R E G I O N A L
M O D E L L I N G
S Y S T E M

Modelling Services Framework

West Regional Model

Full 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 List of Regional Models

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

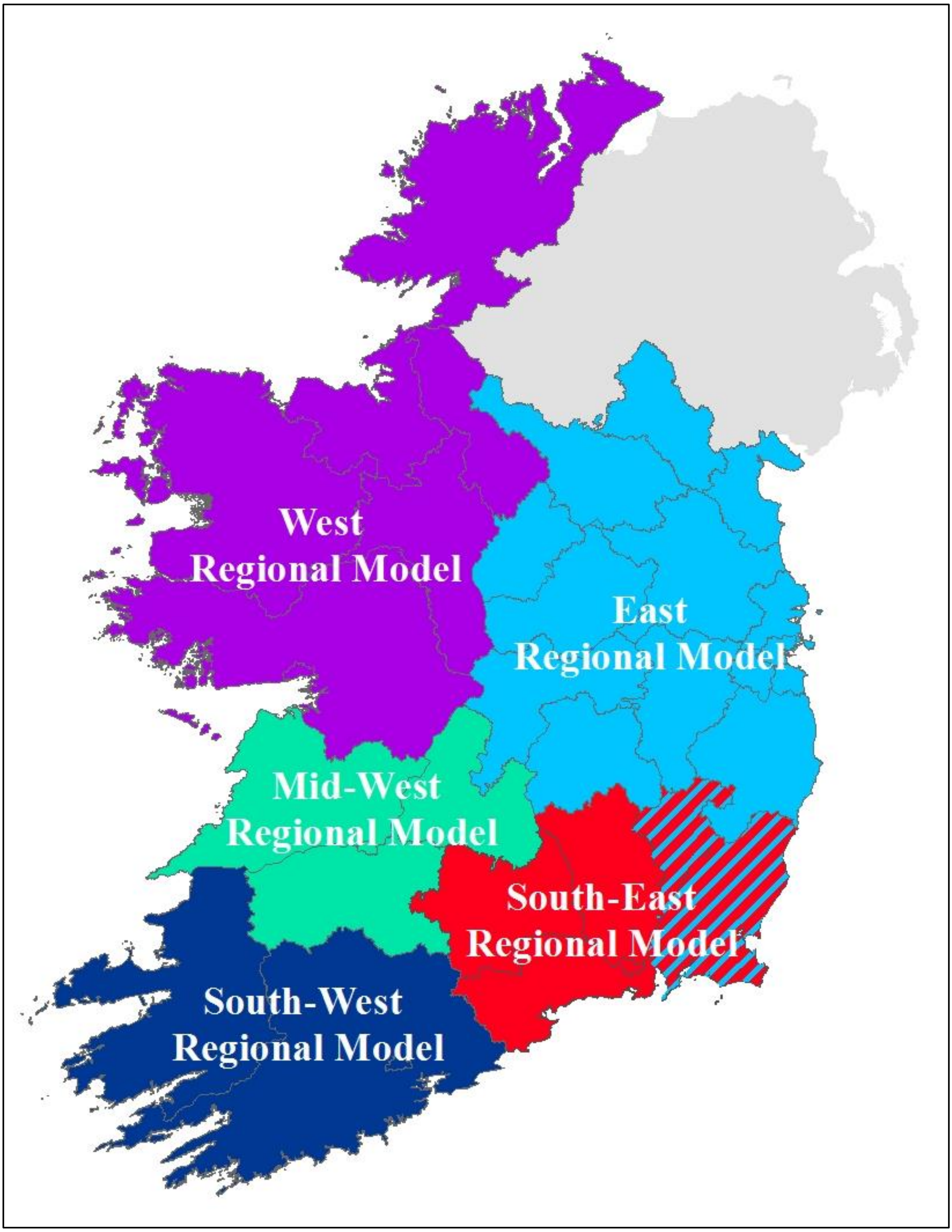


Figure 1.1 Regional Model Areas (the ERM and SERM overlap in the hashed area)

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 WRM (and the other regional models) is shown below in Figure 1.2. The main stages of the regional modelling system are described below.

1.2.1 National Demand Forecasting Model (NDFM)

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

1.2.2 Regional Models

A regional model is comprised of the following key elements:

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

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

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

The Road Model assigns FDM outputs (passenger cars) to the road network and includes capacity constraint, traffic signal delay and the impact of congestion. See the RM 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 Development Report;
- Safety Module Development Report;
- Environmental Module Development Report;
- Health Module Development Report; and
- Accessibility and Social Inclusion Module Development Report.

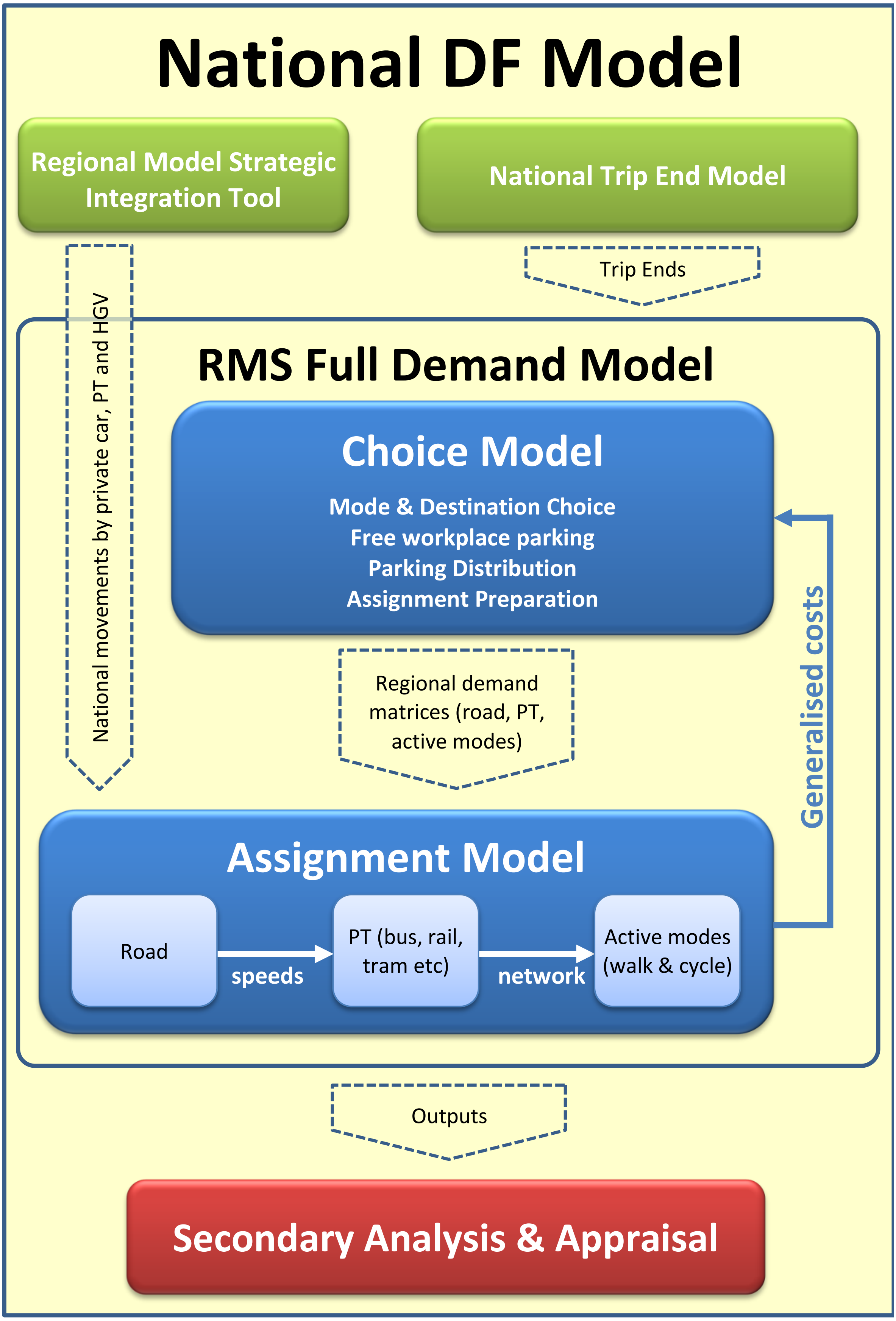


Figure 1.2 National and Regional Model Structure

1.3 Full Demand model (FDM)

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

The FDM consists of the following modules:

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

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

The following module is not yet fully implemented or tested:

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

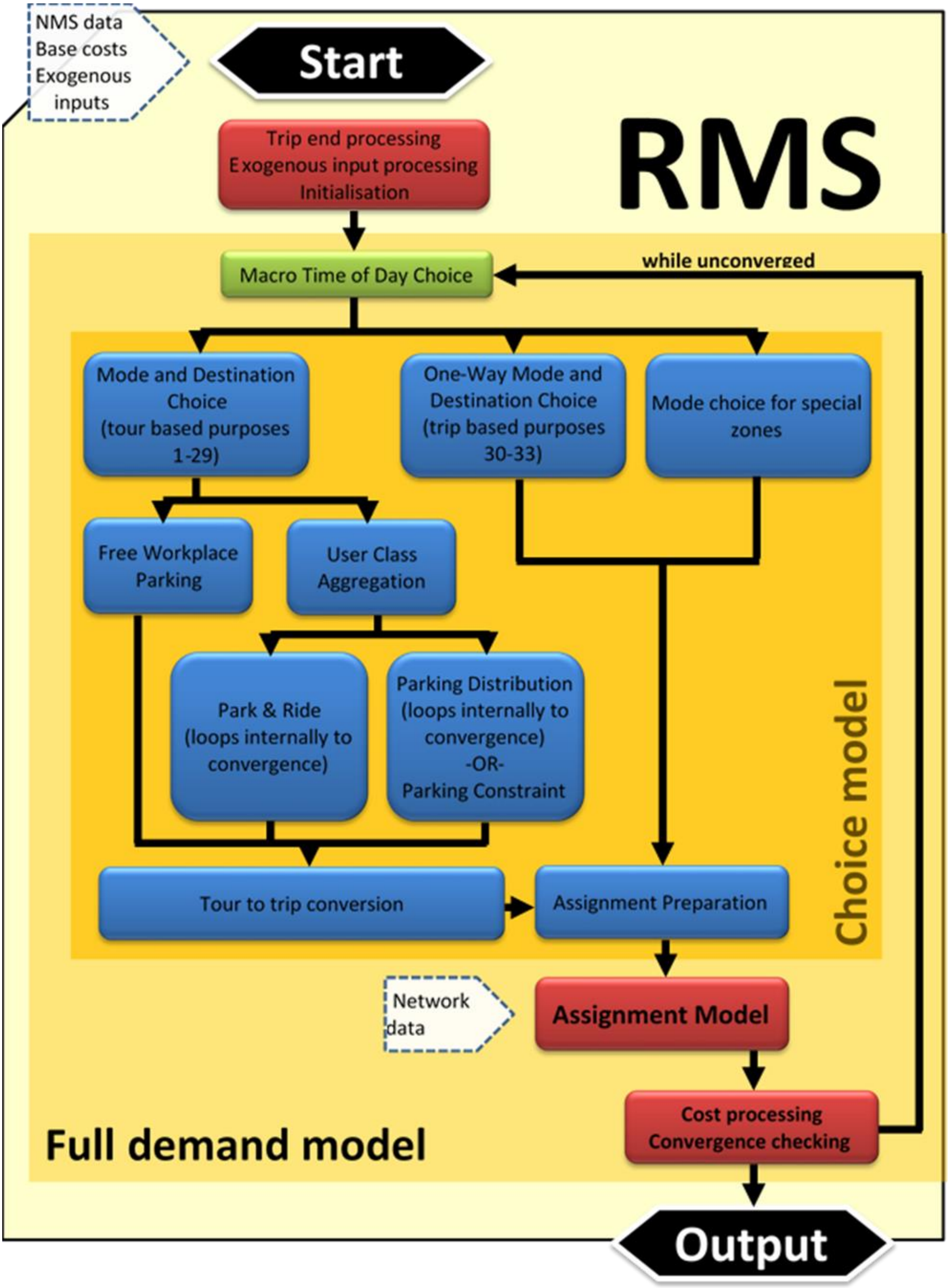


Figure 1.3 RMS Model Structure Overview

1.4 Report Library

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

The NDFM is covered in detail in the report:

- NDFM Development Report

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

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

The full, and finalised FDM specification is reported in:

- RM 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 Western Regional Model.

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

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

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

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

1.5 This report: Calibration and Validation of the RMS for the West Region (WRM)

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

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

1.6 A note on terminology

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

2 RMS Full Model Calibration Methodology

2.1 Introduction

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

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

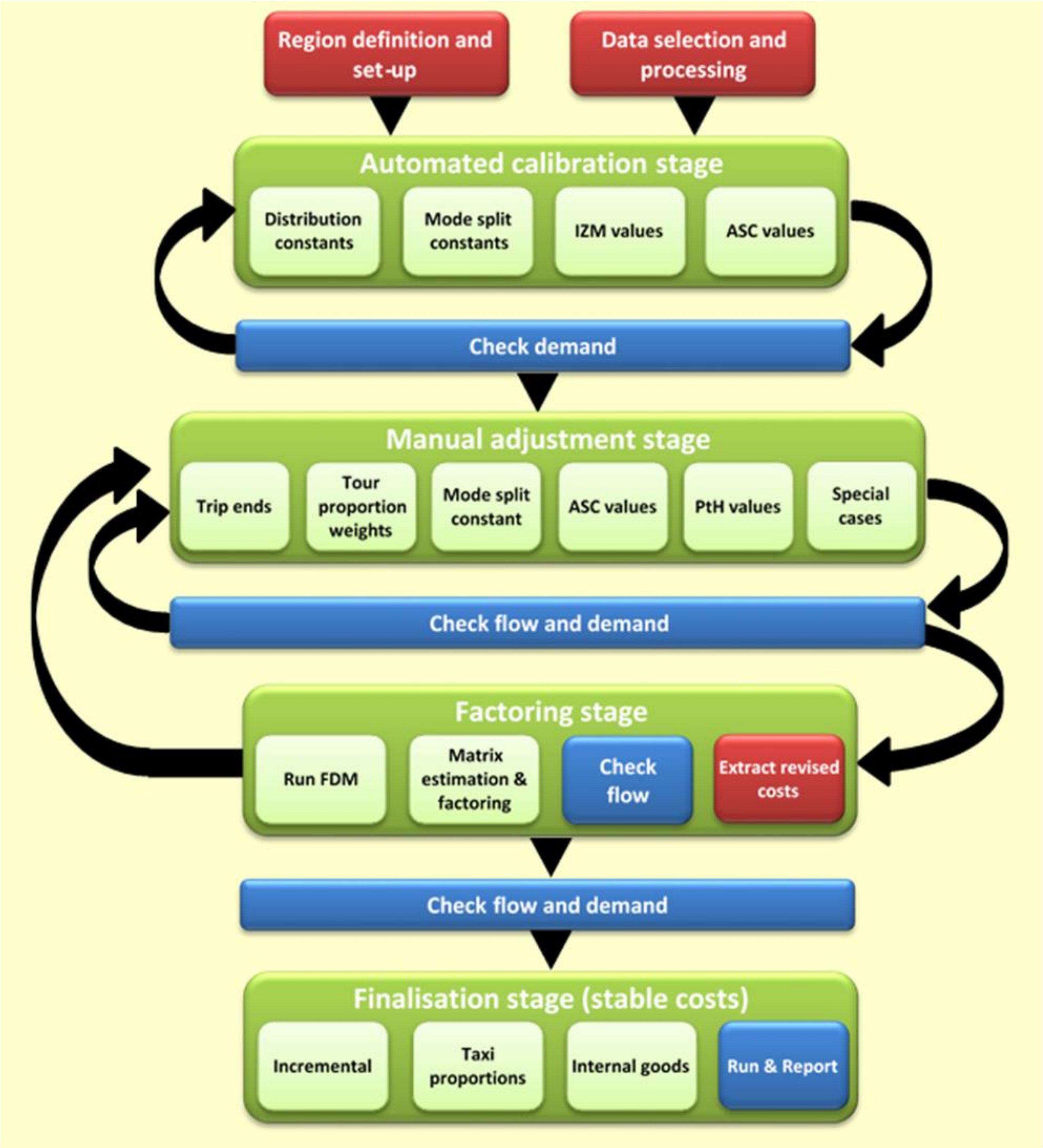


Figure 2.1 FDM calibration process

2.2 Region definition and set-up

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

Table 2.1 Model inputs

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

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

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

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

2.3 Data selection and processing

2.3.1 Observed Demand Data

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

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

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

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

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

2.3.2 Observed Road Data

There was a large volume of data available for road calibration in the WRM. The data relates to two main types of traffic observation, i.e., volumes and journey times. In total, for all the regional models, there were between 6,000 and 7,000 road traffic survey records, including manual classified counts, automatic traffic counts (ATC) and Urban Traffic Control data, which were collated under the Data Collection task. Of these, approximately 272 link flow observations, illustrated in Figure 2.2 and Figure 2.3 below, were utilised as part of the WRM road model calibration.

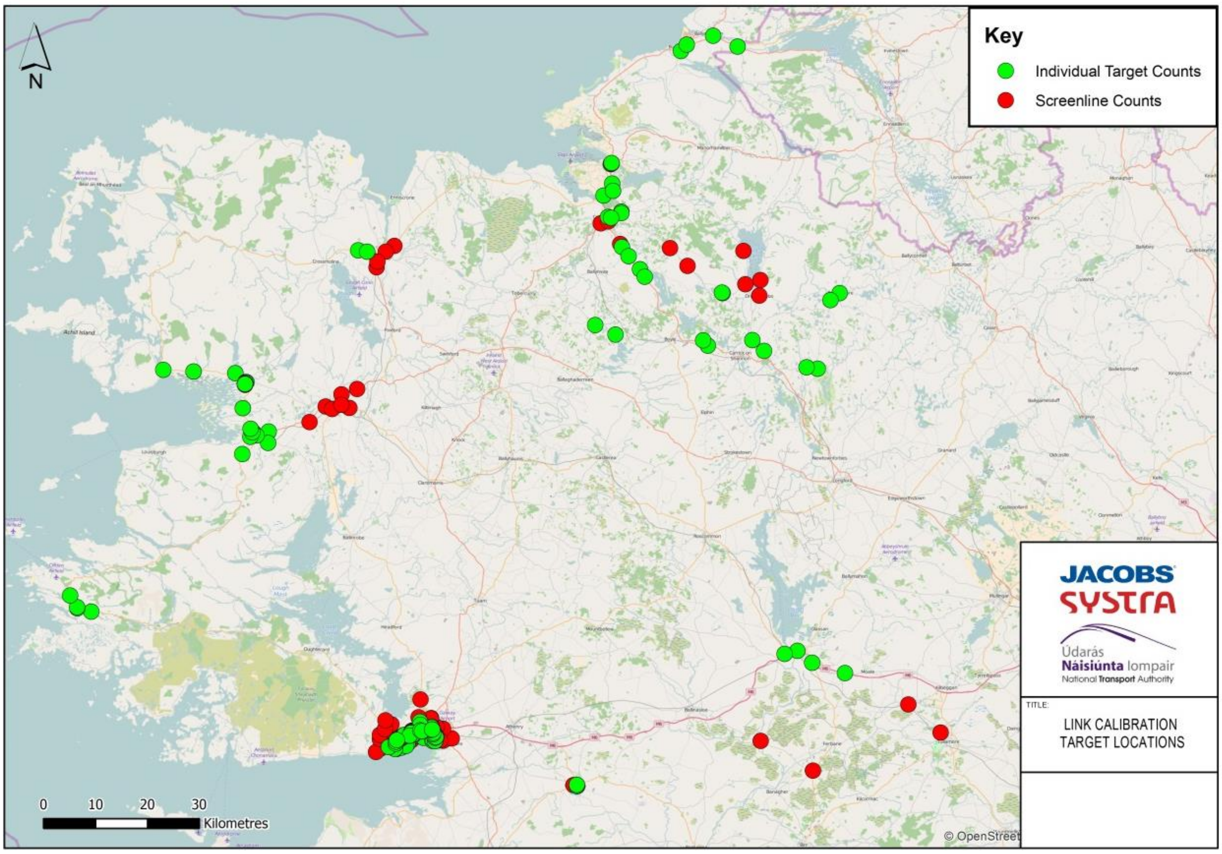


Figure 2.2 Link Calibration Target Locations (wider region)

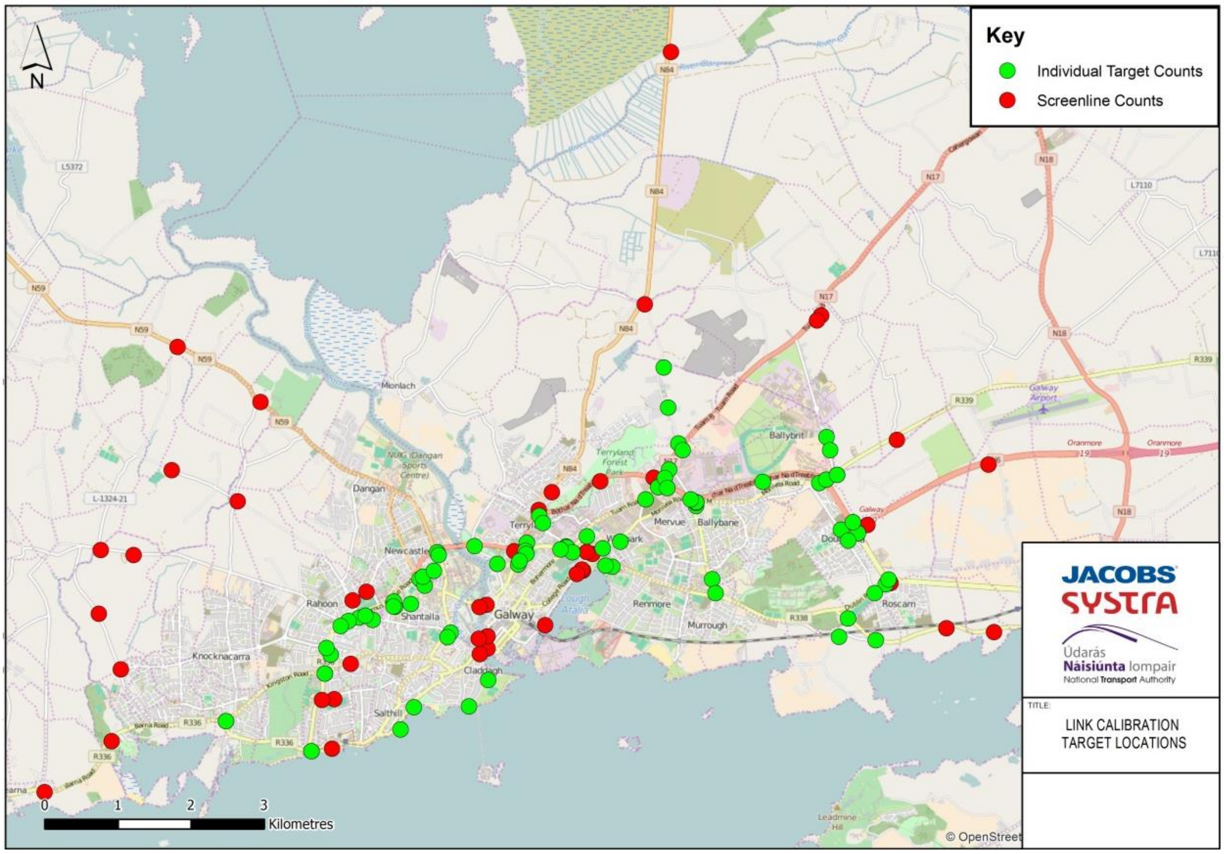


Figure 2.3 Link Calibration Target Locations (Galway)

In addition to this, there was also journey time validation data for 12 routes (inbound and outbound), illustrated in Figure 2.4, taken from TomTom data acquired by the NTA. Further information on observed road data is provided in the WRM Road Model Development Report.

Figure 2.4 TomTom Journey Time Routes

2.3.3 Observed Public Transport Data

Observed PT data for the WRM was collected and processed to build a single database of observed flows for use in the model validation. The following data sources were used:

- Rail: Irish Rail 2013 survey: provides boarding and alighting figures for all rail lines by station; and
- Bus: Nationwide Data Collection (2013 Survey): This database includes:
  - Boarding and alighting survey;
  - Bus Occupancy Surveys; and
  - Bus OD Surveys (not used)

Table 2.2 outlines the various surveys undertaken for different bus services operating in the WRM.

Table 2.2 Bus observed flow data sources

Group	B&A Survey	Occupancy Survey	Locations
BÉ Galway City Services	-	Yes	5 locations
City Direct	-	Yes	5 locations
BÉ Regional Services	Yes	-	Galway Train Station
Private Bus Operators	Yes	-	Galway Coach Station

Boarding and alighting (B&A) surveys were undertaken from 7:00 to 19:00 at two locations in Galway city: Galway Train Station and Galway Coach Station.

Bus Occupancy surveys were undertaken between 07:00 and 19:00 at five different locations and information about service, direction, time, and occupancy was recorded. Figure 2.5 illustrates the locations at which the various PT surveys were undertaken in the WRM. Further information on available PT observed data is presented in the WRM PT Model Development Report.

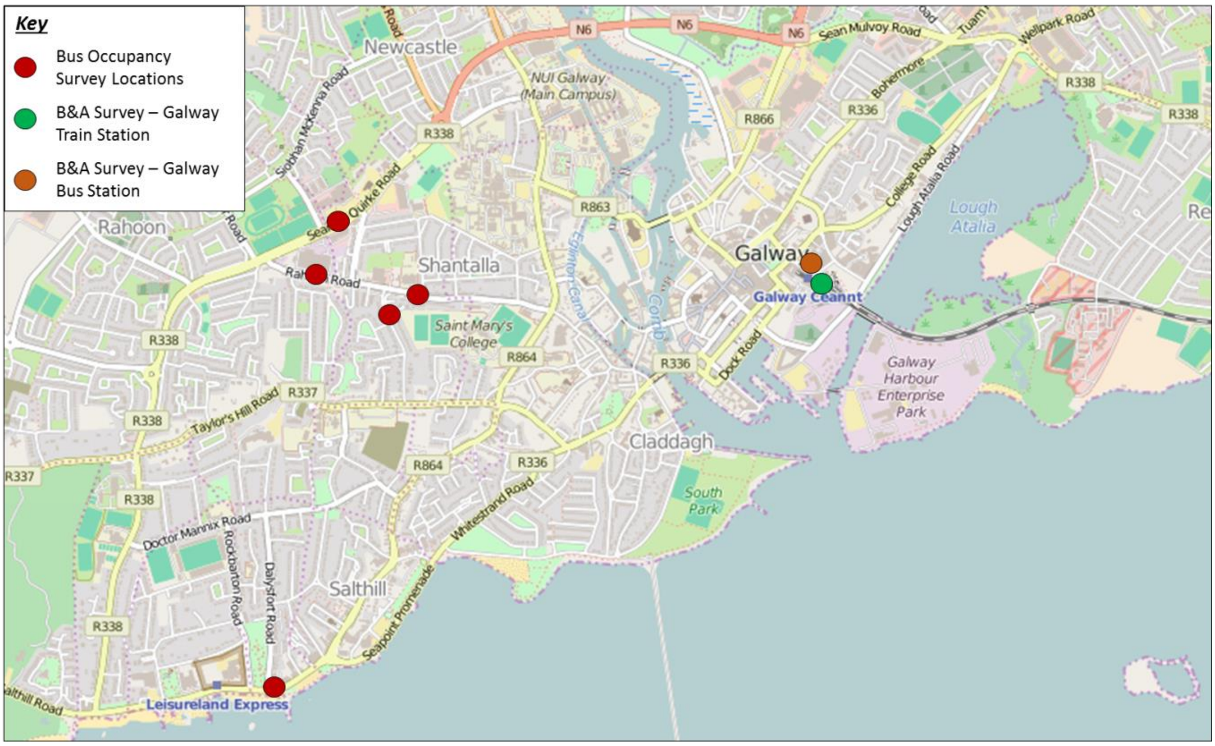


Figure 2.5 Galway City Bus Survey Locations

2.3.4 Observed Active Modes Data

There was no suitable active modes data available for the calibration of the WRM.

2.4 Automated calibration stage

2.4.1 Automated calibration

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

Mathematically the probability of making a choice is:

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

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

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

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

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

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

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

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

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

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

2.4.2 Check demand calibration

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

2.5 Manual adjustment stage

2.5.1 Manual calibration

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

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

This stage may also include:

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

2.5.2 Check flow and demand calibration

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

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

2.6 Assignment Adjustment Stage

2.6.1 Matrix estimation, PT factoring and active modes adjustments

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

2.6.2 Check flows

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

2.6.3 Cost extraction

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

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

2.7 Finalisation

2.7.1 Exit criterion

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

2.7.2 Finalisation

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

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

2.7.3 Reporting

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

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

3 Full Demand Model Calibration Test History

3.1 Region definition and set-up

The process of calibrating the WRM began in December 2015 in version ‘2.0.0: Save 1’ of the RMS FDM.

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

3.2 Calibration / Validation Phases

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

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

Following the updating and enhancement of the model, calibration was completed in Phase 3.

Overall Phase 1 was undertaken from December 2015 to late February 2016 and Phase 2 from March to May 2016. Phase 3 began in early June 2016 and ended in late June 2016.

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

3.3 Phase 1 Test 1

3.3.1 Run details

Model Version: *2.0.0, Save 4*
Date: *02/12/15*

The purpose of Test 1 was to confirm that the core parts of the model were functioning correctly, to check the initial road and PT networks, and to commence the calibration process. Initial costs were those provided from the assignment of the expanded Galway Interim Model matrices to the pre-calibration road network.

3.3.2 Results / outputs

This test run did not complete successfully due to errors in the scripts within the road assignment and connectivity issues identified in the public transport assignment.

The inputs and parameters were checked and corrected, thus allowing the first series of calibration iterations. The resulting comparison of modelled to observed mode share can be seen in Figure 3.1 below. The match was reasonable but there was too little walking and PT use, which coincided with too much cycling.

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

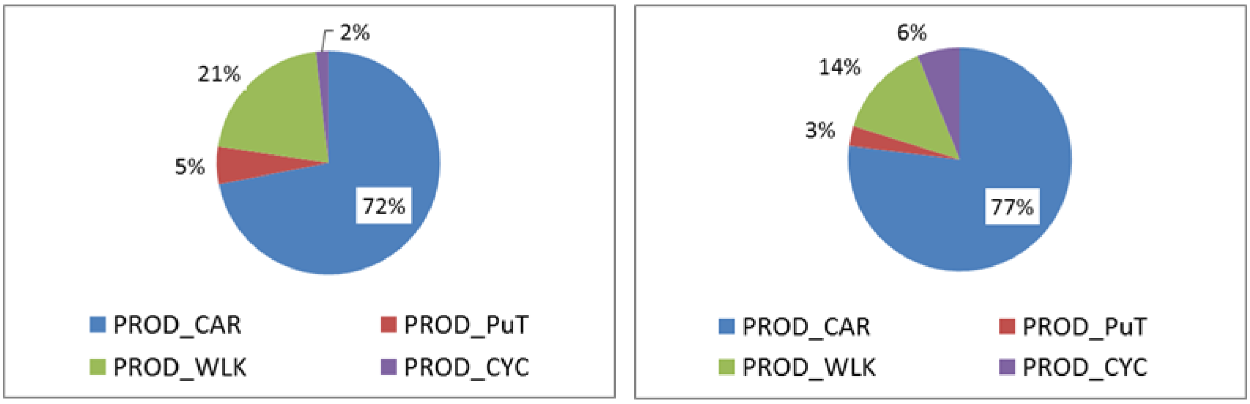


Figure 3.1 First calibration run total mode share

3.4 Phase 1 Test 2

3.4.1 Run details

Model Version: *2.0.0, Save 6 revised*[2]
Date: *11/12/16*

Following Test 1 it was felt that a good solution could not be achieved without improvements to the networks and assignment parameters, particularly the public transport assignment model.

The WRM PT network was checked to ensure full connectivity between zone centroids and coded public transport services. Improvements were made to the scripts used to generate connectors for the public transport model, and ensured that each zone could connect to the public transport model.

3.4.2 Results / outputs

Following the above network improvements, three iterations of automatic calibration were run. This mainly provided an opportunity to check that the calibration application and data extraction processes were operating properly.

[2] Saves 2 to 5 fell between these two test runs. Additionally, as the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 6 strictly refers to the model at a point in its development slightly earlier than that used in this test.

An evaluation of the mode share, intrazonal, and generalised costs for each demand segment was performed as part of this calibration run.

Figure 3.2 below indicates that there was an improvement in the mode share calibration. Intrazonal proportions exhibited large variances to observed data, however, and were flagged for refinement in the next pass.

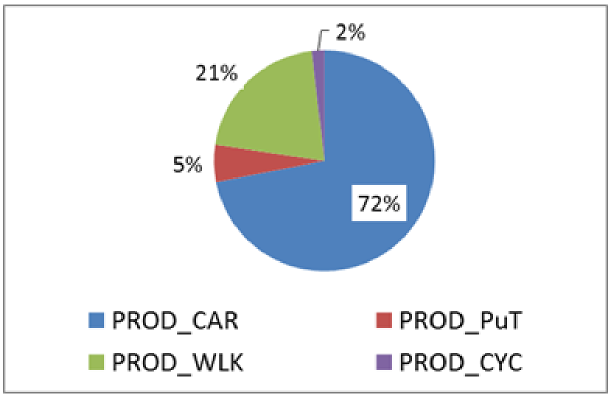
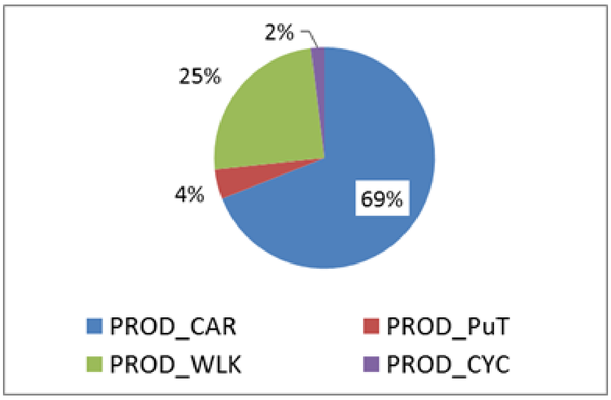
Total Mode Share – Observed	**Total Mode Share - Modelled**
	

Figure 3.2 Second calibration run total mode share

3.5 Phase 1 Test 3

3.5.1 Run details

Model Version: *2.0.0, Save 8 revised*[3]

Date: 11/01/16

Test 3 involved updating the add-ins, specifically the goods vehicle matrices for external trips from RMSIT, integrating road and PT network changes made as a result of investigations under Test 2, and updating the FDM version as well as incorporating the newly updated ASC, alpha and IZM parameters from Tests 1 & 2.

3.5.2 Results / outputs

This model run was the first with both a reasonably stable model version and a full set of inputs, particularly those from RMSIT, and was the first for which outputs could be examined in detail.

As part of this examination, the demand dashboard was updated to include data from POWSCAR as it was more detailed than the NHTS data for commute and education. An issue with the processing of the NHTS data for time period proportions was identified and addressed, improving the calibration targets. Additionally, there were issues identified with unrealistically long walk trips within the observed data, especially for education trips,

[3] Save 7 fell between these two tests. Additionally, as the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 8 strictly refers to the model at a point in its development slightly earlier than that used in this test.

which were caused by students recording their college or university's main office rather than the campus that the students attended. As a result, long walk trips (in excess of 90 minutes), were removed from the observed data.

The calibration process was run again following correction of the above data issues. This revealed two issues with the modelling; first that the levels of demand were low generally and second that there appeared to be problems with the calculation of the intrazonal costs.

Once conclusions from this test had been reached, the bus preloads were added into the road model and the road assignment was re-run to obtain updated costs.

3.6 Phase 1 Test 4

3.6.1 Run details

Model Version: *2.0.0, Save 10*[4]
Date: *27/01/16*

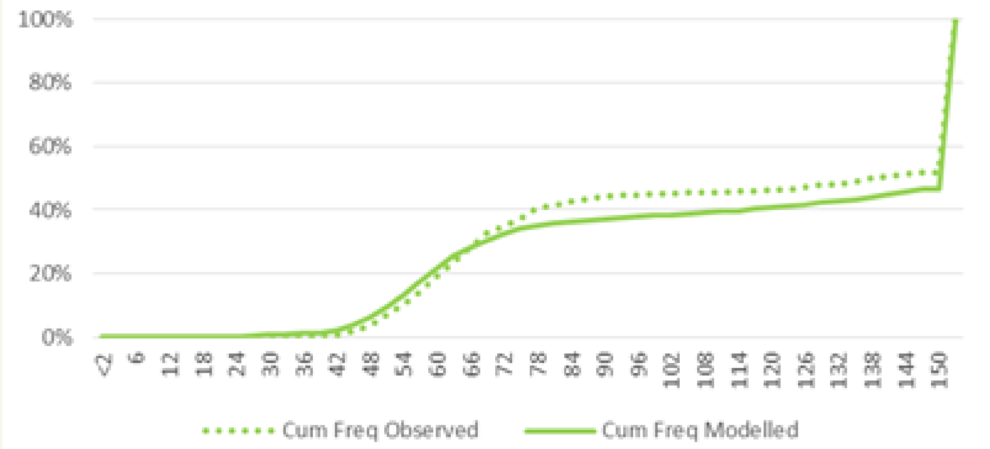
This run incorporated the new costs from Test 3 and included bus preloads in the road model inputs. In addition, there was a range of tests on the effects of capping the PT intrazonal costs at 30 minutes, 60 minutes, and uncapped costs. This was done by modifying the intrazonal costs and re-running the automatic calibration process through 10 loops.

3.6.2 Results / outputs

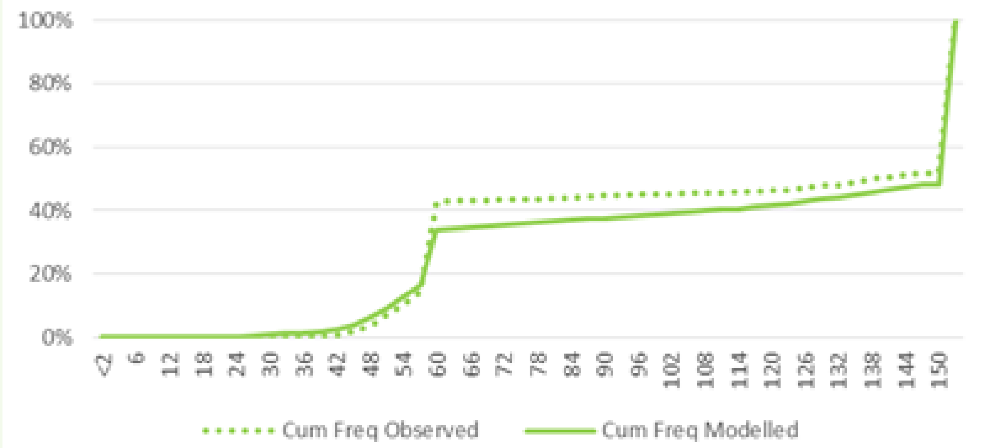
Table 3.1 and Figure 3.3 below show the effects of capping intrazonal costs at the different levels. An unrestricted cost cap results in a match between the observed and modelled generalised cost distributions (Figure 3.3 - top). A 60 minute cap also results in a reasonable match (the observed cost distribution changes as the cost assigned to each observed trip is derived from the model) but a 30 minute cap on the intrazonal costs is too restrictive, affects a large number of zones (Table 3.1) and results in a poor match (Figure 3.3 - bottom). The 60 minute cap was taken forward.

[4] Save 9 fell between these two tests.

PT Gen Cost Curve – uncapped



PT Gen Cost Curve – 60 minute Cap



PT Gen Cost Curve – 30 minute Cap

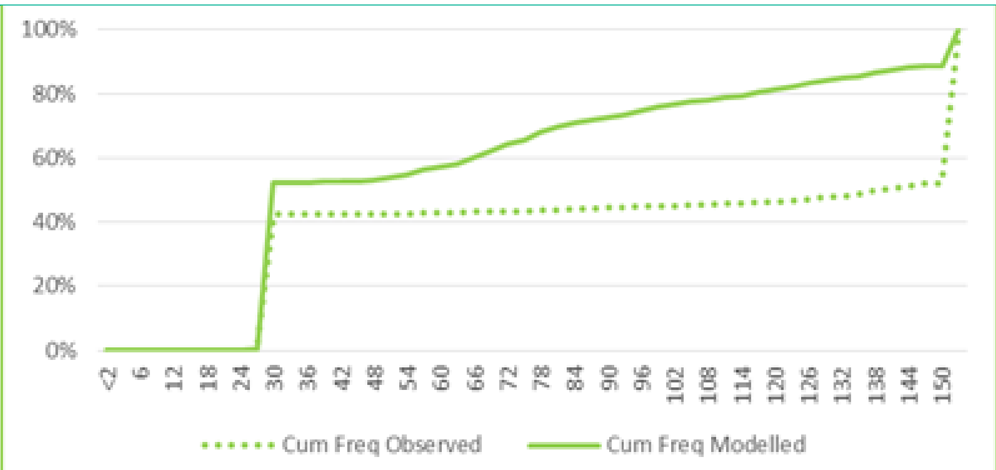


Figure 3.3 Cumulative generalised cost distributions (P05)

Table 3.1 Percentage of intrazonals affected by capping

Check	30 minute	60 minute	Uncapped
% of internal zones affected	77%	39%	n/a
% of all zones affected	77%	38%	n/a
Cap reduces cost by >10 minutes	69%	20%	n/a

3.7 Phase 1 Test 4b

3.7.1 Run details

Model Version: *2.0.1, Save 12*[5]
Date: *03/02/16*

In Test 4b the preferred cost cap was incorporated into the model and the costs were re-skimmed from the assignment models. Additionally, rail fare representation was changed from a fare matrix to a fare curve. Further automated calibration was carried out to improve the match to the generalised costs curves. The demand matrix output format was also changed at this stage.

3.7.2 Results / outputs

Improved calibration results were achieved within the limits of the data examination possible in the automatic calibration stage. The figure below outlines the total modelled mode share in comparison with the total observed mode share.

Total Mode Share – Observed Vs Modelled

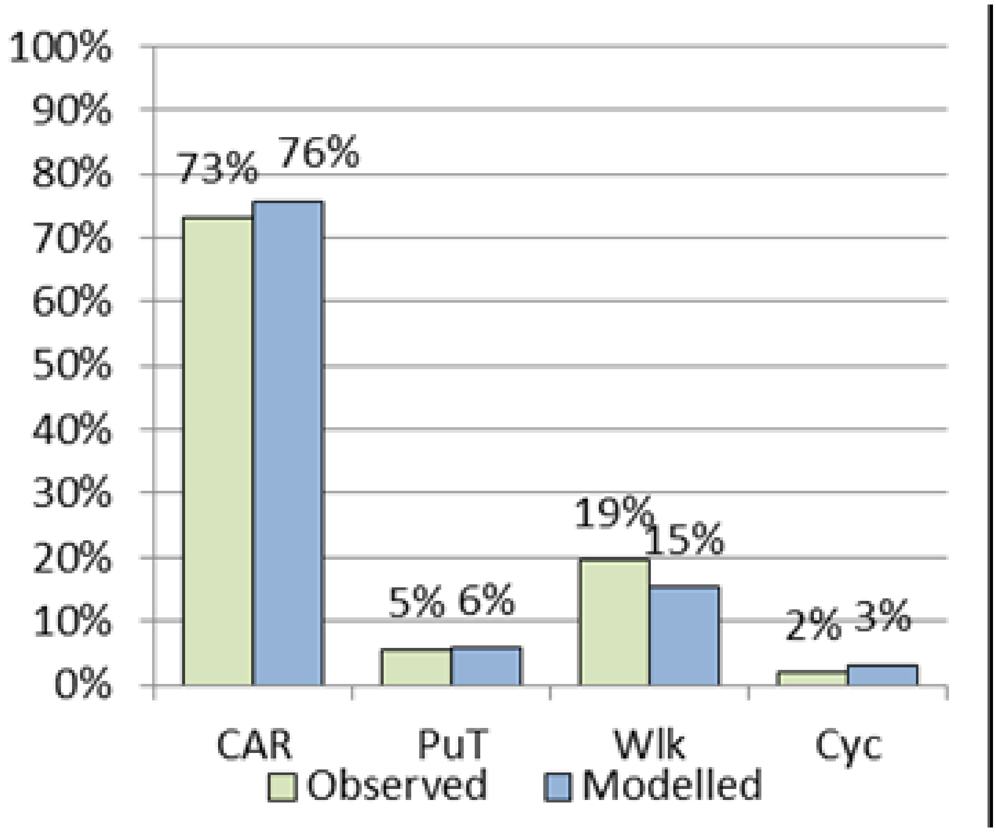


Figure 3.4 Test 4b Total mode share

[5] Save 11 fell between these two tests.

Mode share results were improved, but the issue of overall low demand identified in Test 2 was still present.

3.8 Phase 1 Test 5

3.8.1 Run details

Model Version: *2.0.1, Save 12 revised*[6]

Date: *11/02/16*

Revised input trip ends were used in this test. These resulted from a change to the way in which the trip ends were created and increased the overall number of trip ends by 9%. Additionally, road and public transport networks were updated such that zone centroids were capped at 500m length in buffer areas and new costs were supplied.

3.8.2 Results / outputs

Following these changes this test showed that there was an increase in demand, but initial checks on the road and public transport assignments showed there was still a significant difference between the modelled and observed flows. Figure 3.5 shows 24 hour PT flows and indicates that there are too few modelled trips overall.

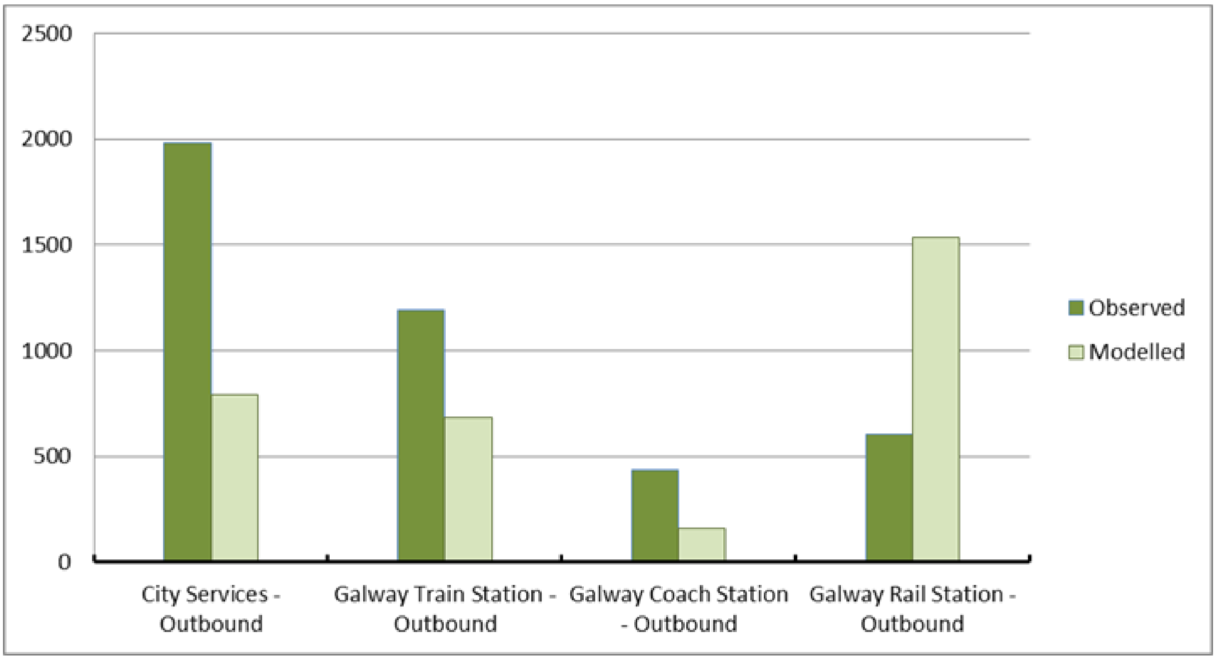


Figure 3.5 24-hour modelled versus observed PT flows – inbound[7]

[6] As the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 12 strictly refers to the model at a point in its development slightly earlier than that used in this test.

[7] Galway Train Station refers to bus services observed at Galway Rail Station

3.9 Phase 1 Test 6

3.9.1 Run details

Model Version: *2.0.1, Save 12 revised*[8]
Date: *09/02/16*

In Test 6 an additional regional uplift of 34% was applied to the trip ends.

3.9.2 Results / outputs

This test provided the required uplift. For example, evaluating the total trips observed and modelled for Purpose 1.

- Prior to this uplift the observed to modelled ratio was 73,864 to 49,293; and
- Post the uplift the observed to modelled ratio was 73,864 to 65,921.

This pattern was observed across the 33 purposes. Further, the mode share and generalised cost curves were better in terms of replicating the base year observed data.

3.10 Phase 1 Test 7

3.10.1 Run details

Model Version: *2.0.1, Save 12 revised*[9]
Date: *22/02/16*

In Test 7 there were some adjustments to the tour proportions based on the outputs of Test 6.

3.10.2 Results / outputs

Examples are shown in Table 3.2, Table 3.3 and Table 3.4 which compare the observed NHTS data to the modelled data before and after the correction. The match improves in some places (green figures), worsens in others (red figures) and is unchanged elsewhere. However, the largest change is for the morning peak and, following the adjustment, no figure is more than 2% out. These results can be examined in more detail in the demand dashboards.

Table 3.2 Mode shares in NHTS Observed Data

	Car	PT	Walk	Cycle	TOT
AM	19%	2%	4%	0%	**26%**
LT	12%	1%	4%	0%	**17%**

[8] As the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 12 strictly refers to the model at a point in its development slightly earlier than that used in this test.

[9] As the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 12 strictly refers to the model at a point in its development slightly earlier than that used in this test.

SR	15%	1%	5%	0%	**21%**
PM	17%	1%	4%	1%	**22%**
OP	10%	0%	2%	0%	**13%**
TOT	**73%**	**5%**	**20%**	**2%**	**100%**

Table 3.3 Modelled mode shares before tour proportion adjustment

	CAR	PT	Walk	Cycle	TOT
AM	22%	3%	5%	1%	**31%**
LT	12%	0%	3%	1%	**15%**
SR	16%	2%	3%	1%	**21%**
PM	16%	1%	3%	1%	**21%**
OP	10%	0%	1%	0%	**12%**
TOT	**76%**	**6%**	**15%**	**3%**	**100%**

Table 3.4 Modelled mode shares after tour proportion adjustment

	CAR	PT	Walk	Cycle	TOT
AM	21%	3%	4%	1%	**28%**
LT	13%	0%	3%	0%	**16%**
SR	18%	2%	3%	1%	**23%**
PM	18%	1%	3%	1%	**22%**
OP	9%	0%	1%	0%	**11%**
TOT	**78%**	**6%**	**13%**	**3%**	**100%**

Matrix estimation and PT factoring was carried out following this test.

3.11 Phase 1 Test 8

3.11.1 Run details

Model Version: *2.0.1, Save 12 revised*[10]
Date: *26/02/16*

Test 8 was the final model run in Phase 1 and involved adding an updated road network to Test 7, as well as updating the input costs. Further to these changes, the ASC and alpha parameters were also refined as part of the automatic/ manual calibration process.

3.11.2 Results / outputs

This test provided a closer calibration of the modelled values and parameters to the observed data, both in terms of the number of trips generated and their distribution.

The figures below show the total trips generated by mode and time period and the overall mode split achieved at the end of the Phase 1 calibration process.

[10] As the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 12 strictly refers to the model at a point in its development slightly earlier than that used in this test.

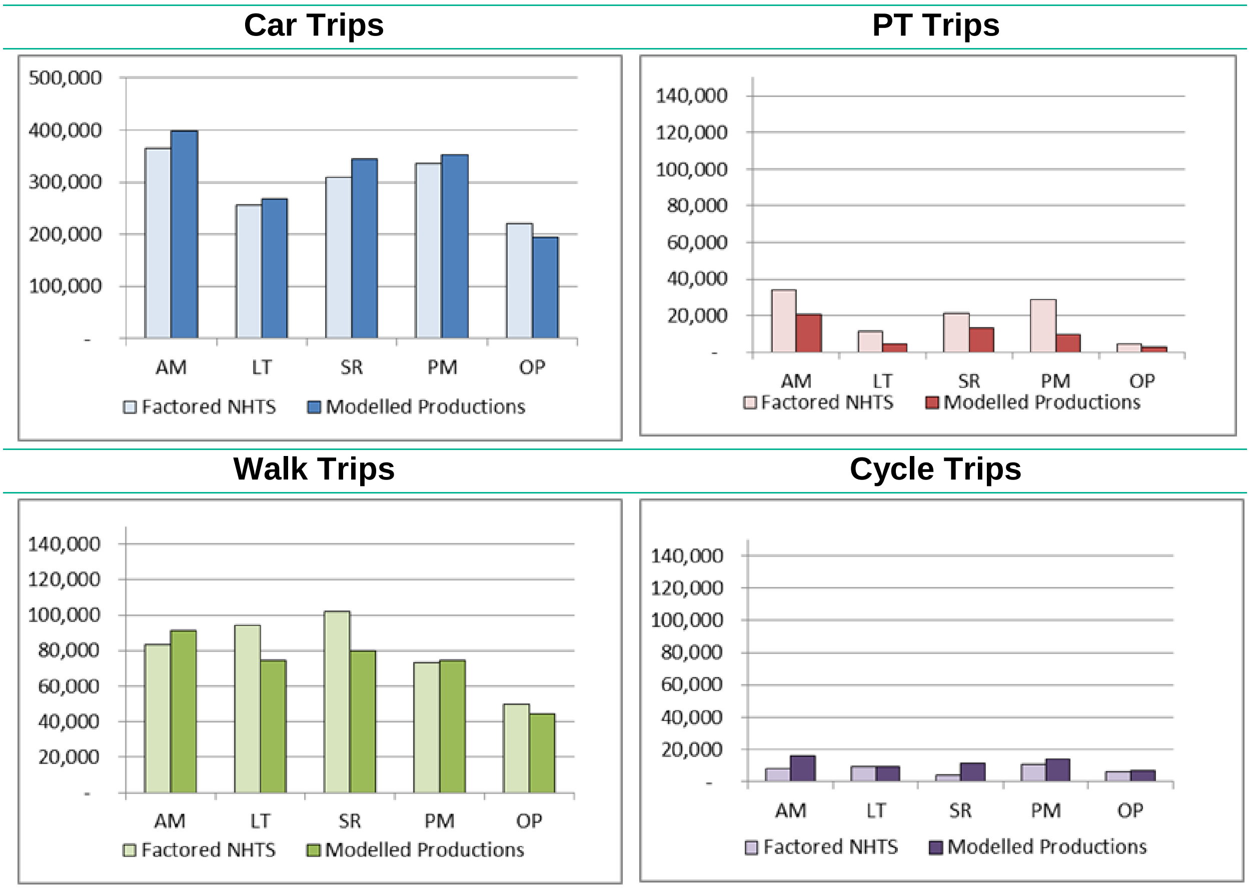


Figure 3.6 Total trips by time period and mode

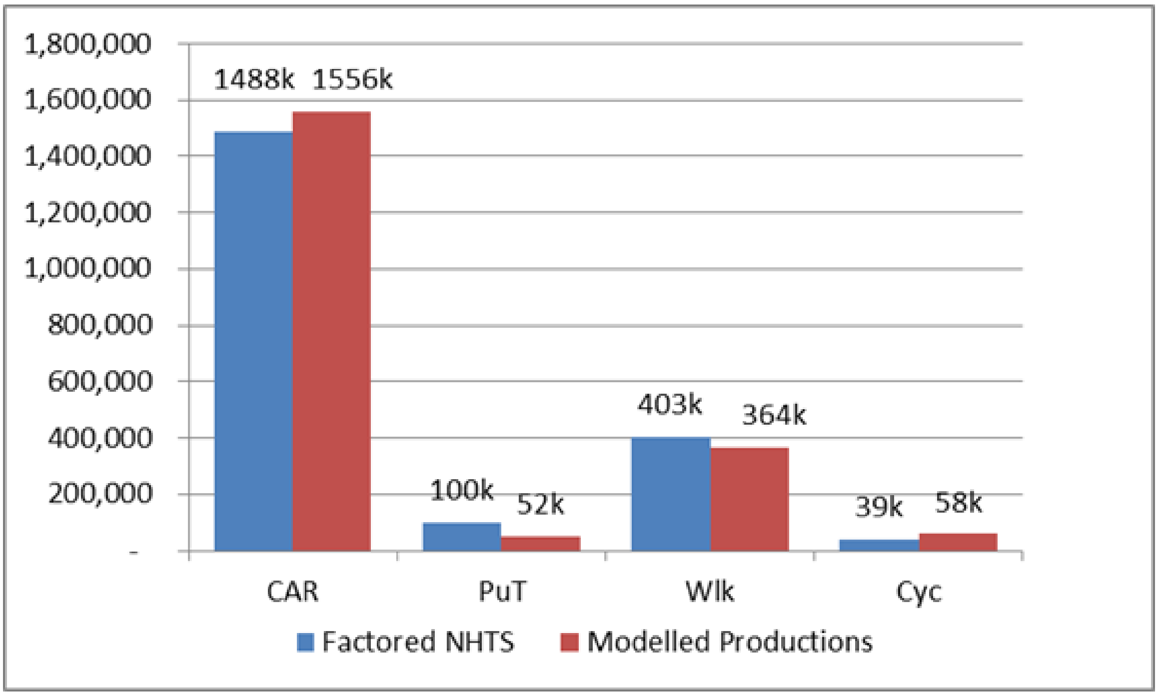


Figure 3.7 Total mode share (24hr)

Road flow calibration / validation (ratio of total flow to flow passing WebTag criteria) was at:

- AM 94% / 79%;
- IP1 94% / 88%;
- IP2 91% / 83%; and
- PM 92% / 83%.

3.12 Post Phase 1 Calibration and Validation Process Review

At this stage, there was a review of the calibration and validation of the WRM and the other regional models and a decision was made to revise some elements of the calibration process. The factoring of trip ends and tour proportions was excluded from calibration in the absence of a sound theoretical basis for these adjustments. Some of the modifications to trip ends made during Phase 1 were considered justified and these were incorporated into NTEM. A new demand forecast, A9, was produced and used in subsequent tests.

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

The model was handed over to the core RMS development team who debugged some processes, resulting in a new version of the model. As a result, it was necessary to restart the calibration process (termed Phase 2).

3.13 Phase 2 Test 1 & 2

3.13.1 Run details

Model Version: *2.0.1, Save 12 revised*[11]
Date: *26/02/16*

Tests 1 & 2 were very simple runs to establish a new baseline following the change of team. Up to date trip ends and other inputs were included but there were no other modifications. The tour proportions were reset to the original values.

3.13.2 Results / outputs

Only basic matrix totals were checked at this stage to ensure that the demand model had run through without error.

[11] As the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 12 strictly refers to the model at a point in its development slightly earlier than that used in this test.

3.14 Phase 2 Test 3-7

3.14.1 Run details

Model Version: *2.0.1, Save 12 revised*[12]

Date: *08/03/16*

Tests 3 to 7 were progressive adjustments to car period to hour factors used to get a feel for relationship between the input and the response. The starting and ending factors, as well as the changes, are shown in Table 3.5.

Table 3.5 Changes in period to hour factors for cars from Phase 2 Tests 3-7

Mode / time period	Starting factor	Ending factor	Change
Car AM	0.42	0.44	+0.02
Car IP1	0.33	0.43	+0.10
Car IP2	0.33	0.51	+0.18
Car PM	0.36	0.49	+0.13
Car OP	0.08	0.08	0.00

3.14.2 Results / outputs

Because these were preliminary tests only matrix totals and road flows were examined in detail. Following Test 3 the road calibration / validation (on percentage difference) was:

- AM 66% / 21%;
- IP1 61% / 25%;
- IP2 48% / 25%; and
- PM 53% / 25% (see the Phase 2 Test 3\3 Road folder for more details).

Following Test 7 this had improved to:

- AM 67% / 21%;
- IP1 55% / 21%;
- IP2 58% / 21 %; and
- PM 59% / 25% (see the Phase 2 Test 7\3 Road folder for more details).

This was an improvement, particularly in the poorly matched IP2 and PM time periods and it also gave a better overall match to the total flows. Following Test 7 matrix estimation was carried out, but the results were not considered suitable for the extraction of new costs.

[12] As the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 12 strictly refers to the model at a point in its development slightly earlier than that used in this test.

3.15 Phase 2 Test 8

3.15.1 Run details

***Model Version:** 2.0.4, Save 14*[13]
***Date:** 09/03/16*

Phase 2 Test 8 used the latest model version, which included:

- Corrected cluster structure at the Add-in stage;
- Improved factoring of attraction trip ends in production free zones;
- Revised PT cost capping

3.15.2 Results / outputs

Matrix estimation was carried out at this stage and pre and post ME road dashboards were prepared. However, the costs were not considered an improvement on those available previously and were not carried forward to Test 9. PT flows were also examined and an example of the fit across the IP1 screenline is shown in Figure 3.8 (for more information see the Phase 2 Test 8\4 PT folder).

[13] Save 13 was not used.

The overall road calibration / validation (on percentage difference) was:

- AM 67% / 21% (before ME) improving to 85% / 92% (after ME);
- IP1 58% / 21% (before ME) improving to 88% / 83% (after ME);
- IP2 62% / 21 % (before ME) improving to 85% /83 % (after ME); and
- PM 60% / 25% (before ME) improving to 86 % / 92% (after ME) (see the Phase 2 Test 8\3 Road folder for more details).

IP1 inbound	IP1 outbound

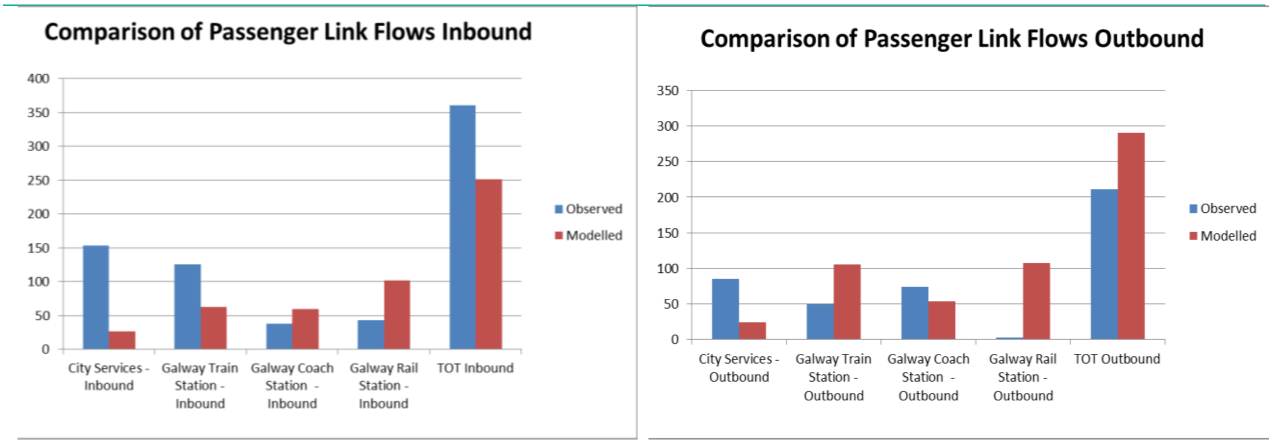


Figure 3.8 Phase 2 Test 8 PT flow calibration levels

3.16 Phase 2 Tests 9 & 10

3.16.1 Run details

Model Version: *2.0.2, Save 14*
Date: *10/03/16*

Test 9 involved adjustments to ASC values as shown in Table 3.6. Test 10 incorporated a newly estimated internal goods matrix and updated costs.

Table 3.6 Changes in ASC values in Test 10 vs Test 8

Trip purpose	Change in car ASC value	Change in PuT ASC value	Change in PnR ASC value	Change in walk ASC value	Change in cycle ASC value
P01-P29	0	+5	0	0	0
P30-P33	-3	+6	0	-3	-3

3.16.2 Results / outputs

Only PT flows were checked at the end of Test 9 (for details see the Phase 2 Test 9\4 PT folder). They were not much improved on previous passes but due to an issue with the PT crowding which was identified at this stage it was considered likely that the new costs would help. Following Test 10 road and PT dashboards were prepared. The PT screenlines were better, within about 30% in all cases but the proportion of trips using rail rather than bus was still high (for details see the Phase 2 Test 10\4 PT folder).

Road calibration (on percentage difference) stood at:

- AM 68% / 83%;
- IP1 59% / 83%;
- IP2 57% / 83 %; and
- PM 61% / 92% (see the Phase 2 Test 10\3 Road folder for more details).

3.17 Phase 2 Test 11

3.17.1 Run details

Model Version: *2.0.2, Save 14 revised*[14]
Date: *24/03/16*

For Test 11 free workplace parking and parking distribution were activated, and updated costs were taken from the preferred road and PT assignments (Test 10). There were a number of subtests using dummy inputs intended to check that these two modules functioned as they were supposed to.

3.17.2 Results / outputs

Visual comparisons of the outputs were made but no formal results were extracted. This was because revised parking data became available and a revised test was run including this. The outcome of this test was confirmation of the correct functioning of the parking processes.

3.18 Phase 2 Test 12

3.18.1 Run details

Model Version: *2.0.2, Save 14 revised*[15]
Date: *24/03/16*

Test 12 used estimated parking data inputs (rather than dummy values) and ran the model through in full.

[14] As the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 14 strictly refers to the model at a point in its development slightly earlier than that used in this test.

[15] As the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 14 strictly refers to the model at a point in its development slightly earlier than that used in this test.

3.18.2 Results / outputs

Only PT and road flow results were extracted at this stage. PT flows worsened, with screenline differences increasing to 50% in some places (for more information see the Phase 2 Test 12\4 PT folder). Road calibration, (on percentage difference), however, remained good at:

- AM 70% / 83%;
- IP1 59% / 83%;
- IP2 57% / 83 %; and
- PM 61% / 92% (see the Phase 2 Test 12\3 Road folder for more details).

Matrix estimation and PT factoring were undertaken following this test.

3.19 Post Phase 2 Test 12 (Parking Distribution review)

As a result of the preliminary work which took place to create the base parking data it became clear that there was a problem with the implementation of the parking distribution module. This was verified by a separate team using the WRM to test strategy options.

However, because the number of parking spaces was greater than total car demand, there was no impact on model results and testing could continue in the existing version, pending the release of a new implementation of the Parking Distribution module.

3.20 Phase 2 Test 14

3.20.1 Run details

Model Version: *2.0.2, Save 14 revised*[16]
Date: *24/03/16*

Test 14 used updated internal goods inputs, incrementals and taxi proportions based on the estimated / factored matrices produced following Test 12.

[16] As the WRM was one of the regions being used for continual testing and upgrade of the FDM, Save 14 strictly refers to the model at a point in its development slightly earlier than that used in this test.

3.20.2 Results / outputs

Although this was a run including incrementals, full pre and post dashboards were not produced. Flows were checked though and road calibration, (on percentage difference), improved to:

- AM 83% / 88%;
- IP1 86% / 96%;
- IP2 83% / 92 %; and
- PM 80% / 88% (see the Phase 2 Test 14\3 Road folder for more details).

PT flow calibration also improved, with screenline flows generally falling within 30% of observed values (for more information see the Phase 2 Test 14\4 PT folder). This was worse than was expected based on the outputs of the PT factoring and our investigations showed that the PT factoring had been run without crowding. This should not have caused any problems in the uncrowded WRM PT network, but it emerged that the issue was compounded due to the crowding not being modelled correctly, which caused delays to appear where none were expected, and this needed to be addressed.

3.21 Phase 2 Test 15_Pre & Test 15_Post

3.21.1 Run details

Model Version: *2.0.2, Save 14 revised*[17]
Date: *31/03/16*

A revised PT network was supplied by the PT development team. The incremental values previously added in Test 14 were removed (hence the outputs of this are termed 'Pre' test took place, e.g. before matrix estimation / factoring). The 'Post' test included the resulting new incrementals, taxi proportions and internal goods matrices. This 'Post' test produced outputs which mimicked the matrix estimated / factored solutions.

3.21.2 Results / outputs

Full road dashboards were created and indicated that the overall road calibration / validation (on percentage difference) was:

- AM 70% / 88% (before ME) improving to 84% / 88% (after ME);
- IP1 65% / 83% (before ME) improving to 90% / 96% (after ME);
- IP2 62% / 92 % (before ME) improving to 87% /92 % (after ME); and
- PM 63% / 92% (before ME) improving to 82 % / 88% (after ME) (see the Phase 2 Test 15 \3 Road folder for more details).

[17] Version 2.0.3 which had a corrected parking distribution module was available by this date. However, the model was not ported into the new version for this test because:
- Testing of the new version was ongoing
- The parking distribution input for this run was set such that it did nothing
- The primary objective of this test was to confirm that the revised PT network functioned correctly

Journey time calibrations were also reasonable with 56% to 84% of routes passing the defined criteria, depending on the peak in question.

Before PT factoring, some screenlines were as much as 59% out. After factoring this was improved to 37% (for more information see the Phase 2 Test 15\4 PT folder).

3.22 Phase 2 Test 17_Pre[18]

3.22.1 Run details

Model Version: *2.0.6*
Date: *20/04/16*

Test 17_Pre applied further ASC adjustments with an additional 5 added to all of the PT values in an attempt to reduce the excess PT flows being generated by the model. Additionally, the parking distribution and free workplace parking capacities were adjusted and parking charges were updated so that the model would continue to assign all COM and EDU trips to free spaces and there would only be minimal redistribution of the trips using other parking. Updated costs based on the outputs from Test 15_Post were also added.

3.22.2 Results / outputs

Road and PT flows were checked for Test 17_Pre. Road calibration, (on percentage difference), improved slightly to:

- AM 72% / 88%;
- IP1 68% / 83%;
- IP2 63% / 75 %; and
- PM 64% / 79% (see the Phase 2 Test 17\3 Road folder for more details).

PT screenline matches improved in most locations though they did worsen in others (for more information see the Phase 2 Test 17\4 PT folder). The outputs from Test 17_Pre were matrix estimated / factored, but only for the purposes of providing updated costs.

3.23 Phase 2 Test 18_Pre & Test 18_Post

3.23.1 Run details

Model Version: *2.0.6*
Date: *27/04/16*

Test 18_Pre took the updated costs from the matrix estimated / factored matrices produced from Test 17_Pre and included updated internal goods matrices. In addition, PT

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[18] Test 16 was used for FDM development tests and did not form part of the WRM Calibration / Validation process

ASC values were adjusted by an additional 5 for P01 to P29 and an additional 3 for the one way purposes, P30 to P33. Matrix estimation / factoring was carried out on the outputs from the 'Pre' test. Test 18_Post was the same as Test 18_Pre but with incrementals and taxi proportions calculated and included.

3.23.2 Results / outputs

Road calibration, (on percentage difference), was good at:

- AM 68% / 88% (before ME) improving to 83% / 88% (after ME);
- IP1 69% / 83% (before ME) improving to 91% / 92% (after ME);
- IP2 60% / 67 % (before ME) improving to 88% /88% (after ME); and
- PM 64% / 79% (before ME) improving to 87% / 92% (after ME) (see the Phase 2 Test 18 \3 Road\1 Pre and Phase 2 Test 18 \3 Road\2 Post folders for more details).

PT screenline matches tended to improve with a maximum difference in the 'Pre' of 46%. In the 'Post' there was a maximum difference of around 20% in all time periods except the IP1 which still tended to be more mismatched (for more information see the Phase 2 Test 18\4 PT folder\1 Pre and Phase 2 Test 18\4 PT folder\2 Post folders).

3.24 Phase 2 Test 19_Pre & Test 19_Post

3.24.1 Run details

Model Version: *2.0.6*

Date: *08/05/16*

This run took the updated costs and internal goods matrices from the result of the matrix estimation / factoring of Test 18_Pre. In addition, the IP1 and PM PT period to hour factors were increased slightly to address output flow shortfalls in these peaks. Matrix estimation / factoring was carried out on the outputs from the 'Pre' test, and Test 19_Post was the same as Test 19_Pre but with incrementals and taxi proportions calculated and included.

3.24.2 Results / outputs

Road calibration, (on percentage difference), was similar to in previous runs and good at:

- AM 69% / 88% (before ME) improving to 84% / 88% (after ME);
- IP1 68% / 83% (before ME) improving to 91% / 92% (after ME);
- IP2 61% / 67 % (before ME) improving to 88% /88% (after ME); and
- PM 62% / 79% (before ME) improving to 86% / 92% (after ME) (see the Phase 2 Test 19\3 Road\1 Pre and Phase 2 Test 19\3 Road\2 Post folders for more details).

PT calibrations were similar with a maximum mismatch, in IP1, of 46% before factoring and 44% after (for more information see the Phase 2 Test 19\4 PT folder\1 Pre and Phase 2 Test 19\4 PT folder\2 Post folders).

3.25 Post Phase 2 Calibration and Validation Process Review

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

3.26 Phase 3 Test 1

3.26.1 Run details

Model Version: *2.0.8b*
Date: *07/06/16*

In this test:

- Parking distribution was turned on;
- Free Workplace Parking (FWPP) was turned on; and
- Parking Constraint turned off.

The model version V2.0.8 included minor upgrades in the parking distribution module and the reimplementation of the parking constraint module. Further information on development of model V2.0.8 is provided in the MSF Demand Model Development Report.

At this stage, the WRM was the first model to implement the Parking Distribution module. Several iterations of the demand model were required in order to calibrate the FWPP and the Parking Distribution module.

Free Workplace Parking

In the absence of data detailing the number of car spaces by zone, FWPP capacities were first set to 10% above the base commute and education car demand.

In this case, all commute and education trips were automatically given a workplace parking space with no associated parking charge. In addition to this, due to the lack of detailed information on the availability and charge associated with paid parking in the model area (on-street/off-street), it was agreed to set the parking charge in the entire model to zero for calibration.

Parking constraint

The parking constraint module intends to restrict the number of car destinations in certain areas such a city centres. However, the lack of accurate data about the actual number of car spaces in Galway city centre makes it difficult to model. Also, it was assumed that the limitation of car spaces is not as crucial as other parameters such as travel time/cost in terms of mode and destination choice in Galway. Therefore, the Parking Constraint module was not turned on in this iteration of the model.

Parking distribution

The parking distribution module (PDist) facilitates the redistribution of trips to nearby zones when the level of demand entering their intended zone reaches the capacity of available parking spaces, or where there are cheaper parking alternatives in nearby zones. It is intended to replicate the fact that there are limited parking spaces available within the city centre, and that people often have to park away from their intended destination in order to find an available space. Further information on parking distribution is provided in the RMS Full Demand Model (FDM) Specification Report.

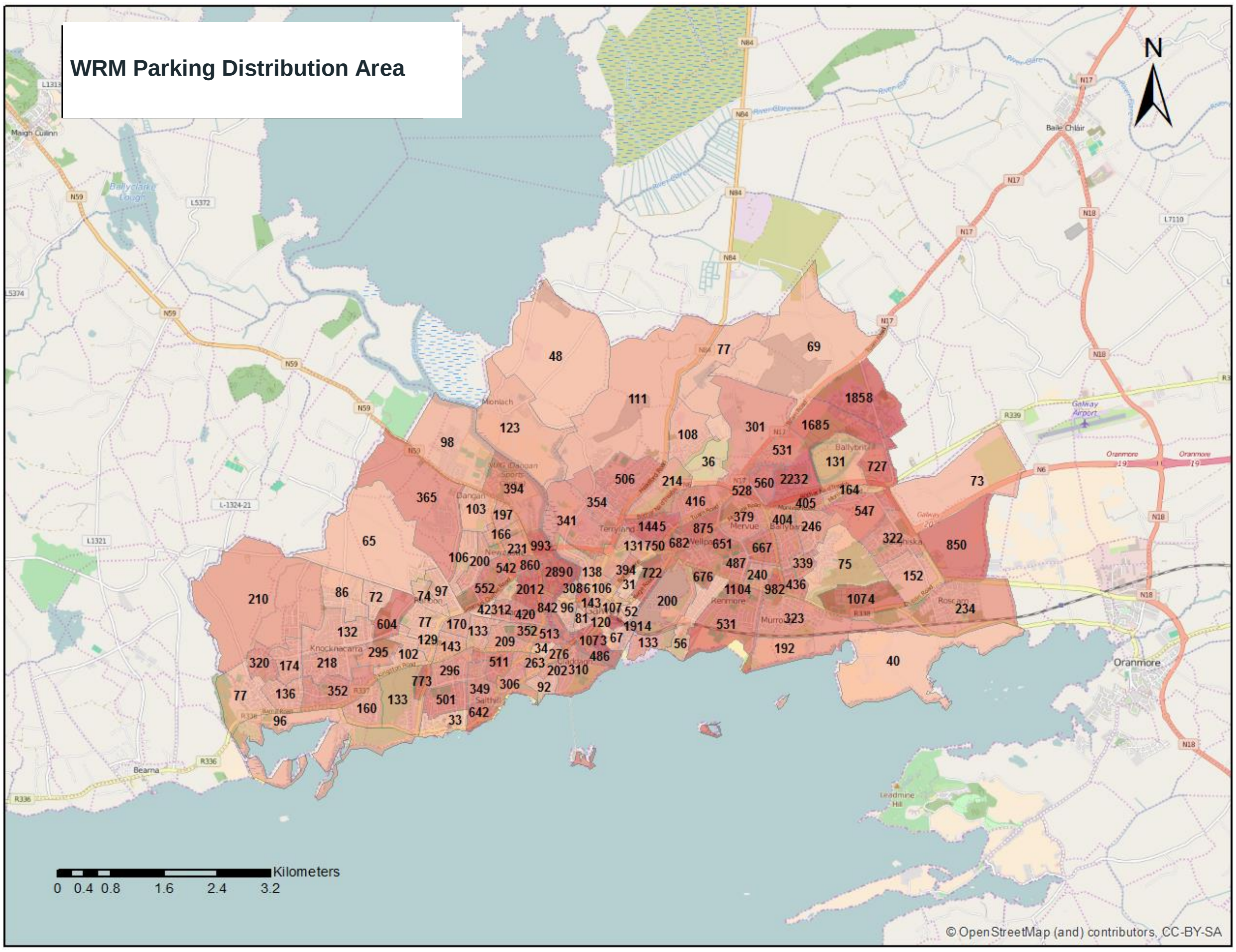

Figure 3.9 WRM Parking Distribution area and capacities[19]

Parking distribution in Galway city was defined using a similar methodology to the other regional models. With no information in terms of the number of car spaces actually available, it was decided to set the capacity of all zones within the parking distribution area to 90% of the car demand in the base year. The red shaded zones in Figure 3.9 were set as the PDist area. This included 141 zones and covered most of the built-up

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[19] OpenStreetMap data is available under the Open Database Licence www.openstreetmap.org/copyright or www.opendatacommons.org/licenses/odbl

area in the city. Seventeen city centre zones were identified as having paid on-street parking and a parking charge was coded, based on the values used for MWRM. The purpose of this is to deter car trips from distributing into those specific zones.

A few iterations of the demand model were needed in order to calibrate the base year capacities and search times for every zone.

At this stage, the additional costs incurred in the Parking Distribution module were not being fed back to the demand model. This was to be included in future versions of the model.

Another impact of turning on the Parking Distribution is the addition of extra costs for the walk leg between the redistributed destination (car park) and the final destination. These walk trips are assigned as part of the active modes assignment matrix. The analysis of all travel matrices and assignment matrices for trip length or mode share purposes should take this feature into account, as the walk legs of car trips should not be analysed as if they are walk trips

3.26.2 Results / outputs

The inclusion of the Parking Distribution module resulted in 146,826 car trips being redistributed in Galway City centre over 24 hours which represented about 10% of total car demand. Given the progressive increase of search time as demand approaches capacity, trips will start to be redistributed to other zones even before capacity is reached.

No dashboards were created before the next run as the special zones demand still had not been added in and the FWPP capacities would need to be changed.

3.27 Phase 3 Test 2

3.27.1 Run details

Model Version: *2.0.8b*
Date: *10/06/16*

In this test, special zones (ports and airports) were added for the WRM. This included the Galway Harbour HGV demand, and the air passenger demand at Knock airport. For this version of the model, the mode share for passengers going from/to the airport is fixed and will not evolve in the future. An additional functionality enabling a mode choice for such trips is to be implemented in future versions of the model (see the MSF Demand Model Development Report for further information).

Galway airport closed in 2011 for commercial flights and only opened temporarily in 2015. The base scenario for all the Regional Models is representing the year 2012, therefore Galway airport will not be represented by a special zone. However, Knock Airport, the 4th largest airport in Ireland in terms of passengers (approximately 700,000/year) is located in the WRM area, and therefore, has its own special zone.

The special zone demand for Knock Airport and Galway Harbour was estimated based on a methodology developed for the MWRM. Further information on this methodology is provided in Annex 2 of this report and in the MWRM Development Report and Specification Note: Airports and Special Zones.

The road and PT networks were amended in order to ensure correct connectivity for those special zones.

For this test, it was agreed to set the FWPP capacities to 9,999 so that all commute and education trips could choose free workplace parking and were not subject to further mode choice.

In parallel, adjustments were made to the input road traffic signal files in order to improve journey time validation on certain routes.

3.27.2 Results / outputs

Road calibration, (on percentage difference), was similar to in previous runs and good at:

- AM 65% / 88% (before ME) improving to 83% / 88% (after ME);
- IP1 67% / 83% (before ME) improving to 92% / 92% (after ME);
- IP2 64% / 63 % (before ME) improving to 87% /88% (after ME); and
- PM 63% / 79% (before ME) improving to 85% / 92% (after ME).

The number of redistributed trips remained equal to the previous run.

On the PT side, the percentage of links within 25% of observed flows for Rail and Bus are:

- AM 50% / 17% (before PT factoring) improving to 100% / 50% (after PT factoring);
- LT 0% / 33% (before PT factoring) improving to 50% / 67% (after PT factoring);
- SR 0% / 50% (before PT factoring) improving to 50% / 67% (after PT factoring); and
- PM 50% / 33% (before PT factoring) improving to 50% / 83% (after PT factoring).

The change of FWPP capacities up to extreme values highlighted an inconsistency in the way the capacities were being processed in the model. An alteration in scripts was required which led to version 2.0.8d being used for the next set of tests.

The level of demand in the special zones is small (61 trips in the AM to Knock Airport, 52 HGV movements to Galway Harbour) and had no impact on the overall level of model calibration.

The analysis of Matrix Estimation showed that the R-square values outside the AM time period could possibly be improved. It was decided to carry out another iteration of Matrix Estimation and PT factoring. Further information on road and PT results are provided in the Phase 3 Test 2\3 Road and Phase 3 Test 2\4 PT folders.

Table 3.7 Matrix estimation analysis

ME R^2	AM	LT	SR	PM
Taxi	0.97	0.94	0.98	0.98
Emp. Bus.	0.93	0.90	0.90	0.90
Commute	0.96	0.92	0.93	0.93
Education	0.97	0.84	0.95	0.95
Car Other	0.99	0.98	0.98	0.98

3.28 Phase 3 Test 3

3.28.1 Run details

Model Version: *2.0.8d*

Date: *17/06/16*

The FWPP module included a minor update mentioned above (phase 3 Test 2), and input FWPP capacities were set to zero. In this case, no commute or education trips are automatically given a free workplace parking space, and as a result, these trips will be considered equally to other purposes in terms of parking charge.

Parking distribution capacities and search times were updated to match a level of 90% occupancy for all distributed zones, and to run a single PDist loop.

3.28.2 Results / outputs

The FWPP had no impact on results as having a 0 capacity for all zones is equal to not having the FWPP module turned on. Costs from this run were passed to the next phase of calibration.

3.29 Phase 3 Test 4

3.29.1 Run details

Model Version: *2.0.8d*
Date: *20/06/16*

This run took the updated costs and internal goods matrices from the result of the matrix estimation and PT factoring undertaken for Phase 3 Test 3.

3.29.2 Results / outputs

The outcome of this run was seen as satisfactory. This run was therefore the last one to be undertaken at this stage.

3.30 Version upgrade and looping to convergence

3.30.1 Model version

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

3.30.2 Inputs

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

3.30.3 Recalibration

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

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

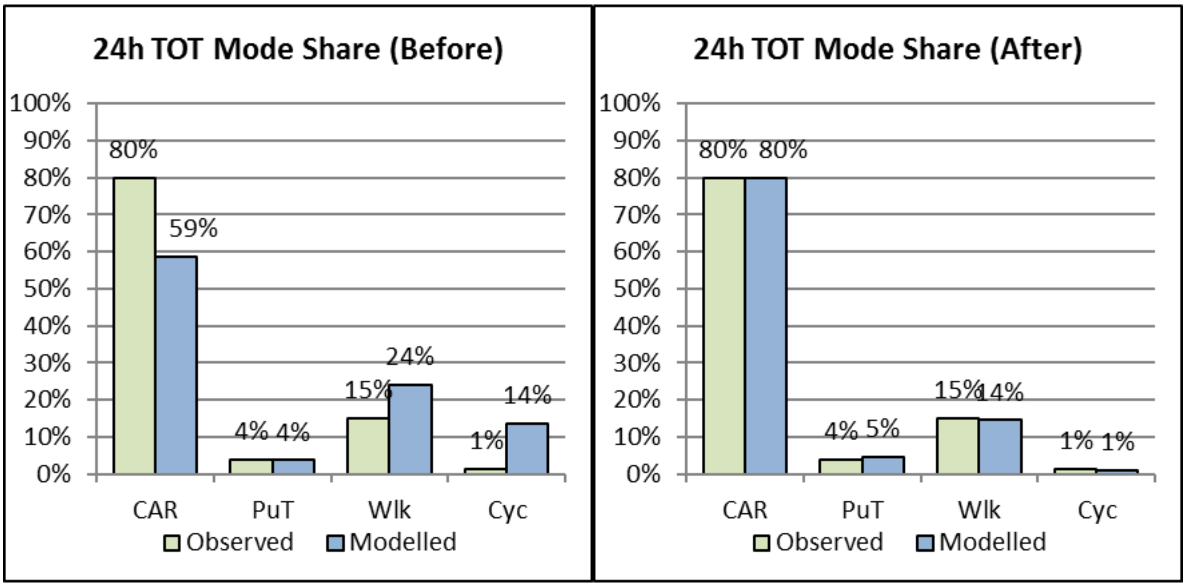


Figure 3.10 24h Total Mode Share before (left) and after (right) recalibration

Following this step, both the road and PT models were recalibrated, using same process as for v2.0.8. A new set of incremental matrices was generated and applied.

3.30.4 Park and Ride calibration

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

4 Final calibration / validation results

4.1 Introduction

The finalised parameters used in the demand model are given in Annex 3 and this chapter gives details of the final calibration and validation, across a whole range of model outputs, including the direct demand model indicators (modal split, generalised cost and trip length distributions, intrazonal trip numbers, and time period distributions). It then considers less direct indicators such as the change in the matrices required to match flows on the ground and the size of the incremental matrices needed to correct the directly output demand matrices to their equivalent estimated / factored partners, as well as the output road and PT movements.

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

4.2 Full results in electronic format

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

- Demand: Final\2 Demand;
- Road: Final\3 Road; and
- PT: Final\4 PT.

4.3 Demand calibration

4.3.1 Modal Split

Figure 4.1 shows the observed and modelled mode shares for the full 24 hour period for the five user classes and for all trips combined. Overall, the match is good although the car and PT mode shares are slightly low, while the walk and cycle mode shares are slightly high. In the EMP, OTH and RET (CON) groups the match is excellent but the COM and EDU groups tend to have too little car and too many walking trips.

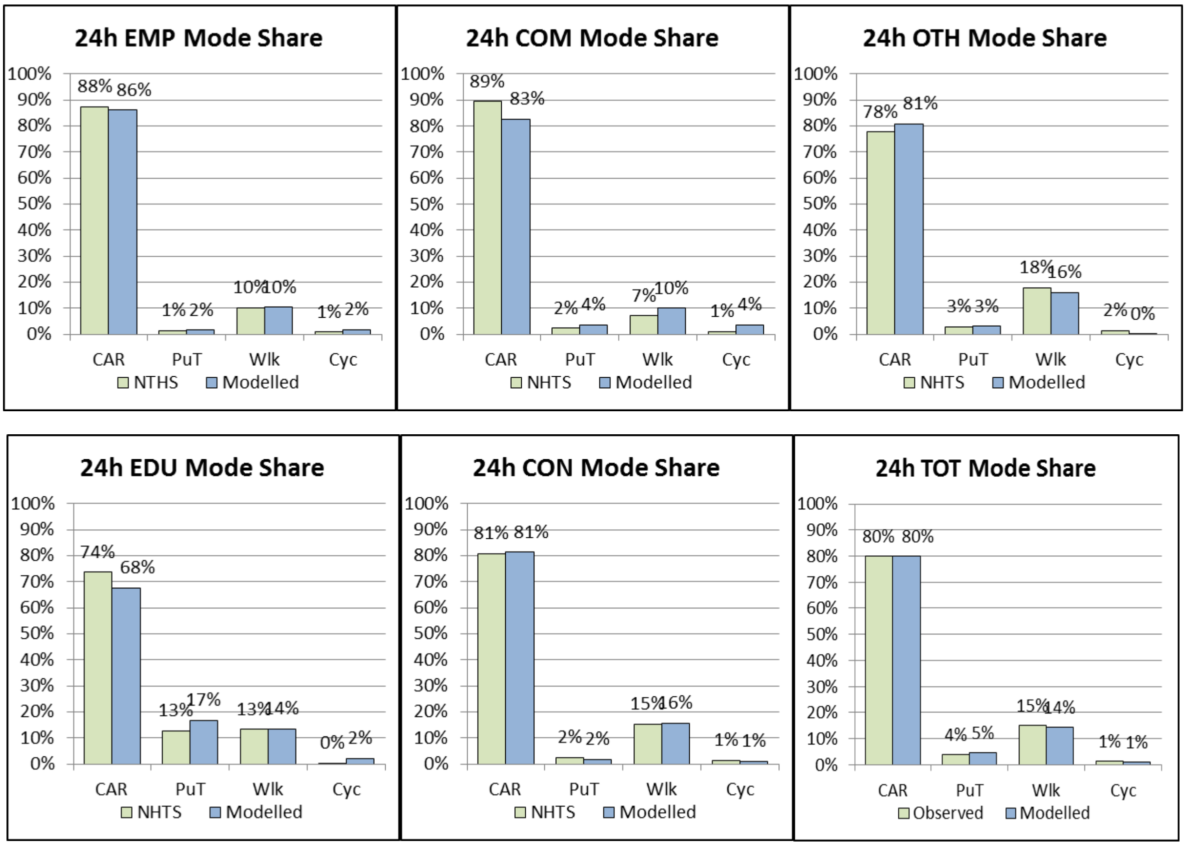


Figure 4.1 Total Mode Share (24hr)

4.3.2 Generalised cost distributions

Figure 4.2 and Figure 4.3 show the generalised costs curves for five user classes across the four daytime time periods. In general there is a good match between the generalised cost data and the modelled outputs, particularly for car, walk and cycle trips. PT trips are less well matched, particularly for the EMP user class.

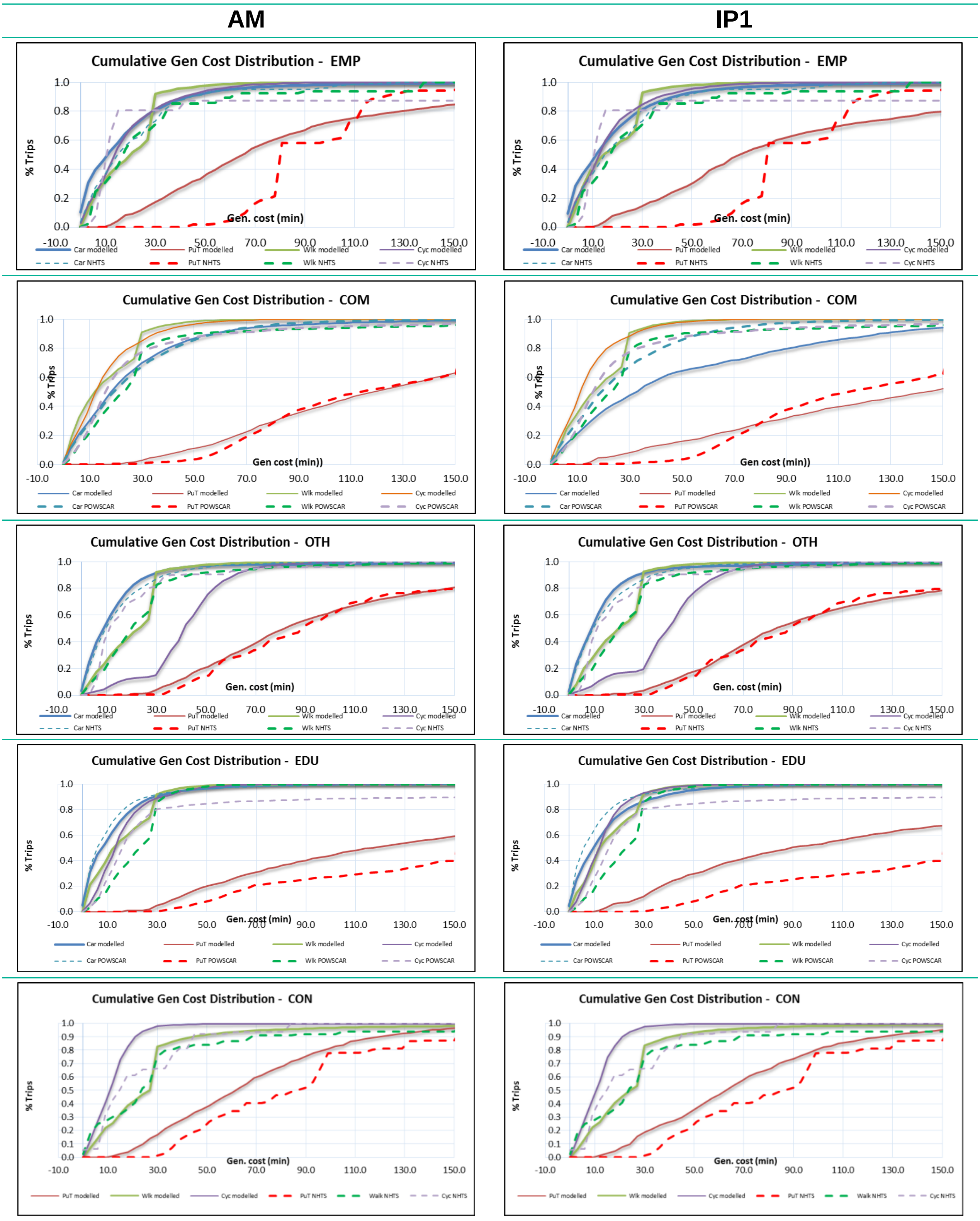


Figure 4.2 Cumulative trip length distributions (AM and IP1)

IP2	PM

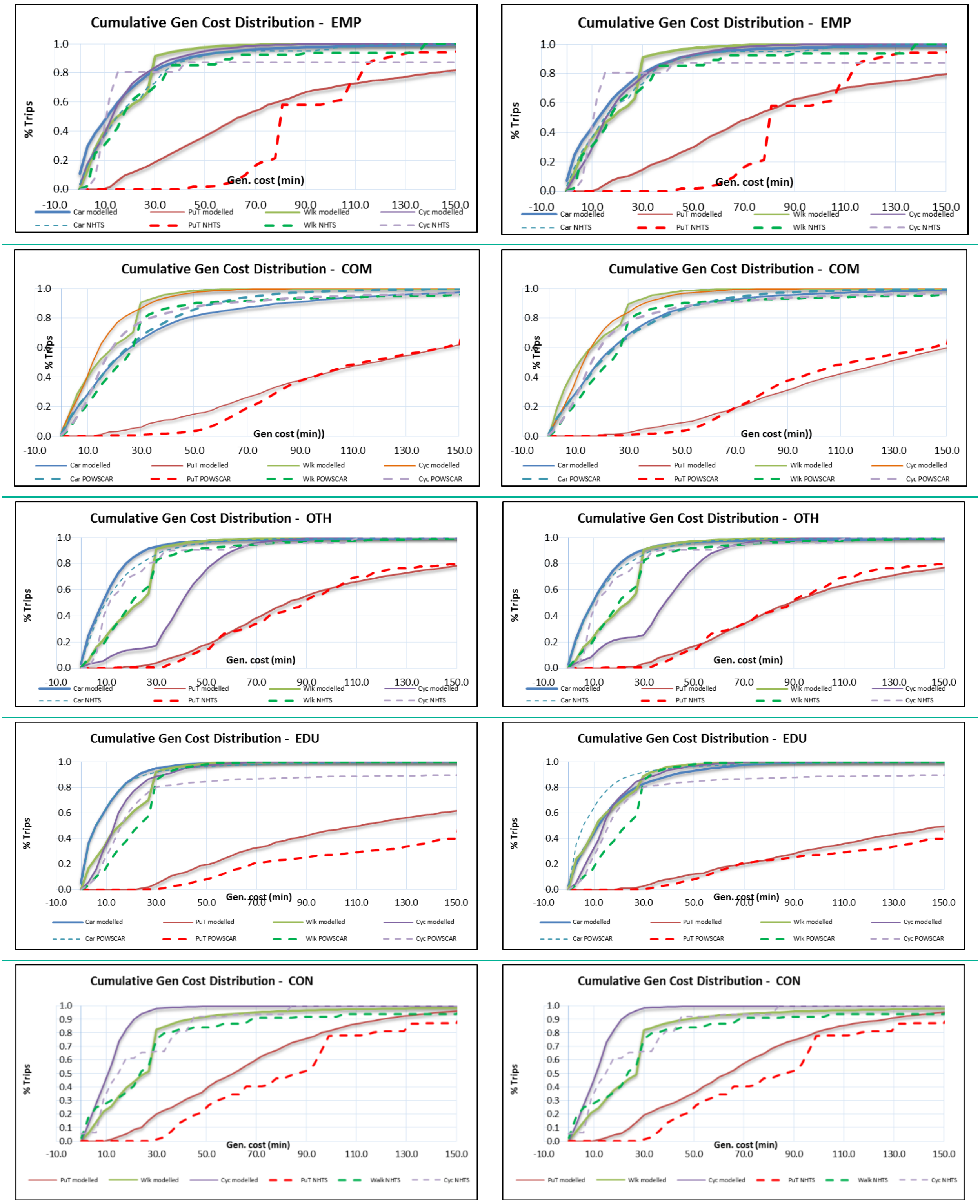


Figure 4.3 Cumulative trip length distributions (IP2 and PM)

4.3.3 Trip length distribution

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

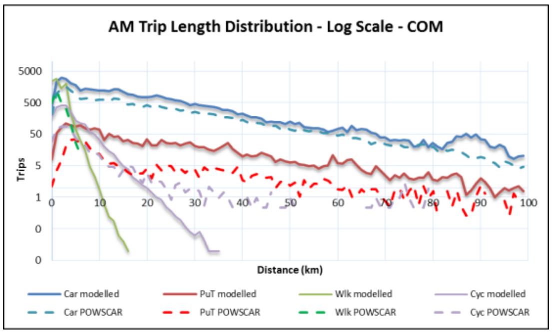
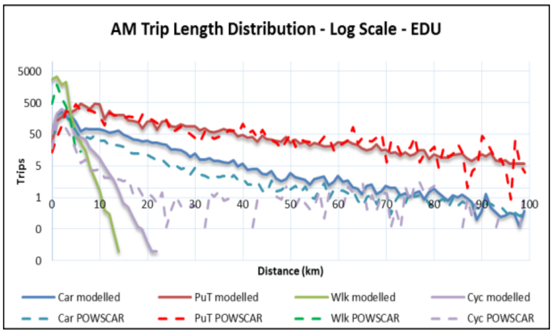
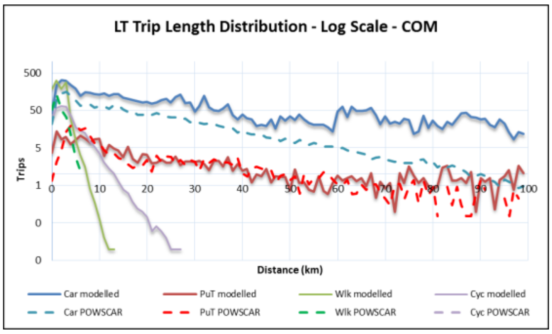
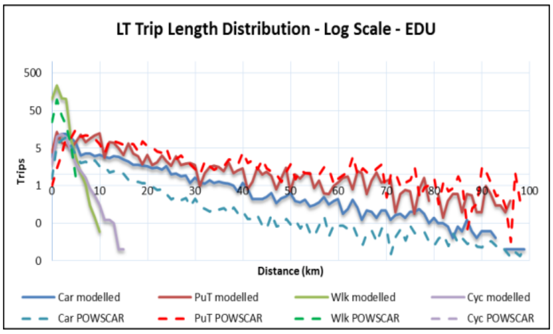
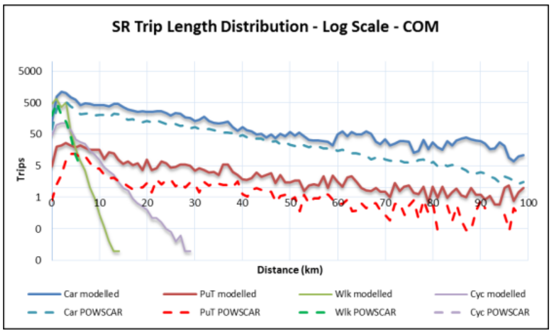
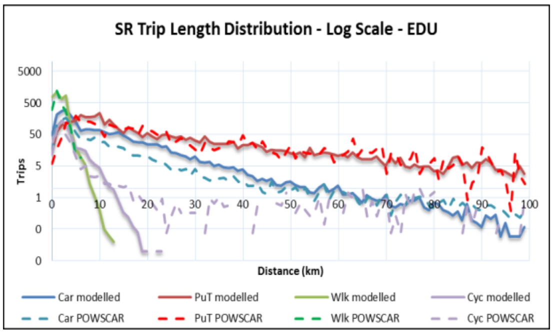
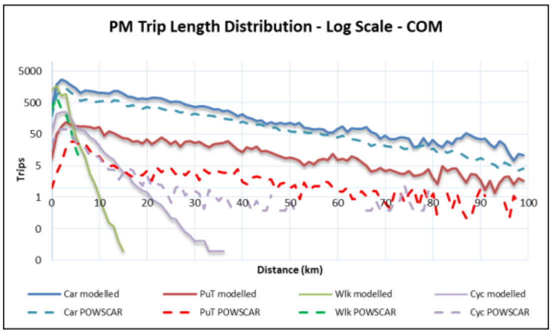
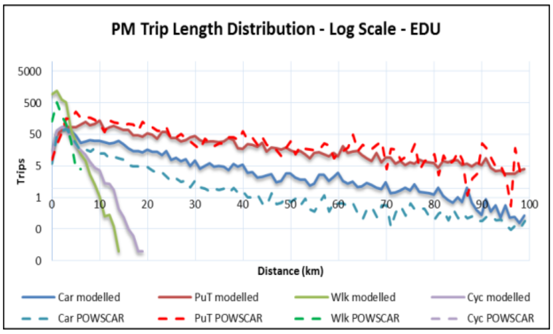
TP	COM	EDU
AM		
IP1		
IP2		
PM		

Figure 4.4 Trip lengths for COM and EDU

4.3.4 Intrazonal Trips

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

Intrazonal demands (as a proportion of total demand) for each time period are shown in Figure 4.5 to Figure 4.8. These show an acceptable level of correspondence between the modelled and observed proportions of intrazonals. The largest disparities are between the modelled and observed proportions of PT and cycle trips and these disparities occur in all of the four time periods illustrated.

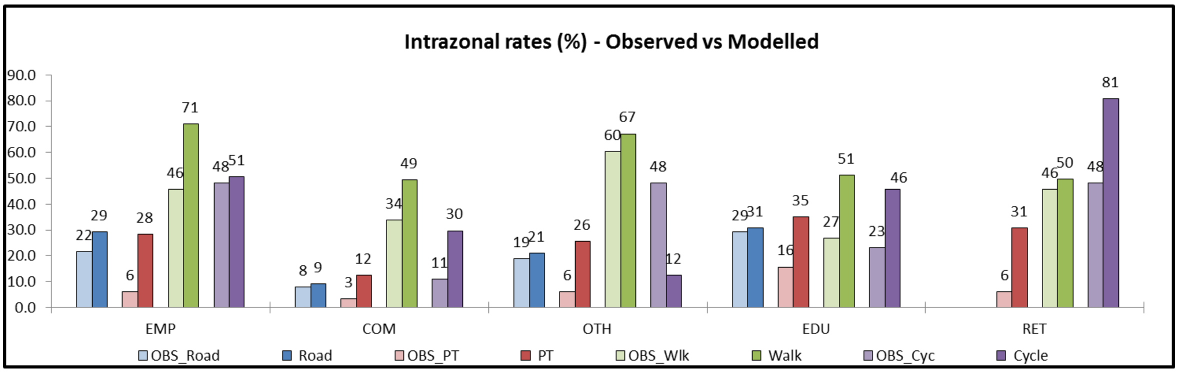


Figure 4.5 AM Intrazonal Trip Rate Proportion

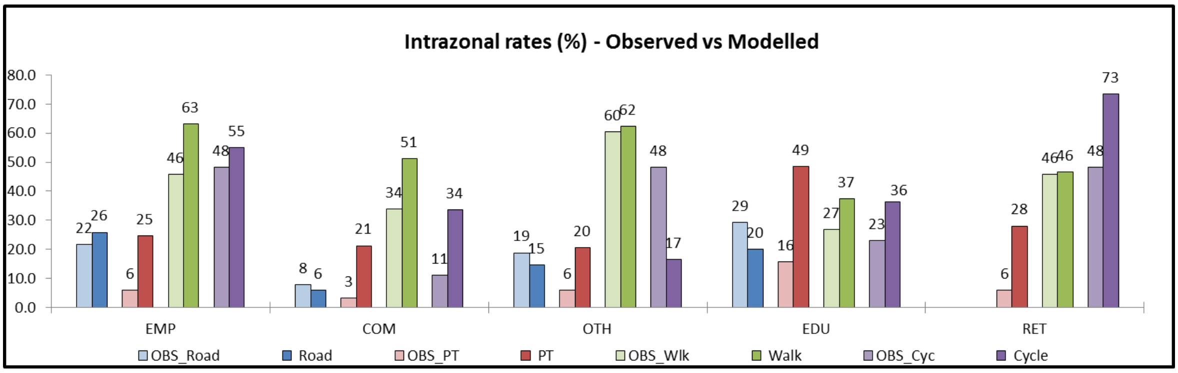


Figure 4.6 IP1 Intrazonal Trip Rate Proportion

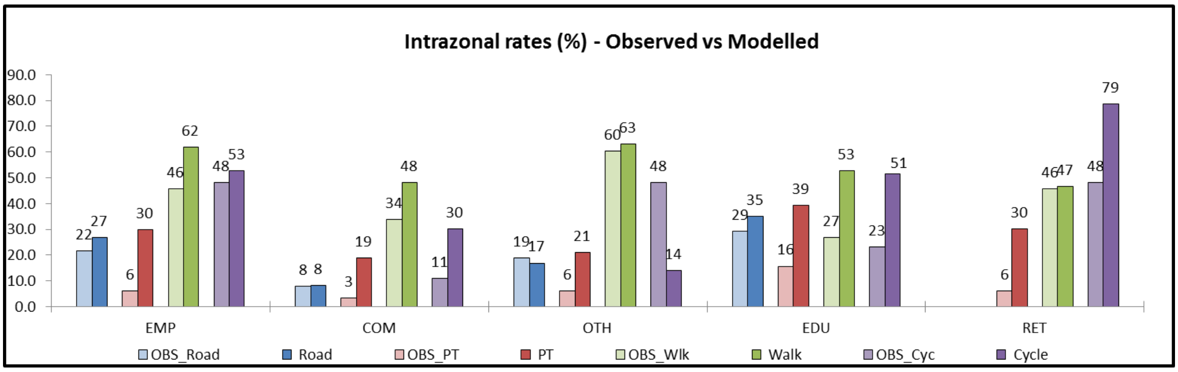


Figure 4.7 IP2 Intrazonal Trip Rate Proportion

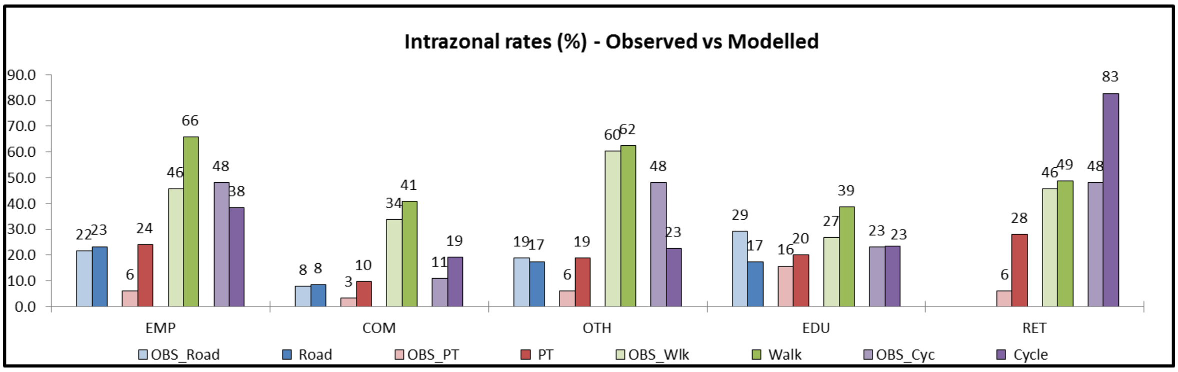


Figure 4.8 PM Intrazonal Trip Rate Proportion

4.3.5 Time period distribution

Figure 4.9 shows a comparison of the number of modelled trips in each time period with the number observed in the NHTS data. The total number of modelled trips in each time period compares well with the observed number of trips, with differences of less than 5% in each daytime time period, and less than 10% in the OP.

The number of observed and modelled trips by each mode in each time period (Figure 4.10) also compares well.

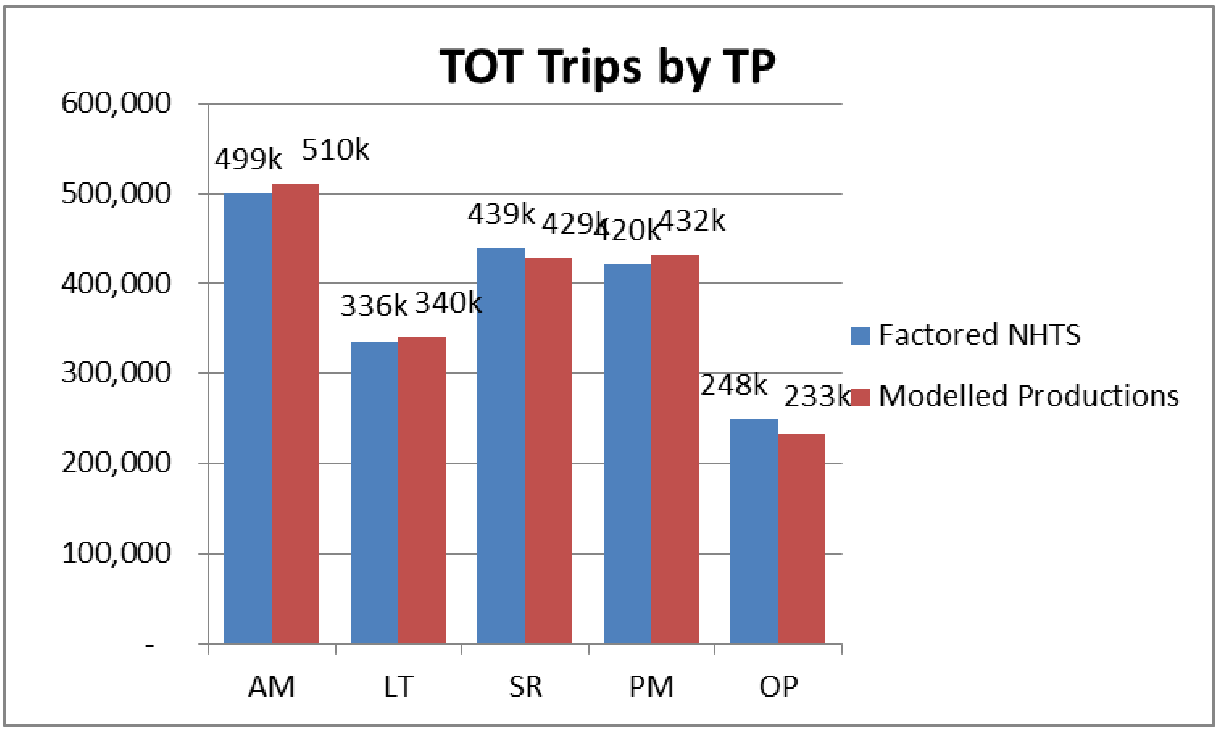


Figure 4.9 Total Trips by Time Period

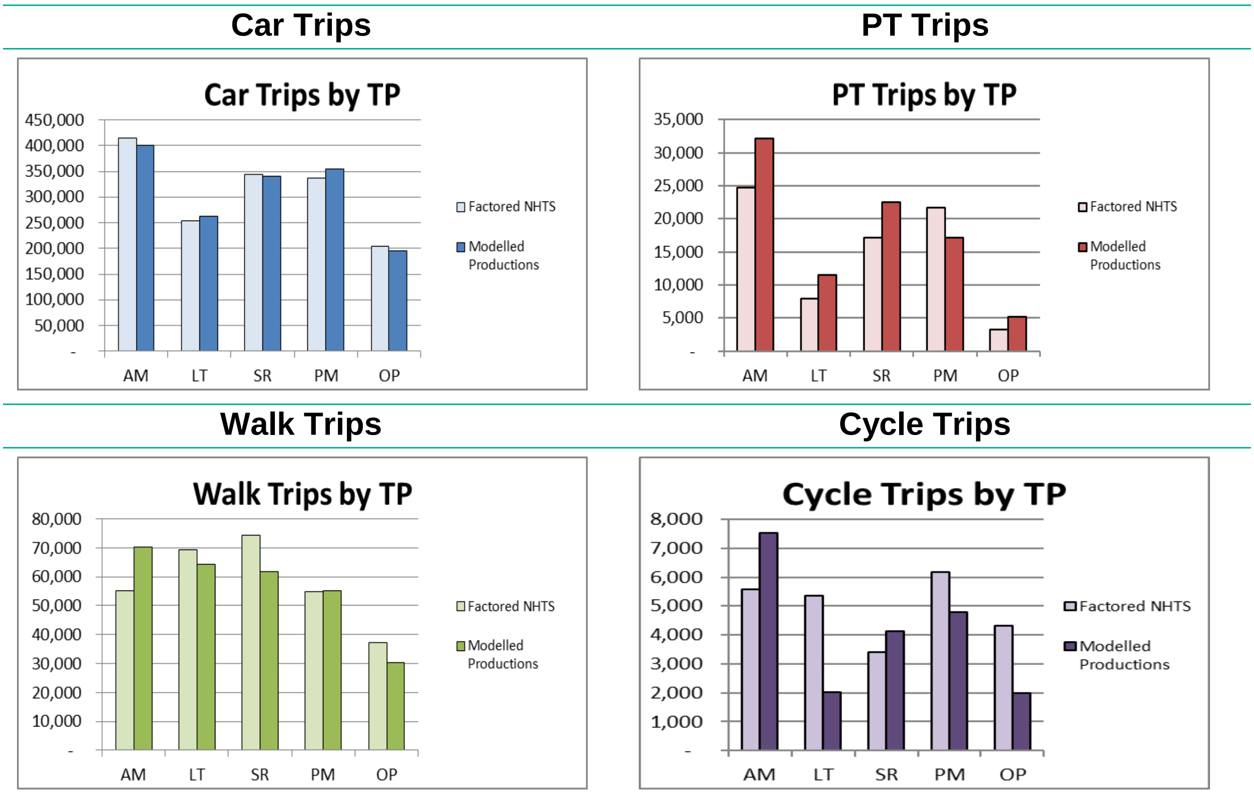


Figure 4.10 Total Trips by Time Period and Mode

4.4 Correcting calibrated demand to match observed movements on the ground

4.4.1 Limitations of demand model calibration

Experience and the intended purpose of the modelling system are factors in deciding whether or not the demand model outputs should be further adjusted in order to attain the guideline link flow comparison. In some cases, a correction process such as matrix estimation can be introduced into the model to 'correct' the demand model outputs and produce the desired assignments. While this does distort the calibrated demand model outputs, it helps to achieve the guideline targets for network calibration. The calibration of assignment matrices should limit divergence between the demand model outputs and the road assignment matrices (post-estimation). Once this is held to within tolerable levels, then calibrated trip length distribution and mode share data from the demand model, among others, should still be respected by road and public transport assignment.

Guidelines on such matrix adjustments require that the trip length distributions of the matrices are held to within small tolerances of the output demand model matrices, as this is the key observed data to which the demand model matrices are calibrated. This restriction is intended to avoid invalidating the underlying demand patterns and mode share calibration whilst allowing limited adjustment to demand model outputs in order to improve modelled flows.

The extent to which matrix adjustment can be applied in order to achieve network model specific targets has to be carefully considered. A balance must be reached that maximizes the quality of demand model outputs with respect to the assignments produced, and minimizes the need for further adjustment. The optimal overall model calibration (according to balanced consideration of all model calibration indicators spanning demand and assignment models) may require acceptance of a lower level of link flow calibration in order to maintain more fundamental aspects of the demand calibration, such as mode share and trip length. The level of compromise accepted is a function of the quality of the full range of observed data across all inputs to the overall calibration process and of the intended use of the model.

4.4.2 Sector to sector movements

In the ideal case the amount of change between the directly output demand matrices and the estimated / factored matrices would be small. A comparison of sector to sector movements before and after matrix estimation / factoring is shown in Figure 4.11 (for road) and Figure 4.12 (for PT). While there are some larger differences in individual cells the overall changes in the trip ends are smaller, almost all 5% or below in the road case.

Differences - Sector to sector matrix															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Tot
-5%	10%	-11%	10%	10%	-24%	-26%	-21%	-6%	5%	7%	-1%	1%	0%	0%	2%
10%	8%	15%	19%	25%	-29%	-15%	-20%	-7%	-13%	8%	0%	-1%	0%	0%	2%
1%	-4%	-12%	36%	8%	-57%	-45%	-33%	-27%	-16%	0%	0%	1%	0%	0%	2%
11%	24%	30%	-6%	9%	-34%	-22%	-12%	-6%	6%	6%	1%	1%	0%	0%	5%
25%	10%	-10%	15%	-6%	-51%	-35%	-29%	-21%	-16%	-8%	0%	1%	0%	0%	4%
-24%	-26%	-30%	-8%	-5%	7%	-2%	-14%	-14%	-37%	-29%	-32%	-29%	-7%	2%	-3%
-24%	-9%	-5%	-32%	-34%	-2%	20%	2%	3%	23%	-37%	2%	23%	4%	-37%	-6%
-16%	-10%	-16%	-22%	-21%	-7%	-2%	0%	21%	-1%	-13%	-34%	1%	-11%	-49%	-3%
-17%	1%	-11%	-18%	-24%	-15%	2%	18%	0%	12%	-19%	3%	4%	-5%	-16%	1%
3%	-4%	1%	26%	11%	-33%	25%	0%	14%	0%	-3%	-22%	0%	-3%	-22%	0%
30%	3%	-13%	18%	-11%	-35%	-31%	-14%	-11%	-3%	-2%	-15%	-1%	2%	0%	-2%
-1%	0%	0%	0%	0%	-11%	4%	-15%	14%	-17%	-18%	-1%	7%	1%	0%	-2%
1%	-1%	1%	12%	5%	-25%	34%	5%	4%	0%	-7%	6%	0%	-6%	-7%	0%
0%	0%	0%	1%	0%	-8%	11%	-15%	-7%	-4%	0%	0%	-9%	-3%	-14%	-4%
0%	0%	0%	0%	0%	3%	-43%	-52%	-15%	-22%	0%	0%	-8%	-12%	0%	0%
5%	5%	0%	7%	2%	-3%	-5%	-3%	2%	-1%	-3%	-2%	-1%	-3%	0%	-1%

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

Differences - Sector to sector matrix															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTAL
105%	57%	58%	103%	63%	22%	-51%	-38%	-31%	-9%	25%	19%	23%	18%	14%	21%
113%	40%	42%	95%	42%	24%	-19%	7%	-15%	13%	15%	16%	21%	22%	24%	40%
107%	37%	10%	93%	37%	34%	-15%	-13%	-28%	-1%	16%	12%	26%	14%	21%	44%
107%	60%	66%	92%	61%	24%	-25%	-32%	-33%	-20%	29%	19%	19%	16%	25%	22%
104%	31%	35%	91%	33%	18%	12%	-14%	-23%	-9%	23%	19%	18%	17%	19%	49%
37%	38%	16%	40%	16%	45%	-10%	-1%	-46%	2%	11%	10%	-23%	-9%	11%	5%
-35%	-5%	0%	-7%	21%	-11%	33%	-21%	-17%	-10%	-10%	-7%	-7%	3%	-16%	-14%
-29%	-6%	-21%	-32%	-23%	-21%	-25%	1%	-31%	-11%	0%	3%	2%	14%	16%	-12%
-14%	-1%	-15%	-15%	-7%	-43%	-25%	-34%	-18%	-29%	-16%	-28%	-26%	-26%	-12%	-20%
-16%	-7%	-9%	-33%	-17%	7%	-16%	-12%	-34%	-5%	1%	-23%	-4%	2%	19%	-10%
0%	-11%	-1%	-21%	-5%	11%	-8%	0%	-17%	-5%	7%	4%	5%	17%	19%	-1%
-15%	-17%	-10%	-28%	-22%	7%	-7%	3%	-27%	-25%	10%	7%	5%	13%	14%	2%
-23%	-22%	-8%	-23%	-25%	-19%	-2%	5%	-30%	-5%	3%	7%	1%	-5%	12%	-2%
-23%	-19%	-33%	-22%	-22%	-11%	4%	11%	-36%	-5%	8%	14%	-12%	3%	11%	-3%
-34%	-24%	-25%	-32%	-35%	11%	-14%	8%	-20%	9%	8%	12%	13%	14%	9%	9%
31%	19%	27%	15%	31%	4%	-21%	-12%	-28%	-7%	10%	2%	-2%	0%	9%	3%

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

4.4.3 R-squared Analysis

The R-squared (R^2) statistic was utilised throughout calibration as a measure to check the changes to road model matrices during estimation. Table 4.1 outlines the matrix estimation change calibration criteria, as specified in TAG Unit M3-1, Section 8.3, Table 5.

Table 4.1 Significance of Matrix Estimation Changes

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

The following sections provide an overview of the r-squared results for each model time period. Further details are provided in the WRM Road Model Development Report.

AM

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

Table 4.2 AM Matrix Change R^2 Analysis

User Class	EMP	COM	EDU	OTH
Cell R-Squared	0.94	0.95	0.98	0.99
Cell Slope	0.96	0.97	0.98	0.99
Cell Y-Intercept	0.00	0.00	0.00	0.00
Trip End R-Squared	0.99	0.99	0.99	1.00
Trip End Slope	0.98	0.97	0.99	0.98
Trip End Y-Intercept	0.14	0.85	0.00	1.40

TAG Unit M3-1, Section 8, Table 5 indicates that an acceptable R^2 value for individual matrix zonal changes is in excess of 0.95, which is exceeded by all user classes with the exception of Employers Business which falls just outside the range. Two of the user classes pass the recommended criteria for zonal slope values between 0.98 – 1.00. The remaining two values of 0.96 – 0.97 for EMP and COM narrowly fail to meet the TAG criteria. The COM, EMP and OTH user classes also narrowly fails the tighter criterion for trip end slope. All other criteria are met in the AM

LT

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

Table 4.3 IP1 Matrix Change R^2 Analysis

User Class	EMP	COM	EDU	OTH
Cell R-Squared	0.93	0.95	0.93	0.99
Cell Slope	0.98	0.97	1.02	0.99
Cell Y-Intercept	0.00	0.00	0.00	0.00
Trip End R-Squared	0.99	0.98	0.98	0.99
Trip End Slope	0.99	0.90	1.07	0.98
Trip End Y-Intercept	0.13	0.48	-0.01	1.44

Two of the four user classes are just outside the acceptable range for the individual cell R^2, with the COM class also falling outside the slope criterion. With regard to the trip end criteria, all of the user classes are within the R^2 criterion, but only one user class fully meets the slope criterion.

SR

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

Table 4.4 IP2 Matrix Change R^2 Analysis

User Class	EMP	COM	EDU	OTH
Cell R-Squared	0.93	0.95	0.98	0.99
Cell Slope	0.98	0.99	0.98	0.99
Cell Y-Intercept	0.00	0.00	0.00	0.00
Trip End R-Squared	0.99	0.97	0.99	0.99
Trip End Slope	0.98	0.98	0.96	0.98
Trip End Y-Intercept	0.09	0.09	0.09	1.58

Three of the user classes pass the individual cell R^2 test, with the remaining one falling just outside the range. All of the user classes meet the cell slope and three of the four meet the trip-end R^2 criteria. For the trip-end slope criterion, all of the user classes narrowly fail the criterion.

PM

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

Table 4.5 PM Matrix Change R^2 Analysis

User Class	EMP	COM	EDU	OTH
Cell R-Squared	0.93	0.96	0.96	0.99
Cell Slope	0.97	0.98	0.97	0.99
Cell Y-Intercept	0.00	0.00	0.00	0.00
Trip End R-Squared	0.98	0.98	0.98	1.00
Trip End Slope	0.98	0.96	0.89	0.98
Trip End Y-Intercept	0.19	1.37	0.12	1.47

Three out of the four user classes pass the individual cell R^2 test, and the one that did not has an R^2 value of 0.93. All four user classes pass the trip end R^2 test. However, for the cell slope test, only the COM and OTH user classes pass, though the other fail narrowly. None of the user classes pass for the trip end slope, though the EMP and OTH classes are close.

4.4.4 Application of estimation / factoring information to the demand model

The information gained from matrix estimation / PT factoring is input into the demand model through the medium of incremental matrices. These give the difference between the directly calculated demand and the estimated / factored demand and so, in the base case, these effectively reproduce the estimated / factored matrices. Once this has taken place, the levels of calibration in the road and PT networks can be meaningfully considered.

Table 4.6 Scale of incremental matrices (incremental total as % assigned total)

Mode	AM	LT	SR	PM
Taxi	0%	0%	0%	0%
Car	-1%	-1%	-1%	-1%
PT	-8%	+2%	+12%	+11%
Walk	0%	0%	0%	0%
Cycle	0%	0%	0%	0%

The incremental values should only form a small part of the assignment matrix and their scale is indicated in Table 4.6.

4.5 Road calibration and validation

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

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

- AM 87% / 77%;
- IP1 93% / 85%;
- IP2 92% / 79 %; and
- PM 88% / 77%.

Journey time validation was reasonable with 60% of routes meeting the pass criteria in the AM and PM peaks and 88% in IP1 and IP2.

4.6 Public transport calibration and validation

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

Figure 4.13 and Figure 4.14 show the modelled versus observed flows at the locations where data is available, and Figure 4.15 and Figure 4.16 show rail boardings by time period. In general, the match to flows is reasonable though it tends to be worse in the inbound IP1 (LT) time period and for the outbound AM. Rail boardings tend to be high overall but the overall pattern is quite good.

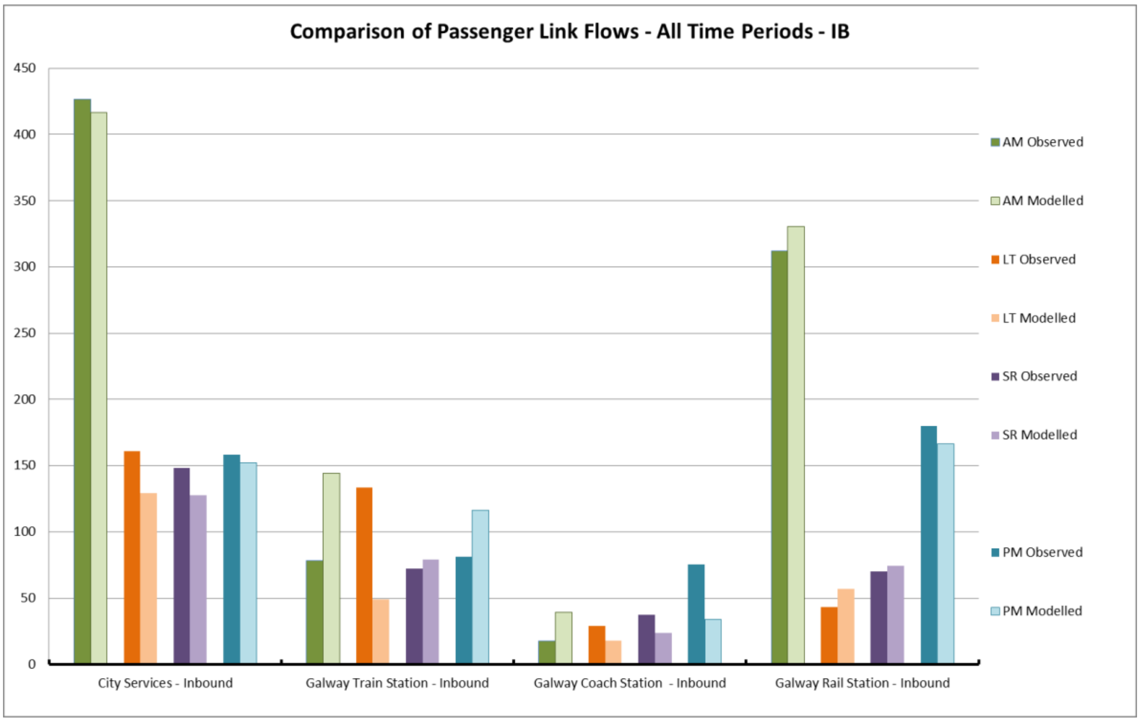


Figure 4.13 Inbound PT passenger flows[20]

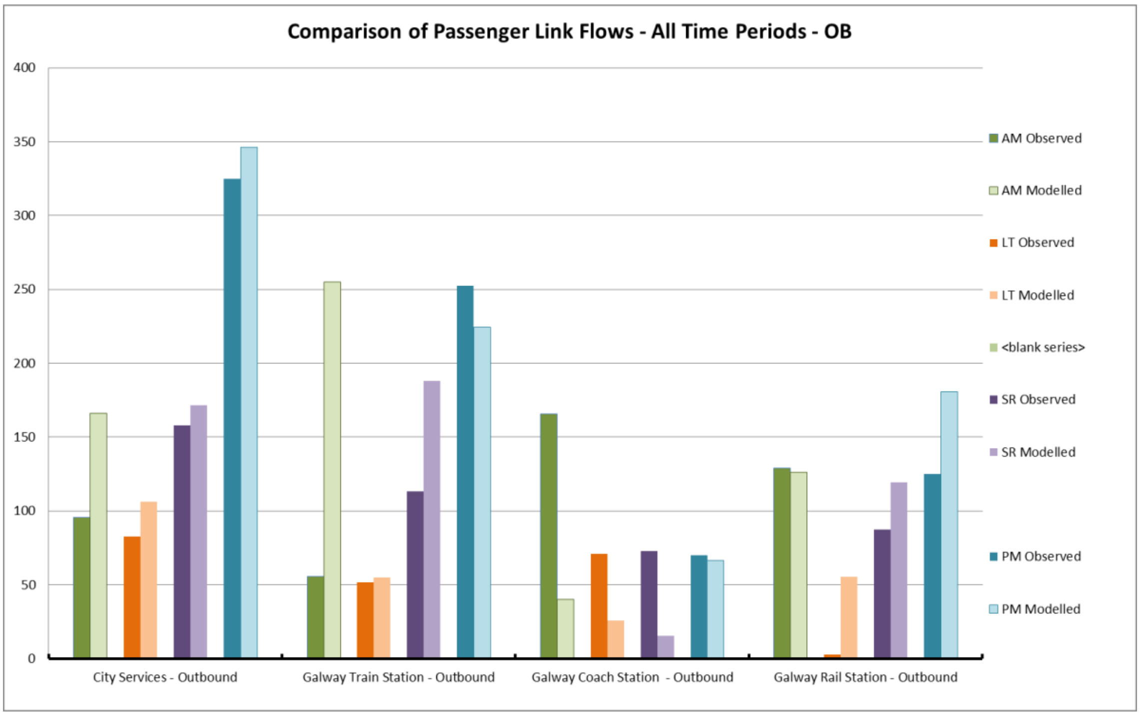


Figure 4.14 Outbound PT passenger flows[21]

[20] Galway Train Station refers to bus services observed at Galway Rail Station

[21] Galway Train Station refers to bus services observed at Galway Rail Station

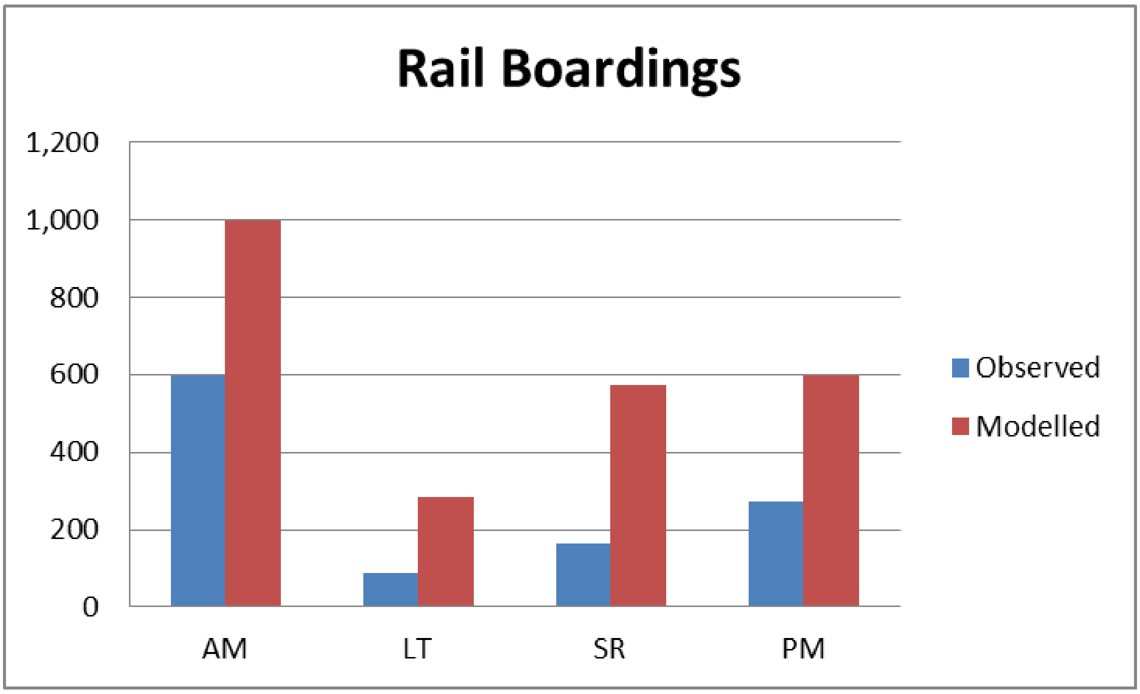


Figure 4.15 Rail boardings by time period

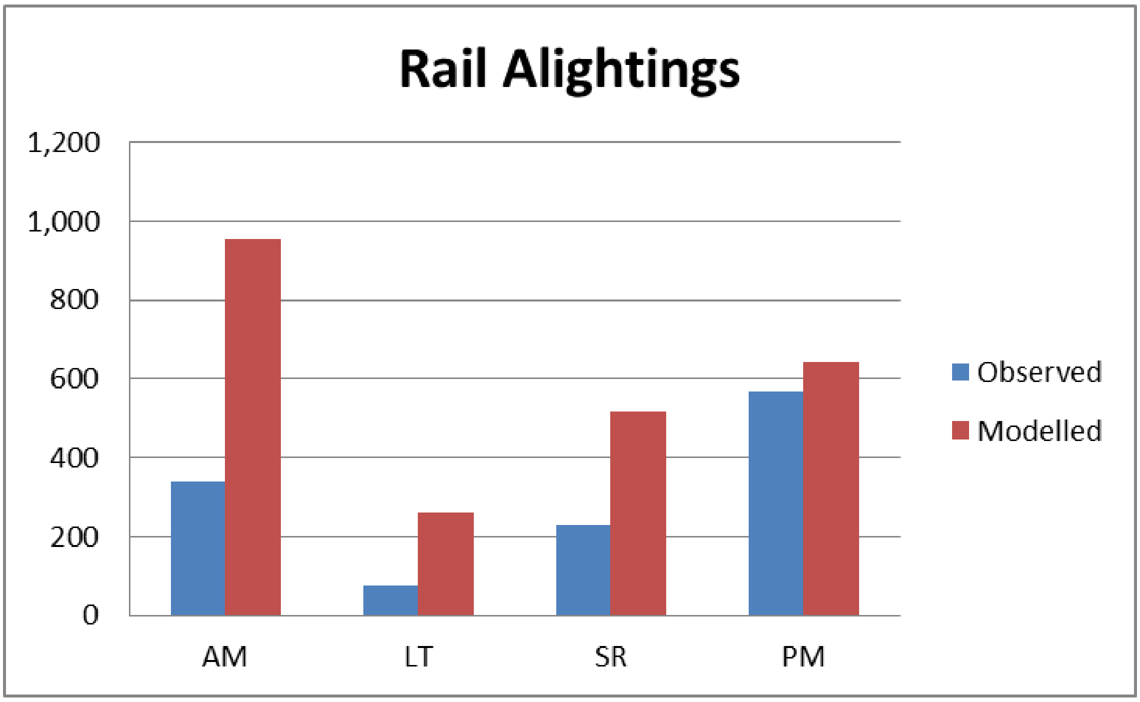


Figure 4.16 Rail alightings by time period

4.7 Overview

Though there is still room for improvement, overall:

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

5 Realism Testing

5.1 Overview

The preceding chapters discuss how the base year scenario of the model was calibrated and validated which reflects its ability to reproduce current conditions. In order to estimate how accurately the model will be able to predict future conditions, it is important to run realism tests before undertaking true forecast year runs. WebTAG recommends a series of three standard realism tests[22], namely:

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

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

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

Where:

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

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

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

Table 5.1 Realism Test Acceptability Criteria

Test	Valid Range	Notes
Fuel	-0.25 to -0.35	Should vary by purpose and certain individual purposes may be outside the range. Discretionary travel should be more elastic and employers' business should be less elastic.
Fare	-0.20 to -0.90	Can be as elastic as -2.0 for some long-term models[23]
Time	0.00 to -0.20	

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

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

5.2 Running the realism tests

5.2.1 Car fuel cost elasticity

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

5.2.2 PT fare elasticity

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

5.2.3 Car journey time elasticity

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

5.3 Results

5.3.1 Car fuel cost elasticity

At the 24 hour level (last column) and the all-purposes level (last row) the elasticities are inside the WebTAG range, with the exception of that for EMP across the whole day (Table 5.2). However, WebTAG does not make specific reference to trips on Employers Business and it seems reasonable that EMP trips would be less sensitive to changes in fuel cost than is usual, as the cost of staff time is generally much higher than the direct cost of business travel. It is therefore plausible that EMP trips should show a low level of sensitivity to car fuel cost, and these low values are replicated across all the individual time periods as well.

Table 5.2 Car fuel cost elasticities

User class	AM	LT	SR	PM	OP*	24 Hour
EMP	-0.178	-0.154	-0.172	-0.169	-0.143	**-0.161**
COM	-0.321	-0.389	-0.293	-0.308	-0.339	**-0.318**
OTH	-0.385	-0.243	-0.256	-0.337	-0.231	**-0.288**
EDU	-0.305	-0.321	-0.295	-0.293	-0.265	**-0.298**
RET**	-0.217	-0.286	-0.311	-0.384	-0.297	**-0.297**
Total	**-0.325**	**-0.251**	**-0.269**	**-0.320**	**-0.250**	**-0.290**

* LT distance skim used for OP
** OTH distance skim used for RET

Other low values can be found for OTH trips in the LT and OP. These values are only fractionally outside the desired range and the mismatches only occur in these individual peaks and so this is not considered to be problematic.

A low value is also given for RET trips in the morning peak. Users in this group are entitled to free bus and rail travel and so if they have chosen to make their trip by car it is probably because there are complicating factors which make the car more than usually attractive. Therefore, it makes some sense that they would be less cost sensitive than other user classes.

High values are found for COM trips in the LT, OTH trips in the AM and RET trips in the PM. Again, these values are only just outside the expected range and at the all-purposes and 24 hour levels these groups respond appropriately.

Overall, despite small localised deviations from the expected range the model is considered to respond appropriately to changes in fuel costs.

5.3.2 PT fare elasticity

At the all-purposes level (last row) and for the COM, OTH and EDU groups all of the values lie within the preferred range, but the EMP and RET groups are less cost sensitive than expected (Table 5.3). RET trips are subject to concessionary travel and do not pay fares regardless of the changes in them. Therefore, the actual expected elasticity in the RET group should be zero, or very near. The values returned are therefore wholly appropriate even though they do not fall inside WebTAG's preferred range. Similarly, to the pattern seen in the car fuel cost case the cost of staff time for EMP trips is generally much higher than the direct costs of staff travel and so it is not surprising that these trips are less sensitive to PT fare changes than is suggested by WebTAG.

Table 5.3 PT fare elasticities

User class	AM	LT	SR	PM	OP*	24 Hour
EMP	-0.164	-0.171	-0.130	-0.164	-0.178	**-0.159**
COM	-0.540	-0.546	-0.521	-0.553	-0.552	**-0.544**
OTH	-0.448	-0.428	-0.461	-0.450	-0.480	**-0.448**
EDU	-0.229	-0.255	-0.209	-0.270	-0.273	**-0.232**
RET*	-0.001	-0.001	-0.002	-0.001	0.000	**-0.001**
Total	**-0.286**	**-0.352**	**-0.266**	**-0.361**	**-0.391**	**-0.307**

* Concessionary travel

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

5.3.3 Car journey time elasticity

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

Table 5.4 Car journey time elasticities

User class	AM	LT	SR	PM	OP*	24 Hour
EMP	-0.089	-0.073	-0.079	-0.094	-0.069	**-0.080**
COM	-0.184	-0.188	-0.167	-0.182	-0.166	**-0.179**
OTH	-0.118	-0.107	-0.100	-0.121	-0.108	**-0.111**
EDU	-0.252	-0.324	-0.202	-0.400	-0.381	**-0.259**
RET	-0.081	-0.091	-0.070	-0.086	-0.067	**-0.080**
Total	**-0.151**	**-0.108**	**-0.116**	**-0.144**	**-0.115**	**-0.130**

6 Conclusion and recommendations

6.1 Introduction

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

6.2 Calibration methodology – key points

The key points relating to the calibration of the WRM are:

- The WRM FDM initially used the standard FDM release version 2.0.8 (with some minor modifications) in combination with region specific inputs and appropriate road, PT, and active modes networks. At the final stage it was converted to 2.0.23.
- All modules are in use and turned on except macro time of day choice.
- The process of FDM calibration for the WRM has followed a repeatable method developed for all of the regional models.
- Calibration / validation outputs are presented in a common, dashboard format.

6.3 Calibration and validation outcomes – key points

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

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

- **Matrix correction and incremental values:** Pre and post correction sector to sector comparisons indicate that the degree of correction required by the assignment matrices is reasonable and incremental values are acceptable in size.
- **Road calibration and validation:** Flow calibration (compared to counts) is excellent with calibrations above 87% and validations above 77% in all cases. Journey time validation is reasonable at 60-88%. The development, calibration, and validation of the road model is covered in more detail in the WRM Road Model Development Report.
- **PT calibration and validation:** Given the limited data availability the level of PT calibration is reasonable. The development, calibration, and validation of the PT model is covered in more detail in the WRM PT Model Development Report.
- **Active modes calibration and validation:** As there is no data available, the calibration and validation of the active modes model has not been covered here. However, the development of the active modes model is covered in more detail in the WRM Active Modes Model Development Report.
- **Realism tests:** Despite some localised variations, overall, the model responds appropriately to change in fuel cost, PT fares and car journey times.

6.4 Recommendations for further development

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

- Continue to refine the model to improve its functionality, flexibility and calibration.
- Continue to refine the base generalised cost inputs to improve stability in early model loops.

Annex 1 Full list of required input files

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

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

Group	Input file
PT network files (factor files for EMP, COM, OTH, EDU, RET and ZOD)	{CATALOG_DIR}\Params\4 PT \4 PT_VOT_Table.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\FARES.MAT
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\FARES_AM.FAR
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\FARES_LT.FAR
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\FARES_PM.FAR
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\FARES_SR.FAR
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\NTL_GENERATE_SCRIPT.txt
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\4 PT_Dump_Links.csv
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\SELECT_LINK_SPEC.TXT
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\SYSTEM_FILE.PTS
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	{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
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	{CATALOG_DIR}\Params\PnR\PnR_Start_File.CSV
	{CATALOG_DIR}\Params\4 PT \4 PT_Assignment_Test.PTM
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	{CATALOG_DIR}\Params\3 Road\Matrix_LowFlow.UFM
	{CATALOG_DIR}\Params\3 Road\SATALL_KR_1ITER.DAT

Annex 2 Special Zones Demand (Airports & Ports)

A2.1 Introduction

This technical note set out the methodology of how the productions and attractions are determined for special airports and zones, and how the matrices are developed for these special zones. This approach, originally developed for the MWRM, was adopted for special zones in other regional models where no further data was available.

A2.2 Knock Airport

Knock Airport is the 4th largest airport in Ireland in terms of passengers (approximately 700,000/year) and is located in the WRM area, and therefore has its own special zone. This section discusses how the highway and PT Attractions and Productions are generated.

A2.2.1 Demand

Terminal traffic – that is passengers who started or ended their journey at Knock Airport was 677,400 in 2012 (Source: DAA). DAA data provided by the NTA was used to break down the annual passenger numbers down to represent a typical weekday in November.

- 677,400 – Annual passenger numbers;
- 40,350 – Monthly passengers in November;
- 7,450 – Typical weekday (5day) passenger numbers; and
- 1,490 – Typical passenger numbers in November on a single day.

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

A2.2.2 Flows by time period

The next consideration was to break down the daily passenger flow by time period. Flight arrival and departure data was obtained from the Knock Airport website. A profile was developed for trips (attractions and productions) from arrivals and departures information. Access to the airport up to an hour and a half before the flight departure was factored into the time period profile build. Table A2.1 presents the time period profile for trips to and from the airport.

Table A2.1 Passenger Trips Profile by time period

Time Periods	Time	Arrivals %	Departures %
AM	0700 - 1000	0%	24%
LT	1000 - 1300	41%	48%
SR	1300 - 1600	36%	19%
PM	1600 - 1900	14%	10%

OP	1900 - 0700	9%	0%
Total		100%	100%

CSO Aviation Statistics for all Irish airports including Knock Airport show that passenger numbers are split 50:50 between arrivals and departures. Therefore, if 677,400 passengers use Knock Airport it will be assumed that the split between arrivals and departures is 338,700 passengers each.

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

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

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

U.K. figures relate to 2009 and 2010 data

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

Knock is not a large airport and, in the absence of specific observed mode share data, it was assumed that 10% of all trips to Knock Airport are by public transport.

A2.3 Car trips per passenger

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

Available case studies from other airports show that typical car occupancy is a value of 2. Taxis and Kiss & Fly trips generate four vehicle trips per return air trip as the cars make the return journey without the air passenger(s). This is in contrast to two trips when passengers park at the Airport. Evidence from other airport studies show car drop-off and pick-up represents 30% - 40% of total trips.

- Cork Airport – drop off / pick up approx. 30%[24]
- Leeds Bradford Airport – drop off / pick up approx. 34%[25]
- Glasgow Airport – drop off / pick up approx. 32.3%[26]

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

A2.4 Output production / attractions

Combining all of the data above gives the overall PT and HW attractions and productions in Table A2.2.

Table A2.2 PT & HW Attractions and Productions

Time Periods	Time	PT Attr	PT Prod	HW Attr	HW Prod
AM	0700 - 1000	18	0	104	0
LT	1000 - 1300	35	30	208	178
SR	1300 - 1600	14	27	83	158
PM	1600 - 1900	7	10	42	59
OP	1900 - 0700	0	7	0	40
		75	75	436	436

A2.4.1 Period to Peak Hour Factor

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

A2.4.2 Split of Inbound and outbound trips by destination type

Due to the minimal demand for internal flights Irish travellers are assumed to derive from homes and businesses, overseas leisure travellers from homes and hotels and overseas business visitors from homes and hotels. In the regional models these splits are based on the NACE codes giving the distributions of hotels, employment and housing and assumptions about the likely directionality of trips at different times of day. The finalised split is shown in Table A2.3.

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

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

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

Table A2.3 Split of Inbound and outbound trips by destination type

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

A2.4.3 Distribution

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

Home Trips

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

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

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

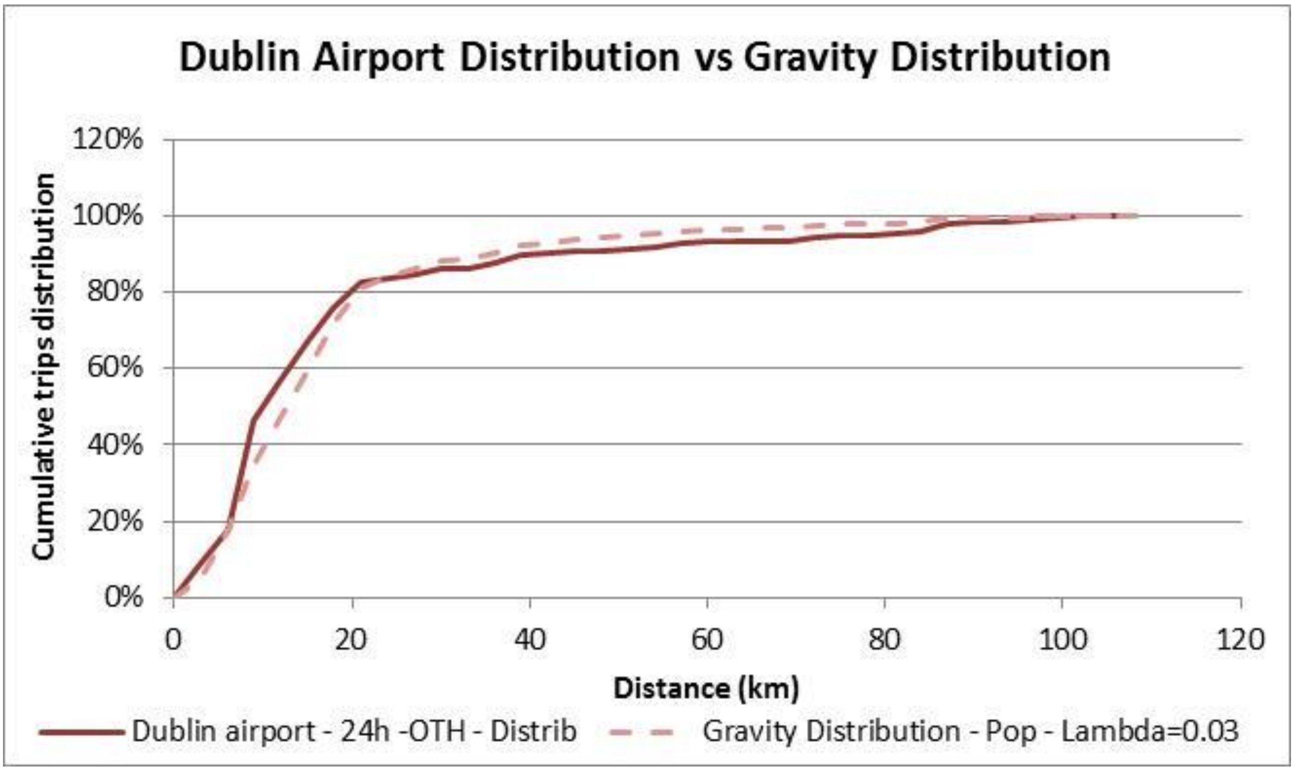

Figure A2.2 Dublin Airport – Distribution vs Gravity Distribution

The exponential gravity model with the estimated sensitivity of 0.03 has therefore been applied to all WRM zones (internal + externals). The obtained distribution is shown Figure A2.3 and suggests that 64% of trips heading to Knock airport are coming from internal zones and 36% of trips are from external zones.

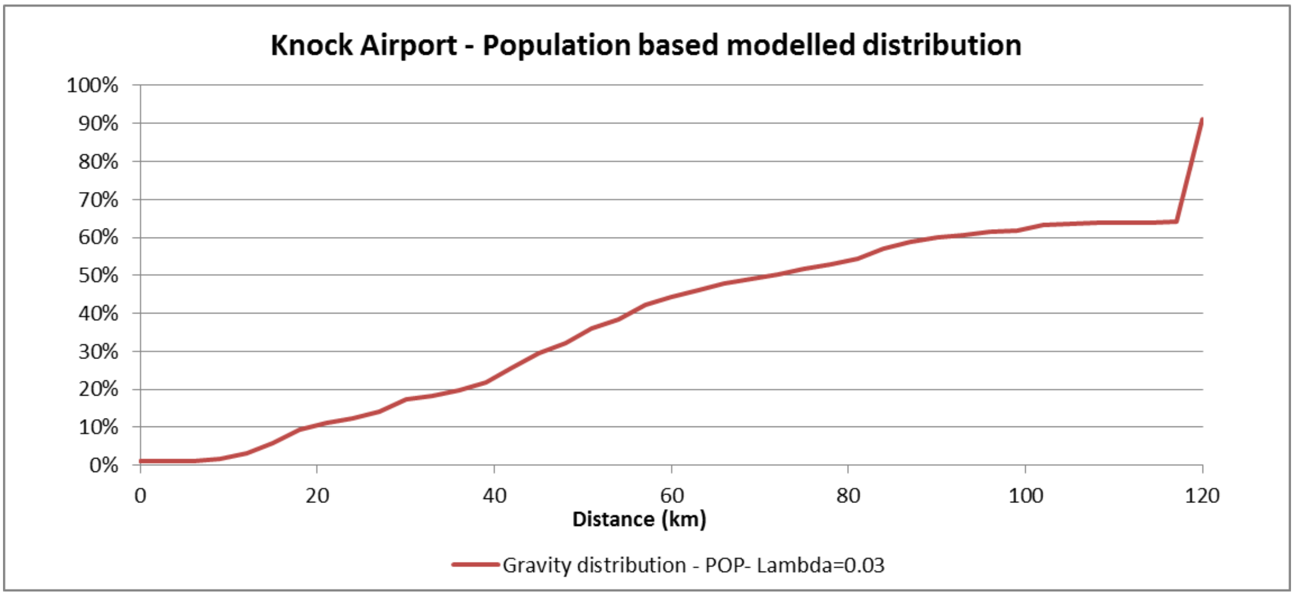

Figure A2.3 Knock Airport – Pop based modelled distribution

Leisure Trips

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

Business Trips

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

A2.5 Galway Port

Galway Port generates a large number of HGV trips onto the network. Its activities include warehousing, logistics and cargo handling. The creation of this special zone ensured that port related HGV movements were considered in the model.

A2.5.1 Demand

Evidence from the CSO statistics (2012) indicates that 461,000 tons of freight went through Galway Port in the last trimester of that year. Based on this figure, the generation of 230 HGV movements was estimated per working day.

A2.5.2 Flows by time period

In order to assign the 230 HGV daily movements to the network it was necessary to determine the percentage of HGV trips by time period.

As no traffic count data was available for the road network around Galway Port, data from Transport Infrastructure Ireland near Foynes Port on the N69 were used. The HGV profile from this site was used to determine the percentage of HGV trips by time period.

A2.5.3 Output productions / attractions

Combining these two sets of factors gives the figures shown in Table A2.4.

Table A2.4 HGV attractions and productions

Time Periods	% HGV Trips by TP	HGV Prod	HGV Attr
AM	24%	27	27
LT	27%	31	31
SR	26%	30	30
PM	13%	15	15
OP	10%	11	11
Total	100%	115	115

A2.6 Distribution

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

Annex 3 Final demand model parameter values

The data included is as follows:

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

Table A3.5 Production tour proportions by purpose

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25
P01	0.02252	0.02928	0.13964	0.46396	0.08108	0.00000	0.01351	0.01126	0.02703	0.00676	0.00000	0.00000	0.00225	0.07207	0.02478	0.00000	0.00000	0.00000	0.01577	0.02928	0.00901	0.00000	0.00901	0.02252	0.02027
P02	0.02252	0.02928	0.13964	0.46396	0.08108	0.00000	0.01351	0.01126	0.02703	0.00676	0.00000	0.00000	0.00225	0.07207	0.02478	0.00000	0.00000	0.00000	0.01577	0.02928	0.00901	0.00000	0.00901	0.02252	0.02027
P03	0.10526	0.04211	0.13684	0.32632	0.03158	0.00000	0.02105	0.03158	0.02105	0.06316	0.00000	0.00000	0.03158	0.06316	0.03158	0.00000	0.00000	0.00000	0.00000	0.06316	0.00000	0.00000	0.01053	0.02105	0.00000
P04	0.10526	0.04211	0.13684	0.32632	0.03158	0.00000	0.02105	0.03158	0.02105	0.06316	0.00000	0.00000	0.03158	0.06316	0.03158	0.00000	0.00000	0.00000	0.00000	0.06316	0.00000	0.00000	0.01053	0.02105	0.00000
P05	0.02581	0.02581	0.84516	0.07097	0.01290	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00645	0.00645	0.00000	0.00000	0.00000	0.00000	0.00645	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
P06	0.03261	0.04348	0.43478	0.36957	0.05435	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01087	0.00000	0.00000	0.00000	0.00000	0.01087	0.02174	0.00000	0.00000	0.00000	0.00000	0.02174
P07	0.01724	0.03448	0.20690	0.41379	0.05172	0.00000	0.00000	0.05172	0.03448	0.00000	0.00000	0.00000	0.01724	0.05172	0.00000	0.00000	0.00000	0.00000	0.00000	0.08621	0.00000	0.00000	0.00000	0.00000	0.03448
P08	0.02581	0.02581	0.84516	0.07097	0.01290	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00645	0.00645	0.00000	0.00000	0.00000	0.00000	0.00645	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
P09	0.03261	0.04348	0.43478	0.36957	0.05435	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01087	0.00000	0.00000	0.00000	0.00000	0.01087	0.02174	0.00000	0.00000	0.00000	0.00000	0.02174
P10	0.01724	0.03448	0.20690	0.41379	0.05172	0.00000	0.00000	0.05172	0.03448	0.00000	0.00000	0.00000	0.01724	0.05172	0.00000	0.00000	0.00000	0.00000	0.00000	0.08621	0.00000	0.00000	0.00000	0.00000	0.03448
P11	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P12	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P13	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P14	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P15	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P16	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P17	0.03902	0.08293	0.02439	0.00976	0.00976	0.00000	0.19024	0.13171	0.01951	0.01463	0.00000	0.00000	0.07317	0.09756	0.00976	0.00000	0.00000	0.00000	0.15122	0.07805	0.00000	0.00000	0.00000	0.00000	0.06829
P18	0.05543	0.05322	0.02217	0.01996	0.00222	0.00000	0.12860	0.07761	0.01996	0.00665	0.00000	0.00000	0.05543	0.10421	0.00665	0.00000	0.00000	0.00000	0.12639	0.13304	0.00000	0.00000	0.00000	0.00000	0.18847
P19	0.00000	0.06818	0.02273	0.04546	0.04546	0.00000	0.22727	0.11364	0.09091	0.02273	0.00000	0.00000	0.06818	0.02273	0.00000	0.00000	0.00000	0.00000	0.11364	0.06818	0.00000	0.00000	0.00000	0.00000	0.09091
P20	0.00000	0.18421	0.00000	0.07895	0.00000	0.00000	0.15790	0.05263	0.07895	0.00000	0.00000	0.00000	0.02632	0.07895	0.00000	0.00000	0.00000	0.00000	0.13158	0.02632	0.00000	0.00000	0.00000	0.00000	0.18421
P21	0.12069	0.05172	0.01724	0.00000	0.00000	0.00000	0.20690	0.10345	0.01724	0.03448	0.00000	0.00000	0.17241	0.10345	0.00000	0.00000	0.00000	0.00000	0.08621	0.01724	0.00000	0.00000	0.00000	0.00000	0.06897
P22	0.02941	0.07353	0.00000	0.00735	0.01471	0.00000	0.30147	0.10294	0.01471	0.00000	0.00000	0.00000	0.20588	0.02941	0.00735	0.00000	0.00000	0.00000	0.06618	0.05882	0.00000	0.00000	0.00000	0.00000	0.08824
P23	0.06329	0.07595	0.00000	0.00000	0.00000	0.00000	0.35443	0.07595	0.00000	0.00000	0.00000	0.00000	0.17722	0.05063	0.00000	0.00000	0.00000	0.00000	0.12658	0.01266	0.00000	0.00000	0.00000	0.00000	0.06329
P24	0.04082	0.04082	0.06122	0.04082	0.00000	0.00000	0.06122	0.12245	0.00000	0.00000	0.00000	0.00000	0.00000	0.22449	0.00000	0.00000	0.00000	0.00000	0.08163	0.20408	0.00000	0.00000	0.00000	0.00000	0.12245
P25	0.01587	0.07937	0.01587	0.03175	0.01587	0.00000	0.04762	0.06349	0.00000	0.01587	0.00000	0.00000	0.03175	0.12698	0.04762	0.00000	0.00000	0.00000	0.14286	0.15873	0.00000	0.00000	0.00000	0.00000	0.20635
P26	0.02439	0.04878	0.00000	0.04878	0.00000	0.00000	0.09756	0.14634	0.02439	0.02439	0.00000	0.00000	0.17073	0.17073	0.00000	0.00000	0.00000	0.00000	0.09756	0.12195	0.00000	0.00000	0.00000	0.00000	0.02439
P27	0.05063	0.06329	0.08861	0.11392	0.01266	0.00000	0.10127	0.10127	0.01266	0.06329	0.00000	0.00000	0.01266	0.03798	0.02532	0.00000	0.00000	0.00000	0.06329	0.08861	0.00000	0.00000	0.00000	0.00000	0.16456
P28	0.10355	0.05030	0.14497	0.09172	0.00296	0.00000	0.12722	0.04734	0.00592	0.00592	0.00000	0.00000	0.11539	0.08284	0.00000	0.00000	0.00000	0.00000	0.07396	0.08580	0.00000	0.00000	0.00000	0.00000	0.06213
P29	0.02564	0.02564	0.23077	0.20513	0.00000	0.00000	0.17949	0.12821	0.00000	0.05128	0.00000	0.00000	0.05128	0.05128	0.00000	0.00000	0.00000	0.00000	0.02564	0.02564	0.00000	0.00000	0.00000	0.00000	0.00000
P30	0.23316	0.00000	0.00000	0.00000	0.00000	0.00000	0.33679	0.00000	0.00000	0.00000	0.00000	0.00000	0.25907	0.00000	0.00000	0.00000	0.00000	0.00000	0.09845	0.00000	0.00000	0.00000	0.00000	0.00000	0.07254
P31	0.23316	0.00000	0.00000	0.00000	0.00000	0.00000	0.33679	0.00000	0.00000	0.00000	0.00000	0.00000	0.25907	0.00000	0.00000	0.00000	0.00000	0.00000	0.09845	0.00000	0.00000	0.00000	0.00000	0.00000	0.07254
P32	0.17865	0.00000	0.00000	0.00000	0.00000	0.00000	0.22382	0.00000	0.00000	0.00000	0.00000	0.00000	0.28131	0.00000	0.00000	0.00000	0.00000	0.00000	0.21561	0.00000	0.00000	0.00000	0.00000	0.00000	0.10062
P33	0.27273	0.00000	0.00000	0.00000	0.00000	0.00000	0.22727	0.00000	0.00000	0.00000	0.00000	0.00000	0.21212	0.00000	0.00000	0.00000	0.00000	0.00000	0.25758	0.00000	0.00000	0.00000	0.00000	0.00000	0.03030

Table A3.6 Attraction tour proportions by purpose

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25
P01	0.02252	0.02928	0.13964	0.46396	0.08108	0.00000	0.01351	0.01126	0.02703	0.00676	0.00000	0.00000	0.00225	0.07207	0.02478	0.00000	0.00000	0.00000	0.01577	0.02928	0.00901	0.00000	0.00901	0.02252	0.02027
P02	0.02252	0.02928	0.13964	0.46396	0.08108	0.00000	0.01351	0.01126	0.02703	0.00676	0.00000	0.00000	0.00225	0.07207	0.02478	0.00000	0.00000	0.00000	0.01577	0.02928	0.00901	0.00000	0.00901	0.02252	0.02027
P03	0.10526	0.04211	0.13684	0.32632	0.03158	0.00000	0.02105	0.03158	0.02105	0.06316	0.00000	0.00000	0.03158	0.06316	0.03158	0.00000	0.00000	0.00000	0.00000	0.06316	0.00000	0.00000	0.01053	0.02105	0.00000
P04	0.10526	0.04211	0.13684	0.32632	0.03158	0.00000	0.02105	0.03158	0.02105	0.06316	0.00000	0.00000	0.03158	0.06316	0.03158	0.00000	0.00000	0.00000	0.00000	0.06316	0.00000	0.00000	0.01053	0.02105	0.00000
P05	0.02581	0.02581	0.84516	0.07097	0.01290	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00645	0.00645	0.00000	0.00000	0.00000	0.00000	0.00645	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
P06	0.03261	0.04348	0.43478	0.36957	0.05435	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01087	0.00000	0.00000	0.00000	0.00000	0.01087	0.02174	0.00000	0.00000	0.00000	0.00000	0.02174
P07	0.01724	0.03448	0.20690	0.41379	0.05172	0.00000	0.00000	0.05172	0.03448	0.00000	0.00000	0.00000	0.01724	0.05172	0.00000	0.00000	0.00000	0.00000	0.00000	0.08621	0.00000	0.00000	0.00000	0.00000	0.03448
P08	0.02581	0.02581	0.84516	0.07097	0.01290	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00645	0.00645	0.00000	0.00000	0.00000	0.00000	0.00645	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
P09	0.03261	0.04348	0.43478	0.36957	0.05435	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01087	0.00000	0.00000	0.00000	0.00000	0.01087	0.02174	0.00000	0.00000	0.00000	0.00000	0.02174
P10	0.01724	0.03448	0.20690	0.41379	0.05172	0.00000	0.00000	0.05172	0.03448	0.00000	0.00000	0.00000	0.01724	0.05172	0.00000	0.00000	0.00000	0.00000	0.00000	0.08621	0.00000	0.00000	0.00000	0.00000	0.03448
P11	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P12	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P13	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P14	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P15	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P16	0.36191	0.04444	0.05714	0.05397	0.01905	0.00000	0.06349	0.00318	0.00000	0.00000	0.00000	0.00000	0.31429	0.03492	0.00318	0.00000	0.00000	0.00000	0.02857	0.00318	0.00000	0.00000	0.00000	0.00000	0.01270
P17	0.03902	0.08293	0.02439	0.00976	0.00976	0.00000	0.19024	0.13171	0.01951	0.01463	0.00000	0.00000	0.07317	0.09756	0.00976	0.00000	0.00000	0.00000	0.15122	0.07805	0.00000	0.00000	0.00000	0.00000	0.06829
P18	0.05543	0.05322	0.02217	0.01996	0.00222	0.00000	0.12860	0.07761	0.01996	0.00665	0.00000	0.00000	0.05543	0.10421	0.00665	0.00000	0.00000	0.00000	0.12639	0.13304	0.00000	0.00000	0.00000	0.00000	0.18847
P19	0.00000	0.06818	0.02273	0.04546	0.04546	0.00000	0.22727	0.11364	0.09091	0.02273	0.00000	0.00000	0.06818	0.02273	0.00000	0.00000	0.00000	0.00000	0.11364	0.06818	0.00000	0.00000	0.00000	0.00000	0.09091
P20	0.00000	0.18421	0.00000	0.07895	0.00000	0.00000	0.15790	0.05263	0.07895	0.00000	0.00000	0.00000	0.02632	0.07895	0.00000	0.00000	0.00000	0.00000	0.13158	0.02632	0.00000	0.00000	0.00000	0.00000	0.18421
P21	0.12069	0.05172	0.01724	0.00000	0.00000	0.00000	0.20690	0.10345	0.01724	0.03448	0.00000	0.00000	0.17241	0.10345	0.00000	0.00000	0.00000	0.00000	0.08621	0.01724	0.00000	0.00000	0.00000	0.00000	0.06897
P22	0.02941	0.07353	0.00000	0.00735	0.01471	0.00000	0.30147	0.10294	0.01471	0.00000	0.00000	0.00000	0.20588	0.02941	0.00735	0.00000	0.00000	0.00000	0.06618	0.05882	0.00000	0.00000	0.00000	0.00000	0.08824
P23	0.06329	0.07595	0.00000	0.00000	0.00000	0.00000	0.35443	0.07595	0.00000	0.00000	0.00000	0.00000	0.17722	0.05063	0.00000	0.00000	0.00000	0.00000	0.12658	0.01266	0.00000	0.00000	0.00000	0.00000	0.06329
P24	0.04082	0.04082	0.06122	0.04082	0.00000	0.00000	0.06122	0.12245	0.00000	0.00000	0.00000	0.00000	0.00000	0.22449	0.00000	0.00000	0.00000	0.00000	0.08163	0.20408	0.00000	0.00000	0.00000	0.00000	0.12245
P25	0.01587	0.07937	0.01587	0.03175	0.01587	0.00000	0.04762	0.06349	0.00000	0.01587	0.00000	0.00000	0.03175	0.12698	0.04762	0.00000	0.00000	0.00000	0.14286	0.15873	0.00000	0.00000	0.00000	0.00000	0.20635
P26	0.02439	0.04878	0.00000	0.04878	0.00000	0.00000	0.09756	0.14634	0.02439	0.02439	0.00000	0.00000	0.17073	0.17073	0.00000	0.00000	0.00000	0.00000	0.09756	0.12195	0.00000	0.00000	0.00000	0.00000	0.02439
P27	0.05063	0.06329	0.08861	0.11392	0.01266	0.00000	0.10127	0.10127	0.01266	0.06329	0.00000	0.00000	0.01266	0.03798	0.02532	0.00000	0.00000	0.00000	0.06329	0.08861	0.00000	0.00000	0.00000	0.00000	0.16456
P28	0.10355	0.05030	0.14497	0.09172	0.00296	0.00000	0.12722	0.04734	0.00592	0.00592	0.00000	0.00000	0.11539	0.08284	0.00000	0.00000	0.00000	0.00000	0.07396	0.08580	0.00000	0.00000	0.00000	0.00000	0.06213
P29	0.02564	0.02564	0.23077	0.20513	0.00000	0.00000	0.17949	0.12821	0.00000	0.05128	0.00000	0.00000	0.05128	0.05128	0.00000	0.00000	0.00000	0.00000	0.02564	0.02564	0.00000	0.00000	0.00000	0.00000	0.00000
P30	0.23316	0.00000	0.00000	0.00000	0.00000	0.00000	0.33679	0.00000	0.00000	0.00000	0.00000	0.00000	0.25907	0.00000	0.00000	0.00000	0.00000	0.00000	0.09845	0.00000	0.00000	0.00000	0.00000	0.00000	0.07254
P31	0.23316	0.00000	0.00000	0.00000	0.00000	0.00000	0.33679	0.00000	0.00000	0.00000	0.00000	0.00000	0.25907	0.00000	0.00000	0.00000	0.00000	0.00000	0.09845	0.00000	0.00000	0.00000	0.00000	0.00000	0.07254
P32	0.17865	0.00000	0.00000	0.00000	0.00000	0.00000	0.22382	0.00000	0.00000	0.00000	0.00000	0.00000	0.28131	0.00000	0.00000	0.00000	0.00000	0.00000	0.21561	0.00000	0.00000	0.00000	0.00000	0.00000	0.10062
P33	0.27273	0.00000	0.00000	0.00000	0.00000	0.00000	0.22727	0.00000	0.00000	0.00000	0.00000	0.00000	0.21212	0.00000	0.00000	0.00000	0.00000	0.00000	0.25758	0.00000	0.00000	0.00000	0.00000	0.00000	0.03030

Table A3.7 Finalised distribution and mode split parameters

Purp	Alpha					Beta	Lambda			ASC values					Intrazonals				
	Car	PT	PnR	Walk	Cyc	All mds	Dest	Md Ch	Act Ch	Car	PT	PnR	Walk	Cyc	Car	PT	PnR	Walk	Cyc
1	0.866	0.280	2.320	0.501	0.418	N/A	-0.266	-0.133	-0.110	-8.000	16.000	-12.00	20.000	50.000	4.690	21.850	10.000	0.830	5.935
2	1.685	0.490	2.320	1.233	1.557	N/A	-0.043	-0.052	-0.104	-8.000	34.000	-12.00	20.000	50.000	4.525	30.000	10.000	14.250	18.180
3	0.001	0.750	1.000	1.047	2.186	N/A	-0.146	-0.230	-0.230	-3.000	48.750	-12.00	0.000	5.000	10.000	-30.00	10.000	-13.70	-14.00
4	0.001	0.714	1.000	1.938	3.151	N/A	-0.043	-0.052	-0.104	-3.000	72.990	-12.00	-5.000	20.000	10.000	23.610	10.000	19.250	17.720
5	1.017	0.130	2.320	0.551	0.857	N/A	-0.154	-0.154	-0.308	-15.00	15.000	-12.00	10.000	25.000	-6.780	-7.110	10.000	-1.380	-11.70
6	1.149	0.152	2.320	0.722	1.103	N/A	-0.129	-0.129	-0.259	-5.000	20.000	-12.00	10.000	20.000	-4.230	3.675	10.000	2.780	1.725
7	0.637	0.147	2.320	1.246	1.985	N/A	-0.120	-0.120	-0.240	0.000	44.940	-12.00	-20.00	0.000	1.520	7.180	10.000	30.000	29.670
8	0.001	0.296	1.000	1.256	1.564	N/A	-0.062	-0.062	-0.124	-10.00	25.000	-12.00	5.000	35.000	10.000	-30.00	10.000	-21.10	-30.00
9	0.001	0.306	1.000	1.228	1.752	N/A	-0.062	-0.062	-0.124	-10.00	20.000	-12.00	10.000	30.000	10.000	9.980	10.000	-0.420	-1.530
10	0.001	0.402	1.000	1.748	2.971	N/A	-0.062	-0.062	-0.124	-10.00	111.53	-12.00	-10.00	15.000	10.000	-6.380	10.000	30.000	30.000
11	1.542	0.440	2.080	0.606	0.579	N/A	-0.160	-0.160	-0.319	-20.00	10.000	-12.00	10.000	80.000	5.600	30.000	10.000	12.490	-15.30
12	2.236	0.745	2.080	0.683	1.103	N/A	-0.160	-0.160	-0.319	-10.00	10.000	-12.00	15.000	70.000	-30.00	3.875	10.000	-30.00	-30.00
13	1.863	0.605	2.080	0.559	0.639	N/A	-0.160	-0.160	-0.319	-20.00	10.000	-12.00	10.000	70.000	-30.00	-3.060	10.000	-30.00	-30.00
14	1.000	0.747	1.000	1.933	2.277	N/A	-0.062	-0.062	-0.124	0.000	40.000	-12.00	-20.00	90.000	-30.00	30.000	10.000	30.000	0.655
15	1.000	0.775	1.000	1.120	1.383	N/A	-0.062	-0.062	-0.124	0.000	10.000	-12.00	0.000	80.000	-30.00	30.000	10.000	-19.80	-30.00
16	1.000	0.751	1.000	1.103	1.254	N/A	-0.062	-0.062	-0.124	0.000	10.000	-12.00	0.000	80.000	-30.00	30.000	10.000	-10.40	-26.30
17	1.485	0.565	2.080	0.483	0.503	N/A	-0.157	-0.157	-0.313	-20.00	5.000	-12.00	20.000	70.000	11.680	30.000	10.000	4.855	-18.40
18	1.325	0.458	2.080	0.437	0.598	N/A	-0.157	-0.157	-0.314	-15.00	5.000	-12.00	15.000	70.000	11.350	30.000	10.000	8.820	-14.60
19	1.000	0.825	1.000	1.572	2.699	N/A	-0.062	-0.062	-0.124	0.000	35.000	-12.00	-10.00	80.000	-30.00	26.700	10.000	14.320	-8.210
20	1.000	0.815	1.000	1.565	2.815	N/A	-0.062	-0.062	-0.124	0.000	35.000	-12.00	-10.00	80.000	-30.00	6.110	10.000	-8.720	-25.20
21	1.309	0.775	2.080	0.377	0.376	N/A	-0.320	-0.160	-0.160	-15.00	10.000	-12.00	10.000	70.000	3.340	30.000	10.000	-0.850	-5.950
22	2.195	0.630	2.080	0.636	0.878	N/A	-0.159	-0.159	-0.318	-15.00	5.000	-12.00	10.000	80.000	4.600	20.900	10.000	-12.30	-0.540
23	1.000	0.865	1.000	2.766	5.194	N/A	-0.062	-0.062	-0.124	0.000	100.00	-12.00	-30.00	70.000	-30.00	-30.00	10.000	-20.90	-30.00
24	0.535	0.191	2.080	0.376	0.292	N/A	-0.159	-0.159	-0.318	-15.00	10.000	-12.00	10.000	70.000	0.360	19.600	10.000	-10.90	3.660
25	0.720	0.230	2.080	0.417	3.052	N/A	-0.158	-0.158	-0.315	0.000	10.000	-12.00	10.000	50.000	6.270	25.420	10.000	5.610	24.760
26	1.000	0.431	1.000	0.859	1.107	N/A	-0.062	-0.062	-0.124	0.000	5.000	-12.00	0.000	80.000	-30.00	30.000	10.000	-10.30	-23.60
27	1.075	0.424	2.080	0.426	0.629	N/A	-0.100	-0.153	-0.306	-9.000	10.900	-12.00	10.000	20.000	-13.90	13.850	10.000	-15.00	-13.10
28	1.117	0.376	2.080	0.132	0.591	N/A	-0.158	-0.158	-0.315	-25.00	10.000	-12.00	20.000	30.000	4.995	26.560	10.000	-3.380	-16.30
29	1.000	0.775	1.000	1.061	2.131	N/A	-0.062	-0.062	-0.124	-5.000	20.000	-12.00	0.000	30.000	-30.00	30.000	10.000	11.030	3.470
30	0.573	0.212	2.080	0.222	0.404	N/A	-0.106	-0.146	-0.291	-12.00	2.140	-12.00	20.000	25.000	-20.30	6.595	10.000	-7.420	-30.00
31	1.000	0.491	1.000	1.092	1.413	N/A	-0.045	-0.062	-0.123	0.000	-2.000	-12.00	0.000	35.000	-30.00	5.115	10.000	-30.00	-30.00
32	1.190	0.383	2.080	0.390	0.392	N/A	-0.103	-0.183	-0.325	-20.00	0.000	-12.00	15.000	70.000	6.140	23.500	10.000	-0.970	-15.30
33	1.000	0.566	1.000	1.681	1.521	N/A	-0.062	-0.152	-0.304	0.000	0.000	-12.00	0.000	80.000	-30.00	30.000	10.000	27.500	5.285

Table A3.8 Finalised period to hour factors

Time Period	Car	PT	Walk	Cycle
AM	0.46864	0.47000	0.54000	0.52000
IP1	0.35267	0.33000	0.33000	0.33000
IP2	0.45467	0.33000	0.33000	0.33000
PM	0.48318	0.60000	0.40000	0.42000
OP	0.08000	0.08000	0.08000	0.08000

Table A3.9 Finalised parking distribution calibration parameters

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

Table A3.10 Finalised special zone calibration parameters

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

Annex 4 Park and Ride Calibration

A4.1 Introduction

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

To undertake this, several steps are required:

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

A4.2 Model development

A4.2.1 Sites

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

Table A4.11 WRM Park and Ride sites

Site	Capacity	Charge (€)	Observed usage
Sligo	42	4	33
Collooney	57	4	20
Ballymote	30	0	43
Boyle	60	4	23
Carrick-on-Shannon	20	0	26
Dromod	30	0	38
Ballina	22	0	16
Foxford	25	0	5
Castlebar	43	4	31
Westport	51	4	31
Claremorris	30	0	20
Ballyhaunis	20	0	12
Castlerea	34	0	15
Roscommon	25	0	16
Ballinasloe	47	4	28
Woodlawn	60	0	20
Attymon	8	0	6
Athenry	70	4	49
Oranmore	140	0	50
Galway	60	4	51
Craughwell	120	0	12
Ardrahan	53	0	5
Gort	120	0	12

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

A4.2.2 Observed usage

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

From this exercise it was determined that there is a supply of 1,167 parking spaces across the 23 sites, with an estimated demand of 562 spaces (48%).

A4.2.3 Site Catchments

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

For destination zone catchments for each site, everywhere within the WRM was added as a destination to allow for park and ride movements as part of an overall journey.

A4.3 Site file generation

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

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

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

A4.4 Park and Ride Calibration

Two main elements influence the park and ride calibration process:

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

A4.4.1 Expected Demand

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

The boardings files were available for each modelled time period (with the exception of OP) and listed the total boardings within that time period at each station. From this data the boardings for each of the 23 stations and sites within the WRM was extracted and proportions calculated for each time period based on the total boardings at the station, for example, for Sligo, it was calculated that 29% of daily boardings took place in the AM period, 13% in IP1, 22% in IP2 and 36% in the PM period.

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

Table A4.12 Derived calibration data

Station	Boardings				Occupied Spaces				Users			
	AM	IP1	IP2	PM	AM	IP1	IP2	PM	AM	IP1	IP2	PM
Sligo	29%	13%	22%	36%	10	4	7	12	14	6	11	17
Collooney	23%	35%	20%	22%	5	7	4	4	7	10	6	6
Ballymote	38%	8%	15%	39%	16	4	7	17	23	5	9	24
Boyle	34%	9%	19%	37%	8	2	4	9	11	3	6	12
Carrick-on-Shannon	8%	11%	25%	56%	2	3	6	15	3	4	9	21
Dromod	17%	25%	23%	35%	7	10	9	13	10	14	12	19
Ballina	54%	0%	22%	24%	9	0	3	4	13	0	5	6
Foxford	48%	5%	20%	27%	2	0	1	1	3	0	1	2
Castlebar	65%	10%	20%	6%	20	3	6	2	29	4	9	3
Westport	62%	12%	26%	0%	19	4	8	0	28	5	12	0
Claremorris	27%	11%	27%	36%	5	2	5	7	8	3	8	10
Ballyhaunis	47%	14%	22%	17%	6	2	3	2	8	2	4	3
Castlerea	44%	9%	21%	26%	7	1	3	4	9	2	5	6
Roscommon	40%	11%	25%	24%	6	2	4	4	9	2	6	5
Ballinasloe	62%	7%	12%	19%	17	2	3	5	25	3	5	8
Woodlawn	47%	2%	20%	32%	9	0	4	6	14	0	6	9
Attymon	0%	0%	0%	0%	0	0	0	0	0	0	0	0
Athenry	44%	7%	19%	31%	22	3	9	15	31	5	13	22
Oranmore	55%	3%	14%	28%	28	1	7	14	40	2	10	20
Galway	24%	10%	28%	37%	12	5	14	19	18	7	21	28
Craughwell	64%	9%	17%	10%	8	1	2	1	11	2	3	2
Ardrahan	57%	12%	25%	6%	3	1	1	0	4	1	2	0
Gort	55%	8%	20%	17%	7	1	2	2	10	1	3	3

A4.4.2 Mode Share

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

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

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

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

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

For the WRM a target usage of Park and Ride was estimated as 801 people. The ASC values were continually reduced but the model did not generate any Park & Ride demand.

A4.5 Site calibration

As there was no Park and Ride usage, Park and Ride site calibration was not undertaken.

A4.6 Recommendations

Several elements should be investigated in future to improve Park and Ride calibration in the WRM. Firstly, other costs within the model for all modes should be investigated. In order to calibrate other elements of the model, costs have been adjusted which has had a negative impact on the Park and Ride module.

Secondly, it would be recommended that observed data is collated at each rail station within the model region in order to produce robust and accurate target levels of site usage. These numbers can then be used to refine the distribution levels of Park and Ride site users in the model and produce a higher level of calibration.

Finally, network coding within the model could be looked at to address accessibility to Park and Ride sites along centroid connectors. Refining this coding could reduce the number of people who currently walk long distances to use rail stations and weight these movements more towards using Park and Ride. This process could also be carried out in conjunction with a review of public transport costs within the model to improve overall calibration levels.

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