Appendix A6.1
Sub Appendix
Appendix 1 –
Transport Modelling Report

Contents

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 **Liffey Valley 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 Liffey Valley Proposed 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 have, in turn, 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[1] 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

[1] Cordoning is the process of creating a smaller area model (network and demand) from a larger model

- Cycling.

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 'DoMinimum' 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 then 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.

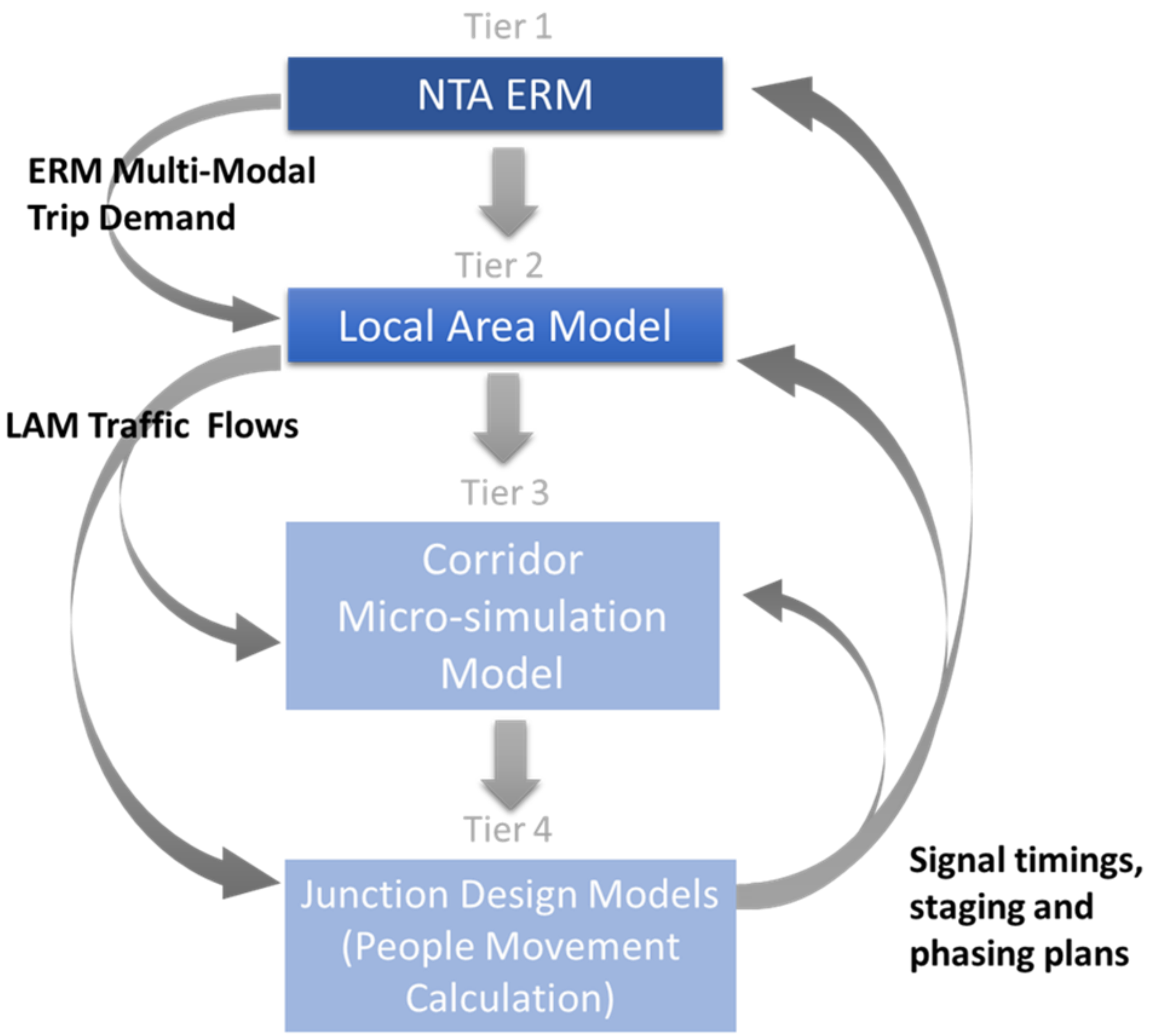


Diagram 3.1: Proposed Scheme Modelling Hierarchy

The purpose of each of the modelling tools is summarised in Table 3.1 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 Mode share Policy assessment (e.g. demand management) Donor Network for LAM	NTA Forecast Planning Data (2020,2028,2043) Future year Proposed Scheme information (Traffic signal plans and timings
Local Area Model (LAM)	General Traffic Redistribution impacts Link Flows (AADTs) Link Speeds Junction turning flows Construction Strategy and Traffic Management measure testing Donor network for Proposed Scheme Micro-sim model	Traffic surveys Journey time data ERM forecast matrices Proposed Scheme designs Proposed Scheme Traffic signal plans and timings
Micro-simulation Model	Operational features Design validation Person delay measurement Bus journey times Queue formation Scheme visualization	LAM demand matrices Proposed Scheme designs Proposed Scheme Traffic signal plans and timings
Junction Design Models / People Movement Calculation	Junction design tool Proposed Scheme signal plan and timing development 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 [2] 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

[2] https://www.nationaltransport.ie/wp-content/uploads/2019/01/National_Household_Travel_Survey_2017_Report_-_December_2018.pdf

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 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.

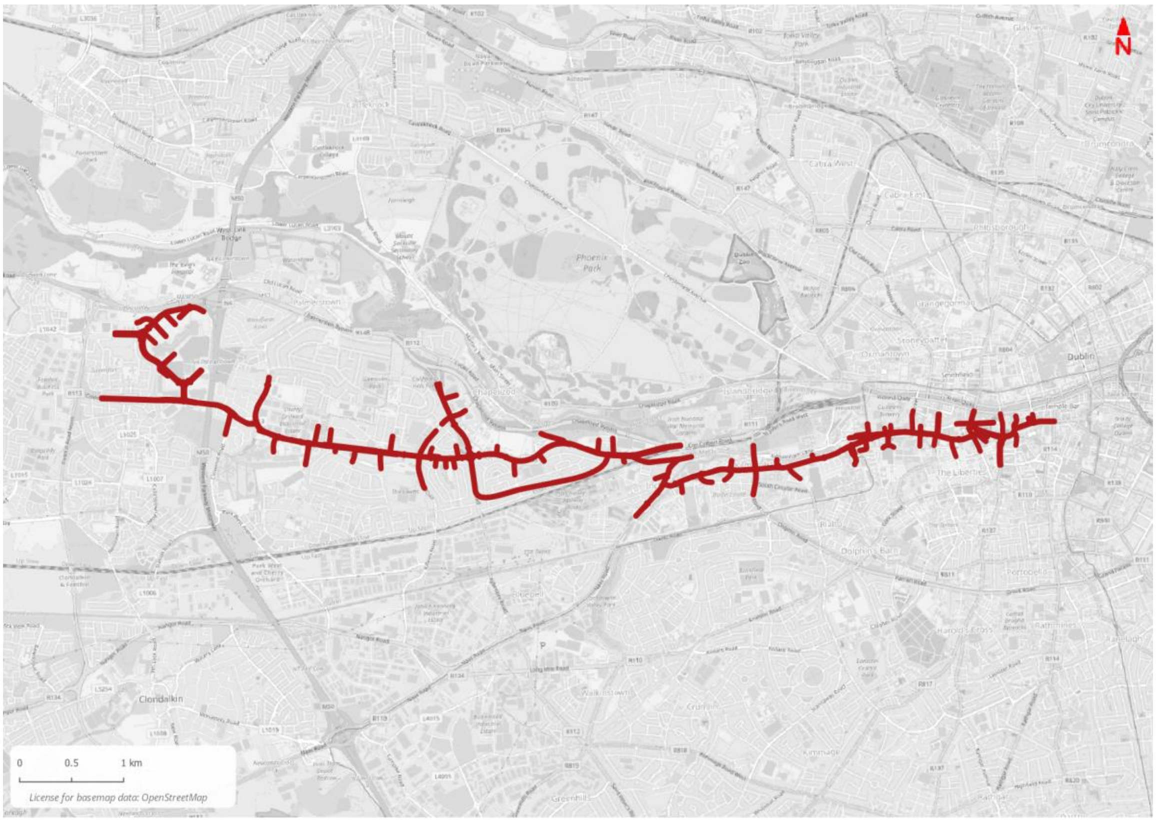


Diagram 3.2: Proposed Scheme Microsimulation Model Network

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.

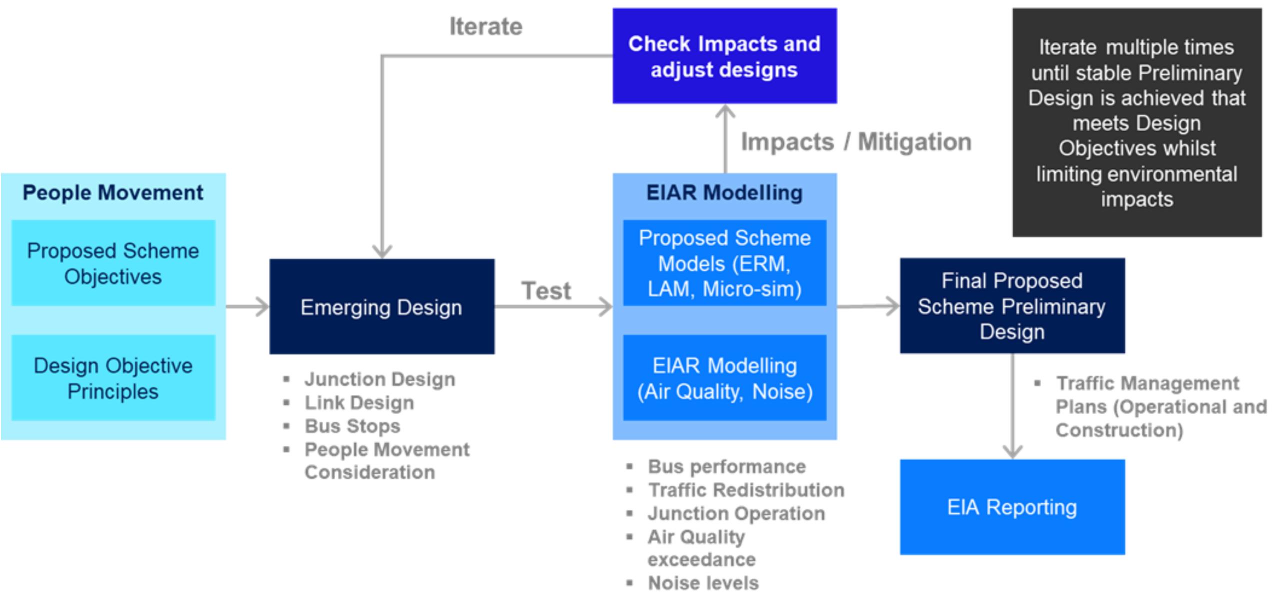


Diagram 3.3: Proposed Scheme Modelling and Design Interaction

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**.**

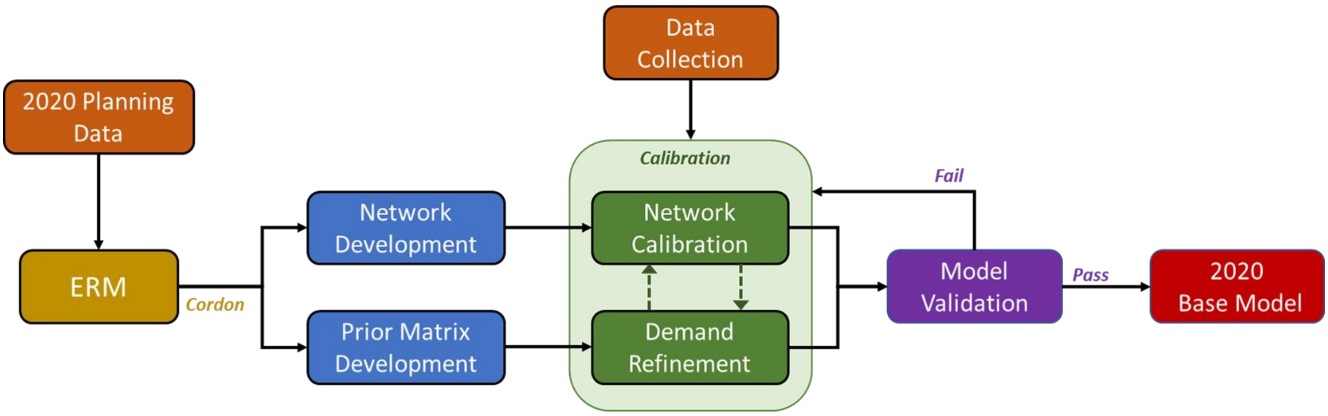


Diagram 3.4: LAM Development Methodology

In summary:

- **ERM Cordon**: The 2020 ERM road assignment was cordoned[3] 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

[3] Cordoning is the process of creating a smaller area model (network and demand) from a larger model

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.

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.

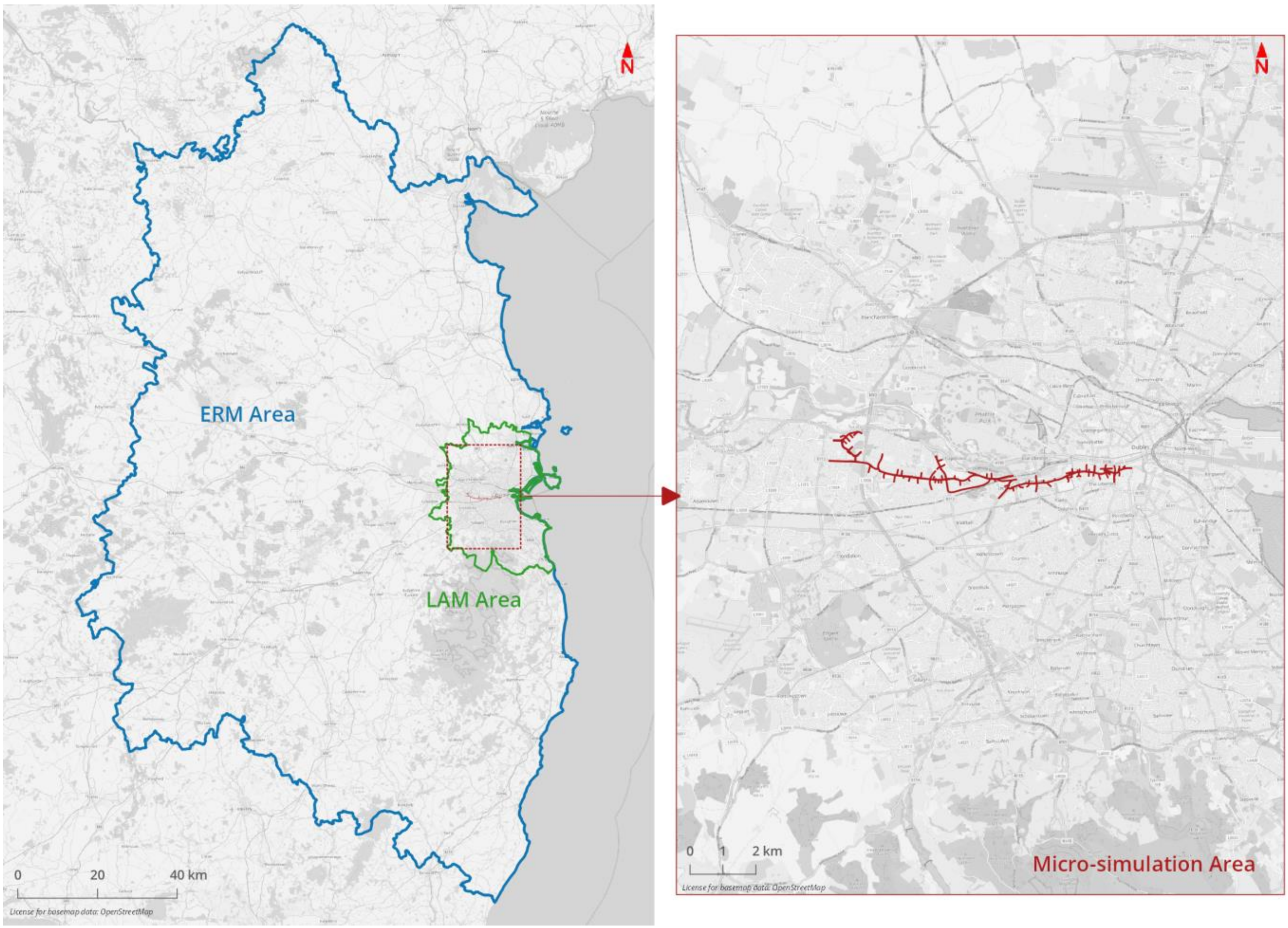


Diagram 4.1: ERM, LAM and Micro-simulation Model Areas

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 kilometre 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] SATURN - Simulation Assignment of Traffic to Urban Road Networks

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.

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 majority of the JTCs were surveyed on 28 November 2019. The ATCs were surveyed from 20 November to 3 December 2019.

Table 5.1: Survey Overview

SURVEY TYPE	COMPANY	NUMBER	DATES
JTC	IDASO LTD	84	Thu 28/11/2019, Thu 13/2/2020
ATC	IDASO LTD	10	21/11/2019 - 2/12/2019

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 60 JTC counts and 14 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 Winetavern Street / Christchurch junction (58503 daily movements). The next busiest junctions are:

- High Street/Bridge Street (45,313 daily movements)
- Fonthill Road/Coldcut Road (37,604 daily movements)
- Bridge Street/Cook Street (37,184 daily movements)
- Fonthill Road/Liffey Valley Green Car Park (36,002 daily movements)

The least busy junction in the study area is the Fonthill Road/Liffey Valley Green Car Park access with 7316 daily movements.

The average weekday ATC flows (all vehicles) are shown in Table 5.3. The highest ATC daily flows are on High Street. Some ATC counts did not have reliable counts for a full week and were excluded from the dataset.

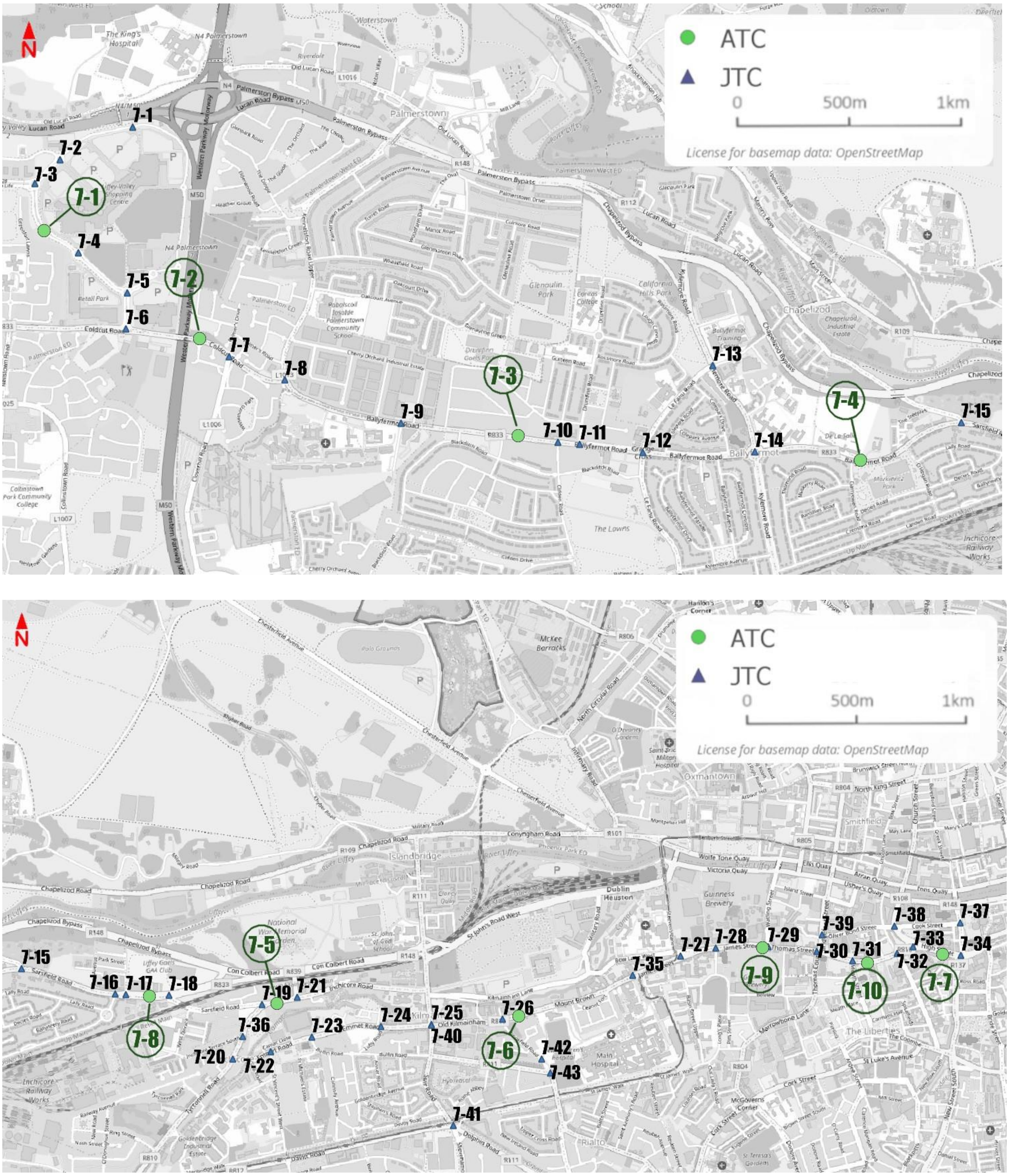


Diagram 5.1: ATC and JTC Traffic Count Locations

Table 5.2: JTC Locations

JUNCTION IDENTIFIER	JUNCTION NAME	TYPE	DAILY MOVEMENTS	AM MOVEMENTS	PM MOVEMENTS
7-1	Fonthill Road/Liffey Valley Red Car Park	Roundabout	7316	218	479
7-2	Fonthill Road/Liffey Valley Yellow Car Park	Roundabout	22602	591	1626
7-3	Fonthill Road/Liffey Valley Green Car Park	Roundabout	36002	1201	2275
7-4	Fonthill Road/Liffey Valley service access	Roundabout	26854	850	1932
7-5	Fonthill Road/Liffey Valley B&Q access	Roundabout	28023	888	2007
7-6	Fonthill Road/Coldcut Road	Signals	37604	1913	2839
7-7	Coldcut Road/Cloverhill Road	Signals	32362	2190	2150
7-8	Kennelsfort Road/Ballyfermot Road	Signals	29416	2024	1984
7-9	Ballyfermot Road/Cherry Orchard Football	Signals	19473	1231	1370
7-10	Ballyfermot Road/Clifden Road	Priority	19119	1205	1005
7-11	Drumfinn Road/Ballyfermot Road	Signals	22009	1497	1155
7-12	Le Fanu Road/Ballyfermot Road	Signals	26861	1966	1591
7-13	Chapelizod Hill Road/Kylemore Road	Signals	18646	1707	1294
7-14	Kylemore Road/Ballyfermot Road	Priority	34646	2422	2314
7-15	St Laurence's Road/Sarsfield Road	Priority	17346	1261	1367
7-16	Sarsfield Road/Landen Road	Signals	17705	1364	1375
7-17	St Marys Ave W/Sarsfield Road	Signals	17453	1386	1361
7-18	Con Colbert Road/Sarsfield Road	Signals	17418	1373	1303
7-19	Inchicore Road/Grattan Cres	Signals	18725	1342	1398
7-20	R839 Grattan Cres/R810 Emmet Road	Signals	27354	1803	1855
7-21	Memorial Road/Inchicore Road	Signals	14005	829	1114
7-22	Emmet Road/St Vincent Street W	Priority	18504	1300	1188
7-23	Emmet Road/Bulfin Road	Priority	18481	1263	1176
7-24	Emmet Road/Luby Road	Priority	13385	862	825
7-25	S Circular Road/Old Kilmainham	Signals	32278	2237	1913
7-26	Shannon Terrace/Old Kilmainham	Priority	14758	873	826
7-27	Bow Lane W/James Street	Signals	23773	1688	1571
7-28	James Street/Echlin Street	Priority	25184	1798	1532
7-29	Watling Street/R810 Thomas Street	Signals	23976	1682	1508
7-30	Bridgefoot Street/Thomas Street	Signals	31374	2211	2028
7-31	R810 Thomas Street/Meath Street	Signals	25003	1824	1536
7-32	Cornmarket/Francis Street	Signals	25478	1860	1356
7-33	High Street/Bridge Street	Signals	45313	3036	2076
7-34	Winetavern Street/Christchurch	Signals	58503	3673	3237
7-35	James Street/Unnamed Road	Priority	19249	1214	996
7-36	Grattan Cres/Inchicore Terrace S	Priority	19318	1346	1429
7-37	Winetavern Street/Cook Street	Priority	17495	1107	1187
7-38	Lower Bridge Street/Cook Street	Signals	37184	2508	1980
7-39	Bridgefoot Street/Oliver Bond Street	Priority	16006	1313	1091
7-40	South Circular Rd/ Old Kilmainham	Signals	21727	1563	1337
7-41	Dolphin Rd/ Grand Canal View	Signals	22198	1698	1516
7-42	Brookfield Rd/ Adelaide Terrace	Priority	9394	671	579
7-43	Brookfield Road/ South Circular Road	Signals	18886	1383	1105

Table 5.3: ATC Locations

ATC IDENTIFIER	ATC LOCATION	DIRECTION	DAILY MOVEMENTS	AM MOVEMENTS	PM MOVEMENTS
7.1A	Fonthill Road between Red Car Park and B&Q	Eastbound	8652	501	545
7.1B		Westbound	6916	190	533
7.2A	Coldcut Road east of M50	Eastbound	12394	580	1039
7.2B		Westbound	13133	1003	801
7.3A	Ballyfermot Road west of Clifden Road	Eastbound	7669	531	375
7.3B		Westbound	6666	358	231
7.4A	Ballyfermot Road east of Garryowen Road	Eastbound	excluded	excluded	excluded
7.4B		Westbound	excluded	excluded	excluded
7.5A	Inchicore Road west of Memorial	Eastbound	7051	424	618
7.5B		Westbound	3894	240	245
7.6A	Old Kilmainham at National Children's Hospital	Eastbound	7575	444	357
7.6B		Westbound	4844	267	241
7.7A	High Street	Eastbound	19365	1330	1004
7.7B		Westbound	7051	424	618
7.8A	Sarsfield Road at Liffey Gaels GAA	Eastbound	3894	240	245
7.8B		Westbound	excluded	excluded	excluded
7.9A	Thomas Street west of Watling Street	Eastbound	excluded	excluded	excluded
7.9B		Westbound	excluded	excluded	excluded
7.10A	Thomas Street east of Meath Street	Eastbound	14045	636	633
7.10B		Westbound	7263	372	687

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.

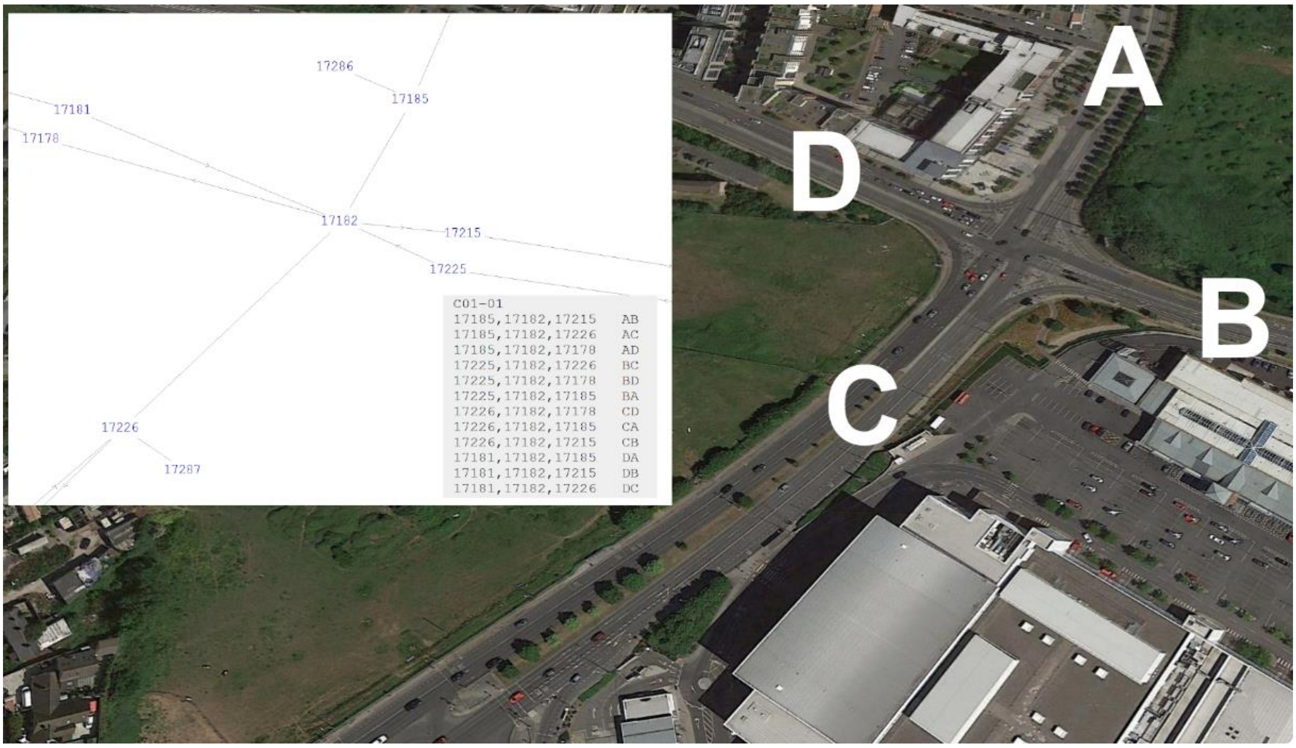


Diagram 5.2: Bus Connects LAM Node Matching (Junction C01-01)

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.

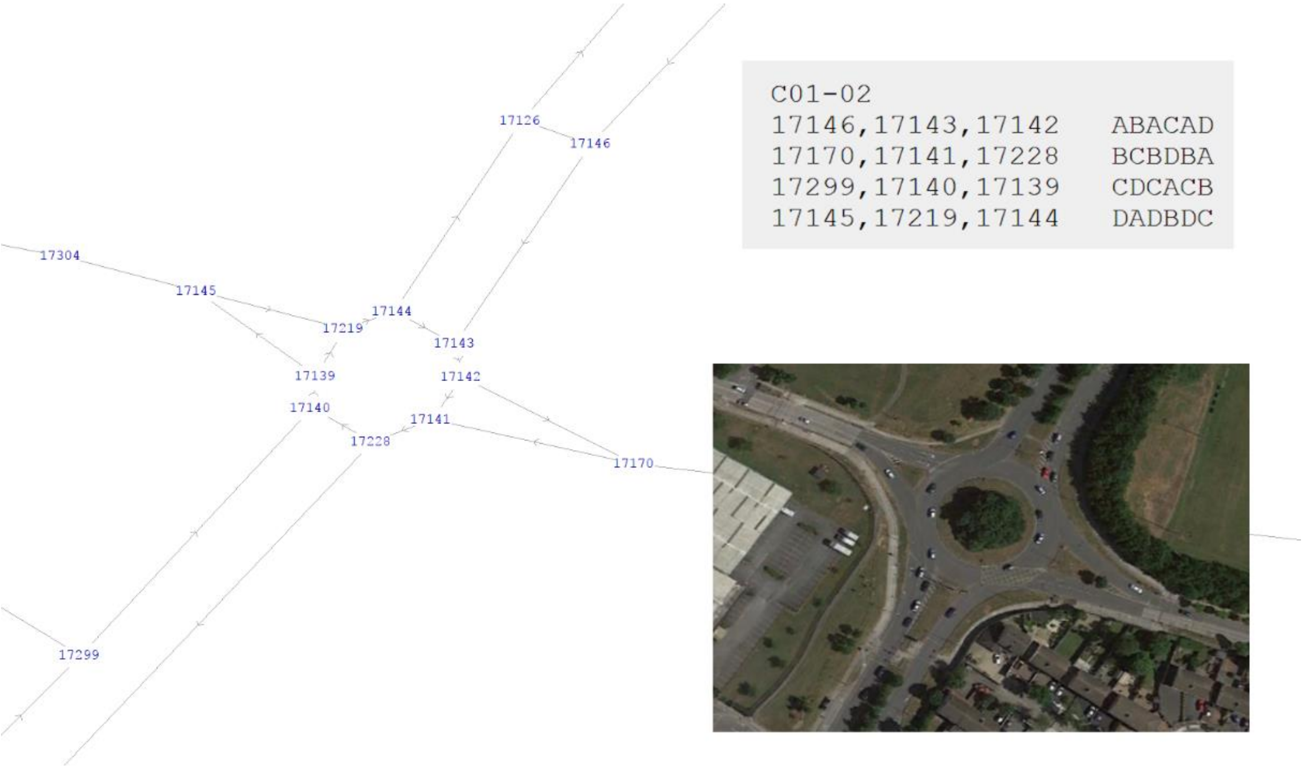


Diagram 5.3: Bus Connects LAM Node Matching (Junction C01-02)

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.

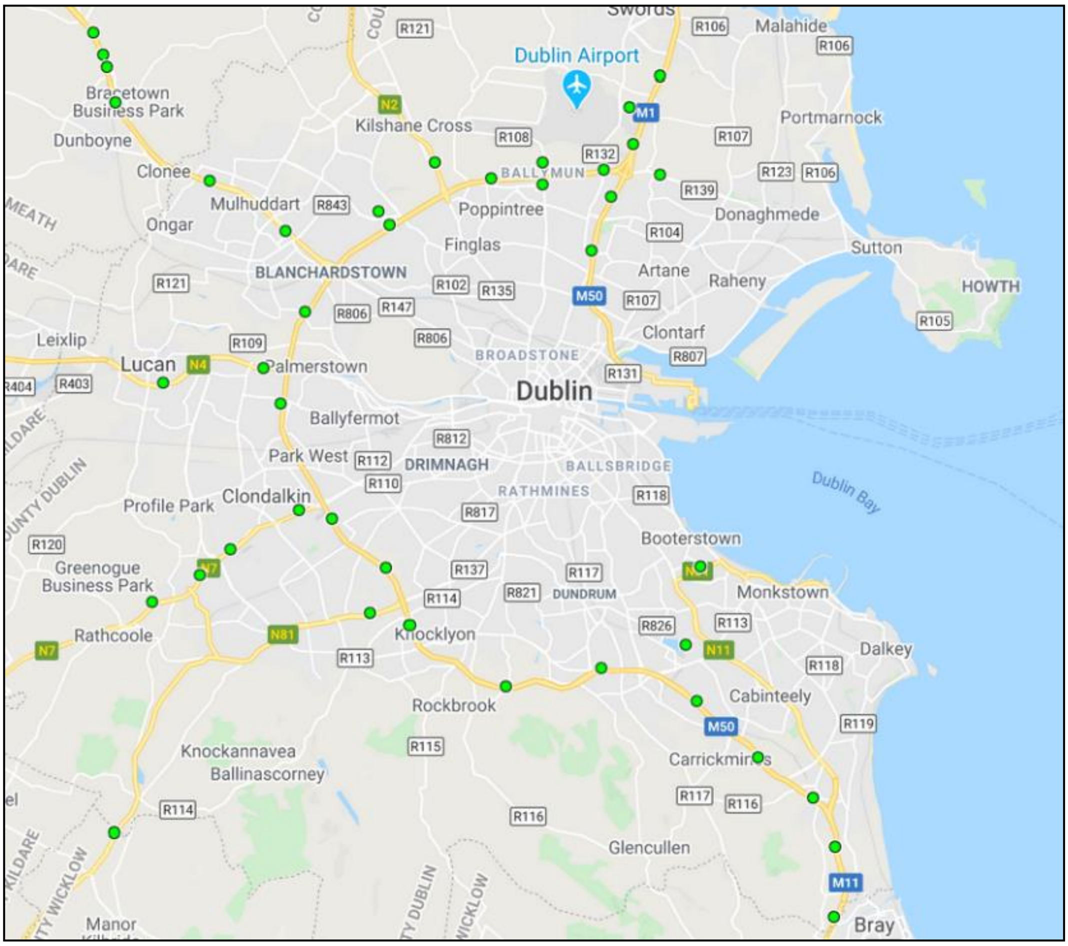


Diagram 5.4: TII Permanent Counter Locations (Source: TII)

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.

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.

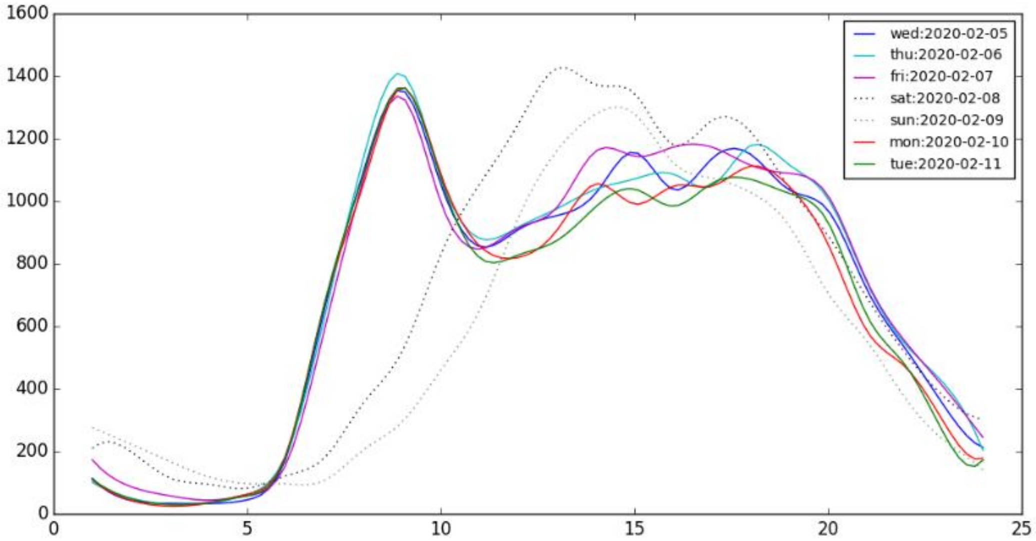


Diagram 5.5: Typical Week Profile (ATC-01-01: Malahide Road Inbound)

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. 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 * AM assigned flows = 07:00 – 10:00 flows;
- 2.885 * LT assigned flows = 10:00 – 13:00 flows;
- 2.868 * SR assigned flows = 13:00 – 16:00 flows; and
- 2.958 * PM assigned flows = 16:00 – 19:00 flows.

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

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

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

$$WADT_{Nov2019} = 1.21 \times 12hr_{WD}\ for\ cars$$
$$WADT_{Nov2019} = 1.07 \times 12hr_{WD}\ for\ LGVs$$
$$WADT_{Nov2019} = 1.08 \times 12hr_{WD}\ for\ HGVs$$

Where:

- $WADT_{Nov2019}$ is the weekly average daily traffic for the 3rd week of November 2019,
- 12hrWD 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.

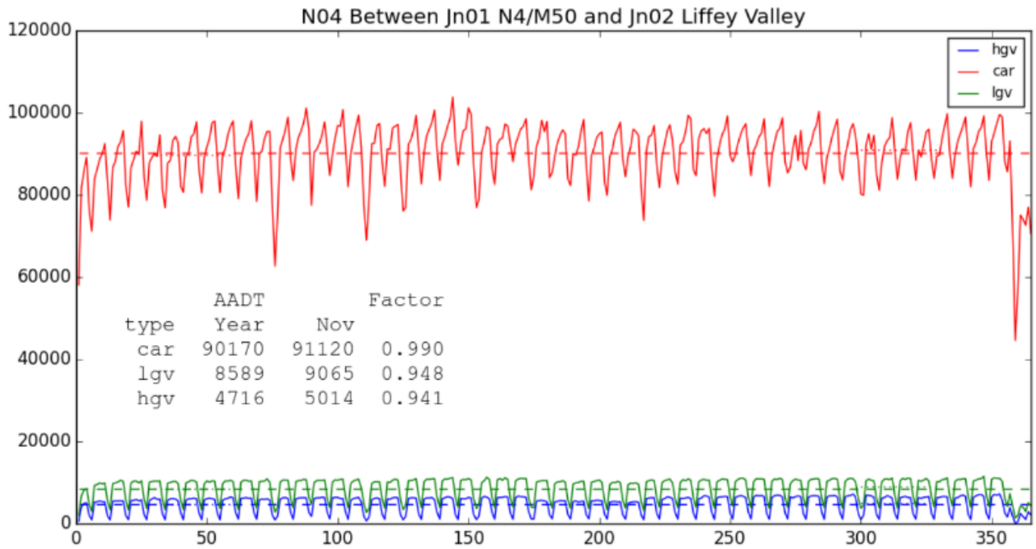


Diagram 5.6: Example Yearly Profile

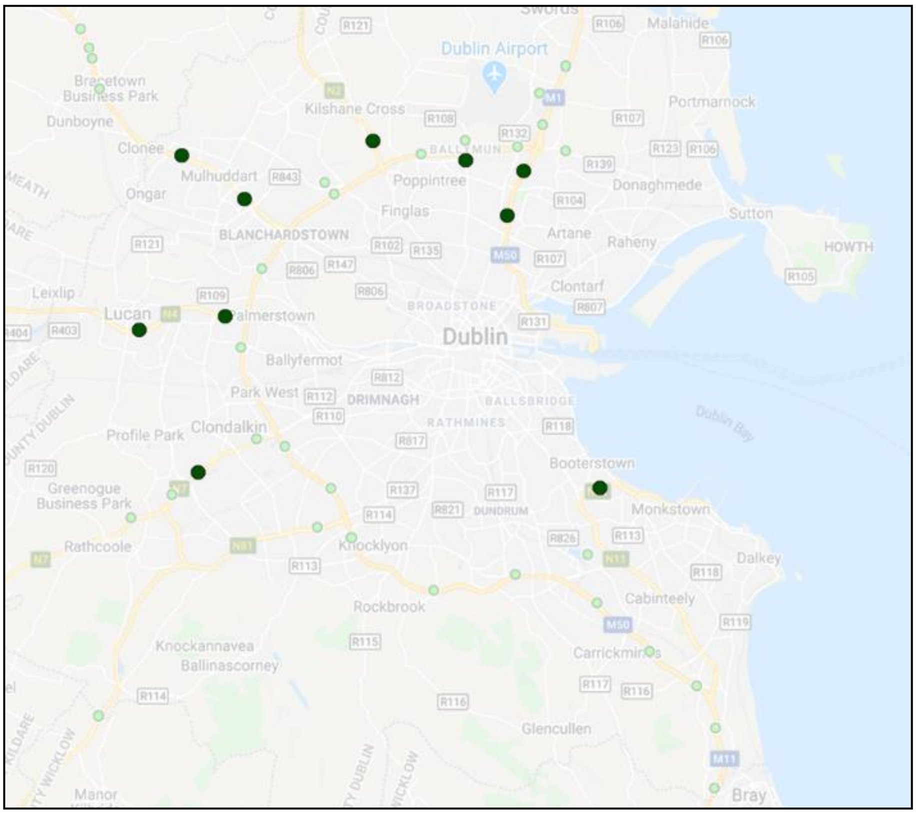


Diagram 5.7: Seasonal Factor Data Sites

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:

$WADT_{Nov}$ 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 * WADTNov for cars

AADT = 0.965 * WADTNov for LGVs

AADT = 0.951 * WADTNov 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.

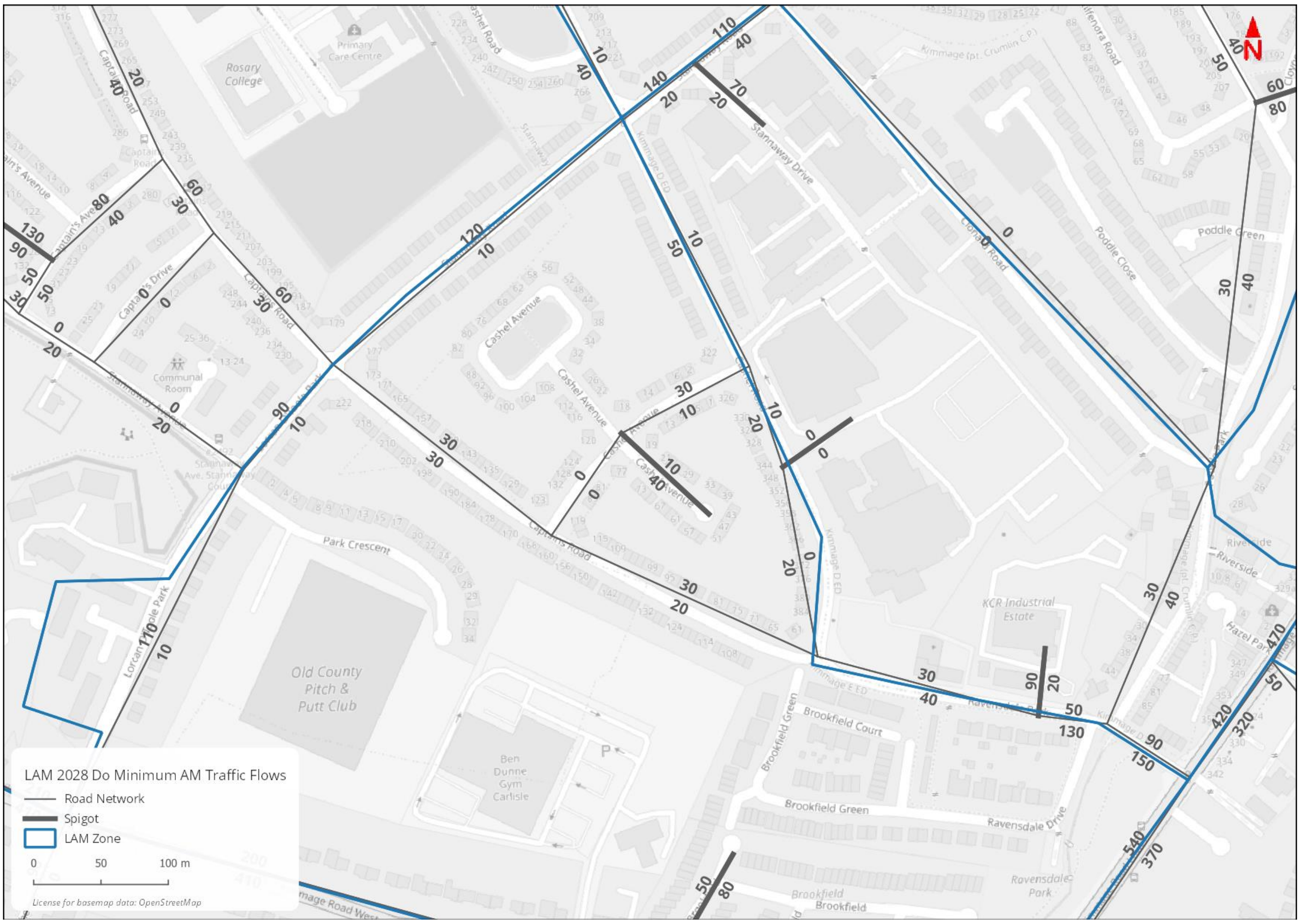


Diagram 5.8: Traffic Zone Boundaries and Modelled Road Network with Access Points (Spigots)

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).

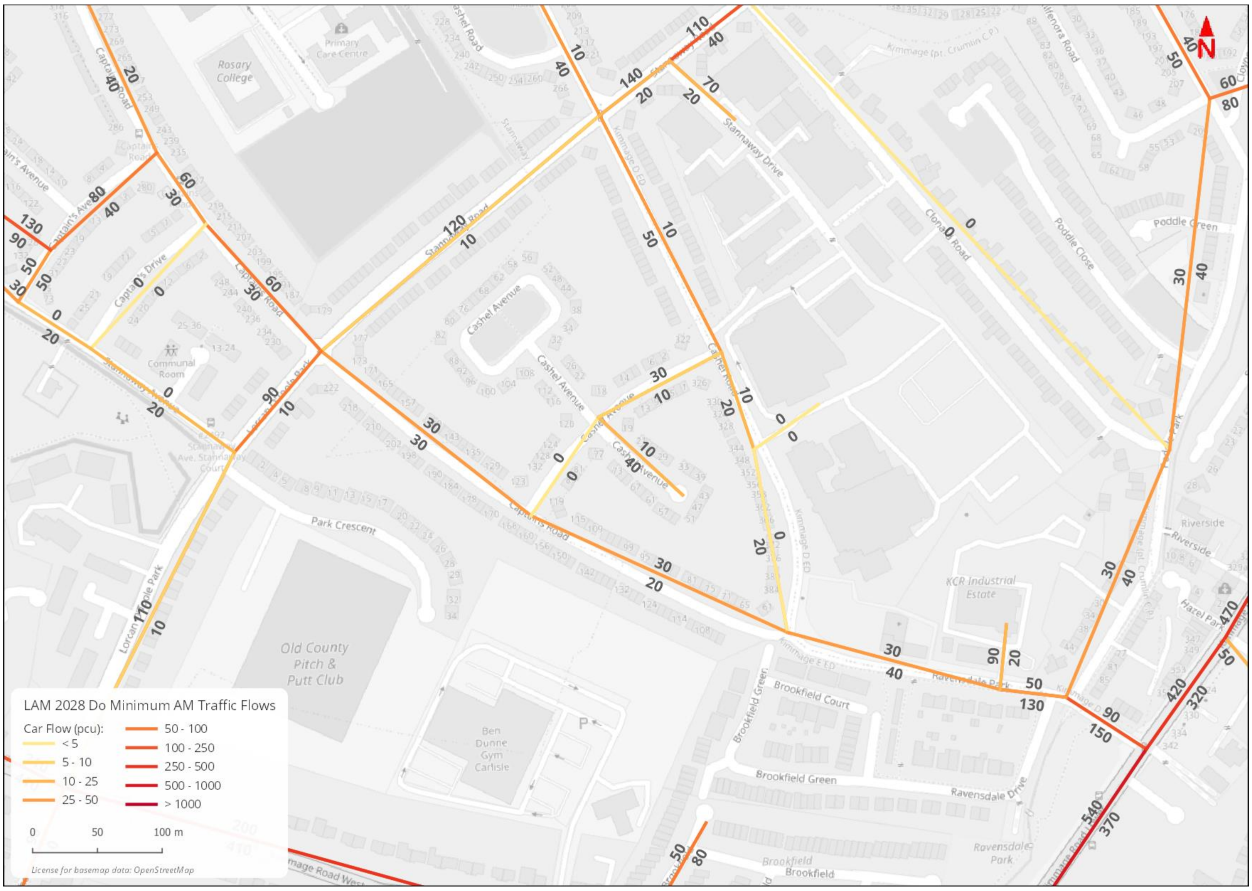


Diagram 5.9: LAM 2028 Do Minimum AM Traffic Flows - Kimmage Area

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 then 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:

$$Additional\ Flow_{Time\ Period} = Minimum\left(\frac{50\% * \ Zone\ Demand_{Time\ Period}}{Zone\ total\ street\ length}, 100\right)$$

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).

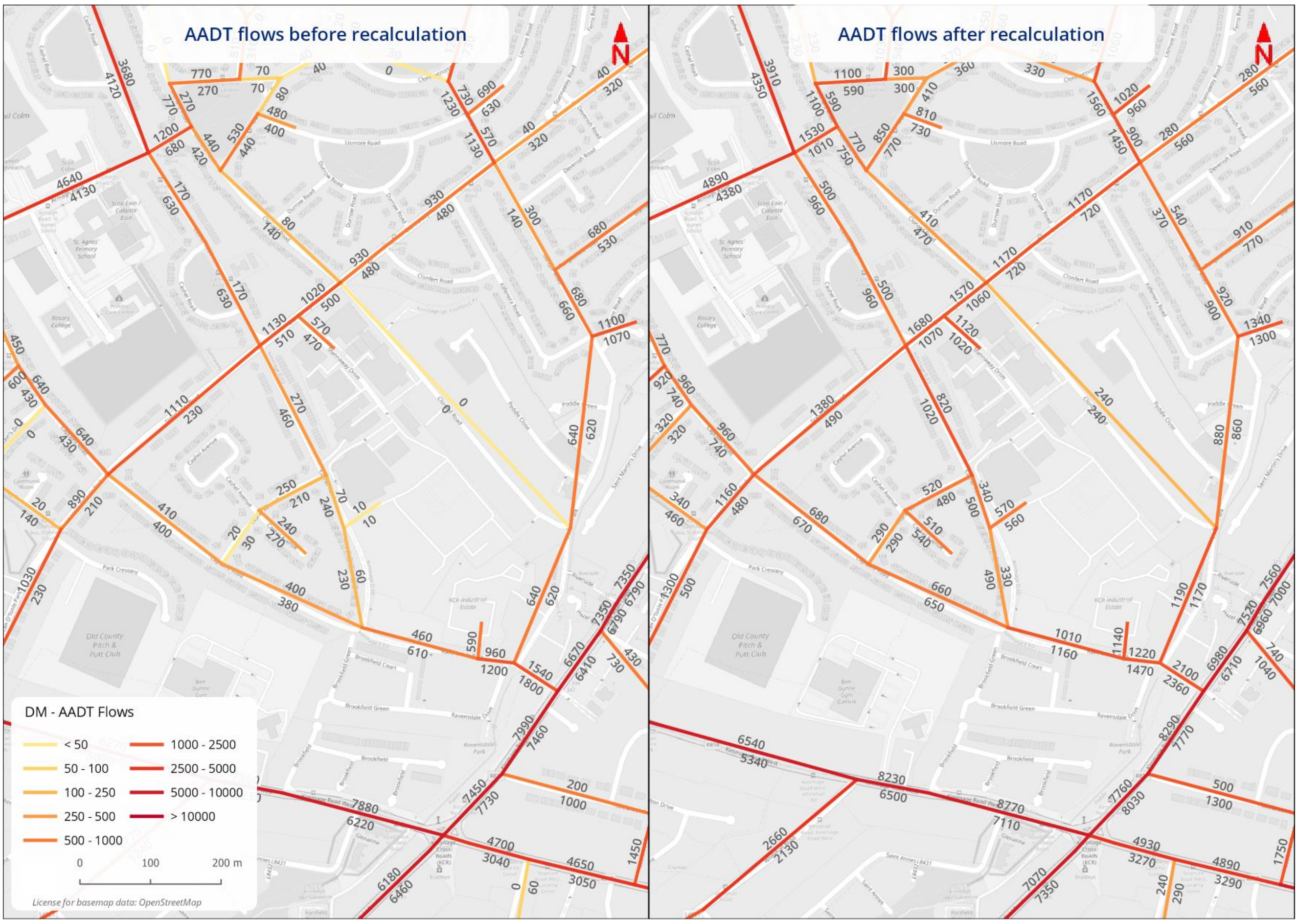


Diagram 5.10: AADT Traffic Flows Before and After AADT Recalculation

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.

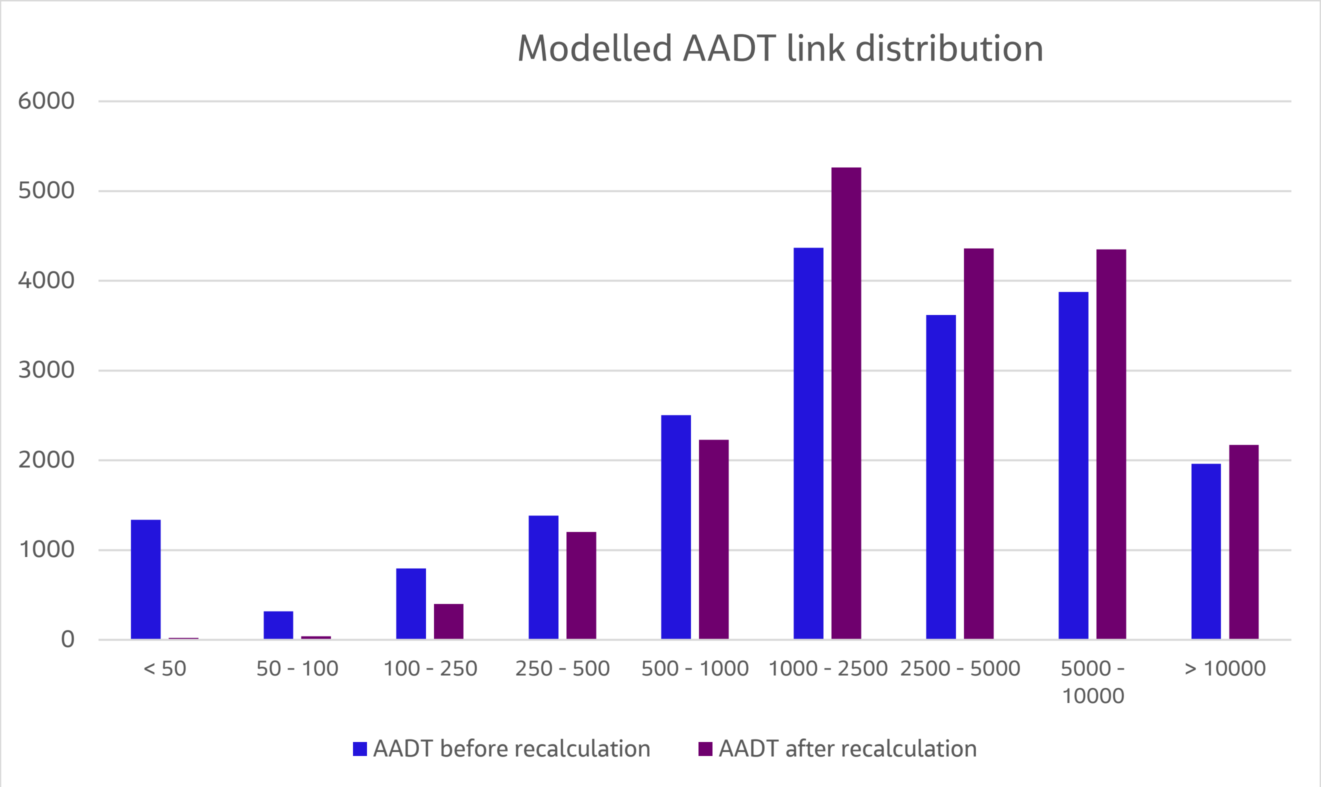


Diagram 5.11: Link Distribution Diagram Before / After on AADT Difference

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[5] 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[6]" 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.

[5] NTA RMS - TN11 Regional Model Coding Guide

[6] 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.

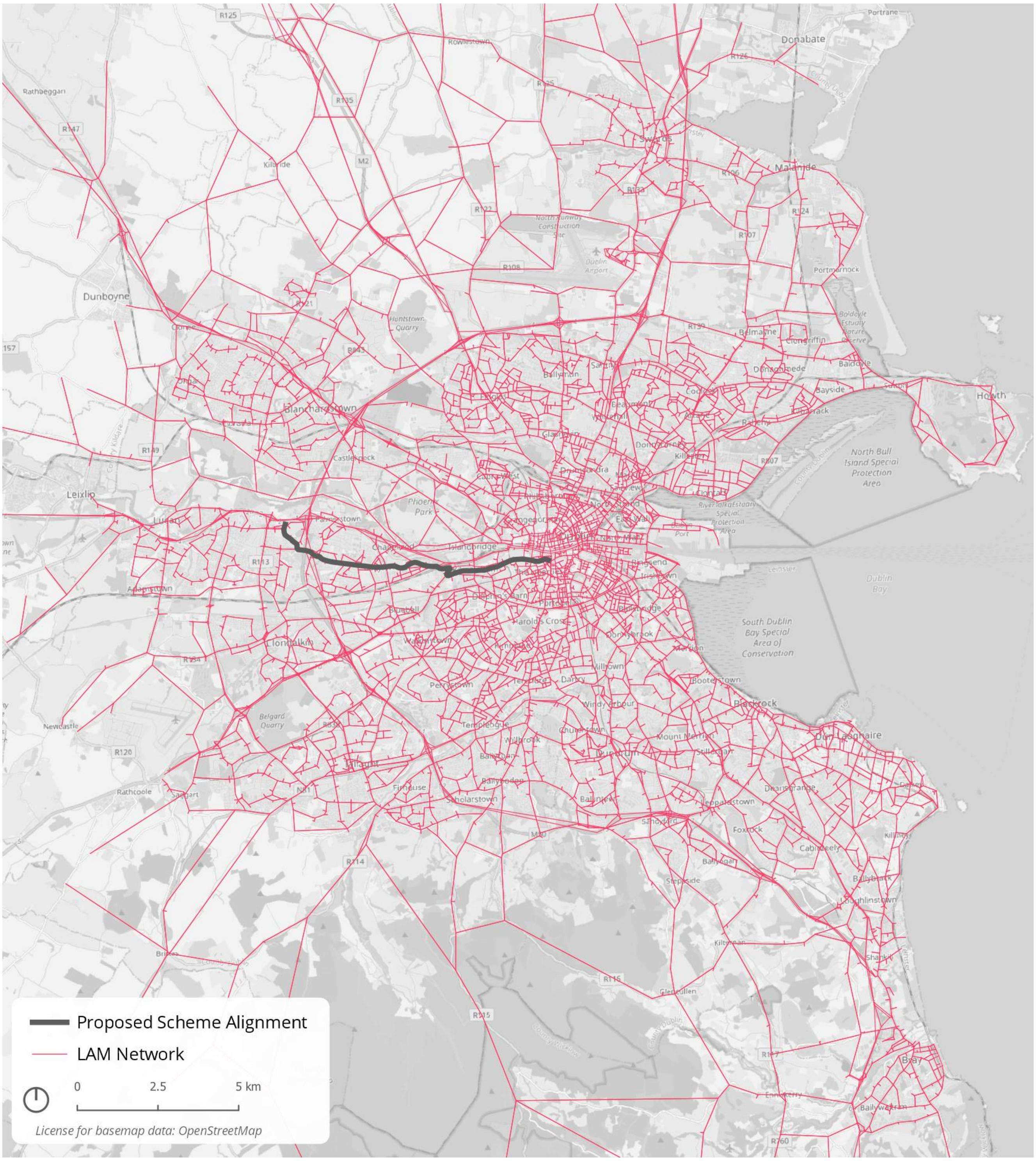


Diagram 6.1: LAM Network and Proposed Scheme Alignment

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[7] and Geo Directory[8] 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;
- **Political Geography** – it should be possible to aggregate all zones to ED level i.e. zone boundaries do not intersect ED boundaries; and

[7] 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.

[8] GeoDirectory is An Post's database of 2.2million commercial and residential property addresses

- **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 criterias 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

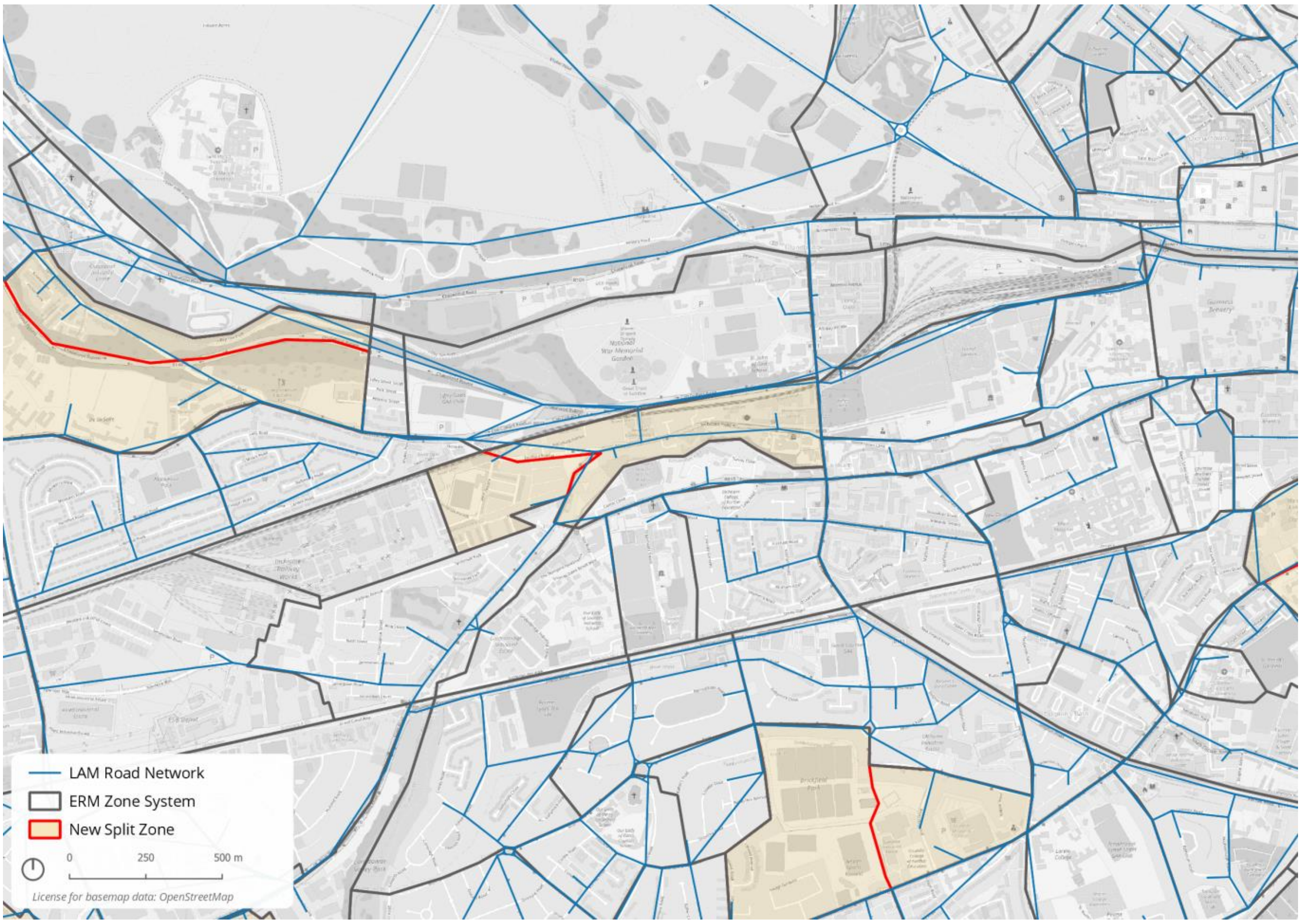


Diagram 6.4: LAM Zone System – Split Zones

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*
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.

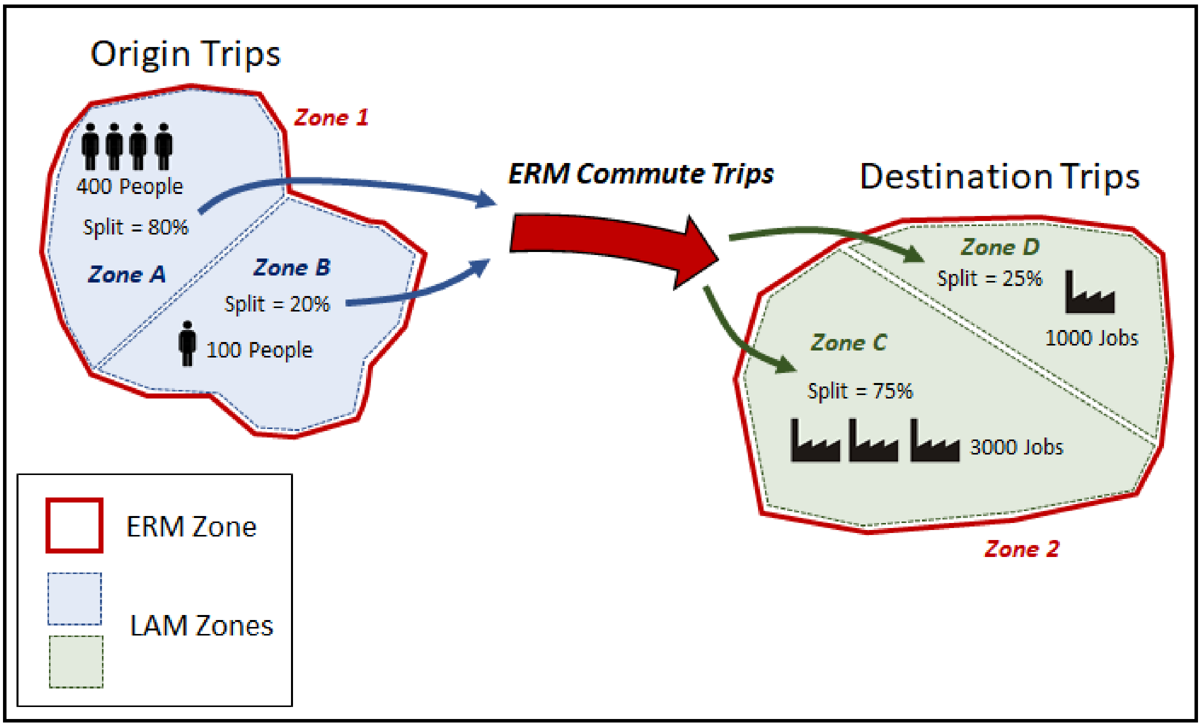


Diagram 6.5: LAM Disaggregation Example – AM Peak Commute Trips

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.

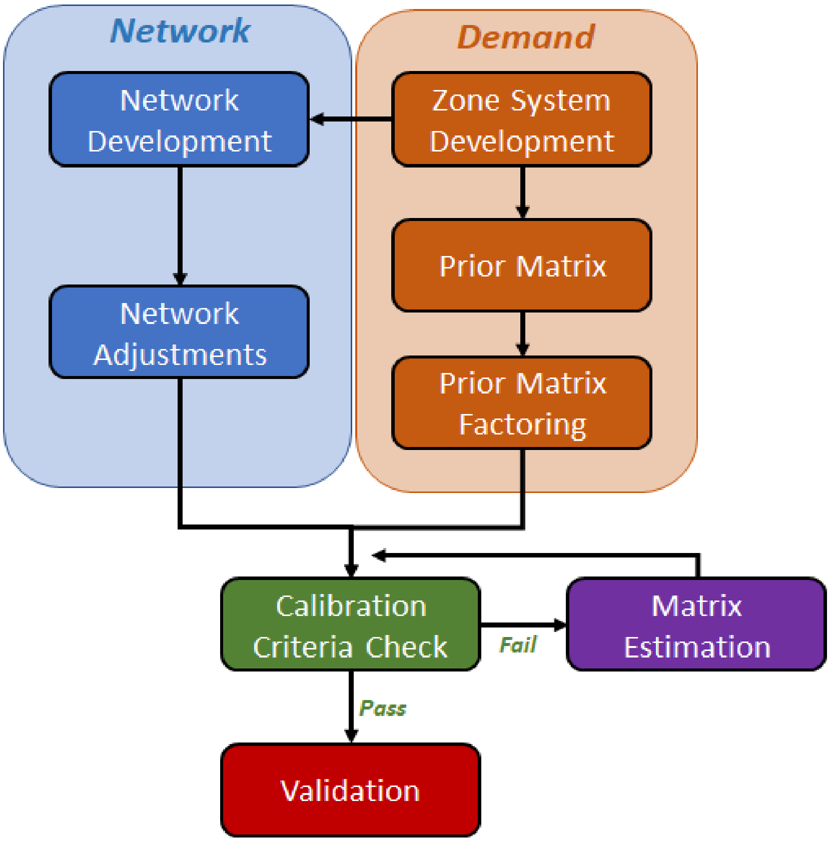


Diagram 6.6: LAM Calibration Process

6.4.2 Calibration Criteria Details

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:

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

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

6.4.2.1 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	

6.4.2.2 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 R2 values); and
- Scatter plots of zonal trip ends, prior to and post matrix estimation, with regression statistics (slopes, intercepts and R2 values).

Table 6.8: Significance of Matrix Estimation Changes

MEASURE	SIGNIFICANCE CRITERIA
Matrix zonal cell value	Slope within 0.98 and 1.02; Intercept near zero; R2 in excess of 0.95
Matrix zonal trip ends	Slope within 0.99 and 1.01; Intercept near zero; R2 in excess of 0.98.

6.4.2.3 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[9] 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:

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

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.

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

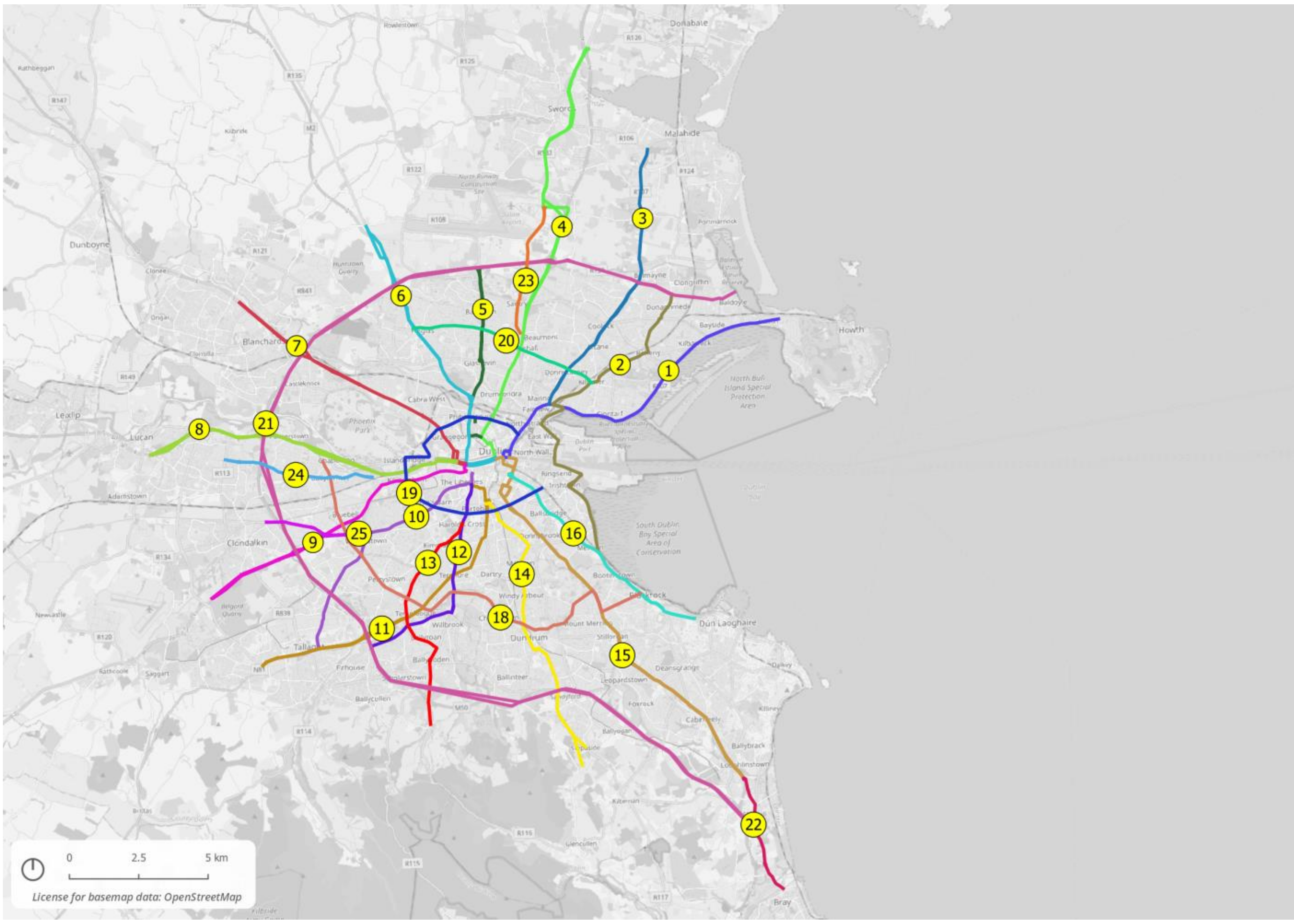


Diagram 6.8: Journey Time Validation Routes

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[10]

CRITERIA	ACCEPTABILITY GUIDELINE
Assigned hourly flows compared with observed flows	
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
Modelled journey times compared with observed times	
Times within 15% or 1 minute if higher	>85% of cases

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.

[10] Table 5.1.5 (pg 23) TII *Project Appraisal Guidelines for National Roads Unit 5.1 - Construction of Transport Models*

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 ad 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 (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.

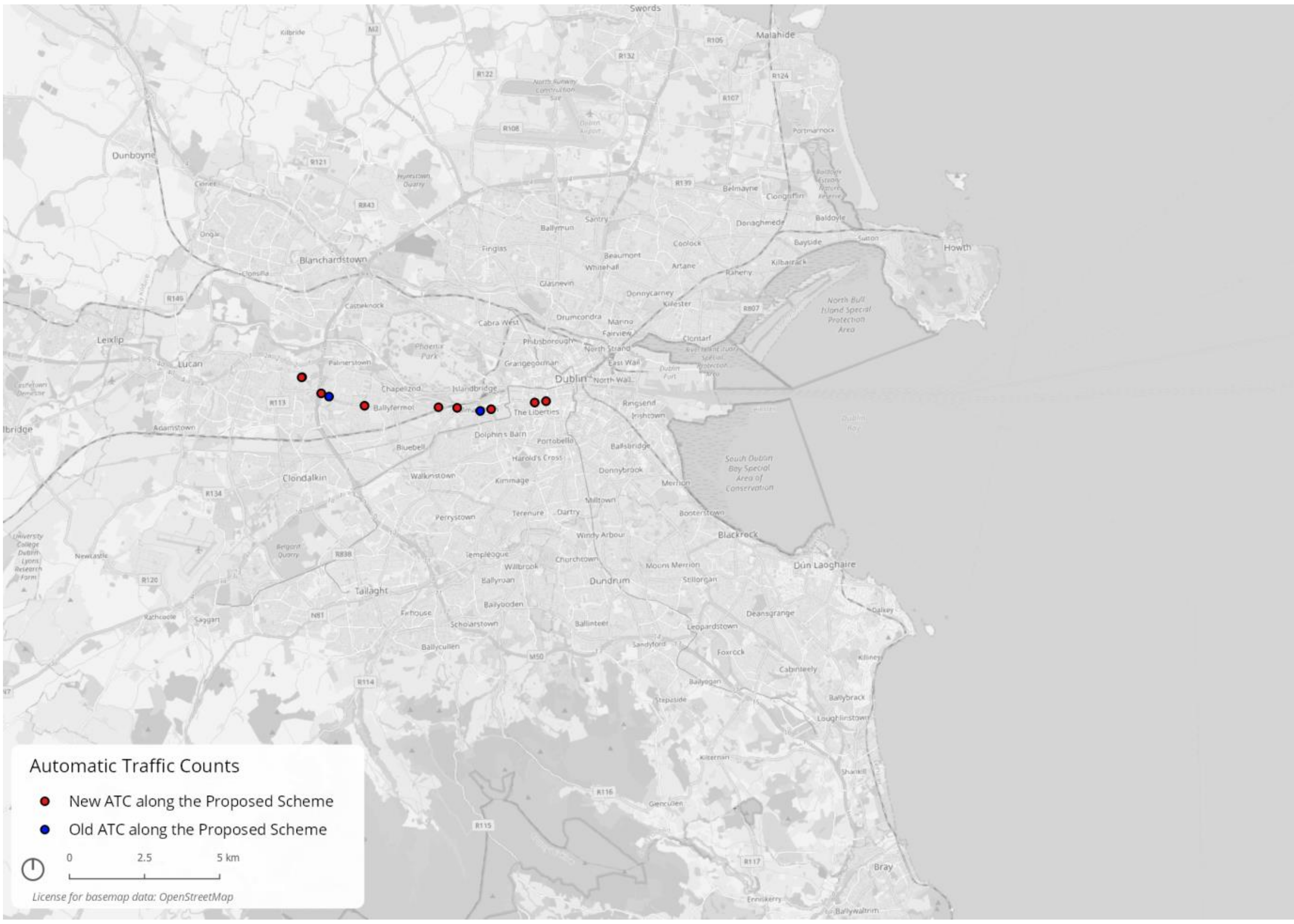


Diagram 6.9: ATC Link Counts Along Route of Proposed Scheme

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	15	87%	80%	87%	93%	93%
	Combined ATC	19	89%	84%	89%	95%	95%
LT	New ATC	15	67%	67%	67%	87%	87%
	Combined ATC	19	74%	74%	74%	89%	89%
SR	New ATC	15	73%	80%	80%	93%	93%
	Combined ATC	19	79%	84%	84%	95%	95%
PM	New ATC	15	73%	73%	80%	87%	87%
	Combined ATC	19	79%	79%	84%	89%	89%

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	15	100%	87%	100%	93%	100%
	Combined ATC	19	100%	89%	100%	95%	100%
LT	New ATC	15	100%	93%	100%	93%	100%
	Combined ATC	19	100%	95%	100%	95%	100%
SR	New ATC	15	100%	93%	100%	93%	100%
	Combined ATC	19	100%	95%	100%	95%	100%
PM	New ATC	15	100%	73%	100%	93%	100%
	Combined ATC	19	100%	79%	100%	95%	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	15	100%	87%	100%	100%	100%
	Combined ATC	19	100%	89%	100%	100%	100%
LT	New ATC	15	100%	80%	100%	100%	100%
	Combined ATC	19	100%	84%	100%	100%	100%
SR	New ATC	15	100%	87%	100%	100%	100%
	Combined ATC	19	100%	89%	100%	100%	100%
PM	New ATC	15	100%	87%	100%	100%	100%
	Combined ATC	19	100%	89%	100%	100%	100%

The above tables highlight that the model shows a good performance at a link count level when compared to TII/TAG guidance targets. Results for cars in the morning (AM) peak model exceeds the recommended target of 85% of links meeting the recommended guidance for both the new ATC's and all links combined. The lunchtime (LT), school run (SR) and evening (PM) periods fall below guidance with ATC's at 67% for LT, 80% for SR and 80% for PM. The results for all links combined are slightly better with 74% for LT, 84% for SR and 84% 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 196 turns across 54 junctions, the location of which are displayed below in Diagram 6.10.

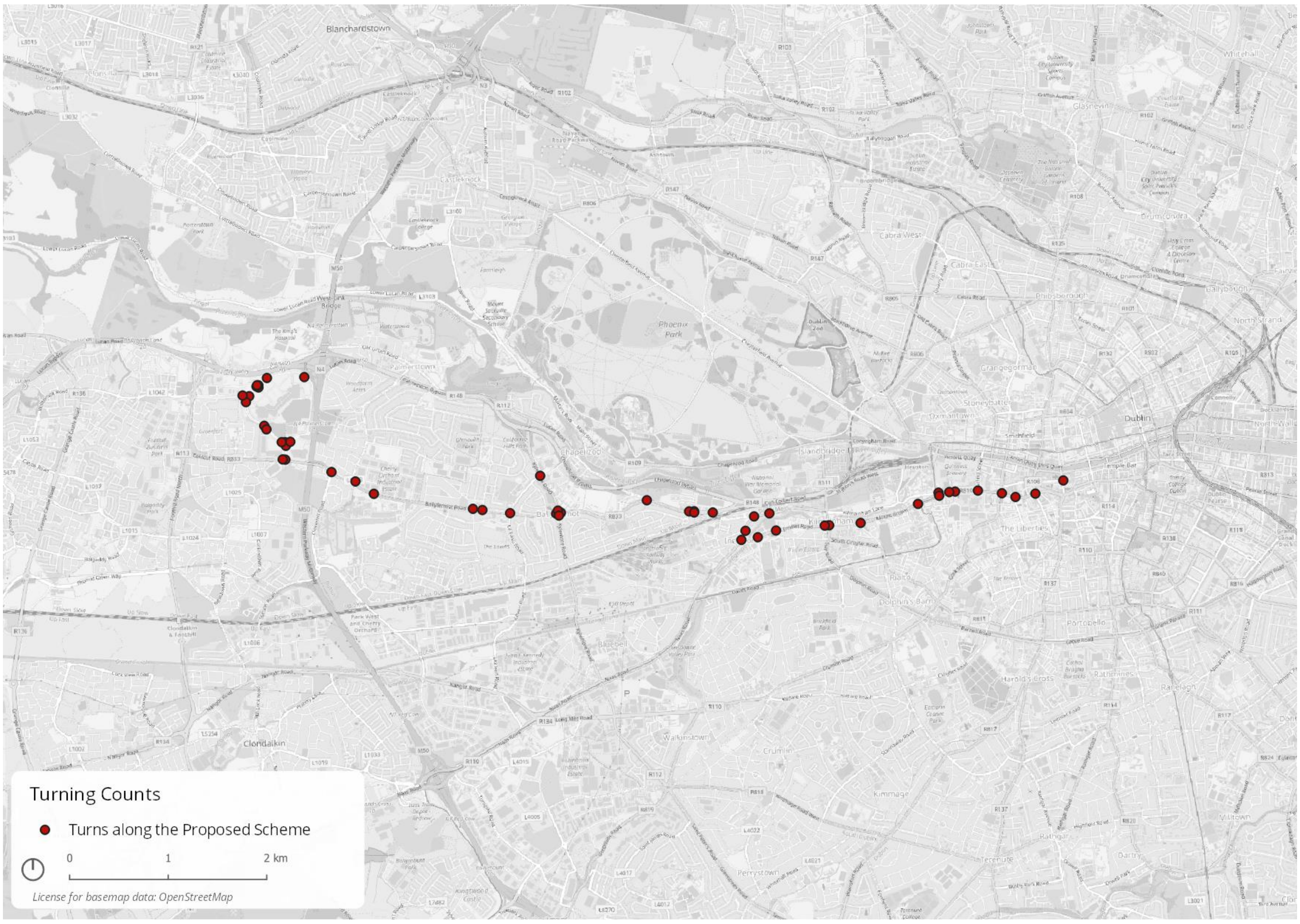


Diagram 6.10: Turning Counts Along Route of Proposed Scheme

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	196	89%	71%	90%	89%	90%
LT	196	87%	68%	87%	85%	87%
SR	196	83%	63%	83%	81%	85%
PM	196	73%	59%	74%	78%	76%

The above table shows a generally good fit along the Proposed Scheme, with the AM and LT models meeting the required TII/TAG guidance for absolute/percentage difference and the SR and PM peaks being 83% and 73% respectively. 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 all above 85%, except for the PM Peak at 76%, 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	196	98%	90%	98%	98%	80%
LT	196	98%	89%	98%	98%	85%
SR	196	98%	88%	98%	98%	79%
PM	196	98%	89%	98%	98%	73%

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	196	98%	97%	98%	98%	77%
LT	196	98%	96%	98%	98%	70%
SR	196	98%	97%	98%	98%	66%
PM	196	98%	98%	98%	98%	64%

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 routes 9 and 24 which relate best to the Proposed Scheme.

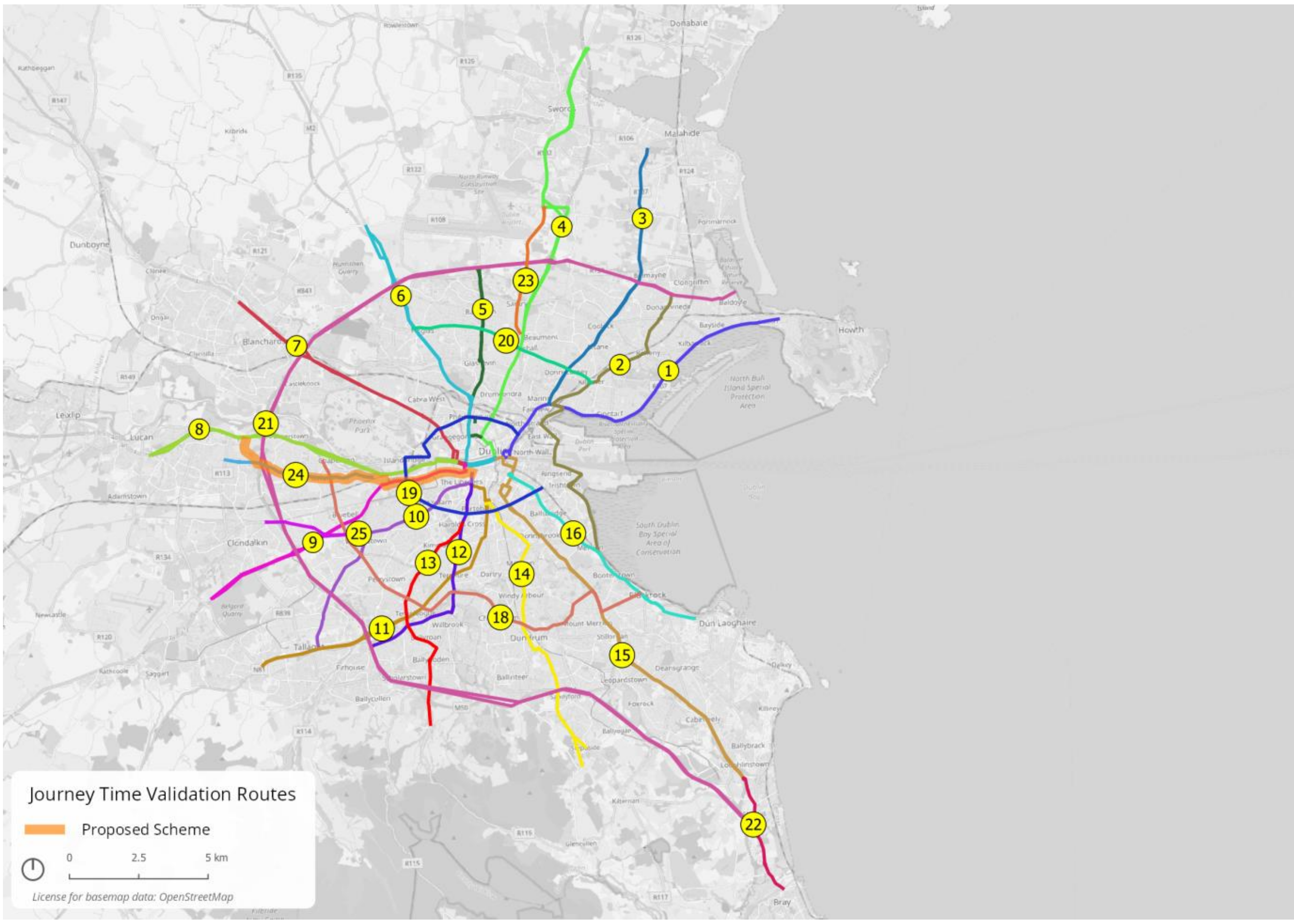


Diagram 6.11: LAM Journey Time Validation Routes

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 routes are 9 and 24 and the graphs for these are shown below for the AM peak period.

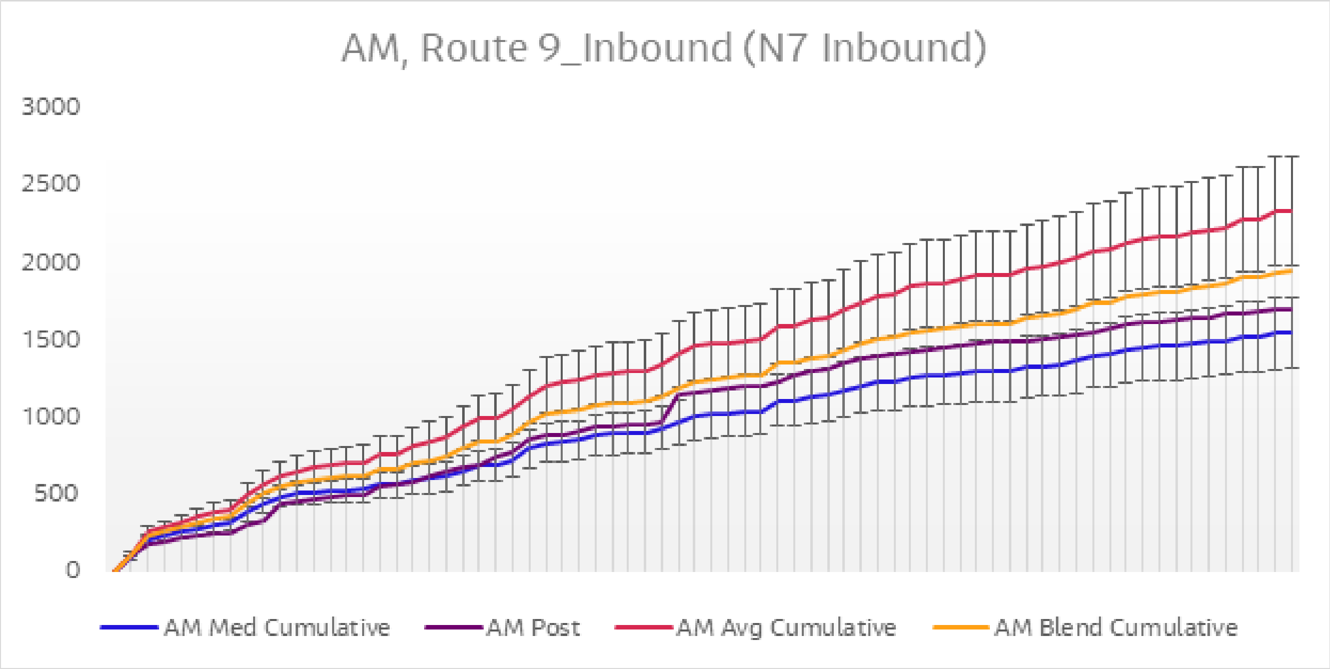


Diagram 6.12: Journey Time Validation Plot – Route 9 Inbound AM

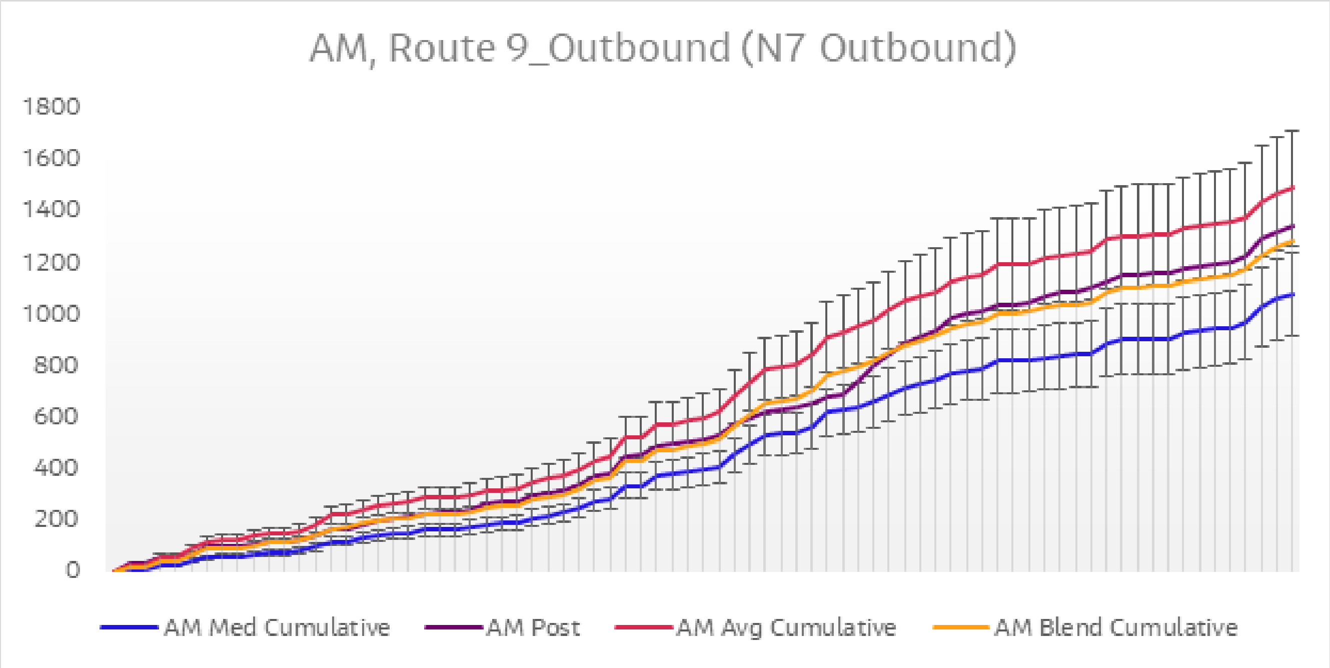


Diagram 6.13: Journey Time Validation Plot - Route 9 Outbound AM

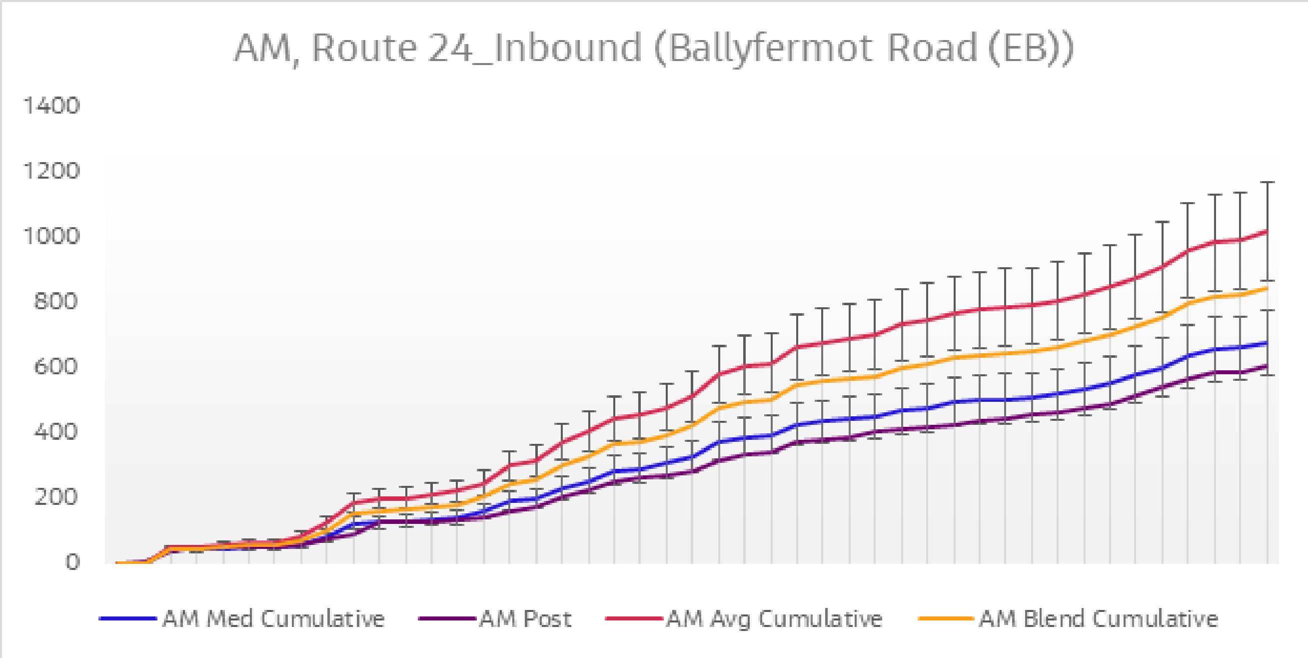


Diagram 6.14: Journey Time Validation Plot - Route 24 Inbound AM

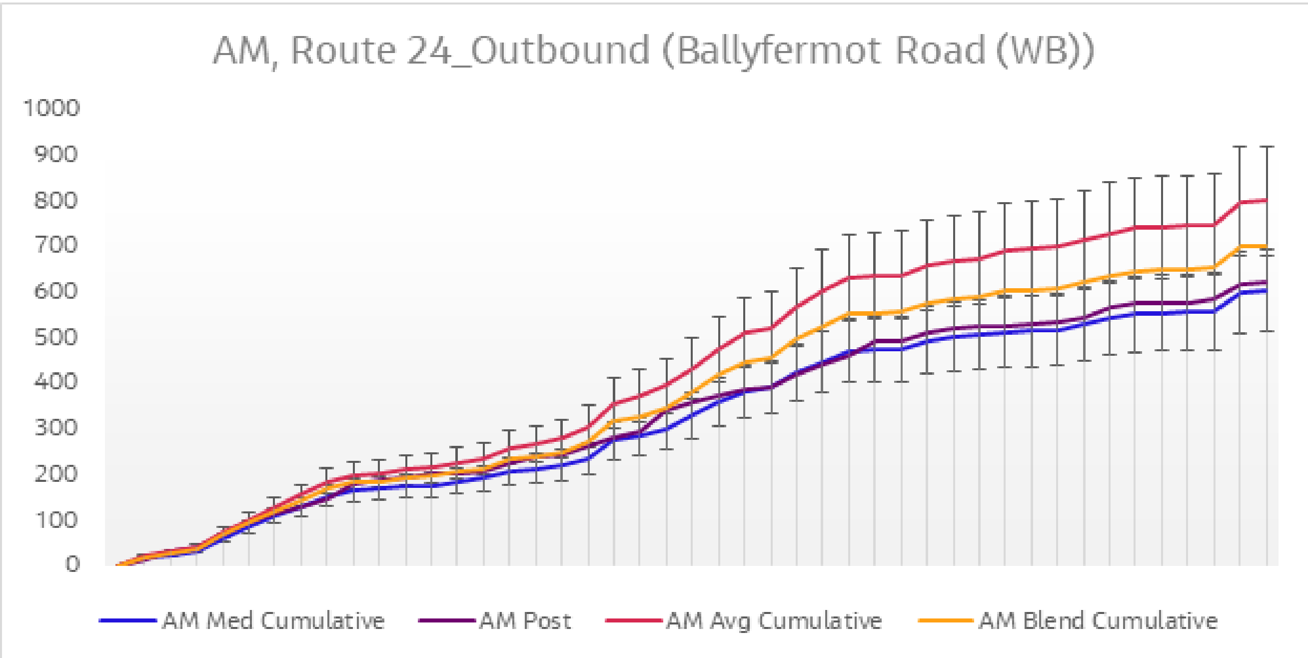


Diagram 6.15: Journey Time Validation Plot - Route 24 Outbound AM

The above Diagrams show a good match between the 50/50 blend of the median and mean observed times and the modelled times, with the cumulative profile matching very closely. For JT Route 9 the modelled time meets the 15% guidance in both directions. For route 24, the outbound movement meets the 15% guidance compared to the 50/50 blend whereas the inbound is slightly fast at 29%.

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 routes are 9 and 24 and the graphs for these are shown below for the LT period.

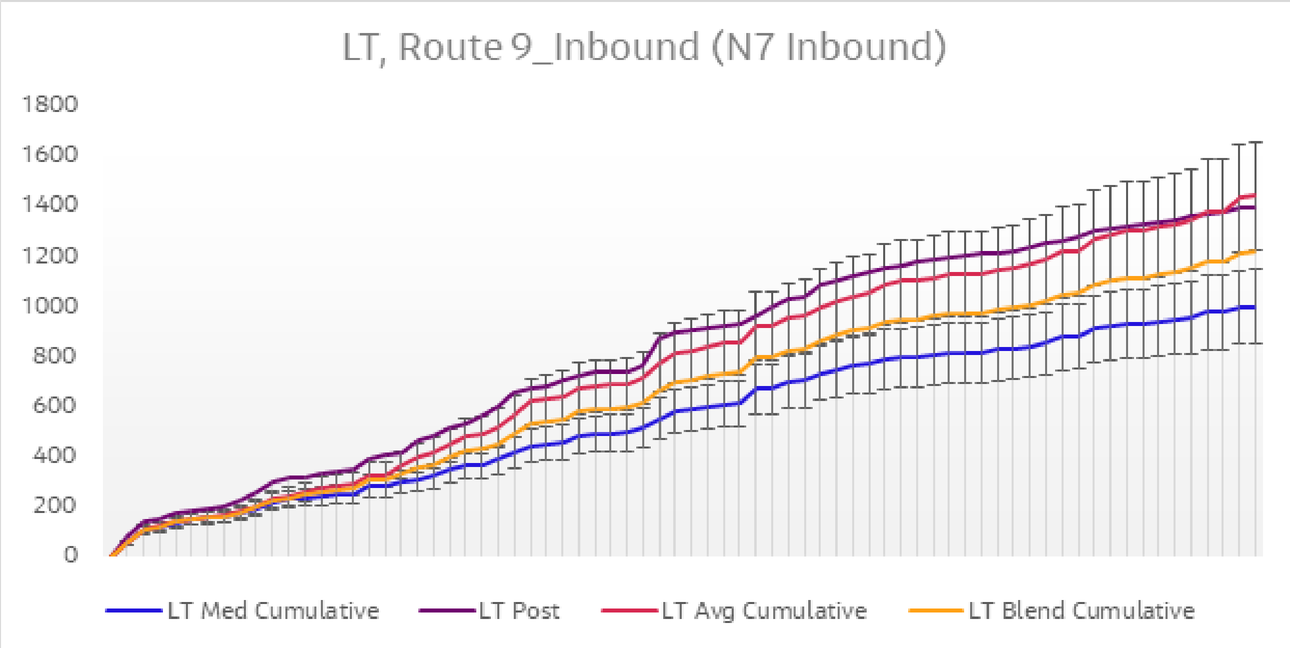


Diagram 6.16: Journey Time Validation Plot - Route 9 Inbound LT

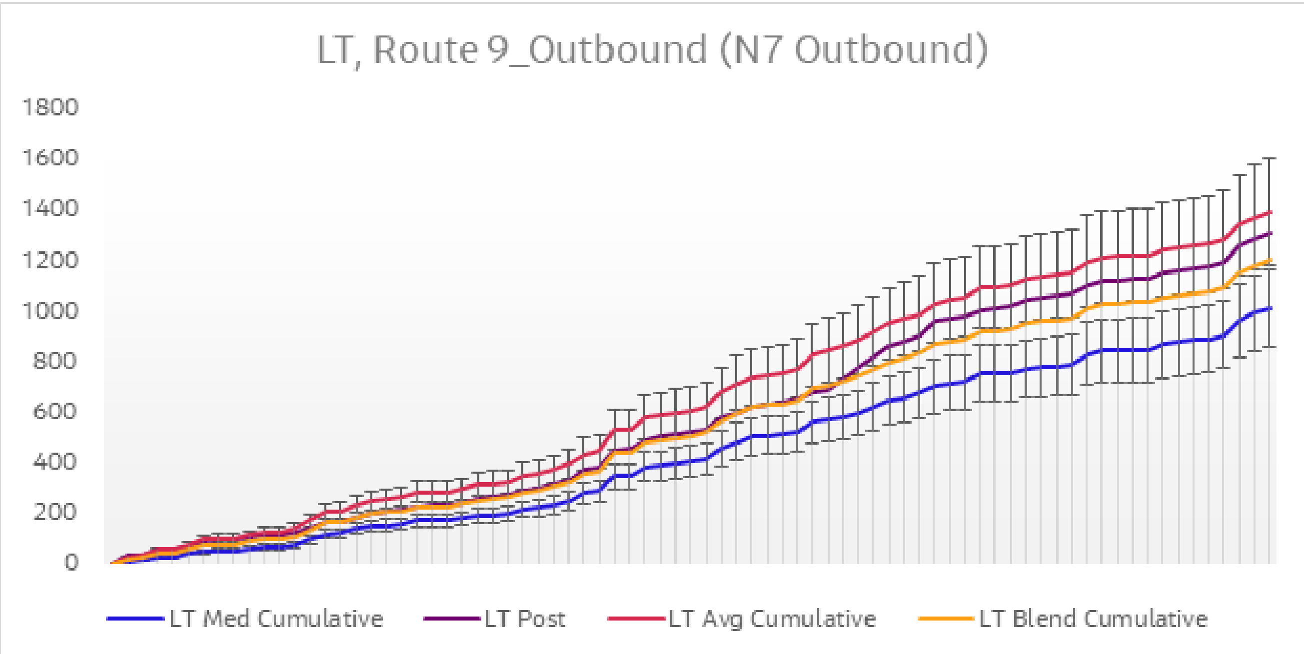


Diagram 6.17: Journey Time Validation Plot - Route 9 Outbound LT

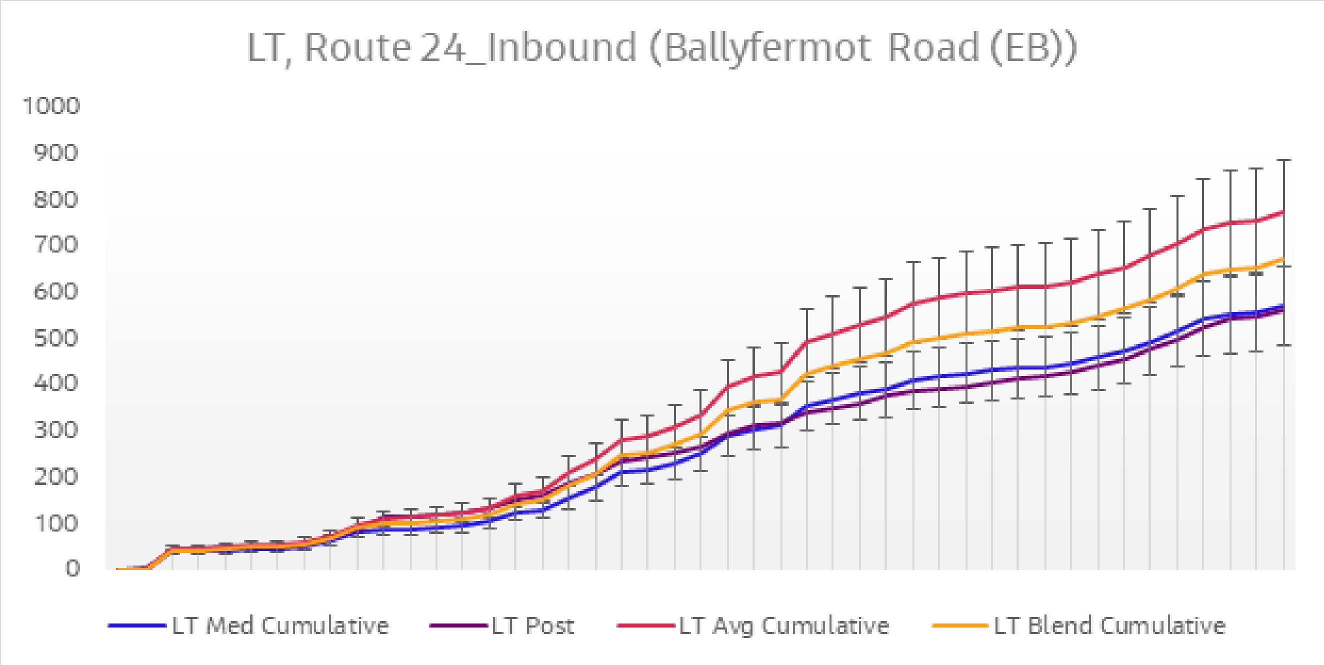


Diagram 6.18: Journey Time Validation Plot - Route 24 Inbound LT

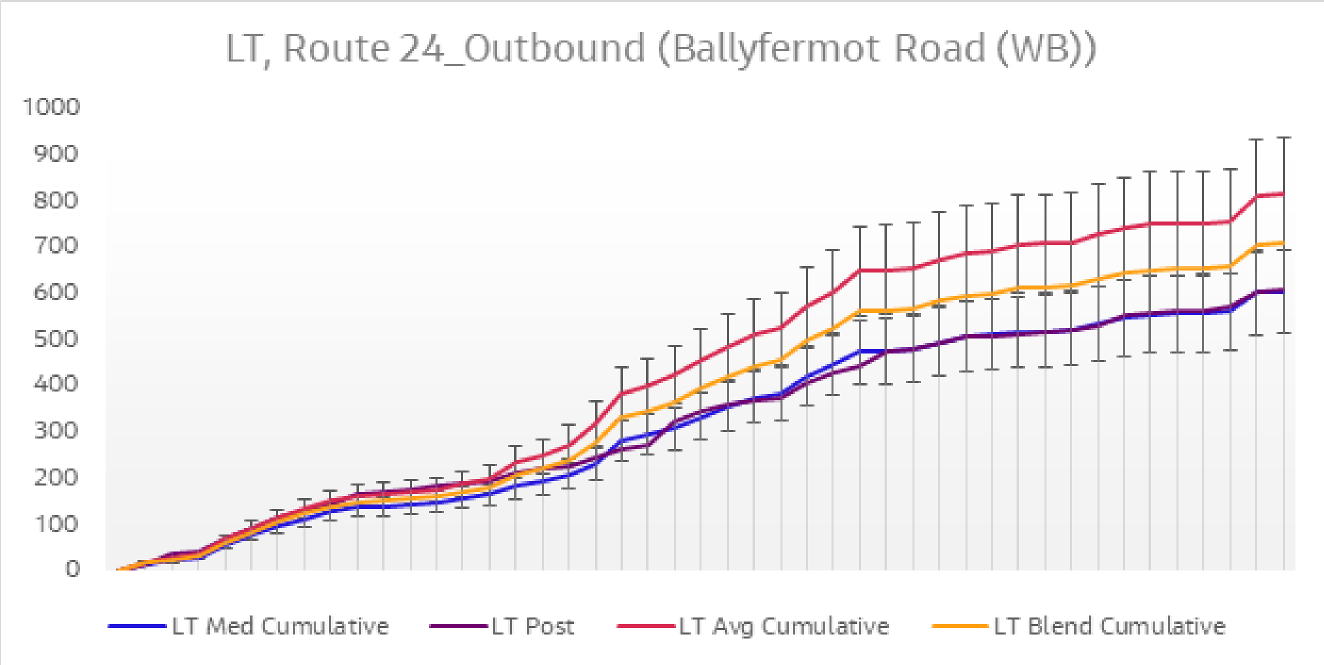


Diagram 6.19: Journey Time Validation Plot - Route 24 Outbound LT

The above Diagrams show a good match between the 50/50 blend of the median and mean observed times and the modelled times in the LT time period, with the cumulative profile matching very closely. For JT Route 9 the modelled time meets the 15% guidance in both directions. For route 24, the outbound movement meets the 15% guidance compared to the 50/50 blend whereas the inbound is slightly fast at 17%.

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 routes are 9 and 24 and the graphs for these are shown below for the SR period.

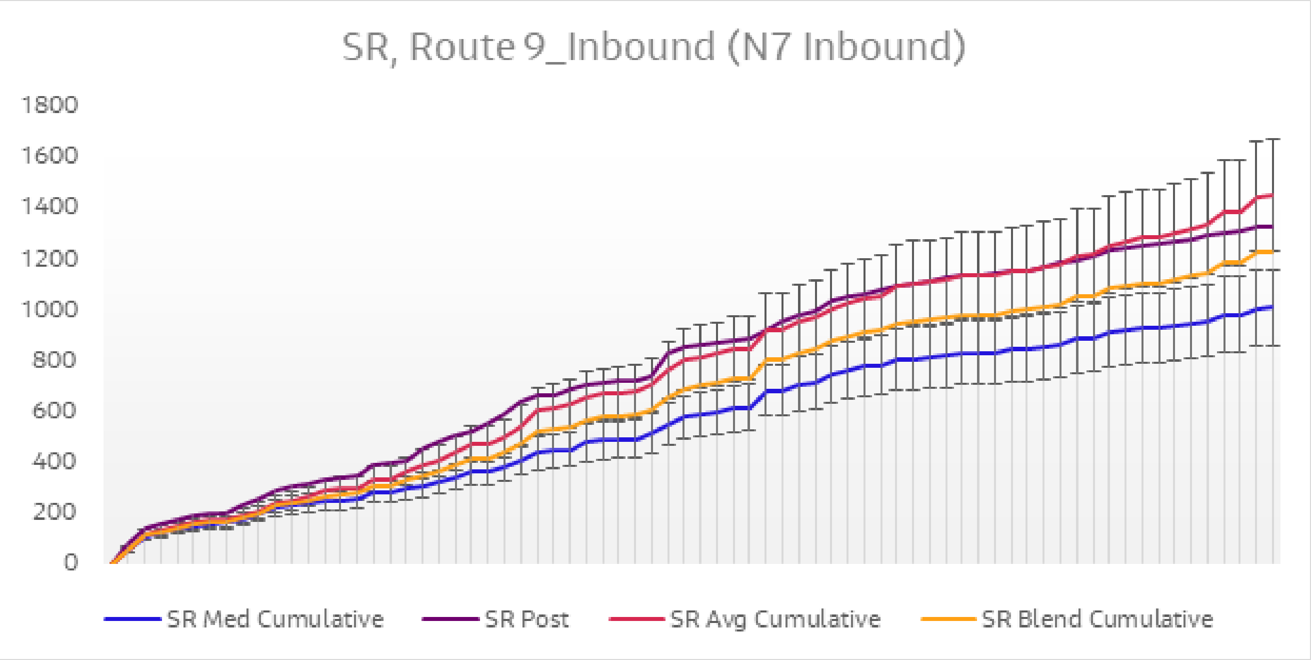


Diagram 6.20: Journey Time Validation Plot - Route 9 Inbound SR

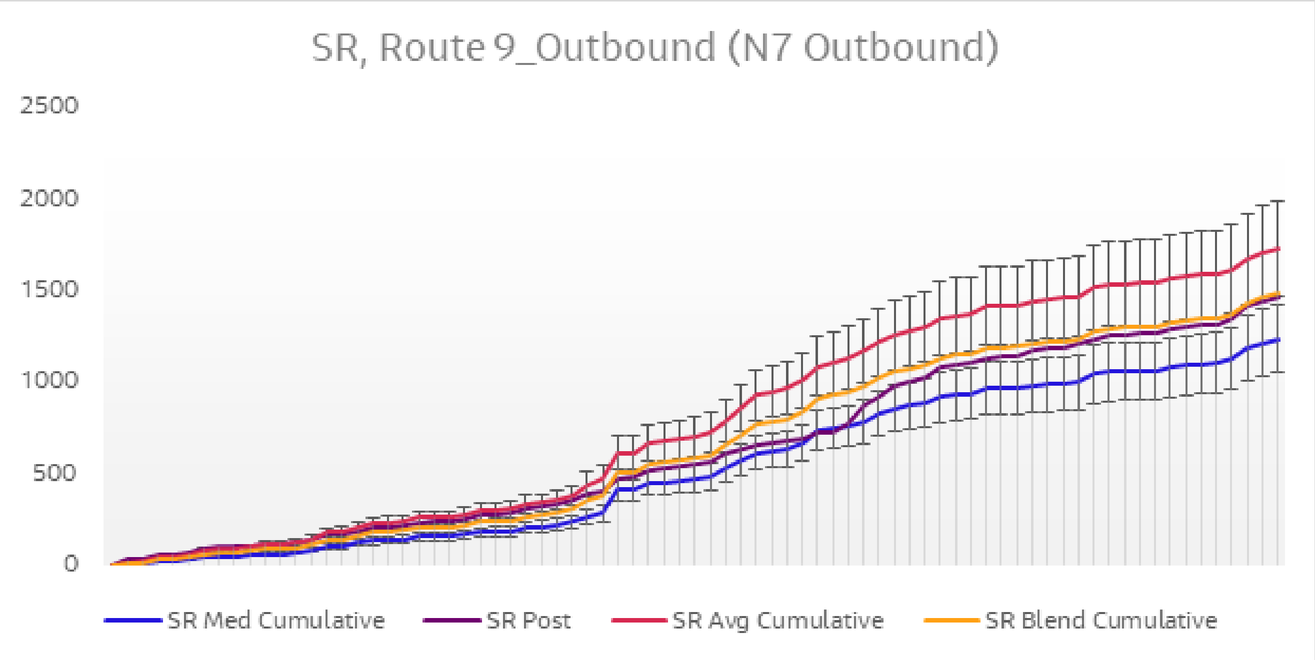


Diagram 6.21: Journey Time Validation Plot - Route 9 Outbound SR

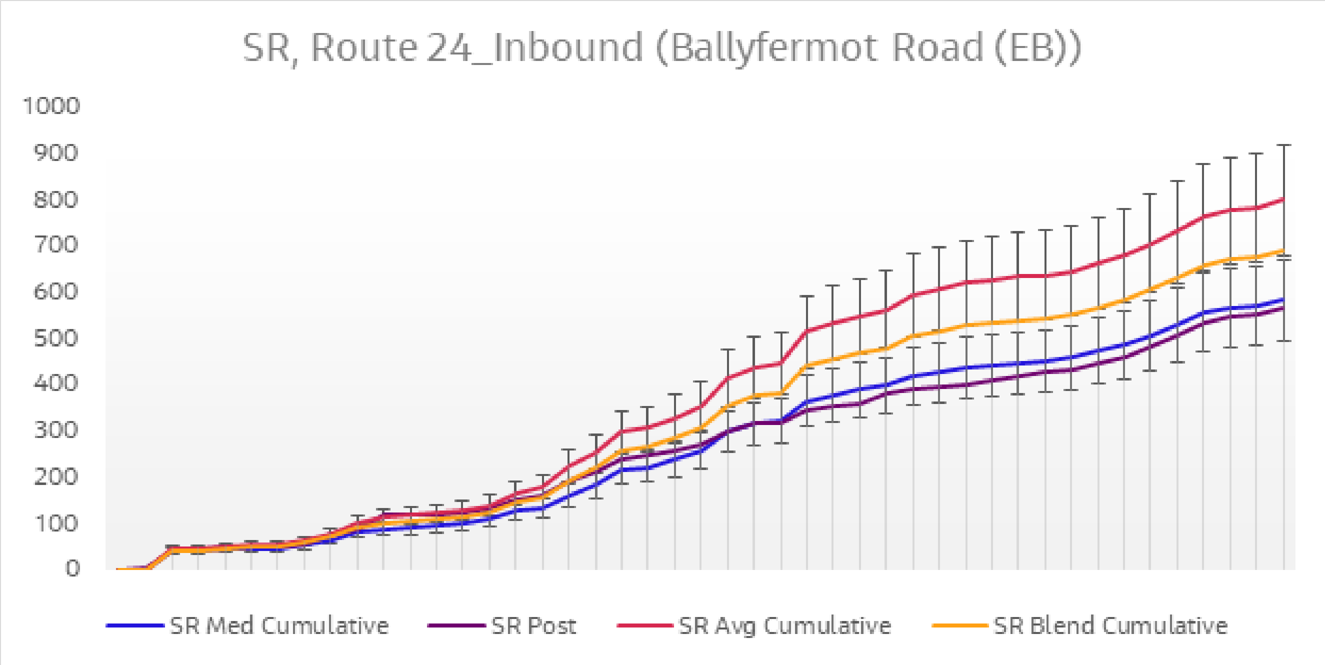


Diagram 6.22: Journey Time Validation Plot - Route 24 Inbound SR

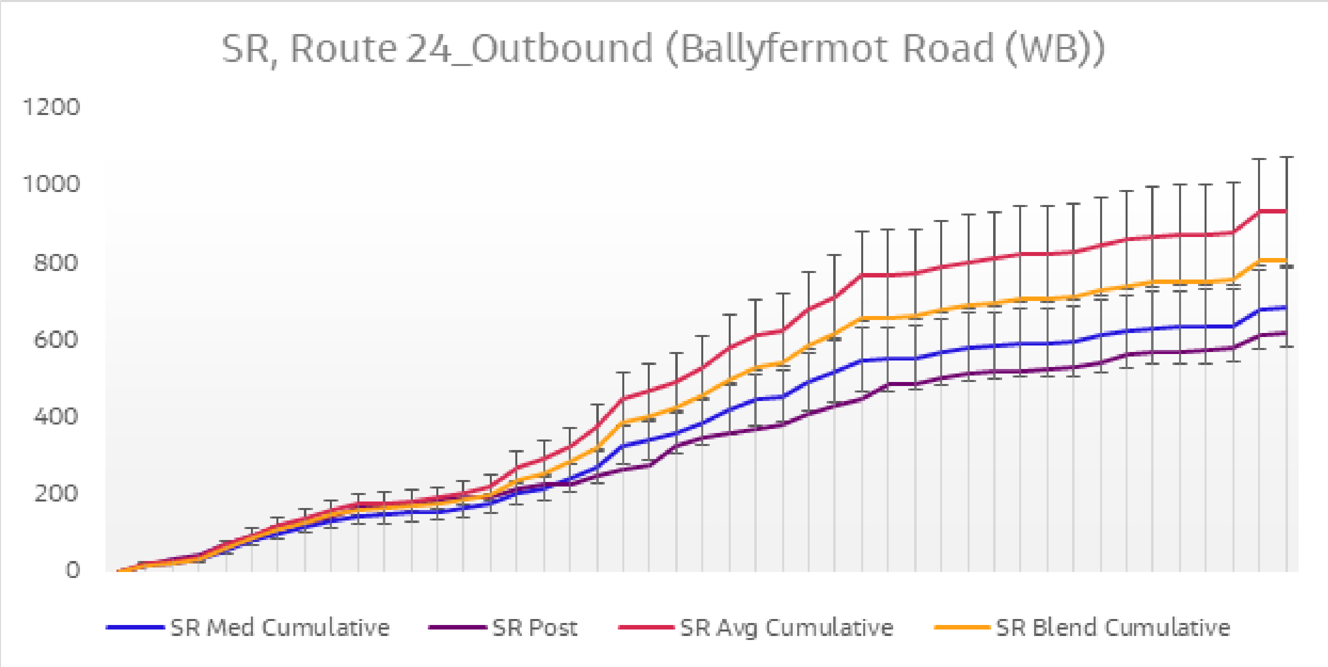


Diagram 6.23: Journey Time Validation Plot - Route 24 Outbound SR

Within the SR period the results show a good match between the cumulative profile of the 50/50 blend of the median and mean observed times and the modelled times. For JT Route 9 the modelled time again meets the 15% guidance in both directions. For route 24, both directions are slightly fast, falling just outside guidance with 18% for the inbound and 24% for the outbound.

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 routes are 9 and 24 and the graphs for these are shown below for the PM peak period.

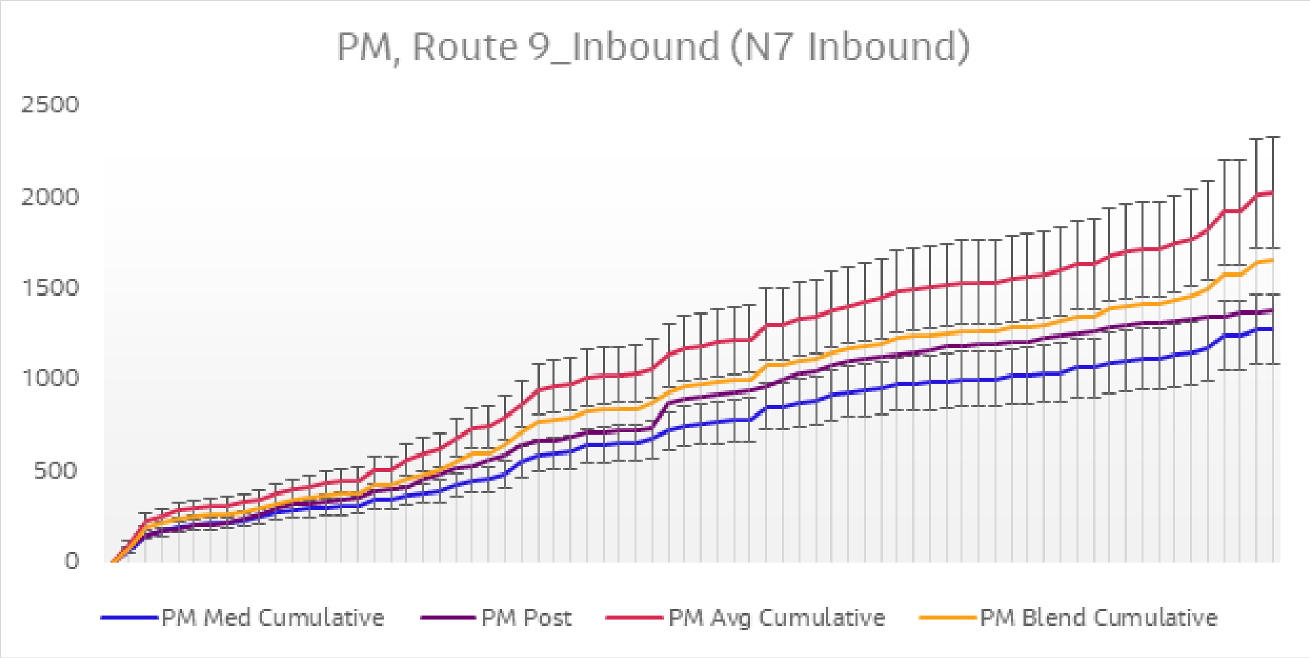


Diagram 6.24: Journey Time Validation Plot - Route 9 Inbound PM

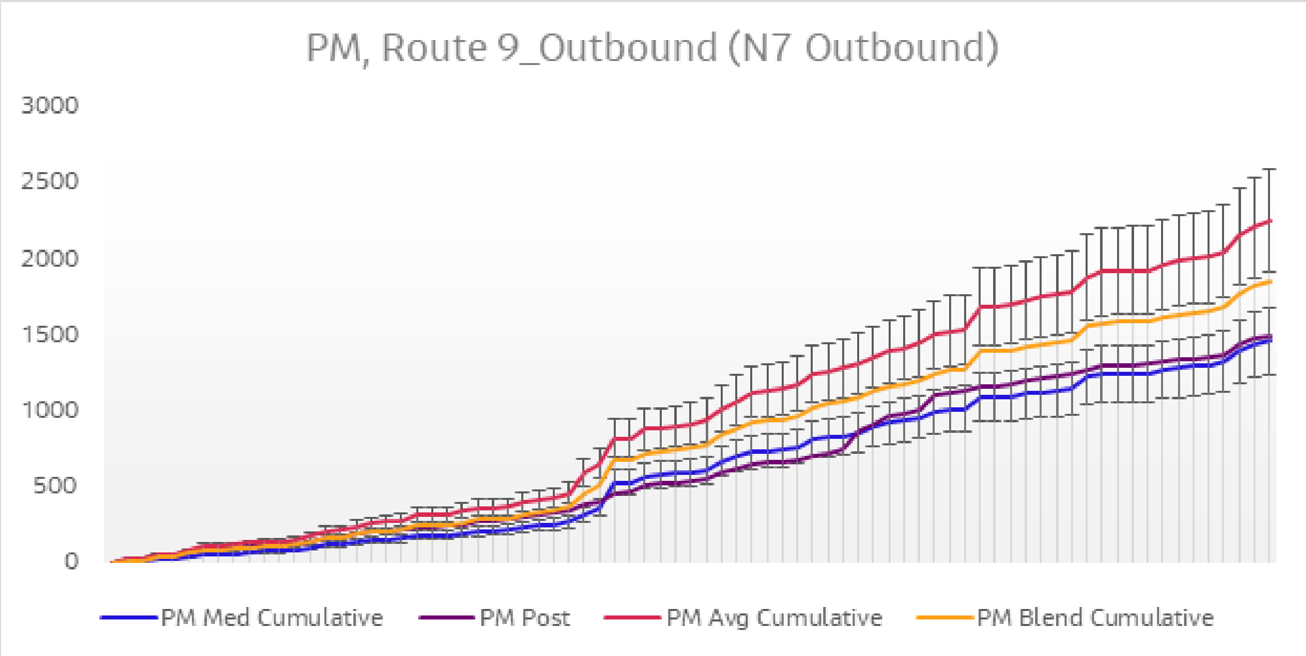


Diagram 6.25: Journey Time Validation Plot - Route 9 Outbound PM

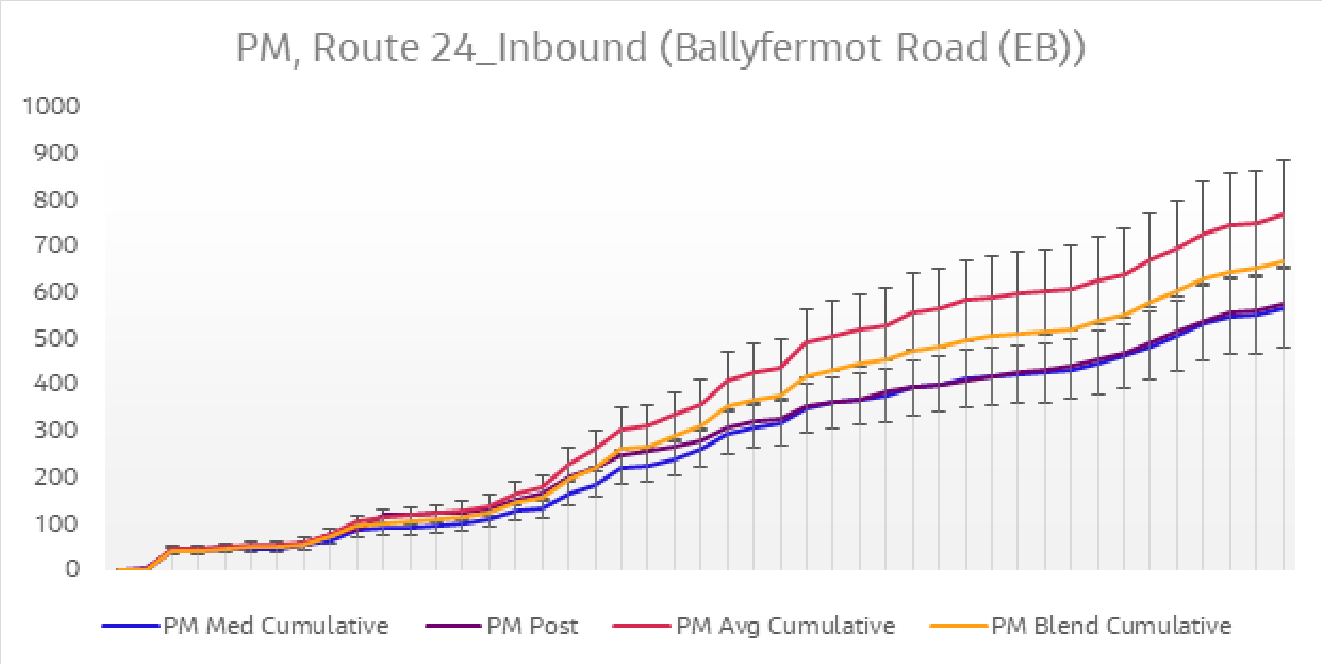


Diagram 6.26: Journey Time Validation Plot - Route 24 Inbound PM

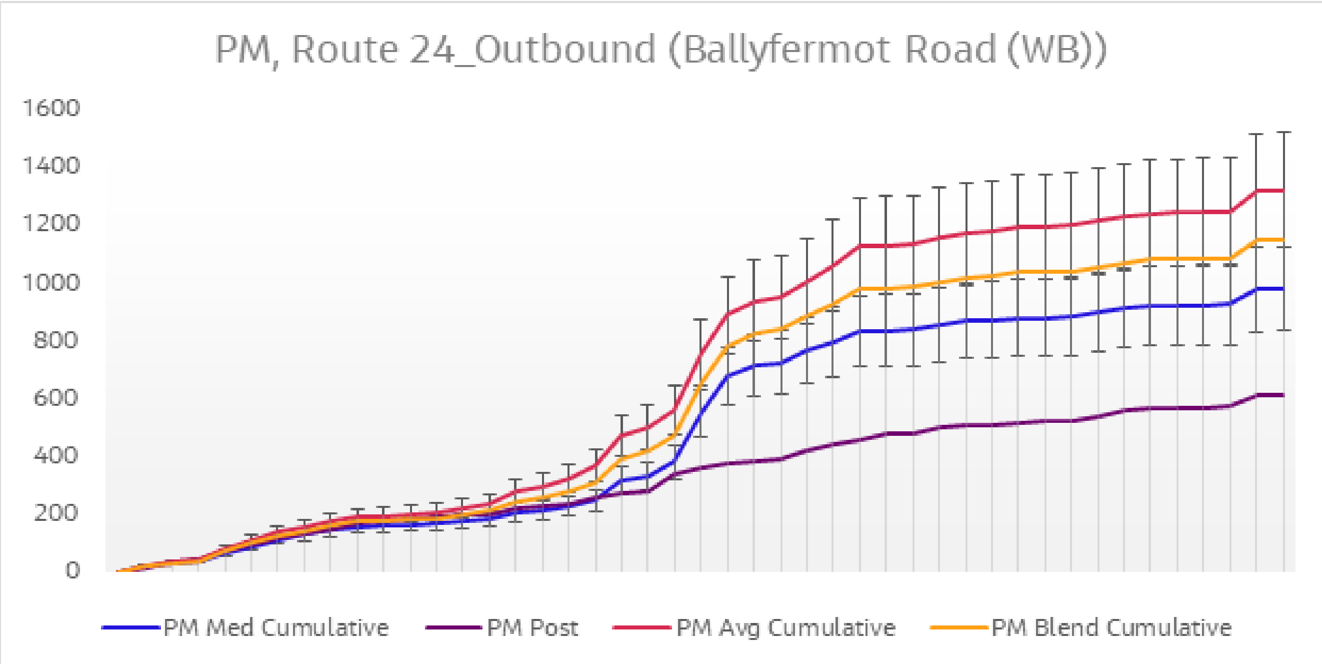


Diagram 6.27: Journey Time Validation Plot - Route 24 Outbound PM

Within the PM period, the modelled times generally match very closely with the median of the observed journey times for routes 9 and 24, meeting the 15% guidance for all directions except JT Route 24 outbound. In this time period there is a large ‘jump’ in the observed profile which was difficult to capture within the model where this did not occur in the AM, LT or SR periods. When compared against 50/50 blend of the mean and median observed journey times the model does not perform quite as well, only meeting guidance for route 24 in the inbound direction and falling outside guidance in the routes with 17% for route 9 inbound, 19% for route 9 outbound and 47% for the route 24 outbound.

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

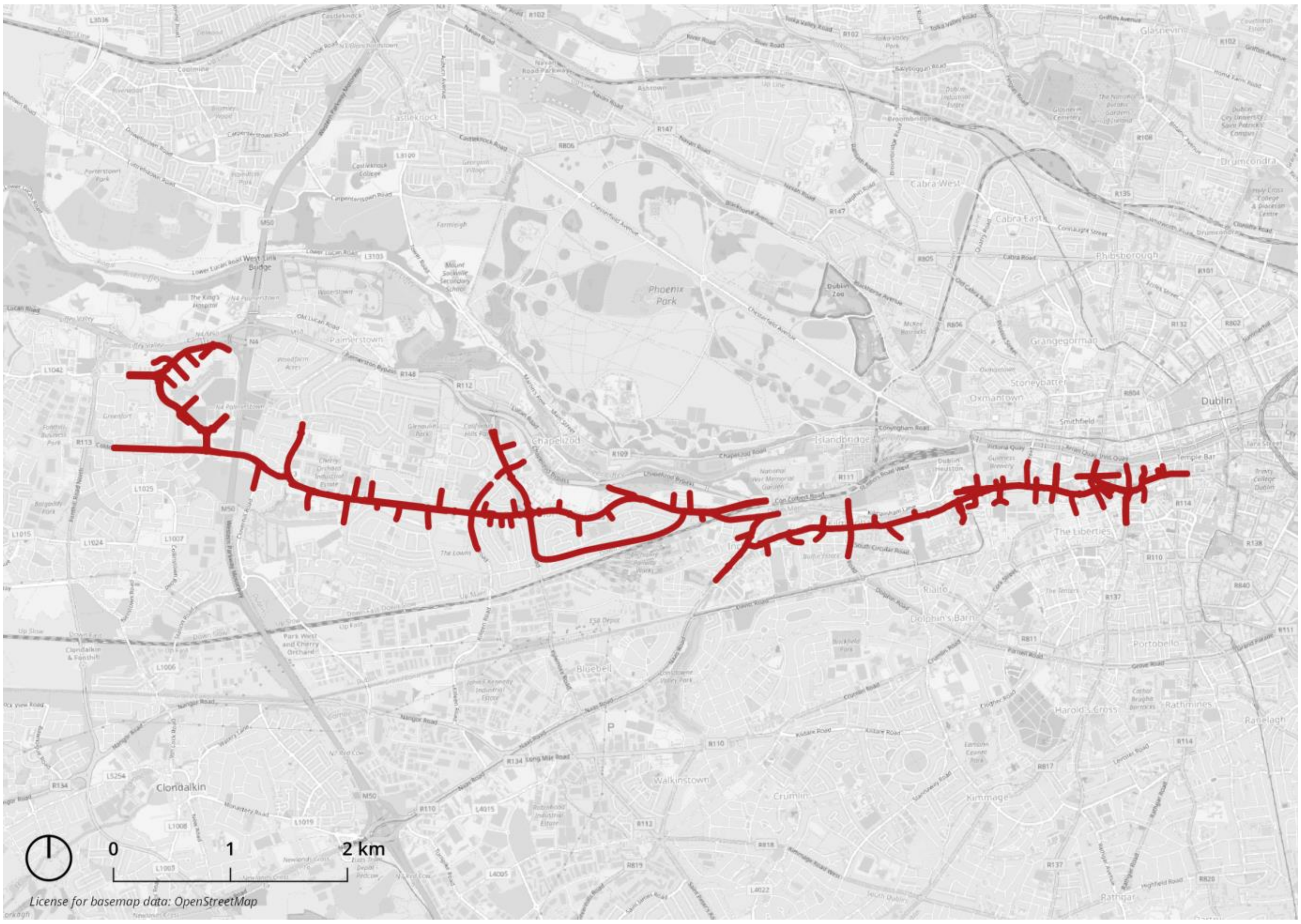


Diagram 7.1: Proposed Scheme Microsimulation Model Network

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 behaviours 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	• 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.
Medium	• For buses arriving out of stage, truncate all non-priority stages to their minimum values. • Offer compensation green to all truncated phases during following cycle. • Offer phase extensions as per low priority.
High	• For buses arriving out of stage, truncate all non-priority phases to their minimum values and immediately insert bus priority stage. • Offer compensation green as per ‘medium’ priority. • Offer phase extensions as per ‘low’ priority.

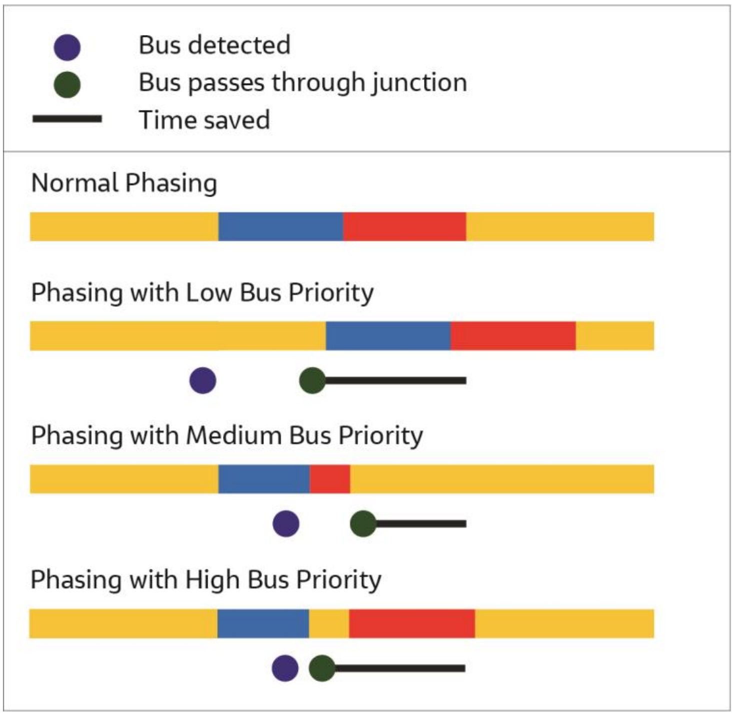


Diagram 7.2: Principles for High, Medium and Low Bus Priority

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[11] 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[12] (NDP) 2018-2027.

[11] https://www.nationaltransport.ie/planning-and-investment/strategic-planning/greater-dublin-area-transport-strategy/
[12] 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**
Heavy Rail Infrastructure					
HR1	DART+ Programme (non-tunnel elements) including additional stations at Cabra, Pelletstown, Woodbrook, Kylemore and Glasnevin	✓	✓	✓	✓
HR2	DART+ Tunnel Element (Kildare Line to Northern Line)	X	X	✓	✓
Light Rail Infrastructure					
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
BusConnects					
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
Park and Ride					
PR1	Rail and Bus based P&R provision (partial implementation by 2028)	✓	✓	✓	✓
Cycling					
CY1	Greater Dublin Area Cycle Network Plan (excluding Radial Core Bus Corridor elements)	✓	✓	✓	✓

GDA Strategy / NDP Schemes		2028		2043	
Scheme Reference	**Description**	**DoMin**	**DoSom**	**DoMin**	**DoSom**
CY2	Greater Dublin Area Cycle Network Plan (including Radial Core Bus Corridor elements)	X	✓	X	✓
National Roads					
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	✓	✓	✓	✓
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	✓	✓
Regional and Local Roads					
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	✓	✓	✓	✓
Demand Management					
DM1	Dublin City Centre Parking Constraint	✓	✓	✓	✓
DM2a	M50 Demand Management Measures - Variable Speed Limits	✓	✓	✓	✓
DM2b	M50 Demand Management Measures - Multi-point tolling	X	X	✓	✓
DM3	Implement demand management measures to address congestion issues on the radial national routes approaching the M50 motorway	X	X	✓	✓

GDA Strategy / NDP Schemes		2028		2043	
Scheme Reference	Description	DoMin	DoSom	DoMin	DoSom
DM4	Further demand management measures that ensure that a maximum 45% car commuter mode share is achieved. (* 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.

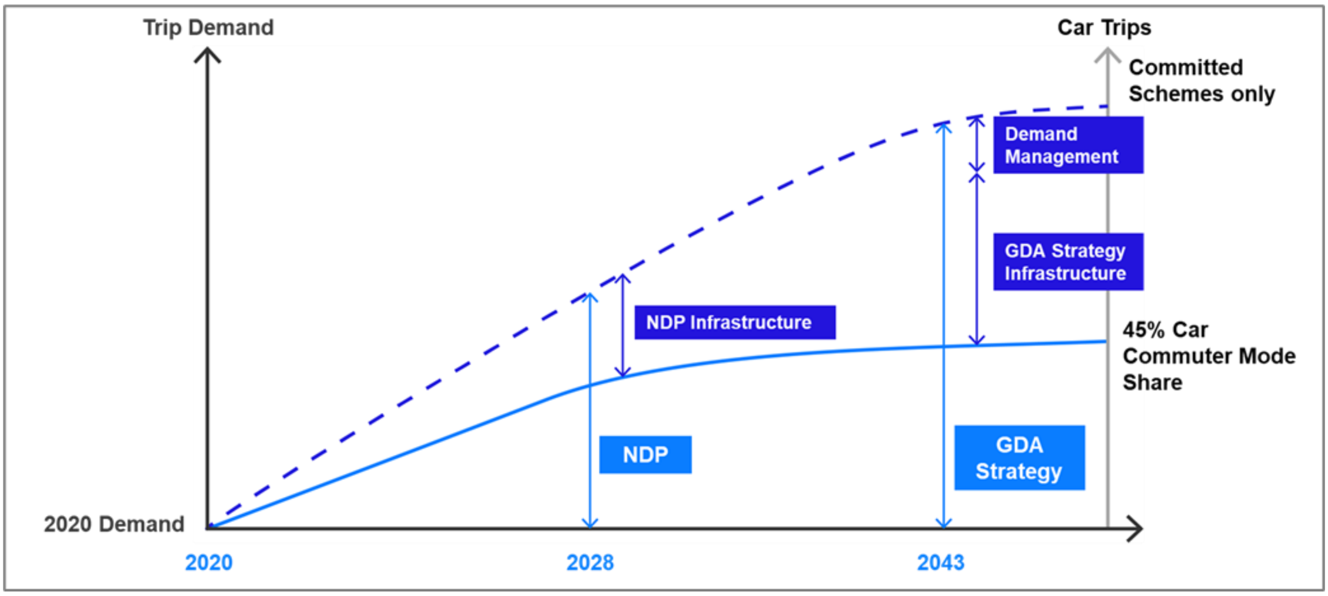


Diagram 8.1: Trip Demand Growth and the GDA Strategy

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.

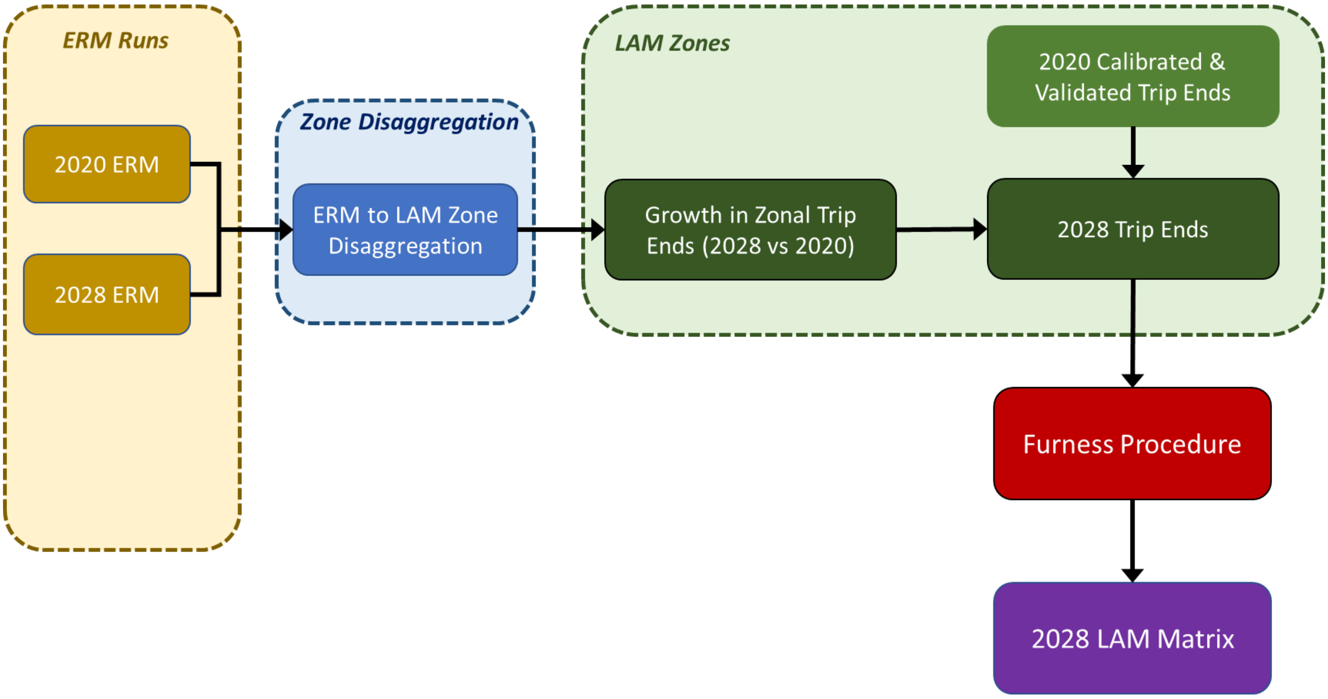


Diagram 8.2: LAM Forecast Matrix Development Process

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[13] 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 Diagram A.1.

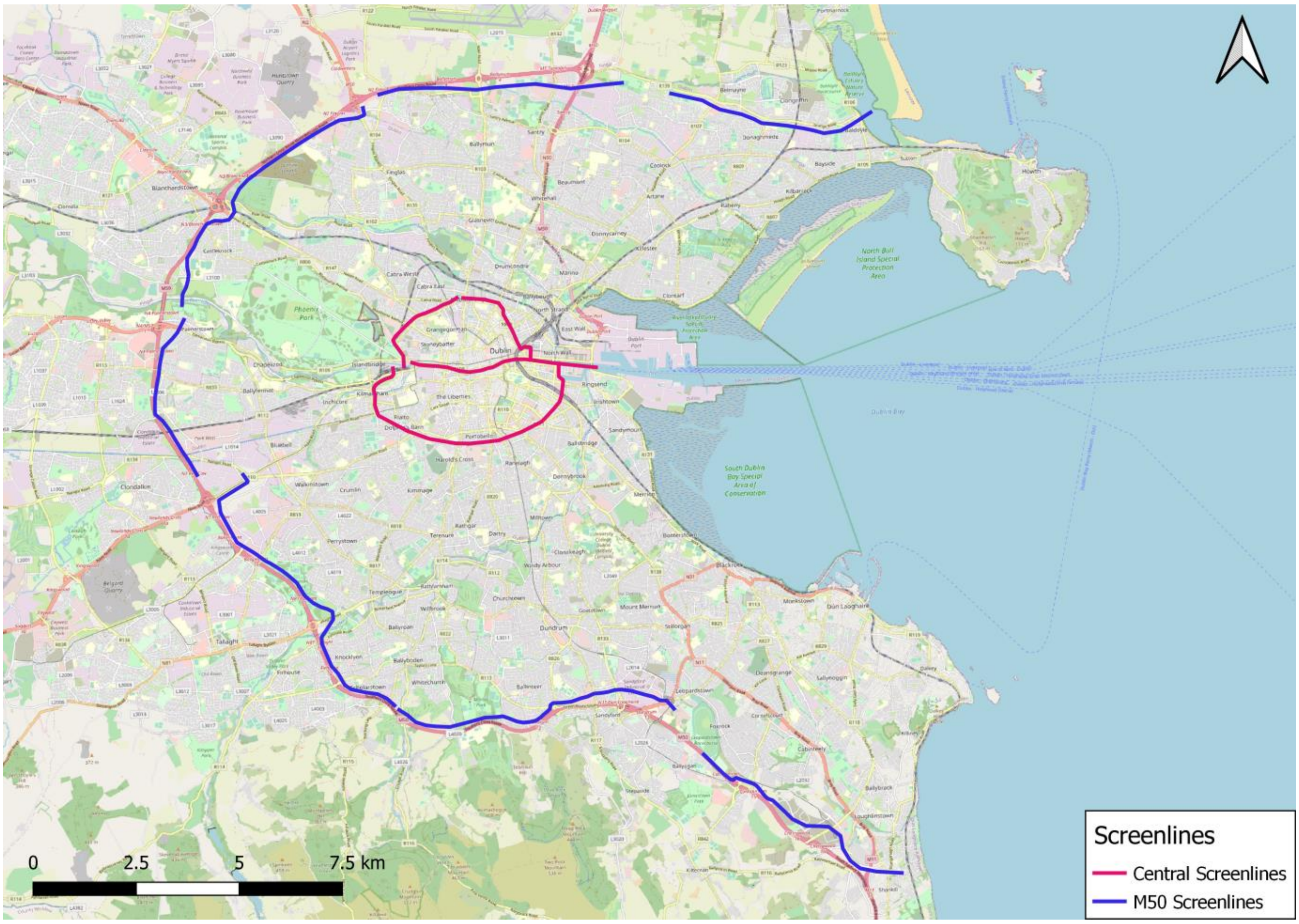


Diagram A.1: Calibration Screenline Coverage

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

- Canal North
- Canal Northeast

[13] 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 Northwest
- Canal Southeast
- 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

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.

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

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

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
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

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 Table A.5 to Table A.8. The results indicate a significant improvement in correlation between modelled and observed flows when compared to the pre-factoring results in Table A.1 to 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.

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

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

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

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 Table A.9.

Table A.9: Traffic Count Calibration Statistics (Pre Matrix Estimation)

<table>
<tr><th colspan="2">Criteria</th><th>Individual flows within 100 v/h for flows less than 700 v/h</th><th>Individual flows within 15% for flows between 700 & 2,700 v/h</th><th>Individual flows within 400 v/h for flows greater than 2,700 v/h</th><th>Individual flows – GEH < 5</th></tr>
<tr><td rowspan="3">AM</td><td>Car</td><td colspan="3">58%</td><td>58%</td></tr>
<tr><td>LGV</td><td colspan="3">98%</td><td>80%</td></tr>
<tr><td>HGV</td><td colspan="3">97%</td><td>85%</td></tr>
<tr><td rowspan="3">LT</td><td>Car</td><td colspan="3">60%</td><td>56%</td></tr>
<tr><td>LGV</td><td colspan="3">97%</td><td>78%</td></tr>
<tr><td>HGV</td><td colspan="3">98%</td><td>83%</td></tr>
<tr><td rowspan="3">SR</td><td>Car</td><td colspan="3">56%</td><td>53%</td></tr>
<tr><td>LGV</td><td colspan="3">98%</td><td>77%</td></tr>
<tr><td>HGV</td><td colspan="3">98%</td><td>82%</td></tr>
<tr><td rowspan="3">PM</td><td>Car</td><td colspan="3">52%</td><td>51%</td></tr>
<tr><td>LGV</td><td colspan="3">97%</td><td>73%</td></tr>
<tr><td>HGV</td><td colspan="3">98%</td><td>80%</td></tr>
</table>

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 is 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

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

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 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 Table A.11 to Table A.14 for the AM, LT, SR and PM peak hours.

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

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

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
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

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

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 Diagram A.2 and consists of 2,201 turns across 441 junctions

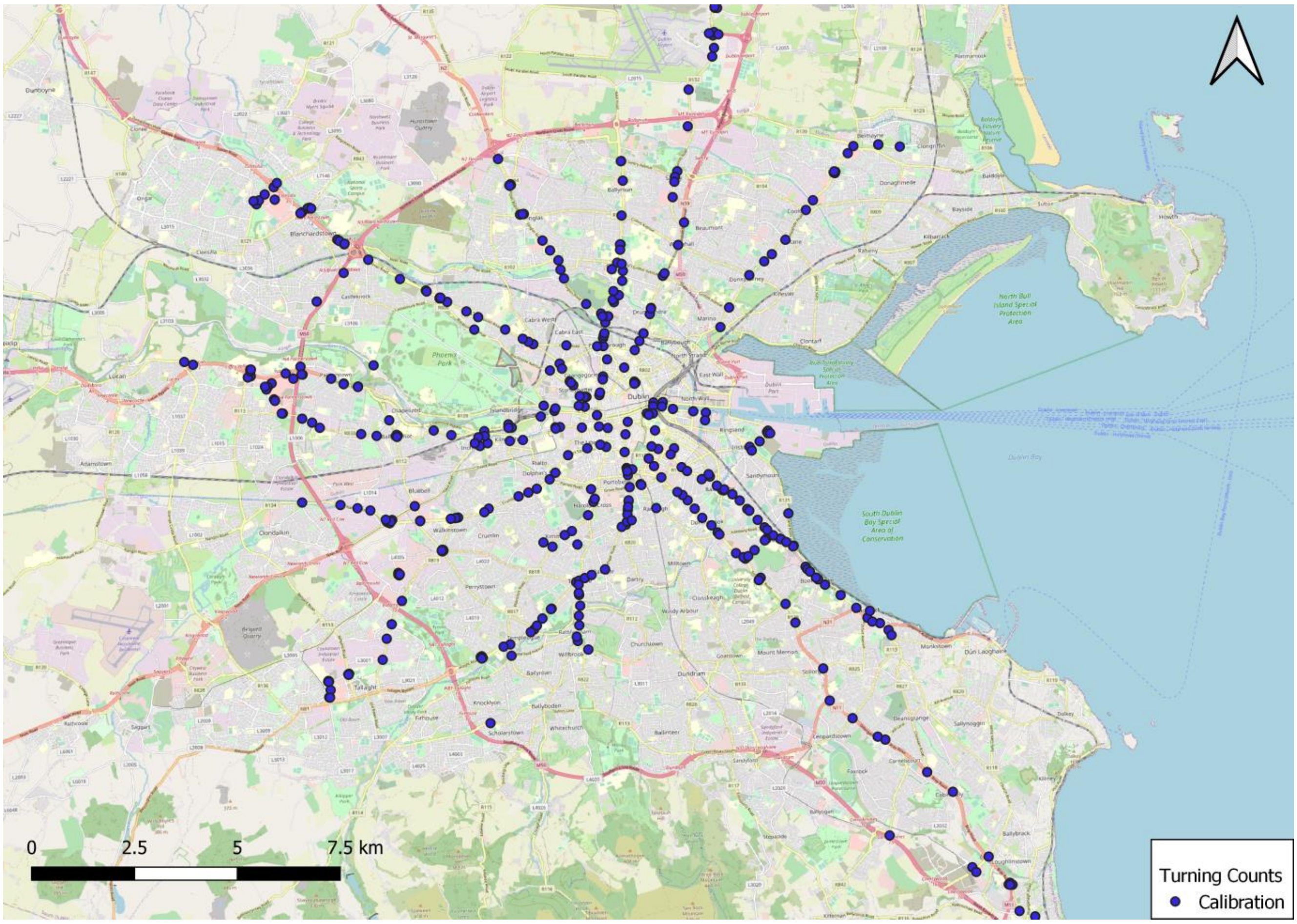


Diagram A.2: Turning Counts Used in Calibration

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.

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%

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^2 measure of goodness of fit were calculated. The results of this analysis are outlined in Table A.17 to Table A.19 below, and 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.

Table A.17: Matrix Zonal Cell Regression Analysis

Measure	Significance Criteria	AM	LT	SR	PM
R^2	R^2 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

Table A.18: Matrix Trip End Regression Analysis – Origins

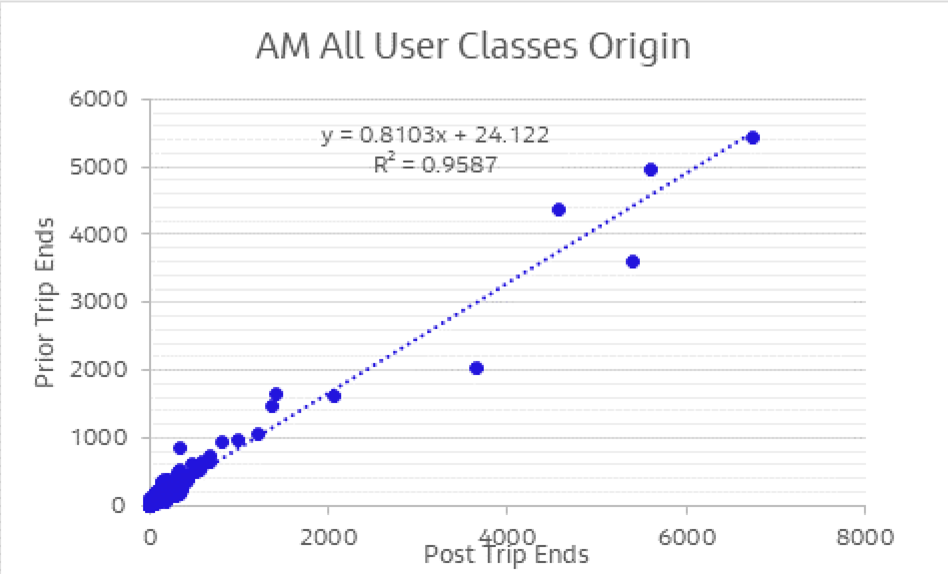
Measure	Significance Criteria	AM	LT	SR	PM
R^2	R^2 in excess of 0.95	0.96	0.97	0.97	0.95
Slope	Within 0.98 and 1.02	0.81	0.80	0.80	0.79
Intercept	Intercept near zero	24.12	19.32	24.45	26.77

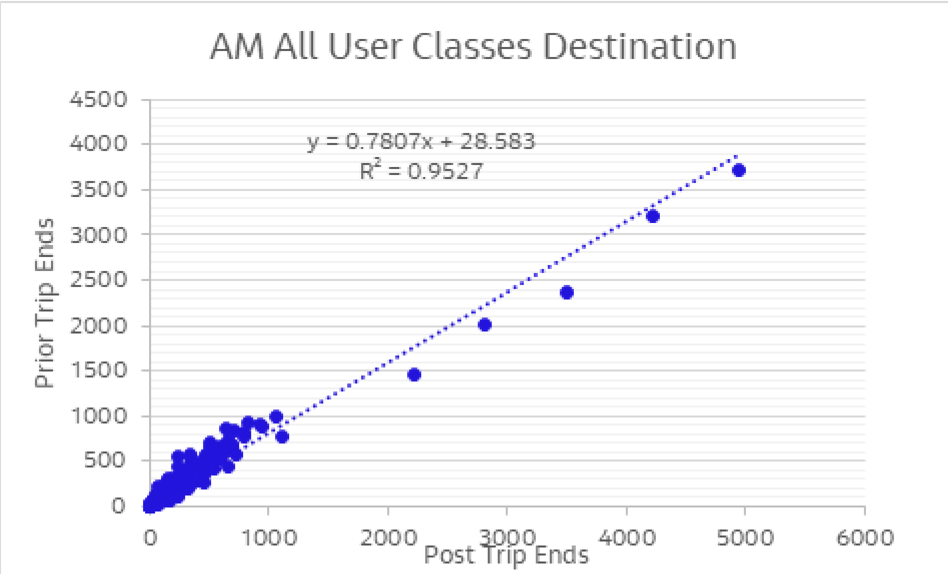
Table A.19: Matrix Trip End Regression Analysis – Destinations

Measure	Significance Criteria	AM	LT	SR	PM
R^2	R^2 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

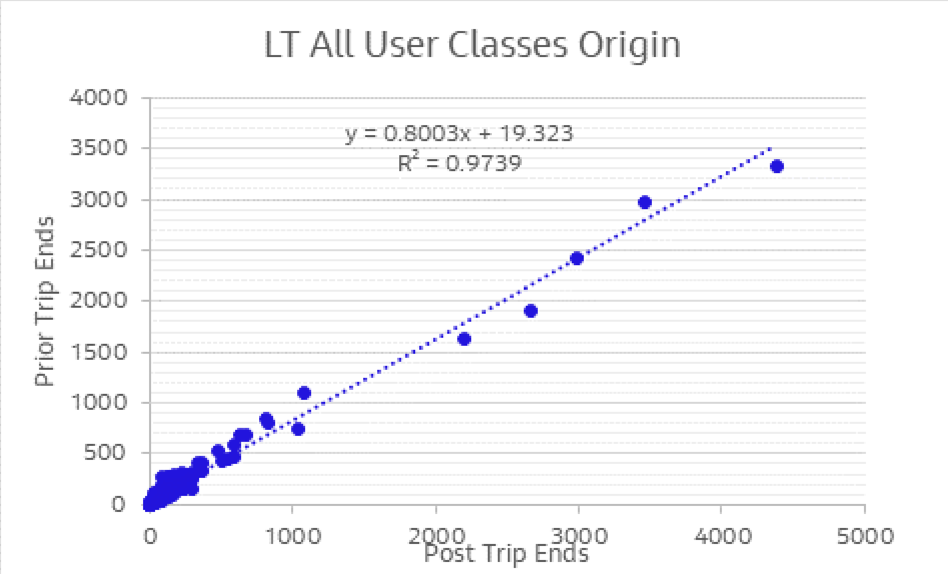
The regression statistics indicate that there is a good correlation between the post calibrated and prior matrices for the R^2 value, with full TII TAG guidance being met for the origins and destinations. Guidance is not quite met for the Slope and Intercept criteria although this is comparable with similar results from the full ERM model[14]. 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.

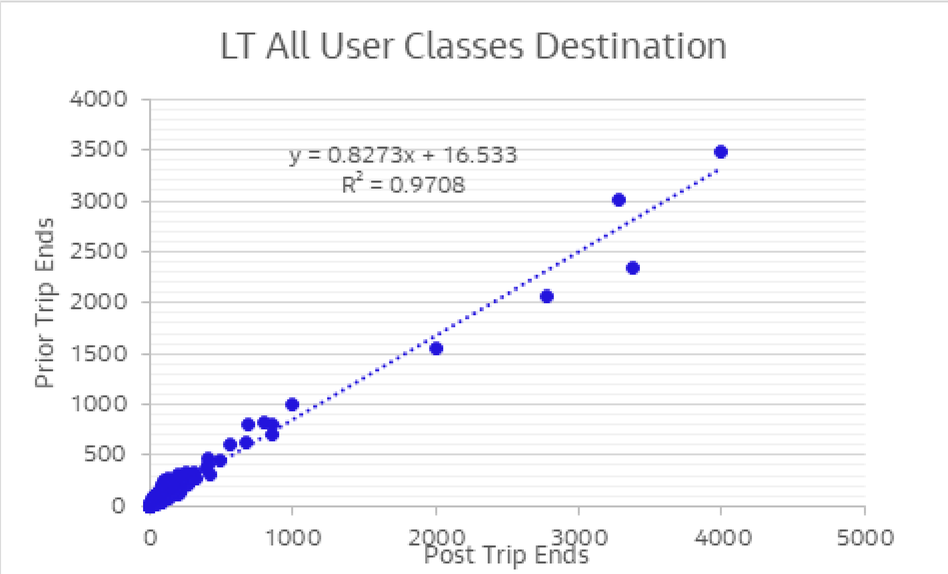
Diagram A.3: Regression Analysis of Matrix Estimation Changes





[14] https://www.nationaltransport.ie/wp-content/uploads/2018/06/ERM_Road_Model_Development_Report_Final-2.pdf


LT All User Classes Origin
y = 0.8003x + 19.323
R^2 = 0.9739
Prior Trip Ends
Post Trip Ends
0
500
1000
1500
2000
2500
3000
3500
4000
0
1000
2000
3000
4000
5000


LT All User Classes Destination
y = 0.8273x + 16.533
R^2 = 0.9708
Prior Trip Ends
Post Trip Ends
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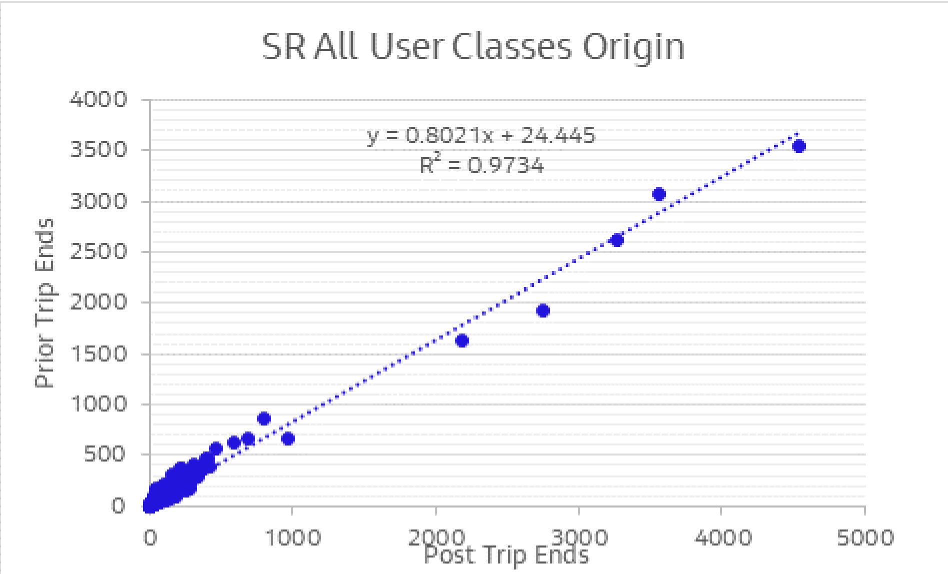
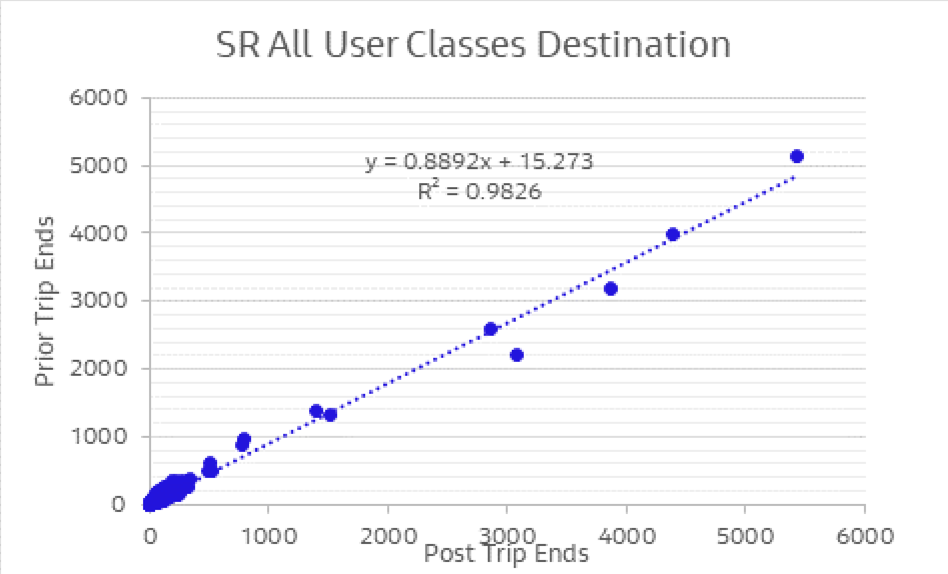
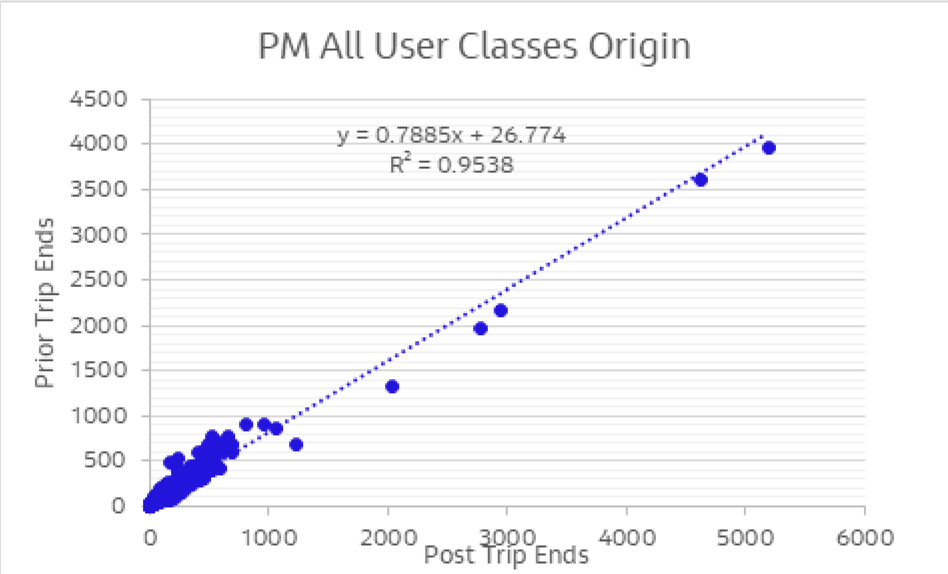
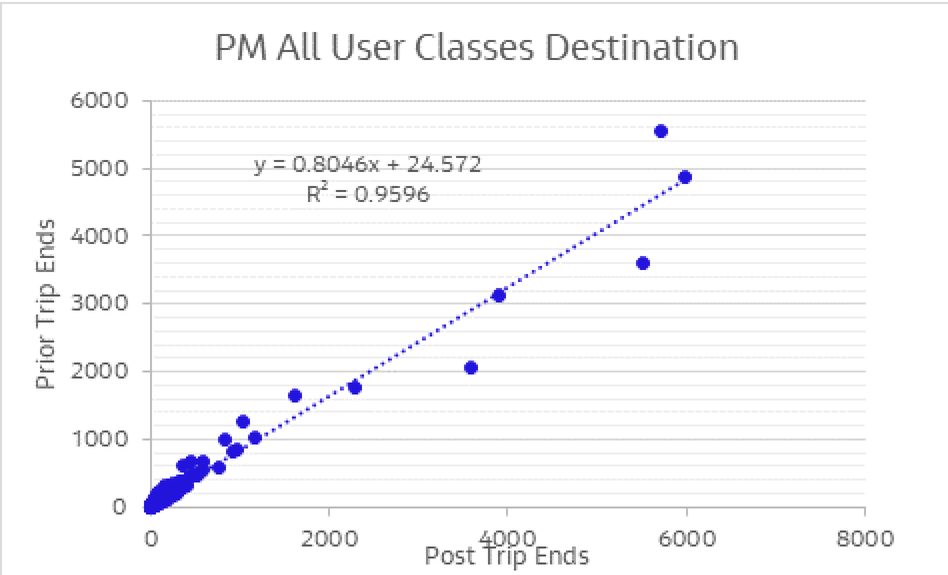
500
1000
1500
2000
2500
3000
3500
4000
0
1000
2000
3000
4000
5000


SR All User Classes Origin
y = 0.8021x + 24.445
R^2 = 0.9734
Prior Trip Ends
Post Trip Ends
0
500
1000
1500
2000
2500
3000
3500
4000
0
1000
2000
3000
4000
5000


SR All User Classes Destination
y = 0.8892x + 15.273
R^2 = 0.9826
Prior Trip Ends
Post Trip Ends
0
1000
2000
3000
4000
5000
6000


PM All User Classes Origin
y = 0.7885x + 26.774
R^2 = 0.9538
Prior Trip Ends
Post Trip Ends
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
6000


PM All User Classes Destination
y = 0.8046x + 24.572
R^2 = 0.9596
Prior Trip Ends
Post Trip Ends
0
1000
2000
3000
4000
5000
6000
8000

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.

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.

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 Diagram A.4 to Diagram A.7 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.

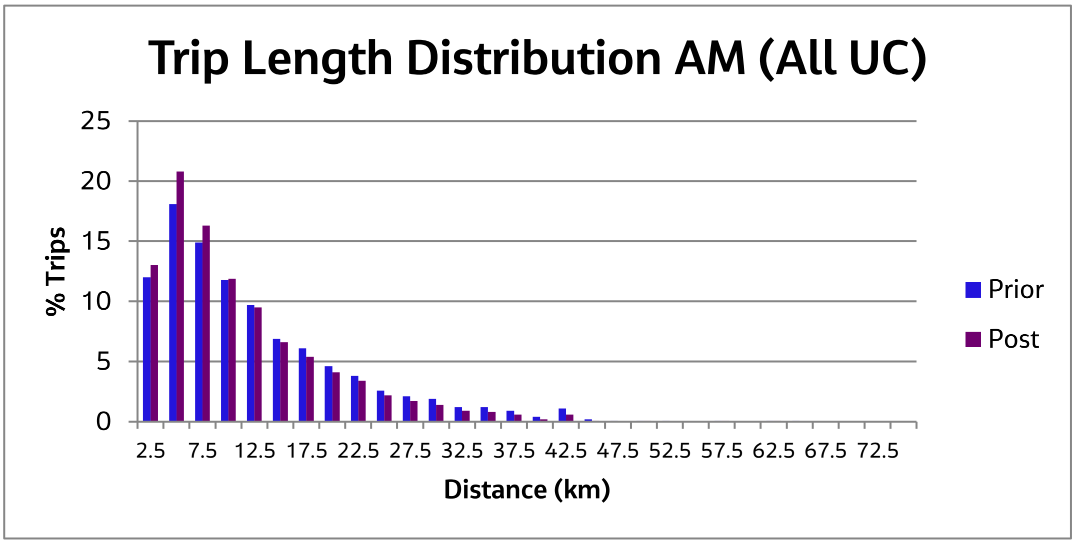


Diagram A.4: AM Peak Trip Length Distribution

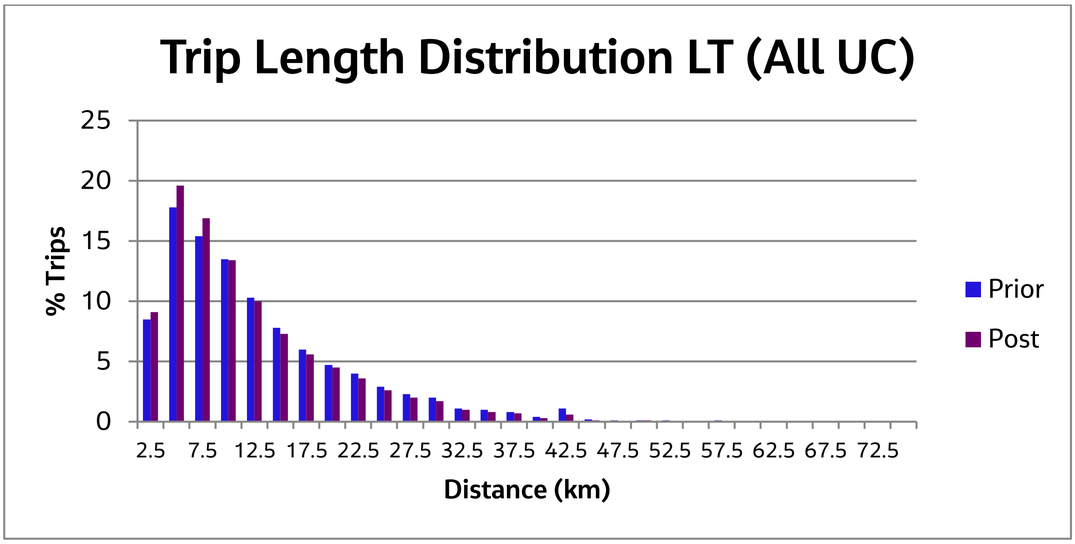


Diagram A.5: LT Peak Trip Length Distribution

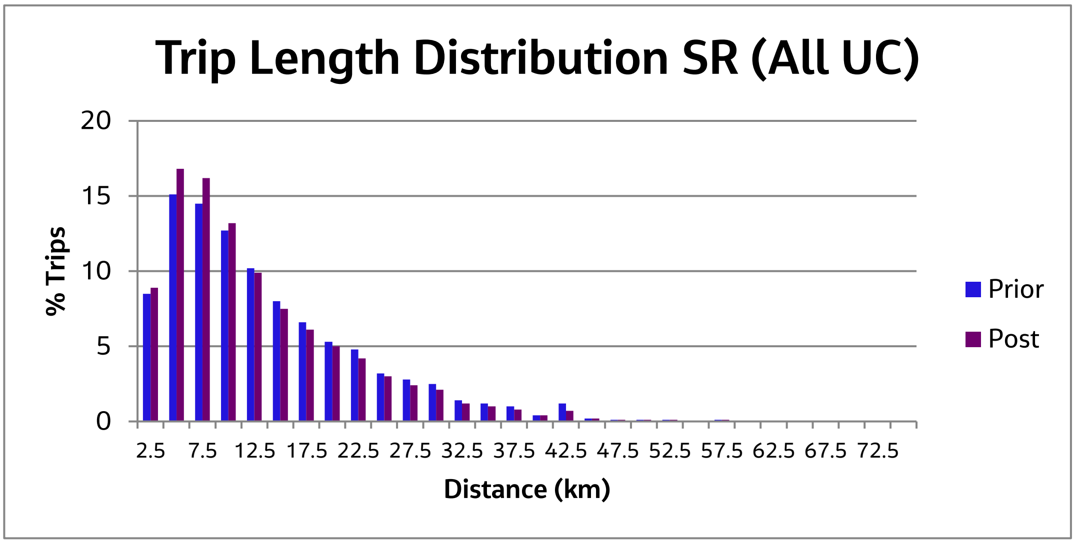


Diagram A.6: SR Peak Trip Length Distribution

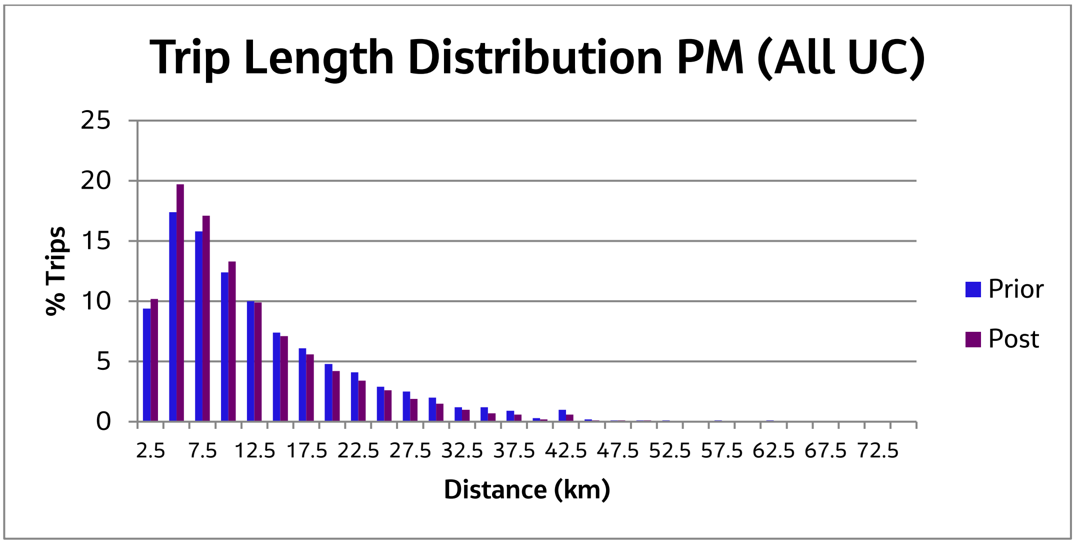


Diagram A.7: PM Peak Trip Length Distribution

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^2 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 (Diagram A.2). This provides a further independent check of the modelled turning movements within the LAM. The coverage of these turning counts is highlighted below in Diagram A.8Diagram and consists of 2,025 turns across 484 junctions.

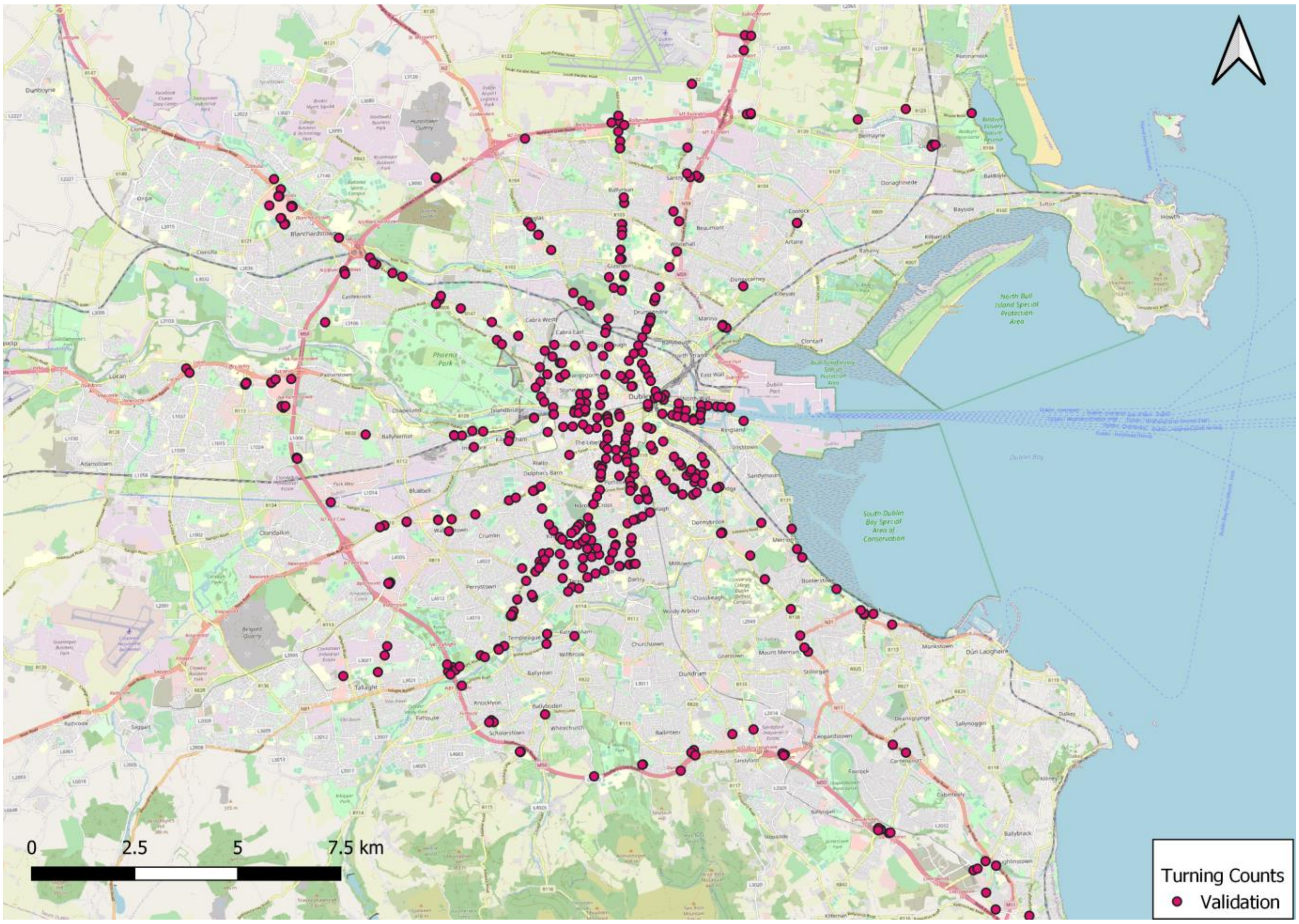


Diagram A.8: Turning Counts Used in Validation

Table A.21 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.

Table A.21: 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
AM	Car	82%			57%	90%
	LGV	100%			90%	100%
	HGV	100%			98%	100%
LT	Car	88%			63%	93%
	LGV	100%			89%	100%
	HGV	100%			98%	100%
SR	Car	85%			59%	92%
	LGV	100%			90%	100%
	HGV	100%			98%	100%
PM	Car	81%			57%	90%
	LGV	100%			91%	100%
	HGV	100%			99%	100%

A.3.1 Journey Time Validation

As outlined in Table A.21, 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.

Table A.22 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.

Table A.22: 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

Table A.23 below shows a breakdown of each individual journey time route for the AM period.

Table A.23: Detailed AM Journey Time Validation Statistics

Route	CBC Correspondence	Observed Median/Mean Blend	Modelled	% Diff	Pass/Fail
1_Inbound	CBC1	2114	1902	-10.0%	Pass
1_Outbound	CBC1	1550	1531	-1.3%	Pass
2_Inbound	CBC16	2586	2355	-8.9%	Pass
2_Outbound	CBC16	2396	1960	-18.2%	Fail
3_Inbound	CBC1	1636	1649	0.8%	Pass
3_Outbound	CBC1	1273	1305	2.5%	Pass
4_Inbound	CBC2	2550	2291	-10.2%	Pass
4_Outbound	CBC2	1882	2346	24.6%	Fail
5_Inbound	CBC3	1449	1206	-16.8%	Fail
5_Outbound	CBC3	1095	1244	13.6%	Pass
6_Outbound	CBC3, CBC4	1389	1498	7.9%	Pass
6_Inbound	CBC3, CBC4	2170	1779	-18.0%	Fail
7_Inbound	CBC5	1732	1406	-18.8%	Fail
7_Outbound	CBC5	1131	1458	28.9%	Fail
8_Inbound	CBC6	1542	1406	-8.8%	Pass
8_Outbound	CBC6	848	876	3.3%	Pass
9_Outbound	CBC7	1281	1341	4.6%	Pass
9_Inbound	CBC7	1939	1695	-12.6%	Pass
10_Inbound	CBC9	2037	2095	2.8%	Pass
10_Outbound	CBC9	1771	1784	0.7%	Pass
11_Inbound	CBC10,CBC12	2605	2216	-14.9%	Pass
11_Outbound	CBC10,CBC12	2071	1636	-21.0%	Fail
12_Inbound	CBC11,CBC12	1981	1502	-24.2%	Fail
12_Outbound	CBC11,CBC12	1429	1253	-12.3%	Pass
13_Inbound	CBC11	1661	1393	-16.1%	Fail
13_Outbound	CBC11	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	CBC13	3143	2461	-21.7%	Fail
15_Outbound	CBC13	2018	1916	-5.1%	Pass
16_Inbound	CBC14,CBC15	2123	1777	-16.3%	Fail
16_Outbound	CBC14,CBC15	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

Route	CBC Correspondence	Observed Median/Mean Blend	Modelled	% Diff	Pass/Fail
21_Westbound	M50	3557	2415	-32.1%	Fail
22_Outbound	CBC13	674	502	-25.5%	Fail
22_Inbound	CBC13	662	570	-13.8%	Pass
23_Outbound	CBC2	587	706	20.3%	Fail
23_Inbound	CBC2	625	636	1.7%	Pass
24_Outbound	CBC7	700	620	-11.4%	Pass
24_Inbound	CBC7	845	602	-28.8%	Fail
25_Outbound	CBC8	548	662	20.8%	Fail
25_Inbound	CBC8	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

Table A.24 below shows breakdown of each individual journey time route for the LT period.

Table A.24: Detailed LT Journey Time Validation Statistics

Route	CBC Correspondence	Observed Median/Mean Blend	Modelled	% Diff	Pass/Fail
1_Inbound	CBC1	1361	1500	10.2%	Pass
1_Outbound	CBC1	1340	1644	22.7%	Fail
2_Inbound	CBC16	1634	1863	14.0%	Pass
2_Outbound	CBC16	1709	1961	14.7%	Pass
3_Inbound	CBC1	1115	1276	14.5%	Pass
3_Outbound	CBC1	1062	1312	23.6%	Fail
4_Inbound	CBC2	1359	1831	34.7%	Fail
4_Outbound	CBC2	1695	2276	34.3%	Fail
5_Inbound	CBC3	827	1048	26.8%	Fail
5_Outbound	CBC3	938	1256	34.0%	Fail
6_Outbound	CBC3, CBC4	1375	1524	10.8%	Pass
6_Inbound	CBC3, CBC4	1592	1723	8.2%	Pass
7_Inbound	CBC5	1065	1192	11.9%	Pass
7_Outbound	CBC5	1036	1279	23.4%	Fail
8_Inbound	CBC6	804	983	22.2%	Fail
8_Outbound	CBC6	771	888	15.1%	Fail
9_Outbound	CBC7	1199	1305	8.8%	Pass
9_Inbound	CBC7	1216	1387	14.1%	Pass
10_Inbound	CBC9	1470	1748	19.0%	Fail
10_Outbound	CBC9	1458	1742	19.5%	Fail
11_Inbound	CBC10,CBC12	1590	1857	16.8%	Fail
11_Outbound	CBC10,CBC12	1479	1558	5.3%	Pass
12_Inbound	CBC11,CBC12	1141	1279	12.1%	Pass
12_Outbound	CBC11,CBC12	1076	1319	22.6%	Fail
13_Inbound	CBC11	1010	1167	15.6%	Fail
13_Outbound	CBC11	999	1120	12.1%	Pass

Route	CBC Correspondence	Observed Median/Mean Blend	Modelled	% Diff	Pass/Fail
14_Inbound	N/A	1310	1562	19.3%	Fail
14_Outbound	N/A	1266	1620	28.0%	Fail
15_Inbound	CBC13	2042	2142	4.9%	Pass
15_Outbound	CBC13	1700	1874	10.2%	Pass
16_Inbound	CBC14,CBC15	1232	1470	19.3%	Fail
16_Outbound	CBC14,CBC15	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	CBC13	518	486	-6.1%	Pass
22_Inbound	CBC13	491	513	4.6%	Pass
23_Outbound	CBC2	636	734	15.4%	Fail
23_Inbound	CBC2	585	578	-1.2%	Pass
24_Outbound	CBC7	708	607	-14.3%	Pass
24_Inbound	CBC7	670	559	-16.5%	Fail
25_Outbound	CBC8	513	626	22.0%	Fail
25_Inbound	CBC8	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

Table A.25 below shows breakdown of each individual journey time route for the SR period.

Table A.25: Detailed SR Journey Time Validation Statistics

Route	CBC Correspondence	Observed Median/Mean Blend	Modelled	% Diff	Pass/Fail
1_Inbound	CBC1	1426	1513	6.2%	Pass
1_Outbound	CBC1	1444	1782	23.4%	Fail
2_Inbound	CBC16	1809	1879	3.9%	Pass
2_Outbound	CBC16	2074	2246	8.3%	Pass
3_Inbound	CBC1	1176	1329	13.0%	Pass
3_Outbound	CBC1	1217	1609	32.2%	Fail
4_Inbound	CBC2	1364	1915	40.4%	Fail
4_Outbound	CBC2	1962	2480	26.4%	Fail
5_Inbound	CBC3	821	1070	30.3%	Fail
5_Outbound	CBC3	1100	1438	30.7%	Fail
6_Outbound	CBC3, CBC4	1493	1790	19.8%	Fail
6_Inbound	CBC3, CBC4	1532	1698	10.8%	Pass
7_Inbound	CBC5	1052	1182	12.4%	Pass
7_Outbound	CBC5	1233	1479	19.9%	Fail

Route	CBC Correspondence	Observed Median/Mean Blend	Modelled	% Diff	Pass/Fail
8_Inbound	CBC6	842	932	10.7%	Pass
8_Outbound	CBC6	922	1149	24.6%	Fail
9_Outbound	CBC7	1478	1465	-0.9%	Pass
9_Inbound	CBC7	1228	1323	7.8%	Pass
10_Inbound	CBC9	1561	1774	13.6%	Pass
10_Outbound	CBC9	1611	1857	15.3%	Fail
11_Inbound	CBC10,CBC12	1607	1825	13.5%	Pass
11_Outbound	CBC10,CBC12	1845	1640	-11.1%	Pass
12_Inbound	CBC11,CBC12	1216	1305	7.3%	Pass
12_Outbound	CBC11,CBC12	1219	1483	21.6%	Fail
13_Inbound	CBC11	1044	1168	11.9%	Pass
13_Outbound	CBC11	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	CBC13	2068	2157	4.3%	Pass
15_Outbound	CBC13	1883	2059	9.4%	Pass
16_Inbound	CBC14,CBC15	1256	1455	15.9%	Fail
16_Outbound	CBC14,CBC15	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
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	CBC13	632	490	-22.5%	Fail
22_Inbound	CBC13	529	515	-2.7%	Pass
23_Outbound	CBC2	657	738	12.4%	Pass
23_Inbound	CBC2	587	585	-0.3%	Pass
24_Outbound	CBC7	808	617	-23.6%	Fail
24_Inbound	CBC7	691	566	-18.1%	Fail
25_Outbound	CBC8	615	628	2.0%	Pass
25_Inbound	CBC8	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

Table A.26 below shows breakdown of each individual journey time route for the PM period.

Table A.26: Detailed PM Journey Time Validation Statistics

Route	CBC Correspondence	Observed Median/Mean Blend	Modelled	% Diff	Pass/Fail
1_Inbound	CBC1	1469	1444	-1.7%	Pass
1_Outbound	CBC1	1803	2392	32.6%	Fail

Route	CBC Correspondence	Observed Median/Mean Blend	Modelled	% Diff	Pass/Fail
2_Inbound	CBC16	2550	1866	-26.8%	Fail
2_Outbound	CBC16	2777	2621	-5.6%	Pass
3_Inbound	CBC1	1225	1318	7.6%	Pass
3_Outbound	CBC1	1558	2067	32.7%	Fail
4_Inbound	CBC2	1579	2011	27.4%	Fail
4_Outbound	CBC2	2572	2694	4.7%	Pass
5_Inbound	CBC3	869	1085	24.9%	Fail
5_Outbound	CBC3	1439	1524	5.9%	Pass
6_Outbound	CBC3, CBC4	2120	1920	-9.5%	Pass
6_Inbound	CBC3, CBC4	1811	1680	-7.2%	Pass
7_Inbound	CBC5	1201	1175	-2.2%	Pass
7_Outbound	CBC5	1779	1583	-11.0%	Pass
8_Inbound	CBC6	1045	925	-11.5%	Pass
8_Outbound	CBC6	1326	1217	-8.2%	Pass
9_Outbound	CBC7	1851	1492	-19.4%	Fail
9_Inbound	CBC7	1651	1374	-16.8%	Fail
10_Inbound	CBC9	1897	1846	-2.7%	Pass
10_Outbound	CBC9	2103	2156	2.5%	Pass
11_Inbound	CBC10,CBC12	1902	2105	10.7%	Pass
11_Outbound	CBC10,CBC12	2539	1736	-31.6%	Fail
12_Inbound	CBC11,CBC12	1331	1367	2.7%	Pass
12_Outbound	CBC11,CBC12	1728	1525	-11.7%	Pass
13_Inbound	CBC11	1100	1195	8.6%	Pass
13_Outbound	CBC11	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	CBC13	2722	2180	-19.9%	Fail
15_Outbound	CBC13	2552	2318	-9.2%	Pass
16_Inbound	CBC14,CBC15	1523	1497	-1.7%	Pass
16_Outbound	CBC14,CBC15	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	CBC13	744	514	-30.8%	Fail
22_Inbound	CBC13	520	511	-1.8%	Pass
23_Outbound	CBC2	803	773	-3.7%	Pass
23_Inbound	CBC2	697	763	9.5%	Pass
24_Outbound	CBC7	1149	613	-46.6%	Fail
24_Inbound	CBC7	667	575	-13.9%	Pass
25_Outbound	CBC8	982	621	-36.8%	Fail
25_Inbound	CBC8	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.