# National Transport Model

## Variable Demand Model

## Model Documentation

April 2012

# National Transport Model

# Variable Demand Model – Model Documentation

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# National Transport Model

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## Glossary of Terms

| | |
|---|---|
| AM | AM Peak |
| CA | Car Available |
| CN | No Car  Available |
| D | Distance |
| EB | Employers Business (Trip Purpose) |
| HK | Commuting (Trip Purpose) |
| HV | Heavy Vehicle |
| IP | Inter Peak |
| LV | Light Vehicle |
| NRA | National Road Authority |
| NTM | National Traffic Model |
| NTpM | National Transport Model |
| NW | Other (Trip Purpose) |
| O-D | Origin-Destination |
| P-A | Production-Attraction |
| PAG | Project Appraisal Guidelines |
| PJT | Perceived Journey Time |
| ROI | Republic of Ireland |
| UDA | User Defined Attributes |
| UK | United Kingdom |
| VDM | Variable Demand Model |
| VehOcc | Vehicle Occupancy |
| VOC | Vehicle Operating Cost |
| WebTAG | Web Transport Appraisal Guidance (UK – Dept. for Transport) |

# 1.0 Introduction

## 1.1 Project Overview

In 2011 the National Roads Authority developed the National Transport Model (NTpM). The NTpM was developed as a multi-modal variable demand model. The structure of the NTpM can be broken down into 4 sub-models:

- Rail Model - National Rail Model (NRM);
- Bus Model - National Bus Model (NBM);
- Traffic Model - National Traffic Model (NTM); and
- Variable Demand Model (VDM)

The VDM is the central tool of the model suite which interfaces with the highway and public transport elements of the NTpM.

## 1.2 Purpose of Report

This report details the inputs, outputs and operation of the VDM module in the NTpM. The report outlines the structure of the VDM and how it interfaces with the various elements that make up the NTpM, and discusses the calibration/validation of the demand model.

## 1.3 Pivot-Point Modelling

The VDM in the NTpM works as a 'Do-Minimum Pivoting' model. Pivot point models take costs from a 'Do-Minimum' scenario as a starting point, and then forecast the change in demand (mode share, distribution, etc) as a function of the changes in cost from the 'Do minimum' or trend based scenario. This approach enables some of the complex behavioural decisions which inform the base demand to be carried through to alternative scenarios. Such an approach is also referred to as 'Incremental' modelling and is a common form of demand modelling in large complex models.

The VDM used in the NTpM consists of two separate components developed using Python[1] software as follows:

- An interface with VISUM that is run from within the VISUM procedures. As well as directly manipulating the demand matrices, it also iteratively loops through the modelled demand segments; and
- A demand model, which is a function called by the interface, taking matrices from the interface and performing the necessary demand model calculations on them, before passing them back to the interface for return to VISUM. It also calculates demand / supply convergence, passing this back to the interface so that VISUM can determine when to stop iterating between demand and supply.

The VDM in the NTpM runs a single demand segment for a complete 15-hour period. The evaluation of what the 'active' segments and associated matrices are, and looping between them, is the role of the interface.

[1] Python is an open source programming language used to integrate systems within Windows (*www.python.org*)

The VDM takes input matrices from the interface, performs demand calculations and then passes back output demand matrices plus scalars (used to determine convergence) to the interface.

# 2.0 Do-Minimum 'Reference' Scenario

## 2.1 Overview

The model uses a 'Do-Minimum Pivoting' process, whereby the cost changes from the 'Do-Minimum' are compared with the costs from a 'Do-Something' when performing the variable demand model calculations. This section of the report outlines the process for creating the Do-Minimum scenario and calculating the Do-Minimum cost skims.

## 2.2 Do-Minimum 'Reference' Inputs

In order for the VDM to calculate cost changes it requires Do-Minimum highway and public transport demand and cost skim matrices. 'Reference' demand refers to the initial or Do-Minimum demand for a given forecast year. A set of 18 demand matrices need to be forecast for the given future year and are outlined in Table 2-1. A full list of all matrices used in the NTpM is presented in Appendix A.

*Table 2-1: Reference Demand Matrices*

| Mode | Time Period | NTpM Matrix Name | NTpM Matrix No. | Reference Demand |
|---|---|---|---|---|
| **Highway** | AM Peak | AMHKLV_Ref | 261 | Commuting |
| | | AMEBLV_Ref | 262 | Business |
| | | AMNWLV_Ref | 263 | Other |
| | | AMHV_Ref | 264 | HGV |
| | Inter Peak | IPHKLV_Ref | 265 | Commuting |
| | | IPEBLV_Ref | 266 | Business |
| | | IPNWLV_Ref | 267 | Other |
| | | IPHV_Ref | 268 | HGV |
| **Rail** | 15 hour (07:00 – 22:00) | CNWDHKRail_Ref | 281 | Commuting (Car Available) |
| | | CAWDHKRail_Ref | 282 | Commuting (No-Car Available) |
| | | CNWDEBRail_Ref | 283 | Business (Car Available) |
| | | CNWDNWRail_Ref | 284 | Other (Car Available) |
| | | CAWDNWRail_Ref | 285 | Other (No-Car Available) |
| **Bus** | 15 hour (07:00 – 22:00) | CNWDHKBus_Ref | 291 | Commuting (Car Available) |
| | | CAWDHKBus_Ref | 292 | Commuting (No-Car Available) |
| | | CNWDEBBus_Ref | 293 | Business (Car Available) |
| | | CNWDNWBus_Ref | 294 | Other (Car Available) |
| | | CAWDNWBus_Ref | 295 | Other (No-Car Available) |

### *2.2.1 'Reference' Network*

When calculating the costs from which to pivot in the 'Do Something' scenario, a future year network needs to be developed for all modes; highway, bus and rail. This is generally the base year networks plus any committed schemes, both in terms of infrastructure and service provision, which are thought to be in place by the given future year.

The 'reference' highway and public transport cost skims are generated by running the reference demand on the reference network.

## 2.3 Running the Do-Minimum 'Reference' Scenario

### *2.3.1 Assign & Skim Model*

Using the 'Assign & Skim' version file, the future year 'reference' demand and networks need to be imported into their respective locations. The model then assigns this demand onto the network for all modes and time periods, and calculates and saves the required 'reference' skim data for use in the VDM module.

The AM and Inter Peak highway outputs from the highway module are weighted to generate 15 hour cost skims for use in the VDM. Table 2-2 presents the procedures which are carried out in the Assign and Skim model.

*Table 2-2: Assign & Skim Outline Procedures*

| Assignment | Outline Procedures |
|---|---|
| **AM Peak Highway Assignment** | Initialises the assignment |
| | Updates the port tunnel toll value for the AM Peak |
| | Sums the AM Peak light vehicle demand into the relevant assignment matrix |
| | Copies the AM Peak HGV demand into the relevant assignment matrix |
| | Assigns the demand, and skims time, distance and tolls |
| | Saves the skim matrices into the relevant matrices |
| | Stores the AM Peak link flows (Light and Heavies) as user defined attributes |
| **Inter Peak Highway Assignment** | Initialises the assignment |
| | Updates the port tunnel toll value for the Inter Peak |
| | Sums the Inter Peak light vehicle demand into the relevant assignment matrix |
| | Copies the Inter Peak HGV demand into the relevant assignment matrix |
| | Assigns the demand, and skims time, distance and tolls |
| | Saves the skim matrices into the relevant matrices |
| | Stores the Inter Peak link flows (Light and Heavies) as user defined attributes |
| **Highway Skims** | Using the AM Peak and Inter Peak skims, these are demand weighted to give a average 15hr time, distance and toll skims for light vehicles and HGVs.<br>[Note that this process contains the highway demand conversion factors] |
| **Rail Assignment** | Initialises the assignment |
| | Sums the purpose and car availability demand into the assignment matrix |
| | Assigns the demand, and skims perceived time and in-vehicle distance |
| | Calculates a fare matrix based on a cost per kilometre |
| **Bus Assignment** | Initialises the assignment |
| | Sums the purpose and car availability demand into the assignment matrix |

| | |
|---|---|
| | Assigns the demand, and skims perceived time and in-vehicle distance |
| | Calculates a fare matrix based on a cost per kilometre |

[Note: there are some hard-coded elements of the procedures file that need to be amended prior to running the Assign and Skim version file. These are as follows; the location of the version file, as this is saved during the procedures, the location of the filters file to update the highway tolls in the different modelled periods, the fare assumptions for rail and bus and the location of the output cost and demand data. The factors to go from AM and Inter Peak hours to 15hrs are also hard-coded, but these should not change over time.]

### *2.3.2 Fares*

Fares are not coded directly into the rail or bus network and therefore cannot be skimmed directly from the highway module. Instead fares are calculated using a fare in cents/km for rail (11 cents) and bus (7 cents) and the in-vehicle distance skim for each mode.

## 2.4 Do-Minimum 'Reference' Outputs

The Assign & Skim model produces twelve 15hr costs skim matrices which are saved externally for use in the 'Do-Something' scenario. These 'reference' cost skims are presented in Table 2-3.

*Table 2-3: 15hr Reference Cost Skims*

| Mode | NTpM Matrix Name | NTpM Matrix No. | Reference Cost Skims |
|---|---|---|---|
| **Highway** | 15TmLV_Ref | 181 | Time (Lights) |
| | 15DsLV_Ref | 182 | Distance (Lights) |
| | 15ChLV_Ref | 183 | Toll (Lights) |
| | 15TmHV_Ref | 184 | Time (HGV) |
| | 15DsHV_Ref | 185 | Distance (HGV) |
| | 15ChHV_Ref | 186 | Toll (HGV) |
| **Rail** | PJT(Rail)_Ref | 187 | Perceived Journey Time |
| | IVD(Rail)_Ref | 188 | In-Vehicle Distance |
| | Fare(Rail)_Ref | 189 | Fare |
| **Bus** | PJT(Bus)_Ref | 190 | Perceived Journey Time |
| | IVD(Bus)_Ref | 191 | In-Vehicle Distance |
| | Fare(Bus)_Ref | 192 | Fare |

All reference demand and cost skims are imported into the NTpM prior to running a Do-Something scenario.

## 2.5 Intra-Zonal Costs

Though the VDM is an incremental model, and this issue is therefore less important than in an absolute formulation, it is important to ensure that the skims input to the demand model have a realistic representation of intra-zonal costs. The diagonal of the costs skims need to be set to 50% of the lowest inter-zonal value.

# 3.0 Running the Do-Something 'Test' Scenario

## 3.1 Overview

When running the NTpM there are a number of inputs required within the VISUM version file, as well as the presence of a series of external files which are used within the demand model. These inputs are presented in Table 3-1.

*Table 3-1: Do-Something Inputs*

| Inputs | Requirements |
|---|---|
| **Demand Matrices** | The 18 'reference' demand matrices used in the Assign & Skim model |
| **Cost Skims** | The 12 'reference' cost skims output from the Assign & Skim model |
| **Networks** | Highway and PT Do-Something networks |
| **External VDM Files** | Reset iteration Script file (Python) – located in same folder as version file |
| | VDM script file (Python) – located in same folder as version file |
| | Elasticities script file (Python) – located in same folder as version file |
| | 4 parameter files (Commuting/Business/Other/HGV) – located in same folder as version file |
| | 1 economics file - located in same folder as version file |

It is important to note that the matrix names and particularly matrix numbers are important to the running of the process. Whilst new matrices for temporary calculations or analysis can be created, the existing matrix directory should not be altered.

"Test" cost skims refer to the Do-Something cost skims for a given forecast year as a result of a change to the supply network or policy implementation.

## 3.2 Modelling/Economic Parameters

In addition to the demand matrices/cost skims, the VDM module requires a number of text input files, one Economic Parameters file and four Modelling Parameters files.

The economic parameters set out in Table 3-2 are required for each trip purpose. These parameters are taken from NRA *PAG Unit: 6.11 National Parameter Values Sheet.* One economics text file is required for the given forecast year e.g. *'2009_Economics.txt'.*

*Table 3-2: Economic Parameters*

| Parameter | Text File Name | Source |
|---|---|---|
| **Value of Time** | *ValueOfTime* | NRA PAG[2] |
| **Fuel Price** | *FuelPrice* | NRA PAG |

[2] Values in the NRA Project Appraisal Guidelines are, in turn, drawn from the Departmental Common Appraisal Framework Guidelines.

| | | |
|---|---|---|
| **Fuel Efficiency** | *Feff* | NRA PAG |
| **Fuel Consumption** | *FIA, FIB & FIC* | NRA PAG |
| **Non-Fuel VOC** | *NFA & NFB* | NRA PAG |
| **Vehicle Occupancy** | *AMVehOcc & IPVehOcc* | NRA PAG |

The modelling parameters are outlined in Table 3-3 and are taken from UK WebTAG guidance and the UK National Travel Survey. A separate modelling parameters text file is required for each trip purpose as follows:

- Commuting – *Com_Paramters.txt*
- Business – *Busi_Paramters.txt*
- Other– *Oth_Paramters.txt*
- HGV – *HGV_Paramters.txt*

*Table 3-3: Modelling Parameters*

| Parameter | Text File Name | Source |
|---|---|---|
| **Extent of interpretation of rail costs in exponential form** | *AlphaLog* | Calibration |
| **Sub-Mode Choice** | *SubModeLamda* | Existing UK Model (EERM) |
| **Distribution** | *HLamda & PLamda* | UK WebTAG |
| **Mode Choice** | *ModeTheta* | UK WebTAG |
| **Trip Frequency** | *TFTheta* | UK National Travel Survey |
| **Cost Damping** | *CDTimePower, CDMoneyPower, CDTimeThresh & CDMoneyBase* | UK WebTAG |
| **Proportions of travel from home** | *AMFromHome, IPFromHome, PMFromHome, OFFromHome and AllFromHome* | UK National Travel Survey |

### 3.3 Running the NTpM VDM

The procedures that are carried out in the Do-Something model run are illustrated in Table 3-4.

*Table 3-4: Do-Something Outlines Procedures*

| Procedure | Process |
|---|---|
| **Run Script** | Runs Python script to reset the demand iteration number to 0 |
| **Import Data** | Imports reference demand and skims from Do-Minimum model |
| **Initial Task** | Copies the reference demand to the current iteration matrices for assignment. |
| | Sets the 'blank' matrix to zero. It is important that all cells in this matrix are zero, so this is reset at the beginning of the model. |
| **Rail Assignment** | Initialises the assignment |
| | Sums the purpose and car availability demand into the assignment matrix |
| | Assigns the demand, and skims perceived journey time and in-vehicle distance |

| | |
|---|---|
| | Calculates a fare matrix based on a cost per kilometre |
| | Stores the Rail Demand (pre VDM) as a user defined attribute |
| **Bus Assignment** | Initialises the assignment |
| | Sums the purpose and car availability demand into the assignment matrix |
| | Assigns the demand, and skims perceived journey time and in-vehicle distance |
| | Calculates a fare matrix based on a cost per kilometre |
| | Stores the Bus Demand (pre VDM) as a user defined attribute |
| **AM Peak Highway Assignment** | Initialises the assignment |
| | Updates the port tunnel toll value for the AM Peak |
| | Sums the AM Peak light vehicle demand into the relevant assignment matrix |
| | Copies the AM Peak HGV demand into the relevant assignment matrix |
| | Assigns the demand, and skims time, distance and tolls |
| | Saves the skim matrices into the relevant matrices |
| | Stores the AM Peak link flows pre VDM (LV and HV) as user defined attributes |
| **Inter Peak Highway Assignment** | Initialises the assignment |
| | Updates the port tunnel toll value for the Inter Peak |
| | Sums the Inter Peak light vehicle demand into the relevant assignment matrix |
| | Copies the Inter Peak HGV demand into the relevant assignment matrix |
| | Assigns the demand, and skims time, distance and tolls |
| | Saves the skim matrices into the relevant matrices |
| | Stores the Inter Peak link flows pre VDM (LV and HV) as user defined attributes |
| **Calculate 15hr Highway Skims** | Using the AM Peak and Inter Peak skims, these are demand weighted to give a average 15hr time, distance and toll skim for light vehicles and HGVs.<br>Note that this process contains the highway demand conversion factors |
| **Run VDM Process** | This runs the external VDM-Lite Python script file |
| | This takes the demand and costs from the assignments, compares the change in costs between the 'current' and 'previous' iteration ('previous' is 'Do Minimum' in the first iteration), and then calculates revised demand and convergence statistics. |
| **Check Convergence** | The %Gap network parameter is used as a convergence target for the VDM process |
| | If this %Gap is more than 0.1, and the number of iterations is less than the maximum of 30, then the procedures goes back to the 'AM Peak highway assignment' step |
| | We do not need to re-assign the PT demand as there is no congestion feedback in the PT assignments, i.e. whatever demand we assign we would get the same skimmed matrices. |
| **Final Rail Assignment** | Initialises the assignment |
| | Sums the purpose and car availability demand into the assignment matrix |
| | Assigns the demand, and skims perceived time and in-vehicle distance |
| | Calculates a fare matrix based on a cost per kilometre |
| | Stores the Rail Demand (post VDM) as a user defined attribute |

| | |
|---|---|
| **Final Bus Assignment** | Initialises the assignment |
| | Sums the purpose and car availability demand into the assignment matrix |
| | Assigns the demand, and skims perceived time and in-vehicle distance |
| | Calculates a fare matrix based on a cost per kilometre |
| | Stores the Bus Demand (post VDM) as a user defined attribute |
| **Final AM Peak Highway Assignment** | Initialises the assignment |
| | Updates the port tunnel toll value for the AM Peak |
| | Sums the AM Peak light vehicle demand into the relevant assignment matrix |
| | Copies the AM Peak HGV demand into the relevant assignment matrix |
| | Assigns the demand, and skims time, distance and tolls |
| | Saves the skim matrices into the relevant matrices |
| | Stores the AM Peak link flows post VDM (LV and HV) as user defined attributes |
| **Final Inter Peak Highway Assignment** | Initialises the assignment |
| | Updates the port tunnel toll value for the Inter Peak |
| | Sums the Inter Peak light vehicle demand into the relevant assignment matrix |
| | Copies the Inter Peak HGV demand into the relevant assignment matrix |
| | Assigns the demand, and skims time, distance and tolls |
| | Saves the skim matrices into the relevant matrices |
| | Stores the Inter Peak link flows post VDM (LV and HV) as user defined attributes |
| **Run Script** | Runs Python script to calculate Do-Minimum and Do-Something total network demand and vehicle/passenger kilometres for each trip purpose |

[Note: there are some hard-coded elements of the procedures file that need to be amended. These are the location of the version file, as this is saved during the procedures, the location of the filters file to update the highway tolls in the different modelled periods, the fare assumptions for rail and bus and the location of the input Do-Minimum cost and demand data. The factors to go from AM and Inter Peak hours to 15hrs are also hard-coded, but these should not change over time.]

### 3.4 VDM Convergence

The VDM process uses the %GAP (network parameter) as a target for convergence. The % GAP is the percentage difference between the current generalised cost and the previous generalised cost (Denominator) divided by the previous generalised cost (Denominator)

%GAP = Numerator/Denominator

The convergence criterion for the demand model is:

- %GAP <0.1; or
- If more than 30 iterations are required then the model stops and convergence should be reviewed.

The %GAP network parameter is required to be less than 0.1 for convergence. If the %GAP is greater than 0.1 (and the model has not completed 30 iterations), then highways costs are calculated and fed back into the demand loop once again until convergence criteria is satisfied.

The public transport demand is only assigned after the final iteration to report flows as there is no capacity constraint built into the public transport assignments (i.e. no matter what demand is assigned the same skims costs are produced).

### 3.5 VDM Output Data

The output data generated following the convergence of the VDM and assignment of the final highway and public transport is as follows:

- 15hr highway demand and total vehicle km by trip purpose (Reference & Test);
- 15hr PT demand and total passenger km by trip purpose (Reference & Test);
- AM & Inter Peak OD vehicle demand, highway;
- 15hr OD person demand, rail; and
- 15hr OD person demand, bus.

# 4.0 Variable Demand Model

## 4.1 Overview

The VDM consists of two separate components developed using Python software as follows:

- VISUM –Demand Model Interface; and
- The Variable Demand Model.

The interface passes the 'reference' and 'test' demand and skim data from the NTpM to the VDM module in the first iteration; in subsequent iterations the output of the VDM from the previous iteration is passed back to the highway module by the interface. The same process applies to the cost skims.

The demand model which is a function called by the interface, taking matrices from the interface and performing the necessary demand model calculations on them, before passing them back to the interface for return to VISUM. It also calculates demand / supply convergence, passing this back to the interface so that VISUM can determine when to stop iterating between demand and supply.

The flow of information that passes between VISUM and the demand model is illustrated in Figure 4-1. Note that the public transport costs are independent of both public transport demand (no crowding) and highway congestion (runs to timetable), so therefore the bus and rail assignments are not included in the demand/supply loop.

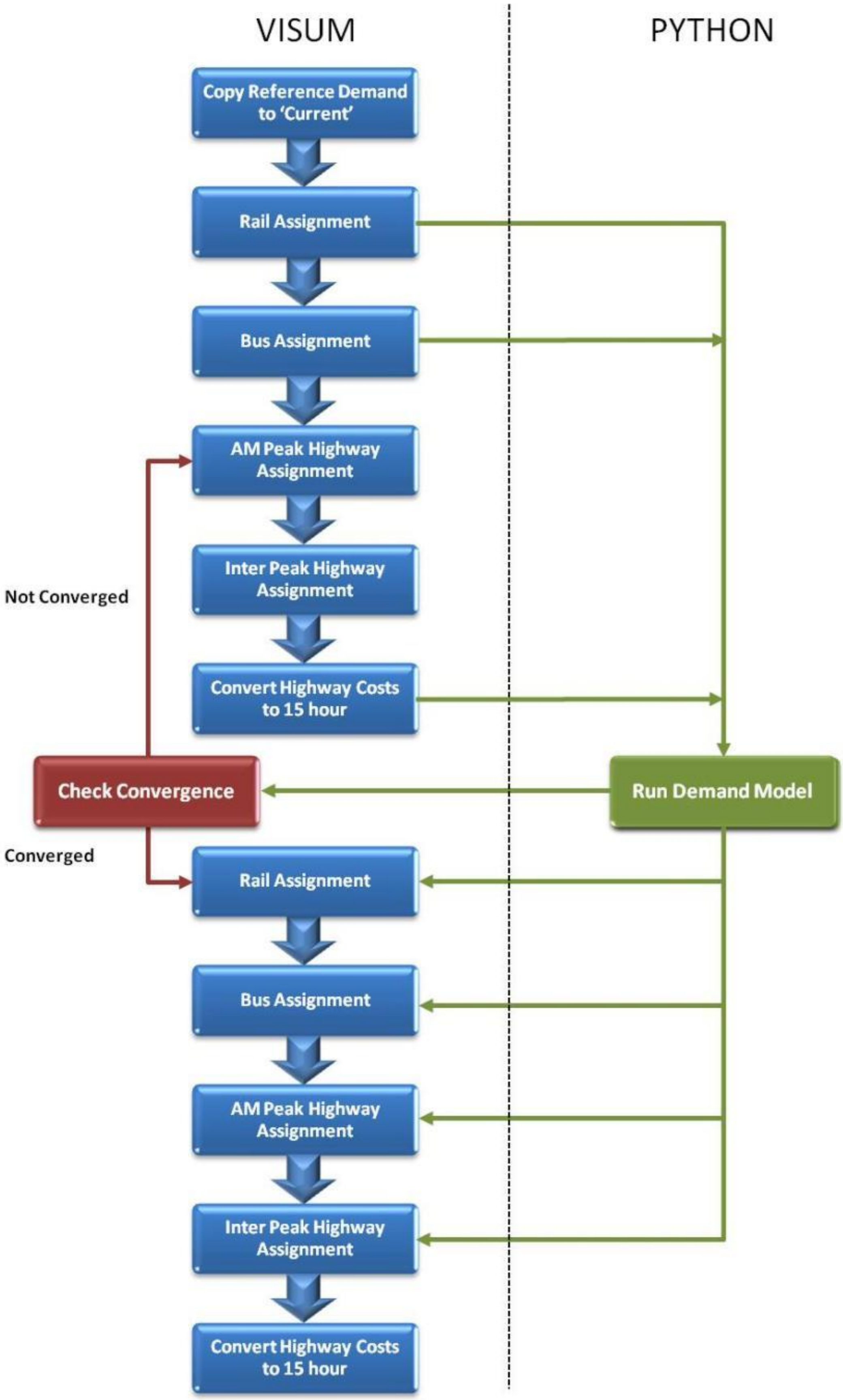



*Figure 4-1: Flow of Information*

### 4.2 Interface with VISUM

The VISUM Wrapper for the demand model is the second part of the Python code that controls the workings of the demand model as follows:

- Imports values from VISUM for the iteration number and the %GAP calculation;
- If evaluated as the 1st iteration, using reference assignments costs;
- Runs the demand model for each demand segment:
  - Imports matrices from VISUM;
  - Runs the demand model
  - Accumulates the %GAP numerator and denominator; and
  - Exports output matrices to VISUM
- Copies the skims to the previous iterations;
- Runs the double constraint for commuting;
- Calculates the %GAP and updating the value in VISUM; and
- Updates the iteration number.

### 4.3 Demand Model

The variable demand model performs the following processes outlined in Table 4-1 using the 'reference' and 'test' demand and skims from VISUM.

*Table 4-1: Demand Process*

| Process | Requirements |
|---|---|
| **1** | Converts highway vehicle demand from AM Peak and Inter Peak origin-destination (O-D) matrices to 15hr production-attraction (P-A) people matrices |
| **2** | Converts rail and bus O-D demand to P-A format (a single Public Transport demand matrix) |
| **3** | Calculates logit composite costs for public transport using the costs from the rail and bus assignments and converts into generalised costs |
| **4** | Calculates generalised cost for highway |
| **5** | Calculate logit composite costs across attractions for highway and public transport for the mode choice model |
| **6*** | Applies an incremental logit mode-choice model to create output origin (vector) matrices by mode. |
| **7** | Applies an incremental logit distribution model to create output full matrices by mode |
| **8** | Calculates the convergence gap numerators and denominators |
| **9** | Converts the highway matrices from 15hr P-A people matrices back to AM Peak and Inter Peak O-D vehicle matrices |
| **10** | Performs an incremental logit sub-mode choice between rail and bus demand using the new public transport demand and converts from P-A to O-D format |

**The mode choice model may be absent or restricted for certain segments, for example, no-car-available trips will be unable to select highway as a mode, and freight traffic will not use the mode choice model at all.*

In addition, a separate double-constraint model is run, taking as an input a number of base and test OD matrices, and applying a Furness-based double-constraint process to the test matrices to keep their attraction totals in-line with the reference matrices. This process is run for the commuting demand segment only.

### 4.4 Production-Attraction Matrices

The highway module of the NTpM outputs origin-destination (O-D) demand (vehicles) for the AM and Inter Peak Hours. This demand needs to be converted to 15 hour production-attraction (P-A) people demand for use in the VDM.

The rail and bus demand outputs of the NTpM are 15 hour O-D demand (people). These demand matrices need to be converted to P-A format for use in the VDM. The process is summarised below:

- Highway demand from the AM Peak and Inter Peak is converted from O-D format to 15-hour P-A people matrices;
- Rail and bus O-D demand is converted to P-A format to establish public transport matrices by rail and bus.

The process uses *'Proportion of Travel from Home'* factors outlined in Table 4-2 and *'Vehicle Occupancy'* factors from the NRA (reference *PAG Unit 6.11: National Parameter Values Sheet*) which are presented in Table 4-3 to generate P-A people matrices.

*Table 4-2: Proportion of Travel From Home Factors*

| FromHomeFac* | Commuting | Business | Other | HGV |
|---|---|---|---|---|
| **AMFromHome** | 0.9637 | 0.8708 | 0.7518 | 0.9637 |
| **IPFromHome** | 0.4306 | 0.4413 | 0.4556 | 0.4306 |
| **PMFromHome** | 0.0630 | 0.2920 | 0.4046 | 0.0630 |
| **OPFromHome** | 0.4895 | 0.3452 | 0.3788 | 0.4895 |
| **AllFromHome** | 0.5000 | 0.5000 | 0.5000 | 0.5000 |

** Source – UK National Travel Survey*

*Table 4-3: NRA Vehicle Occupancy Factors (NRA PAG 2008)*

| Vehicle Occupancy* | Commuting | Business | Other | HGV |
|---|---|---|---|---|
| **AM Peak** | 1.34 | 1.33 | 1.83 | 1 |
| **Inter Peak** | 1.26 | 1.26 | 1.92 | 1 |

** Vehicle occupancy factors do not change over time*

### 4.5 Calculating Generalised Cost

The skim matrices calculated by the highway module (time, distance & toll), and the public transport modules (time, distance & fare) are used to calculate generalised costs for each mode for use in the VDM. The process is summarised below:

- Generalised costs are calculated for road travel using the time, distance and toll skims and NRA economic parameters (reference *PAG Unit 6.11: National Parameter Values Sheet*);

- Logit composite costs are calculated for public transport using the costs from the rail and bus assignments and converting into generalised costs using standard economic parameter values; and
- Logit composite costs are calculated across attractions separately for road and public transport for input to the mode choice model.

### *4.5.1 Generalised Costs - Highway*

Vehicle operating costs (VOC) are calculated for the highway demand using the distance skims, average speeds (based on the time and distance skims) and economic fuel parameters. The fuel and non-fuel economic parameters are presented in Table 4-4 and Table 4-5, respectively.

*Table 4-4: VOC Economic Fuel Parameters*

| Description | Text Name | Commuting | Business | Other | HGV |
|---|---|---|---|---|---|
| **Fuel Consumption A** | FIA | 5.1512 | 5.1512 | 5.1512 | 24.5286 |
| **Fuel Consumption B** | FIB | -0.0862 | -0.0862 | -0.0862 | -0.3858 |
| **Fuel Consumption C** | FIC | 0.0005853 | 0.0005853 | 0.0005853 | 0.002689 |
| **Fuel Efficiency** | FEff | 1 | 1 | 1 | 1 |

*Table 4-5: VOC Economic Non-Fuel Parameters*

| Description | Text Name | Commutting | Business | Other | HGV |
|---|---|---|---|---|---|
| Non Fuel A | NFA | 0 | 5.11 | 0 | 15.695 |
| Non Fuel B | NFB | 0 | 26.1 | 0 | 339.785 |

Values of Time (VOT) are applied to the time skims to calculate the cost of travel. These cost are combined with the VOC to generate a cost per highway trip.

*Table 4-6: Examples of Value of Times (€/hr)*

| Year* | Text Name | Commuting | Business | Other | HGV |
|---|---|---|---|---|---|
| 2009 | ValueofTime | 16.3 | 44.6 | 14.6 | 44.6 |
| 2025 | ValueofTime | 23.6 | 64.6 | 21.1 | 64.6 |

** Value of Time needs to be calculated for the given forecast year*

### *4.5.2 Generalised Costs – Public Transport*

Generalised costs are calculated for public transport using Perceived Journey Time (PJT) costs, in-vehicle distance skims, fares per km travel and economic parameters.

The PJT which is a function of a public transport trip, takes into account the weighted journey time elements that make up the total travel time between a trip origin and destination. The elements and the weighting factors applied are presented in Table 4-7.

*Table 4-7: Perceived Journey Time – Weighting Factors*

| PJT Component | Rail | Bus |
|---|---|---|
| **In-Vehicle Time** | 1.0 | 1.0 |
| **PuT-Aux Ride Time** | 1.0 | 1.0 |
| **Access Time** | 2.0 | 2.0 |
| **Egress Time** | 2.0 | 2.0 |
| **Walk Time** | 2.0 | 2.0 |
| **Origin Wait Time** | 1.5 | 2.0 |
| **Transfer Wait Time** | 2.0 | 2.0 |
| **Number of Transfers** | 5mins | 2mins |

#### *4.5.3 Cost Dampening*

The model applies functions to reduce large cost changes, making the response non-linear to actual cost change, while ensuring that increasing costs always result in decreasing demand and vice versa.

To achieve this, a factor is applied to both time and monetary components of cost change based on the base highway distance between the origin and destination, functions as follows:

$$TimeFactor = \sqrt{20} * \left(\frac{1}{\max(D, 20)}\right)^{0.5}$$

$$MonetaryFactor = \sqrt{20}\mathrm{D_0}^{\eta_s} * \left(\frac{1}{\max(D, 20)}\right)^{0.5} * \left(\frac{1}{\max(\mathrm{D}, \mathrm{D_c})}\right)^{\eta_s}$$

Where D is distance in kilometres, and other parameters are derived from UK WebTAG advice. The cost dampening parameters are presented in Table 4-8.

*Table 4-8: Cost Damping Parameters*

| FromHomeFac* | Commuting | Business | Other | HGV |
|---|---|---|---|---|
| **CDTimePower** | 0.5 | 0.5 | 0.5 | 0.5 |
| **CDMoneyPower** | 0.421 | 0.00 | 0.315 | 0.00 |
| **CDTimeThresh** | 20.0 | 20.0 | 20.0 | 20.0 |
| **CDMoneyThresh** | 6.0 | 5.0 | 6.0 | 5.0 |
| **CDMoneyBase** | 13.9 | 14.8 | 13.0 | 22.9 |

### 4.6 Choice Models (Logit)

#### *4.6.1 Choice Structure*

Following WebTAG guidance destination choice is assumed to be more sensitive than mode choice to travel cost. The choice structure is illustrated in Figure 4-2 and indicates that variable demand responses are more significant than mode share responses. The VDM process therefore follows this hierarchy in identifying the demand response.

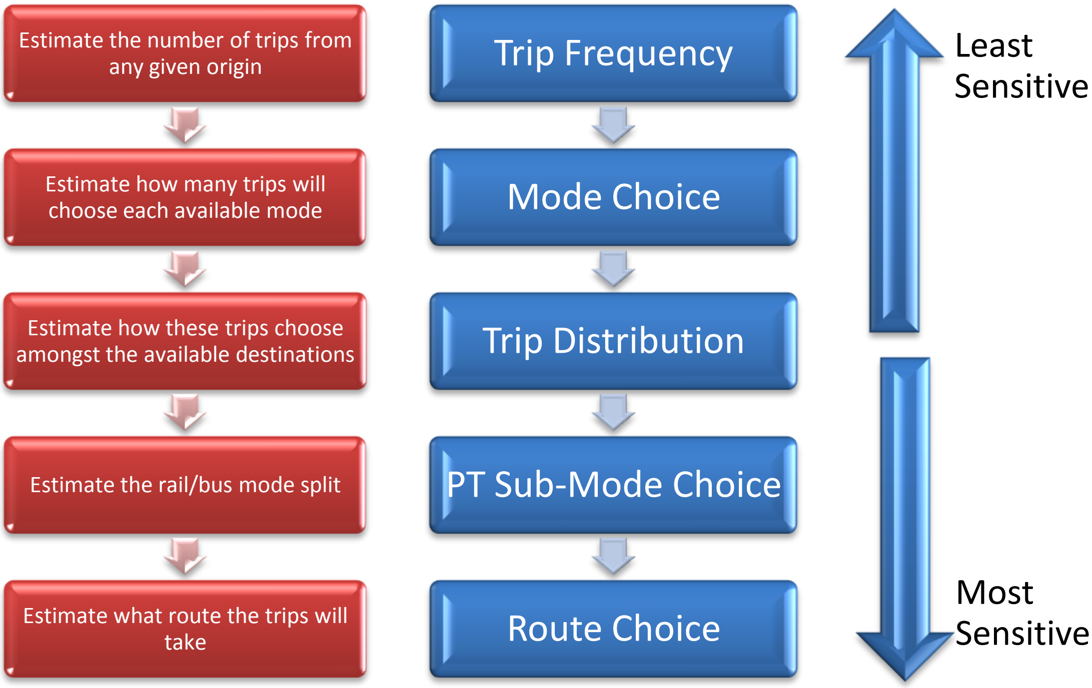



*Figure 4-2: Choice Structure of VDM*

### *4.6.2 Choice Model Formulae*

The formulae used by the demand model are presented in Table 4-9 and Table 4-10.The following terminology is applied:

$i$ = production zone
$j$ = attraction zone
$m$ = mode
$*$ = aggregation over an index
$D$ = Base Demand (people)
$\widehat{D}$ = Model Output Demand, people
$\theta_m$ = Mode Choice sensitivity relative to distribution
$\lambda_d$ = Distribution sensitivity, inverse minutes
$\lambda_s$ = Sub-mode choice sensitivity, inverse minutes
$\Delta C$ = Difference in generalised cost between base and test, minutes

*Table 4-9: Composite Cost Change Formula*

| Composite Cost | Formula |
|---|---|
| **Over Mode Choice** | $\Delta C_{*i*} = \frac{-1}{\theta_m} \log_e \left( \frac{\sum_{mj} D_{mij} \, e^{-\theta_m \, \Delta \, C_{mi*}}}{\sum_{mj} D_{mij}} \right)$ |
| **Over Attraction Zones** | $\Delta \, C_{mi^*} = \frac{-1}{\lambda_d} \log_e \left( \frac{\sum_j D_{mij} \, e^{-\lambda_d \Delta C_{mij}}}{\sum_j D_{mij}} \right)$ |
| **Over Public Transport** | $\Delta C_{miRailBus^*} = \frac{-1}{\lambda_s} \log_e \left( \frac{\sum_{rail,bus} D_{mij} \, e^{-\lambda_s \Delta C_{mij}}}{\sum_{rail,bus} D_{mij}} \right)$ |

*Table 4-10: Hierarchy Logit Model Formula*

| Choice | Formula |
|---|---|
| **Trip Frequency** | $\widehat{D}_{*i*} = D_{*i*} e^{\theta_t \Delta C_{*i*}}$ |
| **Mode Choice** | $\widehat{D}_{mi*} = \widehat{D}_{*i*} \frac{\sum_j D_{mij} \, e^{\theta_m \Delta C_{mi*}}}{\sum_{mj} D_{mij} \, e^{\theta_m \Delta C_{mi*}}}$ |
| **Distribution** | $\widehat{D}_{mij*} = \widehat{D}_{mi*} \frac{D_{mij} e^{-\lambda_d \Delta C_{mij}}}{\sum_j D_{mij} \, e^{-\lambda_d \Delta C_{mij}}}$ |
| **PT Sub-Mode** | $\widehat{D}_{mij} = \widehat{D}_{PTij} \frac{D_{mij} e^{-\lambda_s \Delta C_{mij}}}{\sum_j D_{mij} \, e^{-\lambda_s \Delta C_{mij}}}$ |

## 4.7 Demand Model Calibration

The model sensitivity and cost-dampening parameters have been calibrated starting at UK WebTAG guidance to give an acceptable level of model sensitivity. The model parameters employed in the VDM are set out in Table 4-11.

*Table 4-11: Demand Model Parameters*

| Purpose | AlphaLog | H Lambda $\lambda_d$ | PT Lambda $\lambda_d$ | Mode Theta $\theta_m$ | PT Theta | SubMode Lambda $\lambda_s$ |
|---|---|---|---|---|---|---|
| **Commuting** | 0.33 | -0.065 | -0.033 | 0.68 | 0 | -0.1 |
| **Business** | 0.33 | -0.067 | -0.036 | 0.45 | 0 | -0.1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Other** | 0.33 | -0.090 | -0.036 | 0.53 | 0 | -0.1 |
| **HGV** | n/a | -0.030 | n/a | n/a | 0 | n/a |

A trip-frequency affect could be included within the model, but in this current implementation the trip-frequency sensitivity parameter has been set to 0 to remove this effect.

# 5.0 VDM Validation

## 5.1 Introducton

The UK Department of Transport WebTAG guidance provides details on the validation of variable demand models (WebTAG Unit 3.10.4 – VDM Convergence Realism and Sensitivity). The guidance states that:

> *"Once a variable demand model has been constructed, it is essential to ensure that it behaves 'realistically', by changing the various components of travel costs and times and checking that the overall demand response accords with general experience"*

The WebTAG guidance makes reference to the calculation of elasticities of demand, and how these can be used in the validation process. The guidance states that:

> *"The acceptability of the model's responses is determined by its demand elasticities. These demand elasticities are calculated by changing a cost or time component by a small global proportionate amount and calculating the proportionate change in trips made"*

## 5.2 Realism Testing

WebTAG recommends that the following 'realism tests' are undertaken using the base year model to understand the nature and scale of responses to a series of interventions, and that the results should lie within specified bands:

- Car Fuel Cost Elasticity;
- Car Journey Time Elasticity; and
- Public Transport Fare Elasticity

A number of such tests are outlined below.

### *5.2.1 Car Fuel Elasticity*

Evidence on fuel price elasticity[3] suggests a long term elasticity of fuel consumption to price of -0.12 calibrated from historic data. After allowing for behavioural changes (e.g. switching to more fuel efficient vehicles), the elasticity of traffic (vehicle kms) to fuel price is estimated at -0.12.

This is contrasted with studies synthesising international evidence which sets out a median elasticity of car traffic kms to fuel price of -0.31. While the difference is noted, it is worth highlighting the statistical confidence of the econometric model parameters calibrated from the time series data. These imply some uncertainty, with a 95% confidence interval for the estimated sensitivity (-0.19) of about +/-0.2. Given the comparatively low value in comparison with the international evidence and the difficulties in assembling the time series data, it might be reasonable to conclude that the estimated value is towards the lower end of the international range and that the elasticity of vehicle km to fuel price could lie between about -0.1 and -0.25.

[3] *The Impact of Fuel Prices on Traffic and Fuel Consumption in Ireland, AECOM and Goodbody Economic Consultants, February 2010*

A comparison of UK and Irish values of time and fuel prices for 2009 is set out in Table 5-1. The comparison indicates that fuel costs were about 10% lower in 2009 in Ireland than in UK. Furthermore, guidance on values of time used for economic appraisal would suggest that there is little difference in UK and Irish values of time. The inference is that national differences in prices and values of time might indicate a fuel price elasticity perhaps 10% (2009) and 20% (2008) lower than UK guidance, or around -0.25. There is no suggestion that the values should be identical, as to do so would ignore the particular social, cultural and spatial differences between both jurisdictions.

*Table 5-1: Average Fuel Cost (80kph) (cents/km, 2002 prices)*

| Country | 2002 | 2009 |
|---|---|---|
| **UK** | 6.08 | 6.13 |
| **Ireland** | 5.30 | 5.71 |

*Source: UK, Irish guidance on fuel consumption rates, fuel pump prices, exchange rate, UK RPI and Irish CPI*

Taken in the round, and subject to further evidence, we should expect the fuel price elasticity of the NTpM to be about, and possibly a little below, -0.2.

Within the NTpM, a test was executed which involved increasing fuel cost by 10%. The resulting elasticity of traffic (vehicle kms) to car fuel price is shown in Table 5-2. The result of -0.206 is consistent with expectations as set out above. The relatively low sensitivity of employer's business trip and higher sensitivity of Car Other is plausible and reflects the higher value of time of this segment. The sensitivity of commuting trips to fuel price is relatively low.

*Table 5-2: Fuel Price Elasticity*

| Purpose | Car km to Car Fuel |
|---|---|
| **Commuting** | -0.124 |
| **Business** | -0.148 |
| **Other** | -0.305 |
| **All Car** | -0.206 |

### *5.2.2 Car Journey Time Elasticity*

Table 5-3 sets out the base year direct elasticities of the model to changes in car travel cost and time. The fuel related test involved a 10% increase in fuel cost, and the model was then run to convergence to reflect changes in congestion. The time related test was undertaken by increasing travel times by 10% and applying the demand model (a single iteration).

This reflects the 'doubly constrained' operation of the model – that land use – including employment – is not assumed to change as a function of travel costs, but may indicate a lack of sensitivity for this segment. However given the limited data available for calibration we have not sought to refine the model parameters in this respect.

The sensitivity of the model to car time reflects both the sensitivity to cost and the value of time and is best therefore considered as a verification of the model response rather than a target sensitivity to calibrate the model against. Car trips represent 96% of the person trips represented in the model and this is reflected in the low trip elasticity. The sensitivity of traffic (vehicle to time) is plausible – general research in the UK would indicate a range of up to -2 for this elasticity for example.

*Table 5-3: Highway Elasticities*

| Purpose | Car km to Car Fuel | Car Trips to Car Time | Car km to Car Time |
|---|---|---|---|
| **Commuting** | -0.124 | -0.020 | -0.580 |
| **Business** | -0.148 | -0.001 | -0.904 |
| **Other** | -0.305 | -0.008 | -1.143 |
| **All Car** | -0.206 | -0.011 | -0.882 |

### *5.2.3 Public Transport Fare Elasticities*

The base year elasticity of demand to public transport fares and times is illustrated in Table 5-4. In both tests the model was run to convergence to reflect road congestion effects. Research into fare elasticities show a range broadly between -0.2 and -0.9 (in the longer term) with lower values in contexts with lower fares or for longer trips. The elasticities of -0.14 for trips and -0.41 for passenger km are plausible.

The response in respect of trips is much lower for business than might be expected. The model does not include local urban trips and the public transport trip length varies by purpose with an average of 24km for 'Commuting', 178km for 'Business' and 79km for 'Other'. The application of UK based evidence that values of time increase with trip length results in the lower sensitivity of the 'Other' purpose (in terms of trip kms) than for commuting trips in respect to fare changes. While the model sensitivities are not implausible, direct evidence of Irish elasticities or survey data from which to calibrate model coefficients would facilitate further refinement of the model calibration.

*Table 5-4: Public Transport Elasticities*

| Purpose | PT Trips to PT Fare | PT kms to PT Fare | PT Trips to PT Time |
|---|---|---|---|
| **Commuting** | -0.223 | -1.054 | -1.221 |
| **Business** | -0.077 | -0.436 | -2.934 |
| **Other** | -0.307 | -0.352 | -2.953 |
| **All PT** | -0.140 | -0.414 | -2.089 |

## 5.3 Illustrative Tests

In order to further validate the outputs of the model a number of illustrative tests were undertaken to assess the observed impact of several major public transport and road schemes. In order to do this the relevant schemes that have recently been completed were removed/closed in the NTpM and the model was run, the results of the model were then compared against observed data.

### *5.3.1 M1 Airport to Balbriggan*

The M1 Airport to Balbriggan scheme was opened in June 2003 and is illustrated in Figure 7-1. The observed AADT data recorded in 2004 were:

- M1 – 53,000 AADT; and

- R132 – 35,000 AADT

The AADT on the M1 in 2008 was 80,000 - this indicates a growth of 51% on the M1 between 2004-2008. At a national level traffic growth between 2004-2004 was 16%, which indicates additional demand of 35% on the M1 over this period. This will reflect traffic induced by the scheme together with differences between local and national growth rates.


*Figure 5-1: M1 Airport to Balbriggan*

In order to assess the impact of induced demand, this section of the M1 was closed in the NTpM and the model was re-run. The inherent logic here is that the suppression effect of removing the link is broadly in line with the trip induction effect of providing the link. The model indicated that induced demand accounted for 39% of demand on the M1 in NTpM. The results are presented in Table 5-5.

*Table 5-5: Observed/Modelled Comparison*

| Response | Observed from Available Data | Modelled |
|---|---|---|
| **Induced Vehicle Demand** | 35% | 39% |

### *5.3.2 M6 Kinnegad to Galway*

The phased construction of the M6 between Kinnegad and Galway was completed in December 2009, and is illustrated in Figure 5-2. An observed AADT of 10,500 was recorded in 2008 on the N6 East of Loughrea. Following the completion of the M6 the following AADT was recorded in 2010:

- M6 – 9,500 AADT; and
- R446 (Old N6) – 4,000 AADT

Reassignment of traffic from the old N6 accounts for 68% (6,500 AADT) of the demand on the M6. Assuming no growth between 2008 and 2010, this indicates an induced demand of 32% or 3,000 AADT.

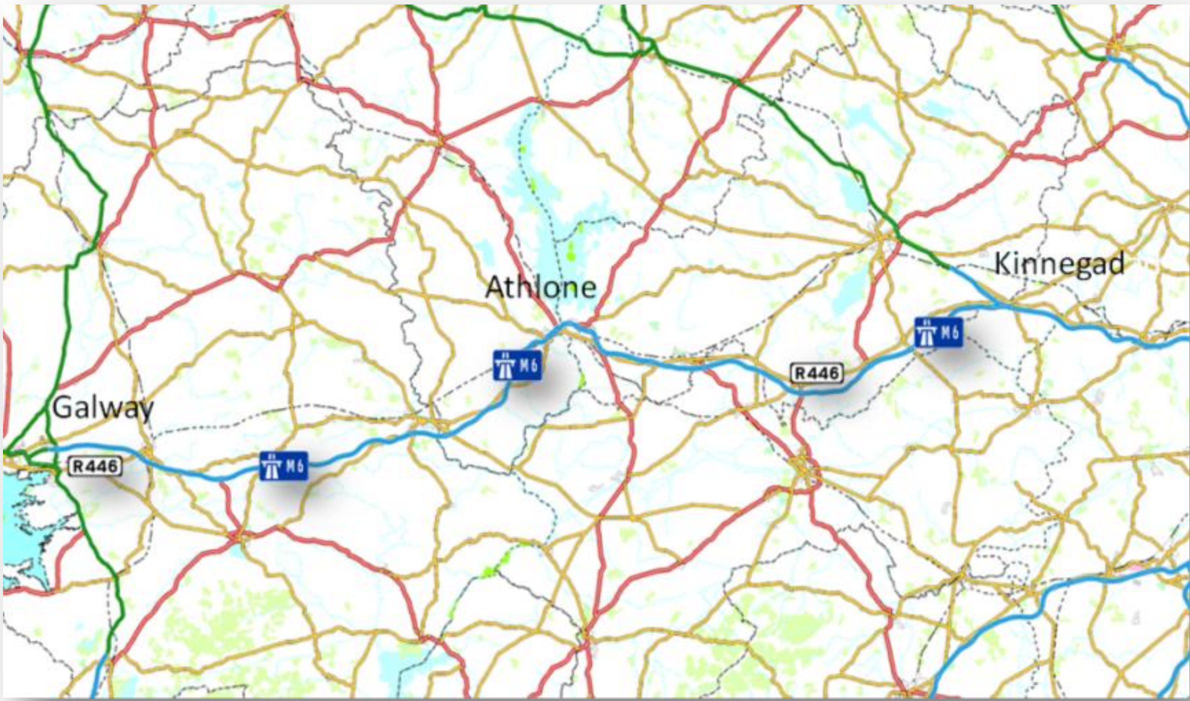



*Figure 5-2: M6 Kinnegad to Galway*

As before, the M6 was closed and the NTpM was re-run. The model indicated that induced demand accounted for 45% of demand on the M6 in NTpM. This is a significant demand response and correlates reasonably well with the 32% estimated from available data.

With respect to rail, Irish Rail indicated that demand along the Dublin-Galway rail corridor reduced by between 20-30% following the opening of the M6 motorway. The model indicates that passenger demand on the corridor reduces by 15-30% on individual links, while end to end passenger demand between Dublin and Galway is down 35-40%. All modelled/observed results are presented in Table 5-6.

*Table 5-6: Observed/Modelled Comparison*

| Response | Observed | Modelled |
|---|---|---|
| **Induced Vehicle Demand** | 32% | 45% |
| **Rail Passenger Demand** | Down 20% - 30% | Link Flows Down 15% - 20%<br>End to End Down 35% - 40% |

### *5.3.3 Dublin to Cork Rail Corridor*

The number of rail services travelling between Dublin and Cork was increased from 5 to 14 services in 2008. There was also a slight reduction in end to end journey time. Irish Rail have informally reported an increase of up to 100% in passenger demand, although this estimate has not been based on isolation of demand directly associated with the Dublin – Cork services.

Reviewing broader research evidence on rail demand elasticities (from the UK Passenger Demand Forecasting Handbook), the scale of change in demand that can be attributed directly to the change in service provision would be expected to be between 50% to 75%.

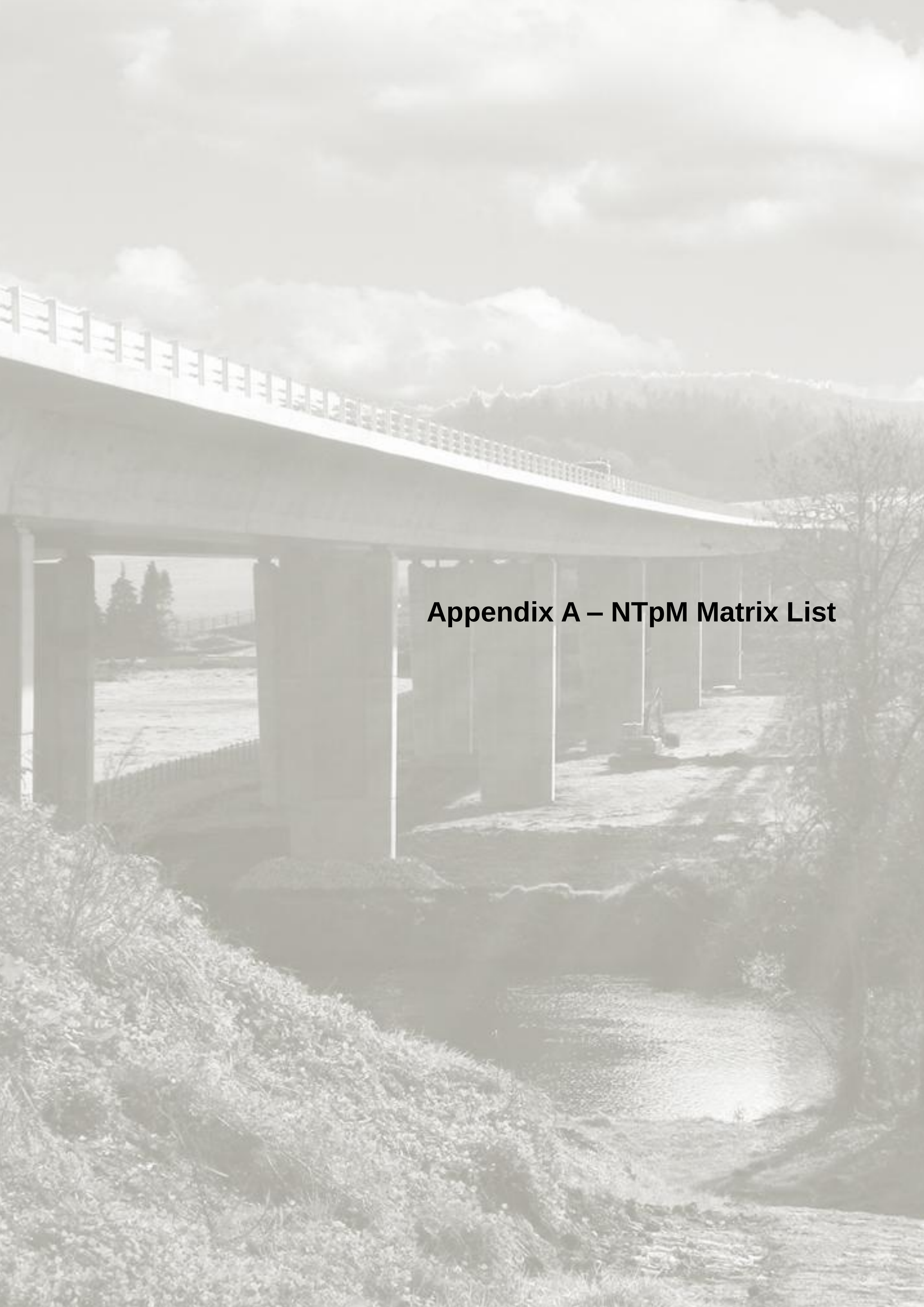

*Figure 5-3: Dublin to Cork Rail Corridor*

In order to assess passenger demand in the model, the number of rail services between Dublin and Cork was reduced to 5 (representing the do-minimum), and compared with a test using 14 services per day (representing the do-something). The model indicated that the passenger demand response of increasing services to hourly frequencies was 35-40% on the rail corridor with end to end passenger demand increasing by 50%.

#### *5.3.4 Conclusion*

The illustrative tests demonstrate that the model is producing credible responses when compared against observed data. This finding is equally applicable to both rail and road network interventions.

# Appendix A – NTpM Matrix List



| Matrix No. | Matrix Name | Matrix Description | Matrix Type | Comments |
|---|---|---|---|---|
| 11 | AssLV | Assignment Demand Light Vehicles | Demand | Highway assignment matrix for light vehicles - calculated for AM / IP within procedures |
| 12 | AssHV | Assignment Demand Heavy Vehicles | Demand | Highway assignment matrix for HGVs - calculated for AM / IP within procedures |
| 13 | AssRail | 15hr Rail Assignment Matrix | Demand | Rail assignment matrix - calculated by summing individual purposes within procedures |
| 14 | AssBus | 15hr Bus Assignment Matrix | Demand | Bus assignment matrix - calculated by summing individual purposes within procedures |
| 51 | AMHKLV | AM Peak Commuting Demand | Demand | Current iteration AM Peak lights commuting demand - (OD vehicles) |
| 52 | AMEBLV | AM Peak Employers' Business Demand | Demand | Current iteration AM Peak lights business demand - (OD vehicles) |
| 53 | AMNWLV | AM Peak Other Demand | Demand | Current iteration AM Peak lights 'other' demand - (OD vehicles) |
| 54 | AMHV | AM Peak HGV Demand | Demand | Current iteration AM Peak lights HGV demand - (OD vehicles) |
| 55 | IPHKLV | Interpeak Commuting Demand | Demand | Current iteration Interpeak lights commuting demand - (OD vehicles) |
| 56 | IPEBLV | Interpeak Employers' Business Demand | Demand | Current iteration Interpeak lights business demand - (OD vehicles) |
| 57 | IPNWLV | Interpeak Other Demand | Demand | Current iteration Interpeak lights 'other' demand - (OD vehicles) |
| 58 | IPHV | Interpeak HGV Demand | Demand | Current iteration Interpeak lights HGV demand - (OD vehicles) |
| 61 | 15HKLV | 15hr Commuting Demand (PA People) | Demand | Current iteration 15hr lights commuting demand - (PA people) |
| 62 | 15EBLV | 15hr Employers' Business Demand (PA People) | Demand | Current iteration 15hr lights business demand - (PA people) |
| 63 | 15NWLV | 15hr Other Demand (PA People) | Demand | Current iteration 15hr lights 'other' demand - (PA people) |
| 64 | 15HV | 15hr HGV Demand (PA People) | Demand | Current iteration 15hr lights HGV demand - (PA people) |
| 71 | CNWDHKRail | 15hr NCA Commuting Rail Demand | Demand | Current iteration rail NCA commuting demand - (OD people) |
| 72 | CAWDHKRail | 15hr CA Commuting Rail Demand | Demand | Current iteration rail CA commuting demand - (OD people) |
| 73 | CAWDEBRail | 15hr CA Employers' Business Rail Demand | Demand | Current iteration rail CA business demand - (OD people) |
| 74 | CNWDNWRail | 15hr NCA Other Rail Demand | Demand | Current iteration rail NCA other demand - (OD people) |
| 75 | CAWDNWRail | 15hr CA Other Rail Demand | Demand | Current iteration rail CA other demand - (OD people) |
| 81 | CNWDHKBus | 15hr NCA Commuting Bus Demand | Demand | Current iteration bus NCA commuting demand - (OD people) |
| 82 | CAWDHKBus | 15hr CA Commuting Bus Demand | Demand | Current iteration bus CA commuting demand - (OD people) |
| 83 | CAWDEBBus | 15hr Ca Employers' Business Bus Demand | Demand | Current iteration bus CA business demand - (OD people) |
| 84 | CNWDNWBus | 15hr NCA Other Bus Demand | Demand | Current iteration bus NCA other demand - (OD people) |
| 85 | CAWDNWBus | 15hr CA Other Bus Demand | Demand | Current iteration bus CA other demand - (OD people) |
| 91 | CNWDHKPT | 15hr NCA Commuting PT Demand (PA) | Demand | Current iteration PT NCA commuting demand - (PA People) |
| 92 | CAWDHKPT | 15hr CA Commuting PT Demand (PA) | Demand | Current iteration PT CA commuting demand - (PA People) |
| 93 | CAWDEBPT | 15hr CA Employers' Business PT Demand (PA) | Demand | Current iteration PT CA business demand - (PA People) |
| 94 | CNWDNWPT | 15hr NCA Other PT Demand (PA) | Demand | Current iteration PT NCA 'other' demand - (PA People) |
| 95 | CAWDNWPT | 15hr CA Other PT Demand (PA) | Demand | Current iteration PT CA 'other' demand - (PA People) |
| 101 | ITA | tAkt | Skim | Latest highway light vehicle time skim |
| 102 | IFW | Fahrweite | Skim | Latest highway light vehicle distance skim |
| 103 | IMA | Maut | Skim | Latest highway light vehicle toll skim |
| 104 | ITA | tAkt | Skim | Latest highway HGV time skim |
| 105 | IFW | Fahrweite | Skim | Latest highway HGV distance skim |
| 106 | IMA | Maut | Skim | Latest highway HGV toll skim |
| 121 | AMTmLV | AM Peak Lights Time Skim | Skim | Latest highway light vehicle AM Peak time skim, saved in procedures |
| 122 | AMDsLV | AM Peak Lights Distance Skim | Skim | Latest highway light vehicle AM Peak distance skim, saved in procedures |
| 123 | AMChLV | AM Peak Lights Toll Skim | Skim | Latest highway light vehicle AM Peak toll skim, saved in procedures |
| 124 | AMTmHV | AM Peak HGV Time Skim | Skim | Latest highway HGV AM Peak time skim saved, in procedures |
| 125 | AMDsHV | AM Peak HGV Distance Skim | Skim | Latest highway HGV AM Peak distance skim saved, in procedures |
| 126 | AMChHV | AM Peak HGV Toll Skim | Skim | Latest highway HGV AM Peak toll skim saved, in procedures |
| 127 | IPTmLV | Interpeak Lights Time Skim | Skim | Latest highway light vehicle Interpeak time skim, saved in procedures |

| Matrix No. | Matrix Name | Matrix Description | Matrix Type | Comments |
|---|---|---|---|---|
| 128 | IPDsLV | Interpeak Lights Distance Skim | Skim | Latest highway light vehicle Interpeak distance skim, saved in procedures |
| 129 | IPChLV | Interpeak Lights Toll Skim | Skim | Latest highway light vehicle Interpeak toll skim, saved in procedures |
| 130 | IPTmHV | Interpeak HGV Time Skim | Skim | Latest highway HGV Interpeak time skim saved, in procedures |
| 131 | IPDsHV | Interpeak HGV Distance Skim | Skim | Latest highway HGV Interpeak distance skim saved, in procedures |
| 132 | IPChHV | Interpeak HGV Toll Skim | Skim | Latest highway HGV Interpeak toll skim saved, in procedures |
| 141 | 15TmLV | 15hr Lights Time Skim | Skim | Latest highway light vehicle 15hr time skim, calculated in procedures - (OD) |
| 142 | 15DsLV | 15hr Lights Distance Skim | Skim | Latest highway light vehicle 15hr distance skim, calculated in procedures - (OD) |
| 143 | 15ChLV | 15hr Lights Toll Skim | Skim | Latest highway light vehicle 15hr toll skim, calculated in procedures - (OD) |
| 144 | 15TmHV | 15hr HGV Time Skim | Skim | Latest highway HGV 15hr time skim, calculated in procedures - (OD) |
| 145 | 15DsHV | 15hr HGV Distance Skim | Skim | Latest highway HGV 15hr distance skim, calculated in procedures - (OD) |
| 146 | 15ChHV | 15hr HGV Toll Skim | Skim | Latest highway HGV 15hr toll skim, calculated in procedures - (OD) |
| 147 | PJT | Perceived journey time | Skim | Latest rail perceived journey time skim - (OD) |
| 148 | IVD | In-vehicle distance | Skim | Latest rail in-vehicle distance skim - (OD) |
| 149 | Fare (R Rail) | Rail Fare Matrix | Skim | Latest rail fare matrix, calculated within procedures - (OD) |
| 150 | PJT | Perceived journey time | Skim | Latest bus perceived journey time skim - (OD) |
| 151 | IVD | In-vehicle distance | Skim | Latest bus in-vehicle distance skim - (OD) |
| 152 | Fare (B Bus) | Bus Fare Matrix | Skim | Latest bus fare matrix, calculated within procedures - (OD) |
| 153 | PTCompCNHK | PT Composite Cost - NCA Commuting | Skim | Latest PT composite cost for NCA commuting, calculated in Python - (PA) |
| 154 | PTCompCAHK | PT Composite Cost - CA Commuting | Skim | Latest PT composite cost for CA commuting, calculated in Python - (PA) |
| 155 | PTCompCAEB | PT Composite Cost - CA Employers' Business | Skim | Latest PT composite cost for CA business, calculated in Python - (PA) |
| 156 | PTCompCNNW | PT Composite Cost - NCA Other | Skim | Latest PT composite cost for NCA 'other', calculated in Python - (PA) |
| 157 | PTCompCANW | PT Composite Cost - CA Other | Skim | Latest PT composite cost for NCA 'other', calculated in Python - (PA) |
| 181 | 15TmLV_Ref | 15hr Lights Time Skim - Reference | Skim | 'Reference' / 'DoMin' highway light vehicle 15hr time skim, calculated in procedures - (OD) |
| 182 | 15DsLV_Ref | 15hr Lights Distance Skim - Reference | Skim | 'Reference' / 'DoMin' highway light vehicle 15hr distance skim, calculated in procedures - (OD) |
| 183 | 15ChLV_Ref | 15hr Lights Toll Skim - Reference | Skim | 'Reference' / 'DoMin' highway light vehicle 15hr toll skim, calculated in procedures - (OD) |
| 184 | 15TmHV_Ref | 15hr HGV Time Skim - Reference | Skim | 'Reference' / 'DoMin' highway HGV 15hr time skim, calculated in procedures - (OD) |
| 185 | 15DsHV_Ref | 15hr HGV Distance Skim - Reference | Skim | 'Reference' / 'DoMin' highway HGV 15hr distance skim, calculated in procedures - (OD) |
| 186 | 15ChHV_Ref | 15hr HGV Toll Skim - Reference | Skim | 'Reference' / 'DoMin' highway HGV 15hr toll skim, calculated in procedures - (OD) |
| 187 | PJT (R Rail)_Ref | Rail Time Skim - Reference | Skim | 'Reference' / 'DoMin' rail perceived journey time skim - (OD) |
| 188 | IVD (R Rail)_Ref | Rail Distance Skim - Reference | Skim | 'Reference' / 'DoMin' rail in-vehicle distance skim - (OD) |
| 189 | Fare (R Rail)_Ref | Rail Fare Matrix - Reference | Skim | 'Reference' / 'DoMin' rail fare matrix, calculated within procedures - (OD) |
| 190 | PJT (B Bus)_Ref | Bus Time Skim - Reference | Skim | 'Reference' / 'DoMin' bus perceived journey time skim - (OD) |
| 191 | IVD (B Bus)_Ref | Bus Distance Skim - Reference | Skim | 'Reference' / 'DoMin' bus in-vehicle distance skim - (OD) |
| 192 | Fare (B Bus)_Ref | Bus Fare Matrix - Reference | Skim | 'Reference' / 'DoMin' bus fare matrix, calculated within procedures - (OD) |
| 211 | 15HKLV_Prev | 15hr Commuting Demand (PA People) - Previous | Demand | Previous iteration 15hr lights commuting demand - (PA people) |
| 212 | 15EBLV_Prev | 15hr Employers' Business Demand (PA People) - Previous | Demand | Previous iteration 15hr lights business demand - (PA people) |
| 213 | 15NWLV_Prev | 15hr Other Demand (PA) - Previous | Demand | Previous iteration 15hr lights 'other' demand - (PA people) |
| 214 | 15HV_Prev | 15hr HGV Demand (PA) - Previous | Demand | Previous iteration 15hr lights HGV demand - (PA people) |
| 221 | 15HKLV_Ref | 15hr Commuting Demand (PA People) - Reference | Demand | Reference iteration 15hr lights commuting demand - (PA people) |
| 222 | 15EBLV_Ref | 15hr Employers' Business Demand (PA People) - Reference | Demand | Reference iteration 15hr lights business demand - (PA people) |
| 223 | 15NWLV_Ref | 15hr Other Demand (PA People) - Reference | Demand | Reference iteration 15hr lights 'other' demand - (PA people) |
| 224 | 15HV_Ref | 15hr HGV Demand (PA People) - Reference | Demand | Reference iteration 15hr lights HGV demand - (PA people) |
| 241 | CNWDHKPT_Prev | 15hr NCA Commuting PT Demand (PA) - Previous | Demand | Previous iteration PT NCA commuting demand - (PA People) |
| 242 | CAWDHKPT_Prev | 15hr CA Commuting PT Demand (PA) - Previous | Demand | Previous iteration PT CA commuting demand - (PA People) |

| Matrix No. | Matrix Name | Matrix Description | Matrix Type | Comments |
|---|---|---|---|---|
| 243 | CAWDEBPT_Prev | 15hr CA Employers' Business Demand (PA) - Previous | Demand | Previous iteration PT CA business demand - (PA People) |
| 244 | CNWDNWPT_Prev | 15hr NCA Other Demand (PA) - Previous | Demand | Previous iteration PT NCA 'other' demand - (PA People) |
| 245 | CAWDMWPT_Prev | 15hr CA Other Demand (PA) - Previous | Demand | Previous iteration PT CA 'other' demand - (PA People) |
| 251 | CNWDHKPT_Ref | 15hr NCA Commuting PT Demand (PA) - Reference | Demand | Reference iteration PT NCA commuting demand - (PA People) |
| 252 | CAWDHKPT_Ref | 15hr CA Commuting PT Demand (PA) - Reference | Demand | Reference iteration PT CA commuting demand - (PA People) |
| 253 | CAWDEBPT_Ref | 15hr CA Employers' Business Demand (PA) - Reference | Demand | Reference iteration PT CA business demand - (PA People) |
| 254 | CNWDNWPT_Ref | 15hr NCA Other Demand (PA) - Reference | Demand | Reference iteration PT NCA 'other' demand - (PA People) |
| 255 | CAWDMWPT_Ref | 15hr CA Other Demand (PA) - Reference | Demand | Reference iteration PT CA 'other' demand - (PA People) |
| 261 | AMHKLV_Ref | AM Peak Commuting Demand - Reference | Demand | 'Reference' / 'DoMin' AM Peak lights commuting demand - (OD vehicles) |
| 262 | AMEBLV_Ref | AM Peak Employers' Business Demand - Reference | Demand | 'Reference' / 'DoMin' AM Peak lights business demand - (OD vehicles) |
| 263 | AMNWLV_Ref | AM Peak Other Demand - Reference | Demand | 'Reference' / 'DoMin' AM Peak lights 'other' demand - (OD vehicles) |
| 264 | AMHV_Ref | AM Peak HGV Demand - Reference | Demand | 'Reference' / 'DoMin' AM Peak lights HGV demand - (OD vehicles) |
| 265 | IPHKLV_Ref | Interpeak Commuting Demand - Reference | Demand | 'Reference' / 'DoMin' Interpeak lights commuting demand - (OD vehicles) |
| 266 | IPEBLV_Ref | Interpeak Employers' Business Demand - Reference | Demand | 'Reference' / 'DoMin' Interpeak lights business demand - (OD vehicles) |
| 267 | IPNWLV_Ref | Interpeak Other Demand - Reference | Demand | 'Reference' / 'DoMin' Interpeak lights 'other' demand - (OD vehicles) |
| 268 | IPHV_Ref | Interpeak HGV Demand - Reference | Demand | 'Reference' / 'DoMin' Interpeak lights HGV demand - (OD vehicles) |
| 281 | CNWDHKRail_Ref | 15hr NCA Commuting Rail Demand - Reference | Demand | 'Reference' / 'DoMin' rail NCA commuting demand - (OD people) |
| 282 | CAWDHKRail_Ref | 15hr CA Commuting Rail Reference Demand | Demand | 'Reference' / 'DoMin' rail CA commuting demand - (OD people) |
| 283 | CAWDEBRail_Ref | 15hr CA Employers' Business Rail Demand - Reference | Demand | 'Reference' / 'DoMin' rail CA business demand - (OD people) |
| 284 | CNWDNWRail_Ref | 15hr NCA Other Rail Demand - Reference | Demand | 'Reference' / 'DoMin' rail NCA other demand - (OD people) |
| 285 | CAWDNWRail_Ref | 15hr CA Other Rail Demand - Reference | Demand | 'Reference' / 'DoMin' rail CA other demand - (OD people) |
| 291 | CNWDHKBus_Ref | 15hr NCA Commuting Bus Demand - Reference | Demand | 'Reference' / 'DoMin' bus NCA commuting demand - (OD people) |
| 292 | CAWDHKBus_Ref | 15hr CA Commuting Bus Demand - Reference | Demand | 'Reference' / 'DoMin' bus CA commuting demand - (OD people) |
| 293 | CAWDEBBus_Ref | 15hr CA Employers' Business Bus Demand - Reference | Demand | 'Reference' / 'DoMin' bus CA business demand - (OD people) |
| 294 | CNWDNWBus_Ref | 15hr NCA Other Bus Demand - Reference | Demand | 'Reference' / 'DoMin' bus NCA other demand - (OD people) |
| 295 | CAWDNWBus_Ref | 15hr CA Other Bus Demand - Reference | Demand | 'Reference' / 'DoMin' bus CA other demand - (OD people) |
| 301 | CNWDHKPT_FromHome | 15hr NCA Commuting PT PAFromHome Matrix | Demand | Reference 15hr NCA Commuting PA From-Home Proportions |
| 302 | CAWDHKPT_FromHome | 15hr CA Commuting PT PAFromHome Matrix | Demand | Reference 15hr CA Commuting PA From-Home Proportions |
| 303 | CAWDEBPT_FromHome | 15hr CA Employers' Business PT PAFromHome Matrix | Demand | Reference 15hr CA Employers' Business PA From-Home Proportions |
| 304 | CNWDNWPT_FromHome | 15hr NCA Other PT PAFromHome Matrix | Demand | Reference 15hr NCA Other PA From-Home Proportions |
| 305 | CAWDNWPT_FromHome | 15hr CA Other PT PAFromHome Matrix | Demand | Reference 15hr CA Other PA From-Home Proportions |
| 998 | HwyDis | Distance for Cost-Dampening (IP Base Distance) | Skim | Copy of base year Interpeak distance skim for cost-dampening - fixed |
| 999 | Blank | Blank | Demand | Zero matrix - re-initialised in procedures |