REGIONAL MODELLING SYSTEM

Modelling Services Framework

South-East Regional Model

Full Demand Model Calibration Report

Údarás Náisiúnta Iompair
National Transport Authority

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Foreword

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

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

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

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

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

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

1 Introduction

1.1 Regional Modelling System

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

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

Table 1.1: Regional Models and their area of coverage

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

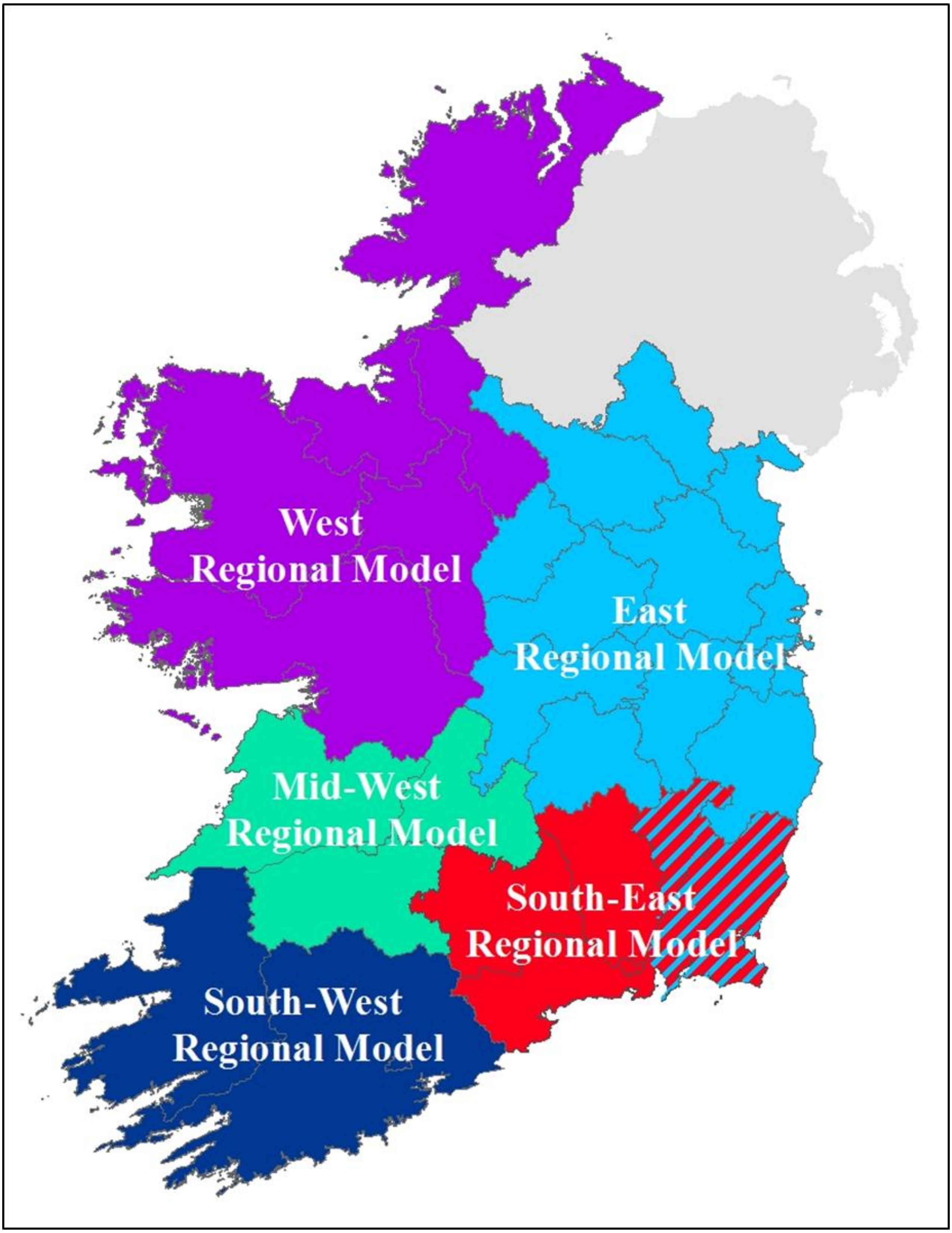


Figure 1.1: Regional Model Areas (the ERM and SERM overlap in the hashed area)

1.2 Regional Modelling System Structure

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

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

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

1.2.1 National Demand Forecasting Model (NDFM)

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

1.2.2 Regional Models

A regional model is comprised of the following key elements:

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

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

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

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

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

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

1.2.3 Appraisal Modules

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

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

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

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

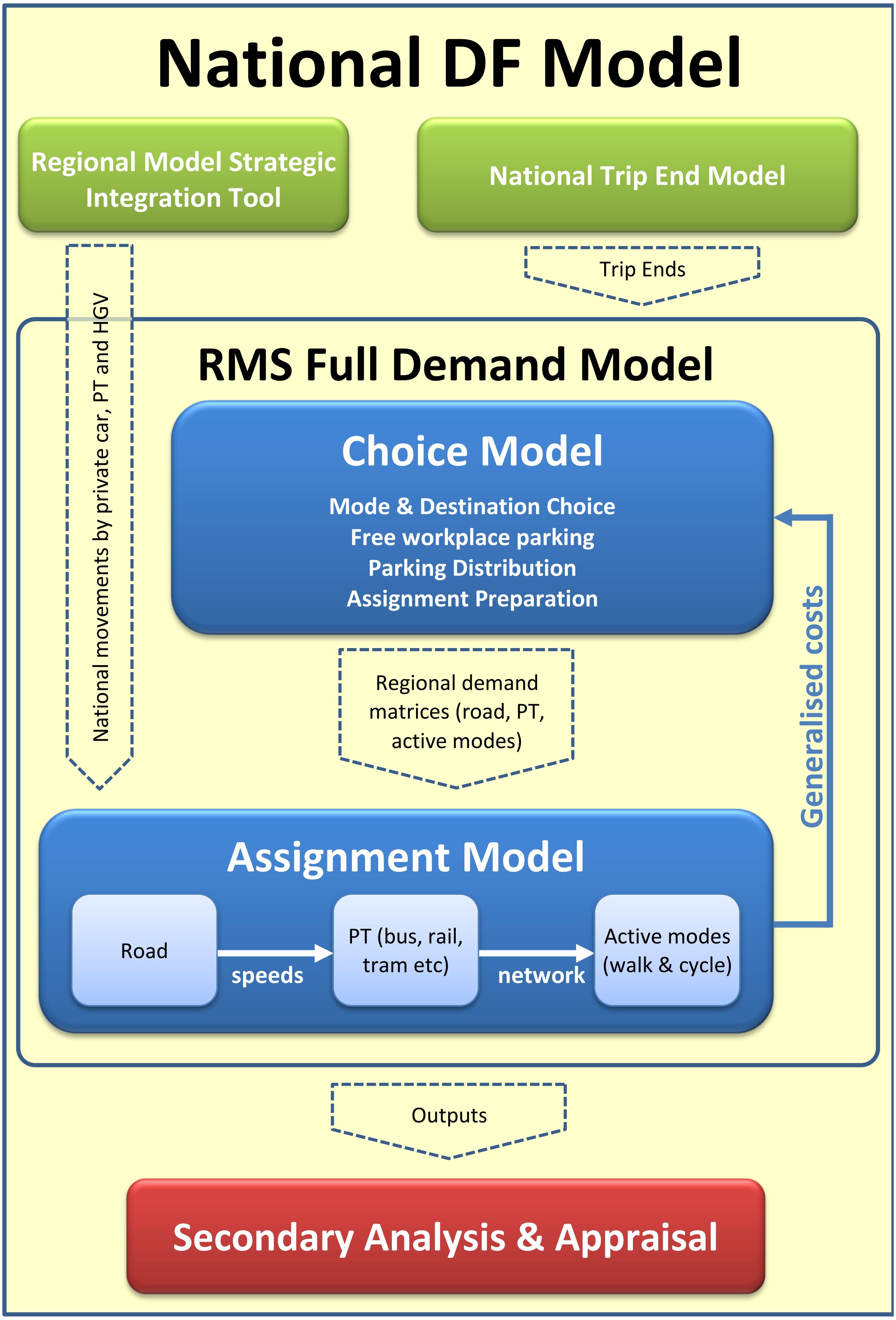


Figure 1.2: National and Regional Model Structure

1.3 Full Demand Model (FDM)

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

The FDM consists of the following modules:

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

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

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

The following module is not yet fully implemented or tested:

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

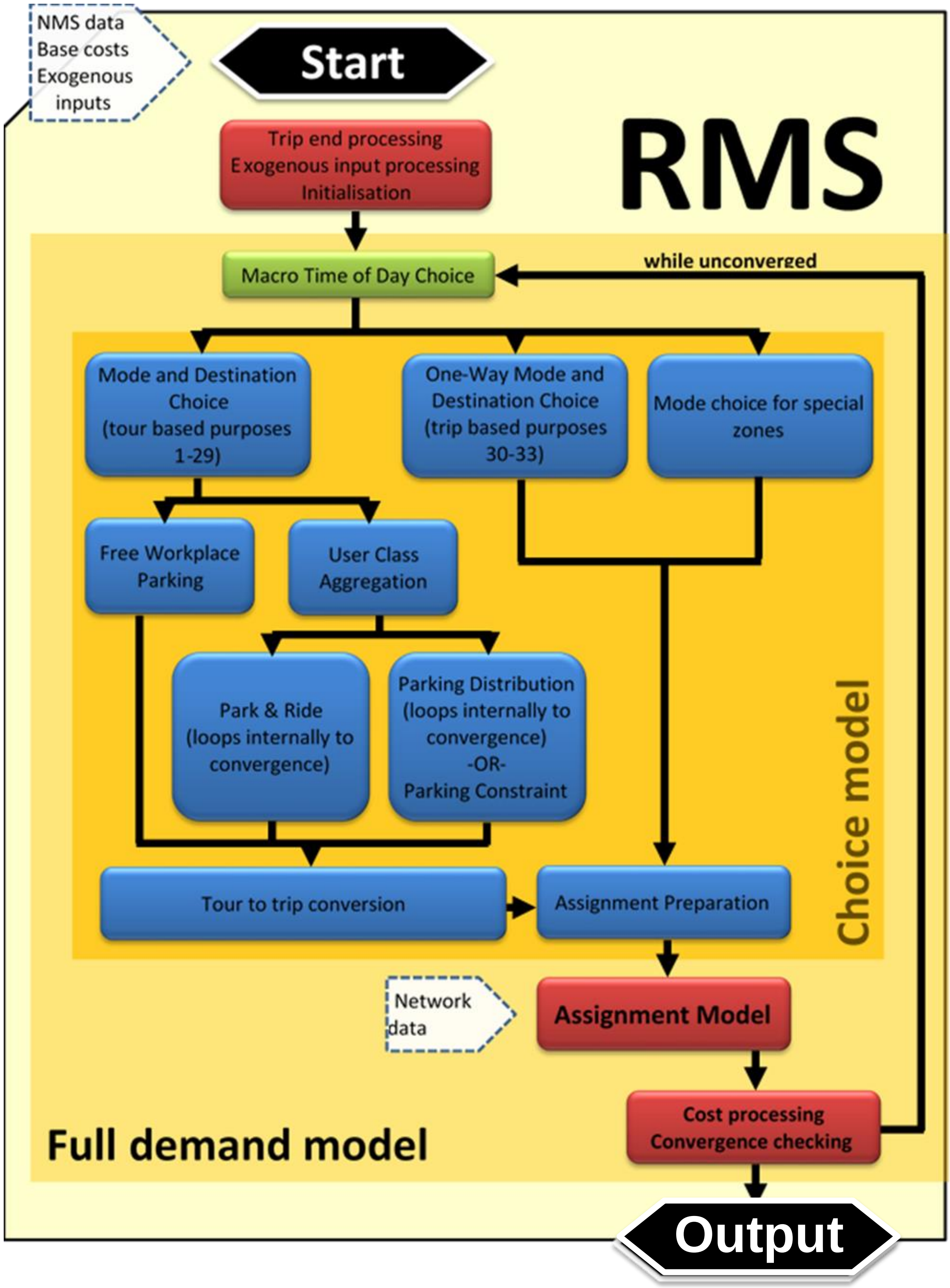


Figure 1.3: RMS Model Structure Overview

1.4 Report Library

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

The NDFM is covered in detail in the report:

- NDFM Development Report

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

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

The full, and finalised FDM specification is reported in:

- RM Spec1 Full Demand Model Specification Report

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

- RM Full Demand Model Development Report

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

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

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

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

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

1.5 This report: Calibration and Validation of the RMS for the South East Region (SERM)

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

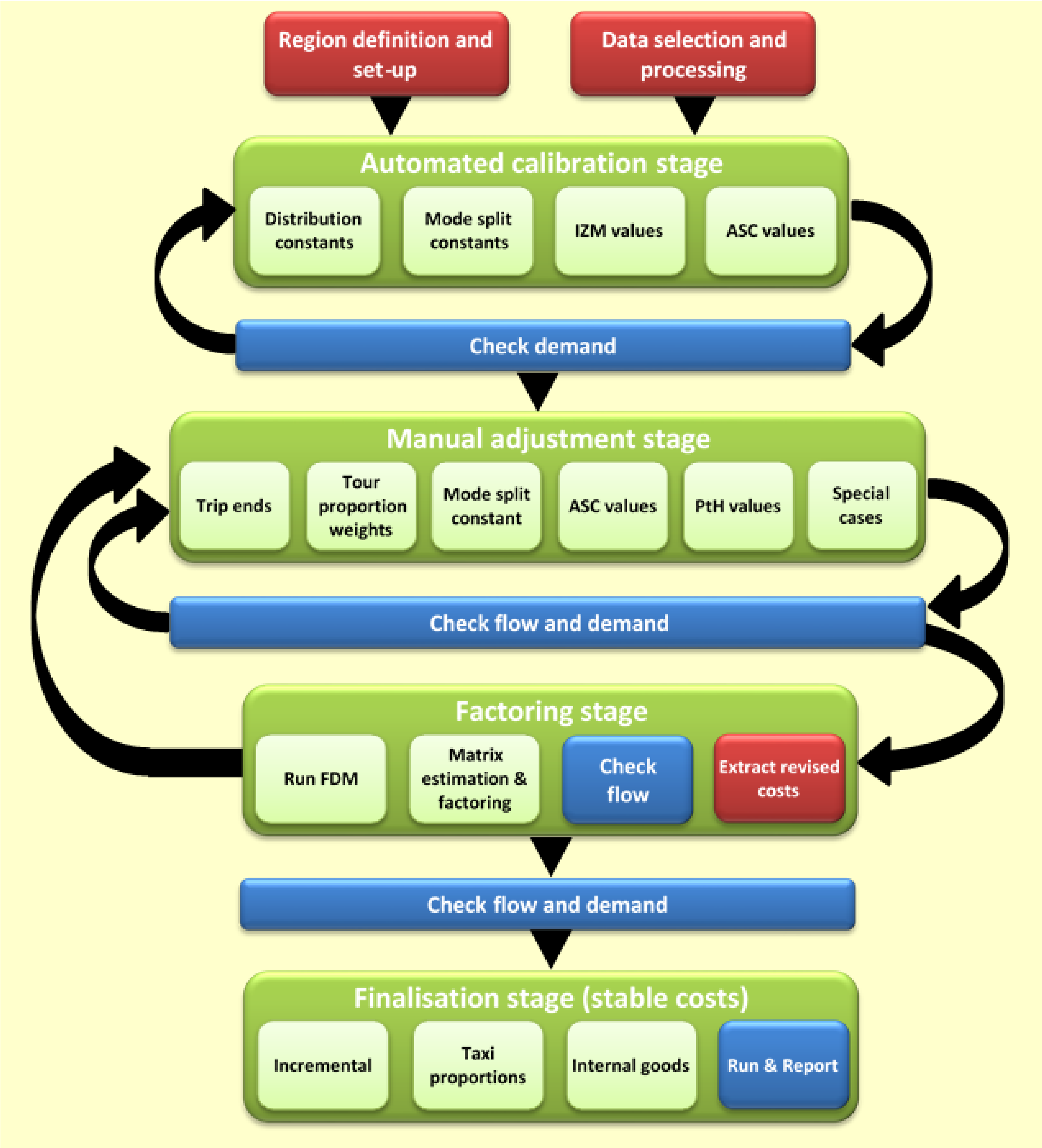


Figure 2.1: FDM calibration process

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 SERM 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 SERM 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 SERM for COM and EDU purposes. The other segments were calibrated to either SERM 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 SERM. 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 470 link counts were available in the modelled area.

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

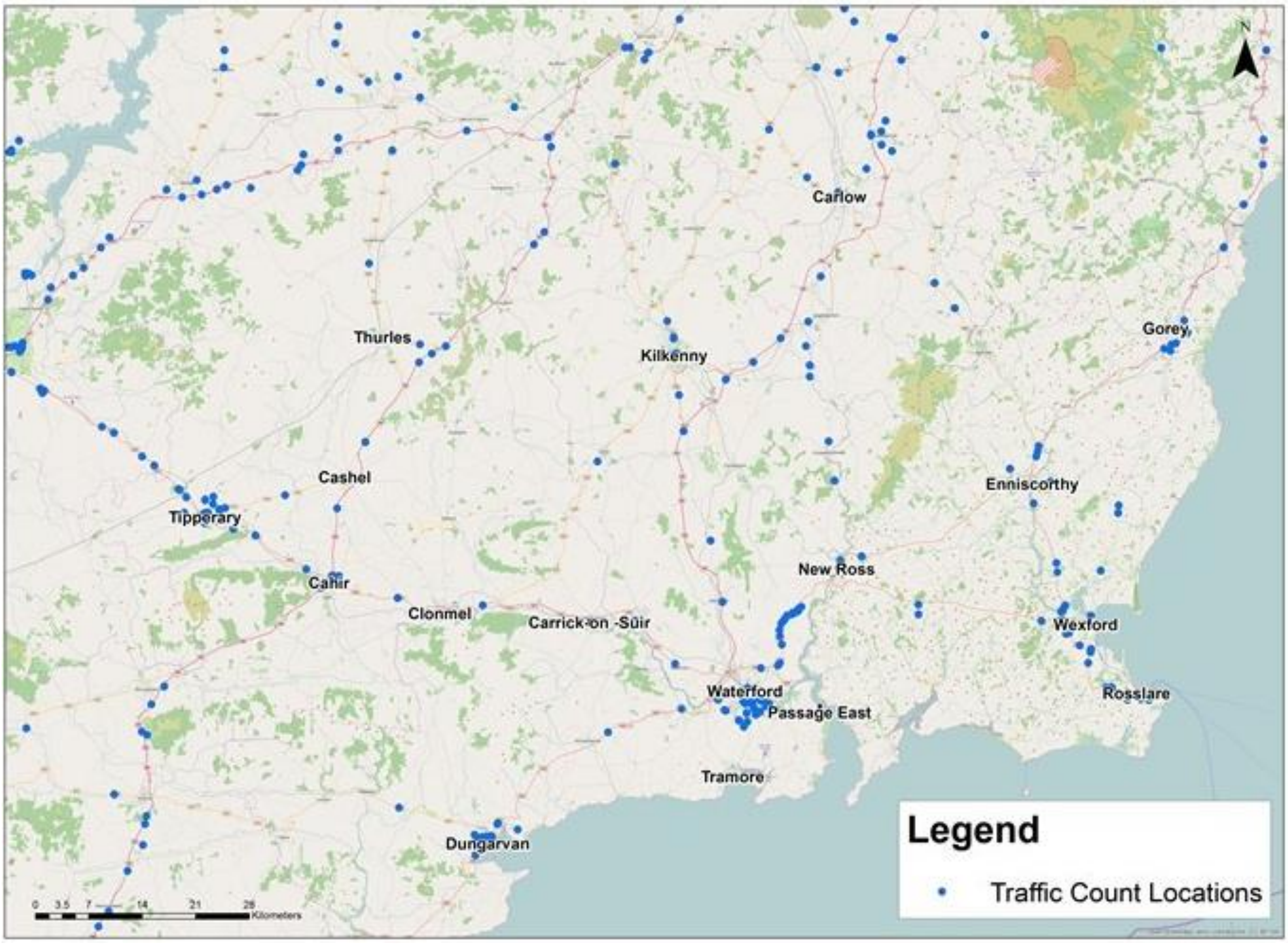


Figure 2.2: Location of Traffic Count Data –SERM area

Journey time validation data for 11 routes (inbound and outbound) was also used and is illustrated in Figure 2.3 below. The journey time data was extracted from TomTom data acquired by the NTA. Further information on observed road data is provided in the SERM Road Model Development Report.

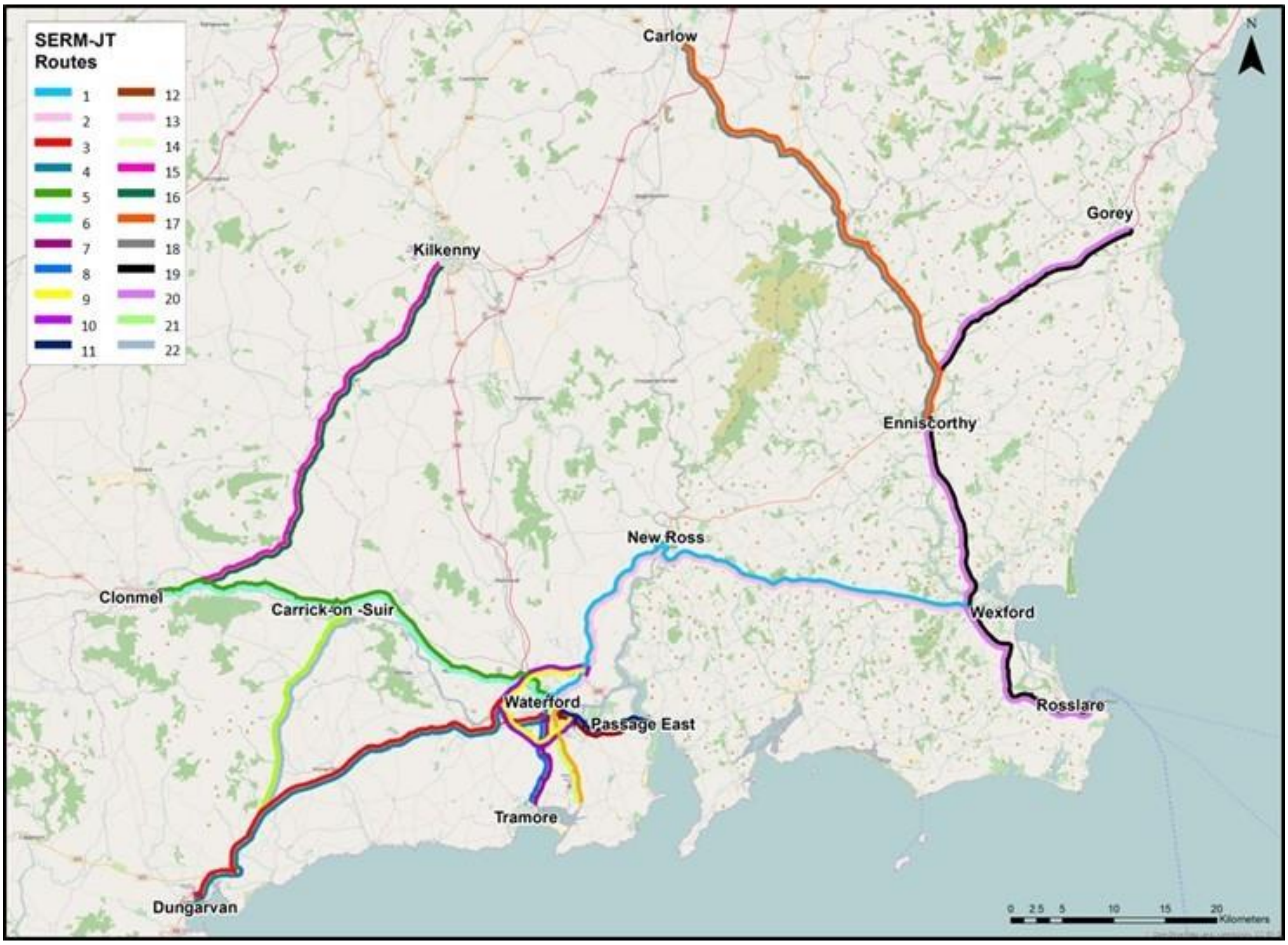


Figure 2.3: TomTom Journey Time Routes

2.3.3 Observed Public Transport Data

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

2.3.4 Observed Active Modes Data

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

2.4 Automated calibration stage

2.4.1 Automated calibration

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

Mathematically the probability of making a choice is:

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

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

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

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

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

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

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

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

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

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

2.4.2 Check demand calibration

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

2.5 Manual adjustment stage

2.5.1 Manual calibration

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

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

This stage may also include:

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

2.5.2 Check flow and demand calibration

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

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

2.6 Assignment Adjustment Stage

2.6.1 Matrix estimation, PT factoring and active modes adjustments

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

2.6.2 Check flows

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

2.6.3 Cost extraction

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

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

2.7 Finalisation

2.7.1 Exit criterion

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

2.7.2 Finalisation

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

1) Internal goods matrices must be taken from the matrix estimated networks and provided as an input to the FDM.

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

2.7.3 Reporting

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

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

3 Calibration Test History

3.1 Introduction

The process of calibrating the South East Regional Model (SERM) began in February 2016 in version '2.0.2: Save 14' of the RMS FDM.

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

3.2 Calibration / Validation Phases

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

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

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

Overall Phase 1 was undertaken from 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 August 2016.

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

3.3 Phase 1 Test 1

Model Version: *2.0.2, Save 14*
Date: *12/02/2016*

3.3.1 Run Details

The purpose of Test 1 was to confirm that the core parts of the model were functioning correctly, to check the initial road and PT networks, and to commence the calibration process.

Initial costs were those provided from the assignment of the developed 'prior' matrices to the pre-calibration road and PT networks. Prior road and PT matrices were developed for the SERM following the repeatable methods guidance developed for the ERM.

3.3.2 Results/Outputs

This run was undertaken to clarify the process of using the model, and to generate updated road, PT and active mode matrices which could be assigned to their respective networks. Following this, matrix estimation[2] was undertaken in the Road Model to provide a better representation of observed flows and hence input costs to the FDM for the next stages of testing.

3.4 Phase 1 Test 2

Model Version: *2.0.2, Save 14*
Date: *19/02/2016*

3.4.1 Run Details

Test 2 was the first full calibration run of the SERM FDM. Updated base generalised costs were taken from a calibrated road assignment, and updated PT and Active mode assignments. As noted in Chapter 2, both automated and manual adjustments were undertaken to estimate alpha and ASC parameters for each of the 33 model purposes. The alpha and ASC parameters were estimated to match observed 24-hour mode share targets and generalised cost distribution curves. These new parameters were updated in the FDM input folders and a full model run was undertaken.

3.4.2 Results/Outputs

The outputs from Test 2 were extracted into the demand, road, and PT dashboards to identify the quality of calibration. The demand dashboard provides a comparison between modelled mode share and trip making by time period, to observed data extracted from the NHTS and POWSCAR. Figure 3.1 illustrates the modelled vs observed 24 hour mode share and trip demand by time period, and indicates that the calibrated SERM FDM is providing a good representation of each.

Full outputs in electronic format are available in the Phase 1 Test 2\2 Demand folder.

[2] Matrix estimation is a programme within SATURN which alters assigned demand matrices to provide a better match between modelled and observed count data (further information on matrix estimation is provided in the SERM Road Model Development Report)

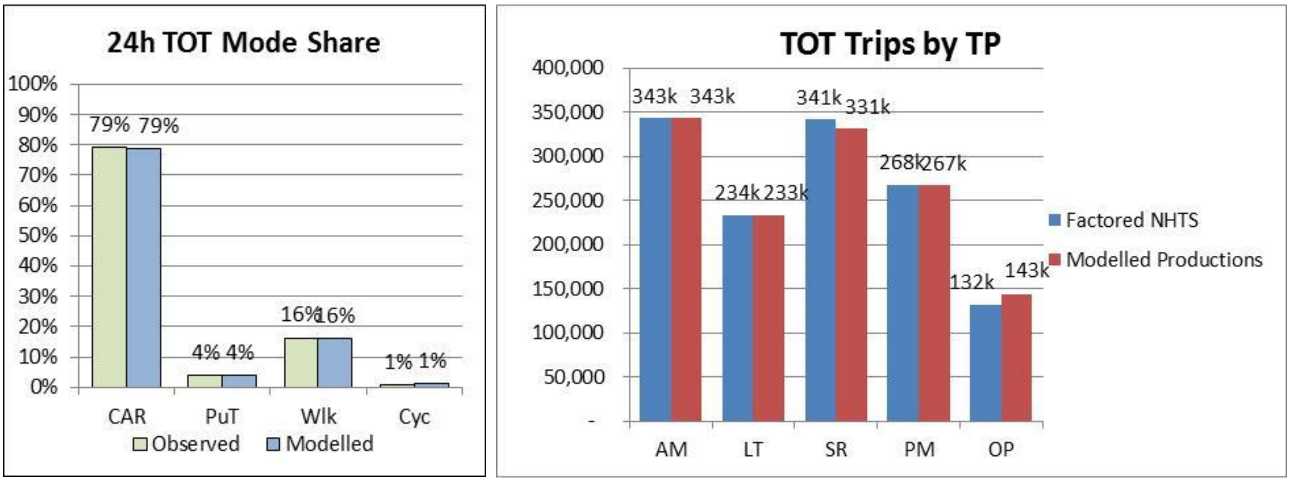


Figure 3.1: Total Mode Share and Trip Demand by Time Period

Figure 3.2 below illustrates the comparison of modelled and observed road network flows at key screenline locations around Waterford City extracted from the road dashboard. The results indicated that modelled road demand entering Waterford City was approximately 10% lower than observed data (further details are provided in the Phase 1 Test 2\3 Road folder).

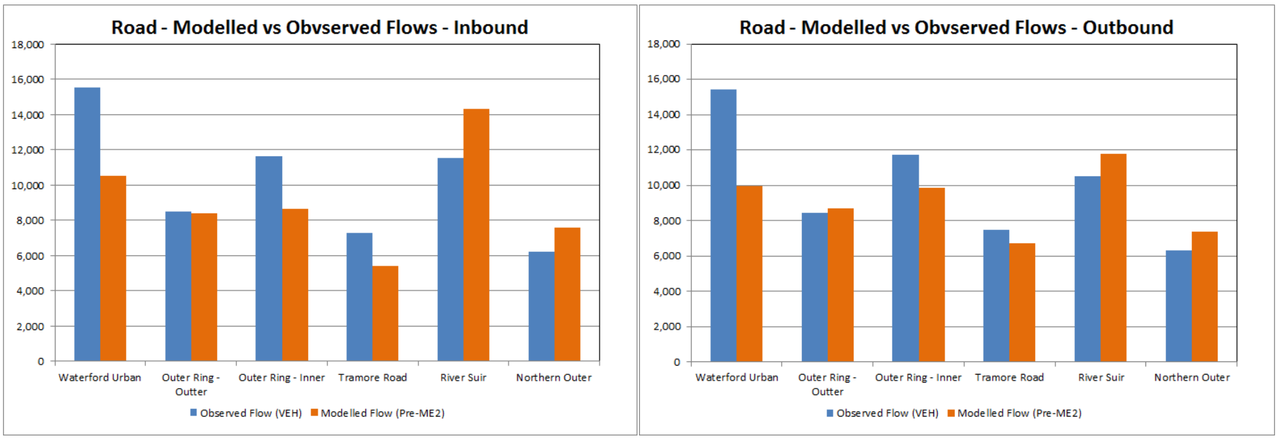


Figure 3.2: Modelled versus Observed Flows

A matrix estimation process was undertaken based on the road demand produced by this test and the calibration /validation results were:

- AM 43% / 54% (before ME) improving to 91% / 80% (after ME);
- IP1 47% / 48% (before ME) improving to 93% / 87% (after ME);
- IP2 40% / 34% (before ME) improving to 92% /86% (after ME); and
- PM 33% / 26% (before ME) improving to 89% / 84% (after ME).

The number of observations passing the WebTAG Flow Criteria was low before ME (less than 54%). The ME process resulted in a significant improvement with more than 84% of links passing the criteria. However, the analysis of R^2 values, showed a significant distortion of the demand caused by the ME process with values included between 0.51 and 0.86. Those values should be closer to 1.

3.5 Phase 1 Test 3

Model Version: *2.0.2, Save 14*
Date: *19/02/2016*

3.5.1 Run Details

Through development of the regional models, it was noted that car demand appeared to be regularly under represented when compared to count data, as highlighted in the previous test. In order to address this issue, a test was run with a 10% uplift factor applied to model trip ends. This factor was calculated based on the differential between modelled and observed demand at screenline level, and applied to the 24 hour trip-ends generated from the NTEM.

3.5.2 Results/Outputs

The results from the uplifted trip end run were passed through the road dashboard to identify the impact achieved (if any). Figure 3.3 illustrates the comparison of modelled and observed road flows at key screenlines around Waterford City. The results indicate that the uplift to trip ends has had a very minor impact with modelled road demand approximately 8-9% lower than observed counts (for further details please see the Phase 1 Test 3\3 Road folder).

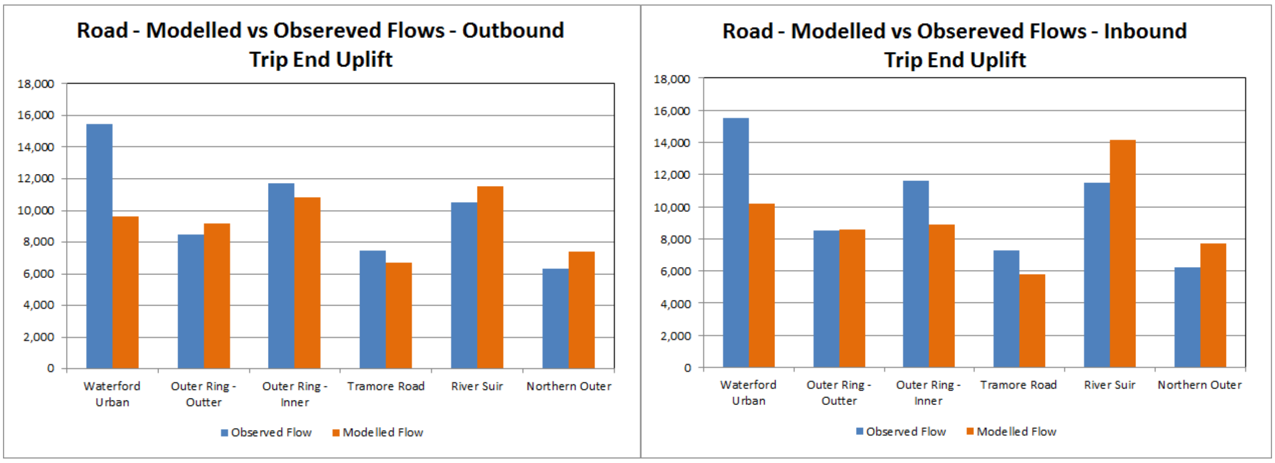


Figure 3.3: Modelled versus Observed Flows

Figure 3.4 illustrates the modelled vs observed 24 hour mode share and trip demand by time period, and indicates that the trip end uplift has not affected the mode share or total trip calibration.

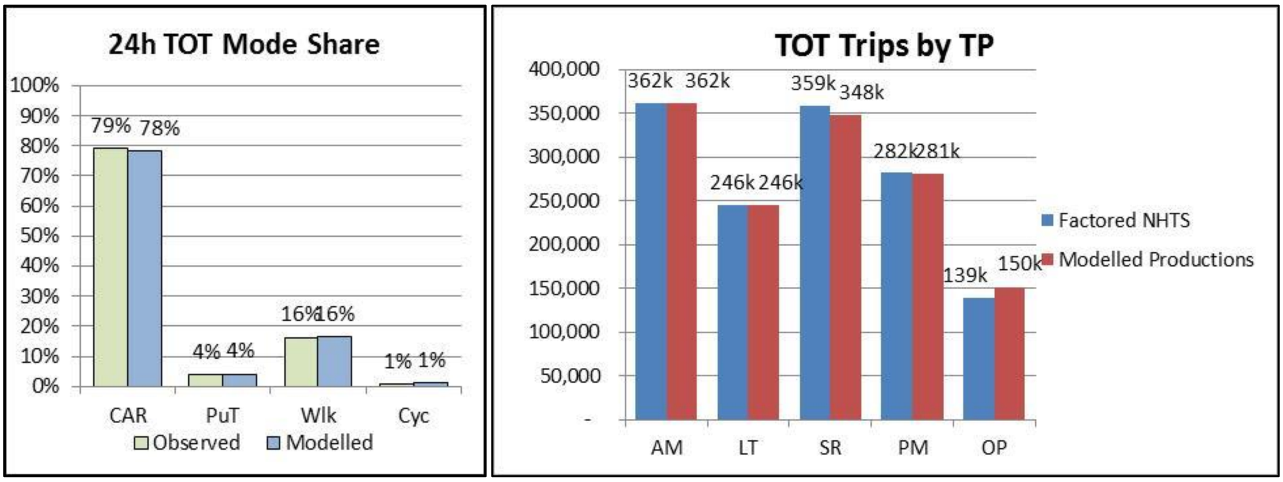


Figure 3.4: Total Mode Share and Trip Demand

It should be noted that, due to the limited availability of PT flow counts within the SERM area, road demand is primarily being utilised as an indicator to highlight how well the FDM is replicating observed flows.

3.6 Phase 1 Test 4

Model Version: *2.0.2, Save 14*
Date: *25/02/2016*

3.6.1 Run Details

As noted in the previous test, the Trip End uplift factor had a limited impact on providing a better match of observed road demand. At this stage, testing was undertaken on adjustments to tour proportions to ensure the correct level of demand was being generated within each time period. A spreadsheet based process was developed which analysed modelled and observed flows entering Waterford city for each time period. Adjustments were then made to the base tour proportions to ensure that the spread of demand throughout the day was in line with evidence from local count data.

These revisions resulted in a reduction in trips in the LT period and an increase for all other time periods except the AM which remained unchanged (Figure 3.5).

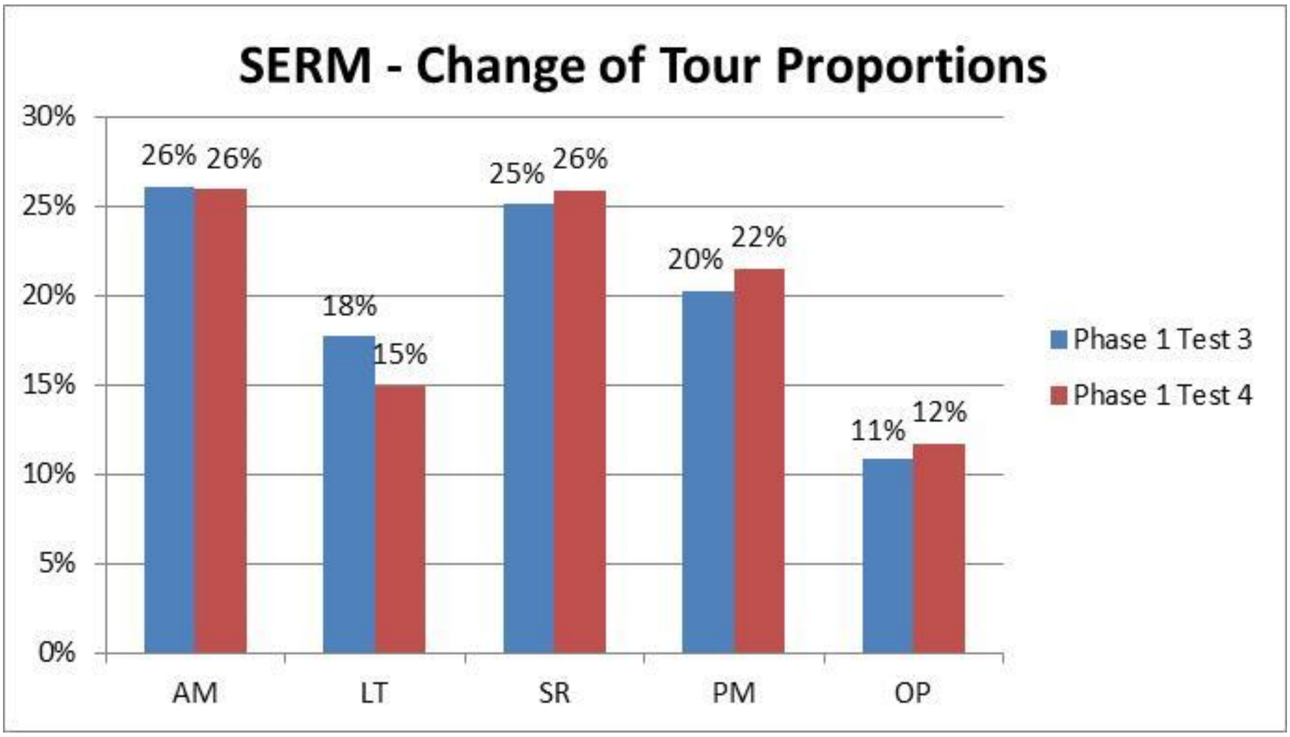
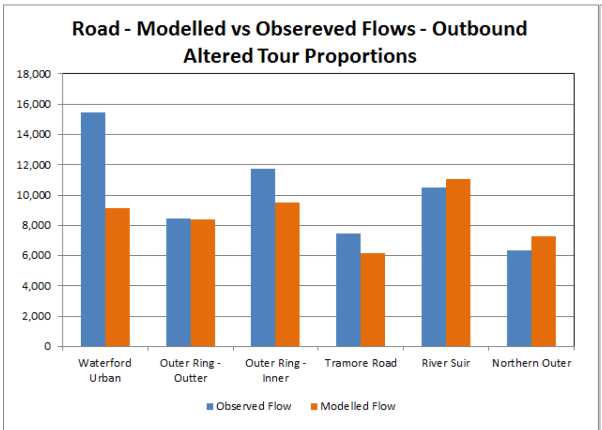


Figure 3.5: Impact of Tour Proportion adjustment on Time Period flows

3.6.2 Results/Outputs

The results from Test 4 were passed through the road dashboard to identify the impact achieved. Figure 3.6, below, illustrates the comparison of modelled and observed road flows at key screenlines around Waterford City. The results indicate that the application of revised tour proportions has had a very minor impact. At some screenlines there was an improvement in modelled demand versus observed, while there was a deterioration at others. In general, however, the overall road demand entering Waterford city was approximately 14% lower than observed counts (for further details please see the Phase 1 Test 4\3 Road folder).



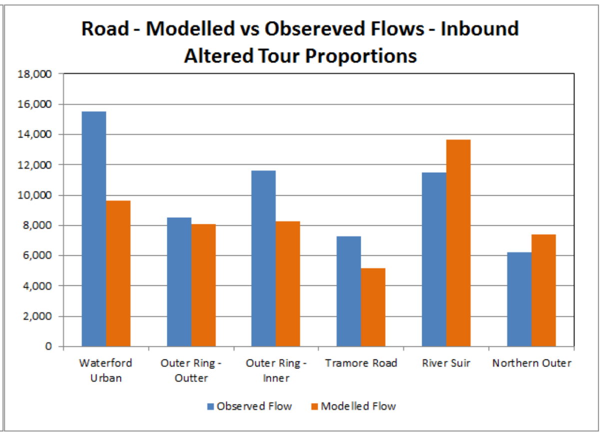


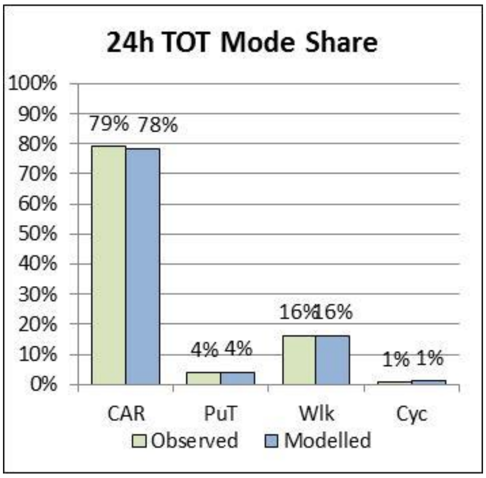
Figure 3.6: Modelled versus Observed Flows

Matrix estimation was undertaken and the calibration /validation results were:

- AM 41% / 49% (before ME) improving to 80% / 81% (after ME);
- IP1 46% / 42% (before ME) improving to 84% / 78% (after ME);
- IP2 42% / 43 % (before ME) improving to 86% /85% (after ME); and
- PM 36% / 38% (before ME) improving to 84% / 80% (after ME).

The analysis of R^2 values, however, continued to show a significant distortion of the demand caused by the ME process with values between 0.54 and 0.80, only fractionally better than in the previous pass.

The demand dashboard continued to show a good match with overall mode share and demand by time period.



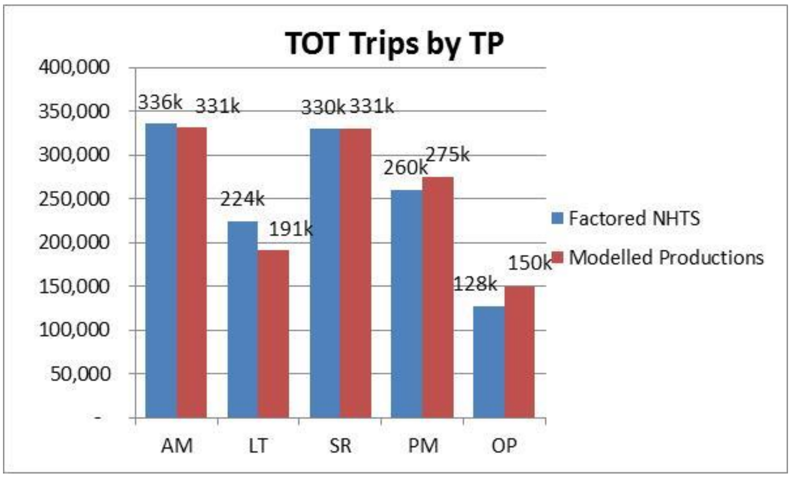


Figure 3.7: Mode Share and Trip Demand by Time Period

The adjustments to Trip Ends and alterations to tour proportions had been shown to be beneficial to other regional models, and as such, were also tested in the SERM (Tests 3 and 4). However, the results of these tests indicated that it would be inappropriate to apply these alterations in the SERM due to the following reasons:

- **Limited impact:** It was found that the adjustment to trip ends and tour proportions was not having a significant impact on providing a better representation of observed road demand; and
- **Lack of PT data:** Road count data was available at identified screenlines outside Waterford City but similar data was not available for PT. For the other regional models, the ASC values were tweaked to move people between car and PT modes to better match observed data. As there was insufficient PT flow count data available for the SERM, it was deemed inappropriate to apply alterations to the calibrated ASC parameter values.

Therefore, these modifications were abandoned and the original demand from the calibrated FDM (without any adjustments) was carried forward for further calibration in the road and PT assignments.

3.7 Post Phase 1 Calibration and Validation Process Review

At this stage, there was a review of the calibration and validation of the SERM and the other regional models and a decision was made to revise some elements of the calibration process. Though they had already been ruled out in the SERM case, the factoring of trip ends and tour proportions was excluded from calibration more generally in the absence of a sound theoretical basis for these adjustments. The exception to this was for some modifications to trip ends made during Phase 1 which were considered justified and these were incorporated into NTEM. On the basis of these, 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.

3.8 Phase 2 Test 1

Model Version: *2.0.8d*
Date: *07/06/2016*

3.8.1 Run Details

As there was a hiatus while upgrades were made to the model at this stage, a detailed review of the road and PT networks was undertaken in an attempt to better represent travel costs and observed demand. This 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 the SERM Road Model Development Report.

A review of the PT network also resulted in changes to some PT connectors, as well as a review of In-Vehicle Time Parameters, vehicle capacities, fares and Boarding and Alighting and Interchange Penalties. This was based on tests undertaken in the SWRM to reduce PT generalised costs and a more detailed description of this is given in the SERM PT Model Development Report.

The alterations made to the road and PT networks resulted in a change in travel costs from those used in the initial calibration of the FDM (Phase 1 Test 1 outlined previously). Therefore, it was deemed necessary to re-run the model with the revised costs and to re-calibrate the FDM parameters to match them. Only the ASC parameters were updated as the distribution curves, which are controlled by the alpha values, were already satisfactory.

3.8.2 Results/Outputs

The modes shares across the 33 demand segments are shown in Figure 3.8 and Figure 3.9 and full electronic information can be found in folder Phase 2/Test 1. Overall, the modelled mode share by demand segment is matching the target mode share very closely, though, in a few cases, the observed mode share cannot be matched perfectly due to limitations in the range of ASC parameters.

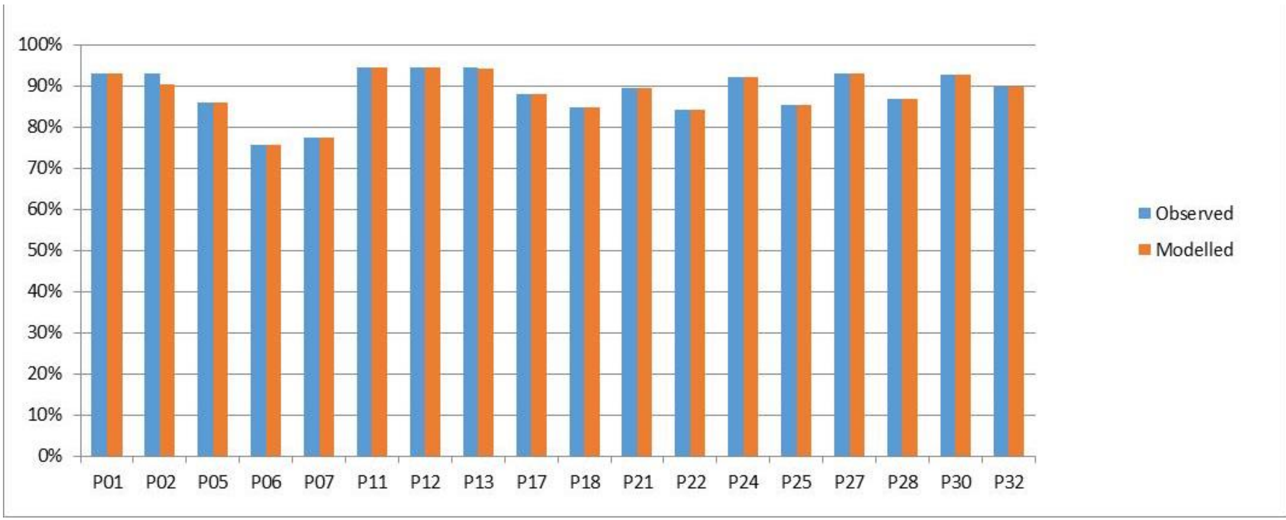


Figure 3.8: Car mode share for Car Available demand segments

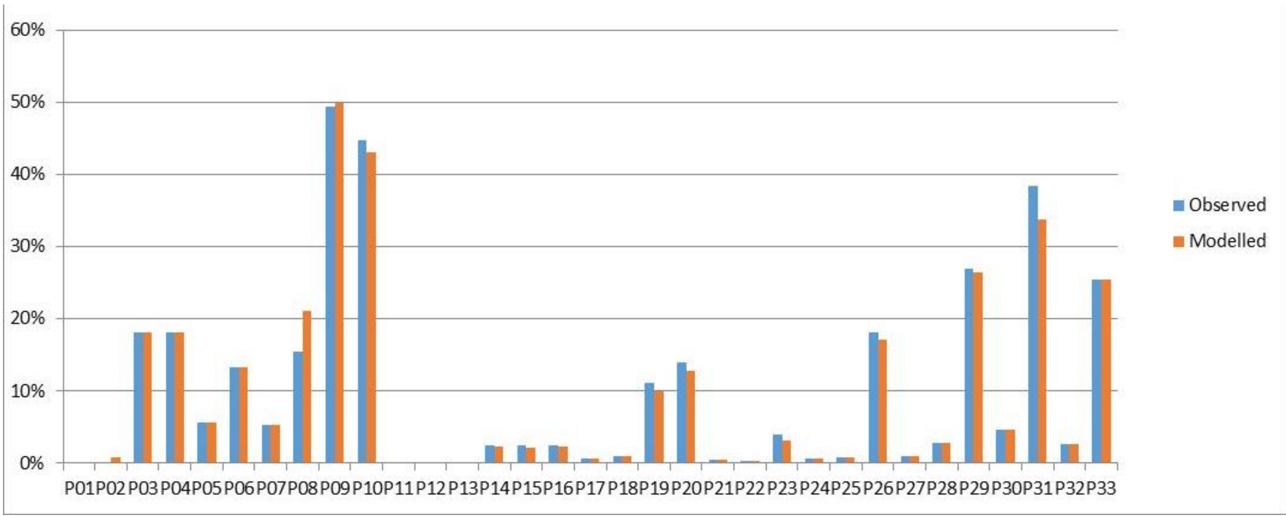


Figure 3.9: PT mode share for all demand segments

3.9 Phase 2 Test 2

Model Version: *2.0.8d*
Scenario Name: *SEBY10*
Date: *08/06/2016*

3.9.1 Run Details

This test involved a full run of the FDM followed by road matrix estimation and PT factoring. ASCs, networks and generalised costs were updated based on the previous run of the FDM.

3.9.2 Results/Outputs

The calibration /validation results were reasonable at:

- AM 41% / 35% (before ME) improving to 80% / 45% (after ME);
- IP1 46% / 53% (before ME) improving to 84% / 88% (after ME);
- IP2 42% / 59 % (before ME) improving to 86% /94% (after ME); and
- PM 36% / 35% (before ME) improving to 84% / 85% (after ME).

The analysis of R^2 values, however, still showed a significant distortion of the demand caused by the ME process with values included between 0.55 and 0.88.

There was no available bus data but the rail boardings and alightings are shown in Figure 3.10. Modelled movements were universally high.

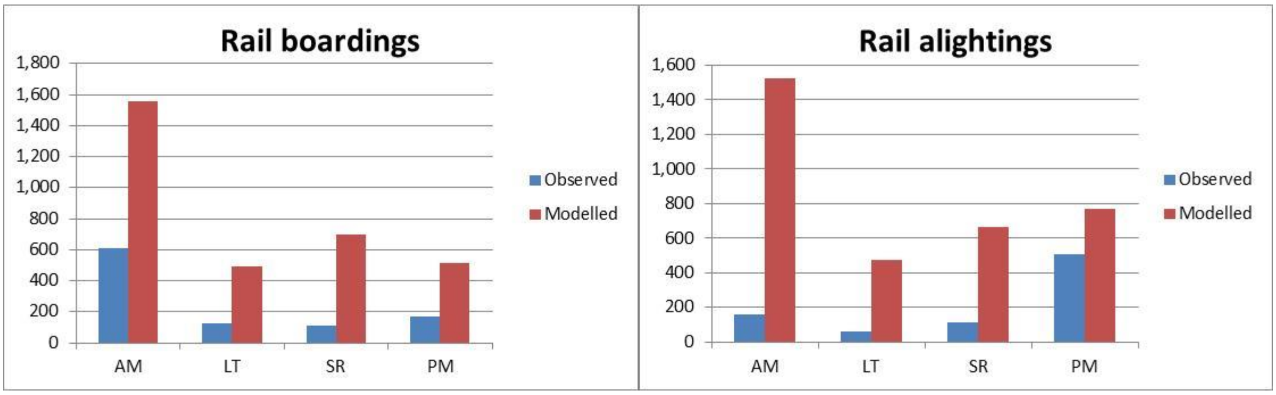


Figure 3.10: Rail boardings and alightings.

Further information on these is provided in the Phase 2 Test 2\3 Road and Phase 2 Test 2\4 PT folders.

3.10 Post Phase 2 Calibration and Validation Process Review

At this stage a detailed audit of the modelled networks was performed and the model was updated to a new version such that the next phase focussed on recalibration including the Parking Distribution and Park and Ride models which called for some additional data inputs.

3.10.1 Free Workplace Parking

In the absence of data detailing the number of car spaces by zone, FWPP capacities were set to 0 such that none of the commute or education trips were given a free parking space. However, with no detailed information on the availability and charge associated with paid parking in the model area, it was agreed to set the parking charge in the entire model to 0 as well.

3.10.2 Parking Distribution

The parking distribution module (PDist) facilitates the redistribution of trips to nearby zones when the level of demand entering their intended zone reaches the capacity of available spaces, or where there are cheaper parking alternatives in nearby zones. The module also provides the constraint mechanism in the model. 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 Waterford was defined in a similar way as inas that used in the larger settlements in the other regional models. With no information in terms of the number of car spaces actually available, the capacity of all zones within the parking distribution area was assumed to be 90% of the demand in the base year. The red shaded zones in Figure 3.11 were set as the PDist area. This includes 53 zones and covers most of the built-up area in the city.

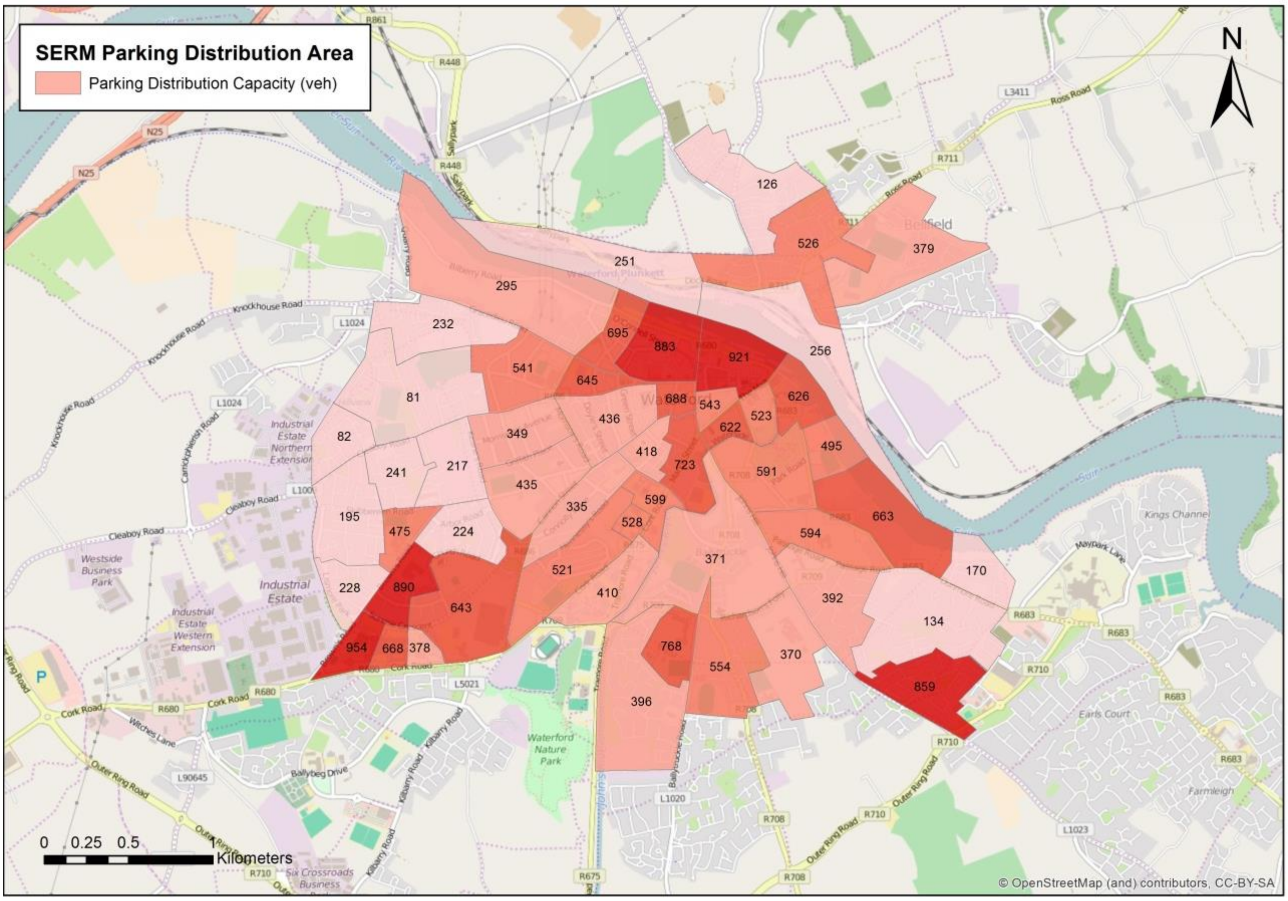


Figure 3.11: SERM Parking Distribution area and capacities[3]

3.10.3 RMSIT Splits

Additionally, the new model version allowed for the adjustment of the RMSIT input, as experience from the MWRM showed that the external demand needed to be adjusted to match observations.

This was done in two stages. Firstly, the factors converting the RMSIT demand from 24 hour totals into periods were revised, based on automatic counts on the main strategic roads crossing the edge of the model. As shown in Table 3.1, the main changes occurred for the LT (-32%) and OP time periods (+49%). Secondly, it was decided to cap the RMSIT demand at 70% of NTEM trip ends. The trip ends for a given zone come from both NTEM (for internal to internal movements) and RMSIT (for external to internal or external to externals). The model undertakes the subtraction of the external trip ends (RMSIT) from the total NTEM trip ends zone by zone in the internal area and so if there is an excess of external trips internal trip ends will be reduced to zero. This change ensures that, for all internal zones, there will be at least 30% of trips retained.

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

Table 3.1: RMSIT Factors

Time Period	Initial NHTS factors	Updated factors
AM	0.190	0.201
LT	0.237	0.160
SR	0.193	0.189
PM	0.242	0.245
OP	0.137	0.205

3.11 Phase 3 Test 1

Model Version: *2.0.8e*
Scenario Name: *SEBY15*
Date: *01/07/2016*

3.11.1 Run Details

This run was performed based using the latest generalised costs coming from the latest road ME and with the latest estimated internal goods matrix. In addition, at this stage, the special zones were added in. These were the Waterford and Rosslare Port's HGV demand, as well as the Rosslare passenger demand.

The special zone demand was estimated based on a methodology developed for the MWRM. Further information on this methodology is provided in Annex 2 of this report.

The road and PT networks needed to be accommodated in order to ensure correct connectivity for the new / revised special zones.

Rosslare port was already coded as a special zone. This was not the case for port of Waterford. One extra zone had to be added to the model which therefore went from 570 to 571 zones. Additionally, all model parameters had to be updated or reviewed.

Results/Outputs

The key results of this stage of FDM calibration are as follows:

- AM 41% / 45% (before ME) improving to 87% / 60% (after ME);
- IP1 51% / 53% (before ME) improving to 92% / 71% (after ME);
- IP2 44% / 53 % (before ME) improving to 87% /59% (after ME); and
- PM 35% / 39% (before ME) improving to 83% / 67% (after ME).

The analysis of R^2 values, showed a less significant distortion of the demand caused by ME than previously with values included between 0.77 and 0.90. Figure 3.12 shows the match between the observed and modelled flows across the screenlines and suggests that the match is good, particularly after ME.

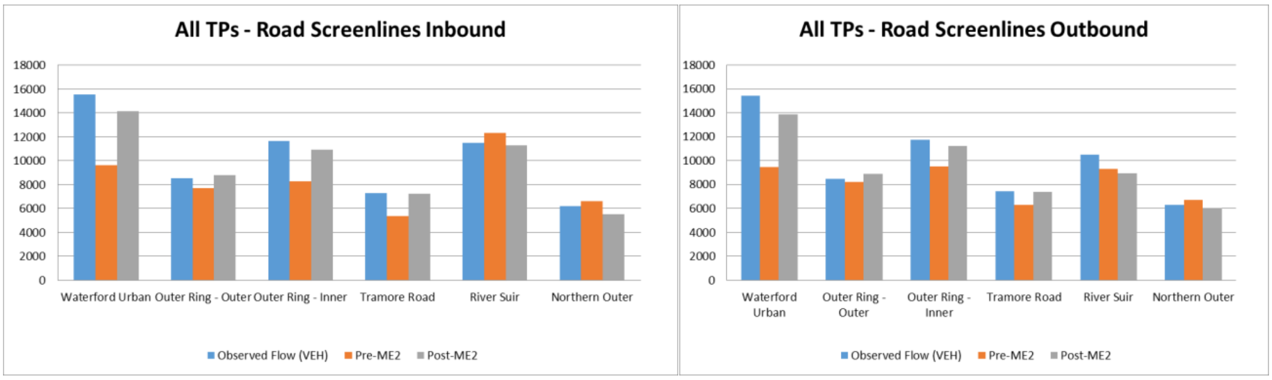


Figure 3.12: Road screenlines

Further information on road results are provided in the Phase 3 Test 2\3 Road folder.

3.12 Phase 3 Test 2

Model Version: *2.0.8e*
Scenario Name: *SEBY17*
Date: *07/07 2016*

3.12.1 Run Details

After the previous run, the road dashboards were used in order to estimate any adjustments needed to the Period to Hour (PtH) factors, and, in addition, a comparison with the PtH factors used for other models was performed.

From this, it was decided to update the PtH factors as per Table 3.2.

Table 3.2: Update of Road Period to hour factors

Time Period	Previous PtH factor	Next PtH factor
AM	0.409	0.443
LT	0.333	0.409
SR	0.333	0.441
PM	0.378	0.490

Additionally, it was noted that the input special zones demand for HGVs had been entered in PCUs rather than movements. Although the difference was very small this was corrected for this run.

3.12.2 Results/Outputs

The results for road calibration / validation were very similar to the previous run with the road calibration standing at:

- AM 41% / 40% (before ME) improving to 87% / 60% (after ME);
- IP1 52% / 53% (before ME) improving to 92% / 71% (after ME);
- IP2 44% /53 % (before ME) improving to 87% /59% (after ME); and
- PM 35% / 33% (before ME) improving to 87% / 61% (after ME).

Figure 3.13 shows the comparison between observed and modelled rail boarding and alightings and indicates that the modelled values are still high. Further information on road and PT results are provided in the Phase 3 Test 2\3 Road and Phase 3 Test 2\4 PT folders.

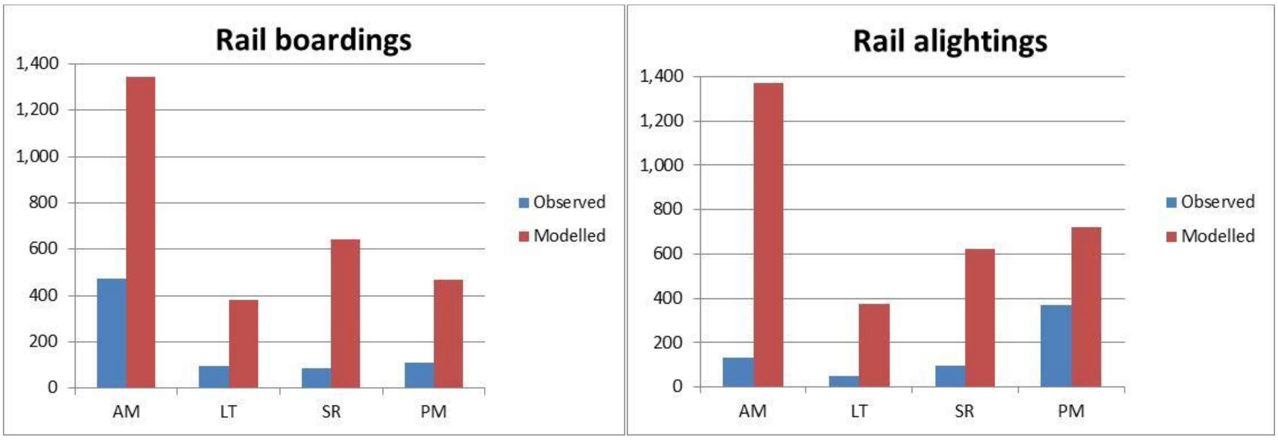


Figure 3.13: Rail boardings and alightings

At this stage, matrix estimation was performed and an analysis of R^2 values showed a fairly significant distortion of the demand with values between 0.66 and 0.92.

3.13 Phase 3 Test 3

Model Version: *2.0.8e*
Scenario Name: *SEBY20*
Date: *03/08/2016*

3.13.1 Run Details

This run included an update to the base generalised costs as calculated by the previous test. In addition, further adjustments and corrections were made to the PT inputs in an attempt to improve the match between observed and modelled rail boardings and alightings. The SERM PT Model Development Report gives more details on the amendments.

The IZM parameters (by mode and by demand segment) were adjusted to reduce the amount of intrazonal demand as there were too many intrazonals in the previous runs.

Finally, ASC values were adjusted in order to further improve the mode split while Period to Hour values were kept unchanged.

3.13.2 Results/Outputs

The calibration/validation results before and after ME were as below:

- AM 39% / 40% (before ME) improving to 86% / 60% (after ME);
- IP1 49% / 59% (before ME) improving to 92% / 71% (after ME);

- IP2 41% / 47 % (before ME) improving to 88% /65% (after ME); and
- PM 40% / 44% (before ME) improving to 84% / 67% (after ME).

This was a significant improvement for the PM while the inter-peaks were slightly worse.

While the match is still less than perfect, Figure 3.14 shows significant improvement in terms of rail boardings and alightings with notable drops in modelled demand.

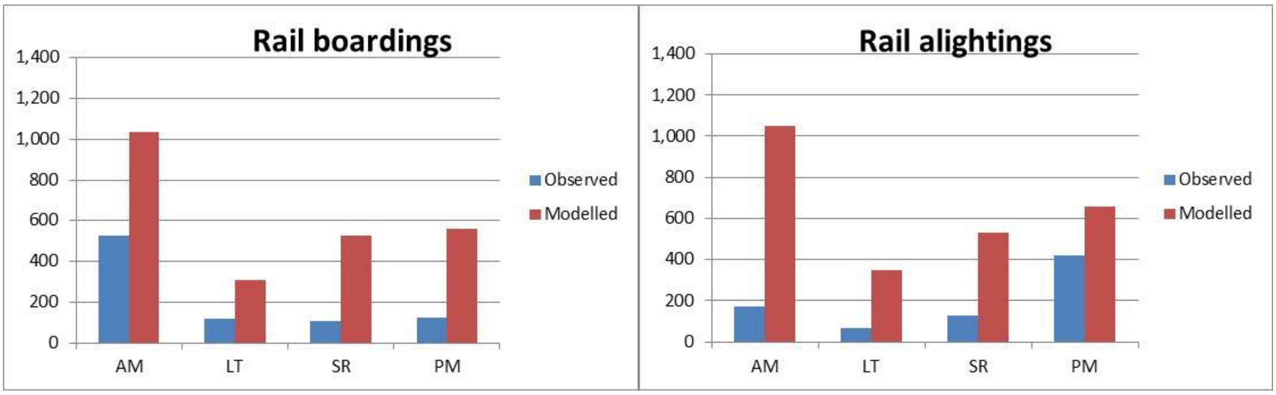


Figure 3.14: Rail boardings and alightings

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

Matrix estimation was performed and the analysis of R^2 values showed an improvement though there was still some distortion of the demand caused by the ME process with values between 0.70 and 0.86.

3.14 Phase 3 Test 4

Model Version: *2.0.8e*
Scenario Name: *SEBY22*
Date: *09/08/2016*

3.14.1 Run Details

For this run, in order to improve the convergence of the PT assignment, the road distribution factor for all coaches was set to 50 instead of 100. Although the seated and crush capacity for coaches was very close, it was noted that the crowding process did not always converge properly (see the SERM PT Model Development Report for further details).

Although this would not make a significant difference there was also a minor correction to a script in the RMSIT integration module so that HGV trips were placed into the right road assignment user class.

Generalised costs were updated based on the previous test.

3.14.2 Results/Outputs

There were no significant changes in road calibration as a result of the changes included in this test. PT movements also did not change significantly although the change of load distribution factor did result in a small difference in terms of PT convergence.

Iteration	LOADDISTFAC=50	LOADDISTFAC=100
1	14.51	14.47
2	2.76	2.75
3	1.9	1.89
4	0.88	0.88
5	0.8	0.78

Figure 3.15: RMS percentage change on link times by crowding iteration

Road matrix estimation and PT factoring were performed and the base generalised costs were updated, followed by the estimation of incremental matrices and a final output run.

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

3.15 Version upgrade and looping to convergence

3.15.1 Overview

Testing in the SERM 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.

3.15.2 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.

3.15.3 Recalibration

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

The final results of the recalibration are shown in the charts below. Using the same inputs in v2.0.23 as in v2.0.8 generates fewer car trips and more walk trips than observed (see the chart on the left-hand side). Post-calibration modelled mode shares (chart on the right-hand side) are closer to the observed data (Figure 3.16).

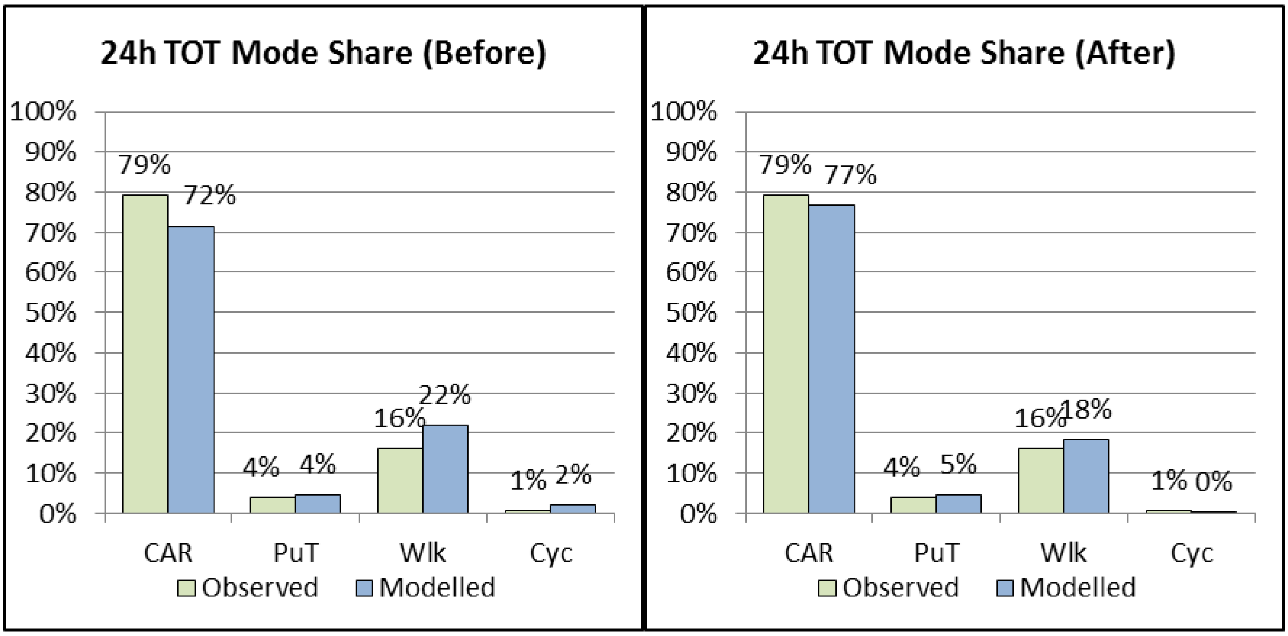


Figure 3.16: 24h Total Mode Share before (left) and after (right) recalibration

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

3.15.4 Park and Ride calibration

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

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

- Demand: z Final\2 Demand;
- Road: z Final\3 Road; and
- 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 a little low overall while the PT and walk shares are a little high.

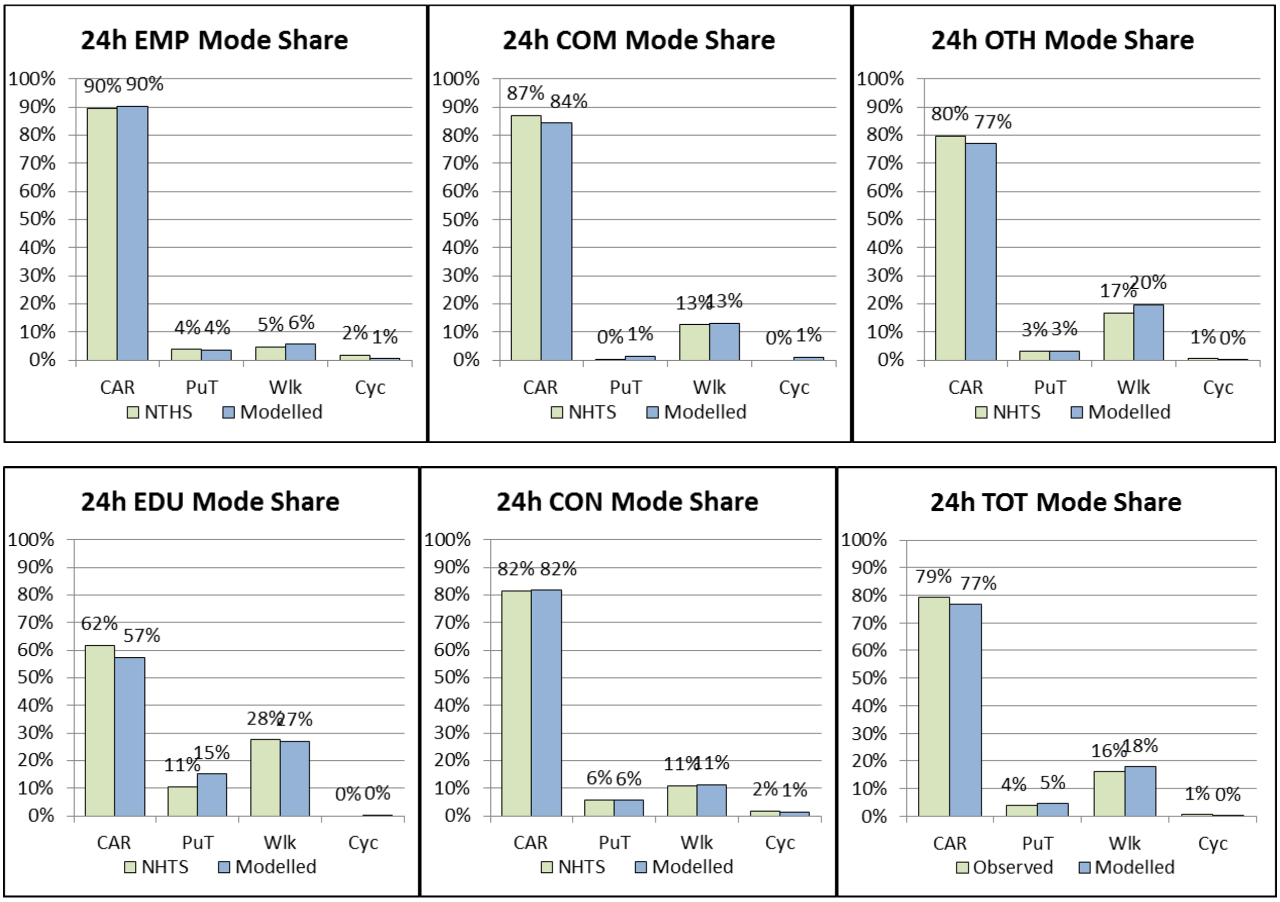


Figure 4.1: Mode share by user class

4.3.2 Generalised cost distributions

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

AM	LT

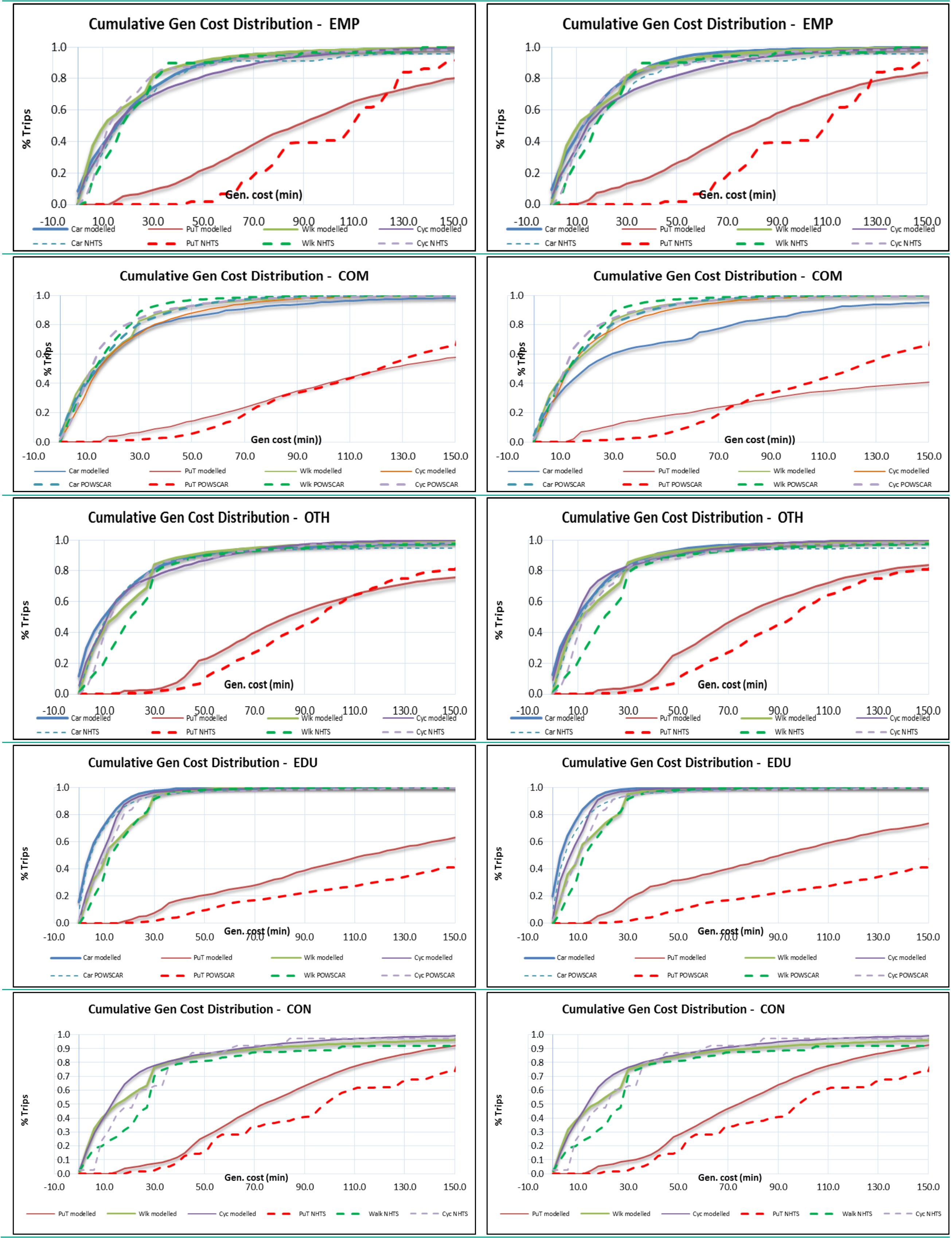


Figure 4.2: Cumulative trip length distributions (AM and LT)

SR	PM

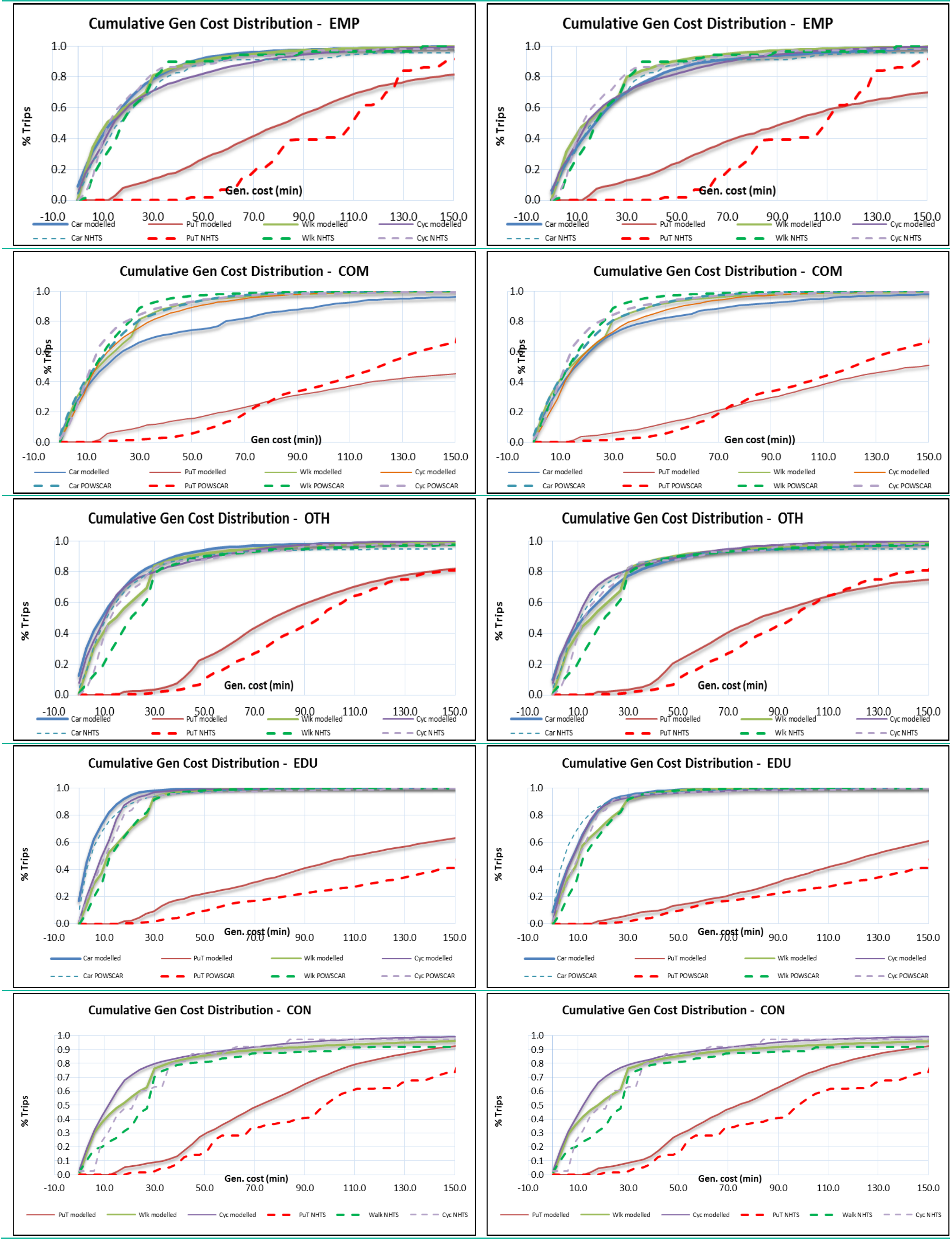


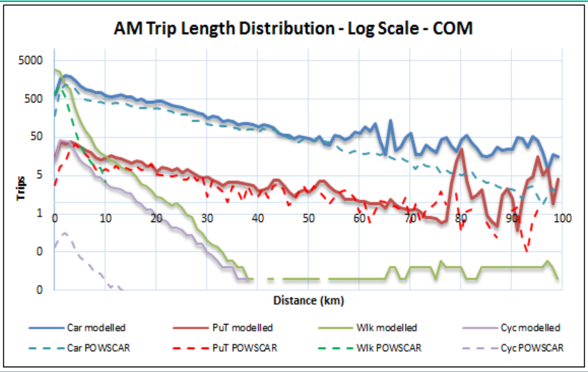
Figure 4.3: Cumulative trip length distributions (SR and PM)

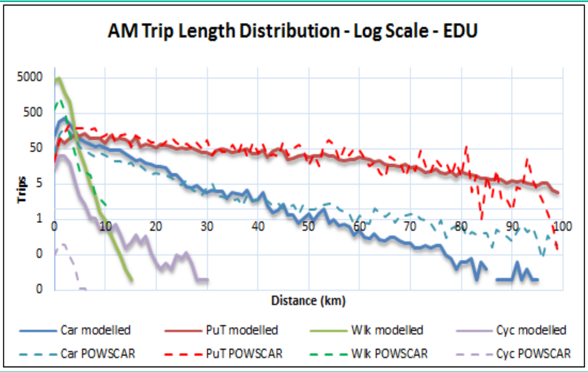
4.3.3 Trip length distribution

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

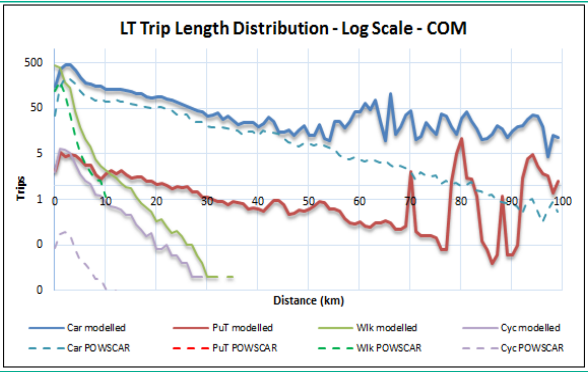
TP **COM** **EDU**

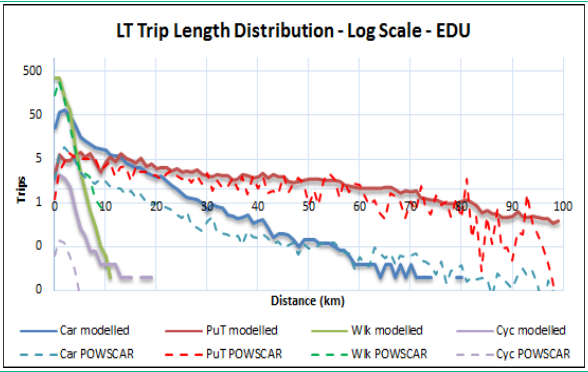
AM



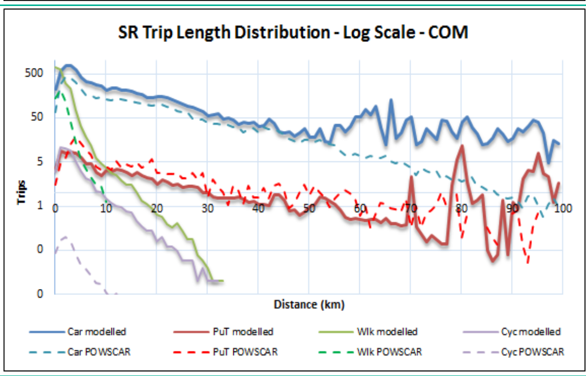


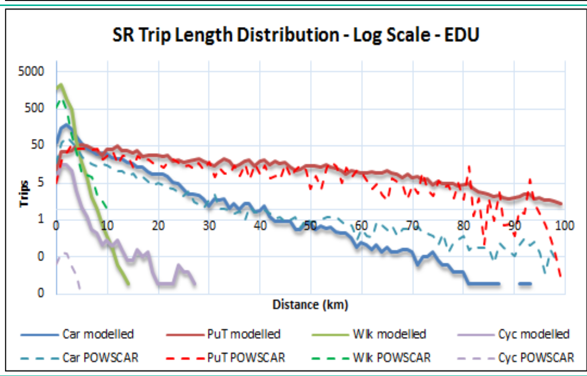
LT



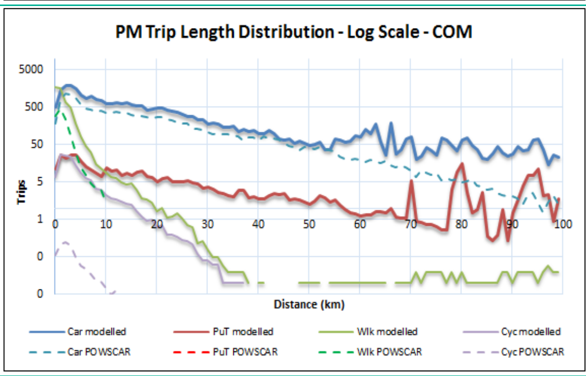


SR





PM



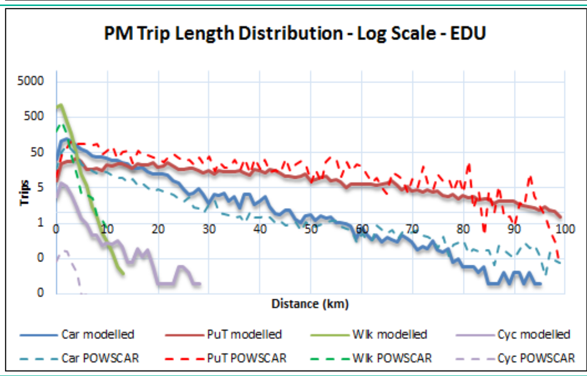


Figure 4.4: Trip lengths for COM and EDU

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.

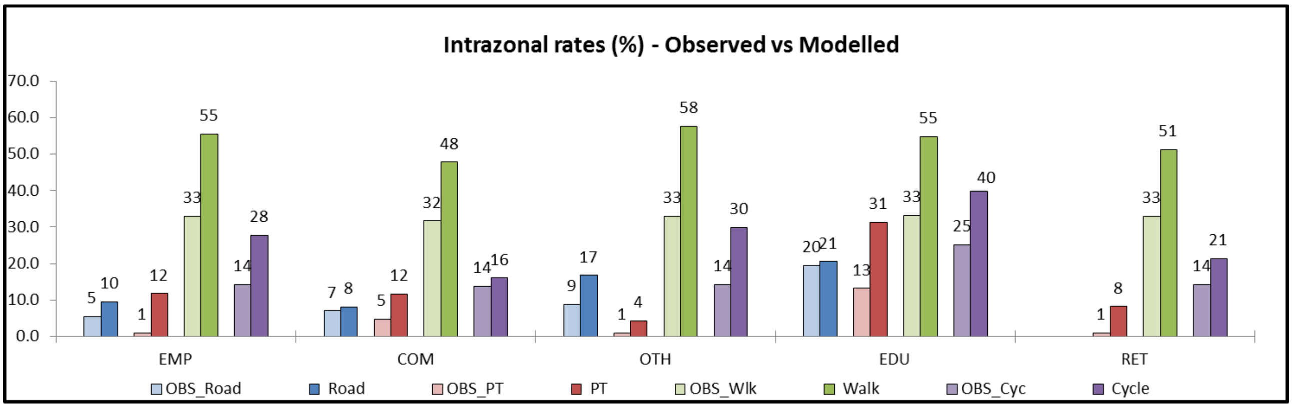


Figure 4.5: AM Intrazonal Trip Rate Proportion

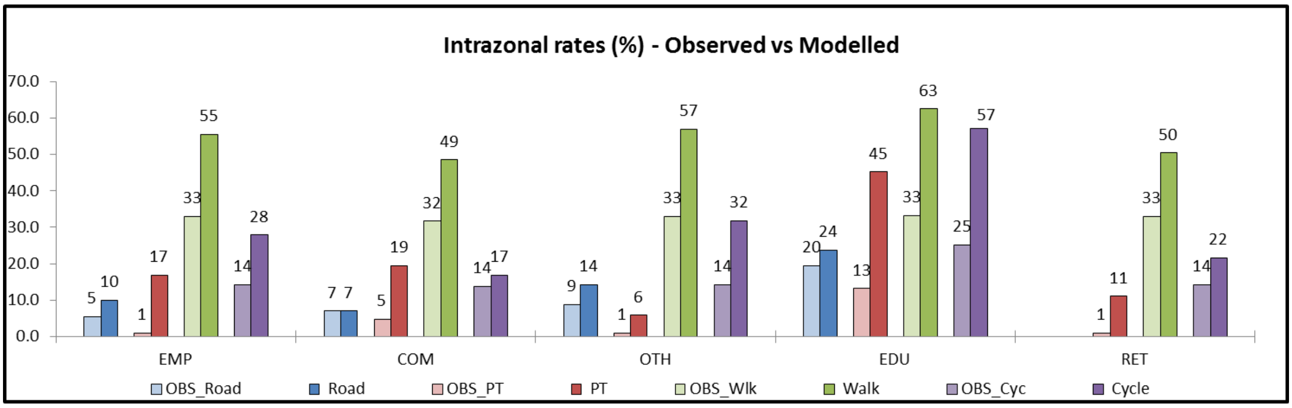


Figure 4.6: LT Intrazonal Trip Rate Proportion

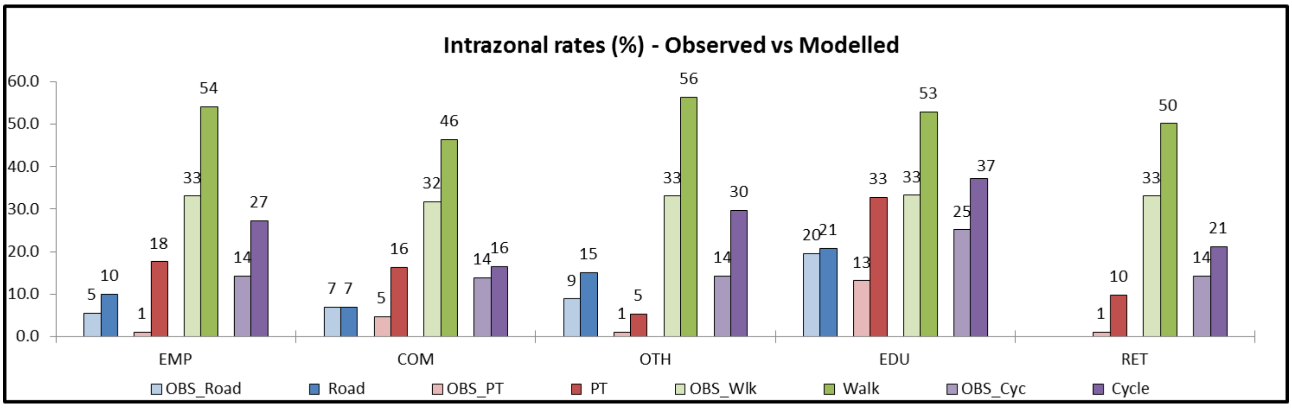


Figure 4.7: SR Intrazonal Trip Rate Proportion

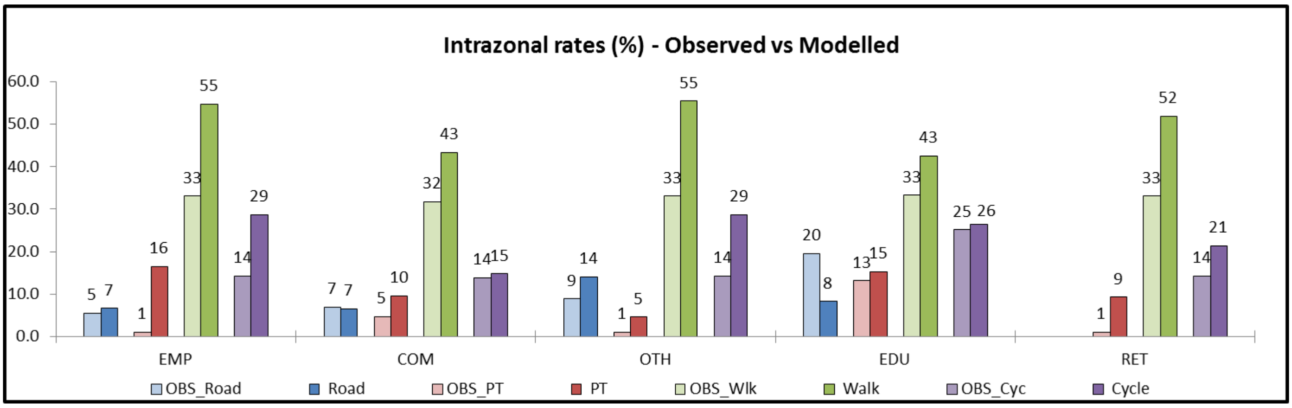


Figure 4.8: PM Intrazonal Trip Rate Proportion

4.3.5 Time period distribution

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

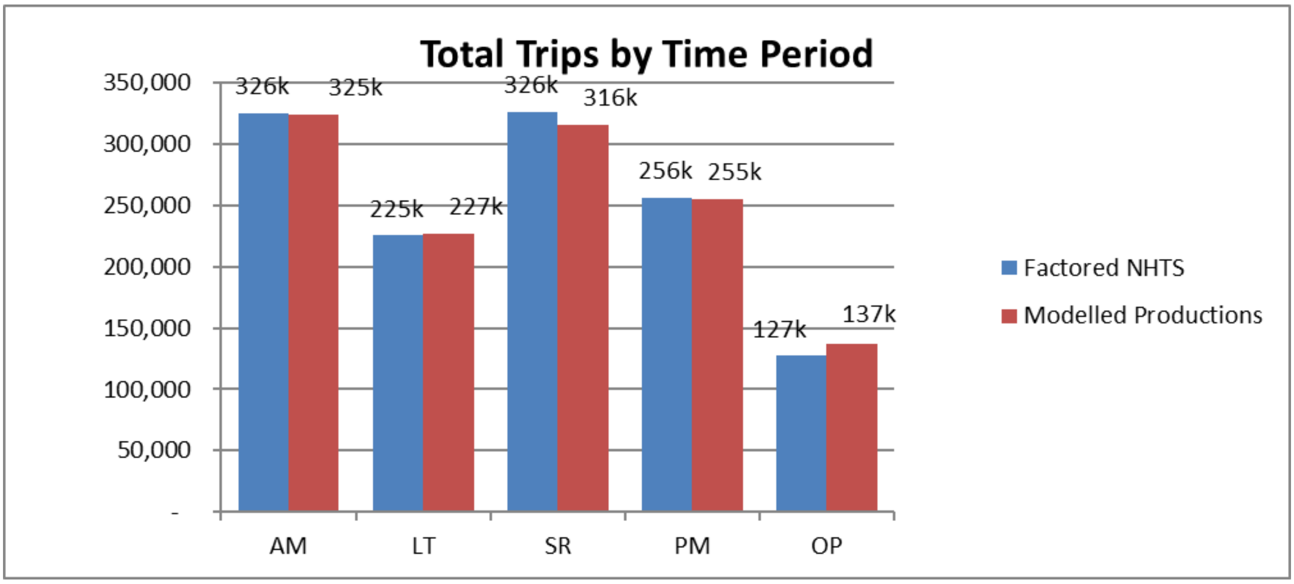
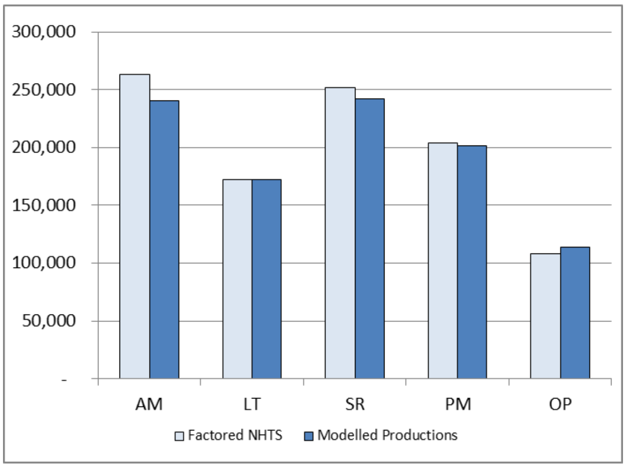


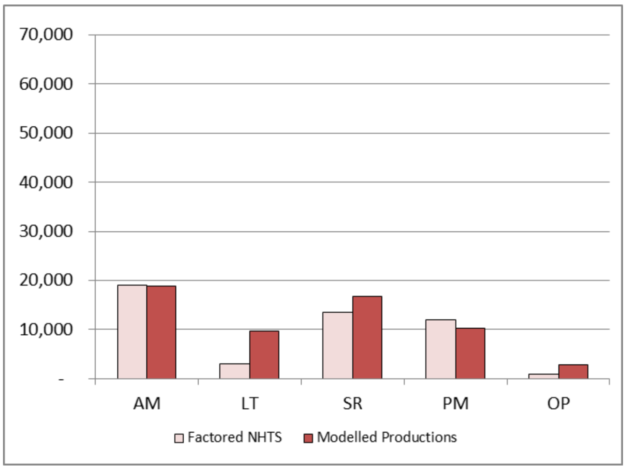
Figure 4.9: Total Trips by Time Period

The number of observed and modelled trips by each mode in each time period (Figure 4.10) also compares well, with car and cycle trips generally slightly underestimated, with walking and PT trips generally slightly overestimated.

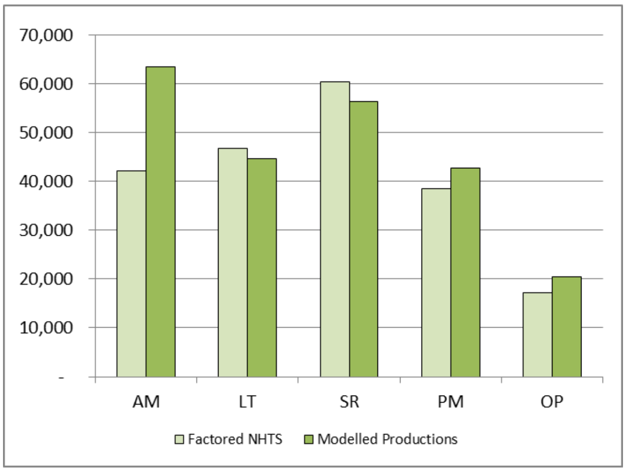
Car Trips



PT Trips



Walk Trips



Cycle Trips

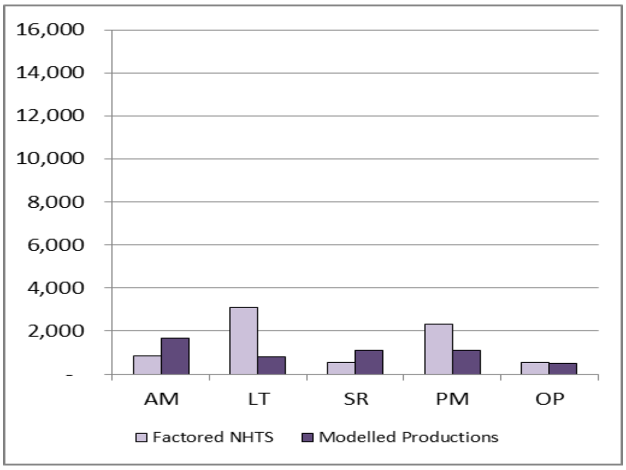


Figure 4.10: Total Trips by Time Period and Mode

4.4 Correcting calibrated demand to match observed movements on the ground

4.4.1 Limitations of demand model calibration

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

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 is shown in Figure 4.11. While there are some larger differences in individual cells, the overall changes in the trip ends are smaller, approximately 4% in total.

Differences - Sector to sector matrix												
1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
-2%	-2%	-6%	-10%	-24%	-2%	-3%	-3%	-8%	-27%	16%	-11%	-2%
-4%	11%	8%	-6%	-36%	-3%	-14%	-17%	-36%	-32%	8%	-27%	-3%
-10%	-6%	-6%	-31%	-36%	1%	-6%	-5%	-3%	5%	-9%	-22%	-8%
-10%	-13%	-33%	16%	2%	2%	-16%	-6%	-13%	-9%	-10%	-55%	3%
-21%	-24%	-15%	5%	-3%	-3%	-24%	8%	-9%	-26%	-19%	-46%	-4%
-2%	-9%	0%	-2%	-8%	-1%	-1%	0%	-21%	1%	9%	-5%	-3%
-1%	-15%	-7%	-10%	-31%	0%	7%	-6%	-4%	-34%	-12%	-2%	-3%
-2%	-9%	-4%	-4%	10%	1%	-4%	2%	-4%	-4%	-4%	-30%	0%
-10%	-35%	-3%	-8%	-12%	-24%	-5%	-6%	2%	4%	-21%	-46%	-3%
-34%	-31%	12%	10%	-25%	-4%	-43%	-1%	6%	6%	-46%	-41%	-1%
11%	4%	-7%	-2%	-25%	8%	-11%	-5%	-17%	-44%	6%	-26%	0%
-18%	-33%	-30%	-53%	-51%	-5%	-3%	-31%	-53%	-37%	-31%	-5%	-22%
-3%	-5%	-8%	5%	-7%	-3%	-3%	-1%	-3%	-2%	0%	-19%	-4%

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

4.4.3 R-squared Analysis

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

Table 4.1: Significance of Matrix Estimation Changes

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

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

TAG Unit M3-1, Section 8, Table 5 indicates that an acceptable R^2 value for individual matrix cells changes is in excess of 0.95, which is not achieved for any purpose, though acceptable values are achieved for some of the trip ends. At the cell level about half the slopes lie inside the required range but the required level is achieved in only two cases for the trip ends. Cell level intercepts are near zero, but trip end intercepts are not, in some cases. Future iterations of the model should work on improving these values.

Table 4.2 to Table 4.5 show the R^2 values for the four modelled time periods.

Table 4.2: AM Matrix Change R^2 Analysis

User Class	Emp. Business	Commute	Education	Other
Cell R-Squared	0.86	0.87	0.92	0.92
Cell Slope	0.98	0.97	0.99	1.02
Cell Y-Intercept	0.00	0.00	0.00	-0.01
Trip End R-Squared	0.96	0.98	0.99	0.97
Trip End Slope	0.88	0.86	0.96	0.89
Trip End Y-Intercept	0.55	4.62	0.14	7.53

Table 4.3: IP1 Matrix Change R^2 Analysis

User Class	Emp. Business	Commute	Education	Other
Cell R-Squared	0.82	0.90	0.87	0.88
Cell Slope	1.04	0.99	1.06	1.05
Cell Y-Intercept	0.00	0.00	0.00	-0.02
Trip End R-Squared	0.96	0.98	0.97	0.97
Trip End Slope	0.93	0.80	1.04	0.91
Trip End Y-Intercept	0.11	1.54	0.02	4.41

Table 4.4: IP2 Matrix Change R^2 Analysis

User Class	Emp. Business	Commute	Education	Other
Cell R-Squared	0.83	0.89	0.86	0.88
Cell Slope	1.02	1.00	1.06	1.04
Cell Y-Intercept	0.00	-0.01	0.00	-0.02
Trip End R-Squared	0.96	0.98	0.97	0.97
Trip End Slope	0.89	0.81	1.01	0.90
Trip End Y-Intercept	0.27	1.01	0.07	6.29

Table 4.5: PM Matrix Change R^2 Analysis

User Class	Emp. Business	Commute	Education	Other
Cell R-Squared	0.92	0.86	0.83	0.91
Cell Slope	1.00	0.96	0.98	1.01
Cell Y-Intercept	0.00	0.00	0.00	0.00
Trip End R-Squared	0.95	0.98	0.97	0.96
Trip End Slope	0.82	0.86	0.99	0.89
Trip End Y-Intercept	0.81	5.84	0.06	9.33

4.4.4 Application of estimation / factoring information to the demand model

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

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

	AM	LT	SR	PM
Taxi	-0.001%	0.001%	0.000%	0.002%
Car	-5.9%	-6.1%	-6.1%	-3.0%
PT / Walk / Cycle	--	--	--	--

4.5 Road calibration and validation

The development, calibration, and validation of the road model is described in detail in the SERM 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 network flow calibration/validation (on percentage difference) was good with overall values for all links falling out at:

- AM 81% / 76%;
- LT 88% / 79%;
- SR 84% / 75 %; and
- PM 77% / 73%.

Journey time validation was good with 82% of trips meeting the pass criteria in the AM and PM peaks, and 95% and 77% in the LT and SR time periods respectively.

4.6 Public transport calibration and validation

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

Observed and modelled boarding and alighting for rail are summarised by time period in Figure 4.12 and Figure 4.13. The results indicate a significant overestimation of rail trips within the SERM.

At the time of writing this report, there is no available observed boarding and alighting data for bus services within the SERM. The availability of further count information would allow for a more detailed assessment of boardings and alightings within the model area, and to identify the reason for any potential bias towards rail travel.

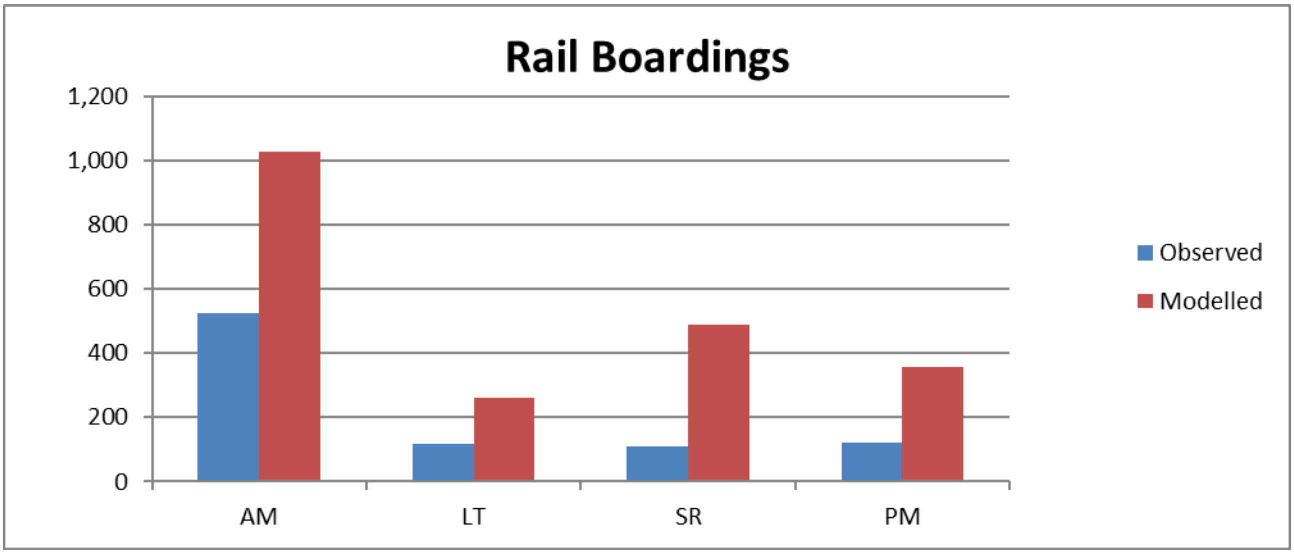


Figure 4.12: Rail boardings by time period

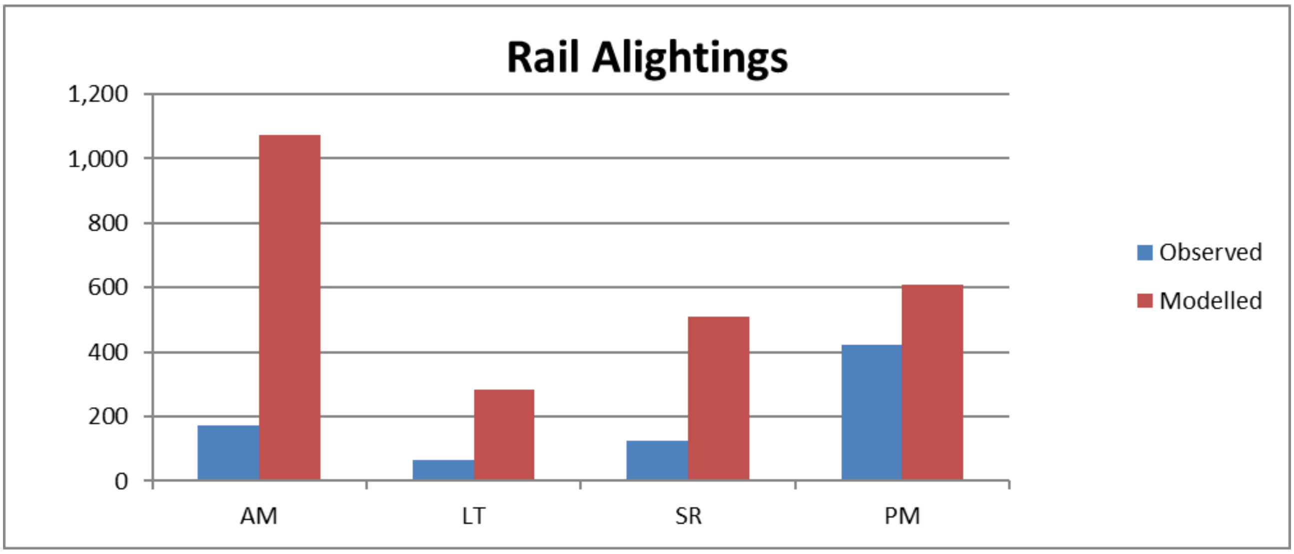


Figure 4.13: Rail alightings by time period

4.7 Active Mode calibration and validation

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

4.8 Overview

Though there is still room for improvement, overall:

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

5 Realism Testing

5.1 Overview

The preceding chapters discuss how the base year scenario of the model was calibrated and validated which reflects its ability to reproduce current conditions. 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.

[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

5.2 Acceptability criteria

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]
Time	0.00 to -0.20	

5.3 Running the realism tests

5.3.1 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 will be 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.

5.3.2 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.

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

5.4 Results

5.4.1 Car fuel cost elasticity

Overall, the elasticities are slightly larger than the WebTAG range, with the exception of EDU trips which are all within the desired range (Table 5.2), and EMP trips, which have much lower elasticities than the WebTAG range across the whole day.

However, it seems reasonable that EMP trips would be less sensitive to changes in fuel cost than is usual, as the cost of staff time is generally much higher than the direct cost of business travel. It is therefore plausible that EMP trips should show a low level of sensitivity to car fuel cost, and these low values are replicated across all the individual time periods as well.

Table 5.2: Car fuel cost elasticities

User class	AM	LT	SR	PM	OP*	24 Hour
EMP	-0.1457	-0.1224	-0.1257	-0.1422	-0.1168	**-0.1301**
COM	-0.3825	-0.4134	-0.3931	-0.3584	-0.3780	**-0.3778**
OTH	-0.4664	-0.3278	-0.3174	-0.4902	-0.3306	**-0.3757**
EDU	-0.2809	-0.3128	-0.2611	-0.2830	-0.2907	**-0.2757**
RET**	-0.4674	-0.3353	-0.3558	-0.4701	-0.3526	**-0.4008**
Total	**-0.4003**	**-0.3135**	**-0.3123**	**-0.4313**	**-0.3226**	**-0.3564**

* LT distance skim used for OP

** OTH distance skim used for RET

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

5.4.2 PT fare elasticity

At the all-purposes level (last row) and for the EMP COM and OTH groups, all of the values lie within the preferred range (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, the EDU group is subject to discounted fares for all Bus Eireann fares. Therefore, the fares represent a smaller part of the generalised costs of most of EDU trips and it is reasonable that these show a lower elasticity than is specified by WebTAG.

Table 5.3: PT fare elasticities

User class	AM	LT	SR	PM	OP*	24 Hour
EMP	-0.2202	-0.2203	-0.2241	-0.2265	-0.2541	**-0.2245**
COM	-0.4929	-0.4871	-0.4898	-0.5049	-0.5054	**-0.4967**
OTH	-0.5630	-0.5234	-0.5437	-0.5557	-0.5733	**-0.5465**
EDU	-0.1473	-0.1524	-0.1409	-0.1613	-0.1341	**-0.1472**
RET*	-0.0041	-0.0028	-0.0045	-0.0042	-0.0018	**-0.0038**
Total	**-0.2385**	**-0.3468**	**-0.2552**	**-0.3173**	**-0.3538**	**-0.2801**

* Concessionary travel

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

5.4.3 Car journey time elasticity

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

Table 5.4: Car journey time elasticities

User class	AM	LT	SR	PM	OP*	24 Hour
EMP	-0.1009	-0.1240	-0.1263	-0.0954	-0.1133	**-0.1139**
COM	-0.0948	-0.0982	-0.0947	-0.0906	-0.0882	**-0.0929**
OTH	-0.1530	-0.3611	-0.3371	-0.1657	-0.3416	**-0.2741**
EDU	-0.2351	-0.2530	-0.2605	-0.2818	-0.1880	**-0.2496**
RET	-0.2326	-0.4322	-0.4031	-0.2303	-0.3903	**-0.3247**
Total	**-0.1622**	**-0.3270**	**-0.3032**	**-0.1580**	**-0.2833**	**-0.2389**

6 Conclusion and recommendations

6.1 Introduction

This report has described the calibration and validation of the FDM component of the South East 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 SERM FDM 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 SERM 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.
- **Generalised Cost Distribution:** Generalised cost curves were calibrated to POWSCAR and NHTS data and are well matched for car, walk and cycle trips. PT trips are less well matched, but only at high costs where there are comparatively fewer trips.
- **Trip Length Distribution:** Trip length distributions for COM and EDU were compared to observed (POWSCAR) trip length distributions. The match is reasonable, particularly in those areas of the curves where the majority of trips occur.
- **Intrazonal Trips:** The proportion of intrazonal trips was calibrated to observed data for each mode, time period and purpose and the modelled pattern is a reasonable match to the observed pattern.
- **Time Period Distribution:** Total trips by time period, and trips by time period and mode, were calibrated to observed data. The overall match is good with car and PT trips generally slightly underestimated and walk trips generally slightly overestimated.

- **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 77% (or 81% excluding the PM) and validations above 73% in all cases. Journey time validation is good at 77-95%. The development, calibration, and validation of the road model is covered in more detail in the SERM Road Model Development Report.
- **PT calibration and validation:** Given the limited data availability for PT calibration, any comparison to observed data must be taken with caution. Further count data is required to carry out a more detailed assessment of how well the PT model is replicating observed conditions in the SERM area. The development, calibration, and validation of the PT model is covered in more detail in the SERM PT Model Development Report.
- **Active modes calibration and validation:** As there is no data available, the calibration and validation of the active modes model was not covered here. However, the development of the active modes model is covered in more detail in the SERM Active Modes Model Development Report.

6.4 Recommendations for further development

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

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

Annex 1 Full list of required input files

Group	Input file
NDFM outputs and tour proportions	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Dem_Zone_Zone_HGV.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Dem_Zone_Zone_M1.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Dem_Zone_Zone_M2.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Dem_Zone_Zone_M3.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Work_Zone_Zone_M1.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Work_Zone_Zone_M2.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Work_Zone_Zone_M3.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Prods_CA.CSV
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Blue_White_Collar.CSV
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Emp_Split.CSV
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Special demands	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\Internal_Goods.MAT
	{CATALOG_DIR}\Runs\{Model Year}\2 Demand\{Growth}\AM_SpecialZones.MAT
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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
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	{CATALOG_DIR}\Params\MDC_Params\P??_ASC.MAT
	{CATALOG_DIR}\Params\MDC_Params\P??_IZM.MAT
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Parking information	{CATALOG_DIR}\Params\GenCost_Params\Parking_VoT.dbf
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	{CATALOG_DIR}\Runs\{Model Year}\{Run ID}\Input\PCharge_{Run ID}{Model Year}.CSV
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	{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
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	{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
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	{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
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	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\3 Road\??\??_PreLd.PLD *(except OP)*

Group	Input file
PT network files (factor files for EMP, COM, OTH, EDU, RET and ZOD)	{CATALOG_DIR}\Params\4 PT \4 PT_VOT_Table.dbf
	{CATALOG_DIR}\Runs\{Model Year}\{RunID}\Input\Additional_PT\FARES.MAT
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	{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
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	{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
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Finalisation files	{CATALOG_DIR}\Params\AssPrep\CarUserToCarDriver.PRM
	{CATALOG_DIR}\Params\AssPrep\PeriodToHour.PRM
	{CATALOG_DIR}\Params\AssPrep\AM_Incrementals.INC
	{CATALOG_DIR}\Params\AssPrep\LT_Incrementals.INC
	{CATALOG_DIR}\Params\AssPrep\SR_Incrementals.INC
	{CATALOG_DIR}\Params\AssPrep\PM_Incrementals.INC
	{CATALOG_DIR}\Params\AssPrep\OP_Incrementals.INC
	{CATALOG_DIR}\Params\AssPrep\TaxiProps.MAT
	{CATALOG_DIR}\Params\AssPrep\Taxi_Incrementals.INC
Preliminary test / dummy files	{CATALOG_DIR}\Params\Active_Assignment \Dummy_Active_Assign.AAM
	{CATALOG_DIR}\Params\Empty.prn
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	{CATALOG_DIR}\Params\PnR\PnR_Blank_Costs.AGC
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Annex 2 Special zones demand estimation

A2.1 Introduction

This chapter sets out the methodology of 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 Rosslare Port (passenger ferry traffic)

This section discusses how the highway and PT Attractions and Productions relating to passenger ferry services using Rosslare Port were generated.

A2.2.1 Demand

There is data available on the number of passengers using Rosslare Port, and the number of cars entering and leaving, but not on car occupancy or mode share.

The number of cars entering or leaving was 270,600 in 2012 (Source: CSO 2012[6]). This figure was broken down to represent a typical weekday in November as follows considering the seasonality of passenger trips, which tend to be higher in the summer, to ensure that a typical weekday was considered.

- 270,600 – Annual car number;
- 22,550 – Estimated number of cars in November;
- 15,460 – Estimated number of cars on weekdays in November; and
- 703 – Estimated number of cars on a week day in November.

The number of passengers who started or ended their journey at Rosslare Port was 904,000 in 2012 (Source: Eurostat 2012[7]) and, in the absence of observed mode share data, the assumption is that public transport mode share is 10%. This value is the same as the assumed public transport mode share at other airports (Shannon, Cork and Knock) and was extracted from figures from the DAA data (2012) provided by the NTA.

Similarly to the car figure this figure was broken down to represent a typical weekday in November:

- 904,000 – Annual passenger numbers;
- 75,330 – Monthly passengers in November;
- 51,660 – Weekdays passenger numbers in November;
- 2,350 – Typical passenger numbers in November on a single day; and,
- 235 – passengers assuming 10% PT use.

[6] http://www.cso.ie/en/databases/

[7] http://ec.europa.eu/eurostat/data/database

It is assumed that flows are split 50:50 between arrivals and departures.

A2.2.2 Flows by time period

The next consideration was to break down the daily passenger flow by time period. Ferry arrival and departure data was obtained from the Rosslare Port website[8]. A profile was developed for trips (attractions and productions) from arrivals and departures information. Access to the port up to an hour and a half before the ferry departure was factored into the time period profile build. Table A2.1 presents the derived time period profile.

Table A2.1: Passenger Trips Profile by time period

Time Periods	Time	Departures %	Arrivals %
AM	0700 - 1000	42%	42%
LT	1000 - 1300	0%	0%
SR	1300 - 1600	0%	0%
PM	1600 - 1900	10%	10%
OP	1900 - 0700	48%	48%
Total		100%	100%

A2.2.3 Output productions / attractions

Applying the time period profile to the typical daily trips gives the car and PT flows shown in Table A2.2 and Table A2.3.

Table A2.2: Cars Attractions and Productions

Time Periods	Time	Departures %	Arrivals %	Cars Attr	Cars Prod
AM	0700 - 1000	42%	42%	**146**	**146**
LT	1000 - 1300	0%	0%	**0**	**0**
SR	1300 - 1600	0%	0%	**0**	**0**
PM	1600 - 1900	10%	10%	**37**	**37**
OP	1900 - 0700	48%	48%	**168**	**168**
Total		100%	100%	**351**	**351**

Table A2.3: PT Attractions and Productions

Time Periods	Time	Departures %	Arrivals %	PT Attr	PT Prod
AM	0700 - 1000	42%	42%	**49**	**49**
LT	1000 - 1300	0%	0%	**0**	**0**
SR	1300 - 1600	0%	0%	**0**	**0**
PM	1600 - 1900	10%	10%	**12**	**12**
OP	1900 - 0700	48%	48%	**56**	**56**
Total		100%	100%	**117**	**117**

[8] http://rosslareeuroport.irishrail.ie/about_us/RosslareEuroport_TrafficVolumes_2002_2011.pdf

A2.2.4 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 port being difficult quantify due to the absence of observed data, the 0.50 factor is considered reasonable.

A2.2.5 Split of inbound / outbound trips by destination type

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

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

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

Although these calculations relate to a sea port rather than an airport no equivalent data is available for sea ports and these figures are considered to represent the best available approximation.

A2.3 Trip 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.

A2.3.1 Home Trips

The matrix build for home trips was developed based on population census data. The trips were distributed based on an exponential gravity model, based on population and distance (shortest distance). The gravity model ensured that both the distance to the port and the population were considered.

The sensitivity to distance was derived from the Dublin Airport trip distribution where an accurate survey was undertaken. All “Other” trip ends of the special zone of Dublin Airport extracted from the ERM model were used at the 24h level. Based on census population and shortest distance, it appears that a lambda value of 0.03 (km^{-1}) is the most appropriate (see figure below).

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

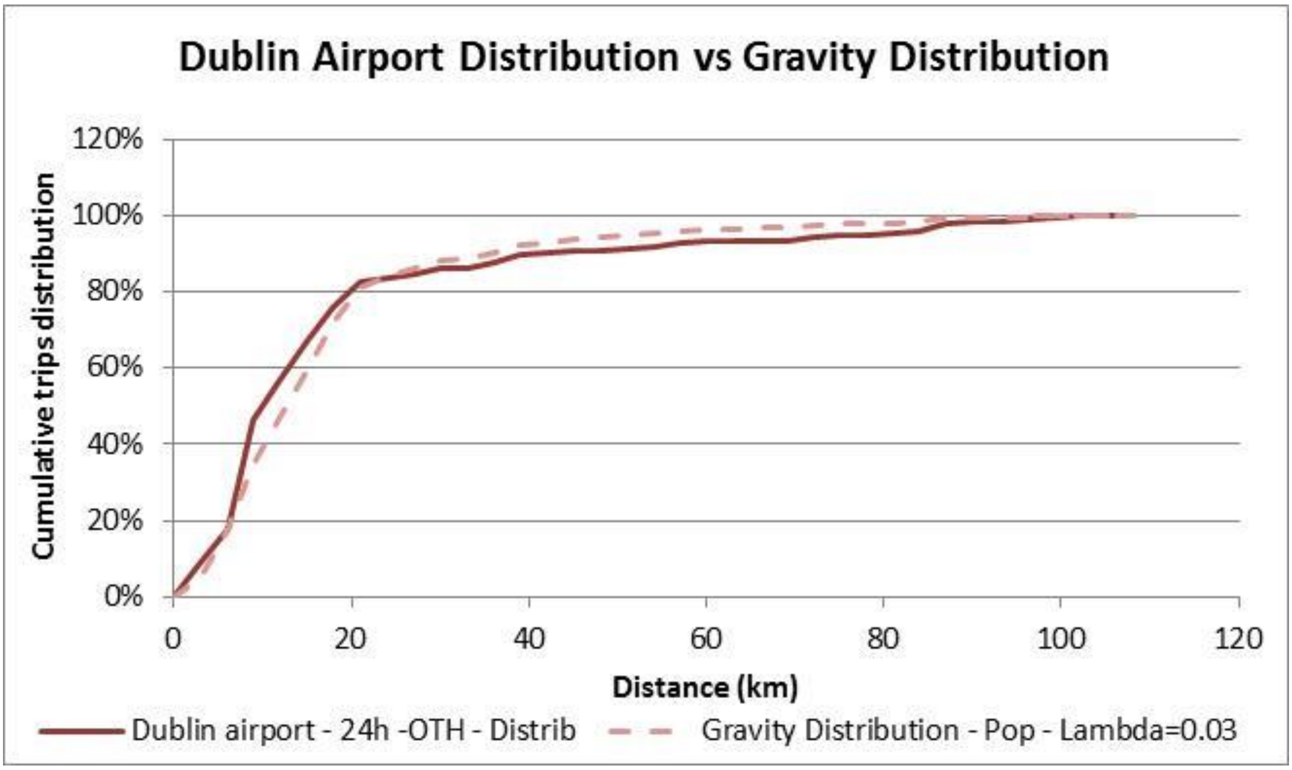

Figure A2.1: Dublin Airport – Distribution vs Gravity

The exponential gravity model with the estimated sensitivity of $\lambda = 0.03$ has therefore been applied to distribute trips on all SERM zones (internal + externals). The obtained distribution is shown in Table A2.2.

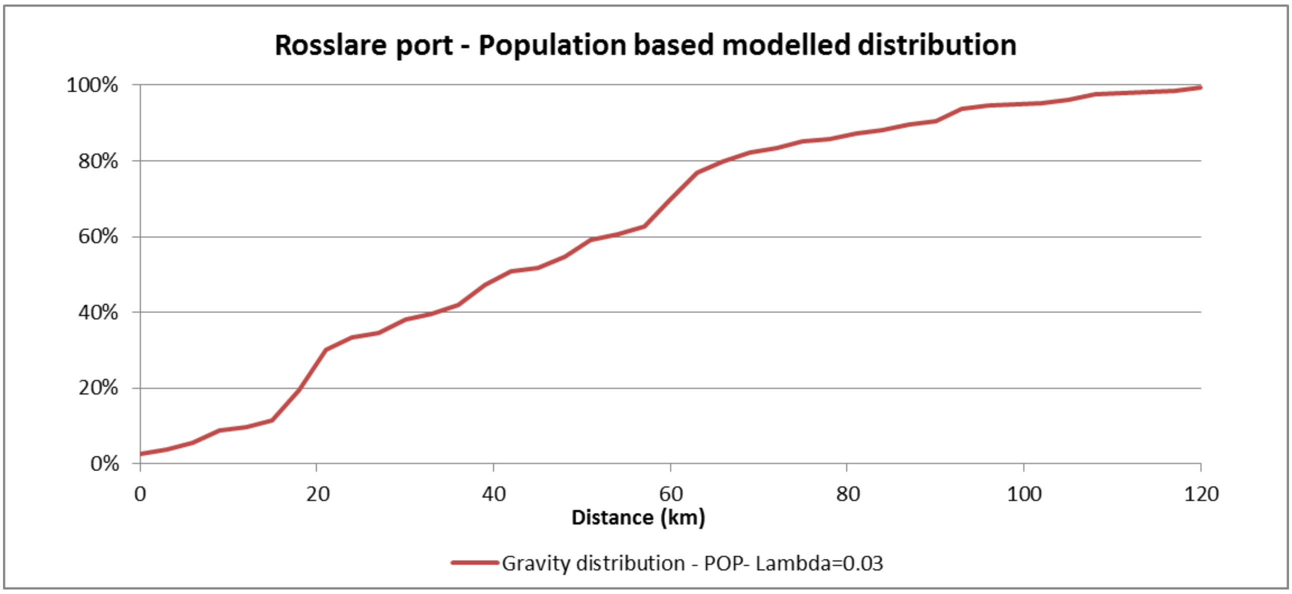

Figure A2.2: Rosslare Port – Population based modelled distribution

Again, although these calculations relate to a sea port rather than an airport no equivalent data is available for sea ports and these figures are considered to represent the best available approximation.

A2.3.2 Leisure Trips

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

A2.4 Rosslare Port (HGV movements)

Rosslare Port contributes a significant number of HGV trips to the network and these need to be considered in the model. This section discusses how the HGV Attractions and Productions relating to Rosslare Port were generated.

A2.4.1 Demand

Evidence from the CSO statistics 2012[9] states that, in the last trimester of 2012, 465,000 tons of freight went through Rosslare Port. Based on these figures, the generation of 1,109 HGV movements for Rosslare Port was estimated per working day.

A2.4.2 Flows by time period

As goods traffic at Rosslare port uses the same ferry services as passengers, the split of HGV trips by time period was based on the time period profile presented in Table A2.1.

[9] http://www.cso.ie/en/databases/

A2.4.3 Output productions and attractions

Table A2.5 shows the HGV productions and attractions produced by combining the estimated demand and time profile.

Table A2.5: HGV attractions and productions

Time Periods	HGV Prod	HGV Attr
AM	231	231
LT	0	0
SR	0	0
PM	58	58
OP	266	266
Total	554	554

A2.4.4 Distribution

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

A2.5 Waterford Port (HGV movements)

Waterford Port contributes a significant number of HGV trips to the network and these need to be considered in the model. This section discusses how the HGV Attractions and Productions relating to Waterford Port were generated.

A2.5.1 Demand

Evidence from the CSO statistics 2012[10] states that, in the last trimester of 2012, 351,000 tons through Waterford Port. Based on these figures, the generation of 1,740 HGV movements for Waterford Port was estimated per working day.

A2.5.2 Flows by time period

For Waterford Port there was no traffic count data was available for the local road network and so data from Transport Infrastructure Ireland near Foynes Port on the N69 was used to give the values in Table A2.6.

Table A2.6: Waterford Goods Trips Profile by time period

Time Periods	Time	Departures %	Arrivals %

[10] http://www.cso.ie/en/databases/

AM	0700 - 1000	24%	24%
LT	1000 - 1300	27%	27%
SR	1300 - 1600	26%	26%
PM	1600 - 1900	13%	13%
OP	1900 - 0700	10%	10%
Total		100%	100%

A2.5.3 Output productions and attractions

Table A2.7 shows the HGV productions and attractions produced by combining the estimated demand and time profile.

Table A2.7: HGV attractions and productions

Time Periods	HGV Prod	HGV Attr
AM	207	207
LT	235	235
SR	227	227
PM	117	117
OP	85	85
Total	870	870

A2.5.4 Distribution

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

Annex 3 Final demand model parameter values

The data included is as follows:

- Table A3.8: Production tour proportions by purpose
- Table A3.9: Attraction tour proportions by purpose
- Table A3.10: Finalised distribution and mode split parameters
- Table A3.11: Finalised period to hour factors
- Table A3.12: Finalised parking distribution calibration parameters
- Table A3.13: Finalised special zone calibration parameters

Table A3.8: 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	0.03226	0.04839	0.11290	0.43952	0.04435	0.00000	0.01613	0.01613	0.04032	0.01613	0.00000	0.00000	0.00403	0.02419	0.03629	0.00000	0.00000	0.00000	0.02419	0.01613	0.00000	0.00000	0.05645	0.06452	0.00806
P02	0.03226	0.04839	0.11290	0.43952	0.04435	0.00000	0.01613	0.01613	0.04032	0.01613	0.00000	0.00000	0.00403	0.02419	0.03629	0.00000	0.00000	0.00000	0.02419	0.01613	0.00000	0.00000	0.05645	0.06452	0.00806
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	0.08219	0.80822	0.06849	0.04110	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
P06	0.03636	0.10909	0.29091	0.40000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.14545	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01818	0.00000	0.00000	0.00000	0.00000	0.00000
P07	0.00000	0.07843	0.35294	0.39216	0.00000	0.00000	0.00000	0.00000	0.01961	0.00000	0.00000	0.00000	0.07843	0.03922	0.00000	0.00000	0.00000	0.00000	0.00000	0.03922	0.00000	0.00000	0.00000	0.00000	0.00000
P08	0.00000	0.08219	0.80822	0.06849	0.04110	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
P09	0.03636	0.10909	0.29091	0.40000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.14545	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01818	0.00000	0.00000	0.00000	0.00000	0.00000
P10	0.00000	0.07843	0.35294	0.39216	0.00000	0.00000	0.00000	0.00000	0.01961	0.00000	0.00000	0.00000	0.07843	0.03922	0.00000	0.00000	0.00000	0.00000	0.00000	0.03922	0.00000	0.00000	0.00000	0.00000	0.00000
P11	0.35233	0.05181	0.08808	0.04663	0.00000	0.00000	0.03109	0.02073	0.00000	0.00000	0.00000	0.00000	0.34197	0.03109	0.00000	0.00000	0.00000	0.00000	0.03109	0.00000	0.00000	0.00000	0.00000	0.00000	0.00518
P12	0.35233	0.05181	0.08808	0.04663	0.00000	0.00000	0.03109	0.02073	0.00000	0.00000	0.00000	0.00000	0.34197	0.03109	0.00000	0.00000	0.00000	0.00000	0.03109	0.00000	0.00000	0.00000	0.00000	0.00000	0.00518
P13	0.35233	0.05181	0.08808	0.04663	0.00000	0.00000	0.03109	0.02073	0.00000	0.00000	0.00000	0.00000	0.34197	0.03109	0.00000	0.00000	0.00000	0.00000	0.03109	0.00000	0.00000	0.00000	0.00000	0.00000	0.00518
P14	0.35233	0.05181	0.08808	0.04663	0.00000	0.00000	0.03109	0.02073	0.00000	0.00000	0.00000	0.00000	0.34197	0.03109	0.00000	0.00000	0.00000	0.00000	0.03109	0.00000	0.00000	0.00000	0.00000	0.00000	0.00518
P15	0.35233	0.05181	0.08808	0.04663	0.00000	0.00000	0.03109	0.02073	0.00000	0.00000	0.00000	0.00000	0.34197	0.03109	0.00000	0.00000	0.00000	0.00000	0.03109	0.00000	0.00000	0.00000	0.00000	0.00000	0.00518
P16	0.35233	0.05181	0.08808	0.04663	0.00000	0.00000	0.03109	0.02073	0.00000	0.00000	0.00000	0.00000	0.34197	0.03109	0.00000	0.00000	0.00000	0.00000	0.03109	0.00000	0.00000	0.00000	0.00000	0.00000	0.00518
P17	0.09174	0.09633	0.03670	0.00917	0.00917	0.00000	0.13303	0.08257	0.02752	0.00000	0.00000	0.00000	0.13761	0.06881	0.00917	0.00000	0.00000	0.00000	0.11927	0.10550	0.00000	0.00000	0.00000	0.00000	0.07339
P18	0.04808	0.05769	0.03846	0.02885	0.00000	0.00000	0.08173	0.14904	0.03365	0.00962	0.00000	0.00000	0.08173	0.11058	0.00962	0.00000	0.00000	0.00000	0.16827	0.06250	0.00000	0.00000	0.00000	0.00000	0.12019
P19	0.04196	0.09790	0.03497	0.01399	0.01399	0.00000	0.23776	0.12587	0.02797	0.00699	0.00000	0.00000	0.06294	0.06294	0.00000	0.00000	0.00000	0.00000	0.13287	0.04196	0.00000	0.00000	0.00000	0.00000	0.09790
P20	0.02830	0.06604	0.01887	0.02830	0.00000	0.00000	0.16038	0.11321	0.03774	0.00000	0.00000	0.00000	0.07547	0.07547	0.00000	0.00000	0.00000	0.00000	0.15094	0.09434	0.00000	0.00000	0.00000	0.00000	0.15094
P21	0.01316	0.10526	0.01316	0.00000	0.00000	0.00000	0.27632	0.13158	0.01316	0.00000	0.00000	0.00000	0.19737	0.02632	0.00000	0.00000	0.00000	0.00000	0.10526	0.01316	0.00000	0.00000	0.00000	0.00000	0.10526
P22	0.01786	0.08929	0.00000	0.00000	0.01786	0.00000	0.23214	0.07143	0.00000	0.00000	0.00000	0.00000	0.05357	0.10714	0.00000	0.00000	0.00000	0.00000	0.17857	0.05357	0.00000	0.00000	0.00000	0.00000	0.17857
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	0.02439	0.04878	0.00000	0.00000	0.00000	0.00000	0.09756	0.21951	0.09756	0.00000	0.00000	0.00000	0.02439	0.00000	0.00000	0.00000	0.00000	0.00000	0.07317	0.21951	0.00000	0.00000	0.00000	0.00000	0.19512
P25	0.02041	0.06122	0.04082	0.08163	0.00000	0.00000	0.10204	0.10204	0.04082	0.04082	0.00000	0.00000	0.02041	0.06122	0.06122	0.00000	0.00000	0.00000	0.06122	0.12245	0.00000	0.00000	0.00000	0.00000	0.18367
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	0.02857	0.11429	0.22857	0.05714	0.02857	0.00000	0.11429	0.08571	0.05714	0.02857	0.00000	0.00000	0.05714	0.00000	0.00000	0.00000	0.00000	0.00000	0.05714	0.02857	0.00000	0.00000	0.00000	0.00000	0.11429
P28	0.10089	0.05935	0.16024	0.12760	0.01484	0.00000	0.09496	0.04154	0.00593	0.01187	0.00000	0.00000	0.11573	0.06825	0.00593	0.00000	0.00000	0.00000	0.05638	0.07715	0.00000	0.00000	0.00000	0.00000	0.05935
P29	0.07692	0.06593	0.19231	0.12088	0.00549	0.00000	0.13736	0.08791	0.02198	0.01099	0.00000	0.00000	0.07143	0.08242	0.00000	0.00000	0.00000	0.00000	0.03846	0.01648	0.00000	0.00000	0.00000	0.00000	0.07143
P30	0.23316	0.00000	0.00000	0.00000	0.00000	0.00000	0.33679	0.00000	0.00000	0.00000	0.00000	0.00000	0.25907	0.00000	0.00000	0.00000	0.00000	0.00000	0.09845	0.00000	0.00000	0.00000	0.00000	0.00000	0.07254
P31	0.23316	0.00000	0.00000	0.00000	0.00000	0.00000	0.33679	0.00000	0.00000	0.00000	0.00000	0.00000	0.25907	0.00000	0.00000	0.00000	0.00000	0.00000	0.09845	0.00000	0.00000	0.00000	0.00000	0.00000	0.07254
P32	0.19114	0.00000	0.00000	0.00000	0.00000	0.00000	0.26870	0.00000	0.00000	0.00000	0.00000	0.00000	0.33518	0.00000	0.00000	0.00000	0.00000	0.00000	0.15235	0.00000	0.00000	0.00000	0.00000	0.00000	0.05263
P33	0.19114	0.00000	0.00000	0.00000	0.00000	0.00000	0.26870	0.00000	0.00000	0.00000	0.00000	0.00000	0.33518	0.00000	0.00000	0.00000	0.00000	0.00000	0.15235	0.00000	0.00000	0.00000	0.00000	0.00000	0.05263

Table A3.9: 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	0.03226	0.04839	0.11290	0.43952	0.04435	0.00000	0.01613	0.01613	0.04032	0.01613	0.00000	0.00000	0.00403	0.02419	0.03629	0.00000	0.00000	0.00000	0.02419	0.01613	0.00000	0.00000	0.05645	0.06452	0.00806
P02	0.03226	0.04839	0.11290	0.43952	0.04435	0.00000	0.01613	0.01613	0.04032	0.01613	0.00000	0.00000	0.00403	0.02419	0.03629	0.00000	0.00000	0.00000	0.02419	0.01613	0.00000	0.00000	0.05645	0.06452	0.00806
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	0.08219	0.80822	0.06849	0.04110	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
P06	0.03636	0.10909	0.29091	0.40000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.14545	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01818	0.00000	0.00000	0.00000	0.00000	0.00000
P07	0.00000	0.07843	0.35294	0.39216	0.00000	0.00000	0.00000	0.00000	0.01961	0.00000	0.00000	0.00000	0.07843	0.03922	0.00000	0.00000	0.00000	0.00000	0.00000	0.03922	0.00000	0.00000	0.00000	0.00000	0.00000
P08	0.00000	0.08219	0.80822	0.06849	0.04110	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
P09	0.03636	0.10909	0.29091	0.40000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.14545	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01818	0.00000	0.00000	0.00000	0.00000	0.00000
P10	0.00000	0.07843	0.35294	0.39216	0.00000	0.00000	0.00000	0.00000	0.01961	0.00000	0.00000	0.00000	0.07843	0.03922	0.00000	0.00000	0.00000	0.00000	0.00000	0.03922	0.00000	0.00000	0.00000	0.00000	0.00000
P11	0.35233	0.05181	0.08808	0.04663	0.00000	0.00000	0.03109	0.02073	0.00000	0.00000	0.00000	0.00000	0.34197	0.03109	0.00000	0.00000	0.00000	0.00000	0.03109	0.00000	0.00000	0.00000	0.00000	0.00000	0.00518
P12	0.35233	0.05181	0.08808	0.04663	0.00000	0.00000	0.03109	0.02073	0.00000	0.00000	0.00000	0.00000	0.34197	0.03109	0.00000	0.00000	0.00000	0.00000	0.03109	0.00000	0.00000	0.00000	0.00000	0.00000	0.00518
P13	0.35233	0.05181	0.08808	0.04663	0.00000	0.00000	0.03109	0.02073	0.00000	0.00000	0.00000	0.00000	0.34197	0.03109	0.00000	0.00000	0.00000	0.00000	0.03109	0.00000	0.00000	0.00000	0.00000	0.00000	0.00518
P14	0.35233	0.05181	0.08808	0.04663	0.00000	0.00000	0.03109	0.02073	0.00000	0.00000	0.00000	0.00000	0.34197	0.03109	0.00000	0.00000	0.00000	0.00000	0.03109	0.00000	0.00000	0.00000	0.00000	0.00000	0.00518
P15	0.35233	0.05181	0.08808	0.04663	0.00000	0.00000	0.03109	0.02073	0.00000	0.00000	0.00000	0.00000	0.34197	0.03109	0.00000	0.00000	0.00000	0.00000	0.03109	0.00000	0.00000	0.00000	0.00000	0.00000	0.00518
P16	0.35233	0.05181	0.08808	0.04663	0.00000	0.00000	0.03109	0.02073	0.00000	0.00000	0.00000	0.00000	0.34197	0.03109	0.00000	0.00000	0.00000	0.00000	0.03109	0.00000	0.00000	0.00000	0.00000	0.00000	0.00518
P17	0.09174	0.09633	0.03670	0.00917	0.00917	0.00000	0.13303	0.08257	0.02752	0.00000	0.00000	0.00000	0.13761	0.06881	0.00917	0.00000	0.00000	0.00000	0.11927	0.10550	0.00000	0.00000	0.00000	0.00000	0.07339
P18	0.04808	0.05769	0.03846	0.02885	0.00000	0.00000	0.08173	0.14904	0.03365	0.00962	0.00000	0.00000	0.08173	0.11058	0.00962	0.00000	0.00000	0.00000	0.16827	0.06250	0.00000	0.00000	0.00000	0.00000	0.12019
P19	0.04196	0.09790	0.03497	0.01399	0.01399	0.00000	0.23776	0.12587	0.02797	0.00699	0.00000	0.00000	0.06294	0.06294	0.00000	0.00000	0.00000	0.00000	0.13287	0.04196	0.00000	0.00000	0.00000	0.00000	0.09790
P20	0.02830	0.06604	0.01887	0.02830	0.00000	0.00000	0.16038	0.11321	0.03774	0.00000	0.00000	0.00000	0.07547	0.07547	0.00000	0.00000	0.00000	0.00000	0.15094	0.09434	0.00000	0.00000	0.00000	0.00000	0.15094
P21	0.01316	0.10526	0.01316	0.00000	0.00000	0.00000	0.27632	0.13158	0.01316	0.00000	0.00000	0.00000	0.19737	0.02632	0.00000	0.00000	0.00000	0.00000	0.10526	0.01316	0.00000	0.00000	0.00000	0.00000	0.10526
P22	0.01786	0.08929	0.00000	0.00000	0.01786	0.00000	0.23214	0.07143	0.00000	0.00000	0.00000	0.00000	0.05357	0.10714	0.00000	0.00000	0.00000	0.00000	0.17857	0.05357	0.00000	0.00000	0.00000	0.00000	0.17857
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	0.02439	0.04878	0.00000	0.00000	0.00000	0.00000	0.09756	0.21951	0.09756	0.00000	0.00000	0.00000	0.02439	0.00000	0.00000	0.00000	0.00000	0.00000	0.07317	0.21951	0.00000	0.00000	0.00000	0.00000	0.19512
P25	0.02041	0.06122	0.04082	0.08163	0.00000	0.00000	0.10204	0.10204	0.04082	0.04082	0.00000	0.00000	0.02041	0.06122	0.06122	0.00000	0.00000	0.00000	0.06122	0.12245	0.00000	0.00000	0.00000	0.00000	0.18367
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	0.02857	0.11429	0.22857	0.05714	0.02857	0.00000	0.11429	0.08571	0.05714	0.02857	0.00000	0.00000	0.05714	0.00000	0.00000	0.00000	0.00000	0.00000	0.05714	0.02857	0.00000	0.00000	0.00000	0.00000	0.11429
P28	0.10089	0.05935	0.16024	0.12760	0.01484	0.00000	0.09496	0.04154	0.00593	0.01187	0.00000	0.00000	0.11573	0.06825	0.00593	0.00000	0.00000	0.00000	0.05638	0.07715	0.00000	0.00000	0.00000	0.00000	0.05935
P29	0.07692	0.06593	0.19231	0.12088	0.00549	0.00000	0.13736	0.08791	0.02198	0.01099	0.00000	0.00000	0.07143	0.08242	0.00000	0.00000	0.00000	0.00000	0.03846	0.01648	0.00000	0.00000	0.00000	0.00000	0.07143
P30	0.23316	0.00000	0.00000	0.00000	0.00000	0.00000	0.33679	0.00000	0.00000	0.00000	0.00000	0.00000	0.25907	0.00000	0.00000	0.00000	0.00000	0.00000	0.09845	0.00000	0.00000	0.00000	0.00000	0.00000	0.07254
P31	0.23316	0.00000	0.00000	0.00000	0.00000	0.00000	0.33679	0.00000	0.00000	0.00000	0.00000	0.00000	0.25907	0.00000	0.00000	0.00000	0.00000	0.00000	0.09845	0.00000	0.00000	0.00000	0.00000	0.00000	0.07254
P32	0.19114	0.00000	0.00000	0.00000	0.00000	0.00000	0.26870	0.00000	0.00000	0.00000	0.00000	0.00000	0.33518	0.00000	0.00000	0.00000	0.00000	0.00000	0.15235	0.00000	0.00000	0.00000	0.00000	0.00000	0.05263
P33	0.19114	0.00000	0.00000	0.00000	0.00000	0.00000	0.26870	0.00000	0.00000	0.00000	0.00000	0.00000	0.33518	0.00000	0.00000	0.00000	0.00000	0.00000	0.15235	0.00000	0.00000	0.00000	0.00000	0.00000	0.05263

Table A3.10: Finalised distribution and mode split parameters

Purp	Alpha					Beta	Lambda			ASC values					Intrazonals				
	Car	PT	PnR	Walk	Cyc	All mds	Dest	Md Ch	Act Ch	Car	PT	PnR	Walk	Cyc	Car	PT	PnR	Walk	Cyc
1	0.987	0.219	2.800	0.200	0.397	N/A	-0.109	-0.133	-0.133	0.000	60.000	19.000	26.000	65.000	-14.04	-9.240	10.000	-21.20	-15.73
2	2.012	0.570	2.500	0.975	1.064	N/A	-0.043	-0.052	-0.052	0.000	60.000	19.000	26.000	85.000	-12.20	20.770	10.000	-17.30	-6.880
3	1.000	0.155	1.000	0.150	0.360	N/A	-0.145	-0.230	-0.230	37.000	5.000	19.000	0.000	30.000	-7.000	-14.31	10.000	-22.20	-17.90
4	1.000	0.925	1.000	1.690	2.814	N/A	-0.043	-0.052	-0.052	37.000	5.000	19.000	-20.00	50.000	-7.000	20.960	10.000	-12.45	2.965
5	1.397	0.083	2.500	0.531	0.744	N/A	-0.152	-0.154	-0.154	0.000	40.000	19.000	17.000	100.00	-11.94	-22.60	10.000	-11.09	-12.79
6	1.950	0.150	2.500	0.615	0.620	N/A	-0.128	-0.129	-0.129	0.000	35.000	19.000	16.000	80.000	0.700	-2.420	10.000	-2.860	-0.070
7	1.132	0.300	2.500	0.623	0.400	N/A	-0.119	-0.120	-0.120	0.000	25.000	19.000	0.000	60.000	-8.500	-1.580	10.000	-3.610	4.260
8	1.900	0.330	1.000	2.363	2.950	N/A	-0.061	-0.062	-0.062	25.000	45.000	19.000	-26.00	50.000	-7.000	-36.50	10.000	-23.40	-29.00
9	1.900	0.280	1.000	1.750	2.200	N/A	-0.061	-0.062	-0.062	25.000	15.000	19.000	-26.00	40.000	-7.000	2.320	10.000	-0.895	6.770
10	1.900	0.350	1.000	1.524	0.500	N/A	-0.061	-0.062	-0.062	25.000	15.000	19.000	-26.00	100.00	-7.000	-11.80	10.000	-6.195	-11.56
11	1.000	0.597	1.900	0.276	0.295	N/A	-0.158	-0.160	-0.160	0.000	45.000	19.000	20.000	100.00	-6.475	23.000	10.000	-7.450	-5.145
12	2.400	0.969	1.900	0.455	0.711	N/A	-0.158	-0.160	-0.160	0.000	45.000	19.000	23.000	100.00	-37.00	12.450	10.000	-37.00	-37.00
13	2.500	0.725	1.900	0.445	0.608	N/A	-0.158	-0.160	-0.160	0.000	45.000	19.000	25.000	100.00	-34.60	6.560	10.000	-37.00	-37.00
14	1.000	1.050	1.000	0.901	0.955	N/A	-0.061	-0.062	-0.062	35.000	0.000	19.000	-5.000	100.00	-37.00	23.000	10.000	-8.660	-2.465
15	1.000	1.105	1.000	0.474	0.568	N/A	-0.061	-0.062	-0.062	35.000	0.000	19.000	10.000	100.00	-37.00	23.000	10.000	-37.00	-28.80
16	1.000	0.884	1.000	0.673	0.695	N/A	-0.061	-0.062	-0.062	35.000	0.000	19.000	-10.00	100.00	-37.00	23.000	10.000	-20.50	-13.91
17	0.500	0.304	1.900	0.200	0.248	N/A	-0.155	-0.157	-0.157	0.000	0.000	19.000	10.000	70.000	-9.250	21.910	10.000	-11.99	-8.580
18	0.400	0.280	1.900	0.150	0.227	N/A	-0.155	-0.157	-0.157	0.000	0.000	19.000	10.000	60.000	-15.41	19.340	10.000	-15.04	-10.49
19	1.900	0.809	1.000	0.494	0.752	N/A	-0.061	-0.062	-0.062	35.000	0.000	-31.00	15.000	100.00	-37.00	23.000	10.000	-26.50	-16.13
20	1.900	0.800	1.000	0.500	1.000	N/A	-0.061	-0.062	-0.062	35.000	0.000	-31.00	15.000	100.00	-37.00	23.000	10.000	-27.70	-12.69
21	0.500	0.250	1.900	0.234	0.311	N/A	-0.158	-0.160	-0.160	0.000	10.000	19.000	10.000	80.000	-13.38	15.700	10.000	-14.70	-10.86
22	1.700	0.400	1.900	0.363	0.500	N/A	-0.157	-0.159	-0.159	0.000	18.000	19.000	15.000	100.00	1.625	21.590	10.000	-8.670	-6.155
23	1.900	1.500	1.000	1.363	1.920	N/A	-0.061	-0.062	-0.062	35.000	2.000	19.000	5.000	100.00	-37.00	23.000	10.000	-37.00	-36.40
24	0.440	0.280	1.900	0.179	0.258	N/A	-0.157	-0.159	-0.159	0.000	3.000	19.000	10.000	60.000	-10.17	23.000	10.000	-8.870	-5.260
25	0.504	0.250	1.900	0.180	0.400	N/A	-0.156	-0.158	-0.158	0.000	5.000	19.000	10.000	70.000	-2.375	22.520	10.000	-9.590	-3.205
26	1.900	0.500	1.000	0.337	0.457	N/A	-0.061	-0.062	-0.062	35.000	2.000	-31.00	10.000	100.00	-37.00	23.000	10.000	-37.00	-27.10
27	0.675	0.300	1.900	0.246	0.297	N/A	-0.099	-0.153	-0.153	1.000	7.000	19.000	11.000	35.000	-12.58	11.790	10.000	-17.90	-15.54
28	0.480	0.203	1.900	0.120	0.249	N/A	-0.156	-0.158	-0.158	0.000	10.750	19.000	20.000	50.000	-7.220	13.570	10.000	-13.42	-6.955
29	1.900	0.554	1.000	0.312	0.602	N/A	-0.061	-0.062	-0.062	45.000	4.000	19.000	20.000	50.000	-37.00	23.000	10.000	-28.80	-13.19
30	0.683	0.230	1.900	0.190	0.246	N/A	-0.105	-0.146	-0.146	1.000	5.000	19.000	22.000	65.000	-14.22	12.340	10.000	-17.00	-13.30
31	1.900	0.628	1.000	0.642	0.744	N/A	-0.045	-0.062	-0.062	51.000	2.000	19.000	15.000	65.000	-37.00	23.000	10.000	-37.00	-36.10
32	0.750	0.314	1.900	0.180	0.287	N/A	-0.102	-0.183	-0.183	0.000	0.000	19.000	15.000	100.00	-5.955	17.430	10.000	-12.79	-9.360
33	1.900	0.600	1.000	0.820	1.202	N/A	-0.061	-0.152	-0.152	35.000	2.000	-31.00	20.000	80.000	-37.00	23.000	10.000	-10.04	-9.230

Table A3.11: Finalised period to hour factors

Time Period	Car	PT	Walk	Cycle
AM	0.44300	0.61000	0.53850	0.51493
IP1	0.40900	0.33000	0.33333	0.33333
IP2	0.44100	0.33000	0.33333	0.33333
PM	0.49000	0.55000	0.39984	0.41999
OP	0.08000	0.08000	0.08000	0.08000

Table A3.12: 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 A3.13: 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 SERM.

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

Fourteen park and ride sites were identified in the SERM, all of which are rail based and outlined in Table A4.14.

Table A4.14: SERM Park and Ride sites

Site	Capacity	Charge (€)	Observed usage
Tipperary	8	0	7
Cahir	6	0	3
Clonmel	12	0	9
Carrick-on-Suir	8	0	2
Waterford	240	4	82
Thomastown	20	0	10
Kilkenny	100	4	74
Bagenalstown	40	4	24
Carlow	190	4	150
Gorey	40	4	30
Enniscorthy	15	4	21
Wexford	5	0	5
Rosslare Strand	10	0	6
Rosslare Europort	15	0	4

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 SERM region. As such, it was decided that the only feasible alternative method for determining site usage was via Google Maps imagery, further supported by BING Maps imagery. While this data is not wholly robust as the date or time of the day when the image was captured is not known it is the only data source available.

From this exercise it was estimated that there is a demand for 427 parking spaces across the fourteen sites, 60% of the available capacity.

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 SERM 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

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

The boardings files were available for each modelled time period (with the exception of OP) and listed the total boardings within that time period at each station. From this data the boardings for each of the fourteen stations and sites within the SERM was extracted and proportions calculated for each time period based on the total boardings at the station, for example, for Waterford, it was calculated that 52% of daily boardings took place in the AM period, 15% in IP1, 24% in IP2 and 9% in the PM period.

These proportions were used to disaggregate the “observed” demand figures by time period to provide car park usage numbers which were then multiplied by the assumed Park and Ride user car occupancy figure of 1.44 to provide the target number of people using each site in each time period. These target figures are shown in Table A4.15.

Table A4.15: Derived calibration data

Station	Boardings				Occupied Spaces				Users			
	AM	IP1	IP2	PM	AM	IP1	IP2	PM	AM	IP1	IP2	PM
Tipperary	6%	90%	0%	4%	0	6	0	0	1	9	0	0
Cahir	55%	22%	0%	23%	2	1	0	1	2	1	0	1
Clonmel	54%	18%	0%	29%	5	2	0	3	7	2	0	4
Carrick-on-Suir	56%	11%	0%	335	1	0	0	1	2	0	0	1
Waterford	52%	15%	24%	9%	42	13	20	7	61	18	29	10
Thomastown	73%	11%	14%	2%	7	1	1	0	10	2	2	0
Kilkenny	43%	11%	35%	10%	32	9	26	8	46	12	37	11
Bagenalstown	60%	11%	17%	11%	14	3	4	3	21	4	6	4
Carlow	40%	14%	26%	20%	61	20	39	30	87	29	56	44
Gorey	10%	22%	31%	36%	3	7	9	11	4	10	14	16
Enniscorthy	27%	8%	26%	38%	6	2	5	8	8	2	8	12
Wexford	27%	6%	26%	41%	1	0	1	2	2	0	2	3
Rosslare Strand	68%	7%	14%	11%	4	0	1	1	6	1	1	1
Rosslare Europort	54%	17%	10%	20%	2	1	0	1	3	1	1	1

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 SERM the target usage of Park and Ride was estimated as 615 people. The PnR ASC values were reduced until the model generated a demand (persons) of 561 against a target demand of 615, a difference of -54 (-10%).

A4.4.3 Site calibration

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

The final level of calibration for PnR sites in the SERM are as follows:

Table A4.16: Site calibration

Site	AM GEH	IP1 GEH	IP2 GEH	PM GEH	OP GEH
Tipperary	5.6	1.3	1.5	1.9	2.0
Cahir	3.7	3.6	1.2	0.7	1.6
Clonmel	5.2	5.8	1.8	0.3	2.5
Carrick-on-Suir	5.6	5.0	1.5	1.5	2.0
Waterford	0.6	4.2	6.3	0.8	3.2
Thomastown	0.4	2.6	1.3	1.0	1.2
Kilkenny	4.5	0.9	8.2	2.9	2.1
Bagenalstown	1.7	2.1	2.9	1.3	1.5
Carlow	10.5	4.4	10.3	8.6	1.8
Gorey	3.5	1.0	4.6	4.3	1.9
Enniscorthy	5.3	6.0	2.7	2.4	2.6
Wexford	6.4	4.9	0.5	0.0	1.9
Rosslare Strand	1.9	0.8	1.4	1.0	0.6
Rosslare Europort	0.7	1.6	0.4	0.4	1.0

At an overall time period level, 57.1% of sites in the AM have a GEH equal to or less than 5, 78.6% in IP1, 78.6% in the IP2, 92.9% in the PM and finally 100% in the OP.

This level of calibration was deemed acceptable as other external factors are having an overall effect on PnR usage, such as the cost of using public transport when added to the cost of using park and ride, and the coding of connectors to rail stations. Given the overall usage of PnR, however, this level of calibration is considered acceptable, but it might be improved in future iterations by an examination of the network coding within the model to address accessibility to PnR sites along centroid connectors. Refining this coding could reduce the number of people who currently walk long distances to use rail stations and weight these movements more towards PnR. This process could also be carried out in conjunction with a review of public transport costs within the model to improve overall calibration levels.

In addition, the collection of observed data at each rail station would help to produce robust and accurate levels of site usage. These numbers could then be used to refine the distribution levels of park and ride site users in the model and produce a higher level of calibration.

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