REGIONAL MODELLING SYSTEM

Modelling Services Framework

Mid-West Regional Model

Demand Model Calibration Report

Údarás Náisiúnta Iompair
National Transport Authority

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Foreword

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

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

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

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

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

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

1 Introduction

1.1 Regional Modelling System

The NTA has developed a Regional Modelling System for the Republic of Ireland to assist in the appraisal of a wide range of potential future transport and land use options. The regional models are focused on the travel-to-work areas of the major population centres of Dublin, Cork, Galway, Limerick, and Waterford. The models were developed as part of the Modelling Services Framework by NTA, SYSTRA and Jacobs Engineering Ireland.

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

Table 1.1 Regional Models and their area of coverage

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

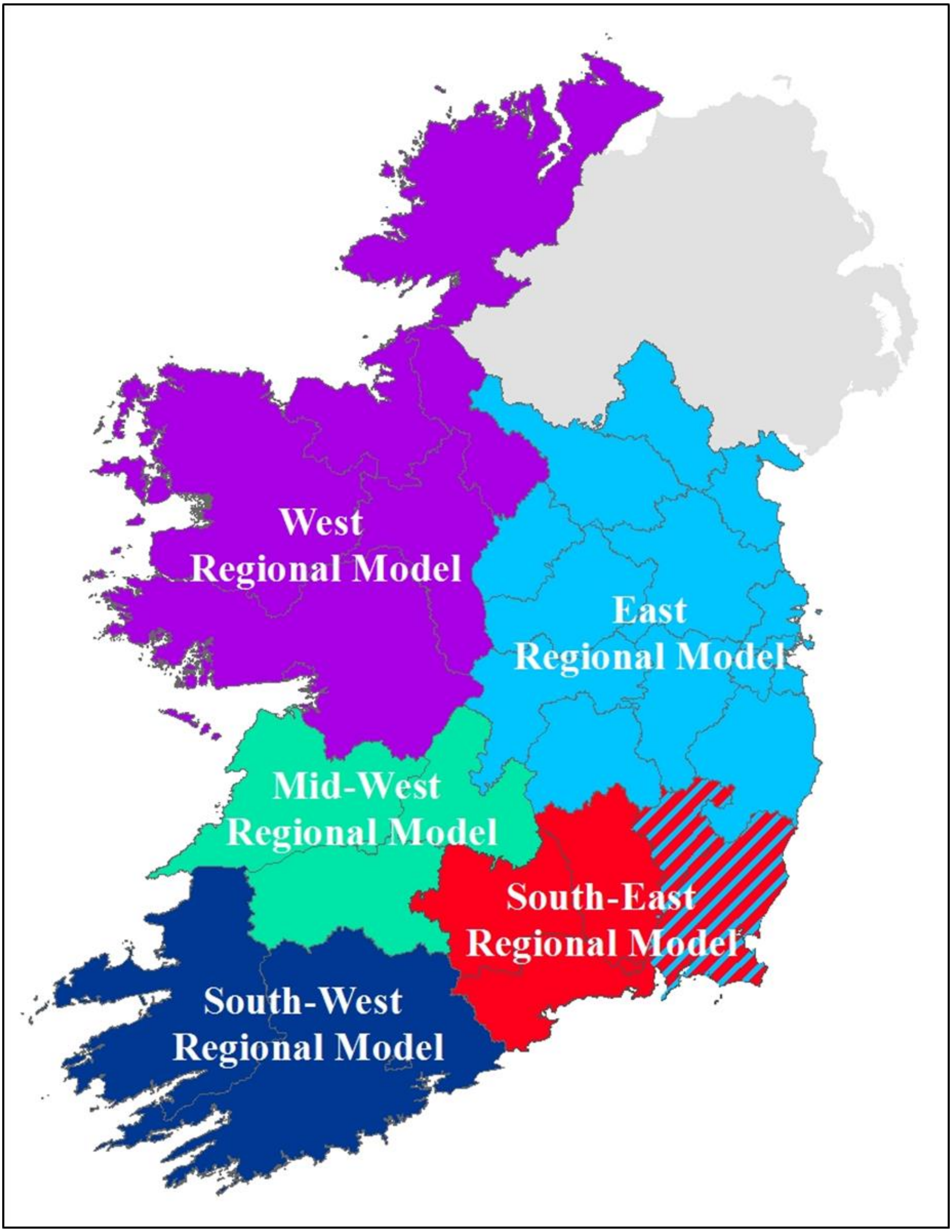


Figure 1.1 Regional Model Areas (the ERM and SERM overlap in the hashed area)

1.2 Regional Modelling System Structure

The Regional Modelling System is comprised of three main components, namely:

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

The modelling approach is consistent across each of the regional models. The general structure of the MWRM (and the other regional models) is shown below in Figure 1.2. The main stages of the regional modelling system are described below.

1.2.1 National Demand Forecasting Model (NDFM)

The NDFM is a single, national system that provides estimates of the total quantity of daily travel demand produced by and attracted to each of the 18,488 Census Small Areas. Trip generations and attractions are related to zonal attributes such as population, number of employees, and other land-use data. See the NDFM Development Report for further information.

1.2.2 Regional Models

A regional model is comprised of the following key elements:

Trip End Integration
The Trip End Integration module converts the 24-hour trip ends output by the NDFM into the appropriate zone system and time period disaggregation for use in the Full Demand Model (FDM).

The Full Demand Model (FDM)
The FDM processes travel demand and outputs origin-destination travel matrices by mode and time period to the assignment models. The FDM and assignment models run iteratively until an equilibrium between travel demand and the cost of travel is achieved.

Assignment Models
The Road, Public Transport, and Active Modes assignment models receive the trip matrices produced by the FDM and assign them in their respective transport networks to determine route choice and the generalised cost for origin and destination pair.

The Road Model assigns FDM outputs (passenger cars) to the road network and includes capacity constraint, traffic signal delay and the impact of congestion. See the RM Spec2 Road Model Specification Report for further information.

The Public Transport Model assigns FDM outputs (person trips) to the PT network and includes the impact of capacity restraint, such as crowding on PT vehicles, on people’s perceived cost of travel. The model includes public transport networks and services for all PT sub-modes that operate within the modelled area. See the RM Spec3 Public Transport Model Specification Report for further information.

Secondary Analysis
The secondary analysis application can be used to extract and summarise model results from each of the regional models.

1.2.3 Appraisal Modules

The Appraisal Modules can be used on any of the regional models to assess the impacts of transport plans and schemes. The following impacts can be informed by model outputs (travel costs, demands and flows):

- Economy;
- Safety;
- Environmental;
- Health; and
- Accessibility and Social Inclusion.

Further information on each of the Appraisal Modules can be found in the following reports:

- Economic Module Specification Report;
- Safety Module Specification Report;
- Environmental Module Specification Report;
- Health Module Specification Report; and
- Accessibility and Social Inclusion Module Specification Report

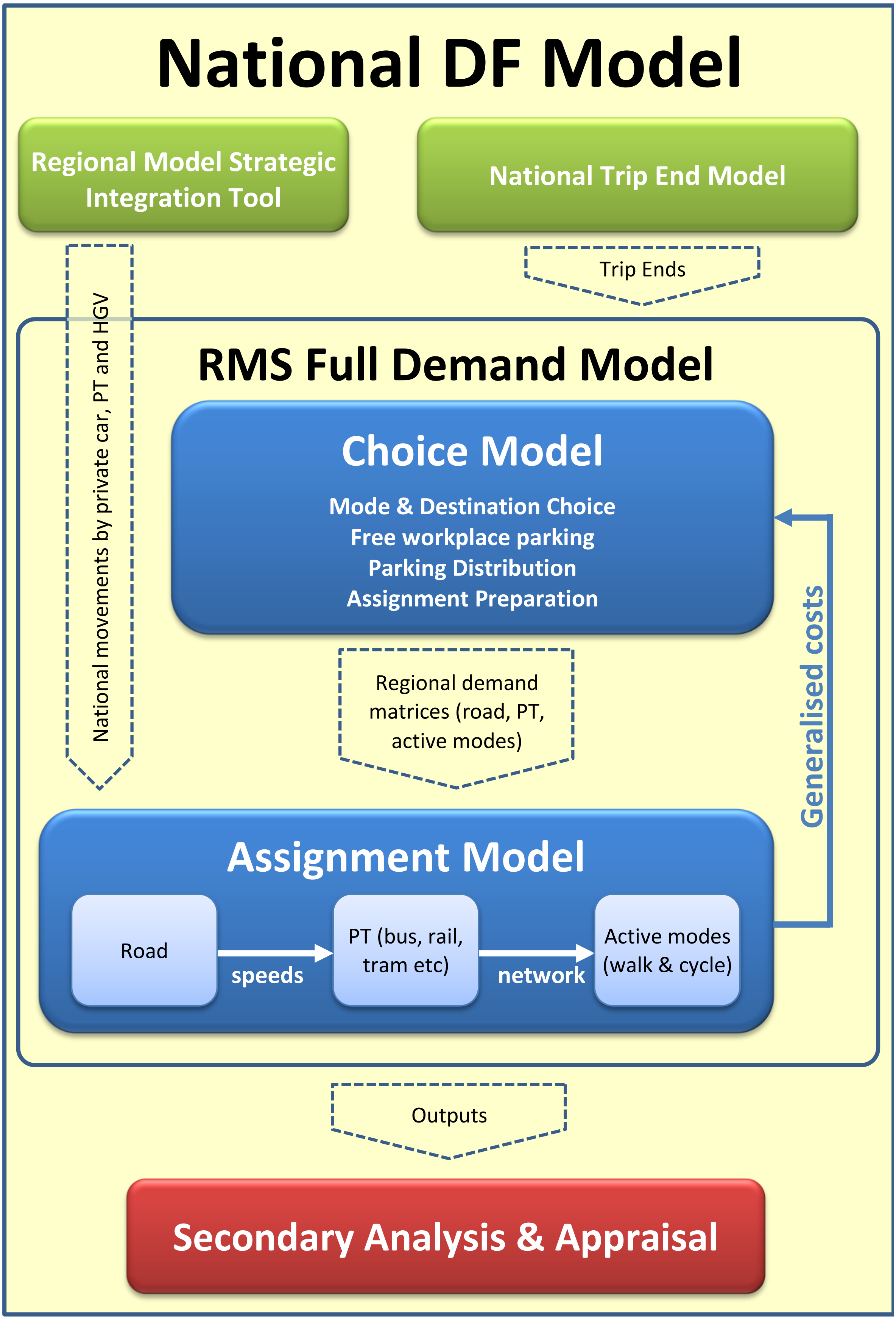


Figure 1.2 National and Regional Model Structure

1.3 Full Demand Model (FDM)

The full demand model is common across all five regions of the RMS. Its form is of the 'absolute' type, so trip matrices for each forecast year are calculated directly from input trip ends and costs. Figure 1.3 on Page 9 shows an overview of the different modules of the FDM, including those which have yet to be fully implemented (in green). The purpose of the FDM is to take input trip ends (at the 24-hour level) and costs (from the road, PT and active modes assignment models) and then to allocate trips to different time periods, modes and destinations for input to the peak-hour road, PT and active modes assignment models.

The FDM consists of the following modules:

- **Trip End Integration:** Converts the 24 hour trip ends output by the National Trip End Model (NTEM) into the appropriate zone system and time period disaggregation for the RMS;
- **Add-in Preparation:** Takes the output of the Regional Model Strategic Integration Tool (RMSIT), factors it if necessary, and converts it into the zone system and time period disaggregation required by the RMS. In addition, it also reads in internal goods movements, and can apply a growth factor to them, and subtracts the long distance movements from the trip ends passed on to the later stages of the model;
- **Initialisation:** Converts the trip ends into tours and the costs into the required formats;
- **Tour Mode & Destination Choice:** Calculates where each production trip end will match with an attraction trip end, and by what mode the trip will be made, given the time when the trip will take place;
- **Free Workplace Parking:** For the journey purposes which have free workplace parking the initial mode & destination choice does not include parking charges. This module takes the initial car demand and decides whether it can be accommodated in the available free workplace parking spaces. For the proportion of the car matrix which cannot be accommodated, and for the corresponding proportions of the other mode matrices, it undertakes a secondary mode split including parking charges;
- **One Way Mode & Destination Choice:** Similar to the main mode & destination choice stages except that it works on the one way trip inputs;
- **Special Zone Mode Choice:** Models mode choice for zones such as ports and airports which are forecast differently than the regular population. Demand must be input for the peak hour in each time period;
- **User Class Aggregation:** Aggregates the initial 33 trip purposes into five user classes for further processing;
- **Park & Ride:** This module takes the trips assigned to Park & Ride by the mode & destination choice stage, works out which Park & Ride site each will use, and

outputs the car and PT legs of each trip as well as information to be used in the calculation of the generalised costs;

- **Parking Distribution:** This allows car trips to park remotely from their destination, which is critical where parking capacity is limited or cheaper parking is available nearby. It only applies to certain areas in each of the regional models. The module gives car trips the choice to park in a number of alternative zones, based on the total trip cost and adds a penalty to over-capacity zones. It outputs the car and walk legs of each trip, as well as information to be used in the calculation of the generalised costs;
- **Parking Constraint:** For models where the details of parking distribution are not of interest this module can be used to apply a basic limit on car demand.
- **Tour to Trip Conversion:** Takes the tour based information, including that using free workplace parking, and converts it into the outbound and return legs needed by the assignment;
- **Assignment Preparation:** Combines the tour based and one way trips, special zone movements and Add-ins and applies vehicle occupancy and period to peak hour factors as appropriate. It also applies incremental adjustments, calculates taxi matrices and allows for greenfield development input;
- **Road Assignment Model:** Uses SATURN to assign traffic to the road network and generate costs;
- **PT Assignment Model:** Assigns public transport demand and generates costs;
- **Active Modes Assignment Model:** Assigns walk and cycle demand and generates costs;
- **Generalised cost calculations:** Takes the road, PT and active modes costs and processes them to generalised costs. It also calculates costs and cost adjustments for Park & Ride and Parking Distribution affected trips;
- **Convergence Check:** Undertakes a comparison of costs and demand from each successive loop to identify if the model has converged within acceptable criteria.

The following module is not yet fully implemented or tested:

- **Macro Time of Day Choice:** This module has not yet been implemented due to a lack of data on time choice behaviour. If implemented, it will allow trips to shift between macro time periods (e.g. from 7-10am to 10am-1pm).

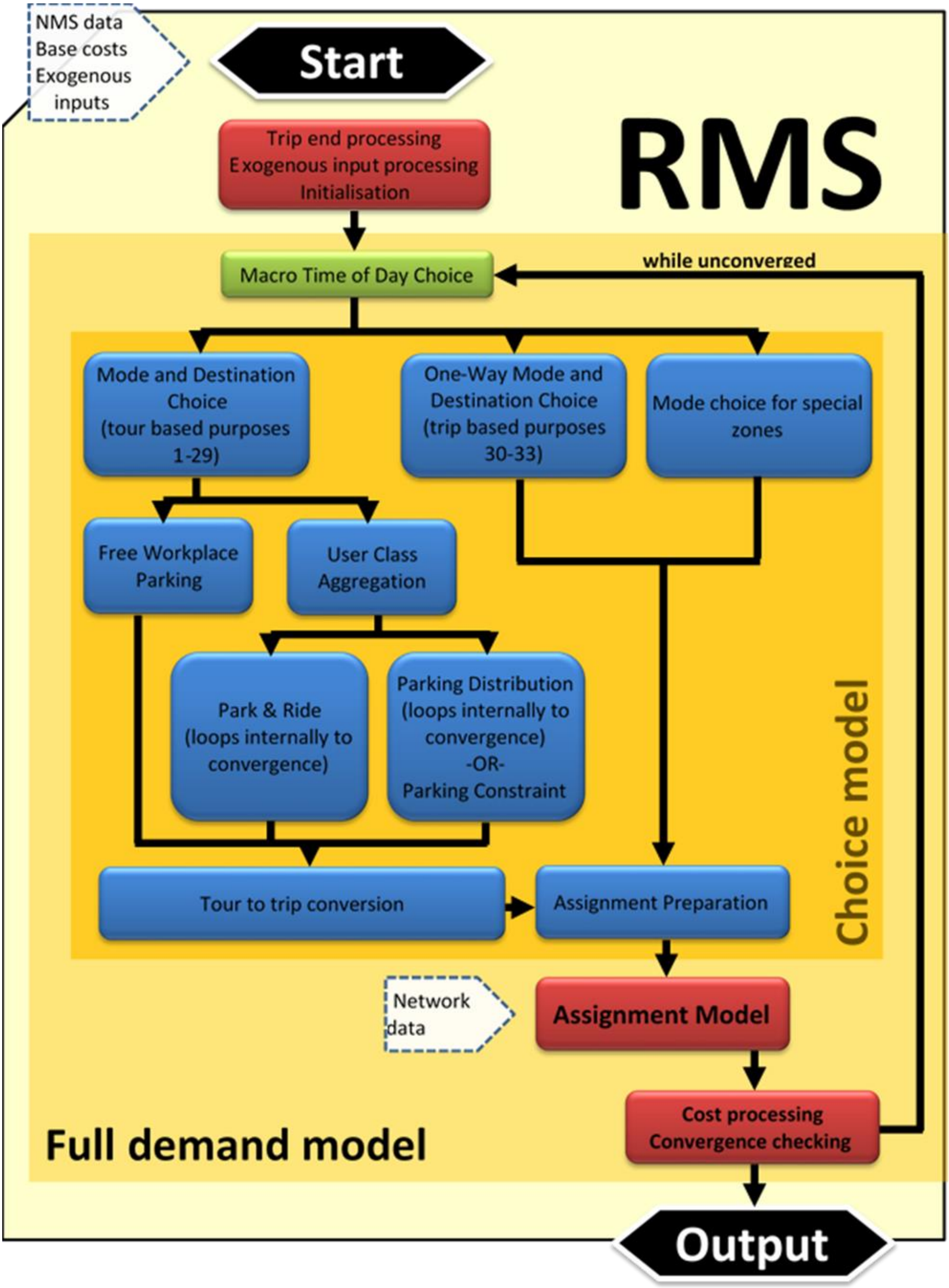


Figure 1.3 RMS Model Structure Overview

1.4 Report Library

This report is one document in a library of reports which describe various aspects of the scoping, building, development, calibration and validation of the NDFM and the five regional models (RMSs).

The NDFM is covered in detail in the report:

- NDFM Development Report

The scoping of the RMS FDM is covered in a number of reports:

- FDM Scope1 Demand Modelling Workshop Recommendations
- FDM Scope2 Demand Segmentation
- FDM Scope3 Modelling Time of Travel
- FDM Scope4 Trips, Tours and Triangles
- FDM Scope5 Car Ownership Scoping Report
- FDM Scope6 Active Modes
- FDM Scope7 Parking Model Specification
- FDM Scope8 Goods Vehicle Model Specification
- FDM Scope9 Taxi Model Specification
- FDM Scope10 Airport and Other Special Zones
- FDM Scope11 External Zones
- FDM Scope12 Base Year Matrix Building
- FDM Scope13 Incorporation of Road Assignment
- FDM Scope14 Public Transport Assignment
- FDM Scope15 Choice Model Specification
- FDM Scope16 Trip End Integration
- FDM Scope17 Modelling of Greenfield Developments
- FDM Scope18 Regional Transport Model Exogenous Variables

The full, and finalised FDM specification is reported in:

- RM Spec1 Full Demand Model Specification Report

The detailed development and testing of the FDM is covered in:

- RM Full Demand Model Development Report

This report deals with the calibration and validation of one of the five RMS models, the Mid-West Regional Model.

The following reports deal with FDM calibration and validation for the other RMS regions.

- WRM Full Demand Model Calibration Report
- SWRM Full Demand Model Calibration Report
- ERM Full Demand Model Calibration Report
- SERM Full Demand Model Calibration Report

Three additional reports give detailed information on the development, calibration and validation of the MWRM assignment models:

- MWRM Road Model Development Report
- MWRM Public Transport Model Development Report
- MWRM Active Modes Model Development Report

1.5 This report: Calibration and Validation of the RMS for the Mid-West Region (MWRM)

This report focuses on the calibration and validation of the RMS in the Mid-West Region, otherwise known as the Mid-West Regional Model or MWRM, including a description of the underlying theoretical process and the individual test runs conducted in the process of refining the model output. The report chapters include:

- **Chapter 2: RMS Full Model Calibration Methodology:** gives an overview of the theoretical process of calibrating and validating the FDM in general terms.
- **Chapter 3: Full Demand Model calibration test history:** in this chapter there is a detailed history of the various test runs undertaken in the process of calibrating the FDM.
- **Chapter 4: Final calibration / validation results:** presents the detailed calibration and validation results.
- **Chapter 5: Realism Testing:** the model's response to sensitivity or realism tests is outlined.
- **Chapter 6: Conclusion:** provides a summary of the process of model calibration and validation and makes recommendations for further work.

1.6 A note on terminology

There are five time periods in the model, one for the off-peak (OP), one for each of the morning and evening peaks (AM and PM) and two for the interpeak. The interpeak time periods were initially labelled 'lunchtime' referring to the period between 10:00 and 13:00 (LT) and 'school run' referring to the period between 13:00 and 16:00 (SR). These were later re-labelled as IP1 and IP2. However, as IP1 and IP2 are three letter codes whereas all of the original codes were two letter codes there were technical reasons why it was easier to retain the LT and SR labels in a number of places. The terms LT and IP1 are therefore used interchangeably, as are SR and IP2.

2 RMS Full Model Calibration Methodology

2.1 Introduction

Calibration involves the adjustment of the parameters which control the road, public transport and demand models, so that model predictions of flow and demand are as close to the observations as possible. Each NTA regional model is calibrated using the same process, which can be divided into distinct stages as shown below in Figure 2.1.

The calibration of the overall model requires the improvement of road and PT network assignment models so as to improve the costs being input to the FDM. It also requires calibration of the FDM so that the output assignment matrices match observed data (trip distributions and mode shares). As both requirements depend on each other, the calibration process is iterative. When the assignment models are calibrated to counts and journey times, and the demand model is responding appropriately to the input costs by outputting matrices that replicate observed data, the overall model is considered to be calibrated.

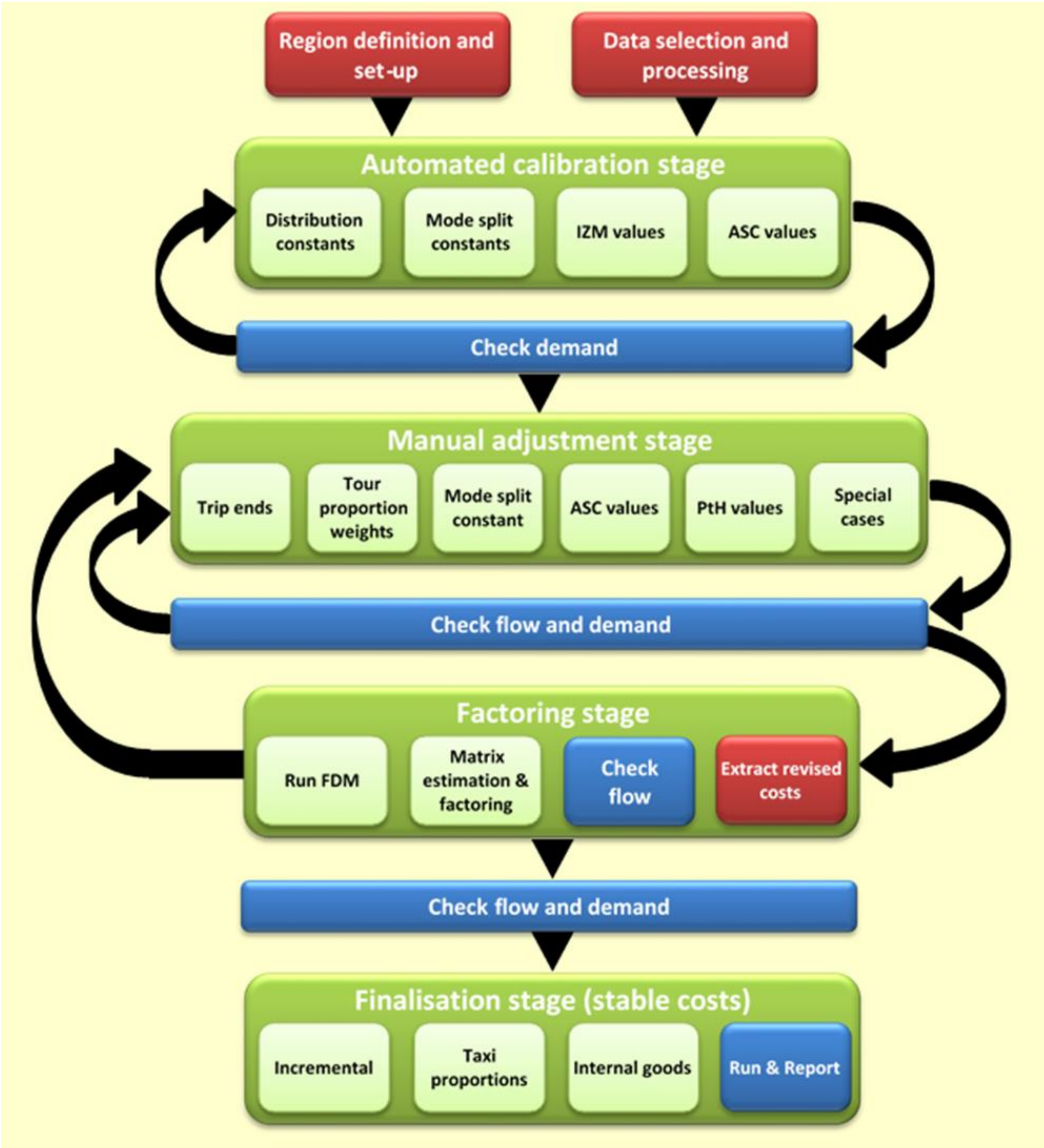


Figure 2.1 FDM calibration process

2.2 Region definition and set-up

The FDM implementation is identical across the regional models. A regional model is composed of the FDM plus the specific inputs required by that region, for example, input matrices expressed in the region's zoning system, or the region's particular road network. There are around 250 input files per regional model. These are listed in full in Annex 1 and they fall broadly into the following categories:

Table 2.1 Model inputs

Type of Input	Notes / Description
NDFM outputs	RMSIT matrices and NTEM trip ends.
Base cost matrices	From the best current estimation of the behaviour of the base network.
Preliminary test files	Dummy matrices and files for the assignment test stage.
Zone information files	Sequential to hierarchical numbering conversions, area, zone to small area correspondences and similar.
Mode and destination choice parameter matrices	Alpha, beta, lambda, ASC and IZM.
Parking information	Capacities, charges and parking parameters.
Greenfield inputs	Any input information for greenfield sites.
Road networks	All road network information files for all five modelled time periods.
PT network files	All PT information including networks, services, fares, values of time, annualisation factors and factor files for the four assigned time periods.
Active modes network files	Additional links and speed information.
Finalisation files	Incrementals, taxi proportions, car user to car driver factors and period to hour factors.

These files are found in the following locations within each model directory:

- {CATALOG_DIR}\Params (for those which are region specific but not run specific)
- {CATALOG_DIR}\Runs\{Year}\Demand (for those which are region and year specific)
- {CATALOG_DIR}\Runs\{Year}\{Growth}\Input (for those which are region, year and scenario specific)

As part of a model's calibration, all input files should be checked to ensure the region, year, and scenario are correct. A smoother calibration can be expected if this checking process is carried out in full.

2.3 Data selection and processing

2.3.1 Observed Demand Data

The MWRM demand calibration data, which was also used at the automatic calibration stage, came from:

- "Census 2011 Place of Work, School or College - Census of Anonymised Records (POWSCAR)" which was processed and used to calibrate the mode splits and trip length distributions for the COM and EDU user classes; and
- 2012 National Household Travel Survey (NHTS) which was processed and used to calibrate the mode splits and trip length distributions for the EMP, OTH and RET.

Mode shares, trip distance, and journey time distributions were produced from these data for calibration. Demand matrices were produced from the observations and assigned to the road/PT models to derive the target trip cost distributions for each of the 33 journey purpose groupings.

The NHTS was used to extract mode shares based on the internal area of the MWRM when possible. If the observed sample was too small for a particular purpose (less than 100 records), all the Non-Dublin NHTS trips were used in order to set the target mode share.

The observed trip length, journey time and generalised cost distributions were extracted from POWSCAR in the internal area of the MWRM for COM and EDU purposes. The other segments were calibrated to either MWRM or all non-Dublin NHTS subsets depending on the available sample size.

2.3.2 Observed Road Data

There was a large volume of data available for road calibration in the MWRM. In total, for all the regional models, there are between 6,000 and 7,000 road traffic survey data records nationwide, including manual classified counts, automatic traffic counts (ATC) and SCATS data, which were collated under the Data Collection task. The data was collated in 2014 and represents data from January 2009 to December 2014. Approximately 250 link counts were available in the modelled area.

Figure 2.2, below, indicates the location of the traffic count data that was collated.

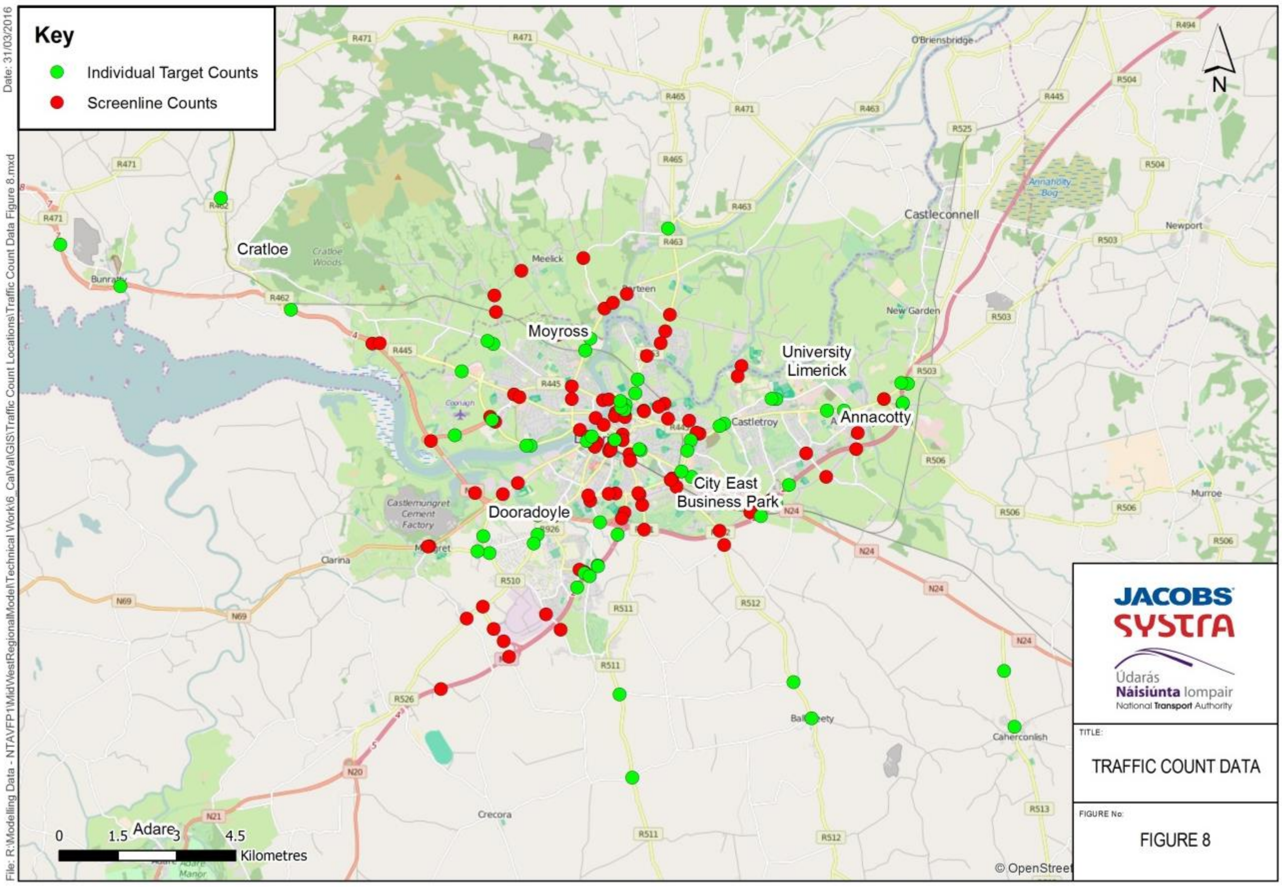


Figure 2.2 Location of Traffic Count Data – MWRM area

Journey time validation data for 14 routes (inbound and outbound) was also used and is illustrated in Figure 2.3 below. There are three journey time categories that form a hierarchy of routes. Category 1 consists of the urban, national primary, motorway and arterial commuter routes. Category 2 comprises regional and secondary routes, while Category 3 include inter urban routes between regional towns. The journey time data was extracted from TomTom data acquired by the NTA. Further information on observed road data is provided in the MWRM Road Model Development Report.

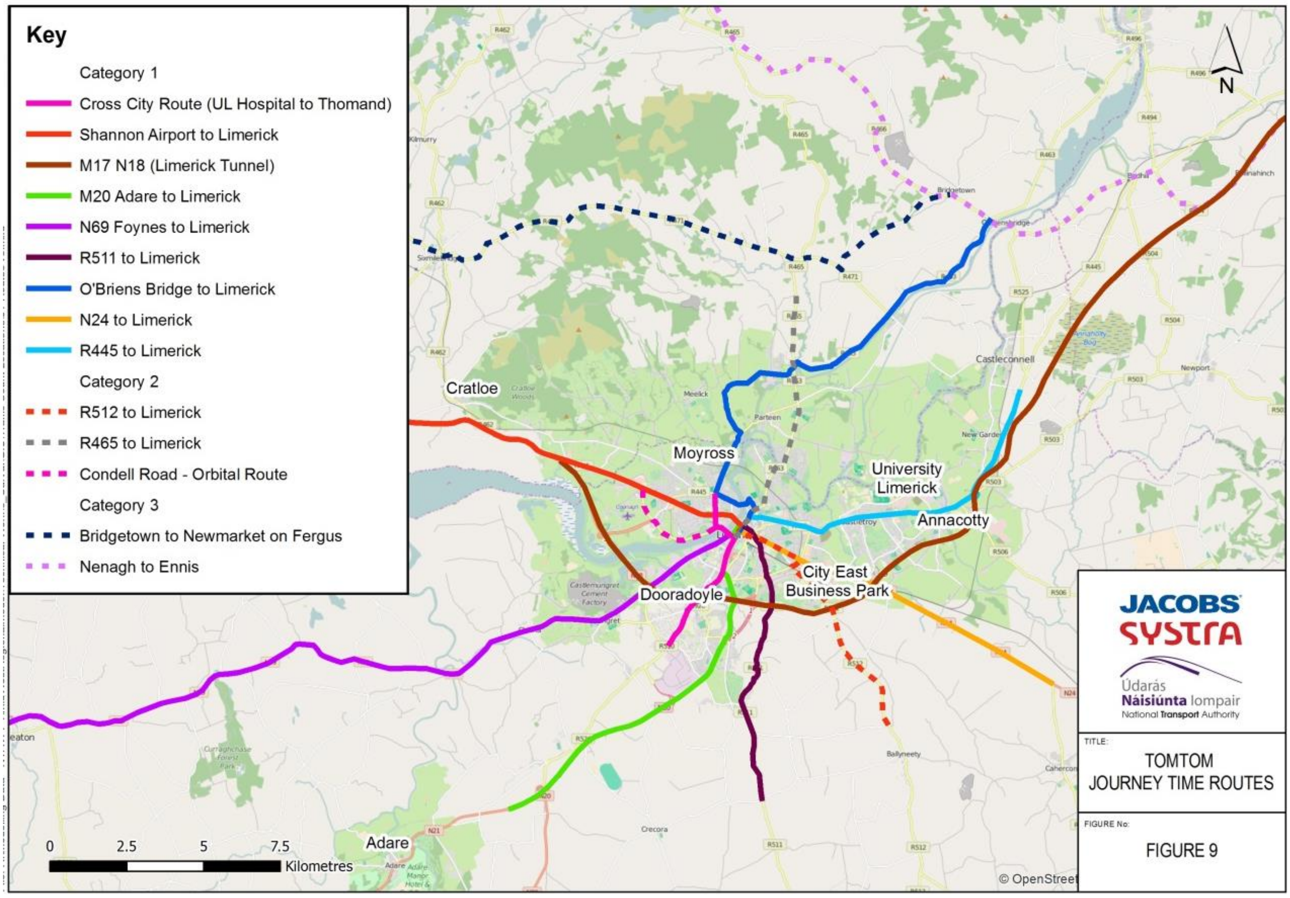


Figure 2.3 TomTom Journey Time Routes

2.3.3 Observed Public Transport Data

Observed Public Transport count data was very limited and only available for Rail boardings and alightings from the 2013 Rail Census. Data from the National Rail Census was processed to obtain boarding and alighting figures for all the rail lines within the MWRM. Only rail stations located within the internal area of the model were considered in the overall summaries.

2.3.4 Observed Active Modes Data

The available active modes data was limited to counts at a small number of locations around Limerick City Centre, and as such, no calibration of the Active Modes assignment model was undertaken. The counts were only used as a sense-check of the results. Further information on available Active Modes observed data is presented in the MWRM Active Modes Report.

2.4 Automated calibration stage

2.4.1 Automated calibration

The automated calibration stage is used to provide an initial, approximate calibration of the demand model. The mode and destination choice loop is iterated while automatically varying selected calibration parameters to try and match key observations, such as the average journey lengths and mode shares.

Mathematically the probability of making a choice is:

$$P_n = \frac{e^{\lambda U_n}}{\sum_{n \in N} e^{\lambda U_n}}$$

Where: λ <0 is the relevant spread parameter;
U_n is the utility (or composite utility) of choice n; and
N is the subset of choices considered.

The utility value, which is required by both the mode and destination choice models, is calculated using the following formula:

$$U_{ij}^{mode} = \alpha^{mode} \times GC_{ij}^{mode} + \beta^{mode} \times \ln\left(GC_{ij}^{mode}\right) + ASC^{mode} + IZM^{mode}$$

The objective of the automated calibration stage is to adjust the lambda values and the utility by mode to match the observed cost distribution, mode share, and level of intrazonals (by mode), for each of the 33 journey purposes.

In the current version of the model the parameters which can be varied by the automated process are:

- Alpha (α): which controls the calculation of trip utilities at the distribution and mode split stages.
- Mode split lambda (λ): which controls the mode split.
- Intrazonal cost adjustments (IZM): which adjust the overall trip length by controlling the level of intrazonal demand.
- Alternative Specific Constants (ASC): which cover the unquantifiable costs perceived by travellers and not otherwise calculated.

Values of the parameters are initially set to 'neutral' values (IZM = 0, ASC = 0, $\alpha = 1$, $\beta = 0$. The main purpose of the lambda is to control sensitivity to costs in the calculation of choice probabilities based on the above utility; the higher it is, the higher the chances of a change in mode or destination when costs change. For mode choice there are separate main mode and active mode lambda values and these values are used in both the mode split and composite cost calculations. The lambda value used in the distribution is set according to WebTag guidance and further adjustments to the distribution calibration result from changes to the other parameters.

Beta values are not used in the current version of the model, and so they are set to zero everywhere. If included, the Beta values could be used to adjust the calculation of trip utilities at the distribution and mode split stages. Similarly, the distribution lambda could also be varied during calibration, instead of remaining fixed, but that is not allowed for in the approach adopted for this version of the model.

The calibrated base assignment models provide the generalised cost inputs to the automated calibration process. This is a fixed input. Alternatively, if a less approximate calibration was required, the generalised costs output from the most recent FDM run could be used as the input.

2.4.2 Check demand calibration

After running the automated calibration stage, the next step is comparing the outputs with the cost, trip length and mode split information in the data. There is a suite of spreadsheets able to do this efficiently and the outputs allow a decision to be made as to whether to proceed to the manual adjustment stage or to refine and repeat the automatic adjustment stage.

2.5 Manual adjustment stage

2.5.1 Manual calibration

Once a reasonable result was achieved using the automated process, manual adjustment could begin.

In some early iterations of the model this stage involved adjustments to trip ends and tour proportion weightings. In some cases, these improved the overall operation of the NDFM and these modifications were retained. In other cases, they tended to complicate a process of output factoring which could be better achieved by other means. For this reason, later iterations of the process did not include adjusted trip ends (with the exception of those which are now incorporated into the NDFM) or, for the most part, tour proportion weightings. Most adjustments in later versions of this stage are to ASC values and Period to Hour factors.

This stage may also include:

- The calibration of the mode split for the demand in some special zones, such as airports.
- The calibration of the Park & Ride module.

2.5.2 Check flow and demand calibration

Once suitable adjustments were made, and the FDM was run through, the standard output dashboards could be used to examine the levels of calibration in the demand, road, PT and active modes models and to decide if further adjustments were required. If further adjustments were required then they could be made, otherwise the process could proceed to the assignment adjustment stage, as described below.

It is important to note that the process is fluid and will switch from FDM calibration to assignment adjustment or vice versa, depending on the course of action suggested by the available results at the time.

2.6 Assignment Adjustment Stage

2.6.1 Matrix estimation, PT factoring and active modes adjustments

At this stage the matrices produced by the demand model may be adjusted to improve the fit of observed to modelled flow in the assignment models, using either matrix estimation (for road), PT factoring (for PT) or simple factoring (for active modes).

2.6.2 Check flows

The results of the adjustments with respect to assignment calibration are then checked to decide if further estimation / factoring is required, or if the pre-estimation matrices could be improved by further FDM calibration.

2.6.3 Cost extraction

The FDM may be improved further at this stage (in terms of distribution and mode split across the region) if the costs used are obtained from the latest assignments.

In later iterations, it may also help to update the (non FDM) processes that create internal goods matrices and taxi proportions with the latest assignment results. This is discussed in more detail below.

2.7 Finalisation

2.7.1 Exit criterion

The above process is repeated until it is observed that new demand model outputs do not produce noticeably different assignments as the previous loop of the process before estimation.

2.7.2 Finalisation

Once a stable solution is achieved the model can be finalised. At this stage three processes are required:

1) Internal goods matrices must be taken from the matrix estimated networks and provided as an input to the FDM.
2) The proportion of OTH[1] trips in each sector which are made by taxi must be extracted from the estimated road networks and provided as an input to the FDM.
3) The difference between the matrices output by the demand model and the matrices output by the estimation / factoring processes must be calculated. These are the incremental matrices and must be provided as in input to the FDM.

[1] OTH refers to the 'other' user class. The remaining user classes are employer's business (EMP), commuting (COM), education (EDU) and retired (RET)

2.7.3 Reporting

With these three updated sets of inputs and a stable set of cost matrices, the final output from the FDM should match the final estimated / factored output and final demand, and flow dashboards can be populated.

3 MWRM Demand Model calibration test history

3.1 Introduction

The process of calibrating the MWRM began in August 2015 in Version 2.0.0, Save 5 of the RMS FDM.

Input files were fully checked to ensure that they matched the latest input formats, were for the correct region and had been upgraded to be the best match to the actual networks on the ground, based upon the lessons learned from Model Version 1 of the ERM and the four other regional models.

3.2 Calibration / Validation Phases

The calibration and validation process can be broadly split into three phases. Phase 1 involved adjustments to trip ends, tour proportions, mode split lambda values and ASC values. Park and Ride (PnR), Free Workplace Parking (FWPP) and Parking Distribution (PDist) were switched off for Phase 1.

Phase 2 incorporated fixes and updates to the FDM and NDFM (which affected all of the regional models). Due to the updates in the NDFM, the trip end and tour proportion adjustments were not required and so were removed during Phase 2.

Phase 3 used an enhanced and updated version of the model with more available functionality and a revised treatment of parking costs which required re-calibration.

Overall Phase 1 was undertaken from November 2015 to late March 2016 and Phase 2 from March to April 2016. Phase 3 began in early May 2016 and ended in August 2016.

The remainder of this chapter describes the calibration of the FDM by phase, detailing the particular tests that were undertaken as part of each phase in turn.

3.3 Phase 1 Test 1

3.3.1 Run Details

Model Version: *2.0.0, Save 5*
Scenario Name: *MWBY01_A3*
Date: *November 2015*
Growth: *A3*

The purpose of Test 1 was to confirm that the core parts of the model were functioning correctly, to check the initial road and PT networks and to commence the calibration process. Initial costs were those provided from the assignment of the Pre FDM MWRM Prior Matrix (v2).

3.3.2 Results / Outputs

The run completed successfully. As the purpose of this run was to demonstrate that the model would run through no specific results were produced at this stage.

3.4 Phase 1 Test 2

3.4.1 Run details

Model Version: *2.0.0, Save 6*
Scenario Name: *MWBY01_A3*
Date: *December 2015*
Growth: *A3*

Input costs were obtained from previous run (Test 1). This run included POWSCAR observed data for the first ten trip purposes and the NHTS for the remaining 23 purposes. Journey time routes were identified and agreed with the NTA.

3.4.2 Results / outputs

Road trips were underestimated, and demand was low across all screenlines in the AM time period. The other time periods were not examined in detail.

3.5 Phase 1 Test 3

3.5.1 Run details

Model Version: *2.0.0, Save 7*
Scenario Name: *MWBY03 _A3*
Date: *20th January 2016*
Growth: *A3*

Matrix estimation on the road model was used to improve the level of demand assigned to the network and hence to provide improved costs for future runs. The PT dashboard was updated to include city centre cordon passenger numbers within the dashboard for validation.

3.5.2 Results / outputs

As the figures below indicate, the modelled mode share was too high for car trips and too low for PT.

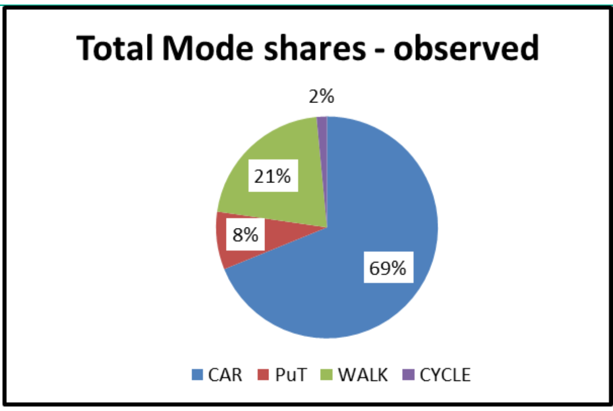
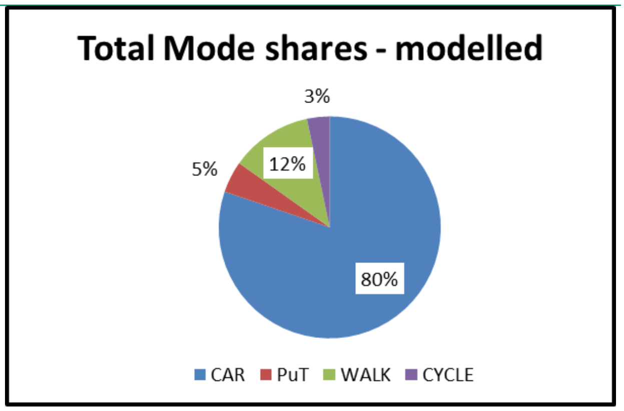
Total Mode Share - Observed	**Total Mode Share - Modelled**
	

Figure 3.1 Test 3 Total Mode Share

3.6 Phase 1 Test 4

3.6.1 Run details

Model Version: *2.0.0, Save 8*
Scenario Name: *MWBY04_A3*
Date: *22nd January 2016*
Growth: *A3*

Input costs were obtained from the previous test run. Revised inputs consisted of new trip ends to correct an error in the processing of Employers Business trip ends. As a result, there was a reduction in the overall demand in the road matrices.

3.6.2 Results / Outputs

This test resulted in slightly improved mode shares compared to the previous test. In the AM, there was a 4% reduction in modelled car trips, but the modelled car mode share remained high, at 76%, compared to the observed mode share of 69%.

Correspondingly, modelled bus and rail passenger flows were significantly lower than observed passenger flows as illustrated in Figure 3.2 which presents pre matrix estimated AM figures showing flows inbound on a number of links.

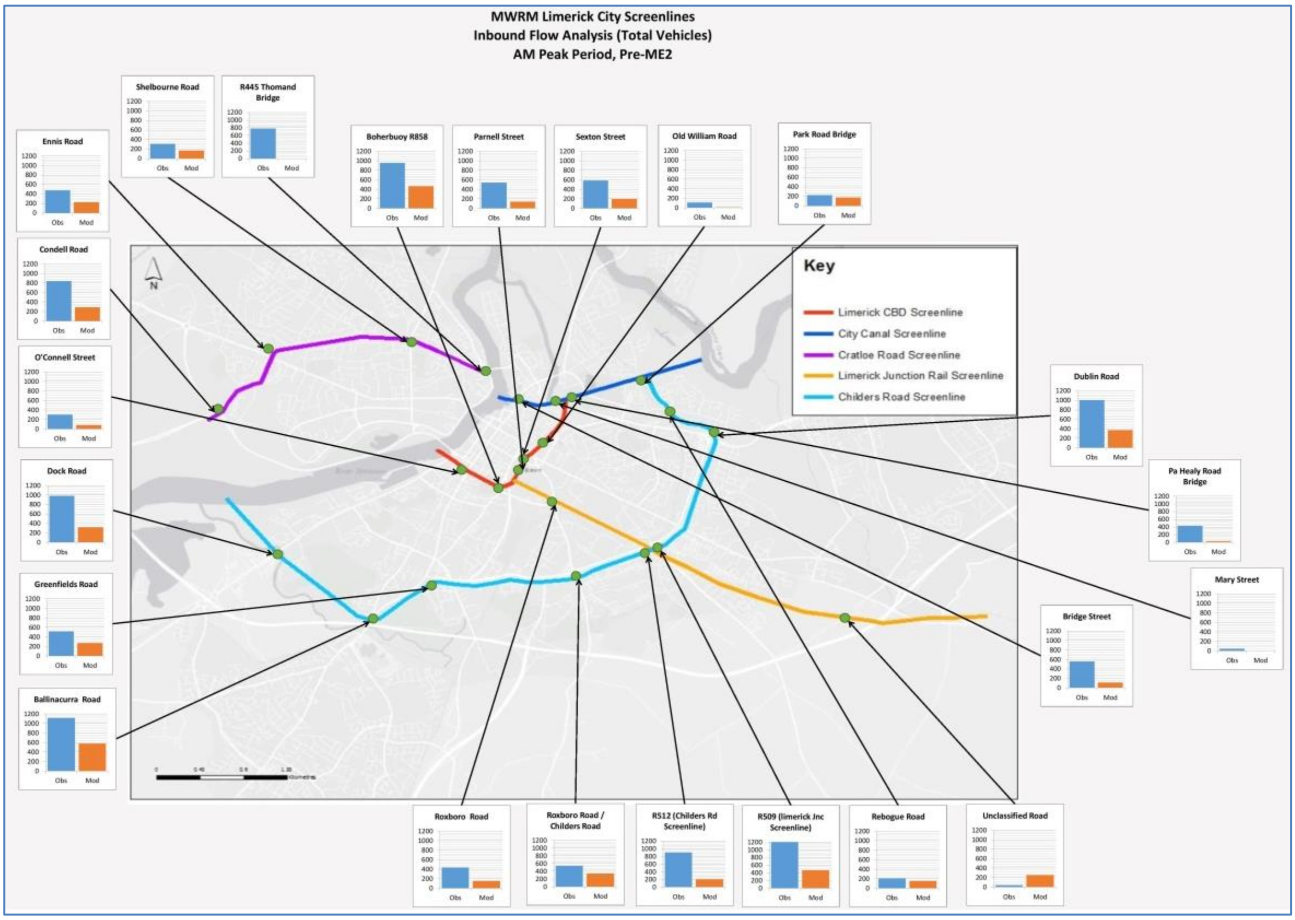


Figure 3.2 AM Inbound Flow Analysis (Pre-ME2)

3.7 Phase 1 Test 5

3.7.1 Run details

Model Version: *2.0.1, Save 12*
Scenario Name: *MWBY05_A3*
Date: *9th February 2016*
Growth: *A3*

Costs applied were obtained from the Test 3 runs and the NHTS observed data used to check the calibrations was updated. The new model version (Save 12) included a corrected intrazonal process and modifications which resulted in a decrease in active modes trips. PDist was turned on but failed to run correctly.

3.7.2 Results / Outputs

The road dashboard demonstrated an improvement in modelled journey times in both pre and post matrix estimation outputs when compared to the 2012 TomTom observed journey time data. Up to this point only household survey, rather than POWSCAR, data was being used to adjust trip length distributions during calibration. From this stage POWSCAR data was also included, and this accounts for the improved match to the TomTom data and improved calibration of the highways model.

The figure below outlines the total modelled mode share in comparison with the total observed mode share.

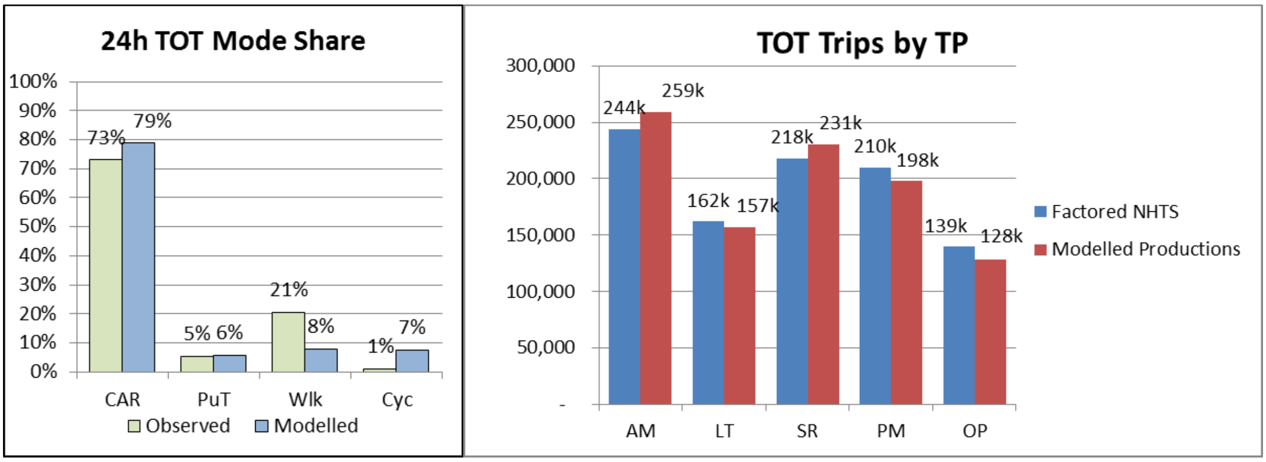


Figure 3.3 Phase 1 Test 5 - Total Mode Share and Trip Demand by Time Period

The modelled mode share compares well with the observed (NHTS) mode share.

3.8 Phase 1 Test 6

3.8.1 Run details

Model Version: *2.0.1, Save 12*
Scenario Name: *MWBY06_A3*
Date: *9th February 2016*
Growth: *A3*

This was a sensitivity test that fed in costs from Test 3 to assess the impact of these on the FDM and the calibration of the model. This was also the first version of the FDM set to run more than one loop and this was achieved by setting the Max DLoop key to 5.

3.8.2 Results / Outputs

This run failed at the end of the first loop due to an error in the way the loop process was referencing the input files. Due to this no detailed outputs are available but the error was addressed for the next test.

3.9 Phase 1 Test 7

3.9.1 Run details

Model Version: *2.0.1, Save 12*
Scenario Name: *MWBY07_A3*
Date: *9th February 2016*
Growth: *A3*

This was a basic sensitivity test with the costs for the road user classes (taxis, employment, commute, education and car other) increased by 20%, relative to the matrices produced from Test 3. This change was made as it was suspected that the road costs were too low and this test sought to investigate how increased costs would affect the calibration of the model.

3.9.2 Results / Outputs

Increased costs on user classes made it more expensive to travel generally and so decreased trips generally and moved more of them to active modes The figure below compares total road trips in Test 5 with this test.

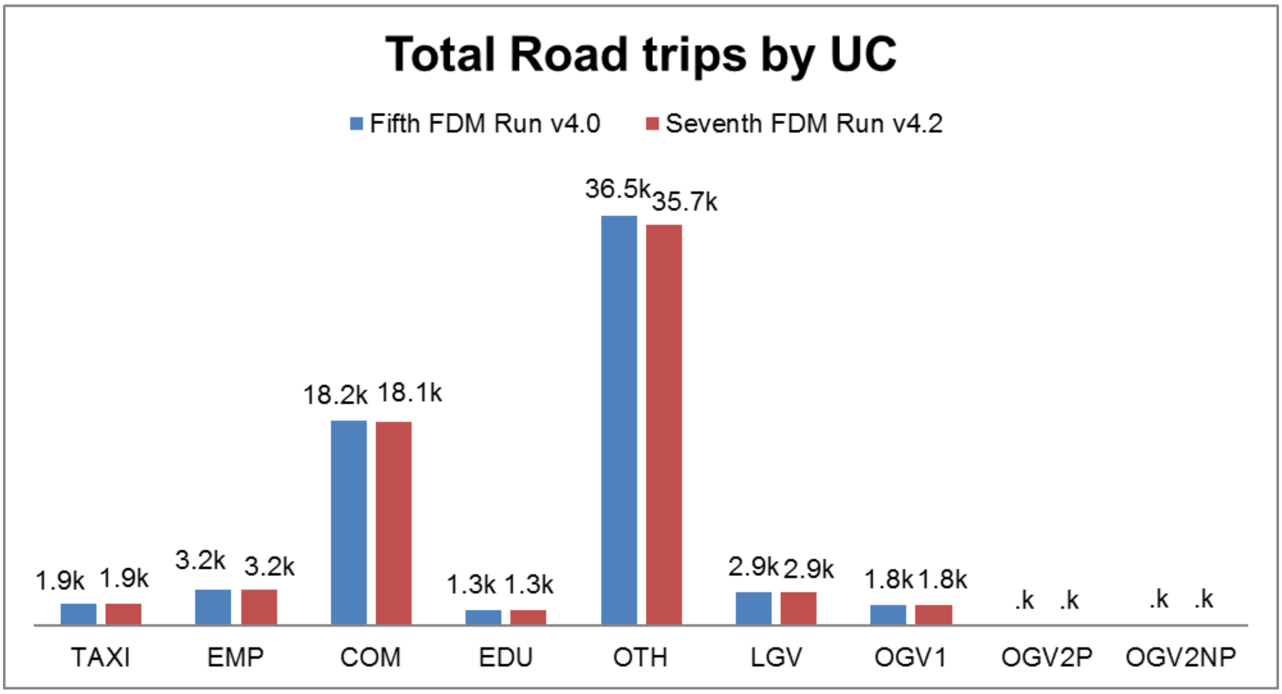


Figure 3.4 Test 7 vs Test 5

Although the results of this test were broadly as expected, a road dashboard indicated that it did not improve road network calibration.

3.10 Phase 1 Test 8

3.10.1 Run details

Model Version: *2.0.1, Save 12*
Scenario Name: *MWBY08_A3*
Date: *11th February 2016*
Growth: *A3*

This was another sensitivity test that looked at a new parking cost application introduced in this FDM version.

3.10.2 Results / Outputs

The result of the introduction of the new parking cost application had no impact on the sector to sector road productions.

3.11 Post Phase 1 Calibration and Validation Process Review

In parallel with the preceeding three tests, a new version of the FDM was being prepared based on tests undertaken in the SWRM. This model was 2.0.2, Save 14 and was the main and (and first ‘stable’) version of the FDM used across all of the regions.

In addition, some of the modifications to the trip ends made during Phase 1 were considered justified and these were incorporated into the NDFM. On the basis of these, a new demand forecast, A9, was produced and used in subsequent tests.

With this new demand forecast, the adjustment of trip ends and tour proportions was excluded from subsequent calibration in the absence of a sound theoretical basis for these adjustments.

Thus, from Phase 2 onwards, the process of calibration / validation only included adjustments to mode split lambda, ASC and period to hour factors.

3.12 Phase 2 Test 1

3.12.1 Run details

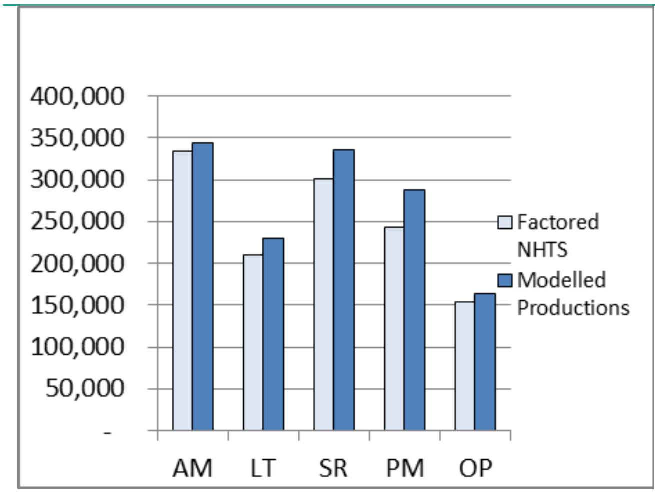
Model Version: *2.0.2, Save 14*
Date: *March 2016*
Growth: *A9*

The inputs to this run were the same as in previous tests, aside from the growth scenario and the new model version.

3.12.2 Results / Outputs

The revised growth scenario resulted in an increase in trip ends and so in demand. The match between these and the household interview data is shown in Figure 3.5.

Car Trips by Time Period



PT Trips by Time Period

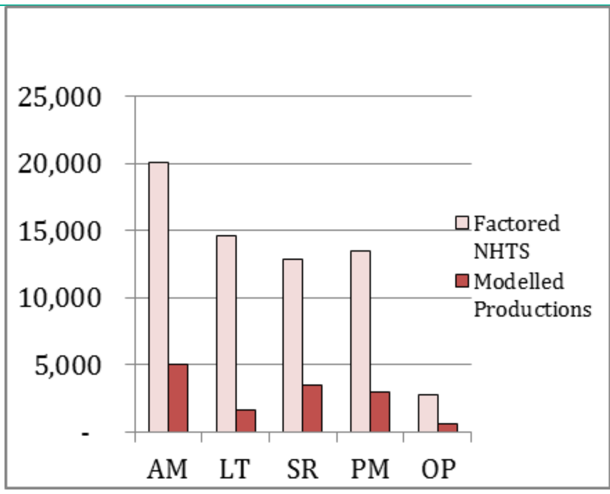


Figure 3.5 Car and PT Trip Ends by Time Period

The increased trip ends resulted in a consequent increase in flows across screenlines which is summarised in the tables below.

Table 3.1 Impact of new growth on road screenlines

Time period	Observed	Modelled (A3)	Modelled (A9)
AM	16,357	10,280	32,577
LT	10,202	4,510	17,599
SR	10,854	6,499	20,978
PM	19,833	8,400	26,646

Table 3.2 Impact of new growth on PT screenlines

Time period	Observed	Modelled (A3)	Modelled (A9)
AM	484	2,877	5,110
PM	487	2,325	6,404

Figure 3.6 and Figure 3.7 below shows the detailed road screenline calibration for inbound and outbound flows before and after matrix estimation. This indicates that the match across several was quite good at this stage.

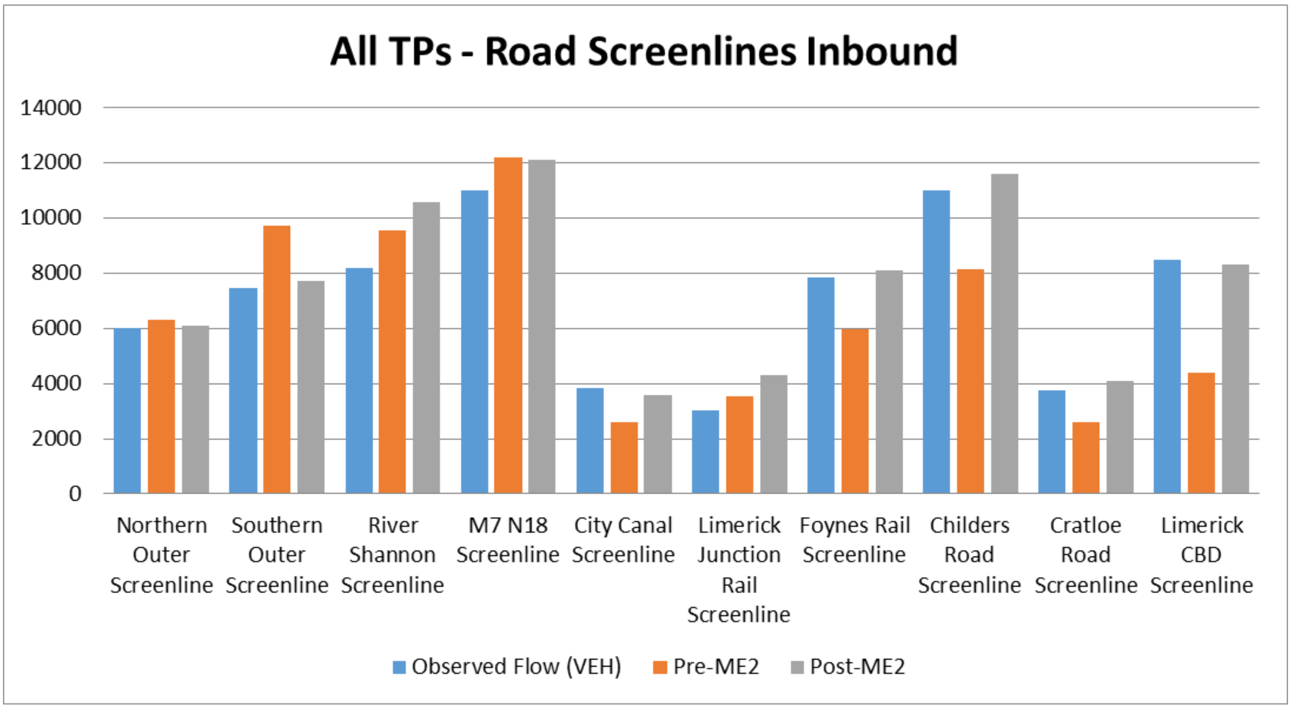


Figure 3.6 Modelled versus observed flows – inbound

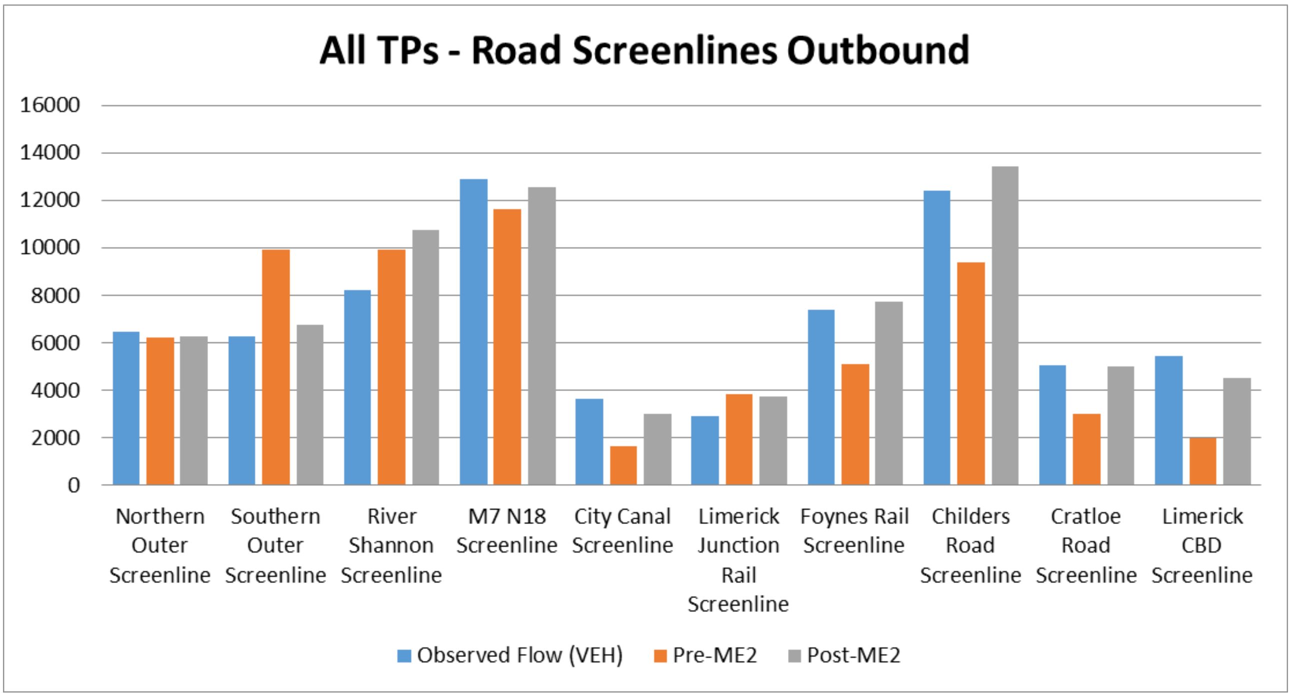


Figure 3.7 Modelled versus observed flows – outbound

Figure 3.8 and Figure 3.9 show the comparison between the modelled and observed PT data indicating that there was still progress to be made here at this stage.

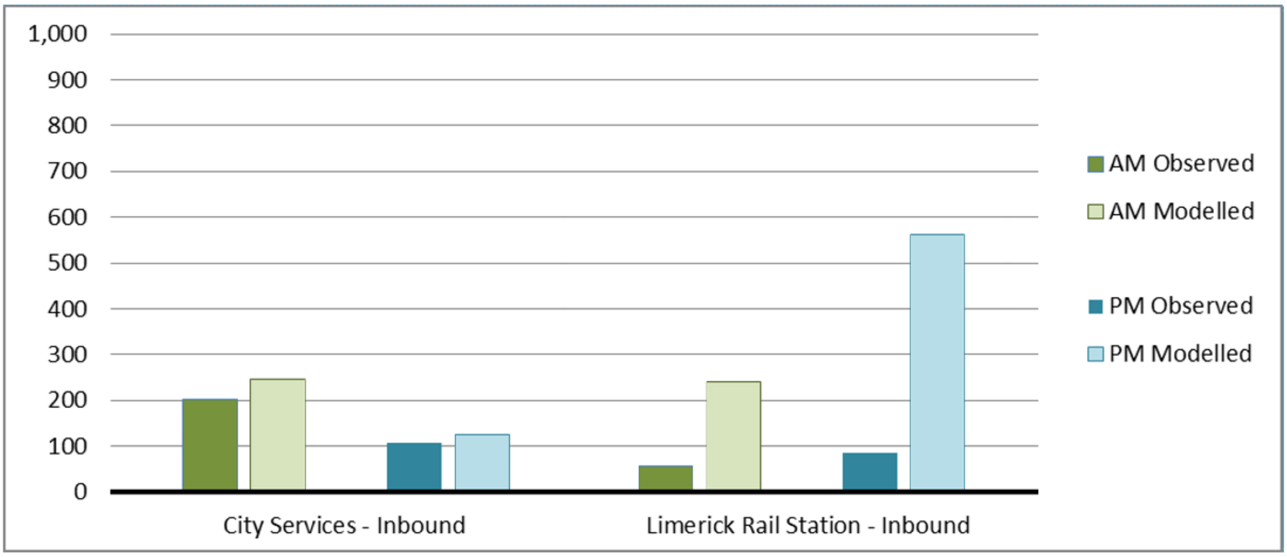


Figure 3.8 Modelled versus observed passenger flows - inbound

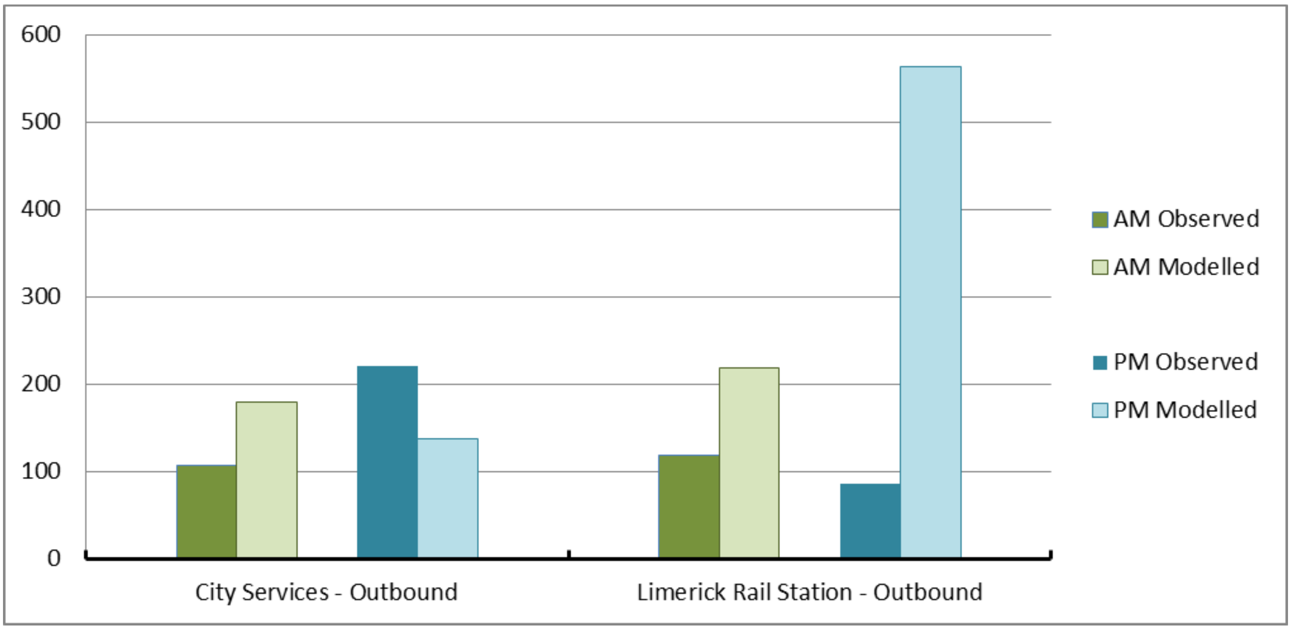


Figure 3.9 Modelled versus observed passenger flows - outbound

3.13 Phase 2 Test 2

Model Version: *2.0.2, Save 14*
Scenario Name: *MWBY16_A9*
Date: *30th March 2016*
Growth: *A9*

3.13.1 Run details

Following Test 1, a review of the road and PT networks was carried out. This resulted in the selection of an improved set of road counts to be used for matrix estimation and in the dashboards, as well as changes to some speed-flow curves and centroid connectors, particularly those for the PT network. More detailed descriptions of these changes can be found in the MWRM Road Model Development Report and MWRM Public Transport Model Development Report. ASC changes were also re-set to allow the calibration process to start over.

3.13.2 Results / Outputs

This run was used only to derive improved Period to Hour (PtH) factors to feed into the next run.

3.14 Phase 2 Test 3

Model Version: *2.0.2, Save 14*
Scenario Name: *MWBY16_A9*
Date: *30th March 2016*
Growth: *A9*

3.14.1 Run details

This test incorporated the new PtH factors and removal of speed flow curves from the Limerick urban area, bringing it into line with urban areas in the other regional models (for more details see the MWRM Road Model Development Report).

3.14.2 Results / Outputs

The new PtH factors had a positive impact on the level of journey time validation in the road network with Table 3.3 showing an example from the AM time period indicating that some extra routes now pass validation.

Table 3.3 Journey time validation (AM peak)

AM	Previous Pre ME	Test 3 Pre ME	Previous Post ME	Test 3 Post ME
Total	28	28	28	28
Pass	19	21	17	18
Pass %	68%	75%	61%	64%

3.15 Phase 2 Test 4

Model Version: *2.0.2, Save 14*
Scenario Name: *MWBY16_A9*
Date: *18th April 2016*
Growth: *A9*

3.15.1 Run details

This test followed a second review of the road network which led to further streamlining of counts and an introduction of some additional count locations to strengthen the screenline data. Costs and PtH values were taken from Phase 2 Test 3.

3.15.2 Results / Outputs

Only AM and PM results were examined in detail as the interpeak results were considered unacceptable following an initial review.

3.16 Phase 2 Test 5

Model Version: *2.0.2, Save 14*
Scenario Name: *MWBY16_A9*
Date: *18th April 2016*
Growth: *A9*

3.16.1 Run details

This test was intended to improve the interpeak matrices by using new costs from Test 4 and revised ASC and PtH values. PnR and PDist were still turned off at this stage but FWPP was turned on.

3.16.2 Results / Outputs

Detailed outputs for this test were not produced but following a review by the NTA of the changes brought about by matrix estimation, there were some amendments made to the matrix estimation process. More details on these can be found in the MWRM Road Model Development Report.

3.17 Phase 2 Test 6

Model Version: *2.0.2, Save 14*
Scenario Name: *MWBY16_A9*
Date: *19th April 2016*
Growth: *A9*

3.17.1 Run details

The inputs from this Test were the same as those for Test 5 with the exception of the road network, which included some minor network changes to link speeds and capacity indices in order to reflect the local road conditions.

3.17.2 Results / Outputs

Table 3.4 shows the level of calibration before and after matrix estimation in this test compared to that in previous tests for the AM time period.

Table 3.4 AM GEH Calibration Performance

AM	Test 3 Pre	Test 3 Post	Test 4 Pre	Test 4 Post	Test 5 Pre	Test 5 Post	Test 6 Pre	Test 6 Post
GEH < 5	33%	**89%**	36%	**87%**	34%	**86%**	31%	**87%**
GEH < 7	44%	**91%**	43%	**91%**	43%	**92%**	43%	**91%**
GEH < 10	53%	**94%**	51%	**94%**	51%	**93%**	53%	**93%**
GEH > 10	47%	**6%**	49%	**6%**	49%	**7%**	47%	**7%**

This table indicates that there was little change in the GEH values in the AM and the same can be said for IP1, IP2 and PM time periods. Journey times improved for the AM, IP1 & IP2 periods but not for PM. The main parameter that improved flow calibration was the PtH factor.

3.18 Post Phase 2 Calibration and Validation Process Review

At this stage the model was handed to the core development team who continued with the calibration process, with a particular view to improving the calibration of PT flows.

3.19 Phase 3 Test 1

Model Version: *2.0.8*
Scenario Name: *MWBY17_A9*
Date: *20th May 2016*
Growth: *A9*

3.19.1 Run details

PDist was turned on which required the model to be recalibrated as this version included revised treatment of parking costs. At this stage a new PT network was supplied by the PT development team which included updates to:

- Fares;
- Capacities;
- Headways;
- In-vehicle Time Factors;
- Boarding Penalties; and
- Non-Transit Legs.

3.19.2 Results / Outputs

The calibration of this run was somewhat worse than that obtained previously but this was expected due to the revised treatment of the parking costs and the primary purpose of this test was to get revised cost skims for the next test.

3.20 Phase 3 Test 2

Model Version: *2.0.8*
Date: *24th May 2016*
Growth: *A9*

3.20.1 Run details

The costs from the previous test were used as an input to this test and the PDist inputs were revised to limit PDist to Limerick city as it was previously operating over an unnecessarily large area. Figure 3.10 illustrates the revised PDist area.

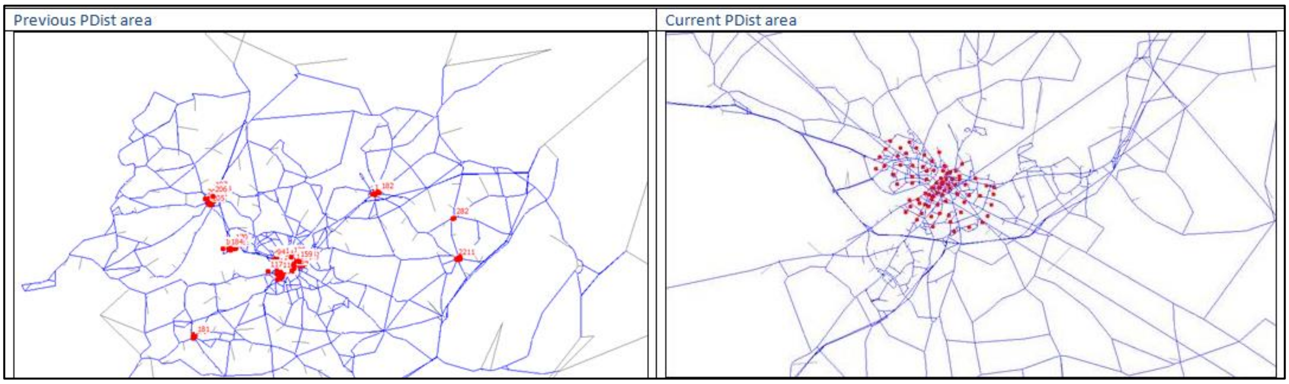


Figure 3.10 Previous and revised PDist Area

3.20.2 Results / Outputs

The results of this test indicated that there appeared to be an excessively large number of external trips. Table 3.5 shows that between 13% and 30% of assigned trips are coming to or going from external zones which is unreasonably high. These trips have a big impact on traffic flows due to their long average trips lengths (129km vs 12km for internal trips).

Table 3.5 Internal vs external trips by time period

	Internals (PCUs)	Externals (PCUs)	% externals
AM	84,509	12,634	13%
LT	38,395	9,995	21%
SR	56,515	11,656	17%
PM	53,266	12,879	20%
OP	7,393	3,174	30%

This resulted in a review of the RMSIT process to ensure that the external trip inputs to each area were appropriate.

3.21 Phase 3 Test 3

Model Version: *2.0.8e*

Scenario Name: *MWBY29_A9 to MWBY33_A9*

Date: *June 2016*

Growth: *A9*

3.21.1 Run details

This run included updated Car Driver to Car User factors (CDCU). PDist was turned on and the model included two additional special zones[2], in addition to some updates to the FDM to improve the FWPP process and the treatment of greenfield sites.

[2] Foynes Port and Shannon Airport – see Annex 2 for more information

As it did not prove possible to update RMSIT, this test included factors to bring the RMSIT modelled flows in line with the observed NRA count data. These factors were based on the labelled count locations shown in Figure 3.11 (M18, M7, M8, N20 and N21) which are found on the edge of the buffer network (red). The factors derived were then applied to external to external trips.

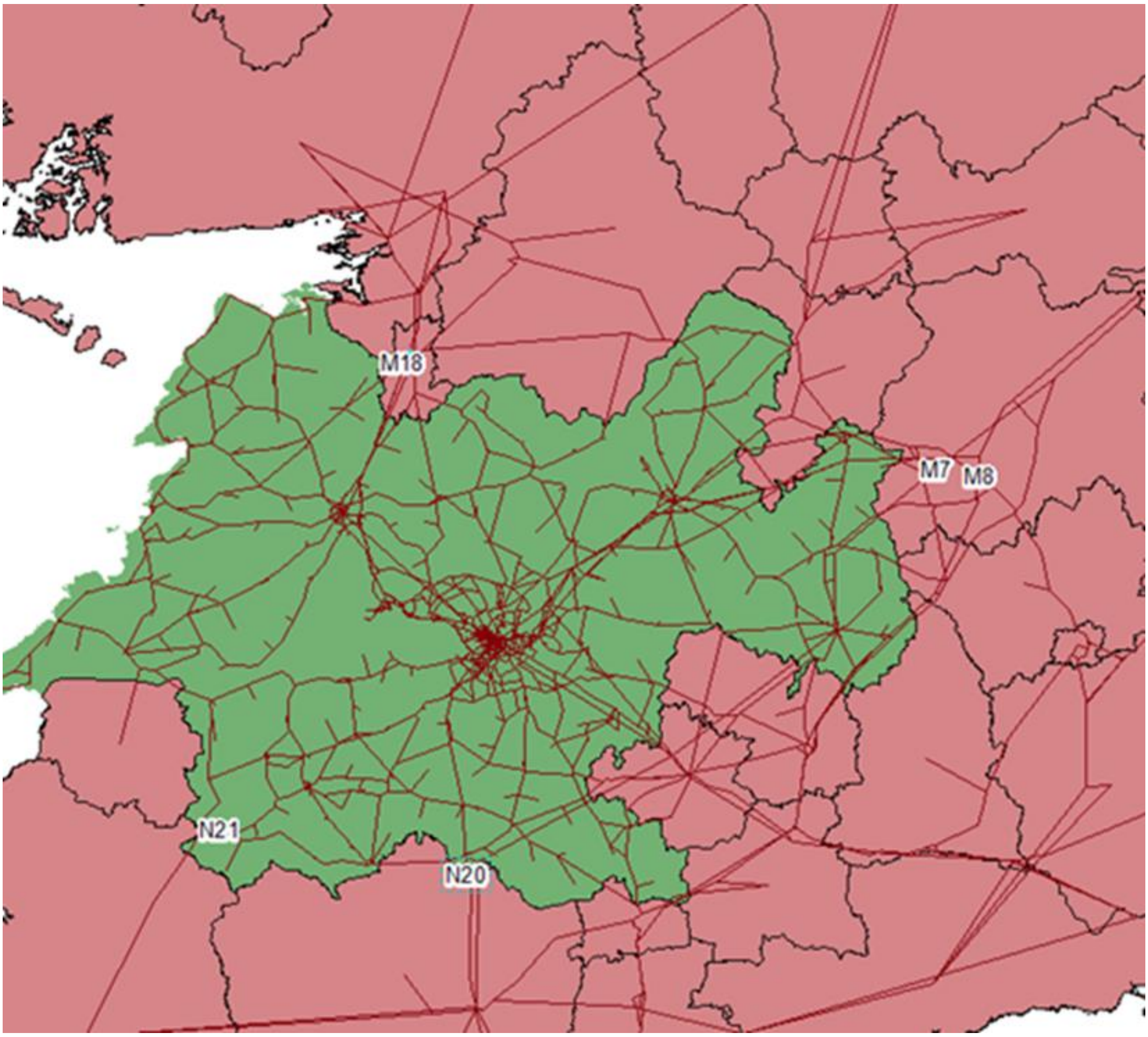


Figure 3.11 NRA count locations used to generate factors for the RMSIT correction

There were a range of subtests included in this test which incorporated tweaks in parameters such as:

- PtH factors;
- ASCs values;
- Base generalised costs (with & without the Limerick Tunnel)

More information on the changes at each stage is given in Table 3.6.

Matrix estimation and PT factoring were carried out for sub-test MWBY32 which gave the best results.

Table 3.6 Details of sub-tests

Sub-test	Comments
MWBY29	RMSIT reduced when exceeds NTEM (capped at 100% of NTEM) PT NT leg file corrected for extra (special) zones
MWBY30	FWPP corrected (scripts now consistent with WRM and SWRM) FWPP capacities set to 0 (COM and EDU now distributed) PDist capacities updated Base gen costs with tunnel open
MWBY31	ASC values adjusted Updated PDist capacities
MWBY32	RMSIT capped at 70% of NTEM HGV demand for special zones corrected (converted to PCUs)
MWBY33	Base gen costs with tunnel closed

3.21.2 Results / Outputs

The output from sub-test MWBY32 were a significant improvement on the results obtained at previous test stages, both due to the improved FDM operation and to the revised matrix estimation process (trip end constraints and a XAMAX = 2 for cars and 15 for goods vehicles). Count calibration and journey time validation both improved and there were also improvements in the flows at the limits of the model (the external movements). Count calibration (screenlines and individual links) stood at:

- AM – 46% pre & 80% post matrix estimation
- IP1 – 64% pre & 86% post matrix estimation
- IP2 – 51% pre & 83% post matrix estimation
- PM – 44% pre & 75% post matrix estimation

The journey time validation is summarised below:

- AM – 79% pre & 82% post matrix estimation
- IP1 – 93% pre & 93% post matrix estimation
- IP2 – 86% pre & 89% post matrix estimation
- PM – 79% pre & 86% post matrix estimation

3.22 Phase 3 Test 4

Model Version: *2.0.8e*
Scenario Name: *MWBY34 to MWBY36*
Date: *5/07/2016-21/07/2016*
Growth: *A9*

3.22.1 Run details

This test took updated base generalised costs resulting from the matrix estimated and PT factored version of Test 3 (sub-test MWBY32) as well as the updated internal goods matrix from this previous test. Incremental matrices were also estimated based on the previous runs.

3.22.2 Results / Outputs

A comparison between the observed and modelled mode shares is shown in Figure 3.12 and indicates that there is a good overall mode share match.

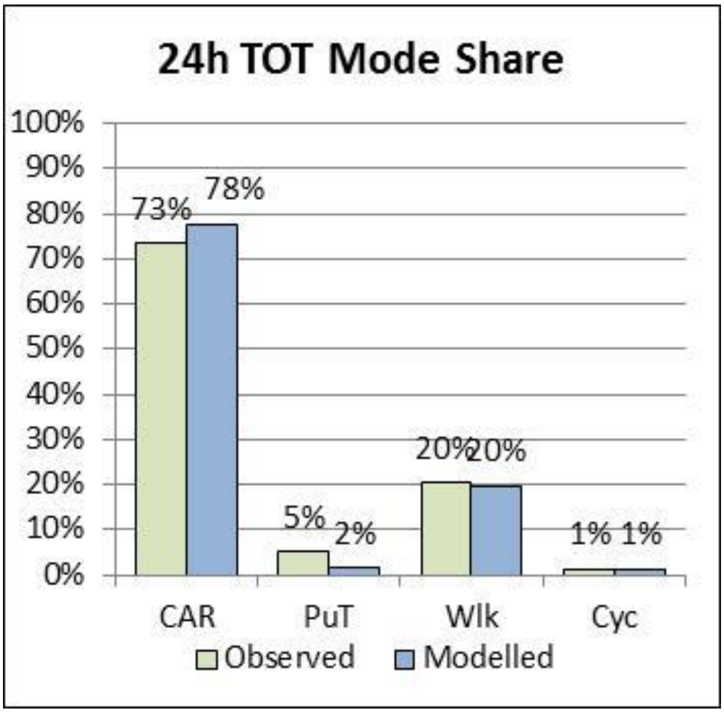


Figure 3.12 Observed vs modelled mode share

On the road model calibration side, journey times and flows were similar to the previous test. The road network performs well, improving the calibration of flows passing WebTag criteria (screenlines and individual links):

- AM – 45% pre & 79% post matrix estimation
- IP1 – 63% pre & 81% post matrix estimation
- IP2 – 50% pre & 82% post matrix estimation
- PM – 42% pre & 75% post matrix estimation

The journey time validation information is summarised below and is only marginally altered compared to that in the previous test.

- AM – 79% pre & 79% post matrix estimation
- IP1 – 93% pre & 93% post matrix estimation
- IP2 – 89% pre & 93% post matrix estimation
- PM – 82% pre & 86% post matrix estimation

For the PT side, total boardings and alightings by time period are summarised in Figure 3.13. Aside from PM rail boarding these results are reasonable.

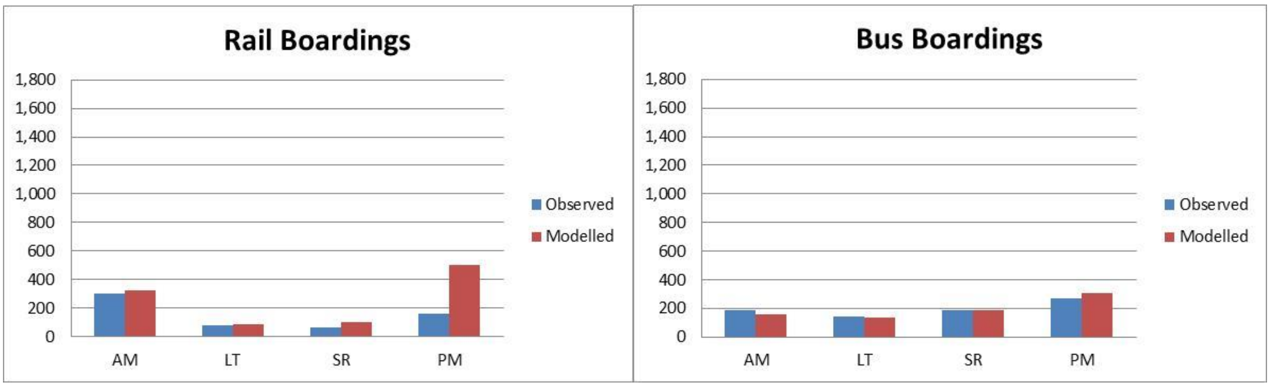


Figure 3.13 Observed vs modelled PT boardings / alightings

Although the results were much improved the demand dashboard still indicated that the car mode share was too high and the PT mode share was too low. In addition, the match for some individual journey time routes was poor and it was felt that traffic patterns in the PM could be improved.

3.23 Phase 3 Test 5

Model Version: *2.0.8e*
Scenario Name: *MWBY37 to MWBY44*
Date: *25/07/2016-03/08/2016*
Growth: *A9*

3.23.1 Run details

In order to address the issues raised by the previous test, a number of adjustments were made to the model inputs.

The demand dashboard showed an overestimated average trip length for PT. In order to correct this the factors calculated to apply to the RMSIT road inputs were also applied to the PT inputs so as to reduce the number of longer distance trips coming from and to external zones.

In parallel, a detailed review of the PT services was undertaken and some adjustments were made to both the rail and bus coded services, particularly in relation to coded journey times and to PT services between County Kerry and Dublin, where the correct rail service was not being provided between Limerick Junction and Portlaoise in the AM time period, resulting in an overestimation of the trips going through Limerick City and Ballybrophy.

3.23.2 Results / Outputs

The best sub-test in this set was MWBY43 and matrix estimation was undertaken for this run. This showed an improvement in the road model calibration as well as journey times improved, flows at the extents of the network and PT boardings / alightings.

For this sub-test count calibration (screenlines and individual links) stood at:

- AM – 45% pre & 78% post matrix estimation
- IP1 – 66% pre & 89% post matrix estimation
- IP2 – 54% pre & 86% post matrix estimation
- PM – 42% pre & 80% post matrix estimation

Journey time validation information is summarised below:

- AM – 82% pre & 75% post matrix estimation
- IP1 – 86% pre & 89% post matrix estimation
- IP2 – 86% pre & 89% post matrix estimation
- PM – 71% pre & 89% post matrix estimation

There was a notable improvement in the match between modelled and observed PT boardings and alightings (Figure 3.14), particularly in the PM time period.

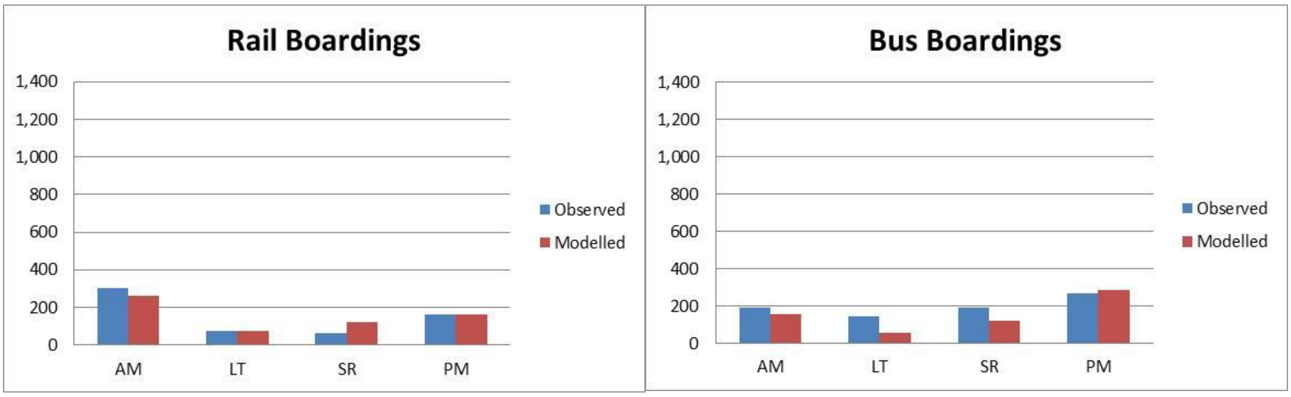


Figure 3.14 Modelled vs observed PT boardings / alightings

3.23.3 Phase 3 Test 6

Model Version: *2.0.8e*
Scenario Name: *MWBY45 to MWBY48b*
Date: *4/08/2016-17/08/2016*
Growth: *A9*

3.23.4 Run details

The sub-tests within Test 6 used base generalised costs from the estimated / factored outputs from Test 5.

In addition, the script coding the allocation of RMSIT matrices into the different matrices of the demand model was corrected resulting in a significant decrease in the proportion of the external demand in the overall PT demand (from 7% to 1% in the AM).

For the final sub-test in this group matrix estimation and PT factoring were performed, incremental matrices were estimated and a final “post-incremental” run produced with the incrementals included.

3.23.5 Results / Outputs

At this stage is was considered that a reasonable level of calibration had been achieved and this run was the last one to be undertaken at this stage.

3.24 Version upgrade and looping to convergence

3.24.1 Model version

Testing in the MWRM continued on an older model version as the newer model versions included the Park & Ride functionality and this required separate calibration. However, once testing of the finalised model version (2.0.23) had been completed using the ERM, the remaining regions were upgraded to that version and recalibrated. In the MWRM this process was undertaken between the 16th January 2017 and the 11th April 2017.

3.24.2 Inputs

Aside from the addition of the Park & Ride inputs there were no other changes to the model inputs made at this stage aside from the adjustments made to the parameters for the purposes of calibrating the model which are described below.

3.24.3 Recalibration

The first step in the recalibration process was to compare the modelled mode shares to observed data, segmented by user class and time period, in order to see how much recalibration was required. Following this, the ASC values for the 33 journey purposes were modified to adjust the relative cost of each mode so give a better match to the observed data. This was an iterative process which took seven passes to reach an acceptable level of calibration for the mode shares. An 8-loop full model run was done each time adjustments were made to the ASCs.

In addition to these ASC adjustments there were some additional sensitivity tests. The first of these was an examination of the effects of network saturation flows on journey times. This test was run in SATURN only and involved increasing the saturation flows by 20%. The rationale behind this was to analyse the sensitivity of the saturation flows and determining their impact on the calibration of journey times. The test indicated that saturation flows had little impact on the journey times, and following this test the TomTom data was re-examined and found to be double counting delays on certain links. This was amended.

The second sensitivity test looked at the Limerick Tunnel which opened in July 2010 and was a significant piece of infrastructure introduced to the MWRM road network. Observed Limerick tunnel movements are from a NRA 2012 dataset, collected not long after the tunnel opened. The road network performance of the MWRM across the River Shannon screenline is particularly weak. As a sensitivity test the Limerick tunnel was closed (AM peak) in order to determine the impact of this on the flows across the screenlines, particularly the River Shannon screenline. This improved the GEH on this screenline from 29.9 to 18.6 and showed that traffic was rerouted through the city centre as a result of tunnel closure. It is difficult to be certain if driver travel patterns would have fully adjusted only two years after the introduction of the Limerick tunnel but as closing it only partially addressed the observed issue, further checks were made and revised observed flow data produced which only considered neutral months. Using this revised data resulted in an improved level of calibration on the River Shannon Screenline.

The final sensitivity test involved increasing the input matrices by 10%. Junctions that then experienced a volume / capacity ratio greater than 85% were reviewed leading to some final network amendments. The details of these amendments can be found in the "MWRM Road Model Development Report".

The final results of the recalibration are shown in the charts below. Using same inputs in v2.0.23 as in v2.0.8 generates less car trips and more walk trips than observed (see chart on the left-hand side). Post-calibration modelled mode shares (chart on the right-hand side) are close to observed data (Figure 3.15).

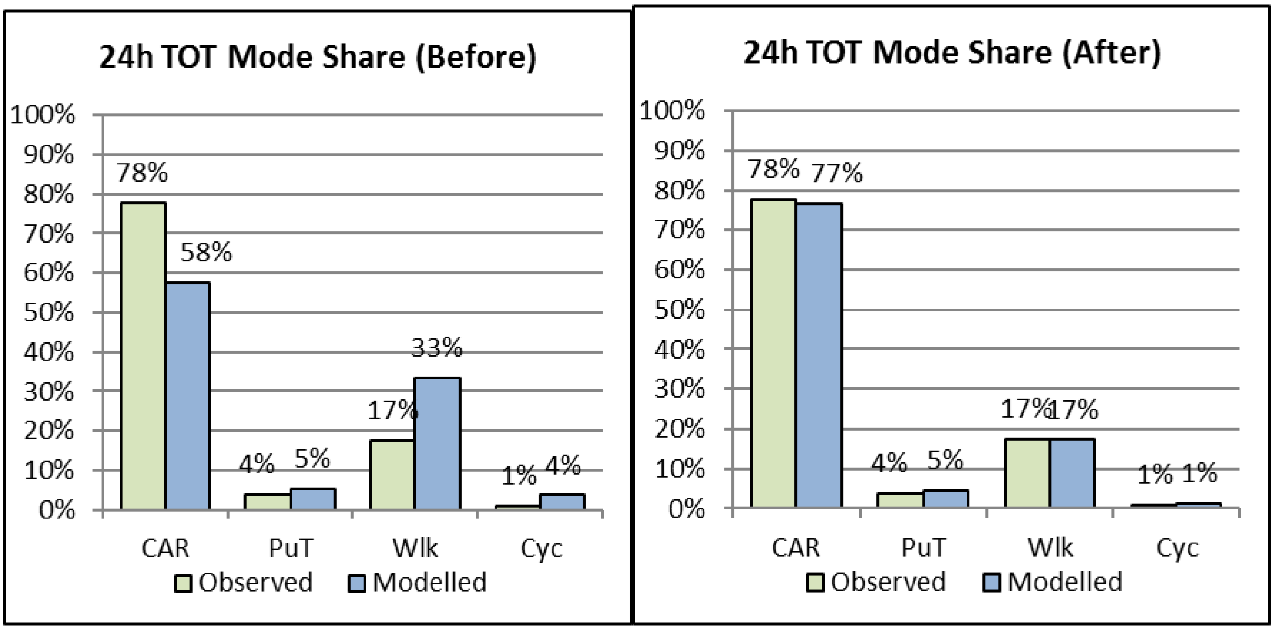


Figure 3.15 Total mode share before (left) and after (right) recalibration

Once suitable revised inputs had been obtained a new set of incremental matrices was generated and the finalised model run produced with these included. The results of this final model run are presented in Chapter 4.

3.24.4 Park and Ride calibration

The Park and Ride mode share is calibrated as part of the main model calibration process. For more information on the development of the Park and Ride model and the site selection calibration process, please see Annex 4.

4 Final calibration / validation results

4.1 Introduction

This chapter provides details of the final calibration and validation, across a whole range of model outputs. These include the direct demand model indicators (modal split, generalised cost and trip length distributions, intrazonal trip numbers, and time period distributions). It then considers less direct indicators such as the change in the matrices required to match flows on the ground and the size of the incremental matrices needed to correct the directly output demand matrices to their equivalent estimated / factored partners, as well as the output road and PT movements.

Active modes have not been considered in detail due to a lack of data but information on the development of the MWRM Active Modes model can be found in the Active Modes Model Development Report.

The finalised parameters used in the demand model are given in Annex 3.

4.2 Full results in electronic format

This chapter provides a detailed summary of the contents of the final demand, road and PT dashboards. However, where more information is desired the full dashboards are contained in the following folders in the accompanying electronic information package:

- Demand: z Final\2 Demand
- Road: z Final\3 Road
- PT: z Final\4 PT

4.3 Demand calibration

4.3.1 Model Split

Figure 4.1 (Page 46) shows the observed and modelled mode shares for the full 24 hour period for the five user classes and for all trips combined. Overall, the match is good although the EDU class shows slightly too much modelled PT use and slightly too little walk and car use compared to the data.

4.3.2 Generalised cost distributions

Figure 4.2 and Figure 4.3 (Pages 47 and 48) show the generalised costs curves for five user classes across the four daytime time periods. In general, there is a good match between the generalised cost data and the modelled outputs, particularly for car, walk and cycle trips. PT trips are less well matched, particularly for the EMP user class and for longer trips. Walk trips are also poorly matched at long distances for the EMP user class.

4.3.3 Trip length distribution

Figure 4.4 (Page 49) shows a comparison between the observed and modelled trip lengths for the COM and EDU user classes (data is unavailable for the other classes). Where there are significant trips for the goodness of fit to be important (greater than one, say) the matches are generally good.

4.3.4 Intrazonal Trips

Intrazonal costs are calculated by the model and IZM adjustments are applied to the costs in order to match observed and modelled intrazonal trip rates.

Intrazonal trip rates for each time period are shown in Figure 4.5 to Figure 4.8 (Page 50). Though the match is not perfect, it would be unrealistic to expect this and in general these show a good correspondence between the modelled and observed proportions of intrazonals. The largest disparities are for the modelled and observed proportions of intrazonal cycle trips in the OTH and RET.

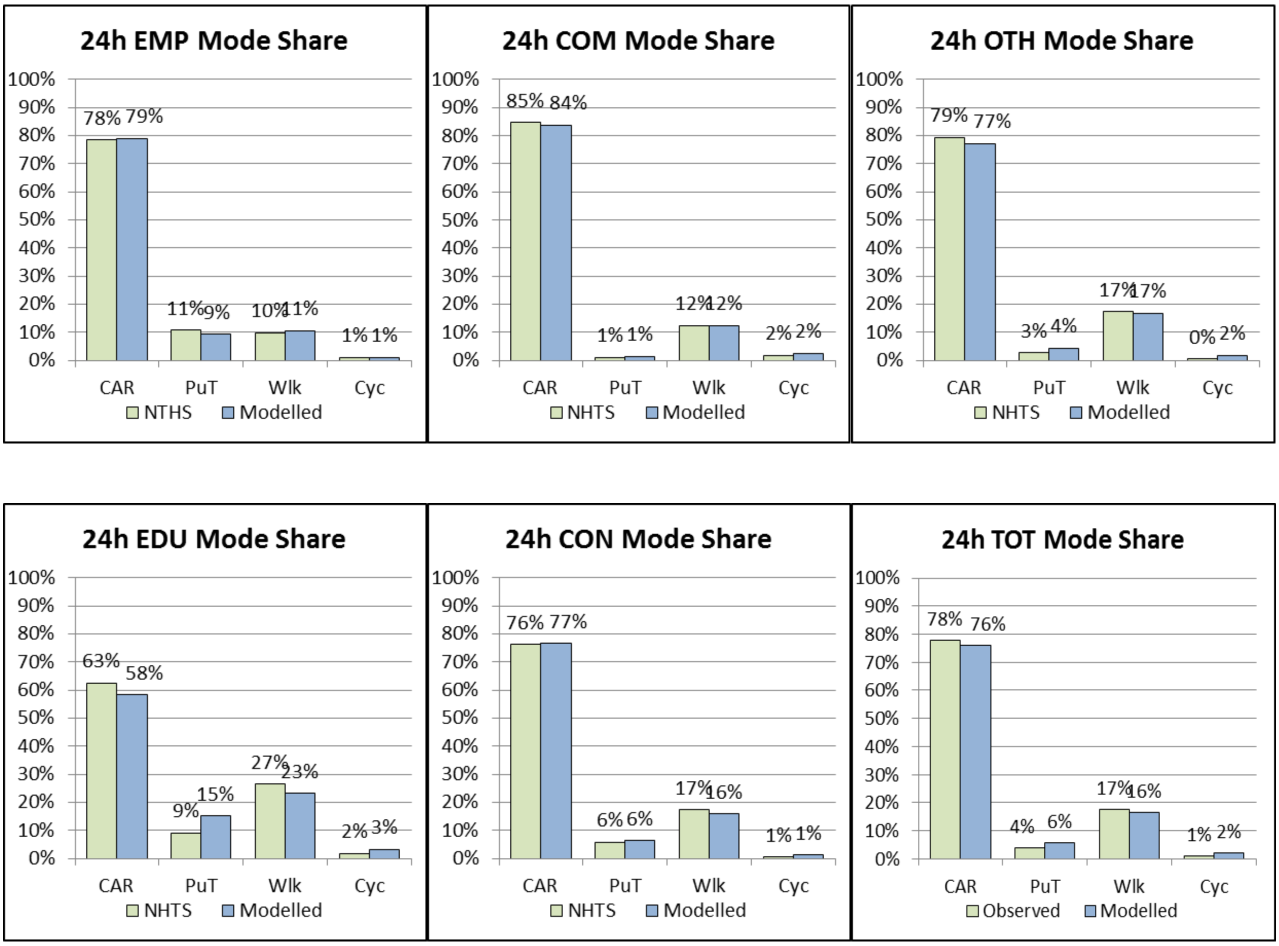


Figure 4.1 Mode share by user class

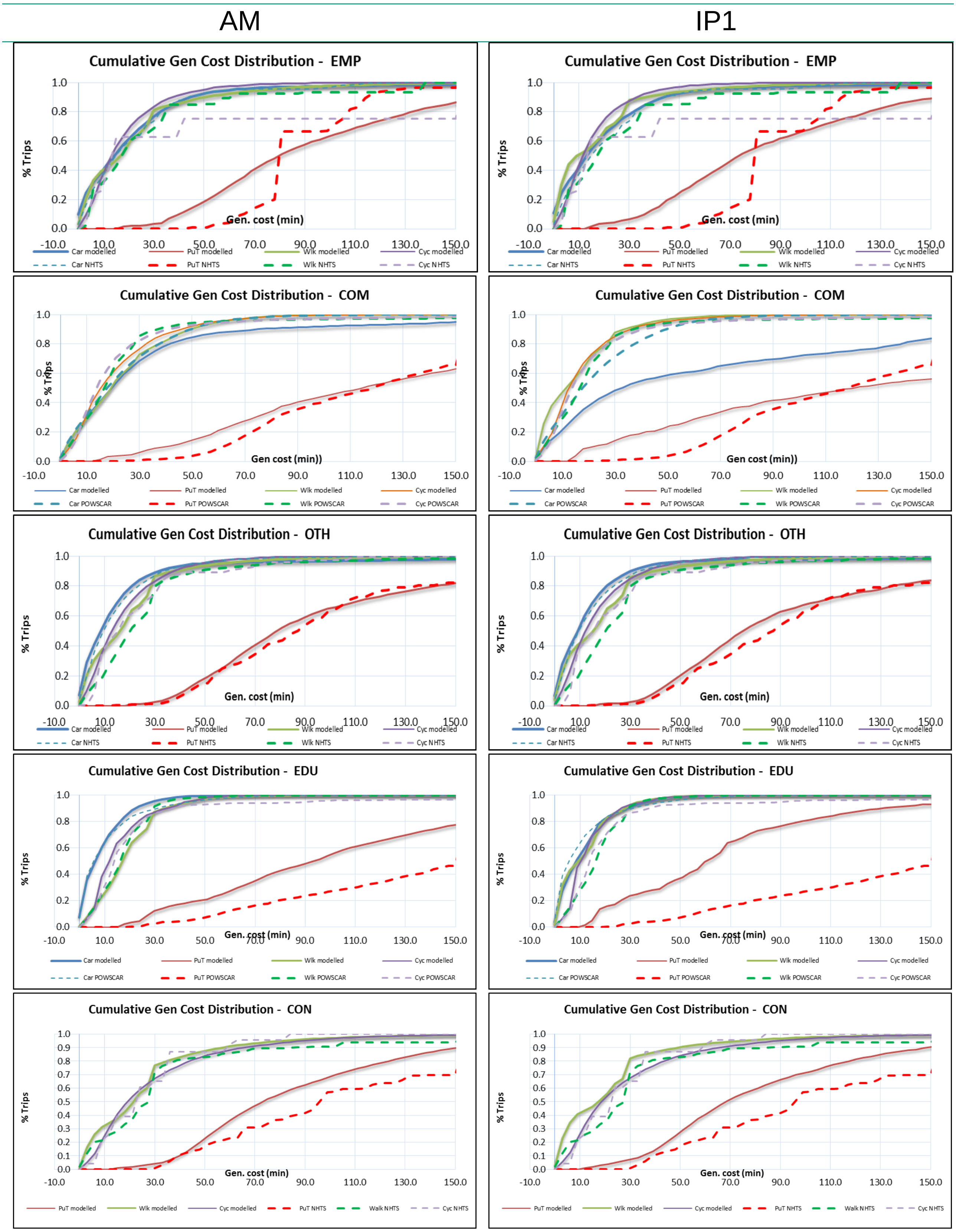


Figure 4.2 Cumulative trip length distributions (AM and IP1)

IP2 | PM

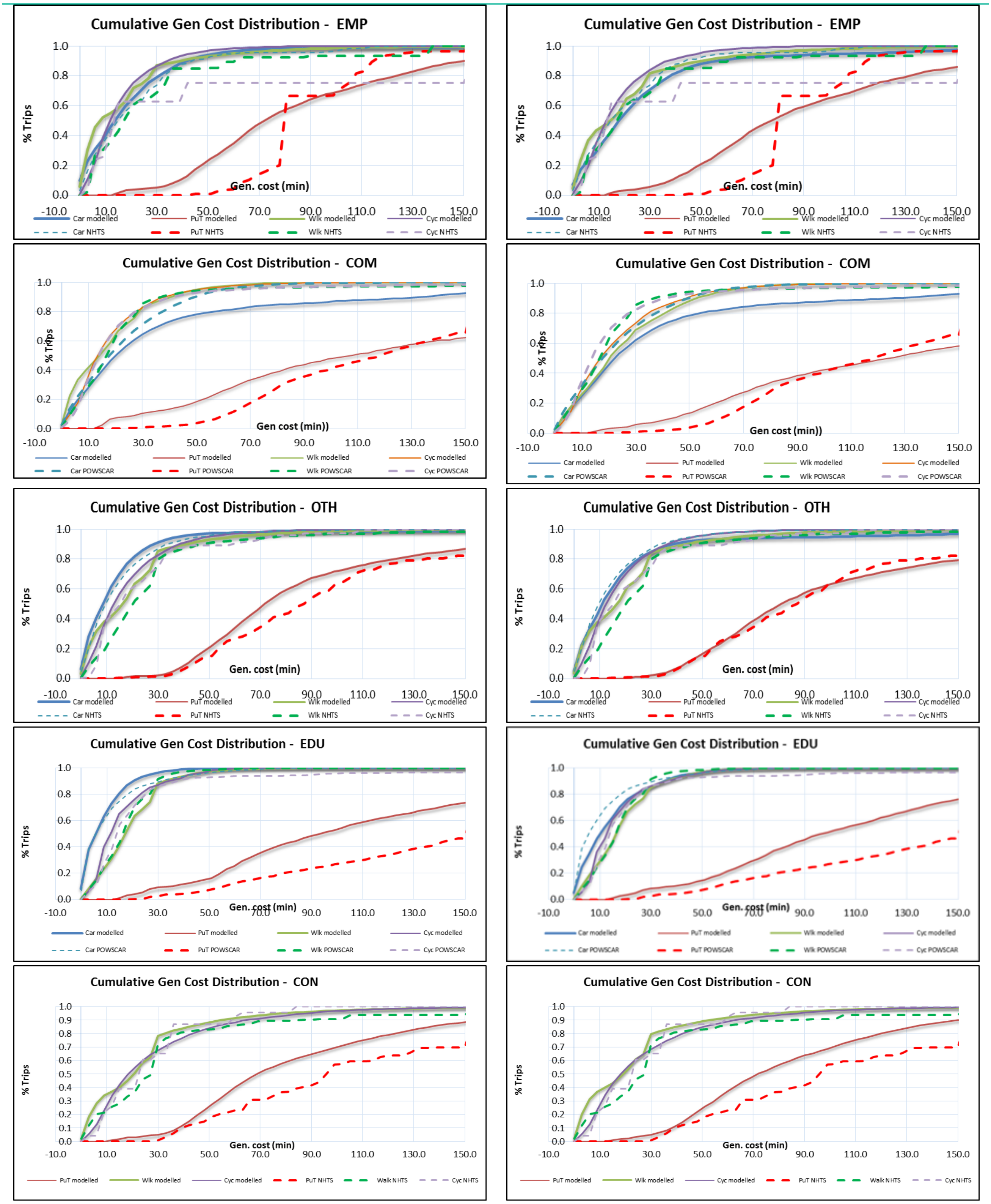


Figure 4.3 Cumulative trip length distributions (IP2 and PM)

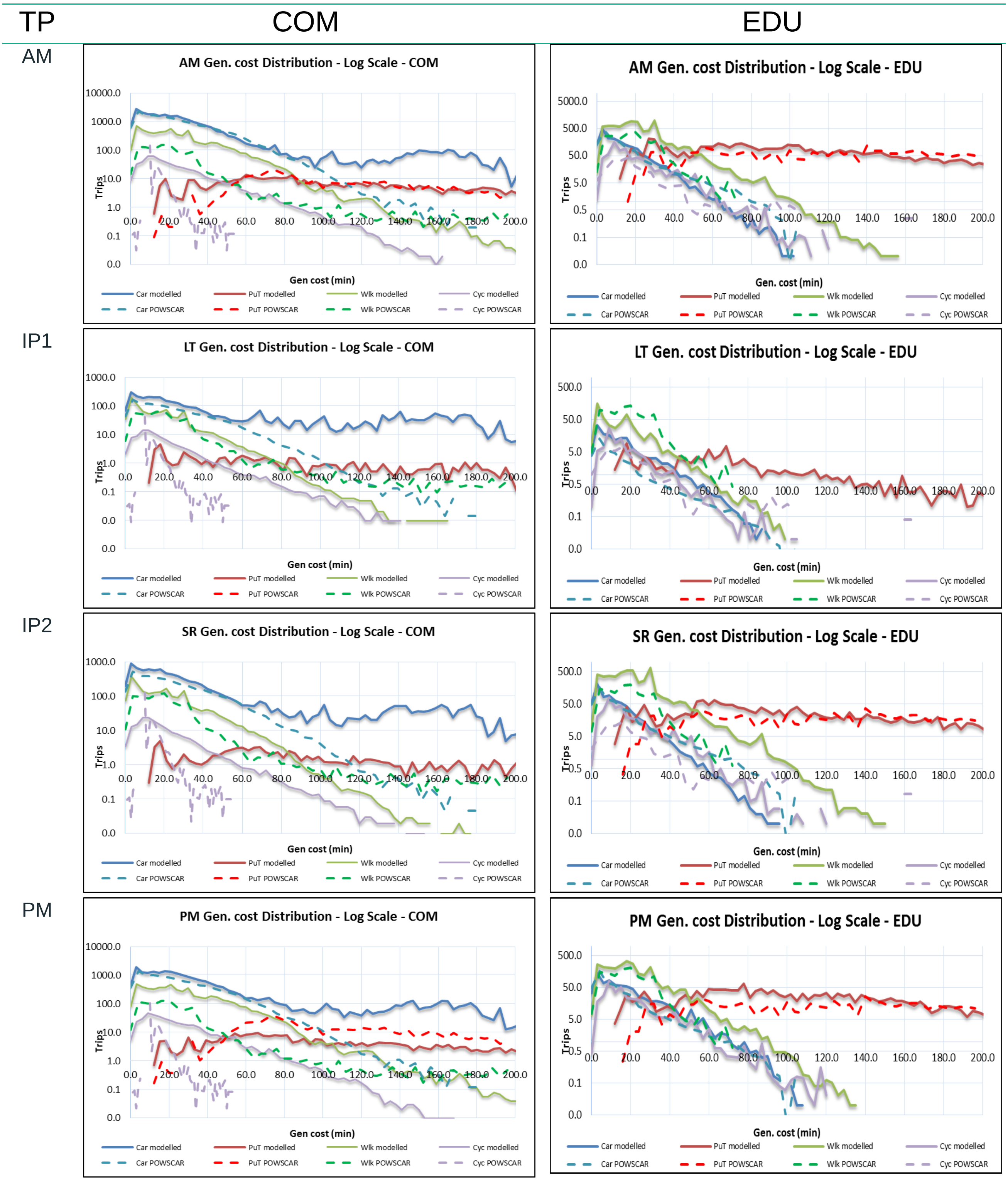


Figure 4.4 Trip lengths for COM and EDU

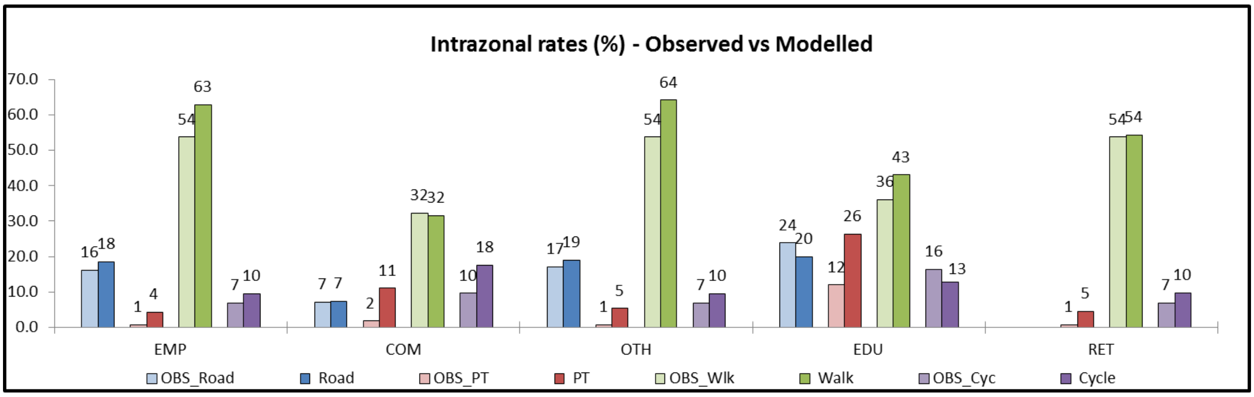


Figure 4.5 AM Intrazonal Trip Rate Proportion

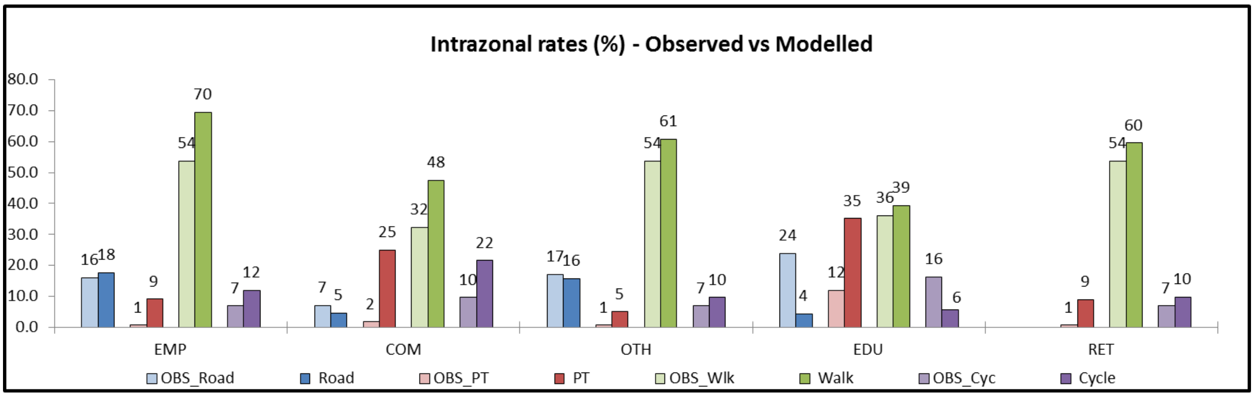


Figure 4.6 IP1 Intrazonal Trip Rate Proportion

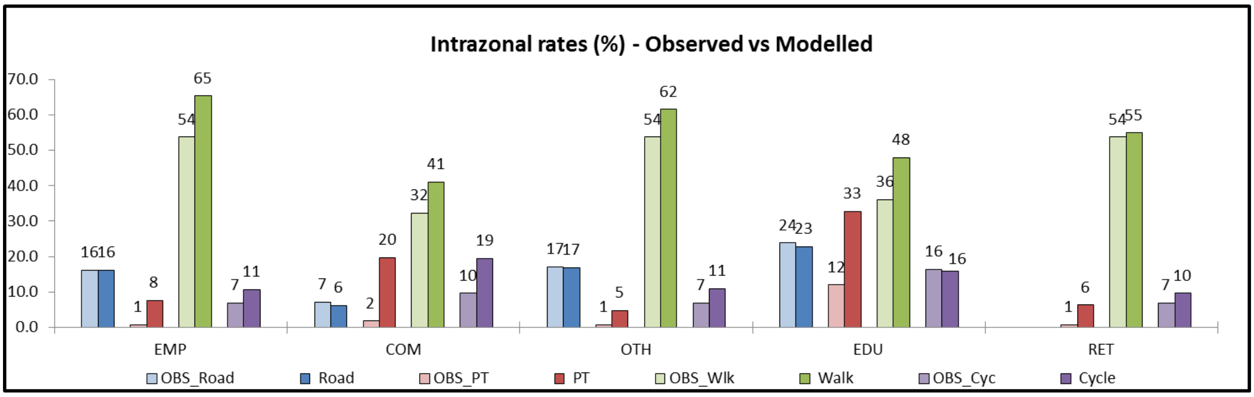


Figure 4.7 IP2 Intrazonal Trip Rate Proportion

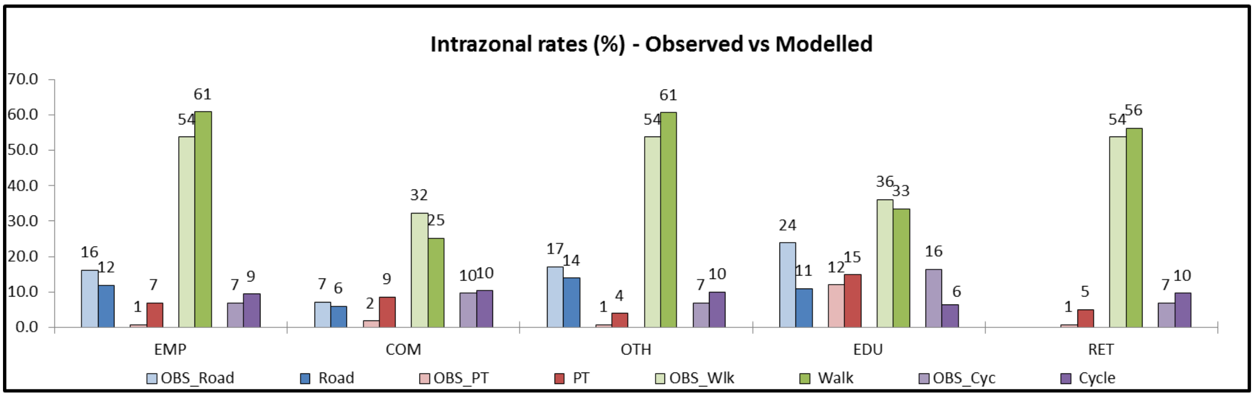


Figure 4.8 PM Intrazonal Trip Rate Proportion

4.3.5 Time period distribution

Figure 4.9 shows a comparison of the number of modelled trips in each time period with the number observed in the NHTS data. The total number of modelled trips in each time period compares well with the observed number of trips, with differences of less than 5% in every case.

The number of observed and modelled trips by each mode in each time period (Figure 4.10) also compares well, although walk trips in the AM are slightly overestimated and those in the LT and OP are slightly underestimated.

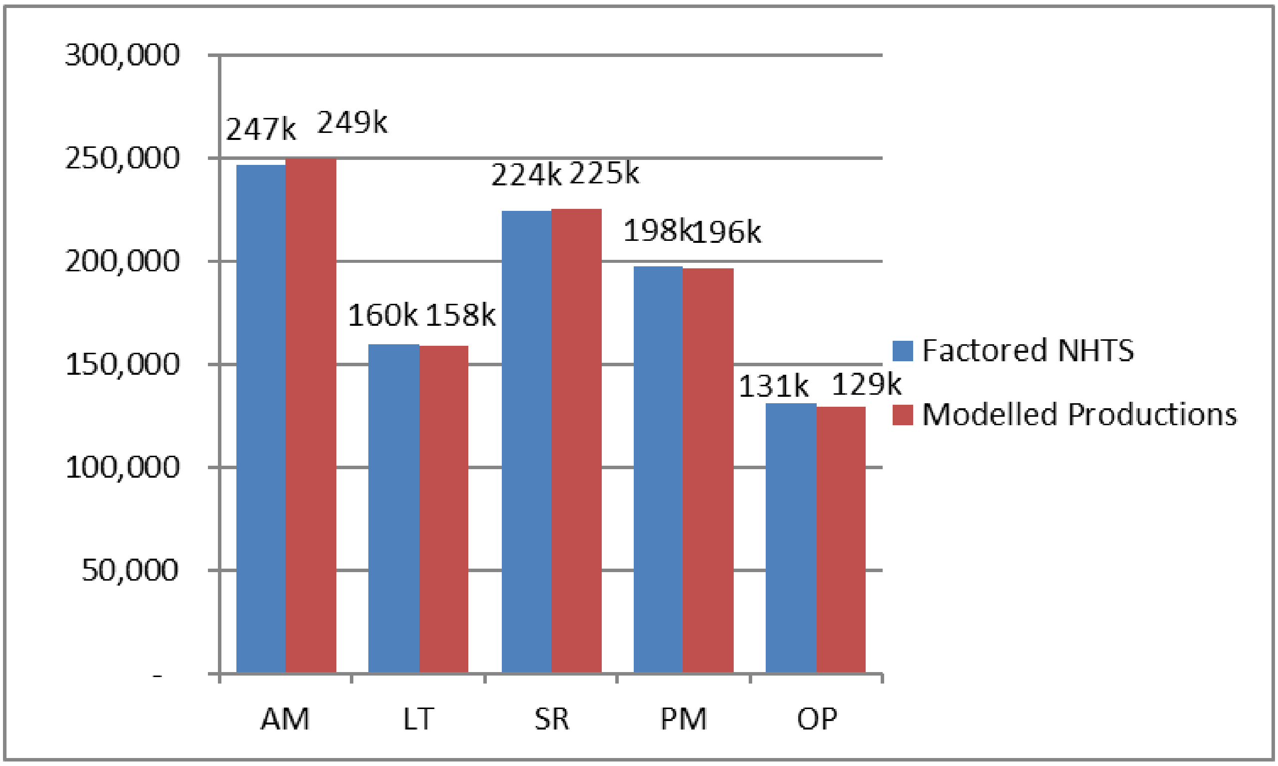


Figure 4.9 Total Trips by Time Period

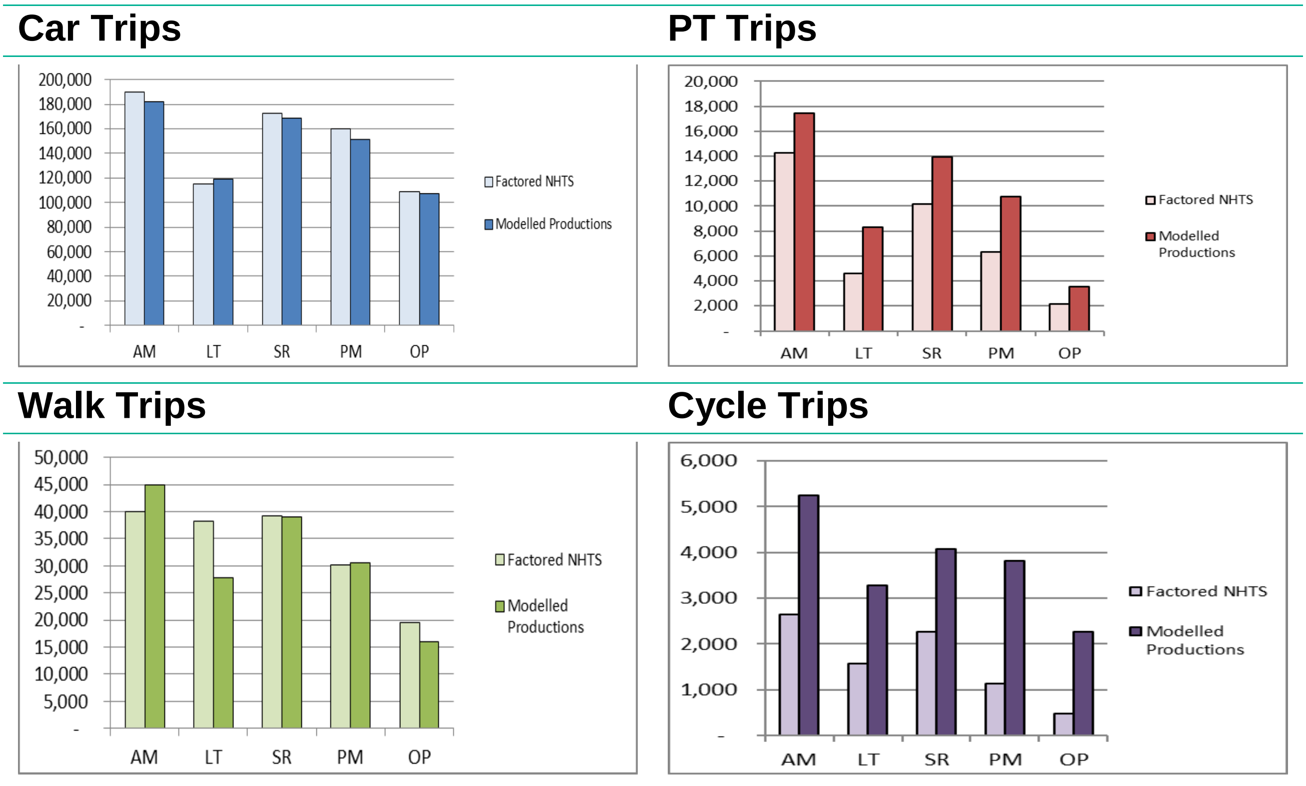


Figure 4.10 Total Trips by Time Period and Mode

4.4 Correcting from calibrated demand to correct movements on the ground

4.4.1 Limitations of demand model calibration

Based on the information reported in the above sections, the demand model is considered to be acceptably calibrated given the data and time available. However, as is the case in the majority of models of this type, the direct assignment of the calculated demand flows to the network does not reproduce the flows on the ground accurately enough for the model to be used to make predictions. To overcome this problem, matrix estimation (for road flows) and PT factoring (for PT flows) was carried out.

4.4.2 Sector to sector movements

In the ideal case the amount of change between the directly output demand matrices and the estimated / factored matrices would be zero. However, as this is unachievable in practice such changes are considered acceptable provided that they are small.

A comparison of sector to sector movements before and after matrix estimation / factoring is shown in Figure 4.11 (for road) and Figure 4.12 (for PT). While there are some larger differences in individual cells the overall changes in the trip ends are smaller, almost all below 10% in the road case.

Differences - Sector to sector matrix												
1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
-8%	-3%	-6%	-14%	24%	4%	-5%	32%	2%	-6%	24%	-13%	3%
4%	-2%	-1%	-1%	7%	11%	7%	28%	-16%	-12%	3%	-14%	2%
-26%	0%	-1%	6%	0%	-5%	15%	13%	-4%	0%	-33%	-36%	-2%
-34%	-8%	25%	-12%	30%	-12%	4%	22%	33%	-9%	138%	29%	4%
58%	19%	13%	30%	-7%	20%	37%	6%	15%	-21%	24%	-2%	12%
11%	21%	10%	-10%	47%	-15%	-8%	7%	9%	14%	25%	-9%	6%
-21%	14%	43%	-1%	48%	9%	-1%	36%	15%	27%	27%	-17%	9%
16%	21%	37%	19%	13%	12%	19%	-7%	42%	24%	14%	-20%	8%
-2%	0%	3%	29%	19%	47%	0%	42%	-2%	-33%	7%	-15%	4%
2%	-3%	-1%	16%	-11%	11%	34%	14%	-28%	-1%	0%	-7%	1%
55%	26%	-16%	82%	5%	110%	-4%	1%	-7%	3%	0%	-34%	0%
0%	-4%	-20%	4%	-8%	17%	-20%	-11%	-13%	-17%	-30%	0%	-2%
2%	5%	9%	4%	12%	7%	4%	7%	1%	0%	1%	-3%	3%

Figure 4.11 24 hour road matrix sector changes with matrix estimation / factoring

Differences - Sector to sector matrix												
1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
-1%	-22%	-4%	-1%	-28%	-6%	-3%	-43%	-8%	-29%	-8%	-19%	-15%
-27%	-22%	-28%	-29%	-23%	-31%	-26%	-53%	-19%	-13%	-24%	-25%	-26%
-2%	-30%	-4%	-12%	-43%	-20%	-12%	-57%	-5%	-42%	-28%	-25%	-19%
14%	-11%	-3%	0%	-21%	5%	-1%	-46%	-4%	-27%	-7%	-27%	-5%
-37%	-26%	-43%	-44%	-12%	-44%	-42%	-57%	-34%	-12%	-39%	-28%	-34%
-7%	-28%	-20%	-16%	-37%	-13%	-17%	-35%	-17%	-38%	-21%	-21%	-22%
14%	-10%	-2%	-1%	-22%	3%	-1%	-48%	-7%	-31%	-7%	-19%	-3%
-49%	-55%	-59%	-52%	-57%	-38%	-52%	-1%	-58%	-59%	-35%	-51%	-33%
-15%	-26%	-5%	-12%	-45%	-23%	-14%	-58%	-3%	-15%	-10%	-19%	-18%
-33%	-16%	-22%	-42%	-16%	-41%	-41%	-58%	-10%	-2%	-13%	-23%	-18%
-6%	-19%	-18%	-7%	-31%	-15%	-6%	-32%	-7%	-13%	0%	-4%	-5%
-12%	-18%	-17%	-22%	-21%	-15%	-16%	-37%	-16%	-25%	-5%	-1%	-5%
-15%	-24%	-17%	-14%	-29%	-22%	-11%	-30%	-13%	-16%	-5%	-6%	-18%

Figure 4.12 24 hour PT matrix sector changes with matrix estimation / factoring

4.4.3 R-squared Analysis

The R-squared statistic was utilised throughout calibration as a measure to check the changes to road model matrices during estimation. Table 4.1 outlines the matrix estimation change calibration criteria, as specified in TAG Unit M3-1, Section 8.3, Table 5.

Table 4.1: Significance of Matrix Estimation Changes

Measure	Significance Criteria
Matrix zonal cell value	Slope within 0.98 and 1.02; Intercept near zero; R^2 in excess of 0.95.
Matrix zonal trip ends	Slope within 0.99 and 1.01; Intercept near zero; R^2 in excess of 0.98.

The following sections provide an overview of the R^2 results for each model time period. Further details are provided in the MWRM Road Model Development Report.

AM

Table 4.2 details the R^2 values for each individual user class for the AM peak Period.

Table 4.2: AM Matrix Change R^2 Analysis

User Class	Emp. Business	Commute	Education	Other
Cell R-Squared	0.90	0.93	0.95	0.97
Cell Slope	0.97	0.97	1.03	0.98
Cell Y-Intercept	0.00	0.00	0.00	0.00
Trip End R-Squared	0.97	0.99	0.99	0.99
Trip End Slope	0.98	0.92	0.94	0.97
Trip End Y-Intercept	0.23	2.49	0.15	2.05

The acceptable R^2 value for individual matrix cell changes is in excess of 0.95, which the Education and Other user classes match or better. The two user classes which do not pass the criteria both have an R^2 value of 0.90 or above. Only one of the user classes (Other) passes the recommended criteria for cell slope values (between 0.98 – 1.02), although the remaining user classes only very narrowly fail to meet the criteria. With regard to the trip end criteria, three of the four user classes are within the R^2 criterion, but none of the classes fully meets the slope criterion. Also, the Commute and Other user classes have issues in meeting the Y-intercept target of near zero.

LT

Table 4.3 details the R^2 values for each individual user class for the LT time period.

Table 4.3: IP1 Matrix Change R^2 Analysis

User Class	Emp. Business	Commute	Education	Other
Cell R-Squared	0.92	0.87	0.94	0.97
Cell Slope	0.97	0.95	0.99	0.98
Cell Y-Intercept	0.00	0.00	0.00	0.00
Trip End R-Squared	0.98	0.97	0.99	0.99
Trip End Slope	0.97	0.94	0.98	0.98
Trip End Y-Intercept	0.16	0.34	0.01	1.50

Three of the four user classes fail to be within the acceptable range for the individual cell R^2, with the Employers Business and Commute user classes also falling outside the slope criterion. With regard to the trip end criteria, three of the four user classes are within the R^2 criterion, but all the classes are just outside the slope criterion. Also, the Other user class struggles to meet the target for the Y-intercept.

SR

Table 4.4 details the R^2 values for each individual user class for the SR time period.

Table 4.4: IP2 Matrix Change R^2 Analysis

User Class	Emp. Business	Commute	Education	Other
Cell R-Squared	0.91	0.90	0.96	0.98
Cell Slope	0.95	0.95	0.94	0.98
Cell Y-Intercept	0.00	0.00	0.00	0.00
Trip End R-Squared	0.98	0.98	0.99	0.99
Trip End Slope	0.96	0.92	0.94	0.97
Trip End Y-Intercept	0.28	1.00	0.05	2.43

Two of the user classes pass the individual cell R^2 and cell slope tests, with the other two falling just outside the range, but still above 0.90. All of the user classes meet the trip-end R^2 criterion. For the trip-end slope criterion, all four user classes fail, and Commute and Other also fail to reach the Y-intercept criterion.

PM

Table 4.5 details the R^2 values for each individual user class for the PM peak period.

Table 4.5: PM Matrix Change R^2 Analysis

User Class	Emp. Business	Commute	Education	Other
Cell R-Squared	0.84	0.90	0.83	0.96
Cell Slope	0.96	0.95	0.81	0.97
Cell Y-Intercept	0.00	0.01	0.01	0.01
Trip End R-Squared	0.96	0.98	0.99	0.98
Trip End Slope	1.03	0.95	1.10	0.99
Trip End Y-Intercept	0.32	3.37	-0.14	2.64

Only the Other user class passes the individual cell R^2 test and the other three user classes have an R^2 value of between 0.83 and 0.90. Only Employers Business fails the trip end R^2 test. None of the user classes meet the criteria for cell or trip end slope, although, with the exception of Education, all fail narrowly. Trip end intercepts are particularly poor for the Commute and Other classes.

Future iterations of the model should work on improving these values across all four time periods.

4.4.4 Application of estimation / factoring information to the demand model

The information gained from matrix estimation / PT factoring is input into the demand model through the medium of incremental matrices. These give the difference between the directly calculated demand and the estimated / factored demand and so, in the base case, these effectively reproduce the estimated / factored matrices. Once this has taken place, the levels of calibration in the assigned road and PT networks can be meaningfully considered. The incremental values should only form a small part of the assignment matrix and their scale is indicated in Table 4.6 which shows the matrix totals in the incremental matrices as a percentage of the assignment matrix totals.

Table 4.6 Scale of incremental matrices

	AM	IP1	IP2	PM
Taxi	0.9%	0.0%	0.0%	0.0%
Car	-2.8%	-0.5%	1.4%	1.9%
PT	-18.0%	-27.0%	-19.0%	-12.0%
Walk	0.0%	0.0%	0.0%	0.0%
Cycle	0.0%	0.0%	0.0%	0.0%

4.5 Road calibration and validation

The development, calibration, and validation of the road model is described in detail in the MWRM Road Model Development Report but the level of flow and journey time calibration / validation reported by the road dashboards is also a key consideration in the assessment of the demand model calibration and so the results are summarised here.

Road calibration (on percentage difference) was good with overall values for all links falling out at:

- AM 73%
- IP1 87%
- IP2 83%
- PM 76%

Journey time validation was good with overall values for two time periods passing the journey time criteria (>85% of routes):

- AM 86%
- IP1 82%
- IP2 86%
- PM 79%

4.6 Public transport calibration and validation

The development, calibration and validation of the public transport model is described in detail in the MWRM PT Model Development Report, but the level of passenger movement and journey time calibration / validation reported by the PT dashboards is also a key consideration in the assessment of the demand model calibration and so the results are summarised here.

Figure 4.13 and Figure 4.14 show the modelled versus observed flows at the locations where data is available and Figure 4.15 and Figure 4.16 show rail boardings by time period. The match to rail flows and rail boardings is reasonable, though the model overestimates flows in the inbound AM. Bus flows tend to be significantly overestimated by the model but as public transport forms a typically low proportion of the total demand this will have only a limited impact on the calibration of the model as a whole.

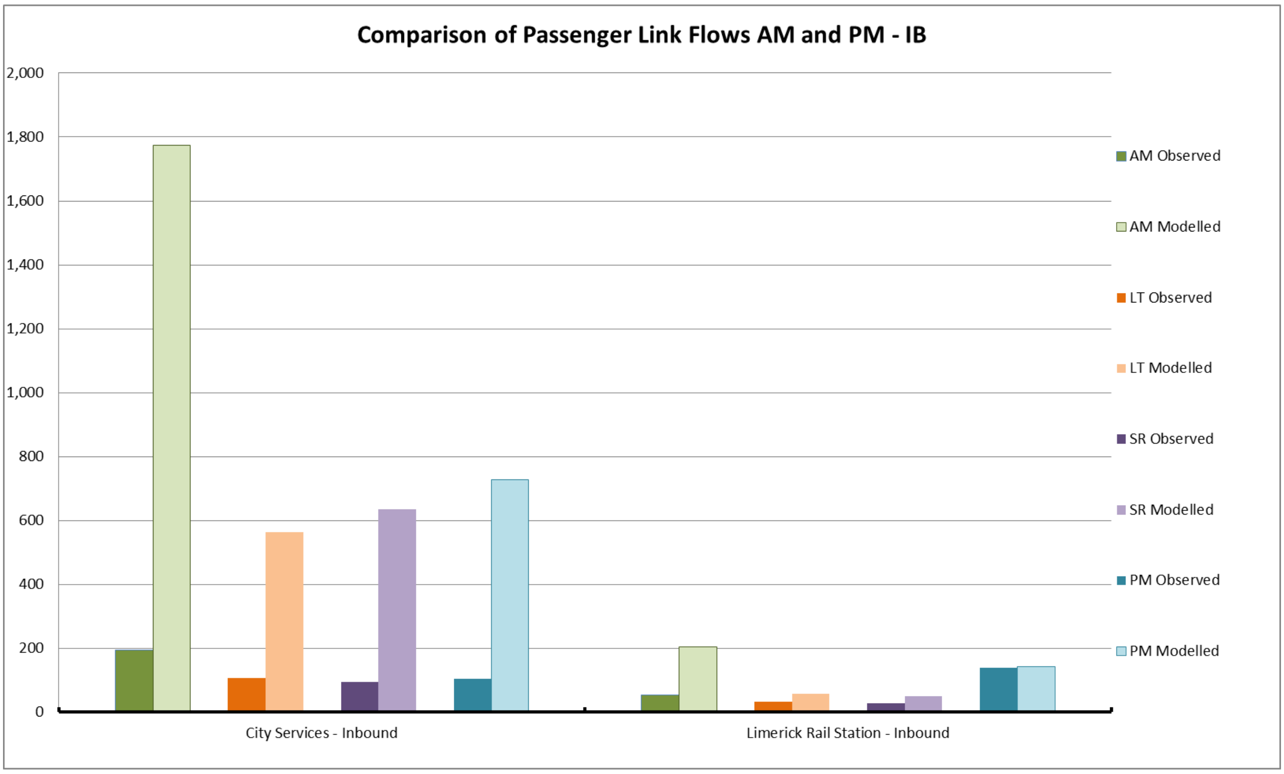


Figure 4.13 Inbound PT passenger flows

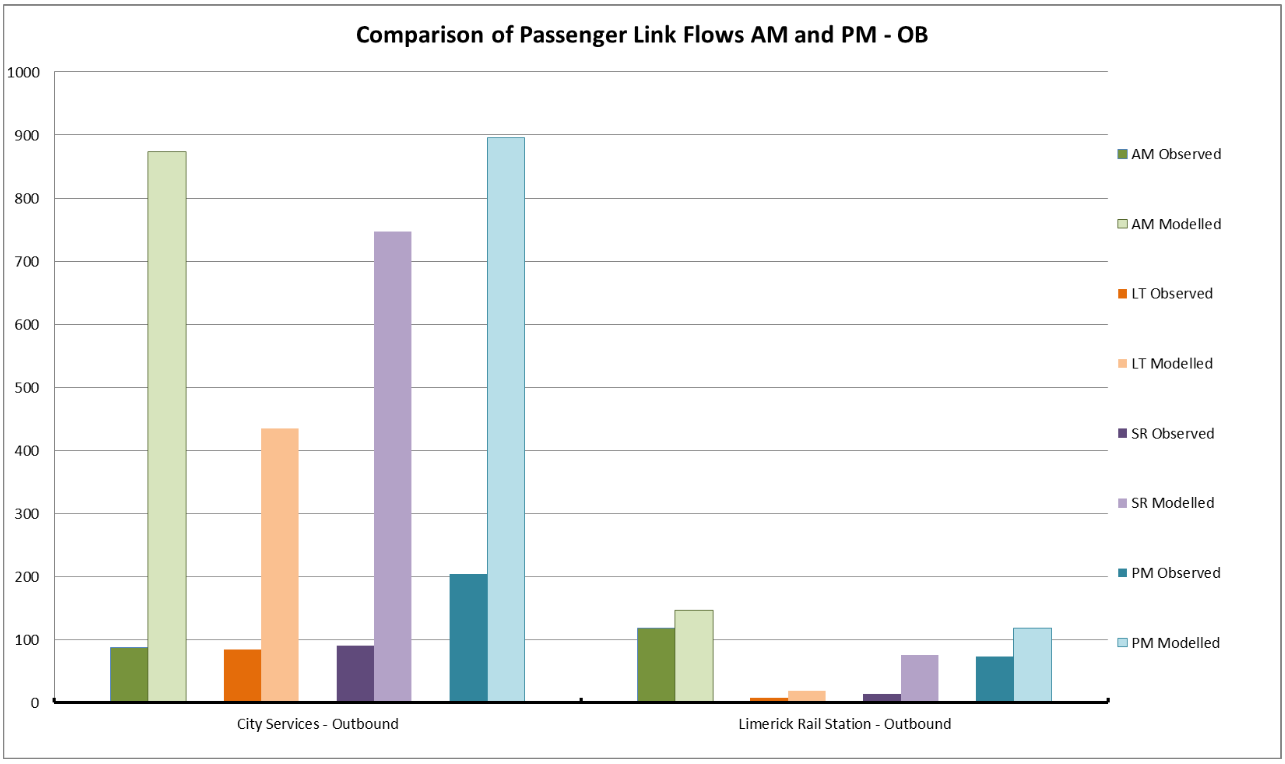


Figure 4.14 Outbound PT passenger flows

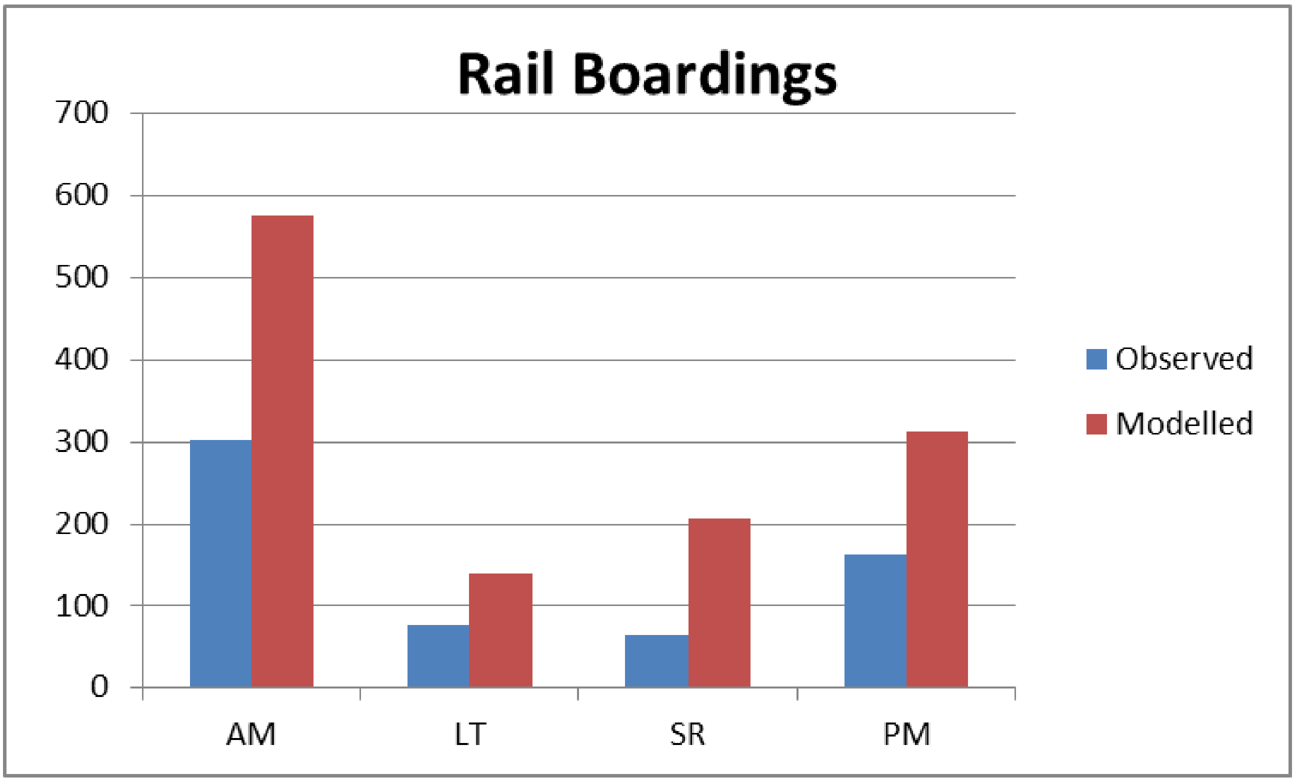


Figure 4.15 Rail boardings by time period

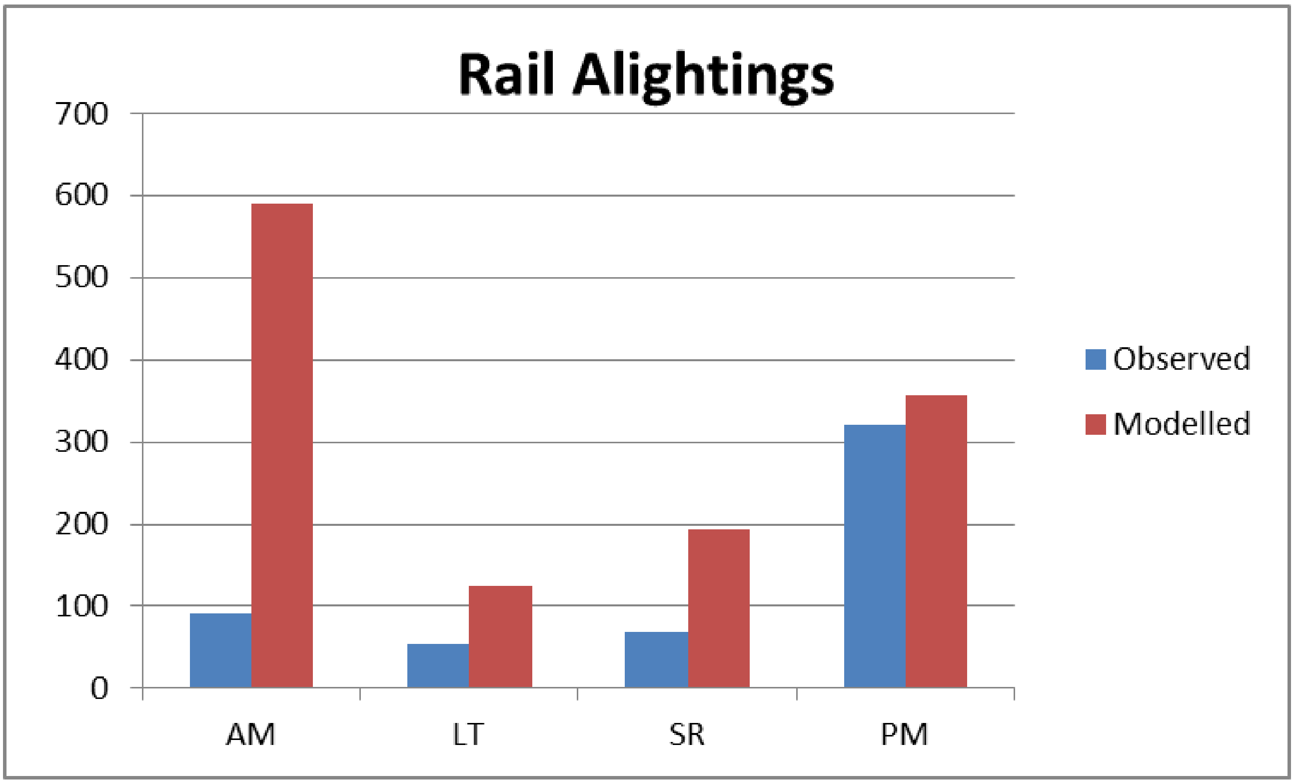


Figure 4.16 Rail alightings by time period

4.7 Active Mode calibration and validation

As there was no count data available with which to calibrate the active modes network it has not been calibrated. However, the mode shares and trip length distributions do look plausible.

4.8 Overview

Though there is still room for improvement, overall:

- Mode splits are considered robust as are generalised cost distributions, trip lengths, intrazonal trip numbers, and time period distributions.
- The amount of matrix estimation / factoring required to convert base output demand matrices to matrices which match behaviour on the ground is reasonable.
- Incrementals form only a small proportion of the overall assignment matrices.
- Road calibration / validation is good.
- PT calibration / validation is reasonable, particularly in view of limited data availability.

5 Realism Testing

The preceding chapters discuss how the base year scenario of the model was calibrated and validated which reflects its ability to reproduce current conditions. However, in order to estimate how accurately the model will be able to predict future conditions, it is important to run realism tests before undertaking true forecast year runs. WebTAG recommends a series of three standard realism tests[3], namely:

- Car fuel cost elasticity;
- PT fare elasticity; and,
- Car journey time elasticity.

Elasticities are a measure of the size of changes to demand which result from a given change in generalised cost and are defined as:

$$e = \frac{\ln(T_1) - \ln(T_0)}{\ln(C_1) - \ln(C_0)}$$

Where:

T_0 is the demand of the initial condition (calibrated base);
T_1 is the demand with the change in place;
C_0 is the generalised cost of the initial condition (calibrated base); and,
C_1 is the generalised cost with the change in place.

Elasticities are derived based on a global summation of relevant costs and demands across the entire simulated area, as the overall demand is tied to the trip ends and hence cannot change. Consequently, the car fuel and car journey time tests will consider car costs and demands and the PT fare tests will consider PT costs and demands.

The values which models need to produce to be acceptable under WebTAG guidance are shown in Table 5.1.

Table 5.1 Realism Test Acceptability Criteria

Test	Valid Range	Notes
Fuel	-0.25 to -0.35	Should vary by purpose and certain individual purposes may be outside the range. Discretionary travel should be more elastic and employers business should be less elastic.
Fare	-0.20 to -0.90	Can be as elastic as -2.0 for some long-term models[4]
Time	0.00 to -0.20	

[3] Chapter 6.4, *TAG Unit M2 – Variable Demand Modelling*, January 2014, Retrieved 1st October 2014 from https://www.gov.uk/government/publications/webtag-tag-unit-m2-variable-demand-modelling

[4] Long-term models represent a steady-state condition where all changes are in place and the initial shock of their introduction has stabilised. The FDM reflects long-term conditions.

5.1 Running the realism tests

5.1.1 Car fuel cost elasticity

The car fuel cost is input to the model via the Value of Distance parameter in the SATURN networks. This parameter was multiplied by 1.1 and the road assignment was re-run and re-skimmed in order to provide new base cost inputs. The model was then re-run through a single FDM loop in order to examine its response.

5.1.2 PT fare elasticity

The PT fares enter the model through a fares matrix and a number of fare tables. The costs in these were scaled by a factor of 1.1 and then a standalone PT assignment was undertaken (with the initial base year road assignment as the underlying network). New costs were skimmed from this run and input to the model as revised base costs. The model was then be run through a single FDM loop and the outputs examined.

5.1.3 Car journey time elasticity

As the majority of the generalised cost of car travel is made up of the time component (due to the comparative magnitude of the generalised cost equation parameters), a good approximation to the change required by this test can be obtained by multiplying the input base cost matrices for cars by 1.1 and then running the model through a single FDM loop.

5.2 Results

5.2.1 Car fuel cost elasticity

Overall, although the car fuel elasticities are slightly higher (more sensitive) than is suggested by the WebTAG range (Table 5.2), the model is considered to respond appropriately to changes in fuel costs.

The EMP and EDU user classes show low fuel elasticities which is plausible as neither or these groups covers their fuel costs themselves. The RET group is particularly cost sensitive which, as these users tend to be time rich and cash poor, and as such have lower values of time is also plausible.

Table 5.2 Car fuel cost elasticities

User class	AM	LT	SR	PM	OP*	24 Hour
EMP	-0.2785	-0.2242	-0.2244	-0.2467	-0.1715	**-0.2313**
COM	-0.3750	-0.4104	-0.3620	-0.3353	-0.3357	**-0.3566**
OTH	-0.4655	-0.4365	-0.4329	-0.4582	-0.4363	**-0.4444**
EDU	-0.2823	-0.3046	-0.2730	-0.2636	-0.2490	**-0.2761**
RET**	-0.5620	-0.5429	-0.5319	-0.5334	-0.4947	**-0.5375**
Total	**-0.3995**	**-0.4259**	**-0.3951**	**-0.3936**	**-0.3968**	**-0.4007**

* LT distance skim used for OP

** OTH distance skim used for RET

5.2.2 PT fare elasticity

Elasticities within the COM and OTH groups lie within the preferred range (Table 5.3). The EMP and RET groups have sensitivities which are well outside the preferred range and are above zero indicating that PT use by these groups increases as fares increase. This is counterintuitive. However, RET trips are subject to concessionary travel and do not pay fares regardless of the changes in them and so the actual expected elasticity in the RET group should be zero, or very near, which it is. EMP uses also do not pay their own fares and the cost of staff time generally far exceeds that of PT fares. It may be that this group, in particular is responding to reduced crowding particularly strongly but this question would benefit from more detailed investigation.

The EDU group shows a rather low sensitivity in comparison to the expected range but, again, these users do not pay their own costs and they are subject to a discount in PT fares so the fare represents a smaller proportion of their overall generalised cost. It is therefore plausible that they are less sensitive to fare increases.

Table 5.3 PT fare elasticities

User class	AM	LT	SR	PM	OP*	24 Hour
EMP	0.3305	0.4572	0.3851	0.3889	0.4116	**0.3865**
COM	-0.3086	-0.2558	-0.2815	-0.3283	-0.2616	**-0.3007**
OTH	-0.3805	-0.3553	-0.3561	-0.3852	-0.3795	**-0.3697**
EDU	-0.1334	-0.0929	-0.1502	-0.1184	-0.1028	**-0.1338**
RET*	0.0629	0.0651	0.0450	0.0536	0.0533	**0.0565**
Total	**-0.1538**	**-0.2074**	**-0.1711**	**-0.1694**	**-0.2151**	**-0.1736**

* Concessionary travel

Overall the model is considered to respond predictably and sensibly to changes in PT fares.

5.2.3 Car journey time elasticity

Table 5.4 shows the response of the model to car journey time changes. In this case all the values lie in or near to WebTAG's preferred range and so there is no reason to expect unpredictable responses to changes in journey times.

Table 5.4 Car journey time elasticities

User class	AM	LT	SR	PM	OP*	24 Hour
EMP	-0.1909	-0.1571	-0.1740	-0.2012	-0.1470	**-0.1746**
COM	-0.1238	-0.1321	-0.1169	-0.1110	-0.1087	**-0.1172**
OTH	-0.1374	-0.1424	-0.1314	-0.1503	-0.1533	**-0.1421**
EDU	-0.2351	-0.2466	-0.2244	-0.2505	-0.2130	**-0.2339**
RET	-0.2726	-0.2554	-0.2536	-0.2608	-0.2360	**-0.2585**
Total	**-0.1694**	**-0.1562**	**-0.1581**	**-0.1602**	**-0.1542**	**-0.1606**

6 Conclusion and recommendations

6.1 Introduction

This report has described the calibration and validation of the FDM component of the MWRM. This section summarises the strengths and weakness of the model revealed by this process and gives a set of recommendations for further enhancements.

6.2 Calibration methodology – Key Points

- The finalised MWRM used the standard FDM release version 2.0.23 in combination with region specific inputs and appropriate road, PT, and active modes networks.
- All modules are in use and turned on except macro time of day choice which has yet to be fully implemented.
- The process of FDM calibration for the MWRM has followed a repeatable method developed for all of the regional models.
- Calibration / validation outputs are presented in a common, dashboard, format.

6.3 Model Validation – Key Points

The model was calibrated to local conditions using data derived from the 2011 POWSCAR and 2012 NHTS data sets.

- **Modal Split:** 24-hour mode share was calibrated to POWSCAR and NHTS data and is good overall, generally lying within 2 percentage points of the observed data, though the mismatch is up to 6 percentage points for some EDU group.
- **Generalised Cost Distribution:** Generalised cost curves were calibrated to POWSCAR and NHTS data and are well matched for car, walk and cycle trips. PT trips are less well matched, but only at high costs where there are comparatively fewer trips.
- **Trip Length Distribution:** Trip length distributions for COM and EDU were compared to observed (POWSCAR) trip length distributions. The match is reasonable, particularly in those areas of the curves where the majority of trips occur.
- **Intrazonal Trips:** The proportion of intrazonal trips was calibrated to observed data for each mode, time period and purpose and the modelled pattern is a good match to the observed pattern, though cycle intrazonals tend to be high.
- **Time Period Distribution:** Total trips by time period, and trips by time period and mode, were calibrated to observed data and the overall match is excellent except for AM and LT walk trips which are slightly mismatched.

- **Matrix correction and incremental values:** Pre and post correction sector to sector comparisons indicate that the degree of correction required by the assignment matrices is reasonable and incremental values are acceptable in size.
- **Road calibration and validation:** Flow calibration (compared to counts) is excellent with calibrations above 73%. Journey time validation is good at 79-86%. The development, calibration, and validation of the road model is covered in more detail in the MWRM Road Model Development Report.
- **PT calibration and validation:** Given the limited data availability the level of PT calibration is reasonable. The development, calibration and validation of the PT model is covered in more detail in the MWRM PT Model Development Report.
- **Active modes calibration and validation:** The mode share and trip length distributions for active modes are reasonable but no count data is available for network calibration. The development of the active modes model is covered in more detail in the MWRM Active Modes Model Development Report.

6.4 Recommendations for further development

It is considered that the model in its current state is sufficiently calibrated to be fit for purpose. However, no model is ever ‘finished’ in the sense that no further improvements can be made. Accordingly, this section sets out some suggested recommendations for future enhancements of the model:

- Continue to refine the model to improve its functionality, flexibility and calibration.
- Continue to refine the base generalised cost inputs to improve stability in early model loops.
- Carry out further investigations of the realism test outputs.

Annex 1 Full list of required input files

Group	Input file
NDFM outputs and tour proportions	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Dem_Zone_Zone_HGV.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Dem_Zone_Zone_M1.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Dem_Zone_Zone_M2.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Dem_Zone_Zone_M3.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Work_Zone_Zone_M1.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Work_Zone_Zone_M2.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Work_Zone_Zone_M3.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Prods_CA.CSV
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Blue_White_Collar.CSV
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Emp_Split.CSV
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\One_Way_NonRetired.CSV
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\One_Way_Retired.CSV
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Two_Way_Attractions_NonRetired.CSV
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Two_Way_Attractions_Retired.CSV
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Two_Way_Productions_NonRetired.CSV
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Two_Way_Productions_Retired.CSV
	{CATALOG_DIR}\Params\Trip_End_Parameters\Base_Prod_Tour_Proportions.MAT
	{CATALOG_DIR}\Params\Trip_End_Parameters\Base_Attr_Tour_Proportions.MAT
Special demands	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Internal_Goods.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\AM_SpecialZones.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\LT_SpecialZones.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\OP_SpecialZones.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\PM_SpecialZones.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\SR_SpecialZones.MAT
	{CATALOG_DIR}\Runs\{Model Year}\{Run ID}\Input\Special_Zones\SZ_data.csv
Base cost matrices	{CATALOG_DIR}\Params\BaseGenCosts\AM_ALL_D0.GCM
	{CATALOG_DIR}\Params\BaseGenCosts\LT_ALL_D0.GCM
	{CATALOG_DIR}\Params\BaseGenCosts\SR_ALL_D0.GCM
	{CATALOG_DIR}\Params\BaseGenCosts\PM_ALL_D0.GCM
	{CATALOG_DIR}\Params\BaseGenCosts\OP_ALL_D0.GCM
	{CATALOG_DIR}\Params\BaseGenCosts\EMP_M3.AGC
	{CATALOG_DIR}\Params\BaseGenCosts\COM_M3.AGC
	{CATALOG_DIR}\Params\BaseGenCosts\OTH_M3.AGC
	{CATALOG_DIR}\Params\BaseGenCosts\EDU_M3.AGC
	{CATALOG_DIR}\Params\BaseGenCosts\RET_M3.AGC
Zone information files	{CATALOG_DIR}\Params\Zone_Conversion\Seq_2_Hier.exe
	{CATALOG_DIR}\PARAMS\SYNTHESIS_SECTOR_V1_1.TXT
	{CATALOG_DIR}\Params\Trip_End_Parameters\SECTOR_LIST.DBF
	{CATALOG_DIR}\Params\Trip_End_Parameters\ZONE_LIST.DBF
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\Zone_Areas.DBF
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\Zone_Lookup.csv
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\SA_Zones_Sector.DBF

Group	Input file
Mode and destination choice parameters MDC for 01-29 One Way for 30-33	{CATALOG_DIR}\Params\MDC_Params\P??_ALPHA.MAT
	{CATALOG_DIR}\Params\MDC_Params\P??_BETA.MAT
	{CATALOG_DIR}\Params\MDC_Params\P??_LAMBDA.MAT
	{CATALOG_DIR}\Params\MDC_Params\P??_ASC.MAT
	{CATALOG_DIR}\Params\MDC_Params\P??_IZM.MAT
	{CATALOG_DIR}\Params\OneWay_Params\P??_ALPHA.MAT"
	{CATALOG_DIR}\Params\OneWay_Params\P??_BETA.MAT"
	{CATALOG_DIR}\Params\OneWay_Params\P??_LAMBDA.MAT"
	{CATALOG_DIR}\Params\OneWay_Params\P??_ASC.MAT"
	{CATALOG_DIR}\Params\OneWay_Params\P??_IZM.MAT"
Parking information	{CATALOG_DIR}\Params\GenCost_Params\Parking_VoT.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{Run ID}\Input\FWPP_{Run ID}{Model Year}.CSV
	{CATALOG_DIR}\Runs\{Model Year}\{Run ID}\Input\PCharge_{Run ID}{Model Year}.CSV
	{CATALOG_DIR}\Runs\{Model Year}\{Run ID}\Input\PDist_{Run ID}{Model Year}.CSV
	{CATALOG_DIR}\Runs\{Model Year}\{Run ID}\Input\PDistParams_{Run ID}{Model Year}.DAT
	{CATALOG_DIR}\Runs\{Model Year}\{Run ID}\Input\PnRSites_{Run ID}{Model Year}.CSV
Greenfield inputs	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Greenfield_Allocation.txt
	{CATALOG_DIR}\Params\Greenfield\Generic_Greenfield_Zone_File.MAT
	{CATALOG_DIR}\Runs\{Year}\2 Demand\{Growth}\GField\GField_Zone_?.csv
Road networks (AM, LT/IP1, SR/IP2, PM or OP)	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\Saturn.dat
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\DefaultOptions.dat
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\DefaultParams.dat
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\SATURN.BUS
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\saturn.111
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_Signals.111
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\saturn.222
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\saturn.333
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\saturn_??.444
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_9UC_Tolls_2011.444
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\saturn.555
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_NRA_JT_2014.666 *(except OP)*
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\JT20{Model Year}_??.666
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_additional.777
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_Bridges.777
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_Inner.777
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_M50.777
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_M50_ATC.777
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_Outer.777 *(AM only)*
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_PreLd.PLD *(except OP)*

Group	Input file
PT network files (factor files for EMP, COM, OTH, EDU, RET and ZOD)	{CATALOG_DIR}\Params\4 PT \4 PT_VOT_Table.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\FARES.MAT
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\FARES_AM.FAR
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\FARES_LT.FAR
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\FARES_PM.FAR
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\FARES_SR.FAR
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\NTL_GENERATE_SCRIPT.txt
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\4 PT_Dump_Links.csv
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\SELECT_LINK_SPEC.TXT
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\SYSTEM_FILE.PTS
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Factor_Files\???_NO_VOT_AM.FAC
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Factor_Files\???_NO_VOT_LT.FAC
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Factor_Files\???_NO_VOT_PM.FAC
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Factor_Files\???_NO_VOT_SR.FAC
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Lines\Bus_{RunID}_{Model Year}.LIN
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Lines\New_Mode_{RunID}_{Model Year}.LIN
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Lines\Rail_{RunID}_{Model Year}.LIN
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\BRT_FareZones.DBF
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\DBus_FareZones.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Luas_Links.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Luas_Nodes.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Metro_Links.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Metro_Nodes.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Rail_Links.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Rail_Nodes.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Walk_Links.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Walk_Nodes.dbf
Active modes	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\AMM\CYCLE_DATA.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\AMM\PED_ONLY.DBF
Finalisation files	{CATALOG_DIR}\Params\AssPrep\CarUserToCarDriver.PRM
	{CATALOG_DIR}\Params\AssPrep\PeriodToHour.PRM
	{CATALOG_DIR}\Params\AssPrep\AM_Incrementals.INC
	{CATALOG_DIR}\Params\AssPrep\LT_Incrementals.INC
	{CATALOG_DIR}\Params\AssPrep\SR_Incrementals.INC
	{CATALOG_DIR}\Params\AssPrep\PM_Incrementals.INC
	{CATALOG_DIR}\Params\AssPrep\OP_Incrementals.INC
	{CATALOG_DIR}\Params\AssPrep\TaxiProps.MAT
	{CATALOG_DIR}\Params\AssPrep\Taxi_Incrementals.INC
Preliminary test / dummy files	{CATALOG_DIR}\Params\Active_Assignment \Dummy_Active_Assign.AAM
	{CATALOG_DIR}\Params\Empty.prn
	{CATALOG_DIR}\Params\FWPP\Dummy_FWPP.MAT
	{CATALOG_DIR}\Params\PnR\PnR_Blank_Costs.AGC
	{CATALOG_DIR}\Params\PnR\PnR_Start_File.CSV
	{CATALOG_DIR}\Params\4 PT \4 PT_Assignment_Test.PTM
	{CATALOG_DIR}\Params\3 Road\Dummy_Demand.UFM
	{CATALOG_DIR}\Params\3 Road\Matrix_LowFlow.UFM
	{CATALOG_DIR}\Params\3 Road\SATALL_KR_1ITER.DAT

Annex 2 Special Zones

A2.1 Introduction

This chapter sets out the methodology for the determination of productions and attractions for special ports and zones and their distribution. A similar approach was adopted for special zones for all regional models, excluding the ERM, in the absence of detailed survey data.

A2.2 Foynes Port

Foynes Port is Ireland's second largest port operation and activities include warehousing, logistics and cargo handling which generates a large number of HGV movements though there are currently no passenger ferry services. This section discusses how the highway Attractions and Productions are generated for HGV traffic.

A2.2.1 Demand

Evidence from the Shanon Foynes Port Masterplan (2011)[5] indicates 3,200 HGV movements per 6-day week, or approximately 530 HGV movements are generated per working day.

A2.2.2 Flows by time period

In order to assign the 530 HGV daily movements to the network it was necessary to determine the percentage of HGV trips by time period. Traffic count data available from Transport Infrastructure Ireland (TII) near Foynes on the N69 was used to determine flows by time period and he HGV profile from this site was used to determine the percentage of HGV trips by time period.

A2.2.3 Output productions / attractions

Combining these two sets of factors gives the figures shown in Table A2.1.

Table A2.1 HGV attractions and productions

Time Periods	% HGV Trips by TP	HGV Prod	HGV Attr
AM	24%	63	63
LT	27%	71	71
SR	26%	69	69
PM	13%	36	36
OP	10%	26	26
Total	100%	265	265

[5] http://www.sfpc.ie/download/SFPC%20MASTERPLAN%20Final.pdf

A2.2.4 Distribution

Having established the expected numbers of trips NACE data was then used to distribute them. NACE is a Statistical Classification of Economic Activities and is used as the CSO Standard Classification of Industrial Activity. In this case, the NACE Building Codes Database version 1.55 was used to determine the port related trips and the proportion of the activity deriving from each relevant zone. Port related activity was assumed to derive from forestry and logging, mining and quarrying, land transport and transport via pipelines, warehousing, and support activities for transportation.

A2.3 Shannon Airport

This section discusses how the HW and PT Attractions and Productions are generated for Shannon Airport

A2.3.1 Demand

Terminal traffic, ie passengers who started or ended their journey at Shannon Airport was 1.3 million in 2012 (Source: DAA). DAA data provided by the NTA and was broken down into annual passenger numbers to represent a typical weekday in November.

- 1,300,000 – Annual passenger numbers
- 93,057 – Monthly passengers in November
- 17,182 – Typical weekday (5day) passenger numbers
- 3,436 – Typical passenger numbers in November on a single day

This approach to breaking down the annual passenger numbers considers the seasonality of high passenger trips in the summer and ensures that a typical weekday is considered.

A2.3.2 Flows by time period

The next consideration was to break down the daily passenger flow by time period. Flight arrival and departure data was obtained from the Shannon Airport website. A profile was developed for trips (attractions and productions) from arrivals and departures information. Access to the airport up to an hour and a half before the flight departure was factored into the time period profile build. Table A2.2 presents the time period profile for trips to and from the airport.

Table A2.2 Passenger Trips Profile by time period

Time Periods	Time	Arrivals %	Departures %
AM	0700 - 1000	23%	25%
LT	1000 - 1300	24%	43%
SR	1300 - 1600	13%	1%
PM	1600 - 1900	25%	25%
OP	1900 - 0700	14%	6%
		100%	100%

CSO Aviation Statistics[6] for all Irish airports including Shannon Airport show that passenger numbers are split 50:50 between arrivals and departures. Therefore, if 1.3 million passengers use Shannon Airport it is assumed that the split between arrivals and departures is 650,000 passengers each.

DAA surveys contained information on mode share for Dublin and a number of UK Airports. Figure A2.1 shows a summary of this data.

U.K Airport	% Public Transport Mode Share for passengers
Stansted	47%
Heathrow	40%
Gatwick	38%
* Dublin	33%
Edinburgh	27%
Glasgow	11%
Newcastle	13%
Manchester	13%

* *Figure for Dublin is from the 2011 NTA survey,*

U.K. figures relate to 2009 and 2010 data

Figure A2.1 PT Mode Share comparison of Dublin with other UK airports

Shannon Airport is remote and not well served by public transport and in the absence of site specific observed mode share data it was assumed that 10% of all trips to Shannon Airport are by public transport.

A2.3.3 Car trips per passenger

There were two final factors to consider before the number of car movements generated by Shannon Aiport could be finalised. These were car occupancies and the proportion of drop off / pick up activity (Kiss & Fly).

Available case studies from other airports show that typical car occupancy is a value of 2. Taxis and Kiss & Fly trips generate four vehicle trips per return air trip as the cars make the return journey without the air passenger(s). This is in contrast to two trips when

[6] http://cso.ie/en/releasesandpublications/er/as/aviationstatistics2013/

passengers park at the Airport. Evidence from other airport studies show car drop-off and pick-up represents 30% - 40% of total trips.

- Cork Airport – drop off / pick up approx. 30%[7]
- Leeds Bradford Airport – drop off / pick up approx. 34%[8]
- Glasgow Airport – drop off / pick up approx. 32.3%[9]

Therefore, car drop off / pick up was be assumed to be 30%.

A2.3.4 Output productions / attractions

Combining all of the data above gives the overall PT and HW attractions and productions in Table A2.3.

Table A2.3 PT & HW Attractions and Productions

Time Periods	Time	PT Attr	PT Prod	HW Attr	HW Prod
AM	0700 - 1000	42	40	249	232
LT	1000 - 1300	74	42	432	243
SR	1300 - 1600	2	23	11	133
PM	1600 - 1900	42	43	249	254
OP	19-00-0700	11	25	65	144
		172	**172**	**1,005**	**1,005**

A2.3.5 Period to Peak Hour Factor

The period to peak hour factor was assumed to be 0.50 in order to get trips from the three-hour time periods to the peak hour period. The factor may appear high but due to the actual distribution of passenger trips to the airport being difficult quantify due to the absence of observed data, the 0.50 factor is considered reasonable.

A2.3.6 Split of Inbound / Outbound trips by destination type

Due to the minimal demand for internal flights Irish travellers are assumed to derive from homes and businesses, overseas leisure travellers from homes and hotels and overseas business visitors from homes and hotels. In the regional models these splits are based on the NACE codes giving the distributions of hotels, employment and housing and assumptions about the likely directionality of trips at different times of day. The finalised split is shown in Table A2.4.

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[7] http://www.corkcoco.ie/co/pdf/359024904.pdf

[8] http://www.leedsbradfordairport.co.uk/media/2175/route-to-2030-surface-access-strategy.pdf

[9] http://www.glasgowairport.com/media/37881/glasgow-surface-access-2009.pdf

Table A2.4 Split of Inbound Outbound trips by destination type

Time Period	Trips to airport			Trips from airport		
	Hotels	Businesses	Homes	Hotels	Businesses	Homes
07:00-10:00	13%	7%	80%	53%	27%	20%
10:00-13:00	40%	10%	50%	40%	10%	50%
13:00-16:00	40%	10%	50%	40%	10%	50%
16:00-19:00	80%	0%	20%	20%	0%	80%
19:00-07:00	80%	0%	20%	20%	0%	80%

A2.3.7 Distribution

In the absence of an Origin-Destination Survey, trip ends were distributed based on a gravity model and attraction factors by type of trips.

Home Trips

The matrix build for home trips was developed based on population data which was used to determine how trips would be distributed using a gravity model with costs based on distance.

The sensitivity to distance was derived from the Dublin Airport trip distribution where an accurate survey was undertaken with origin-destination surveys. All “Other” trip ends of the special zone of Dublin Airport extracted from the ERM model were used at the 24h level. This gave a lambda value of 0.03 (km^{-1}).

$$T_{i \to Airport} = Attr_{airport} \times \frac{Pop_i \times \exp\left(-\lambda . Dist_{i \to Airport}\right)}{\sum_{j \in Zones}\left[Pop_j \times \exp\left(-\lambda . Dist_{j \to Airport}\right)\right]}$$

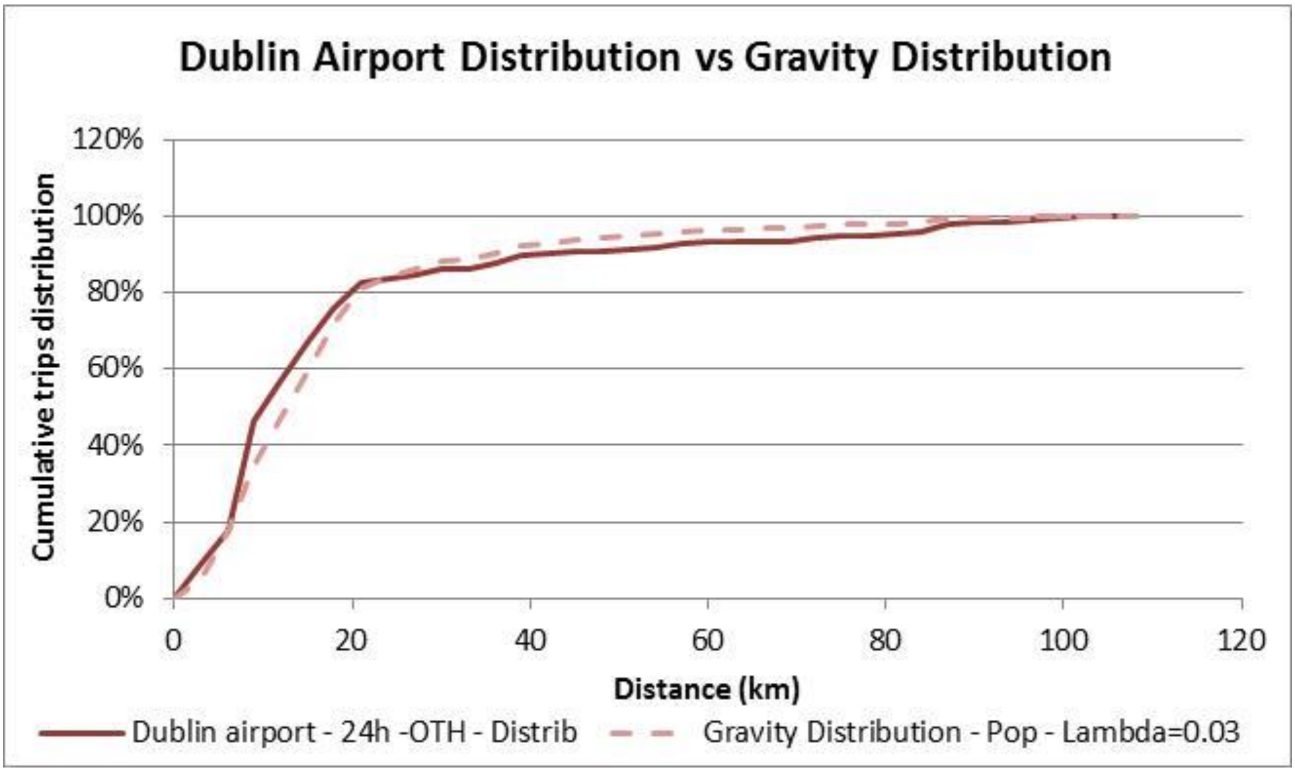

Figure A2.2 Dublin Airport – Distribution vs Gravity Distribution

For Shannon Airport this gravity model gave the modelled distribution shown in Figure A2.3 and gave 25% of trips deriving from Limerick city and 33% from external zones.

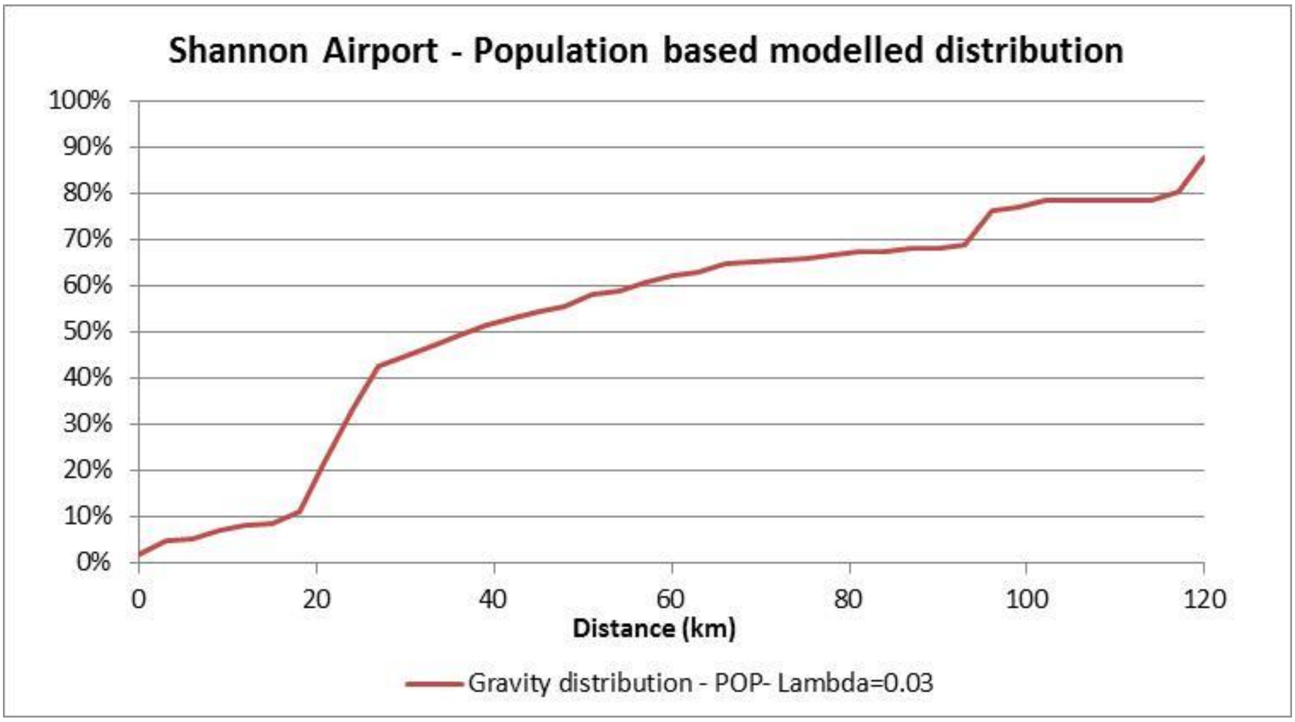

Figure A2.3 Population based modelled distribution

Leisure Trips

The NACE Building Codes dataset was used to determine the distribution of leisure trips. Hotel activity was cross referenced with the MWRM zone plan and the trip distribution was weighted towards urban areas in order to determine the overall distribution of leisure trips.

Business Trips

The distribution of business trips was based on ‘white collar’ commuting attractions from the FDM.

Annex 3 Final demand model parameter values

The data included is as follows:

- Table A3.5 Production tour proportions by purpose
- Table A3.6 Attraction tour proportions by purpose
- Table A3.7 Finalised distribution and mode split parameters
- Table A3.8 Finalised period to hour factors
- Table A3.9 Finalised parking distribution calibration parameters
- Table A3.10 Finalised special zone calibration parameters

Table A3.5 Production tour proportions by purpose

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25
P01	0.02642	0.04528	0.10189	0.49434	0.04906	0.00000	0.00377	0.00755	0.02264	0.00755	0.00000	0.00000	0.01132	0.04906	0.04906	0.00000	0.00000	0.00000	0.00755	0.02642	0.00755	0.00000	0.02264	0.05283	0.01509
P02	0.02642	0.04528	0.10189	0.49434	0.04906	0.00000	0.00377	0.00755	0.02264	0.00755	0.00000	0.00000	0.01132	0.04906	0.04906	0.00000	0.00000	0.00000	0.00755	0.02642	0.00755	0.00000	0.02264	0.05283	0.01509
P03	0.10526	0.04211	0.13684	0.32632	0.03158	0.00000	0.02105	0.03158	0.02105	0.06316	0.00000	0.00000	0.03158	0.06316	0.03158	0.00000	0.00000	0.00000	0.00000	0.06316	0.00000	0.00000	0.01053	0.02105	0.00000
P04	0.10526	0.04211	0.13684	0.32632	0.03158	0.00000	0.02105	0.03158	0.02105	0.06316	0.00000	0.00000	0.03158	0.06316	0.03158	0.00000	0.00000	0.00000	0.00000	0.06316	0.00000	0.00000	0.01053	0.02105	0.00000
P05	0.00000	0.01075	0.81720	0.15054	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.02151
P06	0.00000	0.01786	0.55357	0.42857	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
P07	0.02740	0.10959	0.19178	0.35616	0.04110	0.00000	0.01370	0.05479	0.05479	0.00000	0.00000	0.00000	0.00000	0.12329	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.02740
P08	0.00000	0.01075	0.81720	0.15054	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.02151
P09	0.00000	0.01786	0.55357	0.42857	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
P10	0.02740	0.10959	0.19178	0.35616	0.04110	0.00000	0.01370	0.05479	0.05479	0.00000	0.00000	0.00000	0.00000	0.12329	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.02740
P11	0.35945	0.03226	0.06452	0.07373	0.00461	0.00000	0.04147	0.02304	0.00461	0.00000	0.00000	0.00000	0.30415	0.01843	0.00000	0.00000	0.00000	0.00000	0.04147	0.00461	0.00000	0.00000	0.00000	0.00000	0.02765
P12	0.35945	0.03226	0.06452	0.07373	0.00461	0.00000	0.04147	0.02304	0.00461	0.00000	0.00000	0.00000	0.30415	0.01843	0.00000	0.00000	0.00000	0.00000	0.04147	0.00461	0.00000	0.00000	0.00000	0.00000	0.02765
P13	0.35945	0.03226	0.06452	0.07373	0.00461	0.00000	0.04147	0.02304	0.00461	0.00000	0.00000	0.00000	0.30415	0.01843	0.00000	0.00000	0.00000	0.00000	0.04147	0.00461	0.00000	0.00000	0.00000	0.00000	0.02765
P14	0.35945	0.03226	0.06452	0.07373	0.00461	0.00000	0.04147	0.02304	0.00461	0.00000	0.00000	0.00000	0.30415	0.01843	0.00000	0.00000	0.00000	0.00000	0.04147	0.00461	0.00000	0.00000	0.00000	0.00000	0.02765
P15	0.35945	0.03226	0.06452	0.07373	0.00461	0.00000	0.04147	0.02304	0.00461	0.00000	0.00000	0.00000	0.30415	0.01843	0.00000	0.00000	0.00000	0.00000	0.04147	0.00461	0.00000	0.00000	0.00000	0.00000	0.02765
P16	0.35945	0.03226	0.06452	0.07373	0.00461	0.00000	0.04147	0.02304	0.00461	0.00000	0.00000	0.00000	0.30415	0.01843	0.00000	0.00000	0.00000	0.00000	0.04147	0.00461	0.00000	0.00000	0.00000	0.00000	0.02765
P17	0.04641	0.08439	0.01688	0.02532	0.00422	0.00000	0.15612	0.08861	0.03376	0.01266	0.00000	0.00000	0.08439	0.08017	0.01688	0.00000	0.00000	0.00000	0.15190	0.05907	0.00000	0.00000	0.00000	0.00000	0.13924
P18	0.06050	0.04982	0.02491	0.01779	0.00356	0.00000	0.09253	0.07829	0.01779	0.01779	0.00000	0.00000	0.11032	0.06406	0.00000	0.00000	0.00000	0.00000	0.12100	0.09964	0.00000	0.00000	0.00000	0.00000	0.24199
P19	0.04196	0.09790	0.03497	0.01399	0.01399	0.00000	0.23776	0.12587	0.02797	0.00699	0.00000	0.00000	0.06294	0.06294	0.00000	0.00000	0.00000	0.00000	0.13287	0.04196	0.00000	0.00000	0.00000	0.00000	0.09790
P20	0.02830	0.06604	0.01887	0.02830	0.00000	0.00000	0.16038	0.11321	0.03774	0.00000	0.00000	0.00000	0.07547	0.07547	0.00000	0.00000	0.00000	0.00000	0.15094	0.09434	0.00000	0.00000	0.00000	0.00000	0.15094
P21	0.07895	0.07895	0.00000	0.00000	0.00000	0.00000	0.30263	0.14474	0.03947	0.01316	0.00000	0.00000	0.18421	0.06579	0.00000	0.00000	0.00000	0.00000	0.01316	0.00000	0.00000	0.00000	0.00000	0.00000	0.07895
P22	0.08000	0.04000	0.00000	0.00000	0.00000	0.00000	0.22667	0.17333	0.00000	0.01333	0.00000	0.00000	0.12000	0.02667	0.01333	0.00000	0.00000	0.00000	0.16000	0.08000	0.00000	0.00000	0.00000	0.00000	0.06667
P23	0.06329	0.07595	0.00000	0.00000	0.00000	0.00000	0.35443	0.07595	0.00000	0.00000	0.00000	0.00000	0.17722	0.05063	0.00000	0.00000	0.00000	0.00000	0.12658	0.01266	0.00000	0.00000	0.00000	0.00000	0.06329
P24	0.00000	0.05128	0.00000	0.02564	0.00000	0.00000	0.17949	0.15385	0.00000	0.02564	0.00000	0.00000	0.02564	0.02564	0.07692	0.00000	0.00000	0.00000	0.12821	0.12821	0.00000	0.00000	0.00000	0.00000	0.17949
P25	0.01786	0.01786	0.05357	0.00000	0.00000	0.00000	0.07143	0.08929	0.03571	0.00000	0.00000	0.00000	0.03571	0.12500	0.03571	0.00000	0.00000	0.00000	0.10714	0.10714	0.00000	0.00000	0.00000	0.00000	0.30357
P26	0.02439	0.04878	0.00000	0.04878	0.00000	0.00000	0.09756	0.14634	0.02439	0.02439	0.00000	0.00000	0.17073	0.17073	0.00000	0.00000	0.00000	0.00000	0.09756	0.12195	0.00000	0.00000	0.00000	0.00000	0.02439
P27	0.04545	0.09091	0.12121	0.15152	0.03030	0.00000	0.06061	0.07576	0.01515	0.00000	0.00000	0.00000	0.15152	0.04545	0.00000	0.00000	0.00000	0.00000	0.06061	0.01515	0.00000	0.00000	0.00000	0.00000	0.13636
P28	0.08683	0.06587	0.19162	0.09880	0.02395	0.00000	0.08084	0.07186	0.02395	0.00299	0.00000	0.00000	0.07186	0.05988	0.00299	0.00000	0.00000	0.00000	0.08383	0.06287	0.00000	0.00000	0.00000	0.00000	0.07186
P29	0.10526	0.02632	0.15789	0.15789	0.00000	0.00000	0.13158	0.02632	0.02632	0.00000	0.00000	0.00000	0.07895	0.07895	0.00000	0.00000	0.00000	0.00000	0.05263	0.05263	0.00000	0.00000	0.00000	0.00000	0.10526
P30	0.25862	0.00000	0.00000	0.00000	0.00000	0.00000	0.27586	0.00000	0.00000	0.00000	0.00000	0.00000	0.22414	0.00000	0.00000	0.00000	0.00000	0.00000	0.05172	0.00000	0.00000	0.00000	0.00000	0.00000	0.18966
P31	0.25862	0.00000	0.00000	0.00000	0.00000	0.00000	0.27586	0.00000	0.00000	0.00000	0.00000	0.00000	0.22414	0.00000	0.00000	0.00000	0.00000	0.00000	0.05172	0.00000	0.00000	0.00000	0.00000	0.00000	0.18966
P32	0.22021	0.00000	0.00000	0.00000	0.00000	0.00000	0.23834	0.00000	0.00000	0.00000	0.00000	0.00000	0.32383	0.00000	0.00000	0.00000	0.00000	0.00000	0.14249	0.00000	0.00000	0.00000	0.00000	0.00000	0.07513
P33	0.22021	0.00000	0.00000	0.00000	0.00000	0.00000	0.23834	0.00000	0.00000	0.00000	0.00000	0.00000	0.32383	0.00000	0.00000	0.00000	0.00000	0.00000	0.14249	0.00000	0.00000	0.00000	0.00000	0.00000	0.07513

Table A3.6 Attraction tour proportions by purpose

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25
P01	0.02642	0.04528	0.10189	0.49434	0.04906	0.00000	0.00377	0.00755	0.02264	0.00755	0.00000	0.00000	0.01132	0.04906	0.04906	0.00000	0.00000	0.00000	0.00755	0.02642	0.00755	0.00000	0.02264	0.05283	0.01509
P02	0.02642	0.04528	0.10189	0.49434	0.04906	0.00000	0.00377	0.00755	0.02264	0.00755	0.00000	0.00000	0.01132	0.04906	0.04906	0.00000	0.00000	0.00000	0.00755	0.02642	0.00755	0.00000	0.02264	0.05283	0.01509
P03	0.10526	0.04211	0.13684	0.32632	0.03158	0.00000	0.02105	0.03158	0.02105	0.06316	0.00000	0.00000	0.03158	0.06316	0.03158	0.00000	0.00000	0.00000	0.00000	0.06316	0.00000	0.00000	0.01053	0.02105	0.00000
P04	0.10526	0.04211	0.13684	0.32632	0.03158	0.00000	0.02105	0.03158	0.02105	0.06316	0.00000	0.00000	0.03158	0.06316	0.03158	0.00000	0.00000	0.00000	0.00000	0.06316	0.00000	0.00000	0.01053	0.02105	0.00000
P05	0.00000	0.01075	0.81720	0.15054	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.02151
P06	0.00000	0.01786	0.55357	0.42857	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
P07	0.02740	0.10959	0.19178	0.35616	0.04110	0.00000	0.01370	0.05479	0.05479	0.00000	0.00000	0.00000	0.00000	0.12329	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.02740
P08	0.00000	0.01075	0.81720	0.15054	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.02151
P09	0.00000	0.01786	0.55357	0.42857	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
P10	0.02740	0.10959	0.19178	0.35616	0.04110	0.00000	0.01370	0.05479	0.05479	0.00000	0.00000	0.00000	0.00000	0.12329	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.02740
P11	0.35945	0.03226	0.06452	0.07373	0.00461	0.00000	0.04147	0.02304	0.00461	0.00000	0.00000	0.00000	0.30415	0.01843	0.00000	0.00000	0.00000	0.00000	0.04147	0.00461	0.00000	0.00000	0.00000	0.00000	0.02765
P12	0.35945	0.03226	0.06452	0.07373	0.00461	0.00000	0.04147	0.02304	0.00461	0.00000	0.00000	0.00000	0.30415	0.01843	0.00000	0.00000	0.00000	0.00000	0.04147	0.00461	0.00000	0.00000	0.00000	0.00000	0.02765
P13	0.35945	0.03226	0.06452	0.07373	0.00461	0.00000	0.04147	0.02304	0.00461	0.00000	0.00000	0.00000	0.30415	0.01843	0.00000	0.00000	0.00000	0.00000	0.04147	0.00461	0.00000	0.00000	0.00000	0.00000	0.02765
P14	0.35945	0.03226	0.06452	0.07373	0.00461	0.00000	0.04147	0.02304	0.00461	0.00000	0.00000	0.00000	0.30415	0.01843	0.00000	0.00000	0.00000	0.00000	0.04147	0.00461	0.00000	0.00000	0.00000	0.00000	0.02765
P15	0.35945	0.03226	0.06452	0.07373	0.00461	0.00000	0.04147	0.02304	0.00461	0.00000	0.00000	0.00000	0.30415	0.01843	0.00000	0.00000	0.00000	0.00000	0.04147	0.00461	0.00000	0.00000	0.00000	0.00000	0.02765
P16	0.35945	0.03226	0.06452	0.07373	0.00461	0.00000	0.04147	0.02304	0.00461	0.00000	0.00000	0.00000	0.30415	0.01843	0.00000	0.00000	0.00000	0.00000	0.04147	0.00461	0.00000	0.00000	0.00000	0.00000	0.02765
P17	0.04641	0.08439	0.01688	0.02532	0.00422	0.00000	0.15612	0.08861	0.03376	0.01266	0.00000	0.00000	0.08439	0.08017	0.01688	0.00000	0.00000	0.00000	0.15190	0.05907	0.00000	0.00000	0.00000	0.00000	0.13924
P18	0.06050	0.04982	0.02491	0.01779	0.00356	0.00000	0.09253	0.07829	0.01779	0.01779	0.00000	0.00000	0.11032	0.06406	0.00000	0.00000	0.00000	0.00000	0.12100	0.09964	0.00000	0.00000	0.00000	0.00000	0.24199
P19	0.04196	0.09790	0.03497	0.01399	0.01399	0.00000	0.23776	0.12587	0.02797	0.00699	0.00000	0.00000	0.06294	0.06294	0.00000	0.00000	0.00000	0.00000	0.13287	0.04196	0.00000	0.00000	0.00000	0.00000	0.09790
P20	0.02830	0.06604	0.01887	0.02830	0.00000	0.00000	0.16038	0.11321	0.03774	0.00000	0.00000	0.00000	0.07547	0.07547	0.00000	0.00000	0.00000	0.00000	0.15094	0.09434	0.00000	0.00000	0.00000	0.00000	0.15094
P21	0.07895	0.07895	0.00000	0.00000	0.00000	0.00000	0.30263	0.14474	0.03947	0.01316	0.00000	0.00000	0.18421	0.06579	0.00000	0.00000	0.00000	0.00000	0.01316	0.00000	0.00000	0.00000	0.00000	0.00000	0.07895
P22	0.08000	0.04000	0.00000	0.00000	0.00000	0.00000	0.22667	0.17333	0.00000	0.01333	0.00000	0.00000	0.12000	0.02667	0.01333	0.00000	0.00000	0.00000	0.16000	0.08000	0.00000	0.00000	0.00000	0.00000	0.06667
P23	0.06329	0.07595	0.00000	0.00000	0.00000	0.00000	0.35443	0.07595	0.00000	0.00000	0.00000	0.00000	0.17722	0.05063	0.00000	0.00000	0.00000	0.00000	0.12658	0.01266	0.00000	0.00000	0.00000	0.00000	0.06329
P24	0.00000	0.05128	0.00000	0.02564	0.00000	0.00000	0.17949	0.15385	0.00000	0.02564	0.00000	0.00000	0.02564	0.02564	0.07692	0.00000	0.00000	0.00000	0.12821	0.12821	0.00000	0.00000	0.00000	0.00000	0.17949
P25	0.01786	0.01786	0.05357	0.00000	0.00000	0.00000	0.07143	0.08929	0.03571	0.00000	0.00000	0.00000	0.03571	0.12500	0.03571	0.00000	0.00000	0.00000	0.10714	0.10714	0.00000	0.00000	0.00000	0.00000	0.30357
P26	0.02439	0.04878	0.00000	0.04878	0.00000	0.00000	0.09756	0.14634	0.02439	0.02439	0.00000	0.00000	0.17073	0.17073	0.00000	0.00000	0.00000	0.00000	0.09756	0.12195	0.00000	0.00000	0.00000	0.00000	0.02439
P27	0.04545	0.09091	0.12121	0.15152	0.03030	0.00000	0.06061	0.07576	0.01515	0.00000	0.00000	0.00000	0.15152	0.04545	0.00000	0.00000	0.00000	0.00000	0.06061	0.01515	0.00000	0.00000	0.00000	0.00000	0.13636
P28	0.08683	0.06587	0.19162	0.09880	0.02395	0.00000	0.08084	0.07186	0.02395	0.00299	0.00000	0.00000	0.07186	0.05988	0.00299	0.00000	0.00000	0.00000	0.08383	0.06287	0.00000	0.00000	0.00000	0.00000	0.07186
P29	0.10526	0.02632	0.15789	0.15789	0.00000	0.00000	0.13158	0.02632	0.02632	0.00000	0.00000	0.00000	0.07895	0.07895	0.00000	0.00000	0.00000	0.00000	0.05263	0.05263	0.00000	0.00000	0.00000	0.00000	0.10526
P30	0.25862	0.00000	0.00000	0.00000	0.00000	0.00000	0.27586	0.00000	0.00000	0.00000	0.00000	0.00000	0.22414	0.00000	0.00000	0.00000	0.00000	0.00000	0.05172	0.00000	0.00000	0.00000	0.00000	0.00000	0.18966
P31	0.25862	0.00000	0.00000	0.00000	0.00000	0.00000	0.27586	0.00000	0.00000	0.00000	0.00000	0.00000	0.22414	0.00000	0.00000	0.00000	0.00000	0.00000	0.05172	0.00000	0.00000	0.00000	0.00000	0.00000	0.18966
P32	0.22021	0.00000	0.00000	0.00000	0.00000	0.00000	0.23834	0.00000	0.00000	0.00000	0.00000	0.00000	0.32383	0.00000	0.00000	0.00000	0.00000	0.00000	0.14249	0.00000	0.00000	0.00000	0.00000	0.00000	0.07513
P33	0.22021	0.00000	0.00000	0.00000	0.00000	0.00000	0.23834	0.00000	0.00000	0.00000	0.00000	0.00000	0.32383	0.00000	0.00000	0.00000	0.00000	0.00000	0.14249	0.00000	0.00000	0.00000	0.00000	0.00000	0.07513

Table A3.7 Finalised distribution and mode split parameters

Purp	Alpha					Beta	Lambda			ASC values					Intrazonals				
	Car	PT	PnR	Walk	Cyc	All mds	Dest	Md Ch	Act Ch	Car	PT	PnR	Walk	Cyc	Car	PT	PnR	Walk	Cyc
1	0.865	0.260	1.000	0.400	0.600	N/A	-0.113	-0.136	-0.272	0.000	168.00	0.000	28.000	53.000	-6.500	11.970	10.000	-8.700	-6.950
2	0.800	0.280	1.000	0.550	0.680	N/A	-0.113	-0.136	-0.272	0.000	161.90	0.000	8.000	33.000	0.385	24.090	10.000	0.505	1.685
3	1.000	0.420	1.000	1.200	1.400	N/A	-0.043	-0.052	-0.104	45.000	-3.000	0.000	-22.00	-5.000	-10.50	10.480	10.000	-30.00	-30.00
4	1.000	2.000	1.000	2.700	4.800	N/A	-0.043	-0.052	-0.104	45.000	-3.000	0.000	-12.00	25.000	-10.50	30.000	10.000	-17.40	-17.10
5	1.350	0.120	2.020	0.600	0.781	N/A	-0.154	-0.154	-0.309	-10.00	60.000	0.000	6.000	300.00	-4.970	-11.60	10.000	-1.130	9.640
6	1.200	0.190	1.000	0.800	1.000	N/A	-0.141	-0.141	-0.282	-3.000	50.000	0.000	6.000	50.000	-2.120	14.930	10.000	1.480	5.005
7	0.698	0.220	2.260	0.600	0.800	N/A	-0.160	-0.160	-0.320	-3.000	50.000	0.000	6.000	40.000	10.880	23.420	10.000	15.780	17.510
8	1.000	0.400	1.000	2.200	3.000	N/A	-0.062	-0.062	-0.124	15.000	22.000	0.000	-30.00	20.000	5.000	-30.00	10.000	2.250	-6.140
9	1.000	0.480	1.000	1.600	2.600	N/A	-0.062	-0.062	-0.124	15.000	22.000	0.000	-10.00	20.000	5.000	10.860	10.000	-9.380	1.815
10	1.000	0.685	1.000	1.700	2.300	N/A	-0.062	-0.062	-0.124	15.000	22.000	0.000	-10.00	20.000	5.000	26.810	10.000	30.000	29.770
11	1.117	0.400	1.000	0.444	1.300	N/A	-0.160	-0.160	-0.320	0.000	17.000	0.000	20.000	330.00	-3.530	30.000	10.000	-4.140	5.940
12	1.800	0.520	1.000	0.420	1.250	N/A	-0.160	-0.160	-0.320	0.000	15.000	0.000	29.000	330.00	-30.00	8.290	10.000	-30.00	-23.10
13	1.800	0.500	1.000	0.600	1.200	N/A	-0.160	-0.160	-0.320	0.000	23.000	0.000	22.500	330.00	-30.00	2.690	10.000	-30.00	-27.40
14	1.000	0.955	1.000	0.747	1.800	N/A	-0.062	-0.062	-0.124	31.000	0.000	0.000	0.000	50.000	-30.00	30.000	10.000	-29.80	-7.240
15	1.000	0.948	1.000	0.593	1.600	N/A	-0.062	-0.062	-0.124	31.000	0.000	0.000	5.000	60.000	-30.00	30.000	10.000	-30.00	-9.530
16	1.000	0.784	1.000	0.735	1.604	N/A	-0.062	-0.062	-0.124	31.000	0.000	0.000	-6.000	40.000	-30.00	30.000	10.000	-30.00	-13.40
17	1.000	0.230	1.000	0.210	0.630	N/A	-0.160	-0.160	-0.319	0.000	32.000	0.000	27.000	50.000	3.060	29.030	10.000	-6.790	2.915
18	0.690	0.270	1.000	0.200	0.570	N/A	-0.158	-0.158	-0.315	0.000	9.000	0.000	18.000	30.000	-3.650	29.510	10.000	-9.340	0.240
19	1.000	0.560	1.000	0.600	1.300	N/A	-0.062	-0.062	-0.124	31.000	0.000	0.000	-6.000	10.000	-30.00	30.000	10.000	-30.00	-11.40
20	1.000	0.645	1.000	0.547	1.300	N/A	-0.062	-0.062	-0.124	31.000	0.000	0.000	2.000	30.000	-30.00	30.000	10.000	-30.00	-11.50
21	0.930	0.400	1.000	0.280	1.000	N/A	-0.160	-0.160	-0.320	0.000	17.000	0.000	18.000	312.50	-14.40	27.810	10.000	-17.10	-6.160
22	1.320	0.380	1.000	0.390	1.200	N/A	-0.160	-0.160	-0.320	0.000	85.000	0.000	18.000	312.50	-16.00	25.580	10.000	-18.00	-7.520
23	1.000	1.600	1.000	1.500	2.700	N/A	-0.062	-0.062	-0.124	31.000	0.000	0.000	2.000	70.000	-30.00	30.000	10.000	-30.00	-30.00
24	0.600	0.400	1.000	0.256	0.580	N/A	-0.158	-0.158	-0.316	0.000	0.000	0.000	13.000	330.00	-1.640	30.000	10.000	-5.430	3.440
25	0.700	0.200	1.000	0.218	0.600	N/A	-0.158	-0.158	-0.315	0.000	25.000	0.000	15.000	40.000	6.230	29.160	10.000	-6.010	3.390
26	1.000	0.300	1.000	0.800	0.800	N/A	-0.062	-0.062	-0.124	31.000	0.000	0.000	-10.00	10.000	-30.00	30.000	10.000	-30.00	-26.10
27	0.820	0.340	1.000	0.252	0.560	N/A	-0.105	-0.162	-0.324	0.000	1.500	0.000	10.000	18.000	-20.80	23.240	10.000	-23.30	-15.30
28	0.800	0.200	1.000	0.210	0.650	N/A	-0.154	-0.154	-0.308	0.000	24.000	0.000	24.000	250.00	-1.720	24.230	10.000	-7.580	2.675
29	1.000	0.600	1.000	0.450	0.766	N/A	-0.062	-0.062	-0.124	28.000	-2.000	0.000	5.000	25.000	-30.00	30.000	10.000	-30.00	-15.30
30	0.820	0.250	1.000	0.300	1.000	N/A	-0.104	-0.143	-0.285	0.000	3.000	0.000	35.000	250.00	-11.60	25.620	10.000	-15.80	-3.880
31	1.000	0.420	1.000	1.300	2.500	N/A	-0.045	-0.062	-0.123	50.000	0.000	0.000	-20.00	-10.00	-30.00	26.440	10.000	-30.00	-17.30
32	1.300	0.370	1.000	0.390	0.800	N/A	-0.102	-0.102	-0.203	0.000	30.000	0.000	42.000	65.000	5.565	30.000	10.000	-8.800	3.535
33	1.000	0.750	1.000	1.500	2.100	N/A	-0.035	-0.035	-0.070	31.000	0.000	0.000	-10.00	15.000	-30.00	30.000	10.000	-30.00	-6.640

Table A3.8 Finalised period to hour factors

Time Period	Car	PT	Walk	Cycle
AM	0.62929	0.61000	0.39000	0.39000
IP1	0.46000	0.33333	0.33333	0.33333
IP2	0.51289	0.33333	0.33333	0.33333
PM	0.49000	0.55000	0.41000	0.41000
OP	0.08333	0.08333	0.08333	0.08333

Table A3.9 Finalised parking distribution calibration parameters

Title	Value
Car occupancy	1.18
Minimum search time	0.9 minutes
Maximum search time	15 minutes
Search time scaling parameter	1.46
Value of Time	11.57
Lambda	-0.3
Weight on walk time	2

Table A3.10 Finalised special zone calibration parameters

	Airport EMP	Airport OTH
Charge (parking or taxi fare)	40	30
Lambda	-0.5	-0.5
Alpha car	1.28	1.26
Beta car	0	0
ASC car	0	0
Alpha PT	0.32	0.33
Beta PT	0	0
ASC PT	75	98
Prop car = taxi	0.42	0.42
Prop car = Kiss & Fly/Sail	0.51	0.51

Annex 4 Park and Ride Calibration

A4.1 Park and Ride Model Development

A4.1.1 Introduction

This chapter sets out the Park and Ride model development and calibration methodology for the MWRM.

To undertake this, several steps are required:

- Identify park and ride sites;
- Collate site characteristics such as capacity and charges;
- Identify observed data for calibration;
- Define Park and Ride site catchments;
- Create site files; and,
- Calibrate.

A4.2 Model development

A4.2.1 Sites

Eleven park and ride sites were identified in the MWRM, all of which are rail based and outlined in Table A4.11.

Table A4.11 MWRM Park and Ride sites

Site	Capacity	Charge (€)	Observed usage
Ennis	178	4	62
Sixmilebridge	83	0	4
Limerick	300	4	298
Castleconnell	10	0	2
Birdhall	10	0	2
Neagh	40	2	14
Cloughjordan	20	0	2
Roscrea	19	0	8
Templemore	98	4	25
Thurles	200	4	80
Charleville	430	4	55

The Irish Rail website was consulted to gather pertinent information about each site such as capacity and any associated parking charges.

A4.2.2 Observed usage

Unfortunately, during the data collection programme, no data was collected for Park and Ride sites within the MWRM region. As such, it was decided that the only feasible alternative method for determining site usage was via Google Maps imagery, further supported by BING Maps imagery. While this data is not wholly robust as the date or time of the day when the image was captured is not known it is the only data source available.

From this exercise it was estimated that there is a demand for 552 spaces, 40% of the available capacity.

A4.2.3 Site Catchments

Defining site origin catchments involved identifying all zones which could use each specific site as part of their journey. This process was undertaken manually within ArcGIS. Firstly, both rail stations and the railway line within the MWRM were plotted. Zone centroids were then added to the map. Using a logical approach, by looking at site locations, road corridors and main destination zones, zones which would likely use a park and ride site were recorded and added to the origin catchment column within the site file. This approach assists in constraining the likely number of people who would use a Park and Ride site and prevents illogical movements from being made.

Destination zone catchments were set to cover all zones to allow for Park and Ride movements as part of an overall journey.

A4.3 Site file generation

The site file lists each site and pertinent characteristics for use in calculating demand, including:

- Capacity;
- Charges;
- Attraction Factors;
- Site origin catchments; and
- Site destination catchments.

These attraction factors represent additional costs of using Park and Ride at a particular site and can be either increased or decreased on a site by site basis. These values are set independently for each site for each of the modelled time periods. Adjusting these factors helps manage demand at each site during the calibration process. Initially these factors were set to a default value of 1.1 before further refinement during calibration.

A4.4 Park and Ride Calibration

Two main elements influence the park and ride calibration process:

- Expected demand (target persons); and
- Mode share.

A4.4.1 Expected Demand

With no observed data to use in the calculation of the expected demand for each site in each time period, an alternative method was created to distribute the “observed” capacities recorded from Google Maps imagery. This exercise was completed using the boardings file output by the main Public Transport model.

The boardings files were available for each modelled time period (with the exception of OP) and listed the total boardings within that time period at each station. From this data the boardings for each of the eleven stations and sites within the MWRM was extracted and proportions calculated for each time period based on the total boardings at the station. For example, for Ennis, it was calculated that 45% of daily boardings took place in the AM period, 10% in IP1, 25% in IP2 and 20% in the PM period.

These proportions were used to disaggregate the “observed” demand figures by time period to provide car park usage numbers which were then multiplied by the assumed Park and Ride user car occupancy figure of 1.44 to provide the target number of people using each site in each time period. These target figures are shown in Table A4.12.

Table A4.12 Derived calibration data

Station	Boardings				Occupied Spaces				Users			
	AM	IP1	IP2	PM	AM	IP1	IP2	PM	AM	IP1	IP2	PM
Ennis	45%	10%	25%	20%	28	6	15	12	41	9	22	17
Sixmilebridge	62%	10%	17%	11%	2	0	1	0	4	1	1	1
Limerick	33%	5%	25%	37%	97	16	75	110	140	23	108	158
Castleconnell	73%	17%	0%	10%	1	0	0	0	2	0	0	0
Birdhill	75%	17%	0%	7%	2	0	0	0	2	1	0	0
Neagh	76%	20%	0%	5%	11	3	0	1	15	4	0	1
Cloughjordan	64%	21%	0%	15%	1	0	0	0	2	1	0	0
Roscrea	24%	69%	0%	75%	2	6	0	1	3	8	0	1
Templemore	27%	8%	29%	37%	7	2	7	9	10	3	10	13
Thurles	44%	8%	22%	26%	35	6	18	21	51	9	26	30
Charleville	54%	8%	20%	17%	30	4	11	10	43	6	16	14

A4.4.2 Mode Share

As previous versions of the model were established with Park and Ride switched off, the first step was to re-run the model with Park and Ride switched on, so as to create some demand.

The model generates standard Park and Ride output files which are read automatically into a macro-enabled spreadsheet. These files are:

- PNR_OUTPUT_Site_Usage_By_Tour.csv – which provides demand in persons per site per time period;
- *_PnR_TP_Out.mat – which contains car and PT based trips per purpose type by time period using park and ride; and
- *_MDC_Params – which includes other costs of using each mode.

Once these have been read into the spreadsheet it calculates the mode share and the modelled demand for each of the individual sites.

Park and Ride ASC values were then adjusted and the model re-run until a plausible level of overall Park and Ride usage was obtained.

For the MWRM the target usage of Park and Ride was estimated as 795 people. A modelled demand (persons) of 523 was obtained. Although this was lower than the observed demand no further adjustments were made at this stage as further reduction in PnR costs had no further impact on patronage, and other costs such as PT would need to be adjusted.

A4.4.3 Site calibration

Once a suitable overall level of usage had been obtained, the site choice stage could be calibrated by adjusting the attraction factors for each site and time period until the modelled relative usage of each site matched the observed pattern. Adjustments were undertaken sequentially starting with the AM time period. The new attraction factors were added to the site file and the model was re-run. This process continued iteratively until an acceptable level of calibration was generated for each site (preferably with the majority of sites recording a GEH value of equal to or less than 5), before moving onto the next time period.

The final level of calibration for Park and Ride sites in the MWRM is as follows:

Table A4.13 Site calibration

Site	AM GEH	IP1 GEH	IP2 GEH	PM GEH	OP GEH
Ennis	7.9	4.2	6.7	5.9	0.3
Sixmilebridge	1.3	0.5	1.1	1.1	0.5
Limerick	4.4	4.3	13.7	17.5	3.1
Castleconnell	3.6	0.5	0.2	0.7	0.2
Birdhall	6.4	0.0	0.6	0.6	0.8
Neagh	5.1	2.8	0.1	1.4	0.2
Cloughjordan	1.9	1.1	0.0	0.9	0.0
Roscrea	2.3	4.0	0.0	1.2	0.0
Templemore	4.3	2.3	4.5	5.2	0.1
Thurles	10.0	4.2	7.2	7.7	0.1
Charleville	7.3	3.4	5.6	5.2	0.8

At an overall time period level, 55% of sites in the AM have a GEH equal to or less than 5, 100% in IP1, 54% in the IP2, 55% in the PM and finally 100% in the OP.

This level of calibration was deemed acceptable as other external factors were having an overall effect on Park and Ride usage, such as the coding of connectors to rail stations.

As such a more detailed review of the network coding may be required in order to improve Park and Ride site usage figures. However, given low overall levels of Park and Ride usage in the MWRM and the poor quality of the available data, this level of calibration was considered acceptable.

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