NTM Future Model Development: NTMv2 recalibration

NTMv2R: Demand Model Implementation

Department for Transport

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1. Introduction

1.1. NTMv2 modelling system

The initial version of the National Passenger transport modelling framework was developed in 1999. Since then there has been incremental development and a number of updates to the core components of the modelling system. NTMv2 is the version of the national modelling framework which has been used by the Department to test the impacts of a wide range of scenarios and to produce the road traffic forecasts which are published from time to time.

Central to the modelling framework is a transport demand model which operates at an aggregate level of spatial detail with an innovative structure of distance bands to incorporate additional geography and reflect the various travel options available without including large numbers of zones. To provide traffic forecasting functionality this demand model (formally known as Pass1) is linked to a statistical road capacities and costs module known as FORGE. FORGE represents the supply of road space available and hence as demand for car travel changes the impact on congestion and speeds of travel is taken into account.

This report documents the implementation of the NTMv2 demand model and the updated inputs. It is intended to provide information on the model structure and base year model data sets. A separate report "NTMv2R Demand Model Calibration and Validation"[1] provides details on the updating of the model parameters and realism testing, while the updating of FORGE and the associated interfacing programs (TrafGen and SpeedGen) were carried out by the Department's NTM team.

The demand model represents personal travel by household residents in Great Britain with trips segmented into 105 traveller type segments representing travel for 8 trip purposes and a range of person types (by age / income and working status) and household types (car availability).

The Demand Model from NTM version 2 has been updated to incorporate the latest available NTS data and represent a 2015 Base Year, without any changes to the model choice structure, software and basic implementation which have been taken as defined by NTMv2. This report describes the model structure (unchanged) and the implementation of the revised datasets for the 2015 base year. The updated model is known as NTMv2R.

1.2. Enhancements for NTMv2R

The updating and recalibration of the demand model was carried out as a short term exercise to provide up to date modelling tools for the Department to apply to a number of studies, while a new spatially detailed version of the model is developed.

The premise for the updating work of NTMv2 was to reduce risk and effort by retaining the model structure and implementation unchanged. NTMv2R therefore has exactly the same dimensions as the earlier model and continues to be implemented using the MEPLAN modelling software. There have however been a number of small enhancements incorporated while updating the data inputs as set out below.

The following enhancements have been applied to the demand model:

- Small geographic adjustments to the zone definitions to achieve better compatibility with NTEMv7[2] geography and areas available from the National Transport Survey (NTS);

- The demand model has been linked to NTEMv7 to provide updated trip ends;

[1] NTMv2R_Calibration and Validation_v2.pdf
[2] Travel demand data was taken from NTEM v7.0 published in July 2016. The geography and definitions in NTEM remain unchanged for subsequent NTEM v7.x releases and hence later versions of trip ends could be used for forecasting without any change in definition / processing approach.

- One small change in age group for consistency with the update to the NTEM dataset which provides the trip end inputs. The upper age band has been revised from those age 65+ to those aged 75+.

- Functional form for forecasting vehicle operating costs has been revised in line with changes set out in the WebTAG databook.

- Upgraded to MEPLAN version 5.2 to utilise 64 bit version and streamline running process;

In addition to these modifications the main task has been updating the inputs to the model to incorporate values of time from the WebTAG databook and revise trip characteristics for all modes of travel based on the latest best available data sources, including NTS, Transport Statistics Great Britain, National Express ticket prices, Transport for London road user charge, and MOIRA rail model results. This report provides details for these updated demand model inputs.

Following the updates to the model, the choice parameters and constants were updated through a calibration exercise. The recalibration is reported in the accompanying NTM Futures Development: NTMv2R Demand Model Calibration and Validation Report, RAND Europe 2018.

1.3. Structure of model and report

This Implementation report provides information on the demand model design and data inputs that reflect the level and segmentation of travel demand and the supply and characteristics of alternative travel modes. The companion NTMv2R Demand Model Calibration and Validation report provides information on the data used to calibrate and validate the updated demand model and the resulting parameters and performance achieved.

Chapter 2 of this report sets out the definitions and structure of the demand model which as noted above are largely unchanged from the earlier NTMv2 demand model.

The sources of data and derivation of inputs to the model are described in Chapters 3 and 4 for demand and travel characteristics respectively.

Chapter 5 provides a summary of the impact these updates had on the base year results from the model prior to the recalibration exercise being completed as reported in the Calibration and Validation report.

The Appendices to the report provide supplementary information on the model implementation.

2. Demand model structure

The following sub-sections provide the definitions and inputs used for the different components of the transport demand model. Appendix B provides a standalone summary of the model definitions for reference.

2.1. Overview of the demand model

The demand model operates with production – attraction (PA) trips (which are defined as the from home legs of home based trips and non-home based trips) for a single time period to reflect an average day (full week / 7). Volumes of trip productions by traveller type and trip attractions by trip purpose are taken directly from the DfT's NTEM dataset for the year of interest.

The demand model carries out the distribution and modal split stages of a conventional four stage demand model. It incorporates a high degree of traveller segmentation to enable a range of policies to be tested. The model takes as input the total trip productions and attractions by purpose and traveller type from the multi-modal national trip end model (NTEM).

The demand model is implemented using the MEPLAN software. The two core programs LUSA and TASA use the terms "factor" and "flow" respectively to represent the different demand segments of trip purpose, traveller type and distance band. The input trip ends by trip purpose and traveller type are one set of factors which are then allocated to distance bands using a logit choice model to generate the more detailed set of factors. In the NTMv2R demand model the traveller demand segmentation is consistent throughout the model and hence the flow definitions in TASA are identical to the most detailed set of factors defined in LUSA.

The distribution module of demand model splits the trip productions into distance bands and allocates them to attraction zones to match a set of specified trip attraction constraints. Travel characteristics used in the distribution model are taken from the linked modal split model.

The modal split module splits the trips by traveller type, purpose and distance band into the different modes of travel, which include walking and cycling. Travel characteristics (costs, times and disutilities/generalised costs) are derived from input parameters and a pseudo network.

2.2. Dimensions and units

The dimensions and units used by NTMv2R are shown in Table 2-1. Updates have been made to the prices to reflect the 2015 Base Year. As noted above the model is operating with PA trips (defined as the "from home" leg of home based trips plus non home based trips).

Table 2-1 Dimensions and units

Dimension	Units
Distance	*Miles*
Time	*Minutes*
Cost / Money	*Pence in 2015 prices*
Speed	*Miles per hour*
Disutility	*Generalised Minutes*
Trips	*Average day, outward legs (from home) for HB; one way for NHB*

2.3. Choice mechanisms

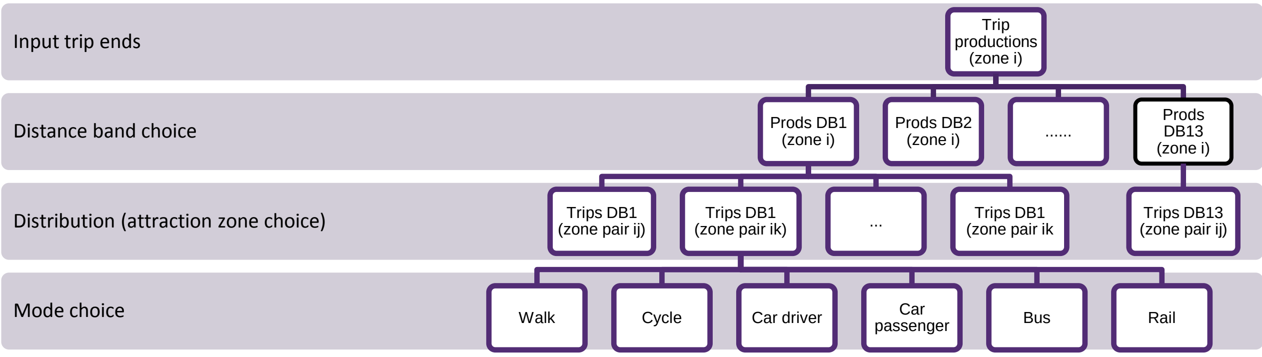
There are three choice mechanisms that operate within the demand model for each input trip production:

- Choice of distance band;

- Choice of attraction zone;
- Choice of mode of travel.

The choices are all modelled using absolute logit choice models and implemented with an assumed structure (unchanged from NTMv2) as shown in Figure 2-1 below.

Figure 2-1 Demand model choice hierarchy



The choice model parameters are set during the model calibration process. The implementation of updates for NTMv2R was undertaken with the old choice parameters from the NTMv2 calibration.

2.3.1. Distance band choice model

The distance band choice model is embedded within the trip distribution model. The trip productions by purpose and traveller type for each zone are inputs to the model. These trip ends are then split into the distance bands with the proportion being calculated using a logit segmentation function based on the relative disutilities of travel from each production zone for the different distance bands. The travel disutilities are calculated by the mode choice model and applied over all modes and attraction zones.

Thus the trip productions, $T_{i.l}$, in zone i, by distance band l, are calculated from the total trip productions for the zone T_i as:

$$T_{i.l} = T_i \frac{exp\left(-\lambda^L u_{i.l}\right)}{\sum_L exp\left(-\lambda^L u_{i.L}\right)}$$

Where: λ^L is the lambda (sensitivity) parameter for distance band choice

L is the full set of distance bands

$u_{i.l}$ the disutility of travel associated with each distance band (*l*) is calculated as the logsum of the disutilities for each zone pair and distance band (*ijl*) from that production zone (*i*) as follows:

$$u_{i.l} = -\frac{1}{\lambda^D} ln\left(\sum_j exp\left(-\lambda^D\left(u_{ijl} + S_{ijl}\right)\right)\right)$$

λ^D is the lambda (sensitivity) parameter for destination choice

S_{ijl} are the size terms as defined below.

All trip purposes are constrained in the base year to match distance band profiles derived from National Travel Survey (NTS) data. This results in iterative adjustments to the disutility of travel $\boldsymbol{u_{i.l}}$ for each distance band. These distance band specific constants are added to the disutility in all forecast / scenario runs which have no distance band constraints applied.

2.3.2. Distribution model

The functional form of the distribution model is a single level, multinomial logit model of discrete choice. The model takes the demand (trip productions) by purpose, traveller type and distance band and then distributes the trips amongst the attraction zones according to the level of disutility of locating in each zone. Zonal trip attractions by purpose from the trip end model are used as constraints to the distribution model.

Thus the PA trips, T_{ijl}, from zone i to zone j by distance band l, are calculated from the trip productions by distance band for the zone $T_{i.l}$ as:

$$T_{ijl} = T_{i.l}\frac{exp\left(-\lambda^D(u_{ijl}+S_{ijl})\right)}{\sum_J exp\left(-\lambda^D(u_{iJl}+S_{iJl})\right)}$$

Where: λ^D is the lambda (sensitivity) parameter for distribution (destination) choice

J is the full set of destination zones

u_{ijl} the disutility of travel associated with each distance band (l) is calculated as the logsum of the modal disutilities for each zone pair and distance band (ijl) as follows:

$$u_{ijl} = -\frac{1}{\lambda^M} ln\left(\sum_M exp\left(-\lambda^M u_{ijl}^M\right)\right)$$

S_{ijl} are the sizeterms that denote the importance for travel in the specific zone pair and distance band given the geography of the country and volume of attractions at the destination. The size terms have not been updated from NTMv2 – ie the geography of the country and associated opportunities are assumed not to have changed.

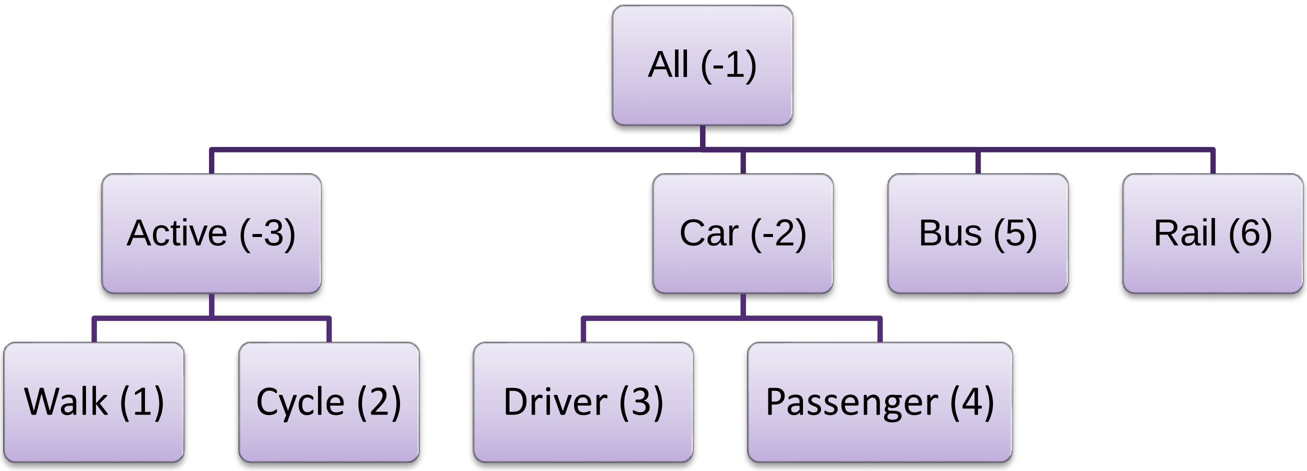
λ^M is the lambda (sensitivity) parameter for mode choice

All trip purposes are doubly constrained to the NTEM v7 trip attraction totals in the base and forecast years. This results in iterative adjustments to the disutility of travel u_{ijl} for each attraction zone j.

2.3.3. Mode choice model

The mode choice model is a hierarchical logit model as shown in Figure 2-2 below, for each of the trip purpose, traveller type and distance band combinations output from the distribution model. Walk and cycle are sub modes of the "active" or non-mechanised mode, while car trips are subsequently split between drivers and passengers.

Figure 2-2 Mode choice hierarchy



Thus the PA modal trips, T_{ijl}^{m}, from zone i to zone j by distance band l, are calculated from the trip productions by distance band for the zone T_{ijl} as:

$$T_{ijl}^{m} = T_{ijl}\frac{exp\left(-\lambda^{M}u_{ijl}^{m}\right)}{\sum_{M} exp\left(-\lambda^{M}u_{ijl}^{M}\right)}$$

Where: λ^{M} is the lambda (sensitivity) parameter for mode choice

M is the full set of modes

u_{ijl}^{m} the disutility of travel associated with each zone pair and distance band (ijl) is calculated from the input characteristics to the demand model for mode m.

2.4. Zone definition

The zones are consistent throughout each stage of the demand model and defined as shown in Table 2-2. NTMv2R zones are designed to be as similar as possible to NTMv2 zones, for consistency with other parts of the model, but aligning with NTEMv7 zone boundaries and using more up-to-date data on built-up areas.

NTEMv7 zones in England and Wales are identical to Middle layer Super Output Areas (MSOA), which nest within Local Authority Districts (LAD) and Regions. NTEMv7 zones in Scotland are based upon groups of Data Zones, which nest within Council Areas (CA) and Regions. This provides a hierarchy of administrative boundaries that allows NTEMv7 zones to be mapped onto NTMv2R zones.

Table 2-2 Zone numbers and descriptions

Zone Number	Description
1	Central London
2	Inner London
3	Outer London
4	N & E Central Conurbation
5	West Central Conurbation
6	N & E Conurbation Surrounds
7	West Conurbation Surrounds
8	N & E Urban Big
9	West Urban Big
10	South Urban Big
11	Not defined
12	N & E Urban Large
13	West Urban Large
14	South Urban Large
15	Not defined
16	Urban Medium
17	Smaller Urban & Rural

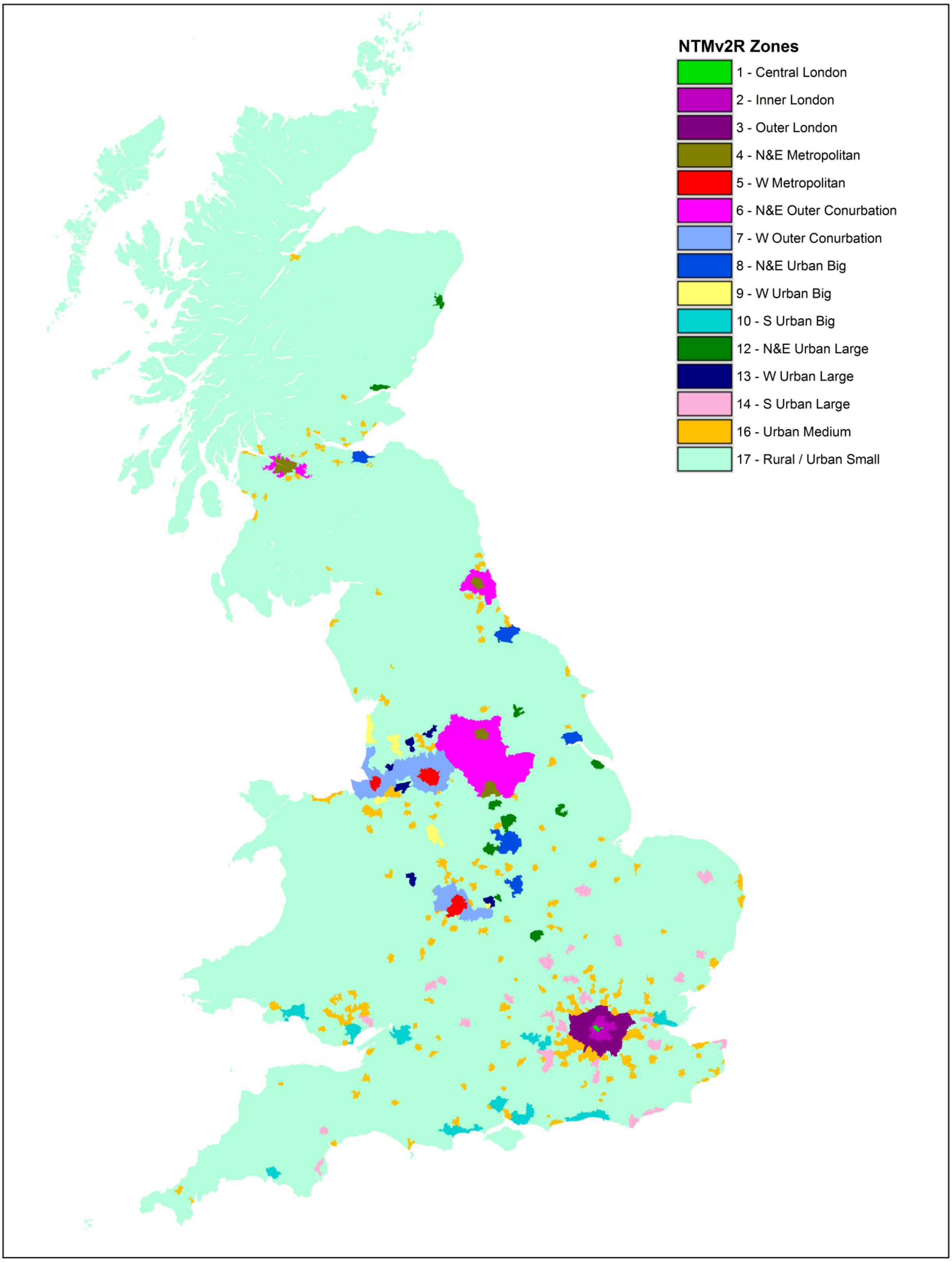
The 15 NTMv2R zones are defined by combinations of Regions and Area Types, as shown in Table 2-3 below. These definitions are identical to NTMv2 – although the exact combinations of NTEMv7 zones that make up each Area Type do not match the previous boundaries perfectly (since NTMv2 was not based on MSOAs). Some settlements will also have changed area type in the updated model for 2015 most likely due to increases in the population in the specific urban area (eg towns between 50,000 and 100,000 population). The area type definitions are taken from the National Travel Survey (NTS) by size of urban area.

Table 2-3 Definition of model zones by Region and Area type

	NTMv2R Area Type ->								
	1	2	3	4	5	6	7	8	9
Region	Central London	Inner London	Outer London	Metropolitan	Outer Conurbation	Urban Big (pop>250k)	Urban Large (pop>100k)	Urban Medium (pop>25k)	Smaller Urban and Rural
London	1	2	3						
South East						10	14	16	17
East of England						10	14	16	17
South West						10	14	16	17
Wales						10	14	16	17
West Midlands				5	7	9	13	16	17
North West				5	7	9	13	16	17
East Midlands				4	6	8	12	16	17
Yorkshire and the Humber				4	6	8	12	16	17
North East				4	6	8	12	16	17
Scotland				4	6	8	12	16	17

The geographical coverage of various types of the model zones throughout the country is as illustrated in Figure 2-3. Table 2-4 shows the combinations of area types and regions making up the demand model zones, and provides a list of the main cities / towns in each zone.

Figure 2-3 NTMv2R zone plan



The Regions are clearly defined in NTEM7 zones, but the Area Types (level of urbanicity) are more difficult to define a correspondence with the NTEM zones (Middle Super Output Areas). The approach that has been taken is:

- Area Types 1 to 3 have been defined using London borough administrative boundaries (which is the same definition as NTMv2);
- Area Type 4 has been defined using MSOA boundaries for England and Wales, and NTEM7 zone boundaries for Scotland, that match the NTMv2 Metropolitan area type as closely as possible;
- Area Type 5 has been defined using Metropolitan District administrative boundaries in England and Wales (which again is the same definition as NTMv2), and the built-up area around Glasgow derived from NTS zone mapping; and
- Area Types 6 to 9 have been defined using built-up areas derived from NTS area type mapping, except for Plymouth[3] (which has instead been defined using administrative boundaries).

Further information is provided in Appendix C.

Table 2-4 Model zones by region and area types with main towns in each zone

<table>
<tr><th rowspan="2">Region</th><th colspan="9">NTMv2R Area Type -></th></tr>
<tr><th>Central London</th><th>Inner London</th><th>Outer London</th><th>Metropolitan</th><th>Outer Conurbation</th><th>Urban Big (pop>250k)</th><th>Urban Large (pop>100k)</th><th>Urban Medium (pop>25k)</th><th>Smaller Urban & Rural</th></tr>
<tr><td>London</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>South East
East of England
South West
Wales</td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3"></td><td></td><td></td><td>Plymouth, Swansea, Cardiff, Bristol, Bournemouth, Southampton, Portsmouth, Brighton, Reading, Southend</td><td>Norwich, Peterborough, Cambridge, Bedford, Milton Keynes, Ipswich, Colchester, Basildon, Oxford, Swindon, Slough, Luton, High Wycombe, St Albans, Eastbourne, Hastings, Margate, Medway Towns, Crawley, Farnborough, Cheltenham, Gloucester, Newport, Torquay, Exeter</td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>West Midlands
North West</td><td>Liverpool, Manchester, Birmingham</td><td></td><td>Blackpool, Preston, Ellesmere Port, Stoke</td><td>Telford, Nuneaton, Warrington, Wigan, Blackburn, Burnley</td></tr>
<tr><td>East Midlands
Yorkshire and the Humber
North East
Scotland</td><td>Sheffield, Leeds, Newcastle, Glasgow</td><td></td><td>Leicester, Nottingham, Hull, Middlesbrough, Edinburgh</td><td>Aberdeen, Dundee, York, Grimsby, Lincoln, Mansfield, Chesterfield, Derby, Northampton</td></tr>
</table>

2.5. Demand segmentation

The demand model is highly segmented, with a total 105 different categories of trips. These segments are made up of permutations of person type, household car availability, income group and trip purposes as set out below. Not all dimensions are included (or appropriate) for every trip purpose. The combinations included in the demand model are also summarised in Section 2.5.5.

2.5.1. Trip purpose

Within the demand model, eight different trip purposes are defined, including six home-based trip purposes and two non-home based trip purposes. They are listed in Table 2-5. The purposes are defined from the NTS variables “trip purpose from” and “trip purpose to”. Escort purposes are treated in the same way as the main purpose (ie escort education is combined with education) since they are attracted to the same

[3] After further review of the zones and underlying area types, DfT requested that Plymouth be moved from Area Type 7 to 6 so as to remain consistent with the existing NTMV2.

locations. If the “trip purpose to” is not home, this defines the purpose of the trip, otherwise the "purpose from” defines the purpose of the trip.

Table 2-5 Trip purpose

Trip purpose	Home based on Non home-based	Description	NTS purpose definitions included
1	Home-based	Work (ie commuting)	Work, Escort work
2	Home-based	Employer’s business	In the course of work, Escort in the course of work
3	Home-based	Education	Education, Escort education
4	Home-based	Personal business and shopping	Food shopping, Non food shopping, Personal business medical, Personal business eat / drink, Personal business other, Escort shopping / personal business
5	Home-based	Recreation, social and visiting friends/relatives	Eat / drink with friends, Visit friends, Other social, Entertain / public activity, Sport: participate, Other escort
6	Home-based	Holidays and day trips	Holiday: base, Day trip / just walk
7	Non Home-based	Employer’s business	In the course of work, Escort in the course of work
8	Non Home-based	Other	All other combinations (except home to home excluded – negligible)

2.5.2. Person type

There are four person types groups, which are formed by combining age with employment status (Table 2-6). The age bands have been revised as part of the update for consistency with NTEM.

Table 2-6 Person types

Person Type	Status	Age
1	Children	0-15
2	Full-time employed	16-74
3	Other (part time employed, students and non employed)	16-74
4	Pensioner	75 and over

For the trip purposes work and employer’s business, the three status groups other than the full-time employed have been grouped together.

2.5.3. Household type

There are five household type groups, which are formed by combining the number of adults and cars within a household as shown in the following Table 2-7: These five categories are used for all home-based trip purposes with the exception of HB holiday and day trips which are not segmented by household type.

Table 2-7 Household type

Household Type	Number of adults	Number of cars
1	1 adult	0 car
2	1 adult	1+ cars
3	2 or more adults	0 car
4	2 or more adults	1 car
5	2 or more adults	2+ cars

2.5.4. Socio-economic group (SEG) / income group

A segmentation of the population into three socio-economic group (SEG) / income groups is used for the work and employer's business trips. The three groups were originally defined from the SEG of the individuals since this data was available from the Census of Population, the Family Expenditure Survey (FES) and the NTS which were all used in the development of the original model. The aggregation of the SEGs into the three income groups has been retained unchanged as shown in Table 2.8.

Table 2.8 SEG / income groups defined

Social class (NTS variable SC_B01ID)	NTMv2R income band
Professional occupations	High
Managerial and technical occupations	High
Skilled occupations – non-manual	Medium
Skilled occupations – manual	Medium
Partly skilled occupations	Low
Unskilled occupations	Low

2.5.5. Combinations modelled

The 105 combinations of the trip purposes, person types, household types and income / SEG groups modelled are shown in Table 2.9 below.

Table 2.9 Trip demand segments represented in Demand model

Purpose	Person type	SEG / Income	1 adult / 0 car	1 adult /1+ car	2+ ad / 0 car	2+ ad / 1 car	2+ad / 2+ car	All
HB Work	Full time emp	High Medium Low	1 6 11	2 7 12	3 8 13	4 9 14	5 10 15	
	Rest of pop'n	All	16	17	18	19	20	
HB EB	Full time emp	High Medium Low	21 26 31	22 27 32	23 28 33	24 29 34	25 30 35	
	Rest of pop'n	All	36	37	38	39	40	
HB Educ	Child (0-15) Full time emp Other 16-74 75+		41 46 51 56	42 47 52 57	43 48 53 58	44 49 54 59	45 50 55 60	
HB PB / Shopping	Child (0-15) Full time emp Other 16-74 75+		61 66 71 76	62 67 72 77	63 68 73 78	64 69 74 79	65 60 75 80	

Purpose	Person type	SEG / Income	1 adult / 0 car	1 adult /1+ car	2+ ad / 0 car	2+ ad / 1 car	2+ad / 2+ car	All
HB Rec / Visiting friends	Child (0-15) Full time emp Other 16-74 75+		81 86 91 96	82 87 92 97	83 88 93 98	84 89 94 99	85 90 95 100	
HB Hols / Day trips	All persons							101
NHB EB	All persons	High Medium Low						102 103 104
NHBO	All persons							105

2.6. Distance bands

The distance bands used within the demand model are shown in Table 2.10. They are the standard 12 bands as used in presentation of data collected in the National Travel Survey (NTS) plus a further distance band to improve the representation of the longest distance trips primarily for the purpose of identifying rail and air trips. Because the NTS collects information on travel distances in miles, the demand model has been implemented using a distance unit of miles.

Table 2.10 Distance band numbers and distance ranges

Distance band	Range (miles)
1	<1 mile
2	1-2 miles
3	2-3 miles
4	3-5 miles
5	5-10 miles
6	10-15 miles
7	15-25 miles
8	25-35 miles
9	35-50 miles
10	50-100 miles
11	100-200 miles
12	200-300 miles
13	> 300 miles

The distribution model estimates the split of the trips by purpose and traveller type into the 13 distance bands. The 105 factors shown in Table 2.9 are thus expanded into 1365 factors that are then allocated amongst the different model attraction zones.

2.7. Modes

The same six modes are used in the demand model as in the NTEM model with the definition of the modes based on the NTS classification of modes as shown in Table 2.11. For some model inputs there is no distinction between the walk and cycle modes and these are sometimes referred to as active modes.

Table 2.11 Definition of demand model modes

Main mode	NTS mode definitions
1 Walk	Walk < 1 mile Walk 1+ miles
2 Cycle	Bicycle
3 Car driver	Private: car driver Motor cycle / scooter / moped: driver Van / lorry: driver Taxi Minicab
4 Car passenger	Private: car passenger Motor cycle / scooter / moped: passenger Van / lorry: passenger Other: private transport
5 Bus	Private (hire) bus London stage bus Other stage bus Express bus Excursion / tour bus
6 Rail	LT underground Surface rail Other public transport (includes Light Rail / metros etc) Domestic Air

2.8. Time periods

Time of day is not explicitly represented in the demand model. It represents travel for an average day (total for the week divided by seven).

Due to the large variation in rail travel characteristics between peak and off-peak travel these two time periods were incorporated for rail travel only in NTMv2 and have been retained for the input of updated characteristics in NTMv2R. In order not to introduce additional complexity associated with time of day choice the different trip purposes have been allocated to the time period in which they predominantly occur and hence adopt the most appropriate travel characteristics.

The correspondence between the rail time period characteristics used and the trip purposes within the demand model is shown in Table 2.12.

Table 2.12 Relationship between demand model purposes and rail time periods

Trip purpose	**Time period – rail characteristics**
Home-based work (HBW)	Peak
Home-based employer's business (HBEB)	Peak
Home-based education (HBEd)	Peak
Home-based personal business / shopping (HBPB/shop)	Inter-peak
Home-based recreation / visit friends (HBRec/VF)	Inter-peak
Home-based holidays / day trips (HBHols)	Inter-peak
Non home-based employer's business (NHBEB)	Peak
Non home-based other (NHBO)	Inter-peak

2.9. Transport network

The transport network for the demand model is represented by a pseudo-network of modal pseudo-links denoting the different distance bands between the demand model zone-pairs. In this pseudo-network trips may travel to a set of attraction zones that are common to all trip productions. The attraction zones are connected to every production zone by a set of stylised links representing the different modes that are available for that distance band. Further details on the implementation and connectivity of the pseudo-network are provided in Appendix E

2.9.1. Link types

The pseudo-network is subdivided into six main categories of pseudo-links:

- Ride links (for each of car, bus/coach, rail, walk and cycle);
- Access / egress links (for bus/coach and rail modes);
- Wait links (for bus/coach and rail modes);
- Parking links (for car modes)
- Interconnection links (extra ride link for rail used to simulate time taken to connect between trains & stations).
- Overcrowding links (for rail- extra ride link to simulate overcrowding disutility)

The dimensions for each of these groups of links are shown in Table 2.13.

Table 2.13 Dimensions of different categories of links

	Defined by combinations that exist of:		
Type of link	**Trip production zone**	**Trip attraction zone**	**Distance band**
Ride links	Yes	Yes	Yes
Access links	Yes	No	No
Egress links	No	Yes	No
Wait links	Yes	No	No
Parking links	No	Yes	No
Interconnection links	Yes	Yes	Yes
Overcrowding links	Yes	Yes	Yes

Not all the combinations of zone pairs and distance bands exist, for example it is not possible to travel from the Inner London area to a rural area within a distance band of under 1 mile. The combinations of zone pairs and distance bands that exist are set out in Appendix D and retained from the earlier NTMv2. They were derived by building paths through a spatially detailed network model.

The attributes attached to the pseudo network of links have been updated with the data sources and information provided in Chapter 4.

2.10. Travel characteristics

Travel characteristics are input to NTMv2R for each of the six travel modes represented in the model:

- Walk
- Cycle
- Car driver
- Car passenger
- Bus
- Rail

The travel characteristics required are generally:

- Travel time (minutes)
- Monetary cost of travel (pence in 2015 prices)

Modes with multiple stages (e.g. walking, waiting and riding on public transport) require separate characteristics for each stage of travel.

The two components (money and time) are combined to create a generalised cost (or disutility) of travel. They are combined using a value of time (pence per minute) appropriate to the traveller type (person type and trip purpose) as set out in Section 2.11 below.

A large proportion of the travel characteristics for each zone pair, traveller type, purpose, mode and distance band are derived from information associated with the modal transport network (coded on pseudo-network). These characteristics are supplemented by trip end characteristics or matrices of fares, costs etc.

2.11. Generalised cost (disutility) formulation

Within the demand model generalised cost is measured in minutes (generalised time). In the MEPLAN software this variable used to influence travel choices is called "disutility".

- Time = the actual elapsed time incurred at each stage of trip (minutes) – not weighted in any way

- Cost = money costs paid for each stage of trip (pence)

- Disutility = generalised costs in minutes including weighted time components, money costs converted to time units using appropriate values of time, additional perceived generalised costs and alternative specific constants.

The following notation for zones and distance bands is adopted (loosely) in the formulations below:

i origin zone

j destination zone

l distance band

$\alpha^m, \beta^m, \gamma^m$ Weights on time component by mode *m*(see Section 4.5 for values implemented)

$ASCs$ Alternative specific constants – mixture of global, origin and destination specific constants for each demand segment and mode. Values derived during model calibration.

A, B, C Guilt factors which determine the proportion of monetary costs associated with car travel and borne by the driver which are perceived by the car passengers

The disutility / generalised cost of each mode is defined slightly differently based on relevant travel characteristics as set out below. The derivation of the cost components (vehicle operating costs etc) are provided in Chapter 4.

To ensure there is no double counting of money costs should the results be used in cost/benefit (welfare) calculations, they must either be shared between travellers (eg car drivers and passengers) or paid by one group. The assumption here is that all costs are paid by the drivers with the passengers perceiving some costs in the form of additional disutility. The proportion of money costs perceived is determined by "guilt factors".

Walk and cycle:

$$Time\ Components = \alpha^m.traveltime_{ijl}$$

$$Cost = 0$$

$Disutility = Time\ Components + ASCs$

Car driver:

$$Time\ components = ridetime_{ijl} + \beta^m.parksearch_j$$

$$Cost = voc_{ijl} + park_j + RUC_j$$

$$Disutility = Time\ components + (Money\ costs)/vot + ASCs$$

Car passenger:

$$Time\ components = \gamma^m.ridetime_{ijl} + \beta^m.parksearch_j$$

where $\gamma^m \geq 1$ for car passenger (parameter being determined as part of calibration)

$Cost = 0$ (ie no money cost in pence)

$$Perceived\ Costs = \left(A.\widetilde{voc}_l + B.park_j + C.RUC_j\right)/vot$$

where $\widetilde{voc}_l$ is the approximate vehicle operating cost based on an average speed of travel as described in Section 4.10.

A, B and C are guilt factors for each cost component

$$Disutility = Time\ components + Perceived\ costs/vot + ASCs$$

Bus:

$$Time\ Components = ridetime_{ijl} + \alpha^m\left(access_i + egress_j\right) + \beta^m.wait_{il}$$

$$Cost = fare_{ijl}$$

$$Disutility = Time\ components + (Money\ costs)/vot + ASCs$$

Rail

$$TimeComponents = ridetime_{ijl} + \alpha^m\left(access_i + egress_j\right) + \beta^m.wait_{il} + interconnect_{ijl} + crowdtime_{ijl}$$

$$Cost = fare_{ijl}$$

$$Disutility = Time\ components + (Money\ costs)/vot + ASCs$$

3. Demand inputs (trip ends)

3.1. National Trip End Model (NTEM)

NTEM produces estimates of person travel by all modes (including walk and cycle) for each zone of Great Britain (MSOA in England and Wales, groups of Data zones in Scotland). The trip ends from NTEM are segmented by trip purpose, person type (including age and working status) and household car availability.

The updated trip end inputs to the demand model are being taken from the NTEM dataset: version 7.0 (July 2016). Standard NTEM forecasts are generated for every fifth forecast year from 2011 to 2051 (ie 2011, 2016, 2021 etc). The base year of NTMv2R is 2015. The required 2015 trip ends were obtained by simple linear interpolation between the two existing NTEM years: 2011 and 2016.

A simple spreadsheet tool was implemented to process any two NTEMv7 trip end databases (two user specified years) and generate the inputs to the demand model.

3.2. SEG/Income segmentation

The NTEM dataset provides all the age, working status and car availability segmentation required, but does not provide any segmentation of trips by the socio economic or income group characteristics of the travellers. NTMv2 segments commuting and business trips into a segmentation labelled as high, medium and low income, but in practice uses data from the National Travel Survey (NTS) on the socio economic group of the traveller. The approach adopted for NTMv2 was retained using the social class variable from NTS (SC_B01ID) allocated to the income bands (as in NTMv2) as follows:

Social class (NTS variable SC_B01ID)	NTMv2R income band
Professional occupations	High
Managerial and technical occupations	High
Skilled occupations – non-manual	Medium
Skilled occupations – manual	Medium
Partly skilled occupations	Low
Unskilled occupations	Low

Where no social class information was recorded in the NTS, the data was omitted from the derivation of the income split. Proportions of trips split by purpose by employment status by household type (household income, composition and car ownership) are derived from NTS 2012-2014, as shown in Table 3-1.

Table 3-1 Proportion of trips by purpose by household type

			Household composition					
Purpose	**Work Status**	**Household Income**	**1 adult 0 car**	**1 adult 1+ car**	**2+ adult 0 car**	**2+ adult 1 car**	**2+ adult 2+ car**	**All**
HB Work	Full-time	High	42.9%	54.7%	32.1%	42.1%	50.7%	
		Medium	31.3%	34.3%	39.1%	37.8%	35.6%	
		Low	25.7%	10.9%	28.8%	20.2%	13.6%	
	Total full-time		100%	100%	100%	100%	100%	
	Rest		100%	100%	100%	100%	100%	
HB EB	Full-time	High	63.0%	59.1%	50.8%	50.0%	62.5%	
		Medium	7.4%	24.4%	26.6%	30.6%	25.6%	
		Low	29.6%	16.5%	22.6%	19.4%	11.9%	
	Total full-time		100%	100%	100%	100%	100%	
	Rest		100%	100%	100%	100%	100%	
NHB EB	All	High						64.4%
		Medium						18.9%
		Low						16.7%
	All Total							100%

While the disaggregation is similar to the assumptions in NTMv2, there are now significantly increased proportions of both commuting and employer's business trips by the full time employed in the high income band, with compensating reductions in the proportions of both commuting and employer's business trips in the medium income band, as shown in Table 3-2. The result is that now the high income band has the most trips, followed by the medium then low income bands. Previously the largest group were the medium income band with the high band containing the smallest proportion.

Table 3-2 Change in income profiles applied to NTEM trip ends

Purpose	Person Type	SEG	1 Adult No Car	1 Adult 1+ Car	2+ Adult No Car	2+ Adult 1 Car	2+ Adult 2+ Car	All
HB Work	**FT Emp**	High	28%	22%	21%	21%	16%	
		Medium	-26%	-26%	-15%	-23%	-19%	
		Low	-2%	3%	-6%	2%	2%	
HB EB	**FT Emp**	High	46%	17%	29%	17%	15%	
		Medium	-54%	-30%	-30%	-28%	-22%	
		Low	8%	13%	1%	10%	7%	
NHB EB	**All**	High						18%
		Medium						-26%
		Low						8%

3.3. Trip end changes

The volume of trips in NTMv2R is a direct result of the input trip ends. There is no frequency response or trip generation as part of the demand model.

The total trips modelled in NTMv2R by purpose are shown in Table 3-3 below compared with those in the earlier DfT forecasts for 2015 (based on NTEM 6.2), and provide a means of cross checking modelled results to ensure all trips are retained at each stage.

Table 3-3 Total trip ends by purpose (2015 average day)

Purpose	NTEM v6.2 (in NTMv2)	NTEM v7.0 (in NTMv2R)	% change
Home based commuting	17,555,334	13,392,939	-23.71%
Home based employer's business	1,799,539	1,690,267	-6.07%
Home based education	9,261,975	8,775,301	-5.25%
Home based personal business and shopping	26,814,407	21,482,116	-19.89%
Home based recreation, visiting friends and relatives	26,398,535	15,059,545	-42.95%
Home based holidays and day trips	2,007,504	2,777,345	38.35%
Non home based employer's business	2,673,083	2,141,277	-19.89%
Non home based other	17,692,512	14,449,135	-18.33%
Total trips modelled (average day)	***104,202,889***	***79,767,926***	***-23.45%***
Home based recreation, visiting friends and relatives, holidays and day trips (combination of above)	28,406,039	17,836,890	-37.21%

For NTEMv7 there have been some significant changes to the trip rates based on evidence from detailed analysis of time trends from the NTS data. This has resulted in fewer trips being forecast per person in 2015 in NTEMv7 than in the earlier NTEM datasets. Thus even though the underlying mid year population assumptions will have changed little, the number of trips occurring in 2015 has fallen compared with earlier NTM forecasts for this year. This is summarised in Chapter 5 on the impacts of the data inputs to NTMv2R.

4. Travel characteristics

4.1. Approach

As noted the approach adopted is for minimal changes to the model, with changes being focused on updating the underlying data to be as close to the new 2015 base year as possible. The price base of the updated model is now 2015 prices.

Where assumptions had been made for the previous NTMv2 calibration in 2003, without any source data, these assumptions have been retained – unless new data sources have emerged in the intervening period which enable improved assumptions to be made.

4.2. Data sources

Where possible the same data providers have been used to provide the input data to the model as NTMv2. This is to minimise the chances of changes being introduced due to differences in definitions and scope of the various datasets available. It has not however been possible to use the same data providers in all cases.

A primary source of the trip characteristics is the National Travel Survey (NTS), and in addition there are other sources used in the updates, including WebTAG Databook, the rail model (MOIRA) and Transport Statistics Great Britain (TSGB).

There are in total eight different sources referenced to assemble the model input characteristics, as listed in Table 4-1, plus the trip end inputs from NTEM covered previously in Chapter 3.

Table 4-1 Sources of data

Item	Source Data	Application in NTMv2R
1	NTS (National Travel Survey) 2012-2014	Income segmentation Distance band profile Bus speed Parking cost London road user charge (car trip proportion paying)
	NTS 2002-2014	Domestic air travel
2	WebTAG Databook 2015	Values of time Vehicle operating cost
3	MOIRA	Rail characteristics (wait, interchange, fares)
4	Transport Statistics Great Britain 2015	Bus fares
5	National Express website	Coach fares
6	FORGE / SpeedGen	Car (road) speeds
7	DfT's CCI spreadsheet used for NTMv2	London road user charge
8	TfL website for Congestion Charge	London road user charge

Trip characteristics and parameters have been updated as refreshed inputs to the Demand model.

(1) NTS dataset provides detailed information of travellers and their trips. To address sample size concerns, NTS data during the three most recent available years (2012 – 2014) are combined together to produce most base-year model inputs, such as income segmentation, distance band profile, bus speed, and parking cost for NTMv2R etc. While more years of data would provide a more robust sample sizes the concern was to keep the attributes (trip lengths, prices etc) as up to date as possible from NTS. The maximum amount of NTS data available from 2002 to 2014 is

applied to estimate air travel in the post processing of the NTMv2R results, in order to achieve an appropriate sample size.

(2) WebTAG Databook: TAG Databook, July 2017 - (version 1.8.2 downloaded 18th October 2017) https://www.gov.uk/government/publications/webtag-tag-data-book-July-2017.

(3) MOIRA predicts railway flow volumes and revenues based on the 2015 National Rail timetable. The forecasting result was provided by DfT to provide updated rail journey characteristics (average interchange time, waiting times and journey time etc).

(4) Transport Statistics Great Britain 2015 on local bus sector presents statements of passengers and operations of buses, including passenger journeys, vehicle miles, fare revenues etc. The relevant information is abstracted to describe the bus fares (cost function).

Source from: https://www.gov.uk/government/statistics/transport-statistics-great-britain-2015

(5) National Express shows prices between pairs of stations for long-distance bus/coach journeys via its website. The prices coupled with crow-fly journey distances are used to estimate long-distance bus trip costs.

Source from: http://www.nationalexpress.com (accessed 7-11 August 2016)

(6) FORGE / SpeedGen. These tools link to the demand model to provide the forecasting functionality for NTMv2R. FORGE is also being updated for the 2015 base year and linked to a new 2015 Traffic Database. The output from running FORGE is the estimated levels of demand and congestion by road type which determine speeds of travel. Information is used from FORGE in the base year for consistency with the approach adopted when forecasting.

(7) The DfT's existing CCI (Cost Change Interface) spreadsheet provides the methodology used to derive the road user charge per person for the different trip purposes based on their incidence at different times of day and likelihood of entering the Charge zone. This approach is reused for NTMv2R.

(8) The current (2015) London Congestion Charge is published on Transport for London's website.

4.3. Travel distances by band (all modes)

The distance band structure adopted is a unique feature of the NTMv2R demand model. A fixed travel distance is assumed for each distance band modelled. These are an input assumption to the model and have not been changed between NTMv2 and NTMv2R.

In the transport demand model, travel distances for each mode are coded on the pseudo network by distance band. The same distances were assumed for all modes in each of the thirteen distance bands as shown in Table 4-2. Distances are coded for the entire journey by the main mode. There is no information on the distances associated with the access and egress stages of public transport trips or the parking stage of car trips relative to the main ride stage of the journey.

Table 4-2 Assumed trip lengths by distance band

Distband	Distance	Mid point (miles)
1	< 1 mile	0.5
2	1 to 2 miles	1.5
3	2 to 3 miles	2.5
4	3 to 5 miles	4
5	5 to 10 miles	7.5
6	10 to 15 miles	12.5
7	15 to 25 miles	20
8	25 to 35 miles	30
9	35 to 50 miles	42.5
10	50 to 100 miles	75
11	100 to 200 miles	150
12	200 to 300 miles	250
13	300 miles and above	350

4.4. Values of time

Values of time (vot) by traveller type are derived from DfT's WebTAG Databook. The TAG Databook July 2017 (v1.8.2) was downloaded and used to source the NTMv2R inputs.

In NTMv2, two core values of time were taken from the databook for business and other travel. A profile was then applied to these to give a traveller type specific value of time by household type and person type based on the pattern of household disposable incomes.

For NTMv2R three basic values of time were taken from the WebTAG Databook v1.8.2 for a 2015 value (base) year in 2015 prices as follows:

Table 4-3 Core values of time (2015 values in 2015 prices)

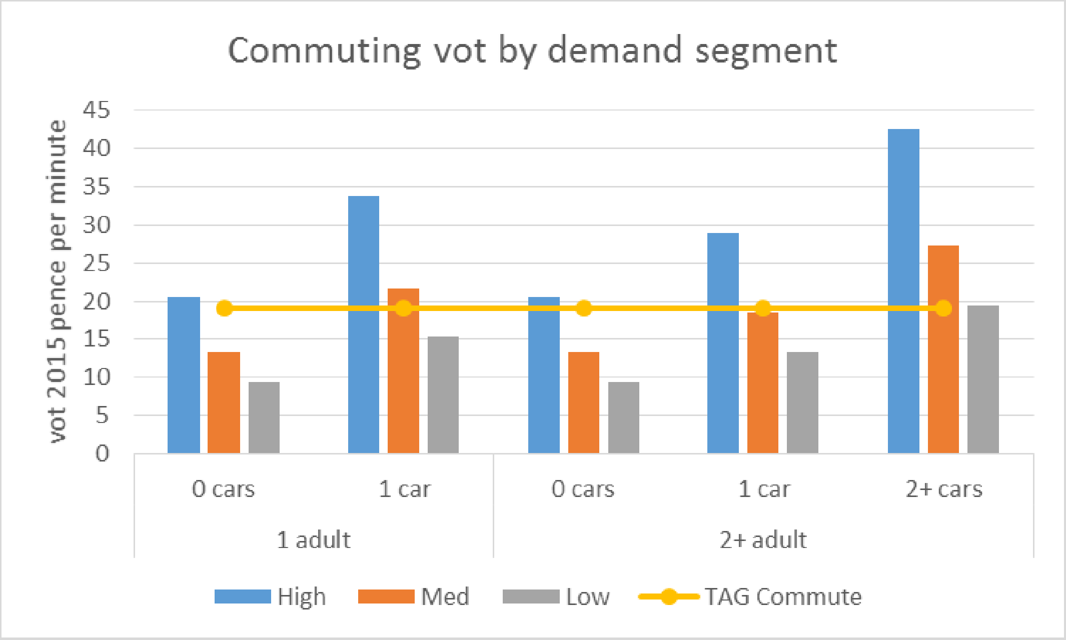
Purpose	VOT (£ per hour)	Source – WebTAG Databook Sheet A1.3.1
Commuting	11.43	Cell E45 – Perceived Cost Commuting
Business	18.59	Cell E40 – Perceived Cost Working Time – average of all working persons (not mode specific)
Other	5.22	Cell E46 – Perceived Cost Other

Source: WebTAG Databook v1.8.2

Further differentiation in values of time was also applied for the different traveller types within the model. For NTMv2 the pattern of variation in weekly disposable income was used to generate value of time profiles These value of time profiles are applied to the three core values of time to provide variations in values of time for the 105 segments have not been updated. They were originally derived using published data from the Family Expenditure Survey (now the Living Costs and Food Survey). The incomes were not readily available for the NTMv2 segmentation so a Furnessing process was adopted using number of households by the dimensions for which incomes were available to estimate the incomes for all household type combinations required (by size / car availability and income / socio economic group).

The resulting pattern of variation in value of time for the commuting trips is shown in Figure 4-1. The same patterns are applied for each trip purpose (commuting, business and other) – with normalised values of time matching those from TAG Databook shown in Table 4-3 above.

Figure 4-1 Variation in value of time by traveller demand segment for commuting trips



4.5. Weighting of time components

Following traditional practice, the values of access / egress walking time and waiting times have been weighted in the calculation of the generalised cost or disutility of travel. The weights applied were taken from NTMv2 with some limited updates. The main cycle trips also have a weight to increase the time component of the generalised cost. Walk trips previously included a weight, though this has now been set to 1 as shown in Table 4-4 since walking as a main mode would not necessarily be weighted and this improved the mode split of the model during calibration. The rail access and egress weight was reduced to bring it within the range of typical values set out in WebTAG guidance (previously sourced from the National Rail Passenger Model). A weight was also considered during calibration for the car passenger travel times to reflect the inconvenience of depending on a driver but was ultimately left with a value of 1 (ie no additional penalty).

Table 4-4 Time weighting by trip stage used in demand model

Trip stage	Weight	Change notes
Bus access & egress	2.0	No change
Bus wait	2.0	No change
Rail access & egress	2.0	Reduced from 2.81
Rail wait	2.0	Reduced from 2.22
Walk trips	1.0	Reduced from 2.0
Cycle trips	2.0	No change
Car (driver and passenger) parking search time	2.0	No change
Car (driver and passenger) ride time	1.0	No change

4.6. Car passenger “guilt” factors

The monetary costs of travelling by car are not paid by both the drivers and passengers. If the full costs are incurred by the driver and influence their travel behaviour then there are no remaining monetary costs for the passengers to incur. While passengers rarely pay the actual car costs (money), their behaviour is closely linked to the behaviour of the drivers.

To improve the responsiveness of car passengers in the demand model, their generalised cost of travel (disutility) includes a "perceived" monetary cost of travel coded in generalised minutes. This implementation has not been updated from NTMv2, though some adjustments have been made to the guilt factors applied during the model calibration stage to improve the behaviour of passengers without introducing large alternative specific constants.

The proportions of monetary costs perceived by the car passengers as a generalised cost (disutility) following the NTMv2R calibration are as follows:

• Fuel costs	87%	previously 50%
• Parking charges	100%	no change
• Congestion charge	100%	no change
• Any additional tolls coded on links	50%	(none coded in Base year model)

4.7. Walk characteristics

No changes from NTMv2 have been made to the characteristics of walking for NTMv2R.

The walk mode has no monetary cost, only an assumed speed and hence travel time. The assumed walking speeds in the model are:

- 2.8 miles per hour for trips to / from zones 1 to 11 (larger urban areas)
- 3.5 miles per hour for trips to / from zones 12 to 17 (smaller urban and rural areas)

Trips between zones with different assumed speeds use an average of the two times (ie an average of the inverse speed) (3.11 mph).

Walking is only defined as a permitted mode of travel in distance bands 1 to 7 inclusive, i.e. for trips up to 25 miles in length.

4.8. Cycle characteristics

No changes have been made to the characteristics of cycling for NTMv2R.

The cycle mode has no monetary cost, only an assumed speed and hence travel time. The assumed cycling speeds in the model are:

- 8 miles per hour for trips to / from zones 1 to 11 (larger urban areas)
- 9 miles per hour for trips to / from zones 12 to 17 (smaller urban and rural areas)

Trips between zones with different assumed speeds use an average of the two times (ie average of inverse speed) (8.47 mph).

Cycling is only defined as a permitted mode of travel in distance bands 1 to 8 inclusive, i.e. for trips up to 35 miles in length.

4.9. Vehicle operating costs – car driver

The vehicle operating costs for car drivers are derived directly from the WebTAG databook (version 1.8.2, July 2017). All costs are calculated in 2015 prices. Perceived costs are used for both the fuel and non-fuel elements of operating costs.

As shown in Equation 4.1, the functional form of fuel consumption estimation has been updated.

$$Fuel\ Consumption\ (litres\ per\ km) = \frac{a}{V} + b + cV + dV^2 \qquad \text{Equation 4.1}$$

Where V is the speed of travel in kilometres per hour and *a*, *b*, *c* and *d* are parameters to the consumption function. The cost of fuel (pence per litre) is then applied to the fuel consumption (litres per km), to give a cost in pence per km. This includes the recent up-lift in the curves to capture the impacts of 'real world emissions' testing.

The non-fuel costs are estimated via Equation 4.2 as following:

$$Non\ fuel\ costs\ (pence\ per\ km) = a^1 + \frac{b^1}{V} \qquad \text{Equation 4.2}$$

where similarly, V is the speed of travel in kilometres per hour; and parameters a^1, b^1 are referenced from WebTAG databook as shown in Table 4-5.

The parameters were set directly in the WebTAG databook to provide the parameters to the above functions in 2015 values and 2015 prices.

Table 4-5 WebTAG Parameter Values for Vehicle Operating Cost (average car)

Fuel cost pence / km	Source table	a	b	c	d
Non-working time	A1.3.13	90.2973	6.0010	-0.0383	0.000402
Working time	A1.3.12	75.2477	5.0012	-0.0319	0.000335
Non fuel (perceived)	**Source table**	**a^1**	**b^1**		
Non-working time	A1.3.9 and A1.3.14	Not perceived			
Working time	A1.3.9 and A1.3.14	5.3515	146.6614		

The vehicle operating costs are implemented using Network cost function 109 in the MEPLAN UTM file. The function number used has not changed from NTMv2, although the definitions of the MEPLAN parameters have changed to accommodate the new functional form.

$$Cost = Charge * ParE + Length * (LngthPar + ParB * Speed + ParA * Speed^2) + Time * TimePar$$

The relationship between the WebTAG parameters and MEPLAN parameters used in the formulae above is given in Table 4-6.

Table 4-6 WebTAG and MEPLAN Parameter Relationships

MEPLAN Parameter	WebTAG Equivalent
LngthPar	$b + a^1$
ParB	c
ParA	d
TimePar	$a + b^1$
ParE	Not applicable – relates to any tolls coded on network

The parameters in Table 4-5 are converted to the model units of distance and time which are miles and minutes (no change from NTMv2). The parameters coded in the model input files are shown in Table 4-7.

Table 4-7 Vehicle operating cost parameters coded to Network Cost function 109

	ParA	LngthPar	ParB	TimePar
Non-working car	6.0253395	9.657	-5.9504400	1.505
Working car	5.0211163	16.660	-4.9587000	3.698

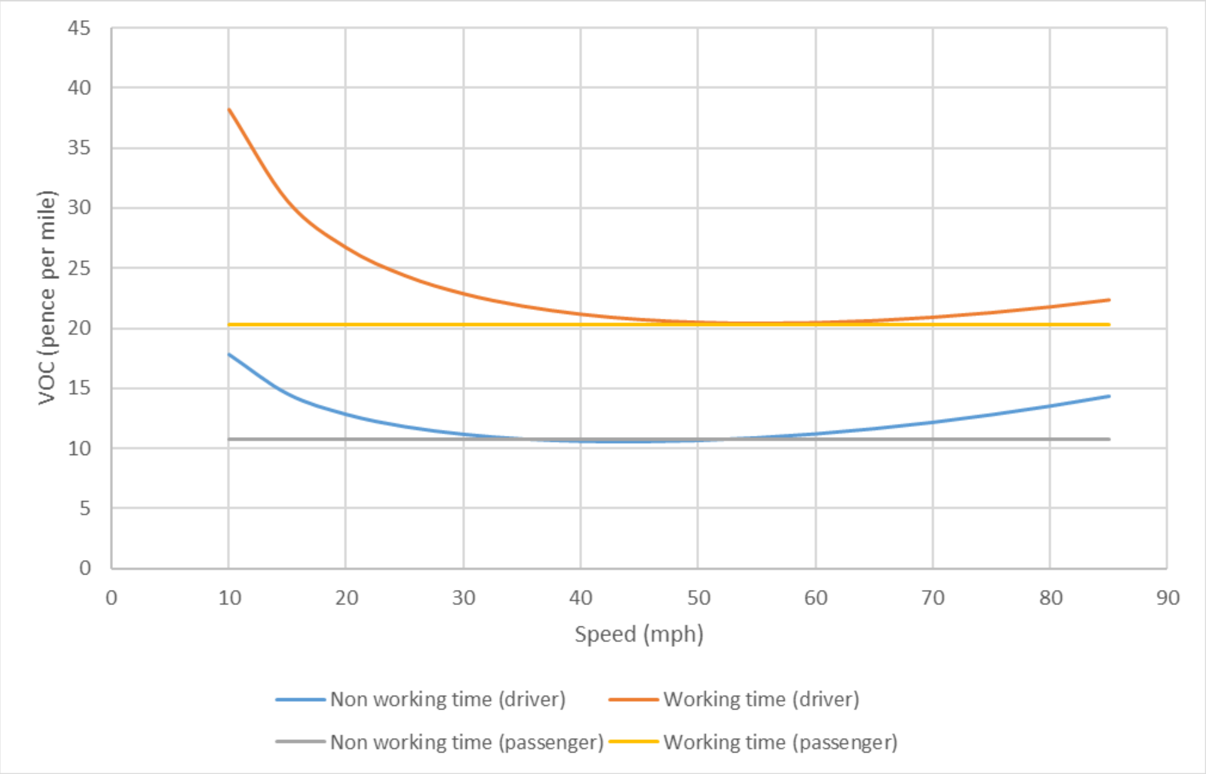
4.10. Vehicle operating costs – car passenger

The preceding section 4.9 describes how the vehicle operating costs for car drivers (the car mode) are implemented in the demand model as a function of speed. The parameters coded are used within the model to calculate the car vehicle operating costs based on the speed of travel input from FORGE for each origin, destination and distance band combined which is coded on the pseudo-network for car travel. The same pseudo network definition is used for both the car driver and car passenger trips. Because the car passengers are not paying the vehicle operating costs directly, the monetary costs defined are zero and instead the values must be translated into a generalised cost (disutility) within the model.

Due to the functionality available in the software, this translation requires a simplification of the derivation of the vehicle operating costs in order to implement the perceived costs using a rule which automatically updates the values when forecasting. The simplification adopted when the demand model was originally implemented, and retained since then, is to estimate an average perceived vehicle operating cost (including fuel and non-fuel costs as applicable) per mile from the average speeds of travel being used. The result of this assumption is shown in Figure 4-2.

This shows that the simplification will match well when the speeds are between 47 and 62 mph for working time trips and for speeds between 35 and 55 mph for non-working time trips. For the zone pair and distance band combinations where speeds are higher or lower the simplification will be underestimating the vehicle operating costs which will particularly be the case for short trips to / from the most urban areas.

Figure 4-2 Vehicle operating costs - driver versus passenger



4.11. Parking charges

Parking cost information is derived from the National Travel Survey in the same way as implemented for NTMv2. Both average parking charges (by mode by trip attraction area type) and the proportion of trips paying for parking are derived from the 2012-2014 National Transport Survey (NTS). The combination of the two sets of information are applied to calculate the average parking charge for each car journey.

The NTS does not provide with separate parking cost information within the Central London from Inner London. However, compared with the majority of Inner London area, Central London has individual patterns of parking supply with significantly higher parking costs for commuters. Hence the NTS-based parking costs for Central London commuters are replaced by more realistic values by assumption.

In practice there are only a small fraction of the car journeys paying for parking, so the charges adopted for NTMv2R are low in all areas as shown in Table 4-8. As the parking charges are small they will not be having a major impact on the performance of the model in the base year. Incorporating the charges and proportions paying does however provide functionality for scenario testing focused on parking or demand management in urban areas.

Table 4-8 Average parking costs paid (2015 pence)

Area Type	Trip purpose							
	HBW	HBEB	HBEdu	HBPB	HBRec	HBHol	NHBEB	NHBOth
1 Central London	500	82.7	2	31.1	24.4	55.8	83.7	28
2 Inner London	22.6	82.7	2	31.1	24.4	55.8	83.7	28
3 Outer London	10.1	81.5	2.8	16.6	18.3	113.8	29.1	12.6
4 N&E Central Conurban	19.3	86	5	25.6	15.5	187.6	39.5	15.6
5 West Central Conurban	19.3	86	5	25.6	15.5	187.6	39.5	15.6
6 N&E Conurban surround	8	31.2	2	9.8	4.3	85.4	11.6	7.9
7 West Conurban surround	8	31.2	2	9.8	4.3	85.4	11.6	7.9
8 South Urban Big	7	27.2	5.7	22.1	8.9	31.9	12.4	10.7
9 N&E Urban Big	7	27.2	5.7	22.1	8.9	31.9	12.4	10.7
10 West Urban Big	5.4	20.8	2.8	20.9	10.5	36.1	17.2	15.1
12 South Urban Large	5.4	17.5	2.5	22.3	9.3	24.5	7.5	14.4
13 N&E Urban Large	6	7.6	2	14.9	3.4	15	10	9.4
14 West Urban Large	13	36.2	2.4	25.8	10.2	22.4	26.5	12.8
16 Urban Medium	4.9	8.7	2.1	15.5	4.9	20.5	8.7	8.7
17 Urban Small & Rural	2.1	4.2	0.4	5.2	3.5	30.9	4.2	6.4

4.12. London Road User Charge

The London congestion charge is coded by trip purpose and destination zone based on an assumed (derived) proportion of the trips ending in each model zone that will have passed through the charged area during the charged time periods.

The approach adopted for NTMv2R is virtually unchanged from that previously implemented by the DfT's NTM team for forecasting using NTMv2 (there was no congestion charge in the original NTMv2 1998 base year model). The tools implemented in the DfT's Cost Change Interface (CCI) workbook have been utilised directly to derive the inputs.

The basic congestion charge was sourced from Transport for London's website (https://tfl.gov.uk/modes/driving/congestion-charge). The implementation assumes most users will make use of the "auto pay" option giving a basic charge of £10.50 per day in 2015 during the charging period (0700--1800 hours). This is the charge assumed for the peak and interpeak periods with a zero charge assumed for the off-peak and weekend time periods.

The percentage of all car trips for each purpose which occur in each of the four time periods (peak, interpeak, off peak and weekend) were taken from the NTS data for 2012 to 2014 with the resulting profiles shown in Table 4-9. This gives the time period weighted charge for each trip purpose.

Table 4-9 Time period profiles by purpose for car (NTS 2012-2014)

Purpose	Peak (charged)	Inter Peak (charged)	Off Peak (free)	Weekend (free)
HBW	62.5%	10.9%	15.2%	11.4%
HBEB	55.1%	25.4%	7.1%	12.4%
HBEd	77.9%	20.6%	0.4%	1.1%
HBPB	23.9%	39.3%	3.8%	33.1%
HBRec	25.8%	21.7%	13.8%	38.6%
HBHol	18.7%	31.8%	5.8%	43.7%
NHBEB	31.3%	57.7%	4.7%	6.3%
NHBO	30.0%	37.7%	5.7%	26.7%

Previously, the average car occupancy was then applied to convert the charge per vehicle to the charge per car user. However within the demand model the car driver is assumed to incur the full (coded) road user charge, with passengers perceiving a proportion of the cost (via the guilt factor). Thus the charge per vehicle is coded directly as the charge in the model files.

The charge per OD trip is then calculated by halving the congestion charge for the home based trips. Just the characteristics for the outward leg and NHB trips are coded for the modelled PAs (consistent with all other attributes). This approach is unchanged from NTMv2.

The resulting charges (outward only for HB trips) for those who pay are as shown in Table 4-10.

Table 4-10 Congestion charge by purpose for those paying

	HBW	HBEB	HBEd	HBPB	HBRec	HBHol	NHBEB	NHBO
Congestion charge	£3.86	£4.23	£5.17	£3.32	£2.50	£2.65	£9.35	£7.10

The final set of input information is the proportion of trips ending in each NTMv2R zone which are assumed to pay the London Congestion Charge. The derivation of these proportions has not been revised and the proportions have been taken directly from NTMv2. The assumed percentages of travellers to each destination paying the charge is shown in Table 4-11.

Table 4-11 Proportion of trips crossing cordon / paying charge (as in NTMv2)

Destination zone:	Zone 1	Zone 2	Zone 3	Rest
Proportion of PEAK trips paying cordon charge	75%	8%	2.5%	0%
Proportion of INTER PEAK trips paying cordon charge	75%	8%	2.5%	0%
Proportion of off peak and weekend trips paying cordon charge	0%	0%	0%	0%

4.13. Car speeds

Car journey speeds by distance band and home area type are derived using the Traffic database linked to the demand model in the Base Year. By assuming the same speeds also applied for the attraction zones, an average car speed for each production zone, attraction zone and distance band is then derived. The assumed car speeds have been applied to car links types in the pseudo network, ranging from 15 mph for the shortest journeys in London to 54 mph for longer journeys in other parts of the country as shown in Table 4-12.

Table 4-12 Car speeds (miles per hour) by distance band by origin area

	Origin Zone														
DistBand	1	2	3	4	5	6	7	8	9	10	12	13	14	16	17
1	15.3	14.9	19.0	18.7	17.6	25.0	24.5	26.6	26.1	28.7	28.6	27.1	30.8	26.5	32.2
2	15.4	15.1	19.1	23.1	18.7	24.6	25.3	26.6	28.2	28.0	28.6	29.8	29.4	26.6	31.0
3	15.4	15.3	20.5	22.8	21.0	25.9	25.4	29.3	30.2	28.0	28.4	28.7	29.6	27.3	30.3
4	15.4	16.4	20.5	22.1	22.5	25.8	25.9	28.6	30.2	28.8	31.4	28.3	27.7	27.1	30.1
5	16.6	18.3	21.9	25.3	26.5	29.3	30.4	32.8	33.8	33.9	34.0	33.7	33.2	29.9	33.3
6	17.4	18.3	21.7	26.2	26.8	28.9	30.6	33.1	34.5	33.9	35.5	34.4	32.2	30.8	33.1
7	19.7	19.1	21.9	26.8	28.9	30.8	32.7	36.1	35.6	36.9	37.3	35.1	32.3	31.9	34.1
8	24.8	23.6	26.3	36.6	39.1	37.5	41.4	43.4	44.3	45.5	44.4	44.9	39.1	39.4	41.2
9	27.8	29.0	32.6	37.3	40.5	38.3	42.1	43.5	44.1	42.9	43.2	42.8	41.5	40.4	42.3
10	35.2	35.2	38.7	40.8	42.8	40.7	43.1	43.1	43.1	43.2	41.9	44.5	43.7	42.3	43.4
11	45.5	45.0	48.3	49.7	49.8	49.4	50.3	49.9	51.6	51.2	50.4	51.4	51.2	50.5	51.2
12	47.8	47.4	49.5	50.9	51.0	50.7	51.4	52.0	52.4	52.1	53.1	51.9	51.8	51.2	52.0
13	50.8	50.5	51.7	52.1	53.0	52.1	53.4	53.1	53.6	53.3	53.0	53.8	53.4	52.4	53.0

4.14. Parking search times

Parking search times are coded as the last leg for each trip destination. The times vary by destination zone to reflect the assumed ease of locating a parking space in the zone.

The assumptions for parking search time were assumed for NTMv2 based on professional judgement and initially were not updated since no better information has been obtained. However once results were reviewed prior to commencing model calibration, it was found that car generalised costs for short distances were significantly lower (better) than for other modes. To more accurately reflect the time accessing / egressing car including time taken to park, the parking search times have been increased by two minutes in all areas. The resulting parking search times assumed are listed in Table 4-13.

Table 4-13 Assumed parking search times by destination zone

Destination Area	Search time (minutes)
Zone 1 - Central London	15
Zone 2 - Inner London	5
Zone 3 - Outer London	4
Zone 4 & 5 - Inner Conurbations	6
Zone 6 to 17 - All other areas	4

4.15. Bus and coach fares

For bus trips, local bus fares are adopted for trips within London, Metropolitan areas or less than 25 miles, while coach prices are applied for longer journeys (greater than 25 miles) outside London and conurbations. In each case, a cost function containing a minimum fixed cost and a cost per mile is applied to determine the modelled cost for travellers.

The per-mile costs of local bus services are derived from the Transport Statistics Great Britain 2014-2015 for London, Metropolitan Areas and Other Areas respectively. The allocation of appropriate fare is determined by the "dominant" trip end area type – which is generally the trip destination or attraction zone. The costs per mile of coaches are estimated from a range of National Express full adult ticket prices linking to a sample of 20 locations spread across the country.

The fixed minimum costs (50p for local buses, and 500p for coaches) are applied by assumption. The tariffs are as shown in Table 4-14.

Table 4-14 Bus and coach fares in 2015 base year

'Dominant' Area Type / Distance Band			Cost function parameters	
Area	Distance	Type	Fixed cost	Cost per mile
London (Zones 1 to 3)	Under 25 miles (Band 1 to 7)	Local bus	50p	30.83p
Metropolitan area (Zones 4 and 5)			50p	34.92p
Other area (Zones 6 to 17)			50p	31.74p
All zones	Above 25 miles (band 8 to 13)	Coach	500p	14.18p

4.16. Bus and coach fare concessions

The fares concessions implemented within the demand model were reviewed. The assumptions implemented in the NTMv2 files received were last modified for scenario testing in 2010 by the Department. The assumptions implemented still appear relevant and hence the concession assumptions have not been revised for NTMv2R.

For bus travel concessions are available for children and pensioners. In the model, these concessions are applied to the HB Education and HB personal business / shopping and social trip purposes for the children and 75+ age group which are explicitly identified. For other trip purposes (commuting, business, holidays and non home-based trips) children and pensioners are not explicitly identified thus no concession is applied.

Although no changes to the assumptions have been made, the change in age bands in the person type definition has automatically introduced a revision. The concessions available for pensioners are now only applied to the age 75+ group of the population rather than 65+ as in the old model. Thus the impact of concessions will be under estimated by the model, and the impact of fares changes will affect a higher proportion of trips in the model than in reality.

Separate concessions are specified for trips wholly within London (to reflect concessions offered by TfL via the Oyster card) and other trips. The bus fare concessions applied in the NTMv2R demand model are listed in Table 4-15.

Table 4-15 Bus fares concessions

Traveller type	Location of trip	Trip Purpose	Distance bands	Concession
Children	Within London	HBEd, HBPB/Shop & HBRec/VF	1 to 7 (bus)	Free
Children	Outside London	HBEd, HBPB/Shop & HBRec/VF	1 to 7 (bus)	50% fare
Children	Everywhere	HBEd, HBPB/Shop & HBRec/VF	8+ (coach)	50% fare
Pensioner (age 75+)	Everywhere	HBEd, HBPB/Shop & HBRec/VF	1 to 7 (bus)	Free
Pensioner (age 75+)	Everywhere	HBEd, HBPB/Shop & HBRec/VF	8+ (coach)	82% fare

4.17. Bus access and egress

The access and egress times between the origin / destination zone and the bus services were assumed in NTMv2 and have not been updated. The assumed access and egress times are shown in Table 4-16.

Table 4-16 Assumed bus access and egress times

Zones	Access Time	Egress Time
1 to 16 – Urban areas	4 minutes	4 minutes
17 - rural areas	6 minutes	6 minutes

4.18. Bus wait times

Bus wait times are implemented for combinations of trip production zone and trip length with urban areas. The wait times were assumed for the NTMv2 model and have been retained unaltered for NTMv2R. The bus wait times implemented are summarised in the following Table 4-17.

Table 4-17 Assumed bus wait times

Zones	Up to 15 miles (Bands 1 to 6)	15 to 100 miles (Bands 7 to 10)	100+ miles (Bands 11 to 13)
1 to 5 (London and Conurbations)	6 minutes	10 minutes	15 minutes
6 to 17 (Urban and rural areas)	7 minutes	10 minutes	15 minutes

4.19. Bus speeds

Average bus speeds by production zone (origin) by distance band are estimated from NTS data for 2012-14 as shown in Table 4-18. The speeds are derived using the travel time and distance variables. Travel time is used in preference to total time since this relates more closely to the time spent moving on a bus rather than waiting time. To avoid issues with sample sizes, zones with similar patterns and the longer distance bands are aggregated into groups in the calculation.

Table 4-18 Estimated average bus speed (miles per hour)

		Origin Area (zone groups and zones)														
No.	Band (miles)	A		B	C				D			E			F	G
		1	2	3	4	5	6	7	8	9	10	12	13	14	16	17
1	<1	2.4	2.4	2.6	2.3	2.3	2.3	2.3	3.2	3.2	3.2	2.2	2.2	2.2	2.9	2.9
2	1-2	4.1	4.1	4.6	5.0	5.0	5.0	5.0	4.7	4.7	4.7	4.7	4.7	4.7	5.0	5.3
3	2-3	5.2	5.2	5.8	6.4	6.4	6.4	6.4	6.1	6.1	6.1	6.3	6.3	6.3	7.2	7.8
4	3-5	6.3	6.3	6.8	7.9	7.9	7.9	7.9	7.2	7.2	7.2	7.6	7.6	7.6	8.7	9.5
5	5-10	7.7	7.7	8.5	9.7	9.7	9.7	9.7	9.2	9.2	9.2	10.0	10.0	10.0	11.4	13.1
6	10-15	9.9	9.9	10.2	11.4	11.4	11.4	11.4	12.8	12.8	12.8	14.8	14.8	14.8	12.9	15.4
7	15-25	14.8	14.8	12.8	15.3	15.3	15.3	15.3	15.6	15.6	15.6	16.1	16.1	16.1	16.5	18.7
8	25-35	28.7	28.7	28.7	20.2	20.2	20.2	20.2	19.1	19.1	19.1	23.2	23.2	23.2	22.2	21.2
9	35-50	31.8	31.8	31.8	26.8	26.8	26.8	26.8	26.1	26.1	26.1	20.7	20.7	20.7	20.7	23.8
10	50-100	27.8	27.8	29.8	27.0	27.0	27.0	27.0	25.2	25.2	25.2	25.7	25.7	25.7	25.3	28.0
11	100-200	32.8	32.8	36.5	34.7	34.7	34.7	34.7	34.8	34.8	34.8	30.3	30.3	30.3	31.5	34.5
12	200-300	32.8	32.8	36.5	34.7	34.7	34.7	34.7	34.8	34.8	34.8	30.3	30.3	30.3	31.5	34.5
13	>300	32.8	32.8	36.5	34.7	34.7	34.7	34.7	34.8	34.8	34.8	30.3	30.3	30.3	31.5	34.5

(Note*: insufficient data available from origin area 3 at distance bands 8 and 9. So data combined for origins 1 to 3 at distance band 8 and 9.)*

4.20. Rail fares

Rail fares have been derived from MOIRA which provides information on revenues based on ticket sales (including season tickets) for the station pair combinations for full, reduced and season tickets.

The revenue data for station pair combinations has been aggregated to the NTMv2R zone pair and distance band (ODL) combinations to give an average revenue per trip for the combinations where data is available. This is then used as representative of the fare paid per trip.

For the model ODL combinations which exist, but for which no information has been extracted from MOIRA, the revenues have been estimated from more aggregate MOIRA information by origin or destination and distance band or failing that purely by distance band using the same methodology as for travel times, as follows:

Revenue(ODL) = Average[Revenue (OL) + Revenue (DL)] *if defined, else:*

Revenue(ODL)=Revenue(L)

This approach provides a complete set of revenue information for the full, reduced and season ticket types which are input to the demand model. In practice the opportunities for making short distance trips between more rural locations will be very limited.

The relationship between the rail ticket types and the fares assumed by trip purpose within the demand model are shown in Table 4-19, these are unchanged. The Season ticket fares and reduced fares are coded for the peak and inter-peak periods in the model while the Full fares are applied as Employer's business specific matrix adjustments to the peak period season ticket fares.

Table 4-19 Relationship between rail ticket types and fares by trip purpose

Trip purpose	Ticket type
HB Work	Season tickets
HB Employer's business	Full tickets
HB Education	Season tickets
HB Personal business / shopping	Reduced tickets (saver fares)
HB Recreation / visiting friend	Reduced tickets (saver fares)
HB Holidays & day trips	Reduced tickets (saver fares)
NHB Employers' business	Full tickets
NHB Other	Reduced tickets (saver fares)

4.21. Rail fare concessions

Rail fare concessions are coded in the model for Children and Pensioners (now defined as adults aged 75+). In NTMv2R the concessions for London residents are obtained from Transport for London's website, and for rail travel elsewhere in the country based on the National Rail website. The assumptions implemented for the 2015 base year are as shown in Table 4-20.

The differences implemented in the peak and inter peak fares take into account the discounts available to everyone for off peak travel and will include a mix of fares based on the use of advanced purchase tickets.

Table 4-20 Rail fare concessions

Traveller type	Location	Rail provider discount	Model assumption
Children	Within London	< 11s travel free (TfL) 11-16 typically pay 50% (with Zip Oyster)	Pay 40% (to take account of some children being free)
	Elsewhere	5 to 15 – 50% discount <5s free (with an adult)	Pay 50%
75+	Within London	60+ Oyster / Freedom card – free travel for residents	Free (pay 0%)
	Elsewhere	Senior rail card – third off	Pay 67% of fare

4.22. Rail ride times

One of the output fields in the MOIRA dataset used to provide rail characteristics for input to the demand model, is the average travel time between each station pair. With the stations allocated to model zones and the distances between stations provided, the journey times are summarised to give the average travel time for each demand model zone pair and distance band combination. These average journey times include time taken for making any transfers between trains / stations in the course of the trip but exclude the wait and access / egress times at the start / end of the journey. These access and wait times are added as separate model inputs as set out in Sections 4.23 and 4.24 below.

Where no information was extracted from MOIRA for a demand model zone pair and distance band (ODL) combination, the time was estimated from more aggregate average journey times as follows:

RideTime(ODL) = Average[RideTime(OL) + RideTime(DL)] *if defined, else:*

RideTime(ODL)=RideTime(L)

This approach provides a complete set of ride time information for all relevant zone pair and distance bands which are input to the demand model. The same average journey time is input for both the peak and inter-peak rail characteristics.

4.23. Rail wait times

Rail wait times are dependent on the frequencies of the rail services available. MOIRA represents such frequencies as service intervals with associated frequency penalties. The frequency penalties are used to derive the rail wait times for NTMv2R. Differences in frequency penalty between full-price and reduced journeys which correspond to the varying service intervals are used to estimate that part of the MOIRA generalised journey time which is due to the frequency penalty.

The results for the set of station pairs were summarised into the NTMv2R zone pair and distance band combinations to give the average frequency penalty (not weighted, simple average based on services available) for full and reduced ticket types.

Wait times are typically assumed to be half the frequency (service interval) for frequent services, with a maximum wait time for less frequent services where passengers schedule their arrival times. The MOIRA frequency penalties effectively include a weight on the wait time to give the generalised journey times. This weight is applied explicitly in the NTMv2R (value of 2 as shown in Table 4-4). The wait times for input to NTM are therefore taken as half of the average frequency penalty up to a maximum wait time of 30 minutes.

NTMv2R requires rail wait information to be coded for peak and inter-peak travel. The full price tickets were assumed to provide information relevant to “peak” travel, while the characteristics associated with reduced ticket types were assumed to relate to “inter-peak” travel. Where no information had been obtained from the MOIRA processing, wait times were infilled using information from the previous NTMv2 which were generally found to have similar magnitude values. The entire set of rail wait times used in the model is as shown in

Table 4-21 for peak travel and Table 4-22 for inter-peak travel with infilled values from NTMv2 shown in red text.

Table 4-21 NTMv2R peak rail wait times by origin area by distance band (minutes)

	Distance Band												
Origin	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.99	0.97	3.33	3.75	4.12	5.85	6.16	6.95	9.07	13.86	15.94	23.62	27.03
2	5.24	4.70	5.30	4.61	5.93	7.78	8.30	10.15	9.99	13.14	15.92	20.25	26.44
3	6.48	7.01	7.01	8.06	7.48	7.72	9.10	9.85	10.26	12.65	15.88	20.24	25.05
4	2.00	9.50	9.50	10.17	15.56	12.23	16.76	13.93	16.53	17.60	18.16	18.52	23.67
5	9.19	8.84	8.70	9.85	11.19	11.25	12.38	13.99	14.72	15.90	15.39	20.97	29.70
6	12.91	19.50	9.00	13.00	13.05	13.55	14.52	15.11	16.29	17.74	17.96	19.91	26.27
7	7.67	10.33	11.63	10.88	10.86	12.24	13.26	14.79	15.67	16.93	17.07	19.53	30.00
8	15.38	29.50	15.50	15.17	20.26	15.57	18.03	18.55	16.90	17.30	18.21	23.62	22.73
9	4.38	4.38	17.50	19.50	17.33	19.50	15.07	15.42	16.87	18.22	19.35	19.25	28.07
10	5.00	7.67	10.32	7.50	7.93	9.20	12.83	12.92	12.04	14.14	16.81	20.17	26.56
12	21.08	13.00	16.00	16.60	16.27	21.59	19.69	18.17	16.57	17.08	19.25	22.97	30.00
13	15.00	15.50	15.00	13.30	15.17	17.56	14.34	16.47	17.43	18.75	19.37	20.42	29.10
14	14.50	13.80	13.80	15.32	15.04	13.34	11.00	10.58	12.57	13.64	17.77	20.79	26.86
16	11.50	12.23	11.28	14.35	12.55	12.13	11.58	12.38	13.72	15.34	18.39	21.10	27.45
17	19.50	18.57	17.90	16.43	15.61	15.25	15.48	14.67	15.59	17.64	20.61	24.59	28.35

Table 4-22 NTMv2R inter-peak rail wait times by origin area by distance band (minutes)

	Distance Band												
Origin	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.12	1.62	3.33	3.75	4.06	5.53	5.68	6.35	7.93	10.63	11.76	15.57	17.27
2	5.19	4.56	5.14	4.48	5.61	7.14	7.49	8.70	8.63	10.39	11.77	13.89	16.97
3	6.18	6.33	6.48	7.36	6.78	6.98	8.03	8.51	8.83	10.16	11.76	13.89	16.28
4	2.00	8.50	8.50	8.50	11.22	9.54	12.18	10.76	12.03	12.61	12.88	13.07	15.60
5	7.88	7.60	7.48	8.35	9.27	9.32	9.96	10.85	11.21	11.79	11.48	14.24	18.60
6	13.01	13.50	7.75	10.50	10.00	10.50	11.03	11.36	11.97	12.66	12.77	13.75	16.88
7	6.83	8.78	9.46	8.99	9.01	9.89	10.40	11.21	11.64	12.27	12.32	13.53	19.92
8	14.57	18.50	11.50	11.33	13.91	11.59	12.81	13.05	12.28	12.43	12.89	15.56	15.11
9	4.77	4.77	12.50	13.50	12.50	13.50	11.32	11.52	12.24	12.88	13.45	13.37	17.79
10	5.00	6.83	7.45	7.00	7.17	7.70	10.26	10.32	9.65	10.90	12.24	13.86	17.03
12	21.08	10.50	11.83	12.10	11.88	14.56	13.59	12.87	12.08	12.32	13.41	15.23	20.39
13	15.00	11.50	15.00	10.50	11.50	12.56	11.03	12.07	12.48	13.14	13.44	13.96	18.30
14	11.00	10.40	10.40	11.41	11.21	10.28	8.99	8.81	10.05	10.63	12.68	14.16	17.18
16	9.25	9.82	9.36	10.88	9.91	9.72	9.35	9.79	10.63	11.48	12.99	14.32	17.48
17	13.50	13.00	12.65	11.92	11.38	11.31	11.49	11.02	11.56	12.63	14.08	16.05	17.93

4.24. Rail interconnection times

The number of interchanges was estimated from the differences in the MOIRA generalised journey times between Full-price and Season tickets. The estimated interconnection numbers were then summarised to give the average number of interchanges for the demand model zone pair and distance band combinations.

This average is not rounded to an integer so for a given zone pair and distance band combination there could for example be a value such as 0.86 interchanges.

Figure 4-3 shows the range of interchange values assumed within the updated demand model. On average there are 1.16 interchanges per modelled combination. The chart shows that a significant number of the model zone pair and distance band combinations (over 500) have no interchanges, while just over 600 have between 1 and 1.5 interchanges. The highest number of interchanges is 6.16.

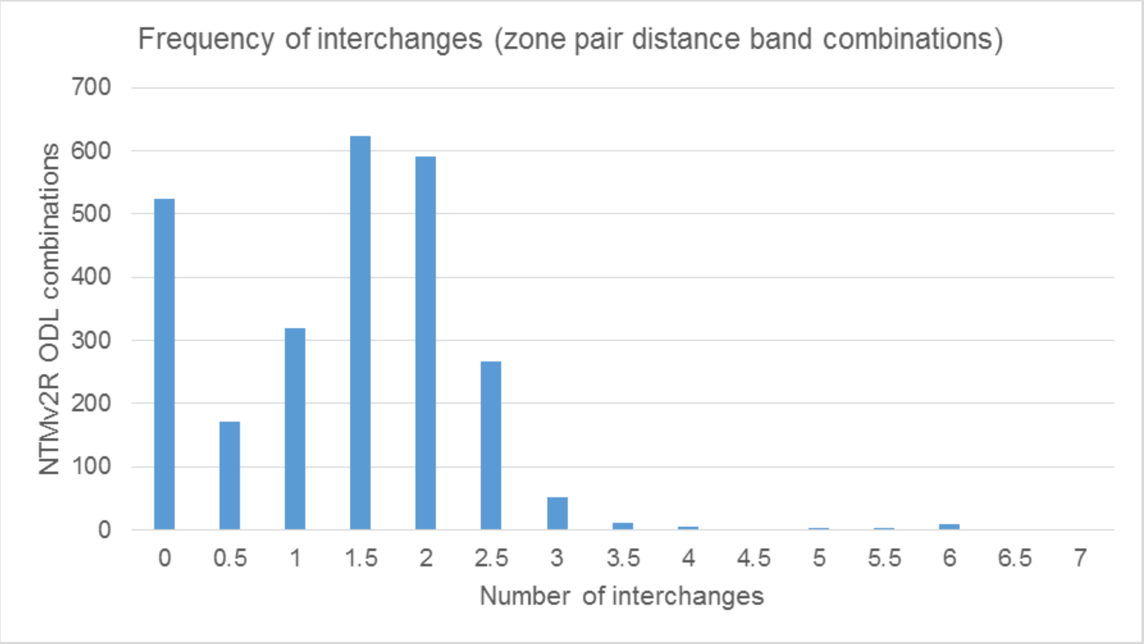
Where no information was extracted directly from MOIRA for a demand model zone pair and distance band (ODL) combination, the number of interchanges was estimated from more aggregate average numbers of interchanges as follows:

Interchanges(ODL) = Average[Interchanges(OL) + Interchanges(DL)] *if defined, else:*

Interchanges(ODL)=Interchanges(L)

This approach provides a complete set of interchange ride time information for all relevant zone pair and distance bands which are input to the demand model.

Figure 4-3 Profile of number of interchanges assumed



WebTAG unit M3-2, public transport assignment modelling, suggests an interchange penalty of 5 to 10 minutes of in-vehicle time per interchange should be included. A 5 minute interchange penalty has been applied to the average number of interchanges for each zone pair and distance band combination.

4.25. Rail access and egress times

Rail access and egress times in NTMv2 were obtained from the earlier National Rail Passenger model operated by the Department. MOIRA provides information on station to station travel but does not provide any information on the time taken to access or egress to / from the rail stations. Use of the National Travel Survey was considered to provide access and egress times, however the sample sizes for rail travel in the National Travel Survey are small. The access and egress times implemented in NTMv2 were reviewed. Separate access times are coded for each origin zone and time period (peak / interpeak) and separate egress times for each destination zone and time period. Since they appeared reasonably intuitive in the way they varied by zone, the NTMv2 values have been retained – but rounded to a whole number of minutes. The resulting access and egress times now implemented are shown in Table 4-23.

Table 4-23 Rail access and egress times by zone

Zone	Access by Origin zone		Egress by Destination zone	
	Peak	Interpeak	Peak	Interpeak
1	6	6	6	6
2	9	8	8	8
3	11	11	11	11
4	11	11	11	11
5	12	12	13	13
6	21	21	21	21
7	16	16	15	15
8	23	22	22	22
9	21	20	20	20
10	14	14	14	14
12	25	23	23	23
13	24	25	25	25
14	18	19	20	20
16	18	18	18	18
17	31	32	32	32

4.26. Rail overcrowding

Rail crowding was included in NTMv2 as additional perceived time for each zone pair and distance band combination for the peak and inter peak models. The information was provided from the national rail passenger model which is no longer available.

The amounts of crowding in the existing NTMv2 model were reviewed with a view to maintaining the values if they were readily understood and could be related to recent statistics on rail usage or crowding. As noted above crowded time is input as an additional perceived time component to the generalised cost of travel. Comparing the crowded times with the actual ride times the most crowded zone pair and distance band combination was found to be zone 16 (urban small) to zone 6 (North and East outer conurbation) in distance band 6 (10 to 15 miles), where the crowding penalty in the peak period is more than six times the journey time. London did not feature as an origin or destination zone in the twenty most crowded zone pair and distance band combinations. Based on these results and the lack of information and ability to unpick the source of the original numbers it was decided not to use the old NTMv2 overcrowding times.

Alternative sources of rail crowding information were investigated for NTMv2R in discussion with the DfT's rail team. Published rail statistics on passenger numbers compared with seats for arrivals and departures by city station and time period were reviewed, as were the number of passengers in excess of capacity (PIXC). At the aggregate city station level the average levels of crowding were not found to be excessive. In the 2015 statistics only Leeds and London have numbers of passengers in excess of the number of seats. Given many of the trains have capacities which include a standing allowance the average level of crowding in the peak periods appears low, though clearly some individual trains are very crowded..

Given the aggregate nature of the demand model both spatially and by time period, it was decided not to implement crowding in the updated 2015 base year model. The overcrowding functionality has however been retained so alterative forecasts can be implemented to test assumed levels of overcrowding should this be of interest to users.

5. Impacts of updates (pre-calibration)

5.1. Context

This chapter provides a summary of the impact of updating the model inputs as set out earlier in the report prior to recalibrating the model. This shows the effect of changes in the assumptions and underlying data on the level of travel demand, the choice of modes and the spread of trips across the distance bands and destination zones. The changes in results shown do not in any way imply errors in either the new or old versions of the model, but demonstrate how significant some of the changes have been. The recalibration process will ensure the updated 2015 model results reflect the observed spread of trips across the mode, destination and distance band options available and that the sensitivity of travellers' choices to changes in travel characteristics is in line with empirical evidence (elasticities), where these exist.

The results presented in this Chapter are the outputs from the updated demand model which includes updated car speed inputs from the FORGE but does not include any iteration of the demand and supply modules, since this is not relevant for the base year, only for forecasting changes. The results are compared against an existing forecast for the 2015 year from the NTMv2 model.

The starting point for the updating of the model inputs was the 2015 forecast scenario provided by DfT called 2015_RTF14_Baseline1_Ref. This scenario includes 2015 forecasts of trip ends derived from the NTEM 6.2 dataset and travel characteristics by mode input / updated by the users to represent the 2015 situation.

5.2. Approach

The demand model is run slightly differently to create the initial base year, compared to running a forecast scenario. To create an initial base year run, the known (required) trip length profiles are imposed as a series of constraints on the volume of trips by distance band. When forecasting / scenario testing these constraints are not used and the model results by distance band will vary due to the changes in the input travel characteristics.

The runs carried out incorporating updated inputs are a series of "forecast" style runs, all implemented and run in exactly the same way. The responses being modelled include mode, destination and trip length changes based on the travel characteristics being input.

This section provides an overview of the evolution of the model results from the starting point (UR1) to the final run (UR42) incorporating all the updates carried out prior to the calibration. These results exclude the following updates which were incorporated during the calibration process but are reported here:

- Changes in passenger guilt factors for vehicle operating costs
- Changes in the weights applied to time components for some stages of travel

Section 5.3 below shows how the move to NTEMv7 trip ends have affected the results. The following section 5.4 summarises the change in results from the updates made. The following sections provide the evolution of a limited number of indicators through the series of updates made and introduced step by step.

5.3. Impact of trip end updates on travel demand levels

The volume of trips in NTMv2R is a direct result of the input trip ends. There is no frequency response or trip generation as part of the demand model.

For NTEMv7 there have been some significant changes to the trip rates based on evidence from detailed analysis of time trends from the NTS data. This has resulted in fewer trips being forecast per person in 2015 in NTEMv7 than in the earlier NTEMv6.2 datasets. Thus even though the underlying mid year population assumptions will have changed little, the number of trips occurring in 2015 has fallen about 23%. The smallest changes are for business and education trips. The change in the balance between recreation and holiday / day trip purposes appears to be due to change in the treatment (classification) of "day trip / just walk" trips in the derivation of trip rates – though overall there is a reduction in these types of trip due to the new trip rates.

Despite the overall reduction in trips, Table 5-1 shows that there is an increase in trips made by those living in 2+ adult households without a car. This is due to changes in the car ownership forecasts for 2015 in the different NTEM versions.

Table 5-1 Total trip ends by car availability (2015 average day)

Car availability (Household type)	NTEM v6.2 (in NTMv2)	NTEM v7.0 (in NTMv2R)	% change
1 adult 0 car	4,824,693	3,723,038	-22.83%
1 adult 1+ car	9,250,906	4,975,476	-46.22%
2+ adults 0 car	5,961,096	6,611,716	10.91%
2+ adults 1 car	30,215,653	19,722,073	-34.73%
2+ adults 2+ cars	31,577,442	25,367,866	-19.66%
Not applicable (HB Hols and NHB trips)	22,373,099	19,367,758	-13.43%
Total trips modelled (average day)	***104,202,889***	***79,767,926***	***-23.45%***

The reduction in trip ends from NTEM mean the number of trips by any mode and by any distance band have experienced a sharp drop as seen in Table 5-2 and Table 5-3.

Among the six modelled modes, car trips reduce most (-25.1% for car driver, and -23.6% for car passenger).

Table 5-2 Difference in trip volume by mode: NTMv2R (NTEM7) vs. NTMv2 (NTEM 6.2)

Mode	HB Work	HB EB	HB Educ	HB PB/Shop	HB RVF	HB Hols	NHB EB	NHB Other	Total
Walk	-15.4%	18.5%	-3.8%	-17.7%	-41.0%	39.2%	-9.7%	-18.5%	*-21.8%*
Cycle	-18.6%	11.2%	-8.7%	-20.4%	-42.3%	37.0%	-16.3%	-20.0%	*-17.6%*
Driver	-27.3%	-14.4%	0.5%	-18.7%	-44.7%	39.8%	-27.7%	-17.1%	*-25.1%*
Passenger	-16.8%	27.5%	-11.2%	-23.0%	-43.2%	38.4%	18.2%	-17.7%	*-23.6%*
Bus	-21.1%	36.2%	-9.5%	-24.6%	-40.7%	36.7%	-1.0%	-21.4%	*-21.8%*
Rail	-24.4%	12.4%	0.3%	-13.7%	-41.4%	28.6%	-5.0%	-32.4%	*-22.4%*
Total	***-23.7%***	***-6.1%***	***-5.3%***	***-19.9%***	***-43.0%***	***38.3%***	***-19.9%***	***-18.3%***	***-23.4%***

These changes are driven entirely by the mix of trips by purpose and traveller type including car availability, and the locations in which the trips are being made (by area type). It should be noted that some purpose and mode combinations have low levels of demand and hence percentage change can be misleading. The slightly increased share of walk, cycle and public transport trips is consistent with a higher proportion of demand now being in urban areas and a lower level of car availability.

The distance-band profile has been shifted as shown in Table 5-3, especially for trips between 3 to 25 miles (trips reduced in these bands more than on average), again caused by the mix of trips and the reduced propensity to travel by car seen in Table 5-2. The longest distance bands are less affected with average trip lengths (based on the profile by distance band) increasing by 4%.

The impact of the changes in demographic and car ownership changes on mode shares by purpose are shown in Table 5-4. This shows that despite significant reductions in trip volumes the impacts on mode shares are fairly limited with the main changes being the car driver / car passenger split, particularly for business trips and a small increase in walking for most purpose.

Table 5-3 Difference in trip volume by distance band: NTMv2R (NTEM7) vs. NTMv2

	Changes in trip volume	
Distance Band (mile)	%	Diff
0-1	-22.2%	-6,494,851
1-2	-23.3%	-4,028,511
2-3	-24.0%	-2,837,029
3-5	-24.8%	-3,662,954
5-10	-25.0%	-3,829,502
10-15	-24.8%	-1,489,552
15-25	-24.9%	-1,154,845
25-35	-23.1%	-405,738
35-50	-20.9%	-260,546
50-100	-16.5%	-214,903
100-200	-10.8%	-53,290
>200	-2.0%	-3,347
Total	***-23.4%***	***-24,435,068***

Table 5-4 Change in mode share NTMv2R (NTEM7) vs. NTMv2 (NTEM 6.2)

Mode	HB Work	HB EB	HB Educ	HB PB/Shop	HB RVF	HB Hols	NHB EB	NHB Other	Total
Walk	1.16%	1.51%	0.70%	0.78%	1.04%	0.01%	1.64%	-0.10%	***0.61%***
Cycle	0.27%	0.34%	-0.06%	-0.01%	0.02%	-0.08%	0.03%	-0.01%	***0.14%***
Driver	-2.74%	-6.85%	1.10%	0.56%	-1.14%	0.39%	-7.03%	0.50%	***-0.89%***
Passenger	1.06%	3.38%	-1.15%	-0.86%	-0.13%	0.00%	4.34%	0.13%	***-0.04%***
Bus	0.31%	0.88%	-0.64%	-0.52%	0.18%	-0.09%	0.44%	-0.17%	***0.16%***
Rail	-0.06%	0.73%	0.06%	0.06%	0.03%	-0.23%	0.58%	-0.35%	***0.03%***
Total	***0.00%***	***0.00%***	***0.00%***	***0.00%***	***0.00%***	***0.00%***	***0.00%***	***0.00%***	***0.00%***

5.4. Impact of updated values of time

The VOTs has been updated according to the latest WebTAG databook as set out in Section 4.4 above. Three values of time are now used rather than two in line with updated guidance. The change in values of time assumed for 2015 is shown in Table 5-5, having moved the model price base from 1998 prices to 2015 prices. This shows that the value of time for commuting trips has increased significantly following the change in guidance.

Table 5-5 Change in assumed values of time for 2015 model

Purpose	NTMv2 (£ / hour) 2015 values in 1998 prices	NTMv2R (£ / hour) 2015 values and prices
Commuting	4.86	11.41
Other		5.21
Business	19.08	18.56

The results shown in Table 5-6 show the impact of updates to VOTs (without other changes) on the modal shares by purpose. The update has increased use of car-driver, bus and rail trips (money becomes less important relative to time). The volume of car-passenger trips reduces significantly by over 25%. The impacts on business trips are slightly different with reduced use of public transport modes.

Table 5-6 Differences in trip volumes by mode: NTMv2R updating VOTs

Mode	HB Work	HB EB	HB Educ	HB PB	HB RVF	HB Hols	NHB EB	NHB Other	*Total*
Walk	-7.1%	-2.6%	0.1%	0.1%	0.3%	1.0%	-2.1%	0.1%	*-0.4%*
Cycle	-9.7%	-3.1%	0.6%	0.5%	0.7%	2.4%	-2.8%	0.3%	*-3.1%*
Driver	6.2%	6.3%	6.3%	11.2%	11.8%	40.3%	4.5%	18.3%	*11.4%*
Passenger	-37.6%	-29.2%	-9.7%	-22.2%	-19.0%	-38.8%	-17.1%	-36.3%	*-25.5%*
Bus	21.0%	-5.2%	2.8%	2.9%	6.0%	17.9%	-5.3%	6.5%	*7.8%*
Rail	10.2%	-6.5%	3.2%	10.1%	10.6%	18.1%	-4.5%	6.0%	*8.2%*
Total	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*

The change in values of time, particularly for commuting, results in longer trips on average. This explains the reduction in walking and cycling which are only relevant for shorter trips. Only trip volume between 50-100 miles has increased by over 5% as shown in Table 5-7.

Table 5-7 Difference in trip volume by distance band: NTMv2R updating VOTs

	Trip Volume	
Distance Band (miles)	**%**	**Value**
0-1	-0.3%	-73,239
1-2	-0.6%	-83,468
2-3	-0.5%	-49,064
3-5	-0.2%	-25,959
5-10	0.1%	14,151
10-15	0.8%	37,882
15-25	1.6%	55,222
25-35	2.5%	33,693
35-50	3.3%	32,398
50-100	5.5%	59,808
100-200	-0.3%	-1,147
>200	-0.1%	-157
Total	*0.0%*	*120*

Table 5-8 shows the relative changes (percentage) in trip volumes by destination zone by mode. Car passenger trips fall significantly. The impact on walk and cycle declines as areas become less urban with compensating increases in public transport use. The more rural areas are however more car focused with absolute impacts on walk, cycle and public transport less pronounced. Central London and Inner London have experienced the most extreme changes since car costs here are high due to parking and the London Congestion Charge and now valued (relative to time) differently.

Table 5-8 Change in trips by destination zone by mode: NTMv2R updating VOT

Zone		Walk	Cycle	Car Driver	Car Passenger	Bus	Rail	*All*
1	Central London	-1.6%	-6.1%	37.7%	-39.0%	3.4%	-2.2%	*0.0%*
2	Inner London	-0.8%	-4.7%	16.6%	-29.9%	6.5%	3.6%	*0.0%*
3	Outer London	-0.5%	-3.8%	12.7%	-25.1%	5.7%	6.9%	*0.0%*
4	N&E Metropolitan Areas	-0.5%	-3.5%	11.5%	-25.4%	7.3%	7.1%	*0.0%*
5	West Metropolitan Areas	-0.5%	-3.5%	11.6%	-25.4%	7.1%	10.3%	*0.0%*
6	N&E Conurbation Surrounds	-0.4%	-2.8%	11.3%	-24.7%	8.9%	17.3%	*0.0%*
7	W Conurbation Surrounds	-0.4%	-3.0%	11.2%	-24.6%	8.5%	13.5%	*0.0%*
8	N&E Urban big	-0.4%	-2.9%	10.5%	-24.4%	7.2%	19.8%	*0.0%*
9	W Urban big	-0.3%	-2.6%	10.7%	-24.4%	7.4%	17.0%	*0.0%*
10	S Urban big	-0.4%	-3.0%	9.7%	-23.4%	7.5%	12.2%	*0.0%*
12	N&E Urban large	-0.4%	-3.0%	10.6%	-25.0%	7.7%	18.7%	*0.0%*
13	W Urban large	-0.4%	-3.4%	10.8%	-24.9%	8.2%	19.1%	*0.0%*
14	S Urban large	-0.4%	-3.2%	10.0%	-23.8%	7.2%	15.7%	*0.0%*
16	Urban medium	-0.3%	-3.1%	10.9%	-25.1%	7.8%	16.0%	*0.0%*
17	Urban small and rural	-0.3%	-2.1%	11.7%	-26.4%	9.6%	21.4%	*0.0%*
Total		*-0.4%*	*-3.1%*	*11.4%*	*-25.5%*	*7.8%*	*8.2%*	*0.0%*

5.5. Overall impact of travel characteristics updates on travel choices

The results shown here show the impact on mode share, trip length profiles and mode shares by destination zone from the updates to travel characteristics after the update to the trip ends – now taken from NTEM v7. Because the trip ends change so significantly this change hides the impacts of updating the travel cost and time attributes which have been applied to a consistent set of trip ends from the NTEM update onwards.

Table 5-9 shows significant changes in the numbers of car drivers, bus and rail passengers overall. There are also major changes for car passengers by purpose but less impact in aggregate. Car driver trips increase for all trip purposes. The numbers of car passengers fall for all purposes except education and holidays which have higher average car occupancy. Walk and cycle are less affected; the changes for HB holiday and day trips are believed to be due to a change in the treatment of just walk day trips. Bus patronage falls for all trip purposes, while rail trips increase for education and some discretionary trips but reduce for commuting and business trips (more focused in the peak) – but also due to the removal of rail destination specific constants for Central and Inner London.

It should be remembered that these changes occur in addition to the significant reduction in trips as a result of moving to NTEM v7 trip ends noted in section 5.3 above.

Table 5-9 Difference in trips by purpose by mode due to updated to travel characteristics

Mode	HB Work	HB EB	HB Edu	HB PB	HB RVF	HB Hols	NHB EB	NHB Other	Total
Walk	-4.9%	2.7%	-1.8%	0.0%	-0.1%	7.0%	0.3%	-0.3%	**-0.7%**
Cycle	-18.6%	-0.7%	-1.8%	-4.0%	-5.2%	4.7%	-3.6%	-3.8%	**-8.0%**
Driver	16.2%	4.8%	13.2%	7.7%	7.2%	6.6%	4.0%	10.0%	**10.0%**
Passenger	-15.1%	-17.2%	19.5%	-3.0%	-1.7%	4.4%	-11.0%	-6.7%	**-2.2%**
Bus	-34.4%	-36.3%	-40.1%	-28.4%	-42.1%	-59.7%	-44.4%	-48.9%	**-37.2%**
Rail	-41.3%	-7.5%	39.6%	9.0%	-4.1%	-18.3%	-4.4%	11.1%	**-16.7%**
TOTAL	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

Source: Run references UR47 v UR1

Despite significant changes by mode, the impacts on overall trip lengths are more limited. There are reductions in the longer distance trips (> 15 miles) with increases in the shorter bands.

Table 5-10 Difference in trips by distance band: due to updated to travel characteristics

	Trip Volume	
Distance Band (mile)	**%**	**Value**
0-1	0.8%	179,952
1-2	0.3%	34,869
2-3	0.1%	10,634
3-5	0.4%	43,986
5-10	0.0%	4,394
10-15	0.1%	6,267
15-25	-2.6%	-89,057
25-35	-0.2%	-3,113
35-50	-2.9%	-28,334
50-100	-7.5%	-81,511
100-200	-11.6%	-51,032
>200	-16.1%	-27,018
Total	***0%***	**38**

There are some spatial variations in the modal impacts as seen in Table 5-11 below for trips each destination zone. The updated model (pre calibration) has fewer rail trips to Central and Inner London, more to Outer London and conurbations and less to all other areas. The increases in rail trips to the Metropolitan areas and Conurbation surrounds are primarily the result of revised parking charges, the removal of rail crowding impacts and for the metropolitan areas the change in trip ends. The impacts of value of time and vehicle operating cost changes are less for trips to the North and East Metropolitan areas so the impact on rail is more limited.

Bus travel reduces everywhere except for trips to Central London where it increases. The impacts are most pronounced in rural areas.

Numbers of car driver trips increase everywhere particularly to Central and Inner London (where the major reduction in rail due to removing destination specific constants results in increases in all other modes); while car passengers decrease in all urban areas but increase slightly in rural areas.

The use of cycle as a mode has generally reduced except for trips to Central London where there are large increases in the number of cyclists, and trips to central conurbations. Walk trips tend to decrease in most places though the impacts are relatively small.

Table 5-11 Difference in trips by destination zone by mode due to updated to travel characteristics

Zone		Walk	Cycle	Car Driver	Car Passenger	Bus	Rail	*All*
1	Central London	18.7%	81.1%	36.5%	-2.0%	6.2%	-41.3%	**0.0%**
2	Inner London	-0.4%	-5.7%	25.0%	-2.8%	-29.4%	-33.4%	**0.0%**
3	Outer London	-1.0%	-11.3%	13.6%	-5.4%	-34.3%	1.3%	**0.0%**
4	N&E Metropolitan Areas	0.2%	-4.0%	11.7%	-5.4%	-31.2%	-1.4%	**0.0%**
5	West Metropolitan Areas	0.3%	-5.0%	10.6%	-4.4%	-32.4%	15.9%	**0.0%**
6	N&E Conurbation Surrounds	-1.6%	-11.1%	9.5%	-4.8%	-31.8%	23.2%	**0.0%**
7	W Conurbation Surrounds	-1.8%	-12.8%	10.0%	-4.3%	-33.1%	10.3%	**0.0%**
8	N&E Urban big	-0.1%	-11.4%	9.4%	-2.6%	-36.4%	-5.8%	**0.0%**
9	W Urban big	-0.4%	-11.8%	9.4%	-2.9%	-37.8%	-16.2%	**0.0%**
10	S Urban big	-0.6%	-12.2%	9.0%	-3.2%	-37.9%	-3.1%	**0.0%**
12	N&E Urban large	-0.3%	-12.4%	8.5%	-2.3%	-36.2%	-23.5%	**0.0%**
13	W Urban large	-1.4%	-14.3%	9.4%	-2.3%	-37.6%	-2.6%	**0.0%**
14	S Urban large	-0.3%	-11.6%	8.4%	-1.3%	-38.0%	-17.1%	**0.0%**
16	Urban medium	-1.7%	-13.8%	9.0%	-2.3%	-35.7%	-11.0%	**0.0%**
17	Urban small and rural	-1.2%	-9.3%	8.7%	0.4%	-50.4%	-5.7%	**0.0%**
Total		**-0.7%**	**-8.0%**	**10.0%**	**-2.2%**	**-37.2%**	**-16.7%**	**0.0%**

5.6. Impacts on modal shares

The cumulative impact on overall mode shares with the introduction of each data update is shown in Figure 5-1 below. Starting from the bottom of the chart and working upwards, each bar shows the overall mode share from the cumulative updates introduced by that stage. The NTMv2 mode shares are shown as the starting point at the bottom of the chart and repeated at the top to show the overall impact.

Walking and cycling shares change little. There are small increases in walking mode shares driven primarily by the runs updating parking search times and reductions due to updating car speeds.

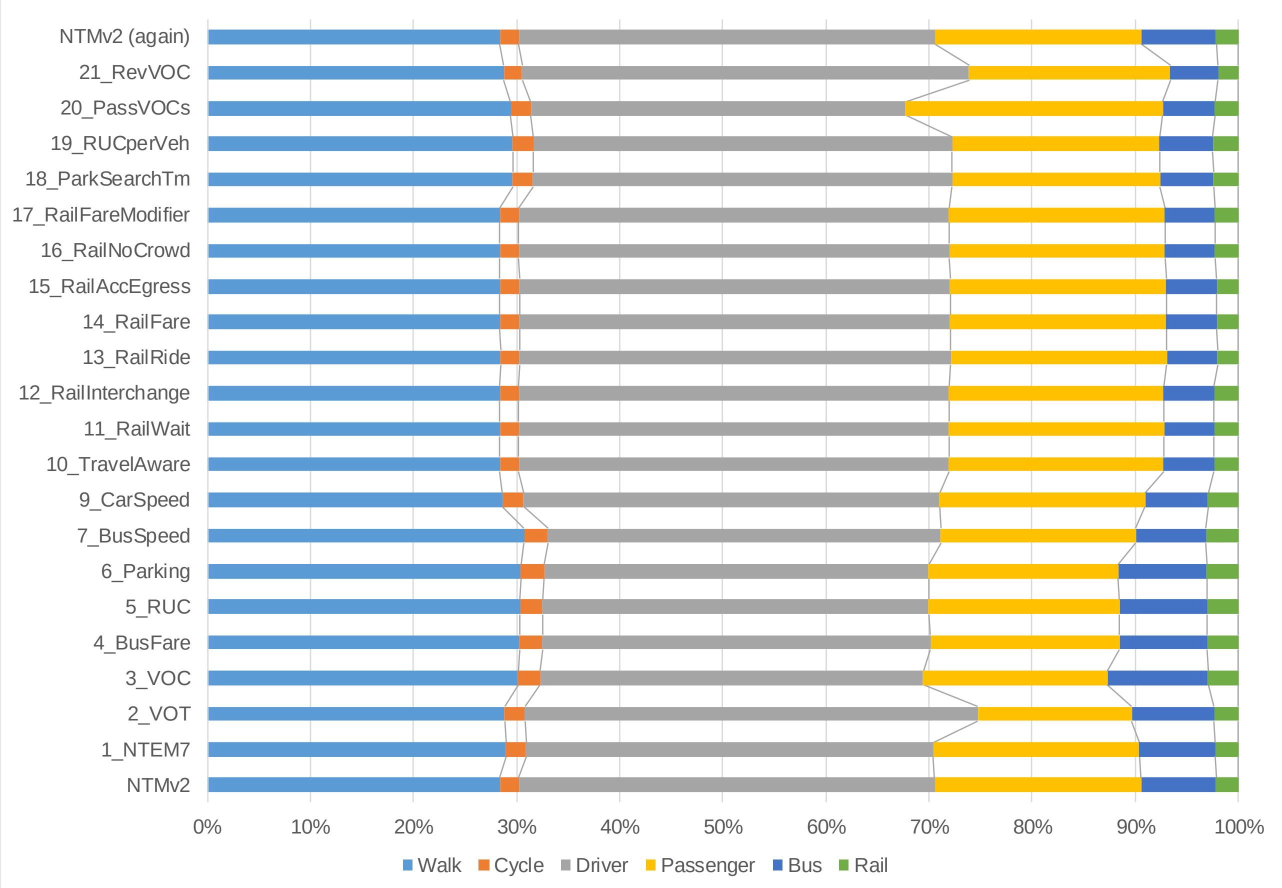
The proportion of trips by car driver has increased primarily as a result of changes in the values of time and to a lesser extent the vehicle operating costs (in aggregate over all the VOC updates).

Car passenger mode share decreases slightly with reductions due to the change in values of time and increases due to changes in the implementation of vehicle operating costs but also due to changes in car speeds and the removal of the travel awareness policies that promoted more bus and cycle usage.

The proportion of travel by bus falls due to changes in bus fares, bus travel speeds and removal of travel aware policies. Updating car speeds has also had a small negative impact on bus travel.

The proportion of travel by rail is small with a small reduction in mode share. This is caused partly by the increase in rail fares but also due to the removal of the calibrated London specific constants encouraging more rail travel to London.

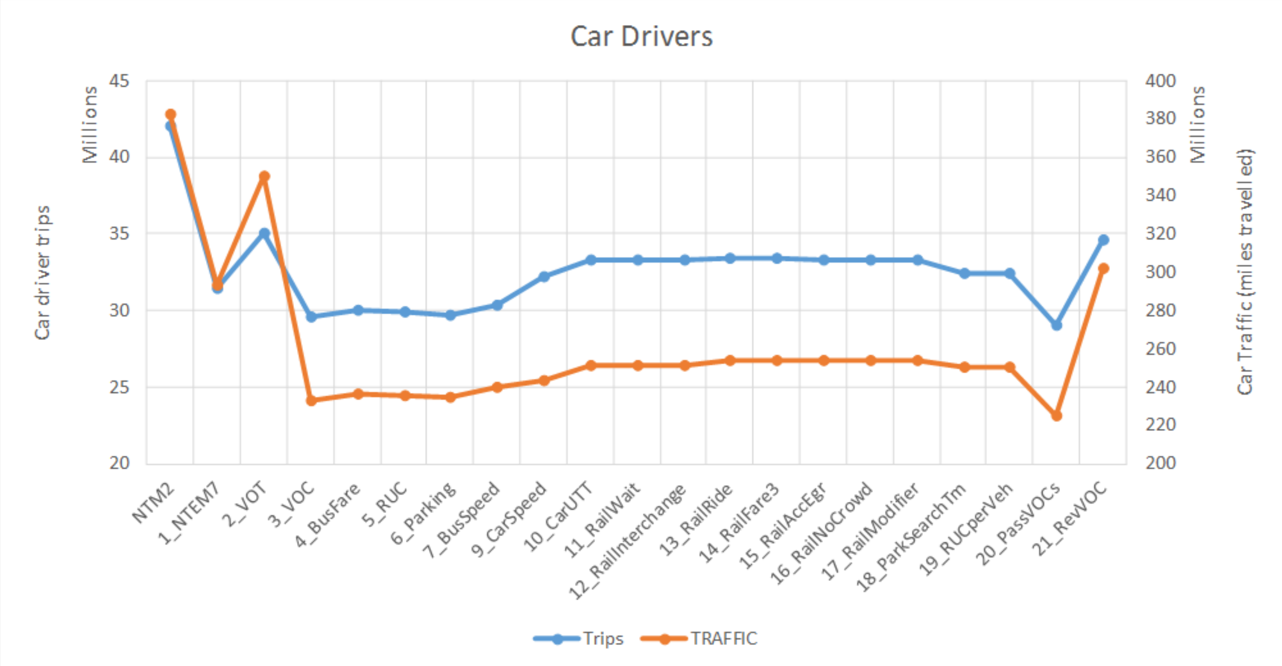
Figure 5-1 Cumulative impact on overall mode shares with each update introduced



5.7. Impacts on car (driver) trips and traffic

Figure 5-2 shows the total number of car trips modelled in each run and the estimated traffic (car driver miles) levels based on a constant trip length for each distance band.

Figure 5-2 Impact on number of car driver trips and car traffic with each update introduced



The impact on the number of car trips is shown by the blue line in the chart. This highlights that there are major reductions in car trips due to the change in trip ends (NTEM v7). Changes in the values of time offset some of the reduction, while the combined impact of the vehicle operating cost changes (introduced in steps 3, 20 and 21 as shown in Figure 5-2) is fairly neutral on the volume of car trips. Because of the NTEM trip end changes the result is still a major reduction in the number of car trips from 42 to 34.6 million trips per average day.

The brown line for car traffic follows a similar pattern but the combined impact of the vehicle operating cost updates is a reduction in the car distances travelled. These large reductions are the result of a small reduction in car trip lengths as well as the fall in car trips.

In summary updating the model inputs without any changes to the model calibration the volume of car trips falls by 18% with the amount of car traffic reducing by 21%. This is driven primarily by the reduction in travel demand input from NTEMv7; and masks the increased car driver mode share (43% compared with 40% previously). Having updated the inputs as reported in this Implementation report, the demand model is recalibrated, as described in the report NTMv2R: Demand Model Calibration and Validation. The calibration process ensures the mode shares and trip lengths closely reflect the data available. Once calibrated the reductions in car travel seen here will not necessarily still hold and revised 2015 traffic levels and future forecasts will be produced.

5.8. Impacts on rail trips to London

This section looks at the small but important category of rail travel to London. Rail is a minor mode, but has a major share of trips to London – particularly Central London.

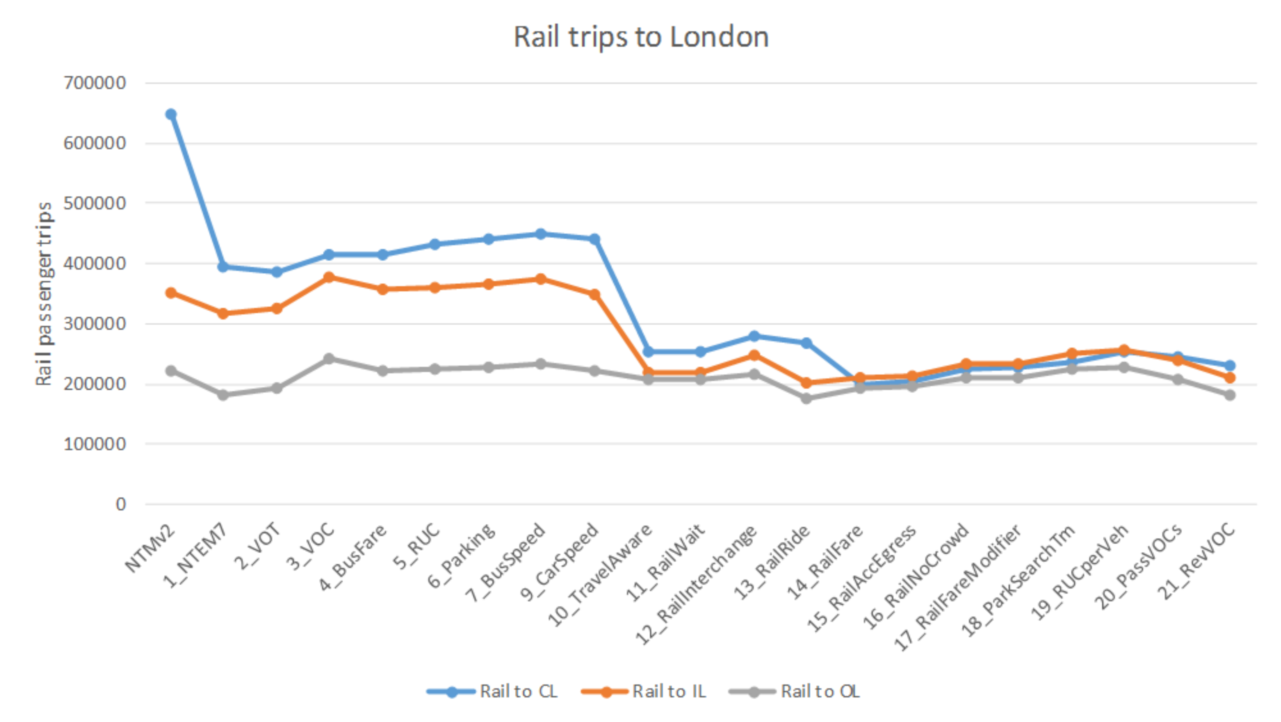
Figure 5-3 shows the number of rail trips in the model to Central, Inner and Outer London. The update in to NTEM v7 trip ends has led to a large reduction in rail trips to Central London with smaller impacts on Inner and Outer London. Given the fall in total trips on updating to NTEM v7, the small reductions to Inner and Outer London are smaller than might be expected.

Increases in vehicle operating costs result in slightly more rail trips to London. Bus fares changes have also had a small negative impact on rail trips to Inner and Outer London, but less so to Central London where the two modes do not really compete.

The other significant reduction shown in Figure 5-3 is when the travel awareness policies were removed. These zone specific constants also contained the Central and Inner London specific rail constants. Retaining these constants would have kept Central London rail trips around 45,000 per day and Inner London trips to 35,000 per day. The destination specific constants will be re-introduced as part of the model recalibration.

The changes to rail ride times and rail fares also reduce rail trips to these zones whereas most other updates have reinforced the use of rail to travel to London.

Figure 5-3 Impact on number of rail passenger trips to London with each update introduced



6. Summary

The version of the national modelling framework used by the Department to test the impacts of a wide range of scenarios and to produce the road traffic forecasts has been updated. Atkins and RAND Europe were commissioned to update and recalibrate the transport demand model, a core component of the modelling framework used to forecast changes in personal travel by all modes. The updated model is known as NTMv2R.

The demand model operates at an aggregate level of spatial detail with an innovative structure of distance bands to incorporate additional geography and reflect the various travel options available. A high level of segmentation is included within the model to reflect different travellers' propensity to use alternative modes and travel different distances for different journey purposes. The updating of the demand model has been carried out assuming no changes in the model design and structure.

This report describes the steps undertaken, data used and assumptions made to update the inputs to the NTMv2 demand model. This completes the first stage of the rebasing of the NTMv2 demand model to create NTMv2R with a 2015 base year. Following the updating exercise reported here, the demand model was recalibrated to ensure the base year results reflected observed data on choice of modes, patterns and lengths of travel for the different trip purposes; and has appropriate responses (elasticities) to changes in different journey attributes such as fuel costs, journey times and public transport fares. The second stage (recalibration) is reported in the companion document: NTMv2R: Demand Model Calibration and Validation.

The most significant revision to the demand model inputs was the change in travel demand taken from NTEMv7. There is a reduction of -23% in the total number of personal trips being made for all purposes and summed over all modes.

Updates in guidance, in line with evidence from research, mean that commuting trips have a higher value of time than in the old NTMv2 model which may affect their responsiveness to changes in travel conditions. Results have been presented in Chapter 5 to show the effect of the changes in input assumptions. However, it must be remembered that these results are based on the model performance using the old NTMv2 choice parameters and alternative specific constants which are then updated in the calibration task.

The NTMv2R Demand Model Calibration and Validation report should be consulted to provide information on the performance of the updated NTMv2R model in the 2015 base year. That report provides results which demonstrate that the updated NTMv2R model produces trip length and mode choice profiles which match well with observed data; and that the elasticities of response to changes in cost and time are in line with the evidence provided in WebTAG guidance.

Appendices

Appendix A. Glossary

ACTIVE MODES	Walking and cycling – sometimes referred to as non-mechanised or slow modes
ASSIGNMENT	The process of loading a matrix of trips on to a network to establish the routes used and the resulting traffic levels.
BLANK FILE	All the input files to the MEPLAN programs consist of lines that are either standard headings to the different groups of data or rows of zeroes to separate the groups and terminate the files. These files without any model data included are known as blank files and are supplied with MEPLAN.
CAPACITY	Amount of space on road links or public transport services for persons or vehicles. For road links this is usually measured in vehicles or cars per hour.
CONSTRAINTS	A user specified amount of an activity to be generated within the specified zone or study area. The trip attractions from NTEM are constraints in each of the three Passes.
COST	Monetary cost
DISTRIBUTION	The process of estimating the pattern of destination or attraction zones for a given origin or production zone.
DISUTILITY	The total value of time, cost, discomfort, inconvenience charges etc of a journey – equivalent to the “generalised cost” or “generalised time” of a trip. Equal to generalised time throughout national modelling system.
ELASTICITY	A measure of response to change. Defined as the ratio of the proportional change resulting from an effect to the proportional change causing the effect.
FACTOR	Any entity whose location is to be modelled within the LUS modules of MEPLAN used for trip distribution models in all 3 passes of national modelling system.
FLOW	The demand for transport, expressed as matrices in the MEPLAN FAF and LAF file. In this model these matrices are passenger trips.
FORGE	Department model to handle capacity constraint of car traffic at a regional level.
LINK TYPE	The basic means of distinguishing different parts of the transport system. In this model the link types classify the roads by road type, area type and sub-region.
LOAD	The volume of traffic on a link.
LUS or LUSA	Module of MEPLAN software used to carry out trip distribution modelling
MEPLAN	Integrated land use and transport modelling software
MODAL CONSTANT	The fixed additional component of the disutility that is independent of time or cost.
MODAL HIERARCHY	The way in which the modal choices are structured.

MODAL SPLIT	The process of allocating the total volume of trips amongst the (user) modes.
MODE	In MEPLAN terms this is the same as NETWORK MODE, ie the mode being used for a specific stage of a journey, eg waiting, riding etc.
NETWORK MODE	The mode of travel for a particular stage of a journey on a specific set of links on the network.
NTEM	The Department's National Trip End Model for estimating the number of trip ends for personal travel based on population and car ownership forecasts.
NTS	National Travel Survey
SIZE TERM	A zone pair weight reflecting the importance of the zone pair for trips by different dimensions (eg purpose, mode and distance band)
SLOW MODES	Active modes: Walking and cycling – sometimes referred to as non-mechanised modes
TAS or TASA	MEPLAN software modules for carrying out modal split and highway assignment stages of national transport modelling system.
TRADE	A transportable factor, ie an activity within the LUSA module that can be produced in one zone and consumed in another. The trips being modelled between origins and destinations or production and attraction zones are handled within LUSA as trades.
TRAVELLER TYPE	Segmentation of the population by person type (age and employment status), household type (size and car ownership) and SEG / income group.
TRIP	A person journey between two points.
TRIP END	The volume of journeys starting or ending in a particular location.
TRIP ATTRACTION	The number of journeys attracted to a particular location – for trips starting or ending at home, this is the other end of the journey.
TRIP PRODUCTION	The number of journeys generated or produced in a particular location – for trips starting or ending at home, this is the home end of the journey.
USER MODE	The main mode of travel for a trip
WEIGHTS	The component of the size terms that reflects the importance of the zone pair, independent of the numbers of trips and their purpose, mode etc.
ZONE	A spatial area defined to represent all activities to, from or within that area.

Appendix B. Demand model definitions

B.1. Dimensions and units

The dimensions and units used by NTMv2R are shown in Table B-1.

Table B-1 Dimensions and Units

Dimension	Units
Distance	*Miles*
Time	*Minutes*
Cost / Money	*Pence in 2015 prices*
Speed	*Miles per hour*
Disutility	*Generalised Minutes*
Trips	*Average day, outward legs (from home) for HB; one way for NHB*

B.2. Zones

The combinations of area type and region which make up the NTMv2R zones are shown in Figure B-1 (copy of Figure 2-3).

Figure B-1 NTMv2R Zone Definitions

	NTMv2R Area Type ->								
	1	2	3	4	5	6	7	8	9
Region	Central London	Inner London	Outer London	Metropolitan	Outer Conurbation	Urban Big (pop>250k)	Urban Large (pop>100k)	Urban Medium (pop>25k)	Rural
London	1	2	3						
South East						10	14	16	17
East of England						10	14	16	17
South West						10	14	16	17
Wales						10	14	16	17
West Midlands				5	7	9	13	16	17
North West				5	7	9	13	16	17
East Midlands				4	6	8	12	16	17
Yorkshire and the Humber				4	6	8	12	16	17
North East				4	6	8	12	16	17
Scotland				4	6	8	12	16	17

B.3. Trip purposes

Eight trip purposes are defined in the NTMv2R demand model: six home based purposes and two non-home based purposes. The definitions of the trip purposes is assumed to be entirely consistent with the purpose definitions in the National Trip End Model (NTEM v7.0) from which the trip ends are obtained. The purposes and their relationship with NTEM are shown in Table B-2.

Table B-2 NTMv2R trip purposes

NTEM7 Trip Purpose		NTMv2R Trip Purpose	
1	HB Work	1	HB Work
2	HB Employers Business (EB)	2	HB EB
3	HB Education	3	HB Educ
4	HB Shopping	4	HB PB/Shop
5	HB Personal Business (PB)	4	HB PB/Shop
6	HB Recreation / Social	5	HB Rec/VF
7	HB Visiting friends & relatives	5	HB Rec/VF
8	HB Holiday / Day trip	6	HB Hols
11	NHB Work	8	NHB Other
12	NHB Employers Business	7	NHB EB
13	NHB Education	8	NHB Other
14	NHB Shopping	8	NHB Other
15	NHB Personal Business	8	NHB Other
16	NHB Recreation / Social	8	NHB Other
18	NHB Holiday / Day trip	8	NHB Other

B.4. Traveller types

The demand segmentation in NTMv2R is derived primarily from the NTEM v7.0 dataset. The segmentation adopted varies by trip purpose to retain / introduce additional segmentation related to employment for commuting and business trips.

The 88 traveller types in NTEM v7.0 are made up of a combination of 8 household types and 11 person types. These map onto 5 household types and 4 person types in NTMv2R. For convenience, household types and person types are shown separately in the tables below, rather than listing out the 88 traveller types in full.

The correspondence between NTEM v7 household types and NTMv2R household types is shown in Table B-3.

Table B-3 Household Type Correspondence

NTEM7 Household Type		NTMv2R Household Type	
1	1 adult household with no car	1	1-Ad/0-Car
2	1 adult household with one or more cars	2	1-Ad/1+Car
3	2 adult household with no car	3	2+Ad/0-Car
4	2 adult household with two or more cars	4	2+Ad/1-Car
5	2 adult household with two or more cars	5	2+Ad/2+Car
6	3+ adult household with no car	3	2+Ad/0-Car
7	3+ adult household with one car	4	2+Ad/1-Car
8	3+ adult household with two or more cars	5	2+Ad/2+Car

The correspondence between NTEM v7 person types and NTMv2R person types is shown in Table B-4.

Table B-4 Person Type Correspondence

NTEM7 Person Type		NTMv2R Person Type	
1	Children (0 to 15)	1	Child (0-15)
2	Males in full time employment (16 to 74)	2	Full time emp
3	Males in part time employment (16 to 74)	3	Other 16-74[4]
4	Male students (16 to 74)	3	Other 16-74
5	Male not employed / students (16 to 74)	3	Other 16-74
6	Male 75+	4	Pensioner
7	Females in full time employment (16 to 74)	2	Full time emp
8	Females in part time employment (16 to 74)	3	Other 16-74
9	Female students (16 to 74)	3	Other 16-74
10	Female not employed / students (16 to 74)	3	Other 16-74
11	Female 75+	4	Pensioner

NTMv2R does not include every combination of trip purpose, household type and person type (160 possible combinations). However, it does include some income segmentation for HB work (full time employed persons), HB employer's business (full time employed persons) and NHB employer's business (all persons), which is applied to the output NTEM v7 data as a separate process (since income information is not available in the NTEM v7 dataset). The resulting 105 modelled combinations in NTMv2R are set out in Table B-5.

Table B-5 NTMv2R Demand model segments

			Household Type					
Purpose	**Person Type**	**SEG / Income**	**1 adult / 0 car (1)**	**1 adult / 1+ car (2)**	**2+ adult / 0 car (3)**	**2+ adult / 1 car (4)**	**2+ adult / 2+ car (5)**	**All**
HB Work (1)	Full time employed (2)	High	1	2	3	4	5	
		Medium	6	7	8	9	10	
		Low	11	12	13	14	15	
	Rest of population	All	16	17	18	19	20	
HB EB (2)	Full time employed (2)	High	21	22	23	24	25	
		Medium	26	27	28	29	30	
		Low	31	32	33	34	35	
	Rest of population	All	36	37	38	39	40	
HB Education (3)	Child (0-15) (1)	All	41	42	43	44	45	
	Full time employed (2)	All	46	47	48	49	50	
	Other 16-74 (3)	All	51	52	53	54	55	
	Pensioner (4)	All	56	57	58	59	60	
	Child (0-15) (1)	All	61	62	63	64	65	

[4] NB: in NTMv2, this age range was 16-64, but has been updated to 16-74 in line with the 2011 Census and derived data

			Household Type					
Purpose	**Person Type**	**SEG / Income**	**1 adult / 0 car (1)**	**1 adult / 1+ car (2)**	**2+ adult / 0 car (3)**	**2+ adult / 1 car (4)**	**2+ adult / 2+ car (5)**	**All**
HB PB / Shopping (4)	Full time employed (2)	All	66	67	68	69	70	
	Other 16-74 (3)	All	71	72	73	74	75	
	Pensioner (4)	All	76	77	78	79	80	
HB Rec / Visiting friends (5)	Child (0-15) (1)	All	81	82	83	84	85	
	Full time employed (2)	All	86	87	88	89	90	
	Other 16-74 (3)	All	91	92	93	94	95	
	Pensioner (4)	All	96	97	98	99	100	
HB Hols / Day trips (6)	All persons	All						101
NHB EB (7)	All persons	High						102
		Medium						103
		Low						104
NHBO (8)	All persons	All						105

B.5. Distance bands

There are 13 distance bands defined in NTMv2R (unchanged). A fixed travel distance is assumed for each distance band modelled – note these distances are in miles consistent with the National Travel Survey. These are an input assumption to the model and have not been changed between NTMv2 and NTMv2R. The assumed distances of travel are shown in Table B-6.

Table B-6 Assumed distances by distance band

Distband	Distance	Average Length (miles)
1	< 1 mile	0.5
2	1 to 2 miles	1.5
3	2 to 3 miles	2.5
4	3 to 5 miles	4
5	5 to 10 miles	7.5
6	10 to 15 miles	12.5
7	15 to 25 miles	20
8	25 to 35 miles	30
9	35 to 50 miles	42.5
10	50 to 100 miles	75
11	100 to 200 miles	150
12	200 to 300 miles	250
13	300 miles and above	350

B.6. Modes

There are six modes of travel defined in the NTMv2R demand model. The definitions of these modes are identical to the modes defined in NTEM v7.0. The relationship to the NTS mode definitions is shown in Table B-7 below.

Table B-7 NTMv2R (and NTEM) modes and source definitions

NTMv2R and NTEM v7 mode	NTS mode definitions
1. Walk	Walk < 1 mile Walk 1+ miles
2. Cycle	Bicycle
3. Car driver	Private: car driver Motor cycle / scooter / moped: driver Van / lorry: driver Taxi Minicab
4. Car passenger	Private: car passenger Motor cycle / scooter / moped: passenger Van / lorry: passenger Other: private transport
5. Bus	Private (hire) bus London stage bus Other stage bus Express bus Excursion / tour bus
6. Rail	LT underground Surface rail Other public transport (includes light rail, metro etc) Domestic air

B.7. Time period

A single time period is used throughout the demand model. The time period covered is an average day. The total weekly trip end demand is taken from NTEM v7.0 and divided by 7 to give the demand for an average day.

Appendix C. Zone definition

C.1. Summary

The demand model zones are defined from a mixture of administrative boundaries and area types. For London, the administrative boundaries are used to define the Regions and area types. For other areas the area type (defined by the population size of the urban area), is the main variable used to define the zones with the administrative boundaries being used to define the Regions and where necessary to refine the area type definitions as set out in this Appendix.

C.2. London zones

The three demand model zones representing London are defined from the London Boroughs which map perfectly onto sets of NTEMv7 zones as follows:

- Area Type 1, Central London, is defined as the two London boroughs of Westminster and City of London.
- Area Type 2, Inner London, is defined as the London boroughs of Camden, Hackney, Hammersmith and Fulham, Haringey, Islington, Kensington and Chelsea, Lambeth, Lewisham, Newham, Southwark, Tower Hamlets and Wandsworth.
- Area Type 3, Outer London, is the rest of the London boroughs (LAD11 codes starting E09), namely Barking and Dagenham, Barnet, Bexley, Brent, Bromley, Croydon, Ealing, Enfield, Greenwich, Harrow, Havering, Hillingdon, Hounslow, Kingston upon Thames, Merton, Redbridge, Richmond upon Thames, Sutton and Waltham Forest.

C.3. Area types

This section provides an overview of the process of assigning the latest National Trip End Model (NTEMv7) zones with an NTMv2R area type from the National Travel Survey (NTS) for use in the updated and recalibrated version of the demand model (NTMv2R).

The process adopted is identical to the method used in the NTEMv7 work for assigning NTEM zones with an NTS area type applicable for trip rates and other parameters. However in this instance, different NTS area type aggregations are used to provide the definition for the NTM zones.

The output from this process was a GIS file that incorporates the NTEM zoning system, the NTMv2R area types and regions and hence the NTMv2R zoning system and a correspondence between NTEMv7 and NTMv2R zones.

C.3.1. NTS area types

Table C-1 provides correspondence between NTS area types (defined by population of the urban area) and the area type aggregations used in NTM. The area types used in NTM are an aggregation of NTS area types. The basis of the aggregated area type definitions have been retained from a previous version of NTEM and NTMv2 area types (1999 /2000).

Table C-1 NTS and NTM area types

NTS area type	Description	NTM area type	Description
1	Inner London	2	Inner London
2	Outer London	3	Outer London
3	West Midlands	5	Outer Conurbation
4	Greater Manchester	5	Outer Conurbation

NTS area type	Description	NTM area type	Description
5	West Yorkshire	5	Outer Conurbation
6	Glasgow	5	Outer Conurbation
7	Liverpool	5	Outer Conurbation
8	Tyneside	5	Outer Conurbation
9	South Yorkshire	5	Outer Conurbation
10	Other urban, population over 250K	6	Urban Big (>250k)
11	Other urban, population over 100K to 250K	7	Urban Large (>100k)
12	Other urban, population over 50K to 100K	8	Urban Medium (>25k)
13	Other urban, population over 25K to 50K	8	Urban Medium (>25k)
14	Other urban, population over 10K to 25K	9	Smaller urban and Rural
15	Other urban, population over 3K to 10K	9	Smaller urban and Rural
16	Smaller urban and Rural	9	Smaller urban and Rural

NB: NTM area types 1 and 4 are missing from the table above. Area type 1 is defined as Central London, and is a subset of Inner London. Area type 4 is defined as Metropolitan, and is made up of central parts of the area type 5 (Outer Conurbation) zones.

C.3.2. Attaching NTM area types to NTEM zones

Within GIS, each NTEM zone was assigned an NTS (NTM) area type (Table C-1) based on where objects from the NTEM zoning system intersect with objects from the NTS area type layer (provided by DfT's NTS team). Additionally, the proportional overlap between NTEM zones and NTS area types was calculated where objects from the two layers intersect. In some instances, more than one NTS area type intersects an NTEM zone. Where an NTEM zone is covered by more than one NTS area type, the zones are assigned the area type that covers the largest proportion. NTEM zones that do not overlap with an NTS area type are assigned an area type value of 9 (Smaller urban and Rural).

Proportional overlap thresholds have been previously investigated in the recent update of NTEM (v7). The purpose of the investigation was to avoid assigning an NTEM zone with an NTS area type that is not representative of that specific NTEM zone. NTS area types were only assigned to NTEM zones that met certain proportional overlap thresholds. NTEM zones that failed to meet the overlap threshold were assigned an area type value of 9 (Smaller urban and Rural). Proportional overlap values of 5%, 10%, 25% and 50% were analysed to establish the most appropriate threshold (i.e. 10% of an NTEM zone overlapped by an NTS area type). An overlap threshold of 10% is used for NTM, consistent with NTEM v7.

C.4. Built-up Area Definitions (non-London)

The process described above assigned an NTM Area Type to each NTEMv7 zone according to its closest match to NTS urban polygon boundaries by area type. Area Types 6-9 (and 5 in Scotland) have been used directly from this process, for all NTEMv7 zones except the following:

- Plymouth is defined by LAD11 code E06000026, and is assigned to Area Type 6.
- Metropolitan areas and Outer Conurbations in England and Wales together make up the LADs that are defined as metropolitan districts. (These are the LAD11 codes starting with E08.)
- Area Type 4, Metropolitan, is defined by groups of MSOA11 codes for specific cities in England. These groups of MSOAs were created by selecting the groups of MSOAs with the closest match to previous NTMv2 zones in these areas.
  - Birmingham (123 MSOAs);
  - Leeds (46 MSOAs);
  - Liverpool (49 MSOAs);

- Manchester (99 MSOAs);
- Newcastle upon Tyne (38 MSOAs); and
- Sheffield (60 MSOAs).

- Area Type 5, Outer Conurbation, is defined as the remaining MSOAs within LAD areas whose LAD11 codes starting E08 which were not included in Area Type 4.

There is one further Metropolitan area (Area Type 4) in Scotland, which is defined a group of NTEMv7 zones comprising the CA for Glasgow City (S12000046) plus part of the CA for South Lanarkshire (S12000029). As for Area Type 4 in England and Wales, this group of NTEMv7 zones was created using the best match of NTEMv7 zones to the NTMv2 conurbation area types. The corresponding Outer Conurbation (Area Type 5) surrounding Glasgow is defined by the rest of the NTS built-up area and is therefore as described in Table C-1.

Appendix D. MEPLAN implementation

D.1. Introduction

The distribution model (both distance band and destination choice) operates in the MEPLAN LUSA software. Within LUSA different categories of trips are represented as “factors” which are defined in the ULP file.

The distribution module of the demand model:

- splits the input trip productions (factors 1401 to 1505 – see Section D.3 below) into distance bands (factors 1 to 1393 – see Section D.2 below); and
- allocates them to attraction zones to match a set of specified trip attraction constraints (factors 1 to 1393 – see Section D.2 below now by zone pair); and
- applies constraints (base year only) to ensure total trips by purpose, segment and distance band match input targets (factors 1601 to 2228 – see Section D.4)
- applies constraints to ensure total trip attractions by purpose (factors 1510 to 1517 – see Section D.3 below) match target inputs by zone.

The choice models and parameters for this functionality are coded in the ULP file. The report “NTMv2R Demand Model Calibration and Validation”, RAND Europe April 2018 provides more information on the choice parameters applied.

The modal split model operates in the MEPLAN TASA software and uses the term *flows* to represent the different categories of trips input from the LUSA distribution model (flow 1 to 1393 identical to factors 1 to 1393 as defined in Section D.2 below). The mode choice model allocates trips amongst MEPLAN User Modes (main mode of travel as defined in Section D.5 below). The Flow / User Mode combinations give the full set of trips by mode for each purpose and traveller type combination. All Flow types are assumed to make use of all modes of travel. Thus those in households without car availability may still travel as car drivers and passengers (as observed in the NTS data). The extent to which each demand segment (flow type) uses each mode is determined during calibration through the use of appropriate choice parameters and alternative specific constants. See the NTMv2R Demand Model Calibration and Validation report for more information.

The mode and sub mode choice models and parameters for this functionality are coded in the UTF file. The report “NTMv2R Demand Model Calibration and Validation”, RAND Europe April 2018 provides more information on the choice parameters applied.

The remaining sections of this appendix provide details of the numbering systems in place at each stage of the model.

D.2. Demand numbering system

The basic segmentation of the travel demand was outlined in Section 2.5. Within the demand model these matrices are further segmented by distance band. The flow and factor numbering system implemented in the software for the trip matrices (for all trips - before mode split) in distance band 1 are shown in Table D-1. The definitions are in the MEPLAN UTF (flow) and ULP (factor) files.

For distance band 2, the equivalent segment numbers for household type dependent trips are those in Table D-1 plus 100; for example, home based work trips for distance band 2 for a full-time employee from a 1 adult/0 car household in the high SEG category is Flow / Factor 101. For distance band 3, the factor and flow numbers are those in Table D-1 plus 200, etc., up to additions of 1200 for distance band 13. For trips independent of household type, 1 is added for each distance band, so for a holiday/day trip in distance band 2, the Flow / Factor is 1302.

Table D-1: Factor and flow numbering for distance band 1 matrices

Purpose	Person type	SEG / Income	1 adult / 0 car	1 adult /1+ car	2+ ad / 0 car	2+ ad / 1 car	2+ad / 2+ car	All
HB Work	Full time emp	High Medium Low	1 6 11	2 7 12	3 8 13	4 9 14	5 10 15	
	Rest of pop'n	All	16	17	18	19	20	
HB EB	Full time emp	High Medium Low	21 26 31	22 27 32	23 28 33	24 29 34	25 20 35	
	Rest of pop'n	All	36	37	38	39	40	
HB Educ	Child (0-15) Full time emp Other 16-64 Pensioner		41 46 51 56	42 47 52 57	43 48 53 58	44 49 54 59	45 50 55 60	
HB PB / Shopping	Child (0-15) Full time emp Other 16-64 Pensioner		61 66 71 76	62 67 72 77	63 68 73 78	64 69 74 79	65 70 75 80	
HB Rec / Visiting friends	Child (0-15) Full time emp Other 16-64 Pensioner		81 86 91 96	82 87 92 97	83 88 93 98	84 89 94 99	85 90 95 100	
HB Hols / Day trips	All persons							1301
NHB EB	All persons	High Medium Low						1321 1341 1361
NHBO	All persons							1381

D.3. Trip production inputs and trip attraction constraints

The trip productions for each of the 105 combinations modelled are input to the demand model by zone. The numbering of the trip production input factors by purpose are shown in Table D-2. The pattern of numbering within each purpose is identical to that shown in Table D-1 above. Trip attractions by purpose and zone are derived from the trip end model and input as constraints to the distribution model as shown in Table D-2.

Table D-2: Trip end inputs – demand model factor numbers

Purpose	Trip production inputs (factors)	Trip attraction constraints (factors)
HB Work	1401 to 1420	1510
HB EB	1421 to 1440	1511
HBEduc	1441 to 1460	1512
HB PB / Shopping	1461 to 1480	1513
HB Rec / VF	1481 to 1500	1514
HB Hols / Day trip	1501	1515
NHB EB	1502 to 1504	1516
NHBO	1505	1517

D.4. Trip production constraints by distance band

A set of constraints are implemented onto the distribution module of the Demand Model. There are 364 factors defined by purpose, household type and distance band, but not by person type or SEG/income group. The constraint factors for distance band 1 are shown in Table D-3. The factors for the remaining 12 distance bands can be obtained by:

1600 + (Distance Band – 1) * 50 + Segment Number (1-28)

The constraints are derived using NTS data on the proportions of trips in each category. The proportions has been applied to the trip end inputs summed over all zones to obtain global constraints for each purpose and household type.

Table D-3: Factor and flow numbering for distance band 1 matrices

Purpose	1 adult / 0 car	1 adult / 1+ car	2+ ad / 0 car	2+ ad / 1 car	2+ad / 2+ car	All
HB Work	1601	1602	1603	1604	1605	
HB EB	1606	1607	1608	1609	1610	
HB Educ	1611	1612	1613	1614	1615	
HB PB / Shop	1616	1617	1618	1619	1620	
HB Rec/ VF	1621	1622	1623	1624	1625	
HB Hols/ Day trips						1626
NHB EB						1627
NHBO						1628

D.5. User and network modes

Within the MEPLAN modal split model there are two types of modes: user modes and network modes. The user mode is equivalent to the main mode of travel, while the network mode (often referred to as Mode in MEPLAN terminology) is dependent upon the part of the network being used and is therefore akin to the stage mode of travel.

The six main modes are split into the 13 distance bands prior to the modal choice process being carried out with the resulting user modes defined as shown in Table D-4 and coded in the MEPLAN UTF file. Based on an analysis of the NTS data, it was assumed that walk and cycle journeys would not occur in the longer distance bands.

Table D-4: User modes by distance band

	Distance bands												
Mode	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Walk	1	11	21	31	41	51							
Cycle	2	12	22	32	42	52	62						
Car driver	3	13	23	33	43	53	63	73	83	93	103	113	123
Car passenger	4	14	24	34	44	54	64	74	84	94	104	114	124
Bus	5	15	25	35	45	55	65	75	85	95	105	115	125
Rail	6	16	26	36	46	56	66	76	86	96	106	116	126

The network modes follow the same numbering pattern as the user modes, as shown in Table D-5 below and are defined in the MEPLAN UTM file. Note that the highest distance band available to the Walk mode is band 6 (10-15 miles) and the highest for Cycle is band 7 (15-25 miles).

To improve the representation of rail in the demand model a further set of network modes for rail were introduced to enable peak and inter-peak travel characteristics to be coded. These have been retained for this 2015 base year update of the model.

In addition to the network modes that represent the ride (in-vehicle) stage of the journey, there are also separate network modes for wait time for bus and rail. These vary by distance band.

There are four further network modes independent of the distance band. These represent the access time to a bus stop/station or rail station, and the time taken to park a car. Mode 132 is for Central & Inner London and metropolitan areas; mode 133 is for the other areas.

Table D-5: Network modes either dependent or independent of distance band

	Distance bands												
Network Mode	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Walk	1	11	21	31	41	51							
Cycle	2	12	22	32	42	52	62						
Car driver	3	13	23	33	43	53	63	73	83	93	103	113	123
Car passenger	4	14	24	34	44	54	64	74	84	94	104	114	124
Bus	5	15	25	35	45	55	65	75	85	95	105	115	125
Rail (peak)	6	16	26	36	46	56	66	76	86	96	106	116	126
Bus Wait	7	17	27	37	47	57	67	77	87	97	107	117	127
Rail Wait	8	18	28	38	48	58	68	78	88	98	108	118	128
Rail (offpeak)	9	19	29	39	49	59	69	79	89	99	109	119	129
Network modes independent of distance band													
Bus Access	130												
Rail Access	131												
Parking – metro	132												
Parking – other	133												

D.6. Existence of zone pair and distance band combinations

The thirteen figures below show if a distance band physically exists between a production and attraction zone pair as implemented in the modelling system. If a 'Y' is recorded in the table, the distance band exists and the block is shaded grey; if the combination is blank it does not exist anywhere within the modelling system. These combinations have been retained unchanged as part of the 2015 re-basing of the model.

	Attraction														
Prod	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**12**	**13**	**14**	**16**	**17**
1	Y	Y													
2	Y	Y	Y												
3		Y	Y											Y	
4				Y											
5					Y										
6						Y									
7							Y								
8								Y							Y
9									Y						
10										Y					Y
12											Y				Y
13												Y			
14													Y		Y
16			Y											Y	Y
17								Y		Y	Y		Y	Y	Y

Distance band 1 (less than 1 mile)

	Attraction														
Prod	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**12**	**13**	**14**	**16**	**17**
1	Y	Y													
2	Y	Y	Y												
3		Y	Y											Y	
4				Y		Y									Y
5					Y		Y								
6				Y		Y									Y
7					Y		Y							Y	Y
8								Y							Y
9									Y						Y
10										Y				Y	Y
12											Y				Y
13												Y		Y	Y
14													Y	Y	Y
16			Y				Y			Y		Y	Y	Y	Y
17				Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Distance band 2 (1 to 2 miles)

	Attraction														
Prod	1	2	3	4	5	6	7	8	9	10	12	13	14	16	17
1	Y	Y	Y												
2	Y	Y	Y												
3	Y	Y	Y											Y	Y
4				Y		Y									Y
5					Y		Y								Y
6				Y		Y								Y	Y
7					Y		Y					Y		Y	Y
8								Y						Y	Y
9									Y					Y	Y
10										Y				Y	Y
12											Y				Y
13							Y					Y		Y	Y
14													Y	Y	Y
16			Y			Y	Y	Y	Y	Y		Y	Y	Y	Y
17			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Distance band 3 (2 to 3 miles)

	Attraction														
Prod	1	2	3	4	5	6	7	8	9	10	12	13	14	16	17
1	Y	Y	Y												
2	Y	Y	Y											Y	
3	Y	Y	Y										Y	Y	Y
4				Y		Y									Y
5					Y		Y							Y	Y
6				Y		Y								Y	Y
7					Y		Y					Y		Y	Y
8								Y						Y	Y
9									Y					Y	Y
10										Y				Y	Y
12											Y			Y	Y
13							Y					Y		Y	Y
14			Y										Y	Y	Y
16		Y	Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
17			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Distance band 4 (3 to 5 miles)

	Attraction														
Prod	1	2	3	4	5	6	7	8	9	10	12	13	14	16	17
1	Y	Y	Y											Y	
2	Y	Y	Y											Y	Y
3	Y	Y	Y										Y	Y	Y
4				Y		Y								Y	Y
5					Y		Y					Y		Y	Y
6				Y		Y	Y							Y	Y
7					Y	Y	Y					Y		Y	Y
8								Y			Y			Y	Y
9									Y			Y		Y	Y
10										Y			Y	Y	Y
12								Y			Y			Y	Y
13					Y		Y		Y			Y		Y	Y
14			Y							Y			Y	Y	Y
16	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
17		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Distance band 5 (5 to 10 miles)

	Attraction														
Prod	1	2	3	4	5	6	7	8	9	10	12	13	14	16	17
1		Y	Y											Y	Y
2	Y	Y	Y										Y	Y	Y
3	Y	Y	Y										Y	Y	Y
4				Y		Y								Y	Y
5					Y	Y	Y					Y		Y	Y
6				Y	Y	Y	Y							Y	Y
7					Y	Y	Y					Y		Y	Y
8								Y			Y			Y	Y
9									Y			Y		Y	Y
10										Y			Y	Y	Y
12								Y			Y		Y	Y	Y
13					Y		Y		Y			Y		Y	Y
14		Y	Y							Y	Y		Y	Y	Y
16	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
17	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Distance band 6 (10 to 15 miles)

	Attraction														
Prod	1	2	3	4	5	6	7	8	9	10	12	13	14	16	17
1			Y										Y	Y	Y
2		Y	Y										Y	Y	Y
3	Y	Y	Y										Y	Y	Y
4				Y		Y								Y	Y
5					Y	Y	Y		Y			Y		Y	Y
6				Y	Y	Y	Y	Y				Y		Y	Y
7				Y	Y	Y	Y	Y	Y			Y		Y	Y
8						Y	Y	Y			Y			Y	Y
9					Y		Y		Y			Y		Y	Y
10										Y			Y	Y	Y
12								Y					Y	Y	Y
13					Y	Y	Y		Y			Y		Y	Y
14	Y	Y	Y							Y	Y		Y	Y	Y
16	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
17	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Distance band 7 (15 to 25 miles)

	Attraction														
Prod	1	2	3	4	5	6	7	8	9	10	12	13	14	16	17
1			Y										Y	Y	Y
2			Y										Y	Y	Y
3	Y	Y	Y										Y	Y	Y
4				Y		Y	Y	Y			Y			Y	Y
5				Y	Y	Y	Y		Y			Y		Y	Y
6				Y	Y	Y	Y	Y			Y	Y		Y	Y
7				Y	Y	Y	Y	Y	Y		Y	Y		Y	Y
8				Y	Y	Y	Y	Y			Y			Y	Y
9					Y		Y				Y	Y		Y	Y
10										Y			Y	Y	Y
12					Y		Y	Y	Y				Y	Y	Y
13					Y	Y	Y		Y			Y		Y	Y
14	Y	Y	Y							Y	Y		Y	Y	Y
16	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
17	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Distance band 8 (25 to 35 miles)

	Attraction														
Prod	1	2	3	4	5	6	7	8	9	10	12	13	14	16	17
1										Y			Y	Y	Y
2			Y							Y			Y	Y	Y
3		Y	Y							Y			Y	Y	Y
4				Y	Y	Y	Y	Y	Y		Y	Y		Y	Y
5				Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
6				Y	Y	Y	Y	Y	Y		Y	Y		Y	Y
7				Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
8				Y	Y	Y	Y	Y	Y		Y		Y	Y	Y
9				Y	Y	Y	Y	Y			Y	Y		Y	Y
10		Y	Y							Y			Y	Y	Y
12				Y	Y	Y	Y	Y	Y			Y	Y	Y	Y
13				Y	Y	Y	Y		Y			Y		Y	Y
14	Y	Y	Y		Y		Y	Y		Y	Y		Y	Y	Y
16	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
17	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Distance band 9 (35 to 50 miles)

	Attraction														
Prod	1	2	3	4	5	6	7	8	9	10	12	13	14	16	17
1							Y	Y		Y	Y		Y	Y	Y
2							Y	Y		Y	Y		Y	Y	Y
3			Y				Y	Y		Y	Y		Y	Y	Y
4				Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
5			Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
6				Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
7				Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
8	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
9				Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
10	Y	Y	Y		Y		Y			Y		Y	Y	Y	Y
12	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
13				Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
14	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
16	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
17	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Distance band 10 (50 to 100 miles)

	Attraction														
Prod	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**12**	**13**	**14**	**16**	**17**
1				Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2				Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3				Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
4	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
5	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
6	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
7	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
8	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
9	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y
10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
12	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y
13	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y
14	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
16	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
17	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Distance band 11 (100 to 200 miles)

	Attraction														
Prod	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**12**	**13**	**14**	**16**	**17**
1				Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y
2				Y	Y	Y	Y	Y	Y	Y		Y		Y	Y
3				Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y
4	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
5	Y	Y	Y	Y		Y		Y		Y	Y		Y	Y	Y
6	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
7	Y	Y	Y	Y		Y		Y		Y	Y		Y	Y	Y
8	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
9	Y	Y	Y	Y		Y		Y		Y	Y		Y	Y	Y
10	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
12				Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y
13	Y	Y	Y	Y		Y		Y		Y	Y		Y	Y	Y
14		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
16	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
17	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Distance band 12 (200 to 300 miles)

	Attraction														
Prod	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**12**	**13**	**14**	**16**	**17**
1				Y		Y		Y			Y			Y	Y
2				Y		Y		Y			Y			Y	Y
3				Y		Y		Y			Y			Y	Y
4	Y	Y	Y				Y	Y		Y	Y		Y	Y	Y
5						Y					Y			Y	Y
6	Y	Y	Y		Y		Y	Y		Y	Y		Y	Y	Y
7						Y				Y	Y			Y	Y
8	Y	Y	Y	Y		Y	Y	Y		Y	Y		Y	Y	Y
9										Y	Y		Y	Y	Y
10				Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y
12	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
13										Y	Y			Y	Y
14				Y		Y		Y	Y	Y	Y		Y	Y	Y
16	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
17	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Distance band 13 (300 miles and above)

Appendix E. Pseudo-network definition

E.1. Introduction

A pseudo network used to conveniently provide travel attributes to the demand model and is defined using the MEPLAN network definition files UTN (network), UTC (co-ordinates) and UTB (bounds and units).

To provide characteristics for a trip from zone A to zone B the first node in the path must be A.00 and the final node B.00 as these define the zone centroids. There is one series of links coded between these zone pairs for each relevant distance band combination so there is no path choice.

This appendix provides details of the pseudo network coding in terms of the series of links coded by mode and the differentiation of links by "link type".

E.2. Connectivity of pseudo network

The following figures show the network connectivity for each mode of travel. Beneath the diagram of connectivity, the node numbering schema is shown in green.

Figure E.1 shows how the car trips can be divided up into two components, the first being the ride link which will vary in length depending on the distance band between the origin and destination zone. Car operating costs and speeds are coded for these link types. The second link represents parking, and the time taken to find a parking space and the cost of parking the vehicle are coded. These will vary depending on the destination area type.

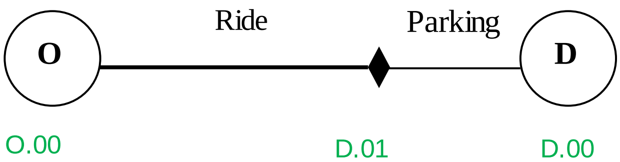


Figure E.1: pseudo network connectivity for car trips (driver and passenger)

The bus mode has four sets of links to travel on through the pseudo network. The access and wait links both have characteristics associated with the trip production zone. The ride section of this link will again vary by the distance band. The final link is the egress link, this is the time that it takes to get from the bus stop or station to the final location in the attraction zone. It is dependent on the characteristics of the attraction zone.

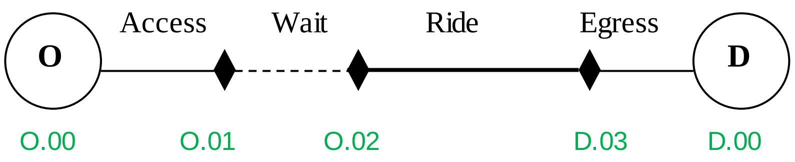


Figure E.2: pseudo network connectivity for bus trips

Rail trips take a similar form to bus, but with two additional ride links- interconnection and overcrowding. These are added to simulate the extra cost and disutility that these factors may impose on a rail journey as input to the demand model. These need to be coded as ride links at present, due to the variation in characteristics by distance band.

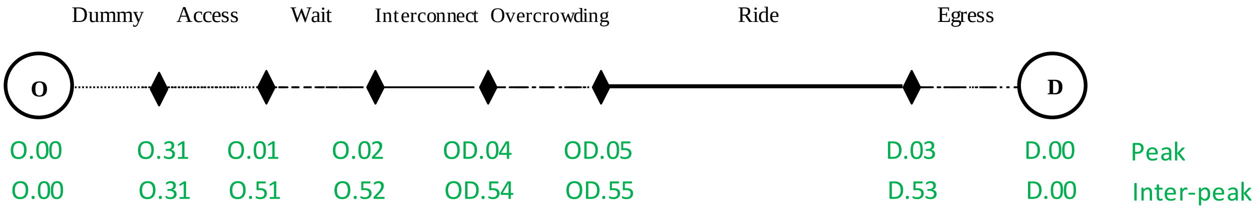


Figure E.3: pseudo network connectivity for rail trips

For slow modes, only the ride link is required to cover the whole length of the journey. This will again depend on the distance band between the origin and destination areas. In this case the ride links will go from centroid to centroid.

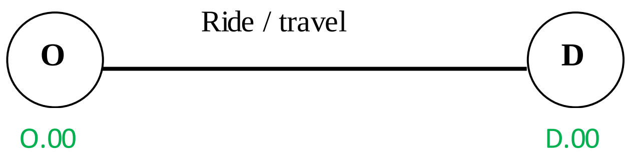


Figure E.4: pseudo network connectivity for walk and cycle trips

E.3. Ride link types

The majority of the demand model link types vary by mode, production and attraction zones and distance band. Link types were numbered using the convention XYYY where X denotes the main mode of travel and YYY denotes combinations of the trip production area type, the distance band and attraction zone.

As an example, Table E-1 below shows the link type numbering system used for most of the main modes of travel from each zone for the different distance bands. Inter-peak rail also has its own set of link types using the 9000 series of numbers. For any attraction area type, there are potentially 13 link types (one per distance band) for each of six modes – car, bus, walk, cycle, peak rail and inter-peak rail. All distance band combinations are shown in the Table, although they do not all exist in reality.

Table E-1 Link type numbering system for ride links

Production	Walk links		Cycle links		Car links		Bus links		Peak Rail links	
Zone	DB1	DB13	DB1	DB13	DB1	DB13	DB1	DB13	DB1	DB13
1	1001	1013	2001	2013	3001	3013	5001	5013	6001	6013
2	1021	1033	2021	2033	3021	3033	5021	5033	6021	6033
3	1041	1053	2041	2053	3041	3053	5041	5053	6041	6053
4	1061	1073	2061	2073	3061	3073	5061	5073	6061	6073
5	1081	1093	2081	2093	3081	3093	5081	5093	6081	6093
6	1101	1113	2101	2113	3101	3113	5101	5113	6101	6113
7	1121	1133	2121	2133	3121	3133	5121	5133	6121	6133
8	1141	1153	2141	2153	3141	3153	5141	5153	6141	6153
9	1161	1173	2161	2173	3161	3173	5161	5173	6161	6173
10	1181	1193	2181	2193	3181	3193	5181	5193	6181	6193
11	1201	1213	2201	2213	3201	3213	5201	5213	6201	6213
12	1221	1233	2221	2233	3221	3233	5221	5233	6221	6233
13	1241	1253	2241	2253	3241	3253	5241	5253	6241	6253
14	1261	1273	2261	2273	3261	3273	5261	5273	6261	6273
15	1281	1293	2281	2293	3281	3293	5281	5293	6281	6293
16	1301	1313	2301	2313	3301	3313	5301	5313	6301	6313
17	1321	1333	2321	2333	3321	3333	5321	5333	6321	6333

E.4. Access, wait and parking link types

Separate link types were defined for the different area types to increase flexibility of the input parameter specification and enable a variety of summary results to be extracted if required. The link type numbering system used in the demand model for the links independent of distance band are shown in Table E-2.

Table E-2 Link types independent of distance band

Demand model zone		PT Access links		PT Wait links		Car links	
(Region & Area type)		Bus	Rail	Bus	Pk Rail	IntPk Rail	Parking
1	Central London	101	201	301	401	421	501
2	Inner London	102	202	302	402	422	502
3	Outer London	103	203	303	403	423	503
4	North & East Metropolitan areas	104	204	304	404	424	504
5	West Metropolitan areas	105	205	305	405	425	505
6	North & East Conurbation surrounds	106	206	306	406	426	506
7	West Conurbation surrounds	107	207	307	407	427	507
8	North & East Urban big (>250k)	108	208	308	408	428	508
9	West Urban big (>250k)	109	209	309	409	429	509
10	South Urban big (>250k)	110	210	310	410	430	510
12	North & East Urban large (100-250k)	112	212	312	412	432	512
13	West Urban large (100-250k)	113	213	313	413	433	513
14	South Urban large (100-250k)	114	214	314	414	434	514
16	Urban medium (25-100k)	116	216	316	416	436	516
17	Urban small (<25k) & Rural	117	217	317	417	437	517