REGIONAL MODELLING SYSTEM

Greater Dublin Area Model Review Scoping Report

Údarás Náisiúnta Iompair
National Transport Authority

CONTENTS

TABLES

FIGURES

Foreword

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

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

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

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

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

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

1 Introduction

1.1 Background

The National Transport Authority's (NTA) responsibilities include strategic transport planning, integrated public transport network development, walking and cycling promotion, public transport infrastructure provision, effective management of traffic and transport demand and the regulation of public transport services. Transport modelling has a fundamental role to play in helping the NTA deliver on these responsibilities. The Modelling Services Framework was commissioned in 2012 to support the NTA in developing and enhancing its transport modelling capabilities as well as supporting the modelling, testing and appraisal of transport and land use plans.

Under the NTA Modelling Framework, SYSTRA and Jacobs Engineering Ireland along with sub-consultants Minnerva Transport Planning have been tasked with advancing the modelling capability of the NTA in line with its national transport planning remit.

1.2 Purpose of Scoping Report 2

This scoping report describes the current GDA Model and then assesses the model's strengths and weaknesses with respect to the model functionality and feature requirements (derived from NTA roles and responsibilities in RMS Scope 1), followed by suggestions for addressing any weaknesses identified.

This Scoping Report is one of four Scoping Reports which provide the basis for the specification of the development of a Regional Modelling System for Ireland, the other Scoping Reports being:

- RMS Scope 1 Greater Dublin Area Model Review;
- RMS Scope 3 Best Practice Approaches; and
- RMS Scope 4 Modelling Data Review.

The key findings and recommendations from each of the four scoping reports are combined and presented in the overall Regional Modelling System scoping report, RMS Scope 5 Scoping Report.

1.3 Scoping Report Contents

The content of Scoping Report 2 is shown below in Table 1.1.

Table 1.1 Report Contents

Chapter	Description
Chapter 2	GDA Model Overview
Chapter 3	Strengths & Weaknesses Assessment of the GDA Model
Chapter 4	Conclusions

2 GDA Model Overview

2.1 Introduction

This chapter provides a high level overview of the current GDA Model in terms of:

- Development history;
- Model characteristics;
- Model structure;
- Car ownership and car availability;
- Model stages;
- Road & public transport assignment;
- Representation of other travel modes; and
- Uses of the model.

2.2 Development History of GDA Model

The GDA model was first developed in 1991 as part of the Dublin Transportation Initiative (DTI) study. The Dublin Transportation Office (DTO) was established in 1996 and took ownership of the model. The DTO was given the remit of maintaining and regularly updating the model and to make it accessible to DTO agencies and third parties on request. Following its establishment in 1996, the DTO undertook a number of updates, tied in with the census years[1], as follows:

1996 Update of travel patterns based on an Origin and Destination survey:

- The extension of the simulation area to include M50(C-ring);
- HGV and light vehicles assigned simultaneously;
- Inclusion of all Dublin Bus and Irish Rail services; and
- Improvements to the Trip Attraction and Generation Model (TAGM) including special treatment of the airport and ports.

2001 Base Model: The model update was informed by the 1999 DTO Model Update Report by Steer Davies Gleave which led to an expansion of the modelled area to incorporate 432 zones covering the GDA and:

- Inclusion of new Public Transport modelling software which included crowding, fares and transfers;
- Representation of park and ride; and
- An update of the model's travel patterns based on a GDA wide employment and education survey.

2002 Base Model: The 2003 audit of the 2001 base model laid out the requirements for the update of the GDA model based on the 2002 Census. This

[1] With the exception of the 2002 base model as the 2001 Census was deferred by a year due to the foot-and-mouth outbreak

included detailed travel to work data (30% Sample) and data from the DTO's 2002 travel to education survey. Enhancements included:

- Additional detail added to the metropolitan area bringing the number of zones to 666 including Louth;
- A review of all model parameters in 2003;
- Development of a new Trip Attraction & Generation (TAGM) model and a new Trip Distribution Model (TDM);
- Development of a hybrid incremental/absolute choice model;
- Expansion of the AM-period to cover 3 hours from 7AM to 10AM including passive peak spreading based on departure times;
- Highway and public transport assignment of trips for each of the 3 hours within the AM peak, and the use of SATRUN PASSQ to transfer traffic queues from one hour to the next;
- Inclusion of 'active mode' trips; and
- Inclusion of multiple journey purposes each treated separately in the Choice structure.

2006 Base Model: As part of the Census update and following a review of the model, an update of the model was undertaken in preparation for its use during the development of the 2010 GDA Transport Strategy. Key elements of this update included:

- Incorporating the 2006 Census travel to work POWCAR data (100% sample) and data from the GDA travel to education and household travel surveys (both surveys undertaken by the DTO in 2006) into the model;
- Updating the trip attraction, generation and distribution components of the model to include the latest 2006 travel and land use data and the GDA Household Survey;
- A 'productions and attractions'-based approach used within the main demand model;
- Extraction and assignment of AM Peak matrices (for each of the three hours) based on arrival times and the removal of the need to use SATURN PASSQ;
- Develop a new afternoon (1400-1500) off-peak model with a similar structure and functionality to the morning peak model;
- Re-calibrate the model to observed 2006 travel behaviour and conditions;
- Introduction of Employer's Business as a journey purpose; and
- Revision of the demand model parameters.

The 2006 base update of the GDA model was started in early 2008 and completed in late 2009. Following this, the DTO was subsumed into the National Transport Authority (NTA) in December 2009.

2.3 Model Characteristics

Table 2.1 below provides an overview of the main characteristics of the current GDA transport model (2006 base) in terms of its coverage, zoning system, time periods modelled, model base and forecast years, transport networks and the classification of travel demand.

Table 2.1 Model Characteristics

Current GDA Model Characteristics	Description of Characteristic
GDA Model Zoning System:	The GDA Transport Model covers the Greater Dublin Area (GDA) and also includes zoning and transport network coding for Co. Louth. The current model has 657 internal zones (Louth Zones are considered external for TAGM) covering the modelled area and 9 external zones representing travel between the modelled area and the rest of Ireland. In the metropolitan area, the zones are subsets of the District Electoral Divisions (DEDs) used to compile Census data. In the hinterland area, model zones are larger and usually an aggregation of DEDs. In order to represent travel patterns at a more aggregate level the 666 zones can be aggregated to 75 sectors, or to 21 coarse zones. Travel demand can also be analysed by District Centre, of which 87 are defined for the GDA. The modelled area and zoning system is illustrated for the main city area in Figure 2.1. The black lines are zone boundaries and the coloured lines represent the road network.
Time Periods Modelled:	The AM model covers the three-hour period from 07:00 to 10:00; the off-peak model covers the single hour from 14:00 to 15:00.
Base & Forecast Years:	The base year for the current peak and off-peak models is 2006. The primary forecast year is 2030.
Networks Represented:	The model contains coded networks for all mechanised modes of travel – including car, HGV, bus, heavy rail, LUAS and Metro. The highway network has two distinct regions: ▪ The whole of the Dublin County area and selected other locations are coded with full junctions details (the simulation network). Figure 2.1 shows the extent of the simulation network within the current GDA model. ▪ Other areas coded without junction details are known as the buffer network (see Appendix A for a map of the model area). HGV routings are coded as part of the highway network, including compliance with banned turns in places. The bus network contains details of all Dublin Bus, Bus Éireann and private operator bus services operating within, into and out of the GDA. Quality bus corridors (QBCs) and bus priority measures are included as part of the highway network. A bespoke programme currently handles QBCs (by overriding the simulated link speeds using data from QBC monitoring reports) and within the simulation area their impact on junction capacity is coded. The rail network contains all Iarnród Éireann services operating in and out of the GDA (arriving at the cordon within the modelled time periods). All current and planned LUAS and Metro lines and services are coded in the model as part of the rail network.

Journey Purposes:	Travel demand is broken down by six journey purposes: home-based work, home-based education, home-based shopping, home-based other, home-based business, non-home-based. The home-based trips are further split into from-home and to-home trips. The non-home based trips are further split into non-home based employers business and non-home based other.
Car Availability	Travel demand is further segmented by two person types – i.e. those who have a car available for their trip and those who do not. Car availability is based on car ownership that is calculated in a separate car ownership model.

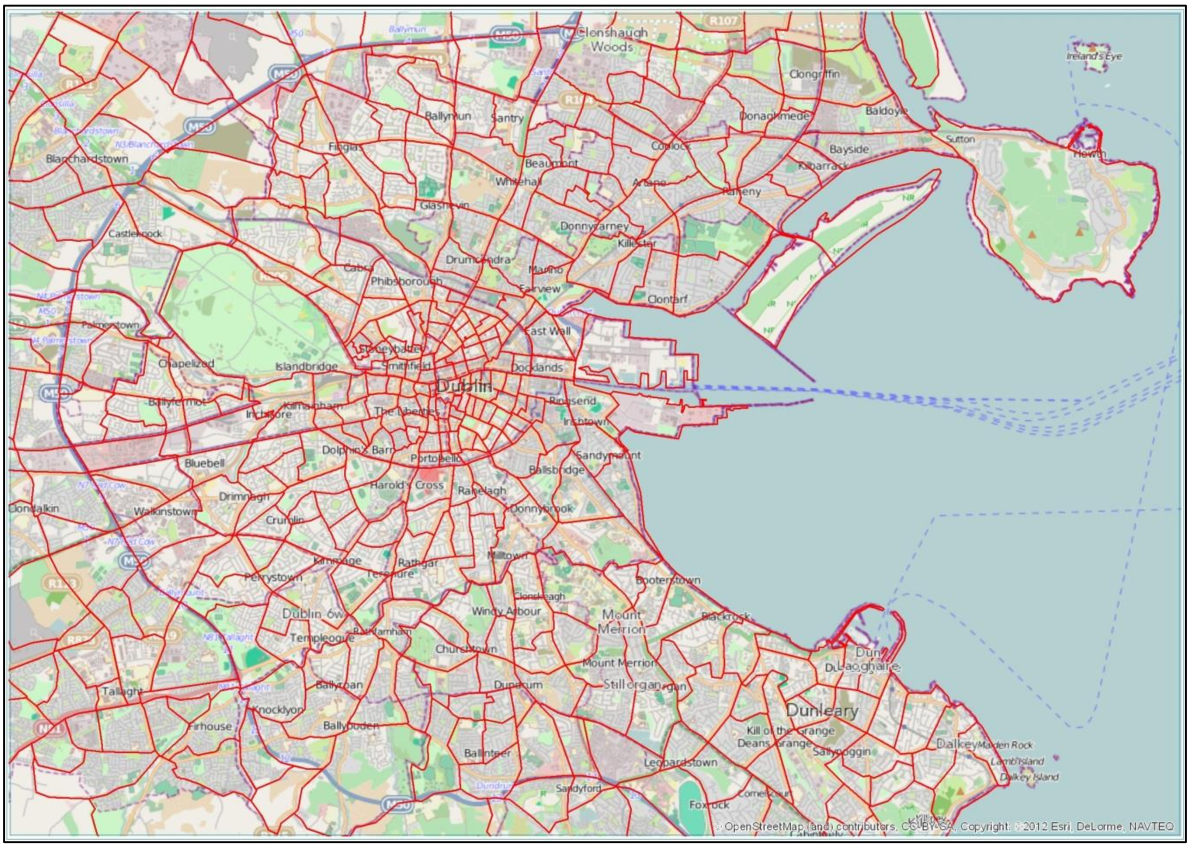

Figure 2.1 Zoning System in City Area

2.4 Structure of GDA Model

The AM and off-peak models have similar structures and components. While the off-peak model follows the classic 4-stage model, the AM model incorporates an additional stage – called hour of travel choice. This stage captures the impacts of peak-spreading whereby people decide to depart at an earlier (or later) time to avoid congestion or crowding during the morning peak. The existing modelling is limited to 'passive' peak spreading in which the peak period is extended to account for the increased time it takes to complete a journey as the result of congestion. General time of day choice, where people decide to travel at different times of the day is not modelled. The structure of the AM-peak model is shown in Figure 2.2 below:

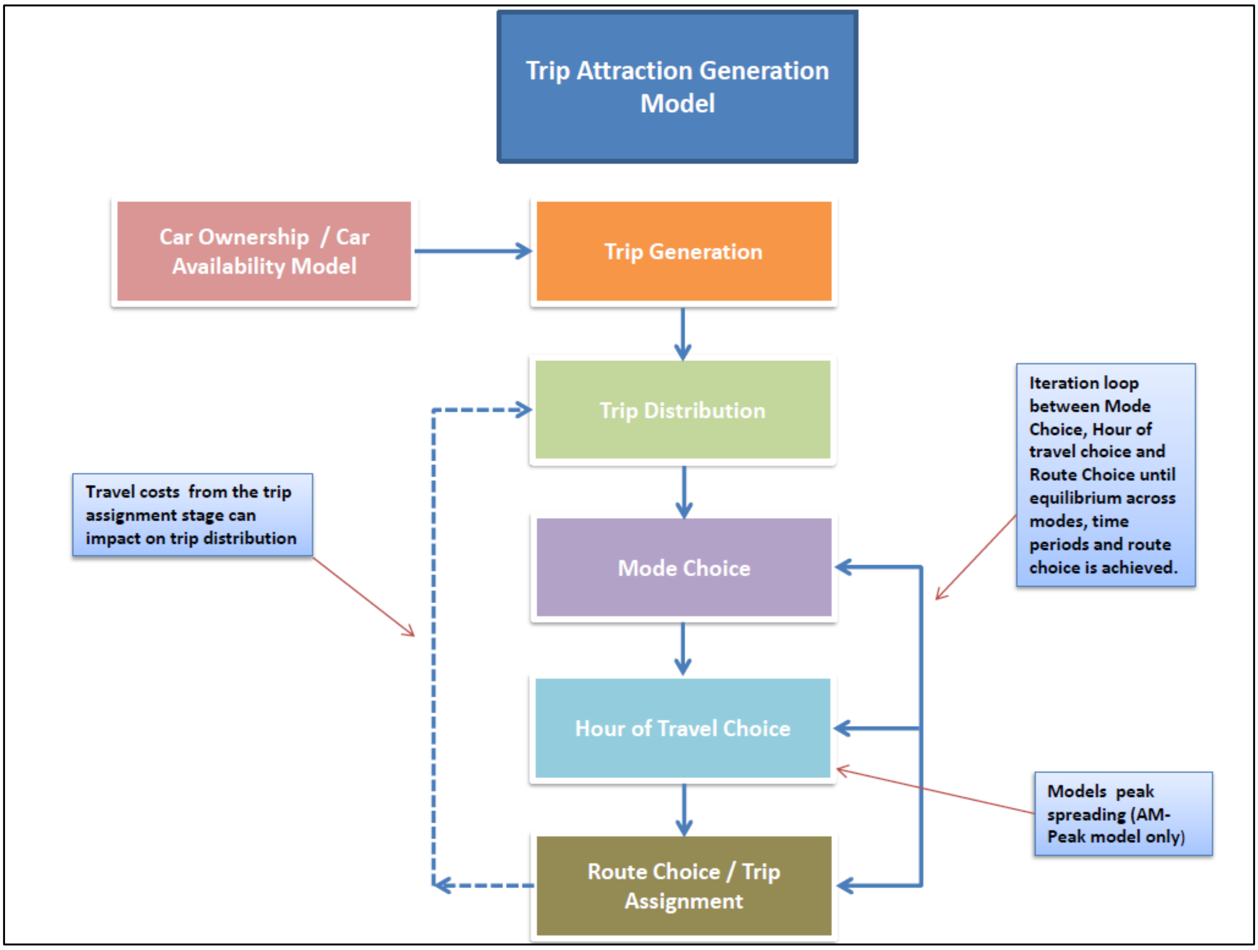

Figure 2.2 GDA Model Structure AM Peak Period[2]

The demand and (network) supply model components are run in an iterative sequence as shown above until equilibrium is achieved across travel modes, route choice and the hour of travel. Optionally, this feedback loop may be extended to include the trip distribution component.

The off-peak model operates in a similar way – but does not include the passive peak spreading functionality. This is because only a single, average off-peak hour is modelled and network congestion and overcrowding during the off-peak hour does not result in trips journey times exceeding an hour.

[2] Taken from NTA report entitled "Transport Modelling Report" which was developed as part of the development of the Draft Transport Strategy 2011-2030.

Implementation

The Trip Attraction & Generation Model (TAGM), Car Ownership/Availability and Trip Distribution components of the NTA's transport model have been implemented in OmniTRANS software. This provides a graphical user-interface, specialist software libraries and facilities for bespoke procedures to be written in the open-source Ruby language.

The highway assignment component is implemented using SATURN software and the public transport assignment uses TRIPS software. Both of these software suites provide their own graphical user interfaces. TRIPS scripting language is also used for implementing the mode and time of day choice elements of the demand modelling.

2.5 Model Stages

Trip Attraction and Generation

The first stage of the model is to estimate the number of trips generated by and attracted to each model zone in any given modelled time period. The main input to the trip attraction and generation model (TAGM) is a planning sheet containing population, employment, education and other demographic and land use data for each modelled zone.

The TAGM relates observed (2006) travel behaviour to the main demographic and land use characteristics of each zone that determine travel demand. The basic assumption underlying the TAGM is that observed all-day trip rates for a given segment of demand (i.e. household car ownership band and journey purpose) remains constant over time, when all trips and all modes of travel are included. Trip rates, derived from observed travel behaviour from the 2006 Household Survey, are pre-calculated and are a second input to the TAGM. Trip rates are calculated for various sub sections of the population as follows:

- Employment Group – split into:
  - Full Time;
  - Part Time;
  - Retired; and
  - Other (Not Working).
- Socio-Economic Group – split into:
  - SEG1 – Employers & Managers, Higher Professional, Lower Professionals, Own Account Workers, Non-Manual;
  - SEG2 – Manual Skilled, Semi-Skilled Manual, Unskilled Manual; and

    - SEG3 – Farmers & Agricultural Workers, all other gainfully occupied and unknown.
- Car Availability[3] – split into:
    - Car Available; and
    - Car Not Available.

Trip rates for a given demand segment are assumed to be constant across the modelled area (e.g. they do not vary in response to the level of public transport provision).

The TAGM applies the 2006 trip rates to zonal population and land use forecasts for any future year to predict the trips to and from each zone in that year. In calculating trip generation levels for each zone, trips are classified by the following (home-based) trip purposes:

- Work (commuting);
- Education [4];
- Shopping;
- Other (social, leisure, personal business etc.); and
- Employer's Business (i.e. business trips in the course of work).

Trip generation levels are also calculated for Non Home Based (or intermediate) trips.

Planning Sheet

In order to apply the observed trip rates to zonal population for any forecast year, the TAGM takes its main input from a forecast year "Planning Sheet". The "Planning Sheet" contains 18 predictive land use variables for each of the 648 internal modelled zones (the 9 external zones are treated separately). These predictive variables are the drivers of travel demand, the most important being:

- Population (broken down by employment status and socio-economic groupings);
- Employment (the number of jobs);
- Education places (split into Primary & Secondary and Tertiary education places); and
- Retail floor space (the number of square metres of retail floor space).

When forecasting, the TAGM applies the (2006) base year trip rates to the forecast year planning sheet with its user-supplied land use data to derive sets of all day trip attraction and trip generation forecasts for each journey purpose. These are broken down into car available and car not available segments.

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[3] Self-reported on a trip by trip basis

[4] Includes/excludes Escort to Education trips

2.6 Car Ownership and Car Availability Sub-Model

The existing TAGM component incorporates separate car ownership and car availability sub-modelling, which splits the outputs of the trip generation stage of the main model into two categories as follows:

- Those with a car available for their trip; and
- Those without a car available for their trip.

The availability of a car is a significant determinant of a person's travel behaviour and in particular has a major impact on the mode of transport they can use. In order to split population into car available and car not available segments in each zone, the TAGM takes input from a Car Ownership / Car Availability model (COM). The purpose of the COM is twofold:

- Track and predict the growth in car ownership over time; and
- Determine the probability that people in a zone will have a car available to them for a particular trip.

In predicting car ownership, the COM employs the standard form of car ownership S-curve. The curve shows vehicle density (expressed as the number of cars owned per 1,000 head of population) plotted against time in years. The S-curve shows three distinct regions as car ownership levels rise over time – very low levels at the start, rapid growth as people's wealth increases, and finally a levelling off of car ownership as the number of cars owned reaches saturation levels.

Analysis of historic car ownership trends in the GDA show that levels of ownership vary significantly depending on:

- Location (people living within the City Centre and large Town Centres have in general much lower levels of car ownership than people living in rural parts of the GDA); and
- Socio Economic Group.

Hence, in order to track and forecast car ownership levels, the COM divides the GDA into 15 different Area Types (based on 5 geographical area bands and three socio economic groupings within each area band).

The five GDA Area Bands are illustrated in Figure 2.3 below.

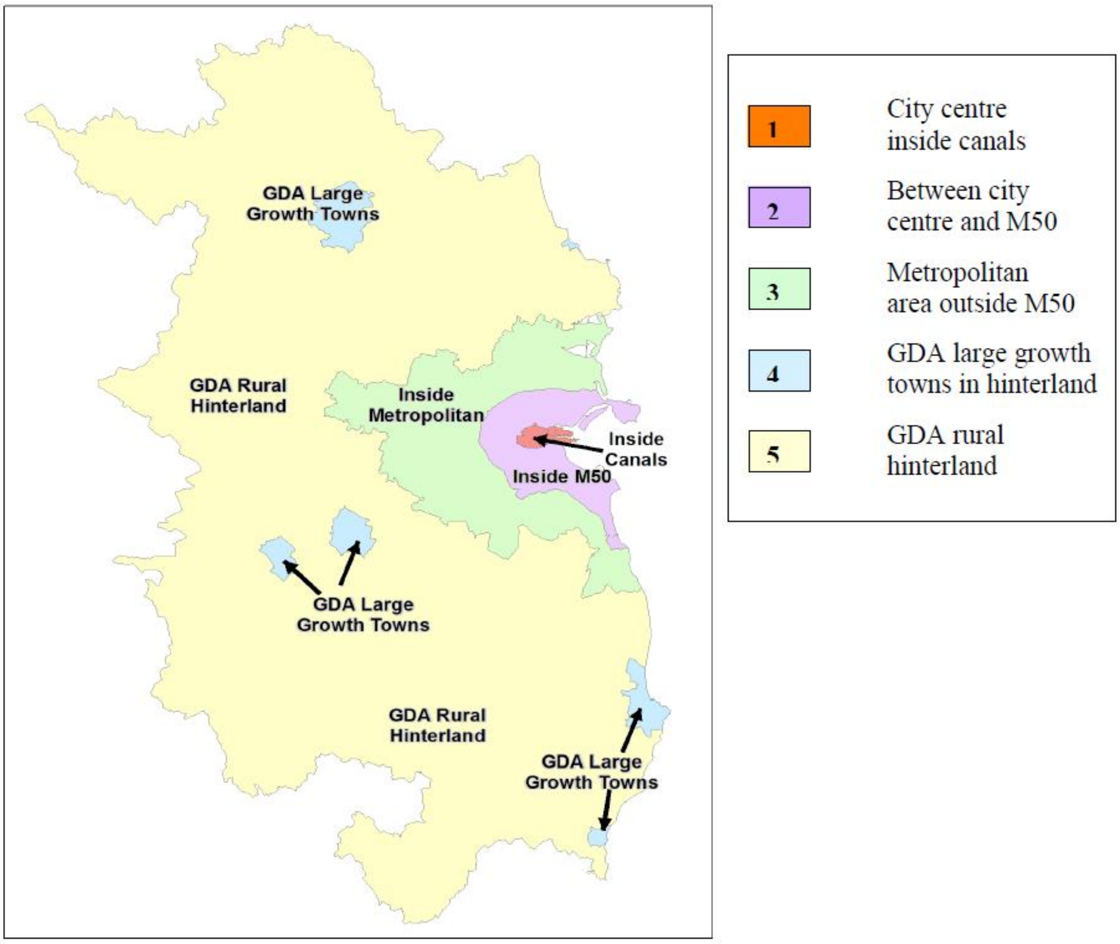

Figure 2.3 Greater Dublin Area Bands

The three socio-economic groupings used in defining Area Types are based on the percentage of Employers, Managers and Higher Professionals (A and B socio economic classes as defined by the CSO) among the working population resident in each modelled zone:

A = High percentage of A and B class – 40% and higher

B = Medium percentage of A and B class – between 10 and 39%

C = Low percentage of A and B class – less than 10%

The combination of the area bands and socio-economic groupings gives 15 different area types that are used to define the Car Ownership Model for the GDA. The COM uses historic car ownership trends (taken from Census data) to calibrate the S-curve for each area type. The result is 15 different car ownership S-curves as shown in Figure 2.4.

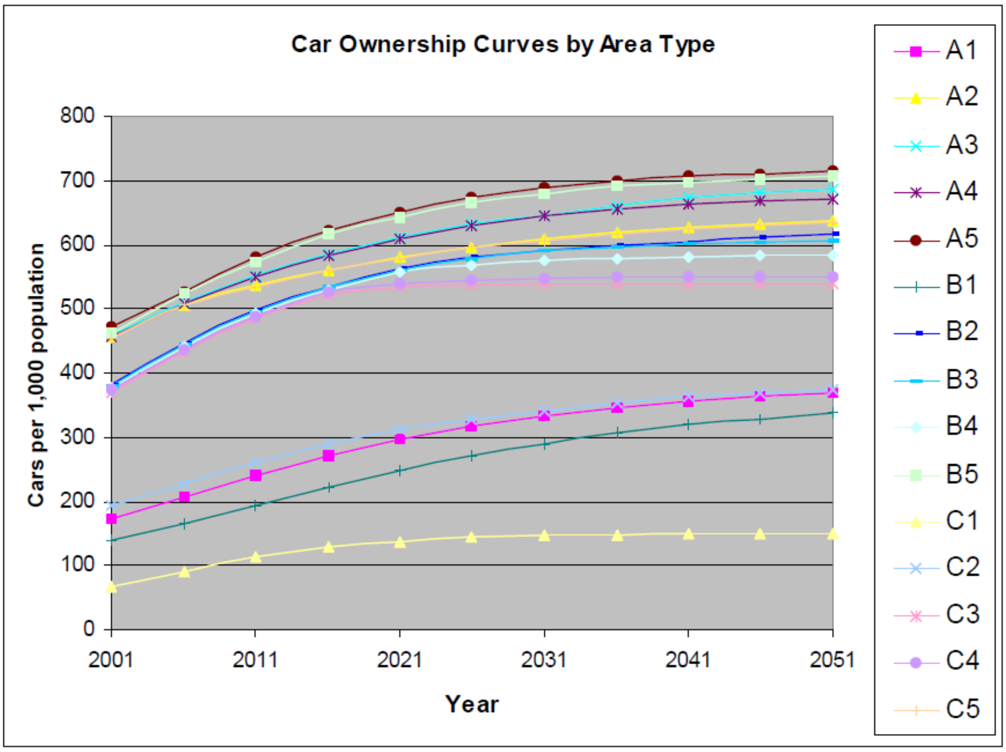

Figure 2.4 Car Ownership Curves

Car Availability

Car ownership data for the GDA is readily available from the CSO Census data over a number of years. However, the essential input required for the TAGM is not car ownership itself, but rather car availability. In transport modelling terms, car availability is defined as the probability that a person will have a car available to them for a particular trip and is strongly dependent on levels of car ownership. The GDA household survey in 2006 gives data on car availability for different journey purposes for a typical day's travel and this data enabled relationships to be developed between zonal car ownership and car availability for each of the different area types. Figure 2.5 illustrates this relationship.

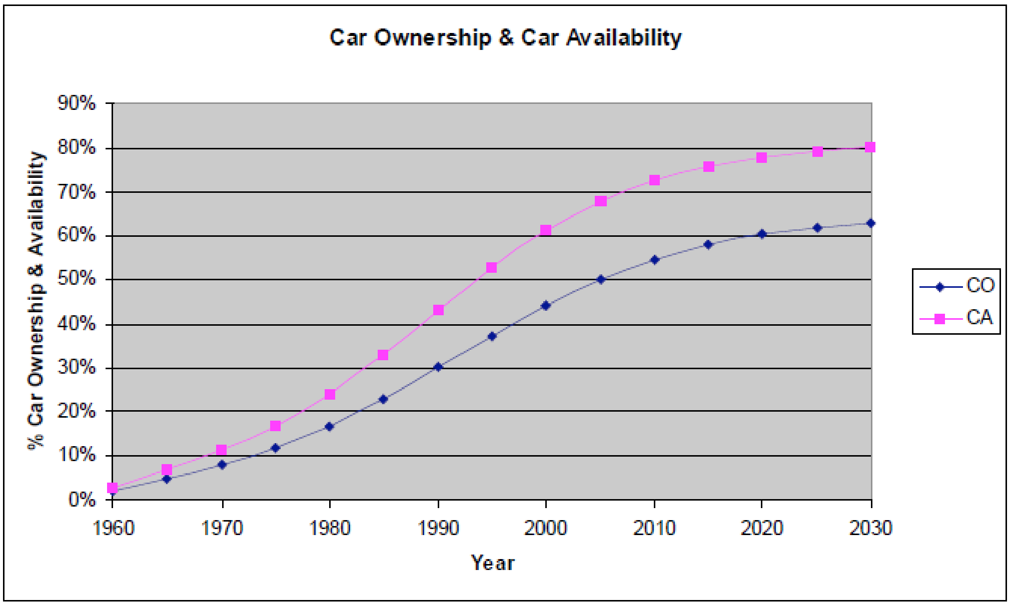

Figure 2.5 Car Ownership and Car Availability

The graph in Figure 2.5 shows that the level of car availability exceeds the level of car ownership – reflecting the fact that average car occupancy is greater than 1 - that is - some people who do not own a car may still have a car available to them as a car passenger when they need to make a particular trip. The COM derives a car ownership versus car availability relationship for all day trips made for each of the six journey purposes. This enables the COM to output percentage car availability rates for each of the six journey purposes for different times of the day.

The output from the COM in turn enables the TAGM to split trip generation rates into two further segments of the zonal population:

- Those with a car available for their trip; and
- Those without a car available for their trip.

In addition to calculating trip generations for different segments of the population, the TAGM also derives zonal trip attractions based on the main zonal land use variables (i.e. jobs, education places and retail floor space). Trip attraction levels are not assumed to be correct in absolute terms – but are rather taken to represent the relative attractiveness of one zone to another in attracting trips for a given journey purpose for work and education.

Trip Distribution

The purpose of the Trip Distribution Model (TDM) is to determine the pattern of trips between origin and destination zones matching the zone trip generations and zone trip attractions (trip ends) produced by the TAGM. Given that the GDA transport model has 666 zones, the output of the TDM (for each pair of Generations and Attractions) is in the form of a matrix of trip patterns of dimension 666 x 666.

Base Year Trip Matrices and Incremental/Absolute Distribution Modelling

While the TAGM and TDM models both produce absolute forecasts for future year conditions, for the most part they are applied in an incremental fashion to base year trip matrices. The quality of the forecasts is therefore strongly affected by the quality of the base year trip matrices.

For work and education trip purposes these base matrices were largely taken directly from the (high sample) GDA education and POWCAR travel to work surveys. The base matrices for other trip purposes were synthesised from the 2006 GDA household travel survey data. These base matrices were subject to further amendment following comparison with traffic count data. The extent of changes arising from these comparisons depends on the trip purpose and time of day for the matrix in question, with least change made for AM work and education trips where observed data was most robust.

The application of incremental (the default) or absolute modelling depends on the extent of changes in land use data between the base and the forecast years. The TDM uses a series of tests / controls to define when changes are sufficiently great to make the base year an inappropriate basis for forecasting the distribution of trips for the future year.

Hence, the two approaches to producing the forecast year trip matrices are as follows:

Factoring: Where well established trip patterns exist in the base year, e.g. Home to Work, this pattern is retained and simply factored up to the new forecast year trip generations and attractions (incremental).

Sectoring: The GDA Transport Model has the facility to aggregate trip patterns using a 75 strategic zone system (called sectors). In the case of a green field site development in a zone or where there is insufficient data in the base year to determine the pattern of trips, the base year trip pattern of the 75 zone sector containing the green field zone is used to give the equivalent forecast year trip pattern (absolute).

In addition to using Factoring and Sectoring, the TDM can also (optionally) use the travel costs that are output during the trip assignment stage of the model to influence travel patterns in the forecast year. If this option is chosen, the TDM uses gravity modelling to determine travel patterns for green field zones that have development in the forecast year, or for zones where there is a major change in population or travel costs between the base and forecast years.

It should be noted that in the version of the model used in developing the GDA transport strategy, the TDM only used a combination of Factoring and Sectoring to produce forecast year trip matrices.

The outputs from the TDM are in the form of trip matrices (666 x 666) for each of the six journey purposes divided into car-available and car-not-available persons (i.e. twelve trip matrices). These trip matrices are the essential inputs into the next three stages of the model described in the next section.

The Mode Choice, Hour of Travel Choice and Route Choice feedback loop

The final three stages of the model – mode choice, hour-of-travel choice and route choice – are interlinked. They are run iteratively as a group in a feedback loop until equilibrium is achieved. The structure of this loop is shown diagrammatically in Figure 2.6 below. The mode choice and hour of travel choice stages are replicated for each of the seven journey purposes, while at the final route choice stage, trips by all journey purposes are amalgamated. The hour of travel choice stage is only executed in the case of the AM-peak model for the three hour period 7 to 10. The current GDA model does include a destination choice mechanism but it is not currently used within the modelling process.

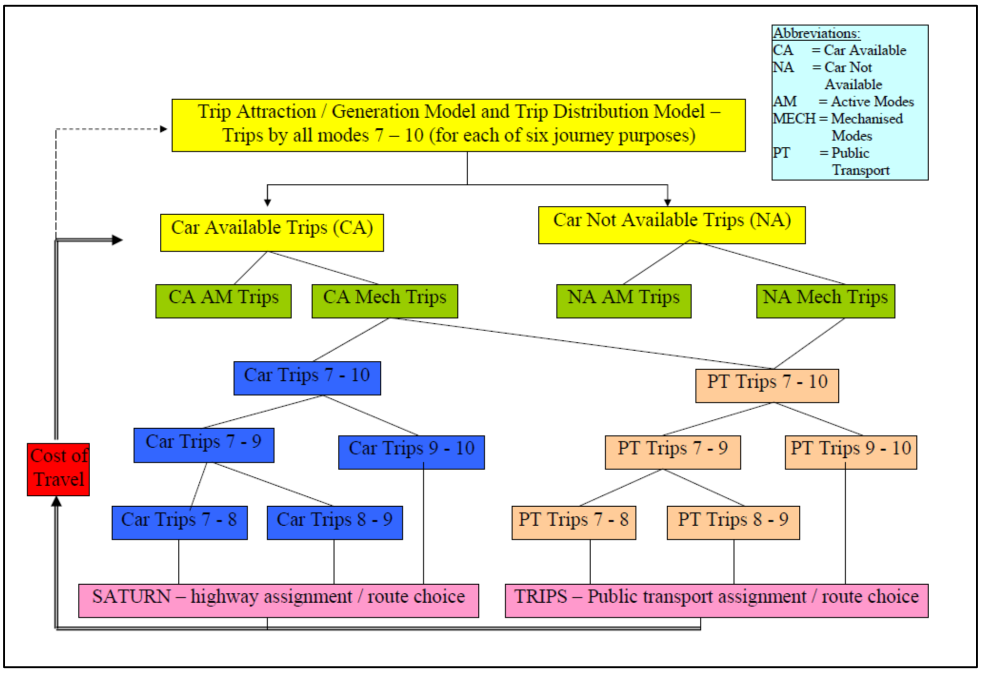

Figure 2.6 Current GDA Demand Model Structure

The feedback loop shown in Figure 2.6 begins with the mode choice stage whose function is to split trips into the different modes of travel - i.e. Car, Public Transport and Active Modes (walk & cycle). Following this, the hour-of-travel choice stage further splits trips into the three modelled hours. In the final stage of the feedback loop, car and public transport (PT) trips are assigned to their respective transport networks between their origin and destination. At this route choice stage, the costs of travel by car and public transport are calculated and then fed back up to the mode choice stage of the model to begin the loop again.

It should be noted that trips by active modes (walking and cycling) do not take part in the route choice stage of the model, and their cost of travel is assumed to be a simple combination of travel distance and time.

The feedback loop between mode choice, hour of travel choice and route choice continues until a defined level of equilibrium is achieved. The criteria for this level of equilibrium are based on the change between successive loops. This equilibrium is based on the premise that all trip makers wish to minimise their cost of travel through the most cost efficient choice of mode, hour of travel and route.

Mode Choice

The purpose of the mode choice stage of the model is to divide the trip matrices as output by the TDM into the different modes of travel. The mode choice stage is replicated for each of the six journey purposes. The structure of the mode choice model for car available trips is shown in Figure 2.7 below. The model is hierarchical - with the top level choice between travel by active modes (walk and cycle) and mechanised modes (car and public transport). This is followed by the split of mechanised mode trips into trips by car and trips by public transport – this lower level split is only carried out in the case of car available trips. Car not available trips have a single level split between trips by active modes and trips by public transport.

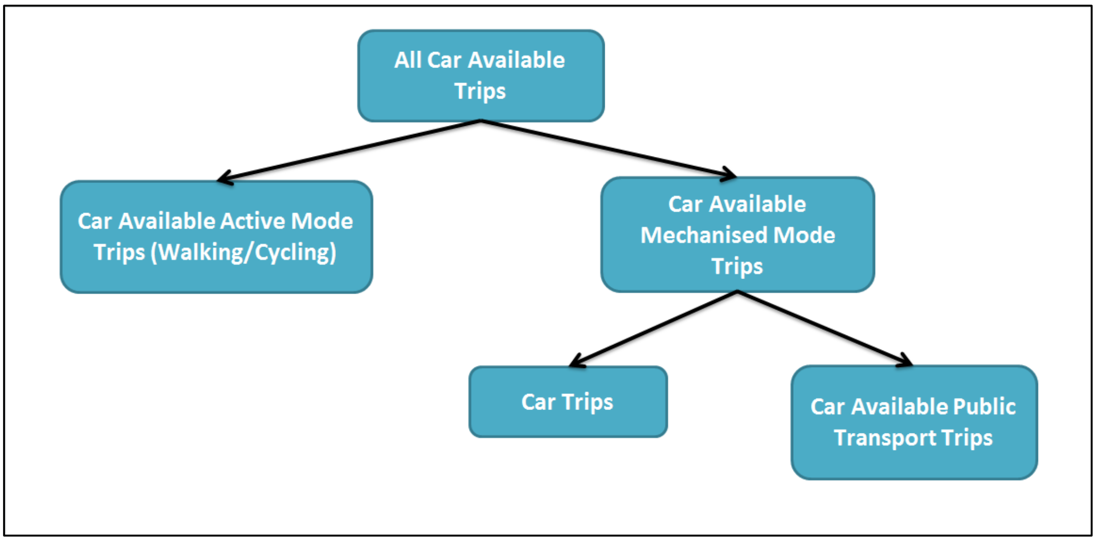

Figure 2.7 Hierarchical Mode Choice for Car Available Trips

General form of mode choice model

Each level of the mode choice model represents a choice between two competing modes of travel (say mode 1 and mode 2) for trips between any origin and destination. The purpose of the model is to predict the percentage of trips that will opt to use each mode, given the costs of travel by each. To do this, the model uses a ‘logit’ formulation of the form:

$$\mathbf{P1 = 1/(1+EXP(-\lambda\Delta C))}$$

Where: **P1** = the percentage of trips that will travel by mode 1,

Δ**C** = the difference in cost of travel by mode 2 and mode 1 = **C2 –C1**,

λ = a measure of people's sensitivity to changes in travel costs, usually calculated from observed data on mode choice.

Given that the choice is between two modes, once the percentage travelling by the first mode is calculated, the percentage travelling by the competing mode (mode 2) will be:

$$P2 = 1 - P1$$

As with the TDM, two forms of mode choice are often used:

- Absolute mode choice – this is as per the formula given above and is used where no robust observed mode choice patterns exist for the competing modes in the model base year;
- incremental mode choice – this uses a variation on the logit formula that predicts the changes in proportions travelling by each mode based on the incremental changes in costs of travel by the competing modes between the base and forecast years. This form is used where good data on observed mode choice patterns is available for the base year.

The mode choice mechanism in the GDA transport model uses a combination of absolute and incremental mode choice. In all cases, where the observed base year data is sufficient to give a rational choice between competing modes, the incremental form of the model is used. The absolute form of the model is used where the observed base year patterns are not reliable e.g.

- There is greenfield site development in the forecast year;
- A new mode of travel (say new Metro or LUAS line) is introduced and affects the number / choice of modes available for a particular trip;
- There is a major change in travel costs between the base and forecast year (this may also occur if a new mode of travel is introduced);
- The percentage of people travelling by one of the competing modes is zero in the base year (it is not possible for the incremental form of the mode choice formula to alter a zero percentage mode share in the base year to a positive percentage share in the forecast year).

Hour of Travel Choice (Passive Peak Spreading)

The AM-peak model includes an additional stage to the traditional 4-stage transport model. This stage, known as 'hour of travel choice', is executed following the mode choice stage and captures passive peak spreading as a response to congestion. This stage is not included in the off-peak model, where peak spreading is not considered to be an issue. Following the mode choice stage, the purpose of the 'hour of travel choice' model is to split trips by mode for the full AM Peak (7 to 10) down further by hour of travel – i.e. 7 to 8, 8 to 9 or 9 to 10. It should be noted that trips by Active Modes (Walk & Cycle) do not participate in this stage of the model – i.e. the notion of peak spreading for these modes is not considered an issue. It should also be noted that 'hour of travel choice' is only applied to trips to Work (i.e. commuter trips). In the case of all other journey purposes, the base year proportion of trips travelling in each of the three AM-peak hours is assumed to remain constant in the forecast year.

As for the mode choice model, the time-of-day choice model has a hierarchical structure. The top level split of trips represents the choice of travelling between 9 and 10 and travelling between 7 and 9. The lower level then splits the 7 to 9 trips further into those travelling between 7 and 8 and those travelling between 8 and 9. This hierarchical split is undertaken for both trips by Car and trips by Public Transport.

The hour of travel choice stage is executed using the same type of logit formulation as the mode choice model. In addition, as elsewhere, a combination of absolute and incremental form of logit choice is used. At the end of the hour of travel choice model, the AM-peak model has six trip matrices for each journey purpose – i.e. a trip matrix for each of the three modelled hours divided into trips by Car and trips by Public Transport. In the case of the off-peak model in which there is no hour of travel choice stage, there are just two trip matrices – one for Car and one for Public Transport. These trip matrices are then assigned to the respective transport networks (highway and public transport) in the route choice stage of the model. This is the final stage of the model, and is described below.

2.7 Road & Public Transport Assignment

The final stage of the current GDA modelling process is the 'trip assignment' or 'route choice' stage. In this stage, the trip matrices that have been broken down by mode and hour of travel are assigned to the respective transport networks. In the case of the AM-peak model, separate assignments of trips for each of the three modelled hours are undertaken for both Car and Public Transport trips (i.e. six assignments in total). These assignments are undertaken in sequence, starting with trips for the hour 7 to 8 and finishing with the hour 9 to 10. In the case of the off-peak model, Car and Public transport trips are assigned for a single modelled hour 2 to 3.

2.8 Highway Assignment

In the case of highway assignment, the goal of the process is to select a route or routes on the highway network for trips from each origin to each destination that will minimise the trip makers' cost of travel. For car trips, the cost of travel is a combination of travel time, travel distance and fixed costs (such as road tolls, parking charges etc.)

$$C_{car} = \alpha.t + \beta.d + P$$

Where,

C_{car} = Cost of travel by car on a given road link

t = Travel time on the link

d = Travel distance on the link

P = Fixed penalties / costs (road tolls, parking charges etc.)

α = Weightings to be applied to travel time

β = Weighting on travel distance – i.e. car running costs per km (fuel, maintenance, tax & insurance, etc.)

Within the transport model, travel costs are represented in time units (minutes or seconds). Hence, monetary costs (e.g. running costs, tolls or parking charges) must be converted to units of time by dividing by the value of time.

The highway assignment proceeds in an iterative fashion with the goal of minimising travel costs for all trips on the highway network. The SATURN modelling is split into two components of 'simulation' modelling in which junction delays are calculated explicitly, and 'buffer area' (outside Dublin County) in which only flow-delay curves that relate travel costs to link characteristics and the volume of traffic on each link are used to calculate travel times.

2.9 Public Transport Assignment

The assignment of public transport trips is undertaken using the TRIPS software. Link travel times are passed from the highway assignment and used in the calculation of bus travel costs. In undertaking public transport route choice, a logit choice formulation is used to calculate the proportion of trips that will choose competing routes based on their relative cost of travel. As trips are assigned to a combined bus and rail network, trip makers can interchange freely between bus, and the different rail modes (Heavy Rail, DART and LUAS). The generalised cost of travel by public transport has a number of components that can be represented as follows:

$$C_{PT} = a1.twk + a2.twt + a3.tiv + a4.tic + a5.F + a6$$

Where,

C_{PT} = the generalised cost of travel by public transport

t_{wk} = walking time to access public transport node (i.e. bus or rail station)

t_{wt} = waiting time at public transport node (= half the PT service headway)

t_{iv} = in vehicle time

t_{ic} = interchange penalty

F = fare charged

a_1 ….. a_5 = weightings to be applied to the different elements of PT travel costs

a_6 = mode constant penalty that reflects the perceived disutility of using public transport relative to car (i.e. in terms of comfort, convenience, personal space etc.) As all public transport costs are represented in time units (i.e. minutes), the weighting **a_5** in the above formula is the inverse of the value of time and is used to convert the public transport fare in euros into minutes. All other weightings are determined during the model calibration process.

Following the assignment stage, the assigned travel costs are passed back to the mode choice stage of the model and the mode choice, hour of travel choice, route choice loop begins again. Iterations of this loop continue until an acceptable equilibrium of trips and travel costs is achieved, at which stage the model run is terminated.

2.10 Heavy Goods Vehicles

Within the GDA transport model, heavy goods vehicles (HGVs) are defined as any commercial goods vehicle with more than four wheels. It should be noted that taxis, vans and other light goods vehicles are all treated as cars within the model.

Trip matrices of heavy goods vehicles are calibrated as part of the calibration of the highway model. The TAGM & TDM applies a global growth factor (based on forecasts of economic growth) to the base year calibrated HGV matrices to produce forecast year equivalents. These trip matrices are then assigned to the highway network as a separate user class and simultaneously with the assignment of car trips.

The highway network for HGVs incorporates HGV bans and restrictions - i.e. parts of the network where HGV movements are not allowed. Following the introduction of the city centre ban on HGV movements after the opening of the Dublin Port Tunnel, some HGVs retain a permit to make deliveries to city centre locations, and hence movement of these vehicles with permits are allowed within the model.

2.11 Park & Ride

The GDA transport model includes the modelling of park and ride trips at specified park and ride sites. Within the model, each park and ride trip is split into two parts:

- Part 1 is a car trip from the trip origin to the park and ride site, and this part of the trip is assigned to the highway network; and
- Part 2 is a public transport trip from the park and ride site to the trip destination using a dedicated PT service, and this part of the trip is assigned to the PT network.

In order to limit trips to the car parking capacity of the park and ride site, a parking charge is added to the generalised cost of travel of part 1 of each park and ride trip.

This parking charge is iteratively adjusted (i.e. through successive runs of the model using different values of the charge) until the number of car trips to the park and ride site is within the capacity of the car parking spaces at this site.

2.12 Uses of the GDA Model

Within the GDA model, key trip making attributes and traveller choices are modelled, such as:

- which route would be taken for a given journey;
- mode for a given journey (or multiple modes, e.g. car/bus, bus/train);
- the **time of day** that the journey is undertaken; and
- **trip costs** e.g. fares, travel time, car operating costs, fuel costs.

The GDA Model, therefore, has many uses including:

Transport Strategy & Policy Formulation

The most important use of the GDA Model is in providing analysis and appraisal support for transport strategy development.

Scheme Assessment & Appraisal

The GDA Model is commonly used for the assessment of schemes that impact on any of the mechanised modes of travel, including public transport modes such as rail, bus and light rail and private modes such as cars and HGV.

Public Transport Planning

The GDA Model may be used to plan public transport schemes, for example in determining the appropriate public transport sub-mode type, during route selection stages or detailed business case development.

Traffic Management Strategies

The GDA Model is commonly used for strategic traffic management assessment as the SATURN highway component of the model is ideally suited for this form of assessment.

Land Use Development Assessment

The GDA Model may also be used to test the impact of large developments.

Demand Management Assessment

The GDA Model can also be used to evaluate the impact of demand management measures, such as:

- Traffic tolling;
- Cordon charge;
- Area charge;

- Road user charge (based on travel distance);
- Parking restrictions; and
- Destination charge.

3 Strengths & Weaknesses Assessment of the GDA Model

3.1 Introduction

The previous chapter presented an overview of the GDA model and its uses. This chapter presents a ‘strengths and weaknesses’ assessment of the current GDA Model relative to the 34 model functionality and features (identified in RMS Scope 1) required to support the NTA in delivering its remit. Suggested improvements to the GDA model are also presented. Table 3.1, below, provides the full model functionality and features list.

Table 3.1 Model Functionality and Features

Order No.	Model Functionality & Feature
1	Accurate mode-choice modelling.
2	A range of appraisal modules.
3	All-day modelling; particularly resident's travel. Represent a minimum of four time periods (AM, Inter-Peak, PM & Off-Peak).
4	Full geographic coverage of the regional area for each city particularly to capture commuting trip patterns.
5	Predict demand on the different public transport services within the GDA & other regions.
6	Origin-Destination modelling of mode choice of residents travel.
7	A detailed representation of the public transport network & services.
8	An easy to use model, built on a software platform that is scalable, customisable, system independent, interoperable and supported.
9	Demand represented in a detailed level of segmentation in terms of journey purposes, car ownership/availability, modes, person types, user classes & socio-economic classes.
10	Good links with other NTA tools & processes.
11	Model all major transport modes including active modes.
12	Time period Origin to Destination modelling of residents car trips.
13	Disaggregate journey purpose for home based trips (i.e. commute, employers business, shopping and education) & for non-home based trips (i.e. employers business & other).
14	Reasonable links with other NTA processes related to the procurement & delivery of transport infrastructure.
15	Time of day choice to consider the impacts of PT crowding.
16	A detailed representation of the road network particularly the impact of congestion on on-street public transport services.
17	The ability to predict changes in destination in response to changing transport provision and/or policy.
18	The ability to link from-home & to-home trips or 'simple tours'.
19	The need for consistent hierarchical modelling with higher (national) & lower (local junction) traffic models.
20	The ability to predict changes in trip destination & time-of-day choice in response to changing traffic conditions.
21	A detailed representation of the road network, including congestion at individual junctions.
22	The ability to predict changes in trip frequency and/or destination in response to changing transport provision and/or policy including some representation of visitor travel.
23	Good representation of Park and Ride.
24	The ability to test the impacts of traffic management schemes on Public Transport services.
25	The ability to test the impacts of changes in parking supply and parking policy including 'Park and Ride' provision.
26	Some ability to represent the contribution of taxis to general traffic levels.
27	A general need to represent travel demand to/from key 'special' zones, particularly Dublin airport.
28	The ability to predict the impacts of 'complex tours', involving 3 or more legs between leaving & returning home (e.g. escorting children to school on the way to work or visiting shops on the way home).
29	A reasonable representation of goods vehicle routing (perhaps with some additional logistics modelling capability (i.e. predicting changes in the goods vehicle fleet over time).
30	Relatively sophisticated representation of different fares & ticketing including integrated ticketing, season tickets & concessionary travel demand.
31	Public Transport use by visitors.
32	Some representation of visitor travel.
33	The particular features of surface access to Dublin airport.
34	Land Use & Transport Interaction (LUTI) Modelling.

The assessment takes cognisance of the numerous workshops and meetings held between the NTA and Consultant's modelling teams to discuss areas for improvement to the GDA Model informed through the NTA's extensive experiences of using the model.

For clarity purposes, the 34 model functionality and features, shown above in Table 3.1, are combined under common modelling categories for the GDA Model strengths and weaknesses assessment, as follows:

- Mode Choice ;
- Appraisal Modules;
- All Day Modelling of Residents' Travel;
- Geographic Coverage;
- Public Transport Network Model and PT Services;
- Representation of Trips for Residents;
- Detailed Level of Demand Segmentation ;
- Active Modes (Walking & Cycling) ;
- Time-of-day Choice Modelling;
- Road Network;
- Destination Choice;
- Public Transport Fares & Ticketing;
- Park and Ride;
- Visitor Travel;
- Parking;
- Trip Frequency;
- Goods ;
- Taxis;
- Airport Access;
- Land Use Transport Interaction (LUTI) Modelling; and
- Model Usability.

3.2 Mode Choice

This relates to the following model functionality and feature requirement:

- Accurate mode-choice modelling.

3.2.1 Current GDA Model Strengths

- The mode choice model includes trips by all the main modes of travel – including car, bus, rail, light rail, park and ride and 'active modes' (i.e. walking and cycling).

3.2.2 Current GDA Model Weaknesses

- The combination of walking and cycling into a single 'active' travel mode limits the ability of the model to reflect each of these rather different modes individually and with sufficient accuracy;
- The modelling of 'active modes' takes no account of the propensity to cycle by gender and age or the impact of cycle hire schemes;
- The lack of a PM model means that the impact of PM travel conditions for return trips is excluded from the mode-choice decision; and
- The order of mode choice in the current choice hierarchy (i.e. more sensitive than destination choice) is generally not standard practice elsewhere.

3.2.3 Suggestions for Improvement

- **Mode choice should be enhanced from the current version to include walking and cycling as separate modes;**
- **Inclusion of tours and all day modelling would enable more accurate mode choice modelling to be included in the PM, and this is recommended;**
- **Further investigation should be undertaken of the data available to enable modelling of taxis as a separate mode; and**
- **The order of the travel choice hierarchy for different journey purposes should be reviewed.**

3.3 Appraisal Modules

This relates to the following model functionality and feature requirement:

- A range of appraisal modules.

An appraisal module is a tool for post-model run analysis of outputs which is specifically designed to automate any repetitive data processing and analysis. This can involve the preparation of model outputs for input to another type of appraisal programme, for example a Geographic Information System, which provides tools for environmental analysis, or a scheme appraisal programme for cost-benefit analysis.

3.3.1 Current GDA Model Strengths

- The existing model uses a clear folder structure for inputs and outputs, providing users with ready access to the output data required for further analysis.

3.3.2 Current GDA Model Weaknesses

- Economic and environmental data preparation or appraisal functionality is not integrated with the transport modelling;
- The current model does not automatically generate the outputs needed to undertake standard scheme assessments, which therefore have to be requested/extracted ‘manually’; and
- In undertaking scheme assessment, the final outputs of the current model are sensitive to model convergence and small changes to the scheme. Hence positive benefits for a scheme can flip to negative benefits as a result of small network changes. This can cause particular problems for the assessment of low capacity public transport schemes (e.g. a new Quality Bus Corridors) – but can also be an issue for larger public transport schemes.

3.3.3 Suggestions for Improvement:

- **Additional secondary analysis features are suggested for inclusion in the model as they are just as important as other core**

model features and they enable accurate and consistent assessment based on model outputs;

- **The modelling System should include procedures to enable efficient economic, environmental, and cost benefit appraisal and analysis; and**
- **Convergence of the model to tight convergence criteria should be assured for all model runs.**

3.4 All Day Modelling of Residents' Travel

This relates to the following model functionality and feature requirement:

- All-day modelling; particularly resident's travel. Represent a minimum of four time periods (AM, Inter-Peak, PM & Off-Peak).

3.4.1 Current GDA Model Strengths

- The current GDA model includes representation of the weekday AM Peak Period (07.00-10.00) and the weekday Inter-Peak Period (14.00-15.00); and
- The AM period is usually the most-important when considering urban congestion, travel to work and travel to education. It is also the most important when assessing the current and future network capacity required to meet peak demand conditions.

3.4.2 Current GDA Model Weaknesses

- The PM peak is not modelled even though congestion levels can exceed those in the AM peak in some parts of the network (in particular in the City Centre); and
- The lack of PM peak period modelling also restricts the ability to calculate 'all-day' travel costs, which limits the basis for economic and environmental assessment of schemes and policies.

3.4.3 Suggestions for Improvement

- **Representation of all-day demand is suggested. This requires at least the addition of the PM peak period in the modelling system; and**
- **The modelling of demand as production/attraction return trips (i.e. simple home-based tours) is preferable to treating travel in each time period as separate 1-way origin-destination trip matrices.**

3.5 Geographic Coverage

This relates to the following model functionality and feature requirement:

- Full geographic coverage of the regional area for each city particularly to capture commuting trip patterns.

3.5.1 Current GDA Model Strengths

- The current GDA model covers the entire GDA area, and takes full account of travel within, into and out of the modelled area; and
- The current zoning system in the GDA is directly linked to Electoral Divisions (EDs), although zones around and within the M50 are sub-divisions of ED. In large measure, this allows Census information and data from other official sources to be applied directly within the model without the need to take further steps to (dis)aggregate data to match the zones.

3.5.2 Current GDA Model Weaknesses

- The zones are much larger outside the core area of Dublin. This reflects the less dense population and transport networks in the Dublin hinterland but also the lesser need for detailed assessment of schemes outside Dublin required of the current GDA model. Urbanisation in the hinterland has not been reflected in the existing zone system with outer zones being too large relative to activity in those areas. Where zones are too large, a significant proportion of trips may be internal to zones and may not appear as flows on the network. This can also lead to overloading of the network in some places;
- Significant areas outside the GDA counties are represented as 'external' zones resulting in an inaccurate representation of travel costs from these areas, especially for public transport; and
- The use of ED boundaries means that many zones, especially in the central areas of the city, follow the course of the road network. This makes the allocation of zone trips to the network (via 'centroid connector' links) difficult to specify.

3.5.3 Suggestions for Improvement

- **An increase in zonal detail is recommended outside the core city centre area.**

3.6 Public Transport Network Model and PT Services

This relates to the following model functionality and feature requirements:

- A detailed representation of the public transport network & services; and
- Predict demand on the different public transport services within the GDA & other regions.

The current GDA model includes all Rail, Luas, Dublin Bus, Bus Éireann and private operator services with one or both ends of the journey in the GDA and accounts for the effect of traffic congestion on bus speeds.

3.6.1 Current GDA Model Strengths

- All public transport routes and services are included in the current GDA model;
- The transport networks represented contain a high level of detail;
- Bus speeds are linked to congested speeds output from the road network model; and
- Crowding is modelled for all public transport including buses, which is important for the calibration of realistic loadings and the impacts of excess demand in the base year.

3.6.2 Current GDA Model Weaknesses

- Taxis are not included as a public transport mode; and
- The GDA model contains little or no local calibration of the generalised cost attributes which influence mode and sub-mode choice (value of time, relative importance of reliability, comfort, frequency etc.).

3.6.3 Suggestions for Improvement

- **Greater network detail should be provided in the vicinity of key public transport service nodes and stops to enable more accurate modelling of access to those services;**
- **Local stated preference surveys should be undertaken to improve GC attributes for various PT sub modes;**
- **Crowding should be tuned off in certain forecast scenarios e.g., when assessing the capacity required to meet future demand; and**
- **Further investigation should be undertaken of potential data sources to enable the modelling of taxis as a separate mode.**

3.7 Representation of Trips for Residents

This relates to the following model functionality and feature requirements:

- Time period Origin to Destination modelling of residents car trips;
- Origin-Destination modelling of mode choice of residents travel;
- The ability to link from-home & to-home trips or ‘simple tours’; and
- The ability to predict the impacts of ‘complex tours’, involving 3 or more legs between leaving & returning home (e.g. escorting children to school on the way to work or visiting shops on the way home).

3.7.1 Current GDA Model Strengths

- The current GDA model represents trips at an Origin-Destination (OD) level. OD matrices for the AM and Off-Peak models are derived from 12-hour PA matrices with trip return factors applied to each modelled time period.

3.7.2 Current GDA Model Weaknesses

- The current GDA Model does not explicitly link trips that are part of simple (outbound and return) or complex (outbound, intermediate and return) tours. Hence trip characteristics in such tours are not linked and, for example, where a car was not used in an outbound tour leg, there is no restriction on mode choice for the return leg; and
- Activity based trips are not modelled in the current GDA Model. For the vast majority of urban / regional strategic transport models this is acceptable and only represents a weakness if travel patterns (deriving from the need to undertake activities) are known to be highly complex spatially and temporally in ways that cannot be captured by a simple or complex tours approach.

3.7.3 Suggestions for Improvement

- **The explicit linking of trips that are part of a simple (from home and return home) tour is recommended, so as to give a more realistic representation of travel demand by mode over the full day; and**
- **Undertake further investigation of the significance of 'simple home-based triangles', particularly involving an 'Escort to Education' leg.**

3.8 Detailed Level of Demand Segmentation

This relates to the following model functionality and feature requirements:

- Demand represented in a detailed level of segmentation in terms of journey purposes, car ownership/availability, modes, person types, user classes & socio-economic classes; and
- Disaggregate journey purpose for home based trips (i.e. commute, employers business, shopping and education) & for non-home based trips (i.e. employers business & other).

3.8.1 Current GDA Model Strengths

- The GDA model includes segmentation by journey purpose (trips to work, school, retail, and other), for home-based and non-home based trips;

- The GDA model includes car available and car non-available segments which improves mode choice modelling; and
- The GDA model segments include the main journey purpose provided by the POWCAR data (i.e. trips from home to work).

3.8.2 Current GDA Model Weaknesses

- The inclusion of all trips that are not school, work, or retail trips in the 'other' category means they are all treated the same way in the model, even though some significant sub-segments should have very different travel characteristics (e.g. Airport passengers, visiting friends). This may not be a weakness if the other segments are not a significant portion of travel demand;
- The car demand representation includes LGVs which have different demand patterns and values of time; and
- Taxi demand is not included as a demand segment. Taxis can take relatively unrestricted path through the network compared with private vehicles and impact bus operation in certain locations.

3.8.3 Suggestions for Improvement

- **As the current Car available / car non-available segmentation does not recognise car competition within a household, an alternative mechanism that recognises cars availability per household member for a particular journey should be included;**
- **LGVs should be treated separately from cars; and**
- **Taxis should be treated as their own demand segment where supported by data.**

3.9 Active Modes (Walking & Cycling)

This relates to the following model functionality and feature requirements:

- Model all major transport modes including active modes.

Walking and cycling trips are included in the model as a single 'Active Mode' demand segment. The cost of travel for Active modes is calculated as a simple combination of calculated average speeds and shortest path distance between zones. Active modes are not assigned to the network. Hence, unlike mechanised modes, their travel costs are not based on the dynamic characteristics of the network related to travel demand.

3.9.1 Current GDA Model Strengths

- Active mode demand is included within the model, and this obviates the need for the model to incorporate a trip frequency response as travel by all modes for the full day are incorporated;
- Active modes are included in the mode choice modelling; and

- Policies that seek to increase trips by walking and cycling can be tested by adjusting skim costs in the model to account for priority or other network improvements that affect costs.

3.9.2 Current GDA Model Weaknesses

- Walking and cycling trips are not treated separately, but as a single ‘Active’ mode;
- The current model does not include the impact of cycling on the amount of road capacity available to other motorised modes, which may be significant enough in localised parts of the network to affect driver behaviour; and
- The current model does not distinguish between on-street and off-street cycling (which may be important for testing future cycling networks), or the impact of traffic volumes or the number of other cyclists on cycling-related behaviour.

3.9.3 Suggestions for Improvement

- **Walking and cycling should be treated as their own modes and made available to the mode choice model, as they have very different properties as transport options; and**
- **Assignment to the road network (including additional walking and cycling paths) should provide some added realism to the calculation of congested travel times through the road network and should be investigated further.**

3.10 Time-of-day Choice Modelling

This relates to the following model functionality and feature requirements:

- Time of day choice to consider the impacts of PT crowding; and
- The ability to predict changes in trip destination & time-of-day choice in response to changing traffic conditions.

3.10.1 Current GDA Model Strengths

- The GDA model includes a Peak Spreading choice model (Micro Time of Day) to represent the phenomenon of trip re-timing in response to congestion levels in the AM peak hour. It splits total AM travel demand according to a choice of 3 arrival hours within the period. This effect is not captured in many strategic models of this kind.

3.10.2 Current GDA Model Weaknesses

- The propensity to vary time-of-day of travel (by journey purpose) has not been recently calibrated to local Dublin conditions;

- Peak Spreading (Micro-Time of Day) choice modelling requires assignment of 3 one-hour periods in the AM period, which is a significant computational overhead.;
- The fact that outbound and return home trips are not explicitly linked makes it difficult to estimate the impact that time-of-day choice in the AM peak will have on the time of the return trip (i.e. those choosing to travel to work before the AM peak are also more likely to leave work before the PM peak); and
- The impacts that peak/off-peak public transport fares or variations in parking charges (e.g. by duration or time-of-day) have on time-of-travel choices are not included.

3.10.3 Suggestions for Improvement

- **The modelling system should include a capability to predict changes in the time of travel, in response to changing traffic conditions, PT crowding, changes in fares and general transport provision; and**
- **It is recommended that an alternative to the current form of Peak spreading model is considered, such as variable peak hour factoring.**

3.11 Road Network

This relates to the following model functionality and feature requirement:

- A detailed representation of the road network particularly the impact of congestion on on-street public transport services;
- A detailed representation of the road network, including congestion at individual junctions; and
- The ability to test the impacts of traffic management schemes on Public Transport services.

3.11.1 Current GDA Model Strengths

- The transport networks represented contain a good level of detail;
- The highway assignment takes account of junction delays, in the ‘simulation’ area;
- Point tolls are modelled by converting toll charges to equivalent time penalties (using the value of time);
- Network speeds from the road network model are passed to the public transport model and used in the calculation of bus travel costs’; and
- QBCs are well modelled with bus speeds based on observed QBC monitoring data.

3.11.2 Current GDA Model Weaknesses

- Signal timings have not as yet been updated in a systematic way since the 2001 model;
- In the outer parts of the GDA (i.e. outside the Dublin Metropolitan area) the transport network lacks detail, generally represented as 'buffer network' within the SATURN model;
- In these areas, a potentially significant proportion of trips will be internal to the large outer zones and will therefore not appear as flows on the network;
- Road user charges (i.e. a charge per km travelled) are applied to car trips in the model by adjusting the standard operating costs of car trips within the SATURN coding to add in the additional charge. This is insufficiently precise to reflect practical road user charging measures. These are typically better modelled as part of demand modelling and not highway assignment; and
- The highway network is not linked to GIS, resulting in difficulties directly linking outputs with GIS assessment tools for environmental appraisal.

3.11.3 Suggestions for Improvement

- **The road network model should include more detail in outer areas;**
- **The road network model should be linked to GIS to enable more efficient environmental appraisal; and**
- **The road network model should represent capacity restraint on the road network as accurately as allowed by the software (i.e. capacity restraint should be applied at junctions, links, or both as required).**

3.12 Destination Choice

This relates to the following model functionality and feature requirement:

- The ability to predict changes in destination in response to changing transport provision and/or policy; and
- The ability to predict changes in trip destination & time-of-day choice in response to changing traffic conditions.

3.12.1 Current GDA Model Strengths

- None.

3.12.2 Current GDA Model Weaknesses

- The current GDA Model implementation doesn't include feedback between travel costs and residents' destination choice; and

- The impact of parking (both parking cost and parking availability) on mode choice is applied in a somewhat artificial manner to restrict car trips to the city centre. The practical lack of impact on destination choice is a significant shortcoming.

3.12.3 Suggestions for Improvement

- **Destination Choice should be included in the main model loop as it is important in enabling the model to reach a stable demand / supply equilibrium over the network; and**
- **A full review of the model choice hierarchy should be undertaken, using standard model calibration techniques to determine the most-appropriate hierarchies by trip purpose.**

3.13 Public Transport Fares & Ticketing

This relates to the following model functionality and feature requirement:

- Relatively sophisticated representation of different fares & ticketing including integrated ticketing, season tickets & concessionary travel demand.

Distance based fares are estimated for each public transport mode on the basis of the origin and destination of the one-way trips and the published fare structure for each PT operator. This means that integrated ticketing is not represented in the model and, for example, a trip which involved both rail and LUAS would incur separate full fares for both the rail journey and the LUAS trip.

3.13.1 Current GDA Model Strengths

- Distance based rail fares based on accurate estimates of station-to-station single fares.

3.13.2 Current GDA Model Weaknesses

- There is no explicit modelling of return fares, season tickets or other discounted/subsidised fares;
- All fares are distance based. This is a weakness in a stage based or zone-based system;
- There is limited ability to test alternative fares policies, in particular integrated ticketing or other forms of ‘Smart’ ticketing;
- Lack of modelling of the impact of season tickets and other discounted fares on public transport use limits the ability to model significant fare changes in future scenarios;
- The lack of inclusion of integrated ticketing in the model was known to impact on the quality of the calibration of LUAS patronage, particularly in the city centre where some passengers can avail of integrated rail and LUAS tickets to make trips on LUAS at a very low additional or marginal cost. On the other hand, the model would

generally have these passengers using 'walk links' because the generalised cost of using LUAS would include a full fare charge in addition to waiting and boarding penalties; and

- Integrated ticket types are not in the GDA public transport fares model. This results in reduced accuracy in representing perceived cost of trip making on an integrated PT system relative to a non-integrated one, and can have distorting effects on the calibration of VOT for PT users.

3.13.3 Suggestions for Improvement

- **The implementation of accurate zonal / stage based fares is suggested; and**
- **The potential to represent the reduced costs offered by integrated ticket products should be further investigated.**

3.14 Park and Ride

This relates to the following model functionality and feature requirement:

- Good representation of Park and Ride; and
- The ability to test the impacts of changes in parking supply and parking policy including 'Park and Ride' provision.

The current GDA transport model includes the modelling of Park and Ride trips at specified Park and Ride sites.

3.14.1 Current GDA Model Strengths

- The capacity of Park and Ride sites is reflected in the demand-forecasting.

3.14.2 Current GDA Model Weaknesses

- There is no attempt to model informal Park and Ride sites (i.e. using adjacent on and off-street parking in the vicinity of the key rail/DART/LUAS stations). No consideration is given to parking location choice, either between alternative P&R sites or between P&R versus 'Park and Walk' sites.

3.14.3 Suggestions for Improvement

- **Similar functionality should be provided for Park and Ride as for Parking, as discussed below in section 3.16, i.e. restraining to available capacity; and**
- **The inclusion of informal Park and Ride is suggested if this type of behaviour is prevalent enough in the GDA. An assessment of parking charges and duration limits in areas surrounding public transport nodes would indicate the potential for informal park**

and ride around Dublin and determine if this recommendation is required.

3.15 Visitor Travel

This relates to the following model functionality and feature requirement:

- Public Transport use by visitors; and
- Some representation of visitor travel.

3.15.1 Current GDA Model Strengths

- Any traffic counts and public transport patronage data used to calibrate the network assignment models includes travel by visitors; and
- The trip data derived from the passenger survey of Dublin Airport (included in the current model) includes trips made by visitors who use the Airport.

3.15.2 Current GDA Model Weaknesses

- The travel behaviour of visitors is not explicitly modelled in the current GDA model and is largely subsumed in the HBO and NHBO trip purpose 'Other' categories and their precise numbers are not yet accurately known. Their travel patterns are in effect assumed to be the same as residents (i.e. while the flows on individual links and services may reflect the geographic variation in visitor travel, the OD patterns of these trips are unlikely to accurately reflect the actual travel patterns of visitors.) e.g. Tour coaches are not modelled;
- The lack of detailed modelling of visitors is likely to be more significant in the inter-peaks, when they are likely to represent a higher proportion of the trips being made;
- The lack of detailed modelling of visitor travel behaviour is likely to become more of an issue if the modelling of active travel (particularly walking) and/or taxis as a mode (rather than just users of road space) is being strengthened;
- The factors influencing visitors travel mode of travel to/from the Airport are not modelled; and
- Factors associated with visitors' potentially-limited knowledge of travel options are not modelled, limiting the model's ability to predict the impacts of improved travel information.

3.15.3 Suggestions for Improvement

- **If supported by data (e.g. Geo-directory data for hotels and visitor data from the Dublin Airport Survey), some explicit recognition of visitor's travel demand should be made within the demand model in the modelling system.**

3.16 Parking

This relates to the following model functionality and feature requirement:

- The ability to test the impacts of changes in parking supply and parking policy including 'Park and Ride' provision.

In the current GDA Model the effect of parking restriction on car trips with destinations in the city centre is represented by a time penalty prior to the mode choice stage. The magnitude of the time penalty is iteratively adjusted following the mode choice stage until the number of car trips with destinations in the specified zones is within the specified parking capacity.

Charges for car trips with destinations in certain zones, for example within the M50, in the city centre or within major town centres are applied in the model in a similar fashion to the charges used to enforce parking restrictions described above. However, in this case a known charge / time penalty is applied to all car trips with destinations in the identified zones and there is no need for the charge to be iteratively adjusted.

3.16.1 Current GDA Model Strengths

- The above functionality provides a basic ability to model the impact of parking costs and parking restrictions on mode choice.

3.16.2 Current GDA Model Weaknesses

- The addition of a user-defined cost added to all car trips with destinations in the restricted area to simulate the effect of limited parking imposes an artificial cost on trips which must be stripped out in undertaking cost-benefit analysis;
- Charges do not vary by time of parking or duration of parking;
- Parking capacity or parking turnover rates are not modelled;
- There is no modelling of parking location choice or of the impact of parking (cost or availability) on time-of-travel choices; and
- Including the 'synthetic' parking charge complicates cost-benefit analysis and ignores the profile of parking space-availability throughout the day (and the associated impact on time-of-travel choices).

3.16.3 Suggestions for Improvement

- **Parking restraint that reflects available parking capacity should be included in the modelling system.**

3.17 Trip Frequency

This relates to the following model functionality and feature requirement:

- The ability to predict changes in trip frequency and/or destination in response to changing transport provision and/or policy including some representation of visitor travel.

3.17.1 Current GDA Model Strengths

- In the TAGM component of the current model trip rates are calculated based on a number of different personal attributes including employment status, car ownership and availability and socio-economic grouping. Hence, these characteristics impact on overall trip frequency for each journey purpose.

3.17.2 Current GDA Model Weaknesses

- The SEG (socio-economic group) attribute used in trip generation modelling is not a sufficiently strong explanatory variable for forecasting. Other personal attributes such as age and gender are omitted.

3.17.3 Suggestions for Improvement

- **A Trip Frequency response is not required if travel demand is comprehensively represented such that the total number of trips remains constant for a particular forecast and the frequency response is accounted for by trips switching between modes (i.e., between mechanised and non-mechanised modes).**

3.18 Goods

Goods relates to the following model functionality and feature requirement:

- A reasonable representation of goods vehicle routing (perhaps with some additional logistics modelling capability (i.e. predicting changes in the goods vehicle fleet over time).

Within the GDA transport model, heavy goods vehicles (HGVs) are defined as any commercial goods vehicle with more than four wheels. It should be noted that taxis, vans and other light goods vehicles are all treated as cars within the model.

Trip matrices of heavy goods vehicles are calibrated as part of the calibration of the highway model. The TAGM and TDM components apply a global growth factor (based on forecasts of economic growth) to the base year calibrated HGV matrices to produce forecast year equivalents. These trip matrices are then assigned to the highway network as a separate user class and simultaneously with the assignment of car trips.

The highway network for HGVs incorporates HGV bans and restrictions - i.e. parts of the network where HGV movements are not allowed.

3.18.1 Current GDA Model Strengths

- The features described above (i.e. heavy goods vehicle matrix calibration, global growth factors and network restrictions) provide some functionality associated with goods vehicle routing.

3.18.2 Current GDA Model Weaknesses

- Other than the use of a global growth factor (based on GDP growth), forecasting of future goods / freight demand is not included in the current TAGM. Hence, there is no ability to predict future changes in goods vehicle flows, for example in response to changes in the economy or land-use changes etc;
- Treating light goods vehicles (LGVs) in the same demand group as cars may distort travel patterns in the car trip matrices;
- There is no ability to predict impacts of changes in logistics management such as freight-distribution centres or the banning of particular vehicle types and limited ability to model or appraise emissions-related policies such as Low Emissions Zones; and
- There is no local calibration of goods vehicle driver behaviour with respect to value of time, willingness to pay tolls and other factors affecting route choice.

3.18.3 Suggestions for Improvement

- **An ability to model future changes in goods vehicle flows should be implemented by the full inclusion of HGVs in the TAGM;**
- **Light goods vehicles should be separated from the modelling of cars;**
- **HGVs should be divided into several HGV classes; and**
- **Local parameters should be estimated for goods vehicles.**

3.19 Taxis

Taxis relate to the following model functionality and feature requirement:

- Some ability to represent the contribution of taxis to general traffic levels.

Taxis are currently included in the traffic counts used to calibrate the traffic model.

3.19.1 Current GDA Model Strengths

- None.

3.19.2 Current GDA Model Weaknesses

- There is no attempt to model the typical routing of taxis through the city (or the variation in this routing between ‘occupied’ and ‘empty’ running). As a result taxis are effectively assumed to have the same travel patterns as the other cars using the road network, despite the

reality that taxis may make use of more direct city routes via bus and taxi only links and bus lanes;
- Taxis are not available as a ‘mode’ within the mode choice model; and
- There is no mechanism to predict changes in taxi traffic over time, or in response to other transport schemes or policies.

3.19.3 Suggestions for Improvement

- **Further investigation of the data available to allow taxis to be included as a separate mode should be undertaken; and**
- **It recommended that, at a minimum, taxi traffic flow should be modelled as a separate vehicle class in the road assignment model.**

3.20 Airport Access

This relates to the following model functionality and feature requirement:

- A general need to represent travel demand to/from key ‘special’ zones, particularly Dublin airport; and
- The particular features of surface access to Dublin airport.

In the existing GDA Model, Airport passenger trips are included in the Home-Based Other matrices. While work related trips are adequately represented by POWCAR Census data 2006, passenger trips are not. However, travel patterns for these trips were obtained from the Airport passenger survey undertaken in 2001.

Airport passenger travel behaviour has unique properties that distinguish it from typical commuter travel behaviour, although the existing GDA model applies the same parameters as for travel to/from other locations and for other trip purposes.

3.20.1 Current GDA Model Strengths

- The large number of non-commuter trips to the airport has been recognised and an attempt has been made to model these as ‘other’ trips; and
- The distinctive time pattern of travel to and from the airport during the day is recognised.

3.20.2 Current GDA Model Weaknesses

- The origins of trips to the airport reflect locations of homes and not the locations of accommodation typically used by visitors; and
- Treating Airport passenger trips as Home Based Other trips means that distinct properties known to affect surface access to airports are not included such as visitors having lower knowledge of travel options and significantly-different car-availability, the impact of heavy luggage, non-standard values of time for air travellers (by direction) or the impact of party size.

3.20.3 Suggestions for Improvement

- **Airport passenger demand should be included as a distinct travel demand segment; and**
- **A distinct Airport segment would require a dedicated forecasting model, and therefore this need should be examined and specified in the review of Best Practice and Data. This review should examine the properties of visitor travel behaviour noted in bullet 2 above under Weaknesses, provided the data support this approach.**

3.21 Land Use Transport Interaction (LUTI) Modelling

This relates to the following model functionality and feature requirement:

- Land Use & Transport Interaction (LUTI) Modelling.

3.21.1 Current GDA Model Strengths

- None.

3.21.2 Current GDA Model Weaknesses

- The GDA Model is not a land use transport interaction model.

3.21.3 Suggestions for Improvement

- **A LUTI model is not required as only prescribed planning scenarios are used by the NTA in strategy development.**

3.22 Model Usability

This relates to the following model functionality and feature requirements:

- An easy to use model, built on a software platform that is scalable, customisable, system independent, interoperable and supported;
- Good links with other NTA tools & processes;
- Reasonable links with other NTA processes related to the procurement & delivery of transport infrastructure; and
- The need for consistent hierarchical modelling with higher (regional) & lower (local junction) traffic models.

The issues discussed under each of the above are detail below.

3.22.1 Ease of Use and Maintenance

- The current model interface does not make it easy for the user to manage multiple scenarios using different combinations of planning inputs and network changes (i.e. where some of the input files and assumptions are shared ‘in common’ with other scenarios);

- There are currently separate model interfaces and folder structures for the AM and inter-peak models, making the management of scenarios and version control more difficult;
- The current model is not designed to support environmental analysis of traffic emissions (air quality or greenhouse gases), which requires daily and/or annualised flows. At present it only provides average hourly flows for broadly classified ‘car’ and ‘HGV’ vehicle categories; and
- The current interface should be improved to, for example, allow the various model components to be run in ‘stand-alone’ mode, to test the coding of input networks, assign just highway or public transport networks, or regenerate the inputs for economic appraisal using revised input parameters etc.

3.22.2 Suggestions for Improvement

- **User friendly interfaces with more efficient ways of accessing outputs for appraisal purposes should be included.**

3.22.3 Interface with other NTA Tools

- The GDA network models are not as detailed and spatially accurate as other NTA GIS data sources (e.g. the Journey Planner) which results in a lack of integration; and
- The current model has been used to provide inputs to some lower tier (micro-simulation) models, but there are no purpose built facilities for doing so in the modelling package.

3.22.4 Suggestions for Improvement

- **The modelling system and GIS tools should be integrated to the greatest extent possible to ensure consistency of planning and data use;**
- ***The model should have consistency and compatibility with GIS; and***
- **Additional procedures should be considered for inclusion in the modelling system that facilitate data transfer within a hierarchy of models (i.e., between more aggregate or disaggregate network or zone systems).**

3.22.5 Software Platforms

- The existing modelling reflects procedures and software systems accumulated and modified over a considerable number of years;
- The TRIPS software used for various aspects of the current model is no longer supported by Citilabs; and

- The three software platforms currently used in the GDA model places extra demands on platform interaction programming and users of the system (e.g. the need to maintain three separate software licences and an ability to use all three software packages.)

3.22.6 Suggestions for Improvement

- The modelling system should minimise the number of modelling software packages it uses, and
- ***The transport modelling software packages used must be up to date and supported.***

3.22.7 Consistent Hierarchical Modelling

- The existing GDA regional model is not linked to a structured hierarchical modelling system.

3.22.8 Suggestions for Improvement

- **The regional modelling system should be designed to fit within a hierarchical modelling system. The hierarchical system should include other Regional Models, each of which will be focussed on the travel to work area of major population centres (including: Dublin, Cork, Galway, Limerick, Waterford). The hierarchical system should also include sub-regional level models that should be built specifically to test local schemes and strategies in large towns and settlements.**

It is also suggested that the hierarchical system include:

- **A Trip End Model should be developed - providing a strategic representation of travel demand across the whole of Ireland. The Trip End Model will provide essential travel demand inputs to the national multi-modal model and to the other transport models in the hierarchy as follows:**
  - **Regional Models – approximately six regional multi-modal transport and demand models will be developed across Ireland (of which, the GDA Model will be one). Each of the regional models will be focussed on the travel to work area of major population centres (including: Cork, Galway, Limerick, Waterford). The modelling system developed for the GDA model should provide a tried and tested template for the development of the other regional models. The processes, structure and data analysis undertaken in the development of the GDA model should be undertaken to ensure repeatable methods are**

established to enable efficiency and consistency in regional modelling throughout Ireland; and

- **Local Models – More detailed 'sub regional' or 'local' models should be built, most likely using micro-simulation or cordoned sub models of regional models, depending on requirements.**

Building a modelling hierarchy should ensure that consistent, appropriate and proportionate modelling tools are available to help inform and appraise a very broad range of potential transport scheme and policy interventions. It will provide the NTA with a consistent and unified structure for using and maintaining the modelling toolkit for Ireland as a whole.

3.23 Summary of GDA Model Suggested Improvements

Table 3.2 below provides an overview of the suggested areas for improving the current GDA Model based on the strengths and weaknesses assessment.

Table 3.2 Summary of GDA Model Improvement Recommendations

Modelling Catagory		Suggested Improvements
Mode Choice	1	a) Mode choice should be enhanced from the current version to include walking and cycling as separate modes. b) Inclusion of tours and all day modelling, as recommended above, would enable more accurate mode choice modelling to be included in the PM, and this is recommended. c) Further investigation of the data available to allow taxis to be included as a separate mode should be undertaken. d) The current model choice hierarchy (by journey purpose) should be reviewed.
Appraisal Modules	2	a) Additional secondary analysis features are suggested for inclusion in the model as they are just as important as other core model features and they enable accurate and consistent assessment based on model outputs. b) The modelling system should include procedures to enable efficient economic, environmental, and cost benefit appraisal and analysis. c) Convergence of the model to tight convergence criteria should be assured for all model runs.
All Day Modelling of Residents' Travel	3	a) Representation of all-day demand is suggested. This requires at least the addition of the PM peak period. b) The modelling of demand as production/attraction return trips (i.e. simple home-based tours) is preferable to treating travel in the separate the time periods as separate 1-way origin-destination trip matrices.
Geographic	4	a) An increase in zonal detail is suggested outside the core city

Coverage		centre area.
Public Transport Network Model and Public Transport Services	5	a) Greater network detail should be provided in the vicinity of key public transport service nodes and stops to enable more accurate modelling of access to those services. b) Local stated preference surveys should be undertaken to improve GC attributes for various PT sub modes. c) Crowding should be tuned off in certain forecast scenarios e.g., when assessing the capacity required to meet future demand. d) Further investigation of the data available to allow taxis to be included as a separate mode should be undertaken.
Representation of Trips for Residents	6	a) The explicit linking of trips that are part of a simple (from home and return home) tour is suggested so as to give a more realistic representation of travel demand by mode over the full day and improved consistency of response to travel cost changes between outward & return journeys. b) Undertake further investigation of the significance of 'simple home-based triangles', particularly involving an 'Escort to Education' leg.
Detailed Level of Demand Segmentation	7	a) Car available / car non-available segmentation does not recognise car competition within a household, as such an alternative scheme that recognises cars availability per household member for a particular journey should be included. b) LGVs should be treated separately from cars. c) Taxis should be treated as their own demand segment.
Active Modes (Walking & Cycling)	8	a) Walking and cycling should be treated as separate modes and made available to the mode choice model, as they have very different properties as transport options. b) Assignment to the road network (including additional walking and cycling paths) should provide some added realism to the calculation of congested travel times through the road network and should be investigated further.
Time-of-day Choice Modelling	9	a) The modelling system should include a capability to predict changes in the time of travel, in response to changing traffic conditions, PT crowding, changes in fares and general transport provision. b) It is recommended that an alternative to the current form of Peak spreading model is considered, such as variable peak hour factoring.
Road Network	10	a) The road network model should include more detail in outer areas, b) The road network model should be linked to GIS to enable more efficient environmental appraisal, c) The road network model should represent capacity restraint on the road network as accurately as allowed by the software (i.e. capacity restraint should be applied at junctions, links, or both as required).
Destination Choice	11	a) Destination Choice should be included in the main model loop as it is important in enabling the model to reach a stable demand / supply equilibrium over the network.

Public Transport Fares & Ticketing	12	a) The implementation of accurate zonal / stage based fares is suggested. b) The potential to represent the reduced costs offered by integrated ticket products should be further investigated.
Park & Ride	13	a) Similar functionality should be provided for Park and Ride as for Parking, as discussed above, i.e. restraining to available capacity. b) The inclusion of informal Park and Ride is suggested if this type of behaviour is prevalent enough. An assessment of parking charges and duration limits in areas surrounding public transport nodes would indicate the potential for informal park and ride around Dublin and determine if this recommendation is required.
Visitor Travel	14	a) If supported by data (e.g. Geo-directory data for hotels and visitor data from the Dublin Airport Survey), some explicit recognition of visitor's travel demand should be made within the demand model in an updated modelling system.
Parking	15	a) Parking restraint that reflects available parking capacity should be included in the modelling system.
Trip Frequency	16	a) A Trip Frequency response is not required if travel demand is comprehensively represented such that the total number of trips remains constant for a particular forecast and the frequency response is accounted for by trips switching among modes (i.e., between mechanised and non-mechanised modes).
Goods	17	a) An ability to model future changes in goods vehicle flows should be implemented by the full inclusion of HGVs in the TAGM, b) Light goods vehicles should be separated from the modelling of cars, c) HGVs should be divided into several HGV classes, d) Local parameters should be estimated for goods vehicles.
Taxis	18	a) Further investigation of the data available to allow taxis to be included as a separate mode should be undertaken. b) It recommended that, at a minimum, taxi traffic flow should be modelled as a separate vehicle class in the road assignment model.
Airport Access	19	a) Airport passenger demand should be included as a distinct travel demand segment. b) A distinct Airport segment would require a dedicated forecasting model, and therefore this need should be examined and specified in the review of Best Practice and Data. This review should examine the properties of visitor travel behaviour noted in bullet 2 above under Weaknesses, provided the data support this approach.
LUTI Modelling	20	a) A LUTI model is not required as only prescribed planning scenarios are used by the NTA in strategy development.
Model Usability	21	a) User friendly interfaces with more efficient ways of accessing outputs for appraisal purposes. b) Consistency and compatibility with GIS. c) The modelling system and GIS tools should be integrated to the

		greatest extent possible to ensure consistency of planning and data use. d) Additional procedures should be considered for inclusion in the GDA model that facilitate data transfer within a hierarchy of models (i.e., between more aggregate or disaggregate network or zone systems). e) The modelling system should minimise the number of modelling software packages it uses, and f) The transport modelling software packages used must be up to date and supported.
Consistent Hierarchical Modelling	22	a) A regional modelling system be designed to fit within a hierarchical modelling system. The hierarchical system should include other Regional Models, each of which should be focussed on the travel to work area of major population centres (including: Cork, Galway, Limerick, Waterford). The hierarchical system should also include sub-regional level models that should be built specifically to test local schemes and strategies in large towns and settlements. b) A Trip End Model - providing a strategic representation of travel demand across the whole of Ireland. c) Regional Models – approximately six regional multi-modal transport and demand models should be developed across Ireland (of which, the GDA Model will be one). Each of which should be focussed on the travel to work area of major population centres (including: Cork, Galway, Limerick, Waterford). The GDA model should provide a tried and tested template for remaining regional model development. The processes, structure and data analysis undertaken in the development of the new model should be undertaken in such a way to ensure repeatable methods are used to enable efficiency and consistency in regional modelling throughout Ireland; and d) Local Models – More detailed 'sub regional' or 'local' models may be built, most likely using micro-simulation or cordoned sub models of regional models, depending on requirements.

4 Conclusions

4.1 Conclusion

This scoping report has assessed the strengths and weaknesses of the current GDA Modelling System relative to the NTA requirements for transport modelling and has made a number of suggestions for improvement. Table 4.1 overleaf, summarises the various functionalities and features implied by the NTA's requirements, highlights those which are represented in the current GDA model and identifies areas where improvement in the current functionality is required. The following colour scheme is utilised to indicate the level of functionality available in the current GDA model:

- **Red:** Functionality is not represented in the current GDA model;
- **Amber**: Functionality is represented in the current GDA model, but not at a sufficient level to meet the requirements of the NTA based on their remit; and
- **Green**: Functionality is fully represented in the current GDA model.

Scoping Report 3 and 4 explore best practice approaches and data requirements for delivering these improvements.

Table 4.1 Summary of GDA Model System Improvements Required

Order No.	Model Functionality & Features	Currently Represented in the GDA Model
1	Accurate mode-choice modelling.	
2	A range of appraisal modules.	
3	All-day modelling; particularly resident's travel. Represent a minimum of four time periods (AM, Inter-Peak, PM & Off-Peak).	
4	Full geographic coverage of the regional area for each city particularly to capture commuting trip patterns.	
5	Predict demand on the different public transport services within the GDA & other regions.	
6	Origin-Destination modelling of mode choice of residents travel.	
7	A detailed representation of the public transport network & services.	
8	An easy to use model, built on a software platform that is scalable, customisable, system independent, interoperable and supported.	
9	Demand represented in a detailed level of segmentation in terms of journey purposes, car ownership/availability, modes, person types, user classes & socio-economic classes.	
10	Good links with other NTA tools & processes.	
11	Model all major transport modes including active modes.	
12	Time period Origin to Destination modelling of residents car trips.	
13	Disaggregate journey purpose for home based trips (i.e. commute, employers business, shopping and education) & for non-home based trips (i.e. employers business & other).	
14	Reasonable links with other NTA processes related to the procurement & delivery of transport infrastructure.	
15	Time of day choice to consider the impacts of PT crowding.	
16	A detailed representation of the road network particularly the impact of congestion on on-street public transport services.	
17	The ability to predict changes in destination in response to changing transport provision and/or policy.	
18	The ability to link from-home & to-home trips or 'simple tours'.	
19	The need for consistent hierarchical modelling with higher (national) & lower (local junction) traffic models.	
20	The ability to predict changes in trip destination & time-of-day choice in response to changing traffic conditions.	
21	A detailed representation of the road network, including congestion at individual junctions.	
22	The ability to predict changes in trip frequency and/or destination in response to changing transport provision and/or policy including some representation of visitor travel.	
23	Good representation of Park and Ride.	
24	The ability to test the impacts of traffic management schemes on Public Transport services.	
25	The ability to test the impacts of changes in parking supply and parking policy including 'Park and Ride' provision.	
26	Some ability to represent the contribution of taxis to general traffic levels.	
27	A general need to represent travel demand to/from key 'special' zones, particularly Dublin airport.	
28	The ability to predict the impacts of 'complex tours', involving 3 or more legs between leaving & returning home (e.g. escorting children to school on the way to work or visiting shops on the way home).	
29	A reasonable representation of goods vehicle routing (perhaps with some additional logistics modelling capability (i.e. predicting changes in the goods vehicle fleet over time).	
30	Relatively sophisticated representation of different fares & ticketing including integrated ticketing, season tickets & concessionary travel demand.	
31	Public Transport use by visitors.	
32	Some representation of visitor travel.	
33	The particular features of surface access to Dublin airport.	

Key:

	Functionality is represented in the current GDA model
	Functionality is represented in the current GDA model, but not at a sufficient level to meet the requirements of the NTA based on their remit
	Functionality is not represented in the current GDA model

Údarás
Náisiúnta Iompair
National **Transport** Authority

National Transport Authority
Dún Scéine
Harcourt Lane
Dublin 2

Údarás Náisúnta Iompair
Dún Scéine
Lána Fhearchair
Baile Átha Cliath 2

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

www.nationaltransport.ie

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