Údarás Náisiúnta Iompair
National Transport Authority

Report on review by the NTA for Carbon Budgets Working Group

Executive Summary

Introduction and scope of work

Under the terms of the MoU between the Council and all relevant Government departments and agencies,[1] the Council requested input from the NTA to help inform the second and third iterations of modelling work undertaken as part of the second carbon budget programme. The request was for expert review and input from the NTA Transport Modelling Team between May and July 2024 to help inform the assumptions and constraints for the third and final iteration of modelling work being carried out to support the evidence base for the CB Proposal for CB3 and CB4.

The request followed engagement between the NTA and the Council's CBWG that commenced in early 2023. The NTA presented to the CBWG on the Regional Modelling System and its capabilities, as well as some example outputs and use cases, particularly those that had a climate focus, such as the scenario and behaviour change policy testing undertaken as part of the preparation of the Climate Action Plan 2023 (CAP23).[2]

The NTA team worked with the UCC TIM (Times Ireland Model) Development Team to determine how best to use the NTA's expertise and tools to support the carbon budgets modelling. It was agreed to focus on a number of key transport indicators, namely person-kilometres, tonne-kilometres and vehicle fleet projections for cars, light goods vehicles (LGVs) and heavy goods vehicles (HGVs). It was agreed that the following scenarios be used for comparison, as they were most aligned with the requirements of the CBWG: the UCC Reference and LED scenarios and the NTA Reference Case and CAP23 scenarios for the years 2028, 2030 and 2043. Additional outputs were extracted from scenarios developed using the NTA Ireland Freight Model and the DoT Irish Fleet Models (cars, LGVs and HGVs), which are maintained by the NTA. A report was produced to help inform the Council's proposal for carbon budgets.[3]

Comparison analysis

Passenger-kilometre comparisons

The total passenger-kilometres are quite similar in both models, with a similar growth trend in their respective base scenarios.[4] This is summarised below in Table A broken down by mode of transport. The NTA CAP23 and UCC LED scenarios for 2030 reflect a necessary shift in passenger-kilometres. A notable difference between the models is the low level of active travel kilometres in all NTA scenarios compared with the UCC LED scenarios. This evidence would suggest that UCC LED levels of active travel kilometres may be too high. An additional point to note is that the NTA Reference Case scenarios do not provide for the level of change in passenger-kilometres by mode that is required to meet the carbon targets. The CAPs seek to address this as they pivot from reference case scenarios.

[1] Climate Change Advisory Council (2022). Memorandum of Understanding between the Irish Climate Change Advisory Council and All Relevant Government Departments and Agencies.
[2] National Transport Authority (2023). Climate Action Plan: Phase 3 Modelling Executive Summary. [online] https://www.nationaltransport.ie/wp-content/uploads/2023/01/Climate-Action-Plan-Phase-3-Modelling-Exec-Summary-v5.6.pdf

[3] NTA report [meaning this report] to be published on Council website.
[4] It should be noted that an annualisation factor has been applied to the regional modelling system outputs to calculate annual billion passenger kilometres (Bpkm) because the regional modelling system outputs are given for an average 24-hour weekday.

Table A: Percentages of passenger kilometres travelled by main mode of transport in the NTA and UCC scenarios.

Mode of transport	2028			2030			2043		
	NTA reference case	UCC reference	UCC LED	NTA CAP23	UCC reference	UCC LED	NTA reference case	UCC reference	UCC LED
Car	83%	75%	69%	71%	75%	67%	81%	75%	**58%**
Public transport	14%	17%	20%	25%	17%	21%	15%	17%	**27%**
Active	4%	8%	11%	5%	8%	12%	4%	8%	**15%**

In Table B summarises the related percentages of passenger kilometres in three distance ranges, namely short, medium and long-range trips for both the NTA scenarios and the UCC / TIM scenarios. The distribution of passenger kilometres is different in each TIM scenarios but is held constant for all forecast years. The total passenger kilometres travelled are also different in each scenario. The totals vary over the forecast years with the BaU scenario total increasing and the Reference scenario decreasing. The distribution of passenger kilometres changes slightly across the NTA scenarios and are somewhat different to the TIM, especially in the short distance range.

Table B: Percentages of passenger kilometres travelled in each of three trip distance ranges.

Trip range	2028			2030			2043		
	NTA reference case	UCC reference	UCC LED	NTA CAP23	UCC reference	UCC LED	NTA reference case	UCC reference	UCC LED
Short range (< 5 km)	8%	20%	22%	7%	20%	23%	8%	20%	24%
Medium range (5–30 km)	47%	43%	42%	47%	43%	41%	46%	43%	41%
Long range (> 30 km)	45%	37%	36%	46%	37%	36%	46%	37%	35%

Freight tonne-kilometre comparisons

The NTA freight tonne-kilometres presented in the report are estimates from the recently developed (All island) Ireland Freight Model and demand management scenarios. These are compared with the UCC scenarios for the years 2022 and 2030. The models have different estimates for 2022 with 18 billion tonne-km in the IFM and 11 billion tonne-km in the TIM. Note that TIM covers the Republic of Ireland, but IFM covers both jurisdictions on this island). The NTA scenario forecasts a slightly lower rate of growth to 2030 than the UCC scenarios. In addition, the NTA demand management work did not identify a scenario that reduced tonne-kilometres travelled in 2030.

Car stock comparisons

The 2022 Car stocks levels are quite similar in the 2 models. This makes the comparisons more valid. The NTA reference case car ownership forecasts align with the UCC reference scenario with the fleet increasing by approximately 30%. The NTA CAP23 scenario aligns with the midpoint between the two UCC scenarios. This is labelled in the graph as “UCC Median”, but it should be clarified that it is not a UCC/TIM scenario; it is merely a plot of the simple average/median values from the UCC Reference and UCC LED scenarios). The NTA has not created a forecast with a reducing fleet size because the historical data record has almost always led to increased car stock. The scenario used to develop the NTA CAP23 car fleet mix projections estimates that 30% of the fleet will be battery electric vehicles (BEVs) by 2030 and 90% of the fleet will be BEV by 2042.

Goods vehicle stock comparisons

The NTA Goods fleet models were used to test four preliminary goods fleet scenarios for SEAI and the EPA "With Existing Measures" (WEM) and "With Additional Measures" WAM projections work. The four scenarios were used for comparison with the UCC scenario and are listed below.

- **SYSTRA2022:** New registrations (new and 2nd-hand imports) fixed at 2022 levels, no change to EU Mandate targets beyond 2022;
- **SYSTRABG0:** SYSTRA's 'Best Guess' with 0% growth, no change to EU Mandate targets;
- **SYSTRABG3:** SYSTRA's 'Best Guess' with 3% per year growth, no change to EU Mandate targets
- **SYSTRAUP5:** SYSTRA's 'Best Guess' with 3% per year growth and an extra 5% added to EU Mandate targets.

Note: No new internal combustion engine (ICE) LGV sales are included post 2035 in all scenarios

LGV stock comparisons

The NTA LGV definition is different from that used by UCC. Therefore, the NTA LGV fleet size in 2022 is approximately 320,000 whereas the UCC fleet size is approximately 400,000. This limits the comparisons to the trends rather than absolute numbers.

The NTA 3% annual growth scenario for LGV fleet aligns with the UCC reference scenario. In both scenarios the HGV fleet nearly doubles by 2050. The NTA zero growth scenario trend falls between the UCC reference and UCC LED scenarios. The NTA fixed sales scenario trend is similar to the UCC LED scenario. In these scenarios the LGV Fleet reduces by approximately 25%. In the NTA scenarios, the LGV fleet is estimated to have between 16% and 20% BEV by 2030 and between 89% and 92% BEV by 2042.

HGV stock comparison

The NTA HGV definition is different from that used by UCC. Therefore, the NTA HGV fleet size in 2022 in approximately 80,000 whereas the UCC fleet size is approximately 40,000. This limits the comparisons to the trends rather than absolute numbers.

The 3% growth scenario for HGV fleet has a similar *rate* of growth to the UCC reference scenario. In both scenarios the HGV fleet nearly doubles by 2050. The NTA no growth scenario trend falls between the UCC reference and UCC LED scenarios. The NTA fixed sales scenario trend is similar to the UCC LED scenario. In these scenarios the HGV Fleet reduces by approximately 25%. In the NTA scenarios, the HGV fleet is estimated to have between 7% and 10% zero emissions vehicles by 2030 and between 41% and 48% zero emissions vehicles by 2042.

Conclusion

In summary, there is good alignment between the data estimated by the NTA and UCC models for passenger kilometres, tonne kilometre and fleet. The potential differences that were identified relate to the projected increase in passenger-kilometres in active modes and the projected changes in freight tonne-kilometres, which have not been found to occur in the NTA scenarios. In addition, the NTA car stock scenario development process was not able to develop a scenario that projected a fleet decline.

Contents

Abbreviations and Acronyms

List of abbreviations and acronyms used throughout this report:

Agencies and Administration:

- **CB** – Carbon Budget;
- **CCAC** – Climate Change Advisory Council;
- **CSO** – Central Statistics Office;
- **DECC** – Department of Environment, Climate and Communications;
- **DoT** – Department of Transport;
- **EPA** - Environmental Protection Agency;
- **ESRI** – Economic and Social Research Institute;
- **EPMG** – **E**nergy **P**olicy **M**odelling **G**roup at UCC;
- **IPCC** – Inter-governmental Panel on Climate Change under the aegis of the United Nations;
- **MaREI** – SFI Research Centre for Energy, Climate and **Ma**rine **RE**search and **I**nnovation co-ordinated by the Environmental Research Institute (ERI) at University College Cork.

- **MoU** – Memorandum of Understanding;
- **NDP** – National Development Plan (2018 – 2027)[5];
- **NPF** – National Planning Framework (2018)[6];

- **NTA** – National Transport Authority;
- **SEAI** – Sustainable Energy Authority of Ireland;
- **SFI** – Science Foundation Ireland;
- **TII** – Transport Infrastructure Ireland;
- **UCC** – University College Cork;

Data Sources underpinning modelling:

- **IBVDS** – **I**rish **B**ulletin of **V**ehicle **D**river **S**tatistics (Dept. of Transport);
- **NHTS** – National Household Travel Survey (NTA, 2017);
- **POWSCAR** – **P**lace **of** **W**ork **S**chool or **C**ollege Census **A**nonymised **R**ecords (CSO, 2016);
- **Other** – numerous other sources not specifically cited, including economic, Revenue Excise fuel clearances, and income data, etc.;
- **SAPS** – **S**mall **A**rea **P**opulation **S**tatistics (CSO, 2016);

Scenarios modelled:

- **BaU** – Business as Usual in UCC / TIM, also referred to as "UCC Ref" in figures;
- **NTA CAP23** – National Transport Authority Climate Action Plan model scenario for 2030 to achieve 51% reduction in GHG emissions from transport;
- **NTA Ref Case** – National Transport Authority Reference Case model scenarios for 2028 and 2042 (and other years not shown in this report); these Ref Case scenarios take account of NPF demographic and land use changes from 2018 – 2042, and NDP infra-structural investments and

[5] https://www.gov.ie/en/policy-information/07e507-national-development-plan-2018-2027/
[6] https://www.gov.ie/en/publication/774346-project-ireland-2040-national-planning-framework/

transport network changes assumed to be delivered an operational by different future years such as 2028, 2030 and 2042.

- **UCC LED** – University College Cork **L**ow **E**nergy **D**emand Scenario (from 2018 to 2050);
- **UCC Median** – Median value of UCC Reference and UCC LED vehicle fleet values (from 2018 to 2050); This median value of the UCC Ref and UCC LED projections was computed for each forecast year;
- **UCC Ref** – University College Cork **Ref**erence Energy Demand Scenario (from 2018 to 2050), and same as the UCC BaU scenario label.

Generic terms relating to Climate Action and electrification:

- **BEV** – Battery electric vehicles;
- **CAP** – Climate Action Plan;
- **EV** – Electric vehicles (i.e. battery electric BEV or plug-in hybrid electric PHEV models). Mild or traditional hybrid vehicle models which cannot be charged via a cable or fully operate in an electric-only mode are excluded;
- **ICE** – Internal Combustion Engine;
- **GHG** – Greenhouse Gases;
- **gCO_2eq. / km** – grams of Carbon Dioxide and equivalent other gases emitted by vehicle per kilometre;
- **HGV** – **H**eavy **g**oods **v**ehicle, consisting of both fixed and articulated vehicles generally meaning over 3.5 tonne laden weight and with 4 axles or more;
- **ktoe** – Kilotonnes oil equivalent (unit of energy consumption)
- **ktCO_2eq.** – Kilotonnes of Carbon Dioxide and equivalent other gases;
- **km –** kilometre;
- **LCV** – **L**ight **C**ommercial **V**ehicle (same as LGV);
- **LDV** – **L**ight **D**uty **V**ehicle (same as LCV or LGV);
- **LGV** – **L**ight **g**oods **v**ehicle (2 axle and less than 3.5 tonne laden weight)[7];
- **MtCO_2eq.** – Megatonnes of Carbon Dioxide and equivalent other gases;
- **OGV** – **O**ver-sized **g**oods **v**ehicle generally meaning no more than 3 axles;
- **PHEV** – Plug-in hybrid electric vehicles;

Model tools and sub-models:

- **CFT** – **C**arbon **F**ootprinting **T**ool;
- **COM** – [NTA] **C**ar **O**wnership **M**odel;
- **COCMP –** [NTA] **C**ar **O**wnership **C**ar Co**mp**etition model;
- **EFOM** –an acronym for **E**nergy **F**low **O**ptimization **M**odel (Van Voort et al., 1982, 1984);
- **ESD** – Energy Systems Dynamics;
- **Fleet Tool** – NTA's spreadsheet vehicle fleet forecasting tool, developed by Systra UK;
- **IFM** – Ireland Freight Model;
- **LDM** – (All Island) **L**ong **D**istance **M**odel of the NTA;
- **MARKAL** –an acronym for **MAR**ket **AL**location model (pre-cursor to TIMES models);

[7] https://www.rsa.ie/road-safety/road-users/professional-drivers/vehicle-safety-legislation/light-commercial-vehicles

- **NDFM** – **N**ational **D**emand **F**orecasting **M**odel of the NTA;
- **NTEM** – **N**ational **T**rip-**E**nd **M**odel of the NTA (similar to UK NTEM);
- **NTpM** – **N**ational **T**rans**p**ort **M**odel of Transport Infrastructure Ireland;
- **PCU** – Passenger Car Unit, an approximate average unit used to describe traffic flow in terms of linear vehicle length plus following space to next vehicle where one car is then equivalent to one PCU; the space between vehicles is accounted for in this unit; typically 1 PCU is approximately 6 metres and a bus of length 18 metres is approximately 3 PCU;
- **RMM** – **Regional Multi-modal Model**– each of the NTA's Regional Models is multi-modal covering walk, cycle, public transport, private car, park-and-ride and a representation of school bus transport for primary and secondary school students; There is also a representation of motorised access to drop people off at public transport stops and stations in rural areas;
- **RMS** – **Regional Modelling System** – this is the NTA's suite of transport modelling and appraisal tools;
- **RMSIT** – **R**egional **M**odelling **S**ystem **I**ntegration **T**ool – distributes long distance and inter-regional trips to regional models and *vice versa* as part of the NTA models;
- **TIM** – Times Ireland Model [for national energy system] developed and maintained by the Energy Policy and Modelling Group at UCC / MaREI;
- **TIMES** –an acronym for **T**he **I**ntegrated **M**ARKAL-**E**FOM **S**ystem is an economic model generator for local, national, multi-regional, or global energy systems, which provides a technology-rich basis for representing energy dynamics over a multi-period time horizon. It is usually applied to the analysis of the entire energy sector but may also be applied to study single sectors such as the electricity and district heat sector.

Definitions

- **RMS Base Year** – The base year is the notional year to which a model is calibrated, and therefore represents the conditions that were observed in that year. For the RMS, the base year is 2016 because it was aligned to the Census 2016 data, however, there can be source data for calibration from other years close to 2016 so it should not be interpreted as being rigidly defined;
- **Net Zero –** the target of completely eliminating the net quantity of greenhouse gases emitted by human activity;
- **Pathway** – Term used to denote the set of measures that aim to achieve the transport system decarbonisation objective, hierarchically built up on the basis of one or more proposed measures;
- **Reference Cases** – This term is used to refer to the agreed NTA Regional Modelling System forecast scenarios for 2028 and 2043 that provide the underlying model inputs so that future model applications have a consistent starting point. The NTA Reference Case scenarios are reflections of the overall effect of the projected growth (population, employment and economic) and expected interventions (and scheduled transport investments) within the country rather than an assessment of any scheme included. The NTA Reference Case scenarios are developed using a Master Scheme List that is agreed by government stakeholders including Local Authorities. These scenarios contain projects within the National Development Plan (NDP), Local Development Plans (LDPs), Project Ireland 2040, Transport Infrastructure Ireland's (TII's) 'Projects and improvements' list, regional transport strategies, local authority documentation, and other relevant sources.
- **CAP modelling reference cases** – Within the context of the Climate Action Plan transport modelling, 'reference cases' are 2018, 2025, and 2030 forecasts without Climate Action Plan interventions, including reasonably expected changes tied with the *National Development Plan 2018-2027*[8] and *Project 2040 National Planning Framework*[9].
- **Scenario** – This term refers to a Regional Modelling System run that is composed of a specific set of assumptions in terms of demand (planning data, forecast year, etc.) and transport supply (networks) which may also include changes to the price of petrol, diesel, etc., or changes in public transport fares and so on;

[8] The *National Development Plan 2018-2027* was published on 16 February 2018, https://www.gov.ie/en/policy-information/07e507-national-development-plan-2018-2027/
[9] The *National Planning Framework - Ireland 2040 Our Plan (NPF) (2018)* was published on 8 December 2020, https://www.gov.ie/en/publication/daa56-national-planning-framework-ireland-2040-our-plan-npf-2018/

Introduction

The over-arching context for this work is set out in a Memorandum of Understanding[10] (MoU) between the Irish Climate Change Advisory Council and all relevant Government Departments and Agencies, which it states, *inter alia*,

> "Scenario modelling is an absolutely necessary tool to develop carbon budgets. This adds to the existing need for access to modelling to inform the ongoing work of the [Climate Change Advisory] Council. Therefore:
>
> In order to develop carbon budgets, the Council needs to model emissions scenarios;
>
> In order for the Department of the Environment, Climate and Communications (hereafter "the Department") to fully understand the budgets developed by Council, the scenarios employed by the Council should, where appropriate, be built using shared modelling tools and common assumptions; and
>
> In order for the Council to fully understand the approach taken by the Department in adopting or adjusting carbon budgets or policies and measures, the Department should share the analysis, i.e. the modelling inputs, outputs and scenarios and assumptions on which its work is based".

Under the terms of the MoU, the Council requested input from the NTA to help inform the second and third iterations of modelling work undertaken as part of the second carbon budget programme. The request was for expert review and input from the NTA Transport Modelling Team between May and July 2024 to help inform the assumptions and constraints for the third and final iteration of modelling work being carried out to support the evidence base for the CB Proposal for CB3 and CB4.

The request followed engagement between the NTA and the Council's CBWG that commenced in early 2023. The NTA presented to the CBWG on the Regional Modelling System and its capabilities, as well as some example outputs and use cases, particularly those that had a climate focus, such as the scenario and behaviour change policy testing undertaken as part of the preparation of the Climate Action Plan 2023 (CAP23).

Resulting Scope of Work

The NTA team worked with the UCC TIM Development Team to determine how best to use the NTA's expertise and tools to support the carbon budgets modelling. It was agreed to focus on a number of key transport indicators, namely person-kilometres, tonne-kilometres and vehicle fleet projections for cars, light goods vehicles (LGVs) and heavy goods vehicles (HGVs). It was agreed that the following scenarios be used for comparison, as they were most closely aligned with the requirements of the CBWG: the UCC Reference and LED scenarios and the NTA Reference Case and CAP23 scenarios for the years 2028, 2030 and 2043. Additional outputs were extracted from scenarios developed using the NTA Ireland Freight Model and the DoT Irish Fleet Models (cars, LGVs and HGVs), which are maintained by the NTA.

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[10] https://www.climatecouncil.ie/aboutthecouncil/governance/memorandumsofunderstanding/

Structure of this report

The report has 4 main sections:

- The National Transport Authority Models – Details of the National Transport Authority Models that were used for this work.
- The UCC Times Ireland Model – Details of the UCC Times Ireland Model that was used for this work.
- NTA Comparative Analysis – Details of the indicator and scenarios used for this task and results of the comparative analysis.
- Conclusions

The National Transport Authority Models

Background

The National Transport Authority is a statutory non-commercial body, which operates under the aegis of the Department of Transport[11]. NTA obtains statutory powers from the following pieces of legislation as amended:

- Public Transport Regulation Act (2009)
- Dublin Transport Authority Act (2008)
- Taxi Regulation Act (2003)
- Vehicle Clamping Act (2015)
- Vehicle Clamping and Signage Regulations (2017)

Dublin Transport Authority Act (2008) sets the objectives and functions of the NTA [12]. Key objectives include "the development of an integrated transport system which contributes to environmental sustainability and social cohesion and promotes economic progress", and "the provision of a well-functioning, attractive, integrated and safe public transport system for all users".

These of objective are achieved through the performance of the functions assigned to the NTA, including actions to "undertake strategic planning of transport", to "promote the development of an integrated, accessible public transport network", and to "promote increased recourse to cycling and walking as a means of transport," as well as the "collection of statistical data and information on transport" and the "conduct of research into transport". `

Rationale for transport modelling in the National Transport Authority

To support to the functions listed above, the NTA has developed and maintains a suite of classic transport models known as the Regional Modelling System. These models, which provide strong, rigorous, detailed, evidence-based and data-led outputs, are used to inform decision making, policy formulation and to provide rational econometric estimates of impacts of strategies and schemes for use in appraisals and business cases. The Regional Modelling System is sometimes referred to as a "digital twin" of the Irish Transport System representing a reasonably faithful approximation of the real-world transport system and the average weekday travel patterns and behaviours of the approximately 5 million people resident in Ireland.

The NTA continues to add to these tools in response to the changing regulatory environment and to support new projects. Most recently, the NTA has developed new models to improve the representation of the movement of goods, the Irish vehicle fleets, and the pathways to achieving the climate targets. The latter two models were developed on behalf of the Department of Transport to support their work developing various Climate Action Plans.

These models, which are described below, make up an "ecosystem" of tools that support the work of the NTA and other stakeholders such as the Climate Change Advisory Council, the EPA, the SEAI and TII.

[11] https://www.nationaltransport.ie/about-us/
[12] http://www.irishstatutebook.ie/eli/2008/act/15/enacted/en/pdf

NTA's "ecosystem" of models

A high-level schematic diagram of the main models available to the NTA is presented in Figure 1. This are grouped under five headings: RMS, Vehicles Stock Models, Ireland Freight Model, Carbon Footprinting Tool and Local Area models. Figure 2 presents a flowchart illustrating how some of the NTA's modelling tools and scenarios were combined to support work on the Climate Action Plans. While each of these groupings operate independently of each other they can use output from others as inputs. For this work, the only outputs from the first three groups were used. Each of group will be introduced in the following sections.

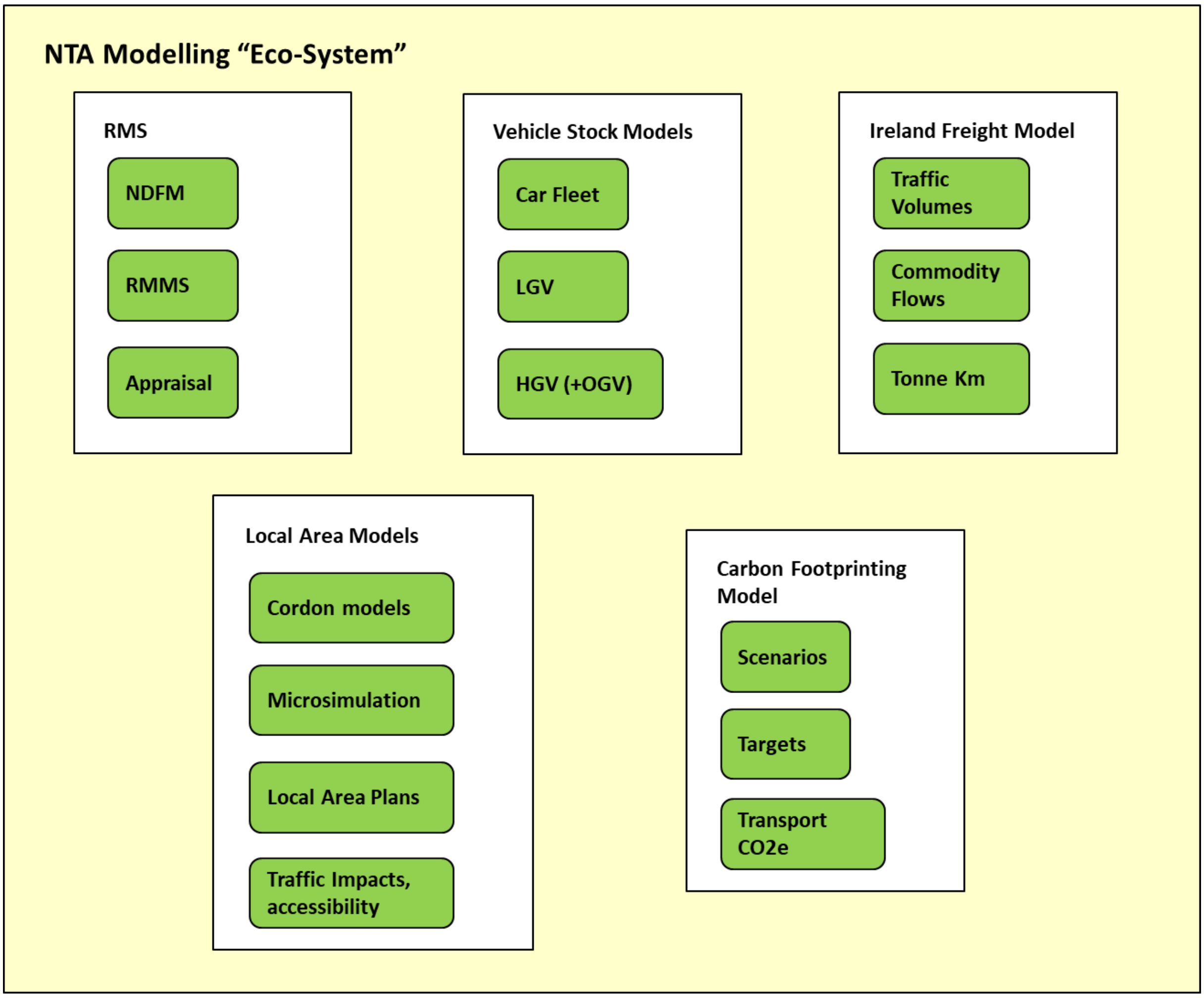

Figure 1: Schematic illustration of the NTA's modelling "eco-system", or suite of high-level models.

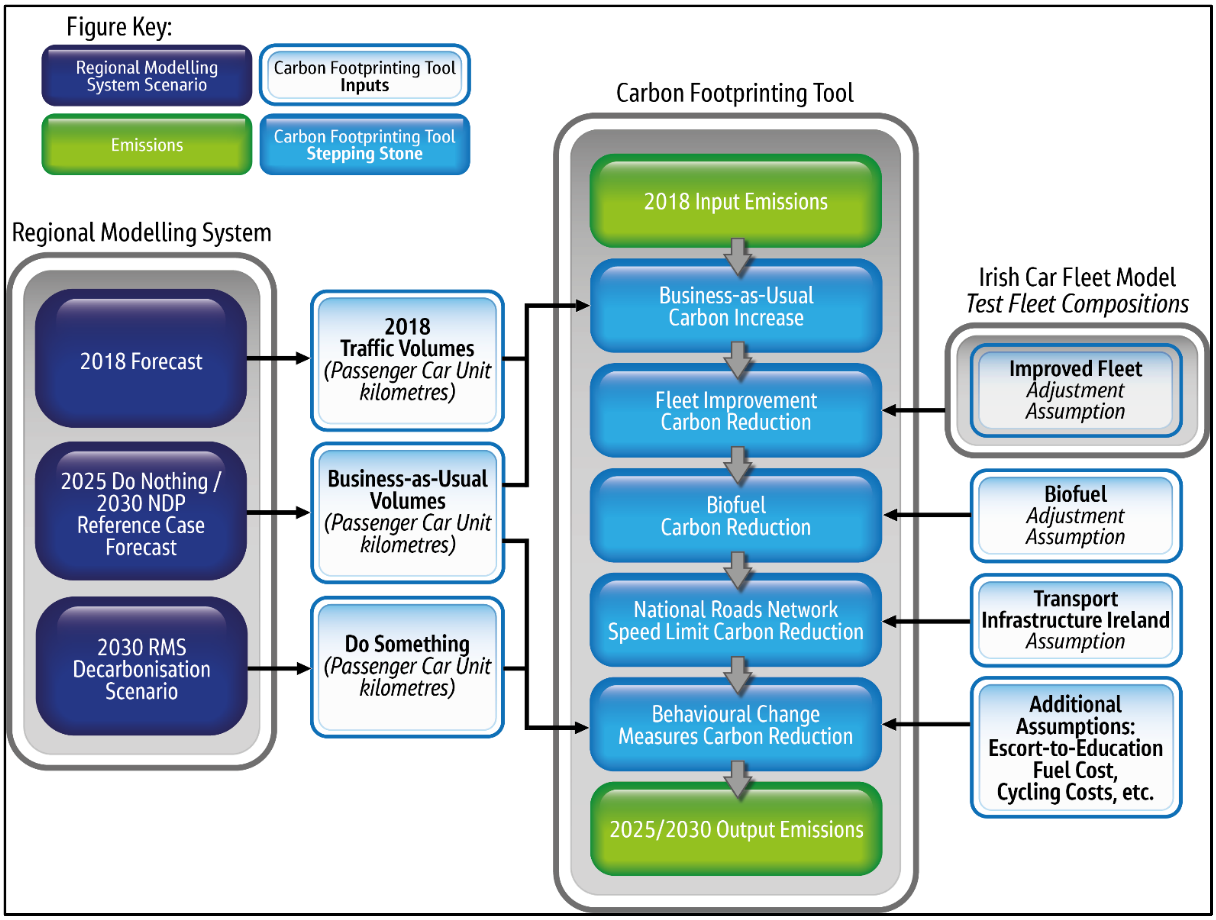

Figure 2: Flowchart illustrating some of the NTA's modelling tools and scenarios with focus on climate action plans.

National Transport Authority Regional Modelling System

Overview

The RMS is the primary tool for analysis of major public transport investments in Ireland, as well as providing critical inputs to inform climate strategies and environment policy within the state. The RMS is based on a traditional four stage transport model comprised of trip generation, trip distribution, mode choice and route assignment. The RMS is a suite of transport sub-models which are grouped into 3 main components: the National Demand Forecasting Model (NDFM), the Regional Multimodal Model (RMM) and Appraisal Module.

> The National Demand Forecasting Model (NDFM) addresses the Trip Generation stage. It operates at a national level.
>
> The Regional Multimodal Model (RMM) addresses Stage 2 – distribution, Stage 3 – mode choice and Stage 4 – Route Assignment. The RMM operates at a regional level.
>
> The Appraisal Module contains the processes required to meet the requirements of sectoral appraisal guidance. This module was not used for this project and is not described in this document. For detail on this module see: NTA Appraisal Toolkit | Regional Modelling System - National Transport.

The primary modules of the NDFM and RMM structure are introduced below along with a brief description of their purpose.

- **National Demand Forecasting Model (NDFM)** – The NDFM model represents the first stage of the traditional four stage transportation model. NDFM incorporates five primary modules:
    a. **Planning Data Adjustment Tool (PDAT)** – prepares the planning data forecasts, which are then used by other applications within the NDFM suite.
    b. **Car Ownership and Car Competition Model (COCMP)** – forecasts the levels of car ownership and competition by CSA.
    c. **National Trip End Model (NTEM)** – provides a forecast of the number of trips which are made on a typical weekday from and to each CSA in Ireland.
    d. **Long Distance Model (LDM)** – provides information on the number of long-distance trips which are made on a typical weekday between individual LDM zones in Ireland and Northern Ireland.
    e. **Regional Model System Integration Tool (RMSIT)** – The primary function of RMSIT is to convert demand matrices generated by the Long-Distance Model into the zoning systems for the individual RMM with entry and exit points represented by route zones.
- **Regional Multi-modal Models (RMM)** – The RMM model represents stages two, three and four of the traditional four stage transportation models. Each RMM contains a set of travel choice models and assignment models. There are seven key components of the RMM which form the Demand Model and Assignment Models.
    f. **Demand Model**
        i. **Mode and Destination Choice Models (MDC)** – The Mode and Destination Choice process is a standard component of any variable demand transport modelling process, specifically tackling the trip distribution and mode choice stages.

ii. **Free Workplace Parking Models (FWPP)** – The purpose of the Free Workplace Parking Model is to replicate the choices that a traveller may face if the demand for free workplace parking is larger than the available supply.

iii. **Park and Ride Site Choice Models** – The purpose of the Park and Ride (PnR) module is to determine which PnR site will be used by each PnR trip and to calculate the associated car and public transport (PT) trip legs.

iv. **Parking Distribution Model (PDIST)** – The PDIST models the choice option to park remotely when there are other factors which may discourage parking in the destination zone such as lack of parking supply.

g. **Assignment Models**

i. **Road Assignment Model** – The purpose of the road assignment model is to represent the physical road network and available route choice of road users.

ii. **PT Assignment Model** – The purpose of the PT assignment model is to represent the system of networks and services and to assigns demand to the public transport networks.

iii. **Active Modes Assignment Model** - The function of the Active Modes model is to assign the walk and cycle trip to the walk and cycle networks.

The different components of the model are discussed in further detail in subsequent sections of this report. Figure 3 provides a high-level view of the overall model architecture.

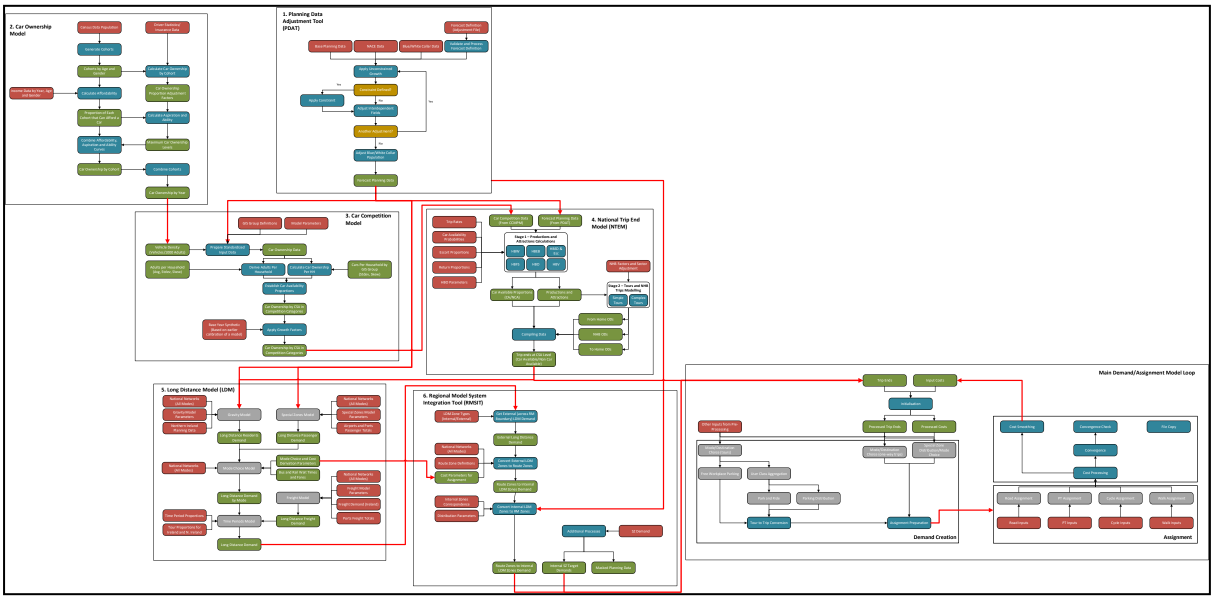

Figure 3: High Level Model Architecture Diagram

Data sources for calibrating:

- CSO's SAPS and POWSCAR data sets;
- NTA's NHTS2012, NHTS2017[13];
- NTA's national rail census surveys of 2016 & 2017;
- NTA's State and Regional airports surveys of 2016;
- CSO's Quarterly Labour Force data series, NACE and employment data;
- Road traffic counts on National primary, secondary roads;

[13] https://www.nationaltransport.ie/planning-and-investment/transport-modelling/national-household-travel-survey/

- Road traffic signals data from local authorities;
- Public transport count and ticketing data;
- Cycle counter data and Dublin City Canal Cordon Count data.
- NTA's State and Regional Airports surveys of 2016;
- CSO's Road Freight Transport Survey 2016
- Road traffic counts on National primary, secondary roads.
- Historical approximate average Income data from ESRI and Revenue
- Department of Transport: Irish Bulletin of Vehicle Driver Statistics and driving licence data.

Model Dimensions

Zoning Systems

There are three main geographic units in the NTA's RMS Most of NDFM operates at CSA level. This is the spatial level that base planning data is provided to PDAT. There were 18,641 CSAs in Ireland in 2016 see Figure 4, the RMMS zones (approximately 4,370), and the coarser Long-Distance Model zones see Figure 5. The CSAs are used to estimate and calculate the fundamental trip demand, both trips produced by each CSA, as well as the trips attracted into each CSA (predominantly attracted to education, employment, retail and other services, hospitals, etc.).

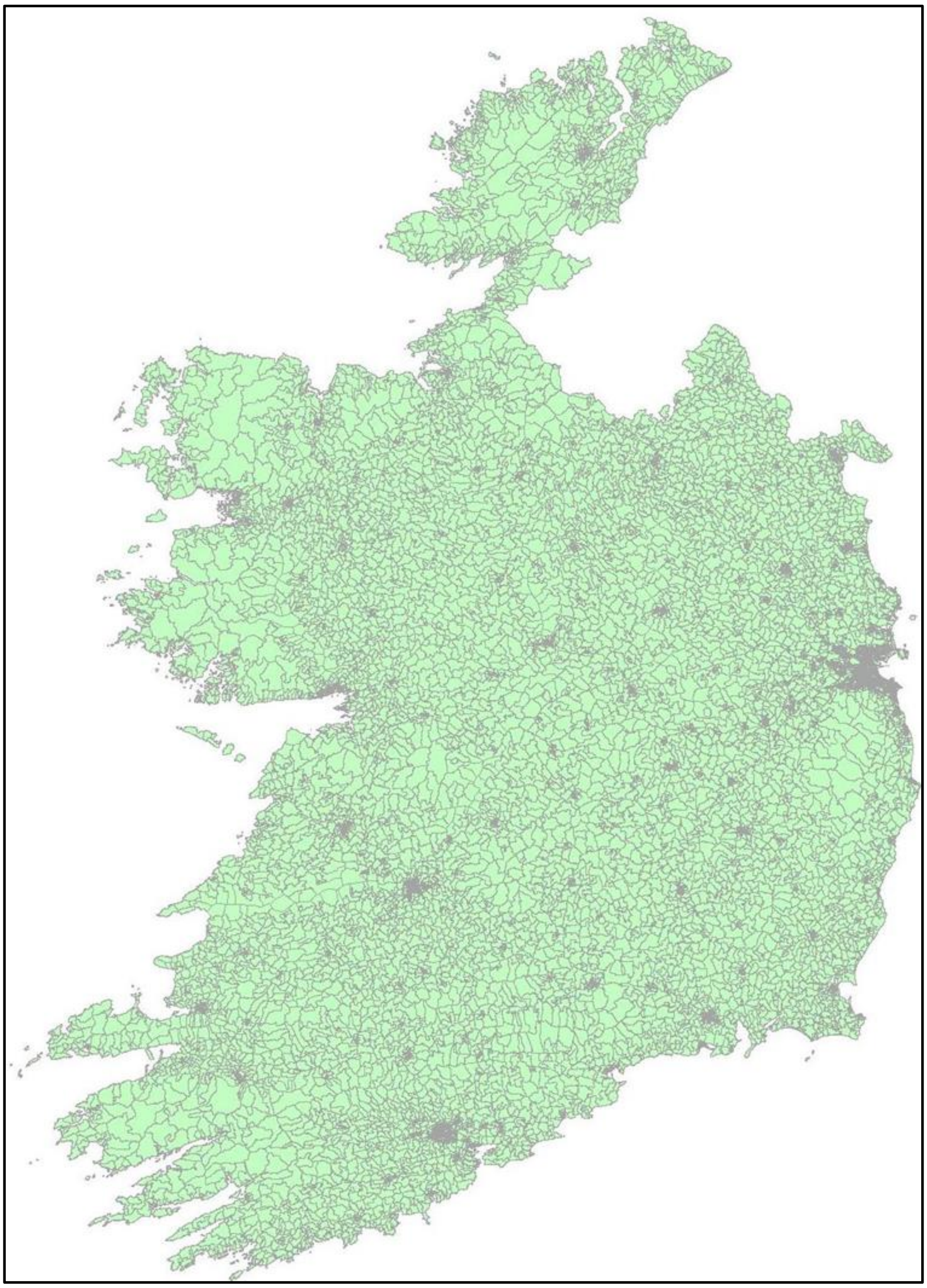

Figure 4: Map illustrating the geography of the CSO's 18,641 Census Small Areas used in the NTA's 2016 RMS.

The LDM has a bespoke zone system which is an amalgamation of CSAs. The zones were defined so as to represent primary settlements and their associated catchment areas. It was also important to represent airports and ports in the zoning system, so these were added as additional zones. In total there are 96 zones in the LDM covering Ireland and Northern Ireland.

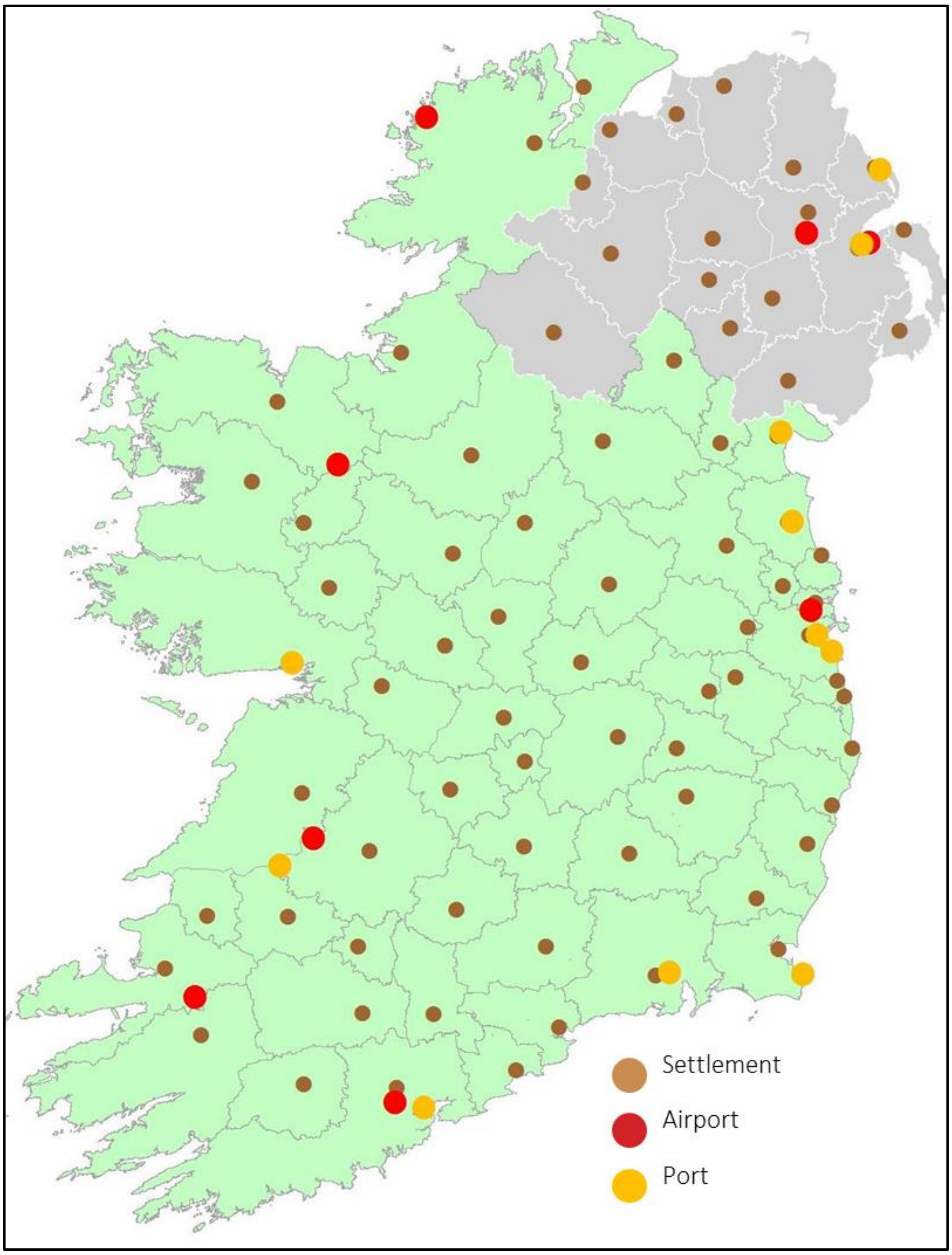

Figure 5: map illustrating the geography of Long-Distance Model zones in the NTA's RMS.

Each regional model has its own zone system. The zones consist of geographic zones represented by polygons, special zones representing special generators such as airports and ports plus road route zones and rail route zones which are used to convert region to region demand matrices generated by LDM into the regional model zoning. The number of zones in each regional model is set out in Table 1. The regional model zones for the ERM are presented in Figure 6.

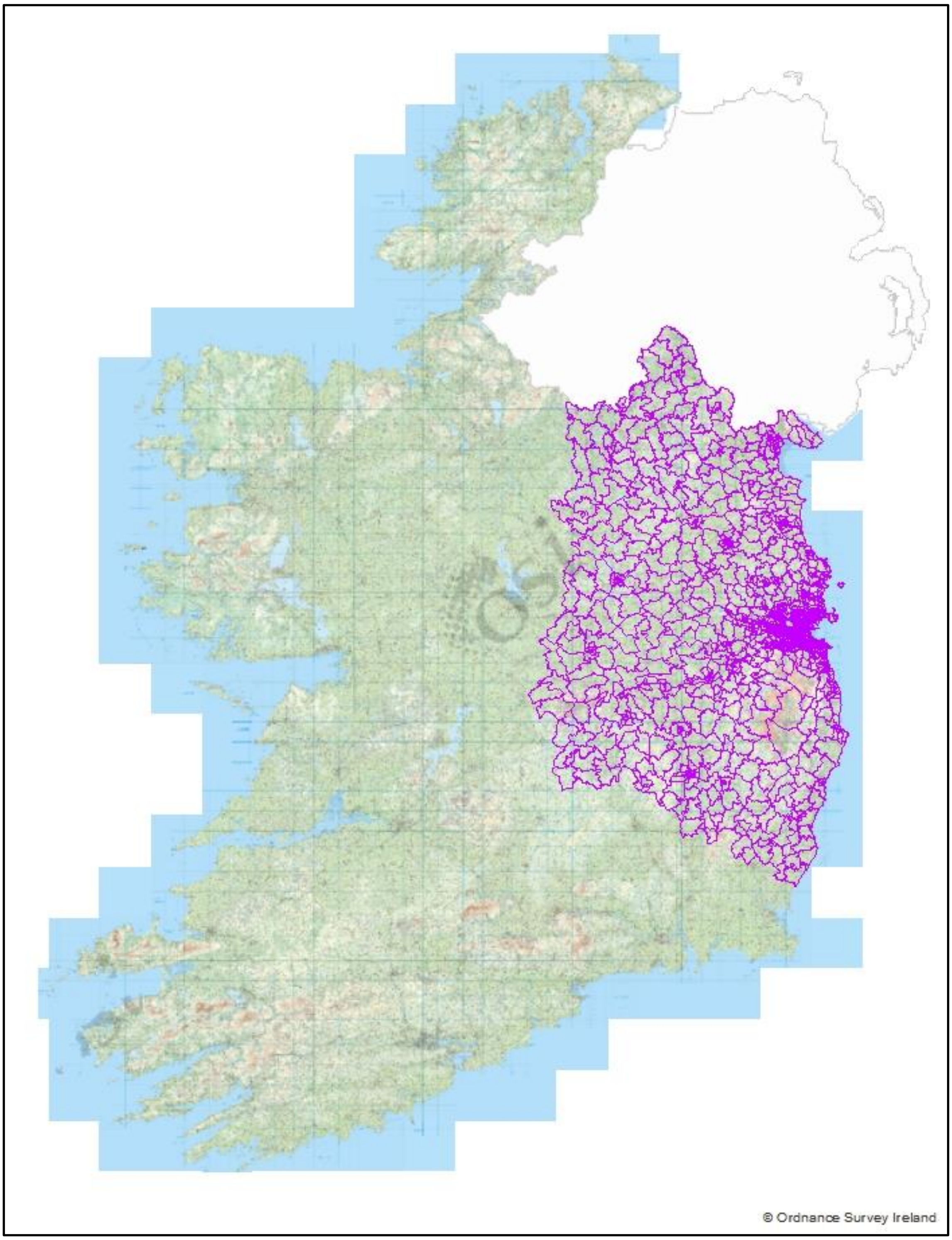

Figure 6: Map illustrating the geography of zones in the NTA's East Regional Model (ERM).

Table 1: Regional Model Zone Systems

Regional Model	Zone Type	Number of Zones
ERM	Geographic Zones	1,904
	Special Zones	3
	Road Route Zones	39
	Rail Route Zones	7
	Total	1,953

Regional Model	Zone Type	Number of Zones
MWRM	Geographic Zones	613
	Special Zones	2
	Road Route Zones	30
	Rail Route Zones	5
	Total	650
SERM	Geographic Zones	623
	Special Zones	2
	Road Route Zones	24
	Rail Route Zones	5
	Total	654
SWRM	Geographic Zones	819
	Special Zones	3
	Road Route Zones	11
	Rail Route Zones	1
	Total	822
WRM	Geographic Zones	798
	Special Zones	3
	Road Route Zones	32
	Rail Route Zones	3
	Total	836

Time Periods

Most of the NDFM operates at the 24hr level. The LDM represents travel demand in five time periods which are aligned with the time periods used in the RMM demand models. Each of the RMM demand model time periods has an associated assignment model peak hour which is derived from the time period demand matrices using factors and is used to derive costs for the next loop of the demand model. The demand model periods represent groups of hours which when combined represent the full 24hrs of the day. Each of the assignment model peak hours sits within its respective demand model peak period. Table 2 below describes the time periods.

Table 2: Regional Demand Model Time Periods and Assignment Model Peak Hours

Time Period	Abbreviation	Demand Model Period	Demand Model Duration	Assignment Model Peak Hour
Morning peak	AM	07:00 – 10:00	3 hours	08:00 – 09:00
Lunch time	LT	10:00 – 13:00	3 hours	12:00 – 13:00
School run	SR	13:00 – 16:00	3 hours	15:00 – 16:00
Evening peak	PM	16:00 – 19:00	3 hours	17:00 – 18:00
Off-peak	OP	19:00 – 07:00	12 hours	20:00 – 21:00

Tour Types

There are 25 tour types defined in the RMS these are defined based on outbound and inbound time periods of trips within the tour. Table 3 below shows the different tour combinations and provides the numbering for each tour type.

Table 3: Regional Model Tour Types and Numbering

		Inbound Time Period				
		AM	IP	SR	PM	OP
Outbound Time Period	AM	1	2	3	4	5
	IP	6	7	8	9	10
	SR	11	12	13	14	15

	PM	16	17	18	19	20
	OP	21	22	23	24	25

Demand Segmentation

Within the RMS there are 33 demand segments. These are described in Table 4. The table also shows how the demand segments are aggregated into user classes for the assignment models because these segments have similar values of travel time or different public transport fares, for example students and retired people who have either reduced or fare-free travel.

Table 4: Listing of 33 demand segments and associated journey purposes used in the NTA's RMS.

Demand Segment	Journey Purpose	Car Availability	3rd characteristic	User class
1	Commute	Available	Blue collar	COM
2	Commute	Available	White collar	COM
3	Commute	Not available	Blue collar	COM
4	Commute	Not available	White collar	COM
5	Education	Available	Primary	EDU
6	Education	Available	Secondary	EDU
7	Education	Available	Tertiary	EDU
8	Education	Not available	Primary	EDU
9	Education	Not available	Secondary	EDU
10	Education	Not available	Tertiary	EDU
11	Escort to education	Available	Primary	OTH
12	Escort to education	Available	Secondary	OTH
13	Escort to education	Available	Tertiary	OTH
14	Escort to education	Not available	Primary	OTH
15	Escort to education	Not available	Secondary	OTH
16	Escort to education	Not available	Tertiary	OTH
17	Other	Available	Employed	OTH
18	Other	Available	Non-working	OTH
19	Other	Not available	Employed	OTH
20	Other	Not available	Non-working	OTH
21	Shopping - food	Available	Employed	OTH
22	Shopping - food	Available	Non-working	OTH
23	Shopping - food	Not available	All	OTH
24	Visit friends / relatives	Available	Employed	OTH
25	Visit friends / relatives	Available	Non-working	OTH
26	Visit friends / relatives	Not available	All	OTH
27	Employers Business	All	All	EMP
28	All	Available	Retired	RET
29	All	Not Available	Retired	RET
30	One-way business	Available	All	EMP
31	One-way business	Not available	All	EMP
32	One-way other	Available	All	OTH
33	One-way other	Not available	All	OTH

Modes

Within the RMS there are 5 main modes. These are public transport, road, walking, cycling and Park and Ride.

National Demand Forecasting Model

The NDFM model represents the first stage of the traditional four stage transportation model. In this first phase of trip generation, the model is used to predict travel demand on a typical weekday in Ireland at Census Small Area (CSA) level. Additionally, the NDFM also estimates inter-regional demand (demand crossing the RMM boundaries), which then forms the external demand for each of the RMM. There are five modules in the NDFM. This section provides further details on the separate modules that make up the NDFM.

- Planning Data Adjustment Tool (PDAT);
- Car Ownership / Car Competition Model (COCMP);
- National Trip End Model (NTEM);
- Long Distance Model (LDM); and
- Regional Model System Integration Tool (RMSIT).

It also estimates interregional demand which crosses the boundary of the five regions as well as a basic representation of cross-border trips to or from Northern Ireland. As illustrated in the schematic process diagram in Figure 7

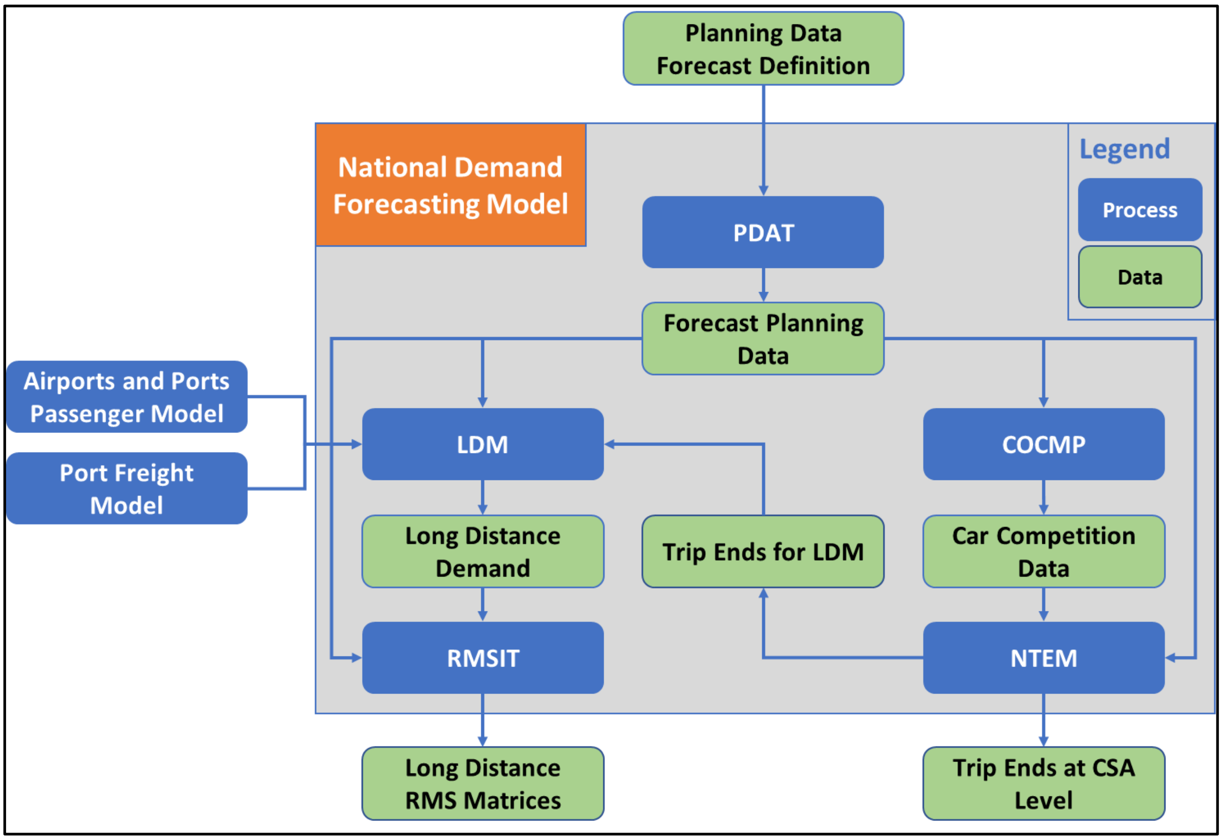

Figure 7: Flowchart illustrating the NTA's National Demand Forecasting Model.

NDFM: Planning Data Adjustment Tool (PDAT)

The Planning Data Adjustment Tool (PDAT) prepares the planning data, which are then used by other applications within the NDFM suite. the PDAT process is an Excel based calculation which produces an input file for the NDFM Cube Voyager model. When the model is run for the base year, base year planning data is used. When the model is run for a forecast year, forecast year growth data is used. The PDAT application allows growth to be applied to planning data in a flexible manner while ensuring that individual fields in the planning data remain consistent.

NDFM: Car Ownership and Car Competition Model (COCMP)

These are two separate modules. The Car Ownership Model (COM) and the Car Competition Model (CCMPM) see Figure 8. The Car Ownership Model – this estimates the number of cars owned per 1,000 adults at a national level. This model is a standalone Excel spreadsheet. The output is used in the Car Competition Model. The Car Competition Model – this estimates the distribution of cars within each individual CSA. Combined the two modules' forecasts levels of car ownership and competition by CSA, segmented into three car competition categories:

- Households with no car (N)
- Households with fewer cars than adults (17+) (F)
- Households with the same number or more cars than adults (17+) (P)

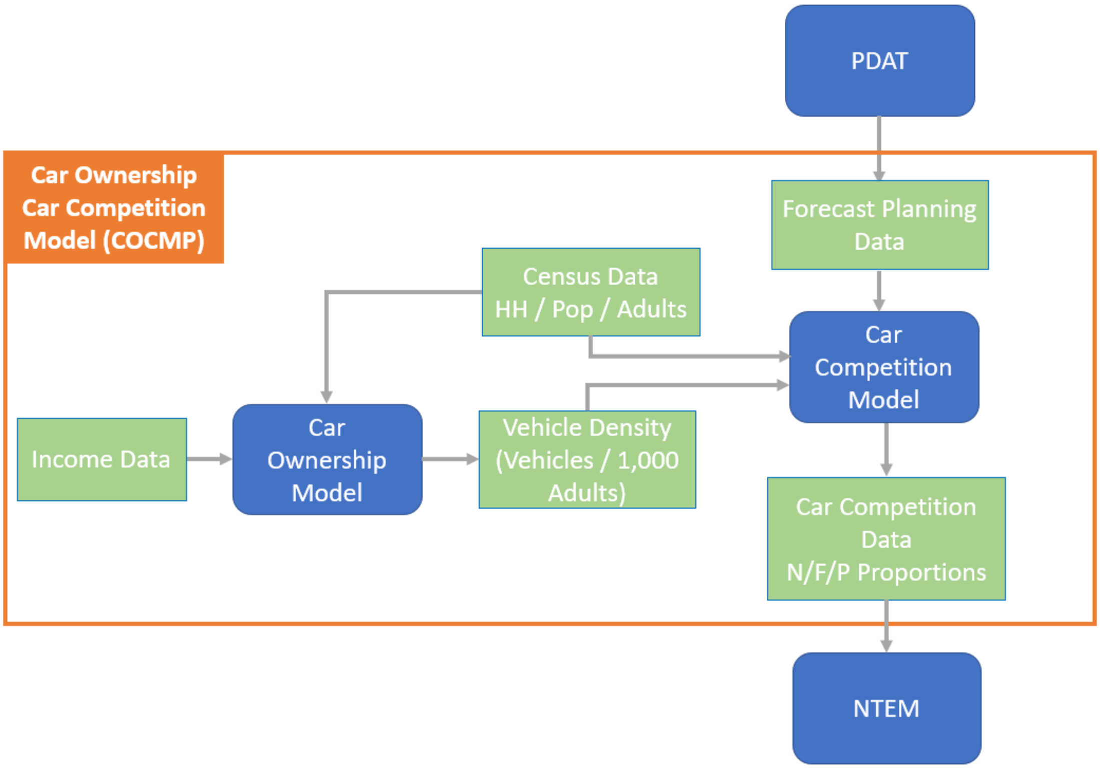

Figure 8: Flowchart illustrating the NTA's Car Ownership National Demand Forecasting Model.

NDFM: National Trip End Model (NTEM)

The NTEM provides a forecast of the number of trips which are made on a typical weekday from and to each CSA in Ireland see Figure 10. NTEM derives trips by purpose based on various attributes of each CSA such as levels of employment and population. Trips and tours are defined as follows:

- A trip constitutes a person travelling from one location to another.
- A tour comprises a series of trips made by one person in a sequence. In NTEM tours are defined to both begin and end at home.

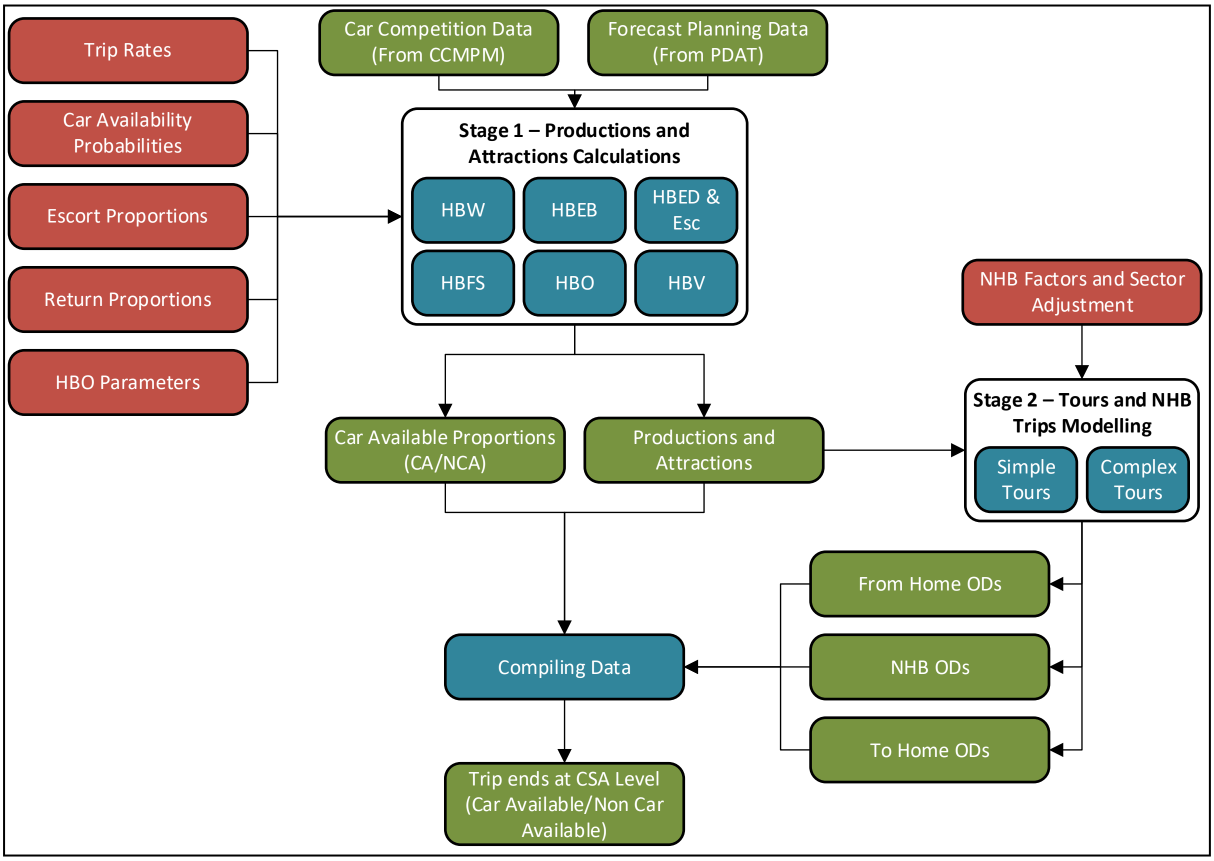

Figure 9: NTEM Process

NDFM: Long Distance Model

The Long-Distance Model (LDM) provides information on the number of long-distance trips which are made on a typical weekday between individual LDM zones in Ireland and Northern Ireland. Long distance trips are considered to be trips that are longer than 20km and are between different LDM zones. The LDM is a complex model in its own right see Figure 10. It incorporates a number of primary components:

- Special Zones Model (SZM) – using total passenger demand for the main ports and airports in Ireland and Northern Ireland, and the national network, the special zones model estimates passenger trip distribution and mode choice.
- Gravity Model – using population and employment data generated by PDAT, trip ends generated by NTEM, and LDM specific national networks, the gravity model estimates 24-hour long-distance residential travel demand in Ireland and Northern Ireland.
- Mode Choice Model – the LDM runs a mode choice procedure for residents and visitors between car, bus and rail using travel costs associated with each mode.
- Time Periods Model – the LDM disaggregates the residents, visitors and freight demand into time periods based on user defined proportions.
- Freight Model – the LDM estimates the distribution of freight demand entering Ireland and Northern Ireland through the main ports, additionally the LDM incorporates inner-Ireland freight demand as a user input.

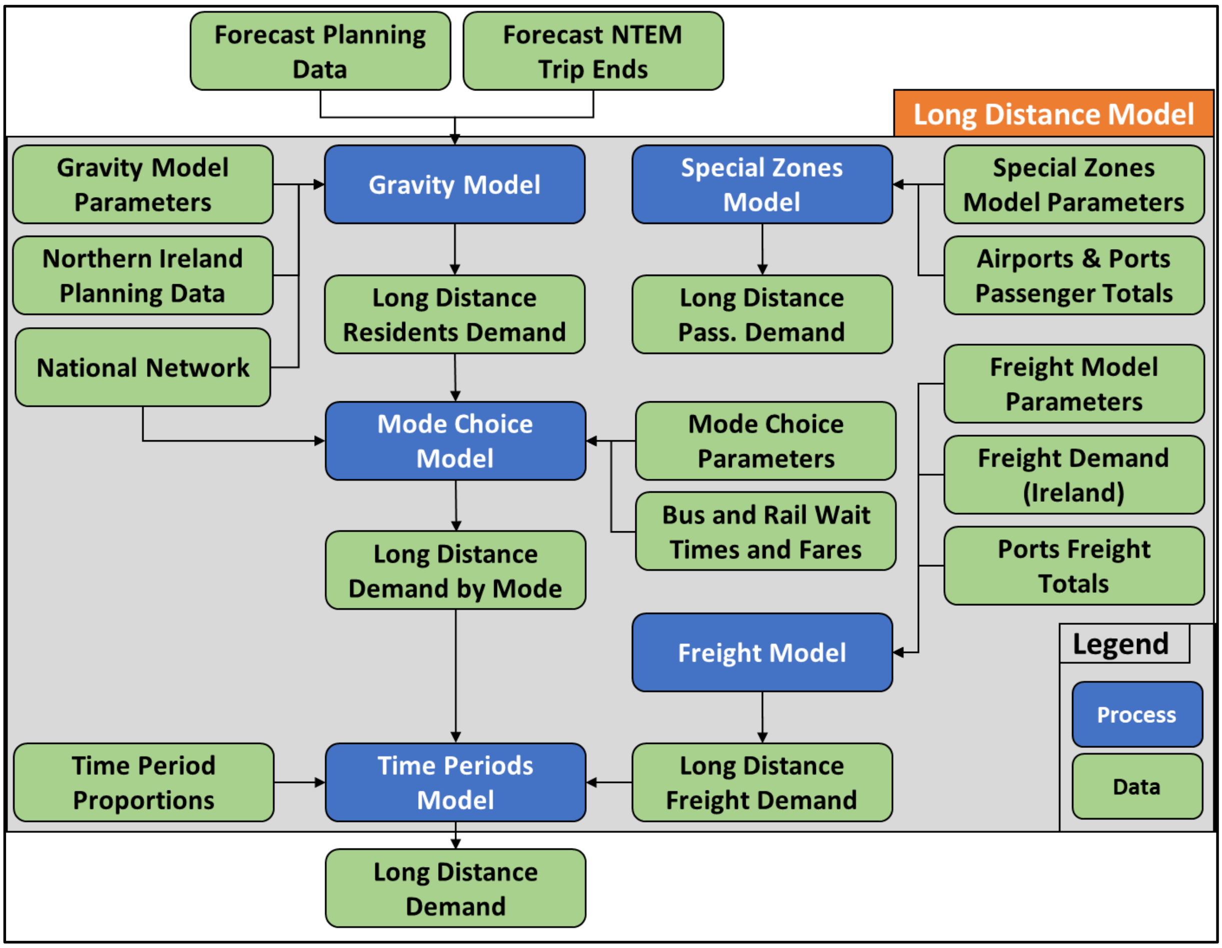

Figure 10: Flowchart illustrating the NTA's Long Distance Model (LDM).

NDFM: RMS Integration Tool (RMSIT)

The purpose of the Regional Modelling System Integration Tool (RMSIT) is to convert demand matrices generated by the LDM into the zoning systems of individual RMMs. The RMSIT sums and then distributes both long distance and inter-regional trips to and from each regional modelled area These trips are assigned to entry and exit points represented by route zones. The process uses Select Link Analysis (SLA) together with the national road and rail networks to convert external LDM zones to route zones, then uses population and employment data and HGV productions and attractions to convert internal LDM zones into the regional model zoning system. A high-level flowchart of the RMSIT is presented in Figure 11.

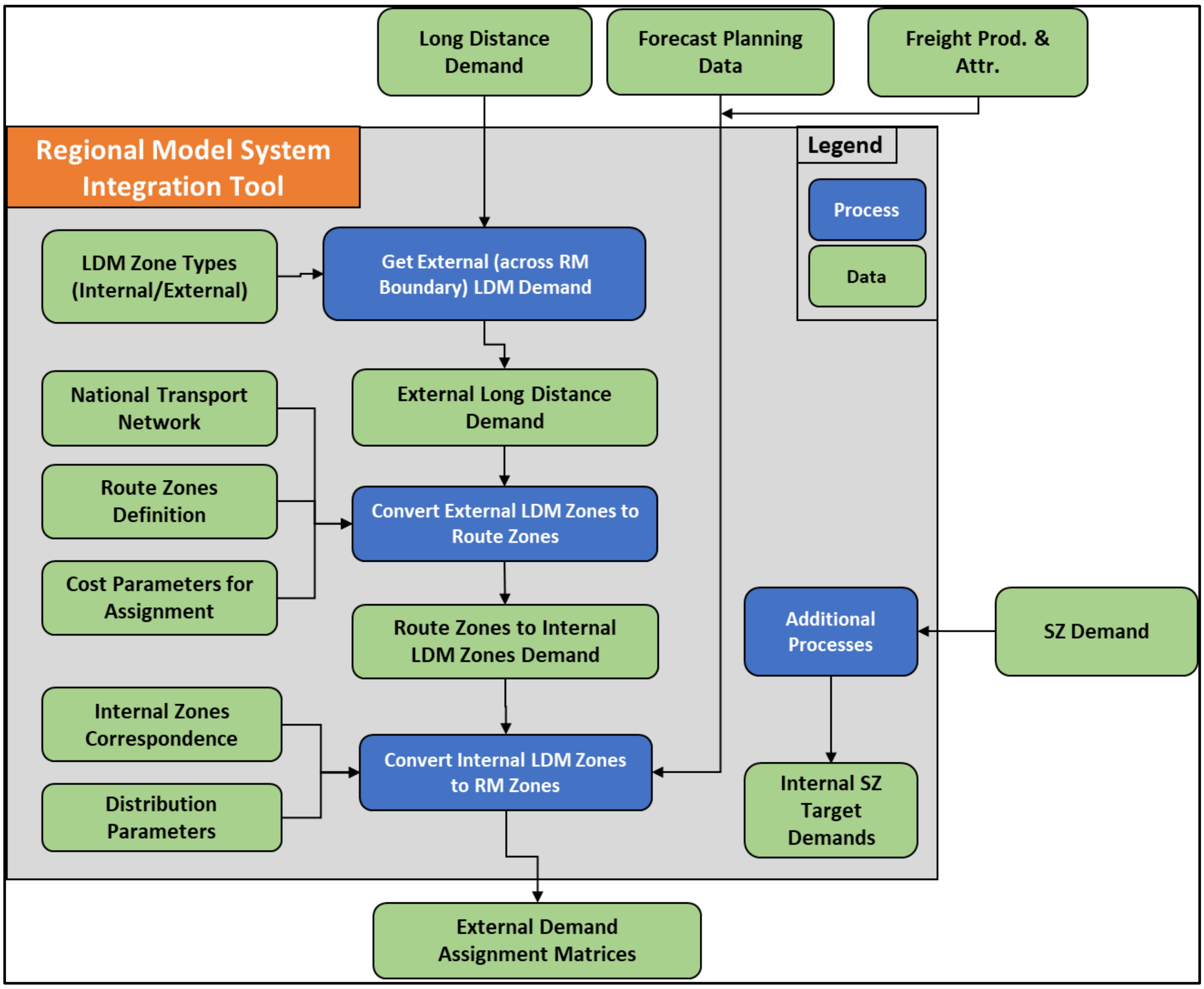

Figure 11: Flowchart illustrating the NTA's Regional Model System Integration Tool (RMSIT) which prepares inter-regional and long-distance demand for assignment in each of the five regional models.

NTA Regional Multimodal Modal Models

The second component of the RMS is the Regional Multimodal Model (RMMS). The RMMS addresses Stage 2 – distribution, Stage 3 – mode choice and Stage 4 – Route Assignment of the four-stage transport model. The RMM contains a set of travel choice models and assignment models that take NDFM outputs and apply them to the respective regional transport networks. The RMM operates as a supply-demand equilibrium process where matrices are passed down from the demand model and costs are passed up from the supply (assignment) models. The process is iterated until convergence is achieved. The RMM is a set of 5 strategic transport models – one for each of the regions surrounding one of the regional cities - Dublin, Limerick, Waterford, Cork and Galway. The five regional models are:

- East Regional Model (ERM)
- Mid-West Regional Model (MWRM)
- South-East Regional Model (SWRM)
- South-West Regional Model (SWRM) and
- West Regional Model (WRM)

The coverage of each regional model, which is presented in Figure 12, has been designed balancing several objectives including complete coverage of the Irish state.

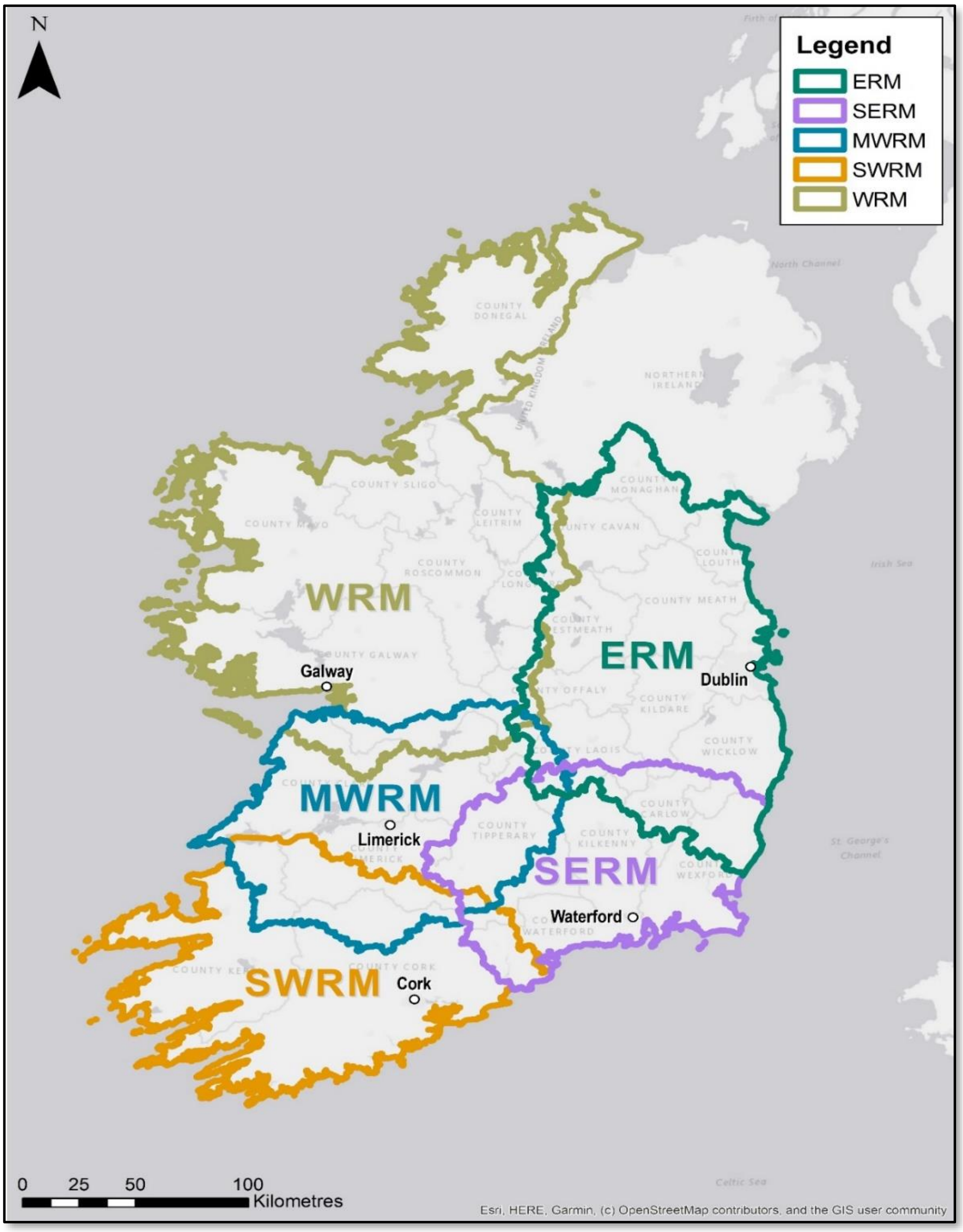

Figure 12: map illustrating the NTA's five Regional Model Areas, which overlap intentionally.

As mentioned earlier, the RMMS is an integrated suite of components These components are depicted schematically in Figure 13. The RMMS is divided into three sub modules – Demand Creation, Assignment and Cost Processing and Convergence. The Demand Creation submodule is where the trip demand (output from NDFM) is subject to distribution (Destination Choice), Mode Choice and the parking models - Free Work-Place Parking, Park-and-Ride and Parking Distribution. The Assignment Module is where the travel demand is assigned (Route Assignment) to the transport networks. The Cost Processing and Convergence module checks if the model has reached equilibrium and processes the costs produced by the Assignment module for use in the Demand Creation Module., these modules follow an iterative process whereby the generalised costs of transport are fed back from the assignments to the mode and destination choice calculations and gradually the demand and supply converge towards equilibrium. As indicated in Figure 13.

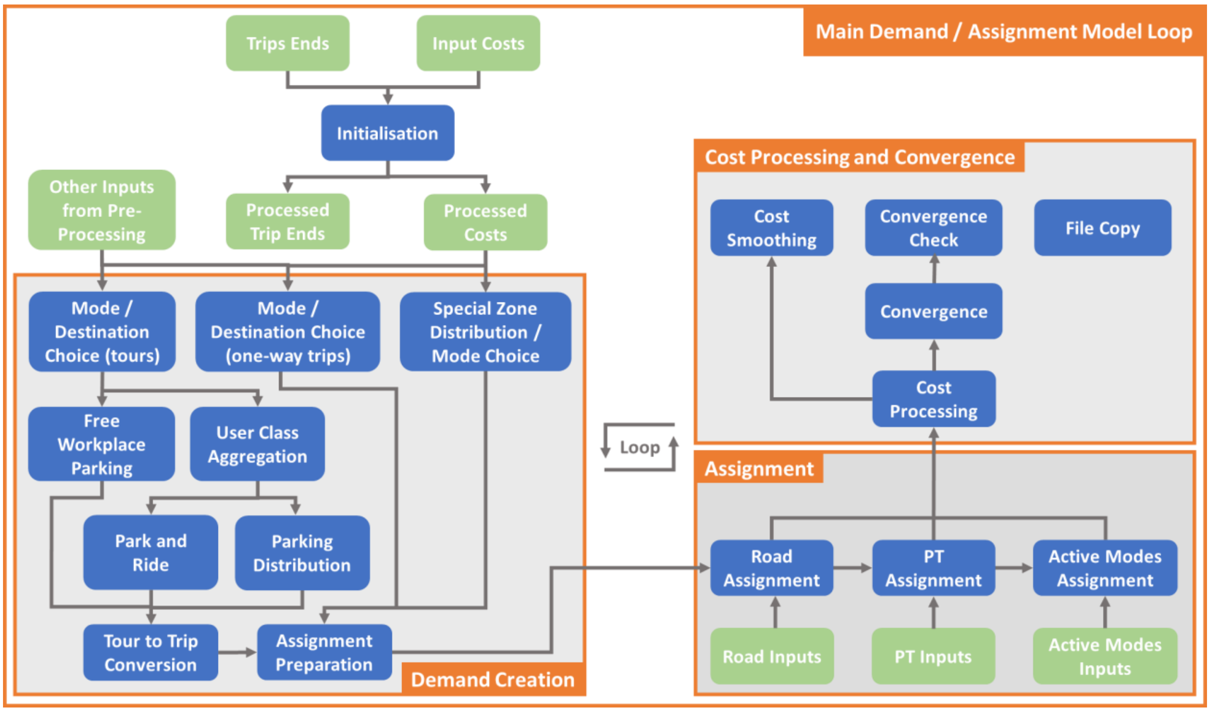

Figure 13: Flowchart illustrating the NTA's Demand / Assignment Model.

Demand Creation Module

Mode and Destination Choice Models (MDC)

The Mode and Destination Choice process is a standard component of any variable demand transport modelling process, specifically tackling the trip distribution and mode choice stages. Within this model these stages have been implemented as a logit choice model which is a widely recognised approach within economics and transport modelling. More specifically, the model takes the form of a nested, or hierarchical, logit model with destination choice undertaken first, followed by mode choice.

Free Workplace Parking Models (FWPP)

This model replicates the choices that a traveller may face if the demand for free workplace parking is larger than the available supply and allows the model to assess the impact of measures which may affect the number of free spaces for all destinations. The FWPP module applies to students parking at educational establishments as well as commuters parking at their place of work.

Park and Ride Site Choice Models

The purpose of the Park and Ride (PnR) module, in Figure 14 is to determine which PnR site will be used by each PnR trip and to calculate the associated car and public transport (PT) trip legs. Within this model, a PnR trip is one which uses road and then PT for an outbound trip and returns using the same set of modes in reverse. PnR is currently only allowed at specific zones which offer formal PnR. This includes dedicated car park sites associated with bus based PnR, or at rail and Luas stations (with or without formal parking). It does not consider drivers who travel to a residential area to park and then get a bus on to their destination to avoid paying a parking charge.

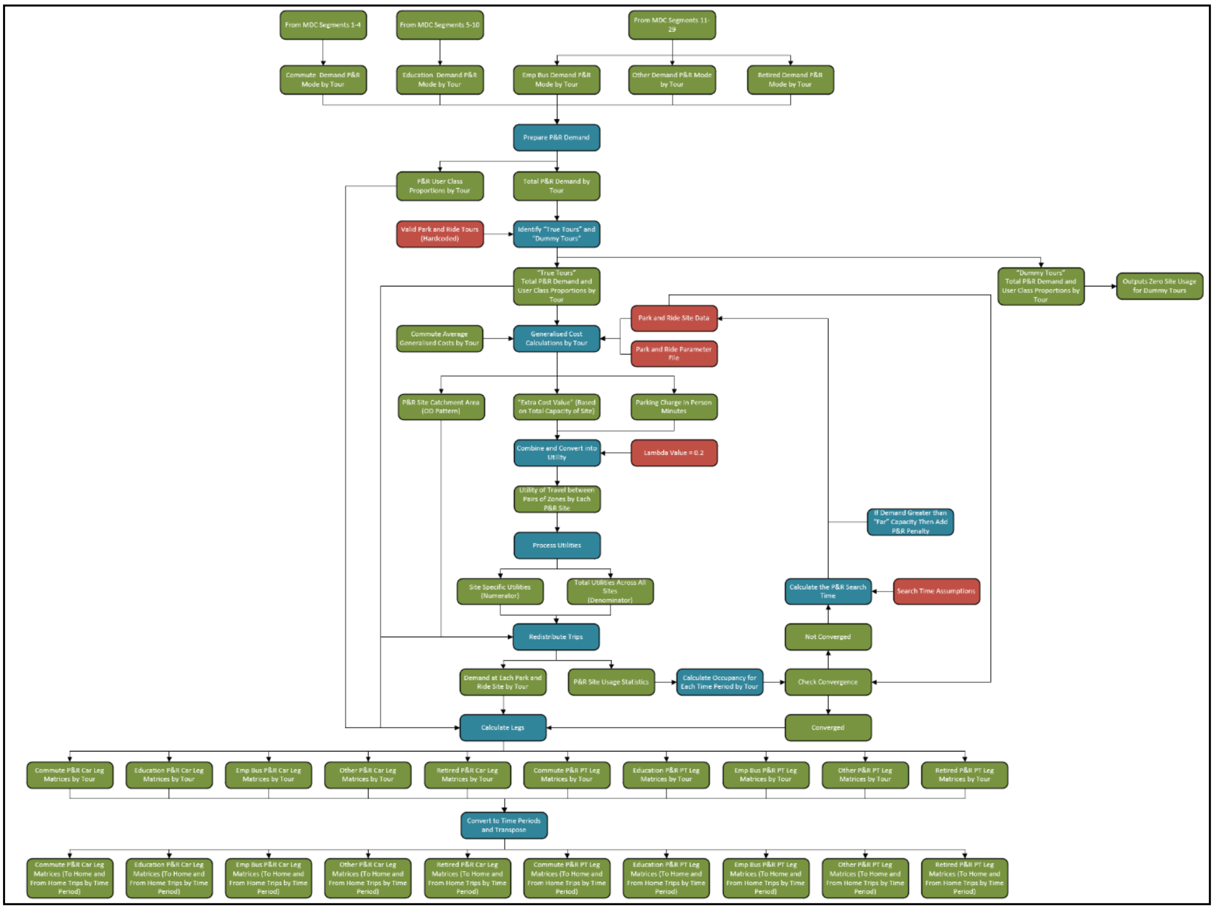

Figure 14: Park and Ride Site Choice Process

Parking Distribution Model (PDIST)

Town and city centres, particularly the historic centres of large cities, are acknowledged to have less parking supply than there is (potential) parking demand, particularly in certain areas. There are three potential user responses to this:

- To switch destination - this would be typified by the decision to travel to an out of town shopping centre with abundant parking rather than a central area with restricted parking;
- To switch mode – to use a non-car mode (or to Park and Ride) to avoid parking at the attraction end of the tour at all; or,
- To park at a location with less restricted parking which is close to, but not at, the attraction point, and to make the final part of the trip on foot.

The first two options are relatively straightforward and are supported by the Mode and Destination Choice model. However, in order to reflect this behaviour, the MDC model relies on appropriate costs being passed to it. In the case of where demand exceeds parking supply, the associated costs of travelling by car should include an element of additional cost so that the MDC model can predict a switch of mode or destination. The parking distribution model is used to identify and reflect these additional costs.

The third point is also addressed by the parking distribution model. This assesses the proportion of the demand which can park in its true destination (attraction) zone and assigns any overspill to neighbouring zones which have capacity to spare after allowing for their own arriving trips. Travellers who park in these neighbouring zones are then assumed to walk to their final destination (attraction) zone. In this sense the parking distribution model is similar to the park and ride model (discussed below) by splitting road trips into two legs, which in this case is a car leg and a walk leg.

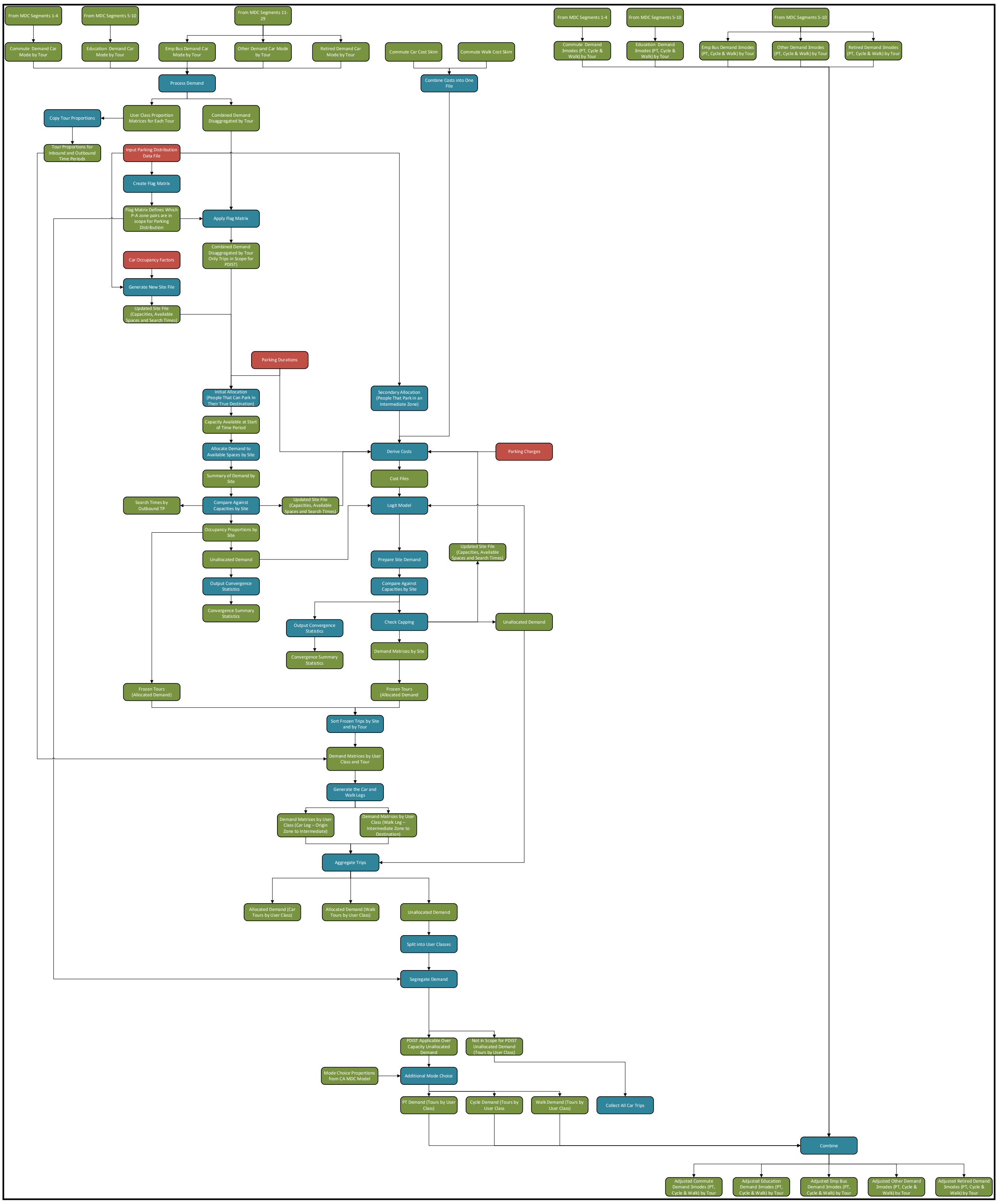

Figure 15: Parking Distribution Model Process

Assignment Module

The Assignment Module comprises three separate assignments, as indicated in Figure 13, for car on the Road network, for public transport on the PT networks and services and walking and cycling on the Pedestrian and Cycle networks. The NTA's transport "supply" networks include:

- all main arterial roads (but *excludes* small, minor, dead-end roads and byways), which cover 75,000km of the 100,000km national network;
- all main scheduled public transport services (but *excludes* demand-responsive services);
- a representation for (rural) school transport provision by the Department of Education;
- all associated walk and cycle links, keeping in mind the strategic purpose of the main NTA models in the RMS;

Road Assignment Model

The purpose of the Road Assignment Model is to represent the physical road network and available route choice of road users. The road assignment model takes a travel demand matrix produced by the Demand Model and assigns it to the road network. This produces outputs of flow by different vehicle classes, speeds, delays etc. It also provides the costs of travel which are passed back up to the choice components of the Demand Model.

The Road Assignment Model (RAM) is implemented in the SATURN software which is a widely used package for these types of models. SATURN uses complex algorithms to undertake assignments and extract required outputs. It also offers a very wide variety of options to the user in terms of how these algorithms work.

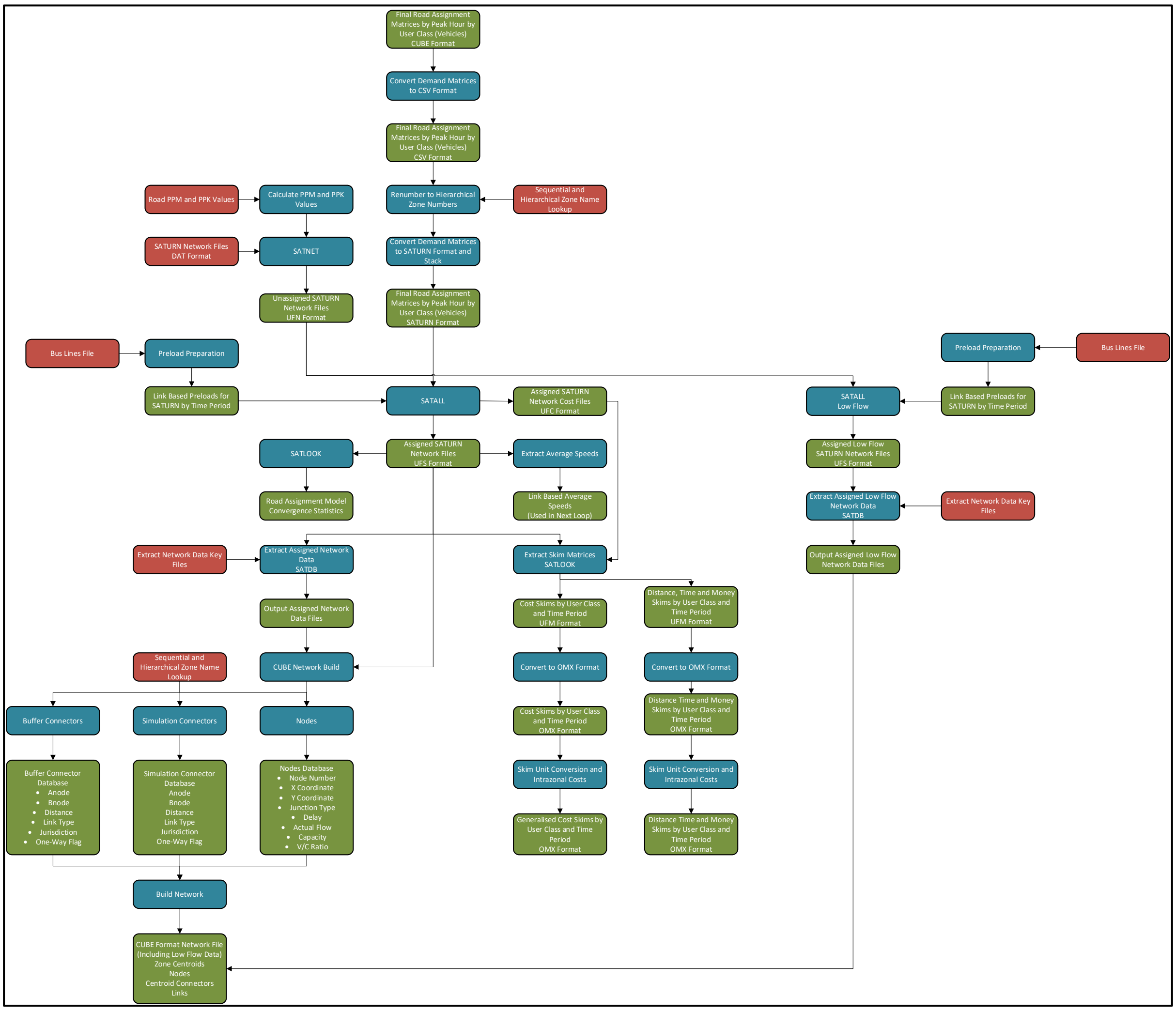

Figure 16: Road Assignment Model Process

An illustration of the road network for the 2016 SWRM is show in Figure 17: map illustrating the 2016 strategic road transport supply network in the SWRM.The highway network in SWRM consists of 4052 assignment nodes (junctions) including 1712 Priority Junctions and 203 Signalised Junctions and 22502 assignment links (road segments).

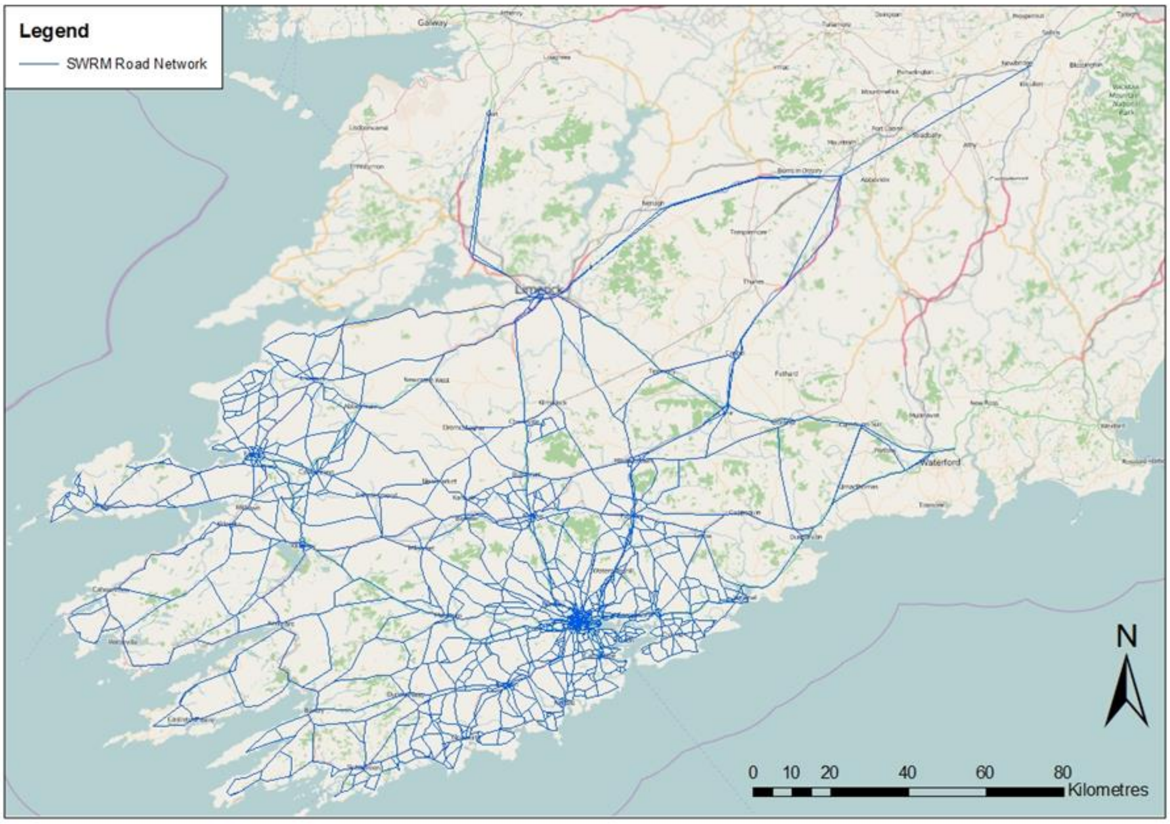

Figure 17: map illustrating the 2016 strategic road transport supply network in the SWRM.

PT Assignment Model

This is a system of networks, services data, assignment algorithms and parameters. Like the road assignment model, the process takes demand matrices produced from the demand model and assigns them to the public transport networks. This produces outputs of passenger flows, boardings and alighting and generates the costs associated with travelling by PT, which are passed back up to the Demand Model. Figure 18: Public Transport Assignment Model Process describes the PTAM process.

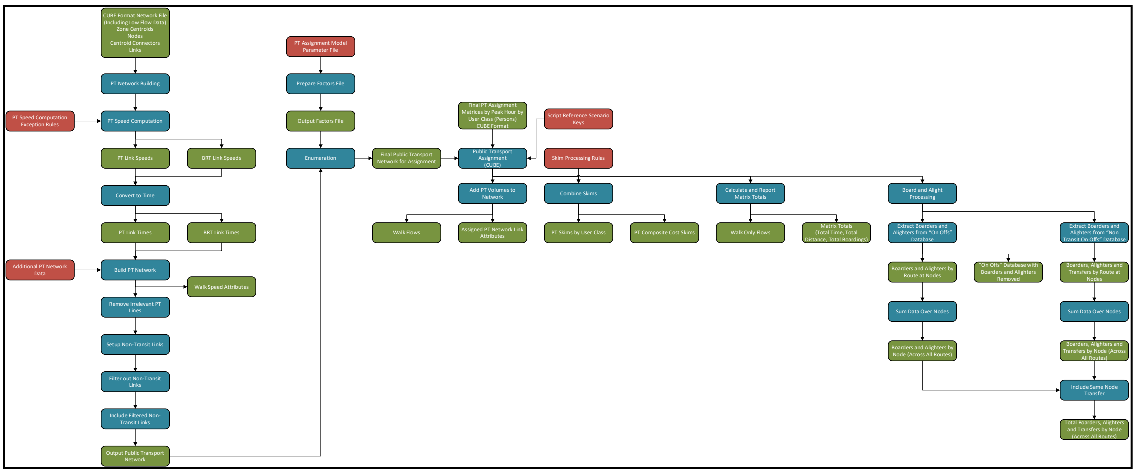

Figure 18: Public Transport Assignment Model Process

The PT network differs from the underlying road network in that it includes are railways, bus and walk -only links. There can also be traffic signal priority for buses in the PT network and internal operational changes to represent approximately the presence and functioning of bus lanes.

Public transport assignment model includes the following PT sub-modes:

- Suburban Commuter Rail
- Other Rail including outer suburban commuter services and inter-city rail;
- Light Rail);
- Urban Bus (both PSO and privately operated); and
- Inter Urban Bus (both PSO and privately operated).

An example illustration of the resulting public transport network for the 2016 SWRM is show in Figure 19. The public transport network in SWRM consists of 42 rail services, 55 Cork City Bus Services, 385 Bus Éireann (non-Cork City) services and 18 other bus services.

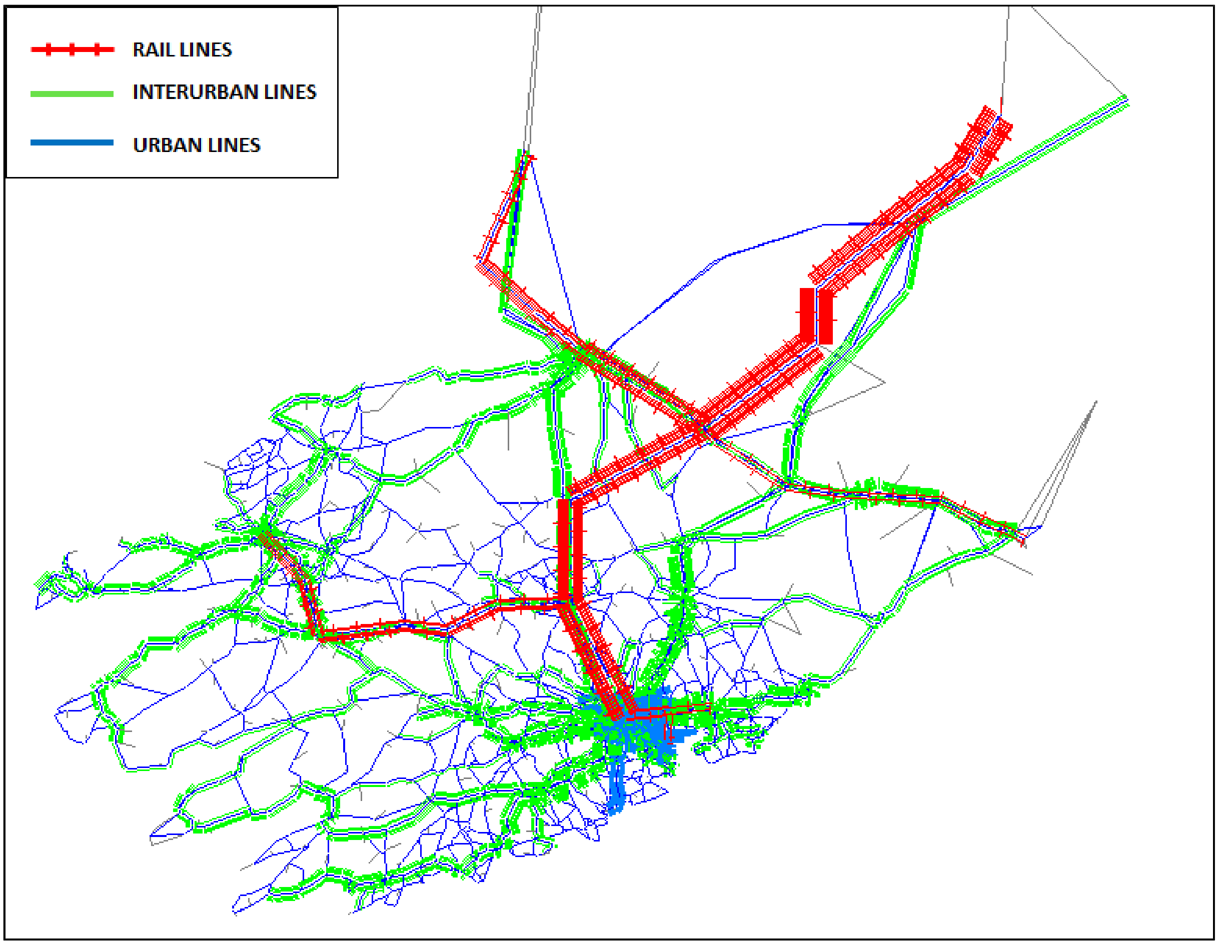

Figure 19: map illustrating the 2016 public transport supply network in the SWRM with rail services shown in red, inter-urban bus routes in green and urban bus route services in blue. Some infrequent or demand-responsive bus services were not represented.

Active Modes Assignment Model

The function of the Active Modes model is to assign the walk and cycle trip matrices output from the Demand Model to the walk and cycle networks. It outputs flow information by walk and cycle and produces the costs of travel which are passed back to the Demand Model.

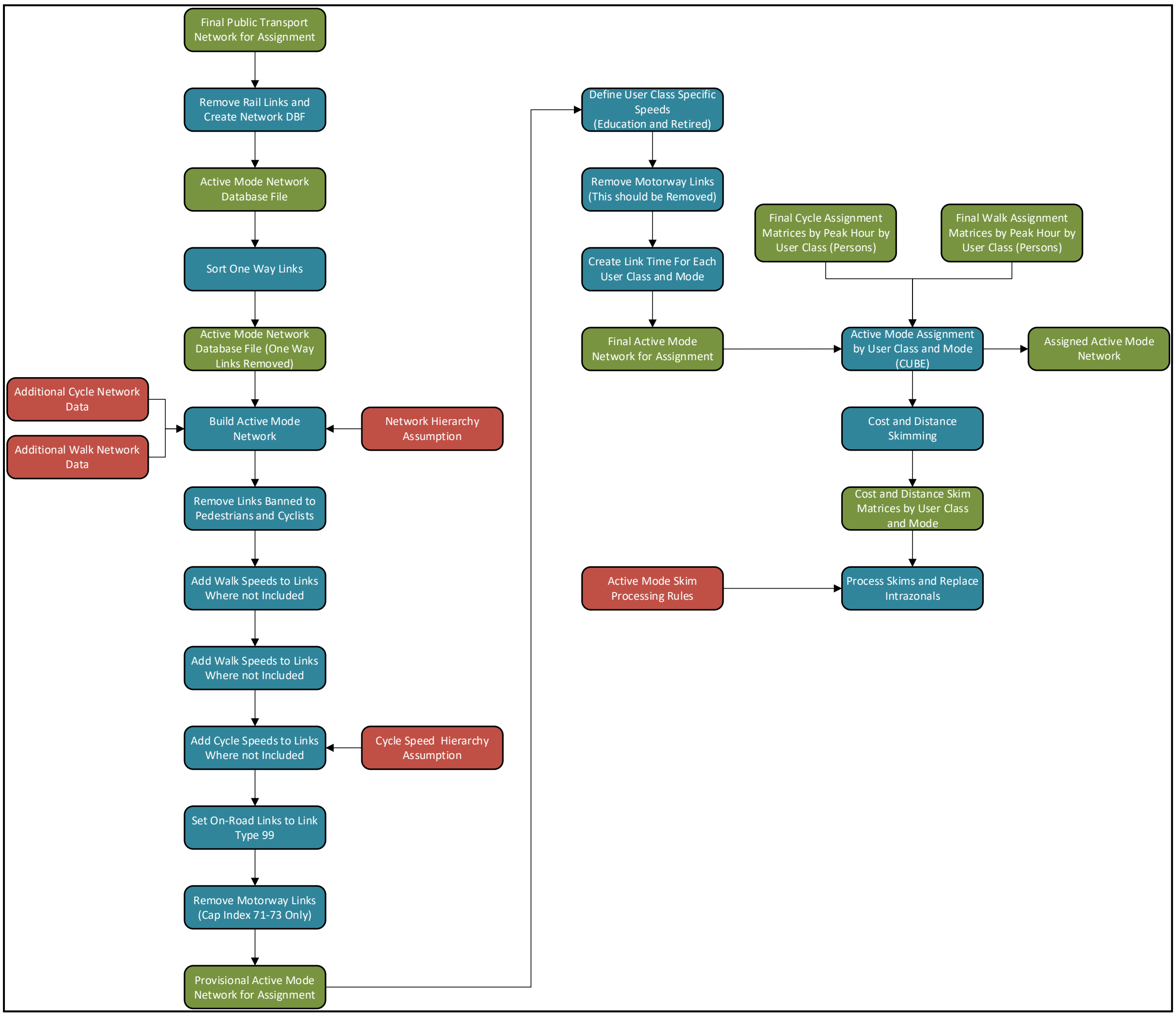

Figure 20 : Active Mode Assignment Model Process

An illustration of the walk assignment network for the 2016 ERM is show in Figure 21. The map illustrates the modelled 2016 weekday AM Peak-hour pedestrian flows in the NTA's East Regional Model (ERM) focused on the city centre of Dublin. The walk network in ERM uses the highway network as a base and consists of 4052 assignment nodes (junctions) and 22502 assignment links (road segments).

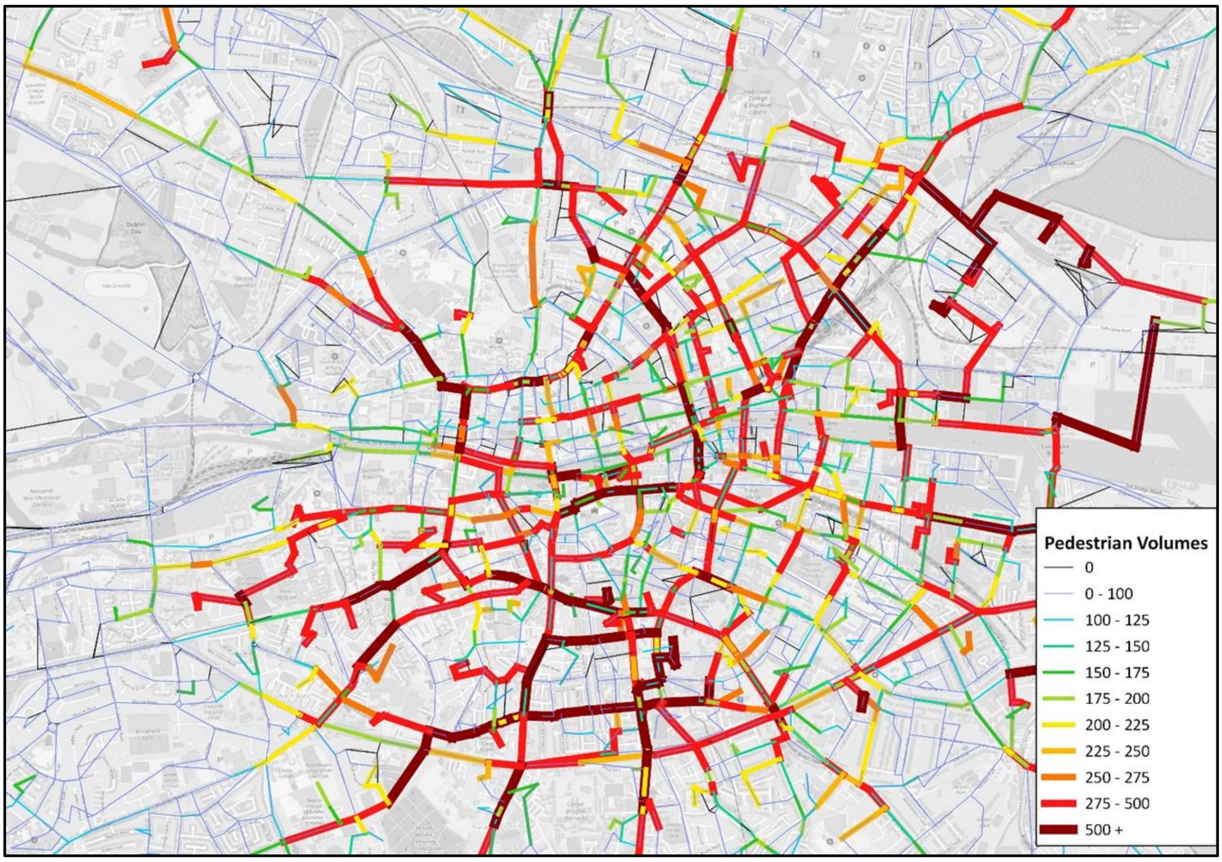

Figure 21: Map illustrating modelled 2016 weekday AM Peak-hour pedestrian flows in the NTA's East Regional Model (ERM), in the city centre of Dublin. Note that trips terminate at model zones.

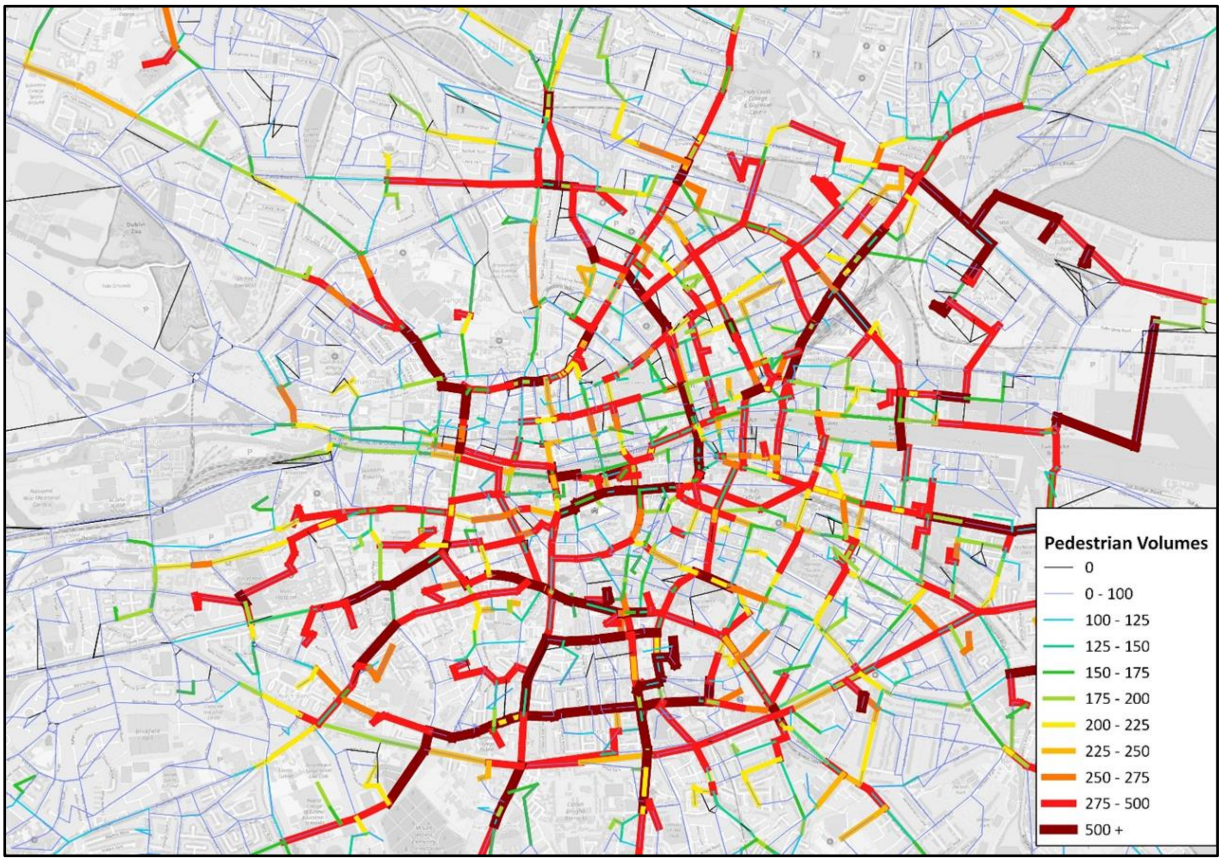

Figure 22: map illustrating modelled 2016 weekday AM Peak-hour pedestrian flows in the NTA's East Regional Model (ERM), in the city centre of Dublin. Note that trips terminate at model zones.

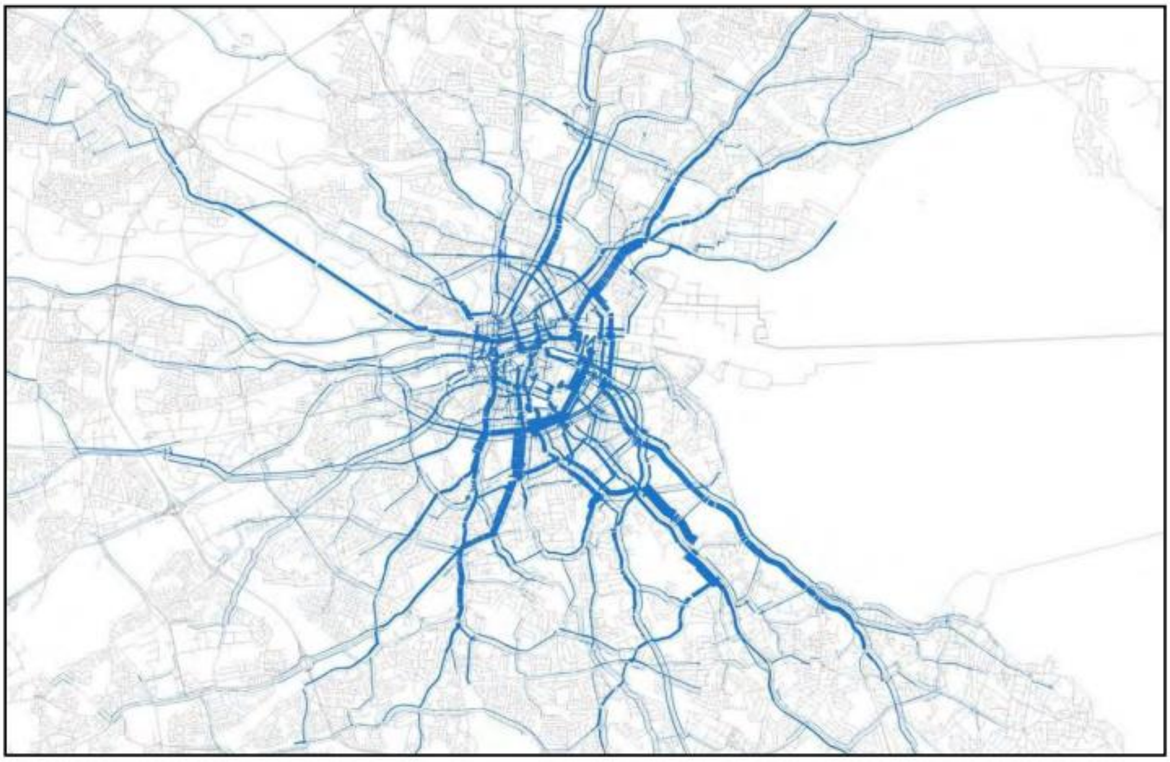

Figure 23: map illustrating modelled 2016 weekday AM Peak-hour cycling flows in the NTA's East Regional Model (ERM), in metropolitan Dublin.

(Vehicle) Fleet Modelling

As mentioned earlier, the NTA has worked the Department of Transport to support their development of various Climate Action. During this work the NTA developed and refined its Car Fleet spreadsheet tool.

The NTA models contain "offline" spreadsheet sub-models for private cars, light goods vehicles and heavy, or oversize goods vehicles. Such models are often referred to as "car stock" models or fleet models and build on available sources of data for both the total numbers and composition of vehicles in the fleet, especially in relation to either engine or fuel type for mechanical propulsion. The NTA's assignment models treat motor vehicles as objects with unit operating costs per kilometre, or per minute, but are otherwise agnostic as to the specific type of vehicle.

These models are then run into the future either with, or without, changes such as policy interventions as per Climate Action Plans or the Carbon Budgets pathways.

NTA Ireland Car Fleet model.

The NTA's Irish Car Fleet (spreadsheet) that uses observed historical data on new and second-hand car purchase rates, scrappage rates, rates of import, etc., by engine and fuel type to estimate engine type proportions in the national fleet.

Table 5: High level summary of National Car Fleet Model

Model: National Car Fleet Model (Owner: NTA/DoT)	
Description: An Excel spreadsheet-based tool which forecasts the average emissions profile of Ireland's national car fleet in any future year between 2023 and 2042. In particular, the tool predicts the future split of the fleet between petrol, diesel, plug-in hybrids, battery electric and 'other' (including mild hybrids etc) and the split of these sub-fleets by age and EURO Class and uses COPERT-based emissions profiles (and assumptions about changes in the distribution of vehicle sizes and network speeds) to estimate the change in the average emissions per km of NO_X, PM10 and CO_2(e)	
Key inputs	**Key outputs**
• National car fleet (by age and fuel type) at the end of 2022 • Scrappage rates (by age and fuel type) • Assumptions regarding the number and fuel type mix of new car sales in each future year	• Age and fuel type profile of the national car fleet in each future year (2023->2042) • Change in the average emissions per km of the national car fleet in each future year
Strengths	**Limitations**
• Sophisticated evidence-based treatment of scrappage and 2nd-hand imports • Ability to quickly change assumptions about the number and/or fuel mix of new car sales • Forecasting starts from the actual Irish car fleet at the end of 2022	• The estimate of the change in average emissions ignores any variation in the average kms by fuel type over time (eg any increase in the annual average mileage of BEVs over time) • The model is not directly linked to the NTA's car ownership model • The trajectory of BEVs and PHEVs in new car sales is an input assumption (rather than being predicted by the model, for example based on the relative purchase prices or the total cost of ownership or availability of the different fuel types)
Key policy questions considered under model	**Current uses**
• Models the impact of different rates of transition from ICE to BEV's in new car sales • Allows the user to introduce bans on ICE sales (new &/or 2nd-hand imports) and scrappage schemes in any future year(s) • Can predict the impacts of 'Buy Smaller' policies • Can predict the impacts of different assumptions regarding changes in the total fleet size over time	• Informing the transport chapter of the Irish Government's Climate Action Plan • Estimating the change in emissions of CO_2(e) per km that is used in the NTA's Carbon Forecasting Tool • Provides the relevant fleet profiles for use in the emissions modelling appraisal tool used in the NTA's Regional Modelling System
Possible future links to other models or opportunities	**Existing links to other models**
• Links to the NTA's car ownership model • Links to models capable of predicting the future fuel-type mix of new car sales (rather than requiring this to be provided as a user input) • Functionality extended to provide estimates of future revenue from Vehicle Registration Tax, annual motor tax and fuel duty	• Outputs are used in the current emissions appraisal module of the NTA's RMS • Predicted change in emissions per km used in the NTA's national CFT model
Output Weblinks	
Not publicly available at this time. Please contact the NTA for access to the tools and available documentation.	

Ireland LGV and HGV Fleet model.

Similar to the car fleet model, the NTA's Irish LGV Fleet (spreadsheet) model was originally developed by Systra UK on behalf of the Department of Transport for work on Climate Action Plan modelling. This future year model uses observed historical data on new and second-hand light goods vehicle purchase rates, scrappage rates, rates of import, etc., by engine and fuel type to estimate engine type proportions in these segments of the national vehicle fleet. For HGVs these are modelled in a similar fashion based on available historical and current data.

Table 6:High level summary of Goods Vehicle Fleet Models for GDA. Note This structure is the same in National Model

<table>
<tr><th colspan="2">Model: Goods Vehicle Fleet Models for the GDA (Owner: NTA/DoT)</th></tr>
<tr><td colspan="2">Description: Three Excel spreadsheet-based tools which forecast the average emissions profile of the set of LGVs, OGV1 and OGV2s registered in the Greater Dublin Area in any future year between 2023 and 2050. In particular, the tool predicts the future split of the fleet between petrol, diesel, plug-in hybrids, battery electric and ‘other’ (including mild hybrids etc) and the split of these sub-fleets by age and EURO Class and uses COPERT-based emissions profiles (and assumptions about changes in the distribution of vehicle sizes and network speeds) to estimate the change in the average emissions per km of NO_X, PM10 and CO_2(e)</td></tr>
<tr><th>Key inputs</th><th>Key outputs</th></tr>
<tr><td>• The set of goods vehicles registered in the GDA counties (by age and fuel type) at the end of 2022
• Scrappage rates (by age and fuel type) – based on the age profile observed in central Dublin in February 2020
• Assumptions regarding the number and fuel type mix of goods vehicle registrations in each future year</td><td>• Age and fuel type profile of the GDA goods vehicle fleets in each future year (2023->2050)
• Change in the average emissions per km of each of the three GDA goods vehicle fleets in each future year</td></tr>
<tr><th>Strengths</th><th>Limitations</th></tr>
<tr><td>• Sophisticated evidence-based treatment of scrappage and 2nd-hand imports within the GDA fleets, based on the observed age profiles observed in central Dublin in February 2020
• Ability to quickly change assumptions about the number and/or fuel mix of new vehicle sales
• Forecasting starts from the actual GDA goods vehicle fleets at the end of 2022</td><td>• The estimate of the change in average emissions ignores any variation in the average kms by fuel type over time - eg any increase in the annual average mileage of Zero Emission Vehicles (ZEVs) over time
• The trajectory of ZEVs in new vehicle sales is an input assumption, rather than being predicted by the model, for example based on the relative purchase prices or the total cost of ownership or availability of the different fuel types
• The model does not distinguish between the various potential types of zero emission technology (hydrogen fuel cells, battery electric etc)</td></tr>
<tr><th>Key policy questions considered under model</th><th>Current uses</th></tr>
<tr><td>• Models the impact of different rates of transition from ICE to ZEV’s in new goods vehicle sales
• Allows the user to introduce bans on ICE sales (new &/or 2nd-hand imports) and scrappage schemes in any future year(s)
• Can predict the impacts of different assumptions regarding changes in the total size of the GDA goods vehicle fleets over time</td><td>• Informing the development of the Demand Management Strategy for the GDA</td></tr>
<tr><th>Possible future links to other models or opportunities</th><th>Existing links to other models</th></tr>
<tr><td>• Links to models capable of predicting the future fuel-type mix of new goods vehicle sales (rather than requiring this to be provided as a user input)
• The Zero emission Vehicle category could be split by ZEV technology (BEV, hydrogen etc)</td><td>• The predicted uptake of ZEVs is used to inform the ‘Decarbonisation Playbook’ which is being used to appraise the GDA Demand Management Strategy</td></tr>
<tr><th colspan="2">Output Weblinks</th></tr>
<tr><td colspan="2">Not publicly available at this time. Please contact the NTA for access to the tools and available documentation.</td></tr>
</table>

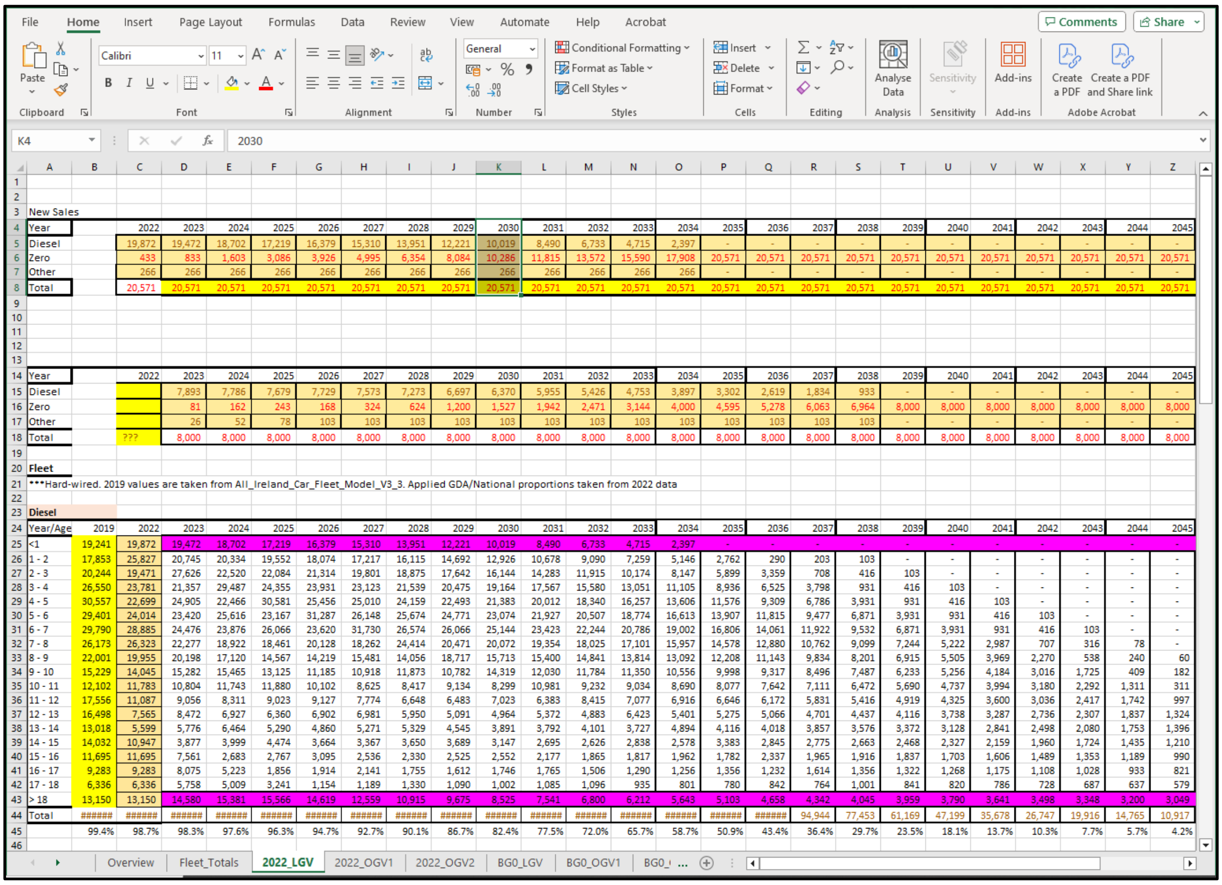

Figure 24: Screenshot illustrating some detail for one LGV forecast scenario in the NTA's Fleet Tool (developed by Systra UK).

Ireland Freight Model (IFM)

The IFM is a multimodal freight demand model for the *island of Ireland* (developed by MDS Transmodal on behalf of the NTA and based heavily on the pre-existing GB Freight Model[14]). It simulates the response of the freight market (road, rail and international short-sea unitised traffic via ferry ports) to changes in the market and policy environment. It provides freight-specific inputs in the form of origin-destination matrices by mode to the Long-Distance Model of the NTA's RMS.

The model has been developed in the first instance for use in the GDA Demand Management Studies (not yet published) but is also available for use at a national and regional level in the rest of Ireland. It must be noted that the IFM was under ongoing development in 2023 – 2024 during the Carbon Budgets modelling engagement between the NTA and UCC and as such the results presented later must be viewed as provisional in nature. It should also be noted that the UCC TIM covers the Republic of Ireland and thus it is not possible to do a simple direct comparison of the models for freight.

[14] https://www.gov.uk/government/publications/great-britain-freight-model-version-5-2022-updates

Table 7: High level summary of the Ireland Freight Model

<table>
<tr><th colspan="2">Model: Ireland Freight Model (IFM) Phase 1 (Owner: NTA/DoT)</th></tr>
<tr><td colspan="2">Description
The IFM (Phase 1) is a multimodal freight demand model for the island of Ireland which simulates the response of the freight market (road, rail and international short sea unitised traffic via ports) to changes in the market and policy environment. It can provide freight-specific inputs in the form of origin-destination matrices by mode to the NTA Regional Modelling System (RMS).</td></tr>
<tr><th>Key inputs</th><th>Key outputs</th></tr>
<tr><td>• CSO Road Freight Survey data
• UK DfT Continuing Survey of Road Goods Traffic
• CSO/Irish Rail freight data
• GBFM freight van data for UK, based on DfT LGV Survey data
• TomTom journey time data
• CSO/UK DfT port/Eurostat traffic data
• HGV distance & time skims and traffics from TII Highways Model
• MDS Transmodal World Cargo Database (trade data for forecasts)
• MDS Transmodal Containership & RORO Databank (route data for short sea unitised traffic)
• Macro-economic data on projected employment & GVA by economic sector for forecasts
• Cost data for modal cost models (industry sources)</td><td>• Tonnes lifted, tonnes moved (Tonne kms), Vehicles and Vehicle kms by mode (OGV1, OGV2, LGV (freight), LGV (servicing), rail, cargo-bike) between OD pairs
• Road movements further split by propulsion type (diesel, battery electric, hydrogen)
• Mode of appearance at ports (RORO, LOLO, deep sea LOLO, bulks)
• Commodity for road freight (NST 2007 for commodities 01-14) within the island of Ireland
• Forecasts to 2030 & 2050
• User costs
• Carbon emissions</td></tr>
<tr><th>Strengths</th><th>Limitations</th></tr>
<tr><td>• Modelling the impact on choice of land-based mode (e.g. road versus rail) and vehicle propulsion type (e.g. battery electric HGV versus diesel HGV) of market-based changes in resource input costs (e.g. cost of fuel, HGV drivers).
• Modelling the impact on choice of land-based mode and vehicle propulsion type of policy-based changes (e.g. road pricing, LEZ etc.)
• Modelling the impact of market- and policy-based changes on the mode of appearance (e.g. RORO versus LOLO) of international short sea unitised freight traffic at ports.
• Modelling the impact of market- and policy-based changes on the routing (e.g. Port of Dublin versus Port of Rosslare) of international short sea unitised freight traffic via ports.</td><td>• The IFM (Phase 1) is a demand model, so it does not constrain capacity on the rail and road networks or at ports. (Phase 2 will simulate network capacity for rail freight services).
• Demand for HGVs and vans with new propulsion types is not restricted by availability. IFM demand should therefore be compared to results from the fleet model
• The routing of all shipping and air freight apart from short sea unitised traffic (RORO and LOLO) is not actively modelled but is only distributed inland from the relevant ports.
• Inherent uncertainty about future costs of propulsion technologies (vehicles, energy & associated energy supply infrastructure)
• No switching between vehicle classes, e.g. from OGV2 to OGV1 or from OGV1 to van</td></tr>
<tr><th>Key policy questions considered under model</th><th>Current uses</th></tr>
<tr><td>• How will market-based changes in resource input costs (e.g. cost of fuel, HGV drivers) affect freight transport by mode and propulsion type of road vehicle?
• How will measures introduced by the public sector (e.g. road pricing, LEZ etc) affect freight transport by mode, propulsion type of road vehicle?
• How will the market- and policy-based changes affect the mode of appearance of international short sea unitised freight traffic at ports?</td><td>• Testing the impact of packages of measures for the GDA Demand Management Scheme.</td></tr>
</table>

The UCC Times Ireland Model (TIM)

The main details for the transport component of the TIM are outlined below and as are some differences in model structure which are important to keep in mind when comparing with the NTA model outputs. The material is copied directly from Balyk et al:

“The TIMES-Ireland Model (TIM) is an optimisation model of the Irish energy system, which calculates the cost-optimal fuel and technology mix to meet future energy service demands in the transport, buildings, industry, and agriculture sectors, while respecting constraints in greenhouse gas emissions, primary energy resources, and feasible deployment rates.”

The [TIM] model's base year is 2018, and all energy flows, emissions, and energy technology stocks are calibrated to the 2018 energy balance (SEAI, 2019).

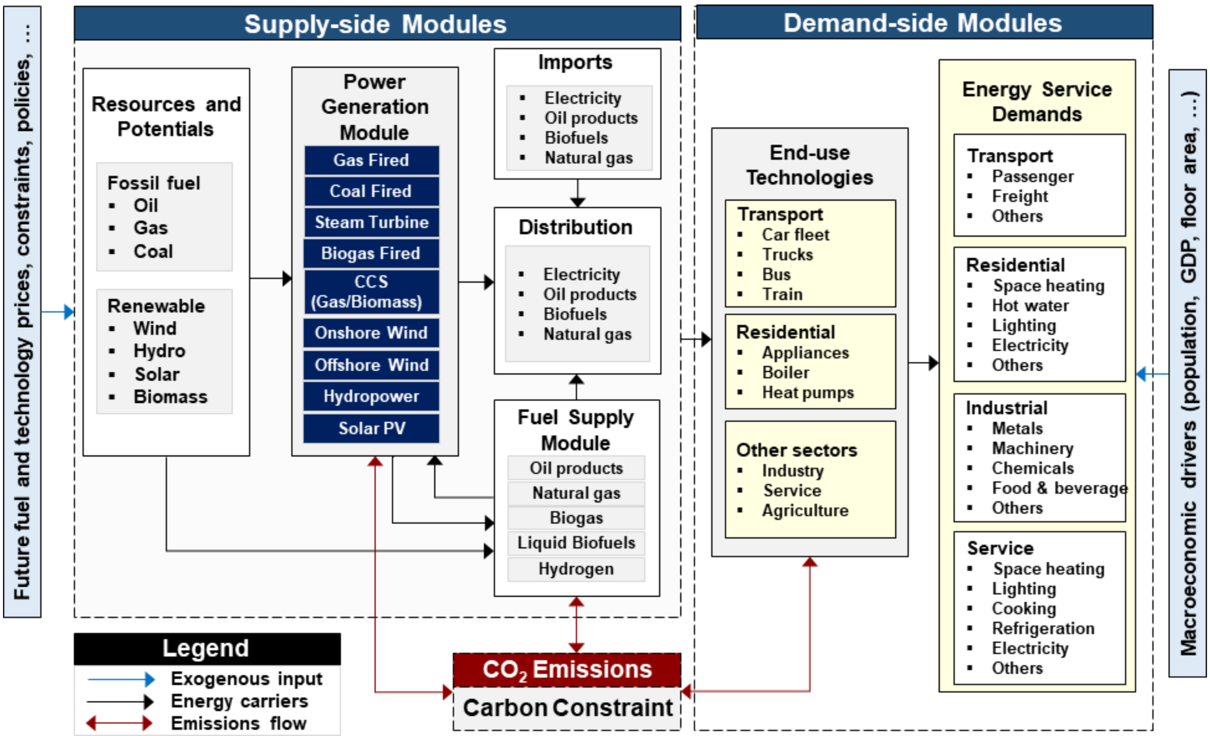

Figure 25: Simplified representation of reference energy system in TIM, Balyk et al.

The forecast energy service demand by sector from the Balyk et al is presented below. The relevant transport demand segments are highlighted using a purple outline.

Energy service demand	Driver/projection source	Value		Unit
		2018	2050	
Non-energy mining	GVA per capita, population	2.07	0.13	PJ
Food and beverages	GVA per capita, population	22.25	34.00	PJ
Textiles and textile products	GVA per capita, population	1.20	4.97	PJ
Wood and wood products	GVA per capita, Population	6.69	7.65	PJ
Pulp, paper, publishing, and printing	GVA per capita, population	0.67	2.31	PJ
Chemicals and man-made fibres	GVA per capita, population	10.60	13.11	PJ
Rubber and plastic products	GVA per capita, population	1.14	0.89	PJ
Other non-metallic mineral products	Modified investment, GNI*	17.77	24.82	PJ
Basic metals and fabricated metal products	GVA per capita, population	19.54	21.73	PJ
Machinery and equipment n.e.c.	GVA per capita, population	1.29	1.69	PJ
Electrical and optical equipment demand	GVA per capita, population	4.27	16.37	PJ
Transport equipment manufacture	GVA per capita, population	0.17	0.04	PJ
Other manufacturing	GVA per capita, population	4.25	6.12	PJ
Construction	GVA per capita, population	4.02	5.90	PJ
Transport demand: short-range passenger travels	Income, population	14.56	21.07	Bpkm
Transport demand: medium-range passenger travels	Income, population	31.28	45.29	Bpkm
Transport demand: long-range passenger travels	Income, population	27.13	38.97	Bpkm
Transport demand: goods vehicles for freight	Growth rate (AECOM, 2019)	11.54	25.14	Btkm
Transport demand: tourism fuel	None, linear decrease assumed	7.72	0.00	PJ
Transport demand: navigation fuel	GDP	3.51	10.04	PJ
Transport demand: unspecified fuel	None, linear decrease assumed	21.78	0.00	PJ
Transport demand: aviation domestic	None, assumed constant	0.23	0.23	PJ
Transport demand: aviation international	International aviation passengers	45.94	62.63	PJ
Residential apartment demand	Population	206.80	628.93	000’
Residential attached demand	Population	766.35	1056.50	000’
Residential detached demand	Population	724.43	889.76	000’
Services – commercial services	GNI*	28.90	47.39	Mm^2
Services – public services	GNI*	58.15	95.35	Mm^2
Services – commercial services – data centres	EirGrid (2017)	5.63	40.30	PJ
Services – public services – public lighting	Government of Ireland (2018)	0.48	0.58	Mlamps

Table 8: Energy Service demands in 2018 and projected to 2050 in TIM from Balyk et al. The unit PJ denotes PetaJoules and Bpkm denotes Billions of person kilometres.

The Overview on Transport demand used in TIM and described in Balyk et al is presented below. The details, which are important for the comparisons are highlighted

> “The transport sector [in TIM] comprehensively describes the end-use transport technologies and freight and mobility demands on a regional basis. This sector is divided into 26 counties across Ireland. To represent region-specific transport characteristics, some main parameters (vehicle fleet, transport infrastructure, fuel consumption, mileage, occupancy rate, and load factor) are differentiated on a county level. Transport demand is split into the following three main categories: passenger, freight, and others. The passenger and freight demands are expressed as activity demands, and others are defined as a final energy demand (in units of PetaJoule). These final energy demands further split into aviation (international and domestic), navigation, fuel tourism, and unspecified, aligned with the energy balance (SEAI, 2019). Fuel tourism refers to cross-border consumers, and a portion of demand is used by unspecified modes.
>
> **“The passenger transport demands are expressed in billion passenger kilometres (Bpkm).** As shown in Table [not reproduced here], the **total passenger demand is divided into three classes of distance range, including short range (less than 5 km), medium range (5–30 km), and long range (more than 30 km; NTA, 2018). A total of four transport modes satisfy travel demands, namely public services (bus, train, and taxi), private cars, powered two-wheelers**

(PTW), and active modes (walk and bike). Non-motorised transport is only used for short-range trips, PTW are used for short- and medium-range travel, urban buses and school buses are used for short- and medium-range travel, intercity buses and heavy trains are used for long-range trips, and light rail can only be used for the short- and medium-range trips in Dublin county. "

Modes	Vehicles	Short range (below 5 km)	Medium range (5–30 km)	Long range (over 30 km)
Public	Bus	8.3 %	13.5 %	16.1 %
	Light train	0.8 %	0.7 %	n/a
	Heavy train	n/a	n/a	8.4 %
	Taxi	1.7 %	2.2 %	1.3 %
Private	Car	51.5 %	83.3 %	74.2 %
	Powered two-wheelers	0.1 %	0.3 %	n/a
Active	Bike	5.4 %	n/a	n/a
	Walk	32.2 %	n/a	n/a
Total passenger demand in 2018 (Bpkm)		14.6	31.3	27.1

Table 9: Transport demands and mode share percentages in 2018 as represented in TIM, Balyk et al. The unit Bpkm denotes Billions of person kilometres.

Transport sector in TIM: BaU energy service demands.

The total passenger kilometres in billion (Bpkms) and freight tonne kilometres in billion (Btkms) along with mode shares are inputs to the transport (energy system) sector in TIM. The following table outlines the energy service demand, the unit and the drivers of these demands in the **BaU** case.

Energy Service Demand	Unit	Driver
Transport Demand: Short-range passenger travels	Bpkms	Income, population
Transport Demand: Medium-range passenger travels	Bpkms	Income, population
Transport Demand: Long-range passenger travels	Bpkms	Income, population
Transport Demand: Goods vehicle for freight	Btkms	Growth rate from NTpM

Table 10: the energy service demand, the unit and the drivers. Note that NTpM refers to the TII National Transport Model.

NTA Comparative Analysis

Introduction

In Spring – Summer 2024 the NTA team worked with the CCAC and the University College Cork (UCC) TIMES-Ireland Model (TIM) development team to determine how best to use the NTA's expertise and tools to support the carbon budgets modelling.

Choice of indicators for comparison

It was agreed to focus on a number of key transport indicators, namely (Billions of) person kilometres (Bpkm), freight tonne-kilometres and vehicle fleet projections for car, LGV and HGV. In order to quantify and estimate current and future year GHG emissions, and in particular, CO2 emissions from transport it is the vehicle and trip kilometres which correlate most closely with total CO2 emissions, rather than transport mode shares. One of the key strengths of the NTA's transport models is that they represent transport demand in reasonably fine-grained detail including trip distribution, mode, destination and route choices. Vehicle occupancies are also represented as well as regional variations.

Choice of scenarios for comparison

It was also agreed that the following scenarios be used for comparison as they were most closely aligned with the requirements of the CBWG: the UCC Reference and Low Energy Demand (LED) scenarios and the NTA Reference Case and CAP23 scenarios for the years 2028, 2030 and 2043. The NTA's Reference Case scenarios are based on the demographic forecasts contained in the NPF and transport networks based on the NDP of the future years of 2043 and 2028 respectively. Additional outputs were extracted from scenarios developed using the NTA Ireland Freight Model (IFM) and the DoT Irish Fleet Models (car, LGV and HGV). This approach was considered to be the most expedient and to be sufficient for the purpose of this comparison work.

The UCC / TIM BaU scenario which is also termed "UCC Ref" and the UCC / TIM LED scenario are described below.

> **UCC Ref**: BaU energy service demand projections for a cumulative carbon budget of 315 mega tonne (between 2020-2050). In the UCC Ref (BaU) scenarios total passenger transport activity increases to around 17,000 pkm per person per year by 2050.
>
> **UCC LED**: Low energy demand (LED) projections for a cumulative carbon budget of 315 mega tonne (between 2020-2050) . In the LED scenarios total passenger transport activity decreases to around 12,000 pkm per person per year by 2050.

To assist in Fleet comparisons the NTA created additional reference point by averaging the UCC Ref and UCC LED fleet projections. This is referred to as the "UCC Med" in the graphs and explained below.

> **UCC Med**: A simple median value calculated as the simple average of UCC Ref and UCC LED projections for each forecast year. This is a label for figures to be presented and does not represent an actual UCC scenario.

As noted above the TIM energy systems model divides the total passenger transport demand into three classes of trip distance range. In the UCC / TIM BaU (UCC Ref) the distribution of trips by distance band is set out in Table 11. For future year scenarios of the BaU, it is been assumed that the distribution of trips based on distance remains the same, but the total distance travelled changes.

Short-range (less than 5 km),	20%
Medium-range (5–30 km),	43%
Long-range more than 30 km	37%

Table 11: TIM BaU distribution of trip demand by distance band

For the UCC LED scenarios, the short distance (< 5km) distribution is assumed to increase by 5% in 2050 whereas the medium (5-30 km) distribution and the long-distance (>30km) distribution are assumed to decrease by 2.5% each.

Comparison Analysis

Passenger Kilometres (Bpkm)

A high-level comparison of the NTA's RMS outputs (summed over the 5 regional models, and then annualised from typical weekday to one year) with the UCC / TIM for two of their future year scenario tests is presented in Figure 26. The red points and trend line for TIM denote their BaU or Reference model while the green points and line indicate the UCC LED scenario. The purple points and line denote the NTA's Reference Case scenarios for future years 2028 and 2043 and the CAP23 scenario for 2030.

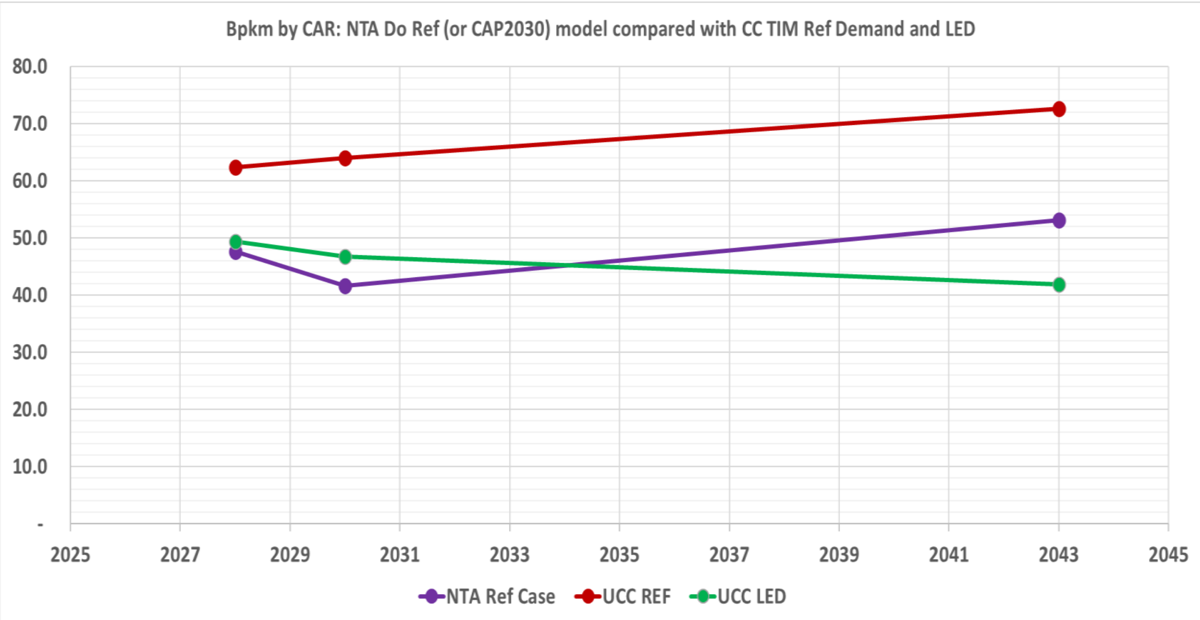

Figure 26: Car demand in Billions of passenger kilometres (Bpkm) per year for NTA's Reference Case Scenarios (purple) and two main UCC /TIM scenarios (green and red).

The billions of person kilometres (Bpkm) by mode of transport across the years 2028, 2030 and 2043 for both the NTA model and UCC/ TIM model scenarios are summarised in Table 12. The NTA CAP23 scenario for 2030 differs from the 2028 and 2043 scenarios insofar as it contains all interventions to achieve the 51% reduction in CO_2e as part of the CAP23 modelling.

The total passenger kilometres (pkm) are quite similar in both models with a similar growth trend in their respective Reference or base scenarios. It should be noted that an annualization factor has been applied to the NTA RMS outputs to calculate annual billion passenger kilometres (Bpkm) because the RMS outputs are estimated for an average 24-hour weekday. The NTA CAP 23 and UCC LED scenarios for 2030 reflect necessary shift in passenger kilometres to PT. It is notable that the current NTA Reference Case scenarios do not achieve the required level of mode shift. A notable difference is the low level of Active Travel kilometres in all NTA scenarios compared with the UCC LED scenarios. This evidence would suggest that UCC LED levels of Active Travel kilometres may be too high.

Bpkm by mode of transport	2028			2030			2043		
	NTA Ref Case	UCC REF	UCC LED	NTA CAP23	UCC REF	UCC LED	NTA Ref Case	UCC REF	UCC LED
Car	83%	75%	69%	71%	75%	67%	81%	75%	58%
PT	14%	17%	20%	25%	17%	21%	15%	17%	27%
Active	4%	8%	11%	5%	8%	12%	4%	8%	15%

Table 12: Bpkm by mode of transport.

The distribution of person-kilometres by mode is presented in Figure 27. The NTA scenarios the percentage of Bpkm by Active mode is between 4 – 5% whereas in the TIM scenario it is between 8% and 15%. In the NTA scenarios the percentage of Bpkm by car mode is between 71% and 80% whereas in the TIM scenario it is between 58% and 75%.

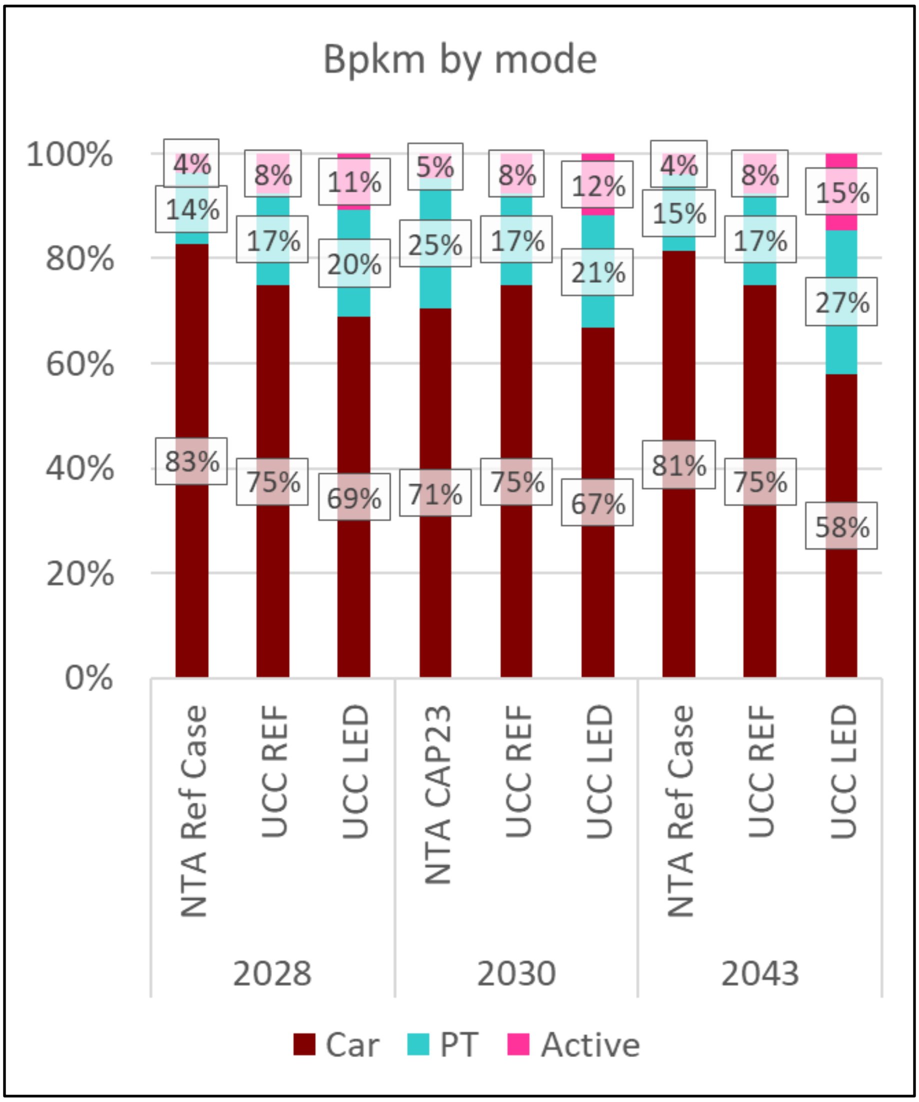

Figure 27: Percentages of Person-kilometres by mode of transport in the NTA and UCC / TIM scenarios.

A key difference underlying the difference in the mode share of passenger kilometres is the distribution of passenger kilometres by distance in the UCC models and scenarios as set out below in

Table 13. The NTA model outputs indicate larger shares of long-distance trips in each year compared to the UCC / TIM.

Bpkm by trip distance range	2028			2030			2043		
	NTA Ref Case	UCC REF	UCC LED	NTA CAP23	UCC REF	UCC LED	NTA Ref Case	UCC REF	UCC LED
Short-range (< 5 km)	8%	20%	22%	7%	20%	23%	8%	20%	24%
Medium-range (5–30 km)	47%	43%	42%	47%	43%	41%	46%	43%	41%
Long-range (> 30km)	45%	37%	36%	46%	37%	36%	46%	37%	35%

Table 13: Table Percentage of Bpkm by trip distance range.

The distribution of person-kilometres by distance is presented in Figure 27. The NTA scenarios the percentage of Bpkm in the Short-range (< 5 km) is between 7% – 8% whereas in the TIM scenario it is between 20% and 24%. In the NTA scenarios the percentage of Bpkm in the Long-range (> 30km) between 45 – 46% whereas in the TIM scenario it is between 35% and 37%.

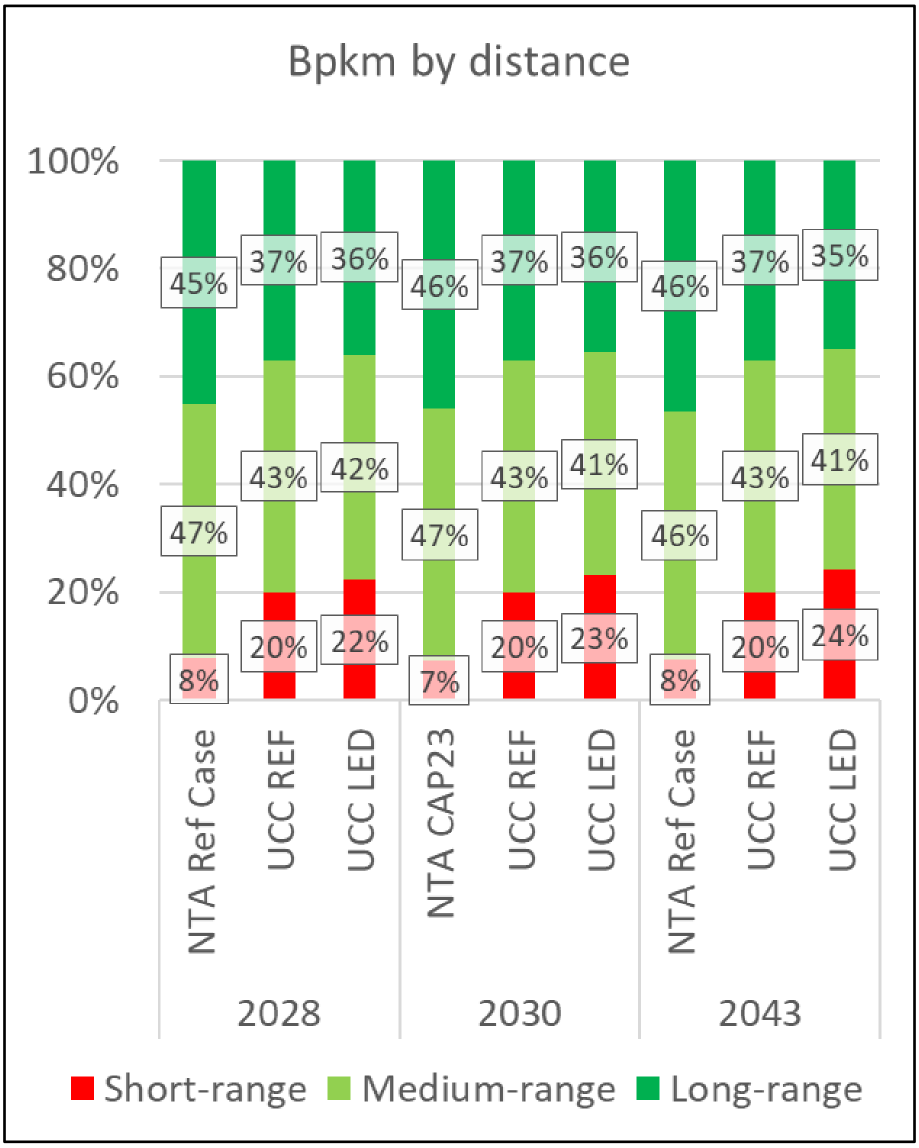

Figure 28: Percentages of Person-kilometres (per year, as estimated) in three distance ranges in the NTA and UCC / TIM scenarios.

Trip kilometres by distance ranges

The absolute total trip distances travelled in the three distance ranges is presented Figure 29. There is broad similarity in pattern for short-distance trips (red), medium-distance (light green) and long-distance trips in dark green. The NTA model indicates a smaller number of short distance trips compared with the UCC TIM model. In absolute terms the NTA model for trip distances travelled is approximately 70% that of the UCC / TIM scenarios.

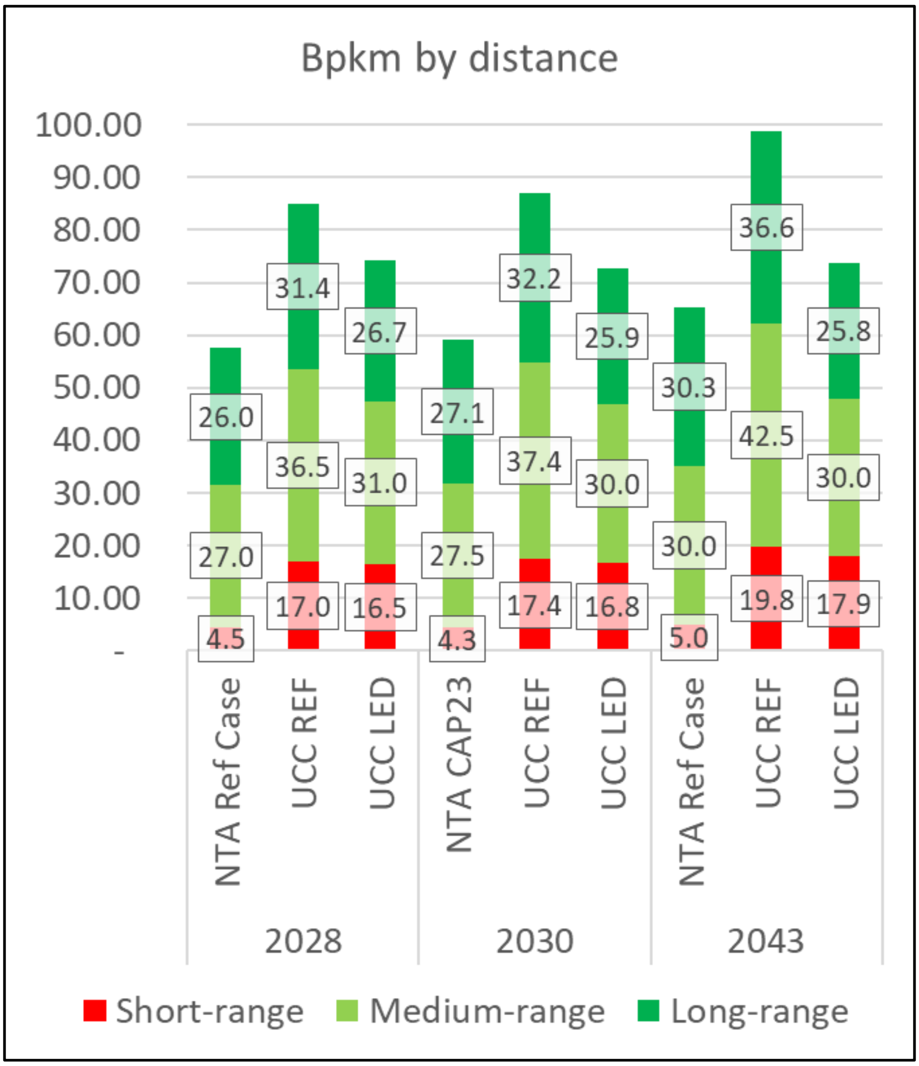

Figure 29: Billions of Person-kilometres (per year, as estimated) for three distance ranges in the NTA and UCC / TIM scenarios.

Trip kilometres by mode of transport

The absolute and percentage trip kilometres (in billions) by mode of transport for each of the nine scenarios are presented in Figure 30 and Figure 27 respectively. As mentioned already, the absolute number of trip kilometres differs from the NTA models to the TIM. For absolute trip kilometres there are reductions in Bpkm in going from the TIM Reference / BaU scenario to the LED scenario. This is not the case for the NTA models where a growth trend in total Bpkm can be seen over the period from 2028 to 2043.

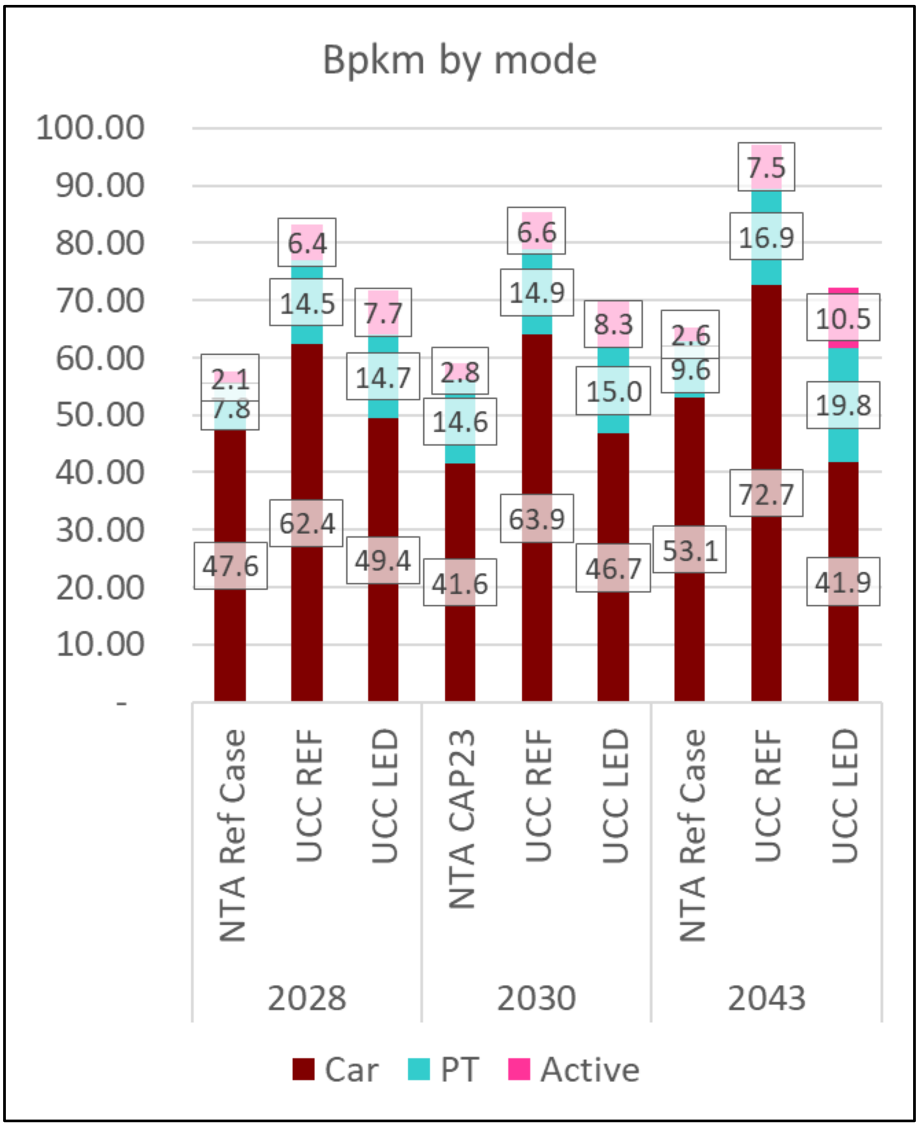

Figure 30: Billions of Person-kilometres (per year, as estimated) by mode of transport in the NTA and UCC / TIM scenarios.

Long distance Trip kilometres by mode of transport

The absolute total trip distances travelled by mode of transport in the case of **long** distance ranges (> 30km) is compared in Figure 31. The reason for focusing on this distance range is that this is where approximately 50% of current CO2e emissions from transport are produced.

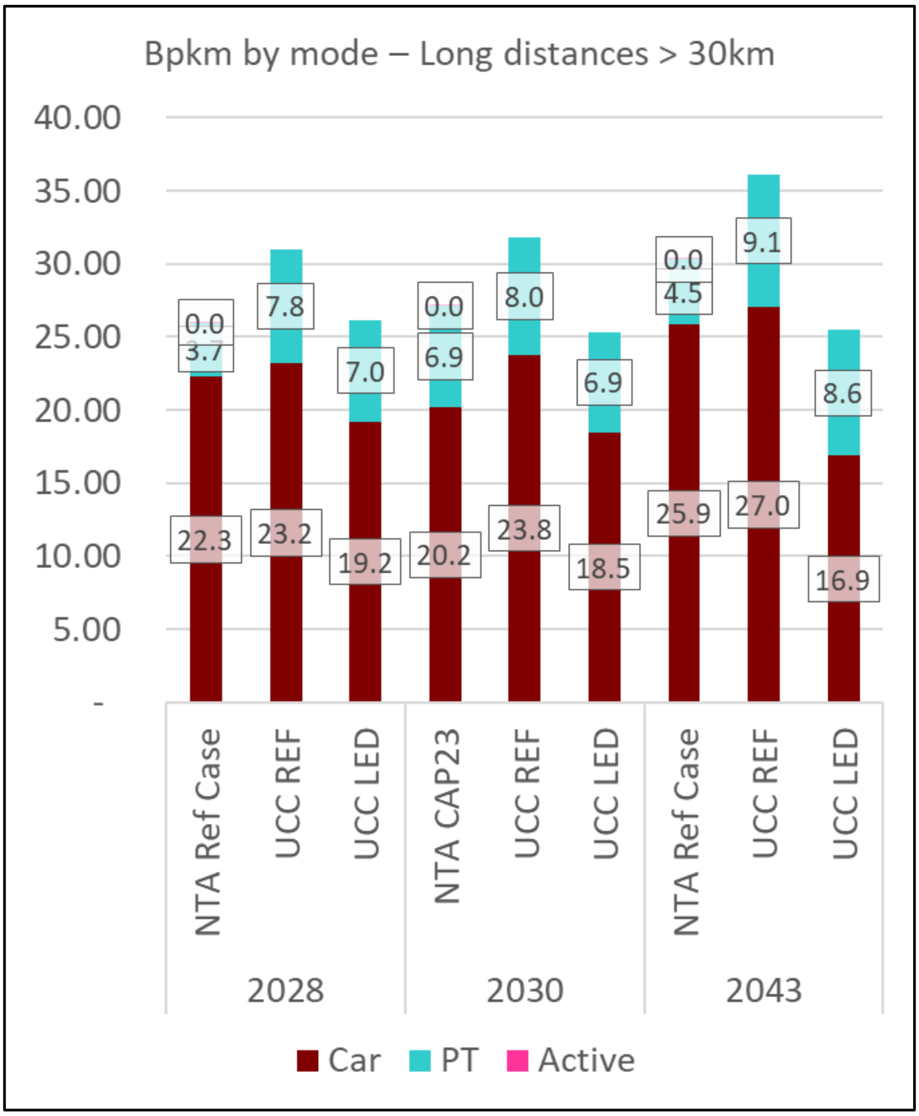

Figure 31: Billions of Person-kilometres (per year, as estimated) by mode of transport for long-distance trips in the NTA's Reference Case Scenarios and two main scenarios in the UCC / TIM scenarios.

The percentage of total trip distances travelled by mode of transport in the case of long distance ranges (> 30km) is compared in Figure 32. This indicates that in percentage terms the NTA and TIM scenarios are fairly closely aligned except in the cases of the NTA Reference Cases for 2028 and 2043 (no behaviour change policy interventions modelled). In these last two scenarios the car mode share for long distance trips is approximately 85% compared with approximately 75% in the nearest equivalent TIM Reference / BaU scenarios.

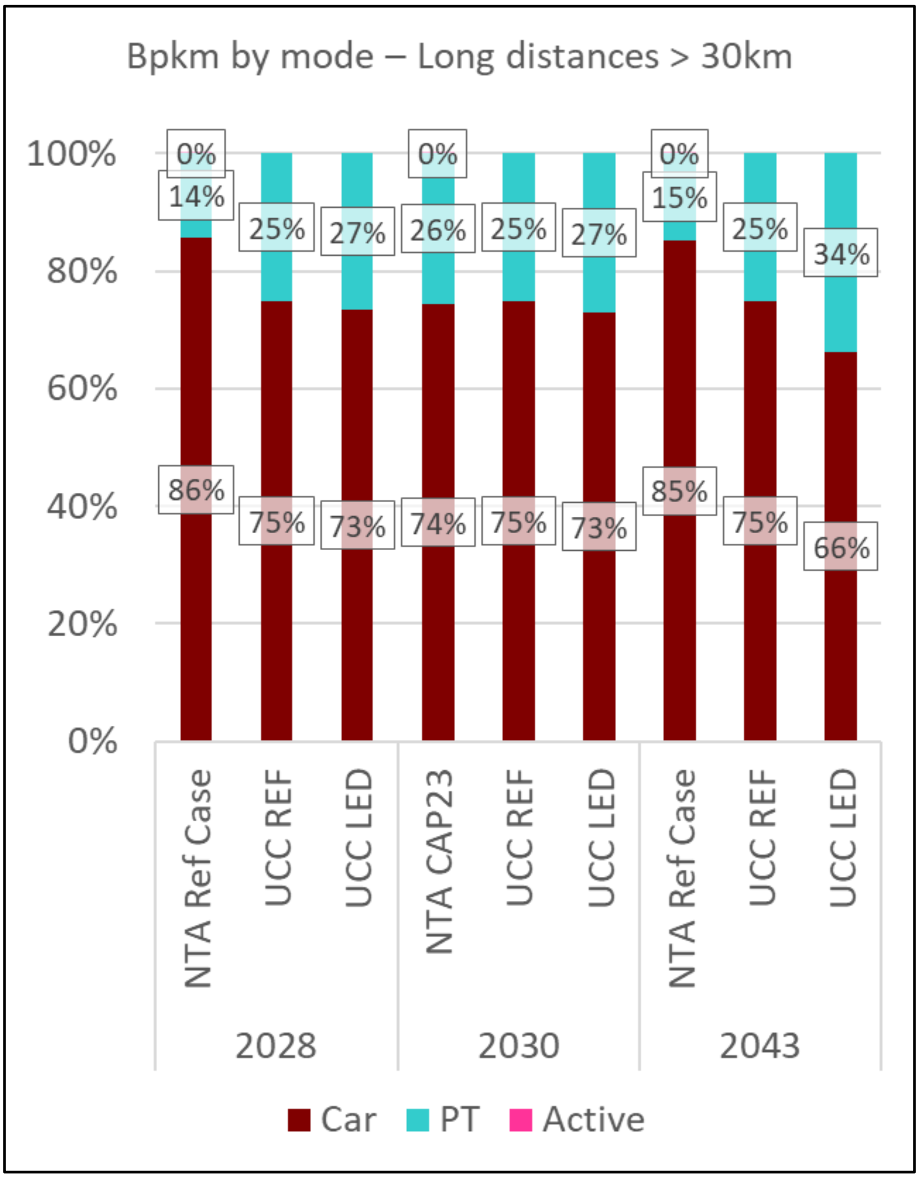

Figure 32: Percentages of Person-kilometres (per year, as estimated) by mode of transport for long-distance trips in the NTA's Reference Case Scenarios and two main scenarios in the UCC / TIM scenarios.

Data from NHTS2023

The quantity plotted is the **cumulative** sum of trip kilometres either by car or by bicycle mode as reported by survey participants is illustrated in Figure 33 and Figure 34. The red arrows indicate approximately the distance where 50% of trip kilometres are demarcated, namely the median distance in the distribution.

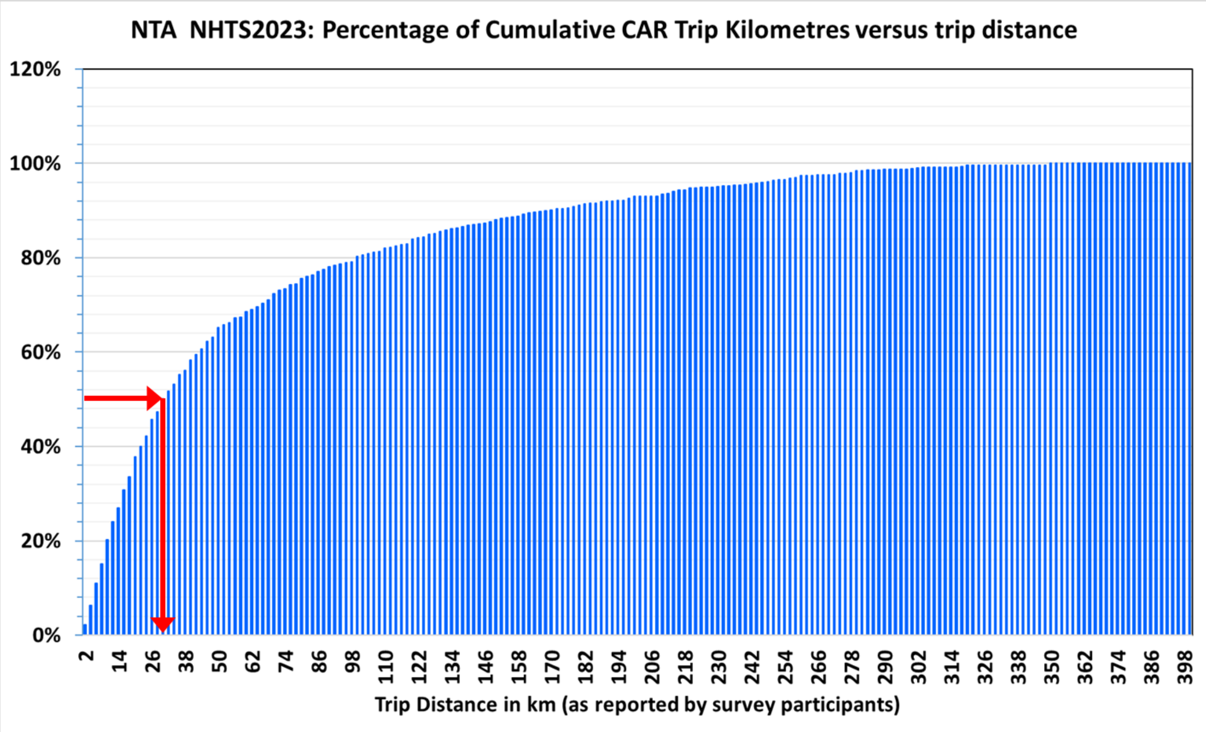

Figure 33: Cumulative Percentage of Car Trip kilometres as reported by survey participants in NHTS2023 as function of trip distance. Approximately 50% of the total car trip distance is accounted for by trips less than 30 kilometres.

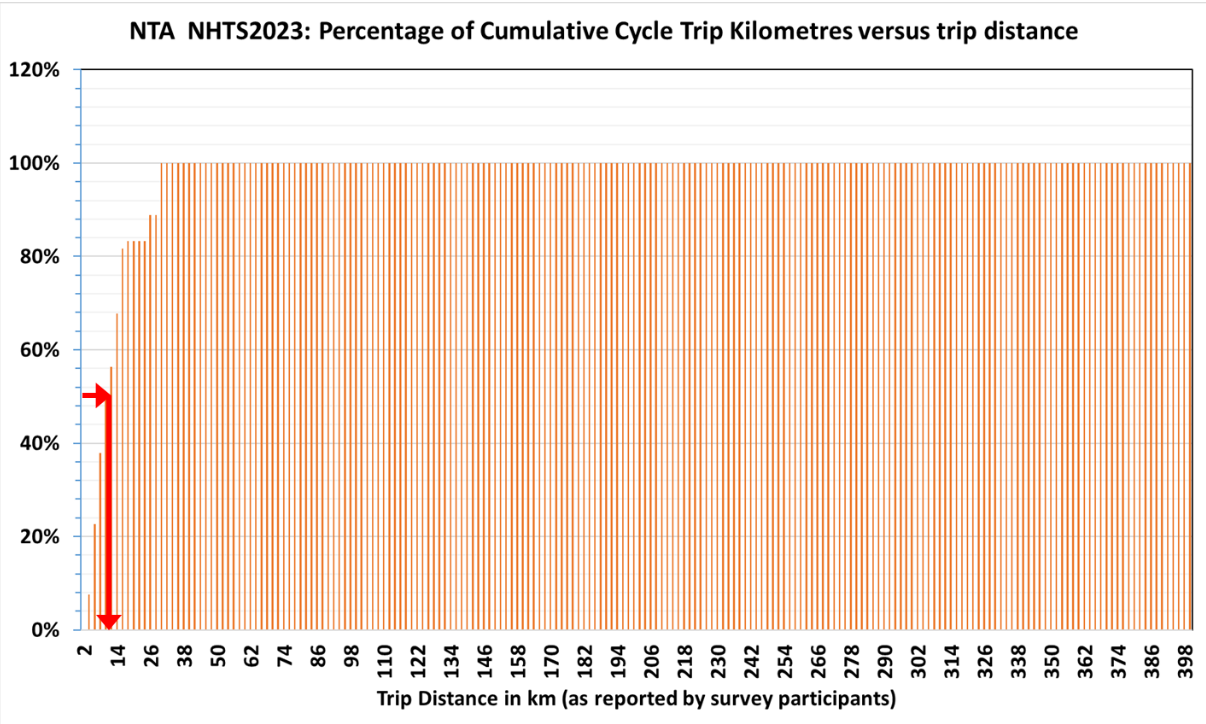

Figure 34: Cumulative Percentage of Cycle Trip kilometres as reported by survey participants in NHTS2023 as function of trip distance. Approximately 50% of the total cycle trip distance is accounted for by trips less than 10 kilometres.

Freight Tonne Kilometre Comparisons

The NTA, working with consultants Systra, Jacobs and MDS Transmodal have developed the Ireland Freight Model (IFM) which is an all-island freight transport network model. The results for IFM are not segregated into the two separate jurisdictions of republic and Northern Ireland. As a result, the

IFM indicates higher tonne-km than the UCC modelled scenario tests. The IFM has been used to test a range of scenario for 2030 estimates of demand and economic growth. These scenarios are presented in Figure 35 and suggest very negligible effects of several policy interventions on the tonne-km metric.

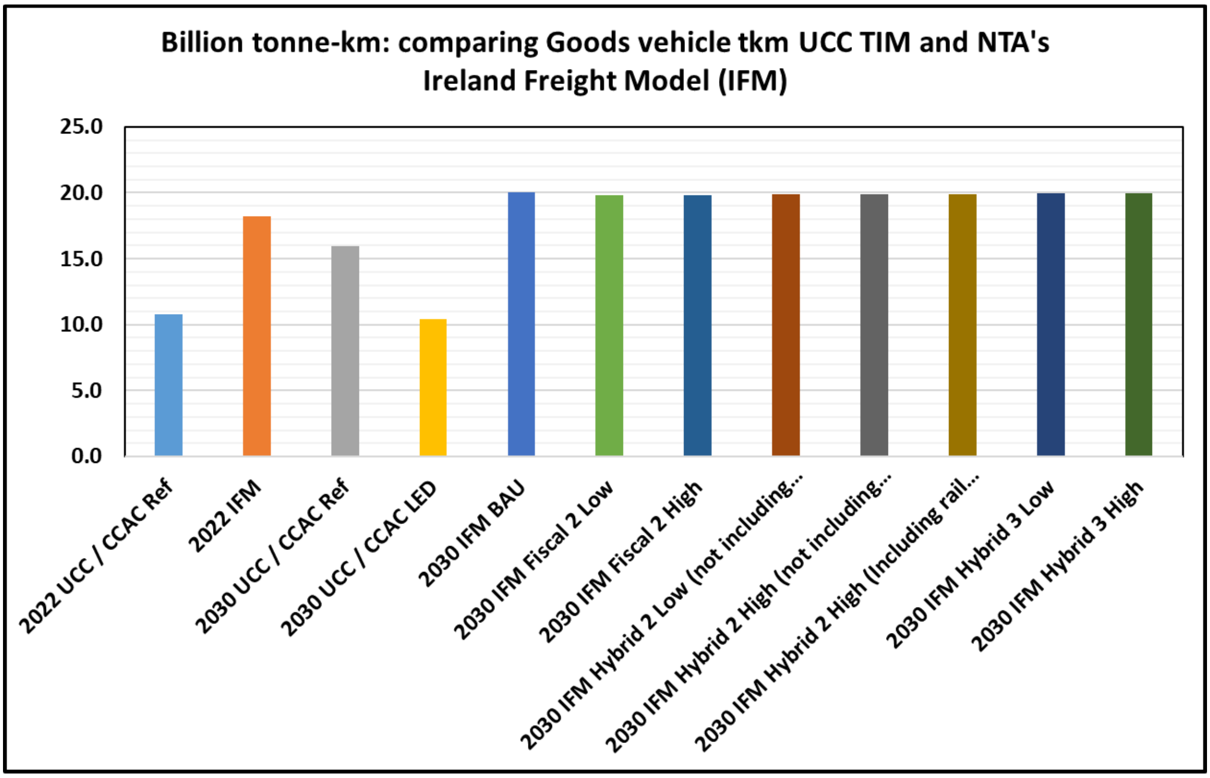

Figure 35: Billions of Tonne-kilometres (per year, as estimated) in the NTA's Ireland Freight Model (IFM). For 2030 several IFM scenario tests indicate approximately the same tonne-km in each case.

Private Car Stock Comparisons

Comparisons of the NTA's private vehicle fleet model and the UCC / TIM scenarios from 2020 to 2042 are presented in Figure 36. The blue line denotes the underlying NTA cohort model. This trend aligns reasonably closely with the UCC / TIM BaU Reference scenario denoted by the red curve.

The purple line denotes the NTA CAP23 model wherein behaviour change policies under the Climate Action Plans were modelled. This trend aligns reasonably closely with the UCC / TIM "Med" values, which are calculated as the simple average of UCC Ref and UCC LED projections for each forecast year. This is a label for figures to be presented and does not represent an actual UCC scenario. "UCC Med" is denoted by the orange curve.

The NTA scenarios do not indicate the fleet size reducing given forecast population and economic growth and long-standing historical trends and tendencies for private car purchase, except during economic recessions which do not form any part for the economic forecasts for GNI or incomes relative to car prices or lease costs. The scenario used to develop the NTA CAP23 Car fleet mix projections estimates 30% BEV by 2030 and 90% BEV by 2042. The UCC / TIM LED scenario indicates that the overall national private car fleet will *need* to reduce in order to achieve the targets whereas the NTA models represent more conservatively how the private fleet appears *likely* to develop out to 2042 based on present data and purchasing behaviours.

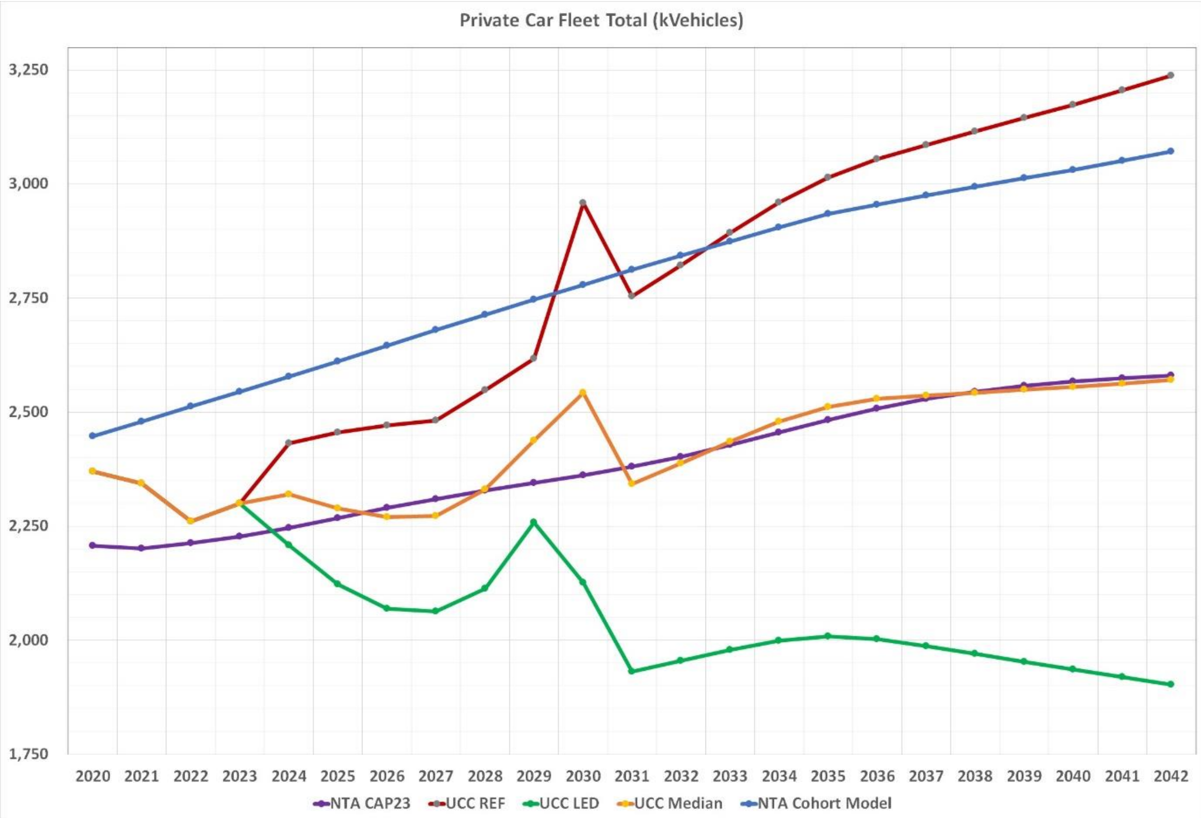

Figure 36: Comparison of the NTA's Ireland Fleet Model for private vehicles (in thousands) and those of the UCC models for their Reference and Low Energy Demand scenarios and the Median

The historical record for private car registration and population data indexed to the 1991 is presented in Figure 37. As noted in the caption the long-run rate of growth for the private car fleet is larger than the growth rate of population.

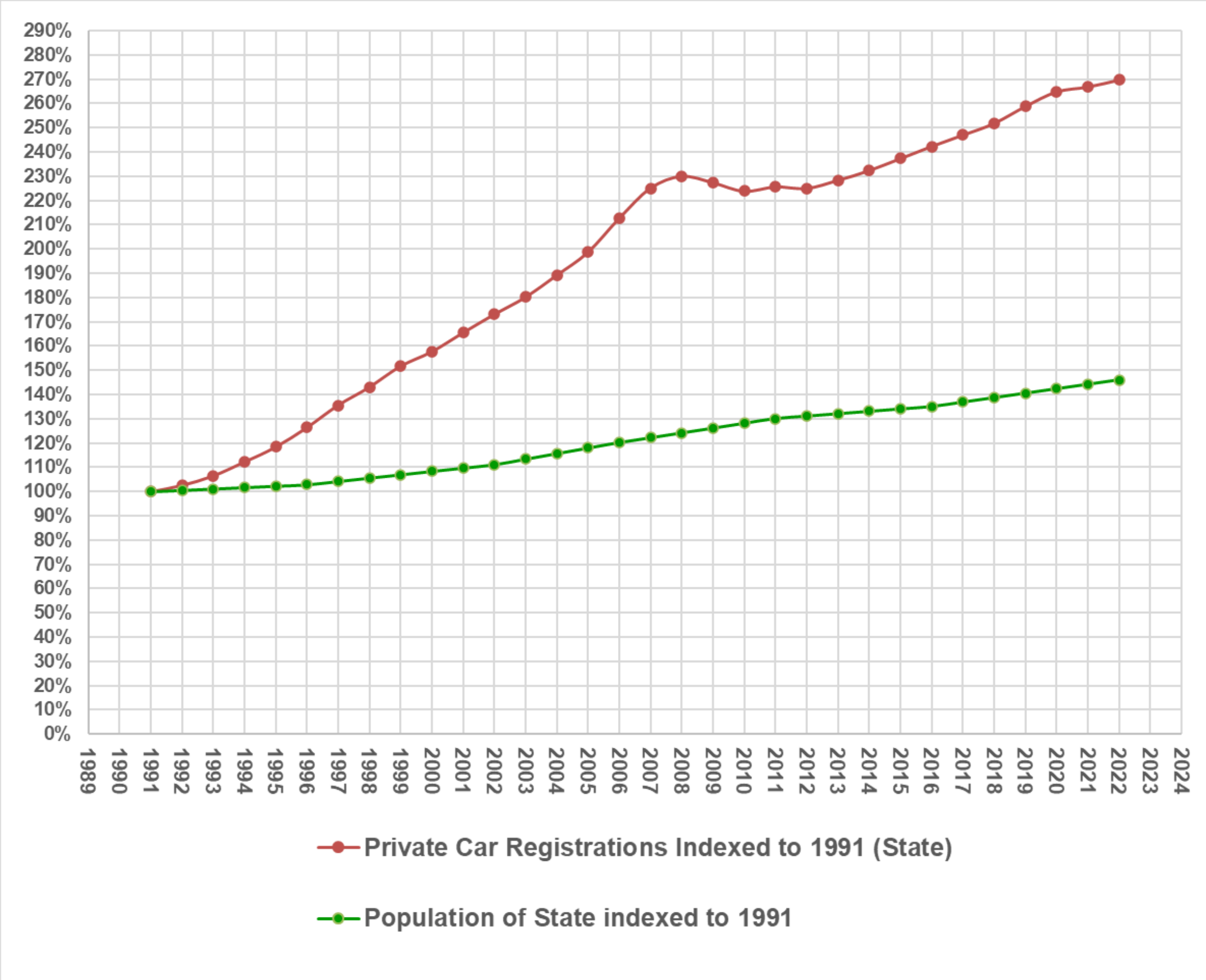

Figure 37: Indexed Private Cars Registered in the Republic of Ireland (red) and population (green).

Recent data for total private car registrations and Class A0 vehicles (zero emission vehicles) are plotted on a logarithmic scale and presented in Figure 38 . The trend of the blue line (ZEV) is approximately straight indicating exponential growth.

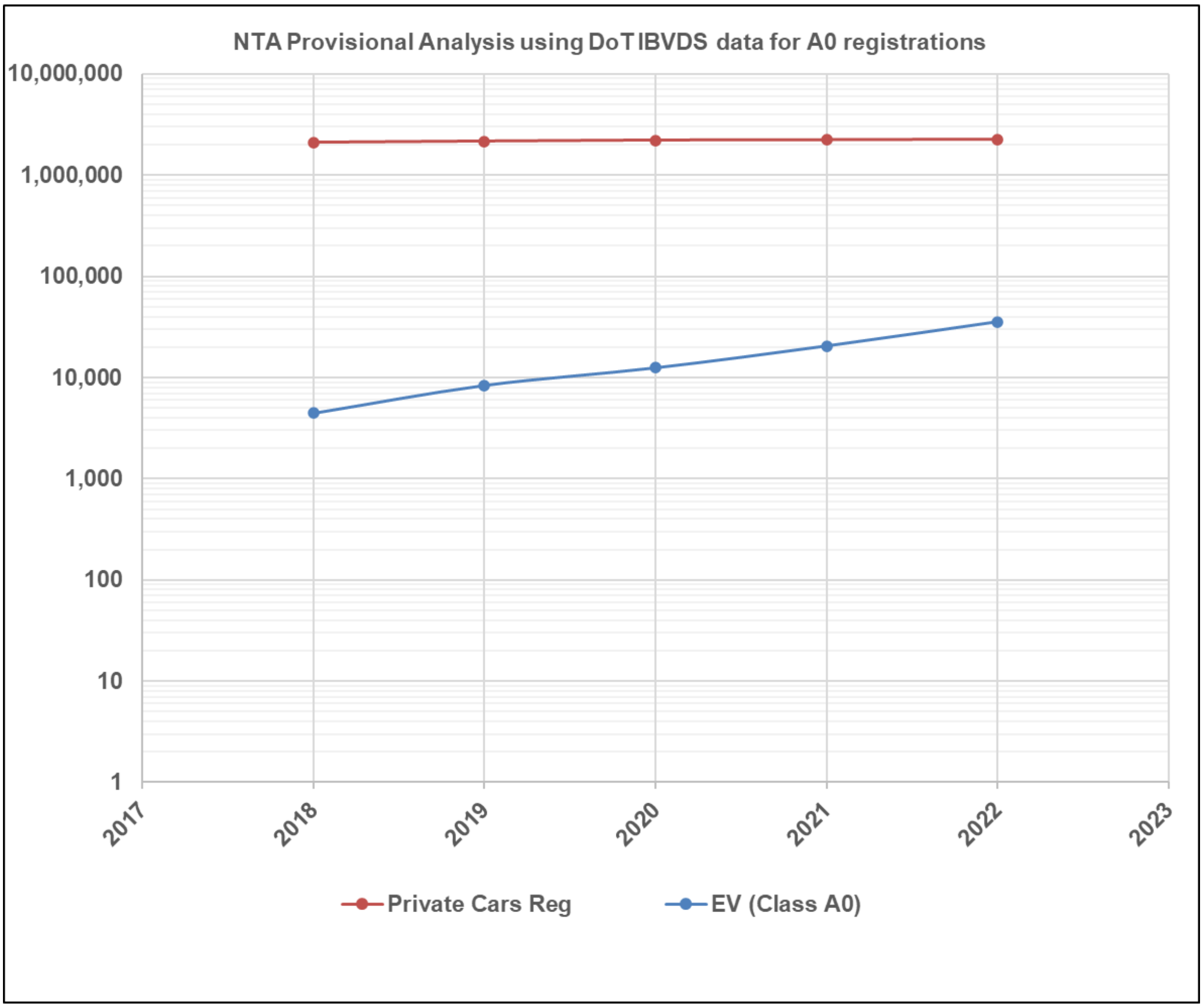

Figure 38: Total Private Cars Registered in the Republic of Ireland (red) and Class A0 vehicles (ZEV) (blue). The data are plotted on a logarithmic scale wherein a straight line trend indicates exponential growth.

Electrification of Private Car Fleet

The output *percentage* breakdown of the private car fleet using the Ireland Car Fleet tool the NTA's CAP23 scenario for 2030 is presented in Figure 39. As mentioned previously, the policy-based target is 30% battery electric vehicles for the NTA model for transport emissions to deliver reductions in CO2e by 51% by 2030 compared with 2018.

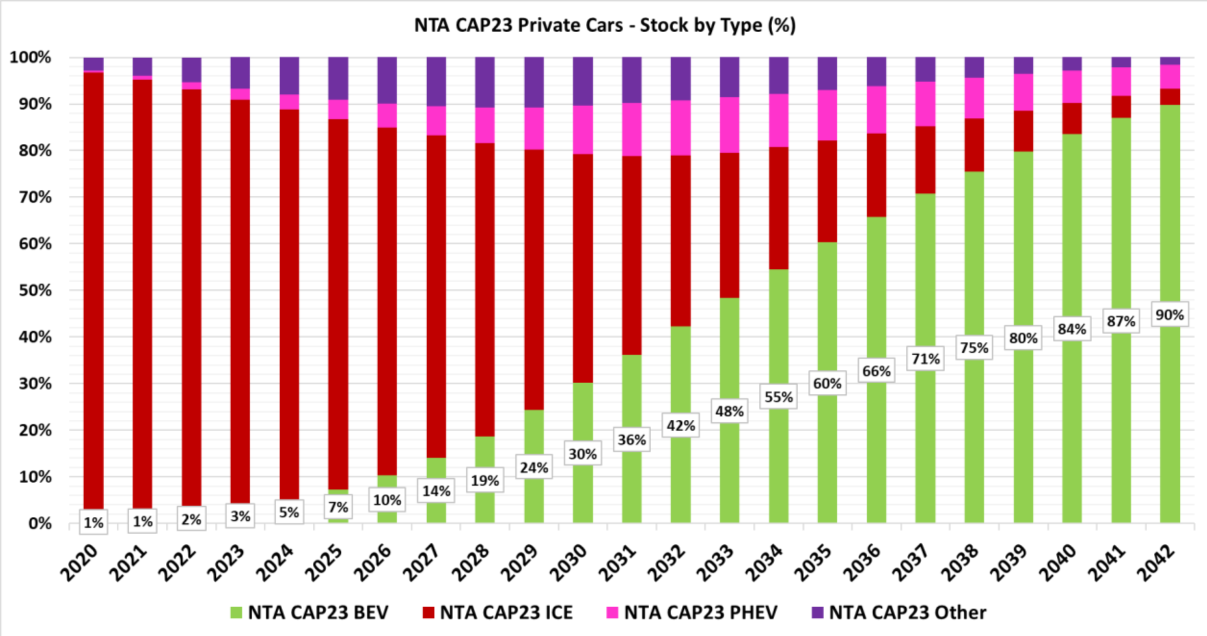

Figure 39: Percentage breakdown of engine fuel mix for the NTA fleet model used for CAP23.

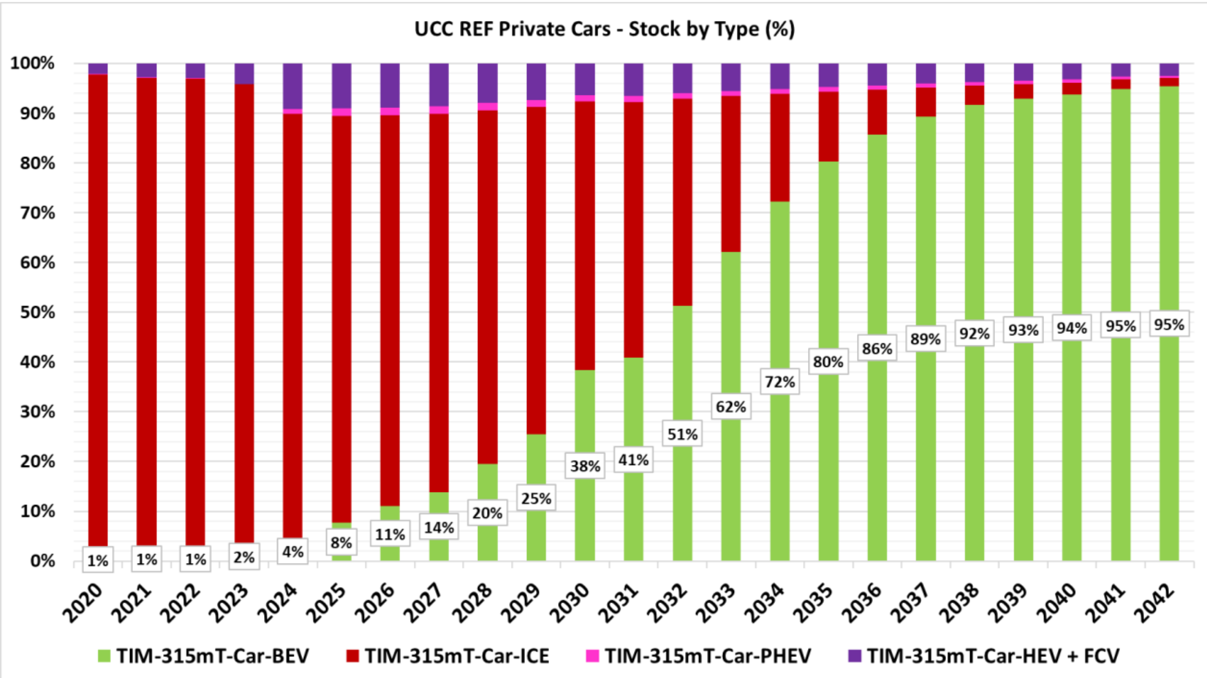

Figure 40: Percentage breakdown of engine fuel mix for the UCC / TIM Reference / BaU model.

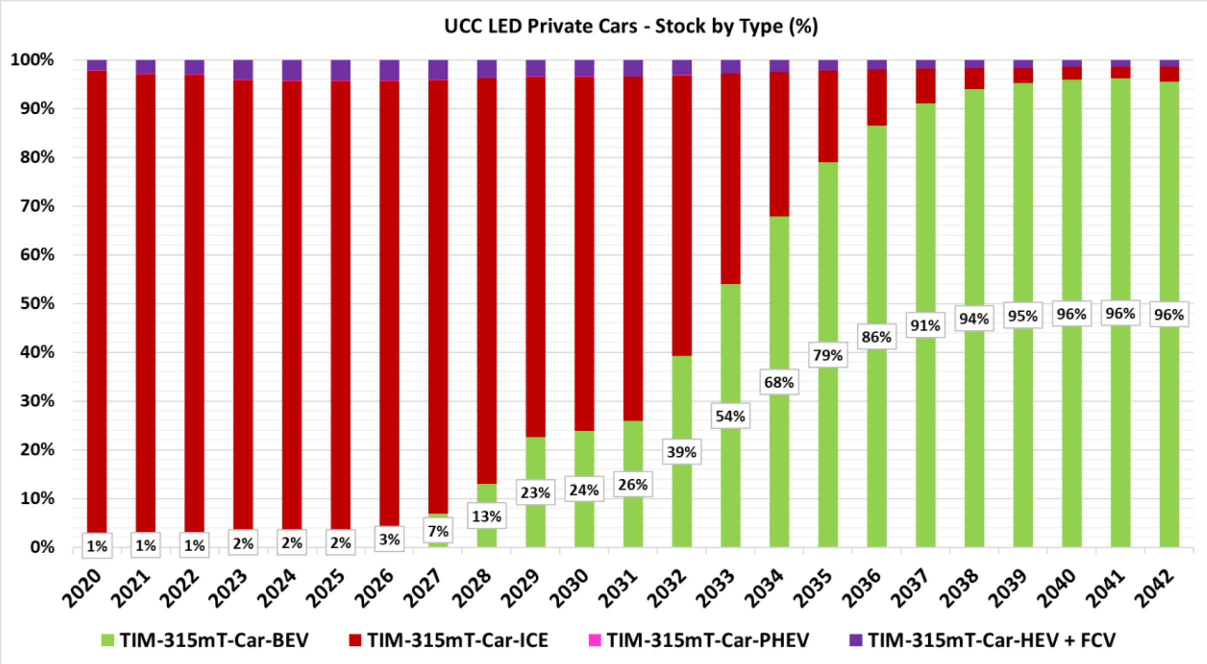

Figure 41: Percentage breakdown of engine fuel mix for the UCC / TIM LED model.

In the UCC / TIM LED scenario for private car stock (national fleet) illustrated above in Figure 41 it should be kept in mind that in this scenario the total number of cars is reducing to 2.126 million whereas in the NTA's CAP23 scenario for 2030 this total is 2.361 million.

Light Goods Vehicle Stock Comparisons

The LGV and HGV stock totals and fleet mixes are preliminary scenarios prepared by the NTA in collaboration with Systra to support the "With Existing Measures" (WEM) and "With Additional Measures" WAM projections work of the SEAI and EPA. These fleet scenarios are described below:

- **SYSTRA2022:** New registrations (new and 2nd-hand imports) fixed at 2022 levels, with **no change** to EU Mandate targets beyond 2022;
- **SYSTRABG0:** SYSTRA's '**B**est **G**uess' with 0% growth, and no change to EU Mandate targets;
- **SYSTRABG3:** SYSTRA's '**B**est **G**uess' with 3% per year growth, and no change to EU Mandate targets;
- **SYSTRAUP :** SYSTRA's '**B**est **G**uess' with 3% per year growth and an extra 5% added to EU Mandate targets for biofuels.
- No new internal combustion engine (ICE) LGV sales post 2035 in all scenarios.

The comparison of these estimates for New LGV fleet (sales) with three UCC scenarios over the period from 2022 to 2050 are presented in Figure 42. The NTA CAP23 model aligns most closely with "UCC Median" which is the simple average of the UCC / TIM Ref and LED scenarios. The 3% "Best Guess" growth scenario aligns with the UCC Reference scenario. The No Growth and Fixed Sales scenarios align with the UCC LED scenario in terms of trend out to 2050. In these NTA scenarios the LGV fleet is estimated to be between 16-20% BEV by 2030 and 89-92% BEV by 2042.

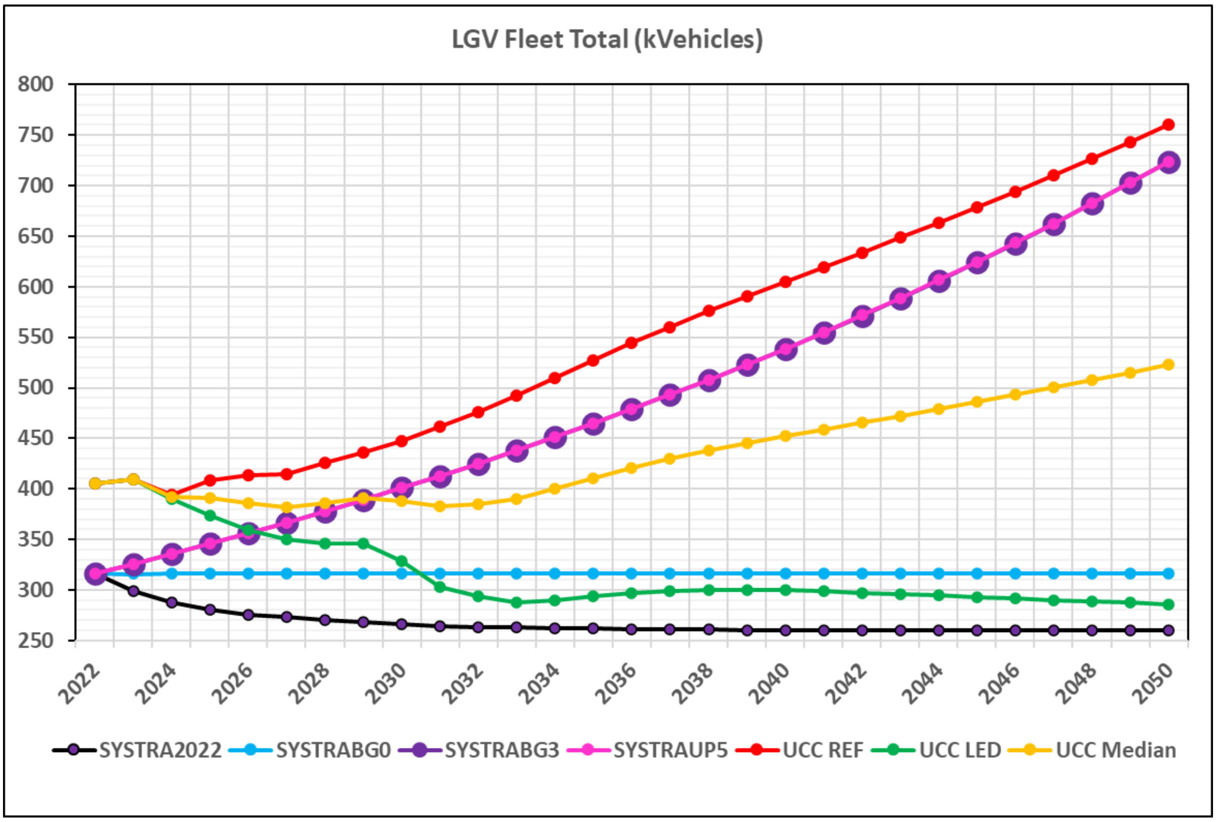

Figure 42: Comparing estimates of future LGV Fleet (1,000s)

A comparison of the estimated new sales of LGV for the NTA/Systra scenarios and the UCC / TIM scenarios is presented in Figure 43. The SYSTRA BG + 3% and SYSTRA UP5 scenarios have the same profile and align approximately with the TIM Reference scenario. The TIM is an overall energy systems optimisation model as a result the new sales profile has large variations from year to year. The NTA (fleet) models are based on observed, historical trends in new vehicle sales, purchases, imports, second hand sales, and have, as a result a more stable profile.

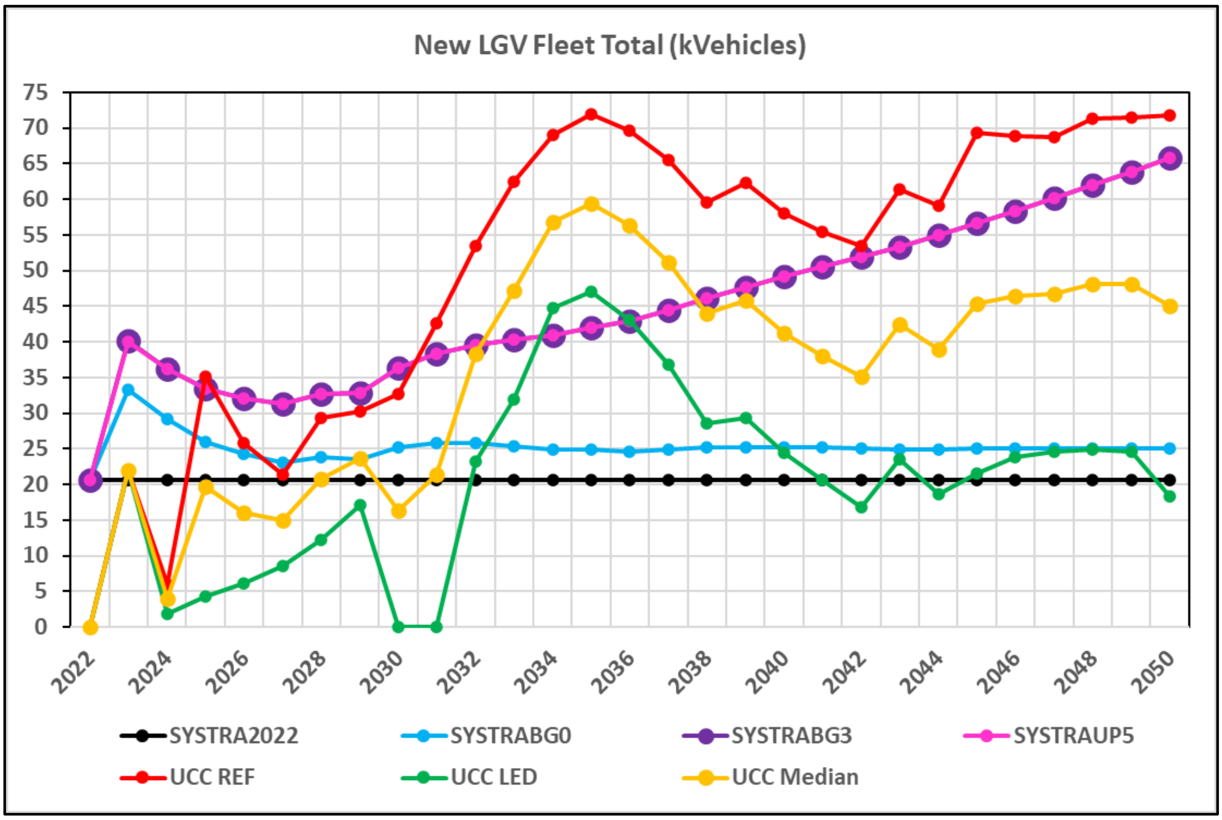

Figure 43: Comparison of the NTA's models for New Light Goods Vehicles (in thousands) and those of the UCC TIM models for their Reference and Low Energy Demand scenarios. "UCC Median" denoted the simple average of the UCC Ref and UCC LED projections. See text for legend.

Heavy Goods Vehicle Stock Comparisons

A comparison of the estimated total Heavy Goods Vehicle fleet between the UCC / TIM scenarios scenario and Systra "Best Guess" scenarios is presented in *Figure 44*. The SYSTRAUP5 scenario aligns most closely with UCC's Reference (Business as Usual) scenario.

The **SYSTRABG3** 3% growth scenario has a similar growth rate to the UCC Reference scenario. The No Growth and Fixed Sales scenario trends fall between the UCC Reference and UCC LED scenarios but with a higher starting point. In these scenarios the HGV fleet is estimated to be between 7-10% ZEV by 2030 and 41-48% ZEV by 2042. Note: the NTA HGV definition is different to that used by UCC making direct comparisons difficult.

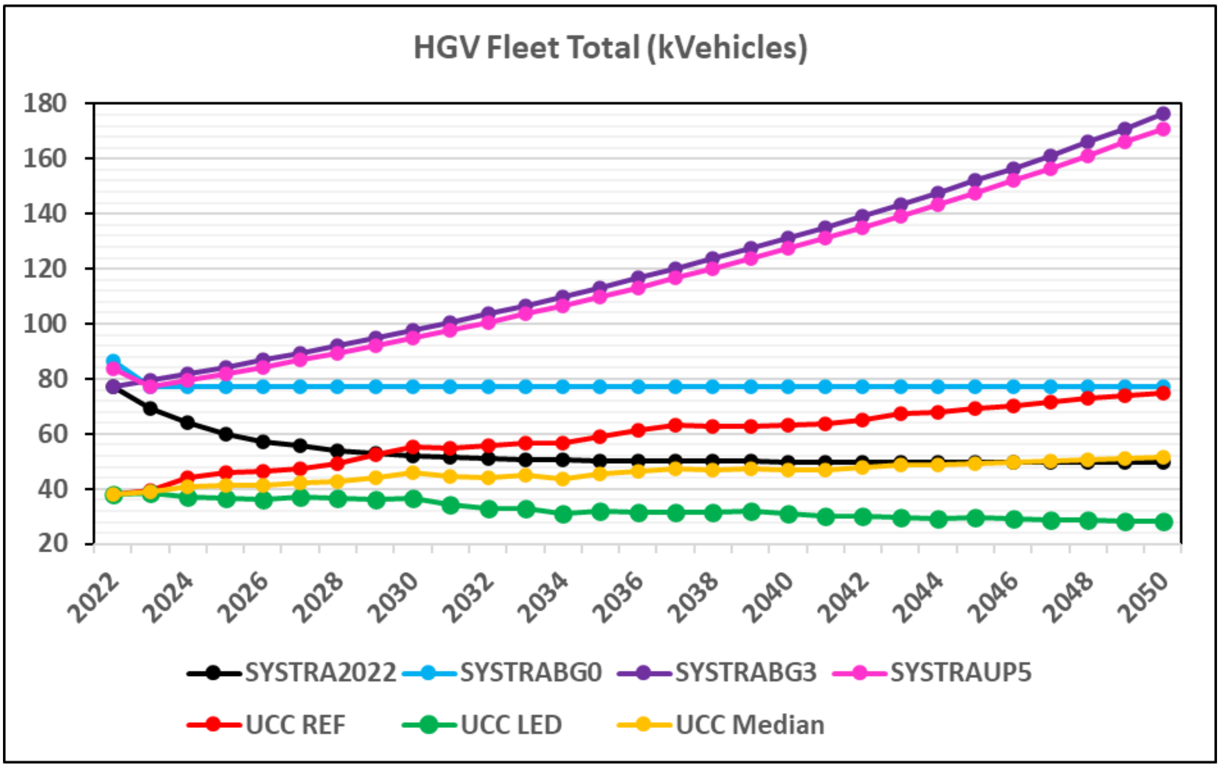

Figure 44: Comparing estimates of future HGV Fleet (1,000s)

Conclusion

In summary, there is good alignment between the estimates of the NTA and UCC. The potential constraints that were identified relate to the projected increase in passenger kilometres in Active Modes and the projected changes in freight tonne kilometres which have not been found to occur in the NTA scenarios. In addition, the NTA Car Stock scenario development process was not able to develop a scenario that projected a fleet decline.

References

1. "TIM: modelling pathways to meet Ireland's long-term energy system challenges with the TIMES-Ireland Model (v1. 0)." Balyk, O., Glynn, J., Aryanpur, V., Gaur, A., McGuire, J., Smith, A., Yue, X. and Daly, H., 2022. *Geoscientific Model Development*, vol. *15*(12), pp.4991-5019.
2. Government of Ireland, Climate Action Plan 2023, https://www.gov.ie/en/publication/7bd8c-climate-action-plan-2023/
3. SEAI (2019): Ireland's Energy Balance 2018, Sustainable Energy Authority of Ireland (SEAI), https://www.seai.ie/publications/2018-National-Energy-Balance-Final.pdf

- NTA's 5 Regional Multi-modal (RMM) Model Development Reports:

  ERM (Dublin): https://www.nationaltransport.ie/wp-content/uploads/2022/09/ERM-Model-Development-Report.pdf

  MWRM (Limerick): https://www.nationaltransport.ie/wp-content/uploads/2022/09/MWRM-Model-Development-Report-1.pdf

  SERM (Waterford): https://www.nationaltransport.ie/wp-content/uploads/2022/09/SERM-Model-Development-Report.pdf

  SWRM (Cork): https://www.nationaltransport.ie/wp-content/uploads/2022/09/SWRM-Model-Development-Report.pdf

  WRM (Galway): https://www.nationaltransport.ie/wp-content/uploads/2022/09/WRM-Model-Development-Report.pdf

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