REGIONAL MODELLING SYSTEM

Údarás Náisiúnta Iompair
National Transport Authority

Modelling Services Framework

South West Regional Model

Full Demand Model Calibration Report – Tender Issue

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Foreword

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

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

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

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

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

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

1 Introduction

1.1 Regional Modelling System

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

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

Table 1.1: Regional Models and their area of coverage

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

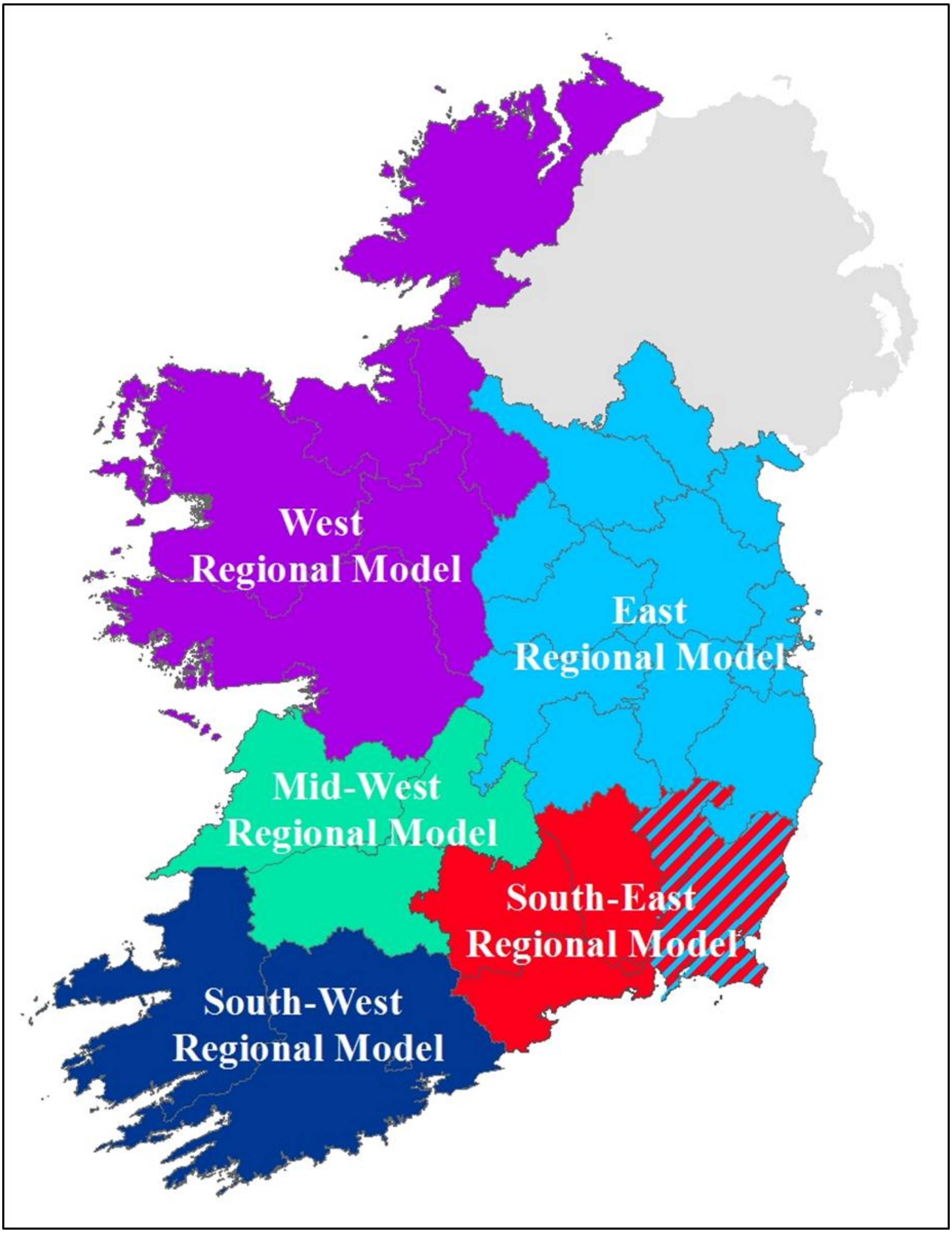


Figure 1.1: Regional Model Areas (the ERM and SERM overlap in the hashed area)

1.2 Regional Modelling System Structure

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

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

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

1.2.1 National Demand Forecasting Model (NDFM)

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

1.2.2 Regional Models

A regional model is comprised of the following key elements:

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

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

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

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

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

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

1.2.3 Appraisal Modules

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

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

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

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

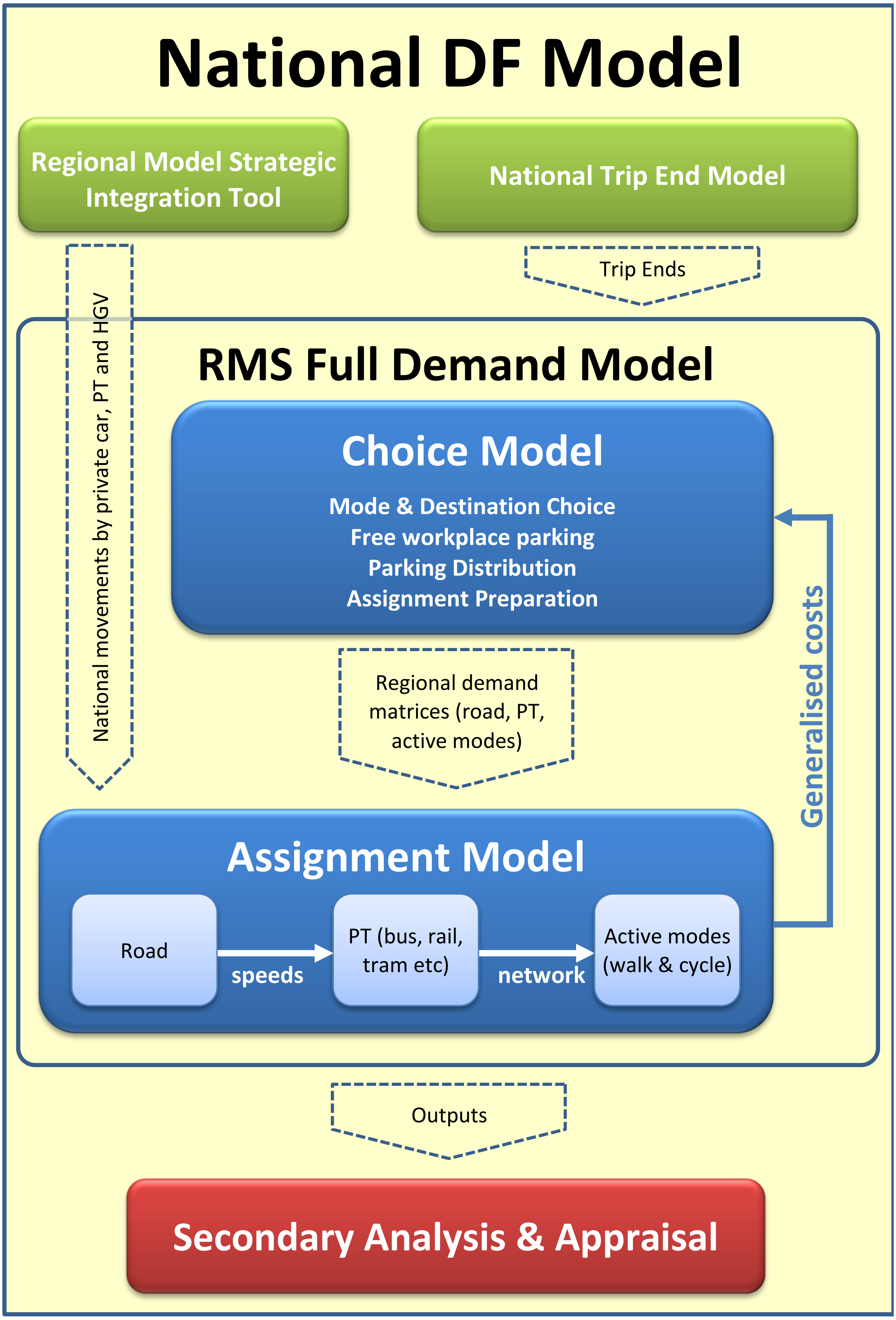

National DF Model
Regional Model Strategic Integration Tool
National Trip End Model
Trip Ends
National movements by private car, PT and HGV
RMS Full Demand Model
Choice Model
Mode & Destination Choice
Free workplace parking
Parking Distribution
Assignment Preparation
Generalised costs
Regional demand matrices (road, PT, active modes)
Assignment Model
Road
speeds
PT (bus, rail, tram etc)
network
Active modes (walk & cycle)
Outputs
Secondary Analysis & Appraisal

Figure 1.2: National and Regional Model Structure

1.3 Full Demand Model (FDM)

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

The FDM consists of the following modules:

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

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

The following module is not yet fully implemented or tested:

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

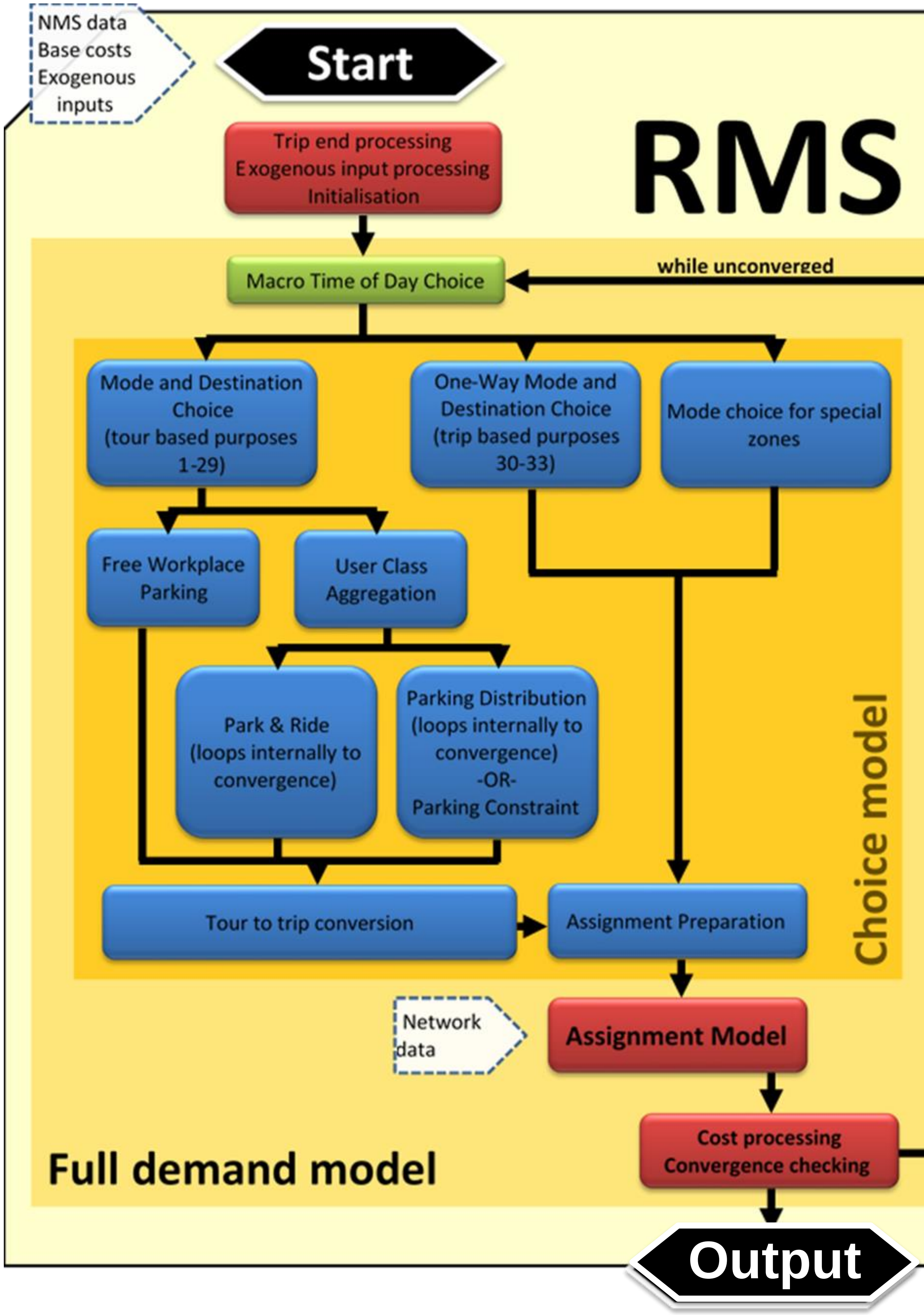


Figure 1.3: RMS Model Structure Overview

1.4 Report Library

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

The NDFM is covered in detail in the report:

- NDFM Development Report

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

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

The full, and finalised FDM specification is reported in:

- RM Spec Full Demand Model Specification Report

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

- RM Full Demand Model Development Report

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

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

- WRM Full Demand Model Calibration Report
- ERM 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 SWRM assignment models:

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

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

This report focuses on the calibration and validation of the RMS in the South West Region, otherwise known as the South West Regional Model or SWRM, 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.

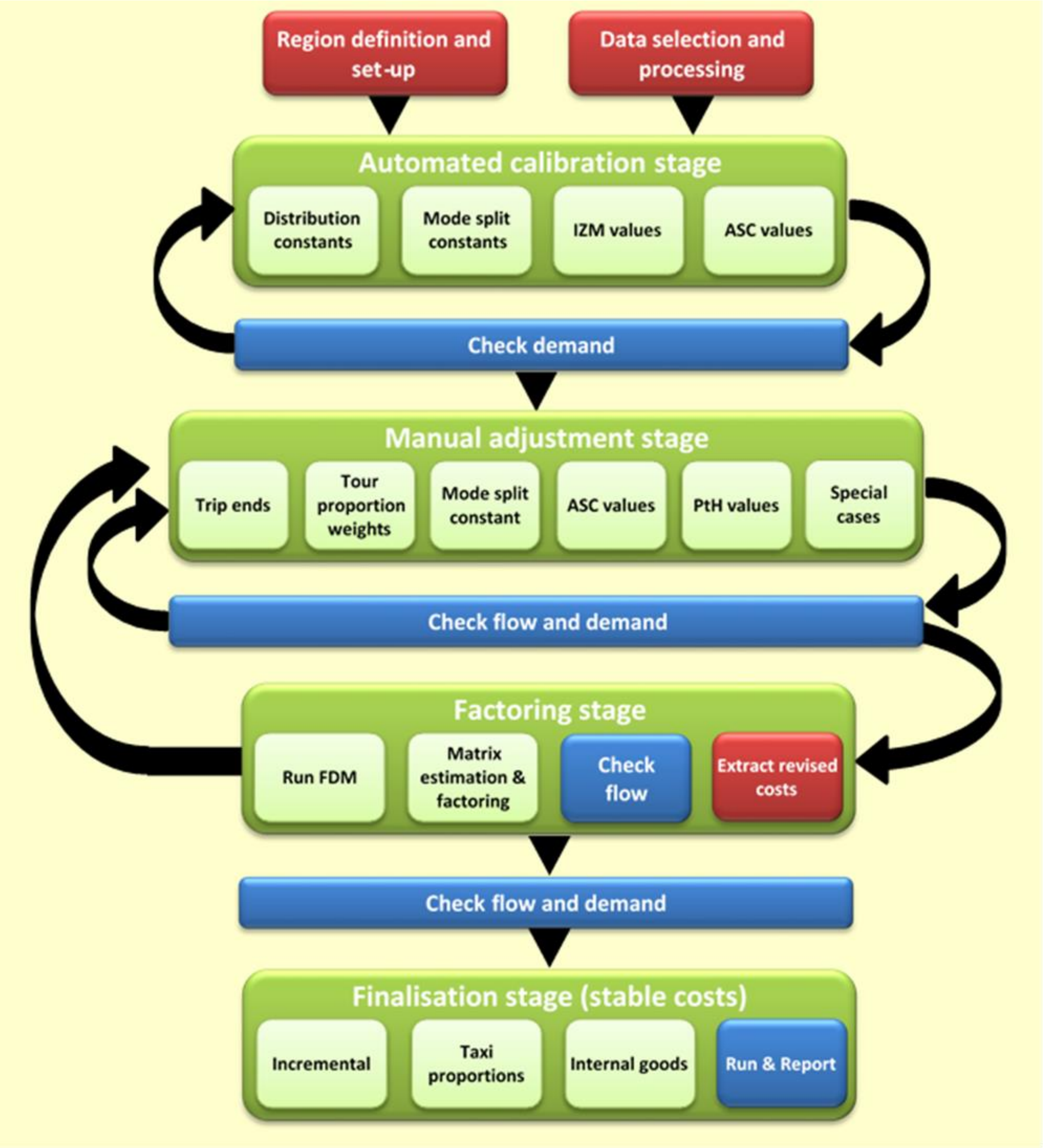


Figure 2.1: FDM calibration process

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 SWRM 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 SWRM 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 SWRM for COM and EDU purposes. The other segments were calibrated to either SWRM 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 SWRM. In total, for all the regional models, there were between 6,000 and 7,000 road traffic survey data records nationwide, including manual classified counts, automatic traffic counts (ATC) and SCATS data, which were collated under the Data Collection task. The data was collated in 2014 and represents data from January 2009 to October 2013. Approximately 247 link counts, illustrated in Figure 2.2 and Figure 2.3 below, were utilised as part of the road model calibration.

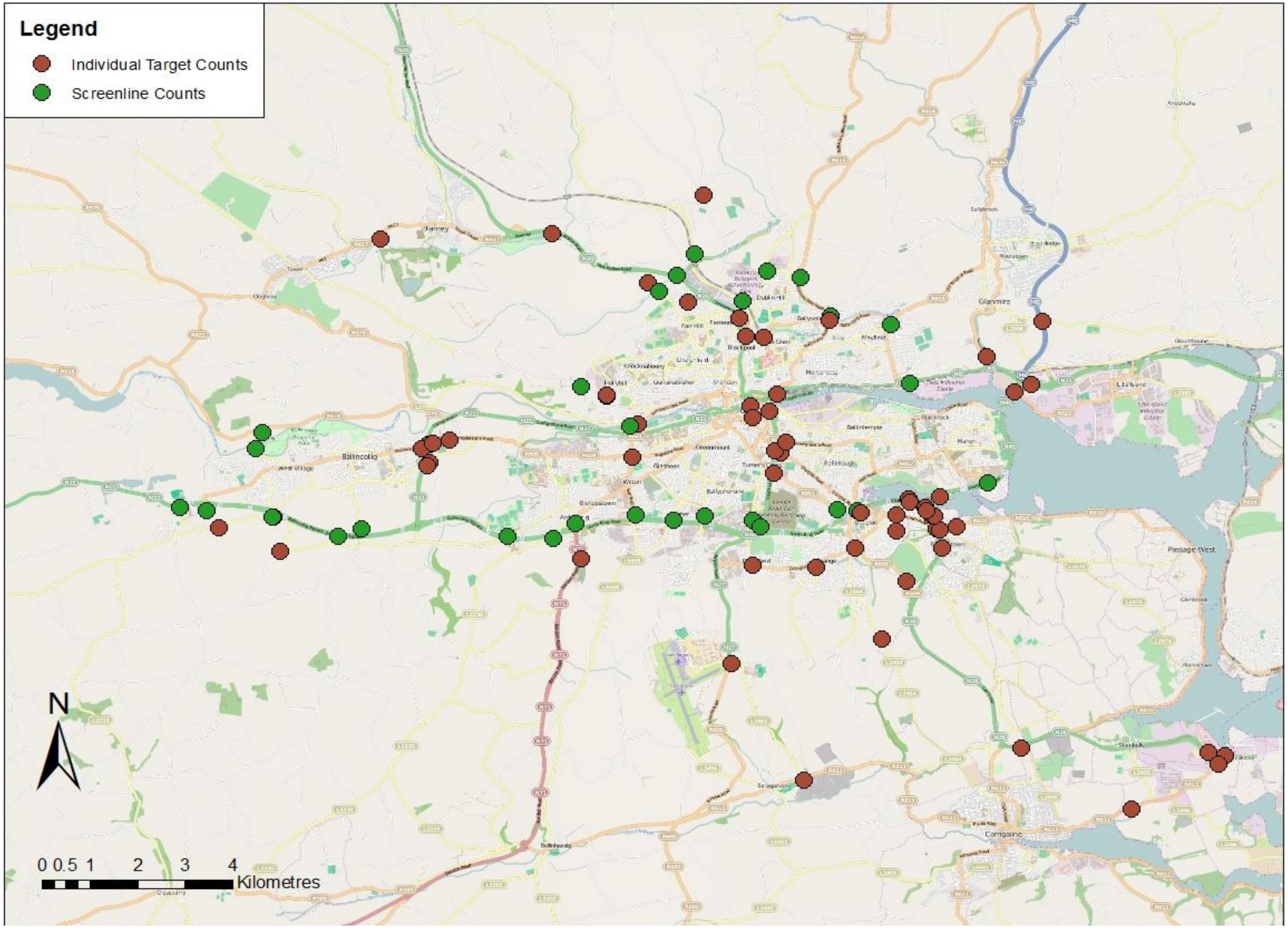


Figure 2.2: Link Calibration Target Locations – Cork City

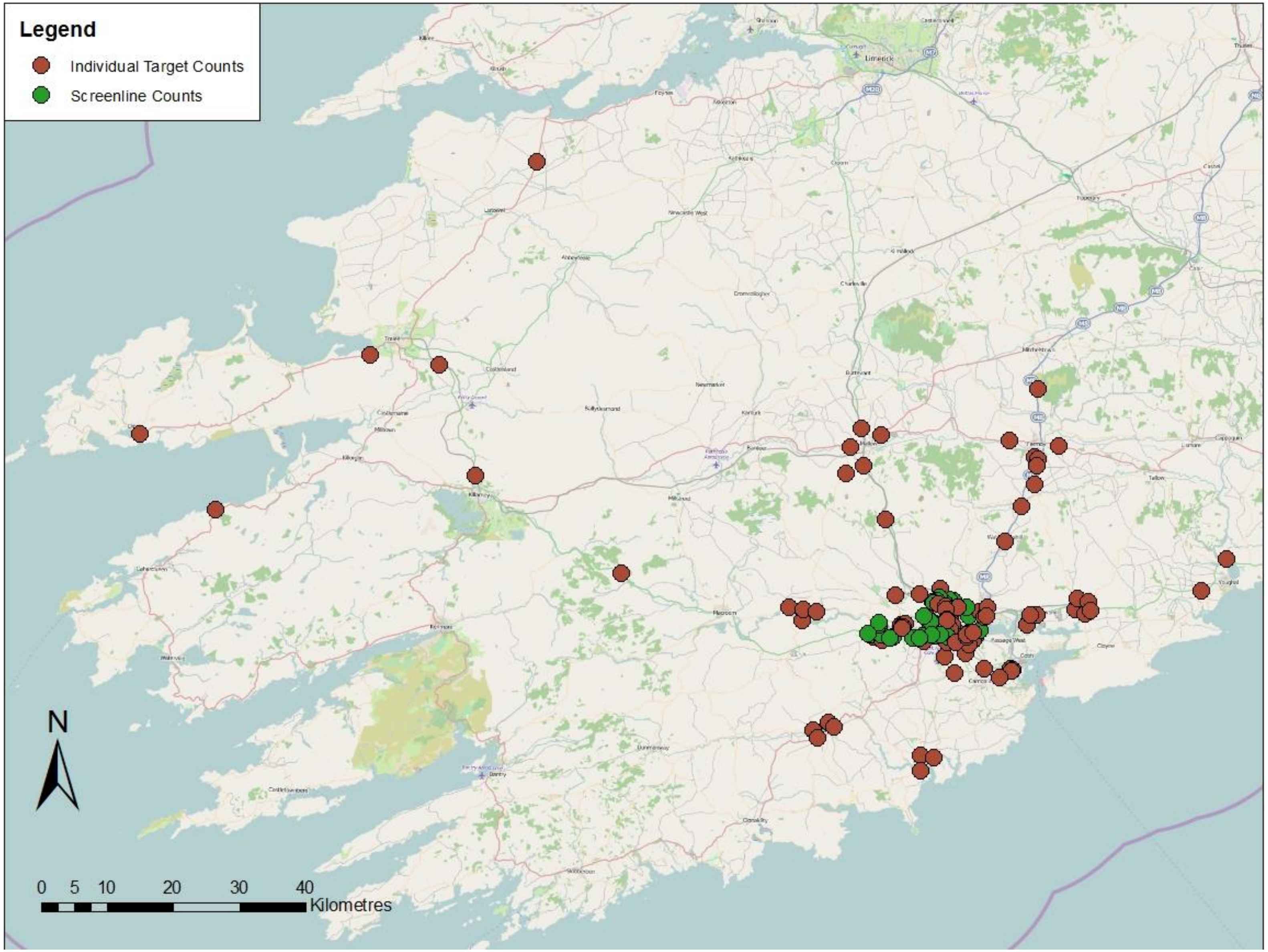


Figure 2.3: Link Calibration Target Locations – County Cork and County Kerry

In addition to this, journey time validation was undertaken for 10 routes (inbound and outbound) which are illustrated in Figure 2.4. The journey time data was extracted from TomTom data acquired by the NTA. Further information on observed road data is provided in the SWRM Road Model Development Report.

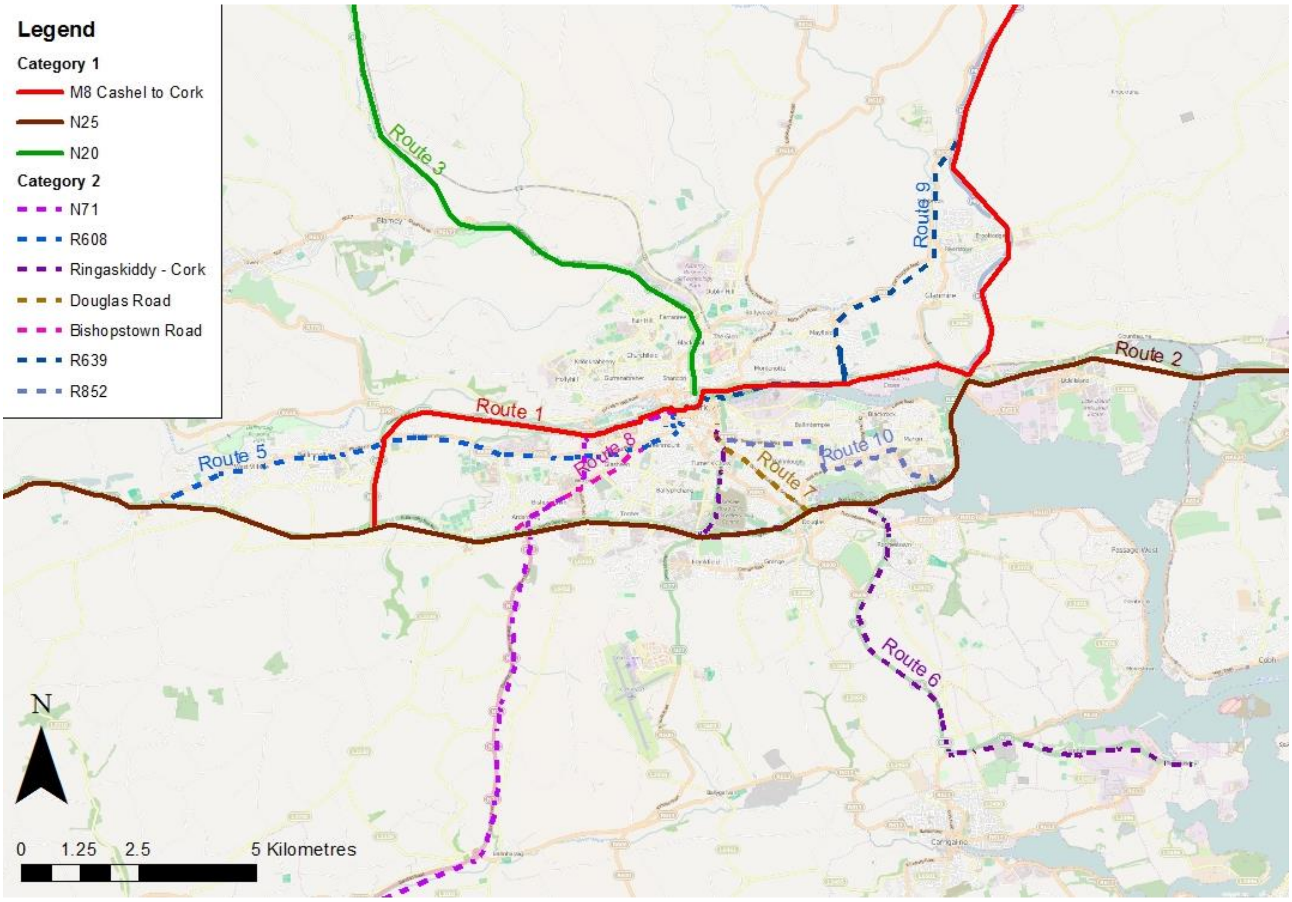


Figure 2.4: TomTom Journey Time Routes

2.3.3 Observed Public Transport Data

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

- Irish Rail 2013 survey which provides boarding and alighting figures for all rail lines by station
- Cork Bus Station Origin/Destination Survey (November 2012)
- Cork Bus Station Boarding and Alighting Counts (November 2012)
- Cork City On-Board Passenger Counts (November 2012)

Table 2.2 shows the different bus surveys applying to the service groups operating in the SWRM.

Table 2.2: Bus service data sources

Service Group	Data Type: Origin / Destination	Data Type: Boarding / Alighting	Data Type: On-board counts
BÉ Cork City Services	Yes	-	Yes
BÉ Regional Services	-	Yes	-
Private Bus Operators	-	Yes	-

Boarding and alighting (B&A) surveys were undertaken from 7:00 to 19:00 at Cork City Bus Station.

Bus occupancy surveys were commissioned specifically for the construction of the SWRM to record the number of bus passengers travelling on bus services at key locations around Cork City. A cordon around central Cork was defined, and locations at which services crossed the cordon identified (Figure 2.5). Occupancy counts were undertaken between 07:00 and 19:00 and covered as many routes and services as possible.

Further information on the available PT observed data is presented in the SWRM Public Transport Model Development Report.

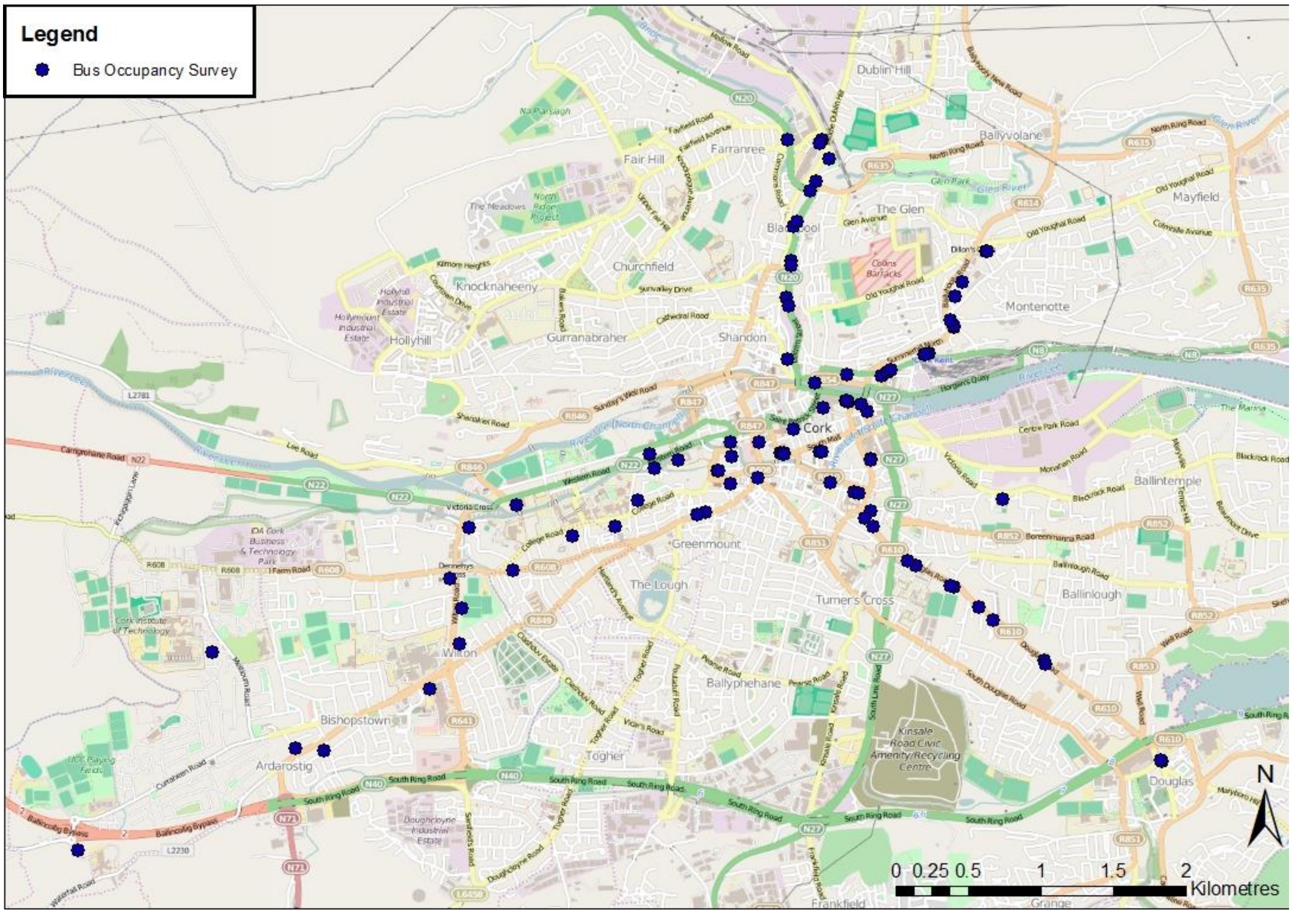


Figure 2.5: Cork City Bus Survey Locations

2.3.4 Observed Active Modes Data

Very limited active modes data, which had been collected for other purposes, was available. This included counts along the Cork City Centre to Passage West Greenway, and at a small number of other locations around the City Centre. Given the limited extent of this data, calibration of the Active Modes model was not undertaken, and this data was only used as a sense-check of the results. Further information on available Active Modes observed data is presented in the SWRM Active Modes Report.

2.4 Automated calibration stage

2.4.1 Automated calibration

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

Mathematically the probability of making a choice is:

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

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

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

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

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

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

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

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

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

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

2.4.2 Check demand calibration

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

2.5 Manual adjustment stage

2.5.1 Manual calibration

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

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

This stage may also include:

- The calibration of the mode split for the demand in some special[1] 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.

[1] Details of the calculation of the demand in the special zones can be found in Annex 2

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[2] 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.

[2] 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 Introduction

The process of calibrating the South West Regional Model (SWRM) began in September 2015.

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 on the lessons learned from earlier model versions.

3.2 Calibration / Validation Phases

The calibration and validation process can be broadly split into three phases. Phase 1 involved adjustment 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 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 September 2015 to mid-February 2016. Phase 2 was undertaken from mid-February to early June, 2016. Phase 3 began in early June 2016 and ended in late June 2016.

3.3 Phase 1 Test 1

3.3.1 Run details

Model Version: *1 (sub-versions not defined)*
Scenario Name: *SWBY04_A3 and SWBY05_A3*
Date: *September 2015*
Growth: *A3*

These first runs of the FDM were carried out in September 2015 in Model Version 1. They used parameters taken from the ERM, with no adjustments to these at this stage, and trip ends from Version A3.

3.3.2 Results / outputs

These were preliminary runs intended only to demonstrate that the model would run through and to get the calibration process started. Initial checks suggest that the costs output by the FDM were still high for some rural areas, but otherwise the FDM was generating reasonable costs.

3.4 Phase 1 Test 2

3.4.1 Run details

Model Version: *1 (sub-versions not defined)*
Scenario Name: *SWBY06_A3 and SWBY07_A3*
Date: *November-December 2015*
Growth: *A3*

Between the first and second runs of the FDM in the south-west, a number of tasks were carried out. Firstly, there was a complete review of the road network which resulted in a number of changes to junction coding and the speed-flow curves used. This is described more fully in the SWRM Road Model Development Report. At the same time, a process to estimate the road assignment matrices was set up, and estimation was used to get new road costs. Checks on PT services were also carried out, and a number of missing services in rural areas identified and corrected. A description of the additional services is given in the SWRM Public Transport Model Development Report. Access to public transport services was also reviewed, and a number of motorised legs were removed to reduce the volume of motorised access trips. In addition, a zone-to-zone walk-only access penalty was added to remove the discontinuity of costs for short PT trips (prior to this there was a spike in PT costs around 30 minutes where PT users were no longer able to walk for their entire journey). The model was also updated to the latest version of the FDM available at that point, and re-calibrated to the estimated road costs and revised PT costs.

3.4.2 Results / outputs

A check of the assigned road demand at the 24-hour level with observed data for each of the screenlines showed that the demand from the FDM was low compared to observed flows on the network (Figure 3.1 and Figure 3.2). This was the most important result from this stage of testing but further information (in digital format) on the results is provided in the Phase 1 Test 2\3 Road and Phase 1 Test 2\4 PT folders.

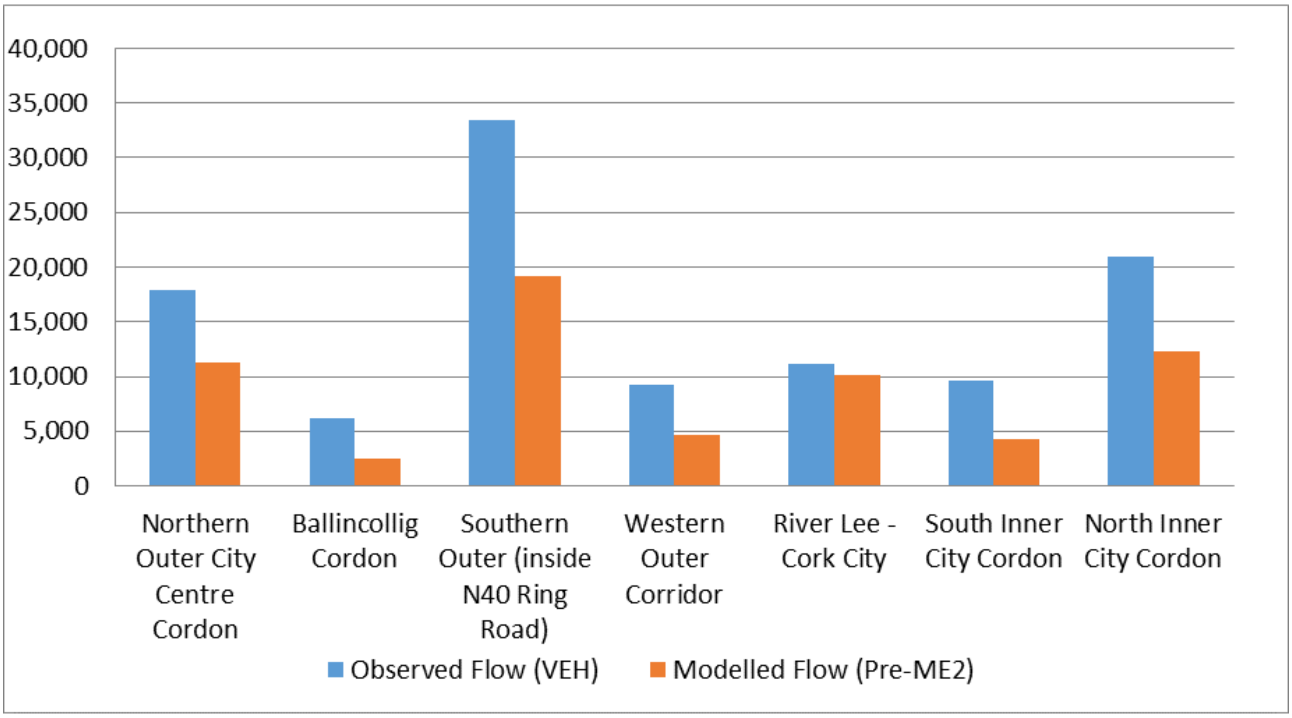


Figure 3.1: 24-Hour Modelled versus Observed Flows – Inbound

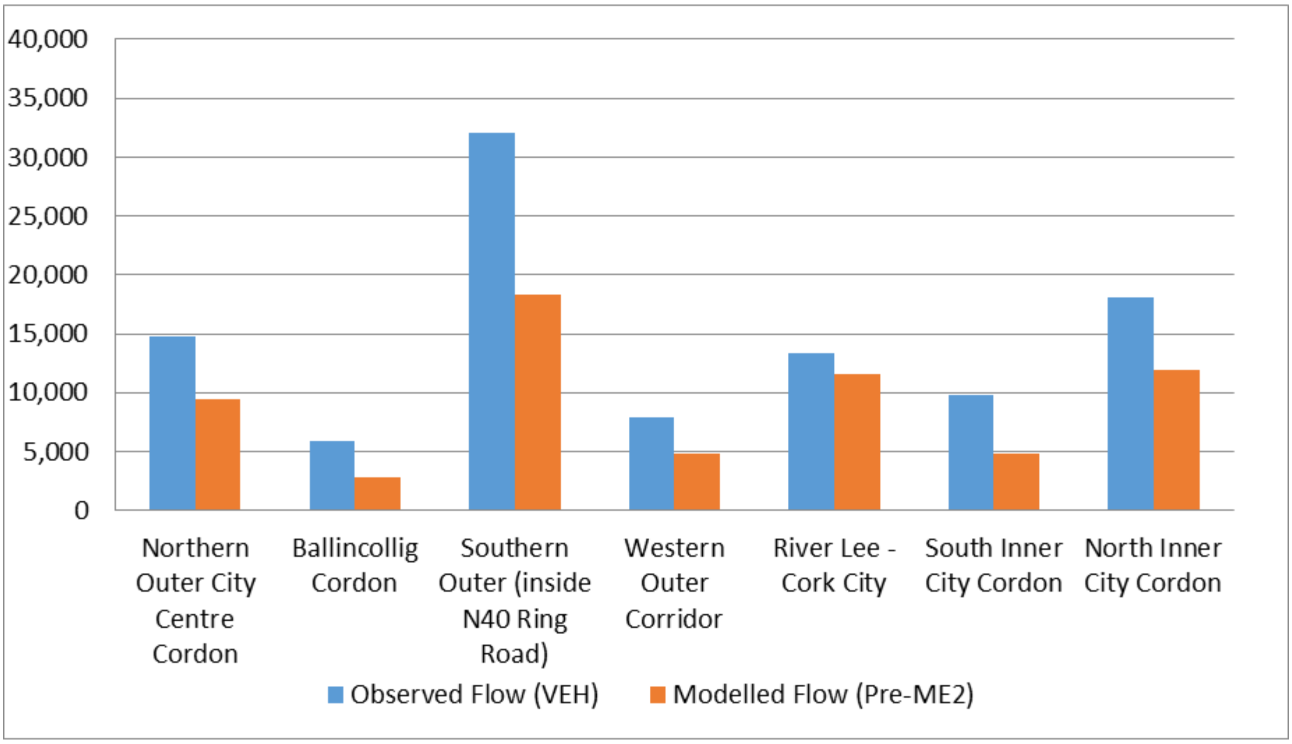


Figure 3.2: 24-Hour Modelled versus Observed Flows – Outbound

3.5 Phase 1 Test 3

3.5.1 Run details

Model Version: *XER_Model_v2.0.0_LMSave2*
Scenario Name: *SWBY08_A3*
Date: *January 2016*
Growth: *A3*

This run included calibration of intra-zonal trips for the first time using the revised calibration process.

3.5.2 Results / outputs

A set of dashboards was created which summarised this re-calibration and selected results from these are presented below. The match between the observed and modelled mode shares was good (Figure 3.3) as was the match between the observed and modelled generalised cost distributions (Figure 3.4) but the modelled flows on the road network were still low compared to observed flows (Figure 3.5 and Figure 3.6). Further information on the demand calibration results are provided in the Phase 1 Test 3\2 Demand folder.

Total Mode Share (24hr) - Observed	Total Mode Share (24hr) - Modelled

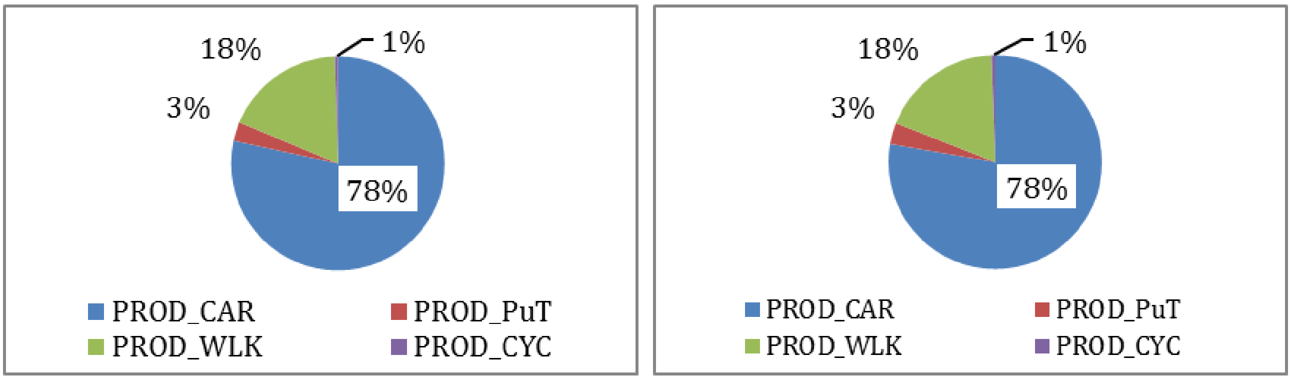
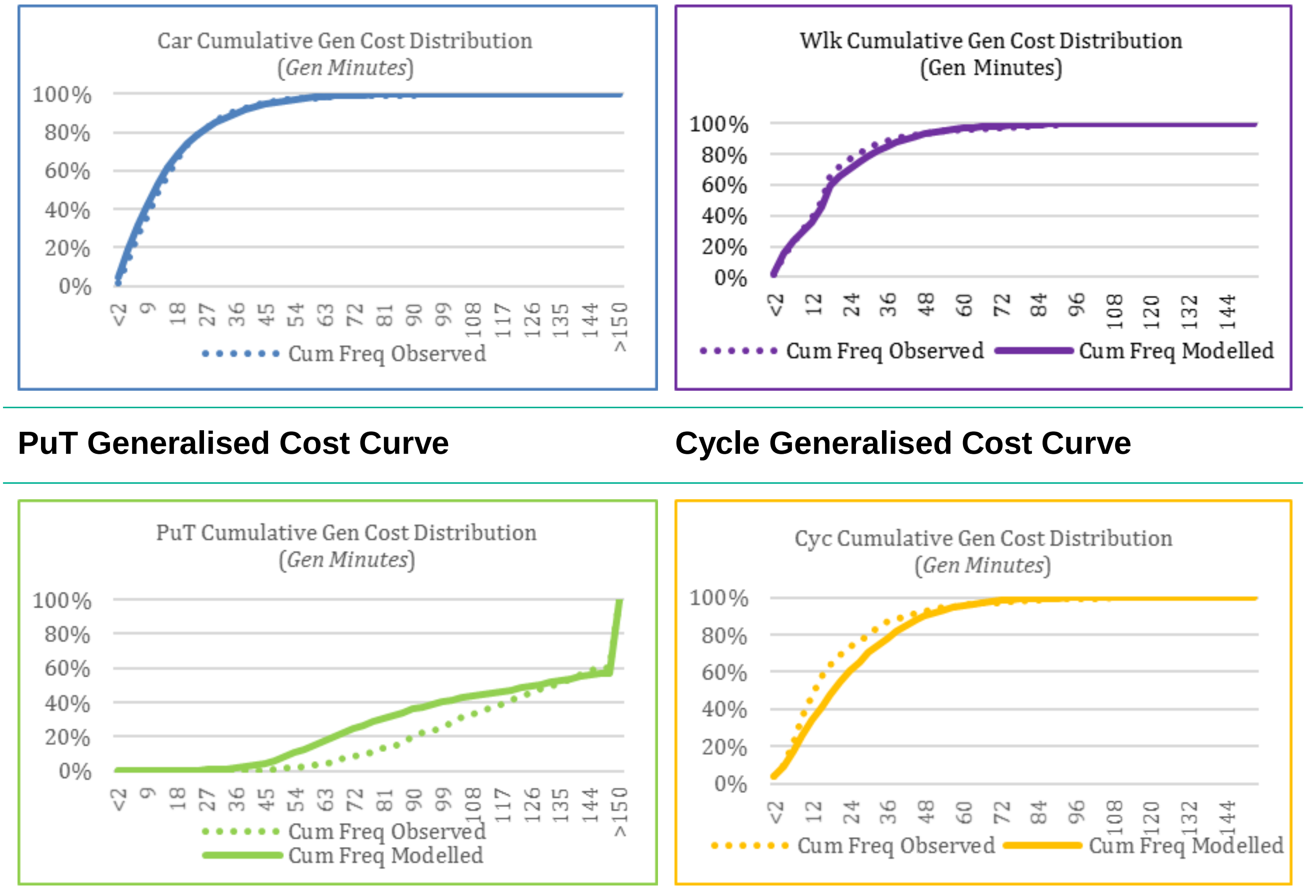


Figure 3.3: Observed and Modelled Mode Share

Car Generalised Cost Curve	Walk Generalised Cost Curve



PuT Generalised Cost Curve	Cycle Generalised Cost Curve

Figure 3.4: Commute White Collar Generalised Cost Curves

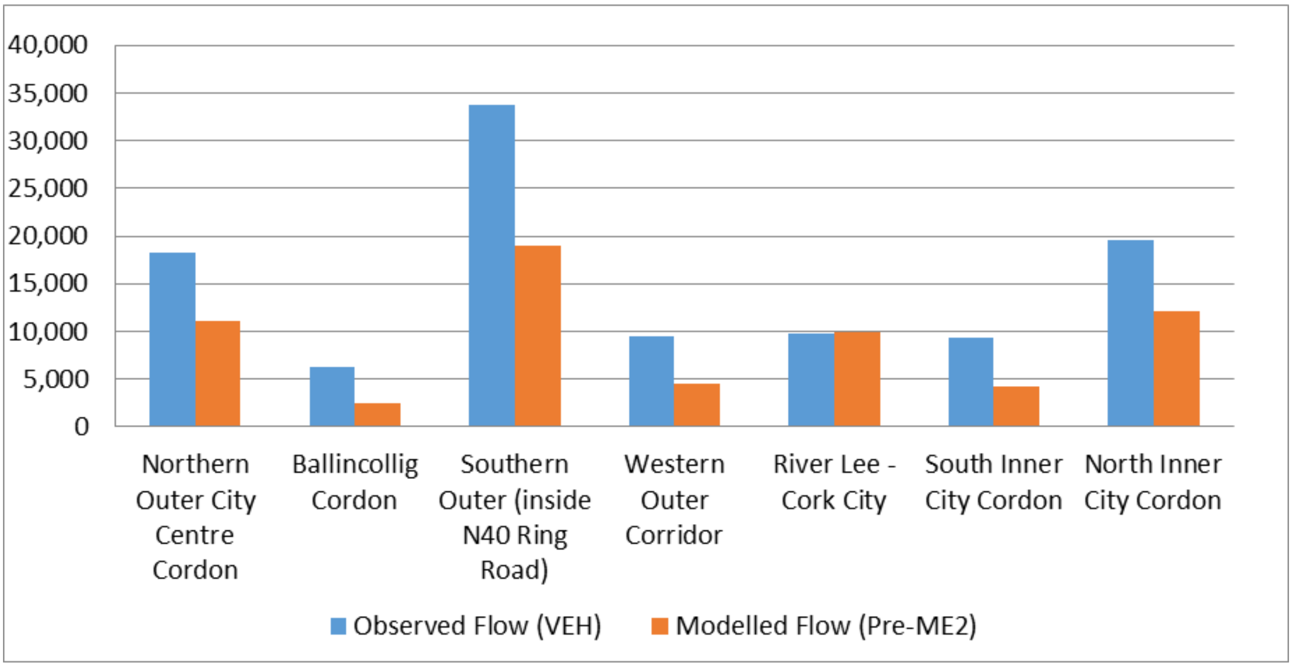


Figure 3.5: 24-Hour Modelled versus Observed Flows – Inbound

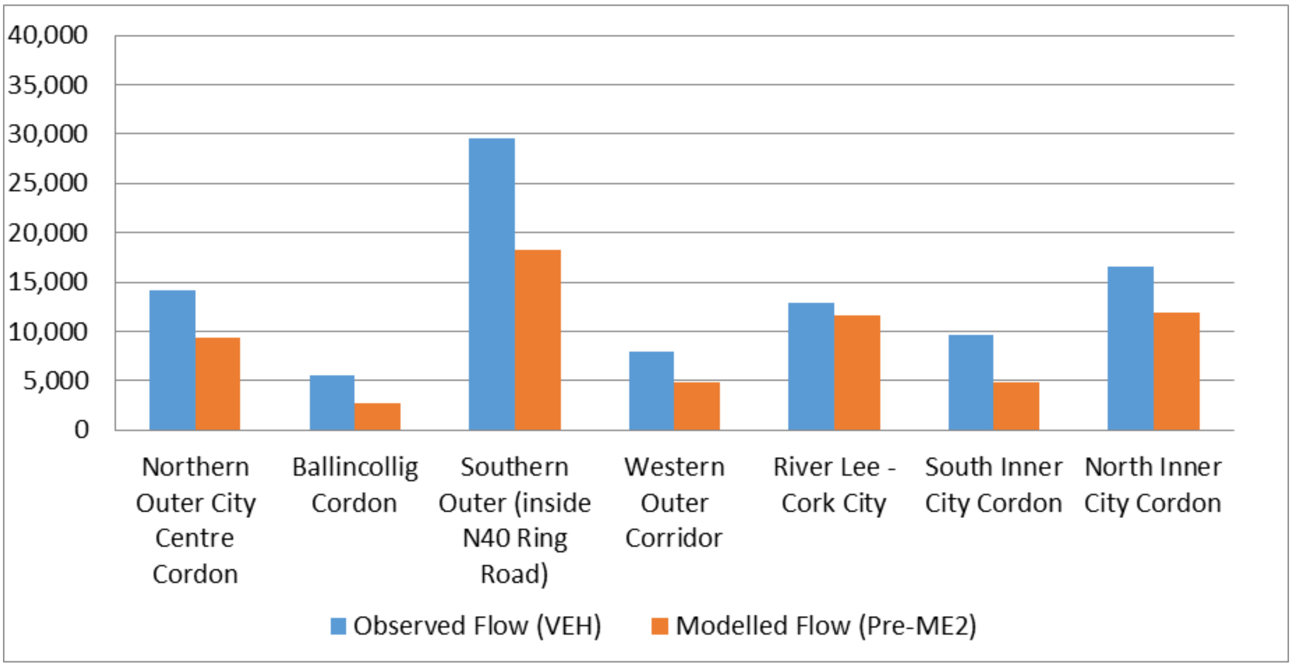


Figure 3.6: 24-Hour Modelled versus Observed Flows – Outbound

3.6 Phase 1 Test 4

3.6.1 Run details

Model Version: *2.0.0: Save10, 2.0.0: Save11 and 2.0.1: Save12*
Scenario Name: *SWBY08_A3 to SWBY10_A3*
Date: *January-February, 2016*
Growth: *A3*

Following the examination of the dashboards from Test 3, a number of further changes were introduced for this test, most notably, the matrix estimation process was revised to bring it in line with the other regional models. Park and Ride was initially switched on but was subsequently turned off because the site choice mechanism was not calibrated.

3.6.2 Results / outputs

A full set of dashboards was produced (demand, road and PT), select results from which are given below. This showed that there was still an issue with low demand, which can be examined in further detail in the electronic versions supplied in the Phase 1 Test 4\3 Road folder.

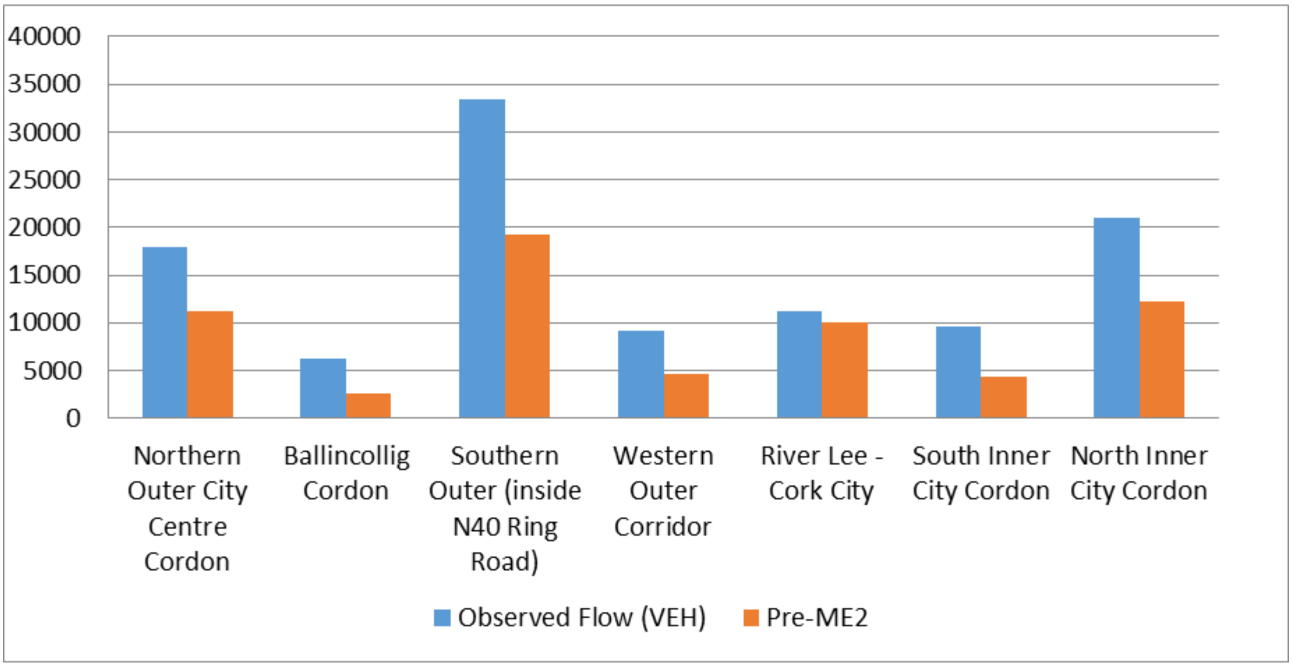


Figure 3.7: 24-Hour Modelled versus Observed Flows – Inbound

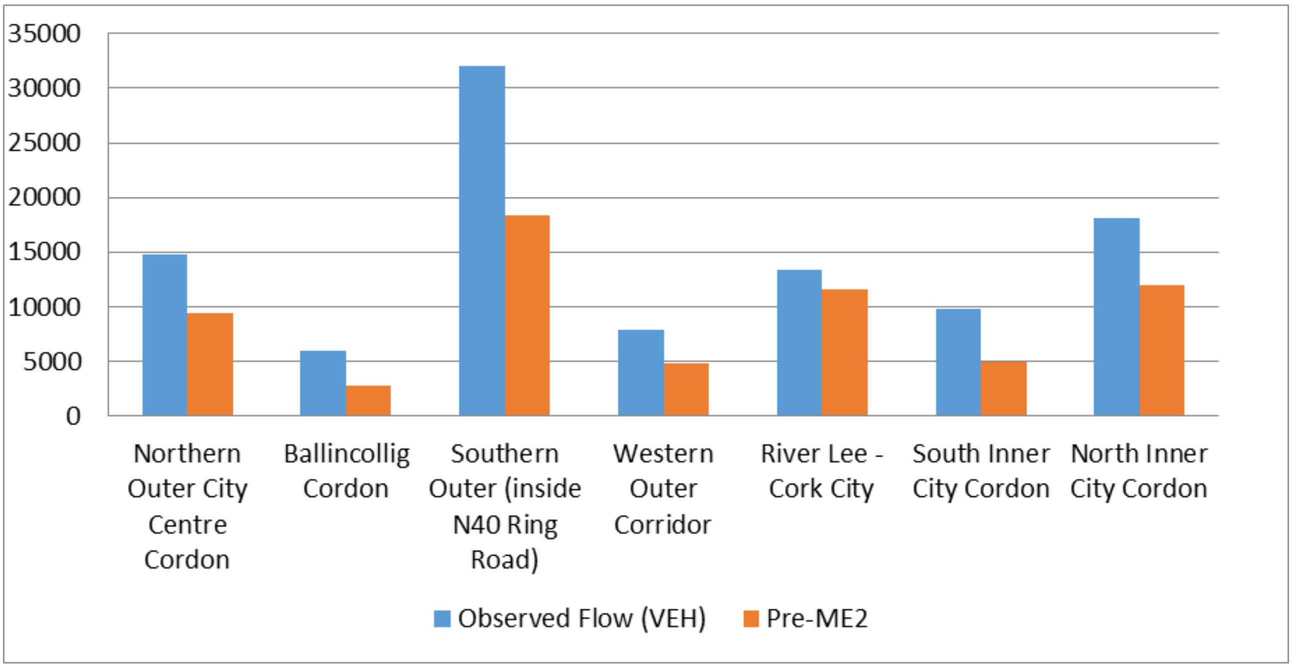


Figure 3.8: 24-Hour Modelled versus Observed Flows – Outbound

3.7 Phase 1 Test 5

3.7.1 Run details

Model Version: *2.0.1: Save12*
Scenario Name: *SWBY10_A4 - SWBY11_A6*
Date: *February 2016*
Growth: *A4-A6*

Throughout the first four iterations of FDM runs, the same set of trip ends (A3) were used but these did not provide an adequate representation of the flow entering and interacting within the SWRM Regional model. Therefore, a series of checks of the assumptions used in creating these trip ends was carried out.

Based on this, an adjustment was made to the Trip Ends to reflect the attractiveness of the urban areas. Previously, a default assumption was made about the split between full and part-time jobs, and this split applied to all CSAs, regardless of whether this area was in the centre of an urban area or in the countryside. Further analysis of the NHTS revealed a different split between full and part-time jobs depending on the type of area, as shown in Table 3.1.

Table 3.1: Full-Time/ Part-Time Job Split by Type of Area

Area type	Full time jobs	Part-time jobs
City Region	76.2%	23.8%
Large Urban Town	69.0%	31.0%
Rural Area	63.7%	36.3%
Small town	65.7%	34.3%

Based on this analysis, a revised split between full and part-time jobs was applied to trip ends to reflect the higher attractiveness of urban areas compared to rural areas and this resulted in Demand (Growth) Forecast A4. Further revisions to the base year outputs from the NDFM, involving a roughly 10% increase in jobs in the main regional cities led to growth forecasts A5 and A6. More details on these updates can be found in the NDFM Development Report.

This test also used costs derived from matrix estimation of the outputs from Test 4.

3.7.2 Results / outputs

These changes resulted in an increase in demand, but initial checks on the road and PT assignments at the 24-hour level showed there was still a significant, though smaller, difference between the modelled and observed flows on the road and PT networks. Summary results are provided below and further information on the road results are provided in the Phase 1 Test 5\3 Road folder.

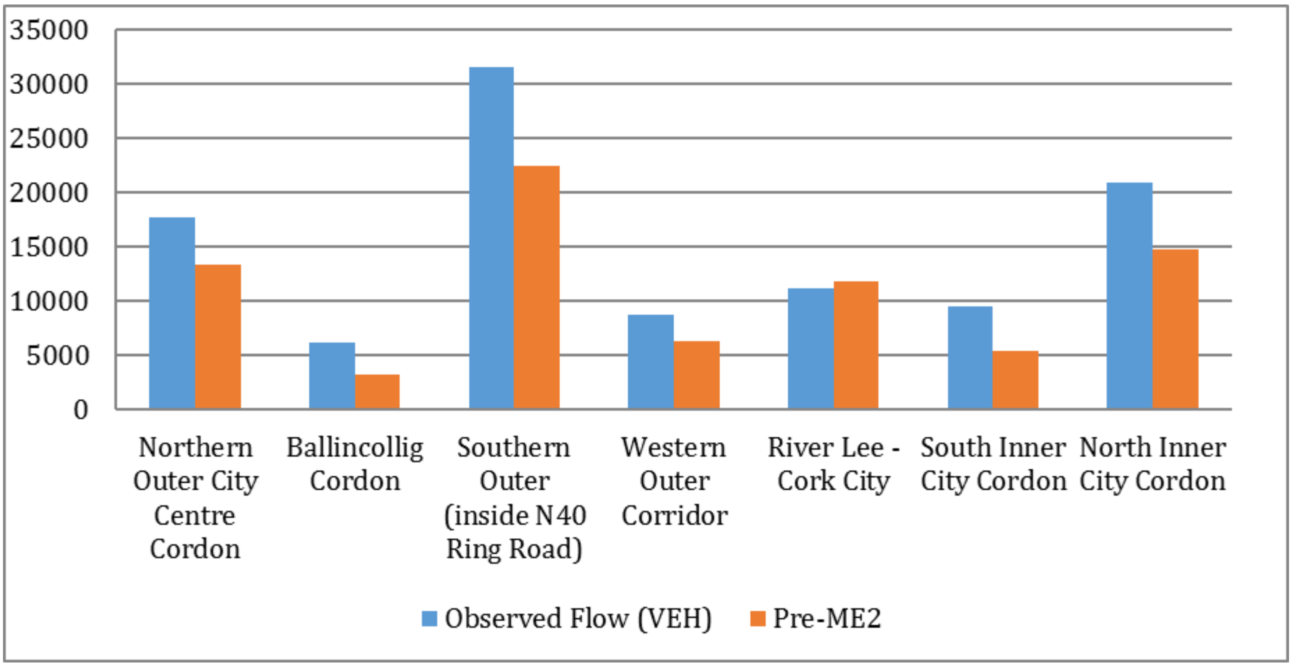


Figure 3.9: 24-Hour Modelled versus Observed Flows – Inbound

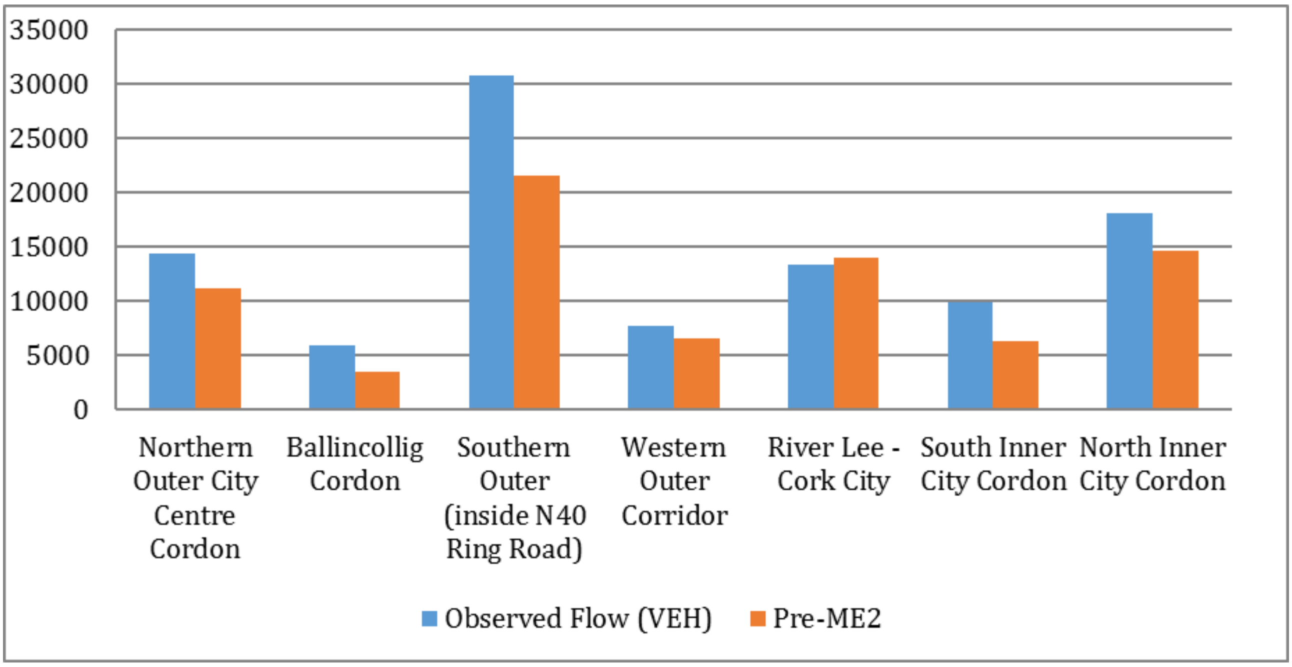


Figure 3.10: 24-Hour Modelled versus Observed Flows – Outbound

3.8 Phase 1 Test 6

3.8.1 Run details

Model Version: *2.0.1: Save12*
Scenario Name: *SWBY12_A7*
Date: *February 2016*
Growth: *A7*

Due to the ongoing issues with low demand an uplift factor of 20% was calculated and applied to the trip ends for this test.

3.8.2 Results / outputs

The impact of the change above is summarised in the tables below. While road and PT flows increased as a result of this uplift, road demand was still low compared to observed demand. Further information on road and PT results are provided in the Phase 1 Test 6\3 Road and Phase 1 Test 6\4 PT folders.

Table 3.2: Impact of Uplift on Road Screenlines

Road Screenlines	Observed	Modelled (before uplift)	Difference	Modelled (20% uplift)	Difference
AM	63,797	49,488	-14,309	56,864	-6,932
LT	36,550	32,041	-4,509	36,112	-437
SR	40,399	34,730	-5,669	39,144	-1,255
PM	65,084	38,899	-26,185	43,770	-21,314

Table 3.3: Impact of Uplift on PT Cordons

PT Cordons	Observed	Modelled (before uplift)	Difference	Modelled (20% uplift)	Difference
AM	5,112	4,540	-572	6,813	1,701
LT	447	701	254	958	511
SR	525	497	-27	778	254
PM	5,172	3,768	-1,404	5,031	-141

3.9 Phase 1 Test 7

3.9.1 Run details

Model Version: *2.0.1: Save12*
Scenario Name: *SWBY13_A7*
Date: *February 2016*
Growth: *A7*

Base tour proportions were derived from the National Household Travel Survey. Following the initial trip end uplift in Test 6, it was deemed necessary for there to be a further adjustment due to the mismatches between the modelled and observed flows. In order to derive appropriate factors, two cordons were established using the sector system as shown in Figure 3.11 on the next page (Sector 12 extends to represent the rest of Ireland and Northern Ireland)

The cordons were chosen to represent flows:

1) Entering/Leaving Cork City – Sectors 3, 4 and 5
2) Entering/Leaving Inner Cork City CBD – Sectors 1 and 2

The adjustment proportions were calculated using the following process:

1) Observed and modelled flows were aggregated within the identified sector groupings;
2) Calculation of the proportion of the modelled demand matrix within the cordons;
3) Calculation of the equivalent observed values based on the proportion above; and
4) Calculation of the adjustment factors needed in order to adjust the modelled demand to match the observed demand.

These factors were used to adjust the trip ends in this test run.

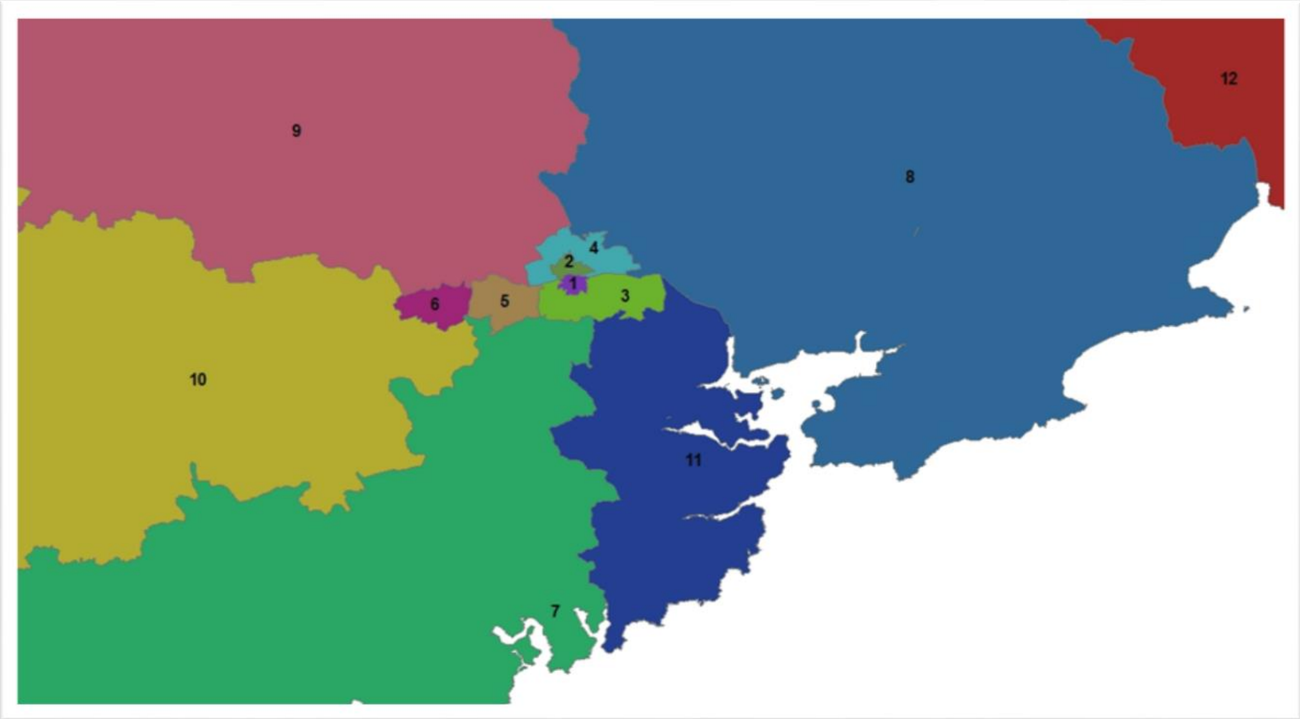


Figure 3.11: SWRM Sectors

3.9.2 Results / outputs

There was a slight improvement in the match between the observed and modelled PT demands but otherwise the effects of these changes were slight (Table 3.4, Table 3.5 and Table 3.6).

Table 3.4: NHTS Observed Data

	CAR	PT	Walk	Cycle	TOT
AM	18%	2%	4%	0%	**25%**
LT	14%	1%	5%	0%	**20%**
SR	19%	1%	5%	0%	**24%**
PM	16%	1%	3%	0%	**20%**
OP	8%	0%	3%	0%	**11%**
TOT	**74%**	**4%**	**21%**	**1%**	**100%**

Table 3.5: Pre Tour Proportion Adjustment

	CAR	PT	Walk	Cycle	TOT
AM	19%	1%	5%	0%	**25%**
LT	14%	1%	4%	0%	**19%**
SR	19%	1%	5%	0%	**24%**
PM	15%	1%	3%	0%	**19%**
OP	10%	0%	2%	0%	**13%**
TOT	**77%**	**4%**	**19%**	**1%**	**100%**

Table 3.6: Post Tour Proportion Adjustment

	CAR	PT	Walk	Cycle	TOT
AM	19%	1%	5%	0%	**25%**
LT	14%	1%	4%	0%	**18%**
SR	18%	1%	5%	0%	**24%**
PM	16%	1%	4%	0%	**20%**
OP	10%	0%	2%	0%	**13%**
TOT	**77%**	**4%**	**19%**	**1%**	**100%**

3.10 Phase 1 Test 8

3.10.1 Run details

Model Version: *2.0.1: Save12*
Scenario Name: *SWBY14_A7 and SWBY15_A7*
Date: *February 2016*
Growth: *A7*

As the potential for tour proportion adjustments had been exhausted, the next adjustments applied were to the Alternative Specific Constants (ASCs). These are part of the utility equation and provide a proxy for those parts of trip costs which cannot be easily quantified.

3.10.2 Results / outputs

The adjustments made for this test run resulted in a slightly worsened level of demand calibration but improved the comparison of the modelled versus observed road and PT flows at the screenline level (Figure 3.12 to Figure 3.15).

Further information on road and PT results are provided in the Phase 1 Test 7\3 Road and Phase 1 Test 7\4 PT folders.

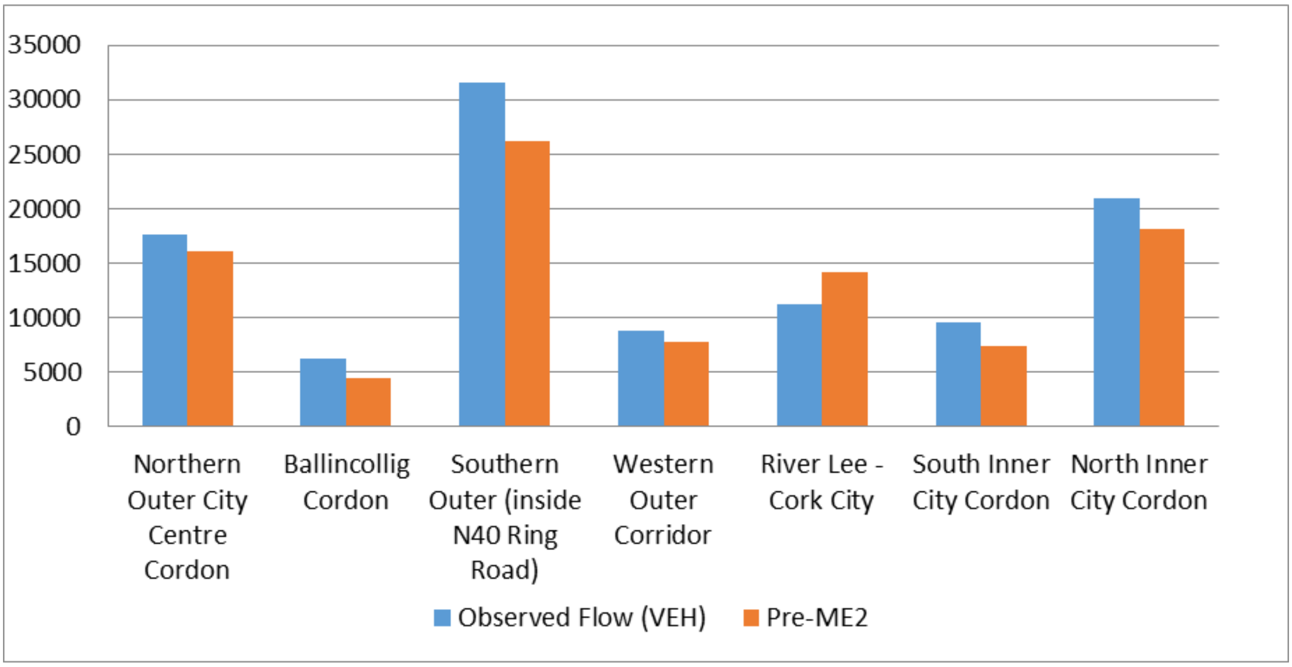


Figure 3.12: 24-Hour Modelled versus Observed Flows – Inbound

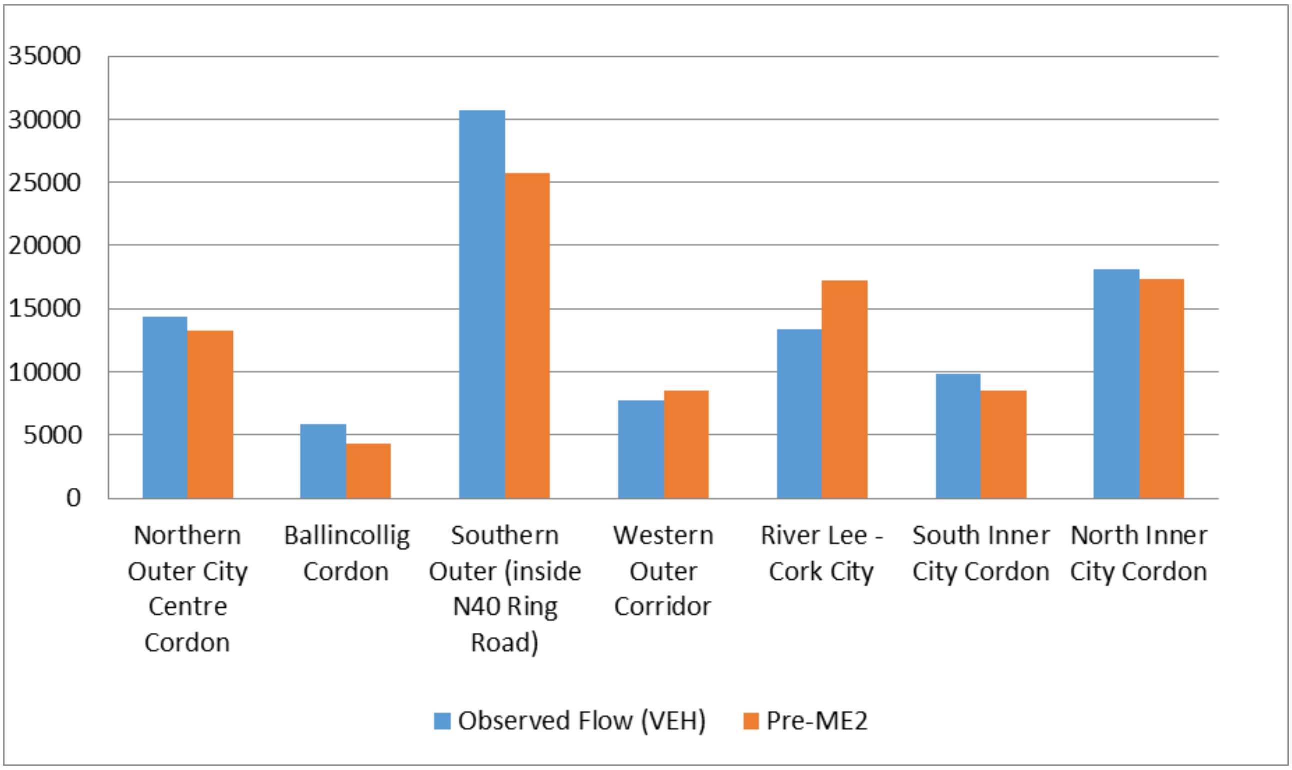


Figure 3.13: 24-Hour Modelled versus Observed Flows – Outbound

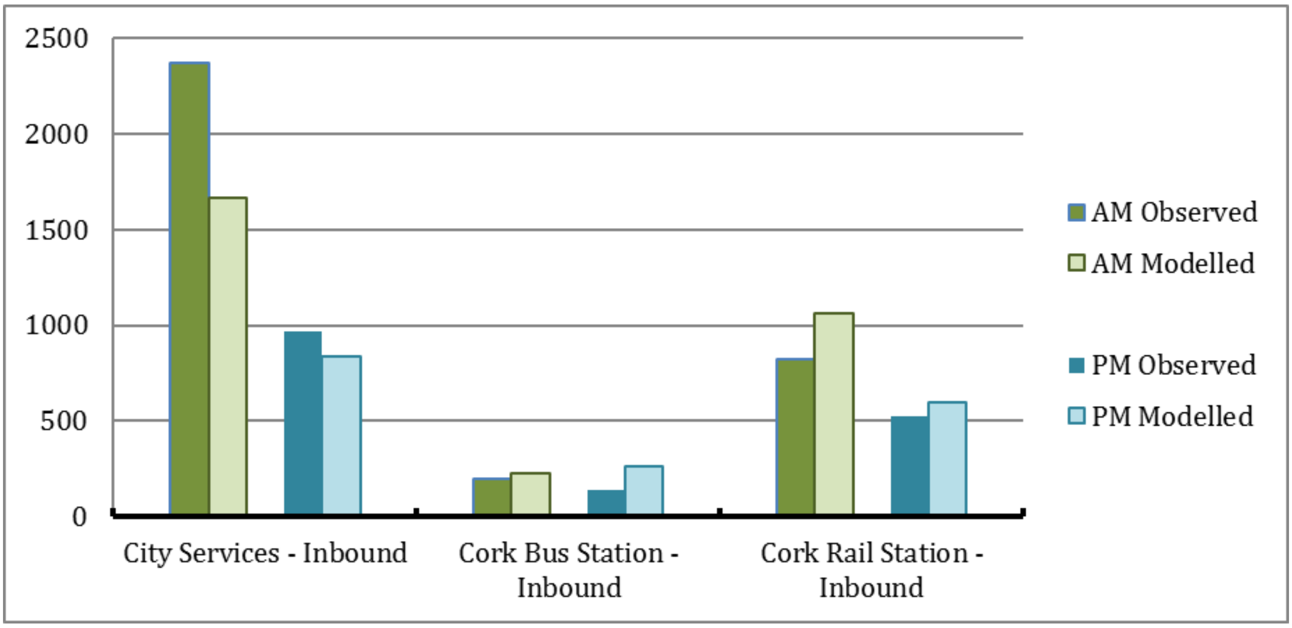


Figure 3.14: Modelled versus Observed Passenger Link Flows – Inbound

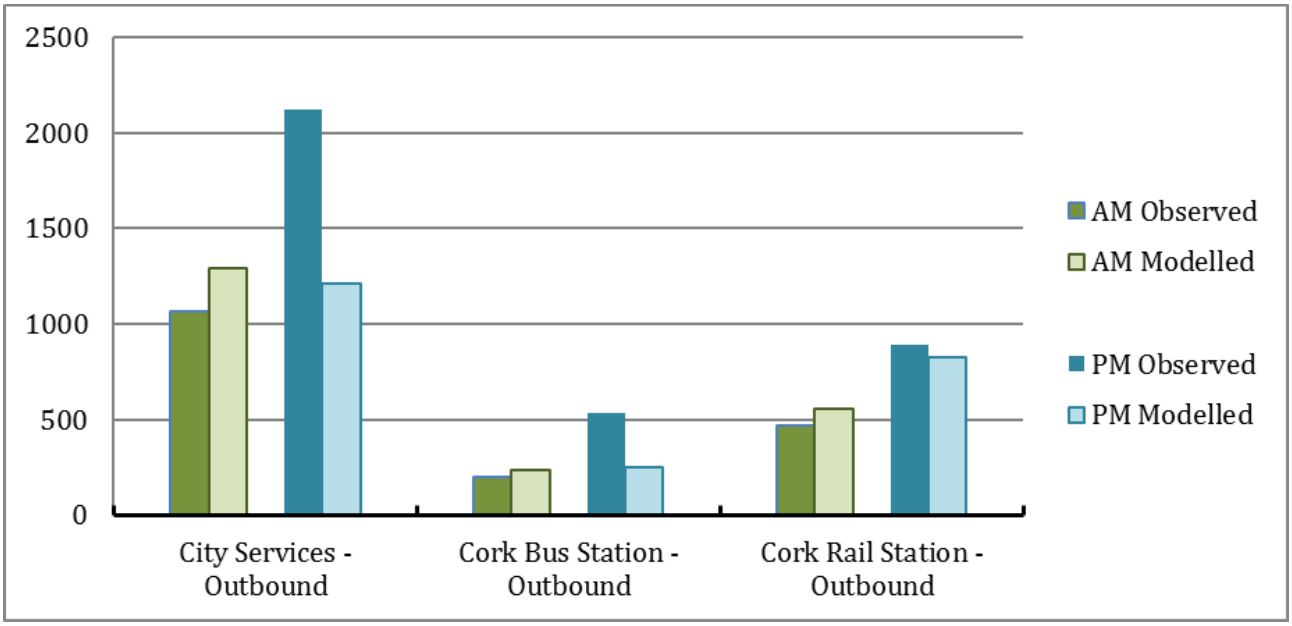


Figure 3.15: Modelled versus Observed Passenger Link Flows – Outbound

3.11 Post Phase 1 Calibration and Validation Process Review

At this stage, there was a review of the calibration and validation of the SWRM 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).

3.12 Phase 2 Test 1

3.12.1 Run details

Model Version: *2.0.2: Save14*
Scenario Name: *Various*
Date: *March 2016*
Growth: *A9*

While the SWRM team waited for the review of the FDM, they conducted a thorough review of the road and PT networks, which resulted in a reduction in the number of road counts used for estimation, as well as changes to some speed-flow curves and centroid connectors. A more detailed description of this is given in SWRM Road Model Development Report. A review of the PT network resulted in changes to PT connectors in Middleton and Mallow, as well as some revisions to In-Vehicle Time parameters and Boarding and Interchange Penalties. A more detailed description of this is given in the SWRM Public Transport Model Development Report. The latest available demand matrices were assigned to these new road and PT networks, and matrix estimation / PT factoring was carried out to produce new costs to feed into this new test.

3.12.2 Results / outputs

The results of this test run showed a better match between pre-estimation demand and observed counts, as shown in Table 3.7. However, this still represents a relatively low percentage of counts passing before matrix estimation, and further information on road and PT results are provided in the Phase 2 Test 1\3 Road folder.

Matrix estimation resulted in the NTA expressing concern about the amount of matrix change with none of the user classes in any time period passing the WebTAG criteria for changes in cells, trip ends or trip lengths.

Table 3.7: Percentage of Counts Passing WebTAG Criteria Pre-Matrix Estimation

Time Period	Percentage of Counts Passing WebTAG Flow Criteria	Percentage of Counts Passing WebTAG GEH Criteria
AM	44%	36%
LT	43%	34%
SR	42%	37%
PM	38%	28%

3.13 Phase 2 Test 2

3.13.1 Run details

Model Version: *2.0.2: Save14*
Scenario Name: *SWBY21_A9- SWBY29_A9*
Date: *March 2016*
Growth: *A9*

There was a further review of the road and PT networks for this test which led to further streamlining of counts and a correction to the Port of Cork matrices. These are described in more detail in SWRM Road Model Development Report.

In the PT model there were changes to:

- Fares;
- Capacities;
- Headways;
- Bus and rail routes;
- In-Vehicle Time Factors;
- Boarding penalties; and
- Non-Transit Legs.

These are described in more detail in SWRM Public Transport Model Development Report.

In addition, a review by the NTA of the changes brought about by matrix estimation resulted in adjustments to the matrix estimation parameters, in particular a reduced XAMAX (the factor limiting the change applied to any individual cell) for some user classes and the introduction of trip end constraints to limit the changes brought about by ME.

3.13.2 Results / outputs

Figure 3.16 shows a comparison of the number of modelled trips in each time period with the observed NHTS data and indicates that this compares well, as does the number of trips by the various modes (Figure 3.17). Further information on road and PT results is provided in the Phase 2 Test 2\3 Road and Phase 1 Test 2\2 PT folders.

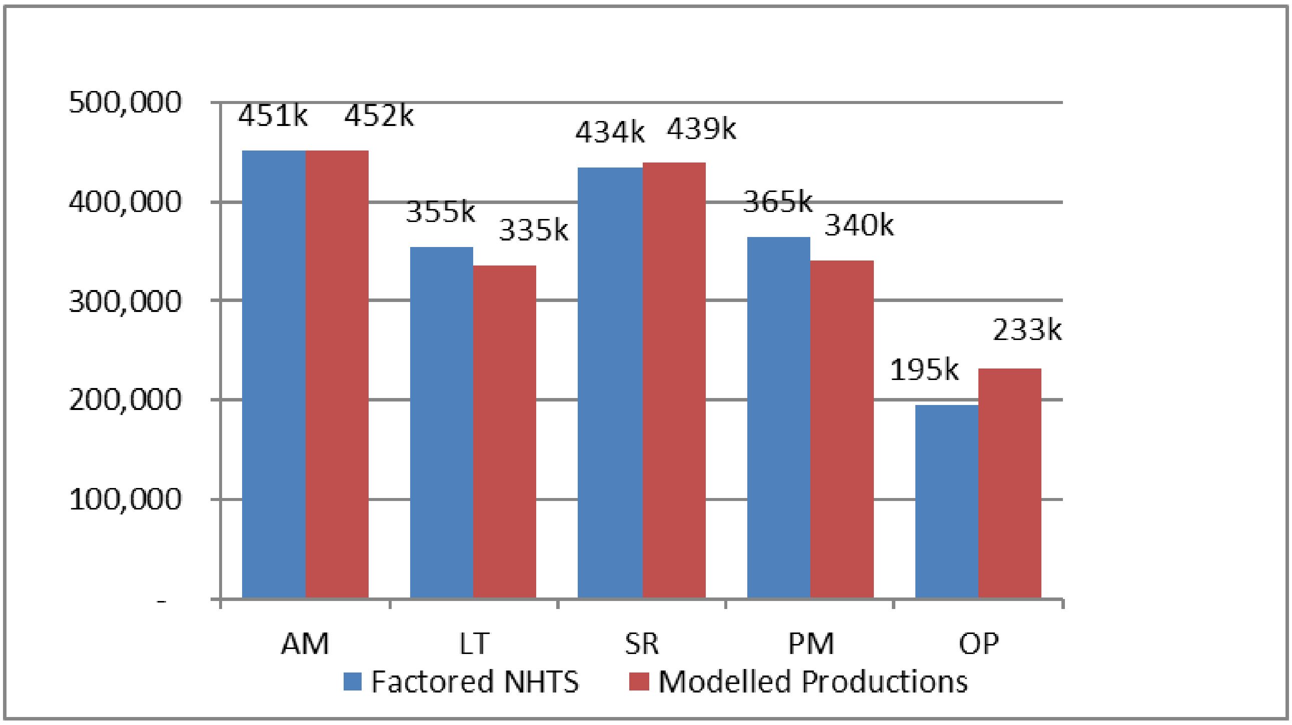


Figure 3.16: Total Trips by Time Period

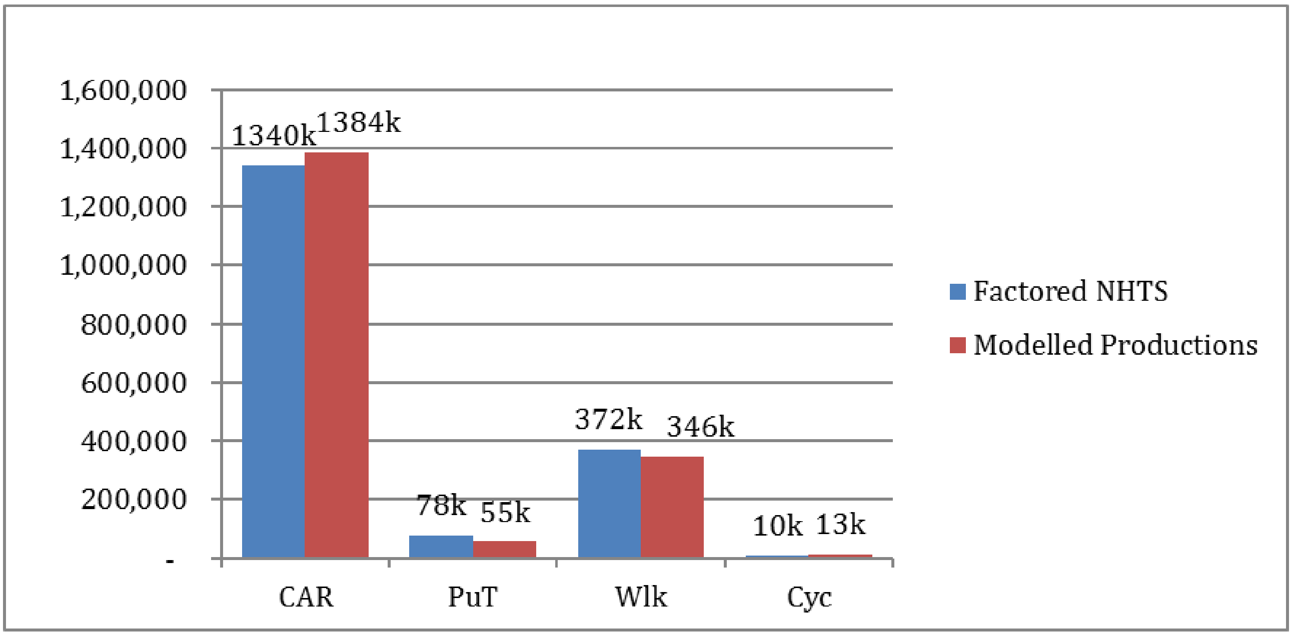


Figure 3.17: Total Mode Share (24hr)

3.14 Post Phase 2 Calibration and Validation Process Review

In May 2016, a new version of the model was released: V2.0.8. This included corrected parking distribution and parking constraint models as well as a number of other minor upgrades.

At this stage the focus of the calibration work was on including the parking models and improving the way the external demand was integrated

3.15 Phase 3 Test 1

3.15.1 Run details

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

Several iterations of the demand model were required in order to calibrate the various car parking processes.

3.15.2 Free Workplace Parking

In the absence of data detailing the number of free workplace spaces in the SWRM area, FWPP capacities were set to 0.

In this case, none of the commute or education trips were automatically given a free workplace parking space. As a result, all commute and education car trips will be considered equally to other purposes in terms of parking charge. However, with no 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 0.

3.15.3 Parking constraint

The parking constraint module can restrict the number of car destinations in certain areas, such as city centres. However, it is only intended for use in preliminary tests where the area of interest is remote from any congested parking areas. Therefore, the Parking Constraint module was not turned on in this model.

3.15.4 Parking distribution

The parking distribution module (PDist) facilitates the redistribution of trips to nearby zones when the level of demand exceeds the capacity available, 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.

Parking distribution in Cork city was defined in a similar way to that used in 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 demand in the base year. The red shaded zones, covering most of the built up area of Cork City (Figure 3.18) were set as the PDist area. A few iterations of the demand model were needed in order to calibrate the base year capacities and search times for every zone.

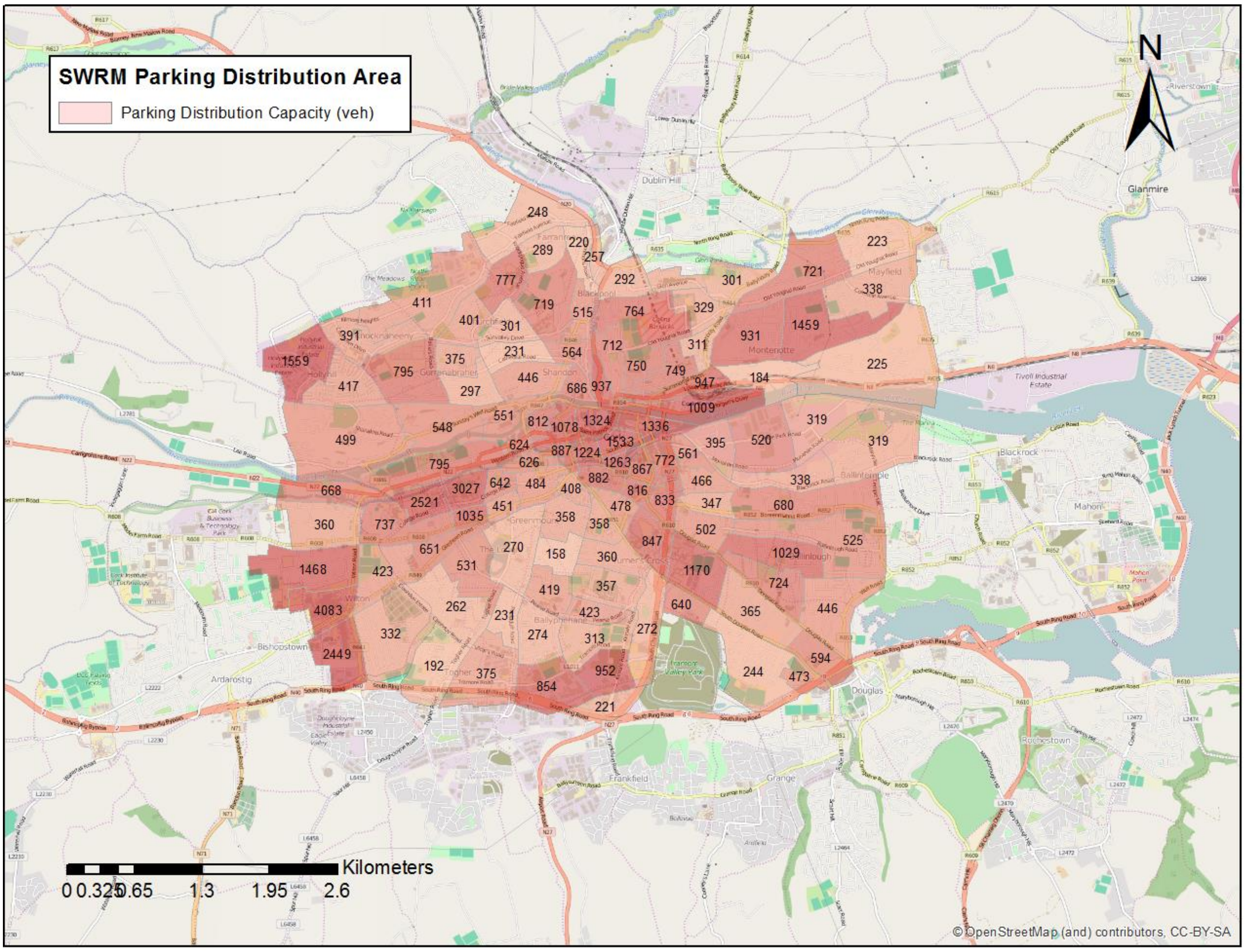


Figure 3.18: SWRM Parking Distribution area and capacities[3]

3.15.5 Results / outputs

Following this test there was a noticeable improvement in the match between modelled and observed flows before matrix estimation / factoring. Headline results for the road

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

network are shown in Table 3.8 and further information on both the road and PT results is provided in the Phase 3 Test 1\3 Road and Phase 3 Test 1\4 PT folders.

Table 3.8: Percentage of Counts Passing WebTAG Criteria Pre- Matrix Estimation

Time Period	Percentage of Counts Passing WebTAG Flow Criteria	Percentage of Counts Passing WebTAG GEH Criteria
AM	49%	70%
LT	50%	85%
SR	53%	45%
PM	52%	40%

Matrix estimation and PT factoring were performed, improving the match between modelled and observed flows somewhat (Table 3.9) but the R^2 values associated with this matrix estimation were not satisfactory, in particular for the LT period (R^2 between 0.69 for COM and 0.94 for EDU and OTH). This indicated that the ME process had introduced a significant change in the demand matrices which was not desirable and needed to be addressed.

Table 3.9: Percentage of Counts Passing WebTAG Criteria Post- Matrix Estimation

Time Period	Percentage of Counts Passing WebTAG Flow Criteria	Percentage of Counts Passing WebTAG GEH Criteria
AM	79%	65%
LT	88%	85%
SR	84%	45%
PM	81%	50%

In spite of the concerns relating to the matrix estimation / factoring processes at this stage the revised matrices were used to update the base generalised costs.

3.16 Phase 3 Test 2

3.16.1 Run details

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

The flows in the LT time period tended to be overestimated and this was resulting in large changes during matrix estimation. At this stage, although this was generally avoided in Phase 3, minor adjustments were made to tour proportions in order to reduce the number of LT road trips and hopefully obtain a closer match between modelled and observed flows before matrix estimation. Table 3.10 shows the changes in trip numbers between this test and the previous one.

Table 3.10: Change in trip numbers - Car Commute

Time period	Car trips: Test 3	Car trips: Test 4
AM	96,188	96,188
LT	18,700	16,836
SR	33,521	33,679
PM	75,007	74,871
OP	36,529	38,367

3.16.2 Results / outputs

Despite the changes matrix estimation at this stage resulted in R^2 values for the LT similar to those obtained previously suggesting that the tour proportion adjustments were not helping.

While this is the key output, detailed information on the road and PT results can be found in the Phase 3 Test 2\3 Road and Phase 3 Test 2\4 PT folders.

3.17 Phase 3 Test 3, Model version 2.0.8e

3.17.1 Run details

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

Following the previous test, a detailed analysis of the road assignment matrices showed that the internal commute demand for LT had gone down by 9.2% but that external demand represented a large part of the LT road commute demand (36% of trips in LT commute compared to 4% of AM commute trips) and so the next step focused on the external demand estimated by RMSIT.

The previous run and similar issues encountered in the MWRM suggested that the external demand needed to be adjusted.

This was done in two stages in both the RMSIT and the Regional Model:

- The factors converting the RMSIT demand from 24h into periods were revised, based on automatic counts on the main strategic roads crossing the edge of the model. As shown in Table 3.11 this resulted in a significant drop in the volume of RMSIT traffic being assigned to the LT.
- The trip ends for a given zone come from both the NTEM (for internal to internal movements) and RMSIT (for external to internal or external to externals). At its first steps, the model undertakes the subtraction of the external trip ends (RMSIT) from the total NTEM trip ends zone by zone in the internal area. Based on tests undertaken in the MWRM, it was decided to cap the RMSIT demand at 70% of

NTEM trip ends. Therefore, for any internal zone, there will be at least 30% of trips staying in the internal area.

Model version 2.0.8e included the capacity to factor RMSIT trip ends downwards.

Table 3.11: Revised RMSIT 24h to Period factors

Time Period	Based on NHTS factors	Updated – Based on road counts
AM	0.145	0.193
LT	0.316	0.161
SR	0.132	0.197
PM	0.250	0.250
OP	0.158	0.199

3.17.2 Results / outputs

Reasonable results were obtained at this stage and so road matrix estimation and PT factoring were performed and the resulting matrices were used to update the base generalised costs.

3.18 Version upgrade and looping to convergence

3.18.1 Model version

Testing in the SWRM 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 SWRM this process was undertaken in early 2017.

3.18.2 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.

3.18.3 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 four 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 PT trips than observed

(Figure 3.19 - left). Post-calibration modelled mode shares (Figure 3.19 - right) are closer to the observed data.

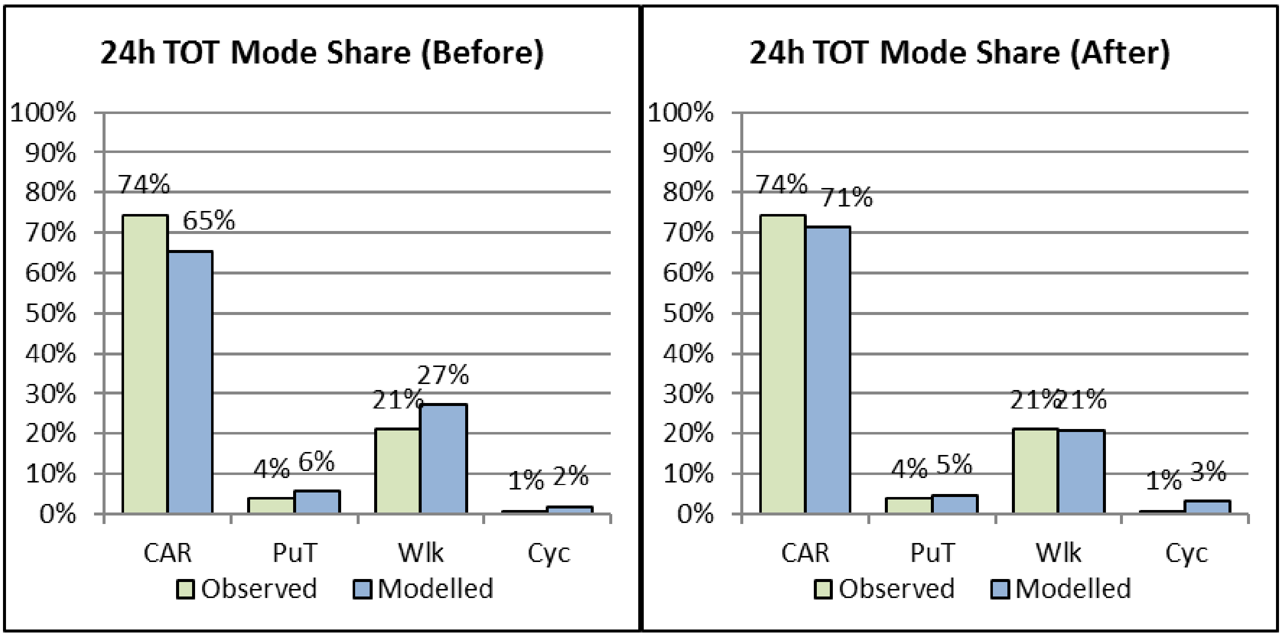


Figure 3.19: 24h Total Mode Share before (left) and after (right) recalibration

3.18.4 Park and Ride calibration

The Park and Ride mode share is calibrated as part of the main model calibration process but the site calibration is separate and was undertaken at this stage. For more information on the development of the Park and Ride model and the site selection calibration process please see Annex 4.

3.18.5 Finalisation

Once a suitable level of calibration was obtained, a new set of incremental matrices was generated allowing the model to be finalised. The final model results are presented in the following chapter.

4 Final calibration / validation results

4.1 Introduction

This chapter provides details of the final calibration and validation, across a whole range of model outputs. These include the direct demand model indicators (modal split, generalised cost and trip length distributions, intrazonal trip numbers, and time period distributions) as well as 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 SWRM Active Modes model can be found in the Active Modes Model Development Report.

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

4.2 Full results in electronic format

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

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

4.3 Demand Calibration

4.3.1 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 mode share is inclined to be slightly low, while the PT and cycle mode shares are occasionally slightly high.

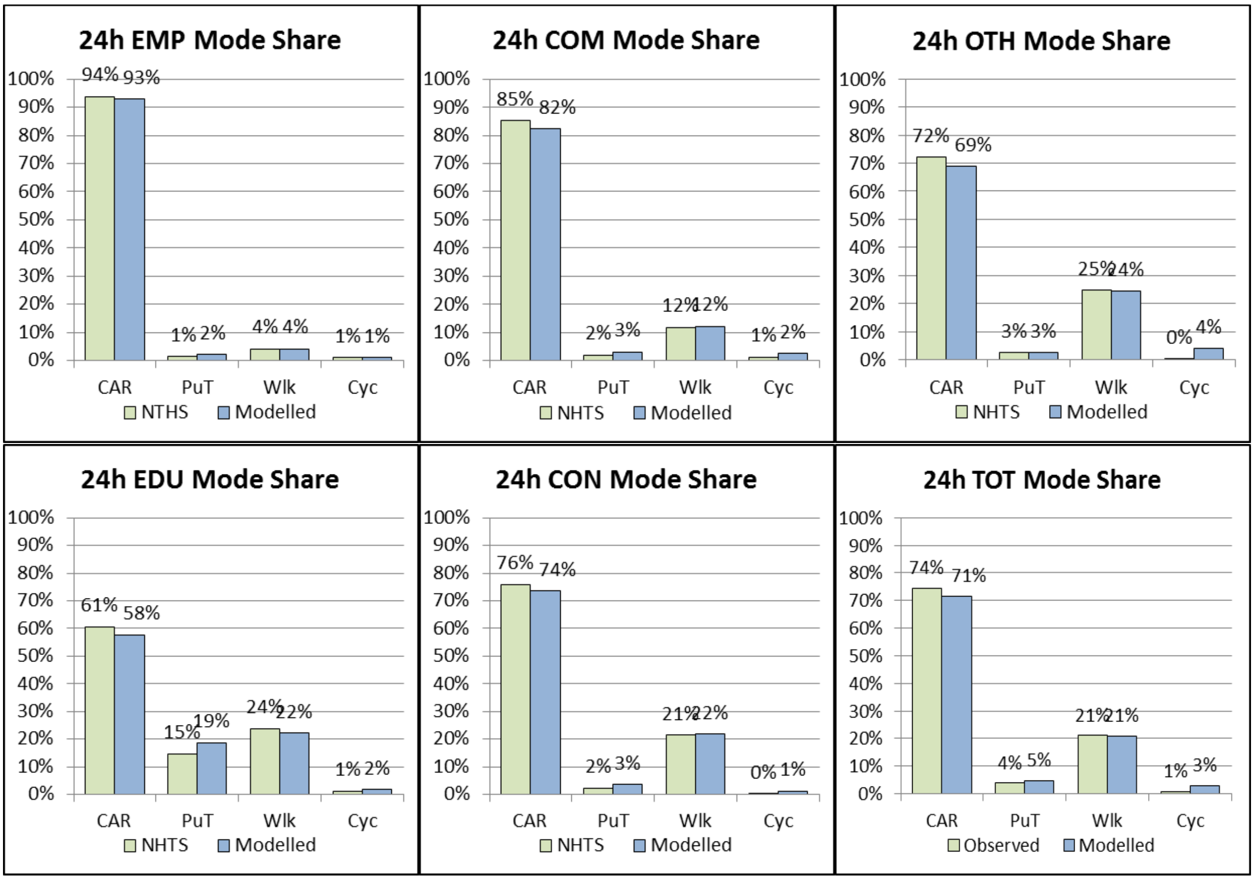


Figure 4.1: Total Mode Share (24hr)

4.3.2 Generalised cost distributions

Figure 4.2 and Figure 4.3 show the generalised cost 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 and walk trips. PT trips are less well matched, particularly for the EMP user class and for longer trips.

AM	IP1

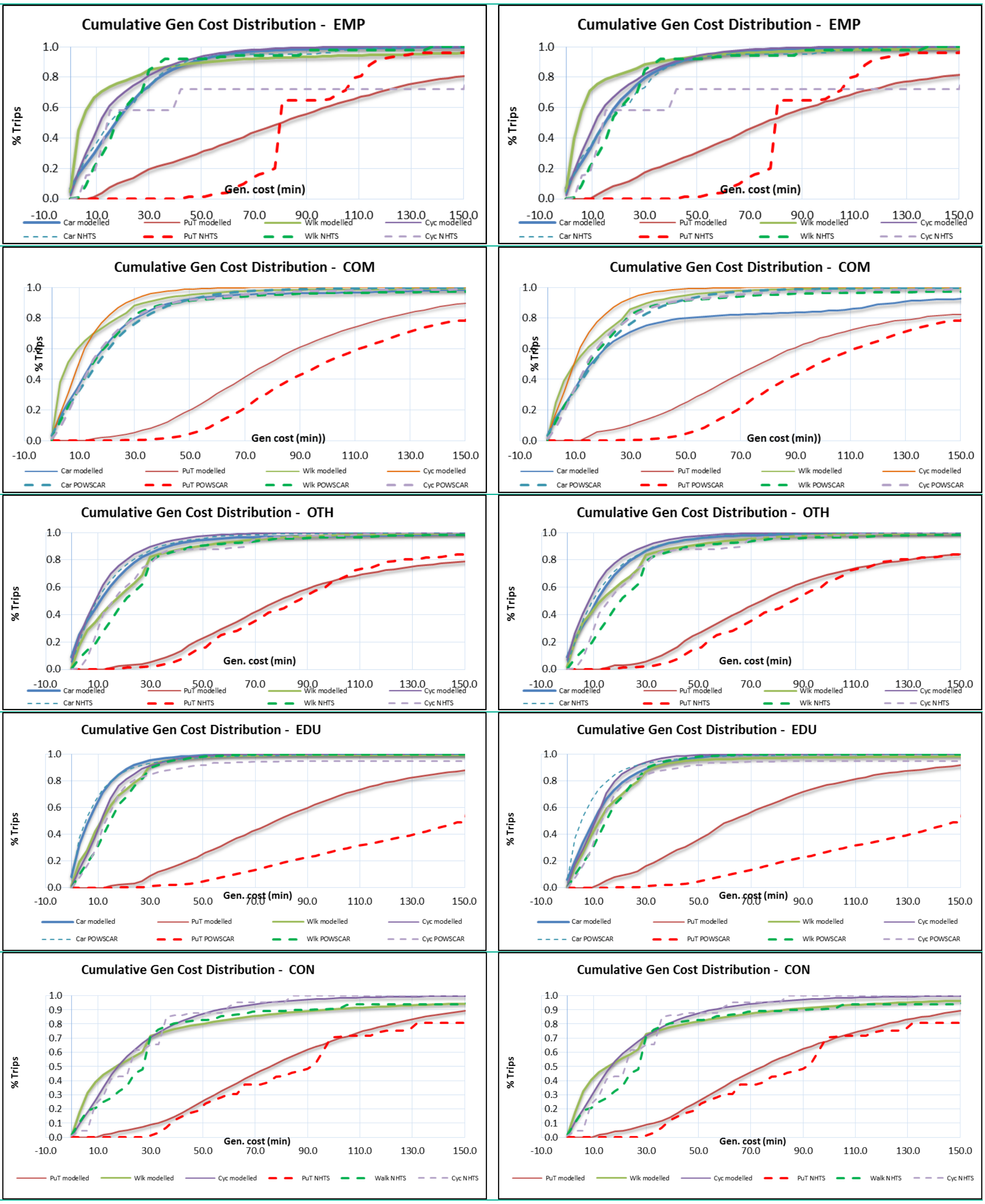


Figure 4.2: Cumulative trip length distributions (AM and IP1)

IP2	PM

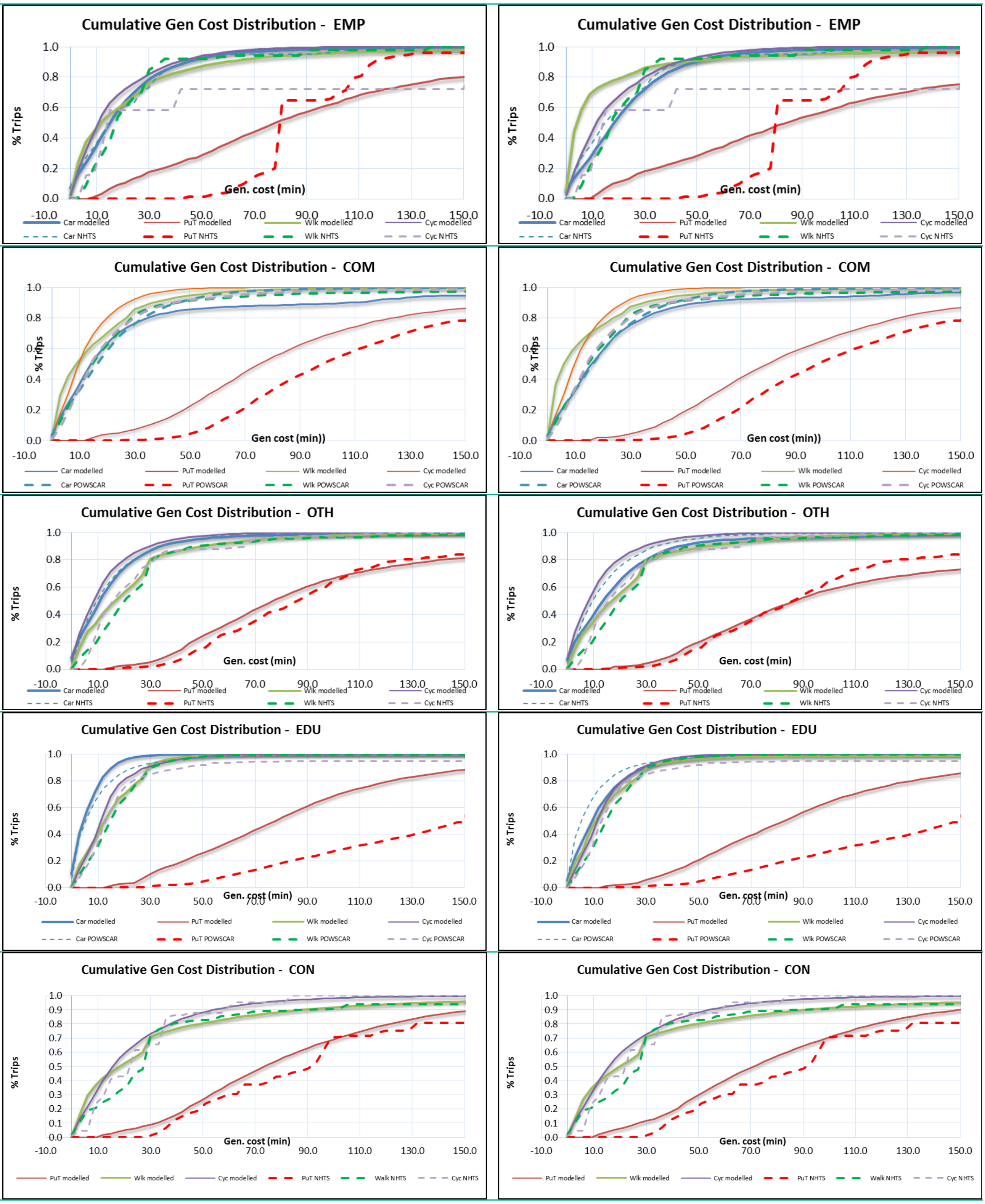


Figure 4.3: Cumulative trip length distributions (IP2 and PM)

4.3.3 Trip length distribution

Figure 4.4 shows a comparison between the observed and modelled trip lengths for the COM and EDU (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.

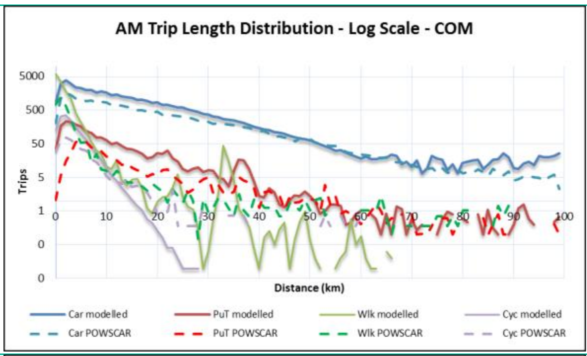
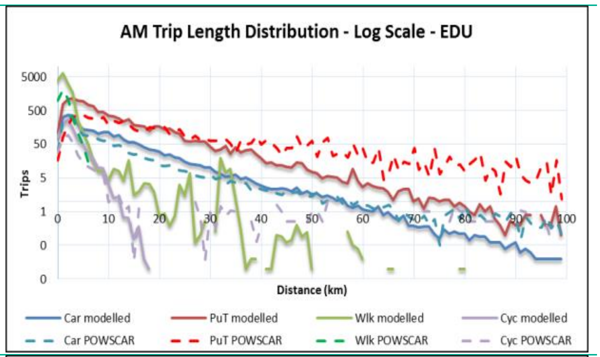
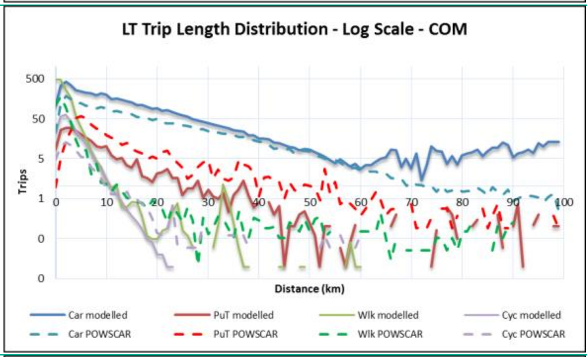
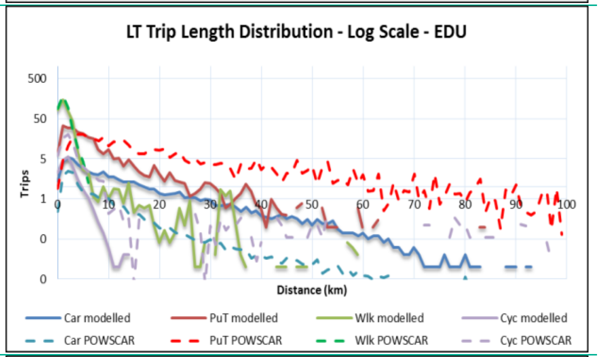
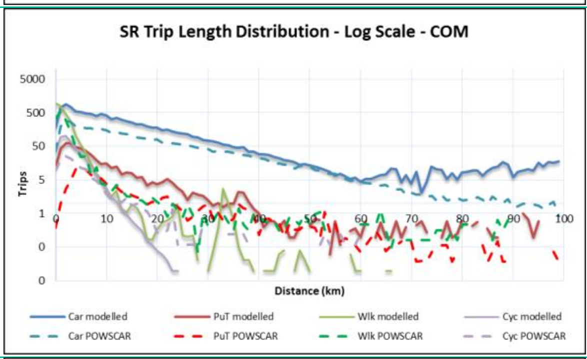
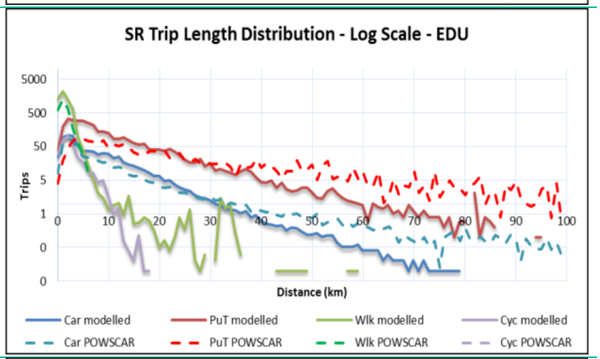
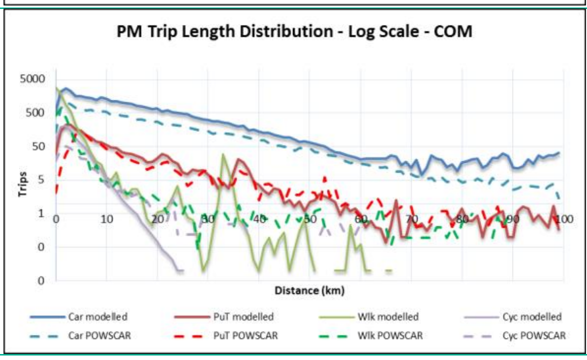
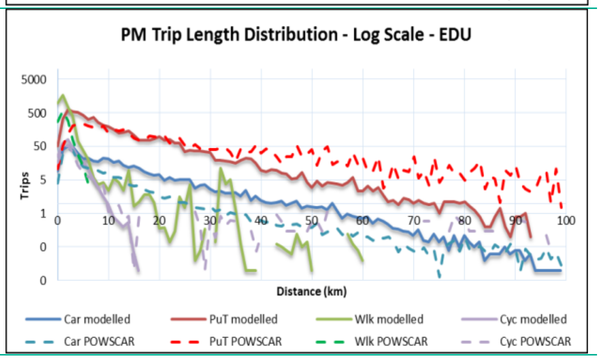
TP	COM	EDU
AM		
IP1		
IP2		
PM		

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 trip rates for each time period are shown in Figure 4.5 to Figure 4.8. Though the match is not perfect, it would be unrealistic to expect this and in general these show a good correspondence between the modelled and observed proportions of intrazonals. The largest disparity is between the modelled and observed proportions of PT and cycle trips in the EMP group, and for walk trips in the COM group. These disparities occur in all of the four time periods.

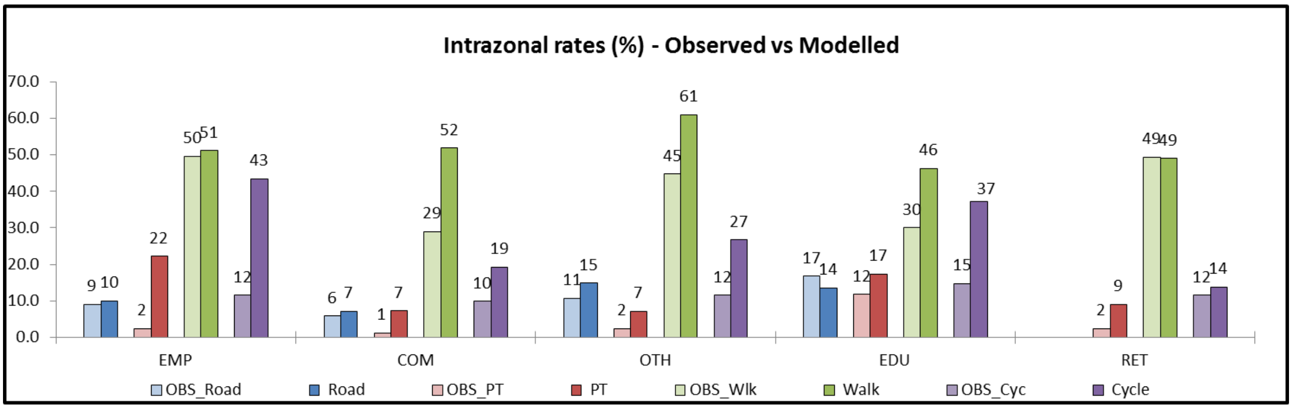


Figure 4.5: AM Intrazonal Trip Rate Proportion

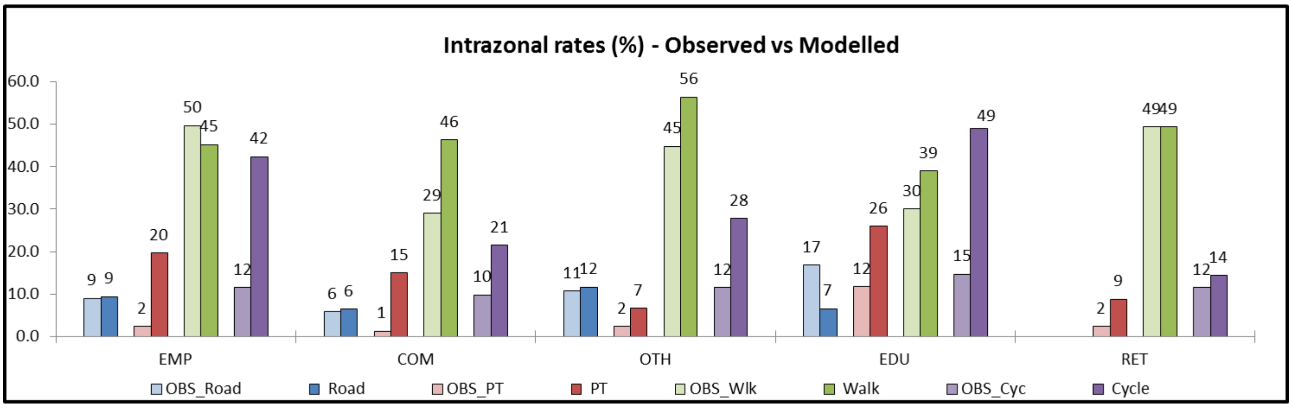


Figure 4.6: IP1 Intrazonal Trip Rate Proportion

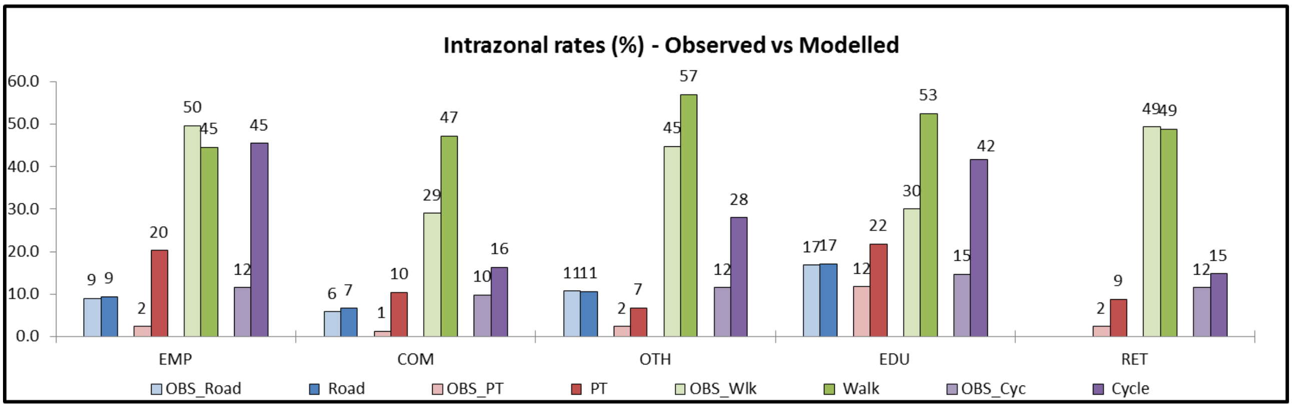


Figure 4.7: IP2 Intrazonal Trip Rate Proportion

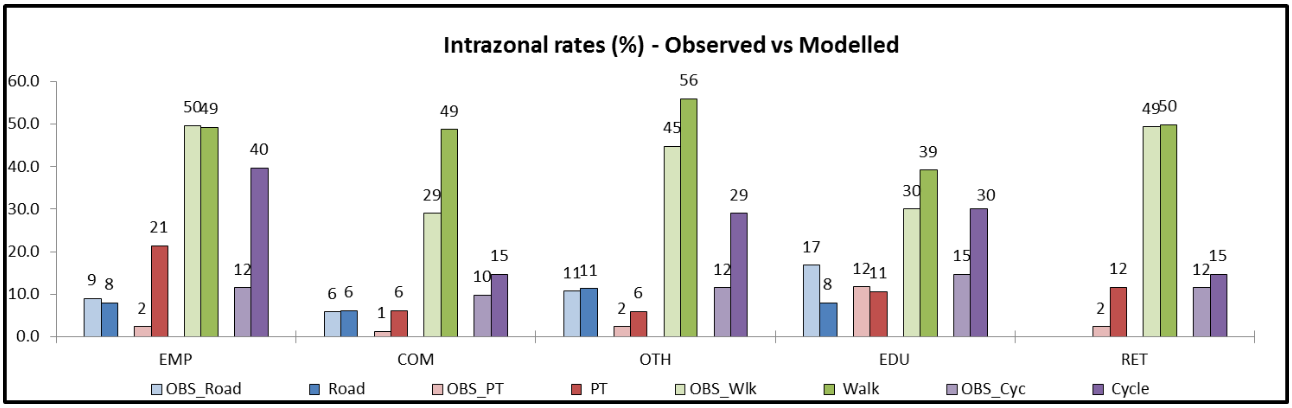


Figure 4.8: PM Intrazonal Trip Rate Proportion

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.

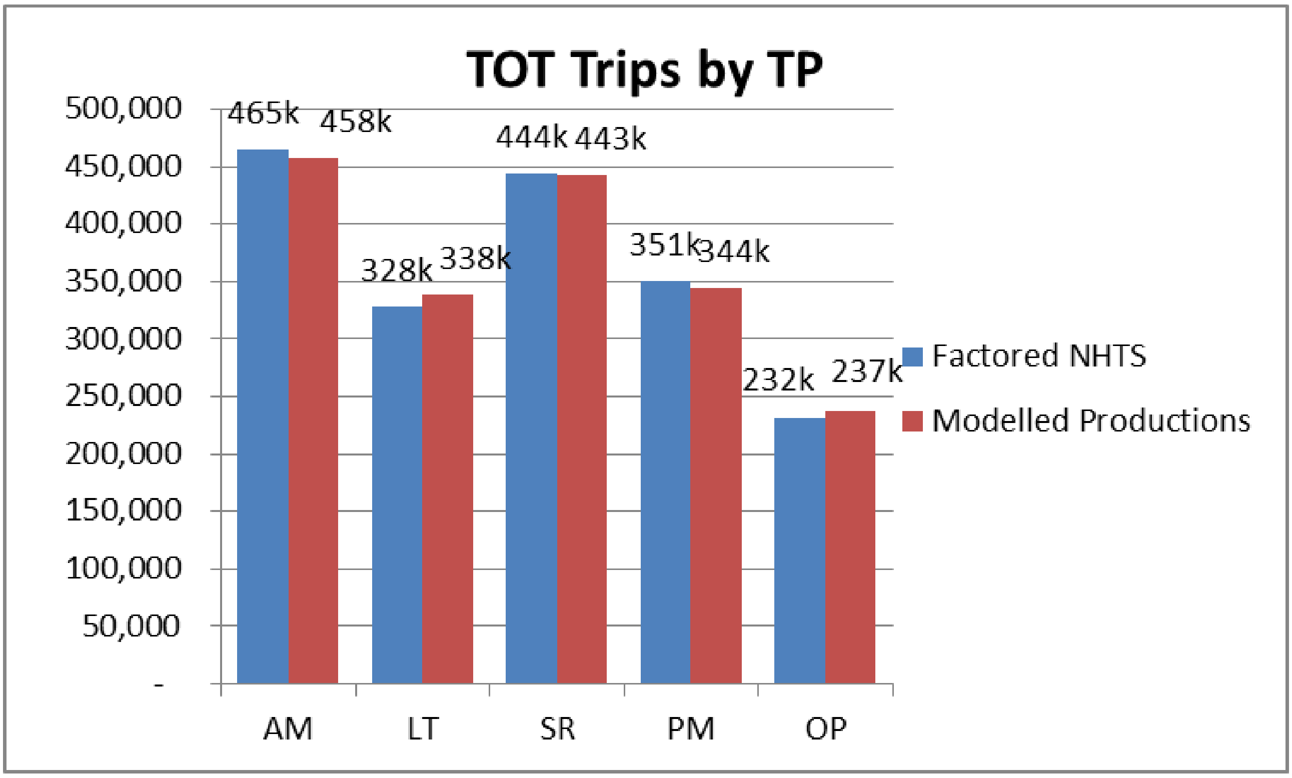
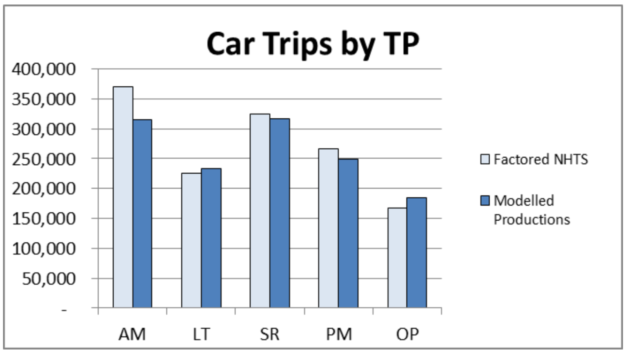
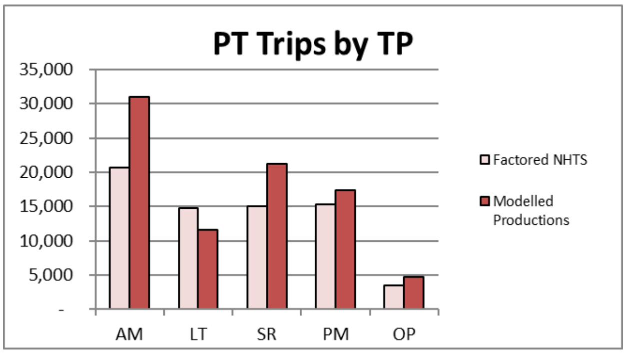


Figure 4.9: Total Trips by Time Period

The number of observed and modelled trips by each mode in each time period (Figure 4.10) also compares well although car trips are slightly underestimated in the AM peak, while the other three modes are high, and cycle trips tend to be high in all peaks.

Car Trips	PT Trips
	

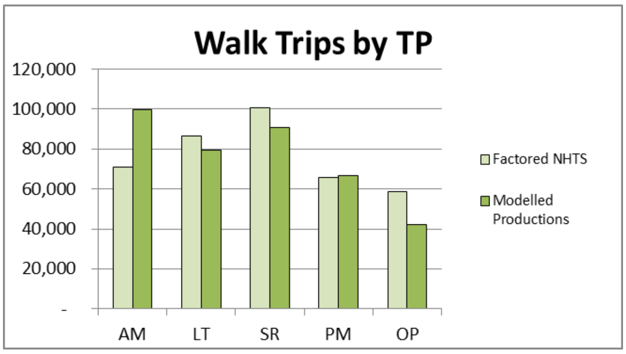
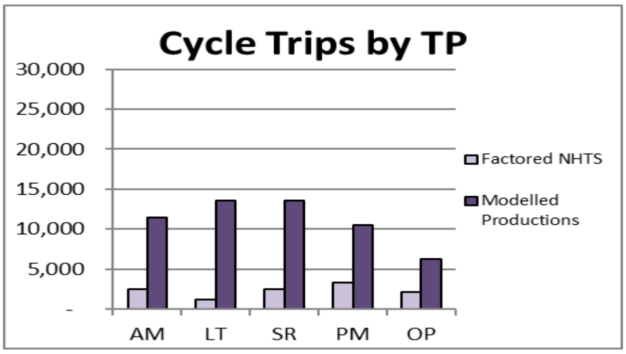
Walk Trips	Cycle Trips
	

Figure 4.10: Total Trips by Time Period and Mode

4.4 Correcting from calibrated demand to correct movements on the ground

4.4.1 Limitations of demand model calibration

Experience and the intended purpose of the modelling system are factors in deciding whether or not the demand model outputs should be adjusted before assignment so as to improve the match between modelled and observed link flows and / or journey times.

In some cases, it is appropriate to introduce a process like matrix estimation, or some alternative method of matrix factoring, to ‘revise’ the demand model outputs and so produce assignments which mimic real world movements more exactly. Although this can help to achieve targets for network calibration, it often results in matrices that are unacceptably different from those output directly by the demand model, limiting the scope for successful modelling of future movements.

Therefore, any process of estimation / factoring needs to limit the divergence between the demand model outputs and the assignment matrices. 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 and the forecasting reliability of the demand model should be improved.

In this model two measures of matrix change are applied:

- Sector to sector movements – these check for changes in the overall ‘shape’ of the matrix and ensure that there are not unacceptably large changes in large scale model flows.
- R-squared analyses – these compare prior and post cell and trip end values to see how close they lie to the x=y line (which would indicate that there had been no change at all).

4.4.2 Sector to sector movements

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

A comparison of sector to sector movements before and after matrix estimation / factoring is shown in Figure 4.11 (for road) and Figure 4.12 (for PT). While there are some larger differences in individual cells the overall changes in the trip ends are smaller, all less than 5% in the road case with the exception of the external sector (sector 12), and all less than 5% for PT.

Differences - Sector to sector matrix												
1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
4%	1%	-7%	-6%	2%	5%	29%	-1%	-14%	-5%	9%	-19%	0%
7%	1%	-13%	-1%	-1%	11%	1%	1%	1%	-4%	-7%	-20%	-2%
-2%	-1%	-1%	-1%	6%	3%	13%	-9%	-11%	-1%	15%	-23%	1%
-1%	-2%	-10%	1%	5%	13%	-5%	5%	7%	1%	-6%	-10%	0%
5%	7%	3%	5%	-4%	15%	-8%	-19%	-6%	21%	1%	-24%	-1%
3%	-14%	6%	-14%	17%	-4%	-2%	-13%	-10%	11%	6%	-19%	0%
16%	10%	12%	6%	8%	10%	1%	-2%	-10%	1%	6%	-25%	2%
5%	-3%	9%	6%	-15%	-16%	-6%	-1%	-8%	-8%	-23%	-7%	-2%
-3%	1%	-17%	16%	-4%	4%	-22%	-4%	1%	-4%	-23%	19%	0%
2%	-15%	7%	-6%	16%	10%	1%	3%	-5%	0%	8%	4%	0%
-3%	-6%	17%	2%	3%	-3%	9%	-17%	-11%	-3%	0%	-34%	1%
-16%	-17%	-11%	-6%	-16%	-20%	-24%	-10%	10%	0%	-38%	9%	-10%
2%	-1%	2%	2%	2%	3%	2%	-2%	-1%	0%	0%	-10%	0%

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

1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
0%	-2%	-4%	-4%	-1%	0%	0%	-5%	4%	-2%	-5%	-3%	-2%
-2%	-2%	-10%	-3%	-5%	-2%	-2%	-3%	2%	-3%	-10%	-3%	-4%
-3%	-9%	-2%	-4%	-3%	-2%	-1%	-6%	2%	-1%	-2%	-3%	-3%
-3%	-3%	-13%	-3%	-9%	-5%	-3%	-4%	1%	-3%	-12%	-3%	-5%
4%	1%	0%	3%	0%	-1%	-1%	-2%	3%	-1%	-3%	-1%	0%
1%	0%	-2%	1%	-1%	0%	-2%	-6%	-1%	-2%	-8%	-2%	-1%
-1%	-5%	-3%	-4%	-3%	-2%	0%	-5%	-1%	0%	-2%	-2%	-1%
-3%	-2%	-8%	-2%	-7%	-3%	-1%	0%	0%	0%	-5%	-1%	-1%
-3%	-3%	-10%	-2%	-5%	-2%	-3%	-1%	0%	0%	-6%	-1%	-2%
-2%	-3%	-4%	-2%	-4%	-1%	0%	-1%	0%	0%	-2%	0%	0%
-7%	-15%	-4%	-11%	-16%	-12%	-1%	-5%	-3%	-3%	-1%	-2%	-4%
-1%	-1%	-2%	-1%	0%	0%	0%	-1%	0%	0%	-2%	0%	-1%
-2%	-4%	-4%	-3%	-3%	-1%	0%	-2%	1%	0%	-3%	-2%	-2%

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

4.4.3 R-squared Analysis

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

Table 4.1: Significance of Matrix Estimation Changes

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

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

AM

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

Table 4.2: AM Matrix Change R^2 Analysis

User Class	Emp. Business	Commute	Education	Other
Cell R-Squared	0.91	0.93	0.97	0.97
Cell Slope	0.98	0.97	1.00	0.99
Cell Y-Intercept	0.00	0.00	0.00	0.00
Trip End R-Squared	0.97	0.99	0.99	0.99
Trip End Slope	0.99	0.97	1.00	0.97
Trip End Y-Intercept	0.11	0.78	0.01	1.69

The acceptable R^2 value for individual matrix zonal changes is in excess of 0.95 which is matched by the Education and Other user classes. The two user classes which do not pass the criteria but both have an R^2 value of greater than 0.91. Three of the user classes pass the recommended criteria for zonal slope values between 0.98 – 1.02. The remaining value of 0.97 for Commute narrowly fails to meet the criteria. With regard to the trip end criteria, three of the four user classes are within the R^2 criterion, but only two user classes fully meet the slope criterion.

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. Business	Commute	Education	Other
Cell R-Squared	0.88	0.85	0.89	0.95
Cell Slope	1.01	0.88	0.96	1.01
Cell Y-Intercept	0.00	0.00	0.00	0.00
Trip End R-Squared	0.97	0.98	0.99	0.99
Trip End Slope	0.99	0.88	0.98	0.99
Trip End Y-Intercept	-0.04	0.81	0.00	0.16

Three of the four user classes are just outside the acceptable range for the individual cell R^2, with the Commute and Education classes also falling outside the slope criterion. With regard to the trip end criteria, three of the four user classes are within the R^2 criterion, but only two user classes fully meet 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. Business	Commute	Education	Other
Cell R-Squared	0.89	0.89	0.97	0.96
Cell Slope	1.01	0.95	1.04	1.01
Cell Y-Intercept	0.00	0.00	0.00	0.00
Trip End R-Squared	0.98	0.98	0.99	0.99
Trip End Slope	0.99	0.93	1.04	0.99
Trip End Y-Intercept	-0.08	0.82	-0.02	0.00

Two of the user classes pass the individual cell R^2 and cell slope tests, with the other two falling just outside the range. All of the user classes meet the trip-end R^2 criterion. For the trip-end slope criterion, two of the user classes narrowly fail.

PM

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

Table 4.5: PM Matrix Change R^2 Analysis

User Class	Emp. Business	Commute	Education	Other
Cell R-Squared	0.88	0.91	0.94	0.95
Cell Slope	1.00	0.97	0.99	0.99
Cell Y-Intercept	0.00	0.00	0.00	0.00
Trip End R-Squared	0.98	0.99	0.99	0.98
Trip End Slope	1.05	0.99	1.02	1.00
Trip End Y-Intercept	0.08	0.68	0.00	1.28

One user class passes the individual cell R^2 test. The other three user classes which do not pass the criterion all have an R^2 value of above 0.88. All 4 user classes pass the trip end R^2 test. For the cell and trip end slope tests, three and two user classes pass respectively, with the other user class(es) falling just outside the ranges for both tests.

4.4.4 Application of estimation / factoring information to the demand model

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

Table 4.6: Scale of incremental matrices

	AM	LT	SR	PM
Taxi	0.0%	0.0%	0.0%	0.0%
Car	-1.0%	-0.8%	-1.0%	1.5%
PT	-10.7%	0.0%	0.0%	-8.6%
Walk	0%	0%	0%	0%
Cycle	0%	0%	0%	0%

4.5 Road calibration and validation

The development, calibration, and validation of the road model is described in detail in the SWRM 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 reasonably good with overall values for all links falling out at:

- AM 82% / 46%;
- IP1 89% / 52%;
- IP2 85% / 50%; and
- PM 79% / 36%.

Journey time validation was reasonable with 70% of trips meeting the pass criteria in the AM peak, 85% in IP1 and 45% in the IP2 and PM peaks.

4.6 Public transport calibration and validation

The development, calibration and validation of the public transport model is described in detail in the SWRM Public Transport 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 and for the time periods where data is available. In general, the match to flows is reasonable, though it tends to be worse in the outbound direction for the city services.

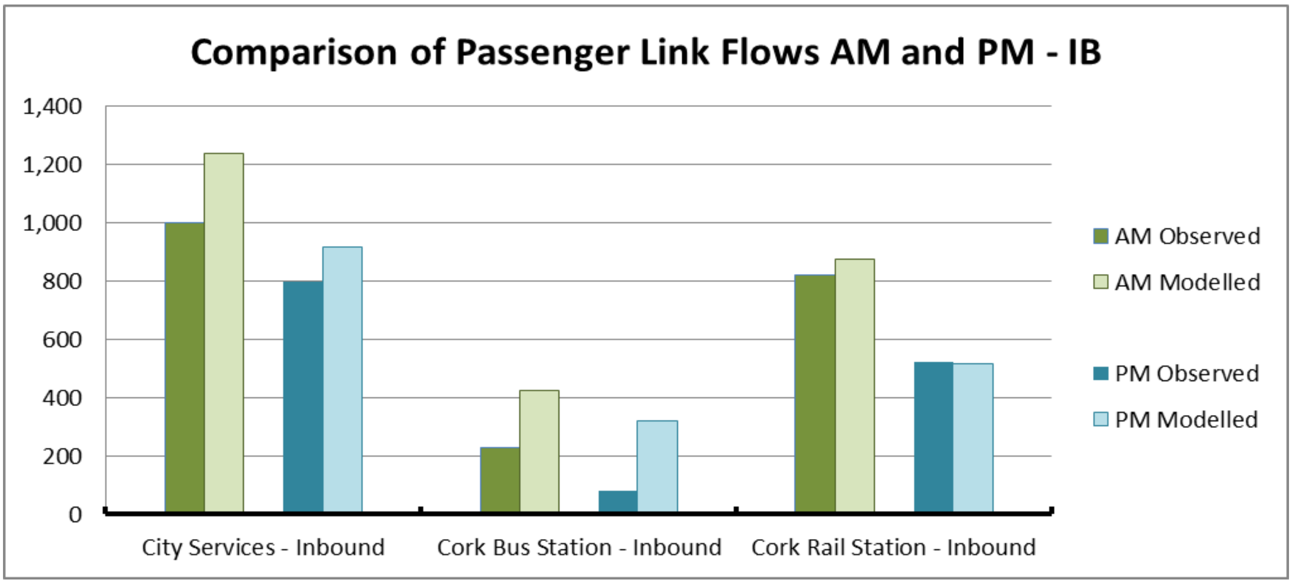


Figure 4.13: Inbound PT passenger flows

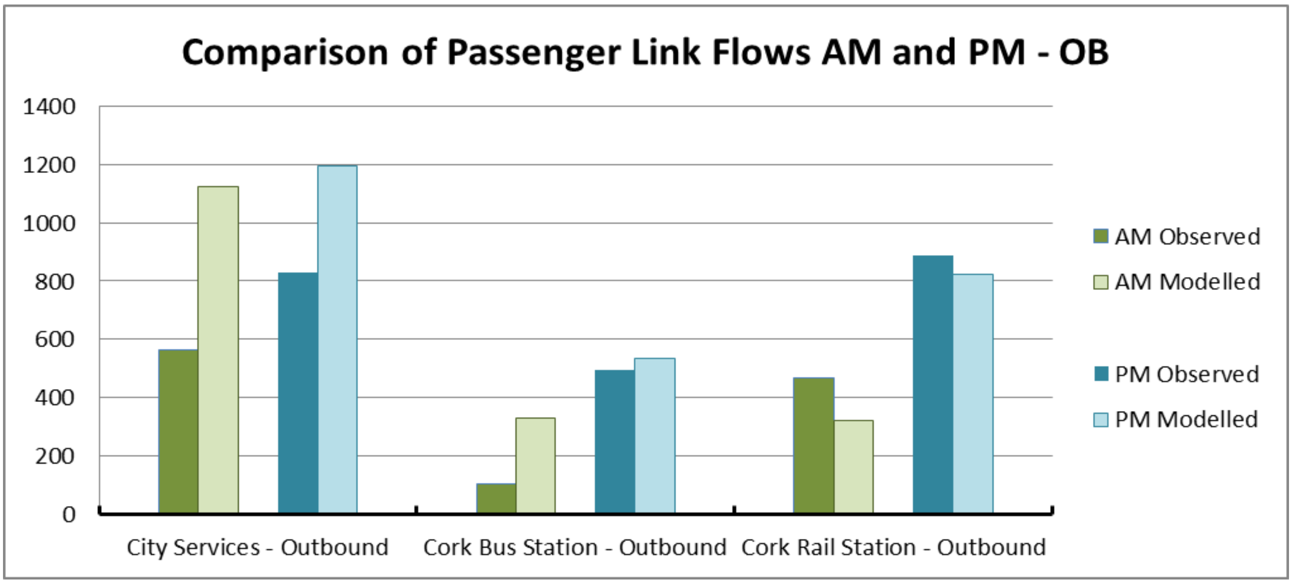


Figure 4.14: Outbound PT passenger flows

Figure 4.15 and Figure 4.16 show rail boardings by time period. The overall pattern is quite good, particularly for the boardings, though alightings are somewhat high in the AM peak and low in the PM peak.

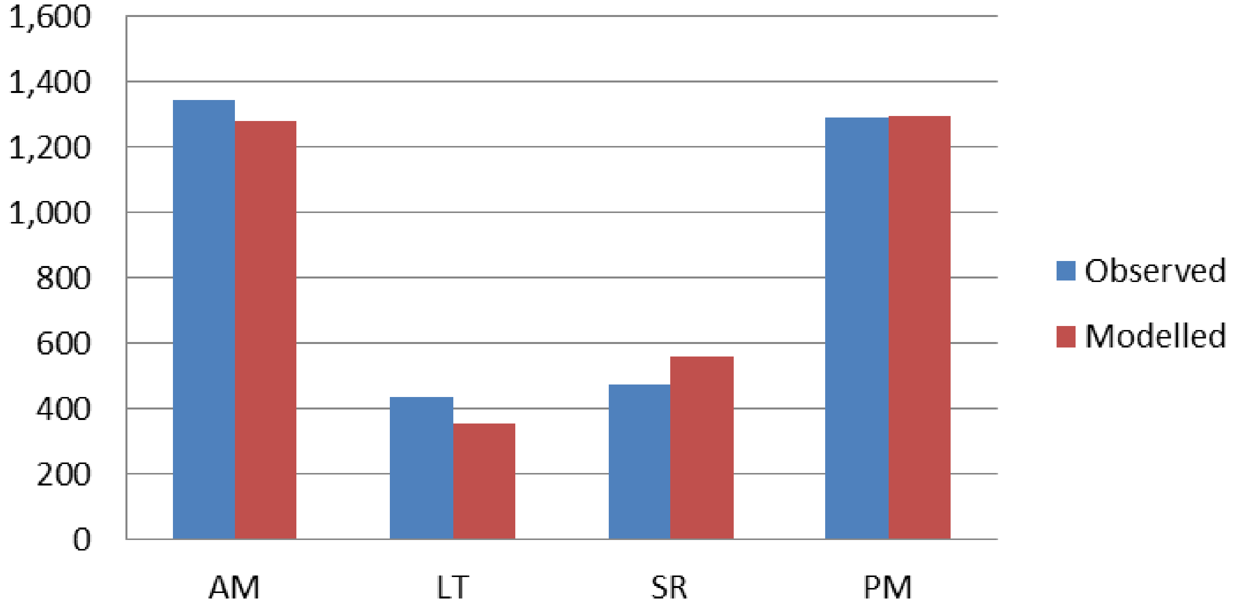


Figure 4.15: Rail boardings by time period

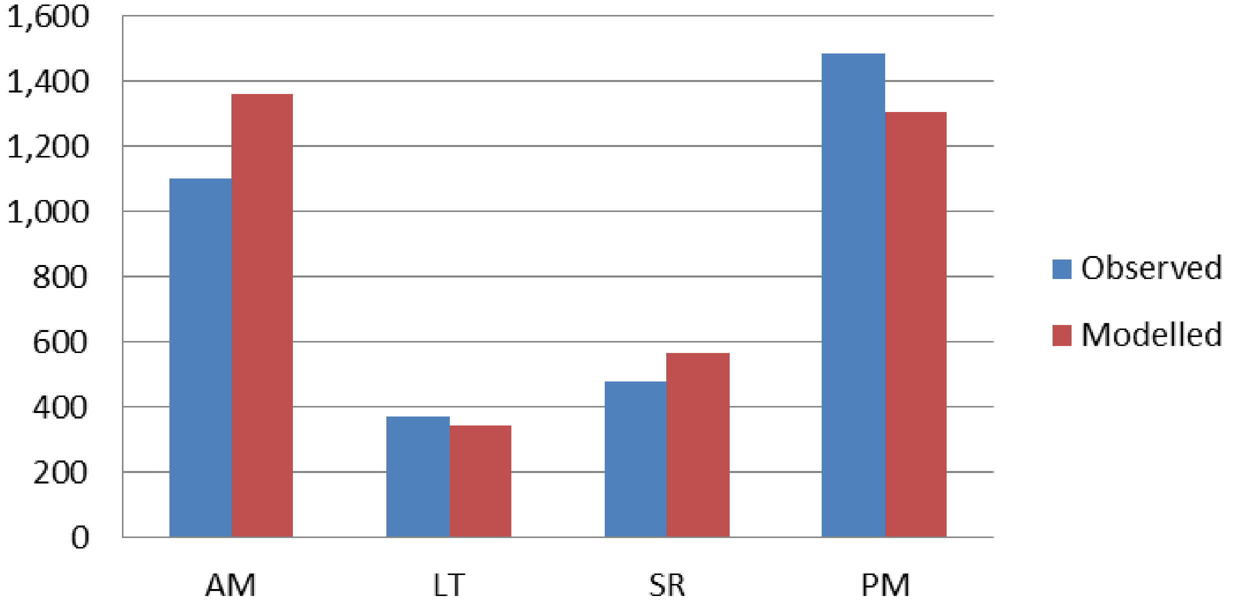


Figure 4.16: Rail alightings by time period

4.7 Active Mode calibration and validation

As there was insufficient count data available with which to calibrate the active modes network it has not been calibrated. However, the mode shares and trip length distributions do look plausible.

4.8 Overview

Though there is still room for improvement, overall:

- Mode splits are considered robust as are generalised cost distributions, trip lengths, intrazonal trip numbers, and time period distributions;
- The amount of matrix estimation / factoring required to convert base output demand matrices to matrices which match behaviour on the ground is more or less reasonable;
- Incrementals form only a small proportion of the overall assignment matrices;
- Road calibration / validation is reasonably good; and
- 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. However, in order to estimate how accurately the model will be able to predict future conditions, it is important to run realism tests before undertaking true forecast year runs. WebTAG recommends a series of three standard realism tests[4], 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[5]

[4] 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

[5] 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.

Time	0.00 to -0.20

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 all-purposes level (last row), the elasticities are inside the WebTAG range with the exception of that for the SR time period which is very fractionally outside the suggested range (Table 5.2).

At the all-day level (last column) EMP and EDU trips tend to have lower elasticities than the suggested range. 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 costs of business travel. It is therefore plausible that EMP trips should show a low level of sensitivity to car fuel cost.

Similarly, EDU users generally do not cover their own fuel costs while RET users, who tend to have high sensitivities, are inclined to be time rich and cash poor with lower values of time, making it plausible that they might respond more strongly to fuel price rises than other groups.

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

Table 5.2: Car fuel cost elasticities

User class	AM	LT	SR	PM	OP*	24 Hour
EMP	-0.1266	-0.0910	-0.0933	-0.1167	-0.0880	**-0.1036**
COM	-0.2467	-0.3365	-0.0871	-0.2957	-0.3165	**-0.2575**
OTH	-0.4278	-0.2714	-0.2650	-0.4000	-0.2922	**-0.3104**
EDU	-0.2382	-0.2123	-0.2328	-0.2161	-0.1970	**-0.2295**
RET**	-0.4732	-0.3491	-0.3389	-0.4548	-0.3393	**-0.3916**
Total	**-0.3188**	**-0.2634**	**-0.2419**	**-0.3376**	**-0.2851**	**-0.2866**

* LT distance skim used for OP

** OTH distance skim used for RET

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 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 cost changes than is suggested by WebTAG. Overall the model is considered to respond predictably and sensibly to changes in PT fares.

Table 5.3: PT fare elasticities

User class	AM	LT	SR	PM	OP*	24 Hour
EMP	-0.1936	-0.1826	-0.1682	-0.1871	-0.1758	**-0.1822**
COM	-0.4900	-0.4377	-0.4473	-0.5104	-0.4656	**-0.4834**
OTH	-0.3873	-0.3614	-0.3659	-0.3741	-0.3860	**-0.3713**
EDU	-0.2327	-0.1864	-0.2385	-0.2216	-0.2184	**-0.2299**
RET*	-0.0032	-0.0007	-0.0018	-0.0012	-0.0023	**-0.0019**
Total	**-0.2572**	**-0.2585**	**-0.2514**	**-0.2800**	**-0.2851**	**-0.2626**

* Concessionary travel

5.3.3 Car journey time elasticity

Table 5.4 shows the response of the model to car journey time changes. In the RET group the responses are more elastic than would be expected, but the majority of other values and all those in the all-day or all-purposes categories are inside the expected range. Although the RET group is slightly more cost sensitive than would be ideal, the overall response is close enough to the preferred range to suggest that 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	-0.0942	-0.0790	-0.0769	-0.0863	-0.0497	**-0.0797**
COM	-0.1261	-0.1119	-0.0929	-0.1320	-0.1076	**-0.1198**
OTH	-0.1754	-0.1328	-0.1401	-0.1874	-0.1587	**-0.1543**
EDU	-0.1977	-0.1868	-0.1493	-0.2762	-0.1733	**-0.1948**
RET	-0.2702	-0.2381	-0.2297	-0.2627	-0.2195	**-0.2460**
Total	**-0.1711**	**-0.1368**	**-0.1421**	**-0.1807**	**-0.1494**	**-0.1565**

6 Conclusion and recommendations

6.1 Introduction

This report has described the calibration and validation of the FDM component of the South 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 finalised SWRM used the standard FDM release version 2.0.23 in combination with region specific inputs and appropriate road, PT, and active modes networks.
- All modules are in use and turned on except macro time of day choice which has yet to be fully implemented.
- The process of FDM calibration for the SWRM 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 4 percentage points of the observed data.
- **Generalised Cost Distribution:** Generalised cost curves were calibrated to POWSCAR and NHTS data and are well matched for car and walk trips. PT trips are less well matched, but only at high costs where there are comparatively fewer trips.
- **Trip Length Distribution:** Trip length distributions for COM and EDU were compared to observed (POWSCAR) trip length distributions. The match is good, 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 reasonable match to the observed pattern, though modelled PT and cycle intrazonals tend to be high in the EMP group and walk intrazonals high for the COM group.

- **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 good though cycle trips tend to be high in all peaks.
- **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 good with calibrations above 79%, though validation is less good. Journey time validation is reasonable at 45 - 85%. The development, calibration, and validation of the road model is covered in more detail in the SWRM Road Model Development Report.
- **PT calibration and validation:** The level of PT calibration is good, despite the limited data available. The development, calibration, and validation of the PT model is covered in more detail in the SWRM PT Model Development Report.
- **Active modes calibration and validation:** As there is very limited data available, the active modes model has not been calibrated or validated. However, the development of the Active Modes Model is covered in the SWRM Active Modes Model Development Report.

6.4 Recommendations for Further Development

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

1) Improve the calibration of the PT, Park and Ride and active modes models
2) Address the external trip issues
3) Reduce the amount of matrix change caused by matrix estimation / PT factoring

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
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	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_9UC_Tolls_2011.444
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	{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
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	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\FARES_AM.FAR
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\FARES_LT.FAR
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\FARES_PM.FAR
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\FARES_SR.FAR
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\NTL_GENERATE_SCRIPT.txt
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\4 PT_Dump_Links.csv
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\SELECT_LINK_SPEC.TXT
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\SYSTEM_FILE.PTS
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Factor_Files\???_NO_VOT_AM.FAC
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	{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
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	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Luas_Nodes.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Metro_Links.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Metro_Nodes.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Rail_Links.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Rail_Nodes.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Walk_Links.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\4 PT\Walk_Nodes.dbf
Active modes	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\AMM\CYCLE_DATA.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Networks\AMM\PED_ONLY.DBF
Finalisation files	{CATALOG_DIR}\Params\AssPrep\CarUserToCarDriver.PRM
	{CATALOG_DIR}\Params\AssPrep\PeriodToHour.PRM
	{CATALOG_DIR}\Params\AssPrep\AM_Incrementals.INC
	{CATALOG_DIR}\Params\AssPrep\LT_Incrementals.INC
	{CATALOG_DIR}\Params\AssPrep\SR_Incrementals.INC
	{CATALOG_DIR}\Params\AssPrep\PM_Incrementals.INC
	{CATALOG_DIR}\Params\AssPrep\OP_Incrementals.INC
	{CATALOG_DIR}\Params\AssPrep\TaxiProps.MAT
	{CATALOG_DIR}\Params\AssPrep\Taxi_Incrementals.INC
Preliminary test / dummy files	{CATALOG_DIR}\Params\Active_Assignment \Dummy_Active_Assign.AAM
	{CATALOG_DIR}\Params\Empty.prn
	{CATALOG_DIR}\Params\FWPP\Dummy_FWPP.MAT
	{CATALOG_DIR}\Params\PnR\PnR_Blank_Costs.AGC
	{CATALOG_DIR}\Params\PnR\PnR_Start_File.CSV
	{CATALOG_DIR}\Params\4 PT \4 PT_Assignment_Test.PTM
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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 estimation

A2.1 Introduction

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

A2.2 Port of Cork / Ringaskiddy

There are three zones that contain Port related trips.

- Port of Cork – City Quays;
- Port of Cork – Ringaskiddy; and
- Port of Cork – Tivoli.

A2.2.1 Port of Cork Model

In 2014 The Port of Cork (PoC) submitted a Strategic Infrastructure Development (SID) application to An Bord Pleanála (ABP), for the provision of a new container terminal and the expansion and upgrading of Port facilities at Ringaskiddy. This development accommodated the relocation of Port facilities from Tivoli and City Quays to Ringaskiddy. In order to assess the traffic impacts of the redevelopment at Ringaskiddy, the Port of Cork Traffic Model was developed.

An existing Saturn model of the Cork Metropolitan area (The Cork Area Strategic Plan (CASP) SATURN model), which was upgraded in 2010 for the Dunkettle interchange study, was used as a base for developing the Port of Cork Model highway network. This model was updated to a 2012 base year using the following information:

- Traffic surveys at Tivoli and Ringaskiddy ports, including turning counts at the Ferry Terminal, conducted in May 2012;
- Roadside interviews at Tivoli and Ringaskiddy and observations at City Quays, conducted in May 2012;
- Journey time surveys along the N28 between Shannon Park Roundabout and Ringaskiddy, conducted May 2012;
- Automatic traffic counts (ATCs) at Bloomfield Interchange and along the N28 between Shannon Park Roundabout and Ringaskiddy, conducted May 2012;
- ATCs along the N28 and other roads near Douglas/ Rochestown, conducted April 2012;
- Manual classified counts (MCCs) along roads near Douglas/ Rochestown, conducted April 2012;
- MCCs near Dunkettle and Cork City undertaken as part of the CASP model update in November 2012; and
- Data from NRA traffic counters along the N25.

All the inputs listed above were then used to enhance the existing network to ensure it represented, as accurately as possible, the existing road network.

A2.2.2 Port of Cork Traffic

Particular attention was paid to traffic generated by the Port of Cork sites in Ringaskiddy, Tivoli and City Quays. Ringaskiddy Port was assigned two zones in the model, one representing the deep-water berth and associated traffic and one representing the ferry terminal. Tivoli and City Quays were both represented by their own specific zones.

To ensure that an accurate level of base year traffic was allocated to the Port sites, the number of trips to and from these zones in the base year was based on a series of ATCs and MCCs which were carried out over a period of two weeks in November 2012.The distribution of Port of Cork trips was determined using information gathered during roadside interview surveys at Tivoli and Ringaskiddy Ports. During these surveys, every vehicle entering and leaving the port provided details on their origin/ destination as well as time of departure, route taken and journey time.

As the trip generation and distribution of port traffic in the POC model was been based on a considerable amount of survey data, the trip patterns could be used directly in the SWRM with the proviso that demands had to be converted from those available in the POC model (08:00-09:00 and 16:00-17:00) to those required by the SWRM.

A2.3 Cork Airport

This section discusses how the highway and PT Attractions and Productions are generated for Cork Airport.

A2.3.1 Demand

Terminal traffic, ie passengers who started or ended their journey at Cork Airport was 2.34 million in 2012 (Source: Cork Airport). Cork Airport statistics were available from the County Cork Council website. These statistics break down the annual passenger numbers to monthly levels and assumptions were made to represent a typical weekday in November.

- 153,934 – Monthly passengers in November
- 28,422 – Typical weekday (5 day) passenger numbers
- 5,684 – Typical passenger numbers in November on a single day

A2.3.2 Flows by time period

The next consideration was to break down the daily passenger flow by time period. Flight arrival and departure data was obtained from the Cork 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%	8%
LT	1000 - 1300	26%	22%
SR	1300 - 1600	19%	24%
PM	1600 - 1900	16%	13%
OP	1900 - 0700	39%	33%
		100%	100%

CSO Aviation Statistics[6] for all Irish airports including Cork Airport show that passenger numbers are split 50:50 between arrivals and departures. Therefore, if 2.34 million passengers use Cork Airport it is assumed that the split between arrivals and departures is 1.17 million 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

Cork Airport is located 8.6km south of Cork City and is reasonably well served by public transport, but PT usage in Ireland outside of Dublin is not high, so in the absence of site

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

specific observed mode share data, it was assumed that 10% of all trips to Cork Airport are by public transport.

A2.3.3 Car trips per passenger

There were two final factors to consider before the number of car movements generated by Cork 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. Specific data was available for Cork Airport indicating that the proportion of drop off / pick up trips was around 30%[7] and this figure was used.

A2.3.4 Output productions / 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	22	0	128	0
LT	1000 - 1300	62	75	362	438
SR	1300 - 1600	69	52	405	306
PM	1600 - 1900	36	45	213	263
OP	19-00-0700	95	112	554	656
		284	**284**	**1,1663**	**1,663**

A2.3.5 Period to Peak Hour Factor

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

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

Due to the minimal demand for internal flights, Irish travellers are assumed to derive from homes and businesses, overseas leisure travellers from homes and hotels, and overseas business visitors from homes and hotels. In the regional models, these splits are based on the NACE codes giving the distributions of hotels, employment, and housing, and

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

assumptions about the likely directionality of trips at different times of day. The finalised split is shown in Table A2.3.

Table A2.3 Split of Inbound Outbound trips by destination type

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

A2.3.7 Distribution

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

Home Trips

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

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

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

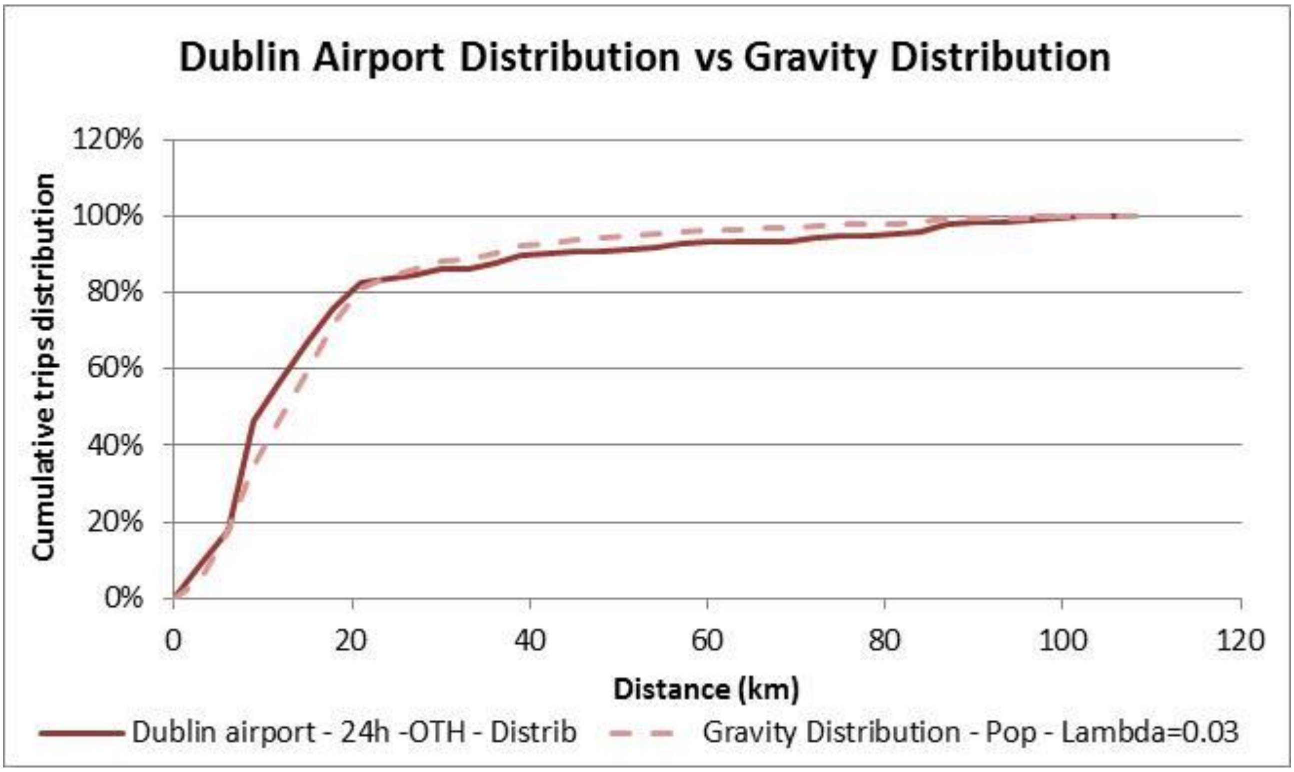

Figure A2.2 Dublin Airport – Distribution vs Gravity Distribution

For Cork Airport this gravity model gave the modelled distribution shown in Figure A2.3.

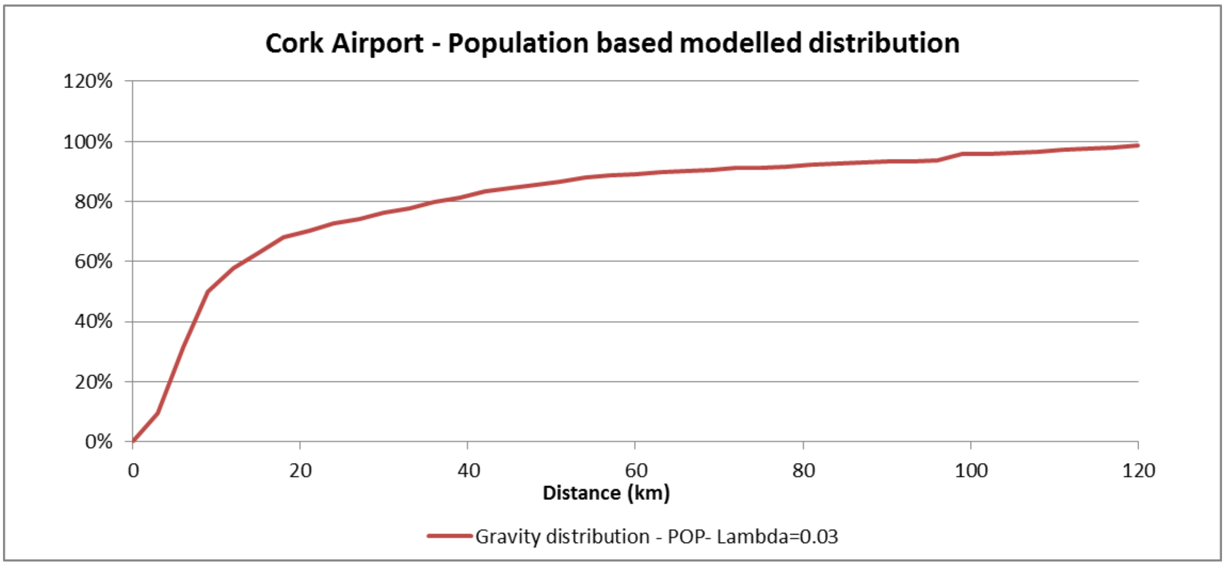

Figure A2.3 Population based modelled distribution

Leisure Trips

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

Business Trips

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

Annex 3 Final demand model parameter values

The data included is as follows:

- Table A3.4:Production tour proportions by purpose
- Table A3.5:Attraction tour proportions by purpose
- Table A3.6:Finalised distribution and mode split parameters
- Table A3.7:Finalised period to hour factors
- Table A3.8:Finalised parking distribution calibration parameters
- Table A3.9:Finalised special zone calibration parameters

Table A3.4: 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	0.01762	0.01982	0.13877	0.43392	0.10793	0.00000	0.01410	0.01256	0.03529	0.02577	0.00000	0.00000	0.00661	0.03745	0.03965	0.00000	0.00000	0.00000	0.00661	0.01982	0.00661	0.00727	0.01727	0.03634	0.01652
P02	0.01762	0.01982	0.13877	0.43392	0.10793	0.00000	0.01410	0.01256	0.03529	0.02577	0.00000	0.00000	0.00661	0.03745	0.03965	0.00000	0.00000	0.00000	0.00661	0.01982	0.00661	0.00727	0.01727	0.03634	0.01652
P03	0.10526	0.04211	0.13684	0.32632	0.03158	0.00000	0.02105	0.03158	0.02105	0.06316	0.00000	0.00000	0.03158	0.06316	0.03158	0.00000	0.00000	0.00000	0.00000	0.06316	0.00000	0.00000	0.01053	0.02105	0.00000
P04	0.10526	0.04211	0.13684	0.32632	0.03158	0.00000	0.02105	0.03158	0.02105	0.06316	0.00000	0.00000	0.03158	0.06316	0.03158	0.00000	0.00000	0.00000	0.00000	0.06316	0.00000	0.00000	0.01053	0.02105	0.00000
P05	0.00000	0.02740	0.77397	0.16438	0.01370	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00685	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01370
P06	0.00000	0.01786	0.44643	0.50000	0.03571	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
P07	0.06250	0.02083	0.16667	0.41667	0.16667	0.00000	0.00000	0.02083	0.10417	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.02083	0.00000	0.00000	0.00000	0.00000	0.02083
P08	0.00000	0.02740	0.77397	0.16438	0.01370	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00685	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01370
P09	0.00000	0.01786	0.44643	0.50000	0.03571	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
P10	0.06250	0.02083	0.16667	0.41667	0.16667	0.00000	0.00000	0.02083	0.10417	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.02083	0.00000	0.00000	0.00000	0.00000	0.02083
P11	0.30104	0.05882	0.09343	0.08997	0.02768	0.00000	0.05190	0.00692	0.00000	0.00000	0.00000	0.00000	0.31142	0.03460	0.00346	0.00000	0.00000	0.00000	0.01038	0.00346	0.00000	0.00000	0.00000	0.00000	0.00692
P12	0.30104	0.05882	0.09343	0.08997	0.02768	0.00000	0.05190	0.00692	0.00000	0.00000	0.00000	0.00000	0.31142	0.03460	0.00346	0.00000	0.00000	0.00000	0.01038	0.00346	0.00000	0.00000	0.00000	0.00000	0.00692
P13	0.30104	0.05882	0.09343	0.08997	0.02768	0.00000	0.05190	0.00692	0.00000	0.00000	0.00000	0.00000	0.31142	0.03460	0.00346	0.00000	0.00000	0.00000	0.01038	0.00346	0.00000	0.00000	0.00000	0.00000	0.00692
P14	0.30104	0.05882	0.09343	0.08997	0.02768	0.00000	0.05190	0.00692	0.00000	0.00000	0.00000	0.00000	0.31142	0.03460	0.00346	0.00000	0.00000	0.00000	0.01038	0.00346	0.00000	0.00000	0.00000	0.00000	0.00692
P15	0.30104	0.05882	0.09343	0.08997	0.02768	0.00000	0.05190	0.00692	0.00000	0.00000	0.00000	0.00000	0.31142	0.03460	0.00346	0.00000	0.00000	0.00000	0.01038	0.00346	0.00000	0.00000	0.00000	0.00000	0.00692
P16	0.30104	0.05882	0.09343	0.08997	0.02768	0.00000	0.05190	0.00692	0.00000	0.00000	0.00000	0.00000	0.31142	0.03460	0.00346	0.00000	0.00000	0.00000	0.01038	0.00346	0.00000	0.00000	0.00000	0.00000	0.00692
P17	0.07166	0.12378	0.02606	0.01303	0.00326	0.00000	0.18567	0.10098	0.03583	0.00652	0.00000	0.00000	0.10424	0.06840	0.00652	0.00000	0.00000	0.00000	0.07818	0.05863	0.00000	0.00000	0.00000	0.00000	0.11726
P18	0.03804	0.05978	0.01902	0.02446	0.01087	0.00000	0.10598	0.08696	0.03804	0.00815	0.00000	0.00000	0.11413	0.10326	0.00815	0.00000	0.00000	0.00000	0.07609	0.10326	0.00000	0.00000	0.00000	0.00000	0.20380
P19	0.05172	0.12069	0.05172	0.00000	0.00000	0.00000	0.25862	0.12069	0.00000	0.00000	0.00000	0.00000	0.03448	0.06897	0.00000	0.00000	0.00000	0.00000	0.12069	0.03448	0.00000	0.00000	0.00000	0.00000	0.13793
P20	0.04000	0.00000	0.04000	0.00000	0.00000	0.00000	0.18000	0.16000	0.02000	0.00000	0.00000	0.00000	0.08000	0.08000	0.00000	0.00000	0.00000	0.00000	0.14000	0.14000	0.00000	0.00000	0.00000	0.00000	0.12000
P21	0.04951	0.07921	0.00000	0.00000	0.00000	0.00000	0.35644	0.13861	0.01980	0.00000	0.00000	0.00000	0.15842	0.07921	0.00990	0.00000	0.00000	0.00000	0.05941	0.02970	0.00000	0.00000	0.00000	0.00000	0.01980
P22	0.05102	0.05102	0.00000	0.00000	0.01020	0.00000	0.18367	0.24490	0.00000	0.00000	0.00000	0.00000	0.10204	0.08163	0.00000	0.00000	0.00000	0.00000	0.13265	0.06122	0.00000	0.00000	0.00000	0.00000	0.08163
P23	0.06329	0.07595	0.00000	0.00000	0.00000	0.00000	0.35443	0.07595	0.00000	0.00000	0.00000	0.00000	0.17722	0.05063	0.00000	0.00000	0.00000	0.00000	0.12658	0.01266	0.00000	0.00000	0.00000	0.00000	0.06329
P24	0.00000	0.04839	0.00000	0.00000	0.00000	0.00000	0.12903	0.06452	0.03226	0.00000	0.00000	0.00000	0.16129	0.19355	0.04839	0.00000	0.00000	0.00000	0.09677	0.06452	0.00000	0.00000	0.00000	0.00000	0.16129
P25	0.00000	0.03077	0.03077	0.04615	0.00000	0.00000	0.03077	0.07692	0.10769	0.04615	0.00000	0.00000	0.07692	0.09231	0.03077	0.00000	0.00000	0.00000	0.06154	0.06154	0.00000	0.00000	0.00000	0.00000	0.30769
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	0.07229	0.06024	0.06024	0.20482	0.01205	0.00000	0.12048	0.06024	0.03615	0.01205	0.00000	0.00000	0.08434	0.04819	0.03615	0.00000	0.00000	0.00000	0.06024	0.02410	0.00000	0.00000	0.00000	0.00000	0.10843
P28	0.10481	0.06873	0.12543	0.09622	0.02062	0.00000	0.07904	0.06529	0.01890	0.00516	0.00000	0.00000	0.12371	0.04811	0.00859	0.00000	0.00000	0.00000	0.05842	0.09794	0.00000	0.00000	0.00000	0.00000	0.07904
P29	0.09000	0.10000	0.17000	0.07000	0.01000	0.00000	0.13000	0.10000	0.03000	0.00000	0.00000	0.00000	0.08000	0.10000	0.00000	0.00000	0.00000	0.00000	0.04000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08000
P30	0.17647	0.00000	0.00000	0.00000	0.00000	0.00000	0.39216	0.00000	0.00000	0.00000	0.00000	0.00000	0.33333	0.00000	0.00000	0.00000	0.00000	0.00000	0.07843	0.00000	0.00000	0.00000	0.00000	0.00000	0.01961
P31	0.17647	0.00000	0.00000	0.00000	0.00000	0.00000	0.39216	0.00000	0.00000	0.00000	0.00000	0.00000	0.33333	0.00000	0.00000	0.00000	0.00000	0.00000	0.07843	0.00000	0.00000	0.00000	0.00000	0.00000	0.01961
P32	0.20952	0.00000	0.00000	0.00000	0.00000	0.00000	0.22313	0.00000	0.00000	0.00000	0.00000	0.00000	0.31157	0.00000	0.00000	0.00000	0.00000	0.00000	0.19592	0.00000	0.00000	0.00000	0.00000	0.00000	0.05986
P33	0.09302	0.00000	0.00000	0.00000	0.00000	0.00000	0.31395	0.00000	0.00000	0.00000	0.00000	0.00000	0.37209	0.00000	0.00000	0.00000	0.00000	0.00000	0.11628	0.00000	0.00000	0.00000	0.00000	0.00000	0.10465

Table A3.5: 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	0.01762	0.01982	0.13877	0.43392	0.10793	0.00000	0.01410	0.01256	0.03529	0.02577	0.00000	0.00000	0.00661	0.03745	0.03965	0.00000	0.00000	0.00000	0.00661	0.01982	0.00661	0.00727	0.01727	0.03634	0.01652
P02	0.01762	0.01982	0.13877	0.43392	0.10793	0.00000	0.01410	0.01256	0.03529	0.02577	0.00000	0.00000	0.00661	0.03745	0.03965	0.00000	0.00000	0.00000	0.00661	0.01982	0.00661	0.00727	0.01727	0.03634	0.01652
P03	0.10526	0.04211	0.13684	0.32632	0.03158	0.00000	0.02105	0.03158	0.02105	0.06316	0.00000	0.00000	0.03158	0.06316	0.03158	0.00000	0.00000	0.00000	0.00000	0.06316	0.00000	0.00000	0.01053	0.02105	0.00000
P04	0.10526	0.04211	0.13684	0.32632	0.03158	0.00000	0.02105	0.03158	0.02105	0.06316	0.00000	0.00000	0.03158	0.06316	0.03158	0.00000	0.00000	0.00000	0.00000	0.06316	0.00000	0.00000	0.01053	0.02105	0.00000
P05	0.00000	0.02740	0.77397	0.16438	0.01370	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00685	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01370
P06	0.00000	0.01786	0.44643	0.50000	0.03571	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
P07	0.06250	0.02083	0.16667	0.41667	0.16667	0.00000	0.00000	0.02083	0.10417	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.02083	0.00000	0.00000	0.00000	0.00000	0.02083
P08	0.00000	0.02740	0.77397	0.16438	0.01370	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00685	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01370
P09	0.00000	0.01786	0.44643	0.50000	0.03571	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
P10	0.06250	0.02083	0.16667	0.41667	0.16667	0.00000	0.00000	0.02083	0.10417	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.02083	0.00000	0.00000	0.00000	0.00000	0.02083
P11	0.30104	0.05882	0.09343	0.08997	0.02768	0.00000	0.05190	0.00692	0.00000	0.00000	0.00000	0.00000	0.31142	0.03460	0.00346	0.00000	0.00000	0.00000	0.01038	0.00346	0.00000	0.00000	0.00000	0.00000	0.00692
P12	0.30104	0.05882	0.09343	0.08997	0.02768	0.00000	0.05190	0.00692	0.00000	0.00000	0.00000	0.00000	0.31142	0.03460	0.00346	0.00000	0.00000	0.00000	0.01038	0.00346	0.00000	0.00000	0.00000	0.00000	0.00692
P13	0.30104	0.05882	0.09343	0.08997	0.02768	0.00000	0.05190	0.00692	0.00000	0.00000	0.00000	0.00000	0.31142	0.03460	0.00346	0.00000	0.00000	0.00000	0.01038	0.00346	0.00000	0.00000	0.00000	0.00000	0.00692
P14	0.30104	0.05882	0.09343	0.08997	0.02768	0.00000	0.05190	0.00692	0.00000	0.00000	0.00000	0.00000	0.31142	0.03460	0.00346	0.00000	0.00000	0.00000	0.01038	0.00346	0.00000	0.00000	0.00000	0.00000	0.00692
P15	0.30104	0.05882	0.09343	0.08997	0.02768	0.00000	0.05190	0.00692	0.00000	0.00000	0.00000	0.00000	0.31142	0.03460	0.00346	0.00000	0.00000	0.00000	0.01038	0.00346	0.00000	0.00000	0.00000	0.00000	0.00692
P16	0.30104	0.05882	0.09343	0.08997	0.02768	0.00000	0.05190	0.00692	0.00000	0.00000	0.00000	0.00000	0.31142	0.03460	0.00346	0.00000	0.00000	0.00000	0.01038	0.00346	0.00000	0.00000	0.00000	0.00000	0.00692
P17	0.07166	0.12378	0.02606	0.01303	0.00326	0.00000	0.18567	0.10098	0.03583	0.00652	0.00000	0.00000	0.10424	0.06840	0.00652	0.00000	0.00000	0.00000	0.07818	0.05863	0.00000	0.00000	0.00000	0.00000	0.11726
P18	0.03804	0.05978	0.01902	0.02446	0.01087	0.00000	0.10598	0.08696	0.03804	0.00815	0.00000	0.00000	0.11413	0.10326	0.00815	0.00000	0.00000	0.00000	0.07609	0.10326	0.00000	0.00000	0.00000	0.00000	0.20380
P19	0.05172	0.12069	0.05172	0.00000	0.00000	0.00000	0.25862	0.12069	0.00000	0.00000	0.00000	0.00000	0.03448	0.06897	0.00000	0.00000	0.00000	0.00000	0.12069	0.03448	0.00000	0.00000	0.00000	0.00000	0.13793
P20	0.04000	0.00000	0.04000	0.00000	0.00000	0.00000	0.18000	0.16000	0.02000	0.00000	0.00000	0.00000	0.08000	0.08000	0.00000	0.00000	0.00000	0.00000	0.14000	0.14000	0.00000	0.00000	0.00000	0.00000	0.12000
P21	0.04951	0.07921	0.00000	0.00000	0.00000	0.00000	0.35644	0.13861	0.01980	0.00000	0.00000	0.00000	0.15842	0.07921	0.00990	0.00000	0.00000	0.00000	0.05941	0.02970	0.00000	0.00000	0.00000	0.00000	0.01980
P22	0.05102	0.05102	0.00000	0.00000	0.01020	0.00000	0.18367	0.24490	0.00000	0.00000	0.00000	0.00000	0.10204	0.08163	0.00000	0.00000	0.00000	0.00000	0.13265	0.06122	0.00000	0.00000	0.00000	0.00000	0.08163
P23	0.06329	0.07595	0.00000	0.00000	0.00000	0.00000	0.35443	0.07595	0.00000	0.00000	0.00000	0.00000	0.17722	0.05063	0.00000	0.00000	0.00000	0.00000	0.12658	0.01266	0.00000	0.00000	0.00000	0.00000	0.06329
P24	0.00000	0.04839	0.00000	0.00000	0.00000	0.00000	0.12903	0.06452	0.03226	0.00000	0.00000	0.00000	0.16129	0.19355	0.04839	0.00000	0.00000	0.00000	0.09677	0.06452	0.00000	0.00000	0.00000	0.00000	0.16129
P25	0.00000	0.03077	0.03077	0.04615	0.00000	0.00000	0.03077	0.07692	0.10769	0.04615	0.00000	0.00000	0.07692	0.09231	0.03077	0.00000	0.00000	0.00000	0.06154	0.06154	0.00000	0.00000	0.00000	0.00000	0.30769
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	0.07229	0.06024	0.06024	0.20482	0.01205	0.00000	0.12048	0.06024	0.03615	0.01205	0.00000	0.00000	0.08434	0.04819	0.03615	0.00000	0.00000	0.00000	0.06024	0.02410	0.00000	0.00000	0.00000	0.00000	0.10843
P28	0.10481	0.06873	0.12543	0.09622	0.02062	0.00000	0.07904	0.06529	0.01890	0.00516	0.00000	0.00000	0.12371	0.04811	0.00859	0.00000	0.00000	0.00000	0.05842	0.09794	0.00000	0.00000	0.00000	0.00000	0.07904
P29	0.09000	0.10000	0.17000	0.07000	0.01000	0.00000	0.13000	0.10000	0.03000	0.00000	0.00000	0.00000	0.08000	0.10000	0.00000	0.00000	0.00000	0.00000	0.04000	0.00000	0.00000	0.00000	0.00000	0.00000	0.08000
P30	0.17647	0.00000	0.00000	0.00000	0.00000	0.00000	0.39216	0.00000	0.00000	0.00000	0.00000	0.00000	0.33333	0.00000	0.00000	0.00000	0.00000	0.00000	0.07843	0.00000	0.00000	0.00000	0.00000	0.00000	0.01961
P31	0.17647	0.00000	0.00000	0.00000	0.00000	0.00000	0.39216	0.00000	0.00000	0.00000	0.00000	0.00000	0.33333	0.00000	0.00000	0.00000	0.00000	0.00000	0.07843	0.00000	0.00000	0.00000	0.00000	0.00000	0.01961
P32	0.20952	0.00000	0.00000	0.00000	0.00000	0.00000	0.22313	0.00000	0.00000	0.00000	0.00000	0.00000	0.31157	0.00000	0.00000	0.00000	0.00000	0.00000	0.19592	0.00000	0.00000	0.00000	0.00000	0.00000	0.05986
P33	0.09302	0.00000	0.00000	0.00000	0.00000	0.00000	0.31395	0.00000	0.00000	0.00000	0.00000	0.00000	0.37209	0.00000	0.00000	0.00000	0.00000	0.00000	0.11628	0.00000	0.00000	0.00000	0.00000	0.00000	0.10465

Table A3.6: 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	1.590	0.510	1.050	0.560	1.000	N/A	-0.110	-0.130	-0.270	0.000	20.000	-3.170	25.000	45.000	-6.130	16.570	5.220	-8.280	-7.500
2	0.890	0.310	0.600	0.510	0.820	N/A	-0.110	-0.140	-0.270	0.000	22.000	-2.190	20.000	40.000	-2.270	24.930	11.330	-1.080	-0.540
3	1.000	0.780	0.890	1.100	2.000	N/A	-0.040	-0.050	-0.100	24.000	7.000	19.500	0.000	30.000	0.000	13.770	6.880	-30.00	-30.00
4	1.000	1.050	1.020	1.730	3.500	N/A	-0.040	-0.050	-0.100	24.000	7.000	19.500	0.000	10.000	0.000	27.020	13.510	-20.60	-14.50
5	1.600	0.200	0.900	0.700	1.050	N/A	-0.160	-0.160	-0.320	0.000	35.000	5.170	20.000	50.000	-3.130	-2.810	-2.970	-0.160	10.650
6	1.490	0.280	0.890	0.580	1.000	N/A	-0.140	-0.140	-0.290	0.000	6.000	-8.930	10.000	20.000	0.890	16.520	8.710	2.730	4.040
7	0.580	0.200	0.390	0.600	0.720	N/A	-0.150	-0.150	-0.310	0.000	15.000	-4.730	10.000	20.000	2.250	11.790	7.020	7.060	6.220
8	1.000	0.750	0.880	2.100	3.100	N/A	-0.060	-0.060	-0.120	20.000	11.000	19.500	-5.000	30.000	0.000	-18.20	-9.100	-18.50	-29.80
9	1.000	0.530	0.770	2.000	2.500	N/A	-0.060	-0.060	-0.120	20.000	11.000	19.500	-5.000	30.000	0.000	22.890	11.450	13.180	4.010
10	1.000	0.740	0.870	1.790	3.000	N/A	-0.060	-0.060	-0.120	20.000	11.000	19.500	5.000	70.000	0.000	14.610	7.300	13.910	13.890
11	1.210	0.500	0.850	0.320	0.540	N/A	-0.160	-0.160	-0.320	0.000	6.000	-6.150	20.000	50.000	-1.760	30.000	14.120	-6.380	-3.150
12	1.700	0.610	1.160	0.400	0.650	N/A	-0.160	-0.160	-0.320	0.000	4.000	-7.840	20.000	45.000	-30.00	7.630	-11.18	-30.00	-30.00
13	1.370	0.410	0.890	0.380	0.630	N/A	-0.160	-0.160	-0.320	0.000	23.000	1.890	21.000	55.000	-30.00	-2.840	-16.42	-30.00	-30.00
14	1.000	1.050	1.030	0.710	1.230	N/A	-0.060	-0.060	-0.120	35.000	7.000	19.500	18.000	70.000	-30.00	30.000	0.000	-28.70	-19.50
15	1.000	1.110	1.050	0.670	1.130	N/A	-0.060	-0.060	-0.120	35.000	7.000	19.500	23.000	70.000	-30.00	30.000	0.000	-30.00	-24.90
16	1.000	0.940	0.970	0.750	1.200	N/A	-0.060	-0.060	-0.120	35.000	7.000	19.500	0.000	70.000	-30.00	30.000	0.000	-30.00	-25.30
17	0.690	0.270	0.480	0.320	0.700	N/A	-0.160	-0.160	-0.320	0.000	10.000	-4.300	0.000	20.000	-2.180	19.750	8.790	-4.430	-0.450
18	0.590	0.240	0.420	0.160	0.420	N/A	-0.160	-0.160	-0.320	0.000	14.000	-2.360	15.000	30.000	-7.590	16.750	4.580	-13.60	-5.210
19	1.000	0.770	0.890	0.640	1.220	N/A	-0.060	-0.060	-0.120	34.000	6.000	19.500	14.000	55.000	-30.00	30.000	0.000	-30.00	-22.30
20	1.000	0.840	0.920	0.720	1.380	N/A	-0.060	-0.060	-0.120	34.000	6.000	19.500	30.000	15.000	-30.00	30.000	0.000	-24.60	-17.30
21	0.590	0.350	0.470	0.200	0.470	N/A	-0.160	-0.160	-0.320	0.000	19.000	0.360	10.000	40.000	-22.30	15.140	-3.580	-22.40	-15.90
22	1.040	0.240	0.640	0.240	0.520	N/A	-0.160	-0.160	-0.320	0.000	47.000	14.120	15.000	45.000	-7.410	11.270	1.930	-15.60	-10.10
23	1.000	1.350	1.180	1.630	3.000	N/A	-0.060	-0.060	-0.120	34.000	6.000	19.500	-5.000	30.000	-30.00	18.780	-5.610	-30.00	-30.00
24	0.380	0.280	0.330	0.320	0.700	N/A	-0.160	-0.160	-0.320	0.000	42.000	12.000	0.000	30.000	-7.300	24.360	8.530	-5.450	3.630
25	0.520	0.240	0.380	0.290	1.100	N/A	-0.160	-0.160	-0.320	0.000	44.000	13.000	0.000	30.000	-3.270	20.280	8.510	-6.460	2.590
26	1.000	0.400	0.700	0.540	0.910	N/A	-0.060	-0.060	-0.120	34.000	6.000	19.500	-3.000	40.000	-30.00	18.400	-5.800	-30.00	-25.90
27	0.700	0.270	0.480	0.270	0.470	N/A	-0.110	-0.160	-0.330	0.000	19.000	-1.500	22.000	25.000	-12.50	5.540	-3.480	-13.90	-14.90
28	0.560	0.170	0.360	0.170	0.330	N/A	-0.160	-0.160	-0.320	0.000	40.000	-0.400	16.000	40.000	-7.820	11.400	1.790	-11.20	-5.450
29	1.000	0.470	0.730	0.370	0.780	N/A	-0.060	-0.060	-0.120	28.000	25.000	19.500	24.000	40.000	-30.00	26.640	-1.680	-30.00	-17.60
30	0.670	0.200	0.440	0.200	0.410	N/A	-0.100	-0.140	-0.280	0.000	18.000	-2.110	27.000	40.000	-12.10	8.030	-2.040	-17.90	-12.10
31	1.000	0.610	0.800	0.940	1.650	N/A	-0.040	-0.060	-0.120	38.000	7.350	19.500	5.450	52.500	-30.00	12.830	-8.590	-30.00	-28.80
32	0.910	0.310	0.610	0.260	0.510	N/A	-0.100	-0.100	-0.210	0.000	19.000	0.620	30.000	50.000	-3.110	24.050	10.470	-17.00	-9.050
33	1.000	0.910	0.960	1.360	2.140	N/A	-0.040	-0.040	-0.070	0.000	0.000	0.000	0.000	0.000	-30.00	30.000	0.000	-23.90	-16.50

Table A3.7: Finalised period to hour factors

Time Period	Car	PT	Walk	Cycle
AM	0.51856	0.61000	0.49800	0.49900
IP1	0.33333	0.33333	0.33333	0.33333
IP2	0.33333	0.33333	0.33333	0.33333
PM	0.49000	0.72588	0.36800	0.44200
OP	0.08333	0.08333	0.08333	0.08333

Table A3.8: 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 A3.9: 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 SWRM, which was later adopted in the other model regions.

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

Eighteen park and ride sites were identified in the SWRM, the majority of which are rail based and outlined in Table A4.10.

Table A4.10: SWRM Park and Ride sites

Site	Capacity	Charge (€)	Observed usage
Banteer	18	4	6
Black Ash	940	5	387
Carrigate	0	0	0
Carrigtwohill	183	4	4
Charleville	430	4	55
Cobh	0	0	0
Cork Kent	481	4	338
Farranfore	40	4	24
Fota	0	0	0
Glounthaune	80	4	37
Killarney	110	4	85
Little Island	61	4	22
Mallow	460	4	190
Midleton	283	4	71
Millstreet	26	4	16
Rathmore	29	4	13
Rushbrooke	0	0	0
Tralee	119	4	59

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 SWRM 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 3,260 parking spaces across the eighteen sites, with an estimated demand for 1,307 spaces (40%).

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 SWRM 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.

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

A4.3 Site file generation

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

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

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

A4.4 Park and Ride calibration

Two main elements influence the park and ride calibration process:

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

A4.4.1 Expected Demand

Time of day data was available for two SWRM sites but for the remaining 16 there were no observations and so an alternative method was used to distribute the estimated demand. This exercise was completed using the boardings file output by the main Public Transport model.

The boardings files were available for each modelled time period (with the exception of OP) and listed the total boardings within that time period at each station. From this data the boardings for each of the remaining sixteen stations and sites within the SWRM was extracted and proportions calculated for each time period based on the total boardings at the station. For example, for Banteer, it was calculated that 49% of daily boardings took place in the AM period, 13% in IP1, 17% in IP2 and 21% 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.

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 SWRM the target usage of Park and Ride was estimated as 1,850 people. The PnR ASC values were reduced until the adjustment generated a modelled demand (persons) of 2,724 against a target demand of 1,850, a difference of 873 (47%). This was considered sufficiently close given the low overall mode share of Park and Ride.

A4.5 PnR Calibration Process

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

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

Table A4.11: Site calibration

Site	AM GEH	IP1 GEH	IP2 GEH	PM GEH	OP GEH
Banteer	2.0	1.9	1.5	0.7	1.0
Black Ash	8.5	10.9	9.4	6.6	5.8
Carrigate	2.3	1.2	1.1	1.0	0.5
Carrigtwohill	4.8	4.5	3.0	2.7	2.5
Charleville	2.6	5.5	0.1	8.4	1.4
Cobh	1.9	1.0	0.9	0.8	0.4
Cork Kent	26.7	7.8	0.6	10.7	8.3
Farranfore	9.5	7.2	6.5	5.4	2.7
Fota	2.3	1.2	1.1	1.0	0.5
Glounthaune	4.8	5.7	3.5	1.7	4.3
Killarney	10.3	11.2	7.8	1.3	6.2
Little Island	6.4	5.4	3.1	0.6	3.1
Mallow	1.9	1.2	1.2	8.3	4.2
Midleton	0.9	6.5	3.1	0.3	4.9
Millstreet	0.8	0.9	1.3	2.7	0.7
Rathmore	3.5	3.0	2.6	1.2	1.6
Rushbrooke	2.4	1.3	1.1	1.0	0.6
Tralee	8.5	6.4	4.2	0.6	4.2

At an overall time period level, 67% of sites in the AM have a GEH equal to or less than 5, 50% in IP1, 83% in IP2, 72% in the PM and finally 83% in the OP.

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

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

Údarás
Náisiúnta Iompair
National **Transport** Authority

National Transport Authority
Dún Scéine
Harcourt Lane
Dublin 2

Údarás Náisúnta Iompair
Dún Scéine
Lána Fhearchair
Baile Átha Cliath 2

Tel: +353 1 879 8300
Fax: +353 1 879 8333

www.nationaltransport.ie