The background is a vibrant yellow. It is decorated with several abstract geometric shapes in shades of blue, teal, and white. These include circles, semi-circles, and rounded rectangular shapes, some of which are layered or overlapping. The shapes are scattered across the page, creating a modern and dynamic visual effect.

# Appendix A6.2

## Transport Modelling Report

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**Appendix A - Full Local Area Model Calibration and Validation**

## List of Acronyms

| Acronym | Definition                               |
|---------|------------------------------------------|
| AADT    | Annual Average Daily Traffic             |
| ATC     | Automatic Traffic Counts                 |
| CBCs    | Core Bus Corridors                       |
| CPO     | Compulsory Purchase Order                |
| CSA     | Census Small Area                        |
| DfT     | UK Department for Transport              |
| DM      | Do Minimum                               |
| DS      | Do Something                             |
| ED      | Engineering Design                       |
| EIARs   | Environmental Impacts Assessment Reports |
| ERM     | East Regional Model                      |
| FDM     | Full Demand Model                        |
| GDA     | Greater Dublin Area                      |
| GEH     | Geoffrey E. Havers statistic             |
| JTC     | Junction Turning Counts                  |
| LAM     | Local Area Model                         |
| LGV     | Light Goods Vehicles                     |
| NDFM    | National Demand Forecasting Model        |
| NDP     | National Development Plan                |
| NHTS    | National Household Travel Survey         |
| NPF     | National Planning Framework              |
| NTA     | National Transport Authority             |
| OGV     | Other Goods Vehicles                     |
| PAG     | Project Appraisal Guidelines             |
| pcu     | passenger car units                      |
| PMS     | People Movement at Signal                |
| PRO     | Preferred Route Option                   |
| RMS     | Regional Modelling System                |
| SAPS    | Small Area Population Statistics         |
| TAG     | Transport Analysis Guidance              |
| TIA     | Transport Impact Assessment              |
| TII     | Transport Infrastructure Ireland         |
| TRL     | Transport Research Laboratory            |

# 1. Introduction

The purpose of this document is to provide a detailed overview of the suite of forecast transport modelling tools that have been developed to support the design development and assessment of the **Ringsend to City Centre Core Bus Corridor Scheme** (hereafter referred to as the Proposed Scheme). The Proposed Scheme is one of the 12 Schemes that make up the BusConnects Dublin – Core Bus Corridor Infrastructure Works (hereafter referred to as the CBC Infrastructure Works).



**Diagram 1.1: Overview of BusConnects Dublin – Core Bus Corridor Infrastructure Works with Ringsend to City Centre Core Corridor Scheme Highlighted**

The Proposed Scheme is being planned to enable and deliver efficient, safe and integrated sustainable transport movement along the corridor.

This report presents an overview of the transport modelling tools that have been developed for the assessment of the Proposed Scheme in relation to traffic and transport. The report details the transport model development process, the traffic data inputs used, the calibration, validation and forecast model development for the suite of transport models.

## 2. Purpose and Structure of this Report

### 2.1 Introduction

This report presents an overview of the transport modelling tools that have been developed for the assessment of the Proposed Scheme in relation to traffic and transport. The transport modelling supports the design development, construction strategy and the traffic and transport impact assessment of the Proposed Scheme. The outputs from the transport modelling for the Proposed Scheme are used to inform other environmental disciplines including Air Quality, Climate, Noise & Vibration, Population and Human Health. The remainder of the report is structured as follows:

#### **Section 3 – Transport Modelling Methodology**

Section Three provides an overview of the transport modelling methodology including the use of the NTA's East Regional Model (ERM), the development of local area and scheme specific micro-simulation modelling to support the assessment of the Proposed Scheme.

#### **Section 4 – Transport Modelling Specification**

Section Four presents information on the specification of the transport modelling tools including the defined model area, demand segmentation, time periods modelled, model software and key assignment parameters.

#### **Section 5 – Data Collection**

Section Five outlines the traffic data collected to support transport model development for the Proposed Scheme.

#### **Section 6 – Local Area Modelling**

Section Six describes the development of the local area model (LAM) including the calibration and validation process adopted and the results achieved to ensure that the LAM is meeting relevant Transport Infrastructure Ireland (TII) and NTA guidelines.

#### **Section 7 – Micro-simulation Modelling**

Section Seven describes the development of the micro-simulation model for the Proposed Scheme including the calibration and validation process adopted and the results achieved that demonstrate that the micro-simulation model is a suitable and robust tool to be used to assess the impact of the Proposed Scheme.

#### **Section 8 – Forecast Model Development**

Section Eight presents the process used for the development of the Do-Minimum and Do-Something (2028 & 2043) suite of transport models, including the process to convert from the ERM to the LAM and in turn the micro-simulation model for the Proposed Scheme.

## 3. Transport Modelling Methodology

### 3.1 Introduction

The following section describes the overall methodology used for developing the various transport modelling tools which, in turn, have been used to support the assessment of the Proposed Scheme. This assessment in relation to the receiving transport environment requires a qualitative assessment of changes to the transport environment, as well as quantitative analysis that has been undertaken using a suite of multi-modal transport modelling tools which have been developed for the Proposed Scheme.

The assessment of traffic and transport benefits and impacts of the Proposed Scheme has required a transport modelling approach which can provide information on, for example, the mode share changes along the route, people movement by different modes of transport travelling along the corridor as well as traffic re-routing impacts on the surrounding road network. The modelling approach has required an assessment of bus, pedestrian and cycle operations and bus reliability with a focus on the movement of people along the route.

To enable this a multi-tiered transport modelling approach has been adopted. The NTA's East Regional Model (ERM) is the primary modelling tool and provides the overarching information on forecast travel demand for each mode of transport. The ERM has been supported by other modelling tools which have provided more granular level traffic information which has allowed for detailed and refined modelling at a local network and junction level. For this purpose, a cordoned<sup>1</sup> corridor-wide, road (motorised vehicle only) based Local Area Model (LAM) has been used in combination with a multi-modal corridor micro-simulation model and local junction models which work in tandem with the NTA's East Regional Model (ERM).

The traffic and transport impact assessment for the Proposed Scheme, has been informed by the suite of modelling tools described above, has been undertaken in accordance with latest guidance including the 'Guidelines on the Information to be contained in Environmental Impact Assessment Reports' (EPA 2017), the 'Traffic and Transport Assessment Guidelines' (TII 2014), the National Cycle Manual (NTA 2011) and the UK Design Manual for Roads & Bridges (DMRB), Volume 11, Section 2, Part 5 (UK Highways Agency 2011).

The traffic and transport assessment has been informed by the following reports which are included as part of the EIAR:

- **Transport Impact Assessment (TIA) (Appendix A6.1)** –includes the comprehensive assessment of the Proposed Scheme covering all transport modes for both Construction and Operational Phases; and
- **Transport Modelling Report (TMR) (Appendix A6.2) (This Report)** - details the model development, data inputs, calibration and validation and forecast model development for the suite of models that have been used to support the assessment.

The assessment of traffic and transport benefits and impacts has taken account of receptors relevant to the Proposed Scheme including:

- Buses;
- Pedestrians / mobility impaired;
- Cyclists;
- General traffic; and
- On-street parking, off-street parking, loading, taxis.

In addition, the following modes of transport have been considered as part of the modelling:

- Public Transport including MetroLink, inter-urban rail, suburban rail, DART, light rail (Luas) and bus;
- Traffic including private car, taxis and goods vehicles;
- Walking; and
- Cycling.

<sup>1</sup> Cordoning is the process of creating a smaller area model (network and demand) from a larger model



The traffic and transport assessments have been carried out in relation to the following scenarios:

- **‘Do Nothing’** – The ‘Do Nothing’ scenario represents the current baseline traffic and transport conditions of the direct and indirect study areas **without** the Proposed Scheme in place and other GDA Strategy projects. This scenario forms the reference case by which to compare the Proposed Scheme (‘Do Something’) for the qualitative assessments only.
- **‘Do Minimum’** – The ‘Do Minimum’ scenario (Opening Year 2028, Design Year 2043) represents the likely traffic and transport conditions of the direct and indirect study areas including for any transportation schemes which have taken place, been approved or are planned for implementation, **without** the Proposed Scheme in place. This scenario forms the reference case by which to compare the Proposed Scheme (‘Do Something’) for the quantitative assessments.
- **‘Do Something’** – The ‘Do Something’ scenario represents the likely traffic and transport conditions of the direct and indirect study areas including for any transportation schemes which have taken place, been approved or are planned for implementation, **with** the Proposed Scheme in place (i.e. the Do Minimum scenario with the addition of the Proposed Scheme). The Do Something scenario has been broken into two phases:
  - Construction Phase (Construction Year 2024) – This phase represents the single worst-case period which will occur during the construction of the Proposed Scheme.
  - Operational Phase (Opening Year 2028, Design Year 2043) – This phase represents when the Proposed Scheme is fully operational.

Further detail on the design years and the transport schemes that are included in the future ‘Do Minimum’ models can be found in section 8.

## 3.2 Proposed Scheme Transport Models

This section sets out the various transport modelling tools that have been developed and used to inform the preparation of the TIA and Chapter 6 (Traffic and Transport) of the EIAR and has supported design decisions. The purpose of each tool is detailed and the use of the tool for each element of the Proposed Scheme is defined.

The modelling tools that have been developed do not work in isolation but instead work as a combined modelling system driven by the ERM as the primary source for multi-model demand and trip growth etc. which is passed to the cordoned local area model, microsimulation models and junction models for the Proposed Scheme which have been refined and calibrated to represent local conditions to a greater level of detail than that contained within the ERM.

Importantly, no one tool can provide the full set of modelling data required to inform both the EIAR and TIA requirements and to support design iterations and decisions e.g. the ERM via the LAM has provided road traffic flow information (for example Annual Average Daily Traffic (AADT) and link speed data which has been used to inform Air Quality and Noise models).

The micro-simulation model is the most appropriate tool to provide the end-to-end bus journey times for the Proposed Scheme based on the detailed interaction of vehicle movements along the corridor. In addition, the LAM has been used directly for supporting design development decisions and to assist with an understanding of the implications of banned turns and potential trip redistribution away from the Proposed Scheme during both the Construction and Operational Phases.

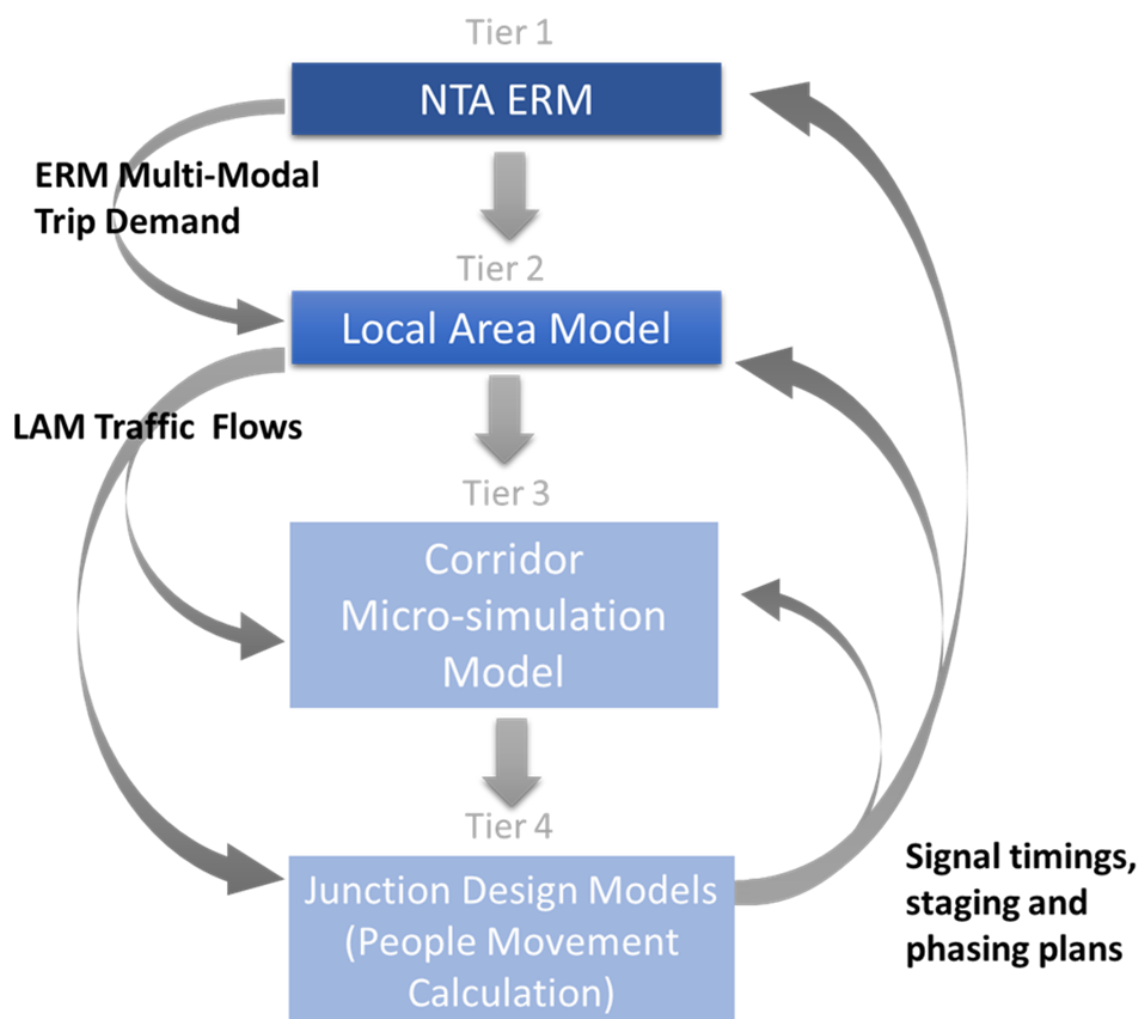
### 3.2.1 Proposed Scheme Transport Modelling Hierarchy

There are four tiers of transport modelling which have been used to assess the Proposed Scheme and these are detailed below and shown graphically in Diagram 3.1.

- **Tier 1 (Strategic Level):** The NTA’s East Regional Model (ERM) is the primary tool which has been used to undertake the strategic modelling of the Proposed Scheme and has provided the strategic multi-modal demand outputs for the proposed forecast years;
- **Tier 2 (Local Level):** A Local Area Model (LAM) has been developed to provide a more detailed understanding of traffic movement at a local level. The LAM is a subset model created from the ERM and contains a more refined road network model used to provide consistent road-based

outputs to inform the TIA, EIA and junction design models. This includes information such as road network speed data and traffic redistribution impacts for the Operational Phase. The LAM also provides traffic flow information for the micro-simulation model and junction design models and has been used to support junction design and traffic management plan testing;

- **Tier 3 (Corridor Level):** A micro-simulation model of the full ‘end to end’ corridor has been developed for the Proposed Scheme. The primary role of the micro-simulation model has been to support the ongoing development of junction designs and traffic signal control strategies and to provide bus journey time information for the determination of benefits of the Proposed Scheme; and
- **Tier 4 (Junction Level):** Local junction models have been developed, for each junction along the Proposed Scheme to support local junction design development. These models are informed by the outputs from the above modelling tiers, as well as the junction designs which are, as discussed above, based on people movement prioritisation.



**Diagram 3.1 Proposed Scheme Modelling Hierarchy**

The purpose of each of the modelling tools is summarised in Table 3.1 below and discussed further in subsequent sections.

**Table 3.1 Modelling tool and purpose**

| Tool    | Purpose                                                                                                                                                     | Inputs                                                                                                                    |
|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| NTA ERM | Forecast Multi-Modal demand impacts Proposed Scheme including both area wide and corridor level<br>Mode share<br>Policy assessment (e.g. demand management) | NTA Forecast Planning Data (2020,2028,2043)<br>Future year Proposed Scheme information (Traffic signal plans and timings) |

| Tool                                                 | Purpose                                                                                                                                                                                                                    | Inputs                                                                                                                                       |
|------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
|                                                      | Donor Network for LAM                                                                                                                                                                                                      |                                                                                                                                              |
| Local Area Model (LAM)                               | General Traffic Redistribution impacts<br>Link Flows (AADTs)<br>Link Speeds<br>Junction turning flows<br>Construction Strategy and Traffic Management measure testing<br>Donor network for Proposed Scheme Micro-sim model | Traffic surveys<br>Journey time data<br>ERM forecast matrices<br>Proposed Scheme designs<br>Proposed Scheme Traffic signal plans and timings |
| Micro-simulation Model                               | Operational features<br>Design validation<br>Person delay measurement<br>Bus journey times<br>Queue formation<br>Scheme visualization                                                                                      | LAM demand matrices<br>Proposed Scheme designs<br>Proposed Scheme Traffic signal plans and timings                                           |
| Junction Design Models / People Movement Calculation | Junction design tool<br>Proposed Scheme signal plan and timing development<br>People Movement Calculation                                                                                                                  | Junction Turning flows from LAM                                                                                                              |

The following sections describe in further detail each of the modelling tools and their role within the assessment of the Proposed Scheme.

### 3.2.2 NTA Regional Modelling System (RMS) and East Regional Model (ERM)

The East Regional Model (ERM) is part of the National Transport Authority's (NTA) 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 comprises the National Demand Forecasting Model (NDFM); five large-scale, detailed, multi-modal regional transport models; and, a suite of Appraisal Modules. The five regional models comprising the RMS are focussed on the travel to-work areas for Dublin (represented by the aforementioned East Regional Model (ERM)), for Cork (represented by the South West Regional Model (SWRM)), for Limerick (represented by the Mid-West Regional Model (MWRM)), for Galway (represented by the West Regional Model (WRM)) and for Waterford (represented by the South East Regional Model (SERM)).

The key attributes of the five regional models include; full geographic coverage of each region, detailed representations of all major surface transport modes including active modes, road and public transport networks and services, and of travel demand for five time periods (AM, 2 Inter-Peaks, PM and Off-Peak). The RMS encompasses behavioural models calibrated to 2017 National Household Travel Survey<sup>2</sup> data that predict changes in trip destination and mode choice in response to changing traffic conditions, transport provision and/or policies which influence the cost of travel.

#### 3.2.2.1 Purpose of the RMS

The NTA uses the RMS to help inform decisions required during strategy development and to assess schemes and policy interventions that are undertaken as part of its remit. The RMS has been developed to provide the NTA with the means to undertake comparative appraisals of a wide range of potential future transport and land use options, and to provide evidence to assist in the decision-making process. Examples of how the RMS can assist the NTA include testing new public transport schemes by representing the scheme in the assignment networks, testing demand management measures by, for example, changing the cost of parking or number of parking spaces within the regional model or testing the impacts of new land use by changing the planning data assumptions within the NDFM.

The RMS includes the 2016 Census/POWSCAR and 2017 National Household Travel Survey (NHTS) data sets and the NTA has included a range of improvements to the main model components where identified and implemented. These improvements include improving and making changes to such elements as the NDFM, development of the Long-Distance Model, updated zoning, networks, and parking modules; best-practice discrete

<sup>2</sup> [https://www.nationaltransport.ie/wp-content/uploads/2019/01/National\\_Household\\_Travel\\_Survey\\_2017\\_Report\\_-\\_December\\_2018.pdf](https://www.nationaltransport.ie/wp-content/uploads/2019/01/National_Household_Travel_Survey_2017_Report_-_December_2018.pdf)

choice modelling using the NHTS and POWSCAR datasets to estimate the parameters of the behavioural models, improved model runtimes, and general model functionality improvements.

### 3.2.2.2 RMS Components

The NTA RMS comprises of the following three main components, namely:

- The National Demand Forecasting Model (NDFM);
- 5 Regional Models (including the ERM); and
- A suite of Appraisal Modules.

The NDFM takes input attributes such as land-use data, population etc., and estimates the total quantity of daily travel demand produced by, and attracted to, each of the 18,641 Census Small Areas in Ireland.

The ERM is a strategic multi-modal transport model representing travel by all the primary surface modes – including, walking and cycling (active modes), and travel by car, bus, rail, tram, light goods and heavy goods vehicles, and broadly covers the Leinster province of Ireland including the counties of Dublin, Wicklow, Kildare, Meath, Louth, Wexford, Carlow, Laois, Offaly, Westmeath, and Longford, plus Cavan and Monaghan.

The ERM 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, carries out mode and destination choice, and outputs origin-destination travel matrices to the assignment models. The FDM and assignment models run iteratively until an equilibrium between travel demand and the cost of travel is achieved; and
- **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 each origin and destination pair.



Destination and mode choice parameters within the ERM have been calibrated using two main sources: Census 2016 Place of Work, School or College - Census of Anonymised Records (2016 POWSCAR), and the Irish National Household Travel Survey (2017 NHTS).

### 3.2.2.3 The use of the ERM for the Proposed Scheme

The NTA's ERM is the most sophisticated modelling tool available for assessing complex multi modal movements within an urban context. This provides a consistent framework for transport assessments. The ERM is the ideal tool to use as a basis for the assessment of the Proposed Scheme and to estimate its multi-modal impact. In addition, it provides the platform to forecast future trip demand and distribution.

The NTA ERM is, therefore, the primary high-level modelling tool for the strategic transport assessment of the Proposed Scheme, providing the sole source of multi-modal forecast trip / person demand for each of the scenarios to be assessed. The ERM provides the strategic impacts and benefits of the Proposed Scheme and the outputs from the ERM provide key inputs to the Transport Impact Assessments (TIA) and EIAR.

### **3.2.3 Local Area Model (LAM)**

To support the detailed assessment of the Proposed Scheme a more disaggregate urban area traffic model was developed, as a cordoned model from the ERM, that could incorporate the most up to date traffic survey data. The LAM has provided the appropriate level of detail required to inform the various disciplines and levels of decision making for the Proposed Scheme e.g. capturing the impact of redistribution of traffic on streets and roads not included within the strategic detail of the ERM. As such, a Local Area Model (LAM) has been developed to support the assessment of the Proposed Scheme.

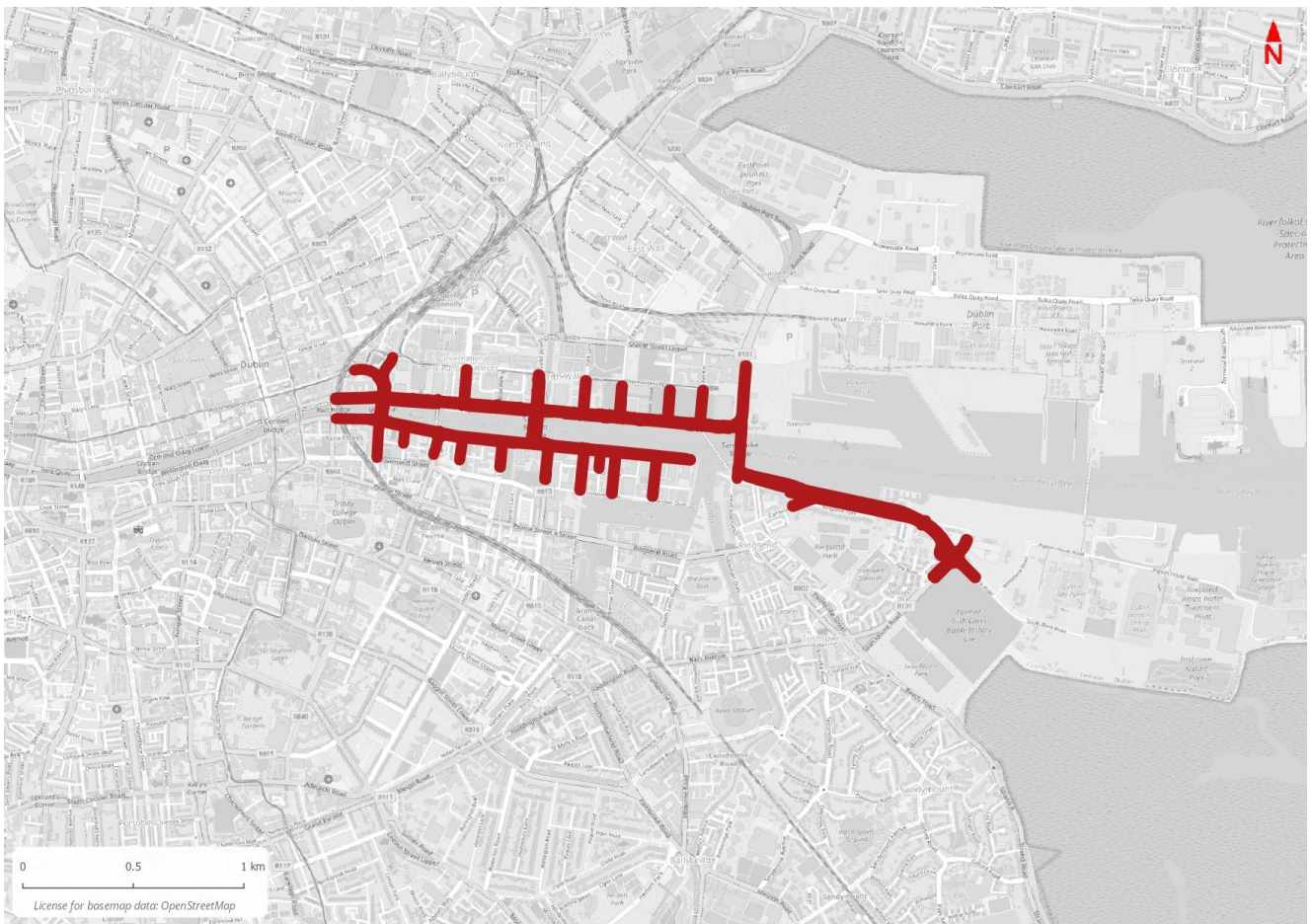
The LAM is compatible with the ERM road network, being a direct extraction from the ERM road model, but with the addition of extra road network and zoning detail. The LAM is calibrated and validated with the most recent 2019/2020 traffic survey data and journey time information, which ensures that the model reflects 'on-the-ground' conditions for the Proposed Scheme in February 2020 (e.g. prior to COVID-19 restrictions).

The LAM which is a more refined version of the road network model component of the ERM has been used to provide all road-based outputs to inform the TIA, EIA and junction design models. i.e. AADTs, road network speed data, traffic re-distribution impacts during construction and operation of the Proposed Scheme. The LAM also provides traffic flow information for the corridor micro-simulation models and junction design models.

### **3.2.4 Proposed Scheme Micro-Simulation Model**

A micro-simulation model has been developed for the full continuous 'end-to-end' route of the Proposed Scheme. The 'end-to-end' Corridor Micro-simulation model has been developed to assist in the operational validation of the scheme designs and to provide visualisation of scheme operability along with its impacts and benefits.

The term 'end-to-end' refers to the point of model 'entry' (start of Proposed Scheme) to the point of model 'exit' (end of Proposed Scheme) rather than the actual bus service terminus points which, in most cases, lies outside of the modelled area. The modelling of the Proposed Scheme shows the differences in travel time for buses along the full length of the Proposed Scheme, including delay at individual locations.



**Diagram 3.2 Proposed Scheme Microsimulation Model Network**

### **3.2.5 Role of the Corridor Micro-Simulation Models**

The Proposed Scheme micro-simulation model has provided key information on end-to-end bus and car journey times along the Proposed Scheme. The Proposed Scheme micro-simulation model is supplied traffic flow information from the LAM and uses consistent information from the junction design models, in terms of signal plans, green times, staging, phasing and offsets. 3D Visualisations of sections of the Proposed Scheme have been developed based on the 2D models to help visualise and demonstrate the benefits and impacts of the scheme to stakeholders.

Overall, the Proposed Scheme micro-simulation model has provided key transport metric inputs to the TIA in terms of operational features, vehicle interaction, person level delay and bus journey time and reliability performance.

### **3.2.6 Proposed Scheme Junction Design Models**

The fourth tier of modelling in the modelling hierarchy to support the assessment of the Proposed Scheme is the individual junction design models that have been developed for junctions along the Proposed Scheme. These junction design models are supplied with traffic flow information from the LAM and from the micro-simulation model for the Proposed Scheme. The LAM, Micro-simulation and local junction models contain consistent design, transport demand, signal phasing and staging information.

### **3.2.7 Role of the Proposed Scheme Junction Design Models**

The junction design models have been used to inform junction design considerations as part of the formulation of the Preliminary Design for the Proposed Scheme. The junction models have been developed for standalone junction assessments and for combinations of secondary (off-line to Proposed Scheme) junctions. The junction models have been used in combination with the Proposed Scheme micro-simulation model at 'hot-spot' locations for operational testing and 'proof of concept' development of the preferred design.

The junction design models are important supporting design tools for analysis of the design proposals and have informed the development of signal plans and phasing at junctions along the Proposed Scheme. The junction models have been used to inform the LAM and Proposed Scheme micro-simulation model, with information such as design amendments, signal plans and timings being fed back in the iterative process where appropriate.

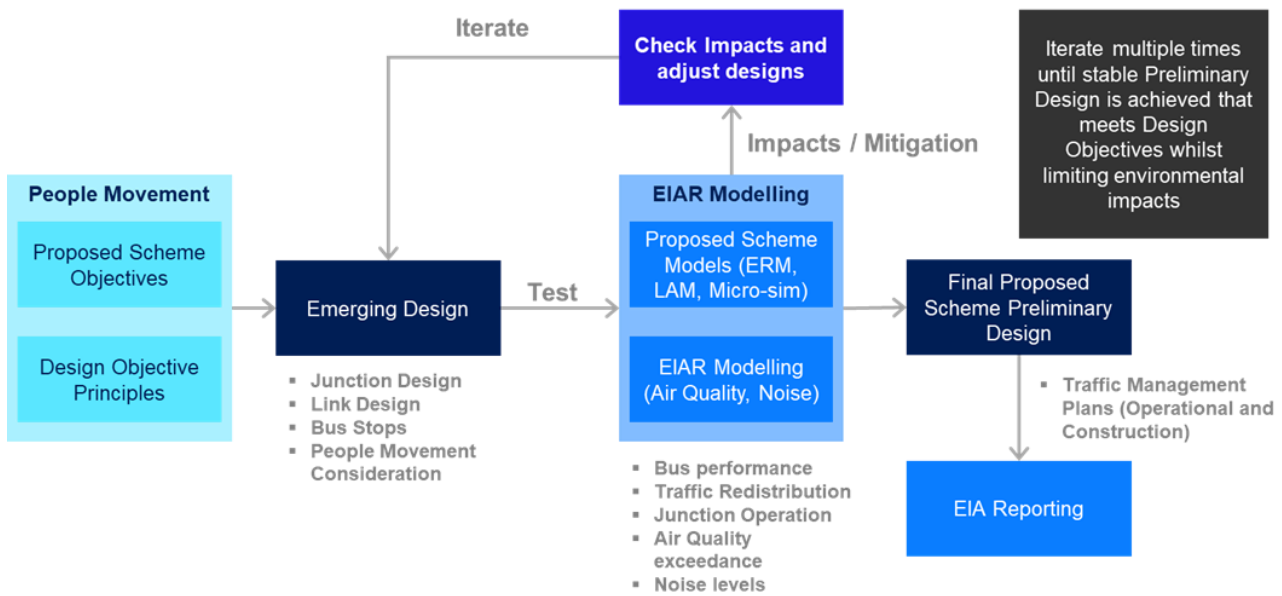
As part an iterative process, the resultant scheme designs were then re-modelled in the ERM, LAM and micro-simulation models to understand the strategic and corridor specific issues and inform the preparation of the TIAs and EIARs and the planning submission for the Proposed Scheme.

### **3.2.8 Iterative Design Process and Mitigation by Design**

Throughout the development of the Preliminary Design for the Proposed Scheme there have been various design stages undertaken based on a common understanding of the maturity of the design at a given point in time. Part of this process, and the reason for developing a multi-tiered modelling framework (described further below), was to ensure the environmental and transport impacts were mitigated to the greatest extent possible during design development and to enable information on potential impacts to be provided from the various Environmental Impact Assessment (EIA) and Transport Impact Assessment (TIA) disciplines back into the design process for consideration and inclusion in the proposals. This process resulted in embedding mitigation into the design process by the consideration of potential environmental impacts throughout the Preliminary Design development process.

Diagram 3.3 below illustrates this process whereby the emerging design for the Proposed Scheme have been tested using the transport models described above as part of an iterative process. The transport models provided an understanding of the benefits and impacts of the proposals (mode share changes, traffic redistribution, bus performance etc.) with traffic flow information also informing other environmental disciplines (Air Quality, Noise and Vibration, Climate etc.) which in turn allowed feedback of potential impacts into the design process to allow for changes and in turn mitigation to be embedded in the designs. The process included physical changes, adjustments to traffic signal staging, phasing and green times to limit traffic displacement as well as traffic management arrangements and/or turn bans where appropriate. This ensured that any displaced traffic was maintained on higher capacity roads, whilst continuing to meet scheme objectives along the Proposed Scheme.

The iterative process concluded when the design team were satisfied that the Proposed Scheme met its required objectives (maximising the people movement capacity of the Proposed Scheme) and that the environmental impacts and level of residual impacts were reduced to a minimum.



**Diagram 3.3 Proposed Scheme Impact Assessment and Design Interaction**

The impacts presented in the TIA and Chapter 6 (Traffic & Transport) of the EIAR are based on the final Preliminary Design for the Proposed Scheme which includes the embedded mitigation developed as part of the iterative design process described above.

### 3.3 Base Model Development Methodology

The base year for the Proposed Scheme models is 2020 (Pre-COVID19) based on the date of traffic surveys undertaken for the CBC Infrastructure Works in November 2019 and February 2020. The following section provides an overview of the ERM, LAM and Proposed Scheme Micro-simulation base models development methodology. The junction design models (Tier 4) are developed for the Proposed Scheme designs and don't require base model development like the Tier 1-3 models.

#### 3.3.1 ERM 2020 Model Development Methodology

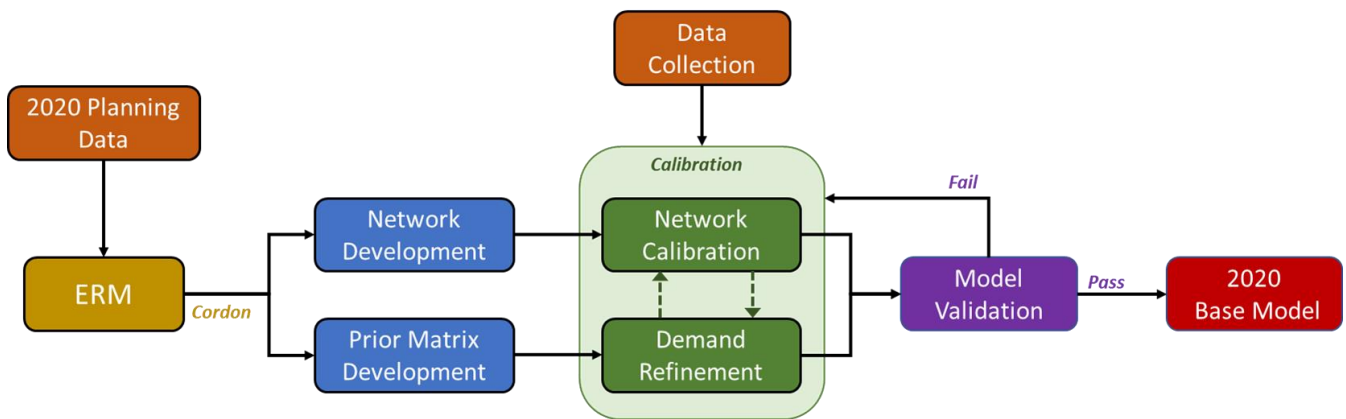
A 2020 baseline (existing conditions) ERM run was required for the development of the LAM and subsequent base models for the Proposed Scheme. This was done through the following steps:

- Update of Road and Public Transport networks to 2020 conditions;
  - The ERM road network was updated to include road schemes that were implemented to February 2020. In addition, the most recent public transport timetable information was provided from the NTA Journey Planner and updated within the ERM.
- Update of demand data (Trip Ends) to 2020;
  - 2016 Census planning data for population, employment and education was updated to 2020 based on a linear interpolation between the 2016 data and the future reference case forecasts provided by the NTA. This data was passed through the NDFM to generate base year demand which was then run in the NTA ERM along with the updated 2020 networks.

#### 3.3.2 LAM Development Methodology

The methodology for developing the LAM from the ERM is illustrated in Diagram 3.4 below.





**Diagram 3.4 LAM Development Methodology**

In summary:

- **ERM Cordon:** The 2020 ERM road assignment was cordoned<sup>3</sup> to extract the initial network and traffic matrix to provide a starting point for the LAM;
- **LAM Network and Prior Matrix Development:** The newly formed LAM was then reviewed in detail which included a review of junction layouts, network speeds, banned turns, missing links etc. The zone system within the LAM was disaggregated, where necessary, to ensure a more accurate representation of traffic loading onto the road network was captured. Further details on the network and zone system development is provided in section 6; and
- **Data Collection:** Traffic survey data including link counts, junction turning counts and journey time information was collected and used to calibrate and validate the LAM (refer to section 5 for further information).

The LAM was calibrated in-line with Transport Infrastructure Ireland’s (TII) Project Appraisal Guidelines (PAG) and the UK Department for Transport (DfT) TAG guidance, and further information is provided in section 6. The LAM was validated in-line with TII and TAG guidance, and further information is provided in section 7 of this report.

### 3.3.3 Proposed Scheme Micro-Simulation Model Development Methodology

The development of the Proposed Scheme Micro-simulation model follows a similar process to that of the LAM, but at a more refined and detailed level along the direct extents of the Proposed Scheme alignment. For example, both the LAM and the micro-simulation model start with an initial prior matrix based on a cordon of the ERM.

Similarly, to the LAM, the Micro-simulation model was calibrated and validated in-line with Transport Infrastructure Ireland’s (TII) Project Appraisal Guidelines (PAG) and the UK Department for Transport (DfT) TAG guidance, and further information is provided in section 7. The micro-simulation model would aim to achieve a higher level of calibration / validation along the Proposed Scheme that the LAM which covers a wider area.

<sup>3</sup> Cordoning is the process of creating a smaller area model (network and demand) from a larger model

## 4. Transport Modelling Specification

### 4.1 Introduction

This section provides an overview of the key parameters that define the Proposed Scheme models, with specific reference to the following aspects:

- Model Area;
- Model Time Periods;
- Demand Segmentation;
- Model Software; and
- Modelling Input Parameters.

### 4.2 Model Area of Proposed Scheme Models

This section provides an overview of the model areas for each of the Proposed Scheme models, namely the ERM, LAM and Proposed Scheme Microsimulation model which are shown in Diagram 4.1 below.

The ERM broadly covers the travel to work area of Dublin city and encompasses the Leinster province of Ireland including the counties of Dublin, Wicklow, Kildare, Meath, Louth, Wexford, Carlow, Laois, Offaly, Westmeath, and Longford, plus Cavan and Monaghan and is shown in Diagram 4.1 below. The LAM covers the main urban area of Dublin, which is the study area for all Proposed Schemes. The Proposed Micro-simulation modelled area includes the direct alignment of the Proposed Scheme and immediate sections of adjoining road networks.



**Diagram 4.1 ERM, LAM and Micro-simulation Model Areas**

## 4.3 Modelled Time Periods

The transport models developed for the Proposed Scheme cover all time periods across a typical average weekday. The ERM demand model covers the following time periods with the road and public transport models assigning a representative 1-hour within each of the 3-hr demand periods:

- AM Peak period covering the period between 07.00-10.00;
- Morning Inter-Peak covering the period between 10.00-13.00;
- Afternoon Inter-Peak covering the period between 13.00-16.00;
- PM Peak period covering the period between 16.00-19.00; and
- Off-Peak covering the period between 19.00-07.00.

The LAM covers the 4 peak hour time periods outlined below:

- AM Peak hour covering the period between 08.00-09.00;
- Morning Inter-Peak hour covering the period between 12.00-13.00;
- Afternoon Inter-Peak hour covering the period between 15.00-16.00; and
- PM Peak hour covering the period between 17.00-18.00.

The Proposed Scheme Microsimulation Model covers the following periods:

- Weekday AM peak between 07:00 and 10:00; and
- Weekday PM peak between 16:00 and 19:00.

## 4.4 Demand Segmentation

Different components of the model require the sub-division of travel demand into various classifications with the most prevalent sub-divisions are by demand segment and user class.

Demand segments are used to categorise trips into meaningful segments where there is a notable difference in travel choice primarily relating to mode choice or destination choice. User classes represent combinations of vehicle type, purpose and person type and are more important for route choice in assignment models where a clear difference exists in how they will be modelled such as value of time or free fares.

### 4.4.1 ERM Demand Segmentation:

The ERM includes 33 different demand purposes which is made up of the following segmentations:

- Home base journey purposes, such as:
  - Commute;
  - Education;
  - Escort to Education;
  - Shopping;
  - Visiting friends/relatives;
  - Employers business; and
  - Other (which combines all trip types not part of the above categories).
- Non-home-based trips, derived from the destinations of home-based trips.

All home-based trips are segmented by car availability, which is a function of household car ownership and competition levels.

### 4.4.2 LAM User Classes

As outlined previously in section 3, the prior travel demand for the LAM was derived from the NTA's ERM. The ERM road assignment matrices contain the following ten user classes:

- UC1 - Car Employer's Business (in work time)
- UC2 - Car Commute (travel to/from work);
- UC3 - Car Other (other non-work purposes such as shopping, visiting friends, etc.);
- UC4 - Car Education (travel to/from school);
- UC5 - Car Retired;
- UC 6 - Taxi;
- UC7 - Light Goods Vehicles (LGV);
- UC8 - Other Goods Vehicles (OGV) 1;
- UC9 - OGV2 Permit Holder (5 or more axles and allowed drive in Dublin city centre); and
- UC10 - OGV2 (5 or more axles and not allowed drive in Dublin city centre).

Each user class has its own defined set of generalised cost parameters based on a price per kilometer and a price per minute. To ensure consistency with the larger strategic ERM, the ten user classes and their associated generalised cost parameters were retained for the LAM.

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

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

### 4.4.3 Proposed Scheme Micro-Simulation Model Segmentation

The Proposed Scheme micro-simulation model contains the following 'vehicle classes':

- Taxi (LV);
- Car (LV);
- LGV (LV);
- OGV1 (HV);
- OGV2 (Permit Holder) (HV);
- OGV2 (Other) (HV);
- Bus (HV);
- Tram;
- Cyclist (standard) (Cycles);
- Cyclist (confident) (Cycles);
- Man (Pedestrians); and
- Woman (Pedestrians).

## 4.5 Model Software

The following section outlines the software in which the Proposed Scheme modelling tools have been developed.

### 4.5.1 ERM Software

The ERM is built within the following transport modelling software packages:

- Road Model is built within SATURN4 software; and
- NDFM, Public Transport Model and Choice Modelling components are built within the CUBE Voyage software.

### 4.5.2 LAM Software

The model software used to develop the LAM is the SATURN suite of transportation modelling programs with the model calibrated and validated using release versions 11.4.07 of the software. SATURN has 6 basic functions:

1. As a combined traffic simulation and assignment model for the analysis of road-investment schemes ranging from traffic management schemes over relatively localised networks (typically of the order of 100 to 200 nodes) through to major infrastructure improvements where models with over 1,000 junctions are not infrequent;
2. As a "conventional" traffic assignment model for the analysis of much larger networks (e.g., up to 6,000 links in the standard PC version, 37,500 in the largest);
3. As a simulation model of individual junctions;
4. As a network editor, data base and analysis system;
5. As a matrix manipulation package for the production of, for example, trip matrices; and
6. As a trip matrix demand model covering the basic elements of trip distribution, modal split, etc.

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<sup>4</sup> SATURN - Simulation Assignment of Traffic to Urban Road Networks

### 4.5.3 Proposed Scheme Micro-Simulation Model Software

The Proposed Scheme micro-simulation model has been developed using PTV VISSIM 11-09. This represents the latest version of the software at the time of writing.

## 4.6 Modelling Input Parameters

### 4.6.1 ERM / LAM Input Parameters

The SATURN application SATNET was used to build the various data files into an assignable road network (UFN) file.

Matrices were then assigned to the network using the SATALL application, where it iterates through assignment and simulation loops until the user defined levels of convergence are reached (RSTOP and STPGAP), or the model reaches the user defined maximum number of assignment and simulation loops (MASL). SATALL uses a converged equilibrium assignment method to assign the traffic to the road network over successive iterations, until user defined convergence criteria are achieved. The key convergence criteria are presented in Table 4.1 and represent a very tight level of convergence.

**Table 4.1 LAM SATURN Convergence Criteria**

| VARIABLE | DESCRIPTION                                                                                                            | VALUE |
|----------|------------------------------------------------------------------------------------------------------------------------|-------|
| MASL     | Maximum number of assignment / simulation loops.                                                                       | 150   |
| PCNEAR   | Percentage change in flows judged to be “near” in successive assignments                                               | 1%    |
| RSTOP    | The assignment / simulation loops stop if RSTOP % of link flows change by less than PCNEAR % in successive assignments | 98%   |
| NISTOP   | Number of successive loops which must satisfy the RSTOP criteria for convergence                                       | 4     |
| STPGAP   | Critical gap value (%) used to terminate assignment / simulation loops                                                 | 0.05  |

### 4.6.2 Micro-simulation Inputs Parameters

The Micro-simulation model includes a range of ‘link behaviour types’. For each ‘link type’, there is a corresponding ‘vehicle types’ and ‘driver behaviour parameter sets’.

## 5. Proposed Scheme Data Collection

### 5.1 Introduction

The following section provides an overview of the data collection exercise undertaken to facilitate the calibration and validation of the LAM, Proposed Scheme micro-simulation and junction models. Existing data sources were reviewed to identify available counts and locate gaps in observed information across the model area. This review was used to define a specification for additional counts which were commissioned for the area. The combination of new commissioned counts, and existing available information, provided a comprehensive dataset for calibration and validation.

### 5.2 Existing Data Review (GAP Analysis)

A review of existing traffic survey data available for the model area was undertaken from the following sources:

- NTA count database: A mixture of Automatic Traffic Counts (ATC) and Junction Turning Counts (JTC) from previous studies covering a range of years;
- TII Counters: Permanent TII ATCs located on national strategic roads across the network with data publicly available online.

The NTA, Dublin City and the other local authorities undertake periodic counts within their administrative areas in connection with their own local schemes. These surveys are conducted throughout the year and a limited set of data was available within the area of the Proposed Scheme.

Information on bus passenger volumes was already available and included in the modelling process as part of the ERM base model calibration and validation, which includes the annual canal and M50 cordon counts as well as ticketing data.

### 5.3 Commissioned Traffic Survey Data

The information in this section presents the methodology adopted to prepare counts as inputs to the model calibration and validation process. The two types of counts used in the study are Junction Traffic Counts (JTCs) and Automatic Traffic Counts (ATCs).

#### 5.3.1 Junction Turning Counts (JTCs)

The JTCs are 24-hour counts broken down into 15 minute segments over a full day. As indicated in Table 5.1 all main junctions along the Proposed Scheme have been included and provide information on the volume, and types of vehicles, making turning movements at each location. This data is utilised within the LAM calibration to ensure that the flow of vehicles through the main junctions on the network is being represented accurately.

#### 5.3.2 Automatic Traffic Counts (ATCs)

The ATC data provides information on:

- The daily and weekly profile of traffic along the Proposed Scheme; and
- Busiest time periods and locations of highest traffic demand on the network.

Both sets of counts were surveyed by IDASO Ltd. The JTCs were surveyed on the 30<sup>th</sup> of February 2020. The ATCs were surveyed between the 28<sup>th</sup> of January 2020 and the 3<sup>rd</sup> of February 2020.

**Table 5.1 Survey Overview**

| SURVEY TYPE | COMPANY | NUMBER | DATES |
|-------------|---------|--------|-------|
|-------------|---------|--------|-------|

|     |       |    |                      |
|-----|-------|----|----------------------|
| JTC | IDASO | 33 | Thu 30/1/2020        |
| ATC | IDASO | 4  | 28/1/2020 - 3/2/2020 |

The various components of traffic have different characteristics in terms of operating costs, growth and occupancy. The surveys used the most common categories as defined by COBA; these are:

- **Cars (CARS):** Including taxis, estate cars, ‘people carriers’ and other passenger vehicles (for example, minibuses and camper vans) with a gross vehicle weight of less than 3.5 tonnes, normally ones which can accommodate not more than 15 seats. Three-wheeled cars, motor invalid carriages, Land Rovers, Range Rovers and Jeeps and smaller ambulances are included. Cars towing caravans or trailers are counted as one vehicle unless included as a separate class;
- **Light Goods Vehicles (LGV):** Includes all goods vehicles up to 3.5 tonnes gross vehicle weight (goods vehicles over 3.5 tonnes have sideguards fitted between axles), including those towing a trailer or caravan. This includes all car delivery vans and those of the next larger carrying capacity such as transit vans. Included here are small pickup vans, three-wheeled goods vehicles, milk floats and pedestrian controlled motor vehicles. Most of this group is delivery vans of one type or another;
- **Other Goods Vehicles (OGV 1):** Includes all rigid vehicles over 3.5 tonnes gross vehicle weight with two or three axles. Also includes larger ambulances, tractors (without trailers), road rollers for tarmac pressing, box vans and similar large vans. A two or three axle motor tractive unit without a trailer is also included;
- **Other Goods Vehicles (OGV 2):** This category includes all rigid vehicles with four or more axles and all articulated vehicles. Also included in this class are OGV1 goods vehicles towing a caravan or trailer; and
- **Buses and Coaches (PSV):** Includes all public service vehicles and work buses with a gross vehicle weight of 3.5 tonnes or more, usually vehicles with more than 16 seats.

## 5.4 Count Data for Calibration and Validation

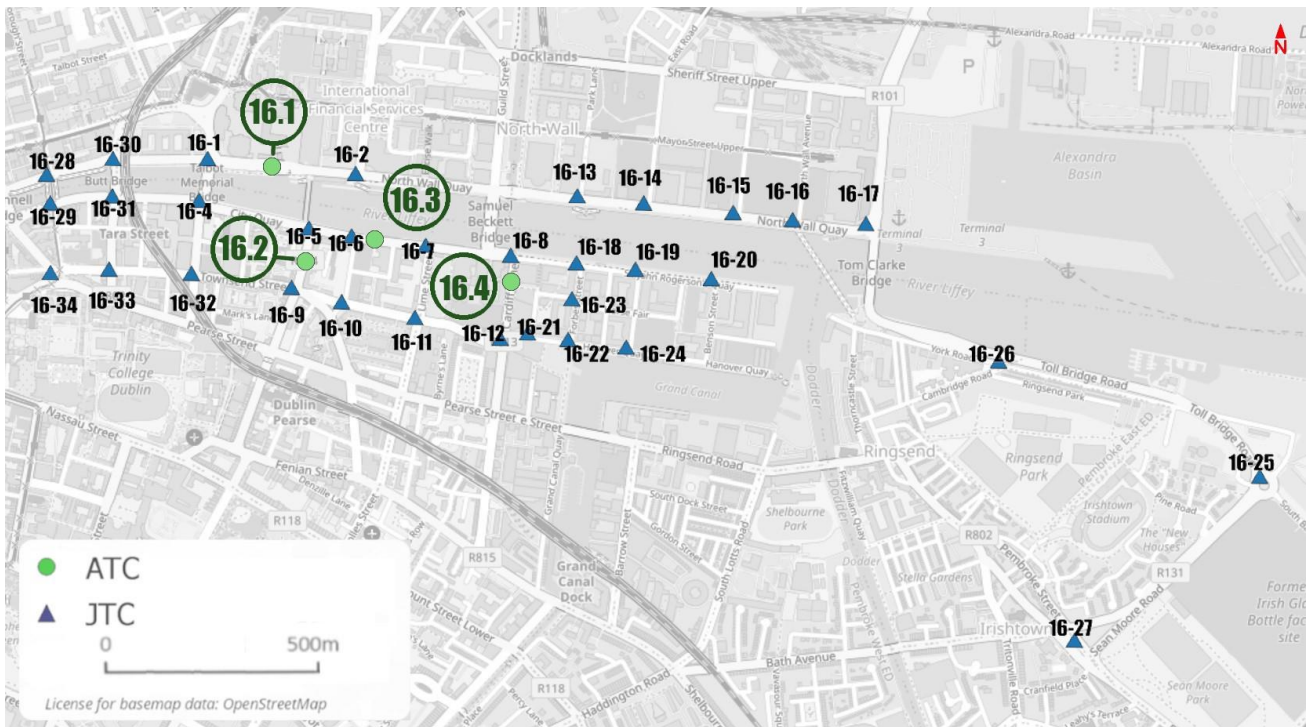
Diagram 5.1 shows the locations of the 33 JTC counts and 4 ATC counts for the Proposed Scheme.

Summary information related to the JTC junctions is provided in Table 5.2. The busiest junction in the study area is the Custom House Quay/Memorial Road junction (40527 daily movements). The next busiest junctions are:

- Eden Quay/Butt Bridge (33,943 daily movements)
- Georges Quay/Butt Bridge (33,608 daily movements)
- North Wall Quay/East Wall Road (31,650 daily movements)
- Tara Street/Townsend Street (30,645 daily movements)

The least busy junction in the study area is the Cambridge Road/York Road junction with 2373 daily movements. The average weekday ATC flows (all vehicles) are shown in Table 5.3. The highest ATC daily flows are on Custom House Quay at Georges Dock.





**Diagram 5.1 ATC and JTC Traffic count location**

**Table 5.2 JTC Locations**

| JUNCTION IDENTIFIER | JUNCTION NAME                              | TYPE     | DAILY MOVEMENTS | AM MOVEMENTS | PM MOVEMENTS |
|---------------------|--------------------------------------------|----------|-----------------|--------------|--------------|
| 16-1                | Custom House Quay/Memorial Road            | Signals  | 40527           | 3450         | 2491         |
| 16-2                | North Wall Quay/Commons Street             | Signals  | 19441           | 1503         | 1267         |
| 16-4                | City Quay/Memorial Road                    | Priority | 30273           | 2605         | 1949         |
| 16-5                | City Quay/Lombard Street                   | Signals  | 19846           | 1696         | 1526         |
| 16-6                | City Quay/Creighton Street                 | Priority | 8012            | 956          | 788          |
| 16-7                | Sir John Rogerson's Quay/Lime Street       | Priority | 6389            | 674          | 686          |
| 16-8                | Sir John Rogerson's Quay/Cardiff Lane      | Signals  | 24182           | 2132         | 1709         |
| 16-9                | Lombard Street/Townsend Street             | Signals  | 20614           | 1812         | 1273         |
| 16-10               | Creighton Street/Hanover Street East       | Priority | 4129            | 458          | 259          |
| 16-11               | Lime Street/Hanover Street East            | Priority | 5869            | 636          | 546          |
| 16-12               | Cardiff Lane/Hanover Street East           | Signals  | 21832           | 1721         | 1202         |
| 16-13               | North Wall Quay/Park Lane                  | Signals  | 14172           | 1072         | 1099         |
| 16-14               | North Wall Quay/New Wapping Street         | Signals  | 14782           | 1294         | 1139         |
| 16-15               | North Wall Quay/Castleforbes Road          | Priority | 12101           | 958          | 889          |
| 16-16               | North Wall Quay/North Wall Avenue          | Priority | 11305           | 897          | 810          |
| 16-17               | North Wall Quay/East Wall Road             | Priority | 31650           | 2434         | 2252         |
| 16-18               | Sir John Rogerson's Quay/Forbes Street     | Priority | 7641            | 909          | 725          |
| 16-19               | Sir John Rogerson's Quay/Blood Stoney Road | Priority | 3476            | 349          | 268          |

| JUNCTION IDENTIFIER | JUNCTION NAME                          | TYPE     | DAILY MOVEMENTS | AM MOVEMENTS | PM MOVEMENTS |
|---------------------|----------------------------------------|----------|-----------------|--------------|--------------|
| 16-20               | Sir John Rogerson's Quay/Benson Street | Priority | 2555            | 246          | 198          |
| 16-21               | Misery Hill/Hibernian Road             | Priority | 5932            | 527          | 352          |
| 16-22               | Misery Hill/Forbes Street              | Priority | 6628            | 859          | 694          |
| 16-23               | Forbes Street/Lazer Lane               | Priority | 6758            | 838          | 596          |
| 16-24               | Hanover Quay/Blood Stoney Road         | Priority | 2800            | 320          | 290          |
| 16-25               | Sean Moore Road/East Link Road         | Priority | 25065           | 1859         | 1620         |
| 16-26               | Cambridge Road/York Road               | Priority | 2373            | 210          | 288          |
| 16-27               | Sean Moore Road/Beach Road             | Signals  | 27526           | 2125         | 1572         |
| 16-28               | Eden Quay/Rosie Hackett Bridge         | Signals  | 16282           | 1196         | 947          |
| 16-29               | Rosie Hackett Bridge/Burgh Quay        | Signals  | 19421           | 1062         | 1437         |
| 16-30               | Eden Quay/Butt Bridge                  | Signals  | 33943           | 2085         | 2484         |
| 16-31               | George's Quay/Butt Bridge              | Signals  | 33608           | 1718         | 2598         |
| 16-32               | Moss Street/Townsend Street            | Signals  | 8280            | 1025         | 471          |
| 16-33               | Tara Street/Townsend Street            | Signals  | 30645           | 2119         | 2145         |
| 16-34               | D'Olier Street/College Street          | Signals  | 20967           | 1494         | 974          |

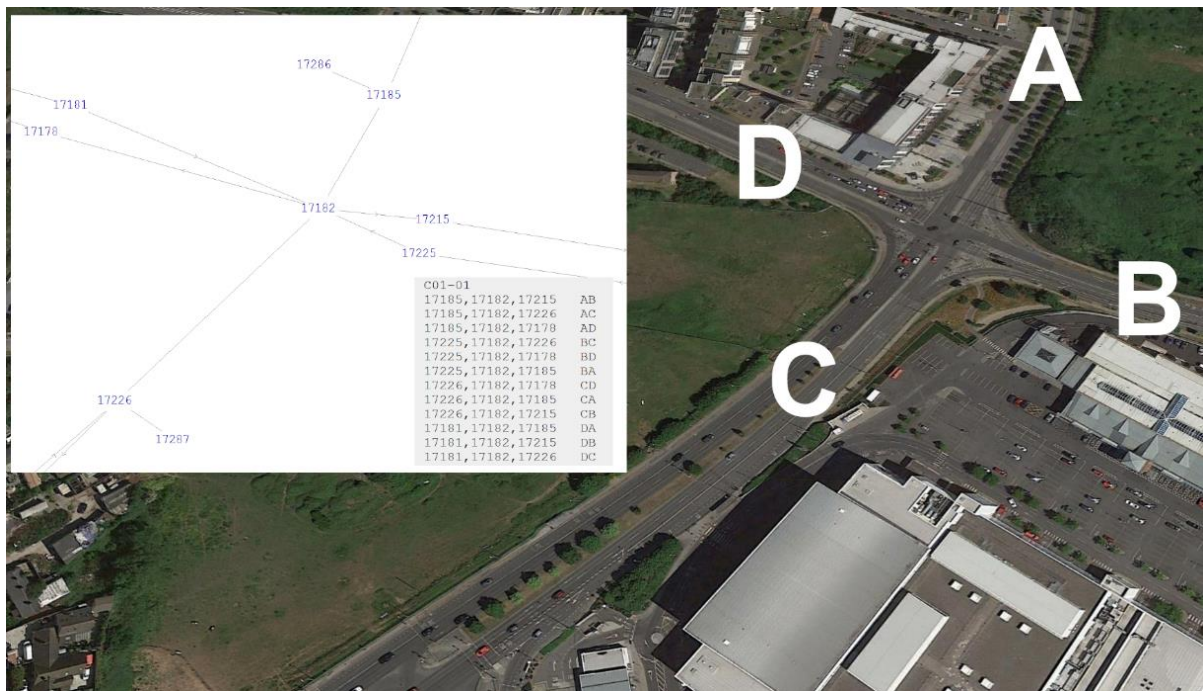
**Table 5.3 ATC Locations**

| ATC IDENTIFIER | ATC LOCATION                      | DIRECTION  | DAILY MOVEMENTS | AM MOVEMENTS | PM MOVEMENTS |
|----------------|-----------------------------------|------------|-----------------|--------------|--------------|
| 16.1A          | Custom House Quay at Georges Dock | Eastbound  | 9299            | 589          | 523          |
| 16.1B          |                                   | Westbound  | 5352            | 336          | 359          |
| 16.2A          | Lombard Street                    | Southbound | 11519           | 641          | 743          |
| 16.3A          | John Rodgerons Quay               | Westbound  | 7000            | 373          | 315          |
| 16.3B          |                                   | Eastbound  | 7023            | 364          | 332          |
| 16.4A          | Cardiff Lane                      | Northbound | 5784            | 349          | 363          |
| 16.4B          |                                   | Southbound | 5420            | 378          | 367          |

Private cars and taxis were aggregated as a single vehicle type for input to the LAM model. The OGV1 and OGV2 categories were also aggregated as HGVs. PSVs are modelled as fixed routes with a specific frequency in the model and as such were not included in the model inputs. PCL counts are not included in the model inputs. Separate input files were prepared for the following time periods.

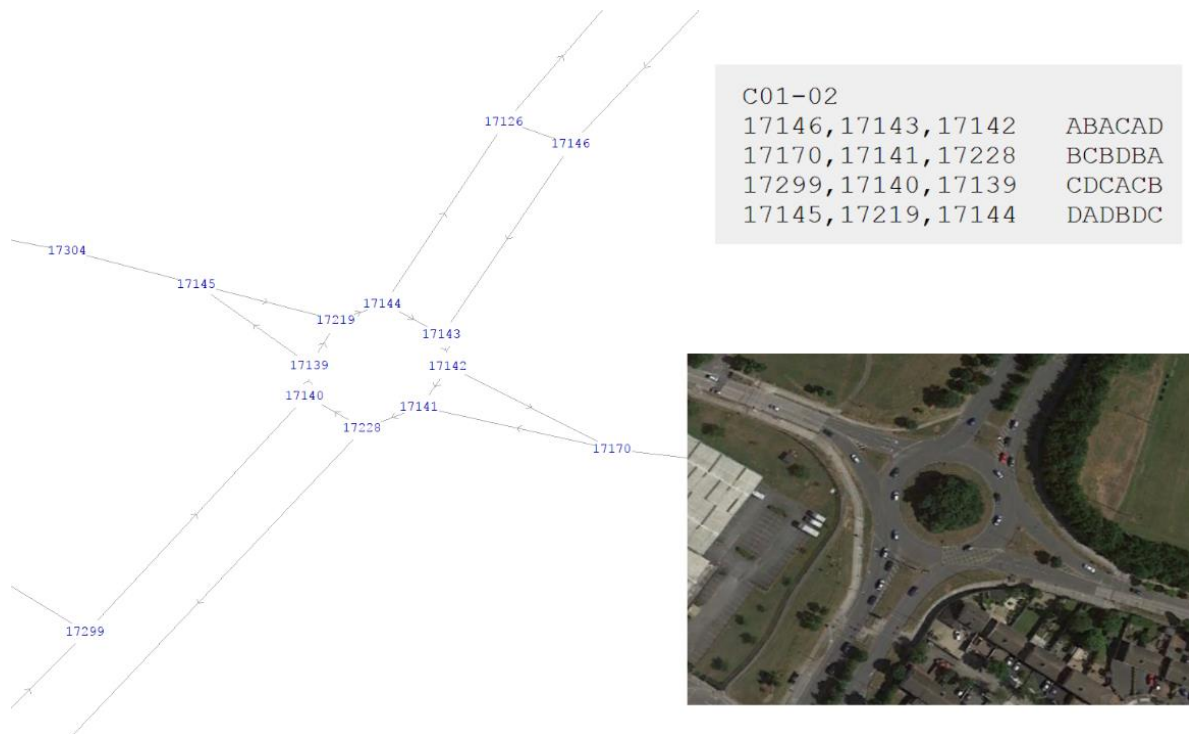
- AM: 0800-0900;
- LT: 1200-1300;
- SR: 1500-1600;
- PM: 1700-1800; and
- OP: 2000-2100.

The JTCs were merged into a 'flat format' database which permits the extraction of counts grouped by modelled hour (AM, LT, SR or PM) and modelled vehicle category (Car, LGV or HGV). Turn count records were given a unique movement identifier (AB, AC, AD etc). These identifiers were then associated with their respective nodes in the LAM. In some cases, there is a unique one-to-one relationship between the turn counts and the SATURN network as shown in Diagram 5.2 below.



**Diagram 5.2 Bus Connects LAM Node Matching (Junction C01-01)**

The flows for complex junctions were obtained by combining certain turning movement flows. An example of this is junction C01-02 on the Malahide Road, shown in Diagram 5.3 below.



**Diagram 5.3 Bus Connects LAM Node Matching (Junction C01-02)**

## **5.5 Road Journey Time Data**

### **5.5.1 TomTom Data Summary**

Journey time data for the Proposed Scheme models has been sourced from TomTom, who calculate journey times using vehicle position data from GPS-enabled devices and provide this on a commercial basis to a number of different users. The NTA purchased a license to access the Custom Area Analysis dataset through the TomTom TrafficStats portal. The NTA has an agreement with TomTom to provide travel time information covering six areas of Ireland and for certain categories of road.

Data is provided based on the area specified by the agreement; however, the date and time range of the data can be specified by the user. For the development of the LAM the following query on the data was applied:

- 2019 weekdays (Monday to Thursday) from mid-January until end of November, excluding all bank holidays and days close to those dates.

The data is provided in the form of a GIS shapefile and accompanying travel time database file. The shapefile contains topographical details for each road segment, which is linked to the travel time database via a unique link ID. The database file then contains average and median travel time, average and median speed, the standard deviation for speed, the number of observations and percentile speeds ranging from 5 to 95 for each link.

### **5.5.2 TomTom Data Processing**

In order to compare the journey times of specific links and routes between the TomTom data and the road assignment models, the two datasets need to be linked. After importing both the road assignment model and TomTom networks into the GIS environment, ensuring both datasets are in the same coordinate system, the selected routes can then be linked using a spatial join functionality.

Before applying the data to the models, it was checked to ensure that it was fit for purpose. The review included checks of the number of observations that form the TomTom average and median times and checks of travel times against Google Maps travel times.

The TomTom Custom Area Analysis dataset was processed to provide observed journey times against which the LAM and Micro-simulation model could be validated along the Proposed Scheme.

### **5.5.3 TomTom Data Application**

The processed journey time data was used to validate the LAM and the micro-simulation models at an end-to-end travel time level, with intermediate segment travel times used to inform the calibration of both models. Further information about the journey time validation process can be found in section 6 and 7 of this report for the LAM and micro-simulation models respectively.

## **5.6 Estimation of AADT Factors**

### **5.6.1 Introduction**

#### **5.6.1.1 Average Annual Daily Traffic (AADT)**

The Annual Average Daily Traffic (AADT) is a standard measure of the daily traffic load on a road section. It represents the annual road flow which has been broken down to an average day. Estimated AADTs for the forecast years are one of the traffic modelling outputs used as part of the Environmental Impact Assessment Report (EIAR) process.

#### **5.6.1.2 Environmental Impact Assessment overview**

Some sections of the EIAR are focused on the environmental impacts of the scheme related to the change in traffic flows on the network. This includes a detailed assessment of noise and Green House Gas (GHG) emissions

due to road traffic. The quantitative assessment is based on traffic information provided by the LAM and calculations using peak hour flows as well as Annual Average Daily Traffic (AADT).

## 5.6.2 Estimating AADTs from traffic counts

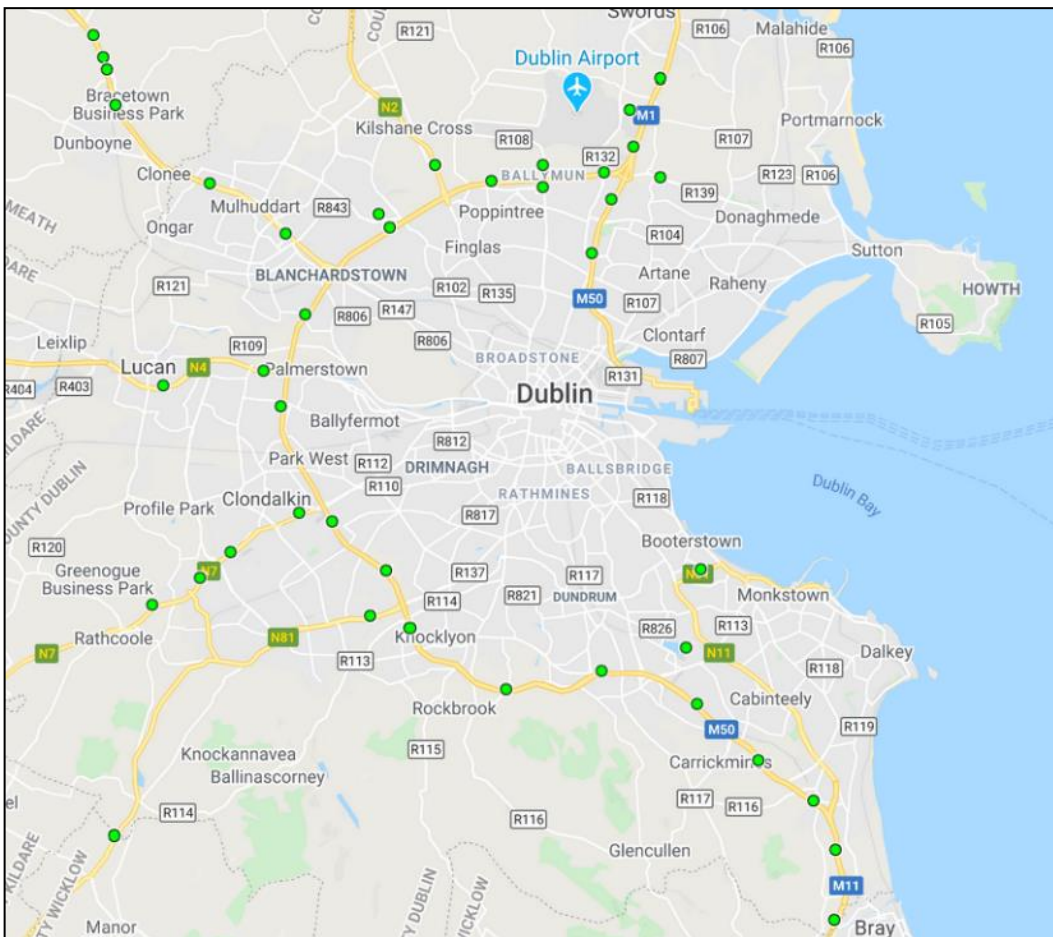
### 5.6.2.1 Introduction

The information in this section presents the methodology adopted to estimate AADT values from the modelled flows. This methodology has been based on the TII Project Appraisal Guidelines (PAG). Unit 16.0: Estimating AADT on National Roads.

### 5.6.2.2 AADT Estimation Methodology

#### 5.6.2.2.1 Permanent Counter Method

According to the PAG, the preferable method of estimating AADT is the Permanent counter method. Currently there are 40 TII Permanent Counters in the BusConnects study area as illustrated in Diagram 5.4 below. The counters are primarily located on the M50 and national routes. As the purpose of this exercise is to estimate AADTs across a broad geographical area in the BusConnects study area on regional and local roads, it was felt that the permanent counter method was not appropriate in this instance.



**Diagram 5.4 TII Permanent Counter Locations**

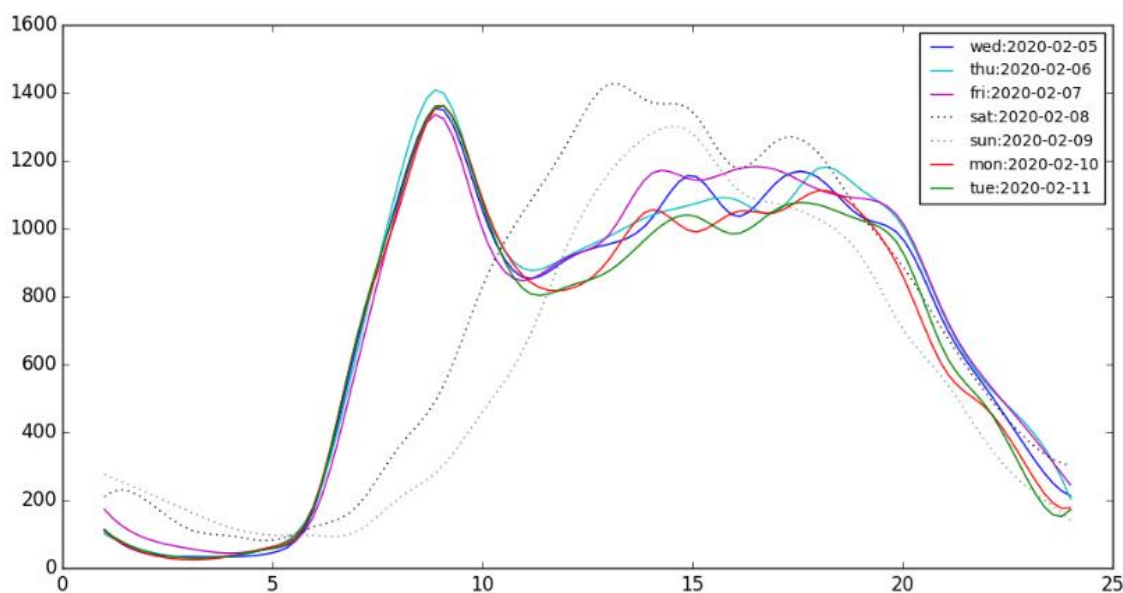
#### 5.6.2.2.2 Localised Period Counter Method

The Localised Period Counter Method utilises local traffic counts to estimate Period Expansion Factors, so that short period model flows (i.e. AM, LT, SR, PM and OP) 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 the BusConnects study area. The steps involved in estimating the AADTs are outlined in the remaining parts of this section.

All the counts used in this process come from the ATC Surveys undertaken for the project in November 2019 and February 2020.

Prior to the analysis the data was filtered to obtain “typical week” of data as indicated in Diagram 5.5. The profile shown is for car flows. The final dataset includes car, LGV and HGV flows for 213 links.



**Diagram 5.5 Typical Week Profile (ATC-01-01: Malahide Road Inbound)**

### 5.6.2.3 AADT Estimation Process

#### Step 1 – 12-hour 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 in the study area during the months of November 2019 and February 2020. 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:

- $2.848 * \text{AM assigned flows} = 07:00 - 10:00 \text{ flows};$
- $2.885 * \text{LT assigned flows} = 10:00 - 13:00 \text{ flows};$
- $2.868 * \text{SR assigned flows} = 13:00 - 16:00 \text{ flows};$  and
- $2.958 * \text{PM assigned flows} = 16:00 - 19:00 \text{ flows}.$

Utilising the above factors therefore allows us to estimate 12-hour (07:00 – 19:00) weekday flows from the four, peak 1-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:

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

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:

$$\begin{aligned} WADT_{Nov2019} &= 1.21 \times 12hr_{WD} \text{ for cars} \\ WADT_{Nov2019} &= 1.07 \times 12hr_{WD} \text{ for LGVs} \\ WADT_{Nov2019} &= 1.08 \times 12hr_{WD} \text{ for HGVs} \end{aligned}$$

Where:

- $WADT_{Nov2019}$  is the weekly average daily traffic for the 3rd week of November 2019; and
- $12hr_{WD}$  is the average 07:00-19:00 weekday (Monday-Friday) traffic for the 3rd week of November 2019.

### Step 3 – AADT Calculation

The final step in the process is to convert the WADT Diagrams calculated above into Annual Average Daily Traffic (AADT) Diagrams. This is done to account for 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. Profile data for ten sites such as that shown in Diagram 5.6 was obtained from the TII Traffic Data website. The sites used are shown in Diagram 5.7.

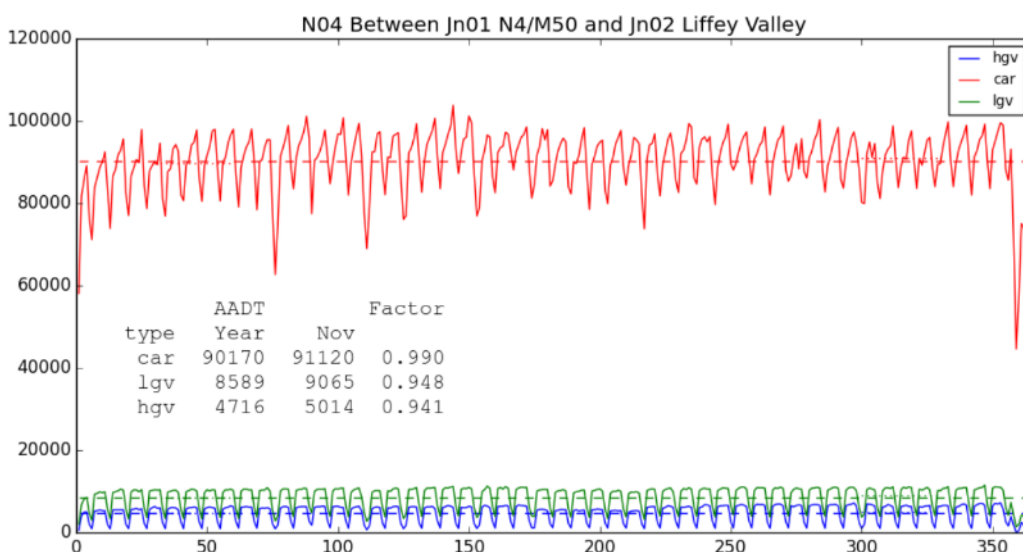
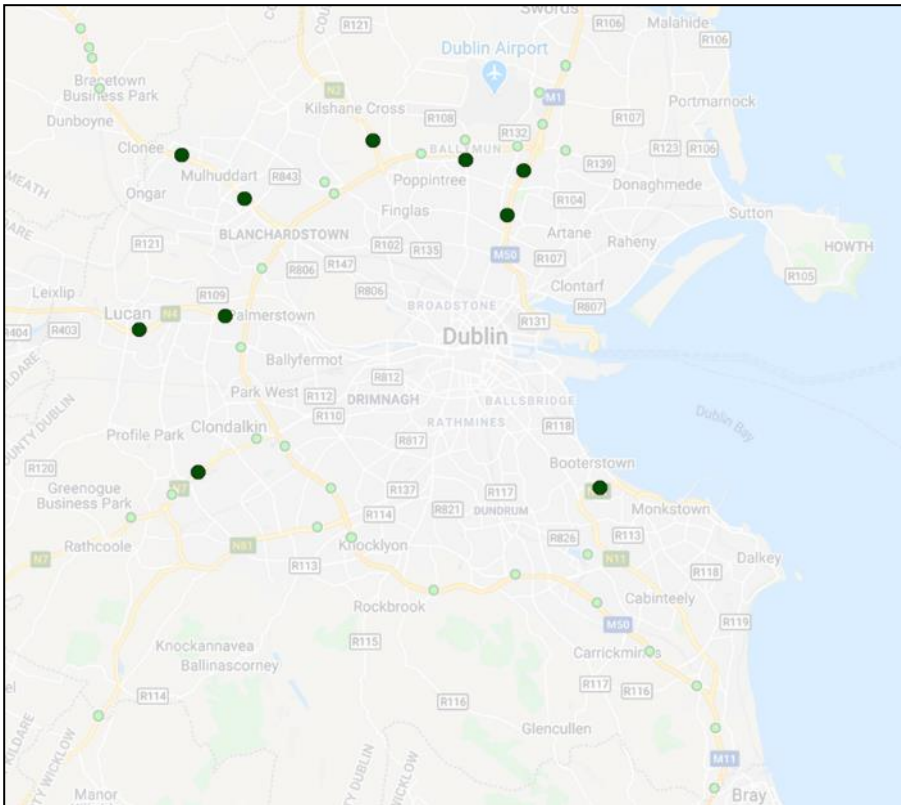


Diagram 5.6 Example Yearly Profile



**Diagram 5.7 Seasonal Factor Data Sites**

A linear regression has been performed based on these annual counts to estimate the seasonal expansion factor (F2). The factors derived are as follows:

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

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

Where:

WADT<sub>Nov</sub> 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 = 0.981 \* WADT<sub>Nov</sub> for cars

AADT = 0.965 \* WADT<sub>Nov</sub> for LGVs

AADT = 0.951 \* WADT<sub>Nov</sub> for HGVs

### 5.6.3 Modelled AADTs

#### 5.6.3.1 Estimated AADTs

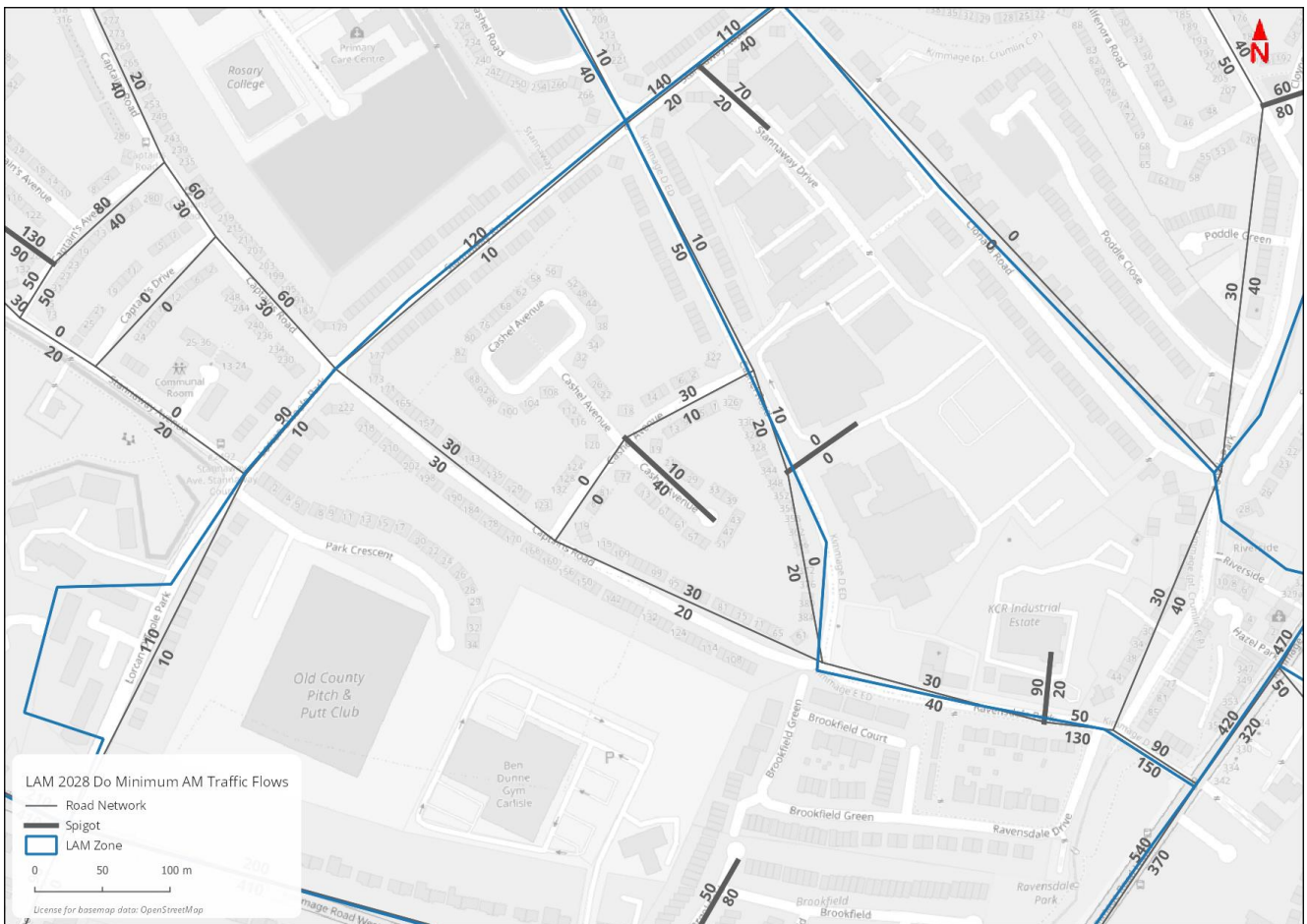
Four representative hours are modelled in the LAM (AM, Lunch Time, School Run and PM). A set of factors have been calculated, based on traffic counts, to convert LAM hourly flows into estimated AADTs, as detailed in section 5.6.2.



### 5.6.3.2 LAM traffic zones

The LAM is a strategic model, aimed at representing road traffic flows at a macroscopic scale. It contains 1,294 traffic zones covering a geographic area extending a few kilometres beyond the M50, meaning that every zone is the aggregation of several households and businesses. Traffic zones combine with the modelled road network at a single point (called a centroid) where all the traffic from/to the zone is loaded, via connectors. The number of connectors is kept as small as possible (ideally 1) to help assignment convergence and consistency in the model outputs.

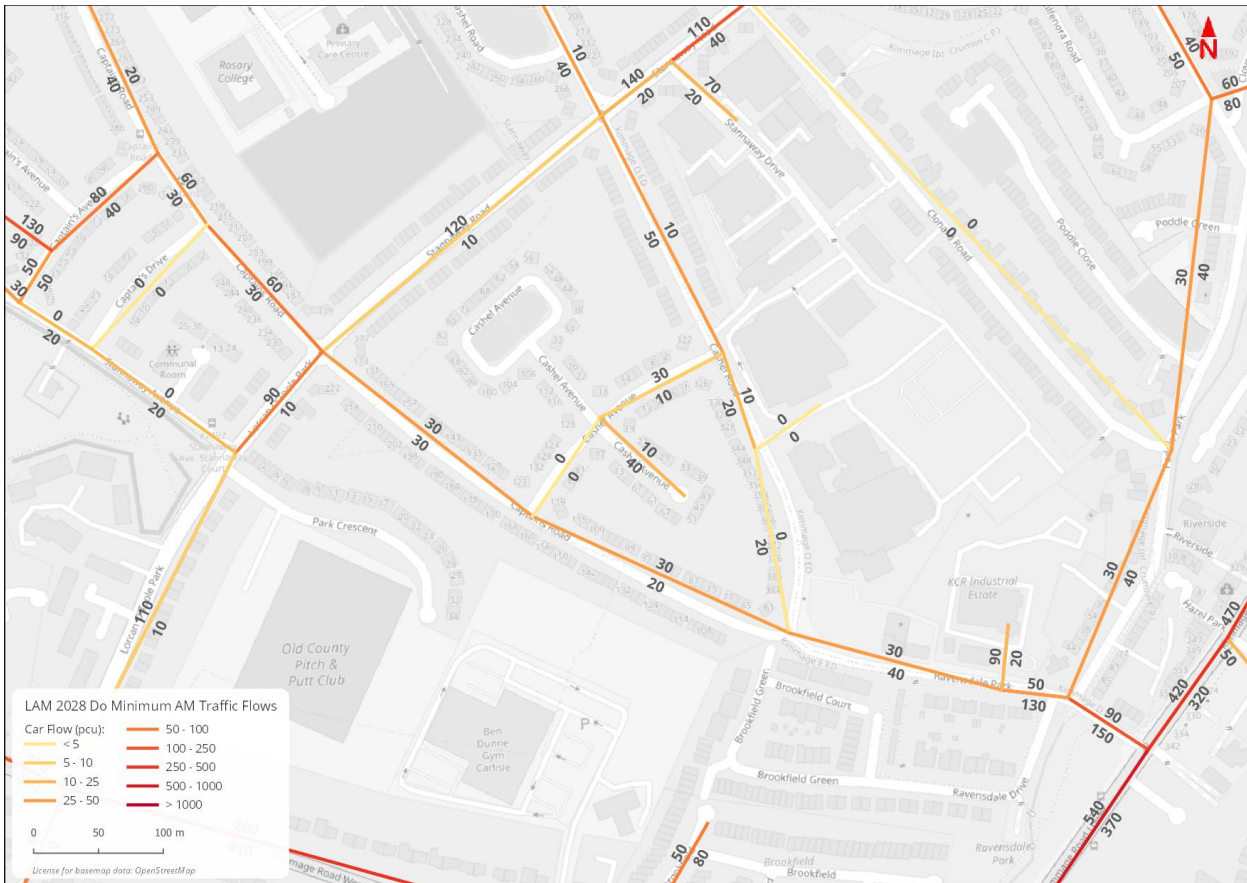
Diagram 5.8 below shows traffic zone boundaries (in blue) and the modelled road network with assigned flows (in grey) plus the spigots (centroid connecting points) highlighted in thick grey. The location of the spigots plays a key part in the route choice of trips from each zone and in some cases can potentially lead to 0 flow on links.



**Diagram 5.8 Traffic zone boundaries and modelled road network with access points (spigots)**

### 5.6.3.3 Modelled AADT limitations

The zone centroid approach can lead to locally underestimated traffic as the assignment software algorithm picks the least cost path between two centroids. Diagram 5.9 below presents the LAM flows (2028 Do Minimum AM) in the Kimmage area, showing several roads where no traffic is assigned (e.g. Clonard Rd).



**Diagram 5.9 LAM 2028 Do Minimum AM traffic flows - Kimmage area**

A road without any assigned flow is acceptable from a strategic transport modelling point of view because of the way traffic can load on the network only through centroid connectors. This however can be an issue for the traffic noise assessment, as a road with no traffic in the reference case (hence zero noise) but some traffic in the Do Something case appears as an infinite relative increase.

The fact that no traffic is assigned to a road in the LAM doesn't mean that there is no actual traffic on that road in reality, but that the level of detail in the model is too coarse to represent the traffic on that road. To address this issue for the noise assessment, an approach has been developed to adjust the modelled AADTs to more accurately represent flows on the residential and local road network.

## 5.6.4 Residential Streets AADT calculation approach

### 5.6.4.1 Rationale

All of the trips loading from a LAM traffic zone do not in reality load from a single point, but instead would start from houses, buildings and car parks spread across the zonal area. It is then fair to assume that there would be at least some traffic on all the streets within a traffic zone, and that this traffic is proportional to the number of trips originating or destinating in the zone.

In addition, it can be assumed that the access traffic is inversely proportional to the length of the street network contained within each zone e.g. longer residential streets with direct housing frontage and/or parking would lead to more activity than similar shorter length streets.

#### 5.6.4.2 Method

To represent access traffic on all minor residential links in the LAM, on a consistent basis, additional traffic flows have been calculated for each zone and each time period. This additional traffic flow is a function of the total zone demand (attraction + production) and the total street length within the zone. Motorways and the National Roads have been excluded from the process as they are unlikely to hold direct access to residential areas. Thus, all the other links located within a zone will receive the same additional load.

To avoid the addition of high flows (e.g. city centre zone with high demand and short length road network), a cap of 100 pcu per hour additional traffic flows has been set.

To account for the fact that some of the zone access traffic is already included in the LAM flows and so as not to double count flow levels reaching the centroid, a conservative 50% factor has been included in the calculations.

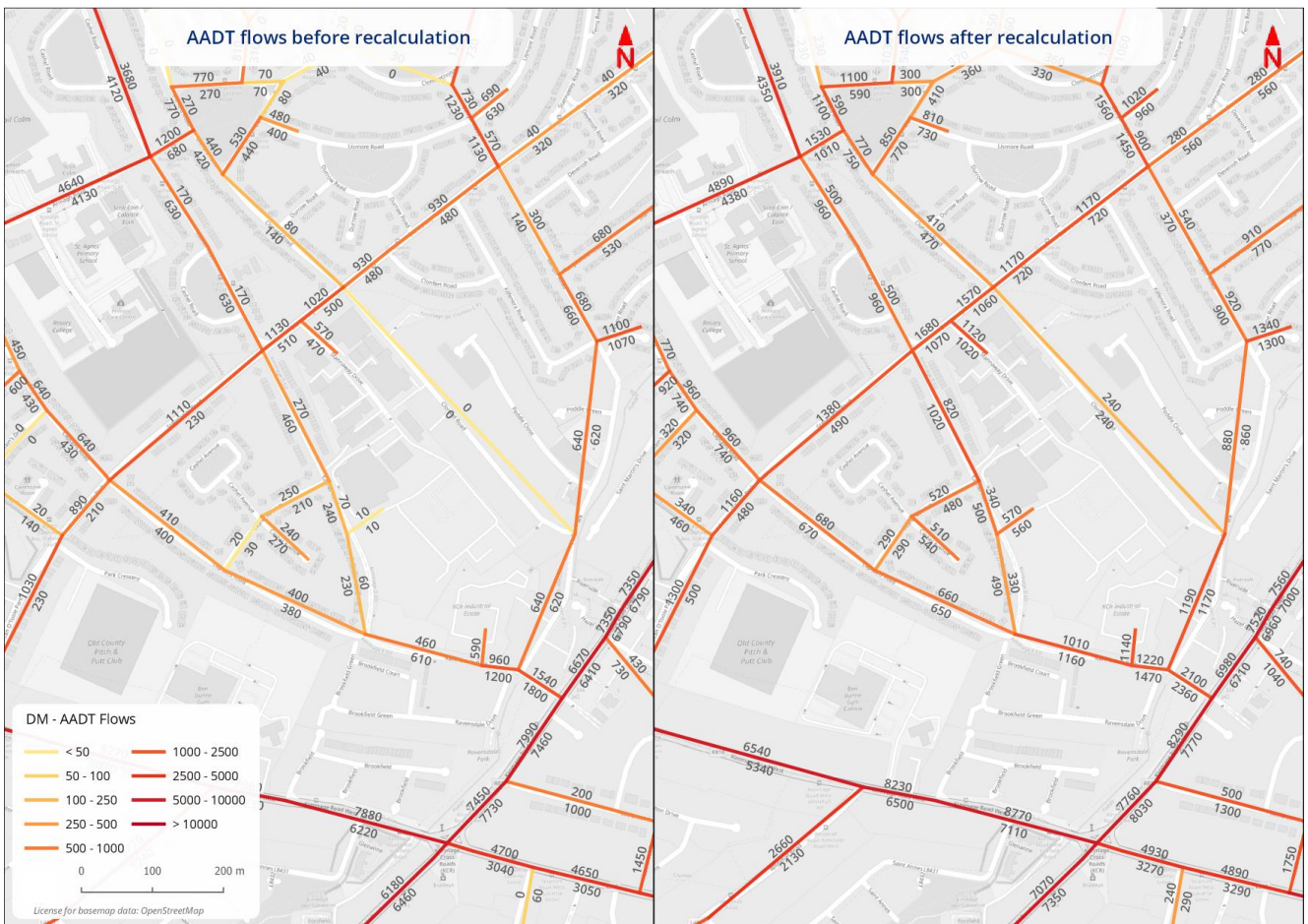
The formula used to calculate the additional flow to add to each link within a specific zone and for a specific time period is the following:

$$\text{Additional Flow}_{\text{Time Period}} = \text{Minimum} \left( \frac{50\% * \text{Zone Demand}_{\text{Time Period}}}{\text{Zone total street length}}, 100 \right)$$

This traffic is then added on top of the LAM modelled flow and AADTs are recalculated. The following section presents the implementation of the method on the 2028 Do Minimum networks.

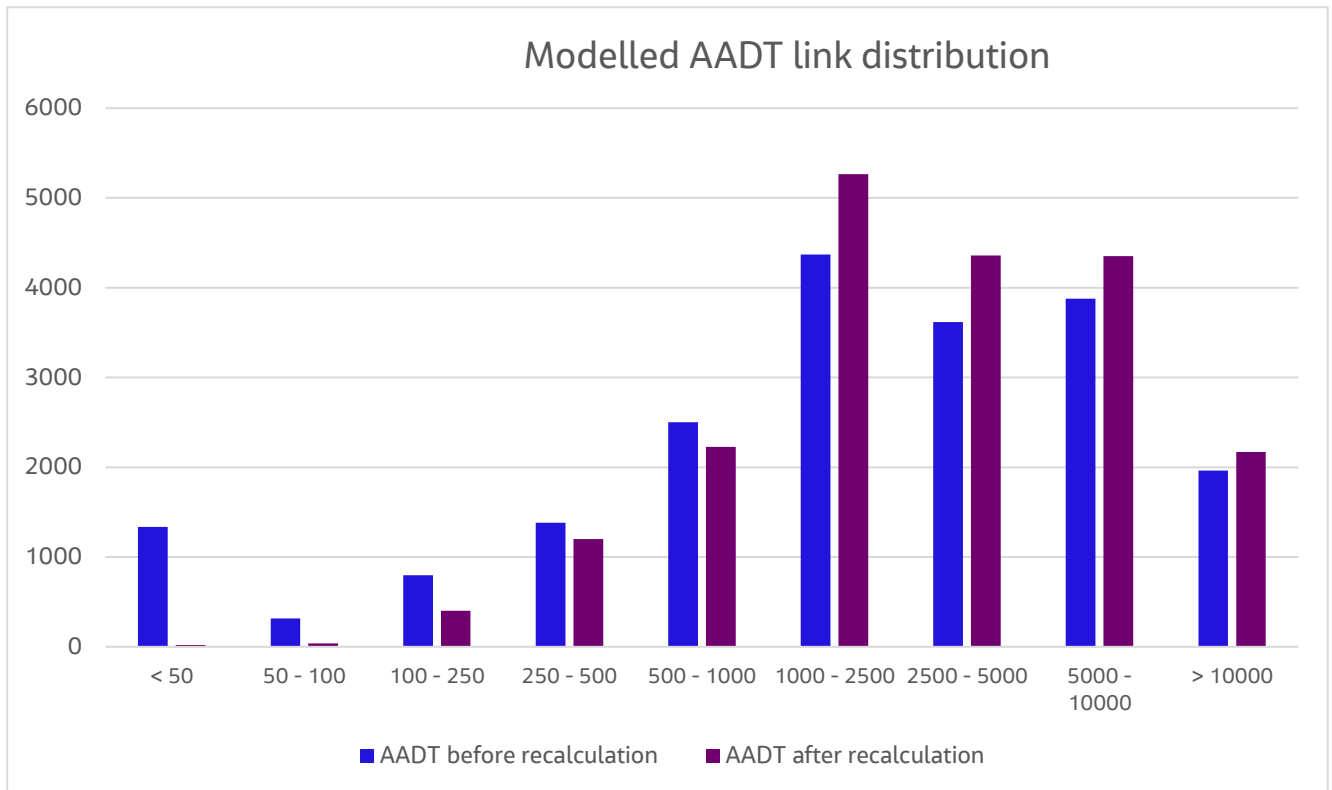
#### 5.6.5 AADT results on residential streets

The AADT adjustment for local and residential streets adds traffic to the local road network without significantly changing the values on the wider network, as shown in Diagram 5.10 below (AADT flows with and without the adjustment in minor roads).



**Diagram 5.10 AADT Traffic flows before and after AADT recalculation**

The modelled AADT link distribution in Diagram 5.11 gives an overview of the impacts of the adjustment on the results. The objective was to improve model outputs accuracy on residential streets, where the LAM doesn't assign any flow and the results show this working appropriately with almost no link with an AADT value below 100 vehicles post-adjustment.



**Diagram 5.11 Link distribution Diagram before/after on AADT difference**

## 6. Local Area Modelling

### 6.1 Introduction

To support the detailed assessment of the Proposed Scheme a more disaggregate urban area traffic model was developed, as a cordoned Local Area Model (LAM) model from the ERM, that incorporates the most up to date traffic survey data. The LAM provides the appropriate level of detail to capture the impact of redistribution of traffic on streets and roads not included within the strategic detail of the ERM.

The LAM is a direct extraction from the ERM road model with the addition of extra road network and zoning detail. The LAM is calibrated and validated with the most recent 2019/2020 traffic survey data and journey time information, which ensures that the model reflects ‘on-the-ground’ conditions for the Proposed Scheme in February 2020 (e.g. prior to COVID-19 restrictions).

The following section provides a detailed overview of the development of the LAM for the Proposed Scheme. It describes the model development (network and zoning) process and the calibration and validation results in the specific area of the Proposed Scheme. Further information on the calibration and validation of the full LAM can be found in Appendix A.

### 6.2 LAM Network and Zone System Development

#### 6.2.1 Introduction

This section provides an overview of the network and zone system developed for the LAM. As noted in section 2 previously, a cordon of the 2020 ERM run was used to generate the initial network and zone system. Further detail was then added to provide a more accurate representation of traffic loading within the model area of the Proposed Scheme.

#### 6.2.2 Network Development

The LAM road network, extracted from a cordon of the ERM, is illustrated in Diagram 6.1. A review was undertaken of all model coding in the study area using digital mapping systems such as Google Earth to ensure it represented, as accurately as possible, the existing road network. This included aspects such as network speed limits, availability of bus lanes, junction layouts, pedestrian crossing points etc.

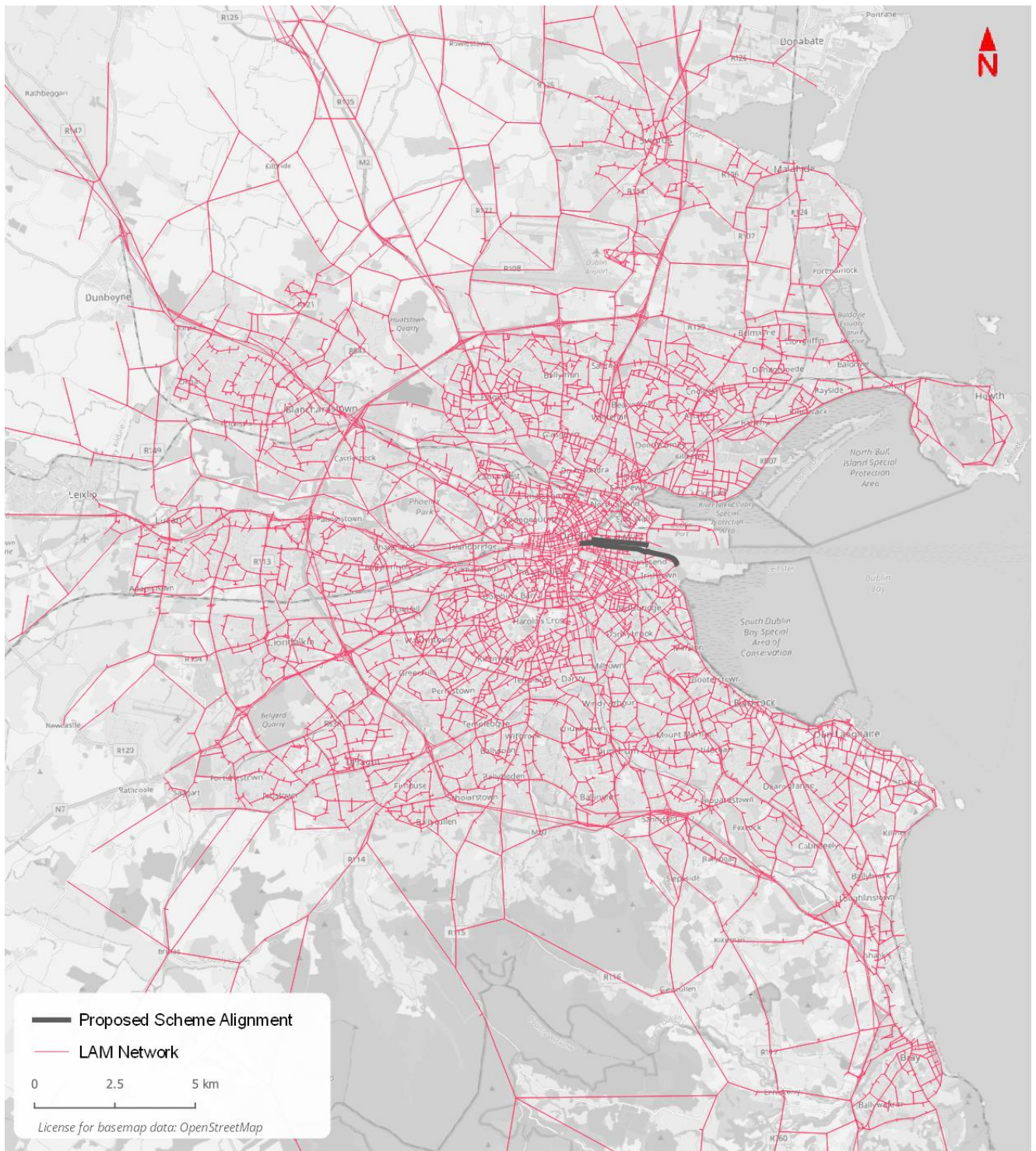
Junction capacities and saturation flows were adopted from the ERM standards<sup>5</sup> developed for the NTA as part of the RMS development, and were further reviewed during the calibration process. Where required, additional detail was added to ensure that traffic was loading onto the road network at the correct locations.

Along the Proposed Scheme, side roads adding more than 50 vehicles per hour in the AM or PM peak hours were identified using traffic survey data and added within the model. Any existing signalised junctions not within the model along the Proposed Scheme were also added. Particular attention was given to the addition of road links that form potential rat-runs through residential streets as pictured in Diagram 6.2 below. In total 117 new links were identified and coded into the LAM to compliment the network already contained within the ERM donor network.

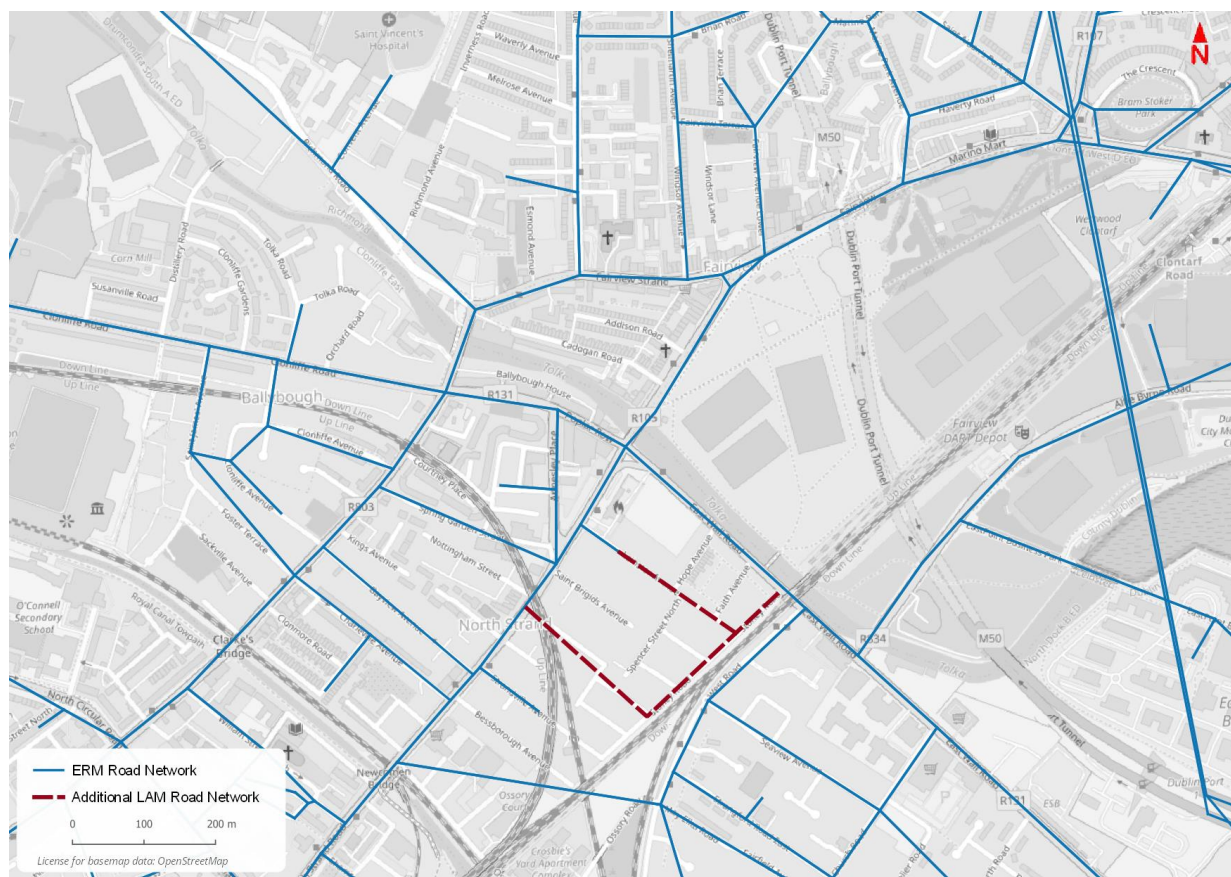
As illustrated in Diagram 6.1, the LAM provides a detailed representation of all significant roads within the study area. To ensure full network coverage and route choice, all roads have been considered, from national primary routes to minor residential streets. The short dead-end links in Diagram 6.2 are “spigots”<sup>6</sup> used to load traffic from the zones accurately onto the network and reflect the further developed zone system that is outlined in section 6.2 below.

<sup>5</sup> NTA RMS - TN11 Regional Model Coding Guide

<sup>6</sup> A small link representing either a single or amalgamation of local roads coded specifically to allow for the connection of a zone into the network in a logical location and allow for modelled junction interactions with the larger road the spigot connects to.



**Diagram 6.1 LAM Network and Proposed Scheme Alignment**



**Diagram 6.2 Example of additional network detail within LAM**

### 6.2.3 LAM Zone System Development

Similar to the road network described previously, the LAM zone system was adopted from the ERM. The ERM zone system was developed using the Census Small Area Population Statistics (SAPS) and Place of Work, School or College Census of Anonymised Records (POWSCAR) to get detailed information on population, employment and education locations across the model area. Other data sources such as MyPlan<sup>7</sup> and Geo Directory<sup>8</sup> were also used to obtain information on specified land-use zoning and the locations of commercial development. The following rules were applied in generating the zone system:

- **Population, Employment and Education** – the number of zones with values of population, number of jobs and persons in education above a certain threshold (~ 2000) should be minimised;
- **Activity Levels** – the number of zones with activity levels that have very low or very high levels of trips should be minimised;
- **Intra-zonal Trips** – threshold values should be applied to the proportion of intra-zonal trips within each zone, to avoid an underestimation of flow, congestion and delay on the network;
- **Land Use** – zones should be created with homogeneous land use and socio-economic characteristics where possible;
- **Zone Size/Shape** – zone size and the regularity of zone shape should be considered in order to avoid issues with inaccurate representation of route choice;

<sup>7</sup> MyPlan is a web map portal providing spatial information relevant to the planning process in Ireland. This site is an initiative of the Department of Housing, Local Government and Heritage in conjunction with Irish Local Authorities.

<sup>8</sup> GeoDirectory is An Post's database of 2.2million commercial and residential property addresses



- **Political Geography** – it should be possible to aggregate all zones to ED level i.e. zone boundaries do not intersect ED boundaries; and
- **Special Generators/Attractors** – large generators/attractors of traffic such as Airports, Hospitals, shopping centres etc. should be allocated to separate zones.

Diagram 6.3 below illustrates the LAM Zone System covering the study area.

A detailed review was undertaken of all ERM zoning and centroid connectors in the study area. A number of zone splits, illustrated in red in Diagram 6.4, as well as the addition of centroid connectors were applied to the ERM zone system in order to provide a more accurate representation of traffic loading onto the road network. Some ERM zones have been split according to the following criteria:

- Zones crossed the Proposed Scheme have been split along the Proposed Scheme alignment; and
- Zones with multiple accesses to the Proposed Scheme have been split if the accesses are significant (signalized junction or access adding more than 50 vehicles on the Proposed Scheme in the morning or evening peak hour)

These criteria led to the creation of 100 new LAM zones split from the ERM zone system, giving a total number of LAM zones as 1294.



**Diagram 6.3 LAM Zone System**

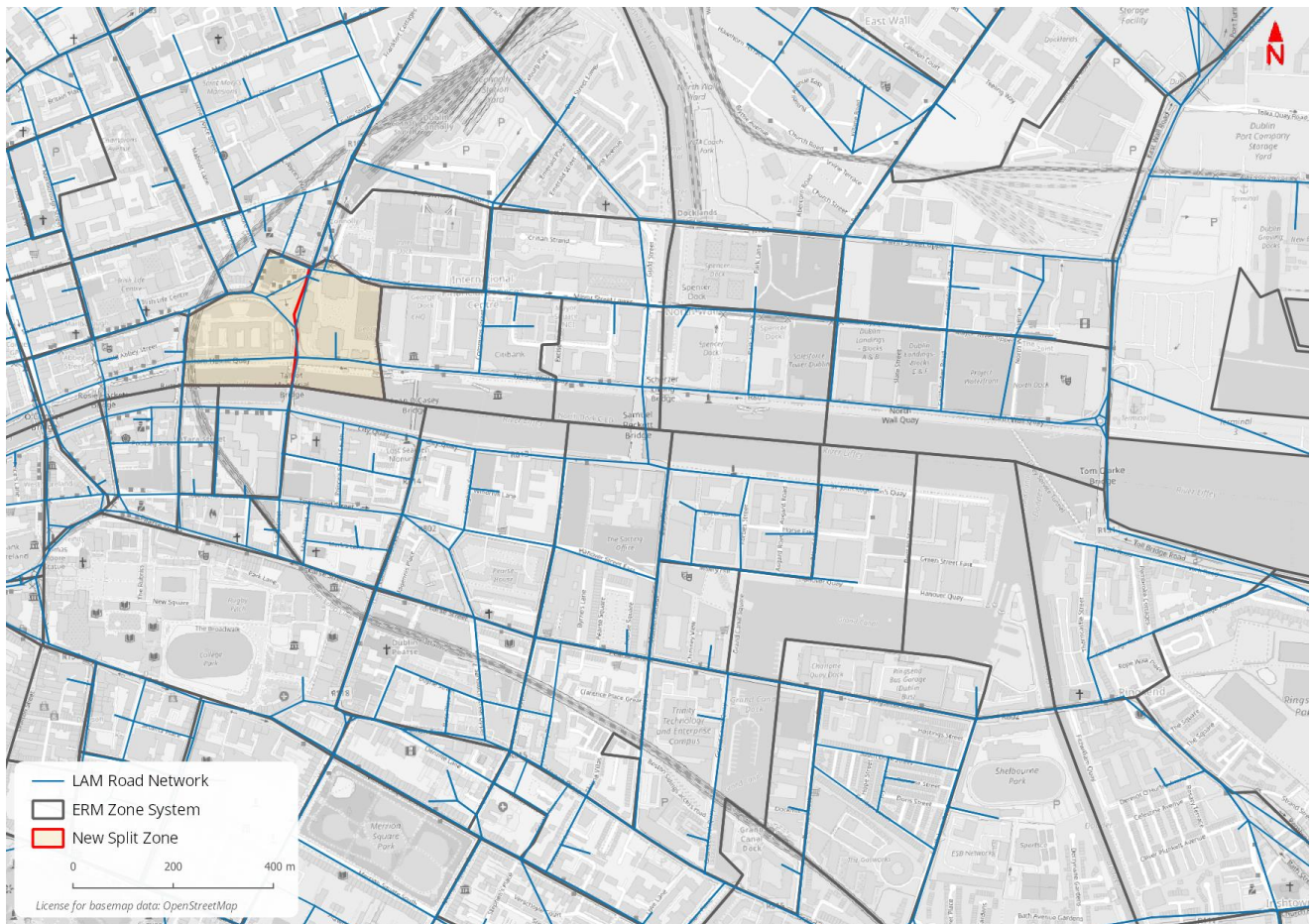


Diagram 6.4 LAM Zone System – Split zones

## 6.2.4 LAM Network Adjustments

The LAM was coded based on best practice approaches developed during the NTA RMS development, and as such, the model provided an accurate and up-to date representation of the existing road network.

When the traffic survey data was processed and analysed, the network coding was re-checked with the following edits undertaken where there was a clear justification for doing so:

- **Junction Capacity:** The SATURN software flags an error where a junction has insufficient modelled capacity to achieve the observed traffic flow. All these instances were reviewed in detail and remedial action was taken where required. This included:
  - Adjusting Signal Timings (mostly synthesised within the model area);
  - Adding/removing flared lanes;
  - Adding/removing approach lanes; and
  - Adjusting saturation flows through junctions.
- **Network Speeds:** The capacity and speeds of modelled links were checked to ensure they were broadly in line with survey information;

- **Zone Connectors:** A review was undertaken on the location of zone connectors in close proximity to count sites to ensure they were providing an accurate representation of traffic loading onto the road network.

### 6.3 LAM Prior Matrix Development

As noted previously in section 2.2, the ERM Full Demand Model (FDM) carries out mode and trip destination choice for all zones within the ERM. The FDM has been calibrated using Census data, and hence, provides a robust and accurate representation of trip distributions across the model network. In order to generate prior matrices for the LAM, a cordon was extracted from a run of the 2019/2020 ERM scenario (described in section 3.4). The cordon function within SATURN, facilitates the extraction of trip matrices for a subset area of the ERM whilst still maintaining route and destination choice from the full model.

A bespoke Cube Voyager module was created to disaggregate the cordoned ERM matrices to each of the LAM zones. This tool used available data on population, employment, and education places by Census Small Area, to split trips to/from each ERM zone between the more detailed LAM zoning system. This allowed for a consistent split of demand within the study area, whilst maintaining consistency with the ERM matrix.

A set of simplifying assumptions, as outlined in Table 6.1, were used to assign the ERM demand by User Class to each of the LAM zones.

**Table 6.1 Method of Disaggregation**

| Time Period | User Class         | Origin    | Destination | Notes                                                                      |
|-------------|--------------------|-----------|-------------|----------------------------------------------------------------------------|
| AM          | Taxi               | Pop + Emp | Pop + Emp   | * Taxis could originate from places of work or people travelling from home |
| AM          | Employers Business | Emp       | Emp         | * assumed travelling from one employment location to another               |
| AM          | Commute            | Pop       | Emp         | * assume travel from home to work in the AM                                |

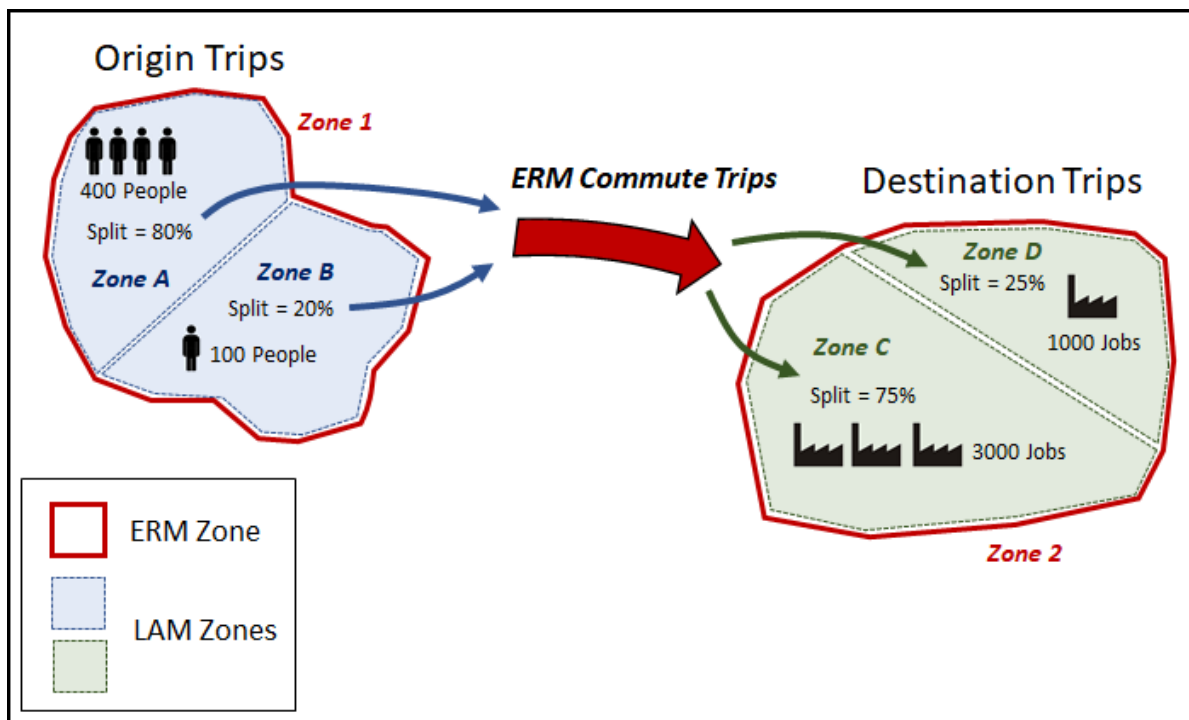
| Time Period | User Class         | Origin    | Destination | Notes                                                                                             |
|-------------|--------------------|-----------|-------------|---------------------------------------------------------------------------------------------------|
| AM          | Education          | Pop       | Edu         | * assume travel from home to school in the AM                                                     |
| AM          | Other              | Pop       | Emp + Edu   | * includes escort to education and one-way commute - distribute based on pupil and job numbers    |
| AM          | LGV                | Emp       | Emp         | * assumed deliveries from one business to another                                                 |
| AM          | OGV1               | Emp       | Emp         | * assumed deliveries from one business to another                                                 |
| AM          | OGV2               | Emp       | Emp         | * assumed deliveries from one business to another                                                 |
| AM          | OGV2_NP            | Emp       | Emp         | * assumed deliveries from one business to another                                                 |
| PM          | Taxi               | Pop + Emp | Pop + Emp   | * Taxis could originate from places of work or people travelling from home                        |
| PM          | Employers Business | Emp       | Emp         | * assumed travelling from one employment location to another                                      |
| PM          | Commute            | Emp       | Pop         | * assume travel from work to home in PM                                                           |
| PM          | Education          | Edu       | Pop         | * assume travel from school to home in PM                                                         |
| PM          | Other              | Pop + Emp | Pop + Emp   | * includes shopping, visiting friends etc. - assume split based on total resident and job numbers |
| PM          | LGV                | Emp       | Emp         | * assumed deliveries from one business to another                                                 |
| PM          | OGV1               | Emp       | Emp         | * assumed deliveries from one business to another                                                 |
| PM          | OGV2               | Emp       | Emp         | * assumed deliveries from one business to another                                                 |
| PM          | OGV2_NP            | Emp       | Emp         | * assumed deliveries from one business to another                                                 |

\* Note: Pop = Population, Emp = Employment & Edu = Education

Diagram 6.5 provides an indicative example of how the disaggregation process is undertaken in the Cube Voyager module for the Commute user class in the AM peak.

The overall commute trips between Zone 1 and Zone 2 is extracted from a cordon of the ERM. Zone 1 is disaggregated into two LAM zones, namely Zone A and Zone B. Whilst Zone 2 is also disaggregated into two LAM zones, Zone C and Zone D.

As outlined in Diagram 6.5, commute trips in the AM are assumed to be travelling from home to work. As such, the origin trips for ERM Zone 1 are split between the LAM zones based on the population numbers in each zone. Likewise, the destination trips to ERM Zone 2 are split between their LAM zones based on the level of employment in each zone.



**Diagram 6.5 LAM Disaggregation Example – AM Peak Commute Trips**

Detailed checks were undertaken at various stages to ensure that no demand from the ERM was lost throughout the disaggregation process. Table 6.2 to Table 6.5 below outline the matrix totals by user class before and after the disaggregation process indicating that all ERM cordoned demand is represented in the LAM matrices for the AM and PM peaks.

**Table 6.2 AM Matrix Total Comparison**

| User Class              | ERM Cordon | LAM Matrix | % Difference |
|-------------------------|------------|------------|--------------|
| Car Emp Business        | 13,489     | 13,489     | 0%           |
| Car Commute             | 88,898     | 88,898     | 0%           |
| Car Other               | 54,258     | 54,258     | 0%           |
| Car Education           | 1,530      | 1,530      | 0%           |
| Car Retired             | 2,078      | 2,078      | 0%           |
| Taxi                    | 5,372      | 5,372      | 0%           |
| LGV                     | 15,256     | 15,256     | 0%           |
| OGV1                    | 12,905     | 12,905     | 0%           |
| OGV2 Permit Holders     | 34         | 34         | 0%           |
| OGV2 Non Permit Holders | 401        | 401        | 0%           |

**Table 6.3 LT Matrix Total Comparison**

| User Class | ERM Cordon | LAM Matrix | % Difference |
|------------|------------|------------|--------------|
|------------|------------|------------|--------------|

|                         |        |        |    |
|-------------------------|--------|--------|----|
| Car Emp Business        | 10,987 | 10,987 | 0% |
| Car Commute             | 17,581 | 17,581 | 0% |
| Car Other               | 56,301 | 56,301 | 0% |
| Car Education           | 365    | 365    | 0% |
| Car Retired             | 9,948  | 9,948  | 0% |
| Taxi                    | 5,728  | 5,728  | 0% |
| LGV                     | 16,199 | 16,199 | 0% |
| OGV1                    | 14,854 | 14,854 | 0% |
| OGV2 Permit Holders     | 33     | 33     | 0% |
| OGV2 Non Permit Holders | 412    | 412    | 0% |

**Table 6.4 SR Matrix Total Comparison**

| User Class              | ERM Cordon | LAM Matrix | % Difference |
|-------------------------|------------|------------|--------------|
| Car Emp Business        | 8,204      | 8,204      | 0%           |
| Car Commute             | 28,940     | 28,940     | 0%           |
| Car Other               | 57,558     | 57,558     | 0%           |
| Car Education           | 886        | 886        | 0%           |
| Car Retired             | 6,139      | 6,139      | 0%           |
| Taxi                    | 5,398      | 5,398      | 0%           |
| LGV                     | 15,442     | 15,442     | 0%           |
| OGV1                    | 12,043     | 12,043     | 0%           |
| OGV2 Permit Holders     | 27         | 27         | 0%           |
| OGV2 Non Permit Holders | 390        | 390        | 0%           |

**Table 6.5 PM Matrix Total Comparison**

| User Class              | ERM Cordon | LAM Matrix | % Difference |
|-------------------------|------------|------------|--------------|
| Car Emp Business        | 12,067     | 12,067     | 0%           |
| Car Commute             | 77,452     | 77,452     | 0%           |
| Car Other               | 55,998     | 55,998     | 0%           |
| Car Education           | 1,247      | 1,247      | 0%           |
| Car Retired             | 3,930      | 3,930      | 0%           |
| Taxi                    | 5,029      | 5,029      | 0%           |
| LGV                     | 14,841     | 14,841     | 0%           |
| OGV1                    | 7,500      | 7,500      | 0%           |
| OGV2 Permit Holders     | 15         | 15         | 0%           |
| OGV2 Non Permit Holders | 259        | 259        | 0%           |

## 6.4 LAM Calibration and Validation Criteria

### 6.4.1 Introduction

Calibration is the process of adjusting the LAM network and demand to ensure that it provides a robust estimate of assignment when compared to 2019/2020 observed traffic characteristics. Generally, the components of the

model that may be adjusted on the demand side are trip distribution and trip production/generation levels, and this usually involves trip 'Matrix Estimation'.

On the supply side (network), modelled junction and link characteristics may be altered if sufficient new information is available to justify changes to the existing network.

The LAM was calibrated and validated in accordance with Transport Infrastructure Ireland's (TII) *Project Appraisal Guidelines (PAG) for National Roads Unit 5.1 – Construction of Transport Models (October 2016)*. This is a widely accepted standard in Ireland that provides robust calibration and validation criteria to which certain types of highway models should adhere. Additionally, the LAM development has followed guidance from the UK's Department for Transport's Transport Analysis Guidance (TAG) unit M3-1, particularly in terms of matrix estimation controls.

The method for the calibration of the LAM is illustrated in Diagram 6.6 overleaf, and comprises of the following key elements:

- **Network and Zone System Development:** The initial LAM network and zone system is derived from the ERM with further detail added where necessary to provide an accurate representation of existing conditions;
- **Network Adjustments:** A detailed review is undertaken of the road network coding taking cognisance of surveyed traffic volumes and network speeds with adjustments made where necessary;
- **Prior Matrix:** The initial prior matrix is extracted from a cordon of the ERM and disaggregated to the LAM zone system based on population, employment and education planning data;
- **Prior Matrix Factoring:** The prior matrix from the ERM is compared to observed counts at screenlines capturing key movements within the model area. Where there are large discrepancies between modelled and observed flows, factoring is undertaken to ensure that the prior matrix better represents observed travel patterns;
- **Calibration Criteria Check:** The LAM is then assessed against guideline calibration criteria in terms of modelled versus observed traffic volumes;
- **Matrix Estimation:** If the model is not passing the initial calibration check, a process known as 'Matrix Estimation' is undertaken to adjust the trip demand in order to provide an improved correlation between counts and modelled flows;
- **Post-Estimation Calibration Check:** The model is then re-tested against the calibration criteria with a focus on correlation between modelled and observed flows, along with an analysis of the demand changes introduced by 'Matrix Estimation'; and
- **Validation:** Once all the calibration criteria have been achieved, the model is passed forward for validation.

The following parts of this section provide an overview of the steps outlined above along with the calibration guidelines for LAM development.



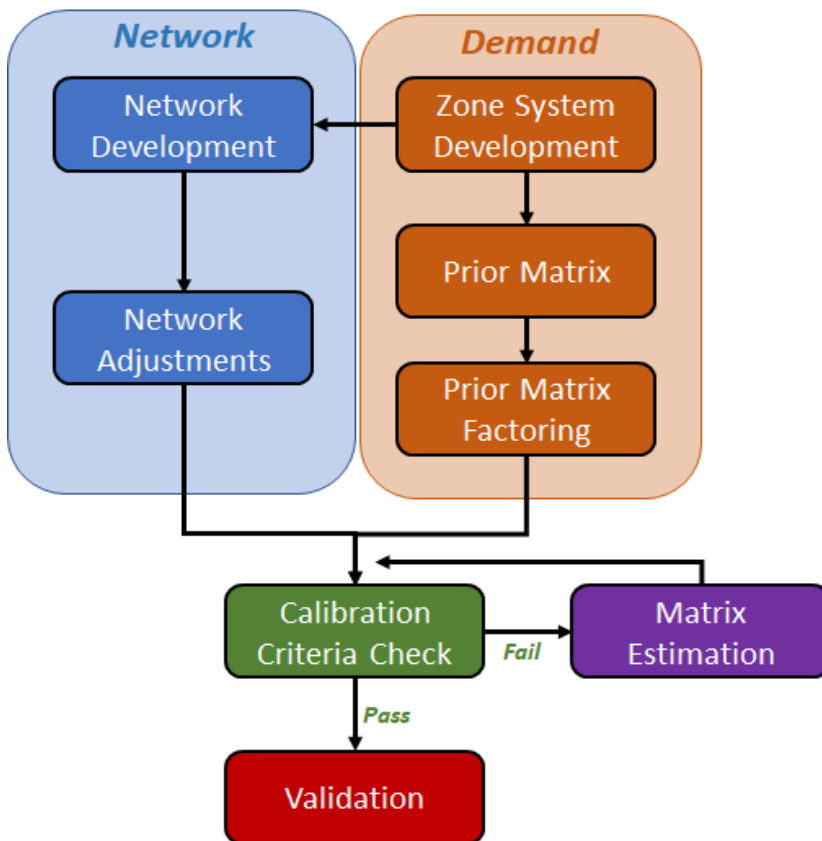


Diagram 6.6 LAM Calibration Process

## 6.4.2 Calibration Criteria Details

### 6.4.2.1 Traffic Flow Calibration

Table 6.6 outlines the TII PAG criteria for permissible differences between observed and modelled traffic flows. The guidelines are measured as absolute and percentage differences at various link flows, and also make use of the Geoffrey E. Havers (GEH) statistic.

The GEH statistic is a measure that considers both absolute and proportional differences in flows. Thus, for high levels of traffic volumes a low GEH may only be achieved if the percentage difference in flow is small. For lower flows, a low GEH may be achieved even if the percentage difference is relatively large. GEH is formulated as:

$$GEH = \sqrt{\frac{(Observed - Modelled)^2}{0.5 \times (Observed + Modelled)}}$$

The reason for introducing such a statistic is the inability of either the absolute difference or the relative difference to cope over a wide range of flows. For example, an absolute difference of 100 passenger car units per hour (pcu/h) may be considered a big difference if the flows are of the order of 100 pcu/h, but would be unimportant for flows in the order of several thousand pcu/h. Equally a 10% error in 100 pcu/h would not be important, whereas a 10% error in, say, 3000 pcu/h might mean the difference between adding capacity to a road or not.

In general, the GEH parameter is less sensitive to the above statistical biases since it would be reasonable to consider that an error of 20 in 100 would be roughly as bad as an error of 90 in 2,000, and both would have a GEH statistic of roughly 2.

As a rule of thumb in comparing assigned volumes with observed flows, a GEH parameter of 5 or less would be an acceptable fit, while GEH parameters greater than 10 would require closer attention.

**Table 6.6 Model Flow Calibration Criteria**

| CRITERIA                                                         | ACCEPTABILITY GUIDELINE |
|------------------------------------------------------------------|-------------------------|
| Individual flows within 100 v/h for flows less than 700 v/h      | >85% of cases           |
| Individual flows within 15% for flows between 700 & 2,700 v/h    |                         |
| Individual flows within 400 v/h for flows greater than 2,700 v/h |                         |
| Individual flows – GEH < 5                                       | >85% of cases           |

#### 6.4.2.2 Screenline Analysis

Screenlines represent an amalgamation of count sites that capture key movements across the model network. TII guidelines suggest that an additional check on the quality of trip matrices should be undertaken by comparing modelled and observed flows across screenlines by vehicle type and modelled time period using the following criteria:

**Table 6.7 Screenline Calibration Criteria**

| CRITERIA                                                                                                                 | ACCEPTABILITY GUIDELINE |
|--------------------------------------------------------------------------------------------------------------------------|-------------------------|
| Total screen line flows (> 5 links) to be within 5%                                                                      | > 85% of cases          |
| GEH statistic: screenline totals < 4                                                                                     | > 85% of cases          |
| Notes: Screenlines containing high flow routes (such as motorways) should be presented both with and without such routes |                         |

#### 6.4.2.3 Analysis of Trip Matrix Changes

##### Regression Analysis

As noted previously, 'Matrix Estimation' was used to adjust the prior trip matrix in order to provide a better correlation between modelled and observed flows. However, both TII and TAG guidance suggest that caution should be taken when using estimation, and that the changes introduced should be monitored to ensure that the original matrices are not overly distorted, thus providing irregular movement patterns.

Table 6-8 outlines the matrix estimation change criteria, as specified in WebTAG Unit M3-1, Section 8.3, Table 5. The guidelines use regression analysis to identify the correlation/relationship between the demand pre and post 'Matrix Estimation', and suggest careful monitoring by the following means:

- Scatter plots of matrix zonal cell values, prior to and post matrix estimation, with regression statistics (slopes, intercepts and R<sup>2</sup> values); and
- Scatter plots of zonal trip ends, prior to and post matrix estimation, with regression statistics (slopes, intercepts and R<sup>2</sup> values).

**Table 6-8 Significance of Matrix Estimation Changes**

| MEASURE                 | SIGNIFICANCE CRITERIA                               |
|-------------------------|-----------------------------------------------------|
| Matrix zonal cell value | Slope within 0.98 and 1.02;<br>Intercept near zero; |

|                        |                                                                                          |
|------------------------|------------------------------------------------------------------------------------------|
|                        | R <sup>2</sup> in excess of 0.95                                                         |
| Matrix zonal trip ends | Slope within 0.99 and 1.01;<br>Intercept near zero;<br>R <sup>2</sup> in excess of 0.98. |

#### 6.4.2.4 Trip Length Distribution Analysis

A further calibration step recommended by TII guidance is to compare trip length distributions for the prior and post calibrated matrices to ensure they have not been overly distorted by the ‘Matrix Estimation’ process.

‘Matrix Estimation’ can sometimes generate increased short distance trips to match count information, thus distorting the profile of trip making on the network. PAG suggests that the coincidence ratio<sup>9</sup> should be used to compare trip length distributions before and after estimation, with a desirable range between 0.7 and 1.0

A coincidence ratio can be used to compare two distributions by examining the ratio of the total area of those distributions that coincide. The coincidence ratio is defined as:

$$CR = \frac{\sum\{\text{Min (TLDs, TLDf)}\}}{\sum\{\text{Max (TLDs, TLDf)}\}}$$

Where TLDs is the source trip length frequency and TLDf is the final trip length frequency. A desirable range for the coincidence ratio is between 0.7 and 1.0 where a ratio of 1.0 suggests an identical distribution.

**Diagram 6.7 Coincidence Ratio Calculation – TII PAG Page 20**

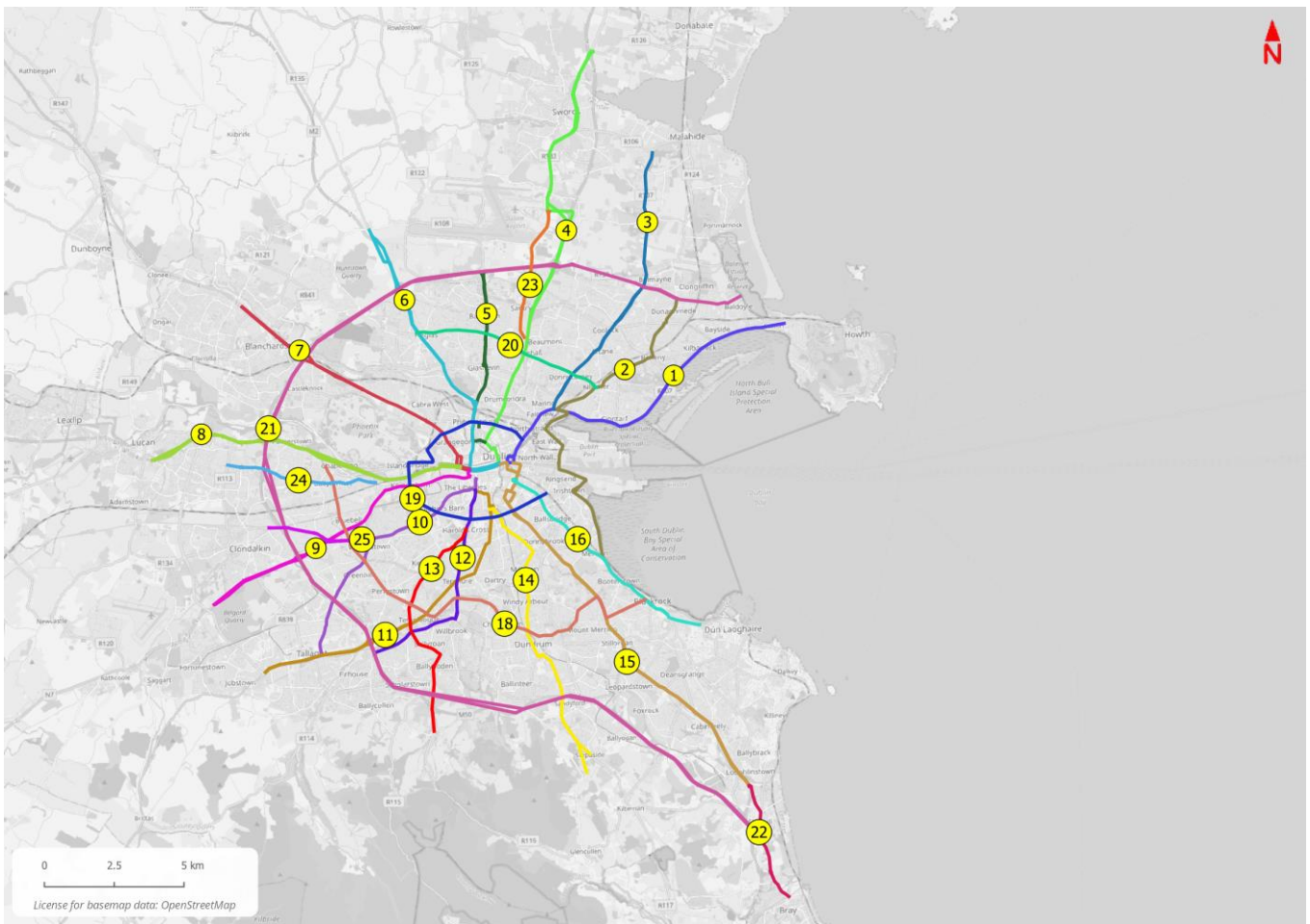
### 6.4.3 Validation Criteria Details

The validation of the model uses additional comparative measures against which the robustness of the calibrated model may be judged. Calibration and validation are separate concepts, however, in reality these two elements are part of an iterative process. If the results of the validation checks are not satisfactory, then the inputs and coding within the model are reviewed and adjusted as required in order to achieve a better representation of reality.

It is important that the information used in calibrating the model, including count data for matrix estimation, is kept separate from that used for validation if it is to be a true independent test of the model. As such two main data sources were used in the validation of the LAM:

- Junction turning counts not utilised during model calibration; and
- Observed journey times on key routes as illustrated below in Diagram 6.8

<sup>9</sup> The coincidence ratio is a calculation used to examine the how the total area under different distributions coincide, with a value of 1 representing an identical distribution.



**Diagram 6.8 Journey Time Validation Routes**

The guidelines for model validation are very similar to those described previously for calibration in section 6.2 and are outlined in Table 6.9.

**Table 6.9 Validation Criteria<sup>10</sup>**

| CRITERIA                                                          | ACCEPTABILITY GUIDELINE |
|-------------------------------------------------------------------|-------------------------|
| <b><u>Assigned hourly flows compared with observed flows</u></b>  |                         |
| Individual flows within 100 v/h for flows less than 700 v/h       | >85% of cases           |
| Individual flows within 15% for flows between 700 & 2,700 v/h     |                         |
| Individual flows within 400 v/h for flows greater than 2,700 v/h  |                         |
| Individual flows – GEH < 5                                        | >85% of cases           |
| <b><u>Modelled journey times compared with observed times</u></b> |                         |
| Times within 15% or 1 minute if higher                            | >85% of cases           |

<sup>10</sup> Table 5.1.5 (pg 23) TII *Project Appraisal Guidelines for National Roads Unit 5.1 - Construction of Transport Models*

### **6.4.3.1 Mean and Median Road Speeds**

Note that on review of the processed journey time results, it became clear that there was a significant difference between the mean and median journey time results. This indicates that the data is likely to be not normally distributed and is skewed. Access to the raw data behind the TomTom results is not available as part of the license agreement and so more detailed investigation for discrepancies/outliers or a subsequent cleaning of the raw data was not possible.

As TomTom data is collected over a long period, it is likely to include periods of disruption caused by roadworks and accidents. These types of incidents are not captured within the base year model congested speeds, so cognisance of this should be taken when comparing the modelled data against that recorded by TomTom. Following a review of mean and median travel times across the TomTom network, it was felt that the median time would likely underestimate congestion impacts, as some of the most severe congestion would potentially be under represented. Whereas the mean times would potentially overestimate congestion as they would also reflect network disruption, such as roadworks and accidents (where the modelling is required to compare against 'average' journey times with no network disruption).

Comparisons with Google Map times showed that the mean of the TomTom data was on average a lot slower in the peak hours, however it matched well with the interpeak journey times.

Following on from this analysis, early comparisons with the model highlighted that although the interpeak periods (LT and SR) matched relatively well against the TomTom mean, the AM and PM were significantly different, which the AM being closer to the median and the PM not matching well with either. This largely reflects the results of the full ERM model where the LT and SR results are notably better than the AM and PM when compared to guidance.

Given the difficulty this presents in terms of providing a consistent target observed value in order to check the validation of the modelled journey times against, a 50/50 blend of the median and mean has been created to provide a consistent target to measure all time periods against. This provides a more balanced and appropriate set of journey times to compare against the modelled data.

Journey time reporting highlights the performance of the modelled times against the mean, median and 50/50 blend in order to give a full appreciation of the variation of the observed data and the models performance against this.

## **6.5 Full LAM Model Calibration and Validation**

Details on the calibration and validation results for the full LAM are provided within Appendix A

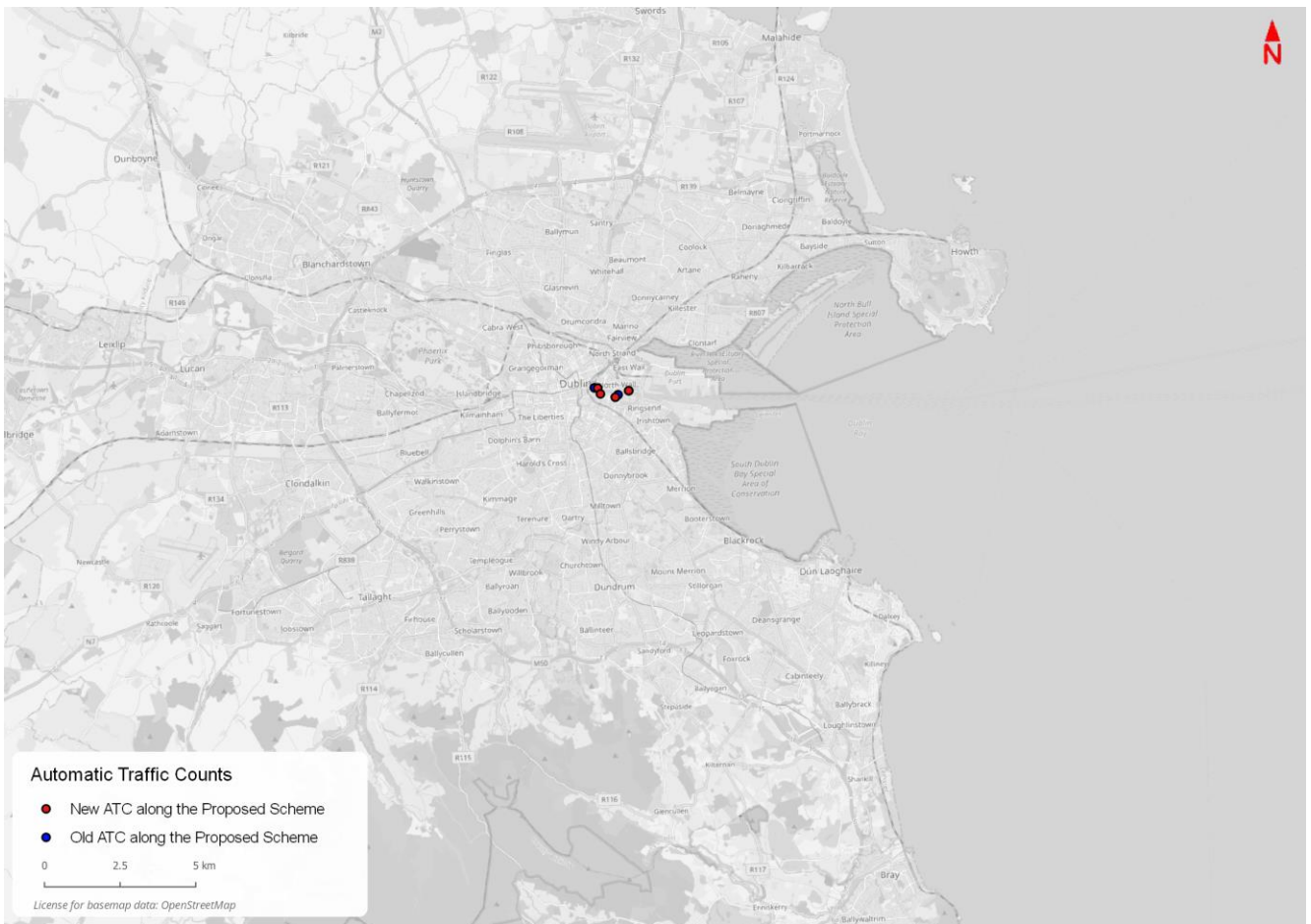
## **6.6 Proposed Scheme Calibration and Validation Summary**

### **6.6.1 Introduction**

This section details the calibration and validation of the model within the specific vicinity of the Proposed Scheme and highlights the performance of the model against guidance in these key areas.

### **6.6.2 ATC Calibration/Validation**

The key focus of the LAM calibration is the link ATC counts which have been collected along the Proposed Scheme routes in November 2019 / February 2020 (i.e. Pre-Covid-19). This data has been supplemented with existing link counts from the 2016 ERM model calibration. Both of which combined form a series of counts along the main route of the Proposed Scheme. The below Diagram 6.9 outlines the location of the ATC links used in the calibration of the LAM for the Proposed Scheme.



**Diagram 6.9 ATC Link counts along route of Proposed Scheme**

The performance of the model across these two sets of ATC counts is outlined below in Table 6.10 to Table 6.12 for all four of the modelled time periods with the focus being on the calibration to the most recently available data.

**Table 6.10 Link Flow Calibration – Proposed Scheme – Cars**

| Time Period | ATC Type     | Total ATC Links on Route | DMRB | GEH <5 | DMRB or GEH <5 | GEH <10 | DMRB or GEH < 10 |
|-------------|--------------|--------------------------|------|--------|----------------|---------|------------------|
| AM          | New ATC      | 7                        | 71%  | 71%    | 71%            | 100%    | 100%             |
|             | Combined ATC | 11                       | 82%  | 82%    | 82%            | 100%    | 100%             |
| LT          | New ATC      | 7                        | 86%  | 86%    | 86%            | 100%    | 100%             |
|             | Combined ATC | 11                       | 91%  | 82%    | 91%            | 100%    | 100%             |
| SR          | New ATC      | 7                        | 57%  | 43%    | 57%            | 86%     | 86%              |
|             | Combined ATC | 11                       | 73%  | 64%    | 73%            | 91%     | 91%              |
| PM          | New ATC      | 7                        | 57%  | 43%    | 57%            | 86%     | 86%              |
|             | Combined ATC | 11                       | 73%  | 55%    | 73%            | 91%     | 91%              |

**Table 6.11 Link Flow Calibration – Proposed Scheme – LGV**

| Time Period | ATC Type     | Total ATC Links on Route | DMRB | GEH <5 | DMRB or GEH <5 | GEH <10 | DMRB or GEH < 10 |
|-------------|--------------|--------------------------|------|--------|----------------|---------|------------------|
| AM          | New ATC      | 7                        | 100% | 100%   | 100%           | 100%    | 100%             |
|             | Combined ATC | 11                       | 100% | 100%   | 100%           | 100%    | 100%             |
| LT          | New ATC      | 7                        | 100% | 100%   | 100%           | 100%    | 100%             |
|             | Combined ATC | 11                       | 100% | 100%   | 100%           | 100%    | 100%             |
| SR          | New ATC      | 7                        | 100% | 71%    | 100%           | 100%    | 100%             |
|             | Combined ATC | 11                       | 100% | 82%    | 100%           | 100%    | 100%             |
| PM          | New ATC      | 7                        | 100% | 71%    | 100%           | 100%    | 100%             |
|             | Combined ATC | 11                       | 100% | 82%    | 100%           | 100%    | 100%             |

**Table 6.12 Link Flow Calibration – Proposed Scheme – HGV**

| Time Period | ATC Type     | Total ATC Links on Route | DMRB | GEH <5 | DMRB or GEH <5 | GEH <10 | DMRB or GEH < 10 |
|-------------|--------------|--------------------------|------|--------|----------------|---------|------------------|
| AM          | New ATC      | 7                        | 100% | 100%   | 100%           | 100%    | 100%             |
|             | Combined ATC | 11                       | 100% | 100%   | 100%           | 100%    | 100%             |
| LT          | New ATC      | 7                        | 100% | 100%   | 100%           | 100%    | 100%             |
|             | Combined ATC | 11                       | 100% | 100%   | 100%           | 100%    | 100%             |
| SR          | New ATC      | 7                        | 100% | 86%    | 100%           | 100%    | 100%             |
|             | Combined ATC | 11                       | 100% | 91%    | 100%           | 100%    | 100%             |
| PM          | New ATC      | 7                        | 100% | 100%   | 100%           | 100%    | 100%             |
|             | Combined ATC | 11                       | 100% | 100%   | 100%           | 100%    | 100%             |

The above tables highlights that the model shows a relatively good performance at a link count level when compared to TII/TAG guidance targets. Results for cars meet the 85% guidance in the lunchtime (LT) period for both the new ATC links and all links combined. Results for the new ATC links are lower in the morning (AM), school run (SR) and evening (PM) time periods with 71%, 57% and 57% respectively. Results for all links combined are better with 82% for AM, 73% for SR and 73% for PM. Both the LGV and HGV meet 100% of the target guidance for all time periods and ATC types.

### 6.6.3 Turning Calibration/Validation

The turning count calibration/validation results along the route of the proposed scheme in presented in this section. Along the route of the Proposed Scheme there are 164 turns across 42 junctions, the location of which are displayed below in Diagram 6.10.





**Diagram 6.10** Turning counts along route of Proposed Scheme

The performance of these turns against guidance is detailed below in Table 6.13

**Table 6.13** Turning Flow Calibration – Proposed Scheme – Cars

| Time Period | Total Number on Route | Individual Flow Criteria | GEH <5 | DMRB or GEH <5 | GEH <10 | Prop within 10% |
|-------------|-----------------------|--------------------------|--------|----------------|---------|-----------------|
| AM          | 164                   | 82%                      | 60%    | 84%            | 88%     | 74%             |
| LT          | 164                   | 90%                      | 69%    | 91%            | 94%     | 73%             |
| SR          | 164                   | 92%                      | 68%    | 92%            | 95%     | 72%             |
| PM          | 164                   | 87%                      | 59%    | 87%            | 90%     | 70%             |

The above table shows a generally good fit along the Proposed Scheme, with the LT, SR and PM models meeting the required TII/TAG guidance for absolute/percentage difference and the AM falling just short of guidance at 82%. The guidance compared to GEH is lower, but a comparison at GEH=10 shows that results are generally close to guidance. The numbers of turns within 10% of the observed proportions is in the range of 70%-74%, indicating the distribution of the flow across the arms is sufficiently accurate.

**Table 6.14** Turning Flow Calibration – Proposed Scheme – LGV

| Time Period | Total Number on Route | Individual Flow Criteria | GEH <5 | DMRB or GEH <5 | GEH <10 | Prop within 10% |
|-------------|-----------------------|--------------------------|--------|----------------|---------|-----------------|
| AM          | 164                   | 100%                     | 95%    | 100%           | 100%    | 64%             |
| LT          | 164                   | 100%                     | 87%    | 100%           | 99%     | 63%             |

|    |     |      |     |      |     |     |
|----|-----|------|-----|------|-----|-----|
| SR | 164 | 100% | 91% | 100% | 99% | 67% |
| PM | 164 | 100% | 93% | 100% | 99% | 59% |

The above table for LGV turns shows a good fit along the Proposed Scheme, with all time periods meeting the TII/TAG guidance for both GEH and % difference. For turns within 10% of the observed proportions, the results are not as high, as the lower levels of flow for LGV results in a wider range of proportions percentages and less dominant individual movements compared to cars, and a large % meet the GEH criteria and so are representative of the observed counts.

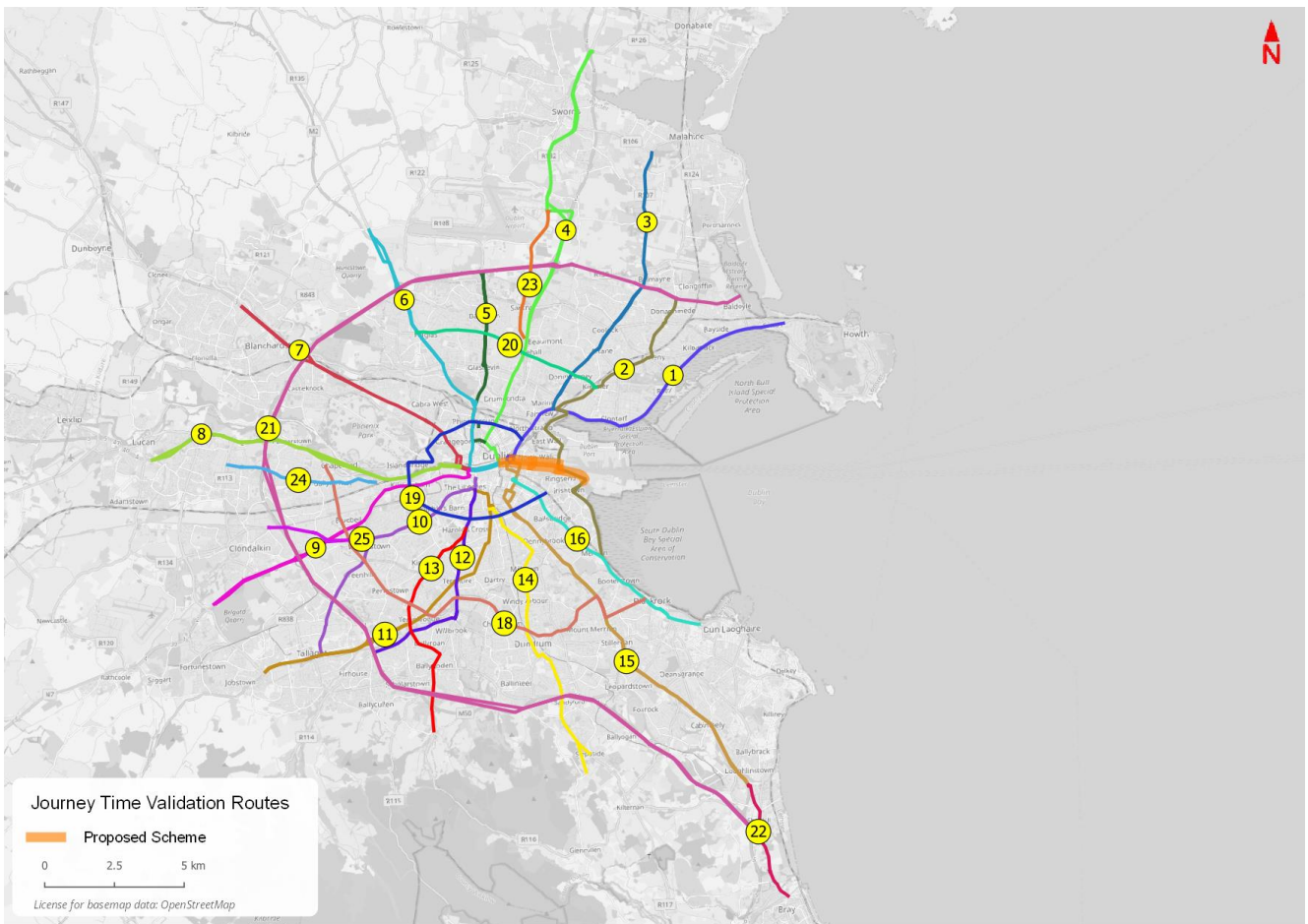
**Table 6.15 Turning Flow Calibration – Proposed Scheme - HGV**

| Time Period | Total Number on Route | Individual Flow Criteria | GEH <5 | DMRB or GEH <5 | GEH <10 | Prop within 10% |
|-------------|-----------------------|--------------------------|--------|----------------|---------|-----------------|
| AM          | 164                   | 100%                     | 96%    | 100%           | 99%     | 56%             |
| LT          | 164                   | 100%                     | 96%    | 100%           | 100%    | 59%             |
| SR          | 164                   | 100%                     | 98%    | 100%           | 100%    | 65%             |
| PM          | 164                   | 100%                     | 98%    | 100%           | 100%    | 65%             |

The above table for HGV turns shows a good fit along the Proposed Scheme, with all time periods meeting the TII/TAG guidance for both GEH and % difference. As with LGV, for turns within 10% of the observed proportions, the results are not as high. This is similarly due to the lower levels of HGVs which results in a wider range of proportion percentages and less dominant movements compared to cars, and a large % meet the GEH criteria and so are representative of the observed counts.

#### 6.6.4 Journey Time Validation

The following sections highlight the level of validation for each individual journey time (JT) route and for each of the four time periods. Also presented is a graph showing the cumulative modelled vs observed journey time profile for journey time route 2 which relate best to the Proposed Scheme.



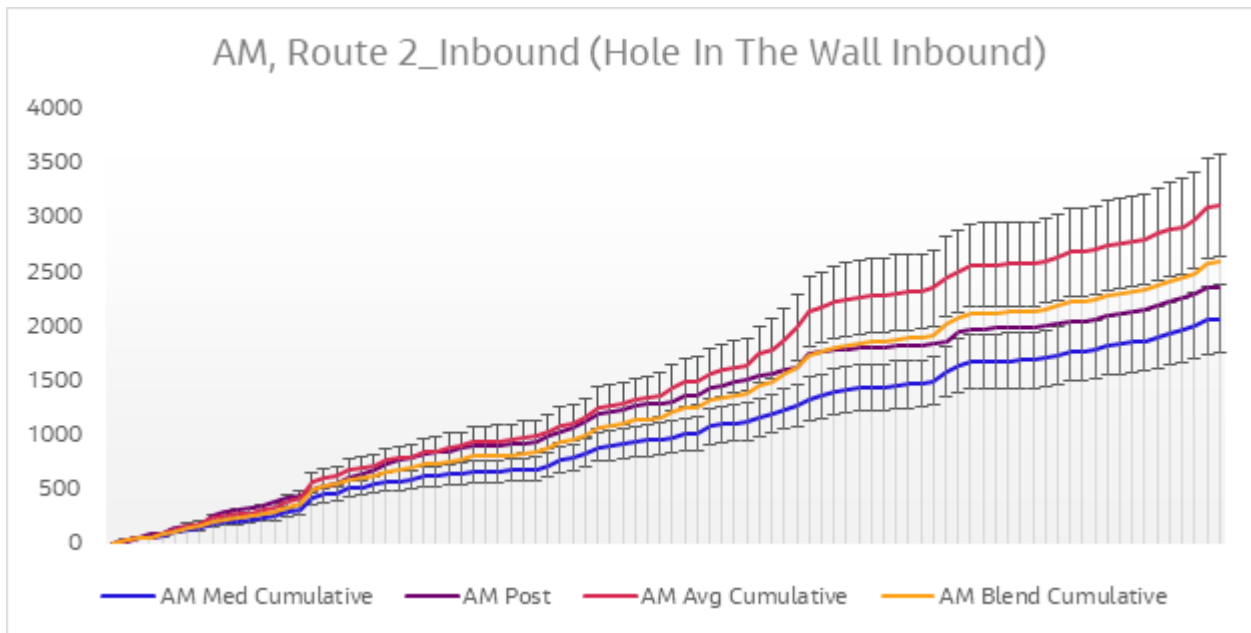
**Diagram 6.11 LAM Journey Time Validation Routes**

As noted in section 6.4.3, the observed journey times are presented across three metrics due to the amount of variability present in the survey data. These three metrics and detailed below and highlight the range of results across the observed time.

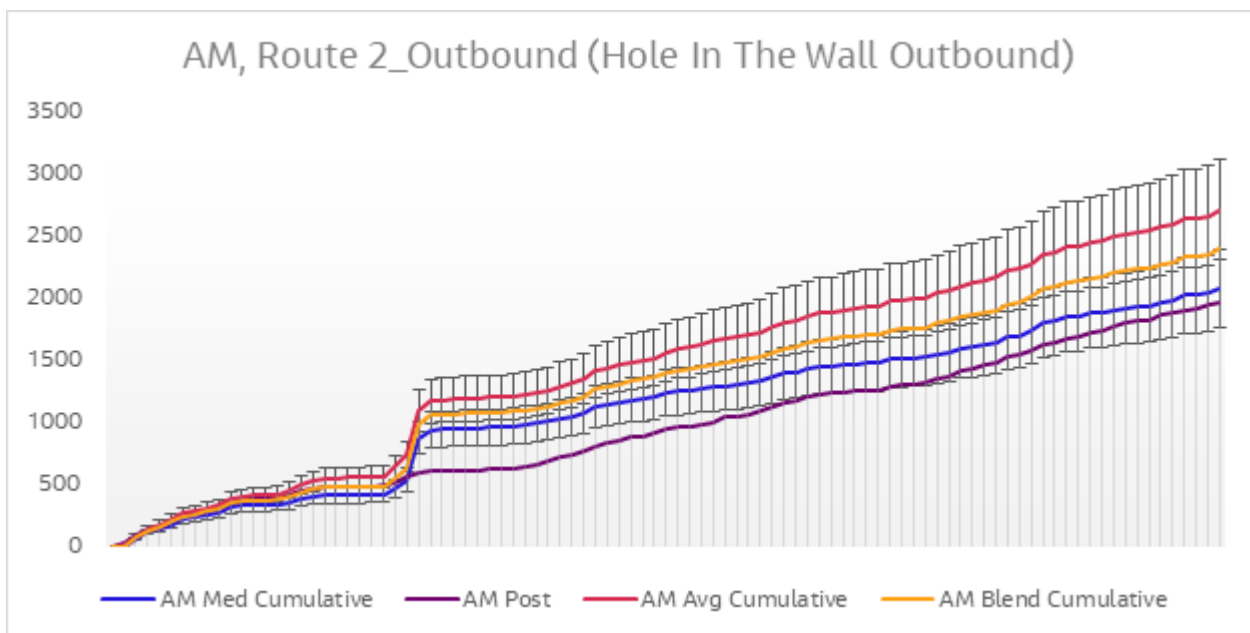
- The mean of the observed journey times;
- The median of the observed journey times; and
- A 50/50 blend of the observed mean and median times. This was used as the target metric during the validation process.

**6.6.4.1 AM Results**

The following graphs highlight the routes which relate to the Proposed Scheme in detail to show how the modelled cumulative profile of time in seconds against distance travelled compares to the observed along the journey route. The key journey time route 2 and the graphs for these are shown below for the AM peak period.



**Diagram 6.12 Journey Time Validation Plot – Route 2 Inbound AM**

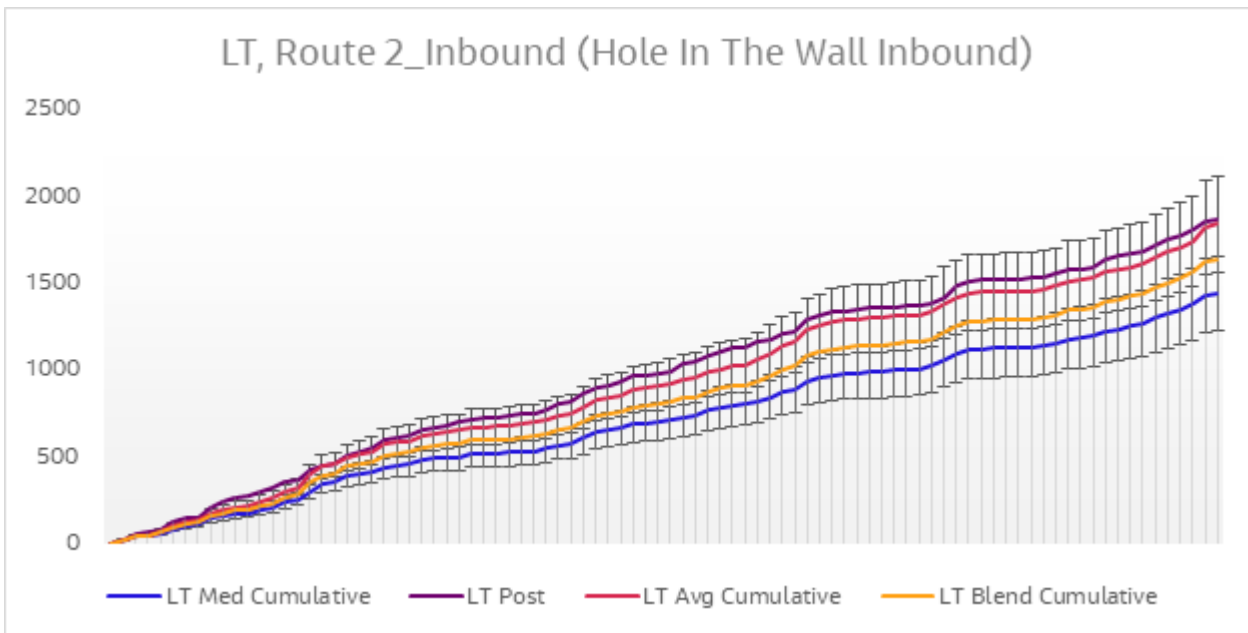


**Diagram 6.13 Journey Time Validation Plot - Route 2 Outbound AM**

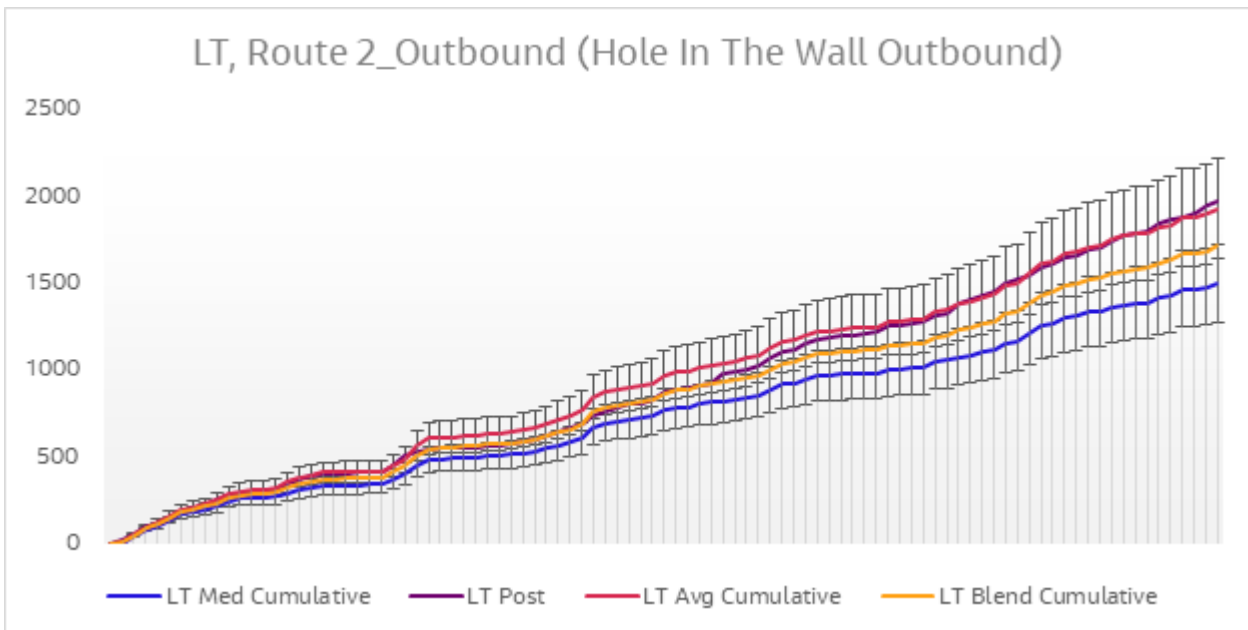
The above Diagrams show a good match between the 50/50 blend of the median and mean observed times and the modelled times for JT Route 2. The 15% guidance is met for the inbound movements whereas the outbound movements is slightly too fast and falls just outside with a difference of 18%

#### 6.6.4.2 LT Results

The following graphs highlight the routes which relate best to the Proposed Scheme in detail to show how the modelled profile compares to the observed along the journey route. The key journey time route 2 and the graphs for these are shown below for the LT period.



**Diagram 6.14 Journey Time Validation Plot - Route 2 Inbound LT**

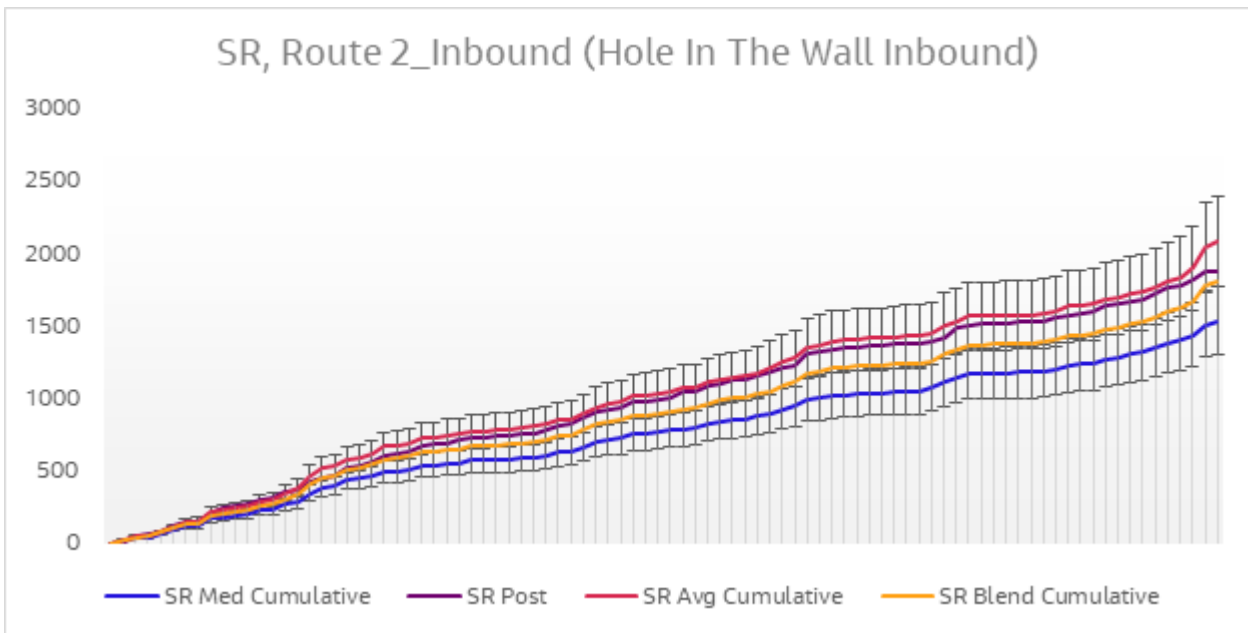


**Diagram 6.15 Journey Time Validation Plot - Route 2 Outbound LT**

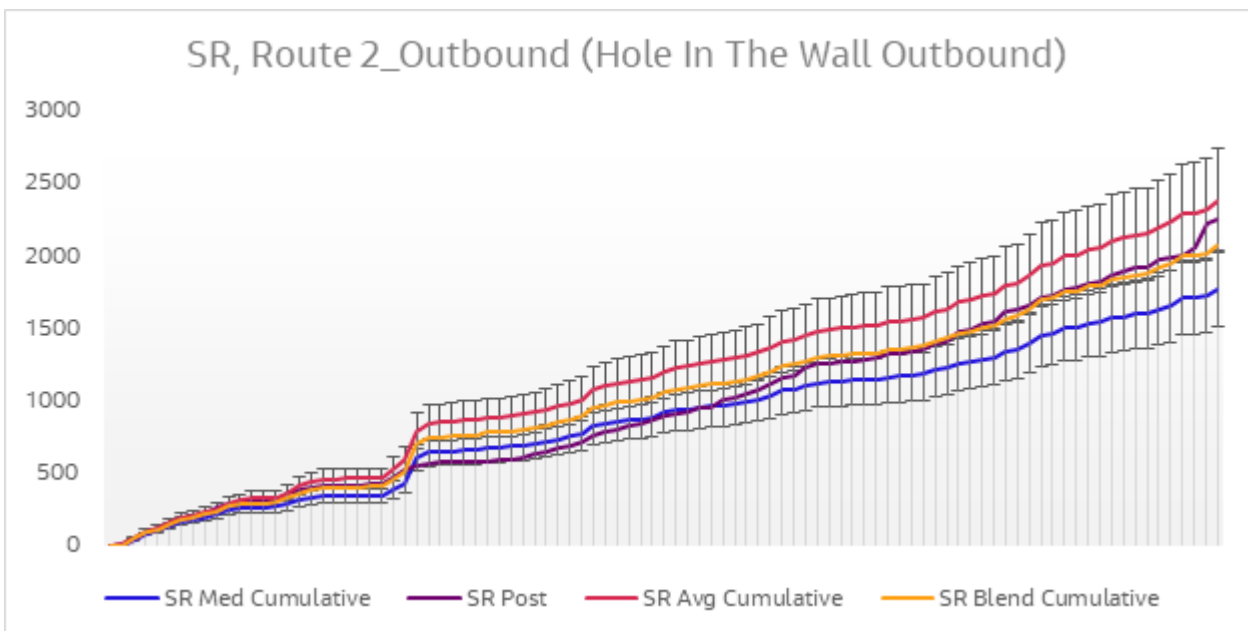
The above Diagrams show that model generally matches the cumulative profile of observed journey time routes well with similar peak and troughs along the route. As discussed previously, the LT is generally closest to the mean of the observed TomTom data and so generally runs slower than the 50/50 blend. In this case the 15% guidance is met against both the 50/50 blend and the mean observed time in both directions.

### 6.6.4.3 SR Results

The following graphs highlight the routes which relate best to the Proposed Scheme in detail to show how the modelled profile compares to the observed along the journey route. The key journey time route 2 and the graphs for these are shown below for the SR period.



**Diagram 6.16 Journey Time Validation Plot - Route 2 Inbound SR**

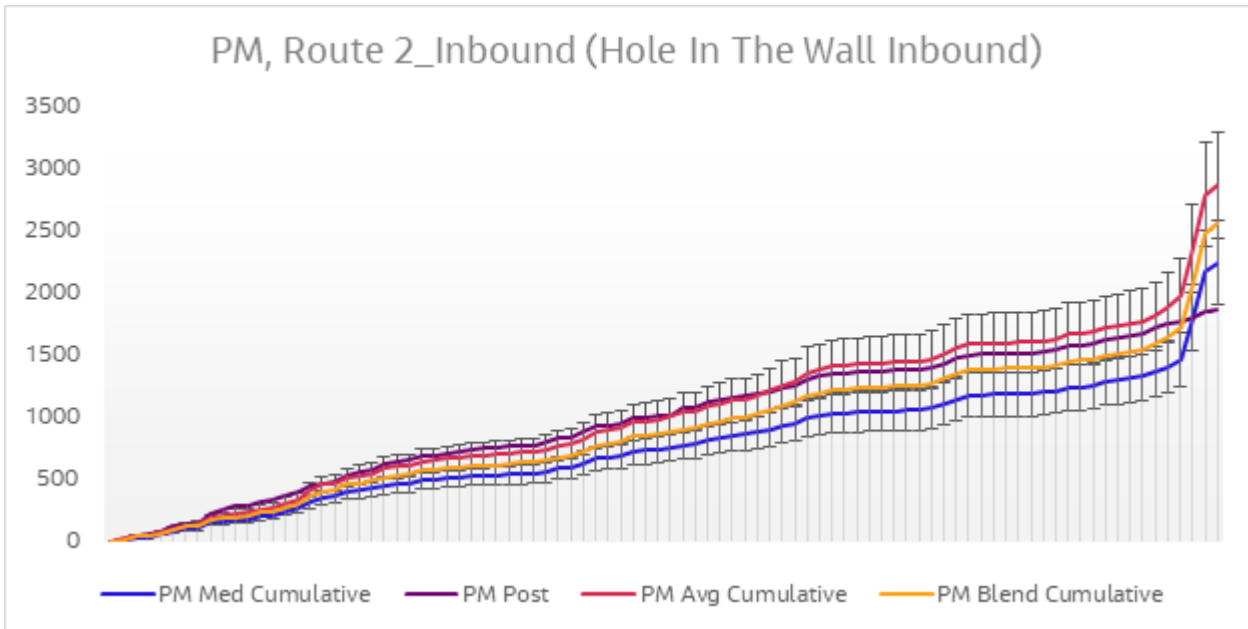


**Diagram 6.17 Journey Time Validation Plot - Route 2 Outbound SR**

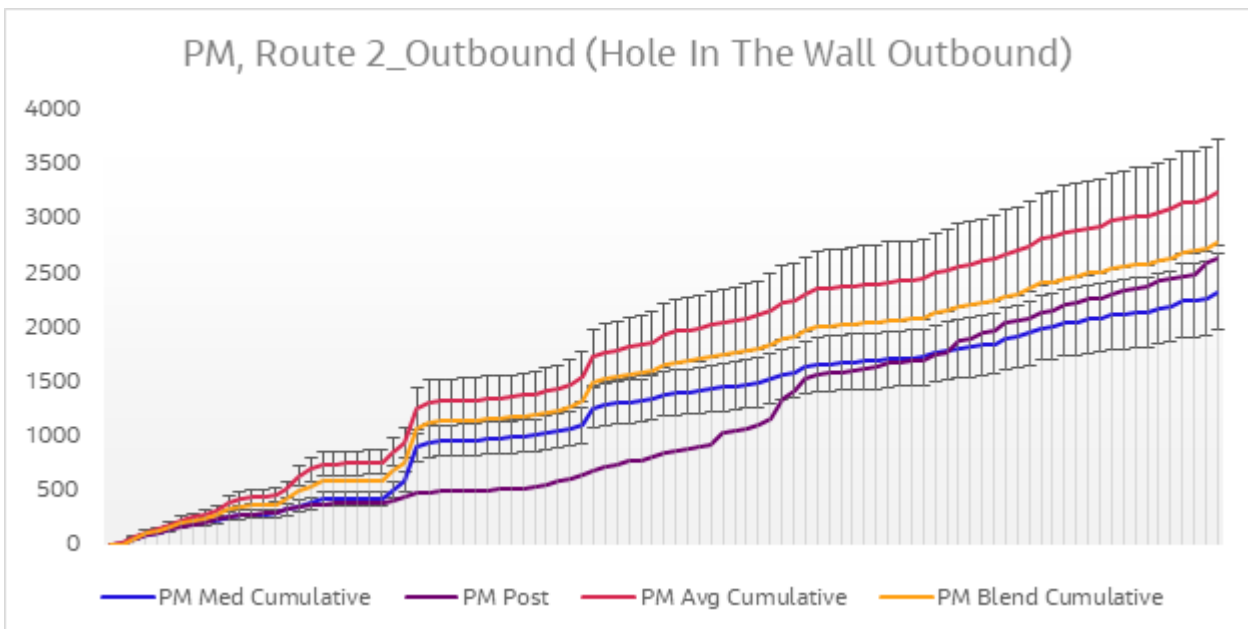
As with the LT period, the SR generally matches the cumulative profile of observed journey time routes well but is slow compared to the 50/50 blend of mean/median but performs well compared directly to the mean. The pattern across the individual routes is also the same as the LT with the 15% guidance being met against both the 50/50 blend and the mean observed time in both directions.

#### 6.6.4.4 PM Results

The following graphs highlight the routes which relate best to the Proposed Scheme in detail to show how the modelled profile compares to the observed along the journey route. The key journey time route 2 and the graphs for these are shown below for the PM peak period.



**Diagram 6-19 Journey Time Validation Plot - Route 2 Inbound PM**



**Diagram 6-18 Journey Time Validation Plot - Route 2 Outbound PM**

Within the PM period, the outbound journey meets the 15% guidance in comparison to the 50/50 blend of mean and median observed times although within the cumulative profile of the route it is slightly fast within the central section. The inbound direction falls outside of guidance with a difference of 27%, however it very closely matches the cumulative profile until the very end where there is a step increase in time in the observed which is not present in any of the other time periods.

### **6.6.5 Summary**

The summary of the performance of the LAM in the vicinity of the Proposed Scheme route is detailed below:

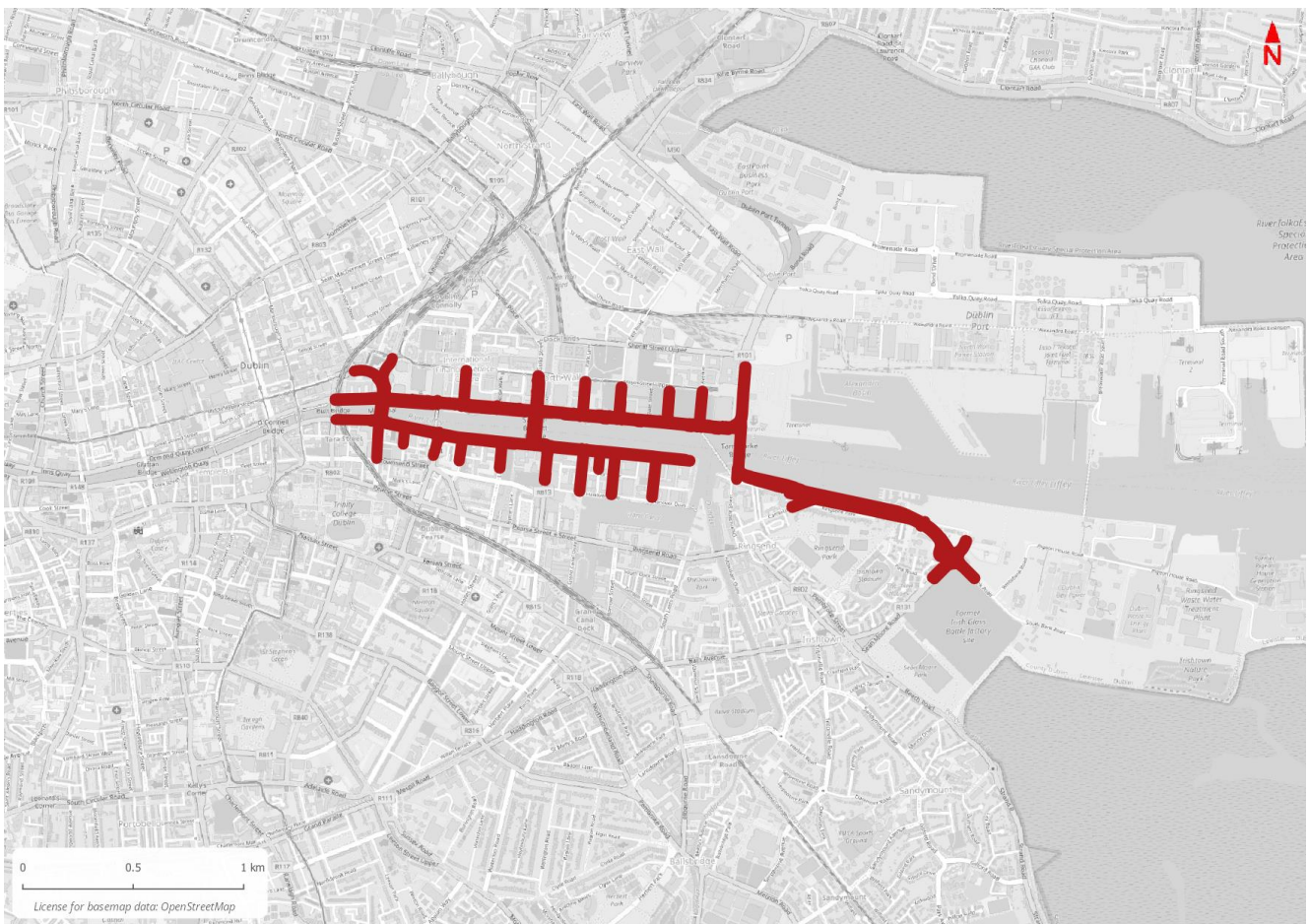
- The LAM calibrates and validates well against link counts along the route of the proposed scheme for all time periods.
- The LAM calibrates and validates well against turning counts for all time periods.
- The modelled journey times from the LAM in the vicinity of the Proposed Scheme is representative of observed journey times, with the cumulative journey time profiles matching well for all time periods.



## 7. Micro-simulation Modelling

### 7.1 Introduction

A micro-simulation model has been developed for the full continuous 'end-to-end' route of the Proposed Scheme. The 'end-to-end' micro-simulation model has been developed to assist in the operational validation of the scheme designs and to provide a visualisation of scheme operability along with its impacts and benefits. The modelling of the Proposed Scheme using the micro-simulation model has shown the differences in travel time for buses as well as general traffic along the full length of the Proposed Scheme, including delay at individual locations. The Proposed Scheme Micro-simulation model network is shown in Diagram 7.1 below



**Diagram 7.1 Proposed Scheme Microsimulation Model Network**

### 7.2 Micro-simulation Model Building

#### 7.2.1 Background Mapping

The Proposed Scheme model has been built on a topographical survey which includes all lane markings, street furniture, visible services, utility covers and boundary information.

Background mapping has been supplemented by video footage of the Proposed Scheme. This has been used to better reflect how drivers treat yellow-box/hatched markings and (in the case of left-turning vehicles) other features such as the end sections of bus lanes.

## 7.2.2 Vehicle Types

The Proposed Scheme model includes a range of vehicle and pedestrian types as outlined in Table 7-1.

**Table 7-1 Vehicle and Pedestrian Types**

| Type Number | Type Name            |
|-------------|----------------------|
| 101         | Taxi                 |
| 201         | Car                  |
| 301         | LGV                  |
| 401         | OGV1                 |
| 402         | OGV2 (permit holder) |
| 403         | OGV2 (other)         |
| 501         | Bus                  |
| 502         | Tram                 |
| 601         | Cyclist (standard)   |
| 602         | Cyclist (confident)  |
| 701         | Pedestrian (man)     |
| 702         | Pedestrian (woman)   |

## 7.2.3 Vehicle Speeds

### 7.2.3.1 Desired Speed Distributions

The Proposed Scheme model includes a range of 'desired speed distributions' as outlined in Table 7.2. All speeds shown are in kph and are industry standard.

**Table 7.2 Desired Speed Distributions**

| Number | Name             | Lower Bound | Upper Bound |
|--------|------------------|-------------|-------------|
| 1001   | 30 km/h – LV     | 25          | 35          |
| 1002   | 30 km/h – HV     | 20          | 30          |
| 2001   | 40 km/h – LV     | 35          | 45          |
| 2002   | 40 km/h – HV     | 30          | 40          |
| 3001   | 50 km/h – LV     | 45          | 55          |
| 3002   | 50 km/h – HV     | 40          | 50          |
| 3501   | 60 km/h – LV     | 55          | 65          |
| 3502   | 60 km/h – HV     | 50          | 60          |
| 4001   | 80 km/h – LV     | 75          | 85          |
| 4002   | 80 km/h – HV     | 70          | 80          |
| 5001   | 100 km/h – LV    | 88          | 130         |
| 5002   | 100 km/h – HV    | 75          | 110         |
| 6001   | Standard Cyclist | 9           | 15          |

|      |                   |    |    |
|------|-------------------|----|----|
| 6002 | Confident Cyclist | 14 | 20 |
|------|-------------------|----|----|

### 7.2.3.2 Reduced Speed Distributions

The Proposed Scheme model includes a range of ‘reduced speed distributions’ as outlined in Table 7.3. Within the model, ‘reduced speed areas’ have been coded to reflect ‘turns’ at junctions and also to control the saturation flow for ‘ahead’ movements. All speeds shown are kph.

**Table 7.3 Reduced Speed Distributions**

| Number | Name                    | Lower Bound | Upper Bound |
|--------|-------------------------|-------------|-------------|
| 8001   | 15 km/h - 1550 Sat flow | 15          | 20          |
| 8002   | 20 km/h - 1750 Sat flow | 20          | 25          |
| 8003   | 25 km/h - 1900 Sat flow | 25          | 30          |
| 8004   | 30 km/h - 1950 Sat flow | 30          | 35          |
| 8005   | 40 km/h - 2050 Sat flow | 40          | 45          |

### 7.2.4 Signal Control

The Proposed Scheme model utilises fixed-time signal plans based on the average of historical SCATS/SCOOT/MOVA log data. Where necessary, green-times have been adjusted to better reflect the timings in operation on the day of traffic data collection.

## 7.3 Micro-simulation Model Calibration and Validation

The Proposed Scheme micro-simulation model has been calibrated and validated using the traffic survey and journey time data described in section 5 in line with Project Appraisal Guidelines for National Roads Unit 5.1 - Construction of Transport Models – Transport Infrastructure Ireland (PE-PAG-02015).

The GEH statistic has been adopted as the main indicator of the extent to which modelled flows match the corresponding observed values. In keeping with PE-PAG-02015, GEH values of less than 5 have been targeted in at least 85% of cases. Attempts have been made to far exceed this guidance to ensure that the micro-simulation model is as accurate as possible in terms of traffic turning movements and journey times along the Proposed Scheme. This ensures the model is fit for purpose to model the impacts and benefits of the Proposed Scheme infrastructure measures.

The model is used predominantly in forecast mode as a design tool, with only the base year driver behaviors and coding brought forward from the base models. The micro-simulation models use flows cordoned directly from the LAM with the Proposed Scheme designs in place. To that end, the micro-simulation models are the operational and micro-level front-end of the modelling suite used to test the Proposed Scheme traffic signal control strategies.

## 7.4 Approach to Providing Bus Priority within the Micro-simulation Model

### 7.4.1 Overview

One of the key motivations for developing the micro-simulation model for the Proposed Scheme was its ability to emulate adaptive traffic signal control and a range of bus priority measures. This differs from both the LAM and junction design models which assume fixed stage sequences and durations.

The general principle for implementing bus priority within the micro-simulation model is based on three levels. An overview of these can be seen in Table 7.4 and Diagram 7.2 below.

**Table 7.4: Principles for high, medium and low bus priority**

| Level of priority | Normal actions                                                                                                                                                                                                                                                                                            |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Low               | <ul style="list-style-type: none"> <li>For buses arriving at the end of green, apply one or more phase extension to enable buses to clear the junction in the current stage.</li> </ul>                                                                                                                   |
| Medium            | <ul style="list-style-type: none"> <li>For buses arriving out of stage, truncate all non-priority stages to their minimum values.</li> <li>Offer compensation green to all truncated phases during following cycle.</li> <li>Offer phase extensions as per low priority.</li> </ul>                       |
| High              | <ul style="list-style-type: none"> <li>For buses arriving out of stage, truncate all non-priority phases to their minimum values and immediately insert bus priority stage.</li> <li>Offer compensation green as per 'medium' priority.</li> <li>Offer phase extensions as per 'low' priority.</li> </ul> |



**Diagram 7.2 Principles for high, medium and low bus priority**

The eventual aspiration is for the Proposed Scheme to operate on a managed headway basis. However, a simplified approach to modelling has been taken which offers either high, medium or low priority at all times, regardless of the headway or lateness of an individual bus. This is due to services being modelled as discrete PT lines.

The approach to modelling also assumes bus priority to be applied to individual junctions rather than as part of a linked sub-region. The decision to do so reflects the suburban nature of the Proposed Scheme and the reductions in general traffic flows which are predicted following the introduction of the Proposed Scheme.

### 7.4.2 Location of Priority Loops

Within the Proposed Scheme micro-simulation model, bus detection using the following methods has been assumed:

- In-ground 'stopline' and 'demand' detectors located 12, 25 and 40m from the junction as standard.
- Optional 'prepare' detectors located up to a further 40m from the junction (80m in total); and

- Optional 'extension' detectors located up to a further 60m from the junction (140m in total).

The use of additional 'prepare' and 'extension' detectors have been considered on a site by site basis. The exact placement of detectors is based on the speed of the road and the distance to upstream bus stops and/or junctions. It is expected that the exact position of such detectors would be validated on site as a key part of the system commissioning.

## 8. Forecast Model Development

### 8.1 Introduction

The following section describes the process to develop the future year forecast models for the assessment of the Proposed Scheme. The section presents detail on the forecast years for the opening and design years as well as the assumptions on background schemes that are anticipated to be in place in these forecast years. The section also presents the assumptions on the future year growth which uses forecast year runs of the ERM.

### 8.2 Proposed Scheme Forecast Assessment Years

The opening year for the scheme is assumed to be 2028, with a design year (opening + 15 years) assumed to be 2043. Transport modelling has therefore been undertaken for the base and two future years: 2028 and 2043.

- Base Year –**2020**
- Opening Year – **2028**
- Design Year – Opening Year plus 15 Year Forecast – **2043**

The assessments within the TIA and EIAR have been carried out in relation to the following scenarios:

- **‘Do Nothing’** – The ‘Do Nothing’ scenario represents the current baseline traffic and transport conditions of the direct and indirect study areas **without** the Proposed Scheme in place and other GDA Strategy projects. This scenario forms the reference case by which to compare the Proposed Scheme (‘Do Something’) for the qualitative assessments only.
- **‘Do Minimum’** – The ‘Do Minimum’ scenario (Opening Year 2028, Design Year 2043) represents the likely traffic and transport conditions of the direct and indirect study areas including for any transportation schemes which have taken place, been approved or are planned for implementation, **without** the Proposed Scheme in place. This scenario forms the reference case by which to compare the Proposed Scheme (‘Do Something’) for the quantitative assessments.
- **‘Do Something’** – The ‘Do Something’ scenario represents the likely traffic and transport conditions of the direct and indirect study areas including for any transportation schemes which have taken place, been approved or are planned for implementation, **with** the Proposed Scheme in place (i.e. the Do Minimum scenario with the addition of the Proposed Scheme). The Do Something scenario has been broken into two phases:
  - Construction Phase (Construction Year 2024) – This phase represents the single worst-case period which will occur during the construction of the Proposed Scheme.
  - Operational Phase (Opening Year 2028, Design Year 2043) – This phase represents when the Proposed Scheme is fully operational.

### 8.3 Do Minimum Network

The following section contains the approach to the development of the 2028 and 2043 ‘Do Minimum’ reference case models which is included within the transport modelling process (i.e. within the four tiers of modelling, presented in section 3, the ERM, LAM, Micro-simulation and junction models) against which the Proposed Scheme has been assessed.

#### 8.3.1.1 Do Minimum Transport Schemes

The core ‘Do Minimum’ scenario is based on the Greater Dublin Area (GDA) Transport Strategy 2016-2035<sup>11</sup> proposals (hereafter referred to as the GDA Strategy). The opening year (2028) assumes a partial implementation of the GDA Strategy in line with the investment proposals contained within the Project Ireland 2040 National Development Plan<sup>12</sup> (NDP) 2018-2027.

<sup>11</sup> <https://www.nationaltransport.ie/planning-and-investment/strategic-planning/greater-dublin-area-transport-strategy/>

<sup>12</sup> <https://www.gov.ie/en/policy-information/07e507-national-development-plan-2018-2027/>

The GDA Strategy provides a robust basis for the ‘Do Minimum’ scenario for the assessment of the Proposed Scheme for the following reasons:

- The GDA Strategy is the approved statutory transportation plan for the region, providing a framework for investment in transport within the region up to 2035;
- The GDA Strategy provides a consistent basis for the 'likely' future receiving environment that is consistent with Government plans and Policies (Project Ireland 2040 National Planning Framework (NPF) and NDP); and
- Schemes within the GDA Strategy are a means to deliver the set of objectives of the GDA Strategy. The sequencing and delivery of the strategy is defined by the implementation plan, but the optimal outcome of aiming to accommodate all future growth in travel demand on sustainable modes underpins the Strategy.

## 8.4 Do Something Network

The ‘Do Something’ Network includes only for the infrastructure elements associated with the Proposed Scheme in addition to those elements included within the ‘Do Minimum’ network.

## 8.5 2028 and 2043 Forecast Year Scheme Definition

Table 8.1 below outlines the schemes that are included in the 2028 and 2043 ‘Do Minimum’ and ‘Do Something’ forecast year scenarios.

**Table 8.1 GDA Strategy / NDP Schemes**

| GDA Strategy / NDP Schemes       |                                                                                                                              | 2028  |       | 2043  |       |
|----------------------------------|------------------------------------------------------------------------------------------------------------------------------|-------|-------|-------|-------|
| Scheme Reference                 | Description                                                                                                                  | DoMin | DoSom | DoMin | DoSom |
| <b>Heavy Rail Infrastructure</b> |                                                                                                                              |       |       |       |       |
| HR1                              | DART+ Programme (non-tunnel elements) including additional stations at Cabra, Pelletstown, Woodbrook, Kilemore and Glasnevin | ✓     | ✓     | ✓     | ✓     |
| HR2                              | DART+ Tunnel Element (Kildare Line to Northern Line)                                                                         | X     | X     | ✓     | ✓     |
| <b>Light Rail Infrastructure</b> |                                                                                                                              |       |       |       |       |
| LR1                              | MetroLink (to Charlemont)                                                                                                    | X     | X     | ✓     | ✓     |
| LR2a                             | LUAS Cross City incorporating LUAS Green Line Capacity Enhancement - Phase 1                                                 | ✓     | ✓     | X     | X     |
| LR3                              | LUAS Green Line Capacity Enhancement - Phase 2                                                                               | X     | X     | ✓     | ✓     |
| LR4                              | Finglas LUAS (Green Line extension Broombridge to Finglas)                                                                   | X     | X     | ✓     | ✓     |
| LR5                              | Extension of LUAS Green Line to Bray                                                                                         | X     | X     | ✓     | ✓     |
| LR6                              | Lucan LUAS                                                                                                                   | X     | X     | ✓     | ✓     |
| LR7                              | Poolbeg LUAS                                                                                                                 | X     | X     | X     | X     |
| LR8                              | Metro South (MetroLink extension Charlemont to Sandyford on LUAS Green Line alignment)                                       | X     | X     | X     | X     |

| GDA Strategy / NDP Schemes |                                                                                                                                                                                                                                                                                     | 2028  |       | 2043  |       |
|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|-------|-------|
| Scheme Reference           | Description                                                                                                                                                                                                                                                                         | DoMin | DoSom | DoMin | DoSom |
| <b>BusConnects</b>         |                                                                                                                                                                                                                                                                                     |       |       |       |       |
| BC1                        | Radial Proposed Core Bus Corridor (Proposed Scheme)                                                                                                                                                                                                                                 | X     | ✓     | X     | ✓     |
| BC2                        | BusConnects Fares / Ticketing Proposals                                                                                                                                                                                                                                             | ✓     | ✓     | ✓     | ✓     |
| BC3                        | BusConnects Network Redesign (Routes and Services)                                                                                                                                                                                                                                  | ✓     | ✓     | ✓     | ✓     |
| BC4                        | Orbital Core Bus Corridors (Proposed Scheme)                                                                                                                                                                                                                                        | X     | X     | X     | X     |
| <b>Park and Ride</b>       |                                                                                                                                                                                                                                                                                     |       |       |       |       |
| PR1                        | Rail and Bus based P&R provision (partial implementation by 2028)                                                                                                                                                                                                                   | ✓     | ✓     | ✓     | ✓     |
| <b>Cycling</b>             |                                                                                                                                                                                                                                                                                     |       |       |       |       |
| CY1                        | Greater Dublin Area Cycle Network Plan (excluding Radial Core Bus Corridor elements)                                                                                                                                                                                                | ✓     | ✓     | ✓     | ✓     |
| CY2                        | Greater Dublin Area Cycle Network Plan (including Radial Core Bus Corridor elements)                                                                                                                                                                                                | X     | ✓     | X     | ✓     |
| <b>National Roads</b>      |                                                                                                                                                                                                                                                                                     |       |       |       |       |
| NR1                        | Reconfiguration of the N7 from its junction with the M50 to Naas, to rationalise junctions and accesses in order to provide a higher level of service for strategic traffic travelling on the mainline                                                                              | X     | X     | ✓     | ✓     |
| NR2                        | Junction upgrades and other capacity improvements on the M1 motorway, including additional lanes south of Drogheda, where required                                                                                                                                                  | X     | X     | ✓     | ✓     |
| NR3                        | Widening of the M7 between Junction 9 (Naas North) and Junction 11 (M7/M9) to provide an additional lane in each direction                                                                                                                                                          | ✓     | ✓     | ✓     | ✓     |
| NR4                        | Widening of the M50 to three lanes in each direction between Junction 14 (Sandyford) and Junction 17 (M11) plus related junction and other changes                                                                                                                                  | X     | X     | ✓     | ✓     |
| NR5                        | Reconfiguration of the N4 from its junction with the M50 to Leixlip to rationalise accesses and to provide additional capacity at the Quarryvale junction                                                                                                                           | X     | X     | ✓     | ✓     |
| NR6                        | Capacity enhancement and reconfiguration of the M11/N11 from Junction 4 (M50) to Junction 14 (Ashford) inclusive of ancillary and associated road schemes, to provide additional lanes and upgraded junctions, plus service roads and linkages to cater for local traffic movements | ✓     | ✓     | ✓     | ✓     |



| GDA Strategy / NDP Schemes      |                                                                                                                                                                                                                                                            | 2028  |       | 2043  |       |
|---------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|-------|-------|
| Scheme Reference                | Description                                                                                                                                                                                                                                                | DoMin | DoSom | DoMin | DoSom |
| NR7                             | Enhancements of the N2/M2 national route inclusive of a bypass of Slane, to provide for additional capacity on the non-motorway sections of this route, and to address safety issues in Slane village associated with, in particular, heavy goods vehicles | X     | X     | ✓     | ✓     |
| NR8                             | Widening of the N3 between Junction 1 (M50) and Junction 4 (Clonee), plus related junction and necessary changes to the existing national road network                                                                                                     | X     | X     | ✓     | ✓     |
| NR9                             | Development of a road link connecting from the southern end of the Dublin Port Tunnel to the South Port area, which will serve the South Port and adjoining development areas                                                                              | X     | X     | ✓     | ✓     |
| <b>Regional and Local Roads</b> |                                                                                                                                                                                                                                                            |       |       |       |       |
| RR1                             | N3 Castaheany Interchange Upgrade                                                                                                                                                                                                                          | ✓     | ✓     | ✓     | ✓     |
| RR2                             | N3–N4: Barnhill to Leixlip Interchange                                                                                                                                                                                                                     | ✓     | ✓     | ✓     | ✓     |
| RR3                             | North-South Road – west of Adamstown SDZ linking N7 to N4 and on to Fingal                                                                                                                                                                                 | ✓     | ✓     | ✓     | ✓     |
| RR4                             | Glenamuck District Distributor Road                                                                                                                                                                                                                        | ✓     | ✓     | ✓     | ✓     |
| RR5                             | Leopardstown Link Road Phase 2                                                                                                                                                                                                                             | ✓     | ✓     | ✓     | ✓     |
| RR6                             | Porterstown Distributor Link Road                                                                                                                                                                                                                          | ✓     | ✓     | ✓     | ✓     |
| RR7                             | R126 Donabate Relief Road: R132 to Portrane Demesne                                                                                                                                                                                                        | ✓     | ✓     | ✓     | ✓     |
| RR8                             | Oldtown-Mooretown Western Distributor Link Road                                                                                                                                                                                                            | ✓     | ✓     | ✓     | ✓     |
| RR9                             | Swords Relief Road at Lord Mayors                                                                                                                                                                                                                          | ✓     | ✓     | ✓     | ✓     |
| RR10                            | Poolbeg development roads                                                                                                                                                                                                                                  | ✓     | ✓     | ✓     | ✓     |
| RR11                            | Cherrywood development roads                                                                                                                                                                                                                               | ✓     | ✓     | ✓     | ✓     |
| RR12                            | Clonburris development roads                                                                                                                                                                                                                               | ✓     | ✓     | ✓     | ✓     |
| <b>Demand Management</b>        |                                                                                                                                                                                                                                                            |       |       |       |       |
| DM1                             | Dublin City Centre Parking Constraint                                                                                                                                                                                                                      | ✓     | ✓     | ✓     | ✓     |
| DM2a                            | M50 Demand Management Measures - Variable Speed Limits                                                                                                                                                                                                     | ✓     | ✓     | ✓     | ✓     |
| DM2b                            | M50 Demand Management Measures - Multi-point tolling                                                                                                                                                                                                       | X     | X     | ✓     | ✓     |

| GDA Strategy / NDP Schemes |                                                                                                                                                                                                                                                                                                  | 2028  |       | 2043  |       |
|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|-------|-------|
| Scheme Reference           | Description                                                                                                                                                                                                                                                                                      | DoMin | DoSom | DoMin | DoSom |
| DM3                        | Implement demand management measures to address congestion issues on the radial national routes approaching the M50 motorway                                                                                                                                                                     | X     | X     | ✓     | ✓     |
| DM4                        | Further demand management measures that ensure that a maximum 45% car commuter mode share is achieved.<br><br>(* For clarity, measures DM2a, DM2b and DM3 are not explicitly modelled but are considered to be included as part of the suite of measures to achieve the above mode share target) | X     | X     | ✓     | ✓     |

## 8.6 Forecast Travel Demand

Transport demand is a key input to the modelling process, which is directly related to the land-use data fed into the NTA ERM at the outset of the modelling process. Population, Employment and Education attractions must be prepared and defined at the Census Small Area (CSA) level to be input to the RMS.

The NTA has defined a 2040 National Planning Framework (NPF) planning sheet, based on 2016 Census data, regional growth projections and their knowledge of Local Authority development plans. Population, Employment and Education attraction growth are located in areas that are likely to be developed between now and 2040.

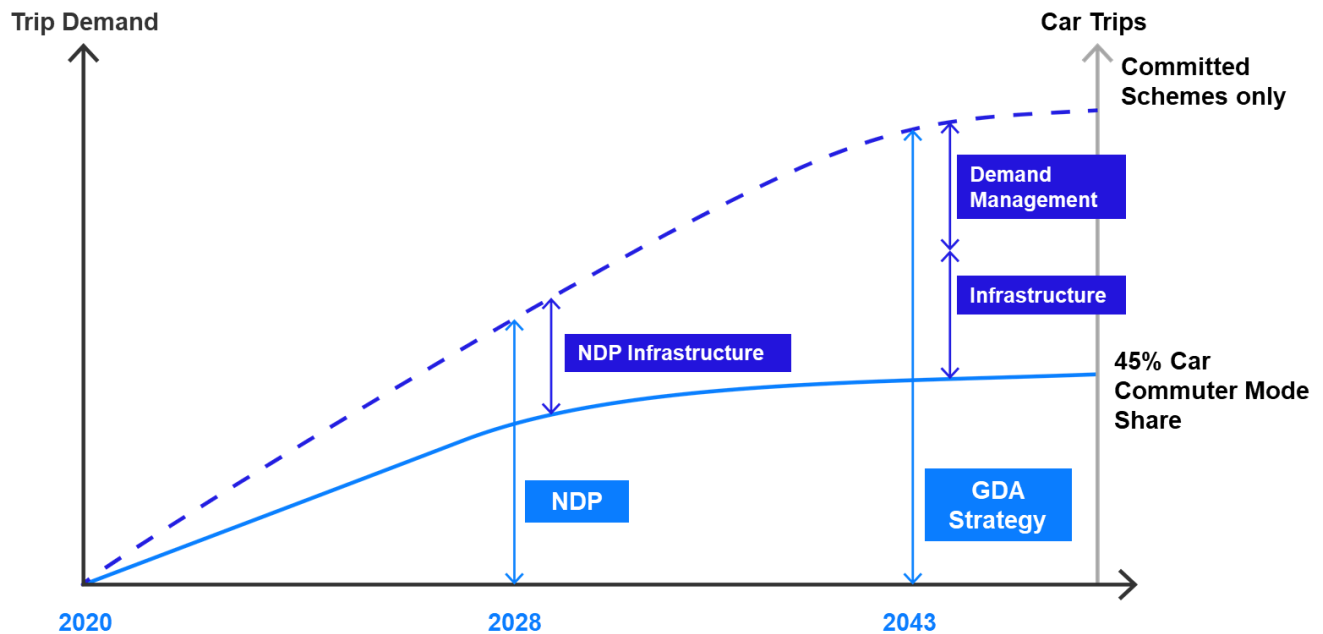
The NTA has provided the necessary planning sheets for the forecast assessment years (2028, 2043), which has been derived by linear interpolation between the 2016 Census data and the NTA's 2040 NPF reference case planning sheet. It has been assumed that the demand forecasts are fixed with no change in distribution for scenario testing.

Forecast reference case scenarios have been created for the agreed forecast years for the CBC Infrastructure Works. The scheme opening year (2028) is based on the investment priorities contained within the National Development Plan (NDP), whilst the Design Year (2043 – Opening year plus 15) is based on the full implementation of the GDA Strategy measures.

It is envisaged that the population will grow by 11% up to 2028 and 25% by 2043 (above 2016 census data levels). Similarly, employment growth is due to increase by 22% by 2028 and 49% by 2043 (Source: NTA Reference Case Planning Sheets 2028, 2043). The assessment also assumes that goods vehicles (HGVs and LGVs) continue to grow in line with forecasted economic activity with patterns of travel remaining the same. For example, the modelling assumes a 45% and 77% increase in goods traffic versus the base year in 2028 and 2043 respectively.

The GDA Strategy (along with existing supply side capacity constraints e.g., parking availability, road capacity etc.) has the effect of limiting the growth in car demand on the road network into the future. This is shown diagrammatically in Diagram 8.1. Total trip demand (indicated by the dashed line) will increase into the future in line with demographic growth (population and employment levels etc.). To limit the growth in car traffic and to ensure that this demand growth is catered for predominantly by sustainable modes, a number of measures will be required, that include improved sustainable infrastructure and priority measures delivered as part of the NDP/GDA Strategy. In addition to this, demand management measures will play a role in limiting the growth in transport demand, predominantly to sustainable modes only. The result will be only limited or no increases overall in private car travel demand. The Proposed Scheme will play a key role in this as part of the wider package of GDA Strategy measures.

In general, total trip demand (combining all transport modes) will increase into the future in line with population and employment growth. A greater share of the demand will be by sustainable modes (Public Transport (PT), Walking, Cycling). Private car demand will still grow but not linearly in line with demographics.

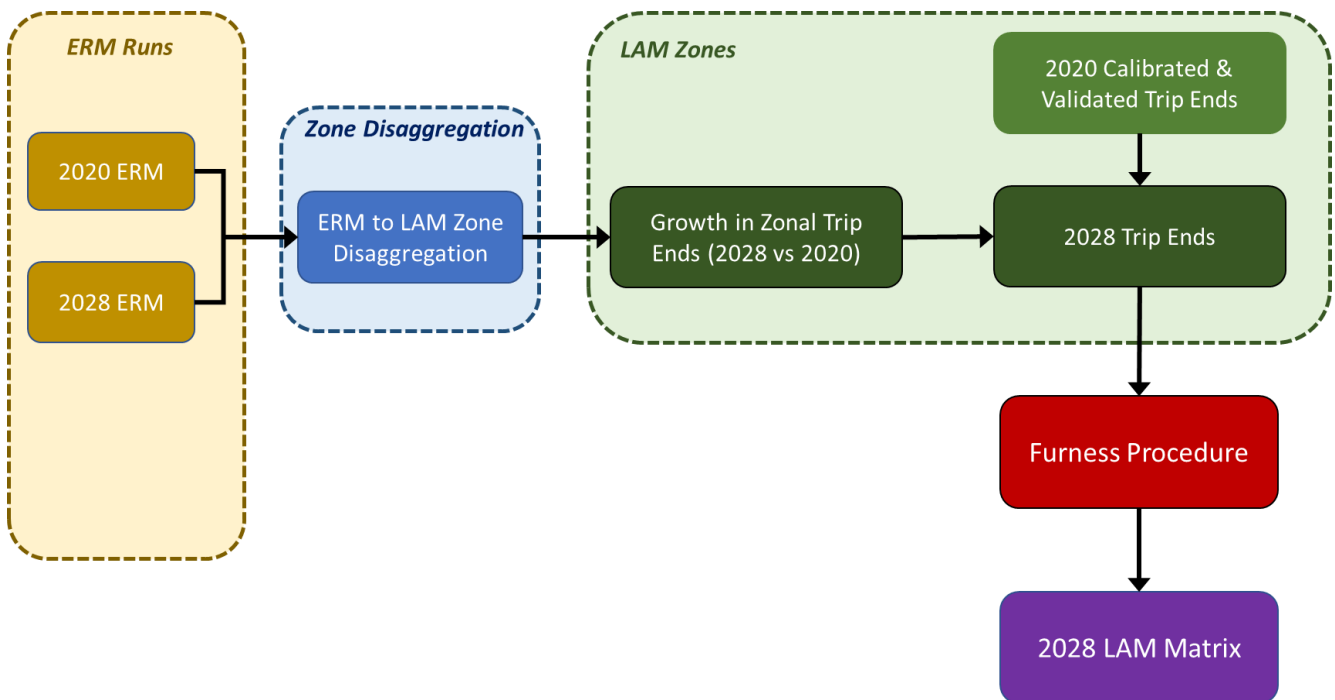


**Diagram 8.1 Trip Demand Growth and the GDA Strategy**

In terms of the transport modelling scenarios for the traffic and transport assessment, as per the Strategy proposals, there are no specific demand management measures included in the Do Minimum scenario in the 2028 Opening year, other than constraining parking availability in Dublin at existing levels. For the design year, 2043 scenario, a proxy for a suite of demand management measures is included in the Do Minimum (Ref: DM4) in line with the target to achieve a maximum 45% car driver commuter mode share target, across the GDA, as outlined in the Strategy.

### 8.6.1 LAM Forecast Matrix Development

Prior forecast trip matrices for the LAM in 2028 and 2043 are developed based on a cordon of the Proposed Scheme ERM 2028 and 2043 Do Minimum and Do Something models. To produce the LAM forecast year matrices, the trip end growth between the 2020 and 2028 / 2043 ERM cordoned matrices has been applied to each of the LAM time period (AM, LT, SR, PM) calibrated base models to produce the equivalent 2028 and 2043 matrices. Diagram 8.2 below gives a graphical overview of the approach to creating the 2028 LAM demand matrices for the Proposed Scheme. The 2043 matrices are created in the same manner using 2043 runs of the ERM.



**Diagram 8.2 LAM Forecast Matrix Development Process**

## 8.6.2 Microsimulation Forecast Matrix Development

### 8.6.2.1 Overview

Forecast trip matrices for the Proposed Scheme micro-simulation model in 2028 and 2043 have been developed based outputs from the LAM.

### 8.6.2.2 Do Minimum Scenario

In the case of the Do Minimum Scenario, cordon matrices have been extracted from the 2028/2043 Do Minimum LAM for the areas covered by the Proposed Scheme micro-simulation model. Cordon matrices have been 'unstacked' and converted from pcus into vehicles before being compressed/expanded to match the zone structure in the micro-simulation models.

Hourly demand for the micro-simulation model 'shoulder' hours has been derived by factoring up or down the 08:00-09:00 and 17:00-18:00 Do Minimum matrices based on the relative number of trips simulated in each of the hours within the 2020 base year micro-simulation model.

With hourly 2028/2043 Do Minimum demand matrices for each of the hours simulated by the micro-simulation models derived, demand has been disaggregated into 15-minute arrivals using the profiles from the 2020 base year micro-simulation model.

In the case of cyclists, which are not modelled in the LAM, 'global' uplifts have been applied to movements in the 2020 base year micro-simulation model to reflect the 2028 and 2043 Do Minimum scenario.

### 8.6.2.3 Do Something Scenario

Development of the 2028 and 2043 Do Something micro-simulation demand follows a similar process to that of the Do Minimum.

In this case, cordon matrices have been extracted from the 2028/2043 Do Something LAM for the areas covered by the micro-simulation model before being converted into vehicles and compressed into a consistent zone structure.

Production of demand for the micro-simulation Do Something shoulder hours and use of 15-minute profiles from the micro-simulation base model has been applied as per the Do Minimum.

With regards to cyclists, 'global' uplifts have been applied to movements in the 2020 base year micro-simulation model to reflect the 2028 and 2043 Do Minimum scenario.

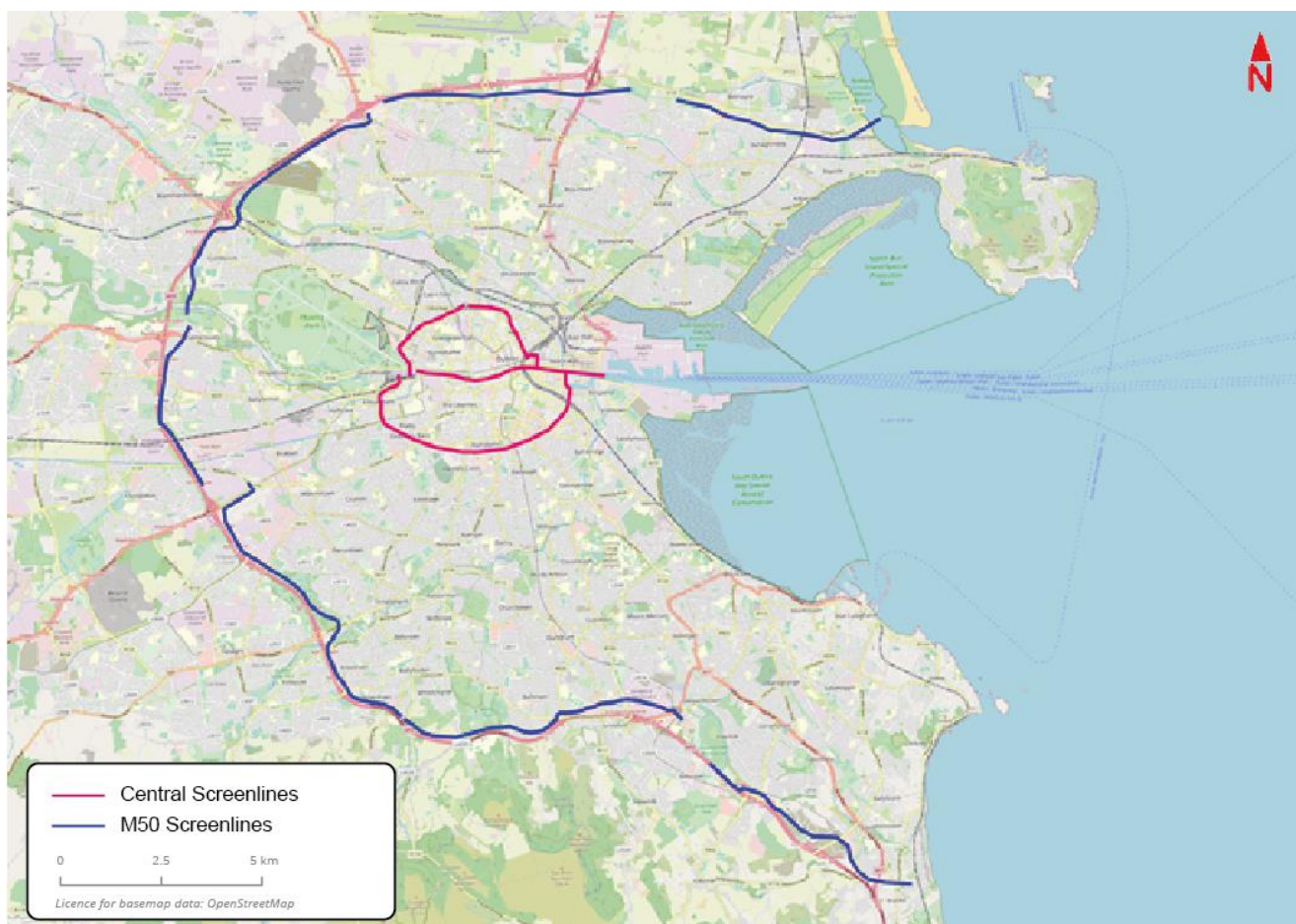
## Appendix A. Full Local Area Model Calibration and Validation

### A.1 Introduction

This appendix provides further details on the calibration and validation process and results for the full Local Area Model which covers most of the urban area of Dublin.

### A.2 LAM Prior Matrix Factoring

An initial step in the calibration of the LAM is to adjust the prior trip matrix provided from the ERM to better represent observed trip patterns at a strategic level to more recent traffic survey data. The disaggregated prior matrix extracted from the ERM was assigned to the LAM road network. Modelled flows were then compared to observed count data at identified screenlines<sup>13</sup> to establish whether the model was accurately representing key movements within the study area. These screenlines represent two cordons, an outer cordon around the M50 and an inner cordon around the central canal area (bounded generally by the Grand Canal and Royal Canal). The coverage of the screenlines is detailed below in Apx Diagram A.1.



**Apx Diagram A.1 Calibration Screenline Coverage**

This coverage consists of 13 individual screenlines which have been identified for the LAM calibration, namely:

- Canal North
- Canal Northeast
- Canal Northwest
- Canal Southeast

<sup>13</sup> A screenline is a set of count locations that have been grouped together to form a line of counts. It is used to understand trip patterns at a more aggregate level

- Canal Southwest
- M50 N Cordon
- M50 NE Cordon
- M50 NW Cordon
- M50 S Cordon
- M50 SE Cordon
- M50 SW Cordon
- M50 W Cordon
- River Liffey

Apx Table A.1 outlines the comparison between modelled and observed traffic flows at each of the screenlines for the disaggregated ERM matrix. The results indicate a significant difference in flows, in particular, for movements entering/exiting the model via the western boundary, and traffic exiting to the north and entering from the east.

**Apx Table A.1 AM ERM Disaggregated Matrix Screenline Comparison**

| Screenline                 | Observed Flow | Modelled Flow | % Difference | GEH  |
|----------------------------|---------------|---------------|--------------|------|
| Canal North - Inbound      | 1874          | 2250          | 20%          | 8.3  |
| Canal North - Outbound     | 1289          | 1766          | 37%          | 12.2 |
| Canal Northeast - Inbound  | 2346          | 2779          | 18%          | 8.5  |
| Canal Northeast - Outbound | 1712          | 1327          | 22%          | 9.9  |
| Canal Northwest - Inbound  | 3176          | 3600          | 13%          | 7.3  |
| Canal Northwest - Outbound | 1758          | 2440          | 39%          | 14.9 |
| Canal Southeast - Inbound  | 4053          | 4848          | 20%          | 11.9 |
| Canal Southeast - Outbound | 3012          | 3625          | 20%          | 10.6 |
| Canal Southwest - Inbound  | 5288          | 5266          | 0%           | 0.3  |
| Canal Southwest - Outbound | 3324          | 4168          | 25%          | 13.8 |
| M50 N Cordon - Inbound     | 6727          | 5412          | 20%          | 16.9 |
| M50 N Cordon - Outbound    | 4929          | 4763          | 3%           | 2.4  |
| M50 NE Cordon - Inbound    | 3337          | 3445          | 3%           | 1.8  |
| M50 NE Cordon - Outbound   | 2438          | 2627          | 8%           | 3.8  |
| M50 NW Cordon - Inbound    | 5991          | 6596          | 10%          | 7.6  |
| M50 NW Cordon - Outbound   | 5209          | 5032          | 3%           | 2.5  |
| M50 S Cordon - Inbound     | 7107          | 6342          | 11%          | 9.3  |
| M50 S Cordon - Outbound    | 4541          | 4561          | 0%           | 0.3  |
| M50 SE Cordon - Inbound    | 5759          | 5411          | 6%           | 4.7  |
| M50 SE Cordon - Outbound   | 3355          | 3195          | 5%           | 2.8  |
| M50 SW Cordon - Inbound    | 9219          | 7644          | 17%          | 17.2 |
| M50 SW Cordon - Outbound   | 6628          | 6300          | 5%           | 4.1  |
| M50 W Cordon - Inbound     | 4864          | 4730          | 3%           | 1.9  |
| M50 W Cordon - Outbound    | 2993          | 3614          | 21%          | 10.8 |
| River Liffey - Northbound  | 4453          | 5021          | 13%          | 8.3  |
| River Liffey - Southbound  | 6019          | 6781          | 13%          | 9.5  |

**Apx Table A.2 LT ERM Disaggregated Matrix Screenline Comparison**

| Screenline                 | Observed Flow | Modelled Flow | % Difference | GEH  |
|----------------------------|---------------|---------------|--------------|------|
| Canal North - Inbound      | 1545          | 1658          | 7%           | 2.8  |
| Canal North - Outbound     | 1419          | 1717          | 21%          | 7.5  |
| Canal Northeast - Inbound  | 1895          | 1908          | 1%           | 0.3  |
| Canal Northeast - Outbound | 1651          | 1623          | 2%           | 0.7  |
| Canal Northwest - Inbound  | 2077          | 2141          | 3%           | 1.4  |
| Canal Northwest - Outbound | 1911          | 2051          | 7%           | 3.1  |
| Canal Southeast - Inbound  | 3200          | 3414          | 7%           | 3.7  |
| Canal Southeast - Outbound | 2923          | 3083          | 5%           | 2.9  |
| Canal Southwest - Inbound  | 3604          | 3548          | 2%           | 0.9  |
| Canal Southwest - Outbound | 3581          | 4451          | 24%          | 13.7 |
| M50 N Cordon - Inbound     | 4541          | 4083          | 10%          | 7.0  |
| M50 N Cordon - Outbound    | 4880          | 4509          | 8%           | 5.4  |
| M50 NE Cordon - Inbound    | 2419          | 2394          | 1%           | 0.5  |
| M50 NE Cordon - Outbound   | 2513          | 2315          | 8%           | 4.0  |
| M50 NW Cordon - Inbound    | 3923          | 4071          | 4%           | 2.3  |
| M50 NW Cordon - Outbound   | 3673          | 3851          | 5%           | 2.9  |
| M50 S Cordon - Inbound     | 3859          | 3931          | 2%           | 1.1  |
| M50 S Cordon - Outbound    | 3643          | 3986          | 9%           | 5.6  |
| M50 SE Cordon - Inbound    | 2470          | 2765          | 12%          | 5.8  |
| M50 SE Cordon - Outbound   | 2611          | 2824          | 8%           | 4.1  |
| M50 SW Cordon - Inbound    | 6511          | 5722          | 12%          | 10.1 |
| M50 SW Cordon - Outbound   | 5601          | 5397          | 4%           | 2.8  |
| M50 W Cordon - Inbound     | 2981          | 3162          | 6%           | 3.3  |
| M50 W Cordon - Outbound    | 3213          | 3254          | 1%           | 0.7  |
| River Liffey - Northbound  | 4329          | 5109          | 18%          | 11.4 |
| River Liffey - Southbound  | 4750          | 5473          | 15%          | 10.1 |

**Apx Table A.3 SR ERM Disaggregated Matrix Screenline Comparison**

| Screenline                 | Observed Flow | Modelled Flow | % Difference | GEH |
|----------------------------|---------------|---------------|--------------|-----|
| Canal North - Inbound      | 1417          | 1578          | 11%          | 4.2 |
| Canal North - Outbound     | 1661          | 1793          | 8%           | 3.2 |
| Canal Northeast - Inbound  | 1898          | 1767          | 7%           | 3.1 |
| Canal Northeast - Outbound | 1991          | 2019          | 1%           | 0.6 |
| Canal Northwest - Inbound  | 2134          | 2133          | 0%           | 0.0 |
| Canal Northwest - Outbound | 2500          | 2468          | 1%           | 0.6 |
| Canal Southeast - Inbound  | 3077          | 3485          | 13%          | 7.1 |
| Canal Southeast - Outbound | 3244          | 3274          | 1%           | 0.5 |
| Canal Southwest - Inbound  | 3355          | 3409          | 2%           | 0.9 |
| Canal Southwest - Outbound | 4532          | 4944          | 9%           | 6.0 |
| M50 N Cordon - Inbound     | 4685          | 4250          | 9%           | 6.5 |
| M50 N Cordon - Outbound    | 5469          | 5389          | 1%           | 1.1 |
| M50 NE Cordon - Inbound    | 2724          | 2490          | 9%           | 4.6 |



| Screenline                | Observed Flow | Modelled Flow | % Difference | GEH  |
|---------------------------|---------------|---------------|--------------|------|
| M50 NE Cordon - Outbound  | 3191          | 2524          | 21%          | 12.5 |
| M50 NW Cordon - Inbound   | 4192          | 4430          | 6%           | 3.6  |
| M50 NW Cordon - Outbound  | 4501          | 4877          | 8%           | 5.5  |
| M50 S Cordon - Inbound    | 4080          | 3802          | 7%           | 4.4  |
| M50 S Cordon - Outbound   | 4641          | 4822          | 4%           | 2.6  |
| M50 SE Cordon - Inbound   | 2936          | 2772          | 6%           | 3.1  |
| M50 SE Cordon - Outbound  | 3249          | 3514          | 8%           | 4.6  |
| M50 SW Cordon - Inbound   | 6794          | 5872          | 14%          | 11.6 |
| M50 SW Cordon - Outbound  | 7107          | 6347          | 11%          | 9.3  |
| M50 W Cordon - Inbound    | 3021          | 3077          | 2%           | 1.0  |
| M50 W Cordon - Outbound   | 3866          | 3538          | 8%           | 5.4  |
| River Liffey - Northbound | 4690          | 5733          | 22%          | 14.5 |
| River Liffey - Southbound | 4628          | 5258          | 14%          | 9.0  |

**Apx Table A.4 PM ERM Disaggregated Matrix Screenline Comparison**

| Screenline                 | Observed Flow | Modelled Flow | % Difference | GEH  |
|----------------------------|---------------|---------------|--------------|------|
| Canal North - Inbound      | 1476          | 1679          | 14%          | 5.1  |
| Canal North - Outbound     | 1630          | 2101          | 29%          | 10.9 |
| Canal Northeast - Inbound  | 1999          | 2014          | 1%           | 0.3  |
| Canal Northeast - Outbound | 2458          | 2303          | 6%           | 3.2  |
| Canal Northwest - Inbound  | 2202          | 2385          | 8%           | 3.8  |
| Canal Northwest - Outbound | 3407          | 3230          | 5%           | 3.1  |
| Canal Southeast - Inbound  | 3191          | 3889          | 22%          | 11.7 |
| Canal Southeast - Outbound | 3631          | 3992          | 10%          | 5.9  |
| Canal Southwest - Inbound  | 3317          | 3510          | 6%           | 3.3  |
| Canal Southwest - Outbound | 5194          | 5796          | 12%          | 8.1  |
| M50 N Cordon - Inbound     | 5417          | 5277          | 3%           | 1.9  |
| M50 N Cordon - Outbound    | 6300          | 6198          | 2%           | 1.3  |
| M50 NE Cordon - Inbound    | 2726          | 2525          | 7%           | 3.9  |
| M50 NE Cordon - Outbound   | 3237          | 3075          | 5%           | 2.9  |
| M50 NW Cordon - Inbound    | 4927          | 4978          | 1%           | 0.7  |
| M50 NW Cordon - Outbound   | 6011          | 6307          | 5%           | 3.8  |
| M50 S Cordon - Inbound     | 4843          | 4631          | 4%           | 3.1  |
| M50 S Cordon - Outbound    | 6085          | 6155          | 1%           | 0.9  |
| M50 SE Cordon - Inbound    | 3360          | 3409          | 1%           | 0.8  |
| M50 SE Cordon - Outbound   | 4393          | 4262          | 3%           | 2.0  |
| M50 SW Cordon - Inbound    | 6527          | 5719          | 12%          | 10.3 |
| M50 SW Cordon - Outbound   | 7013          | 7163          | 2%           | 1.8  |
| M50 W Cordon - Inbound     | 2779          | 3360          | 21%          | 10.5 |
| M50 W Cordon - Outbound    | 4811          | 5185          | 8%           | 5.3  |
| River Liffey - Northbound  | 5396          | 5980          | 11%          | 7.8  |
| River Liffey - Southbound  | 4942          | 5289          | 7%           | 4.9  |

In order to provide a better starting point for model calibration, the disaggregated ERM matrix was factored at a screenline level to better represent observed traffic volumes. Two-week ATC data was available at all roads entering the M50 and canal screenline boundaries, and as such, give a good representation of average traffic flows entering/exiting the model area in the AM, LT, SR and PM peak hours.

Select link analysis was undertaken to identify origin-destination (OD) movements passing each screenline, and factors were applied to closer align total modelled screenline flows with observed movement patterns.

The results of the screenline factoring process are presented in Apx Table A.5 to Apx Table A.8. The results indicate a significant improvement in correlation between modelled and observed flows when compared to the pre-factoring results in Apx Table A.1 to Apx Table A.4. Whilst the results represent an improvement, there are still some differences at some screenlines. However, the factored matrix provides an improved representation of observed traffic movements to/from the model area, and as such, was taken forward to the next stages in the calibration process.

**Apx Table A.5 AM Post-Factoring Matrix Screenline Comparison**

| Screenline                 | Observed Flow | Modelled Flow | % Difference | GEH  |
|----------------------------|---------------|---------------|--------------|------|
| Canal North - Inbound      | 1874          | 2195          | 17%          | 7.1  |
| Canal North - Outbound     | 1289          | 1720          | 33%          | 11.1 |
| Canal Northeast - Inbound  | 2346          | 2524          | 8%           | 3.6  |
| Canal Northeast - Outbound | 1712          | 1377          | 20%          | 8.5  |
| Canal Northwest - Inbound  | 3176          | 3478          | 10%          | 5.2  |
| Canal Northwest - Outbound | 1758          | 2306          | 31%          | 12.2 |
| Canal Southeast - Inbound  | 4053          | 4449          | 10%          | 6.1  |
| Canal Southeast - Outbound | 3012          | 3407          | 13%          | 7.0  |
| Canal Southwest - Inbound  | 5288          | 5254          | 1%           | 0.5  |
| Canal Southwest - Outbound | 3324          | 3975          | 20%          | 10.8 |
| M50 N Cordon - Inbound     | 6727          | 5635          | 16%          | 13.9 |
| M50 N Cordon - Outbound    | 4929          | 4539          | 8%           | 5.7  |
| M50 NE Cordon - Inbound    | 3337          | 3408          | 2%           | 1.2  |
| M50 NE Cordon - Outbound   | 2438          | 2430          | 0%           | 0.2  |
| M50 NW Cordon - Inbound    | 5991          | 6667          | 11%          | 8.5  |
| M50 NW Cordon - Outbound   | 5209          | 5094          | 2%           | 1.6  |
| M50 S Cordon - Inbound     | 7107          | 6710          | 6%           | 4.8  |
| M50 S Cordon - Outbound    | 4541          | 4525          | 0%           | 0.2  |
| M50 SE Cordon - Inbound    | 5759          | 5682          | 1%           | 1.0  |
| M50 SE Cordon - Outbound   | 3355          | 3185          | 5%           | 3.0  |
| M50 SW Cordon - Inbound    | 9219          | 8249          | 11%          | 10.4 |
| M50 SW Cordon - Outbound   | 6628          | 6342          | 4%           | 3.5  |
| M50 W Cordon - Inbound     | 4864          | 4975          | 2%           | 1.6  |
| M50 W Cordon - Outbound    | 2993          | 3495          | 17%          | 8.8  |
| River Liffey - Northbound  | 4453          | 4700          | 6%           | 3.7  |
| River Liffey - Southbound  | 6019          | 6416          | 7%           | 5.0  |

**Apx Table A.6 LT Post-Factoring Matrix Screenline Comparison**

| Screenline            | Observed Flow | Modelled Flow | % Difference | GEH |
|-----------------------|---------------|---------------|--------------|-----|
| Canal North - Inbound | 1545          | 1676          | 8%           | 3.3 |

|                            |      |      |     |      |
|----------------------------|------|------|-----|------|
| Canal North - Outbound     | 1419 | 1720 | 21% | 7.6  |
| Canal Northeast - Inbound  | 1895 | 1959 | 3%  | 1.5  |
| Canal Northeast - Outbound | 1651 | 1650 | 0%  | 0.0  |
| Canal Northwest - Inbound  | 2077 | 2140 | 3%  | 1.4  |
| Canal Northwest - Outbound | 1911 | 2062 | 8%  | 3.4  |
| Canal Southeast - Inbound  | 3200 | 3421 | 7%  | 3.8  |
| Canal Southeast - Outbound | 2923 | 3122 | 7%  | 3.6  |
| Canal Southwest - Inbound  | 3604 | 3520 | 2%  | 1.4  |
| Canal Southwest - Outbound | 3581 | 4468 | 25% | 14.0 |
| M50 N Cordon - Inbound     | 4541 | 4234 | 7%  | 4.6  |
| M50 N Cordon - Outbound    | 4880 | 4648 | 5%  | 3.4  |
| M50 NE Cordon - Inbound    | 2419 | 2438 | 1%  | 0.4  |
| M50 NE Cordon - Outbound   | 2513 | 2352 | 6%  | 3.3  |
| M50 NW Cordon - Inbound    | 3923 | 4091 | 4%  | 2.6  |
| M50 NW Cordon - Outbound   | 3673 | 3927 | 7%  | 4.1  |
| M50 S Cordon - Inbound     | 3859 | 3966 | 3%  | 1.7  |
| M50 S Cordon - Outbound    | 3643 | 4063 | 12% | 6.8  |
| M50 SE Cordon - Inbound    | 2470 | 2777 | 12% | 6.0  |
| M50 SE Cordon - Outbound   | 2611 | 2853 | 9%  | 4.6  |
| M50 SW Cordon - Inbound    | 6511 | 5817 | 11% | 8.8  |
| M50 SW Cordon - Outbound   | 5601 | 5617 | 0%  | 0.2  |
| M50 W Cordon - Inbound     | 2981 | 3186 | 7%  | 3.7  |
| M50 W Cordon - Outbound    | 3213 | 3311 | 3%  | 1.7  |
| River Liffey - Northbound  | 4329 | 5109 | 18% | 11.4 |
| River Liffey - Southbound  | 4750 | 5556 | 17% | 11.2 |

**Apx Table A.7 SR Post-Factoring Matrix Screenline Comparison**

| Screenline                 | Observed Flow | Modelled Flow | % Difference | GEH |
|----------------------------|---------------|---------------|--------------|-----|
| Canal North - Inbound      | 1417          | 1517          | 7%           | 2.6 |
| Canal North - Outbound     | 1661          | 1746          | 5%           | 2.1 |
| Canal Northeast - Inbound  | 1898          | 1733          | 9%           | 3.9 |
| Canal Northeast - Outbound | 1991          | 1796          | 10%          | 4.5 |
| Canal Northwest - Inbound  | 2134          | 2072          | 3%           | 1.4 |
| Canal Northwest - Outbound | 2500          | 2402          | 4%           | 2.0 |
| Canal Southeast - Inbound  | 3077          | 3187          | 4%           | 2.0 |
| Canal Southeast - Outbound | 3244          | 3222          | 1%           | 0.4 |
| Canal Southwest - Inbound  | 3355          | 3287          | 2%           | 1.2 |
| Canal Southwest - Outbound | 4532          | 4850          | 7%           | 4.6 |
| M50 N Cordon - Inbound     | 4685          | 4527          | 3%           | 2.3 |
| M50 N Cordon - Outbound    | 5469          | 5691          | 4%           | 3.0 |
| M50 NE Cordon - Inbound    | 2724          | 2582          | 5%           | 2.7 |
| M50 NE Cordon - Outbound   | 3191          | 2768          | 13%          | 7.7 |
| M50 NW Cordon - Inbound    | 4192          | 4383          | 5%           | 2.9 |
| M50 NW Cordon - Outbound   | 4501          | 4861          | 8%           | 5.3 |

|                           |      |      |     |     |
|---------------------------|------|------|-----|-----|
| M50 S Cordon - Inbound    | 4080 | 3955 | 3%  | 2.0 |
| M50 S Cordon - Outbound   | 4641 | 4819 | 4%  | 2.6 |
| M50 SE Cordon - Inbound   | 2936 | 2940 | 0%  | 0.1 |
| M50 SE Cordon - Outbound  | 3249 | 3432 | 6%  | 3.2 |
| M50 SW Cordon - Inbound   | 6794 | 6162 | 9%  | 7.8 |
| M50 SW Cordon - Outbound  | 7107 | 6574 | 7%  | 6.4 |
| M50 W Cordon - Inbound    | 3021 | 3099 | 3%  | 1.4 |
| M50 W Cordon - Outbound   | 3866 | 3663 | 5%  | 3.3 |
| River Liffey - Northbound | 4690 | 5304 | 13% | 8.7 |
| River Liffey - Southbound | 4628 | 5116 | 11% | 7.0 |

**Apx Table A.8 PM Post-Factoring Matrix Screenline Comparison**

| Screenline                 | Observed Flow | Modelled Flow | % Difference | GEH  |
|----------------------------|---------------|---------------|--------------|------|
| Canal North - Inbound      | 1476          | 1600          | 8%           | 3.2  |
| Canal North - Outbound     | 1630          | 2055          | 26%          | 9.9  |
| Canal Northeast - Inbound  | 1999          | 1948          | 3%           | 1.1  |
| Canal Northeast - Outbound | 2458          | 2152          | 12%          | 6.4  |
| Canal Northwest - Inbound  | 2202          | 2210          | 0%           | 0.2  |
| Canal Northwest - Outbound | 3407          | 3130          | 8%           | 4.8  |
| Canal Southeast - Inbound  | 3191          | 3611          | 13%          | 7.2  |
| Canal Southeast - Outbound | 3631          | 3692          | 2%           | 1.0  |
| Canal Southwest - Inbound  | 3317          | 3308          | 0%           | 0.2  |
| Canal Southwest - Outbound | 5194          | 5502          | 6%           | 4.2  |
| M50 N Cordon - Inbound     | 5417          | 5279          | 3%           | 1.9  |
| M50 N Cordon - Outbound    | 6300          | 6046          | 4%           | 3.2  |
| M50 NE Cordon - Inbound    | 2726          | 2523          | 7%           | 4.0  |
| M50 NE Cordon - Outbound   | 3237          | 3179          | 2%           | 1.0  |
| M50 NW Cordon - Inbound    | 4927          | 4793          | 3%           | 1.9  |
| M50 NW Cordon - Outbound   | 6011          | 6367          | 6%           | 4.5  |
| M50 S Cordon - Inbound     | 4843          | 4778          | 1%           | 0.9  |
| M50 S Cordon - Outbound    | 6085          | 6087          | 0%           | 0.0  |
| M50 SE Cordon - Inbound    | 3360          | 3594          | 7%           | 4.0  |
| M50 SE Cordon - Outbound   | 4393          | 4201          | 4%           | 2.9  |
| M50 SW Cordon - Inbound    | 6527          | 6126          | 6%           | 5.0  |
| M50 SW Cordon - Outbound   | 7013          | 7060          | 1%           | 0.6  |
| M50 W Cordon - Inbound     | 2779          | 3398          | 22%          | 11.1 |
| M50 W Cordon - Outbound    | 4811          | 5175          | 8%           | 5.1  |
| River Liffey - Northbound  | 5396          | 5550          | 3%           | 2.1  |
| River Liffey - Southbound  | 4942          | 4993          | 1%           | 0.7  |

### A.2.1 Pre-estimation Calibration Check

The factored prior matrix was assigned to the pre-calibration LAM road network to determine how well the LAM replicated observed traffic volumes. The results of this are outlined in Apx Table A.9.

**Apx Table A.9 Traffic Count Calibration Statistics (pre Matrix Estimation)**

| Criteria  |            | Individual flows within 100 v/h for flows less than 700 v/h | Individual flows within 15% for flows between 700 & 2,700 v/h | Individual flows within 400 v/h for flows greater than 2,700 v/h | Individual flows – GEH < 5 |
|-----------|------------|-------------------------------------------------------------|---------------------------------------------------------------|------------------------------------------------------------------|----------------------------|
| <b>AM</b> | <b>Car</b> |                                                             | 58%                                                           |                                                                  | 58%                        |
|           | <b>LGV</b> |                                                             | 98%                                                           |                                                                  | 80%                        |
|           | <b>HGV</b> |                                                             | 97%                                                           |                                                                  | 85%                        |
| <b>LT</b> | <b>Car</b> |                                                             | 60%                                                           |                                                                  | 56%                        |
|           | <b>LGV</b> |                                                             | 97%                                                           |                                                                  | 78%                        |
|           | <b>HGV</b> |                                                             | 98%                                                           |                                                                  | 83%                        |
| <b>SR</b> | <b>Car</b> |                                                             | 56%                                                           |                                                                  | 53%                        |
|           | <b>LGV</b> |                                                             | 98%                                                           |                                                                  | 77%                        |
|           | <b>HGV</b> |                                                             | 98%                                                           |                                                                  | 82%                        |
| <b>PM</b> | <b>Car</b> |                                                             | 52%                                                           |                                                                  | 51%                        |
|           | <b>LGV</b> |                                                             | 97%                                                           |                                                                  | 73%                        |
|           | <b>HGV</b> |                                                             | 98%                                                           |                                                                  | 80%                        |

The results indicate a good performance in terms of flow criteria and GEH for both LGV and HGVs in the prior demand. However, the car results are outside of guideline recommendations. In particular, the percentage of total traffic at all count locations with a GEH less than 5 is modest across all time periods with 58% in the AM, 56% in the LT, 53% in the SR and 51% in the PM. The results for the individual flow criteria are also at a similar level

Based on the above, it was decided that further calibration adjustments including ‘Matrix Estimation’ were required for AM, LT, SR and PM prior matrices to improve the fit between model flows and observed traffic volumes.

### A.2.2 Matrix Estimation

‘Matrix Estimation’ is a process used to adjust trip demand so that there is an improved correlation between counts and modelled flows. The base prior matrix is fed into a SATURN programme called SATME2. SATME2 then adjusts origin-destination patterns to produce a trip demand matrix that better replicates traffic counts when assigned to the network.

The prior matrix is adjusted only after all options for improving the network are exhausted. Any matrix adjustment must significantly improve the match between observed and modelled flows, and not introduce more trips into a zone than could realistically be expected. Controls are placed on zones to ensure that the trip demand generated is sensible and in line with census population and employment statistics and that the donor trip distribution provided by the ERM is not adjusted too much to maintain direct compatibility between the ERM and LAM.

The algorithm driving the SATME2 estimation process tends to reduce long trips in place of chains of short trips, especially when counts are spread over the entire area, which may not fully reflect reality. Constraints are therefore placed on the adjustment process to protect the number of movements and distribution of the trips contained within the original car trip matrix.

### A.2.3 Post-estimation Calibration

The post ‘Matrix Estimation’ model was then re-tested against the TII and TAG calibration criteria to assess performance. This was undertaken in an iterative process, with adjustments made to the road network where necessary to facilitate a better correspondence between model and observed flows e.g. altering junction capacity to facilitate count demand, fixing routing issues and rat-running etc.

A calibration and validation dashboard was created to identify areas of the network requiring adjustment/improvement that was not meeting the calibration guidelines. Once all options for network improvement were exhausted, ‘Matrix Estimation’ was re-run to try and achieve a better match between modelled

and observed flows. The iteration between network alterations and ‘Matrix Estimation’ was carried out until the calibration criteria had been achieved.

#### A.2.4 Traffic Flow and GEH Calibration Results

Apx Table A.10 summarises the traffic flow and GEH calibration results for the LAM after the matrix estimation process, for each of the modelled time periods.

**Apx Table A.10 Traffic Count Calibration Statistics (Post Matrix Estimation)**

| Criteria |     | Individual flows within 100 v/h for flows less than 700 v/h | Individual flows within 15% for flows between 700 & 2,700 v/h | Individual flows within 400 v/h for flows greater than 2,700 v/h | Individual flows – GEH < 5 |
|----------|-----|-------------------------------------------------------------|---------------------------------------------------------------|------------------------------------------------------------------|----------------------------|
| AM       | Car |                                                             | 79%                                                           |                                                                  | 78%                        |
|          | LGV |                                                             | 99%                                                           |                                                                  | 89%                        |
|          | HGV |                                                             | 98%                                                           |                                                                  | 88%                        |
| LT       | Car |                                                             | 82%                                                           |                                                                  | 79%                        |
|          | LGV |                                                             | 99%                                                           |                                                                  | 90%                        |
|          | HGV |                                                             | 99%                                                           |                                                                  | 91%                        |
| SR       | Car |                                                             | 80%                                                           |                                                                  | 78%                        |
|          | LGV |                                                             | 99%                                                           |                                                                  | 88%                        |
|          | HGV |                                                             | 98%                                                           |                                                                  | 91%                        |
| PM       | Car |                                                             | 76%                                                           |                                                                  | 74%                        |
|          | LGV |                                                             | 98%                                                           |                                                                  | 87%                        |
|          | HGV |                                                             | 98%                                                           |                                                                  | 88%                        |

The results in Apx Table A.10 demonstrate that a good calibration has been achieved across the four modelled times periods at the individual link level. All criteria is met for LGV and LGV for both absolute/percentage difference and GEH. For private cars, when looking at the absolute/percentage difference results, all time periods are generally close to the 85% guidance with 79% for AM, 82% for LT, 80% for SR and 76% for PM. GEH criteria results are generally in the mid to high 70s for each time period apart from the PM which matches in 74% of cases.

## Screenline Flows

As noted in previously, counts have been grouped into screenlines covering movements into/out of the LAM from the North, West and South as well as a similar cordon within Dublin city centre.

The comparison between modelled and observed traffic flows at each of the screenlines is presented in Apx Table A.11 to Apx Table A.14 for the AM, LT, SR and PM peak hours.

**Apx Table A.11 AM Screenline Calibration Statistics (Post-Estimation) – Total Flows**

| Screenline                 | Observed Flow | Modelled Flow | % Difference | GEH  |
|----------------------------|---------------|---------------|--------------|------|
| Canal North - Inbound      | 1874          | 1884          | 1%           | 0.2  |
| Canal North - Outbound     | 1289          | 1452          | 13%          | 4.4  |
| Canal Northeast - Inbound  | 2346          | 2211          | 6%           | 2.8  |
| Canal Northeast - Outbound | 1712          | 1448          | 15%          | 6.6  |
| Canal Northwest - Inbound  | 3176          | 2610          | 18%          | 10.5 |
| Canal Northwest - Outbound | 1758          | 1922          | 9%           | 3.8  |
| Canal Southeast - Inbound  | 4053          | 3988          | 2%           | 1.0  |
| Canal Southeast - Outbound | 3012          | 2873          | 5%           | 2.6  |
| Canal Southwest - Inbound  | 5124          | 5221          | 2%           | 1.4  |
| Canal Southwest - Outbound | 3317          | 3260          | 2%           | 1.0  |
| M50 N Cordon - Inbound     | 6727          | 6331          | 6%           | 4.9  |
| M50 N Cordon - Outbound    | 4929          | 4396          | 11%          | 7.8  |
| M50 NE Cordon - Inbound    | 3399          | 3230          | 5%           | 2.9  |
| M50 NE Cordon - Outbound   | 2447          | 2392          | 2%           | 1.1  |
| M50 NW Cordon - Inbound    | 5739          | 5828          | 2%           | 1.2  |
| M50 NW Cordon - Outbound   | 5209          | 5019          | 4%           | 2.7  |
| M50 S Cordon - Inbound     | 7107          | 6421          | 10%          | 8.3  |
| M50 S Cordon - Outbound    | 4541          | 4378          | 4%           | 2.4  |
| M50 SE Cordon - Inbound    | 5759          | 5640          | 2%           | 1.6  |
| M50 SE Cordon - Outbound   | 3355          | 3243          | 3%           | 2.0  |
| M50 SW Cordon - Inbound    | 9219          | 8680          | 6%           | 5.7  |
| M50 SW Cordon - Outbound   | 6628          | 6222          | 6%           | 5.1  |
| M50 W Cordon - Inbound     | 4746          | 4897          | 3%           | 2.2  |
| M50 W Cordon - Outbound    | 3217          | 3235          | 1%           | 0.3  |
| River Liffey - Northbound  | 4453          | 4317          | 3%           | 2.1  |
| River Liffey - Southbound  | 6019          | 5289          | 12%          | 9.7  |
| Canal North - Inbound      | 1874          | 1884          | 1%           | 0.2  |

**Apx Table A.12 LT Screenline Calibration Statistics (Post-Estimation) – Total Flows**

| Screenline                 | Observed Flow | Modelled Flow | % Difference | GEH |
|----------------------------|---------------|---------------|--------------|-----|
| Canal North - Inbound      | 1545          | 1599          | 3%           | 1.4 |
| Canal North - Outbound     | 1419          | 1563          | 10%          | 3.7 |
| Canal Northeast - Inbound  | 1895          | 1729          | 9%           | 3.9 |
| Canal Northeast - Outbound | 1651          | 1446          | 12%          | 5.2 |
| Canal Northwest - Inbound  | 2077          | 1945          | 6%           | 2.9 |

|                            |      |      |     |     |
|----------------------------|------|------|-----|-----|
| Canal Northwest - Outbound | 1911 | 1924 | 1%  | 0.3 |
| Canal Southeast - Inbound  | 3200 | 3094 | 3%  | 1.9 |
| Canal Southeast - Outbound | 2923 | 2718 | 7%  | 3.9 |
| Canal Southwest - Inbound  | 3499 | 3758 | 7%  | 4.3 |
| Canal Southwest - Outbound | 3655 | 3594 | 2%  | 1.0 |
| M50 N Cordon - Inbound     | 4541 | 4232 | 7%  | 4.7 |
| M50 N Cordon - Outbound    | 4880 | 4350 | 11% | 7.8 |
| M50 NE Cordon - Inbound    | 2487 | 2357 | 5%  | 2.6 |
| M50 NE Cordon - Outbound   | 2569 | 2441 | 5%  | 2.6 |
| M50 NW Cordon - Inbound    | 3914 | 3827 | 2%  | 1.4 |
| M50 NW Cordon - Outbound   | 3673 | 3701 | 1%  | 0.5 |
| M50 S Cordon - Inbound     | 3859 | 3811 | 1%  | 0.8 |
| M50 S Cordon - Outbound    | 3643 | 3651 | 0%  | 0.1 |
| M50 SE Cordon - Inbound    | 2470 | 2549 | 3%  | 1.6 |
| M50 SE Cordon - Outbound   | 2611 | 2595 | 1%  | 0.3 |
| M50 SW Cordon - Inbound    | 6511 | 5931 | 9%  | 7.4 |
| M50 SW Cordon - Outbound   | 5601 | 5221 | 7%  | 5.2 |
| M50 W Cordon - Inbound     | 2943 | 2963 | 1%  | 0.4 |
| M50 W Cordon - Outbound    | 3337 | 3379 | 1%  | 0.7 |
| River Liffey - Northbound  | 4329 | 4345 | 0%  | 0.2 |
| River Liffey - Southbound  | 4750 | 4540 | 4%  | 3.1 |

**Apx Table A.13 SR Screenline Calibration Statistics (Post-Estimation) – Total Flows**

| Screenline                 | Observed Flow | Modelled Flow | % Difference | GEH |
|----------------------------|---------------|---------------|--------------|-----|
| Canal North - Inbound      | 1417          | 1498          | 6%           | 2.1 |
| Canal North - Outbound     | 1661          | 1851          | 11%          | 4.5 |
| Canal Northeast - Inbound  | 1898          | 1727          | 9%           | 4.0 |
| Canal Northeast - Outbound | 1991          | 1717          | 14%          | 6.4 |
| Canal Northwest - Inbound  | 2134          | 1973          | 8%           | 3.5 |
| Canal Northwest - Outbound | 2500          | 2509          | 0%           | 0.2 |
| Canal Southeast - Inbound  | 3077          | 2843          | 8%           | 4.3 |
| Canal Southeast - Outbound | 3244          | 3064          | 6%           | 3.2 |
| Canal Southwest - Inbound  | 3284          | 3347          | 2%           | 1.1 |
| Canal Southwest - Outbound | 4590          | 4523          | 1%           | 1.0 |
| M50 N Cordon - Inbound     | 4685          | 4375          | 7%           | 4.6 |
| M50 N Cordon - Outbound    | 5469          | 5150          | 6%           | 4.4 |
| M50 NE Cordon - Inbound    | 2706          | 2558          | 5%           | 2.9 |
| M50 NE Cordon - Outbound   | 3272          | 3025          | 8%           | 4.4 |
| M50 NW Cordon - Inbound    | 4412          | 4220          | 4%           | 2.9 |
| M50 NW Cordon - Outbound   | 4501          | 4639          | 3%           | 2.0 |
| M50 S Cordon - Inbound     | 4080          | 4016          | 2%           | 1.0 |
| M50 S Cordon - Outbound    | 4641          | 4654          | 0%           | 0.2 |
| M50 SE Cordon - Inbound    | 2936          | 2933          | 0%           | 0.0 |
| M50 SE Cordon - Outbound   | 3249          | 3323          | 2%           | 1.3 |



| Screenline                | Observed Flow | Modelled Flow | % Difference | GEH |
|---------------------------|---------------|---------------|--------------|-----|
| M50 SW Cordon - Inbound   | 6794          | 6401          | 6%           | 4.8 |
| M50 SW Cordon - Outbound  | 7107          | 6518          | 8%           | 7.1 |
| M50 W Cordon - Inbound    | 3149          | 3129          | 1%           | 0.4 |
| M50 W Cordon - Outbound   | 3946          | 3829          | 3%           | 1.9 |
| River Liffey - Northbound | 4690          | 4632          | 1%           | 0.8 |
| River Liffey - Southbound | 4628          | 4399          | 5%           | 3.4 |

**Apx Table A.14 PM Screenline Calibration Statistics (Post-Estimation) – Total Flows**

| Screenline                 | Observed Flow | Modelled Flow | % Difference | GEH |
|----------------------------|---------------|---------------|--------------|-----|
| Canal North - Inbound      | 1476          | 1499          | 2%           | 0.6 |
| Canal North - Outbound     | 1630          | 1965          | 21%          | 7.9 |
| Canal Northeast - Inbound  | 1999          | 1951          | 2%           | 1.1 |
| Canal Northeast - Outbound | 2458          | 2078          | 15%          | 8.0 |
| Canal Northwest - Inbound  | 2202          | 1972          | 10%          | 5.0 |
| Canal Northwest - Outbound | 3407          | 3096          | 9%           | 5.5 |
| Canal Southeast - Inbound  | 3191          | 3003          | 6%           | 3.4 |
| Canal Southeast - Outbound | 3631          | 3483          | 4%           | 2.5 |
| Canal Southwest - Inbound  | 3281          | 3324          | 1%           | 0.8 |
| Canal Southwest - Outbound | 5217          | 5086          | 3%           | 1.8 |
| M50 N Cordon - Inbound     | 5417          | 5244          | 3%           | 2.4 |
| M50 N Cordon - Outbound    | 6300          | 5675          | 10%          | 8.1 |
| M50 NE Cordon - Inbound    | 2733          | 2741          | 0%           | 0.2 |
| M50 NE Cordon - Outbound   | 3157          | 3172          | 0%           | 0.3 |
| M50 NW Cordon - Inbound    | 4961          | 4798          | 3%           | 2.3 |
| M50 NW Cordon - Outbound   | 6011          | 5731          | 5%           | 3.7 |
| M50 S Cordon - Inbound     | 4843          | 4875          | 1%           | 0.5 |
| M50 S Cordon - Outbound    | 6085          | 5655          | 7%           | 5.6 |
| M50 SE Cordon - Inbound    | 3360          | 3287          | 2%           | 1.3 |
| M50 SE Cordon - Outbound   | 4393          | 4091          | 7%           | 4.6 |
| M50 SW Cordon - Inbound    | 6527          | 6277          | 4%           | 3.1 |
| M50 SW Cordon - Outbound   | 7013          | 6647          | 5%           | 4.4 |
| M50 W Cordon - Inbound     | 3083          | 3017          | 2%           | 1.2 |
| M50 W Cordon - Outbound    | 4527          | 4514          | 0%           | 0.2 |
| River Liffey - Northbound  | 5396          | 4927          | 9%           | 6.5 |
| River Liffey - Southbound  | 4942          | 4706          | 5%           | 3.4 |

px Table A.15 Screenline Calibration Criteria Check

| Criteria                                            | Acceptability Guideline | AM  | LT  | SR  | PM  |
|-----------------------------------------------------|-------------------------|-----|-----|-----|-----|
| Total screen line flows (> 5 links) to be within 5% | > 85% of cases          | 58% | 58% | 50% | 62% |
| GEH statistic: screenline totals < 4                | > 85% of cases          | 65% | 77% | 65% | 65% |
| Either 5% or GEH < 4                                | > 85% of cases          | 73% | 85% | 92% | 73% |

The screenline results show AM, LT, SR and PM generally perform well against the TII/TAG guidance criteria when looking at passing either via 5% or GEH < 4. As can be seen when looking at the individual screenlines there is not much in the way of extreme outliers with those not fully meeting guidance generally being relatively close.

For the AM the largest outliers are *M50 SW Cordon – Inbound* with an 8% difference and GEH of 7.6 and *River Liffey – Southbound* with a 15% difference and GEH of 11.9. All other screenlines that do not fully meet guidance are generally close to one or both guideline targets.

For the LT period the largest outlier is *M50 N Cordon – Outbound* with a difference of 11% and GEH of 7.8. All other screenlines that do not fully meet guidance are generally close to one or both guideline targets.

For the SR period the only large outlier is the *Canal Northeast – Outbound* screenline with a difference of 14% and GEH of 6.4. All other screenlines that do not fully meet guidance are very close to the guideline targets.

For the PM period the largest outliers again are the *Canal Northeast – Outbound* screenline with a difference of 15% and GEH of 8 and *M50 N Cordon - Outbound* with a difference of 10% and GEH of 8.1. All other screenlines that do not fully meet guidance are very close to one or both guideline targets.

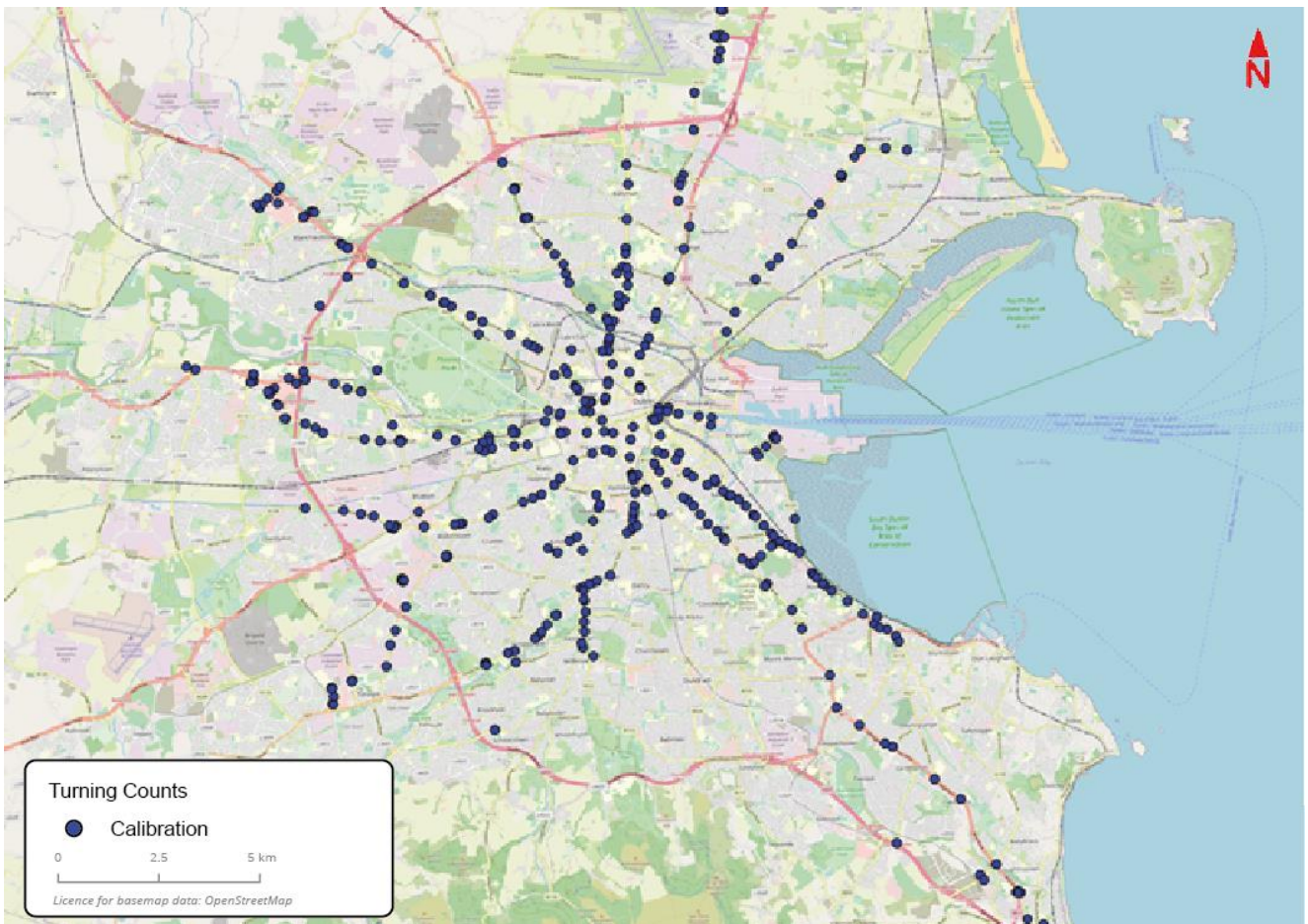
## Turning Flows

The model calibration takes into account not only link calibration but also turning movements at key junctions within the LAM network. The guidance for link calibration is used to compare observed and modelled turning flows.

This is an improvement on solely relying on the ERM calibration which only considered link calibration. It was deemed appropriate to calibrate at a turning movement level for the purposes of the CBC Infrastructure Works to add additional robustness to the performance of the LAM in the vicinity of the Proposed Scheme.

In addition to this guidance, presented below is also a comparison of the turning proportions at each junction to show that the model is correctly replicating the distribution of traffic across each arm and not just total demand at a particular junction. This is not an officially designed set of guidance and so a target has been assumed of 85% of turns matching within 10% of the observed proportion at each junction.

The turning counts used in the calibration process are outlined below in Apx Diagram A.2 and consists of 2,201 turns across 441 junctions



**Apx Diagram A.1 Turning counts used in Calibration**

Note that due to the large number of calibration and validation turning counts (4,226), there has been no smoothing process applied to ensure that any 1 day turning counts were directly comparable to observed link counts nearby that were undertaken in either November 2019 or February 2020. Due to greater accuracy of the link count data collected with regards to the duration over which counts are collected (2-week ATCs), they are prioritized within the matrix estimation process. Given this, the turning distribution may be the better metric in some cases, when comparing observed vs modelled turning flows.

**Apx Table A.16 Turning Flow Calibration**

| Criteria |     | Individual flows within 100 v/h for flows less than 700 v/h | Individual flows within 15% for flows between 700 & 2,700 v/h | Individual flows within 400 v/h for flows greater than 2,700 v/h | Individual flows – GEH < 5 | Turning proportion within 10% of observed |
|----------|-----|-------------------------------------------------------------|---------------------------------------------------------------|------------------------------------------------------------------|----------------------------|-------------------------------------------|
| AM       | Car |                                                             | 86%                                                           |                                                                  | 69%                        | 90%                                       |
|          | LGV |                                                             | 100%                                                          |                                                                  | 90%                        | 79%                                       |
|          | HGV |                                                             | 100%                                                          |                                                                  | 98%                        | 73%                                       |
| LT       | Car |                                                             | 89%                                                           |                                                                  | 71%                        | 89%                                       |
|          | LGV |                                                             | 99%                                                           |                                                                  | 89%                        | 83%                                       |
|          | HGV |                                                             | 100%                                                          |                                                                  | 97%                        | 78%                                       |
| SR       | Car |                                                             | 87%                                                           |                                                                  | 68%                        | 89%                                       |
|          | LGV |                                                             | 100%                                                          |                                                                  | 90%                        | 84%                                       |
|          | HGV |                                                             | 100%                                                          |                                                                  | 97%                        | 77%                                       |
| PM       | Car |                                                             | 85%                                                           |                                                                  | 68%                        | 89%                                       |

|  |     |      |     |     |
|--|-----|------|-----|-----|
|  | LGV | 100% | 92% | 78% |
|  | HGV | 100% | 98% | 66% |

Apx Table A.16 shows that full TII/TAG guidance is met in all times periods with regards to the absolute/percentage difference individual link criteria. GEH criteria is satisfied for LGV and HGV in all time periods with the results being in the high 60% or 70% region for private cars, for all time periods. For the turning proportions at each junction, private cars fully meet the suggested targets while LGV's and HGV's generally just below the car levels.

### Analysis of Trip Matrix Changes - Regression

As noted in previously, both TII and TAG model development guidance recommend that care is taken when applying 'Matrix Estimation', and stringent checks should be carried out to ensure that the model demand is not overly distorted.

Pre and Post 'Matrix Estimation' matrices were plotted and the slope, and R<sup>2</sup> measure of goodness of fit were calculated. The results of this analysis are outlined in Apx Table A.17 to Apx Table A.19 below, and Apx Diagram A.3 overleaf.

Within the ERM, the Goods Vehicle matrices are not calculated as accurately as for car trips as they are not generated directly by the Full Demand Model. As such, SATME2 was allowed to make more changes to the prior LGV and HGV matrices to match traffic count data.

#### Apx Table A.17 Matrix Zonal Cell Regression Analysis

| Measure        | Significance Criteria            | AM   | LT   | SR   | PM   |
|----------------|----------------------------------|------|------|------|------|
| R <sup>2</sup> | R <sup>2</sup> in excess of 0.95 | 0.84 | 0.87 | 0.86 | 0.81 |
| Slope          | Within 0.98 and 1.02             | 0.73 | 0.75 | 0.73 | 0.71 |
| Intercept      | Intercept near zero              | 0.03 | 0.02 | 0.25 | 0.29 |

#### Apx Table A.18 Matrix Trip End Regression Analysis – Origins

| Measure        | Significance Criteria            | AM    | LT    | SR    | PM    |
|----------------|----------------------------------|-------|-------|-------|-------|
| R <sup>2</sup> | R <sup>2</sup> in excess of 0.95 | 0.96  | 0.97  | 0.97  | 0.95  |
| Slope          | Within 0.98 and 1.02             | 0.81  | 0.80  | 0.80  | 0.79  |
| Intercept      | Intercept near zero              | 24.12 | 19.32 | 24.45 | 26.77 |

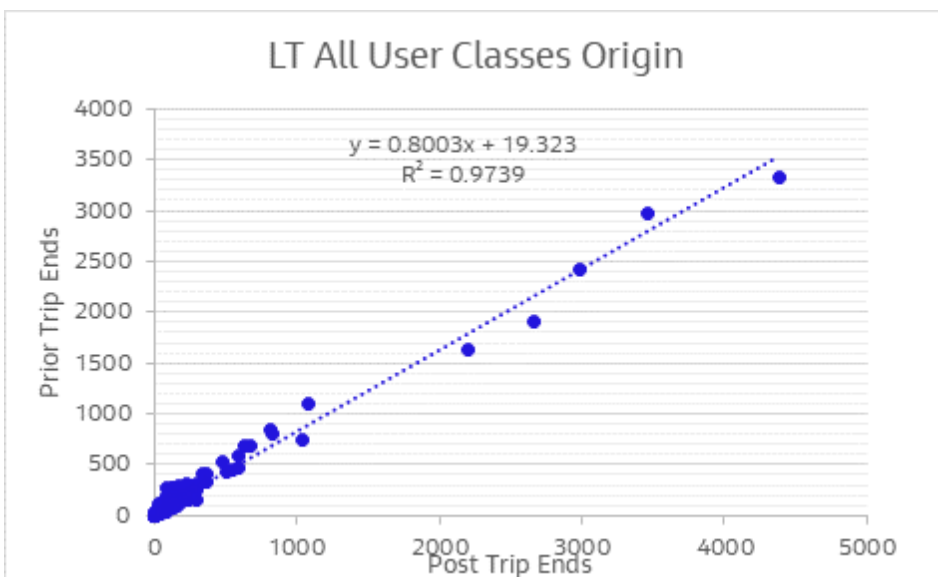
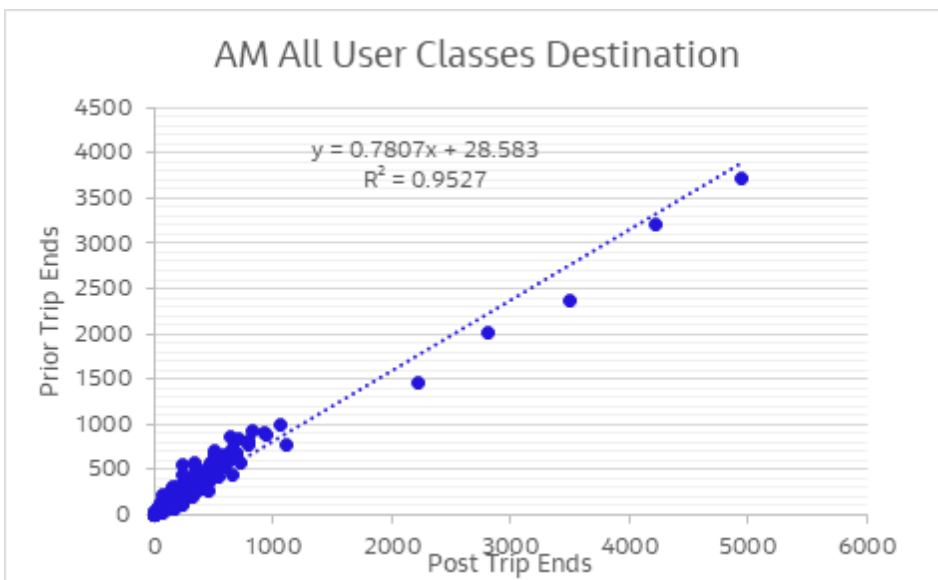
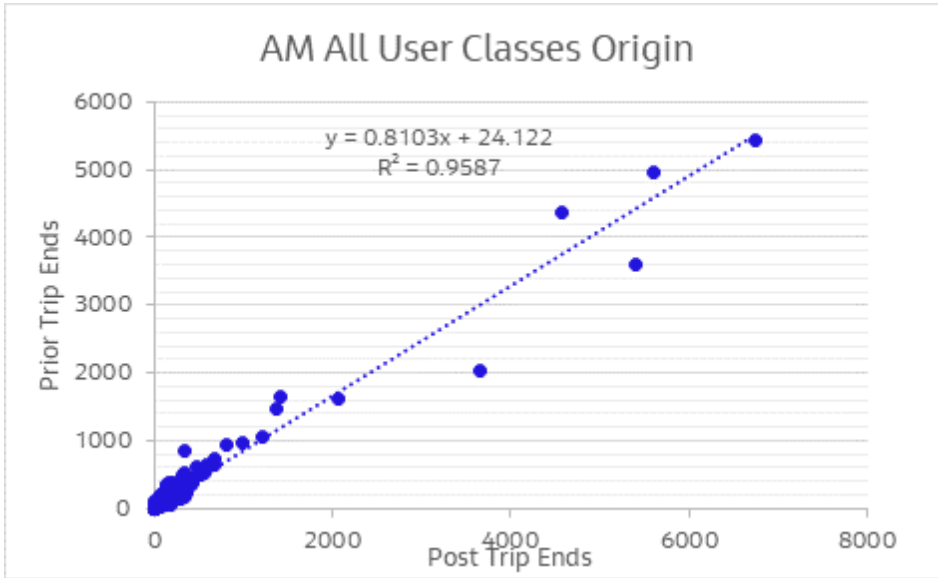
#### Apx Table A.19 Matrix Trip End Regression Analysis – Destinations

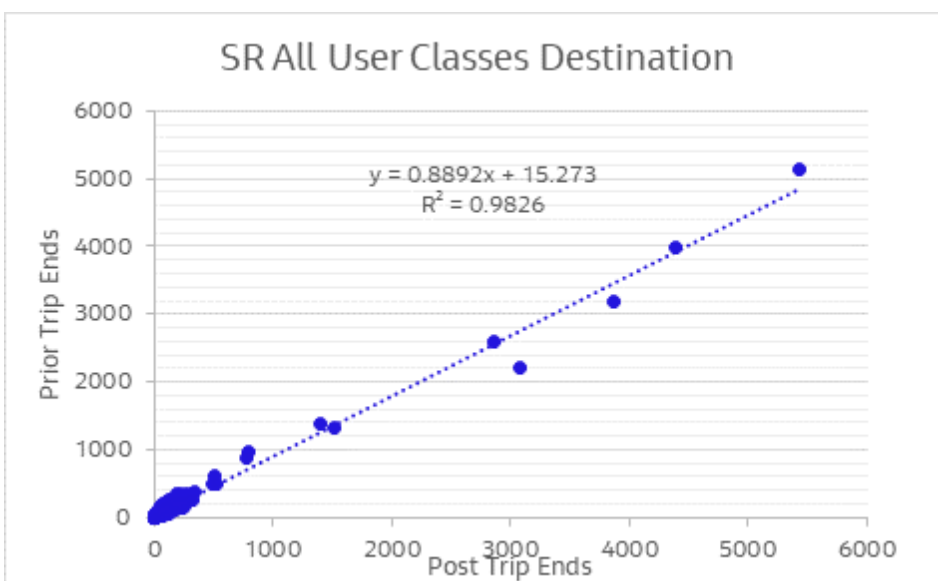
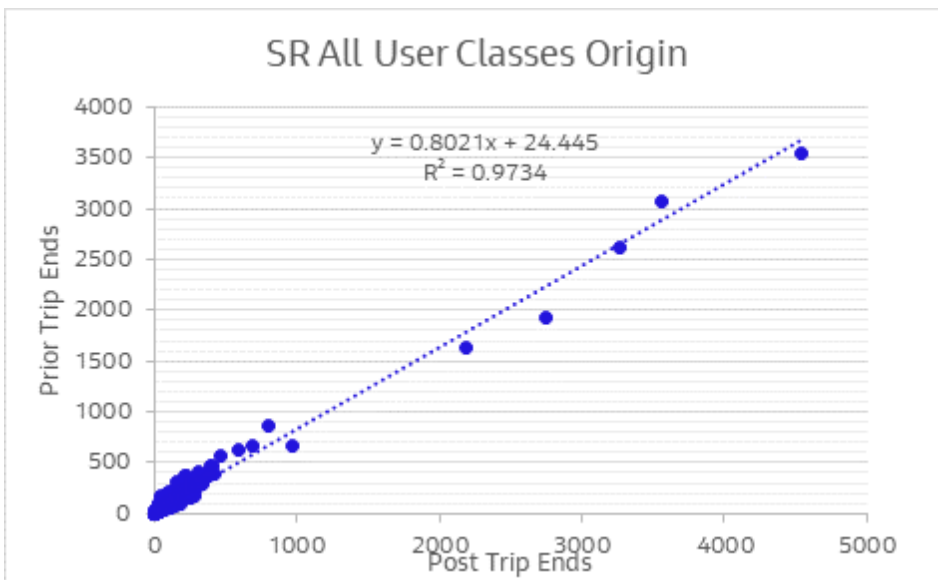
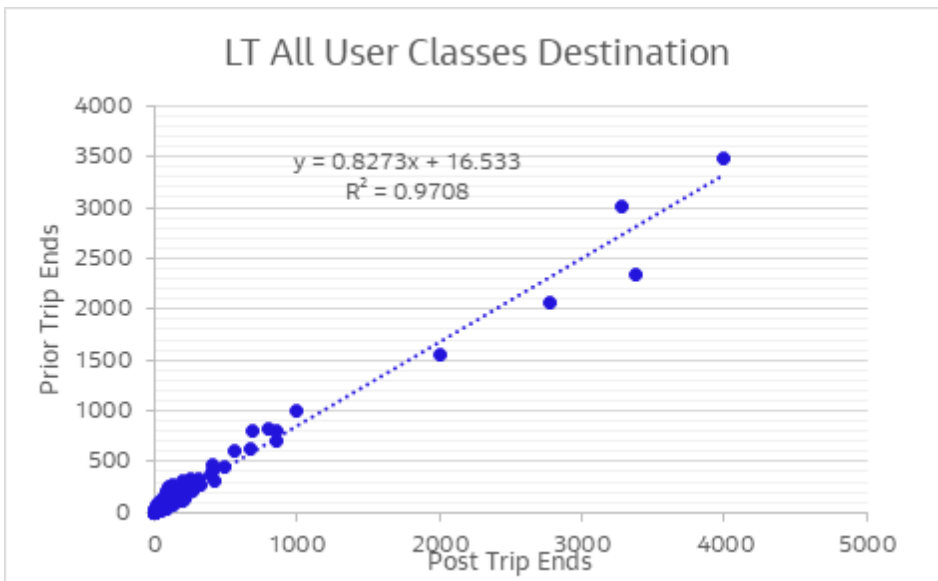
| Measure        | Significance Criteria            | AM    | LT    | SR    | PM    |
|----------------|----------------------------------|-------|-------|-------|-------|
| R <sup>2</sup> | R <sup>2</sup> in excess of 0.95 | 0.95  | 0.97  | 0.98  | 0.96  |
| Slope          | Within 0.98 and 1.02             | 0.78  | 0.83  | 0.89  | 0.80  |
| Intercept      | Intercept near zero              | 28.58 | 16.53 | 15.27 | 24.57 |

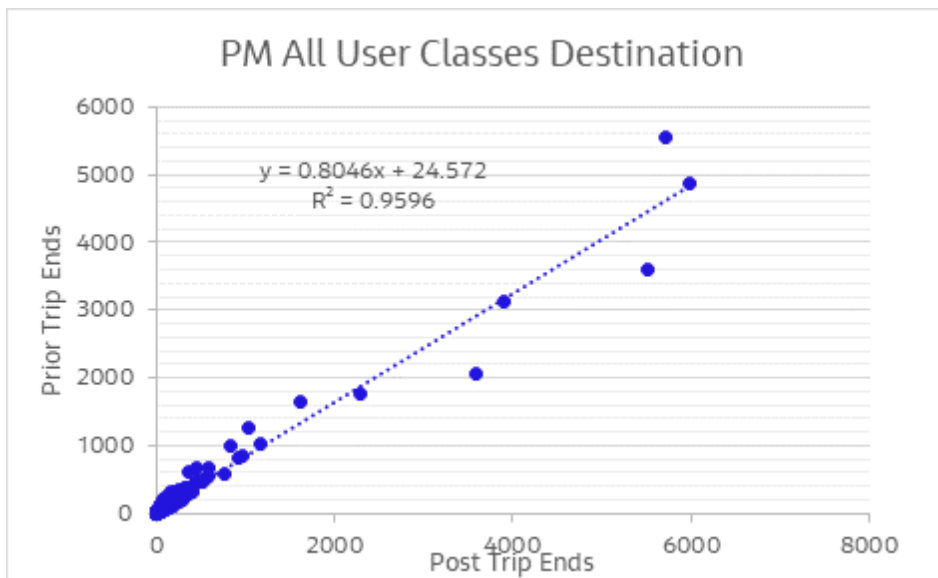
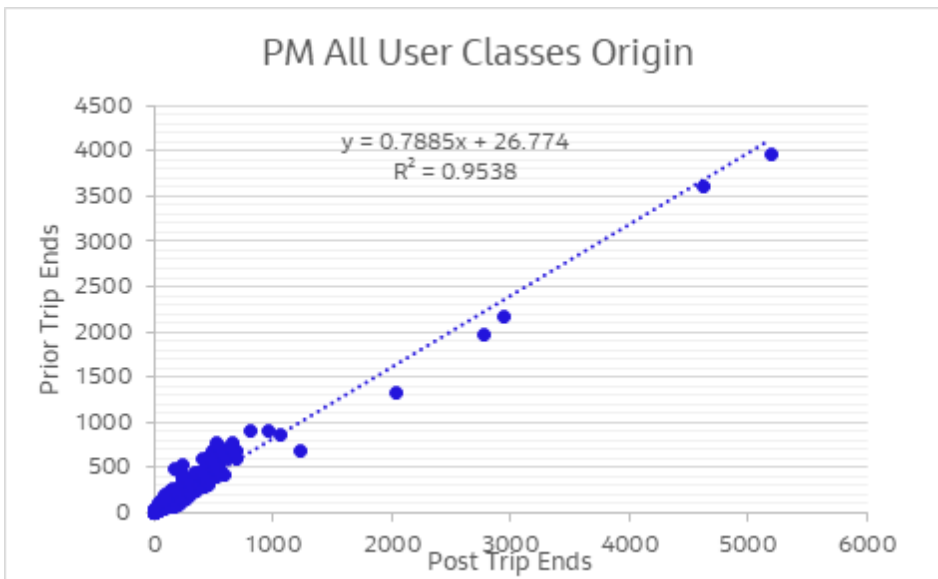
The regression statistics indicate that there is a good correlation between the post calibrated and prior matrices for the R<sup>2</sup> value, with full TII TAG guidance being met for the origins and destinations. Guidance is not quite met for the Slope and Intercept criteria although this is comparable with similar results from the full ERM model<sup>14</sup>. The results provide confidence that 'Matrix Estimation' has not made significant changes to the prior matrices derived from the ERM, except where it was deemed prudent based on available traffic count data.

<sup>14</sup> [https://www.nationaltransport.ie/wp-content/uploads/2018/06/ERM\\_Road\\_Model\\_Development\\_Report\\_Final-2.pdf](https://www.nationaltransport.ie/wp-content/uploads/2018/06/ERM_Road_Model_Development_Report_Final-2.pdf)

**Apx Diagram A.2 Regression Analysis of Matrix Estimation Changes**







### Analysis of Trip Matrix Changes – Trip Length Distribution

TII guidance recommends comparing trip length distributions for the prior and post calibrated matrices to ensure they have not been overly distorted by the 'Matrix Estimation' process.

The 'Matrix Estimation' programme SATME2 can sometimes generate increased short distance trips to match count information, thus distorting the profile of trip making on the network. PAG suggests that the coincidence ratio should be used to compare trip length distributions before and after estimation, with a desirable range between 0.7 and 1.0.

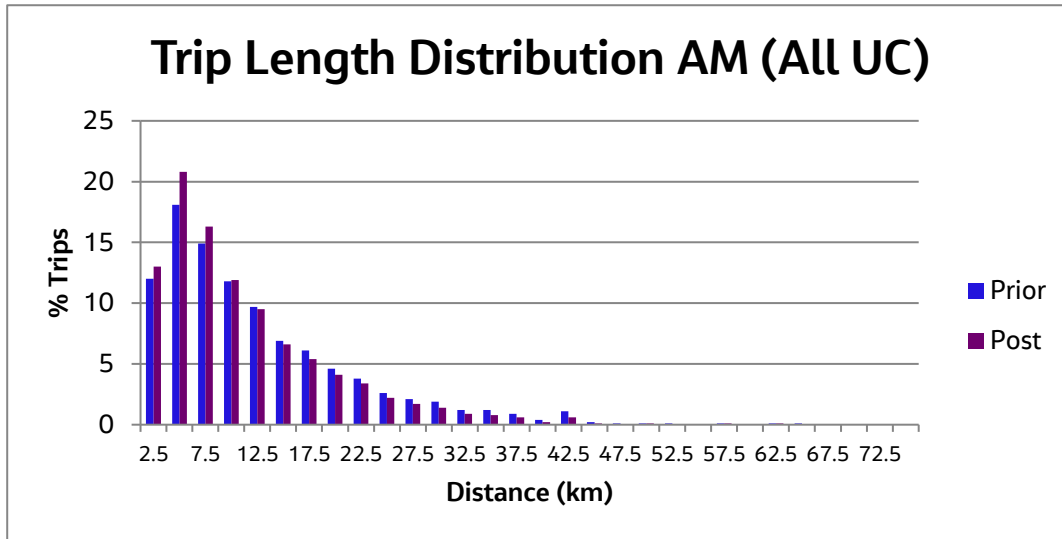
Apx Table A.20 below outlines the coincidence ratios for each of the calibrated LAM time periods. The coincidence ratios suggest that there has been some minor distortion of trip lengths but that it is within acceptable bounds.

**Apx Table A.20 Trip Length Analysis - Coincidence Ratios**

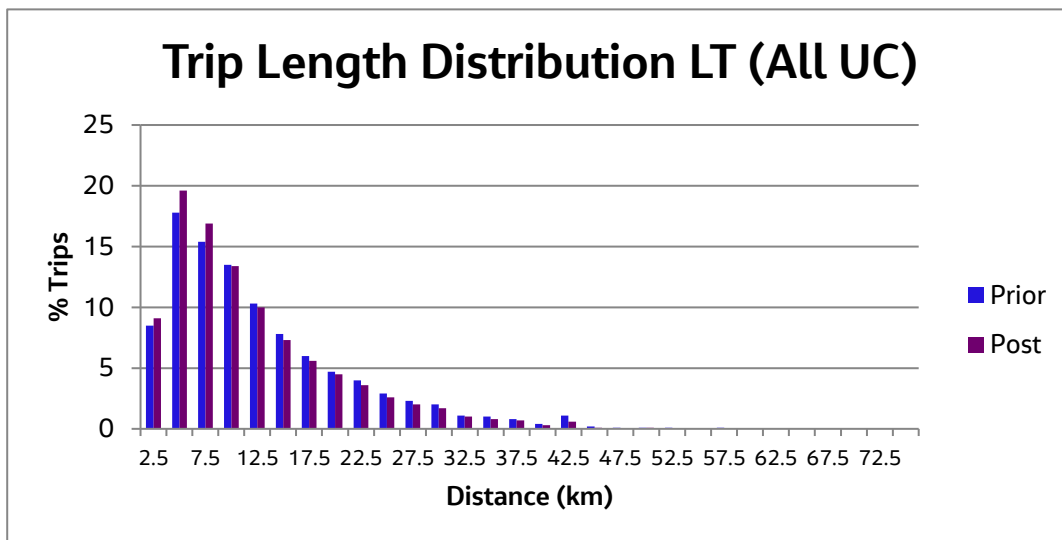
| Measure           | Significance Criteria | AM   | LT   | SR   | PM   |
|-------------------|-----------------------|------|------|------|------|
| Coincidence Ratio | Between 0.7 and 1.0   | 0.90 | 0.92 | 0.92 | 0.90 |

The trip length distributions illustrated from Apx Table A.21 to Apx Table A.24 below display the proportion of trips travelling various distances for both the pre and post estimation matrices. The results indicate that there have

been some changes, however, the general shape of the distributions is similar. The changes overall are not large, and therefore, it is considered that 'Matrix Estimation' has not overly distorted the overall trip length distribution inherited from the ERM.

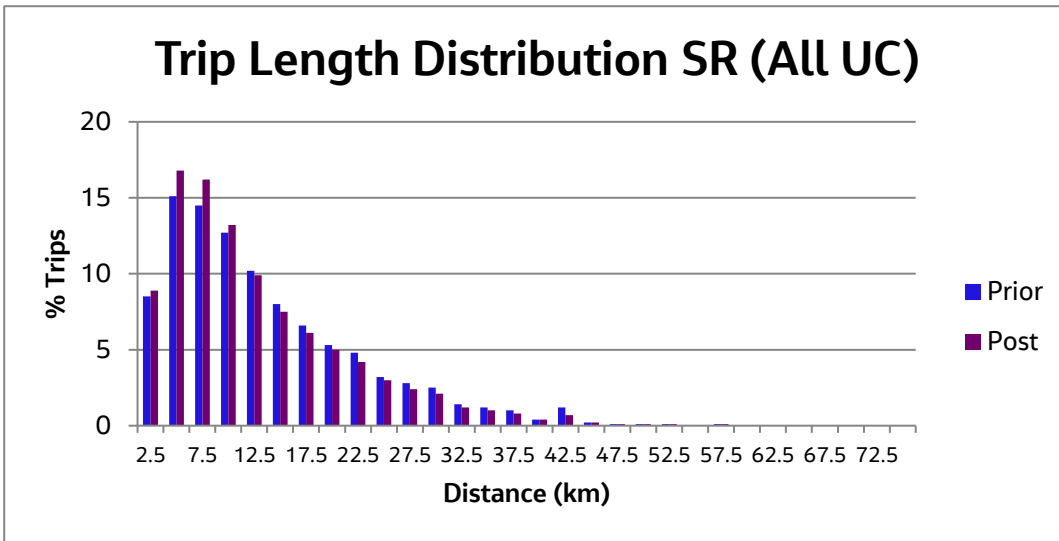


Apx Table A.21 AM Peak Trip Length Distribution

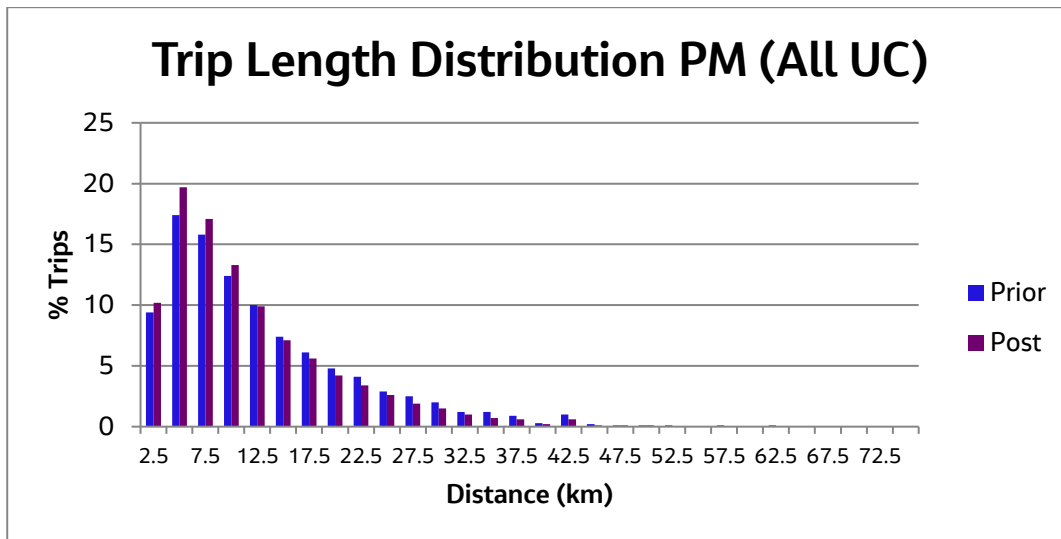




Apx Table A.22 LT Peak Trip Length Distribution



Apx Table A.23 SR Peak Trip Length Distribution



Apx Table A.24 PM Peak Trip Length Distribution

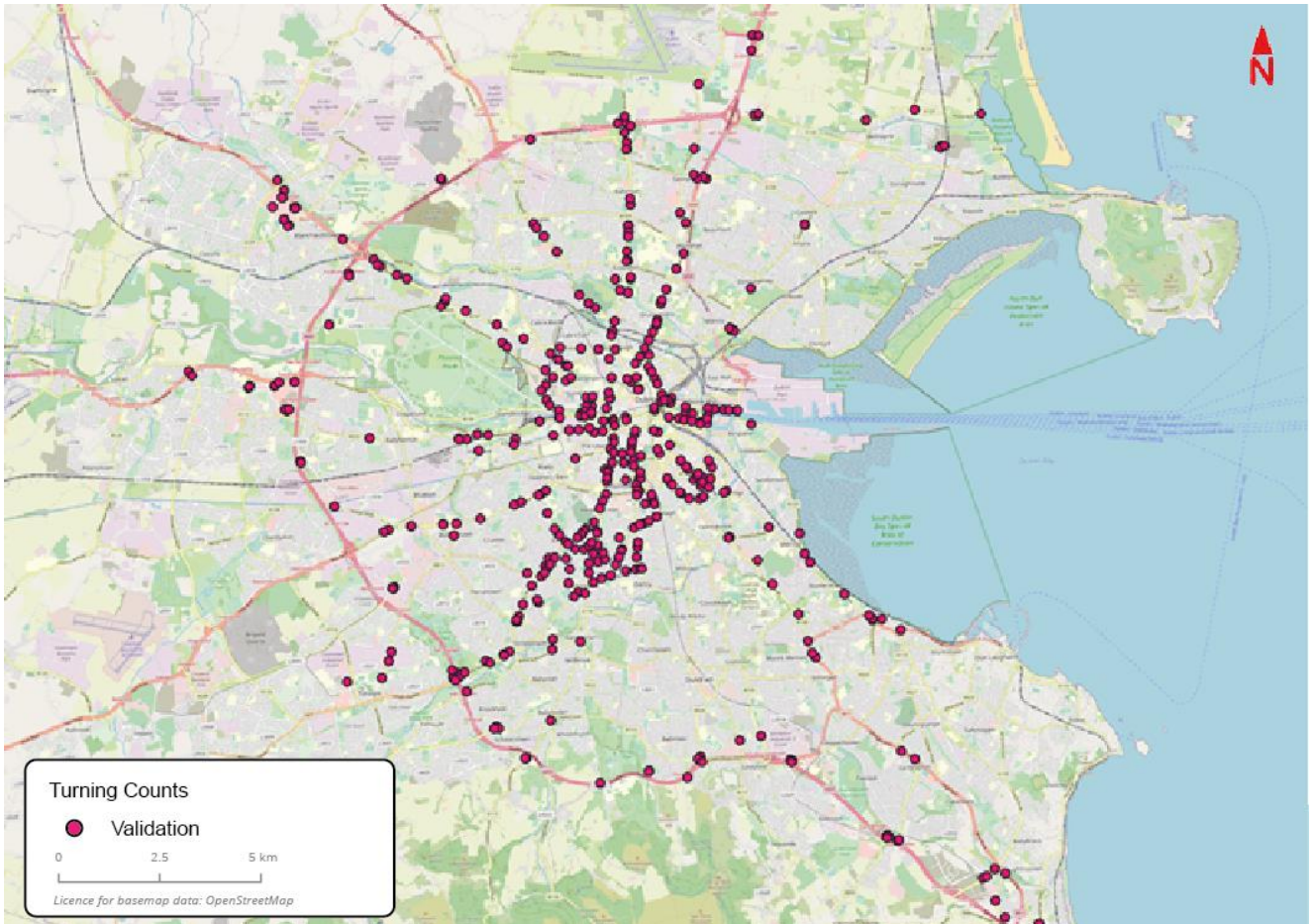
### A.2.5 LAM Calibration Summary

The previous parts of this section have outlined the methodology used to calibrate the LAM to better reflect observed traffic survey data. In summary:

- A combination of network edits and ‘Matrix Estimation’ process has been used to provide a better correlation between modelled and observed traffic flows;
- The calibrated model meets all TII and DfT TAG guidance for links for the LGV and HGV user classes. For cars each of the time periods fall just short of the 85% guidance although still perform well.
- The screenline results show AM, LT, SR and PM generally perform well against the TII/TAG guidance criteria. There are no large outliers across the time periods with those which do not fully meet guidance generally very close to the guideline targets in terms of % and GEH.
- For turning counts, the full TII/TAG guidance is met in all times periods with regards to the absolute/percentage difference individual link criteria for Private Cars, with LGV’s and HGV’s generally performing well. This highlights the turning flows in the LAM generally calibrate well against observed data.
- The R<sup>2</sup> and slope results provide confidence that ‘Matrix Estimation’ has not made significant changes to the prior matrices derived from the ERM, except where it was deemed prudent based on available traffic count data; and
- The coincidence for the trip length distribution ratio is well within TII guidelines and, as such, it is considered that ‘Matrix Estimation’ has not overly distorted the overall trip length distribution inherited from the ERM. The individual graphs highlight that there are no large changes in the proportion of trips lengths pre and post estimation.

### A.3 Full LAM Validation

Traffic flow validation was carried out for an independent set of turning counts not initially included within calibration. This provides a further independent check of the modelled turning movements within the LAM. The coverage of these turning counts is highlighted below in Apx Diagram A.4 and consists of 2,025 turns across 484 junctions.



**Apx Diagram A.3 Turning counts used in Validation**

Apx Table A.25 summarizes the turning count validation results for the LAM for each of the modelled time periods. The results demonstrate that a good level of validation has been achieved in the model across each of the peak periods when compared to observed using absolute and % TII/TAG guidance. LT and SR both meet the guidance with AM and PM very close at 82% and 81% respectively for private car. All criteria is met for LGVs and HGVs. All time periods perform well when comparing the observed and modelled turning proportions at the junction across Car, LGV and HGV

**Apx Table A.25 Turning Count Validation Statistics**

| Criteria  |            | Individual flows within 100 v/h for flows less than 700 v/h | Individual flows within 15% for flows between 700 & 2,700 v/h | Individual flows within 400 v/h for flows greater than 2,700 v/h | Individual flows – GEH < 5 | Turning proportion within 10% of observed |
|-----------|------------|-------------------------------------------------------------|---------------------------------------------------------------|------------------------------------------------------------------|----------------------------|-------------------------------------------|
| <b>AM</b> | <b>Car</b> |                                                             | 82%                                                           |                                                                  | 57%                        | 90%                                       |
|           | <b>LGV</b> |                                                             | 100%                                                          |                                                                  | 90%                        | 100%                                      |
|           | <b>HGV</b> |                                                             | 100%                                                          |                                                                  | 98%                        | 100%                                      |
| <b>LT</b> | <b>Car</b> |                                                             | 88%                                                           |                                                                  | 63%                        | 93%                                       |
|           | <b>LGV</b> |                                                             | 100%                                                          |                                                                  | 89%                        | 100%                                      |
|           | <b>HGV</b> |                                                             | 100%                                                          |                                                                  | 98%                        | 100%                                      |
| <b>SR</b> | <b>Car</b> |                                                             | 85%                                                           |                                                                  | 59%                        | 92%                                       |
|           | <b>LGV</b> |                                                             | 100%                                                          |                                                                  | 90%                        | 100%                                      |
|           | <b>HGV</b> |                                                             | 100%                                                          |                                                                  | 98%                        | 100%                                      |
| <b>PM</b> | <b>Car</b> |                                                             | 81%                                                           |                                                                  | 57%                        | 90%                                       |
|           | <b>LGV</b> |                                                             | 100%                                                          |                                                                  | 91%                        | 100%                                      |
|           | <b>HGV</b> |                                                             | 100%                                                          |                                                                  | 99%                        | 100%                                      |

### A.3.1 Journey Time Validation

As outlined in Apx Table A.25, TII guidelines recommend that modelled journey times should be within +/- 15% of the observed time, or 1 minute if higher, in more than 85% of cases. As described earlier in the report, this has been presented as a comparison to the Mean, Median and a 50/50 Mean/Median blend of the observed journey times due to the significant differences between them and to allow full transparency when comparing the range of observed values to the modelled results.

Apx Table A.26 below illustrates the results of the journey time comparison across both all routes and the routes that correspond with Proposed Schemes (across the full CBC Infrastructure Works) for the AM, LT, SR and PM peak hours.

**Apx Table A.26 Overall Journey Time Validation Statistics**

| Time Period | Selected Coverage      | 15% Med Criteria | 15% Avg Criteria | 15% Blend Criteria |
|-------------|------------------------|------------------|------------------|--------------------|
| AM Peak     | All Routes             | 58%              | 29%              | 50%                |
|             | Proposed Scheme Routes | 58%              | 33%              | 55%                |
| LT Peak     | All Routes             | 19%              | 81%              | 58%                |
|             | Proposed Scheme Routes | 20%              | 80%              | 55%                |
| SR Peak     | All Routes             | 19%              | 79%              | 58%                |
|             | Proposed Scheme Routes | 18%              | 85%              | 60%                |
| PM Peak     | All Routes             | 31%              | 31%              | 60%                |
|             | Proposed Scheme Routes | 30%              | 33%              | 63%                |

The above table highlights that the LAM shows a range of results when compared to the different interpretations on the raw observed TomTom data as outlined in section 5.6. All time periods in the LAM have been validated to be closer to the 50/50 blend of the observed mean and median and around 60% of the Proposed Scheme routes match the observed on this basis. The LT and SR modelled periods perform well when compared to the mean of the observed data, whereas the AM and PM modelled journey times broadly fall between the mean and median. This is broadly comparable to the journey times results from the full ERM model.

Given the variation in observed times, notably in the AM and PM peaks, it is difficult to find a balance which would validate well across all peaks. As the LT and SR represent less congested conditions, the good performance against the mean indicates that the network appears to be operating sensibly. In order to more closely match the AM and PM to the mean, large scale network changes would be required which would likely result in the LT and SR periods no longer validating as well.

It should also be noted that the journey times from the 2019 TomTom data has been calculated as an average across Monday-Thursday, which may result in slower journey times when compared to a Monday-Friday average. It was considered more prudent to use Monday-Thursday data as more representative of worst case 'average weekday' conditions for the development of the LAM.

## AM Journey Time Results

Apx Table A.27 below shows a breakdown of each individual journey time route for the AM period.

**Apx Table A.27 Detailed AM Journey Time Validation Statistics**

| Route       | Proposed Scheme Correspondence       | Observed Median/Mean Blend | Modelled | % Diff | Pass/Fail |
|-------------|--------------------------------------|----------------------------|----------|--------|-----------|
| 1_Inbound   | Proposed Scheme1                     | 2114                       | 1902     | -10.0% | Pass      |
| 1_Outbound  | Proposed Scheme1                     | 1550                       | 1531     | -1.3%  | Pass      |
| 2_Inbound   | Proposed Scheme16                    | 2586                       | 2355     | -8.9%  | Pass      |
| 2_Outbound  | Proposed Scheme16                    | 2396                       | 1960     | -18.2% | Fail      |
| 3_Inbound   | Proposed Scheme1                     | 1636                       | 1649     | 0.8%   | Pass      |
| 3_Outbound  | Proposed Scheme1                     | 1273                       | 1305     | 2.5%   | Pass      |
| 4_Inbound   | Proposed Scheme2                     | 2550                       | 2291     | -10.2% | Pass      |
| 4_Outbound  | Proposed Scheme2                     | 1882                       | 2346     | 24.6%  | Fail      |
| 5_Inbound   | Proposed Scheme3                     | 1449                       | 1206     | -16.8% | Fail      |
| 5_Outbound  | Proposed Scheme3                     | 1095                       | 1244     | 13.6%  | Pass      |
| 6_Outbound  | Proposed Scheme3, Proposed Scheme4   | 1389                       | 1498     | 7.9%   | Pass      |
| 6_Inbound   | Proposed Scheme3, Proposed Scheme4   | 2170                       | 1779     | -18.0% | Fail      |
| 7_Inbound   | Proposed Scheme5                     | 1732                       | 1406     | -18.8% | Fail      |
| 7_Outbound  | Proposed Scheme5                     | 1131                       | 1458     | 28.9%  | Fail      |
| 8_Inbound   | Proposed Scheme6                     | 1542                       | 1406     | -8.8%  | Pass      |
| 8_Outbound  | Proposed Scheme6                     | 848                        | 876      | 3.3%   | Pass      |
| 9_Outbound  | Proposed Scheme7                     | 1281                       | 1341     | 4.6%   | Pass      |
| 9_Inbound   | Proposed Scheme7                     | 1939                       | 1695     | -12.6% | Pass      |
| 10_Inbound  | Proposed Scheme9                     | 2037                       | 2095     | 2.8%   | Pass      |
| 10_Outbound | Proposed Scheme9                     | 1771                       | 1784     | 0.7%   | Pass      |
| 11_Inbound  | Proposed Scheme10, Proposed Scheme12 | 2605                       | 2216     | -14.9% | Pass      |
| 11_Outbound | Proposed Scheme10, Proposed Scheme12 | 2071                       | 1636     | -21.0% | Fail      |
| 12_Inbound  | Proposed Scheme11, Proposed Scheme12 | 1981                       | 1502     | -24.2% | Fail      |
| 12_Outbound | Proposed Scheme11, Proposed Scheme12 | 1429                       | 1253     | -12.3% | Pass      |
| 13_Inbound  | Proposed Scheme11                    | 1661                       | 1393     | -16.1% | Fail      |
| 13_Outbound | Proposed Scheme11                    | 1307                       | 1187     | -9.2%  | Pass      |
| 14_Inbound  | N/A                                  | 2563                       | 1803     | -29.7% | Fail      |
| 14_Outbound | N/A                                  | 1608                       | 1659     | 3.2%   | Pass      |
| 15_Inbound  | Proposed Scheme13                    | 3143                       | 2461     | -21.7% | Fail      |
| 15_Outbound | Proposed Scheme13                    | 2018                       | 1916     | -5.1%  | Pass      |

| Route        | Proposed Scheme Correspondence      | Observed Median/Mean Blend | Modelled | % Diff | Pass/Fail |
|--------------|-------------------------------------|----------------------------|----------|--------|-----------|
| 16_Inbound   | Proposed Scheme14,Proposed Scheme15 | 2123                       | 1777     | -16.3% | Fail      |
| 16_Outbound  | Proposed Scheme14,Proposed Scheme15 | 1355                       | 1364     | 0.7%   | Pass      |
| 18_Westbound | N/A                                 | 2863                       | 2443     | -14.7% | Pass      |
| 18_Eastbound | N/A                                 | 3275                       | 2518     | -23.1% | Fail      |
| 19_Eastbound | N/A                                 | 3105                       | 2568     | -17.3% | Fail      |
| 19_Westbound | N/A                                 | 3342                       | 2241     | -32.9% | Fail      |
| 20_Eastbound | N/A                                 | 1470                       | 1098     | -25.3% | Fail      |
| 20_Westbound | N/A                                 | 1510                       | 1030     | -31.8% | Fail      |
| 21_Eastbound | M50                                 | 3190                       | 2384     | -25.3% | Fail      |
| 21_Westbound | M50                                 | 3557                       | 2415     | -32.1% | Fail      |
| 22_Outbound  | Proposed Scheme13                   | 674                        | 502      | -25.5% | Fail      |
| 22_Inbound   | Proposed Scheme13                   | 662                        | 570      | -13.8% | Pass      |
| 23_Outbound  | Proposed Scheme2                    | 587                        | 706      | 20.3%  | Fail      |
| 23_Inbound   | Proposed Scheme2                    | 625                        | 636      | 1.7%   | Pass      |
| 24_Outbound  | Proposed Scheme7                    | 700                        | 620      | -11.4% | Pass      |
| 24_Inbound   | Proposed Scheme7                    | 845                        | 602      | -28.8% | Fail      |
| 25_Outbound  | Proposed Scheme8                    | 548                        | 662      | 20.8%  | Fail      |
| 25_Inbound   | Proposed Scheme8                    | 739                        | 616      | -16.6% | Fail      |

The table above highlights that there is a range of results in the AM peak period when comparing the modelled journey times when compared to a 50/50 blend of the mean and median observed TomTom data. Although not all meet the 15% criteria, there are a number which fall into the 15-20% range and therefore are relatively close to guidance. The largest outliers are 14-Inbound, 19-Westbound, 20-Westbound and 21-Westbound, which all just are at or exceed a 30% difference compared to the observed. It should be noted than none of these are located on Proposed Scheme routes although 21-Westbound is on the M50.

## LT Journey Time Results

Apx Table A.28 below shows a breakdown of each individual journey time route for the LT period.

### Apx Table A.28 Detailed LT Journey Time Validation Statistics

| Route      | Proposed Scheme Correspondence        | Observed Median/Mean Blend | Modelled | % Diff | Pass/Fail |
|------------|---------------------------------------|----------------------------|----------|--------|-----------|
| 1_Inbound  | Proposed Scheme1                      | 1361                       | 1500     | 10.2%  | Pass      |
| 1_Outbound | Proposed Scheme1                      | 1340                       | 1644     | 22.7%  | Fail      |
| 2_Inbound  | Proposed Scheme16                     | 1634                       | 1863     | 14.0%  | Pass      |
| 2_Outbound | Proposed Scheme16                     | 1709                       | 1961     | 14.7%  | Pass      |
| 3_Inbound  | Proposed Scheme1                      | 1115                       | 1276     | 14.5%  | Pass      |
| 3_Outbound | Proposed Scheme1                      | 1062                       | 1312     | 23.6%  | Fail      |
| 4_Inbound  | Proposed Scheme2                      | 1359                       | 1831     | 34.7%  | Fail      |
| 4_Outbound | Proposed Scheme2                      | 1695                       | 2276     | 34.3%  | Fail      |
| 5_Inbound  | Proposed Scheme3                      | 827                        | 1048     | 26.8%  | Fail      |
| 5_Outbound | Proposed Scheme3                      | 938                        | 1256     | 34.0%  | Fail      |
| 6_Outbound | Proposed Scheme3,<br>Proposed Scheme4 | 1375                       | 1524     | 10.8%  | Pass      |
| 6_Inbound  | Proposed Scheme3,<br>Proposed Scheme4 | 1592                       | 1723     | 8.2%   | Pass      |

| Route        | Proposed Scheme Correspondence      | Observed Median/Mean Blend | Modelled | % Diff | Pass/Fail |
|--------------|-------------------------------------|----------------------------|----------|--------|-----------|
| 7_Inbound    | Proposed Scheme5                    | 1065                       | 1192     | 11.9%  | Pass      |
| 7_Outbound   | Proposed Scheme5                    | 1036                       | 1279     | 23.4%  | Fail      |
| 8_Inbound    | Proposed Scheme6                    | 804                        | 983      | 22.2%  | Fail      |
| 8_Outbound   | Proposed Scheme6                    | 771                        | 888      | 15.1%  | Fail      |
| 9_Outbound   | Proposed Scheme7                    | 1199                       | 1305     | 8.8%   | Pass      |
| 9_Inbound    | Proposed Scheme7                    | 1216                       | 1387     | 14.1%  | Pass      |
| 10_Inbound   | Proposed Scheme9                    | 1470                       | 1748     | 19.0%  | Fail      |
| 10_Outbound  | Proposed Scheme9                    | 1458                       | 1742     | 19.5%  | Fail      |
| 11_Inbound   | Proposed Scheme10,Proposed Scheme12 | 1590                       | 1857     | 16.8%  | Fail      |
| 11_Outbound  | Proposed Scheme10,Proposed Scheme12 | 1479                       | 1558     | 5.3%   | Pass      |
| 12_Inbound   | Proposed Scheme11,Proposed Scheme12 | 1141                       | 1279     | 12.1%  | Pass      |
| 12_Outbound  | Proposed Scheme11,Proposed Scheme12 | 1076                       | 1319     | 22.6%  | Fail      |
| 13_Inbound   | Proposed Scheme11                   | 1010                       | 1167     | 15.6%  | Fail      |
| 13_Outbound  | Proposed Scheme11                   | 999                        | 1120     | 12.1%  | Pass      |
| 14_Inbound   | N/A                                 | 1310                       | 1562     | 19.3%  | Fail      |
| 14_Outbound  | N/A                                 | 1266                       | 1620     | 28.0%  | Fail      |
| 15_Inbound   | Proposed Scheme13                   | 2042                       | 2142     | 4.9%   | Pass      |
| 15_Outbound  | Proposed Scheme13                   | 1700                       | 1874     | 10.2%  | Pass      |
| 16_Inbound   | Proposed Scheme14,Proposed Scheme15 | 1232                       | 1470     | 19.3%  | Fail      |
| 16_Outbound  | Proposed Scheme14,Proposed Scheme15 | 1156                       | 1322     | 14.4%  | Pass      |
| 18_Westbound | N/A                                 | 2058                       | 2287     | 11.1%  | Pass      |
| 18_Eastbound | N/A                                 | 2103                       | 2371     | 12.7%  | Pass      |
| 19_Eastbound | N/A                                 | 2226                       | 2270     | 2.0%   | Pass      |
| 19_Westbound | N/A                                 | 2054                       | 2204     | 7.3%   | Pass      |
| 20_Eastbound | N/A                                 | 997                        | 1118     | 12.1%  | Pass      |
| 20_Westbound | N/A                                 | 1016                       | 973      | -4.3%  | Pass      |
| 21_Eastbound | M50                                 | 2173                       | 2209     | 1.7%   | Pass      |
| 21_Westbound | M50                                 | 2161                       | 2195     | 1.6%   | Pass      |
| 22_Outbound  | Proposed Scheme13                   | 518                        | 486      | -6.1%  | Pass      |
| 22_Inbound   | Proposed Scheme13                   | 491                        | 513      | 4.6%   | Pass      |
| 23_Outbound  | Proposed Scheme2                    | 636                        | 734      | 15.4%  | Fail      |
| 23_Inbound   | Proposed Scheme2                    | 585                        | 578      | -1.2%  | Pass      |
| 24_Outbound  | Proposed Scheme7                    | 708                        | 607      | -14.3% | Pass      |
| 24_Inbound   | Proposed Scheme7                    | 670                        | 559      | -16.5% | Fail      |
| 25_Outbound  | Proposed Scheme8                    | 513                        | 626      | 22.0%  | Fail      |
| 25_Inbound   | Proposed Scheme8                    | 579                        | 523      | -9.8%  | Pass      |

The table above highlights that there is a range of results in the LT period when comparing the modelled journey times when compared to a 50/50 blend of the mean and median observed TomTom data. The largest outliers are

5-Outbound at 34% and 4 Inbound and Outbound differing by 34.7% and 34.3% respectively when compared to the observed journey times. As discussed above, the LT models matches much more closely when compared to the mean of the journey times.

### SR Journey Time Results

Apx Table A.29 below shows breakdown of each individual journey time route for the SR period.

**Apx Table A.29 Detailed SR Journey Time Validation Statistics**

| Route        | Proposed Scheme Correspondence       | Observed Median/Mean Blend | Modelled | % Diff | Pass/Fail |
|--------------|--------------------------------------|----------------------------|----------|--------|-----------|
| 1_Inbound    | Proposed Scheme1                     | 1426                       | 1513     | 6.2%   | Pass      |
| 1_Outbound   | Proposed Scheme1                     | 1444                       | 1782     | 23.4%  | Fail      |
| 2_Inbound    | Proposed Scheme16                    | 1809                       | 1879     | 3.9%   | Pass      |
| 2_Outbound   | Proposed Scheme16                    | 2074                       | 2246     | 8.3%   | Pass      |
| 3_Inbound    | Proposed Scheme1                     | 1176                       | 1329     | 13.0%  | Pass      |
| 3_Outbound   | Proposed Scheme1                     | 1217                       | 1609     | 32.2%  | Fail      |
| 4_Inbound    | Proposed Scheme2                     | 1364                       | 1915     | 40.4%  | Fail      |
| 4_Outbound   | Proposed Scheme2                     | 1962                       | 2480     | 26.4%  | Fail      |
| 5_Inbound    | Proposed Scheme3                     | 821                        | 1070     | 30.3%  | Fail      |
| 5_Outbound   | Proposed Scheme3                     | 1100                       | 1438     | 30.7%  | Fail      |
| 6_Outbound   | Proposed Scheme3, Proposed Scheme4   | 1493                       | 1790     | 19.8%  | Fail      |
| 6_Inbound    | Proposed Scheme3, Proposed Scheme4   | 1532                       | 1698     | 10.8%  | Pass      |
| 7_Inbound    | Proposed Scheme5                     | 1052                       | 1182     | 12.4%  | Pass      |
| 7_Outbound   | Proposed Scheme5                     | 1233                       | 1479     | 19.9%  | Fail      |
| 8_Inbound    | Proposed Scheme6                     | 842                        | 932      | 10.7%  | Pass      |
| 8_Outbound   | Proposed Scheme6                     | 922                        | 1149     | 24.6%  | Fail      |
| 9_Outbound   | Proposed Scheme7                     | 1478                       | 1465     | -0.9%  | Pass      |
| 9_Inbound    | Proposed Scheme7                     | 1228                       | 1323     | 7.8%   | Pass      |
| 10_Inbound   | Proposed Scheme9                     | 1561                       | 1774     | 13.6%  | Pass      |
| 10_Outbound  | Proposed Scheme9                     | 1611                       | 1857     | 15.3%  | Fail      |
| 11_Inbound   | Proposed Scheme10, Proposed Scheme12 | 1607                       | 1825     | 13.5%  | Pass      |
| 11_Outbound  | Proposed Scheme10, Proposed Scheme12 | 1845                       | 1640     | -11.1% | Pass      |
| 12_Inbound   | Proposed Scheme11, Proposed Scheme12 | 1216                       | 1305     | 7.3%   | Pass      |
| 12_Outbound  | Proposed Scheme11, Proposed Scheme12 | 1219                       | 1483     | 21.6%  | Fail      |
| 13_Inbound   | Proposed Scheme11                    | 1044                       | 1168     | 11.9%  | Pass      |
| 13_Outbound  | Proposed Scheme11                    | 1188                       | 1228     | 3.4%   | Pass      |
| 14_Inbound   | N/A                                  | 1347                       | 1559     | 15.8%  | Fail      |
| 14_Outbound  | N/A                                  | 1448                       | 1733     | 19.7%  | Fail      |
| 15_Inbound   | Proposed Scheme13                    | 2068                       | 2157     | 4.3%   | Pass      |
| 15_Outbound  | Proposed Scheme13                    | 1883                       | 2059     | 9.4%   | Pass      |
| 16_Inbound   | Proposed Scheme14, Proposed Scheme15 | 1256                       | 1455     | 15.9%  | Fail      |
| 16_Outbound  | Proposed Scheme14, Proposed Scheme15 | 1236                       | 1504     | 21.7%  | Fail      |
| 18_Westbound | N/A                                  | 2356                       | 2338     | -0.8%  | Pass      |
| 18_Eastbound | N/A                                  | 2307                       | 2447     | 6.1%   | Pass      |
| 19_Eastbound | N/A                                  | 2647                       | 2302     | -13.1% | Pass      |
| 19_Westbound | N/A                                  | 2145                       | 2253     | 5.0%   | Pass      |



| Route        | Proposed Scheme Correspondence | Observed Median/Mean Blend | Modelled | % Diff | Pass/Fail |
|--------------|--------------------------------|----------------------------|----------|--------|-----------|
| 20_Eastbound | N/A                            | 1354                       | 1050     | -22.4% | Fail      |
| 20_Westbound | N/A                            | 1364                       | 989      | -27.5% | Fail      |
| 21_Eastbound | M50                            | 2403                       | 2324     | -3.3%  | Pass      |
| 21_Westbound | M50                            | 2410                       | 2539     | 5.4%   | Pass      |
| 22_Outbound  | Proposed Scheme13              | 632                        | 490      | -22.5% | Fail      |
| 22_Inbound   | Proposed Scheme13              | 529                        | 515      | -2.7%  | Pass      |
| 23_Outbound  | Proposed Scheme2               | 657                        | 738      | 12.4%  | Pass      |
| 23_Inbound   | Proposed Scheme2               | 587                        | 585      | -0.3%  | Pass      |
| 24_Outbound  | Proposed Scheme7               | 808                        | 617      | -23.6% | Fail      |
| 24_Inbound   | Proposed Scheme7               | 691                        | 566      | -18.1% | Fail      |
| 25_Outbound  | Proposed Scheme8               | 615                        | 628      | 2.0%   | Pass      |
| 25_Inbound   | Proposed Scheme8               | 493                        | 533      | 8.3%   | Pass      |

The table above highlights that there is a range of results in the SR period when comparing the modelled journey times when compared to a 50/50 blend of the mean and median observed TomTom data. The largest outliers are route 3 outbound at 32.2%, route 4 inbound at 40.4% and 5 Inbound and Outbound at 30.3% and 30.7% difference between the modelled and observed journey times respectively. As discussed above, the SR models matches much more closely when compared to the mean of the journey times.

### PM Journey Time Results

Apx Table A.30 below shows breakdown of each individual journey time route for the PM period.

**Apx Table A.30 Detailed PM Journey Time Validation Statistics**

| Route      | Proposed Scheme Correspondence        | Observed Median/Mean Blend | Modelled | % Diff | Pass/Fail |
|------------|---------------------------------------|----------------------------|----------|--------|-----------|
| 1_Inbound  | Proposed Scheme1                      | 1469                       | 1444     | -1.7%  | Pass      |
| 1_Outbound | Proposed Scheme1                      | 1803                       | 2392     | 32.6%  | Fail      |
| 2_Inbound  | Proposed Scheme16                     | 2550                       | 1866     | -26.8% | Fail      |
| 2_Outbound | Proposed Scheme16                     | 2777                       | 2621     | -5.6%  | Pass      |
| 3_Inbound  | Proposed Scheme1                      | 1225                       | 1318     | 7.6%   | Pass      |
| 3_Outbound | Proposed Scheme1                      | 1558                       | 2067     | 32.7%  | Fail      |
| 4_Inbound  | Proposed Scheme2                      | 1579                       | 2011     | 27.4%  | Fail      |
| 4_Outbound | Proposed Scheme2                      | 2572                       | 2694     | 4.7%   | Pass      |
| 5_Inbound  | Proposed Scheme3                      | 869                        | 1085     | 24.9%  | Fail      |
| 5_Outbound | Proposed Scheme3                      | 1439                       | 1524     | 5.9%   | Pass      |
| 6_Outbound | Proposed Scheme3,<br>Proposed Scheme4 | 2120                       | 1920     | -9.5%  | Pass      |
| 6_Inbound  | Proposed Scheme3,<br>Proposed Scheme4 | 1811                       | 1680     | -7.2%  | Pass      |
| 7_Inbound  | Proposed Scheme5                      | 1201                       | 1175     | -2.2%  | Pass      |
| 7_Outbound | Proposed Scheme5                      | 1779                       | 1583     | -11.0% | Pass      |
| 8_Inbound  | Proposed Scheme6                      | 1045                       | 925      | -11.5% | Pass      |
| 8_Outbound | Proposed Scheme6                      | 1326                       | 1217     | -8.2%  | Pass      |
| 9_Outbound | Proposed Scheme7                      | 1851                       | 1492     | -19.4% | Fail      |
| 9_Inbound  | Proposed Scheme7                      | 1651                       | 1374     | -16.8% | Fail      |
| 10_Inbound | Proposed Scheme9                      | 1897                       | 1846     | -2.7%  | Pass      |

| Route        | Proposed Scheme Correspondence      | Observed Median/Mean Blend | Modelled | % Diff | Pass/Fail |
|--------------|-------------------------------------|----------------------------|----------|--------|-----------|
| 10_Outbound  | Proposed Scheme9                    | 2103                       | 2156     | 2.5%   | Pass      |
| 11_Inbound   | Proposed Scheme10,Proposed Scheme12 | 1902                       | 2105     | 10.7%  | Pass      |
| 11_Outbound  | Proposed Scheme10,Proposed Scheme12 | 2539                       | 1736     | -31.6% | Fail      |
| 12_Inbound   | Proposed Scheme11,Proposed Scheme12 | 1331                       | 1367     | 2.7%   | Pass      |
| 12_Outbound  | Proposed Scheme11,Proposed Scheme12 | 1728                       | 1525     | -11.7% | Pass      |
| 13_Inbound   | Proposed Scheme11                   | 1100                       | 1195     | 8.6%   | Pass      |
| 13_Outbound  | Proposed Scheme11                   | 1397                       | 1330     | -4.8%  | Pass      |
| 14_Inbound   | N/A                                 | 1580                       | 1612     | 2.0%   | Pass      |
| 14_Outbound  | N/A                                 | 2120                       | 1815     | -14.4% | Pass      |
| 15_Inbound   | Proposed Scheme13                   | 2722                       | 2180     | -19.9% | Fail      |
| 15_Outbound  | Proposed Scheme13                   | 2552                       | 2318     | -9.2%  | Pass      |
| 16_Inbound   | Proposed Scheme14,Proposed Scheme15 | 1523                       | 1497     | -1.7%  | Pass      |
| 16_Outbound  | Proposed Scheme14,Proposed Scheme15 | 1801                       | 1610     | -10.6% | Pass      |
| 18_Westbound | N/A                                 | 2995                       | 2418     | -19.3% | Fail      |
| 18_Eastbound | N/A                                 | 2557                       | 2671     | 4.5%   | Pass      |
| 19_Eastbound | N/A                                 | 3611                       | 2289     | -36.6% | Fail      |
| 19_Westbound | N/A                                 | 2677                       | 2499     | -6.6%  | Pass      |
| 20_Eastbound | N/A                                 | 1409                       | 1103     | -21.7% | Fail      |
| 20_Westbound | N/A                                 | 1471                       | 1032     | -29.9% | Fail      |
| 21_Eastbound | M50                                 | 3670                       | 2406     | -34.5% | Fail      |
| 21_Westbound | M50                                 | 3285                       | 2366     | -28.0% | Fail      |
| 22_Outbound  | Proposed Scheme13                   | 744                        | 514      | -30.8% | Fail      |
| 22_Inbound   | Proposed Scheme13                   | 520                        | 511      | -1.8%  | Pass      |
| 23_Outbound  | Proposed Scheme2                    | 803                        | 773      | -3.7%  | Pass      |
| 23_Inbound   | Proposed Scheme2                    | 697                        | 763      | 9.5%   | Pass      |
| 24_Outbound  | Proposed Scheme7                    | 1149                       | 613      | -46.6% | Fail      |
| 24_Inbound   | Proposed Scheme7                    | 667                        | 575      | -13.9% | Pass      |
| 25_Outbound  | Proposed Scheme8                    | 982                        | 621      | -36.8% | Fail      |
| 25_Inbound   | Proposed Scheme8                    | 786                        | 541      | -31.1% | Fail      |

The table above highlights that there is a range of results in the PM peak period when comparing the modelled journey times when compared to a 50/50 blend of the mean and median observed TomTom data. The PM contains larger outliers compared to the 15% guidance compared to the other periods with 24 Outbound at -46.6%, 25 Outbound at -36.8% and 19 Eastbound at -36.8%. 25 Outbound and 19 Eastbound represent notable increases in journey time compared to the AM peak period which are difficult to model in an average model such as the LAM without and are likely due to outliers in the observed data.

## A.4 Summary

The previous parts of this section have outlined the validation checks undertaken to assess the robustness of the calibrated LAM. In summary:

- The LAM meets all TII and TAG validation criteria for the turning counts with regards to absolute/percentage difference. The results against GEH criteria meet guidance for LGV/HGV but are slightly below guidance for Private Cars. All vehicle types and time periods perform well when comparing observed and modelled turning proportions.
- The journey times have been compared against a 50/50 blend of the mean and median TomTom data due to the significant difference in the journey time results given by the individual mean and median results. In each period the overall modelled times are close to guidance, matching in approximately 60% of routes. The LT and SR perform significantly better when compared directly against the mean of the observed. The above is comparable if not slightly improved in comparison to the ERM validation results.