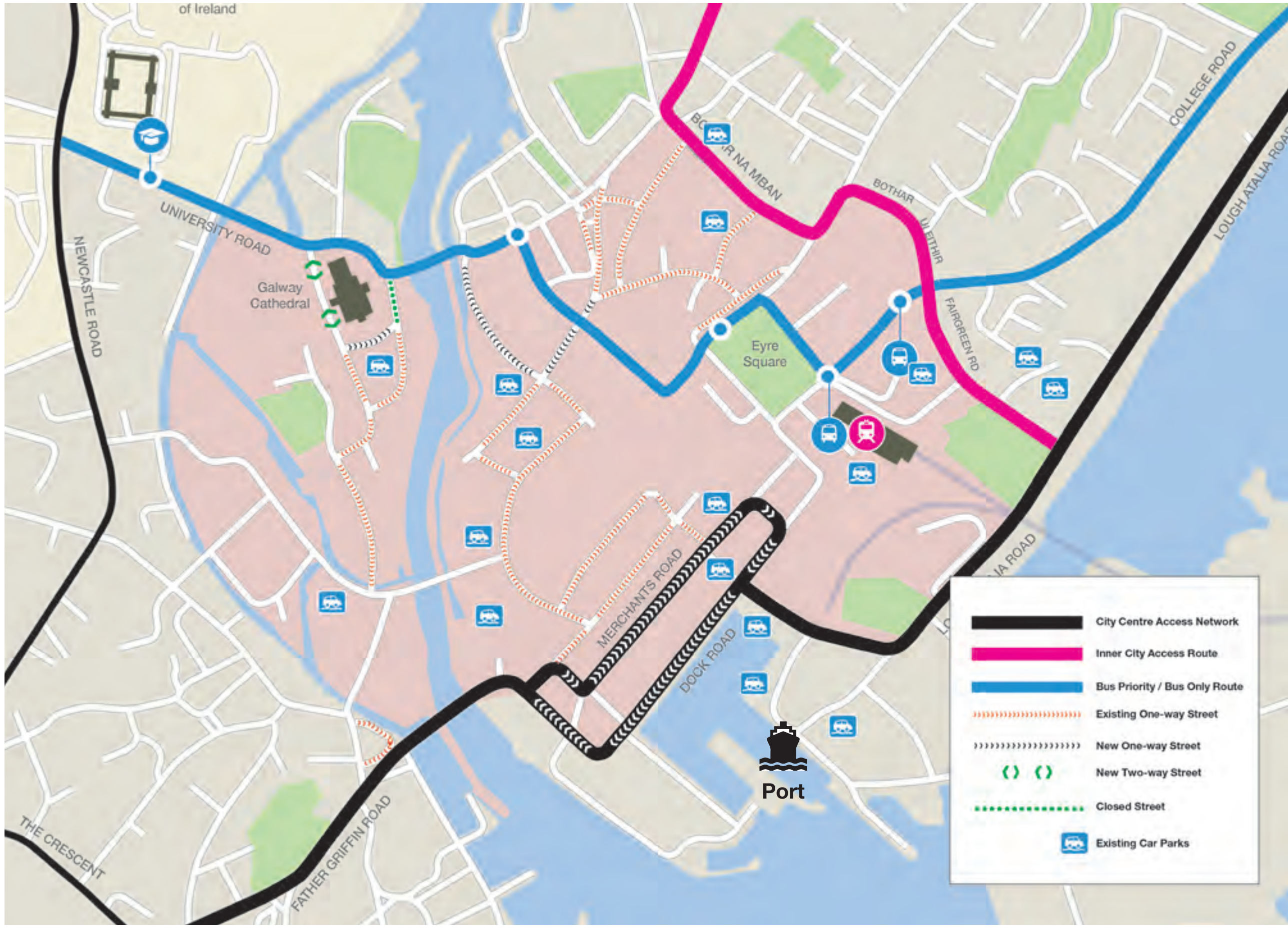
4.4 Core City Centre Access

The core city centre area inside of the city centre access network, will see road space reallocated to prioritise public transport and active modes. This will in turn facilitate public realm improvements along the Cross-City Link corridor, but requires changes in movements for private cars within the city centre to facilitate this. The proposed movement strategy can be seen in Figure 4.3. Access to off-street car parking is maintained via these movements. The city centre remains accessible, but priority is no longer given to the private car in this area.

Key Changes
The core city centre area will experience the following changes in movements:

- University Road, Salmon Weir Bridge, Eyre Square, Victoria Place, Forster Street and College Road will become public transport and local access only;
- St Mary Street will become one-way west-bound;
- Newtownsmith will become one-way north-bound; and
- Access to the Cathedral and car park by car will be from the western side only. This access will become two-way.

Figure 4.3 Core City Centre Area



The core city centre area within the City Centre Access Network will see road space reallocated to prioritise public transport and active modes.

Core City Centre Area concept - Eyre Square North

4.5 Road and Street Network

The existing wider road network is crucial to the operation of the city and surrounding region. Due to the rural nature of the immediate surroundings of the city, and given the wide distribution of destinations and trips to, within and across the study area, it will not be possible to provide sufficient public transport alternatives to fully address the transport demand. Even with the anticipated increased uptake in walking, cycling and public transport use, the regional and national road network is likely to suffer an increasing degree of congestion. In the peripheral urban and rural areas travel by private car will therefore remain a key part of the transport system as a whole.

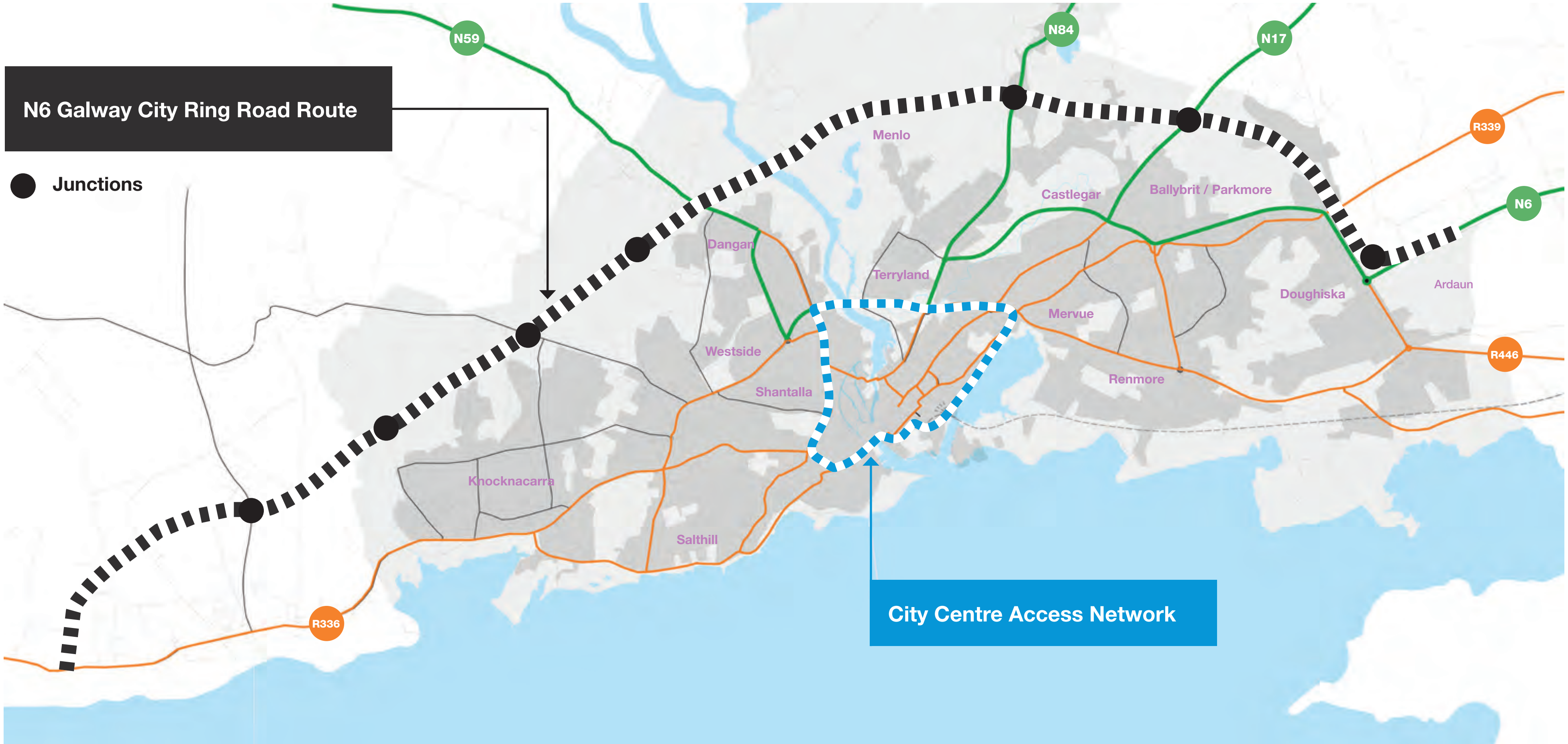
Upgrades to junctions along the N6 have and will continue to improve the performance of this road, but scope for additional capacity is limited by the number and nature of the river crossings. In order to enhance Galway's function as a regional city and to permit continued growth, an additional river crossing is required. The N6 Galway City Ring Road project has identified the most suitable corridor for an orbital road scheme for Galway. The route for this road scheme is presented in Figure 4.4.

The importance and benefits of the proposed orbital route to the delivery of an overall integrated Transport Strategy for Galway have been established as part of the strategy development process, as set out earlier in Chapter 3. Table 4.2 summarises the aims, proposals and alternatives considered for the road and street network measures.

Table 4.2 Road and Street Network

Strategic Aims	Proposed Measures	Design Development and Consideration of Alternatives
Provide resilience of operation of the road network such that all travellers have a reliable (not necessarily fast) journey time.	An outer orbital route is recommended in order to enhance resilience of the Galway Transport Strategy, by reducing congestion on other principal roads, and providing opportunity for re-allocation of road space within the city for bus priority and cycle lanes. In addition to the outer orbital route, a number of ancillary, localised road links are proposed to improve connectivity at a local level for motorised traffic, pedestrians, cyclists and buses.	Upgrades of junctions along the N6 have and will continue to improve the performance of this road, but this is limited by the number and nature of the river crossings. A new orbital road link is required to enhance the resilience of the network, and cater for growth of the city. The N6 Galway City Ring Road project has investigated options – and a feasible corridor has been identified for an orbital road – with associated road links. Numerous public transport scenarios were modelled in order to assess non road-based solutions – but provision of a new orbital road was found to provide the best overall benefit (in tandem with multi-modal improvements elsewhere). The road schemes proposed as part of the GTS are not exhaustive, and further road upgrades or new road links may be necessary for redevelopment of existing sites, or for new developments such as the planned Ardaun corridor, for example.
Provide road network improvements to cater for those journeys which are not able to be a made (in a viable manner) by public transport, by cycle, or on foot.	An outer orbital route will provide a convenient route for some car-based journeys which are not able to be made easily by other modes – such as through-journeys.	

Figure 4.4 N6 Galway City Ring Road



4.6 Parking

As with all urban centres, the supply and management of parking is fundamentally linked to the management of travel demand. While the supply of parking is not mutually exclusive of public transport, there is a need to strike a balance between the two. Within the city centre, there are over 4,000 off-street parking spaces, and a further 700-800 on-street spaces. A number of these car parks are primarily structured around long-stay parking, which is available for as little as €4 per day.

As part of this strategy, it is proposed to reduce the dominance of car parking within the city, and particularly to shift the emphasis from on-street to managed off-street parking provision. This effectively requires high-quality alternatives to car-based commuting; namely, the walking, cycling and public transport proposals outlined in the Transport Strategy. A number of the existing car park sites within the city represent development opportunity sites, and over time the development of these sites may see a natural reduction in parking stock.

Parking aims and proposed measures are summarised in Table 4.3.

Table 4.3 Parking

Strategic Aims	Proposed Measures	Design Development and Consideration of Alternatives
To provide efficient access arrangements for city centre car parks.	It is proposed to rationalise the city centre street hierarchy such that well-signed routes to car parks are available via the city centre access network and local access routes. Variable Message Signage is also proposed on approaches to the city as well as an associated Parking Guidance System.	Parking is a key element of choice of travel mode, and also can be a physical detriment to city-centre streets. Management of access routes, on-street parking, and pricing are considered as supporting an overall strategy to improve transport conditions in the city centre. In order to discourage commuter car parking and encourage transfer to public transport, it is proposed to restrict car parking within the city centre area. In addition, a strong focus on encouraging major employers to develop robust mobility management proposals will form part of the longer-term strategy for addressing the existing demand for car parking within the city centre. The adoption of reduced parking standards for developments that are located in proximity to core (high-frequency) public transport is also proposed.
To ensure that parking is not significantly cheaper than public transport.	To adopt a philosophy that parking fees are similar or more than typical bus fares. E-parking (parking by phone or text) fees may assist in equalising parking and bus prices.	
To reduce the impact of parking on the city centre environment and movement of buses and cycles.	It is proposed to remove most of the on-street parking in the city centre to provide more road-space for pedestrians and public transport, while retaining disabled driver parking. Improved enforcement is also proposed. Some rationalisation of on-street parking on radial access routes will also assist bus movement.	

4.7 HGV Management

Efficient freight transport and delivery systems are essential for the economic activity of the city and surrounding areas. Galway Port and industrial areas need reliable transport connections for the movement of goods, while commercial outlets and shops need dependable distribution systems to manage stock levels and provide customer deliveries. Given the dispersed rural nature of the region and limited national rail network, movement by road is, and will continue to be, the dominant mode of freight transfer in the region. Consequently, development and management of the road network must take the movement of goods vehicles into account.

While a planned redevelopment of Galway Port is currently in the planning process, it is not a project that forms part of the GTS. Although it may influence local freight movements if implemented, the GTS approach to HGV management will remain the same irrespective of this. Furthermore, the use of Lough Atalia Road as a part of the City Centre Access Network maintains access and egress from Galway Port (with or without expansion).

HGV management aims and proposed measures are summarised in Table 4.4.

Table 4.4 HGV Management

Strategic Aims	Proposed Measures	Design Development and Consideration of Alternatives
Restrict HGV access to the city centre to only those vehicles with destinations (or origins) in the city centre.	HGV movement around the city will be accommodated via the city centre access network, including access to the city centre and the port.	The HGV Management Strategy needs to balance the operational requirements of Galway Port, Industrial Areas and the city centre commercial district with the need for efficient movement of people and the creation of an attractive city environment. Restrictions on HGV movements to dedicated routes only, such as the city centre access network, and limiting the timing of deliveries in the city centre are therefore considered essential to the Transport Strategy.
Manage the routing and timing of deliveries to the central area.	A loading and delivery strategy for the core city centre area is proposed, restricting access to off-peak hours, similar to the current arrangements on Shop Street and Quay Street.	

A central objective of the strategy is to provide an efficient, reliable and attractive bus service for Galway.

Introduction

Improvement to local public transport is a key aspect of much of the strategic objectives, namely:

- enhancing accessibility through an efficient and reliable transport network; and
- maximising opportunities for interchange in order to integrate transport modes.

At present, public transport in the city comprises buses and taxis, and proposals to upgrade these services have been assessed and developed as part of the Transport Strategy.

Options assessment as part of the Transport Strategy development identified that a high-quality, high-frequency bus service is the most appropriate form of public transport provision for Galway City and its' environs.

5.1 Public Transport in Galway City

Public transport in Galway currently has a low mode share with usage below 10% of motorised travel. A step-change in the provision and usage of public transport is needed to meet the Transport Strategy objectives, and hence an essential component of the Transport Strategy is to provide an efficient, reliable and attractive bus-based public transport service for Galway, such that a high proportion of trips to and within the city and environs are able to be made by bus. This requires the achievement of both journey-time reliability and journey speeds sufficient to make the service competitive against private car usage.

The methodology undertaken to develop the proposed Galway City Bus Network was as follows:

1. Develop the most appropriate bus network for the study area, based on origin-destination patterns, and maximising network coverage and services to the principal trip attractors and generators; and
2. Development of infrastructural priority proposals for the network, based on on-site investigations to determine engineering constraints.

A key element of the bus network is that the proposed high-frequency services will operate cross-city, which will provide direct services for passengers wishing to travel to work on either side of the city, and improve east-west connectivity to include Bearna and Oranmore.

Once established, it is intended that the level of travel demand on the proposed network will be regularly monitored, with some routes potentially being upgraded to Bus Rapid Transit (BRT) services in the future by increasing the level of frequency and service provision accordingly, if development along the routes intensifies and patronage increases sufficiently.

On approaches to, and through the city centre, it is essential that public transport travels relatively unhindered by road congestion (to achieve high patronage and to ensure that services are financially viable). This will require implementation of traffic management measures and the removal of through-traffic from the city centre, as set out in Section 4, in order to prioritise bus services.

In order to provide a framework for developing measures, a series of aims for local public transport have been set out – allowing for network proposals to be developed. The proposals are set out in Table 5.1.

5 Local Public Transport

Table 5.1 Local Public Transport

Strategic Aims	Proposed Measures	Design Development and Consideration of Alternatives
Maximise patronage attraction by providing a high-frequency public transport network.	The existing main bus corridors are proposed to be upgraded to 'high frequency' public transport routes which will form a 'fixed' spine of future public transport in Galway. These routes are proposed as follows: **West** • Western Distributor Road – Seamus Quirke Road – University Hospital Galway – University Road, and on to Eyre Square • Knocknacarra – R336 Coast Road – Salthill – Newcastle Road – University Hospital Galway – University Road, and on to Eyre Square **East** • Parkmore – Ballybrit – Monivea Road – Wellpark Road – College Road – Eyre Square • Parkmore – Doughiska – Old Dublin Road – College Road – Eyre Square **City Centre** • University Road – Salmon Weir Bridge – Eglinton Street – Eyre Square – Forster Street – College Road	Design development has considered various alternative public transport route corridors on the basis of: • Matching the proposed network with the existing bus lanes; and • Evaluation of the physical road space and land-use within which bus priority infrastructure can realistically be delivered within the constraints of the existing land-use. The impacts of altering land-uses were also considered. To the west, the Seamus Quirke Road – Western Distributor Road corridor has existing bus priority measures in place and, crucially, there is space available for future provision of bus lanes (along Western Distributor Road) – and hence this represents the most suitable corridor – although other corridors west of the city may carry localised bus services. To the east, Old Dublin Road is an established bus corridor with substantial bus priority measures already in place. On the west side of the city centre core area, a 'bus-only' route via Salmon Weir Bridge was identified as the most appropriate and feasible means of delivering the essential combination of short and reliable journey times through the city centre. Alternatives were also considered as follows: • Via Wolfe Tone Bridge - there is very poor connection with the bus lane corridor on Seamus Quirke Road; and • Use of Quincentenary Bridge as a major bus corridor for radial and cross-city routes was not considered to be the most appropriate as the majority of passengers throughout the day are destined for key attractors south of the bridge, and in the city centre, as well as to the east. In the case of cross-city journeys, it is considered essential that buses operate through the central area for interchange with other services at Eyre Square and at Ceannt and Fairgreen Stations (but with bus priority to maintain speed and reliability). On the east side of the city centre, establishing a bus priority route along College Road was identified via travel demand as the most appropriate and feasible means of ensuring that buses and coaches could travel directly to from both the Old Dublin Road and Wellpark Road. Alternatives were also considered as follows: • Bohermore – does not provide direct connection with Old Dublin Road/Wellpark Road, and hence there is a high degree of risk of congestion at Moneenageisha causing journey time delay; and • Lough Atalia Road – considered to be more suitable as a city centre distributor road, as it provides a route to car parks on the south side of the city centre (and to the docks area).
Provide city-wide network coverage / connectivity to all parts of the city.	Local buses may also be required to maximise the overall bus network and to provide bus connectivity to areas that lie outside of the principal bus network. Local buses will also provide connection and transfer to and from the city bus network. This ancillary local network will necessarily evolve over time (e.g. as developments proceed), and hence does not represent a fixed network. As patronage increases over time, these routes may be upgraded to higher frequency services, where practical to do so.	
Provide reliable journey times.	Bus Lanes and Bus Priority measures have been designed at a conceptual level along the proposed bus network corridors as follows: • Western Distributor Road – Seamus Quirke Road Corridor; • Salthill Road / St Mary's Road / Newcastle Road Corridor; • Old Dublin Road Corridor; • Wellpark Road / Monivea Road Corridor; and • City Centre Corridor (University Road – Salmon Weir Bridge – Eglinton Street – Eyre Square – Forster Street – College Road).	

5.2 Developing the Galway City Public Transport Network

Using the existing bus route alignments as a starting point, a cross-city network proposal was developed. This proposal was based on linking the residential origins to the key destination locations.

The routing of buses was modified in some cases to better reflect the current origin-destination combinations extracted from the 2011 POWSCAR data, and all routes were designed to allow for cross-city interchange at key locations – most noticeably at stops within the core city centre area.

By pairing cross-city routes, it was possible to reduce the number of services to 5, making the network more legible for residents and visitors alike. Figure 5.1 illustrates the proposed bus routes.

The proposed routes are:

Green Route
Knocknacarra – City Centre – Parkmore Industrial Estate (via Seamus Qurike Road and Dublin Road);

Red Route
Knocknacarra – City Centre – Parkmore Industrial Estate (via Salthill and Ballybrit Industrial Estate);

Blue Route
Clybaun Road – City Centre – Castlegar (via Dr. Mannix Road and Tirellan);

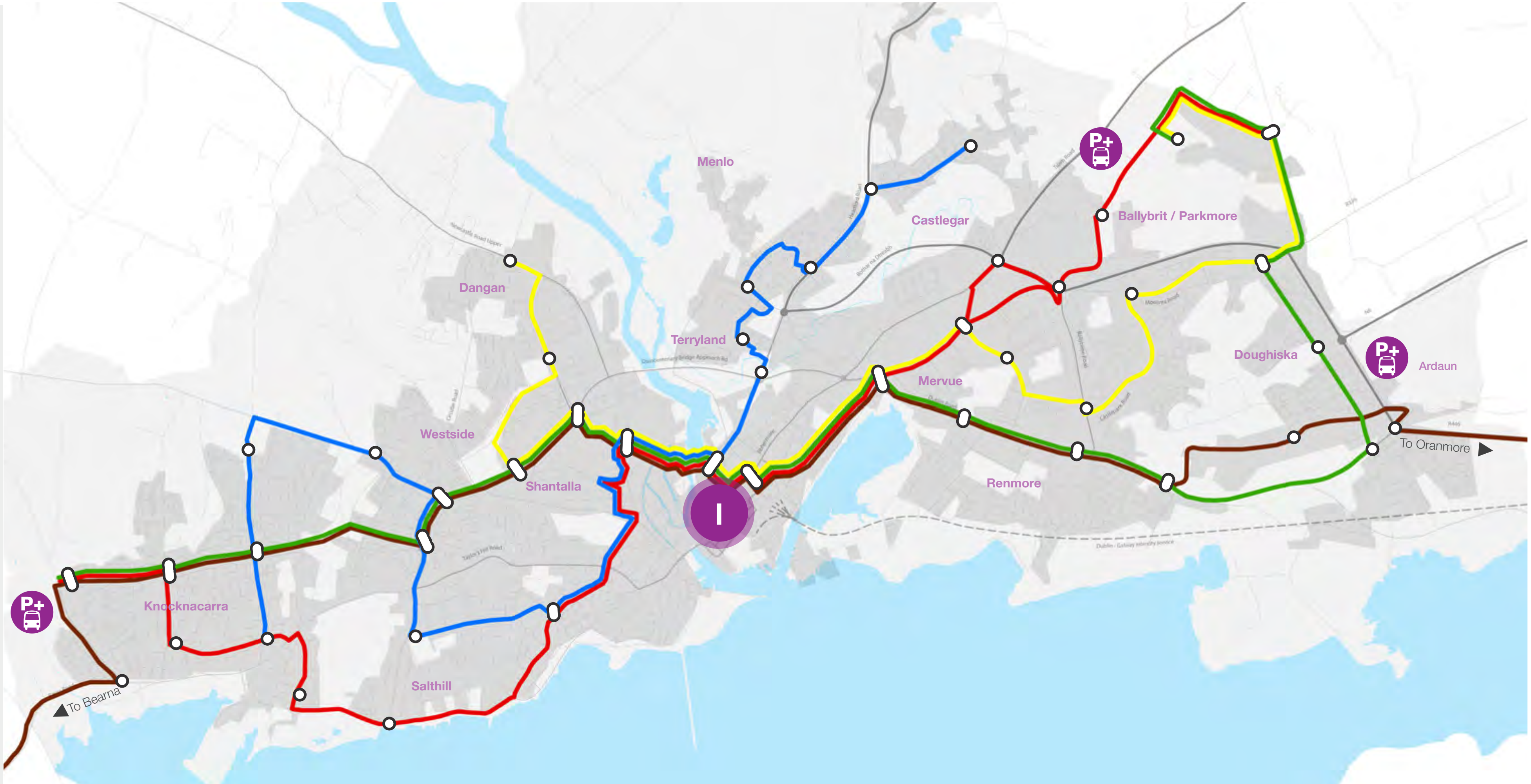
Yellow Route
Dangan – City Centre – Parkmore Industrial Estate (via Westside Shopping Centre and Castlepark); and

Brown Route
Bearna – City Centre – Oranmore (via Seamus Quirke Road and Deerpark Industrial Estate)

Indicative Park & Ride Locations

City Centre Interchange

Figure 5.1 Proposed Bus Routes



5.2 Developing the Galway City Public Transport Network (cont'd)

All routes will serve the major trip attractors of the City Centre, Galway University Hospital and NUIG, as well as linking all major destinations across the city into the public transport network.

Service Frequency

It is critical that the new network is serviced by frequent and reliable bus services. One of the problems with the current bus provision in Galway is the relatively poor frequency of services across the network, with only one route (of the 11 currently serving Galway City) operating more than 4 buses per hour per direction in the peak hour.

To ensure that the bus is a convenient and fast transport option in Galway, as well as to ensure that interchange is considered as an integral element of the bus network, it is essential that the frequency and reliability of bus services is maintained across the bus network, and throughout the day. It is an aspiration of this strategy that all 5 routes will operate at a 15-minute frequency (or better) during the peak period (with the red and green routes likely to operate at a 10-minute frequency or better initially based on existing demand). It is also an objective of this strategy to ensure that a high bus frequency is maintained across the whole day to ensure that the bus network is a viable alternative to other trip purposes, as well as peak hour commuting.

Infrastructure Proposals

A number of the 5 routes proposed above lie on existing principal public transport corridors, and are already served by some of the existing city bus services. These sections of the proposed network, which will route in a direct manner on key travel corridors will be the primary focus for implementation of significant infrastructural priority measures (through provision of bus lanes, removal of pinch points and delays, and maximising the efficiency and reliability of services on the proposed bus network) to make the bus service more attractive than the private car. Other sections of the proposed bus network are more heavily constrained in terms of engineering design due to their less-direct routing and due to the route characteristics – these sections of the proposed bus network will be provided with priority infrastructure where feasible.

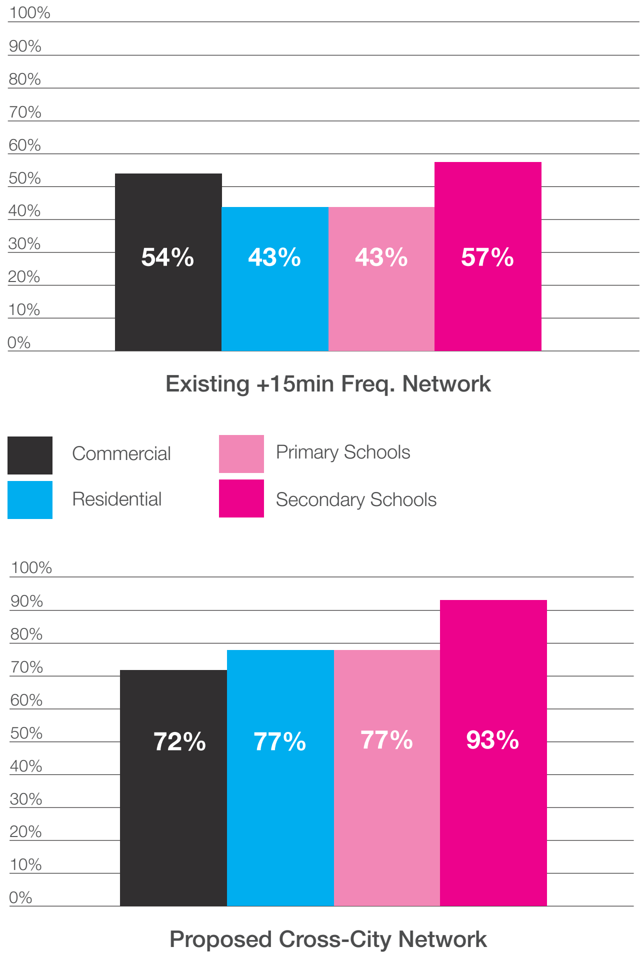
Network Catchment

An analysis of the population and employment catchment of the proposed bus network was undertaken. This assessment quantifies the number of residential and commercial properties within a 10-minute walking catchment of the proposed bus network. This analysis considers the existing road network, and does not take into account any proposed improvements in pedestrian accessibility to the bus routes, however it does provide a good indication of how well the new bus network will serve Galway City. The spatial catchment of the cross-city bus network is set out in Figure 5.2.

The spatial coverage of the proposed bus network was also assessed against the existing coverage of bus services in Galway. To facilitate a direct comparison, the existing bus services were amalgamated to establish the road routes which are currently served by buses passing at a frequency of more than 4 per hour. Within the study area there are circa 35,000 properties, 90% of which are residential. It is the intention to ensure that as many of these properties as possible are within 10 minutes walking distance of a bus service. Figure 5.3 shows the percentages of properties which are within a 10-minute walking catchment of the existing and proposed bus network. It is clear that the proposed cross-city network will provide a much higher level of accessibility to a high-frequency bus service, with over 70% coverage of both residential and commercial properties, and between 77-93% coverage of primary or post-primary schools. This compares well to the existing bus provision, which offers a high frequency service to only 43% of residential properties, 54% of commercial premises and 43-57% of primary or post-primary schools.

Figure 5.2 Cross-City Bus Network Catchment

Figure 5.3 10-minute walking catchment of existing and proposed high-frequency bus networks



5.3 City Centre Public Transport Interchange

It is recognised that usage of public transport can be made significantly more attractive and convenient (as an alternative to the car) by providing opportunities for transfer between services, which can significantly increase the journey options for travellers. The number of destinations served on a single end-to-end service can be increased significantly by providing easy transfer to other services.

The opportunities for public transport interchange in the city centre under the Transport Strategy are illustrated in Figure 5.4, with aims and proposed measures summarised in Table 5.2.

Figure 5.4 City Centre Public Transport Interchange

Table 5.2 City Centre Public Transport Interchange

Strategic Aims	Proposed Measures	Design Development and Consideration of Alternatives
Maximise range of destinations served by providing convenient interchange between public transport services.	Eyre Square has been identified as the main hub for Bus/Bus transfer – as well as Bus/Train and Bus/Coach at Ceannt Station/Fairgreen Station. Other key bus transfer hubs will be located at: • University Hospital; and • University Road/Cathedral.	The location of interchange points is a function of the public transport routes. Design development has focused on Eyre Square as the primary location for interchange – due to its inherent advantages over other locations, as follows: • It is located on the majority of the proposed bus routes; • It is proximate to Ceannt Station (bus and rail) and Fairgreen Station (bus); • It is already accommodating key bus stops; • It is a busy area and hence provides bus passengers with a secure waiting environment; and • It has retail and café/snack premises close by, which enhance the interchange experience.
Implement multi-mode ticketing which allows transfer between modes.	It is proposed that all services will allow for cross-ticketing such that passengers can transfer between routes without extra charges.	

5.4 Supporting Measures for Local Public Transport

Traffic Restrictions in the City Centre
It is essential to the operation of a successful public transport system that bus priority is provided within the city centre area. Traffic management proposals to achieve this include:

- Restrictions to general traffic flow on University Road, College Road, Forster Street, Eglinton Street, Williamsgate Street, Prospect Hill, Victoria Place and around Eyre Square;
- Segregation of pedestrians from buses at Salmon Weir Bridge through provision of a new, parallel pedestrian bridge adjacent to the existing structure; and
- Designation of Salmon Weir Bridge as a public transport-only bridge crossing

Bus Fleet and Stops
As part of the public transport quality of service provision under this strategy, it is proposed to:

- Upgrade the existing city bus fleet for comfort (seating arrangements, Wi-Fi enabled vehicles, etc.);
- Provide vehicles suitable for access by mobility impaired persons, including wheelchair accessibility and space provision;
- Provide high-quality bus shelter facilities including seating, information panels, real-time information displays, with a standardised bus stop pole style and secure cycle parking where appropriate;
- Review and rationalise the spacing of stops across the network; and
- Integrate the bus fleet Automatic Vehicle Location (AVL) system and the Galway City Council Urban Traffic Control (UTC) system in order to allow the adaptive UTC system to enable and/or improve bus priority at signalised junctions.

Ticketing and Payment
It is proposed to:

- Introduce a simplified payment structure, comprising alternative fares for radial journeys to the city centre only and for cross-city journeys;
- Introduce the phased implementation of an easy to use cashless payment system by means of the Leap card and off-board ticketing;
- Investigate other forms of contactless payment in the coming years;
- Explore potential future integration with Demand-Responsive Transport systems, including Mobility as a Service (MaaS) – which essentially means that travel can be made across different modes but using a single mobile device application for journey information and payment.

Marketing and Branding
It is intended that a single 'brand' is applied to all local public transport in Galway (across all transport organisations); this will take the form of logos, maps, ticketing, timetables and signs. Branding will also be included in Mobility Management initiatives at major employment/educational facilities and School Transport Plans.

Access on Foot to Public Transport Stops
It is essential that passengers can walk directly to stops on the public transport network, and measures are proposed as follows:

- Around the city, it is proposed to carry out a continuous programme of improvements to address permeability and severance issues prevalent, with a view to maximising the walking catchment to stops on the bus network; and
- Other improvements along links and at junctions will seek to improve facilities for pedestrians, in particular those with mobility impairments.

Taxi and Demand Responsive Services
Eyre Square will remain the main central taxi rank. Locations on the east and west of the city centre will also be identified such that taxis can travel directly to/from outer areas of the city without a need to travel through the centre.

It is recognised that taxi services will over time migrate to SMART-orientated, demand-responsive transport with information and payment via SMART device technology.

6 Regional Public Transport

6.1 Regional/Intercity/Commuter Bus & Coach Network

The principal destinations within the city for regional and national bus services will be Eyre Square, at Ceannt Station and at Fairgreen Coach Station. There are also coach parking facilities on Merchants Road and at Galway Cathedral.

Regional services travelling to and from Galway City will for the most part avail of the bus network infrastructure proposals within the city area, in addition to other proposals outside the city, including, for example the Tuam Road bus corridor scheme currently under development.

As part of the Cross-City Link proposal, the proposed traffic restrictions on College Road will significantly benefit services from the south, east and north-east; it is envisaged that College Road will become the primary route to and from the City for these services. College Road provides direct access to Fairgreen Coach Station, and to Ceannt Station, via Eyre Square. For services approaching from the west and north-west, the proposed infrastructure measures on the western side of the city, and the proposed restrictions on University Road and at Salmon Weir Bridge will provide high-quality connectivity to and from the city centre.

Regional Public Transport aims and proposed measures are summarised in Table 6.1.

Table 6.1 Regional Public Transport

Strategic Aims	Proposed Measures	Design Development and Consideration of Alternatives
Coaches/buses should have reliable journey times in the city.	Bus lanes proposed for city bus services are in general also suitable for buses and coaches with origins outside the city.	Design development has focused on city centre traffic management and local bus priority measures – especially in the city centre. These measures are considered to match the aims for efficient and reliable coach services.
Good access in and out of bus/coach termini in the city centre.	The proposed city centre traffic management, with reduced through-traffic and local distributor routes will ensure that coaches are able to access termini with minimal congestion.	
Interchange between regional and local public transport.	A high-quality city bus network will provide interchange opportunities for regional bus travellers – such that passengers can switch modes at a rationalised number of hubs outside the city centre.	

6.2 Rail

Ceannt Station will remain the terminus for rail services to Galway City. Redevelopment works at Ceannt Quarter and improvements at Eyre Square and Fairgreen as part of the Cross-City Link proposals will enhance the passenger experience for rail travel. Garraun will continue to serve as a rail terminus for Oranmore.

In addition, the proposed improved pedestrian and cycle environment within the city centre will contribute to a more attractive rail commute.

Rail service aims and proposed measures are summarised in Table 6.2.

Table 6.2 Rail

Strategic Aims	Proposed Measures	Design Development and Consideration of Alternatives
Increase frequency of rail services.	Rail services will be increased in frequency, subject to sufficient passenger demand and usage.	Ceannt Station re-development will provide an opportunity in the future to enhance interchange between rail and local public transport.
Interchange between regional and local public transport.	Ceannt Station will remain the terminus for rail services to Galway City, and pending major upgrades at the station will significantly improve the offering for passengers. In addition, pending redevelopment works in the vicinity at Ceannt Quarter will re-energise this part of the city centre, and this will complement Eyre Square and Fairgreen as a collective hub for interchange between services within Galway City Centre.	

6.3 Park & Ride

Galway has a high proportion of travel with one end of the journey outside the city. The provision of Park & Ride sites on multiple approaches to the city will be important, and serving these with 'normal' scheduled bus services will maximise their financial viability, and will also offer a wider range of destinations with passengers being able to interchange between routes on the proposed bus network.

This will provide alternatives to the private car for those accessing the city from the county and wider region, and thereby reduce traffic flows to and from the city.

Potential corridors for Park & Ride have been identified as part of the bus network development. It is intended that the capacity of these Park & Ride locations will grow organically over time as demand increases, but will initially be small-scale facilities.

Park & Ride facilities will be developed within the existing road corridor and boundary where possible, or on existing brownfield sites in the first instance. Where this is not possible, greenfield sites will be explored. Any site investigation will require consideration of potential environmental impacts.

Park & Ride aims and proposed measures as part of the Transport Strategy are summarised in Table 6.3.

Table 6.3 Park & Ride

Strategic Aims	Proposed Measures	Design Development and Consideration of Alternatives
Maximise destinations reachable by Park & Ride services.	It is proposed to base Park & Ride on the city-wide high-frequency public transport network – such that a range of destinations can be reached.	Potential Park & Ride sites are proposed on the M6, the N17 and west of the city. Locations will need to be investigated in detail and associated bus services planned (as part of the city bus services).
Ensure that Park & Ride is financially sustainable.	Basing Park & Ride on the city-wide public transport network will maximise the financial viability of Park & Ride services. It is intended that the cost of Park & Ride will be integrated with the overall public transport journey fare for passengers.	

6.4 Tourist Coach Parking Management

Tourist/visitor coaches will need to be provided with suitable drop-off/pick-up locations in the city centre, with layover spaces provided in managed locations outside the core city centre area. Routing for coaches can be planned such that use is made of priority bus lanes where appropriate.

Tourist Coach Parking Management aims and proposed measures are summarised in Table 6.4.

Table 6.4 Tourist Coach Parking Management

Strategic Aims	Proposed Measures	Design Development and Consideration of Alternatives
Suitable drop-off/pick-up locations; Controlled coach drop-off/pick-up in the core city centre area; Provision of managed layover coach parking areas outside of the core city centre area.	Possible sites identified to eliminate layover in city centre proper are: Galway Cathedral; Galway Harbour; and Merchants Road.	Potential drop-off/pick-up will need to be investigated in detail and associated designated access routes in the city centre (e.g. using the Cross-City Link bus priority corridor).

7.1 Cycling

In order to meet the strategic objectives of the Transport Strategy, the overall aspiration of the proposed cycle network is to provide a safe and comfortable environment for cyclists in the city and surrounding areas, in turn supporting an increase in the number of cyclists and encouraging a greater modal shift from the private car to cycling.

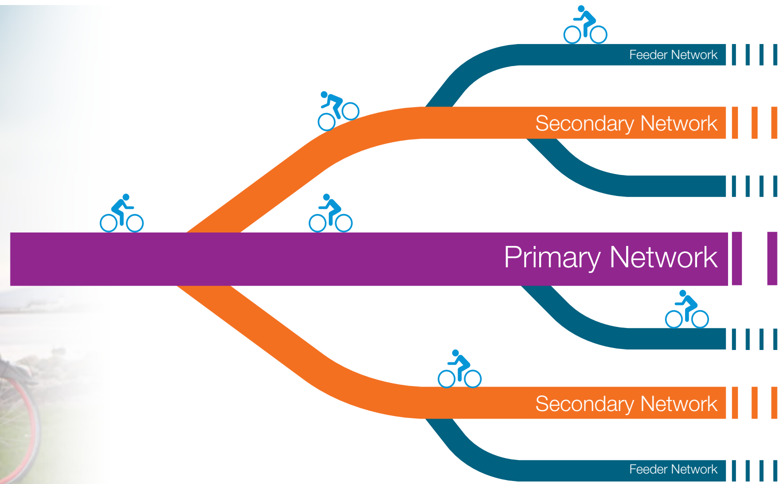
As an area with relatively flat topography and a compact city centre, Galway is well suited to cycling as a means of transport. However, the existing cycling facilities in the city and surrounding areas are limited and discontinuous. The cycle network proposed in this Transport Strategy is intended to maximise the provision of high quality dedicated cycling facilities and to improve measures giving priority to cyclists, encouraging uptake in cycling both for commuting and as a leisure activity in the city and surrounding areas.

The cycle network proposals have been built on investigations made in previous studies as outlined in Section 2. Where possible, the proposed routes are fully segregated, with cyclists physically separated from motorised traffic. In other cases, the network includes on-road cycle lanes and/or wide bus lanes to cater for both buses and cyclists along the same route.

In addition to this, it is intended that proposed traffic management measures will limit access to parts of the city for private motorised vehicles, thereby improving the environment for cyclists, pedestrians and public transport vehicles.

The overall cycle plan has been developed on the basis of three levels of network which support each other and reinforce connections across the study area. These networks are classified as 'primary', 'secondary' and 'feeder' routes, indicating the desired function and character of the cycle route.

With a relatively flat topography and a compact city centre, Galway is ideally suited to cycling as a means of transport.

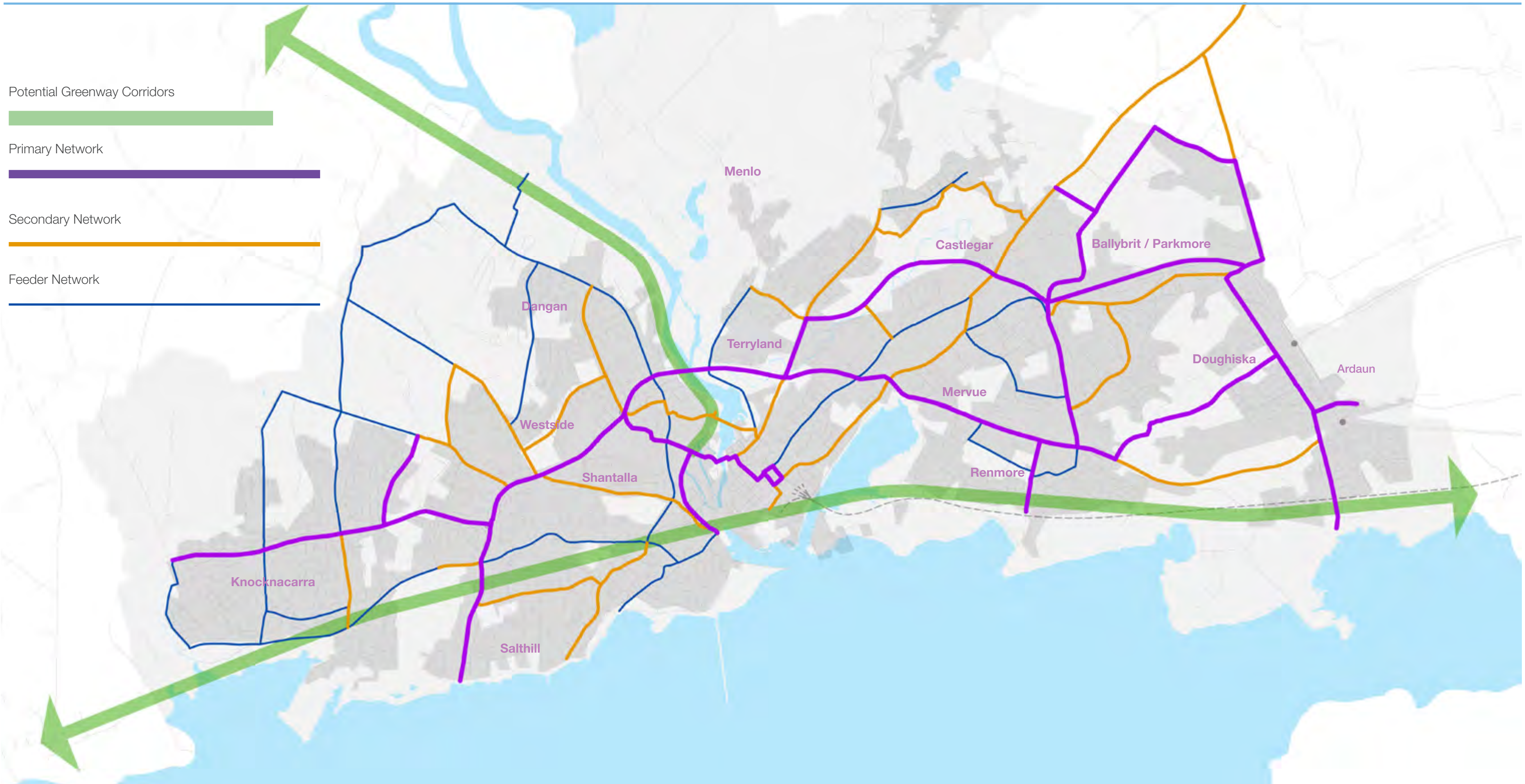


In order to provide a framework for developing measures, a series of aims and proposed measures for cycling have been established, as summarised in Table 7.1. These provide a basis for developing specific plans for infrastructure proposals. The resulting proposed cycle network in this Transport Strategy is presented in Figure 7.1.

Table 7.1 Cycle Network Infrastructural Design Measures

Strategic Aims	Proposed Measures	Design Development and Consideration of Alternatives
To provide a primary 'trunk' cycle network which will provide a convenient and safe route for medium-distance radial commuter / leisure journeys.	The primary network includes two Greenways providing connectivity for cyclists from nearby towns and villages; one along the western bank of the River Corrib from Galway City to Oughterard, via Maigh Cuilinn; and one along the coast from An Spidéal to Oranmore, passing through Galway City. The latter will continue east, connecting to the Dublin-Galway Cycleway. As part of the Greenway network, it is proposed to carry out investigations to determine the feasibility of connecting from Eyre Square to Renmore via the existing rail crossing over Lough Atalia or via lands at Galway Port, as an alternative to a route to the north of Lough Atalia. Additional primary routes include a cross-city route to the north of the city, building on existing facilities, and a route through the city centre, along with some key north-south links. In general, primary routes are either segregated, off-road cycle only paths, or dedicated cycle lanes along new or existing roads. Wherever possible, these routes are separated from traffic by kerbs or edge markings.	Design development has considered various alternative cycle route corridors on the basis of: • Matching the primary network with the existing Greenway proposals and areas of high demand; and • Evaluation of the physical roadspace within which cycle infrastructure can realistically be delivered within the constraints of the existing land-use. Conceptual designs have been prepared along sample links and at junctions and pinch points to verify that the proposed networks can be realised. The cycle network design has also included identifying junction upgrades (at a conceptual level) at numerous locations around the city, notably the signalisation of several large roundabout junctions. This will improve the safety of cyclists at these junctions, providing signalised crossing facilities and simplified junctions for cyclists to navigate.
To provide a secondary cycle network which will provide a recognisable grid network for local journeys, and will be connected to the primary network for longer journeys.	The secondary network provides connections from residential areas and areas of employment to the primary network and key destinations. Secondary links are a combination of off-road cycle paths, cycle lanes along existing roads, shared bus and cycle lanes, and traffic-calmed roads. They often run parallel to primary routes, providing an alternative link. In addition to this network, feeder links have been identified on streets and roads which are highly constrained or more suited to other modes, but need to cater for cyclists also. These are generally cycle-friendly advisory routes where traffic calming and management measures allow cyclists and motorists to mix safely.	
To increase options for cycling in and across the city centre.	Through-traffic will be removed from the core city centre area. This will reduce the amount of traffic on these roads, creating a shared environment where cyclists can safely use the existing street network. Cyclists will be permitted to use Salmon Weir Bridge, which is to be designated as public transport-only as part of the Cross-City Link.	

Figure 7.1 Proposed Cycle Network



7.2 Supporting Measures for Cycling

Bike Share Scheme
The Coca-Cola Zero Bike Share Scheme was launched in Galway in 2014. In Galway City, there are currently 15 hire stations. Further stations are planned, with future expansion possible depending on uptake. It is anticipated that the development of cycle facilities as outlined above will encourage higher numbers of cyclists, both on private and shared bikes.

Bicycle Parking
Bicycle parking will be provided and/or upgraded near bus stops and key destinations such as the city centre, the rail and bus stations, schools and colleges, the hospitals, shopping areas and other large workplaces.

Permeability and Wayfinding
Permeability is a key constraint for cyclists and pedestrians in Galway. Links between residential areas and/or workplaces will be improved for use by active modes, providing more direct routes. In addition, a cycle route signage programme is proposed in parallel to the development of the cycle network.

As a city of learning with a compact, walkable city centre, Galway enjoys a high walking mode share of approximately 23%

7.3 Walking

Galway has significant potential to build on the existing pedestrian environment for the city's residential and commercial community, shoppers and the significant number of tourists who visit the city all year round.

As a city of learning with a compact, walkable city centre, Galway enjoys a high walking mode share of approximately 23% providing a strong foundation from which a prominent and sustainable walking culture can be fostered.

The benefits of pedestrian priority within the city centre are long-recognised, with the pedestrianised area from William Street through Shop Street, High Street and Quay Street representing a major asset to the local economy. Further afield, the canal walkways and the promenade at Salthill are other flagship pedestrian features, as well as amenity routes along the natural assets of Lough Atalia and River Corrib.

While the vast majority of the pedestrian network in the city and suburbs is of reasonably good quality, there are locations where the pedestrian offering is limited, with sub-standard footpaths, lack of crossing facilities and low priority allocation in the hierarchy of road users being common issues affecting pedestrians, particularly those with mobility impairments. Research carried out in recent years has indicated that the proportion of walking trips decreases considerably with increasing distance from the city centre.

The limited number of crossings of River Corrib within the city centre also hinders walking, in particular due to poor quality pedestrian facilities and heavy traffic flow on the bridges.

Within the core city centre area, there will be a continued focus on improving and prioritising the pedestrian network to encourage and accommodate movement between places and to cater for mobility impaired persons. The adoption of an integrated strategy, which removes significant volumes of motorised transport from the core city centre area will create the space to achieve this, thereby reinforcing the concept of Galway as a 'walking city'.

The Cross-City Link initiative outlined in Section 4 of this report will seek to reinforce the pedestrian at the top of the hierarchy of modes and underpin the planned transformation of the city centre. Outside of the city centre, emphasis will be given to increasing permeability within suburban residential areas, improving and updating pedestrian networks, increasing pedestrian safety and maximising pedestrian accessibility to the public transport network. Specific emphasis is also placed on improving connectivity and permeability within and to the industrial sites to the east of the city, including to, from and between Ballybrit and Parkmore Industrial Parks.

In order to provide a framework for developing measures, a series of aims and proposed measures for walking have been established, which provide a basis for developing specific plans for infrastructure proposals, as summarised in Table 7.2.

Table 7.2 Walking Network Design

Strategic Aims	Proposed Measures	Design Development and Consideration of Alternatives
To provide improvements for pedestrians along city centre public transport corridors.	Provide a new pedestrian river crossing at Galway Cathedral, adjacent to Salmon Weir Bridge; Establish and implement a city centre public realm improvement programme (signage, surface materials and lighting), including pedestrianisation schemes, to create a comfortable, well connected walking environment.	Design development has considered: • Priority movements for pedestrians and areas of key desire lines; • Conflict points between modes and selecting appropriate corridors to cater for each mode (i.e. prioritising footpaths, cycle lanes and/or bus lanes in particular locations); • Gap analysis in the existing pedestrian network; • Identification of areas of concern with regards to pedestrian safety; • Junction upgrade proposals, incorporating pedestrian crossing facilities; and • Permeability and pedestrian access to residential and employment areas. Conceptual designs have been prepared along sample road sections and at key junctions to illustrate potential layouts and the feasibility of proposed upgrades or other works.
To increase priority given to pedestrians over road traffic.	Transform the character of the core city centre area with a clear emphasis on pedestrians through extended pedestrianised areas, traffic management, reducing pedestrian wait times at crossings, removal of through traffic, limiting on-street parking availability and revised road and junction layouts; Enhance the pedestrian offering through upgrade of major roundabout junctions to include signalisation, and provide dedicated pedestrian facilities and priority.	
To increase legibility and wayfinding.	Define a safe, legible city centre pedestrian network, providing for ease of movement for all users, including persons with mobility, visual and hearing impairments, and for those using buggies and prams; Implement a Smart Information and Integrated Wayfinding Strategy for the city centre for all modes, including pedestrians. This will include wayfinding signage across the city and provision of information on walking, cycling and public transport networks, to benefit the community and visitors alike.	
To increase the quality, comfort and safety of the pedestrian facilities.	A structured, prioritised programme of improvements will be undertaken across the pedestrian network, including providing new footpath facilities, widening existing facilities, providing new and improved crossing facilities, removal of street clutter, adapting junction layouts in order to minimise crossing distances and reduce vehicle speeds, and a program of improvements to pedestrian permeability through residential areas in order to create safe, secure environments that encourage and foster a strong walking culture.	

7.4 Supporting Measures for Walking

This Transport Strategy will ensure that the needs of pedestrians, including the mobility impaired and disabled, are fully considered in the design of all new facilities and upgrades of existing facilities. This will include:

- Revision of road junction layouts, where appropriate, to provide dedicated pedestrian crossings, reduce pedestrian crossing distances, provide more direct pedestrian routes and reduce the speed of turning traffic;
- Creation of permeable pedestrian environments in residential areas, amenable to walking, and maximising accessibility to the proposed bus network;
- In conjunction with An Garda Síochána the Local Authorities will evaluate and, where appropriate, seek the introduction of lower speed limits in the core city centre area and on residential streets;
- Cooperation with An Garda Síochána in the enforcement of laws in relation to parking on footpaths;
- Removal of unnecessary street clutter to facilitate ease of movement along streets and through 'places'; and
- Leisure Walking: Advance the roll-out of the greenway network, including the Oranmore-City Centre-Bearna Geenway and the extension of the Dangan Greenway to Oughterard via Maigh Cuilinn.

Permeability is a key constraint for cyclists and pedestrians in Galway. Links between residential areas and workplaces alike will be continuously improved as part of a structured, prioritised implementation programme based on the above principles.

This Transport Strategy will ensure that the needs of pedestrians and the mobility impaired and disabled are fully considered in the design of all new facilities and upgrades of existing facilities.

7.5 Public Realm

Galway City Council has committed to delivering a Public Realm Strategy in 2016.

The quality of the pedestrian environment is an important characteristic which influences residents, commuters, tourists and shoppers in their choice of destination and main mode of travel. The reallocation of road space to public transport in the city centre must therefore be accompanied by an associated improvement of the public realm. This section outlines a number of specific measures to be implemented supporting Galway as a 'walking city' and enhancing the city centre public realm, in turn strengthening Galway City ahead of becoming European Capital of Culture for 2020.

Cross-City Link

The Cross-City Link project is intended to significantly improve public transport, walking and cycling within the core city centre area. The Cross-City Link proposal includes the following elements, which contribute to public realm enhancements:

Bus Priority

The route will be subject to traffic restrictions such that road sections become essentially bus-only, with a commensurate reduction in traffic flows – but with local access and deliveries allowed on a permitted basis.

Universal Design
The GTS will adopt an approach to design that is inclusive of all persons, in particular those who face specific challenges on a day-to-day basis when utilising the various modes of transport to travel around the city.

It is an objective of the GTS therefore to foster and sustain an inclusive approach to the operation of the transport network, and all of its constituent travel modes. Network proposals, including both new proposals and the improvement of existing facilities, will be undertaken in a manner that fully considers the accessibility requirements of all prospective users.

General Traffic
General traffic will be excluded from the corridor from Salmon Weir Bridge to the north-eastern end of Forster Street. There is a further bus priority section proposed for College Road to prevent general traffic from entering and leaving the city centre via College Road, with Lough Atalia Road designated as the main access route for general traffic.

Deliveries and Local Access
Certain permitted vehicles will be allowed to travel on the Cross-City Link route for delivery and business purposes. A management system will be implemented in respect of permits, delivery times and locations of access. Local businesses and residents will continue to be able to access their property.

Legibility and Linkage
The Cross-City Link will define a clear, legible corridor, linking places which currently have high pedestrian footfall and movement within the city centre. It will encompass the NUIG Campus and University Hospital, past the Cathedral and Courthouse, through Eyre Square and on towards the Sportsgrounds. It creates a space within the city and immediate environs that considers pedestrians, cyclists and public transport above the private car, and will greatly strengthen these modes as viable choices for commuters and visitors alike.

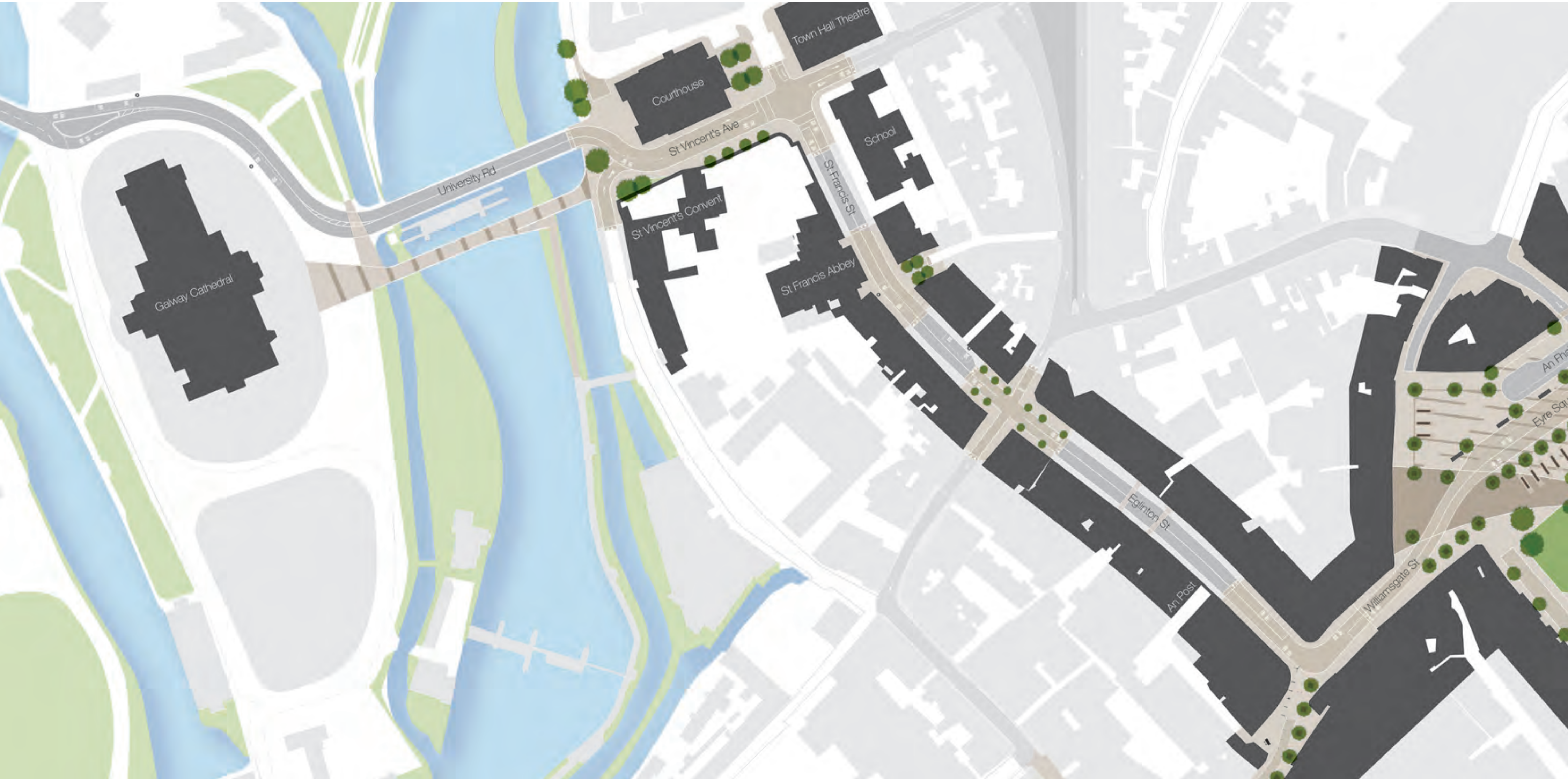
Key Locations
Key locations along the route to be upgraded, in respect of the urban environment to create comfortable spaces for pedestrians, are:

- **University Road** - the gateway to the city from the west, accessing the canal network, NUIG and Nun's Island (from the junction with Newcastle Road to Salmon Weir Bridge);
- **Cathedral Quarter** - comprising the front entrance to Galway Cathedral and surrounding street space;
- **A New Pedestrian Bridge** adjacent to Salmon Weir Bridge, providing a pedestrian alternative to the sub-standard pedestrian facilties on Salmon Weir Bridge;
- **Courthouse (Waterside)** - a key riverfront area adjacent to the Cathedral Quarter;
- **St. Francis Street/Eglinton Street** - providing connectivity to the existing pedestrian areas on William Street, Shop Street and environs;
- **Eyre Square** - the principal destination within the city centre for shopping and recreation;
- **Ceannt Quarter** - incorporating Ceannt Station, and rail/bus interchange; and
- **College Road** - the gateway to the city from the east.

The Cross-City Link is presented overleaf, with a number of views along the route illustrated in the following pages.

Note that the following illustrations are conceptual only and will be the subject of a separate design process.

The Cross-City Link - urban realm proposals




Prospect Hill
Forster St
Eyre Square
Frenchville Lane
Station Rd

The Cross-City Link - Eyre Square South

The Cross-City Link - Eglinton Street

8.1 Smarter Mobility

Smarter Mobility can be described as the way intelligent transport services are changing how cities function. Intelligent Transport Solutions (ITS) use technology to increase efficiency, safety and co-ordination across transport networks.

The Local Authorities, supported by the National Transport Authority, will continue to adopt Smarter Mobility and ITS as a means of improving the overall transport experience in Galway, building on initiatives such as the City Urban Transport Management Centre (UTMC). The UTMC forms the hub for urban traffic control in the city together with the recently-introduced Parking Guidance System (PGS), Variable Message Signs (VMS), CCTV and fault monitoring system.

Other improvements progressed by the NTA in recent years include the introduction of integrated ticketing through the Leap card, the provision of Real-Time Passenger Information at bus stops, and the roll out of the city Bike Share Scheme.

Smarter Mobility policies and ITS will be used to support and 'future-proof' proposed infrastructure, implement changes and add value to the operation of the transport network by maximising efficiency and ensuring the optimum performance of the entire network.

Smarter mobility projects can be broadly categorised into three groups:

- Projects which provide additional capacity to the transportation network;
- Projects which incorporate demand management; and
- Projects which utilise intelligent systems to deliver overall efficiency and cost savings to passengers.

Projects can fall under more than one category and deliver multiple benefits.

Additional capacity can be gained through the efficient use of the network by being more resilient to change and giving greater ease of movement to the most appropriate mode at different locations.

Demand management measures will be developed over time and will potentially include bus and pedestrian priority at traffic signals, managing parking fee structures to reduce the attractiveness of car travel to and from the city centre, and traffic management to reinforce the revised hierarchy of need within the core city centre area from the private car to other modes. Potential measures will originate at a 'policy' level so that measures can be developed and be classified as meeting policy aims. Projects which include enforcement of similar policies would also be considered as demand management measures.

Intelligent systems include those which utilise current and future technologies in order to deliver services in a more efficient manner. Over their lifetime these systems will deliver the intended service at a lower cost and offer a higher level of service to the customer. Cost savings can be earned through streamlining of delivery, reduction in power consumption and encouraging modal shift.

Proposed Smarter Mobility and ITS projects for Galway as part of this Transport Strategy include:

- Removing non-essential private cars from an area within the core city centre;
- Maintaining, expanding and integrating Galway City Council's Urban Traffic Management Centre (GCC UTMC);
- Providing an integrated ticketing system or universal method of payment across all modes;
- Creating and operating a smart parking system for Galway City;
- Creating a smart street lighting system for Galway;
- Providing an integrated wayfinding system for all modes;
- Auditing all traffic signal junctions to ensure correct layout, configuration and operation is in place;
- Creating smart priority routes for pedestrians and cyclists;
- Providing smart parking facilities for cyclists;
- Providing a "last mile" taxi service for bus users;
- Providing a zone-based, variable pricing structure for public transport;
- Examining demand-based variable pricing for parking;
- Encouraging and providing for electric vehicle usage over time;
- Enforcement of red light running and parking restrictions; and
- Ensuring all proposals are future-proofed for Co-operative ITS (or C-ITS, which entails vehicles and devices being capable of communicating).

Galway City Council have progressed the adoption of Smarter Mobility and ITS, as can be seen in the construction and commissioning of the City's Urban Transport Management Centre.

8.2 Travel to Places of Education

School travel is a critical factor affecting transport in Galway, particularly in the morning peak period. School trips by car are a substantial contributor to local congestion and have a significant impact on travel times by all modes. In many instances, a trip to a school to drop off children forms part of a different trip, usually a journey to work, and as a result it is challenging to develop overarching solutions to school travel applicable to the entire study area. Bespoke solutions are often required for individual school sites. Galway City Council will liaise with the Department of Education in order to examine the impact of school admission policies on school travel demand.

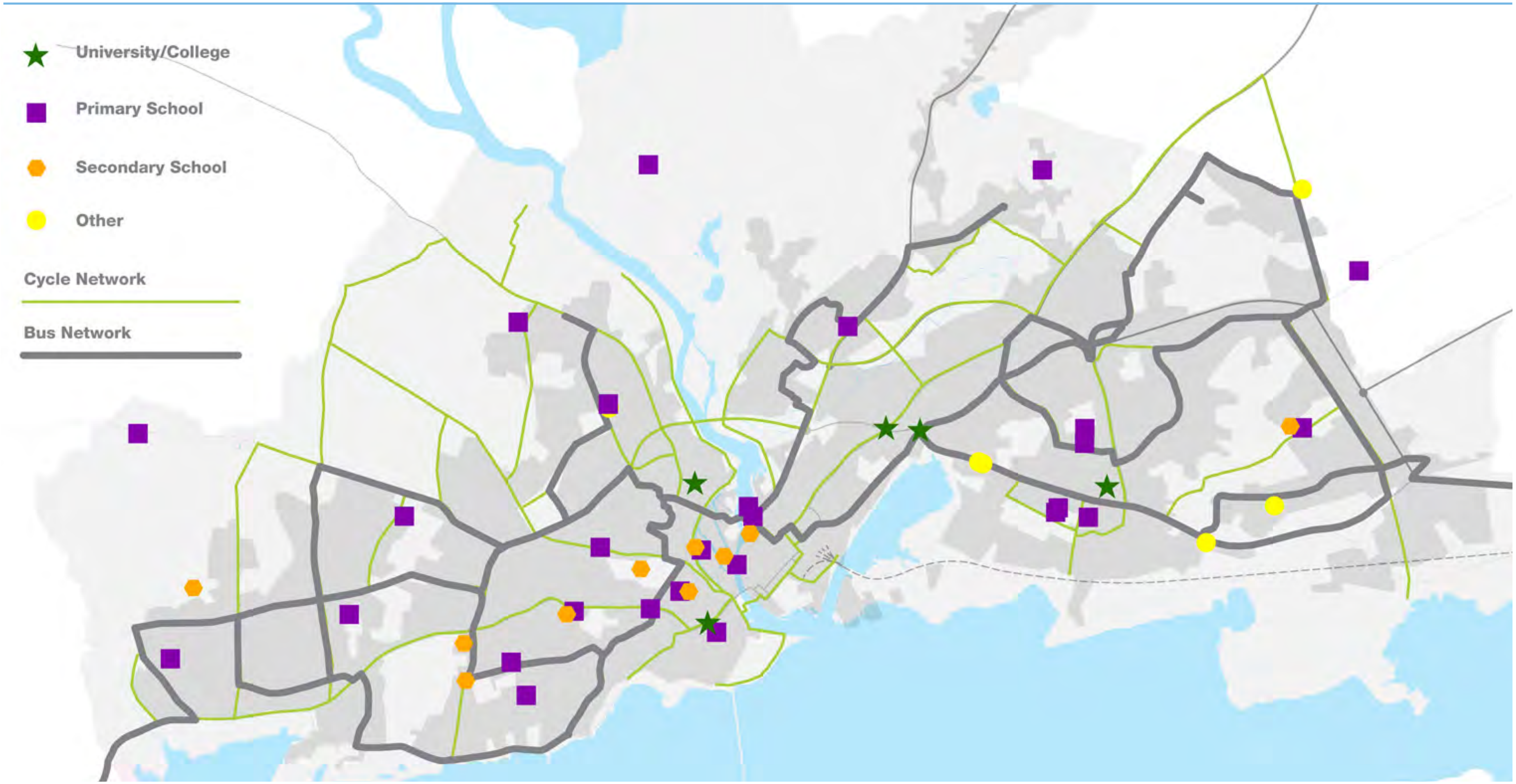
However, across the study area, improvements to school transport arrangements proposed as part of this Transport Strategy combine the following:

- Behavioural change programmes which encourages students and schoolchildren to travel to school by modes other than the car;
- General strategic improvements of bus, cycle and walking networks will provide safe opportunities for students to use non-car modes – especially when bus and cycle networks are planned to serve educational centres;
- Permeability improvements targeted at walking and cycling modes, improving accessibility to the bus network, and also minimising excessive routing for those who wish to walk or cycle to school;
- Promotion of school travel plans, and participation in the Green Schools Travel initiative; and
- At second and third levels, implementing mobility management planning for student travel, combined with targeted promotion of alternatives to the private car to better inform students of their travel options.

Figure 8.1 illustrates the locations of educational facilities within the Galway City in the context of the proposed Transport Strategy bus and cycle networks. As outlined in Section 5.2, the proposed cross-city bus network will result in 77% of primary schools and 93% of secondary schools having a high-frequency bus service within a 10-minute walking catchment.

School travel is a critical factor affecting transport in Galway, particularly in the morning peak period.

Figure 8.1 Proposed Bus and Cycle Networks and locations of educational facilities



8.3 Land-Use Integration

The integration of land-use and transportation is essential in creating sustainable city living. The alignment of settlement and land-use patterns to an integrated transportation strategy can provide opportunities to reduce car dependency and allow for greater investment in alternative means of travel including public transport, walking and cycling. It also delivers considerable benefits in terms of reduced congestion, reduced greenhouse gas emissions, enhanced health and wellbeing and has benefits for the public realm.

The consolidation of settlement into areas that are close to employment centres, shops, community and educational facilities is a strategic policy of Galway City Council, which is reflected in policies and objectives relating to land-use in the Draft City Development Plan (2017-2023). The strategy for the city promotes the sustainable development of key brownfield sites such as Ceannt Station, the Inner Harbour and the Headford Road area, consolidation of existing residential areas, and significant new development at Ardaun on the eastern edge of the city.

This is further supported in the Draft City Development Plan (2017-2023) through the development of sustainable residential neighbourhoods, where the reliance on private transport is reduced and where services are provided locally, allowing access by walking and cycling. The consolidation and concentration of development reduces travel demand, allows for the effective provision of services including public transport, and enables more sustainable patterns of travel.

At a local level, the preparation of Local Area Plans and masterplans provides a framework for mixed-use development in conjunction with this strategy and the application of sustainable densities at locations adjacent to public transport routes. Collectively, these plans will ensure that sustainable patterns of travel can be achieved.

The primary goals of land-use and transport integration in responding to the need to travel may be summarised as follows:

Reducing *the need to travel;*
Reducing *the distance travelled;*
Reducing *the time taken to travel;*
Promoting *walking and cycling; and*
Promoting *public transport use.*

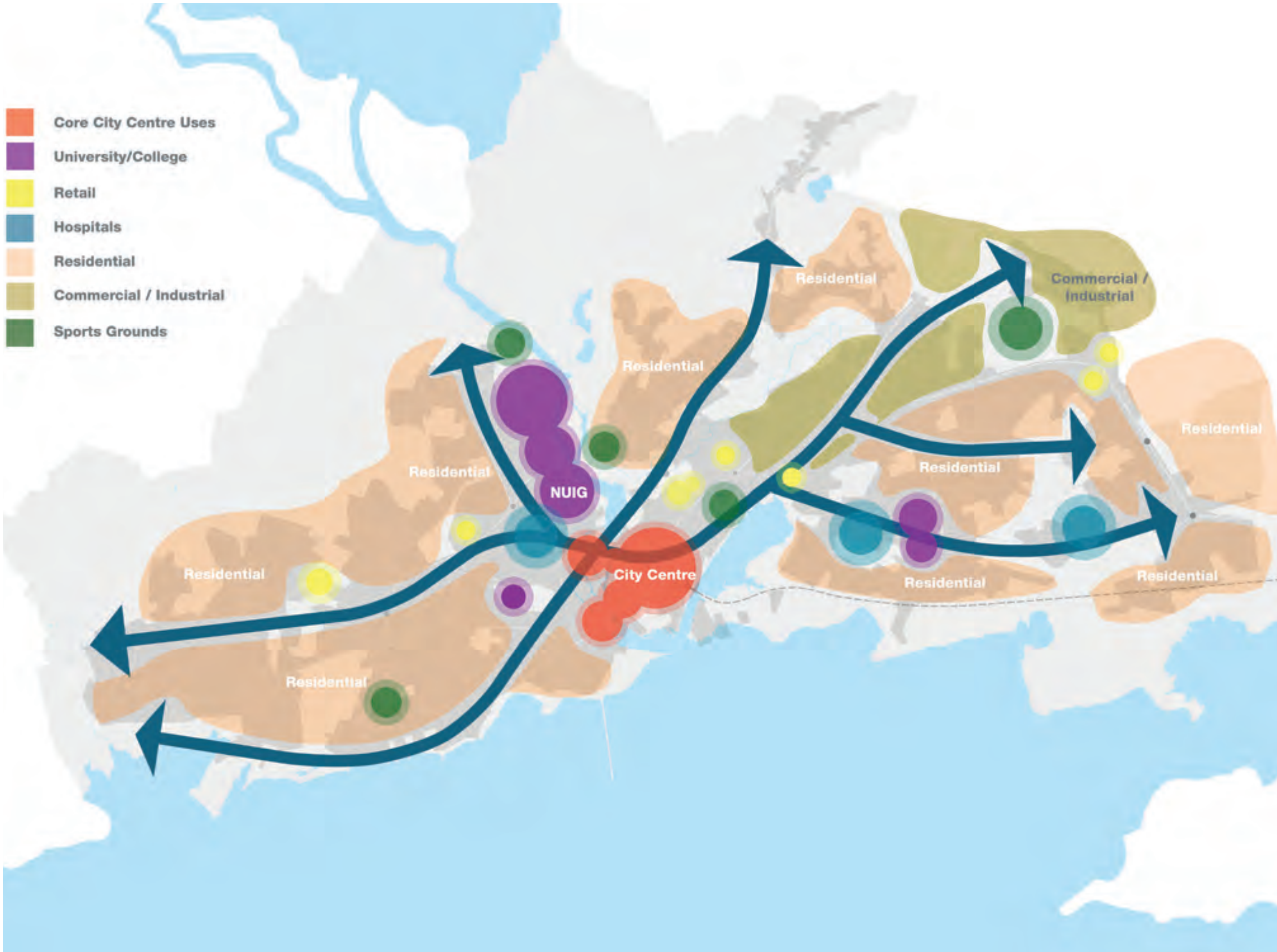
Existing land-uses and key trip attractors relative to the public transport corridors proposed in this Transport Strategy are presented in Figure 8.2.

The following land use principles are therefore intended to guide development in Galway:

- High-volume, trip intensive developments, such as offices and retail, should primarily be focused into the city centre, or areas well served by public transport;
- Residential development located proximate to high capacity public transport should be prioritised over development in less accessible locations;
- All non-residential development proposals should be subject to maximum parking standards – these standards should vary with location with regard to the centrality of the proposal within the city and the level of public transport provision. Area-based parking standards could be considered;
- For all major employment developments and all new and extended schools, travel plans/mobility management initiatives should be conditioned as part of planning permissions and be carried out in a manner consistent with existing NTA guidance;
- To the extent practicable, residential development should be carried out sequentially, whereby lands which are, or will be most accessible by walking, cycling and public transport – including infill and brownfield sites – are prioritised;

- Planning at the local level should promote walking, cycling and public transport by maximising the number of people living within walking and cycling distance of their neighbourhood or district centres, public transport services, and other services at the local level such as schools;
- New development areas should be fully permeable for walking and cycling and the retrofit of walking and cycling facilities should be undertaken where practicable in existing neighbourhoods, in order to a give competitive advantage to these modes;
- Where possible, developments should provide for filtered permeability. This would provide for walking, cycling, public transport and private vehicle access but at the same time would restrict or discourage through trips by private car;
- To the extent practicable, proposals for right-of-way extinguishments or other requirements should only be considered where these do not result in more circuitous walking and cycling trips for local residents accessing public transport or local destinations; and
- In urban areas, including the numerous towns, villages and settlements, the Design Manual for Urban Roads and Streets (DMURS) will guide localised proposals with a view to reaffirming walking, cycling and public transport modes over the private car.

Figure 8.2 Land-Use Integration with proposed public transport routes



8.4 Behavioural Change

Behavioural change, as it applies to transport, is about making people aware of the range of travel choices available for the variety of trips which they make on a daily basis and encouraging the use of more sustainable travel choices where feasible. Measures to encourage this involve the targeted promotion of public transport, walking, cycling and car sharing as alternatives to single-occupancy private car use.

They comprise a highly personalised approach aimed at engaging a group of people, making them think about their travel choices, providing them with full information, and encouraging and incentivising the use of alternatives.

In recent years, fostered by the Government's Smarter Travel policy document, and supporting initiatives and work undertaken by a number of agencies, there has been an increased awareness of the benefits that such programmes can deliver. The NTA is responsible for the management of the Smarter Travel Workplaces and Campuses Programme and administers the Green Schools Travel Module on behalf of the Department of Transport, Tourism and Sport. In addition to these two core programmes, the NTA funds behavioural change initiatives via the Regional Cities Sustainable Transport Grants Programme for Galway City.

These programmes have been highly successful in reducing car use in many locations across the country and if maintained and expanded, can be predicted to have a regional-level impact on travel behaviour in the Galway Metropolitan Area.

As an example, the recent national rise in cycling to primary school between 2006 and 2011 – the first such rise in a generation – occurred at the same time as Green Schools Travel began to roll out on a significant scale. Furthermore, the Galway University Hospitals group were named 'Smarter Travel Workplace of the Year' in 2015 following their efforts in working towards a reduction in single-occupancy car trips to and from the hospital.

These programmes form a core element of this strategy and as such, it commits to the continued implementation and support for Smarter Travel Workplaces and Campuses and a School Travel programme over its lifetime. Behavioural change initiatives will continue to be promoted in Galway to travellers within, to and from the city in order to encourage the use of sustainable travel modes, chiefly public transport, walking, cycling and car-sharing as alternatives to single-occupancy private car use. Initiatives will be developed and targeted at various locations and at varying scales, for example at workplaces, schools and neighbourhoods.


eircom
UNLIMITED
with superfast fibre broadband from eircom
€35
1800 303 601
eircom

Implementation

This strategy is intended to frame the long-term build-out of transport in Galway City and environs for the next 20 years. The implementation of the strategy, and delivery of the specific proposals, will be through a series of multi-annual 'implementation plans' which will be agreed between the Councils and funding agencies, in particular the NTA.

The implementation plans will set out short-term delivery programmes for the proposals of the Galway Transport Strategy, and will be fully cognisant of funding availability, as well as requirements and timelines of statutory planning processes.

It will also be necessary to evaluate the potential environmental impacts associated with the individual elements of the GTS as they are implemented, in accordance with the mitigation measures and the statutory processes outlined within the Strategy.

Ultimately, this will ensure that the strategy can be delivered in a timely and efficient manner, and that the transport benefits for Galway are maximised.

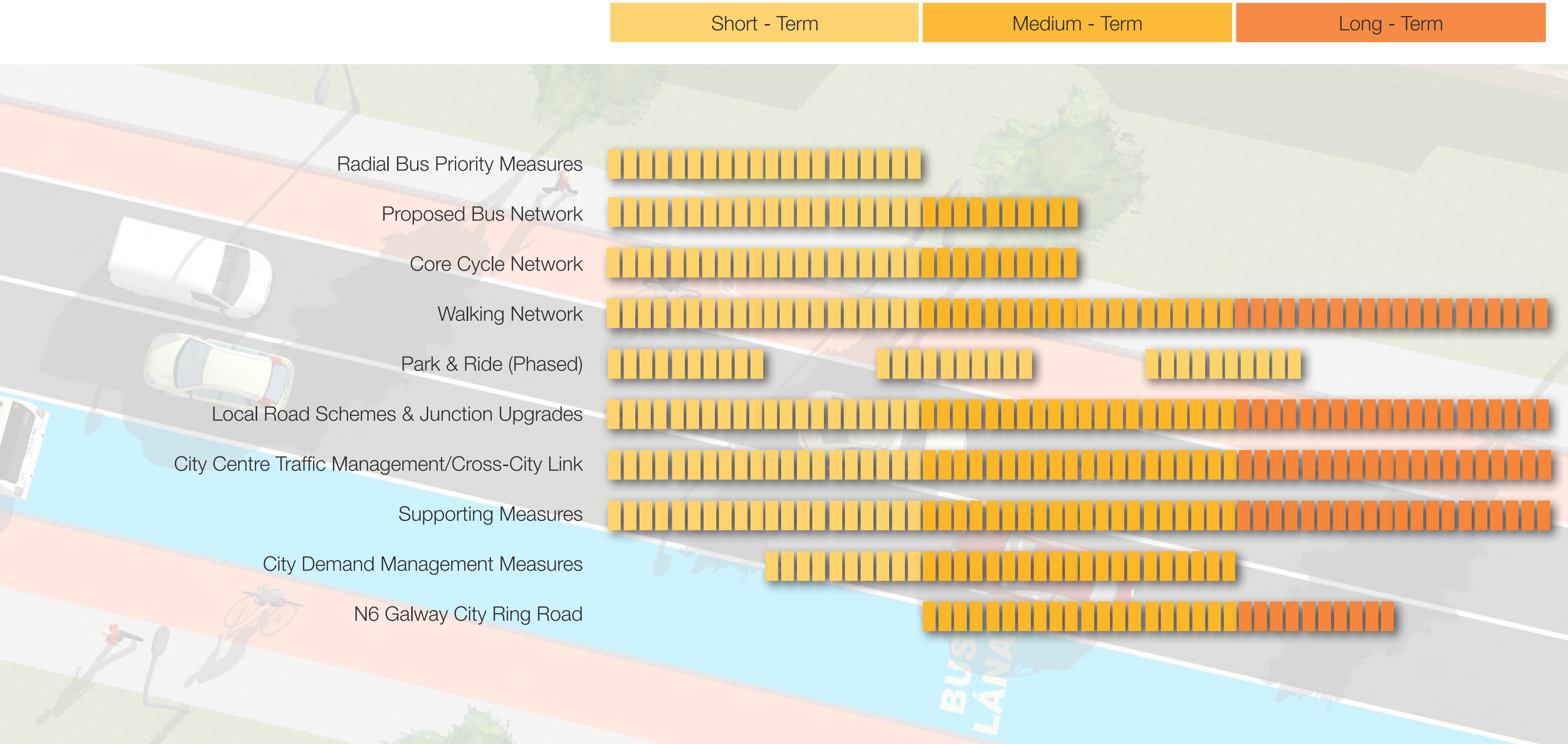
It is anticipated that the annual service plans of the City and County Councils will also reflect the contents of these implementation plans.

Provision will be made for the periodic review of the strategy to take account of emerging trends, and any emergence of new development opportunities, or to reflect the changing requirements of the evolving Galway transport network.

From a strategic planning perspective, it is anticipated that the implementation of the Galway Transport Strategy will be phased over three broad time bands (Short-Term, Medium-Term and Long-Term). This timeframe for delivery is set out in Figure 9.1.

Ultimately, this will ensure that the strategy can be delivered in a timely and efficient manner, and that the transport benefits for Galway are maximised.

Figure 9.1 Indicative Phasing of Implementation of Galway Transport Strategy



Implementation and Outcomes

Outcomes

The implementation of the proposals set out in this strategy will result in positive outcomes for Galway, providing long-term transport, tourism, commercial/retail and public realm benefits for the city and its environs. These benefits are listed below:

Future-Proofing the City – to ensure Galway can continue to grow as an economic and cultural centre in the West of Ireland, the strategy frames the future transport needs of the city and its environs, in terms of Public Transport, Walking, Cycling and Strategic Road provision.

Facilitating New Transport Infrastructure –

- **Public Transport:** Ensuring that the 'Cross-City Link' is introduced to increase the amount of people able to access the heart of the city by public transport;
- **Walking and Cycling:** Likewise, ensuring that a network of cycle and walking routes is developed across the city and environs to provide safe, convenient and comfortable links to key destinations from residential areas; and
- **Road Network:** Providing improved access and movement across, and within Galway City and environs, and facilitating the development of a strategic relief road which will meet the long term road capacity requirements of the city, as well as offering vastly improved accessibility to the west of County Galway.

Improved Efficiency of the overall transport network, by optimising the use of limited city centre road space, facilitating a greater degree of access to the city.

Improved Environment, Urban Realm and Ambience – Enhancing the streetscape of the city centre, reducing noise and air pollution and freeing up more space where people can walk, shop, socialise and enjoy the city.

Tourism, Commercial and Retail Benefits – Improving the overall commercial/retail and tourist environment of Galway, with additional transport capacity for shoppers and visitors accessing the city centre, and also key tourist locations such as Salthill Promenade and Galway Racecourse.


CITY SIGHTSEEING TOUR
TOURS DAILY from 11am to 4.30pm
CITY SIGHTSEEING TOUR
Hop On Hop Off
STOP 1


Deane
Darcy
Deane
Martin
Morris
TAXI
BV

"a connected city region driven by smarter mobility"

Appendix G

N6 GCRR Junctions Strategy

Galway County Council

N6 Galway City Ring Road

Phase 3 Junction Strategy

GCOB-4.04.03.17.004

Issue 3 | 28 February 2017

Job number 233985

Ove Arup & Partners Ireland Ltd

Arup
Corporate House
Ballybrit Business Park
Ballybrit
County Galway
Ireland
www.arup.com

ARUP

Document Verification

ARUP

Job title		N6 Galway City Ring Road		**Job number** 233985	
Document title		Phase 3 Junction Strategy		**File reference** 4.04.03-17.004	
Document ref		GCOB-4.04.03.17.004			
Revision	**Date**	**Filename**	GCOB-4.04.03.004 (Phase 3 Junction Strategy)_D1.docx		
Draft 1	18 Oct 2016	**Description**	First draft for review		
			Prepared by	Checked by	Approved by
		Name	Michael Gaughan/ Eileen McCarthy		
		Signature			
Issue 1	28 Oct 2016	**Filename**	GCOB-4.04.03.004 (Phase 3 Junction Strategy)_I1.docx		
		Description	First Issue		
			Prepared by	Checked by	Approved by
		Name	Michael Gaughan/ Eileen McCarthy	Mary Hurley	Eileen McCarthy
		Signature			
Issue 2	3 Nov 2016	**Filename**	GCOB-4.04.03.004 (Phase 3 Junction Strategy)_I2.docx		
		Description	Second issue		
			Prepared by	Checked by	Approved by
		Name	Michael Gaughan/ Eileen McCarthy	Mary Hurley	Eileen McCarthy
		Signature			
Issue 3	28 Feb 2017	**Filename**	GCOB-4 04 03 17 004 (Phase 3 Junction Strat)_I3.docx		
		Description	Third Issue		
			Prepared by	Checked by	Approved by
		Name	Michael Gaughan / Eileen McCarthy / David Conlon	Mary Hurley	Eileen McCarthy
		Signature			

Issue Document Verification with Document ✓

Contents

1 Introduction

1.1 Overview

The N6 Galway City Ring Road (N6 GCRR) is currently at *Phase 3 Design* and *Phase 4 EIA/EAR & The Statutory Processes*. The objective of Phase 3 is to develop the design of the N6 GCRR to a stage where a sufficient level of detail exists to establish landtake requirements and to progress the scheme through the statutory processes which is the matter of Phase 4.

The proposed N6 GCRR comprises the construction of approximately 5.6km of a single carriageway from the western side of Bearna as far as the Ballymoneen Road and approximately 11.9km of dual carriageway from Ballymoneen Road to the eastern tie in with the existing N6 at Coolagh, Briarhill, and associated link roads, side roads, junctions and structures.

The purpose of this report is to examine the most appropriate junction strategy for the proposed N6 GCRR.

1.1.1 TEN-T Network

The TEN-T requires that all roads that form part of the network, as a minimum, be a high quality road. Regulation (EU) No 1315/2013 sets out the requirements for high quality roads that shall form part of the network, both Core and Comprehensive, and states under Article 17(3), the following:

> *High-quality roads shall be specially designed and built for motor traffic, and shall be either motorways, express roads or conventional strategic roads.*
>
> *(a) A motorway is a road specially designed and built for motor traffic, which does not serve properties bordering on it and which:*
>
> > *(i) is provided, except at special points or temporarily, with separate carriageways for the two directions of traffic, separated from each other by a dividing strip not intended for traffic or, exceptionally, by other means;*
> >
> > *(ii) does not cross at grade with any road, railway or tramway track, bicycle path or footpath; and*
> >
> > *(iii) is specially sign-posted as a motorway.*
>
> *(b) An express road is a road designed for motor traffic, which is accessible primarily from interchanges or controlled junctions and which:*
>
> > *(i) prohibits stopping and parking on the running carriageway; and*
> >
> > *(ii) does not cross at grade with any railway or tramway track.*
>
> *(c) A conventional strategic road is a road which is not a motorway or express road but which is still a high-quality road.*

The ‘express road’ and "conventional strategic road" are not clearly defined as particular road cross-section types in Irish standards. Selection of either a motorway or express road would restrict frontage access and necessitate suitable provision is made for non-motorised users. The conventional strategic road does not necessarily require that access is restricted to junctions.

The N6 GCRR forms part of the TEN-T Comprehensive Network which has implications on the choice of cross-section per the regulations above. Selection of two of these cross-section options will also restrict access to junctions only. This in turn has implications on the junction strategy in so far as particular junction forms are only compatible with certain cross-sections as per current standards as set out in the Design Manual for Roads and Bridges (DMRB).

1.1.2 N6 Galway City Ring Road

The proposed N6 GCRR ties into the existing R336 at an at-grade roundabout junction approximately 2km to the west of Bearna Village and then proceeds as a single carriageway to the north of Bearna Village. It continues eastwards as a single carriageway to cross the county/city boundary at the western fringes of Knocknacarra.

Once within the city environs, traffic volumes increase and as a result the N6 GCRR is a dual carriageway to the east of Ballymoneen Road. The dual carriageway continues east to cross the existing N59 Moycullen Road at Dangan and travels on a viaduct over the NUIG recreational facilities before crossing the River Corrib on a bridge structure.

To the east of the River Corrib the proposed road development continues east on embankment, on a viaduct section and through a tunnel section before crossing the N84 Headford Road at Ballinfoyle. The proposed road development continues east through the townland of Castlegar to cross the N17 Tuam Road.

The proposed road development then continues eastwards entering the Galway Racecourse Tunnel at Ballybrit to the north of the racetrack. On emerging from the tunnel the proposed road development continues south, crossing over the R339 Monivea Road on embankment and continuing south to enter a cutting as it reaches its juncture with the existing N6 at Coolagh.

1.2 Objectives

The objectives to be considered in determining the junction strategy include the following:

- Restriction of access to junctions as N6 GCRR is of strategic importance and part of the TEN-T Comprehensive Network
- Connectivity to National and Regional road network
- Serve existing travel demand
- Junctions must be located so as to relieve traffic congestion

- Sufficient junctions to provide a minimum level of accessibility to the region to support further economic, social and territorial development
- Junction form must deliver capacity as experience has shown that the network breaks down due to junction failure due to capacity problems
- Promote a mobility that is efficient and safe

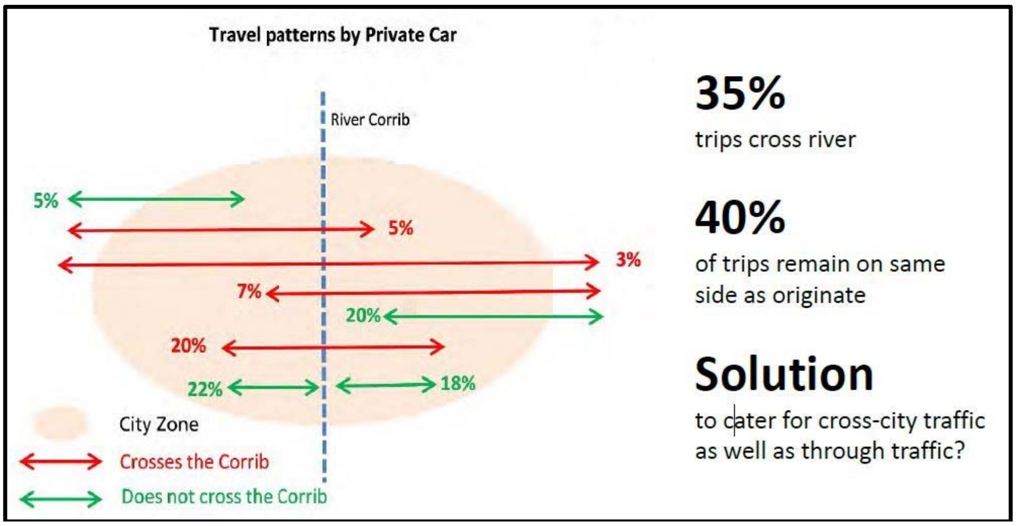
2 Phase 2 Route Selection

2.1 Traffic Analysis

Analysis of the travel patterns has given an understanding of travel demand in Galway City and its environs, which in turn has guided the junction strategy which matches demand.

As shown in **Figure 1** below, 35% of all car trips into and around Galway City cross the River Corrib. Of this total number of cross-river trips, approximately 9% are bypass traffic (i.e. 3% of 35%). Some 40% of all trips remain on the same side of the city as where they started i.e. do not cross the river. Approximately 20% of all trips are to/from the west side of Galway City to/from the east side of Galway City within the city zone.

Figure 1: Existing Travel Patterns



Note: *arrows include traffic in both directions, inclusive of trips both into the zone and out of the zone*

This analysis shows that the transport solution must be multi-modal catering for the following various demands:

- High proportion of short journeys within the city extents can be accomplished via public transport, cycling or walking i.e. approximately 40% of journeys commencing in the city which remain on the same side of the city as they started are short trips, both in time and distance
- A further 20% of journeys are from one side of the city to the other, again short journeys which are clear targets for a shift to public transport if there is an efficient system available
- Connectivity to the national road network for those on the western side of the River Corrib which is only possible at present by using one of the city centre bridge crossings

2.2 Phase 2 Junction Strategy

The analysis of the travel patterns gave an understanding of travel demand in Galway City and its environs and formed the basis of the junction strategy which was presented on the Emerging Preferred Route Corridor (EPRC).

The choice of grade separation on the dual carriageway section was selected based on a review of the traffic volumes on the mainline and the intersecting minor roads. As per **Figure 2** below, TII publication DN-GEO-03043, (formerly known as NRA TD 41-42), the anticipated traffic volumes at all the intersections with the national roads, i.e. N6, N17, N84 and N59 are beyond the maximum recommended for simple to ghost island junctions and into the range of roundabout or other type of junction.

Figure 2: Possible Junction Types for Different Major Road Carriageway Types

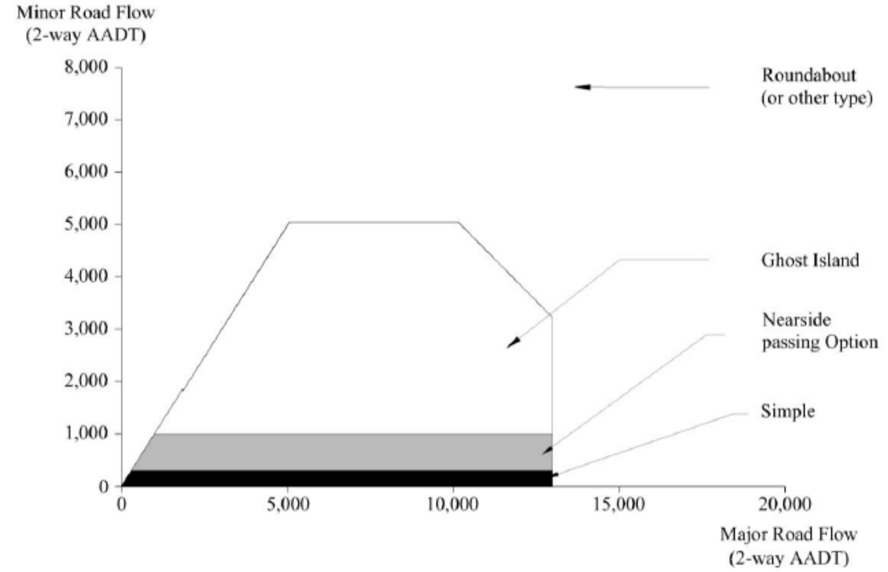


Figure 2/2 : Approximate Level of Provision of T-junctions on New Single Carriageway Roads for Various Major and Minor Road Design Year Traffic Flows (Paras 2.20, 2.22)

This correlates with guidance from Chartered Institution of Highways and Transportation (1997) and utilised by the European Commission which illustrates suitable junction types based on traffic flows, refer to **Figure 3**. Flows on the mainline and national road junctions on the N6 GCRR are in the realm of grade separation based on this chart.

Figure 3: Type of junction based on traffic flows (IHT 1997)

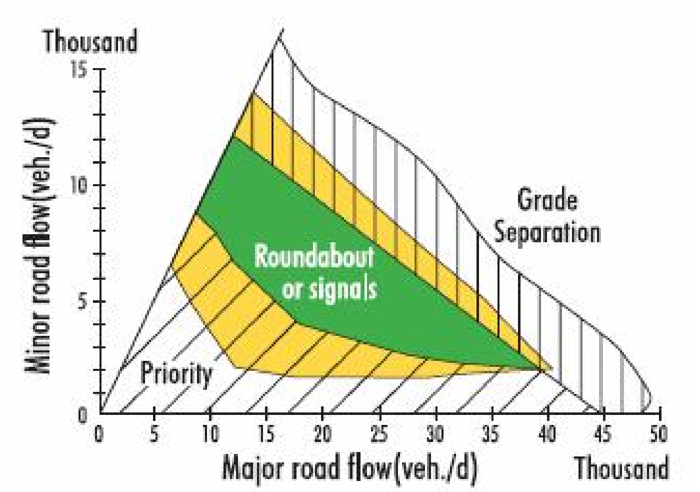


Figure 9 Type of junction based on traffic flows (IHT 1997)

Phase 2 traffic analysis showed that the junctions contributed to significant delay along the key routes which were assessed to establish the performance of options. Therefore, a solution that offers a resolution to these significant delays has the benefit of contributing significantly in the economic assessment of benefits. As congestion relief is a key objective of the proposed scheme, grade separation is the preferable junction form on the dual carriageway section.

The Phase 2 Junction Strategy is summarised in the Route Selection Report, Section 3.4 as follows:

> *Therefore, it is anticipated that grade separated junctions will be provided at the N6/M6 interface, and on the N17, N84 and N59. Furthermore it is likely that there will be at least two further at-grade junctions between the N59 grade-separated junction and the R336 tie-in.*

This included junctions as set out in **Table 1**.

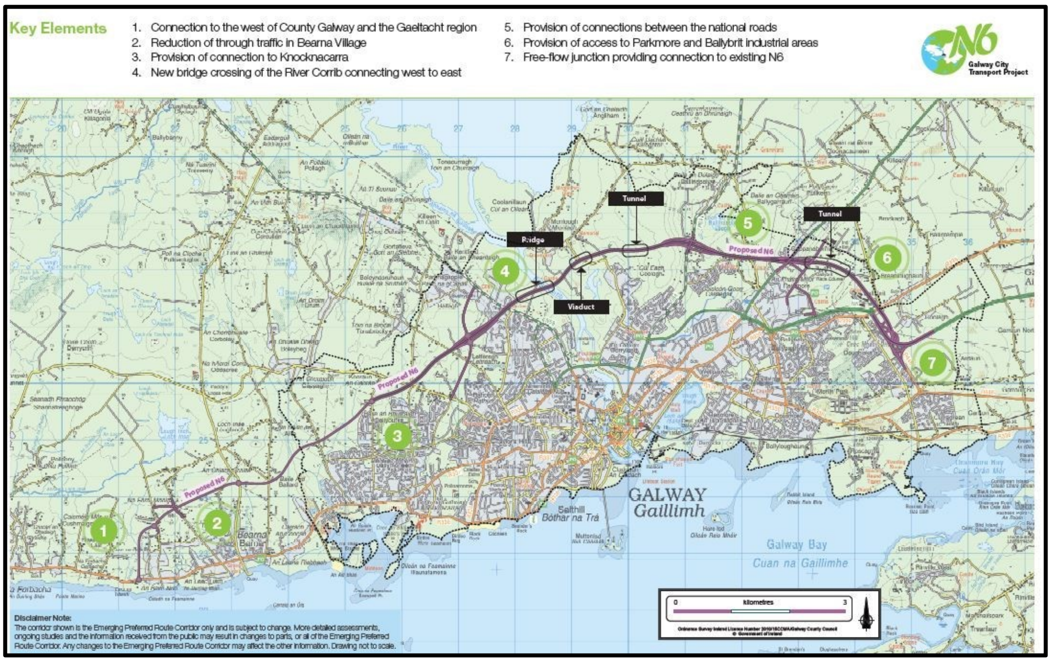
Table 1: EPRC Junction Strategy

Location	Type
R336	Roundabout (Western Terminus)
Foraí Maola	Roundabout with access only to south, cul-de-sac on north
Bearna to Moycullen Road	Roundabout
Ballymoneen Road	Roundabout
N59 Junction	Grade Separated Junction
N84 Junction	Grade Separated Junction
N17 Junction	Grade Separated Junction (with west facing ramps only)
Parkmore Link Road Junction	Grade Separated Junction (with west facing ramps only)
N6 (Coolagh) Junction	Grade Separated Junction

2.3 Emerging Preferred Route Corridor

During Phase 2, Route Selection, a preliminary junction strategy was developed and presented to the public as part of public consultation on the Emerging Preferred Route Corridor. The Emerging Preferred Route Corridor (EPRC) is presented in **Figure 4** below.

Figure 4: Emerging Preferred Route Corridor



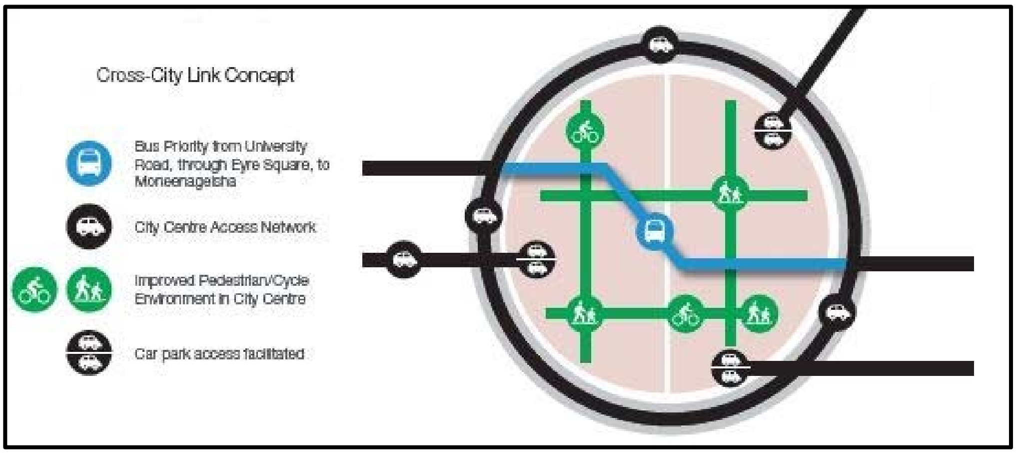
3 Phase 3 Design

3.1 Design Development

During Phase 3, significant public consultation, which included home and site visits, was undertaken with directly affected property owners. These visits offered a unique opportunity to the Design Team to appreciate both the perspective of the end user of the N6 GCRR as well as the receiving environment into which it is proposed to introduce the N6 GCRR.

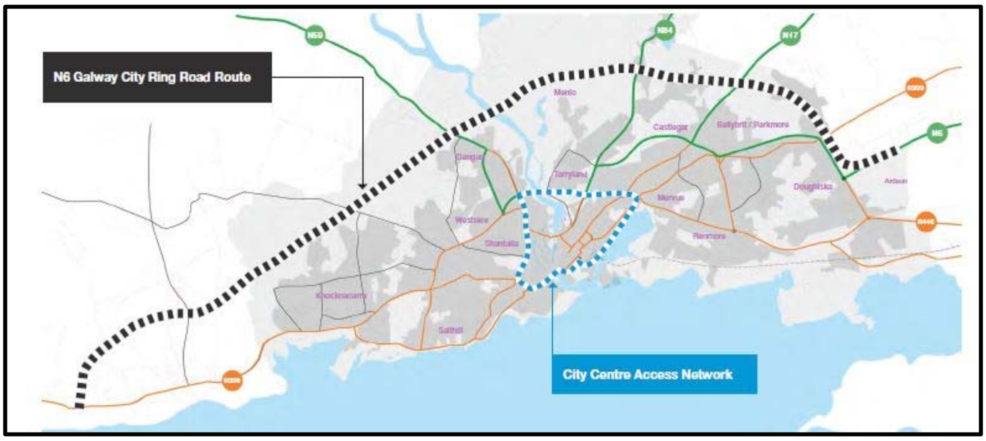
In parallel, significant work was undertaken on the overall transport solution, particularly the analysis to devise the most appropriate form of transport for the various journey types. The Galway Transport Strategy (GTS), which was prepared by Galway City Council and Galway County Council in conjunction with the National Transport Authority, is the output of this analysis and includes an evaluation of transport options for all modes, and has affirmed the strategic need for a ring road and a new crossing of the River Corrib, in order to implement the level of service required for each mode of transport, including walking, cycling, public transport and private vehicle. The basis of GTS is to get the core area of the city working for public transport, cycling and walking by implementing hard solutions to block access for through traffic. This will force traffic out of the core area and into using alternative modes. The strategy is best illustrated in **Figure 5**.

Figure 5: Galway Transport Strategy: Cross-City Link Concept



Significant traffic modelling work using the Western Regional Transport Model was undertaken as part of Phase 3 work. Analysis shows that a certain proportion of journeys will still be served by private vehicle with the objective being to move these trips from the city centre access network onto the proposed N6 GCRR. Therefore, connectivity to this ring road via junctions is critical to optimise the transfer of journeys to the ring road. **Figure 6** illustrates the relationship between the city centre access network and the N6 GCRR.

Figure 6: Relationship of City Centre Access Network to N6 GCRR



The conclusions of the Galway Transport Strategy has influenced the junction strategy in so far as the junctions on the mainline are located to reflect demand and additional lanes are included at various locations along the existing road network to accommodate bus only lanes, cycle tracks and footpaths. An overview of each of the major junctions attaching to the mainline and the rationale for the proposed junction form is documented in Section 3.2.

3.2 Phase 3 Proposed Junctions

3.2.1 R336 Junction

The EPRC arrangement at the western terminus of the N6 GCRR was an at-grade roundabout in an area known as An Baile Nua as shown in **Figure 7**.

Figure 7: EPRC R336 Junction

3.2.1.1 Location Characteristics

The R336 Bearna Road is a regional road running along the south coast of County Galway connecting Galway to Bearna Village to Spiddal and onwards to Rossaveel. The N6 GCRR terminates at the R336 at a ninety degree angle west of Bearna Village, thus creating a junction in the area. The existing R336 geometry in the vicinity of this proposed junction is of a reasonable standard with a posted speed limit of 60km/h. There are many properties accessing directly onto the R336, and this becomes continuous once the 50km/h zone is encountered, which subsequently leads to Bearna Village.

3.2.1.2 Traffic Mix

In the vicinity of the proposed junction the R336 caters for daily traffic volumes of approximately 13,000 per day in the 2039 design year. The traffic splits at the N6 GCRR junction with 11,000 diverting onto the N6 GCRR and 3,000 continuing into Bearna Village on the R336. Approximately 3% of the traffic constitutes Heavy Goods Vehicles (HGV's).

3.2.1.3 Junction Requirements

The volumes anticipated are medium. Preliminary analysis of Figures 2/1 and 2/2 of TII publication DN-GEO-03043, (formerly known as NRA TD 41 - 42) highlights that the anticipated volumes are in the order of those recommended for roundabout or signalised junctions. This correlates with guidance from Chartered Institution of Highways and Transportation (1997) and utilised by the European Commission which illustrates suitable junction types based on traffic flows, refer to **Figure 3**.

3.2.1.4 Junction Selection

At this location one of the overriding objectives is to reduce speeds in order to inform drivers of a major decision point. Drivers can chose to remain on the existing R336 to enter the 50km/h zone to Bearna Village or choose to divert onto the N6 GCRR to bypass the village and built-up area. The junction must also convey all road users in an efficient same manner, including motor vehicles, buses, trucks, bicycles, and pedestrians.

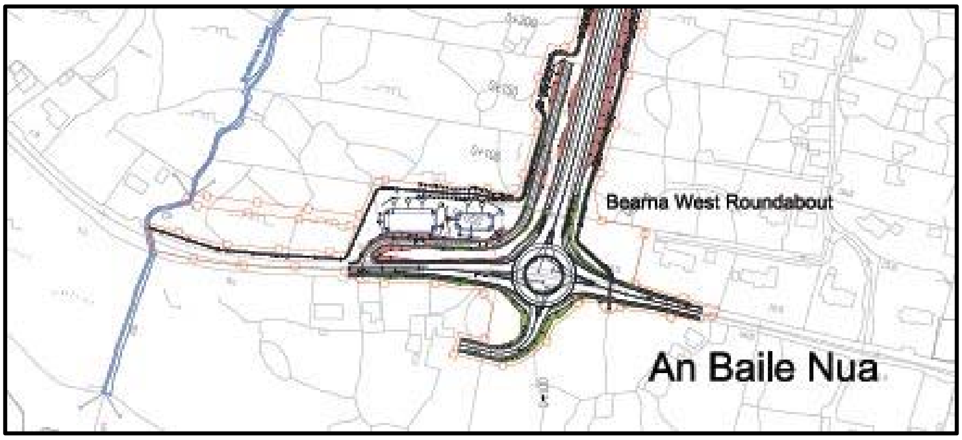
The level of provision required in accordance with TII DN-GEO-03043 is a roundabout junction. The following are the primary reasons why a roundabout junction constitutes the most suitable layout:

- A roundabout is a large physical feature which informs drivers of change
- A roundabout would minimise delay for road users whilst maintaining the safe passage of all road users through the junction
- The roundabout is designed to accommodate traffic volumes
- The roundabout is designed to take account of local topographical constraints

- The roundabout can safely accommodate and provide access to severed lands
- Conflicting right turn movements are well managed
- Flows are more balanced on the main and minor roads at this location
- The roundabout is in a rural setting, remote from high volumes of pedestrian footfall
- A roundabout would have sufficient capacity to cater for future development and growth.

The proposed R336 Junction layout is shown in **Figure 8**.

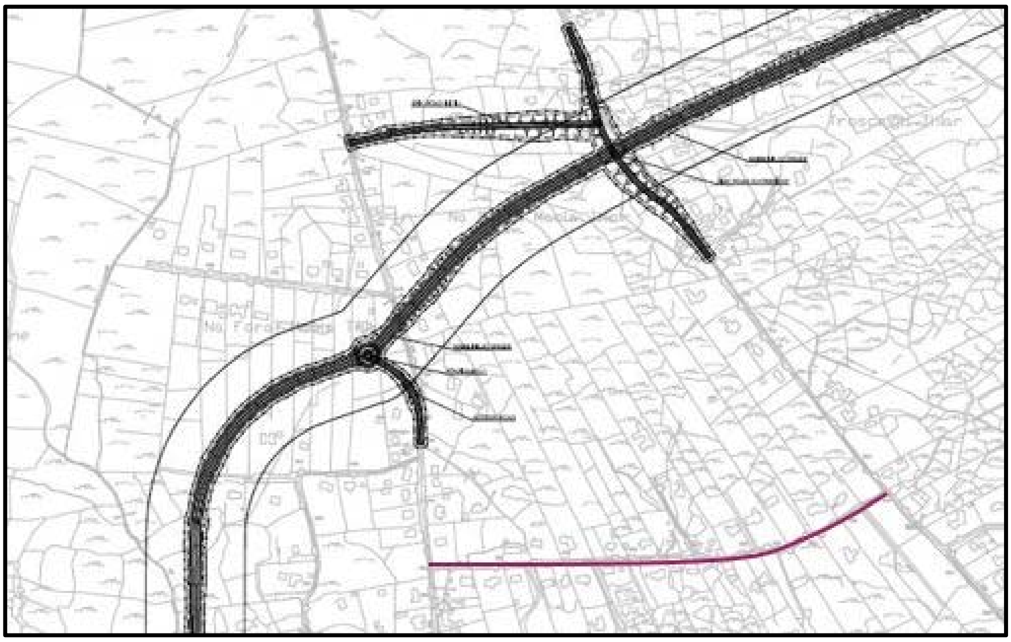
Figure 8: R336 Junction



3.2.2 Foraí Maola Junction

The EPRC arrangement at Foraí Maola and Troscaigh is shown in **Figure 9**, with an at-grade roundabout at Foraí Maola with access only to the south and an overbridge at Troscaigh.

Figure 9: EPRC Junction at Foraí Maola & Troscaigh



Key issues identified on the EPRC layout included the following:

- An at-grade roundabout junction at Foraí Maola which only provides access to the south is simply a junction to change direction due to use of tight radii to avoid house demolitions
- An at-grade roundabout junction at Foraí Maola which only provides access to the south severs this pocket of homes from Bearna Village and forces homeowners on a circuitous journey of 3km on substandard local roads
- An overbridge on the Troscaigh Road merely creates an embankment in front of all the homes which is a visual impact for all homes
- The proposed link between Foraí Maola Road and Troscaigh Road to the north of the N6 GCRR was not acceptable to the public due to the substandard parallel local road to the south on which the public would travel to detour back to cross the N6 GCRR (shown in pink above)
- The junction option chosen at Foraí Maola cannot be considered in isolation of the junction option at Troscaigh as the link road to the north may be required with certain combination of junction types

Various options were investigated and presented to the public as shown on **GCOB-SK-D-015** in **Appendix A** for the Foraí Maola/Troscaigh area.

3.2.2.1 Location Characteristics

Foraí Maola is a community located west of Bearna Village and north of the existing R336 in west Galway. The area is characterised by residential and land holdings. The N6 GCRR travels through the area and crosses the existing local road at grade. The local road facilitates access to a number of residential and land holdings as well as accommodating leisure activities such as walking and cycling. The existing local road network in the vicinity of this proposed junction is geometrically substandard and its cross-section is constrained.

3.2.2.2 Traffic Mix

In the vicinity of the proposed junction the local road caters for daily traffic volumes of less than 300 per day in the 2039 design year. The N6 GCRR in the same vicinity caters for daily traffic volumes of approximately 11,000 in the design year with 3% thereof constituting Heavy Goods Vehicles (HGV's). The existing routes in the area accommodate pedestrian and cyclist activity throughout the day.

3.2.2.3 Junction Requirements

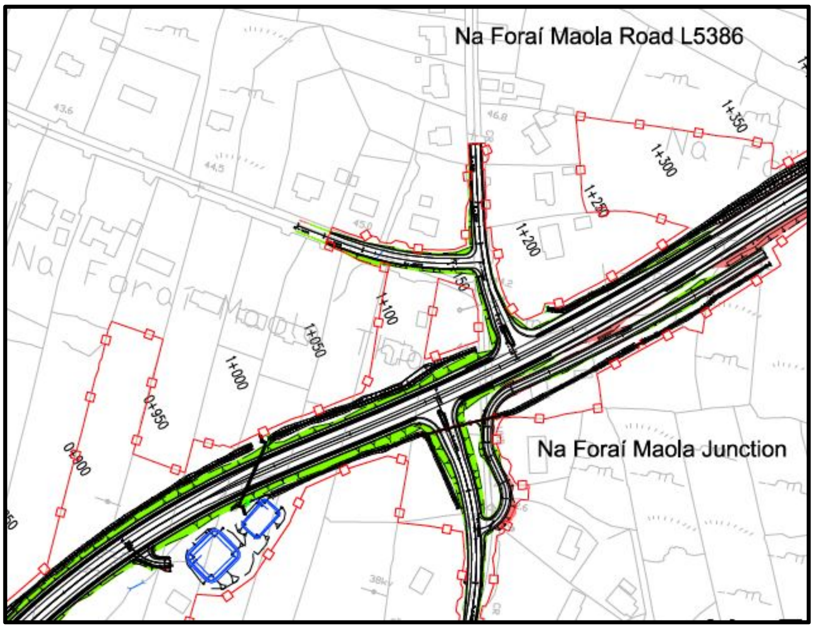
The volumes anticipated are low, the purpose of providing a junction in this area would be to retain connectivity and access whilst also ensuring that the N6 GCRR is not a physical barrier dividing the community. As noted by the World Road Association and TII DMRB the level of provision needs to be considered. Preliminary analysis of Figures 2/1 and 2/2 of TII publication DN-GEO-03043, (formerly NRA TD 41 - 42) highlights that the anticipated volumes are below those recommended for nearside passing option to roundabout and in the simple junction range. This correlates with guidance from Chartered Institution of Highways and Transportation (1997) and utilised by the European Commission which illustrates suitable junction types based on traffic flows, refer to **Figure 3**.

3.2.2.4 Junction Selection

At this location one of the overriding objectives is retaining connectivity and access in the area. It is for this reason that initial designs included junction layouts which provided an acceptable level of provision in accordance with TII DN-GEO-03043 (formerly NRA TD41/42), namely a simple junction with non-motorised user facilities. Although not required, it was considered desirable to provide a ghost island junction in order to enhance operational safety performance. **Figure 10** shows the layout of the junction initially proposed at Foraí Maola.

During Phase 3 the extent of the scheme to be designated as part of the TEN-T network was expanded to include the single carriageway. This upgraded the status of the single carriageway to that of a strategic route which implies that local traffic is subservient. Consequently, as the junctions in Foraí Maola and Troscaigh served local traffic exclusively, their provision required re-examination.

Figure 10: Foraí Maola Junction



Re-examination of the area was guided by manual traffic counts which were undertaken in the area in November 2016. These counts reiterated that the existing traffic volumes in the area are low and that traffic movements are thus of local rather than strategic importance. Further, these counts highlighted that the area acts as a pedestrian and cyclist thoroughfare throughout the day. This prompted the examination of alternative options in the area. The alternatives examined targeted the key criteria previously targeted, namely, the retention of connectivity and access in the area whilst ensuring that the N6 GCRR is not a physical barrier dividing the community. This re-examination resulted in the removal of the proposed stagger layout illustrated in **Figure 10** and its replacement with an overbridge option as illustrated in **Figure 11**.

Figure 11: Foraí Maola Area

The option was developed taking cognisance of community feedback on similar options. An overbridge option, with parallel link roads, in this area constitutes the most suitable layout for the following reasons:

- The strategic purpose, from the point of view of mainline traffic, is maintained.
- Community connectivity is maintained via a dedicated overbridge and parallel roads.
- The parallel link roads and overbridge provide a safe and secure, albeit longer, route for pedestrians and cyclists.
- The interface between pedestrians, cyclists and mainline traffic on the N6 GCRR is removed thereby reducing the possibility of collisions.
- The overbridge has been located so as to minimise its visual impact on properties in the area.
- The parallel link roads connect routes of a similar nature, the shock of a transition from a high quality route to a lower standard of route is minimised.

3.2.3 Troscaigh Junction

Various options were investigated and presented to the public as shown on **GCOB-SK-D-015** in **Appendix A** for the Foraí Maola/Troscaigh area.

3.2.3.1 Location Characteristics

Troscaigh is a community located west of Bearna Village and north of the existing R336 in west Galway. The area is characterised by residential and land holdings. The N6 GCRR travels through the area and crosses the existing local road at grade. The local road facilitates access to a number of residential and land holdings as well as accommodating leisure activities such as walking and cycling. The existing local road network in the vicinity of this proposed junction is geometrically substandard and its cross-section is constrained..

3.2.3.2 Traffic Mix

In the vicinity of the proposed junction the local road caters for daily traffic volumes of less than 300 per day in the 2039 design year. The N6 GCRR in the same vicinity caters for daily traffic volumes of approximately 11,000 in the design year with 3% thereof constituting Heavy Goods Vehicles (HGV's). The existing routes in the area accommodate pedestrian and cyclist activity throughout the day.

3.2.3.3 Junction Requirements

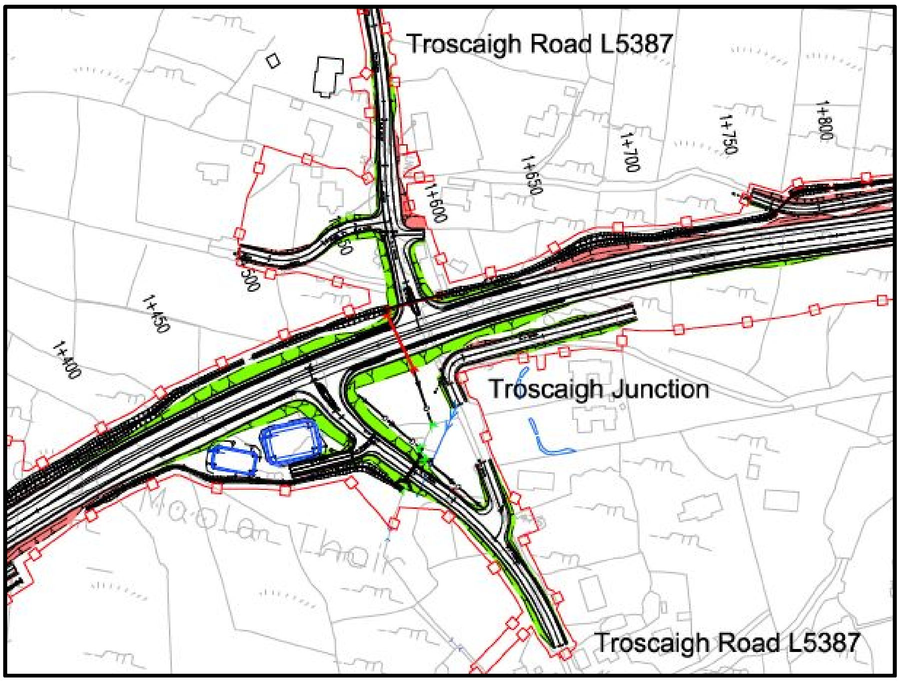
The volumes anticipated are low, the purpose of providing a junction in this area would be to retain connectivity and access whilst also ensuring that the N6 GCRR is not a physical barrier dividing the community. As noted by the World Road Association and TII DMRB the level of provision needs to be considered. Preliminary analysis of Figures 2/1 and 2/2 of TII DN-GEO-03043 (formerly NRA TD41/42) highlights that the anticipated volumes are below those recommended for nearside passing option to roundabout and in the simple junction range. This correlates with guidance from Chartered Institution of Highways and Transportation (1997) and utilised by the European Commission which illustrates suitable junction types based on traffic flows, refer to **Figure 3**.

3.2.3.4 Junction Selection

At this location one of the overriding objectives is retaining connectivity and access in the area. It is for this reason that initial designs included junction layouts which provided an acceptable level of provision in accordance with TII DN-GEO-03043 (formerly NRA TD41/42), namely a simple junction with non-motorised user facilities. Although not required it was considered desirable to provide a ghost island junction in order to enhance operational safety performance. **Figure 12** shows the layout of the junction initially proposed at Troscaigh.

During Phase 3 the extent of the scheme to be designated as part of the TEN-T network was expanded to include the single carriageway. This upgraded the status of the single carriageway to that of a strategic route which implies that local traffic is subservient. Consequently, as the junctions in Foraí Maola and Troscaigh served local traffic exclusively, their provision required re-examination.

Figure 12: Troscaigh Junction



Re-examination of the area was guided by manual traffic counts which were undertaken in the area in November 2016. These counts reiterated that the existing traffic volumes in the area are low and that traffic movements are thus of local rather than strategic importance. Further, these counts highlighted that the area acts as a pedestrian and cyclist thoroughfare throughout the day. This prompted the examination of alternative options in the area. The alternatives examined targeted the key criteria previously targeted, namely, the retention of connectivity and access in the area whilst ensuring that the N6 GCRR is not a physical barrier dividing the community. This re-examination resulted in the removal of the proposed stagger layout illustrated in **Figure 12** and its replacement with an overbridge option as illustrated in **Figure 11**.

The option was developed taking cognisance of community feedback on similar options. An overbridge option, with parallel link roads, in this area constitutes the most suitable layout for the following reasons:

- The strategic purpose, from the point of view of mainline traffic, is maintained.
- Community connectivity is maintained via a dedicated overbridge and parallel roads.
- The parallel link roads and overbridge provide a safe and secure, albeit longer, route for pedestrians and cyclists.
- The interface between pedestrians, cyclists and mainline traffic on the N6 GCRR is removed thereby reducing the possibility of collisions.
- The overbridge has been located so as to minimise its visual impact on properties in the area.

- The parallel link roads connect routes of a similar nature, the shock of a transition from a high quality route to a lower standard of route is minimised.

3.2.4 Bearna – Moycullen Road Junction

3.2.4.1 Location Characteristics

The Bearna – Moycullen road is a local road connecting Bearna Village to the N59 Moycullen Road. The N6 GCRR intersects the Bearna – Moycullen road north of Bearna Village creating a junction in the area. The existing Bearna – Moycullen road geometry in the vicinity of this proposed junction is of a reasonable standard and the cross-section is constrained due to property boundaries.

3.2.4.2 Traffic Mix

In the vicinity of the proposed junction the Bearna – Moycullen road caters for daily traffic volumes of approximately 2,300 per day in the 2039 design year. The N6 GCRR in the same vicinity caters for daily traffic volumes of approximately 11,000 on the western approach and 18,000 on the eastern approach in the 2039 design year with 3% thereof constituting Heavy Goods Vehicles (HGV's).

3.2.4.3 Junction Requirements

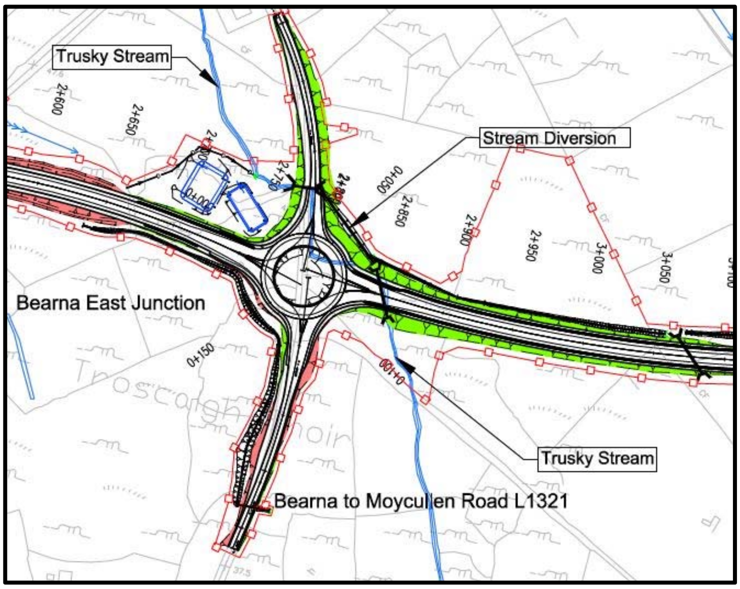
The volumes anticipated are medium. As noted by the World Road Association and TII DMRB the level of provision needs to be considered. Preliminary analysis of Figures 2/1 and 2/2 of TII DN-GEO-03043 (formerly NRA TD41/42) highlights that the anticipated volumes are in the order of those recommended for roundabout or signalised junctions. This correlates with guidance from Chartered Institution of Highways and Transportation (1997) and utilised by the European Commission which illustrates suitable junction types based on traffic flows, refer to **Figure 3**.

3.2.4.4 Junction Selection

The main objective of the junction is to increase convenience, comfort and safety while at the same time enhancing the efficient movement of all road users (motor vehicles, buses, trucks, bicycles, and pedestrians). At this location one of the overriding objectives is providing connectivity and access to the village of Bearna and its surrounds.

The level of provision required in accordance with TII DN-GEO-03043 is a roundabout junction. It is considered desirable to provide a roundabout junction in order to enhance operational safety performance. It is beneficial to provide a major junction in this location taking cognisance of the existing developments in the area and future development proposals. The provision of a roundabout junction would increase convenience, comfort and safety and facilitate the efficient movement of all road users. **Figure 13** shows the proposed Bearna – Moycullen Junction layout.

Figure 13: Bearna – Moycullen Road Junction



The following are the primary reasons why a roundabout junction is the most suitable layout:

- A roundabout would minimise delay for road users whilst maintaining the safe passage of all road users through the junction
- A roundabout would be designed to accommodate traffic volumes, speed and any local topographical or other constraints such as land availability
- Conflicting right turn movements are well managed.
- Appropriate design standards would be applied which would minimise safety risks for all road users (motor vehicles, buses, trucks, bicycles, and pedestrians).
- Flows are more balanced on the main and minor roads at this location
- The roundabout is in a rural setting, remote from high volumes of pedestrian footfall
- A roundabout would have sufficient capacity to cater for future development and growth

3.2.5 Cappagh Road Junction

3.2.5.1 Location Characteristics

Cappagh Road is a local road at the western terminus of the Western Distributor Road which is an urban street in the residential area of Knocknacarra, on the western edges of the city. Cappagh Road runs north south connecting the hinterland to Western Distributor Road and onwards south to the existing R336. The N6 GCRR intersects Cappagh Road north of the Western Distributor Road creating a junction in the area. The existing Cappagh Road geometry in the vicinity of this proposed junction is sub-standard and the cross-section is constrained due to property boundaries.

During Phase 2, an underbridge was proposed on Cappagh Road but this had a significant visual impact on homes in the area of Cappagh Road and also restricted all views to the south in this area. The lack of a junction on Cappagh Road also attracted traffic to Ballymoneen Road as it became the single dispersal point of traffic from the N6 GCRR to the western area of Knochnacarra. This is less than desirable given that Ballymoneen Road is a residential street on a very steep gradient running north south immediately to the east of Cappagh Road with significant numbers of vulnerable road users during school times due to the presence of a very large new secondary school. Therefore, during design development, the provision of a junction on Cappagh Road was investigated.

3.2.5.2 Traffic Mix

In the vicinity of the proposed junction Cappagh Road to the south of the N6 GCRR caters for daily traffic volumes of approximately 6,500 per day in the 2039 design year. The daily volumes to the north of N6 GCRR in 2039 design year are low at less than 300. The N6 GCRR in the same vicinity caters for daily traffic volumes of approximately 18,000 in the 2039 design year with 3% thereof constituting Heavy Goods Vehicles (HGV's).

3.2.5.3 Junction Requirements

The volumes anticipated are medium. As noted by the World Road Association and TII DMRB the level of provision needs to be considered. Preliminary analysis of Figures 2/1 and 2/2 of TII DN-GEO-03043 (formerly NRA TD41/42) highlights that the anticipated volumes are in the order of those recommended for roundabout or other junction form such as signalised junctions. This correlates with guidance from Chartered Institution of Highways and Transportation (1997) and utilised by the European Commission which illustrates suitable junction types based on traffic flows, refer to **Figure 3**.

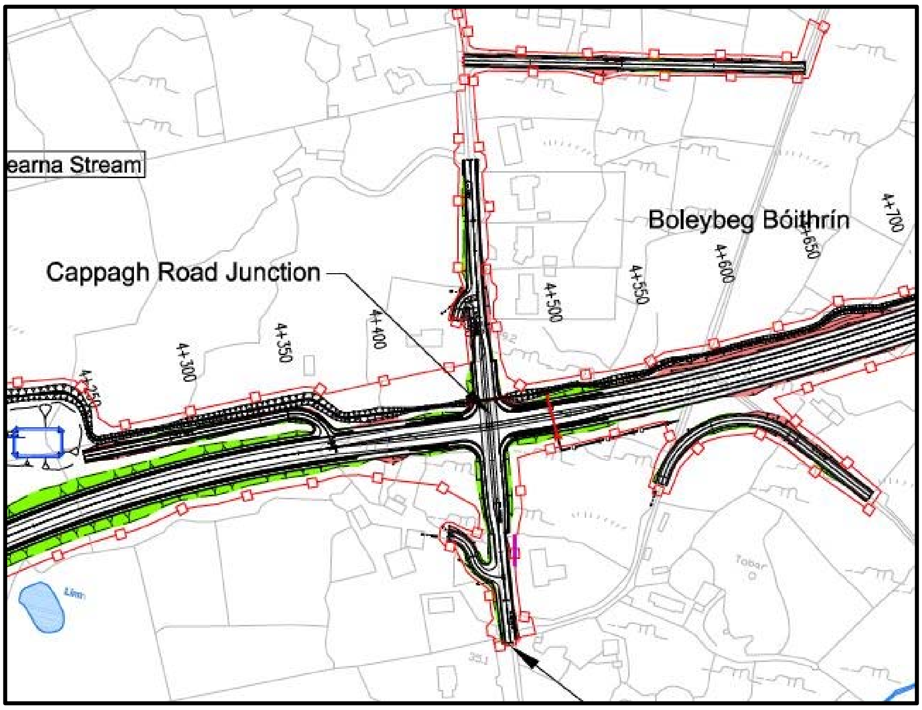
3.2.5.4 Junction Selection

The main objectives of this junction to inform the driver of the change from the rural environment to the urban environment, to facilitate the cross movement of vulnerable road users and to provide connectivity to match demand.

The level of provision required in accordance with TII DN-GEO-03043 is a roundabout junction or other junction form. Initially, in Phase 3 a roundabout was proposed for Cappagh Road Junction. However, traffic modelling showed that the volume to capacity ratios on the roundabout arms of the N6 GCRR would exceed allowable and be close to capacity. Therefore, detailed modelling using LinSig was undertaken to optimise this junction, the result of which was to design it as a signalised junction. This has the effect of reducing the volume to capacity ratios to an acceptable level with residual capacity for the future.

It is considered desirable to provide a signalised junction in order to enhance operational safety performance and to facilitate the efficient movement of all road users. **Figure 14** shows the proposed Cappagh Road Junction layout.

Figure 14: Cappagh Road Junction



The following are the primary reasons why a signalised junction is the most suitable layout:

- A signalised junction provides an appropriate junction with an urban street designed in accordance with the design principles set out in the Design Manual for Urban Roads and Streets.
- The Galway City Development Plan contains an objective for a transport link between Cappagh Road and Ballymoneen Road along the lines of the proposed N6 GCRR, with the Western Distributor Road becoming a dedicated public transport, cycling and pedestrian movement corridor
- A signalised junction prevents total control by the dominant traffic movement during peak hour traffic flow
- Initial tests of this junction as a roundabout indicated that the predicted turning movements were imbalanced, resulting in limited gaps in traffic forming on the main east-west corridor, thereby restricting movements from the minor approaches, particularly during peak hour periods.

Therefore, a signalised junction was proposed in order to support traffic movements from all approaches.

- Model tests with signals at this location indicated that the junction would operate within capacity during all modelled time periods.

Various options were developed and presented to the public for Cappagh Road area as shown on **GCOB-SK-D-032** in **Appendix A**.

3.2.6 Ballymoneen Road Junction

3.2.6.1 Location Characteristics

Ballymoneen Road is an urban street which runs in a north south direction, connecting Rahoon Road to Western Distributor and on south to the existing R336. The N6 GCRR intersects Ballymoneen Road north of the Western Distributor Road creating a junction in the area. The existing Ballymoneen Road geometry in the vicinity of this proposed junction is sub-standard and the gradient further south is approximately 9% as it approaches the intersection with Western Distributor Road. There also is a new secondary school with over 900 pupils on this street.

3.2.6.2 Traffic Mix

In the vicinity of the proposed junction Ballymoneen Road to the south of the N6 GCRR caters for daily traffic volumes of approximately 6,000 per day in the 2039 design year. The daily volumes to the north of N6 GCRR in 2039 design year are lower at 4,000. The N6 GCRR in the same vicinity caters for daily traffic volumes of approximately 18,000 in the 2039 design year with 2% thereof constituting Heavy Goods Vehicles (HGV's).

3.2.6.3 Junction Requirements

The volumes anticipated are medium. As noted by the World Road Association and TII DMRB the level of provision needs to be considered. Preliminary analysis of Figures 2/1 and 2/2 of TII DN-GEO-03043 (formerly NRA TD41/42) highlights that the anticipated volumes are in the order of those recommended for roundabout or other junction form such as signalised junctions. This correlates with guidance from Chartered Institution of Highways and Transportation (1997) and utilised by the European Commission which illustrates suitable junction types based on traffic flows, refer to **Figure 3**.

3.2.6.4 Junction Selection

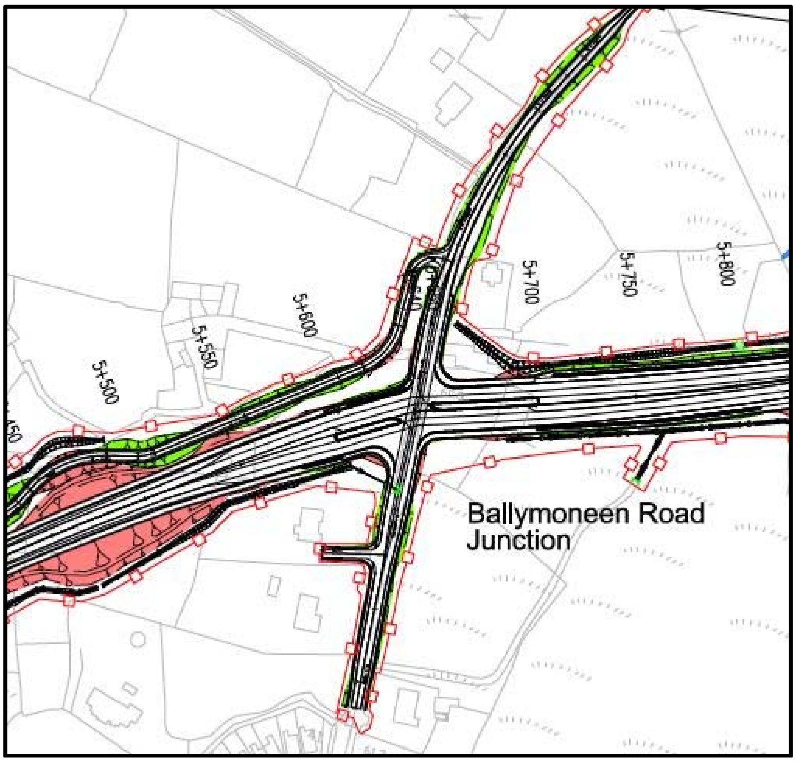
The main objectives of this junction to inform the driver of the change from single carriageway with at-grade connections to a dual carriageway with grade separated junctions, whilst also facilitating the cross movement of vulnerable road users and to provide connectivity to match demand.

The level of provision required in accordance with TII DN-GEO-03043 is a roundabout junction or other junction form. Initially, in Phase 3 a roundabout was proposed for Ballymoneen Road Junction. However, traffic modelling showed that the volume to capacity ratios on the roundabout arms of the N6 GCRR would exceed allowable and be close to capacity. Therefore, detailed modelling using

LinSig was utilised to optimise this junction, the result of which was to design it as a signalised junction. This has the effect of reducing the volume to capacity ratios to an acceptable level with residual capacity for the future.

It is considered desirable to provide a signalised junction in order to enhance operational safety performance and to facilitate the efficient movement of all road users. **Figure 15** shows the proposed Ballymoneen Road Junction layout.

Figure 15: Ballymoneen Road Junction

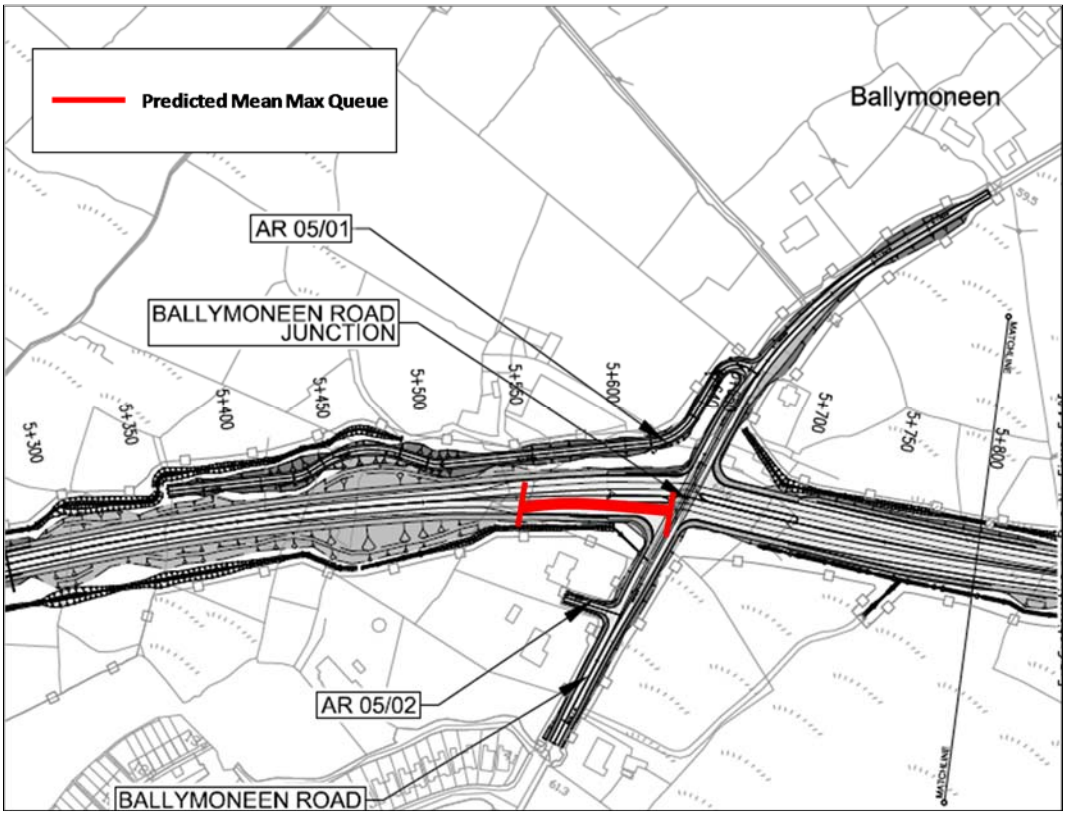


The following are the primary reasons why a signalised junction is the most suitable layout:

- A signalised junction provides an appropriate junction with an urban street designed in accordance with the design principles set out in the Design Manual for Urban Roads and Streets
- The Galway City Development Plan contains an objective for a transport link between Cappagh Road and Ballymoneen Road along the lines of the proposed N6 GCRR, with the Western Distributor Road becoming a dedicated public transport, cycling and pedestrian movement corridor
- Initial tests of this junction as a roundabout indicated that the predicted turning movements were imbalanced, resulting in limited gaps in traffic forming on the main east-west corridor, thereby restricting movements from the minor approaches, particularly during peak hour periods. Therefore, a signalised junction was proposed in order to support traffic movements from all approaches.

- LINSIG[1] modelling, based upon the preliminary highway designs, indicated that the junction would operate at a maximum Degree of Saturation (DOS)[2] of 75% in the AM peak period (busiest period at this junction). This is within the acceptable capacity threshold for a signalised junction. Operationally, the largest mean maximum queue (MMQ)[3], in the AM peak, is predicted to be in the order of 14.5 pcu[4] and occurs on the eastbound approach. The figure below, **Figure 16**, highlights the extent of this predicted queuing, which is circa 80 meters in length and will not impact on any of the upstream or downstream junctions.

Figure 16: Ballymoneen Road Junction Queuing



[1] LINSIG is an industry standard software tool which allows traffic engineers to model signalised junctions and their effect on capacities and queuing. LINSIG also allows for the optimisation of traffic signals to increase capacity and reduce delays at junctions

[2] Degree of Saturation (DoS) – is the measure of capacity on any given lane, with 90% taken as the practical capacity threshold.

[3] Mean Maximum Queue (MMQ) – is average maximum queue in Passenger Carrier Units (PCUs) per lane.

[4] Passenger Car Unit (PCU) - to represent general traffic - common vehicle types are assigned a conversion factor so that an equivalent PCU value can be generated from classified vehicle data. In line with TFL Guidance, PCU conversion are as follows; Bicycle = 0.2PCUs, Motorcycle = 0.4PCUs, Car = 1PCU, Van = 1PCU, OGV1 = 1.5PCUs, OGV2 = 2.3PCUs, and PSVs=2PCUs.

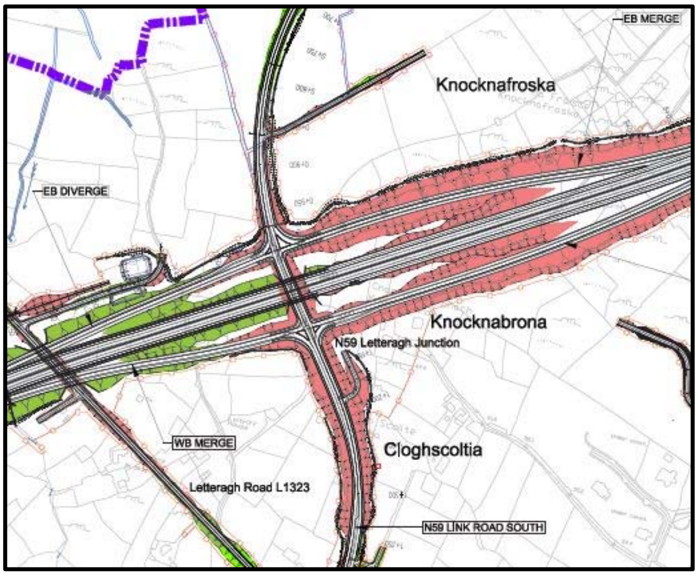
3.2.7 N59 Junction

The N59 Letteragh Junction is a standard grade separated junction, but is offset from the N59. The purpose of this offset from the N59 is two-fold, firstly to minimise the direct impact on residential property at the N59 bridge crossing and secondly to provide better connectivity and traffic distribution from the proposed N6 GCRR to Knocknacarra and the crossing of the N59 area. The N59 Link Road South connects to the Letteragh Road and Rahoon Road which effectively distributes traffic accessing NUIG South (south of the Quincentenary Bridge), Knocknacarra and UHG, whilst the N59 Link Road North facilitates traffic accessing NUIG North (Dangan Sports Grounds), N59 and Connemara.

During Phase 3, the cross-section from Ballymoneen Road to N6 Coolagh Junction changed to an Urban Motorway D2UM (RCD/000/7) with posted speed limit of 100km/h. This cross-section was selected following completion of an incremental analysis which essentially is a holistic approach to cross-section selection. Adopting this cross-section addressed issues which were identified as associated with a Type 2 dual carriageway namely the overrun of wire rope safety barrier systems into the opposing carriageway upon impact and the lack of a hard shoulder and consequently lack of an emergency service access route.

As per TII standard DN-GEO-03031 (formerly TD 9), Table 6/1, full grade separation is required for the junctions on a standard motorway. The junction as selected in Phase 2 was a dumbbell grade separated junction. However, traffic modelling and design development during Phase 3 resulted in the replacement of the roundabouts at the termini of the slip lanes with signalised junctions. **Figure 17** shows the proposed N59 Junction layout.

Figure 17: N59 Junction

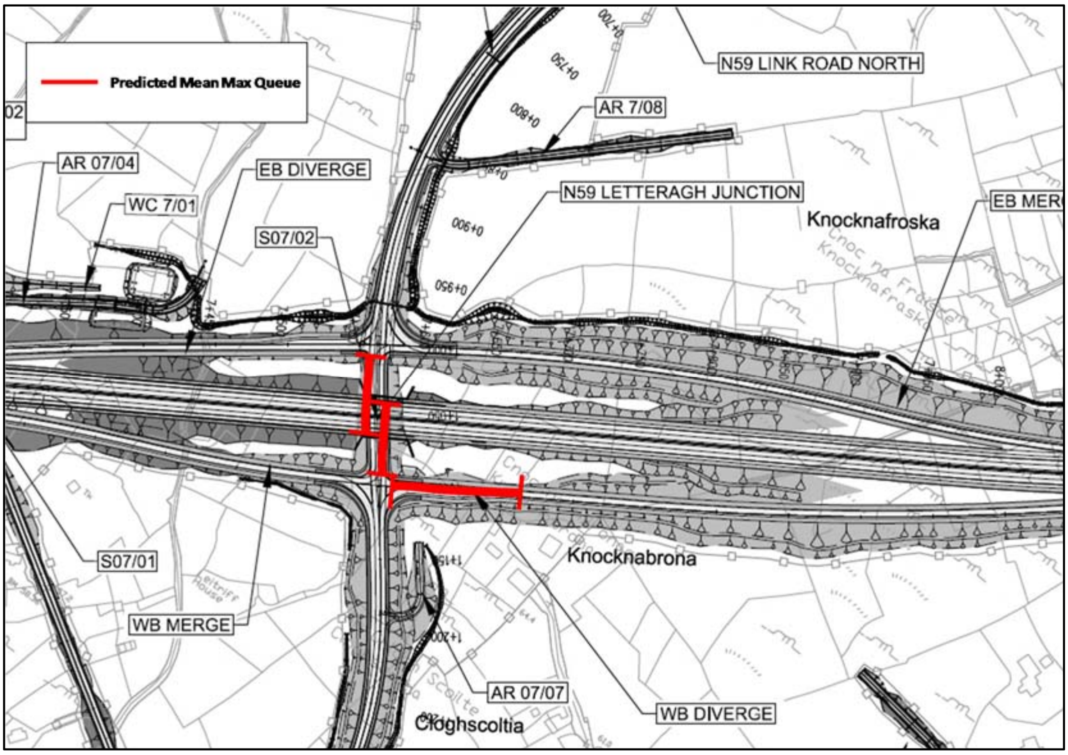


The N59 Junction is a grade separated junction with signalised junctions at the slip termini for the following reasons:

- Grade separation is required for Urban Motorway

- A signalised junction provides an appropriate junction with an urban street designed to the Design Manual for Urban Roads and Streets, and the N59 Link Road is a street with footpaths and lighting.
- A signalised junction prevents total control by the dominant traffic movement during peak hour traffic flows.
- Consequently, all junctions on the N59 link, up and downstream of the N59 grade separated junction, are signalised.
- LINSIG modelling, based upon the preliminary highway designs, indicate that the northern junction would have a maximum Degree of Saturation (DOS) of 67% in the AM peak period (busiest at this junction), based upon a cycle time of 65 seconds. The mean maximum queues (MMQ) in the AM peak at this junction are predicted to be in the order of 10 pcu on the northbound approach and 4.9 on the eastbound approach (off-ramp).
- Modelling of the southern junction shows a maximum Degree of Saturation (DOS) of 86% in the AM peak period, based upon a cycle time of 65 seconds. This is within the acceptable capacity threshold for a signalised junction. The mean maximum queues (MMQ) in the AM peak at this junction are predicted to be in the order of 15pcu on the westbound approach (off-ramp) and 9 PCUs on the southbound approach. Linsig Modelling indicates that these queues (which are illustrated in the figure below, **Figure 18**) will clear in one cycle and do not impact on the performance of neighbouring junctions.

Figure 18: N59 Junction Queuing

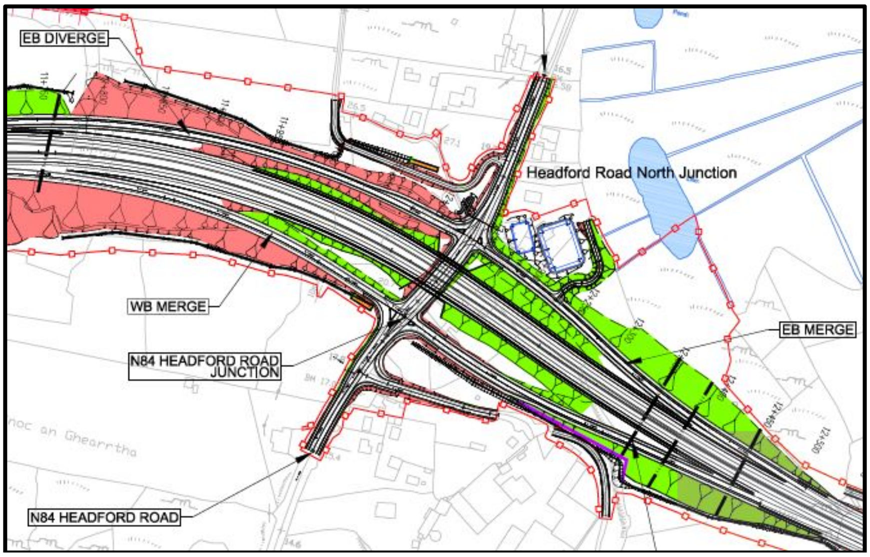


3.2.8 N84 Junction

The N84 Junction is a standard grade separated junction located on the N84 Headford Road to connect with the N84 national road traffic. The junction is located directly on the N84 to match demand at this entry point to the city from Mayo and the northern part of the county. Whilst this is the minimum footprint achievable, this junction layout does directly impact on residential property in this area due to the presence of ribbon development along the N84.

As per TII standard DN-GEO-03031 (formerly TD 9), Table 6/1, full grade separation is required for the junctions on a standard motorway. The junction form proposed at this location is a diamond grade separated junction to limit the impact to the surrounding area. Traffic modelling during Phase 3 also justifies the use of signals at the termini of the slip lanes in order to manage peak hour traffic flows. **Figure 19** shows the proposed N84 Junction layout

Figure 19: N84 Junction



The N84 Junction is a grade separated junction with signalised junctions at the slip termini for the following reasons:

- Grade separation is required for Urban Motorway
- A signalised junction prevents total control by the dominant traffic movement during peak hour traffic flows.
- LINSIG modelling of the northern Junction, based upon the preliminary highway designs, indicates that the junction would have a maximum Degree of Saturation (DOS) of 86% in the AM peak period (busiest at this junction), based upon a cycle time of 65 seconds. This is within the acceptable capacity threshold for a signalised junction. The mean maximum queues (MMQ) in the AM peak are predicted to be in the order 14.2 pcu on the southbound approach and 10.1 on the northbound approach, while the eastbound approach (off ramp) is predicted to have queue lengths of 2.2 pcu. The results of the analysis indicate that all queuing dissipates in a single cycle and has no impact on the operation of upstream junctions. There is also

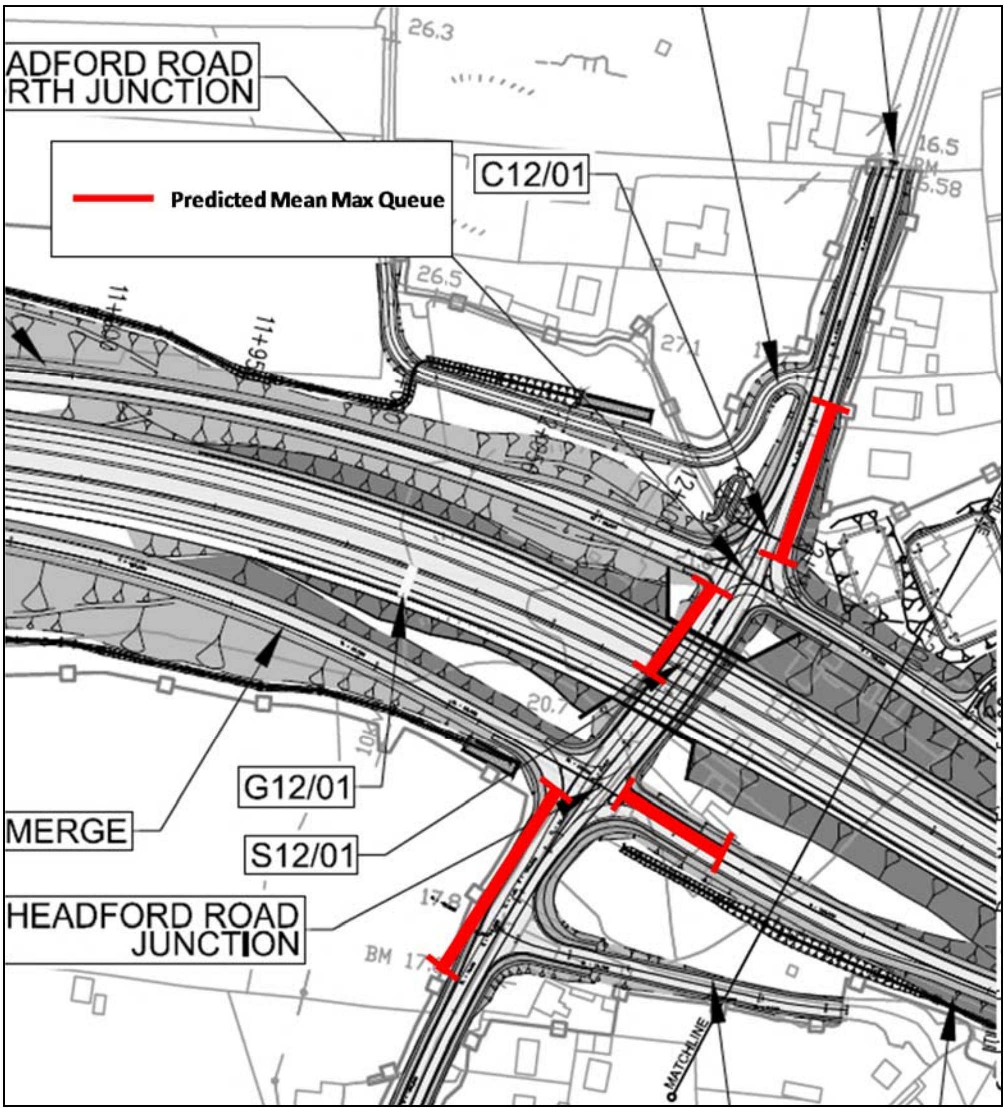
potential for the operation of this junction to be improved through the implementation of some form of Vehicle Actuation, such as MOVA[5], with associated speed discrimination loops at the junction.

- LINSIG modelling of the southern junction indicates that the junction would have a maximum Degree of Saturation (DOS) of 85.5% in the PM peak period (busiest at this junction), based upon a cycle time of 65 seconds. This is within the acceptable capacity threshold for a signalised junction. The mean maximum queues (MMQ) at this junction in the PM peak are predicted to be in the order of 2.6 pcu on the southbound approach and 17.2 on the northbound approach. The westbound approach (off ramp) has queues of 8.8 pcu. The level of queuing predicted (illustrated in the figure below, **Figure 20**) is predicted to clear in a single cycle and will not impact on any adjoining junctions.

- It would be considered appropriate to implement some form of queue monitoring at this location to ensure no blocking back to adjacent junctions occurs at this location. The queues and delays could be controlled by having both junction operating under a linked MOVA system.

[5] MOVA (Microprocessor Optimised Vehicle Actuation) - MOVA is designed to cater for the full range of traffic conditions, from very low flows through to a junction that is overloaded. For the
MOVA (Microprocessor Optimised Vehicle Actuation) - MOVA is designed to cater for the full range of traffic conditions, from very low flows through to a junction that is overloaded. For the
major part of the range - before congestion occurs, MOVA operates in a delay minimising mode; if any approach becomes overloaded, the system switches to a capacity maximising procedure. MOVA is also able to operate at a wide range of junctions, from the very simple ‘shuttle-working’, to large, multi-phase multi-lane sites.

Figure 20: N84 Junction Queuing

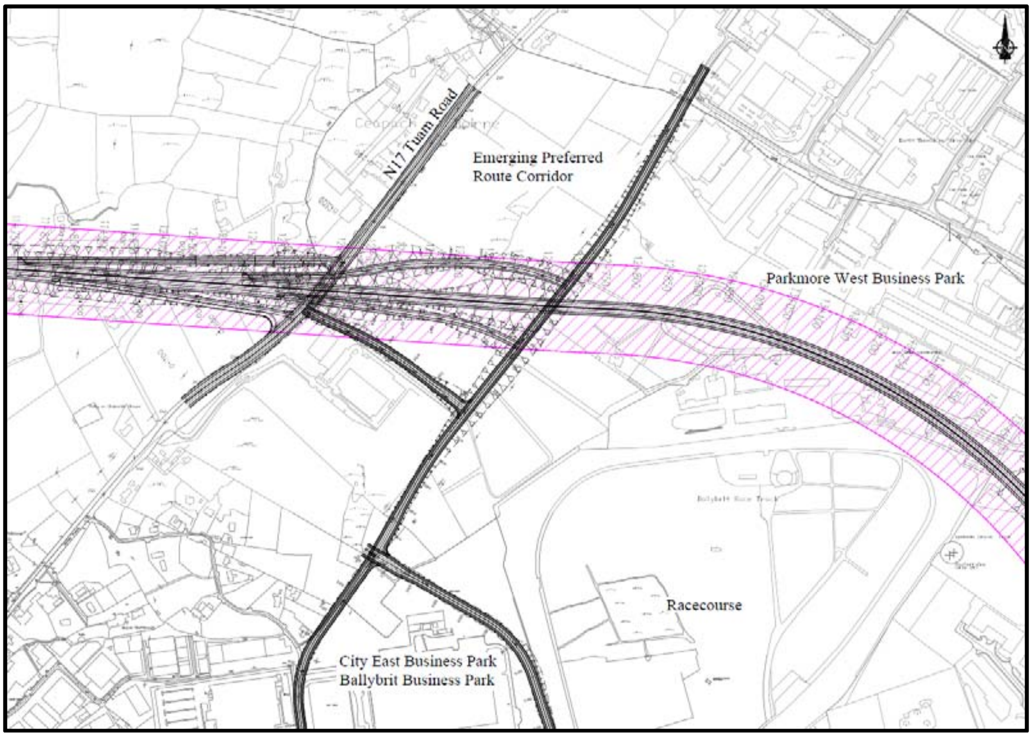


3.2.9 N17 Junction & Parkmore Link Road Junction

The provision of a full movement, high quality junction at the intersection of the N6 GCRR and the existing N17 presented itself as attractive and necessary due to its location adjacent to the primary business and industrial centres in Galway and the fact that the N17 is a primary access to the city. Some of the business and commercial areas served by the N17 include Ballybane Industrial Estate, Parkmore Industrial Estates, City North Business Park, City East Business Park, Galway Technology Park, Mervue Business Park and Liosban Industrial Estate. These business and industrial areas are major attractions due to the level of employment facilitated and are thus major trip generators.

The design in the vicinity of the N17 Tuam Road, Galway Racecourse and Ballybrit as presented in the EPRC is shown in **Figure 21** below. This provides access to N17 and Parkmore Link Road from N6 GCRR eastbound and access to N6 GCRR westbound from Parkmore Link Road and N17. This split arrangement was necessary to accommodate the volumes coming from the west of the city trying to access both N17 and Parkmore Link Road in the morning peak hour and the reverse movement in the evening peak hour.

Figure 21: EPRC at N17 and Parkmore Link Road



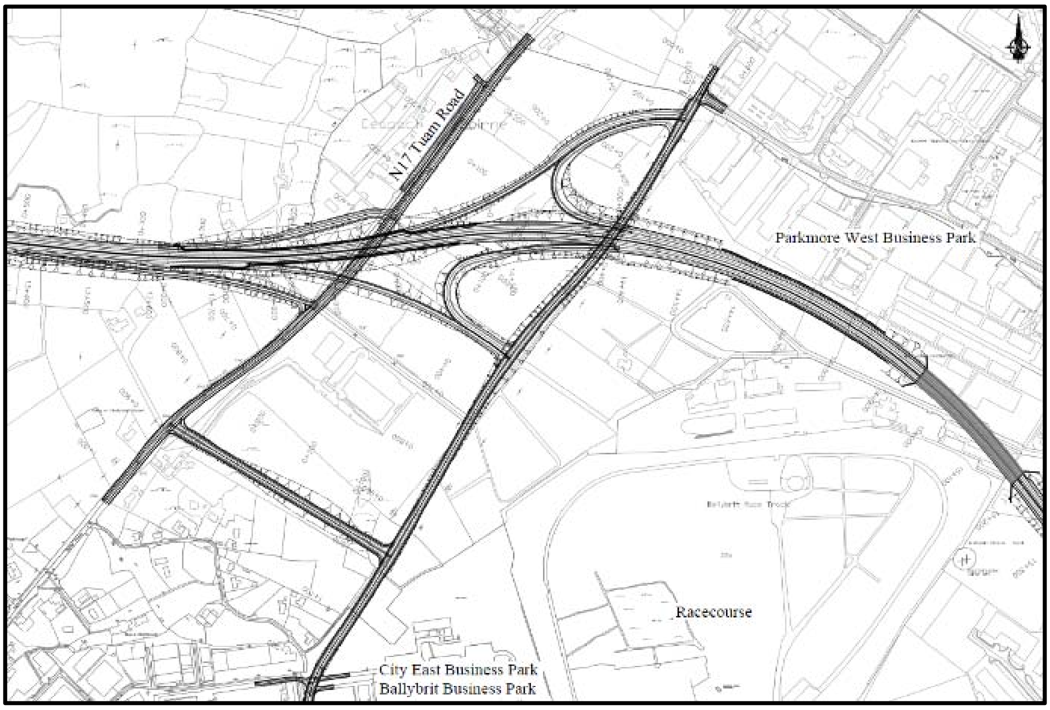
Various submissions were received in response to this design with the key points noted as follows:

- Consider provision of access from the N6 GCRR westbound to Parkmore Link Road to cater for the morning peak traffic demand into Parkmore from the N6 eastbound

- Consider provision of access to the N6 GCRR eastbound from Parkmore Link Road to cater for the evening peak traffic demand to exit from Parkmore to the N6 eastbound
- Consider provision of east facing slips to/from the Parkmore Link Road to cater for emergency access to the tunnel at the western end

Thereafter, alternative design options in the N17 area were examined so as to develop a more holistic and acceptable design. Further public consultation was undertaken in October 2015 on two distinct options: one option without east facing slips and one option with east facing slips. The option which included east facing slips was determined to be preferable following feedback from landowner meetings, submissions and further assessment. The preferred option developed at this time is presented in **Figure 22**.

Figure 22: N17 and Parkmore Link Road Junction October 2015



This option included an eastbound merge from the Parkmore Link Road to the N6 GCRR and a westbound diverge from the N6 GCRR to the proposed Parkmore Link Road resulting in the provision of a full movement junction catering for all stakeholders and in particular meeting the requirements of the emergency services by providing direct access to the tunnel from the N17 area.

An assessment of the need to provide a direct link from N17 southbound and N17 northbound to the N6 GCRR eastbound was also carried out, but the demand for this movement was very low. This is due to the fact that N17 southbound traffic wishing to go eastbound have already diverted east in advance of arrival at this junction with the N6 GCRR i.e. via M17/M18 or Parkmore Road. Therefore this low demand is facilitated via the single carriageway link road between the N17 and the Parkmore Link Road, as opposed to introducing a costly third tier of structures to the junction.

This also has the effect of retaining eastbound traffic destined for Parkmore and Ballyrbrit employment areas on the N6 GCRR until they arrive at their final destination. This in turn releases significant capacity in the existing Briarhill Junction and improves the volume to capacity ratio at this junction.

Following detailed traffic analysis in November 2016 capacity surpluses were identified on a number of slip roads associated with the layout developed in the N17 area as illustrated in **Figure 22**. This, combined with queries raised by the road safety audit regarding the complexity of the proposed layout, prompted its evaluation and refinement. This evaluation focused on simplifying the layout whilst maintaining adequate junction capacity. This evaluation resulted in the removal of the westbound merge from the Parkmore link road to the N6 GCRR and the removal of the eastbound diverge therefrom to the Parkmore link road as illustrated in **Figure 23**. These were removed as the traffic volumes associated therewith could be accommodated via the remaining slip roads and associated link roads. Their need had previously been warranted, at EPRC, due to the absence of an eastbound merge from the proposed Parkmore link road to the N6 GCRR and diverge therefrom to the proposed Parkmore link road. A deficit which was remedied.

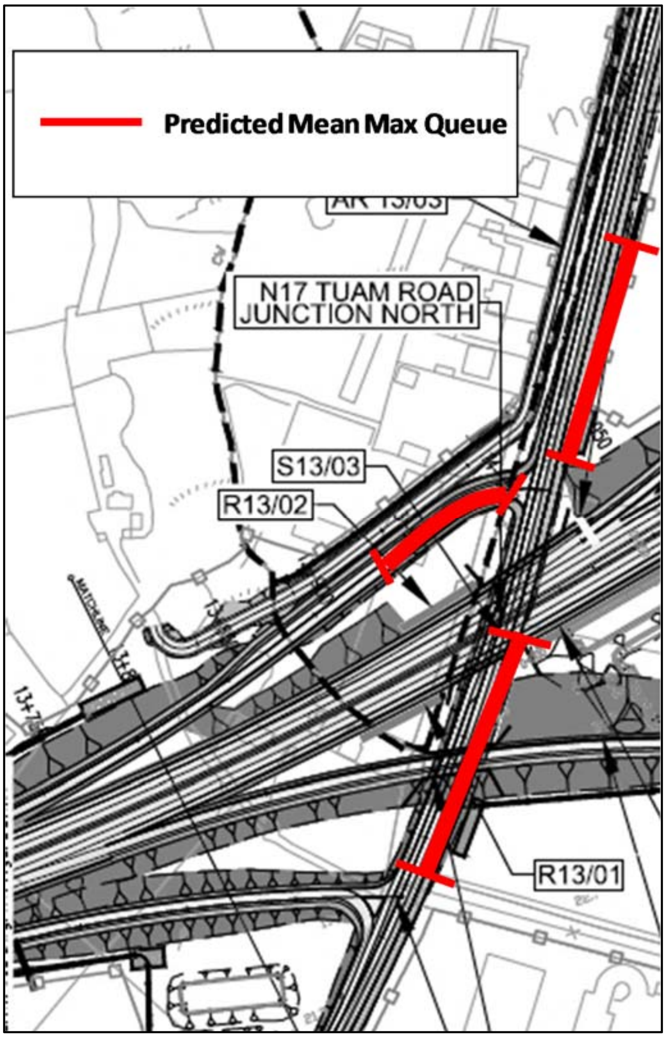
Figure 23: Refined N17 and Parkmore Link Road Junction November 2016

The refined N17 junction comprises a grade separated junction and associated link roads. The slip termini, as well as all junctions integral to the operation of the junction, are signalised. This junction form and modus operandi is the most suitable at this location for the following reasons:

- LINSIG modelling, based upon the preliminary highway designs, indicate that the southern junction would have a maximum Degree of Saturation (DOS) of 89% in the AM peak period (busiest at this junction), based upon a cycle time of 90 seconds. The mean maximum queues (MMQ) in the AM peak at this junction are predicted to be in the order of 16 pcu on the Southbound approach and 2 PCUs on the Northbound approach.

- Modelling of the Northern junction shows a maximum Degree of Saturation (DOS) of 70% in the AM peak period, based upon a cycle time of 90 seconds. This is within the acceptable capacity threshold for a signalised junction. The mean maximum queues (MMQ) in the AM peak at this junction are predicted to be in the order of 15pcu on the Southbound approach and 10 PCUs on the eastbound approach (off-ramp).
- LINSIG Modelling indicates that these queues (which are illustrated in the figure below, **Figure 24**) will clear in one cycle and do not impact on the performance of neighbouring junctions.

Figure 24: Proposed N17 and Parkmore Link Road Junction Queuing

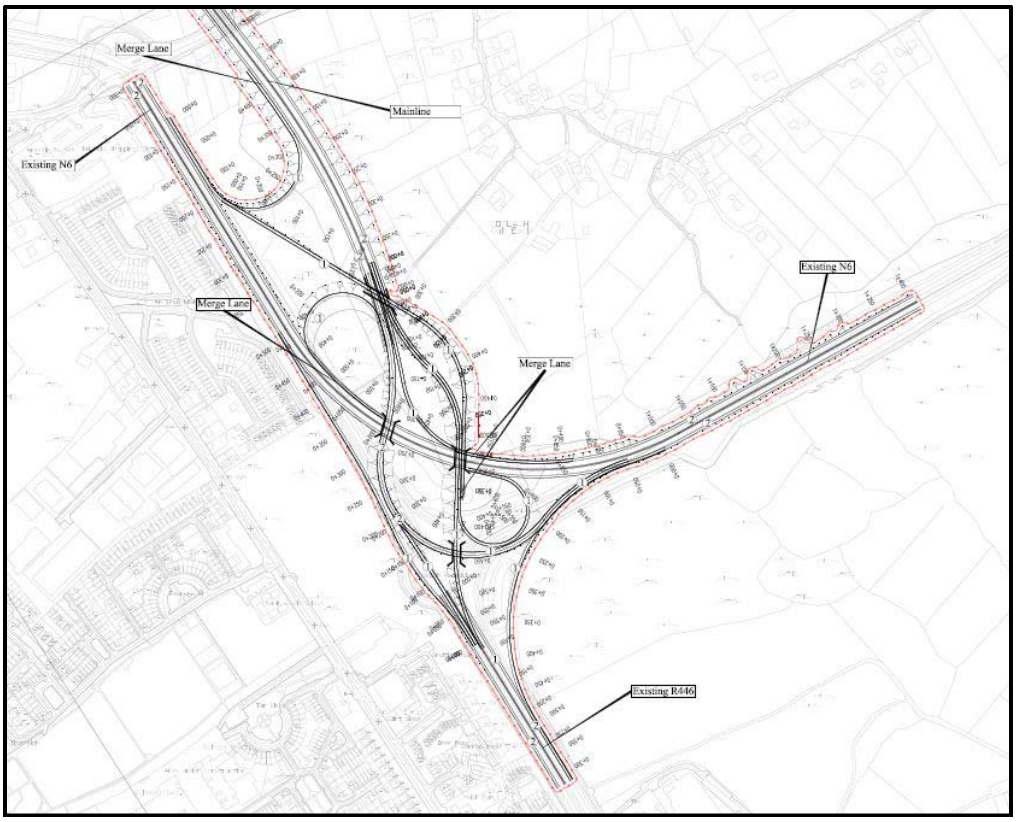


3.2.10 N6 Coolagh Junction

The eastern terminus of the N6 GCRR connects to the N6/M6. The provision of a full movement, high quality junction at the intersection of the N6 GCRR and the existing N6 terminus is necessary due to the fact that the N6 is the primary access to Galway from the east and will become the primary access to Galway from the south once the M17/M18 is constructed. This area to the east of Galway is also the focus of future development for Galway with the development of Ardaun.

The design in the vicinity of the N6 GCRR eastern terminus as presented in the EPRC is shown in **Figure 25** below.

Figure 25: EPRC at N6 Coolagh Junction



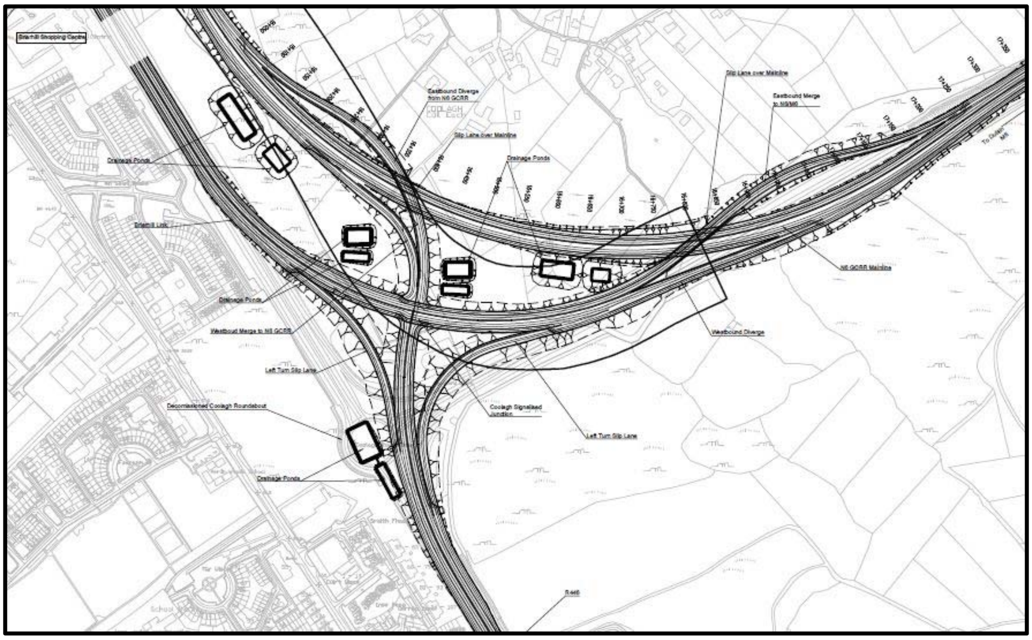
Whilst this layout provides free-flow movement for all trips, the key issues associated with it are as follows:

- Mainline is on the through route to the existing Briarhill Junction with the N6 GCRR diverging/merging from this mainline via dedicated links
- Confusion may arise with signage as N6 will ultimately follow the ring road
- Design speed on the mainline through to the existing Briarhill Junction is 85km/h. This requires a relaxation in horizontal alignment due to the use of a below desirable horizontal curve necessary for connection
- Geometric departures required for merge/diverge movements due to constrained layout and spacing of link roads

- Link road design speeds of 50km/h
- Additional structures to accommodate all movements
- Lane layout is not intuitive, which may lead to driver confusion
- Public feedback is that it is convoluted and very difficult to understand

A full review of this junction was undertaken complete with traffic data to rationalise the junction and to ensure priority is retained for the N6 GCRR. The preferred option is presented in **Figure 26**.

Figure 26: Proposed N6 GCRR Coolagh Junction



This junction layout addresses the issues raised above by including an at-grade signalised junction on the existing network connection, retaining priority on the N6 GCRR, retaining design speed on the N6 GCRR at 100km/h and also results in removal of some structures and a reduction in construction complexity.

3.2.11 Summary of Phase 3 Junction Strategy

Traffic analysis and journey type analysis has concluded with the presentation of the overall transport solution for Galway City, and the N6 GCRR is an essential component of this overall strategy. The proposed junction strategy for the N6 Galway City Ring Road is set out in Table 2.

Table 2: N6 Galway City Ring Road Junction Strategy

Location	Type
R336	Roundabout (Western Terminus)
Bearna to Moycullen Road	Roundabout
Cappagh Road	Signalised at-grade Junction
Ballymoneen Road	Signalised at-grade Junction
N59 Junction	Grade Separated Junction
N84 Junction	Grade Separated Junction
N17 Junction	Grade Separated Junction
N6 Coolagh Junction	Grade Separated Junction

4 Conclusions

The junction strategy of the N6 GCRR is designed to meet the objectives set out in section 1.2 of this report. As presented, the strategy meets the objectives for the following reasons:

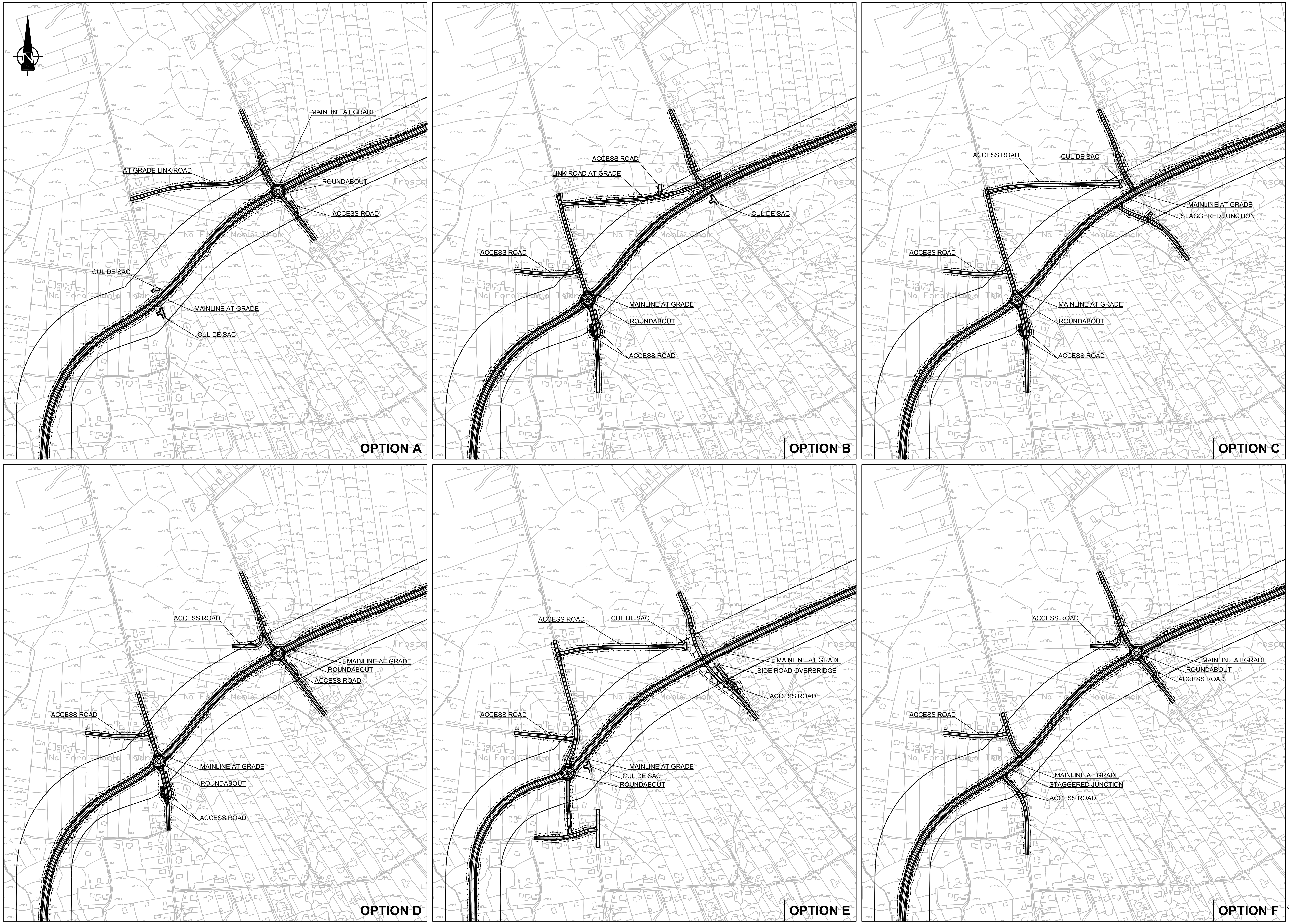
- Provides a high quality road with strategic access in accordance with TEN-T designation.
- Provides connectivity to the national roads via junctions to maximise the transfer of cross-city movements to the new road infrastructure, thus releasing and freeing the existing city centre zone from congestion caused by traffic trying to access a city centre bridge to cross the River Corrib
- Improves connectivity to the Western Region i.e. the county areas and hinterland beyond the city zone
- Caters for the strong demand between zones on either side of the city
- Facilitates crossing the River Corrib without negotiating the city centre
- Provides this additional river crossing with connectivity back to the city either side of the bridge crossing Provides essential city street links to better distribute traffic
- Attracts traffic from the city centre zone thus facilitating reallocation of road space to public transport leading to improve journey time reliability for public transport, supporting a mobility that is efficient and safe
- Facilitates improved city centre environment for all due to reduced congestion, thus encouraging walking and cycling as safe transport modes.

Appendix A

Drawings

A1

PHASE 3 - DRAFT



Legend:

Design Option

Emerging Preferred Route Corridor

Disclaimer Note:
The corridor shown is the Emerging Preferred Route Corridor only and is subject to change. More detailed assessments, ongoing studies and the information received from the public may result in changes to parts, or all of the Emerging Preferred Route Corridor. Any changes to the Emerging Preferred Route Corridor may affect the other information.

Nóta Séanta:
Is é an chonair atá léirithe ná an Chonair Bhealaigh is Dealraithí a Roghnófar, d'fhéadfaí athraithe teacht air. Is mar thoradh ar mheasúnaithe níos mionchruinne, ar staidéar leanúnach agus ar eolas ón bpobal go ndéanfar athruithe go dtí an chonair Bhealaigh is Dealraithí a Roghnófar ina iomláine nó go dti chuid dó. D'fhéadfadth tionchar a bheith ag aon athraithe ar an Chonair Bhealaigh is Dealraithí a Roghnófar ar eolas eile.

Clients

Consultant

ARUP

Corporate House
City East Business Park
Ballybrit, Galway, Ireland.

Tel +353 (0)91 460675
www.N6GalwayCity.ie
www.arup.ie

Job Title
N6 Galway City Transport Project

Scale: 1:5000 @ A1
Date: August 2015

Issue	Date	By	Chkd	Appd
I1	10/08/2015	GOD	HK	EMC

Drawing Title
Bearna Alternatives
Design Options A - F
Plan

Drawing Status
For Information

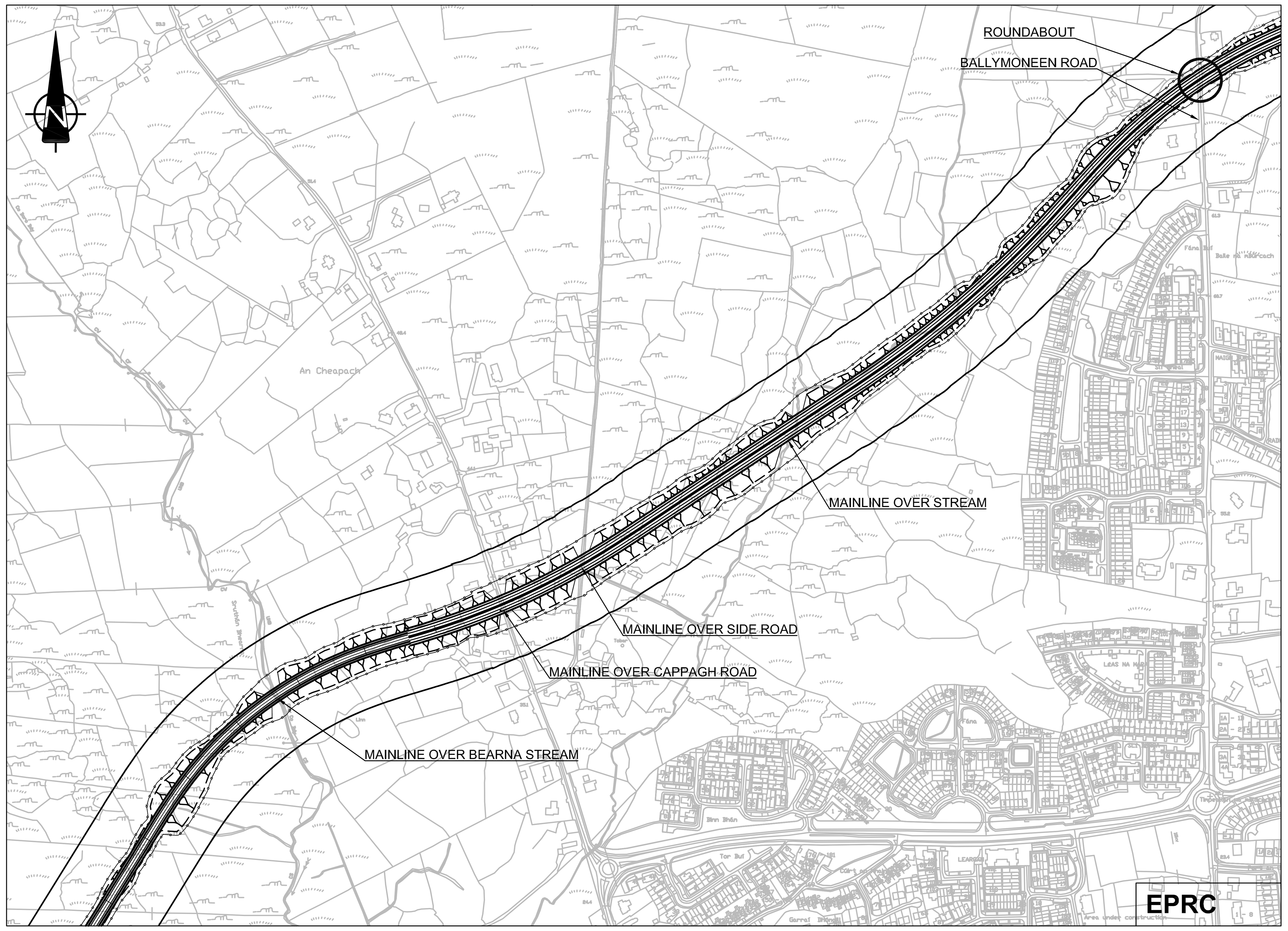
Job No	Drawing No	Issue
233985-00	GCOB-SK-D-015	I1

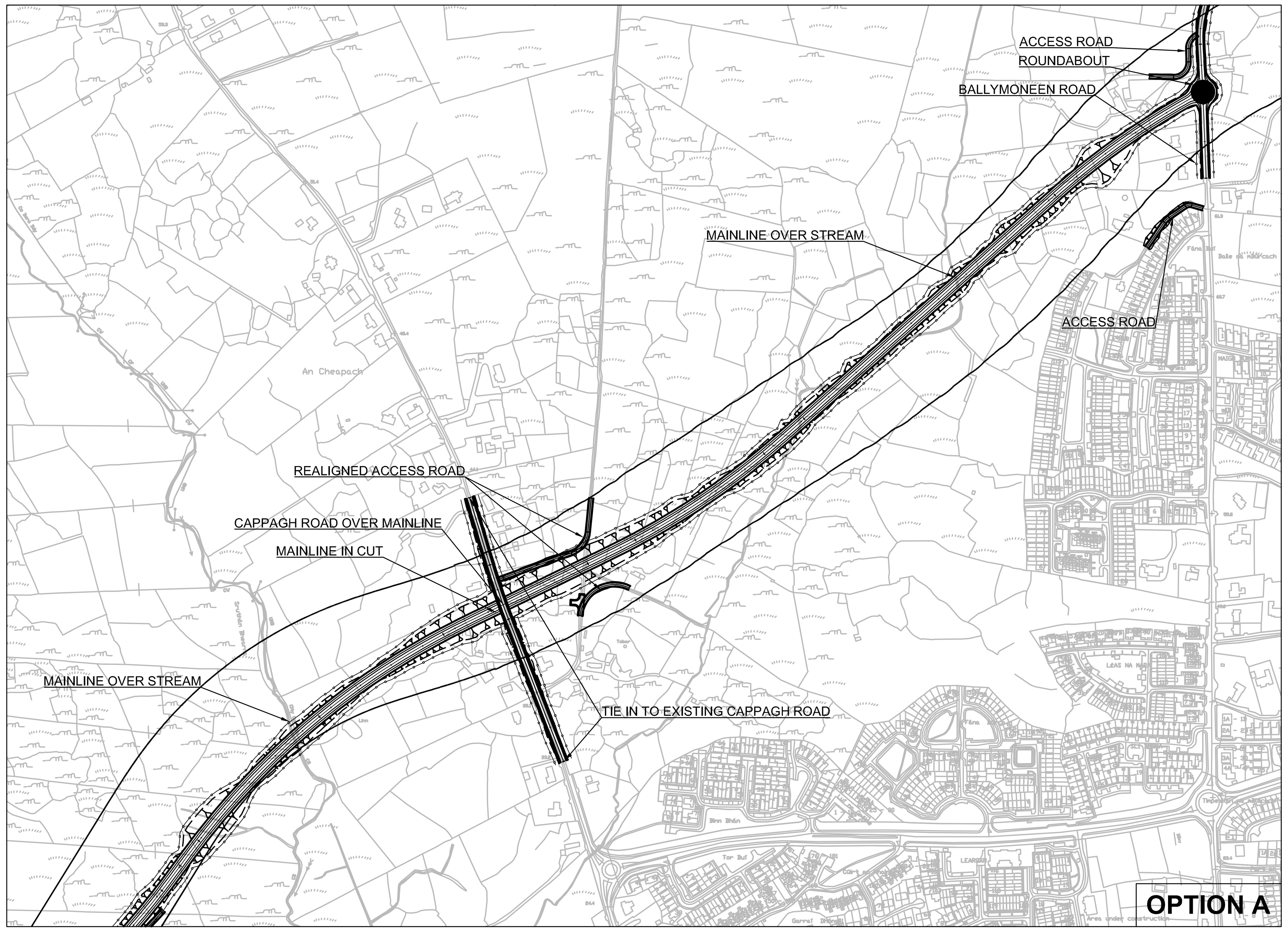
Do not scale

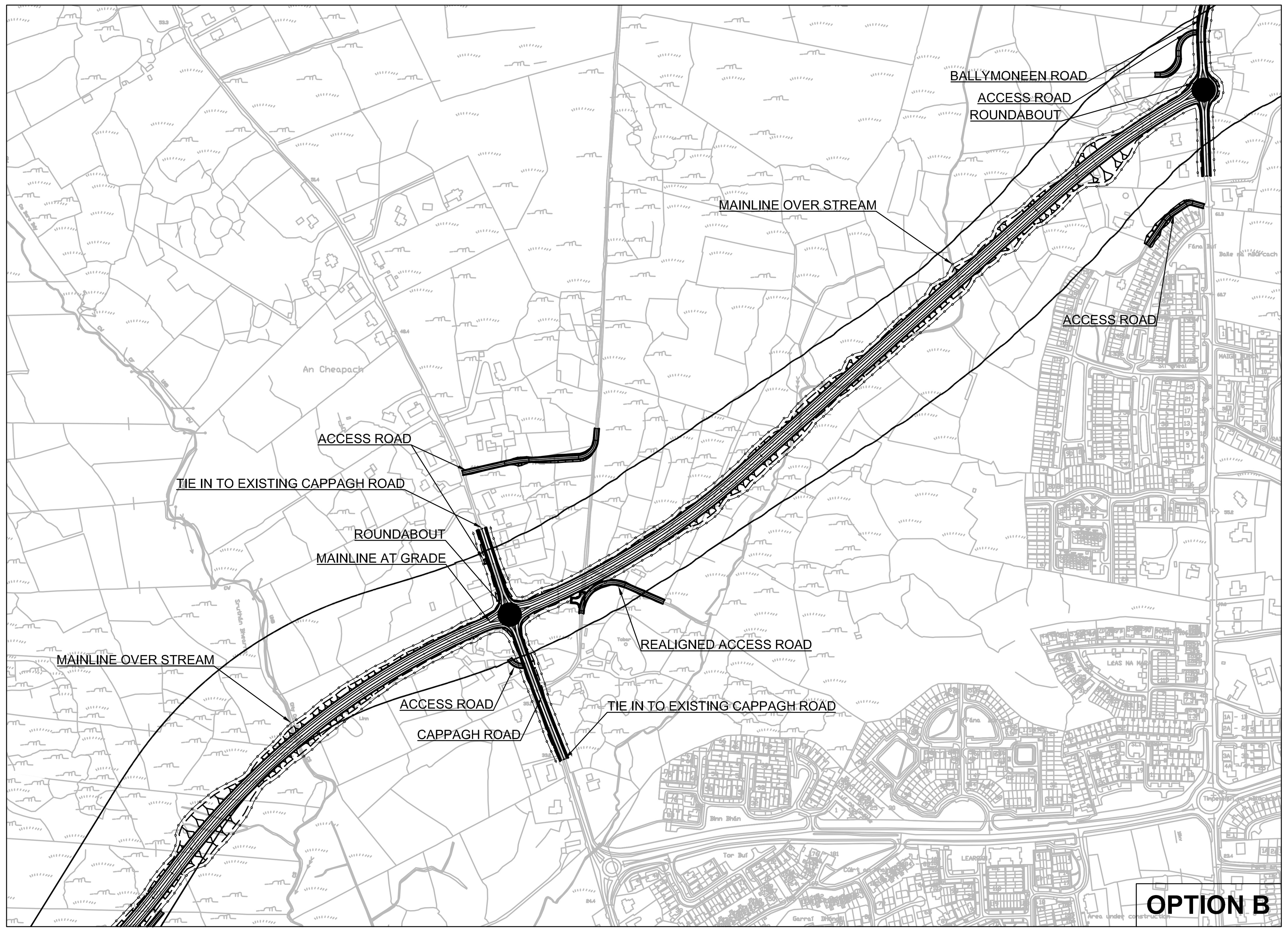
PHASE 3 - DRAFT

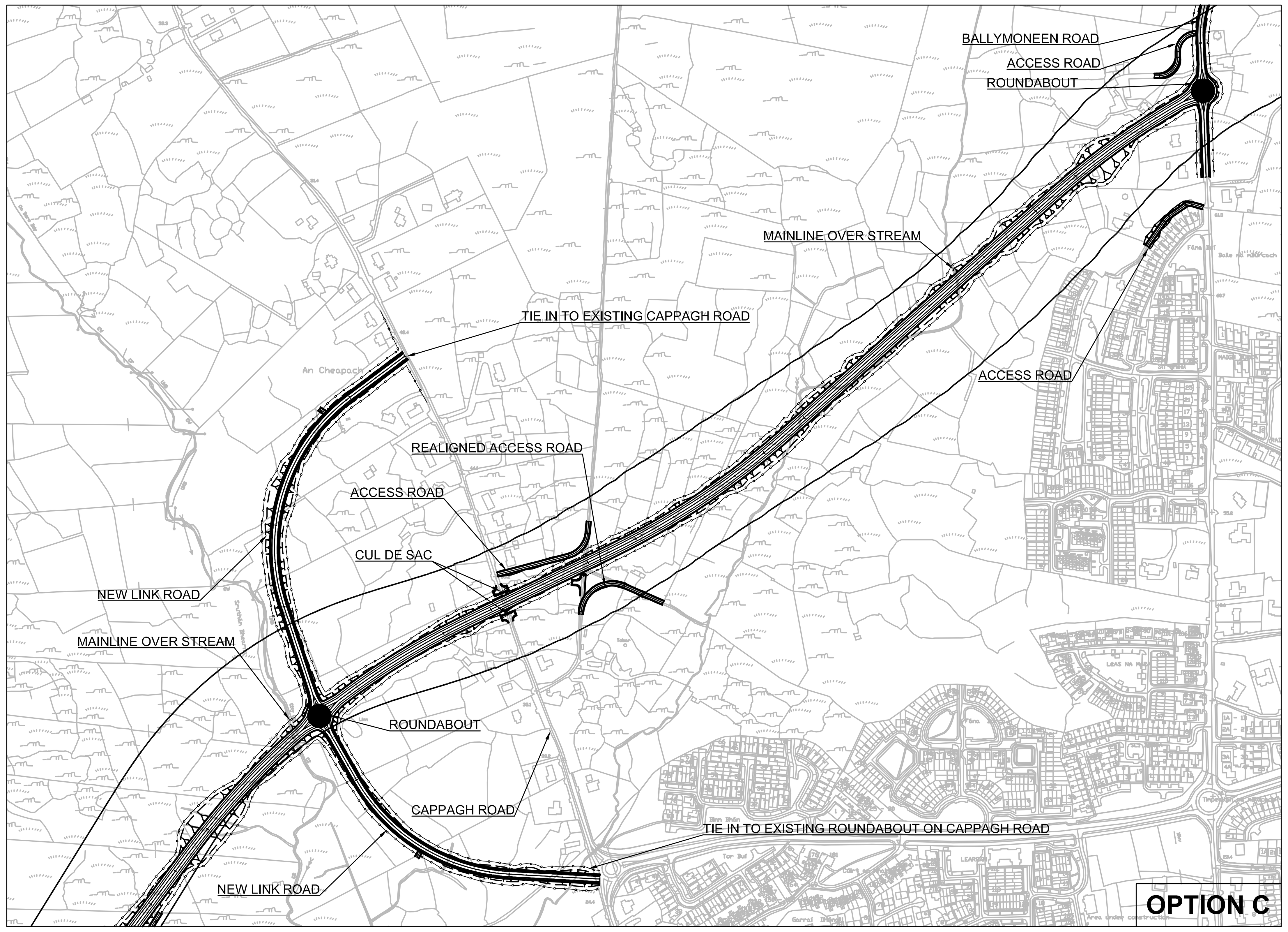
Legend:

- Design Option
- Emerging Preferred Route Corridor









Disclaimer Note:
The corridor shown is the Emerging Preferred Route Corridor only and is subject to change. More detailed assessments, ongoing studies and the information received from the public may result in changes to parts, or all of the Emerging Preferred Route Corridor. Any changes to the Emerging Preferred Route Corridor may affect the other information.

Nóta Séanta:
Is é an chonair atá léirithe ná an Chonair Bhealaigh is Dealraithí a Roghnófar, d'fhéadfaí athraithe teacht air. Is mar thoradh ar mheasúnaithe níos mionchruinne, ar staidéar leanúnach agus ar eolas ón bpobal go ndéanfar athruithe go dtí an chonair Bhealaigh is Dealraithí a Roghnófar ina iomláine nó go dti chuid dó. D'fhéadfadth tionchar a bheith ag aon athraithe ar an Chonair Bhealaigh is Dealraithí a Roghnófar ar eolas eile.

Clients

An Roinn Iompair Turasóireachta agus Spóirt — Department Transport, Tourism and Sport

N6 Galway City Transport Project

TII — Bonneagar Iompair Éireann — Transport Infrastructure Ireland

Consultant

ARUP

Corporate House
City East Business Park
Ballybrit, Galway, Ireland.

Tel +353 (0)91 460675
www.N6GalwayCity.ie
www.arup.ie

Job Title: N6 Galway City Transport Project

Scale: 1:5000 @ A1

Date: August 2015

Issue	Date	By	Chkd	Appd
I1	21/08/2015	GOD	HK	EMC

Drawing Title: Bearna Alternatives (Cappagh) EPRC & Design Options A - C Plan

Drawing Status: For Information

Job No	Drawing No	Issue
233985-00	GCOB-SK-D-032	I1

Do not scale

Appendix H

Sensitivity Test Network Statistics

SENSITIVITY TEST MODELLING RESULTS

NETWORK PERFORMANCE INDICATORS

Low and High Growth Network performance indicators for the 2024 (Opening Year) and 2039 (Design Year) are outlined in the tables below, extracted from each of the model assignments.

Low Growth Network Performance Indicators – Morning Peak Hour

Scenario	Total Vehicle Distance (pcu. Kms)	Total Network Travel Time (pcu. Hrs)	Total Network Delay (pcu. Hrs)	Average Vehicle Speed (kph)
2024 Do-Min	228,003	7,801	2,374	29.2
2024 Do-Something	263,409	7,005	1,579	37.6
2039 Do-Min	253,164	9,227	3,227	27.4
2039 Do-Something	298,383	7,941	1,929	37.6

Low Growth Network Performance Indicators – IP 1

Scenario	Total Vehicle Distance (pcu. Kms)	Total Network Travel Time (pcu. Hrs)	Total Network Delay (pcu. Hrs)	Average Vehicle Speed (kph)
2024 Do-Min	147,811	4,327	921	34.2
2024 Do-Something	162,195	4,139	773	39.2
2039 Do-Min	169,265	5,029	1,168	33.7
2039 Do-Something	188,652	4,767	943	39.6

Low Growth Network Performance Indicators – IP 2

Scenario	Total Vehicle Distance (pcu. Kms)	Total Network Travel Time (pcu. Hrs)	Total Network Delay (pcu. Hrs)	Average Vehicle Speed (kph)
2024 Do-Min	174,510	5,217	1,127	33.5
2024 Do-Something	194,257	5,100	1,006	38.1
2039 Do-Min	196,871	6,043	1,472	32.6
2039 Do-Something	222,885	5,772	1,196	38.6

Low Growth Network Performance Indicators – Evening peak Hour

Scenario	Total Vehicle Distance (pcu. Kms)	Total Network Travel Time (pcu. Hrs)	Total Network Delay (pcu. Hrs)	Average Vehicle Speed (kph)
2024 Do-Min	211,833	7,042	2,063	30.1
2024 Do-Something	239,517	6,394	1,434	37.5
2039 Do-Min	235,047	8,179	2,701	28.7
2039 Do-Something	270,201	7,295	1,794	37

High Growth Network Performance Indicators – Morning Peak Hour

Scenario	Total Vehicle Distance (pcu. Kms)	Total Network Travel Time (pcu. Hrs)	Total Network Delay (pcu. Hrs)	Average Vehicle Speed (kph)
2024 Do-Min	224,298	7,657	2,342	29.3
2024 Do-Something	260,136	6,829	1,512	38.1
2039 Do-Min	253,554	8,912	2,980	28.5
2039 Do-Something	299,351	7,774	1,822	38.5

High Growth Network Performance Indicators – IP 1

Scenario	Total Vehicle Distance (pcu. Kms)	Total Network Travel Time (pcu. Hrs)	Total Network Delay (pcu. Hrs)	Average Vehicle Speed (kph)
2024 Do-Min	149,076	4,333	912	34.4
2024 Do-Something	164,275	4,168	774	39.4
2039 Do-Min	174,094	5,159	1,217	33.7
2039 Do-Something	194,813	4,855	943	40.1

High Growth Network Performance Indicators – IP 2

Scenario	Total Vehicle Distance (pcu. Kms)	Total Network Travel Time (pcu. Hrs)	Total Network Delay (pcu. Hrs)	Average Vehicle Speed (kph)
2024 Do-Min	174,123	5,168	1,103	33.7
2024 Do-Something	194,430	5,059	984	38.4
2039 Do-Min	201,410	6,103	1,475	33
2039 Do-Something	228,540	5,835	1,204	39.2

High Growth Network Performance Indicators – Evening peak Hour

Scenario	Total Vehicle Distance (pcu. Kms)	Total Network Travel Time (pcu. Hrs)	Total Network Delay (pcu. Hrs)	Average Vehicle Speed (kph)
2024 Do-Min	207,936	6,749	1,872	30.8
2024 Do-Something	235,577	6,191	1,341	38.1
2039 Do-Min	234,510	7,985	2,570	29.4
2039 Do-Something	269,949	7,060	1,638	38.2

JOURNEY TIMES

The tables below detail the results of the journey time comparison as extracted from the 2024 and 2039, low and high growth, traffic models. The journey time routes used for the assessment of impact are shown in the Figure below.

Journey Time Routes

2024 AM Peak Journey Time Results – Low Growth

Route Description	2024 DM Seconds	2024 DM - Minutes	2024 DS Seconds	2024 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	1063	17.7	806	13.4	-257	-24.2%
Route 1 - Outbound	684	11.4	679	11.3	-5	-0.7%
Route 2 - Inbound	1338	22.3	1171	19.5	-167	-12.5%
Route 2 - Outbound	1197	20.0	1225	20.4	28	0
Route 3 - Inbound	441	7.4	304	5.1	-137	-31.1%
Route 3 - Outbound	259	4.3	267	4.5	8	3.1%
Route 4a - Inbound	730	12.2	670	11.2	-60	-8.2%
Route 4a - Outbound	785	13.1	676	11.3	-109	-13.9%
Route 4b - Inbound	1080	18.0	704	11.7	-376	-34.8%
Route 4b - Outbound	1078	18.0	698	11.6	-380	-35.3%
Route 5 - Inbound	1118	18.6	992	16.5	-126	-11.3%
Route 5 - Outbound	1202	20.0	1049	17.5	-153	-12.7%
Route 6 - Inbound	1068	17.8	1112	18.5	44	4.1%
Route 6 - Outbound	939	15.7	961	16.0	22	2.3%
Route 7 - Inbound	1364	22.7	1224	20.4	-140	-10.3%
Route 7 - Outbound	1272	21.2	1198	20.0	-74	-5.8%
Route 8 - Inbound	822	13.7	811	13.5	-11	-1.3%
Route 8 - Outbound	608	10.1	603	10.1	-5	-0.8%
Route 9 - Inbound	360	6.0	359	6.0	-1	-0.3%
Route 9 - Outbound	360	6.0	358	6.0	-2	-0.6%
Route 10 - Inbound	578	9.6	473	7.9	-105	-18.2%
Route 10 - Outbound	703	11.7	534	8.9	-169	-24.0%
Route 11 - Inbound	1299	21.7	980	16.3	-319	-24.6%
Route 11 - Outbound	1094	18.2	892	14.9	-202	-18.5%

2024 IP 1 Journey Time Results – Low Growth

Route Description	2024 DM Seconds	2024 DM - Minutes	2024 DS Seconds	2024 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	692	11.5	673	11.2	-19	-2.7%
Route 1 - Outbound	661	11.0	655	10.9	-6	-0.9%
Route 2 - Inbound	1046	17.4	1122	18.7	76	7.3%
Route 2 - Outbound	1104	18.4	1138	19.0	34	3.1%
Route 3 - Inbound	288	4.8	292	4.9	4	1.4%
Route 3 - Outbound	258	4.3	266	4.4	8	3.1%
Route 4a - Inbound	645	10.8	606	10.1	-39	-6.0%
Route 4a - Outbound	687	11.5	649	10.8	-38	-5.5%
Route 4b - Inbound	597	10.0	609	10.2	12	2.0%
Route 4b - Outbound	850	14.2	551	9.2	-299	-35.2%
Route 5 - Inbound	925	15.4	891	14.9	-34	-3.7%
Route 5 - Outbound	1092	18.2	964	16.1	-128	-11.7%
Route 6 - Inbound	959	16.0	978	16.3	19	0
Route 6 - Outbound	924	15.4	945	15.8	21	2.3%
Route 7 - Inbound	1018	17.0	1036	17.3	18	1.8%
Route 7 - Outbound	1271	21.2	1154	19.2	-117	-9.2%
Route 8 - Inbound	628	10.5	663	11.1	35	5.6%
Route 8 - Outbound	603	10.1	629	10.5	26	4.3%
Route 9 - Inbound	358	6.0	358	6.0	0	0.0%
Route 9 - Outbound	359	6.0	358	6.0	-1	-0.3%
Route 10 - Inbound	415	6.9	436	7.3	21	5.1%
Route 10 - Outbound	438	7.3	439	7.3	1	0.2%
Route 11 - Inbound	813	13.6	751	12.5	-62	-7.6%
Route 11 - Outbound	964	16.1	859	14.3	-105	-10.9%

2024 IP 2 Journey Time Results – Low Growth

Route Description	2024 DM Seconds	2024 DM - Minutes	2024 DS Seconds	2024 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	706	11.8	680	11.3	-26	-3.7%
Route 1 - Outbound	673	11.2	659	11.0	-14	-2.1%
Route 2 - Inbound	1064	17.7	1143	19.1	79	7.4%
Route 2 - Outbound	1124	18.7	1154	19.2	30	2.7%
Route 3 - Inbound	290	4.8	294	4.9	4	1.4%
Route 3 - Outbound	259	4.3	267	4.5	8	3.1%
Route 4a - Inbound	642	10.7	610	10.2	-32	-5.0%
Route 4a - Outbound	704	11.7	652	10.9	-52	-7.4%
Route 4b - Inbound	598	10.0	605	10.1	7	1.2%
Route 4b - Outbound	911	15.2	580	9.7	-331	-36.3%
Route 5 - Inbound	929	15.5	896	14.9	-33	-3.6%
Route 5 - Outbound	1116	18.6	1003	16.7	-113	-10.1%
Route 6 - Inbound	1042	17.4	1008	16.8	-34	-3.3%
Route 6 - Outbound	950	15.8	982	16.4	32	3.4%
Route 7 - Inbound	1048	17.5	1040	17.3	-8	-0.8%
Route 7 - Outbound	1279	21.3	1271	21.2	-8	-0.6%
Route 8 - Inbound	621	10.4	653	10.9	32	5.2%
Route 8 - Outbound	624	10.4	681	11.4	57	9.1%
Route 9 - Inbound	358	6.0	358	6.0	0	0.0%
Route 9 - Outbound	360	6.0	358	6.0	-2	-0.6%
Route 10 - Inbound	426	7.1	468	7.8	42	9.9%
Route 10 - Outbound	452	7.5	445	7.4	-7	-1.5%
Route 11 - Inbound	790	13.2	792	13.2	2	0.3%
Route 11 - Outbound	1046	17.4	948	15.8	-98	-9.4%

2024 PM Journey Time Results – Low Growth

Route Description	2024 DM Seconds	2024 DM - Minutes	2024 DS Seconds	2024 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	710	11.8	686	11.4	-24	-3.4%
Route 1 - Outbound	732	12.2	674	11.2	-58	-7.9%
Route 2 - Inbound	1144	19.1	1239	20.7	95	8.3%
Route 2 - Outbound	1175	19.6	1178	19.6	3	0.3%
Route 3 - Inbound	290	4.8	294	4.9	4	1.4%
Route 3 - Outbound	259	4.3	267	4.5	8	3.1%
Route 4a - Inbound	765	12.8	667	11.1	-98	-12.8%
Route 4a - Outbound	810	13.5	688	11.5	-122	-15.1%
Route 4b - Inbound	799	13.3	627	10.5	-172	-21.5%
Route 4b - Outbound	600	10.0	645	10.8	45	7.5%
Route 5 - Inbound	1207	20.1	1020	17.0	-187	-15.5%
Route 5 - Outbound	1189	19.8	1071	17.9	-118	-9.9%
Route 6 - Inbound	1103	18.4	1021	17.0	-82	-7.4%
Route 6 - Outbound	1015	16.9	1046	17.4	31	3.1%
Route 7 - Inbound	1212	20.2	1063	17.7	-149	-12.3%
Route 7 - Outbound	1593	26.6	1372	22.9	-221	-13.9%
Route 8 - Inbound	618	10.3	636	10.6	18	2.9%
Route 8 - Outbound	789	13.2	857	14.3	68	8.6%
Route 9 - Inbound	359	6.0	359	6.0	0	0.0%
Route 9 - Outbound	360	6.0	359	6.0	-1	-0.3%
Route 10 - Inbound	595	9.9	426	7.1	-169	-28.4%
Route 10 - Outbound	500	8.3	486	8.1	-14	-2.8%
Route 11 - Inbound	883	14.7	744	12.4	-139	-15.7%
Route 11 - Outbound	1334	22.2	1070	17.8	-264	-19.8%

2039 AM Peak Journey Time Results – Low Growth

Route Description	2039 DM Seconds	2039 DM - Minutes	2039 DS Seconds	2039 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	1121	18.6	834	13.2	-287	-25.6%
Route 1 - Outbound	687	11.6	681	11.4	-6	-0.9%
Route 2 - Inbound	1396	23.0	1212	20.3	-184	-13.2%
Route 2 - Outbound	1264	20.5	1263	21.7	-1	0
Route 3 - Inbound	483	8.0	316	5.3	-167	-34.6%
Route 3 - Outbound	259	4.3	267	4.5	8	3.1%
Route 4a - Inbound	739	12.2	686	11.5	-53	-7.2%
Route 4a - Outbound	1245	15.9	682	11.4	-563	-45.2%
Route 4b - Inbound	1285	21.1	794	13.8	-491	-38.2%
Route 4b - Outbound	799	20.0	725	11.9	-74	-9.3%
Route 5 - Inbound	1277	23.3	1039	17.9	-238	-18.6%
Route 5 - Outbound	1352	22.1	1108	18.4	-244	-18.0%
Route 6 - Inbound	1124	18.1	1123	18.8	-1	-0.1%
Route 6 - Outbound	958	15.9	988	16.4	30	3.1%
Route 7 - Inbound	1488	27.3	1286	22.5	-202	-13.6%
Route 7 - Outbound	1457	24.2	1292	20.9	-165	-11.3%
Route 8 - Inbound	943	18.7	870	16.7	-73	-7.7%
Route 8 - Outbound	625	10.9	606	9.9	-19	-3.0%
Route 9 - Inbound	361	6.0	359	6.0	-2	-0.6%
Route 9 - Outbound	361	6.0	358	6.0	-3	-0.8%
Route 10 - Inbound	593	11.1	493	7.6	-100	-16.9%
Route 10 - Outbound	703	11.9	563	16.9	-140	-19.9%
Route 11 - Inbound	1545	27.1	1072	18.5	-473	-30.6%
Route 11 - Outbound	1099	20.9	953	15.8	-146	-13.3%

2039 IP 1 Journey Time Results – Low Growth

Route Description	2039 DM Seconds	2039 DM - Minutes	2039 DS Seconds	2039 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	709	11.8	677	11.3	-32	-4.5%
Route 1 - Outbound	667	11.1	657	11.0	-10	-1.5%
Route 2 - Inbound	1056	17.6	1130	18.8	74	7.0%
Route 2 - Outbound	1113	18.6	1144	19.1	31	2.8%
Route 3 - Inbound	289	4.8	293	4.9	4	1.4%
Route 3 - Outbound	258	4.3	266	4.4	8	3.1%
Route 4a - Inbound	670	11.2	613	10.2	-57	-8.5%
Route 4a - Outbound	699	11.7	653	10.9	-46	-6.6%
Route 4b - Inbound	633	10.6	617	10.3	-16	-2.5%
Route 4b - Outbound	982	16.4	569	9.5	-413	-42.1%
Route 5 - Inbound	961	16.0	905	15.1	-56	-5.8%
Route 5 - Outbound	1181	19.7	1001	16.7	-180	-15.2%
Route 6 - Inbound	965	16.1	987	16.5	22	2.3%
Route 6 - Outbound	930	15.5	966	16.1	36	3.9%
Route 7 - Inbound	1052	17.5	1055	17.6	3	0.3%
Route 7 - Outbound	1329	22.2	1218	20.3	-111	-8.4%
Route 8 - Inbound	636	10.6	688	11.5	52	8.2%
Route 8 - Outbound	619	10.3	660	11.0	41	6.6%
Route 9 - Inbound	358	6.0	358	6.0	0	0.0%
Route 9 - Outbound	360	6.0	358	6.0	-2	-0.6%
Route 10 - Inbound	415	6.9	441	7.4	26	6.3%
Route 10 - Outbound	440	7.3	439	7.3	-1	-0.2%
Route 11 - Inbound	866	14.4	795	13.3	-71	-8.2%
Route 11 - Outbound	1077	18.0	915	15.3	-162	-15.0%

2039 IP 2 Journey Time Results – Low Growth

Route Description	2039 DM Seconds	2039 DM - Minutes	2039 DS Seconds	2039 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	729	12.2	687	11.5	-42	-5.8%
Route 1 - Outbound	683	11.4	662	11.0	-21	-3.1%
Route 2 - Inbound	1074	17.9	1159	19.3	85	7.9%
Route 2 - Outbound	1137	19.0	1162	19.4	25	2.2%
Route 3 - Inbound	291	4.9	295	4.9	4	1.4%
Route 3 - Outbound	259	4.3	268	4.5	9	3.5%
Route 4a - Inbound	666	11.1	616	10.3	-50	-7.5%
Route 4a - Outbound	715	11.9	656	10.9	-59	-8.3%
Route 4b - Inbound	643	10.7	620	10.3	-23	-3.6%
Route 4b - Outbound	1066	17.8	595	9.9	-471	-44.2%
Route 5 - Inbound	975	16.3	910	15.2	-65	-6.7%
Route 5 - Outbound	1210	20.2	1040	17.3	-170	-14.0%
Route 6 - Inbound	1041	17.4	1024	17.1	-17	-1.6%
Route 6 - Outbound	972	16.2	1015	16.9	43	4.4%
Route 7 - Inbound	1093	18.2	1063	17.7	-30	-2.7%
Route 7 - Outbound	1457	24.3	1289	21.5	-168	-11.5%
Route 8 - Inbound	628	10.5	672	11.2	44	7.0%
Route 8 - Outbound	667	11.1	694	11.6	27	4.0%
Route 9 - Inbound	358	6.0	358	6.0	0	0.0%
Route 9 - Outbound	360	6.0	359	6.0	-1	-0.3%
Route 10 - Inbound	428	7.1	508	8.5	80	18.7%
Route 10 - Outbound	470	7.8	445	7.4	-25	-5.3%
Route 11 - Inbound	835	13.9	797	13.3	-38	-4.6%
Route 11 - Outbound	1208	20.1	1007	16.8	-201	-16.6%

2039 PM Peak Journey Time Results – Low Growth

Route Description	2039 DM Seconds	2039 DM - Minutes	2039 DS Seconds	2039 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	721	12.0	691	11.5	-30	-4.2%
Route 1 - Outbound	774	12.9	682	11.4	-92	-11.9%
Route 2 - Inbound	1212	20.2	1330	22.2	118	9.7%
Route 2 - Outbound	1188	19.8	1186	19.8	-2	-0.2%
Route 3 - Inbound	291	4.9	296	4.9	5	1.7%
Route 3 - Outbound	259	4.3	268	4.5	9	3.5%
Route 4a - Inbound	820	13.7	656	10.9	-164	-20.0%
Route 4a - Outbound	848	14.1	696	11.6	-152	-17.9%
Route 4b - Inbound	939	15.7	632	10.5	-307	-32.7%
Route 4b - Outbound	1389	23.2	700	11.7	-689	-49.6%
Route 5 - Inbound	1346	22.4	1048	17.5	-298	-22.1%
Route 5 - Outbound	1275	21.3	1113	18.6	-162	-12.7%
Route 6 - Inbound	1113	18.6	1045	17.4	-68	-6.1%
Route 6 - Outbound	1059	17.7	1099	18.3	40	3.8%
Route 7 - Inbound	1227	20.5	1094	18.2	-133	-10.8%
Route 7 - Outbound	1690	28.2	1532	25.5	-158	-9.3%
Route 8 - Inbound	619	10.3	641	10.7	22	3.6%
Route 8 - Outbound	882	14.7	958	16.0	76	8.6%
Route 9 - Inbound	359	6.0	359	6.0	0	0.0%
Route 9 - Outbound	361	6.0	360	6.0	-1	-0.3%
Route 10 - Inbound	567	9.5	427	7.1	-140	-24.7%
Route 10 - Outbound	527	8.8	497	8.3	-30	-5.7%
Route 11 - Inbound	972	16.2	772	12.9	-200	-20.6%
Route 11 - Outbound	1556	25.9	1108	18.5	-448	-28.8%

2024 High Growth AM Peak Journey Time Results

Route Description	2024 DM Seconds	2024 DM - Minutes	2024 DS Seconds	2024 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	1061	17.7	898	15.0	-163	-15.4%
Route 1 - Outbound	685	11.4	679	11.3	-6	-0.9%
Route 2 - Inbound	1336	22.3	1175	19.6	-161	-12.1%
Route 2 - Outbound	1196	19.9	1225	20.4	29	0
Route 3 - Inbound	435	7.3	304	5.1	-131	-30.1%
Route 3 - Outbound	259	4.3	266	4.4	7	2.7%
Route 4a - Inbound	725	12.1	669	11.2	-56	-7.7%
Route 4a - Outbound	799	13.3	679	11.3	-120	-15.0%
Route 4b - Inbound	1074	17.9	692	11.5	-382	-35.6%
Route 4b - Outbound	1046	17.4	683	11.4	-363	-34.7%
Route 5 - Inbound	1228	20.5	973	16.2	-255	-20.8%
Route 5 - Outbound	1156	19.3	1007	16.8	-149	-12.9%
Route 6 - Inbound	1076	17.9	1101	18.4	25	2.3%
Route 6 - Outbound	944	15.7	960	16.0	16	1.7%
Route 7 - Inbound	1362	22.7	1201	20.0	-161	-11.8%
Route 7 - Outbound	1260	21.0	1235	20.6	-25	-2.0%
Route 8 - Inbound	821	13.7	795	13.3	-26	-3.2%
Route 8 - Outbound	603	10.1	605	10.1	2	0.3%
Route 9 - Inbound	360	6.0	359	6.0	-1	-0.3%
Route 9 - Outbound	360	6.0	358	6.0	-2	-0.6%
Route 10 - Inbound	571	9.5	469	7.8	-102	-17.9%
Route 10 - Outbound	663	11.1	496	8.3	-167	-25.2%
Route 11 - Inbound	1313	21.9	946	15.8	-367	-28.0%
Route 11 - Outbound	1047	17.5	854	14.2	-193	-18.4%

2024 High Growth IP 1 Journey Time Results

Route Description	2024 DM Seconds	2024 DM - Minutes	2024 DS Seconds	2024 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	696	11.6	674	11.2	-22	-3.2%
Route 1 - Outbound	662	11.0	655	10.9	-7	-1.1%
Route 2 - Inbound	1047	17.5	1122	18.7	75	7.2%
Route 2 - Outbound	1106	18.4	1139	19.0	33	3.0%
Route 3 - Inbound	288	4.8	292	4.9	4	1.4%
Route 3 - Outbound	258	4.3	266	4.4	8	3.1%
Route 4a - Inbound	645	10.8	607	10.1	-38	-5.9%
Route 4a - Outbound	688	11.5	650	10.8	-38	-5.5%
Route 4b - Inbound	602	10.0	608	10.1	6	1.0%
Route 4b - Outbound	838	14.0	552	9.2	-286	-34.1%
Route 5 - Inbound	923	15.4	891	14.9	-32	-3.5%
Route 5 - Outbound	1082	18.0	960	16.0	-122	-11.3%
Route 6 - Inbound	960	16.0	980	16.3	20	0
Route 6 - Outbound	924	15.4	947	15.8	23	2.5%
Route 7 - Inbound	1002	16.7	1036	17.3	34	3.4%
Route 7 - Outbound	1206	20.1	1152	19.2	-54	-4.5%
Route 8 - Inbound	630	10.5	667	11.1	37	5.9%
Route 8 - Outbound	604	10.1	631	10.5	27	4.5%
Route 9 - Inbound	358	6.0	358	6.0	0	0.0%
Route 9 - Outbound	359	6.0	358	6.0	-1	-0.3%
Route 10 - Inbound	415	6.9	433	7.2	18	4.3%
Route 10 - Outbound	438	7.3	438	7.3	0	0.0%
Route 11 - Inbound	825	13.8	752	12.5	-73	-8.8%
Route 11 - Outbound	977	16.3	850	14.2	-127	-13.0%

2024 High Growth IP 2 Journey Time Results

Route Description	2024 DM Seconds	2024 DM - Minutes	2024 DS Seconds	2024 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	696	11.6	674	11.2	-22	-3.2%
Route 1 - Outbound	662	11.0	655	10.9	-7	-1.1%
Route 2 - Inbound	1047	17.5	1122	18.7	75	7.2%
Route 2 - Outbound	1106	18.4	1139	19.0	33	3.0%
Route 3 - Inbound	288	4.8	292	4.9	4	1.4%
Route 3 - Outbound	258	4.3	266	4.4	8	3.1%
Route 4a - Inbound	645	10.8	607	10.1	-38	-5.9%
Route 4a - Outbound	688	11.5	650	10.8	-38	-5.5%
Route 4b - Inbound	602	10.0	608	10.1	6	1.0%
Route 4b - Outbound	838	14.0	552	9.2	-286	-34.1%
Route 5 - Inbound	923	15.4	891	14.9	-32	-3.5%
Route 5 - Outbound	1082	18.0	960	16.0	-122	-11.3%
Route 6 - Inbound	960	16.0	980	16.3	20	0
Route 6 - Outbound	924	15.4	947	15.8	23	2.5%
Route 7 - Inbound	1002	16.7	1036	17.3	34	3.4%
Route 7 - Outbound	1206	20.1	1152	19.2	-54	-4.5%
Route 8 - Inbound	630	10.5	667	11.1	37	5.9%
Route 8 - Outbound	604	10.1	631	10.5	27	4.5%
Route 9 - Inbound	358	6.0	358	6.0	0	0.0%
Route 9 - Outbound	359	6.0	358	6.0	-1	-0.3%
Route 10 - Inbound	415	6.9	433	7.2	18	4.3%
Route 10 - Outbound	438	7.3	438	7.3	0	0.0%
Route 11 - Inbound	825	13.8	752	12.5	-73	-8.8%
Route 11 - Outbound	977	16.3	850	14.2	-127	-13.0%

2024 High Growth PM Peak Journey Time Results

Route Description	2024 DM Seconds	2024 DM - Minutes	2024 DS Seconds	2024 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	708	11.8	680	11.3	-28	-4.0%
Route 1 - Outbound	675	11.3	659	11.0	-16	-2.4%
Route 2 - Inbound	1065	17.8	1146	19.1	81	7.6%
Route 2 - Outbound	1125	18.8	1154	19.2	29	2.6%
Route 3 - Inbound	289	4.8	294	4.9	5	1.7%
Route 3 - Outbound	258	4.3	267	4.5	9	3.5%
Route 4a - Inbound	641	10.7	610	10.2	-31	-4.8%
Route 4a - Outbound	704	11.7	652	10.9	-52	-7.4%
Route 4b - Inbound	597	10.0	603	10.1	6	1.0%
Route 4b - Outbound	892	14.9	575	9.6	-317	-35.5%
Route 5 - Inbound	925	15.4	894	14.9	-31	-3.4%
Route 5 - Outbound	1110	18.5	995	16.6	-115	-10.4%
Route 6 - Inbound	1048	17.5	1009	16.8	-39	-3.7%
Route 6 - Outbound	951	15.9	983	16.4	32	3.4%
Route 7 - Inbound	1043	17.4	1038	17.3	-5	-0.5%
Route 7 - Outbound	1275	21.3	1323	22.1	48	3.8%
Route 8 - Inbound	621	10.4	652	10.9	31	5.0%
Route 8 - Outbound	624	10.4	684	11.4	60	9.6%
Route 9 - Inbound	358	6.0	358	6.0	0	0.0%
Route 9 - Outbound	360	6.0	358	6.0	-2	-0.6%
Route 10 - Inbound	423	7.1	472	7.9	49	11.6%
Route 10 - Outbound	452	7.5	444	7.4	-8	-1.8%
Route 11 - Inbound	786	13.1	739	12.3	-47	-6.0%
Route 11 - Outbound	1039	17.3	929	15.5	-110	-10.6%

2039 High Growth AM Peak Journey Time Results

Route Description	2039 DM Seconds	2039 DM - Minutes	2039 DS Seconds	2039 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	1123	18.6	887	13.2	-236	-21.0%
Route 1 - Outbound	687	11.6	680	11.4	-7	-1.0%
Route 2 - Inbound	1389	23.0	1213	20.3	-176	-12.7%
Route 2 - Outbound	1243	20.5	1278	21.7	35	0
Route 3 - Inbound	480	8.0	318	5.3	-162	-33.8%
Route 3 - Outbound	259	4.3	267	4.5	8	3.1%
Route 4a - Inbound	729	12.2	681	11.5	-48	-6.6%
Route 4a - Outbound	831	15.9	683	11.4	-148	-17.8%
Route 4b - Inbound	1274	21.1	785	13.8	-489	-38.4%
Route 4b - Outbound	1104	20.0	702	11.9	-402	-36.4%
Route 5 - Inbound	1322	23.3	1027	17.9	-295	-22.3%
Route 5 - Outbound	1173	22.1	1025	18.4	-148	-12.6%
Route 6 - Inbound	1098	18.1	1121	18.8	23	2.1%
Route 6 - Outbound	956	15.9	975	16.4	19	2.0%
Route 7 - Inbound	1541	27.3	1284	22.5	-257	-16.7%
Route 7 - Outbound	1316	24.2	1297	20.9	-19	-1.4%
Route 8 - Inbound	979	18.7	851	16.7	-128	-13.1%
Route 8 - Outbound	612	10.9	609	9.9	-3	-0.5%
Route 9 - Inbound	361	6.0	359	6.0	-2	-0.6%
Route 9 - Outbound	360	6.0	358	6.0	-2	-0.6%
Route 10 - Inbound	598	11.1	489	7.6	-109	-18.2%
Route 10 - Outbound	672	11.9	512	16.9	-160	-23.8%
Route 11 - Inbound	1577	27.1	1088	18.5	-489	-31.0%
Route 11 - Outbound	1139	20.9	885	15.8	-254	-22.3%

2039 High Growth IP 1 Journey Time Results

Route Description	2039 DM Seconds	2039 DM - Minutes	2039 DS Seconds	2039 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	716	11.9	679	11.3	-37	-5.2%
Route 1 - Outbound	668	11.1	657	11.0	-11	-1.6%
Route 2 - Inbound	1057	17.6	1131	18.9	74	7.0%
Route 2 - Outbound	1117	18.6	1148	19.1	31	2.8%
Route 3 - Inbound	289	4.8	293	4.9	4	1.4%
Route 3 - Outbound	258	4.3	266	4.4	8	3.1%
Route 4a - Inbound	666	11.1	613	10.2	-53	-8.0%
Route 4a - Outbound	701	11.7	654	10.9	-47	-6.7%
Route 4b - Inbound	653	10.9	620	10.3	-33	-5.1%
Route 4b - Outbound	985	16.4	574	9.6	-411	-41.7%
Route 5 - Inbound	978	16.3	907	15.1	-71	-7.3%
Route 5 - Outbound	1165	19.4	994	16.6	-171	-14.7%
Route 6 - Inbound	965	16.1	990	16.5	25	2.6%
Route 6 - Outbound	931	15.5	968	16.1	37	4.0%
Route 7 - Inbound	1081	18.0	1060	17.7	-21	-1.9%
Route 7 - Outbound	1450	24.2	1223	20.4	-227	-15.7%
Route 8 - Inbound	640	10.7	695	11.6	55	8.6%
Route 8 - Outbound	620	10.3	657	11.0	37	6.0%
Route 9 - Inbound	358	6.0	358	6.0	0	0.0%
Route 9 - Outbound	360	6.0	358	6.0	-2	-0.6%
Route 10 - Inbound	415	6.9	436	7.3	21	5.1%
Route 10 - Outbound	440	7.3	438	7.3	-2	-0.5%
Route 11 - Inbound	902	15.0	771	12.9	-131	-14.5%
Route 11 - Outbound	1084	18.1	920	15.3	-164	-15.1%

2039 High Growth IP 2 Journey Time Results

Route Description	2039 DM Seconds	2039 DM - Minutes	2039 DS Seconds	2039 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	729	12.2	686	11.4	-43	-5.9%
Route 1 - Outbound	684	11.4	661	11.0	-23	-3.4%
Route 2 - Inbound	1077	18.0	1170	19.5	93	8.6%
Route 2 - Outbound	1140	19.0	1160	19.3	20	1.8%
Route 3 - Inbound	290	4.8	295	4.9	5	1.7%
Route 3 - Outbound	259	4.3	267	4.5	8	3.1%
Route 4a - Inbound	664	11.1	615	10.3	-49	-7.4%
Route 4a - Outbound	714	11.9	656	10.9	-58	-8.1%
Route 4b - Inbound	648	10.8	619	10.3	-29	-4.5%
Route 4b - Outbound	1106	18.4	600	10.0	-506	-45.8%
Route 5 - Inbound	974	16.2	904	15.1	-70	-7.2%
Route 5 - Outbound	1207	20.1	1034	17.2	-173	-14.3%
Route 6 - Inbound	1038	17.3	1025	17.1	-13	-1.3%
Route 6 - Outbound	972	16.2	1017	17.0	45	4.6%
Route 7 - Inbound	1121	18.7	1057	17.6	-64	-5.7%
Route 7 - Outbound	1461	24.4	1394	23.2	-67	-4.6%
Route 8 - Inbound	630	10.5	671	11.2	41	6.5%
Route 8 - Outbound	692	11.5	699	11.7	7	1.0%
Route 9 - Inbound	358	6.0	358	6.0	0	0.0%
Route 9 - Outbound	360	6.0	359	6.0	-1	-0.3%
Route 10 - Inbound	425	7.1	476	7.9	51	12.0%
Route 10 - Outbound	467	7.8	445	7.4	-22	-4.7%
Route 11 - Inbound	848	14.1	775	12.9	-73	-8.6%
Route 11 - Outbound	1185	19.8	994	16.6	-191	-16.1%

2039 High Growth PM Peak Journey Time Results

Route Description	2039 DM Seconds	2039 DM - Minutes	2039 DS Seconds	2039 DS - Minutes	Diff (Seconds)	% Difference
Route 1 - Inbound	733	12.2	692	11.5	-41	-5.6%
Route 1 - Outbound	742	12.4	678	11.3	-64	-8.6%
Route 2 - Inbound	1194	19.9	1318	22.0	124	10.4%
Route 2 - Outbound	1194	19.9	1185	19.8	-9	-0.8%
Route 3 - Inbound	292	4.9	295	4.9	3	1.0%
Route 3 - Outbound	259	4.3	268	4.5	9	3.5%
Route 4a - Inbound	795	13.3	669	11.2	-126	-15.8%
Route 4a - Outbound	825	13.8	690	11.5	-135	-16.4%
Route 4b - Inbound	783	13.1	633	10.6	-150	-19.2%
Route 4b - Outbound	1588	26.5	699	11.7	-889	-56.0%
Route 5 - Inbound	1201	20.0	1024	17.1	-177	-14.7%
Route 5 - Outbound	1316	21.9	1074	17.9	-242	-18.4%
Route 6 - Inbound	1097	18.3	1046	17.4	-51	-4.6%
Route 6 - Outbound	1030	17.2	1083	18.1	53	5.1%
Route 7 - Inbound	1188	19.8	1076	17.9	-112	-9.4%
Route 7 - Outbound	1754	29.2	1451	24.2	-303	-17.3%
Route 8 - Inbound	624	10.4	641	10.7	17	2.7%
Route 8 - Outbound	929	15.5	928	15.5	-1	-0.1%
Route 9 - Inbound	359	6.0	359	6.0	0	0.0%
Route 9 - Outbound	361	6.0	360	6.0	-1	-0.3%
Route 10 - Inbound	622	10.4	425	7.1	-197	-31.7%
Route 10 - Outbound	545	9.1	495	8.3	-50	-9.2%
Route 11 - Inbound	880	14.7	841	14.0	-39	-4.4%
Route 11 - Outbound	1675	27.9	1058	17.6	-617	-36.8%

RATIO OF FLOW TO CAPACITY

The Tables below summarise junction evaluations for the 2024 and 2039-High and Low Growth – AM and PM Core Scenarios.

Number of Links at or over capacity- AM Peak – LOW GROWTH

		2024			2039		
		DM	**DS**	**Impact**	**DM**	**DS**	**Impact**
Key Junctions (N6 / R338)	RFC > 90%	16	9	Positive	24	11	Positive
Entire Network	RFC > 90%	170	90	Positive	230	133	Positive

Number of Links at or over capacity- IP 1 – LOW GROWTH

		2024			2039		
		DM	**DS**	**Impact**	**DM**	**DS**	**Impact**
Key Junctions (N6 / R338)	RFC > 90%	4	2	Positive	8	5	Positive
Entire Network	RFC > 90%	27	11	Positive	57	30	Positive

Number of Links at or over capacity- IP 2– LOW GROWTH

		2024			2039		
		DM	**DS**	**Impact**	**DM**	**DS**	**Impact**
Key Junctions (N6 / R338)	RFC > 90%	8	4	Positive	12	6	Positive
Entire Network	RFC > 90%	56	30	Positive	88	49	Positive

Number of Links at or over capacity- PM Peak– LOW GROWTH

		2024			2039		
		DM	**DS**	**Impact**	**DM**	**DS**	**Impact**
Key Junctions (N6 / R338)	RFC > 90%	18	5	Positive	21	7	Positive
Entire Network	RFC > 90%	169	76	Positive	209	138	Positive

Number of Links at or over capacity- AM Peak – HIGH GROWTH

		2024			2039		
		DM	**DS**	**Impact**	**DM**	**DS**	**Impact**
Key Junctions (N6 / R338)	RFC > 90%	16	8	Positive	20	12	Positive
Entire Network	RFC > 90%	158	76	Positive	209	116	Positive

Number of Links at or over capacity- IP 1 – HIGH GROWTH

		2024			2039		
		DM	**DS**	**Impact**	**DM**	**DS**	**Impact**
Key Junctions (N6 / R338)	RFC > 90%	4	2	Positive	9	5	Positive
Entire Network	RFC > 90%	26	12	Positive	62	28	Positive

Number of Links at or over capacity- IP 2– HIGH GROWTH

		2024			2039		
		DM	**DS**	**Impact**	**DM**	**DS**	**Impact**
Key Junctions (N6 / R338)	RFC > 90%	8	4	Positive	12	6	Positive
Entire Network	RFC > 90%	49	27	Positive	93	52	Positive

Number of Links at or over capacity- PM Peak– HIGH GROWTH

		2024			2039		
		DM	**DS**	**Impact**	**DM**	**DS**	**Impact**
Key Junctions (N6 / R338)	RFC > 90%	18	4	Positive	20	6	Positive
Entire Network	RFC > 90%	146	61	Positive	198	109	Positive