Transport Modelling Report

Greater Dublin Area
Draft Transport Strategy
2011-2030

2030 vision

Údarás
Náisiúnta Iompair
National Transport Authority

Contents

1. Introduction – role of GDA Transport Model in the assessment of Strategy measures

The development of the Draft Strategy for the Greater Dublin Area (GDA) involved a number of stages including:

1. Establishing the Vision statement for Dublin, a set of 5 high level objectives and specific transport related sub objectives for the Strategy for the target year 2030,

2. Agreeing (in conjunction with the RPG's and other stakeholders) the essential land use and other macro economic forecasts that are the main determinants of travel demand in the 2030 target year,

3. Developing a list of possible measures / transport schemes and undertaking a preliminary assessment of these measures against the agreed objectives,

4. Assembling schemes into three themed packages based on the high level objectives and assessing the packages (and variants of the packages) against the sub objectives,

5. Assembling the Draft Strategy that combines the best impacts of the three packages and undertaking a full two stage evaluation of the Draft Strategy as follows:

   (a). Evaluation against the strategy objectives,
   (b). Multi criterion evaluation (including cost benefit analysis).

The Decision Making process involved in developing the Draft Strategy has been supported by:

- Critical input form stakeholders and the public,
- Analysis of available data on current and forecast patterns and trends,
- Scenario testing, analysis and outputs fron the GDA transport model – supported by other data analysis tools.

This technical volume gives a description of the GDA transport model that was the main analysis tool used to develop the Draft Transport Strategy. It describes the model and its components and gives an account of the major update of the am-peak and off-peak models undertaken in 2008 and 2009 in preparation for its use in developing the Draft Strategy.

2. Description of the GDA Transport Model and its components

2.1 Introduction / Background

The GDA tansport model is a strategic multi-modal, network based transport model covering the Greater Dublin Area (i.e. the counties of Dublin, Meath, Kildare and Wicklow). The model includes all the main surface modes of travel (including tavel by car, bus, rail, heavy goods vehicles, walking and cycling). The model currently comprises a morning peak model covering the three hour period between 07:00 and 10:00 and an afternoon inter-peak model covering the single hour between 14:00 and 15:00.

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

1997: Update of travel patterns based on a GDA wide Origin and Destination survey,

2001: Expansion of the modelled area and inclusion of new Public Transport modelling software. Update of model's travel patterns based on GDA wide employment survey.

2004: Following an extensive audit of the model by WSP consultants and a full review of all model parameters by MVA Consultants in 2003 – a major update of the am-peak model model was undertaken to include the following audit recommendations:

- Incorporating the 2002 Census travel to work data and the data from the DTO's 2002 travel to education survey into the model,
- Development of a new Trip Attraction & Generation model and a new Trip Distribution Model using the 2002 Census and other travel data,
- Expansion of the am-peak to cover 3 hours from 7am to 10am,
- Incorporating Walking and Cycling trips into the model,
- Revision of all model parameters based on the MVA parameter review.

2008: Following a review of the model by Steer Davies Gleave consultants – a further full update of the model was undertaken to prepare it for use in developing the GDA Transport Strategy. The main elements of this update were to:

- Incorporate the 2006 Census travel to work data and data from the GDA travel to education and household travel surveys (both surveys undertaken by the DTO in 2006) into the model and re-calibrate the model to observed 2006 travel behaviour and conditions,
- Re-develop the Trip Attraction & Generation and Trip Distribution Models to incorporate the 2006 land use and travel datasets,
- Develop a new afternoon off-peak model to have a similar structure and functionality to the morning peak model and calibrate the model to observed 2006 off-peak travel conditions.

The latest update of the DTO's transport model was started in early 2008 and was completed in late 2009. Following this, the DTO was subsumed into the National Transport Authority (NTA) that was established in December 2009. The GDA transport model is now owned by the NTA, who are the authority responsible for its maintenance and use.

2.2 Summary of model characteristics

Listed below is a summary of the main characteristics of the NTA's transport model for the GDA in terms of the area covered, zoning system used, time periods modelled, model base and forecast years, transport networks modelled and the classification of travel demand.

Zoning: The GDA Transport Model covers the full Greater Dublin Area (GDA) and also includes zoning and transport network coding for Co. Louth. The current model has 657 internal fine zones 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 Electroal Divisions (DED's) used to compile Census data. In the hinterland area, zones are much larger and are an amalgamation of DED's.

In order to represent travel patterns at a more aggregate level, the model has the facility to amalgamate the 657 fine zones to 75 strategic zones (called sectors), or to 21 coarse zones. In addition, travel demand can be analysed in terms of travel within and between 87 District Centres defined for the GDA. The modelled area and fine zoning system is shown in Figure 1 below.

Model Periods: Two separate periods of the day are modelled. The am-peak model covers the three-hour period from 07:00 to 10:00, while the off-peak model covers the single hour from 14:00 to 15:00.

Base and Forecast Years: The base year for the current peak and off-peak models is 2006, while the main forecast year is 2030 – the target year for the GDA Transport Strategy.

Modelled Networks: 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. In the Dublin County area, full junctions details are included for all major junctions (the simulation network), while outside Dublin County, junctions details are not included (the buffer network). HGV routings are coded as part of the highway network.

The bus network contains details of all Dublin Bus, Bus Eireann and private operator bus services operating within, into and out of the GDA. Quality bus corridors and bus priority measures are included as part of the highway network, and in the simulation area their impact on junction capacity is coded.

The rail network contains all Iarnrod Eireann services operating in and out of the GDA. Existing and future LUAS and Metro lines and services are coded in the model as part of the rail network.

Sections of the road, and public transport networks as coded in the model are shown in Figures 2a and 2b below.

Travel Demand: In the case of both the am-peak and off-peak models, travel demand is broken down by six journey purposes – i.e. Work (commuting), Education, Employer's Business, Shopping, Other and Non Home Based. Travel demand is further segmented by two person types – i.e. those with a car available for their trip (Car Available), and those without a car available for their trip (Car Not Available).

Figure 1 – Modelled Area and Model Zoning

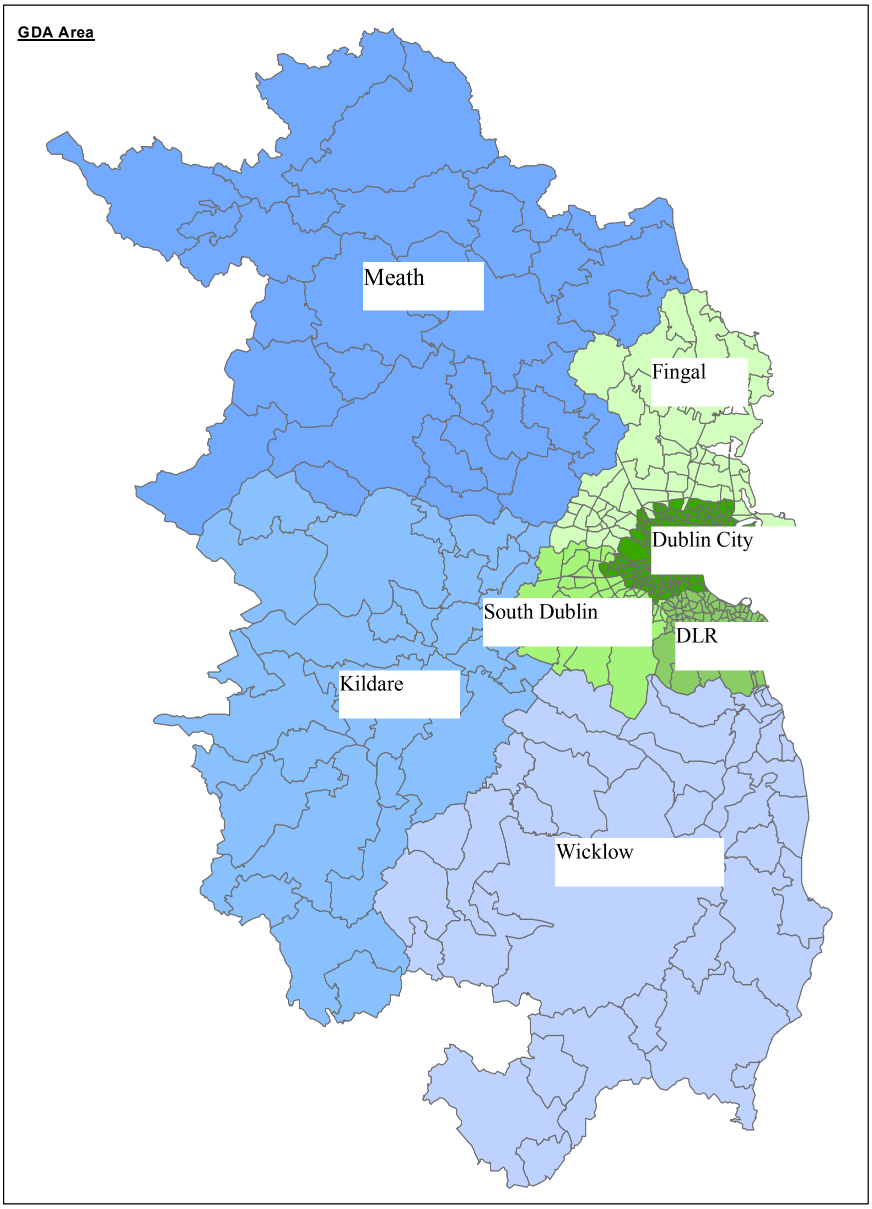


Figure 2a – Section of the Road Network as coded in the GDA Transport Model

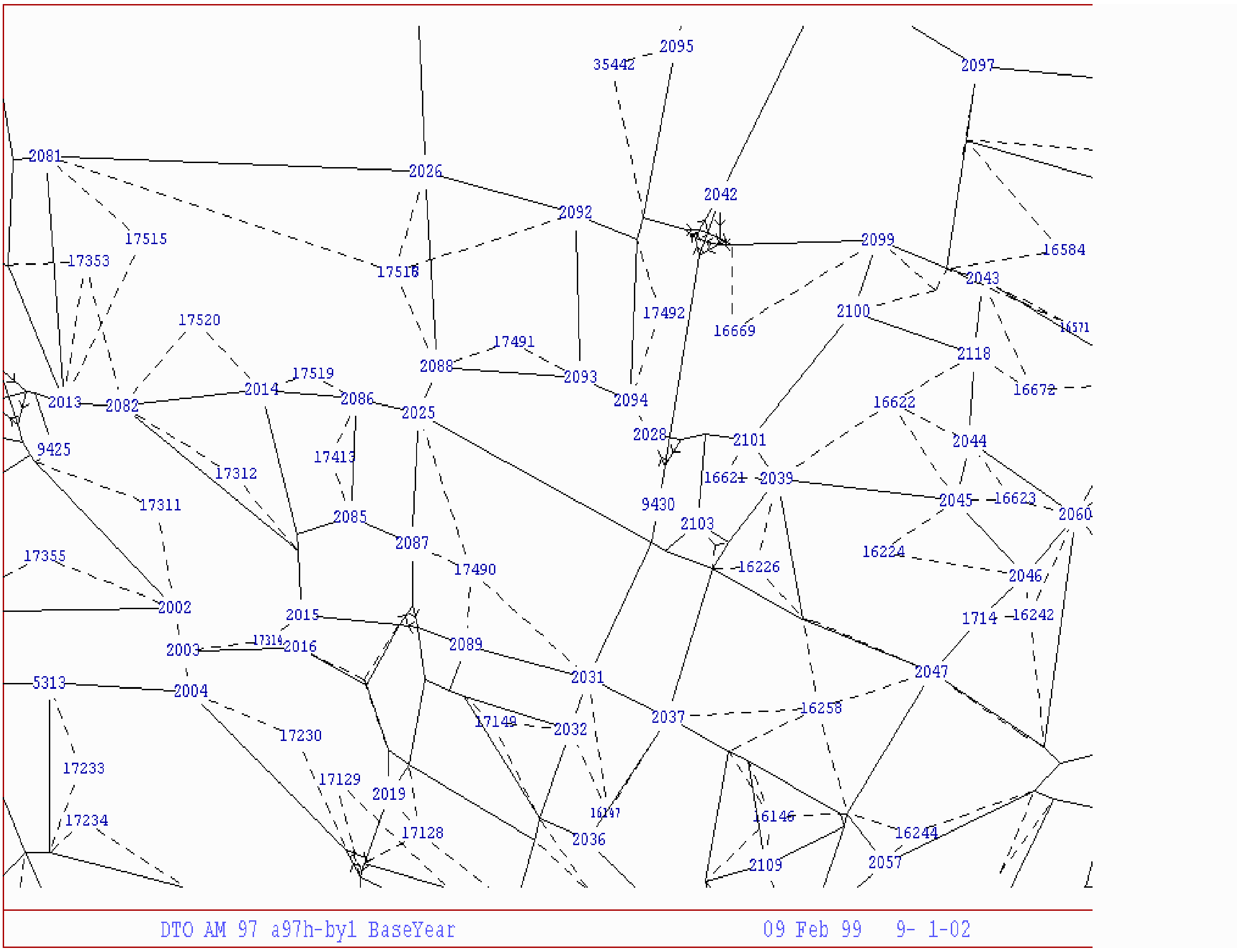
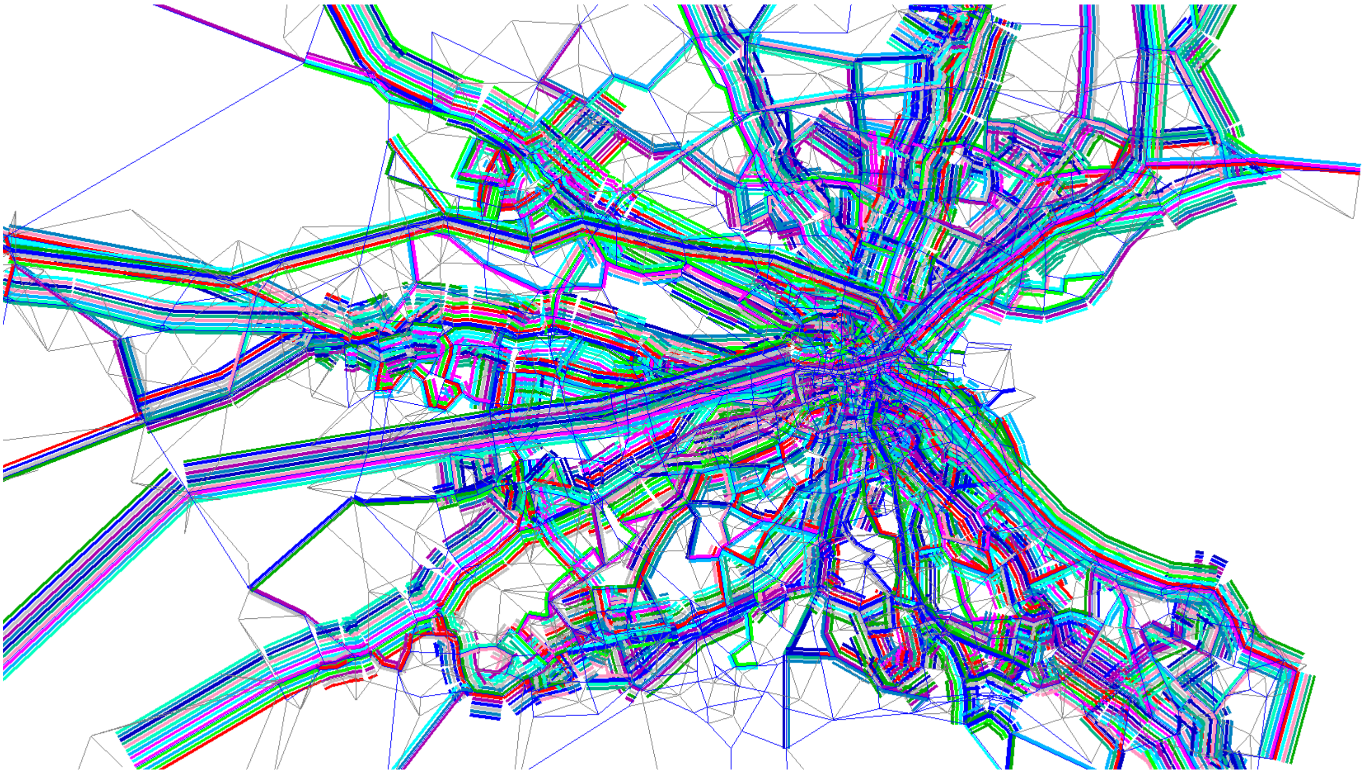


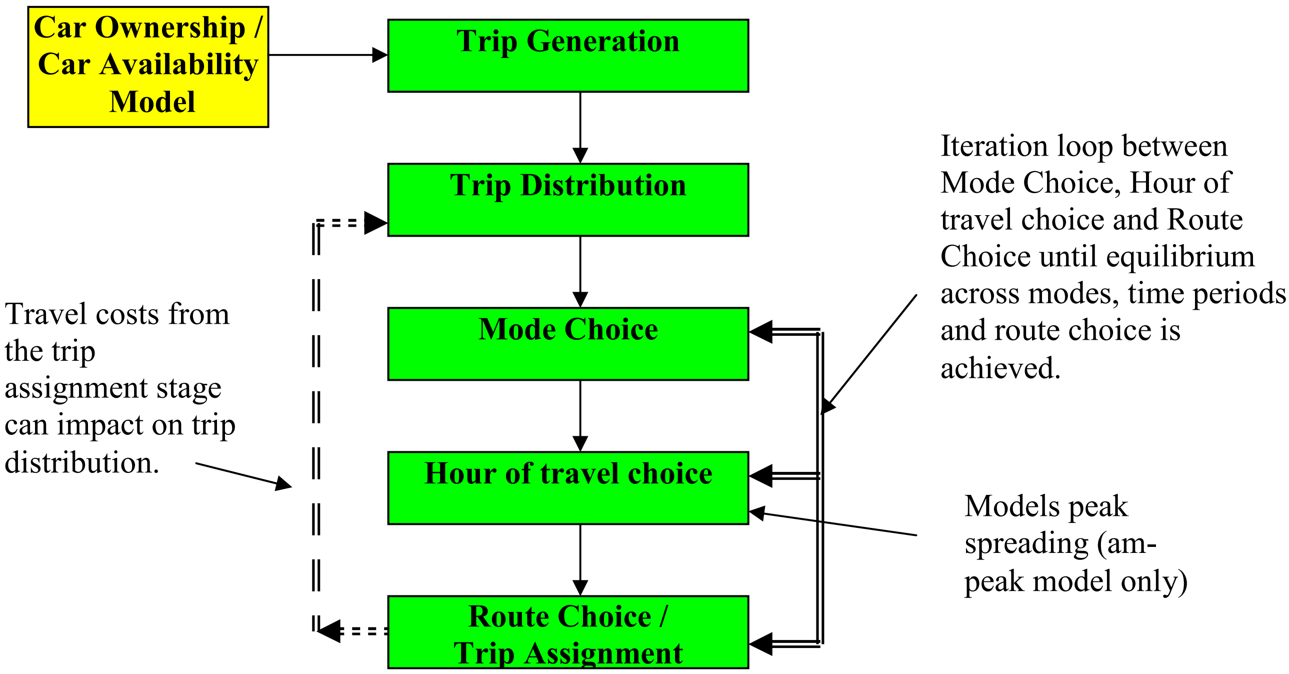
Figure 2b – Section of Public Transport Network – coded in GDA Transport Model



2.3 *Model Structure*

The am-peak and off-peak models have similar structures and components. While the off-peak model follows the classic 4-stage model, the am-peak model incorporates an additional stage – called hour of travel choice. This is used to model the impacts of peak spreading where people decide to depart at an earlier (or later) time to avoid congestion or crowding during the morning peak. The structure of the am-peak model is shown in Figure 3 below:

Figure 3 – Structure of am-peak Model



In practice, though the different model components are run in the sequence shown in Figure 3, they are not run in isolation from each other. In particular, the model includes an iterative feedback loop between the mode choice, hour of travel choice and route choice stages. Iteration proceeds until an equilibrium is achieved across travel modes, hour of travel and route choice.

In addition, the am peak model has a facility to feed back travel costs (calculated during the route choice stage of the model) to the trip distribution stage to test the impact of travel cost changes on travel patterns. However, this feedback loop is an optional feature that was not invoked in the version of the model used to develop the Draft GDA Transport Strategy.

The off-peak model has a similar structure – but does not include the hour of travel choice stage. This is because only a single off-peak hour is modelled, and network congestion and overcrowding during the off-peak hour does not in general cause people to re-time their trip to a different hour.

Both am-peak and off-peak models incorporate a separate Car Ownership & Car Availability sub model, the outputs of which feed into the trip generattion stage of the main model. The purpose of the car ownership & car availability model is to split trip makers into two groups as follows:

- Those with a car available for their trip,
- Those without a car available for their trip.

2.4 *Model Components / Stages*

This section describes each of the model components / stages shown in figure 3 above. It should be noted that a full technical description of the first two model stages - trip generation and trip distribution - is contained in the report:

"TAGM_TDM Final Report – Final report on the updating of the Trip Generation, Attraction and Distribution Models".

Hence, this section describes the Trip Generation and Trip Distribution stages in summary form only, while also describing the other three model stages.

2.4.1 Trip Generation

This stage of the model refers to the estimation and prediction of the number of trips that will be generated by each model zone and the number of trips attracted to each model zone in any given modelled time period – i.e. the trip generation stage refers to both trip generation and trip attraction.

The Trip Attraction & Generation Model (TAGM) is a sub model of the NTA's transport model that has been developed within the OmniTrans modelling software package. The first step undertaken by the TAGM is to calculate all-day trip rates for the GDA population. To do this, the model uses a number of important datasets as follows:

- 2006 Census travel to work data (POWCAR),
- 2006 GDA travel to education survey,
- 2006 GDA household survey,
- 2006 CSO small area population statistics (SAPS).

These datasets enable the TAGM to relate 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 remain constant over time, when all trips and all modes of travel are included. Hence, once the TAGM has calculated observed trip rates for 2006, it can then apply these to zonal population and land use forecasts for any future year to predict the trips that will be generated by each zone in that year.

In calculating trip generation rates for each zone, trips are classified by the following (home-based) trip purposes:

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

Tips rates are also calculated for Non Home Based (or intermediate) trips.

In addition to calculating trip rates for the population as a whole within each zone, the TAGM also calculates trip rates for various sub sections of the population as follows:

- Employment Group – split into:
    - Full Time
    - Part Time
    - Retired
    - 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
    - SEG3 – Farmers & Agricultural Workers, All other gainfully occupied and unknown.
- Car Availability – split into:
    - Car Available
    - Car Not Available.

In calculating all-day trip rates for the different journey purposes and different segments of the population, the TAGM uses observed travel behaviour from the 2006 GDA household survey.

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". A section of the "Planning Sheet" is illustrated in Figure 4 below and is in the form of an Excel spreadsheet containing 18 predictive land use variables (only 10 of these are shown) for each of the 657 modelled zones. These predictive variables are the drivers of travel demand, and the most improtant ones are:

- Population (broken down by employment and socio-economic groupings),
- Employment (the number of jobs in each zone),
- Education places (split into Primary & Secondary and Tertiary education places),
- Retail floor space (the number of sq. m. of retail floor space in each zone).

Figure 4 – section of the "Planning Sheet" – the main input to the TAGM

Model Zone	Zone Name	Zone Area	O_Area Type	D_Area Type	Pop Total	SEG1 %	SEG2 %	SEG3 %	Emp FullTime	Emp PartTime	Retired
1	11101	143090	22	4	1,761	55.66	32.97	11.37	836.99	157.50	224.47
2	11103	2404723	20	8	38	46.33	40.10	13.58	16.65	2.74	3.83
3	11104	392480	22	1	596	46.33	40.10	13.58	261.33	42.88	60.07
4	11105	587195	22	3	5,722	58.25	31.15	10.60	2508.64	411.57	576.69
5	11106	379102	22	1	4,607	58.25	31.15	10.60	2022.47	331.95	464.80
6	13101	76494	31	6	879	33.51	42.90	23.58	324.24	89.75	50.23
7	13102	84536	31	5	1,252	33.51	42.90	23.58	461.72	127.80	71.53
8	13103	138069	31	1	1,867	33.51	42.90	23.58	689.13	190.74	106.75
9	13111	118605	31	1	1,683	35.86	46.20	17.94	754.72	115.53	78.62
10	13112	105131	31	1	2,322	35.86	46.20	17.94	1041.37	159.41	108.48
11	13121	42856	21	1	924	59.50	28.73	11.77	512.51	57.45	48.96
12	13122	86847	21	1	377	46.25	36.69	17.06	209.20	23.45	19.98
13	13123	118184	21	1	1,110	59.50	28.73	11.77	615.87	69.03	58.83
14	13124	126467	21	1	1,253	59.50	28.73	11.77	695.19	77.93	66.42
15	13125	79473	21	4	987	59.50	28.73	11.77	547.29	61.35	52.28

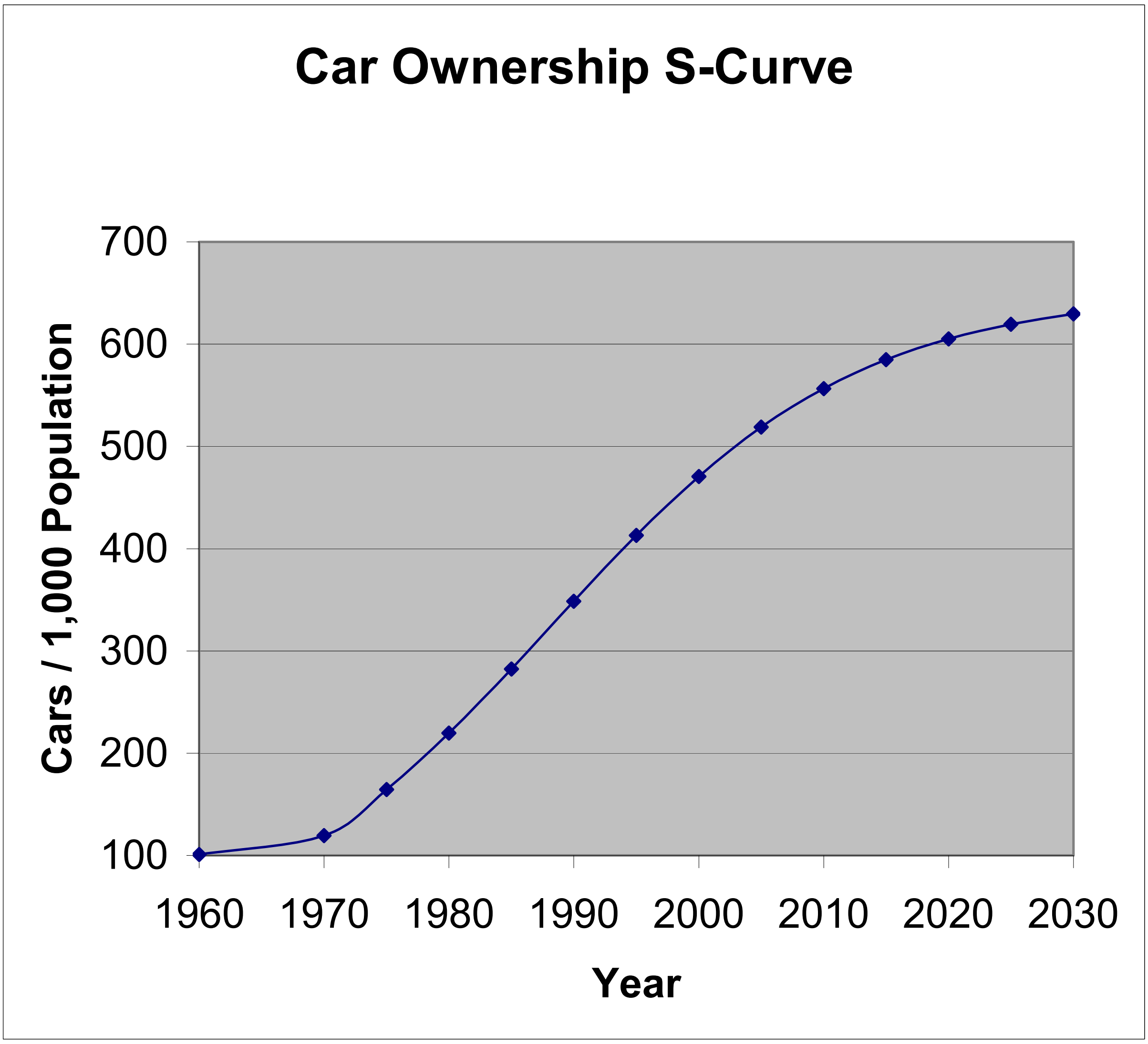
Car Ownership / Car Availability Model

The availability of a car is also a significant determinant of a person's travel behaviour, and in particular has a major impact on the mode of transport they will 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 as shown in Figure 5 below. The curve shows vehicle density (expressed as the number of cars owned per 1,000 population) on the Y-axis, plotted against time in years on the X-axis. 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.

Figure 5 – Car Ownership S-Curve



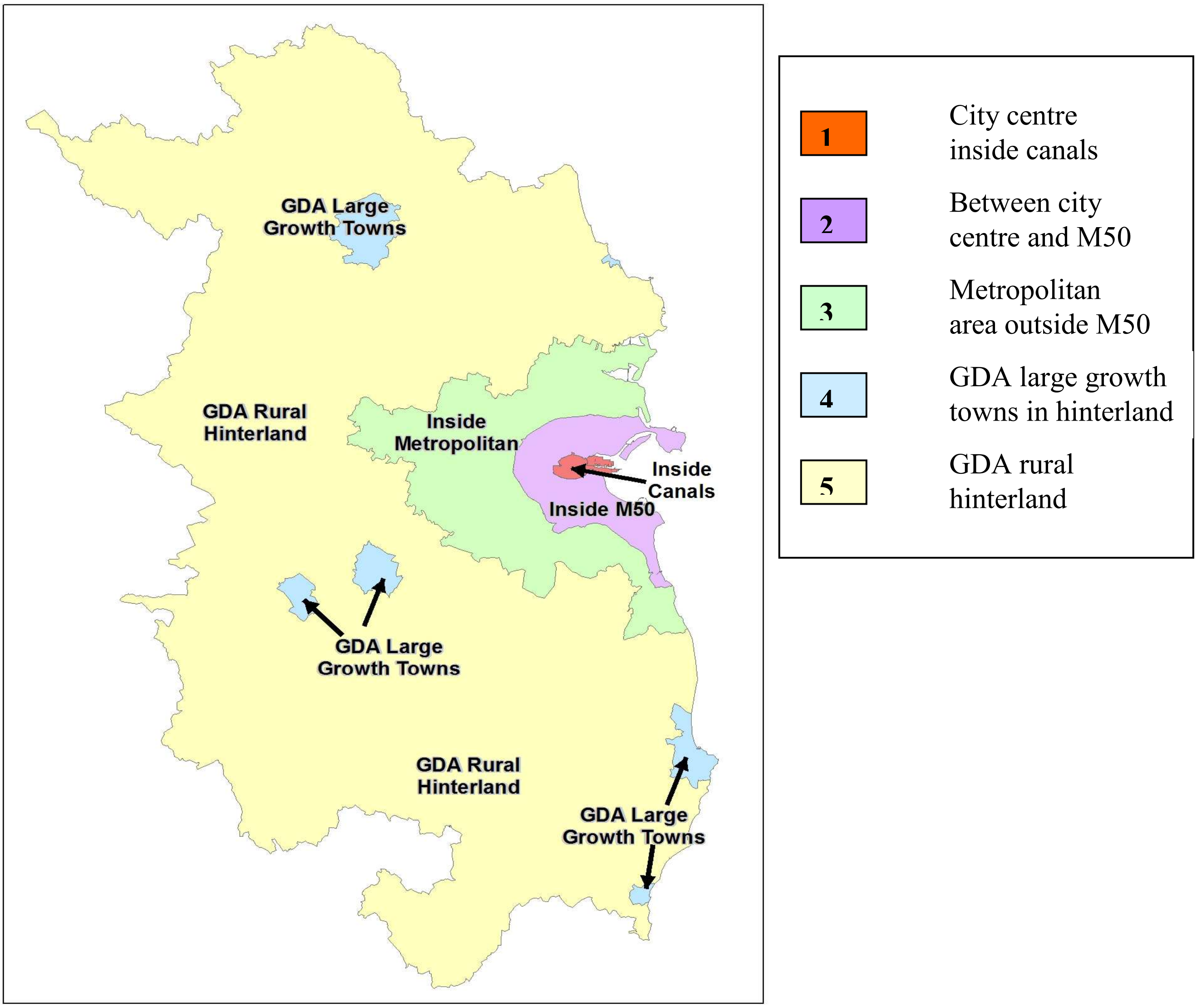
Analysis of historic car ownership trends in the GDA shows that levels of ownership vary significantly depending on:

- 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).
- Socio Economic Group (Managers and Higher professional workers in general have higher levels of car ownership than semi skilled or unskilled workers).

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 6 below.

Figure 6 - GDA 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 in each modelled zone – i.e.

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%

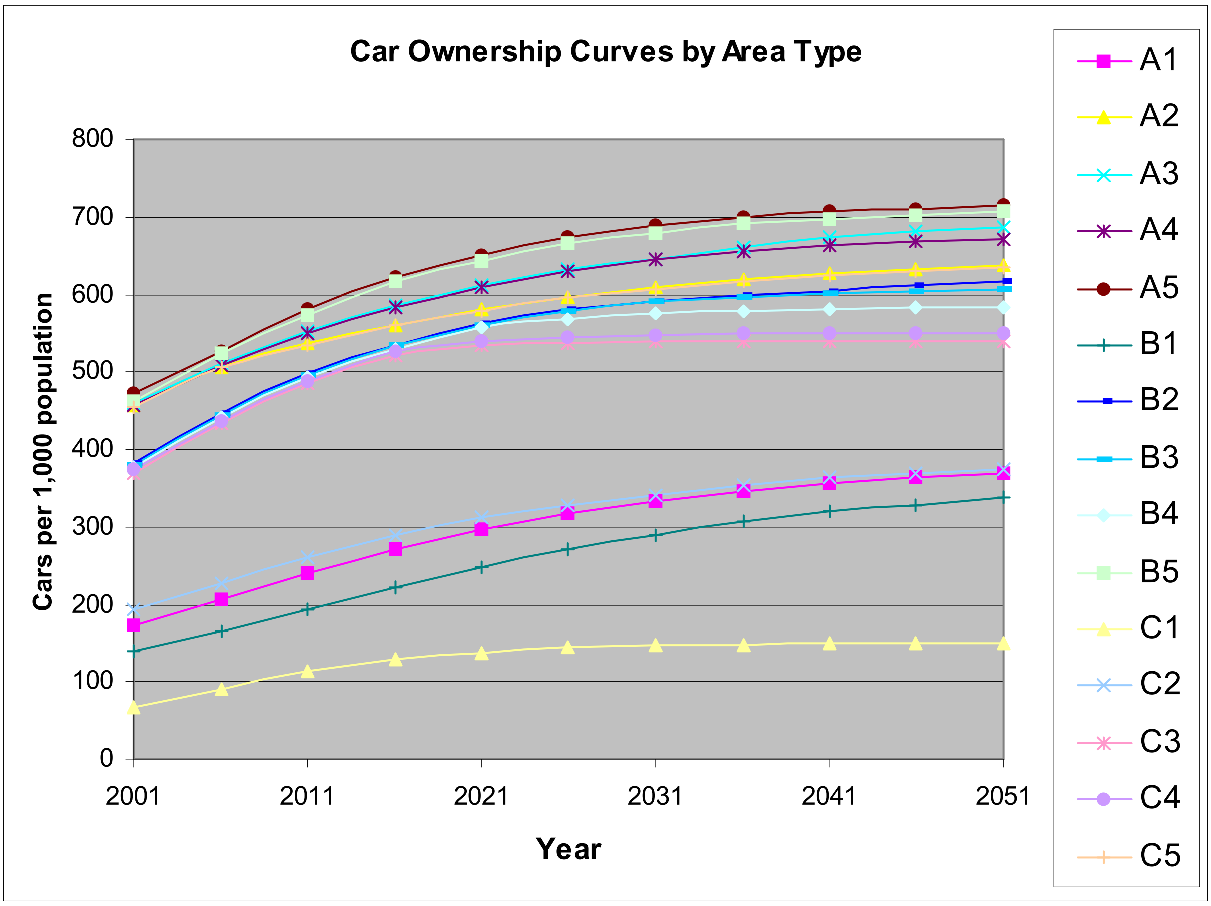
The combination of the area bands and socio-economic groupings gives the 15 different area types that are used to define the Car Ownership Model for the GDA - these area types are listed in Table 1 below:

Table 1 – Area Types used in the Car Ownership Model

Area Band Name	Area Band Description
A1	High AB social class within the City Centre
A2	High AB social class between City Centre and M50
A3	High AB social class in Metropolitan area outside M50
A4	High AB social class in Growth town in Hinterland
A5	High AB social class in Rural Hinterland
B1	Medium AB social class within the City Centre
B2	Medium AB social class between City Centre and M50
B3	Medium AB social class in Metropolitan area outside M50
B4	Medium AB social class in Growth town in Hinterland
B5	Medium AB social class in Rural Hinterland
C1	Low AB social class within the City Centre
C2	Low AB social class between City Centre and M50
C3	Low AB social class in Metropolitan area outside M50
C4	Low AB social class in Growth town in Hinterland
C5	Low AB social class in Rural Hinterland

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 illustrated in figure 7 below:

Figure 7 – GDA Car Ownership Curves for 15 Area Types



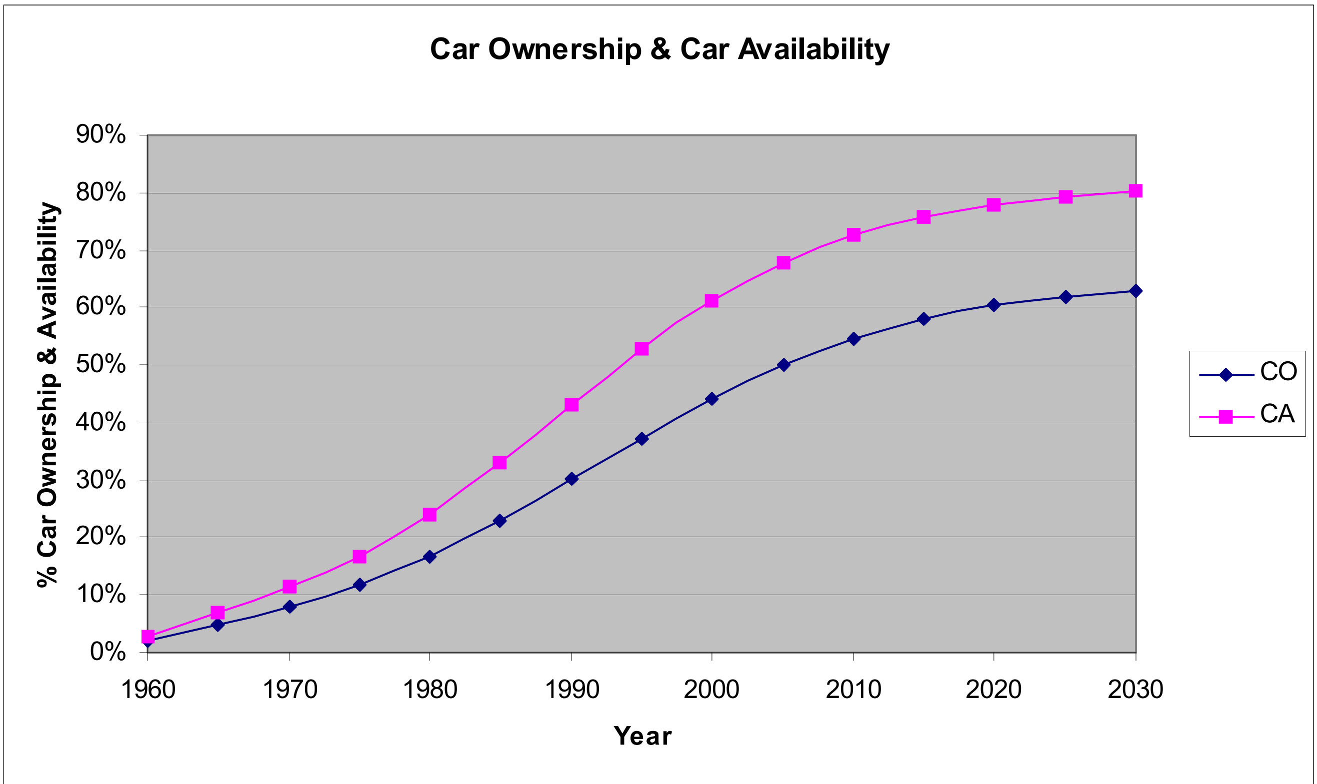
It should be noted from figure 7 that all GDA area types are shown to be in the third phase of the standard car ownership S-Curve – i.e. approaching car ownership saturation levels. However the saturation levels vary greatly by Area Type and are the most significant determinant of the predicted levels of car ownership in each modelled zone in the forecast year .

Car Availability

Car ownership data for the GDA is readily available from the CSO Census data over a number of years and hence it is relatively straightforward to track trends and derive forecasts based on these trends. 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. One specific example of this relationship is shown in figure 8 below:

Figure 8– Car Ownership and Car Availability



The graph in figure 8 shows that levels of car availability generally exceed levels of car ownership – reflecting the fact that average car occupancy levels are 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 purpose. This enables the COM to output % car availability rates for each of the six journey purposes for different times of the day.

The outputs 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,
- Those without a car available for their trip.

In addition to calculating trip generation rates for different segments of the population, the TAGM also derives zonal trip attraction rates based on the main zonal land use variables (i.e. Jobs, Education Places and Retail Floor Space). However, trip attraction rates are not assumed to be correct in absolute terms – but are rather taken to represent the relative attractiveness of one zone relative to another in attracting trips for a given journey purpose.

Following the derivation of trip generation rates for different segments of the population and trip attraction rates related to the zonal land use variables, the TAGM applies these trip rates to the forecast year planning sheet to derive sets of all day trip attraction and trip generation forecasts for each journey purpose broken down by car available and car not available segments. The final step undertaken by the TAGM is to balance trip generations and attractions (assuming total trip generations are correct in absolute terms), and output the resultant trip generation and attraction vectors to the trip distribution model described below.

2.4.2 Trip Distribution

The purpose of the Trip Distribution Model (TDM) is to determine the pattern of trips between the sets of trip generations and trip attractions (called trip ends) produced by the TAGM. The TDM is a sub model of the GDA transport model and is also implemented using the OmniTrans software package. Its function is to determine to what zones the trips generated at any particular origin will travel. 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. A sample section of such a matrix output is illustrated in figure 9 below.

Figure 9 – Sample trip matrix (first 10 origins and destinations only shown)

Generations

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**…**	**…**	**…**	
1	1	30	0	0	12	0	4	20	12	0…	…	…	**1,245**
2	2	1	2	30	400	0	1	3	1	0…	…	…	**3,425**
3	30	2	1	2	100	2	0	4	0	4…	…	…	**741**
4	80	30	2	1	20	4	0	1	0	1…	…	…	**201**
5	5	400	100	20	1	2	30	5	0	0…	…	…	**6,425**
6	20	0	0	500	2	0	4	9	0	7…	…	…	**2,564**
7	4	1	2	20	14	0	4	1	2	4…	…	…	**121**
8	2	1	5	1	12	0	1	4	0	2…	…	…	**65**
9	0	1	1	4	12	0	0	4	0	1…	…	…	**1,026**
10	0	8	4	3	4	1	0	0	0	0…	…	…	**348**
:	:	:	:	:	:	:	:	:	:	:…	…	…	**:**
:	:	:	:	:	:	:	:	:	:	:…	…	…	**:**
:	:	:	:	:	:	:	:	:	:	:…	…	…	**:**
	421	**1,056**	**745**	**2,365**	**7,541**	**89**	**324**	**412**	**154**	**231**	**…**	**..**	**…**	**324,156**

Attractions

Matrix Total

In addition to using the forecast year trip ends as output from the TAGM, the TDM also uses known calibrated trip distributions from the base year. These distributions are based on observed travel patterns from the GDA household and education surveys and the POWCAR travel to work dataset. The travel patterns represented by the base year matrices are also tested and calibrated in the GDA transport model to ensure that when assigned to the transport networks, the model outputs match closely to observed network characteristics (in terms of traffic flows and journey times). This process - known as base year model calibration – is described later in section 3 of this technical note.

The calibration of the base year model also generates base year travel costs that can (optionally) be fed back into the TDM to impact on travel patterns. However, this feedback mechanism was not employed in the version of the model used to develop the GDA Transport Strategy.

In summary, the TDM uses the following inputs:

- All day forecast year Trip Generations and Attractions from the TAGM,
- Base year trip distribution matrices for the am-peak and off-peak periods.

Each of these essential inputs are broken down by six journey purposes and segmented by car available and car not available persons.

The TDM uses a combination of two methods to derive forecast year travel patterns in the form of 666 x 666 trip matrices for each modelled time period:

Factoring: Where well established trip patterns exist in the base year, this pattern is retained and simply factored up to the new forecast year trip generations and attractions.

Sectoring: As explained in section 2.2, 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.

In addition to using Factoring and Sectoring, the TDM can also (optionally) use the travel costs that are output during the route choice / trip assignment stage of the model to influence travel patterns in the forecast year. If this option is chosen, the TDM uses a form of "gravity model" 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.

The Gravity Distribution is based on the Newton's gravitational formula, and in modelling trip distribution takes the form:

$$\mathbf{T_{ij} = O_i \,.\, D_j \,.\, f(C_{ij})}$$

Where $\mathbf{T_{ij}}$ is the number of trips between origin **O** and destination **D**. $\mathbf{O_i}$ is the total trips generated at origin **O** and $\mathbf{D_j}$ is the number of trips attracted to destination **D**. $\mathbf{f(C_{ij})}$ is called the deterrence function based on the cost of travel between **O** and **D**. The TDM uses a log-normal form of the deterrence function as follows:

$$\mathbf{f(C_{ij}) = EXP(\lambda \,.\, C_{ij})}$$

Where λ is a measure of people's sensitivity to travel costs.

It should be noted that in the version of the model used in developing the GDA transport strategy, the TDM uses a combination of Factoring and Sectoring only to produce forecast year trip matrices. Gravity distribution was not used as there was no historical data available to show the impact of travel costs on travel patterns over time and hence give a robust calibration of the Gravity Model.

The outputs from the TDM are in the form of trip matrices (666 x 666) for each of the six journey purposes divided by 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.

2.4.3 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 together iteratively in a feedback loop until an equilibrium position is achieved. The structure of this loop is shown diagramatically in figure 10 below. The mode choice and hour of travel choice stages are replicated for each of the six 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.

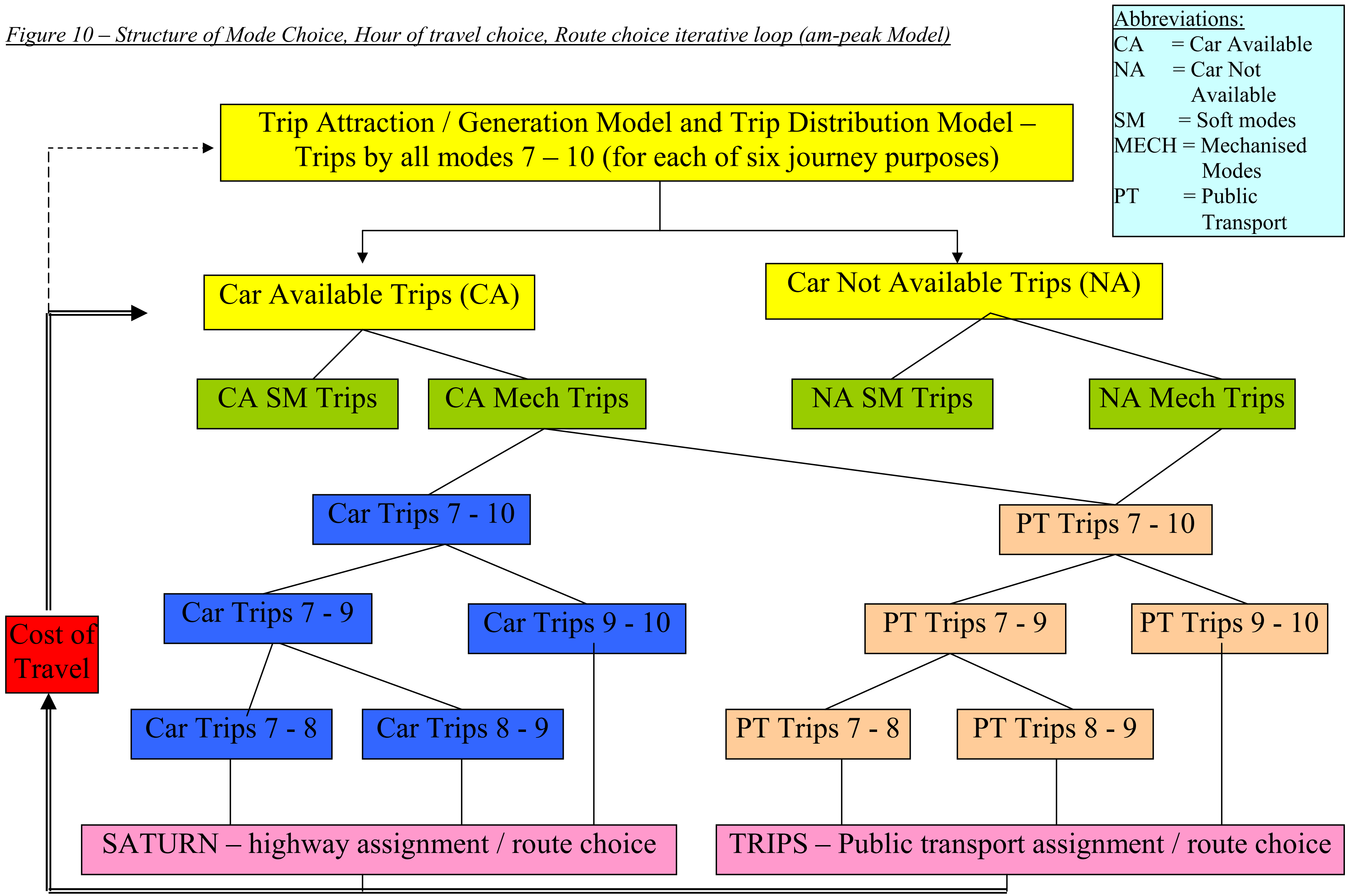
The feedback loop shown in figure 10 begins with the mode choice stage whose function is to split trips into the different modes of travel - i.e. Car, Public Transport and Soft Modes (walk & cycle). Following this, the hour of travel choice stage further splits trips into the three modelled hours (this stage is run for the am-peak model only where the three hour period 7 to 10 is modelled). In the final stage of the feedback loop, car and public transport (PT) trips are assigned to their respective transport networks. In this final stage, trips are assigned to specific routes (on either the highway or PT network) 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 coice stage of the model to begin the loop again.

It should be noted that trips by soft modes (walk & cycle) 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 an equilibrium position is achieved. This equilibrium is based on the premise that all trip makers wish to mimimise their cost of travel, through the most cost efficient choice of mode, hour of travel and route. The point of equilibrium corresponds to a scenario where no trip maker can lower his / her cost of travel by switching either mode, hour of travel or route.

The three model stages in this feedback loop are described further below.

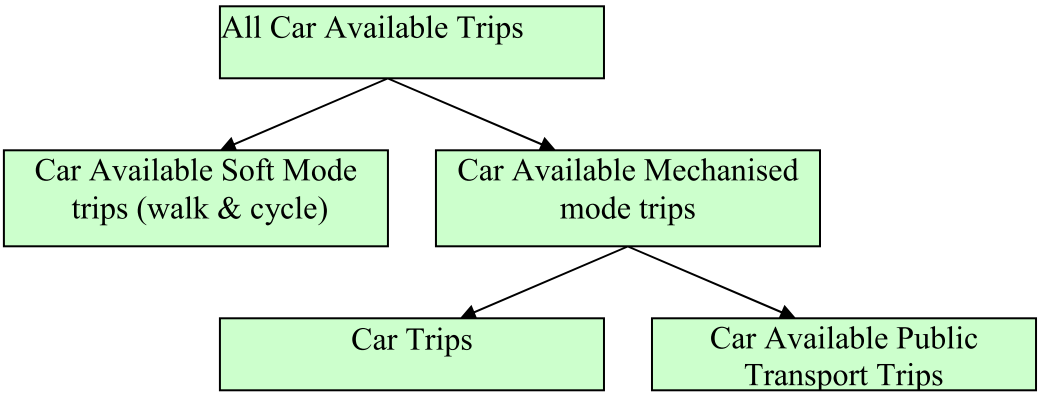
Figure 10 – Structure of Mode Choice, Hour of travel choice, Route choice iterative loop (am-peak Model)



2.4.4 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 sturcture of the mode choice model for car available trips is shown in figure 11 below. The model is hierarchical - with the top level choice between travel by soft modes (walk & 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 soft modes and trips by public transport.

Figure 11 – Hierarchical Mode Choice for Car Available Trips



General for of mode choice mode

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 the model is to predict the percentage of trips that will opt to use each mode, given the relative costs of travel by each. To do this, the model uses a so-called "logit" formulation of the form:

$$\mathbf{P_1 = 1/(1+EXP(-\lambda\Delta C))}$$

Where $\mathbf{P_1}$ = the percentage of trips that will travel by mode 1,
ΔC = the difference in cost of travel by mode 2 and mode 1 = $\mathbf{C_2 - C_1}$,
λ = a measure of people's sensitivity to changes in travel costs.

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:

$$\mathbf{P_2 = 1 - P_1}$$

In practice, two forms of "logit" 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 patters 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).

2.4.5 Hour of travel choice

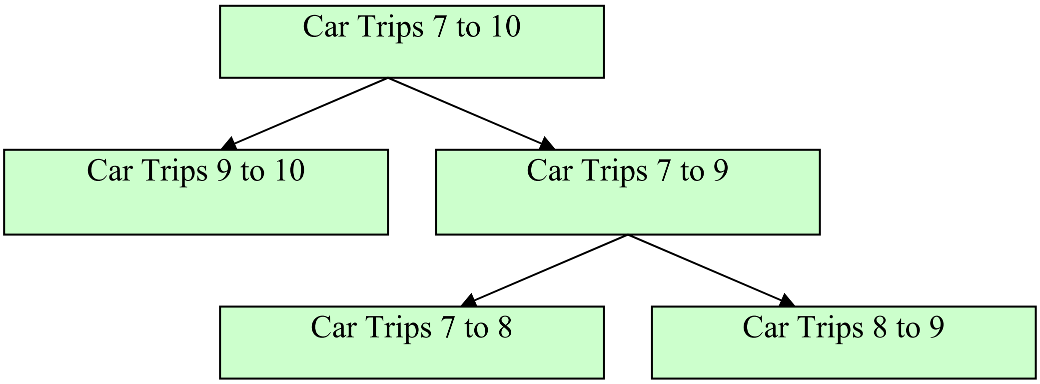
The am-peak model includes an addition stage to the traditional 4-stage transport model. This stage, known as "hour of travel choice", is executed following the mode choice stage and captures the phenomenon of peak spreading as a response to congestion. This stage is not included in the off-peak model, where peak spreading is not considered to be an issue.

In the am peak, the trip matrices that are the main input into the mode choice, hour of travel choice and route choice stages of the model incorporate trip by all modes for the three hour period 7 to 10. As explained above, the mode choice stage splits these matrices by mode of travel (Car, Public Transport and Soft Modes). Following the mode choice stage, the purpose of the "hour of travel choice" model is to split these trips 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 Soft 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.

The structure of the hour of travel choice model (for trips by Car) is shown in figure 12 below. Like the mode choice model, it 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.

Figure 12 – Hierarchical hour of travel choice (for Car Trips)



The hour of travel choice stage is executed using the same "logit" formulation as the mode choice model. In addition, as in the case of mode choice, 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 – for the single modelled hour (2 to 3) for each of the journey purposes. These trip matrices are then assigned to the respective transport networks (highway and public transport) in the route choice stage of the the model. This is the final stage of the model, and is described below.

2.4.6 Route Choice / Trip Assignment

The final stage of the modelling process is the "route choice" or "trip assignment" 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. Car trips are assigned using the SATURN software, while public transport trips are assigned to the combined bus and rail network using the TRIPS / CUBE software.

SATURN assignment

In the case of SATURN, the goal of the assignment 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.):

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

Where,

$\mathbf{C_{car}}$	= 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.)

In urban road networks (as in the GDA), where traffic congestion has a significant impact on people's perceived cost of travel, travel time tends to have a much higher weighting than vehicle running costs (i.e. α will be much greater than β). This would not be the case in rural / uncongested road networks where travel distances tend to be longer and vehicle running costs are a significant proportion of the overall cost of travel.

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.

SATURN undertakes a number of route assignments in an iterative fashion with the goal of minimising travel costs for all trips on the highway network. Following each iteration of trip assignment, SATURN undertakes a detailed simulation of traffic flow through junctions on the selected route / routes – where these junction details are coded in the simulation area. This means that in calculating travel costs, SATURN explicitly includes the travel time cost of delays caused by traffic congestion at junctions. In the parts of the network that are in Buffer (outside Dublin County), SATURN relies on the use of flow-delay curves that relate travel costs to link characteristics and the volume of traffic on each link.

PT assignment using TRIPS / CUBE

The assignment of public transport trips is undertaken using the TRIPS / CUBE software. However, highway link travel times are passed from the SATURN assignment and used in the calculation of bus travel costs. In undertaking public transport route choice, the TRIPS / CUBE software uses a logit type choice formulation 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, LUAS, Metro etc). The generalised cost of travel by public transport has a number of components that can be represented as follows:

$$\mathbf{C_{PT} = a_1.t_{wk} + a_2.t_{wt} + a_3.t_{iv} + a_4.t_{ic} + a_5.F + a_6}$$

Where,

$\mathbf{C_{PT}}$	=	the generalised cost of travel by public transport
$\mathbf{t_{wk}}$	=	walking time to access public transport node (i.e. bus or rail station)
$\mathbf{t_{wt}}$	=	waiting time at public transport node (= half the PT service headway)
$\mathbf{t_{iv}}$	=	in vehicle time
$\mathbf{t_{ic}}$	=	interchange penalty
F	=	fare charged
$\mathbf{a_1 \ldots a5}$	=	weightings to be applied to the different elements of PT travel costs
$\mathbf{a_6}$	=	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 in TRIPS / CUBE are represented in time units (i.e. minutes), the weighting $\mathbf{a_5}$ 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 – described later in section 3.

Following the assignment stage, SATURN and TRIPS / CUBE pass back the assigned travel costs 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 equilibrium of trips and travel costs is achieved, at which stage the model run terminates. At the stage of equilibrium, it is not possible to reduce the cost of travel for any individual trips by a change of travel mode, travel time or route.

2.5 Other Model Functionality

In addition to the main model components / stages as described above, the GDA transport model incorporates additional functionality that allows it to simulate other travel behaviour and responses to different transport interventions. These are described briefly below:

2.5.1 Handling other travel modes

In addition to dealing with trips by Car, Public Transport, Walking and Cycling, the GDA transport model also includes trips made by:

- Heavy Goods Vehicles (HGV's)
- Park and Ride (PNR)

The manner in which the model treats trips by these two modes is described below:

Heavy Goods Vehicles

Within the GDA transport model, heavy goods vehicles (HGV's) 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 (described later in section 3). 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 by SATURN to the highway network as a separate user class and simultaneously with the assignment of car trips.

The highway network for HGV's 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 HGV's retain a permit to make deliveries to city centre locations. In the model, HGV's with a city centre permit are treated as a separate vehicle class in SATURN and assigned to a network that does not include the blanket city centre HGV ban.

Park and 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 using SATURN,
- part 2 is a public transport trip from the park and ride site to the trip destination using the dedicated PT service, and this part of the trip is assigned to the PT network using TRIPS / CUBE.

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.

2.5.2 *Capturing the impact of travel demand management measures*

The impact of various travel demand measures can be captured within the GDA Transport Model and affect people's mode choice, hour of travel choice and route choice. The manner in which various demand management measures are modelled is described below:

Traffic tolling

Point tolls are converted to equivalent time penalties (using the model's value of time), and the appropriate time penalty is applied to the coding of the highway link in the model that contains the tolling point. Hence, in the Saturn assignment, all trips passing through the modelled link incur a time penatly equivalent to the toll amount.

Cordon charge

In the case of a cordon charge, all links that cross the cordon are identified and time penalties (equivalent to the cordon charge) are applied / coded to these links.

Area charge

In the case where a charge is applied to all car trips with origins or destinations within a specific area, the model separates out these trips as a separate user class of highway trips. This user class will have its own matrix of travel costs following the Saturn assignment, and the model adds a time penalty (equivalent to the area charge) to the these travel costs in advance of the mode choice and hour of travel choice stages of the mode.

Road user charge (based on travel distance)

Where road user charges are applied to car trips (i.e. a charge per km travelled), the model adjusts the standard operating costs of car trips within the Saturn coding to add in the additional charge.

Parking restrictions

Where parking restrictions / limits are placed on car trips with destinations in certain zones (e.g. within the city centre), the model applies a zonal destination charge to these trips prior to the mode choice stage. The magnitude of the charge / time penalty is iteratively adjusted until the number of car trips (following the mode choice stage) with destinations in the specified zones is within the specified parking cap.

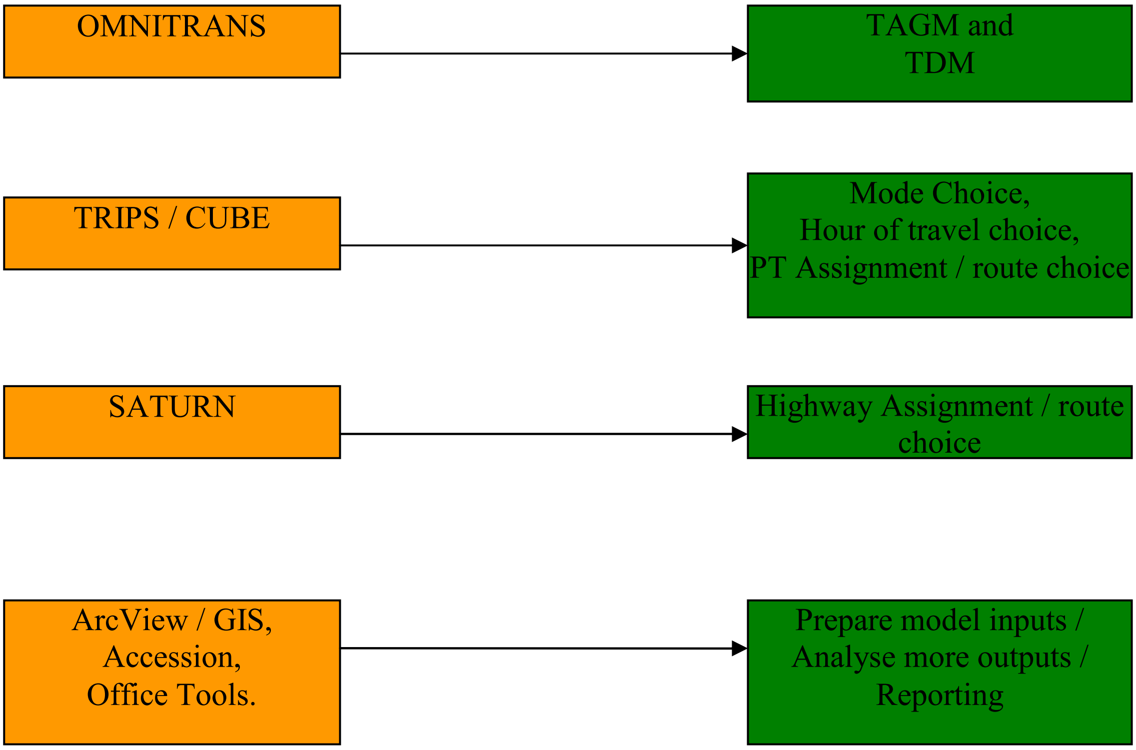
Destination charge

Charges for car trips with destinations in certain zones (e.g. 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 / limit 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.

2.6 Model Software Used

The different software packages used for different stages of the GDA transport model are shown diagramatically in figure 13 below. In addition to the main modelling software packages used to execute runs of the model, a range of display, analysis and reporting tools are used to prepare model inputs and analyse its outputs.

Figure 13 – Software packages used



3. Update and calibration of am-peak and off-peak models

3.1 Purpose of the model update

A major update of the GDA transport model began in spring 2008. The main purpose of the model update was to:

- Rebase and recalibrate the model to 2006 - basing it on the most up to date travel and demographic data from the 2006 Census and also travel data from the GDA Household and Education surveys for the same year,
- Ensure that the model would be a suitable tool for transport scenario testing and undertaking a full assessment of the final draft strategy.

In January 2008, the Strategy Steering Group decided to establish a Decision Support Expert Group (DSEG), whose main task was to oversee the model update and approve the final updated model for use in developing the Strategy.

3.2 Travel data collected for model update

In preparation for the model update, a significant volume of travel and other data was assembled in 2007 including:

- Census travel to work data for 2006 (made available from the Central Statistics Office (CSO). This dataset comprises 1.8 million individual travel to work records covering the 26 counties – 800,000 of which refer to trips within the Greater Dublin Area,

- GDA 2006 travel to education survey, comprising 130,000 individual travel to education trips in the GDA and covering trips to Primary, Secondary and Third Level educational establishments,

- GDA 2006 household travel survey, comprising completed weekly travel diaries for 2,5000 households spread throughout the GDA,

- Demographic and land use data from the 2006 Census – including details of zonal population, employment, education places and retail floor space. The population data for each zone is broken down by age, socio-economic group and employment status,

- Extensive traffic count data at sites throughout the GDA and covering the morning peak period (7 to 10), the afternoon off-peak period (2 to 3) and the evening peak period (5 to 6),

- Passenger counts on Bus, Heavy Rail and LUAS services for 2006 covering the morning peak, afternoon off-peak and evening peak periods,

- Journey time surveys for 2006 on all major radial routes into the city centre and on selected orbital routes, undertaken for the am-peak and afternoon off-peak periods.

3.3 Model update tasks

The model update began with a review of the current am-peak model that was based on the 2002 Census and the afternoon off-peak model that was last updated in 2001. The review was undertaken by Steer Davies Gleave consultants and was completed in June 2008. The main recommendations of the model review were:

- The current structure of the am-peak model should be retained with a number of minor changes,
- An extra journey purpose should be added for business trips - undertaken as part of one's daily work,
- The afternoon off-peak model should be rebuilt and re-structured to have a similar structure to that of the am-peak, but without the "hour of travel choice" stage.

Following the model review, the steps required to update the transport model were clear. The main model update tasks are itemised in Table 2 below.

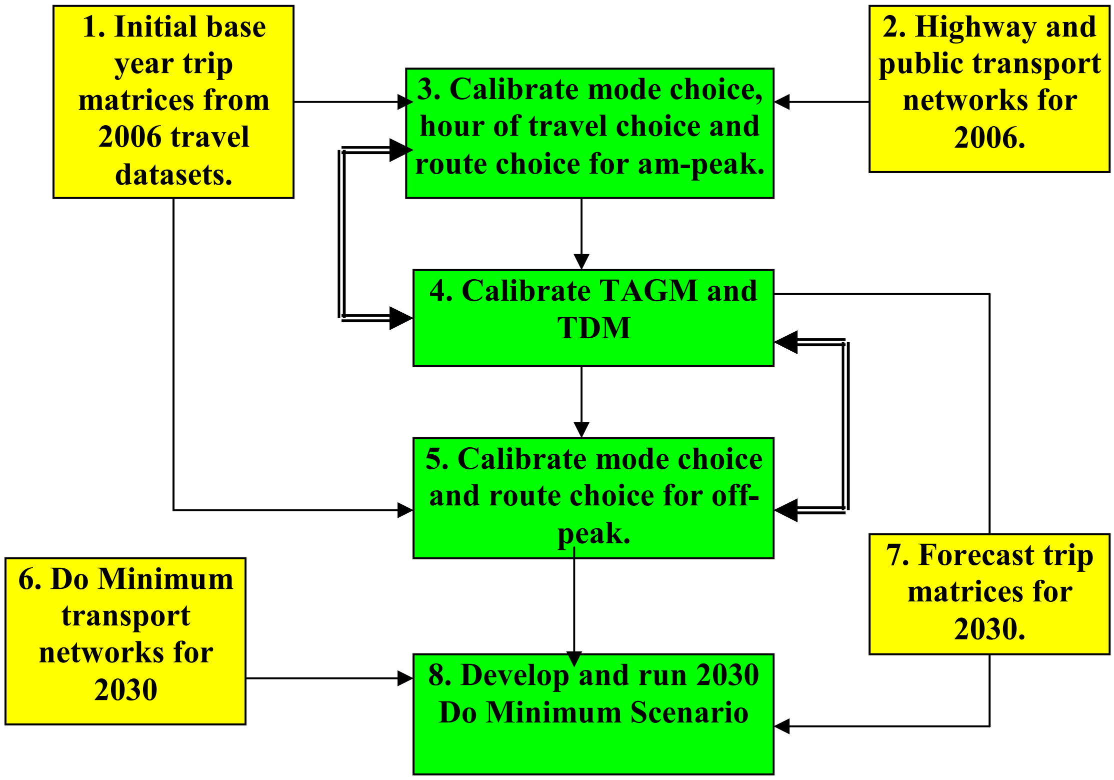
Table 2 – List of Model Update Tasks

Task No.	Task Description	Done By
1.	Extract (initial) 2006 travel demand matrices using data from the available travel datasets.	NTA & Minnerva
2.	Update coding of transport networks in model to 2006 using data from GDA local authorities and public transport operators.	NTA
3.	Calibrate the mode choice, hour of travel choice and route choice components of the 2006 am-peak model.	Steer Davies Gleave
4.	Update and recalibrate the TAGM & TDM and generate 2006 trip matrices for both am-peak and off-peak models.	Minnerva
5.	Calibrate the mode choice and route choice components of the 2006 off-peak model.	Steer Davies Gleave
6.	Code the 2030 Do Minimum highway and public transport networks.	NTA
7.	Agree main land use, economic and demographic forecasts for 2030 and compile a 2030 Planning sheet as intput into the forecast TAGM & TDM. Generate 2030 trip matrices for Am-peak and Off-Peak models.	NTA
8.	Run and test the 2030 Do Minimum scenario using the new Am-peak and off-peak models.	NTA

Note: Items 3 and 4 were undertaken in parallel

Though the model update tasks were in general terms undertaken in the order shown in table 2 above, some tasks had to be undertaken in parallel with significant amounts of iteration / feedback between tasks. The process is shown diagramatically in Figure 14 below.

Figure 14 – Model update tasks



Each of the model update tasks is described in turn below.

Task 1. *Extract initial trip matrices for am-peak and off-peak models*

In order to begin the process of updating and calibrating the am-peak and off-peak models, it was necessary to produce initial trip matrices using the 2006 observed travel datasets. Trip matrices were produced for:

- Six journey purposes (Work, Business, Education, Shopping, Other, Non Home Based),
- Three modelled hours (07:00 to 08:00, 08:00 to 09:00, 09:00 to 10:00, 14:00 to 15:00),
- Five modes of travel (Walk, Cycle, Car, Public Transport, HGV),
- Two user classes (Car available and car not available).

Work trips were extracted using the Census travel to work dataset (POWCAR), while Education trips were extracted from the GDA travel to education dataset. Both these datasets include comprehensive details of trips to work and education including, origin and destination of trips, travel time, mode of travel etc.

In the case of the other journey purposes, the GDA household survey gives similar type data but has too small a sample to give an accurate representation of travel patterns. Hence, in the case of shopping, business and other trips, trip matrices from the 2002 version of the model were used, but were adjusted to agree with trip generation rates for each journey purpose taken from the 2006 GDA household survey.

In the case of trips by HGV, the trip matrices from the 2002 model were used and factored up to 2006 levels of demand using GNP growth data for the intervening four year period.

Data on percentage car availability for the am-peak and off-peak periods for each of the six journey purposes was extracted using the GDA household survey and used to divide trip matrices into the two user categories.

The initial trip matrices extracted in task 1 were the starting point for model update tasks 3, 4 and 5 described below.

Task 2. Update coding of transport networks to 2006

Information on changes to the highway network between 2002 and 2006 was collected from the GDA local authorities, and the major changes to highway links and junctions were added to the 2002 model coding to update it to a 2006 base. In addition, data on changes to public transport routes and services was collected from the main public transport providers and coded into the model. The main public transport change from the 2002 model was the coming into operation of two new LUAS lines – Green and Red lines.

A full set of network coding checks was undertaken as part of the model calibration process described later – hence the focus of the initial network update was to incorporate the major changes to the transport networks in the four year period 2002 to 2006.

Task 3. Calibrate mode choice, hour of travel choice and route choice model for the am-peak

The first priority for the model update was the calibration of the am-peak model (i.e. mode choice, hour of travel choice and route choice components), as this would be the principal analysis tool used to develop and test transport sceanrios for the draft strategy. The off-peak model would be required at a later stage in the full evaluation of the draft strategy.

The calibration of the am-peak model was undertaken by consultants Steer Davies Gleave, and they began this task in mid 2008. The work was undertaken in parallel with task 4 – calibration of the TAGM and TDM components - described later. A detailed account of the process and the final calibration results are included in two technical reports produced by Steer Davies Gleave as follows:

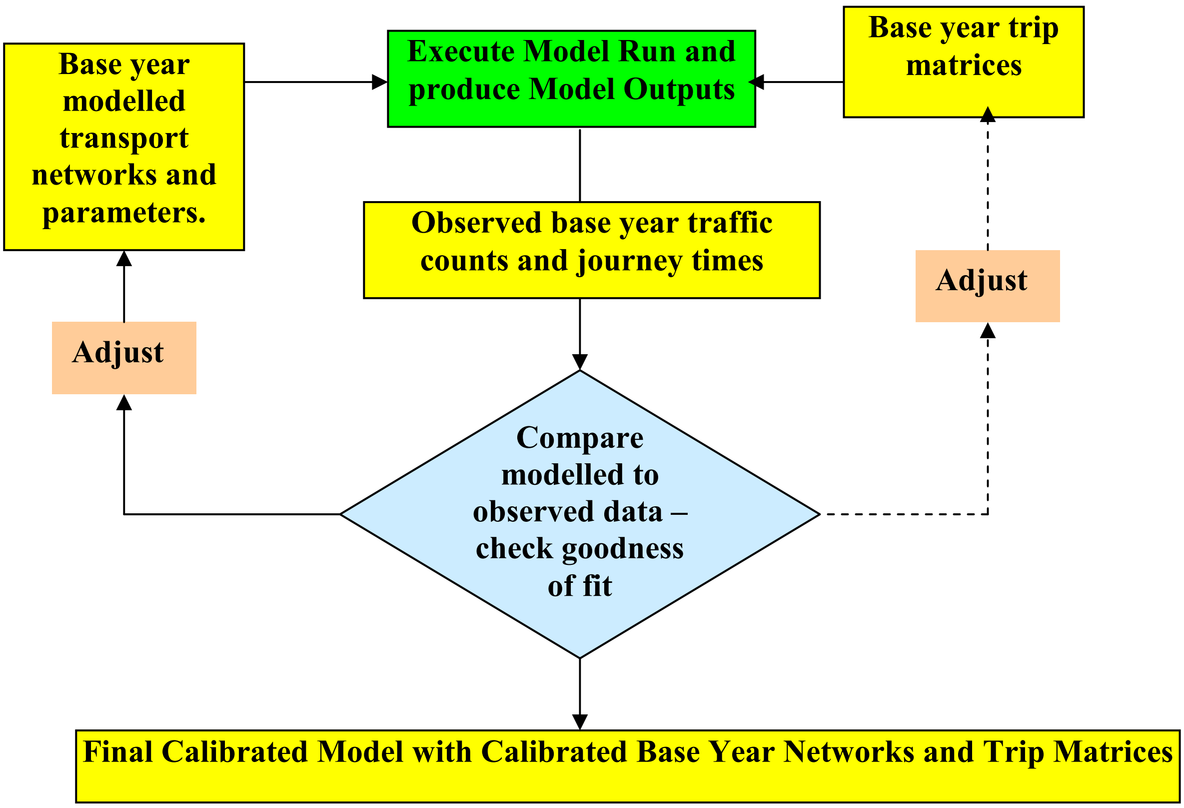
"Calibration of the am-peak highway and PT model",
"Calibration of the mode choice and hour of travel choice model."

In summary terms, the model calibration was an iterative process in which the outputs from the different model stages were compared with observed data to check goodness of fit. Following each iteration, refinements were made to trip matrices, modelled network coding and model parameters until model outputs produced a good match to observed values. The following checks were undertaken for each model component:

Highway route choice:	Check modelled flows against observed traffic counts for cars and hgvs Check modelled journey times against observed journey times
PT route choice:	Check modelled passenger flows against observed passenger counts
Mode choice:	Check modelled mode choice against observed mode choice
Hour of travel choice:	Check the split of trips into the three modelled am-peak hours against the observed split.

In practice, model calibration was a lengthy process involving numerous model runs followed by the checking of critical model outputs against observed data to determine goodness of fit. Following this, adjustments were made to model parameters, coding and inputs to correct areas where the fit of modelled outputs to observed data was poor. The process is shown diagramatically in figure 15 below:

Figure 15 - Model calibration process



It should be noted that the main focus of model adjustments during the calibration proces to achieve a better model fit was to correct flaws in network coding and adjust model parameters. As the base year trip matrices (extracted as part of task 1 described above) were generated from highly comprehensive observed travel patterns, changes to these matrices during the calibration process were kept to a minimum.

In addition, the model calibration process involved successive iteration with the calibration of the TAGM and TDM components – task 4 described later. Trip matrices from the TAGM & TDM were fed into the calibration of the model choice, hour of travel choice and route choice process. In turn, final calibrated matrices were fed back into the TAGM & TDM. This iterative proceedure was to ensure that the final calibration gave a good match for all 5 stages of the am-peak model.

Task 4. *Calibration of the TAGM and TDM to produce final trip matrices for the am-peak and off-peak models.*

The work of calibrating the TAGM & TDM was undertaken by Minnerva consultants. They began their work in spring 2008 and the task was undertaken in parallel with task no. 3 – described above.

Minnerva consultants produced a full description of the process of updating the TAGM and TDM components of the model is the technical note:

"Final report on the updating of the trip generation, attraction and distribution models".

A summary description of the process is given below.

The first task of calibrating the TAGM & TDM was the calculation of observed base year trip rates. In order to derive base year trip rates, the following inputs were supplied to the consultants:

- Initial base year trip matrices – generated in task 1 described above,

- Base year "planning sheet" containing 18 land use and demographic variables that determine the level of travel demand. These included:

    - Population - broken down by three socio economic groupings and by four work gropings – based on the Census small area population statistics (SAPS),
    - Employment - numbers of jobs in each zones – taken from the Census travel to work dataset (POWCAR),
    - Education places - broken down by Primary & Secondary and Tertiary – taken from the GDA education survey.
    - Retail floor space - sq. m. of retail floor space – using the An Post Geodirectory.

- The numbers of trips made throughout the day by each of six journey purposes – taken from the GDA household survey and broken down by:
    - Hour of travel,
    - Car available and car not available persons.

Using the 2006 "Planning Sheet" variables, and observed travel behaviour from the GDA household survey, the TAGM derived all day (07:00 to 19:00) trip rates for six journey purposes broken down by:

- Three socio-economic groups (SEG1, SEG2 and SEG3),
- Four working groups (Working full time, working part time, retired, not working),
- Two categories of trip makers (Car available and car not available).

The calculated trip rates were then applied to the "Planning Sheet" variables to derive trip generations and attractions for each journey purpose. Using the all-day trip generations and attractions as a control, the Trip Distribution Model (TDM) generated time specific trip matrices for each journey purpose based on the observed base year distribution in the am-peak and off-peak periods.

The calibration of the TAGM and TDM components was an iterative process, with adjustments being made to model parameters after each iteration to ensure a good fit between observed and modelled travel patterns. The main checks undertaken at each stage were:

- Modelled trip generations and attractions for each journey purpose against observed trip rates,
- Modelled trip length distribution against observed distribution,
- Modelled travel patterns for each journey purpose against observed patterns.

Following the successful calibration process, the main outputs from the TAGM and TDM were in the form of trip matrices broken down by:

- Six journey purposes,
- Two modelled time periods (3-hour am-peak, 1-hour afternoon off-peak),
- Car available and car not available persons.

The new TAGM & TDM can also produce trip matrices for the 3-hour evening peak period – and these are available to be used if an evening peak model is developed at a later stage.

The trips matrices for the am-peak were fed into the calibration of the mode choice, hour of travel choice and route choice components (task 3). In this way, there were successive iterations between tasks 3 and 4 until a good fit for all 5 stages of the am-peak model was achieved.

Trip matrices for the off-peak period produced by the newly calibrated TAGM & TDM were used in the calibration of the mode choice and route choice components of the off-peak model described below.

Task 5. Calibrate mode choice and route choice components of the off-peak model.

Following the successful calibration of all 5 stages of the am-peak model, the next task was to calibrate the mode choice and route choice components of the off-peak model. This task was undertaken by Steer Davies Gleave (SDG) consultants who began this work in April 2009.

In accordance with SDG recommendations in the model review 2008, task 5 involved restructuring / rebuilding the off-peak model to have a similar structure to the am-peak model and then calibrating its mode choice and route choice components. The main inputs to this process were:

- Off-peak trip matrices as output by the calibrated TAGM & TDM,
- Updated off-peak transport networks (Highway and PT) output from task no. 2,
- A comprehensive set of off-peak traffic counts and public transport passenger counts,
- Journey time survey data for the off-peak period,
- Established model structures for the existing 2001 off-peak model and the newly calibrated am-peak model.

The process of calibrating the off-peak model was similar to the process undertaken for the am-peak model (Step 3), but was made simpler because of the following differences:

- The off-peak model covers a single hour (14:00 to 15:00)
- The off-peak model does not include an hour of travel choice component.

A full description of the calibration process and full calibration statistics are included in two technical notes produced by the consultants:

"Calibration of the off-peak assignment model,"
"Calibration of the off-peak mode choice model."

Following the successful calibration of the am-peak and off-peak models, the models were approved by the DSEG for use in developing the transport strategy. The next step was to develop and test the Do Minimum scenario for the Strategy.

Task 6. Code the 2030 Do Minimum transport networks

The purpose of developing a Do Minimum transport scenario, is that this scenario forms the base against which all other forecast year transport scenarios were tested using the model. The first step in developing the Do Minimum scenario for 2030 was to get agreement with the Strategy Steering Group on what transport schemes would be included, and then to code the transport network changes into the newly calibrated model. The 2030 Do Minimum transport scenario included the following major schemes that were not in place in the 2006 base:

- Dublin Port Tunnel,
- City centre HGV bans (associated with the Dublin Port Tunnel),
- M50 Upgrade,
- LUAS Line extensions B1 and C1,

These major schemes were coded into the highway and public transport networks for 2030. In addition, the 2030 Do Minimum scenario included a cap on car parking supply in the city centre (within the canals). This was implemented by iteratively setting a destination charge for all car trips with destinations within the canals until the number of car trips to city centre destinations in 2030 did not exceed the 2006 levels.

Task 7. Generate Do Minimum trip matrices for 2030

In order to produce forecast trip matrices for the am-peak and off-peak periods, it was necessary to develop a 2030 forecast year "planning sheet" as input to the new TAGM and TDM. A detailed description of the forecasting methodology is given in the note:

"GDA Strategy population and employment forecast methodology".

In summary form, the process of developing the forecast year "planning sheet" was as follows:

- Agree the overall GDA forecasts of population and employment for 2030, based on CSO national forecasts and figures agreed with the Regional Planning Guidelines,

- Break down the population and employment forecasts by administrative region in consultation with the GDA local authorities,

- Develop two alternative distributions (A and B) of population and employment into the 666 model zones based on:

    - current RPG's (distribution scenario A)
    - greater consolidation in the city centre, major urban centres and in close proximity to high capacity rail services (distribution scenario B).

- Estimate the remaining 16 "planning sheet" variables based on the population and employment distributions.

For the purposes of the Do Minimum scenario, the Scenario B population and employment distribution was used. The Scenario A distribution would be run as a test later on in the development of the draft Strategy.

Once the 2030 Do Miminum "planning sheet" was compiled, it was input into the new TAGM & TDM which output trip matrices for the forecast year.

Task 8. Test the 2030 Do Minimum scenario in the model

The final step in the GDA model update was the running and testing of the 2030 Do Minimum scenario. The main inputs to this process were the 2030 Do Minimum coded transport networks (from task 6) and the 2030 Do Minimum trip matrices (from task 7).

In the case of the am-peak, the 2030 Do Minimum model test involved running (in an iterative feedback loop) the mode choice, hour of travel choice and route choice components of the model until equilibrium was achieved – using the 2030 Do Minimum transport networks and trip matrices as input. In the case of the off-peak, the hour of travel choice stage is omitted, and the route choice / assignment stage is executed for a single modelled hour.

Both sets of model runs produced detailed outputs for the 2030 Do Minimum scenario. The main model outputs were traffic flows, public transport passenger flows, journey times, measures of queuing / congestion, measures of peak spreading (am-peak only) etc. These outputs were checked to ensure that the model was producing sensible results and reacting to the changes in the transport networks and travel demand (between 2006 and 2030).

The model outputs were presented to the Strategy Steering Committee, and it was agreed that the new model was producing sensible results and functioning correctly. They agreed to use the newly calibrated model in developing the GDA transport strategy.

4. Suitability of GDA Transport Model as an aid to developing the Draft Strategy

The GDA Transport Model was the principal analysis tool used in the testing of transport scenarios that lead to the development of the Draft Strategy. The model was also the principal tool used in the full evaluation of the Draft Strategy. The model has many strengths and features that make it the ideal tool to aid the strategic planning process. However, like all models, it has limitations, represents only a part of the reality of travel behaviour, and makes a number of assumptions that must be borne in mind when making decisions based on its outputs. Listed below are the main strengths of the GDA transport model as well as its principal limitations and assumptions.

4.1 Strengths

- The model includes trips by all the main modes of travel – including trips by walking and cycling,
- Unlike many other strategic models used elsewhere, the highway assignment stage takes full account of junction delays caused by congestion, and thereby produces a realistic representation of car and bus journey times on the road network,
- The model includes a high level of segmentation of trip makers and their journey purposes,
- Travel bevahiour as represented in the model is based on comprehensive and detailed travel surveys and travel datasets not generally available in strategic models elsewhere,
- The model covers the full GDA, and takes full account of travel within, into and out of the modelled area,
- As the model is also used as the basis for scheme evaluation, the transport networks represented contain a level of detail beyond that which would be required for its use as a strategic transport planning tool,
- To enhance its functionality, the GDA transport model includes an additional stage ("hour of travel choice") in the modelling process. This additional stage is used to represent the phenomenon of peak spreading as a response to congestion and is not captured in many strategic models of this kind.

4.2 Limitations / assumptions

- Though walking and cycling trips are included in the model, they are not assigned to equivalent walking and cycling networks. Hence, whereas the cost of travel by mechanised modes is based on travel demand and network characteristics, the cost of travel for non mechanised modes is calculated as a simple combination of travel time and distance. The model is thus limited in its ability to test policies that seek to increase trips by walking and cycling. In particular, the model cannot automatically capture the time savings and other user benefits accruing to pedestrians and cyclists as a result of priority and other network improvements that confer advantage on these modes,

- The model has the option to incorporate a feedback mechanism from the trip assignment / route choice stage to the trip distribution stage, and hence simulate the impact of travel costs on travel patterns in any forecast year.

However, no robust data currently exists to enable calibration / validation of the gravity distribution used in this feedback process, and hence this functionality is not used in the version of the model used in developing the GDA transport strategy. In addition, changing travel costs do not impact on total trip generations and attractions, and do not influence where people will live relative to work and other services in any forecast year. Hence the model does not automatically account for the impact of transport supply on land use, and any such impacts must be manually supplied as input to the TAGM via the "planning sheet".

- As with all strategic transport models of this kind, model parameters (e.g. value of time, sensitivity to travel costs, mode constants etc) are set during the process of calibration to observed base year data. As calibrated parameters remain unchanged for any forecast year, the model cannot automatically account for possible changes to these parameters over time. Hence, for example, the model cannot take account of a shift in perception of a given mode of travel as a result of increased reliability, comfort, ease of use etc.

- The model contains significant network detail within the M50 where zone sizes are small. However in the outer parts of the GDA, zone sizes are large and the transport network is coded in much less detail. In these areas, a larger proportion of trips will be internal to zones and will not appear as flows on the transport networks.

4.3 Summary

Like all models, the GDA transport model has its limitations, incorporates a number of assumptions and represents only part of the reality of travel and travel behaviour. However, once these limitations are recognised, its functionality, level of detail, inclusion of all travel modes and its area of coverage make it an eminently suitable tool to be used in conjunction with other data analysis tools to aid the development of the Strategy.